The Observing Air-Sea Interactions Strategy (OASIS)

– A UN Ocean Decade Program, co-led by ***NOAA,***

Linking Air-Sea Interaction In Situ Observations, Satellites and Earth System Models

for A Predicted, Safe, Healthy, Clean, and Productive Ocean

airseaobs.org/get-involved

OASIS Co-Chairs: **Meghan Cronin (NOAA OAR PMEL, USA)**, Christa Marandino (GEOMAR, Germany) & Sebastiaan Swart (University of Gothenburg, Sweden)
SCOR Working Group #162 & OASIS community

NESDIS STAR CoastWatch Annual Meeting | Virtual Presentation | 23 May 2024

Talk Outline:

How does the ocean influence atmosphere?
How does the atmosphere force the ocean?

We need more than just SST & winds

NOAA/OAR/PMEL's Ocean Climate Station's
Air-sea interaction observations

OceanObs19 & UN Ocean Decade – an opportunity for the community to strategize and implement transformative changes to ocean observing

Observing Air-Sea Interaction Strategy (OASIS) Activities

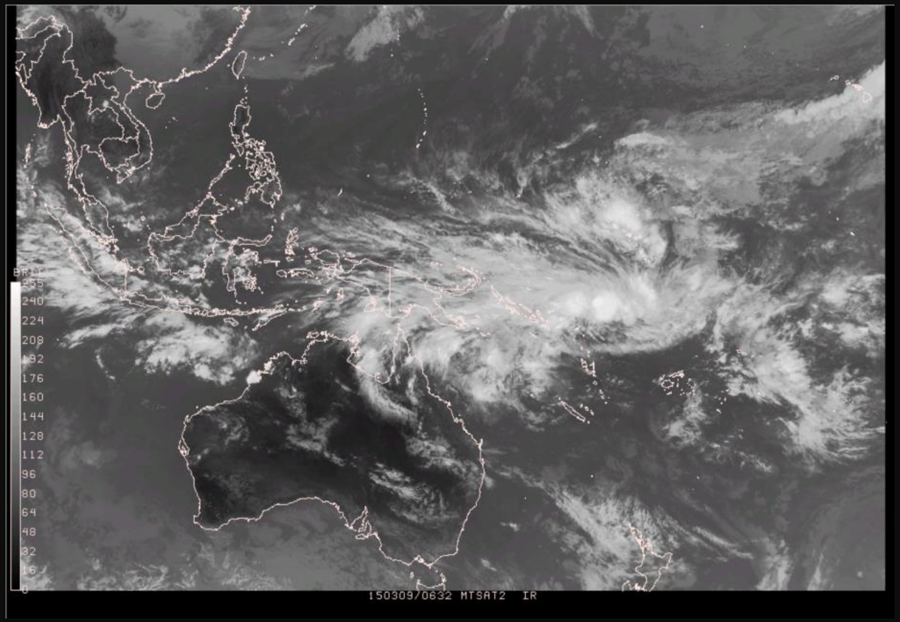
Source: A Luna Blue – Raymond. Vecteezy.

Source: A Luna Blue – Raymond. Vecteez

The Ocean is a source of heat & water….

…fueling atmospheric convection

“A Wild Week in the Tropical Pacific” posted meteorologist Michael Folmer. **Active convection associated with multiple tropical cyclones, MJO, and a weak El Niño.**
https://satelliteliaisonblog.com/2015/03/



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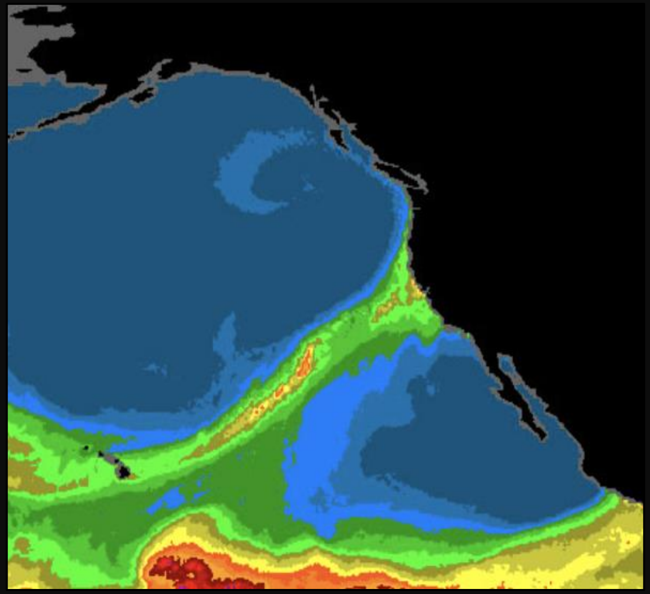
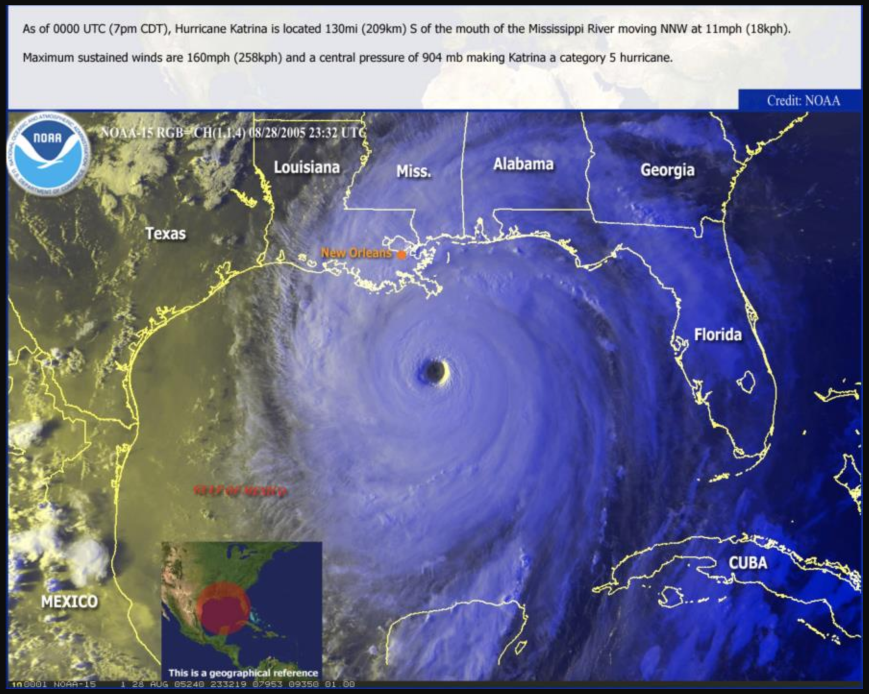


Image: NOAA



The Ocean is a source of heat & water….

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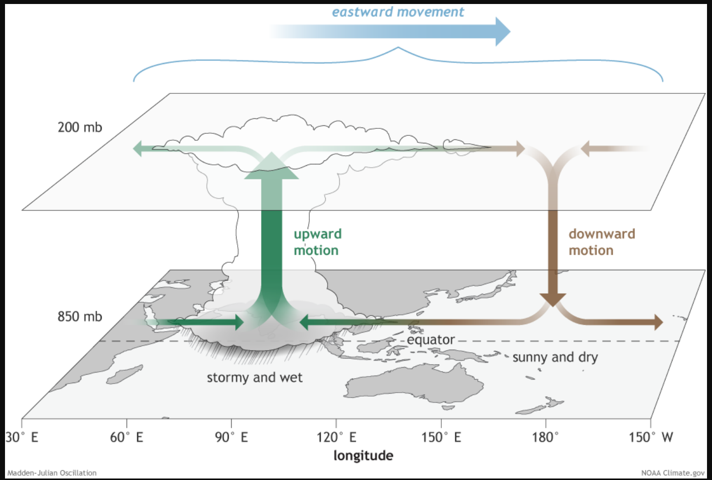
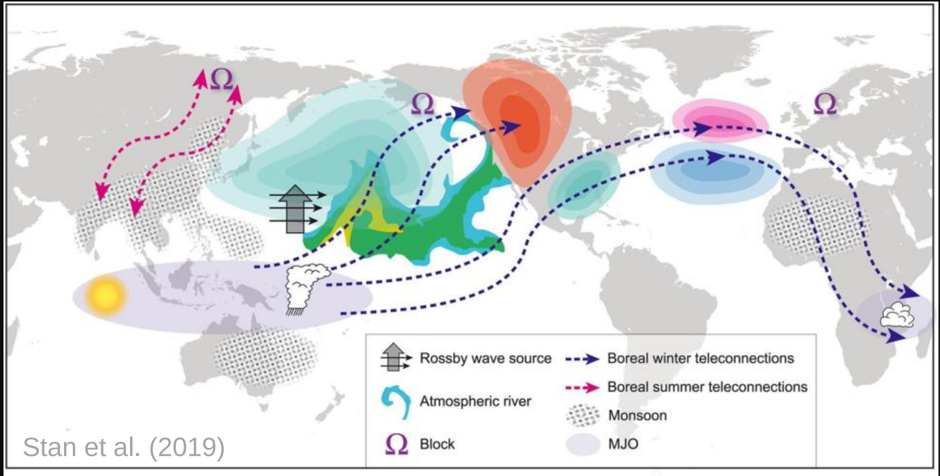




Stan et al. (2019)

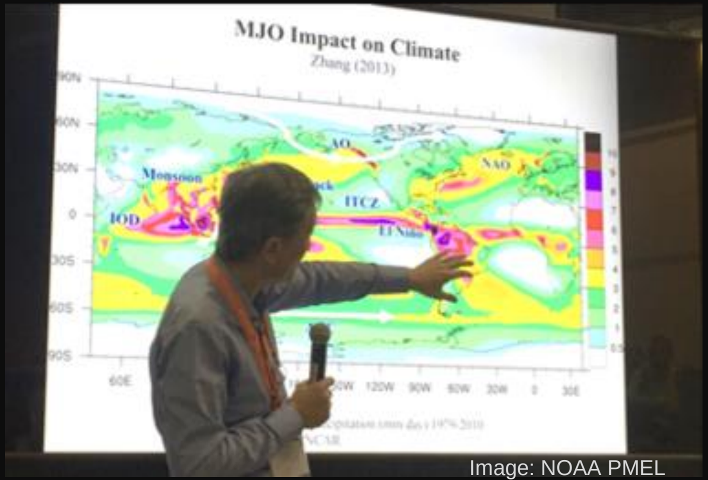
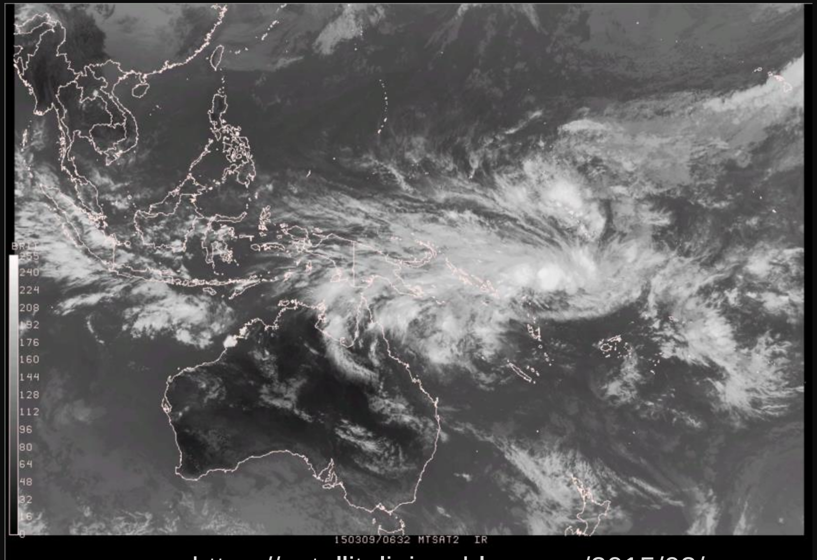


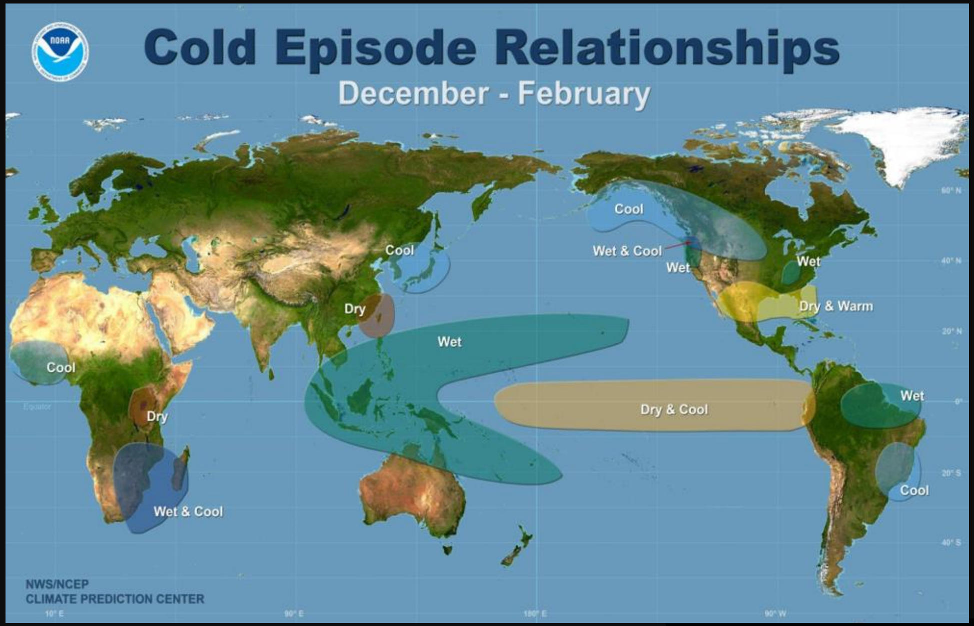
Image: NOAA PMEL

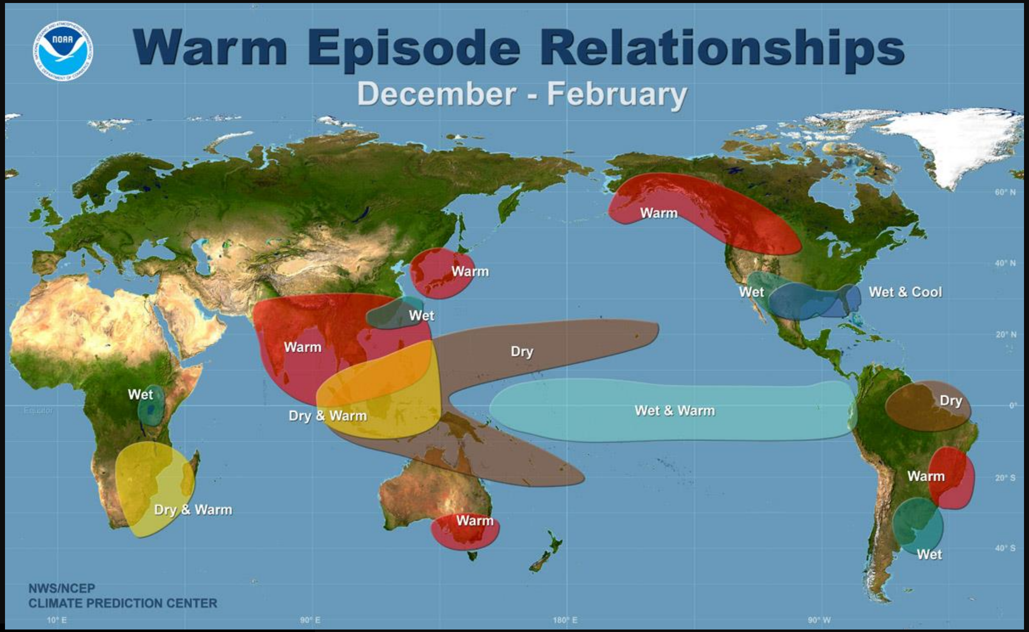


https://satelliteliaisonblog.com/2015/03/

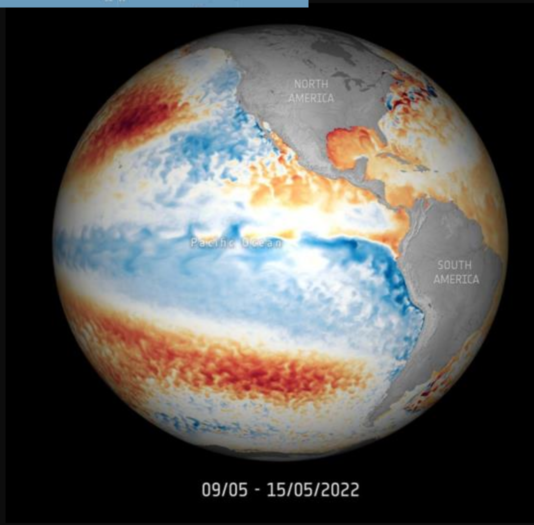
These Air-Sea Interactions can lead to teleconnections….

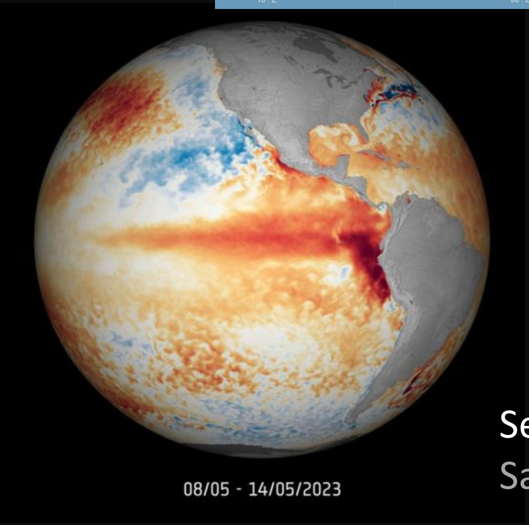
…affecting weather and climate across the world





La Niña "Cold Episode"

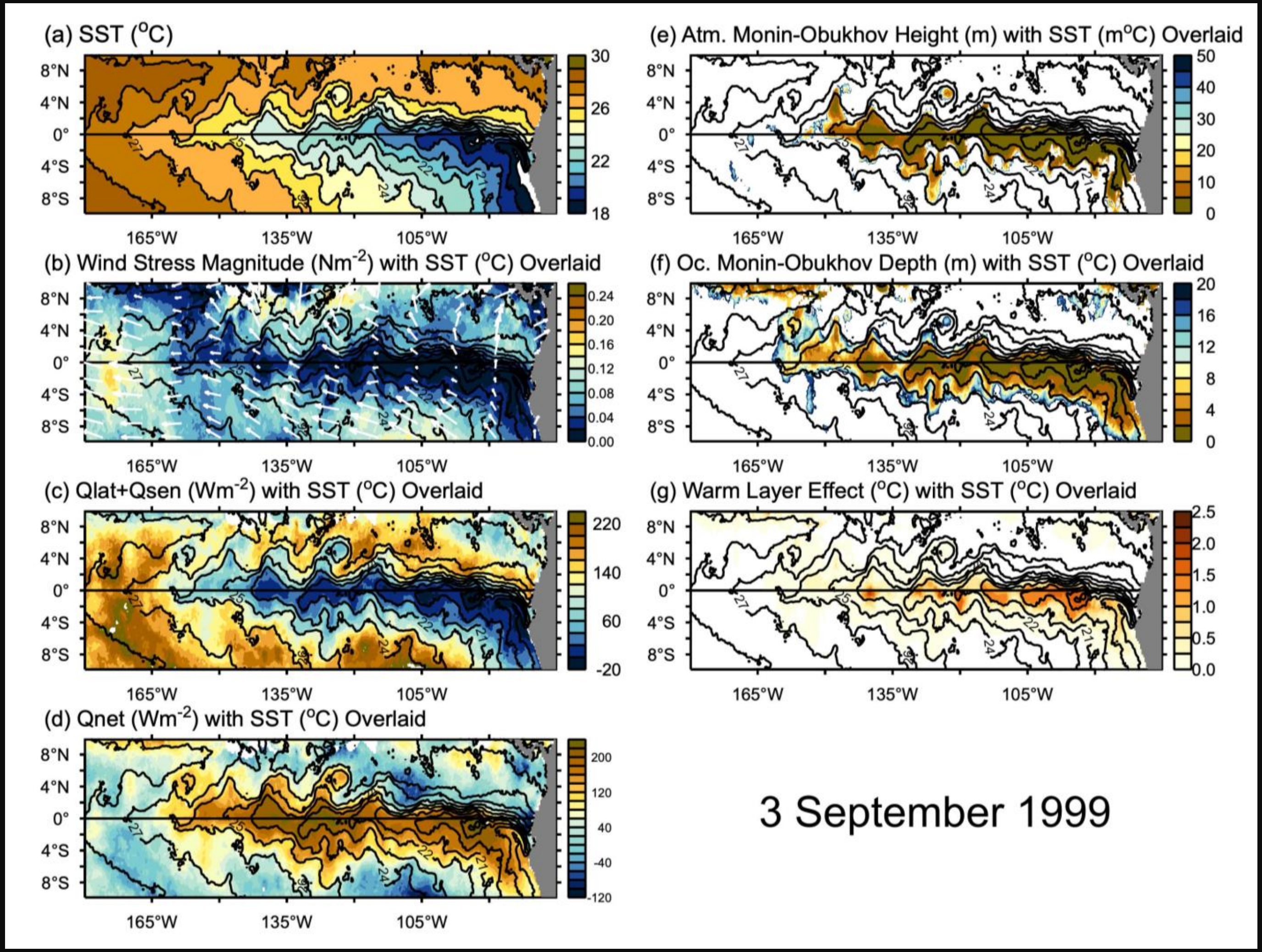




El Niño "Warm Episode"

Sea Surface Temperature Anomalies
Satellite images: ESA

SST fronts and mesoscale gustiness matter



Air-sea fluxes stabilize both Oc. & Atm. Boundary layers on cold side of SST front…

… leading to a diurnal cycle of SST…

…which can be computed from daily-averaged fluxes if gustiness is parameterized

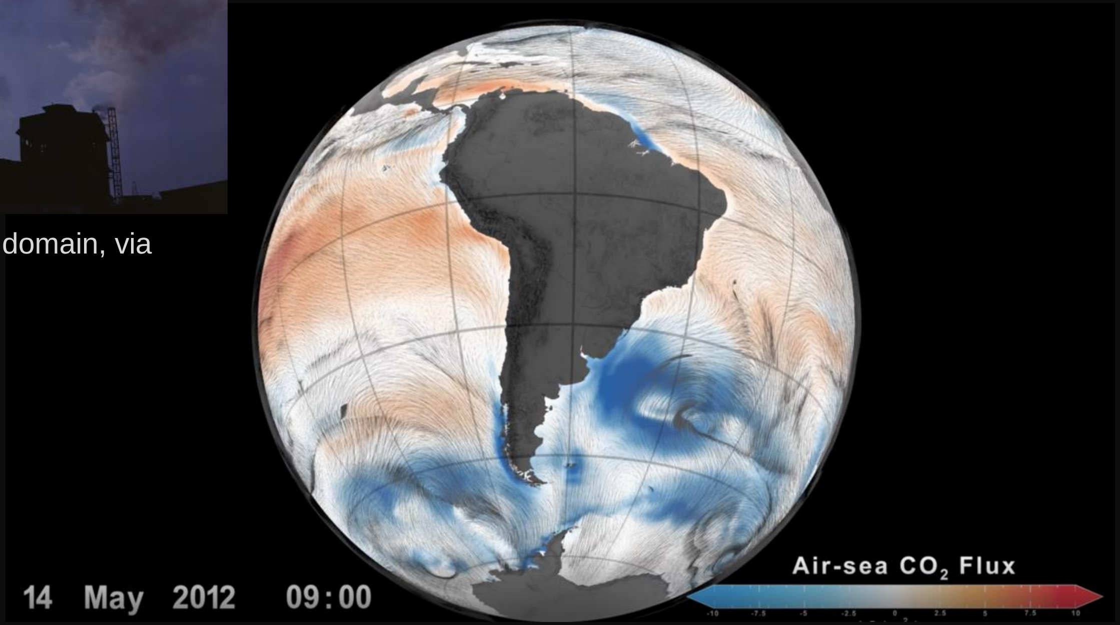
SST Front causes a front in air-sea fluxes

Cronin et al. (2024) "Diurnal warming rectification in tropical Pacific linked to sea surface temperature front"

The Ocean helps draw down carbon dioxide….

…but at a cost

Alfred T. Palmer, Public domain, via Wikimedia Commons



Ocean uptake of carbon dioxide (blue) and outgassing (red) for 14 May 2012, based upon ECCO-Darwin Global Ocean Biogeochemistry Model. Credit: NASA Goddard's Scientific Visualization Studio.

Laboratory experiment,showing **pterapod shell dissolving over the course of 45 days in seawater adjusted to an ocean chemistry projected for the year 2100.** Image: NOAA PMEL.

[Credit: Hong Nguyen | Unsplash]

"Climate change is already affecting every region on Earth, in multiple ways.

The changes we experience will increase with further warming.

INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Extreme heat

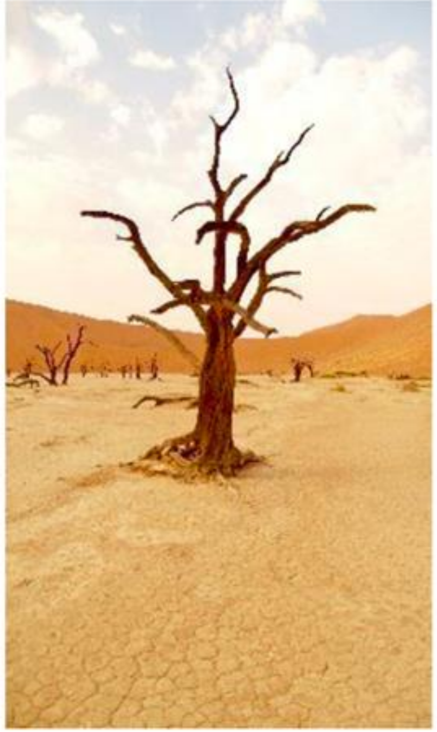
More frequent

More intense

Heavy rainfall

More frequent

More intense



Drought

Increase in some regions

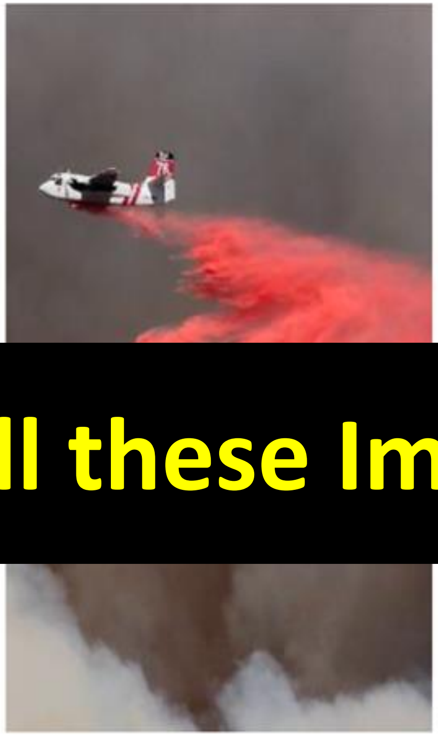
Fire weather

More frequent

Ocean

Warming
Acidifying
Losing oxygen




The Ocean Plays a Role in all these Impacts

Extreme heat
More frequent
More intense

Heavy rainfall
More frequent
More intense

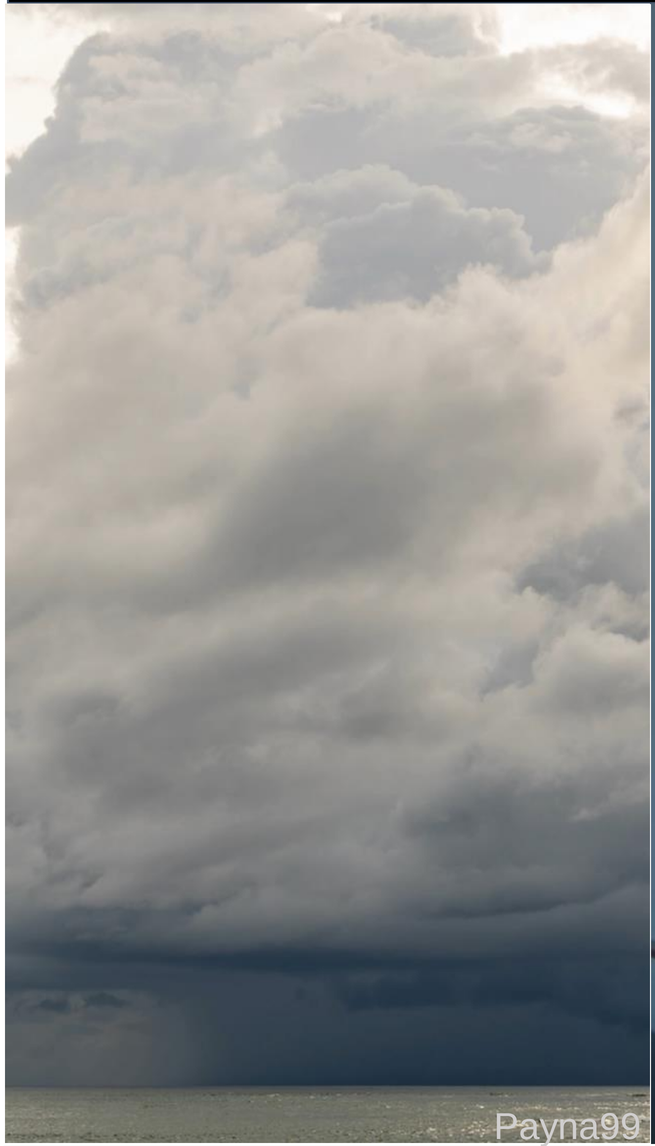
Drought
Increase in some regions

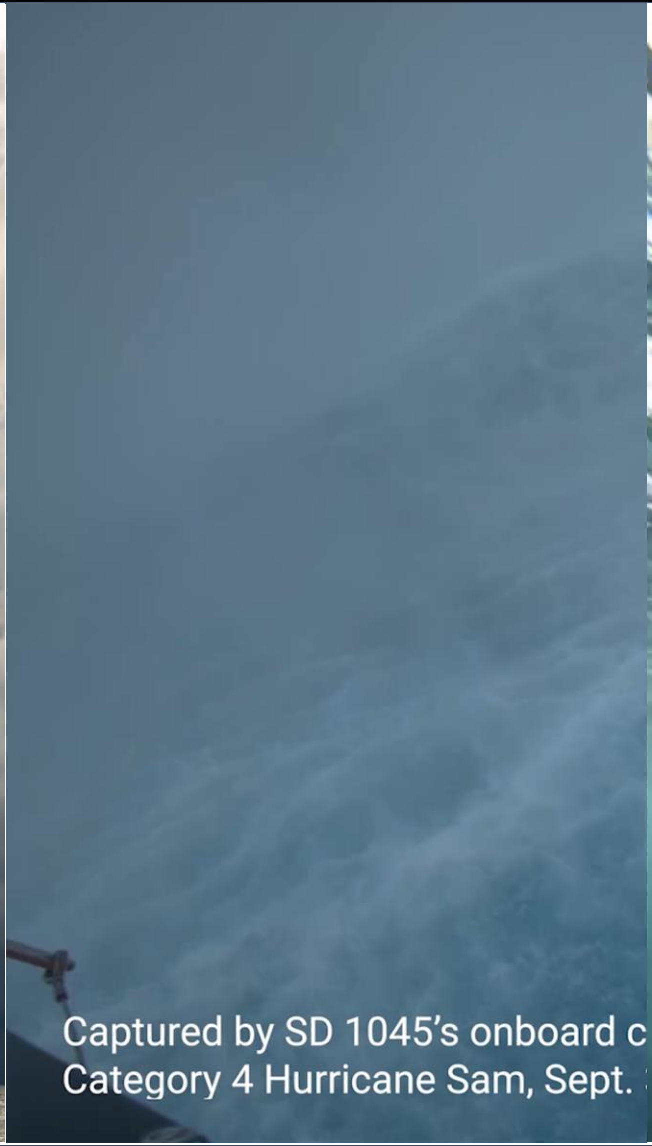
Fire weather
More frequent

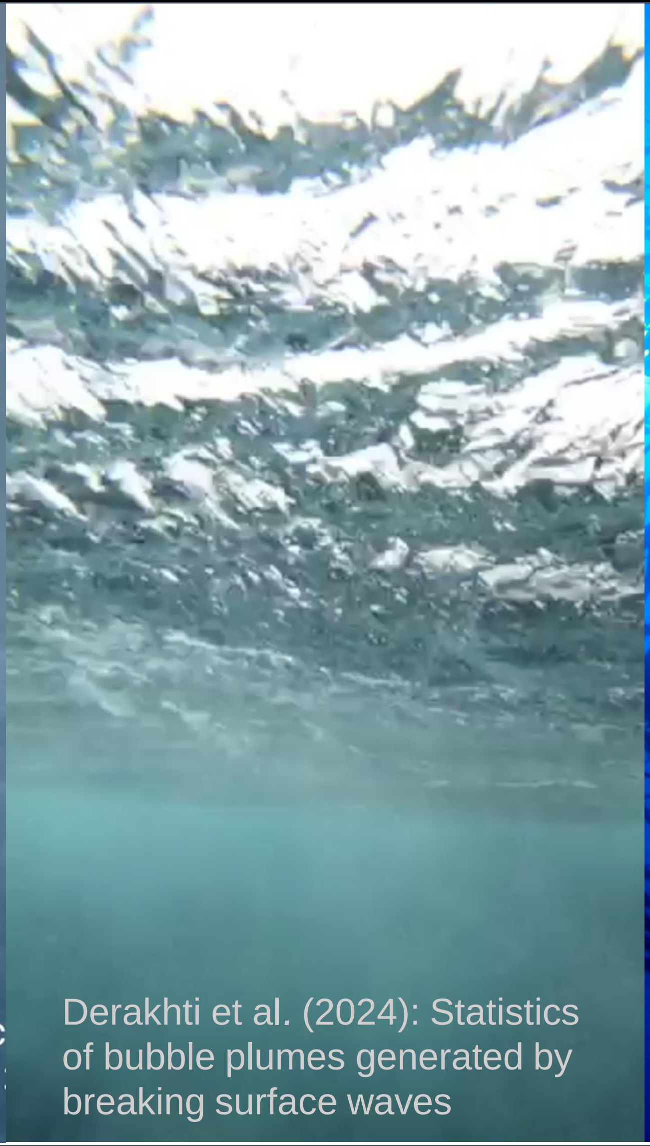
Ocean
Warming
Acidifying
Losing oxygen

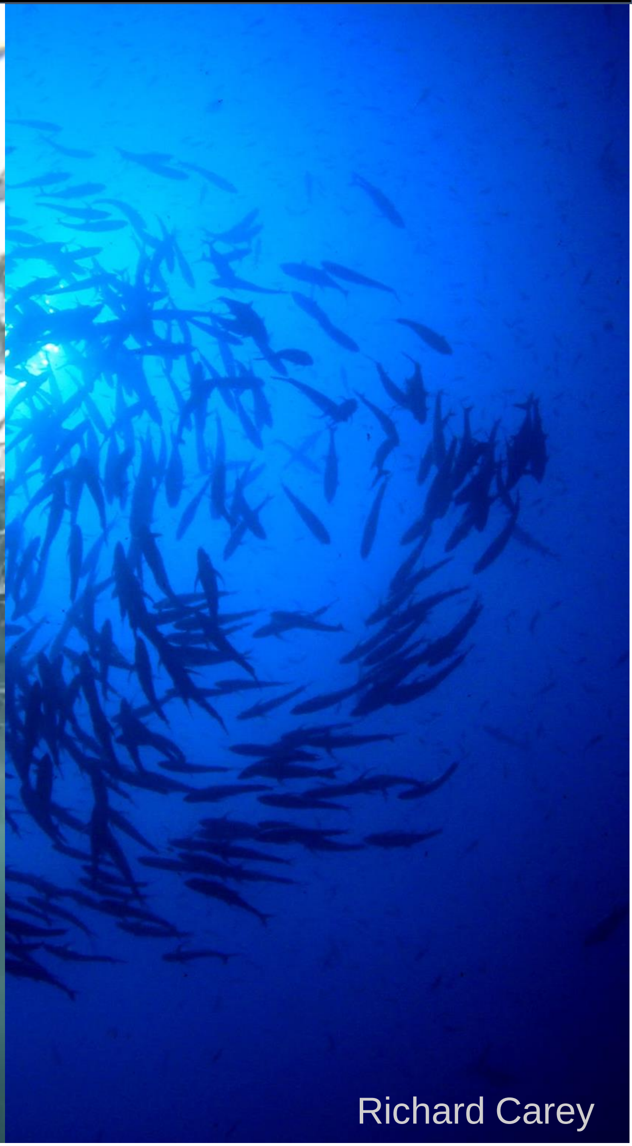
Photo Credits from left: 1. Luiz Guimaraes 2. Jonathan Ford 3. Peter Burdon 4. Ben Kuo 5. NOAA

Air-Sea Fluxes of HEAT, MOISTURE, MOMENTUM, and GAS are all connected & affect…









… the WATER Cycle, ENERGY Cycle, CARBON Cycle, and LIFE Cycle

1. The Ocean & Atmosphere communicate through Air-Sea Fluxes of Heat, Water, Momentum, Gas and Particles

2. These surface fluxes are interconnected, particularly during extreme events. **The Energy, Water, Carbon and Life cycles are all interconnected during extreme events**

3. Must consider the Air-Sea Transition Zone as an entity

4. Fronts and gustiness matter to the air-sea fluxes. Implications for modeling & observational strategies

The only part of the GOOS that measure air-sea fluxes are OceanSITES & DBCP mooring networks & Ship-based Meteorological SOT (Ship Obs. Team) network

Ocean Observing System
Report Card 2023
GOOS Observations Coordination Group (OCG)

NOAA OAR GOMO supports ~40% of GOOS

In a flat funding environment, it is very hard to maintain, let alone grow the observing system

IN SITU OBSERVING SYSTEM STATUS

The Global Ocean Observing System (GOOS) observes our ocean through the "eyes" of thousands of ocean observing platforms that are constantly monitoring the ocean to capture the signature of various ocean phenomena. These platforms collect physical, biogeochemical and biological Essential Ocean and Climate Variables. These observations flow into data systems and are crucial for tracking, predicting and adapting to climate change, accurate weather and extreme event prediction, monitoring biodiversity for achieving key global targets, and informing sound decisions by local communities and national governments around sustainable development.

To highlight the status and development of this Global Ocean Observing System, the **2023 Ocean Observing System Report Card** provides insight into the current status of the global observing networks and shows how these networks provide vital data for society. This edition showcases achievements and challenges in tracking marine heatwaves, advancing safety of life at sea, and ensuring seagrass ecosystems continue to support coastal life.

The diversity of coastal and biological observing activities is one of the current big challenges, both to integrate new data flows and to expand capacity globally to meet real and urgent needs. This is one of the key areas that needs additional coordination capacity, new and low-technologies, however it also offers opportunities to develop a truly integrated global observing system.

See *in situ* networks table for map legend. Latest locations of operational platforms and ships as of July 2023; reference lines sampled since January 2022. Symbols size is not to scale, in the map they are exaggerated to an order of hundreds kilometers for readability. Data source: OceanOPS.

Over the past year, the observing system remained stable in terms of platforms and instruments at sea, however, there have been significant advances in technology, autonomous instruments, multidisciplinary approaches, and in international collaboration. Growing investment in biogeochemical sensors and deep autonomous Argo profiling floats are one of the factors driving GOOS evolution. In addition, emerging components of the system like smart cables and Unmanned Surface Vehicles continued to develop, in part due to strong collaboration with private sector partners.

The evolution of the observing system to observe biological and ecological phenomena has been underway for years, and it is now accelerating as GOOS continues to catalyze discussions to monitor change in the ocean ecosystem around 12 Essential Ocean Biological Variables, such as seagrass habitats, and to promote open access to data.

The existing *in situ* and satellite observing system is challenged to effectively track marine heatwaves, and the GOOS community is working to design and develop an ocean observation strategy to improve marine heatwave forecasts and provide actionable data and information to stakeholders. High-quality metocean (above ocean atmospheric) data from ships and autonomous instruments are vital for forecasting extreme events such as tropical cyclones, issuing timely warnings, and ensuring safety at sea. However, further observations are needed globally to improve weather and climate forecasts.

The GOOS international partnership, along with national investments from North Hemisphere countries, need to prioritize expanding basic observing coverage in Indian and Southern Ocean regions. Regular basin-based coordination meetings are improving the system's implementation bridging gaps and collaborating with national academic fleets, regional bodies, and third-parties like shipping industry and ocean racing.

In the face of climate change, the global community must work together to improve the coverage, quality, and multidisciplinary nature of the observing system to meet vital forecasting services and societal needs. OceanOPS can help make these connections.

Mathieu Belbéoch, OceanOPS Manager

Highlights

GOOS is pleased to report that the global ocean observing networks monitored by OceanOPS, have now all mostly recovered from the impact of COVID-19 on their operations.

GOOS *in situ* networks[1]	Implementation: Status[2]	Data & metadata: Real time[3]	Data & metadata: Archived delayed mode[4]	Data & metadata: Metadata[5]	Best practices[6]	GOOS delivery areas[7]: Operational services	GOOS delivery areas[7]: Climate	GOOS delivery areas[7]: Ocean health
Ship based meteorological - SOT	★★☆	★★☆	★★☆	★★½	★★☆	✓	✓	
Ship based oceanographic - SOT	★★½	★★½	★★★	★★☆	★★★	✓	✓	
Repeated transects - GO-SHIP	★★★	Not applicable	★★★	★½☆	★★★		✓	✓
Sea level gauges - GLOSS	★★½	★★☆	★★★	½☆☆	★★☆	✓	✓	
Time series sites - OceanSITES	★★☆	Not applicable	★★½	★☆☆	★★☆		✓	✓
Coastal moored buoys - DBCP	★★★	★★★	★★★	★☆☆	★★½	✓	✓	✓
Tsunami buoys - DBCP	★★½	★★★	★★★	★★☆	★★★	✓		
Tropical moored buoys - DBCP	★★½	★★★	★★★	★★★	★★☆	✓	✓	✓
HF radars	★½☆	★½☆	½☆☆	½☆☆	★★★	✓	✓	

GOOS *in situ* networks[1]	Implementation: Status[2]	Data & metadata: Real time[3]	Data & metadata: Archived delayed mode[4]	Data & metadata: Metadata[5]	Best practices[6]	GOOS delivery areas[7]: Operational services	GOOS delivery areas[7]: Climate	GOOS delivery areas[7]: Ocean health
Drifting buoys - DBCP	★★★	★★½	★★½	★★½	★★★	✓	✓	
Profiling floats - Argo	★★★	★★★	★★★	★★★	★★½	✓	✓	
Deep & biogeochemistry floats - Argo	★½☆	★★½	★★½	★★★	★★☆	✓	✓	✓
OceanGliders	★½☆	★★☆	★☆☆	★★☆	★★☆	✓	✓	✓
Animal borne sensors - AniBOS	½☆☆	★☆☆	★★☆	½☆☆	★★☆	✓	✓	✓

(1) More information at goosocean.org (2) Status: status of the implementation compared to the community widely adopted targets when it exists; network self-assessed status when target doesn't exist. (3) Real time: data freely available, without any restriction, on Global Telecommunication System of WMO and internet. (4) Archived delayed mode: data of the highest quality available for scientific analysis (*e.g.* climate studies). (5) Metadata completeness by OceanOPS: ocean-ops.org/metadata (6) Best practices: community reviewed and easily accessible documentation encompassing the observations lifecycle (7) See Network Specification Sheets:goosocean.org > Observations > Network Specification Sheets. More information on networks status & indicators definition at: ocean-ops.org/reportcard

Powered by OceanOPS

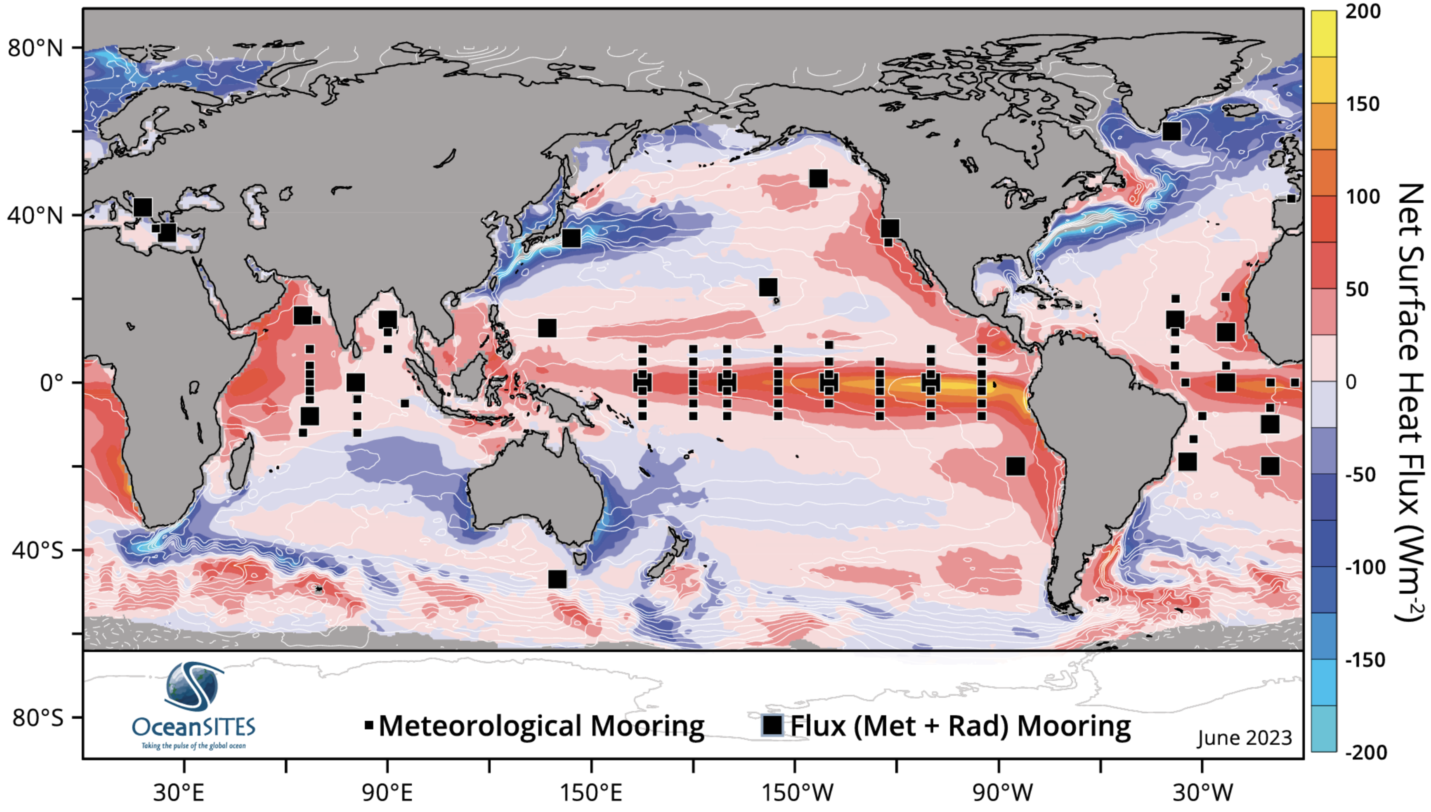
unesco Intergovernmental Oceanographic Commission

WORLD METEOROLOGICAL ORGANIZATION

UN environment United Nations Environment Programme

International Science Council

- Most OceanSITES surface moorings are supported by NOAA. Many have joint support from other countries.
- All tropical moored buoys & some extratropical buoys telemeter data to modeling centers in near-realtime.
- Some near-realtime METOC data are used to constrain models. This was original purpose of tropical moorings.
- Data are also used for assessing satellite & model products
- Most of the “Flux” moorings also monitor air-sea CO_2 flux, and surface ocean acidification.
- High resolution, long time series of multiple variables used for analyzing processes governing climate system



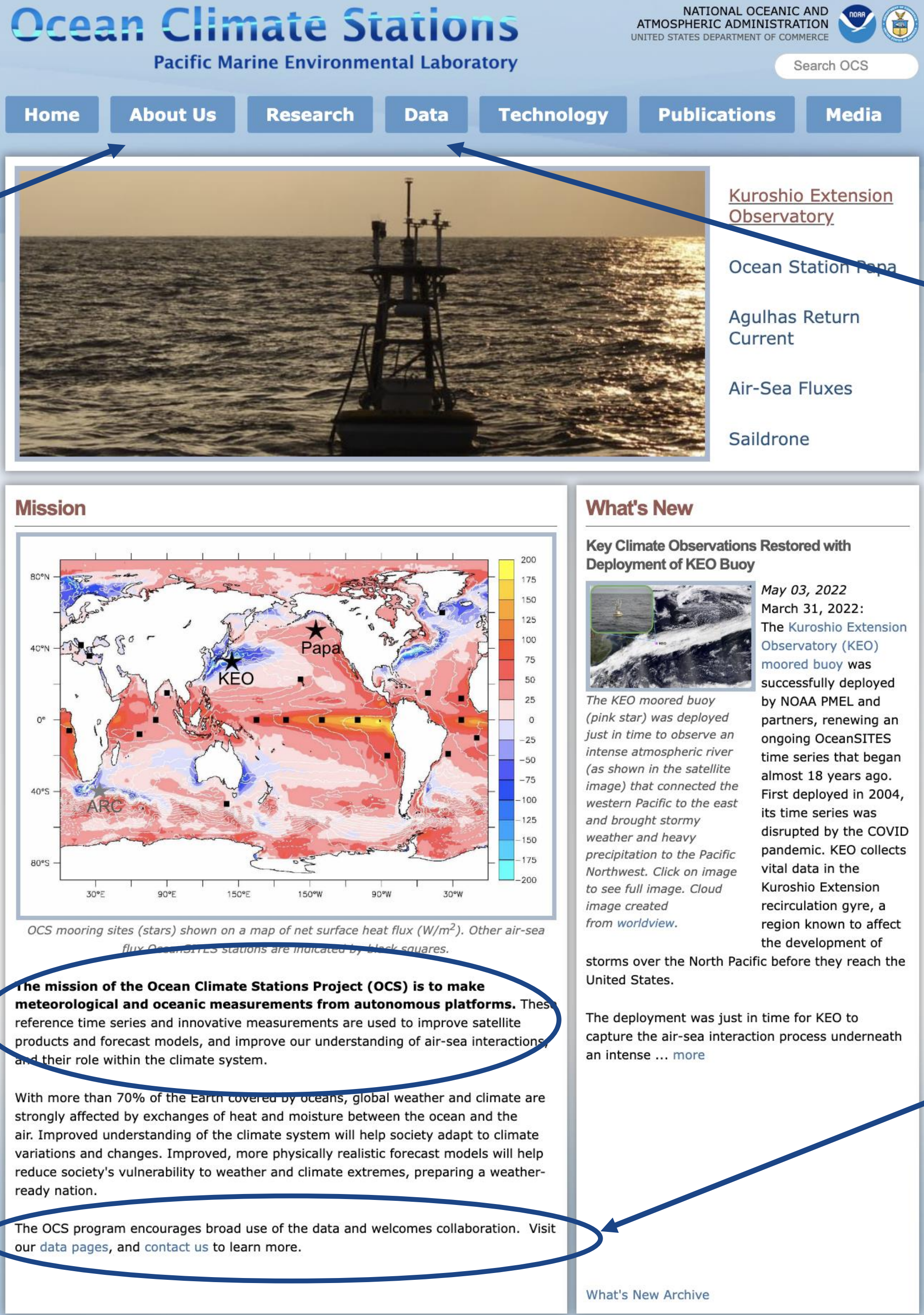
NOAA/NWS/NDBC is recapitalizing Tropical Pacific Observing System (TPOS). Will have fewer, but more capable moorings.

Cronin et al. (2023)

https://www.pmel.noaa.gov/ocs/

NOAA PMEL Ocean Climate Station group in 2023

The mission of the Ocean Climate Stations Project (OCS) is to make meteorological and oceanic measurements from autonomous platforms.



Ocean Climate Stations

Pacific Marine Environmental Laboratory

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

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Kuroshio Extension Observatory

Ocean Station Papa

Agulhas Return Current

Air-Sea Fluxes

Saildrone

Mission

OCS mooring sites (stars) shown on a map of net surface heat flux (W/m^2). Other air-sea flux OceanSITES stations are indicated by black squares.

The mission of the Ocean Climate Stations Project (OCS) is to make meteorological and oceanic measurements from autonomous platforms. These reference time series and innovative measurements are used to improve satellite products and forecast models, and improve our understanding of air-sea interactions and their role within the climate system.

With more than 70% of the Earth covered by oceans, global weather and climate are strongly affected by exchanges of heat and moisture between the ocean and the air. Improved understanding of the climate system will help society adapt to climate variations and changes. Improved, more physically realistic forecast models will help reduce society's vulnerability to weather and climate extremes, preparing a weather-ready nation.

The OCS program encourages broad use of the data and welcomes collaboration. Visit our data pages, and contact us to learn more.

What's New

Key Climate Observations Restored with Deployment of KEO Buoy

The KEO moored buoy (pink star) was deployed just in time to observe an intense atmospheric river (as shown in the satellite image) that connected the western Pacific to the east and brought stormy weather and heavy precipitation to the Pacific Northwest. Click on image to see full image. Cloud image created from worldview.

May 03, 2022
March 31, 2022:
The Kuroshio Extension Observatory (KEO) moored buoy was successfully deployed by NOAA PMEL and partners, renewing an ongoing OceanSITES time series that began almost 18 years ago. First deployed in 2004, its time series was disrupted by the COVID pandemic. KEO collects vital data in the Kuroshio Extension recirculation gyre, a region known to affect the development of storms over the North Pacific before they reach the United States.

The deployment was just in time for KEO to capture the air-sea interaction process underneath an intense ... more

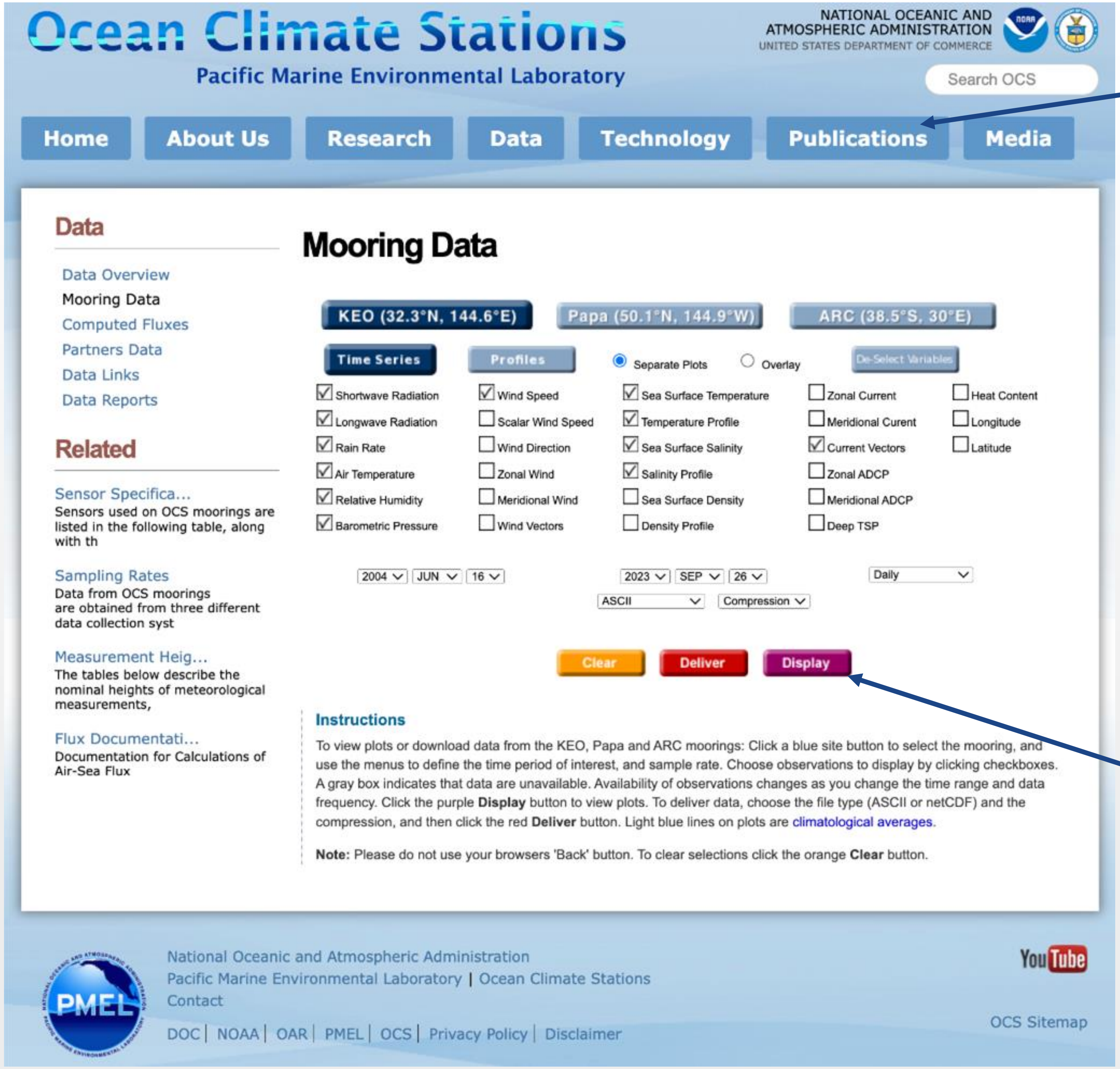
What's New Archive

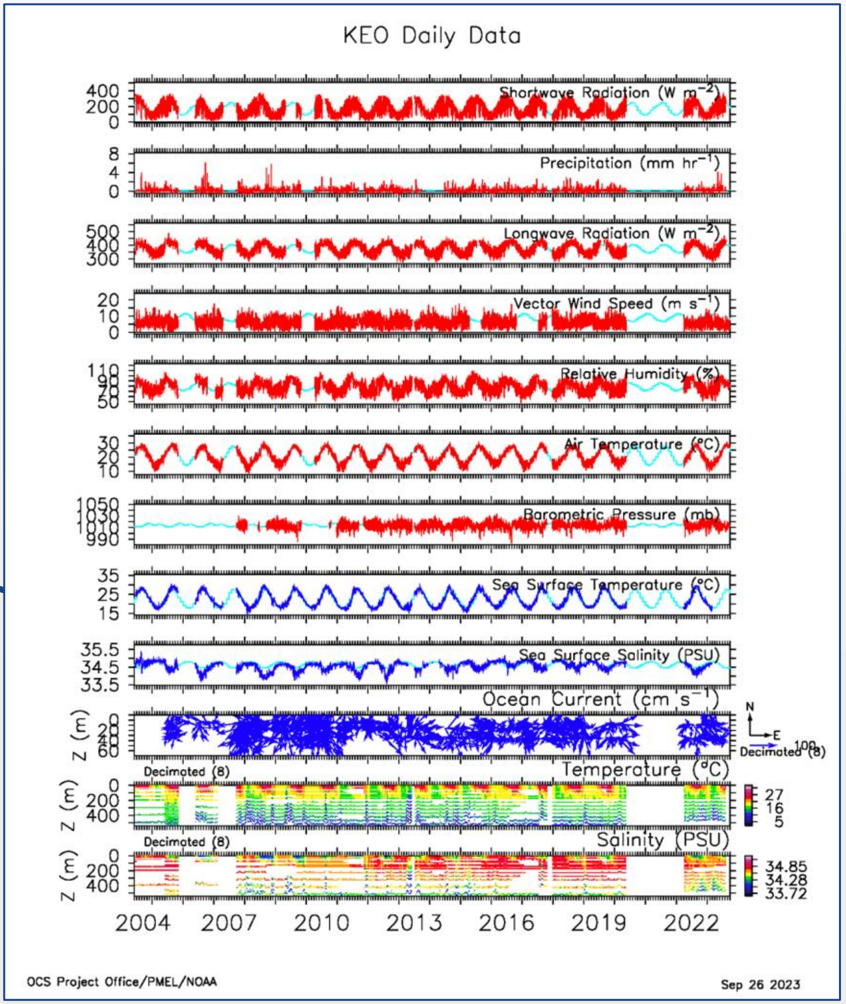
Data!

"The OCS project encourages broad use of the data and welcomes collaboration"

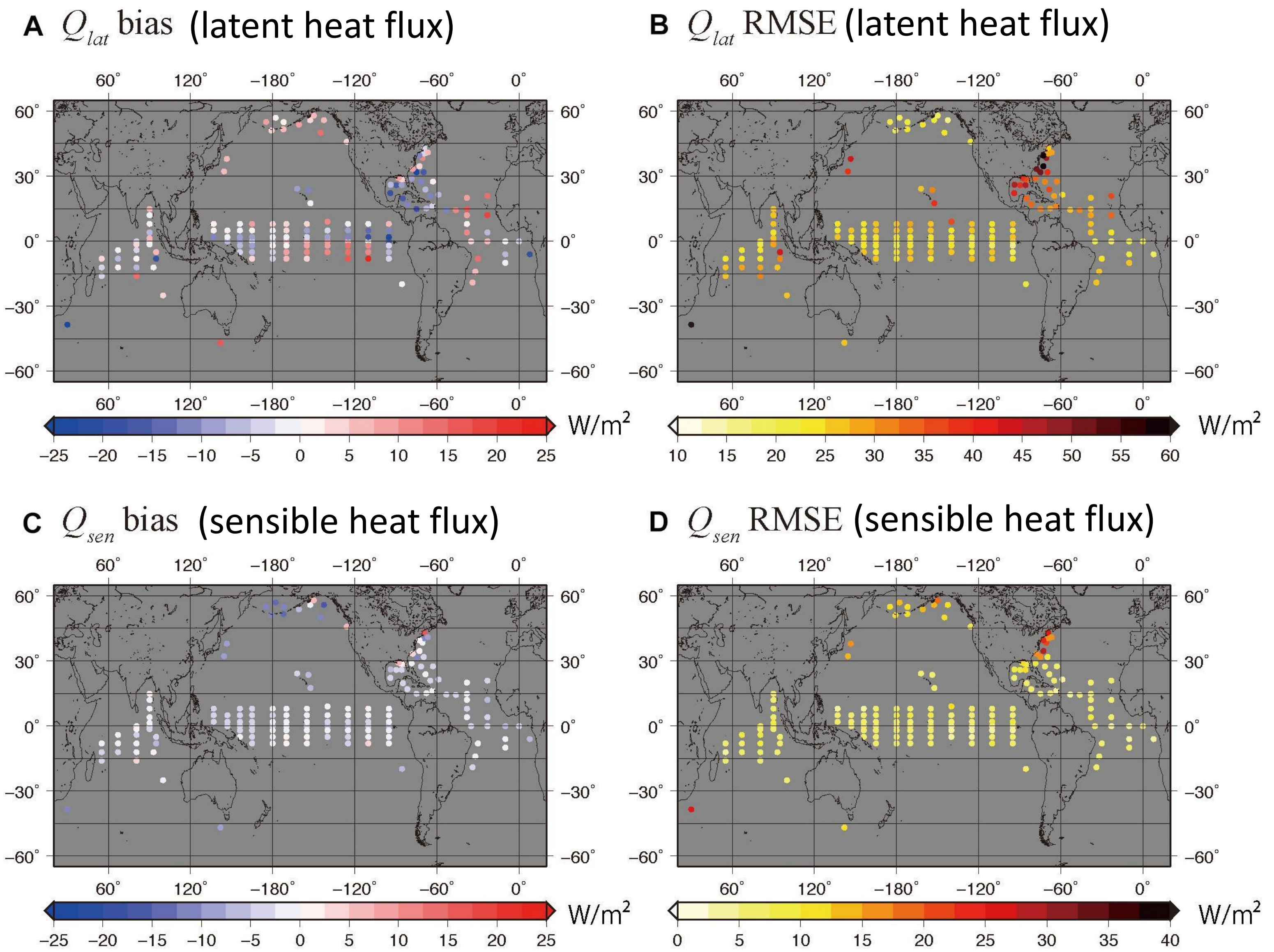
- Meghan Cronin, lead PI

Over 79 peer-reviewed papers since 2020.
More than 20 of these use the OCS data to assess biases in Satellite and Model products





Comparison of J-OFURO3 air-sea heat fluxes versus daily-averaged **buoys** for the period 2002–2013, in units W m^{-2}



From Cronin et al. (2019), based upon Tomita et al. (2017, Figure 5)

OceanSITES data are used to assess uncertainties in remotely sensed flux Essential Ocean Variables and corresponding error in net surface heat flux (Q_{net}) and wind stress products

Observable	Sensor	Horizontal Temporal Resolution	Sensor accuracy of swath (and contribution to Q_{net} uncertainty)	Uncertainty of gridded product at available daily or monthly resolution (and contribution to Q_{net} uncertainty)	References
Ocean surface wind speed and direction	Scatterometer and Passive Microwave Radiometer	25 km/12 h	0.6–1.6 m s^{-1} (13–26 W m^{-2})	0.6–1.6 m s^{-1} (9.6–26 W m^{-2})	Yu and Jin, 2012; Zhang et al., 2018
Skin SST	Infrared Radiometer; Passive Microwave Radiometer (which measures an approximation to the sub-skin temperature)	1 km/12 h	0.2–0.6 K (9–26 W m^{-2})	0.2–0.6 K (9–26 W m^{-2})	Corlett et al., 2014; Gentemann and Hilburn, 2015; Kilpatrick et al., 2015; Tu et al., 2015; Bulgin et al., 2016
Near surface air temp	Technology advancements needed	25 km/12 h	1.3–1.55 K (18–22 W m^{-2})	0.5–1.55 K (6–22 W m^{-2})	Jackson and Wick, 2010; Roberts et al., 2010; Yu and Jin, 2018
Near surface specific air humidity	Passive Microwave Radiometer	25 km/12 h	1–1.3 g/kg (20–26 W m^{-2})	0.8–1 g/kg (16–20 W m^{-2})	Roberts et al., 2010; Tomita et al., 2018; Yu and Jin, 2018
Surface solar radiation	Imagers (multi-channel), CERES, ancillary	100 km/3 h	55 W m^{-2} (55 W m^{-2})	11 W m^{-2} (11 W m^{-2})	Rutan et al., 2015; Kato et al., 2018
Surface longwave radiation	Imagers (multi-channel), CERES, ancillary	100 km/3 h	20 W m^{-2} (20 W m^{-2})	5 W m^{-2} (5 W m^{-2})	Rutan et al., 2015; Kato et al., 2018

*Accuracy values estimated from comparisons with buoys. Contribution to error in net surface heat flux computed from the tropical database as per **Table 1**. Column 2 (Sensor) describes instrumentation and where technological advances are needed. Column 5 shows daily resolution of gridded fields for all variables except solar and longwave radiation. For these, monthly averaged resolution is shown. Unless otherwise noted, accuracies are total uncertainties, including random uncertainty. Also unless otherwise noted, accuracies are estimated from globally distributed comparisons. As the quoted effect of these uncertainty values on the net heat flux are based on Tropical/sub-Tropical measurements they may not apply at mid-high latitudes. Uncertainties of the gridded products do not include uncertainties due to sampling error, and therefore underestimate the true uncertainty by some unknown percentage.*

Table 3 from Cronin et al. (2019)

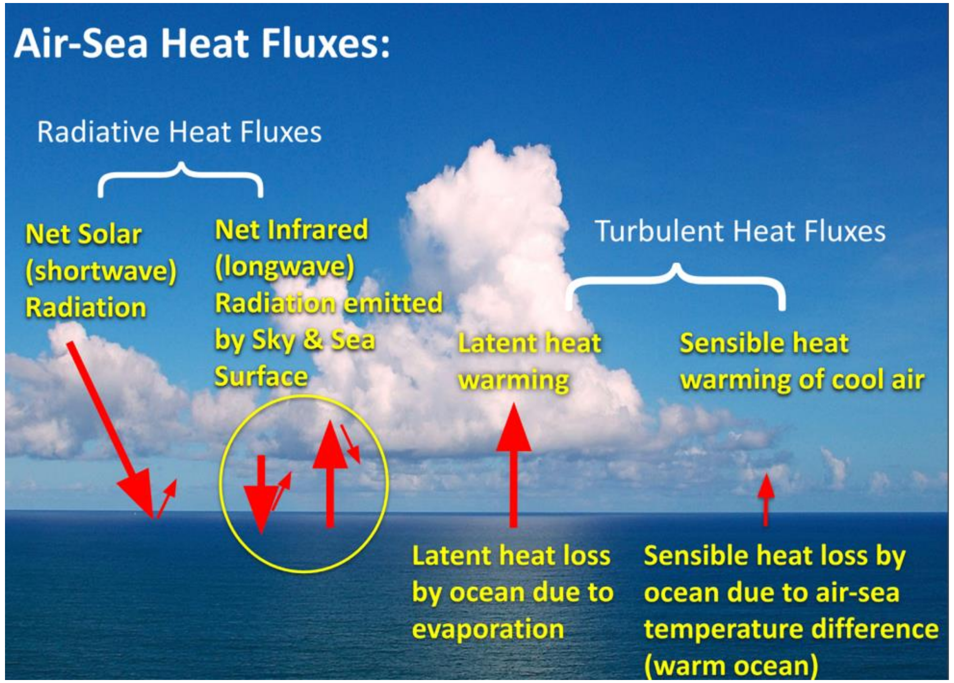
What Ocean Observations are needed to make transformative change over the next decade?

frontiers in Marine Science
REVIEW
published: 31 July 2019
doi: 10.3389/fmars.2019.00430

OCEAN OBS'19

Air-Sea Fluxes With a Focus on Heat and Momentum

Meghan F. Cronin[1]*, Chelle L. Gentemann[2], James Edson[3], Iwao Ueki[4], Mark Bourassa[5,6], Shannon Brown[7], Carol Anne Clayson[3], Chris W. Fairall[8], J. Thomas Farrar[3], Sarah T. Gille[9], Sergey Gulev[10], Simon A. Josey[11], Seiji Kato[12], Masaki Katsumata[4], Elizabeth Kent[11], Marjolaine Krug[13], Peter J. Minnett[14], Rhys Parfitt[5,6], Rachel T. Pinker[15], Paul W. Stackhouse Jr.[12], Sebastiaan Swart[16,17], Hiroyuki Tomita[18], Douglas Vandemark[19], Robert A.Weller[3], Kunio Yoneyama[4], Lisan Yu[3] and Dongxiao Zhang[20]



Net Surface Heat Flux into Ocean = Net Solar Radiation – Net Infrared Radiation – Sensible Heat Loss Loss by Ocean – Latent Heat of Evaporation Loss by Ocean

$$\mathbf{Qnet} = \mathbf{SWR}\,(1 - albedo) - emissivity\,(\mathbf{LWR} - sigma\,\mathbf{T_0}^4) - density_{air}\,C_T\,C_P\,\mathbf{WS}\,(\mathbf{T_{air}} - \mathbf{T_0}) - density_{air}\,C_H\,L\,\mathbf{WS}\,(\mathbf{q_{air}} - \mathbf{q_{0,sat}})$$

Requires 7 to 8 Surface Ocean & Atmosphere Measurements *parameter or constant*

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Check for updates

OCEAN OBS'19

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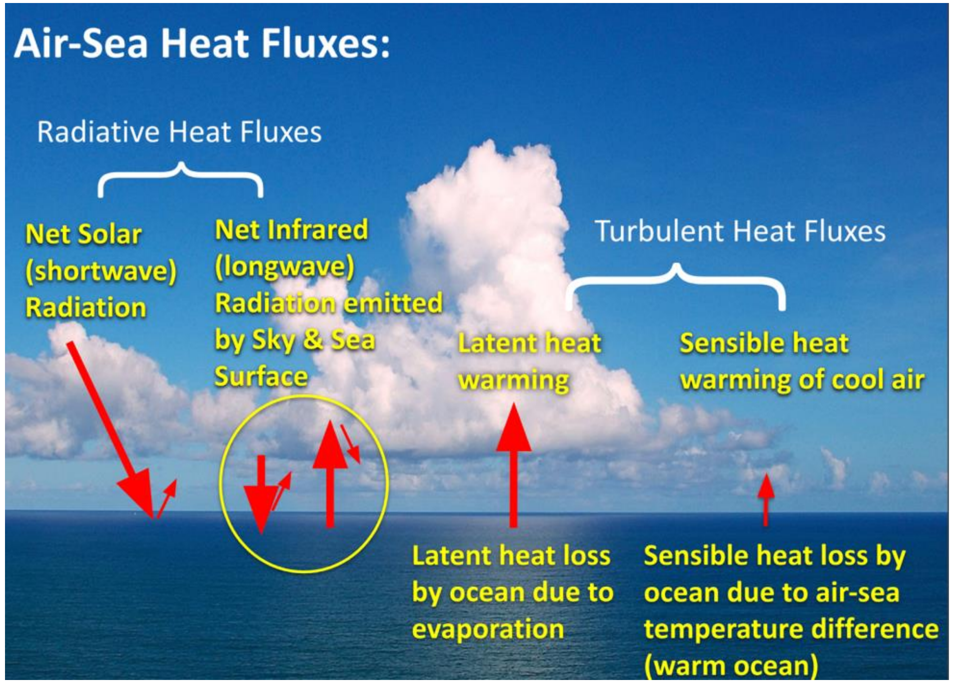


Satellite air-sea heat flux capabilities:

Heat Fluxes

Radiaative Turbulent Heat Fluxes

Flux EOV/ECV	2018	2019 · 2020 · 2021 · 2022 · When
Bulk SST	Partially met	Adequate
Skin Temperature	Partially met	Adequate
Wind Speed and Direction	Partially met	Adequate
Air Temperature	Not met	Adequate
Humidity	Not met	Adequate
Bulk Surface Currents	Partially met	Adequate
Skin Surface Currents	Not met	Adequate
Surface Solar Radiation	Partially met	Adequate
Surface Longwave Radiation	Partially met	Adequate
Albedo	Partially met	Met
Sea State	Requirement Unknown	Requirement Known

Red	Requirement not met / inadequate
Orange	Requirement partially met / threshold
Yellow	Requirement adequately met / breakthrough
Green	Requirement fully met / ideal goal

Recommendations:

- **Measure all state variables from same platform**. This applies for both *in situ* & satellite platforms.
- **Better sampling** in regions where ocean influences weather and climate: *tropics, frontal zones, fast timescales (diurnal-synoptic)*
- Observe **wide range of regimes**, e.g. high-latitudes, extremes,…
- Improved **air-sea coupling in models**

OASIS

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Observing Air-Sea Interactions Strategy (OASIS) is harmonizing community recommendations from OceanObs'19 and UN Decade Laboratories…

…into three **Grand Ideas**

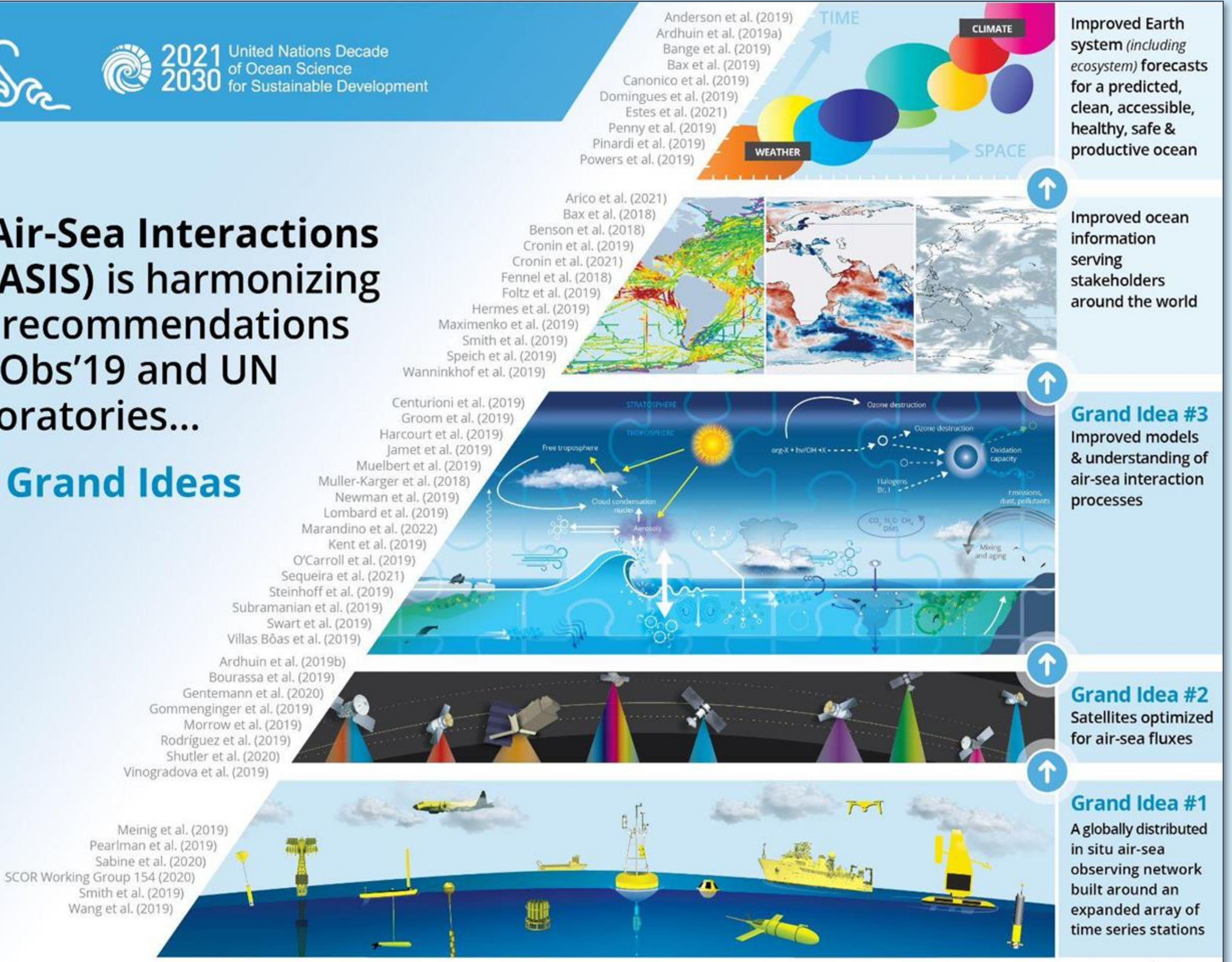
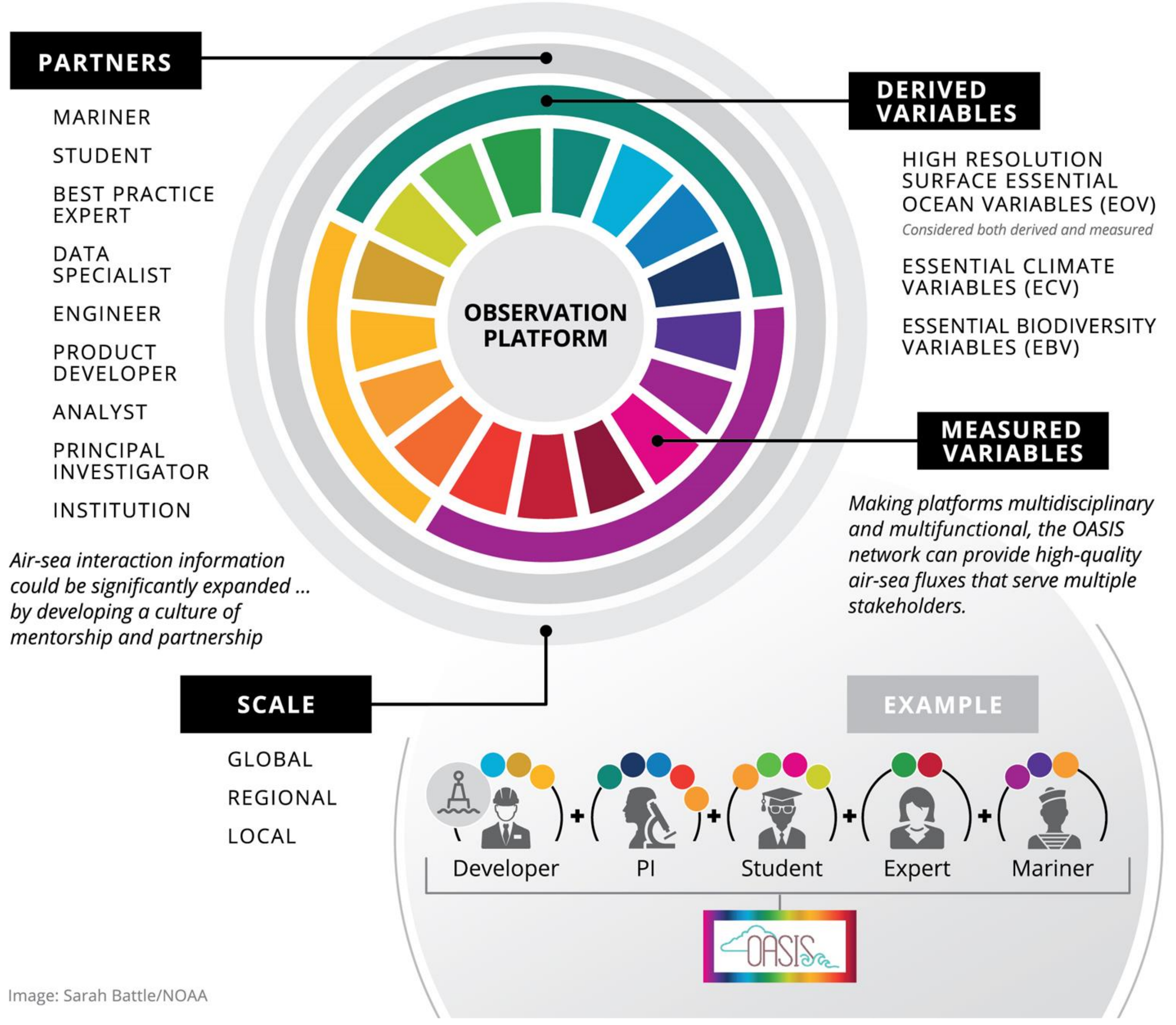


Image: Sarah Battle/NOAA visit: airseaobs.org

OASIS Theory of Change

Credit: Polar Glider, Gothenburg University, (c) Louise Biddle

2018 SOLAS summer school
© Jesssica Gier



Air-sea interaction information could be significantly expanded … by developing a culture of mentorship and partnership

Making platforms multidisciplinary and multifunctional, the OASIS network can provide high-quality air-sea fluxes that serve multiple stakeholders.

Image: Sarah Battle/NOAA

Lead Institution: SCOR Working Group #162

Co-Chairs:
Meghan Cronin (**NOAA PMEL**, USA)
Christa Marandino (GEOMAR, GERMANY)
Seb Swart (University of Gothenburg, SWEDEN)

OASIS is an international UN Decade programme, co-led by NOAA.

OASIS Mission & Vision

OASIS Mission is to develop a practical, integrated approach for observing air-sea exchanges associated with the Energy, Water, Carbon and Life Cycles

Recent hybrid OASIS workshop had more than 54 in person participants, with Early Career Ocean Professionals from Africa, South America, Asia, Australia, Europe, and North America

OASIS envisions a pathway to Get Involved in Ocean-Atmosphere Interaction Science for Sustainable Development. **www.airseaobs.org/get-involved**

OASIS Activities

To Join Task Teams: airseaobs.org/get-involved

Grand Idea #1: Expanding the in situ observing system – Fill Gaps in GOOS!

- ☑ Technology Development Dream Team
- ☑ Uncrewed Surface Vehicle Network for the Global Ocean Observing System
  - ☑ Webinar Series!

Grand Idea #2: Improve air-sea interaction observing from satellites

  - ☑ Webinar Series!

Grand Idea #3: Improve hierarchy of Earth System Models for air-sea interactions

- ☑ Building international partnerships to expand process study field campaigns

OASIS Theory of Change

- ☑ Best Practices and Interoperability Experiments
- ☑ Partnership & Capacity Strengthening
- ☑ FAIR Data & OASIS Products

Webinar Series: airseaobs.org/resources/webinars

Grand Idea #1: Fill Gaps in GOOS

MABL observing in need of Technology Development

2021 United Nations Decade
2030 of Ocean Science for Sustainable Development

OASIS Observing Air-Sea Interactions Strategy

New satellites can be optimized to observe surface boundary layer air-temperature and moisture…. but **Need New Technology** for validation & tuning

… and for forecasts.

Flux EOV/ECV	2018	2019	2020	2021	2022	When?
Bulk SST	Partially met					Adequate
Skin Temperature	Partially met					Adequate
Wind Speed and Direction	Partially met					Adequate
Air Temperature	Not met					Adequate
Humidity	Not met					Adequate
Bulk Surface Currents	Partially met					Adequate
Skin Surface Currents	Not met					Adequate
Surface Solar Radiation	Partially met					Adequate
Surface Longwave Radiation	Partially met					Adequate
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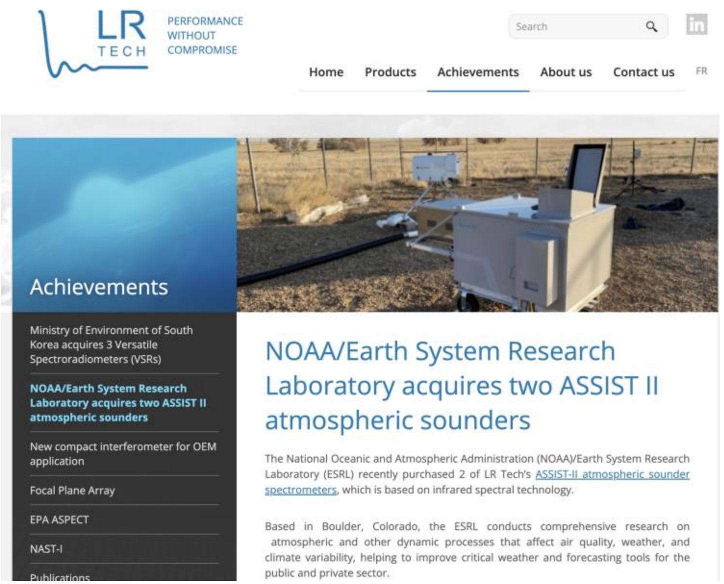

NEED: Atmospheric profiling capability for deployment on ocean platforms, that are

- smaller
- lower-powered
- cheaper
- more robust for marine environment
- can be deployed on a moving platform

Grand Idea #1: Fill Gaps in GOOS

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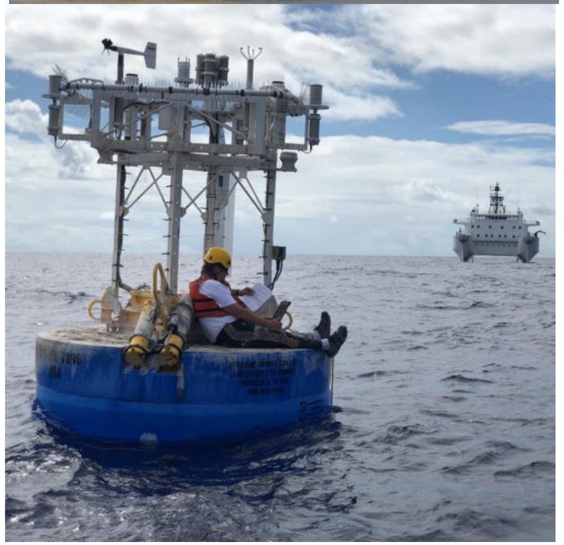
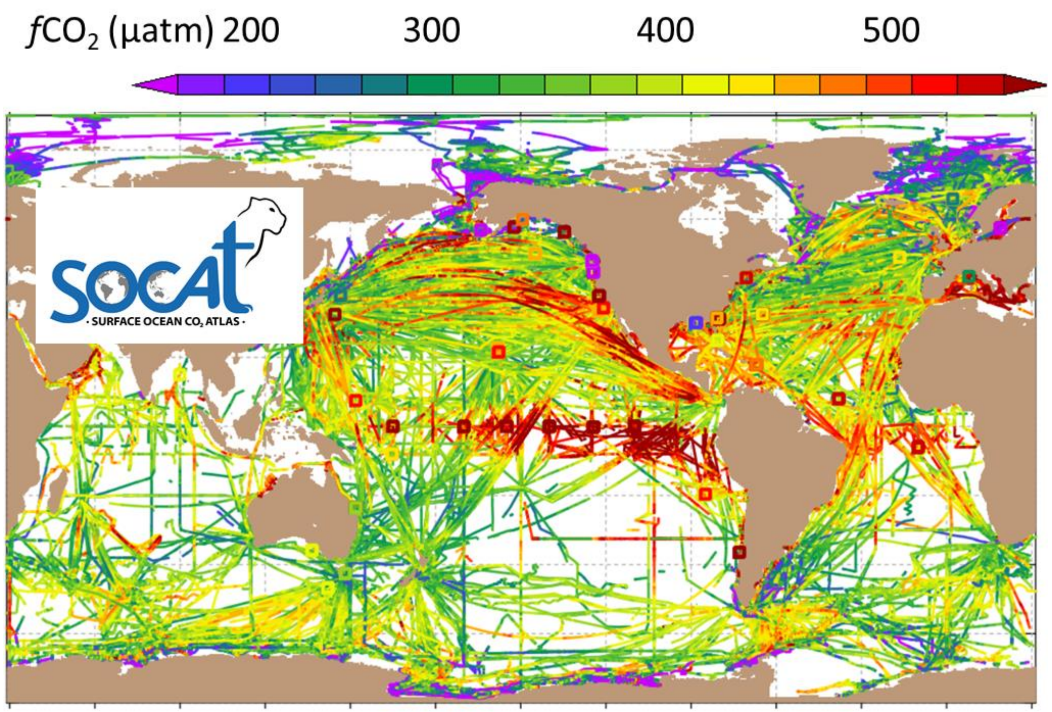
OASIS Observing Air-Sea Interactions Strategy

Need more obs. from Established Platforms:



Surface ocean CO_2 flux (uptake) measurements collected since 1957



Wanninkhof et al. (2019) **“A Surface Ocean CO_2 Reference Network, SOCONET and Associated Marine Boundary Layer CO_2 Measurements”**

soconet · SURFACE OCEAN CO_2 OBSERVING NETWORK ·

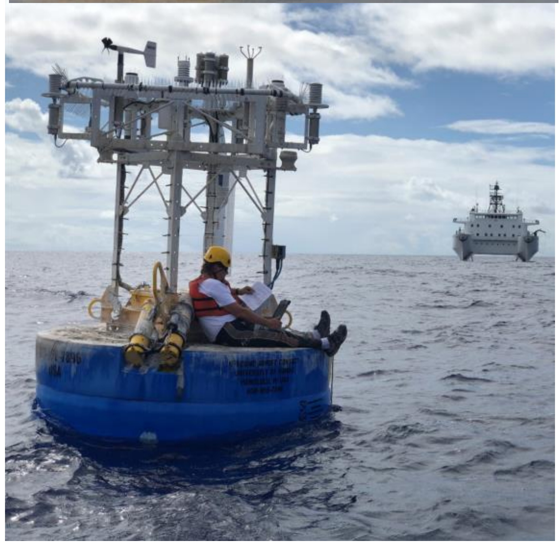
Need obs. from New Technologies:

Grand Idea #1: Fill Gaps in GOOS

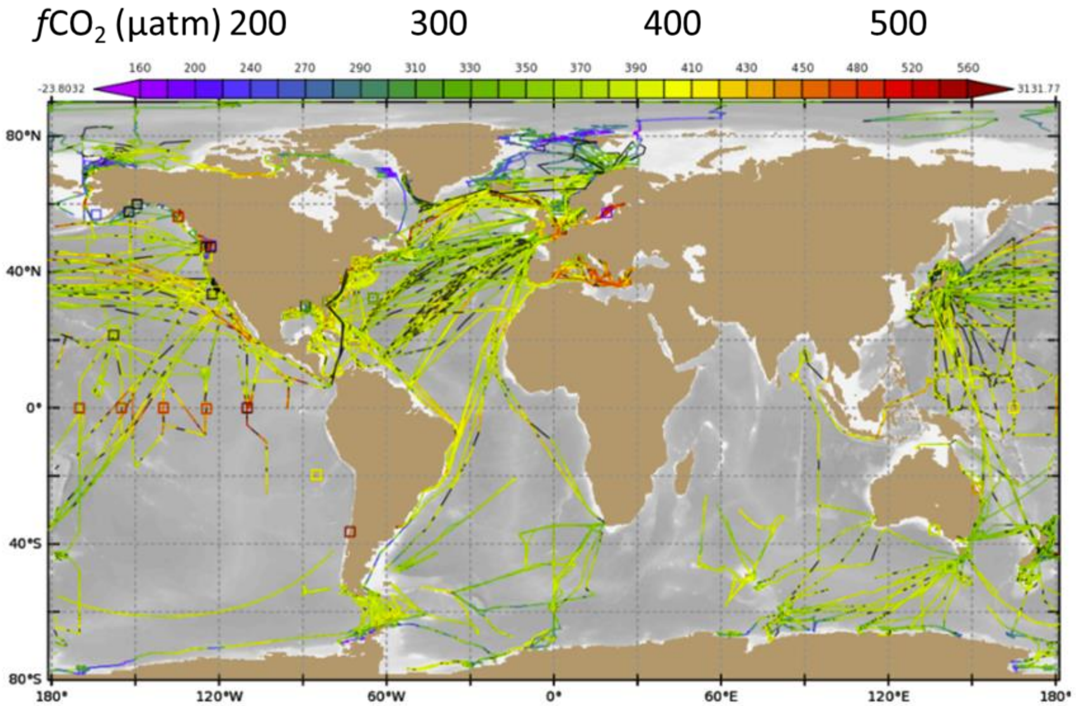
2021 2030 United Nations Decade of Ocean Science for Sustainable Development

OASIS Observing Air-Sea Interactions Strategy

Need more obs. from Established Platforms:



Surface ocean CO_2 flux (uptake) measurements collected in 2015



Wanninkhof et al. (2019) **“A Surface Ocean CO_2 Reference Network, SOCONET and Associated Marine Boundary Layer CO_2 Measurements”**

soconet · SURFACE OCEAN CO_2 OBSERVING NETWORK ·

Need obs. from New Technologies:

Grand Idea #1: Fill Gaps in GOOS

An Emerging Uncrewed Surface Vehicle Network

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OASIS Observing Air-Sea Interactions Strategy

Attribute Report out

- Global in scale
- Observes one or more Essential Ocean Variables or Essential Climate Variables
- Environmental stewardship awareness
- Undertakes capacity development and technology transfer
- Ensures metadata quality and deliver
- Develops and follows standards and best practices
- Delivers data that are free, open and available in a timely manner
- Community of practice
- Observations are sustained
- Maintains network mission and targets

GOOS

Global in scale - Greater than regional, and as far as feasible, intention to be global.

Joined up with EuroSeas who have been developing network in Europe

EuroSea

Persistent, scalable, diverse, manoeuvrable

Observes one or more EOVs or ECVs - Contributes to meeting requirements through observing one or more of the GOOS Essential Ocean Variables or GCOS[1] Essential Climate Variables.

New capability for observing direct covariance wind stress for Saildrone (Reeves Eyre et al. 2023)

Multidisciplinary AIR and SEA instrument-based observations

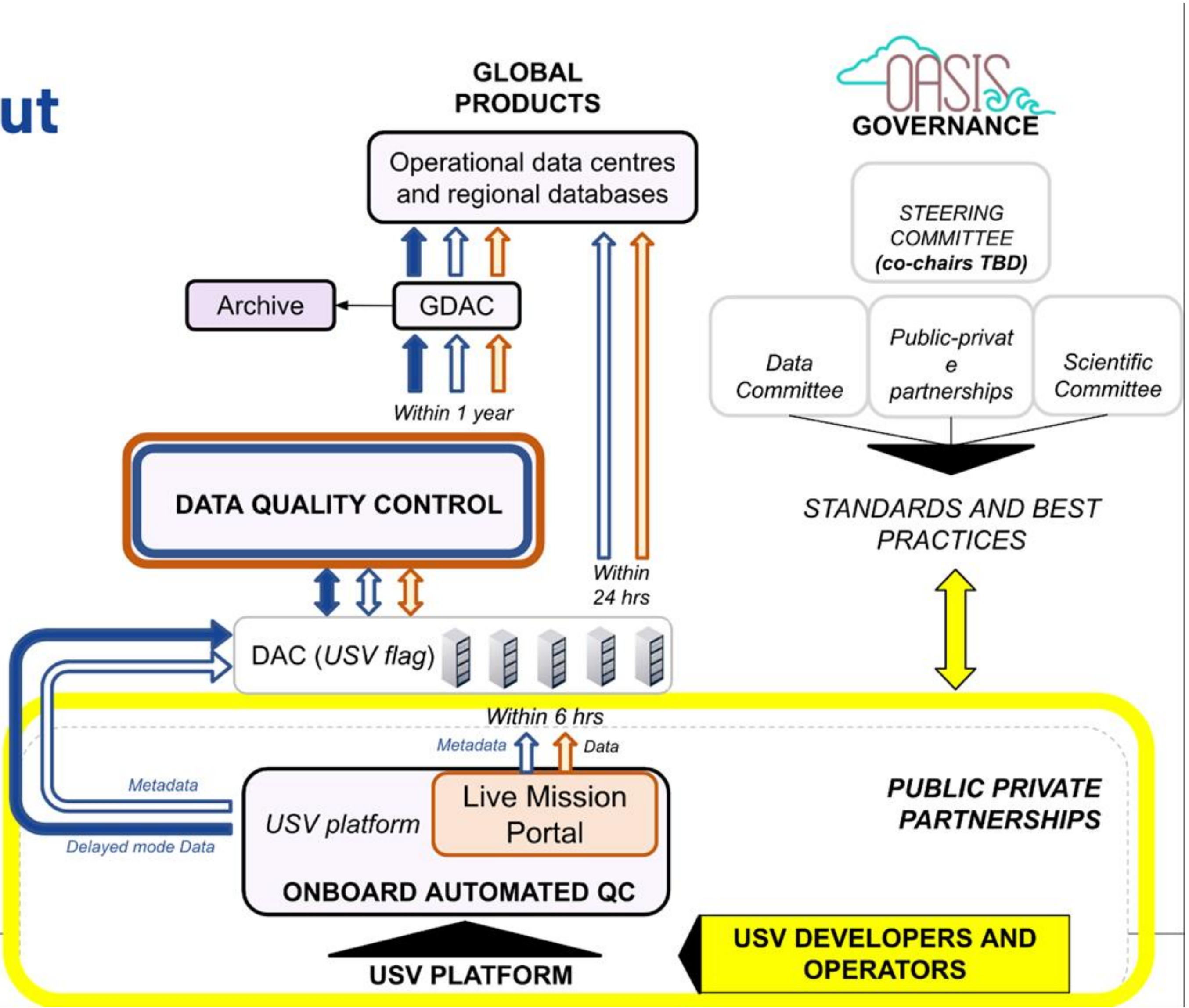
Atmosphere	Land	Ocean
Surface	**Hydrosphere**	**Physical**
• Precipitation	• Groundwater	✓ Ocean surface heat flux
✓ Pressure	• Lakes	• Sea ice
✓ Radiation budget	• River discharge	✓ Sea level
✓ Temperature	**Cryosphere**	✓ Sea state
✓ Water vapour	• Glaciers	✓ Sea surface currents
✓ Wind speed and direction	• Ice sheets and ice shelves	✓ Sea surface salinity
Upper-air	• Permafrost	✓ Sea surface stress
• Earth radiation budget	• Snow	✓ Sea surface temperature
• Lightning	**Biosphere**	✓ Subsurface currents
• Temperature	• Above-ground biomass	✓ Subsurface salinity
• Water vapor	• Albedo	✓ Subsurface temperature
• Wind speed and direction	• Evaporation from land	**Biogeochemical**
Atmospheric Composition	• Fire	✓ Inorganic carbon
• Aerosols	• Fraction of absorbed photosynthetically active radiation (FAPAR)	✓ Nitrous oxide
• Carbon dioxide, methane and other greenhouse gases	• Land cover	✓ Nutrients
• Clouds	• Land surface temperature	✓ Ocean colour
• Ozone	• Leaf area index	✓ Oxygen
• Precursors for aerosols and ozone	• Soil carbon	✓ Transient tracers
	• Soil moisture	**Biological/ecosystems**
		✓ Marine habitats
		✓ Plankton

Environmental stewardship awareness - Actively develops ideas to minimize environmental footprint and contributes positively towards a healthy ocean.

> Renewable energy sources
> Non-expendable
> Flexible and resilient

Intrinsically environmental

Grand Idea #1: Fill Gaps in GOOS
An Emerging Uncrewed Surface Vehicle Network



Grand Idea #1: Fill Gaps in GOOS
An Emerging Uncrewed Surface Vehicle Network

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

OASIS Observing Air-Sea Interactions Strategy

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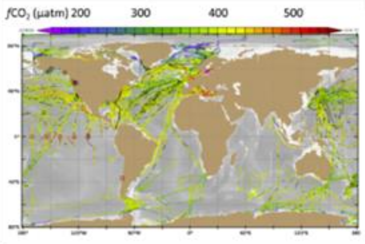
- Community of practice
- Observations are sustained
- Maintains network mission and targets

Observations are sustained - Sustained over multiple years, beyond time-span of single research or experimental projects, undertaking routine, systematic and essential ocean observations

NOAA Surface Ocean CO2 Monitoring network
Missions duration ~ 6 months;
Biofouling often the only limiting factor

Currently funded as single missions for research campaigns and pilot studies

Maintains network mission and targets - A role in the GOOS is defined and progress towards targets can be tracked and progress assessed.



Will be developed by proposed Community of Practice

USV network for GOOS that will **FILL GAPS** in space, time, disciplines and complement existing GOOS infrastructure

GOOS

38

Grand Idea #1: Fill Gaps in GOOS
An Emerging Uncrewed Surface Vehicle Network

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

OASIS Observing Air-Sea Interactions Strategy

“The endorsed UN Ocean Decade Project’s goal is to build an **Observing Air-Sea Interaction Strategy (OASIS)** & **Community of Practice** for this emerging **Uncrewed Surface Vehicle (USV) network**"

-- Sarah Nicholson (South Africa)

ECOP PI representing Emerging USV Network

Sarah Nicholson (South Africa)

Ruth Patterson (Australia)

“Join our OASIS **webinar series** for developing a **Community of Practice** for the emerging **Uncrewed Surface Vehicle (USV) network**"

-- Ruth Patterson (Australia), ECOP co-lead for OASIS USV Webinar series

Patterson et al. Community of Practice paper in prep

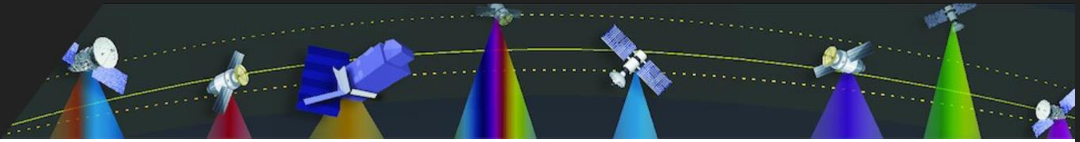
Webinar Series: airseaobs.org/resources/webinars

Grand Idea #2: Optimize Satellite Observations

Emerging Opportunities for Air-Sea Fluxes from Space

Town Hall, Friday, 23 Feb. 2024, 12:45 CT
Ocean Sciences Meeting 2024, Room 217-219

Organized by Sarah Gille (SIO)
Moderated by Meghan Cronin (NOAA PMEL), co-chair of OASIS
Overview of opportunities to optimize satellites for air-sea fluxes
Discussion



*"Continue this discussion at our weekly '**OASIS Air-Sea Fluxes from Space' webinar** on Tuesdays 11 AM EST. Register to get the zoom link at* https://forms.gle/KjHQ7BvjHtJ97TjT6.

-- Sarah Gille (Scripps, USA)

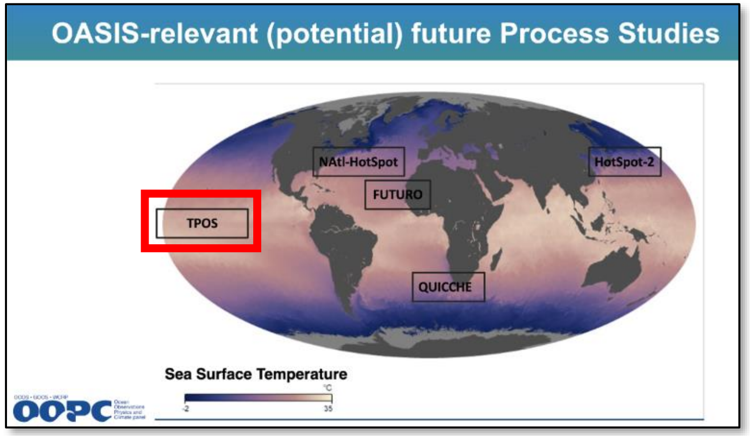
May 7, 2024 NASA announced the selection of four proposals for concept studies of missions to benefit humanity through the study of Earth science, including:

The Ocean Dynamics and Surface Exchange with the Atmosphere (ODYSEA)
This satellite would simultaneously measure ocean surface currents and winds to improve our understanding of air-sea interactions and surface current processes that impact weather, climate, marine ecosystems, and human wellbeing. It aims to provide updated ocean wind data in less than three hours and ocean current data in less than six hours. The proposal is led by Sarah Gille at the University of California in San Diego

Agenda

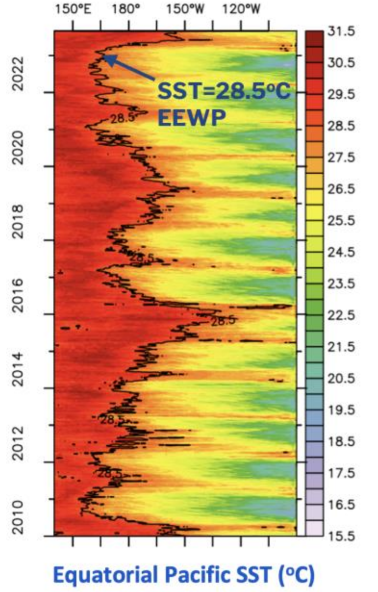
I. Welcome: Objectives of town hall
   A. OASIS vision – Meghan Cronin, NOAA PMEL
   B. In situ air-sea fluxes (OOI & OceanSITES) – Jim Edson, WHOI
II. Lightning talks
   A. Multiple satellites: Vector winds – Tony Lee, JPL
   B. CIMR: High resolution SST, winds, etc. – Fabrice Collard, Ocean Data Lab
   C. Butterfly: Turbulent buoyancy fluxes (future NASA) – Carol Anne Clayson, WHOI
   D. Harmony: Winds, currents, waves (ESA, launch in ~2029) – Paco Lopez Dekker, TU Delft
   E. SeaSTAR: Coastal & MIZ currents, winds, waves (seeking funding) – Christine Gommenginger, NOC
   F. ODYSEA: Winds and currents (under review, NASA/CNES) – Sarah Gille, SIO
III. Discussion: The big picture & community objectives.

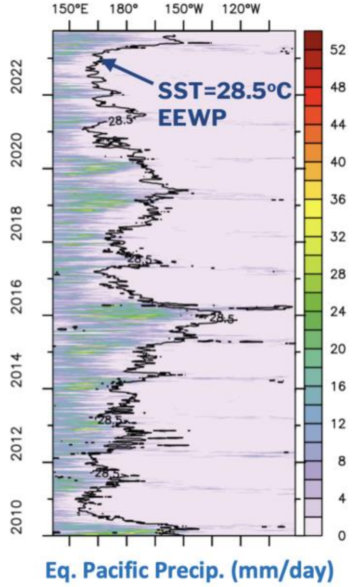
Grand Idea #3: Improve Earth-System Models
TPOS Equatorial Pacific Experiment (TEPEX)

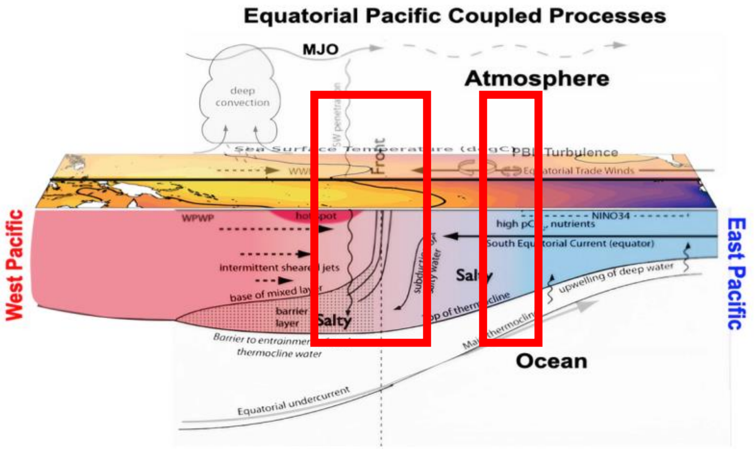


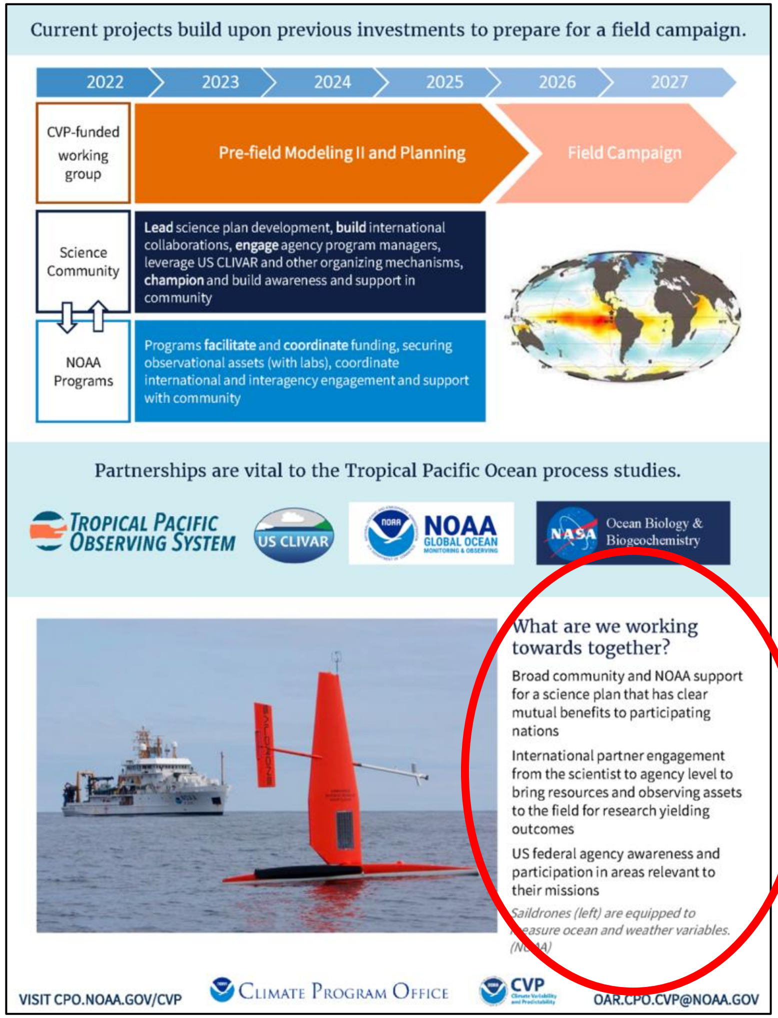
Prediction of ENSO and its world impacts would be improved if we had a better understanding of physics governing:

- *Zonal movement of the Eastern Edge of equatorial Pacific Warm Pool*
- *Equatorial Pacific upwelling & mixing*



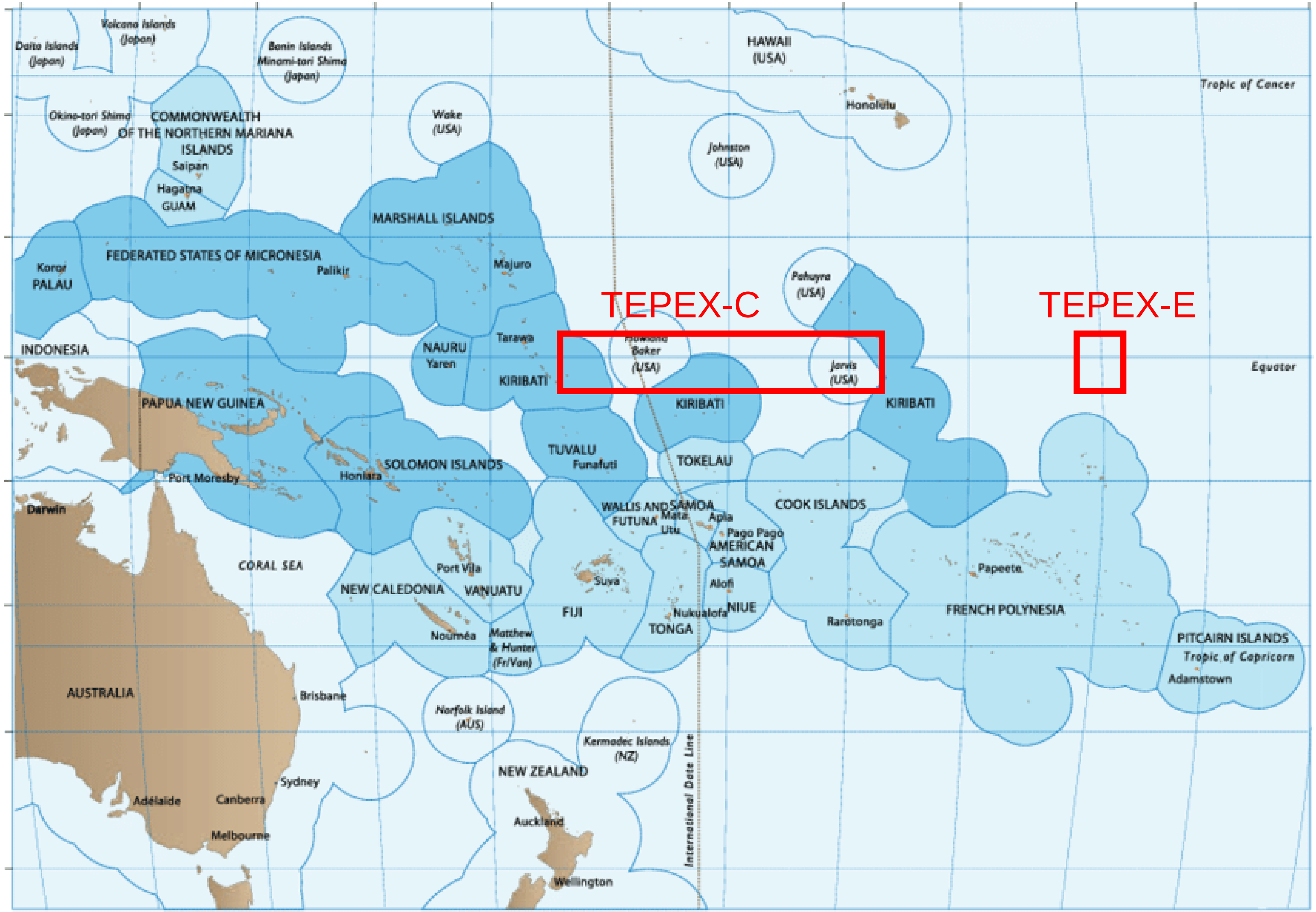






OASIS is working to help build international support for TEPEX

OASIS Theory of Change: Partnership & Capacity Strengthening



OASIS Theory of Change: Best Practices

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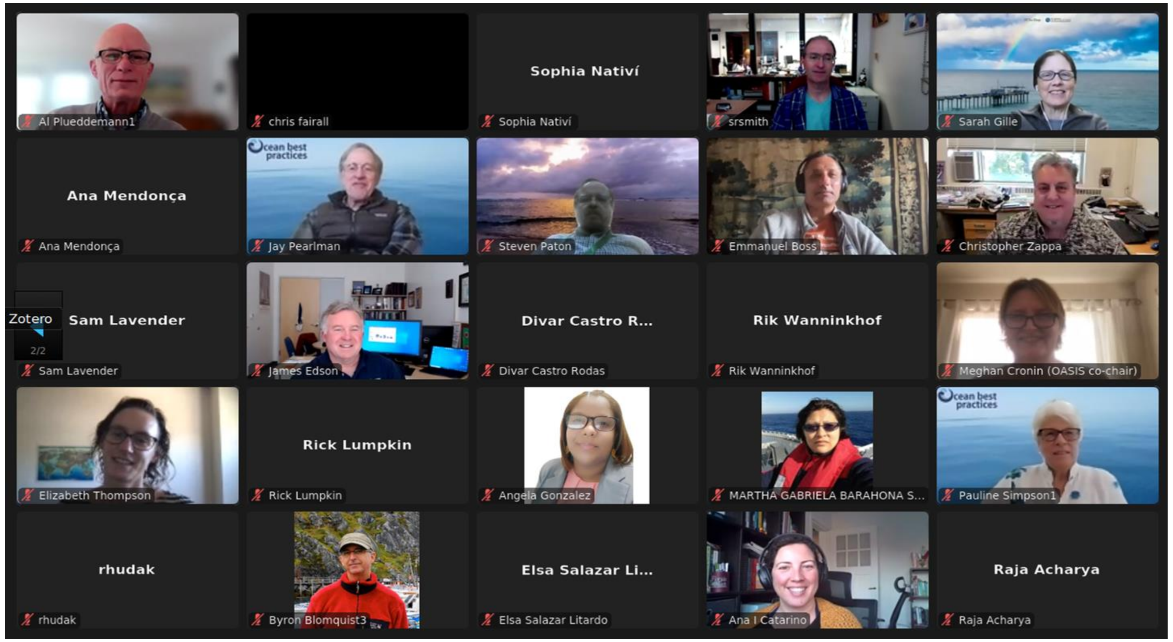
OASIS Observing Air-Sea Interactions Strategy

"Community recommended practices and standards can help guide technology development design decisions, and can help lead to innovative solutions that meet the needs of the OASIS community"

-- Lucia Gutierrez Loza, Best Practice Theme Team ECOP co-lead

Lucia Gutierrez Loza (Norway)



From Ocean Best Practice Systems (OBPS) Air-Sea Interactions workshop, held virtually 11 Oct 2022 at 0700 & 1600 UTC.

Gutierrez Loza et al. Commentary Submitted to MTSJ Decade issue

Riihimaki et al. (2024) Ocean Surface Radiation Measurement Best Practices.

Get Involved: airseaobs.org/get-involved

OASIS Theory of Change: FAIR data

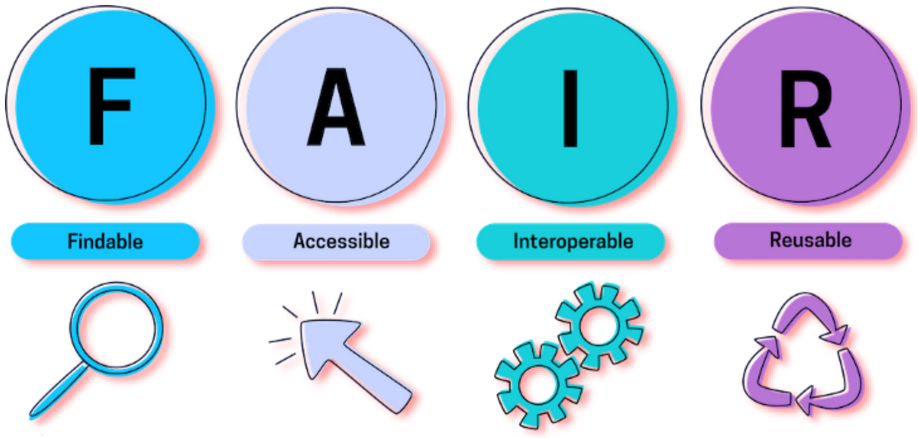


Image: Medium article "[Making Data F.A.I.R.](#)"

"Our aim is to tackle the grand challenge of standardising air-sea flux terminology, making flux data products and open source code findable and accessible, and elevating the visibility from observation to user data."

-- Marcel du Plessis
FAIR data ECOP co-lead

github link for Discussion about adoption of CF standard names for flux variables: https://github.com/cf-convention/discuss/issues/206

Get Involved: airseaobs.org/get-involved

Get Involved!

OASIS (Observing Air-Sea Interactions Strategy) provides a pathway to Get Involved in Air-Sea Interaction Ocean Science **for Sustainable Development**

OASIS - SOLAS Scholars from the Surface Ocean-Lower Atmosphere Studies (SOLAS) Open Science Conference in Cape Town South Africa, Sep 25-29, 2022

Get Involved: airseaobs.org/get-involved