NGGPS Ocean/Waves/Sea Ice Projects

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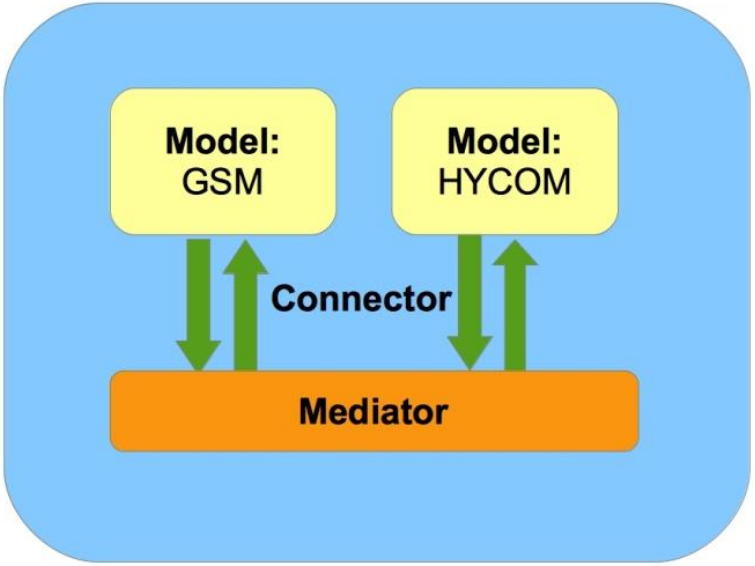
Outline

- EMC Ocean Projects (3)
- EMC Wave Projects (2)
- Other Internal/External Projects (2)
- Major Accomplishments
- Priority Focus for 2016
- Primary Needs

EMC: HYCOM in NEMS

- EMC Software Engineer/Scientist (1 FTE Supported by NGGPS)
- Collaborators : Cecelia's Group; NRL – Alan Wallcraft;
- Work Completed
  - A NUOPC cap for HYCOM using ESMF calls
  - HYCOM running coupled to GSM (GFS) in NEMS
  - HYCOM added to UGCS seasonal
- Work in progress
  - Testing 3-way coupling with GSM-HYCOM-CICE
- Deliverables (end of year)
  - HYCOM running in NEMS in a 3-way coupled GSM-HYCOM-CICE system for UGCS

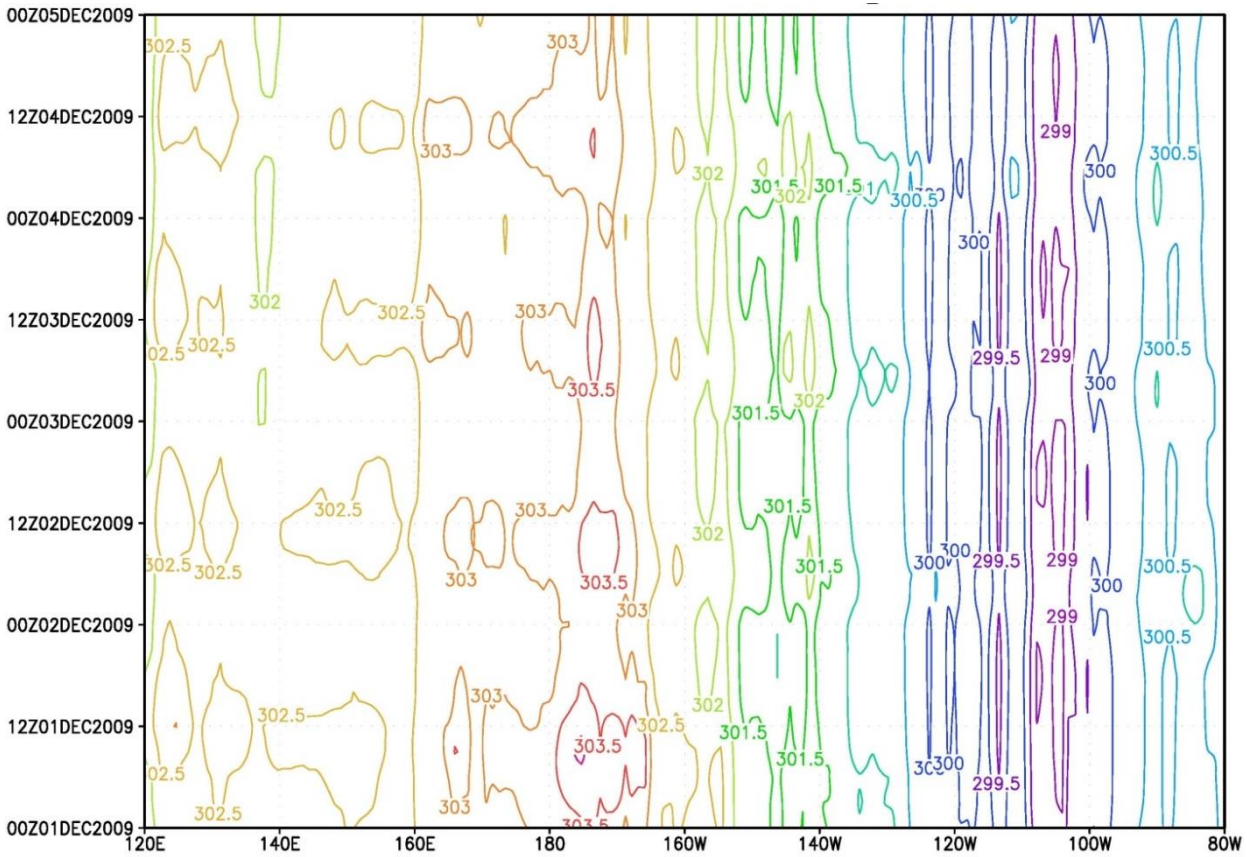
EMC: HYCOM in NEMS



- GSM uses the global Gaussian T126 grid
- HYCOM uses the global 0.24 degree tri-polar grid
- Coupling time interval between Mediator (coupler) and HYCOM: 2 hours
- Coupling time interval between Mediator (coupler) and GSM: 1 hour
- Length of run: 4 days

EMC: HYCOM in NEMS

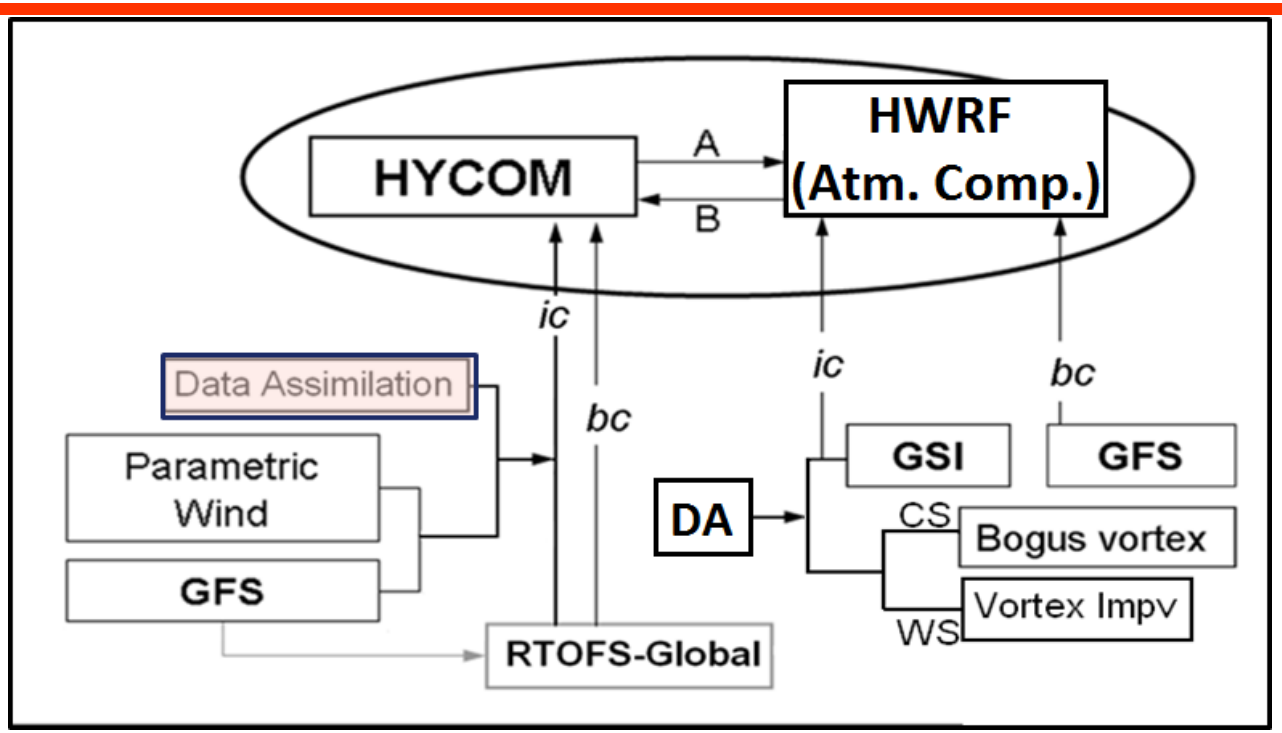
SST along 3ºN



EMC: HYCOM-HWRF Coupling

- EMC Software Engineer (1 FTE supported by NGGPS)
- Collaborators : URI, AOML
- Work Completed
  - Porting of HYCOM running scripts to HWRF infrastructure (in Python)
  - A robust initialization procedure for the coupled system
- Work in progress
  - Ongoing real time testing of the coupled system in real-time
  - Investigate 3-way coupling with WaveWatch III®
- Deliverables (end of year)
  - Operationally ready HYCOM-HWRF coupled system for all basins targeted for 2017 HWRF upgrade

EMC: HYCOM-HWRF Coupling



Exchange Variables

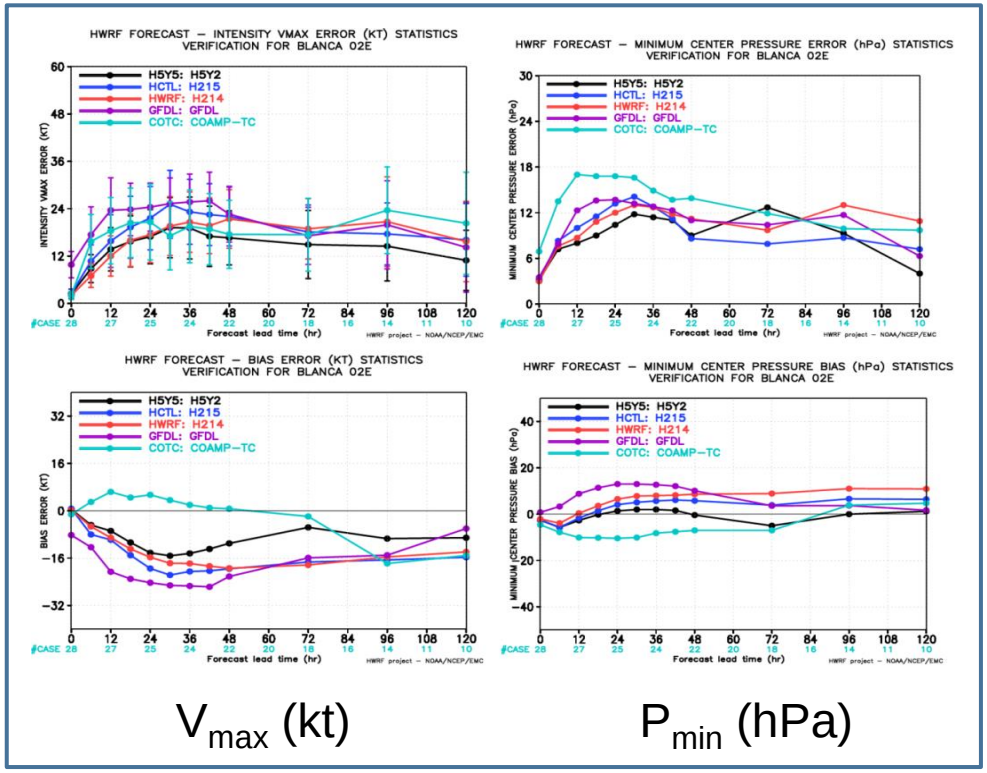
A: Sea surface temperature (SST)

B: 1. Precipitation
2. Atmospheric pressure
3. Heat fluxes
4. Wind stress

ic = initial Conditions
bc = boundary conditions
CS/WS = cold/warm start
DA = data assimilation
GFS = Global Forecast System
GSI = Gridpoint Statistical Interpolation

EMC: HYCOM-HWRF Coupling

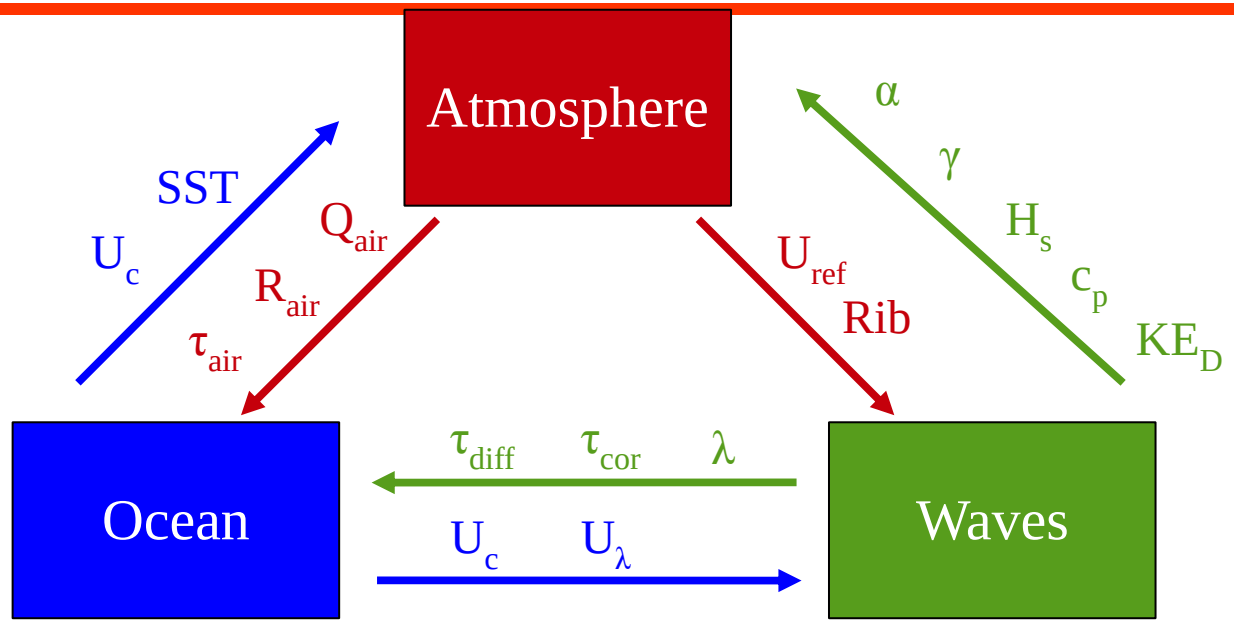
Hurricane Blanca (2015): Intensity Forecast Verification



V_{max} (kt) P_{min} (hPa)

2015 HWRF coupled to HYCOM performs best for early lead hours, cf POM coupling, H214 and other non-HWRF's, as much as 12 kt (12h cf GFDL) or 11 hPa (12h cf COTC).

A 3 way coupled modeling system



Hurricane model air-sea fluxes depend on **sea state, sea spray**, and include **surface current**.

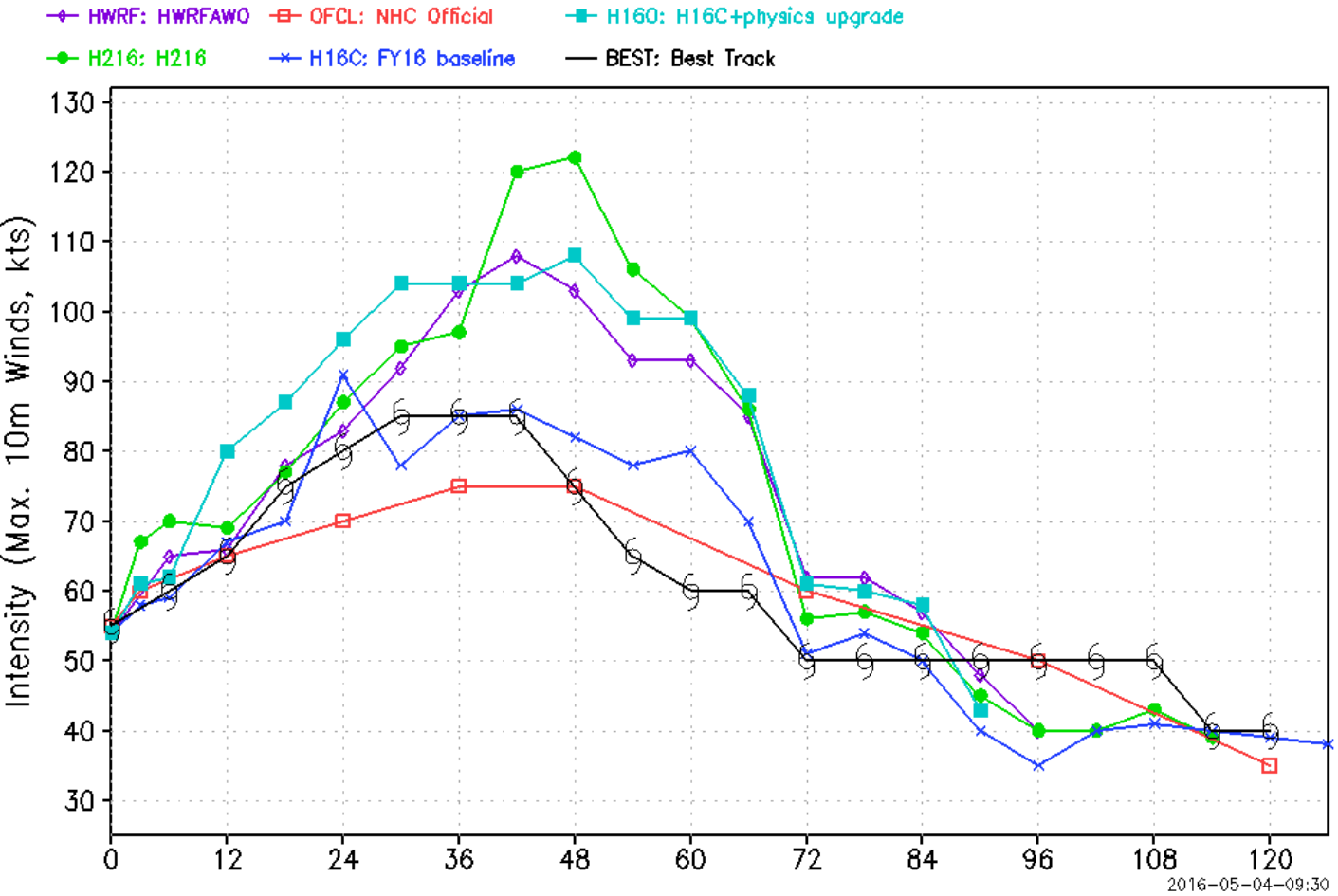
Wave model forced by **sea state** dependent **wind** forcing and includes **surface current.**

Ocean model forced by **heat flux**, sea state dependent **wind stress** modified by **growing or decaying wave fields and Coriolis-Stokes effect.** Turbulent mixing is modified by the Stokes drift (**Langmiur turbulence**).

ctsy: URI Team

Operational HWRF: TC Intensity Vmax

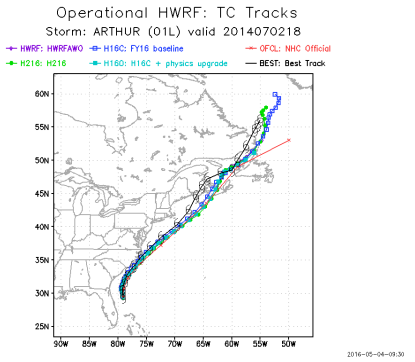
Storm: ARTHUR (01L) valid 2014070218



Coupled

Uncoupled

Official



ctsy: HWRF Tea

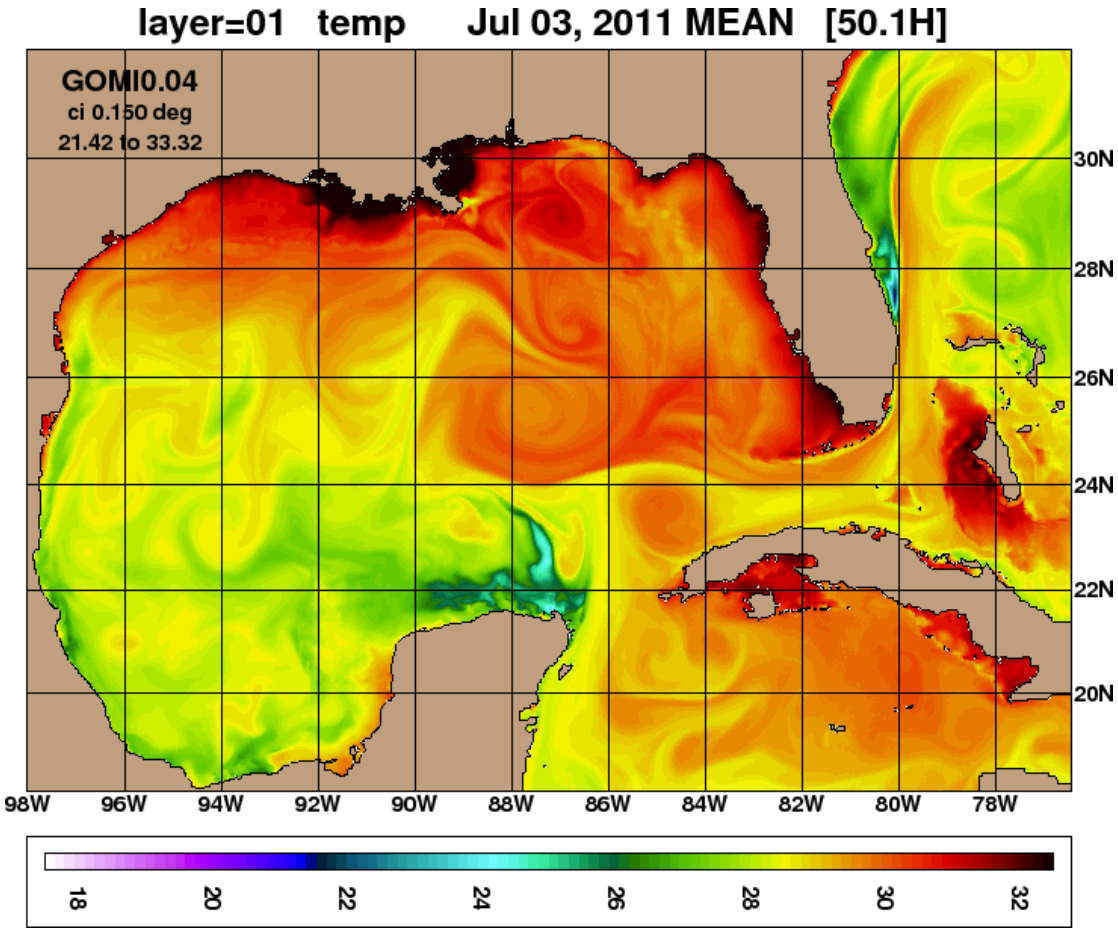
EMC: NCODA (Navy Coupled Ocean Data Assimilation)

- 2 FTEs (supported by NGGPS)
- Collaborators : NRL, NAVOCEANO
- Work Completed
  - Porting of NCODA codes for Quality Control and Variational Data Assimilation on NWS compute systems
  - Set up of a regional Gulf of Mexico HYCOM 1/24^{o} model as a test bed for end to end testing for the full system
- Work in progress
  - Testing of 2D and 3D variational data assimilation of SST, SSH and T-S vertical profiles using canned data sets
  - Adopting NCODA QC procedures to NCEP data streams including updating NCEP data streams to satisfy NCODA QC code requirements
  - Drive the HYCOM model with the analysis fields using an incremental sequential update cycle
- Deliverables (end of year)
  - End to end data assimilation cycle for the Gulf of Mexico using canned data sets
  - Near real time GOM assimilation system using NCEP data streams

EMC: NCODA (Navy Coupled Ocean Data Assimilation)

- Deliverables (end of next year)
  - An end to end data assimilation system for the global model
  - A near real time data assimilation system for the global model and use it to drive the forecast system
- Future Plans
  - Transition to operations after extensive validation

EMC: NCODA (Navy Coupled Ocean Data Assimilation)



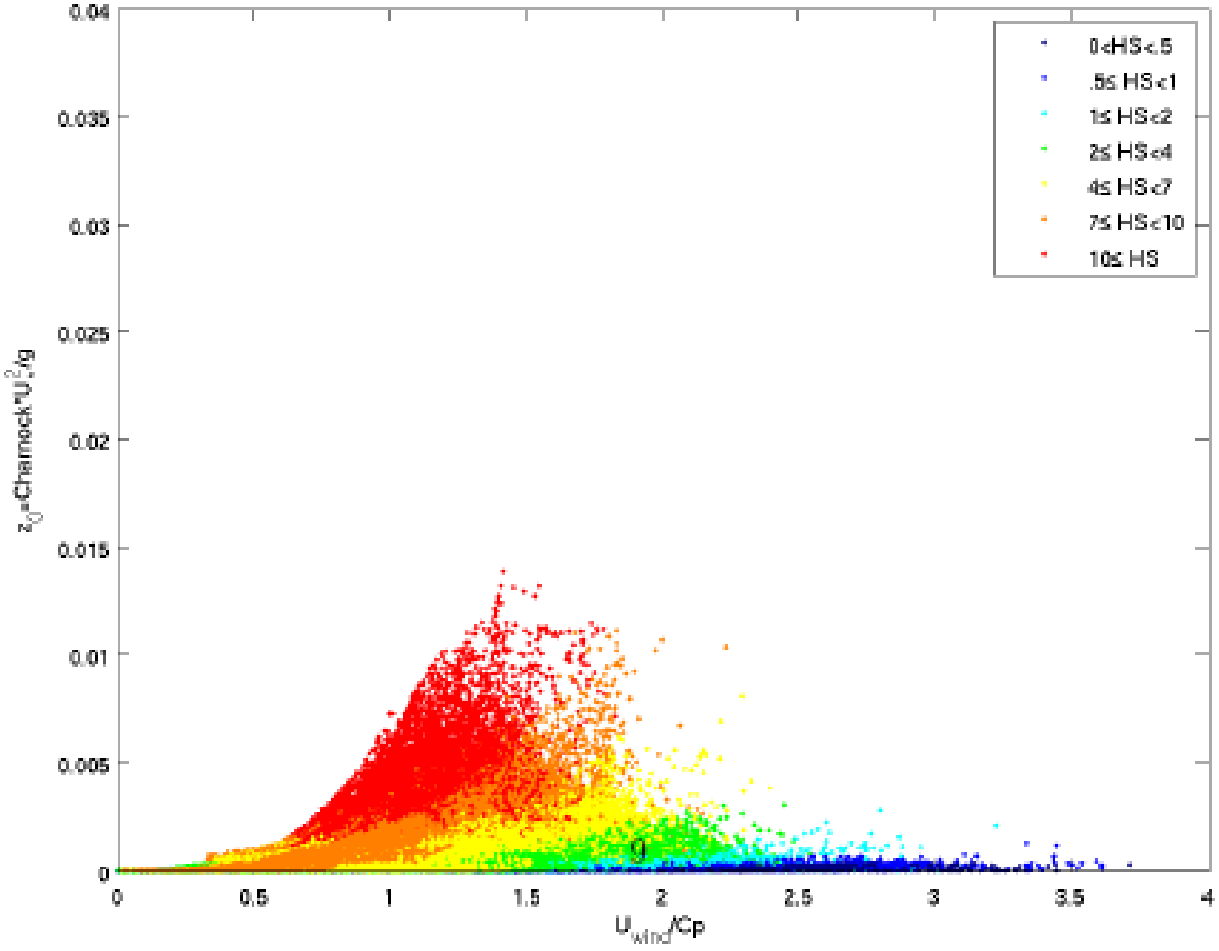
EMC: Waves in NEMS

- EMC Software Engineer/Scientist (1 FTE Supported by NGGPS)
- Collaborators : NRL – Tim Campbell ; Cecelia's Group
- Work Completed
  - A NUOPC cap for the WAVEWATCH III model using ESMF calls
  - WAVEWATCH III model running one way coupled to the UGCS seasonal system
- Work in progress
  - Adding the WAVEWATCH III model to the NEMS weather application
  - Building and testing the sea state dependent drag formulation feedback on GSM
- Deliverables (end of year)
  - Having the wave model run in the UGCS system one way (wave model driven with atmospheric model)
  - Build the feedback coupling from the wave model to the atmospheric model (sea state dependent drag formulation)
  - Develop the processes for ocean coupling in the NUOPC cap for WAVEWATCH III (Stokes drift based mixing)

EMC: Waves in NEMS

- Deliverables (end of next year)
  - Build the connections between the wave model and the ocean model
    - From the ocean model – currents averaged over wave representative depth
    - From the wave model – Stokes drift for wave induced Langmuir mixing, wave length for peak frequency (to provide representative depth)
    - Variables needed to parametrize wave induced mixing in ocean models are already being computed in the wave model, and both MOM6 and versions of HYCOM have developed wave induced mixing parametrizations.
  - Have a two – way coupled wave atmosphere model for weather applications
- Future plans
  - Build ocean – wave –atmosphere coupled systems for global, regional and hurricane applications
    - Global development is currently under way for UGCS application
    - A coupled hurricane system (and associated physics packages) has been developed in partnership with URI using an in house NCEP coupler (will be transitioned to NEMS). Extensive testing will happen this year
    - Planning talks have begun to couple waves model (in unstructured grid formulation) with atmospheric and circulation models (like FVCOM)

Sea state dependent drag – Bottom Roughness



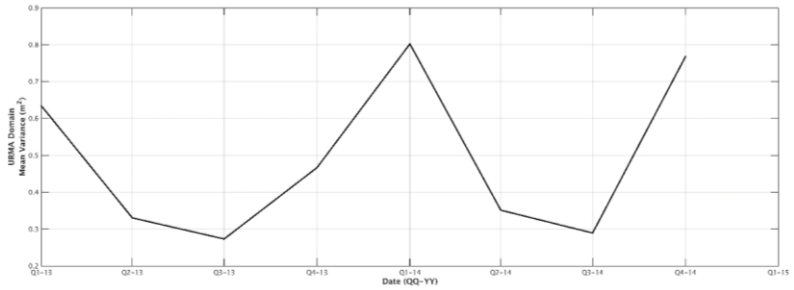
EMC: Wave Data Assimilation

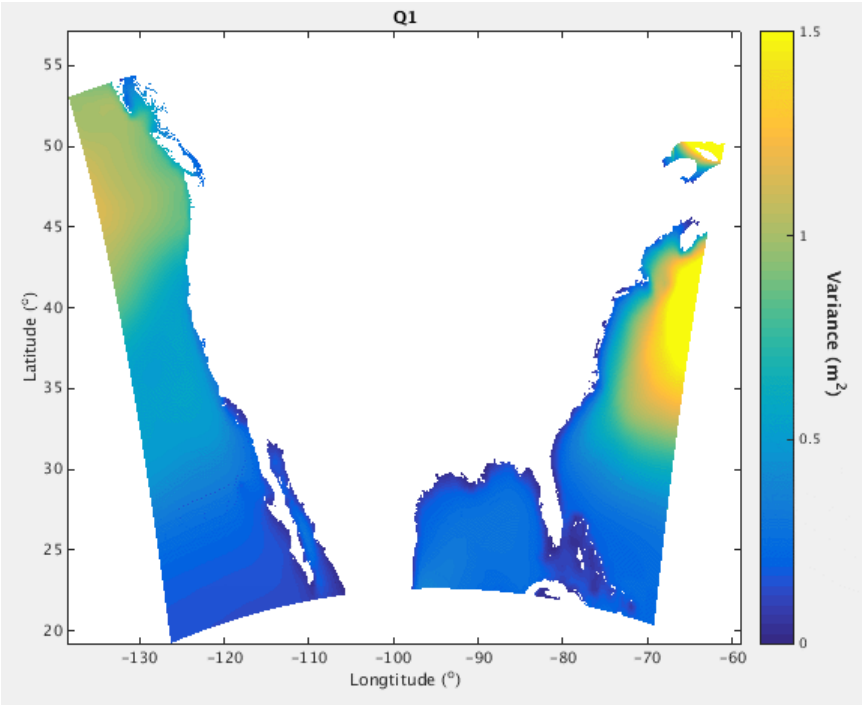
- EMC Scientist (1 FTE supported by NGGPS)
- UMD collaboration : Steve Penny (leveraging with work for the coupled DA for the climate system ; other proposed research ideas to improve skill scores beyond week 2)

- Deliverables
  - An analysis of wave fields as part of RTMA ~ FY16
  - An LETKF based DA system for wave model ~ FY17 (prototype will be tested with the UGCS DA project)
  - A GSI based variational system for deterministic system ~ FY17

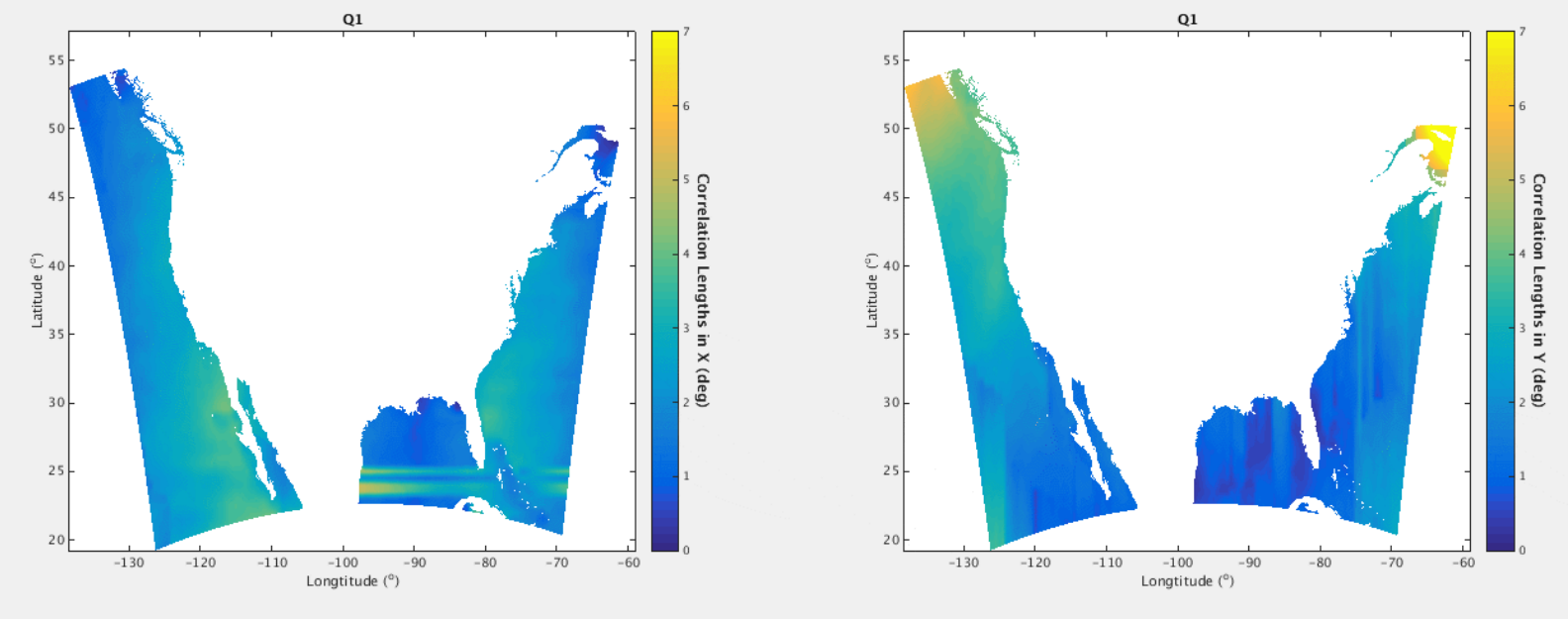
CONUS : Variance

Mean Variance for CONUS





CONUS : Correlation Lengths in X- and Y-direction



Local Phenomena

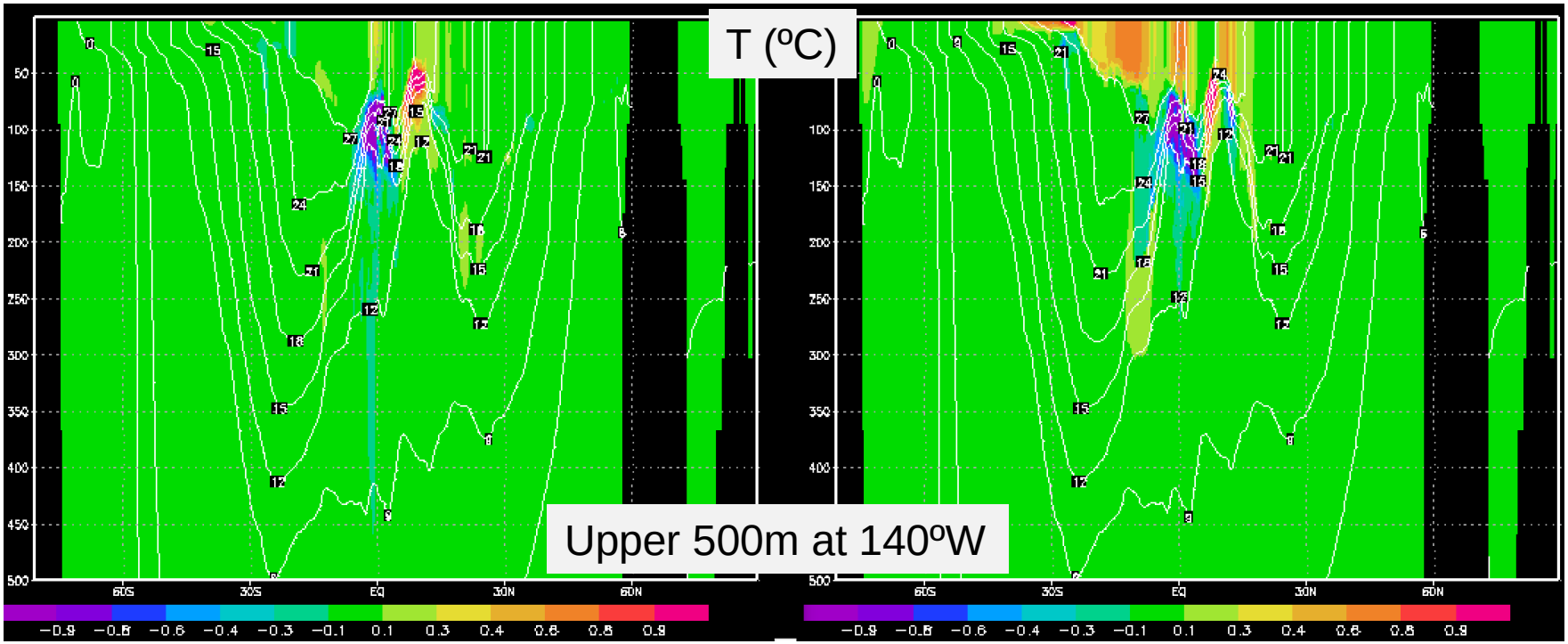
Near the equator the variance has lower values but the correlation lengths in both directions are longer.

UMD: Ocean-LETKF Software Development

- Lead PI: Prof. Steve Penny
- Collaborators: EMC, CPC, NASA GMAO, NRL-SSC, INCOIS (India), and INPE (Brazil)
- Multiple independent Ocean-LETKF data assimilation systems have been merged into a **single** codebase with support for: MOM4p1, MOM5, MOM6, HYCOM, and ROMS.
- Major performance improvements: from ~8-10 minute analysis step down to ~45 seconds on 256 cores.
- Codebase available on Github.com repository for restricted access: https://github.com/UMD-AOSC/Ocean-LETKF

UMD: Ocean-LETKF Software Development

- L2 SST Assimilation (Pathfinder) – ANALYSIS INCREMENT projected into mixed layer via analysis weights:



Temperature and Salinity Profiles Only

T/S Profiles plus SST projected into mixed layer

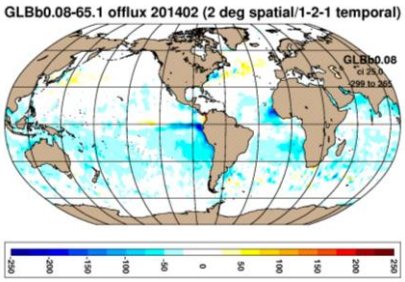
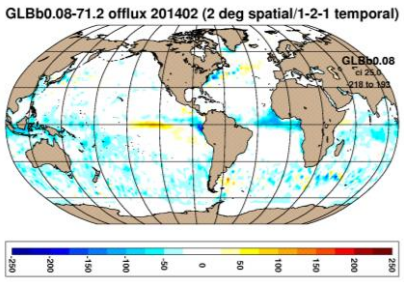
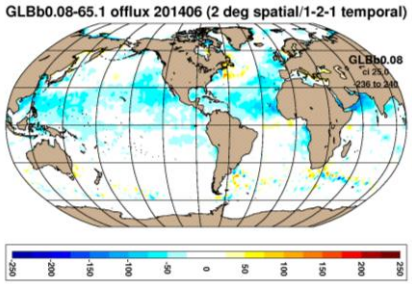
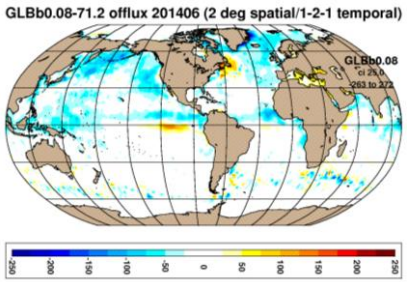
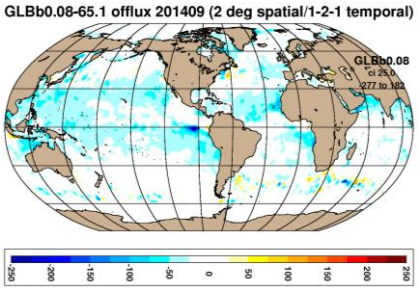
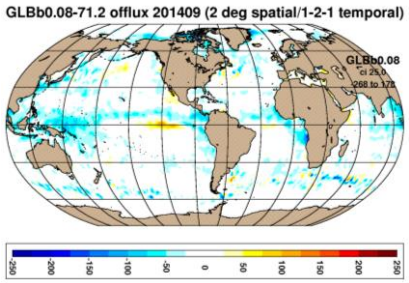
UMD: Ocean-LETKF Software Development

- Transition to operations funded (CPO/MAPP, NESDIS). 1 FTE computational scientist to be hired at CPC.
- Sea-Ice LETKF funded (CPO/MAPP; PI-Carton) to support analyses using CICE/SIS/SIS2. 0.5 FTE scientist supported.
- Ocean initialization for coupled HYCOM/HWRF funded (NESDIS). 1 FTE scientist hired at EMC.
- Continued collaboration with CDAS/CFSv3 development team

NRL: Flux Bias Estimates from Different Atmospheric Forcing Products

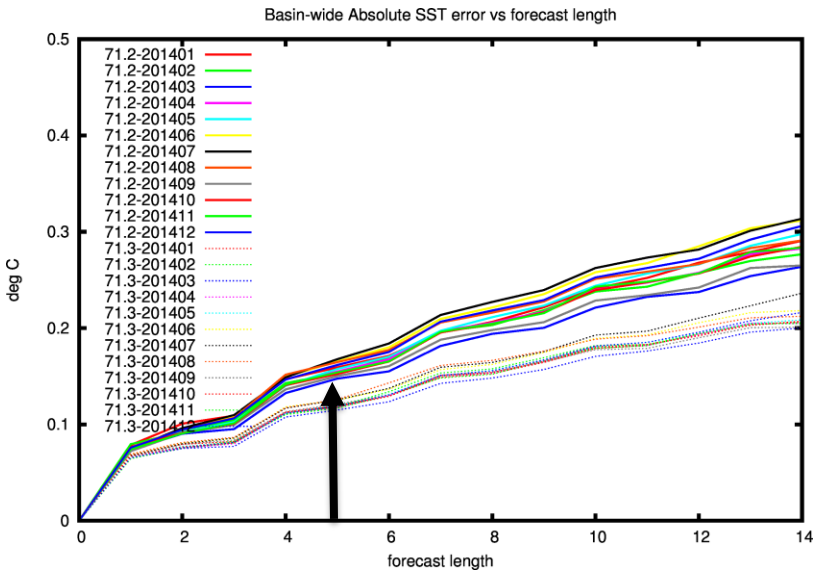
- Lead PI: Dr. Pat Hogan
- Collaborators: EMC
- Main objective: Examine the ocean response to Navy-NAVGEM and NCEP-GFS Atmospheric forcing. Determine biases and apply calibrations.
- Developed a method for calibrating total net surface heat flux based on ocean SST forecast error. Monthly averaged SST error is translated into a monthly net heat flux offset where 1°C SST error = -250 W/m^2.
- Both NAVGEM and GFS show a warm bias over the northern (southern) hemisphere in summer (winter). Both show an overall positive SST bias (ocean too warm).

GFS vs. NAVGEM: Monthly Total Heat Flux Correction

	NAVGEM 1.3	NCEP-GFS
Feb. 2014		
June 2014		
Sept. 2014		

Calibrated vs. Uncalibrated GFS forced SST biases in HYCOM

Monthly Mean Forecast vs. Analysis SST Errors (°C)



~ 0.29°C @ 14 days

~ 0.20°C @ 14 days

~ 0.16°C @ 5 days

~ 0.12°C @ 5 days

Mean Absolute Bias

Both indicate an overall warm ocean SST bias

Summary: Major Deliverables

- NUOPC caps for HYCOM and WAVEWATCH III models using ESMF calls, HYCOM and WAVEWATCH III coupled to GSM
- Baseline Ocean-LETKF data assimilation systems have been set up with MOM6 and HYCOM (for regional domains), under development for WAVEWATCH III.
- NCODA prototype variational DA for GOM under development. Targeting for global application in support of operational global RTOFS

Summary: Main Priority

- Progress towards unified coupled systems:
  - Functional one-way (and multi-way) coupling of Ocean, Wave, Atmosphere and Sea Ice components within NEMS
  - Continue development of coupled DA (ensemble based) methods

– Building operational ocean and wave DA systems

Summary: Major Need

- New hires (Ocean Data Assimilation, Sea Ice Data Assimilation)