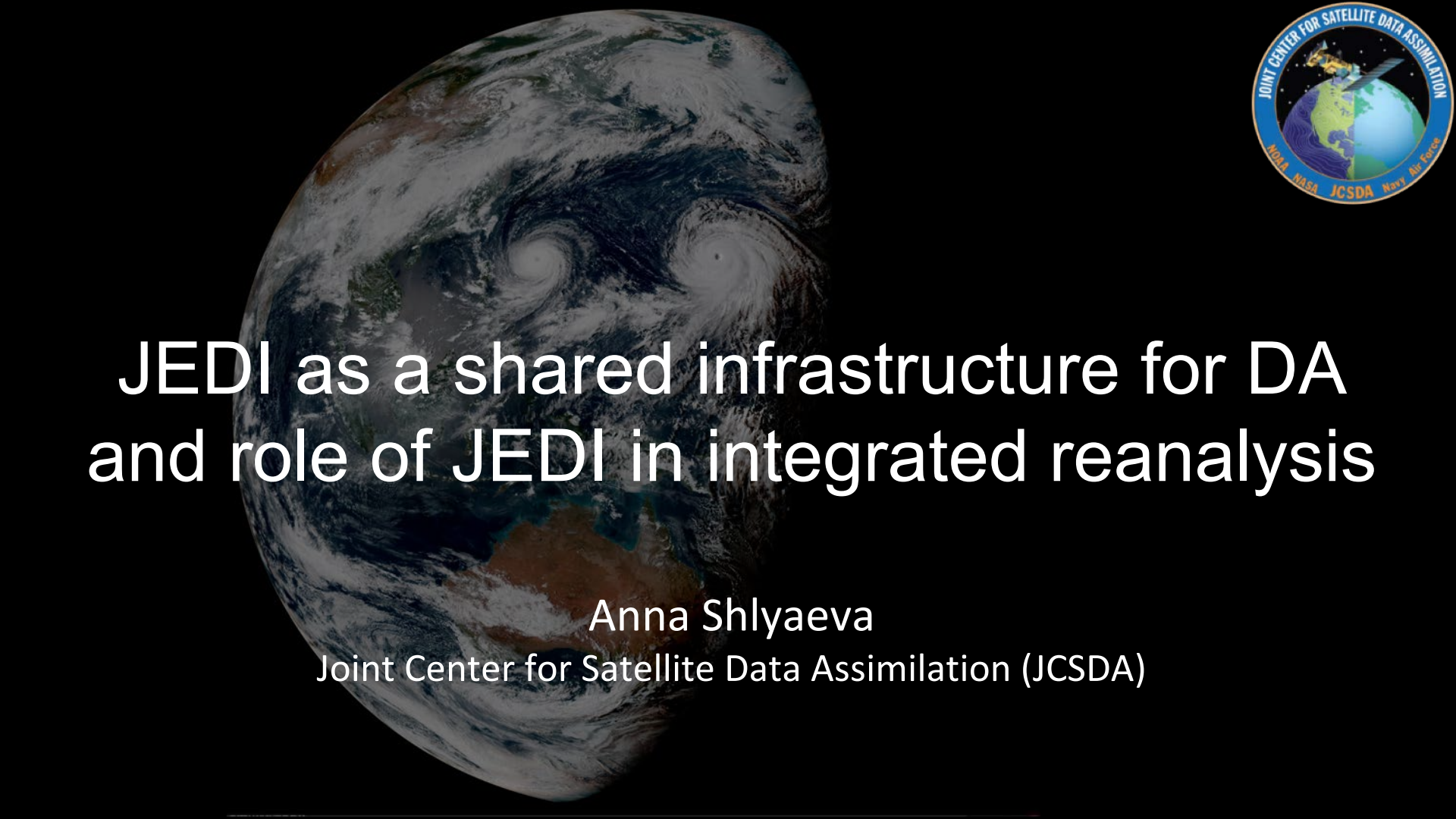

JEDI as a shared infrastructure for DA and role of JEDI in integrated reanalysis

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JCSDA and JEDI

Joint Effort for Data assimilation Integration (JEDI): collaborative development of a unified DA system between JCSDA partners:

- From toy models to Earth system coupled models
- For research and operations (including O2R2O)
- Share as much as possible without imposing one approach

JCSDA partners: NOAA, NASA, Navy, Air Force; collaborations with MetOffice and NCAR. Most of them plan in the next 5-10 years to use JEDI for at least some of the Earth system component DA operationally or near operationally.

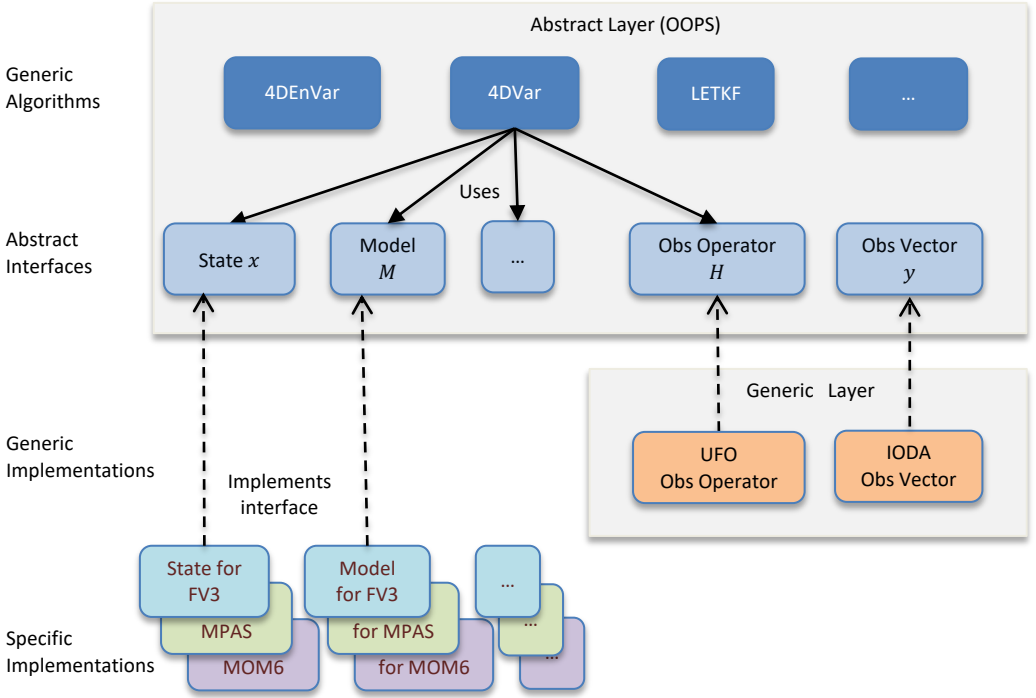
JEDI: Abstraction and Genericity

JEDI is designed to separate the concepts of:
- data assimilation algorithms
- estimated system's specifics
- observations specifics

as cleanly as possible.

Most (Gaussian) DA algorithms can be written using concepts of x, y, H, M, B, R, without knowing what grid x is distributed on, how many different observed variables y may contain, and whether M is an atmospheric, a sea ice, or a multi-component coupled model.

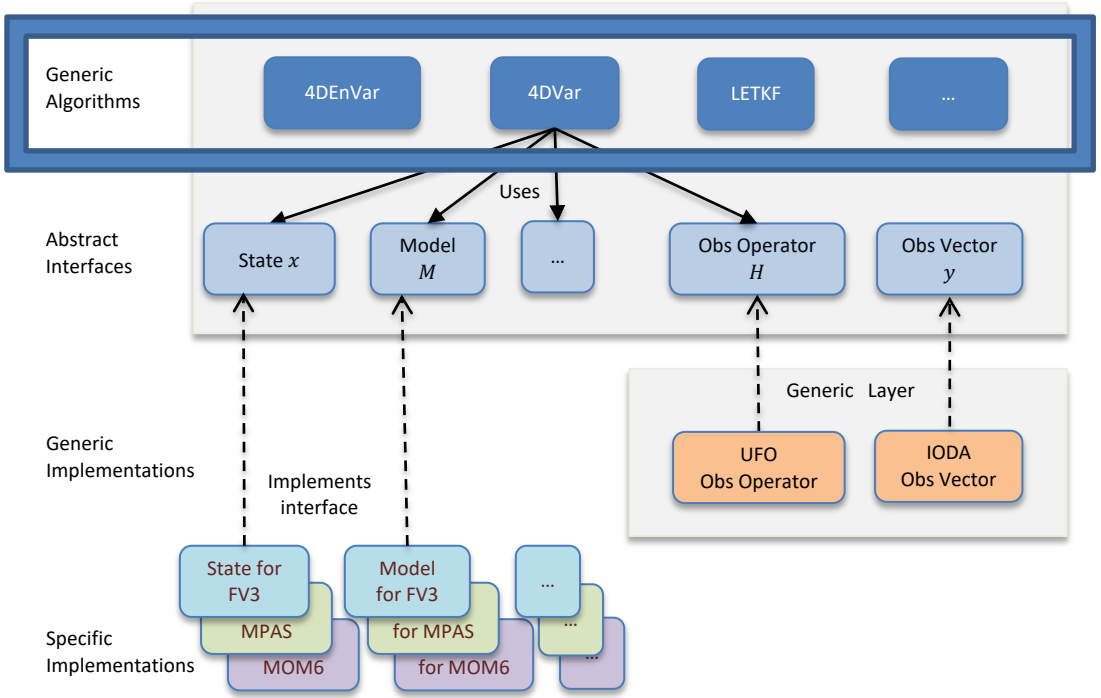
The key of this design is the "abstract interfaces" that are used by DA algorithms and implemented by specific models and specific observations.



JEDI: DA Algorithms

DA algorithms implemented in JEDI:

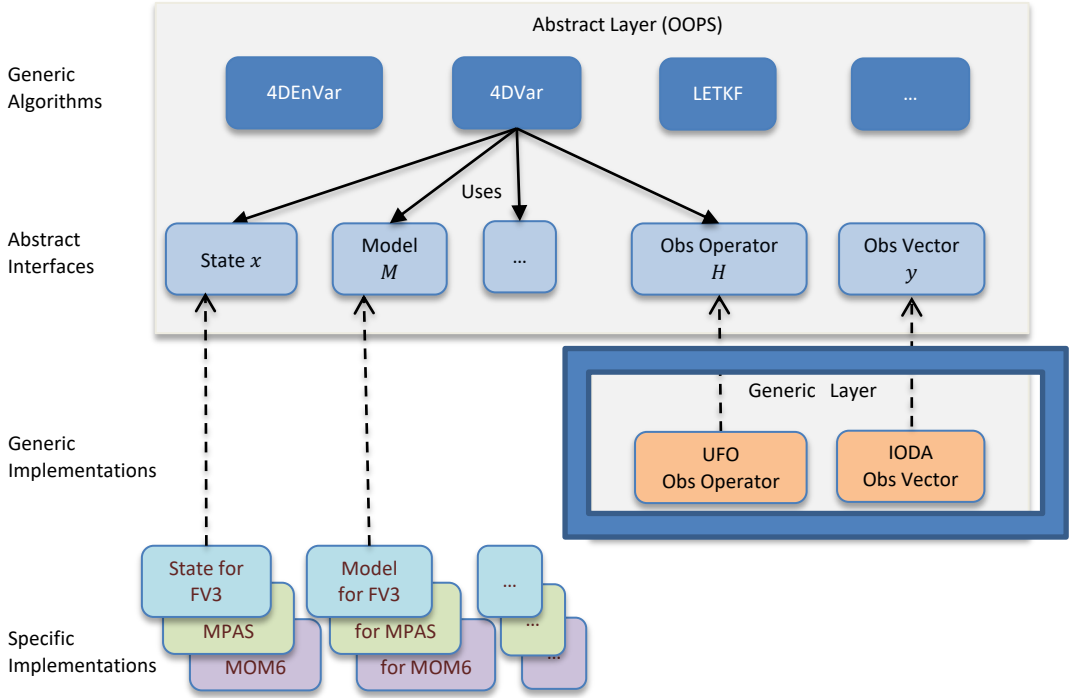
- 3DVar, 3DVar-FGAT, 4DEnVar, strong-constraint 4DVar, weak-constraint 4DVar
- EDA (with any Var from the above), block-Lanczos EDA
- LETKF, LGETKF (allows for model-space vertical localization)



JEDI: Observations

Some examples of observation operators implemented for JEDI,

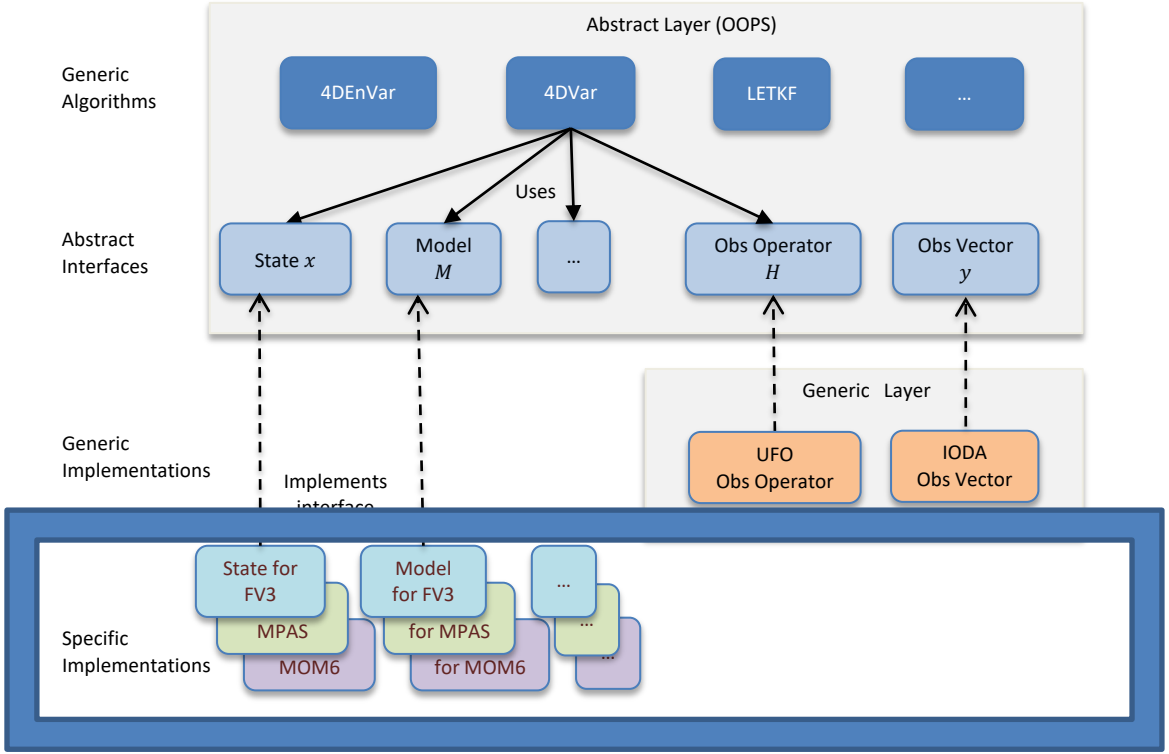
- CRTM, RTTOV
- Multiple GNSSRO refractivity and bending angle operators
- Conventional atmospheric and ocean obs
- Cool skin temperature
- In situ particulate matter
- Sea ice thickness



JEDI: Models

Models interfaced to JEDI:

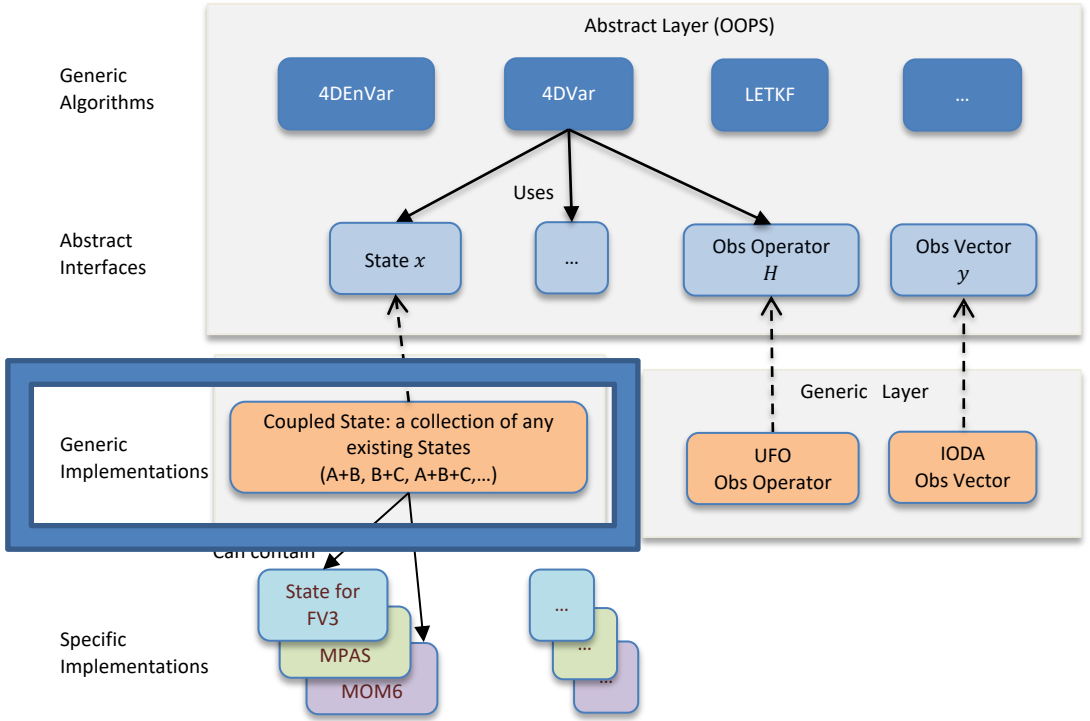
- Toy models: Lorenz95, QG
- Atmosphere: FV3 (NOAA GFS, NASA GEOS), MPAS (MMM/NCAR), Neptune (Navy), Lfric (UK MetOffice), UM (UK MetOffice)
- Ocean: MOM6 (SOCA), ROMS
- Sea ice: CICE5/6 (limited functionality)
- Land: Noah-MP, WRF-Hydro
- Composition: GFS with aerosols, GEOS-FP, GEOS-CF, GEOS-Chem



JEDI: moving towards coupled DA

Generic coupled interfaces:

If the coupled model components already have a JEDI interface, a generic "coupled" state interface can be used to couple any existing JEDI-interfaced model states. Currently under development at JCSDA.



JEDI and coupled DA development

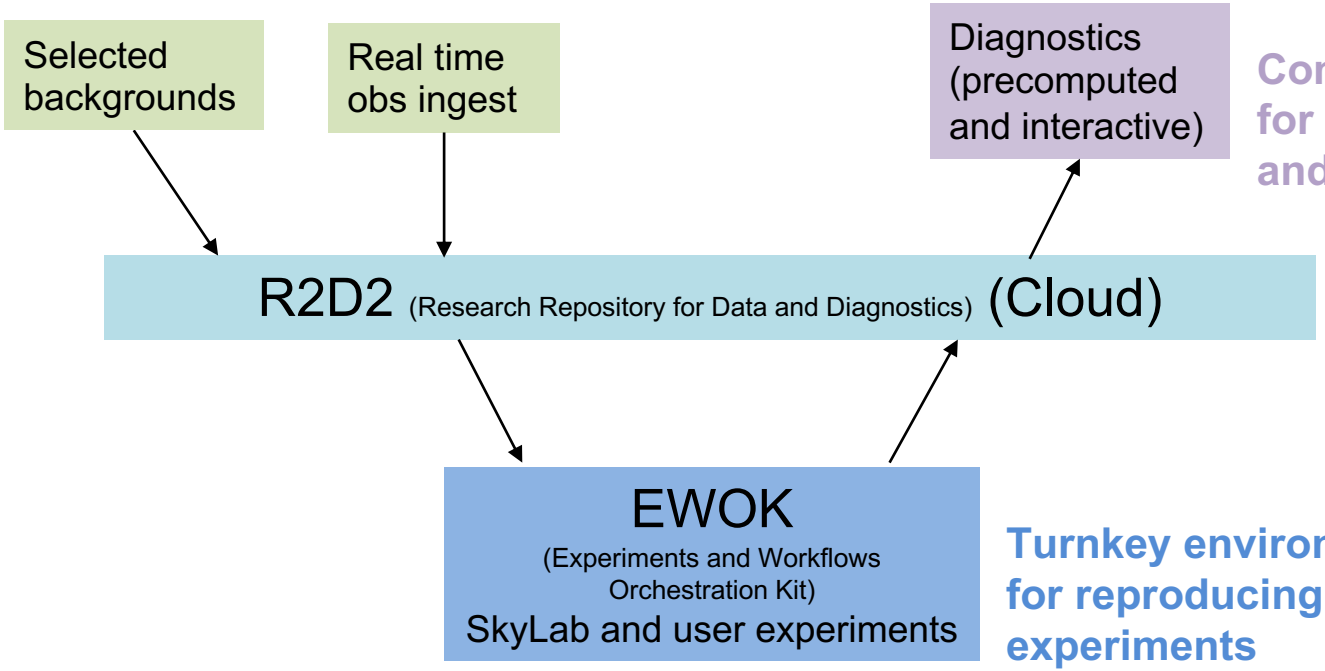
$$\Delta x_k^a = \mathbf{B}\mathbf{M}^{\mathbf{T}}\mathbf{H}^{\mathbf{T}}\left(\mathbf{H}\mathbf{M}\mathbf{B}\mathbf{M}^{\mathbf{T}}\mathbf{H}^{\mathbf{T}} + \mathbf{R}\right)^{-1}\left(y - H\left(M\left(x_{k-1}^a\right)\right)\right)$$

Code design of JEDI simplifies technical aspects of coupled DA, but does not solve scientific questions.

Plans for coupling using JEDI:

- Coupling via *M* (outside of DA, use I/O in DA) - weakly coupled DA
- Coupling via *H* - use coupled state in observation operator (and its TL/AD for variational applications)
- Coupling via **B** – use cross-covariances between different components
- Coupling via *M* (inside a single DA executable without using I/O) – run coupled model within DA (e.g. for outer loop coupling)

Collaboration and sharing experiments: Skylab, JCSDA Ecosystem



Common diagnostics for easy comparisons and collaborations

Turnkey environment for reproducing experiments

Turn-key ecosystem for community development from/to SkyLab

Education and Outreach

- JEDI Academies: a week of lectures and practical sessions on JEDI (7 events since June 2018).
- Work in progress on JEDI-EDU: series of tutorials that can be used for teaching DA (JEDI with toy models -> JEDI with realistic models), collaboration with CSU.
- Hope to have active visitor's program and regular hackathons with both the agencies, and academia community.

What do you see are the most significant advances for the field of reanalysis in 5-10 years?

- Progress in coupled DA (various degrees of coupling between various components)
- Shared/easy-to-access observations database, shared responsibilities for reprocessing and adding data
- Shared/easy-to-access reanalysis database, tools for diagnostics, comparing results

What do you see are the most significant barriers to progress in the field of reanalysis?

- Reanalysis is a conservative effort (costs are high, risks have to be low)

Which collaborations are currently working and which collaborations need to be fostered?

- What can be learned from the experience of collaboration within JEDI?