Coupled Air-Sea Interaction Team Report

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HFIP Telecon, 14 November 2012
Outline

1. Team reorganization
2. NCEP: operational development
3. URI: Coupled modeling
4. NRL-Monterey: COAMPS-TC
5. ESRL and URI: NOAA/ESRL sea spray flux parameterizations
6. AOML: idealized HWRF v.3.2 ocean response study
1. Team 8 Reorganization

- Name changed to “coupled air-sea interaction” team
- New members
  - Hyun-Sook Kim (EMC)
  - Joe Cione (HRD)
  - Eric Uhlhorn (HRD)
- Hyun-Sook Kim replaced Hendrik Tolman as co-lead
2. NCEP: Operational Development
RTOFS Global HYCOM

• KPar update using monthly Ocean Color Observation
• Implementing latest ESMF version in progress

Wave Watch III

• 3-way coupling in progress
• ESMF compliance and WWIII modularization will be completed in next 6 months.
1. Eddy-resolving, 1/12-degree and 32-layers (better res. in the mixed layer) HYCOM
2. IC/BC from RTOFS Global
3. Provide uniform ocean to E. Pac, W.Pac and Atlantic – easier to configure
4. Data Assimilation – Global
5. Data Assimilation – Regional (in progress)
6. Re-locatable, practically anywhere in the world
7. ESMF compliant – advantage for 3-way coupling

Same config. as the Global
Air-Sea Exchange Parameters – Cd and Ck

2012 HWRF Cd & Ck

Cd for 2011 HWRF and GFS

1. 2012 Cd ~2.5E-3 (GFS) vs. 2E-3 (HWRF)
2. The inflection point:
   5 – 10 m/s for HWRF;
   ~2.5m/s for GFS.
Heat Flux Comparison between HWRF and GFS

**Year 2012**

Improvement of radiational heat flux (little difference between them)

But,

1. Daily max. increases with time (both for total and HWRF for net SWRad).
2. HWRF Net LW Rad. is ~30% smaller than the GFS.

**Before Year 2012**

An ad hoc correction was implemented in the coupled system.
Parallel run for three basins – Atlantic, East Pac. (West Pac. In progress)

Results shown for two Atlantic hurricanes” Issac (09L) and Sandy (18L) (59 cases)

HWRF – blue
HyHWRF - red

abs. TRACK

abs. INTENSITY

INTENSITY bias
SST Evaluation

SST simulation comparison between subset Global HYCOM (blue) and coupled simulations (red)
- coupled shows lower SST by \(\sim 0.20^\circ C\) on average. \(\Rightarrow\) may be related to FLUX (later)

a) Footprint SST  - cooling during (left) and before (right) the storm along track

SST Cooling:
- 0.5\(^\circ\)C footprint average
- but, peak as large as 3.5\(^\circ\)C

Initial Condition for 06Z
2012/08/26 cycle

The cooling verification is still in progress

Example – w/ TMI SST

In terms of large scale comparison – good agreement;

However, point-point comparison >???
Ongoing HY-HWRF Evaluation

• Target for operational implementation: 2015
• Ocean model evaluation
  • Is the ocean model correctly reproducing the relevant physical processes that control SST cooling?
  • Will focus on subsurface dynamical and thermodynamical balances
• Evaluation of air-sea fluxes
  • Must also be physics-based
• Hurricane Isaac will be an important test case
Real-Time Transmitted Data as of Sep. 2012

I. Types
   A. AXBTs from WC-130J and P3
   B. SeaGlider from NDBC
   C. Argo Drifters from SIO
   D. NDBC buoys

II. Quality check
   1. A. AXBTs

~35% bad data

Due to Message Format Error ??? – still in investigation lead by Beth Sanabia.
Real-Time Transmitted Data

SeaGlider from NDBC
(POC: Walt McCall)

The first time in the GOM !!!
NDBC is in the process of acquiring QC package from NAVOCEANO. ➔ Help to remove some noise.

Web site for Wpac and Epac
http://www.ndbc.noaa.gov/gliders.php

Cooling due to Isaac (09L)
3. URI: Coupled Modeling
URI Contribution to Ocean/Wave Models
Team Report for the HFIP Telecon

Isaac Ginis, Richard Yablonsky, Biju Thomas, and Melissa Kaufman

University of Rhode Island, Graduate School of Oceanography
Narragansett, Rhode Island, United States

HFIP Telecon
14 November 2012
Incorporating URI’s air-sea interface module into a coupled HWRF-wave-ocean model

Surface wind

Significant wave height

HWRF-WAVEWATCH: Hurricane Irene (2011) 24-h forecast
Determining optimal ocean model resolution for HWRF coupling

- 1/2° and 1/3° grid spacing produce unrealistically weak cooling
- 1/6° is reasonable, but still underestimates cooling relative to 1/12° and 1/18°
- 1/12° and 1/18° are very similar, so little value is added by using 1/18°
Evaluating Global HYCOM & feature-based ocean initialization for HWRF using NOAA/AOML/HRD’s 16 July 2009 AXBTs
16 July 2009: Sea surface height comparison

CCAR historical gridded SSH*

Feature Based: No AXBT assimilation

Global HYCOM

Feature Based: With AXBT assimilation

*http://eddy.colorado.edu/ccar/ssh/hist_gom_grid_viewer
16 July 2009: AXBT temperature profiles

Temperature profiles (upper 300 m) are from Global HYCOM (blue), feature-based model without AXBT assimilation (red), feature-based model with AXBT assimilation (green), and AXBT observation (black).
HWRF’s 2012 operational POM-TC
United and East Atlantic domains

~1/6° horizontal grid spacing
URI’s new MPIPOM-TC transatlantic domain

~1/12°
horizontal
grid spacing
4. NRL Monterey: COAMPS-TC
COAMPS Coupling Interface

**WAVE**
- Ocean feedback module
- Atmos feedback module
- ESMF interface

**ATMOS**
- Internal nested grids
- Atmos exchange grid
- ESMF interface

**OCEAN**
- Internal nested grids
- Ocean exchange grid
- ESMF interface

**DRIVER / COUPLER**
- Fluxes computed in surface subroutine using ocean & wave feedback
- Atmos & wave feedback used in ocean update & mixing subroutines

**Feedback Modules**
- Atmos feedback module
- Ocean feedback module

**Processes**
- Charnock
- Sea surface temperature
- Sea surface height, surface current
- 10-meter wind
- Sea level pressure, surface wind stress, surface heat flux, surface moisture flux, shortwave radiation
- Stokes drift current, wave radiation stress gradient, bottom orbital wave current

Chen et al. 2011 (NRL Review)
Wind-Wave Coupling

Three different methods of wind-wave coupling have been tested in COAMPS-TC
• Janssen (1991) and Doyle (2001) – scalar wave stress
• Moon et al. (2004) – wave age and wind speed
• URI (Ginis) – similar to Moon

Currently is implemented a fourth UM wind-wave scheme
• Donlean et al. (2012) – vector wave stress
Including the wave feedback to the atmosphere produced a much higher value of momentum drag near the eyewall region.
Effect of Sea Spray on Fanapi Simulations

Averaged fluxes within 150 km radius of eye

- New sea spray increases more sensible flux
- Smaller increase in latent heat flux
- Fully coupled run has a 32% less total flux over the ocean compared to the uncoupled run
- New sea spray provides about 5% flux increase
- With new sea spray, there is still a large flux difference between coupled and uncoupled runs
Fanapi Altimeter Wave/Wind Comparisons (model adjusted +6 hours)

- COAMPS significant wave height and wind forecast compare well with altimeter near Fanapi after adjusting the track bias.
- Max of 6 m significant wave height west of Fanapi.
Ivan Current Evaluation
Coupled (w and w/o Stokes’ drift)

<table>
<thead>
<tr>
<th>SHALLOW ADCPs</th>
<th># COMP. BINS</th>
<th>TOP BIN DEPTH</th>
<th>BOTTOM BIN DEPTH</th>
<th>CCC</th>
<th>MDE with SDC (deg)</th>
<th>MDE w/o SDC (deg)</th>
<th>% improvement</th>
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<tbody>
<tr>
<td>M1</td>
<td>13</td>
<td>6</td>
<td>52</td>
<td>0.86</td>
<td>6.21</td>
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<td>M2</td>
<td>14</td>
<td>4</td>
<td>54</td>
<td>0.87</td>
<td>10.35</td>
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<td>54</td>
<td>0.78</td>
<td>10.93</td>
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<tr>
<td>M4</td>
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<td>10</td>
<td>82</td>
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<td>M5</td>
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<td>83</td>
<td>0.81</td>
<td>14.24</td>
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<tr>
<td>M6</td>
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<td>9</td>
<td>81</td>
<td>0.82</td>
<td>15.60</td>
<td>16.22</td>
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<td>ALL SHALLOW AVG.</td>
<td></td>
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<td>0.82</td>
<td>11.41</td>
<td>11.95</td>
<td>4.53</td>
</tr>
</tbody>
</table>

| DEEP ADCPs |              |                |                  |     |                   |                   |               |
| M7          | 13           | 52             | 492              | 0.73| 4.68              | N/A               | N/A           |
| M8          | 13           | 52             | 492              | 0.88| 10.65             | N/A               | N/A           |
| M9          | 13           | 50             | 492              | 0.80| 7.65              | N/A               | N/A           |
| M10         | 13           | 50             | 500              | 0.87| 15.87             | N/A               | N/A           |
| M11         | 13           | 53             | 493              | 0.86| 15.26             | N/A               | N/A           |
| M12         | 13           | 53             | 513              | 0.73| 17.92             | N/A               | N/A           |
| M13         | 13           | 50             | 500              | 0.76| 12.53             | N/A               | N/A           |
| M14         | 13           | 52             | 502              | 0.81| 11.38             | N/A               | N/A           |
| ALL DEEP AVG. |          |                |                  | 0.81| 11.99             | N/A               | N/A           |

The passing of Stokes’ Drift Current from SWAN to NCOM shows improvement in both the Mean Directional Error (MDE) and current velocity. In an extreme event such as Hurricane Ivan, the SDC can be as much as 10-20% of the total current velocity near the surface.
Lesson learned

• Validation of TC structure in the atmosphere, ocean, and wave help to guide the parameterization improvements

• Validation statistics can be used to obtain information about the coupled model error covariance

Challenge

• Diagnostic of culprit parameterizations in the coupled model require in-depth analysis of model physics interaction and atmosphere, ocean, and wave observations in different ocean basins

Outstanding issues

• Lack of correction in the data assimilation cycle to account for the displacement of background ocean cold wake due to track error
• Coupled model took about 6h to adjust to the bogus vortex
5. ESRL and URI: Sea Spray Flux Parameterization
Summary of the Improved ESRL Sea-Spray Parameterization Work

Jian-Wen Bao, Chris Fariall

• Implemented the scheme in the fully coupled GFDL hurricane in collaboration with the URI team

• Conducted both idealized and real-case simulation experiments for parametric adjustment

• Shared the program module with HFIP partners, the NOPP partners and other research groups over the world

• Made plans to test out the module in the fully coupled HWRF model
6. AOML: Idealized HWRF v.3.2 Ocean Response Study
Sensitivity of HWRF V3.2 to the Ocean

• Problem: poor quantitative understanding of the sensitivity of forecast intensity to changing ocean conditions in coupled forecast models (when/where can the ocean be important?)
• Approach: Perform idealized HWRF V3.2 study minimizing impact of atmospheric processes that affect intensity
  – Idealized atmosphere
    • Idealized initial vortex embedded in stationary atmosphere
  – Idealized ocean
    • 1-D ocean model coupled to HWRF v.3.2
  – Ocean fields advected to east to mimic westward storm speed

• Parameter study:
  – Storm size (small vs. large)
  – Storm translation speed (2, 4, 6, 8, 10 m s\(^{-1}\))
  – TCHP or OHC (25, 85, 148 kJ cm\(^{-2}\))
**Intensity Evolution**

Large Storm, $6 \text{ m s}^{-1}$ (mean RMW = 47 km)

- **a)** Minimum $p$
- **b)** $\overline{WS_{10}}$, Hot Ocean
- **c)** $\overline{WS_{10}}$, Cool Ocean

Small Storm, $6 \text{ m s}^{-1}$ (mean RMW = 15 km)

- **d)** Minimum $p$
- **e)** $\overline{WS_{10}}$, Hot Ocean
- **f)** $\overline{WS_{10}}$, Cool Ocean

- RI completed by forecast hour 30 for all uniform ocean experiments
- Slow decrease in minimum $p$ after hour 60 for both warm and hot ocean cases
- Cool ocean (low TCHP) significantly limits intensity
Parameter Dependence of SST Cooling and Enthalpy Flux

Minimum SST in cold wake

Maximum enthalpy flux
Parameter Dependence of Intensity

Minimum central pressure

Maximum \((WS)_{10}\)
7. Workshop Summary

- Strategies for evaluating and improving model performance
  - Diagnostic requirements
    - Metrics
      - Determine if model components are correctly reproducing the relevant physical processes
      - Do not rely solely on the accuracy of track and intensity forecasts
  - Observational requirements
    - Evaluate the accuracy with which model components reproduce the selected metrics
    - Are additional observations (operational and targeted) required?
    - Can we obtain co-located observations of ocean, atmosphere, waves, and fluxes?
      - Existing datasets versus new field programs
  - Collaborations required
    - Among people evaluating the atmospheric, oceanic, and wave models plus the flux parameterizations
    - Among different modeling groups (HWRF, COAMPS-TC, etc.)
    - HFIP Team 8 needs to provide this coordination
  - Target a study of hurricane Isaac due to extensive observations
  - Workshop report will be released shortly