JEDI-based data assimilation for the UFS marine components

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JCSDA/UCAR

(With help from numerous JCSDA, NOAA, and NASA in-kinds)

Who is JCSDA?

Joint Center for Satellite Data Assimilation (JCSDA):

Interagency partnership dedicated to improving and accelerating use of research and operational satellite data in weather, ocean, climate and environmental analysis and prediction systems

Marine DA in-kinds and collaborators

What is SOCA: Sea-ice, Ocean, and Coupled Assimilation

Overall Goals:

1. **Provide a “menu of marine DA options” based on JEDI**
   for operational DA implementation at NOAA / NASA, and use by the community, focusing on the marine UFS components.

2. **Consolidate DA development efforts and code sharing**
   share components across models (i.e. steal from the atmosphere people!)

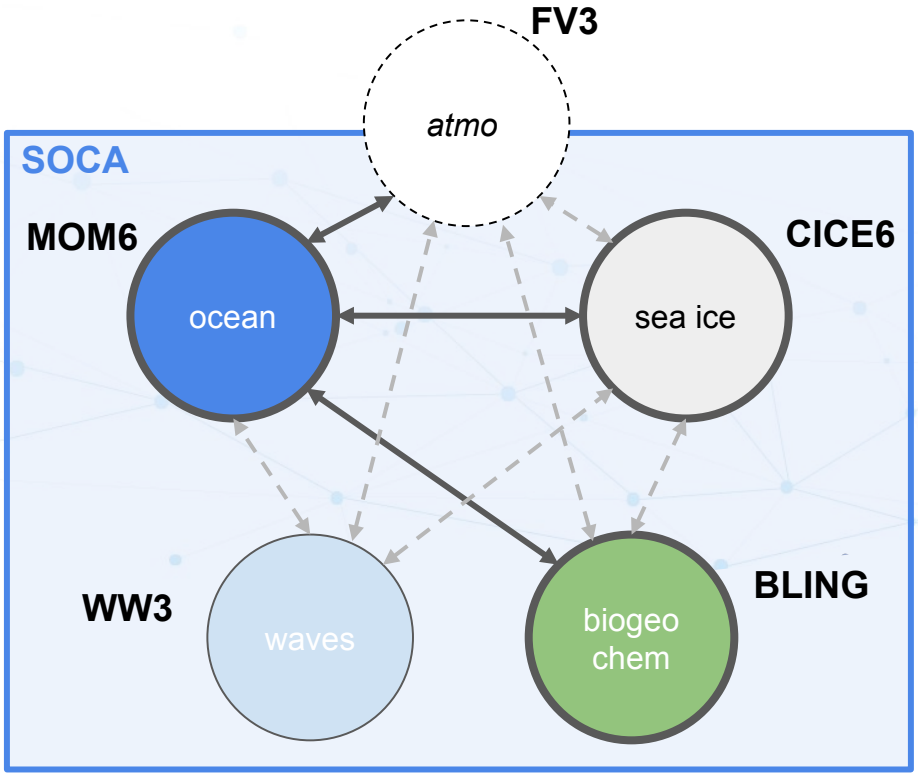
3. **Accelerate marine DA R2O and innovation**
   Advance “coupled assimilation” methods. Engage community development

What is SOCA: Sea-ice, Ocean, and Coupled Assimilation

The components of SOCA

we are developing data assimilation for:

- **ocean (MOM6)**
- **sea ice (CICE6)**
- ***ocean biogeochemistry (BLING)***
- **air-sea interactions**
- waves (Wavewatch3)
  (insufficient resources to focus on waves at this time, any volunteers??)



SOCA: targets for NOAA/NASA

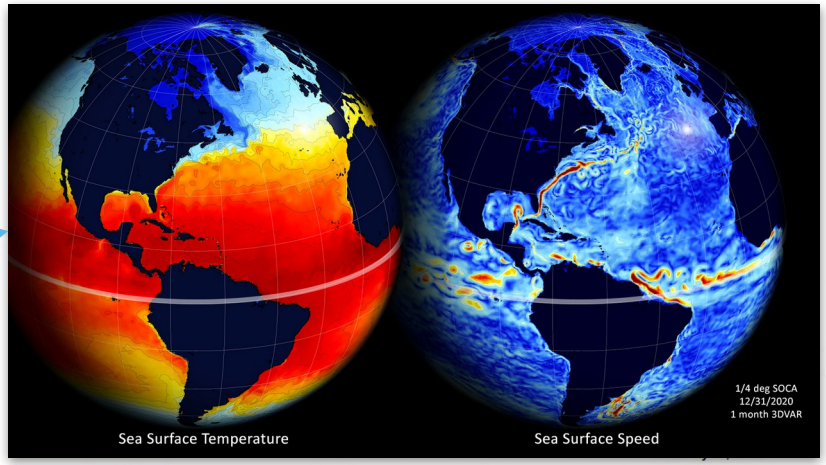
Global DA

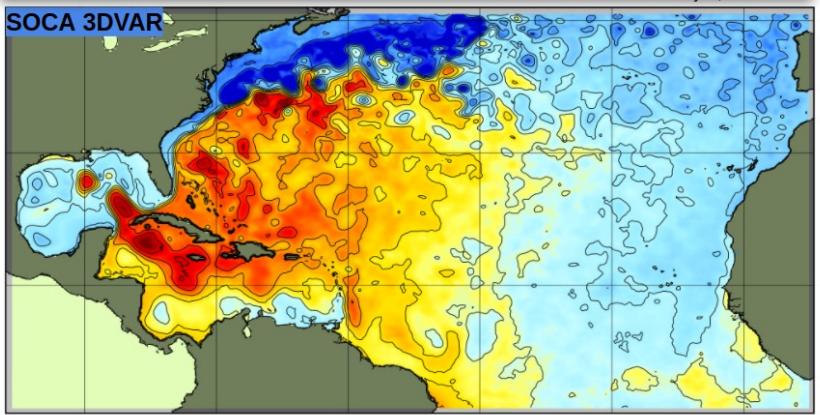
¼ degree ocean/ice initialization

- **NOAA NG-GODAS** ✅
  (40 year 3DVAR reanalysis on AWS)
- **NOAA GFSv17 / GEFSv13**
  (initialized using Hybrid LETKF-EnVAR)
- **NASA GEOS**
  In development for next GEOS system

Regional DA

- **NOAA 1/12 deg HAT10 regional**
  with eventual benefits for HAFS initialization





SOCA: developing a “menu” of ocean/ice DA options

Working now

- 3DVAR
- 3DVAR-FGAT
- LETKF
- Hybrid LETKF-EnVAR ⭐
  (target for NOAA operations)
- Hybrid EDA-EnVAR

2023

- **4DLETKF / 4DEnVAR**
- SOCA/UFS supported in JCSDA Skylab

2024

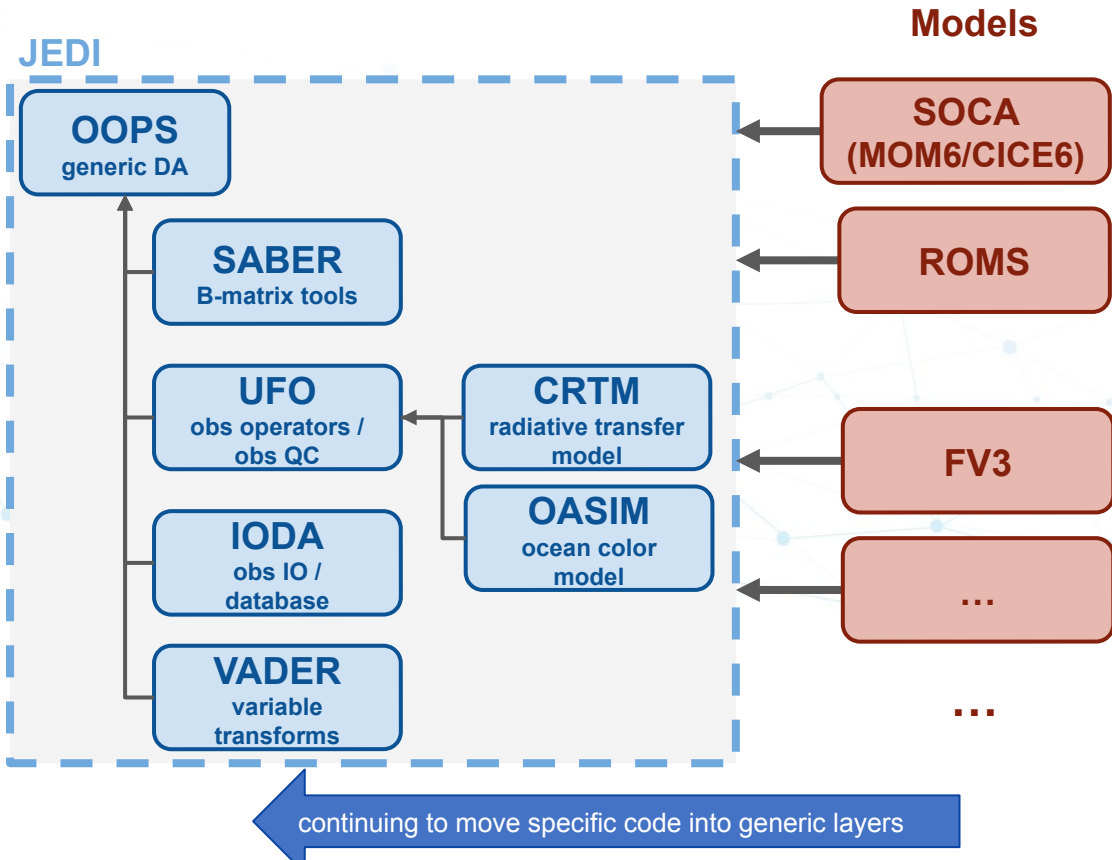
- **4DVAR**
- coupled multi-component covarianc
- future JEDI methods
  (e.g. particle filter)

in progress

SOCA: Built on JEDI

JEDI: Joint Effort for Data assimilation Integration

- A model and component agnostic toolkit
- The ocean DA community is small, any common JEDI parts we use that were developed by other groups (i.e. atmosphere DA) is a win!
- A common DA system for all UFS components will accelerate coupled DA science

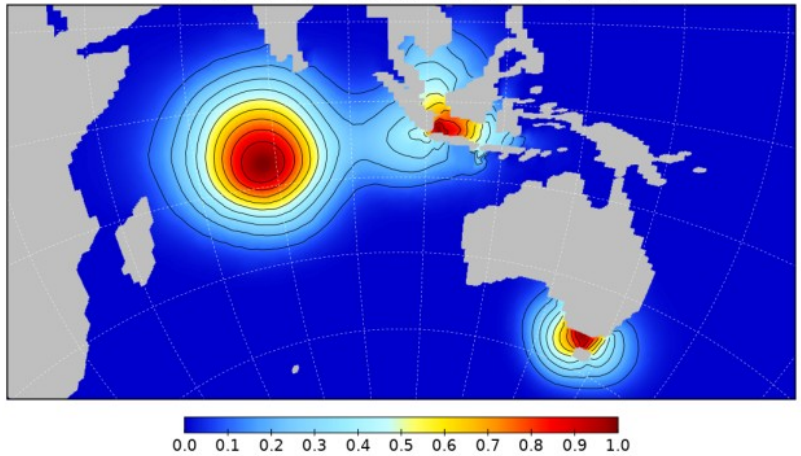


JEDI: example of common components used by SOCA

Examples of generic JEDI components used
(with no, or minimal, coding on our part!)

- **SABER** - static B model.
  Able to simulate a diffusion operator (normally ocean specific, and difficult to implement correctly), but faster!

SABER - emulating a diffusion operator



JEDI: example of common components used by SOCA

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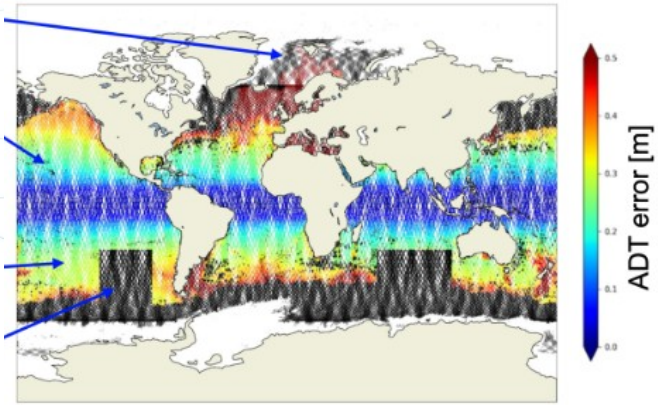
- **UFO**- Forward operators and QC filters



land mask →

remove if bkg too cold →

O-B check →

gross bounds check →

obs error inflation →

remove troublesome regions →

```
obs filters:
- filter: Domain Check
  where:
  - variable: {name: sea_area_fraction@GeoVaLs}
    minvalue: 0.9

- filter: Domain Check
  where:
  - variable: { name: sea_surface_temperature@GeoVaLs}
    minvalue: 5.0

- filter: Background Check
  absolute threshold: 0.2

- filter: Bounds Check
  minvalue: -2.0
  maxvalue: 2.0

- filter: Perform Action
  action:
    name: assign error
    error function:
      name: LinearCombination@ObsFunction
      options:
        variables: [mesoscale_representation_error@GeoVaLs,
                    absolute_dynamic_topography@ObsError]
        coefs: [1.0, 1.0]

- filter: BlackList
  where:
  - variable:
      name: latitude@MetaData
    minvalue: -65
    maxvalue: -30
  - variable:
      name: longitude@MetaData
    minvalue: -125
```

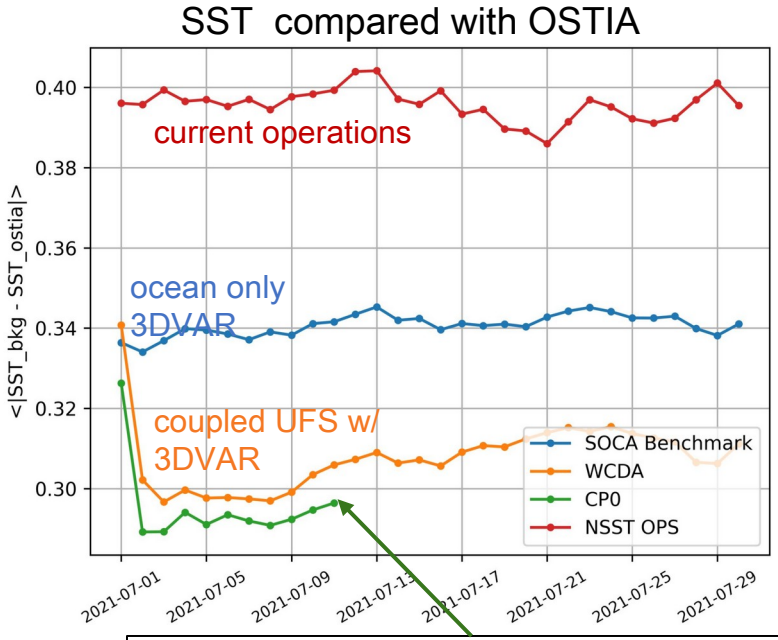
SOCA: Highlight on adoption at NOAA/EMC

NOAA/EMC using SOCA for GFSv17/GEFSv13

- ocean/ice DA is SOCA Hybrid LETKF-EnVAR
- atmo DA is existing GSI (i.e. not JEDI)

The current weakly coupled EMC testbed results so far are very encouraging

- Foundation temperature is increasingly better
- GSI's AVHRR radiance O-B improves when SST foundation improves
- Ocean current slightly better defined



Hybrid EnVAR w/ static ens: Status as of 07-11-2023.
Hybrid EnVAR with 30 offline members

(G. Vernieres, NOAA/EMC)

SOCA: Highlight on adoption at NOAA/EMC

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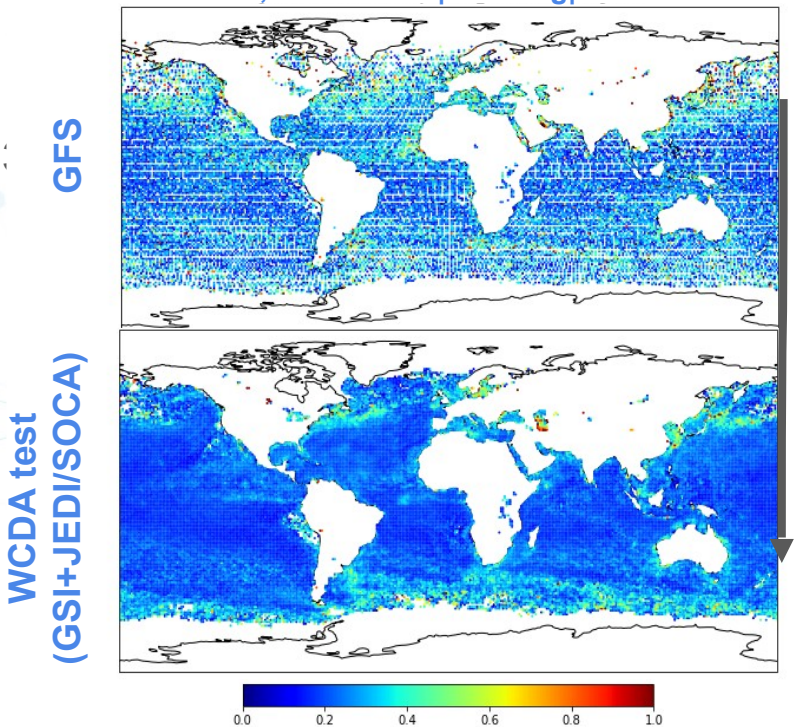
AVHRR NOAA-18, channel 3 <|Obs-Bkg|> from GSI/CRTM



- More obs passed the GSI QC
- Smaller O-B almost everywhere

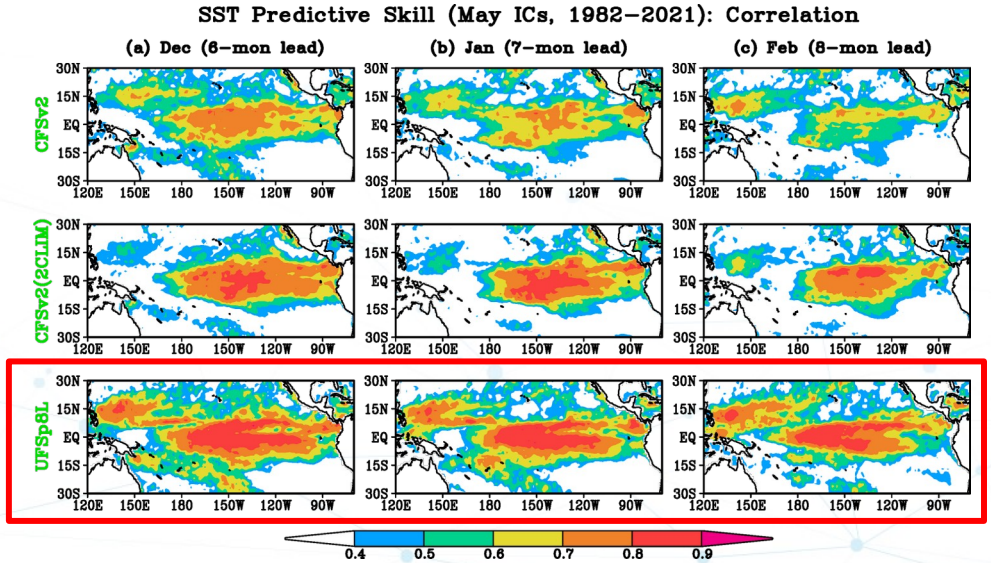
(G. Vernieres, NOAA/EMC)

SOCA: Highlight on adoption at NOAA/CPC

NOAA/CPC performing experiments with UFSp8

- ENSO hindcast experiments with UFSp8
- initialized with SOCA ocean/ice DA (called GLORe here)

The UFSp8 initialized with GLORe has better ENSO forecast than the current operational system (CFSv2)



	ATM. model	ATM. resolution	OCN./ICE model	OCN./ICE resolution	ATM. IC	OCN. IC	ICE IC
CFSv2	Spectral GFS	T126 (~100km) L64	MOM4 +SIS	1/2deg	CFSR	CFSR	CFSR
UFSp8L	FV3+Thompson microphysics+...	C96 (~100km) L64	MOM6 +CICE6	1deg	CFSR	GLORe	GLORe

(J. Zhu, NOAA/CPC)

SOCA: The future: coupled DA!

By having all earth system component DA under JEDI, we can make progress on coupled DA.

Plan to focus heavily on this in 2023/2024

2023: Coupled hofx

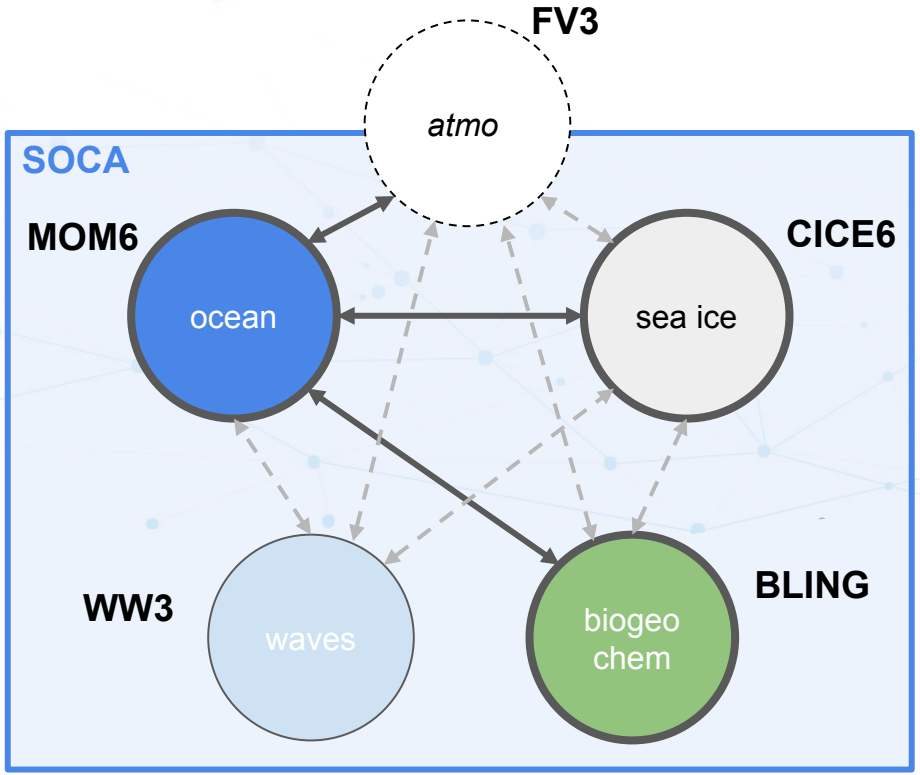
(surface sensitive radiances)

- **CRTM** - infrared (AVHRR), microwave (GMI),
- **OASIM -** ocean color (PACE/VIIRS/MODIS)

2024: Coupled covariances

(observation impacts across components)

- via explicit balances (e.g. sea-ice/SST)
- via ensemble (LETKF/EnVAR)



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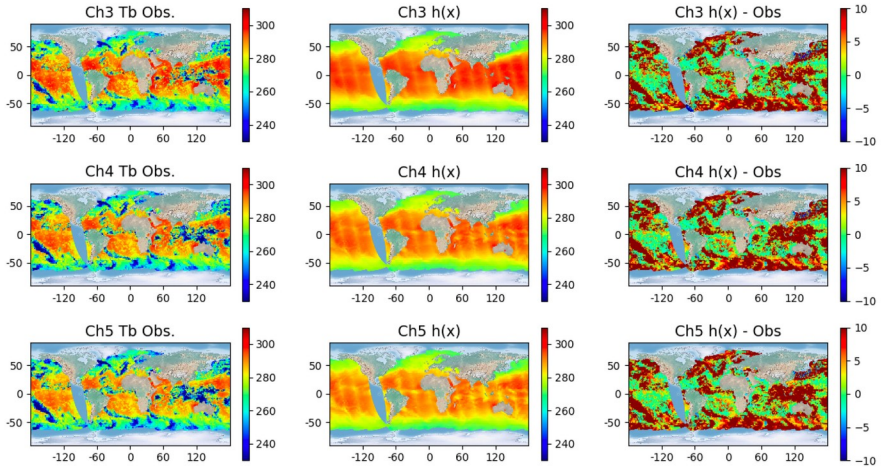
CRTM: SST sensitive IR channels



AVHRR METOP-A (Dec 15, 2020), 24 hour window, GEOS (C360 atmosphere, ¼ degree ocean),

(H. Ebrahimi)

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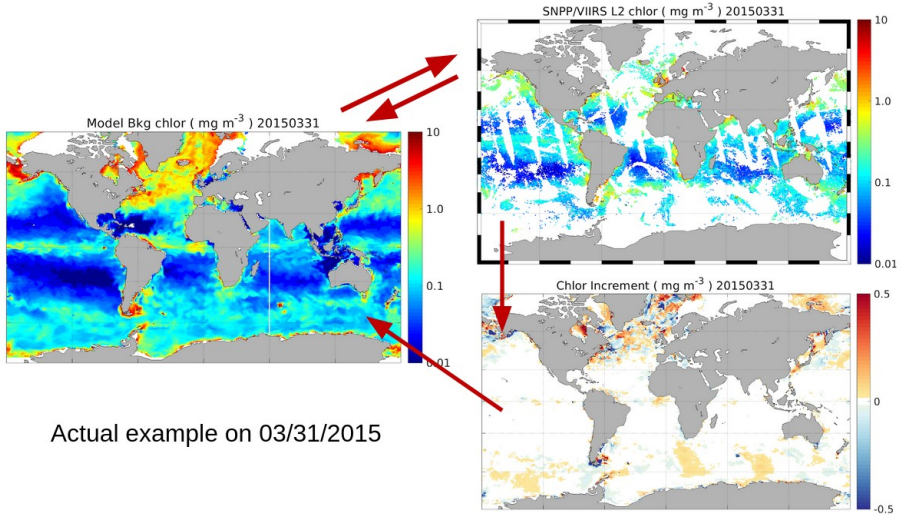
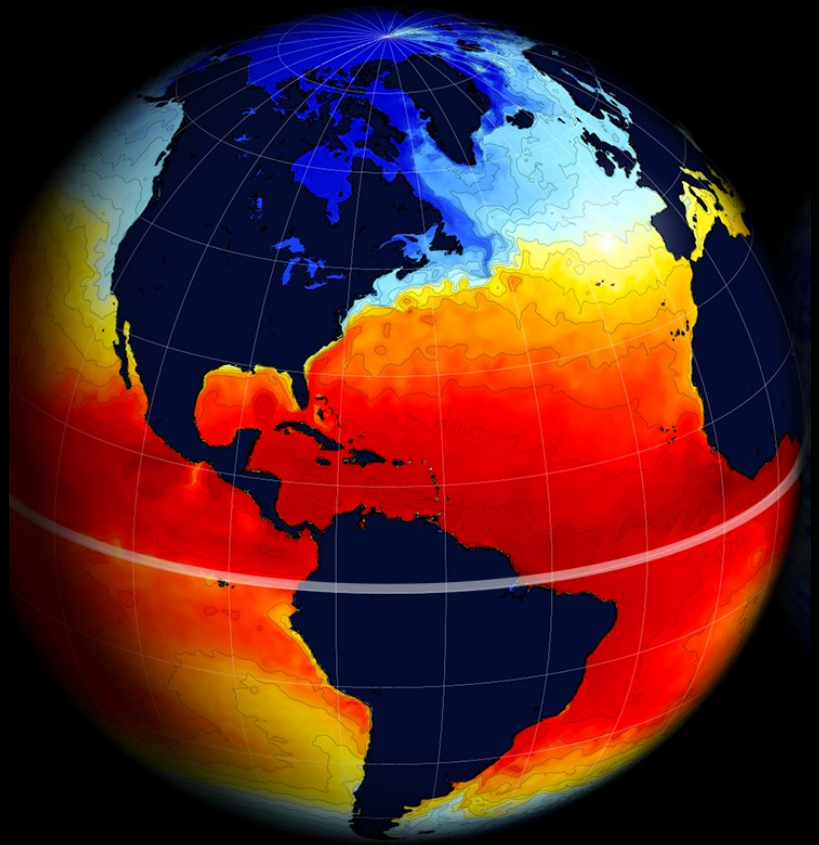
OASIM: Ocean Color DA

3DVARiational daily chlorophyll analysis (01/01/2015-03/31/2015)



Actual example on 03/31/2015

(H. Ebrahimi, X. Liu NOAA/*EMC*)



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SOCA: https://github.com/jcsda/soca

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