Enhancement of the oceanic turbulent fluxes estimated from remotely sensed data

A. Bentamy, IFREMER. France
S. Grodsky, Univ. of Maryland. USA
R. Pinker, Univ. of Maryland. USA
K. Katsaros, NOAA. USA.
A. Mestas-Nuñez, Univ Corpus Christi. USA.
J. Hanafin, Univ de Bretagne Ouest (LPO/UBO). France.
B. Blanke, Univ de Bretagne Ouest (LPO/UBO). France.
F. Desbiolles, Univ de Bretagne Ouest (LPO/UBO). France.
Surface Flux Determination: Bulk Aerodynamic Method

- Most common and easy method used for estimating the surface fluxes since they can be parameterized in terms of mean surface quantities:

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

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

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

- Thus to calculate evaporation correctly we need: \( U(u,v), q_a, q_s, T_s, T_a \) and an appropriate model of \( C_D, C_E \) and \( C_H \)

- NOTE: Over the ocean we assume that our estimated fluxes should identically equal the eddy covariance fluxes
Retrieving Surface Winds from Backscatter Coefficient Measurements

Calibration Procedure: Determination of Geophysical Model Function (GMF):

\[ \sigma^0 = f(U, \theta, \chi, P, fc, \ldots) \]
Specific Air Humidity

SSM/I : 19GHz, 22GHz, 37GHz, 85GH

Specific Air Humidity: \[ q_a = f(T_{B19V}, T_{B19H}, T_{B22V}, T_{B37V}) \]

(Bentamy et al, 2003)
Useful Satellite Measurements for Turbulent Flux Estimations

ERS-1: Aug 91 – May 96
ERS-2: Apr 95 – Jan 01
ADEOS-1: Sep 97 – Jun 98
QSCAT: Jul 99 – Nov 09
ADEOS-2: Dec 02 – Jul 03
METOP: Dec 06 – Present
OCEANSAT: Dec 09 – Present
WindSat: Feb 03 – Present
SSM/I 10: Dec 90 – Nov 97
SSM/I 11: Dec 91 – May 00
SSM/I 13: May 95 – Nov 09
SSM/I 14: May 97 – Aug 08
SSM/I 15: Dec 99 – Present(?)
AMSU N15: Jan 2000 – Present
AMSU N16: Oct 00 – Present
AMSU N17: Jul 02 – Present
AMSU N18: Sep 05 – Present
AMSU MTP: Mar 07 – Present
AMSRE AQ: Jun 02 – Present

OceanFlux Meeting 24 - 26 September Brest
New Release of Turbulent Fluxes (Bentamy et al, 2013)
Main Changes

- **Wind**:
  - QuikScat retrievals (V3 (Fore et al, 2011)) including (Bentamy et al, 2012) results

- **Specific Air Humidity**:
  
  \[ q_{a_{10}} = f_1(T_{b_{19V}}) + f_2(T_{b_{19H}}) + f_3(T_{b_{22V}}) + f_4(T_{b_{37V}}) + g(SST) + h(\Delta T) \]

  \( T_b \) are from SSM/I F11 – F15

- **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.
Daily Fluxes from Remotely Sensed Data
LHF Seasonal Patterns

OceanFlux Meeting
24-26 September Brest
SHF Seasonal Patterns
Validation Procedure

• Local/Regional Validations
  ➢ Experiment data: ETL; EGEE; GASEX; SHOWEX
  ➢ Buoy Estimates: TAO; PIRATA; RAMA; NDBC; MFUK

• Global Comparisons
  ➢ In-situ: ICOADS (NOCS)
  ➢ Re-analyses: ERA Interim (ECMWF); CFSR (NCEP/NCAR)
  ➢ Satellite: SeaFlux V1 (WHOI)
Assessment of the Turbulent Flux Accuracy

Spatial and temporal Collocation of Daily Estimates

In-Situ / Satellite

In-Situ / ICOADS (Berry et al, 2011)
Assessment of the Turbulent Flux Accuracy

- Spatial and temporal Collocation of Daily Estimates
- Outliers are excluded

<table>
<thead>
<tr>
<th></th>
<th>LHF (W/m²)</th>
<th>SHF(W/m²)</th>
<th>Stress(10⁻³N/m²)</th>
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<tr>
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<td>Bias</td>
<td>SDE</td>
<td>Bias</td>
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<td>31.5</td>
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<td>Brunke et al, 2011</td>
<td>ERA-I</td>
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Brunke et al, 2011
RMS Differences between Buoy (MFUK; NDBC; Tropical) – Ifremer / Ifremer – Seaflux

RMS Differences between
Buoy (MFUK; NDBC; Tropical) – Ifremer / Ifremer – Seaflux

ICOADS / Satellite Comparisons
Impact of Basic Variables

\[ dLhf = \left( \frac{\partial Lhf}{\partial U} \right) dU + \left( \frac{\partial Lhf}{\partial Ce} \right) dCe + \left( \frac{\partial Lhf}{\partial Qa} \right) dQa + \left( \frac{\partial Lhf}{\partial Qs} \right) dQs \]

\[ = dLHF_U + dLHF_{Ce} + dLHF_{Qa} + dLHF_{Qs} \]

\[ Lhf = \rho \times Lv \times U \times (Qs - Qa) \]

\[ dU = U_{noos} - U_{satellite}; \quad dCe = Ce_{noos} - Ce_{satellite}; \quad dQa = Qa_{noos} - Qa_{satellite}; \quad dQs = Qs_{noos} - Qs_{satellite} \]
ICOADS / Satellite Comparisons
Impact of Basic Variables

\[ dShf = \left( \frac{\partial Lhf}{\partial U} \right) dU + \left( \frac{\partial Lhf}{\partial Ch} \right) dCh + \left( \frac{\partial Lhf}{\partial Ta} \right) dTa + \left( \frac{\partial Lhf}{\partial Sst} \right) dSst \]

\[ = dLHF_U + dLHF_{Ch} + dLHF_{Ta} + dLHF_{Sst} \]

\[ Shf = \rho \times CP \times U \times (Sst - Ta) \]

\[ dU = U_{buoy} - U_{satellite}; \quad dCh = Ch_{buoy} - Ch_{satellite}; \quad dTa = Ta_{buoy} - Ta_{satellite}; \quad dSst = Qsst_{buoy} - Qsst_{satellite} \]
Summary / Perspectives

- Flux Improvements are achieved
- Better Results at global scale
- Good Agreement with In-situ Estimates
- Further Validations
- Spatial and Temporal Resolutions Issues
- Forcing Impact: exp. Upwelling systems
- Extended Time Period: 1992 - 2012
Ocean Surface Momentum and Heat Fluxes from remotely Sensed Observations.

\[ Q_{\text{net}} = Q_{\text{sensible}} + Q_{\text{latent}} + Q_{\text{SWnet}} + Q_{\text{LW}} \]

Freshwater = Evaporation – Precipitation

Wind stress = (downward momentum flux)

- Determination, improvement, and analysis of turbulent fluxes estimated from multi-satellite observations at high spatio-temporal resolutions over global ocean.