Ocean State Diagnostics from Scatterometers

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Abstract

Wind and stress climatologies are shown from both scatterometers and atmosperic reanalyses by models, sampled and processed in identical ways. This facilitates the investigation of systematic monitoring artefacts in reanalyses and thus establishes confidence in the reliability of monitorng by reanalyses to identify real trends and processes in the atmosphere by the climate research community.

In a preliminary analysis, we observe very persistent differences and large discrepancies between scatterometer and reanalyses in the derivatives, i.e., in wind stress divergence and curl.

I. Introduction

The state of the ocean is a major aspect of the earth's climate system. Excess heat is accumulated in the ocean and transported. Since winds drive ocean circulation, air-sea interaction plays a crucial role in the exchange of momentum and heat between atmosphere and ocean. In addition, oceans represent the largest surface of the earth. The Copernicus Marine Environment Monitoring Service [1] (CMEMS) provides a yearly report of the state of the global oceans and regional seas near Europe [2]. The 2017 Ocean State Report (OSR) is being constructed and a section on ocean vector winds and stresses is being included to emphasize the role of winds/stress/ice in ocean processes. KNMI is coordinating the contributions from the CMEMS Ocean and Sea Ice Thematic Assembly Centre (OSI TAC).

Scatterometer ocean vector wind measurements thus play an important role in the monitoring of the earth's system. Users may explore scatterometer winds directly and, due to their sparse sampling, monthly climatologies may be established from scatterometer wind or stress climate data records (CDR) of these essential climate variables (ECV). Intercalibrated and stable instrument records are an important asset in the monitoring of the earth system and intercalibrated data sets have been constructed over the recent decades, e.g. [3].

On the other hand, atmospheric reanalyses exist that are synthesized from the global observing system (GOS) and an atmospheric circulation model, through data assimilation techniques. As the GOS changes in time, reanalyses may show artificial trends and biases. These can be detected by instrument CDRs of ECVs, such as from scatterometers.

Wind and stress climatologies and anomalies are being computed globally, seasonally and in the large basins (Atlantic, Pacific and Indian ocean) for the zonal and meridional wind and stress vector components. In addition, a focus is put on the extremes where percentile trends are being computed. Moreover, 2016 has seen major sea ice anomalies in both Arctic and Antarctic, which will be evaluated in a multi-parameter analysis. Finally, further analysis of the mid Atlantic and Pacific cold SST anomalies in terms of wind, stress and variability will be elaborated. Here, a preliminary presentation of the results is provided.

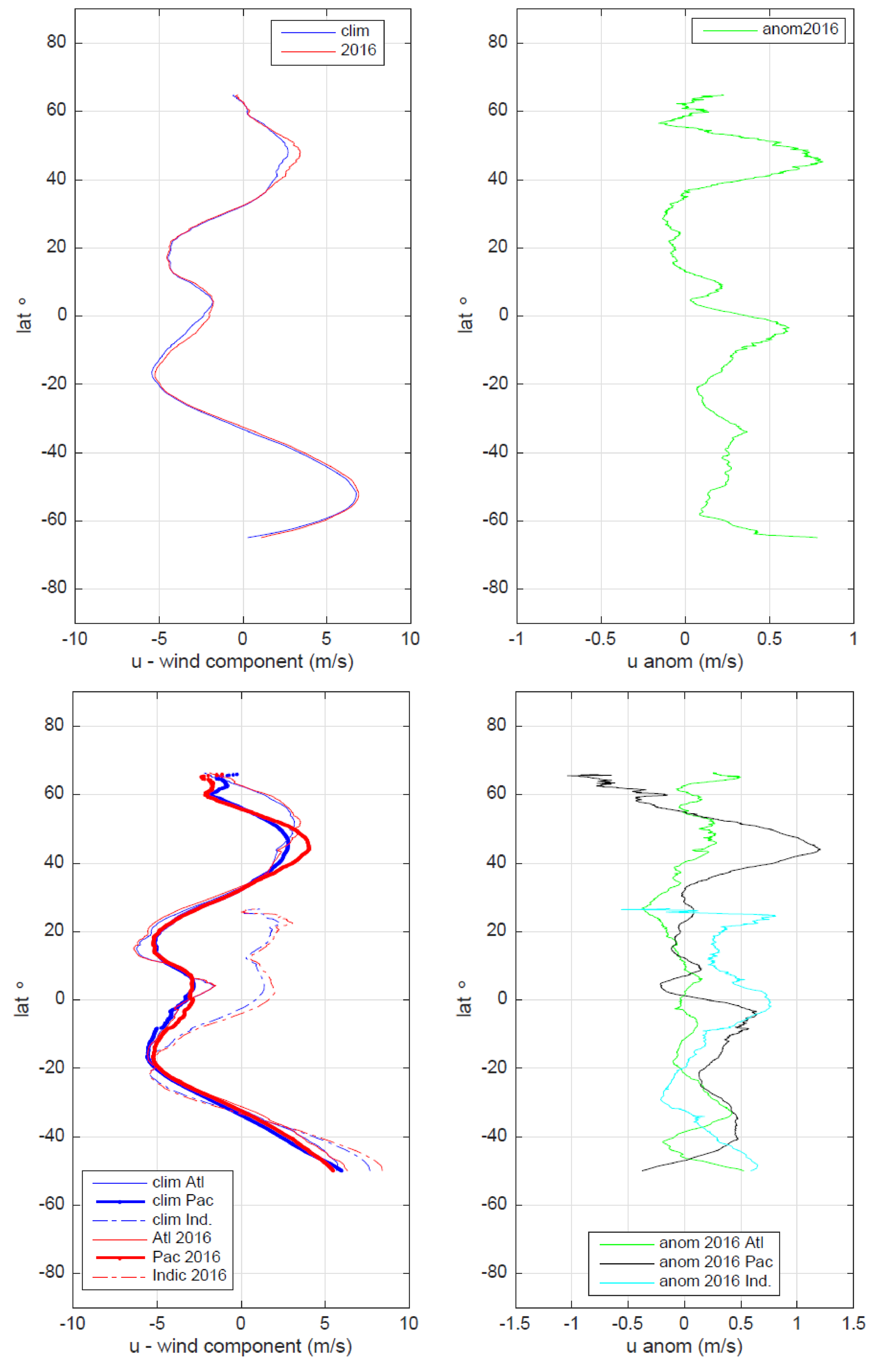

Figure 1:

Left: Zonally-averaged 10m zonal wind speed; top is global and bottom for basins as indicated. Blue line is for the climatology (2007-2014) and the red line for the annual mean in 2016.

Right: Anomaly in the year 2016, clearly largest at 45N in the Pacific.

II. ASCAT-A Scatterometer climatology

In the CMEMS OSR a reference climatology up to the end of 2014 is used and for the ASCAT-A scatterometer 2007 to 2014 is used as in Figure 1 in the right-hand-side plots. It shows the zonally averaged 10m zonal wind speed climatology and the 2016 values. The top is global and on the right it shows that 2016 had generally positive zonal wind anomalies. From the bottom plots for basins as indicated, it is clear that the most positive anomaly values at 45N occur in the Pacific. This coincides with generally cold SSTs at these latitudes (not shown). Figure 2 shows that 2015 was also a year with positive global zonal wind anomalies, resulting in a positive decadal trend. This trend is mainly caused by the northern hemisphere mid-latitudes and by the ITCZ El Nino (not shown).

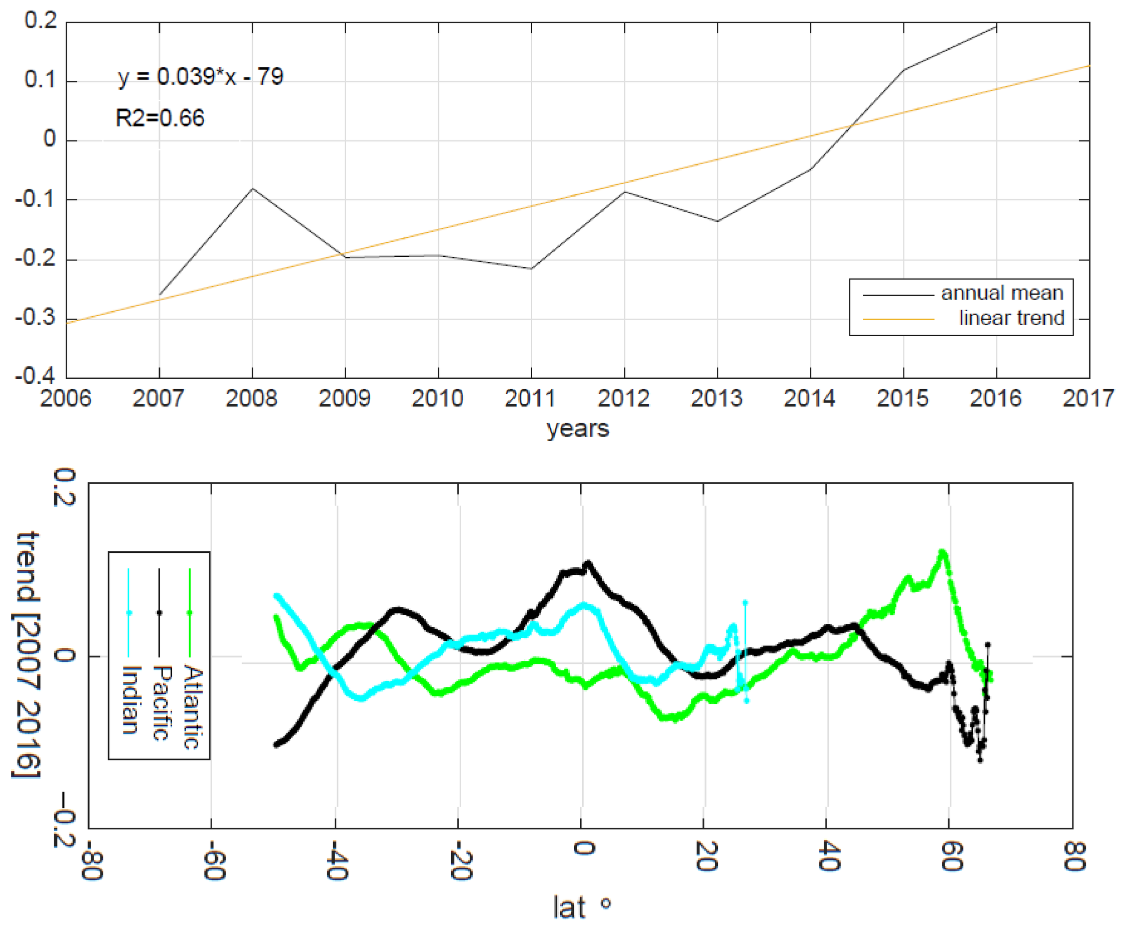

Figure 2: Positive decadal global zonally-averaged 10m zonal wind speed trend in ASCAT-A (top) and its distribution over the main basins.

III. ASCAT-A versus ERA interim winds

We verify the consistency of ERA interim with ASCAT-A winds.

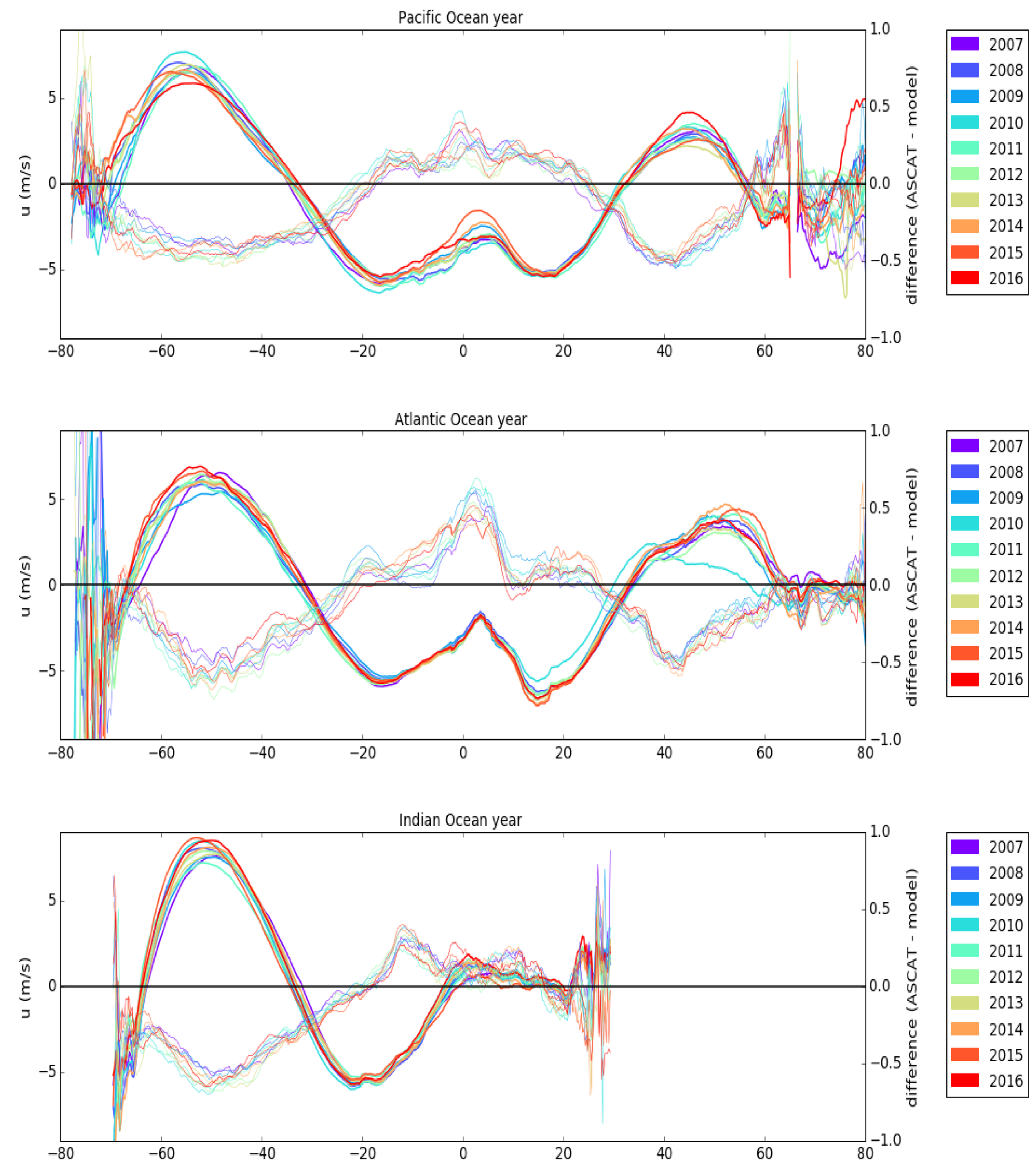

Figure 3: Zonally-averaged 10m zonal wind speed distribution over the main basins for ASCAT-A on left axis (thick) and the difference with ERA-interim on the right axis (thin). Note that ERA westerlies are too high.

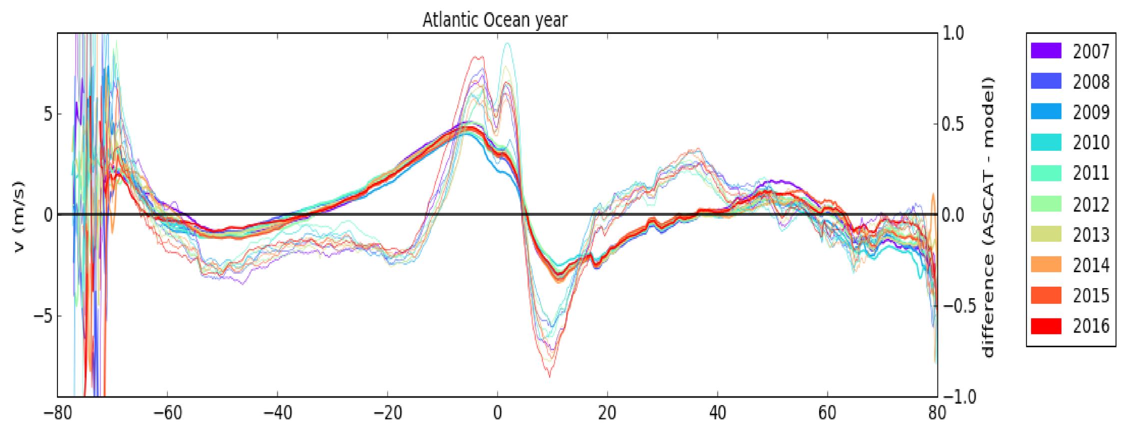

Figure 4: As Figure 3 but, meridional wind speed for the Atlantic Ocean.

Figure 3 repeats the annual-mean zonal-mean zonal wind as a function of latitude over the main basins for ASCAT-A. Particularly the 2010 Atlantic mean behaves anomalously in the Atlantic, while other year-to-year changes are more modest. The difference with ERA-interim appears rather systematic and the same from year to year with occasionally very large values in excess of 0.5 m/s, while only a ~0.1 m/s year-to-year spread is visible. It is clear that the ERA westerlies are exaggerated in the ERA model dynamical closure.

The meridional winds in Figure 4 show a more complex, but equally persistent, bias pattern, probably due to reduced wind turning in the stable boundary layer, reducing poleward flow.

IV. Comparison of divergence and curl

ERA interim fields have an effective resolution of a few 100 km. This implies that spatial derivatives will be rather smooth. In this section we compare ASCAT-A and ERA-interim wind stress curl and divergence on a climatological time scale.

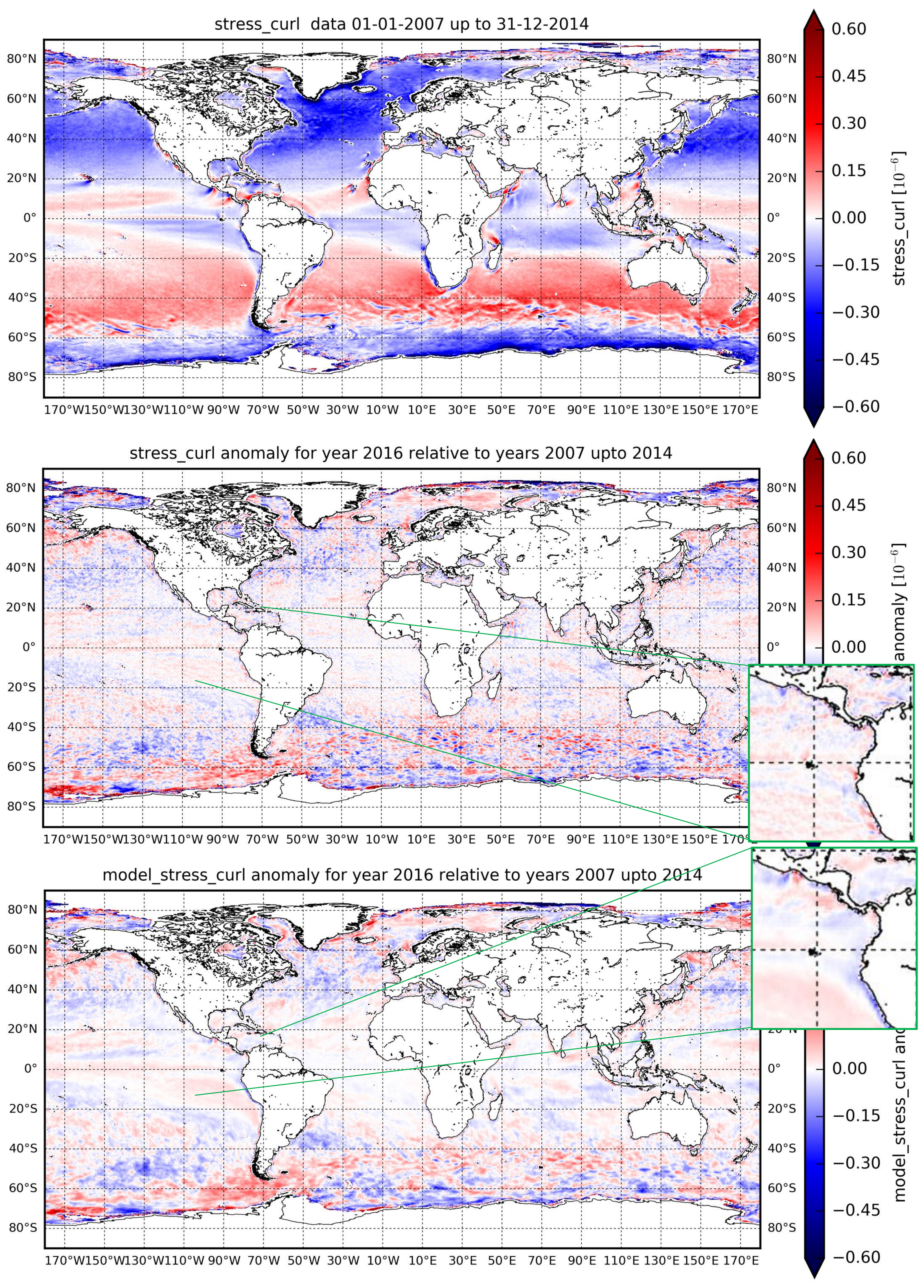

Figure 5: ASCAT-A wind stress curl from 2007-2014 (top) and ASCAT-A anomaly (middle). ERA anomaly of 2016 w.r.t. ERA 2007-2014 climatology (bottom) for 2016. Detailed zooms over middle America.

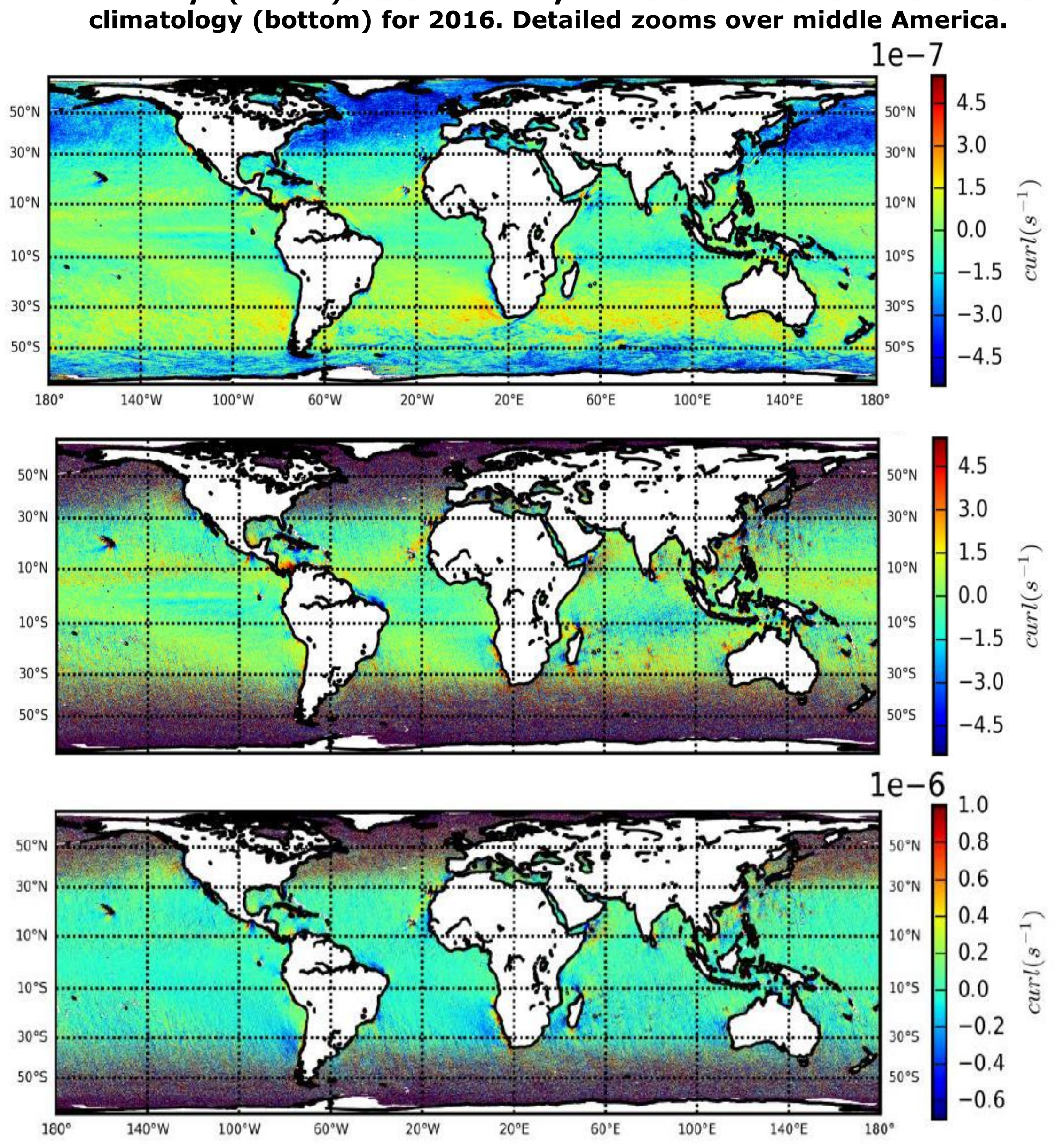

Figure 6: DFAS, Derivatives-First Averaging-Second , curl for ASCAT-A ascending orbits over 2013 (top) and AFDS, Averaging-First Derivatives-Second curl (middle). Difference DFAS minus AFDS.

Figure 6 shows that averaging swath data before taking derivatives causes abundant noise in the climatology, particularly at the higher latitudes with fast and variable winds.

Conclusions

Climatological wind anomalies are investigated and being linked to other geophysical parameters for the CMEMS Ocean State Report.

Moreover, the scatterometer stable instrument records and ERA anomalies are statistically compared for Quality Assurance at the time and locations sampled by the scatterometer.

In a preliminary analysis, we observe discrepancies due to:

- Resolution, particularly in the wind derivatives; curl and div;
- Parameterization, particularly very persistent systematic biases;
- Exaggerated westerlies.

In a next step climatologies of variability will be added for use in the Ocean State Report. Moreover, strategies will be devised to better combine observed and modelled records in user applications.

References and further information

[1] Copernicus Marine Environment Monitoring Service (CMEMS), marine.copernicus.eu
[2] CMEMS Ocean State Report – issue 1, www.tandfonline.com/doi/full/10.1080/1755876X.2016.1273446
[3] Belmonte et al., Cone Metrics: A New Tool for the Intercomparison of Scatterometer Records, www.doi.org/10.1109/JSTARS.2017.2647842
[4] ERA-Interim, www.ecmwf.int/en/research/climate-reanalysis/era-interim

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