Southampton Oceanography Centre
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

Quantifying The Effects Of Airflow Distortion On Wind Speed Measurements From Voluntary Observing Ships

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Merchant ships

Typical anemometer location.

The ships are large ‘block like’ shapes which can distort the airflow above the ship.

The anemometers may not be very well exposed.

Airflow distortion: Effect on bulk surface fluxes

- 10 % error in the **mean** wind speed
  - ➢ 27 % error in the momentum flux.

- 10 % error in **mean** wind speed
  - ➢ 10 % error in the heat flux.

Airflow distortion can lead to errors of either sign in the wind speed and it is important to quantify these biases

OUTLINE

1) Specify a generic model to describe a ship.

2) Wind tunnel testing of the airflow over a generic ship geometry.

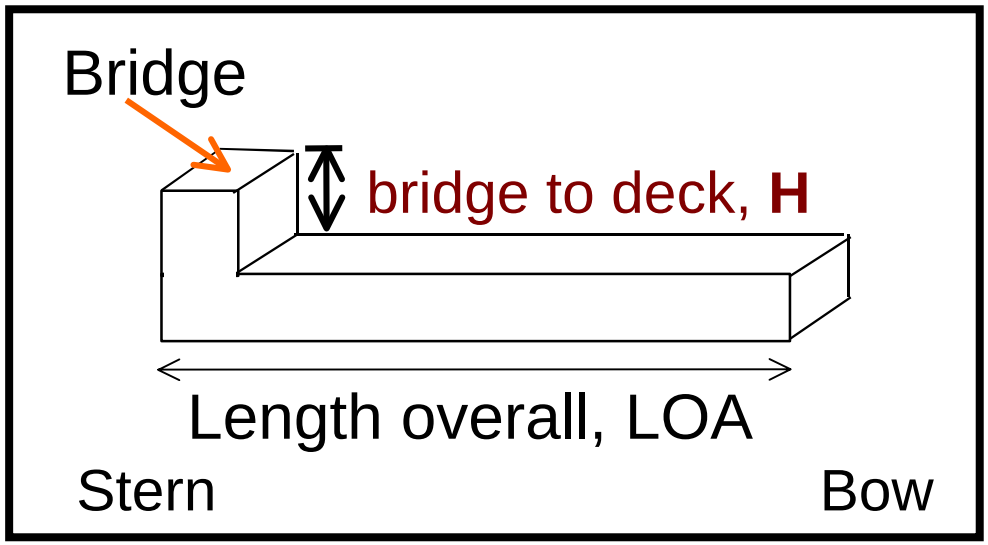
3) Numerical simulation of the airflow

4) Compare the results to *in situ* wind speed data

A generic ship model

- We can’t model the 7000 individual VOS
- However, they fall into generic categories which have well defined characteristics
- Tankers and bulk carriers have similar shapes and account for 35% of the world fleet
- From the tankers length we can estimate other dimensions which are important for the airflow characteristics

A generic tanker/bulk carrier

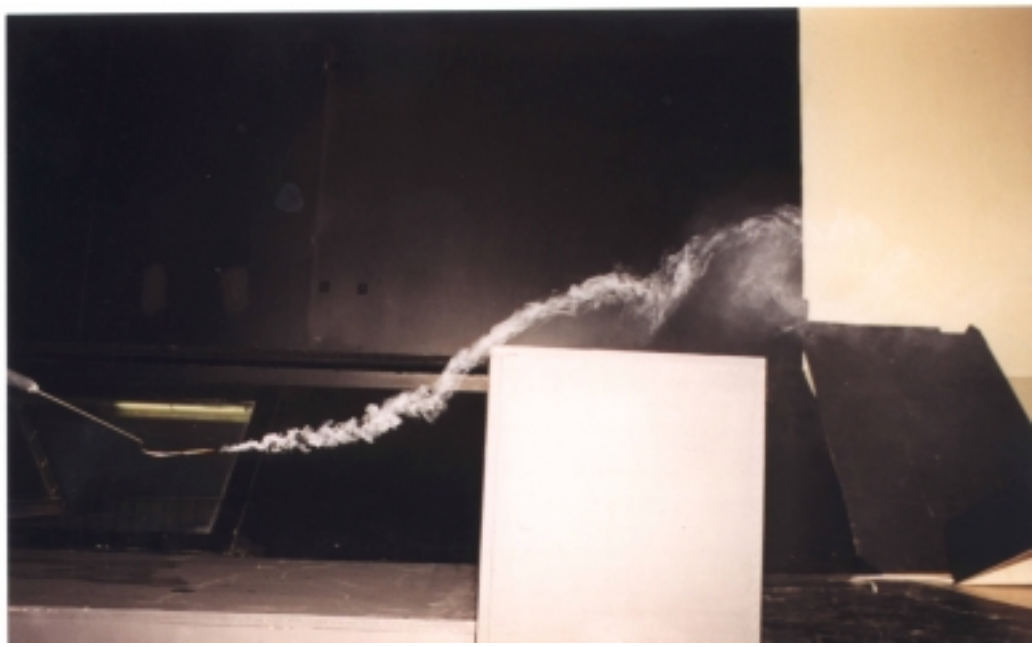


All principal ship dimensions have an approximate linear relationship to the ships length overall.

We will show that the height of the bridge above the deck, H, is important for predicting the flow patterns

The bow step is unimportant for tankers and bulk carriers

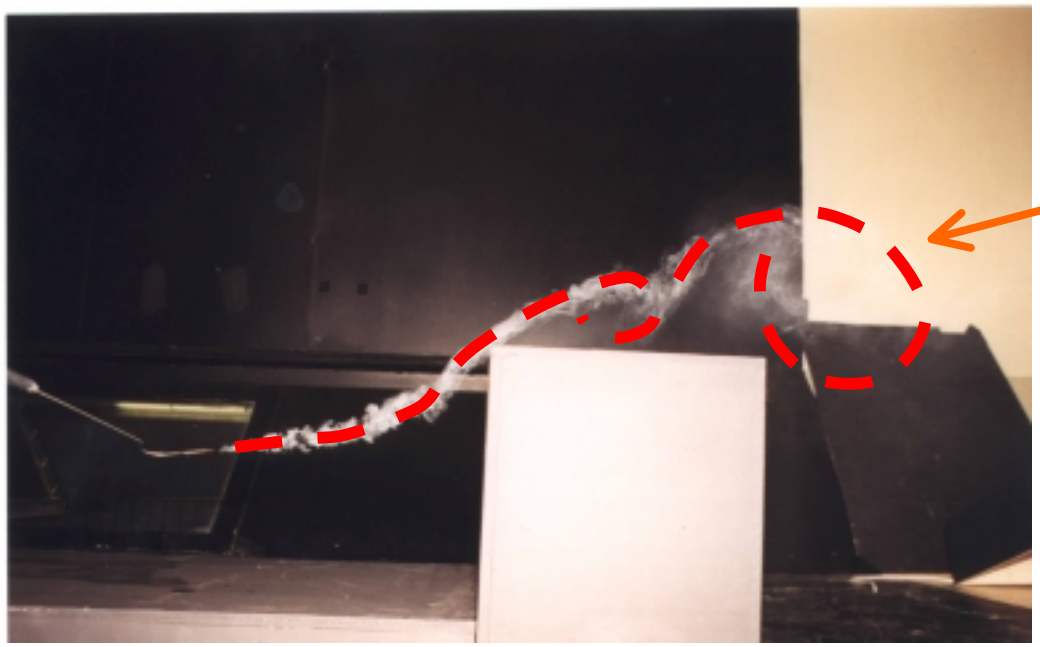
Wind tunnel studies: smoke tests



Flow direction

Basic flow visualisation of the airflow above the bridge of the tanker.

Wind tunnel studies: smoke tests



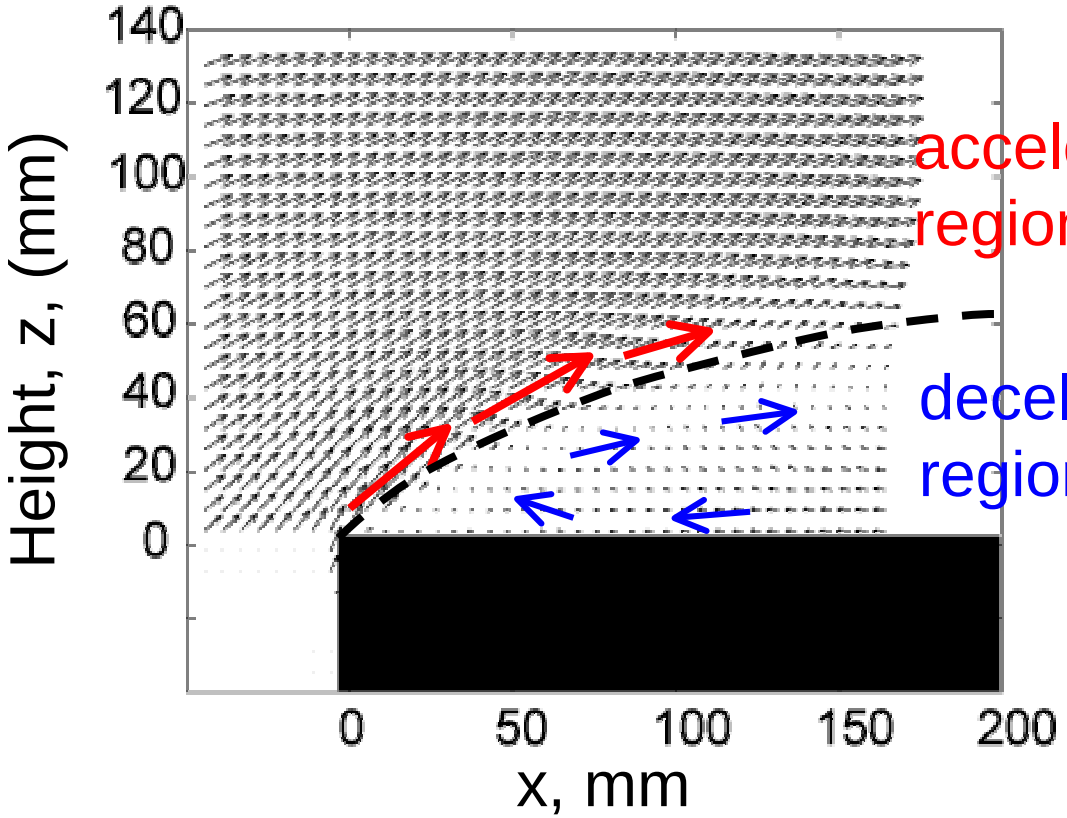
Vortices produced close to the top of the bridge.

Flow direction

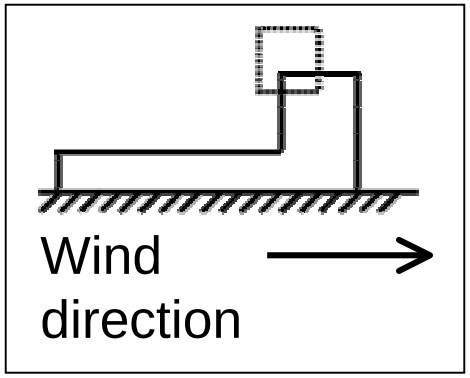
Complex flow pattern above the bridge.

Wind tunnel measurements

General flow pattern above the bridge of the tanker.



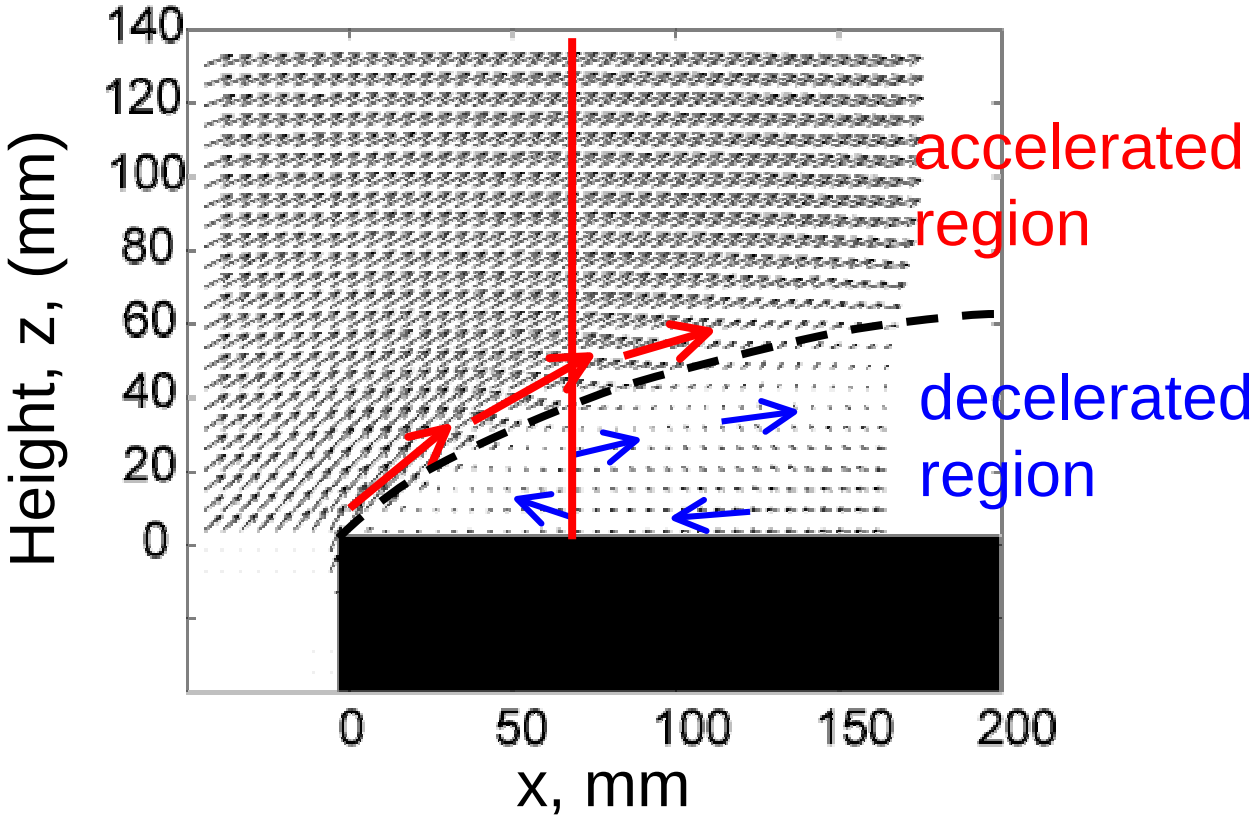
2-D sheet of velocity data

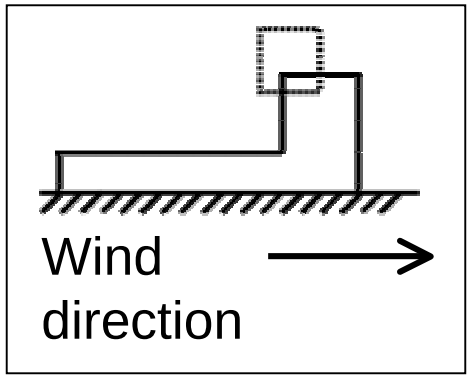


Anemometers placed close to the bridge top will experience severe deceleration and possibly flow reversal.

Wind tunnel measurements

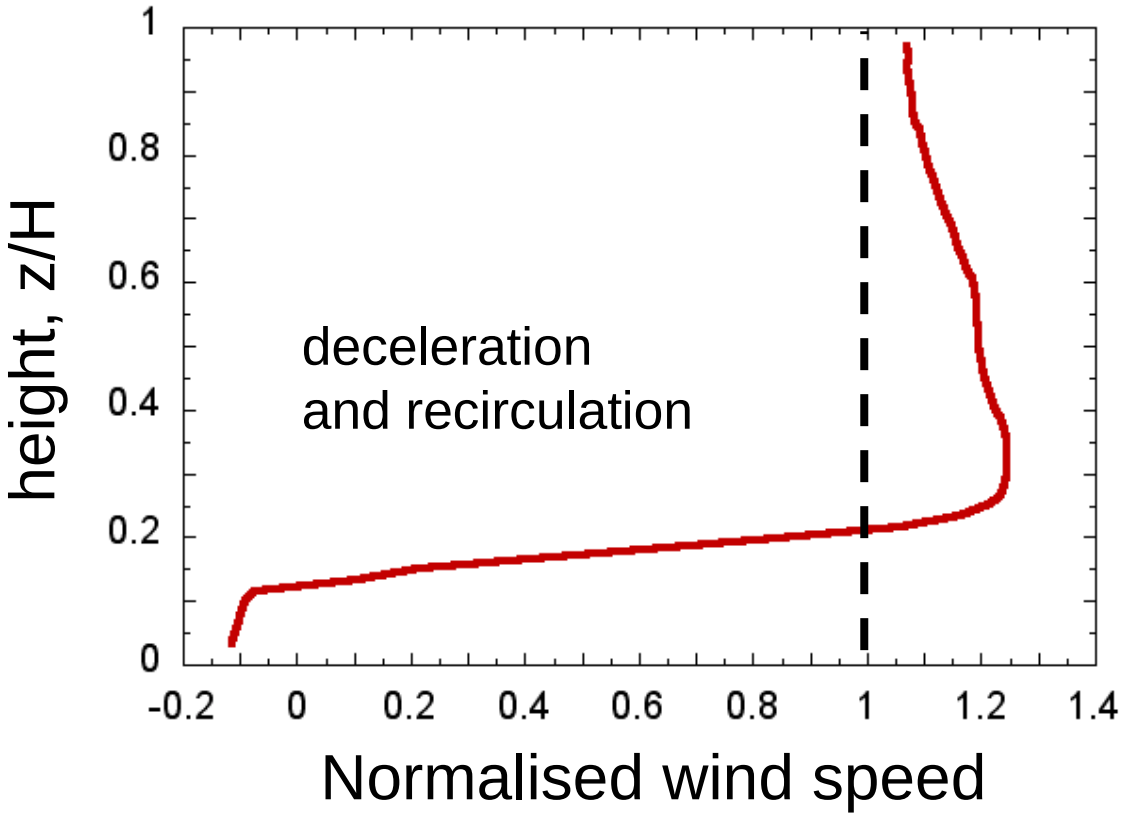
General flow pattern above the bridge of the tanker.

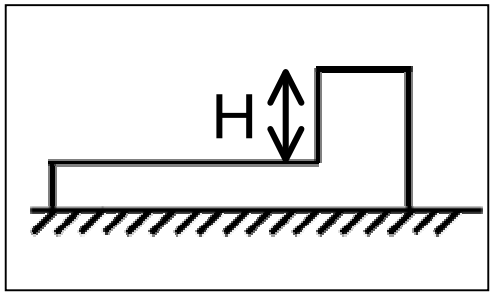




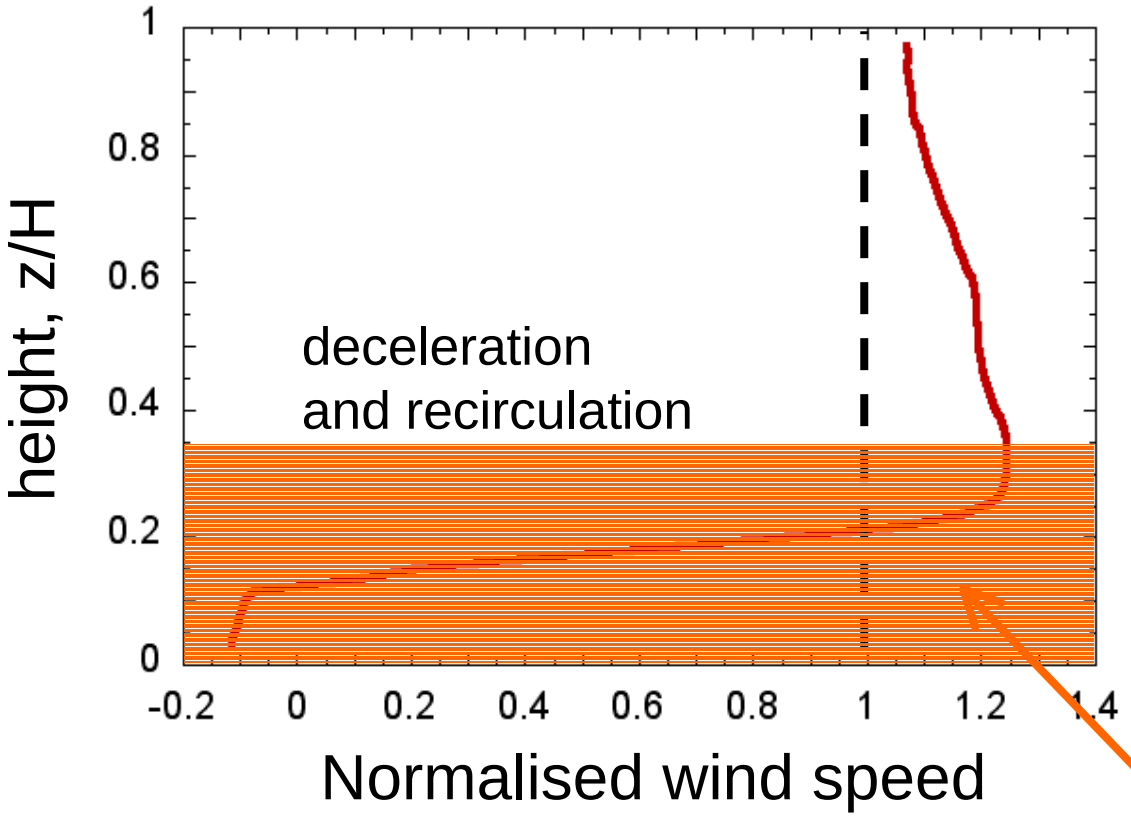
Anemometers placed close to the bridge top will experience severe deceleration and possibly flow reversal.

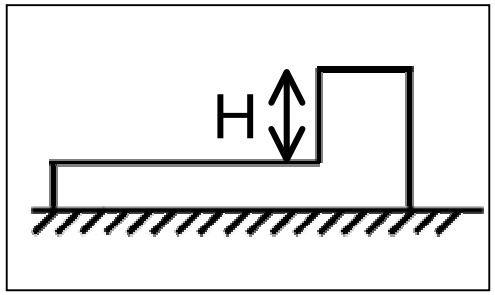
Normalised wind speed profile





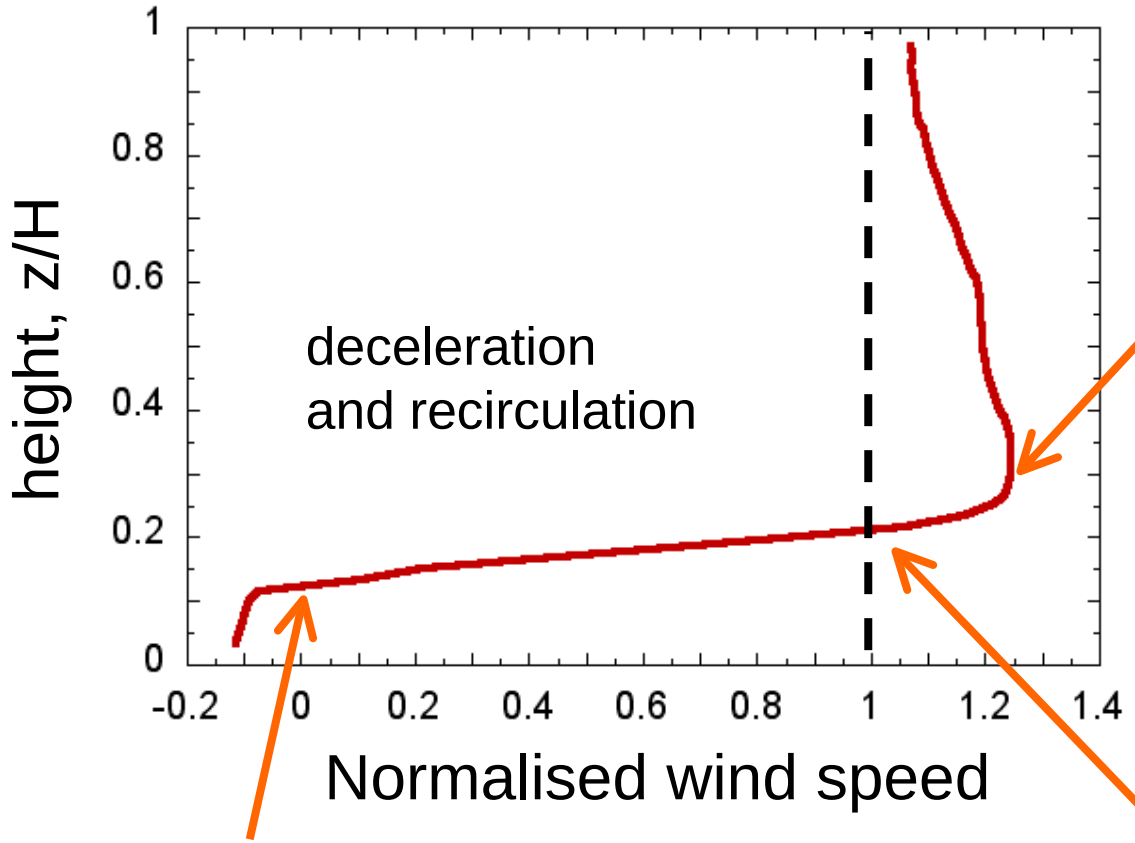
Normalised wind speed profile



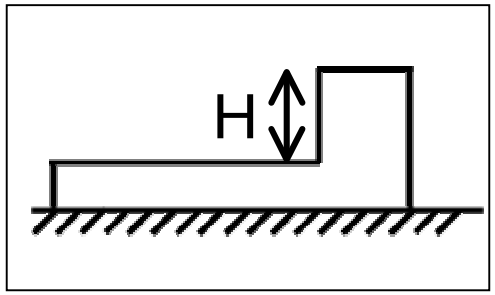


Region of high velocity gradients

Normalised wind speed profile



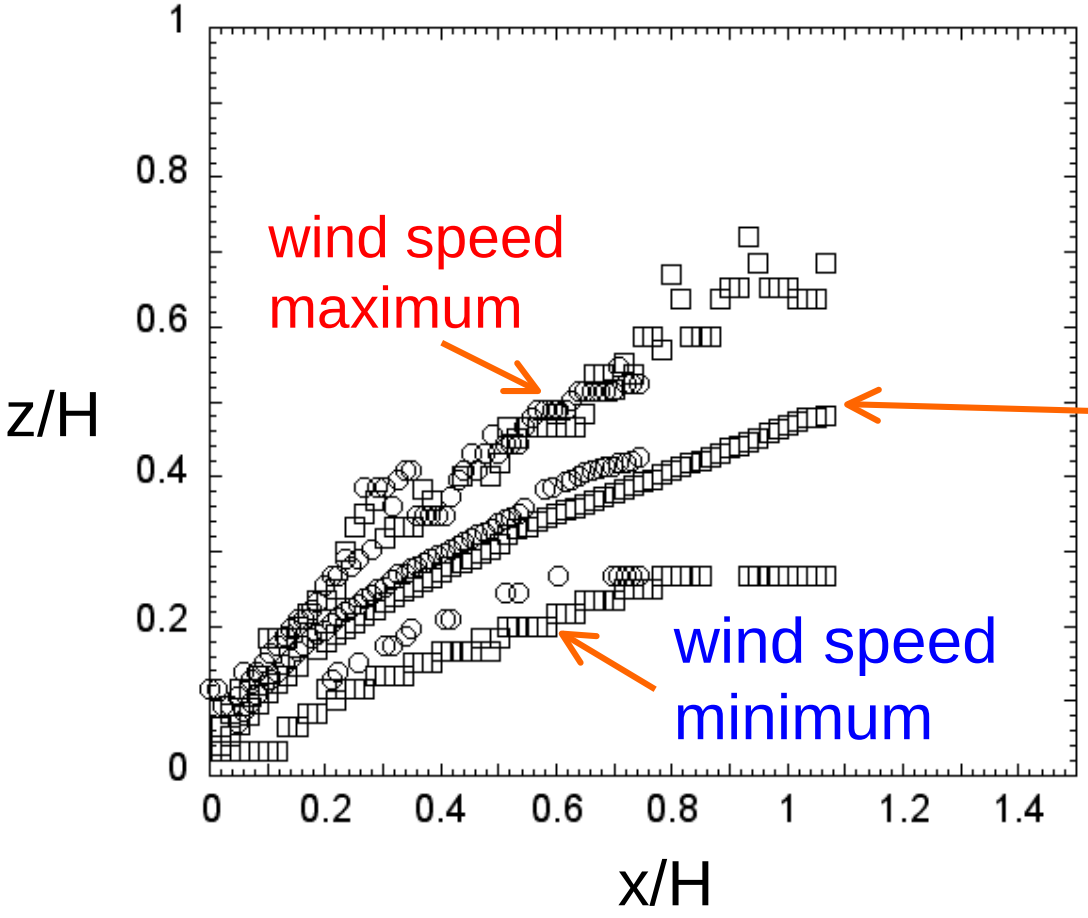
wind speed maximum



wind speed minimum
(normalised wind speed=0)

boundary between accelerated and decelerated flows

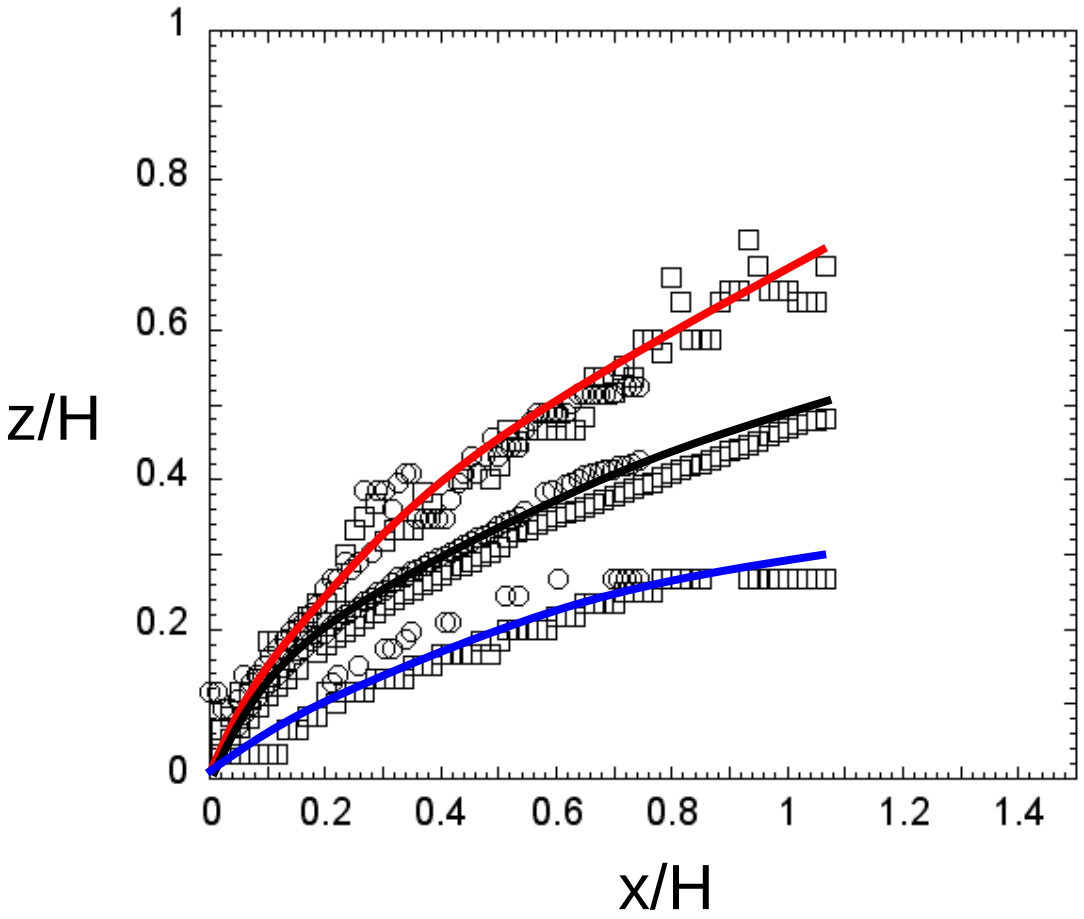
Scaling laws for the flow field



Gives the position of the flow features.

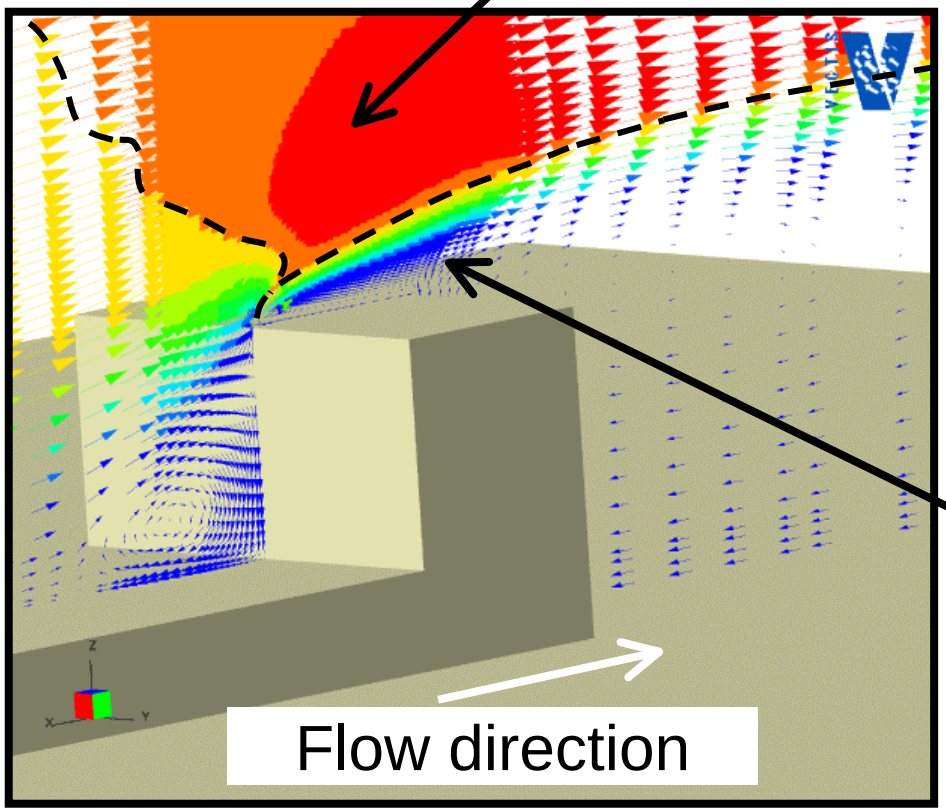
The important features of the flow field can be simply predicted from the bridge to deck height

Scaling laws for flow field



Using these simple relationships the sign of the bias can be determined for an anemometer position and bridge to deck height H

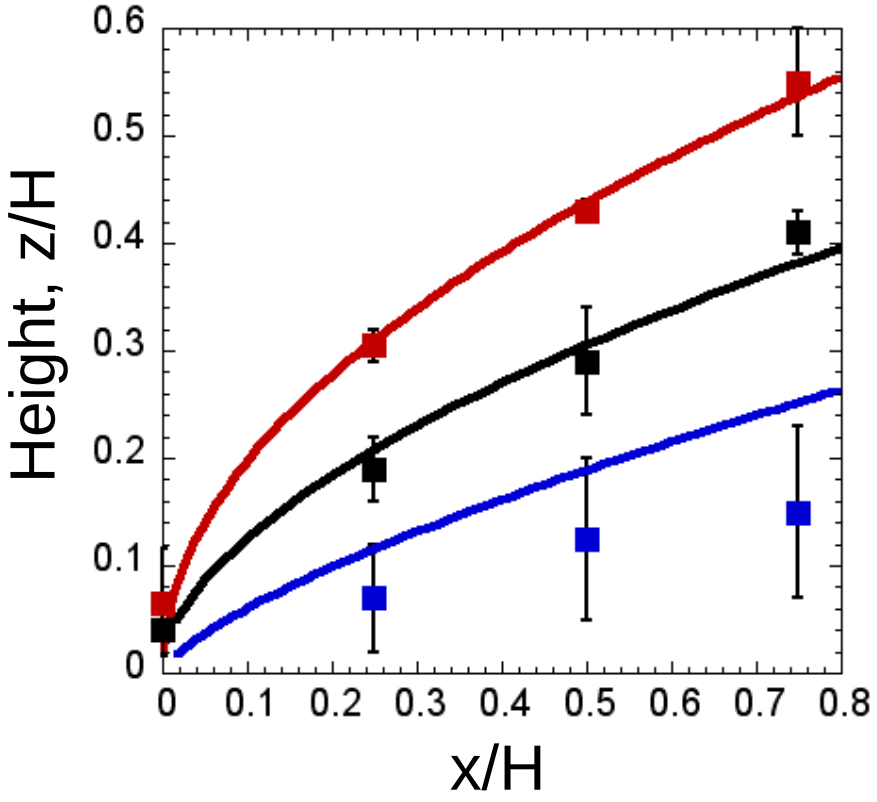
CFD modelling of the airflow



3D simulation of the airflow over the tanker.

Qualitatively, the numerical model reproduces the general flow pattern quite well.

CFD and wind tunnel predictions of the general flow pattern



maximum

boundary between flow regimes

minimum [within decelerated region]

CFD [tanker and deckhouse]
wind tunnel

CFD model is able to predict the general flow pattern well.

- There is a good agreement between the wind tunnel and CFD results
- These suggest the flow distortion scales with the bridge to deck height
- We now need to validate these results
- At present we do not have any observations made on tankers
- We do have observations from a research ship

In situ wind speed measurements from RRS *Charles Darwin*

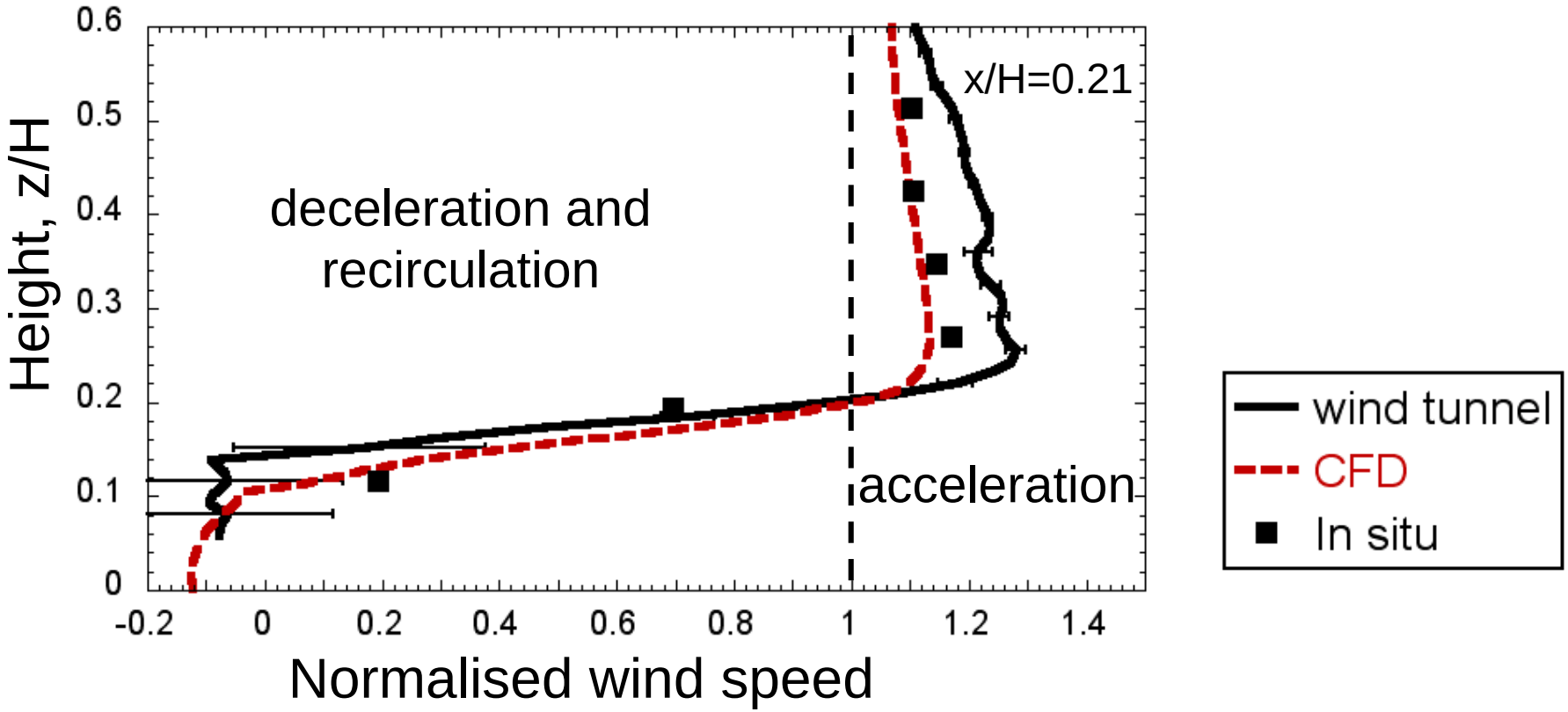
Measurements where made using 6 anemometers.

Instruments where located on a 6m mast.

Only beam-on wind speed data used.

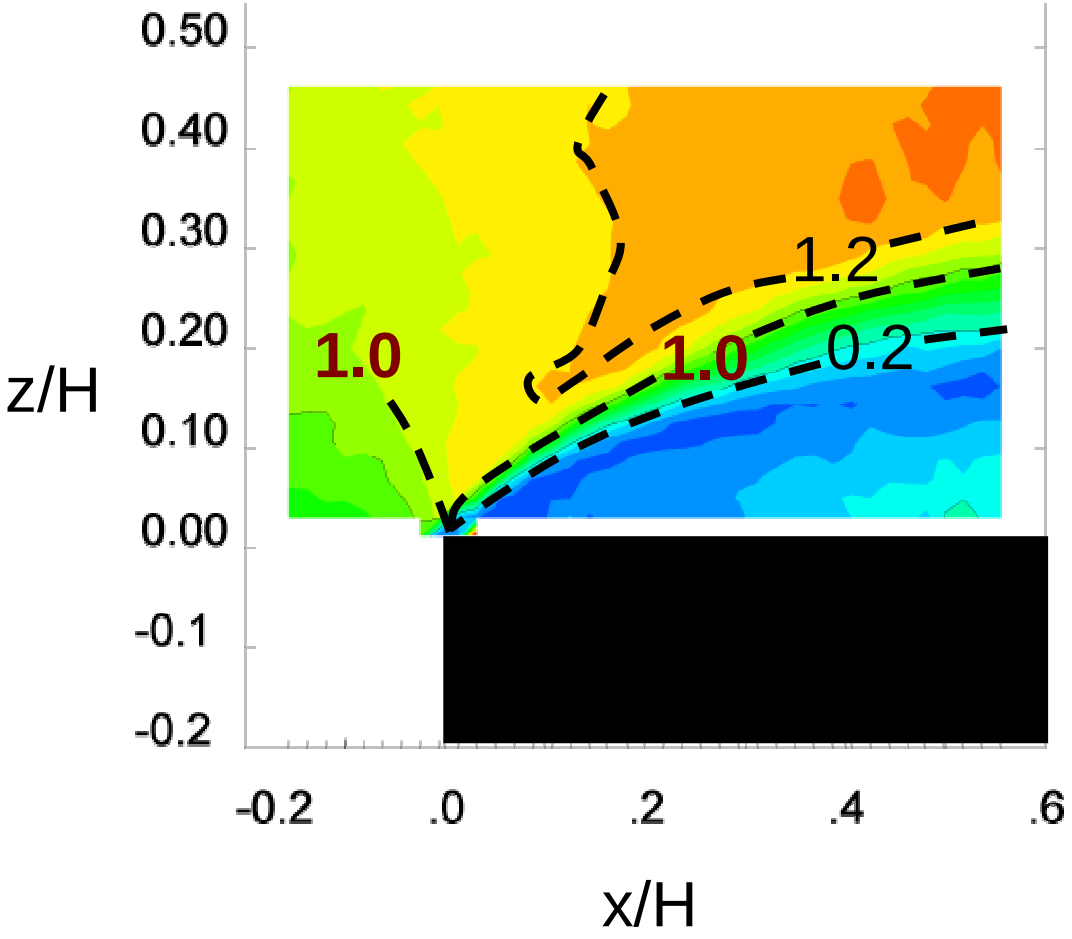
Wind speed profile measured above a ‘block like’ ship.

Comparison of results with *in situ* wind speed measurements



The wind speed can be biased high by 15 ±5%, or completely decelerated.

Recommendations for locating anemometers



Normalised wind field above tanker bridge.

Region of high velocity gradients close to 1.0

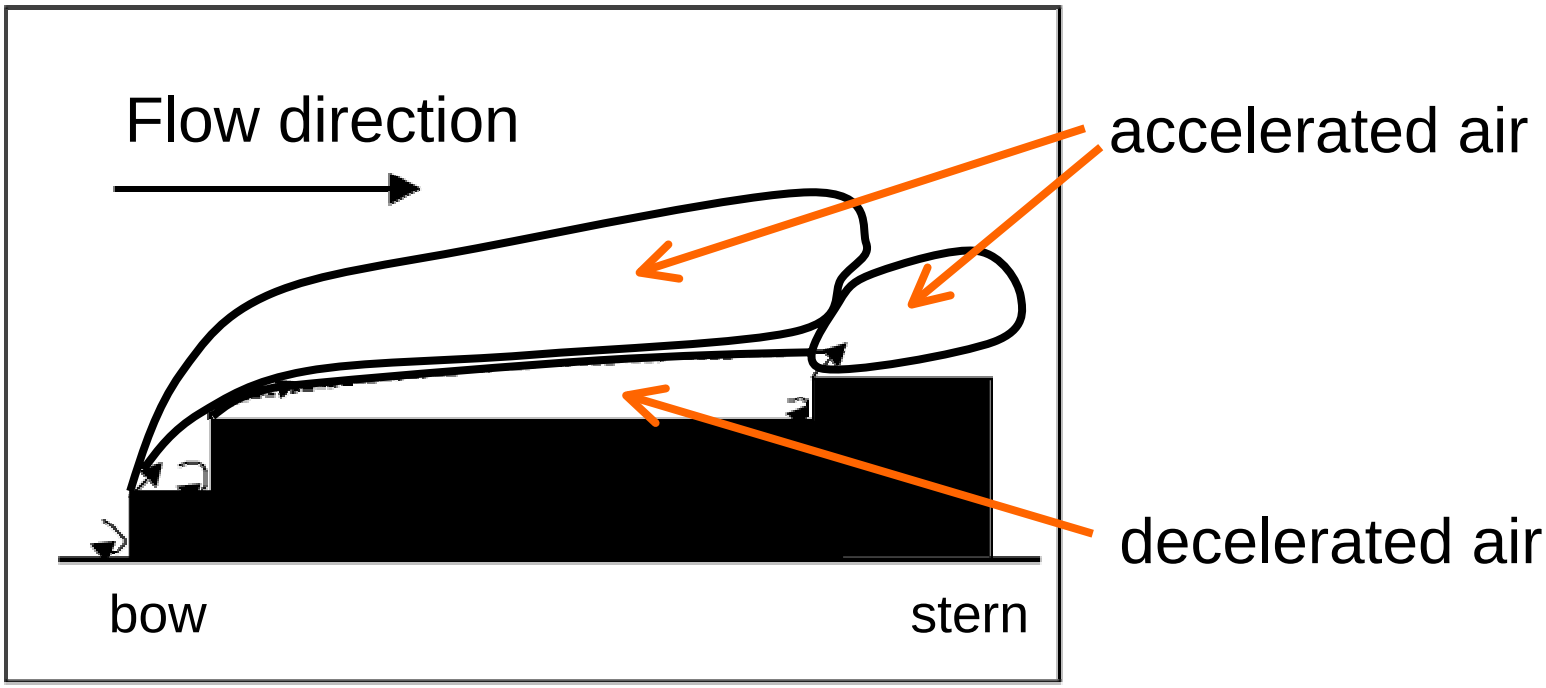
Anemometers located above the bridge should be placed as far forwards and as high as possible.

Conclusions: Tanker

- We can estimate the wind speed errors for tankers of known size and anemometer position
- Wind speed measurements made from anemometers above the bridge can be biased high by 15±5%, or low by 100%.
- Anemometers located above the bridge should be placed as far forwards and as high as possible.
- Anemometer location and ship length metadata are needed
- Future work: we need to make measurements on VOS to validate these results

Contact
ben.moat@soc.soton.ac.uk
www.soc.soton.ac.uk/JRD/MET/cfd_shipflow.php

Container ship



The bow influences the airflow at the bridge.