JCSDA Next Generation Earth System DA
Tom Auligné and team, Joint Center for Satellite Data Assimilation
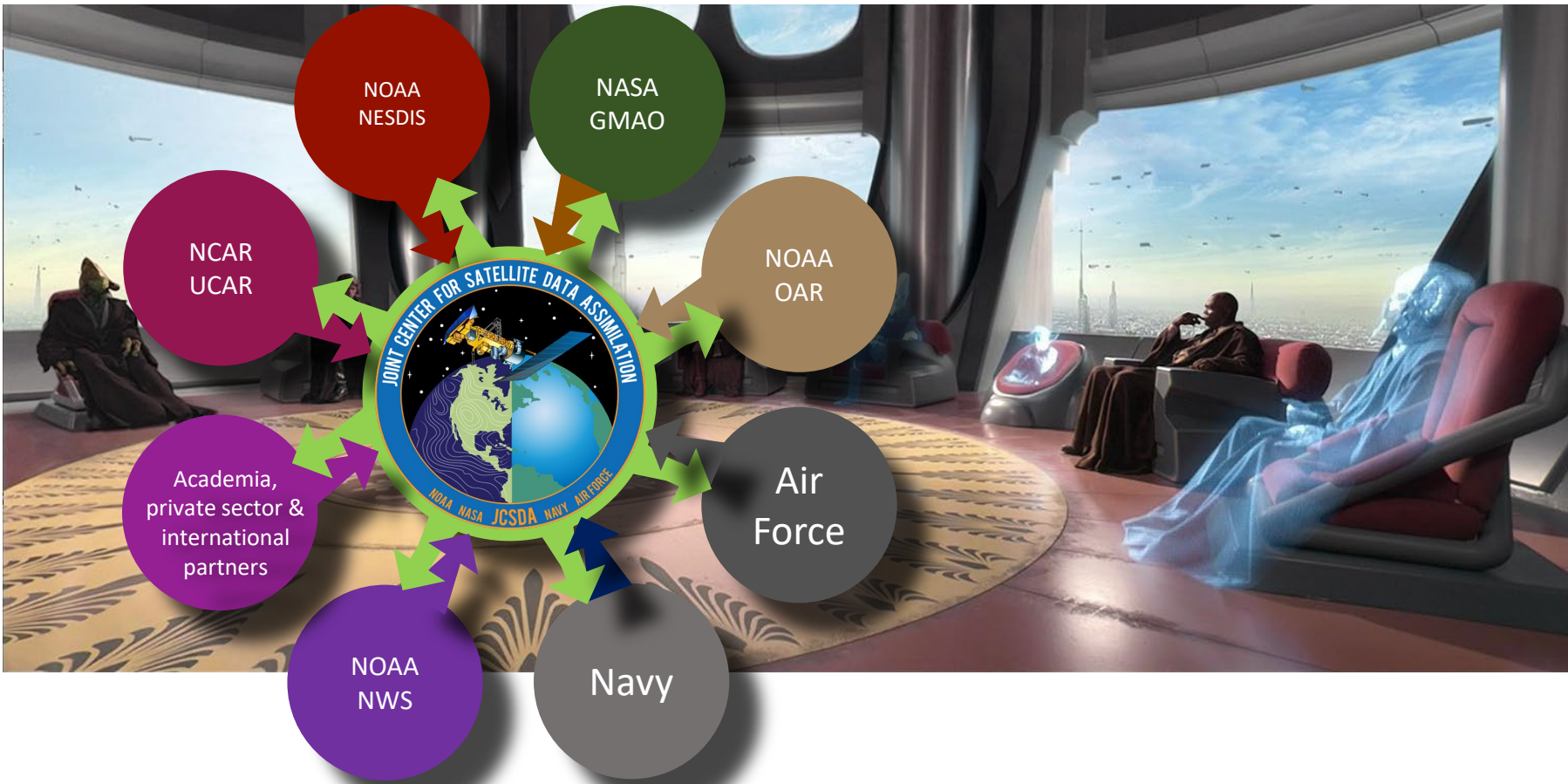
What is JEDI?

Joint Effort for Data assimilation Integration (JEDI)

Consortium of *Jointness:* share as much as possible without imposing a single approach

Consortium of *Jointness:* *s*hare as much as possible without imposing a single approach

Goals

- Next-generation **unified** DA for Earth system science

- Increase **R2O/O2R** transition rate

- Improve **science productivity** and **code performance**

Collaborative working practices

- Open-source code management
- Agile project methodology
- CI/CD using containers & cloud

Modern software principles

- Separation of concerns
- Generic programing

$$\Delta x_a = \mathbf{B}\mathbf{M}^{\mathbf{T}}\mathbf{H}^{\mathbf{T}}\left(\mathbf{H}\mathbf{M}\mathbf{B}\mathbf{M}^{\mathbf{T}}\mathbf{H}^{\mathbf{T}} + \mathbf{R}\right)^{-1}\left(y_o - H(M(x_b))\right)$$

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

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.

DA algorithms implemented:
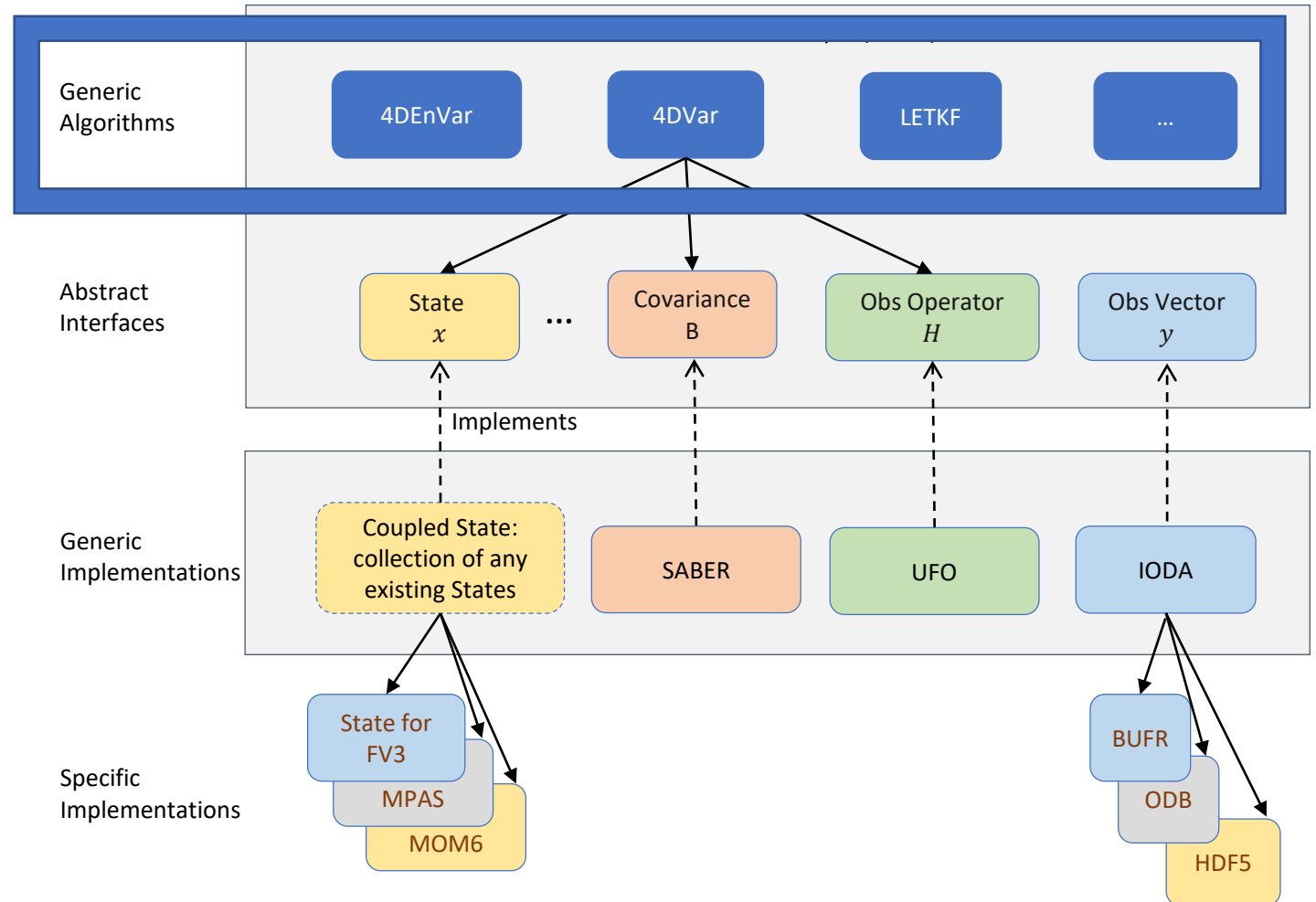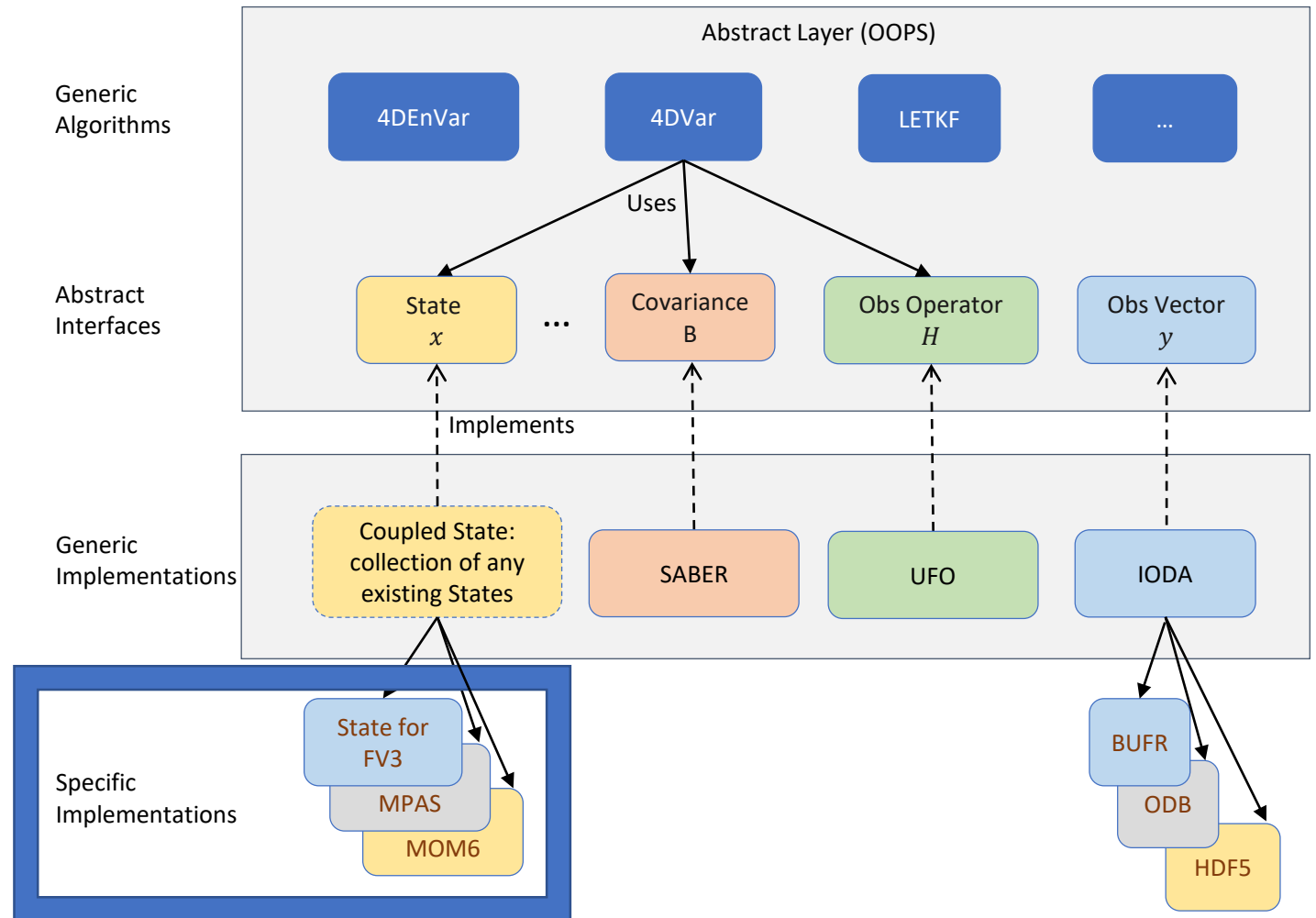
- 3DVar, 3DVar-FGAT, 4DEnVar, strong & weak-constraint 4DVar, dual-space, ...

- EDA (with any Var from above), block-Lanczos EDA

- LETKF, LGETKF (model-space vertical localization)

- Particle flow filter
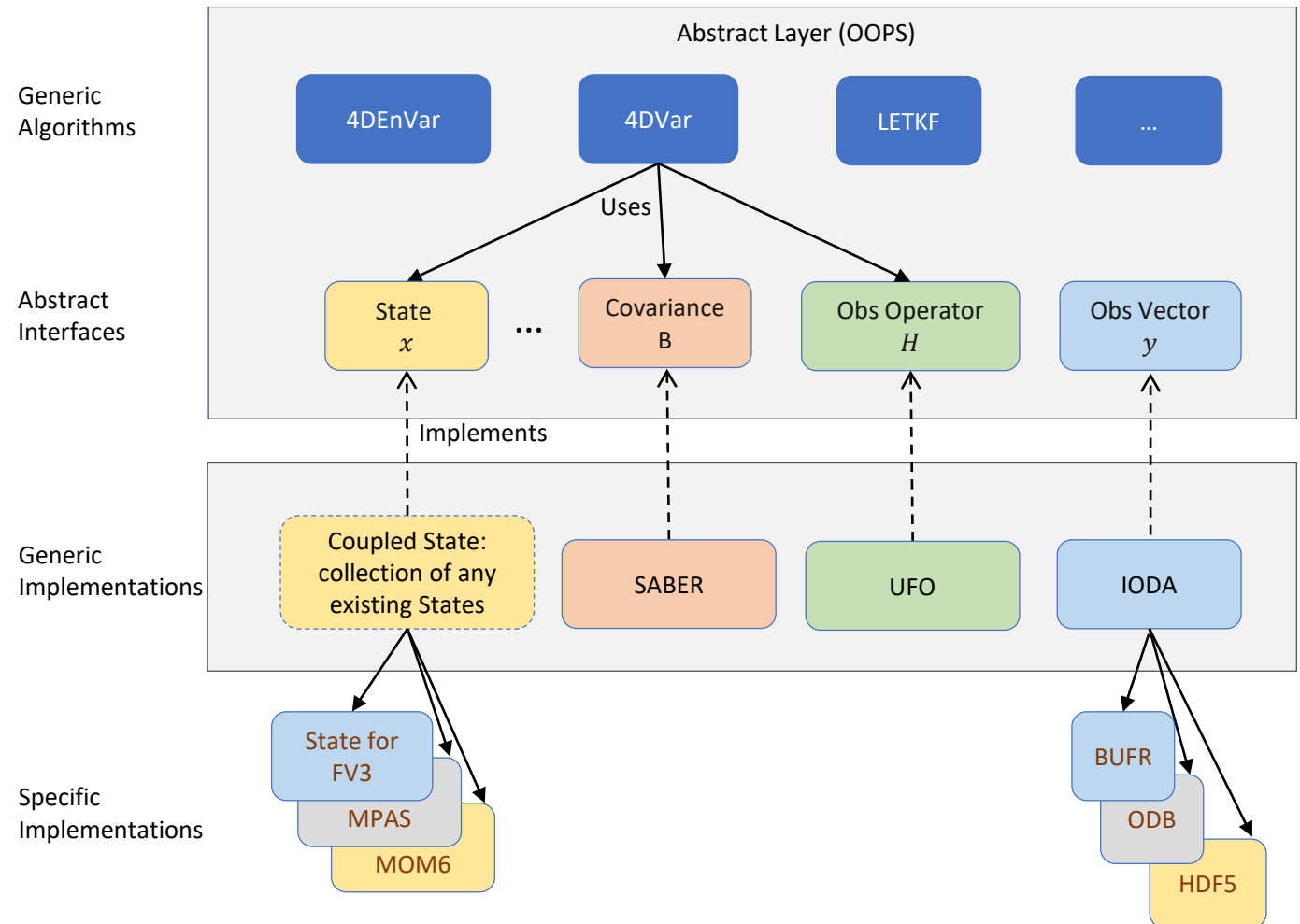
JEDI - Design Principles and Notional Status

| MODEL	TYPE	CENTER
UFS	Global Atmosphere	NOAA
GEOS	Global Atmosphere	NASA
NEPTUNE	Global atmosphere	Navy
MPAS	Global atmosphere	NCAR
LFRic	Global atmosphere	Met Office
Unified Model	Global atmosphere	Met Office
UFS CAM	Regional atmosphere	NOAA
MPAS-Regional	Regional atmosphere	NCAR
WRF	Regional atmosphere	NCAR
UFS GSDChem	Global constituents	NOAA
GEOS-AERO	Global aerosols	NASA
UFS CAM-CMAQ	Regional air quality	NOAA
MOM6	Global ocean	NOAA
ROMS	Regional ocean	NOAA
SIS2	Sea-ice	NOAA
CICE6	Sea-ice	NOAA
WW-III	Wave	NOAA
NOAH-MP	Land and Snow	NOAA
QG	Toy model	ECMWF
Lorenz 95	Toy model	ECMWF
Shallow Water	Toy model	NOAA

Some examples of obs operators:

- CRTM, RTTOV satellite radiances
- Scatterometer neutral wind
- Multiple operators for GNSSRO refractivity and bending angle
- Ground based GNSS
- Conventional atmospheric obs
- Corrected surface pressure
- Total column water vapor
- Conventional ocean obs
- Cool skin temperature
- Absolute dynamic topography
- Sea ice fraction and thickness
- Aerosol optical depth
- In situ particulate matter
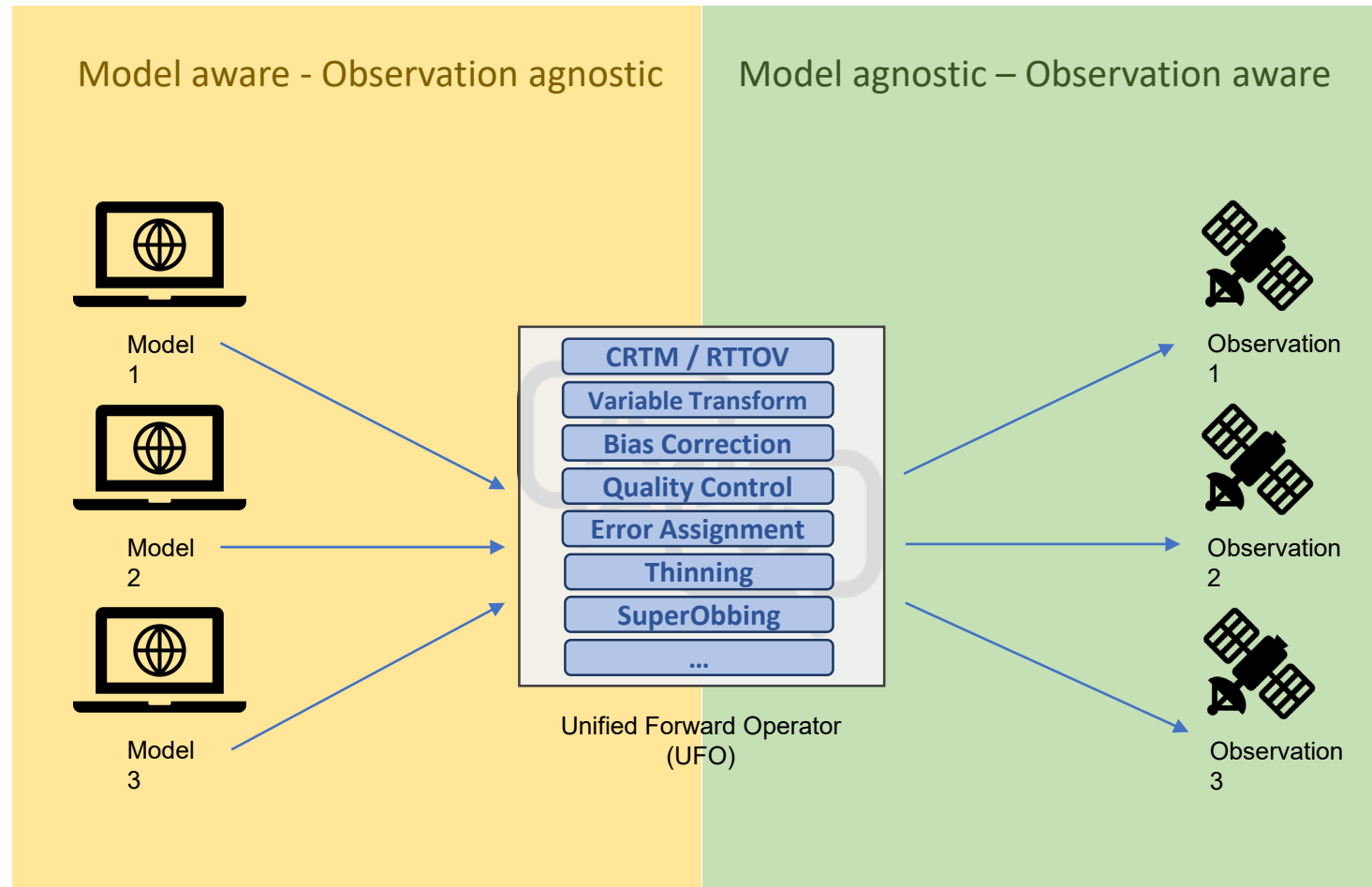- Radar reflectivity and radial velocity
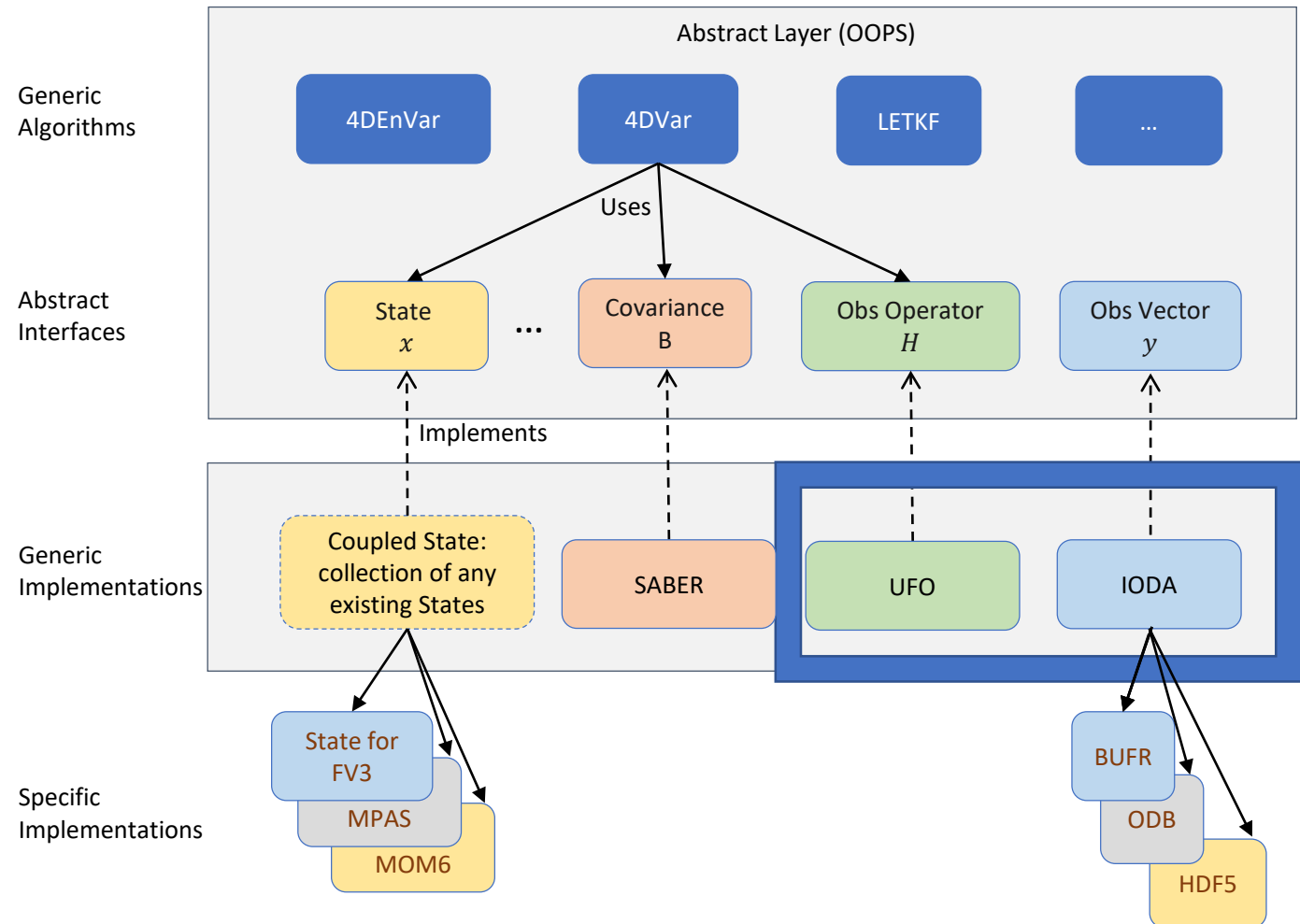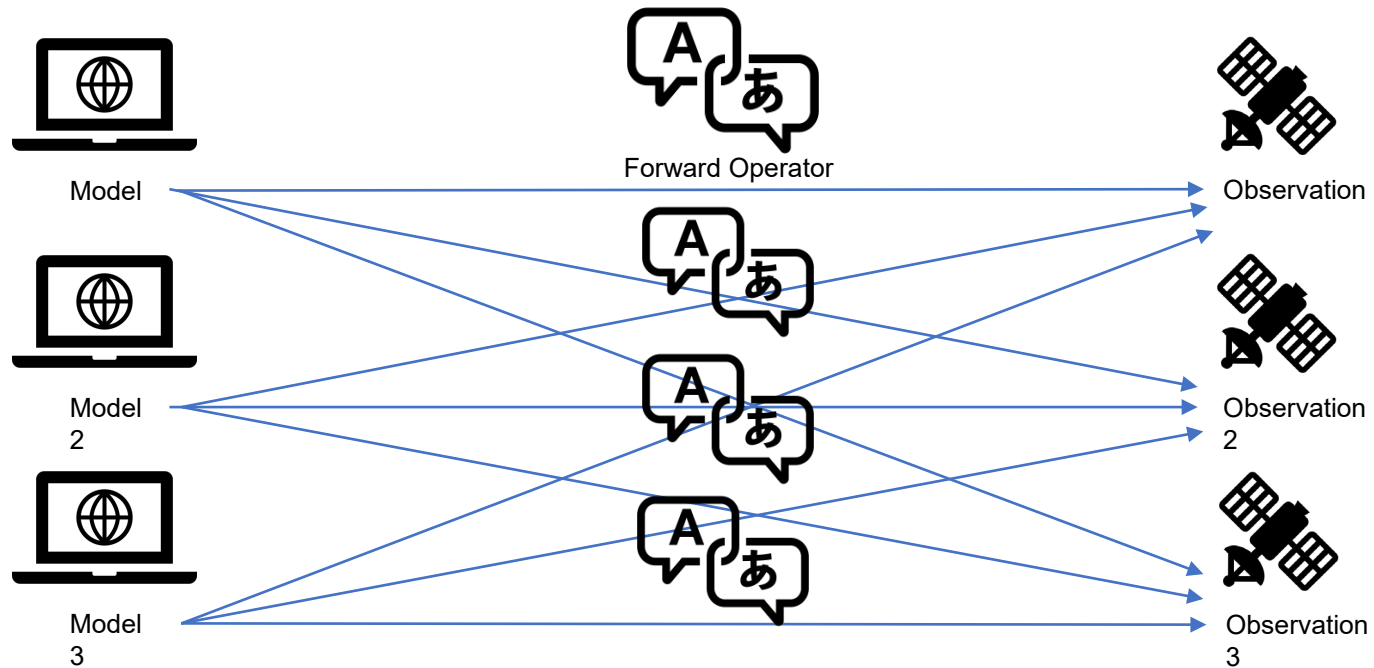
Duplication of effort

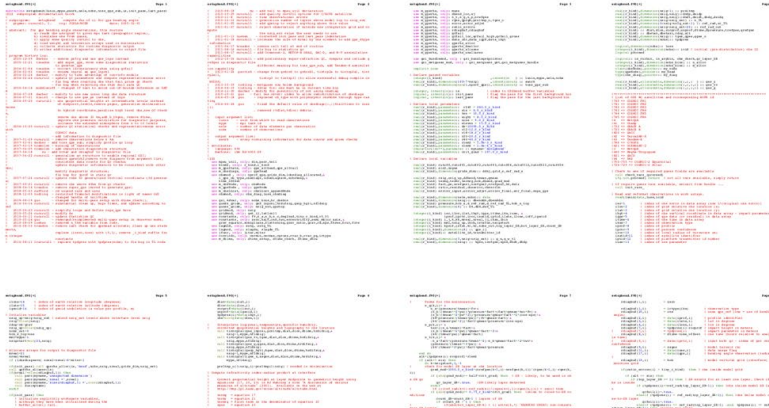# Unified Forward Operator (UFO)

The App Store of observation operators!!

UFO - Generic QC Filters (No Coding!)

Quality Control

```
ObsTypes:
- ObsOperator:
    name: GnssroBndGSI
  ObsFilters:
  - Filter: Domain Check
    where:
    - variable:  impact_height
      minvalue: 0
      maxvalue: 50000
  - Filter: Background Check
    variables: [bending_angle]
    threshold: 3.0
```

```
ObsFilters:
- Filter: Domain Check
  variable:
    ascending_flag
    is_not_in: 1
  where:
  - variable:
    occulting_sat_id
    is_in: 825
```

Rejecting KOMPSAT5 rising profiles

● Rejected observations

```
obs filters:
- filter: Domain Check
  where:
  - variable: {name: sea_area_fraction@GeoVaLs}
    minvalue: 0.9
- filter: Domain Check
  where:
  - variable: { name: sea_surface_temperature@GeoVaLs}
    minvalue: 5.0
- filter: Background Check
  absolute threshold: 0.2
- filter: Bounds Check
  minvalue: -2.0
  maxvalue: 2.0
  action:
    name: assign error
    error function:
      name: LinearCombination@ObsFunction
      options:
        variables: [mesoscale_representation_error@GeoVaLs,
                    obs_absolute_dynamic_topography@ObsError]
        coefs: [0.1,
                0.01]
- filter: BlackList
  where:
  - variable:
      name: latitude@MetaData
    minvalue: -65
    maxvalue: -30
  - variable:
      name: longitude@MetaData
    minvalue: -125
    maxvalue: -90
- filter: BlackList
  where:
```

Land mask

Reject ADT obs if SST<5°C

Reject ADT obs if |Obs-Bkg|<0.2 m

Reject ADT obs outside of [-2.0m, 2.0m]

Assign ADT obs error [m]

Reject ADT obs in specific region
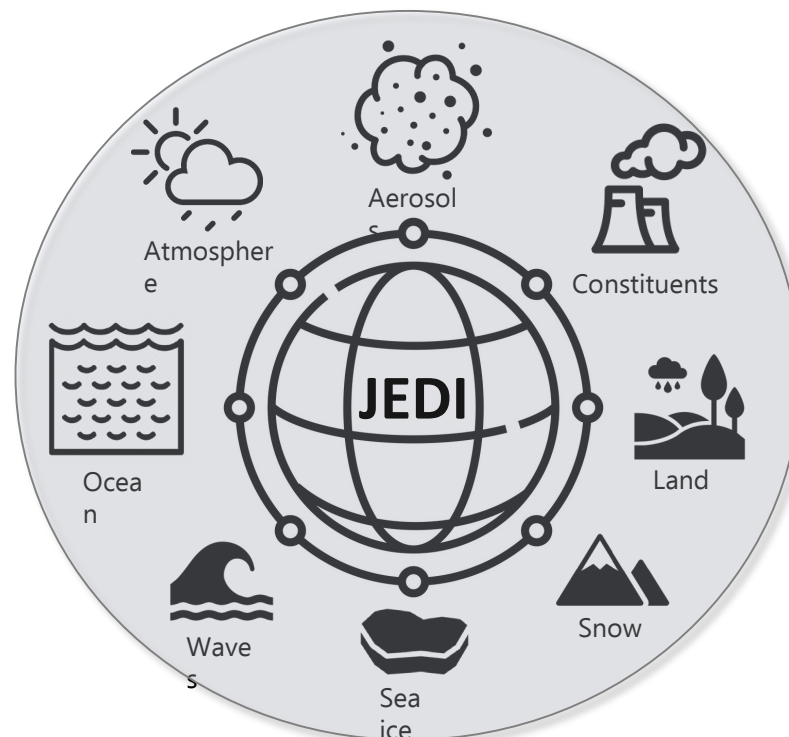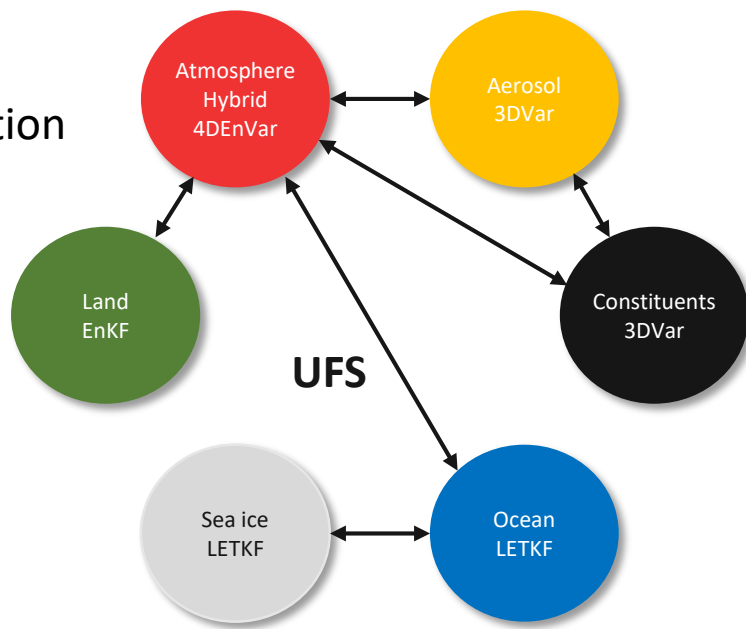

ADT error [m]

JEDI - A New Dawn (for Earth System DA)

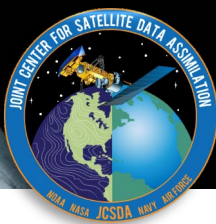**Phase 1**: match skills of operational systems

GEOS-FP

GFS-v17
GEFSv13

NEPTUNE

LFRic
GALWEM

HAFSv3
RRFSv2
RTMAv4

MERRA-3

2023	2024	2025

Phase 2: foster scientific innovation
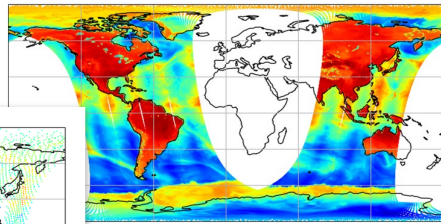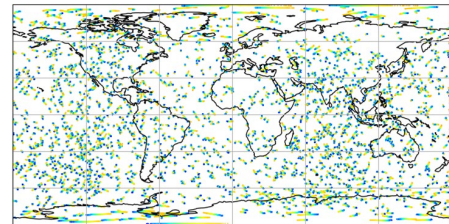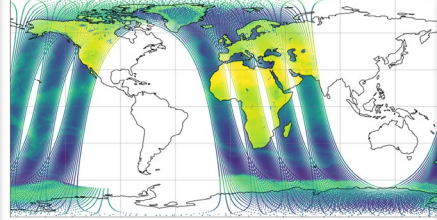
Atmosphere
Hybrid
4DEnVar

Aerosol
3DVar

Land
EnKF

Constituents
3DVar

UFS

Sea ice
LETKF

Ocean
LETKF

Atmosphere

Aerosols

Constituents

Ocean

JEDI

Land

Waves

Sea ice

Snow

JEDI - A New Dawn (for Earth System DA)
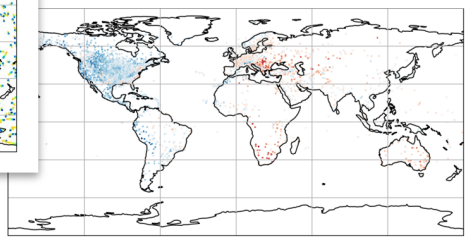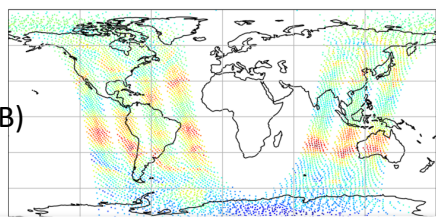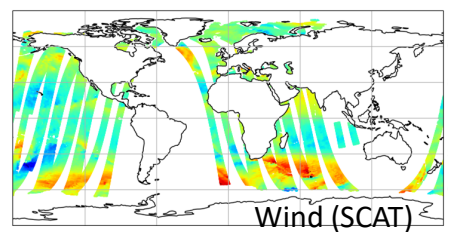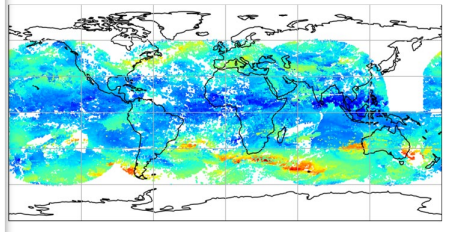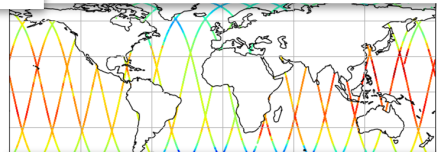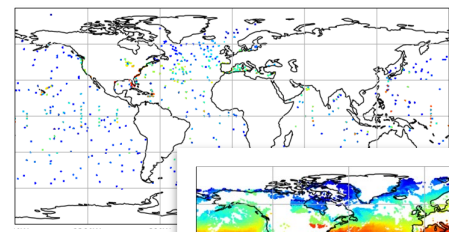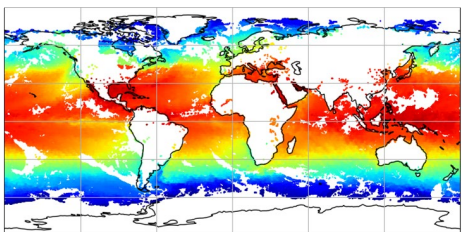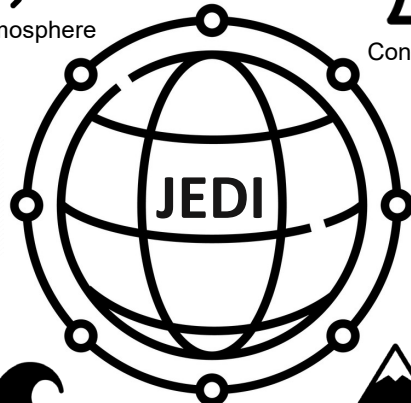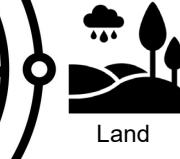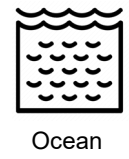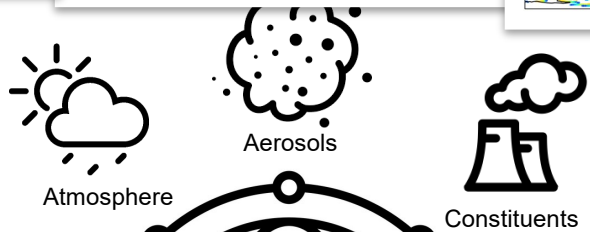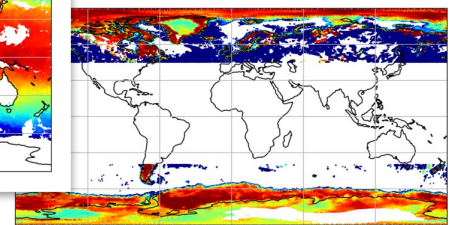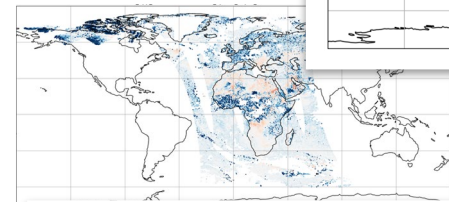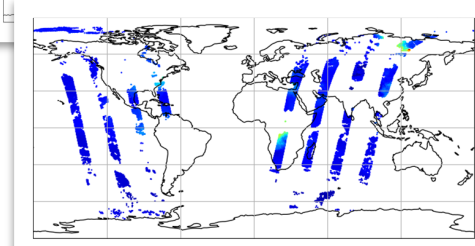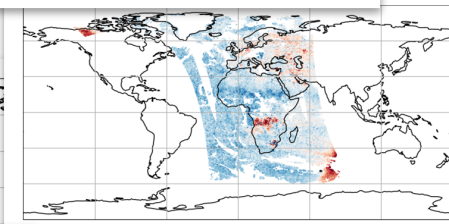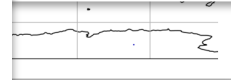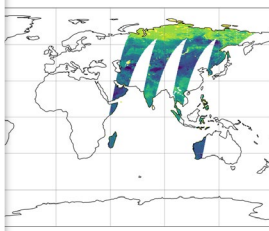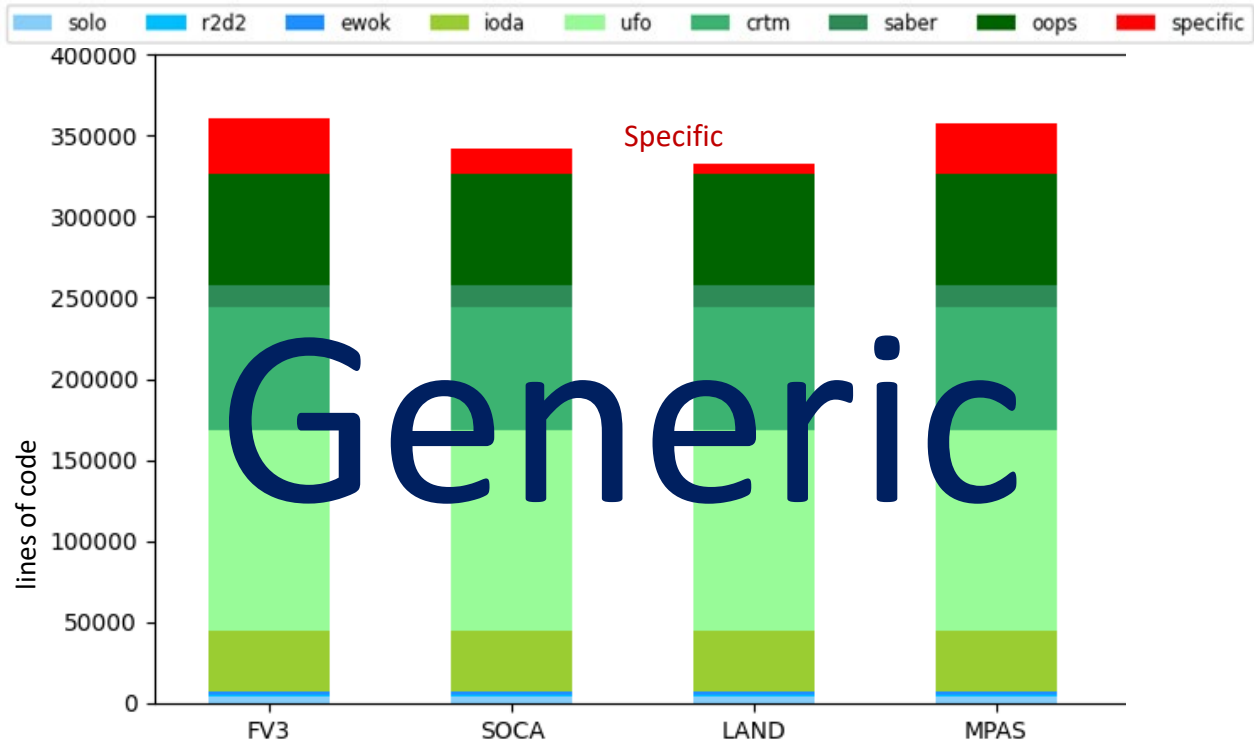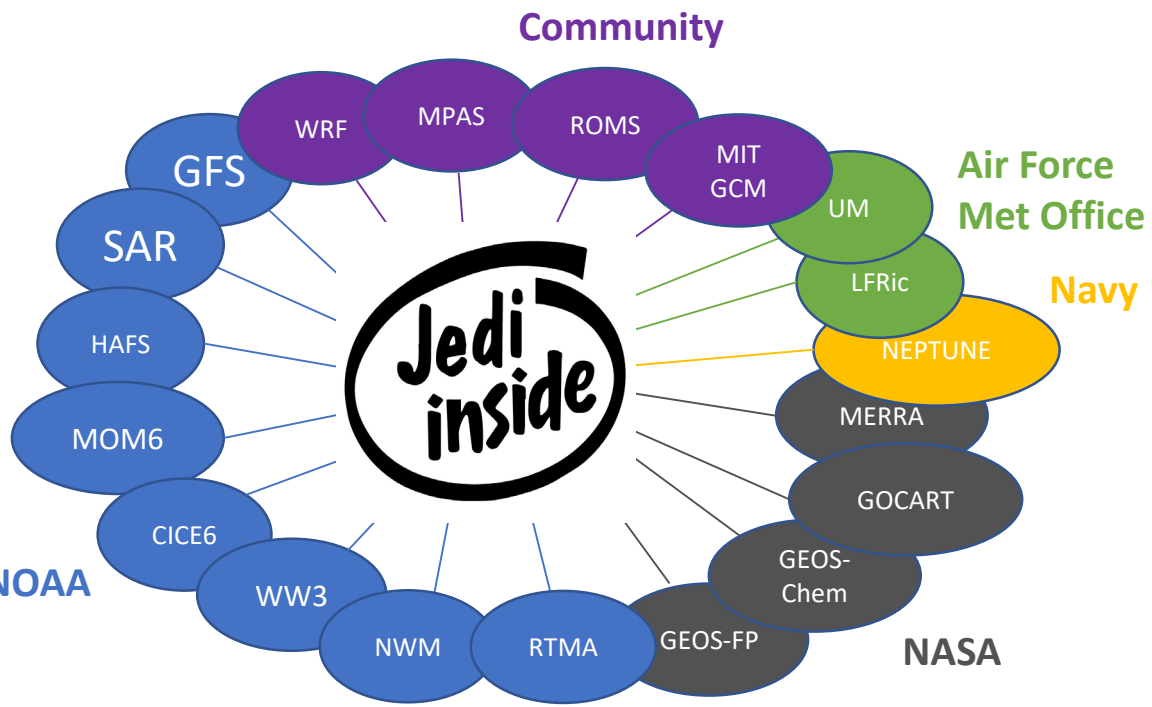
JEDI = unified DA system with multiple configurations

Scientific diversity without reinventing the wheel

How to Learn more about JEDI?

Next JCSDA Science Workshop: May 16-18, 2023 in Boulder, CO (+virtual)

Training

Online tutorials (www.jcsda.org)
7 JEDI Academies (week-long)
500+ padawans (35 universities
+ 11 private + 9 international)

Public Releases

2021-6-11	JEDI-FV3 v1
2021-9-24	JEDI-MPAS v1
2021-11-4	JEDI-SOCA v1
2022-07-18	JEDI-SKYLAB v1
2022-10-11	JEDI-SKYLAB v2
2023-01-09	JEDI-SKYLAB v3

JEDI Academies

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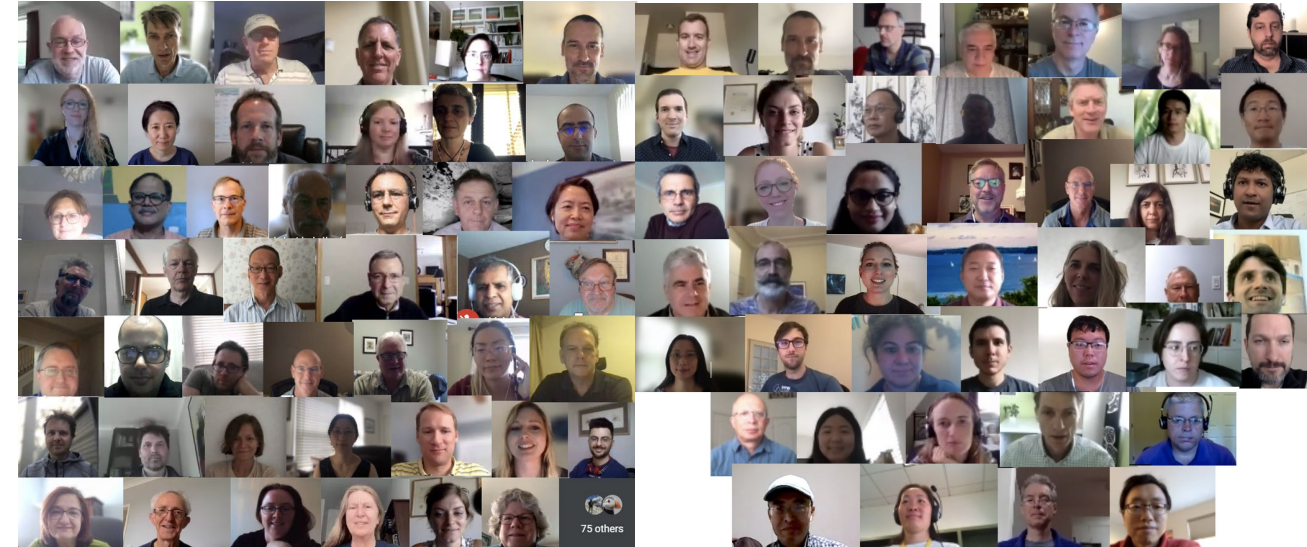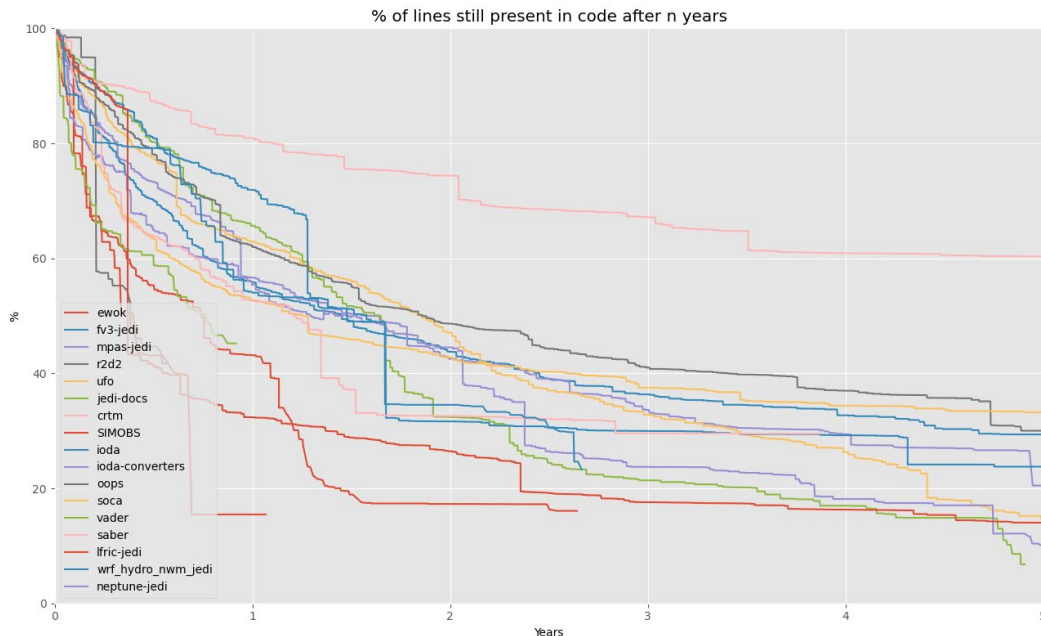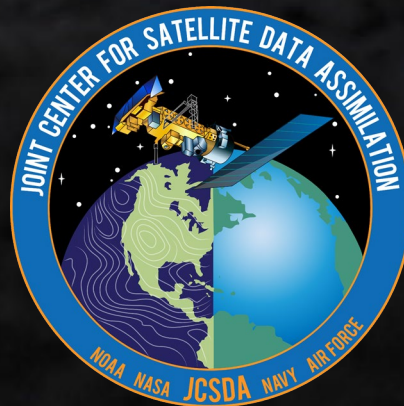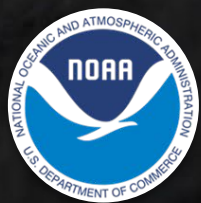+ 11 private + 9 international)

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2022-10-11	JEDI-SKYLAB v2
2023-01-09	JEDI-SKYLAB v3

JCSDA IS HIRING

% of lines still present in code after n years

ewok
fv3-jedi
mpas-jedi
r2d2
ufo
jedi-docs
crtm
SIMOBS
ioda
ioda-converters
oops
soca
vader
saber
lfric-jedi
wrf_hydro_nwm_jedi
neptune-jedi

How to contribute

- Discuss planned contributions ahead of time *(inclusive)*
- Effort is oriented toward optimal genericity *(reusable)*
- You may not be the sole owner of design/code *(collaborative)*
- Basic object-oriented training may be needed *(modular)*
- Developers need to also write tests and documentation *(CI/CD)*
- You may need to keep up with quickly evolving system *(agile)*

Questions