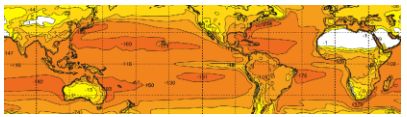
OHF



Towards improved estimate of turbulent heat flux over Global Oceans
OHF Project

esa European Space Agency

STSE Support To Science Element

Evaluating and Improving the Turbulent Components of the Net Heat Flux

Collaboration CLIVAR / WCRP

Ifremer

PML Plymouth Marine Laboratory

mio Mediterranean Institute of Oceanography

NERSC

National Oceanography Centre NATURAL ENVIRONMENT RESEARCH COUNCIL

Deutscher Wetterdienst Wetter und Klima aus einer Hand

DWD

OCEAN.RU Russian Academy of Sciences P.P.Shirshov Institute of Oceanology

University of Maryland

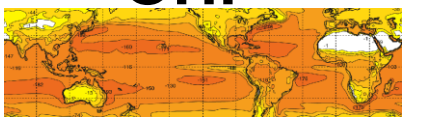
University of Reading

Woods Hole Oceanographic Institution

Florida State University 1851

Major Heat Budget Terms at the Sea Surface

OHF



$$Q_{net} = Q_{SW} + Q_{LW} + Q_{latent} + Q_{sensible}$$

Q_{SW} : Shortwave Radiation Heat Flux (AA^*: +30 to +260 Wm^{-2})
Q_{LW} : Longwave Radiation Heat Flux(-60 to -30 Wm^{-2})
Q_{latent} : Latent Heat Flux (-130 to -10 Wm^{-2})
$Q_{sensible}$: Sensible Heat Flux (-42 to -2 Wm^{-2})

(*: *AA* stands for Annual average)

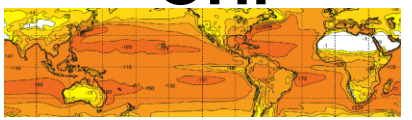
$$Q_{latent} = \rho L_v C_E W(Q_a - Q_s)$$
$$Q_{sensible} = \rho C_p C_H W(T_a - T_s)$$

W = Wind Speed
Qa = Specific Air humidity
Qs = Specific surface humidity
Ta = Air temperature
Ts = Sea surface temperature (SST)

Bulk variables would be estimated from remotely sensed observations

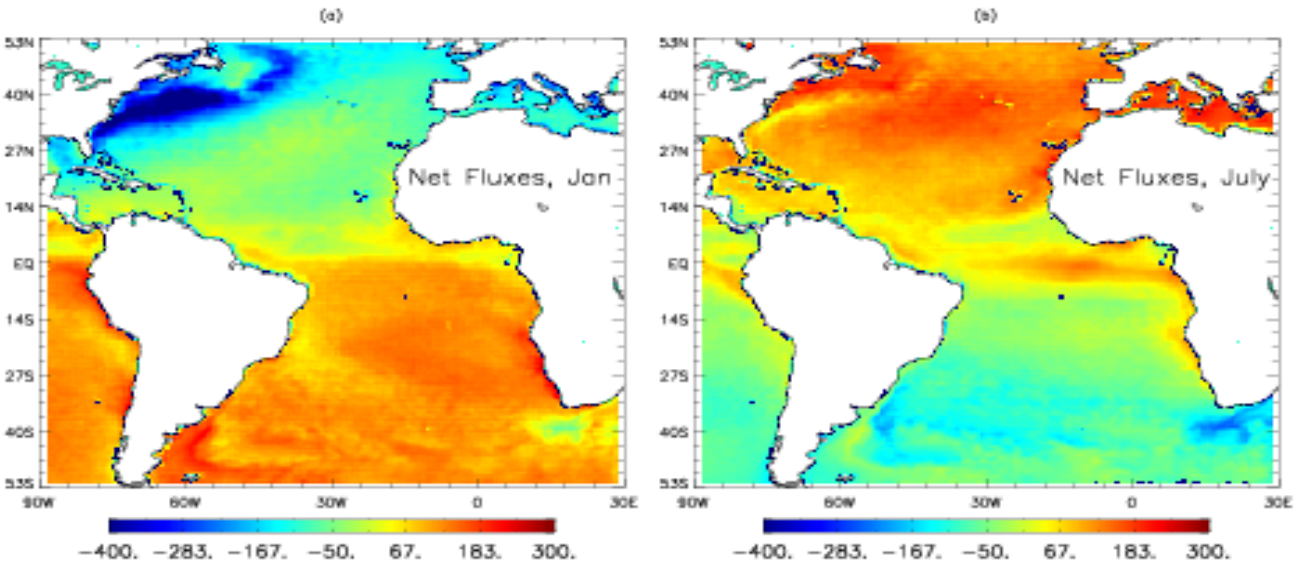
MOTIVATION

OHF

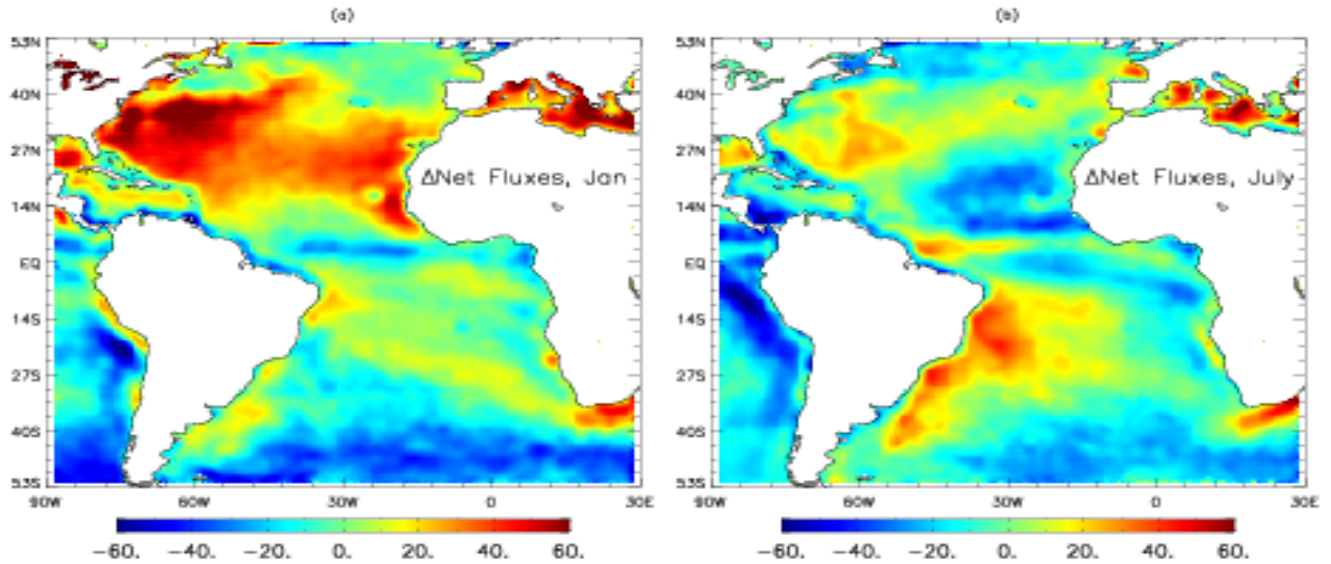


Pinker R. T., Bentamy Abderrahim, Katsaros Kristina, Ma Y., Li C. (2014). Estimates of net heat fluxes over the Atlantic Ocean. Journal Of Geophysical Research-oceans, 119(1).

Net Flux

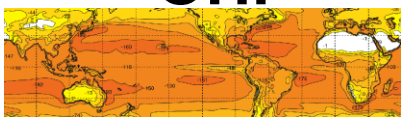


Net Flux Diff

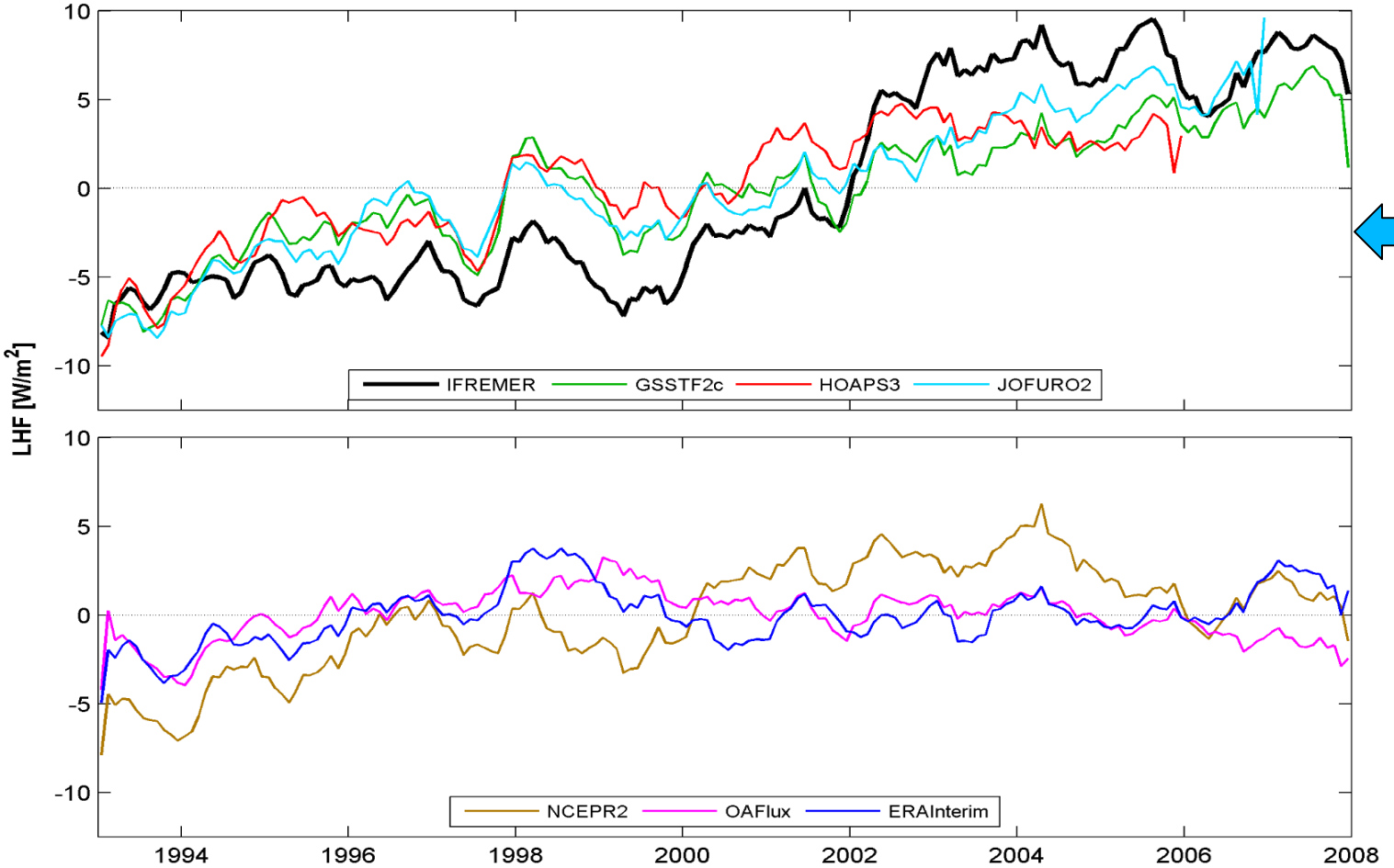


Motivation

OHF



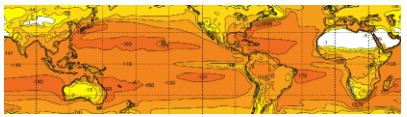
LHF Anomaly (Mestas *et al*, 2014)



Wind Consistency Issue

OHF

Ocean Heat Flux Project

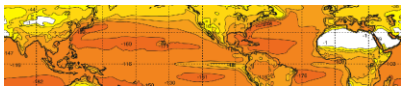


Requirements

- Quantify the different types of uncertainties of EO-based surface fluxes
  - Inputs, algorithms, parameterization, …..
- Develop an ensemble approach to generate multiple realizations of EO based flux products
  - Strengths of existing data
  - Latest bulk parameterization
  - Reprocessing L1b and L2b satellite data
- consistency of the Net Heat Flux product components
  - Using Argo data on a series of Cages
- Develop a community-led Flux Platform to share, access and inter-compare easily different sets of flux
  - Fostering close collaboration between different
  - combining in situ measurements and EO data

OHF Products

OHF

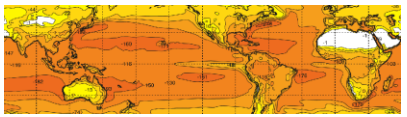


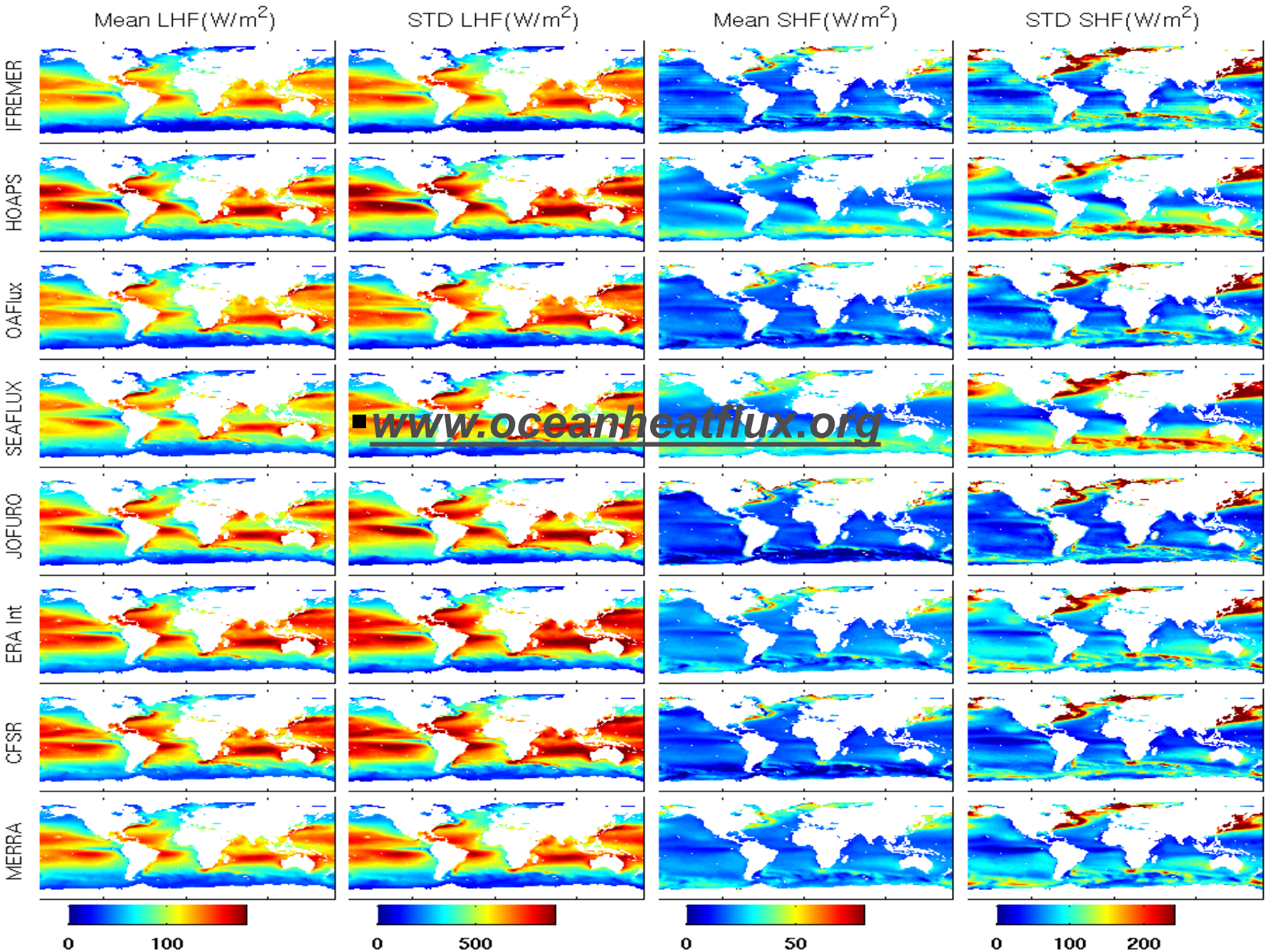
	Wsp	Qa	SST	Ta	τ	LHF	SHF	LW	SW	Period	Spatial Resolution	Temporal Resolution	Format
IFREMER	X	X	X	X	X	X	X			1999 – 2009	0.25°×0.25°	Daily	NetCdf
HOAPS	X	X	X	X		X	X	X	X	1987 - 2008	0.5°×0.5°	6-hourly and Monthly	NetCdf
OAFLux	X	X	X	X		X	X	X	X	1985 - 2014	1°×1°	Daily	NetCdf
SEAFLUX	X	X	X	X		X	X			1998 - 2007	0.25°×0.25°	3-hourly	Binary
J-OFURO	X	X			X	X	X			1988 - 2008	1°×1° 0.25°×0.25°	Daily Monthly	NetCdf
ERA Interim	X	X	X	X	X	X	X	X	X	1992 - 2012	0.75°×0.75°	6-hourly	Grib
CFSR	X	X	X	X	X	X	X	X	X	1992 - 2012	0.38°×0.38°	6-hourly	Grib
MERRA	X	X	X	X	X	X	X			1992 - 2012	0.50°×0.66°	Daily/Monthly	NetCdf
NOCS2	X	X	X	X		X	X			1992 – 2010	1°×1°	Daily Monthly	NetCdf

+ In-situ measurements (Moorings, Ships, Campaigns)

Annual Mean of OHF LHF and SHF

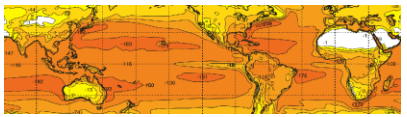
OHF



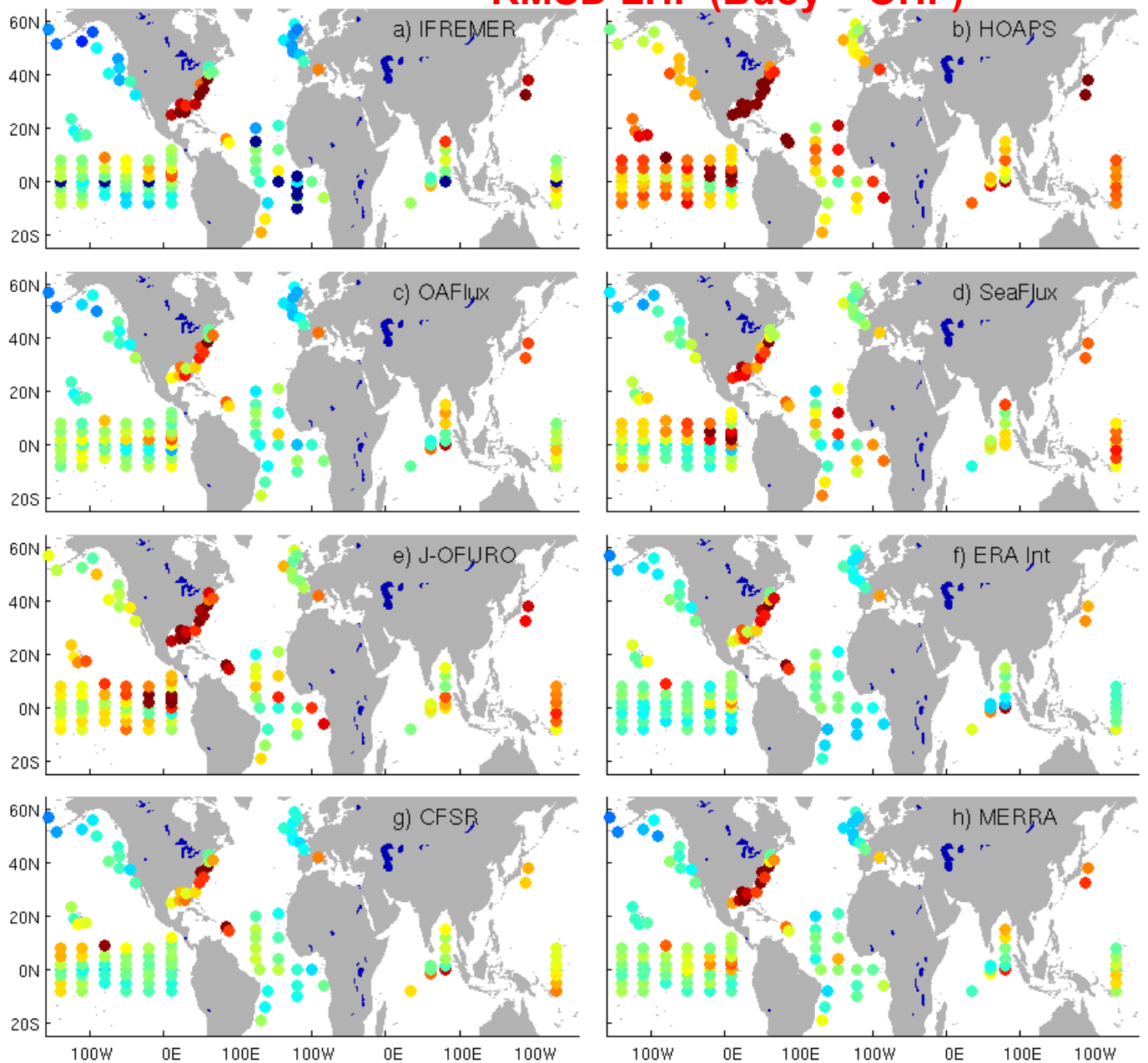


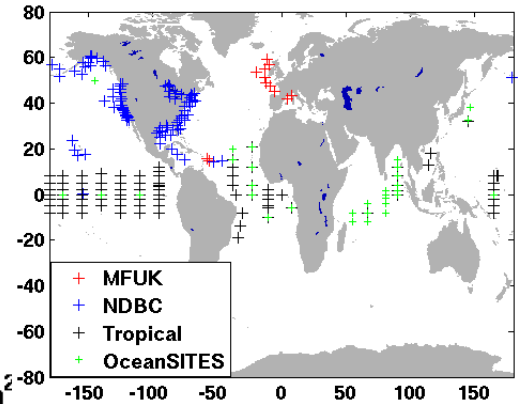
OHF LHF Product Accuracy

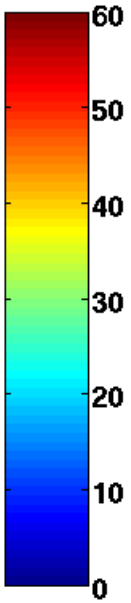
OHF



RMSD LHF (Buoy – OHF)

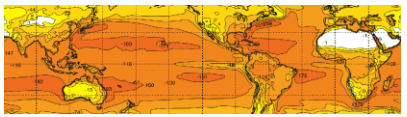




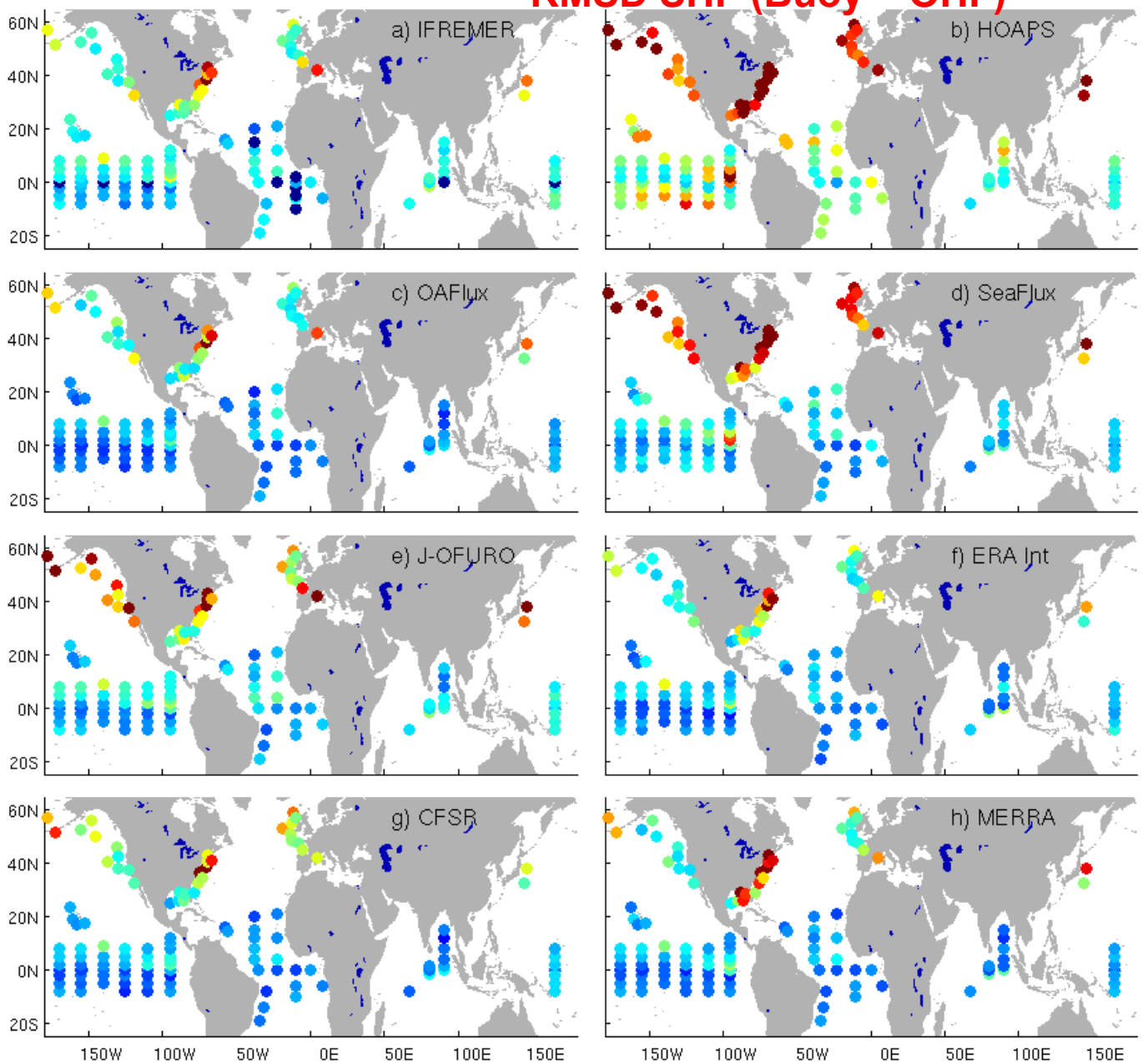


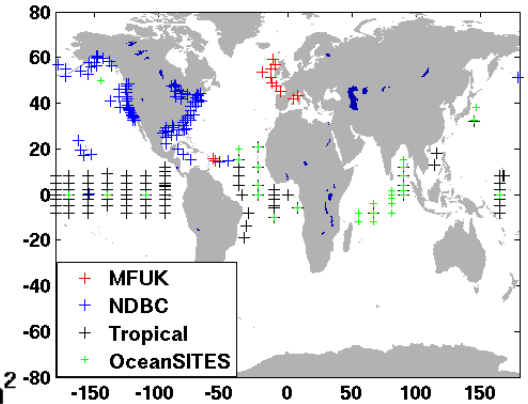
OHF SHF Product Accuracy

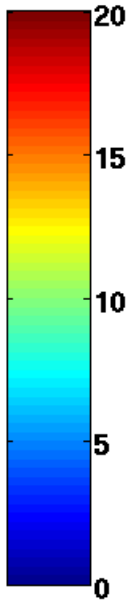
OHF



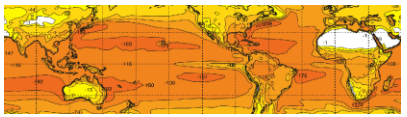
RMSD SHF (Buoy – OHF)







OHF



OHF Ensemble Determination

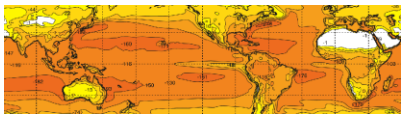
Error characteristics determined from in-situ and products comparison results

OHF MultiProduct Ensemble (OHF/MPE)

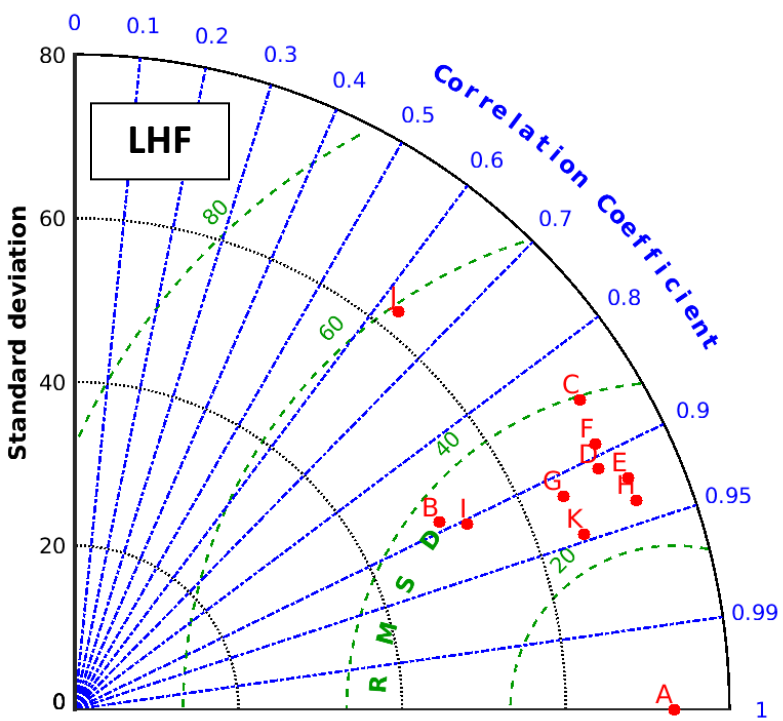
- **OHF/MPE is estimated based on the use of the standardized IFREMER, HOAPS, OAFlux, SeaFlux, J-OFURO, ERA Interim, and CFSR daily fluxes. It is calculated on a daily basis over the standardized OHF product grid map (0.25 0.25) over global free ice oceans.**
- **MERRA data is not used for OHF/MPE calculation. It is kept for further inter-comparison issues.**

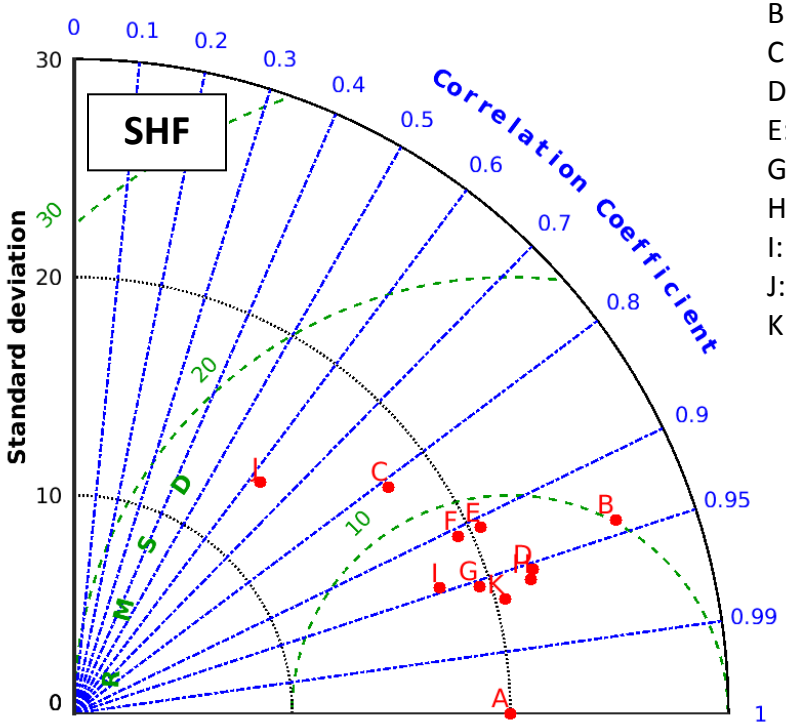
Ensemble (OHF/MPE) and Standardized Product Evaluation

OHF



Taylor diagram summarizing the intercomparison results between daily <u>OceanSites</u> buoys and OHF a) LHF and b)SHF products calculated for the period 2000 - 2007

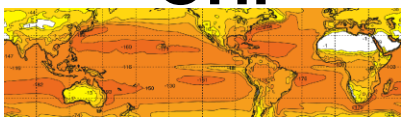


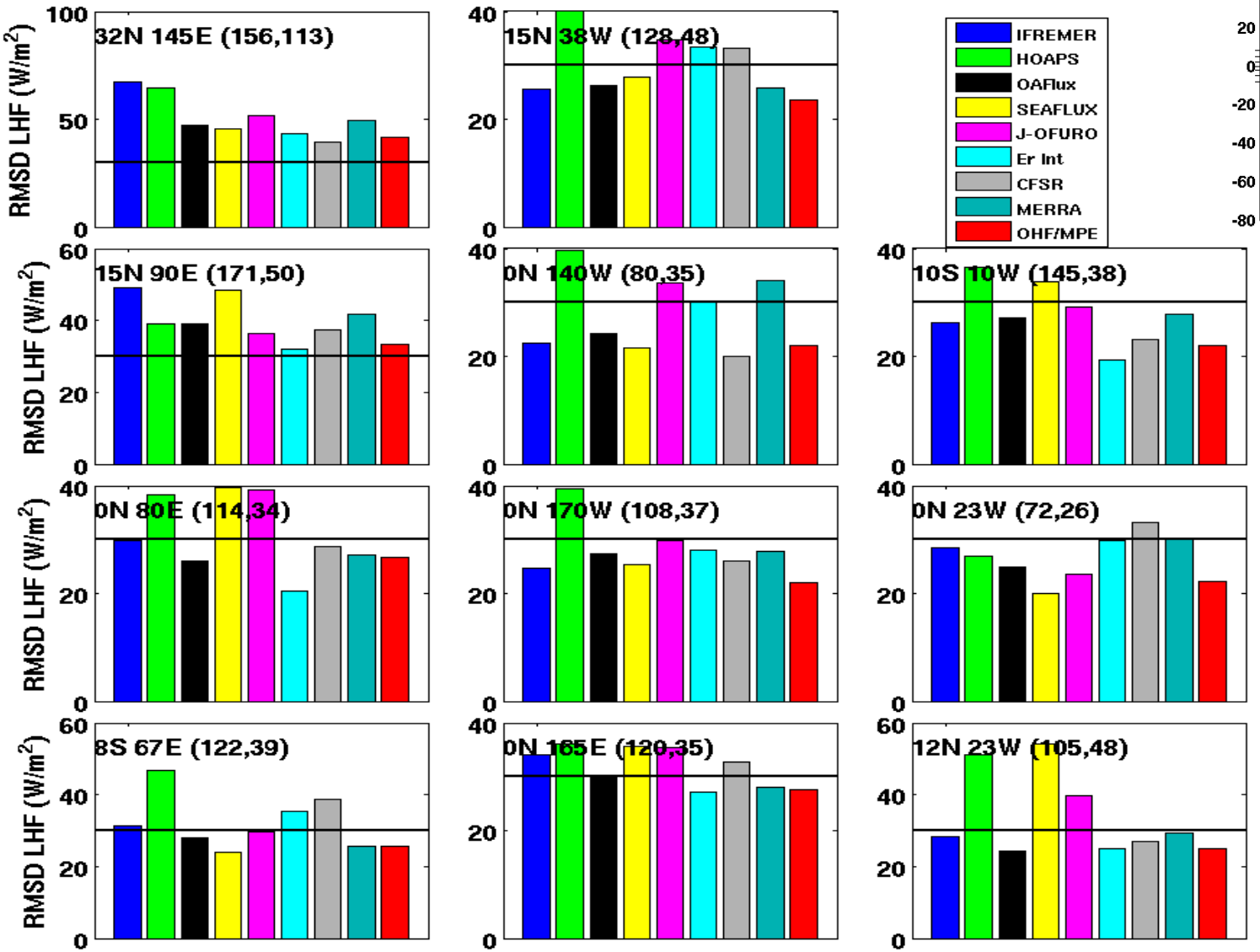


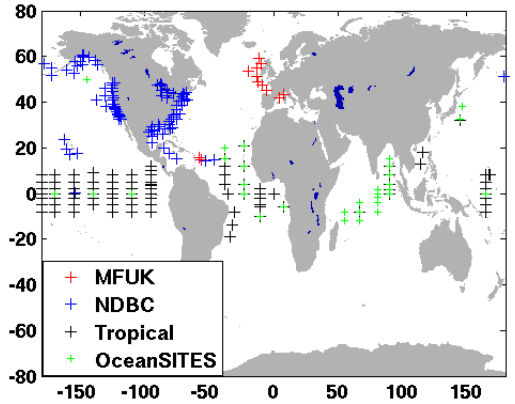
A : OceanSite buoy
B : Ifremer
C : Hoaps
D : OAFlux
E: SeaFlux
G: J-Ofuro
H: Era Interim
I: Cfsr
J: Nocs2
K: Ensemble(OHF/MPE)

LHF RMSD at individual selected OceanSites buoy and each OHF product.

OHF





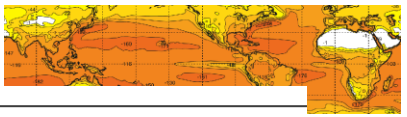


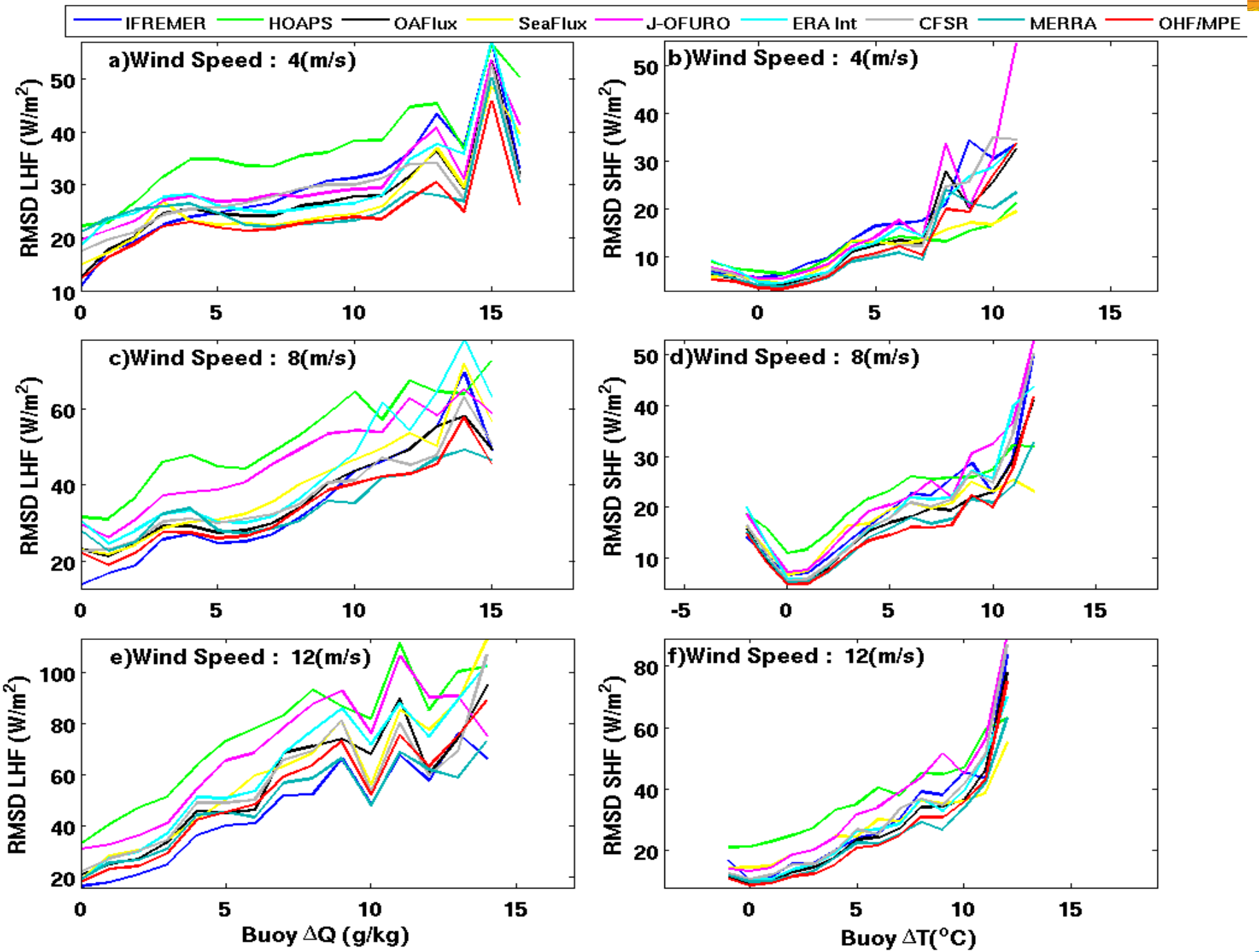
Error sources:

- **Wind Speed**
- **Specific air humidity**
- **Air temperature**
- **ΔQ**
- **ΔT**

LHF Accuracy as a Function of Bulk Variables

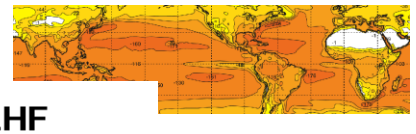
OHF



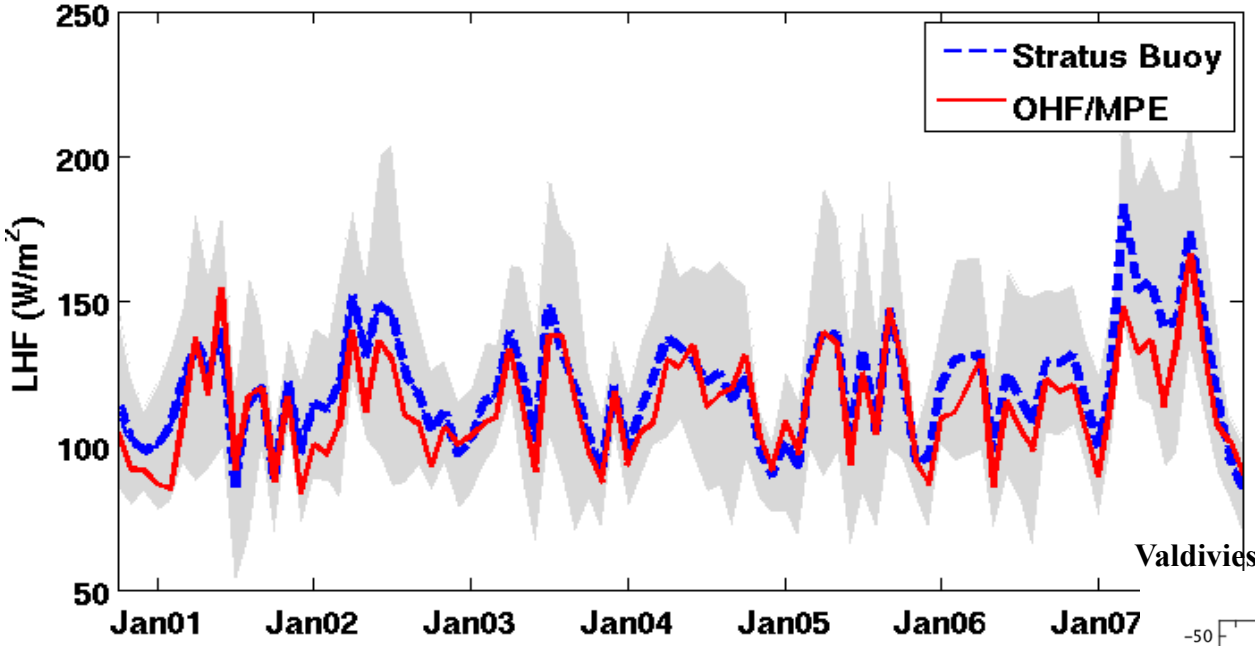


OHF LHF and SHF Time Series

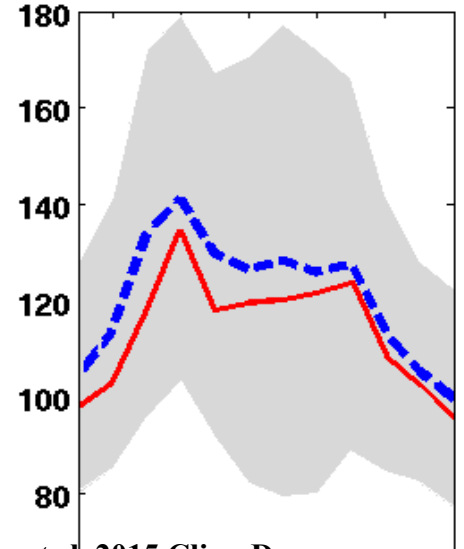
OHF



Monthly LHF Time Series



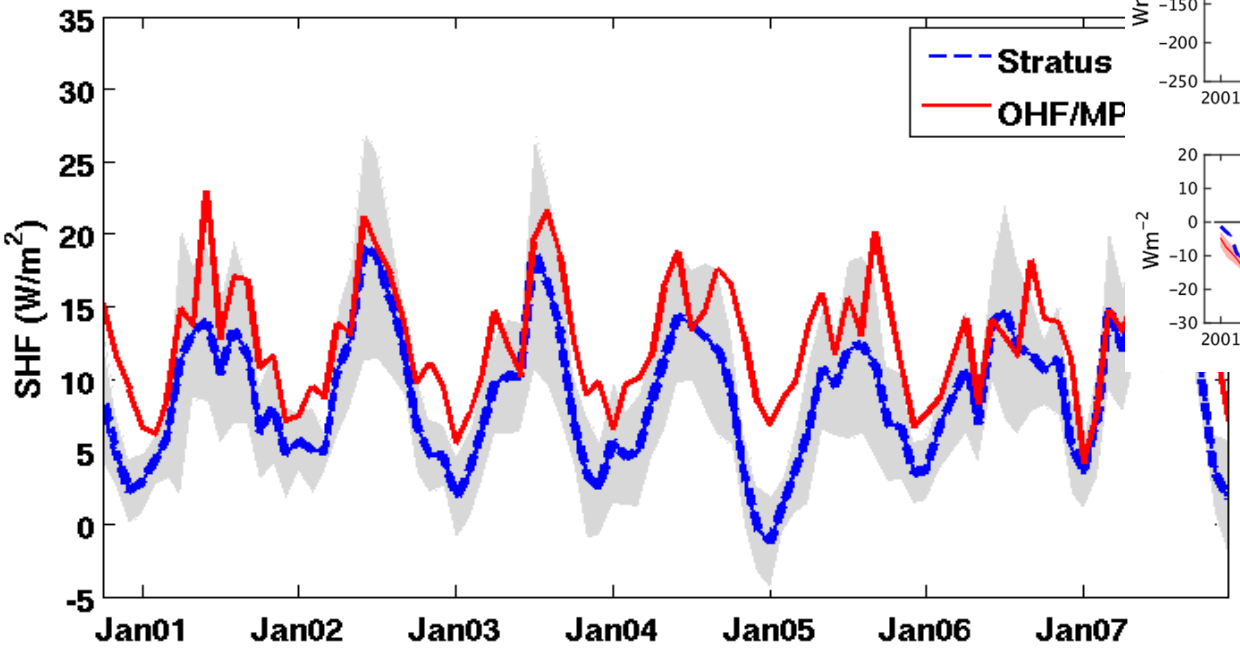
Seasonal LHF

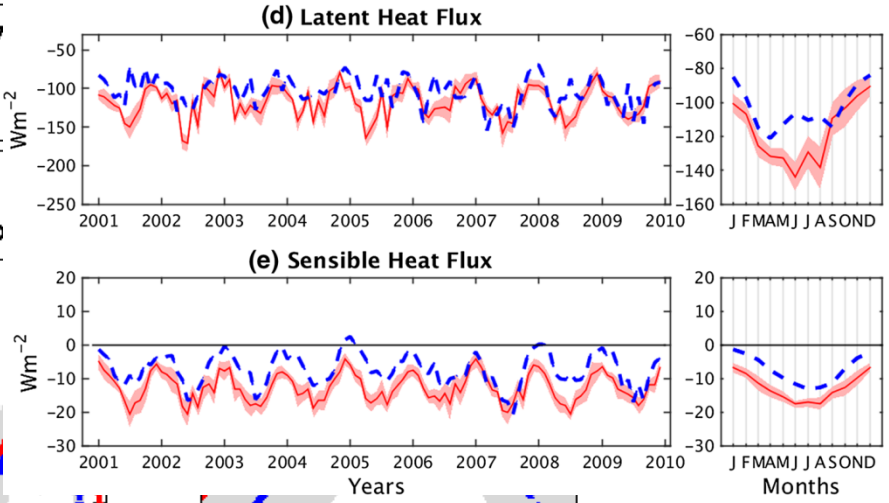


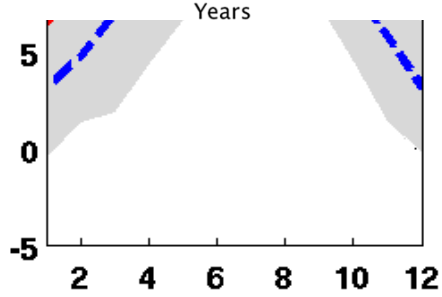
Stratus Buoy
19.9 S, 85.3 W
((WHOI),
Weller *et al*, 2014)

Valdivieso *et al*, 2015 Clim. Dyn. *DOI 10.1007/s00382-015-2843-3*

Monthly SHF Time Series

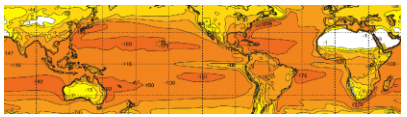






Uncertainties of OHF LHF and SHF Products

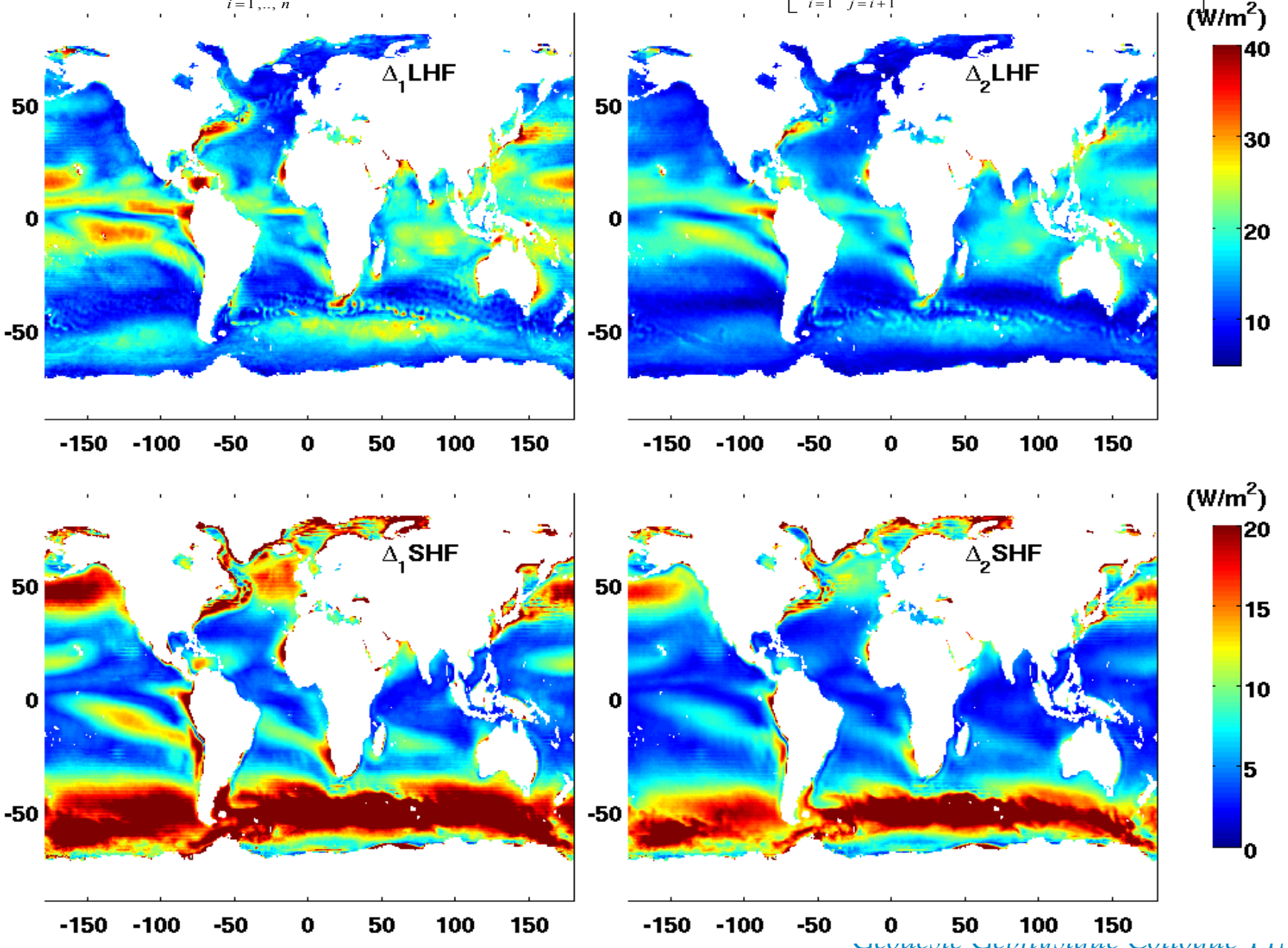
OHF

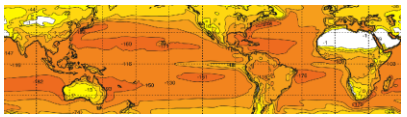


Găinuşă-Bogdan *et al*, 2015 (JGR)

$$\Delta_1 OHF = \max_{i=1,\ldots,n} \left(\left| OHF_i - MPE \right| \right)$$

$$\Delta_2 OHF = \left[\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} (OHF_i - OHF_j)^2 / C_2^n \right]^{1/2}$$





Summary

- ✓ Consolidation of heat flux product requirements
  - Sampling, accuracy, input data, error characteristics, format, method, algorithms, ….
- ✓ Homogenization/Standarization of heat flux data
  - Sensitivity studies and algorithm improvement
- ✓ Determination of ensemble dataset
  - Better accuracy results compared to observational and re-analysis products
  - Investigation of OHF product uncertainties
- ✓ OHF portal and facilities
  - **http://www.oceanheatflux.org/**
  - Access to the full available daily OHF and the related bulk variables
  - Same format for all data
  - Documentations, reports, **tools**
  - Online inter-comparisons
  - Online flux computations
  - Online sensitivity tests

OHF Portal and Facility

- ***www.oceanheatflux.org***
- ***http://www.ifremer.fr/datavore/exp/dvor/***