Surface wind research activities at the Met Office

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1. Neutral Wind Observation Operator

Currently scatterometer wind components are assimilated as “real” 10m winds.

However the products we assimilate from KNMI (ASCAT, ScatSat) and NRL (WindSat) are all “equivalent neutral” 10m winds. This means that atmospheric stability affects are ignored in the transformation from roughness to 10m wind.

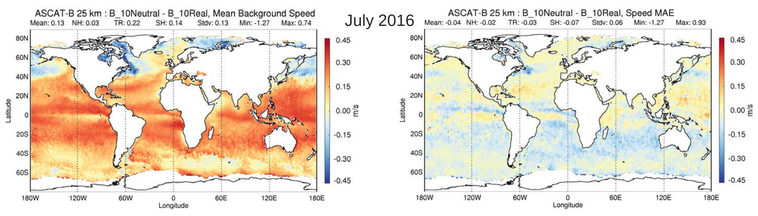
This leads to a discrepancy in the way we are using the winds. The global average difference in wind speed is around 0.17 m/s, with much larger differences locally

$$(v_1 - v_0) = \frac{u_*}{k}\left[\ln\left(\frac{z_1 + z_{om}}{z_{om}}\right) - \Psi_m(\zeta_1) + \Psi_m(\zeta_{0m})\right]$$

L Monin-Obukhov length scale
$z_{0,m}$ roughness length for momentum
u* friction velocity
z_1 lowest model level
k Von Kármán constant

$$\zeta_1 = (z_1 + z_{0m})/L \qquad \zeta_{0m} = z_{0m}/L$$

Fig: On avg, marine boundary layer is weakly unstable (neutral > real). Speed MAE is reduced with neutral operator



Neutral B – Real B

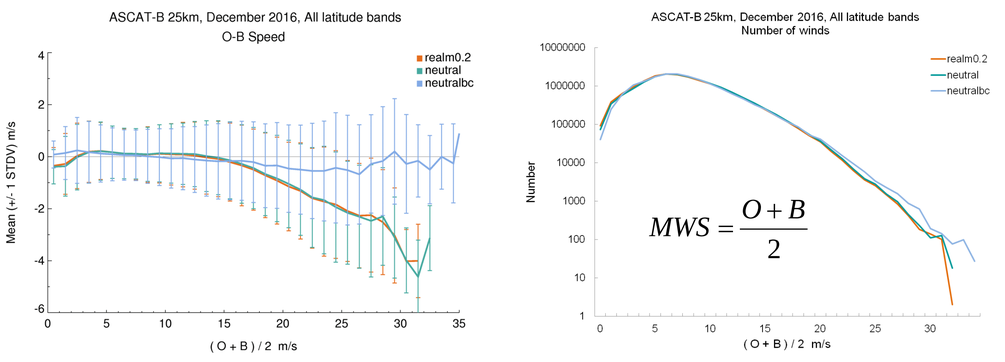
Neutral |O-B| – Real |O-B|

2. Wind Speed Bias Correction

Fig: For the neutral operator there remains a large negative O-B difference at higher wind speeds, with ASCAT biased low compared to the model (green line).

For ASCAT using the real operator we simply subtracted 0.2 m/s to account for the average difference between neutral and real 10m winds (orange line in figures).

Regression of O-B versus mean wind speed (MWS) is used to obtain a non-linear calibration curve (assume that O and B have the same random error distribution).



Applying correction based on 6 months of data gives an improved fit between ASCAT and model for MWS > 15 m/s (blue line in figures). The correction results in more ASCAT winds at high MWS and less at very low MWS.

3. Forecast Impact

Impact of neutral operator and MWS bias correction assessed across two seasons

Winter: 2016/11/15 – 2017/02/20 (~90 days)

Summer: 2017/06/20 – 2017/09/30 (~95 days)

Experiments (OS40 baseline, N320L70 UM, N108/N216 4D-VAR hybrid VAR)

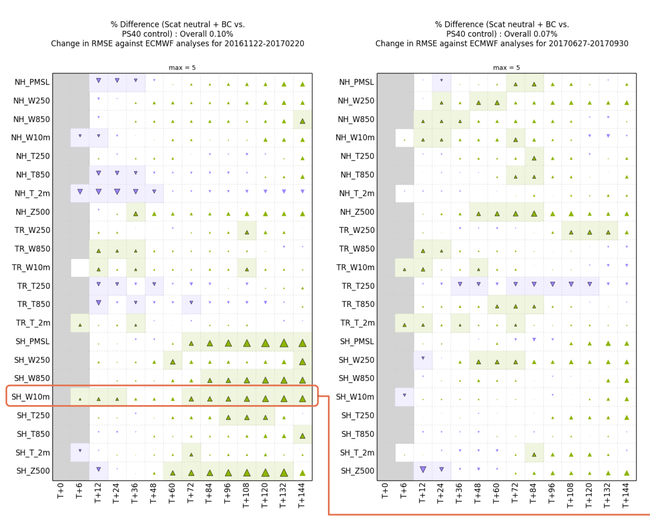
Reference: Scatwinds as real winds, biases ASCAT -0.2 m/s, WindSat cubic.

Neutral+BC: Scatwinds as neutral winds, MWS bias correction

Fig: Scorecards of forecast RMSE vs. ECMWF analyses:

Winter

Summer



▲ Green: positive impact

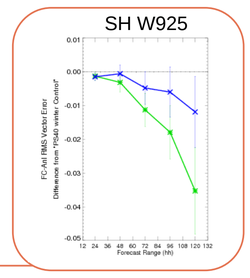
▼ Blue: negative impact

▲ Shaded box: stat. significant

Number of significant positive/negative impacts

Winter: 48/21

Summer 37/12



Neutral

Neutral+BC

T+6 background fit to Scatwinds is reduced by 30-50% for mean absolute U difference

4. Evaluation of TDS-1 Wind Speeds

Global Navigation Satellite Systems-Reflectometry (GNSS-R) exploits signals of opportunity from GNSS transmitters, forward scattered off the Earth surface.

GNSS-R applications to ocean remote sensing include retrieval of sea surface height, mean-square slope or ocean surface wind speed (WS).

Interest in improving spatial/temporal sampling through affordable multi-satellite constellations (such as CYGNSS), complementing existing wind observations.

We evaluate WS from the UK TechDemoSat-1 (TDS1-) mission, inverted using NOC/Southampton retrieval algorithm for low-moderate wind speeds (Foti et al. 2015).

For inversion using Bistatic Radar Equation WS O-B std. deviation is 2.1 m/s. As instrument only operates 2/8 days we focus on case studies with ASCAT and the model.

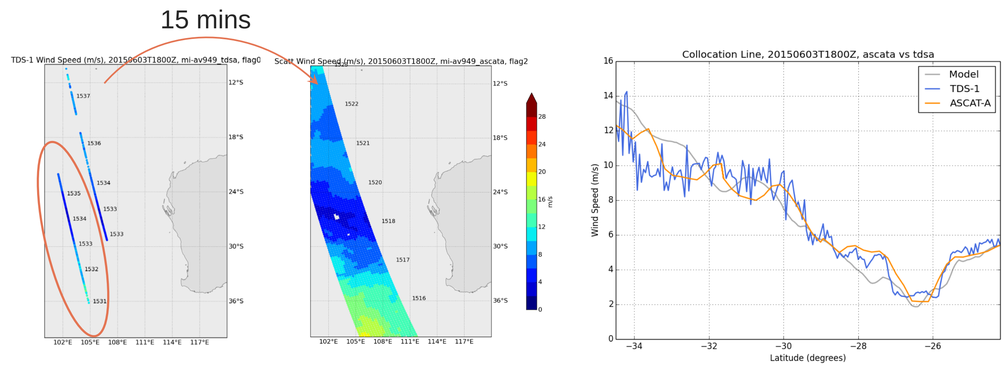


Fig: Collocating TDS with ASCAT for specular points circled in red shows similar trends in WS but TDS could benefit from along-track averaging. TDS noise above ~ 8 m/s.

Foti et al. (2015), Spaceborne GNSS reflectometry for ocean winds: First results from UK TechDemoSat-1 mission, *Geo-phys. Res. Lett.*, 42, 5435-5441.

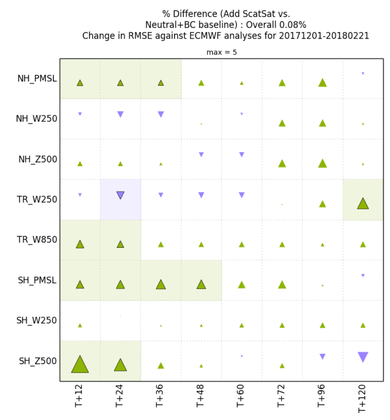
5. ScatSat Impact

ScatSat (launched 2016/09) 50 km OSI SAF winds O-B broadly comparable to ASCAT.

Fig: scorecard vs ECMWF shows small, statistically significant, positive impacts at short lead times e.g. PMSL at days 1-2.

Adding ScatSat improves STDV O-B fit to ASCAT and WindSat.

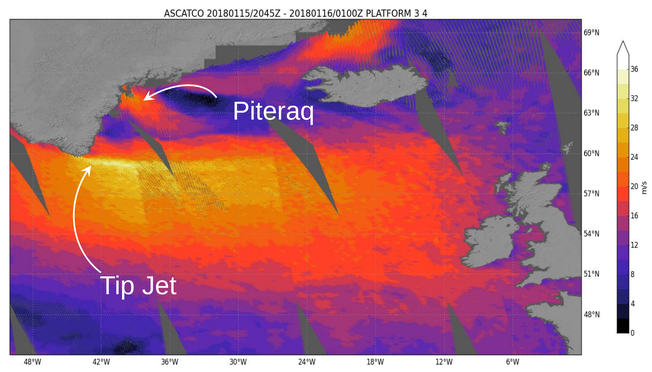
T+6 fit to other observations improved e.g. CrIS temperature sounding channels improved by 0.5% in the lower troposphere.



ASCAT imagery @MetOffice_Sci

Met Office Science @MetOffice_Sci — 25 Jan 2018

The scatterometer on @eumetsat Metop-A/B satellite captured storm force winds in the Atlantic last week, including a hurricane force Greenland tip jet and a violent downslope wind that forms in the region of Ikermiit, Greenland, known as a Piteraq



Summary

- Observation operator has been updated to allow the assimilation of scatterometer winds as neutral stability 10m winds rather than real 10m winds.
- A new bias correction based on the mean wind speed has been implemented which improves scatterometer/model biases at higher speeds in particular.
- Experiments with neutral operator and new biases gives largely small impact on forecast RMSE, but the impacts that are statistically significant are mostly beneficial.
- Addition of ScatSat-1 on top gives some benefit at short lead times.
- Above changes planned for operational implementation at OS41, ~2018/09
- Evaluation of GNSS-R wind speeds from TDS-1 is on-going and efforts are now focussed on case studies where there are close matchups with ASCAT.
- Future: can we increase maximum speed threshold from 25 m/s to 30m/s, or higher?

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