The Joint Effort for Data assimilation Integration (JEDI)

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(Presented by Jim Yoe)
The Joint Effort for Data assimilation Integration (JEDI) is a collaborative development between JCSDA partners.

Develop a unified data assimilation system:

- From toy models to Earth system coupled models
- Unified observation (forward) operators (UFO)
- For research and operations (including R2O/O2R)
- Share as much as possible without imposing one approach
Abstract Design: separation of concerns

Abstract interfaces are the most important aspect of the design.
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Model Space Interfaces

Observation Space Interfaces

Infrastructure and working practices
Model Design: $x_t = M(x_0)$

**Setup** (lots of stuff)

**Timestep**

**Clean-up** (sometimes)

- grid.create(…)
- model.create(…)
- model.initialize(…)
- model.step(…)
- model.finalize(…)

**Time Loop**
Model Design: Post-processors

- Between model “steps” OOPS calls post-processors
  - OOPS manages when post-processing should be called
  - Post-processing moved away from model code (separation of concerns)
  - Adding a post-processor is just adding it to a list

- A post-processor can be anything that
  - Is called (regularly) during model integration
  - Does not modify the State

- OOPS relies on post-processors for isolating data assimilation from the model (separation of concerns)
  - Computing simulated observations H(x)
  - Jc-DFI, ...
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Model Space Interfaces

Observation Space Interfaces

Infrastructure and working practices
Observation Space Objectives

- Share observation operators between JCSDA partners and reduce duplication
  - Include instruments science teams

- Faster use of new observing platforms
  - Regular satellite missions are expensive
  - Cube-sat have short expected life time

- Unified Forward Operator (UFO)
  - Build a community app-store of observation operators ("op-store")
• In most existing systems, observation operators directly access state/model data

• Observation operators, and as a result DA systems, are very model specific
• JEDI/UFO introduces standard interfaces between the model and observation worlds
• Observation operators are independent of the model and can easily be shared, exchanged, compared
UFO Observation “filters”

• JEDI/UFO calls abstract “observation filters” before and after the actual observation operator

• Filters can be written once and used with many observation types

• Observation filters are generic and have access to
  - Observation values and metadata
  - Simulated observation value (post-filter)
  - Their own private data

• Examples:
  - Quality control (background check, buddy check, cloud detection...)
  - Thinning
  - Saving linearization trajectory or Jacobians
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, possibly several implementations?
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Model Space Interfaces

Observation Space Interfaces

Infrastructure and working practices
Code and repositories

FV3GFS
GEOS
MOM6
MPAS
LFRic
NEPTUNE

OOPS

eckit

UFO

CRTM
IODA

Observation and Model Spaces are independent
Collaborating: Repositories

Permission to fork repository are very easy to obtain
Contributing code is very controlled:
- Pushing a branch requires write permission on central repository
- Pull request triggers code review and approval for merging to higher level branch
Governance and code reviews

**Governance** is about management keeping in control and deciding what features should be in the system.

**Code reviews** are about quality of the code.

Two different levels of control:
- Good code can stay outside of central repository (stability of interfaces is important).
- A desired feature that does not satisfy quality requirements cannot be accepted as is.

Testing is a pre-requisite for code reviewing.

Different people and different pace: *Separation of concerns...*
Infrastructure, working practices

- Project methodology inspired by Agile/SCRUM
  - Adapted to distributed teams and part time members

- Collaborative environment
  - Easy access to up-to-date source code (github)
  - Easy exchange of information (Confluence, zenhub)

- Flexible build system (ecbuild-based)

- Coding norms

- Documentation, tutorials, JEDI Academy
Infrastructure, working practices

- Continuous Integration, Testing framework
  - Toolbox for writing tests
  - Automated running of tests (on push to repositories)

- Effort on portability
  - Automatically run tests with several compilers
  - JEDI available in containers (Docker, singularity)

- Enforce software quality (correctness, coding norms, efficiency)

- Change in working practices take time...
Code Sprints

- Gather 8-10 people in a room for 2 weeks
  - NICAS B Matrix (Aug 2017)
  - Observation Operators (Nov. 2017)
- Efficient use of time, especially for part time contributors
- Involve people from all partner institutions in project
- Very motivating (before, during, after)
Summary

• JEDI is critical to next-generation DA development (hence to NGGPS)
• Provides scalability/reusability to support multiple applications, users, and contributors
• Builds off successful example (Object Oriented Prediction System – OOPS)
• Coding began in August, 2017
  – Successful components already exist
    • See SOCA example in JCSDA Round-Up Presentation
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Organized by projects:
- CRTM (Community Radiative Transfer Model)
- JEDI (Joint Effort for Data assimilation Integration)
- SOCA (Sea-ice Ocean Coupled Assimilation)
- NIO (New and Improved Observations)
- IOS (Impact of Observing Systems)