Water vapour, temperature, and ice particles in polar mesosphere as measured by SABER/TIMED and OSIRIS/Odin instruments

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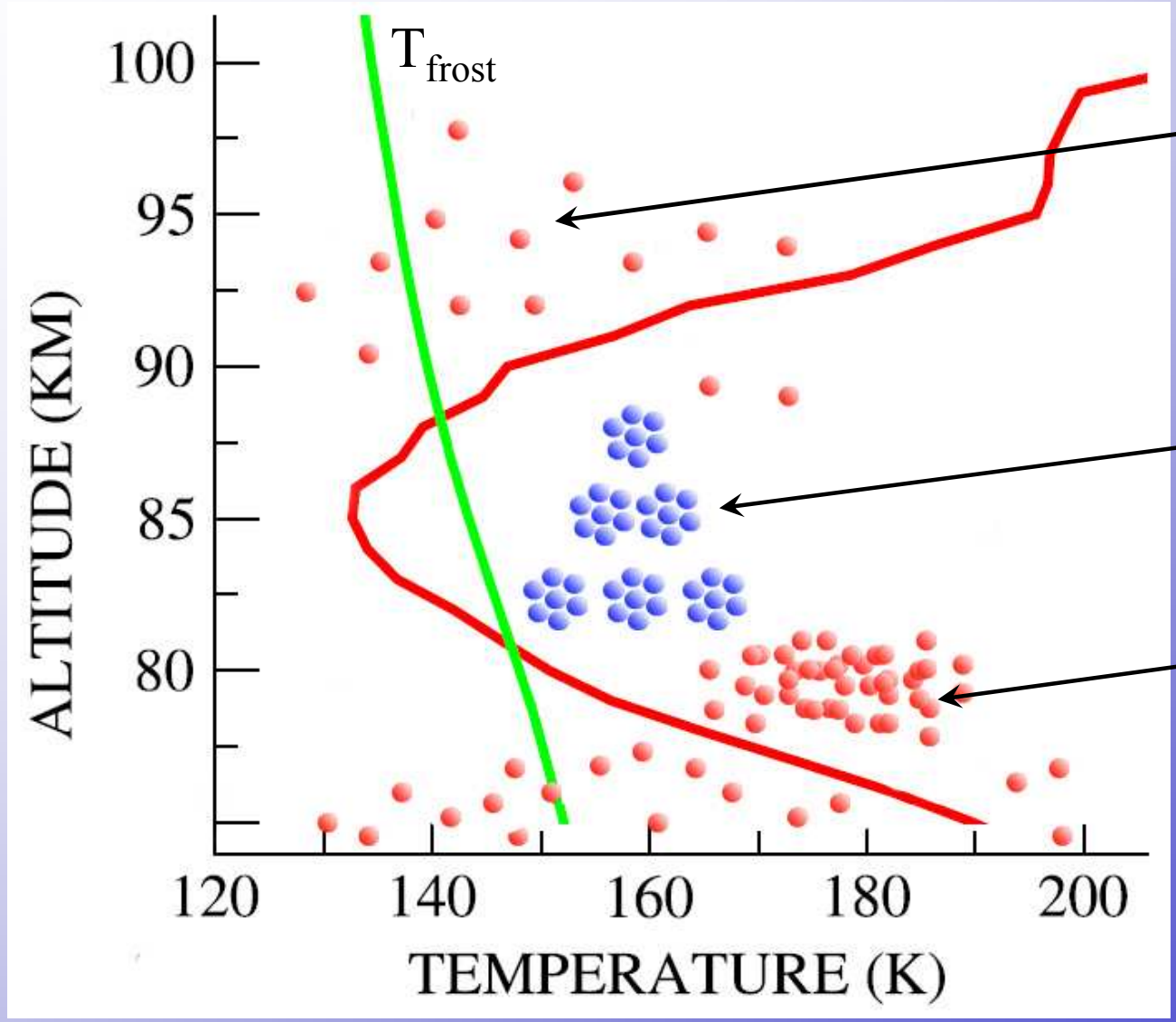
Outline

- General idea: trace the PMC/T/H_2O correlations
- Instruments: OSIRIS/Odin and SABER/TIMED
- "Climatological" and "instantaneous" approaches
- Coincidence criteria for instantaneous profiles
- Separating the tangent-point from near/far field observations
- PMC – mesopause temperature correlations
- PMC – water vapor correlations
- Conclusions

Water vapor, temperature and PMCs



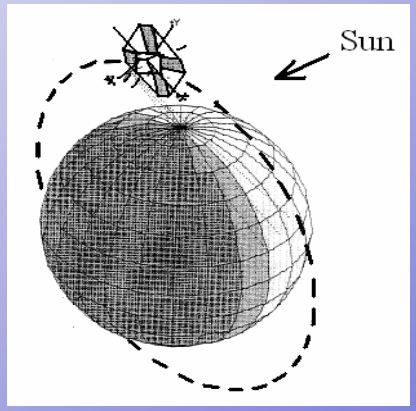
Water vapor

Precipitating ice particles

Sublimated ice = enhanced H_2O

The OSIRIS Instrument Aboard the Odin Satellite

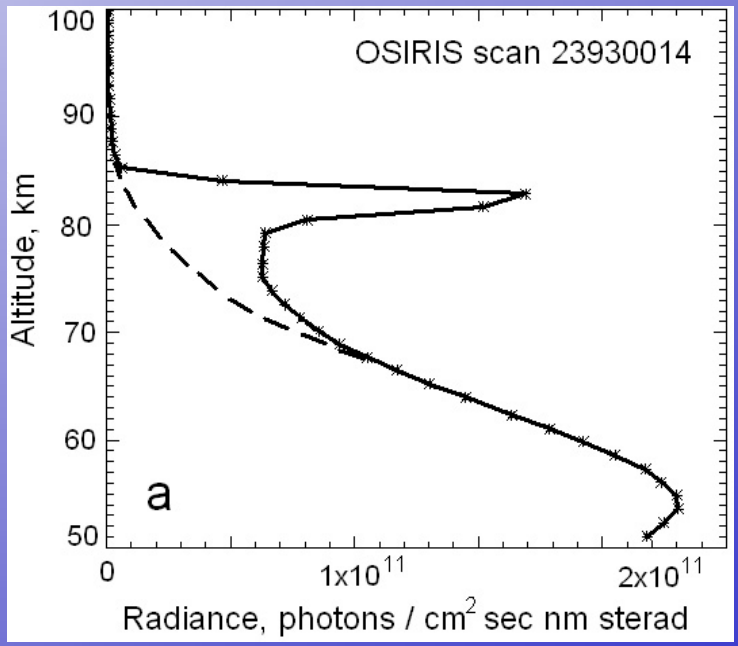
Odin satellite: polar, sun-synchronous, near terminator ~600 km orbit. Scan modes: 6–60 km, 6–100 km, and 60–100 km. Operates since 2001.



OSIRIS: Optical Spectrograph and InfraRed Imager System.

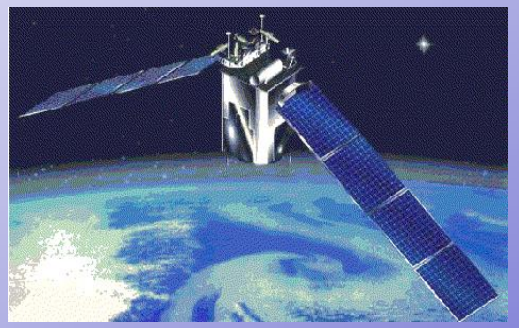
Spectral range:	280–810 nm
Spectral resolution:	~ 1 nm
Exposure time:	2–5 s
Vertical resolution:	1.3–2 km

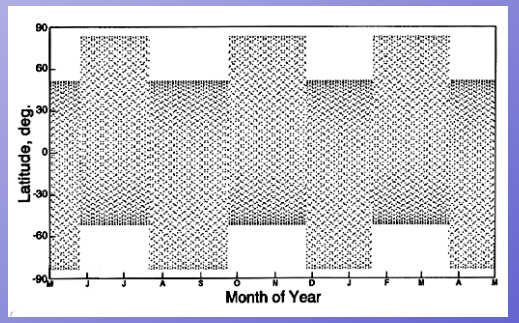
(mesospheric scan mode)



The SABER Instrument Aboard the TIMED Satellite

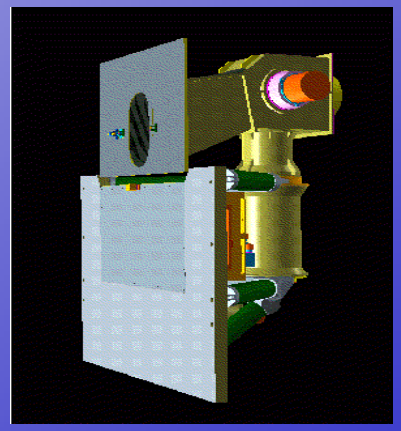
TIMED: Thermosphere, Ionosphere, Mesosphere Energetics & Dynamics
74.1° inclined 625 km orbit;
Latitudinal coverage: 83°S–52°N / 53°S–82°N
Data available since 25 January 2002





SABER: Sounding of the Atmosphere Using Broadband Emission Radiometry

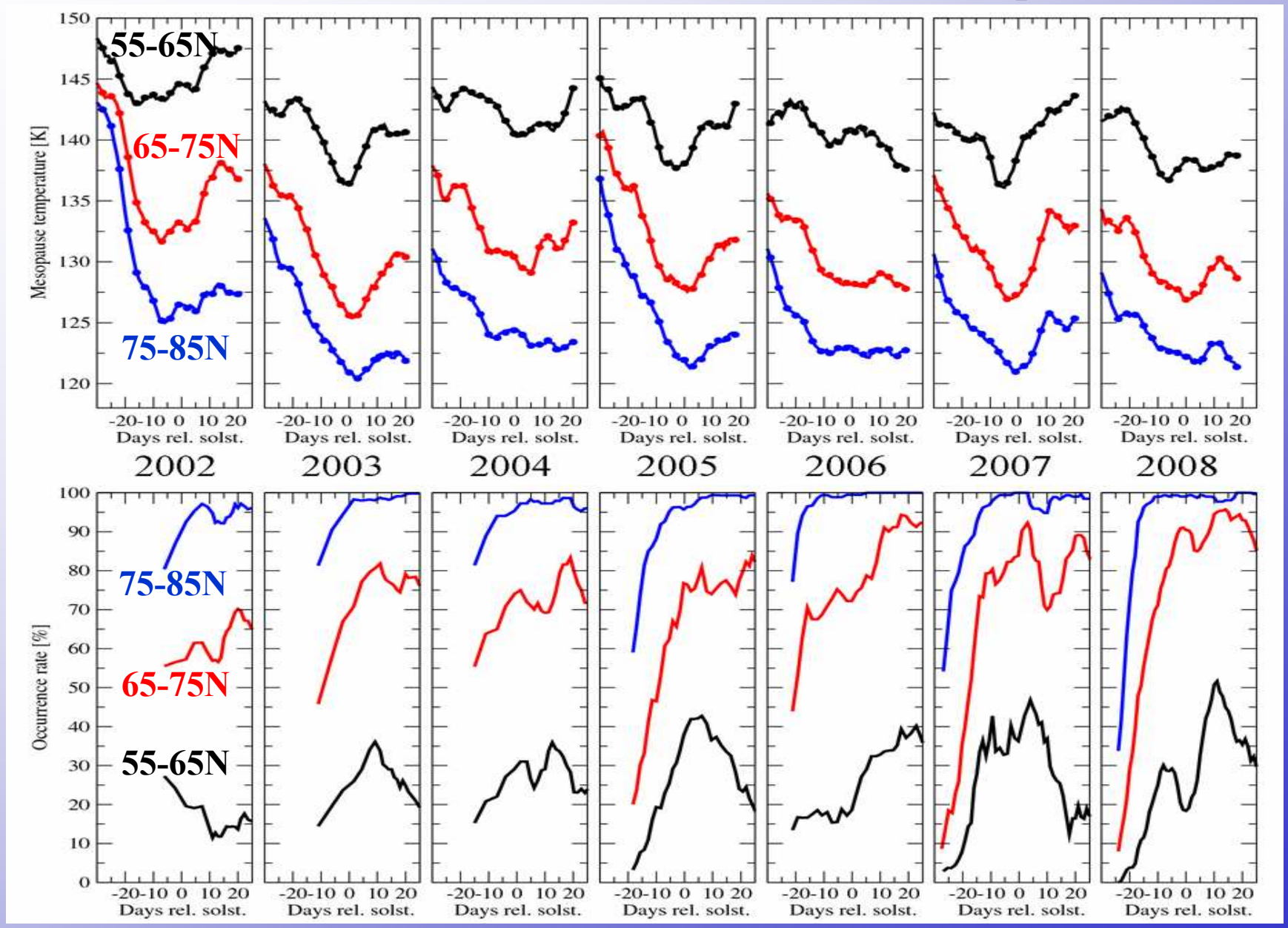
- Limb scanning infrared radiometer (~10–100 km, ~2 km footprint)
- 10 broadband channels (1.27–17 μm)
- Products: kinetic temperature, pressure, CO_2, O_3, H_2O, NO, O_2, OH, O, H



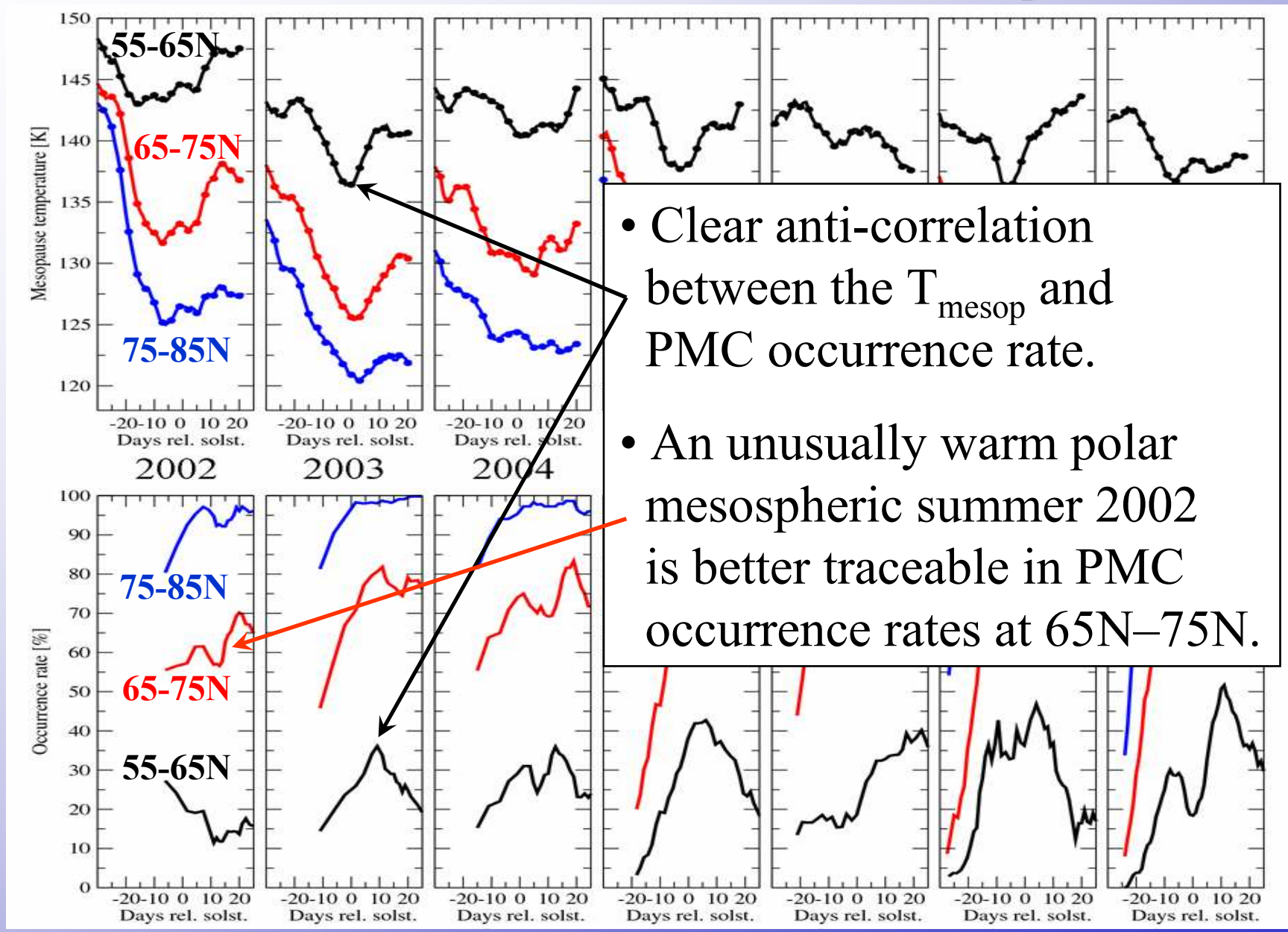
Climatological approach

- Zonal averages of T and PMCs. H_2O not included.
- 6 latitudinal "belts": 55S–65S, 55N–65N, 65S–75S, 65N–75N, 75S–85S, and 75N–85N.
- Tracing correlation of mesopause temperature vs PMC occurrence rate
- Daily averages with 7 day sliding window smoothing

PMC occurrence rates vs T_{mesop}

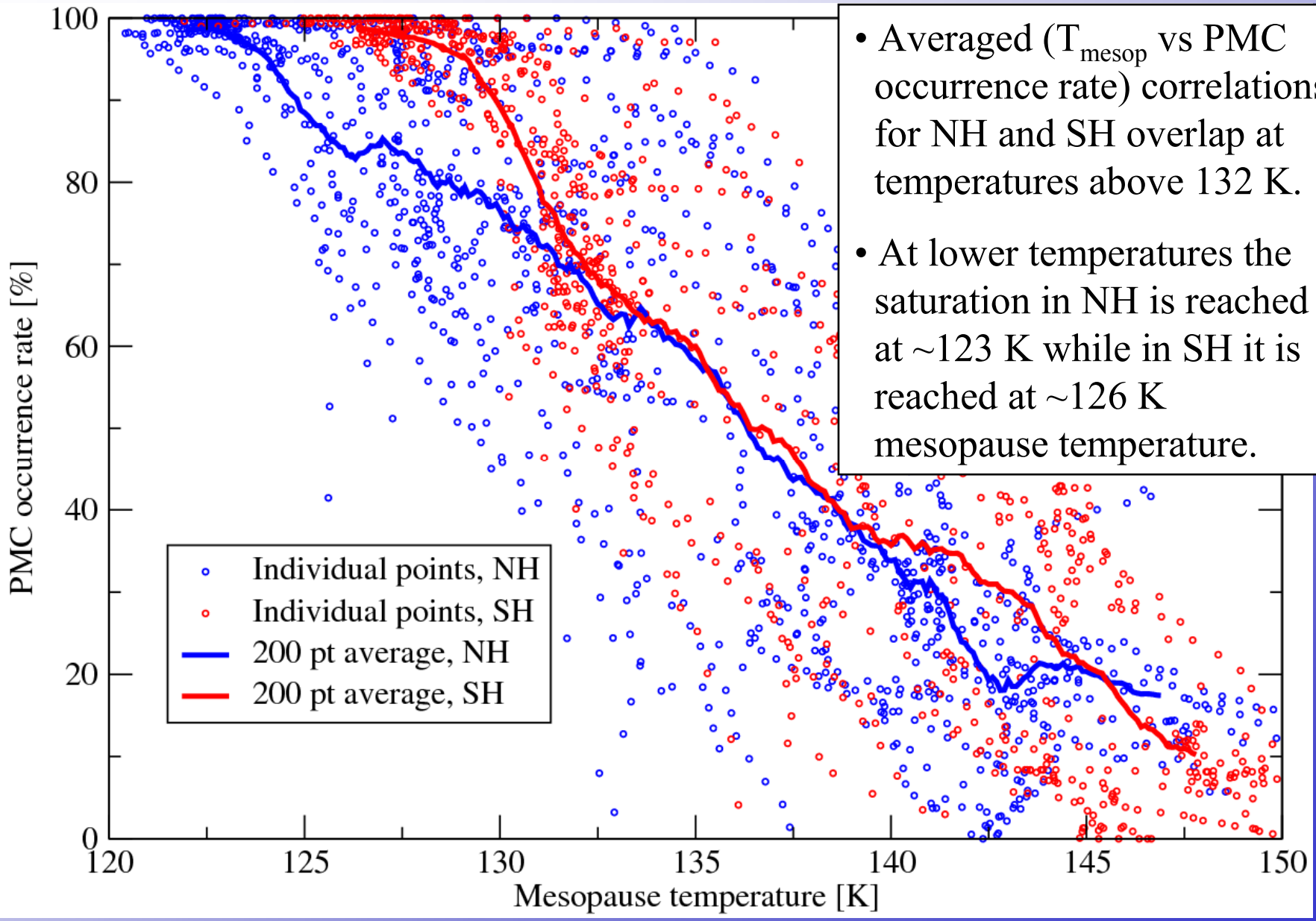


PMC occurrence rates vs T_{mesop}



- Clear anti-correlation between the T_{mesop} and PMC occurrence rate.
- An unusually warm polar mesospheric summer 2002 is better traceable in PMC occurrence rates at 65N–75N.

PMC occurrence rates vs T_{mesop} correlation plot

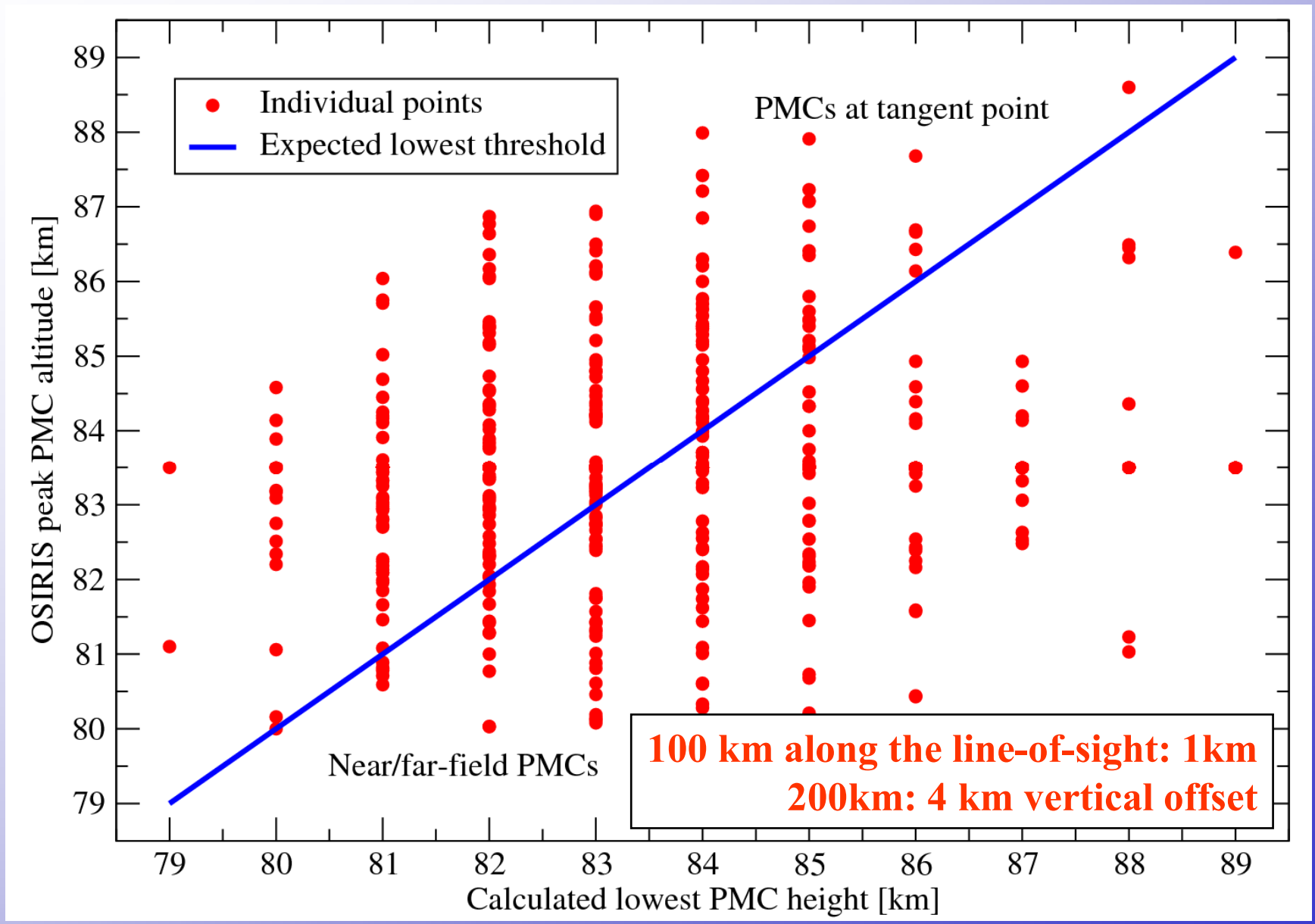


- Averaged (T_{mesop} vs PMC occurrence rate) correlations for NH and SH overlap at temperatures above 132 K.
- At lower temperatures the saturation in NH is reached at ~123 K while in SH it is reached at ~126 K mesopause temperature.

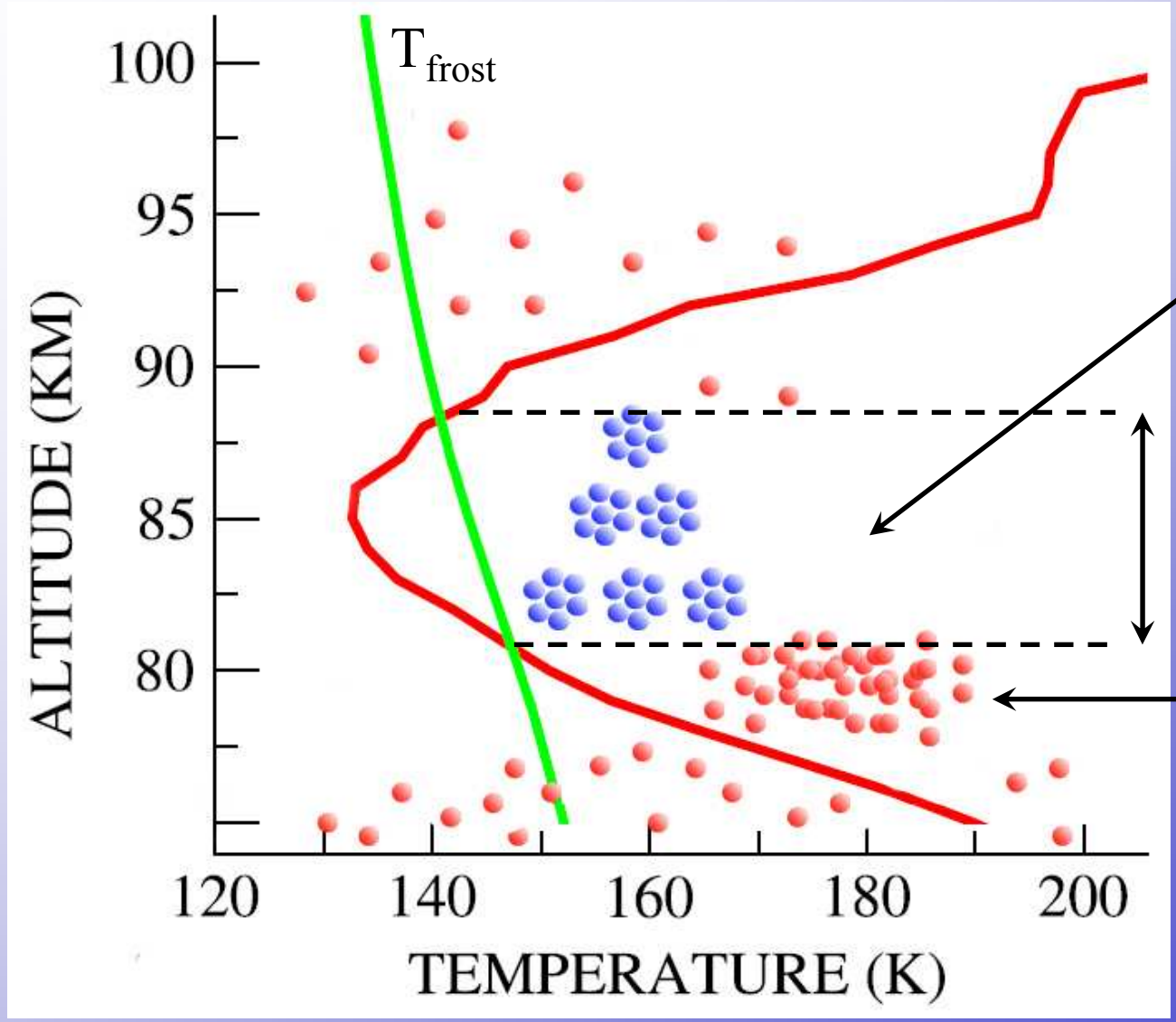
Instantaneous profiles comparison approach: coincidence criteria and profile selection

- "Overlapping weight" for each coincidental pair of scans:
  $\gamma = \Delta t \times 4 + \Delta \eta \times 5 + \Delta \zeta \times 1 + 6 / (90 - \theta_z)$
  t: time, η : lat, ζ : lon, θ_z : SZA
- Excluding the scans with:
  $\Delta t > 1$ hour, $\Delta \eta > 4°$, $\Delta \zeta > 20°$, $\theta_z > 89°$
- 1083 overlapping measurements in 2002–2008.
- Additional filtering: "invisible" PMCs (not observed or non-existent): ~50% and near/far field PMC observations: another ~50% out of remaining 50%.

Near/far field and tangent point PMCs



Definitions for next slides

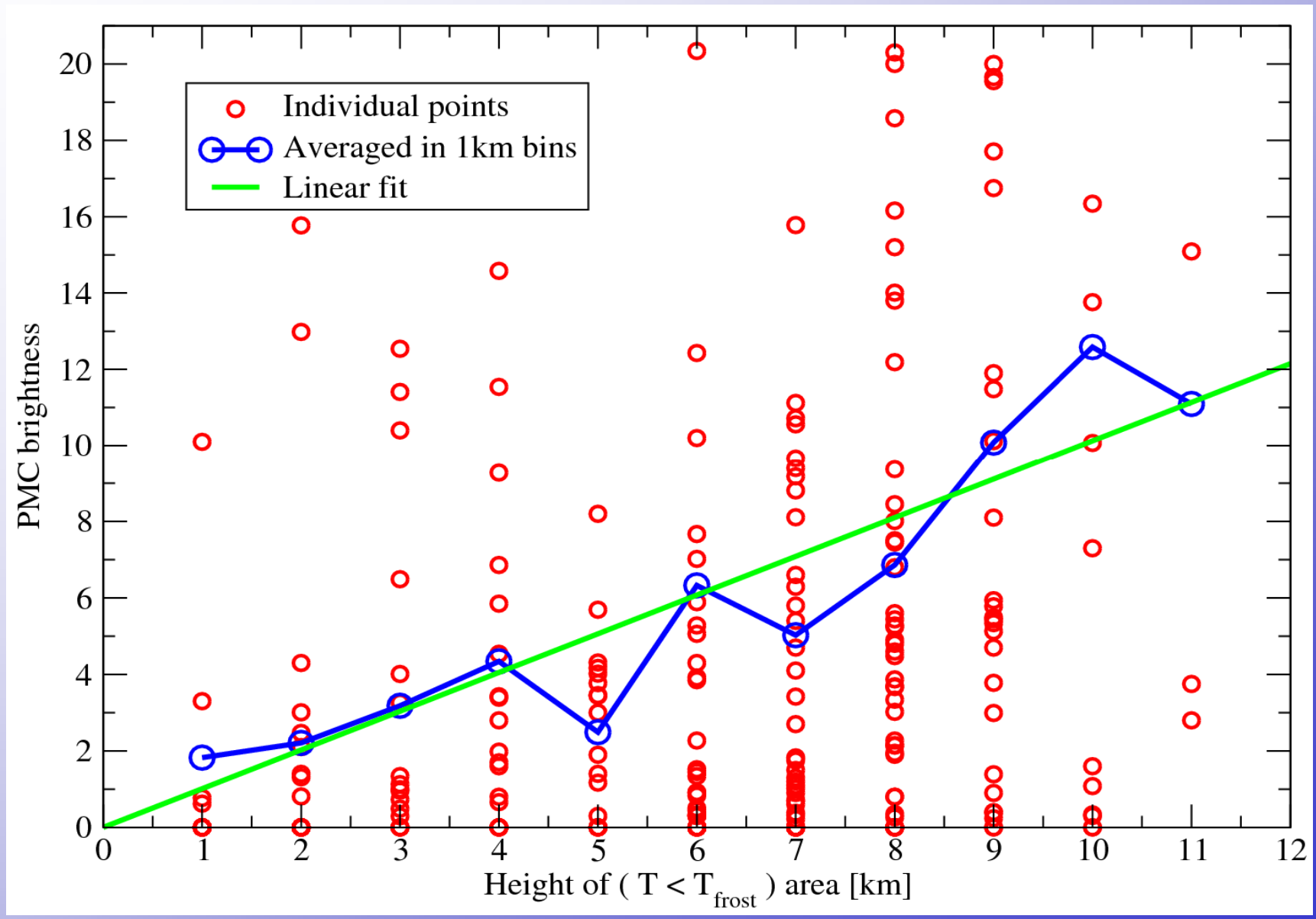


H_2O_{cloud} (only gaseous water !!!)

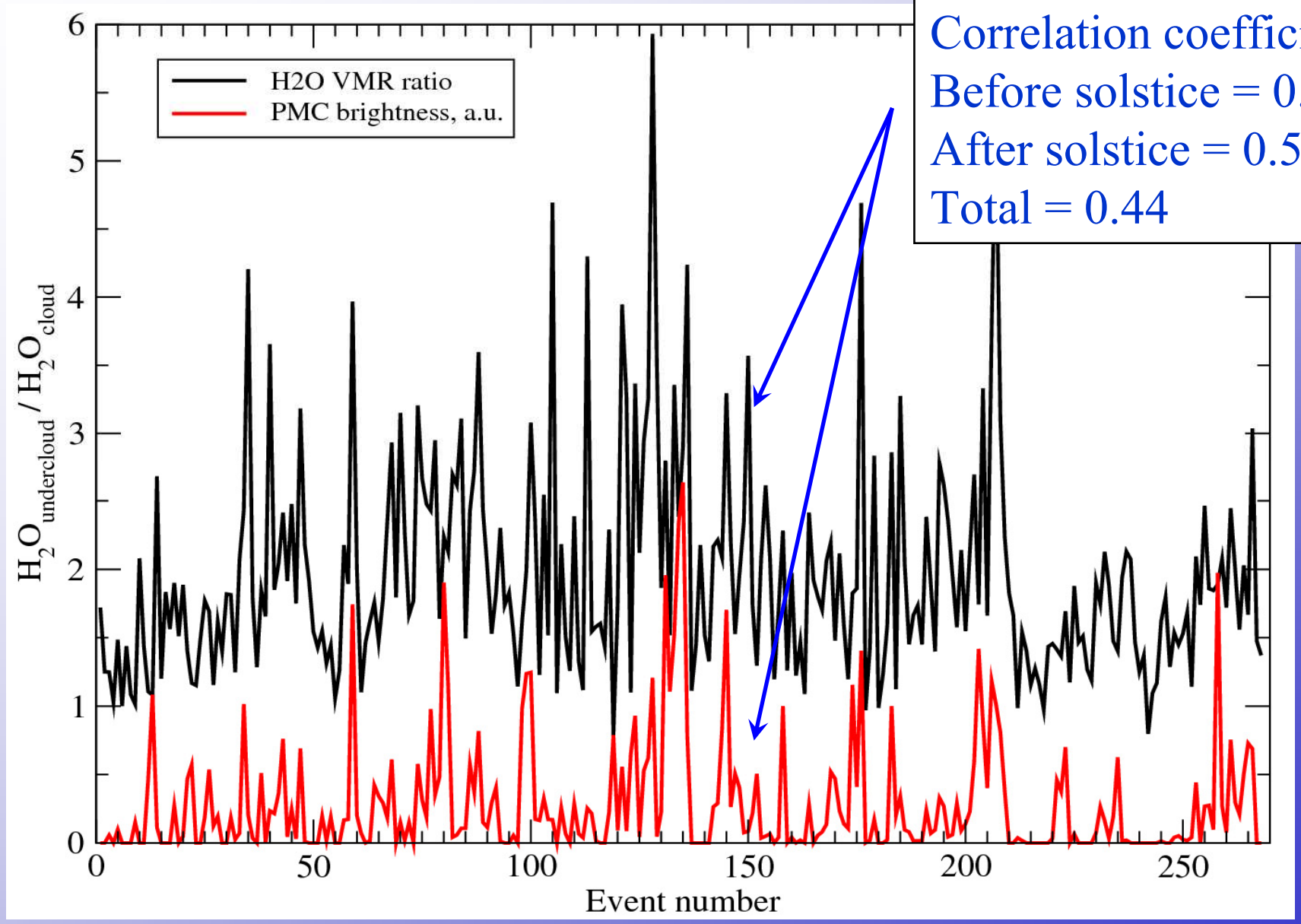
H_{frost}

$H_2O_{undercloud}$ (2km layer)

PMC brightness vs integrated H_{frost}



PMC brightness vs H_2O in and below the cloud



Correlation coefficient:
Before solstice = 0.32
After solstice = 0.53
Total = 0.44

Conclusions

Observed correlations between T, H_2O and PMC correspond to our current understanding of the physics of the region:

- Anticorrelation between T_{mesop} and PMC occurrence rate.
- Correlation between integrated height of ($T<T_{frost}$) area and PMC brightness.
- Correlation between $H_2O_{undercloud}/H_2O_{cloud}$ and PMC brightness is a signature of freeze-drying and cloud sublimation.

Significant number (~50%) of PMC observations come from near/far field – important for future analysis of similar measurements.