An algorithm for Sea Surface Wind Speed from MWR

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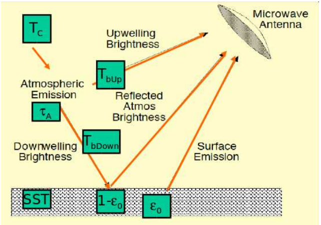
Overview

1. Introduction
2. The MWR wind speed algorithm
   - Model function tables
   - Wind direction effect
   - Wind speed retrieval
3. Validation results
4. Conclusions
5. References and Acknowledgment

Introduction

This work is a collaboration between CONAE and CFRSL. It was recently accepted for publication on IEEE JSTARS Aquarius Special Issue.

The MWR sea surface wind speed algorithm is based on Wentz's work (1992) to estimate Wind vector from SSMI. He assumed that the TOA T_b:



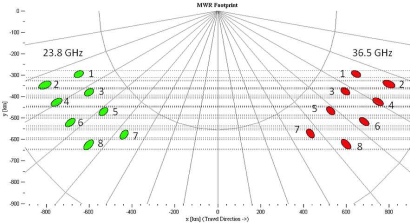
$$T_{b37V} = F_V(W,\tau)$$
$$T_{b37H} = F_H(W,\tau)$$

$$F(W,\tau) = T_{bU} + \tau[\varepsilon\, SST + (1-\varepsilon)(1+\omega W)(T_{bD} + \tau T_{ex})]$$

W: Wind Speed, τ: Atmospheric transmissivity, T_{bU} and T_{bD} up- and downwelling T_b, ε: Sea surface emissivity, T_{ex}=2.73 K, SST: Sea Surface Temperature and ω: diffuse scattering coeff.

The MWR wind speed algorithm

- For MWR:
  - 36.5GHz band
  - 52° (odd bemas)
  - 58° (even beams).
- Using Newton-Raphson, F can be simplified:



$$
\begin{aligned}
T_{b36.5V} &\approx F_V(W_0,\tau_0) + \left(\frac{\partial F_V}{\partial W}\right)_{(W_0,\tau_0)} (W - W_0) + \left(\frac{\partial F_V}{\partial \tau}\right)_{(W_0,\tau_0)} (\tau - \tau_0) \\
T_{b36.5H} &\approx F_H(W_0,\tau_0) + \left(\frac{\partial F_H}{\partial W}\right)_{(W_0,\tau_0)} (W - W_0) + \left(\frac{\partial F_H}{\partial \tau}\right)_{(W_0,\tau_0)} (\tau - \tau_0)
\end{aligned}
$$

If the model function F is known, this system of two equations with two unknowns (W and τ) can be solved using an iterative procedure.

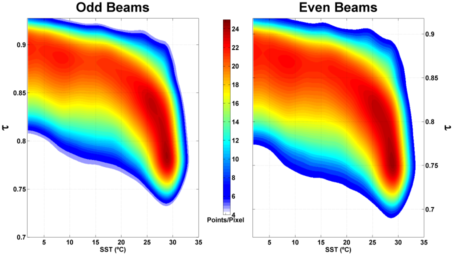
Model function tables

Collocoted data set:

- MWR T_b,
- NCEP environmental parameters,
- WindSat and SSMIS F17 wind speed and rain (RemSS),
- RTM (Simulated T_{bUp}, T_{bDown} and τ).
- Match-up for:
  - Rain free pixels
  - Temporal resolution: $\pm$1h.
  - Spatial resolution: $\sim$25km.

Tunning period: July-December 2012

With N$\sim 5.4\times10^6$ we generate 4 3D tables $T_b(WS, \tau, SST)$. H- and V-pol for Even (58°) and Odd (52°) beams.



Density plot of SST/τ values that exist in the match-up data

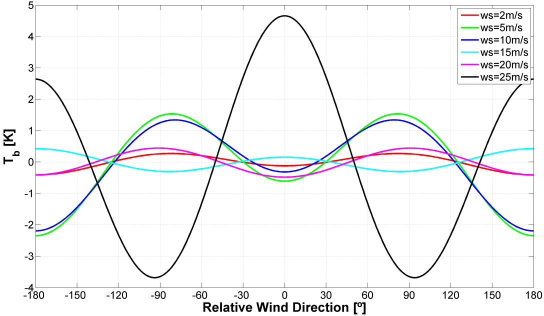
Wind direction effect

WD is modeled as an excess of T_b which is removed:

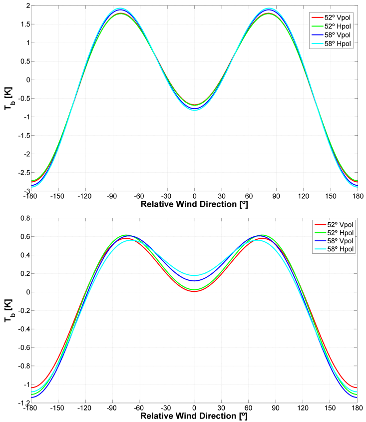
$$T_{b_{correced}} = T_{b_{measured}} - T_{bExcess}$$

$$T_{bExcess} = \beta_1 cos(\chi_{rel}) + \beta_2 cos(2 * \chi_{rel})$$

β's fifth order polinomial in WS. χ_{rel}: relative wind direction (wind blowing toward the antenna).



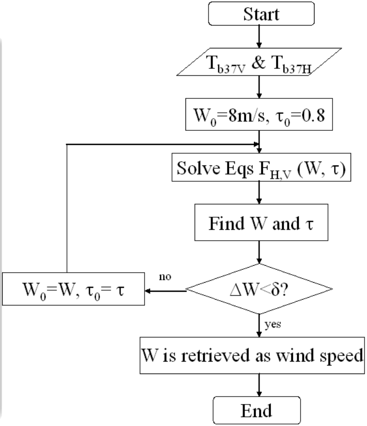
Odd beams in vertical polarization for several wind speed values.



Combinations of polarizations and incidence angles, ws=6m/s (top) and ws=12m/s (bottom).

Wind speed retrieval: algorithm summary

- **Inputs:** MWR $T_{b36.5}$ V and Hpol. Ancillary/Auxillary: NCEP wind direction and SST, MWR azimuth angle.
- An iterative procedure is implemented using Newton-Raphson's method until *W* converges.
- **Outputs:** sea surface Wind Speed at 10 m height [m/s], Atmospheric transmissivity at 36.5 GHz (τ).



WindSat and SSMIS comparisons

Validation data set: January-September 2013

With N$\sim$9.5$\times 10^6$ we perform a validation month by month, for even and odd beams separately.

- WindSat and SSMIS collocated dataset satisfy: WindSat wind speed $<$ 25m/s, SST$>$ 280°K and rain free pixels.
- Differences between both data sets:

$$\Delta W = W_{MWR} - W_{WS/SSMIS}.$$

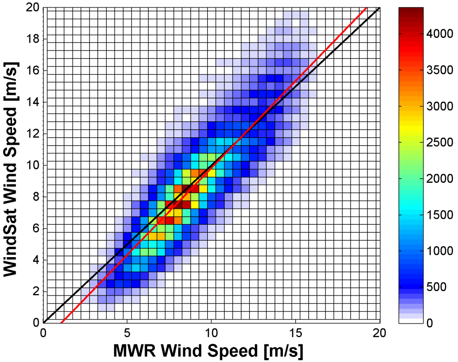
- Linear regression analysis:

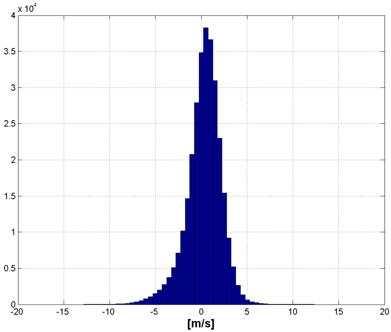
$$W_{WS/SSMIS} = aW_{MWR} + b.$$

- Statistical parameters calculated: r^2, a, b, Mean ΔW and STD ΔW.

where $W_{WS/SSMI}$ are RemSS WindSat and SSM/I wind speed respectivelly, and W_{MWR} is our MWR wind speed result.

vs WindSat (July 2013 - Odd beams)

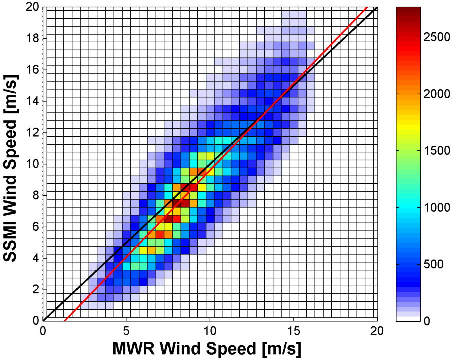


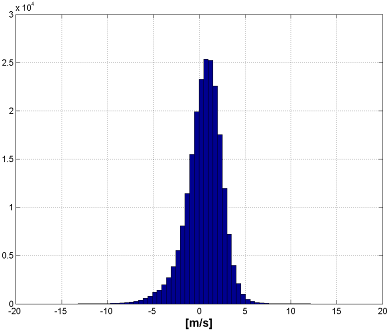


$$N = 298209$$
$$r^2 = 0.70$$
$$a = 1.10$$
$$b = -1.18$$

$$\text{Mean}\,\Delta W = 0.29$$
$$\text{STD}\ \Delta W = 1.89$$

vs SSMIS (July 2013 - Odd beams)





N=215635

r^2=0.70

a=1.11

b=-1.44

Mean ΔW=0.50

STD ΔW=1.95

Conclusions

- The mean error is <1m/s and standard deviation <2m/s for all wind speed values (based on the histogram of ΔW).
- Even beams show sligthly better performance.
- For even beams: $0.78 < r^2 < 0.82$, error standard deviation ≤ 1.57.
- For odd beams: $0.56 < r^2 < 0.70$, error standard deviation ≤ 2.17.
- MWR sea surface wind speed retrieval data are quite acceptable for scientist analysis.
- Note: The presented algorithm uses T_b V6.0 for tuning and validation. A preliminary study show an improvement in the wind speed retrieval using T_b V7.0 in both, tuning and validation.

References and Acknowledgment

- F. J. Wentz, *"Measurement of oceanic wind vector using satellite microwave radiometers"*, *IEEE Trans. Geosci. Remote Sensing*, vol. 30, no. 5, pp. 960–972, 1992.
- C.B.Tauro, Y. Hejazin, M.Jacob, and L. Jones, *"An algorithm for Sea Surface Wind Speed from SAC-D/Aquarius MicroWave Radiometer",Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Journal of*, accepted for publication, 2015.

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For more information see in the Poster Sesion...

MWR SEA SURFACE WIND SPEED RETRIEVAL: ALGORITHM DESCRIPTION AND VALIDATION RESULTS.