A high-resolution global analysis of ocean-surface vector winds (1987 -)

- Methodology, Strategy, Challenges, and uncertainty estimation

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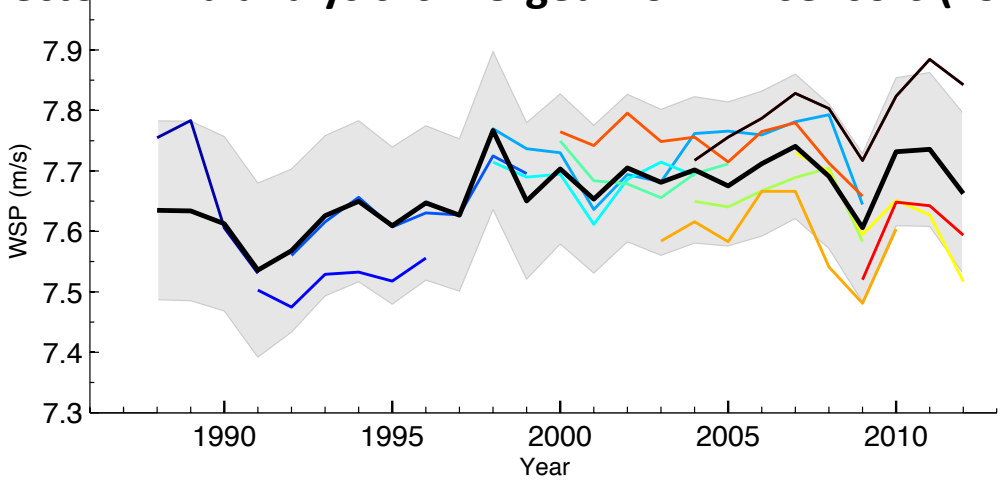
OAFlux: Objectively Analyzed air-sea Fluxes Project

(http://oaflux.whoi.edu)

OAFlux vector wind analysis is merged from 12 sensors (1987 onward, 0.25-degree)



SSMI, SSMIS, AMSRE, WIndSat, and QuikSCAT from RSS

ASCAT from SAF OSI/KNMI

Inclusion of ASCAT-B and OSCAT are planned

Methodology:

- Objectively analysis based on the least-variance linear statistical estimation
- A cost function is formulated for the objective analysis:

$$F = \sum_k \alpha_k (u_{ana} - u_{o,k})^2 + \sum_k \alpha_k (v_{ana} - v_{o,k})^2 + \sum_m \beta_m (\sqrt{u_{ana}^2 + v_{ana}^2} - w_{o,m})^2 + Dyn(vort, div)$$

Three JGR papers on the framework of the OAFlux vector wind analysis:

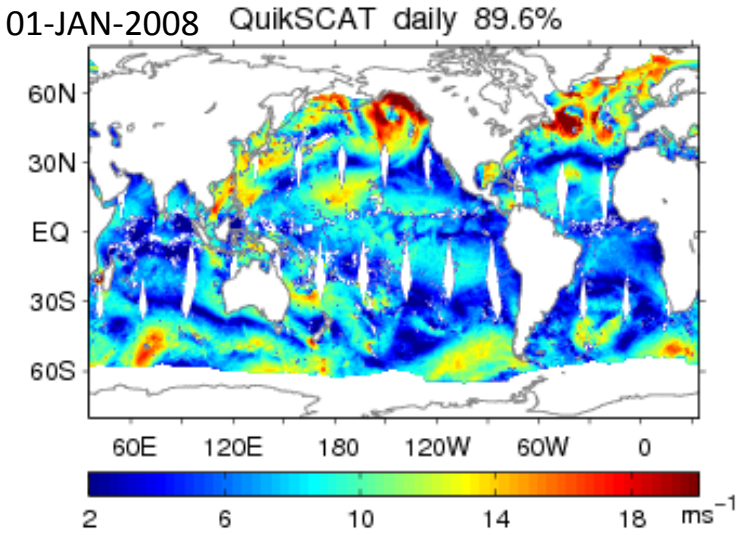
Yu, L. and X. Jin, 2014: A high-resolution global analysis of ocean surface vector wind analysis merged from scatterometers and passive microwave radiometers.

Part 1. Insights into the methodology and results (minor revision required)

Part 2. Confidence and sensitivity analysis (under review)

Part 3. Buoy validation (published).

Satellite observations are needed at *every* ocean grid when constructing a gridded product.



Coverage provided by scatterometers

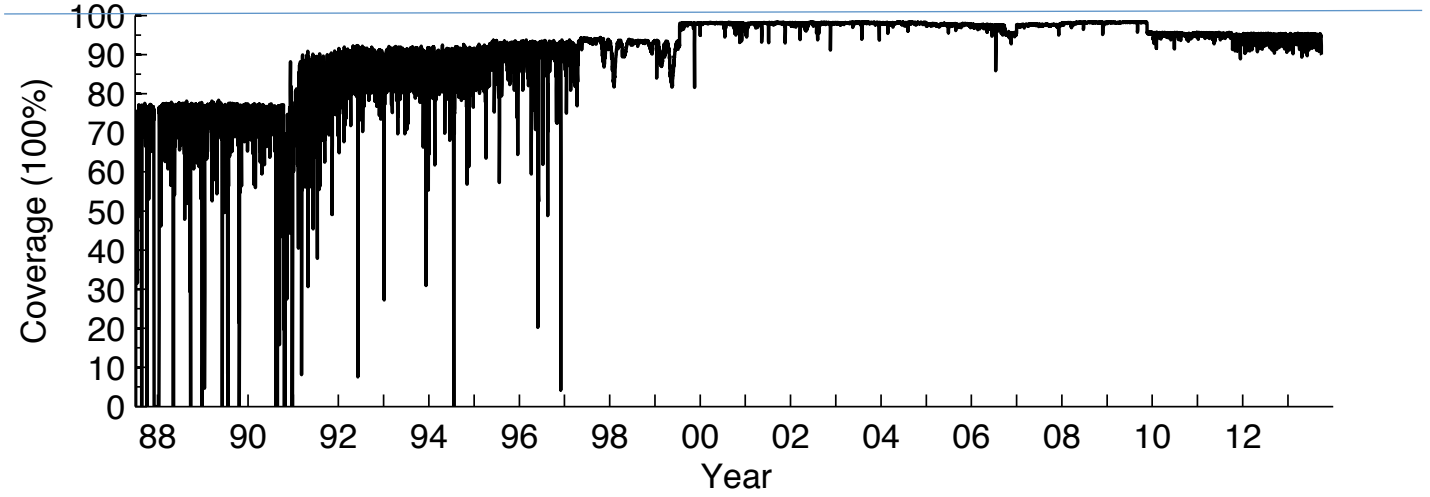
Combination	6-hourly (%)	Daily (%)
QuikSCAT	36	90
QuikSCAT + ASCAT A	50	96
ASCAT- A	22	68
ASCAT A+B	32	79
ASCAT A+B +OSCAT	51	95
OSCAT	33	90

The need defines the key issues for the development:

- Resolution
- Role of the radiometer wind speed observations
- Art of using reanalysis winds
- Role of in situ buoy measurements
- Identification of major sources of uncertainty
- Other issues, such as sea ice mask, land-sea mask, etc

There is always a need to develop tools for filling the missing gaps. We reach out to radiometers in developing the OAFlux analysis.

Daily Coverage provided by 12 sensors (scatterometers + radiometers)



Before QuikSCAT, the maximum daily coverage ~ up to 92%

For the QuikSCAT period onward, a 100% daily coverage is still unlikely because of rain.

-> **Temporal resolution:**

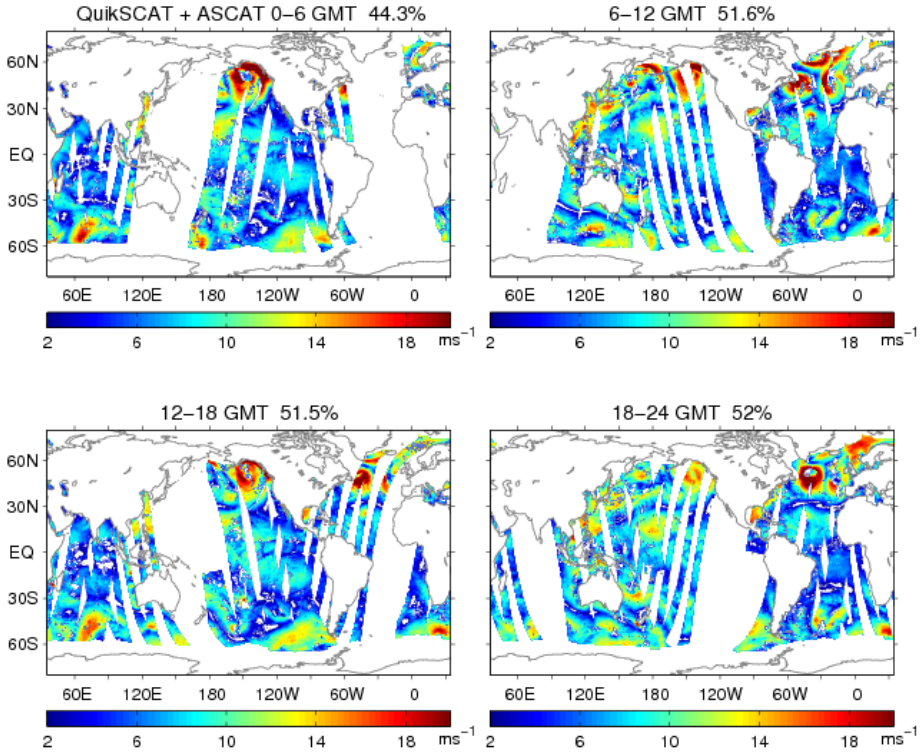
A compromise between the global coverage and the analysis period.
We chosen daily resolution for maximum satellite coverage.

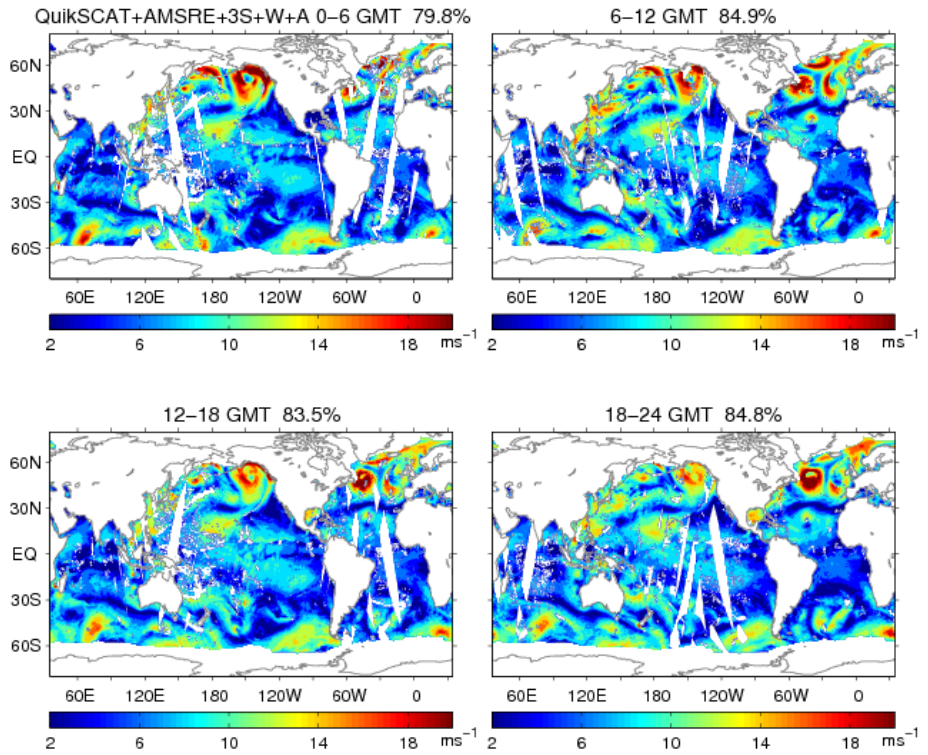
Would higher temporal resolution do a better job in representing daily means?

Let's experiment the 6-hourly synthesis (01 JAN 2008)

Scatterometers only
QuikSCAT+ ASCAT-A

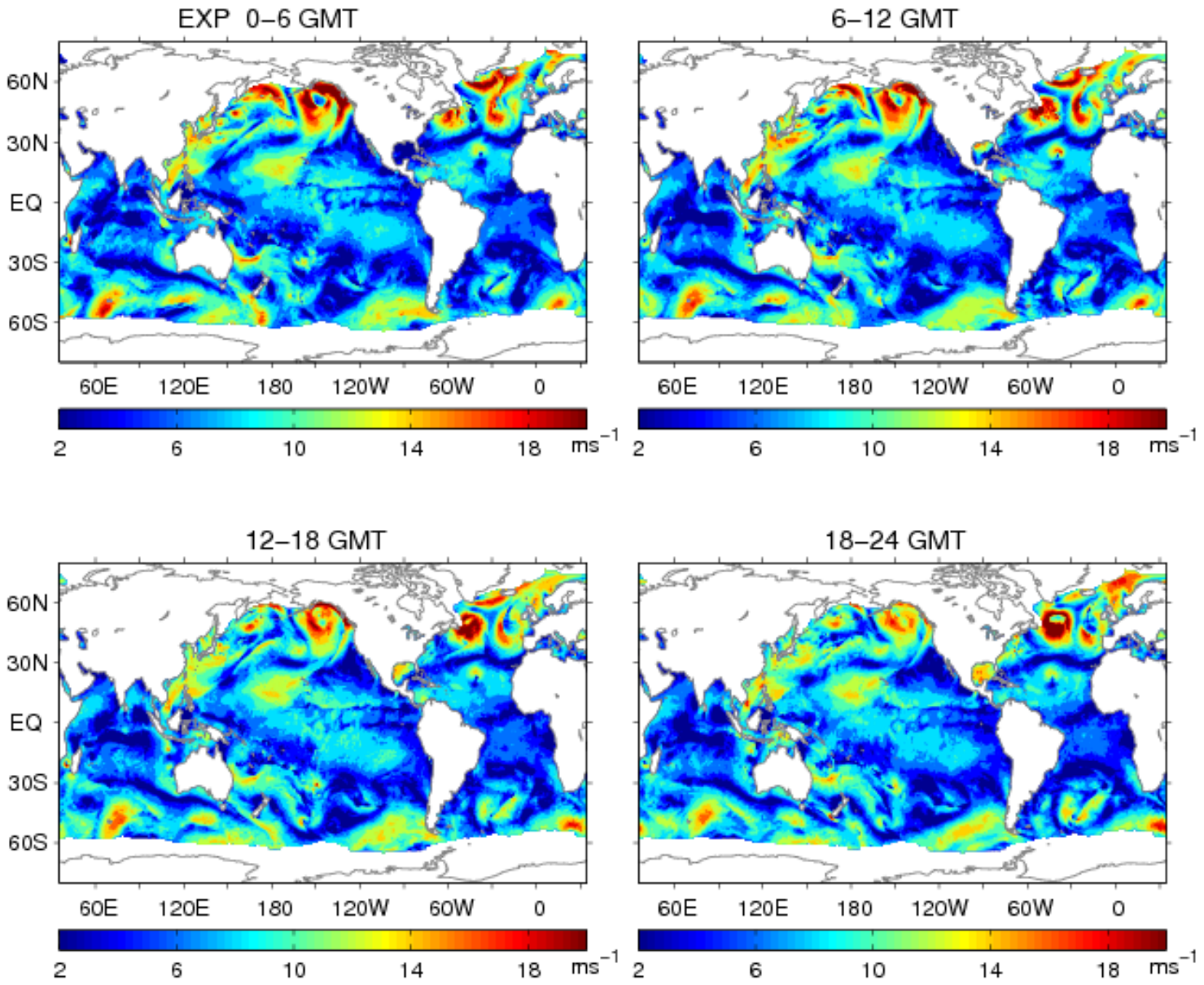
Scatterometers + radiometers
QuikSCAT+ ASCAT-A + 5 radiometers



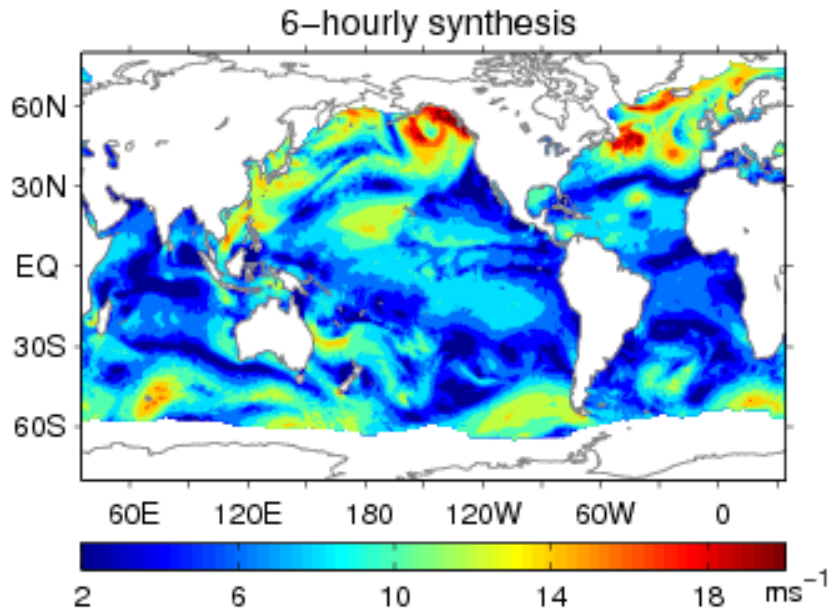


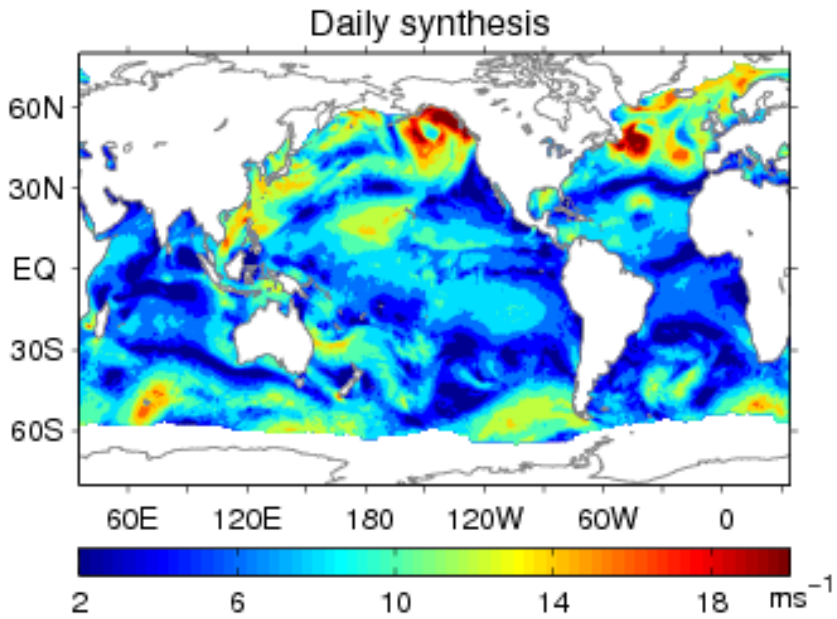
Role of radiometers: reducing missing data gaps in scatterometer

6-hourly synthesis

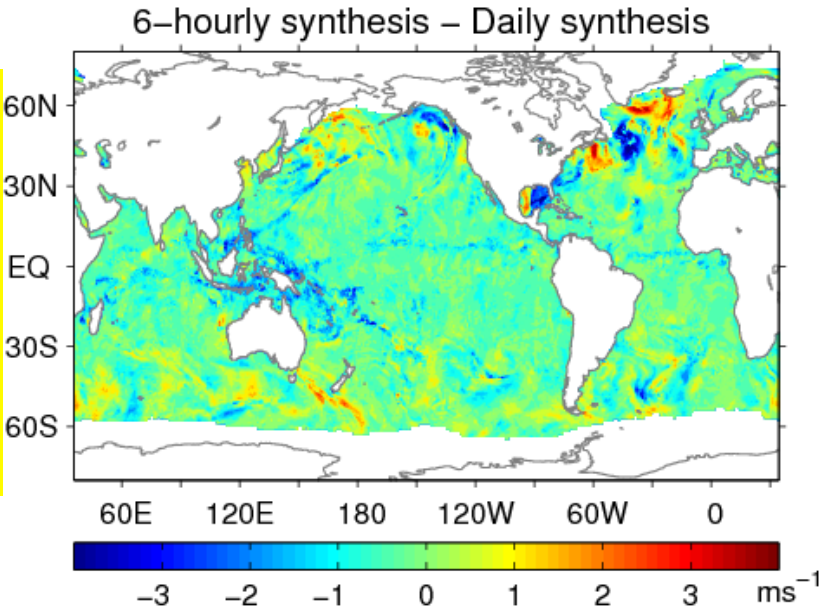


Daily mean: 6-hourly synthesis versus daily synthesis





Difference between the two daily means



Daily synthesis is a reasonable representation of the daily-mean field except for the western Pacific warm pool region and the extratropical storm latitudes.

At what temporal resolution can sub-daily variability be best represented?

Why do we need reanalysis winds?

Reanalysis winds are used for
(i) providing background directional information for radiometer observations; (ii) data

Methodology:

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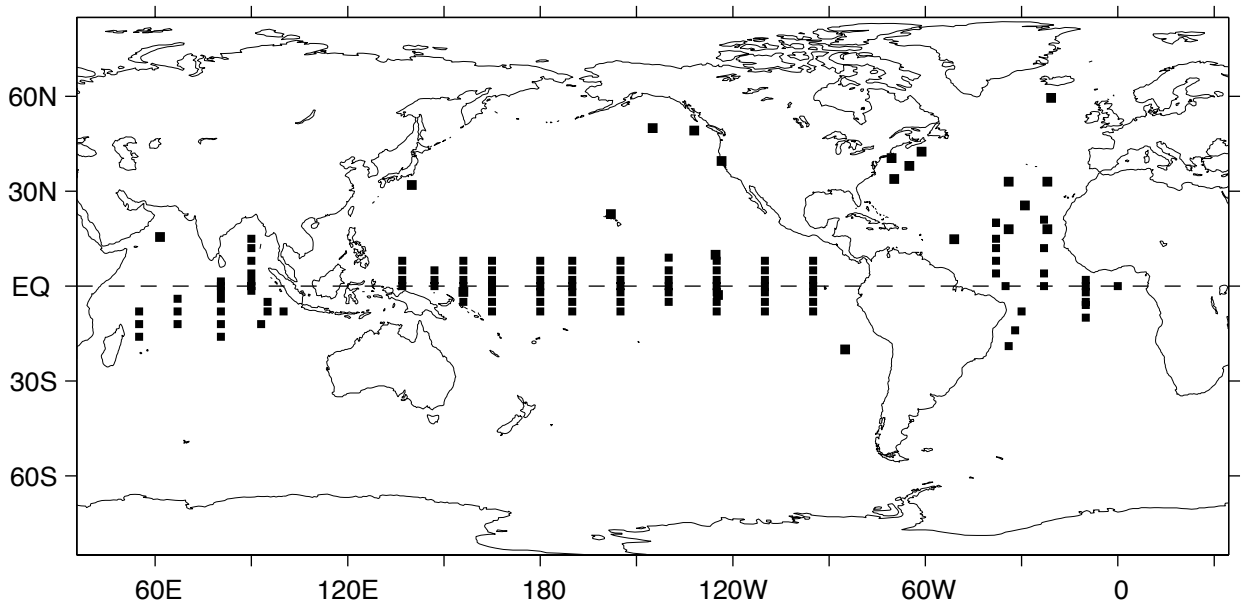
- A cost function is formulated for the objective analysis:

$$F = \sum_k \alpha_k (u_{ana} - u_{o,k})^2 + \sum_k \alpha_k (v_{ana} - v_{o,k})^2 + \sum_m \beta_m (\sqrt{u_{ana}^2 + v_{ana}^2} - w_{o,m})^2 + Dyn(vort, div)$$

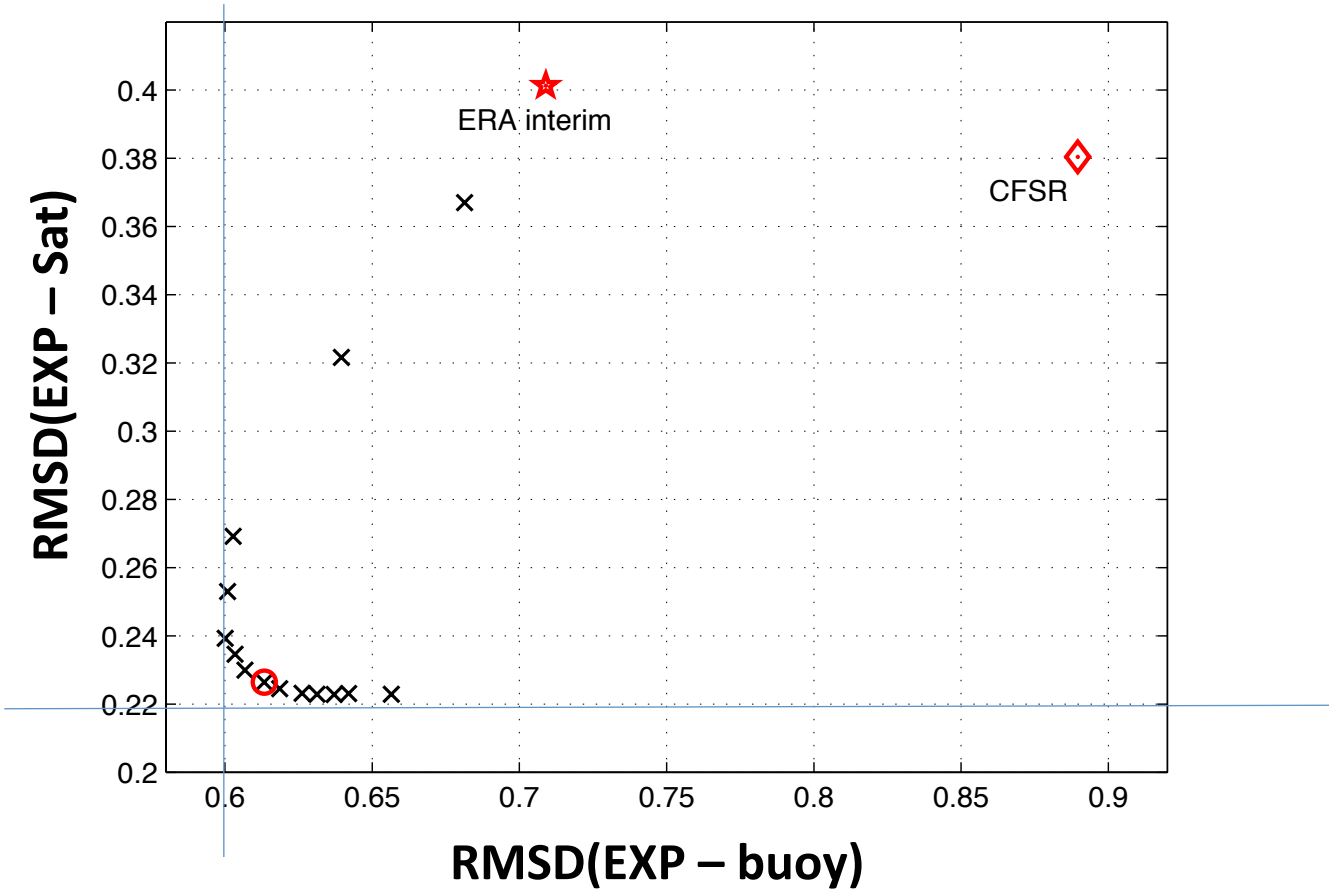
Can buoys help to choose the "weights" for the reanalysis constraints?

Location of 126 buoys



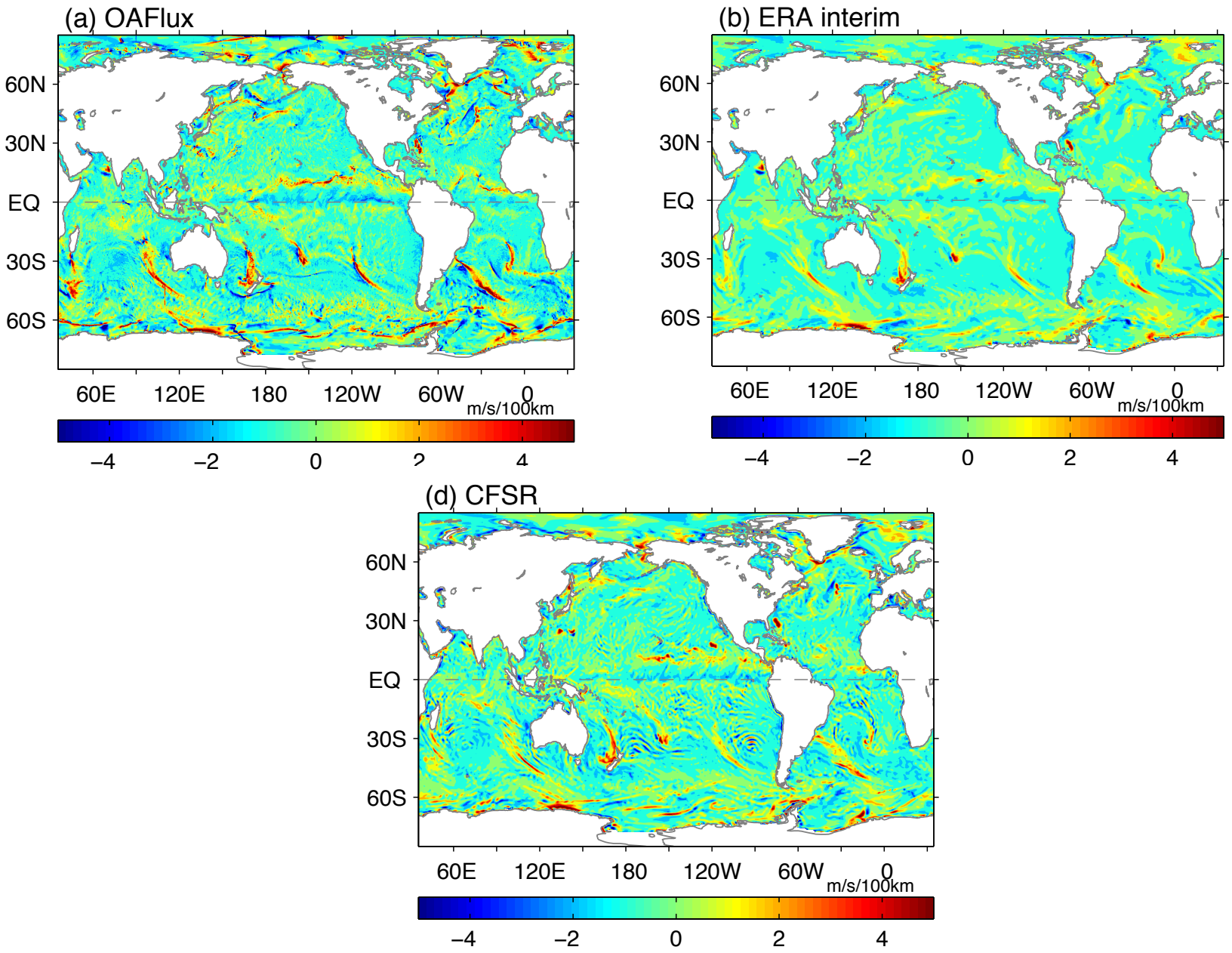
How much weights should be assigned to reanalysis winds?

Two criteria: (1) RMSD (EXP – Buoy); (2) RMSD(EXP – Sat)

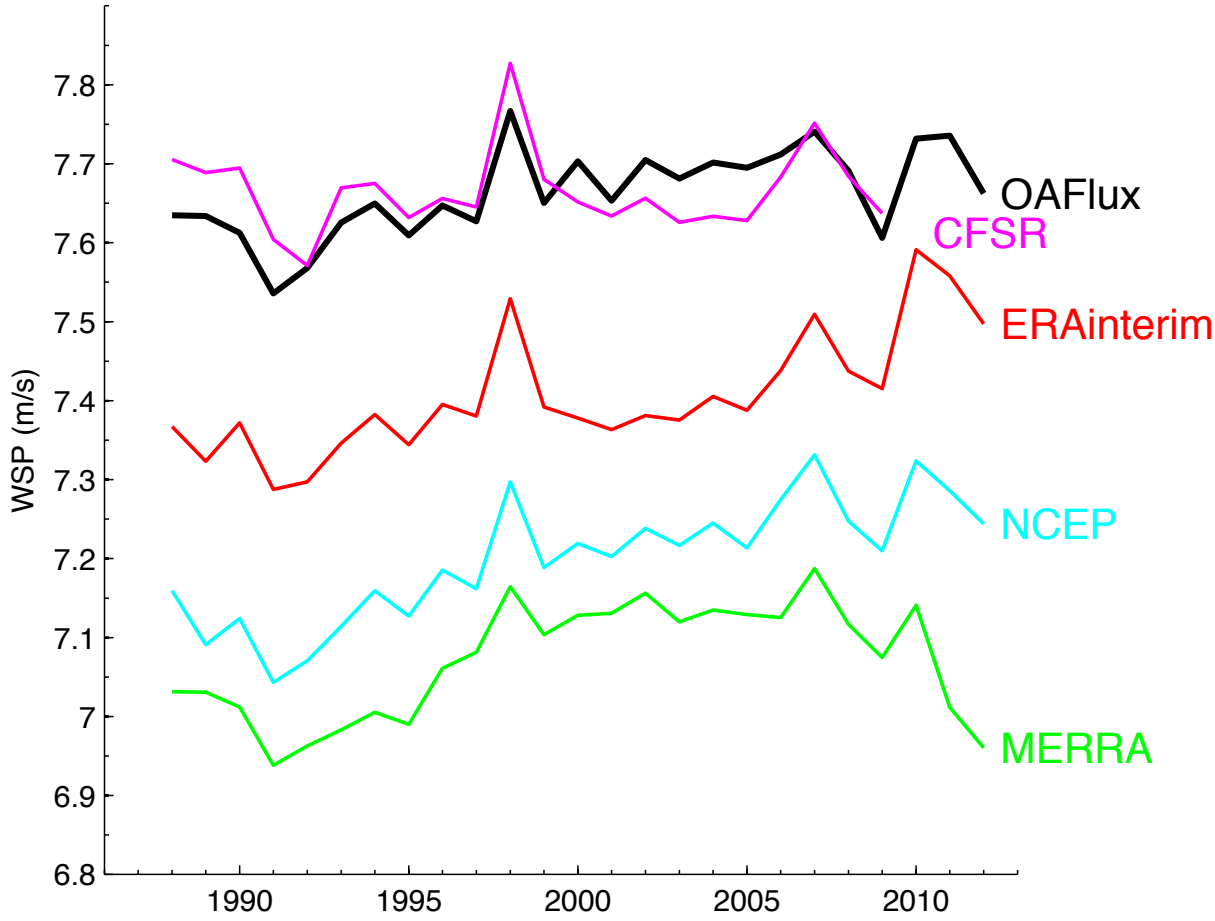


X: experiment based on the set of pre-specified weights

OAFlux vs ERAinterim and CFSR: wind convergence, 01-Jan-2008

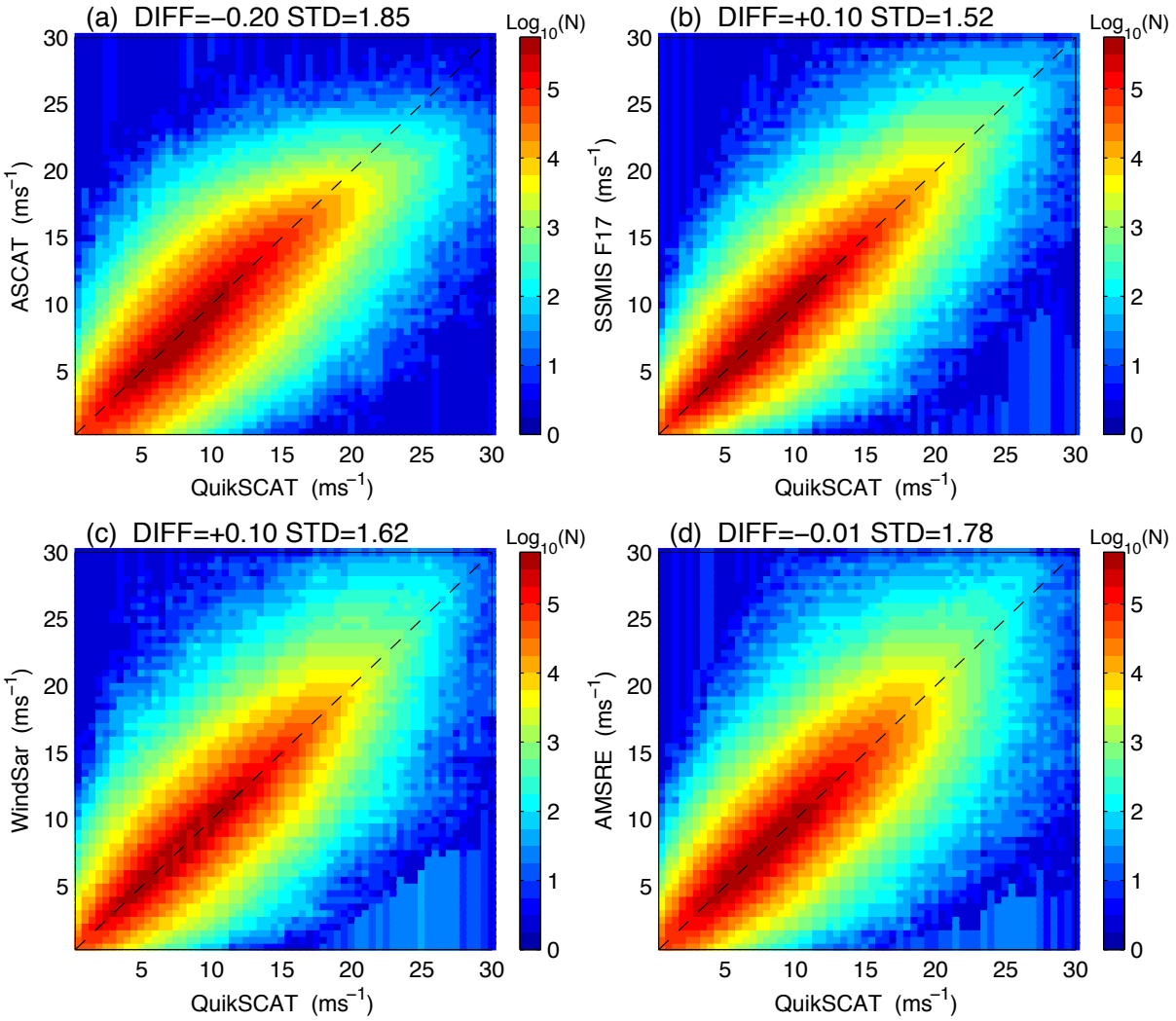


Time series comparison between OAFlux and reanalysis winds



NOAA Climate Reanalysis Task Force Team activity

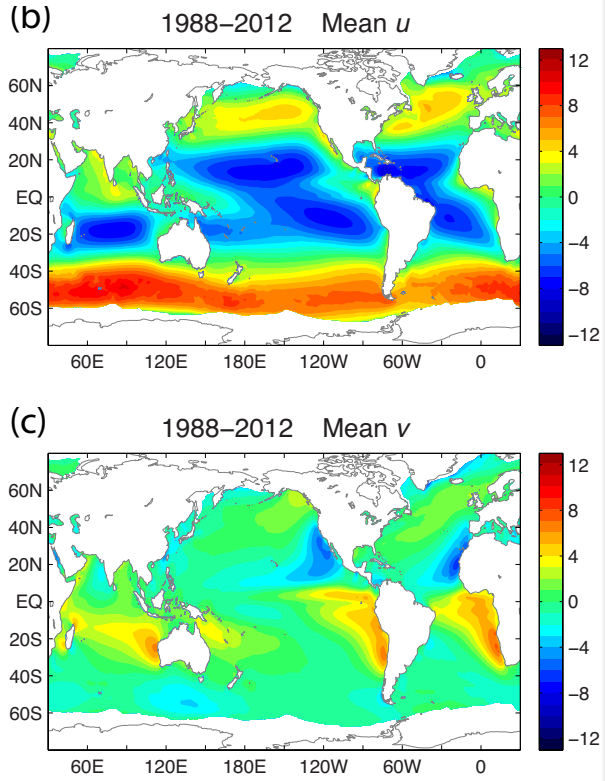
Sources of uncertainty: High winds, in addition to rain



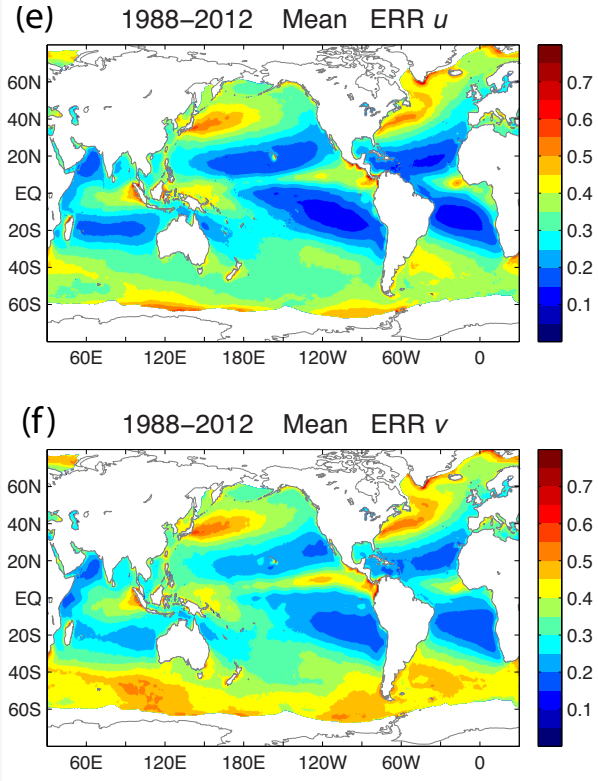
There are differences in high winds between sensors.

Map of uncertainty: High winds and rain

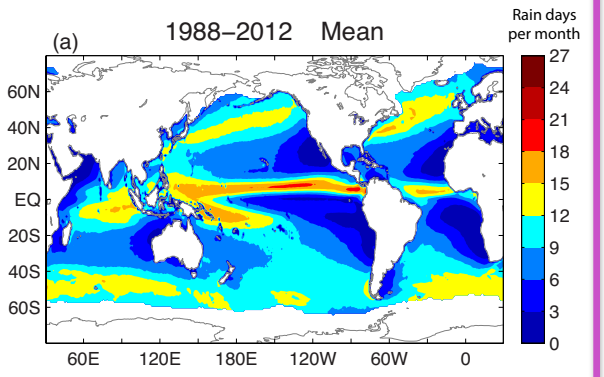
Time-Mean u, v



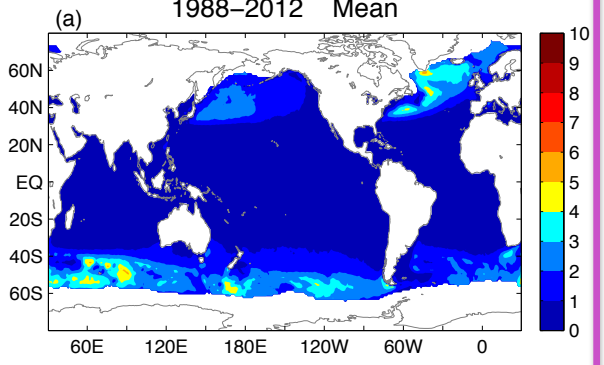
Time-Mean u, v errors



Rain Flag Pattern

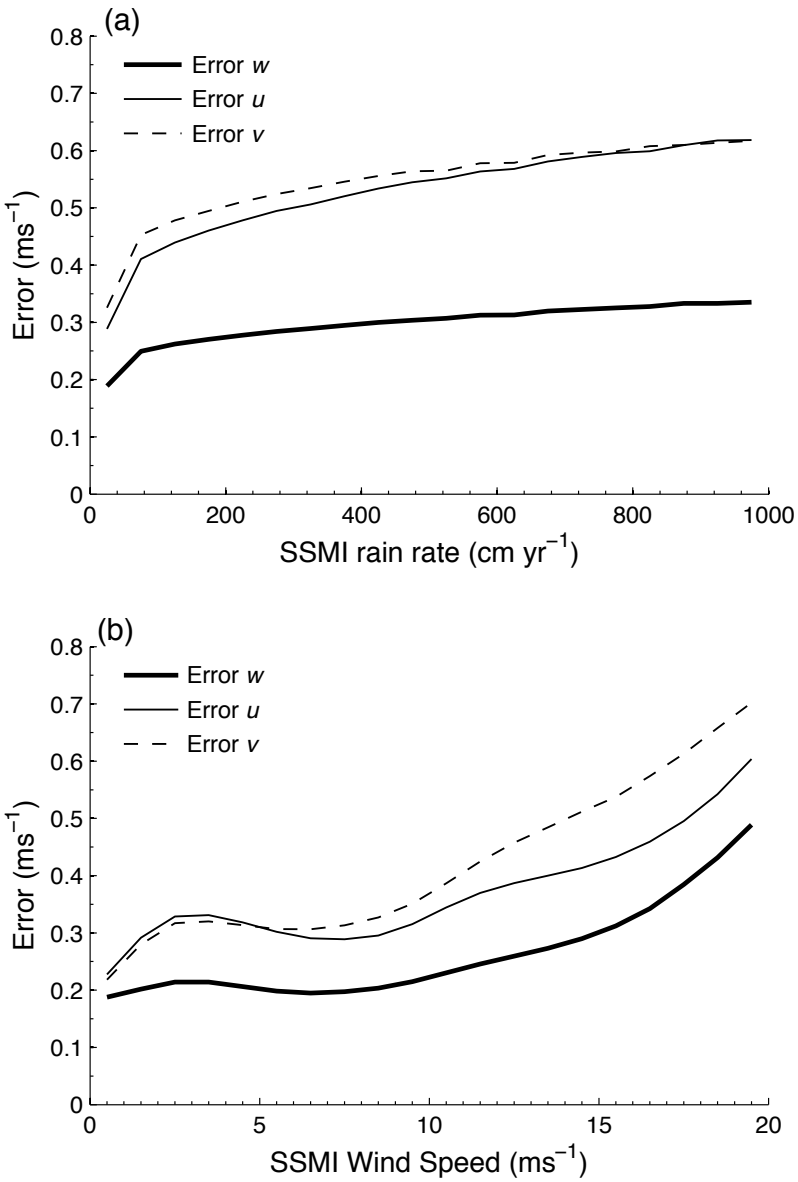


High-wind Pattern



- Mean patterns of u and v are different, but the mean errors patterns are similar.
- The errors patterns reflect the influence of rain and high winds.

Map of uncertainty estimates: High winds and rain



Summary

The need of observations at every ocean grid when constructing a gridded product articulates the need to solve the following key issues:

1) Temporal Resolution:
a compromise between global coverage and the analysis period

2) Role of the radiometer wind speed observations
we utilize radiometers to fill missing data gaps in scatterometers and use the developed framework to reconstruct the vector wind between 1987-1999.

3) Art of using reanalysis winds:
can we use in situ buoy to guide the selection of the right amount of reanalysis contribution?

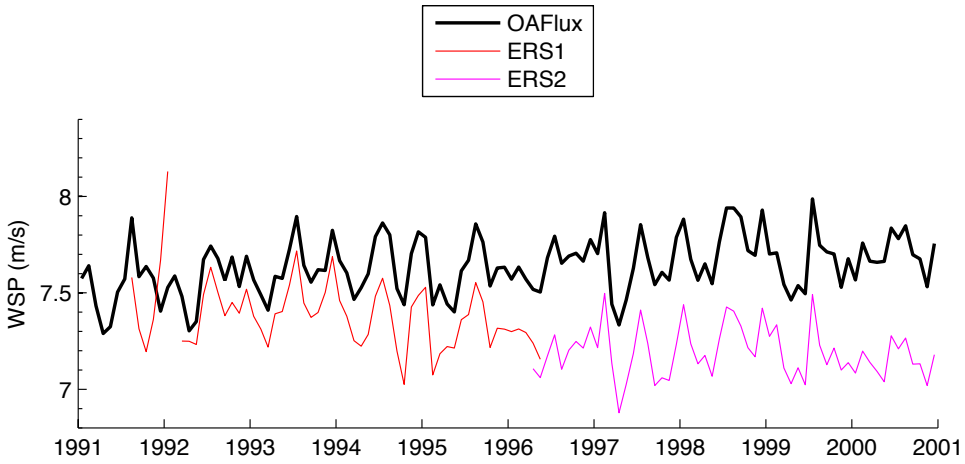
4) **Role of in situ buoy measurements:**
i) validation, ii) independent reference for tuning the error specification for reanalysis

5) **Major sources of uncertainty: high winds and rain**

6) **Other issues, such as sea ice mask, land-sea mask, are discussed in our papers.**

Cross-validation between products:

OAFlux is independent of ERS-1/2



Add offset to ERS-1/2