Towards a WCDA system for the GFSv17 at NCEP: Preliminary results for the ocean and sea-ice

May 9-11, 2023 Ocean Predict

NATIONAL WEATHER SERVICE

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Outline

- Background
- Overview of the WCDA system
- Experiments
- Preliminary Results
- Summary

Background

- Planned upgrade (GFSv17) of the current operational GFSv16 for MRW and S2S
  - dynamically coupled
  - Atmos: FV3 dy-core at ~13km/9km horiz resol (C768/C1152), 127 vert layers (w/ NSST)

    (NSST: Near Sea Surface Temperature: Xu Li, 2007)
  - Aerosols: GOCART, same resolution as the atmosphere
  - Ocean: GFDL MOM6 at 0.25 deg horiz resol, 75 vertical hybrid layers
  - Sea-ice: Los Alamos Sea-ice CICE6 at 0.25 deg horiz resol.
  - Waves: NOAA/NCEP WAVEWATCHWIII
  - Land/Snow: Noah-multi parameterization (noah-pm), same resolution as the atmosphere

Weakly Coupled DA (WCDA)

Target WCDA system:

- **Atmosphere**: hybrid 4DEnVAR, 4D LETKF for perturbations (GSI)
- **NSST**: by product of the above (GSI). Probably not part of JEDI/SOCA for v17
- **Land/Snow**: Ens. OI (JEDI/FV3-JEDI)
- **Ocean & Sea-ice**: Hybrid EnVAR with LETKF perturbations (JEDI/SOCA). Probably only 3D background error covariances but 4D h(x)
- **Aerosol**: 3DVAR FGAT (JEDI/FV3-JEDI)

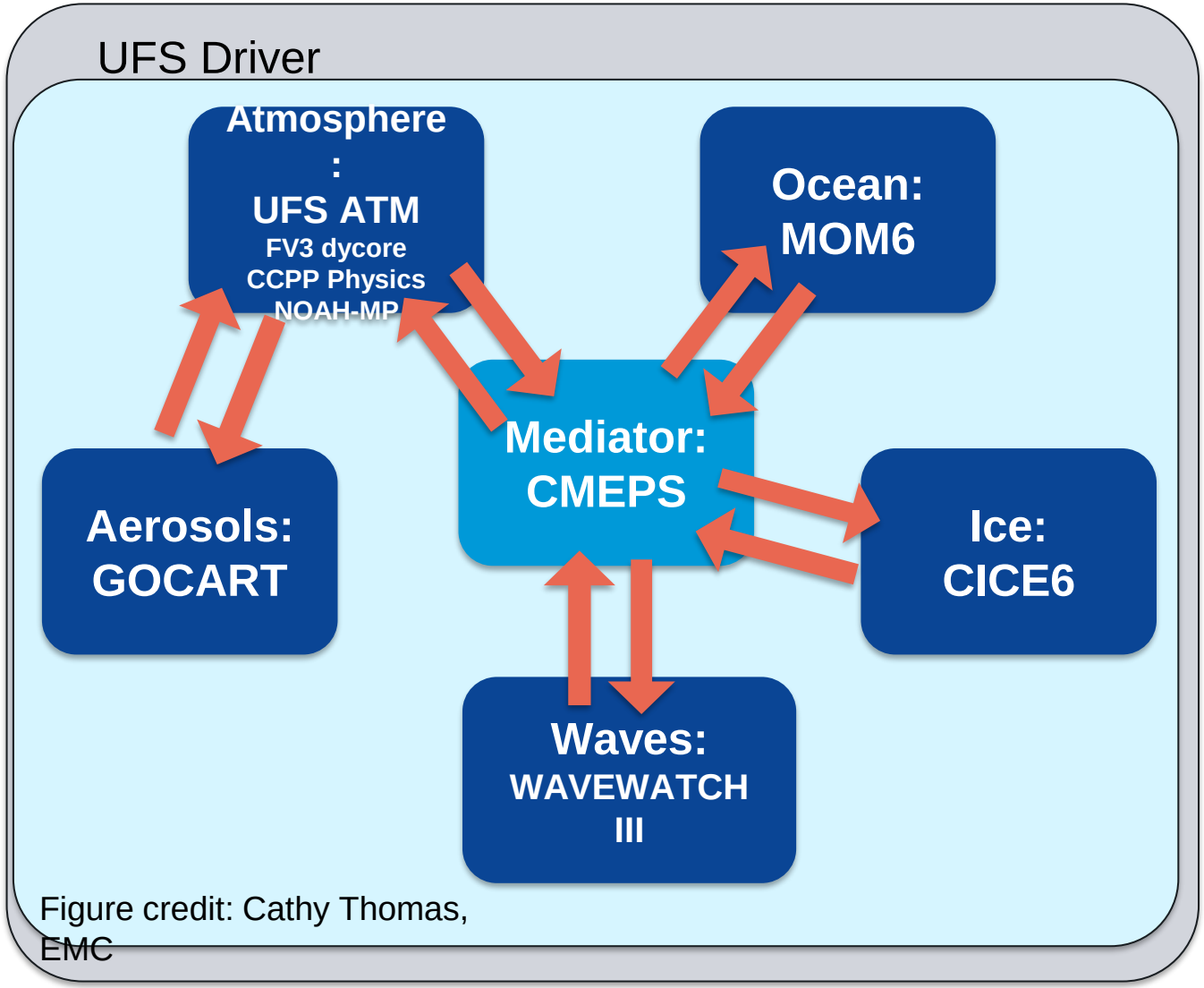
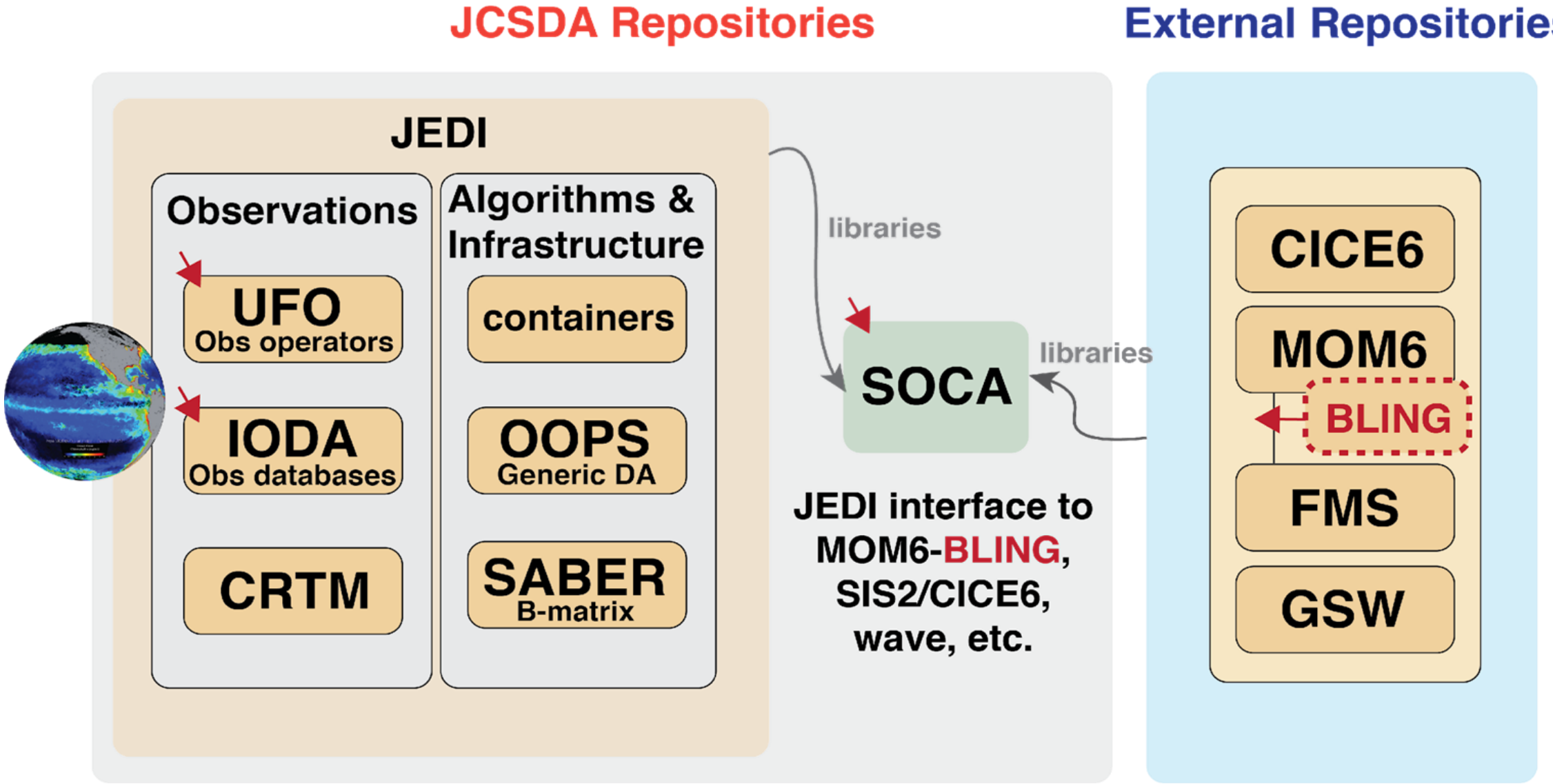


Figure credit: Cathy Thomas, EMC

Joint Effort for Data Assimilation Integration (JEDI)



Experiments

Weakly Coupled DA System (WCDA) as an initial prototype of GFSv17

- Atmos - C384 (½ resol of operational GFSv16)

  3DVAR FGAT (GSI)

- Ocean - 0.25deg

  3DVAR/FGAT w/ IAU (JEDI/SOCA)

- Sea-ice - 0.25deg
- Period: July-2021
- IC: Benchmark SOCA based short reanalysis (~6 months)
- Two sets:
  - no-ocn-DA (WCDA+Atmos-DA)
  - WCDA: (WCDA+ Atmos-DA+Ocean/Sea-ice -DA)

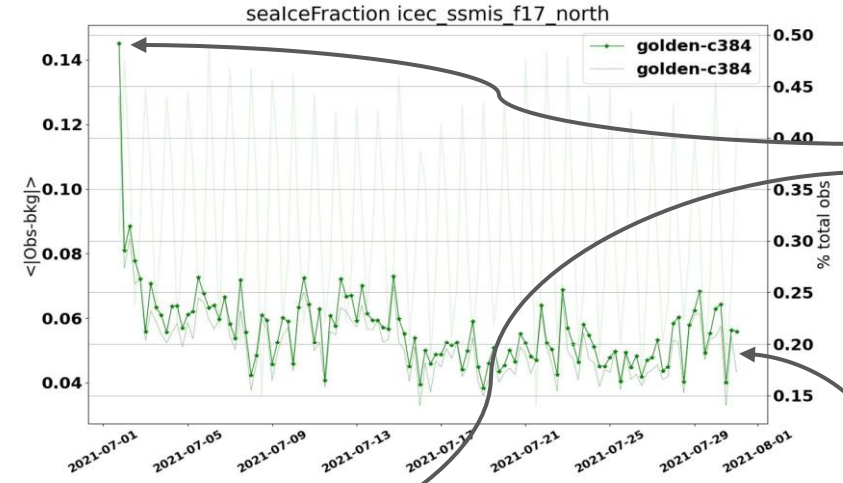
Experiments

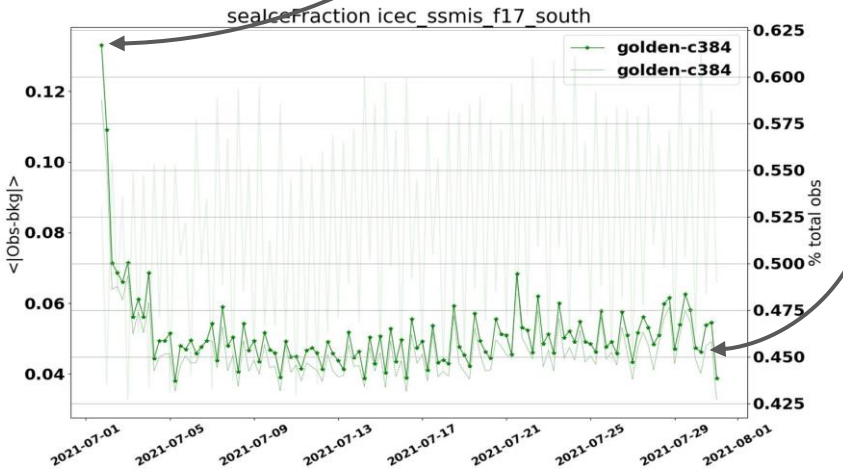
- Marine Observations:
  - SST (L3U) retrievals: VIIRS-NPP, AVHRR-MetOp <A,B,C>
  - ADT (L2): Sentinel <3a,3b>, Jason-3, SARAL/Altika
  - Icec (L2): SSMIS <F17,F18>

- Atmospheric Observations
  - Conventional
    - Surface obs
    - Sondes
    - Profilers
    - Aircraft
    - Buoys
    - Ships
  - Satellite Radiances
    - Infrared (polar/geostationary): CrIS, IASI, GOES, AVHRR, VIIRS
    - Microwave (polar): AMSU-A, ATMS, MHS, SSMIS
  - Derived Satellite Products
    - Derived Motion Winds: GOES 16/18, Meteosat-10, Himawari-9
    - Scatterometer Winds: Metop-B ASCAT
    - Ozone column/profiles: OMPS, OMI

Weakly Coupled DA: preliminary results

Seaice concentration OMB statistics

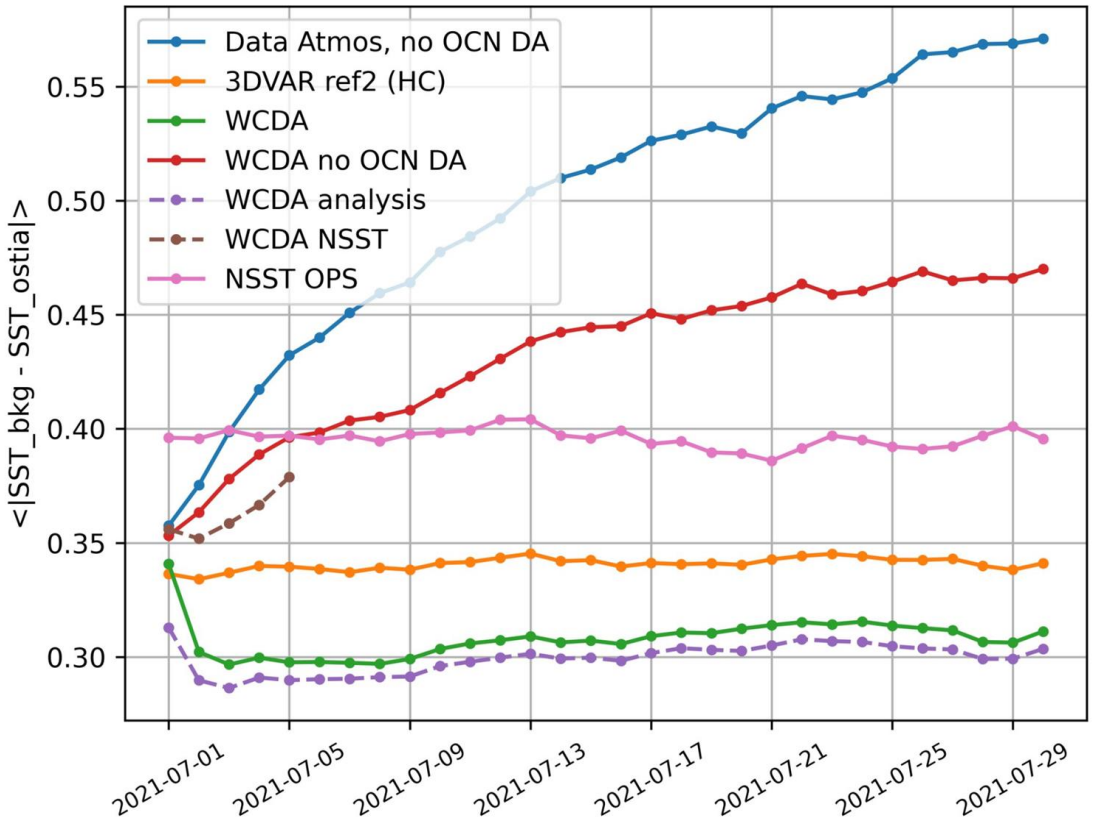




Started from a benchmark SOCA based short reanalysis (~6 months)

Significant error reduction in the WCDA system

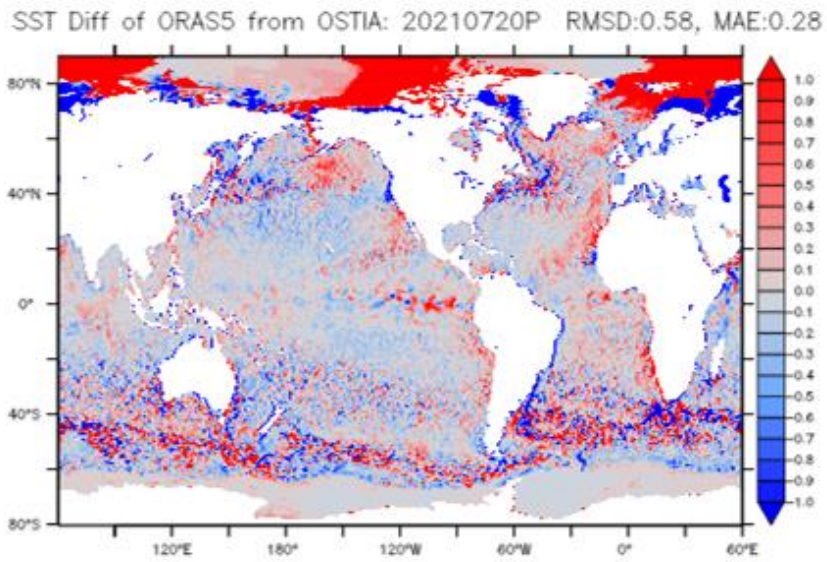
Comparison against independent L4 OSTIA SST [60S-60N]



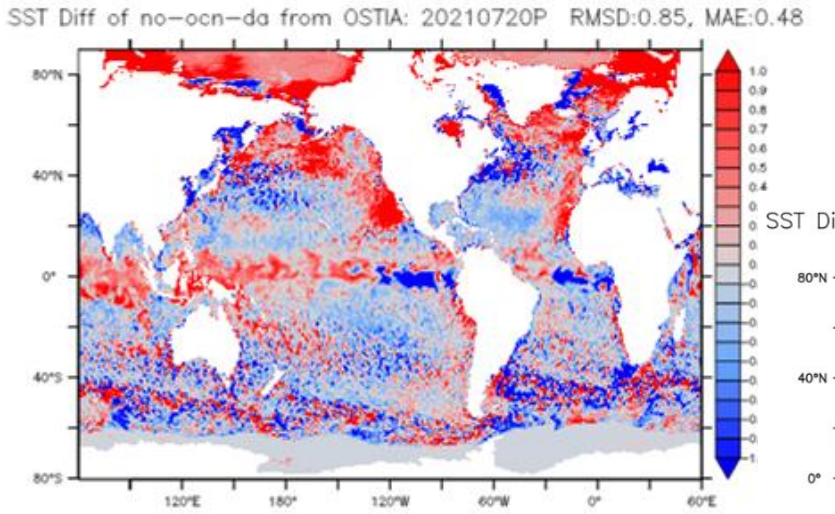
Weakly Coupled DA: preliminary results

SST bias derived from OSTIA for the pentad ave of 2021-01-16~2021-07-20 (Global)

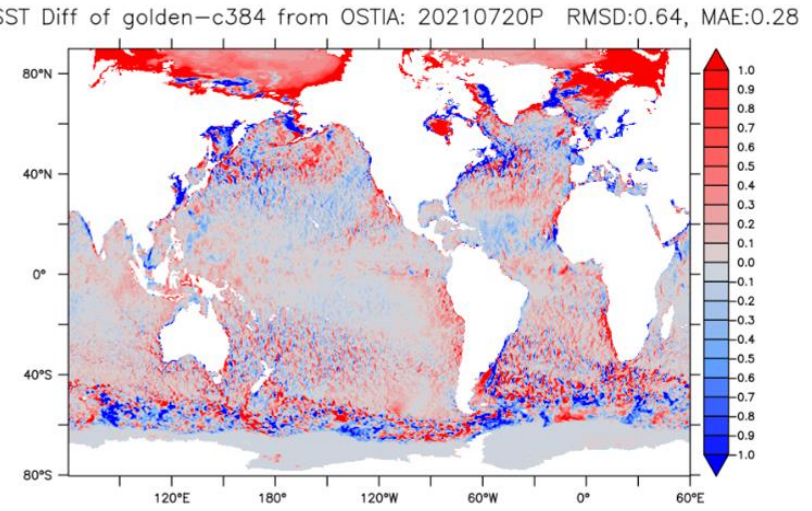
ORAS5



no ocn DA, WCDA



WCDA

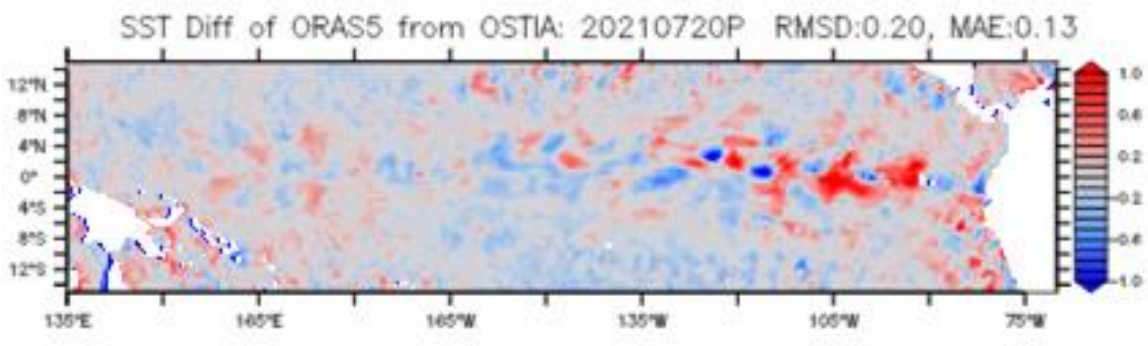


- Generally WCDA is comparable with ORAS5 in MAE
- In Eastern Tropical Pacific, WCDA is clearly improved

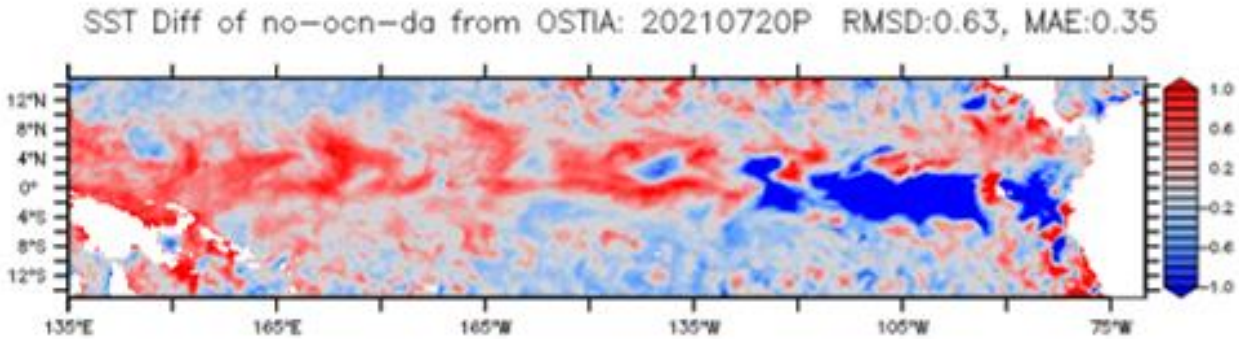
Weakly Coupled DA: preliminary results

SST bias derived from OSTIA for the pentad ave of 2021-07-16~2021-07-20 (Tropical Pacific)

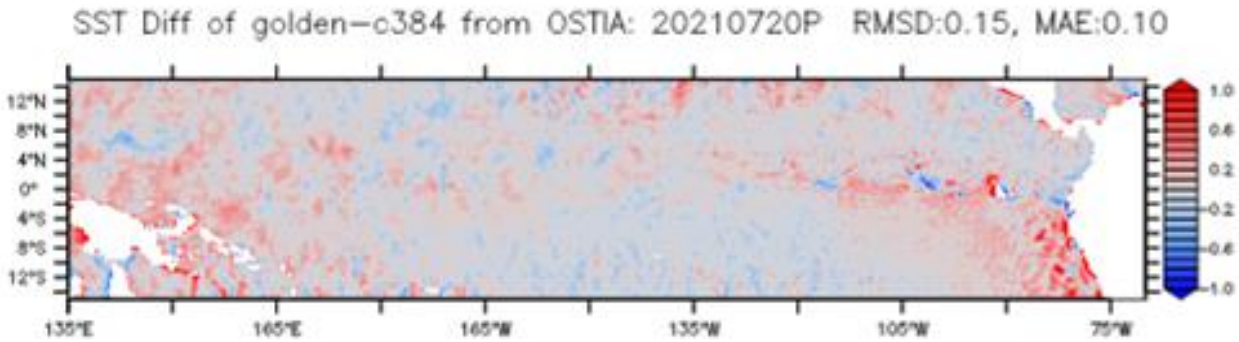
ORAS5



No ocn DA, WCDA



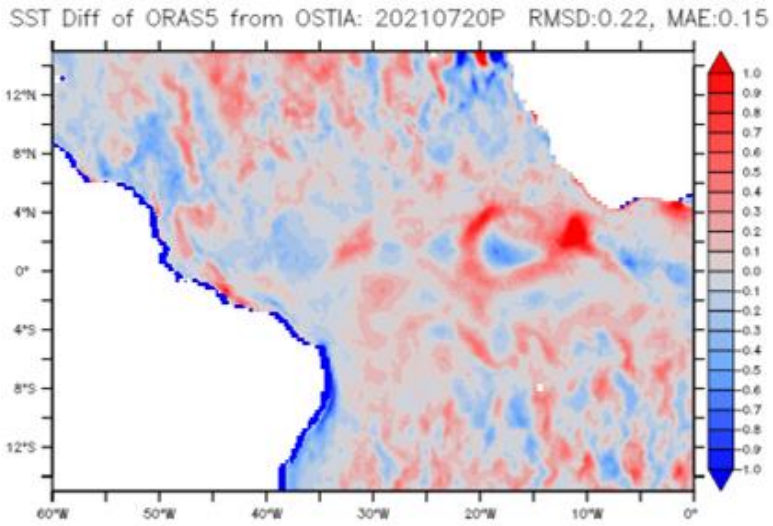
WCDA

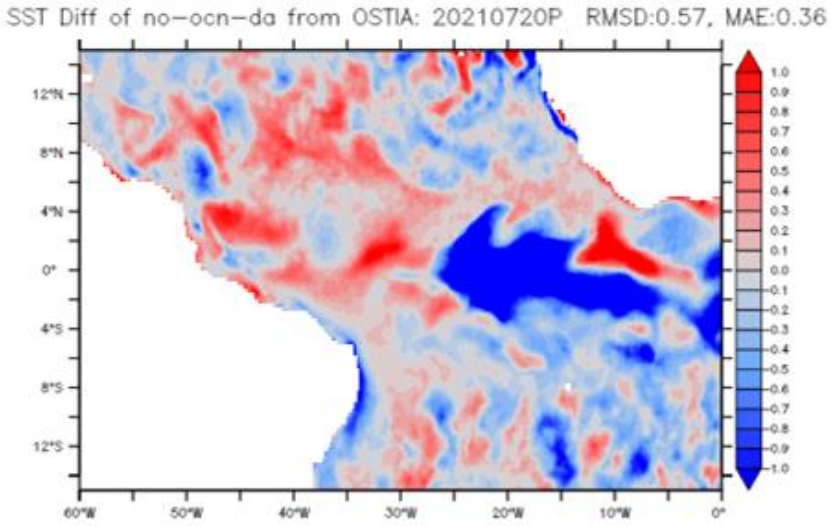


- In Tropical Pacific, WCDA is closer to OSTIA than ORAS5
- In eastern Tropical Pacific, WCDA show better SST in comparison with NO-DA and even ORAS5

Weakly Coupled DA: preliminary results

ORAS5

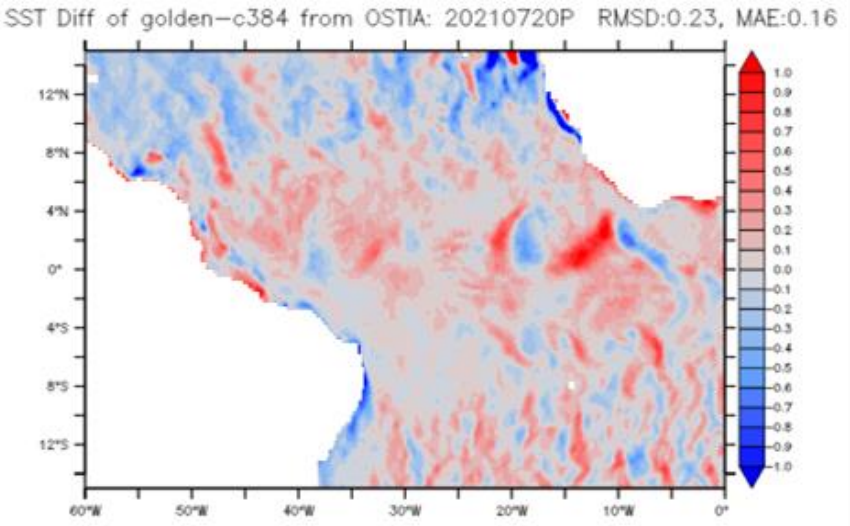




No ocn DA, WCDA

SST bias from OSTIA of
ORAS5 (upper left)
no-ocn-da (upper right)
golden-c384 (lower right)
pentad ave of
20210716~20210720

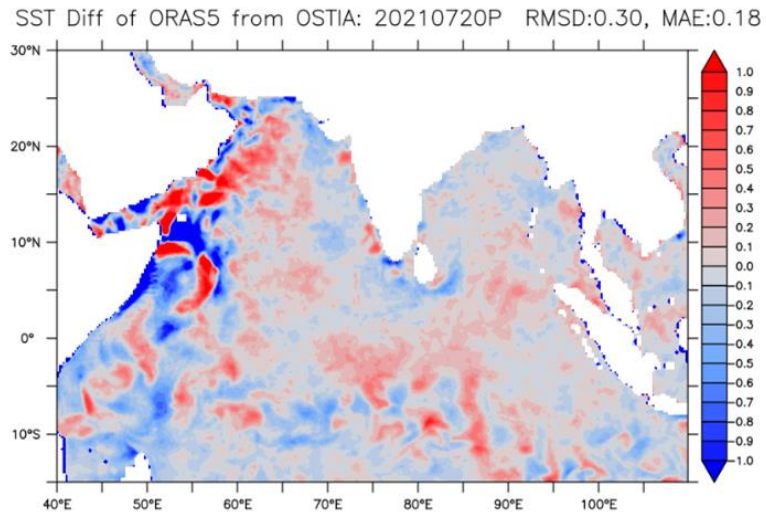
WCDA



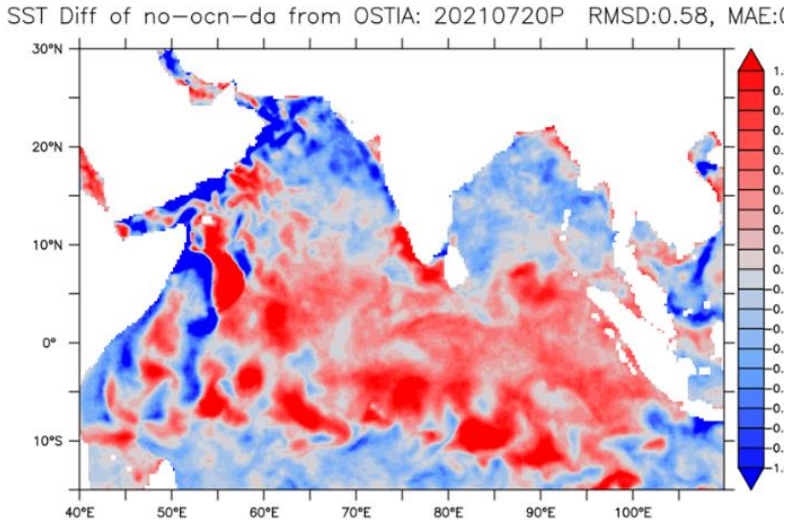
- In Tropical Atlantic, WCDA is comparable to ORAS5
- NO-DA has cold SST bias in the eastern Tropical Atlantic

Weakly Coupled DA: preliminary results

ORAS5

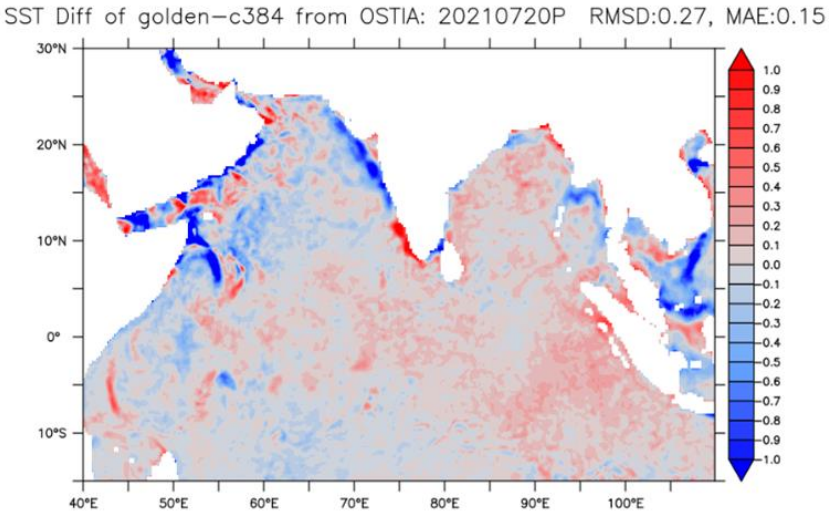


No ocn DA, WCDA



SST bias from OSTIA of
ORAS5 (upper left)
no-ocn-da (upper right)
golden-c384 (lower right)
pentad ave of
20210716~20210720

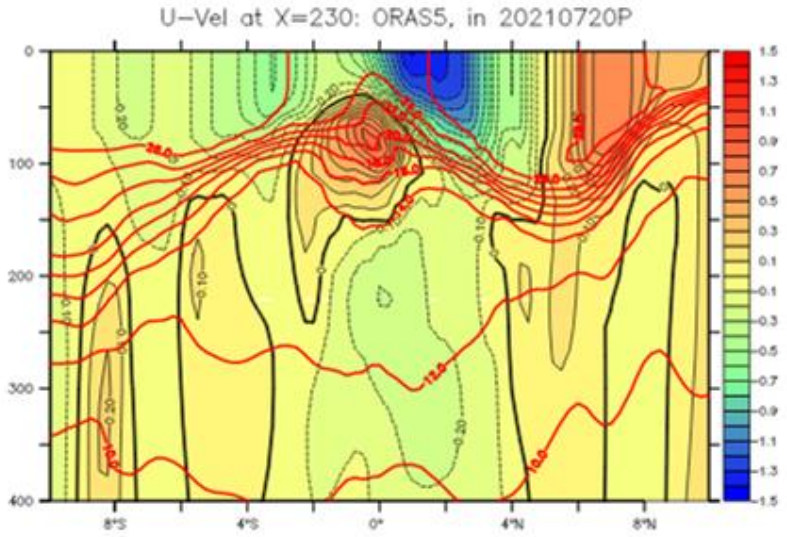
WCDA



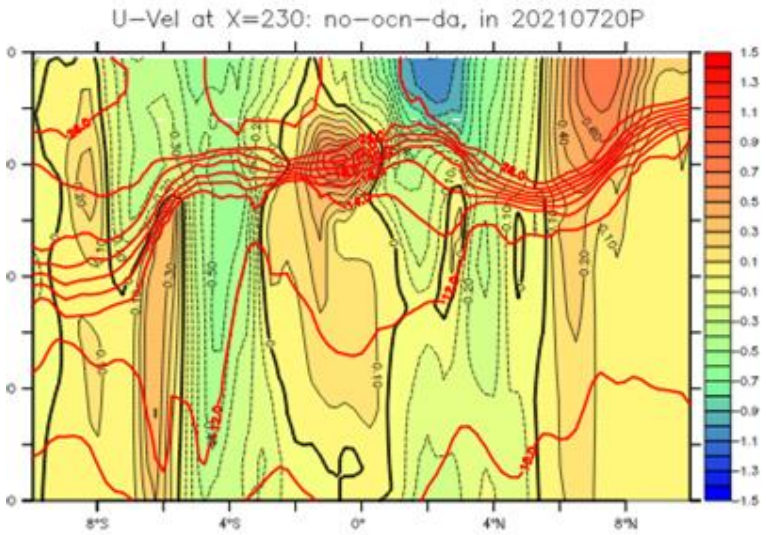
- In Indian Ocean, WCDA is closer to OSTIA than ORAS5
- In western Tropical Indian Ocean, WCDA has better SST than ORAS5

Weakly Coupled DA: preliminary results

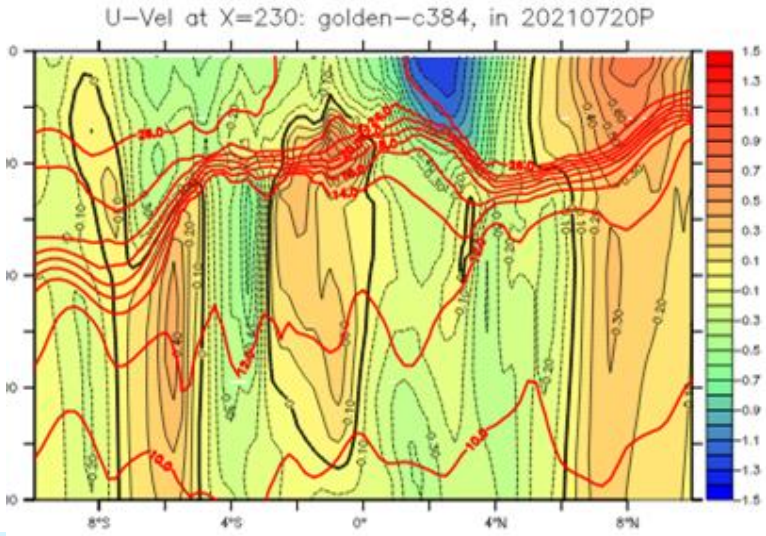
ORAS5



No ocn DA, WCDA



Zonal Velocity (shaded) and T (contour) at 230° of
ORAS5 (upper left)
no-ocn-da (upper right)
golden-c384 (lower right)
pentad ave of
20210716~20210720

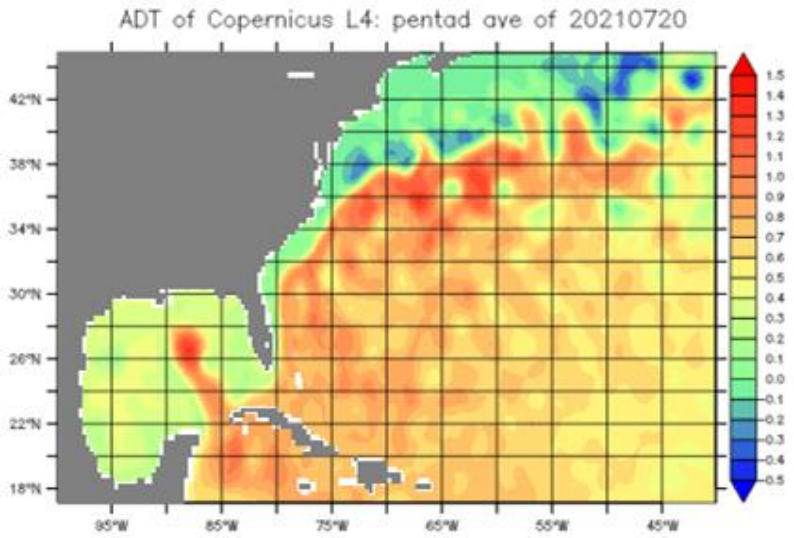


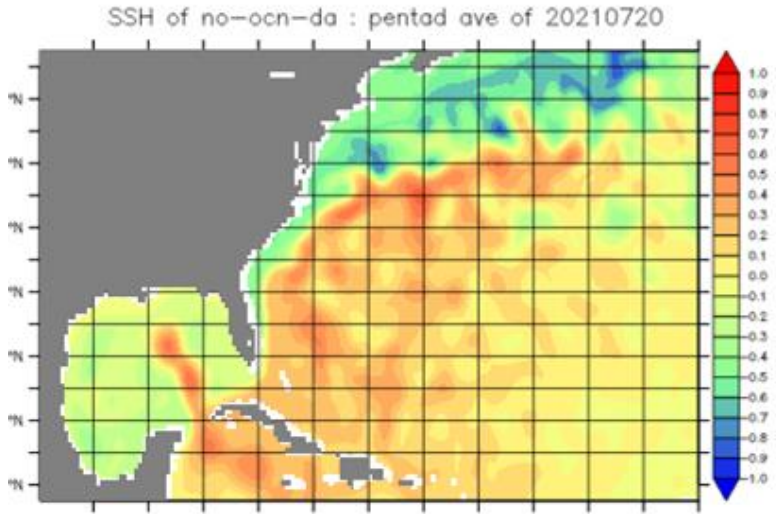
WCDA

- WCDA and NO-DA capture the Equatorial Under Current in the thermocline at EQ
- The thermocline structure of WCDA is generally consistent with ORAS5

Weakly Coupled DA: preliminary results

ADT

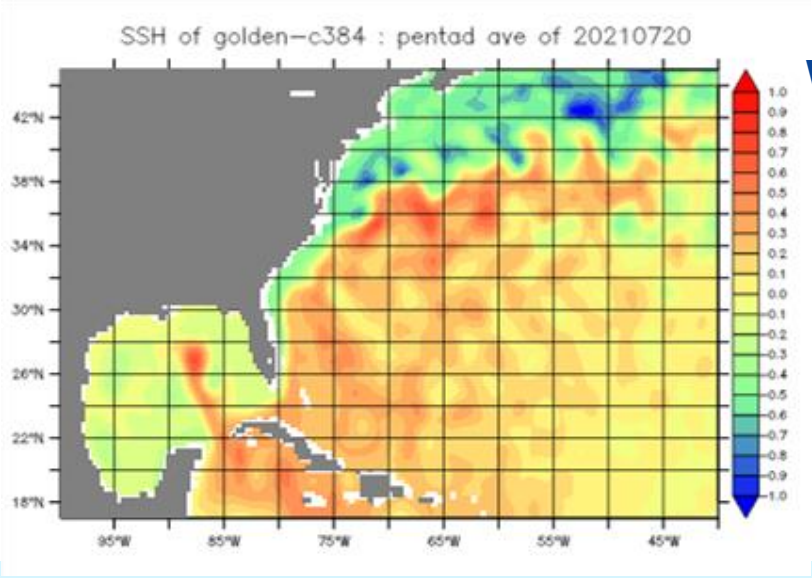




No ocn DA, WCDA

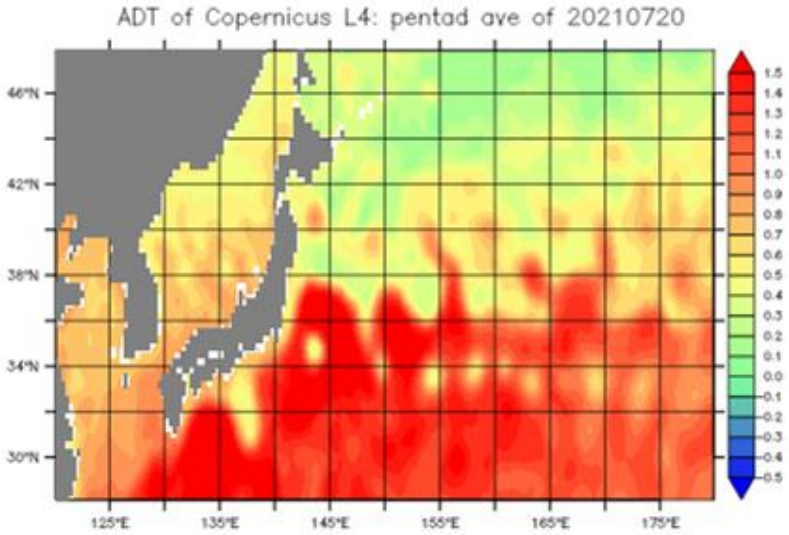
ADT/SSH of
copernicus (upper left)
no-ocn-da (upper right)
golden-c384 (lower right)
pentad ave of 20210720

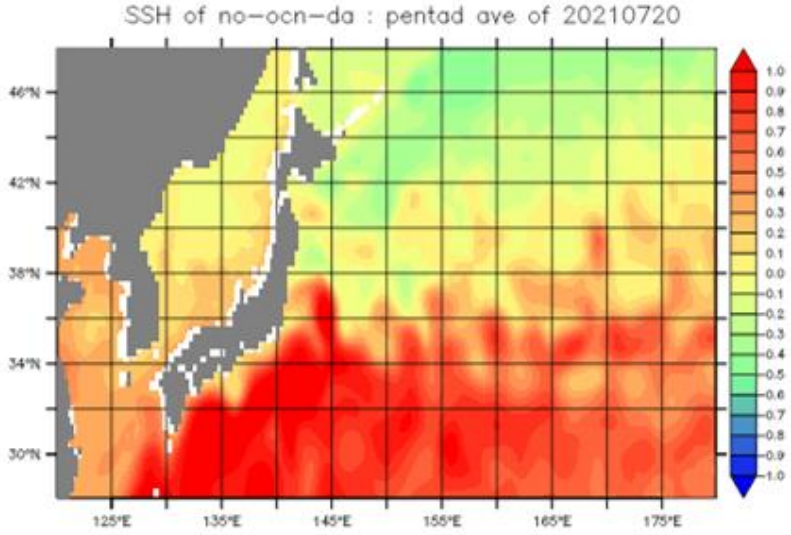
- SSH distribution of WCDA is consistent with Copernicus L4 data.
- SSH of no-ocn-da also agree well with Copernicus-L4, which would mean that the pentad ave of 2021-07-20 still have the initial memory of 2021-07-01.

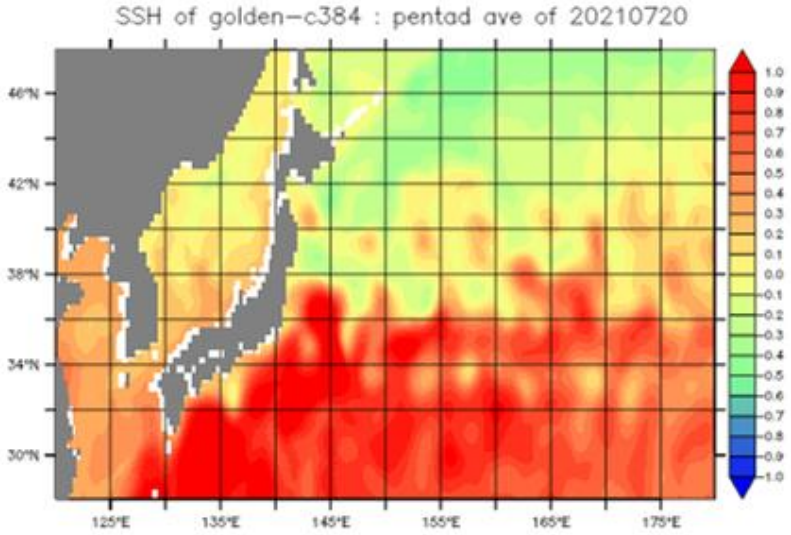


WCDA

Weakly Coupled DA: preliminary results



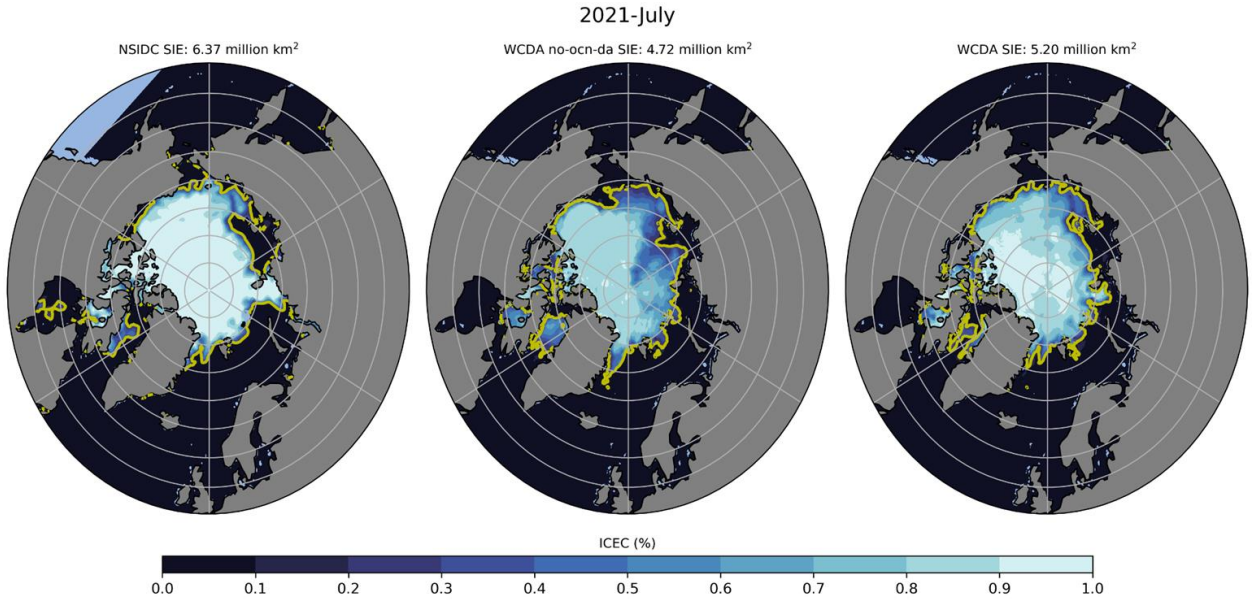




ADT/SSH of
copernicus (upper left)
no-ocn-da (upper right)
golden-c384 (lower right)
pentad ave of 20210720

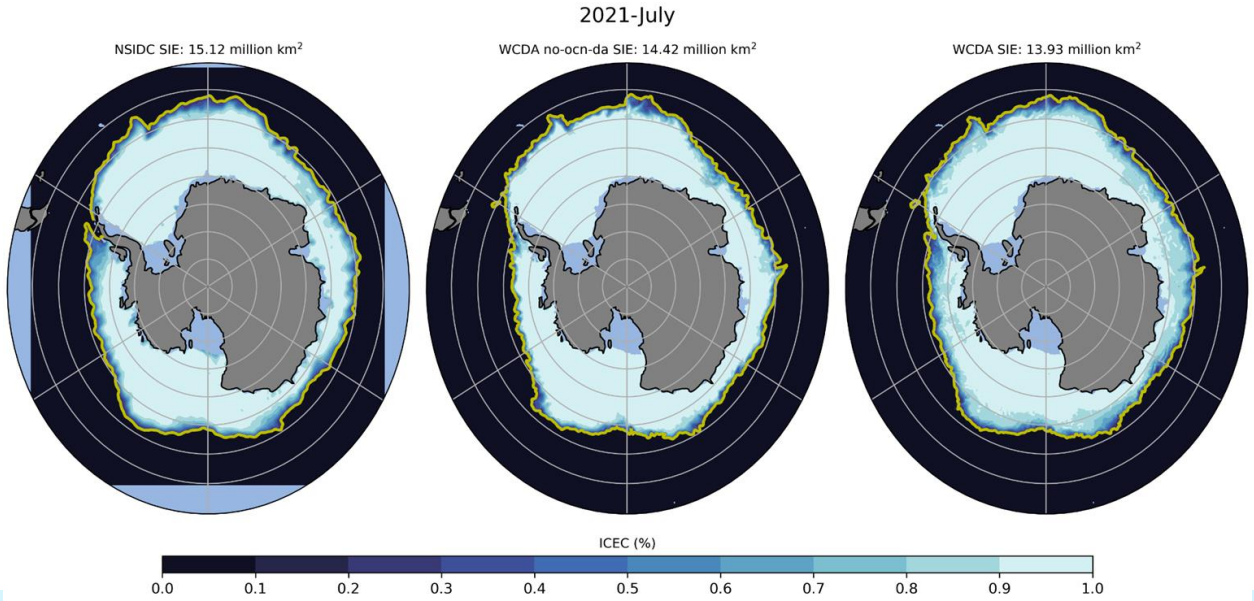
- In Kuroshio, the coastal meandering mode south of Japan is reproduced in WCDA.

Weakly Coupled DA: preliminary results

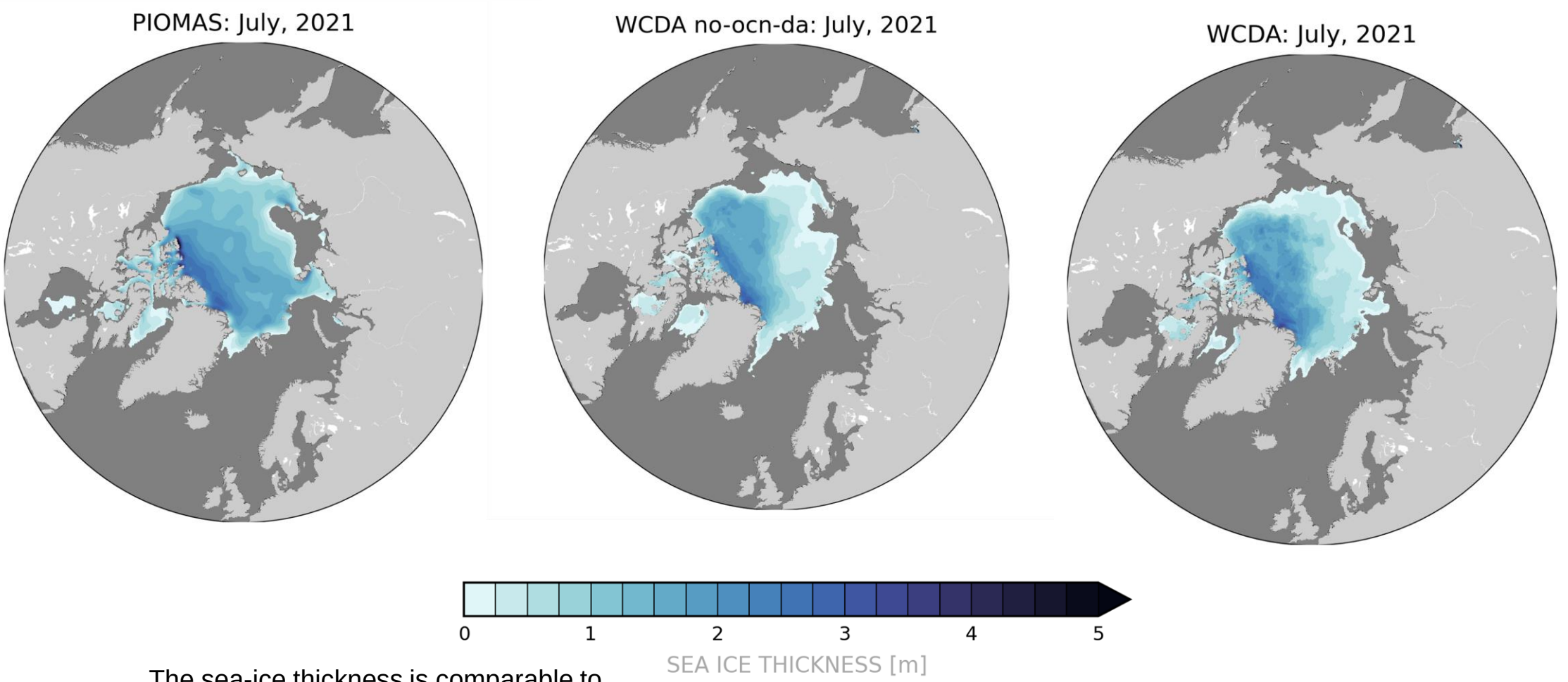


With ocn/sea-ice da, the sea-ice concentration and the extent are improved

In the Southern Hemisphere, more ice melt occurs in the WCDA as compared to the no-ocn-da.
The sea-ice extent results are comparable.



Results - SIT



The sea-ice thickness is comparable to PIOMAS and extends to the East Siberian Sea, where the thickness is underestimated

Summary

- The omb stats for SST have significantly improved.
  - Using a better atmospheric analysis - atmos DA
  - 3DVAR FGAT in the ocean analysis
- In the Arctic, the sea-ice concentration in WCDA is much improved and the sea-ice thickness is comparable to PIOMAS.
- In the Antarctic, the WCDA shows more ice melt than the no-ocn-da run.
  - issues with local maxima of the sea-ice thickness still exist in CICE6 especially in the Antarctic

Next Steps

- Include in situ profile data from NCEP data tanks
- Improve the background error to better simulate the ocean temperature and salinity

Extra Slides

Overview of cycling

MOM6 3D-IAU: incremental analysis updating