Python for HWRF Training

Christina Holt – DTC, ESRL/GSD, CIRES

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Motivation & Goals

- A need was identified for additional training specifically focused on python for HWRF geared towards HWRF developers
- DTC & EMC decided to host focused training
  - python scripts should not be obstacle for development!
- Developers were polled for interest and range of topics necessary to gain better understanding of Python for HWRF
- Goals
  - ✓ Provide developers with general overview and tools necessary to better understand HWRF python scripts
  - ✓ Provide resources to help after returning to home institution

Agenda

Thursday November 19		
1:30 PM	System Overview	Kathryn
2:00 PM	Object-oriented Scripts	Sam
2:30 PM	Rocoto for HWRF	Christina
3:00 PM	Configuring	Sam
3:30 PM	Break	
3:50 PM	Logs Overview	Christina
4:20 PM	Scripts: Part 1	Christina

Friday November 20		
9:00 AM	Scripts: Part 2	Christina
10:00 AM	Database	Sam
10:30 AM	Break	
10:45 AM	Debugging	Christina

System Overview

Kathryn Newman

HWRF Python Scripts Training

Miami, FL

November 19, 2015

Outline

- Current HWRF capabilities
  - Default configurations
  - Other capabilities & basic information

- Resources for users and developers
  - Documentation
  - HWRF Developer website
  - EMC HWRF web documentation
  - General Python help

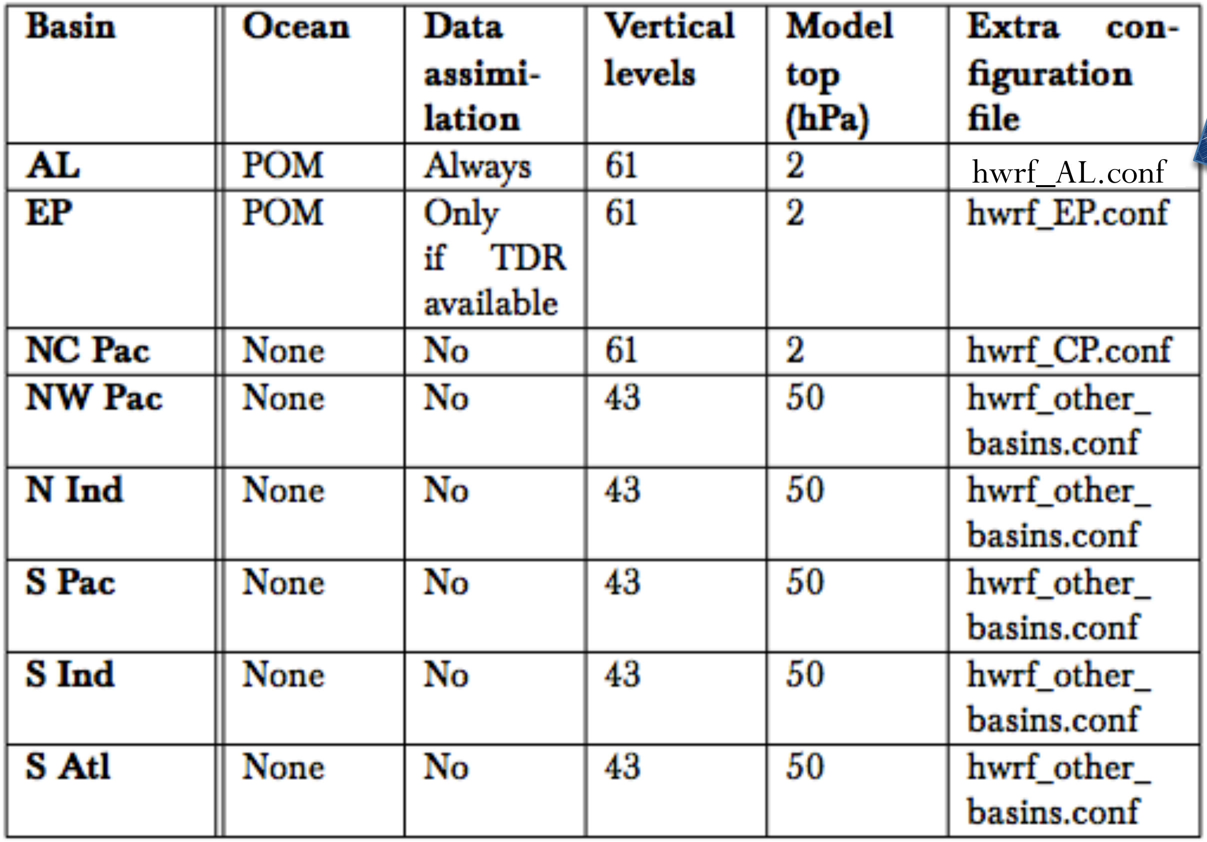
Current HWRF capabilities

Default configurations

Additional capabilities

Misc

Default settings for each basin



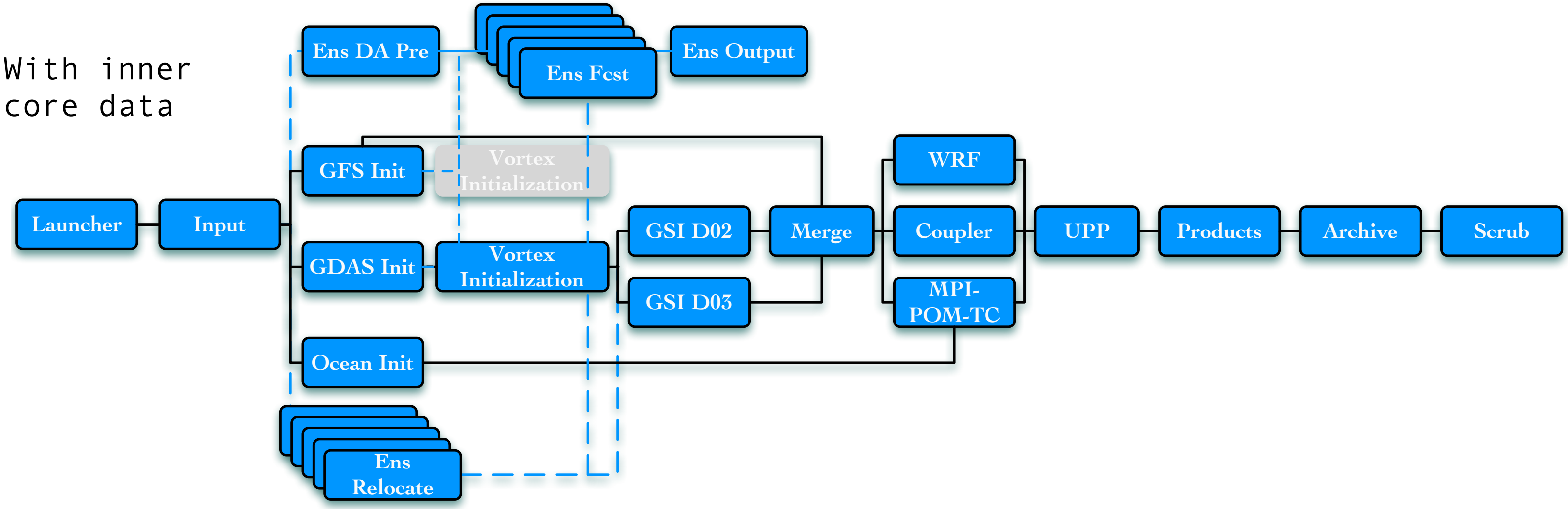
Basin	Ocean	Data assimilation	Vertical levels	Model top (hPa)	Extra configuration file
AL	POM	Always	61	2	hwrf_AL.conf
EP	POM	Only if TDR available	61	2	hwrf_EP.conf
NC Pac	None	No	61	2	hwrf_CP.conf
NW Pac	None	No	43	50	hwrf_other_basins.conf
N Ind	None	No	43	50	hwrf_other_basins.conf
S Pac	None	No	43	50	hwrf_other_basins.conf
S Ind	None	No	43	50	hwrf_other_basins.conf
S Atl	None	No	43	50	hwrf_other_basins.conf

Empty – to ensure uses default configuration

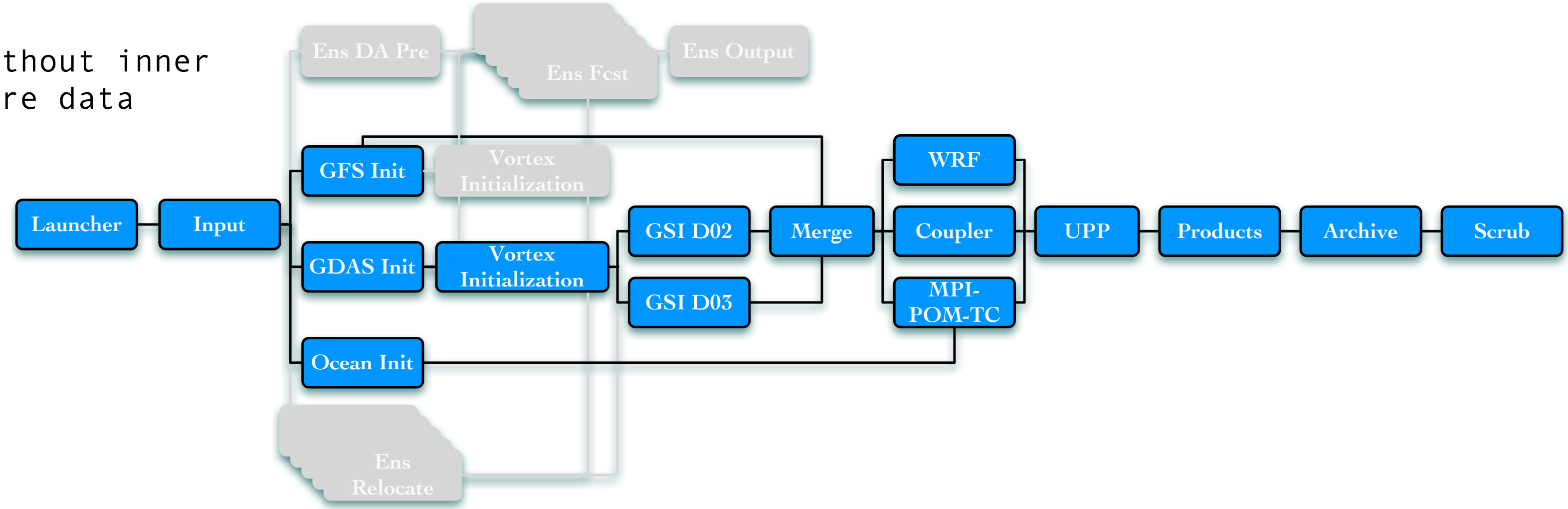
Default operational configurations.

Atlantic Basin

With inner
core data



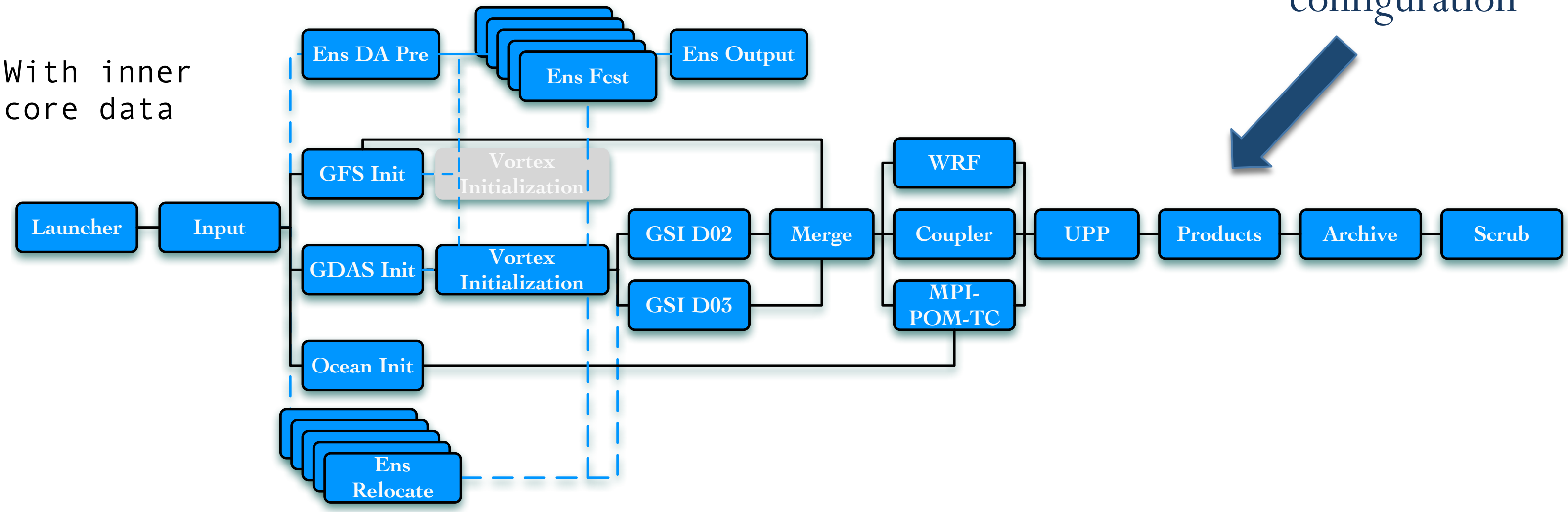
Without inner
core data



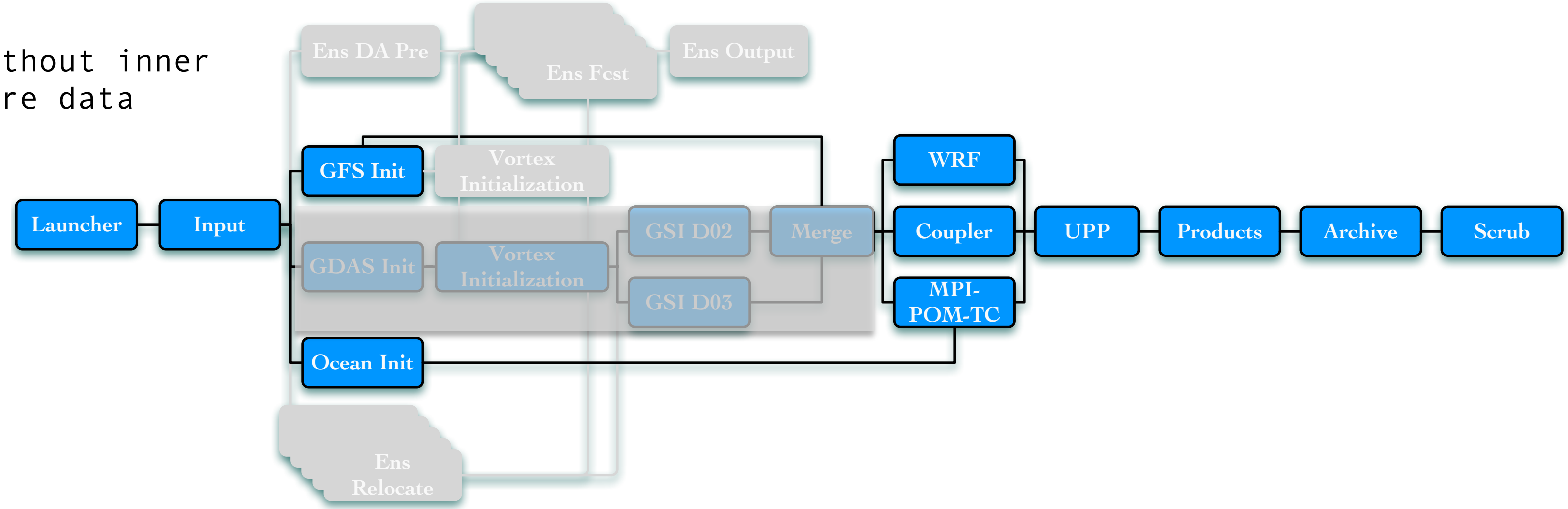
Eastern Pacific Basin

Same as AL configuration

With inner core data



Without inner core data



All other basins

- Starting in 2015, HWRF is run operationally for all ocean basins globally.
  - Configuration of the vertical levels differs depending on which basin

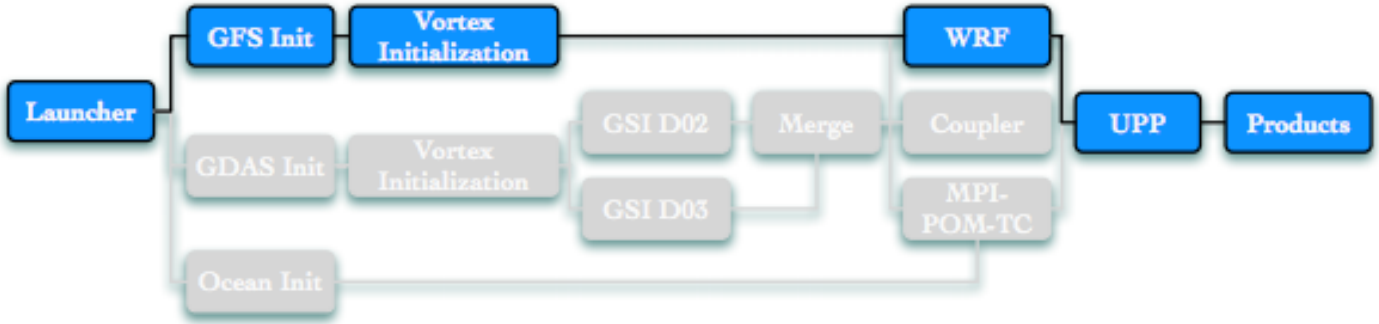


*Figure is simplified (no input, archive, scrub)

Running HWRF for non-operational configurations will be discussed later…

http://www.emc.ncep.noaa.gov/HWRF/scripts/available_configurations.html

Other capabilities

- Full system in all basins
  - 61 layer vertical structure, GSI data assimilation, POM ocean coupling, and a 40 member ensemble
- 27:9:3 resolution
- Lower vertical structure (Lower model top and 43 vertical levels)
- 3 km configuration
- GEFS-based HWRF ensemble
- Different forecast length (Any 6-hrly forecast length from 12 up to 126 hours)
- Changing physics schemes
  - SAS in all domains, Thompson MP, Ferrier-Aligo with species advection
- Disable GSI, DA ensemble, ocean coupling, initialization
- Run without spectral files
- Multistorm capability
  - HWRF multistorm capability in HWRF trunk
  - Instructions for running included in standard checkout doc/multistorm.md and http://www.emc.ncep.noaa.gov/HWRF/scripts/HWRF_MULTISTORM.html

Module files

Scripts directory structure overview

HWRF directory structure

Module files

- New build process on Jet (optional)
  - Using module files included in the HWRF system

```
module use /${HOMEhwrf}/modulefiles/$site # $site=jet, wcoss, etc.

module load HWRF/build
```

  - Purges all loaded modules in user's environment and load those necessary for HWRF compile
  - Once HWRF module is loaded, compile

Scripts Directory structure

- **HWRF launching script**
  - Sets up the workflow for a particular cycle
- **Data pushing/pulling scripts**
  - Pulls data for input to HWRF
  - Data tanks to BUFR files
  - Pushes data to tape, archival
- **Initialization scripts**
  - Ocean, spectral processing, relocate, GSI, merge
- **Forecast and post-processing**
  - GSI post, forecast, unipost, post, products, output
- **Data Assimilation Ensemble**
  - ensda_pre, ensda, ensda_post

Scripts I and II lectures give much more detail!

HWRF directory structure

- Knowing where data will show up can tell you a lot about what is going on with HWRF and why.
- The HWRF system has several key directories
  - **HOMEhwrf**: installation directory
  - **WORKhwrf**: the work directory for each cycle. Each storm and cycle has its own work directory. In Rocoto workflow, this directory contains logs
  - **intercom**: a directory used trade data between jobs for one storm and cycle. This is inside the WORKhwrf directory
  - **com**: the com directory for each cycle. A job for one storm or cycle will never access another storm or cycle except through its com directory
  - **log**: contains log files that are not specific to a storm or cycle

Resources for users and developers

Documentation

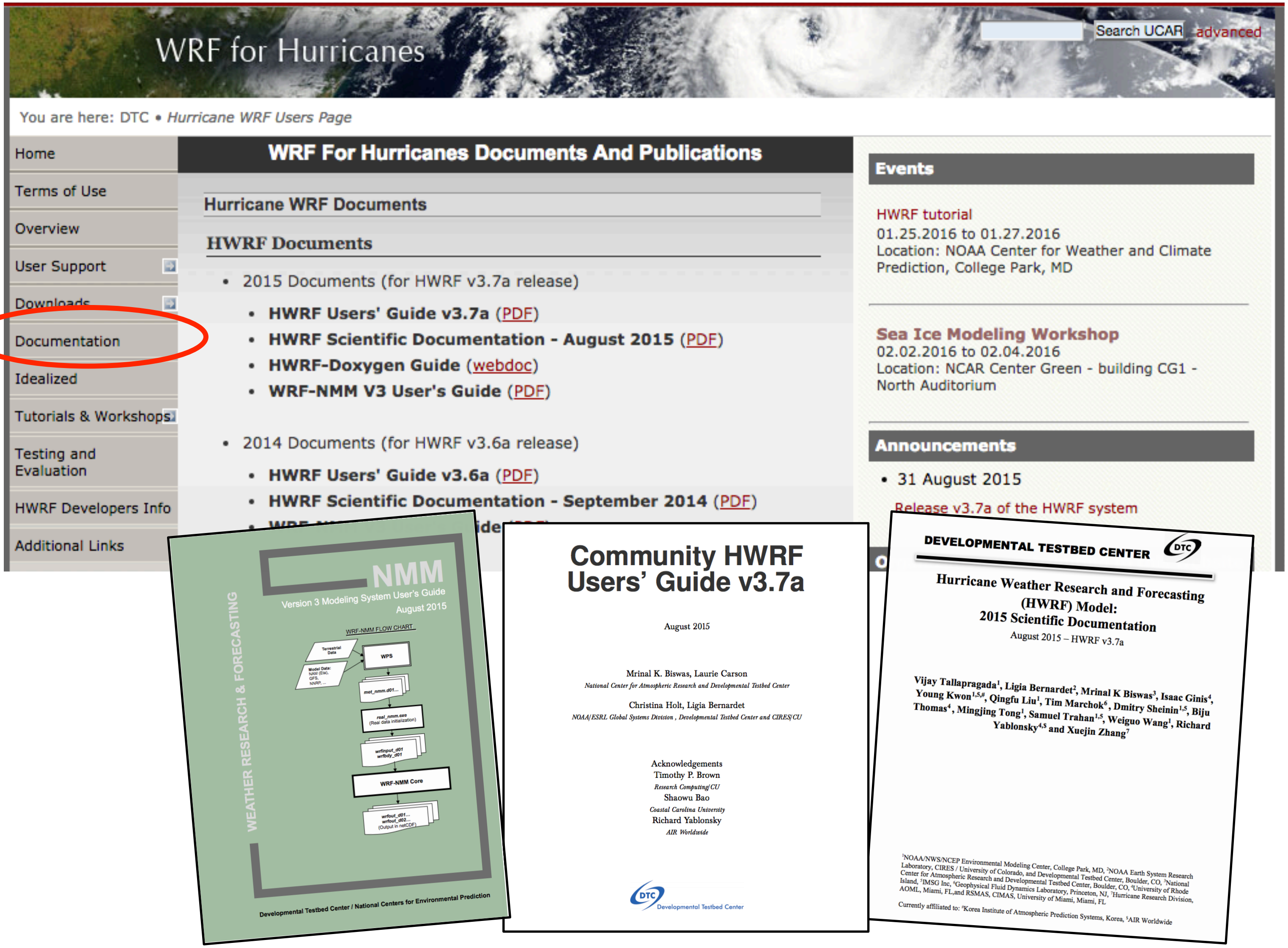
Developer webpage

Developer committee meetings and mailing list

Doxygen

www.dtcenter.org/HurrWRF/users

User support webpage



WRF for Hurricanes

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-Doxygen 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)

Events

HWRF tutorial
01.25.2016 to 01.27.2016
Location: NOAA Center for Weather and Climate Prediction, College Park, MD

Sea Ice Modeling Workshop
02.02.2016 to 02.04.2016
Location: NCAR Center Green - building CG1 - North Auditorium

Announcements

- 31 August 2015

Release v3.7a of the HWRF system

WEATHER RESEARCH & FORECASTING

NMM

Version 3 Modeling System User's Guide
August 2015

WRF-NMM FLOW CHART

Developmental Testbed Center / National Centers for Environmental Prediction

Community HWRF Users' Guide v3.7a

August 2015

Mrinal K. Biswas, Laurie Carson
National Center for Atmospheric Research and Developmental Testbed Center

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Shaowu Bao
Coastal Carolina University
Richard Yablonsky
AIR Worldwide

Developmental Testbed Center

DEVELOPMENTAL TESTBED CENTER

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

August 2015 – HWRF v3.7a

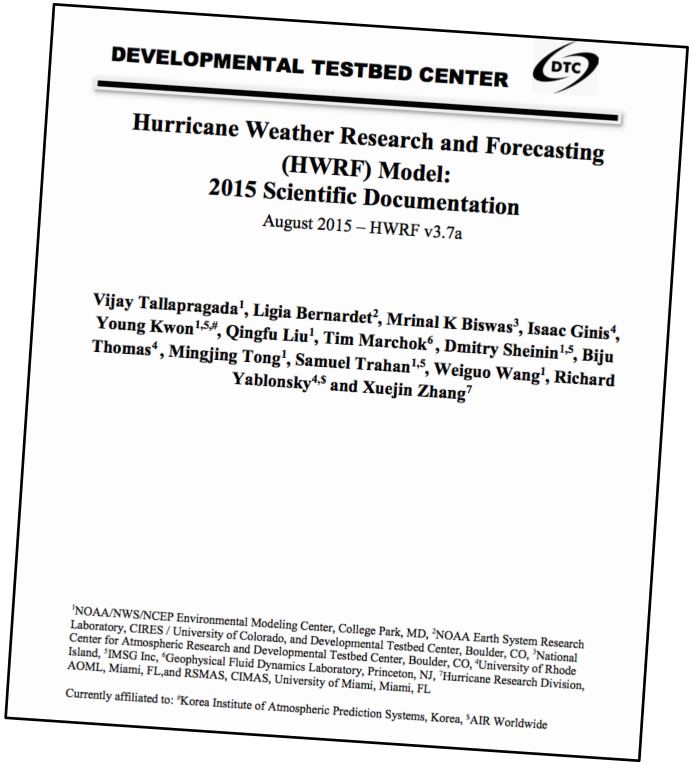
Vijay Tallapragada[1], Ligia Bernardet[2], Mrinal K Biswas[3], Isaac Ginis[4], Young Kwon[1,5,#], Qingfu Liu[1], Tim Marchok[6], Dmitry Sheinin[1,5], Biju Thomas[4], Mingjing Tong[1], Samuel Trahan[1,5], Weiguo Wang[1], Richard Yablonsky[4,$] and Xuejin Zhang[7]

[1]NOAA/NWS/NCEP Environmental Modeling Center, College Park, MD, [2]NOAA Earth System Research Laboratory, CIRES / University of Colorado, and Developmental Testbed Center, Boulder, CO, [3]National Center for Atmospheric Research and Developmental Testbed Center, Boulder, CO, [4]University of Rhode Island, [5]IMSG Inc, [6]Geophysical Fluid Dynamics Laboratory, Princeton, NJ, [7]Hurricane Research Division, AOML, Miami, FL,and RSMAS, CIMAS, University of Miami, Miami, FL

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



DEVELOPMENTAL TESTBED CENTER

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Currently affiliated to: [#]Korea Institute of Atmospheric Prediction Systems, Korea, [$]AIR Worldwide

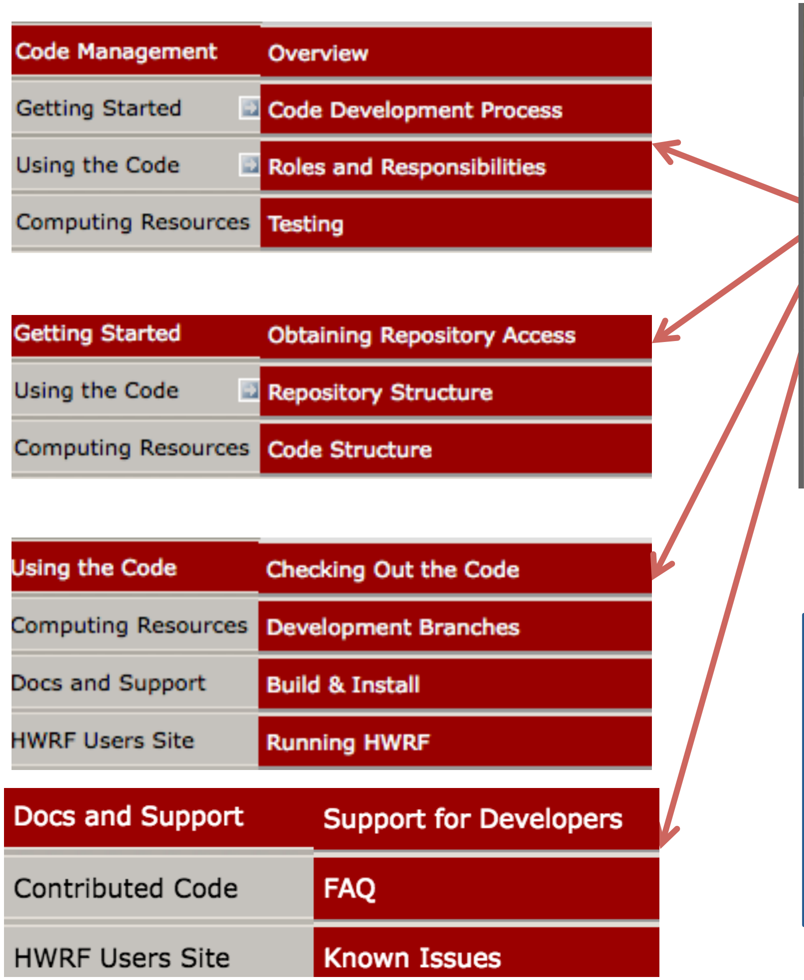
http://www.dtcenter.org/HurrWRF/users/docs/scientific_documents/HWRF_v3.7a_SD.pdf

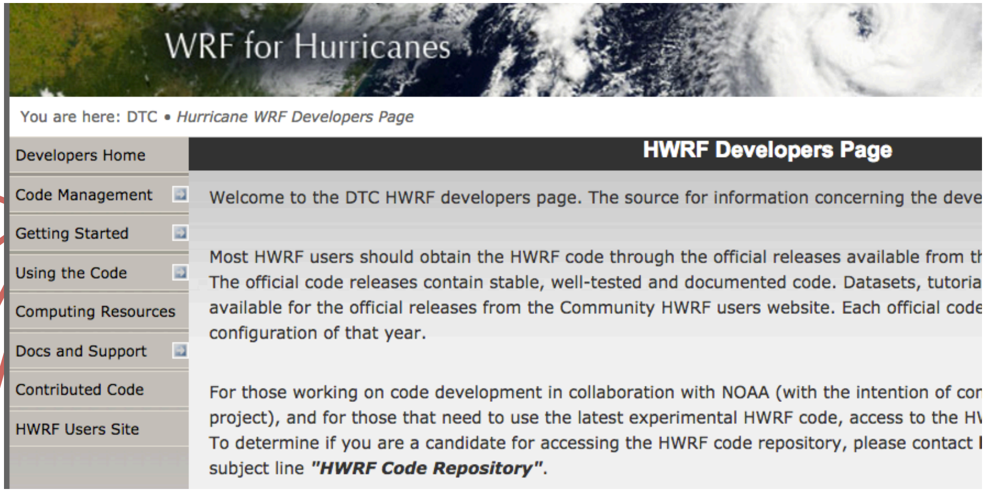
HWRF v3.7a User's Guide

- 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/developers

HWRF Developers Website





Welcome to the DTC HWRF developers page. The source for information concerning the deve

Most HWRF users should obtain the HWRF code through the official releases available from th
The official code releases contain stable, well-tested and documented code. Datasets, tutoria
available for the official releases from the Community HWRF users website. Each official code
configuration of that year.

For those working on code development in collaboration with NOAA (with the intention of cor
project), and for those that need to use the latest experimental HWRF code, access to the HV
To determine if you are a candidate for accessing the HWRF code repository, please contact I
subject line ***"HWRF Code Repository"***.

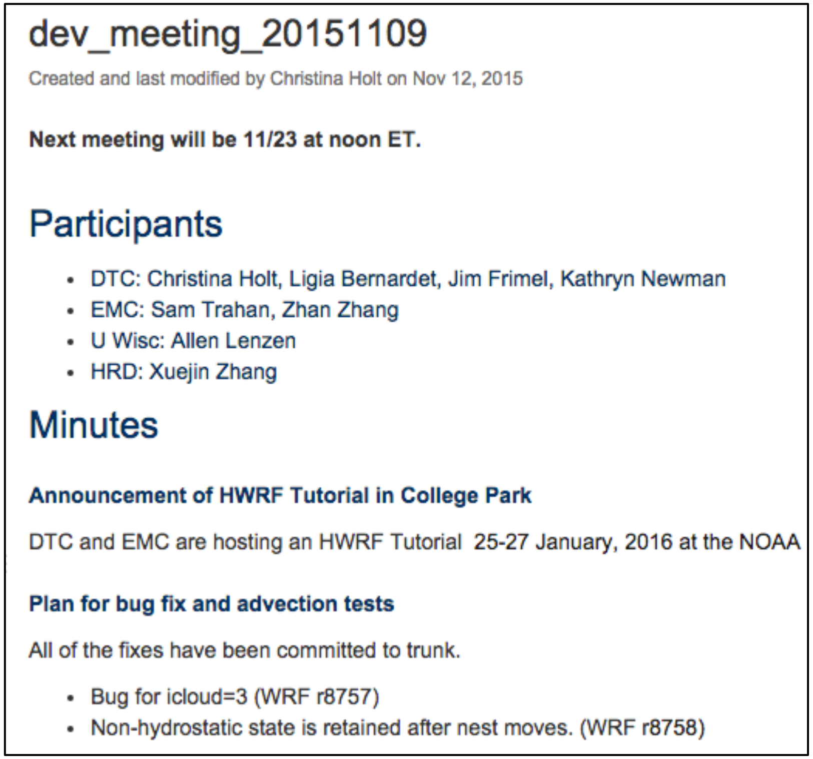
Information hub for all developers

Trainings offered in 2014:

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

Communications

- **HWRF Developers Committee**
  - All developers welcome to 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
  - 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.

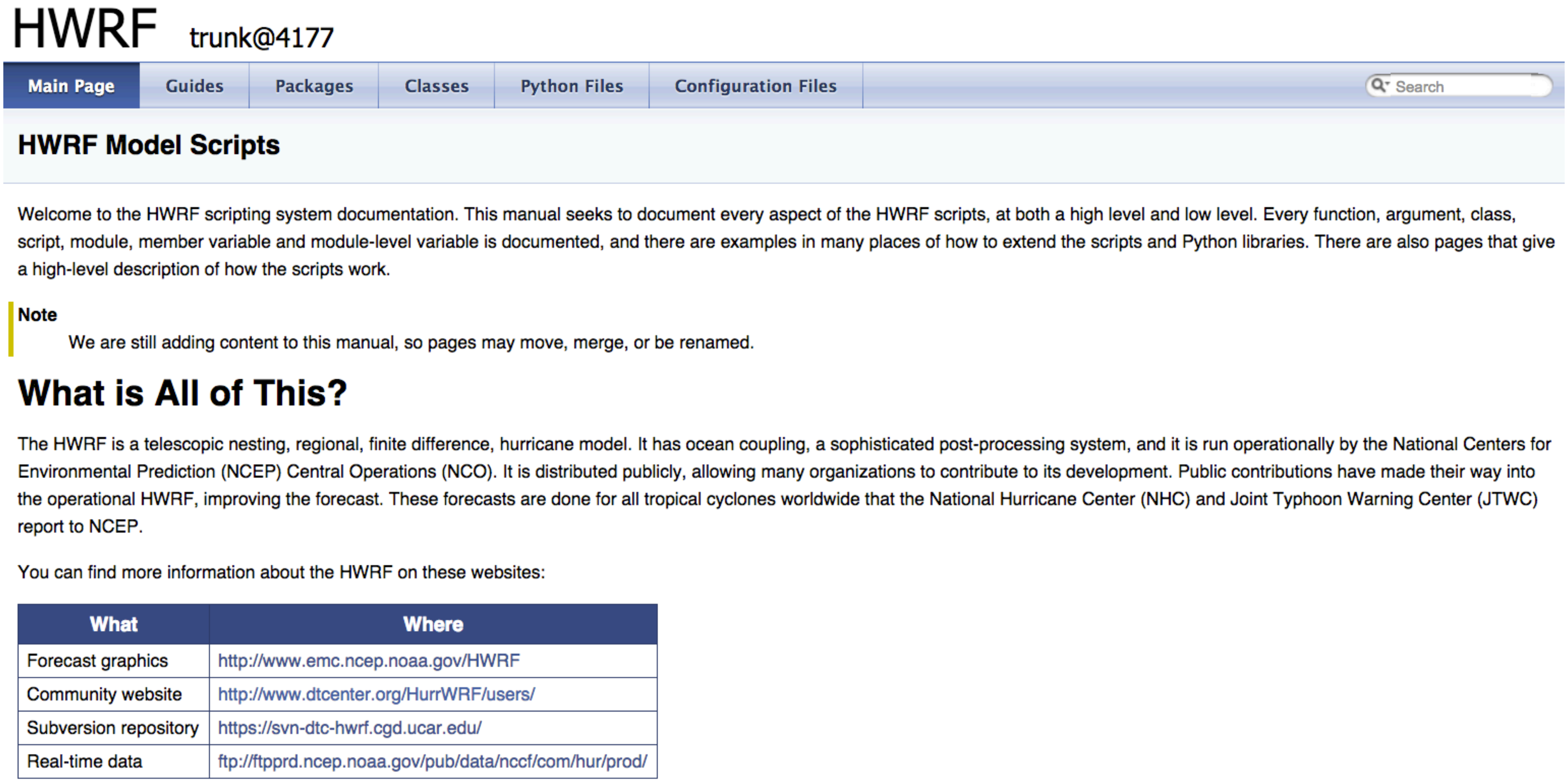
- Bug for icloud=3 (WRF r8757)
- Non-hydrostatic state is retained after nest moves. (WRF r8758)

EMC HWRF scripts documentation page

- What is doxygen?
- Scripting system documentation
  - Documents every aspect of the HWRF scripts (high and low level)
  - Every function, argument, class, script, module, member variable and module-level variable is documented
- Where?
  - http://www.emc.ncep.noaa.gov/HWRF/scripts/index.html
  - Generating the website:

```
svn checkout https://svn-dtc-hwrf.cgd.ucar.edu/trunk HWRF
cd HWRF/sorc/
make doc
cd ../doc
# copy the html/ directory to a web server
```

Doxygen



HWRF trunk@4177

HWRF Model Scripts

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?

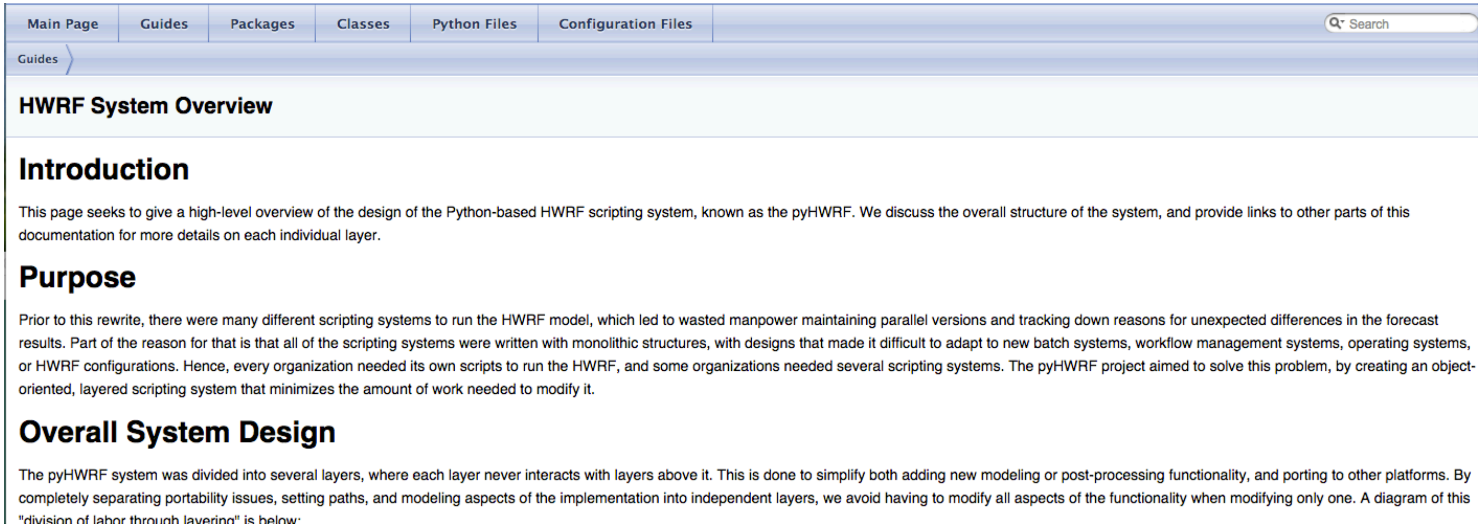
The HWRF is a telescopic nesting, regional, finite difference, hurricane model. It has ocean coupling, a sophisticated post-processing system, and it is run operationally by the National Centers for Environmental Prediction (NCEP) Central Operations (NCO). It is distributed publicly, allowing many organizations 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	http://www.emc.ncep.noaa.gov/HWRF
Community website	http://www.dtcenter.org/HurrWRF/users/
Subversion repository	https://svn-dtc-hwrf.cgd.ucar.edu/
Real-time data	ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/hur/prod/

Doxygen

- Configuring and running HWRF
  - HWRF configuration guide
  - HWRF Rocoto workflow
  - HWRF multistorm
- Developing the HWRF
  - Includes high level overview pages



HWRF System Overview

Introduction

This page seeks to give a high-level overview of the design of the Python-based HWRF scripting system, known as the pyHWRF. We discuss the overall structure of the system, and provide links to other parts of this documentation for more details on each individual layer.

Purpose

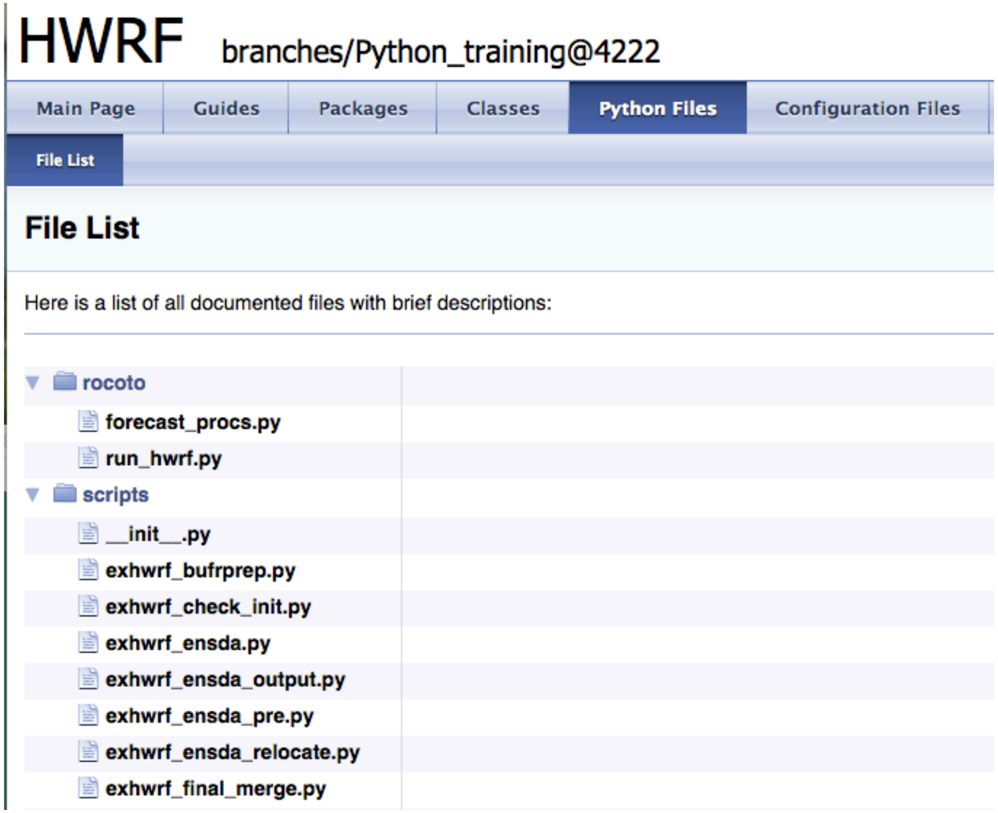
Prior to this rewrite, there were many different scripting systems to run the HWRF model, which led to wasted manpower maintaining parallel versions and tracking down reasons for unexpected differences in the forecast results. Part of the reason for that is that all of the scripting systems were written with monolithic structures, with designs that made it difficult to adapt to new batch systems, workflow management systems, operating systems, or HWRF configurations. Hence, every organization needed its own scripts to run the HWRF, and some organizations needed several scripting systems. The pyHWRF project aimed to solve this problem, by creating an object-oriented, layered scripting system that minimizes the amount of work needed to modify it.

Overall System Design

The pyHWRF system was divided into several layers, where each layer never interacts with layers above it. This is done to simplify both adding new modeling or post-processing functionality, and porting to other platforms. By completely separating portability issues, setting paths, and modeling aspects of the implementation into independent layers, we avoid having to modify all aspects of the functionality when modifying only one. A diagram of this "division of labor through layering" is below:

Doxygen

- Includes Guides
  - Installing, configuring, running HWRF, scripts overview
- Packages
- Classses
- Python Files
- Configuration Files



File List

Here is a list of all documented files with brief descriptions:

- rocoto
  - forecast_procs.py
  - run_hwrf.py
- scripts
  - __init__.py
  - exhwrf_bufrprep.py
  - exhwrf_check_init.py
  - exhwrf_ensda.py
  - exhwrf_ensda_output.py
  - exhwrf_ensda_pre.py
  - exhwrf_ensda_relocate.py
  - exhwrf_final_merge.py

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 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.

Questions?