UFS Land-DA Workflow

-   Day 2: Structure and Features   -

<u>Chan-Hoo Jeon</u>, Gillian Petro, Jong Kim, Eddie Snyder, Kris Booker

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

NOAA Earth Prediction Innovation Center (NOAA/EPIC)

Outline

- Components of land-DA workflow

- Structure of land-DA workflow

- Tasks of land-DA workflow

- Workflow manager: Rocoto

- Configuration of land-DA workflow

- Log files

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Key Components of Land-DA Workflow

- **Land**: UFS (**U**nified **F**orecast **S**ystem) Weather Model
  - Coupled model: atmosphere (FV3+CCPP), ocean (MOM6/HYCOM), ice (CICE), land (**Noah-MP**), air quality (CMAQ), atmospheric data (DATM), wave (WaveWatch III)
  - Coupling options available in UFS land-DA workflow:
    - Option 1 (APP=**LND**): land (Noah-MP) + atmospheric data (DATM)
    - Option 2 (APP=**ATML**): land (Noah-MP) + atmosphere (FV3+CCPP)

- **DA**: JCSDA JEDI (**J**oint **E**ffort for **D**ata-assimilation **I**ntegration)
  - **External** component: built separately with JEDI-bundle for efficiency (**not** included in workflow repo.)
  - Algorithms: 3D-Var, LETKF (Local Ensemble Transform Kalman Filter)
  - Snow observation data options: GHCN, IMS, SFCSNO

- **Workflow**: Pre-processing / Post-processing Tools
  - JCB (JEDI Configuration Builder), tile2tile_converter, IODA converting scripts, and python scripts

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Github Repository of UFS Land-DA Workflow

URL of authoritative GitHub repository

Develop branch

(hidden) CI/CD test: Jenkins nightly ctest

Documentation

Static data (fix) files

J-job scripts

Machine-specific module (library) files

Parameter / template / configuration files

Main script for each task

Submodule components and build scripts

Utility scripts

Version files

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Executables (submodules) of Workflow

- The Git submodules point to the specific commits of other external repositories.

Note that the JEDI components are not included in the repository.

Workflow Tasks

- Tasks of UFS land-DA workflow:

Task name	Description	Application
JCB	Generate JEDI configuration YAML file	LND / ATML
PREP_DATA	Prepare observation / DATM forcing data files	LND / ATML
PRE_ANAL	Create surface data files from restart files	LND
ANALYSIS	Run JEDI and add increment to surface data files	LND / ATML
POST_ANAL	Create restart files for warm-start from surface data and restart files	LND / ATML
FORECAST	Run forecast model	LND / ATML
PLOT_STATS	Plot results of ANALYSIS and FORECAST	LND / ATML
FCST_IC	Generate initial condition (IC) files only for APP = ATML & cold-start	ATML

Task: JCB (JEDI Configuration Builder)

- Generates a JEDI input configuration YAML file.
- Components
  - **JCB**: python package
  - **JCB-algorithms**: collection of JEDI DA algorithms
    - 3dvar (for 3D-Var)
    - letkf (for LETKF)
    - etc.
  - **JCB-gdas**: items for each analysis
    - Snow
    - Marine
    - Atmosphere
- In the UFS land-DA workflow, two JEDI algorithms of '3dvar' and 'letkf' are available only for snow analysis.

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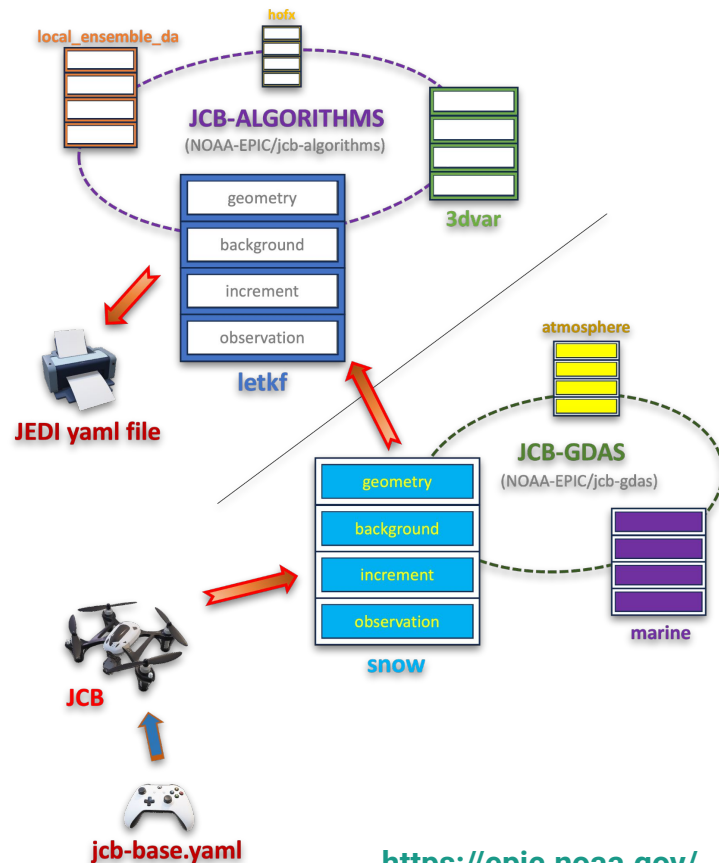
DATM Forcing Data / Snow Observation Data in 'PREP_DATA'

- DATM forcing data in case of APP=**LND** (for UFS weather model):

  - **ERA5** (**E**CMWF **R**e-**A**nalysis v**5**): can be downloaded from Climate Data Store (CDS).
    (European Centre for Medium-range Weather Forecasts)

  - **GSWP3** (**G**lobal **S**oil **W**etness **P**roject phase **3**): Available only for 1901-2010.

- Snow observation data (for JEDI; available in **JCB**):

  - **GHCN** (**G**lobal **H**istorical **C**limatology **N**etwork)

  - **IMS** (**I**nteractive **M**ultisensor **S**now and **I**ce **M**apping **S**ystem)

  - **SFCSNO** (Global Telecommunication System data)

- Will be discussed in detail on Day 3 (pre/post-processing)

Flow of Data/Restart Files by Workflow Tasks

- The surface data ('sfc_data') and restart files play an important role in running both the UFS weather model and JEDI over cycles.
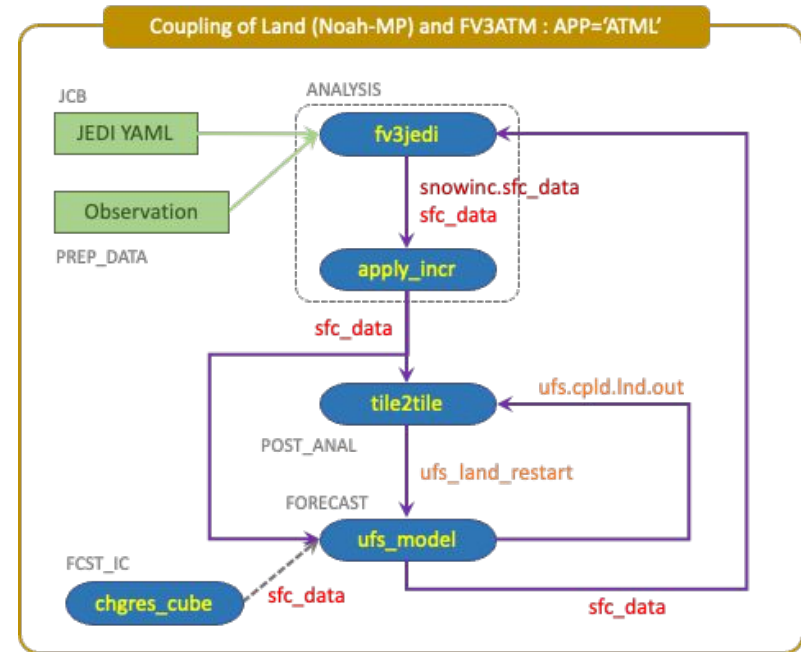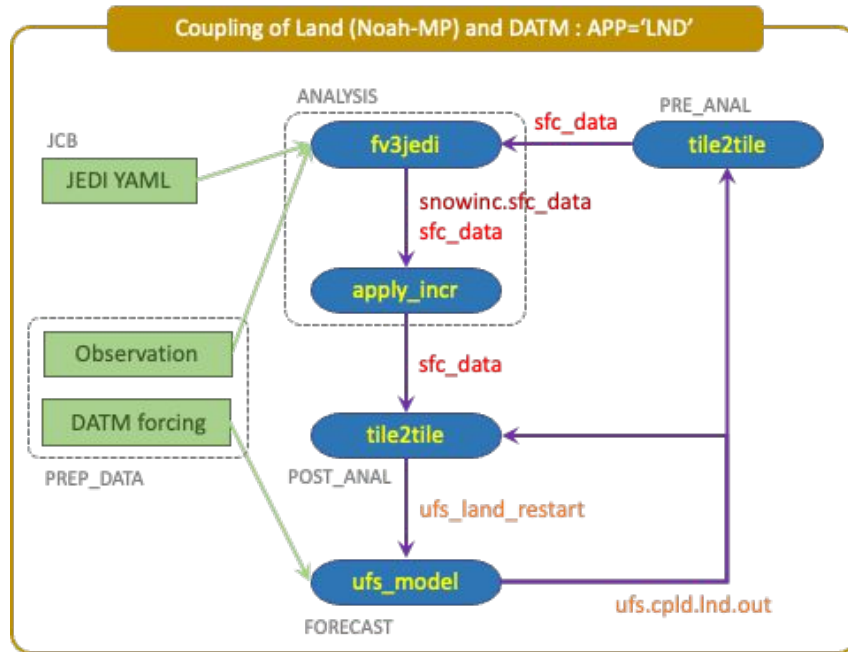
Note that the workflow manager 'Rocoto' will manage all tasks automatically.

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Workflow Manager: Rocoto

- Rocoto is a workflow management tool developed by NOAA/GSL.

- The workflow environment variables, tasks, and their dependencies are defined in the Rocoto XML file 'land_analysis.xml'.

- Rocoto submits the workflow tasks when their dependencies are satisfied ('rocotorun') and tracks the progress of the workflow tasks ('rocotostat').

- The order of the workflow tasks can be determined by the task and file (data) dependencies of each task.

- The YAML template of the Rocoto XML file is in the 'parm/templates' directory.

- If the 'cron' is available, the Rocoto submission can be automated.

Rocoto XML File: Configuration

- Configuration YAML file 'land_analysis.yaml' for Rocoto XML file:

Task name

Group name

Group name

```
workflow:
  attrs:
    realtime: false
    scheduler: slurm
    cyclethrottle: 24
    taskthrottle: 24
  cycledef:
    - attrs:
        group: cycled
      spec: 202501190000 202501200000 24:00:00
    - attrs:
        group: first_cycle
      spec: 202501190000 202501190000 24:00:00
    - attrs:
        group: cycled_from_second
      spec: 202501200000 202501200000 24:00:00
  entities:
    ACCOUNT: "epic"
    APP: "LND"
    ATM_IO_LAYOUT_X: "1"
    ATM_IO_LAYOUT_Y: "1"
```

```
    NPZ: "127"
    nnodes_forecast: "1"
    nprocs_forecast: "26"
    nprocs_forecast_atm: "12"
    nprocs_forecast_lnd: "12"
    nprocs_per_node: "26"
    OBSDIR: ""
    OBS_GHCN_SNOW: "NO"
    OBS_IMS_SNOW:  "YES"
    OBS_SFCSNO: "YES"
```

```
tasks:
  task_jcb:
    attrs:
      cycledefs: cycled
      maxtries: 2
    envars:
      ACCOUNT: "&ACCOUNT;"
      COMROOT: "&COMROOT;"
      cyc: "&cyc;"
      DATAROOT: "&DATAROOT;"
      DATE_CYCLE_FREQ_HR: "&DATE_CYCLE_FREQ_HR;"
      FRAC_GRID: "&FRAC_GRID;"
      HOMElandda: "&HOMElandda;"
      JEDI_ALGORITHM: "&JEDI_ALGORITHM;"
      KEEPDATA: "&KEEPDATA;"
      MACHINE: "&MACHINE;"
      model_ver: "&model_ver;"
      NPZ: "&NPZ;"
      OBS_GHCN_SNOW: "&OBS_GHCN_SNOW;"
      OBS_IMS_SNOW: "&OBS_IMS_SNOW;"
      OBS_SFCSNO: "&OBS_SFCSNO;"
      PDY: "&PDY;"
```

Environment parameters used in this task.

All environment parameters used in the workflow tasks must be defined in the 'entities' group

- The Rocoto XML file is generated from the Rocoto configuration YAML file by the python package 'uwtools'.

- The configuration YAML file is generated from the workflow configuration file by the setup script.

Configuration of Workflow

- The XML file of the workflow manager 'Rocoto' can be generated by the setup python script 'setup_wflow_env.py' in 'land-DA_workflow/parm'.

- All parameters, which are necessary for the Rocoto XML file and workflow scripts, are defined in this setup script with the default values.

- These default values are replaced with those specified in the configuration file 'config.yaml'. This means that users do not have to modify the setup script for their experiments. They can add any parameters they want to change to the 'config.yaml' file.

- This setup script finally generates a Rocoto XML file by the python package 'uwtools' within a new experimental case directory.

```
setup_wflow_env.py
  ┌─────────────────────┐
  │   detect_platform   │
  └─────────────────────┘
  ┌─────────────────────┐
  │  set_default_parm   │
  └─────────────────────┘
  ┌─────────────────────┐
  │  set_machine_parm   │
  └─────────────────────┘
  ┌─────────────────────┐      config.yaml
  │ Update parameter    │ ◄┄┄┄
  │ values              │
  └─────────────────────┘
  ┌─────────────────────┐
  │ Calculate some      │
  │ parameter values    │
  └─────────────────────┘
  ┌─────────────────────────────┐
  │ template.land_analysis.yaml │
  └─────────────────────────────┘
            yaml
  ┌─────────────────────────────┐
  │   land_analysis.yaml        │
  └─────────────────────────────┘
            uwtools
  ┌─────────────────────────────┐
  │   land_analysis.xml         │
  └─────────────────────────────┘
  ┌─────────────────────────────┐
  │ Set up experimental case    │
  │ directory                   │
  └─────────────────────────────┘
```
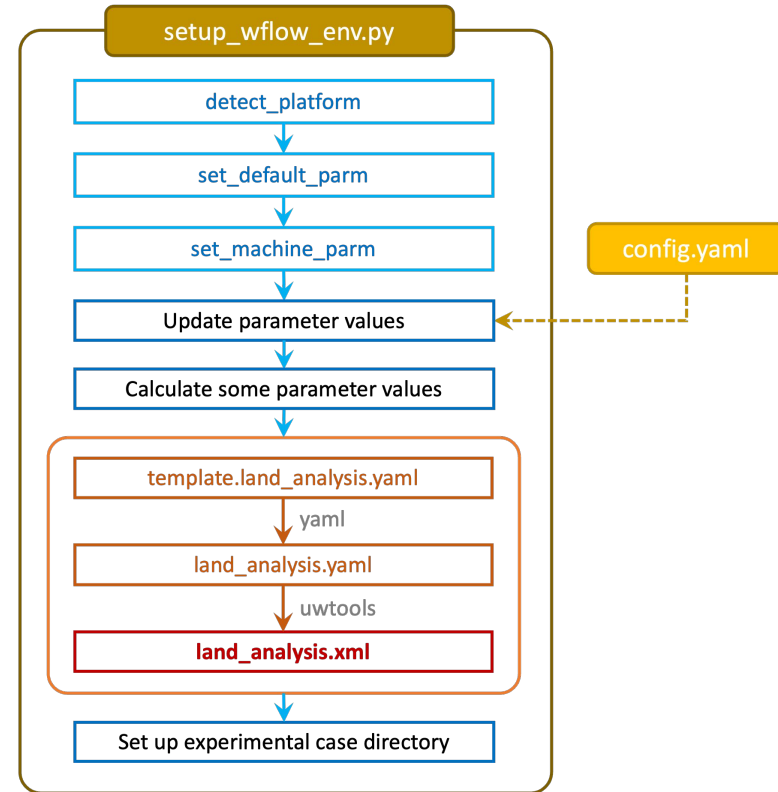
Configuration Script 'config.yaml'

HPC project account name →

DATM forcing data option: era5 / gswp3 →

Cycle frequency in hours →

Forecast length in hours for each cycle →

Parameters of land model (Noah-MP) in UFS weather model →

Flag for GHCN observation: 'YES' / 'NO' →

Flag for SFCSNO observation: 'YES' / 'NO' →

```
ACCOUNT: epic
APP: LND
ATMOS_FORC: era5
COLDSTART: 'NO'
COUPLER_CALENDAR: 2
DATE_CYCLE_FREQ_HR: 24
DATE_FIRST_CYCLE: 2025011900
DATE_LAST_CYCLE: 2025012500
DT_ATMOS: 900
DT_RUNSEQ: 3600
envir: test_cadre1
EXP_CASE_NAME: cadre1_lnd_era5_ims
FCSTHR: 24
JEDI_ALGORITHM: 3dvar
LND_CALC_SNET: .true.
LND_IC_TYPE: custom
LND_INITIAL_ALBEDO: 0.25
LND_LAYOUT_X: 1
LND_LAYOUT_Y: 2
LND_OUTPUT_FREQ_SEC: 21600
MED_COUPLING_MODE: ufs.nfrac.aoflux
model_ver: v2.1.0
net: landda
NPROCS_ANALYSIS: 6
NPZ: 127
OBS_GHCN_SNOW: 'NO'
OBS_IMS_SNOW: 'YES'
OBS_SFCSNO: 'YES'
RES: 96
RUN: landda
WE2E_TEST: 'NO'
```

← Application: LND / ATML

← Flag for cold-start: 'YES' / 'NO'

← First date of cycles

← Last date of cycles

Experimental case name

← JEDI algorithm: 3dvar / letkf

Number of vertical layers (+1) in forecast (UFS weather model)

← Flag for IMS observation: 'YES' / 'NO'

Grid resolution per tile (C96=1 degree≈100km)

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Sample Configurations

- Sample configuration files for CADRE DA-training:
  - land-DA_workflow/parm/config_samples/samples_cadre/

| Filename prefix	App	DATM forcing	JEDI algorithm	Observation	Cold/Warm start	Number of cycles	Note
cadre0	LND	ERA5	LETKF	GHCN	Cold start	2	To prepare restart files for CADRE1
cadre1	**LND**	**ERA5**	**3D-Var**	**IMS + SFCSNO**	**Warm start**	**7**	**Benchmark case (01/19/25-01/25/25)**
cadre2	**LND**	**GSWP3**	**LETKF**	**GHCN**	**Warm start**	**2**	**Another forcing and observation options**
cadre3	**ATML**	**N/A**	**3D-Var**	**GHCN**	**Cold start**	**2**	**Option 2: Noah-MP + FV3ATM**
cadre4	LND	ERA5	3D-Var	GHCN	Warm start	7	Same as CADRE1 but for **GHCN** stand-alone
cadre5	LND	ERA5	3D-Var	IMS	Warm start	7	Same as CADRE1 but for **IMS** stand-alone

Six Tiles in Input / Output

- Some input / output files such as 'sfc_data' and 'restart' files have six tiles. This is because the FV3 dynamical core of the UFS weather model uses the cubed-sphere grid that represents the globe with six tiles.
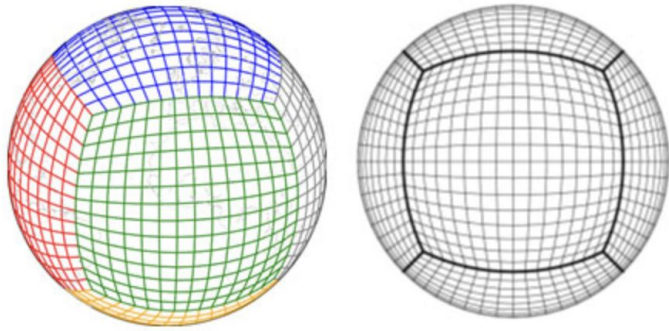
Cubed-sphere grid of FV3 (NOAA/GFDL)

(gfdl.noaa.gov/fv3/fv3-grids/)
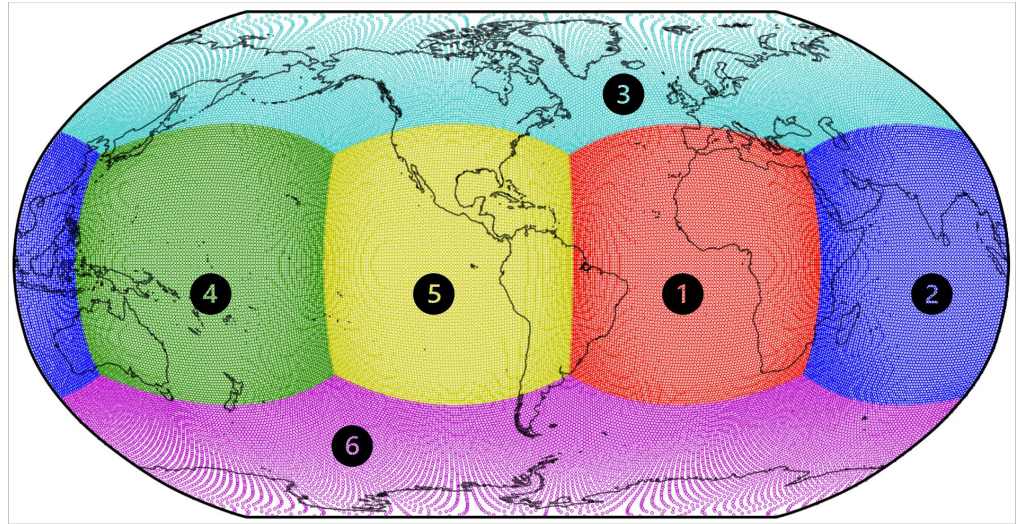
How to Check Log Files

- The log files of the workflow tasks can be found in 'com/output/logs/'.

- Some log files generated by executables are in the work directory of each workflow task under the 'tmp' directory:

ptmp/{envir}/com

task name   cycle date   job id (queue number)

```
[Chan-hoo.Jeon@hfe10 tmp_dir]$ ls
analysis.2000020200.10255800    forecast.2000020200.10256023    jcb.2000020300.10255309
analysis.2000020300.10256549    forecast.2000020300.10256983    plot_stats.2000020200.10256289
DATA_SHARE                      jcb.2000020200.10255306         plot_stats.2000020300.10257011
```

- For users' convenience, the symbolic links to the above log/work directories are provided in the experimental case directory:

experimental case directory

symlink to LOG directory

```
[Chan-hoo.Jeon@hfe10 cadre1_lnd_era5_ims]$ ls
com_dir                land_analysis_lock.db    land_analysis.yaml        log_dir            log.rocoto_run
land_analysis.db    land_analysis.xml        launch_rocoto_wflow.sh    log.rocoto_launch    tmp_dir
```

symlink to COM (input/output) directory

symlink to WORK directory

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Status of Workflow Tasks

- APP='**LND**'; warm-start   'rocotostat' / log.rocoto_launch

CYCLE	TASK	JOBID	STATE	EXIT STATUS	TRIES	DURATION
202501190000	jcb	10256999	SUCCEEDED	0	1	11.0
202501190000	prep_data	10256998	SUCCEEDED	0	1	66.0
202501190000	pre_anal	10257000	SUCCEEDED	0	1	13.0
202501190000	analysis	10257028	SUCCEEDED	0	1	150.0
202501190000	post_anal	10257121	SUCCEEDED	0	1	10.0
202501190000	forecast	10257199	SUCCEEDED	0	1	106.0
202501190000	plot_stats	10257229	SUCCEEDED	0	1	90.0
202501200000	jcb	10257001	SUCCEEDED	0	1	11.0
202501200000	prep_data	10257226	SUCCEEDED	0	1	35.0
202501200000	pre_anal	10257222	SUCCEEDED	0	1	6.0
202501200000	analysis	10257408	SUCCEEDED	0	1	105.0
202501200000	post_anal	10257507	SUCCEEDED	0	1	9.0
202501200000	forecast	10257523	SUCCEEDED	0	1	104.0
202501200000	plot_stats	10257686	SUCCEEDED	0	1	83.0

- APP='**ATML**'; cold-start

CYCLE	TASK	JOBID	STATE	EXIT STATUS	TRIES	DURATION
202212210000	prep_data	10263602	SUCCEEDED	0	1	15.0
202212210000	fcst_ic	10263603	SUCCEEDED	0	1	110.0
202212210000	forecast	10263819	SUCCEEDED	0	1	561.0
202212220000	jcb	10263604	SUCCEEDED	0	1	10.0
202212220000	prep_data	10263605	SUCCEEDED	0	1	307.0
202212220000	analysis	10264158	SUCCEEDED	0	1	139.0
202212220000	post_anal	10264305	SUCCEEDED	0	1	9.0
202212220000	forecast	10264306	SUCCEEDED	0	1	558.0
202212220000	plot_stats	10264610	SUCCEEDED	0	1	70.0

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UFS Land-DA Workflow

- Day 2: Interactive Session with Sample Cases -

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