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Uncertainties in CO_2 transfer velocities due to bias in shipboard wind measurements caused by airflow distortion

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Global ocean CO_2 uptake can be estimated from parameterizations of the gas transfer velocity (k) and globally mapped differences between the concentration of CO_2 in the ocean (pCO_{2sw}) and atmosphere (pCO_{2atm}). Global maps of the wind speed are also required since the transfer velocity is strongly dependent on wind speed.

Oceanic observations of k are derived from platforms like e.g. sea-going ships. In addition to possible measurement errors in the estimates of k, wind speed measurements obtained from ships are subject to two major errors: (1) correction of relative wind measurements to wind speeds referenced to fixed earth and wind direction referenced to true north, and (2) correction of the wind speed for airflow distortion by the platform, which varies with the relative wind direction. The first correction can be performed by standard ship parameters (like ship's heading, course and speed over ground) which should be a standard procedure. The second correction requires quantification of the wind speed biases with the relative wind directions, commonly obtained by computational fluid dynamics (CFD) modelling of the measurement platform.

We created digital geometries of the Japanese research vessels R/V Mirai (gross tonnage 8687 tons) and R/V Hakuho Maru (gross tonnage 3987 tons) and are presently computing the biases in mean wind speed at the ship anemometer location at the top of

the foremast using the large eddy simulation (LES) code GERRIS. All wind directions from 0˚ to 360˚ will be simulated in steps of 15˚. Preliminary results are showing the highest biases in mean wind speed at relative wind direction of 180˚ (wind from aft) with -15% and -53% at R/V Mirai and R/V Haukho Maru, respectively. The lowest biases are at +/- 30˚ (on-bow wind) with 2.8-10% and 2.6-9.5% and up to 17% and 20% in the ranges +/- 30˚-90˚.

An obvious method to improve the wind measurement quality without having the computed biases is to limit the measurements used to on-bow flow sectors from +/- 30 to up to +/- 90˚. This approach would avoid the highest errors from aft-wind directions; however, the biases on mean wind speed at on-bow flow (+/-90˚) are at the two discussed ships at minimum 2.6% to up to 20%. Taking the error propagation into account, the errors for transfer velocities due to bias in wind speed measurements are a factor of 2 or 3 higher when employing commonly used quadratic or cubical relationships of wind speed and transfer velocity. Initial results on the effect of the wind speed biases to the uncertainties of the transfer velocity will be presented.