Improved Characterisation and Bias Adjustment of Ship Winds in ICOADS

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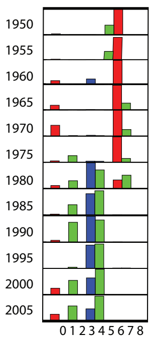
Observations of wind speed made by ships are a vital part of the climate record. Wind speed has been recorded for more than two centuries and these observations are archived in the International Comprehensive Ocean-Atmosphere Dataset (ICOADS, Worley et al. 2005). The consistency of the marine wind record has often been questioned due to the changing mix of visual observations and measured winds combined with increasing measurement heights and changing observing practices. The need for accurate and comprehensive information on observation method and instrument heights has long been recognised.

This poster shows the potential for improvement in wind flagging, at least in the period 1950-1970. The use of geostropic winds calculated from daily in situ pressure fields as a method for wind speed adjustment is investigated. Comparison with other data sources suggests that adjustment of visual winds to agree with anemometer wind speeds in the period after 1985 is required and an empirical adjustment to do this is presented.

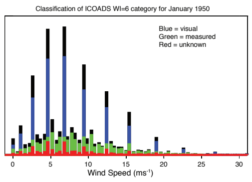
Unknown measurement methods

ICOADS contains a "wind indicator" flag (wi) which provides information on measurement method and original units of measurement, where available. The measurement method information is essential as different adjustments need to be applied to each measurement method (e.g. Thomas et al. 2005). The flags used in ICOADS are shown in the Table below.

Code	Measurement Method	Units
0	estimated	ms^{-1}
1	measured	ms^{-1}
2	estimated	unknown
3	estimated	knots
4	measured	knots
5	estimated	Beaufort Force
6	estimated or unknown	unknown or unknown
7	measured	unknown
8	measured	probably ms^{-1}



The figure shows how the flags in ICOADS change over time, red bars indicate unknown measurement method, green bars measured winds and blue bars winds visual estimated from sea state using a Beaufort Equivalent Scale (e.g. Kent and Taylor 1997). The flag "wi=6" is a mixture of visually estimated wind with unknown units and winds of unknown method, the legacy of inadequate historical metadata.



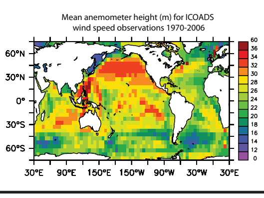
The figure to the right shows the results of an attempt to automatically classify the ambiguous flags for January 1950 into original measurement methods. The results are reasonably good, but classification in later years is less sucessful.

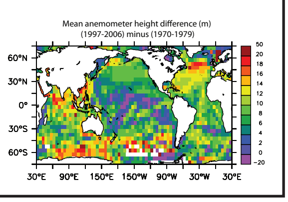
A further problem is that if winds are measured and then converted and coded in Beaufort Force then the distribution will have the characteristic peaks detected by the automatic method. However in this early period there are unlikely to be to many measured winds, although some are detected (green bars above). There are too many "wi=6" observations to discard them, so typically studies have included them as visual estimates. The results above suggest this can be improved on by identifying some measured wind speeds.

The measurement method assignment depends on being able to group reports from a single ship, or ships with the same characteristics, possibly from the same country. Any reports without such information are currently impossible to classify, although new approaches to identifying ship tracks presented at this meeting may in the future be helpful.

Measurement Heights

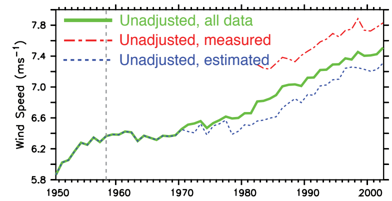
It is important to know the measurement method as anemometers on the ships tend to be significantly higher than the 10m reference level for visual winds. If unadjusted, an increasing proportion of measured winds would lead to a spurious increasing wind trend (Cardone et al. 1990, Thomas et al. 2008). Additionally any increase in mean anemometer height would add to this spurious trend. Information on anemometer heights is available in the World Meteorological Organisation (WMO) "List of Selected, Supplementary and Auxiliary Ships", see Kent et al. (2007) for further information. These measurement heights are associated with individual ICOADS observations and the resulting mean anemometer heights are plotted below (left panel). The right panel shows the difference in measurement height over the past few decades, clearly indicating the upward trend in anemometer heights.

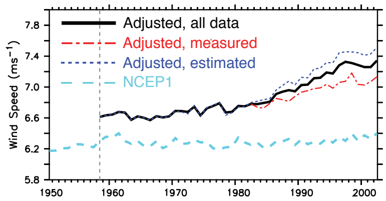




Trends in ICOADS Winds

At MARCDAT-II Thomas et al. (2008) presented fully bias adjusted winds from ICOADS, updating the work of Cardone et al. (1990). They showed that whilst the adjustments reduced the trends in the winds, in the well-sampled regions used in their study trends remained in the ICOADS winds which were not seen in either the NCEP1 (Kistler et al. 2001) or ERA40 (Uppala et al. 2005) atmospheric reanalysis (not shown). They also showed that visual winds showed greater trends than anemometer winds and concluded that some observers were either using, or being influenced by, unadjusted anemometer winds and hence reporting wind speeds that were too high.



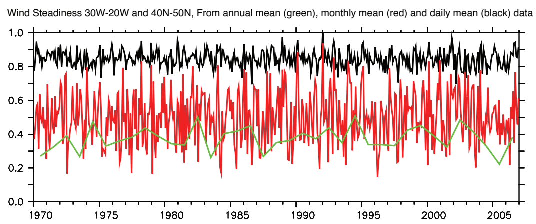


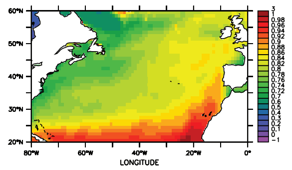
It has been argued that marine winds can be calibrated using pressure information (Ward and Hoskins 1996) although Lindau (2006) asserted that a combination of errors in the data and the unsteadiness of the wind would make the results of any such calibration unreliable. This is certainly the case for monthly winds averaged using simple gridding, but can we do better with improved datasets?

Wind Steadiness

The plot below shows wind steadiness (ratio of vector averaged wind speed to scalar averaged wind speed) for a well-sampled region of the North Atlantic. The monthly steadiness (red) is indeed low and variable, and the annual steadiness is lower still (green). However the daily steadiness is between about 0.8 and 0.9, and much less variable, suggesting that it might be possible, in well sampled regions, to improve the consistency of the winds using pressures.

One concern was that the high daily steadiness might be the result of poor sampling. For example, if there is only one observation per day then the vector and scalar mean winds will be the same and the steadiness will be one. This was tested by plotting the steadiness against number of samples to ensure that sampling was adequate to represent the variability of the wind. It should be noted that applying the adjustment suggested by Lindau (2006) to account for variations in wind direction uncertainty acts to increase the steadiness but does not noticeably affect the trend in steadiness.

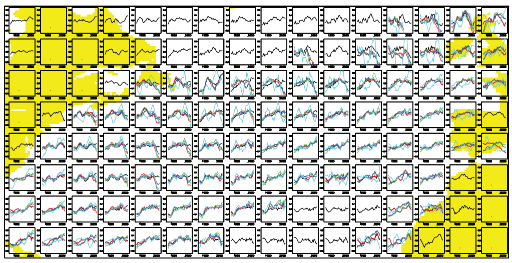




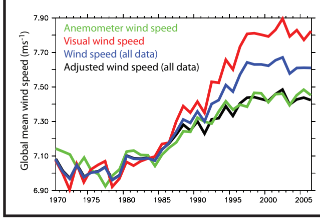
Monthly Wind Steadiness Calculated from Daily Wind Estimates and Averaged Over the Period 1970 to 2006.

Anomalies and Adjustment

The plots on the right compare annual wind speed anomalies in the North Atlantic. Across much of the basin there is an increasing trend, seen in each data source. In regions where the steadiness is high (see map above) the geostropic anomalies (light blue) increase in a similar pattern to the in situ wind speed (red, blue), and the NCEP1 data masked for co-location with in situ (red). The geostropic anomalies are erratic in regions of low steadiness. In poorly sampled regions where the masked NCEP1 and full NCEP1 are significantly different, the masking improves the agreement with the in situ data quite dramatically.



Annual wind speed anomalies from a variety of sources, averaged in 5-degree boxes and smoothed with a 5-year running mean filter.Black is NCEP, red is NCEP co-located with in situ data, green is the scalar mean wind speed, blue is the vector mean wind speed, and light blue is the scaled geostropic wind speed calcuated from pressure gradients.



These plots provide evidence that the wind speed is increasing in many regions, and that trends seen in the anemometer wind speed data are likely to be realistic. An adjustment is therefore applied to the visual wind speed data to bring the trends into agreement with the anemometer wind speeds. Visual winds (following adjustment for Beaufort Scale) are left unadjusted up to the end of 1985, after this date a factor is applied to reduce visual wind speeds by up to 5% (varying linearly from zero to 5% by the end of 1999, and thereafter is constant at 5%). The plot to the left shows the global mean wind speed before and after adjustment. We note that in the future it might be desirable to develop regional adjustments.

References

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Acknowledgements

ICOADS was downloaded from the NCAR Research Data Archive which is managed by the Data Support Section of the Computational and Information Systems Laboratory at NCAR, Boulder, Colorado.

NCEP Reanalysis data (Kistler et al. 2001) provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, USA, from their Web site at http://www.cdc.noaa.gov/.

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