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 geostrophic 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. 2003). The flags used in ICOADS are shown in the Table below.

<table>
<thead>
<tr>
<th>Flag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>wi=1</td>
<td>Unadjusted, all data</td>
</tr>
<tr>
<td>wi=2</td>
<td>Adjusted, all data</td>
</tr>
<tr>
<td>wi=3</td>
<td>Unadjusted, estimated</td>
</tr>
<tr>
<td>wi=4</td>
<td>Adjusted, estimated</td>
</tr>
<tr>
<td>wi=5</td>
<td>Adjusted, measured</td>
</tr>
</tbody>
</table>

The figure shows how the flags in ICOADS change over time. Red bars indicate unknown measurement method, green bars measured winds and blue bars visual winds estimated from data using a Beaufort Equivalent Scale (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 successful.

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 too 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 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 unlikely to be too many measured winds, although some are detected (green bars above). 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 in a day, then one wind 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.

**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.

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 geostrophic 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.

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.

**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 trend (Cardone et al. 1990). 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?

**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 geostrophic 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.

**Acknowledgements**

ICOADS was declassified from the National Research Data Archive which is managed by the Data Support Office of the Computational and Information Sciences Laboratory at NCMD, Argonne National Laboratory (NCL, Argonne, IL). The ICARUS data (Kplit et al. 2007) provided by the NOAA-CRES Critical Diagnostic Center. User Guide: ICARUS. USA, from the ftp site of www.cress.ucar.edu.

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Kistler et al. 2001. The NCEP-NCAR 50-year reanalysis: Monthly means CD-ROM and full NCEP1 are significantly different, in sampled regions where the masked NCEP1 and full NCEP1 are significantly different, the masking improves the agreement with the in situ data quite dramatically.

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