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"Where will our knowledge take you?"

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 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

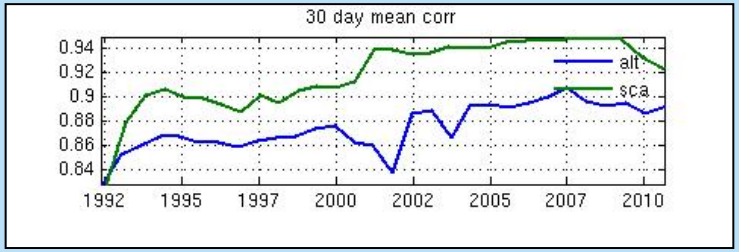
- New source terms in WAVEWATCHIII 4.12 (Ardhuin et al, 2010) with a critical look at parameterization

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?*

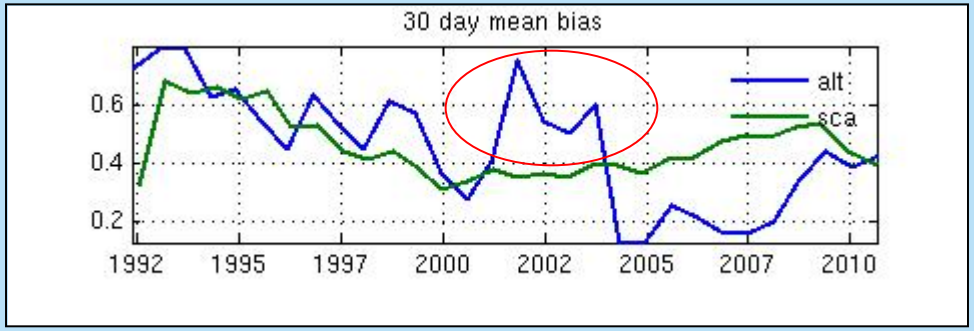
- Upon answering, one has to consider that each satellite mission has unique characteristics and that the assimilation of observations into the CFSR is not constant over time.

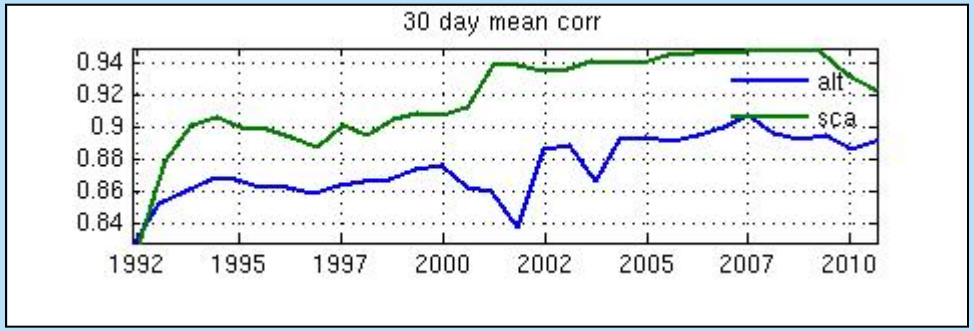


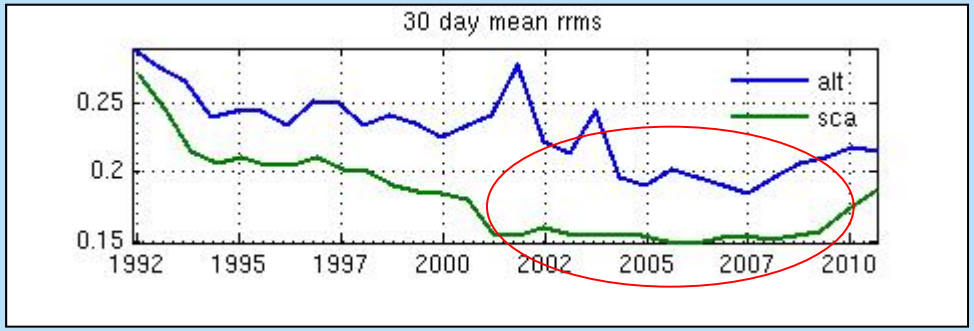
- Hence, it is difficult to say something about the contribution of measurements and model data to the total error.
- Satellite measuments are calibrated with buoy data (per mission) with the aid of buoys data. Buoy measurements are considered ground truth (…).
- If the errors can be correlated to any 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



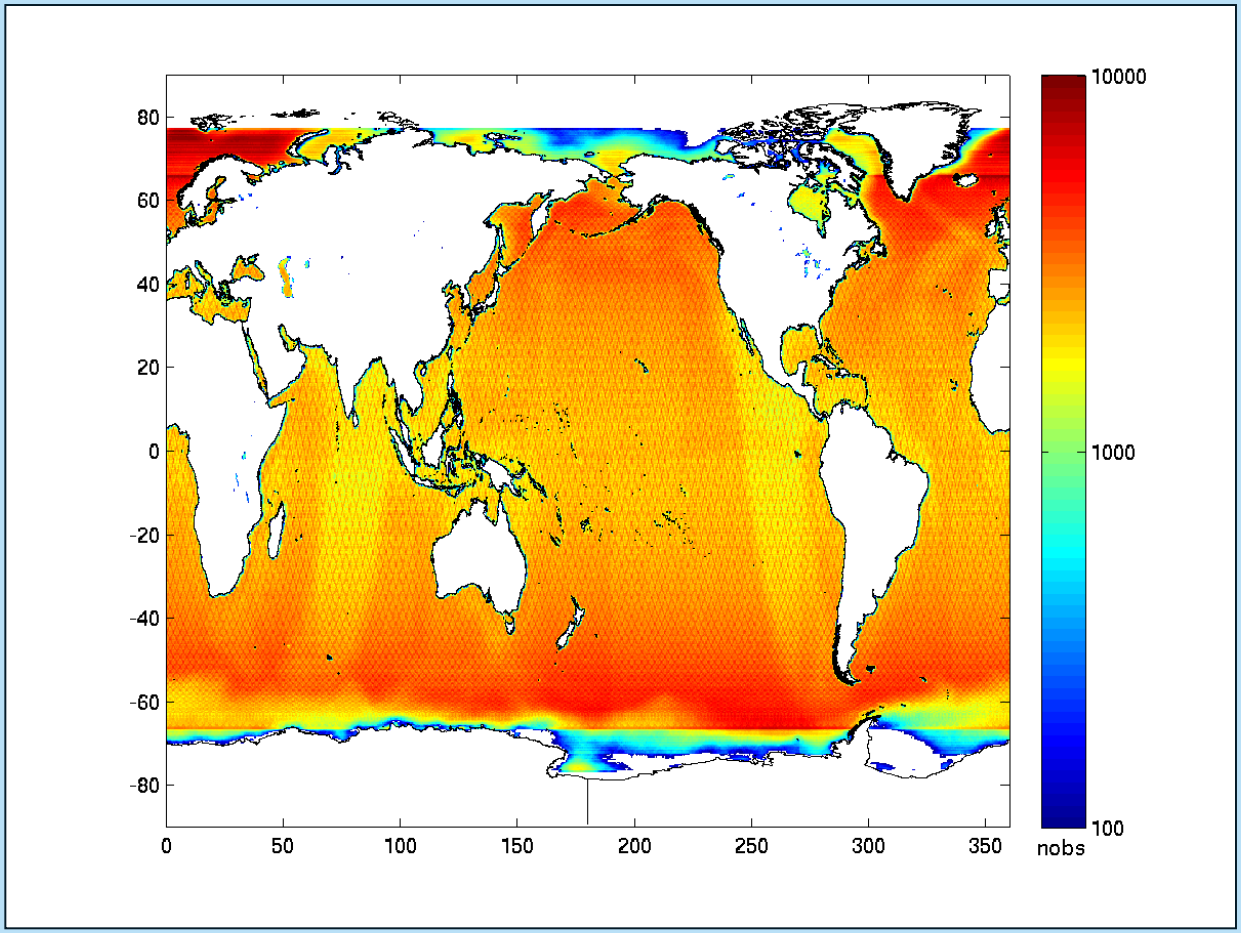




- GFO or Jason large bias 2001 – 2004
- Most scatterometer data is assimilated into CFSR. This clearly shows between 2001 and 2009 where Quickscat is used.
- 2010 breaks the trend because assimilation and the BMTA database use different missions (NRL WindSat vs. ASCAT data)
- Altimeter scores lower than 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



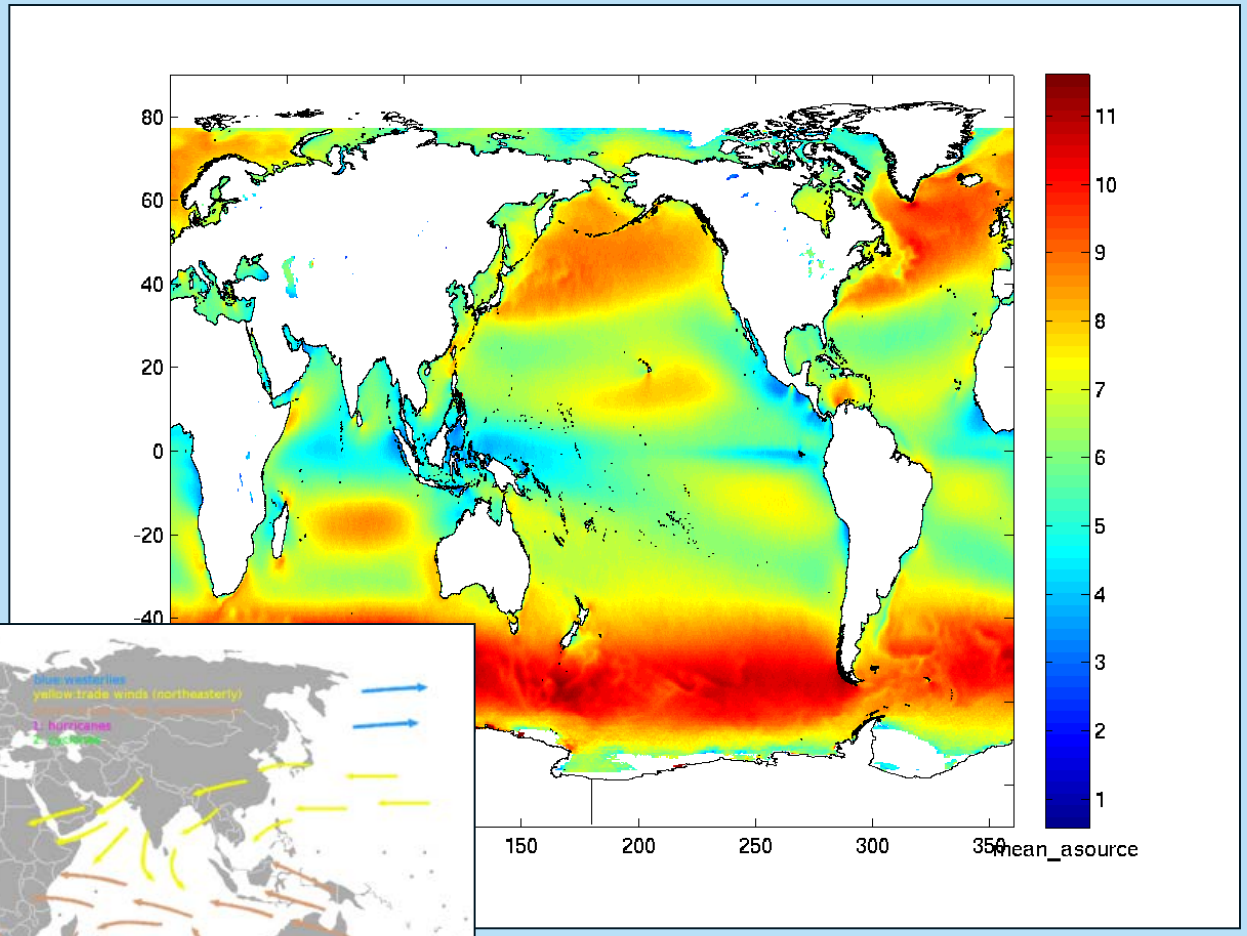
Wind speed average from satellite

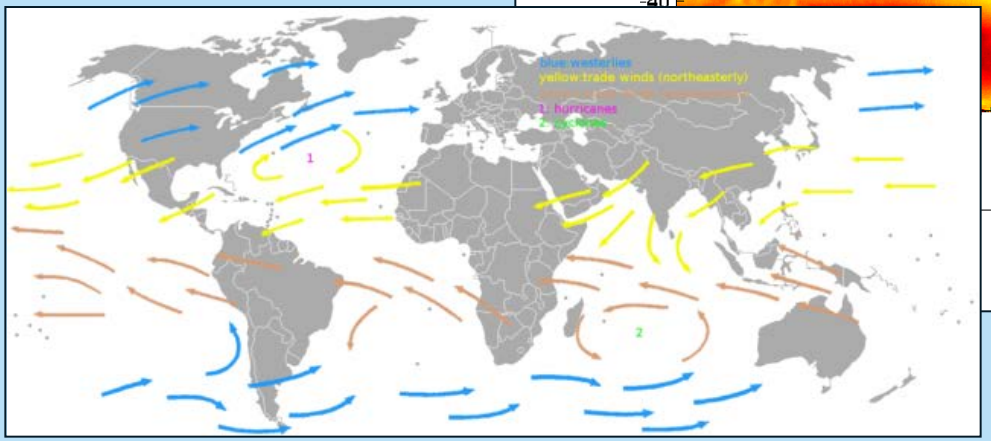
Higher speeds

- Roaring 40’s
- Northern Westerlies

Lower speeds

- Doldrums / ITCZ





Left: prevailing winds (courtesy to wikipedia)

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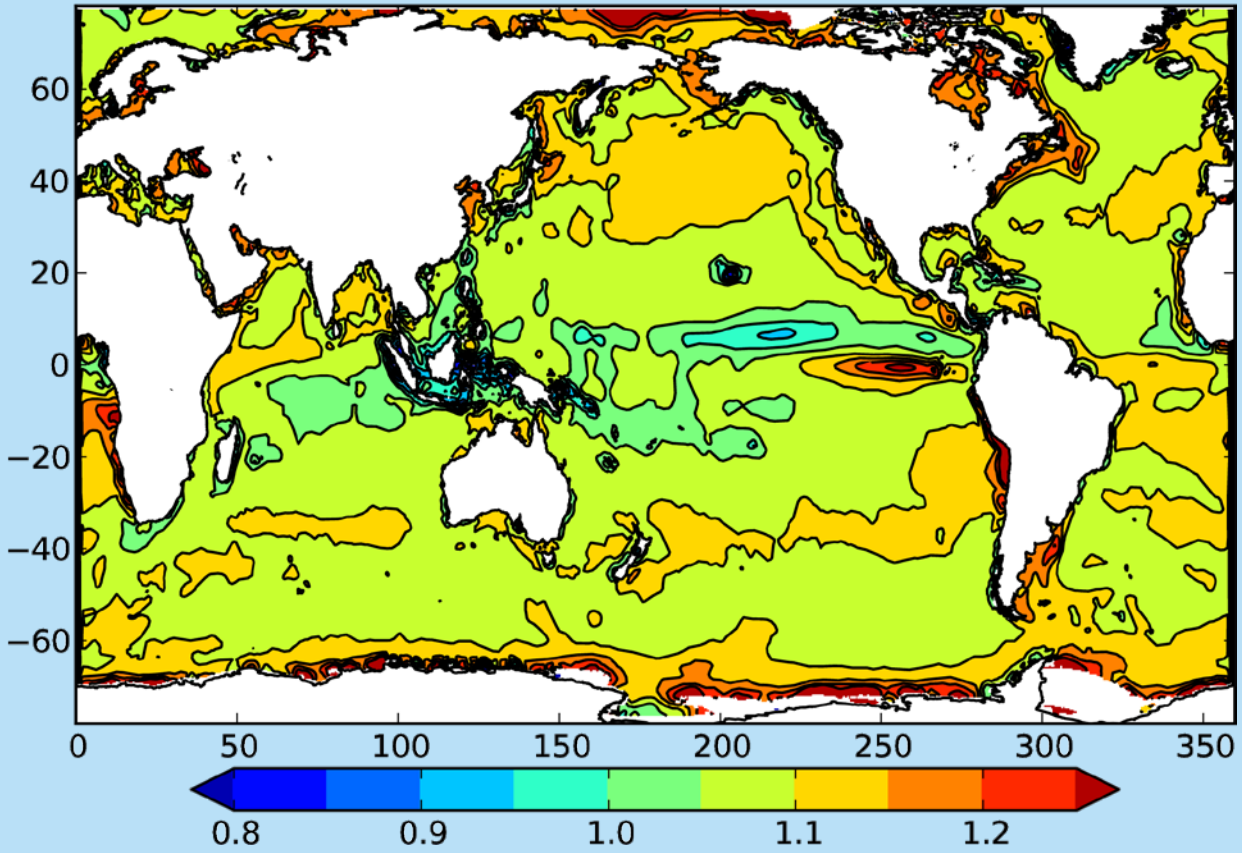
RQ 1: $< MODEL_{uncalibrated} >/< SATELLITE >$

- 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



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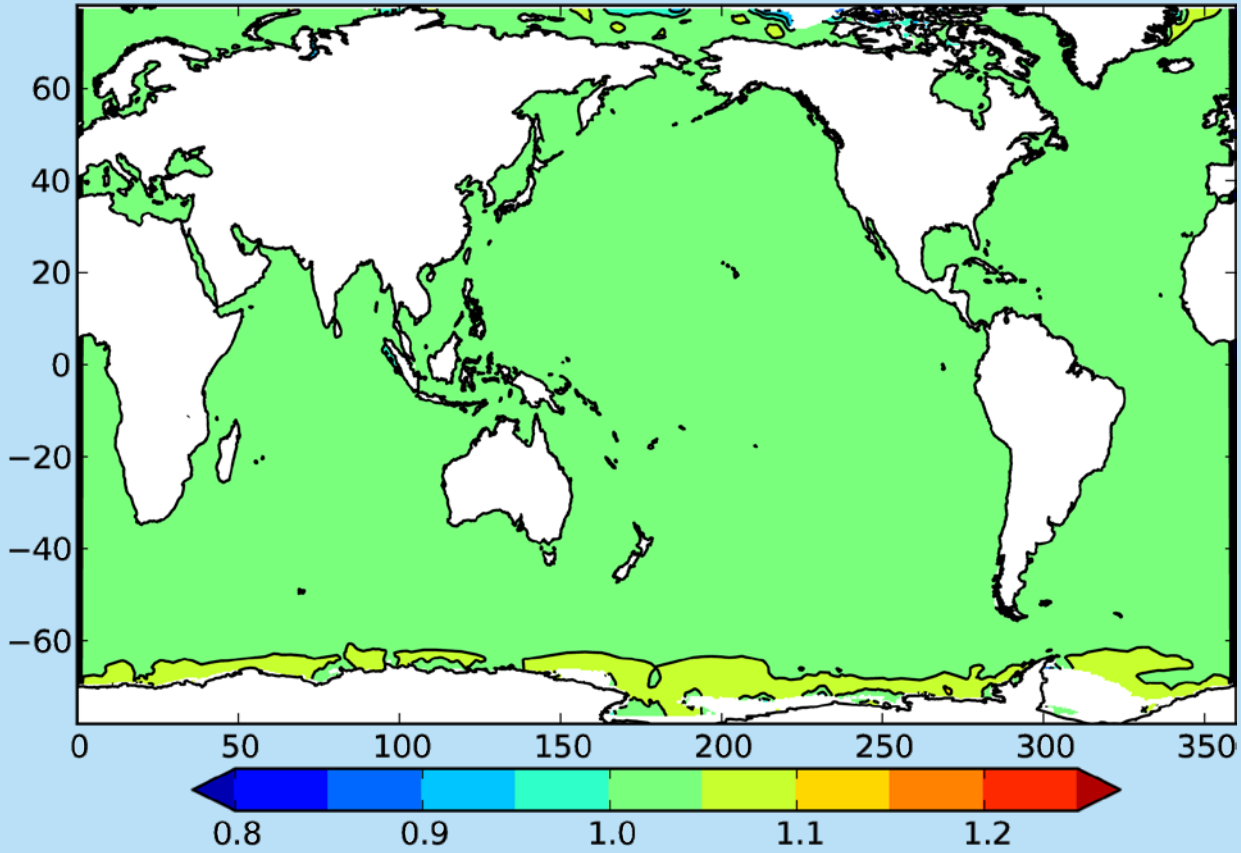
RQ 1: $< MODEL_{calibrated} >/< SATELLITE >$

- 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



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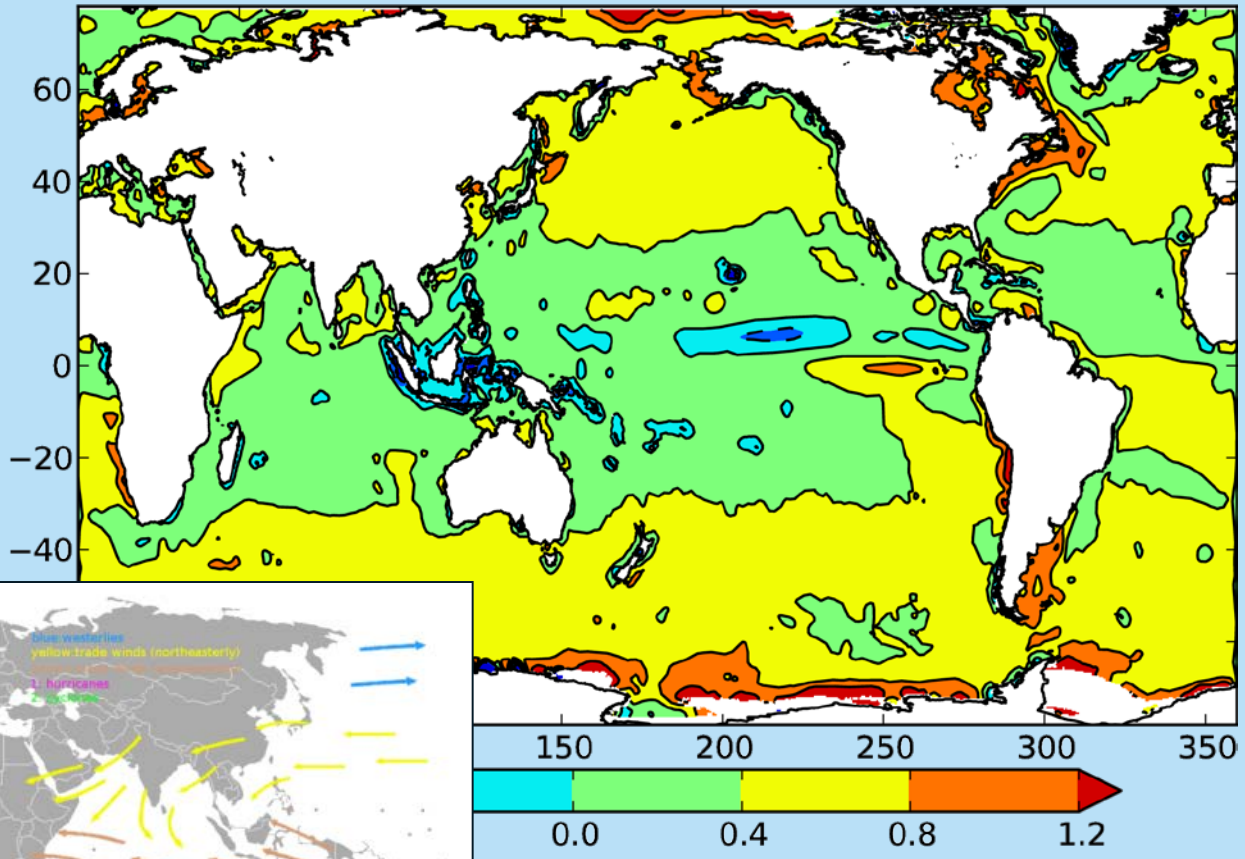
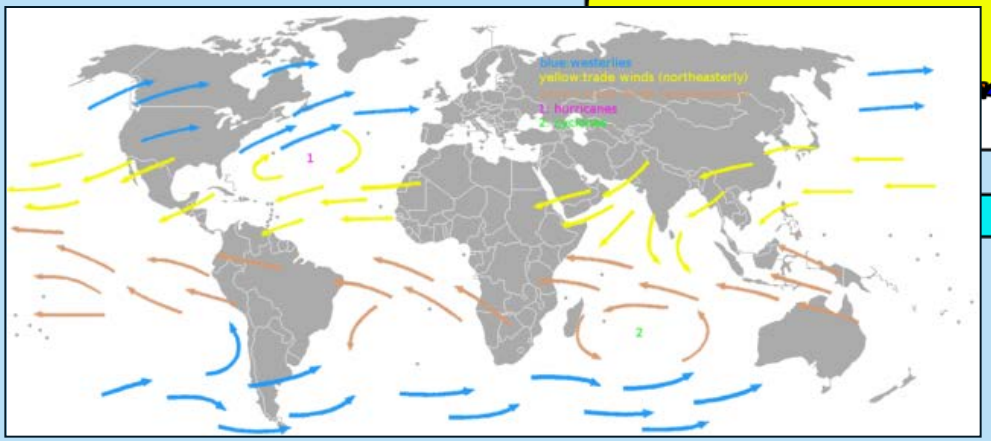
RQ 2: Wind speed bias

- 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





Left: prevailing winds schematisation

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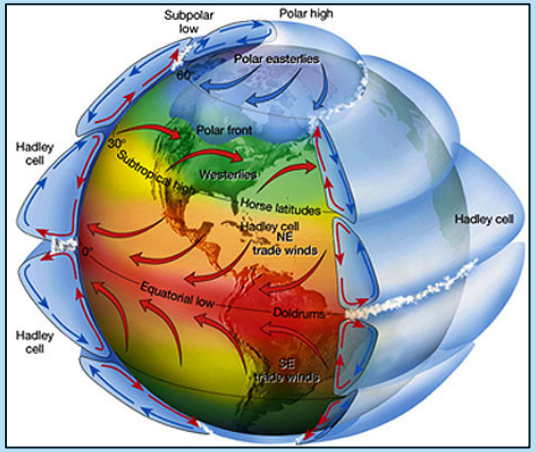
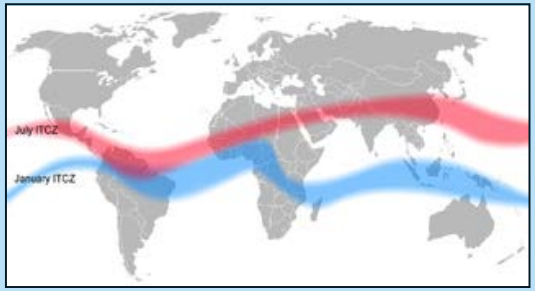
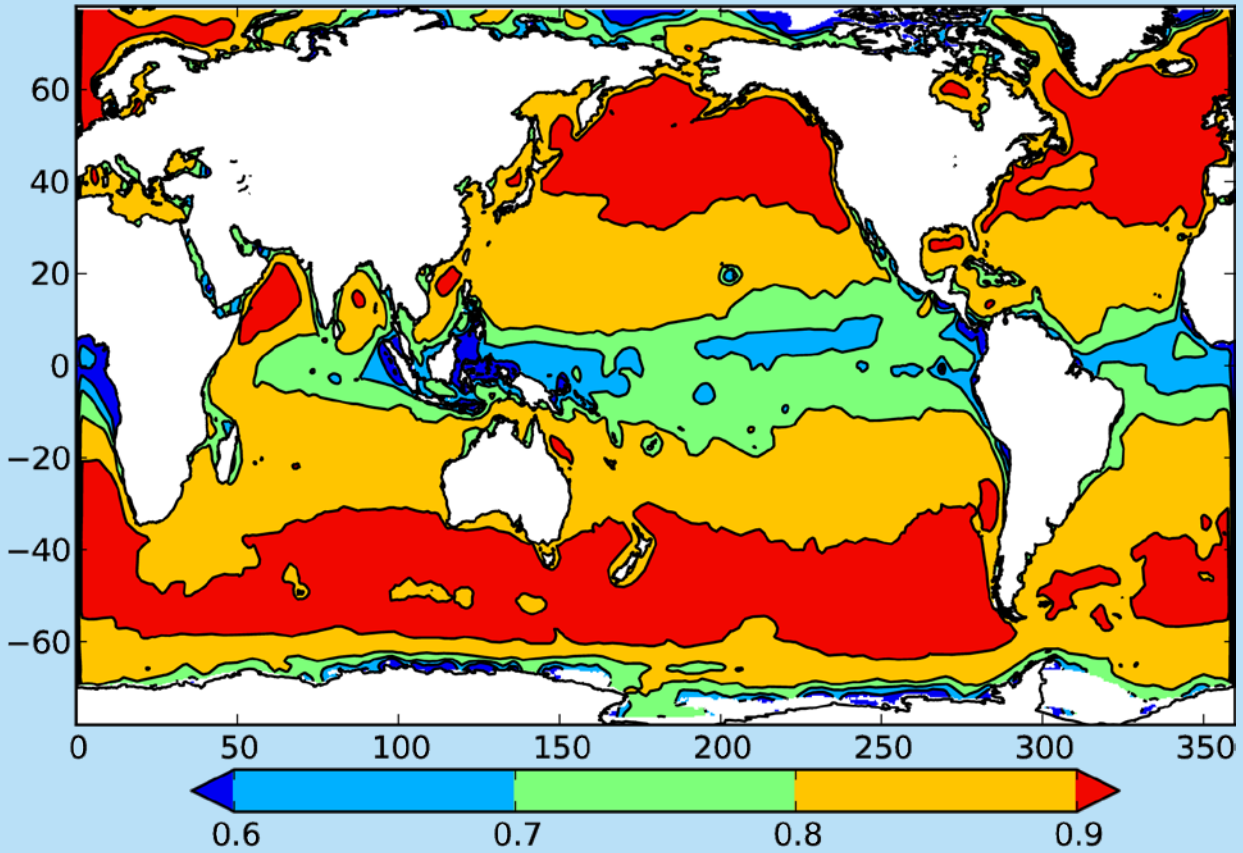
RQ 2: Wind speed correlation







- *Global air circulation (upper left)*
- *ITCZ oscillation (middle left)*
- *Thunder storms in Pacific ITCZ (lower left)*
- *correlation coefficients (right)*

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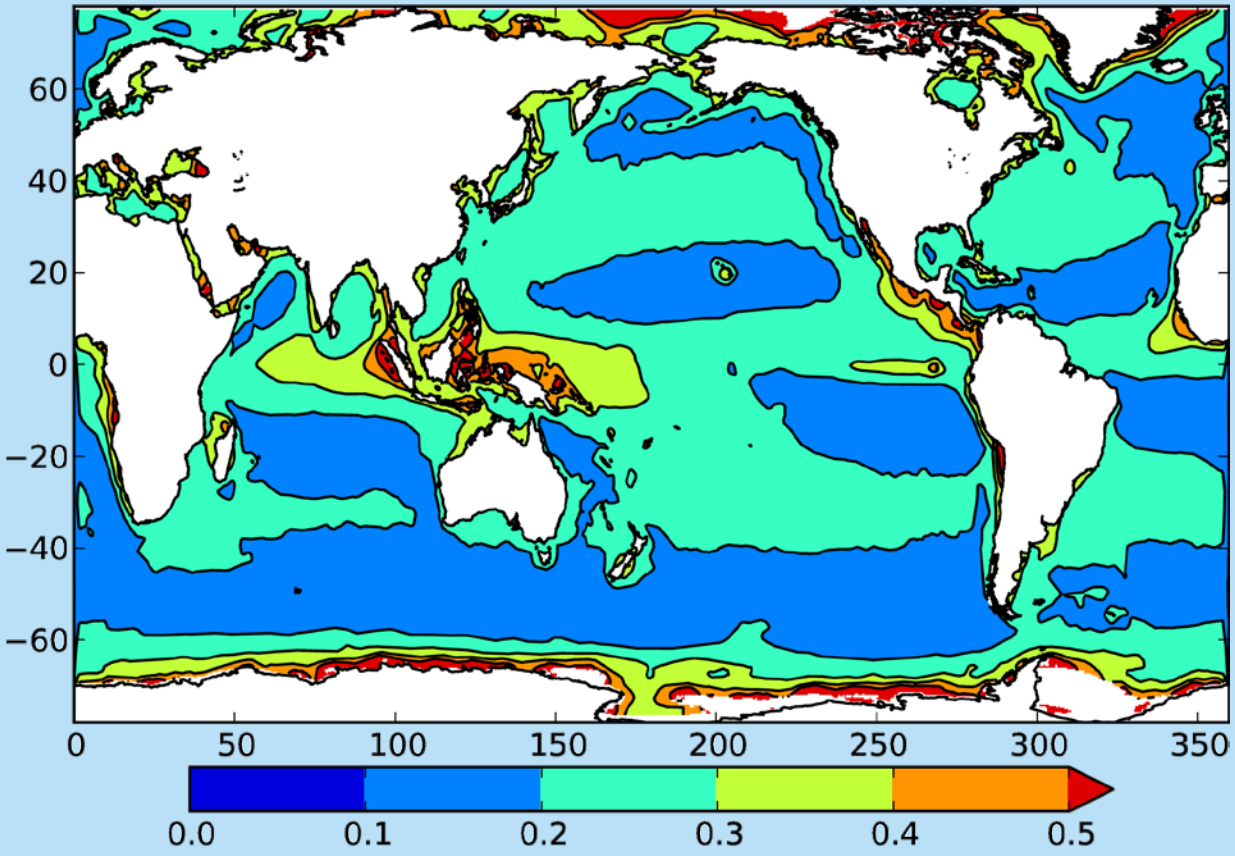
RQ 2: Relative Root Mean Square

- 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.



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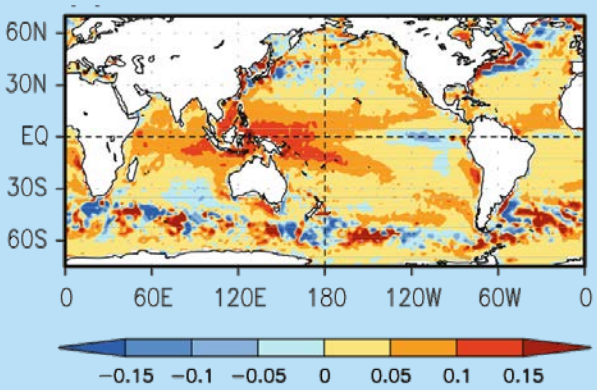
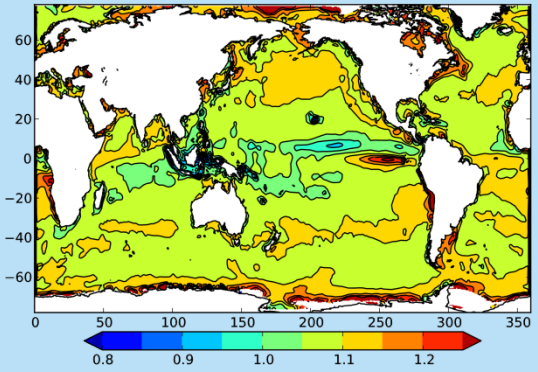
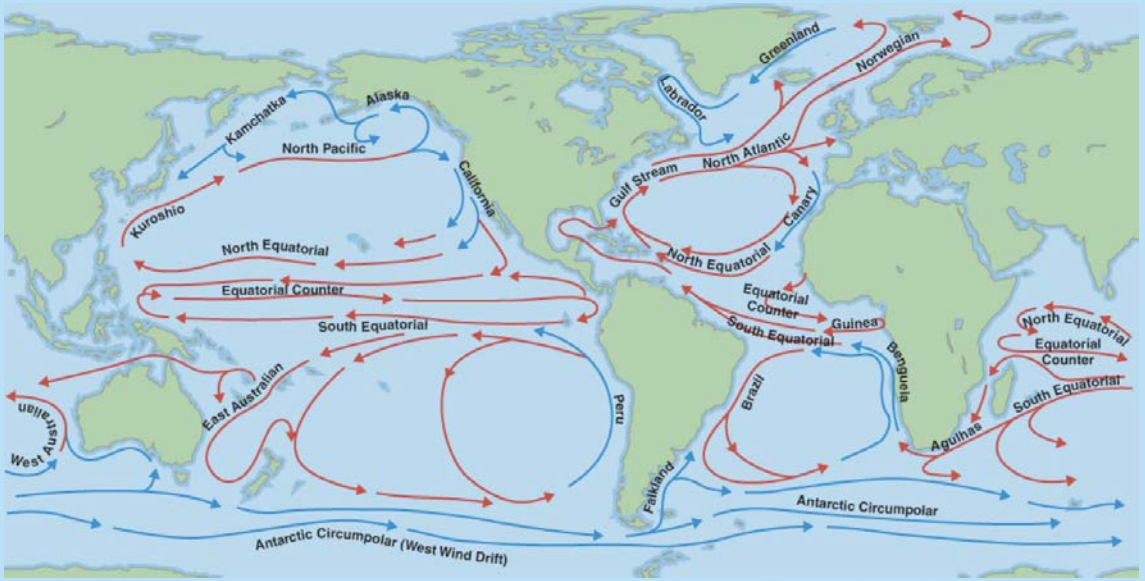
RQ 2: SST and ocean circulation

- 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)***

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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 meteorologcal 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.