NCEP Update - 2017

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Menu

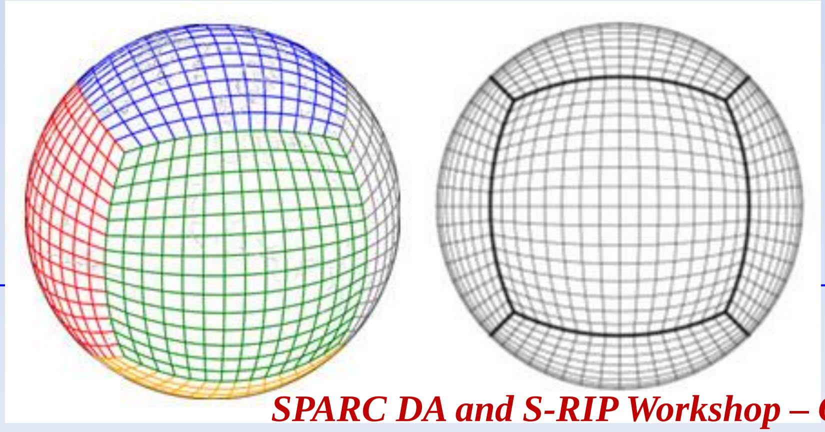
- NCEP Updates
  - Global weather model
  - Global sub-seasonal model
- Joint Centers for Satellite Data Assimilation
- Climate Prediction Center Updates
  - Conventional Observational Reanalysis (CORe)
- Improvements to global model ozone forecasts

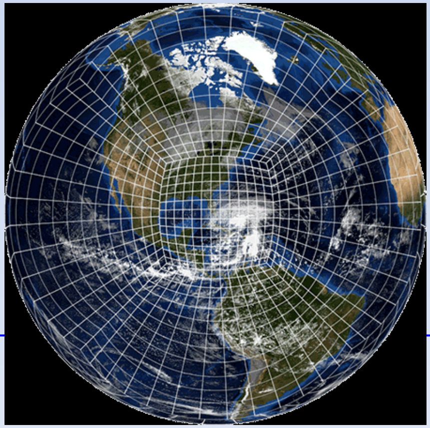
NCEP Global Weather Model Highlights

- 2017 : the last upgrade to the Global Spectral Model (GSM)
- NCEP with community input continues to develop a FV3 based unified model system.
- To be implemented in Spring/Summer 2019.
- Given enough computing resources there will no longer be a single deterministic model.
- The global weather model will join the global sub-seasonal model and the climate model as being ensemble based.

Dynamic Core: FV3

- The non-hydrostatic finite volume dynamical core (FV3) at the Geophysical Fluid Dynamics Laboratory (GFDL)
- Finite-volume cubed-sphere dycore is a scalable and flexible core capable of both hydrostatic and non-hydrostatic simulation
- Designed to be computationally efficient
- Capable of predicting high impact weather events from the smallest to the largest scales, a new breed of "seamless" weather-climate model.





Initial Steps

- **NGGPS under FV3 dynamic core:**
  - Next Generation Global Prediction System
  - Experimental version in FY18; operational in FY19
  - Transition of Global and Meso Branch activities to FV3 in FY17!
  - Focus of work from this point forward tied to FV3 transition
- **Strategic Implementation Plan (SIP) for unified modeling:**
  - Functional area WGs were formed
  - Community (other NOAA labs, Universities, Private Sector) involvement workshop
- **Environmental Modeling Center reorganization (2017)**
  - Shift from legacy multi-models to unified modeling framework
  - Break down stovepipes (e.g., no more separate Global, Meso branches)
  - Address gaps/shortfalls (e.g., DA, V&V/diagnostics, systems eng.)

End State

- **Unified modeling framework**
  - Fully coupled; single dycore with scale-aware physics
  - Multi-tiered layers for R&D community, core development partners
  - NCEP/EMC no longer developers – now implementors
- **National, community system**
  - All partners working from single Strategic Implementation Plan
  - Research community, interagency partners, and internal NOAA operations all working together for a national capability

NCEP GFS Model Upgrades

- 2017: Current Spectral model is T1534 (13 km)/ L64
- 2018: No change, just assimilate more S-NPP/JPSS-1 and GOES-R observations
- 2018: (FV3 in parallel) C768 (13 km) L64
- 2019: C1152 (9 km) L127, model top 80 km

NCEP GEFS Model Upgrades

- Sub-Seasonal Model
- Lower resolution than GFS, but with 20 ensemble members.
- Plans are to extends out to 35 days
- FV3 based GEFS will start producing reforecasts in mid 2018
- Will have a reanalysis performed (1998-present)
  - For bias adjustments
  - NOAA/ESRL doing most of this work.
  - Should be worth evaluating

Joint Centers for Satellite Data Assimilation

JCSDA: management and coordination

Communication, education, and outreach

External Research Program

Visiting Scientist Program

CRTM: Community Radiative Transfer Model

Acceleration of CRTM computations via software optimization

Improved physical representation for aerosols, clouds, precipitation, and land surface

NIO: New and Improved Observations

Assimilation of Radiance Data Over Land and Sea-Ice

Prepare for the assimilation of AHI, JPSS, GOES-16, COSMIC-2

JEDI: Joint Effort for Data assimilation Integration

Optimization of data assimilation

IODA :Interface for observation data access

Background and Observation Error Covariance matrices

SOCA: Sea-ice, Ocean, Coupled Assimilation

Implementation of initial Sea-ice DA

Develop plan for unified Ocean DA

IOS: Impact of Observing System

Standing capability to assess observation impact

Toward real-:me FSOI intercomparison

Evaluation of Commercial Weather Data Pilot (CWDP)

GFDPT: Global Forecast Dropout Prediction Tool

Transition to NCEP

While CPC is waiting for fv3 based CFSv3…

Conventional Observations Reanalysis - CORe

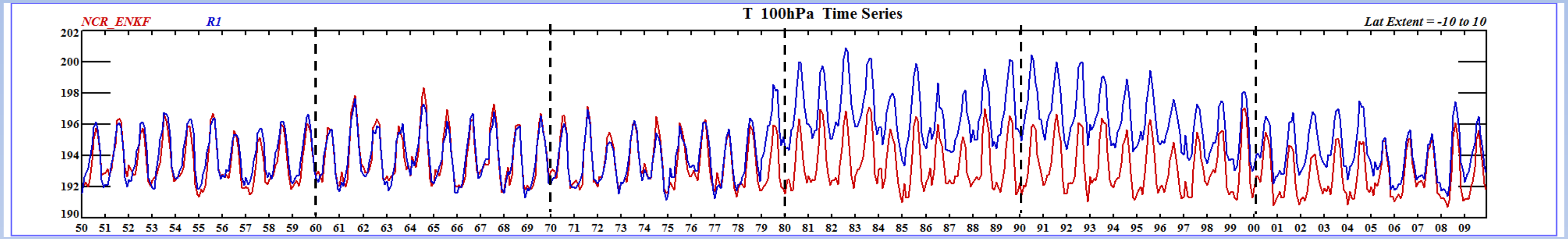
- Atmospheric reanalyses can be optimized to produce the **most accurate** reanalysis by assimilating **all observations** including satellite observations.
- However, this type of reanalysis often shows **discontinuities** in various time series with the introduction of new satellite systems.
- The NCEP/Climate Prediction Center (CPC) would like to replace NCEP/NCAR Reanalysis (R1) with something newer / better.
- The replacement reanalysis has to have accuracy of R1, eliminate the gross artifacts from the introduction of various satellites and span from the 1950's to the present.
- Can a conventional observation reanalysis satisfy these requirements?

Conventional Observations Reanalysis - CORe

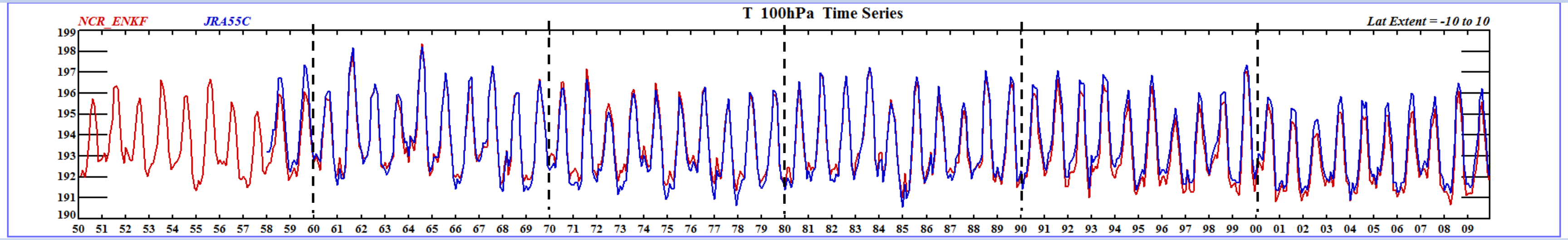
- CORe was recently completed for the period of 1950 to 2009.
- CORe is an atmospheric reanalysis based on the latest Semi-Lagrangian NCEP/GFS model using EnKF DAS.
  - 80 member ensemble
  - T254/L64 vs T62L28 for R1
- To test feasibility of the EnKF based analysis over periods with different density and time-varying quality of conventional observed data
- Conventional data + cloud track winds* + GPS-RO (COSMIC)* (*these satellite data are not sensitive to biases in sensors*)
- CORe was produced by running six simultaneous decadal streams of analyses with one year overlap
- Accomplished most of demands for troposphere and lower stratosphere
- Extending CORe from 2009 to present then run in real time.

Eq 100mb Temps

CORe, **R1** **10S-10N**



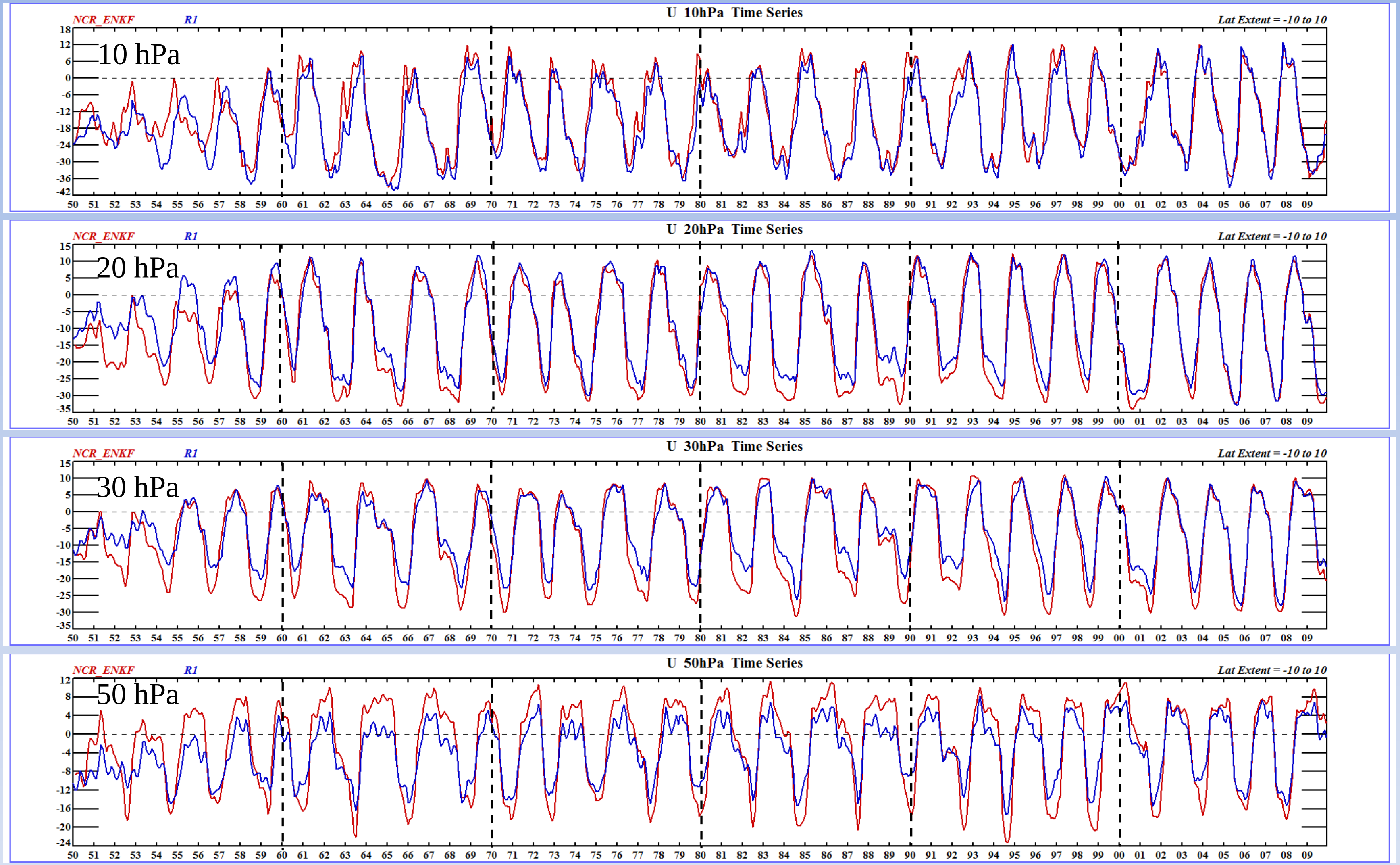
CORe, **JRA55C**



R1 has major temp change after 1979. CORe and JRA55C agree post 1979 and are consistent with pre-1979 values.

QBO Winds

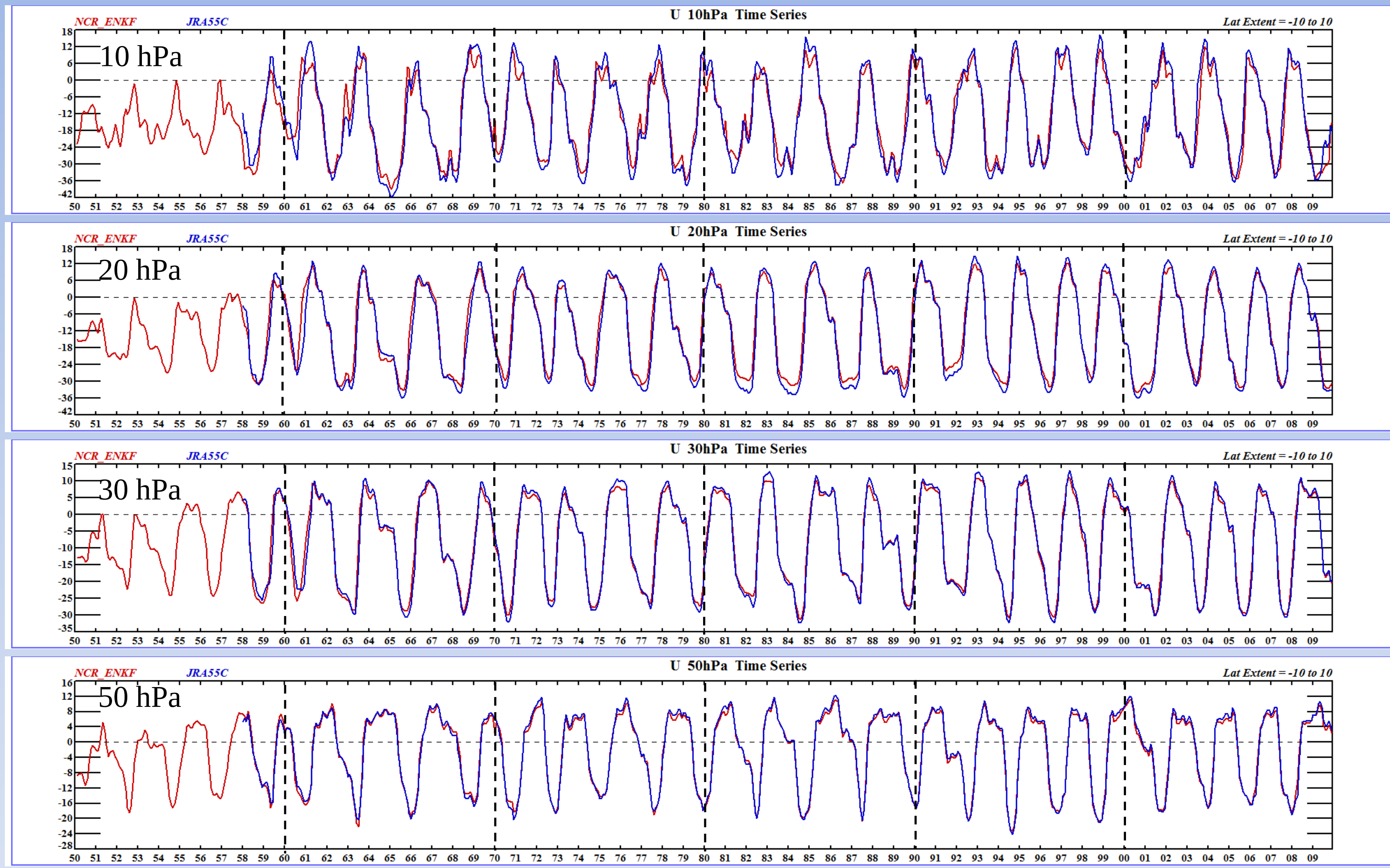
CORe, R1



R1 and CORe QBO winds differ substantially below 10 mb.
Both have amplitude issues in 1950's

QBO Winds

CORe, JRA55C

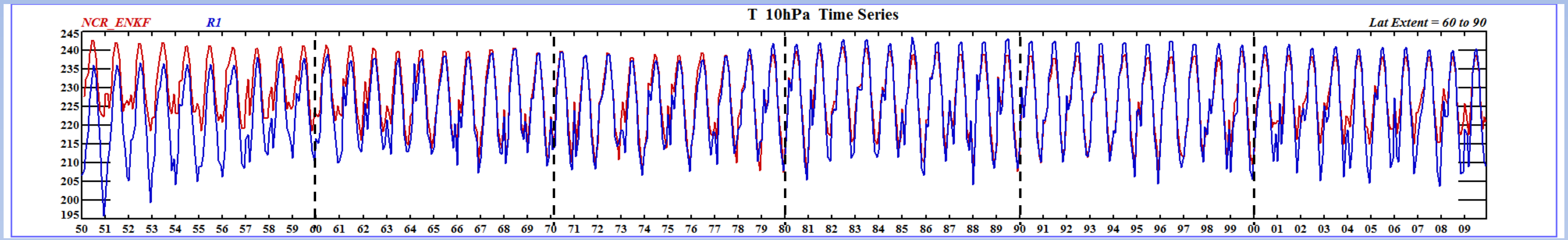


JRA55C and CORe QBO winds have very good agreement at all QBO levels.

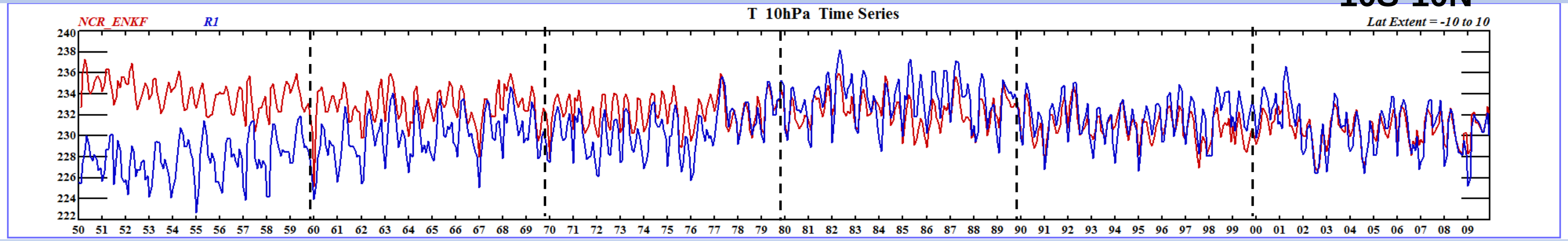
10 hPa Temps

CORe, **R1**

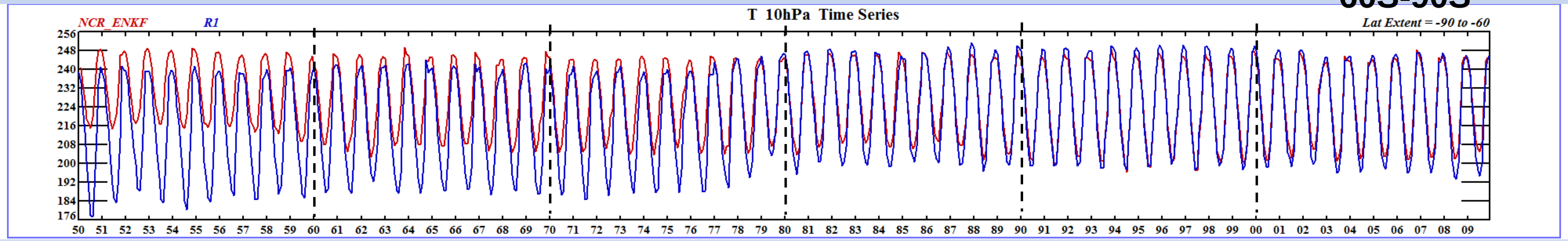
60N-90N



10S-10N



60S-90S

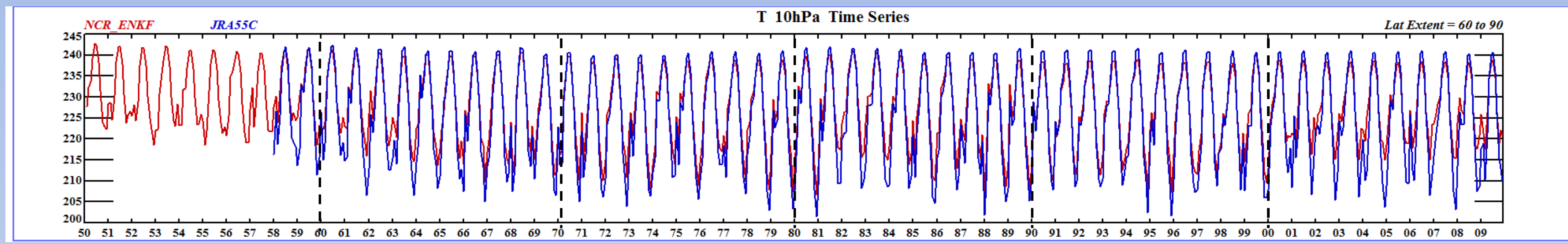


R1 and CORe temps agree below 10mb. Not many raobs reaching 10mb in SH. CORe has issues in 1950's and seasonal amplitude before 1988 is smaller.

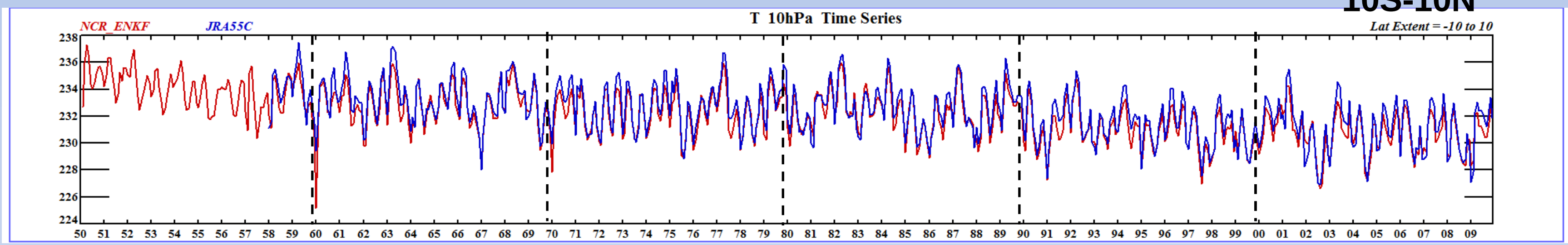
10 hPa Temps

CORe, JRA55C

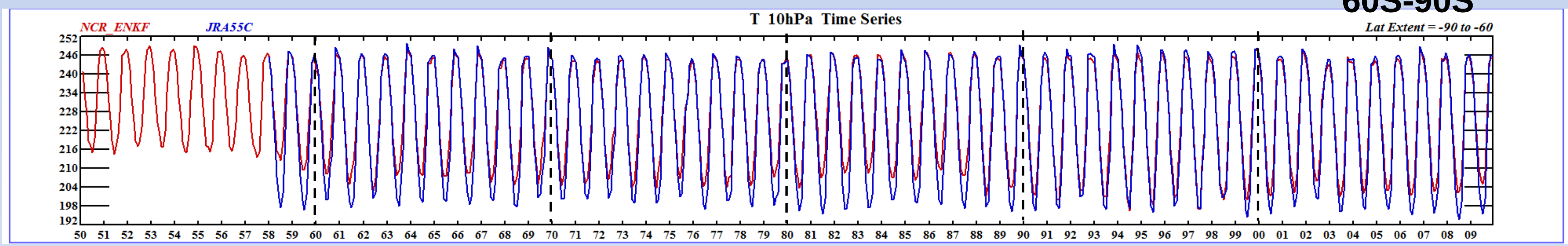
60N-90N



10S-10N



60S-90S



R1 and CORe temps agree below 10mb. Not many raobs reaching 10mb in SH. CORe has issues in 1950's and seasonal amplitude before 1988 is smaller.

Improving the Global Model Ozone Forecasts

- The Problem:
  - GFS loses ozone in the tropics and gains ozone in the polar latitudes over multi-day forecasts.
- Currently the GFS uses only part of CHEM2D-OPP
- Task is to use all components of CHEM2D-OPP
  - Hopefully will improve ozone forecasts.

CHEM2D-OPP

$$\frac{df}{dt} = \underbrace{(P-L)^o}_{1} + \underbrace{\frac{\partial(P-L)}{\partial f}}_{2}\bigg|_o (f - f^o) + \underbrace{\frac{\partial(P-L)}{\partial T}}_{3}\bigg|_o (T - T^o) + \underbrace{\frac{\partial(P-L)}{\partial c_{O_3}}}_{4}\bigg|_o (c - c^o_{O_3})$$

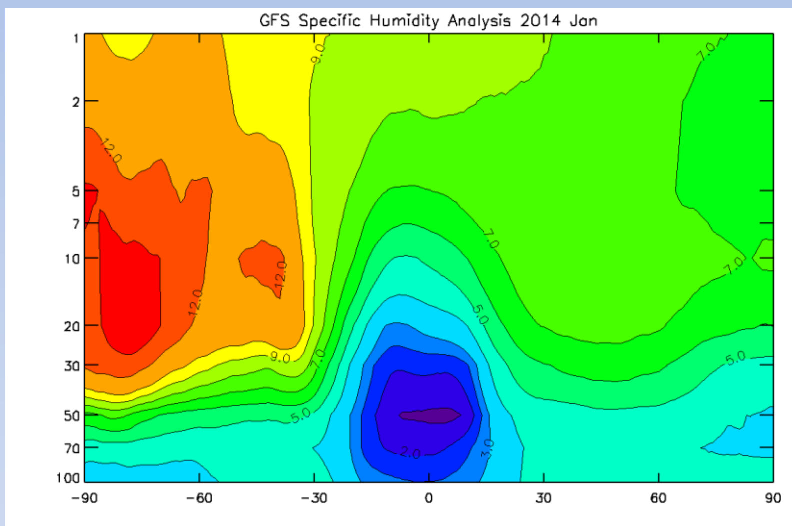
- Four coefficients that need to be tuned to the model
- First two terms are used currently in GFS
  - Production/Loss coefficients
  - Change in P/L with respect to ozone amount
- Third and Forth terms are being evaluated for operations
  - Change in P/L wrt temperature
  - Change in P/L wrt column ozone above

Results

- Found that Third term was critical for better ozone forecasts
- Requires good temperature forecasts
  - GFS temperature fcsts get cooler with time especially in summer hemisphere in middle and upper stratosphere
- Determined that probable cause of erroneous temperature fcsts were due to high water vapor content in stratosphere
  - GFS is VERY moist in stratosphere
- Experimenting with nudging GFS water vapor to a climatology in first 24 hrs of forecast.
- Obtained partial improvement in temperature forecasts
  - Resulted in partial improvement in ozone forecast.
- Experiments to accelerate driving water vapor to climatology are ongoing.

JAN

GFS SPFH Anal 2014



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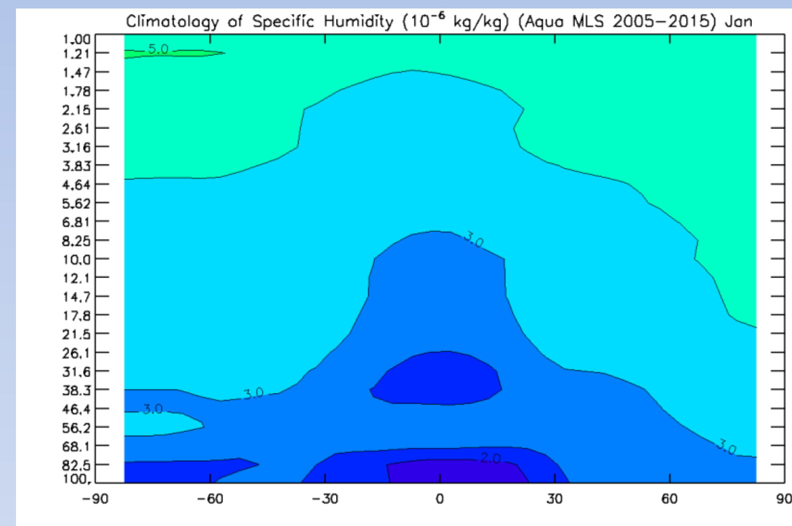
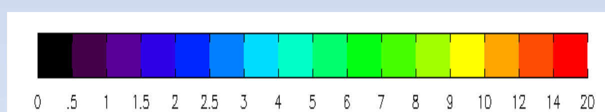
Aura MLS 2005-2015





10^{-6} kg/kg

Summary

- NCEP migration to unified-community based - FV3 analysis and forecast model continues.
- Expected implementation to operations in summer 2019
- Model vertical resolution will double and top of model raised to 80 km.
- Assimilation system working to be in step with forecast needs.
- FV3 based climate forecast system is several years away
- CPC looking to use CORe as replacement for R1
- Experiments to improve ozone forecasts are giving promising results.

Extra Slides

Modeling Advisory Committee Recommendations

- Simplify NCEP production suite!
- Unified modeling under single dycore + meso-unification (3-km ensemble)
- Pursue required HPC upgrades
- Strategic plan for modeling with community fully engaged
- Central NOAA authority for modeling (not supported by NOAA)

JEDI Objectives

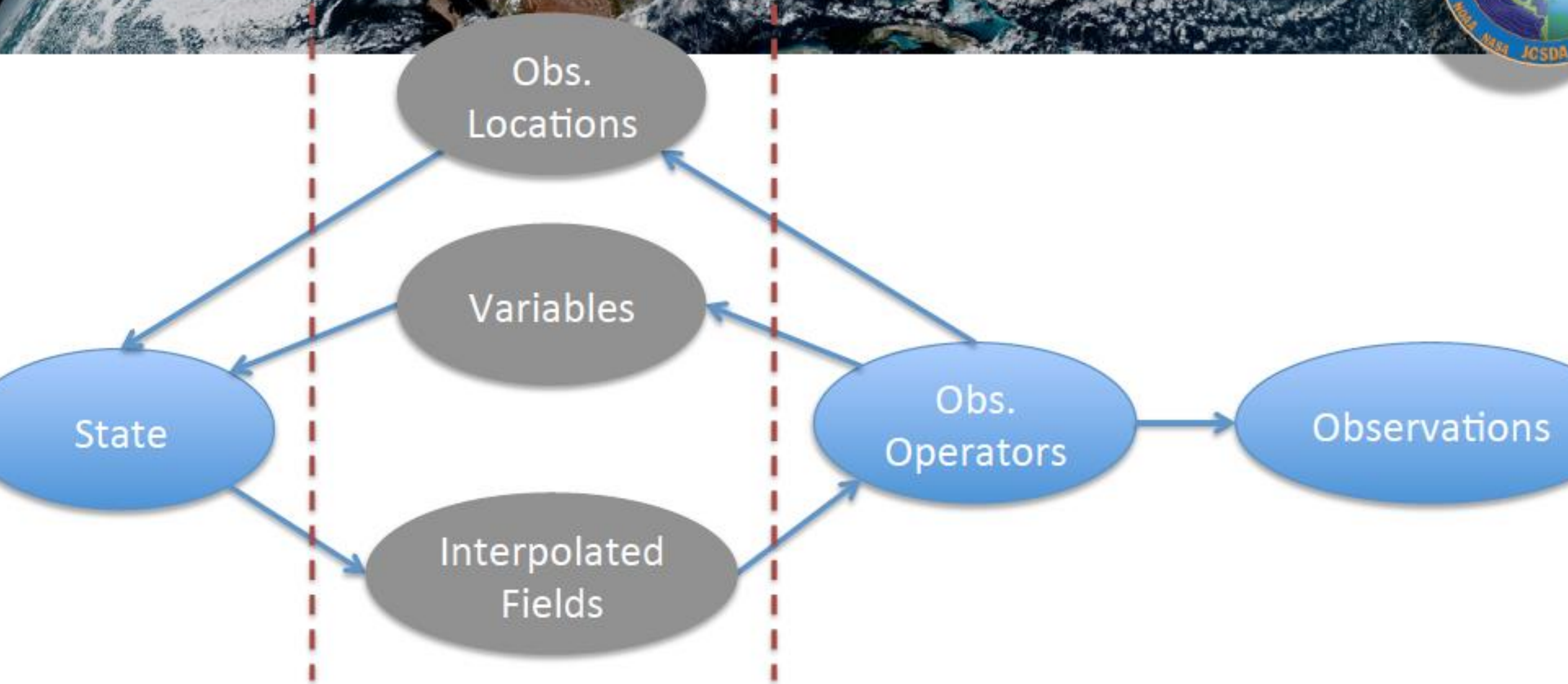
A collaborative development spearheaded by JCSDA partners of the next-generation unified data assimilation:

- For research and operations (including R2O/O2R)
- For various components of the Earth system, including coupled
- Mutualize as much as possible without imposing single approach

BENEFITS

1. Facilitate **innovation** to address next scientific challenges
2. Increase **R2O** transition rate
3. Increase **science productivity** and code **performance**

Unified Forward Operator (UFO)



- JEDI Unified Forward Operator (UFO) introduces standard interfaces between the model and observation worlds
- Observation operators become *model-agnostic* and can easily be shared, exchanged, compared

nterface for Obs. Data Access (IODA)

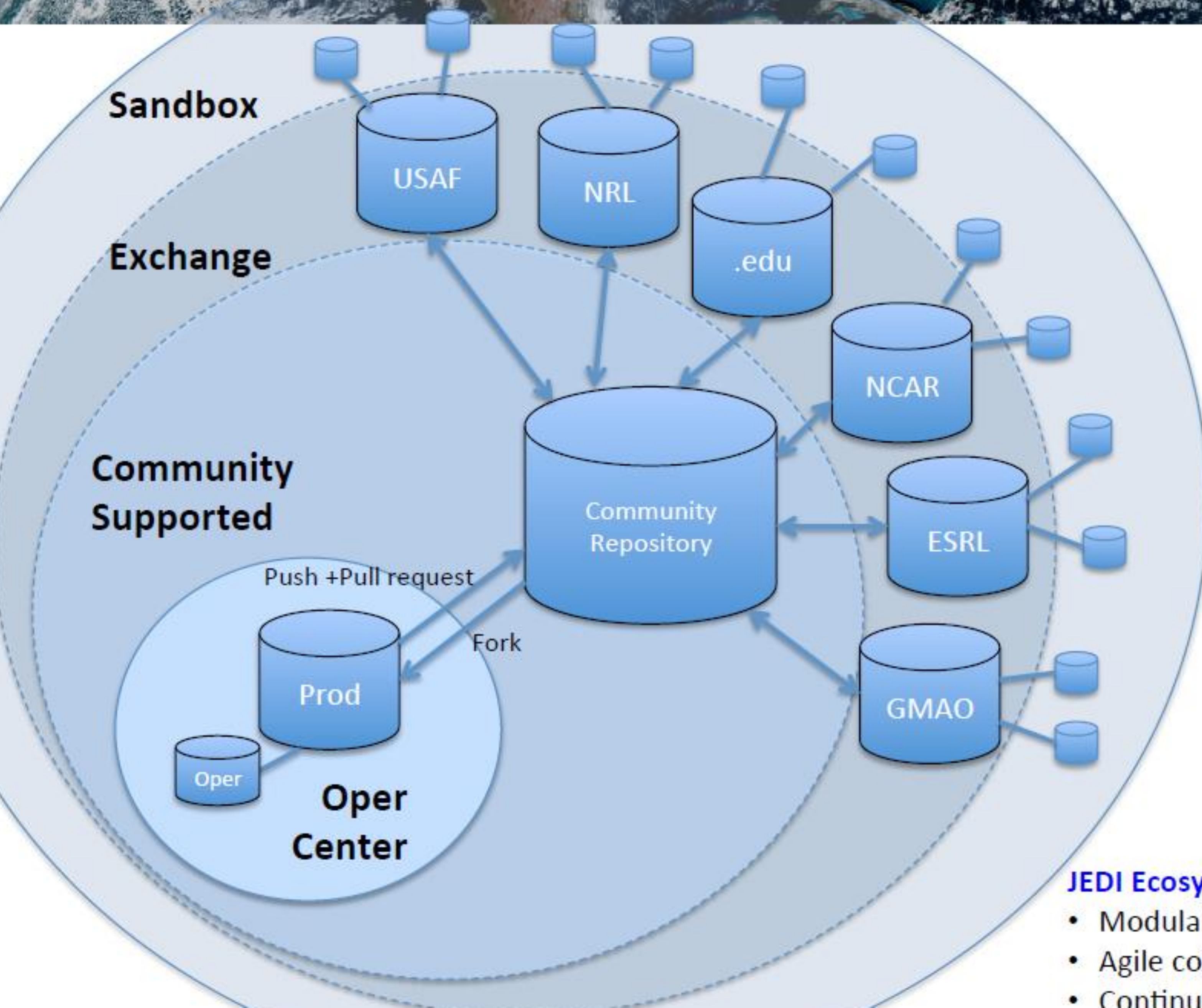
Interface to isolate science code from data storage

Three levels:
- Long term storage (historic database)
- Files on disk (one DA cycle)
- In memory handling of observations (hardware specific?)

Two environments:
- Plotting, analyzing, verifying on workstation
- DA and other HPC applications (MPI, threads, GPUs...)

Goal: one interface, insulating scientists from software engineering implementation(s).

Ecosystem Bridging R & O



JEDI Ecosystem

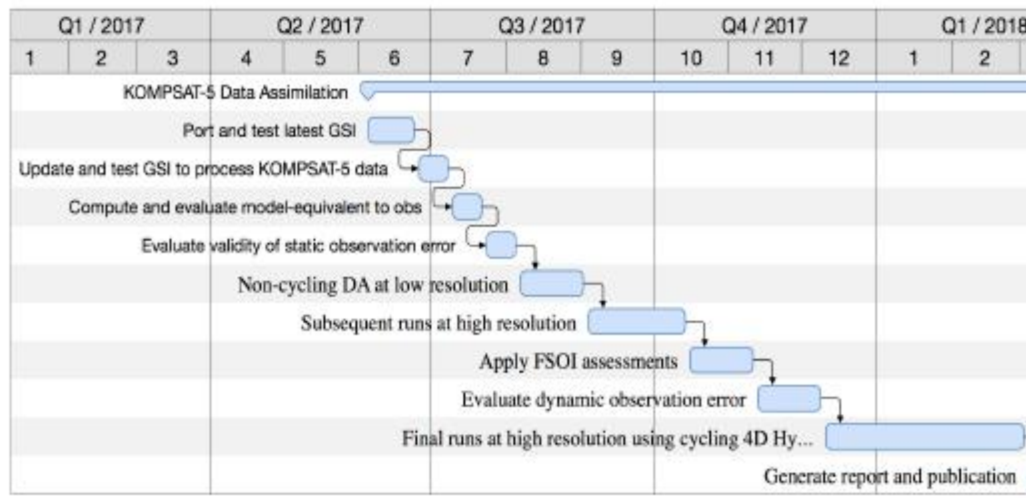
- Modular, flexible, OO code
- Agile collaborative developm
- Continuous integration

Sensor Readiness: GNSS Radio Occultation

- JCSDA hiring GNSSRO scientists to complement current staff

- COSMIC 2A data
  - Optimize, evaluate and test impact in GFS
  - Support operational implementation

- Korea's KOMPSAT-5 data
  - Evaluate and test impact in GFS
  - Support operational implementation



- CWDP Data
  - Round 1 data evaluated (current staff)