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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "The influence of transformed Reynolds number limitation on gas transfer parameterizations and global DMS and CO_2 fluxes" *by* Alexander Zavarsky and Christa A. Marandino

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Fairall:"In my view a reduction on global fluxes of 10% is significant enough to justify publication. However, the paper appears to be hastily written and not carefully crafted to make it easy for the reader. It is hard to read, difficult to follow and contains a bewildering variety of coefficients, percentages, and information that is poorly organized. I have no confidence I actually know which coefficients were used where. On a side note, my own opinion is that the phenomenon they are characterizing (reduction in k in certain air-sea conditions) is almost certainly not flow separation but it is possible their

use of Retr is capturing a lot of what is happening. Since ZA18 is published, I think my skepticism should not prevent publication of this paper and I don't want to argue that point here."

We thank Dr. Fairall for his review and helpful comments. We would be interested in hearing, perhaps off-line, why he does not think that flow separation is a likely suspect. Regarding the manuscript writing, we have gone through the text thoroughly to try to minimize confusion. We hope that we have adequately modified the manuscript with regard to both clarity and to the points raised below.

Fairall:"Here are some specific comments: P2 line 18 Suggest identifying ZA18 here and using it throughout."

We aim to use ZA18 just like we use N00 or W14, namely to refer to the respective k vs u parameterization and not to the published paper. Therefore, we would like to keep the full reference as a citation and when the parameterization is used we use ZA18.

Fairall:"P2 Line 21 In ZA18 theta is defined as the angle between the wave direction and utr, which would be at 90 deg to what is said here."

We changed the wording here, especially as our use of wave crest is unclear.

Retr is the Reynolds number transformed into the reference system of the moving wave. utr is the wind speed transformed into the wave's reference system, Hs the significant wave height, ηair the kinematic viscosity of air and Θ the angle between the wave direction and direction of utr

Fairall:"I am somewhat confused by fig D1 in ZA18 which states both that the 'wave crests are moving to the left' and that 'The wave C2 travels from left to right'."

You are right. It is a mistake in the subtext of the figure. This has been reported to the production editors and should be corrected in the final version. The figure is the correct one.

Fairall:"P3 line 14 'W14 must already have gas transfer limitation included as it is solely dependent on carbon isotopes to estimate the air-sea flux over several years'. Not sure what you mean here. Are carbon isotopes relevant to this? Do you mean that the mean flux is associated with averages that include the mean contribution of non-limited and limited conditions? I think you mean it is applicable to average wind speed conditions as is. Please clarify."

We changed the wording in this paragraph to make it clearer. A few more words to make our point: Since W14 is based on the amount of 14C in the global oceans, the gas transfer from source region (atmosphere) to sink region (ocean) encompasses all the processes we seek to understand by investigating air-sea gas exchange. Therefore, the gas transfer suppression mechanism is also included. Other measurement techniques, such as dual-tracer or eddy covariance, act on different scales: Minutes to days and a few kilometers on the spatial scale. These techniques, because of their local and short spatial and temporal scales, might not experience all processes influencing gas transfer at every measurement. This might be an advantage to identify new processes, but has the major disadvantage that gas transfer parameterizations based on one or the other dataset might not include certain important processes, such as gas transfer suppression.

Fairall:"P4 line 25. You might not want to push the 'flow separation' aspect since it is not necessary to your development here."

We are describing the process that causes, in our opinion, gas transfer suppression. The model reduces the wind speed u10 to a windspeed ualt, which according to the transformed Reynolds number, does not create flow separation and therefore no gas transfer suppression. We would like to keep our hypothesis in this text.

Fairall:"P5 line As I interpret the mathematics, reducing the wind speed until ABS(Retr)=6.7E-5 will cause Retr=-6.7E-5. Also, I don't see why you need to iterate. Is it not true that ualt=(cp-6.7E5*nu/Hs)/cos(th1-th2) where th1 is the direction of

the wind and th2 is the direction of the waves in the earth frame?"

The wind speed in the earth's reference system must be transformed into the wave's reference system by subtracting the respective vectors. Then the angle between the wind direction and the wave moving in the v direction (for example from east to west) has to be calculated. You describe the relative directions in the earth's reference system. For our model, however, everything must be transferred into the wave's reference system. The transformation is described in Appendix C of Zavarsky et al., (2018). We do not think ualt is analytically solvable, because th1 and ualt change in the wave's reference system with a change of u10, which then changes in the earth's reference system.

Fairall:"P5 line 13 It looks like you change the wind speed because that is in the k parameterization."

Of course, the most widely used gas transfer parameterizations are related to wind speed. We think that gas transfer suppression is a wind-wave interaction. We change the wind speed because it is one of the major factors in gas transfer and flow separation. The wind speed (in the wave's reference system) is obviously influencing the flow separation. We set the wave field as constant or externally prescribed. Therefore, we use the wind speed as parameter. A change in wind speed u10 (earth's reference system) changes utr in the wave's reference system. If we change by iteration u10 and as a consequence utr we can evaluate at which u10 flow separation sets in and can use this to correct for it.

Fairall:"P5 line 29 'We subtract a linear dependency using the ZA18 parameterization, to account for the gas transfer limitation in k0'. I don't understand this."

For the ZA18 parameterization u10 is just replaced by ualt . ZA18 is a parameterization based on DMS gas transfer measurements. DMS gas transfer velocities are not greatly influenced by bubble mediated gas transfer. We think that gas transfer suppression only affects interfacial gas transfer. Therefore, we subtract a parameterization which reflects interfacial gas transfer only from the non-linear relationships that include bubble-mediated effects. Please see the answer to the next comment as well.

Fairall:"I think you need to provide a few equations to make it clear. Eq (13) looks wrong to me; you have removed most of the linear part and left only the bubble part. Should it be k*(u10-ualt) instead? Also, do you actually use (13) anywhere? I do not see it referred to anywhere else in the document. Is NI00 the same as N00?"

You are right about equation 13, but it should be k*(u10)-k*ualt. I corrected that. It was correct in the Matlab code, so the data is still right. I also added another equation to make it clear. Sorry, we used two abbreviations for the Nightingale 2000 parameterization. NI00 was replaced throughout by N00.

Fairall:"P6 lines 6-7 You said that already."

We deleted these two sentences. Thanks.

Fairall:"P6 line 15 Change to 'plotted at the corrected...'"

We changed it accordingly. Thanks.

Fairall:"P6 line 17. Is ZAV17 the same as ZA18?"

We removed ZA17. Capital letters and the year number do not refer to the paper, but to the parameterization derived from this paper.

Attached is also an updated version of the manuscript.

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2018-32/acp-2018-32-AC1-supplement.pdf

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