Supplementary Material to

“The influence of spatial distribution of leads and ice floes on the atmospheric boundary layer over fragmented sea ice”

Marta Wenta, Agnieszka Herman

Institute of Oceanography, University of Gdansk, Poland
Email:marta.wenta@phdstud.ug.edu.pl
Supplementary Table 1: Model setup parameters.

<table>
<thead>
<tr>
<th>Weather Research and Forecasting Model configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model domain</td>
<td>Rectangular, periodic boundaries used in both horizontal directions</td>
</tr>
<tr>
<td>Horizontal Resolution</td>
<td>100 m</td>
</tr>
<tr>
<td>Number of grid points</td>
<td>200 x 200</td>
</tr>
<tr>
<td>Physics Parametrization</td>
<td>Description</td>
</tr>
<tr>
<td>Microphysics (mp)</td>
<td>WRF Single-Moment 5-class-scheme</td>
</tr>
<tr>
<td>Sea Ice Options</td>
<td>Treat ice as fractional field</td>
</tr>
<tr>
<td>Longwave Radiation (ra)</td>
<td>RRTMG Scheme, an improved version of RRTM (Rapid Radiative Transfer Model)</td>
</tr>
<tr>
<td>Shortwave Radiation (ra)</td>
<td>Goddard Shortwave Scheme (insignificant during Arctic winter)</td>
</tr>
<tr>
<td>Surface Layer (sf)</td>
<td>Eta Similarity Scheme used in Eta Model</td>
</tr>
<tr>
<td>Land Layer (sf)</td>
<td>Noah Land Surface Model (with 4 soil layers)</td>
</tr>
<tr>
<td>Planetary Boundary Layer (bl)</td>
<td>No Planetary Boundary Layer parametrization</td>
</tr>
</tbody>
</table>

Supplementary Note S1. Initial atmospheric profiles and conditions

Supplementary Figure 1: Vertical profiles of radiometer cloud data (left) and cloud radar data (right) over the SHEBA station on 23. Feb. 1998. (source: Earth System research Laboratory, www.esrl.noaa.gov/psd/arctic/sheba, accessed 16 Feb 2017).

Vertical profiles of relative humidity $h_r$, wind speed $U$, potential temperature $T_i$, and atmospheric pressure $P_i$ are obtained, along with surface pressure value $P_s$, in order to configure model idealized run (Fig. 4 in the main text). The following equations are applied to obtain required vapor mixing ratio $w$ and altitude profiles $H_i$:

\[
\begin{align*}
    w &= 621.97 \cdot e \\
    e &= \frac{P_s - e_s}{e_s \cdot h_r} \\
    e_s &= 6.11 \cdot 10^{7.574 T_i} \\
    H_i &= \frac{P_s ((\frac{e_s}{e})^{1/7} - T_i)}{0.0065}
\end{align*}
\]  

(1)
Supplementary Note S2. Sea ice distribution maps

Supplementary Figure 2: Sea ice map for ice concentration $c = 50\%$, number of leads $N_l = 33$ (a), $N_l = 20$ (b).

Supplementary Figure 3: Sea ice map for ice concentration $c = 50\%$, number of leads $N_l = 14$ (a), $N_l = 11$ (b).

Supplementary Figure 4: Sea ice map for ice concentration $c = 90\%$, number of leads $N_l = 7$ (a), $N_l = 4$ (b).
Supplementary Figure 5: Sea ice map for ice concentration $c = 90\%$, number of leads $N_l = 3$ (a), $N_l = 2$ (b).

Supplementary Figure 6: Sea ice map for ice concentration $c = 50\%$, number of floes $N_f = 50$ (a), $N_f = 100$ (b).

Supplementary Figure 7: Sea ice map for ice concentration $c = 50\%$, number of floes $N_f = 500$ (a), $N_f = 1000$ (b).
Supplementary Figure 8: Sea ice map for ice concentration $c = 50\%$, number of floes $N_f = 5000$ (a), and for ice concentration $c = 90\%$ $N_f = 50$ (b).

Supplementary Figure 9: Sea ice map for ice concentration $c = 90\%$, number of floes $N_f = 100$ (b), $N_f = 500$ (c).

Supplementary Figure 10: Sea ice map for ice concentration $c = 90\%$, number of floes $N_f = 1000$ (a), $N_f = 5000$ (b).
Supplementary Figure 11: Simulation initiated with zero wind speed profile, sea ice concentration $c = 50\%$ and number of leads $N_l = 20$. (a) Area averaged water vapour content. (b) Area averaged W-E wind component.
Supplementary Figure 12: As in Fig. 11, (a) and (b) Area averaged temperature.
Supplementary Figure 13: (a) Cloud liquid water total mass for ice concentration $c = 90\%$ and number of floes $N_f = 50$. (b) Water vapor total mass for ice concentration $c = 50\%$ and number of floes $N_f = 5000$. 
Supplementary Figure 14: (a) Area averaged latent heat flux, ice concentration $c = 90\%$, number of leads $N_l = 4$ (b) Area averaged sensible heat flux, ice concentration $c = 50\%$, number of leads $N_l = 20$. 
Supplementary Figure 15: Water vapor total mass for wind profile No. 4 (Fig. 3 in the main text), different leads distributions. (a) ice concentration $c = 90\%$, (b) ice concentration $c = 50\%$. 
Supplementary Figure 16: Box-and-whisker plots of the results for mean latent heat flux for (a) zero wind simulation and (b) wind profile No. 5 (Fig. 3 in the main text); ice concentration $c = 90\%$, different numbers of floes compared. See Figs. 12 and 13 in the main text for similar plots for $Q_{c, tot}$.

Supplementary Figure 17: Box-and-whisker plots of the results for mean latent heat flux for (a) wind profile No. 4 (b) wind profile No. 3 (Fig. 3 in the main text); ice concentration $c = 90\%$, different numbers of leads compared.
Supplementary Figure 18: Histograms of wind speed $U_w$ and surface–air mixing ratio difference $(q_s - q_a)$ for four selected cases with $c = 0.5$, (a,c): leads, $N_l = 11$; (b,d): round floes, $N_f = 50$; without wind (a,b) and wind profile No. 5 (c,d). Each histogram is based on data from all grid points and times for which results were saved (i.e., every 10 minutes). Bin widths equal 0.25 m/s and 0.1 g/kg, respectively, and the color scale, showing the number of data points within each bin, is logarithmic. Bins without data points are white. Magenta crosses show combinations of area-averaged values ($\langle U_w \rangle$ versus $\langle q_s - q_a \rangle$) throughout each simulation. See Fig. 14 in the main text for analogous histograms of $U_w$ and $T_s - T_a$. 
Supplementary Figure 19: As in Supplementary Fig. 18, but for $U_w$ versus $(T_s - T_a)$ and for ice concentration $c = 0.9$. 
Supplementary Figure 20: As in Supplementary Fig. 18, but for ice concentration $c = 0.9$. 
Supplementary Figure 21: Box-and-whisker plots of the ratio $\alpha_l$ (a–d) and $\alpha_s$ (e–h) in simulations with leads (a,c,e,g) and round floes (b,d,f,h) without ambient wind. The ice concentration is written above each plot. Each box shows the interquartile range (blue rectangle) and median (red line), outliers are marked with red crosses.
Supplementary Figure 22: As in Supplementary Fig. 21, but for wind profile No. 2.