CONDITIONS FOR PMC FORMATION IN 2002-2008
ESTIMATED FROM TIMED/SABER MEASUREMENTS

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A simplified model of PMC formation

Sublimated ice = enhanced H₂O

L_{frost}: the vertical size of the area where PMCs can form

Precipitating ice particles

Water vapor

T_{frost}
OSIRIS PMC brightness vs integrated $L_{frost}$

Feofilov & Petelina, JGR, 2010
PMC brightness correlated with $H_2O$ VMR in and below the cloud (Feofilov & Petelina, 2010)
The SABER Instrument Aboard the TIMED Satellite

TIMED: Thermosphere, Ionosphere, Mesosphere Energetics & Dynamics
74.1° inclined 625 km orbit;
Latitudinal coverage: 83°S–52°N / 53°S–82°N
Data available since 25 January 2002

SABER: Sounding of the Atmosphere Using Broadband Emission Radiometry

• Limb scanning infrared radiometer
  (~10–100 km, ~2 km footprint)
• 10 broadband channels (1.27–17 µm)
• Products: kinetic temperature, pressure, CO₂, O₃, H₂O, NO, O₂, OH, O, H
General idea and approach

• A simplified model of PMC particles lifecycle is shown on Fig. 1. It does not take into account meridional transport effects that are important in some cases. However, as Fig. 2 and 3 show (see also [Feofilov and Petelina, JGR, 2010]), there is an obvious correlation between the local atmospheric parameters and PMC brightness.

• The latter appears to be proportional to \( L_{\text{frost}} \), the vertical size of the area where \( T<T_{\text{frost}} \), and to the ratio of \( H_2O \) VMR below and in the cloud that are related to the ice sublimation and freeze drying effects, respectively.

• In this work we continued studying the polar summer mesosphere using SABER/TIMED instrument (Fig. 4) and plotted the maps of \( L_{\text{frost}} \) and \( (H_2O_{\text{undercloud}} / H_2O_{\text{cloud}}) \) ratio for polar summer seasons of 2007-2008 (see the examples on Fig. 7-9).
Results and discussion

• Fig. 7 shows the $L_{\text{frost}}$ distribution that gives the estimate for the PMC brightness as follows from Fig. 2.

• Fig. 8 demonstrates the ratio of $\frac{H_2O_{\text{undercloud}}}{H_2O_{\text{cloud}}}$ for the same conditions. Both figures demonstrate the similar latitudinal behavior: the values shown tend to increase to the pole. The fine structures seen on these plots are similar. This proves the concept used in [Feofilov and Petelina, 2010].

• Fig. 9 shows the PMC albedo measured by CIPS instrument onboard AIM satellite for the same days. The meridional behavior is consistent with that seen in Fig. 7 and 8 while the fine structure does not always repeat that of those figures. This is linked with high temporal variability of the mesospheric area within the day.
Vertical size of $T < T_{frost}$ area, $L_{frost}$, 2007, 183-196

- $T_{frost}$ estimated in accordance with Murphy and Koop, 2005.
- SABER V1.07 data (P,T)
- $H_2O$ profiles retrieved in accordance with Feofilov et al, 2009.
- $3^\circ$ lat $\times$ $10^\circ$ lon bins
- Two-week averages of $L_{frost}$ values is shown.
- Larger $L_{frost}$ values “predict” brighter clouds.
- Latitudinal behavior agrees with that of CIPS PMC brightness (see Fig. 9).
$H_2O_{\text{undercloud}} / H_2O_{\text{cloud}}$ ratio, 2007, 183-196

- Parameters are the same as on Fig. 7.
- Ratio of $H_2O$ VMR below and in the cloud is shown.
- Only the cases with $T < T_{\text{frost}}$ = “allowed” PMCs are considered.
- Typical ratio for the non-PMC cases is 2.
- Note the similarities in the structures seen on this figure and Fig. 7 marked by dashed circles.
• CIPS 03.20 level 4 data.
• 3° lat × 10° lon bins.
• Daily overlaps with SABER selected.
• Two-week average of daily “snapshots” presented.
• Latitudinal behavior agrees with that seen on Fig. 7 and 8 though the structures do not always match.