NATIONAL WEATHER SERVICE

Demystifying NCEP's Global-Workflow

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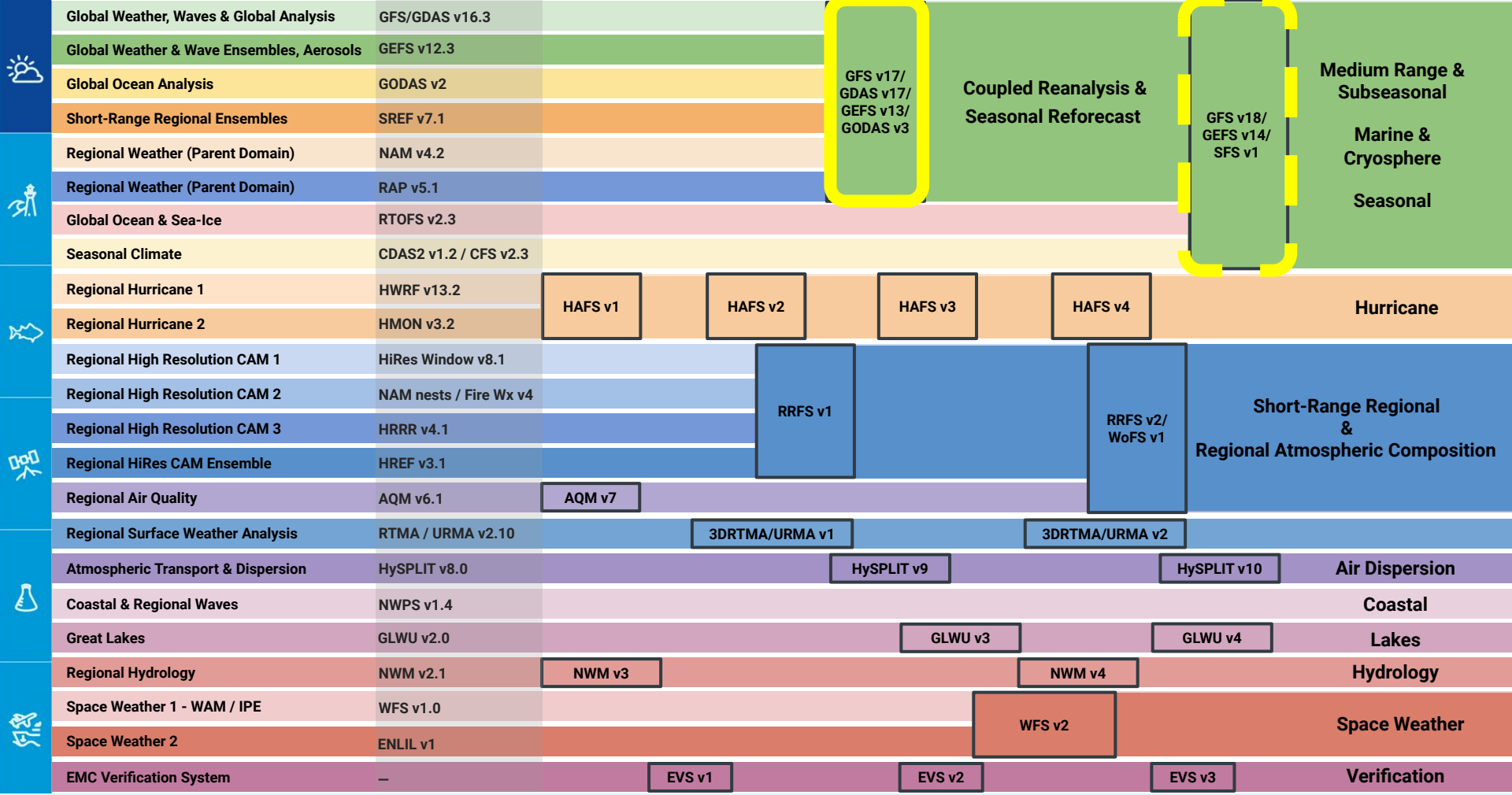
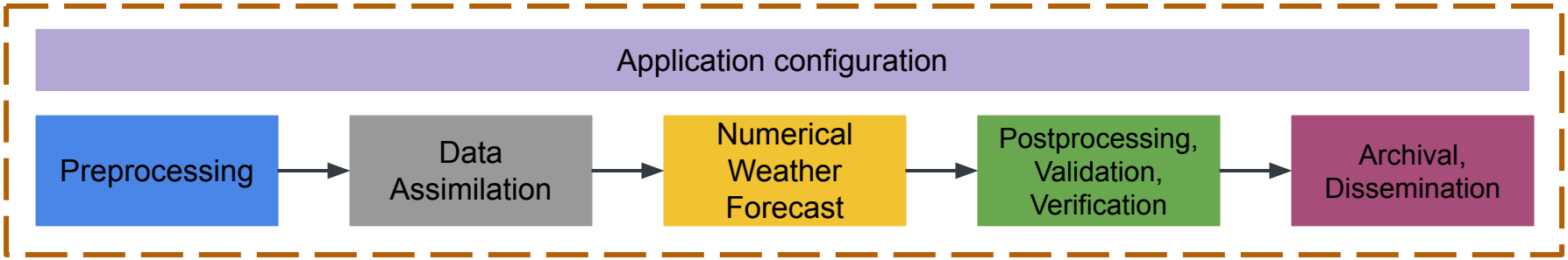
On Behalf of the Contributors of the Global-Workflow Project
July 25, 2023

Unifying Innovations in Forecasting Capabilities Workshop – July 24-28, 2023 – Boulder CO


Global Weather, Waves & Global Analysis
GFS/GDAS v16.3
Global Weather & Wave Ensembles, Aerosols
GEFS v12.3
Global Ocean Analysis
GODAS v2
Short-Range Regional Ensembles
SREF v7.1
Regional Weather (Parent Domain)
NAM v4.2
Regional Weather (Parent Domain)
RAP v5.1
Global Ocean & Sea-Ice
RTOFS v2.3
Seasonal Climate
CDAS2 v1.2 / CFS v2.3
Regional Hurricane 1
HWRF v13.2
Regional Hurricane 2
HMON v3.2
Regional High Resolution CAM 1
HiRes Window v8.1
Regional High Resolution CAM 2
NAM nests / Fire Wx v4
Regional High Resolution CAM 3
HRRR v4.1
Regional HiRes CAM Ensemble
HREF v3.1
Regional Air Quality
AQM v6.1
Regional Surface Weather Analysis
RTMA / URMA v2.10
Atmospheric Transport & Dispersion
HySPLIT v8.0
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
–
GFS v17/ GDAS v17/ GEFS v13/ GODAS v3
Coupled Reanalysis & Seasonal Reforecast
GFS v18/ GEFS v14/ SFS v1
Medium Range & Subseasonal
Marine & Cryosphere
Seasonal
HAFS v1
HAFS v2
HAFS v3
HAFS v4
Hurricane
RRFS v1
RRFS v2/ WoFS v1
Short-Range Regional & Regional Atmospheric Composition
AQM v7
3DRTMA/URMA v1
3DRTMA/URMA v2
HySPLIT v9
HySPLIT v10
Air Dispersion
Coastal
GLWU v3
GLWU v4
Lakes
NWM v3
NWM v4
Hydrology
WFS v2
Space Weather
EVS v1
EVS v2
EVS v3
Verification

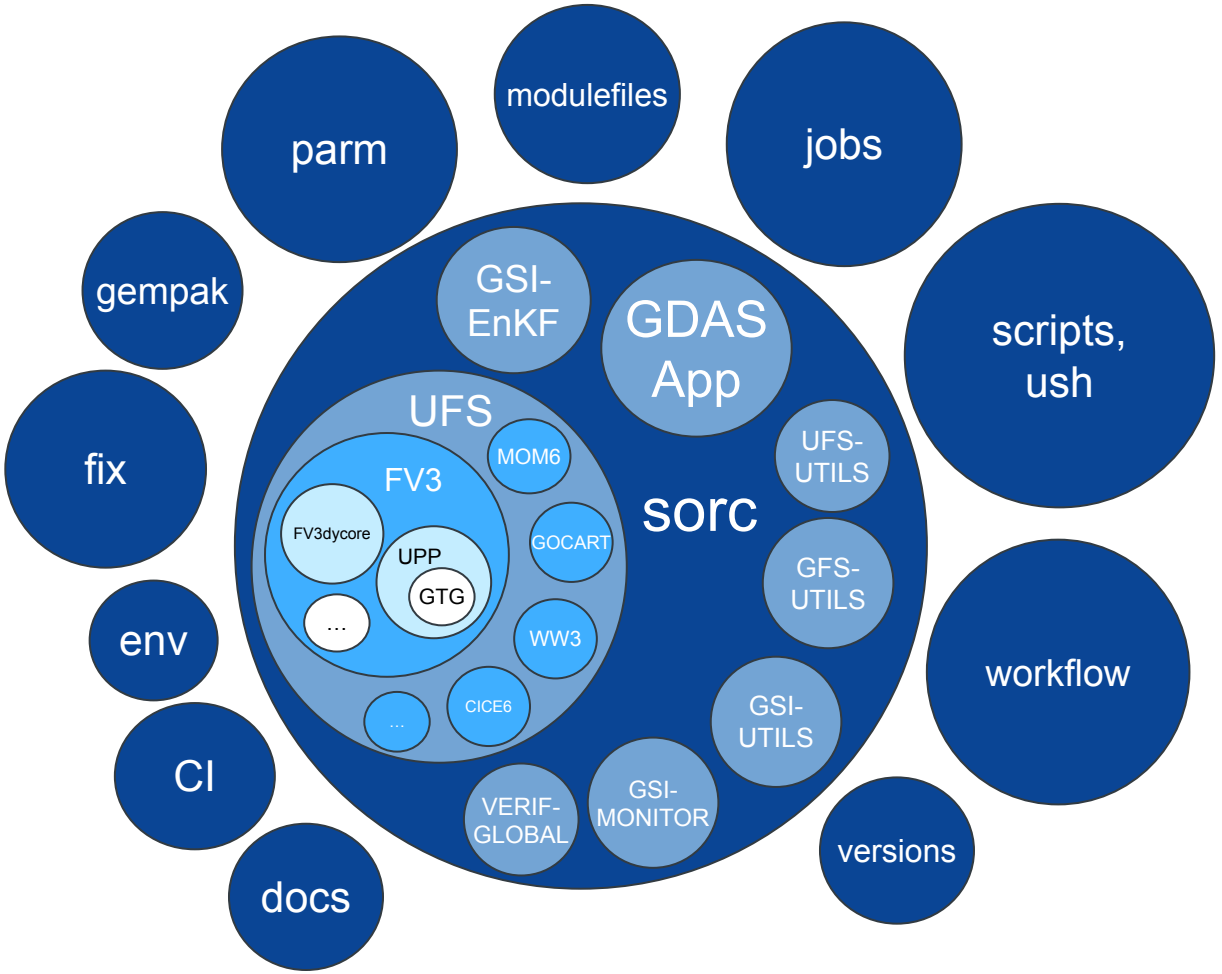
Global-Workflow



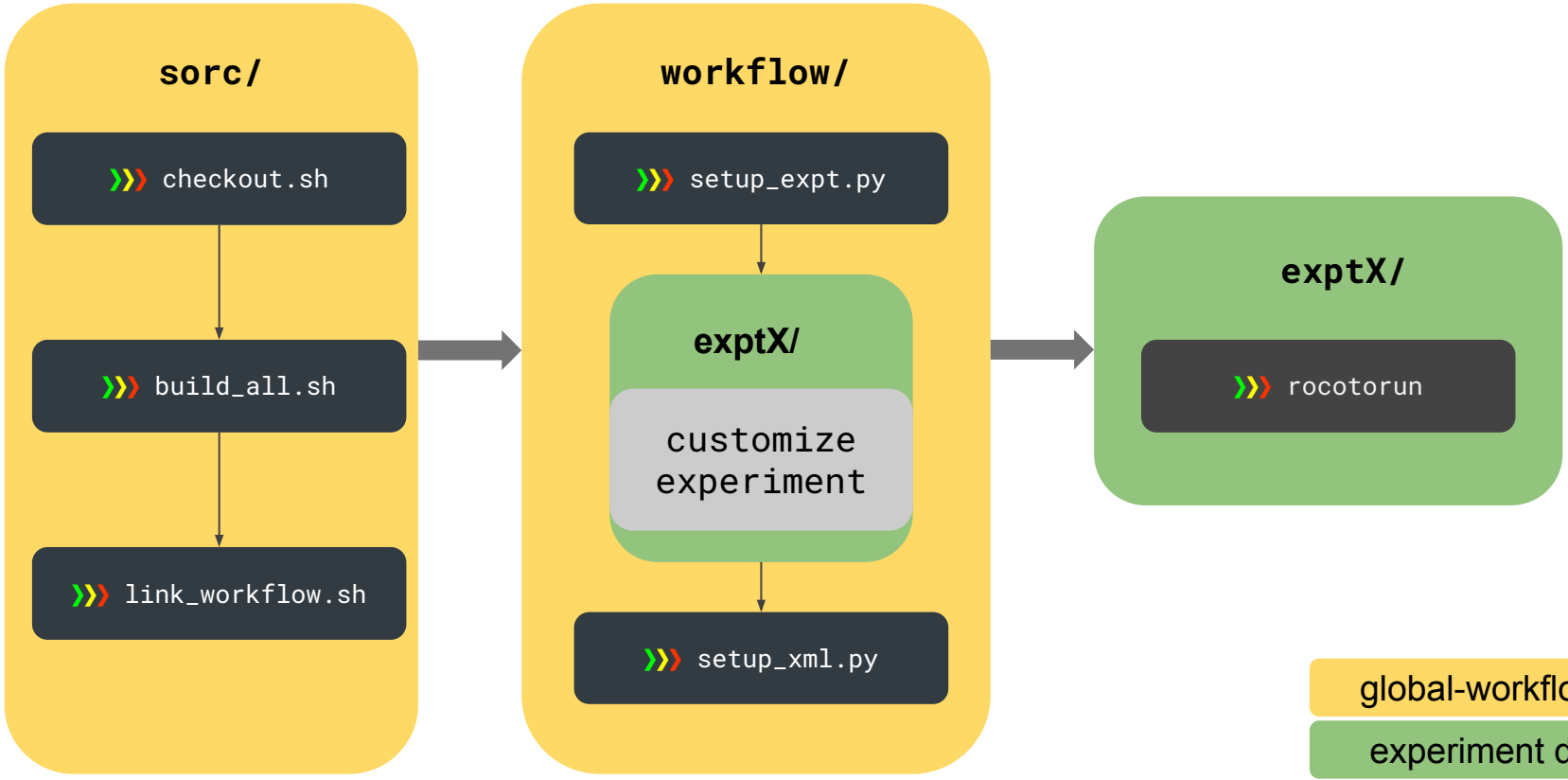
- Global-Workflow is a **system of components and scripts** to operate the process for applications **from end to end**
- “Fully” automated with minimal user intervention for execution
- Must ensure each step runs at the correct time and data is passed between them properly

Global Workflow Superstructure w/ Components

External repositories	10+
Executables built	53 + JEDI
Scripts	369+
Jobs	67+



Procedure


sorc/
checkout.sh
build_all.sh
link_workflow.sh
workflow/
setup_expt.py
exptX/
customize experiment
setup_xml.py
exptX/
rocotorun
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]

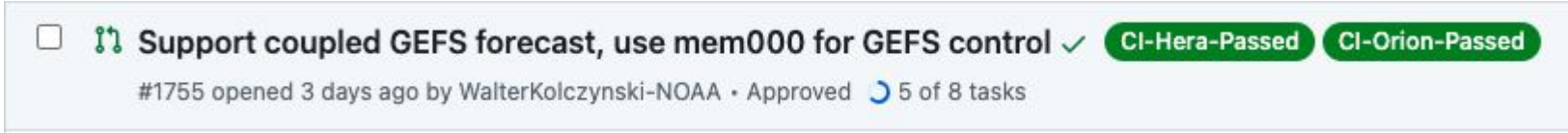
Modularity

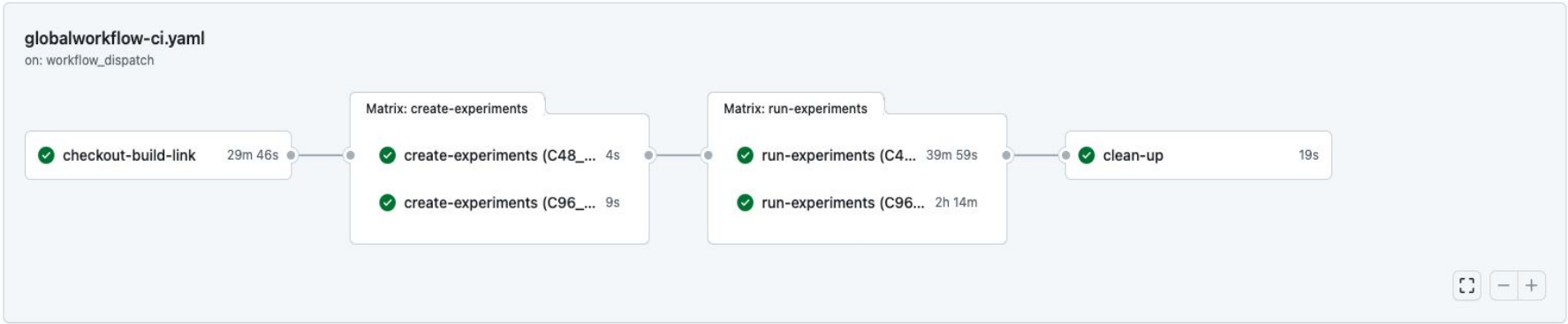
- Ability to **run any component** of the workflow as a **standalone** job
  - Observation pre-processing
  - Post-processing, product generation
- **Machine-specific abstraction** to a single directory (`env/`) to enable portability of the workflow
- Affords flexibility to create **combinations of DA 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**





Testing - Code Coverage

noaa-emc / wxflow / feature/tests

Coverage | Flags | Commits | Pulls

Branch Context

feature/tests

Source: latest commit 548a9a3

Coverage on branch

68.92%

561 of 814 lines covered

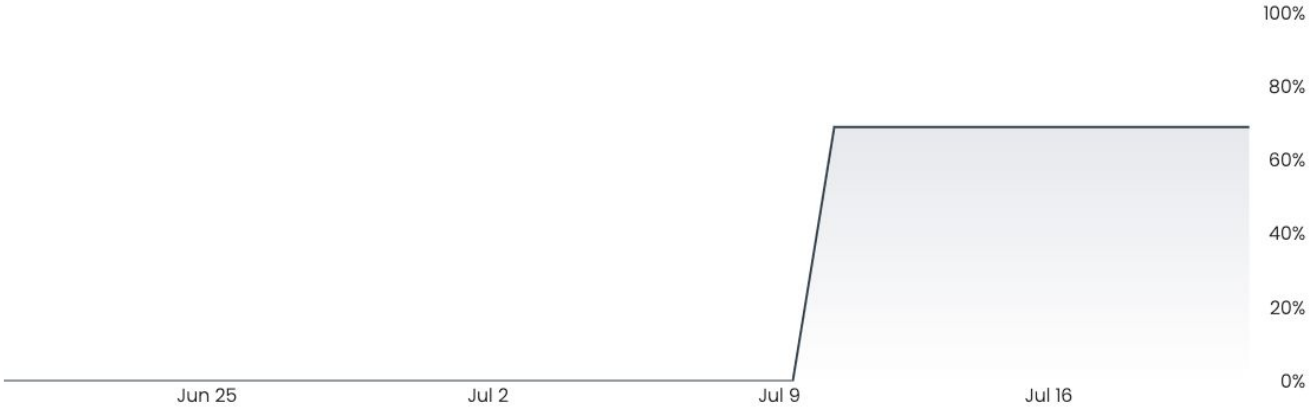
30 Days trend

+68.92%

Yaml Configuration

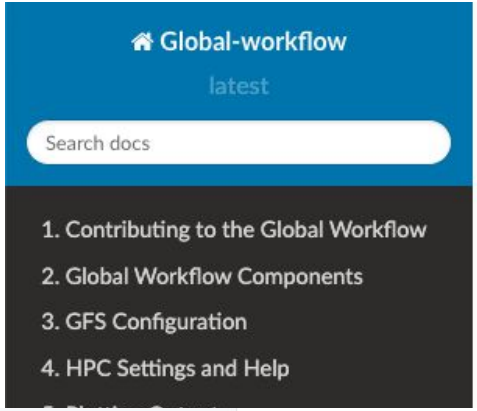
Learn more about PR comment, target and flags

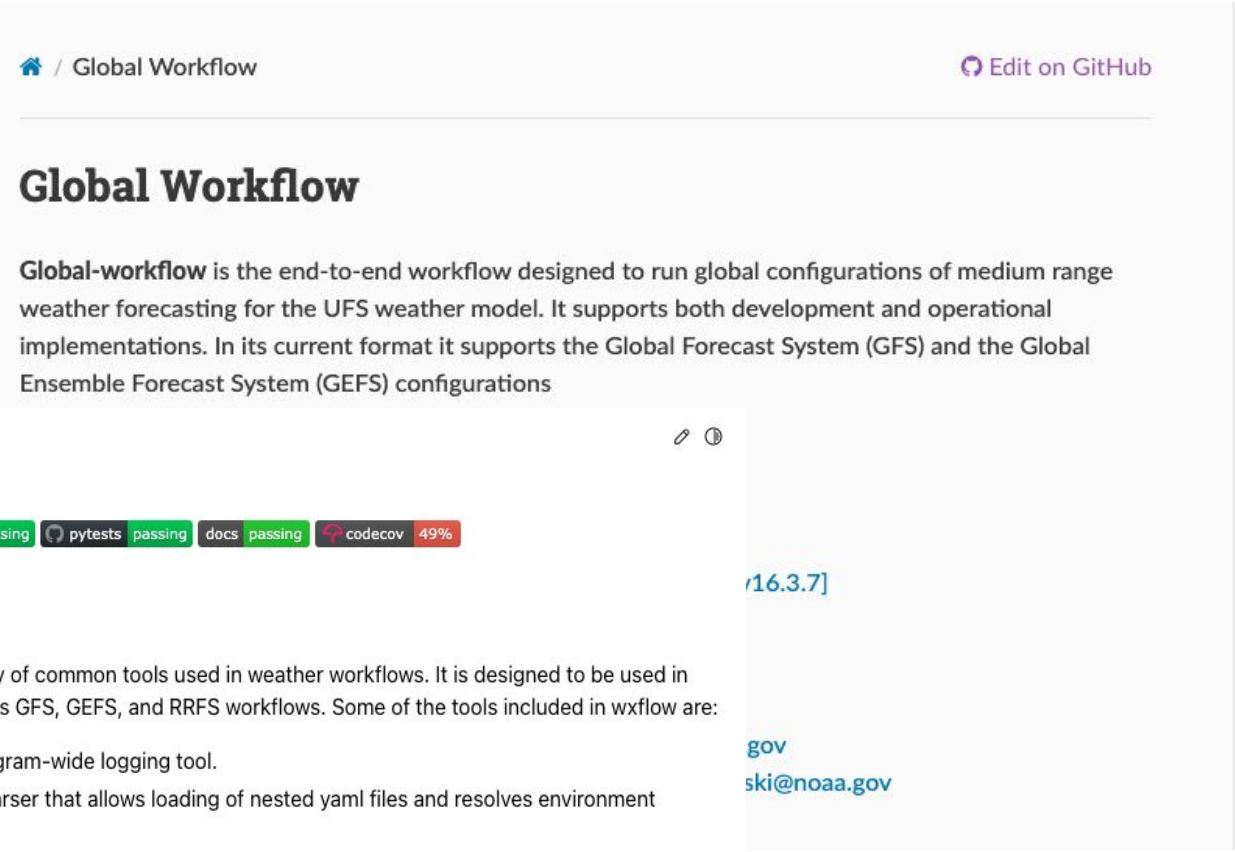
Hide Chart



wxflow / src / wxflow

Documentation

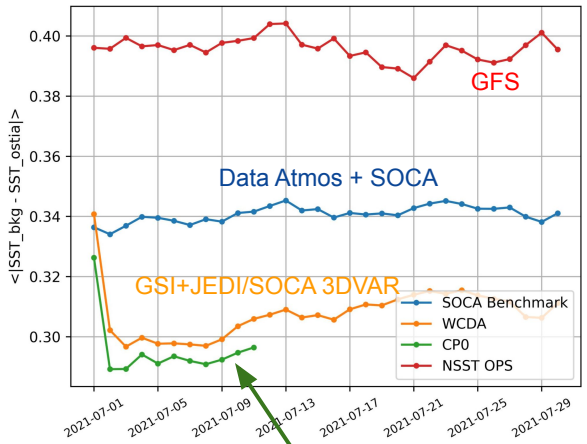




User and Developer Contributions

Ocean DA [Guillaume Vernieres@EMC]

comparison against OSTIA

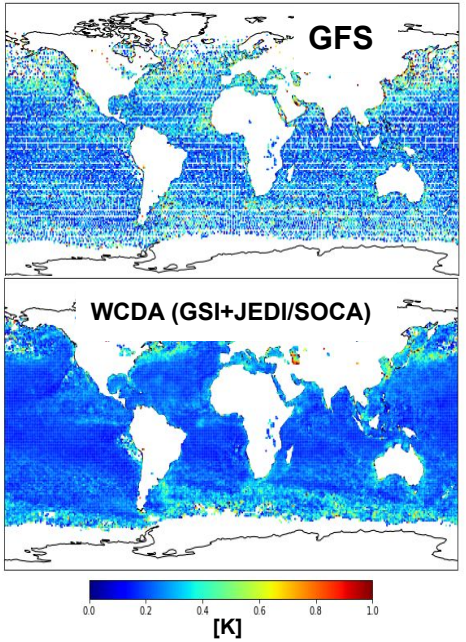


GSI+JEDI/SOCA Hybrid EnVAR

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

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

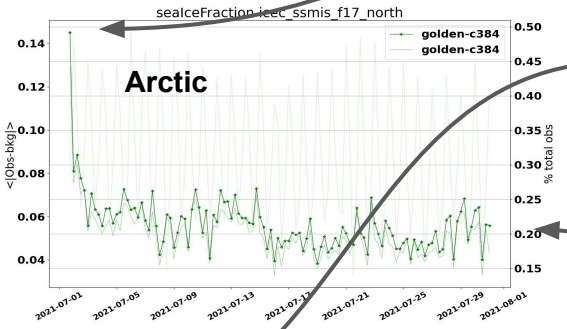
AVHRR NOAA-18, channel 3 <|Obs-Bkg|> from

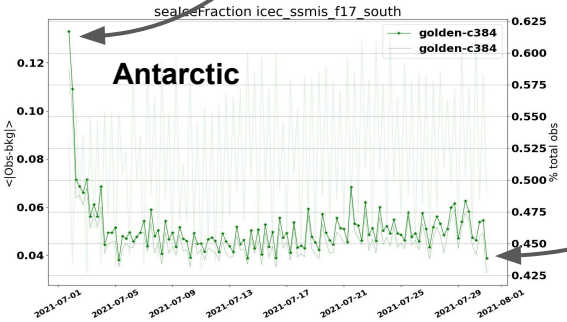


- More obs passed the GSI QC
- Smaller O-B almost everywhere

Sealce DA [Guillaume Vernieres@EMC]

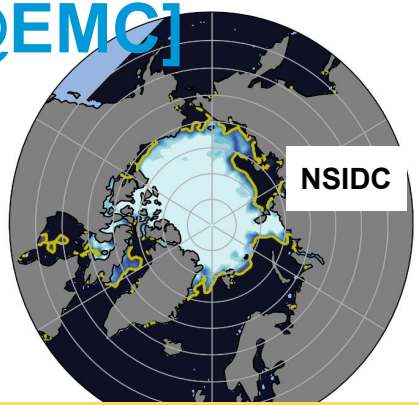
Seaice concentration OMB statistics



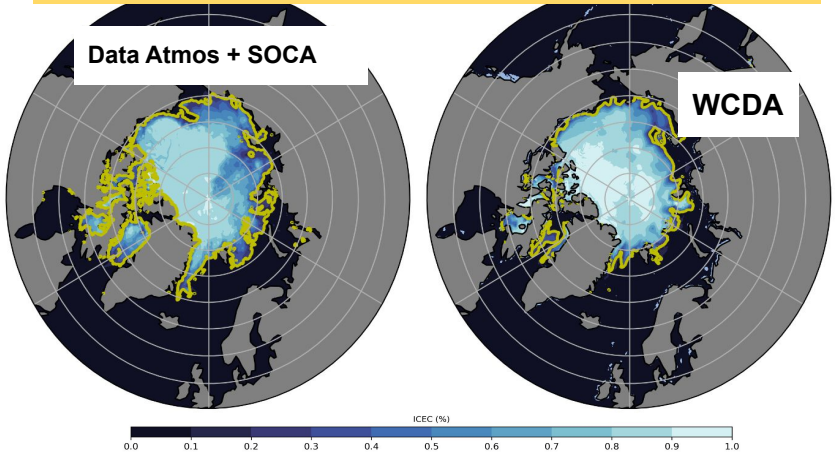


Started from a benchmark SOCA based short reanalysis (~6 months)

Significant error reduction in the WCDA system



Better sea ice extent in the WCDA prototype



Aerosol DA [Cory Martin@EMC]

Aerosol **O**ptical **D**epth (AOD) DA using VIIRS AOD observations

Initial results show NMC estimates reduce standard deviations, while BUMP covariance results in lower mean differences.

Global Mean and Stddv O-F statistics

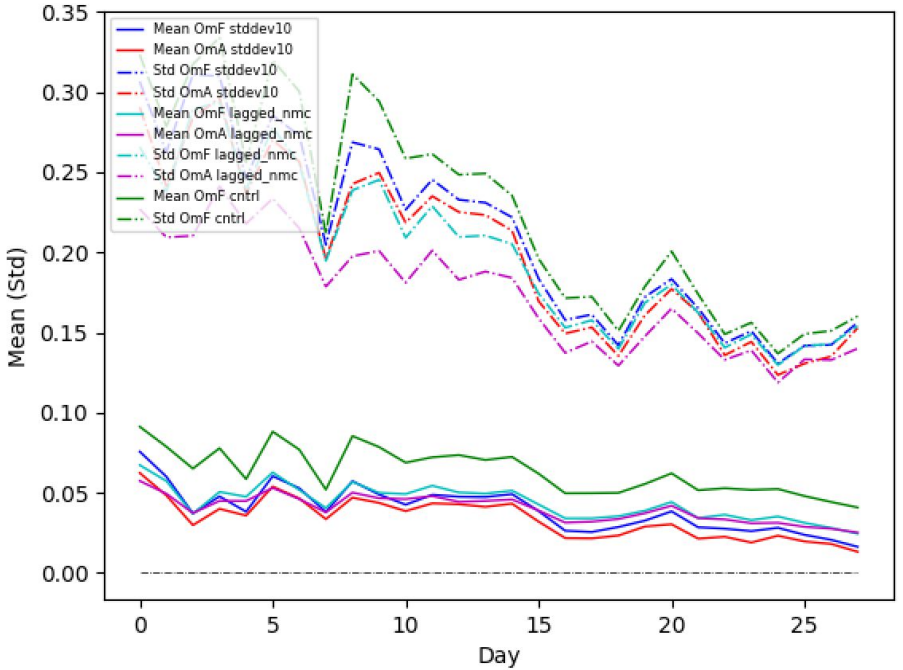
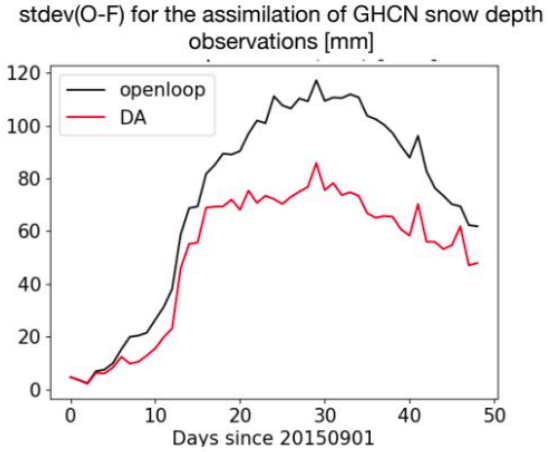


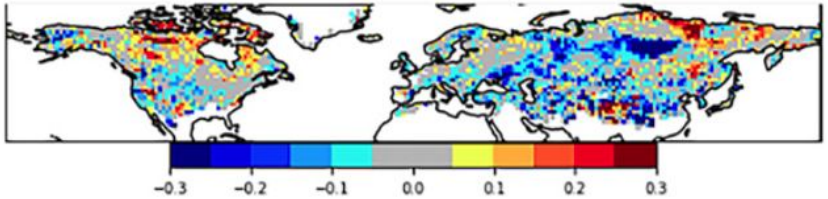
Fig. courtesy Andy Tangborn, SAIC@NOAA/NWS/NCEP/EMC

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!



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



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)

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

Questions

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