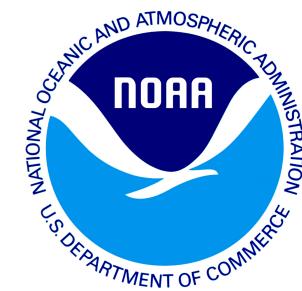


# Python for HWRF Training

Christina Holt – DTC, ESRL/GSD, CIRES

Samuel Trahan – NOAA/EMC, IMSG



# Motivation & Goals

- HWRF Developers have expressed a need for more specific training using the Python scripts implemented in operations in 2015
- HWRF is a very complex system that keeps growing in complexity
- As research and development continues to be funded and required developers have a greater need to know the details of the complex scripting system

# Agenda

9:00	HWRF System Overview	Christina
9:30	HWRF Internals Overview	Sam
9:50	Object-oriented Scripts	Christina
10:10	ProUtil & Data Delivery	Sam
10:40	<b>~*~* Break *~*~</b>	
11:00	Logs Overview	Christina
11:20	Troubleshooting	Sam
11:50	Configuring	Sam
12:30	<b>~*~* Lunch *~*~</b>	
1:30	Rocoto for HWRF	Christina
2:00	Database	Sam
2:30	Debugging	Christina
3:00	<b>~*~* Break *~*~</b>	
3:30-5:00	Adding a Workflow Component	Christina & Sam

# Resources for users and developers

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Documentation

Developer webpage

Developer committee meetings and mailing list

Doxxygen

# User support webpage

The screenshot shows the "WRF for Hurricanes" user support page. On the left is a vertical sidebar with links: Home, Terms of Use, Overview, User Support, Downloads, Documentation (which is circled in red), Idealized, Tutorials & Workshops, Testing and Evaluation, HWRF Developers Info, and Additional Links. The main content area has a header "WRF For Hurricanes Documents And Publications". Under "Hurricane WRF Documents", there's a section for "HWRF Documents" containing links to various documents from 2015 and 2014. Below this are two large preview images of document covers: one for the "NMM Version 3 Modeling System User's Guide August 2015" and another for the "Community HWRF Users' Guide v3.7a". To the right of these images is a "Events" section listing a "HWRF tutorial" (01.25.2016 to 01.27.2016) at NOAA Center for Weather and Climate Prediction, College Park, MD, and a "Sea Ice Modeling Workshop" (02.02.2016 to 02.04.2016) at NCAR Center Green - building CG1 - North Auditorium. Further down is an "Announcements" section with a link to "Release v3.7a of the HWRF system". At the bottom right is a box for the "DEVELOPMENTAL TESTBED CENTER" featuring the "Hurricane Weather Research and Forecasting (HWRF) Model: 2015 Scientific Documentation". The footer contains acknowledgements and a note about NOAA/NWS/NCEP Environmental Modeling Center affiliation.

You are here: DTC • Hurricane WRF Users Page

**WRF For Hurricanes Documents And Publications**

**Hurricane WRF Documents**

**HWRF Documents**

- 2015 Documents (for HWRF v3.7a release)
  - **HWRF Users' Guide v3.7a** ([PDF](#))
  - **HWRF Scientific Documentation - August 2015** ([PDF](#))
  - **HWRF-Doxxygen Guide** ([webdoc](#))
  - **WRF-NMM V3 User's Guide** ([PDF](#))
- 2014 Documents (for HWRF v3.6a release)
  - **HWRF Users' Guide v3.6a** ([PDF](#))
  - **HWRF Scientific Documentation - September 2014** ([PDF](#))

**Community HWRF Users' Guide v3.7a**

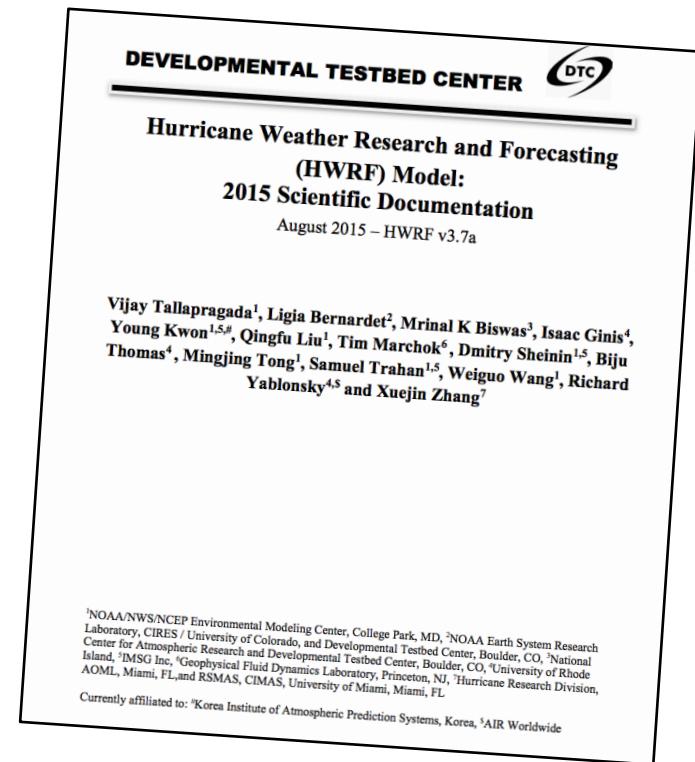
**DEVELOPMENTAL TESTBED CENTER**

**Hurricane Weather Research and Forecasting (HWRF) Model: 2015 Scientific Documentation**

NOAA/NWS/NCEP Environmental Modeling Center, College Park, MD; NOAA Earth System Research Center, CERES / University of Colorado, and Developmental Testbed Center, Boulder, CO; National Oceanic and Atmospheric Administration Research and Development Testbed Center, Boulder, CO; University of Rhode Island, RI; DMSC Inc., Germantown, MD; Geophysical Fluid Dynamics Laboratory, Princeton, NJ; National Centers for Environmental Prediction, Washington, DC; National Centers for Atmospheric Research Division, Boulder, CO; Currently affiliated to: Korea Institute of Atmospheric Prediction Systems, Korea; AIR Worldwide

# Scientific Documentation

- Technical information covering each HWRF component
  - Authorship includes developers and experts
  - Chapters covering:
    - HWRF introduction
    - HWRF Initialization
    - MPI POM-TC
    - Physics Packages in HWRF
    - Design of moving nest
    - Use of GFDL Vortex Tracker
    - The idealized HWRF framework



# HWRF v3.7a User's Guide

- Includes detailed instructions on running each component
  - Geared towards public release, so some aspects will be missing
  - Running with wrappers, no Rocoto information
- Content:
  - Introduction & software installation
  - Running HWRF
  - HWRF preprocessing system
  - Vortex Relocation
  - DA
  - Merge
  - MPIPOM-TC
  - Forecast Model
  - Post processor
  - Forecast products
  - Idealized

[http://www.dtcenter.org/HurrWRF/users/docs/users\\_guide/HWRF\\_v3.7a\\_UG.pdf](http://www.dtcenter.org/HurrWRF/users/docs/users_guide/HWRF_v3.7a_UG.pdf)

# HWRF Developers Website

Code Management	Overview
Getting Started	<input checked="" type="checkbox"/> <a href="#">Code Development Process</a>
Using the Code	<input checked="" type="checkbox"/> <a href="#">Roles and Responsibilities</a>
Computing Resources	<a href="#">Testing</a>
Getting Started	<a href="#">Obtaining Repository Access</a>
Using the Code	<input checked="" type="checkbox"/> <a href="#">Repository Structure</a>
Computing Resources	<a href="#">Code Structure</a>
Using the Code	<a href="#">Checking Out the Code</a>
Computing Resources	<a href="#">Development Branches</a>
Docs and Support	<a href="#">Build &amp; Install</a>
HWRF Users Site	<a href="#">Running HWRF</a>
Docs and Support	<a href="#">Support for Developers</a>
Contributed Code	<a href="#">FAQ</a>
HWRF Users Site	<a href="#">Known Issues</a>

The screenshot shows the "WRF for Hurricanes" page. At the top is a banner with a satellite image of a hurricane. Below it is a breadcrumb trail: "You are here: DTC • Hurricane WRF Developers Page". The main content area has a header "HWRF Developers Page" and a welcome message: "Welcome to the DTC HWRF developers page. The source for information concerning the deve...". To the left is a sidebar with links: "Developers Home", "Code Management", "Getting Started", "Using the Code", "Computing Resources", "Docs and Support", "Contributed Code", and "HWRF Users Site".

**Information hub for all developers  
Trainings offered by DTC:**

- HWRF automation with the Rocoto workflow management system
- HWRF code management

# Communications

- **HWRF Developers Committee**

- All developers welcome to attend biweekly meetings
- Forum for discussion, plans, and updates for development, including testing, evaluation, and technical aspects

- **Mailing list for exchanging information about development**

- [hwrf\\_developers@rap.ucar.edu](mailto:hwrf_developers@rap.ucar.edu)
- All those with HWRF repository access are members

## dev\_meeting\_20151109

Created and last modified by Christina Holt on Nov 12, 2015

Next meeting will be 11/23 at noon ET.

### Participants

- DTC: Christina Holt, Ligia Bernardet, Jim Frimel, Kathryn Newman
- EMC: Sam Trahan, Zhan Zhang
- U Wisc: Allen Lenzen
- HRD: Xuejin Zhang

### Minutes

#### Announcement of HWRF Tutorial in College Park

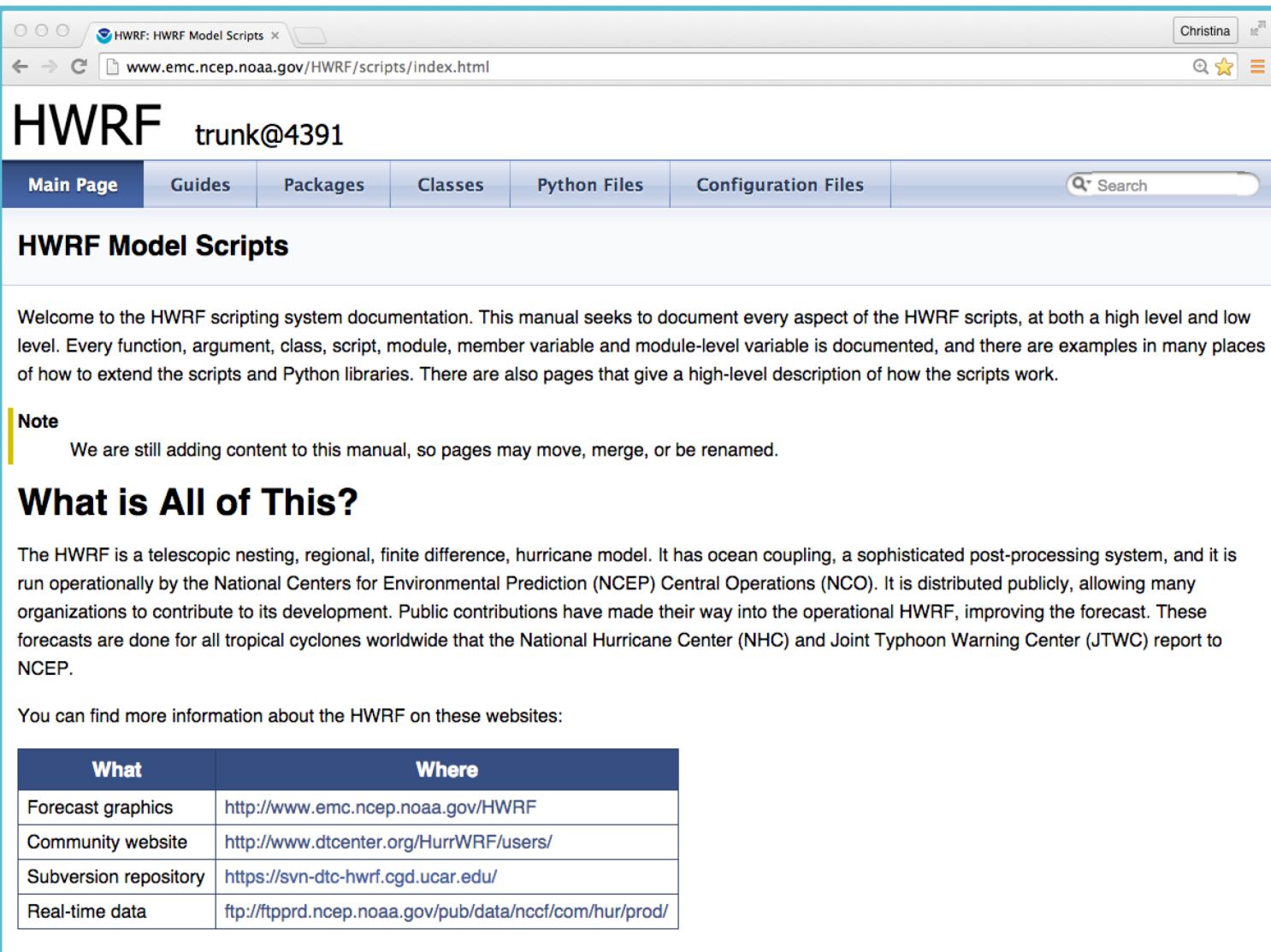
DTC and EMC are hosting an HWRF Tutorial 25-27 January, 2016 at the NOAA

#### Plan for bug fix and advection tests

All of the fixes have been committed to trunk.

- Bug for icloud=3 (WRF r8757)
- Non-hydrostatic state is retained after nest moves. (WRF r8758)

# Doxygen Website



The screenshot shows a web browser window displaying the "HWRF Model Scripts" documentation. The title bar reads "HWRF: HWRF Model Scripts". The address bar shows the URL "www.emc.ncep.noaa.gov/HWRF/scripts/index.html". The page header includes the text "HWRF trunk@4391" and a navigation menu with links for "Main Page", "Guides", "Packages", "Classes", "Python Files", and "Configuration Files". A search bar is also present. The main content area features a section titled "HWRF Model Scripts" with a welcome message about the documentation's purpose and content. Below this, a "Note" section states that the manual is still being developed and subject to change. A large heading "What is All of This?" is followed by a detailed description of the HWRF model. At the bottom, there is a list of websites where users can find more information.

Welcome to the HWRF scripting system documentation. This manual seeks to document every aspect of the HWRF scripts, at both a high level and low level. Every function, argument, class, script, module, member variable and module-level variable is documented, and there are examples in many places of how to extend the scripts and Python libraries. There are also pages that give a high-level description of how the scripts work.

**Note**  
We are still adding content to this manual, so pages may move, merge, or be renamed.

## What is All of This?

The HWRF is a telescopic nesting, regional, finite difference, hurricane model. It has ocean coupling, a sophisticated post-processing system, and it is run operationally by the National Centers for Environmental Prediction (NCEP) Central Operations (NCO). It is distributed publicly, allowing many organizations to contribute to its development. Public contributions have made their way into the operational HWRF, improving the forecast. These forecasts are done for all tropical cyclones worldwide that the National Hurricane Center (NHC) and Joint Typhoon Warning Center (JTWC) report to NCEP.

You can find more information about the HWRF on these websites:

What	Where
Forecast graphics	<a href="http://www.emc.ncep.noaa.gov/HWRF">http://www.emc.ncep.noaa.gov/HWRF</a>
Community website	<a href="http://www.dtcenter.org/HurrWRF/users/">http://www.dtcenter.org/HurrWRF/users/</a>
Subversion repository	<a href="https://svn-dtc-hwrf.cgd.ucar.edu/">https://svn-dtc-hwrf.cgd.ucar.edu/</a>
Real-time data	<a href="ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/hur/prod/">ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/hur/prod/</a>

# General Python help

- Online (<https://docs.python.org/release/2.6.6/>)
- Open python in a terminal and use help() function for particular function. An example to get information with a Python list:

```
$ python  
$ help(list)
```

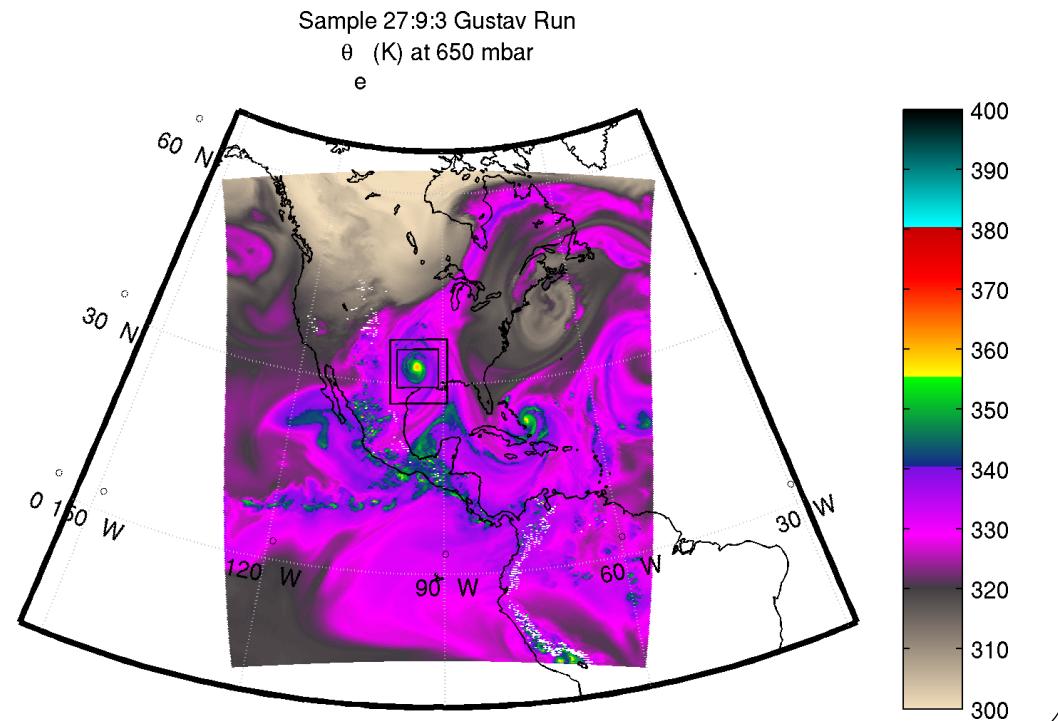
- Must use Python v2.6.6.
  - Only version available on NOAA machines
  - 2.7 may be used in future because it's the long-term support release
  - Version 3 is basically a different language

# HWRF System Overview

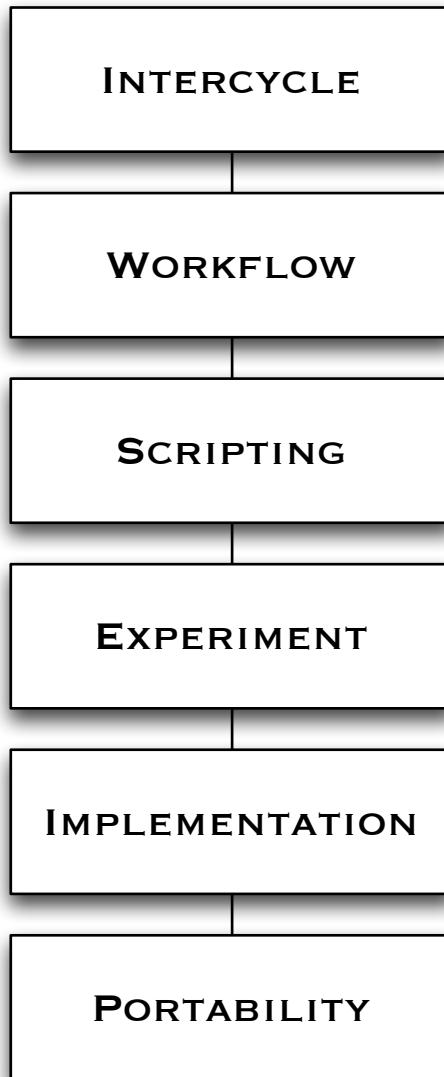
Overview of the system design

Jobs of each task

Common configurations and  
available capabilities

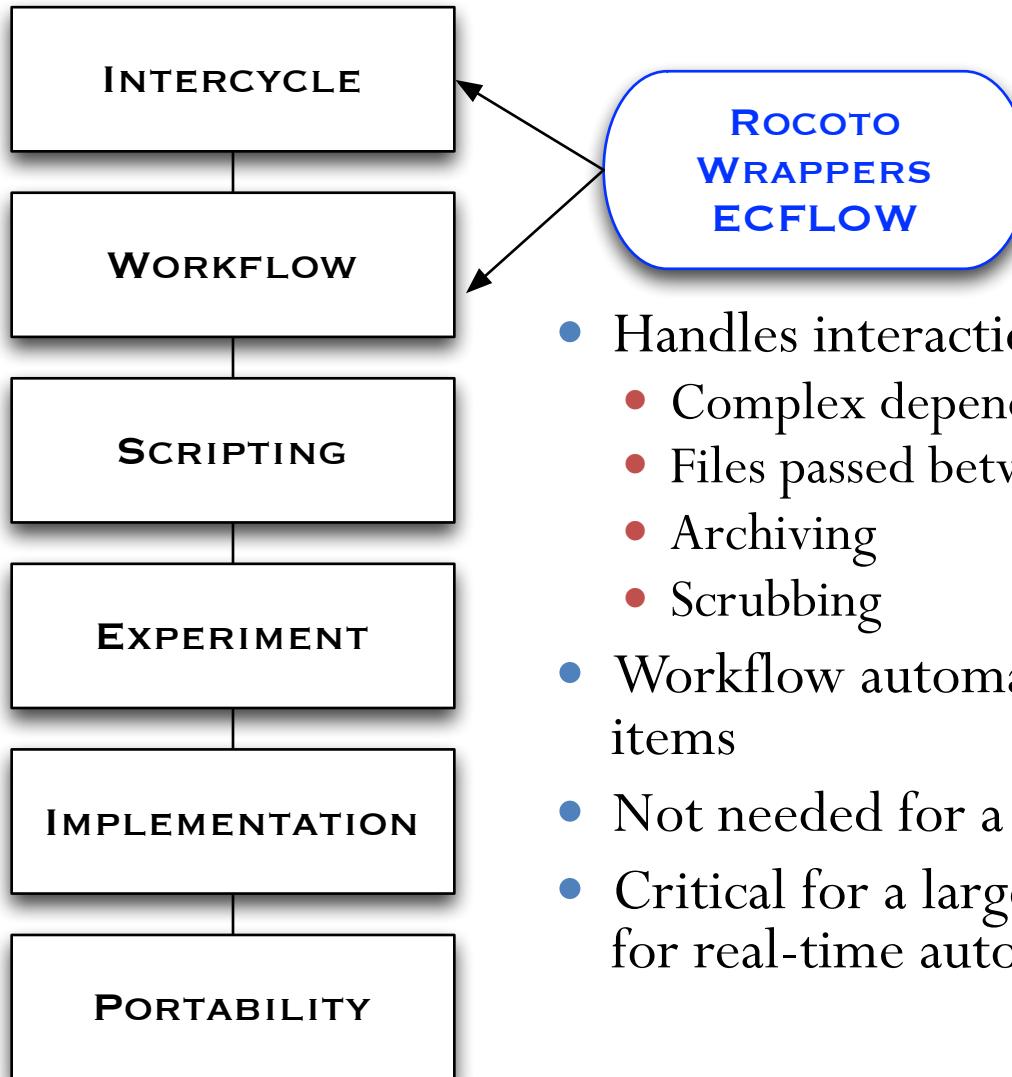


# HWRF System: Overview



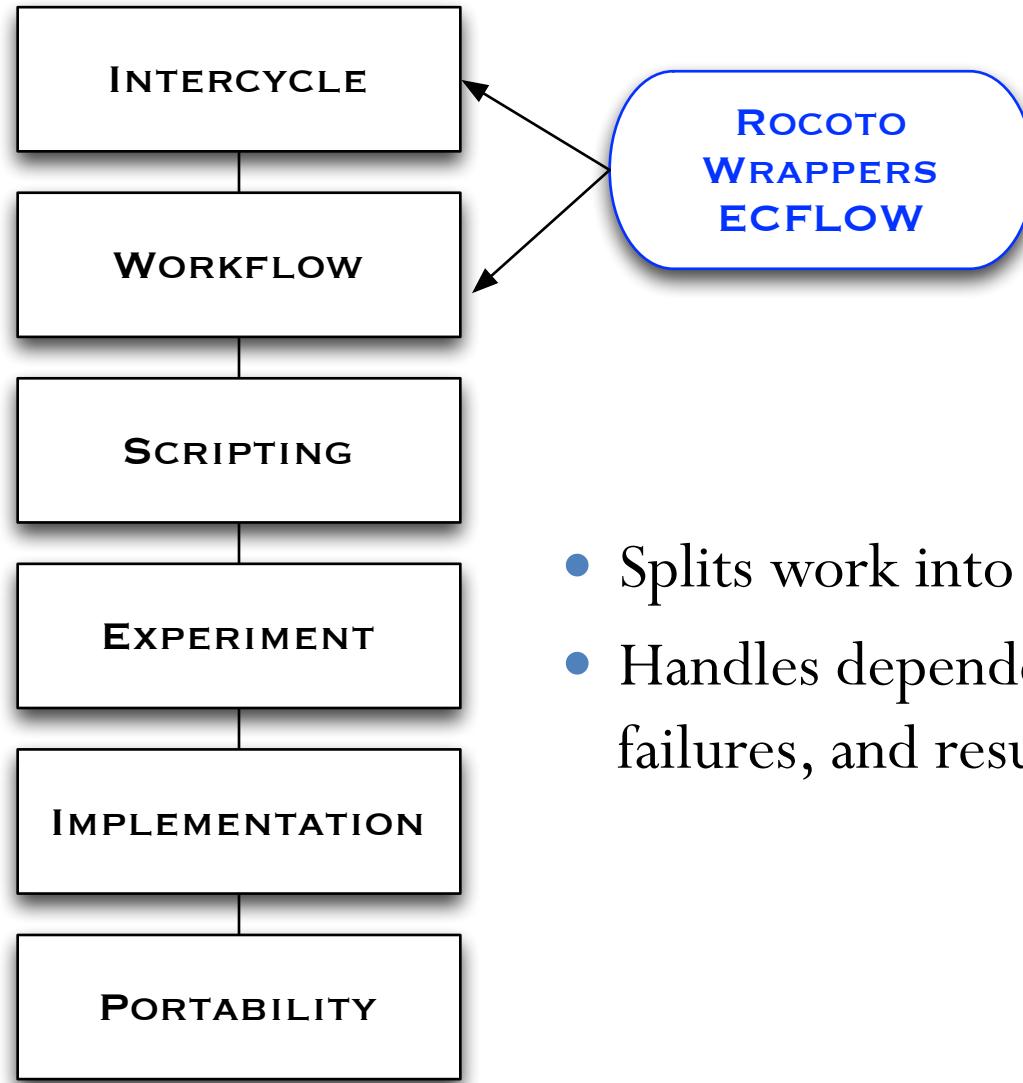
- 6 layers of scripts that are responsible for preparing for and running the 118 (for now) HWRF executables of the end-to-end system
- Most of these layers are written using an object-oriented (O-O) Python design
- O-O design makes the system highly configurable and reduces the footprint of the system drastically

# HWRF System: Intercycle Layer



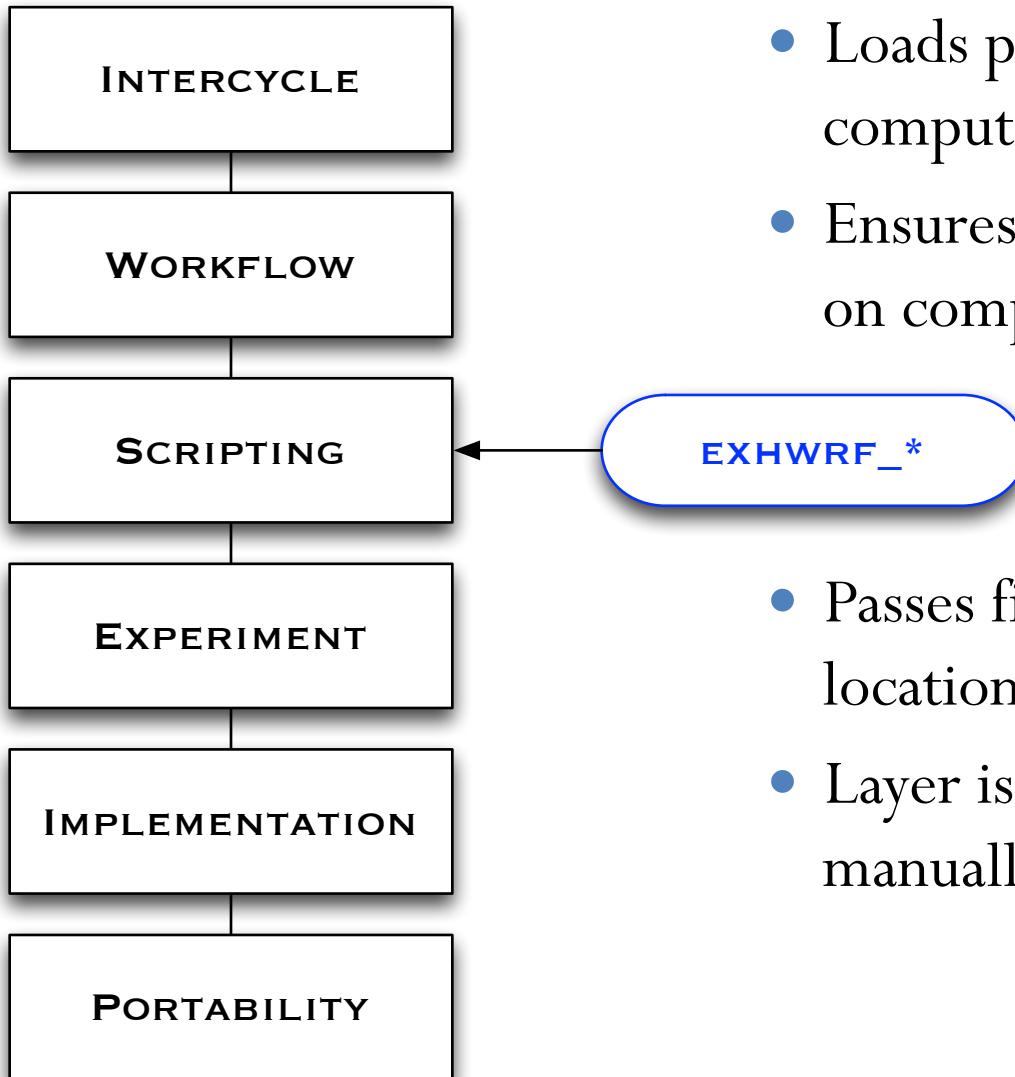
- Handles interactions between several cycles
  - Complex dependencies
  - Files passed between them
  - Archiving
  - Scrubbing
- Workflow automation takes care of these items
- Not needed for a case study
- Critical for a large retrospective study, and for real-time automation

# HWRF System: Workflow Layer



- Splits work into multiple batch jobs
- Handles dependencies, submission, failures, and resubmission of jobs

# HWRF System: Scripting Layer



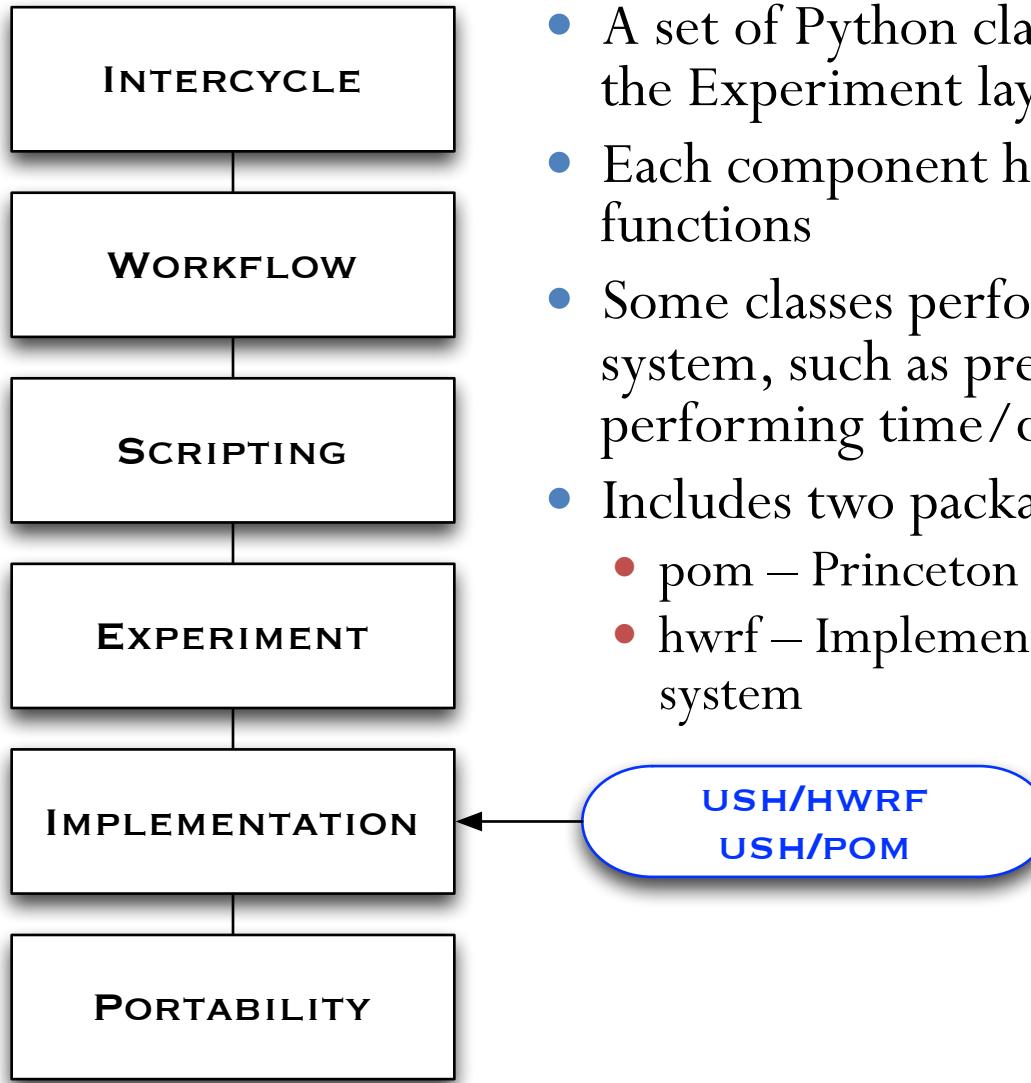
- Loads programs and libraries into computing environment
- Ensures connection to file system on compute node
- Passes file and executable locations to the next lower layer
- Layer is optional – can be done manually by user

# HWRF System: Experiment Layer



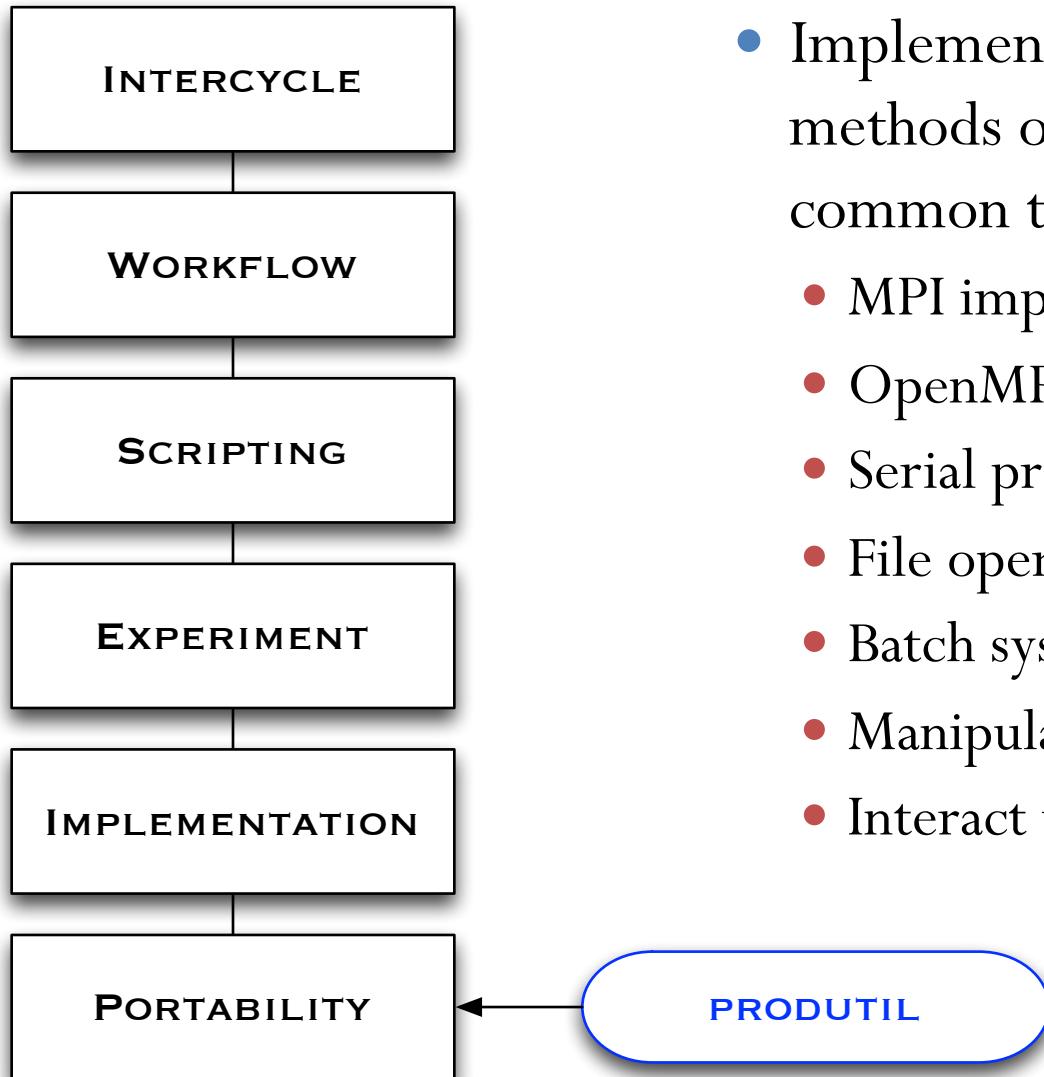
- Describes the HWRF workflow
- Creates the object structure that connects all the pieces
  - i.e. GSI should use input from the GDAS relocation output
  - Each object has a run() function to perform the actual task

# HWRF System: Implementation Layer



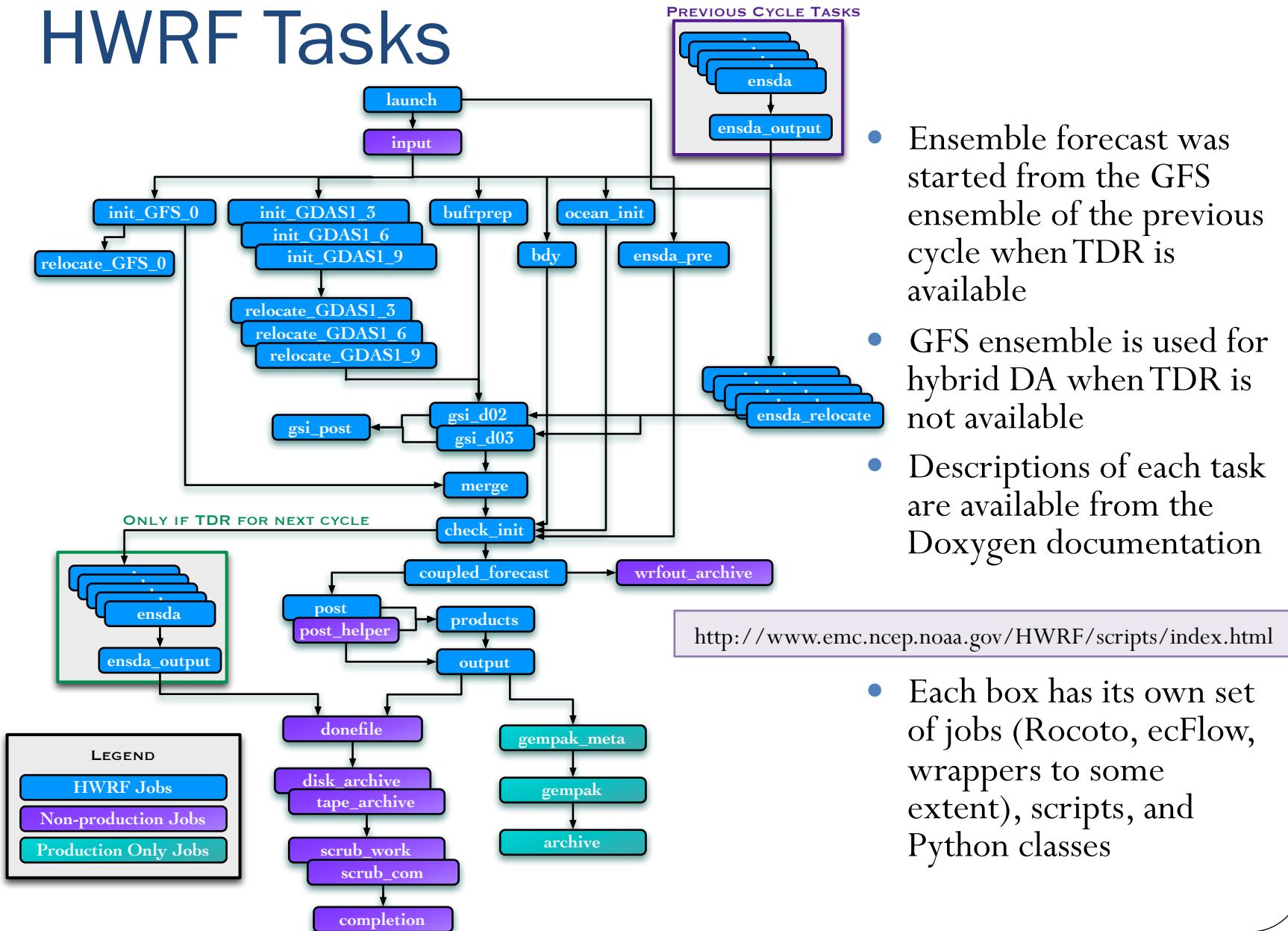
- A set of Python classes and functions used by the Experiment layer to run HWRF
- Each component has its own class and set of functions
- Some classes perform utilities to support the system, such as predicting filenames and performing time/date arithmetic
- Includes two packages
  - pom – Princeton Ocean Model initialization
  - hwrf – Implementation of most of the HWRF system

# HWRF System: Portability Layer



- Implements cross-platform methods of performing common tasks
  - MPI implementation
  - OpenMP
  - Serial programs
  - File operations
  - Batch system interaction
  - Manipulate resource limitations
  - Interact with database file

# HWRF Tasks



# HWRF Default Configurations

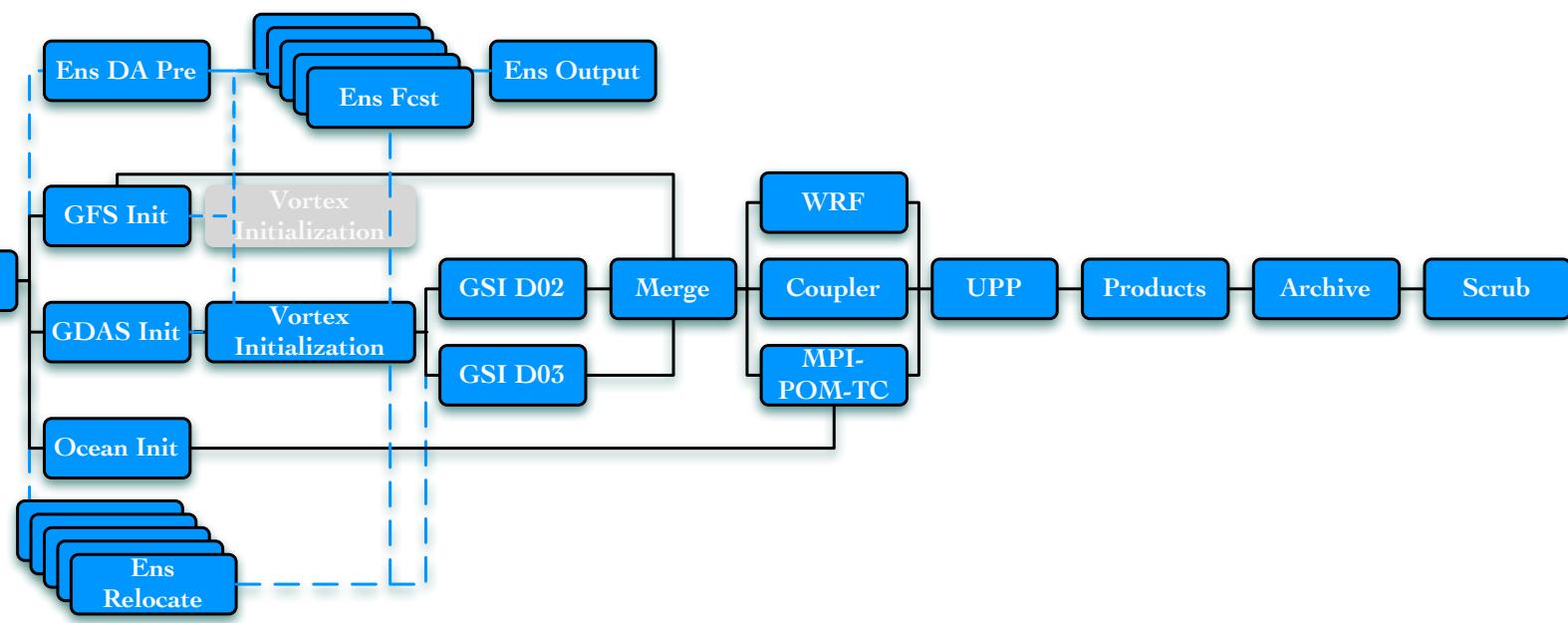
2016 Defaults

<b>Basin</b>	<b>Ocean</b>	<b>Data Assim</b>	<b>Ensemble</b>	<b>Vertical</b>	<b>Model Top</b>	<b>Extra .conf File</b>
N.Atl	3D POM	Always	TDR Only	61 level	2 mbar	hwrf_AL.conf (empty)
NE.Pac	3D POM	TDR Only	TDR Only	61 level	2 mbar	hwrf_EP.conf
NC.Pac	3D POM	TDR Only	TDR Only	61 level	2 mbar	hwrf_CP.conf
NW.Pac	3D POM	Never	Never	43 level	50 mbar	hwrf_other_basins.conf
N.Ind	3D POM	Never	Never	43 level	50 mbar	hwrf_other_basins.conf
S.Pac	3D POM	Never	Never	43 level	50 mbar	hwrf_other_basins.conf
S.Ind	3D POM	Never	Never	43 level	50 mbar	hwrf_other_basins.conf
S.Atl	None	Never	Never	43 level	50 mbar	hwrf_other_basins.conf

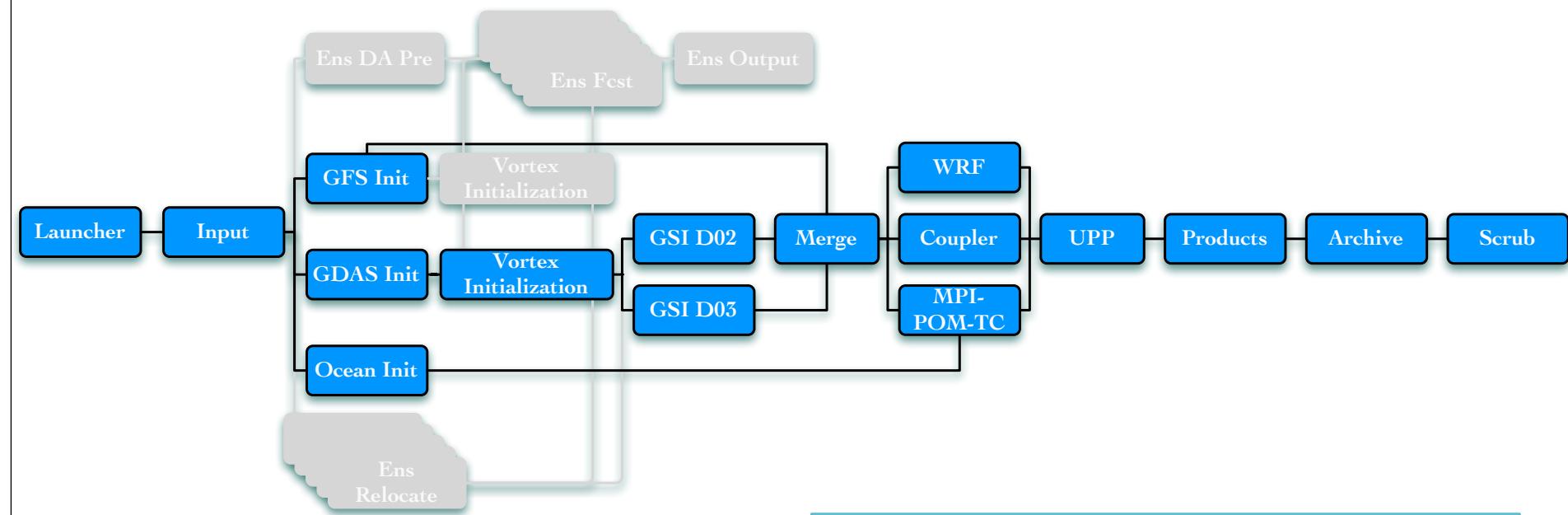
2015 Defaults

<b>Basin</b>	<b>Ocean</b>	<b>Data Assim</b>	<b>Ensemble</b>	<b>Vertical</b>	<b>Model Top</b>	<b>Extra .conf File</b>
N.Atl	3D POM	Always	TDR Only	61 level	2 mbar	hwrf_AL.conf (empty)
NE.Pac	3D POM	TDR Only	TDR Only	61 level	2 mbar	hwrf_2015_EP.conf
NC.Pac	None	Never	Never	61 level	2 mbar	hwrf_2015_CP.conf
NW.Pac	None	Never	Never	43 level	50 mbar	hwrf_2015_other_basins.conf
N.Ind	None	Never	Never	43 level	50 mbar	hwrf_2015_other_basins.conf
S.Pac	None	Never	Never	43 level	50 mbar	hwrf_2015_other_basins.conf
S.Ind	None	Never	Never	43 level	50 mbar	hwrf_2015_other_basins.conf
S.Atl	None	Never	Never	43 level	50 mbar	hwrf_2015_other_basins.conf

# HWRF Workflow: AL or EP w/TDR

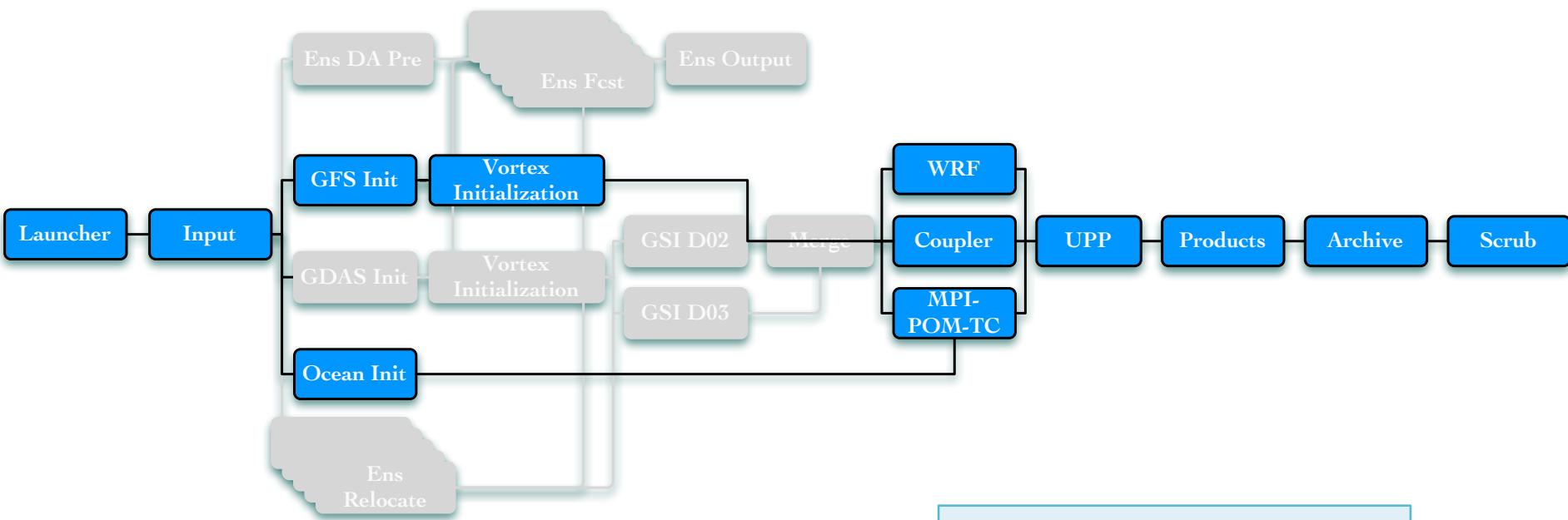


# HWRF Workflow: Atlantic w/o TDR



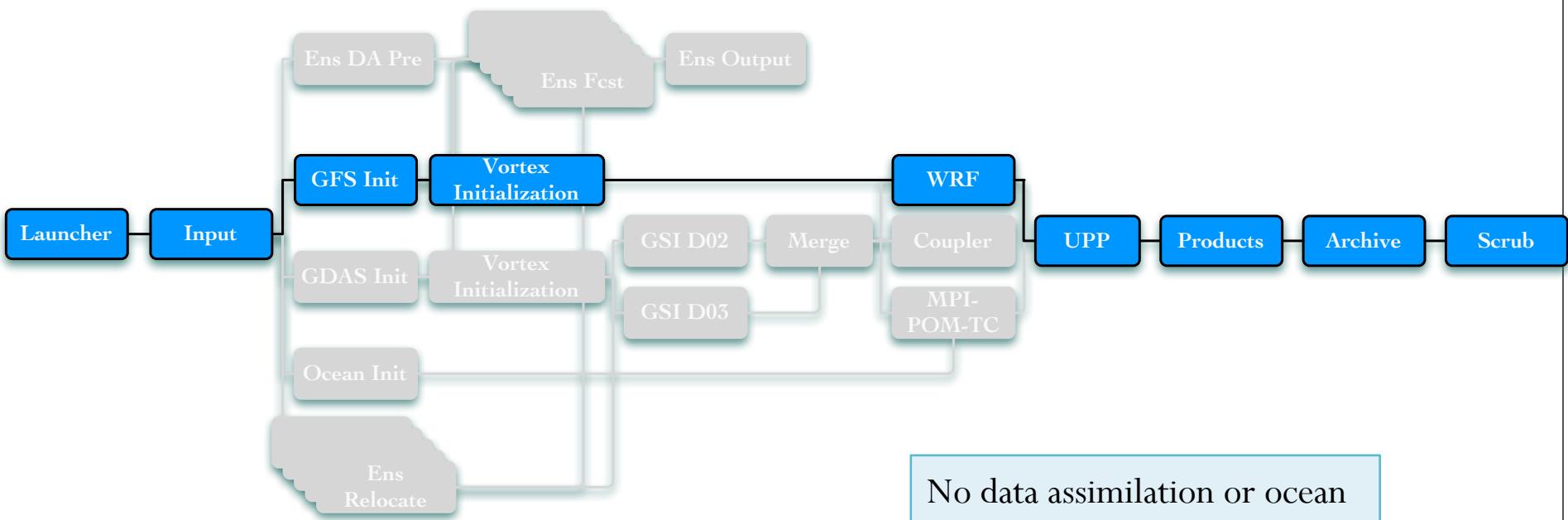
Data assimilation is performed with ensemble covariances provided by the global ensemble

# HWRF Workflow: EP w/o TDR



No data assimilation is  
performed when TDR is  
unavailable

# HWRF Workflow: All other basins



No data assimilation or ocean coupling in other basins.  
Lower vertical resolution is also used for forecast

# Other Available Configurations

- Full system in all basins
- 27:9:3 resolution
- Lower vertical structure (Lower model top & 43 vertical levels)
- GEFS-based HWRF ensemble
- Different forecast length (6 hrly from 12 – 126 hours)
- Physics schemes
  - Scale-aware SAS, GFS PBL with EDMF, SAS, Thompson microphysics
- Disable select components
  - GSI, DA Ensemble, Ocean Coupling, Initialization
- Run without spectral files
- Multistorm capability

For information on running these additional configurations, visit:  
[http://www.emc.ncep.noaa.gov/HWRF/scripts/available\\_configurations.html](http://www.emc.ncep.noaa.gov/HWRF/scripts/available_configurations.html)

# Questions?

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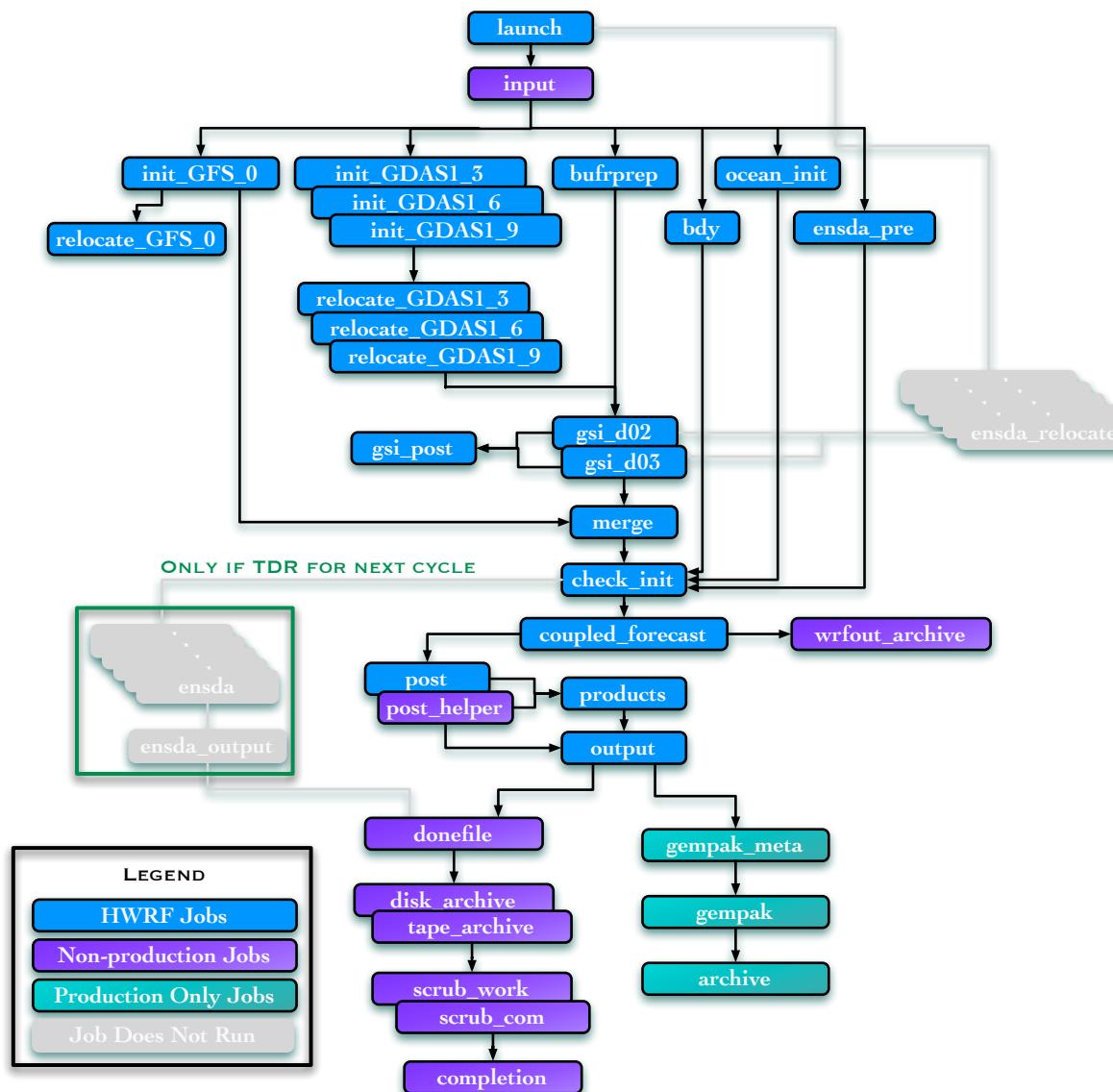
Next up....

HWRF Internals Overview

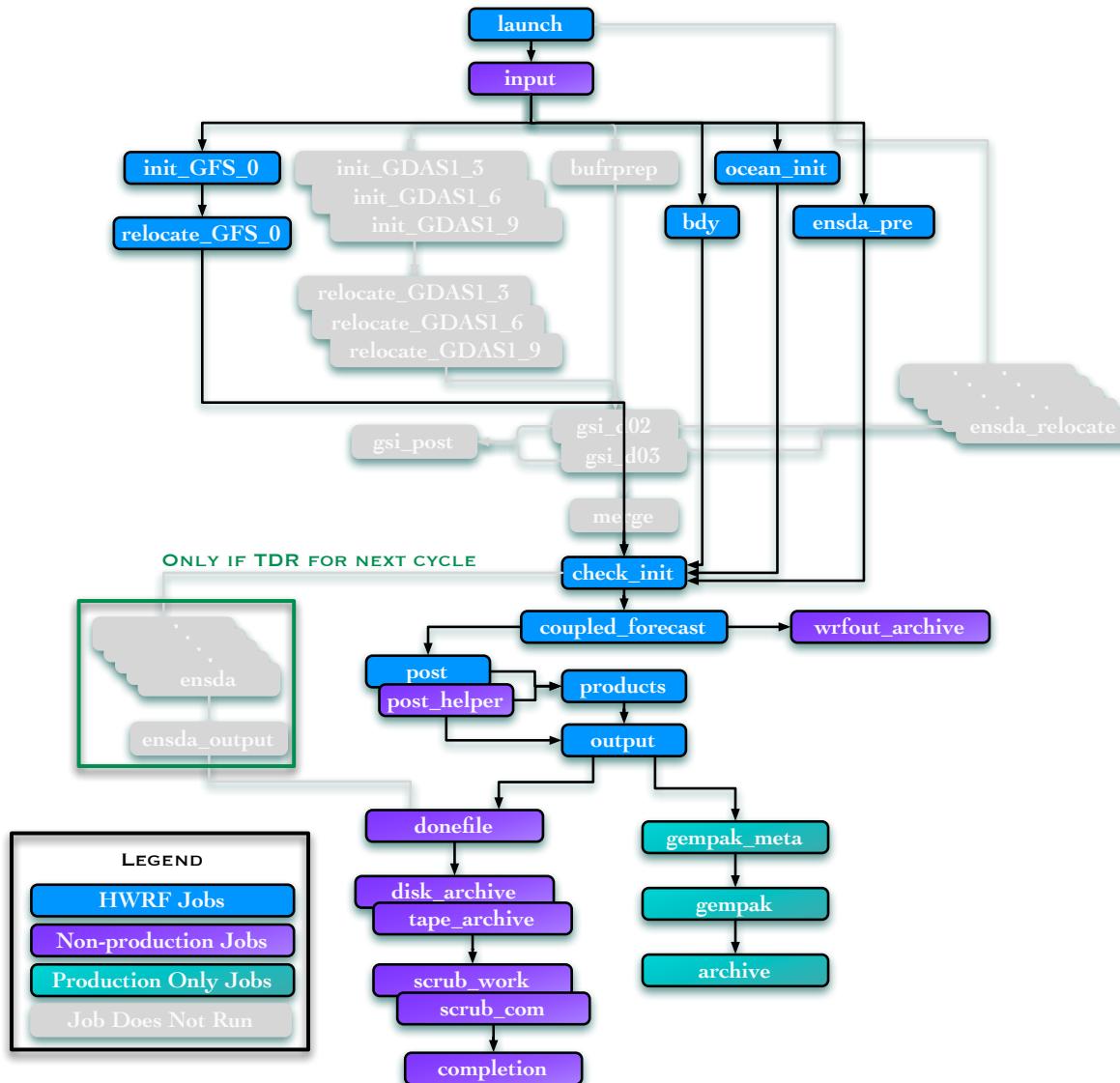
# Extras

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# HWRF Tasks: AL Default w/o TDR



# HWRF Tasks: EP Default w/o TDR



# HWRF Tasks: Other basins

