RTOFS Global v1.1.0

EMC-CCB Meeting May 12, 2015

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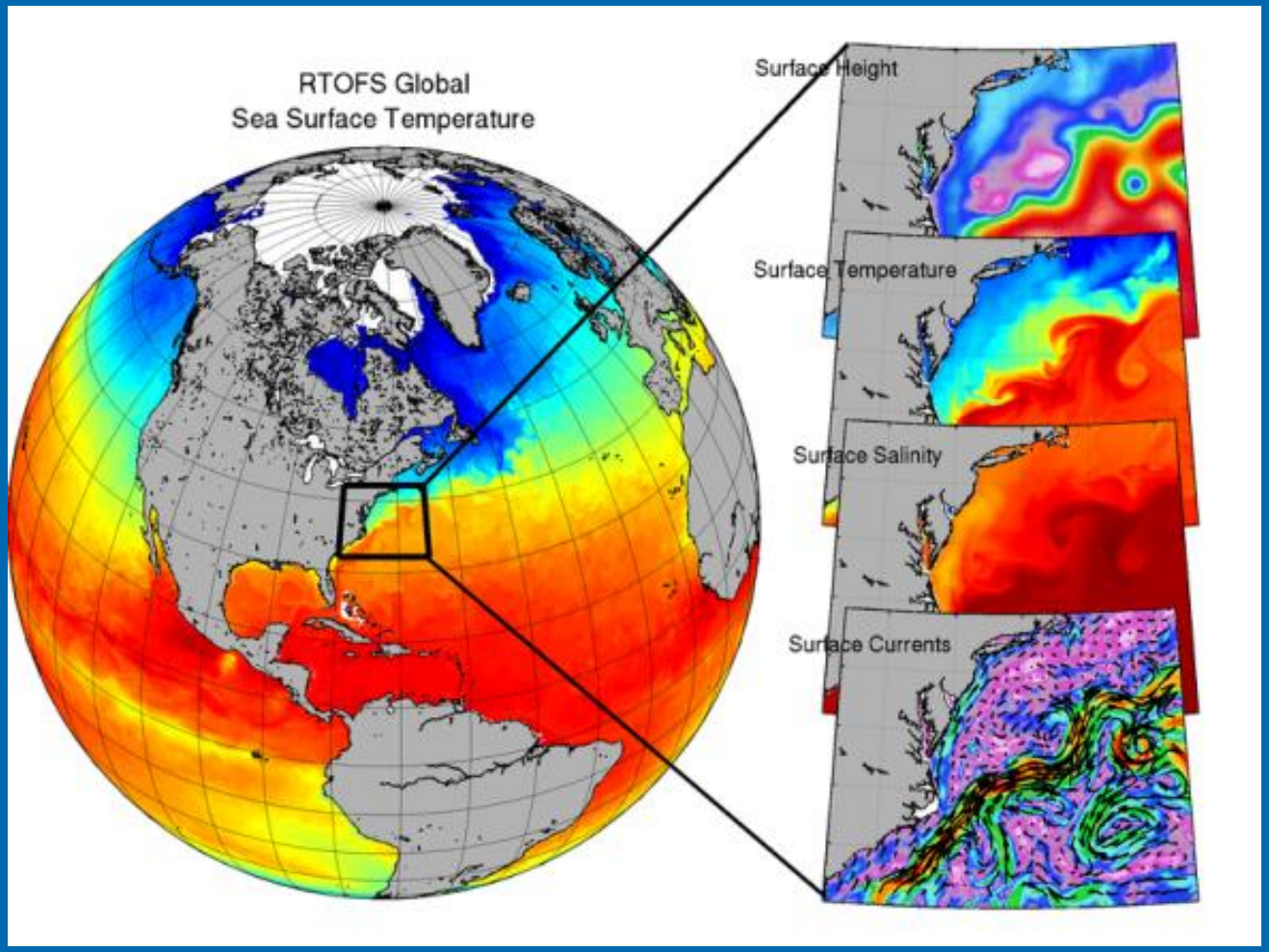
Outline

- Current status of RTOFS Global v1.0
- Upgrades for v1.1
- Evaluation
- Resource/product changes for v1.1.

RTOFS-Global v1.0

- RTOFS Global is the first global eddy-resolving ocean forecast system at NOAA/NCEP implemented in close collaboration with the US Navy.
- This global system is based on a 1/12 degree HYCOM (HYbrid Coordinate Ocean Model) developed by the US Navy with a Pan-Am Global Grid (4500 x 3928).
- The system has 32 vertical hybrid layers (isopycnal in the deep, isolevel in the mixed layer and sigma in shallow waters).
- The initialization is based on a daily live feed of analysis fields provided by NAVOCEANO from a 3D-VAR data assimilation scheme (NCODA) developed by the US Navy which assimilates daily observations (T,S, U,V and sea surface height) in a sequential incremental update cycle.
- The daily global ocean forecasts at NCEP are forced with the GFS surface fluxes of radiation, precipitation and momentum.
- **Strong collaboration with US Navy, leveraging core HYCOM and data assimilation developments at NRL.**

1/12 Degree Global Domain



Primary Users:

NWS:
EMC,OPC,NHC,
WFO/NWPS

NOS:
CO-OPS, IOOS RA's

OAR:
OWAQ, AOML/HRD

US Coast Guard

Primary research partners: NRL, ESRL, AOML, NESDIS, JCSDA, JAEA (Japan), UMD, FSU, MSU, INCOIS (India)

Current Status

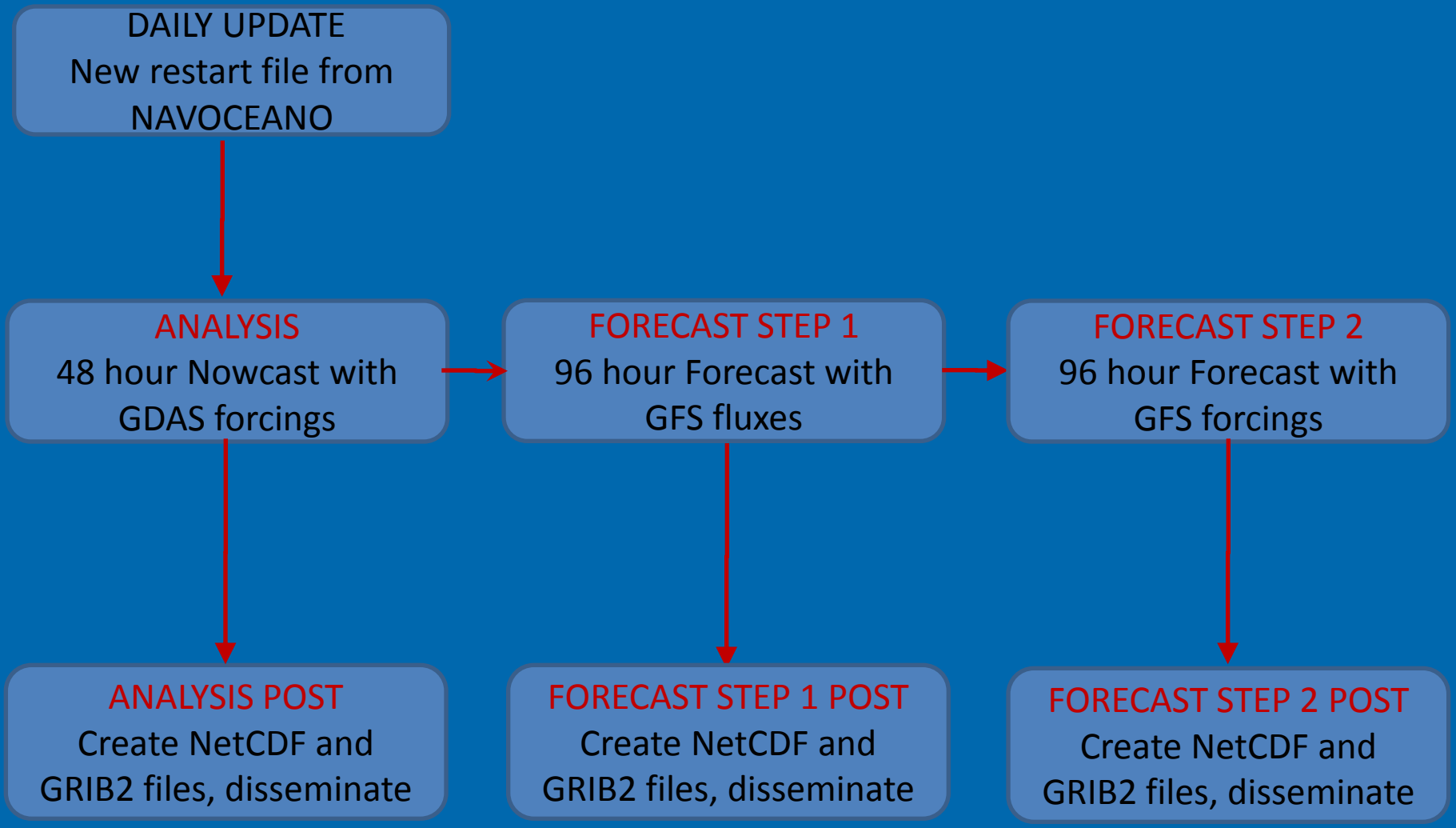
- NCEP implemented RTOFS-Global v1.0 in operations on 10/25/11
- NAVO is delivering initialization data daily.
- MMAB/EMC has converted Navy model to be forced with GFS/GDAS fluxes.
- Multiple data distribution channels have been developed:
  - NOMADS (operational)
  - FTP (operational)
  - AWIPS (operational)
  - ~~NOMADS (development)~~

Model run setup

RTOFS-Global using 00z – 12z cycles:

- 00z cycle: Dedicated to model initialization:
  - For now, take data from Navy, propagate several days as needed to adjust to GDAS/GFS forcings.
  - Will become full assimilation cycle using last 5-7 days of real time data, MOA with Navy on implementing NCODA at NCEP.
- 06z cycle; Forecast days 1-4
- 12z cycle: Forecast days 5-8
- 18z cycle (in reserve)

RTOFS-Global Job Structure
Overview of Stages



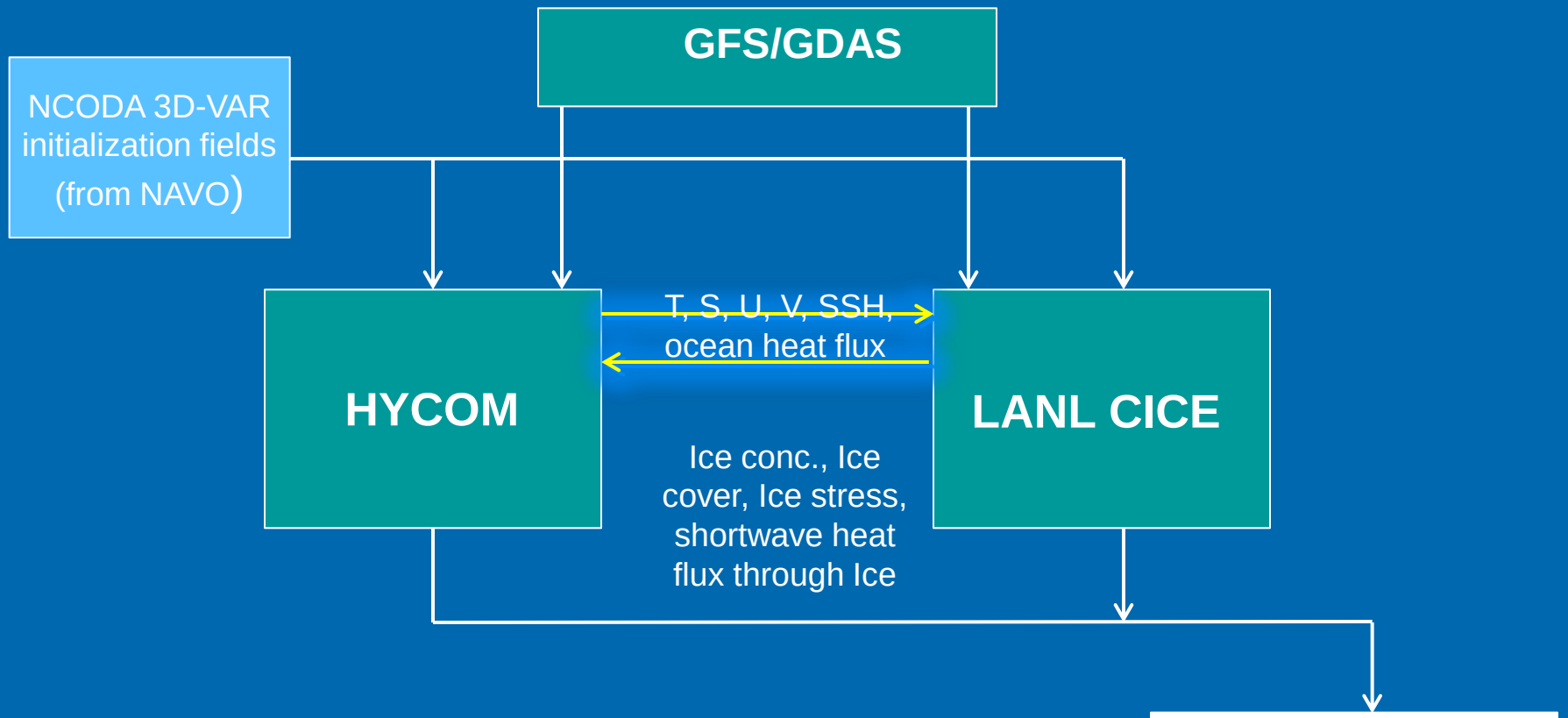
Version 1.1.0

Primary upgrades:

- 41 hybrid layers (increased from 32 layers), iso-levels mostly in the top 200m
- Improved bathymetry which allows better representation of shallow points (minimum depth 5m)
- Updated climatology fields from GDEM 3 to GDEM 4
- An updated equation of state (17 terms vs 9 terms)
- Two-way coupled HYCOM with Los Alamos CICE (Community Ice CodE) (which replaces Energy-Loan Sea-Ice model)
  - 1 hour coupling frequency
  - Using ESMF v4.0 (non-NUOPC)

Developed fully at US Navy (GOFS 3.1) with ongoing independent validation.

HYCOM CICE coupling



Ocean- Sea Ice fields exchanged via ESMF 4.0

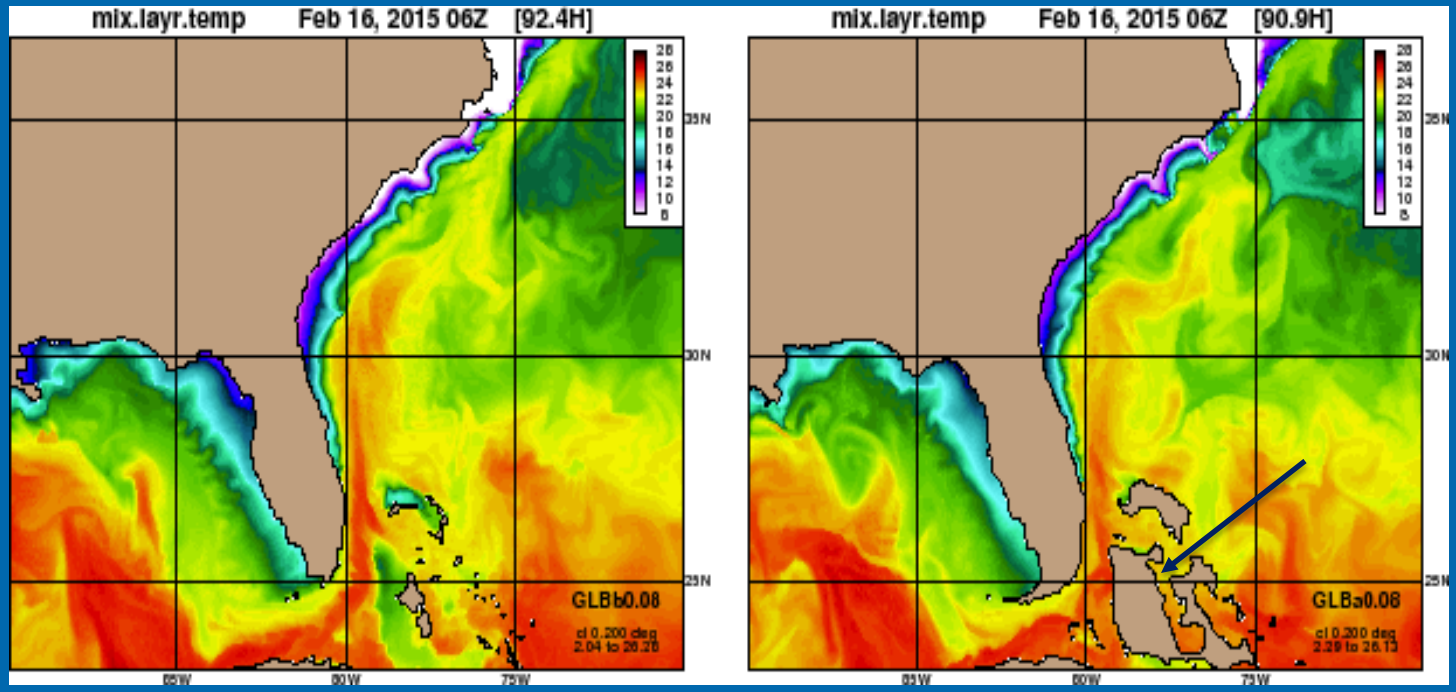
Outputs:

T, S, U, V, SSH, Ice Drift, Ice Thickness

Evaluation

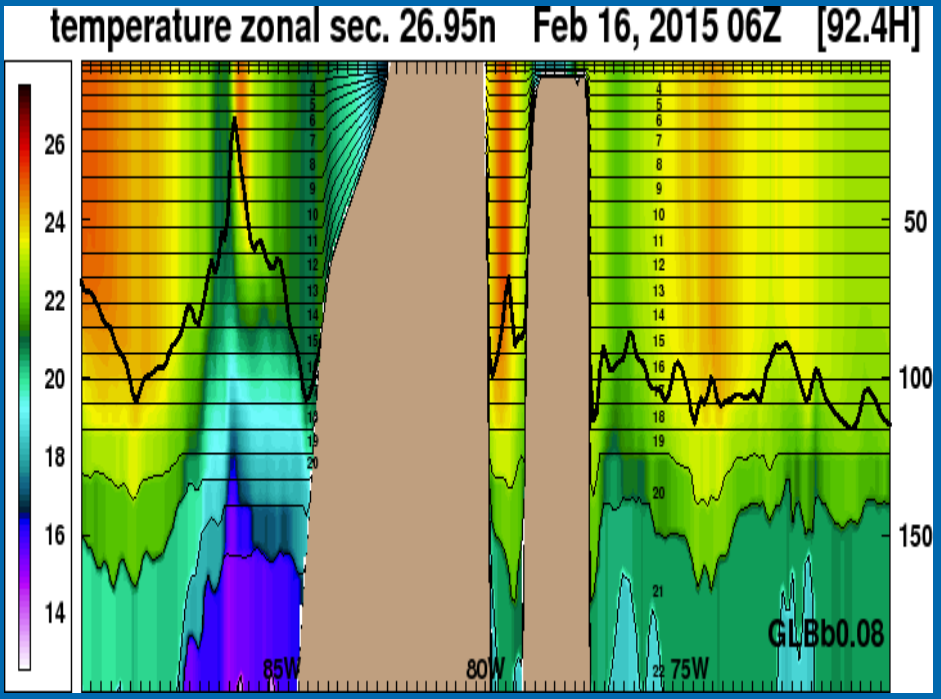
- Coastline/water mass representations
- GS Location
- SSH comparisons
- SST comparisons
- Florida Cable transports
- Profile metrics
- Polar Ice cover

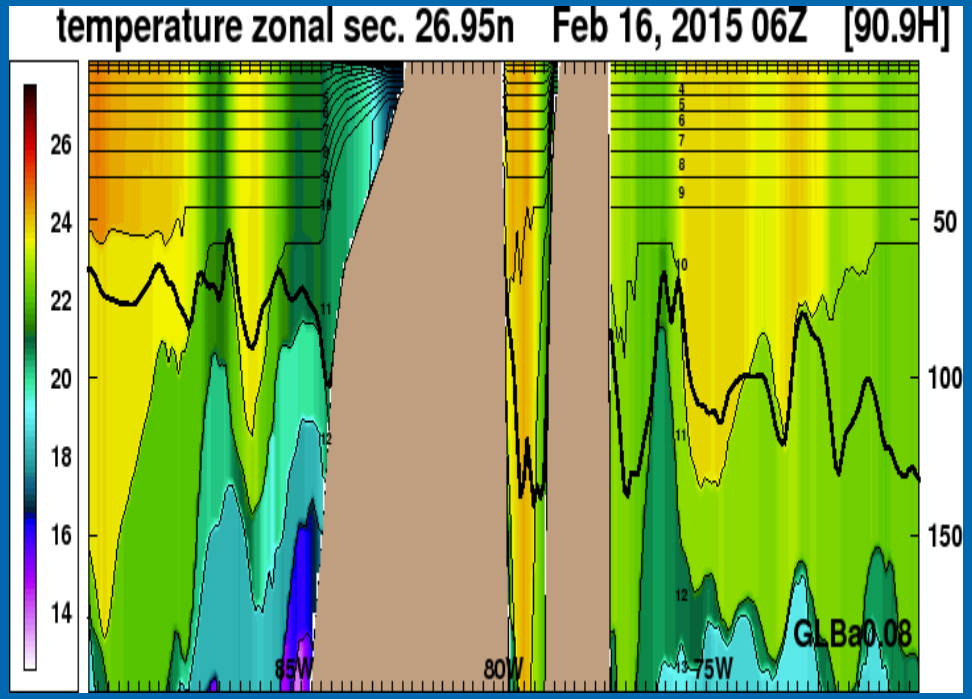
RTOFS v1.1 vs RTOFS v1.0
Improvements in Bathymetry



RTOFS-Global SST v 1.1 (left) and version 1.0 (right). The shallow region north of Grand Bahamas is present in version 1.1 while it was masked as land in version 1.0.

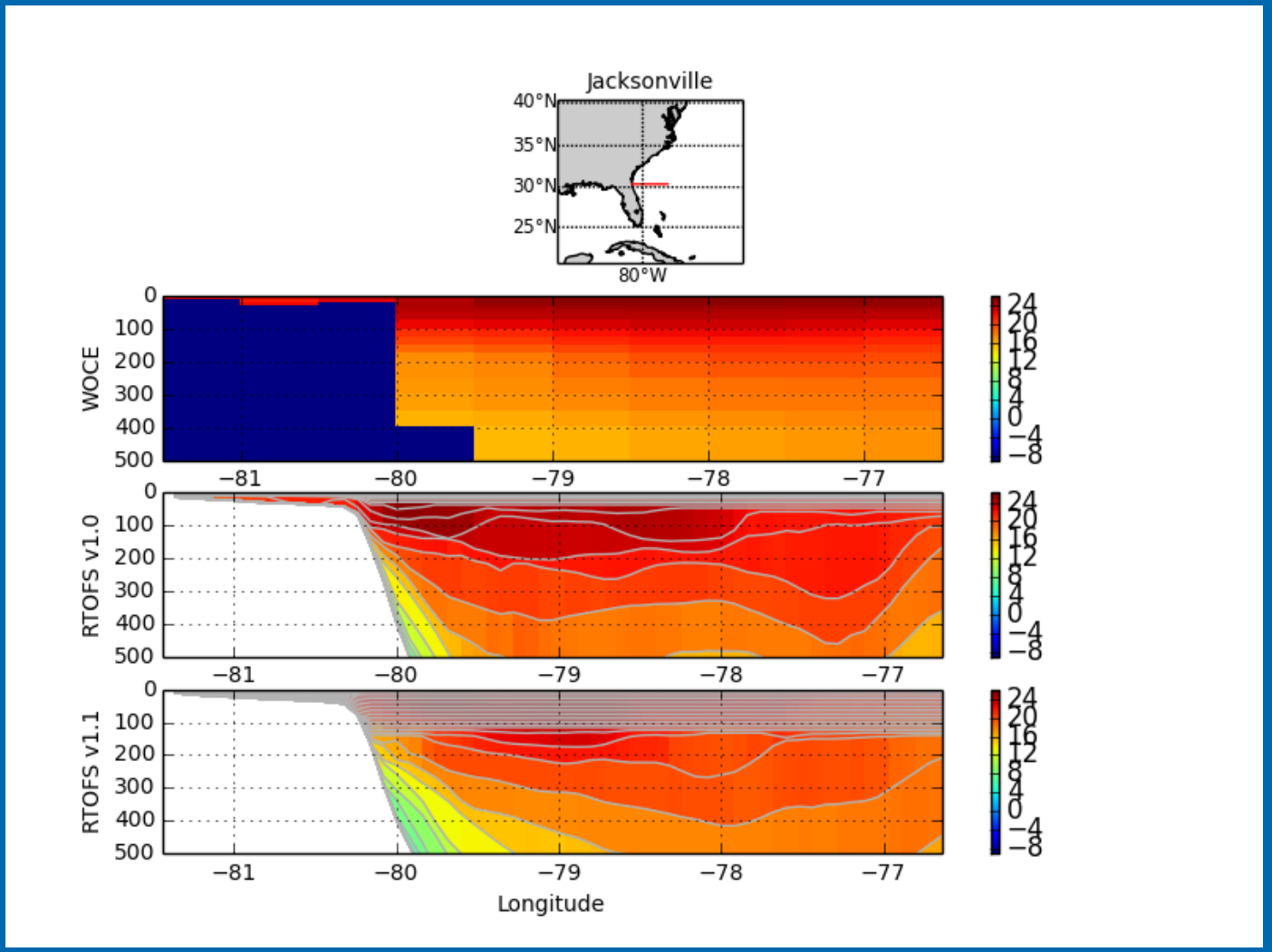
RTOFS v1.1 vs RTOFS v1.0
Zonal Temperature Cross Sections





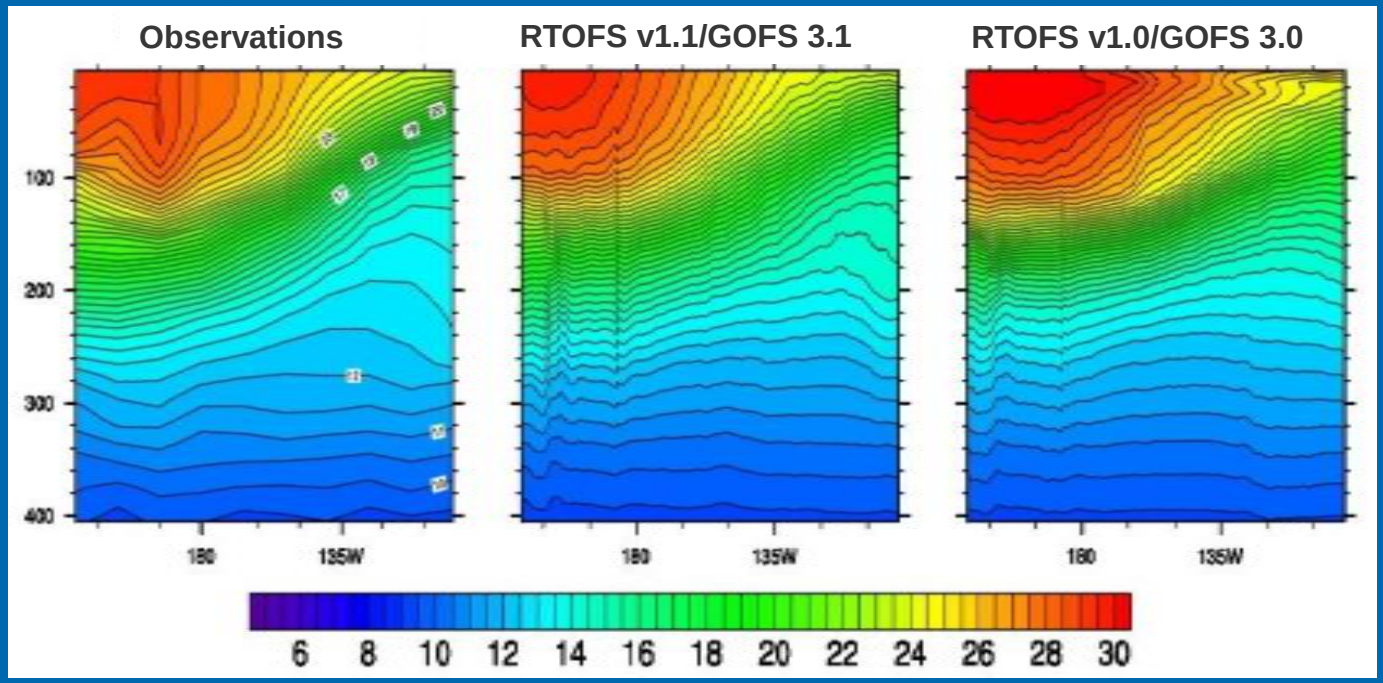
Higher vertical resolution section at 27 N, passing just north of Grand Bahamas, from RTOFS-Global versions 1.1 (left) and version 1.0 (right).

WOCE vs RTOFS v1.0 vs RTOFS v1.1
Vertical Temperature Cross Section



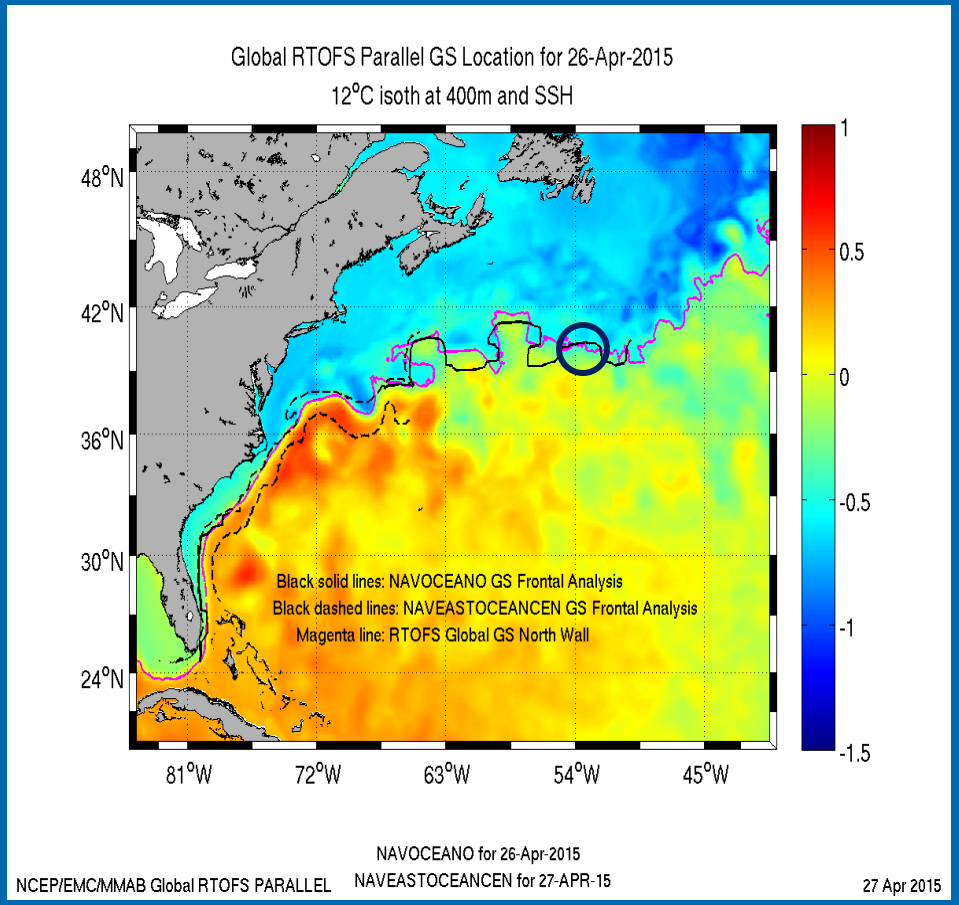
Improved representation for both coastal ocean and deep ocean upper stratified layers

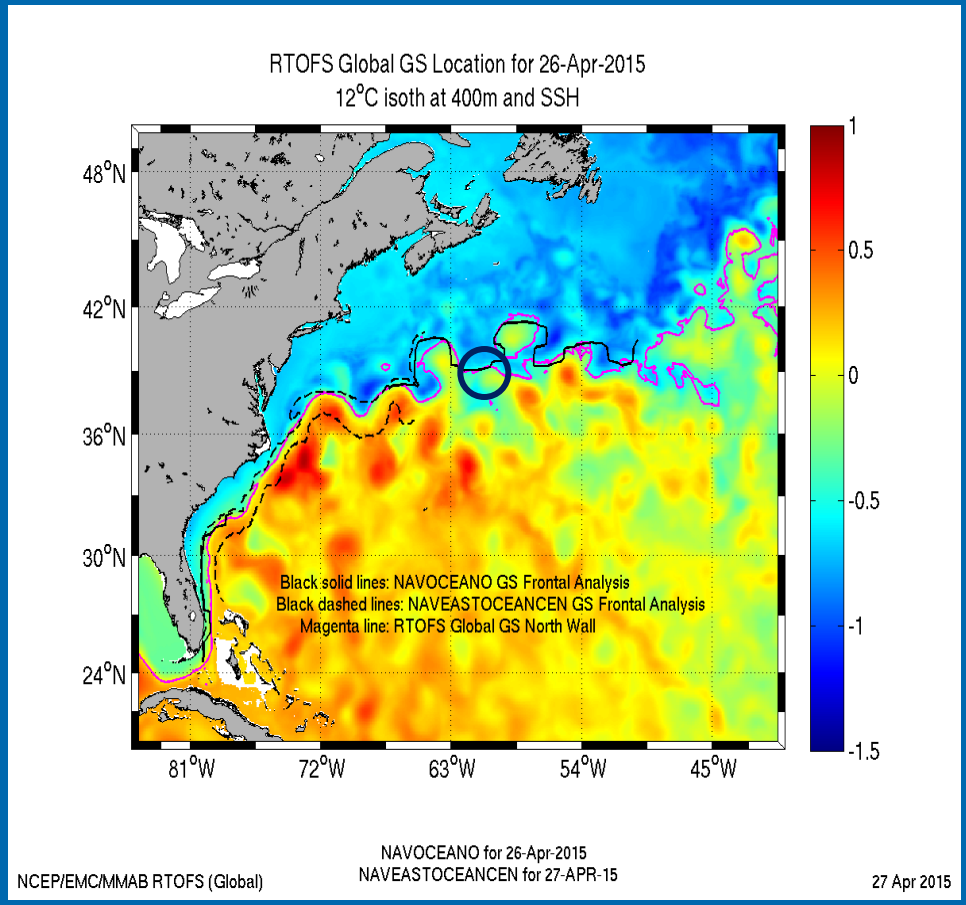
Obs vs RTOFS v1.1 vs RTOFS v1.0
Vertical Temperature Cross Section for Fall 2013



Better representation of warm pool/cold tongue in equatorial Pacific (reference: Pat Hogan@NRL)

RTOFS v1.1 vs RTOFS v1.0

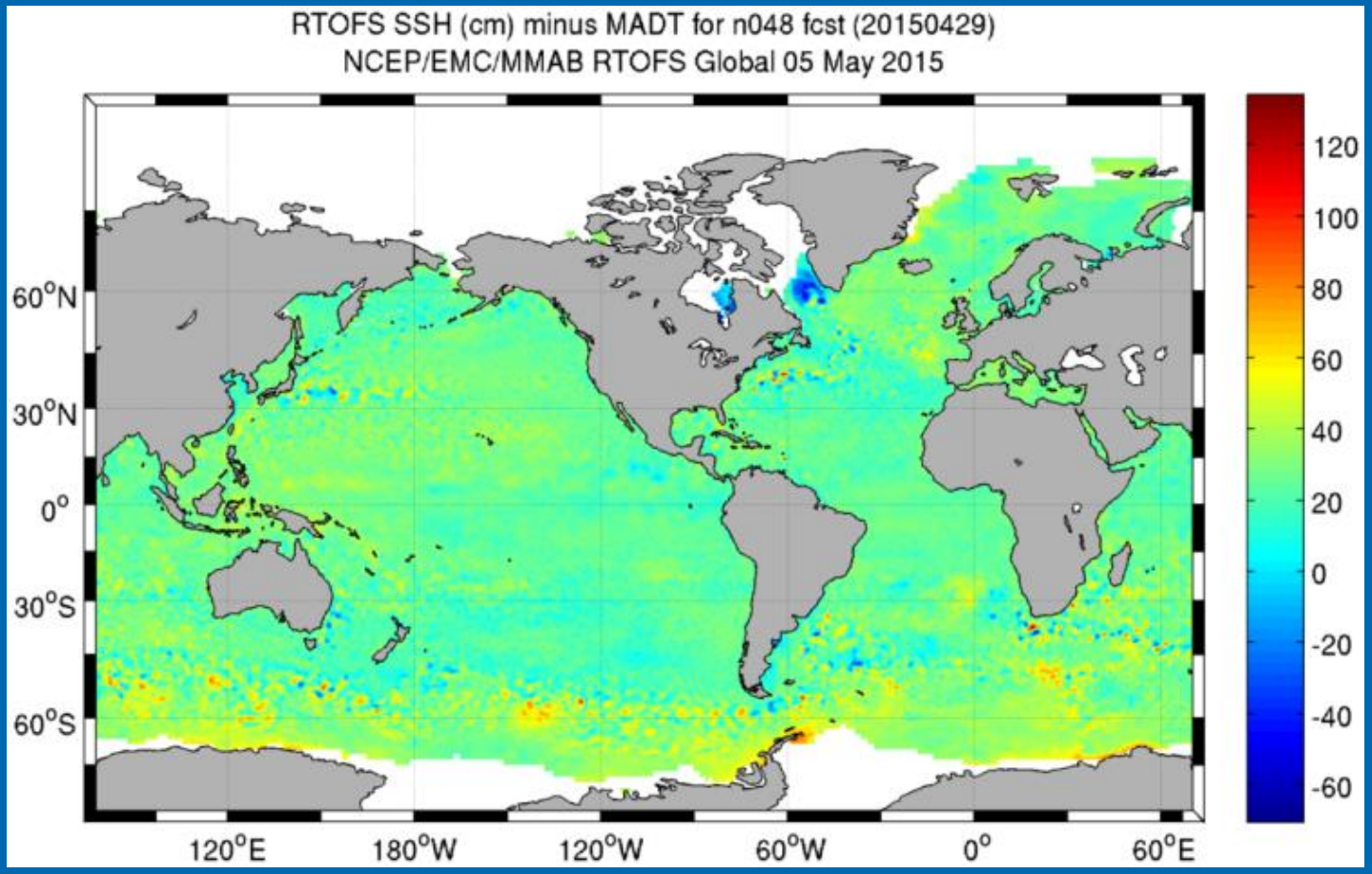




GS North Wall location very similar with small differences near meanders.

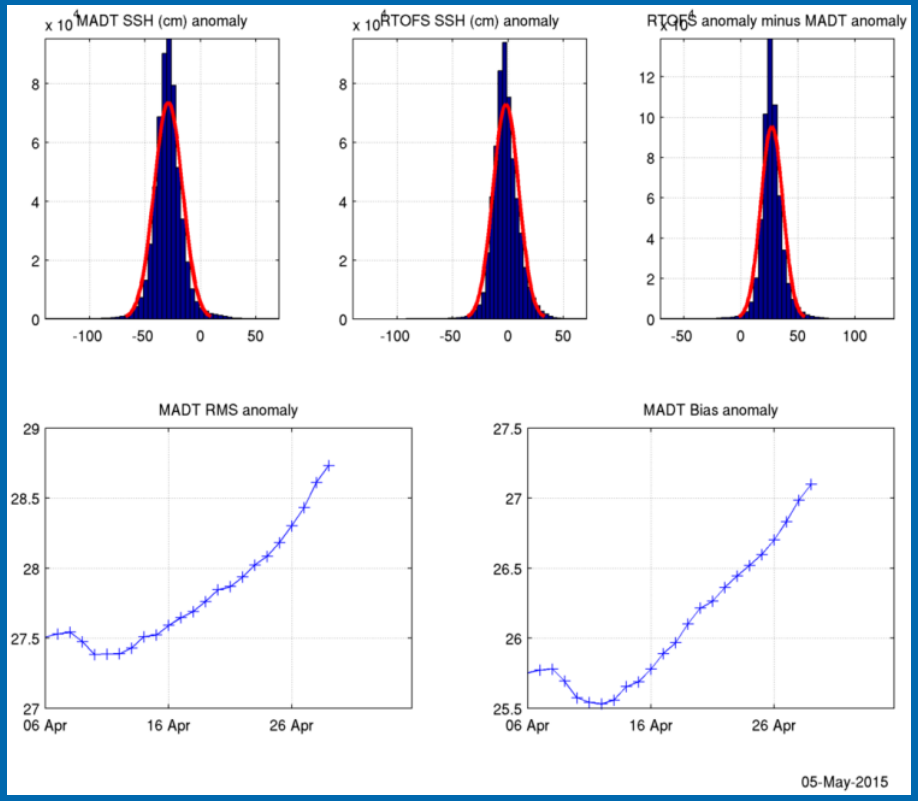
OPC to help with quantitative Hausdorff distance measures

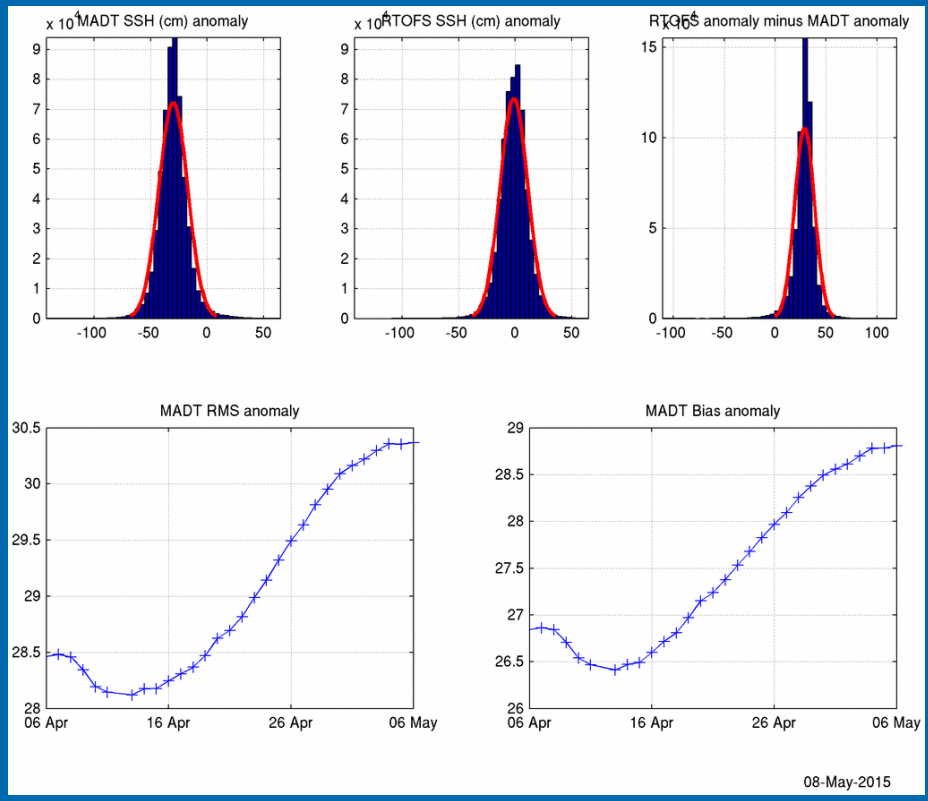
RTOFS vs MADT SSHA



Most of the differences are in regions of large variability

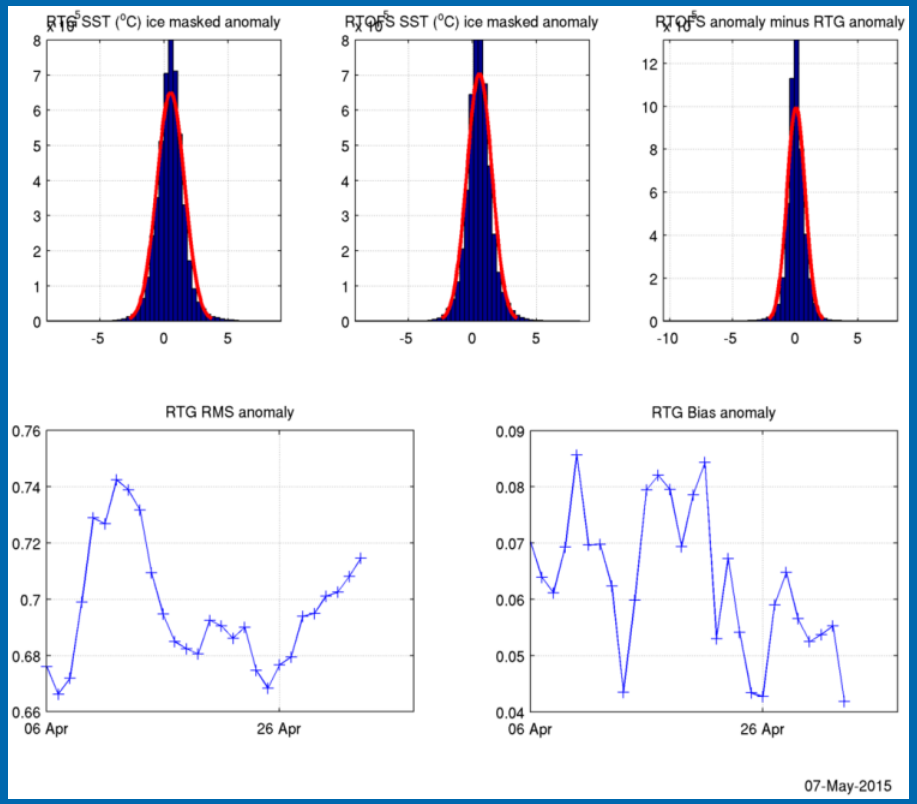
RTOFS v1.1 vs RTOFS v1.0 vs MADT SSHA (Global)

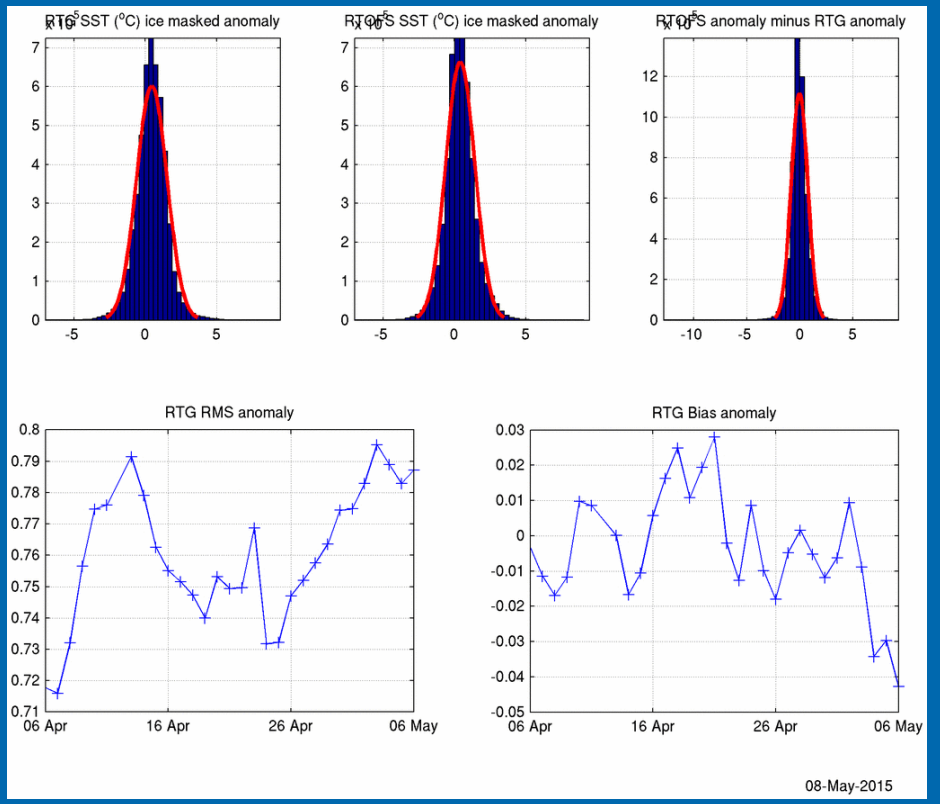




The two simulations are comparable with the parallel (left panel) performing marginally better (approx. 1 cm RMSE and bias).

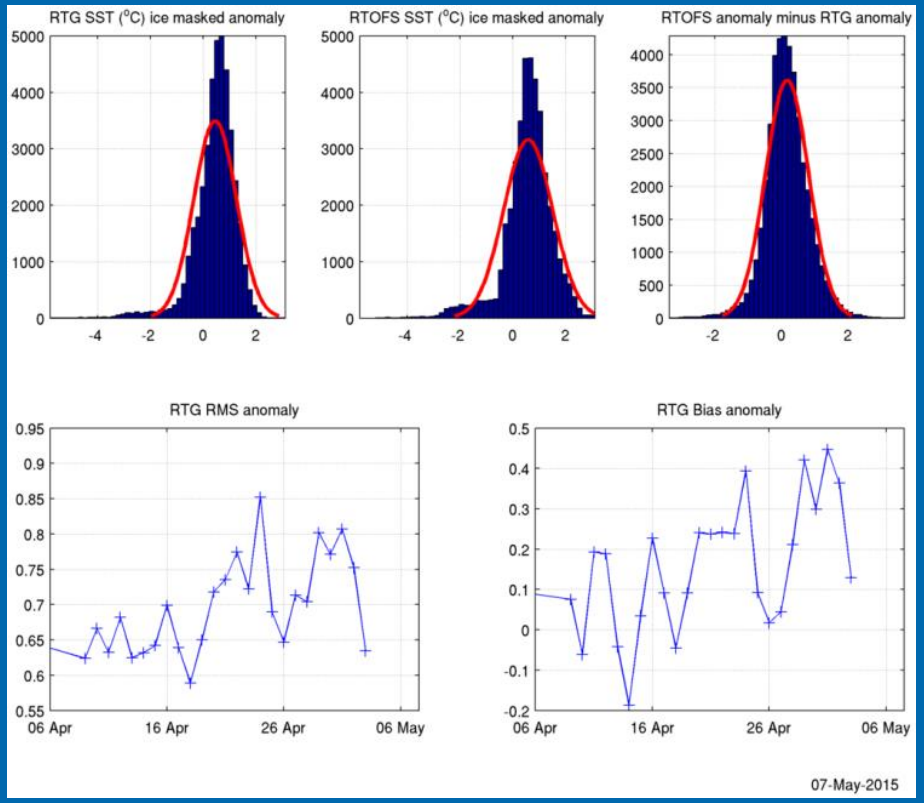
RTOFS v1.1 vs RTOFS v1.0 vs RTG SST (Global)

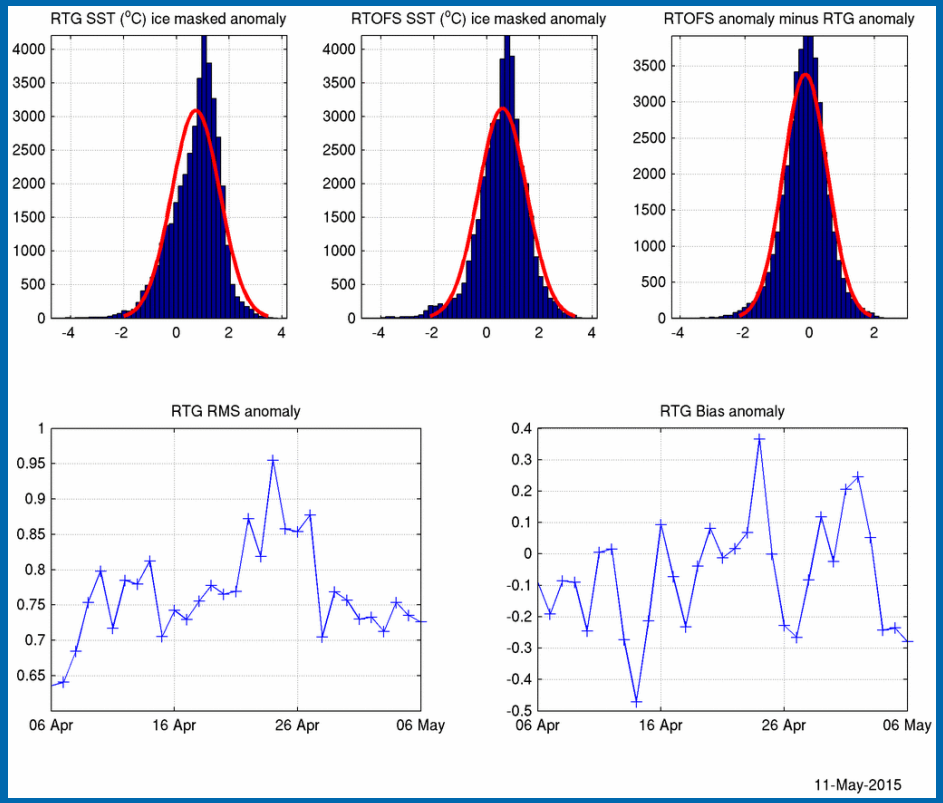




The two simulations are comparable with the parallel (left panel) performing marginally better with smaller RMSE but with a larger average bias/overestimation.

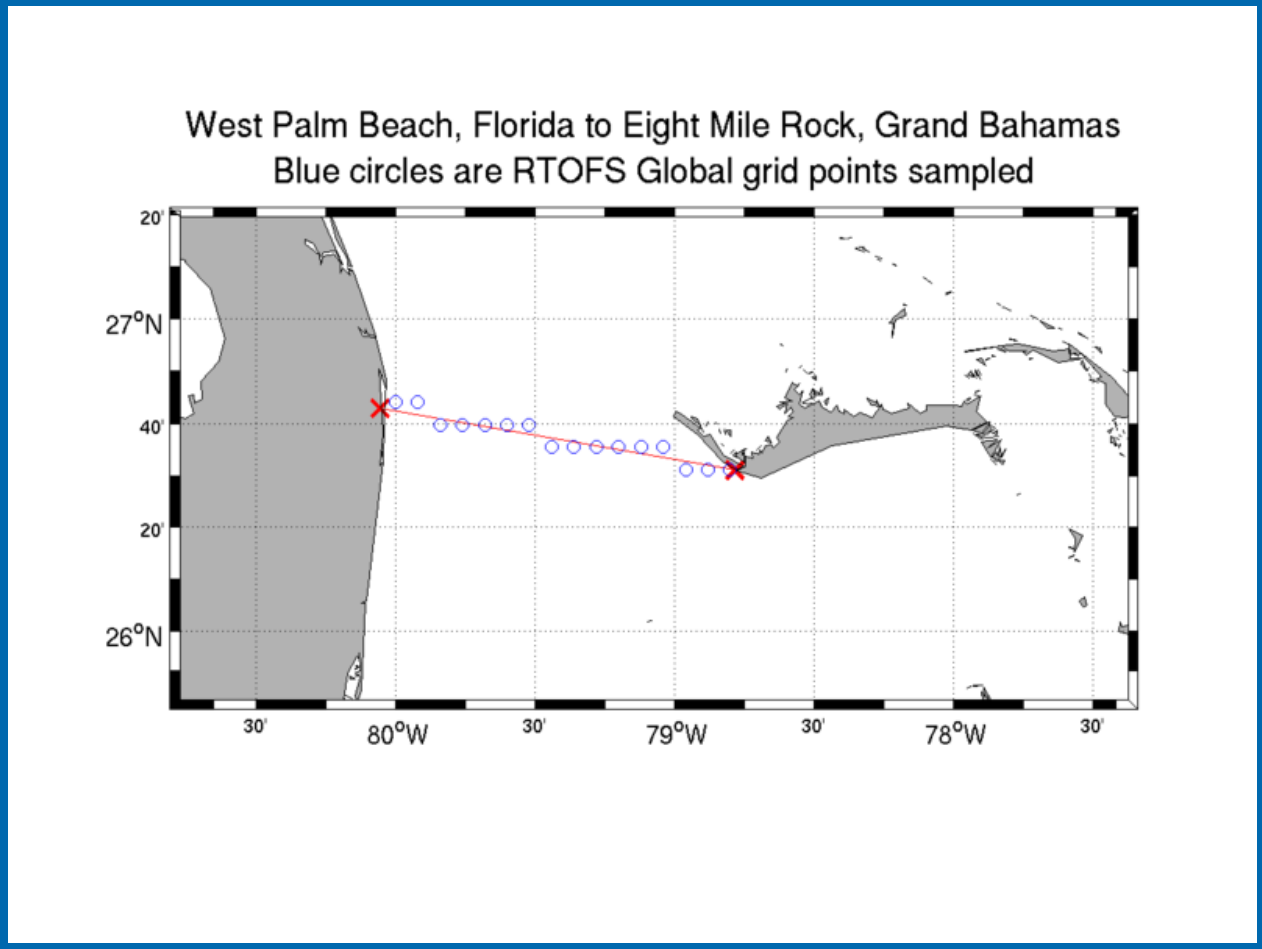
RTOFS v1.1 vs RTOFS v1.0 vs RTG SST (Gulf of Mexico)





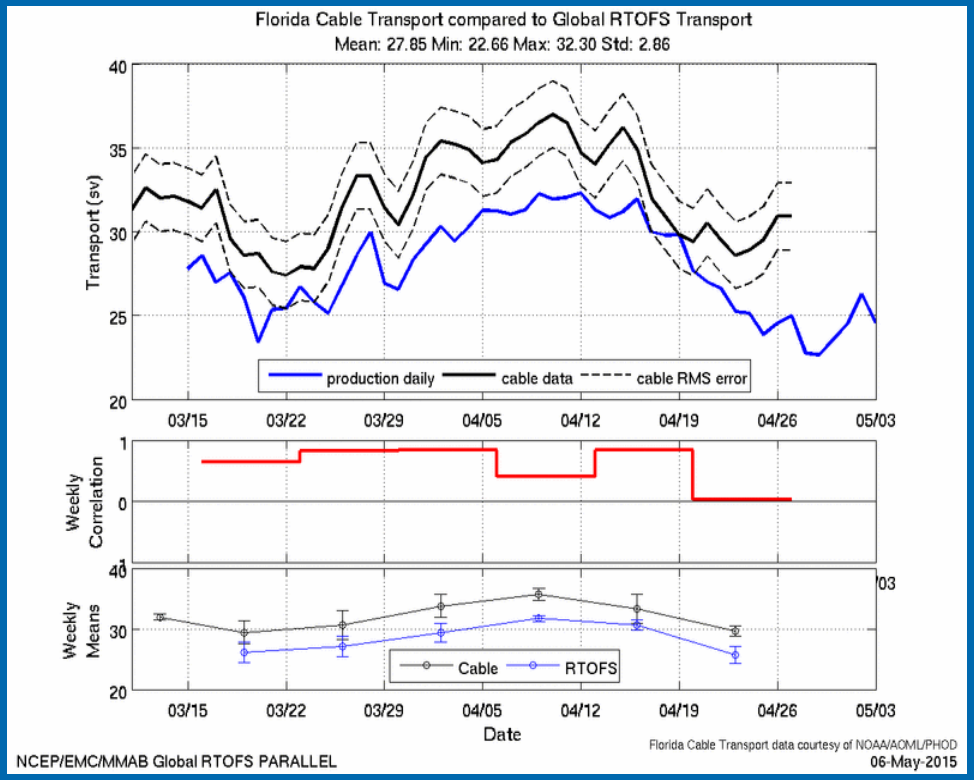
The two simulations are comparable with the parallel (left panel) performing marginally better with smaller RMSE but with a larger average bias/overestimation.

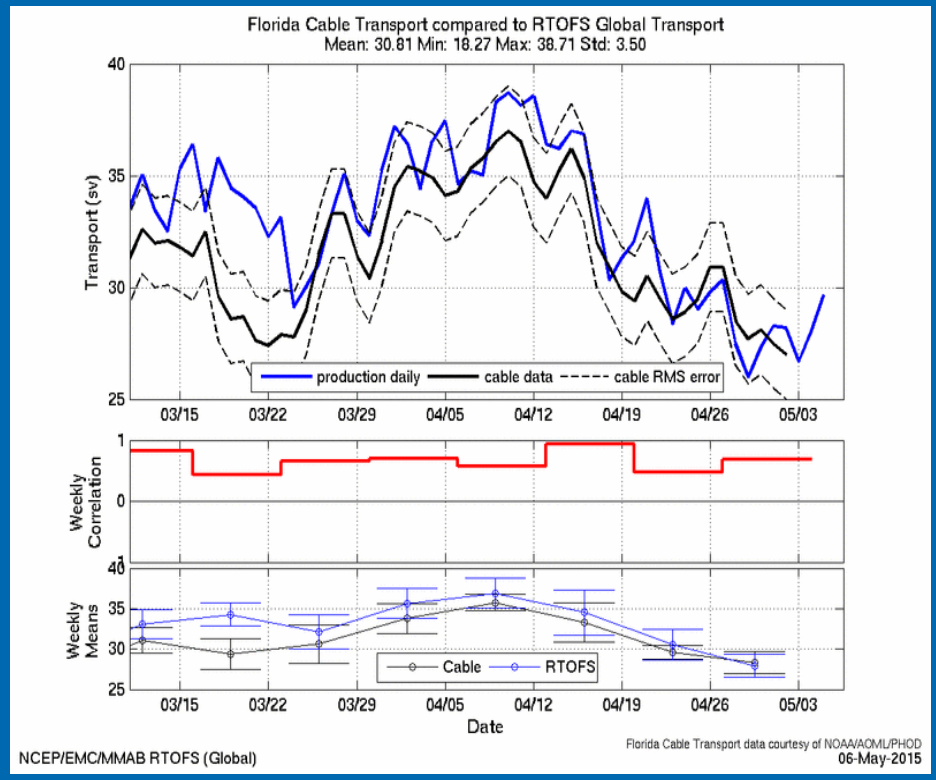
Florida Cable Transports



The transport variations of the Florida current using a submarine cable (data from NOAA/AOML).

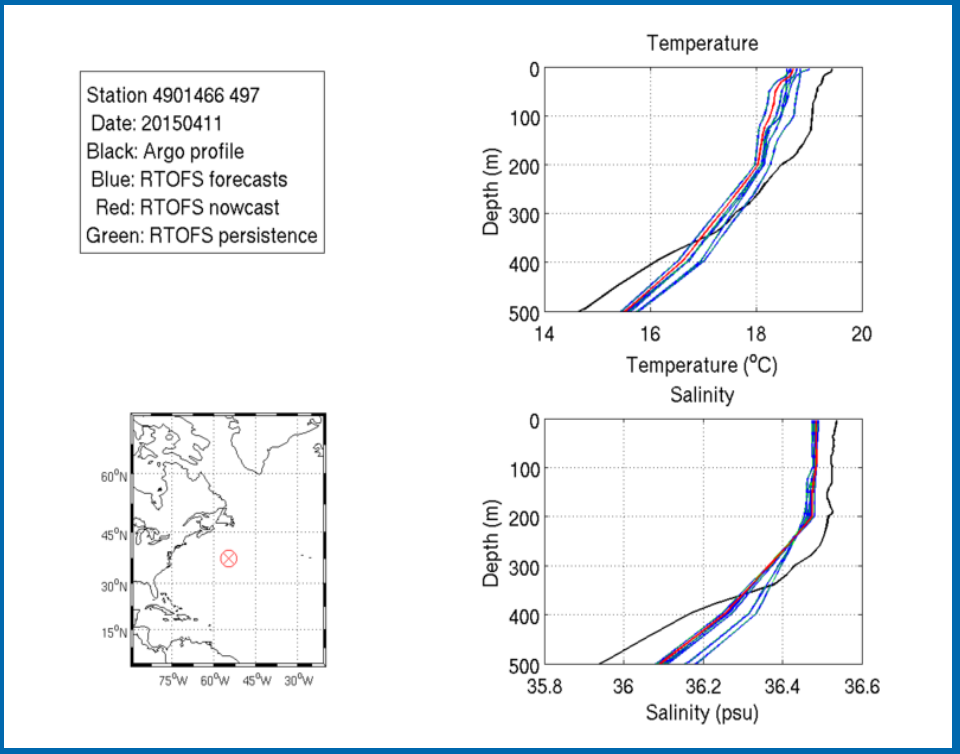
Florida Cable Transports
RTOFS v1.1 vs RTOFS v1.0

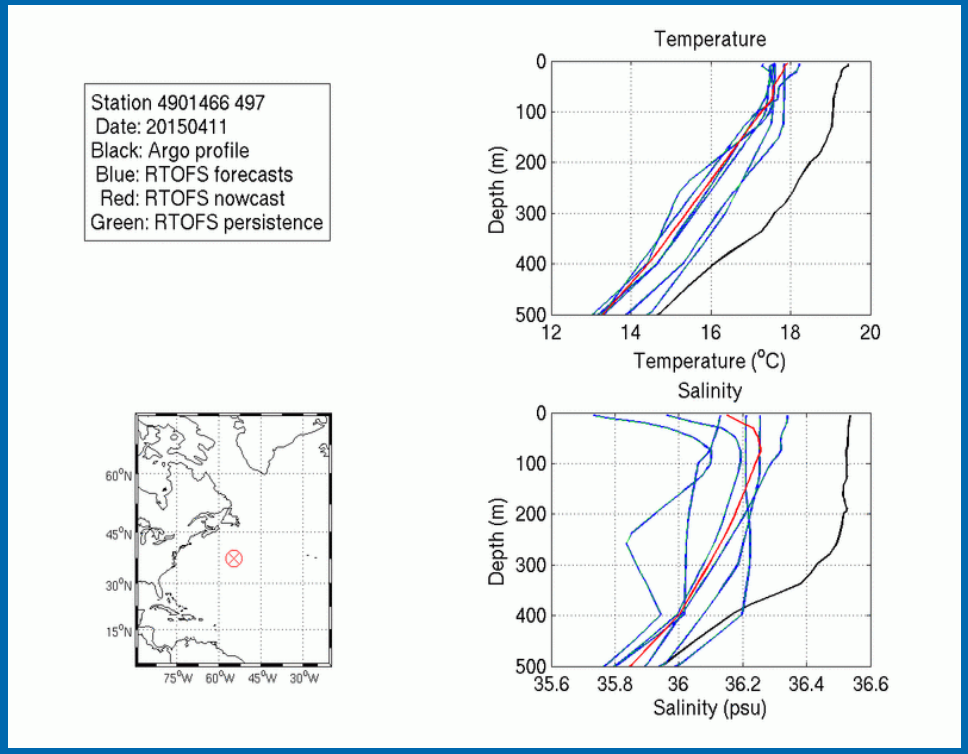




Parallel (left panel) underestimates while prod overestimates. Less variability in the parallel due to higher vertical resolution of the fast moving current in the top 200m.

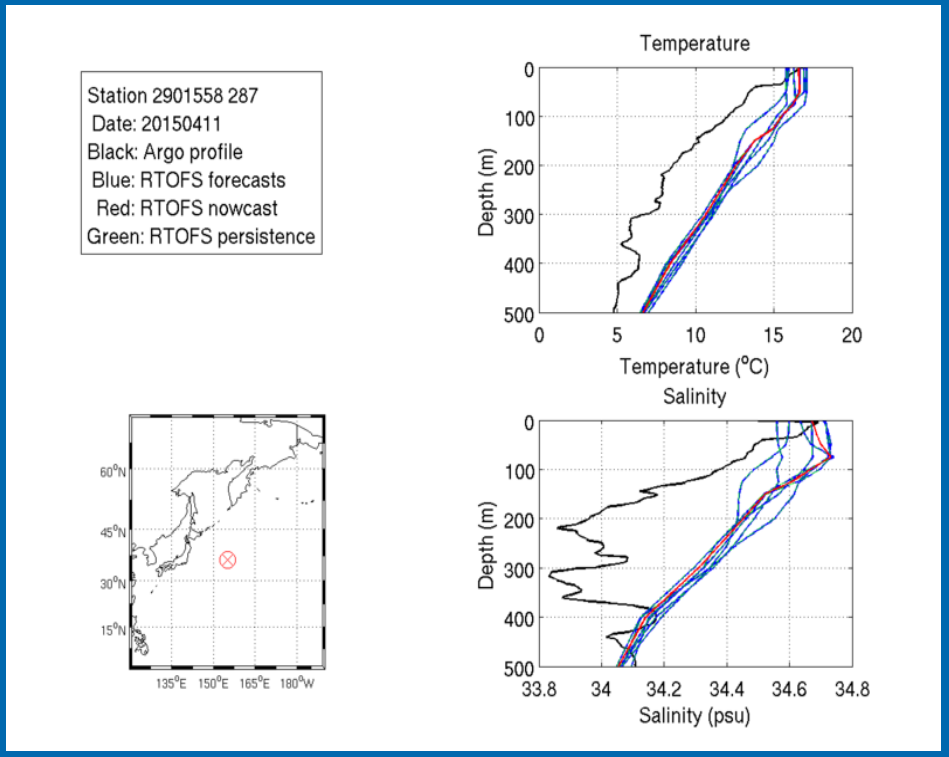
RTOFS v1.1 vs RTOFS v1.0 Vs ARGO

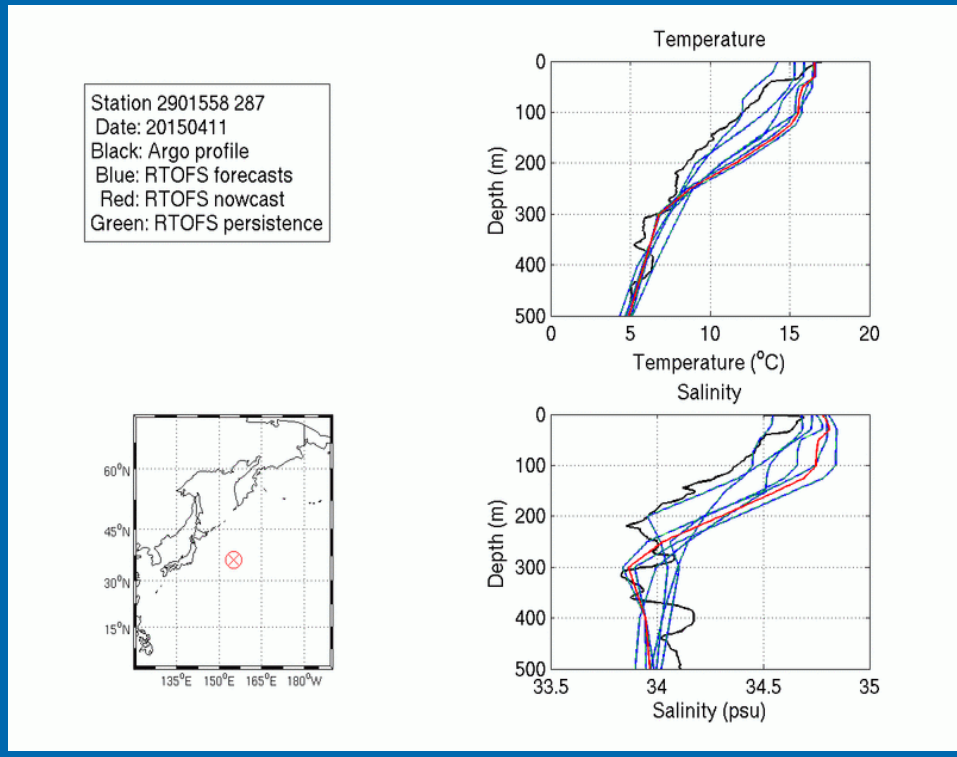




At this location, both parallel (left panel) T & S profiles show much better agreement with ARGO data and significantly less variability in forecasts especially for salinity.

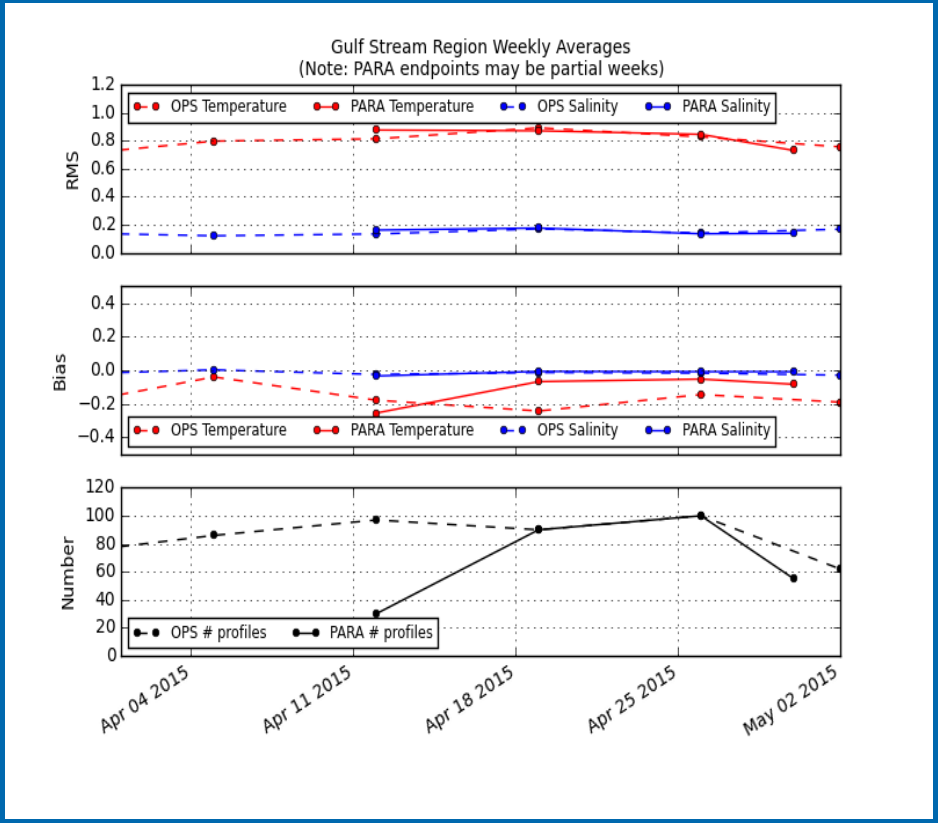
RTOFS v1.1 vs RTOFS v1.0 Vs ARGO

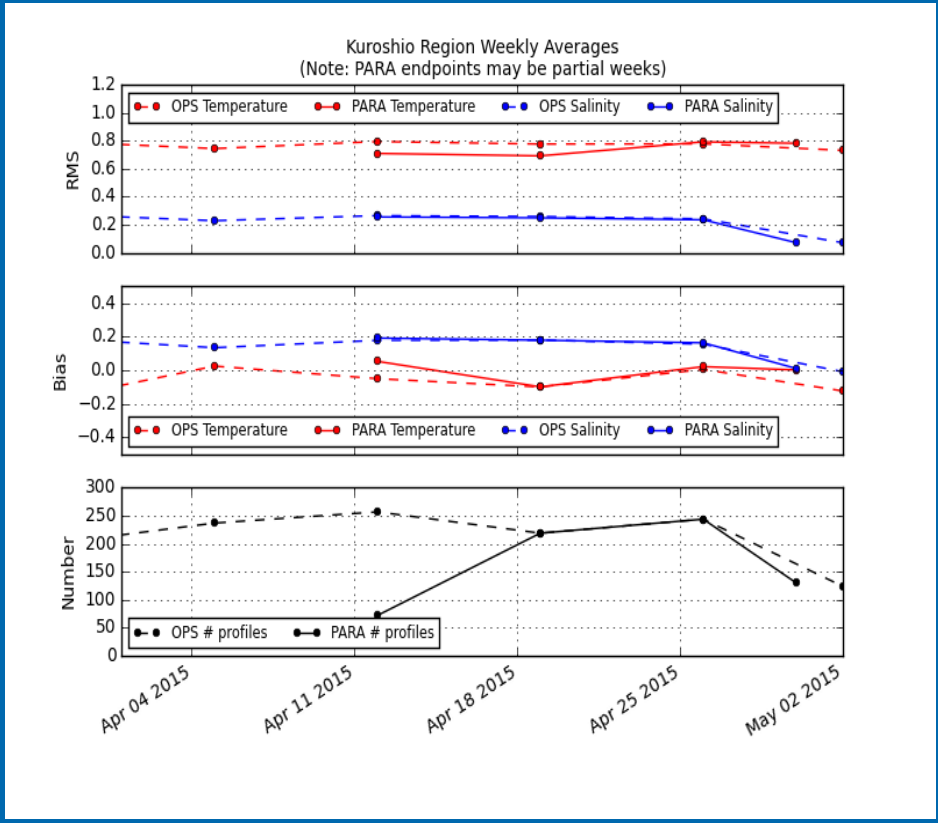




While at this location, production (right panel) T & S show much better agreement with ARGO data but enhanced variability in forecasts especially for salinity.

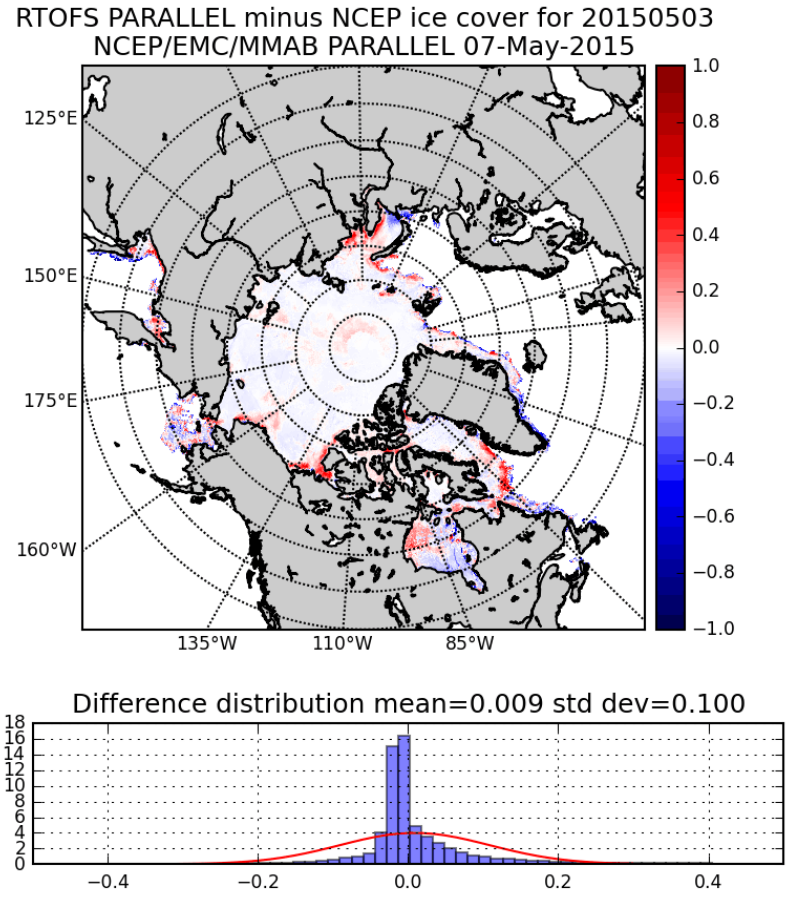
RTOFS v1.1 vs RTOFS v1.0 Vs ARGO

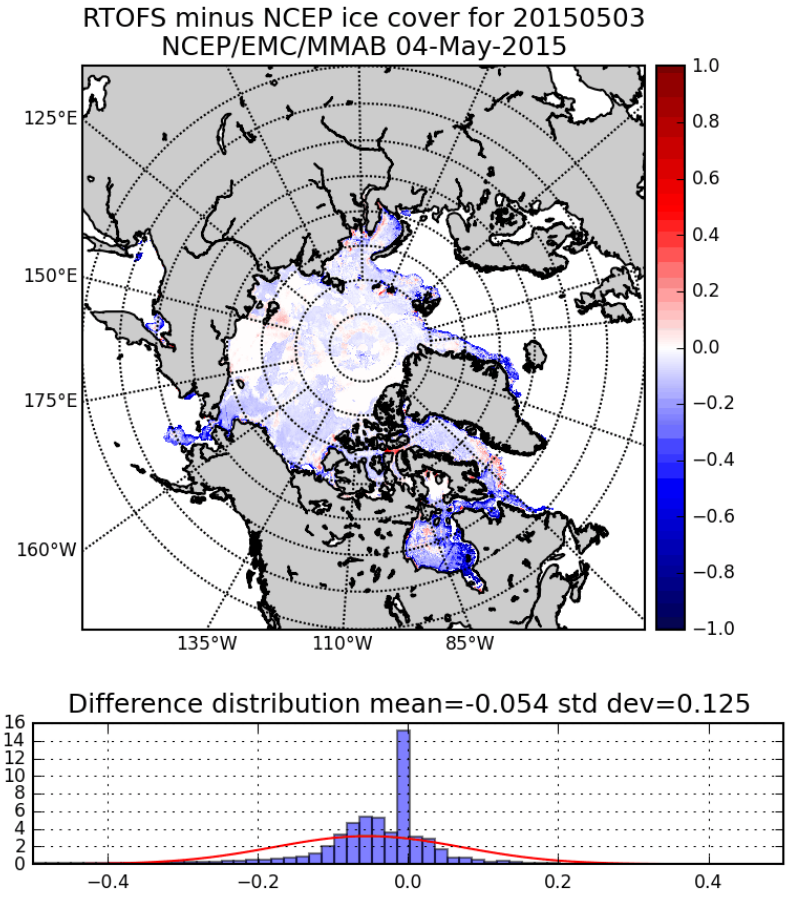




Weekly averaged (and depth averaged) profiles for these two regions show little difference between prod and para.

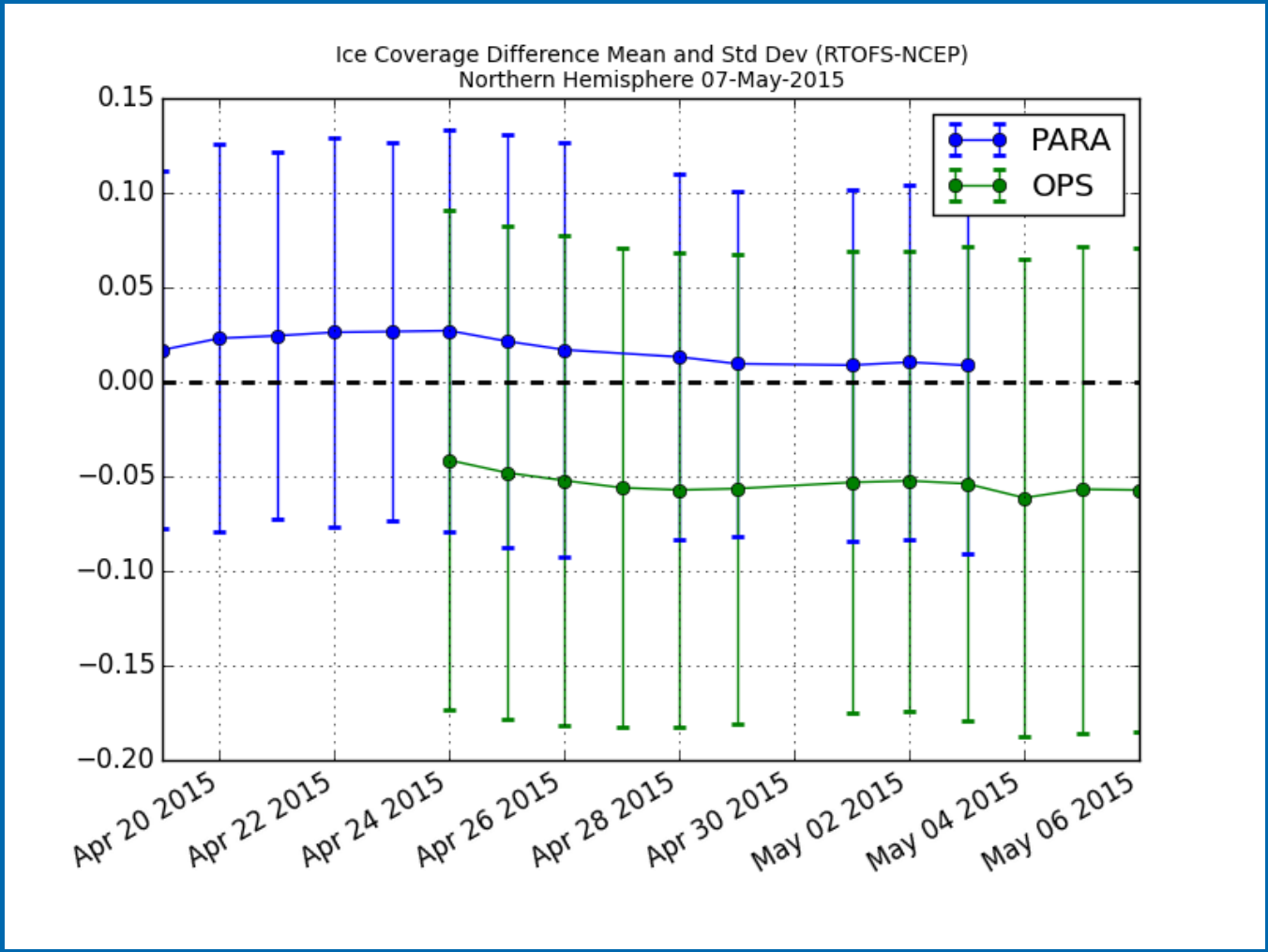
Sea Ice Cover RTOFS v1.1. vs RTOFS v1.0 vs Analysis





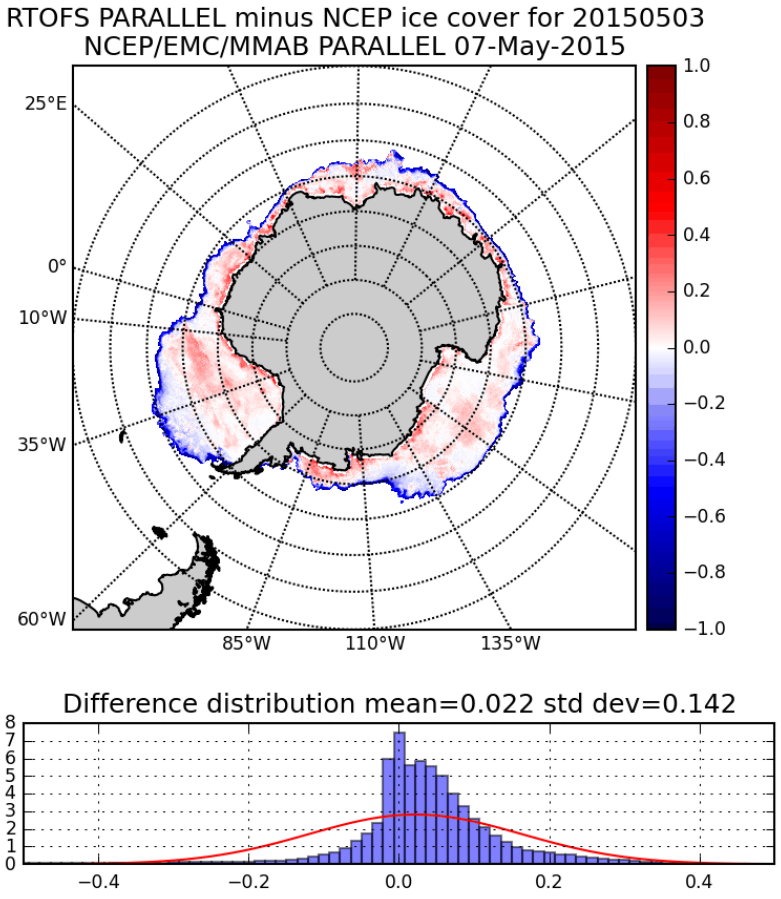
Differences in the Arctic region (May 2015)

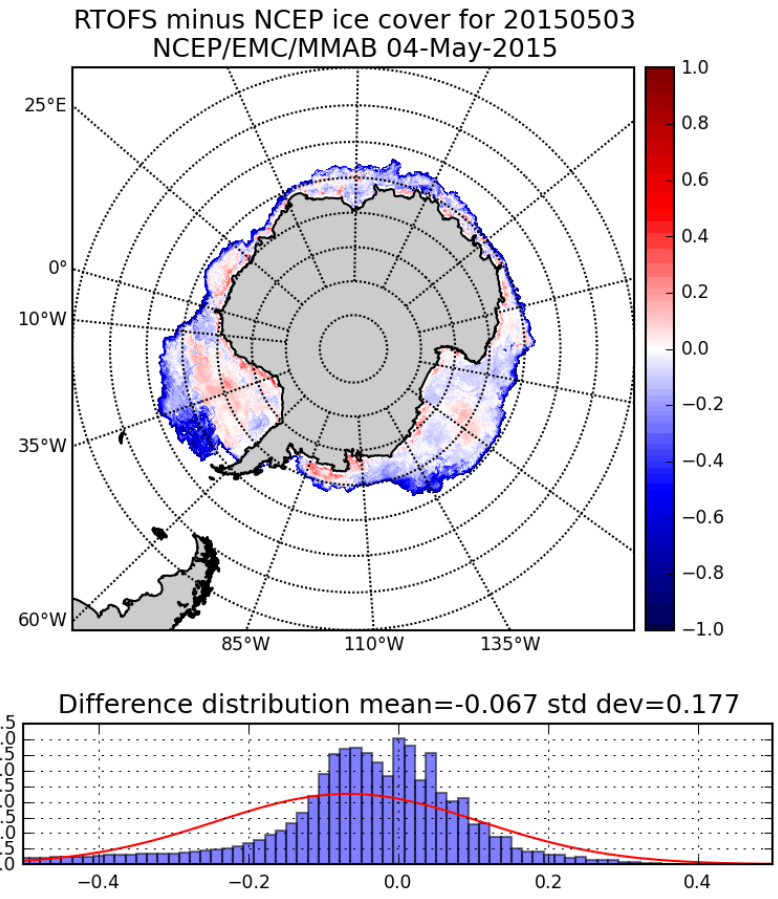
Sea Ice Cover RTOFS v1.1. vs RTOFS v1.0 vs Analysis



Mean differences in the Arctic region

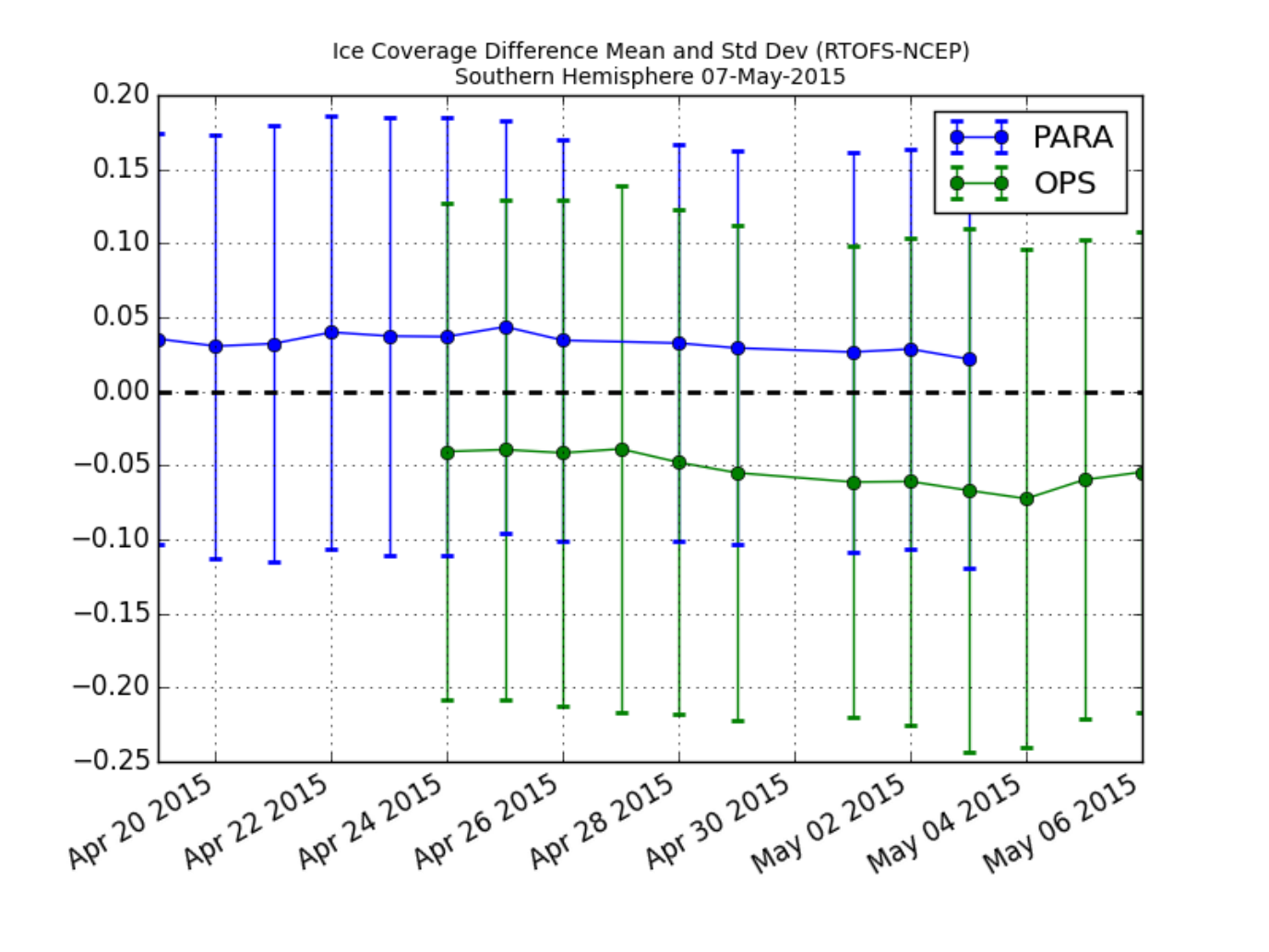
Sea Ice Cover RTOFS v1.1. vs RTOFS v1.0 vs Analysis





Differences in the Antarctic region (May 2015)

Sea Ice Cover RTOFS v1.1. vs RTOFS v1.0 vs Analysis



Mean differences in the Antarctic region

Version 1.1.0

Primary impacts:

- Better coastline/water-mass representation for coupled applications (air-sea fluxes for Hurricanes)
- Finer resolution for mixed layer (9 additional near surface layers)
- Improved vertical coastal resolution for downstream applications
- Improved Sea Ice coverage in polar regions
- Additional ice products/forecasts (ice thickness, ice concentration, ice drift and speed)

Resources

- CPU: **v1.1** 1800 PE or 75 nodes
  v1.0 2134 PE or 134 nodes
- Runtime: **v1.1** 18 minutes per day
  v1.0 10 minutes per day
- Disc: **v1.1** ~25% more than **v1.0** (CICE files, 41 levels, OPC products)
- Workflow: **v1.1** same as **v1.0**

RTOFS-Global v1.0 Product Suite

- Class I : Global netCDF files on native horizontal grid but interpolated to isolevels. Delivery via NOMADS, ftpprd and ~~NODC archives.~~

  - Surface 3 hourly files (8 variables) ~ 120 GB per cycle
  - Volume 3d files daily (8 variables, 33 Z levels) ~ 160 GB per cycle.

  Target: General user; maximum flexibility for slicing/dicing data using NOMADS/OpenDAP servers (both GDS & TDS).

- Class II: Sub-regional and basin GRIB2 files on Mercator grid. Delivery via ftpprd and AWIPS.

  Surface 3 hourly files (7 variables) ~ 5 GB per cycle

  Target: Internal NWS needs to provide results on AWIPS or via FTP.

RTOFS-Global v1.0 Product Suite

- Class III: Regional (CONUS-East, CONUS-West, Alaska) netCDF files.

  Delivery via NOMADS and ftpprd.

  - Volume 6 hourly files (u,v,T,S)

  Target: Other centers within NCEP (NHC, OPC) and NOS OFS systems

- Daily graphics available via web (polar) with restricted access to daily monitoring metrics

  Target: General public, collaborators

RTOFS-Global v1.1 Additional Products

- Additional n000, f000 data for aggregated variables from GDS/NOMADS servers
- OPC: Global NetCDF files (time series of variables)

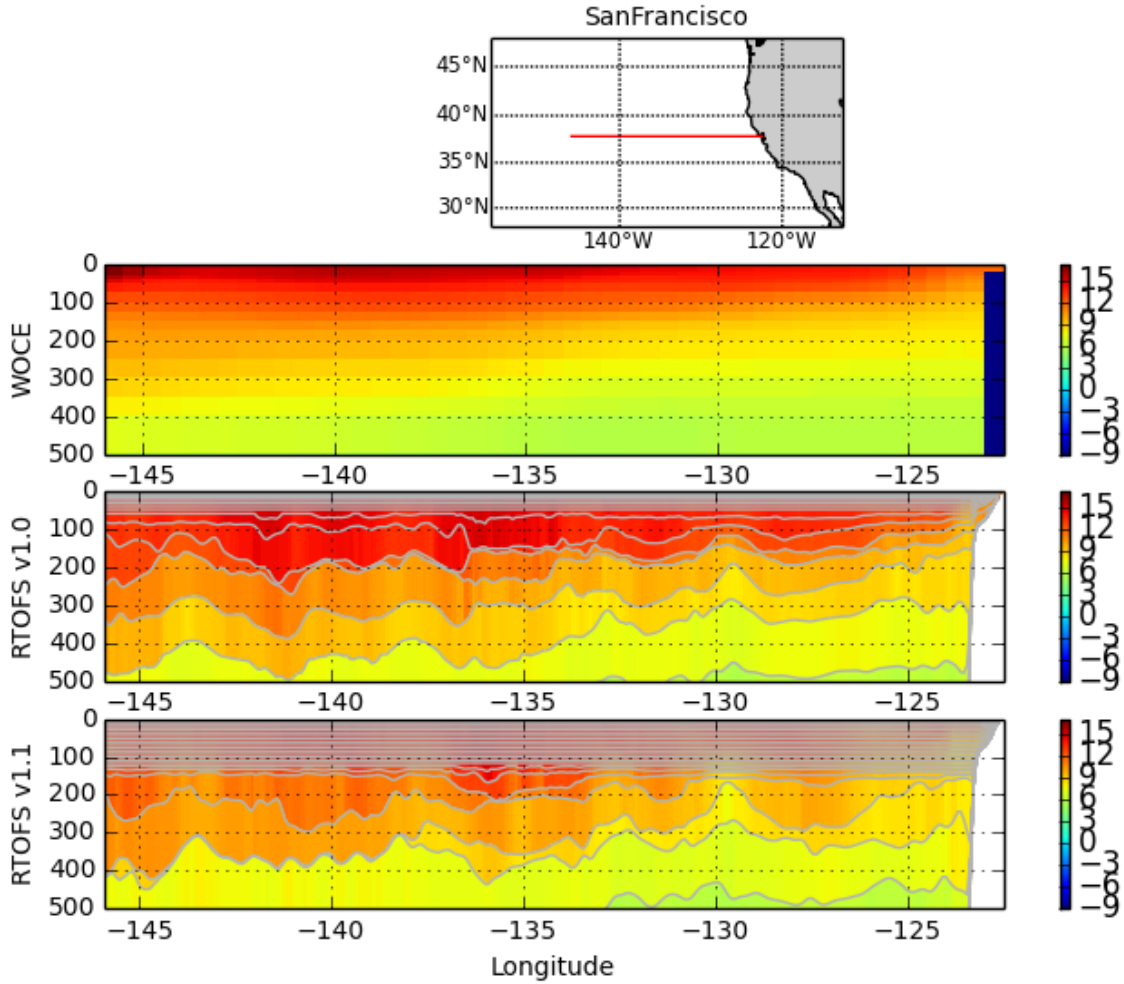
  Delivery via OPC ftp servers.

  - Surface hourly files (u, v, T, S, SSH)

  Target: OPC, USCG/SAROPS
- Product upgrade planned for FY16 Q2 (Sea Ice, HWRF-HYCOM, Ecosystems)

Back Up

WOCE vs RTOFS v1.0 vs RTOFS v1.1
Vertical Temperature Cross Section



Higher vertical resolution for upper ocean processes (mixed layer)

Recent upgrades for v1.0

- GRIB2 output to ops (OSIP) (Dec: 2013)
- Seven NOS regions use BC's in Coastal Ocean Modeling Framework (March 2014)
- 2 IOOS RA's (NANOOS, GOMOOS) also use v1.0 for BC's. (March 2014)