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SI_S3-2_ Supplementary information to Section 3.2

Climate models and associated simulations available for the present assessment

Climate models allow for policy-relevant calculations such as the assessment of the levels of carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions compatible with a specified climate stabilization target, such as the 1.5°C or 2°C global warming scenarios. Climate models are numerical models that can be of varying complexity and resolution (e.g., Le Treut et al., 2007). Presently, global climate models are typically Earth System Models (ESMs), in that they entail a comprehensive representation of Earth system processes, including biogeochemical processes.

In order to assess the impact and risk of projected climate changes on ecosystems or human systems, typical ESM simulations have a too coarse resolution (100km or more) in many cases. Different approaches can be used to derive higher-resolution information. In some cases, ESMs can be run globally with very-high resolution, however, such simulations are cost-intensive and thus very rare. Another approach is to use Regional Climate Models (RCM) to dynamically downscale the ESM simulations. RCMs are limited-area models with representations of climate processes comparable to those in the atmospheric and land surface components of the global models but with a higher resolution than 100km, generally down to 10-50km (e.g., CORDEX, Giorgi and Gutowski, 2015; Jacob et al., 2014a; Cloke et al., 2013; Erfanian et al., 2016; Barlow et al., 2016) and in some cases even higher (convection permitting models, i.e. less than 4km, e.g., Kendon et al., 2014; Ban et al., 2014; Prein et al., 2015). Statistical downscaling is another approach for downscaling information from global climate models to higher resolution. Its underlying principle is to develop statistical relationships that link large-scale atmospheric variables with local / regional climate variables, and to apply them to coarser-resolution models (Salameh et al., 2009; Su et al., 2016). Nonetheless, at the time of writing, we note that there are only very few studies on 1.5°C climate using regional climate models or statistical downscaling.

There are various sources of climate model information available for the present assessment. First, there are global simulations that have been used in previous IPCC assessments and which were computed as part of the World Climate Research Programme (WCRP) Coupled Models Intercomparison Project (CMIP). The IPCC AR4 and SREX reports were mostly based on simulations from the CMIP3 experiment, while the AR5 was mostly based on simulations from the CMIP5 experiment. We note that the simulations of the CMIP3 and CMIP5 experiments were found to be very similar (e.g., Knutti and Sedláček, 2012; Mueller and Seneviratne, 2014).

In addition to the CMIP3 and CMIP5 experiments, there are results from coordinated regional climate model experiments (CORDEX), which are available for different regions (Giorgi and Gutowski, 2015). For instance, assessments based on publications from an extension of the IMPACT2C project (Jacob and Solman, 2017; Vautard et al., 2014) are newly available for 1.5°C projections.

Recently, simulations from the “Half a degree Additional warming, Prognosis and Projected Impacts” (HAPPI) multi-model experiment have been performed to specifically assess climate changes at 1.5°C vs 2°C global warming (Mitchell et al., 2017). The HAPPI protocol consists of coupled land-atmosphere initial condition ensemble simulations with prescribed sea surface temperatures (SSTs), sea-ice, greenhouse gas (GHG) and aerosol concentrations, solar and volcanic activity that coincide with three forced climate states: present-day (2006-2015), and future (2091-2100) either with 1.5°C or 2°C global warming (prescribed from the modified SST conditions).

Beside climate models, other models are available to assess changes in regional and global climate system (e.g. models for sea level rise, models for floods, droughts, and freshwater input to oceans, cryosphere/snow models, models for sea ice, as well as models for glaciers and ice sheets). Analyses on impacts of a 1.5°C and 2°C climate using such models include e.g. Schleussner et al. (2016) and publications from the Inter-Sectoral Impact Model Intercomparison Project (ISI–MIP) Project (Warszawski et al., 2014), which have recently derived new analyses dedicated to 1.5°C and 2°C assessments.

Methods for the attribution of observed changes in climate and their relevance for assessing projected changes at 1.5° or 2°C global warming

As highlighted in previous IPCC reports, detection and attribution is an approach which is typically applied to assess impacts of greenhouse gas forcing on observed changes in climate (e.g., Hegerl et al., 2007; Seneviratne et al., 2012; Bindoff et al., 2013). The reader is referred to these past IPCC reports, as well as to the IPCC good practice guidance paper on detection and attribution (Hegerl et al., 2010), for more background on this topic. It is noted that in the IPCC framework, “attribution” means strictly “attribution to anthropogenic greenhouse gas forcing”. In some literature reports, in particular related to impacts, “attribution” is sometimes used in the sense of an observed impact that can be attributed to observed (regional or global) change in climate without considering whether the observed change in climate is itself attributable to anthropogenic greenhouse gas forcing. This definition is not used in this chapter. However, it is noted that in such cases the presence of “detected” changes can be reported.

Attribution to anthropogenic greenhouse gas forcing is an important field of research for these assessments. Indeed, global climate warming has already reached 1°C compared to pre-industrial conditions (Section 3.3), and thus “climate at 1.5°C global warming” corresponds to approximately the addition of half a degree warming compared to present-day warming. This means that methods applied in the attribution of climate changes to human influences can be relevant for assessments of changes in climate at 1.5°C warming, especially in cases where no climate model simulations or analyses are available for the conducted assessments. Indeed, impacts at 1.5°C global warming can be assessed in parts from regional and global climate changes that have already been detected and attributed to human influence (e.g., Schleussner et al., 2017). This is because changes that could already be ascribed to anthropogenic greenhouse gas forcing pinpoint to components of the climate system which are most responsive to this forcing, and thus will continue to be under 1.5°C or 2°C global warming. For this reason, when specific projections are missing for 1.5°C global warming, some of the assessments provided in Section 3.3, in particular in Table 3.1, build upon joint assessments of a) changes that were observed and attributed to human influence up to present, i.e. for 1 °C global warming and b) projections for higher levels of warming (e.g. 2°C, 3°C or 4°C) to assess the most likely changes at 1.5°C. Such assessments are for transient changes only (see Section 3.2.2.1).

The propagation of uncertainties from climate forcings to impacts on the ecosystems

The uncertainties associated with future projections of climate change are calculated using ensembles of model simulations (Flato et al., 2013). However, models are not fully independent, and the use of model spread as an estimator of uncertainty has been called into question (Annan and Hargreaves, 2017). Many studies have been devoted to this major problem, which is crucial for policymakers. The sources of uncertainty are diverse (Rougier and Goldstein, 2014), and they must be identified to better determine the limits of predictions. The following list includes several key sources of uncertainty:

1. Input uncertainties include a lack of knowledge about the boundary conditions and the noise affecting the forcing variables;
2. Parametric and structural uncertainties are related to the lack of knowledge about some processes (i.e., those that are highly complex or operate at very fine scales) and the lack of clear information about the parameterisations used in models and the differences among the models. It has also been shown that different combinations of parameters can yield plausible simulations (Mauritsen et al., 2012).
3. Observational errors include noise and the unknown covariance structure in the data used.
4. Scale uncertainty originates from the fact that impact studies require a finer scale than ESM outputs can provide (Khan and Coulibaly, 2010).
5. The offline coupling of climate - impact models introduces uncertainty because this coupling permits only a limited number of linkage variables and does not allow the representation of key feedbacks. This procedure may cause a lack of coherency between the linked climate and impact models (Meinshausen et al., 2011).
6. Important biases also include the consequences of tuning using a restricted range of climate states, i.e., the periods from which climate data are available. Large biases in projections may be produced when future forcings are very different than those used for tuning.
7. It is also assumed that ESMs yield adequate estimates of climate, except for an unknown translation (Rougier and Goldstein, 2014). Usually, this translation is estimated by performing an anomaly correction (the difference between the control simulation and the observed field). Such correction represents an additional uncertainty that is often ignored in the final estimate of the error bars.

Due to these uncertainties in the formulation, parametrisation, and initial states of models, any individual simulation represents only one step in the pathway followed by the climate system (Flato et al., 2013). The assessment of these uncertainties must therefore be done in a probabilistic way. It is particularly important when the signal to noise ratio is weak, as it could be when we want to assess the difference of risks between 1.5°C and 2°C global warming.

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SI_S3-3_Supplementary information to Section 3.3

Supplementary text

Section S3.1 Change in global climate as assessed in the AR5

The GMST warming compared to pre-industrial levels has at the time of writing this report (2017) reached approximately 1 °C (Chapter 1). At the time of writing of the AR5 WG1 report (i.e. for time frames up to 2012; Stocker et al. 2013), Hartmann et al. (2013) assessed that the globally averaged combined land and ocean surface temperature data as calculated by a linear trend, showed a warming of 0.85 [0.65 to 1.06] °C, over the period 1880–2012, when multiple independently produced datasets existed, and about 0.72 [0.49 to 0.89] °C over the period 1951–2012. Hence most of the global warming has occurred since 1950 and it has continued substantially in recent years.

The above values are for global mean warming, however, regional trends can be much more varied. With few exceptions, most land regions display stronger trends in the global mean average, and by 2012, i.e. with a warming of ca. 0.85 °C (see above), some land regions already displayed warming higher than 1.5°C (Figure 3.1).

It should be noted that more recent evaluations of the observational record suggest that the estimates of global warming at the time of the AR5 may have been underestimated (Cowtan and Way, 2014; Richardson et al., 2016) . Indeed, as highlighted in Section 3.3.1 and also discussed in Chapter 1, sampling biases and different approaches to estimate GMST (e.g. using water vs air temperature over oceans) can sensibly impact estimates of GMST warming as well as differences between model simulations and observations-based estimates (Richardson et al., 2016).

A large fraction of the detected global warming has been attributed to anthropogenic forcing (Bindoff et al., 2013b). The AR5 (Bindoff et al., 2013b) assessed that it is *virtually certain* that human influence has warmed the global climate system and that it is *extremely likely* that human activities caused more than half of the observed increase in GMST from 1951 to 2010 (see supplementary Figure S3.1). The AR5 (Bindoff et al., 2013b) assessed that greenhouse gases contributed a global mean surface warming *likely* to be between 0.5 °C and 1.3 °C over the period 1951–2010, with the contributions from other anthropogenic forcings *likely* to lie between – 0.6 °C and 0.1 °C, from natural forcings *likely* to be between – 0.1 °C and 0.1 °C, and from internal variability *likely* to be between –0.1 °C and 0.1 °C. Regarding observed global changes in temperature extremes, the IPCC SREX report assessed that since 1950 it is *very likely* that there has been an overall decrease in the number of cold days and nights and an overall increase in the number of warm days and nights at the global scale, that is, for land areas with sufficient data (Seneviratne et al., 2012).

Observed global changes in the water cycle, including precipitation, are more uncertain than observed changes in temperature (Hartmann et al., 2013; Stocker et al., 2013). The AR5 assessed that it is very likely that global near surface and tropospheric air specific humidity have increased since the 1970s (Hartmann et al., 2013). However, AR5 also highlighted that during recent years the near surface moistening over land has abated (*medium confidence*), and that as a result, there have been fairly widespread decreases in relative humidity near the surface over the land in recent years (Hartmann et al., 2013). With respect to precipitation, some regional precipitation trends appear to be robust (Stocker et al., 2013), but when virtually all the land area is filled in using a reconstruction method, the resulting time series of global mean land precipitation shows little change since 1900. Hartmann et al. (2013) highlight that confidence in precipitation change averaged over global land areas since 1901 is low for years prior to 1951 and medium afterwards. However, for averages over the mid-latitude land areas of the Northern Hemisphere, Hartmann et al. (2013) assessed that precipitation has likely increased since 1901 (*medium confidence* before and *high confidence* after 1951). For other latitudinal zones area-averaged long-term positive or negative trends have low confidence due to data quality, data completeness or disagreement amongst available estimates (Hartmann et al., 2013). For heavy precipitation, the AR5 assessed that in land regions where observational coverage is sufficient for assessment, there is *medium confidence* that anthropogenic forcing has contributed to a global-scale intensification of heavy precipitation over the second half of the 20th century (Bindoff et al., 2013b).

Supplementary Figures

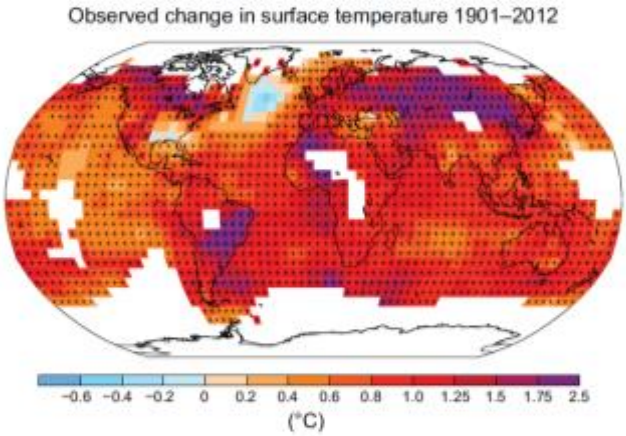
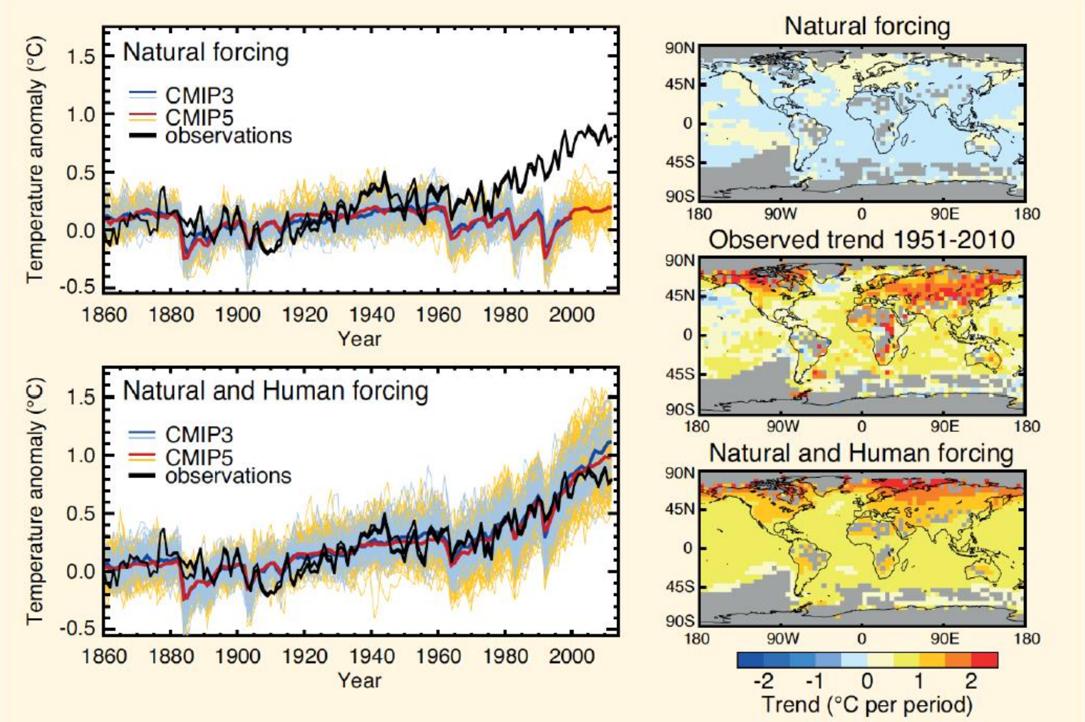


Figure S3.1 Map of the observed surface temperature change from 1901 to 2012 derived from temperature trends determined by linear regression from one dataset. Trends have been calculated where data availability permits a robust estimate (i.e., only for grid boxes with greater than 70% complete records and more than 20% data availability in the first and last 10% of the time period). Other areas are white. Grid boxes where the trend is significant at the 10% level are indicated by a + sign. From Stocker et al. (2013).



FAQ 10.1, Figure 1 | (Left) Time series of global and annual-averaged surface temperature change from 1860 to 2010. The top left panel shows results from two ensemble of climate models driven with just natural forcings, shown as thin blue and yellow lines; ensemble average temperature changes are thick blue and red lines. Three different observed estimates are shown as black lines. The lower left panel shows simulations by the same models, but driven with both natural forcing and human-induced changes in greenhouse gases and aerosols. (Right) Spatial patterns of local surface temperature trends from 1951 to 2010. The upper panel shows the pattern of trends from a large ensemble of Coupled Model Intercomparison Project Phase 5 (CMIP5) simulations driven with just natural forcings. The bottom panel shows trends from a corresponding ensemble of simulations driven with natural + human forcings. The middle panel shows the pattern of observed trends from the Hadley Centre/Climatic Research Unit gridded surface temperature data set 4 (HadCRUT4) during this period.

Figure S3.2. Attribution of global warming change (from IPCC AR5; Bindoff et al., 2013a).

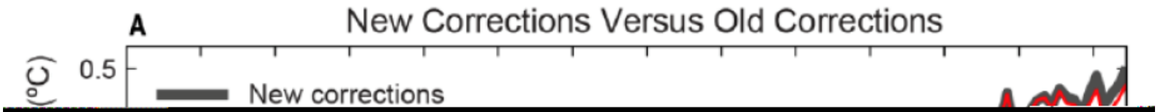


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Figure S3.3. Global temperature warming using older and newer corrections (Karl et al., 2015).

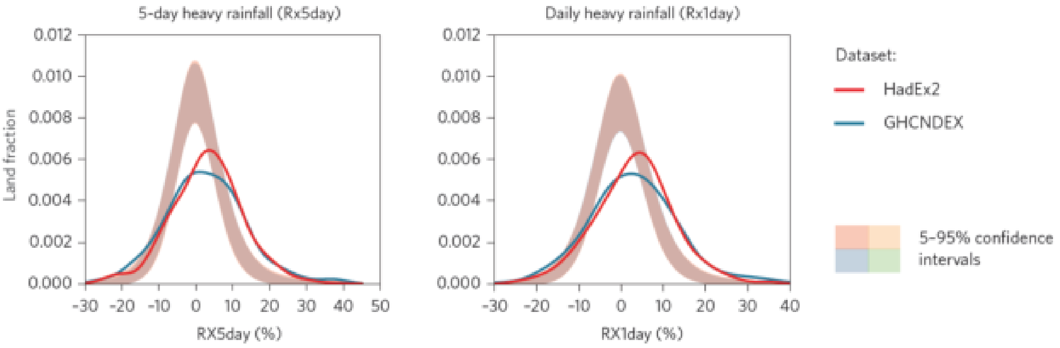

Figure S3.4 : Differences in extreme precipitation event indices for 0.5 °C warming over the observational record. Probability density functions show the globally aggregated land fraction that experienced a certain change between the 1991–2010 and 1960–1979 periods for the HadEX2 and GHCNDEX datasets. Light-coloured envelopes illustrate the changes expected by internal variability alone, estimated by statistically resampling individual years. [Based on Schleussner et al. (2017)]

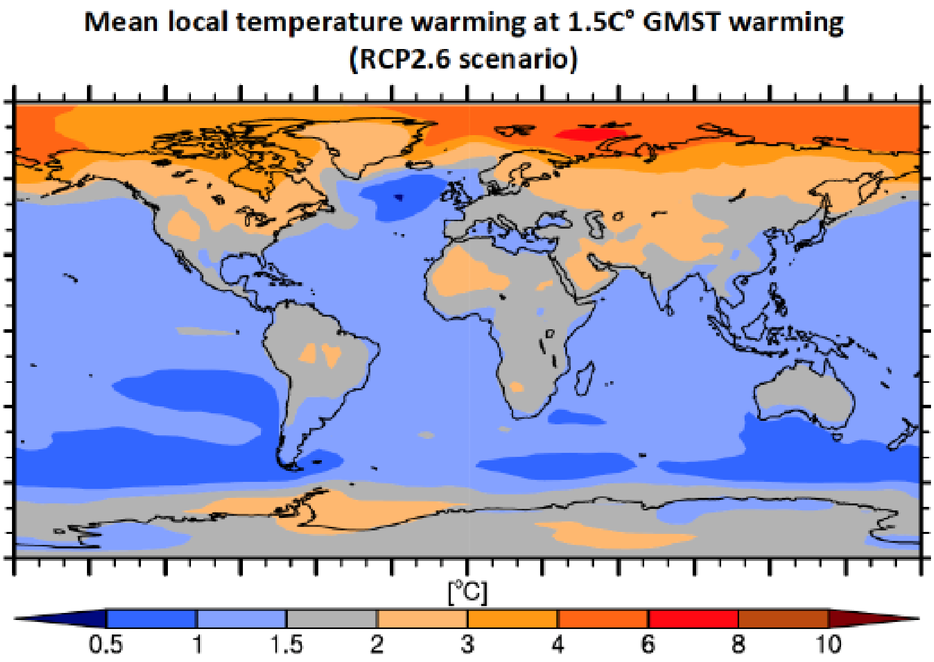

Figure S3.5 : Same analysis as left-hand part of Fig. 3.4 but based on RCP2.6 scenario CMIP5 simulations.

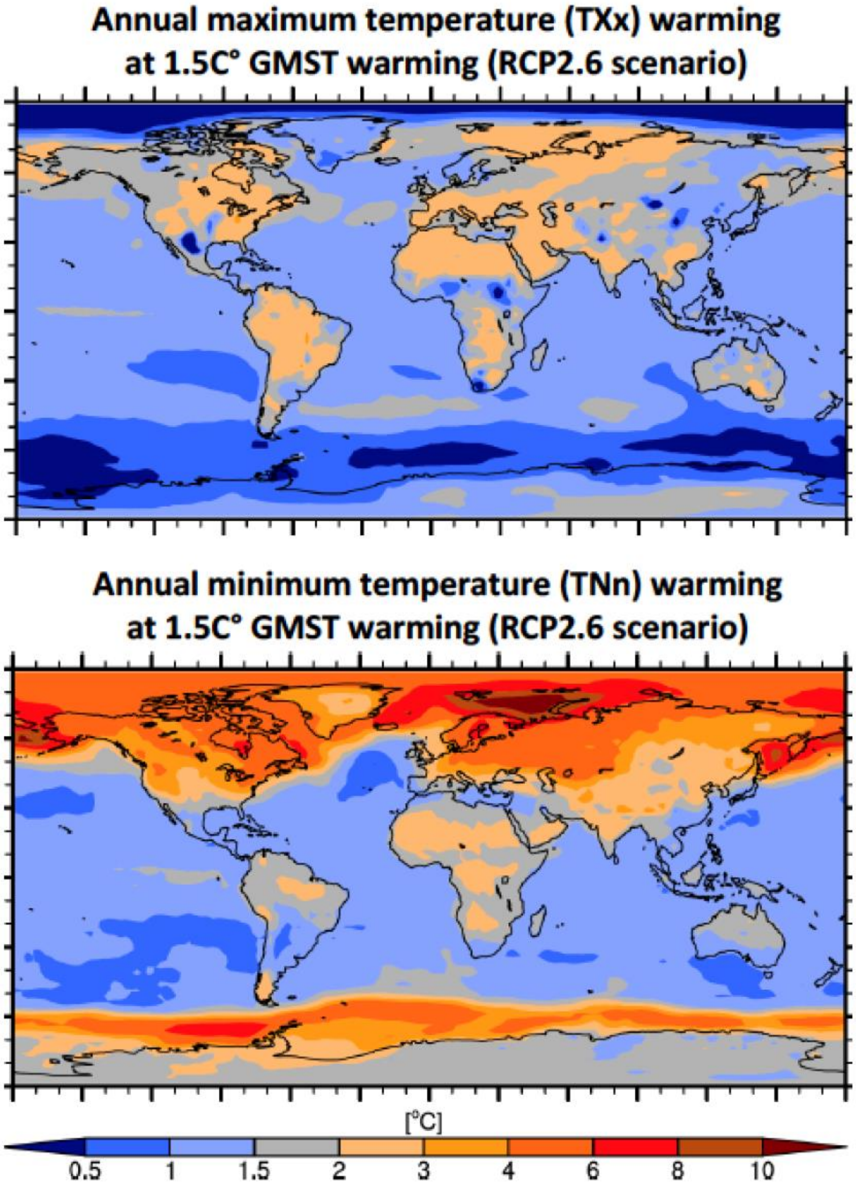

Figure S3.6: Same analysis as left-hand part of Fig. 3.3 but based on RCP2.6 scenario CMIP5 simulations.

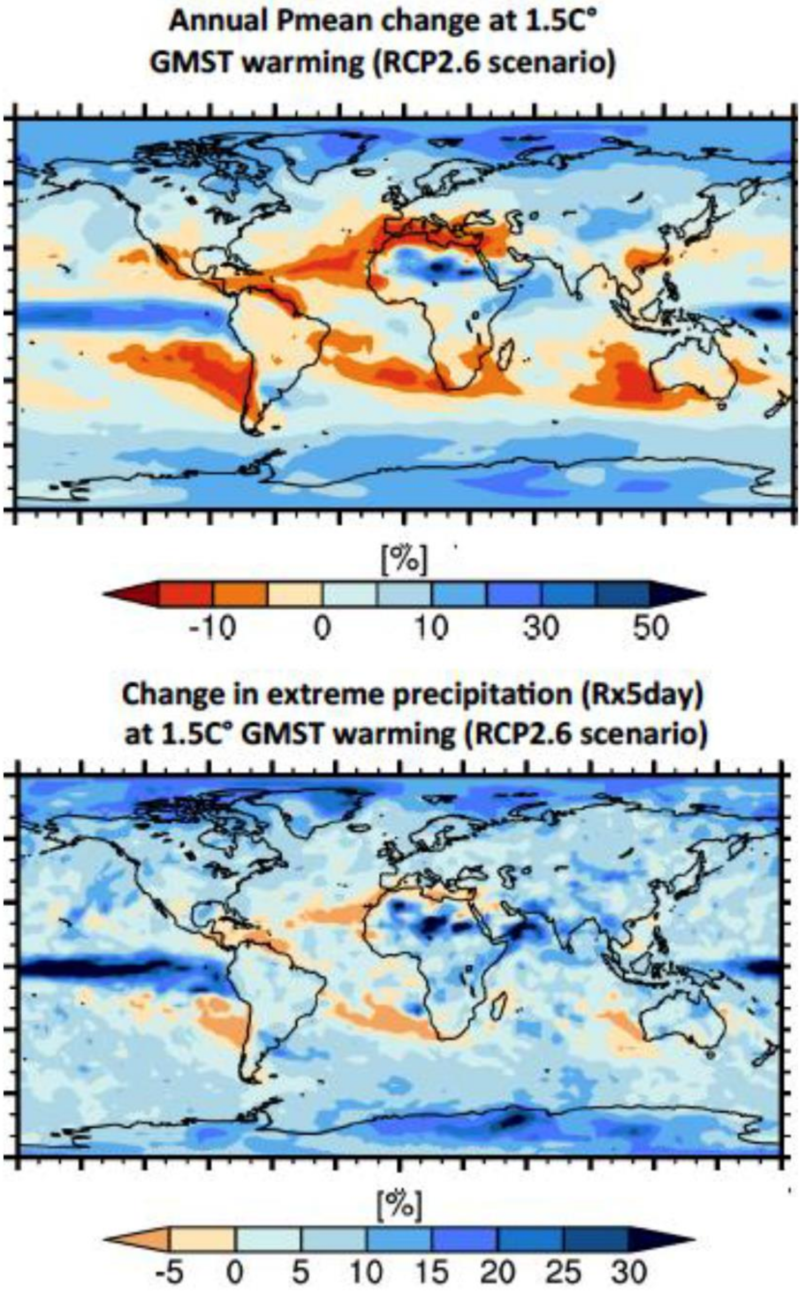

Figure S3.7: Same analysis as left-hand part of Fig. 3.6 but based on RCP2.6 scenario CMIP5 simulations.

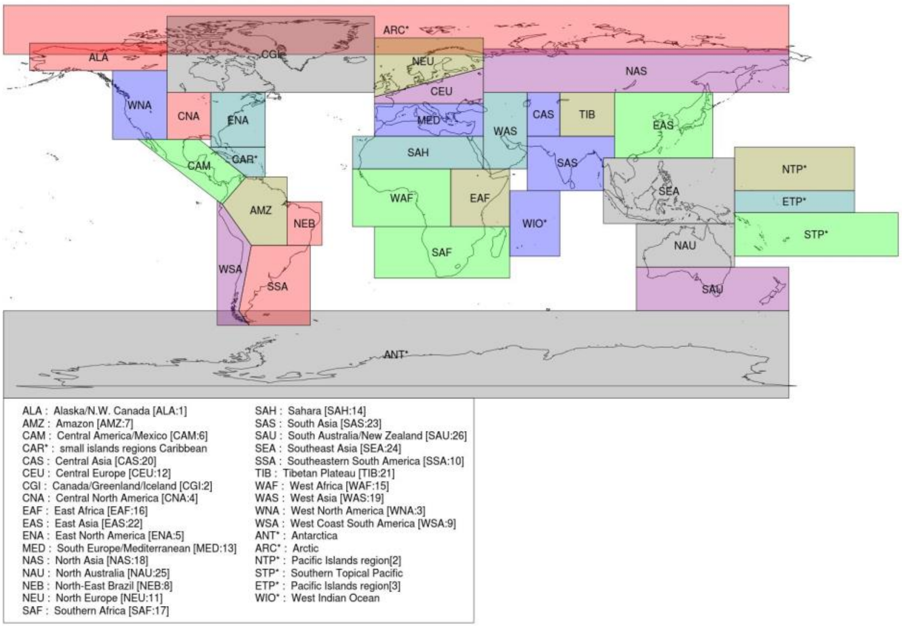

Figure S3.8: SREX Regions

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SI_S3-4_Supplementary information to Section 3.4

Table S1 - S3.4.2 Freshwater resources

Summary Table

Sector	Driver (standard symbols) *link to 3.3	Risks at 1.5ºC above pre-industrial *global	Change in risk from 1.5ºC to 2ºC *global (if the risks are higher at 2 than 1.5, this number is positive)	Region (Red = High) (hotspots)	Cited papers (numbered list)	Key risks from AR5	RFC
Water scarcity	runoff	240 million in 2100(2086-2115 average)	240 million in 2100(2086-2115 average)	Global	(Gerten et al. 2013)		
Water resources	discharge	8% of global population	6% of global population	Global	(Schewe et al. 2014)		
Water resources	discharge reduction >20%	5% of global population	8% of global population	Global	(Schewe et al. 2014)		
Water resources	discharge reduction >1σ	0.5% of global population	5.5% of global population	Global	(Schewe et al. 2014)		
Water resources	anuual runoff per capita	1330 [379-2997] million in 2050	184 [-152-431] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		
Water resources	anuual runoff per capita	1575 [379-2997] million in 2050	219 [-195-408] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		
Water resources	anuual runoff per capita	1887 [379-2997] million in 2050	270 [-113-411] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		
Water resources	anuual runoff per capita	1656 [379-2997] million in 2050	211 [-37-376] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		
Water resources	anuual runoff per capita	1375 [379-2997] million in 2050	191 [-154-436] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		
Water scarcity, irrigation water demand		-13 km^3/yr in 2030-2065	2 km^3/yr in 2030-2065	India	(Wada et al. 2013)		
Water scarcity, irrigation water demand		54 km^3/yr in 2030-2065	16 km^3/yr in 2030-2065	China	(Wada et al. 2013)		

Sector	Driver (standard symbols) *link to 3.3	Risks at 1.5ºC above pre-industrial *global	Change in risk from 1.5ºC to 2ºC *global (if the risks are higher at 2 than 1.5, this number is positive)	Region (Red = High) (hotspots)	Cited papers (numbered list)	Key risks from AR5	RFC
Water scarcity, irrigation water demand		-2 km^3/yr in 2030-2065	7 km^3/yr in 2030-2065	Pakistan	(Wada et al. 2013)		
Water scarcity, irrigation water demand		-5 km^3/yr in 2030-2065	10 km^3/yr in 2030-2065	USA	(Wada et al. 2013)		
Water scarcity, irrigation water demand		244 km^3/yr in 2030-2065	24 km^3/yr in 2030-2065	Global	(Wada et al. 2013)		
Water scarcity, irrigation water withdrawal	potential irrigation water demand	58 km^3/yr in 2011-2040(RCP2.6)	-13 km^3/yr in 2011-2040(RCP2.6)	Global	(Hanasaki et al. 2013)		
Water scarcity, irrigation water withdrawal	potential irrigation water demand	74 km^3/yr in 2011-2040(RCP4.5)	-55 - -29 km^3/yr in 2011-2040(RCP4.5)	Global	(Hanasaki et al. 2013)		
Water scarcity, irrigation water withdrawal	potential irrigation water demand	55 km^3/yr in 2011-2040(RCP8.5)	9.6 km^3/yr in 2011-2040(RCP8.5)	Global	(Hanasaki et al. 2013)		
increased flooding, population affected	flooding	100% in 2003-2040(RCP8.5)	70%	Global	(Alfieri et al. 2017)		
increased flooding, damage	flooding	120% in 2003-2040(RCP8.5)	50%	Global	(Alfieri et al. 2017)		
flood-prone population	increased river flood frequency	253 [83-473] million in 2050	26 [-6-5] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		
flood-prone population	increased river flood frequency	280 [93-525] million in 2050	29 [-9-5] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		

Sector	Driver (standard symbols) *link to 3.3	Risks at 1.5ºC above pre-industrial *global	Change in risk from 1.5ºC to 2ºC *global (if the risks are higher at 2 than 1.5, this number is positive)	Region (Red = High) (hotspots)	Cited papers (numbered list)	Key risks from AR5	RFC
flood-prone population	increased river flood frequency	317 [105-596] million in 2050	34 [-12-6] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		
flood-prone population	increased river flood frequency	268 [90-503] million in 2050	29 [-9-4] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		
flood-prone population	increased river flood frequency	250 [83-468] million in 2050	26 [-6-5] million in 2050	Global	(Arnell and Lloyd-Hughes 2014)		
monthly population exposed to extreme drought		114 million	76 million	Global	(Smirnov et al. 2016)		
population exposed to drought		-103 million in 2026-2030	357 million in 2040-2042	the Haihe River Basin, China	(Sun et al. 2017)		
groundwater resources	decrease of renewable groundwater resources of more than 70%	1.6%[1.0-2.2] of global land area	0.4%[0.1-0.4]	Global	(Portmann et al. 2013)		

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Detailed Table

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(ºC)	Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(ºC)
Water scarcity, world population	global	%	1980-2009			19GCM from the CMIP3 archive, MAGICC6, RCP8.5,2086-2115			Y	4		4	1,5	
Water scarcity, world population	global	%	1980-2009			19GCM from the CMIP3 archive, MAGICC6, RCP8.5,2086-2115			Y		8	8	2	
Water scarcity, world population	global	%	1980-2009			19GCM from the CMIP3 archive, MAGICC6, RCP8.5,2086-2115			Y			10	3	

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date (make clear if uses present day population and assumes constant)**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)**	**Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
water resources, global population	global	%	1980-2010	SSP2	0,7	transition of RCP8.5 in 2021-2040, eleven GHMs by five GCMS	T		Y			8	1,7	1
water resources, global population	global	%	1980-2010	SSP2	0,7	transition of RCP8.5in 2043-2071, eleven GHMs by five GCMS	T		Y			14	2,7	2
water scarcity, increased water resources stress	global	million people	1961-1990	SSP1	0,3	transition of RCP2.6 in 2050, 19 GCMs	E			1330				
water scarcity, increased water resources stress	global	million people	1961-1990	SSP1	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				1514			

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date (make clear if uses present day population and assumes constant)**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)**	**Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
water scarcity, increased water resources stress	global	million people	1961-1990	SSP2	0,3	transition of RCP2.6 in 2050, 19 GCMs	E			1575				
water scarcity, increased water resources stress	global	million people	1961-1990	SSP2	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				1794			
water scarcity, increased water resources stress	global	million people	1961-1990	SSP3	0,3	transition of RCP2.6 in 2050, 19 GCMs	E			1887				
water scarcity, increased water resources stress	global	million people	1961-1990	SSP3	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				2157			

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date (make clear if uses present day population and assumes constant)**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)**	**Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
water scarcity, increased water resources stress	global	million people	1961-1990	SSP4	0,3	transition of RCP2.6 in 2050, 19 GCMs	E			1656				
water scarcity, increased water resources stress	global	million people	1961-1990	SSP4	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				1867			
water scarcity, increased water resources stress	global	million people	1961-1990	SSP5	0,3	transition of RCP2.6 in 2050, 19 GCMs	T			1375				
water scarcity, increased water resources stress	global	million people	1961-1990	SSP5	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				1566			

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date (make clear if uses present day population and assumes constant)**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)**	**Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
increased flooding, increased river flood frequency	global	million people	1961-1990	SSP1	0,3	transition of RCP2.6 in 2050, 19 GCMs	T			253				
increased flooding, increased river flood frequency	global	million people	1961-1990	SSP1	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				279			
increased flooding, increased river flood frequency	global	million people	1961-1990	SSP2	0,3	transition of RCP2.6 in 2050, 19 GCMs	T			280				
increased flooding, increased river flood frequency	global	million people	1961-1990	SSP2	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				309			
increased flooding, increased	global	million people	1961-1990	SSP3	0,3	transition of RCP2.6 in 2050, 19 GCMs	T			317				

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(ºC)	Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(ºC)
river flood frequency														
increased flooding, increased river flood frequency	global	million people	1961-1990	SSP3	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				351			
increased flooding, increased river flood frequency	global	million people	1961-1990	SSP4	0,3	transition of RCP2.6 in 2050, 19 GCMs	T			268				
increased flooding, increased river flood frequency	global	million people	1961-1990	SSP4	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				297			
increased flooding, increased river flood frequency	global	million people	1961-1990	SSP5	0,3	transition of RCP2.6 in 2050, 19 GCMs	T			250				

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(ºC)	Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(ºC)
increased flooding, increased river flood frequency	global	million people	1961-1990	SSP5	0,3	transition of RCP4.5 in 2050, 19 GCMs	T				276			
water scarcity, irrigation water demand	global	%	1980-2010		0,7	five GHMs and five GCMs, RCP2.6,2035-2065	E		Y			8,6	around 2.3	around 1.5
water scarcity, irrigation water demand	global	%	1980-2010		0,7	five GHMs and five GCMs, RCP4.5,2035-2065	T		Y			9,4	2.3-3.3	1.5-2.5
water scarcity, irrigation water demand	India	%	1980-2010		0,7	five GHMs and five GCMs, RCP2.6,2035-2065	E		Y			-1,7	around 2.3	around 1.5
water scarcity, irrigation	India	%	1980-2010		0,7	five GHMs and five GCMs,	T		Y			-1,5	2.3-3.3	1.5-2.5

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(ºC)	Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(ºC)
water demand						RCP4.5,2035-2065								
water scarcity, irrigation water demand	China	%	1980-2010		0,7	five GHMs and five GCMs, RCP2.6,2035-2065	E		Y			10,3	around 2.3	around 1.5
water scarcity, irrigation water demand	China	%	1980-2010		0,7	five GHMs and five GCMs, RCP4.5,2035-2065	T		Y			13,3	2.3-3.3	1.5-2.5
water scarcity, irrigation water demand	Pakistan	%	1980-2010		0,7	five GHMs and five GCMs, RCP2.6,2035-2065	E		Y			-0,6	around 2.3	around 1.5
water scarcity, irrigation water demand	Pakistan	%	1980-2010		0,7	five GHMs and five GCMs, RCP4.5,2035-2065	T		Y			1,6	2.3-3.3	1.5-2.5

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date (make clear if uses present day population and assumes constant)**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)**	**Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
water scarcity, irrigation water demand	USA	%	1980-2010		0,7	five GHMs and five GCMs, RCP2.6,2035-2065	E		Y			-2,4	around 2.3	around 1.5
water scarcity, irrigation water demand	USA	%	1980-2010		0,7	five GHMs and five GCMs, RCP4.5,2035-2065	T		Y			2,4	2.3-3.3	1.5-2.5
Water scarcity, water withdrawal	global	%	1971-2000	SSP1-5	0,4	RCP2.6, 2011-2040, MIROC-ESM-CHEM, H08			Y			1,4	2,1	1,7
Water scarcity, water withdrawal	global	%	1971-2000	SSP1-5	0,4	RCP2.6, 2011-2040, GFDL-ESM2M, H08			Y	1,8		1,8	1,5	1,1
Water scarcity, water withdrawal	global	%	1971-2000	SSP1-5	0,4	RCP2.6, 2071-2100, GFDL-			Y			1,1	1,6	1,2

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(ºC)	Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(ºC)
						ESM2M, H08								
Water scarcity, water withdrawal	global	%	1971-2000	SSP1-5	0,4	RCP4.5, 2011-2040, MIROC-ESM-CHEM, H08			Y			1,4	1,9	1,5
Water scarcity, water withdrawal	global	%	1971-2000	SSP1-5	0,4	RCP4.5, 2011-2040, HadGEM2-ES, H08			Y			0,6	2,1	1,7
Water scarcity, water withdrawal	global	%	1971-2000	SSP1-5	0,4	RCP4.5, 2011-2040, GFDL-ESM2M, H08			Y			2,3	1,6	1,2
Water scarcity, water withdrawal	global	%	1971-2000	SSP1-5	0,4	RCP8.5, 2011-2040, MIROC-ESM-CHEM, H08			Y			2	2,1	1,7
Water scarcity,	global	%	1971-2000	SSP1-5	0,4	RCP8.5, 2011-2040, GFDL-			Y			1,7	1,6	1,2

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(ºC)	Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(ºC)
water withdrawal						ESM2M, H08								
	global	%	1976-2005			transition, seven GCMs,EC-EARTH3-HR v3.1, RCP8.5	T			100	170			
	global	%	1976-2005			transition, seven GCMs, EC-EARTH3-HR v3.1, RCP8.5	T			120	170			
River flood, flood fatality	global	%	1991-2005	SSP1, 3		RCP8.5	T							
River flood, potential economic loss	global	%	1991-2005	SSP1, 3		RCP8.5	T							
monthly population exposed to	global	million	1955-2005			SPEI, 16 CMIP5,			Y	114,3		114,3		

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(ºC)	Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(ºC)
extreme drought		people				RCP8.5,2021-2040								
monthly population exposed to extreme drought	global	million people	1955-2005			SPEI, 16 CMIP5, RCP8.5,2041-2060			Y		190,4	190,4		
groundwater resources	global	%	1971-2000		0,4	five GCMs, RCP8.5, 2070-2099	T			1,6				
groundwater resources	global	%	1971-2000		0,4	five GCMs, RCP8.5, 2070-2099	T				2			
the daily probability of exceeding the chloride standard for drinking water	Lake Ijsselmeer, the Netherlands	%	1997-2007		0,5	KNMI scenario G, 2050			Y			3,1	1,5	1
the daily probability of	Lake Ijsselmeer, the	%	1997-2007		0,5	KNMI scenario W+, 2050			Y			14,3	2,5	2

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date (make clear if uses present day population and assumes constant)**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)**	**Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
exceeding the chloride standard for drinking water	Netherlands													
the maximum duration of the exceedance	Lake Ijsselmeer, the Netherlands	days	1997-2007		0,5	KNMI scenario G, 2050			Y			124	1,5	1
the maximum duration of the exceedance	Lake Ijsselmeer, the Netherlands	days	1997-2007		0,5	KNMI scenario W+, 2050			Y			178	2,5	2
Change of DO concentration	Qu'Appelle River ,Canda	%	2012-2015			four GCMs, RCP2.6, 2050-2055				-0,16		-0,16		
Change of DO concentration	Qu'Appelle River ,Canda	%	2012-2015			four GCMs, RCP4.5, 2050-2055					-0,32	-0,32		

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(ºC)	Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(ºC)
Change of NH4-N concentration	Qu'Appelle River ,Canda	%	2012-2015			four GCMs, RCP2.6, 2050-2055				-0,52		-0,52		
Change of NH4-N concentration	Qu'Appelle River ,Canda	%	2012-2015			four GCMs, RCP4.5, 2050-2055					-0,86	-0,86		
Change of NO3-N concentration	Qu'Appelle River ,Canda	%	2012-2015			four GCMs, RCP2.6, 2050-2055				-0,57		-0,57		
Change of NO3-N concentration	Qu'Appelle River ,Canda	%	2012-2015			four GCMs, RCP4.5, 2050-2055					-0,91	-0,91		
Change of PO4-P concentration	Qu'Appelle River ,Canda	%	2012-2015			four GCMs, RCP2.6, 2050-2055				-0,02		-0,02		
Change of PO4-P concentration	Qu'Appelle River ,Canda	%	2012-2015			four GCMs, RCP4.5, 2050-2055					-0,04	-0,04		

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date (make clear if uses present day population and assumes constant)**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)**	**Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
groundwater level	Northwest Bangladesh	m	1991-2009		0,6	MLR			Y			-0,15	1,6	1
groundwater level	Northwest Bangladesh	m	1991-2009		0,6	MLR			Y			-0,5	2,6	2
groundwater level	Northwest Bangladesh	m	1991-2009		0,6	MLR			Y			-0,86	3,6	3
groundwater level	Northwest Bangladesh	m	1991-2009		0,6	MLR			Y			-1,64	4,6	4
groundwater level	Northwest Bangladesh	m	1991-2009		0,6	MLR			Y			-2,01	5,6	5
irrigation cost	Northwest Bangladesh	10^3 BDT ha^{-1}	1991-2009		0,6	MLR			Y			0,05	1,6	1
irrigation cost	Northwest Bangladesh	10^3 BDT ha^{-1}	1991-2009		0,6	MLR			Y			0,14	2,6	2
irrigation cost	Northwest Bangladesh	10^3 BDT ha^{-1}	1991-2009		0,6	MLR			Y			0,25	3,6	3

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date (make clear if uses present day population and assumes constant)**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)**	**Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
irrigation cost	Northwest Bangladesh	10^3 BDT ha^{-1}	1991-2009		0,6	MLR			Y			0,44	4,6	4
irrigation cost	Northwest Bangladesh	10^3 BDT ha^{-1}	1991-2009		0,6	MLR			Y			0,54	5,6	5

Table S2 - S3.4.3 Terrestrial and wetland ecosystems

To be developed

Summary Table

	Driver (standard symbols) *link to 3.3	Risks at 1.5°C above pre-industrial *global	Change in risk from 1.5°C to 2°C *global (if the risks are higher at 2 than 1.5, this number is positive)	Region (Red = High) (hotspots)	Cited papers (numbered list)	Key risks from AR5	RFC

Detailed table

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(°C)	Delta T relative to pre-industrial; delta T(°C) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(°C)

1

Table S3 - S3.4.4 Ocean systems

To be developed

Summary Table

	Driver (standard symbols) *link to 3.3	Risks at 1.5°C above pre-industrial *global	Change in risk from 1.5°C to 2°C *global (if the risks are higher at 2 than 1.5, this number is positive)	Region (Red = High) (hotspots)	Cited papers (numbered list)	Key risks from AR5	RFC

Detailed table

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(°C)	Delta T relative to pre-industrial; delta T(°C) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(°C)

Table S4 - S3.4.5 Coastal and low lying areas

Summary Table

	Driver (standard symbols) *link to 3.3	**Risks at 1.5ºC above pre-industrial *global**	**Change in risk from 1.5ºC to 2ºC *global (if the risks are higher at 2 than 1.5, this number is positive)**	**Region (Red = High) (hotspots)**	**Cited papers (numbered list)**	**Key risks from AR5**	**RFC**
						See Fig 5.1 (Wong et al. 2014) Relative sea level rise Storms Extreme sea level Temperature CO2 concentration Freshwater input Ocean acidification	
						For islands, see Box 29.4 from (Nurse et al. 2014)	
Area situated below the 1 in 100 year flood plain (th km^2) (50th percentile)	Sea-level rise	574 in 2050	1 in 2050	Global	(Brown a et al.)		
Area situated below the 1 in 100 year flood plain (th km^2) (50th percentile)	Sea-level rise	620 in 2100	17 in 2100	Global	(Brown a et al.)		
Area situated below the 1 in 100 year flood plain (th km^2) (50th percentile)	Sea-level rise	666 in 2200	39 in 2200	Global	(Brown a et al.)		
Area situated below the 1 in 100 year flood plain (th km^2) (50th percentile)	Sea-level rise	702 in 2300	65 in 2300	Global	(Brown a et al.)		
Population situated below the 1 in 100 year flood plain (millions) (50th percentile)	Sea-level rise	127-138 in 2050	1 in 2050	Global	(Brown a et al.)		
Population situated below the 1 in 100 year flood plain (millions) (50th percentile)	Sea-level rise	103-153 in 2100	2-5 in 2100	Global	(Brown a et al.)		

	Driver (standard symbols) *link to 3.3	**Risks at 1.5ºC above pre-industrial *global**	**Change in risk from 1.5ºC to 2ºC *global (if the risks are higher at 2 than 1.5, this number is positive)**	**Region (Red = High) (hotspots)**	**Cited papers (numbered list)**	**Key risks from AR5**	**RFC**
Population situated below the 1 in 100 year flood plain (millions) (50th percentile)	Sea-level rise	133-207 in 2300 (assuming no s-e change after 2100)	15-25 in 2300 (assuming no s-e change after 2100)	Global	(Brown a et al.)		
People at risk (th people / yr) (5th, 50th and 95th percentiles)	Sea-level rise	32 [20-44] in 2050	4 [4-3] in 2050	Global	(Nicholls et al.)		
People at risk (th people / yr) (5th, 50th and 95th percentiles)	Sea-level rise	61 [42-84] in 2100	25 [28-47] in 2100	Global	(Nicholls et al.)		
People at risk (th people / yr) (5th, 50th and 95th percentiles)	Sea-level rise	108 [76-136] in 2200 (assuming no s-e change after 2100)	16 [15-32] in 2200 (assuming no s-e change after 2100)	Global	(Nicholls et al.)		
People at risk (th people / yr) (5th, 50th and 95th percentiles)	Sea-level rise	138 [99-174] in 2300 (assuming no s-e change after 2100)	39 [22-34] in 2300 (assuming no s-e change after 2300)	Global	(Nicholls et al.)		
People at risk (th people / yr) (5th, 50th and 95th percentiles)	Sea-level rise	35 [19-59] in 2050	4 [1-2] in 2050	Global	(Warren b et al.)		
People at risk (th people / yr) (5th, 50th and 95th percentiles)	Sea-level rise	73 [32-122] in 2050	15 [9-21] in 2100	Global	(Warren b et al.)		
Cumulative land loss due to submergence (th sq km) (5th, 50th and 95th percentiles)	Sea-level rise	35 [20-49] in 2050	1 [0-2] in 2100	Global	(Warren b et al.)		

	Driver (standard symbols) *link to 3.3	Risks at 1.5°C above pre-industrial *global	Change in risk from 1.5°C to 2°C *global (if the risks are higher at 2 than 1.5, this number is positive)	Region (Red = High) (hotspots)	Cited papers (numbered list)	Key risks from AR5	RFC
Cumulative land loss due to submergence (th sq km) (5th, 50th and 95th percentiles)	Sea-level rise	62 [40-85] in 2100	8 [5-4] iin 2100	Global	(Warren b et al.)		

Table 3.5 Detailed summary table for Coastal and low lying areas

To be developed

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date (make clear if uses present day population and assumes constant)	Baseline global T used in paper (pre-industrial, or other, and did you have to convert? Eg if your paper gives delta T relative to 1990 you add 0.5C)	Climate scenario used (e.g. RCP, SRES, HadCM3 in 2050s, etc)	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario? How long it is above 1.5C and what is the max temp and when?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(°C)	Delta T relative to pre-industrial; delta T(°C) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(°C)

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Table S5 - 3.4.6 Food security and food production systems

Summary Table

Driver (standard symbols) *link to 3.3	**Risks at 1.5ºC above pre-industrial *global**	**Change in risk from 1.5ºC to 2ºC *global (if the risks are higher at 2 than 1.5, this number is positive)**	**Region (Red = High) (hotspots). a=1, to z=26**	**Cited papers (numbered list)**	**Key risks from AR5**	**RFC**
Heat stress	-9/10% yield production (cereals)	-13/14% yield production (cereals)	Global	3	5	
Heat stress	+ 1.56% Yield losses (rice)	- - -	22	6	5	
Cold stress	- 2.5% Yield losses (rice)	- - -	22	6	5	
Drought	-9/10% yield production (cereals)	-13/14% yield production (cereals)	Global	3	5	
Warming	+2.7% yield production (cereals)	+0.33% yield production (cereals)	Global	4	5	
Warming	-2% yield production (cereals)	-5.3% yield production (cereals)	6, 13, 17, 25, 26	4	5, 6	
Warming	7% yield production (soybean)	1% yield production (soybean)	Global	4	5, 6	
Warming	6% yield production (soybean)	6% yield production (soybean)	6, 13, 17, 25, 26	4	5	
Warming	-6.75% yield production (maize)	-9% yield production (maize)	12	1	5	
Warming	-9% yield production (maize)	-12% yield production (maize)	3, 4, 5	1	5	

Driver (standard symbols) *link to 3.3	**Risks at 1.5ºC above pre-industrial *global**	**Change in risk from 1.5ºC to 2ºC *global (if the risks are higher at 2 than 1.5, this number is positive)**	**Region (Red = High) (hotspots). a=1, to z=26**	**Cited papers (numbered list)**	**Key risks from AR5**	**RFC**
Warming	-11.7% yield production (maize)	-15.6% yield production (maize)	7, 8, 10	1	5	
Warming	-10.6% yield production (maize)	-14.2% yield production (maize)	16	1	5	
Precipitation	~ -10, -15 % yield production (maize)	~ -15, -20% yield production (maize)	7, 8, 10	2	5	
Precipitation	~ -5, -10 % yield production (maize)	~ -10, -15% yield production (maize)	7, 8, 10	2	5	
Precipitation	~ 0, -5% yield production (maize)	~ -5, -10% yield production (maize)	7, 8, 10	2	5	
Precipitation	~ 0, +5% yield production (maize)	~ 0, -5% yield production (maize)	7, 8, 10	2	5	
Warming	- - -	- 3·2% food availability per person	Global	5	5	
Warming	- - -	- 4·0% fruit and vegetable consumption per person	Global	5	5	
Warming	- - -	-0.7% red meat consumption per person	Global	5	5	
Warming	- - -	- 3·2% food availability per person	Global	5	5	
Warming	- - -	~ -3% yield production (maize)	4, 5	7	5	
Heat stress	- - -	~ -1% yield production (maize)	4, 5	7	5	
Drought	- - -	~ -7.5% yield production (maize)	4, 5	7	5	
Warming	- - -	~ -2.5% yield production (soybean)	4, 5	7	5	
Heat stress	- - -	~ -2% yield production (soybean)	4, 5	7	5	
Drought	- - -	~ -12% yield production (soybean)	4,5	7	5	
warming	~ -5.4% yield production (wheat)	~ -7.1% yield production (wheat)	21, 22	8, 9	5	

Detailed Table

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date	Baseline global T used in paper (pre-industrial, or other, and did you have to convert?	Climate scenario used	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(°C)	Delta T relative to pre-industrial; delta T(°C) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(°C)
Water scarcity	Mediterranean	%	1986-2005		0,6	RCP8.5, ISI-MIP			Y	-9	-17			
Crop yield - Wheat	tropical regions	%	1986-2005		0,6	RCP8.5, ISI-MIP			Y	-9	-16			
Crop yield - Maize	tropical regions	%	1986-2005		0,6	RCP8.5, ISI-MIP			Y	-3	-6			
Crop yield - Soy	tropical regions	%	1986-2005		0,6	RCP8.5, ISI-MIP			Y	6	7			
Crop yield - Rice	tropical regions	%	1986-2005		0,6	RCP8.5, ISI-MIP			Y	6	6			
Crop yield - Wheat	global	%	1986-2005		0,6	RCP8.5, ISI-MIP			Y	2	0			
Crop yield - Maize	global	%	1986-2005		0,6	RCP8.5, ISI-MIP			Y	-1,5	-6			
Crop yield - Soy	global	%	1986-2005		0,6	RCP8.5, ISI-MIP			Y	7	1			
Crop yield - Rice	global	%	1986-2005		0,6	RCP8.5, ISI-MIP			Y	7	7			

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert?**	**Climate scenario used**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
Crop yield	France	%	1980-2009		Mean seasonal T (°C) 1980-2009 (17°C)	Temperature (-3, 0, +3, +6, +9°C) and CO2 concentration (360, 450, 540, 630, 720 ppm) factor levels				-6,75	-9			
Crop yield	USA	%	1980-2009		Mean seasonal T (°C) 1980-2009 (21°C)	Temperature (-3, 0, +3, +6, +9°C) and CO2 concentration (360, 450, 540, 630, 720 ppm) factor levels				-9	-12			
Crop yield	Brazil	%	1980-2009		Mean seasonal T (°C) 1980-2009 (25°C)	Temperature (-3, 0, +3, +6, +9°C) and CO2 concentration (360, 450, 540, 630, 720 ppm) factor levels				-11,7	-15,6			
Crop yield	Tanzania	%	1980-2009		Mean seasonal T (°C) 1980-2009 (27°C)	Temperature (-3, 0, +3, +6, +9°C) and CO2 concentration (360, 450, 540, 630, 720 ppm) factor levels				-10,6	-14,2			
Crop yield - Maize	Drylands	%	1971-1981	SSP2		RCP8.5, 2006-2100				~ -0.9	~ -1.1			

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert?**	**Climate scenario used**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
Crop yield - Maize	Humid lands	%	1971-1981	SSP2		RCP8.5, 2006-2100				~ 3.2	~ 3.5			
Crop yield - Maize	Global	%	1971-1981	SSP2		RCP8.5, 2006-2100				~ 2.6	~ 2.8			
Crop - Wheat	Global	%	1981-2010			Temperature (+2, +4°C) factor levels				-9	-12			
Crop yield - Maize	Brazil	%	1982-2012		Precipitation: -30 to -20%	Temperature (+0.5, +1, +1.5, +2, +2.5, +3°C) and precipitation (-30, -20,-10,0,+10,+20,+30%) factor levels				~ -10, -15	~ -15, -20			
Crop yield - Maize	Brazil	%	1982-2012		Precipitation: -20 to -10%	Temperature (+0.5, +1, +1.5, +2, +2.5, +3°C) and precipitation (-30, -20,-10,0,+10,+20,+30%) factor levels				~ -5, -10	~ -10, -15			
Crop yield - Maize	Brazil	%	1982-2012		Precipitation: -10 to 0%	Temperature (+0.5, +1, +1.5, +2, +2.5, +3°C) and precipitation (-30, -20,-10,0,+10,+20,+30%) factor levels				~ 0, -5	~ -5, -10			

Risk	**Region**	**Metric (unit)**	**Baseline time period against which change in impact measured**	**Socio-economic scenario and date**	**Baseline global T used in paper (pre-industrial, or other, and did you have to convert?**	**Climate scenario used**	**Is it for transient (T) or equilibrium (E) (if known)?**	**Is it an overshoot scenario?**	**Is the modelling approach used in that publication dynamic (Y/N)**	**Projected impact at 1.5C above pre-industrial**	**Projected impact at 2C above pre-industrial**	**Projected impact at delta T(ºC)**	**Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)**	**Delta T relative to baseline temp(T1); delta T1(ºC)**
Crop yield - Maize	Brazil	%	1982-2012		Precipitation: 0 to +30%	Temperature (+0.5, +1, +1.5, +2, +2.5, +3°C) and precipitation (-30, -20,-10,0,+10,+20,+30%) factor levels				~ 0, +5	~ 0, -5			
Crop yield - Wheat	Global	%	1960-2012	SSP1,2,3		RCP2.6 (+1.8°C), 4.5(+2.7°C), 6.0(+3.2°C), 8.5(+4.9°C), 2000-2100				58	59			
Crop yield - Maize	Global	%	1960-2012	SSP1,2,3		RCP2.6 (+1.8°C), 4.5(+2.7°C), 6.0(+3.2°C), 8.5(+4.9°C), 2000-2100				29	23			
Crop yield - Soy	Global	%	1960-2012	SSP1,2,3		RCP2.6 (+1.8°C), 4.5(+2.7°C), 6.0(+3.2°C), 8.5(+4.9°C), 2000-2100				53	47			
Crop yield - Rice	Global	%	1960-2012	SSP1,2,3		RCP2.6 (+1.8°C), 4.5(+2.7°C), 6.0(+3.2°C), 8.5(+4.9°C), 2000-2100				36	41			

Risk	Region	Metric (unit)	Baseline time period against which change in impact measured	Socio-economic scenario and date	Baseline global T used in paper (pre-industrial, or other, and did you have to convert?	Climate scenario used	Is it for transient (T) or equilibrium (E) (if known)?	Is it an overshoot scenario?	Is the modelling approach used in that publication dynamic (Y/N)	Projected impact at 1.5C above pre-industrial	Projected impact at 2C above pre-industrial	Projected impact at delta T(ºC)	Delta T relative to pre-industrial; delta T(ºC) (deltaT1+column F)	Delta T relative to baseline temp(T1); delta T1(ºC)
Crop yield - onions	Netherland	Fraction	1992-2008			Temperature (+1 and +2) factor levels, 2042-2058				~ -0.255	~ -0.37			
Crop yield - potatoes	Netherland	Fraction	1992-2008			Temperature (+1 and +2) factor levels, 2042-2058				~ -0.09	~ -0.42			

SI_S3-4-4_Supp Information on Oceans Systems

Update of Expert assessment by Gattuso et al. (2015).

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Risk assessment update: November 18, 2017 (by expert team plus lead authors of Chapter 3, Special report on the Implications of 1.5^{o}C).

This PDF file includes:

Supplementary Text

Tables S1 and S2

Full Reference List

Background information and rationale of expert judgment on the risk of impact due to CO_2 levels by 2100 (Fig. 2)

This supplementary material provides the background information and rationale for the construction of the burning embers diagrams used in Figure 2 to represent the risk of impacts from CO_2 levels (by 2100) for keystone marine and coastal organisms and ecosystem services. This is the expert judgment by the group on the overall risk - balancing negative, neutral and positive impacts across species and regions using current literature.

Table S1 Definition of the colour codes used in for the risk of impacts due to climate change, including ocean acidification, shown in Fig. 2 (Gattuso et al. 2015) and updated in March 2018.

		Average global sea surface temperature (SST)		
Component	Colour transition		2015	2018
Seagrasses (mid latitude)	White to Yellow	Begin	0.5	
		End	0.8	
	Yellow to Red	Begin	1.5	
		End	1.8	
	Red to Purple	Begin	2.2	
		End	3	

		Average global sea surface temperature (SST)		
Component	Colour transition		2015	2018
Mangroves	White to Yellow	Begin	1.8	1.5
		End	3	2.5
	Yellow to Red	Begin	3	2.5
		End	3.2	2.7
	Red to Purple	Begin	N/A	
		End	N/A	
Warm water corals	White to Yellow	Begin	0.3	0.2
		End	0.4	0.4
	Yellow to Red	Begin	0.5	0.4
		End	0.8	0.6
	Red to Purple	Begin	0.8	0.7
		End	1.5	
Pteropods (high latitude)	White to Yellow	Begin	0.7	
		End	0.8	
	Yellow to Red	Begin	0.8	
		End	1.5	
	Red to Purple	Begin	1.5	
		End	2	
Bivalves (mid latitude)	White to Yellow	Begin	0.4	
		End	0.6	
	Yellow to Red	Begin	0.9	
		End	1.1	
	Red to Purple	Begin	1.3	
		End	1.5	
Krill (high latitude)	White to Yellow	Begin	0.7	
		End	0.9	
	Yellow to Red	Begin	1	
		End	1.6	
	Red to Purple	Begin	1.8	
		End	3.2	
Finfish	White to Yellow	Begin	0.5	
		End	0.7	
	Yellow to Red	Begin	1.1	

		Average global sea surface temperature (SST)		
Component	Colour transition		2015	2018
		End	1.3	
	Red to Purple	Begin	1.4	
		End	1.6	
Open-ocean carbon uptake	White to Yellow	Begin	1	
		End	1.5	
	Yellow to Red	Begin	2	
		End	3.2	
	Red to Purple	Begin	N/A	
		End	N/A	
Coastal Protection	White to Yellow	Begin	0.5	
		End	0.8	
	Yellow to Red	Begin	1.5	
		End	1.8	
	Red to Purple	Begin	2.2	
		End	3.2	
Recreational services from coral reefs	White to Yellow	Begin	0.6	
		End	0.8	
	Yellow to Red	Begin	1	
		End	1.5	
	Red to Purple	Begin	2	
		End	3.2	
Bivalve fisheries and aquaculture (mid-latitude)	White to Yellow	Begin	1.1	
		End	1.3	
	Yellow to Red	Begin	1.7	
		End	1.9	
	Red to Purple	Begin	2.8	
		End	3.2	
Fin fisheries (low latitude)	White to Yellow	Begin	0.7	0.5
		End	0.9	0.7
	Yellow to Red	Begin	1	0.9
		End	1.2	1.1
	Red to Purple	Begin	2	2
		End	2.5	2.5

		Average global sea surface temperature (SST)		
Component	Colour transition		2015	2018
Fin fisheries (high latitude)	White to Yellow	Begin	0.7	
		End	0.9	
	Yellow to Red	Begin	2.2	
		End	3.2	
	Red to Purple	Begin	N/A	
		End	N/A	

<u>Expert assessment</u>: Original assessment done by Gattuso et al. (2015) using the ARC5 and literature published up to 2014. Current assessment updated for literature from 2015 to early 2018. References for the current assessment are listed at the end of this document, followed by the numerically listed references cited by Gattuso et al. (2015). This is Supplementary on-line material for the special report on the implications of 1.5ºC warming.

1. Seagrasses (mid latitude)

Update: Recent literature supports the consensus reached by Gattuso et al., (2015) with increasing ocean temperatures a major threat, with the potential loss of key species such as *Posidonia oceanica* in the Mediterranean by mid-century (Jordà et al., 2012). Recent work has shown that increasing temperatures is a major threat to the shoot density (Guerrero-Meseguer et al., 2017) and quality of the seagrass *Zostera marina* (Repolho et al., 2017). Other studies in related systems reveal sub-chronic changes to the quality of seagrass shoots and leaves (Unsworth et al., 2014) and have speculated on the impact that these changes might have on coastal food webs (York et al. 2016). Several studies have speculated on the impact of rising seas, storms and flooding on seagrass productivity (Ondiviela et al., 2014; Pergent et al., 2015; Rasheed et al., 2014; Telesca et al., 2015). The consistency of the literature for the last two years with that examined since AR5 suggest that the current risk levels for seagrasses proposed by Gattuso et al (2015) are appropriate.

Expert assessment by Gattuso et al. (2015; SOM):

Seagrasses, important habitats in coastal waters around the world, will be affected by climate change through a number of routes including direct effects of temperature on growth rates (159, 160), occurrence of disease (161), mortality and physiology, changes in light levels arising from sea level changes, changes in exposure to wave action (162), sometimes mediated through effects on adjacent ecosystems (163), and also by changes in the frequency and magnitude of extreme weather events. There will be changes in the distribution of seagrass communities locally and regionally. Here we take the example of temperate seagrasses including *Posidonia oceanica* from the Mediterranean, *Zostera* spp from the USA, Europe, and Australia, because the information on the effects of ocean warming and acidification for these species from several field studies is robust. Results indicate that temperate seagrass meadows have already been negatively impacted by rising sea surface temperatures (164). Models based on observations of natural populations indicate that at temperature increases of 1.5 to 3°C mortality of shoots of seagrasses will be such that populations will be unsustainable and meadows will decline to the point where their ecological functions as a habitat will cease (reduction to 10% of present density of a healthy meadow; *ref*).

The confidence level is very high under RCP2.6 because of strong agreement in the literature. Confidence declines to high under RCP8.5 due to some uncertainty surrounding regional differences. For example, it has been suggested that the balance of effects on seagrass populations in the North East Atlantic could tip to positive due to the hypothetical opening of ecological niches with the decline of more sensitive species, and potential reduction of carbon limitation by elevated CO2 which may help to ameliorate negative effects of other environmental drivers, such as warming, known to impact seagrass growth and survival (97).

2. Mangroves

Update: Recent literature is consistent with previous conclusions regarding the complex changes facing mangroves, together with increasing concern regarding the interaction between climate change (e.g. elevated air and water temperatures, drought, sea level rise) and local factors (deforestation, damming of catchments and reduced sediment and freshwater) as outlined below. Decreases in the supply of sediments to deltas and coastal areas is impeding the ability of mangroves to keep pace with sea level rise through shoreward migration (Lovelock et al., 2015). At the same time, recent extremes associated with EL Nino (e.g. extreme low sea level events, Duke et al., 2017; Lovelock et al., 2017). Shoreward migration is also challenged by the increasing amounts of coastal infrastructure preventing the relocation of mangroves (Di Nitto et al., 2014; Saunders et al., 2014). In some areas, mangroves are increasing in distribution (Godoy and De Lacerda, 2015). The total loss projected for mangrove loss (10–15%) under a 0.6 m sea level rise continue to be dwarfed by the loss of mangroves to deforestation (1-2% per annum). The risk level for mangroves remains where it has been, decreasing from high confidence to low confidence, for RCP2.6 to RCP8.5, respectively.

Expert assessment by Gattuso et al. (2015; SOM):

Mangroves are critically important coastal habitat for numerous species. Mangrove responses to increasing atmospheric CO_2 are complex, with some species thriving while others decline or exhibit little or no change (*ref*). Temperature increase alone is likely to result in faster growth, reproduction, photosynthesis, and respiration, changes in community composition, diversity, and an expansion of latitudinal limits up to a certain point (*ref*). Mangroves have already been observed to retreat with sea level rise (*ref*). In many areas mangroves can adapt to sea level rise by landward migration, but these shifts threaten other coastal habitats such as salt marshes, which have other important biogeochemical and ecological roles. It is in areas with steep coastal inclines or coastal human infrastructure limiting landward migration that mangroves are most at risk. Climate change may lead to a maximum global loss of 10 to 15% of mangrove forest for a sea level rise of 0.6 m (high end of IPCC projections in AR4), but must be considered of secondary importance compared with current annual rates of deforestation of 1 to 2% (*ref*). A large reservoir of below-ground nutrients, rapid rates of nutrient flux microbial decomposition, complex and highly efficient biotic controls, self- design and redundancy of keystone species, and numerous feedbacks, all contribute to mangrove resilience to various types of disturbance.

Mangrove response is species-specific and interacts with temperature, salinity, nutrient availability and patterns of precipitation. Many of these parameters are also subject to regional and local variation, as well as to human-induced pressures which changes over the coming decades are difficult to assess. Thus, the confidence level decreases from high under RCP2.6 to low under RCP8.5.

3. Warm-water corals

Update: Exceptionally warm conditions of 2015-2017 drove an unprecedented global mass coral bleaching and mortality event which affected coral reefs in a large number of countries (information still being gathered; Normile, 2016). In the case of Australia, 50% of reef-building corals across the Great Barrier Reef died in unprecedented back-to-back bleaching events (Hughes et al., 2017). Elevated sea temperatures and record mortality was recorded from the Central to the Far northern sectors of the Great Barrier Reef. Similar impacts occurred in a range of regions including the Indian Ocean, Western Pacific, Hawaii and Caribbean oceans (Normile, 2016) . The set of events has increased risk with current conditions being of high risk, and even low levels of future climate change being largely catastrophic for coral reefs. There continues to be a very high level of confidence as to the impacts under RCP 2.6, as well as a high confidence for those under RCP 8.5.

Expert assessment by Gattuso et al. (2015; SOM):

Warm-water corals form reefs that harbor great biodiversity and protect the coasts of low lying land masses. There are very high levels of confidence that impacts were undetectable up until the early 1980s, when coral reefs in the Caribbean and eastern Pacific exhibited mass coral bleaching, as well as temperature-related disease outbreaks in the Caribbean Sea (*ref*). Given a conservative lag time of 10 years between the atmospheric concentration of CO2 and changes in sea surface temperature, the atmospheric CO2 level of 325 ppm reached in the early 1970s was sufficient to initiate widespread coral bleaching and decline of coral health worldwide (*ref*). As the 1980s unfolded, visible impacts of increasing sea surface temperature were seen in a widening number of areas, with the first global event in 1997-1998 and the loss of 16% of coral reefs (high confidence; *ref*). Further increases in atmospheric carbon dioxide and sea surface temperature have increased the risk to corals (high confidence), with multiple widespread bleaching events, including loss of a large fraction of living corals in the Caribbean in 2005 (*ref*) and a subsequent global bleaching in 2010 (e.g. *ref*), and current conditions suggesting the development of a third global event in 2015-2016 (C.M. Eakin, unpublished observation). If CO_2 levels continue to increase, there is a very high risk that coral reefs would be negatively affected by doubled pre-industrial CO2 through impacts of both warming-induced bleaching and ocean acidification (high confidence), supported by a wide array of modeling [e.g. *ref*], experimental (e.g. *ref*), and field studies (*ref*). This leads to a very high level of confidence under RCP2.6 and a high level of confidence under RCP8.5.

4. Pteropods (high latitude)

Update: Literature from the last two years is largely consistent with the expert assessment by Gattuso et al. (2015). There is increasing evidence of declining aragonite saturation in the open ocean with the detection of impacts that are most pronounced closest to the surface and with the severe biological impacts occurring within inshore regions. In this regard, pteropod shell dissolution has increased by 19-26% in both nearshore and offshore waters since the Pre-industrial period (Feely et al., 2016). Impacts of ocean acidification are also cumulative with other stresses such as elevated sea temperature and hypoxia (Bednaršek et al., 2016). These changes are consistent with observations of large portions of the shelf waters associated with the Washington-Oregon-California coast being strongly corrosive, with 53% of onshore and 24% of offshore pteropod individuals showing severe damage from dissolution (Bednaršek et al., 2014). Several researchers propose that pteropod condition be used as a biological indicator which they argue will become increasingly important as society attempts to understand the characteristics and rate of change in ocean acidification impacts on marine organisms and ecosystems (Bednaršek et al., 2017; Manno et al., 2017). The last two years of research has increased confidence in our understanding of the impact of ocean acidification on pteropods under field conditions. The question of the genetic adaptation of pteropods to increasing ocean acidification remains unresolved although the observation of increasing damage to pteropods from field measurements argues against this being a significant factor in the future.

Expert assessment by Gattuso et al. (2015; SOM):

Pteropods are key links in ocean food webs between microscopic and larger organisms, including fish, birds and whales. Ocean acidification at levels anticipated under RCP8.5 leads to a decrease in pteropod shell production (*ref* - *ref*), an increase in shell degradation (*ref* , *ref*), a decrease in swimming activity when ocean acidification is combined with freshening (*ref*), and an increase in mortality that is enhanced at temperature changes smaller than those projected for RCP8.5 (*ref*, *ref*). Shell dissolution has already been observed in high latitude populations (*ref*). Aragonite saturation (Ωa) levels below 1.4 results in shell dissolution with severe shell dissolution between 0.8 and 1 (*ref*). Despite high agreement amongst published findings, uncertainty remains surrounding the potential to adapt to environmental drivers because long-term laboratory experiments with pteropods are notoriously difficult. Hence the confidence level is medium under RCP2.6. However, confidence increases to very high under RCP8.5 because it is almost certain that genetic adaptation to such large and rapid changes in pH and temperature will not be possible.

5. Bivalves (mid latitude)

Update: Literature has rapidly expanded since 2015 with a large number of studies showing impacts of ocean warming and acidification on wide range of life history stages of bivalve molluscs (e.g. Asplund et al., 2014; Castillo et al., 2017; Lemasson et al., 2017; Mackenzie et al., 2014; Ong et al., 2017; Rodrigues et al., 2015; Shi et al., 2016; Velez et al., 2016; Waldbusser et al., 2014; Wang et al., 2016; Zhao et al., 2017; Zittier et al., 2015). Impacts on adult bivalves include decreased growth, increased respiration, and reduced calcification with larval stages tending to have an increase in developmental abnormalities and elevated mortality after exposure (Lemasson et al., 2017; Ong et al., 2017; Wang et al., 2016; Zhao et al., 2017). Many recent studies have also identified interactions between factors such as increased temperature and ocean acidification, with salinity perturbations as well as decreases in oxygen concentrations (Lemasson et al., 2017; Parker et al., 2017; Velez et al., 2016). Changes in metabolism with increasing ocean acidification has been detected in a number of transcriptome studies, suggesting a complex and wide-ranging response by bivalves to increasing CO_2 and temperature (Li et al., 2016a, 2016b). Observations of reduced immunity which may have implications for disease management (Castillo et al., 2017). These changes are likely to impact the ecology of oysters, and may be important when it comes to the maintenance of oyster reefs, which provide important ecological structure for other species. Bivalves, for example, are more susceptible to the impacts of temperature and salinity if they have been exposed to high levels of CO_2, leading to the suggestion that there will be a narrowing of the physiological range and hence distribution of oyster species such as *Saccostrea glomerata* (Parker et al., 2017). Confidence level is adjusted to high for RCP2.6 as well as RCP8.5 given the convergence of recent literature. These studies continue to report growing impacts as opposed to a reduction under rapid genetic adaptation by bivalve molluscs. The overall levels of risk are retained - reflecting the moderate risk that already exists, and the potential for transformation into high very high levels of risk with relatively small amounts of further climate change.

Expert assessment by Gattuso et al. (2015; SOM):

Both cultured and wild bivalves are an important food source worldwide. Temperate bivalve shellfish, such as oysters, clams, mussels and scallops, have already been negatively impacted by ocean acidification. In the Northwest United States, Pacific oyster larval mortality has been associated with upwelling of natural CO2-rich waters acidified by additional fossil fuel CO2 (high confidence; *ref*). Ocean acidification acts synergistically with deoxygenation (*ref*) and warming (*ref, ref*) to heighten physiological stress (*ref*) on bivalve shellfish (high confidence), suggesting that future ocean conditions that include warming, deoxygenation, and acidification will be particularly difficult for members of this taxon. Archaeological/geological and modeling studies show range shifts of bivalves in response to prior and projected warming (*ref*) and acidification (*ref*). Model projections also anticipate decreases in mollusk body size under continued harvesting as conditions change farther from the present (*ref*). Impacts are expected to be high to very high when CO_2 concentrations exceed those expected for 2100 in the RCP2.6 and 4.5 levels (medium certainty; *ref*, *ref*). The confidence level is medium both under RCP2.6 and RCP8.5 primarily due to the possibility of bivalves adapting over generations (*ref*), or for specific species to outcompete other wild species in future conditions (e.g., *ref*).

6. Krill (high latitude)

Update: Sea ice continues to retreat at record rates in both polar oceans with both the Artic and Antarctica being among the fastest warming regions on the planet (Notz and Stroeve, 2016; Turner et al., 2017). In Antarctic waters, a decrease in sea ice represents a loss of critical habitat for krill (David et al., 2017). Projected changes of this habitat through increasing temperature and acidification could have major impacts on food, reproduction and development, and hence the abundance of this key organism for Antarctic food webs. Differences appear to be a consequence of regional dynamics in factors such as regional variation in ice, productivity, and predation rates, and an array of other factors (Steinberg et al., 2015). Other factors such as interactions with factors such as ocean acidification and the shoaling of the aragonite saturation horizon are likely to play key roles. (Kawaguchi et al., 2013; Piñones and Fedorov, 2016). While factors such as ocean acidification and the loss of sea ice (due to increasing temperature) are unambiguous in their effects, there continues to be considerable uncertainty around the details of how krill populations are likely to be respond to factors such as changing productivity, storms, and food webs. Consequently, the level of confidence of future risks remain at medium under RCP2.6, and low under RCP8.5.

Expert assessment by Gattuso et al. (2015; SOM):

Krill (euphausid crustaceans) is a critical link in the food web at higher latitudes, supporting mammals and birds among many other species. Distributional changes and decreases in krill abundance have already been observed associated with temperature increase (*ref*). The effect of changes in the extent of sea ice is considered to be an indirect effect of temperature. Temperature effects are predicted to be regional (*ref*). If the extent of sea ice is maintained, populations in cooler waters may experience positive effects in response to small increases in temperature. In contrast, populations in warmer areas may experience some negative temperature effects by 2100 under RCP2.6. Since all life stages are associated with sea ice, decreases in krill stocks are projected to occur concurrently with the loss of sea ice habitat, potentially outweighing possible positive impacts (*ref*). Increases in sea surface temperature of 1 to 2˚C have significant impacts on krill. From Fig. 4 in Flores et al. (*ref*) severe disruptions of the life cycle are expected at a level of 2°C sea surface temperature rise and 500 µatm pCO_2. Therefore, high impact on populations would be reached approximately at the CO_2 level projected for 2100 by RCP4.5. Conditions in 2100 under the RCP2.6 scenario would be around the upper limit of the high-risk range. Negative effects of ocean acidification on reproduction, larval and early life stages have been observed above 1250 µatm pCO2, a value that is likely to be reached in parts of the Southern Ocean by 2100 under RCP8.5 (*ref*). Figure 1 in Flores et al. (*ref*) shows that the area with strongest sea ice decline partly overlaps with areas of high krill density (from the Peninsula to the South Orkneys). There is also a significant warming trend in this area which may force populations southwards into less productive regions. Substantial decline in the viability of major krill populations in the Southern Ocean may occur within the next 100 years (*ref*), which could have catastrophic consequences for dependent marine mammals and birds. The genetic homogeneity of krill suggests that rapid adaptation through natural selection of more tolerant genotypes is unlikely (*ref*). Considering uncertainties surrounding regional changes, some potentially positive effects and the relatively small number of studies, the level of confidence of future risks is medium under RCP2.6 and low under RCP8.5.

7. Finfish

Update: Impacts and responses identified in 2015 regarding the relative risk of climate change to finfish have strengthened. In this regard, there is a growing number of studies indicating that different stages of development may also be made more complex by fish having different stages of the life-cycle in different habitats, which may each be influenced by climate change in different ways and to different extents, as well as evidence of differing sensitivities to change between different stages (Esbaugh, 2017; Ong et al., 2015, 2017). Increasing numbers of fish species have been identified as relocating to higher latitudes, with tropical species being found increasingly in temperate zones (‘tropicalization’, Horta E Costa et al., 2014; Verges et al., 2014; Vergés et al., 2016)) and temperate species being found in some polar regions (‘Borealization’, Fossheim et al., 2015). Concern has been raised that greater number of extinctions will occur in the tropics as species relocate (Burrows et al., 2014; García Molinos et al., 2015; Poloczanska et al., 2016). Changing conditions in polar regions are particularly risky due to the rapid rates of warming (Notz and Stroeve, 2016; Turner et al., 2017). One of the consequences of this is that an increasing number of fish species are expanding their distributional ranges into the Arctic, being followed by large, migratory fish predators. The borealization of fish communities in the Arctic is leading to a reorganisation of species and ecological processes which is not well understood (Fossheim et al., 2015). Robust evidence and high agreement (*high confidence*) for the impacts of climate change on fish continues as evidence mounts from experimental, field and modelling sources which underpin an increasing confidence in the detection and attribution of current climate impacts on finfish in the present day and those at RCP2.6.

Expert assessment by Gattuso et al. (2015; SOM):

Marine fishes are important predators and prey in ocean ecosystems, contributing substantially to coastal economies, food security and livelihood. Warming-induced shifts in the abundance, geographic distribution, migration patterns, and phenology of marine species, including fishes, were reported and projected with very high confidence in the IPCC AR5 report (2). Empirical and theoretical evidence of range shifts in response to temperature gradients are reported across various taxa and many geographical locations (*ref*- *ref*), with observations suggesting that range shifts correspond with the rate and directionality of climate shifts —or 'climate velocity'— across landscapes (*ref*). Observed range shifts associated with ocean warming may result in hybridization between native and invasive species through overlapping ranges, leading to reduced fitness and thus potentially increasing the risks of genetic extinction and reducing the adaptability to environmental changes (*ref*, *ref*). Some taxa are incapable of keeping pace with climate velocities, as observed with benthic invertebrates in the North Sea (*ref*). The tropicalization of temperate marine ecosystems through poleward range shifts of tropical fish grazers increases the grazing rate of temperate macroalgae as seen in Japan and the Mediterranean (*ref*). Such trophic impacts resulting from climate-induced range shifts are expected to affect ecosystem structure and dynamic in temperate reefs (*ref*). Projected future changes in temperature and other physical and chemical oceanographic factors are expected to affect the distribution and abundance of marine fishes, as elaborated by species distribution models with rate of shift at present day rate under the RCP8.5 scenario (*ref*). Limiting emissions to RCP2.6 is projected to reduce the average rate of range shift by 65% by mid 21st century (*ref*). Shifts in distribution of some species may be limited by the bathymetry or geographic boundaries, potentially resulting in high risk of local extinction particularly under high CO2 emissions scenarios (*ref*). While evidence suggests that adult fishes can survive high levels of CO2, behavioral studies have found significant changes in species' responses under levels of CO2 elevated above those of the present day level (*ref*). Long-term persistence of these phenomena remains unknown. Based on the above, fishes already experience medium risk of impacts at present day (high confidence). Risk increases from medium to high by end of 21st century when emissions change from RCP2.6 to RCP 4.5 and become very high under RCP8.5, highlighting the potential non-reversibility of the potential impacts.

Some evidence for direct and indirect impacts of ocean acidification on finfish is available but varies substantially between species. Also, understanding about the scope of evolutionary adaptation for marine fishes to climate change and ocean acidification are limited, although it is unlikely that majority of the species can fully adapt to expected changes in ocean properties without any impacts on their biology and ecology. Overall, we have robust evidence and high agreement (thus high confidence) from experimental data, field observations and mathematical modelling in detecting and attributing impacts for finfish in the present day and under RCP2.6. The uncertainty about the sensitivity to ocean acidification and scope for evolutionary adaptation leads to medium confidence levels for their risk under high emissions scenarios.

8. Open ocean carbon uptake

Update: Several recent studies have shown a decreasing CO_2 flux into the Pacific and Atlantic Oceans, southern ocean, and ocean in general (Iida et al., 2015). Concern over changes to the circulation of the ocean (e.g. MOC) has grown since 2015, with the observation of cooling surface areas of the Atlantic (Rahmstorf et al., 2015). Confidence level continues to be high for both RCP 2.6 and RCP8.5 – especially given the well-known physical and chemical process involved. Impacts from sudden changes to circulation continue remain uncertain.

Expert assessment by Gattuso et al. (2015; SOM):

The uptake of anthropogenic carbon by the ocean in the industrial period and in the future is a service that is predominantly provided by physico-chemical processes (*ref*). The sensitivity of ocean carbon uptake to increasing cumulative CO2 emissions, including effects of changing ocean chemistry, temperature, circulation and biology, is assessed along the following lines of quantitative evidence: (i) the fraction of total cumulative anthropogenic emissions taken up by the ocean over the industrial period and the 21st century in CMIP5 Earth System Model projections for the four RPCs (*ref*); (ii) the fraction of additional (marginal) emissions remaining airborne or taken up by the ocean for background atmospheric CO2 following the four RCPs (*ref*). In addition, the risk of large-scale reorganization of ocean circulation, such as a collapse of the North Atlantic overturning circulation and associated reductions in allowable carbon emissions towards CO2 stabilization, is increasing with the magnitude and rate of CO2 emissions, in particular beyond the year 2100. Confidence level is high for both RCP 2.6 and RCP8.5 because the underlying physical and chemical process are well known.

9. Coastal protection

Update: Sea level rise and intensifying storms place particular stresses on coastal environments and communities. Coastal protection by ecosystems as well as man-made infrastructure are important in terms of mitigating risks ranging from the physical destruction of ecosystems and human infrastructure to the salinization of coastal water supplies and direct impacts on human safety (Bosello and De Cian, 2014). Risks are particularly high for low-lying areas, such as carbonate atoll islands in the tropical Pacific where land for food and dwelling and water are limited, and effects of a rising sea plus intensifying storms create circumstances may make many of these island systems uninhabitable within decades (Storlazzi et al., 2015). Even in advantaged countries such as the United States, these factors place millions at serious risk from even modest changes in inundation, with over 4 million US based people at serious risk in response to a 90 cm sea level rise by 2100 (Hauer et al., 2016).

Both natural and human coastal protection have the potential to reduce the impacts (Fu and Song, 2017). Coral reefs, for example, provide effective protection by dissipating around 97% of wave energy, with 86% of the energy being dissipated by reef crests alone (Ferrario et al., 2014). Natural ecosystems, when healthy, also have the ability to repair themselves after being damaged, which sets them apart from coastal hardening and other human responses that require constant maintenance (Barbier, 2015; Elliff and Silva, 2017). Recognising and restoring coastal ecosystems such as coral reefs, mangroves and coastal vegetation in general may be more cost-effective than human remedies in terms of seawalls and coastal hardening, where costs of creating and maintaining structures may not always be cost-effective (Temmerman et al., 2013).

The last two years have seen an increase in the number of studies identifying the importance of coastal ecosystems as important to the protection of people and property along coastlines against sea level rise and storms. Analysis of the role of natural habitats in the protection people and infrastructure in Florida, New York and California, for example, has delivered a key insight into the significance of the problems and opportunities for the United States (Arkema et al., 2013). Some ecosystems which are important to coastal protection can keep pace with sea level rise, but only if other factors such as harvesting (i.e. of oysters; Rodriguez et al., 2014) or sediment supply (i.e. to mangroves, Lovelock et al., 2015) are managed. Several studies have pointed to the opportunity to reduce risks by recognising the interdependency of human remedies for coastal protection and ecosystem responses to increasing sea levels. Several authors have proposed holistic approaches to mitigating damage from sea level rise such as ensuring human infrastructure enables the shoreward relocation of coastal vegetation such as mangroves and salt marsh. The latter enhancing coastal protection as well as having other important ecological functions such as habitat for fish and the sources of a range of other resources (Saunders et al., 2014).

Recent studies have increasingly stressed the coastal protection needs to be considered in the context of new ways of managing coastal land, including protecting and managing coastal ecosystems as they also undergo shifts in their distribution and abundance (André et al., 2016). These shifts in thinking require new tools in terms of legal and financial instruments, as well as integrated planning that involves not only human communities and infrastructure, but also ecosystem responses. In this regard, the interactions between climate change, sea level rise and coastal disasters are being increasingly informed by models (Bosello and De Cian, 2014) with a widening appreciation of the role of natural ecosystems as an alternative to hardened coastal structures (Cooper et al., 2016).

Increase evidence of a rapid decay in ecosystems such as coral reefs and mangroves has increased the confidence surrounding conclusions that risks in coastal areas are increasing. Escalation of coastal impacts arising from Super Storm Sandy and Typhoon Haiyan (Long et al., 2016; Villamayor et al., 2016) have improved understanding of the future of coastal areas in terms of impacts, response and mitigation (Rosenzweig and Solecki, 2014; Shults and Galea, 2017). This leads to a high level of confidence in understanding of how coastal protection is like to play a role under RCP 2.6. The interactions between people, infrastructure and natural ecosystems in the coastal zone, however, are complex leaving a low level of confidence in our understanding of the nature of risks under RCP8.5.

Expert assessment by Gattuso et al. (2015; SOM):

Estimating the sensitivity of natural coastal protection to climate change requires to combine sensitivity across different ecosystems, especially coral reefs, mangrove forests and seagrass beds. Other ecosystems provide coastal protection, including salt marshes, macroalgae, oyster and mussel beds, and also beaches, dunes and barrier islands (stabilized by organisms; 104, 211), but there is less understanding of the level of protection conferred by these other organisms and habitats (104). Although studies indicate some of these systems are already impacted by the effects of rising CO2, or suggest they will be in the near future, levels of sensitivity are not well established, are highly variable, and in some cases their overall influence on coastal protection may be uncertain (i.e., species are replaced by functional equivalents in this context; ref. 212).

We reason that some coastal protection has already been lost—a result of impacts on coral reefs, seagrasses and other ecosystems from sea temperature rise. In the case of corals, this began in the late 1970s. Recent papers demonstrate collapse in three-dimensional structure of reefs in the Caribbean (*ref*) and the Seychelles (*ref*), the second phase of which appears to be climate-related. Other studies show that some areas have not recovered from the 1997-98 and 2010 bleaching events and that some reefs have collapsed there (e.g. parts of the Seychelles). There is thus little doubt that the coastal protection function of some reefs has already been reduced. A decreasing protection may also be the case for seagrasses, although such effects have not been measured. It should also be noted that other human impacts have already largely destroyed, or are progressively destroying some of these ecosystems, through direct action (e.g. 85% oyster reefs lost globally and 1-2% of mangrove forests cut down per annum; *ref*). It therefore appears that some impact on coastal protection has already occurred but we lack data to extrapolate globally, hence the confidence level is low in the present day.

Confidence in the loss of coastal protection decreases with increasing CO2 emissions because coastal protection is conferred by a range of habitats and the co-dependency or interactions between them make projections difficult. For example, protection to seagrass beds conferred by coral reefs or the replacement of salt marsh with mangrove forest (*ref, ref*). Additionally, human-driven pressure on these ecosystems is inherently difficult to forecast decades from now due to the possible implementation of new policies. Interacting effects of different symptoms of climate change such as increased temperature, decreasing pH, salinity, nutrient availability, patterns of precipitation and occurrence of pathogens will all influence the physiological response of individual species and ecosystems and thus further reduce the predictability of responses at higher emissions. Confidence is thus medium under RCP2.6 and low under RCP8.5.

10. Recreational services from coral reefs

Update: Tourism is one of the largest industries globally. A significant part of the global tourist industry is associated with tropical coastal regions and islands (Spalding et al., 2017). Coastal tourism can be a dominant money earner in terms of foreign exchange for many countries, particularly small island developing states (SIDS; Weatherdon et al., 2016). The direct relationship between increased global temperatures, elevated thermal stress, and the loss of coral reefs (see section above, and Box 3.6, main report) has raised concern about the risks of climate change for local economies and industries based on coral reefs. Risks to the recreational services of coral reefs from climate change are considered here.

The recent heavy loss of coral reefs from tourist locations worldwide has prompted interest in the relationship between increasing sea temperatures, declining coral reef ecosystems, and tourist revenue (Normile, 2016). About 30% of the world's coral support tourism which generates close to $36 billion (USD) on an annual basis (Spalding et al., 2017). Tourist expenditure, in this case, represents economic activity which supports jobs, revenue for business and taxes. Climate change in turn can influence the quality of the tourist experience through such aspects through changing weather patterns, physical impacts such as storms, and coastal erosion, as well as the effects of extremes on biodiversity within a region. Recent impacts in the Caribbean in 2017 highlight the impacts of climate change related risks associated with coastal tourism, with the prospect that many businesses will take years to recover from impacts such as hurricanes Harvey, Irma and Maria (Gewin, 2017; Shults and Galea, 2017)

A number of projects have attempted to estimate the impact (via economic valuation) of losing key coral reef ecosystems such as the Great Barrier Reef (Oxford_Economics, 2009; Spalding et al., 2017). A recent study by Deloitte_Access_Economics. (2017) revealed that the Great Barrier Reef contributed $6.4 billion (AUD) and 64,000 jobs annually to the Australian economy in 2015-16. In terms of its social, economic and iconic value to Australia, the Great Barrier Reef is worth $56 billion (AUD). The extreme temperatures of 2015-2017 removed 50% of the reef-building corals on the Great Barrier Reef (Hughes et al., 2017), there is considerable concern about the growing risk of climate change to the Great Barrier Reef, not only for its value biologically, but also as part of a series of economic risks at local, state and national levels.

Our understanding of the potential impacts of climate change on tourism within small island and low-lying coastal areas in tropical and subtropical is made less certain by the flexibility and creativity of people. For example, the downturn of coral reefs in countries that are dependent on coral reef tourism doesn't necessarily mean a decline in gross domestic product (GDP), given that some countries have many other options for attracting international revenue. As well, our understanding of future tourist expectations and desires are uncertain at this point. Consequently, we feel that maintaining medium confidence at RCP 2.6 and RCP 8.5 at medium levels is consistent with the evidence from the past 2015-17 and Gattuso et al. (2015).

Expert assessment by Gattuso et al. (2015; SOM):

The impacts of CO_2 and sea surface temperature on the condition of coral reefs ultimately affect the flow of ecosystem goods and services to human communities and businesses. There is an interesting lag between the degradation of corals and coral reefs and a detectable effect on human users. For this reason, the risk of impacts on human recreation and tourism begins significantly later than ecosystem changes are detected by marine scientists. As of 2015, atmospheric CO_2 concentration is 400 ppm and average sea surface temperature is 0.8°C above that of the pre-industrial period. Mass bleaching and mortality events have degraded coral populations and this has negatively impacted the recreational choices of a few, but not most, clients (high confidence; *ref*). This impact on tourists' choice is expected to reach moderate to high-levels as CO_2 approaches 450 ppm, at which point reefs begin net erosion and sea level, coral cover, storms, and other environmental risks become significant considerations in destination attractiveness (medium confidence). By 600 ppm, the breakdown of the structure of most reefs becomes obvious, other changes such as reduced coral cover and increased sea level and storm damage mean that significant coastal recreation and tourism becomes difficult in most circumstances and many operations may be discarded (*ref*). This will have a very high impact on recreational services (medium confidence). Confidence levels under RCP2.6 and RCP8.5 are medium because predicting tourists' expectations several decades from now remains relatively uncertain.

11. Bivalve fisheries and aquaculture (mid latitude)

Update: Aquaculture is one of the fastest growing food sectors and is becoming increasingly essential to meeting the demand for protein for the global population (FAO, 2016). Studies published over the period 2015-2017 showed a steady increase in the risks associated with bivalve fisheries and aquaculture at mid-latitude locations coincident with increases in temperature, ocean acidification, introduced species, disease and other associated risks (Clements et al., 2017; Clements and Chopin, 2016; Lacoue-Labarthe et al., 2016; Parker et al., 2017). These have been met with a range of adaptation responses by bivalve fishing and aquaculture industries (Callaway et al., 2012; Weatherdon et al., 2016).

Risks are also likely to increase as a result of sea level rise and intensifying storms which pose a risk to hatcheries and other infrastructure (Callaway et al., 2012; Weatherdon et al., 2016). Some of the least predictable yet potentially most important risks associated with the invasion of diseases, parasites and pathogens, which may be mitigated to a certain extent by active intervention by humans. Many of these have reduced the risks from these factors although costs have increased in at least some industries. By the end of century, risks are likely to be moderate under RCP 2.6 though very high under RCP 8.5, similar to the evidence and conclusions of **Gattuso et al. (2015)** below.

Expert assessment by Gattuso et al. (2015; SOM):

Ecosystem services provided by temperate bivalves include marine harvests (both from capture fisheries and aquaculture), water quality maintenance, and coastal stabilization. Of these, marine harvests are easiest to quantify, and have been the subject of several assessments. Confidence is high that ocean acidification has already jeopardized marine harvest revenues in the Northwest United States (*ref*). Although the affected hatcheries have taken steps to enhance monitoring, alter hatchery water intake and treatment, and diversify hatchery locations (*ref*), these adaptations will only delay the onset of ocean acidification-related problems (high confidence). Wild harvest populations are fully exposed to ocean acidification and warming, and societal adaptations like these are not applicable. Services provided by bivalves will continue even if populations migrate, decrease in size, or individuals become smaller, so effects are somewhat more delayed than those on shellfish themselves. In 2100, impacts are expected to be moderate under RCP2.6 and very high under RCP8.5. The level of confidence declines as a function of increasing CO2 emissions due to the uncertainty about the extent of local adaptations: medium under RCP2.6 and low under RCP8.5.

12. Fin fisheries (low latitude)

Update: Low latitude fin fisheries, or small-scale fisheries, provide food for millions of people along tropical coastlines and hence play an important role in the food security of a large number of countries (Mcclanahan et al., 2015; Pauly and Charles, 2015). In many cases, populations are heavily dependent on these sources of protein given the lack of alternatives (Cinner et al., 2012, 2016; Pendleton et al., 2016). The climate related stresses affecting fin fish (section 7 above), however, are producing a number of challenges for small scale fisheries based on these species (e.g. (Bell et al., 2017; Kittinger, 2013; Pauly and Charles, 2015).

Recent literature (2015-2017) has continued to outline growing threats from the rapid shifts in the biogeography of key species (Burrows et al., 2014; García Molinos et al., 2015; Poloczanska et al., 2013, 2016) and the ongoing rapid degradation of key habitats such as coral reefs, seagrass and mangroves (see section1-3 above as well Box 3.6, main report). As these changes have accelerated, so have the risks to the food and livelihoods associated with small-scale fisheries (Cheung et al., 2010). These risks have compounded with non-climate stresses (e.g. pollution, overfishing, unsustainable coastal development) to drive many small-scale fisheries well below the sustainable harvesting levels required to keep these resources functioning as a source of food (Mcclanahan et al., 2015; McClanahan et al., 2009; Pendleton et al., 2016). As a result, projections of climate change and the growth in human populations increasingly predict shortages of fish protein for many regions (e.g. Pacific, e.g. Bell et al., 2013, 2017; Indian Ocean, e.g. McClanahan et al., 2015). Mitigation of these risks involved marine spatial planning, fisheries repair, sustainable aquaculture, and the development of alternative livelihoods (Kittinger, 2013; Mcclanahan et al., 2015; Song and Chuenpagdee, 2015; Weatherdon et al., 2016). Threats to small-scale fisheries have also come from the increasing incidence of alien (nuisance) species as well as an increasing incidence of disease, although the literature on these threats is at a low level of development and understanding (Kittinger et al., 2013; Weatherdon et al., 2016).

As assessed by Gattuso et al. (2015), risks of impacts on small-scale fisheries are medium today, but are expected to reach very high levels under scenarios extending beyond RCP 2.6. The research literature plus the growing evidence that many countries will have trouble adapting to these changes places confidence a high level as to the risks of climate change on low latitude in fisheries. These effects are more sensitive, hence the higher risks at lower levels of temperature change.

Expert assessment by Gattuso et al. (2015; SOM):
Evidence of climate change altering species composition of tropical marine fisheries is already apparent globally (*ref*). Simulations suggest that, as a result of range shifts and decrease in abundance of fish stocks, fisheries catch is likely to decline in tropical regions (*ref, ref*). Projections also suggest that marine taxa in tropical regions are likely to lose critical habitat (e.g., coral reefs), leading to a decrease in fisheries productivity (*ref*). Because of the magnitude of impacts, capacity for the fisheries to reduce such risks by protection, repair or adaptation is expected to be low (*ref*). Thus, these impacts increase with increasing CO2 emissions. Risk of impacts is close to medium level in present day, and increases to high and very high when CO2 concentration reaches the levels expected in 2100 under RCP4.5 and RCP8.5, respectively.

The scope of adaptation for low latitude fin fisheries is narrow because of the high level of impacts on ecosystems and fisheries resources, lack of new fishing opportunities from species range shifts to compensate for the impacts, and relatively lower social-economic capacity of many countries to adapt changes. Thus, confidence level is high on projected impacts on low latitude fin fisheries.

13. Fin fisheries (mid and high latitude)

Update: While risks and reality of decline are high for low latitude fin fisheries, projections for mid to high latitude fisheries include increases in fishery productivity in many cases (Cheung et al., 2013; FAO, 2016; Hollowed et al., 2013; Lam et al., 2014; Hollowed et al., 2013). These changes are associated with the biogeographical shift of species towards higher latitudes (‘borealization’, Fossheim et al., 2015) which brings benefits as well as challenges (e.g. increased risk of disease and alien species). Factors underpinning the expansion of fisheries production to high latitude locations include warming and increase light and mixing due to retreating sea ice (Cheung et al., 2009). As a result of this, fisheries in the cold temperate regions of the North Pacific and North Atlantic are undergoing major increase primary productivity and consequently in the increased harvest of fish from Cod and Pollock fisheries (Hollowed and Sundby, 2014). At more temperate locations, intensification of some upwelling systems is also boosting primary production and fisheries catch (Shepherd et al., 2017; Sydeman et al., 2014), although there are increasing threats from deoxygenation as excess biomass falls into the deep ocean, fueling higher metabolic rates and oxygen drawdown (Bakun et al., 2015; Sydeman et al., 2014).

Similar to the assessment by Gattuso et al. (2015), our confidence in understanding risks at higher levels of climate change and longer periods diminishes over time. The ability of fishing industries to adapt to changes is considerable although the economic costs of adapting can be high. Consequently, our confidence level remains high under RCP 2.6 and low at RCP 8.5.

Expert assessment by Gattuso et al. (2015; SOM):

Evidence that climate change effects altering species composition in mid and high latitude fisheries can already be observed globally, with increasing dominance of warmer-water species since the 1970s (*ref*). Global-scale projections suggest substantial increases in potential fisheries catch in high latitude regions (*ref*, *ref*) under RCP8.5 by mid- to end-21st century. However, ocean acidification increases uncertainty surrounding the potential fisheries gain because the Arctic is a hotspot of ocean acidification (*ref*). Risks of impacts of warming, ocean acidification and deoxygenation on mid-latitude regions are variable (*ref*, *ref*). Overall, existing fish stocks are expected to decrease in catch while new opportunities for fisheries may emerge from range expansion of warmer-water. Declines in catch have been projected for fisheries in the Northeast Pacific (*ref*), Northwest Atlantic (*ref*), and waters around the U.K. (*ref*) by mid 21st century under SRES A1B and A2 scenarios (equivalent to RCP6.0 to 8.5). While it is uncertain whether small-scale fisheries will have the mobility to follow shifts in ranges of target species, those with access to multiple gears types may be able to adapt more easily to climate-related changes in stock composition. Societal adaptation to reduce the risk of impacts is expected to be relatively higher than tropical fisheries. Thus, medium risk is assigned from present day, and risk increases to high when CO2 concentration is beyond level expected from RCP4.5.

Risk to fisheries at mid and high latitudes depends on how the fishers, fishing industries and fisheries management bodies respond and adapt to changes in species composition and distribution. Prediction of the scope of such adaptive response is uncertain particularly under greater changes in fisheries resources. Thus, the confidence level is high under RCP2.6 and low under RCP8.5

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SI_S3-4-7_Supp Info to Health's section

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Table S6- S3.4.7 - 1: Decades when 1.5 °C, 2.0°C, and higher degrees of warming are reached for multi-climate model means

Generation	Scenario	Decade 1.5°C reached	Decade 2.0°C reached	dT 2080-2099	dT 2090-2099
SRES	B1	2039-2048	2065-2074	2.18	2.27
SRES	A1b	2029-2038	2045-2054	3.00	3.21
SRES	A2	2032-2041	2048-2057	3.39	3.83
RCP	2.6	2047-2056	[a]	1.48	1.49
RCP	4.5	2031-2040	2055-2064	2.32	2.37
RCP	6.0	2036-2045	2058-2067	2.63	2.86
RCP	8.5	2026-2035	2040-2049	3.90	4.39

[a] 2.0°C not reached

Table S7- S3.4.7 - 2: Projected temperature-related risks to human health associated with climate change

Region	***Health outcome metric***	***Baselines***	***Climate model(s)***	***Scenario***	***Time periods of interest***	***Impacts at baseline***	***Projected impacts at 1.5°C***	***Projected impacts at 2°C***	***Other factors considered***	***Reference***
Global and 21 regions	Heat-related mortality in adults over 65 years of age	1961-1990	BCM2.0, EGMAM1, EGMAM2, EGMAM3, CM4vl	A1B	2030, 2050		In 2030, 92,207 additional heat-related deaths without adaptation (ensemble mean) and 28,055 with adaptation under BCM2 scenario; the Asia Pacific, Asia, North Africa / Middle East, Sub-Saharan Africa, Europe, and north America at higher risk.	In 2050, 255,486 additional heat-related deaths without adaptation and 73,936 with adaptation under BCM2 scenario; the same regions are at higher risk.	Population growth and aging; improved health in elderly due to economic development; three levels of adaptation (none, partial, and full)	(WHO 2014)
Global	Heatwave area calculated as the area with heatwaves divided by the total land area; number of heatwave days	1971-2000	HadGEM2-ES, bias corrected, from ISIMIP	RCP2.6 with SSP1, RCP6.0 with SSP2, RCP8.5 with SSP3	2030-2050, 2080-2100		Number of heatwave days approximately doubles by 2030-2040, with higher risk under RCP8.5-SSP3. Under RCP6.0-SSP2, the		Population density, % of population over 65 years of age; per capita GDP; education levels	(Dong et al. 2015)

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
							general spatial risk distribution is similar to RCP8.5-SSP3, but the average risk is lower. Very high-risk areas are in Africa and Asia.			
Global	Extremely hot summers over land areas (>3 SD anomalies)	1861-1880	26 models from CMIP5	RCP2.6, RCP4.5, RCP8.5	to 2100	Probability of an extremely hot summer (>3 sigma) in 1996-2005 (compared with 1951-1980) is 4.3%	Probability of an extremely hot summer is approximately 25.5% and probability of an exceedingly hot summer (>5 sigma) is approximately 7.1% above pre-industrial	Extremely hot summers are projected to occur over nearly 40% of the land area		(Wang et al. 2015)
Global	Population exposure to hot days and heatwaves	1961-1990	21 CMIP5 GCMs	Temperature change based on pattern scaling	Up to 2100	Increasing exposure to heatwaves already evident	The frequency of heatwave days increases dramatically as global mean	Overall, exposure to heatwaves is reduced by more than 75% in all models in each region		(Arnell et al. 2017)

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
							temperature increases, although the extent of increase varies by region. Increases are greatest in tropical and sub-tropical regions where the standard deviation of warm season daily maximum temperature is least, and therefore, a smaller increase in temperature leads to a larger increase in heat wave frequency.	if global mean surface temperatures do not increase to 2°C; the avoided impacts vary by region.		
Global; nine regions and 23 countries	Temperature excess mortality (cold and heat)	1984-2015	ISI-MIP	RCP 2.6, RCP 4.5, RCP6.0, RCP 8.5	1990-2099	85 879 895 (observed overlapping periods)	In temperate areas (e.g. northern Europe, east Asia, and Australia), less intense			Gasparrini et al. 2017

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
							warming is projected to decrease cold-related excess which would have a null or marginally negative net effect (e.g. in Australia ranging from -1.2% to -0.1% with the net change in 2090-2099			
Global; nine regions and 23 countries	Temperature-related mortality	Pre-industrial	HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM	RCP 8.5				An increase from 1.5°C to 2°C would result in a substantial rise in heat-related mortality in most of the countries. Heat-mortality impacts increases between +0.11% and +2.13%, with most	No population change or adaptation	Vicedo-Cabrera et al. submitted

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
								countries in South Europe and South-East Asia showing increments above +1%. In contrast, cold-related mortality decreases in all countries, ranging between -0.27% and -0.98%. These decrements are of a lower magnitude compared to the corresponding heat-related impacts, producing a net increase in excess mortality in about half of the countries.		

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
Global	Temperature-related mortality	2005-2015	HAPPI project	RCP2.6; weighted average of RCP 2.6 and RCP4.5			A half a degree additional warming between the current decade and 1.5°C leads to higher heat stress in e.g. the Eastern USA, Central Africa, the Middle East, Southern Europe, India, Eastern Asia and Russia. Modelling the most extreme historical heat-mortality event shows that for key European cities, stabilizing climate at 1.5°C would decrease extreme temperature-	Days of extreme summer heat are more frequent and of higher intensity. In high-population regions, e.g. Central Africa, India and Europe, an additional 10-20 days of extreme heat could occur annually, compared with 1.5°C.	No population change or adaptation	Mitchell et al. submitted

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
							related mortality by 15-22% per summer compared with stabilization at 2°C.			
Global	Exposure to extreme heatwaves	1971-2005	EC-EARTH-HR v3.1 downscaled 7 GCMs from CMIP5	RCP8.5	2006-2100	Warming of 0.8°C from 1880-1900 for 20-year period centered on 2005	At +1.5°C, increase in the magnitude and frequency of extreme heatwaves over most of the globe; about 14% of population exposed to heatwaves at least once in 5 years	At +2°C, further increase in the magnitude and frequency of extreme heatwaves over most of the globe, with new regions affected; about 37% of population exposed at least once in 5 years or 1.7 billion additional people	Population projections under SSP3	Dosis et al. submitted
Japan, Korea, Taiwan, USA, Spain, France, Italy	Heat-related mortality for 65+ age group	1961-1990	BCM2	A1B	2030, 2050		In 2030, heat-related excess deaths increased	In 2050, heat-related excess deaths are higher than	Three adaptation assumptions: 0, 50, and 100%	Honda et al. 2014

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
							over baselines in all countries, with the increase dependent on the level of adaptation	for 2030, with the increase dependent on the level of adaptation		
Australia (five largest cities) and UK	Temperature-related mortality	1993-2006	UKCP09 from HadCM3; OzClim 2011	A1B, B1, A1FI	2020s, 2050s, 2080s	For England and Wales, the estimated % change in mortality associated with heat exposure is 2.5% (95% CI: 1.9 - 3.1) per 1°C rise in temperature above the heat threshold (93rd %ile of daily mean temperature). In Australian cities, the estimated overall % change in mortality is 2.1% (95% CI: 1.3, 2.9).	In the 2020s, heat-related deaths increase from 1,5O3at baseline to 1,511 with a constant population and 1,785 with the projected population. In Australia, the numbers of projected deaths are 362 and 475, respectively, with a baseline of 214 deaths.	In the 2050s, heat-related deaths further increase to 2,866 with a constant population and to 4.012 with the projected population. In Australia, the numbers of projected deaths are 615 and 970, respectively	Projected population change	Vardoulakis et al. 2014

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
Australia	Temperature-related morbidity and mortality; days per year above 35°C	1971-2000	CSIRO	2030 A1B low and high; 2070 A1FI low and high	2030, 2070	4-6 dangerously hot days per year for un-acclimatized individuals	Sydney - from 3.5 days at baseline to 4.1-5.1 days in 2030; Melbourne - from 9 days at baseline to 11-13 days in 2030	Sydney – 6-12 days and Melbourne – 15-26 in 2070		Hanna et al. 2011
Brisbane, Sydney, and Melbourne Australia	Temperature-related mortality	1988-2009	62 GCMs, with spatial downscaling and bias correction	A2, A1B, B1	2050s, 2090s		In 2030, net temperature-related mortality (heat – cold) increases in Brisbane under all scenarios, increases in Sydney under A2, and declines in Melbourne under all scenarios	In 2050, there are further net temperature related mortality (heat-cold) increases in Brisbane under all scenarios, increases in Sydney under A2 and A1B, and further declines in Melbourne under all scenarios		Guo et al. 2016
Brisbane Australia	Years of life lost due to temperature extremes (hot and cold)	1996-2003		Added 1° to 4°C to observed daily temperature	2000, 2050	In 2000, 3,077 temperature-related years of life lost	For 1°C above baseline, years of life lost increase	For 2°C above baseline, years of life lost increase		Huang et al. 2012

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
				to project for 2050		for men, with 616 years of life lost due to hot temperatures and 2,461 years of life lost due to cold. The numbers for women are 3,495 (total), 9O3(hot), and 2,592 (cold).	by 1,014 (840 to 1,178) for hot temperatures and decrease by 1,112 (-1,337 to -871) for cold temperatures	by 2,450 (2,049 to 2,845,) for hot temperatures and decrease by 2,069, (-2,484 to -1,624) for cold temperatures		
Quebec, Canada	Heat-related mortality	1981-1999	Ouranos Consortium; SDSM downscaled HADCM3	A2 and B2 (projected impacts the same)	2020 (2010 – 2039), 2050 (2040 – 2069), 2080 (2070 – 2099)		2% increase in summer mortality in 2020	4-6% increase in summer mortality in 2050		Doyon et al. 2008
Montreal, Canada	Heat-related mortality	June – August 1990 - 2007	Canadian Global Circulation Model, 3.1, CSIRO Mark 3.5, ECHAM5, MRRC (Canadian regional climate model)	B1, A1B, A2	June-August 2020-2037	55 (95% CI = 32-79) attributed deaths during June-August	Temperature-related mortality during June-August more than doubled for Tmax (78-161 deaths)		Assumed no change in mean daily death count; no demographic change; no change in ozone levels; no adaptation	Benmarhnia et al. 2014

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
USA	Heat-related mortality	1999-2003	GISS-II downscaled using MM5	A1B	2048-2052			For 2048-2052, May-September excess heat-related mortality projected to be 3700-3800 from all causes and 21,000 – 27,000 from non-accidental deaths	Projected population change	Voorhees et al. 2011
USA	Avoided climate impacts of heatwaves and cold spells	1981-2005	CESM-LE with RCP8.5; CEMS-ME with RCP4.5. Includes urban heat island effect	RCP4.5, RCP8.5	2061-2080	Mean annual total heatwave days range from 4.4-6.3; similar range for cold spells		Following RCP4.5 reduces heat wave days by about 50 %. Large avoided impacts are demonstrated for individual communities. Heatwaves also start later in the season under RCP4.5.		Oleson et al. 2015
USA, 209 cities	Heat- and cold-related mortality	1990 (1976-2005)	Bias corrected (BCCA)	RCP6.0	2030 (2016-2045), 2050 (2036-2065),		In 2030, a net increase in premature deaths, with	In 2050, a further increase in premature	Held population constant at 2010 levels;	Schwartz et al. 2015

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
			GFDL-CM3, MIROC5		2100 (2086-2100)		decreases in temperature-related winter mortality and increases in summer mortality; the magnitude varied by region and city with an overall increase of 11,646 heat-related deaths.	deaths, with decreases in temperature-related winter mortality and increases in summer mortality; the magnitude varied by region and city with an overall increase of 15,229 heat-related deaths.	mortality associated with high temperatures decreased between 1973-1977 and 2003-2006	
USA, 209 cities	Mortality associated with cold spells	1960-2050	CMIP5 20 biased corrected (BCCAv2) multi-model dataset	RCP2.6, RCP4.5, RCP6.0, RCP8.5	1960-2050			Small decrease in projected mortality risk from 1960 to 2050, with significant variation across regions	Assumed no change in demography or baseline mortality rate	Wang et al. 2016
USA, 82 communities	High-mortality heatwaves that increase	1981-2005	CESM-LE with RCP85, CESM-ME with RCP4.5	RCP4.5, RCP8.5	2061-2080	Depending on modeling approach, 5-6 high mortality		At least seven more high-mortality heatwaves	Projected population change (SSP3, SSP5) and three	Anderson et al. 2016

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
	mortality by 20%					heatwaves annually, with approximately 2 million person-days of exposure per year		expected in a twenty-year period in the study communities under RCP8.5 than RCP4.5 when assuming no adaptation. Projections are most strongly influenced by the adaptation scenario.	scenarios of adaptation (no, lagged, on pace)	
USA, 10 large metropolitan areas	Temperature-related mortality	1992-2002	40 downscaled climate models from CMIP5	RCP4.5, RCP8.5	2045-2055, 2085-2095	Association between mean daily temperature and mortality was U-shaped in each city, with minimum mortality temperature ranging from 22.8°C in New York to 29.7°C in Houston. Total temperature-		Under both RCPs, heat-related mortality increases and cold-related mortality decreases in 2050; the decline in cold-related mortality that does not offset heat-related mortality in most areas. The changes	Projected population change	Weinberger et al. 2017

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
						related mortality was >29,110 in 1997		are smaller under RCP4.5. Total temperature-related mortality of 32.285 for a 1997 population under RCP8.5		
Washington State, USA	Heat-related mortality	1970-1999	PCM1, HadCM	Average of PCM1-B1 and HadCM-A1B; humidex baseline; number & duration of heatwaves calculated	2025, 2045, 2085		Under moderate warming in 2025, 96 excess deaths in Seattle area.	Under moderate warming in 2045, 156 excess deaths in Seattle area.	Holding population constant at 2025 projections	Jackson et al. 2010
Eastern USA	Heat-related mortality	2002-2004	CESM1.0 downscaled using WRF	RCP4.5, RCP8.5	2057-2059	187 + 173 (2, 614) annual deaths in 2002-2004		Excess mortality attributable to heatwaves could result in 200-7,807 deaths / year under RCP8.5; average excess mortality is 1,4O3deaths/	Projected population change in 2050	Wu et al. 2014

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
								year under RCP4.5 and 3,556 under RCP8.5		
Rhode Island, USA	Heat-related emergency department admissions and heat-related morality	2005-2012	CMIP5 multi-model ensemble bias corrected (BCCA)	RCP4.5, RCP8.5	2046-2053, 2092-2099, projections for April - October	Between 2005 and 2012, an increase in maximum daily temperature from 75 to 85F is associated with 1.3% and 23.9% higher rates of all cause and heat-related emergency department visits. Between 1999-2011, there is a 4.0% increase in heat-related mortality.		Under RCP8.5, in 2046-2053, there would be about 0.5% and 6.8% more all-cause and heat-related ED admissions, respectively, and 0.7% more deaths annually. Risks are lower under RCP4.5.	Population and other factors held constant	Kingsley et al. 2016
Boston, New York, Philadelphia, USA	Heat-related mortality	1971-2000	CMIP5 bias corrected (BCSD)	RCP4.5, RCP8.5	2010 – 2039, 2040 – 2069, 2070 -2099	Baseline heat-related mortality is 2.9 – 4.5 / 100,000	In the 2020s under both RCPs, heat-related mortality increased to	In the 2050s, heat-related mortality increased to 8.8 – 14.3 / 100,000	Population constant at 2000	Petkova et al. 2013

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
						across the three cities	5.9 – 10 / 100,000	under RCP4.5 and to 11.7 to 18.9 / 100,000 under RCP8.5		
New York City, NY	Heat-related mortality	Each model's 30-year baseline average	Downscaled and bias corrected (BCSD) WCRP CMIP5, including 33 GCMs	RCP4.5, RCP8.5	2020s (2010-2039), 2050s (2040-2069), 2080s (2070-2099)	638 heat-related deaths annually between 2000 and 2006. Heat-related mortality relatively constant during the first part of the 20th century, then decreased from the 1970s to 2000s		Median projected annual heat-related deaths varied greatly by RCP, adaptation, and population change scenario, ranging from 150 to 1549 in the 2050s	Five scenarios of population projections by gender; two adaptation scenarios plus no adaptation scenario	Petkova et al. 2017
Houston, Texas	Heat-related non-accidental mortality	1991-2010	CESM simulations for RCP8.5 and for RCP4.5; used HRLDAS for downscaling	RCP4.5, RCP8.5	2061-2080			Median annual non-accidental mortality under RCP4.5 about 50% less than under RCP8.5. For	Demographics and income in SSP3 and SSP5; urban heat island	Marsha et al. 2016

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
								RCP4.5, 5,032 deaths under SSP3 and 7,935 deaths under SSP5. For RCP8.5, 5,130 deaths under SSP3 and 8,079 deaths under SSP5.		
Europe	Heat-related respiratory hospital admissions	1981-2000	RCA3 dynamically downscaled results from CCCSM3, ECHAM5, HadCM3, ECHAM4	A1B, A2	2021-2050	The estimated proportion of respiratory hospital admissions due to heat is 0.18% at baseline in the EU27; the rate is higher for Southern Europe (0.23%). 11,000 respiratory hospital admissions across Europe in reference period	For all of Europe, 26,000 heat-related respiratory hospital admissions annually in 2021-2050. Southern Europe projected to have 3-times more heat attributed respiratory admissions		Population projections	Astrom et al. 2013

Region	***Health outcome metric***	***Baselines***	***Climate model(s)***	***Scenario***	***Time periods of interest***	***Impacts at baseline***	***Projected impacts at 1.5°C***	***Projected impacts at 2°C***	***Other factors considered***	***Reference***
Europe	Heat-related mortality	1971-2000	SMHI RCA4/HadGEM2 ES r1 (MOHC)	RCP 4.5; RCP8.5	2035–2064; 2071–209		2035-2064 excess heat mortality to be 30,867 and 45,930	2071–2099 excess heat mortality to be 46,690 and 117,333 attributable deaths/year		Kendrovski et al. 2017
UK	Temperature-related mortality	1993-2006	9 regional model variants of HadRm3-PPE-UK, dynamically downscaled	A1B	2000-2009, 2020-2029, 2050-2059, 2080-2089	At baseline, 1,974 annual heat-related and 41,408 cold-related deaths	In the 2020s, in the absence of adaptation, heat-related deaths would increase to 3,281 and cold-related deaths to increase to 42,842	In the 2050s, the absence of adaptation, heat-related deaths projected to increase 257% by the 2050s to 7,040 and cold-related mortality to decline about 2%	Population projections to 2081	Hajat et al. 2014
Netherlands	Temperature-related mortality	1981-2010	KNMI’ 14; G-scenario is a global temperature increase of 1°C and W-scenario an increase of 2°C		2050 (2035-2065)	At baseline, the attributable fraction for heat is 1.15% and for cold is 8.9%; or 1511 deaths from heat and 11,727 deaths from cold	Without adaptation, under the G scenario, the attributable fraction for heat is 1.7-1.9% (3329-3752 deaths) and for cold is 7.5-7.9% (15,020-15,733 deaths).	Without adaptation, under the W scenario, the attributable fraction for heat is 2.2-2.5% (4380-5061 deaths) and for cold is 6.6-6.8% (13,149-13699 deaths).	Three adaptation scenarios, assuming a shift in the optimum temperature, changes in temperature sensitivity, or both; population growth and declining	Huynen and Martens 2015

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
							Adaptation decreases the numbers of deaths, depending on the scenario.	Adaptation decreases the numbers of deaths, depending on the scenario.	mortality risk per age group	
Skopje, Macedonia	Heat-related mortality	1986-2005; May - September	MRI-CGCM3, IPSL-CM5A-MR, GISS-E2-R	RCP8.5	2026-2045, 2081-2100	About 55 attributable deaths per year	Heat-related mortality would more than double in 2026-2045 to about 117 deaths		Two models to project population growth; PM10	Martinez et al. 2016
Korea	Burden of disease from high ambient temperatures	2011	CMIP5	RCP 4.5; RCP8.5	2030; 2050	DALY for all-cause mortality in 2011 was 0.49 (DALY/1000) DALY for cardio-and cerebrovascular disease was 1.24 DALY/1000	In 2030 DALY for all-cause mortality, 0.71 (DALY/1000) DALY for cardio-and cerebrovascular disease is 1.63 (1.82) DALY/1000	In 2050, DALY for all-cause mortality, 0.77 (1.72) (DALY/1000) DALY for cardio-and cerebrovascular disease is 1.76 (3.66) DALY/1000		Chung et al. 2017
Beijing, China	Heat-related mortality	1970-1999	Downscaled and bias corrected (BCSD) 31	RCP4.5, RCP8.5	2020s (2010-2039), 2050s (2040-2069),	Approximately 730 additional annual heat-	In the 2020s, under low population growth and	In the 2050s under low population growth, and	Adults 65+ years of age; no change plus low,	Li et al. 2016

Region	*Health outcome metric*	*Baselines*	*Climate model(s)*	*Scenario*	*Time periods of interest*	*Impacts at baseline*	*Projected impacts at 1.5°C*	*Projected impacts at 2°C*	*Other factors considered*	*Reference*
			GCMs in WCRP CMIP5; monthly change factors applied to daily weather data to create a projection		2080s (2070-2099)	related deaths in 1980s	RCP4.5 and RCP8.5, heat-related deaths projected to increase to 1,012 and 1,019, respectively. Numbers of deaths are higher with medium and high population growth.	RCP4.5 and RCP8.5, heat-related deaths projected to increase to 1,411 and 1,845, respectively.	medium, and high variants of population growth; future adaptation based on Petkova et al. 2014, plus shifted mortality 5%, 15%, 30%, 50%	
Beijing, China	Cardiovascular and respiratory heat-related mortality	1971-2000	Access 1.0, CSIRO Mk3.6.0, GFDL-CM3, GISS E2R, INM-CM4	RCP4.5, RCP8.5	2020s, 2050s, 2080s	Baseline cardiovascular mortality 0.396 per 100,000; baseline respiratory mortality 0.085 per 100,000	Cardiovascular mortality could increase by an average percentage of 18.4% in the 2020s under RCP4.5 and by 16.6% under RCP8.5. Statistically significant increases are projected for respiratory mortality.	Cardiovascular mortality could increase by an average percentage of 47.8% and 69.0% in the, 2050s and 2080s under RCP4.5, and by 73.8% and 134% under RCP8.5. Similar increases are projected for		Li et al. 2015

Region	***Health outcome metric***	***Baselines***	***Climate model(s)***	***Scenario***	***Time periods of interest***	***Impacts at baseline***	***Projected impacts at 1.5°C***	***Projected impacts at 2°C***	***Other factors considered***	***Reference***
								respiratory mortality.		
Africa	Five thresholds for number of hot days per year when health could be affected, as measured by maximum apparent temperature	1961-2000	CCAM (CSIRO) forced by coupled GCMs: CSIRO, GFDL20, GFDL 21, MIROC, MPI, UKMO. CCAM was then downscaled. Biased corrected using CRU TS3.1 dataset	A2	2011-2040, 2041-2070, 2071-2100	In 1961-1990, average number of hot days (maximum apparent temperature > 27°C) ranged from 0 to 365, with high variability across regions.	In 2011-2040, annual average number of hot days (maximum apparent temperature > 27°C) projected to increase by 0-30 in most parts of Africa, with a few regions projected to increase by 31-50.	In 2041-2070, annual average number of hot days (maximum apparent temperature > 27°C) projected to increase by up to 296, with large changes projected in southern Africa and parts of northern Africa	Projected population in 2020 and 2025	Garland et al. 2015

Abbreviations: DALY: Disability adjusted life year; RCP: Representative Concentration Pathway; SSP: Shared Socioeconomic Pathway

Table S8 - 3.4.7 - 3: Projected health risks of undernutrition and dietary change associated with climate change

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
Global and 21 regions	Undernutrition	1961-1990	BCM2.0, EGMAM1, EGMAM2, EGMAM3, CM4vl	A1B	2030, 2050		In 2030, 95,175 additional undernutrition deaths without adaptation and (ensemble mean) 131, 634 with adaptation under the low growth scenario and 77, 205 under the high growth scenario; Asia, and Sub-Saharan Africa, at highest risk	In 2050 risks are generally lower in most regions because of underlying trends, with 84, 695 additional undernutrition deaths without adaptation, 101, 484 with adaptation under the low growth scenario and 36, 524 under the high growth scenario	Population growth; improved population health; crop models include adaptation measures	WHO 2014
Global and 17 regions	Undernourished population; DALY (disability) caused by underweight of a child under 5 years of age	2005-2100	5 models from ISIMIP (GFDL-ESM2, NorESM1-M, IPSL-CM5A-LR, HadGEM2-ES, MIROC-	RCP2.6 and 8.5 with SSP2 and SSP3	2005-2100	Baseline assumed no climate change (no temperature increase from present)	In 2025 under SSP3, global undernourished population is 530-550 million at 1.5 °C. Global mean DALYs of	In 2050 under SSP3, global undernourished population is 540-590 million at 2.0 °C. Global mean DALYs of	Population growth and aging; equity of food distribution	Hasegawa et al. 2016

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
			ESM-CHEM)				11.2 per 1000 persons at 1.5°C.	12.4 per 1000 persons at 2°C.		
Global divided into 17 regions	DALYs from stunting associated with undernutrition	1990-2008	12 GCMs from CMIP5	Six scenarios: RCP2.6 + SSP1, RCP4.5 + SSPs 1-3, RCP8.5 + SSP2, SSP3	2005 - 2050	57.4 million DALYs in 2005	In 2030, DALYs decrease by 36.4 million (63%), for RCP4.5, SSP1, and by 30.4 million (53%) and 16.2 million (28%) for RCP8.5, SSP2 and SSP3, respectively	By 2050, DALYs decrease further to 17.0 million for RCP4.5, SSP1, and to 11.6 million for RCP8.5, SSP2. DALYs increase to 43.7 million under RCP8.5, SSP3	Future population and per capita GDP from the SSP database	Ishida et al. 2014
Global	Deaths associated with the impact of climate change on food production	1986-2005	International model for policy analysis of agricultural commodities and trade (IMPACT); purpose-built global health model estimated changes in mortality associated	RCP8.5 + SSP2; RCPs 2.6, 4.5 and 6.0 plus SSPs 1 and 3 for sensitivity analyses	2050			By 2050, per-person reductions of 3·2% (SD 0·4%) in global food availability, 4·0% (0·7%) in fruit and vegetable consumption, and 0·7% (0·1%) in red meat consumption	Projected changes in population and GDP; increases in food availability and consumption in the reference scenario without climate change	Springmann et al. 2016

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
			with changes in dietary and weight-related risk factors, focusing on changes in the consumption of fruits and vegetables, and red meat, and on changes in bodyweight associated with changes in overall caloric availability; HADGEM2-ES, ISPL-CM5A-LR, MIROC-ESM_CHEM					. These changes associated with 529 000 climate-related deaths worldwide (95% CI 314 000–736 000). Twice as many deaths associated with reductions in fruit and vegetable consumption than in climate-related increases in underweight. Highest risks projected in southeast Asia and western Pacific.	resulted in 1·9 million avoided deaths (95% CI 0·9–2·8 million) in 2050 compared with 2010. Climate change reduced the number of avoided deaths by 28% (95% CI 26–33).	

Abbreviations: DALY: Disability adjusted life year; **RCP:** Representative Concentration Pathway; **SSP:** Shared Socioeconomic Pathway

Table S9- 3.4.7 – 4: Projected vectorborne disease risks to human health associated with climate change

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
Malaria										
Global	Malarial distribution	1980-2009, 1980-2010	CMIP5, HadGem2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM, GFDL-ESM2M, NorESM1-M	RCP2.6, RCP4.5, RCP6.0, RCP8.5	2030s (2005-2035), 2050s (2035-2065), 2080s (2069–2099)	Before interventions, epidemic malaria widespread in mid-latitudes and some northern regions,		In the 2050s, length of the malaria transmission season increases over highland areas in most regions, however, the net effect on populations at risk relatively small in Africa, with large regional differences	Malaria models: LMM_RO, MIASMA, VECTRI, UMEA, MARA	Caminade et al. 2014
China	Human population exposed to 4 malarial vectors	Malarial records (2000-2010)	BCC-CSM1-1, CCCma_CanESM2, CSIRO-Mk3.6.0	RCP2.5, RCP4.5, RCP8.5	2030s, 2050s	Exposure to An. dirus = 26.4 M; An. minimus= 162.8 M; An. Lesteri = 619.0 M; An. sinensis = 1005.2 M	In the 2030s, environmentally suitable area for two vectors increases by an average of 49% and 16%, under all	In the 2050s, environmentally suitable area for these vectors decreases by an average of 11% and 16%, with an increase of 36% and 11% for two other vectors.		Ren et al. 2016

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
							scenarios. Overall, a substantial increase in the population exposed.	Increase in the population exposed larger than in the 2030s.		
China	Malaria vectors An. dirus, An. minimus, An. lesteri, An. sinensis	2005-2008	BCC-CSM1-1, CCCma_CanESM2, CSIRO-Mk3.6.0 from CMIP5	RCP2.6, RCP4.5, RCP8.5	2020-2049, 2040-2069		In the 2030s, environmentally suitable areas for An dirus and An minimus increase by an average of 49% and 16%, respectively	In the 2050s environmentally suitable areas for An dirus and An minimus decrease by 11% and 16%, respectively. An increase of 36% and 11%, in environmentally suitable area of An lesteri and An sinensis	Land use, urbanization	Ren et al. 2016
Northern China	Spatial distribution of malaria	2004-2010	GCMs from CMIP3	B1, A1B, A2	2020, 2030, 2040, 2050	Average malaria incidence 0.107% per annum in northern China	In 2020, malaria incidence increases 19%-29%, and increases 43%-73% in 2030, with increased	In 2040, malaria incidence increases 33%-119% and 69%-182% in 2050, with increased spatial distribution	Elevation, GDP, water density index held constant	Song et al. 2016

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
							spatial distribution			
Africa	Malaria transmission	1960-2005	CanESM2, IPSL-CM5A-LR, MIROC-ESM, MPI-ESM-LR	RCP2.6, RCP8.5	2030-2099		Over the period 2030-2099, increase in the regional extent and length of transmission season, with greater impacts at RCP2.6 (temperatures can be too hot for malaria under RCP8.5)		Land use change	Tompkins et al. 2016
Sub-Saharan Africa	Malaria	2006-2016	21 CMIP5 models	RCP 4.5, RCP 8.5	2030, 2050, 2100		In 2030, under RCP 8.5, many parts of western and central Africa will have no malaria, but significant malaria	Climate change will redistribute the spatial pattern of future malaria hotspots especially under RCP 8.5.	Various environmental variables	Semakula et al. 2017

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
							hotspots will be along the Sahel belt, east and southern parts of Africa.			
West Africa	Malaria	1975-2005	CMIP5 models CCSM4, MPI-ESM-MR	RCP8.5	2030-2060, 2070-2100			Reduced malaria burden in a western sub-region and insignificant impact in an eastern sub-region.	Used the Hydrology, Entomology and Malaria Transmission Simulator (HYDREMATS)	Yamana et al. 2016
South and Southeast Asia	Malarial spatial pattern	1950-2000	MIROC-H	A2	2050, 2100	Malaria a risk in all countries		For 2050, a decrease in climate suitability in India (northern and eastern regions), southern Myanmar, southern Thailand, the region bordering Malaysia, Cambodia, eastern Borneo and the	Eco-climatic index	Khormi and Kumar 2016

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								Indonesian islands. However, even if suitability decreases, most of the areas should remain conducive for the spread of malaria. Regions where climate suitability increases are southern and south-eastern mainland China and Taiwan.		
Korea	Malaria	2001-2011	HadGEM3-RA based on HadGEM2-AO	RCP4.5	2011-2039, 2040-2069, 2070-2100	Malaria continues to regularly occur	In 2040-2069, the simulated time series indicated a slight increase in malaria, with a longer transmission season and early peak			Kwak et al. 2014

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
							month for cases			
South America	Malaria	Current	NASA GISS-E2-R, ENES HadGEM2-ES	RCP8.5	2070	25% of South America has a climate suitable for malaria (P. falciparum) transmission		In 2070, geographic range increases to 35% based on an increase in temperature of 2-3°C on average and a decrease in precipitation		Laporta et al. 2015
Aedes										
Global	Distributions of Ae. aegypti and Ae. albopictus	1950–2000	CMIP4 model projections: BCCR-BCM2.0, CSIRO-MK3.0, CSIRO-MK3.5, INM-CO3.0, MIROC medium resolution, NCAR-CCSM3.0	A2, B1, A1B	2050	Model predictions for the present day reflected the known global distributions of the two species		In 2050, projections indicated complex global rearrangements of potential distributional areas		Campbell et al. 2015
Global	Distribution of Ae. aegypti	1950-2000	CSIRO-Mk3.0, MIROC-H	A1B, A2	2030, 2070	Strong concordance between actual records	In 2030, climatically favorable			Khormi and Kumar 2014

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
						and predicated conditions	areas for Ae. aegypti globally projected to contract. Currently unfavorable areas, such as inland Australia, the Arabian Peninsula, southern Iran and parts of North America may become climatically favorable			
Global	Aedes-transmitted viruses	Current mean, maximum, and minimum monthly temperature	BCC-CSM1.1, HadGEM2-CC, HadGEM2-ES, CCSM4.	RCP2.6, RCP4.5, RCP 6.0, RCP 8.5.	2050, 2070			Shifting suitability will track optimal temperatures for transmission, potentially leading to poleward	Population count data	Ryan et al. 2017

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								shifts. Especially for Ae. albopictus, extreme temperatures are likely to limit transmission risk in current zones of endemicity, especially the tropics.		
Global	Chikungunya	Present-day	CESM 1 bcg, FIO ESM, GISS e2-r, INM CM4, MPI-ESM-lr	RCP4.5, RCP8.5	2021-2040, 2041-2060, 2061-2080			Projections under both scenarios suggest the likelihood of expansion of transmission-suitable areas in many parts of the world, including China, sub-Saharan Africa, South America, the United States, and continental Europe	Population density	Nils et al. 2017

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
Global and regional	Habitat suitability for the Asian tiger mosquito, a vector chikungunya, dengue fever, yellow fever and various encephalitides	2000-2009; ECHAM5/ MESSy2	CMIP5: CCSM4, HadGEM2-CC, HadGEM2-ES, ISPL-CM5A-MR, MIROC5, MPI-ESM-LR, MRI-GCCM3, CSIRO-Mk3.60, EC-EARTH	A2, RCP8.5	2045-2054	Ae. albopictus habitat suitability index > 10% is 3,495 x106 individuals; for >70%, 1,788 x106 in a land area of 22 x 106 km2		For a habitat suitability index > 70%, approximately 2.4 billion individuals in a land area of nearly 20 million km2 potentially exposed to Ae. albopictus		Proestos et al. 2015
North America, United States	Climate suitability for Ae. albopictus vector for dengue, chikungunya, and vectorborne zoonoses such as West Nile virus (WNV), Eastern Equine Encephalitis virus, Rift Valley Fever virus, Cache Valley virus and	1981-2010	8 RCMs: CanRCM4, CRCM5, CRCM 4.2.3, HIRHAM5, RegCM3, ECPC, MM5I, WRF	RCP4.5, RCP8.5, A2	2020s (2011–2040), 2050s (2041–2070).	Index of precipitation and temperature suitability was highly accurate in discriminating suitable and non-suitable climate	In 2011-2040 under RCP4.5, climate suitability increases across US, with the magnitude and pattern dependent on parameter projected and RCM	In 2041-2070 under RCP4.5, areal extent larger than in earlier period; under 8.5, areal extent larger	Climatic indicators of Ae. albopictus survival; overwintering conditions (OW); OW combined with annual air temperature (OWAT); and an index of suitability	Ogden et al. 2014a

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
	LaCrosse virus									
Southeast USA	Ae. aegypti populations and dengue cases	1961-1990	GCM simulated baseline	A1B	2045-2065	Under baseline climate, dengue transmission may be possible in several sites in the southeast US		The potential for dengue transmission will continue to be seasonal throughout the southeastern US, without becoming a year-round phenomenon except perhaps in southern Florida that may have winter dengue activity. The length of the potential transmission season will increase for most sites		Butterworth et al. 2016
Southeast USA	Aedes aegypti popu lations and dengue cases	1981-2000 (for weather stations); 1961-1990 (for GCM simulations)	15 GCMs	SRA1B	2045-2065	Dengue transmission is possible at several U.S. locations during summer,		Conditions may become suitable for virus transmission in a larger number of		Butterworth et al. 2017

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
						particularly in southern Florida and Texas.		locations and for a longer period		
Mexico	Dengue	1985-2007	National Institute of Ecology; added projected changes to historic observations	A1B, A2, B1	2030, 2050, 2080	National: 1.001/100.000 cases annually Nuevo Leon: 1.683/100.000 cases annually Queretaro: 0.042/100.000 cases annually Veracruz: 2.630/100.000 cases annually	In 2030, dengue incidence increases 12-18%	In 2050, dengue incidence increases 22-31%.	At baseline, population, GDP, urbanization, access to piped water	Colon-Gonzalez et al. 2013
Europe, Eurasia and the Mediterranean	Climatic suitability for Chikungunya outbreaks	1995-2007	COSMO-CLM, building on ECHAM5	A1B and B1	2011-2040, 2041-2070, 2071-2100	Currently, climatic suitability in southern Europe. The size of these regions will expand during the 21st century	In 2011-2040, increases in risk are projected for Western Europe in the first half of the	In 2041-2070, projected increased risks for central Europe.		Fischer et al. 2013

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
							21st century			
Europe	Potential establishment of Ae. albopictus	Current bioclimatic data derived from monthly temperature and rainfall values	Regional climate model COSMO-CLM	A1B, B1	2011-2040, 2041-2070, 2071-2100		In 2011-2040, higher values of climatic suitability for Ae. albopictus increases in western and central Europe	Between 2011-40 and 2041-70, for southern Europe, only small changes in climatic suitability are projected. Increasing suitability at higher latitudes is projected for the end of the century.		Fischer et al. 2011
Europe	Dengue fever risk in 27 EU countries	1961-1990	COSMO-CLM (CCLM) forced with ECHAM5/MPIOM	A1B	2011-2040, 2041-2070, 2071-2100	Number of dengue cases are between 0 and 0.6 for most European areas, corresponding to an incidence of less than 2 per 100 000 inhabitants	In 2011-2040, increasing risk of dengue in southern parts of Europe	In 2041-2070, increased dengue risk in many parts of Europe, with higher risks towards the end of the century. Greatest increased risk around the Mediterranea	Socioeconomic variables, population density, degree of urbanization and log population	Bouzid et al. 2014

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								n and Adriatic coasts and in northern Italy		
Europe, and 10 cities in Europe with three reference cities in tropical and sub-tropical regions	Dengue epidemic potential for Aedes vectors	1901-2013	CRU-TS 3.22	RCP2.6, RCP4.5, RCP6.0, RCP8.5	2070–2099					Liu-Helmersson et al. 2016
Greece and Italy	Invasive Aedes spread and establishment	2003-2012	NASA GISS GCM model E	A1B	2050			Future climatic conditions estimated to favor Aedes albopictus and Aedes aegypti spread and establishment over Greece and Italy		Tagaris et al. 2017
Australia	Future dengue epidemic potential	1990–2011	CIMSiM, MPI ECHAM5	A2, B1	2046-2064	Dengue transmission possible in all study centers, with different transmission probability, depending on		Under A2, decreased dengue transmission projected; some increases		Williams et al. 2016

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
						location and month		likely under B1		
Queensland, Australia	Dengue outbreaks	1991-2011	MPI ECHAM 5 model	A2, B1	2046-2065		Aedes aegypti abundance increases under B1 16.6% and decreases 42.3% under A2; temperature increase of about 0.6°C			Williams et al. 2014
Guangzho, south-western China	Effects of seasonal warming on the annual development of Ae. albopictus	1980-2014	Mechanistic population model (MPAD), generating fifteen seasonal warming patterns	Fifteen seasonal warming patterns generated based on temperature increases from 0.5 to 5°C.			At an increase of 1°C, warming effects facilitate the development of species by shortening the diapause period in spring and winter. In summer, effects are primarily negative by			Jia et al. 2017

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
							inhibiting mosquito development; effects are mixed in autumn			
New Caledonia	Dengue fever spatial heterogeneity	1995-2012	10 CMIP5 models: bcc-csm1-1, CanESM2, CCSM4, CNRM-CM5, HadGEM2-CC, inmcm4, IPSL-CM5A-MR, IPSL-CM5B-LR, MPI-ESM-LR, NorESM1-M	RCP4.5, RCP8.5	2010- 2029, 2080-2099	24,272 dengue cases	In 2010-2029, under RCP8.5, average (across communes) dengue mean annual incidence rates during epidemic years could raise by 29 cases per 10,000 people per year		Socioeconomic covariates	Teurlai et al. (2015)
Dhaka, Bangladesh	Weather variability impacts on dengue	2000-2010	Future monthly temperature was estimated by combining recorded baseline with projections	MMD-A1B	2100	Over study period, 25,059 dengue cases.		For a 2°C increase without adaptation, 2,782 additional dengue cases. For increase by	1.3% increase in population	Banu et al. 2014

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								3.3°C, 16,030 additional cases by 2100		
Tanzania	Distribution of infected Aedes aegypti co-occurrence with dengue epidemics risk	1950-2000	CMIP5		2020, 2050	Currently high habitat suitability for Aedes aegypti in relation to dengue epidemic, particularly near water bodies	Projected risk maps for 2020 show risk intensification in dengue epidemic risks areas, with regional differences	In 2050, greater risk intensification and regional differences		Mweya et al. 2016
West Nile Virus										
North America	Geographic distribution of West Nile Virus (WNV)	2003–2011	USHCN, WorldClim, Seven GCMs, from the IPCC 4th assessment	A1B	2050-2060, 2080-2090			In 2050-2060, A northward and altitudinal expansion of the suitability of WNV, driven by warmer temperatures and lower annual precipitation.		Harrigan et al. 2014

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
USA	Population dynamics of three WNV vectors	1970-2000	LARS-WG, CCSM	A2, B1	2045-2065, 2080-2099			In both time periods, changes in mosquito population dynamics vary by location; mosquito activity periods expected to increase in the northern latitudes		Brown et al. 2015
USA	West Nile Neuro-invasive disease	1986-2005	CCSM4, GISS-E2-R, CanESM2, HadGEM2-ES, MIROC5	RCP4.5, RCP8.5	2050, 2090			Increase of expected annual number of cases to ≈2000 - 2200 by 2050	All-age, county-level, population projections	Belova et al. 2017
Southern USA	Cx. quinquefasciatus (WNV vector) populations	1970-1999	USHCN, LARS-WG, AR4 GCM ensemble	A2	2021-2050	In the eastern USA, vector displays a latitudinal and elevational gradient		In 2021-2050, projected summer population depressions are most severe in the south and almost absent further north;		Morin and Comrie 2013

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								extended spring and fall survival is ubiquitous. Projected onset of mosquito season is delayed in the southwestern USA; increased temperature and late summer and fall rains extend the mosquito season		
Canadian prairie provinces	Spatial and temporal distribution of Cx. tarsalis and WNV infection rate	Monthly climatology data, 1961-1990; abundance of Cx. tarsalis and WNV infection rate, 2005-2008	Linear mixed model and generalized linear mixed model used temperature and precipitation as the primary explanatory variables; NCAR-PCM run 2, MIMR, UKMO-HadGEM1	A2, A1B, B1	2020 (2010–2039), 2050 (2040–2069) and 2080 (2070–2099)	Highest abundance of Cx. tarsalis occurred in the southern Canadian prairies under baseline climate conditions and all future scenarios		In 2050 under the median scenario, in current endemic regions, WNV infection rate increases 17.9 times. Abundance of Cx. tarsalis increases 1.4		Chen et al. 2013

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								times. Geographical distribution of Cx. tarsalis increases 33,195 km2 northward (1.6-fold).		
Europe, Eurasia, and the Mediterranean	Distribution of human WNV infection	Monthly temperature anomalies relative to 1980-1999, environmental variables for 2002-2013	NCAR CCSM3	A1B	2015-2050		In 2025, progressive expansion of areas with an elevated probability for WNV infections, particularly at the edges of the current transmission areas	In 2050, increases in areas with a higher probability of expansion	Prevalence of WNV infections in the blood donor population	Semenza et al. 2016
Lyme disease and other tick-borne diseases										
North America (mainly Ontario and Quebec, Canada, and Northeast	Capacity of Lyme disease vector (Ixodes scapularis) to reproduce	1971–2010	CRCM4.2.3, WRF, MM5I , CGCM3.1, CCSM3	A2	1971-2000, 2011–2040, 2041–2070	In 1971–2010, reproductive capacity increased in North America	In 2011-2040, mean reproductive capacity increased,	In 2041-2070, further expansion and numbers of ticks projected. R0 values		Ogden et al. 2014b

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
and Midwest, U.S)	under different environmental conditions					increased consistent with observations	with projected increases in the geographic range and number of ticks	for I. scapularis are projected to increase 1.5 to 2.3 times in Canada. In the U.S. values are expected to double.		
Eastern U.S.	Lyme disease vector Ixodes scapularis	2001-2004	WRF 3.2.1	RCP4.5, RCP8.5	2057-2059	Peak Month and Peak Population had the greatest discriminatory ability across all life stages		Mean, median, and peak populations increase across most of the eastern U.S., with the largest increases under RCP8.5; regions with the highest tick populations expanded northward and southward; season of questing adults	10 dynamic population features	Dhingra et al. 2013

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								increases in the south and decreases in the north		
U.S., 12 eastern states with > 90% of current cases	Lyme Onset Week (LOW)	1992–2007	5 AOGCMs from CMIP5	RCP2.6, RCP4.5, RCP6.0, RCP8.5	2025-2040, 2065-2080	LOW for 1992–2007 is 21.2 weeks	In 2025–2040, LOW is 0.4–0.5 weeks earlier, based on an increase in temperature of 1.2–1.7°C, with regional differences. The largest changes under RCP8.5			Monaghan et al. 2015
Southeastern US, NY	Emergence of I. scapularis, leading to Lyme disease	1994-2012			2050	19 years of tick and small mammal data (mice, chipmunks)	In the 2020s, the number of cumulative degree-days enough to advance the average nymphal peak by 4–	In the 2050s, the nymphal peak advances by 8–11 days, and the mean larval peak by 10–14 days, based on 2.22–3.06°C increase in		Levi et al. 2015

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
							6 days, and the mean larval peak by 5–8 days, based on 1.11–1.67°C increase in mean annual temperature	mean annual temperature		
Texas – Mexico transboundary region	Lyme disease transmission (I. scapularis with B. burgdorferi)	2011-2012 (for tick distribution)	CCCMA, CSIRO, HADCM3	A2A, B2A	2050	9% of tick samples were I. scapularis; 45% of these infected with B. burgdorferi		In 2050, habitat suitable for I. scapularis will remain relatively stable	MaxEnt model	Feria-Arroyo et al. 2014
Southern Quebec (34 sites)	Risk of Borrelia burgdorferi, (bacteria causing Lyme disease in North America)	May to October 2011	CRCM 4.2.3, CMIP3 ensemble	A1b, A2, B1	2050	Borrelia burgdorferi detected at 9 of the 34 study sites. Risk ranged from 0.63 to 0.97, except in one site that was null)		In 2050, northern range of B. burgdorferi expands by approximately 250–500 km – a rate of 3.5–11 km per year		Simon et al. 2014

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
Europe	Climatic niche of Ixodes ricinus	1970-2010	CCCAMCGCM3.1-T47	A2, B2	2050, 2080	Current distribution of Ixodes ricinus is 3.1x106 km2		In 2050, increase of climatic niche of about 2-fold and higher climatic suitability under B2 than A2, both in latitude and longitude, including northern Eurasian regions (e.g. Sweden and Russia), that were previously unsuitable	Species distribution modeling	Porretta et al. 2013
Europe	Climate suitability for ticks	1971-2010	IPSLCM5A-LR, MIROC-ESM-CHEM, GFDL-ESM2M, NorESM1-M	RCP2.6, RCP4.5, RCP6.0, RCP8.5	2050-2098	Seven of eight tick species exhibited strong climatic signals within their observed distributions		Varying degrees of northward shift in climate suitability for tick species with a climate signal, with the greatest shifts under the most extreme		Williams et al. 2015

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								RCPs and later in the century		
Other										
Continental portions of US and Mexico	Chagas disease; forecast the distribution of the host vector (Triatoma gerstaeckeri and T. sanguisuga)	1980-2012	CCCMA, CSIRO, HDCM3	A2, B2	2050	Present range of T. gerstaeckeri = 1903784 km2 Present range of T. sanguisuga habitat = 2628902 km2		In 2050, a northern and eastern shift of T. gerstaeckeri and a northern, eastern, and southern distributional shift of T. sanguisuga		Garza et al. 2014
Venezuela	Chagas disease: number of people exposed to changes in the geographic range of five species of triatomine species	1950–2000	CSIRO3.0	A1B, B1	2020, 2060, 2080		In 2020 decreasing population vulnerability	In 2060, effects more pronounced, with less of a change under B1	MaxEnt model of climatic niche suitability	Ceccarelli and Rabinovich 2015
Venezuela and Argentina	Chagas Disease (vectors Rhodnius prolixus and Triatoma infestans)	1950–2000	HadGEM2-ES	RCP4.5, RCP6.0, RCP8.5	2050	4751 new cases of Tr. cruzi human infection annually in provinces at high-to-		In 2050, heterogeneous impact on the climatic niches of both vector species, with		Medone et al. 2015

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
						moderate transmission risk		a decreasing trend of suitability of areas that are currently at high-to-moderate transmission risk		
South America	Distributions of the vector and pathogen causing cutaneous leishmaniasis (Lutzomyia flaviscutellata and Leishmania amazonensis)	1950–2000	ACCESS1.0, BCC-CSM1.1, CCSM4, CNRM-CM5, GFDL-CM3, GISS-E2-R, HadGEM2-AO, HadGEM2-ES, HadGEM2-CC, INM-CM4, IPSL-CM5A-LR, MIROC5, MRI-CGCM3, MIROC-ESM-CHEM, MPI-ESM-LR, MIROC-ESM, NorESM1-M	RCP4.5, RCP8.5	2050	Occurrence of L. flaviscutellata included 342 presence records (277 from Brazil)		In 2050, pattern of climate suitability shifts, with expansion of regions with suitable climates, depending on model and RCP	Used two algorithms for each species datasets: presence only (BIOCLIM and DOMAIN), presence/background (MaxEnt and GARP), and presence/absence	Carvalho et al. 2015

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
South America	Range of vectors of leishmaniasis	1978-2007 vector data from Argentina, Brazil, Bolivia, Paraguay; 1960-1990 climate data	HadGEM2-ES	RCP4.5, RCP8.5	2050	Current range of Lutzomyia intermedia is 1,958,675 km2 and of Lutzomyia neivai is 2,179,175 km2		In 2050, L. intermedia mostly contracts in the southern part of its range by 41.1% (RCP4.5) or 46.8% (RCP8.5), perhaps with expansion in northeast Brazil; L. neivai mostly shifts its range southwards in Brazil and Argentina, with an overall contraction of 14.8% (RCP4.5) or 16.2% (RCP8.5)	Ecological niche modeling	McIntyre et al. 2017
Colombia	Visceral leishmaniasis caused by the	Present	CSIRO, Hadley	A2A, B2A	2020, 2050, 2080		In 2020, shift in the altitudinal distributio	In 2050, even greater geographic area of	MaxEnt model; three topographical variables	Gonzalez et al. 2013

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
	trypanosomatid parasite Leishmania infantum						n in the Caribbean Coast and increase in the geographic area of potential occupancy under optimistic scenario	potential occupancy, with a greater impact under A2.		
Russian Federation, Ukraine, and Other Post-Soviet States	Geographical spreading and potential risk of infection of human dirofilariosis (zoonotic disease)	1981-2011	Russian Committee of Hydrometeorology		2030	In 1981 to 2011, 2154 cases of human dirofilariosis reported in the former USSR	By 2030, an increase of 18.5% in transmission area and 10.8% in population exposure		Growing degree-days (GDDs) matrix and SRTM digital elevation models to project 2030 estimates; constant population	Kartashev et al. 2014
Romania	Zoonotic disease risk as measures by the distribution of thermophilic ticks (H. marginatum	present	CCSM4	RCP2.6, RCP4.5, RCP6.0, RCP8.5	2050, 2070	Range of H. marginatum = 97,992 km2; range of R. annulatus =28,181 km2		In 2050, under all RCPs, range increases (range expansion and range shift) for both tick species, with the largest increase		Domsa et al. 2016

Region	Health outcome metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
	and R. annulatus)							under RCP8.5		
Baringo county, Kenya	Rift Valley Fever (RVF) virus vectors	2000	NOAA GFDLCM3	RCP4.5	2050	Lowlands highly suitable for all RVF vector species		In 2050, increase in the spatial distribution of Cx. quinquefasciatus and M. africana in highland and mid-latitude zones	Ecological niche modeling	Ochieng et al. 2016

Table S10 - 3.4.7 – 5: Projected air pollution risks to human health

Region	Health outcome metric	Baselines	Climate model(s) and air pollution models	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
Global	PM2.5 and O3-related and respiratory mortality	2000	GFDL, AM3	A1B	1981-2000 2081-2100	Adults (aged 30+) YLL for all-cause mortality per 1,000 pop = 123 years		21st century climate changes to increase all-cause premature associated with PM2.5 exposure increased 4% relative to YLL from total PM2.4 (2months additional life lost per 1,000/persons globally). Less than 1% increase in respiratory disease mortality associated with O3		Fang et al. 2013
Global	PM 2.5 and O3-related mortality	2000	ACCMIP model; CESM	RCP 2.6; RCP 4.5; RCP 6.0; RCP 8.5	2000; 2030; 2050; 2100	Global ozone mortality 382 000 (121 000 to 728 000) deaths year -	PM2.5 related mortality peaks in 2030 (2.4-2.6Million deaths/year	By 2100 increases in ozone related deaths (across all four RCPS)	Population projected from 2010-2100	Silva et al., 2016

Region	Health outcome metric	Baselines	Climate model(s) and air pollution models	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
						1; global mortality burden of PM2.5 1.70 (1.30 to 2.10) million deaths year -1	–except for RCP 6.0); O3-related mortality peaks in 2050 (1.18-2.6 million/deaths annually)	between 1.09 and 2.36 million deaths year -1; decrease of PM2.5 global deaths in 2100 (for all four RCPs) between).95 and 1.55 million deaths year -1.		
Global & Europe and France	PM2.5-related cardiovascular and O3-related respiratory mortality	2010	IPSL-cm5-MR, LDMz-INCA, CHIMERE	RCP4.5 (for Europe and France)	2010-2030-2050	Global CV mortality 17243	In 2030, in Europe PM2.5-related cardiovascular (CV) mortality decreases by 1.9% under CLE; and 2.2% under MFR. In 2030 O3-related respiratory mortality decreases by 0.2% under	In 2050 3.8% decrease in PM2.5 related CV mortality under CLE and MFR.	Population 2030 – sensitivity analysis	Likhvar et al., 2015

Region	Health outcome metric	Baselines	Climate model(s) and air pollution models	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
							CLE and 3% under MFR			
Europe	O3-related mortality and respiratory hospitalization	1961-1990	MATCH-RCA3, ECHAM4, HadCM3	AIB, A2	1961-1990; 1990-2009; 2021-2050; 2041-2060	Baseline (1961-1990) O3-related mortality 25,915 - 28,012; O3-related hospitalizations 35,596 - 38,178	In 2021-2050, O3-related mortality to increase by 13.7% (with A2 scenario) and 8.6% with A1B scenario			Orru et al. 2013
Europe	PM2.5 and O3-related mortality	2000	ECHAM5, DEHM, MATCH	A1B	2000s; 2050s; 2080s	Average mortality in 2000 related to air pollution: 35,000 (DEHM) and 28,000 (Match)		(Climate only) 2050s an 8 -11% increase in mortality and a 15-16% increase in 2080. (Climate + emissions): 2050, 36-64% and in 2080s, 53-84% decrease in 03-related mortality; and for PM2.5, a decrease of	Population projection 2050; PM 2.5 future infiltration change	Geels et al. 2015

Region	Health outcome metric	Baselines	Climate model(s) and air pollution models	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								62-65% in 2050 and a decrease of 78-79% in 2080s.		
UK	O3-related morbidity and mortality	2003	EMEP-WRF	A2, B2	2003, 2030	O3-attributable mortality and morbidity in 2003: 11,500 deaths and 30,700 hospitalizations	With no threshold for O3, increase of premature mortality and hospitalization of 28% (under B2 +CLE scenario) – greatest health effects; A2 premature morbidity and mortality projections: 22%. With 35ppbv, 52% increase in mortality and morbidity (under B2+CLE)	Increases in temperatures by 5°C, projected O3 mortality will increase from 4% (no O3 threshold) to 30% (35ppbv O3 threshold)	Population projections increase, +5°C scenario	Heal et al. 2013

Region	Health outcome metric	Baselines	Climate model(s) and air pollution models	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
Poland	PM2.5 mortality	2000	ECHAM5-RefCM3, CAMx	A1B	1990s; 2040s; 2090s	39,800 premature deaths related to PM2.5 air pollution	0.4 to 1°C in 2040; 6% decrease in PM2.5 related mortality in 2040s	2 -3°C in 2090s; 7% decrease in PM25 related mortality in 2090s		Tainio et al. 2013
US	O3 morbidity and mortality	2000	CESM, GISS, WRF, CMAQ	RCP 8.5; RCP 6.0	1995-2005; 2025-2035		In 2030, 37 and 420 additional excess deaths annually due to 03.			Fann et al. 2015
US	PM2.5 and O3-related annual mortality	2000s	CESM, WRF, CMAQ	RCP 8.5	2002-2004; 2057-2059			2050s, 7,500 additional PM2.5 related mortalities; 2,100 O3-related deaths (with population constant). With 2050 population, 46,00 less PM2.5-related deaths and 1,300 additional O3-related deaths.	Population projection 2050	Sun et al. 2015

Region	Health outcome metric	Baselines	Climate model(s) and air pollution models	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
US	PM2.5 related annual and O3-related summer mortality	2000	IGSM-CAM, CAM-Chem	POL 4.5, POL 3.7	1980-2010, 2035-2055, 2085-2115			In 2050, 11,000 (POL4.5) and 13,000 (POL3.7) PM2.5 and O3-related deaths In 2100; 52,000 (POL4.5) and 57,000 (POL3.7) PM2.5 and O3-related deaths	2000	Garcia-Mendez et al. 2015
US	O3 summer mortality	2000	Global & regional climate and ozone models and Bayesian model	A2	2000, 2050			In 2050, 1,212 additional O3-related mortalities (with present emissions) and 4,473 less premature mortalities under future emissions		Alexeff et al. 2016
94 US areas (urban)	O3 summer mortality	1995-2005	Spatial monotone ozone-	RCP 6.0	1995-2005; 2025-2035		In 2025-2035, an increase of		2000 and 2030 population	Wilson et al. 2017

Region	Health outcome metric	Baselines	Climate model(s) and air pollution models	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
			temperature surface model				7.7% (35 ppb O3 threshold) to 14.2% (75 ppb O3 threshold) O3-related mortalities compared to baseline			
Atlanta Metropolitan Area	O3-related ED visits	1999-2004	CRCM; HRM3; RCM3; WRFG; CCM3; CGCM3; GFDL; HadCM3	A2	1999-2004; 2041-2070	178,645 asthma/wheeze ED visits (mean 146/day)		In 2041-2070, annual excess ED visits O3-related visits =267-466 (depending on model) – compared to baseline		Chang et al. 2014
Japan	PM2.5 related mortality	2000	NICAM-Chem, high and low -esolution model (HRM and LRM)	RCP 4.5	2000-2003; 2030-2033	31,300 PM2.5 excess mortality	In 2030 from 63.6% increase to 8.7% decrease in PM2.5 related mortality. (High resolution model).		Population projection 2030	Goto et al. 2016

Region	Health outcome metric	Baselines	Climate model(s) and air pollution models	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
Korea	O3 summer mortality	2001-2010	ICAMS	RCP 2.6; RCP 4.5; RCP 6.0; RCP 8.5	1996-2005; 2016-2025; 2046-2055		In the 2020s, summer mortality to increase by: 0.5%,0. 0%,0.4, and0.4% due to temperature change. In the 2020s, due to O3 concentration change, mortality to increase by 0.0%, 0.5%, 0.0%, and 0.5%	In the 2050s, summer mortality to increase by: 1.9%, 1.5%, 1.2%, and 4.4% by temperature change. In the 2050s, due to O3 concentration, mortality to increase by 0.2%, 0.2%, 0.4%, and 0.6%	Current mortality trends expected to increase, temperature effects compared	Lee et al. 2017
Sydney	O3-related mortality	1996-2005	CGCM, CCAM, TAPM-CMT	A2	1996-2005; 2051-2060	Average estimated annual deaths from ozone over the period 1996-2005: 20 (40ppn), 79 (25 ppb), and 257 (0 ppb)		In 2050, increase of O3-related mortality from 2.3% (0 ppb O3 threshold) to 27.3% (40 ppb O3 threshold).		Physick et al. 2014

Region	Health outcome metric	Baselines	Climate model(s) and air pollution models	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
U.S (12 metropolitan areas)	O3 inhalation exposures	2000	APEX, CESM, MIP5, WRF, CMAQ	RCP 4.5; RCP 6.; RCP 8.5	1995-2005; 2025-2035	At least on exceeded/year	Comparing 2030 to 2000, almost universal trend with at least three exceedances (of DM8H exposure above the 60 ppb and 70 bbp threshold)	Health implications Increase as population exposures to O3 increases based on the degree of radiative forcing in 2100	Population projections using IPCC SRES and adapted for U.S.	Dionisio et al. 2017
U.S (561 western counties)	PM2.5 (directly attributable to wildfires) and morbidity	2004-2009	GEOS-Chem and newly developed fire prediction model; CMIP3	A1B	2004-2009; 2046-2051	Wildfires contribute on average 12% total daily PM2.5 in 561 counties; 57million people affected by at least one smoke wave	For 2046-2051 the average wildfire-specific PM2.5 level est. to increase approx. 160% with a max of >400%; est. that more than 82million will be affected by at least one smoke wave.		Projected population using A1B and 2050 projections from ICLUS	Liu et al. 2016

Abbreviations: DALY: Disability adjusted life year; RCP: Representative Concentration Pathway; SSP: Shared Socioeconomic Pathway

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SI_S3-4-9_Supp Info on Key Economic Sectors

Table S11 – S3.4.9 Projected Risks at 1.5°C and 2°C

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
Impact on GDP	Global	Per capita GDP growth	2006-2015 GDP (1960-2012)	HAPPI	RCP2.6 RCP8.5 SSP1 SSP2 SSP4 SSP5	2100		Economic impacts close to indistinguishable from current conditions	Lower economic growth for large set of countries (5% lower by 2100 relative to 1.5°C)	High uncertainties of GDP projections	Petris et al. 2017
Energy (Electricity demand)	US	Electric sector models: GCAM-USA ReEDS IPM		MIT IGSM-CAM	REF CS3 REF CS6 POL4.5 CS3 POL3.7 CS3 TEMP 3.7 CS3	2015-2050			Increase in electricity demand by 1.6 to 6.5 % in 2050		McFarland et al. 2015
Energy (demand)	Global	Economic and end-use energy model Energy service demands for space heating and cooling			RCP2.6 (2°C) RCP8.5 (4°C) RCP8.5 constan	2050-2100		Economic loss of 0.31% in 2050 and 0.89% in 2100 globally	GDP negative impacts in 2100 are highest (median: -0.94%)		Park et al. 2017

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
					t after 2020 (1.5°) SSP1 SSP2 SSP3				under 4.0°C (RCP8.5) scenario compared with a GDP change (median: -0.05%) under 1.5°C scenario		
Energy (Hydropower)	US (Florida)	Conceptual rainfall-runoff (CRR) model: HYMOD MOPEX	1971-2000	CORDEX (6 RCMs) CMIP5, bias corrected	RCP4.5	2091-2100			Based on a min/max temp. increase of 1.35°-2°C, overall stream flow to increase by an average of 21% with pronounced seasonal variations, resulting in increases		Chilkoti et al. 2017

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
									in power generation (72% winter, 15% autumn) and decreasing (-14%) in summer		
Energy (Hydropower)	Global	Gross hydropower potential; global mean cooling water discharge	1971-2000	5 bias-corrected GCMs	RCP2.6 RCP8.5	2080			Global gross hydropower potential expected to increase (+2.4% RCP2.6; +6.3% RCP8.5) Strongest increases in central Africa, Asia, India, and northern high latitudes. 4.5-15% decrease	Socio-economic pathways	Vliet et al. 2016

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
									in global mean cooling water discharge with largest reductions in US and Europe		
Energy (Hydropower)	Brazil	Hydrological Model for natural water inflows (MGB)	1960-1990	HadCM3 Eta-CPTEC-40		2011-2100		A decrease in electricity generation of about 15% and 28% for existing and future generation systems starting in 2040		Other water use and economic development scenarios	Rodrigo de Queiroz et al. 2016
Energy (Hydropower)	Ecuador	CRU TS v.3.24 monthly mean temperature, precipitation and potential evapotranspiration (PET) conceptual hydrological model	1971-2000	CMIP5 bias corrected using PET	RCP8.5 RCP4.5 RCP2.6	2071-2100			Annual hydroelectric power production to vary between − 55 and + 39% of the mean historical output.	ENSO impacts	Carvajal et al. 2017

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
		assessing runoff and hydropower electricity model							Inter-GCM range of projections is extremely large (-82%-+277%)		
Energy (Wind)	Europe	Near surface wind data: Wind energy density means; Intra and inter annual variability	1986-2005	21 CMIP5 Euro-CORDEX	RCP8.5 RCP4.5	2016-2035 2046-2065 2081-2100		No major differences in large scale wind energetic resources, inter-annual or intra-annual variability in near term future (2016-2035)	Decreases in wind energy density in eastern Europe, Increases in Baltic regions (-30% vs. +30%). Increase of intra-annual variability in Northern Europe, decrease in	Changes in wind turbine technology	Carvalho et al. 2017

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
									Southern. Inter-annual variability not expected to change		
Energy (Wind)	Europe	Near Surface Wind Speed Wind Power Simulated energy mix scenario		Euro-CORDEX	RCP4.5 RCP8.5	2050		Changes in the annual energy yield of the future European wind farms fleet as a whole will remain within ±5%			Tobin et al. 2016
Energy (Wind)	Europe	Potential wind power generation		ENSEMBLES 15 RCM 6 GCM	SRES A1B				In Europe, changes in wind power potential will remain within ±15 and ±20 %		Tobin et al. 2015
Energy (Solar)	Europe	Mean PV power generation	1970-1999	Euro-CORDEX	RCP4.5	2070-2099			Solar PV supply by the end of	Solar spectrum distributio	Jerez et al. 2015

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
		potential (PVPot); Surface wind velocity (SWV); radiation (RSDS); Surface air temp (TAS)			RCP8.5				2100 should range from (-14%; +2%) with largest decreases in Northern countries	n and the air mass effect	
Energy (solar)	Global	energy yields of photovoltaic (PV) systems		CMIP5	RCP8.5	2006-2049		Decreases in PV outputs in large parts of the world, but notable exceptions with positive trends in large parts of Europe, South-East of North America and the South-East of China.			Wild et al. 2015
Tourism	Europe	Climate Index for Tourism;		Euro-CORDEX	RCP4.5	+2° C			Varying magnitude		Grillakis et al. 2016

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
		Tourism Climatic Index (3 variants)			RCP8.5				of change across different indices; Improved climate comfort for majority of areas for May to October period; June to August period climate favorability projected to reduce in Iberian peninsula due to high temperatures		
Tourism	Southern Ontario (Canada)	Weather-visitation models (peak, shoulder, off-season)				1° to 5° C warming		Each additional degree of warming experienced		Social variables e.g. weekends	Hewer et al. 2016

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								annual park visitation could increase by 3.1%, annually.		or holidays	
Tourism	Europe	Natural snow conditions (VIC); Monthly overnight stay; Weather Value at Risk	1971-2000	Euro-CORDEX	RCP2.6 RCP4.5 RCP8.5	+2°C periods: 2071-2100 2036-2065 2026-2055			Under a +2°C global warming up to 10 million overnight stays are at risk (+7.3 million nights) Austria and Italy are most affected.	Tourism trends based on economic conditions	Damm et al. 2016
Tourism	Sardinia (Italy) and the Cap Bon peninsula (Tunisia)	Overnight stays; weather/climate data (E-OBS)	1971-2000	EU-FP6 ENSEMBLES (ECH-REM, ECH-RMO, HCH-RCA and ECH-RCA)		2041-2070			Climate-induced tourism revenue gains especially in the shoulder seasons	GDP; Prices, Holidays; Events	Koberl et al. 2016

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
									during spring and autumn; threat of climate-induced revenue losses in the summer months due to increased heat stress.		
Tourism	Iran (Zayandehroud River route)	Physiologically equivalent temperature (PET)	1983-2013	HADCM3	B1 A1B	2014-2039		The PET index shows a positive trend with a reduction in number of climate comfort days (18 < PET < 29), particularly in the western area			Yazdanpanah et al. 2015
Tourism	Portugal	Arrivals of inbound tourists; GDP						Increasing temperatures are projected to lead to a			Pintassilgo et al. 2016

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
								decrease of inbound tourism arrivals between 2.5% and 5.2%, which is expected to reduce Portuguese GDP between 0.19% and 0.40%.			
Transportation (shipping)	Arctic Sea (north sea route)	Climatic loses; Gross gains; Net gains		PAGE-ICE	RCP4.5 RCP8.5 SSP2	2013-2200		Large-scale commercial shipping is unlikely possible until 2030 (bulk) and 2050 (container) under RCP8.5.	The total climate feedback of NSR could contribute 0.05% to global mean temperature rise by 2100 under RCP8.5 adding $2.15 Trillion to the Net Present	Business restrictions	Yumashev et al. 2016

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
									Value of total impacts of climate change over the period until 2200. The climatic losses offset 33% of the total economic gains from NSR under RCP8.5 with the biggest losses set to occur in Africa and India.		
Transportation (shipping)	Arctic Sea	Sea-ice ship speed (in days) Sea Ice Thickness (SIT)	1995-2014	CMIP5	RCP2.6 RCP4.5 RCP8.5	2045-2059 2075-2089			Shipping season 4-8 under RCP8.5, double that of RCP2.6		Melia et al. 2016

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
									Average transit times decline to 22 days (RCP2.6) and 17 (RCP8.5)		
Transportation (shipping)	Arctic Sea (Northern Sea Route)	Mean time of NSR transit window; Sea ice concentration	1980-2014	CMIP5	RCP4.5 RCP8.5	2020-2100			Increase in transit window by 4 (RCP4.5) and 6.5 (RCP8.5) months		Khon et al. 2017
Transportation (air)	Global (19 major airports)	Takeoff weight (TOW) restrictions	1985-2005	CMIP5	RCP4.5 RCP8.5	2060-2080			On average, 10–30% of annual flights departing at the time of daily maximum temperature may require some weight restriction below	Improved aircraft or airport design	Coffel et al. 2017

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
									their maximum takeoff weights which may impose increased cost on airlines		
Water	Europe	Runoff Discharge Snowpack based on hydrological models: E-HYPE Lisflood WBM LPJmL		CMIP5 CORDEX (11) Bias corrected to E-OBS	RCP2.6 RCP4.5 RCP8.5	1.5° C 2° C 3° C		Increases in runoff affect the Scandinavian mountains; Decreases in runoff in Portugal	Increases in runoff in Norway, Sweden, & N. Poland; Decreases in runoff around Iberian, Balkan, and parts of French coasts.		Donnelly et al. 2017
Water	Global (8 river regions)	River runoff Glob-HM Cat-HM		HadGEM2-ES IPSL-CM5A-LR; MIROCESM-CHEM;	RCP8.5	1° C 2° C 3° C 1971-2099		Projected runoff changes for the Rhine (decrease), Tagus	Increased risk of decreases in low flows (Rhine)		Gosling et al. 2017

Sector (sub sector)	Region	Metric	Baselines	Climate model(s)	Scenario	Time periods of interest	Impacts at baseline	Projected impacts at 1.5°C	Projected impacts at 2°C	Other factors considered	Reference
				GFDL-ESM2; NorESM1-M;				(decrease) and Lena (increase) with global warming	(−11% at 2 °C to −23% at 3 °C) Risk of increases in high flows increases for Lena +17% (2 °C) to +26% (3 °C)		

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