Supplement of Atmos. Chem. Phys., 18, 15623–15641, 2018
https://doi.org/10.5194/acp-18-15623-2018-supplement

Atmospheric Chemistry and Physics
Open Access
EGU

Supplement of

Widespread polar stratospheric ice clouds in the 2015–2016 Arctic winter – implications for ice nucleation

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S1 Sensitivity study of the effect of different R_{ice} thresholds on PSC classification

As discussed previously, the $1/R_{ice}$ threshold of 0.3 best matches the ice PSC observations in the lower branch of the PSC occurrence histogram in Figure 4. Nevertheless, we explore the effect of different $1/R_{ice}$ thresholds (0.3, 0.2, and a variable threshold var = $0.20 < 1/R_{ice} < 0.31$) on ice PSC occurrence in Figure S1. In addition to the PSC classification for different thresholds, we add the region with temperatures below T_{ice} based on meteorological temperature data from the integrated forecast system IFS (cycle 41r1) of ECMWF and measured water vapor mixing ratios. For the $1/R_{ice}$ threshold of 0.3 the PSC area classified as ice by WALES $A_{ice,WALES}$ agrees best with A_{ice} derived from weather predictions. This is evident in particular between 22 and 24 km.

For comparison, we show results from the classification with the variable threshold $1/R_{ice}$ = var used in the CALIOP climatology in Figure 2. The $1/R_{ice}$ = var threshold is described in more detail in section 2.2 and uses a dynamic, altitude dependent variation of the $1/R_{ice}$ boundary between $0.20 < 1/R_{ice} < 0.31$ based on observed abundances of HNO_3 and H_2O. For this case, $A_{ice,WALES}$ is slightly lower than A_{ice} from meteorological analysis in particular between 22 and 24 km. Further, the $1/R_{ice}$ = 0.2 threshold leads to even lower $A_{ice,WALES}$. For our case, the relative difference of $A_{ice,WALES}$ for $1/R_{ice|NAT}$ = var compared to $1/R_{ice}$ = 0.3 is 8.2%. The relative difference relative of $A_{ice,WALES}$ for $1/R_{ice}$ = 0.2 to $1/R_{ice}$ = 0.3 amounts to 21.8%.

The $1/R_{ice}$ = 0.3 threshold best matches the ice PSC observations by WALES at temperatures below T_{ice} on 22 January 2016. However, the $1/R_{ice}$ = var threshold might be an appropriate fit for the CALIOP data evaluation with changing HNO_3 and H_2O concentrations throughout the winter 2015/2016.

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Data availability: The observational data are available at https://halo-db.pa.op.dlr.de. Operational meteorological analysis are achieved in the MARS archive at ECMWF (https://www.ecmwf.int/en/forecasts/documentation-and-support/changes-ecmwf-model/ifs-documentation).

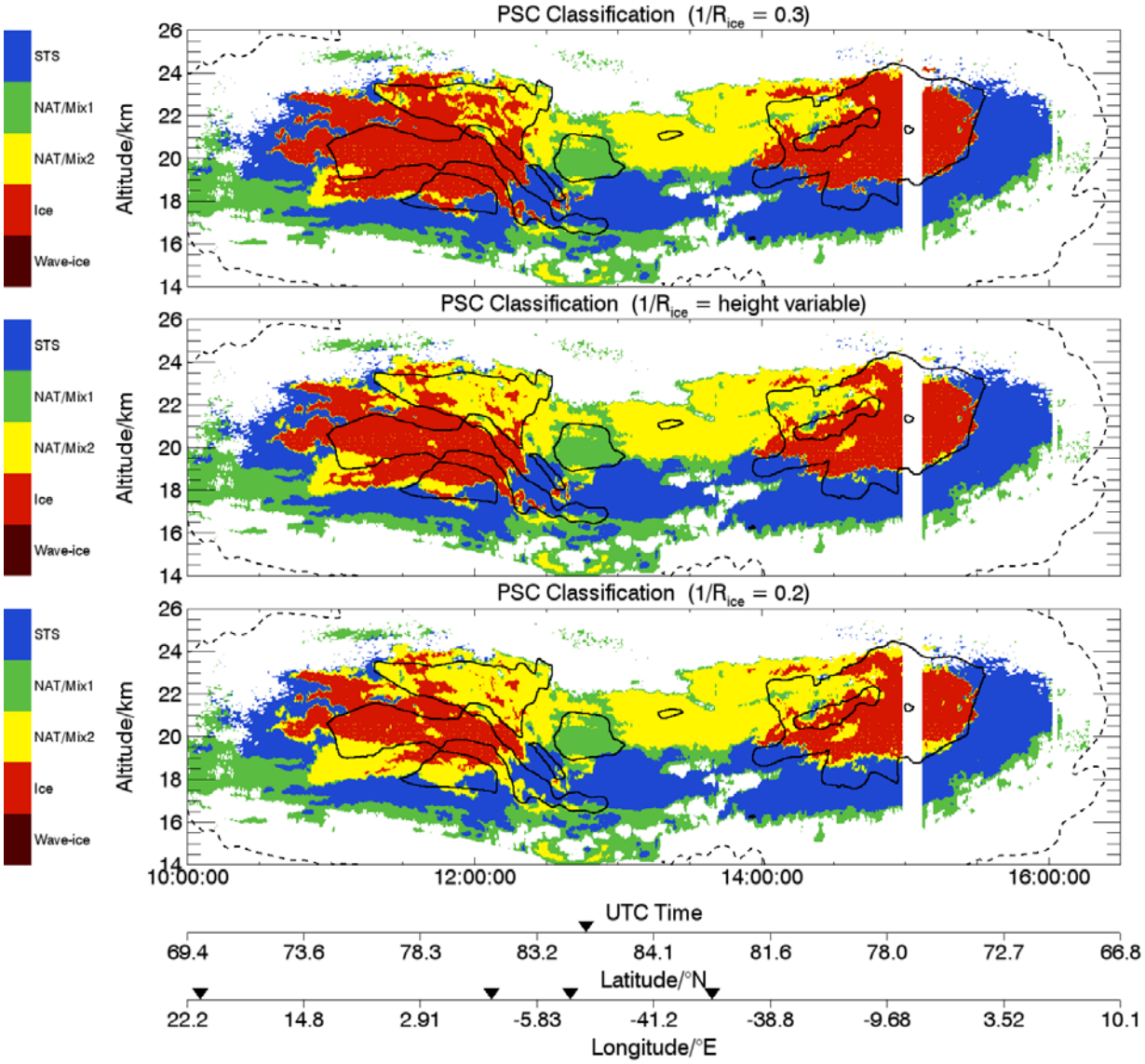

Figure S1 PSC type classifications for different thresholds $1/R_{ice}$ of ice versus NAT/Mix2 separation. The upper panel shows the classification after Pitts et al. (2011), but with a boundary of $1/R_{ice} = 0.3$ as in Figure 5. The middle panel adopts an altitude dependent variation of the boundary between 0.2 and 0.31, based on MLS measurements of HNO_3 and H_2O (Pitts et al., 2018). For the lower panel this threshold is set to $1/R_{ice} = 0.2$, the standard value of Pitts et al. (2009). In addition, the areas with temperatures below T_{NAT} (dashed line) and T_{ice} (solid line) as derived from 6-hourly IFS operational analysis (cycle 41r2) interpolated to 1-hourly time steps using forecast data, the water vapor field measured by WALES and a climatological HNO_3 profile are shown.