Demystifying NCEP’s Global-Workflow

Rahul Mahajan
On Behalf of the Contributors of the Global-Workflow Project
July 25, 2023
<table>
<thead>
<tr>
<th>Regional Hurricane 1</th>
<th>HWRF v13.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Hurricane 2</td>
<td>HMON v3.2</td>
</tr>
<tr>
<td>Regional High Resolution CAM 1</td>
<td>HiRes Window v8.1</td>
</tr>
<tr>
<td>Regional High Resolution CAM 2</td>
<td>NAM nests / Fire Wx v4</td>
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<tr>
<td>Regional High Resolution CAM 3</td>
<td>HRRR v4.1</td>
</tr>
<tr>
<td>Regional HiRes CAM Ensemble</td>
<td>HREF v3.1</td>
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<tr>
<td>Regional Air Quality</td>
<td>AQM v6.1</td>
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<tr>
<td>Regional Surface Weather Analysis</td>
<td>RTMA / URMA v2.10</td>
</tr>
<tr>
<td>Atmospheric Transport &amp; Dispersion</td>
<td>HySPLIT v8.0</td>
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<tr>
<td>Coastal &amp; Regional Waves</td>
<td>NWPS v1.4</td>
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<tr>
<td>Great Lakes</td>
<td>GLWU v2.0</td>
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<tr>
<td>Regional Hydrology</td>
<td>NWM v2.1</td>
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<tr>
<td>Space Weather 1 - WAM / IPE</td>
<td>WFS v1.0</td>
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<td>Space Weather 2</td>
<td>ENLIL v1</td>
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<tr>
<td>EMC Verification System</td>
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</tbody>
</table>

**Co coupled Reanalysis & Seasonal Reforecast**

<table>
<thead>
<tr>
<th>GFS v17/ GDAS v17/ GEFS v13/ GODAS v3</th>
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<tbody>
<tr>
<td>RRFS v1</td>
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<tr>
<td>RRFS v2/ WoFS v1</td>
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**Short-Range Regional & Regional Atmospheric Composition**

<table>
<thead>
<tr>
<th>HAFS v1</th>
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<tbody>
<tr>
<td>HAFS v2</td>
</tr>
<tr>
<td>HAFS v3</td>
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<tr>
<td>HAFS v4</td>
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</table>

**Regional Weather (Parent Domain)**

<table>
<thead>
<tr>
<th>NAM v4.2</th>
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<tr>
<td>RAP v5.1</td>
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</table>

**Global Weather & Wave Ensembles, Aerosols**

<table>
<thead>
<tr>
<th>GEFS v12.3</th>
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<tbody>
<tr>
<td>GODAS v2</td>
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</tbody>
</table>

**Global Ocean Analysis**

| GODAS v2 |

**Short-Range Regional Ensembles**

| SREF v7.1 |

**Seasonal Climate**

| CDAS2 v1.2 / CFS v2.3 |

**Global Ocean & Sea-ice**

**Regional Surface Weather Analysis**

| RTMA / URMA v2.10 |

**Atmospheric Transport & Dispersion**

<table>
<thead>
<tr>
<th>HySPLIT v8.0</th>
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<tbody>
<tr>
<td>HySPLIT v9</td>
</tr>
<tr>
<td>HySPLIT v10</td>
</tr>
</tbody>
</table>

**Coastal & Regional Waves**

| NWPS v1.4 |

**Great Lakes**

| GLWU v2.0 |

**Regional Hydrology**

| NWM v2.1 |

**Space Weather 1 - WAM / IPE**

| WFS v1.0 |

**Space Weather 2**

| ENLIL v1 |

**EMC Verification System**

| – |

**Verification**

| EVS v1 |
| EVS v2 |
| EVS v3 |

**Seasonal**

**Medium Range & Subseasonal**

**Marine & Cryosphere**

**Space Weather**

**Verification**
Global-Workflow

- Global-Workflow is a **system of components and scripts** to operate the process for applications **from end to end**
- “Fully” automated with minimal user intervention for execution
- Must ensure each step runs at the correct time and data is passed between them properly
Global Workflow Superstructure w/ Components

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>External repositories</td>
<td>10+</td>
</tr>
<tr>
<td>Executables built</td>
<td>53</td>
</tr>
<tr>
<td>Scripts</td>
<td>369+</td>
</tr>
<tr>
<td>Jobs</td>
<td>67+</td>
</tr>
</tbody>
</table>
Procedure

- **sorc/**
  - ```checkout.sh```
  - ```build_all.sh```
  - ```link_workflow.sh```

- **workflow/**
  - ```setup_expt.py```
  - ```setup_xml.py```
  - **exptX/**
    - ```customize experiment```
    - ```rocotorun```

- **exptX/**
  - global-workflow
  - experiment dir
Portability

- WCOSS2 – NWS Operational SuperComputer
- NOAA RDHPCS
  - Hera
  - Orion, Hercules (coming soon)
  - Jet*
- NOAA ParallelWorks AWS (forecast-only)
- UWisc. SSEC S4*

* support from Dave Huber; pre-EPIC
Operability

- **Applications**: GFS and GEFS (SFS coming soon)
- **Supported modes**: Forecast-only and cycled (reanalysis and reforecast capabilities will be added as part of SFS development)
- **Model development**: ATM[AW], S2S[WA]
- **DA development**: Component DA and WCDA:
  - Atmosphere
    - GSI-based [3DVar, Hybrid 3D/4D EnVar]
    - JEDI-based; fv3-jedi [3DVar, EnKF]
  - Aerosols
    - JEDI-based; fv3-jedi [3DVar]
  - Ocean and Ice
    - JEDI-based; soca [3DFGAT, 3DEnVar]
  - Land Assimilation
    - JEDI-based; fv3-jedi [LETKFOI]
Modularity

- Ability to **run any component** of the workflow as a **standalone** job
  - Observation pre-processing
  - Post-processing, product generation
- **Machine-specific abstraction** to a single directory (env/) to enable portability of the workflow
- Affords flexibility to create **combinations of DA and components** for WCDA applications
- Inline and offline product generation
- Inline and offline verification and validation
- Turns OFF operational and downstream product generation for development parallels
- **Refactoring** of older tasks and addition of new tasks follow:
  - Hierarchical design based on **OOP**
  - Break down of tasks into sub-tasks for **efficient use of resources**
  - Uses repeatable functions from **wxflow** - a repository of tools for weather workflows
Testing

- **Unit testing** with pytests for python scripts
- Workflow **end-to-end tests:**
  - C48 S2S forecast-only
  - C48 atmosphere forecast-only
  - C96/C48 cycled DA
- Job-by-job testing development in progress

- Using **Github Actions** and self-hosted **Github Runners**
- Linters for shell and python scripts
- **Automated Testing** on Hera and Orion with every PR

[Support coupled GEFS forecast, use mem000 for GEFS control]

#1755 opened 3 days ago by WalterKolczynski-NOAA • Approved 5 of 8 tasks

globalworkflow-ci.yaml

<table>
<thead>
<tr>
<th>Matrix: create-experiments</th>
<th>Matrix: run-experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>checkout-build-link 29m 46s</td>
<td>run-experiments (C4... 39m 58s</td>
</tr>
<tr>
<td>create-experiments (C4... 4s</td>
<td>run-experiments (C96... 2h 14m</td>
</tr>
<tr>
<td>create-experiments (C96... 9s</td>
<td>clean-up 19s</td>
</tr>
</tbody>
</table>
Testing - Code Coverage

Coverage [Branch Context: feature/tests]

Coverage on branch: 68.92%

80 Days Trend: +68.92%

YAML Configuration
Learn more about PR comment, target and flags

Hide Chart

Department of Commerce // National Oceanic and Atmospheric Administration // National Weather Service

UIFCW // July 24-28, 2023 // Boulder, CO
Global Workflow

Global-workflow is the end-to-end workflow designed to run global configurations of medium range weather forecasting for the UFS weather model. It supports both development and operational implementations. In its current format it supports the Global Forecast System (GFS) and the Global Ensemble Forecast System (GEFS) configurations.

wxflow

wxflow is a Python library of common tools used in weather workflows. It is designed to be used in NWP applications such as GFS, GEFS, and RRFS workflows. Some of the tools included in wxflow are:

- logger: A generic program-wide logging tool.
- yamlttools: A YAML parser that allows loading of nested yaml files and resolves environment variables.
User and Developer Contributions
Ocean DA [Guillaume Vernieres@EMC]

**cp0**: Status as of 07-11-2023. Ocean & sea ice hybrid EnVAR with 30 offline members

Better estimate of the foundation temperature leads to better simulation of radiances sensitive to SST.

AVHRR NOAA-18, channel 3 \(|\text{Obs-Bkg}|\) from GFS

- More obs passed the GSI QC
- Smaller O-B almost everywhere

Data Atmos + SOCA

GSI+JEDI/SOCA 3DVAR

GSI+JEDI/SOCA Hybrid EnVAR

Ocean DA 

Comparison against OSTIA
Sealce DA [Guillaume Vernieres@EMC]

- **Seaice concentration OMB statistics**

**Arctic**: Started from a benchmark SOCA based short reanalysis (~6 months)

**Antarctic**: Significant error reduction in the WCDA system

**Better sea ice extent in the WCDA prototype**

Data Atmos + SOCA

NSIDC
Aerosol Optical Depth (AOD) DA using VIIRS AOD observations

Initial results show NMC estimates reduce standard deviations, while BUMP covariance results in lower mean differences.
Snow DA [Jiarui Dong@EMC, Clara Draper@PSL]

The current way GFS updates land surface states is behind our operational peers, this work (facilitated in part through our transition to JEDI) will help alleviate that!

Snow DA can reduce RMSE of T2m from the model compared to ERA5 (above is difference in RMSE between a control run and with OI snow DA)

Improvement in snow depth from using OI DA (red) vs control (black) with the UFS and JEDI (note at coarse resolution)

See Gichamo and Draper, 2022 (DOI:10.1175/WAF-D-22-0061.1) for details on the OI snow DA
Summary

- global-workflow serves multiple needs for applications that are being developed as part of operational upgrades
- Making a lot of progress towards modernization of the code base as well as keeping the system running towards operational milestones
- Automated testing has helped with ensuring critical applications keep running with every update
- Engagement with the science development teams in developing capabilities of future needs has been beneficial towards planning of core capabilities in the global-workflow
- Much work is needed to make the system more agile, extensible, configurable and portable all the while retaining reproducibility and operational readiness