# UFS Land-DA Workflow

## - Day 1: Quick Land-DA Session Intro -

Jong Kim, Chan-Hoo Jeon, Eddie Snyder, Gillian Petro, Kris Booker

(Key stakeholder groups: NOAA/EMC, PSL, GSL, NESDIS ; NCAR ; JCSDA)

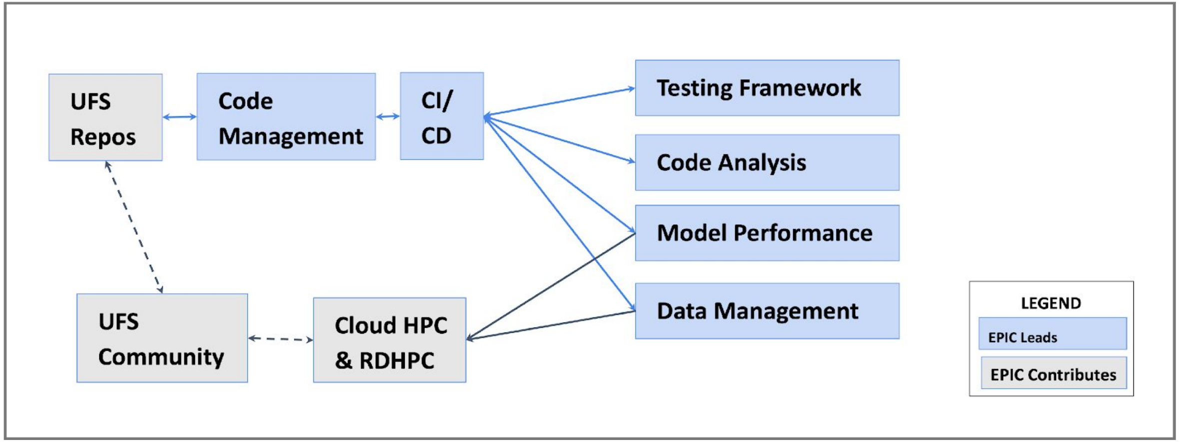
NOAA Earth Prediction Innovation Center (NOAA/EPIC)

# Outlines

- NOAA EPIC mission activities and Land DA motivation
- UFS (United Forecast System) Weather Model and Standalone JEDI-based NOAH-MP Land Data Assimilation Application
- Data Assimilation workflow component and structure
  - Model configuration and data assimilation workflow tasks
  - Consistency of workflow structure across UFS DA Applications: Land DA, SRW, etc.
    - File naming convention, environment variables and parameters, vertical workflow directory structure
  - Workflow management system and configuration tools: Rocoto, JEDI configuration Builder (JCB), Unified Workflow (UW) tools
- Analysis output and log files: CADRE DA sample configurations with choice of model and DA configuration options
  - Snow depth analysis: GHCN/IMS/GTS data sets, focus on 2025 January case for IMS data set with 3DVar with ERA5 forcing

# EPIC’s Keymission Activities

- NOAA created the Earth Prediction Innovation Center (EPIC) to improve operational weather forecast systems through scientific and technical innovation via model co-development with the Weather Enterprise — government, industry and academia.



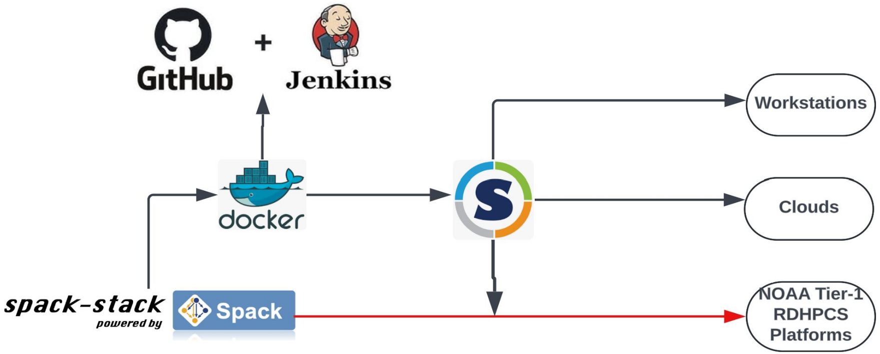

**EPIC Infrastructure Focuses on:**

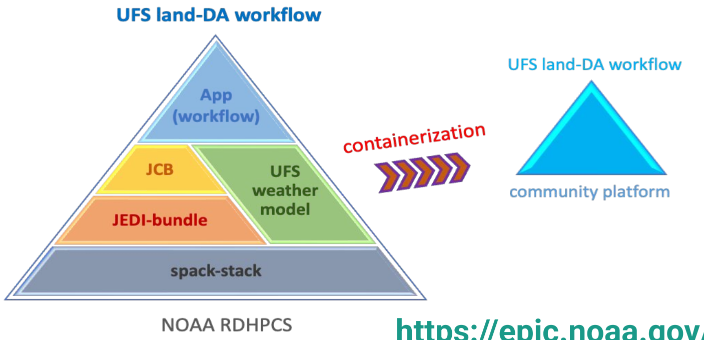
- Develop/provide necessary Software Infrastructure;
- Manage, maintain, test, and evaluate the UFS WM and Apps source code;
- Develop and maintain the appropriate frameworks;
- Support the transition of the UFS WM to Cloud-based HPC

https://epic.noaa.gov/

# Platform Agnostic Deployment

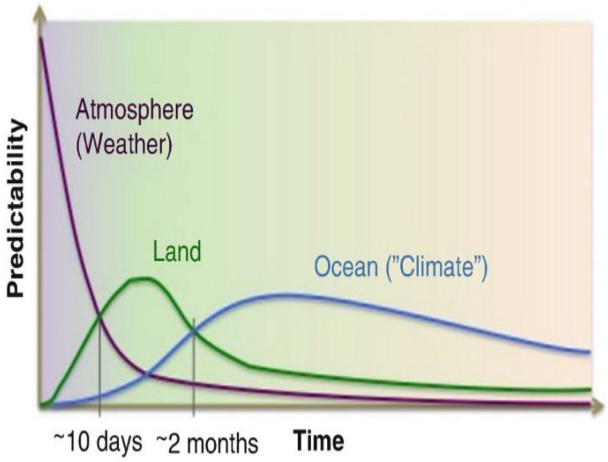
- DevOps CI/CD Jenkins pipelines across NOAA RDHPCS and clouds platforms with containerization approaches
  - Docker and Singularity container images: [https://hub.docker.com/u/noaaepic](https://hub.docker.com/u/noaaepic)
  - Spack-stack: a framework for installing software libraries to support NOAA's Unified Forecast System (UFS) applications and the Joint Effort for Data assimilation Integration (JEDI) coupled to several Earth system prediction models (MPAS, NEPTUNE, UM, FV3, GEOS, UFS), [https://github.com/JCSDA/spack-stack](https://github.com/JCSDA/spack-stack)
  - UFS Apps Workflow end-to-end test system for code integration: CMake CTest and analysis baselines, sample DA configurations



# Land Data Assimilation Motivation

- **Gichamo and Draper, Weather and Forecasting, 2022**
- **Operational forecast models increasingly involve with coupled Earth modeling and data assimilation system**
- **Quantification and prediction of land surface state variability:**
  - Critical for initialization of weather and climate forecasts
  - Hydrological community applications include agricultural forecasting, drought and flood risk assessments, etc.
  - Land states can provide predictability in subseasonal-to-seasonal time scale: soil temperature and moisture, snow temperature, etc.
  - Strong influence of land surface flux and moisture partition on the atmospheric boundary layer
  - **Quantification and correction of forecast bias is important prior to analysis**
    - JEDI Unified Forward Operator (UFO) can be applied to compare forecast results against observations: ***H(x) or HofX for model state variables including*** **soil moisture, soil temperature, and snowpack**




Courtesy of Ek and Dirmeyer

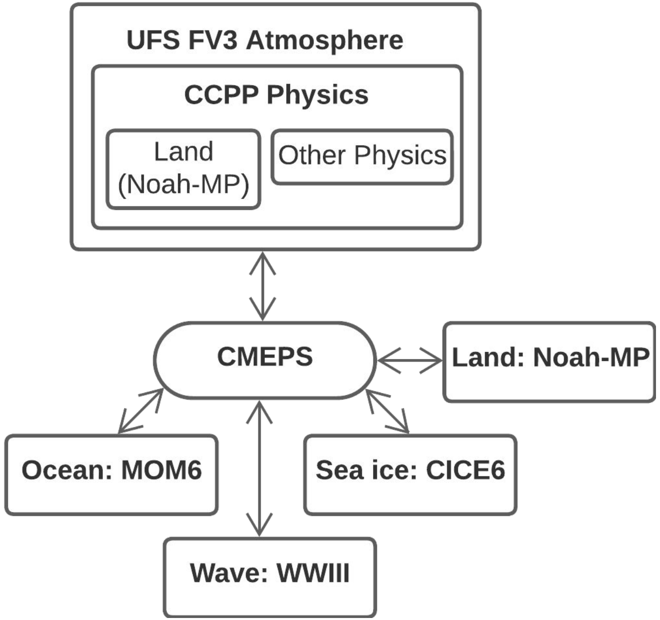
# UFS Weather Model Coupling Options

- **Current coupling options: 11 components for 14 coupling applications**
  - **Noah-MP coupling options: DATM (ERA5 and GWSP3 atmospheric forcings) and FV3-LND**
  - **[https://github.com/ufs-community/ufs-weather-model](https://github.com/ufs-community/ufs-weather-model)**

| UFS Build Configurations | FV3: Atmosphere | ☑ DATM: Aata Atmosphere | MOM6 or HYCOM: Ocean | DOCN: Data Ocean | CICE6: Sea Ice | ☑ WW3: Wave | GOCART: Aerosol | AQM: Air Qaulity | Noah-MP or LM4: Land Component | ☑ Fire Behavior |
|---|---|---|---|---|---|---|---|---|---|---|
| Global S2SWA | ☑ | ☐ | ☑ | ☐ | ☑ | ☑ | ☑ | ☐ | ☐ | ☐ |
| Global S2SW | ☑ | ☐ | ☑ | ☐ | ☑ | ☑ | ☐ | ☐ | ☐ | ☐ |
| Global S2S | ☑ | ☐ | ☑ | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Global or regional ATM | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Global or regional ATMW | ☑ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ |
| Global or regional ATMAERO | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ | ☐ |
| Global or regional ATMAQ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ |
| Global ATMF | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ |
| Global or regional HAFS-ALL | ☑ | ☐ | ☑ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Global or regional HAFS-MOM6W or HAFSW | ☑ | ☐ | ☑ | ☐ | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ |
| Global NG-GODAS | ☐ | ☑ | ☑ | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Global LND | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ |
| Global ATML | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ |

# Noah-MP Component Model: UFS Weather Model

- **Supported Coupling Configurations**
  - **DATM+LND (incl. restart capability)**
    - **Tested with GSWP3 and ERA5 input provided by CDEPS data components**
  - **FV3+LND side-by-side configuration (no feedback from land)**
    - **FV3/CCPP/Noah-MP also runs**
    - **Aims to compare the results coming from component model and CCPP**
  - **FV3+LND fully coupled (incl. restart capability)**
    - **Fully active atmosphere coupled two-way with land component**
    - **Supports also running land component in high resolution**

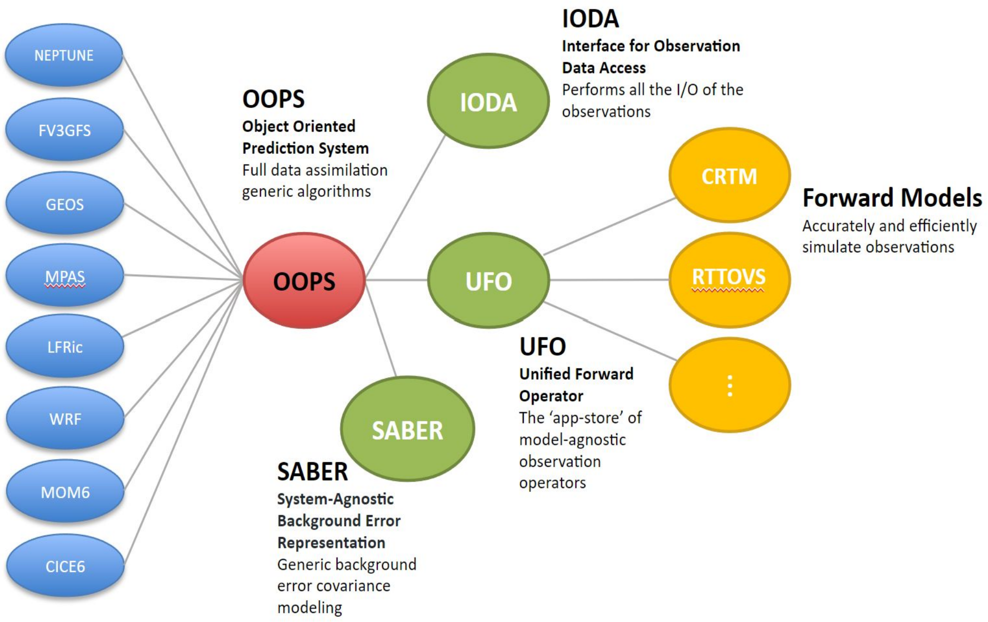


# The Joint Effort for Data assimilation Integration (JEDI)

- Collaborative development led by the Joint Center for Satellite Data Assimilation (JCSDA)
- JEDI provides a software infrastructure for data assimilation software infrastructure
- Key points:
  - Model agnostic, generic and portable from toy models to operational Earth system coupled models
  - Data assimilation on the model native grid
  - No restriction with one specific DA methodology or algorithm
  - Framework for generic observation handling capability and model-independent observation operators
  - Unified observation data process: Interface for Observation Data Access (IODA)
- FV3-JEDI: interfaces between the generic JEDI components and UFS
  - Noah-MP snow data assimilation: file-based pseudo model approach to read the state of a forecast from FV3 restart files

# JEDI Core Components and Application Interfaces

- Oriented Prediction System (OOPS) – the operating system for JEDI. Provides wholly generic algorithms for running data assimilation and forecast models.
- Unified Forward Operator (UFO) – an ‘app-store’ of observation operators.
- Integrated Observation Data Access (IODA) – generic handling of observations.
- System Agnostic Background Error Representation (SABER) – gathering of all the state of the art B matrix methods in a generic fashion.



# JEDI Analysis Yaml Templates and Examples

- JEDI example yamls: 3DVar, LETKF-OI
    - https://github.com/NOAA-EPIC/CADRE-DA-training/tree/main/jedi-yaml-examples
    - JEDI component user's guide: https://jointcenterforsatellitedataassimilation-jedi-docs.readthedocs-hosted.com/en/latest/inside/jedi-components/index.html
    - UFS Weather Model: NOAH-MP Component Model with different coupling and forcing choices
    - Observations: snow depth data to assimilate GHCN, IMS, and SFCSNO with various filters
    - Background Error Covariance Modeling for 3DVar: SABER BUMP NICAS
    - LETKF-OI: a pseudo-ensemble and localization to approximate the error covariance functions used in the OI (Frolov et al, 2022, QJRMS)
    - JEDI JCB snow analysis yaml templates: aligned with the GFS-v17 Land DA features
        - https://github.com/NOAA-EMC/jcb-algorithms
        - https://github.com/NOAA-EMC/jcb-gdas/tree/develop/model/snow
        - https://github.com/NOAA-EMC/jcb-gdas/tree/develop/observations/snow