

# NCEP Hurricane Modeling: HWRF 2016 Upgrade Plans

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# Overview

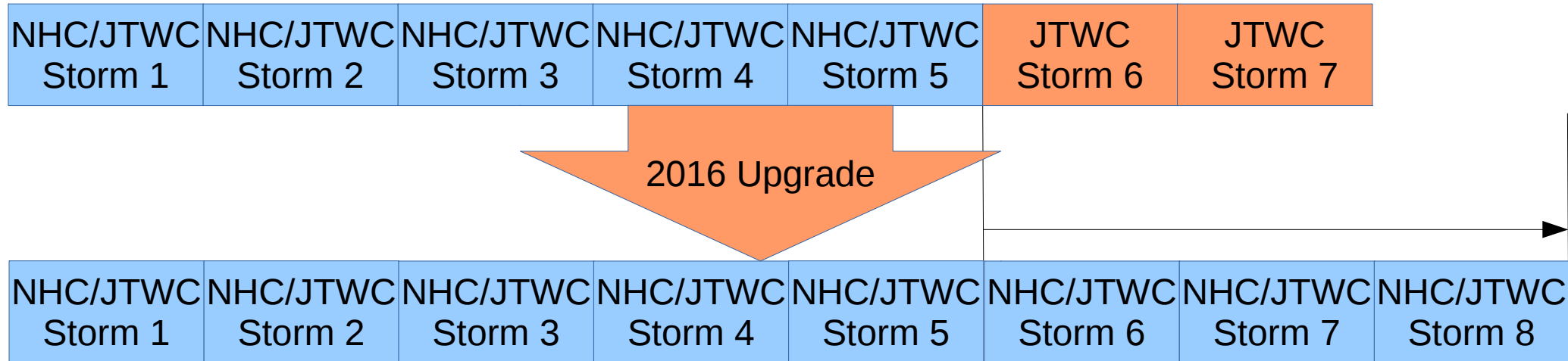
- Upgrades
- Test Plan

# 2016 HWRF Upgrades Overview

*Blue* Upgrades are Mandatory

- *NHC Eight Storm Support*
- Atmospheric Dynamics
  - *30s timestep*
  - *non-hydrostatic “sanity fix”*
- Data Assimilation
- Ocean/Wave Coupling
  - Ocean coupling for all storms
  - Improved POM initialization OR HyCOM coupling
  - Wavewatch 3 Coupling
- Physics Parameterizations
  - *icloud=3 bug fix*
  - New or improved parameterizations
- Output Products

# Eight Storm Support Requested by NHC



- NHC/CPHC storms have higher priority.
  - 2016 upgrade: NHC/CPHC can use all eight slots, pushing out JTWC
- JTWC will have no slots if NHC reports eight storms/invests
  - JTWC slots handle Guam and NWS Pacific responsibilities.
  - CPHC shares NHC slots so Hawaii storms are covered.
- **Storm Choices require a human (forecaster) decision if nstorms > 8.**

# Dynamics

## 30s Atmospheric Outer Domain Timestep

- Current outer domain timestep:
  - AL/EP/CP:  $38\frac{4}{7}$  s - needed to finish in 96 min with 61 levels
  - Elsewhere:  $33\frac{3}{4}$  s - needed due to strong WP/IO storms
- Problem:
  - >80 m/s winds sustained for a day or more can crash model with  $38\frac{4}{7}$  s timestep, even over ocean with coupling
- Solution:
  - 30s timestep in all basins** can handle any possible storm
- Added bonuses:
  - Physics, dynamics more frequent.
  - All interesting periods are divisible by 30 seconds.

# Dynamics

## Non-Hydrostatic “Sanity Fix”

- 2004-2015: **Non-hydrostatic state is discarded when the nest moves.**
  - $w$  and  $dw/dt$  gone
  - Huge shocks in MSLP, small shocks in 10m wind
  - Bigger problem at higher resolution.
  - Historically, this was needed to keep the model stable.
- **Fix: retain state except near nest boundaries.**
  - No shock, but still lose  $w$ ,  $dw/dt$  near boundary.
  - Will investigate retaining near boundary too.
- **May also need 30s timestep** for some cases.

# Data Assimilation

## CP Support Doable but not WP Yet

- There have been inquiries about assimilating data in storms near Hawaii and Guam to support flights through high-priority storms.
- **Could add Central Pacific data assimilation when inner core observations are present.**
  - **Requires dataflow modifications (including header information).**
- Cannot do West Pacific DA by 2016.
  - West Pacific DA support is highly experimental.
  - Can be considered for 2017 subject to funding.
  - May need to add more WP-area observations (MTSAT, FY, etc.).

# Data Assimilation

## ENSDA Upgrades

- **ENSDA for all cycles (even without TDR)**
  - All AL/EP cases.
  - Will consider CP cases subject to further testing.
- GFS ENKF analysis vortex sometimes far from right location
  - Errors of >100km seen.
  - Can have huge impact on data assimilation.
- **Add jobs to relocate GFS ENKF vortex.**



# Ocean/Wave Upgrades

## Improved MPIPOM-TC Initialization

- HWRF/GFDL MPIPOM-TC model ocean initialization uses GDEM climatology that has dubious value in current East Pacific climate.
  - **RTOFS initialization** can provide up-to-date state
    - Daily ocean model 192hr forecast.
    - Based on current ocean conditions.
  - **No code or script yet provided by URI.**
  - **Requires developments to complete in the next few weeks**

# Ocean/Wave Upgrades

## HYCOM Ocean Coupling

- Alternative to POM, similar model to RTOFS
  - **HYCOM lacks POM's super-cooling issues in EP.**
  - Widely-used community ocean model
  - **Well-tested with HWRF** coupling (~7 years)
  - Past years' tests had weak bias, minor track degradation.
- Recent results
  - Much **improved intensity in strong EP storms**
  - Little effect on track
  - Will do a larger-scale test over the next few weeks.

# Ocean/Wave Upgrades

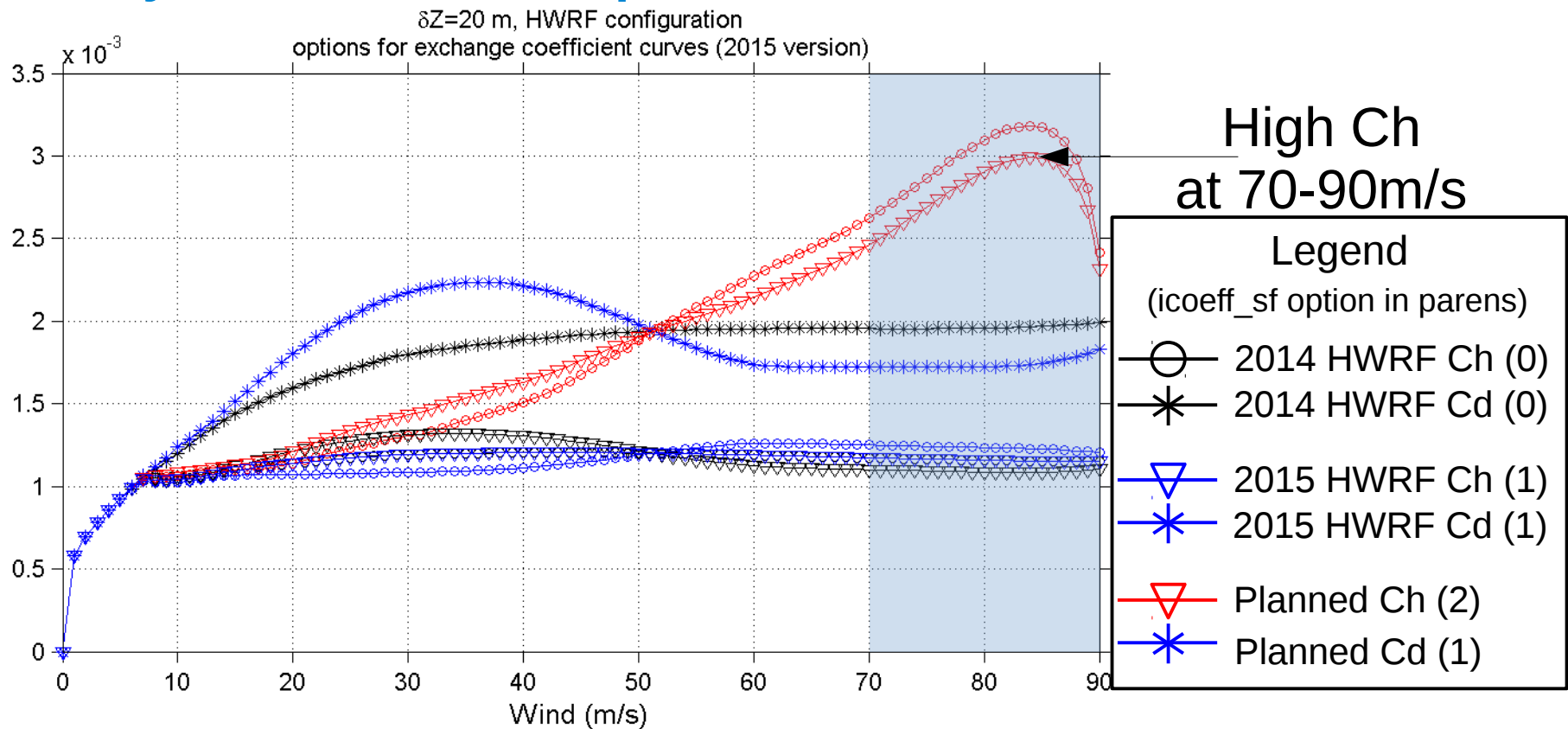
## Wavewatch 3 (WW3) Coupling

- Allows wave forecasts from HWRF
  - **First step to merging the NCEP HWRF and Hurricane Wave models into a single forecasting model.**
- Improves representation of drag on atmospheric winds
- One-way coupling is well-tested, can be implemented in 2016 (unification of hurricane waves into HWRF)
- **Waiting on URI for two-way code and documentation**
  - Two-way code not yet provided, one-way provided without documentation or even basic code commenting.
  - URI has ignored requests for documentation of cryptic, uncommented code they added to WRF and WW3.
  - **Lack of documentation prevents EMC from picking up the project where URI left off.**

# Physics Upgrades

## Improved Ch Rejected in 2015

- Improved match to observations in 10-60 m/s region.
- **Some Cat 5 storms became 100m/s hypercanes.**
- Will investigate 70-100m/s region and retry.
  - **May need worldwide ocean coupling**
  - **May need 30s timestep**



# Physics Upgrades

icloud=3 bug fix

- Bug in partial cloudiness scheme:
  - Cloud water added to subsaturated regions every 15-18 minutes and evaporates or rains out quickly.
  - Consequences on forecast is unknown.
  - **Bug invalidates past convection and advected microphysics experiments.**
- The fix:
  - False cloud water exists only during radiation timesteps to allow partial cloudiness in RRTMG, as intended.
  - **New H215 control run is being done with this and the non-hydrostatic “sanity fix.”**

# Physics Upgrades

Microphysics: Thompson or Advected F-A

- Two candidates:
  - **Thompson scheme OR**
  - **Advected version of Ferrier-Aligo scheme**
    - Same as current scheme, but advect:
      - Species: QI, QC, QR (QS was always unused, set to 0)
      - $QRIMEF = F\_rimef * QI$
    - CWM is a diagnostic variable.
- Past experiments invalidated by icloud=3 bug.
  - **Will re-test against H215 rerun with fixes.**

# Physics Upgrades

## Inner Domain Convection

- Options:
  - **Grell-Freitas** (GF) convection scheme in all domains
  - **Scale-aware SAS** in all domains (NOT MesoSAS)
- **Still waiting on Grells to provide GF code.**
  - Current version does not work with HWRF
- Will retest based on H215 rerun with fixes.

# Physics Upgrades

## Modified 2015 GFS PBL Scheme

- Unmodified 2015 GFS PBL has huge weak bias.
- Added wind-dependent alpha from 2015 HWRF.
  - Validated against observations (HRD, NHC)
    - **Questions remain about 10m wind vs. 500m wind.**
    - Same problem in 2012-2015 operational HWRF models.
  - **Results similar to current HWRF PBL**
  - No increase in runtime or memory use.
- Using latest code makes maintenance easier.
- 11 years newer but provides no improvement in skill.
- **Results suggest we need to investigate alternative PBL and surface layer options for 2017. That is a large project.**



# Product Upgrades

## HWRF in AWIPS2

- AWIPS:
  - AWIPS version 1 could not handle moving grids
  - AWIPS version 2 may have sufficient support.
- NCO gathering list of requested fields.
- EMC may add new grid or fields to match.
- **Planning AWIPS support when 2016 HWRF goes live in June 2016.**
  - **Mainly contingent on NCO's workload** as most of the work will be theirs.

# Product Upgrades

## Vortex Tracking

- **GFDL Vortex Tracker upgrade**
  - Will fix rare problems with losing small, strong storms.
  - HWRF vortex following algorithm upgrade to match
- Possible new 3-domain storm-following GRIB to support AWIPS will also be on COM and FTP.
  - Same grid as tracker input.

# Product Upgrades

## Sustained and Gust Wind Swath

- 30 second timestep allows 60 second sustained wind calculations.
- Code will calculate for every gridpoint, every timestep:
  - Wind gusts.
  - One minute sustained 10m wind.
- Outputs:
  - **Two wind swaths on website: gust, sustained**
  - New model-generated track

# Product Upgrades

## Model-Generated Track and Intensity

- NHC-EMC collaboration
  - Generate intensity from high-frequency information in the model (sustained wind).
  - Generate track from 3 minute location information.
  - **Solves problems of small features not representative of the vortex dominating storm intensity.**
  - Must be run inside model.
  - Similar algorithm to GFDL Vortex Tracker.
- **Will be provided as alternative ATCF track.**
  - GFDL Vortex Tracker still used for official track.

# 2016 T&E Plan Summary

	Sensitivity Tests	GFS Upgrade	Infrastructure Upgrades (Baseline)	Physics Upgrades	Wave Model	Final 2016 HWRF Test	Operational Transition
	Multiple	H16Z	H16B	H16P	H16W	H216 (EMC)	H216 (NCO)
Detail	Old GFS Various HWRF sensitivity tests	New GFS Old HWRF with minimal bug fixes	New GFS HWRF with infrastructure upgrades. May have MP upgrade.	All physics upgrades	Wave coupling included	Final HWRF config	NCO runs parallel of fake storms to test dataflow. Customers verify. Repeat until approval.
Cases	Limited Storms 2011-2015	2013-2015 Mostly AL/CP/EP	2013-2015 Mostly AL/CP/EP	2013-2015 Mostly AL/CP/EP	2013-2015 Storms of wave interest	2013-2015 All Bains	Fake Storms
Platforms	WCOSS Jet/Theia	Luna/Surge Jet	Luna/Surge Jet	Luna/Surge Jet	Luna/Surge Jet	Luna/Surge Jet	Luna/Surge (NCO)
Dates	2015 June-Dec	2016 Jan-Feb	2016 Jan-Feb	2016 Jan-Feb	2016 Jan-Feb	2016 Mar-June	2016 May

# 2016 HWRF

## Worst Case Resource Requirements Per Cycle

	2015 HWRF	2016 HWRF
COM Output	260 GB	620 GB (8 storms)
Forecast Window	3816 cores	9600 cores
ENSDA Window	1920 cores, 30 min	3840 cores, 120 min
Initialization	2200 cores	3160 cores
FTP Size	70 GB	90 GB
AWIPS	- nothing -	8 Storms
COM Input	200 GB	400 GB (RTOFS added)

# Resource Issues and Concerns

- Transition of HWRF to Cray (Luna and Surge)
- GFS Upgrades are not planned for implementation until May 2016
- Planned upgrade components require allocation of production resources (including 8<sup>th</sup> storm capability)
- Requires close collaboration with NHC, DTC, URI and others for evaluation of pre-implementation tests
- Time is running out for including HFIP supported research contributions that can transition to operations

# Test Plan

## Sensitivity Tests (Jun-Dec 2015)

- Sensitivity Tests (~200-400 cases)
  - Operational (2015) GFS
  - New control: H215 with fixes (running now)
  - New POM Init vs. HyCOM Coupling
  - Thompson vs. Advected F-A
  - ENSDA Relocation
  - Timestep and products
  - Operational (2016) GFS
- Order of tests may change.
- Will use all NOAA clusters where we have resources.



# Test Plan

## Pre-Implementation Phase (Jan-Feb 2016)

- **Larger tests run on WCOSS Cray Luna/Surge and Jet as needed**
  - With new (2016) GFS and new (2016) RTOFS
  - 2016 RTOFS may have been run on 2015 GFS, but hopefully 2016.
  - **Only limited GFS data will be available, restricting storm selection.**
- **Baseline:**
  - Chosen ocean model, DA configuration, output products.
  - May or may not have new microphysics.
- **“No Upgrade” test:**
  - 2015 HWRF with bug fixes run with new GFS/RTOFS
- **Physics test:**
  - All physics upgrades, including microphysics if not in baseline
- **Wave test:**
  - Wave coupling with chosen ocean model.
  - May be merged with physics test.

# Test Plan

## Final Retrospective (Mar-Jun 2016)

- **Mar-Jun: Final HWRF Retrospective**
  - Parent models:
    - **Uses the final GFS retrospectives and**
    - **RTOFS retrospectives run on the GFS retrospectives.**
  - Large test
    - All baseline cases
    - “IT test” cases to validate model technical capabilities
    - Any cases requested by forecasters.
    - At least three storms in each basin: A, B, C, E, L, P, S, W
  - Run on WCOSS Cray Luna/Surge, use Jet as needed
  - **2016 Hurricane Wave model tested on output**
  - Native output archived (all model components)

# Test Plan

## Implementation Phase (Jan-May 2016)

- Jan-Feb: **New “IT test” method developed, as discussed with NCO in June.**
  - **Resolves problems that arise from the lack of an operational parallel that non-hurricane models have.**
- Mar-Apr: EMC runs new “IT test” method
  - Automated system makes NHC, JTWC storm files.
  - Automated setup\_hurricane merges them.
  - Run on real-time GFS data.
  - ecFlow-based workflow runs HWRF.
  - EMC real-time website plots output.
  - Results are validated for correctness.

# Test Plan

## Implementation Phase (Jan-May 2016)

- April 1 code handoff as previously agreed.
- Apr-May: **NCO runs new “IT test” method**
  - Use real-time RTOFS and GFS data.
  - AOC and HRD send test flag and TDR data in EP&AL
    - and CP if support is desired
  - **Output sent to paranomads, com, HPSS, AWIPS2**
  - Includes downstream NCEP Hurricane Wave Model
  - **All interested parties evaluate.**

- **Process is repeated until approval.**
- **Critical to avoid past technical glitches like one month of missing archives, or JTWC not receiving tracks.**

# Test Plan

## HWRF Upgrade (June 2016)

- **June 1, 2016 HWRF Upgrade**
  - Probable HWRF AWIPS2 Availability
    - **If AWIPS2 is not yet ready for HWRF in June, HWRF will upgrade anyway, and AWIPS2 support will be added later in the season.**

