CAN QUIKSCAT FILL PIRATA WIND GAPS TO ESTIMATE THE SURFACE HEAT BUDGET?

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1. Introduction

The Pilot Research Moored Array in the Tropical Atlantic (PIRATA) project maintains an array of twelve ATLAS moorings in the tropical Atlantic since 1998 (Figure 1). Daily means of meteorological (wind, relative humidity, short-wave radiation, and rain) and oceanographic (temperature and salinity profiles) data are available for each site. We use the PIRATA data to estimate the surface heat components through a bulk formulation. The surface heat balance is given by:

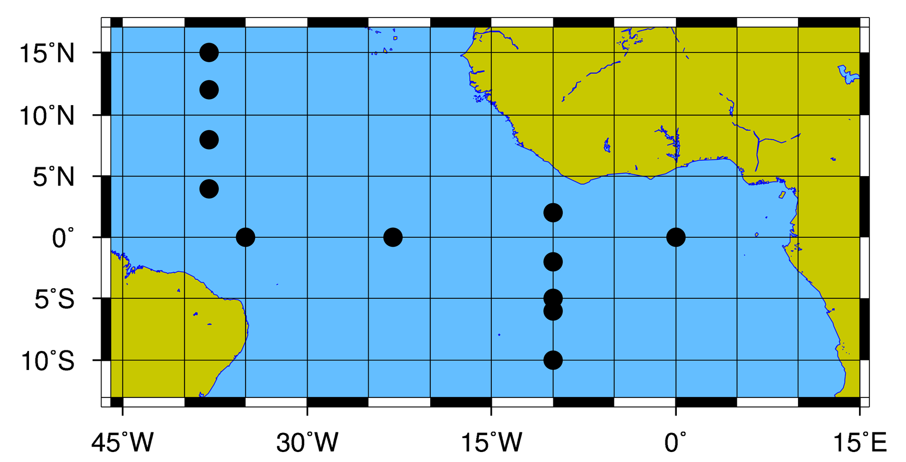

FIGURE 1: *Location of the PIRATA buoys.*

$$Q_0 = Q_{sw} + Q_{lw} + Q_{lat} + Q_{sen} + Q_r \quad (1)$$

$Q_0 \rightarrow$ Total Surface Heat Flux
$Q_{sw} \rightarrow$ Short Wave
$Q_{lw} \rightarrow$ Long Wave
$Q_{lat} \rightarrow$ Latent
$Q_{sen} \rightarrow$ Sensible
$Q_{rf} \rightarrow$ Precipitation

The PIRATA data have gaps (Figure 2) due to technical problems and vandalism. Faulty instruments can cause large data gaps because maintenance cruises are performed only once per year. One possible solution would be to interpolate the missing PIRATA data. However, data gaps spanning days to seasons are common and much longer than the characteristic scale of variability. Therefore, interpolation is not an option.

The Q_{lat}, Q_{sen} and Q_{rf} components depend on wind data and suffer from the discontinuities of its time series. The problem with these components affects the total balance. Therefore, we examine an alternative source of wind estimates in the region to fill the PIRATA data gaps. Figure 2 shows the Q_{lat}, Q_{sen} and Q_{rf} data recovery that results from the inclusion of QuikSCAT wind measurements.

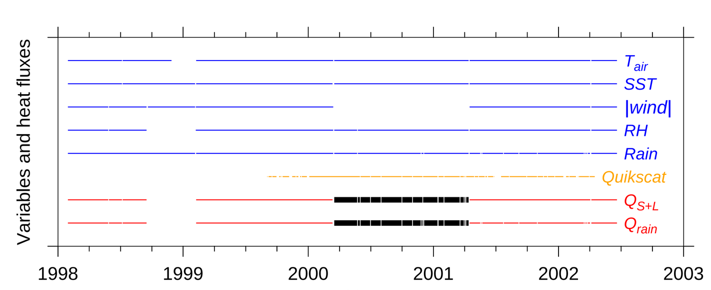

FIGURE 2: *Availability of PIRATA variables (blue) used in latent, sensible and rainfall heat fluxes (red) estimates. The black line is the recovery of heat flux estimates when the PIRATA wind data are complemented with QuikSCAT (orange).*

2. Methodology

The buoy anemometers are 4 m above the sea surface while the scatterometer data is estimated at a 10 m height. To compare these two data sets they are referenced to the same height. We compared three methods to estimate the equivalent PIRATA wind at 10 m:

Large and Pond (1981)

$$C_{DN} = \begin{cases} 1,15 \times 10^{-3} & \text{se } u_{10} < 10 \\ 4,9 \times 10^{-4} + 6,5 \times 10^{-5} u_{10} & \text{se } u_{10} \geq 10 \end{cases} \quad (2)$$

$$u_{10} = u \left[1 + \frac{\ln(\frac{z}{10})\sqrt{C_{DN}}}{\kappa} \right]^{-1} \quad (3)$$

u is the wind velocity in level z, u_{10} the equivalent wind at 10m, κ the Von Karman constant and C_{DN} the drag coeficient transfer.

Smith (1988) simplified for neutral stratification

$$u_{10} = \frac{u_*}{\kappa} \ln\left(\frac{10}{z_0}\right) \quad (4)$$

where

$$z_0 = z_c + z_s = \frac{\alpha_c u_*^2}{g} + \frac{0,11\nu}{u_*} \quad (5)$$

α_c is the Charnock constant, u_* friction velocity and ν the ciscosity.

Smith (1988) without simplification

$$u_{10} = \frac{u_*}{\kappa} \left[\ln\left(\frac{10}{z_0}\right) - \Psi_u \right] \quad (6)$$

Ψ_u is the stability function.

QuikSCAT and PIRATA wind time series were smoothed using a Blackman–Tukey low-pass convolution filter. This filter keeps the variability with periods longer than a month. The difference of the mean, the correlation, and the root mean square difference were estimated between the original and filtered wind data.

The Q_{lat} is the dominant heat loss term ($\sim 100\ Wm^{-2}$) in the surface heat balance at the PIRATA study area (Castelão, 2002). In addition it strongly depends on the wind estimates. Therefore, the error analysis because of the inclusion of QuikScat winds through the three equivalent wind methods concentrates in Q_{lat}.

3. Results

Results from the three methods to estimate the equivalent wind are statistically identical for the mean values. This suggests a predominantly neutral boundary layer condition. Therefore, the use of the simplest of the three methods, (Large and Pond, 1981), does not imply in a loss of precision. Furthermore, this method does not depend on other parameters (e.g.: air–sea temperature difference, humidity) and therefore provides more useful data.

A mean correlation of 0.93 and a rms difference of 0.4 ms^{-1} are observed between the filtered time series of the *in situ* and scatterometer wind magnitudes. The original data show a correlation of 0.86 and a rms difference of 0.9 ms^{-1}. These values indicate that the two sensors capture the same variability.

The buoys at 04°N 38°W and 08°N 38°W show the largest rms difference between filtered equivalent buoy and Quikscat winds: 1.2 and 1.1 ms^{-1} respectively. These relatively large differences were analyzed in Polito et al. (2001). They present evidence that tropical instability waves are locally responsible for increasing the difference between buoy and scatterometer wind speeds. Because the buoy is anchored the air speed measured by its anemometer is on a fixed frame of reference. In contrast, the scatterometer uses the radar signal backscattered by surface capillary–gravity waves to produce wind estimates. These winds are obtained through an empirical formula that assumes **(a)** a neutral atmospheric boundary layer and **(b)** a static ocean surface. Thus, the estimated air speed is **relative** to the sea surface and depends on the **stability** of the planetary boundary layer.

The latent heat flux is calculated using both *in situ* and satellite–derived wind data and a difference of 14 Wm^{-2} is observed between these estimates. The error analysis shows that most of the uncertainties derive from the relative humidity.

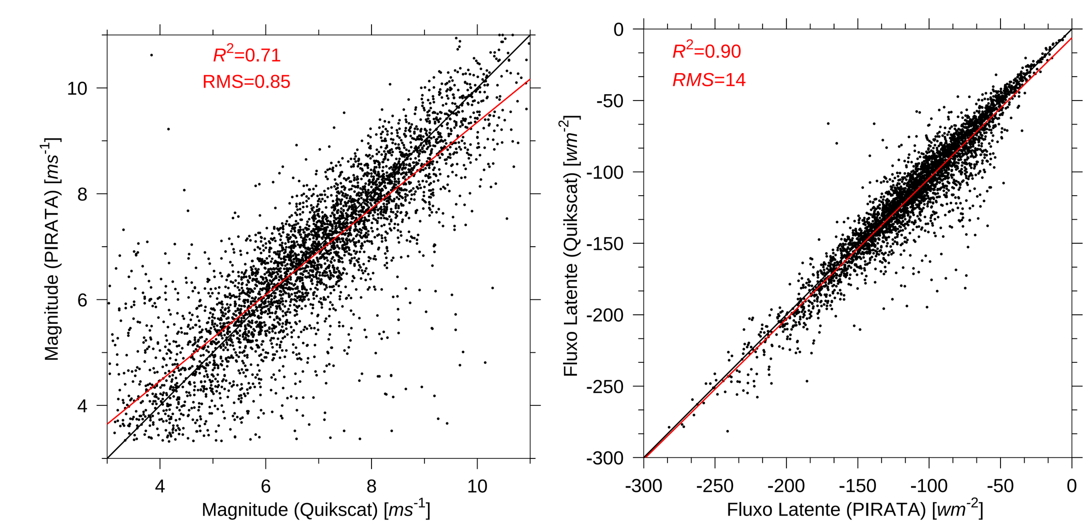

FIGURE 3: *Wind speed measured by PIRATA and Quikscat(left) and respective latent heat fluxes.*

4. Conclusions

Quikscat scatterometer wind data can be used to fill PIRATA buoy data gaps. The uncertainty introduced by Quikscat winds is similar to the statistical fluctuations associated with buoy data alone.

Our calculations show that the error introduced by complementing PIRATA data with Quikscat winds is within the error bars of all wind–dependant heat flux components. For time scales longer than a month these errors are even smaller.

Three methods for the estimation of the equivalent wind at 10 m are tested. As the results are statistically identical in this region, the simplest method was adopted, Large and Pond (1981). Because this method assumes neutral stability, the equivalence of the results of the three methods is interpreted as an indication that neutral stability is the mean prevailing condition.

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