Windspeeds in Extra-Tropical Cyclones: Climate Reanalyses vs Satellite Scatterometers

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Introduction

Climate reanalyses are widely regarded as our "best guess" at past climates, and are routinely used to verify the structure of meteorological phenomena in contemporary climate model integrations.

Uncertainties in these reanalyses mean it is important to verify the accuracy of reanalysis data directly against observations. This has been difficult in the past using surface observations in the vicinity of cyclones due to the static nature and inhomogeneous coverage of the observations, but the wealth of continuous satellite data that now exists allows for certain well documented properties to be verified against these.

This study aims to assess whether climate reanalyses are indeed our best guess in extreme windspeed environments, given that we now have relatively long (>10 years) windspeed records from satellite scatterometers.

Windspeeds in Extra-Tropical Cyclones are extracted from the ERA Interim climate reanalysis and ECMWF Operational IFS model using a detection and tracking technique, and are compared to their respective windspeeds retrieved by the QuikSCAT satellite using Remote Sensing System's v1 (Ku-2001) and v4 (Ku-2011) Geophysical Model Function (GMF).

Objective

This research aims to evaluate the accuracy of Extra-Tropical Cyclone (ETC) windspeed representation in models and climate reanalyses by comparing with scatterometer datasets. It is hoped areas of uncertainty in both scatterometer observations and models will be uncovered as a result.

Data and Data Processing

ERA Interim
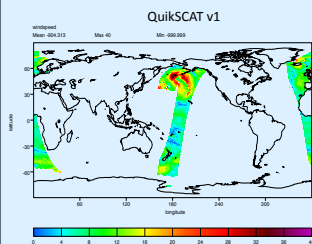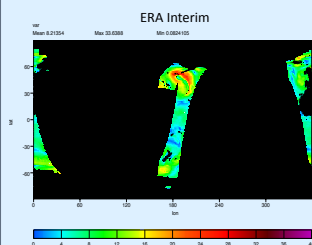
QuikSCAT v1

DATA

1) ECMWF ERA Interim:
Currently available for the period 1989-present day.
4D-Var data assimilation scheme.
Spectral T255 (~80km) horizontal resolution.

2) QuikSCAT RSS products v1/v4:
Available for the period 1999-2009.
QSv1 dataset produced using Ku-2001 GMF.
QSv4 dataset produced using Ku-2011 GMF.
25km Horizontal resolution.
1800km swath width.

3) ECMWF Operational IFS:
Cycle 31r1 used
Available 2006-2009
16km Horizontal Resolution

DATA PROCESSING

•Daily QuikSCAT data are converted into seasonal files consisting of global windspeed data split into 2 hourly windows (0000, 0600, 12000 and 1800∓ +/- 1hour). This short window is chosen so that issues due to temporal differences in model/satellite data are kept to a minimum.

•QuikSCAT is interpolated to the ERA Interim resolution. This is done so that the dataset with the finest resolution is interpolated to the coarser one.

•Reanalysis data is then masked in regions QuikSCAT was unable to retrieve windspeeds.

•This produces seasonal files with identical global measurement distribution as the QuikSCAT files and allows for direct comparison of the statistics between the two datasets.

Extra-Tropical Cyclone Detection and Tracking

Detection

•Vorticity is extracted from the ERA Interim dataset at the 850hPa level, and is smoothed to a spectral grid at T42 resolution.

•Larger scale background field (planetary scale waves with wavenumber ≤5) is then removed.

•The resolution provided (spectral band of 6 ≤ detectable centre ≤ 42) is fine enough to exclude larger scale disturbances, but coarse enough to reduce smaller scale noise in the data (Hoskins and Hodges, 2002).

•A threshold of $1.0 \times 10^{-5} s^{-1}$ must be exceeded in the vorticity field for detection. If this threshold is exceeded, the maximum vorticity in the region is taken as the storm centre.

Tracking

•An objective feature tracking technique (Hodges, 1994; 1995; 1999) imposes maximum displacement constraints in order to link detected centres that are spatially and temporally near. This produces Extra-Tropical Cyclone tracks.

•Those systems with <60% of tracks in the mid-latitudes (30°- 60°N/S) are removed as they could be tropical/polar disturbances.

•A minimum duration filter of at least 48hrs is also applied to remove short-lived systems unlikely to be ETCs.

•Maximum and mean windspeeds in a 6 degree radius around the vorticity storm centre at each time frame are taken.
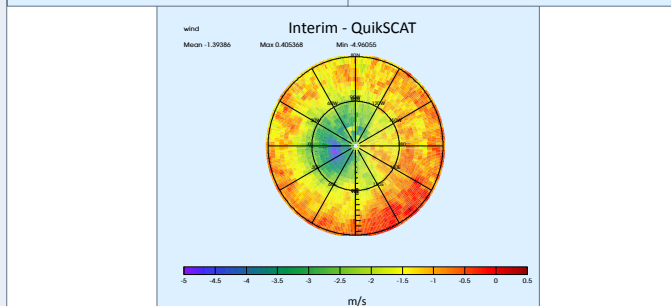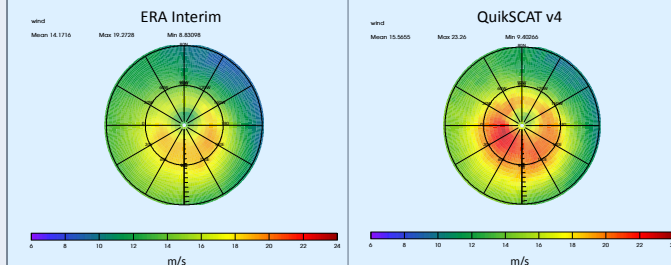
Results: Maximum Windspeed Counts

In the top right figure, the Operational Model has been interpolated to the QuikSCAT 25km grid and then masked by the QSv1 dataset. It can be seen that the operational model drops to zero counts per month by $35ms^{-1}$, whereas both QuikSCAT versions continue to count storms above $40ms^{-1}$. However, the general shape of the Interim and QSv4 curves between $15ms^{-1}$ and $30ms^{-1}$ are similar.
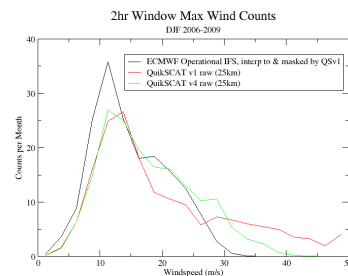
In the bottom right figure, both QuikSCAT datasets have been interpolated to the ERA Interim resolution, and Interim has been masked with separately with each of the QuikSCAT versions. It can be seen by the minimal difference in the Interim curves that there is only a very negligible effect of masking using one or the other of the QuikSCAT datasets. As with the top right plot, both QuikSCAT datasets count more intense windspeeds than ERA Interim. The Interim curve looks remarkably similar to the Operational curve in the top right, especially given the differences in their resolution. It is thought this may be due to increased assimilation of high wind speed observations in the Interim Reanalysis.

2hr Window Max Wind Counts
DJF 2006-2009

2hr Window Max Wind Counts
DJF 1999-2009
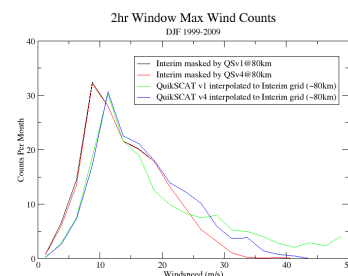
Results: Composites: DJF 1999-2009, ETCs >25ms⁻¹

ERA Interim

QuikSCAT v4

Interim - QuikSCAT

References

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Acknowledgements

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