Polar Vortex or Solar Cycle: Which is the major driver of 10 years of PMC Variability at McMurdo, Antarctica?

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Why do we care and study PMCs?

PMC observations can serve as indicators for long-term changes in the atmosphere and climate. The McMurdo lidar projects were supported by the National Science Foundation (NSF) grants OPP-0839091, OPP-1246405, OPP-1441726, and OPP-2108428.

Mesopause becomes the coldest region on Earth during summer! Instead of being dry, MLT is super saturated! Mesopause becomes the coldest region on Earth during summer!

Great mysteries surrounding PMCs:

- A solar cycle signature is clearly seen from 1978-2002 but disappeared afterwards. Why?
- Which is the major driver of PMC variability: Polar Vortex vs Solar Cycle?
- Could PMCs be potential indicators of long-term climate change?

Scientific discoveries from 10 years (2010-2020) of lidar and 14 years (2007-2021) of CIPS PMC Observations

- Large interannual variability in PMC brightness that does not show an obvious anticorrelation with the solar cycle.
- PMC centroid altitude $Z_c$ follows a normal distribution.
- PMC brightness ($\beta_{\text{total}}$ and CIPS albedo) follows a lognormal distribution.
- Verified latitudinal dependence – PMC $Z_c$ increases with latitude (Chu et al., 2011).
- Verified SH PMCs ~ 1 km higher than NH PMCs (Chu et al., 2011).

Lidar PMCs at 3 stations: South Pole (90°S), McMurdo (78°S) and Rothera (67.5°S).

CIPS data: Level 3 ground station summary per orbit confined to 500 km around McMurdo. 2017-2018 season omitted due to orbit issues with AIM satellite.

Conclusions

- Did the solar cycle signature really disappear? NO. The dynamical forcing of the polar vortex overshadows radiative forcing causing solar cycle to take a back seat in PMC variability.
- On adding the effect of solar cycle to the linear relationship of polar vortex breakup timing and PMC brightness the correlation improves by 21% indicating that polar vortex breakup timing plays a major role, while solar cycle plays a minor role on PMC brightness variability.
- How to use PMCs as indicators of long-term climate change, given that the dynamical forces cause such strong variability in PMCs? This requires further considerations.

Questions for future work

- We now know that polar vortex breakup dominates PMC variability in 2007-2021 and thus, solar cycle takes a backseat. But in 1978-2002 what made the solar cycle overshadow polar vortex when polar vortex breakup timing showed similar variability?
- Could dynamical forcing of the polar vortex overshadow radiative forcing causing the solar cycle to take a back seat in PMC variability?
- On adding the effect of solar cycle to the linear relationship of polar vortex breakup timing and PMC brightness the correlation improves by 21% indicating that polar vortex breakup timing plays a major role, while solar cycle plays a minor role on PMC brightness variability.
- How to use PMCs as indicators of long-term climate change, given that the dynamical forces cause such strong variability in PMCs? This requires further considerations.