CFSR surface wind calibration for wave modelling purposes

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Motivation

- Community recognized methodology uses satellite to calibrate wave models.
- What is tuned by the calibration: errors in wind or waves, or both?
- Errors are separated as part of a new BMT ARGOSS global spectral wave database.
Background: Three phase approach

Phases:

CFSR calibration
- CFSR wind speed (Saha et al, 2010) on T382 grid (~20 minutes)
- Calibrate as ax+b using “consultant” satellite database 1992 – 2011 (Groenewoud, 2011)
- CFSR switches to T574 (~12 minutes) on 1-jan-2011. Interpolate calibration constants from T382 grid

High resolution hindcast (v361)
- Chalikov – Tolman (1996, 2002b) source terms in WAVEWATCH 3.14
- 30 minute global grid, bathymetry based on GEBCO2
- Obstruction values from GSHHS coastline analysis

High resolution hindcast (v401) with updated source terms
- New source terms in WAVEWATCHIII 4.12 (Ardhuin et al, 2010) with a critical look at parameterization

Later phases can comprise, for instance, new wind calibration techniques.
Research questions

1. **Can systematic errors be removed from surface wind speeds in order to separate wind and parametrisation errors?**

   • Upon answering, one has to consider that each satellite mission has unique characteristics and that the assimilation of observations into the CFSR is not constant over time.

   • Hence, it is difficult to say something about the contribution of measurements and model data to the total error.

   • Satellite measurements are calibrated with buoy data (per mission) with the aid of buoys data. Buoy measurements are considered ground truth (...).

   • If the errors can be correlated to any global patterns like ocean currents or weather climate, it can be expected that they are model errors. This leads to:

2. **Can any systematic errors in the surface wind be correlated to meteorological or air-sea interaction related phenomena?**
Glance at agreement over time

- GFO or Jason large bias 2001 – 2004
- Most scatterometer data is assimilated into CFSR. This clearly shows between 2001 and 2009 where Quickscat is used.
- 2010 breaks the trend because assimilation and the BMTA database use different missions (NRL WindSat vs. ASCAT data)
- Altimeter scores lower than scatterometer. Firstly because it is not assimilated, secondly it measures the variable wind speed near land where scatterometer does not.
- Transition point in 1994 – 1995 as observed by Chawla et al. (2013)
Number of samples per cell

- Satellite database stops at 78 North and South latitudes
- Based on the number of measurements available, scatterometer data will be dominant in the calibration on open sea whereas altimeter will gradually take over towards the coast
- Ignore cells with less than 100 samples
Wind speed average from satellite

Higher speeds
- Roaring 40’s
- Northern Westerlies

Lower speeds
- Doldrums / ITCZ

Left: prevailing winds (courtesy to wikipedia)
RQ 1: $\langle \text{MODEL}_{\text{uncalibrated}} \rangle / \langle \text{SATELLITE} \rangle$

- Systematic errors in surface wind show strong spatial coherence
- General overestimation of wind
- Underestimation in East Pacific
- Calibrate with $ax+b$ where $a$ and $b$ are computed with single value decomposition of samples between the 10 and 99% quantiles
RQ 1: <MODEL$_{calibrated}$> / <SATELLITE>

- Poles remain problematic
- Polar satellite measurements not abundant and quality questionable
- Surface winds around Indonesian archipelagos still slightly underestimated (<2%)
- Answer is yes, systematic errors can be removed
RQ 2: Wind speed bias

- Underestimation in Inter Tropical Convergence Zone (ITCZ)
- An overestimation is observed on the lee side of continents
- Generally a bias of 0.5 m/s beyond horseshoe latitudes
RQ 2: Wind speed correlation

- Global air circulation (upper left)
- ITCZ oscillation (middle left)
- Thunder storms in Pacific ITCZ (lower left)
- correlation coefficients (right)
RQ 2: Relative Root Mean Square

- RRMSE and correlation show low skill of CFSR in the tropics (but CFSR is not alone!!)
- Low skill near Galapagos islands
- Remarkable effect North pacific and California currents
- Low skill is of concern for wave modellers. The skill of a wave model is generally higher than an atmospheric model because the system is slower, but bad winds still result in poorly modelled waves.
RQ 2: SST and ocean circulation

- Wang et al (2011) computed bias in SST.
- Close relation to ocean circulation
- Exact mechanism not understood, but underestimation in SST seems to lead to overestimation of surface wind in the easterlies and vice versa in the westerlies.

- SST bias (upper left)
- Uncalibrated wind speed ratio (upper right)
- Ocean circulation (bottom)
Conclusions

1. Can systematic errors be removed from surface wind speeds in order to separate wind and parametrisation errors?
   - Linear calibration removes bias and scales model wind
   - When calibrating wave model, bias is caused by wave model, not wind

2. Can any systematic errors in the surface wind be correlated to meteorological or air-sea interaction related phenomena?
   - Intertropical convergence zone (ITCZ) plays a large role. Low correlations and large errors are observed.
   - Sea Surface Temperature and ocean circulation appear to influence the quality of the CFSR surface winds.
Recommendations

• Compute statistics of calibrated winds against satellite data.
• Wave modelling for phases two and three: gradual upgrade to 30 year spectral hindcast database based Ardhuin (2010) source terms.
• Calibration per season will account for the oscillation of the ITCZ.
• Can we apply a tail fit?
• How do the directions compare and what is the consequence for the global grid?
• Get better understanding of relation SST, ocean circulation and surface wind.