Review of the manuscript

Influence of leads widths distribution on turbulent heat transfer between the ocean and the atmosphere

by S. Marcq and J. Weiss and V. Smirnov

In this paper mean heat fluxes over the open water fraction of an arctic region of 60×66 km^2 size are determined using existing approaches depending on the widths of leads. Based on a high resolution SPOT satellite image a power law distribution is derived for the number of leads as a function of lead width. Application of this distribution together with the flux parametrization depending on lead width results in fluxes which are 55 % larger than those resulting from a method which is not accounting for lead width.

The topic of this work is of high relevance for polar climate modeling. The manuscript is in most parts well written and results and methods are mostly clearly presented. Nevertheless, I recommend to clarify and improve several points before a final publication. The following revisions have been written without the knowledge of the second review to obtain independent conclusions. But as can be seen several revisions point into the same direction as those suggested by the other review.

Revisions

1. abstract: number 80 % is mentioned, but a citation is not given neither in the abstract nor in the text. Probably the authors mean upward heat fluxes, since the downward fluxes over sea ice can balance the upward fluxes over leads (Lüpkes et al., 2008b, Overland et al. 2000).

2. page 2768, lines 5-15 and eq. (1): The description of heat flux determination in this paper ignores wind speed U. Fluxes are proportional to the product $U\Delta T$. C is not the turbulent exchange coefficient. It is the transfer coefficient for heat and its stability dependence is determined via MO theory using similarity functions for which many different formulations are available. The corresponding sentences should be modified in this way.

3. page 2769, eq. (2): I suggest to skip the Venkatram formula because it is constructed for a larger scale and is not used in the formulation of heat transfer used in the present work. The occurrence of the formula might lead to confusion. Figure 1 can still be shown as a general description of the process.

4. Page 2770, lines 10: As far as I understand the Andreas and Cash (1999) paper observations were obtained downstream of the leads, not over leads as mentioned in the manuscript. I find this difference important, since observations over open leads or over leads with very thin ice remain still a challenging task for the future. The fluxes downstream of a lead might be influenced by the fetch over sea ice.

5. page 2771: The Andreas and Cash (1999) parameterization is an important step, even so I suggest to discuss uncertainties of the results of this paper related to the parameterization. One of these uncertainties is probably due to Equation (7) for the determination of the TIBL giving values which are independent on external conditions. The TIBL is about 5 m for a fetch of $X_f = 200$ m. One can speculate that this low value is probably due to a near-surface stable stratification of the incoming air flow. Weinbrecht and Raasch (2001) obtain by Large Eddy Simulation (LES) values of 30-40 m for TIBL under (probably weaker) stable conditions. Lüpkes et al. (2008a) show that for near-neutral inflow as sometimes occurs also in the winterly Arctic the TIBL depends on the boundary layer wind speed, the surface buoyancy over the lead and on the background mixed layer height.

6. Line 20: In the sentence ' ...They only calculate ...' skip 'only'. It is called the MO similarity theory, not the theory of MO similarity.

7. equation (10): the Prandtl number should not occur here. Mention that k is the v. Karman constant (which value is used?).

8. Section 2.2.2: Looking into the work of Alam and Curry (1997) it seems that the main part of the parametrization is by Clayson et al. (1996). In the present paper this should be made clear.

9. page 2773, line 10: In the Alam and Curry work Bourassa (1997) is used for roughness, what is improved in Bourassa (2001)? The surface renewal theory was developed by Brutsaert (1975). Clayson is only applying it. This should be made more clear.

   One of the uncertainties related to the roughness parametrization is that it refers to open water. At temperatures of -20 to -30°C open water in leads will be covered very quickly by a thin ice layer causing a change in roughness.

10. page 2773, line 10: I suggest to skip the short Appendix B and include its text in section 2.2.2

11. Page 2776, line 15-20. '... The contribution to heat flux from the ice ...' Probably, the upward contribution is meant ? (see revision 1).

12. page 2779, line 10: replace 'an uniform' by 'a uniform'.

13. page 2779, line 25: Is it possible to include a figure showing H_s as a function of a? This would help to understand the description at the bottom of this page. In its present version I find it difficult to follow.

14. page 2780: Are the developed parametrizations valid for leads smaller than 10 m? I would expect that the uncertainty of the observations are larger for the smaller lead sizes.

15. Discussion section: I suggest to address here the mentioned uncertainties of the parametrizations. Another open point is the role of refreezing of a lead which due to figure 2 would reduce the effect of size dependence, since the air ice temperature difference would decrease in this case. On the other hand, it could be stressed that the upward heat transport over leads results in a corresponding downward heat transport over sea ice as described in Lüpkes et al. (2008b). This means that the dependence of upward heat flux on lead width would generate also a width dependence of the downward flux and stability over the ice surface.

16. There is a paper by Maslanik and Key (1995) who have also calculated heat fluxes over lead ensembles. One of their conclusions was that the ensemble of lead widths is well represented by the mean lead width. How is the relation to the present findings?

References

Brutsaert, W., 1975: A theory for local evaporation (or heat transfer) from rough and smooth surfaces at ground level, Water Resour. Res. 11, 543-550.

Maslanik, J.A., and J. Key, 1995: On treatments of fetch and stability in large-area estimates of sensible heat flux over sea ice, J. Geophys. Res., 100,(C3),4573-4584.

Overland, J.E., McNutt, S.L., Groves, J., Salo, S., Andreas, E.L., and P.O.G. Persson, 2000: Regional sensible and radiative heat flux estimates for the winter Arctic during the Surface Heat Budget of the Arctic Ocean (SHEBA) experiment, J. Geophys. Res., 105(C6), 14,093- 14,102.

Weinbrecht, S., and S. Raasch, 2001: High-resolution simulations of the turbulent flow in the vicinity of an Arctic lead, J. Geophys. Res., 106 (C11), 27,035-27,046.

Other references are given in the manuscript.