The NOPP Operational Wave Model Improvement Project

Toward a next generation of wind wave model physics

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Motivation

NOPP project:
Improving Wind Wave Predictions;
Global and Regional Scales

- Considering progress in understanding of wave model physics, particularly dissipation and economical interaction approximations, Linwood, Don and Hendrik started pushing for this project after the 2008 Ocean Sciences meeting.

- Buy-in from:
  - ONR, BOEM (was MMS) with funding.
  - NOAA, USACE, NRL with in-kind contributions.

- Focus on operational modeling, basin and shelf scale.
  - Several “surf-zone” proposals also funded.
Outline of paper:

- NOPP teams
- Validation data.
- Validation techniques.
- 30 year hindcast.
- Code management.
- Outlook.

Conclusion:

- Making great progress toward improved operational models.
- Laying ground work for community model development and modeling environment.
### NOPP teams

<table>
<thead>
<tr>
<th>PI-s</th>
<th>Topics</th>
<th>Focus areas</th>
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</thead>
<tbody>
<tr>
<td>Ardhuin</td>
<td>in+ds</td>
<td>Dissipation (breaking, swell, bottom) Unstructured grids in WW III.</td>
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<tr>
<td>Babanin</td>
<td>in+ds</td>
<td>Observations based + swell diss.</td>
</tr>
<tr>
<td>Banner</td>
<td>in+ds</td>
<td>Extreme conditions, explicit breaking prediction, fluxes including sea spray</td>
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<tr>
<td>Perrie</td>
<td>nl</td>
<td>Two-Scale Approximation.</td>
</tr>
<tr>
<td>Tim Janssen</td>
<td>nl (shal)</td>
<td>Combine quads &amp; triads, field data sets.</td>
</tr>
<tr>
<td>Zakharov /</td>
<td>nl+in+ds</td>
<td>Advanced statistical and dynamical nonlinear models + input and dissipation</td>
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<tr>
<td>Pushkarev</td>
<td></td>
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<tr>
<td>Kaihatu /</td>
<td>shal</td>
<td>Traditional mud and vegetation models Two-layer Boussinesq mod. Field data.</td>
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<td>Sheremet</td>
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<tr>
<td>Van Vledder</td>
<td>shal</td>
<td>Shallow water models and obs., including surf beats.</td>
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<tr>
<td>Hanson</td>
<td>shal</td>
<td>Duck data sets, spatial partitioning.</td>
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<tr>
<td>Organization</td>
<td>PIs</td>
<td>In-kind contributions</td>
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<tr>
<td>USACE</td>
<td>Resio Smith</td>
<td>FRF + Currituck Sound data. New source terms / studies (in+nl+ds) IMEDS + Additional model metrics WAM/STWAVE + ADCIRC coupling Partitioning + tracking (with NCEP)</td>
</tr>
</tbody>
</table>
Validation data

Two type of validation / data important for operational wave models.

- Model needs to work all the time:
  - Bulk long term validation / development against routine observations.
    - In-situ, altimeter, SAR (?).
- Model needs to make physical sense.
  - Directed measurement campaigns focused on specific physics of waves.
    - Individual campaigns.
    - Data mining of routine observations.

- Select data set types and conditions, rather than campaigns.
<table>
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<tr>
<th>Conditions</th>
<th>Data sources</th>
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<tr>
<td>Long term validation</td>
<td>In-situ, altimeters, SAR.</td>
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<tr>
<td>Wind Sea and Swell</td>
<td>“JONSWAP”, Great Lakes, Lake George, SAR, Tehuantepec, Duck. Spectral partitioning of buoy data.</td>
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<tr>
<td>Non-Aligned winds</td>
<td>Slanting fetch, Tropical cyclones (Duck, SRA, WSRA).</td>
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<tr>
<td>Extreme conditions</td>
<td>TCs, data mining.</td>
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<tr>
<td>Diminishing winds</td>
<td>FAIRs, data mining, tradewind and monsoon data (INCOIS, …)</td>
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<tr>
<td>Shallow water</td>
<td>Data sets provided by teams, older bottom friction data sets.</td>
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</tbody>
</table>
Validation techniques

Going beyond the traditional validation techniques used for wave models.

- Traditional: bulk error measures:
  - Mean, std, SI, r², scatter/pdf, sometimes qq …
- Event-based statistics:
  - Peak values, timing, shape of signal.
- Spectral wave model validation:
  - Ridge plots identifying individual swell events.
  - IMEDS analysis using spectral partitioning.
- For forecasting, hit-miss statistics are very important, but rarely used in scientific papers.
- Use additional relevant physical parameters, mss, peakedness, etc ….
Validation techniques

Using more concise presentations.

- Taylor diagram.
  - Variance
  - Correlation
  - Error

- Target plot
  - Bias
  - Error

Wind speed during January 2010 based on 75 buoys
The Climate Forecast System (CFS) reanalysis and re-forecasting project (CFSRR) provides a 30+ year high resolution wind field

- 0.5° hourly wind and temperature fields.
- Associated 0.5° daily ice analyses.

This data set appears ideal to be the basis of a wave reanalysis over the same 30+ year period.

- There is insufficient data in any period to obtain a data-dominated analysis, therefore
- It makes more sense to do a hindcast without assimilation, and use data possibly later for bias corrections of the hindcast only.
- Ideal as basis for long-term validation in NOPP project.

http://cfs.ncep.noaa.gov/cfsr
WAVEWATCH III community modeling code management environment

- Traditionally code distributed as “tarball”, code delivered back to NCEP the same way.
- Does not work with many teams working on same code
  - Subversion (svn) server for version control.
  - Each team has code manager with access to server and latest developmental model versions thereon.
  - Code managers at NCEP merge individual contribution into “trunk” version of code.

- Best practices guide for community model development of WAVEWATCH III as deliverable for NOPP project. NCEP intends to maintain this environment after project is finished.
WAVEWACTH III added capabilities:

- Curvilinear and unstructured grids.
- Quasi-stationary model version.
- New source terms.
  - GMD and nonlinear filter.
  - Two moveable bed bottom friction terms.
  - Ifremer physics packages.
- Massively expanded output options (coupling).
- Post-processing tools:
  - Re-gridding.
  - NetCDF output.
- Coupling interfaces:
  - ESMF.
  - PALM.
Outlook

In the pipeline:

- Spatial and temporal tracking of wave fields:
  - Porting internal partitioning to SWAN.
  - Space-time tracking (external / internal).
- NCEP planning first physics upgrade in operational wave models based on NOPP project in 2012 (following slides).
- NCEP planning NOPP “consensus” upgrade in 2014/5.
  - Replacing DIA and other “deep” source terms.
  - New products for SOLAS, specifically wave breaking.
  - Full polar coverage (tri-polar / curvilinear Arctic grid).
  - Unstructured coastal grids (2-3 km resolution).
  - Upgrades shelf physics.
- Physics packages should be easily portable to SWAN, WAM, STWAVE if so desired.
Outlook

NCEP physics upgrade based on Ifremer results, tested with NCEP global and Great Lakes winds.

Biases Dec. 2009 – Feb 2010

old

new
Outlook

Monthly global errors 2009

Bias (m)

SI

RMS (m)

$R^2$

-0.1 -0.05 0 0.05 0.1 0.15 0.2 0.25

-0.1 0 0.05 0.1 0.15 0.2 0.25

0.3 0.35 0.4 0.45 0.5

0.89 0.9 0.91 0.92 0.93 0.94 0.95

env - js1 - js2

Tolman Banner Kaihatu, Nov. 2, 2011

12th waves conference, 15/19
Great Lakes buoy 45007, 2009
old physics
Outlook

Great Lakes buoy 45007, 2009
new physics
Outlook

Taylor diagram and alternative version for several GL buoys for 2009

GLERL-Donelan (2G)
WW III Tolman and Chalikov
WW III Ifremer
Conclusion:

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Thank you!