Analysis of Turbulent Flux Quality

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New Release of Turbulent Fluxes

Bentamy, A., S. A. Grodsky, K. Katsaros, A. M. Mestas-Nuñez, B. Blanke and F. Desbiolles , 2013: Improvement in air–sea flux estimates derived from satellite observations, International Journal of Remote Sensing, 34 (14), DOI:10.1080/01431161.2013.787502.

Wind stress $$\tau=(\tau_x,\tau_y)=\rho\ C_D\ \bar{U}(u,v)$$

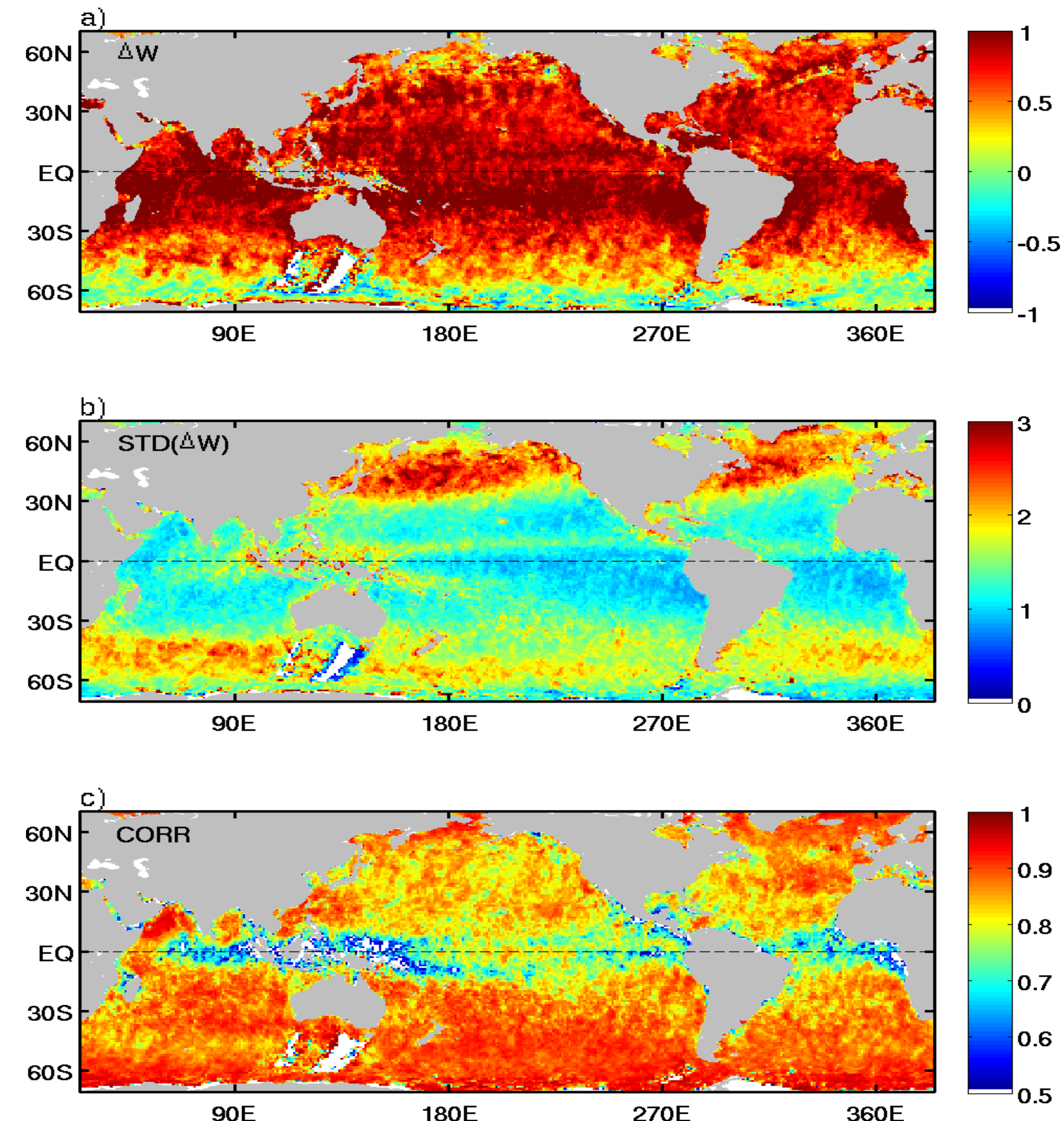
Latent heat flux $$Q_{latent}=-l\rho\ C_E\ \bar{U}(q_a-q_s)$$

Sensible heat flux $$Q_{sens}=-\rho C_p C_h \bar{U}(T_a-T_s)$$

- Coare3.0 Parameterizations (Fairall et al, 2003)

Consistency Issues : Difference QuikSCAT – ERS-2

Bentamy A., Grodsky S. A., Chapron B., Carton J. A., 2013: Compatibility of C- and Ku-band scatterometer winds: ERS-2 and QuikSCAT. J. Marine System 117-118, 72-80

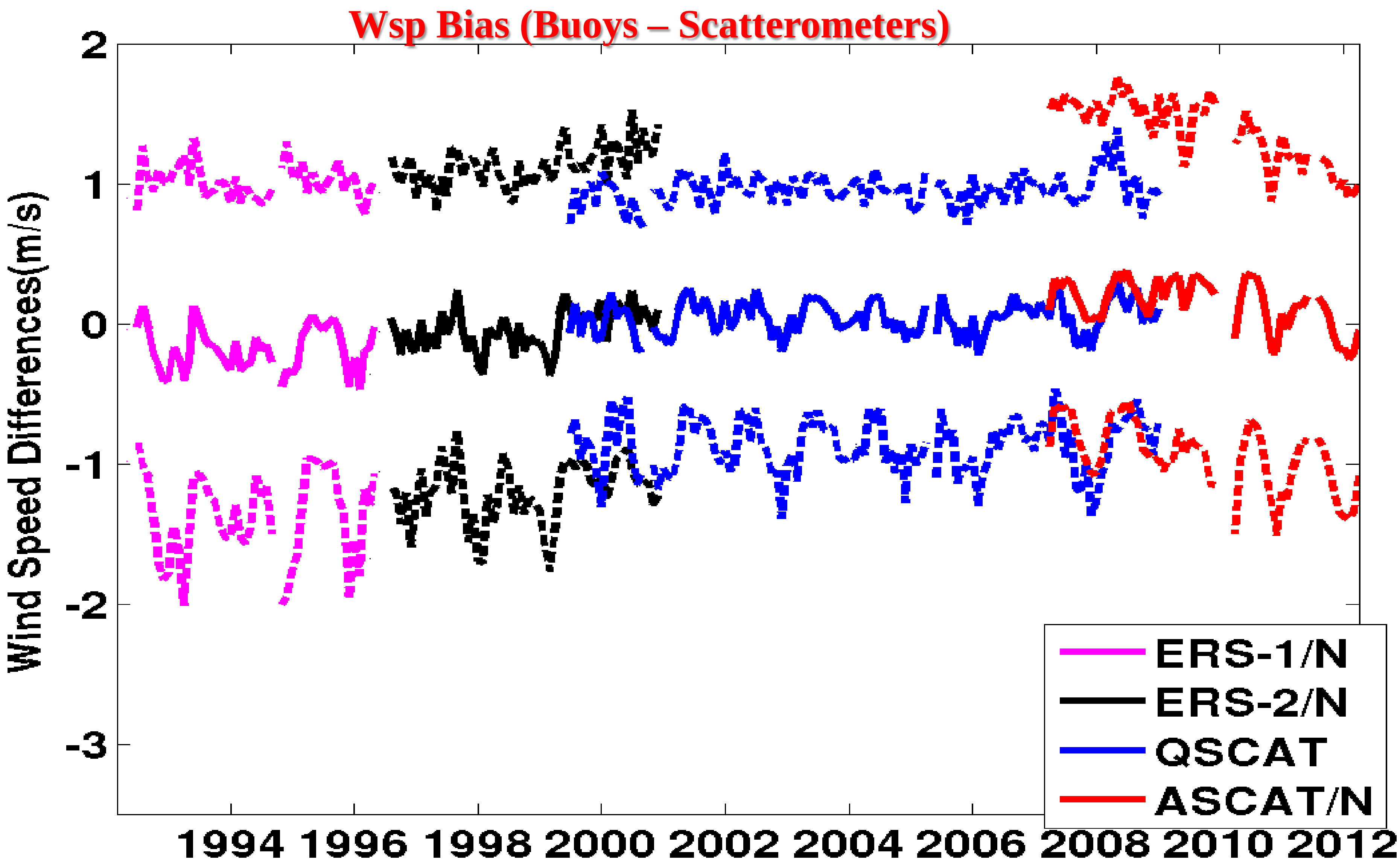


Estimation of Turbulent Fluxes: Main Changes

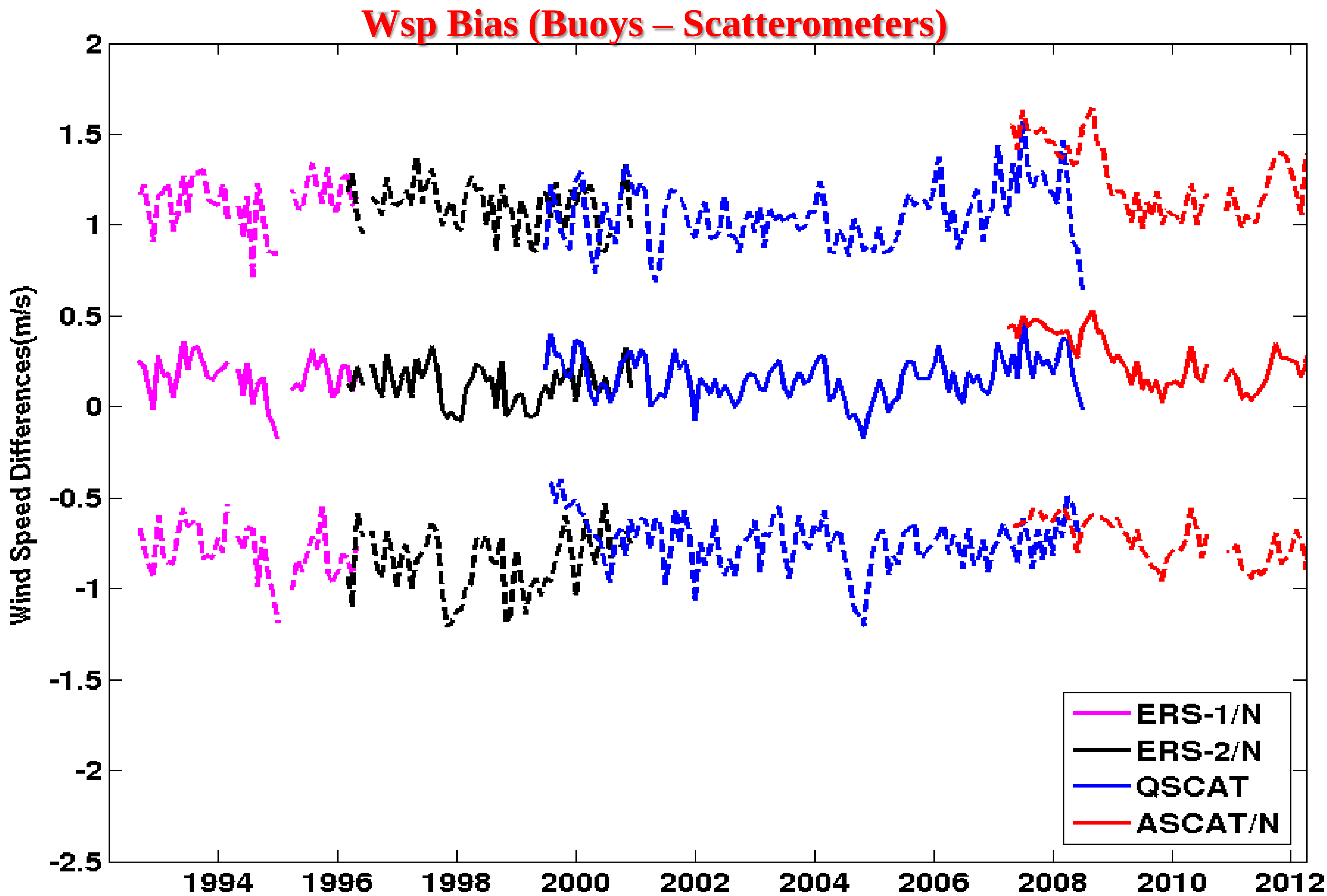
- **Wind** *(L2b products)*:
  - ERS-1 (Ifremer)
  - ERS-2 (Ifremer)
  - QuikSCAT (JPL/PODAAC)
  - ASCAT (SAF OSI / KNMI)
- **Consistency** (*Bentamy et al, 2012; Grodsky et al, 2012; Bentamy et al, 2013*)
  - ASCAT / QuikSCAT
  - ERS-2 / QuikSCAT
  - ERS-1 / ERS-2

- **Reprocessing**
  - Correction of QuikSCAT
  - Correction of ASCAT
  - Characterisation of ERS-1 and ERS-2 σ^0 biases
  - Retrievals of ERS-1 and ERS-2 from Cmod5.n

Long Time Series of Scatterometer Winds Comparisons Versus NDBC Buoys



Long Time Series of Scatterometer Winds Comparisons Versus Tropical Buoys



New Release of Turbulent Fluxes (Bentamy *et al*, 2013)
Main Changes

- **Specific Air Humidity :**

  qa_{10} = f(Tb,SST,Ta)

  Tb are from SSM/I F10 – F15

- **Consistency** **(Fundamental Climate Data Record (Berg et al, 2012))**
  - **Tb are from Univ colorado / NOAA/NESDIS**

- **Reprocessing**
  - $qa_{10} = f_1(Tb_{19V}) + f_2(Tb_{19H}) + f_3(Tb_{22V}) + f_4(Tb_{37V}) + g(SST) + h(\Delta T)$
  - Calibration based on collocated Tb and qa_{10} from ICOADS and buoys

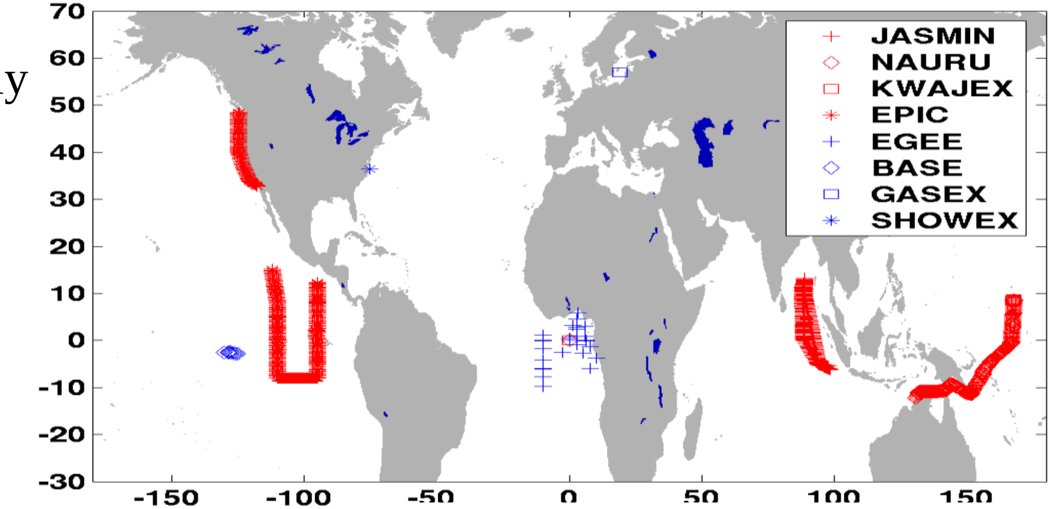
New Release of Turbulent Fluxes (Bentamy *et al*, 2013)

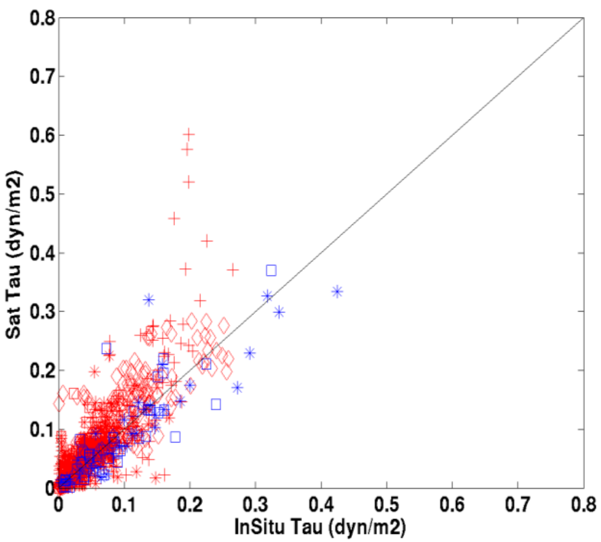
- **Air Temperature:**
  - Corrected Era Interim
- **Sea Surface Temperature**
  - HR SST V2 (Reynolds et al, 2007)

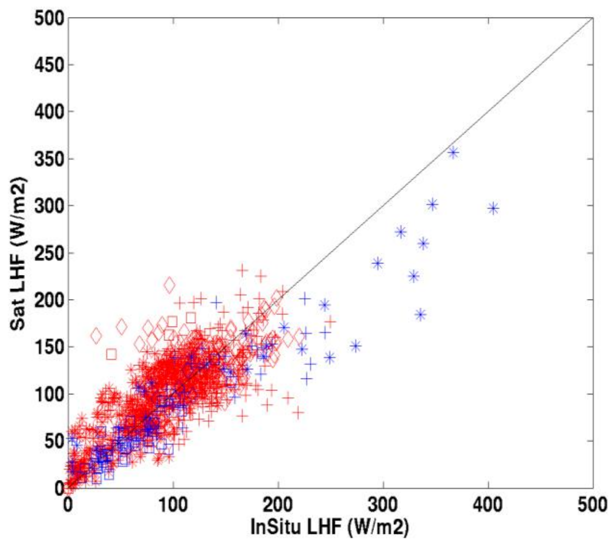
Objective Method (Bentamy *et al* , 2011)
Calculations of Global Daily and Monthly 0.25°x0.25° Flux Analyses.

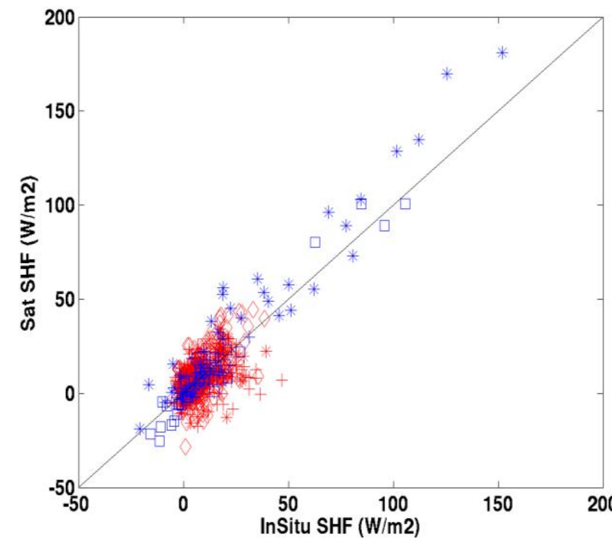
Assessment of the Turbulent Flux Accuracy

- Spatial and temporal Collocation of Daily Estimates

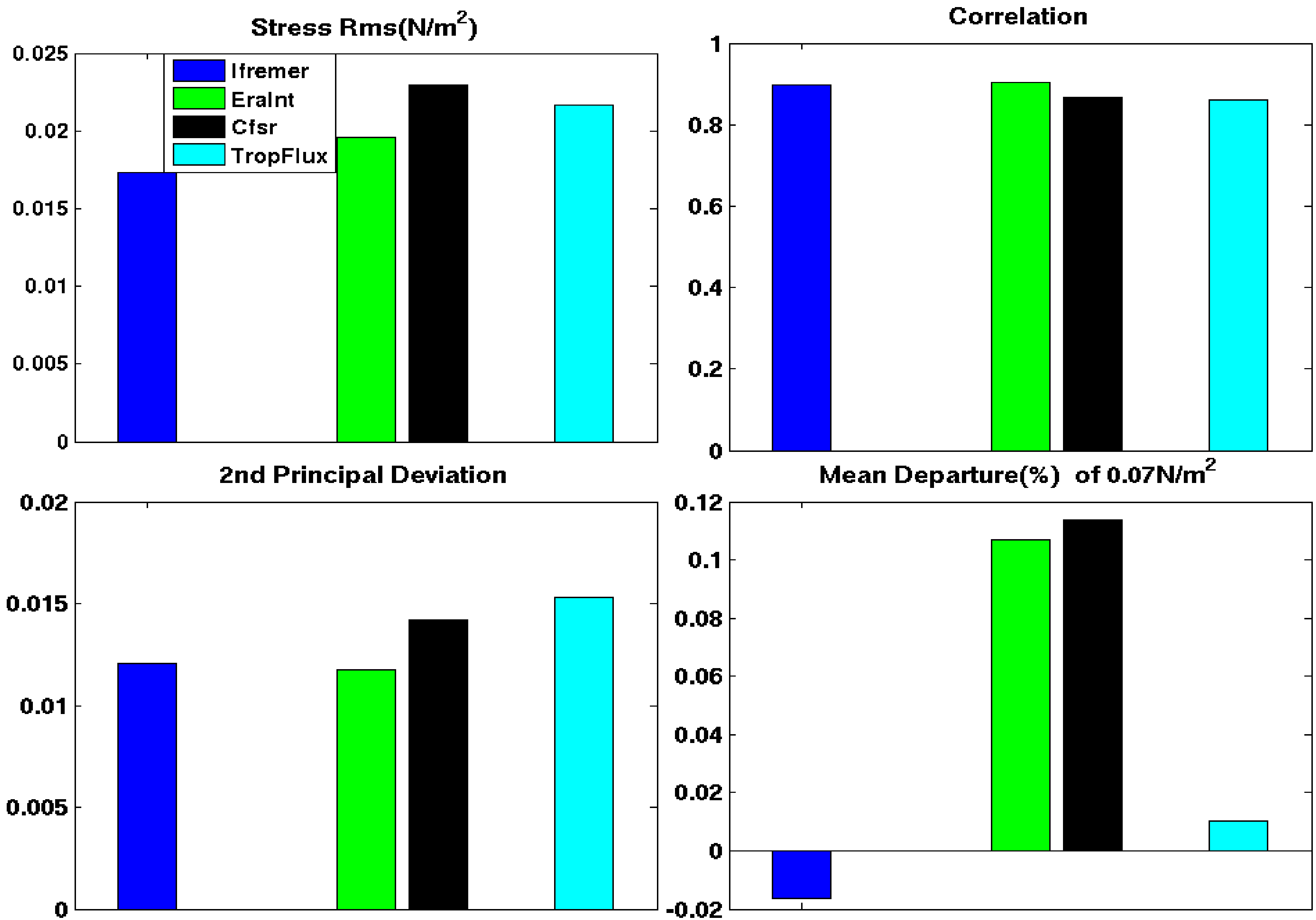




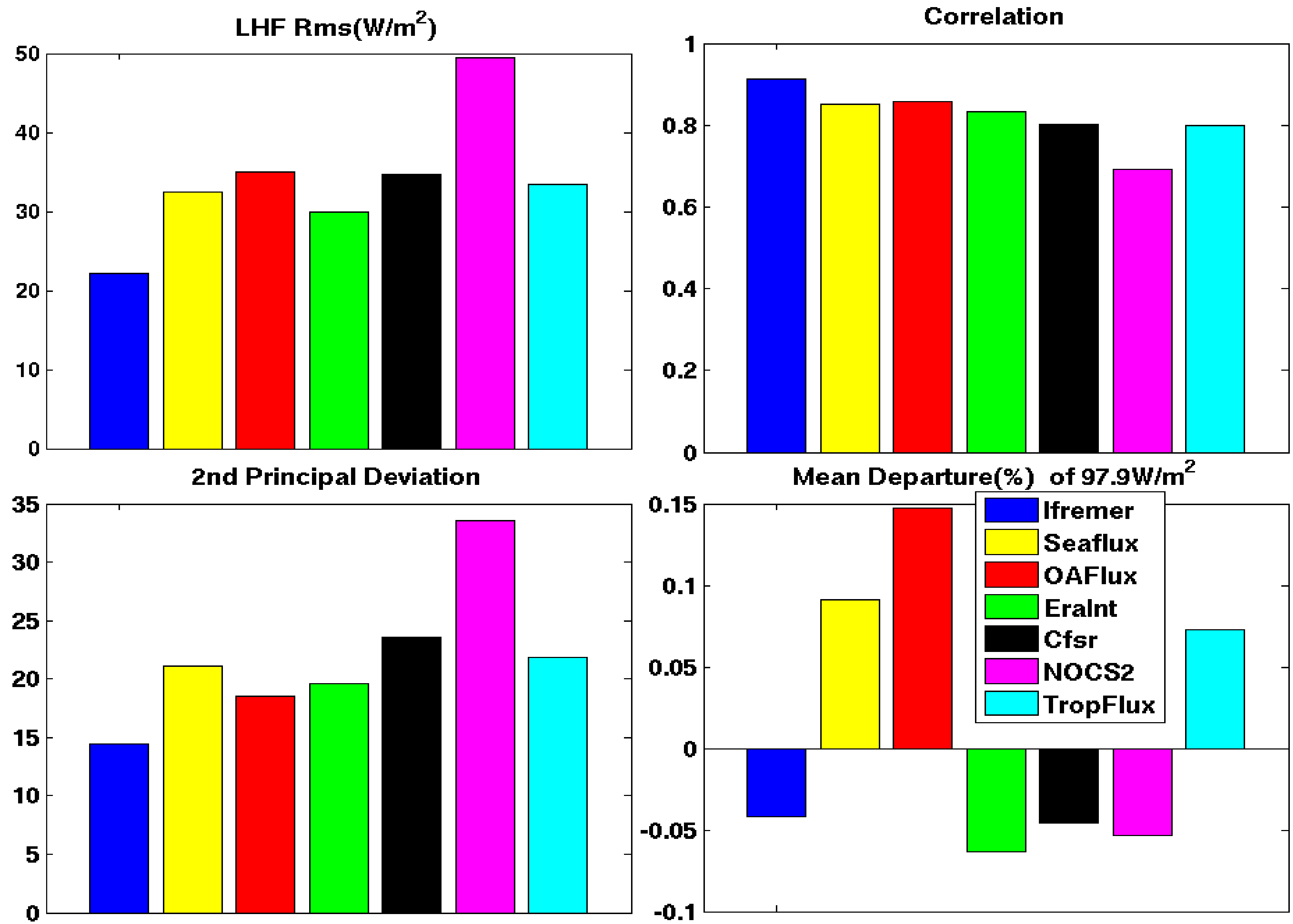




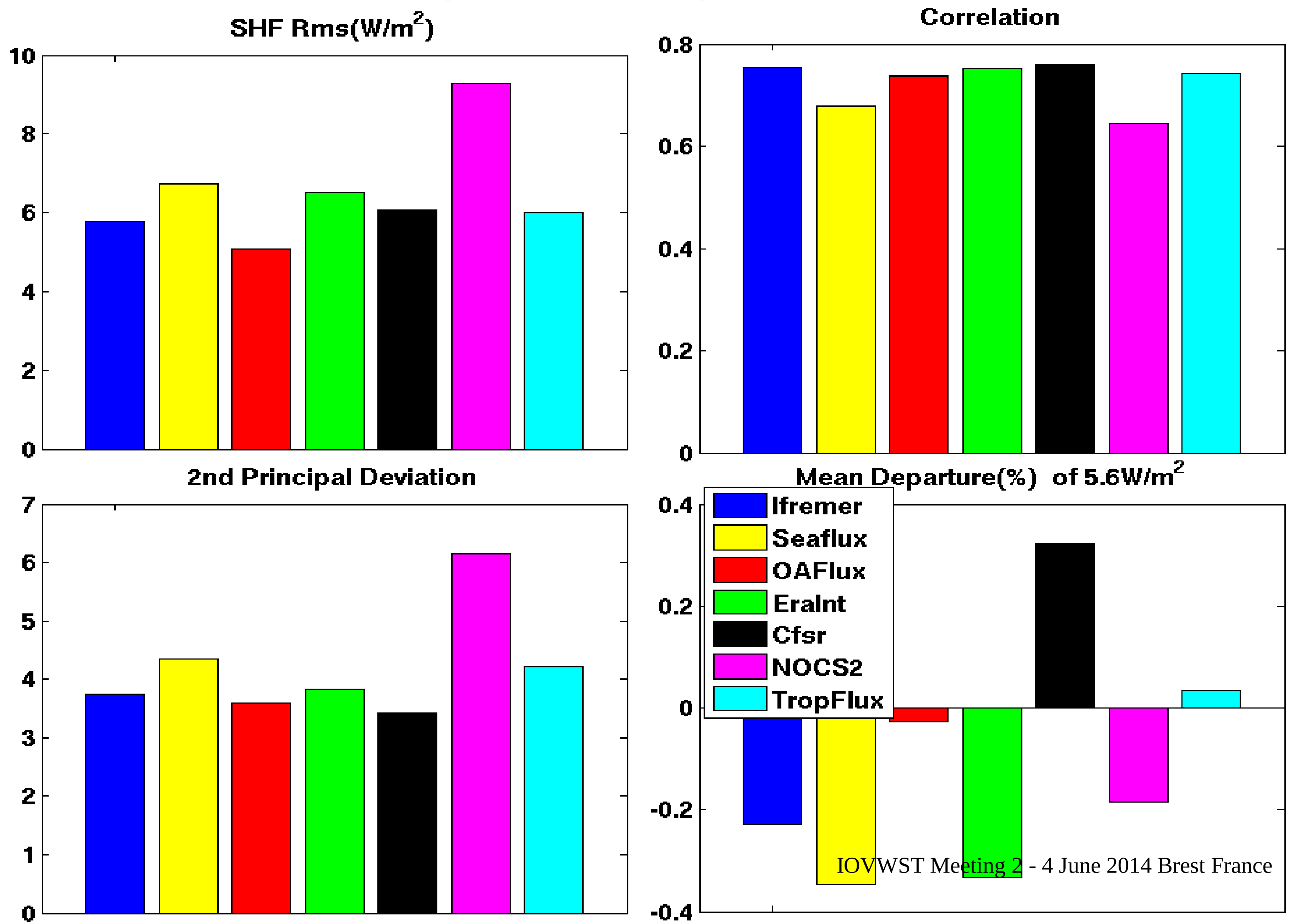
Assessment of the Wind Stress Accuracy: TAO, PIRATA, RAMA



Assessment of the Latent Heat Flux Accuracy: TAO, PIRATA, RAMA

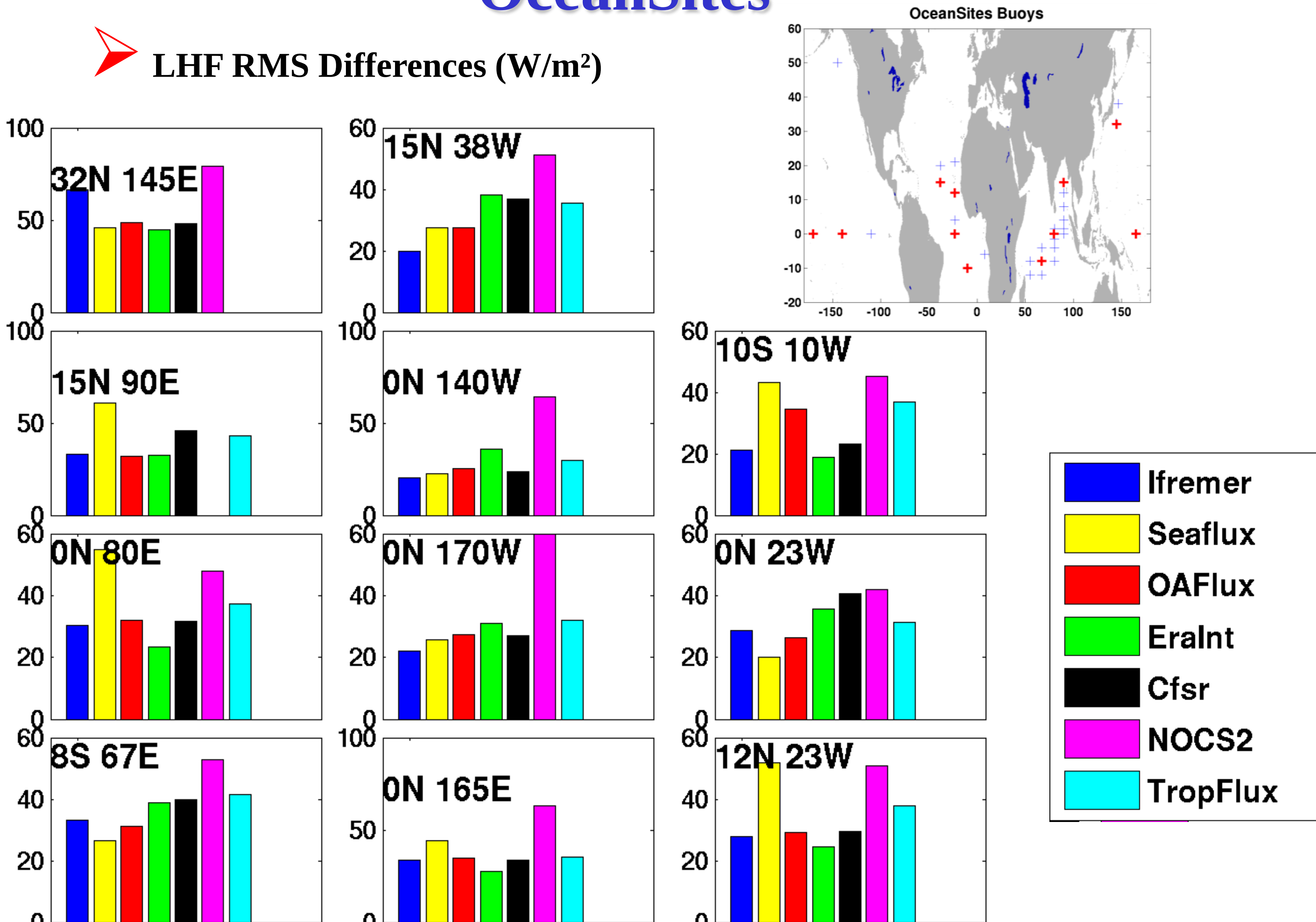


Assessment of the Sensible Heat Flux Accuracy:
TAO, PIRATA, RAMA



Assessment of the Latent Heat FluxAccuracy: OceanSites

- **LHF RMS Differences (W/m²)**



Towards Improved Estimates of Ocean Heat Flux (TIE-OHF) ESA ITT

Ocean Heat Flux Recommendations and Priorities

- WCRP, 2013: Report from the World Climate Research Program (WCRP). May 2013 (http://www.wmo.int/pages/prog/sat/meetings/documents/ET-SUP-7_Doc_08-03_WCRP.pdf)
- CLIVAR/ESA scientific consultation workshop on: "Earth Observation Measurement Constraints on Ocean Heat Budget". July 2013
- WOAP, 2012: Report action plan for WCRP activities on surface fluxes, WCRP informal report (http://www.wcrp-climate.org/documents/woap_fluxes_report_01_2012.pdf)
- Yu, L., K. Haines, M. Bourassa, S. Gulev, S. Josey, T. Lee, M. Cronin, A. Kumar, 2012: CLIVAR GSOP WHOI Workshop report on Ocean Syntheses and Surface Flux Evaluation Woods Hole, Massachusetts, 27-30 November 2012
- Oke, PR, O'Kane, TJ 2011, Observing system design and assessment, in A Schiller, GB Brassington (eds.), Operational Oceanography in the 21st Century, Springer, Amsterdam, pp.123-151
- Pinker R. T., A. Bentamy, K. B. Katsaros, Y. Ma, and C. Li, 2014: Estimates of net heat fluxes over the Atlantic Ocean. J. Geophy. Res. VOL. 119, 1–18, doi:10.1002/2013JC009386, 2014

Towards Improved Estimates of Ocean Heat Flux

- Institut Français pour la Recherche et l'Exploitaion de la MER (**IFREMER**)
- Institute of Oceanology, Russian Academy of Sciences (**IORAS**)
- Institut Méditerranéen d'Océanologie (**MIO**)
- German Weather Service (**DWD**)
- Nansen Environmental and Remote Sensing Center (**NERSC**)
- Plymouth Marine Laboratory (**PML**)
- Univ. Maryland (**UM**) :
- Univ. Reading (**UR**) :
- Woods Hole Oceanographic Institution (**WHOI**)

Requirements for Ocean Heat Flux Improvements

- **Improvements of the retrievals (Bulk Variables)**
  - **Surface Winds**
  - **Specific Air humidity**
  - **Air and Surface Temperatures**
- **Long Time Consistency of Bulk Variables over Global Ocean**
- **Homogenization of OHF measurements used as 'Truth"**
- **OHF parameterizations particularly for high and low wind conditions**
- **Global Long Time Series of OHF**
- **Validations and inter-comparisons of available products at Global and Regional Scales**
- **Make Variable and OHF data accessible**

Towards Improved Estimates of Ocean Heat Flux
Expected Results

Reference Data Set Generation

✓Collecting and archiving EO (especially from ESA sources) and non EO data as well as satellite L3 and L4 and NWP flux products available during common period of at least 10 years.

✓Assessment of the data quality. It will be determined through comprehensive comparisons with *in situ* flux data

✓Homogenization of the spatial and temporal resolutions among the selected products.

✓Determination of product differences at various spatial and temporal scales, and according to atmospheric and oceanic parameters of interest.

✓Checking for consistency of the ensemble based on the assessment of the heat budget closure for different regions ("cage" approach).

Summary / To Do

✓Progress in the consistency of scatterometer retrievals

✓ Paper describing the methods and the validation of retrievals will be submitted

✓ Reprocessing of turbulent fluxes based on the new scatterometer retrievals and FCDR data

✓ Determination of accuracies

- Global statistics meet the accuracy requirements
- Further investigations are needed for local assessment

✓ Calculation of Long time series of daily and monthly bulk variables and turbulent fluxes

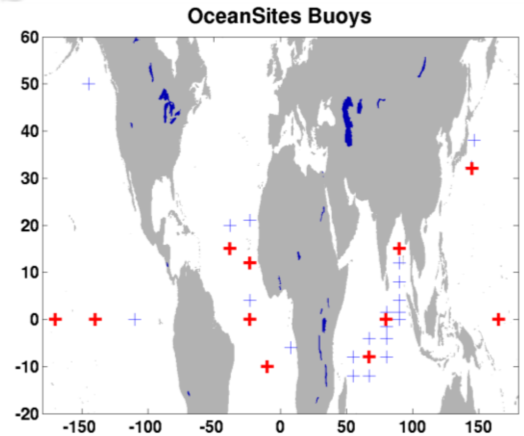
✓ Uncertainties for each daily and monthly global ocean data file online and available for users

✓ Determination of reference data set for inter-comparison purpose

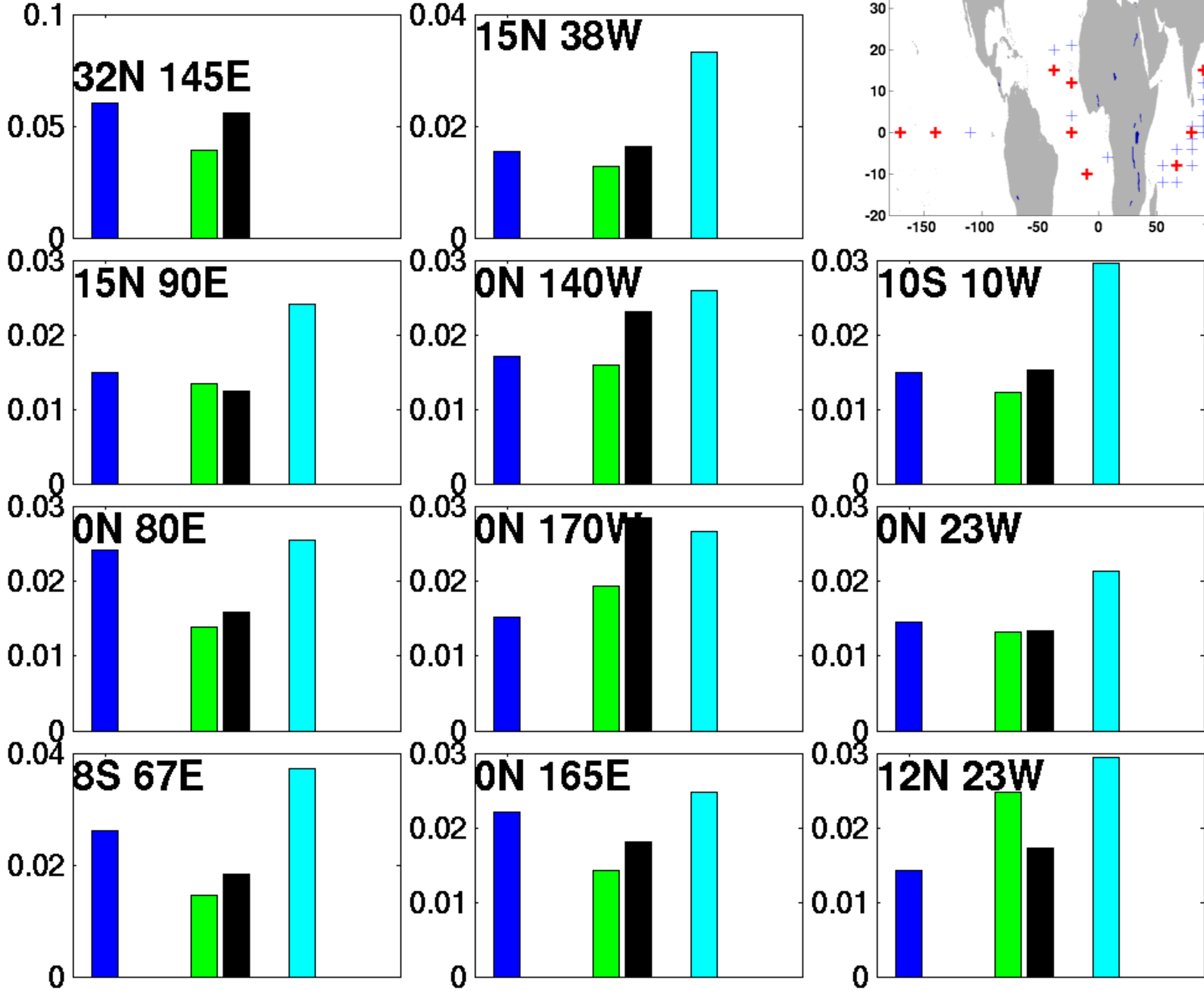
✓Product generation, Inter-comparison and uncertainty characterization

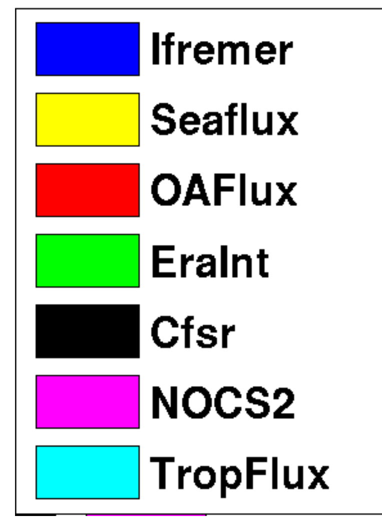
✓Data portal development

Assessment of the Wind Stress Accuracy: OceanSites

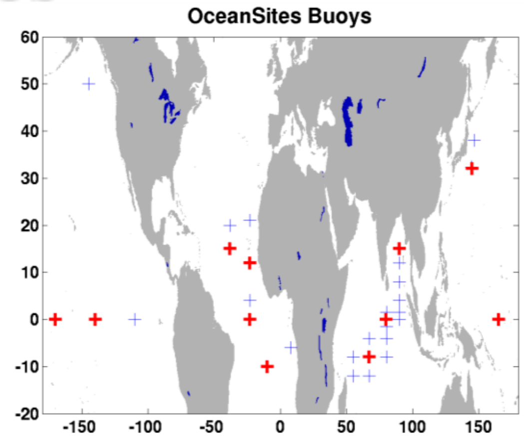


- RMS Differences (dyn/m²)





Assessment of the Sensible Heat Flux Accuracy: OceanSites



- RMS Differences (W/m²)