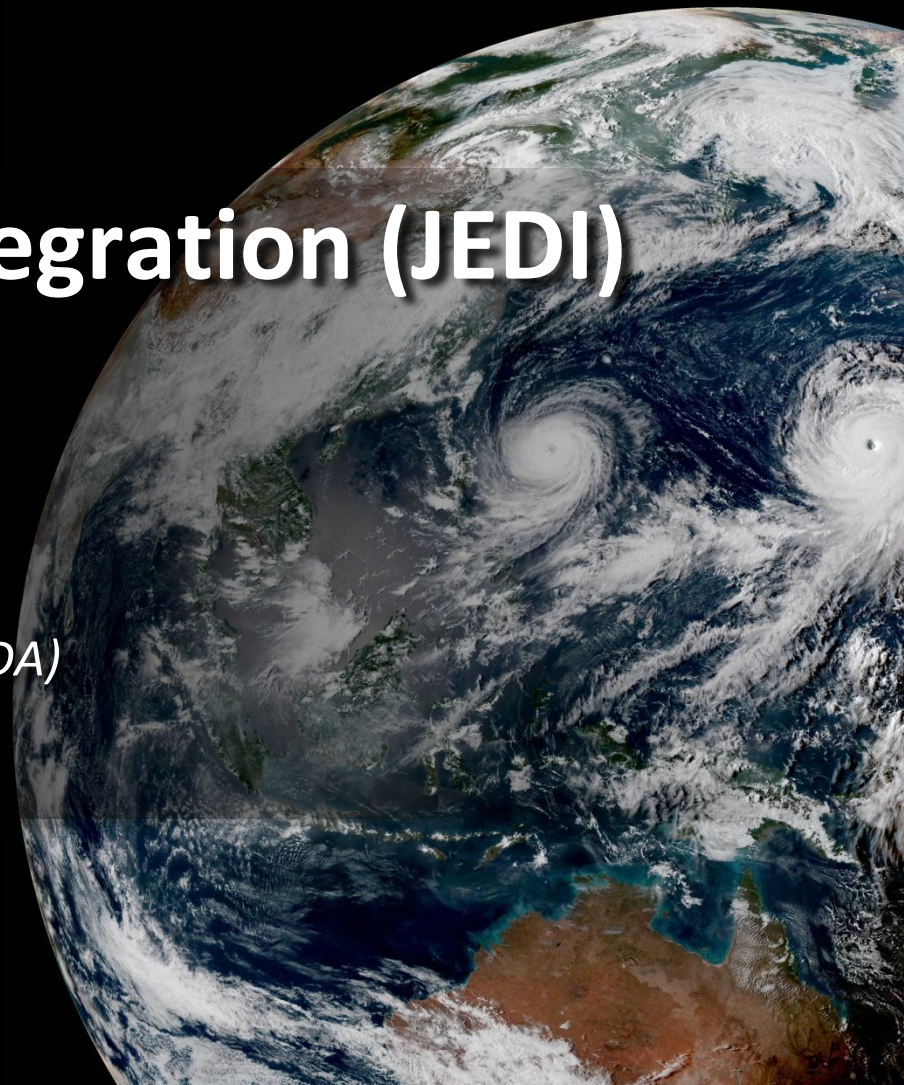
Joint Effort for Data assimilation Integration (JEDI) Status Update

Thomas Auligné, Director, Joint Center for Satellite Data Assimilation (JCSDA)



JEDI

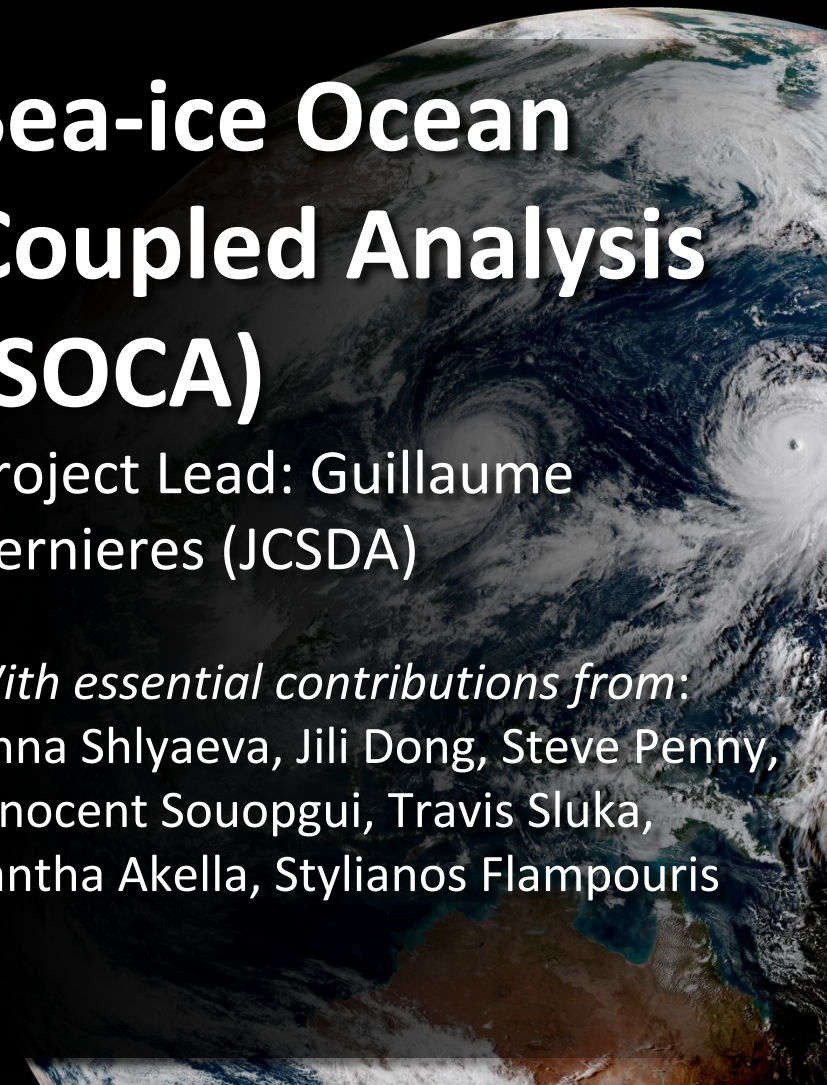
Project Lead: Yannick Trémolet (JCSDA)

With essential contributions from: Amal El Akkraoui, Anna Shlyaeva, Ben Johnson, Ben Ruston, Benjamin Ménétrier, BJ Jung, Bob Oehmke, Bryan Flynt, Bryan Karpowicz, Chris Harrop, Clara Draper, Dan Holdaway, David Davies, David Rundle, Dom Heinzeller, François Vandenberghe, Gael Descombes, Guillaume Vernières, Jeff Whitaker, Jing Guo, John Michalakes, Marek Wlasak, Mariusz Pagowski, Mark Miesch, Mark Potts, Ming Hu, Rahul Mahajan, Ricardo Todling, Sarah King, Scott Gregory, Sergey Frolov, Steven Herbener, Steve Sandbach, Tom Auligné, Will McCarty, Xin Zhang.

Sea-ice Ocean Coupled Analysis (SOCA)

Project Lead: Guillaume Vernieres (JCSDA)

With essential contributions from: Anna Shlyaeva, Jili Dong, Steve Penny, Innocent Souopgui, Travis Sluka, Santha Akella, Stylianos Flampouris



JEDI:: Ambitious Project Timeline

- Avr 2017: Unified DA Planning Meeting

Functional Prototype

- Aug 2017: Coding begins
- Mar 2018: Basic 3DEnVar prototype

YOU ARE HERE

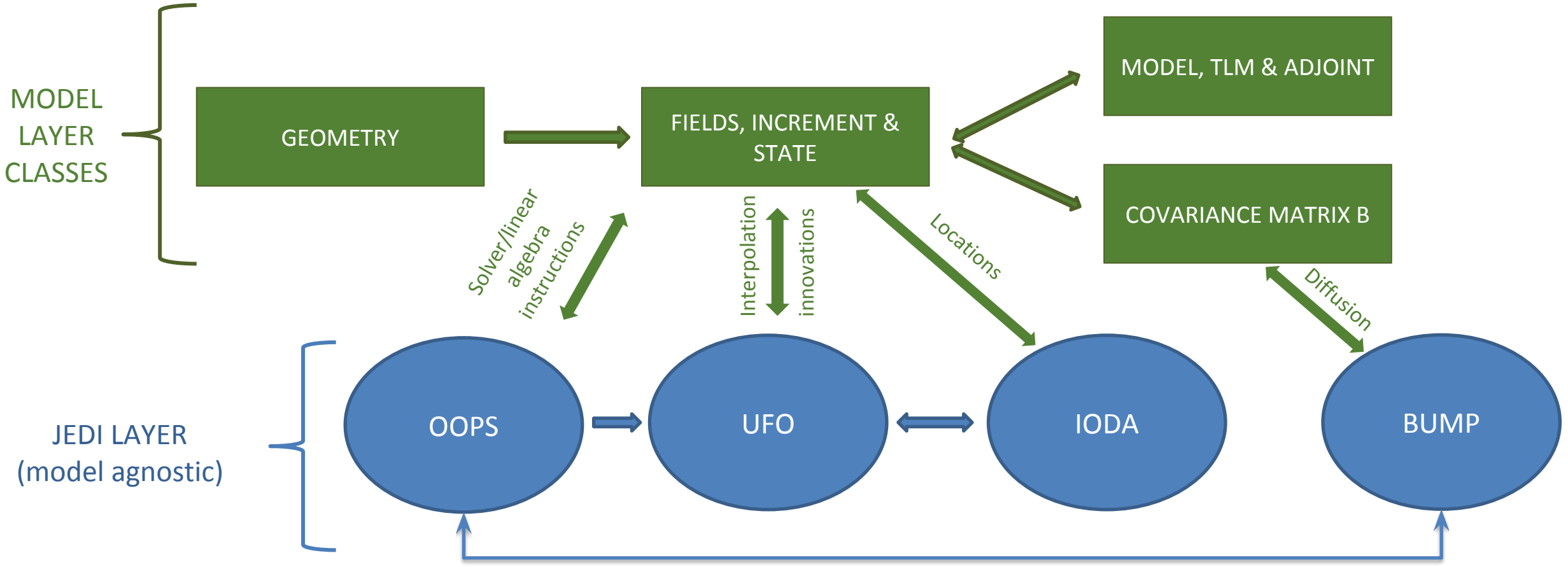
Rapid Development

- Aug 2018: Improved prototype, incl. basic Hybrid 4DVar
- Nov 2018: Prototype evaluation panel

Toward Operations

- Nov-Dec 2018: Code release and JEDI Academy
- Mar 2020: JEDI-UFO operational implementation
- Mar 2021: JEDI-Solver (Var + Ens.) operational implementation

JEDI:: Model Interfacing

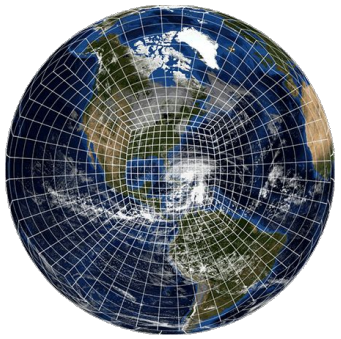


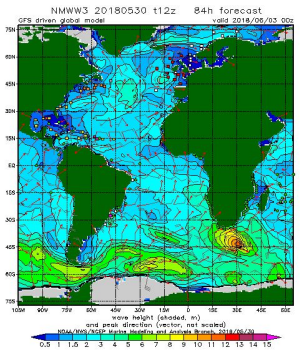
JEDI:: Model Interfacing Status

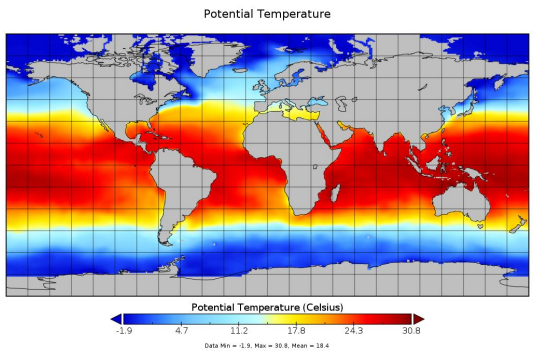
	State	3D H(x)	M(x)	4D H(x)	3D-Var	TL/AD	4D-Var
FV3-GFS (NOAA)	✓	✓	✓	✓	✓	✓*	✓
FV3-GEOS (NASA)	✓	✓	✓	✓	✓	✓*	✓
MPAS (NCAR)	✓	✓	✓		✓	N/A	N/A
WRF (NCAR/NOAA)	✓						
LFRic (UKMO)	✓	✓	✓		✓	?	
NEPTUNE (NRL)	✓					?	
CICE5 (NOAA)	✓	✓			✓	N/A	N/A
MOM6 (NOAA)	✓	✓			✓	N/A	N/A

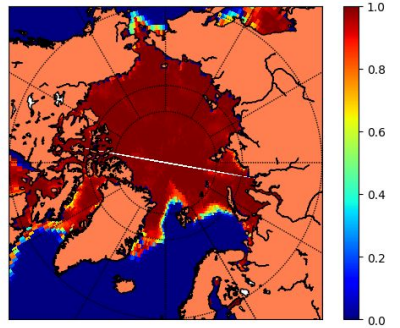
✓ = technically working ✓ = in progress

* Linearized physics under progress

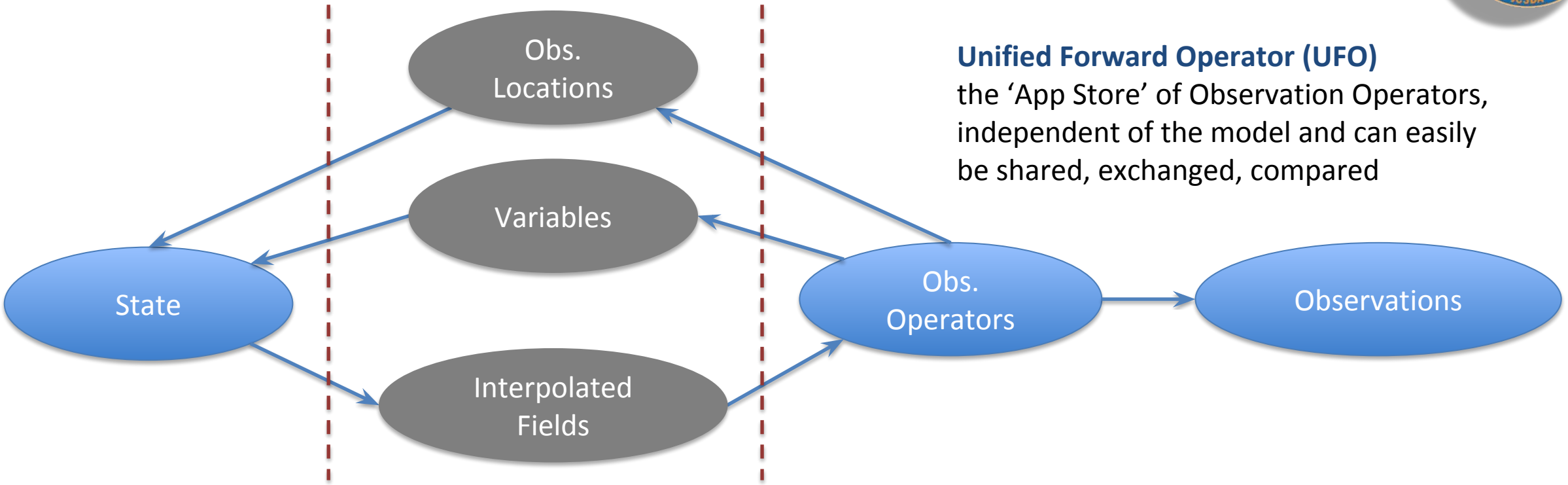








JEDI:: Unified Forward Operator (UFO)



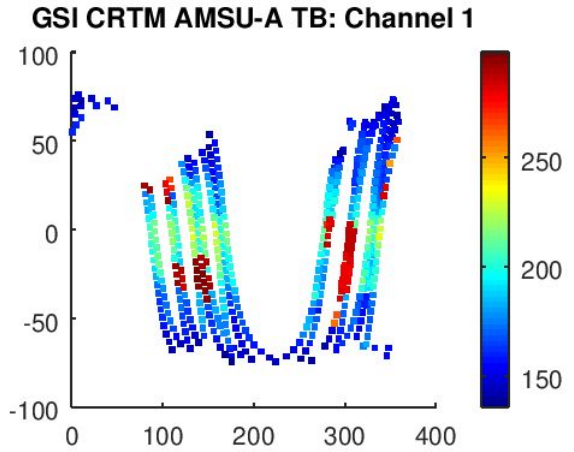
Unified Forward Operator (UFO)
the 'App Store' of Observation Operators, independent of the model and can easily be shared, exchanged, compared

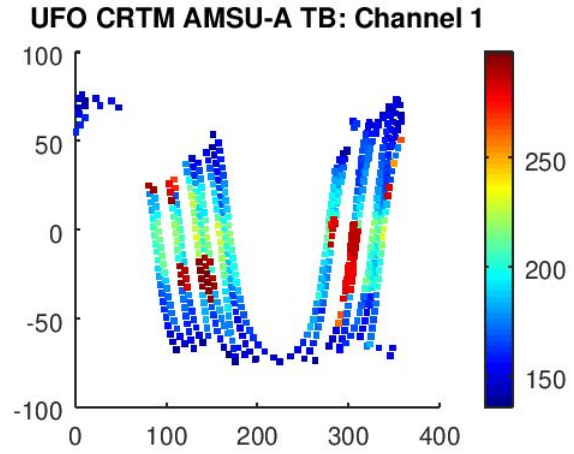
UFO Version 0.1

- Interpolation from model native grids to observation locations
- Interface for Observation (IODA) based on NCDIAG API (NetCDF4)
- Interface for generic Quality Control
- Subset of instruments

JEDI:: Unified Forward Operator (UFO) Status

	Nonlinear	Linear (tangent)	Adjoint
Radiosonde T	✓	✓	✓
Aircraft	✓	✓	✓
Aerosol Optical Depth	✓	✓	✓
Satellite Radiances (tested with AMSUA)	✓	✓	✓
GNSSRO Refractivity	✓	✓	✓
GNSSRO Bending Angle	✓	✓	✓





SOCA:: Unified Forward Operator (UFO) Status

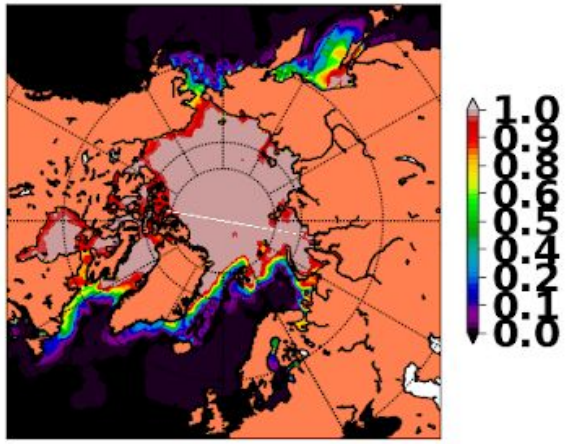
	Nonlinear	Linear (tangent)	Adjoint	Platform
Sea-ice Fraction	N/A	✓	✓	Suomi NPP (& L4 composite)
Sea-ice Thickness	✓	✓	✓	Cryosat-2
Sea Surface Height	N/A	✓	✓	Jason-3
Insitu Temperature	✓	✓	✓	Argo, TAO, RAMA, PIRATA, XBT, CTD
Practical Salinity	N/A	✓	✓	
Sea Surface Temperature	N/A	✓	✓	NOAA-19
Diurnal SST	✓	✓	✓	NOAA-19
Significant Wave Height	✓	✓	✓	Jason-3

SOCA:: Coupled Data Assimilation (SST / Sea-ice)

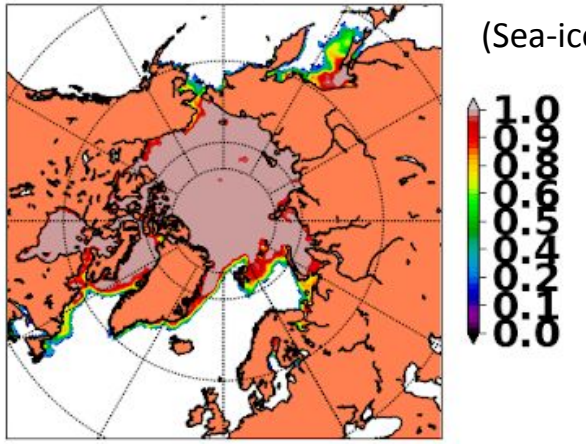
Engineering results only!

Balance b/w upper ocean temperature and sea-ice fraction

Ana

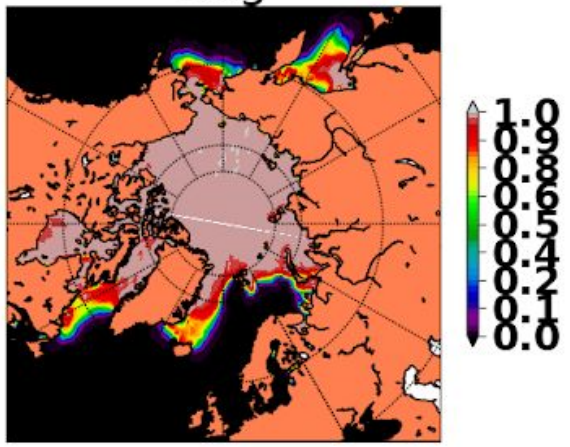


Obs

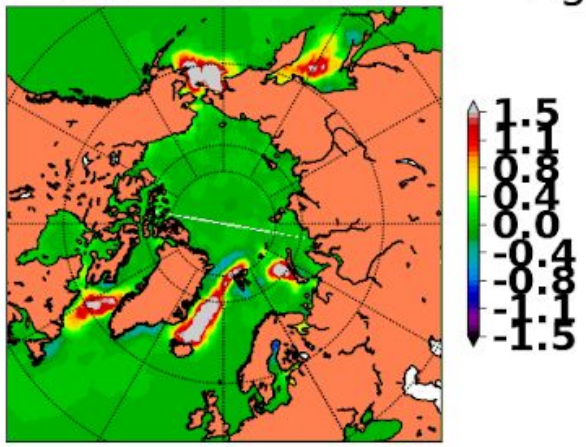


(Sea-ice fraction obs)

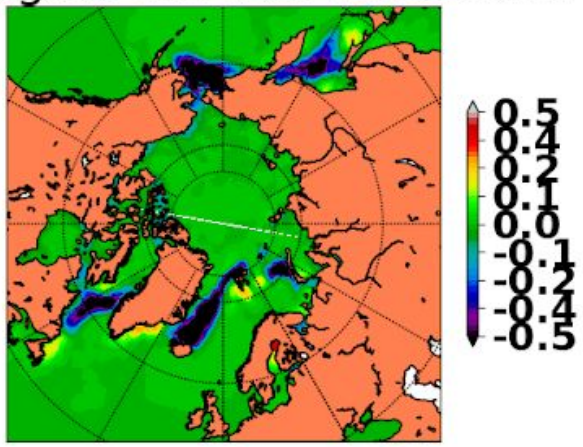
Bkg



sst increment



Aggregate ice frac increment



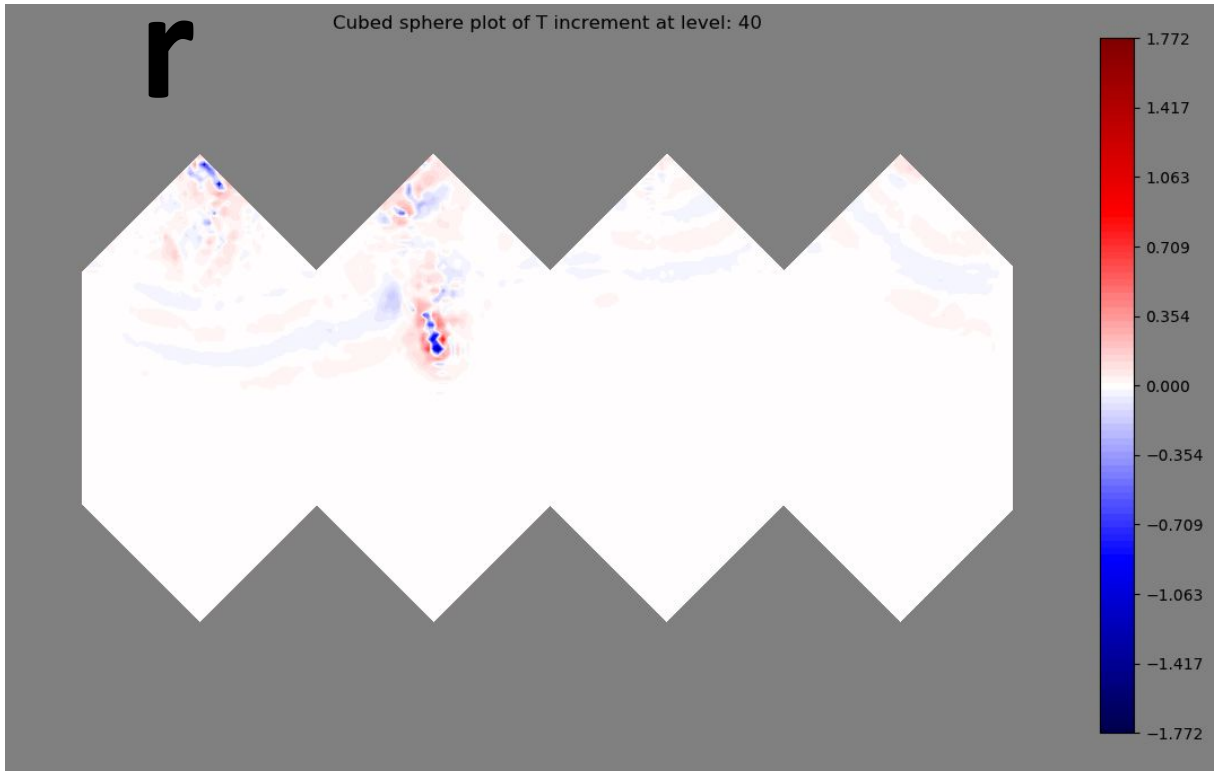
JEDI:: Analysis Increments (FV3 with Radiosondes)

Engineering results only!

4DVa

- Realistic FV3 background; C48 (200km) resolution; B = I; GMAO FV3 TLM/ADJ
- Real satellite radiance observations (AMSU-A)
- Interpolation from model native grid to observations
- DRIPCG solver from OOPS

r



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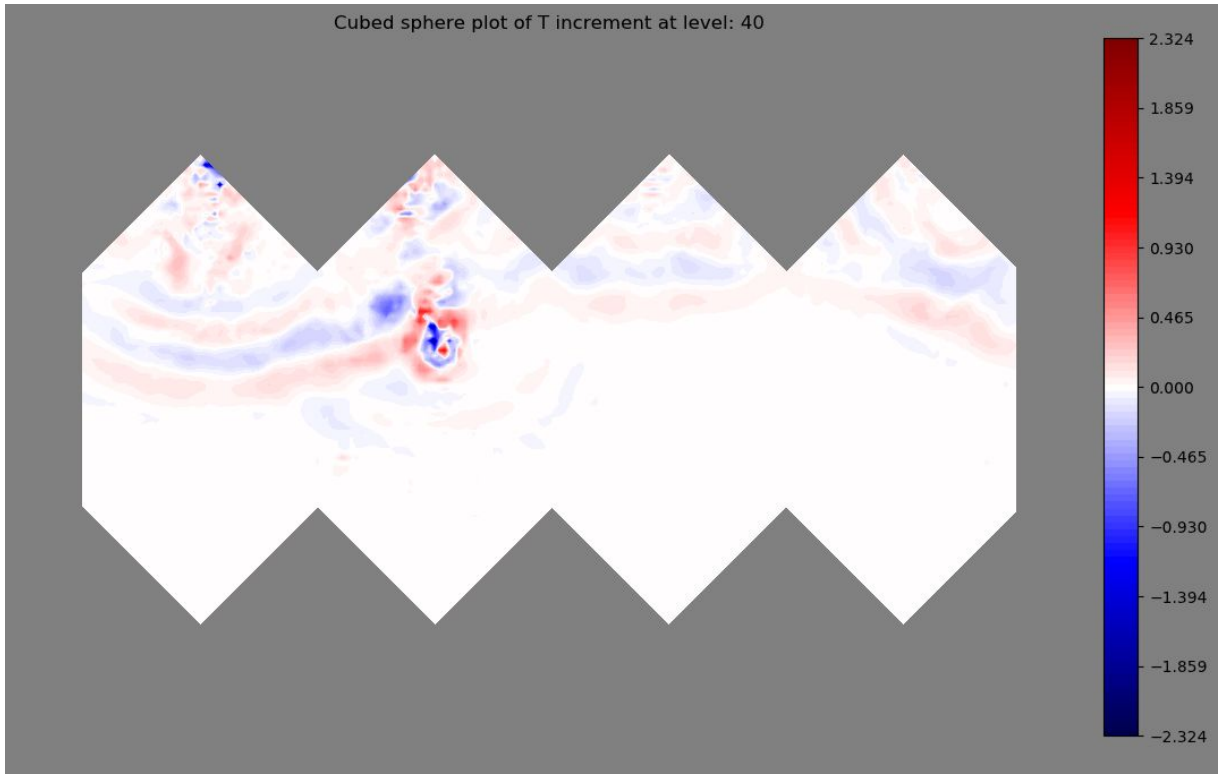
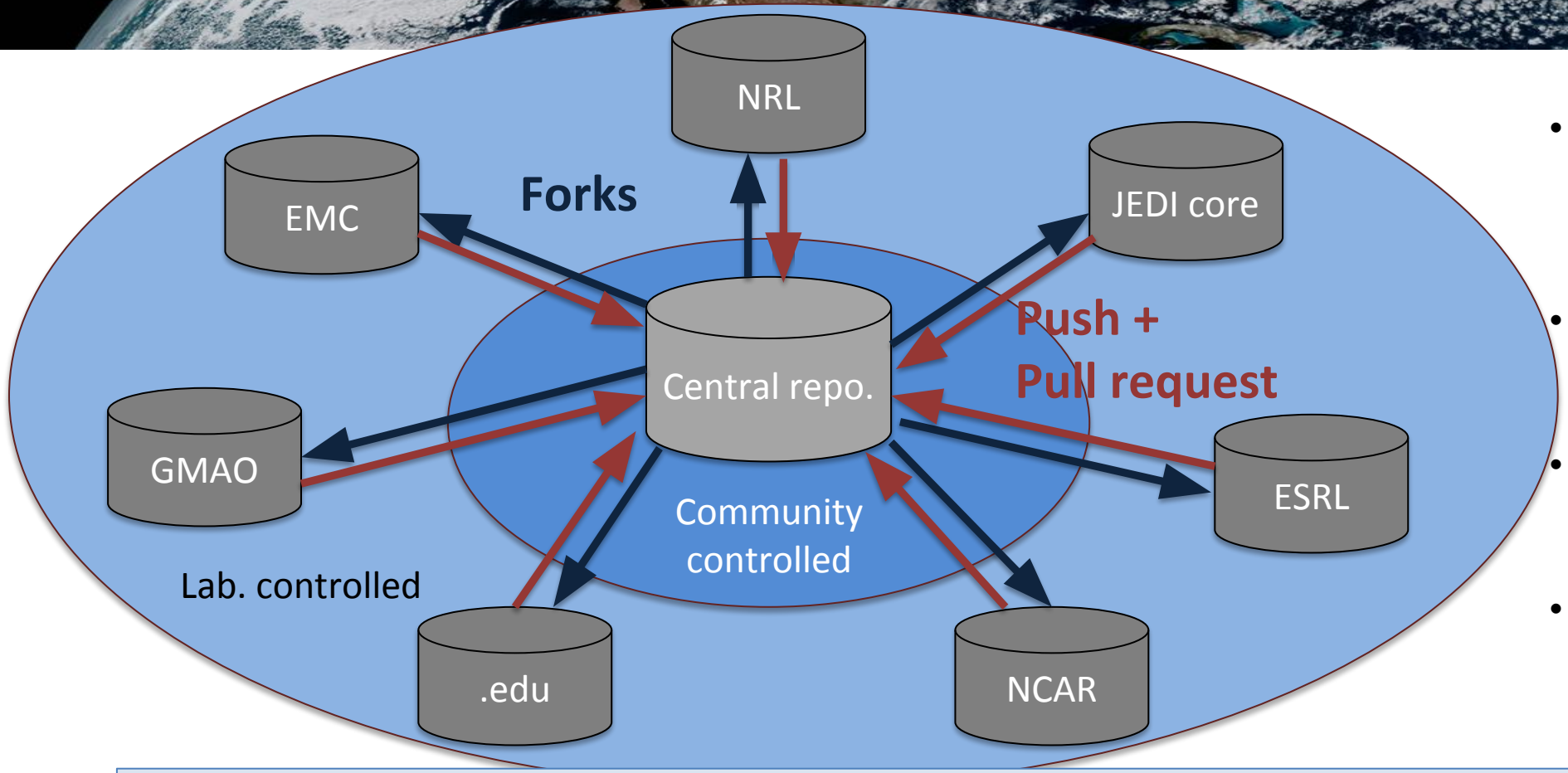


6h

JCSDA:: Revolution in Ecosystem and Working Practices



- Strong community engagement @coding level (not 'working groups')
- Transparent and inclusive process
- Continuous online discussions + testing
- Fast-paced code development + reviews

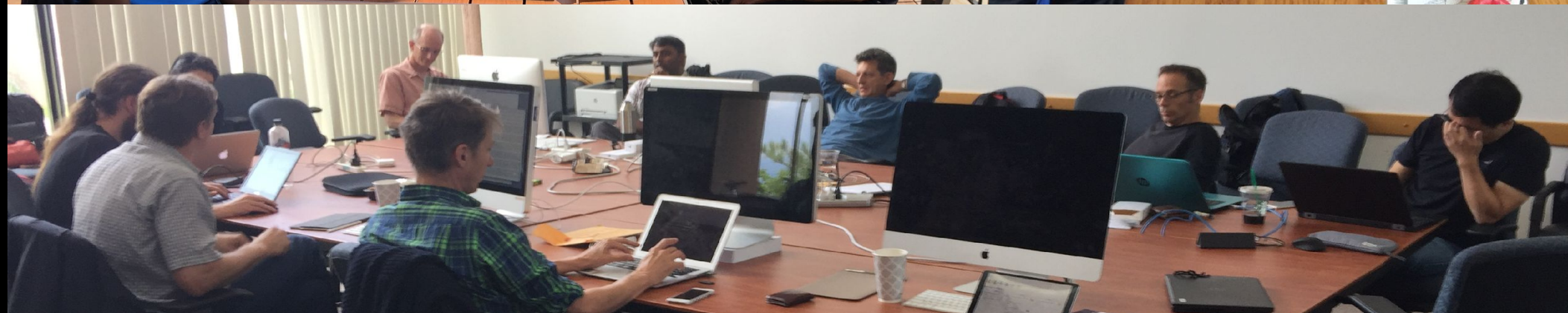
- Community repositories on github.com/JCSDA + flexible build system + 'graduate student test'
- Improved collaborative environment (Zenhub issue tracking, Sphinx/ReadTheDocs/Doxygen, Singularity containers)
- Enforce software quality (correctness, coding norms, efficiency)
- Initial work toward continuous integration

Discussion

NCAR, JCSDA, OAR, EMC, NRL, NASA

https://youtu.be/2_4iF3hatoo

NRL, NASA



JCSDA, NCAR, GMAO,
OAR, EMC, Météo-France,
Met Office, NRL

JEDI:: Model Interfacing

GEOMETRY

Variables (geom)
- Grid dimension
- Processor layout.
- Grid lat-lon
- Halo points
- FV3 communication structure

Methods
- Geometry constructor (inline and from file)
- Clone geometry
- Geometry destructor

FIELDS / INCREMENT

Variables (fld)
- %geom
- u, v, T, q, ps, etc
- Surface for CRTM

Methods
- Constructor/destructor
- All linear algebra for doing DA, e.g. dot prod.
- Variable transforms.
- Interpolation to observation locations (cube to lat-lon).
- Change of resolution.

MODEL, TLM & ADM

Variables
- %fld
- Additional model variables.
- u', v', T' etc

Methods
- Constructor/destructor
- Prepare model runs
- Propagate models
- Trajectory for TLM/ADM

COVARIANCE

Variables
- %fld
- Balanced variables

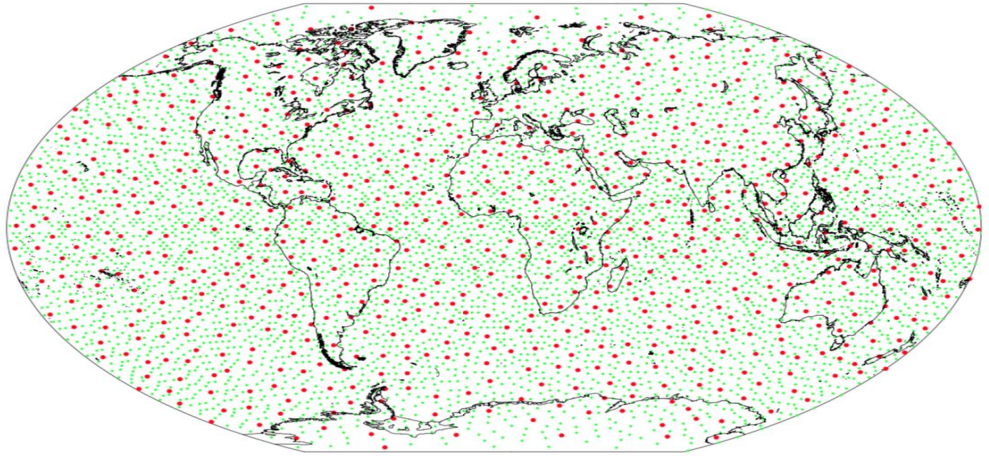
Methods
- Constructor/destructor
- sqrt(B)
- $\text{sqrt}(B)^T$
- inv(sqrt(B))
- $\text{inv}(\text{sqrt}(B))^T$

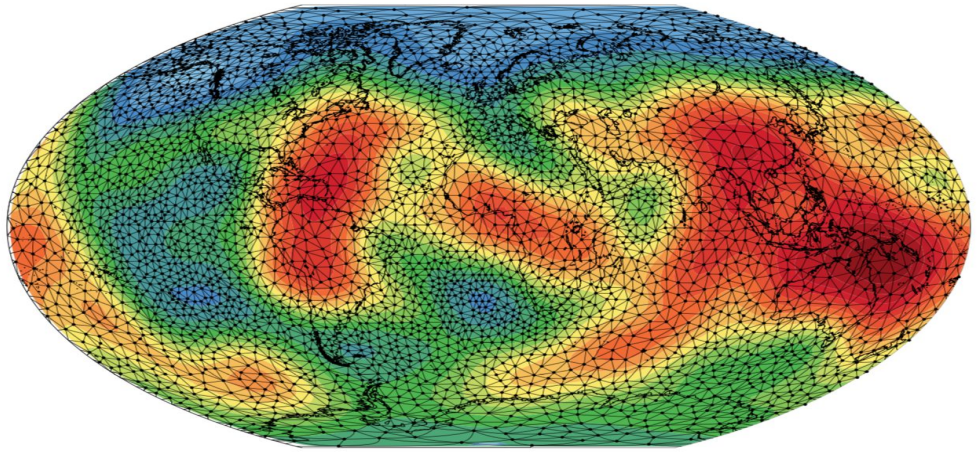
Reporting and Community Engagement

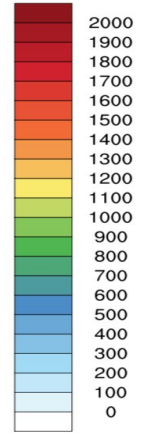
- Apr 2017:
  - Unified DA Planning Meeting
  - **JCSDA Executive Team Meeting**
  - NSF National Strategic Computing Initiative Workshop
  - NOAA/OAR/ESRL/GSD Retreat
  - NOAA SIP Community Workshop
  - NOAA Testbeds and Proving Grounds Workshop
  - NCAR/UCAR Day of Networking and Discovery
- May 2017:
  - JCSDA Science Workshop
  - CRTM Users and Developers Workshop
  - UNIDATA Modeling Research in the Cloud Workshop
  - **JCSDA Annual Science and Technical Review Workshop**
- Jun 2017:
  - NSF Workshop: Modeling Research in the Cloud
- July 2017:
  - DTC/JCSDA/EMC Joint GSI/EnKF Tutorial
  - NCAR/MMM Retreat
  - **JCSDA Quarterly Review and Quarterly Report**
  - **JCSDA MOB Meeting**
- Aug 2017:
  - JCSDA Code sprint (B matrix and model interfaces)
  - National ESPC Meeting
  - **JCSDA Code Sprint: B matrix and model interfaces**
- Sep 2017:
  - NASA Agency Executive briefing
  - WMO Symposium on DA
  - **JCSDA Executive Team Meeting**
- Oct 2017:
  - NOAA Agency Executive briefing
  - UCP/COSMIC Annual Program Review
  - **JCSDA Quarterly Review and Quarterly Report**
  - **JCSDA Executive Team Meeting**
  - **JCSDA MOB Meeting**

- Nov 2017:
  - NOAA Building a Weather-Ready Nation by Transitioning R2O
  - **JCSDA Code Sprint: Unified Forward Operator**
  - International TOVS Study Conference XXI
- Dec 2017:
  - AGU Fall Meeting
- Jan 2018:
  - **JCSDA Symposium @AMS Annual Meeting**
  - NOAA SIP Coordination Meeting
- Feb 2018:
  - **JCSDA Executive Retreat and Quarterly Report**
  - Space-based Lidar Winds Working Group
  - KOMPSAT5 Data Acquisition SRR meeting
- Mar 2018:
  - **JCSDA MOB Meeting**
- Apr 2018:
  - NOAA OAR/NWS Joint Hurricane Supplemental Meeting
  - Workshop on Initialization of High-resolution Earth System Models
  - NOAA Annual Testbeds and Proving Grounds Workshop
  - NCAR/UCAR Day of Networking and Discovery
  - **JCSDA Quarterly Review and Quarterly Report**
  - **JCSDA Executive Team Meeting**
  - **JCSDA Code Sprint: Marine Forward Operators**
- May 2018:
  - **JCSDA Annual Science and Technical Review Workshop**
  - TPOS2020 Workshop: bridging observations, modeling and DA
  - OAR Weather Portfolio Meeting
- June 2018:
  - WMO Data Assimilation and Observing Systems Working Group
  - **JCSDA 1st JEDI Academy**
- July 2018:
  - Workshop on Sensitivity Analysis and DA in Meteorology and Oceanography
  - **JCSDA Colloquium on Satellite Data Assimilation**
  - ~~**JCSDA Code Sprint: generating CRTM coefficients**~~

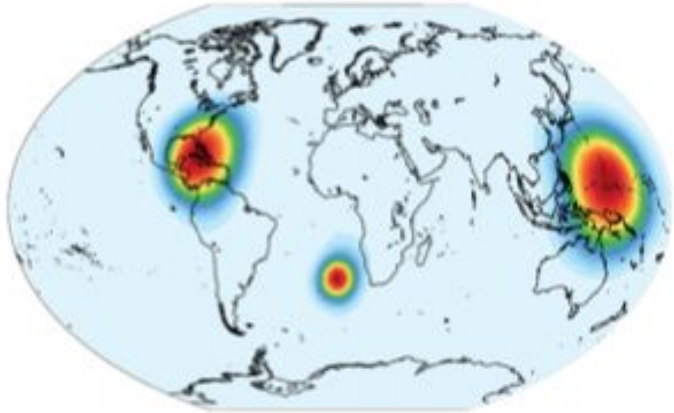
JEDI:: B-matrix Unstructured Mesh Package (BUMP)

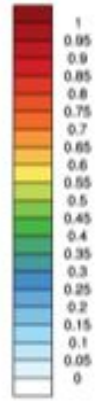






Convolution with a heterogeneous length-scale





Scope: Generic prototype background error covariances (Ménétrier, 2018)