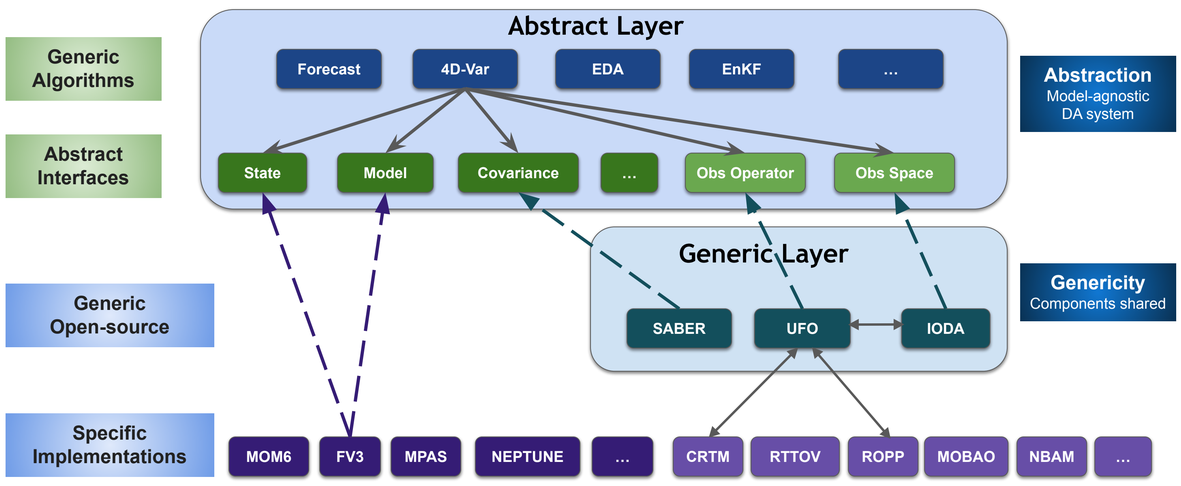
Evaluation and impact assessment capability for observations in JCSDA JEDI Skylab

B. Ruston*, H. Shao, G. Thompson, F. Vandenberghe, F. Diniz,
H. Zhang, L. Hayden and S. Maticka
*benr@ucar.edu www.jcsda.org

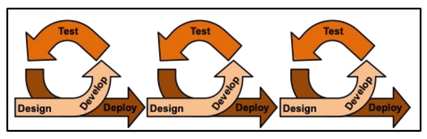
Empowering Environmental Analysis: The JCSDA JEDI Project

The Joint Center for Satellite Data Assimilation (JCSDA) is an interagency partnership dedicated to advancing research in applying satellite data to operational goals in environmental analysis and prediction. Within JCSDA, the **Joint Effort for Data Assimilation Integration (JEDI)** project plays a crucial role. JEDI involves collaboration between scientists and software engineers to establish a unified data assimilation framework, specifically focusing on different components of the Earth system and various applications. The primary goal of JEDI is to streamline community efforts, enhance research efficiency, and facilitate the transition from development teams to operational use. This framework, known for its versatility, enables the integration of diverse data types into weather, ocean, climate, and environmental analysis and prediction systems, contributing to accelerated advancements in satellite data utilization.

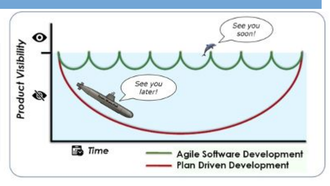


Revolutionizing Data Assimilation: The Dynamic Design of JEDI

In its pursuit of innovation, the JEDI framework champions the creation of abstracted interfaces for a diverse range of data assimilation approaches. Departing from the conventional numerical weather analysis and prediction systems with proprietary and disjointed algorithms, JEDI adheres to an open-source paradigm. This approach ensures specific configurations can be maintained in yaml control files, providing a transformative shift towards comparability and integration. Furthermore, the JEDI system undergoes constant and rapid development, challenging the traditional notion of version handoffs. Instead, it embraces a dynamic structure, fostering swift responses to events and serving as an enhanced platform for feature planning and design.



Agile testing
- Continuous process, feedback for each iteration
- Issues are fixed within the same iteration
- Easier to review



Efficient and Adaptable: JEDI's UFO

The JEDI system efficiently incorporates multiple options for simulating observations, quality control modification, and observation error specification. The **Unified Forward Operator (UFO)** serves as the generic component where these specifications occur, allowing seamless operation by different observation operators through abstraction of model interfaces. For GNSS-RO, options like NOAA's Bending Angle Model (NBAM), the UK Met Office operator, or the ROPP from EUMETSAT ROM-SAF are available with abstracted error models and selectable quality control. Fast models like the JCSDA Community Radiative Transfer Model (CRTM) and EUMETSAT NWP-SAF RTTOV provide options for satellite radiances. Notably, the system allows for easy modification of observations, data assimilation methods, and quality control filtering without code modifications, creating an environment conducive to rapid development.

Configuration

The configuration settings, via yaml file, read by JEDI to deploy different forward operators for GNSS-RO bending angle.

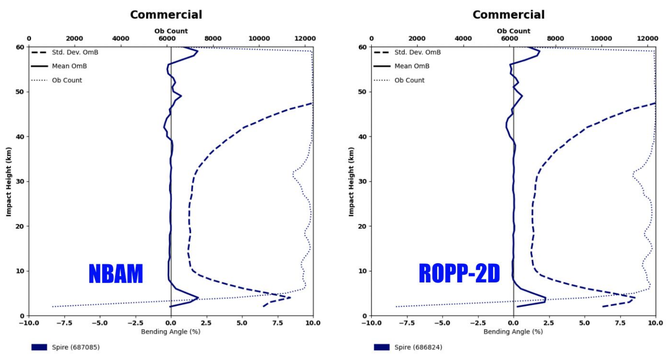
```
obs operator:
  name: GnssroBndNBAM
  obs options:
    _mpas_modeltop: 30
    use_compress: 1
    sr_steps: 2
    vertlayer: full
    super_ref_qc: NBAM
```
NOAA NBAM

```
obs operator:
  name: GnssroBndROPP1D
```
ROPP 1D

```
obs operator:
  name: GnssroBndROPP2D
    obs options:
      n_horiz: 31
      res: 40.0
      top_2d: 10.0
```
ROPP 2D

Intercomparison

The NOAA NBAM, and EUMETSAT ROPP operators in 2D are compared for a common observations and model background state.



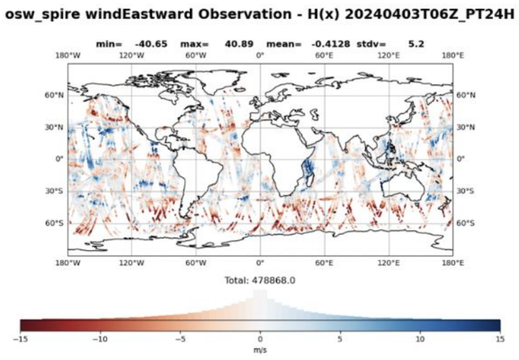
Skylab: Showcasing JEDI's Continuous Integration

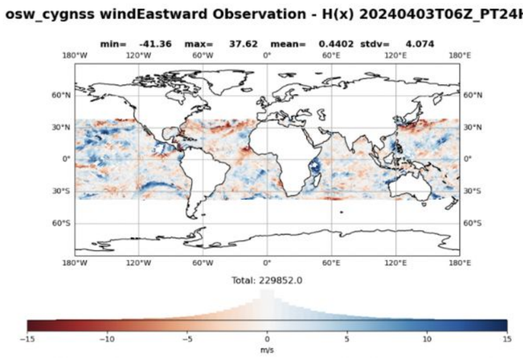
To showcase capabilities, validate, and ensure continuous integration within JEDI, the Skylab system is regularly deployed. Skylab v1 was released in July 2022, and the latest Skylab v8 in April 2024. For detailed information, visit JEDI Skylab at jcsda.org/jediskylab. The current Skylab demonstration system encompasses sensors used by operational partners and incorporates additional research and commercial sensors like TEMPEST, TROPICS, COWVR, Windborne balloonsondes, and GNSS-RO from PlanetiQ, and Spire. Innovations are demonstrated as well such as the direct assimilation of GOES radiances and reflectances. JEDI developers utilize the Skylab demonstrator to examine configurations and explore new data types, such as GNSS-R ocean surface winds, TEMPO, and small satellite MW constellations. Coordination with partners on feature development and growth guides integration and testing priorities, with the JCSDA annual operating plan being revised based on their input.

Skylab Monitoring: Enhancing Observation Analysis in JEDI

The Skylab system is a highly configurable data assimilation demonstration capability. After selecting the model interface, DA solver, and observations the system generates feedback files that include observations, first-guess and analysis departures. These feedback files can be stored in databases like the MetOffice ODB or the JEDI Research Repository for Data and Diagnostics (R2D2). Utilizing this unified framework, generic visualizations are crafted with the flexibility to analyze and explore observations in various specialized ways.

Spire | **GNSS-R Ocean Surface Wind** | **CYGNSS**





Skylab Demonstration: Advancing Environmental Observations and Emerging Technologies

for Enhanced Decision-Making

JEDI Skylab supports a diverse range of observations in the UFO related to environmental monitoring. The application utilizes various sensing techniques, including in-situ observations, atmospheric motion vectors, snow-related derived products, infrared and microwave radiances, scatterometer data, GNSS-RO, scalar wind from GNSS-R, and visible information from GOES. Skylab serves as a platform to showcase emerging technologies, exemplified by additional coverage of GNSS-RO, ocean surface winds from GNSS-R, and involvement with small satellites like TROPICS, TEMPEST, and COWVR. JCSDA actively explores advanced techniques such as all-sky assimilation, variational bias correction, observation error correlation derivation and application, visible reflectances, and ground-based and spaceborne RADAR. The maturity levels of these efforts vary, emphasizing the creation and demonstration of capabilities crucial for exploration decisions, determined by the larger supporting consortium of JCSDA.

Summary of atmospheric observation support:

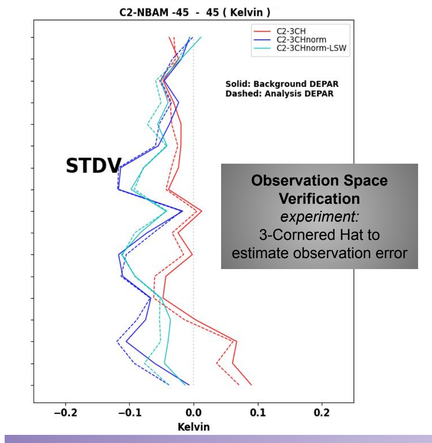
Satellite:
- AMSU-A
- ATMS
- MHS
- IASI
- CRIS
- GNSS-RO (including all ROMEX sensors)
- AMSR/2
- GMI
- GOES-ABI
- SSMIS
- TROPICS
- TEMPEST
- COWVR

In-Situ:
- Radiosonde
- Aircraft
- AMV
- Scatterometer
- SYNOP
- METAR
- Ship
- Buoy
- Supplemental Balloon-Sonde
- GHCN-Snowdepth

Skylab: Enabling Observational Exploration

The distinctive concept behind JEDI involves the development of open-source code with configurations tailored to specific applications, weather centers, or experiments. This approach facilitates the exploration of both routinely used observations and newly gathered ones for investigation. Feedback from the assimilation cycle is provided in files that utilize the Interface for Observation Data Access (IODA). The common IODA standard facilitates and makes feasible a universal set of data mining techniques, visualizations, and validation and verification processes.

STDV Departure Statistics for COSMIC-2



Observation Space Verification
experiment:
3-Cornered Hat to estimate observation error

RMS with ERA-5 as verifying analysis

Model Space Verification
experiment:
GNSS-R Ocean Surface Wind

JEDI: Advancing Data Assimilation in NWP

JEDI provides data assimilation support to weather centers at NOAA, NASA, the US AirForce and Navy, and the UK Met Office. The JEDI Skylab demonstrator, has been deployed with multiple models and diverse solver methods, to explore data assimilation techniques and observation impacts. JCSDA partners are demonstrating the capability to replicate operational configurations, in addition JEDI has been used to swiftly integrate new technology. All partners are actively preparing operational deliveries of JEDI-based components for their respective NWP DA systems.

Other related presentations

- **Shao, H.** *Fri 13Sep2024*: **ROMEX Unveiled: An International Collaborative Effort**
- **Zhang, H.** *Fri 13Sep2024*: **Inter-comparison of GNSS RO Quality Control Methods in NWP**
- **Hayden-Mattson L.** *Fri 13Sep2024*: **Dynamic Error Estimation for GNSS Radio Occultation Observations in the JEDI Data Assimilation System**
- **Vandenberghe, F.** *Tue 17Sep2024*: **High SNR GNSS-RO observations assessment with JEDI-ROPP**