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Efficient Integration of Radar Observations and NWP models through JEDI for Model Evaluation and Data Assimilation

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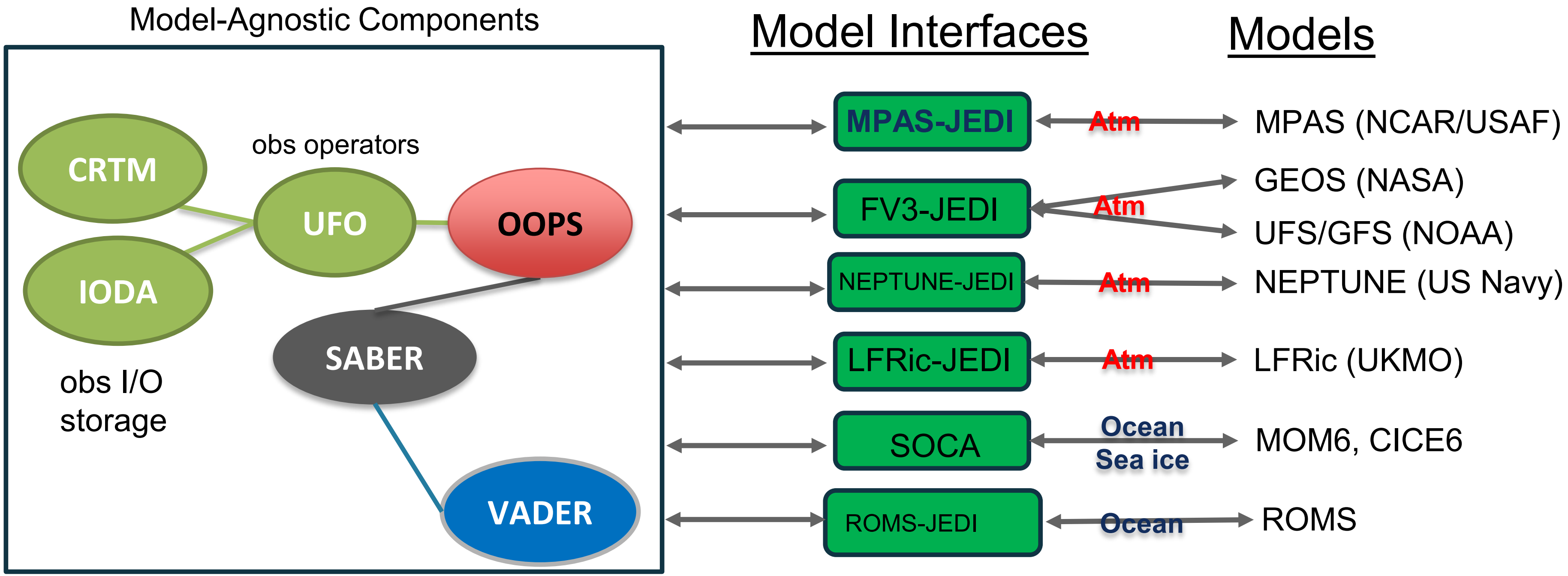
NCAR Operated by UCAR

JEDI: Joint Effort for Data assimilation Integration

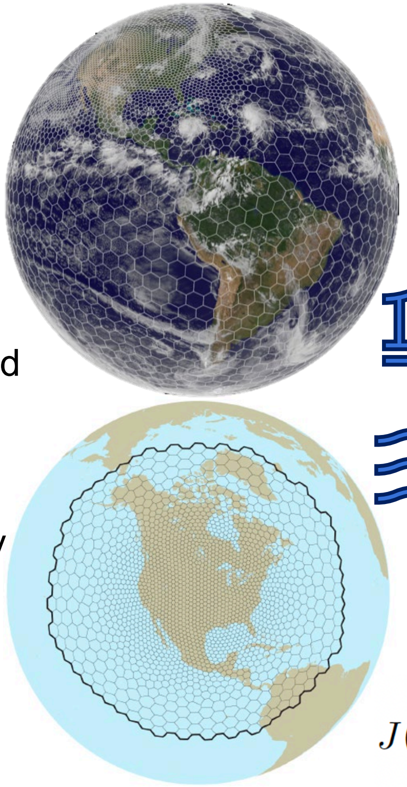
A new DA framework led by Joint Center for Satellite Data Assimilation, with contributions from multiple agencies/groups



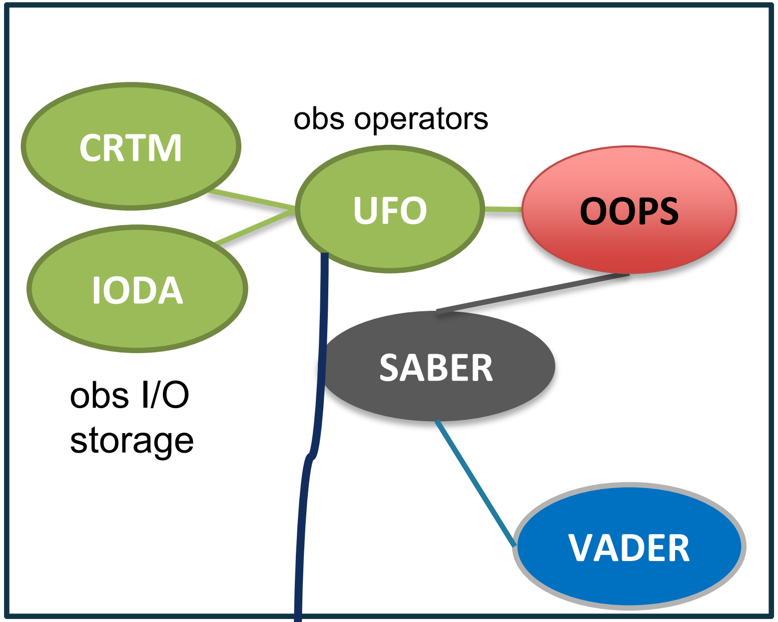
MPAS-JEDI: global/regional unified DA system for MPAS-A

MPAS-A:
Model for Prediction
Across Scales –
Atmosphere

Global/regional unified
Model built on
unstructured grids
With regional
Refinement capability



Model-Agnostic Components



$$J(\boldsymbol{x}) = \frac{1}{2}(\boldsymbol{x}-\boldsymbol{x}_b)^{\mathbf{T}}\mathbf{B}^{-1}(\boldsymbol{x}-\boldsymbol{x}_b) + \frac{1}{2}[H(\boldsymbol{x})-\boldsymbol{y}]^{\mathbf{T}}\mathbf{R}^{-1}[H(\boldsymbol{x})-\boldsymbol{y}]$$

H(x): compute model equivalent of observations y https://www2.mmm.ucar.edu/projects/mpas-jedi/tutorial/202509NCAR/

Welcome to the MPAS-JEDI tutorial practice guide

This web page is intended to serve as a guide through the practice exercises of this tutorial. Exercises are split into seven main sections, each of which focuses on a particular aspect of using the MPAS-JEDI data assimilation system.

In case you would like to refer to any of the lecture slides from previous days, you can open the Tutorial Agenda in another window. The test dataset can be downloaded from Here.

You can proceed through the sections of this practical guide at your own pace. It is highly recommended to go through the exercises in order, since later exercises may require the output of earlier ones. Clicking the grey headers will expand each section or subsection.

0. Prerequisites and environment setup

1. Compiling/Testing MPAS-JEDI

2. Converting NCEP BUFR obs into IODA-HDF5 format

3. Running MPAS-JEDI's HofX application

4. Generating localization files and running 3D/4DEnVar with "conventional" obs

5. Running 3DVar and hybrid-3DEnVar with satellite radiance data

6. Plotting OMB/OMA from two experiments

7. Running regional MPAS-JEDI

8. Cycling DA with MPAS-A and MPAS-JEDI

9. Generating the multivariate background error covariance statistics

10. Running EDA and LETKF

mpasjedi_hofx3d.x

Perform horizontal/vertical interpolation from MPAS grid to observation locations, and then apply observation operators,

Computing in parallel.

https://github.com/JCSDA/ufo/tree/develop/src/ufo/operators

Radar-related observation operators in released JEDI-UFO

radardopplerwind	C++ version of radial velocity operator
radarradialvelocity	Fortran version of radial velocity operator
radarreflectivity	Reflectivity operators, one by OU and one by UKMO for different microphysics
rttov crtm	Interfaces to two radiative transfer models for satellite radiance DA, but could also compute reflectivity from active sensors, e.g., GPM-DPR, EarthCare-CPR

ufo / src / ufo / operators / radarreflectivity

- ..
- CMakeLists.txt
- ObsDirectZDA.cc
- ObsDirectZDA.h
- ObsDirectZDA.interface.F90
- ObsDirectZDA.interface.h
- ObsDirectZDATLAD.cc
- ObsDirectZDATLAD.h
- ObsDirectZDATLAD.interface.F90
- ObsDirectZDATLAD.interface.h
- radarZ_interface.f90
- radarZ_module.f90
- ufo_directZDA_mod.f90
- ufo_directZDA_tlad_mod.f90
- ufo_directZDA_util_mod.f90

For variational data assimilation, tangent linear and adjoint code of forward operator are also needed

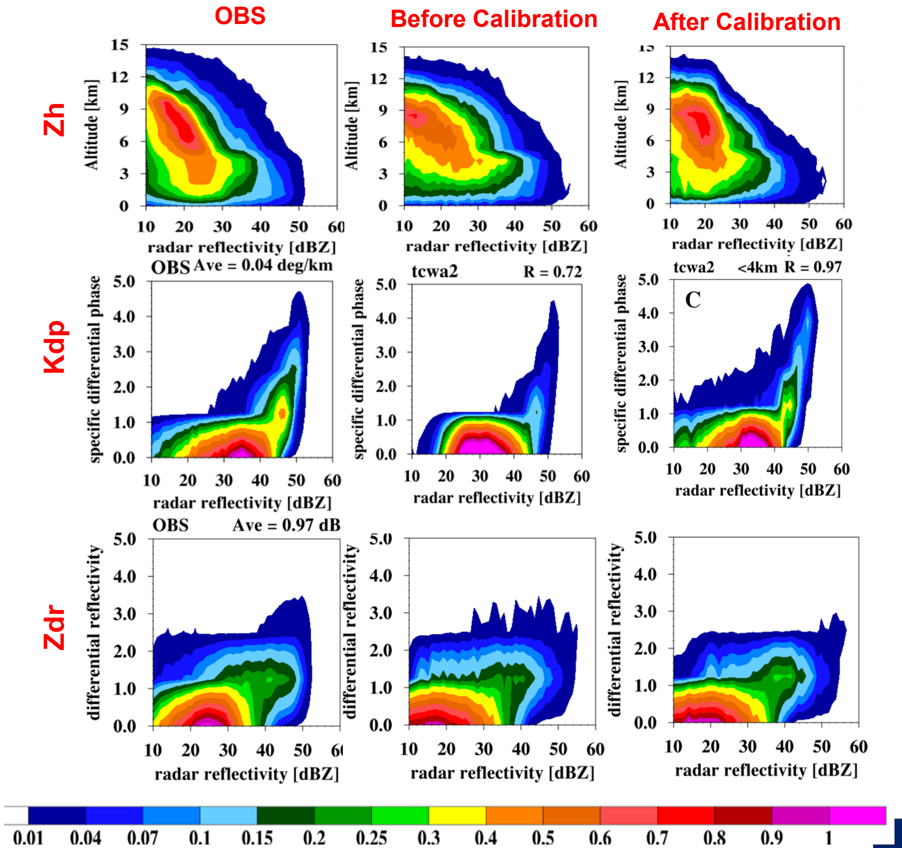
PPRO: Parameterized Polarimetric Radar Operator

Feature	Zhang21	TCWA2
PSD assumption	Exponential	Gamma
Scattering method	T-matrix	Rayleigh approximation
Fitted functions	Polynomials of Dm and Wx (mass content)	Complex functions of more parameters
Microphysics	Thompson, WSM6, NSSL, TCWA2	TCWA2 (Taiwan CWA)
Melting treatment	Melting models (Zhang21 or Liu et al. 2024)	Melted fraction from TCWA2 MP scheme

For general use as a standalone library, will be made publicly available soon

Also interfaced into JEDI-UFO for HofX or DA purposes

MPAS-JEDI's HofX tool supported calibration of a 2-moment microphysics scheme "TCWA2" using dual-pol radar obs



Improved Frequency distribution after calibration

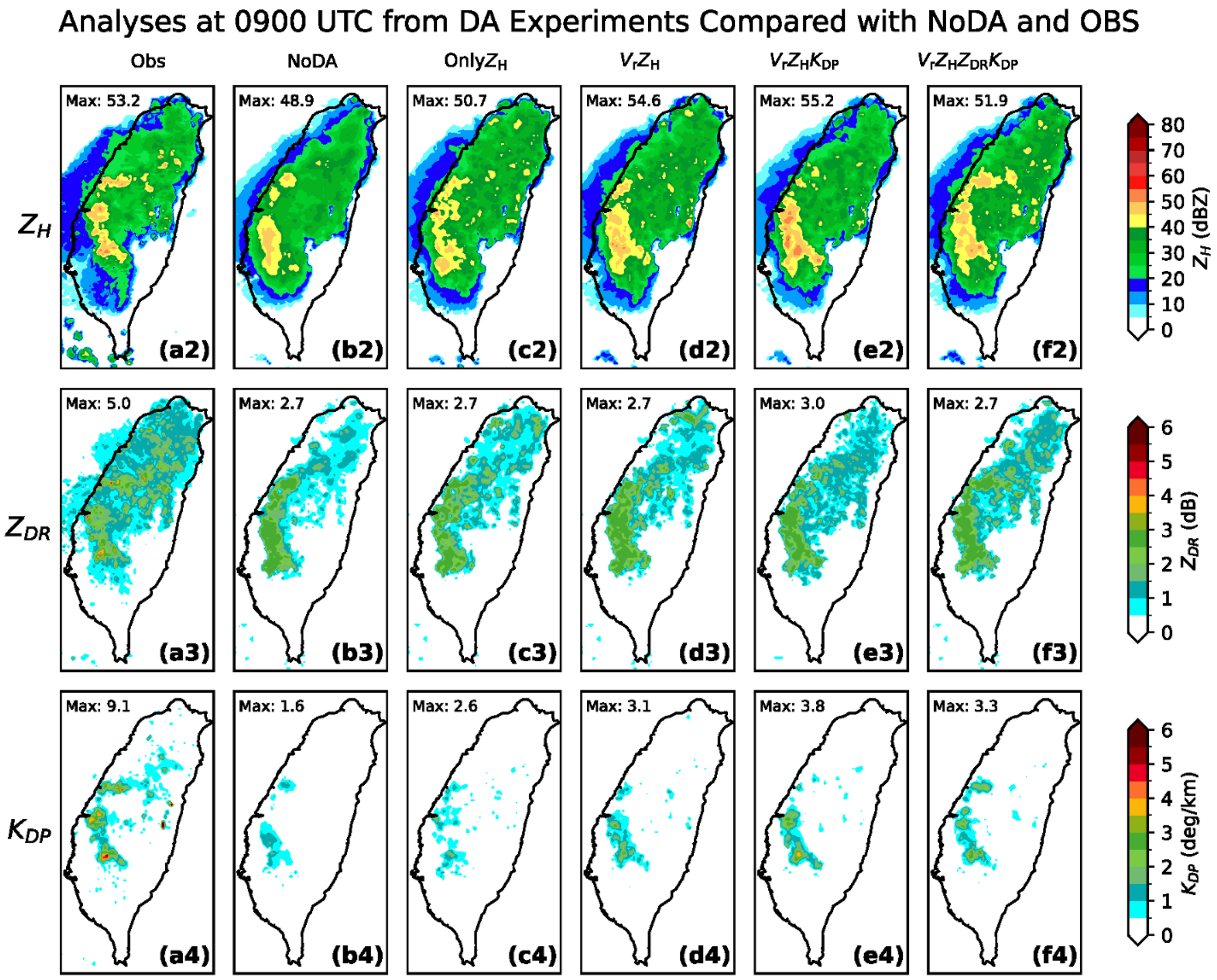
Taiwan Afternoon thunderstorm 24 Jun 2022

(Tzu-Chin Tsai, CWA)

Dual-pol radar DA with MPAS-JEDI and PPRO

Taiwan afternoon thunderstorm on 24 June 2022

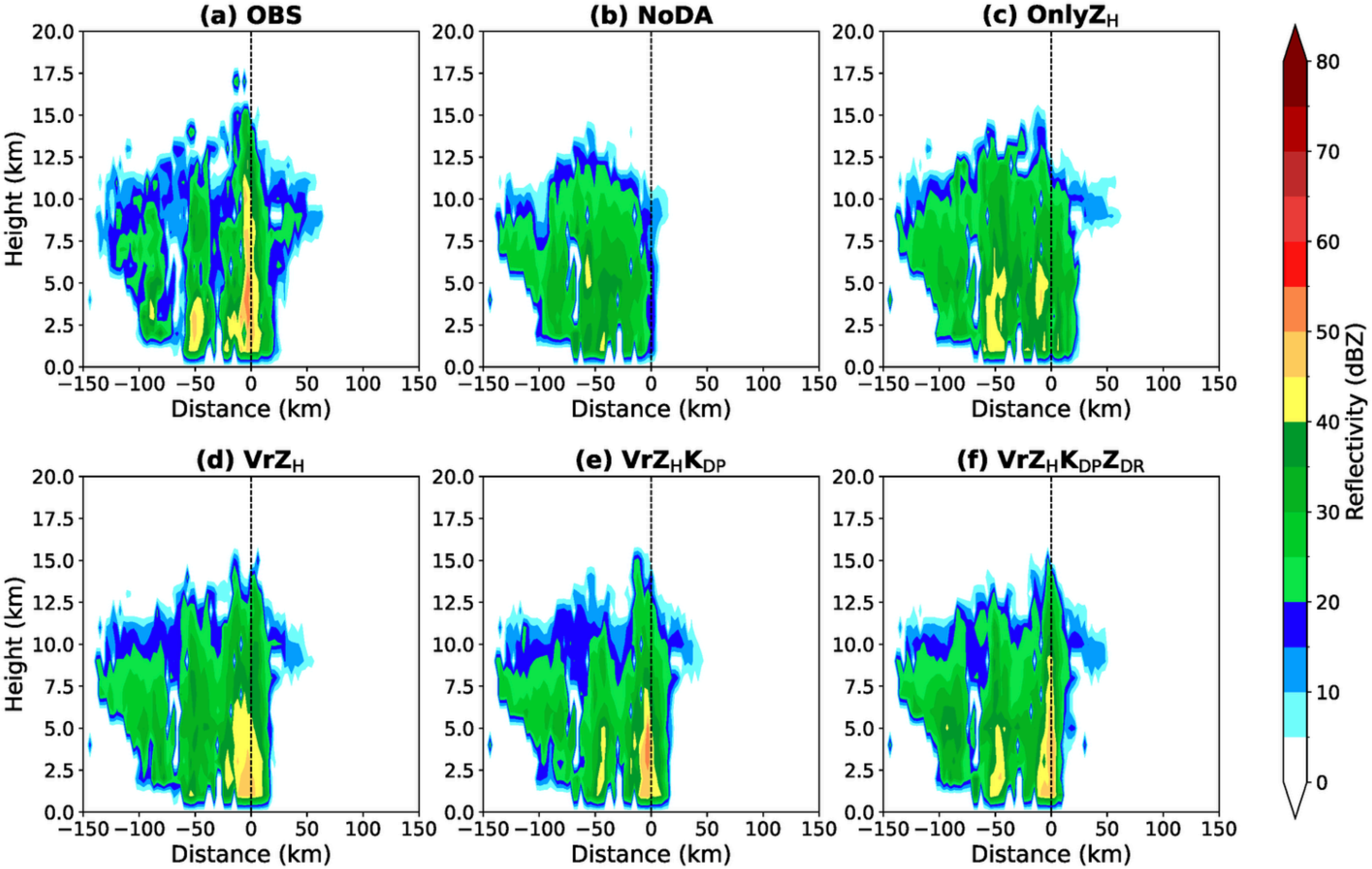
Kong et al., 2026



Dual-pol radar DA with MPAS-JEDI and PPRO

Taiwan afternoon thunderstorm on 24 June 2022

Kong et al., 2026



Concluding Remarks

- JEDI's HofX application is a powerful tool to support observation-based NWP model evaluation and improvement
  - Build-in interpolation functions from complex model grids to obs locations
  - Many obs operators in JEDI-UFO have access to multiple atmospheric models
- JEDI's data assimilation capability can improve initial condition for model forecasts or just produce analysis/reanalysis for process studies
  - If assimilating radar obs alone, it can be viewed as a retrieval tool
  - More powerful with capability to assimilate many types of observations together
- Can be a good tool for synergistic analysis/integration of ground-based, airborne, and spaceborne radar/lidar data with further developments
  - Barriers for radar community to adopt and contribute?