ASSESSING THE EFFECT OF AIRFLOW DISTORTION ON VOS WIND SPEED MEASUREMENTS

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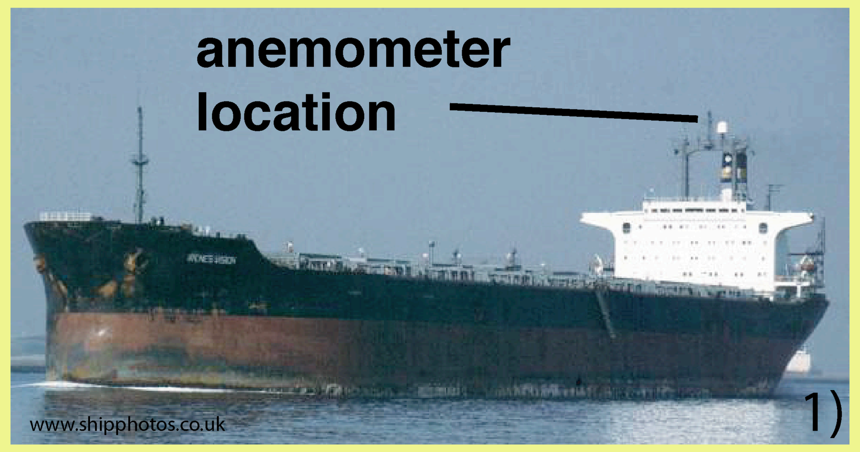
1. Introduction

Wind speed measurements from Voluntary Observing Ships (VOS) are vital to climate studies, in particular for estimating air-sea fluxes. However, the wind speed measurements obtained from ship-mounted anemometers can be biased by the distortion of the airflow due to the presence of the ships' hull and superstructure. Here we describe the numerical model used to quantify these biases and our initial progress in applying the model results to VOS wind data.

2. A simple ship shape

Merchant ships vary greatly in shape and size and it would be impractical to study the flow over each individual ship. Therefore a simple ship shape was developed (Moat et al. 2005a) which represented liquid tankers, bulk carriers and general cargo ships: these represent about a third of the VOS which report anemometer winds. The figures below show a typical tanker (Fig. 1) and a numerical simulation of the airflow over the simple ship shape (Fig. 2).



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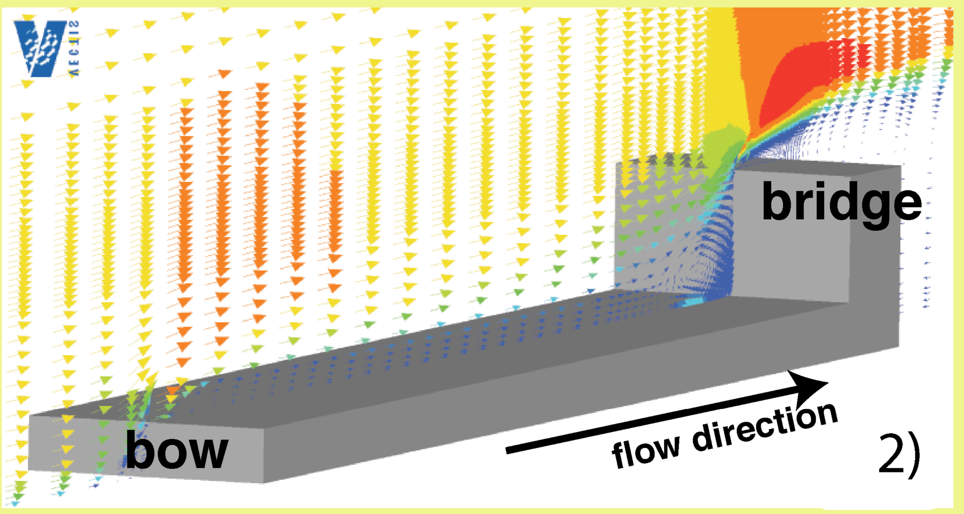

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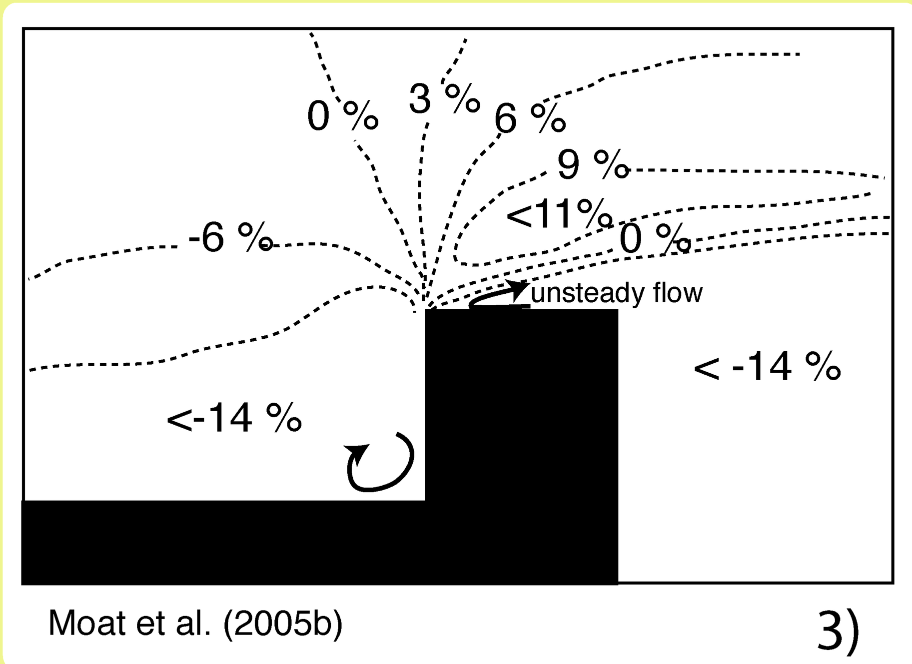
3. Numerical model results

The commercial CFD code VECTIS was used to make 3-D simulations of the airflow over the simple ship shape. The wind speed bias (% of the free stream or un-distorted wind speed) along the centreline of the ship for a bow-on flow is shown in Fig. 3.

The bias is highly dependent on the anemometer position. Close to the bridge top the flow is severely decelerated and unsteady, and may reverse direction. Above this region the flow is accelerated by 10% or more. In order to minimise the wind speed bias, anemometers should be mounted as high as possible and towards the upwind edge of the structure. Comparisons with in situ wind speed data showed that the model wind speeds were accurate to 4% or better (Moat et al. 2005c).



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The pattern of flow scales with the height of the obstacle. For bow-on flows this is the height of the bridge above the cargo deck, and for beam-on flows the relevant height is that of the bridge top above the water line. Hence the bias is also dependent on wind direction relative to the ship.

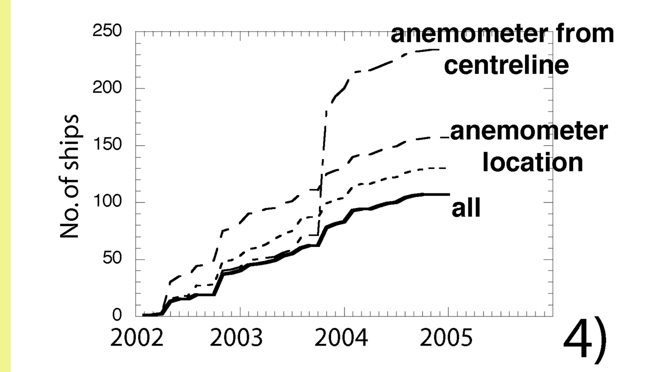
To illustrate the dependence of the bias on wind direction, we take an example of an anemometer mounted 5 m above the bridge of a tanker of length 200 m. The anemometer is assumed to lie on the centreline of the ship, half way between the forward and aft edges of the bridge top. The wind speed bias at this location is +10 % for flows directly over the bow and about -30 % for flows directly over the beam. There is greater variation in the beam-on flows as the anemometer is located close to the region of unsteady flow.

4. Model application: progress to date

The results of the study of the simple ship shape can be applied to wind directions within 30 degrees of bow-on and beam-on for liquid tankers, bulk carriers and general cargo ships. Wind speed data from all other ships types can also be corrected if the wind direction is within 30 degrees of the beam. The results cannot be applied to bow-on winds for other types since the presence of upwind obstacles (cranes/containers etc.) cause additional, unquantified, flow distortion effects.

If a ship's dimensions and anemometer position are included in the WMO International List of Selected, Supplementary and Auxiliary Ships (known as WMO Pub. 47) metadata then the bias in the mean wind speed for bow-on and beam-on flows can be determined from the model of Moat et al. (2005b). Parameters such as anemometer position have only been included in the WMO Pub. 47 since 2002. If the metadata are not available, an estimate of the ship dimensions can be made by the method suggested by Moat et al. (2005a) using a) ship type and length obtained from the Lloyds of London Register of Shipping, and b) some assumptions with regard to typical anemometer positions.

The number of ships reporting particular metadata parameters are shown cumulatively for the period January 2002 to December 2004 in Fig. 4. At present a total of 107 ships have reported all the metadata parameters required to quantify the wind speed bias. The amount of metadata is steadily increasing and we intend to apply the data retrospectively.



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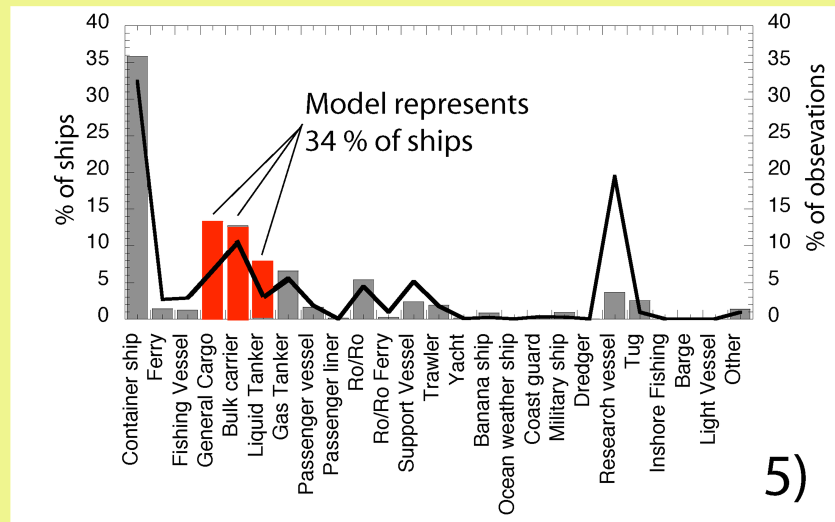

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The distribution of ship types reporting anemometer wind speed measurements between 2002 and 2004 is shown in Fig. 5. Data from Lloyds Register was used to fill in missing WMO Pub. 47 ship type reports. The ship types represented by the simple ship shape are shown in red. These types provide 20% of the total anemometer wind speed reports.

5. Conclusions

- The wind speed bias is highly dependent on both the anemometer location and relative wind direction, and varies from decelerations of 100% to accelerations of 10% or more.
- Flow distortion effects can be minimised by locating anemometers as high as possible above the bridge top and towards the front edge of the bridge.
- We intend to apply these results to ICOADS anemometer winds.

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References:

Moat, B. I., M. J. Yelland, R. W. Pascal and A. F. Molland, 2005a: An overview of the airflow distortion at anemometer sites on ships, International Journal of Climatology (CLIMAR-II Special Issue), 25(7), 997-1006.

Moat, B. I., M. J. Yelland and A. F. Molland, 2005b: Quantifying the airflow distortion around merchant ships, part II: application of model results, accepted by the Journal of Atmospheric and Oceanic Technology.

Moat, B. I., M. J. Yelland, R. W. Pascal and A. F. Molland, 2005c: Quantifying the airflow distortion around merchant ships, part I: validation of a CFD model, accepted by the Journal of Atmospheric and Oceanic Technology.