Supplement of

Sensitivity of polar stratospheric cloud formation to changes in water vapour and temperature

F. Khosrawi et al.

Correspondence to: F. Khosrawi (farahnaz.khosrawi@kit.edu)

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Supplement

Result of the trajectory ensemble statistic for $T_{\text{NAT}}$:

Table 1: Total time where the temperature along the back trajectory is below the NAT existence threshold temperature (sum over all 738 back trajectories) for a stratospheric H$_2$O mixing ratios of 4.75, 5.0, 5.25, 5.5 and 6.0 ppmv. The calculation was performed assuming an HNO$_3$ mixing ratio of 3, 5 and 7 ppbv. Note: The total trajectory ensemble time is 107 010 h (738 trajectories $\times$ 145 h)

| HNO$_3$ (ppbv) | H$_2$O (ppmv) | $T_{<T_{\text{NAT}}}$ (h) | $T_{<T_{\text{NAT}}}$ (h) | $T_{<T_{\text{NAT}}}$ (h) |
|----------------|---------------|---------------------|---------------------|---------------------|
| 3              | 4.75          | 32960               | 36776               | 40584               |
| 3              | 5             | 34486               | 38301               | 42171               |
| 3              | 5.25          | 36024               | 39782               | 43779               |
| 3              | 5.5           | 37476               | 41310               | 45210               |
| 3              | 5.75          | 38802               | 42709               | 46533               |
| 3              | 6             | 40128               | 44080               | 47869               |
| 5              | 4.75          | 38275               | 42133               | 45951               |
| 5              | 5             | 39824               | 43810               | 47568               |
| 5              | 5.25          | 41430               | 45319               | 49051               |
| 5              | 5.5           | 42893               | 46711               | 50560               |
| 5              | 5.75          | 44331               | 48126               | 51994               |
| 5              | 6             | 45667               | 49460               | 53447               |
| 7              | 4.75          | 41849               | 45746               | 49513               |
| 7              | 5             | 43512               | 47312               | 51179               |
| 7              | 5.25          | 45062               | 48811               | 52750               |
| 7              | 5.5           | 46463               | 50298               | 54262               |
| 7              | 5.75          | 47870               | 51735               | 55580               |
| 7              | 6             | 49196               | 53180               | 56787               |
Table 2: Increase in time where the temperature along the back trajectory is below the threshold temperature (sum over all 738 back trajectories) for a stratospheric H$_2$O increase of 0.25, 0.5, 0.75 and 1.0 ppmv, respectively, and for a stratospheric H$_2$O decrease of 0.25 ppmv. The calculation was performed assuming an HNO$_3$ mixing ratio of 3, 5 and 7 ppbv.

| HNO$_3$ (ppbv) | H$_2$O increase (ppmv) | $\Delta t$ for $T< T_{\text{NAT}}$ (h) | $\Delta t$ for $T< T_{\text{NAT}}$ (h) | $\Delta t$ for $T< T_{\text{NAT}}$ (h) |
|----------------|-----------------------|-----------------|-----------------|-----------------|
| 3              | -0.25                 | -1526           | 2290            | 6098            |
| 3              | 0.25                  | 1538            | 5296            | 9293            |
| 3              | 0.5                   | 2990            | 6824            | 10727           |
| 3              | 0.75                  | 4136            | 8223            | 12047           |
| 3              | 1.0                   | 5642            | 9594            | 13383           |
| 5              | -0.25                 | -1459           | 2309            | 6127            |
| 5              | 0.25                  | 1606            | 5495            | 9227            |
| 5              | 0.5                   | 3069            | 6887            | 10736           |
| 5              | 0.75                  | 4507            | 8302            | 12170           |
| 5              | 1.0                   | 5843            | 9326            | 13623           |
| 7              | -0.25                 | -1663           | 2234            | 6001            |
| 7              | 0.25                  | 1550            | 5299            | 9238            |
| 7              | 0.5                   | 2951            | 6786            | 10750           |
| 7              | 0.75                  | 4358            | 8223            | 12068           |
| 7              | 1.0                   | 5684            | 9668            | 13275           |
Result of the trajectory ensemble statistic for $T_{\text{ice}}$:

Table 3: Total time where the temperature along the back trajectory is below the ice formation threshold temperature (sum over all 738 back trajectories) for a stratospheric $\text{H}_2\text{O}$ increase of 4.75, 5.0, 5.25, 5.5, 5.75 and 6.0 ppmv. Note: The total trajectory ensemble time is 107,010 h (738 trajectories $\times$ 145 h).

| $\text{H}_2\text{O}$ (ppmv) | $T < T_{\text{ice}}$ (h) | $T < T_{\text{ice}}$ (h) | $T < T_{\text{ice}}$ (h) |
|---------------------------|--------------------------|--------------------------|--------------------------|
| 4.75                      | 340                      | 771                      | 1530                     |
| 5                         | 571                      | 1159                     | 2152                     |
| 5.25                      | 870                      | 1685                     | 3030                     |
| 5.5                       | 1240                     | 2286                     | 4270                     |
| 5.75                      | 1738                     | 3133                     | 5523                     |
| 6                         | 2299                     | 4296                     | 6789                     |

Table 4: Increase in time where the temperature along the back trajectory is below the ice formation threshold temperature (sum over all 738 back trajectories) for a stratospheric $\text{H}_2\text{O}$ increase of 0.25, 0.5, 0.75 and 1.0 ppmv, respectively, and for a stratospheric $\text{H}_2\text{O}$ decrease of 0.25 ppmv.

| $\text{H}_2\text{O}$ increase (ppmv) | $\Delta t$ for $T < T_{\text{ice}}$ (h) | $\Delta t$ for $T < T_{\text{ice}}$ (h) | $\Delta t$ for $T < T_{\text{ice}}$ (h) |
|-------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|
| -0.25                               | -231                                     | 200                                      | 959                                      |
| 0.25                                | 299                                      | 1114                                     | 2459                                     |
| 0.5                                 | 669                                      | 1715                                     | 3699                                     |
| 0.75                                | 1167                                     | 2562                                     | 4952                                     |
| 1                                   | 1728                                     | 3725                                     | 6218                                     |
Correlation of water vapour and temperature (525-825 K):
Correlations of temperature and water vapour anomalies were derived for different time scales (all seasons, specific season, single months). The time series are based on data within 70° and 90°N equivalent latitude. A large majority of these calculations indicate an anti-correlation between these two parameters in the altitude range between 475 and 525 K (see main paper). The correlations are strong in winter and very weak in summer. The figures below show some examples for different data sets for the potential temperature range 525-825 K: (top) T, H2O: Envisat/MIPAS and (bottom) T, H2O: Aura/MLS (Figure 1). The data are averaged over the months January, February and March. The derivation of the anomalies considers the entire time series. The correlation is not as strong as at 475-525 K, but still negative. The weak correlation in the Envisat/MIPAS data is caused by a positive correlation at the begin of the time period considered.

Figure 1: Correlation of temperature (blue) and water vapour (red) anomaly derived from Envisat/MIPAS (top) and Aura/MLS (bottom) for the potential temperature range 525-825 K (3-month average consisting of the months January, February and March; MIPAS: 2002-2012, MLS: 2005-2014).