Integrating Ocean Color in NOAA/NCEP's Next-generation Global Ocean Data Assimilation System (NG-GODAS)

National Weather Service

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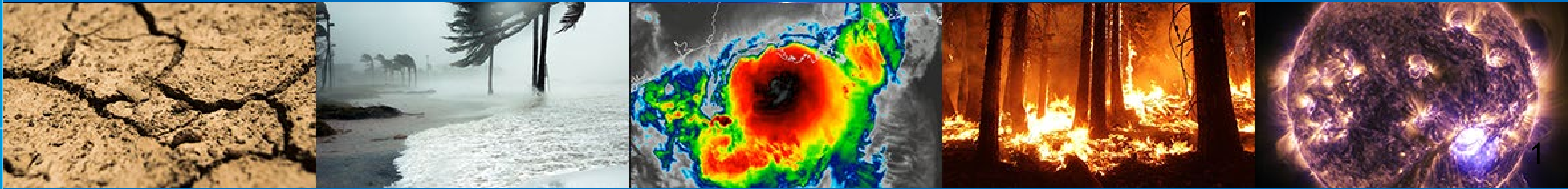
NOCCG Seminar, June 2, 2021



Outline

- **Overview of JPSS-PGRR funded project (ongoing - FY23)**

  "Implementation of ocean biogeochemical modeling and ocean color data assimilation in the UFS in support of NCEP's weather, S2S, and ecological predictions"

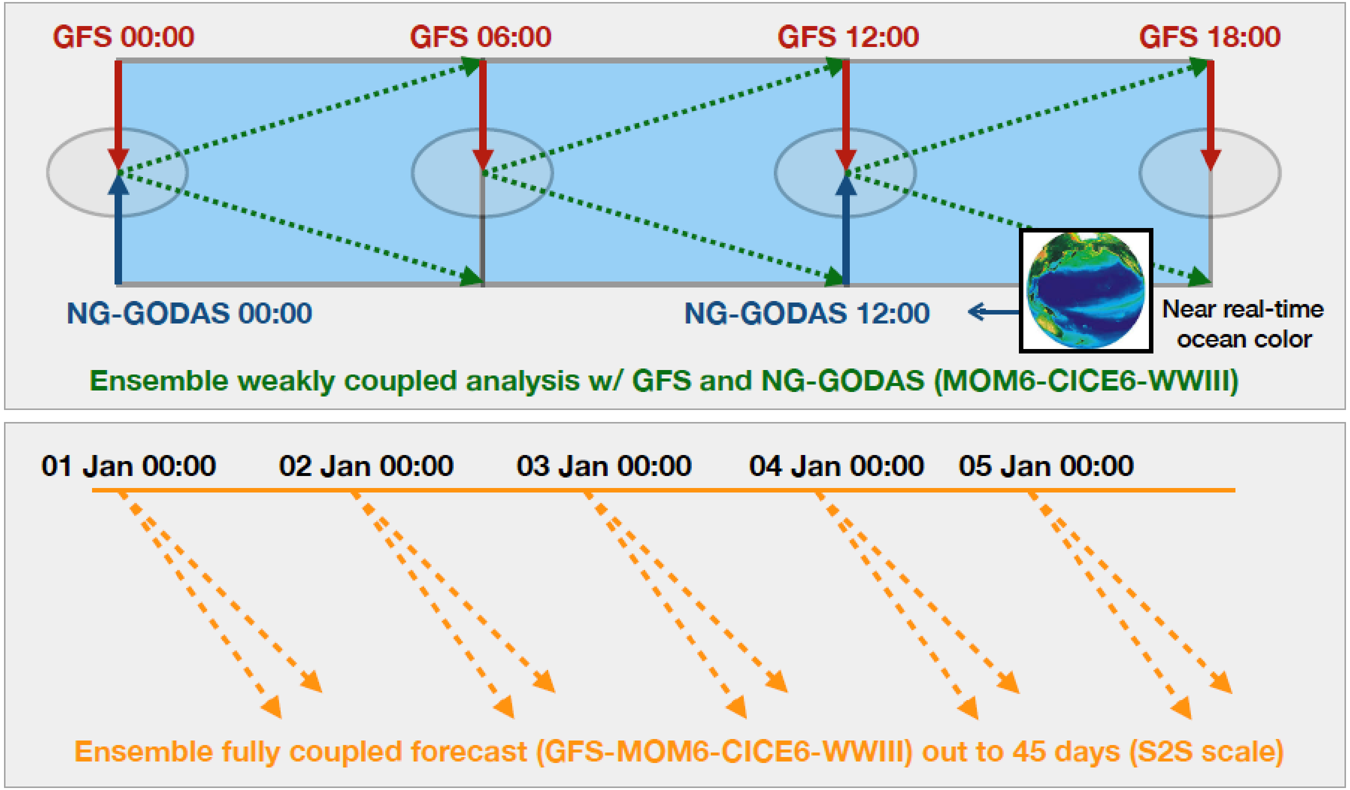
- **Why ocean color for NG-GODAS?**
- **Model system – DATM-MOM6-BLING-CICE6 based on JEDI/SOCA**
- **Prototype 1° 3DVAR experiments – daily chlorophyll analysis (2015 test cases)**
- **Challenges and next steps**

JPSS-PGRR FY21-23 "Implementation of ocean biogeochemical modeling and ocean color data assimilation in the Unified Forecast System in support of NCEP's weather, S2S, and ecological predictions"

The **overarching goals** of this project are to …

- Support NOAA/NCEP's **operational weather forecasts** at Subseasonal-to-Seasonal (S2S) scales by improving ocean state initialization through the ingestion of near real-time ocean color data and the integration of biophysical feedback in the marine component of the UFS;
- Start building NOAA/NCEP's **ecological forecast capabilities** for monitoring critical changes and "tipping points" in coastal ecosystems.

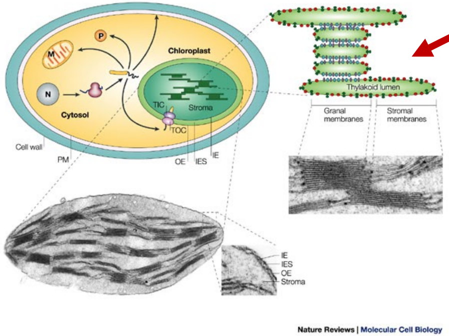
GEFS: the Global Ensemble Forecast System



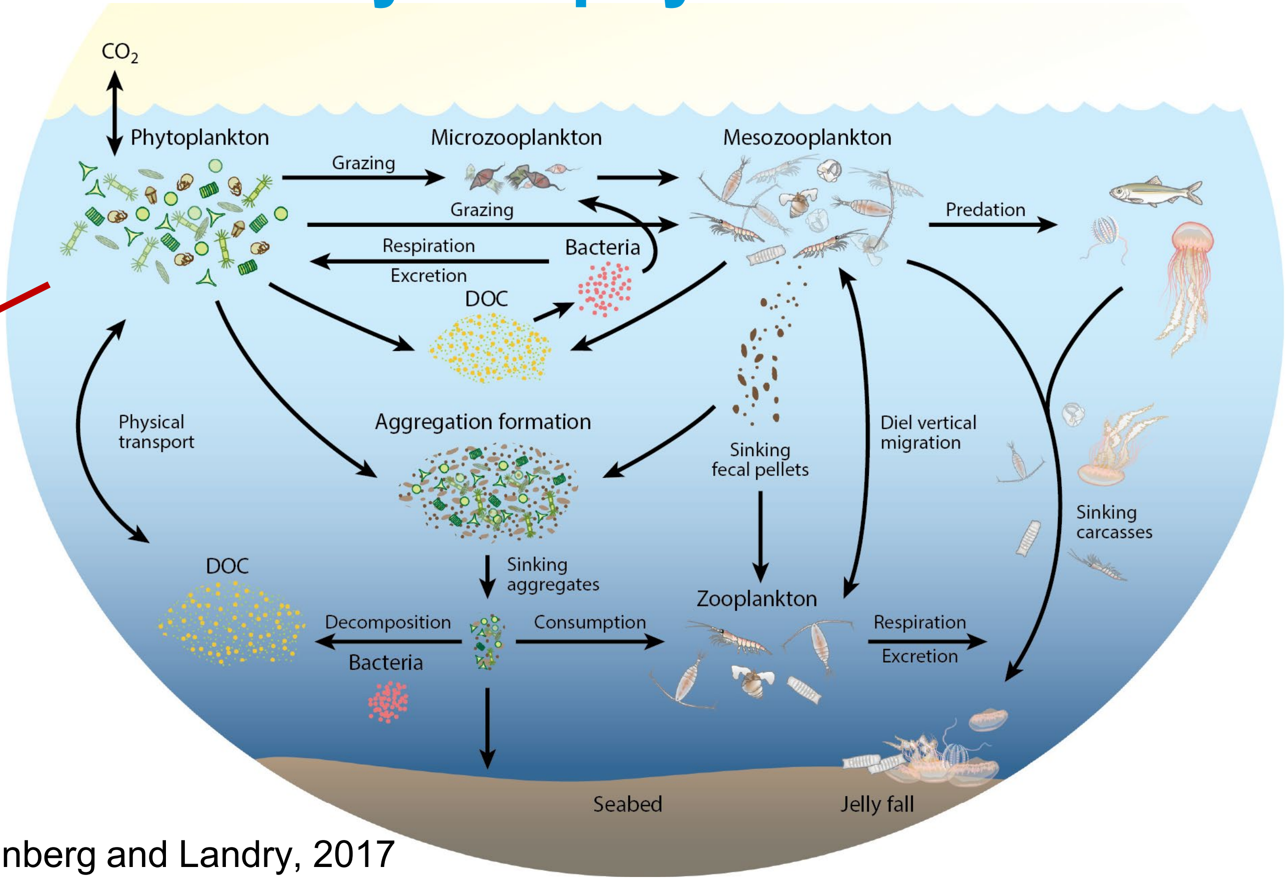
NOAA NCEP's GEFS weakly coupled analysis (top) and ensemble forecasts (bottom). Adapted from Fig. 1 in Saha *et al.*, 2010. For illustration purposes only.

Ocean biogeochemistry: biophysical feedback

Radiative heating



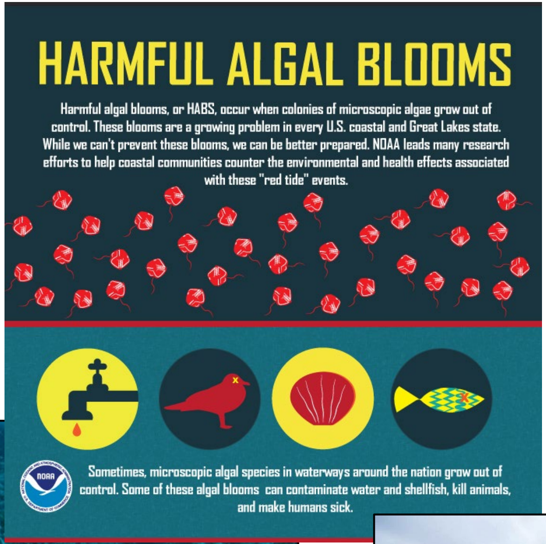
Soll and Schleiff 2004



Steinberg and Landry, 2017

Needs for ecological forecasts

HABs…
Hypoxia…
Acidification…
Fisheries



BLING – Biogeochemistry with Light Iron Nutrient and Gas

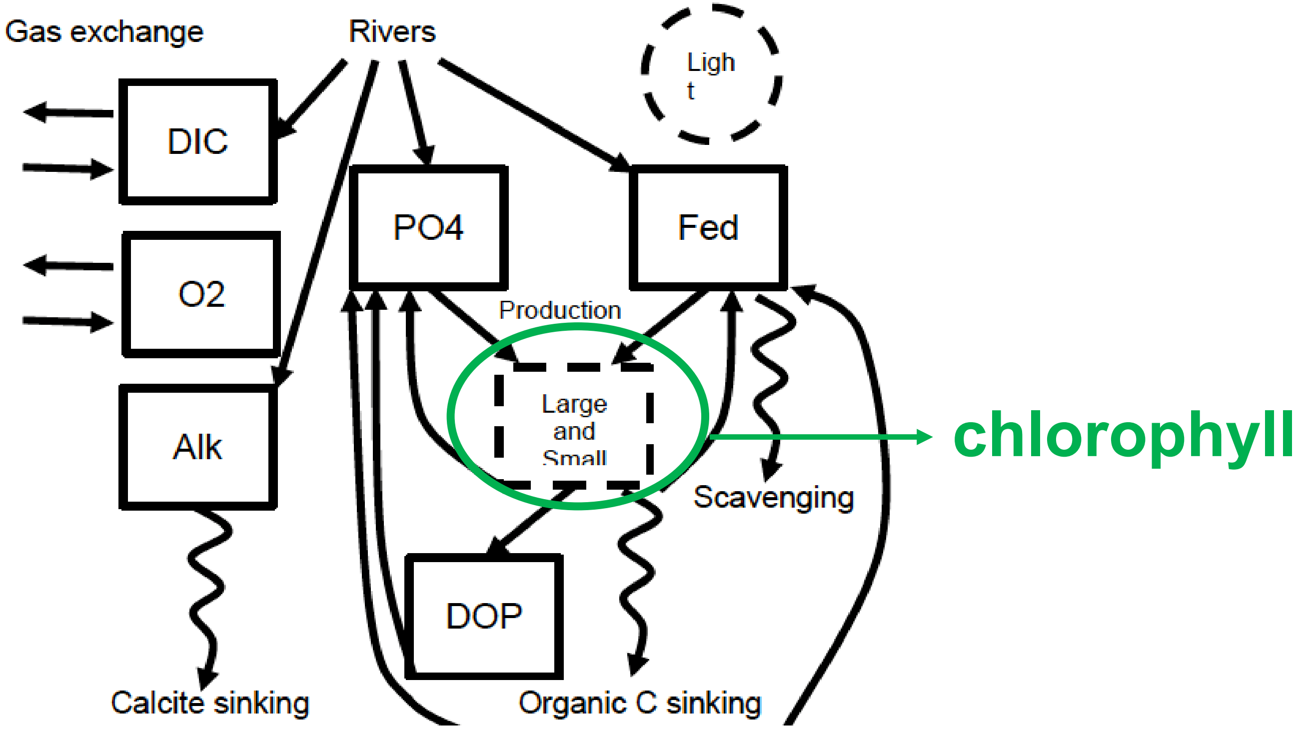


Figure. Simplified model schematic of BLINGv2 ocean biogeochemical model (Dunne *et al*., 2020)

Model System: UFS-marine DA (+BLING)

The coupled **DATM–MOM6–CICE6** based on NEMS/CMEPS has been developed. In tandem with the FV3-MOM6-CICE6 but without feedback to the atmosphere.

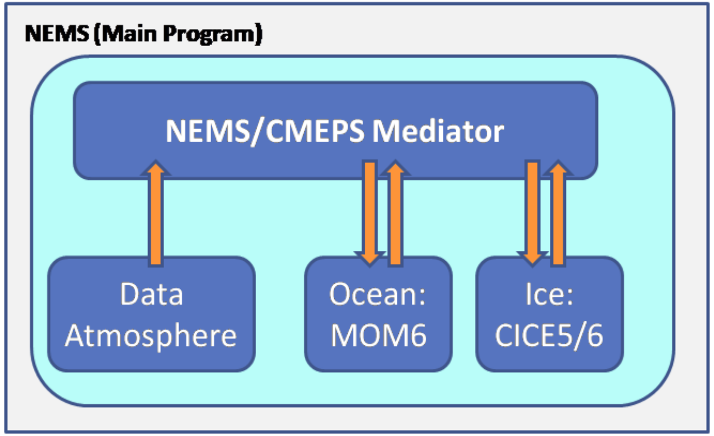
Forcing: CFSR, GEFS Reanalysis, and weekly 11 member ensemble are available

Ocean: MOM6 (GFDL):

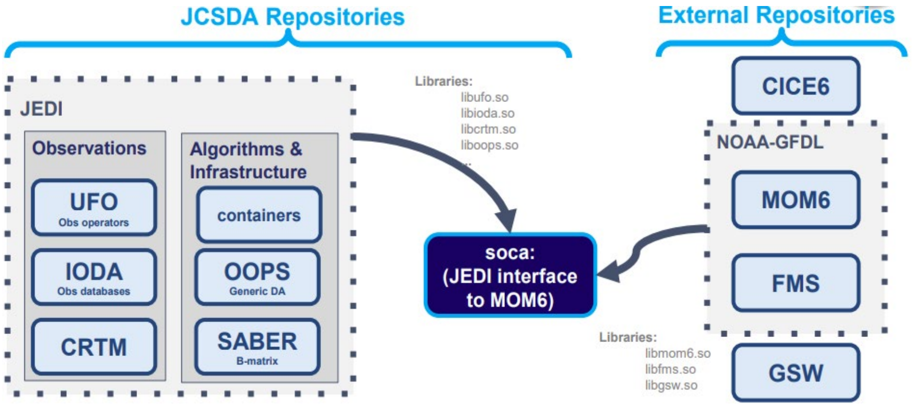
- 0.25° spatial resolution
- 75 layer hybrid vertical coordinates

Sea-Ice: Los Alamos CICE6

- Same grid as the ocean



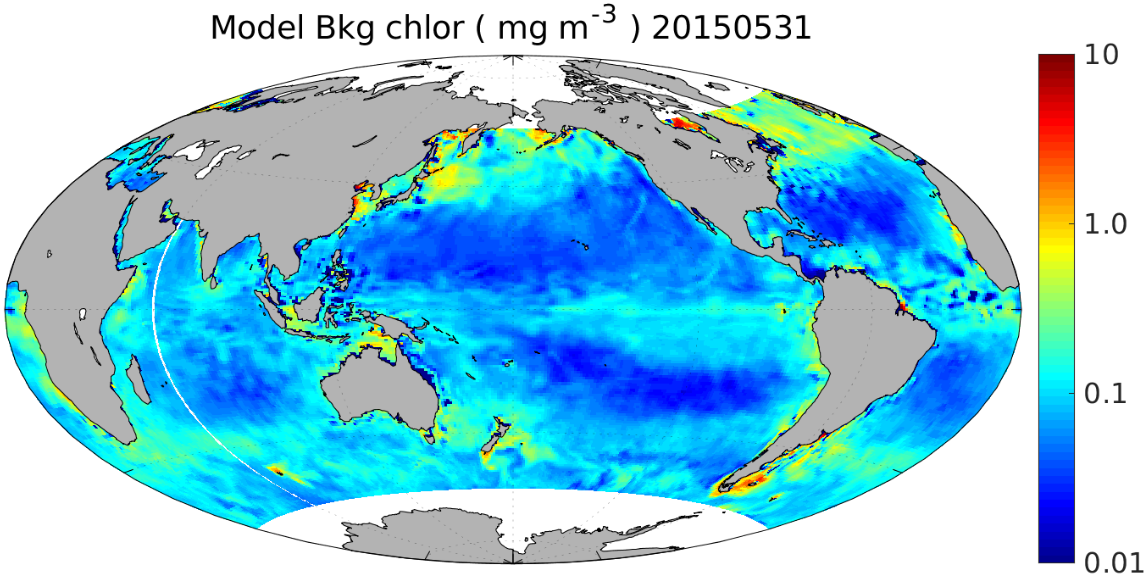
JEDI SOCA Interfaces: MOM6-CICE6



Integrating Ocean Color into the system

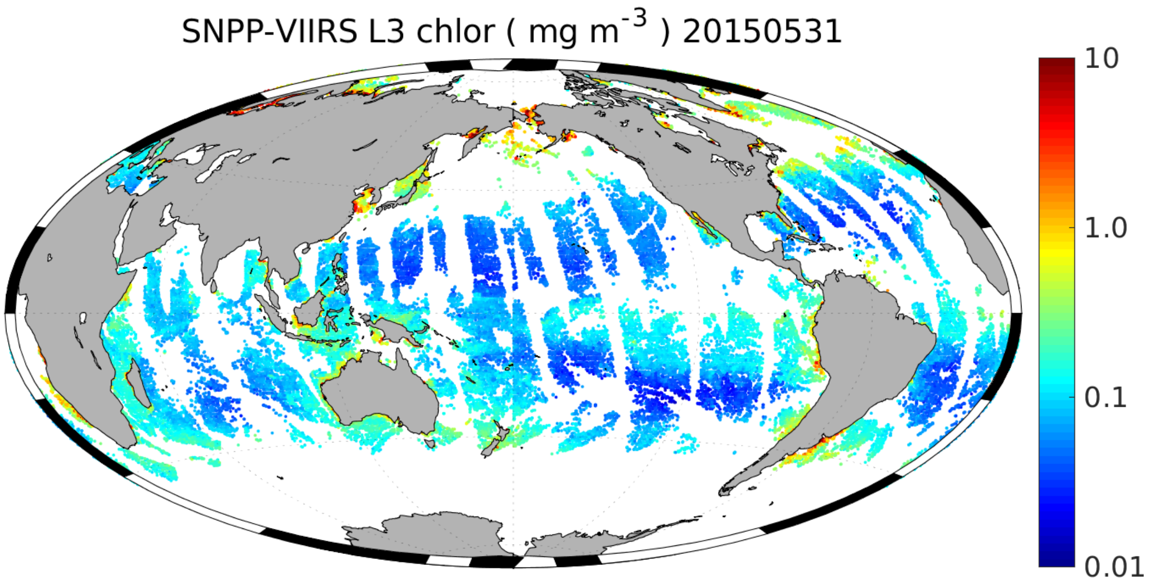
- **Ocean color data flow**: SNPP-VIIRS and NOAA20-VIIRS (L2, L3) *chlor_a* from CoastWatch; SeaWiFS and Aqua-MODIS *chlor_a* (L2, L3) and VIIRS poc (L2) from OB.DAAC;
- **IODA-converter**: preprocess observations for ingestion by JEDI/SOCA (unified format), thinning, retrieve (L2) or define (L3) error/flag info;
- **Forward operators**: model space -> obs. space, filters for quality control and thinning, error inflation;
- Appropriately apply *chlor_a* or *poc* “increments” to model and run checkpoints -> **analysis** restart; **balance** other BGC fields (e.g. PO_4);
- **DA cycle** (e.g. 24-h): model restart -> analysis -> 24h “forecast” -> model restart.

Interim 1° NG-GODAS Reanalysis (3DVAR)



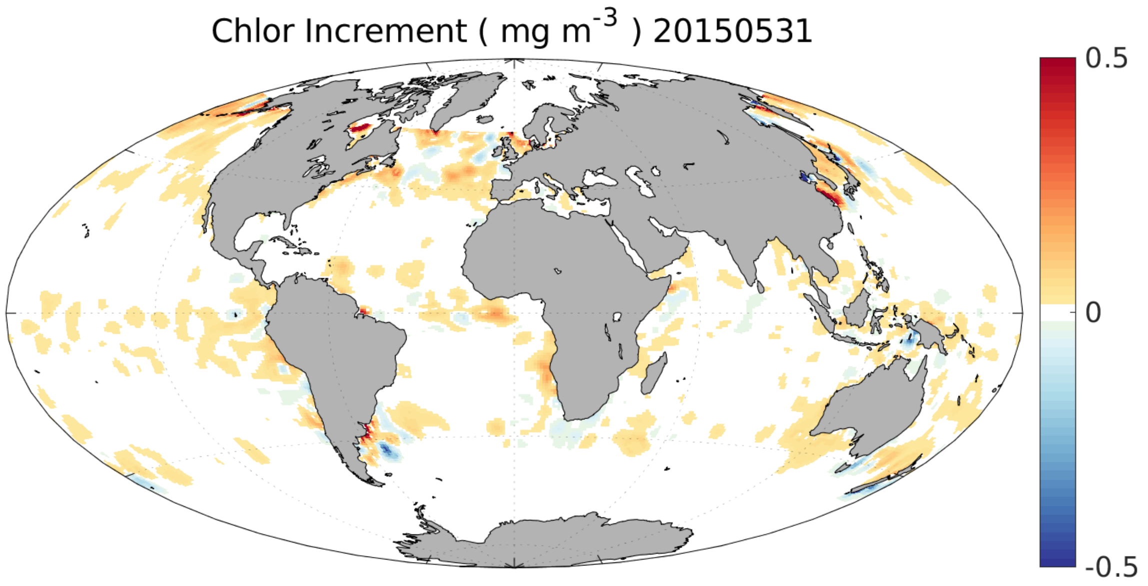
BLING model simulated chlorophyll concentration (snapshot at 12h, 05/31/2021)

Interim 1° NG-GODAS Reanalysis (3DVAR)



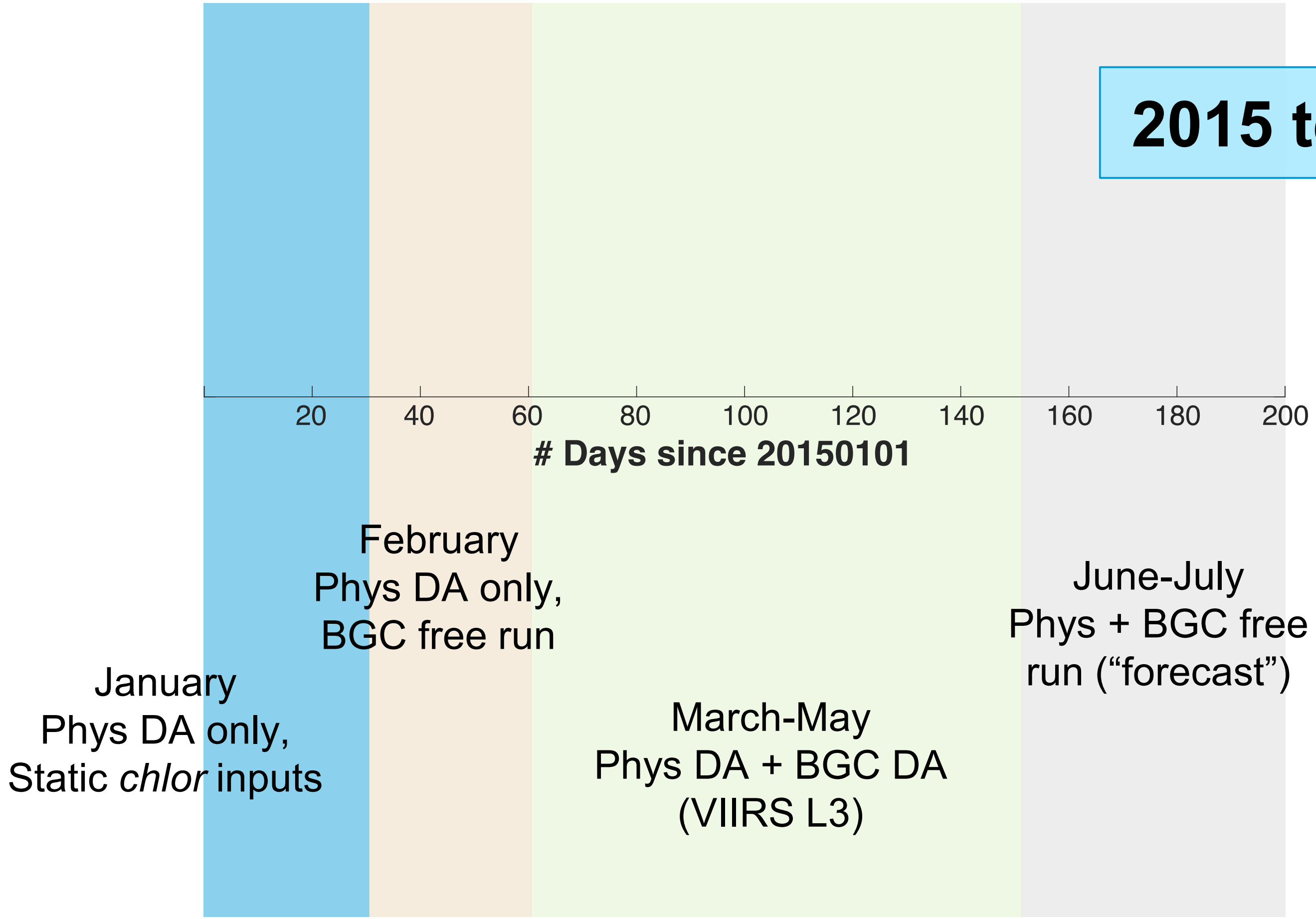
SNPP-VIIRS L3 chlorophyll retrievals (daily composite, 05/31/2021)
Preprocessing: 50% random thinning, <30 mg m^{-3}, assuming 30% observational error

Interim 1° NG-GODAS Reanalysis (3DVAR)



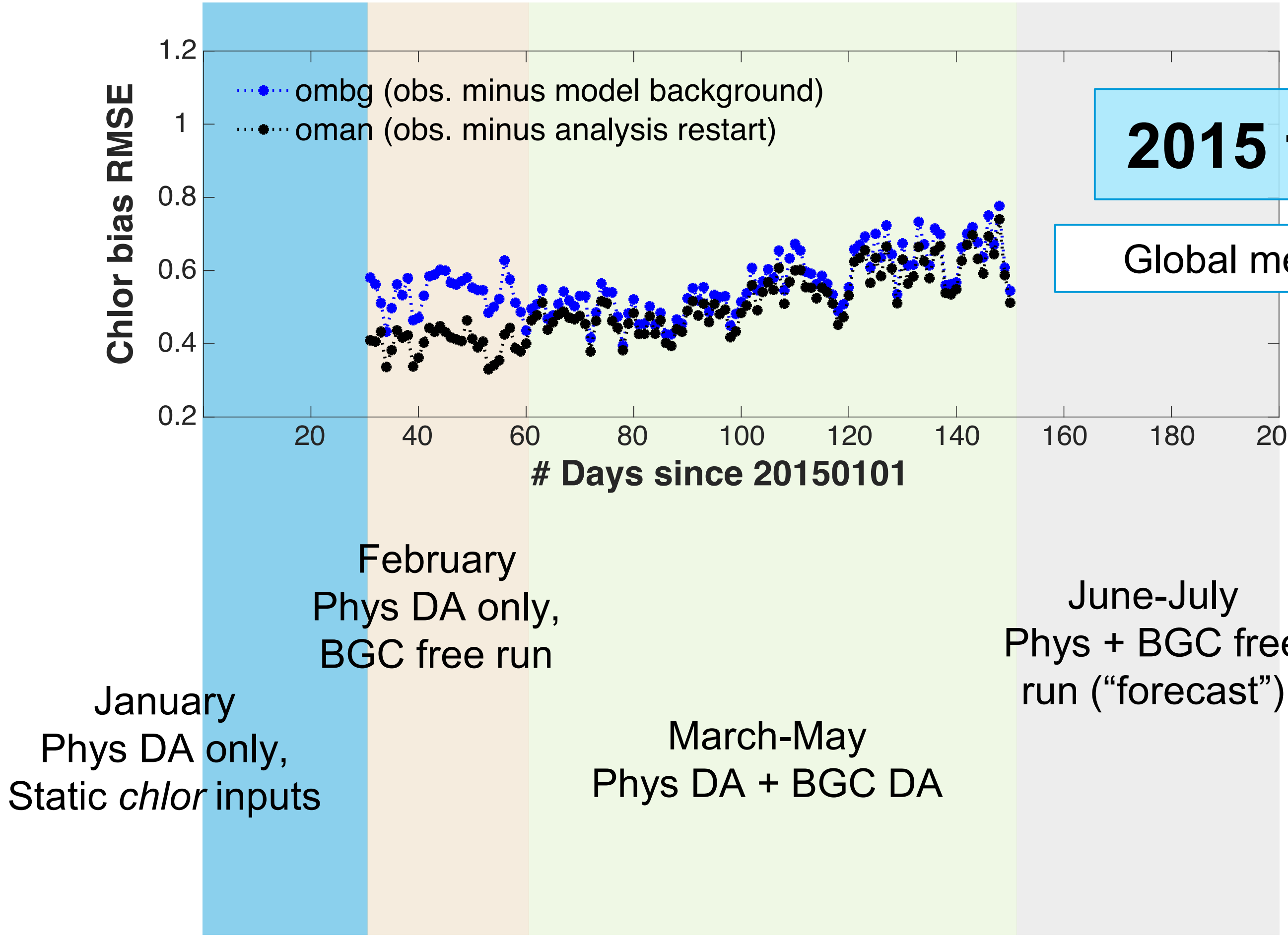
Increments computed by JEDI/SOCA using the variational scheme
Post-processing: checkpoints, “balancing” (i.e. po4, biomass_p) -> analysis

2015 test case



2015 test case

Global mean, 60S – 60N



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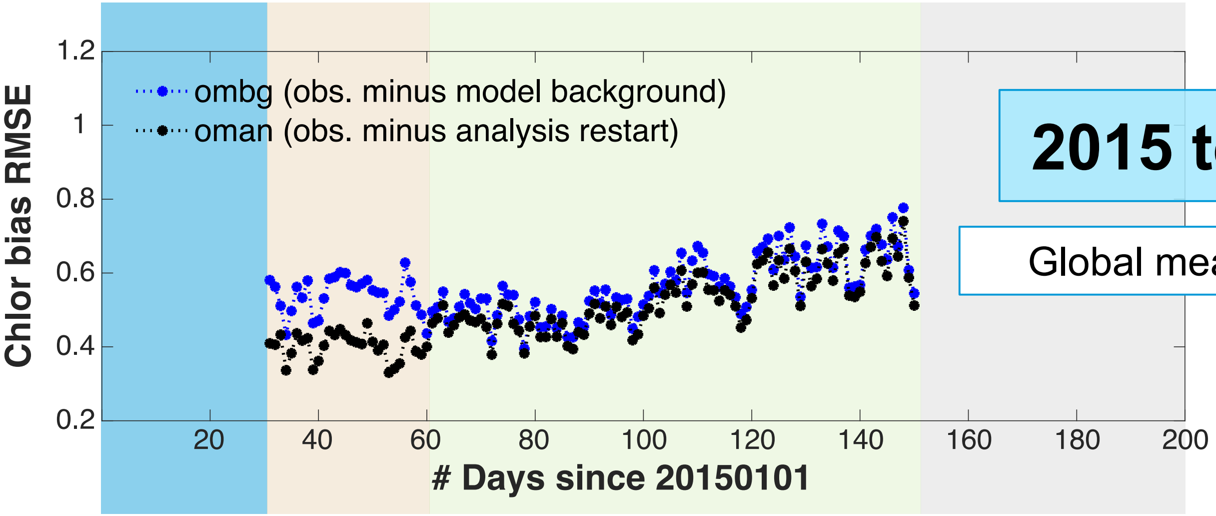
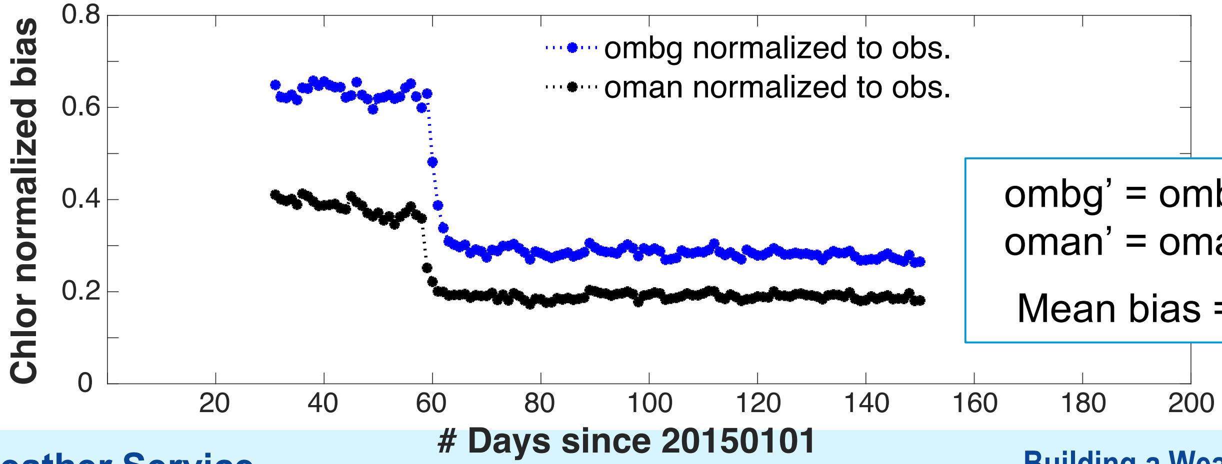
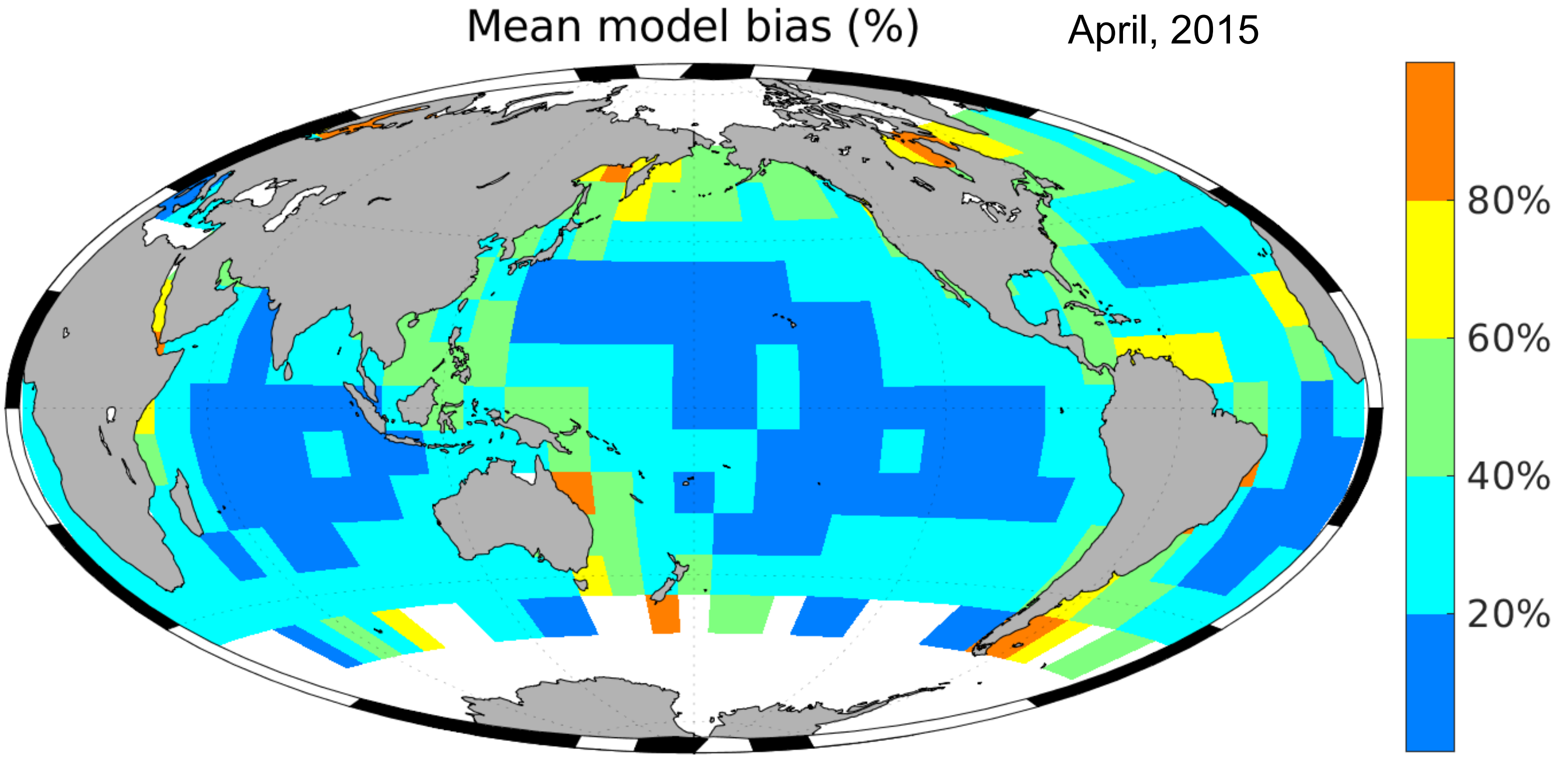
Global mean, 60S – 60N



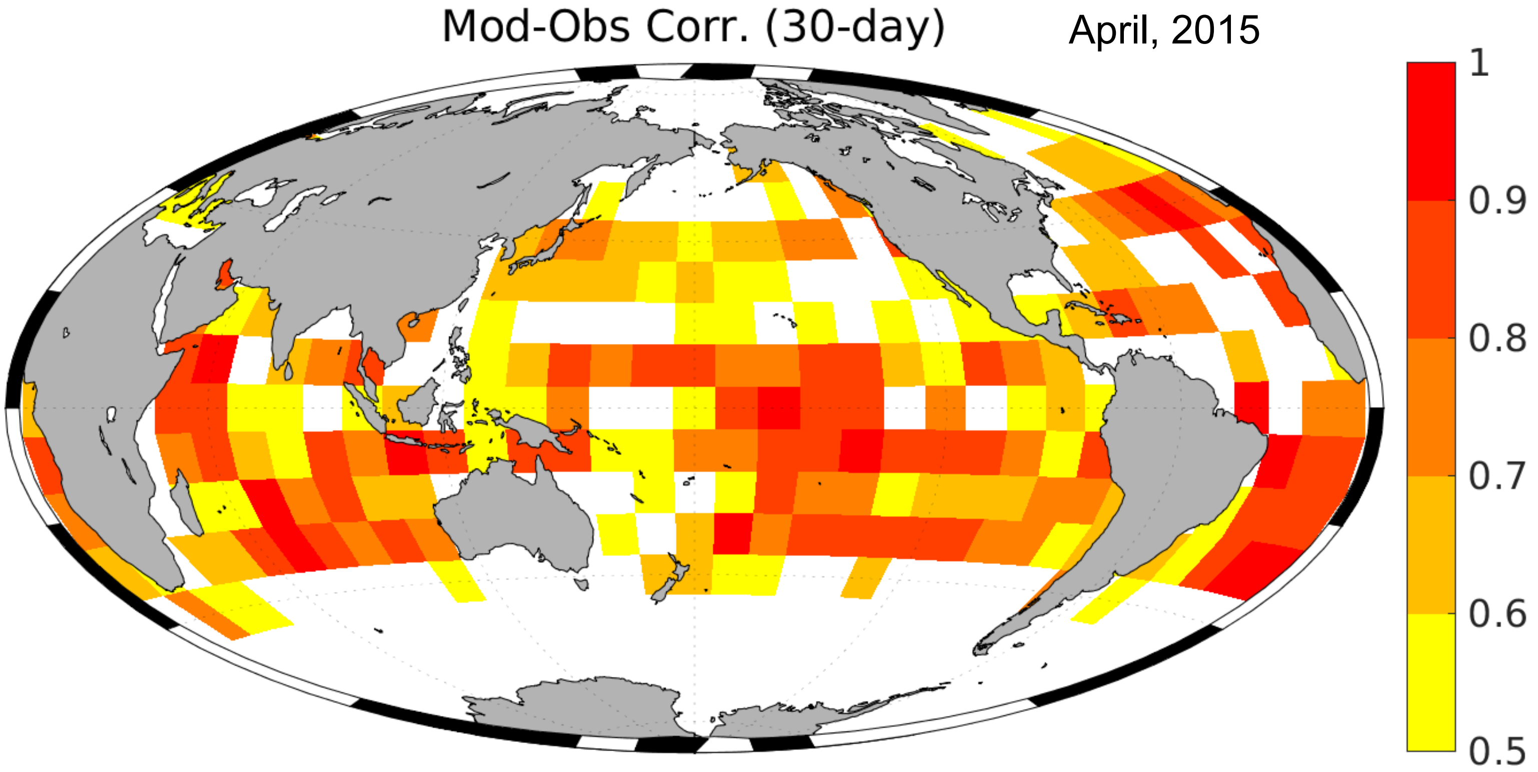


ombg’ = ombg / (obs + 0.0001)
oman’ = oman / (obs + 0.0001)

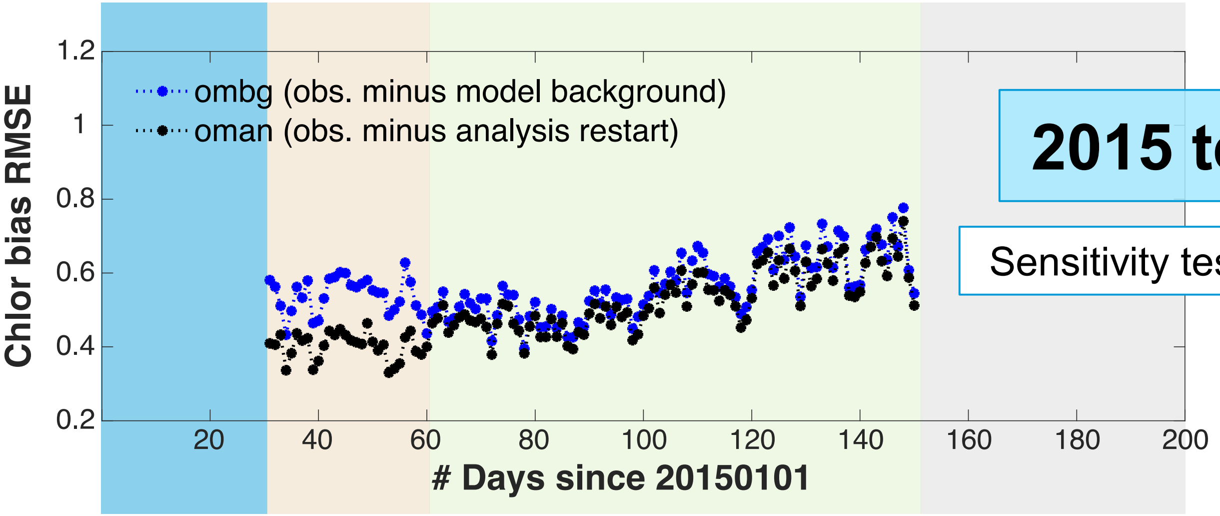
Mean bias = avg(abs(ombg’))



Mean model bias (ombg') averaged over each 10°x10° grid over the 30-day period

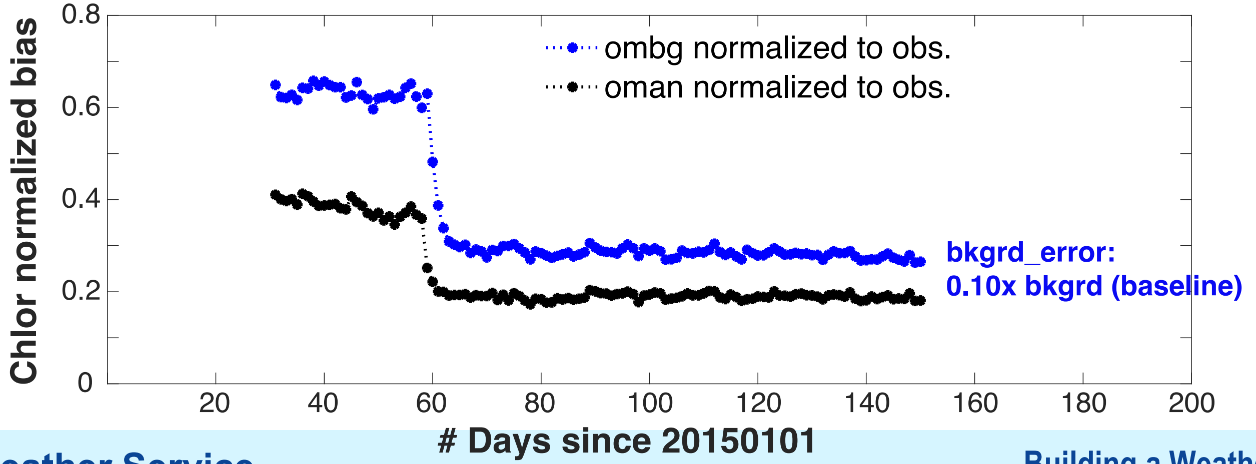


Temporal correlation (n<=30) btw mod. and obs. daily means over each 10°x10° grid (where $p<0.05$)



2015 test case

Sensitivity test: DA constraints



2015 test case

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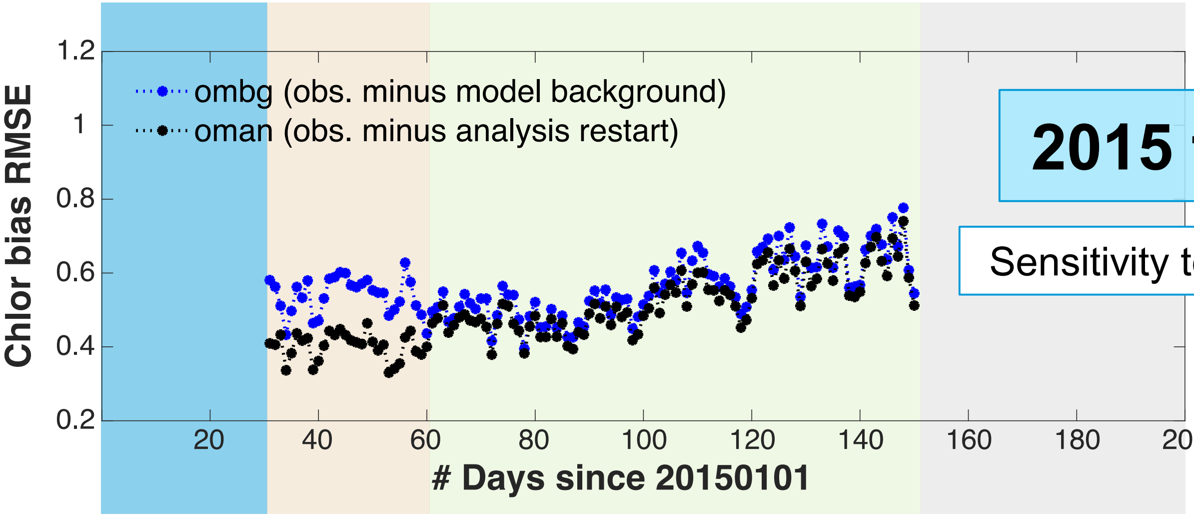

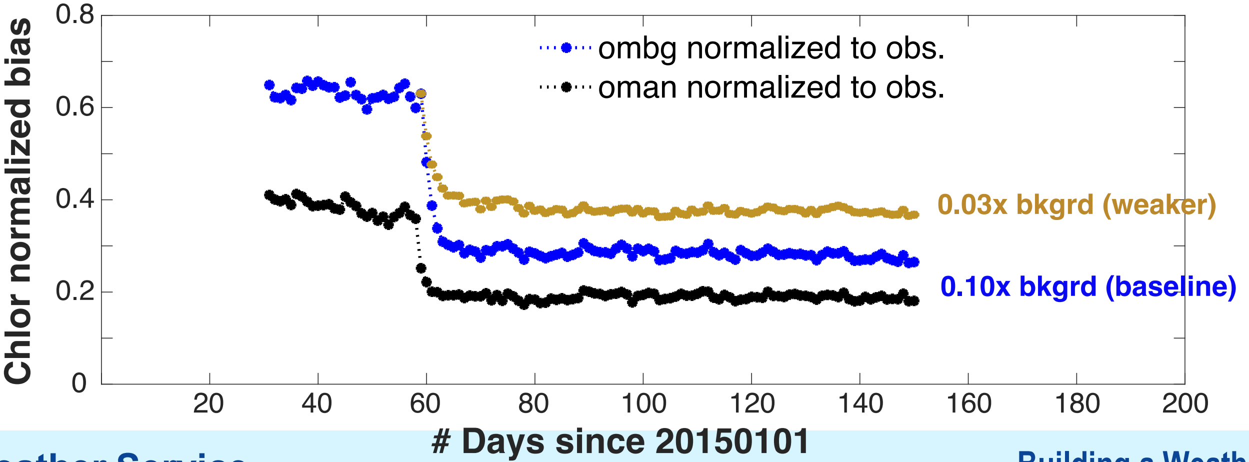

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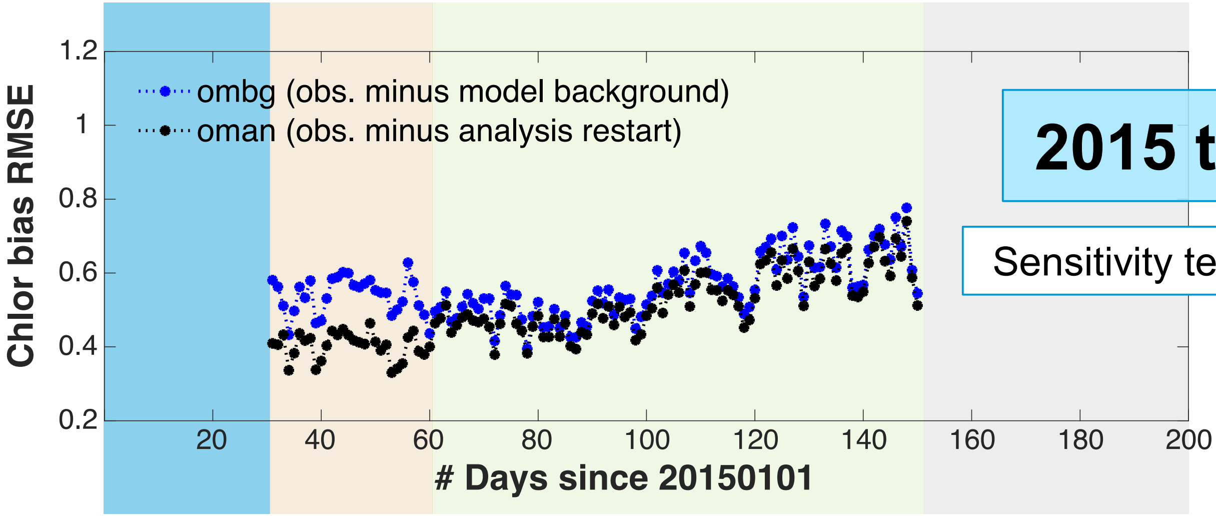

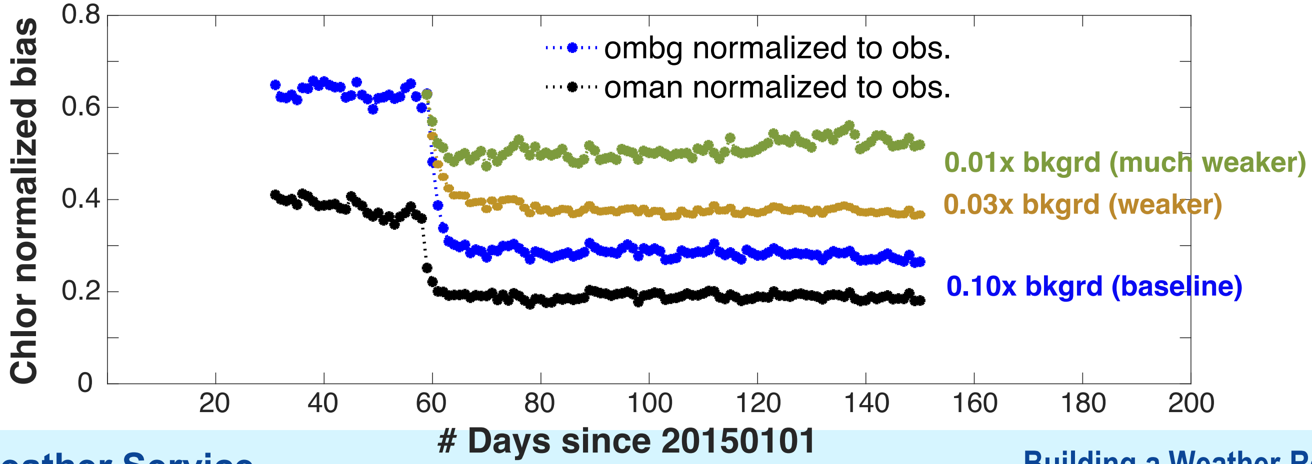

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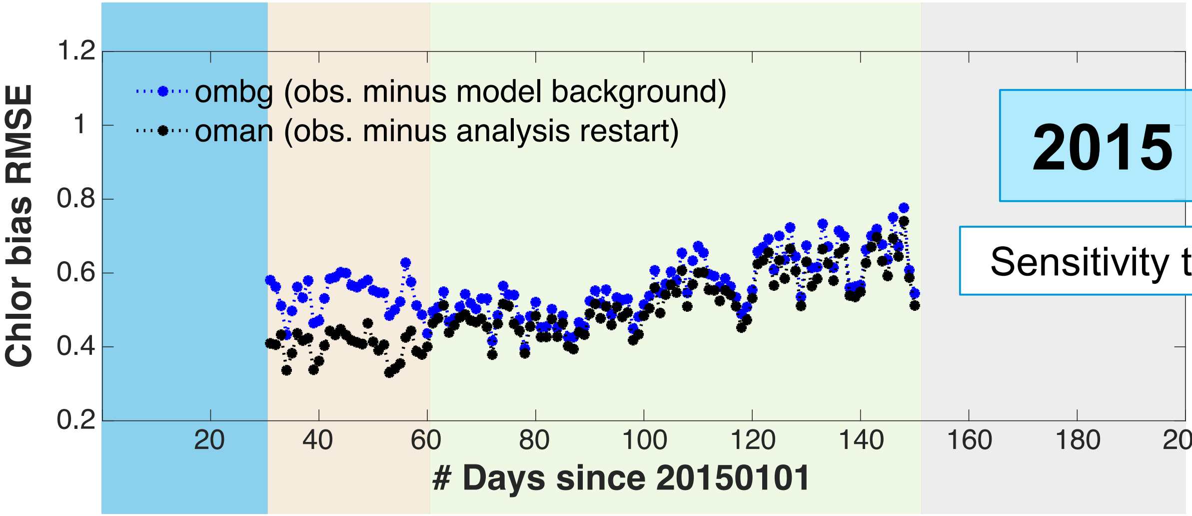
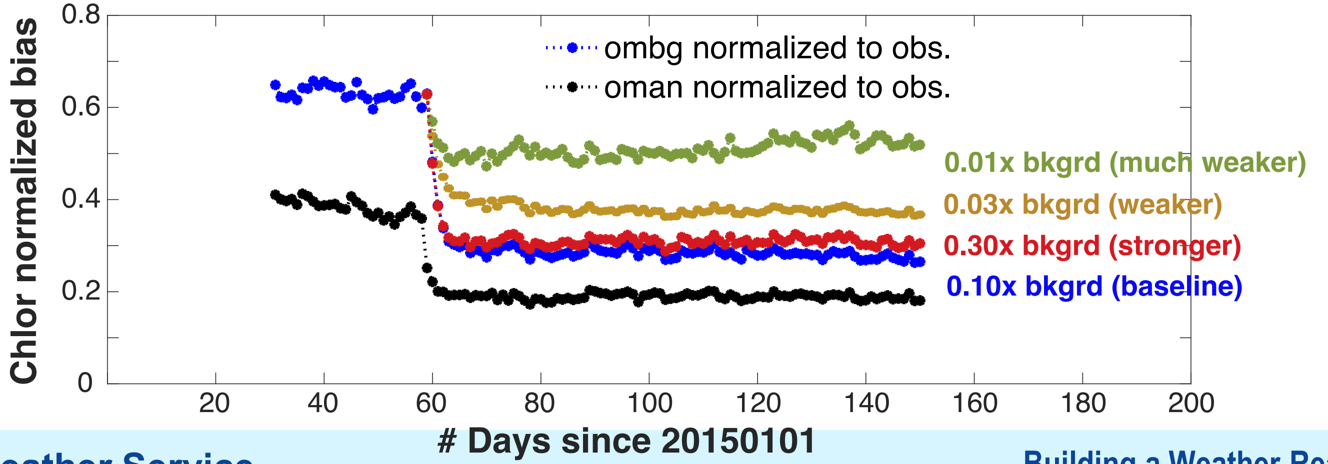
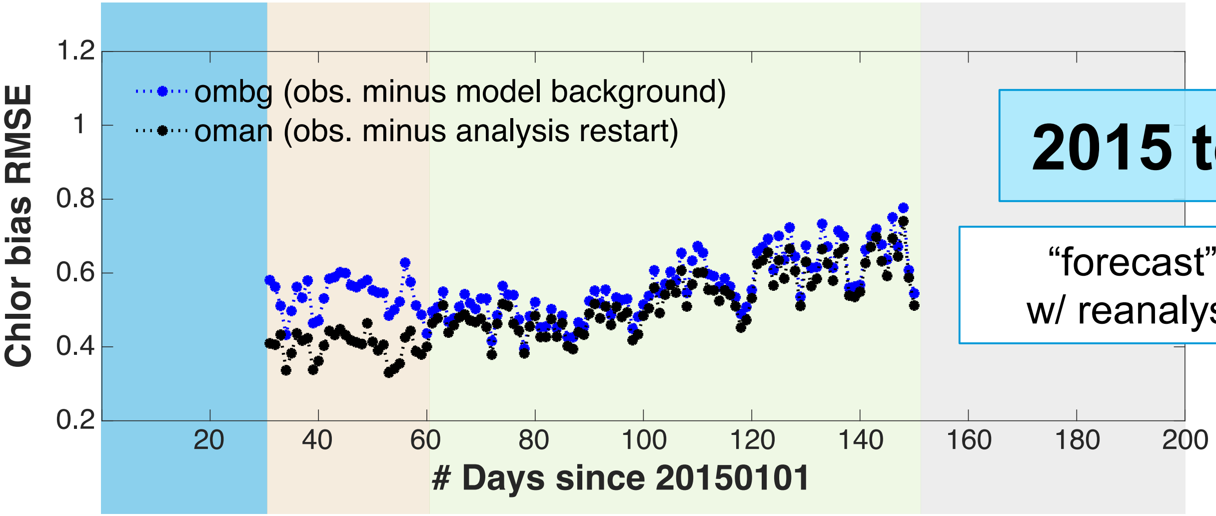
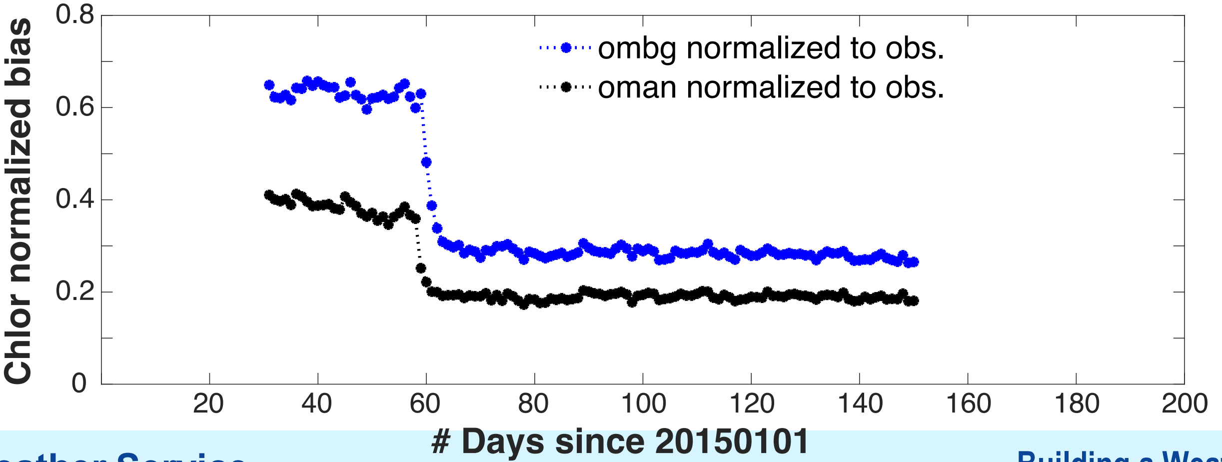


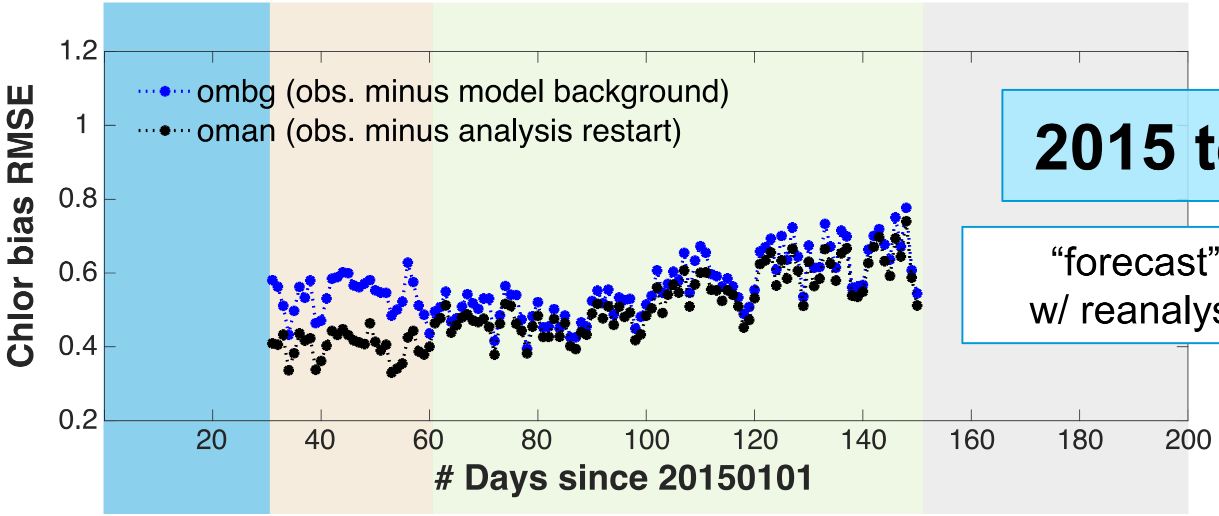




2015 test case

"forecast" experiments
w/ reanalysis atm forcing





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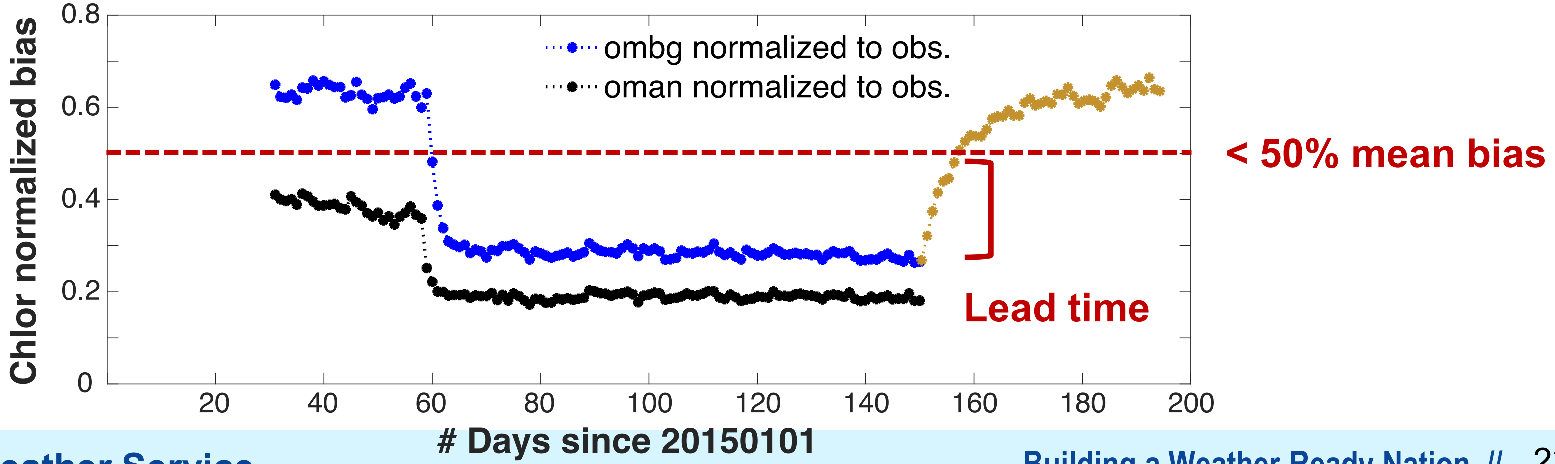
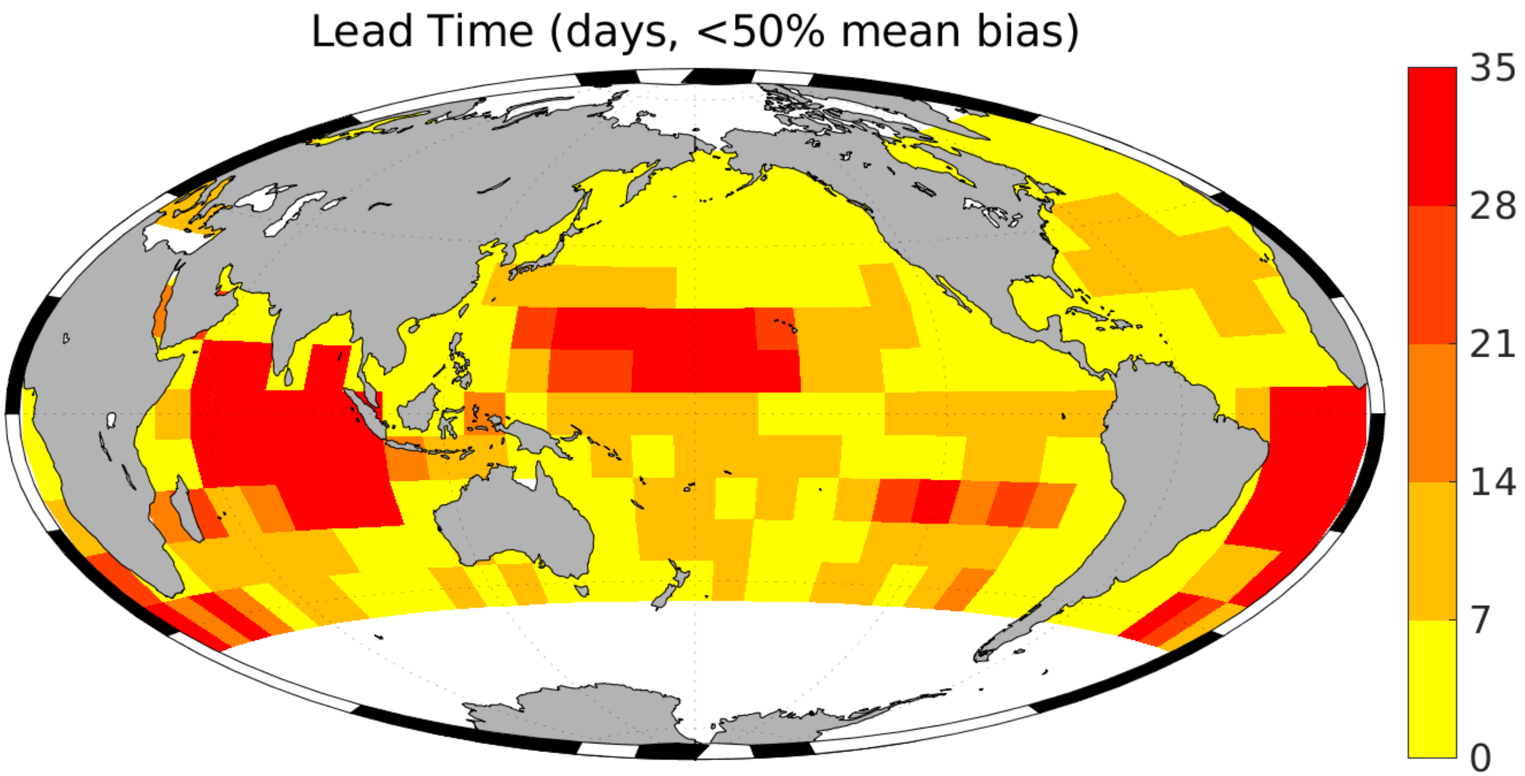
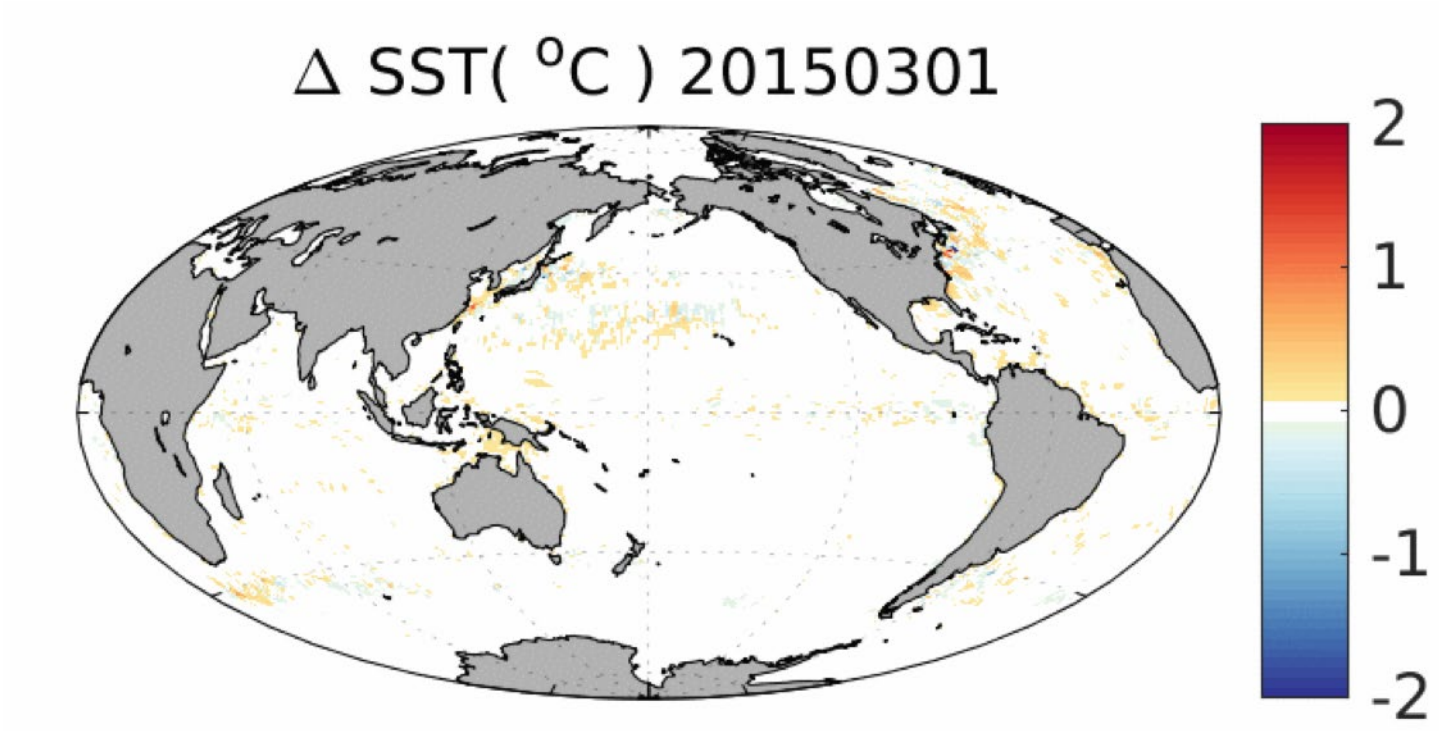


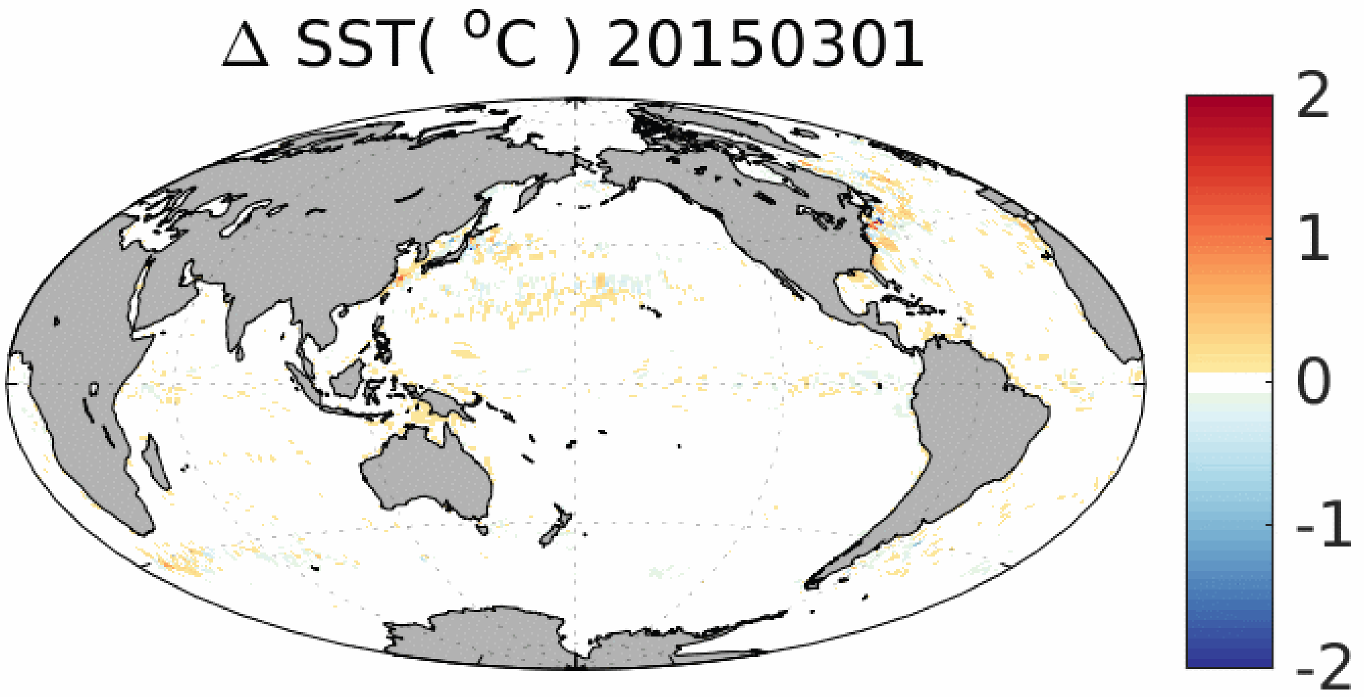

Lead Time (days, <50% mean bias)
35
28
21
14
7
0

Impact of chlorophyll analysis (e.g. on SST)



SST (NG-GODAS phys+bgc DA) – SST (NG-GODAS phys DA only)

Impact of chlorophyll analysis (e.g. on SST)



SST (NG-GODAS phys+bgc) – SST (NG-GODAS phys only)

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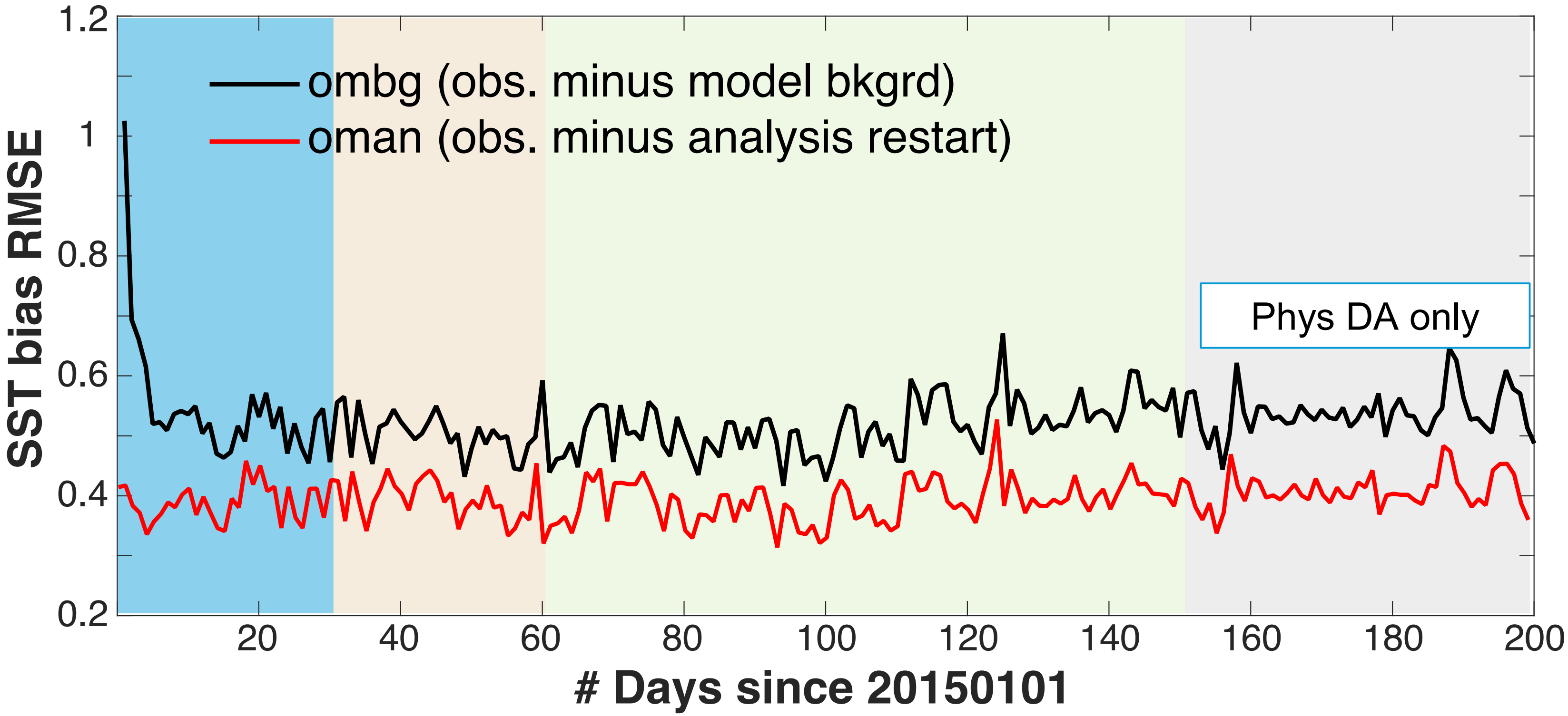

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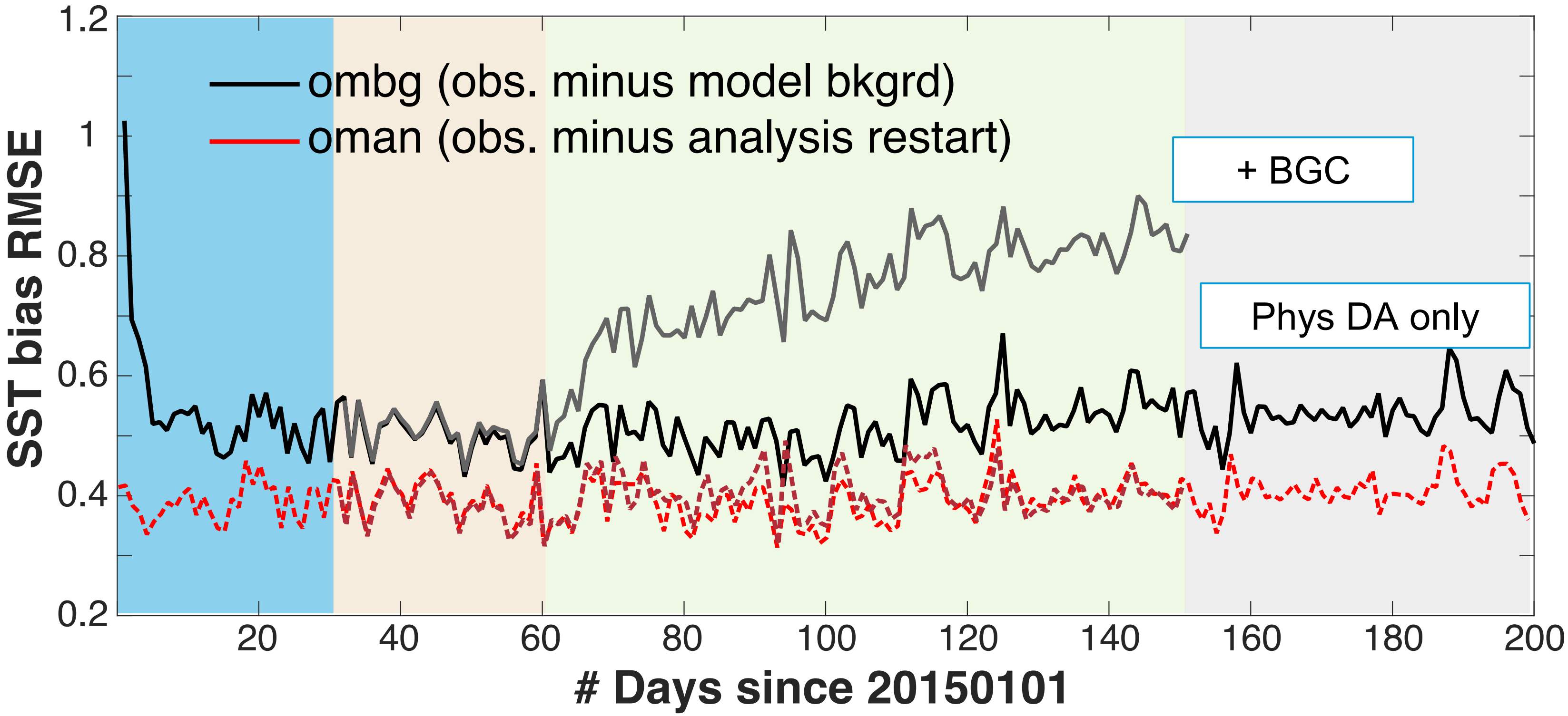
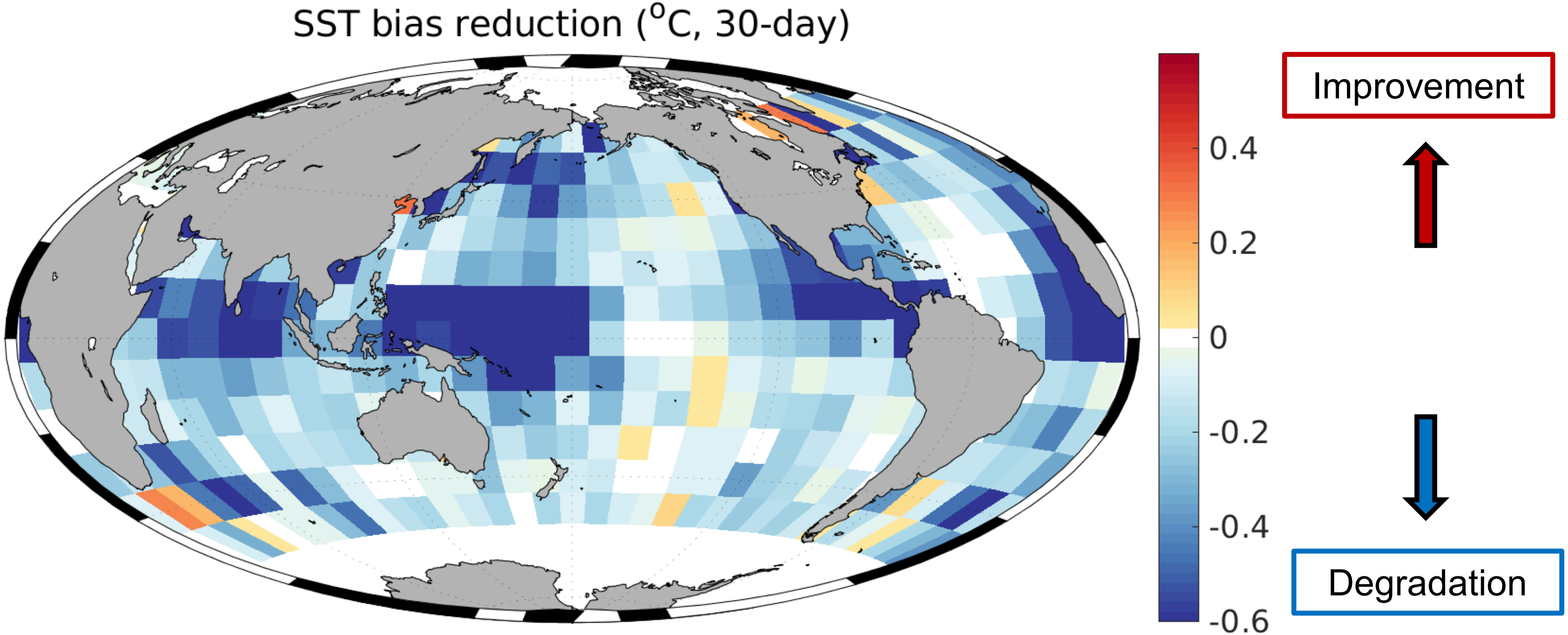


Impact of chlorophyll analysis (e.g. on SST)

April, 2015



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Modeling Global Ocean Biogeochemistry With Physical Data Assimilation: A Pragmatic Solution to the Equatorial Instability

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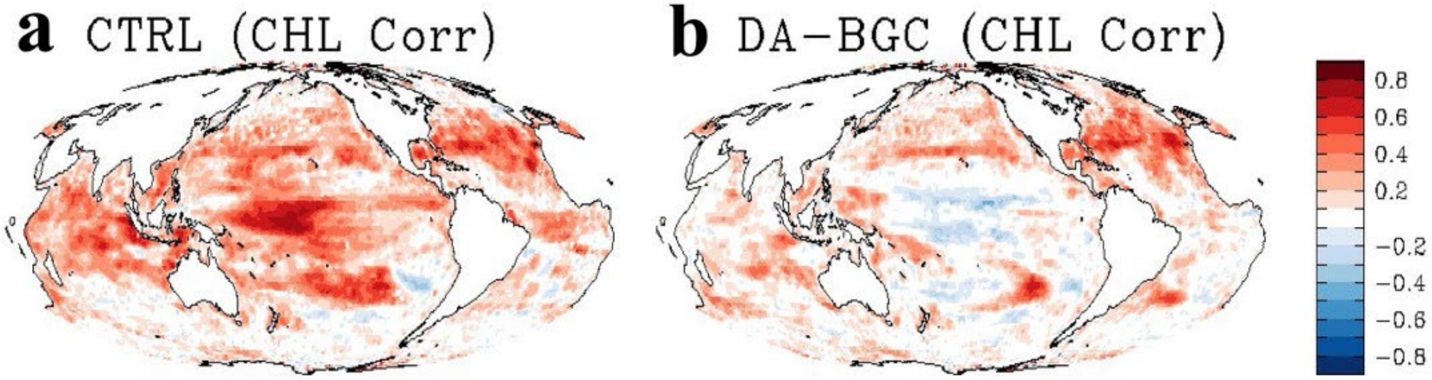

NO ocean DA

w/ Ocean DA

Lessons Learned & Next Steps

- Better understand error functions and covariance model;
- Explore Super-Obing and IAU (IAU incremental analysis updating) options;
- Apply logarithmic transformations to BGC states/obs
- Compare existing DA methods in NG-GODAS: 3DVAR, LETKF, hybrid 3D-EnVar;
- Configure a fully coupled system (e.g. UFS-weather model) to evaluate the impact of BGC DA.

Thank you! Questions?