Abstract

Wind and stress climatologies are shown from both scatterometers and atmospheric reanalyses by models, sampled and processed in identical ways. This facilitates the investigation of systematic monitoring artifacts in reanalyses and thus establishes confidence in the reliability of monitoring 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 (CMEMS) provides a yearly report of the state of the global oceans and regional seas near Europe [6]. 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. CMEMS 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 spatial sampling, monthly climatologies may be established from scatterometer wind or stress climate data records (CDR) of these essential climate variables (ECVs). 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 model, which is applied on a high data assimilation system. 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 scatterimeters.

Wind and stress climatologies and anomalies are being computed globally, especially around 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.

II. ASCAT-A Scatterometer climatology

In the CMEMS OSR a reference climatology up to the end of 2014 is used and from ASCAT-A scatterometer 2007 to 2016 is used as in Figure 1 in the right-hand-side plots. It shows the zonally averaged 10m 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 partly caused by the northern hemisphere mid-latitudes and by the ITZY El Nino (not shown).

Figure 3 repeats the annual-mean zonal-mean zonal wind as a function of latitude for the main basins for ASCAT-A. Particularly the 2010 Atlantic mean behaves anomalously in the Atlantic, while other year 10m zonal wind speed anomalies are moderate. The difference between ERA-interim and ASCAT-A 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 winds in Figure 3 show similarities, except for the year 2007 which is clearly different. The ERA westerlies are generally more persistent, bias pattern, probably due to reduced wind turning in the stable boundary layer, reducing poleward flow.

III. ASCAT-A versus ERA interim winds

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

IV. Comparison of divergence and curl

ERA interim fields have an effective resolution of a few 150 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 ERA interim (middle). ERA anomaly of 2016 w.r.t. ERA 2007-2014 (climatology) (bottom) for 2016. Detailed infancy over Middle Atlantic (not shown).

Figure 6: D45S, Derivatives-first Averaging-Second curl for ASCAT-A (top) and D45S, Averaging-First Derivatives-secon curl (middle). Difference D45S minus ERA.

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

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 2014. Right: Anomaly in the year 2016, clearly largest at 45N in the Pacific.

Figure 2: Scatterometer observation: gray, ERA interim: black, ERA interim anomaly of 2016 w.r.t. ERA 1987-2014 (climatology) for 2016.

Figure 3: Zonally-averaged 10m zonal wind speed distribution over the main basins for ASCAT-A (left axis) 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 5: Positive zonal anomaly over large basins from ASCAT-A and ERA interim for 2016.