

Sea ice Ocean Coupled Data Assimilation (SOCA): Status Update



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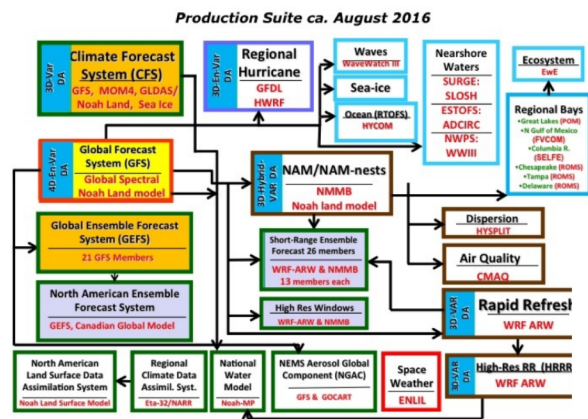
NOAA/EMC Contributors:

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Marine DA development



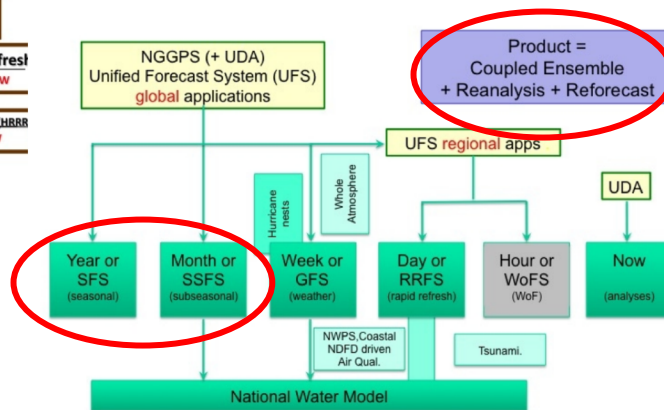
Strategic Vision Simplify Modeling Suite



Courtesy Bill Lapenta

Starting from the quilt of models and products created by implementing solutions rather than addressing requirements

... we will move to a product based system that covers all present elements of the production suite in a more systematic and efficient way



UDA: Unified Data assimilation
SFS: Seasonal Forecast System
SSFS: Subseasonal Forecast System

GFS: Weather Forecast System
RRFS: Rapid Refresh Forecast System
WoFS: Warn on Forecast System

SOCA deliverables
JEDI based
Initialization of the
marine components

Short term
SSFS, SFS, Reanalysis

Long term
RTOFS, UFS

Credits: Arun Chawla

Status: Marine IODA



IODA: Interface for Observation Data Access

Sufficient set of marine UFO for S2S initialization and re-analysis

- Conventional observations from FNMOC/GODAE:
 - Argo, CTD, XBT
 - Moorings: TAO, PIRATA, RAMA
 - Gliders, surface drifters, ...
- NESDIS absolute dynamic topography:
 - Jason 2-3
 - SARAL
 - Cryosat-2
 - Sentinel-3a
- Radiance based retrievals
 - NESDIS SST
 - JPL/RSS SSS (SMAP)
 - EMC ice fraction
- But no Ice thickness/freeboard observations...

Status: Marine UFO

(March-April 2019 code sprint)



UFO: Unified Forward Operator

	Nonlinear	Linear (tangent)	Adjoint
Sea-ice Fraction	N/A	Done	Done
Sea-ice Thickness	Done	Done	Done
Sea Surface Height	N/A	Done	Done
Insitu Temperature	Done	Done	Done
Practical Salinity	N/A	Done	Done
Sea Surface Temperature	N/A	Done	Done
Cool skin SST	Done	Done	Done
Sea Surface Salinity	N/A	Done	Done
Significant Wave Height			

generic UFO: Interpolation only

Status: Marine IODA/UFO

(March-April 2019 code sprint)



Data base	IODA converter	H(x)	3DVAR
FNMOG:: Profiles (Profilers and moorings)			
FNMOG:: Surface Drifters			
NESDIS:: RADS			
NCEP-Data tank:: L2-SST (AVHRR: GOES-16, VIIRS-NPP, HIMAWARI-8, NOAA-19, METOP-A)			
NCEP bufr:: Profiles, ships, buoys, drifters, gliders, altimeters, ...			
EMC::Ice fraction			
JPL & RSS:: SMAP			
Hybrid-GODAS all obs			
GMAO all obs			
NESDIS::SST (All sensors)			

Status: JEDI model encapsulation



CURRENT DEVELOPMENTS

Each of these is a working coupled application which is actively being tested

FV3 – WW3
Effects of waves on atmospheric stress at ocean surface

FV3 – MOM6 – CICE5
Coupled system for S2S scales (25 km atm, 1/4 deg ocean and ice)

MOM6 – CICE5
Ocean ice coupled model to look at polar dynamics and for developing a marine DA system

FV3 – MOM6 – CICE5 – WW3
Additional development of Langmuir mixing (25 km atm, 1/4 deg ocean and ice, 1/2 deg waves)

FV3 – CHEM
Atmosphere, aerosols interaction

ADCIRC – WW3
Wave and surge coupling (COASTAL ACT)

JEDI encapsulation of marine models

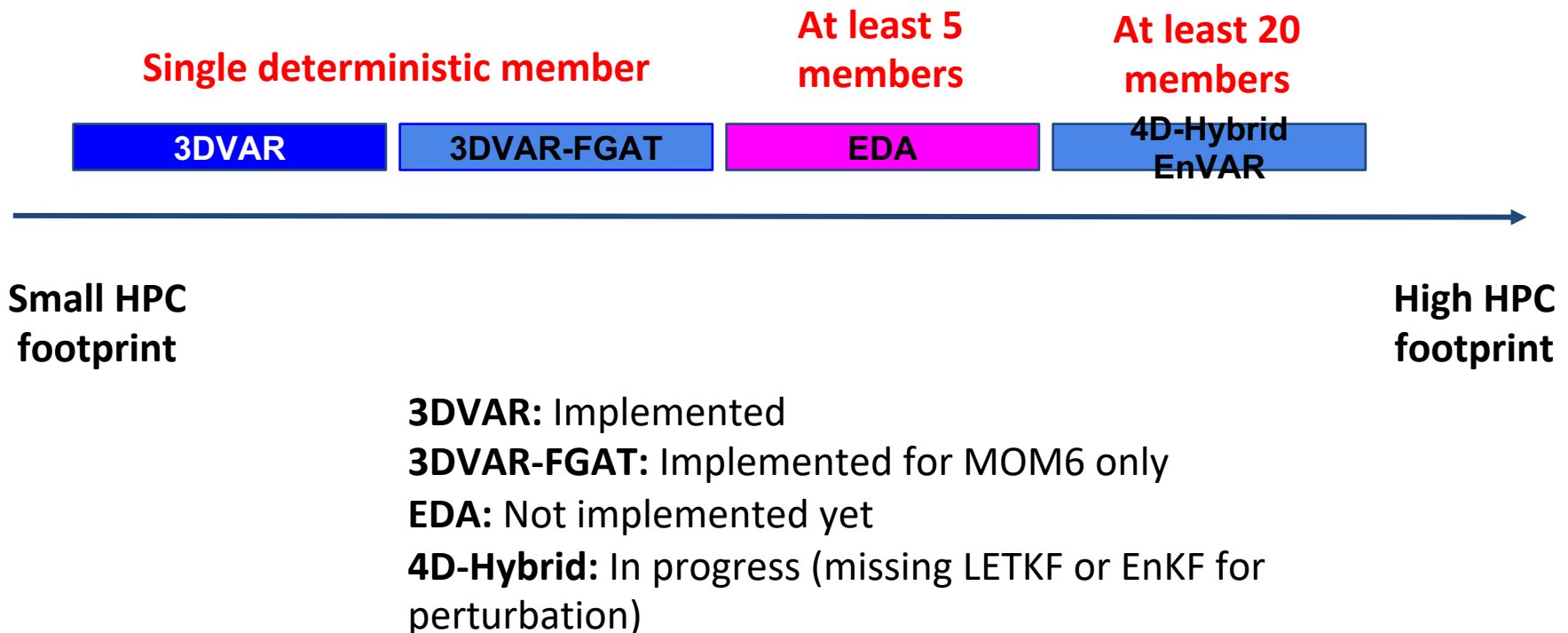
- MOM6 + Generic sea-ice
- GEOS (MOM6)
- CICE6
- WW3



Status: Algorithm Implementation



DA methods targeted for implementation



Note: All VAR algorithms are available in observation or state space

Status: Algorithm Implementation

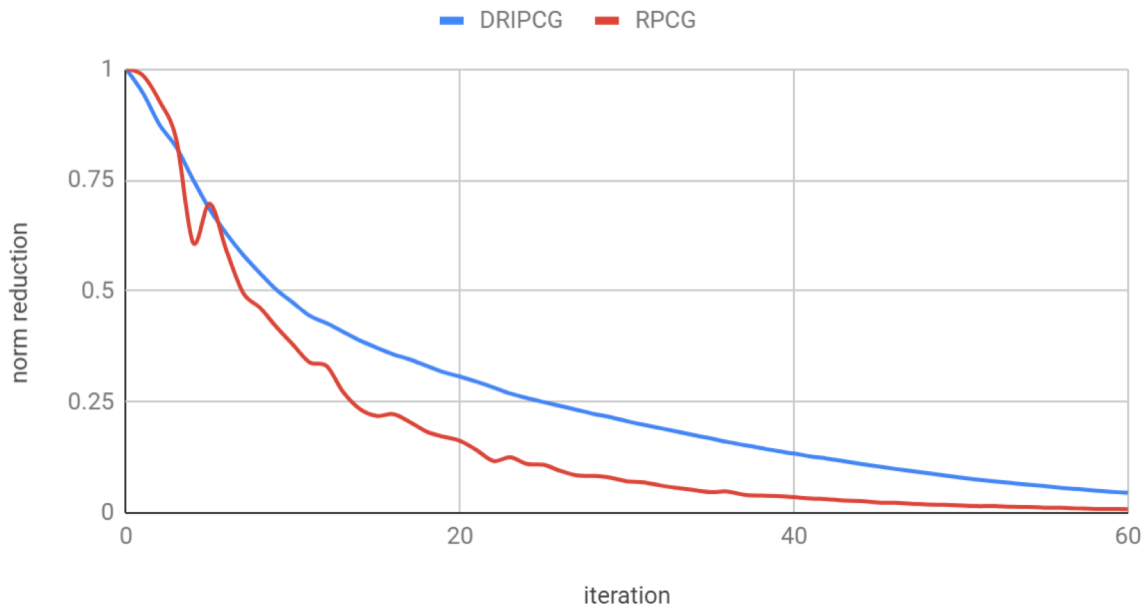


Switch to dual-space solver

DRIPCG (state) to RPCG (obs)

DRIPCG and RPCG

- Faster convergence
- less memory used (70% less)



Obs-space configuration

```
209 ◀
210 variational: ◀
211 iteration: ◀
212 resolution: ◀
213 num_ice_cat: 5 ◀
214 num_ice_lev: 4 ◀
215 num_sno_lev: 1 ◀
216 linearmodel: ◀
217 varchange: Identity ◀
218 version: IdTLM ◀
219 tstep: PT1H ◀
220 variables: *soca_vars ◀
221 minner: 5 ◀
222 gradient_norm_reduction: 1e-15 ◀
223 test: 'on' ◀
224 prints: ◀
225 diagnostics: ◀
226 departures: onbg ◀
227 ◀
228 minimizer: ◀
229 algorithm: RPCG ◀
230 ◀
231 output: ◀
232 datadir: Data ◀
233 exp: 3dvarfgat ◀
234 type: an ◀
235 ◀
236 final: ◀
237 diagnostics: ◀
```

State-space configuration

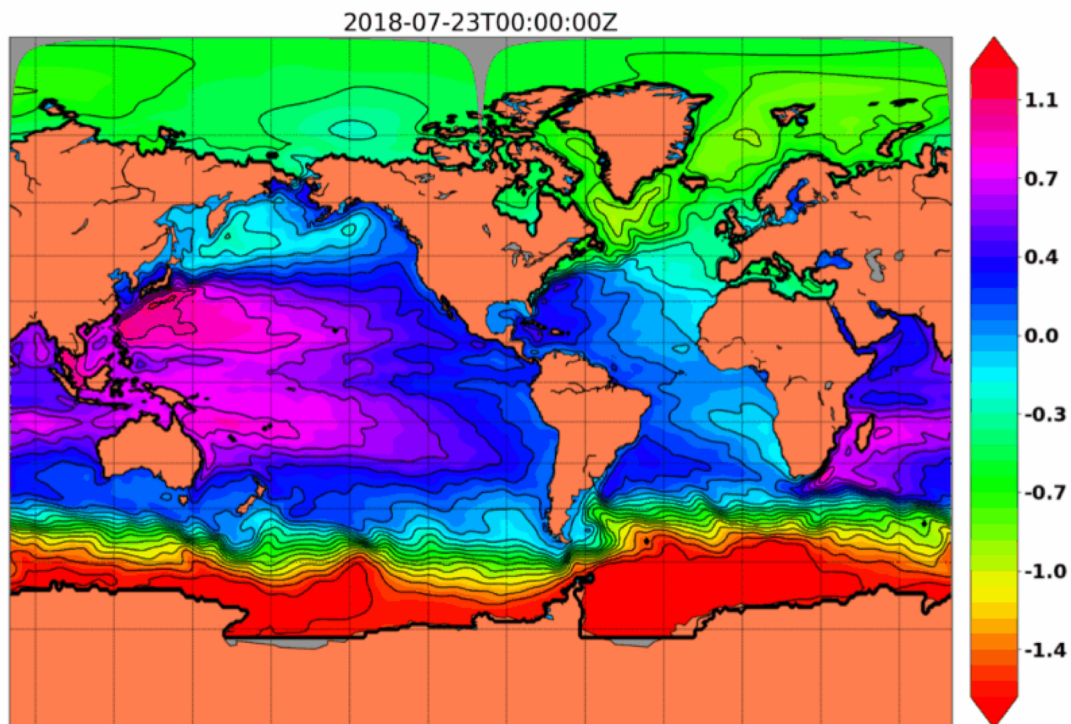
```
209 ◀
210 variational: ◀
211 iteration: ◀
212 resolution: ◀
213 num_ice_cat: 5 ◀
214 num_ice_lev: 4 ◀
215 num_sno_lev: 1 ◀
216 linearmodel: ◀
217 varchange: Identity ◀
218 version: IdTLM ◀
219 tstep: PT1H ◀
220 variables: *soca_vars ◀
221 minner: 5 ◀
222 gradient_norm_reduction: 1e-15 ◀
223 test: 'on' ◀
224 prints: ◀
225 diagnostics: ◀
226 departures: onbg ◀
227 ◀
228 minimizer: ◀
229 algorithm: DRIPCG ◀
230 ◀
231 output: ◀
232 datadir: Data ◀
233 exp: 3dvarfgat ◀
234 type: an ◀
235 ◀
236 final: ◀
237 diagnostics: ◀
```


Status Overview: Cycling



3DVAR cycling with multivariate Static B

- GFDL MOM6 at 1 degree (since January 2018)
- ¼ degree MOM6-CICE5-FV3 in progress (May 24, 2019)



- Assimilation of Jason-3 ADT
- 24hr window (2018-07-23 to 2018-07-30)
- 3DVAR-fgat

Examples: 30 days Cycling

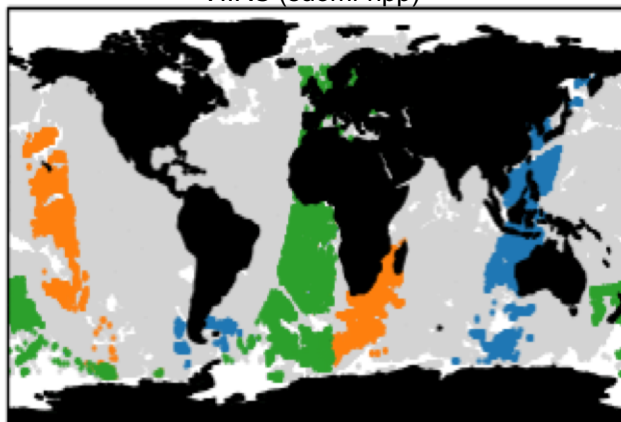
1 deg MOM6



1 day of observations
(2018-04-15)

sea surface temperature (IR)

AVHRR (metopa, noaa19)
VIIRS (suomi-npp)



sea surface salinity

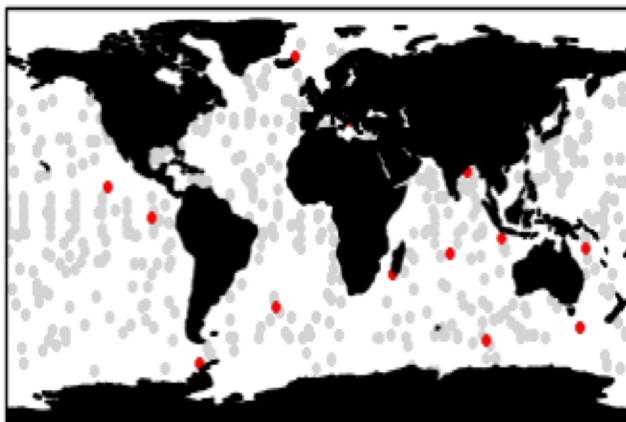
SMAP



In situ T/S

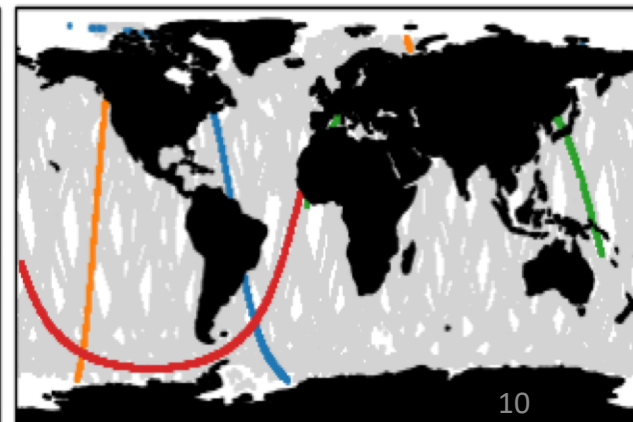
sea surface temperature (MW)

GMI, AMSR2, WindSat



Altimetry

Jason-2, Jason-3, Sentinel-3a,
Cryosat-2, SARAL



Examples: 30 days Cycling

1 deg MOM6



Satellite sensors cycled through 3DVAR

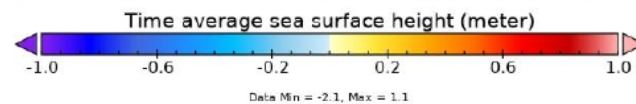
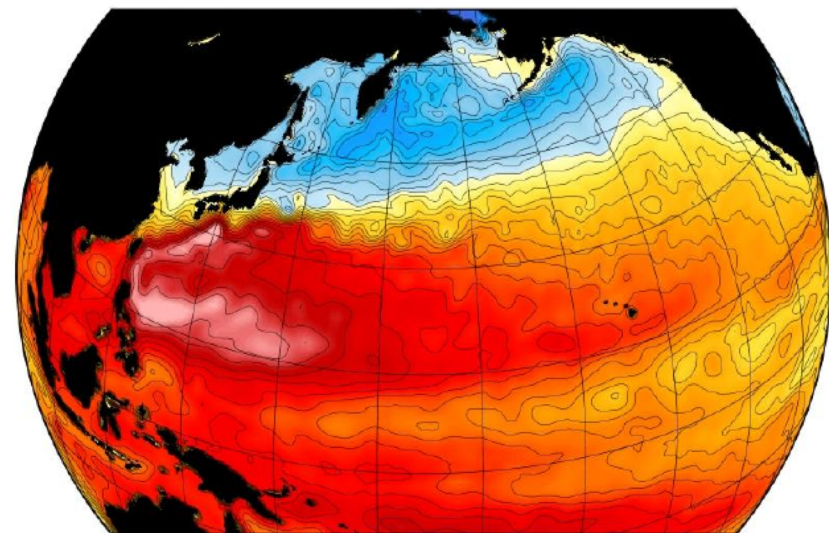
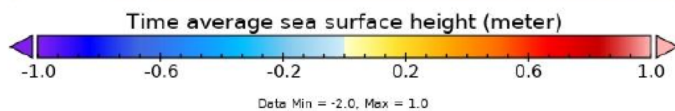
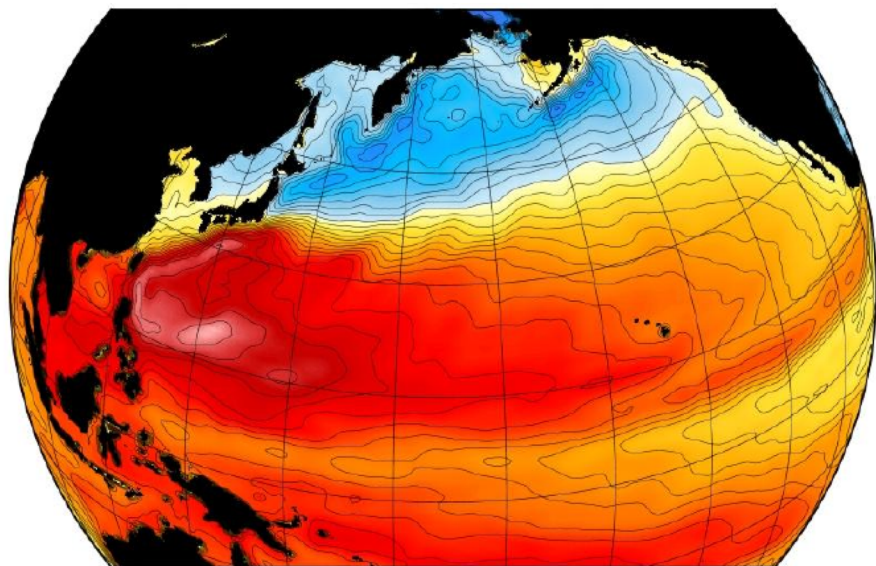
	sensor	satellite	thinning	obs_count (2018-04-15)
SST - IR	AVHRR	NOAA-19	99.5%	110,470
		METOP-A	99.5%	145,929
	VIIRS	NPP	99.5%	230,524
	ABI	GOES16		-
SST - MW	GMI	GPM	75.0%	106,308
	AMSR2	GCOM-W1	75.0%	129,684
	WindSat	WindSat	75.0%	101,781
SSS	SMAP	SMAP	0.0%	458,886
altimetry (ADT)	-	Jason-2		
	-	Jason-3		
	-	Sentinel-3a		
	-	Cryosat-2		
	-	SARAL		
			0.0%	240,017
Ice fraction - MV	SSMIS	F-17 F-18	95.00%	93,157
				1,616,756 Total

Examples: 30 days Cycling

1 deg MOM6



Assimilating satellite SST (NESDIS/ACSP0 AVHRR L2P) and altimetry (Jason-2, Jason-3, Sentinel-3a, Cryosat-2, SARAL)
24 hour window, MOM6 1 degree model.... after 30 days.
Kuroshio large meander correctly placed

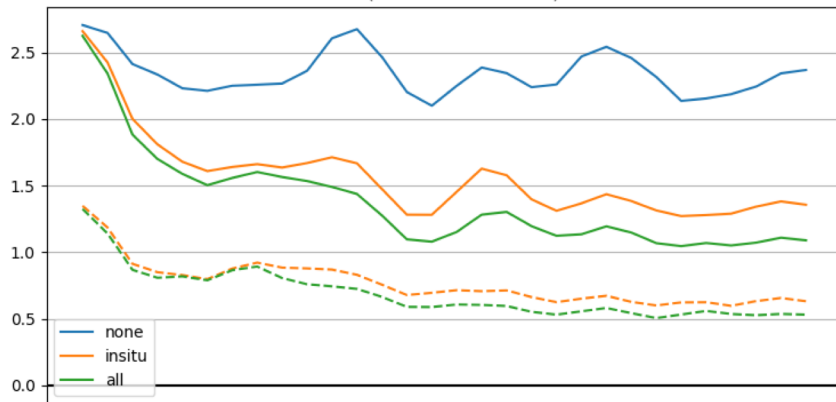


Examples: 30 days Cycling

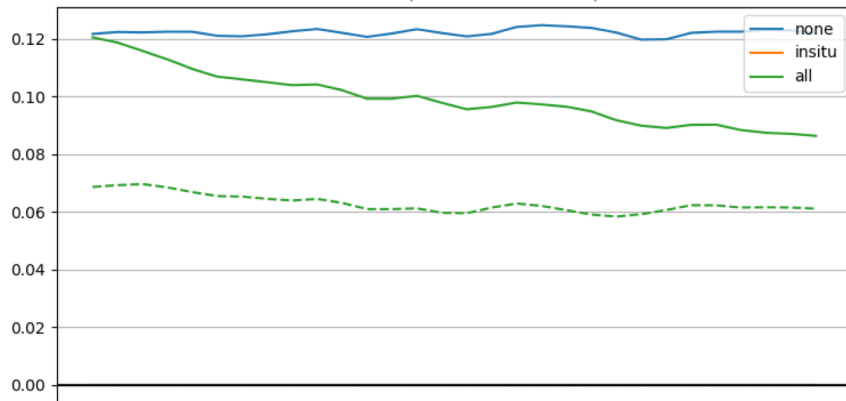
1 deg MOM6



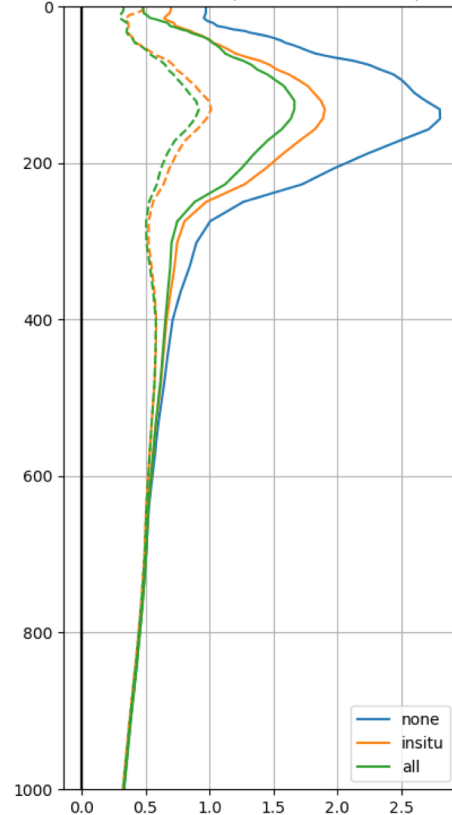
rmsd insitu T (Pacific TP 20S-20N) 50-200m



rmsd SSH (Pacific TP 20S-20N)



rmsd insitu T (Pacific TP 20S-20N)



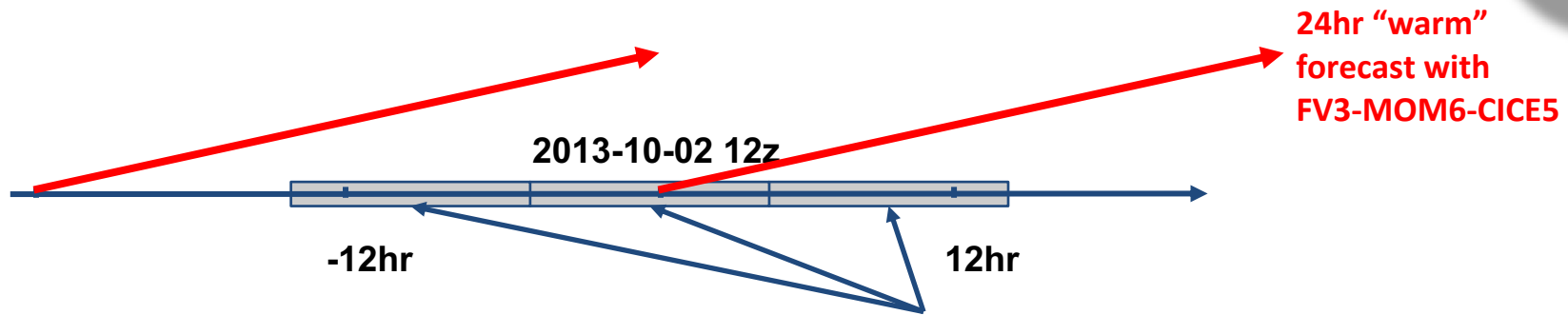
profiles: 6617

20180401 to 20180430

2018-04-15

2018-05-15

Examples: MOM6-CICE5-FV3 cycling



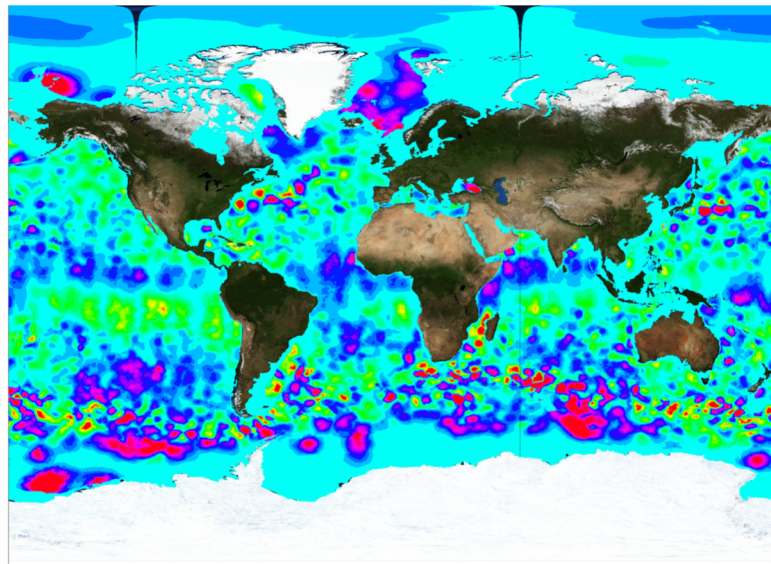
Concatenated observation in ioda format

24hr window, start 2013-10-01

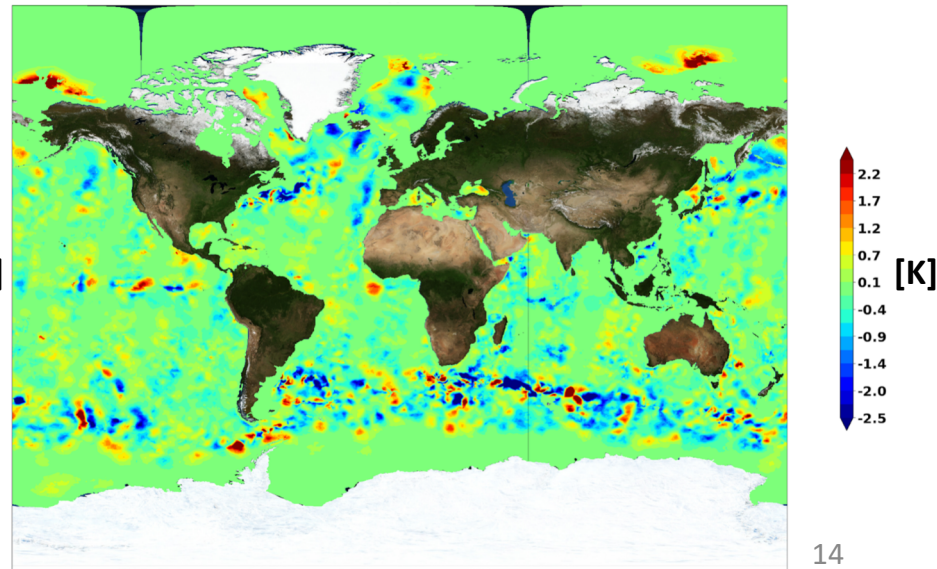
3DVAR for $\frac{1}{4}$ degree MOM6

GMI L2 SST + NESDIS-RADS ADT (SARAL, CryoSat-2, Jason-2, Jason-3)

$\frac{1}{4}$ degree SSH increment



$\frac{1}{4}$ degree SST increment



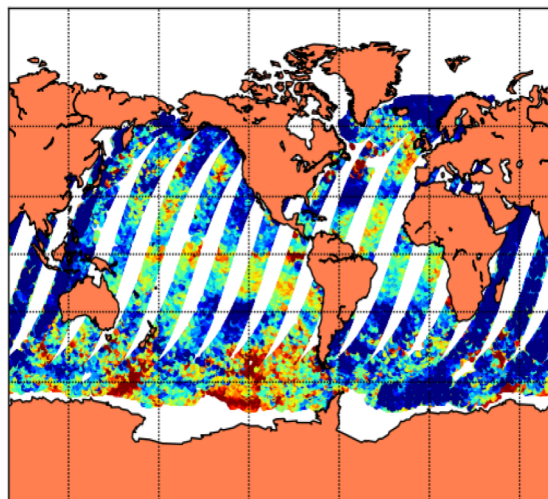
Status Overview: Coupled DA multi-domain UFO



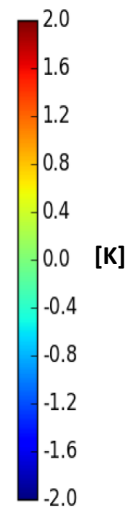
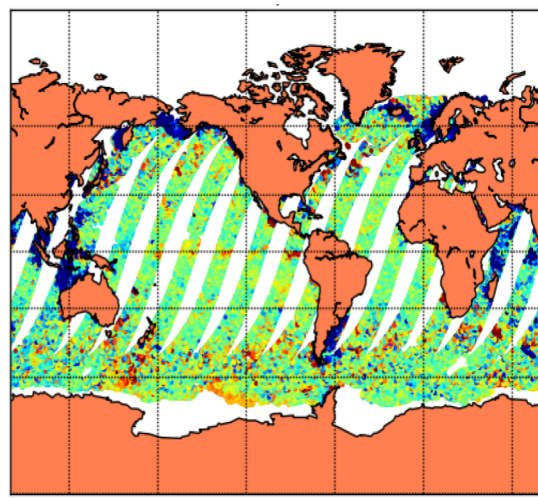
Coupled UFO: Ocean surface/Atmosphere

- OSE with AMSU-A & GMI (See Hamideh Ebrahimi poster)
- Cool skin

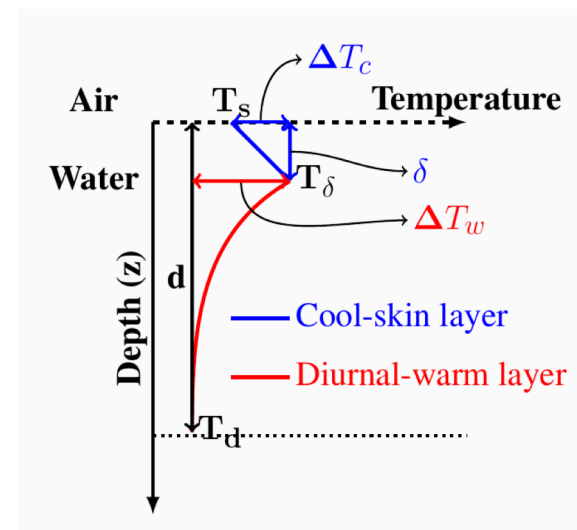
Observed - Background skin sst



Observed - Analysis skin sst



Cool skin SST UFO



Implemented by Hamideh, figure from Santha

April 15, 2018 (24hr window)

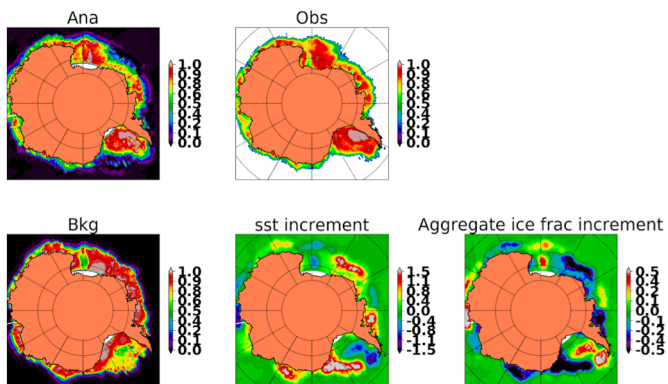
Status Overview: Coupled DA

coupled B

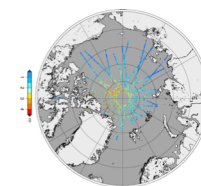


Coupled Covariance model: Ocean/Sea-ice

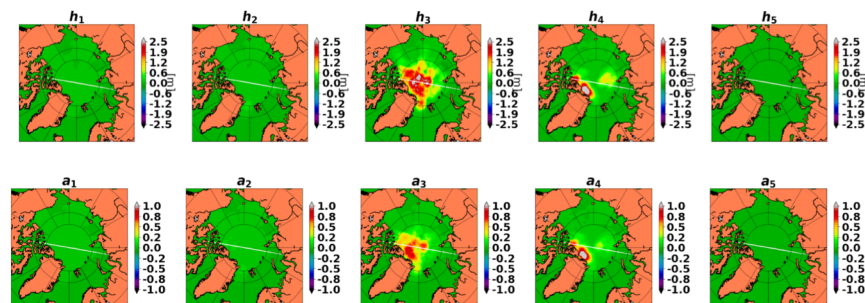
Coupled increment (sst & ice-fraction) resulting from the assimilation of sea-ice concentration.



3DVAR



Sea-ice thickness Level 2 processing (Alfred Wegener Institute). Data set provided courtesy of Dr. Sinéad Louise Farrell.



3DEnVAR

FY2019 plans



FY2019 to do list:

- Prototype DA system for NOAA/EMC & NASA/GMAO (ocean & sea-ice)
- Participation in the SSF benchmark tests (NOAA/EMC)
- NOAA/CPC Ocean monitoring?
- Prototype implementation of a 4D EnVAR/LETKF
- Prototype Coupled UFO (CRTM based SMAP, GMI)
- Diurnal SST UFO (Cool skin UFO done)
- CICE6 & WW3 interfaces

FY2019 code sprints:

- Marine IODA/UFO (March/April 2019)
- Marine model interface (NOAA MOM6-FV3-CICE, GEOS coupled, WW3, CICE6)
- Multi-domain UFO