

Improved PSC Detection and Characterization from OMPS Limb Profiler

Matthew DeLand^{1,2}, Mark Schoeberl³

¹Science Systems and Applications, Inc. (SSAI)

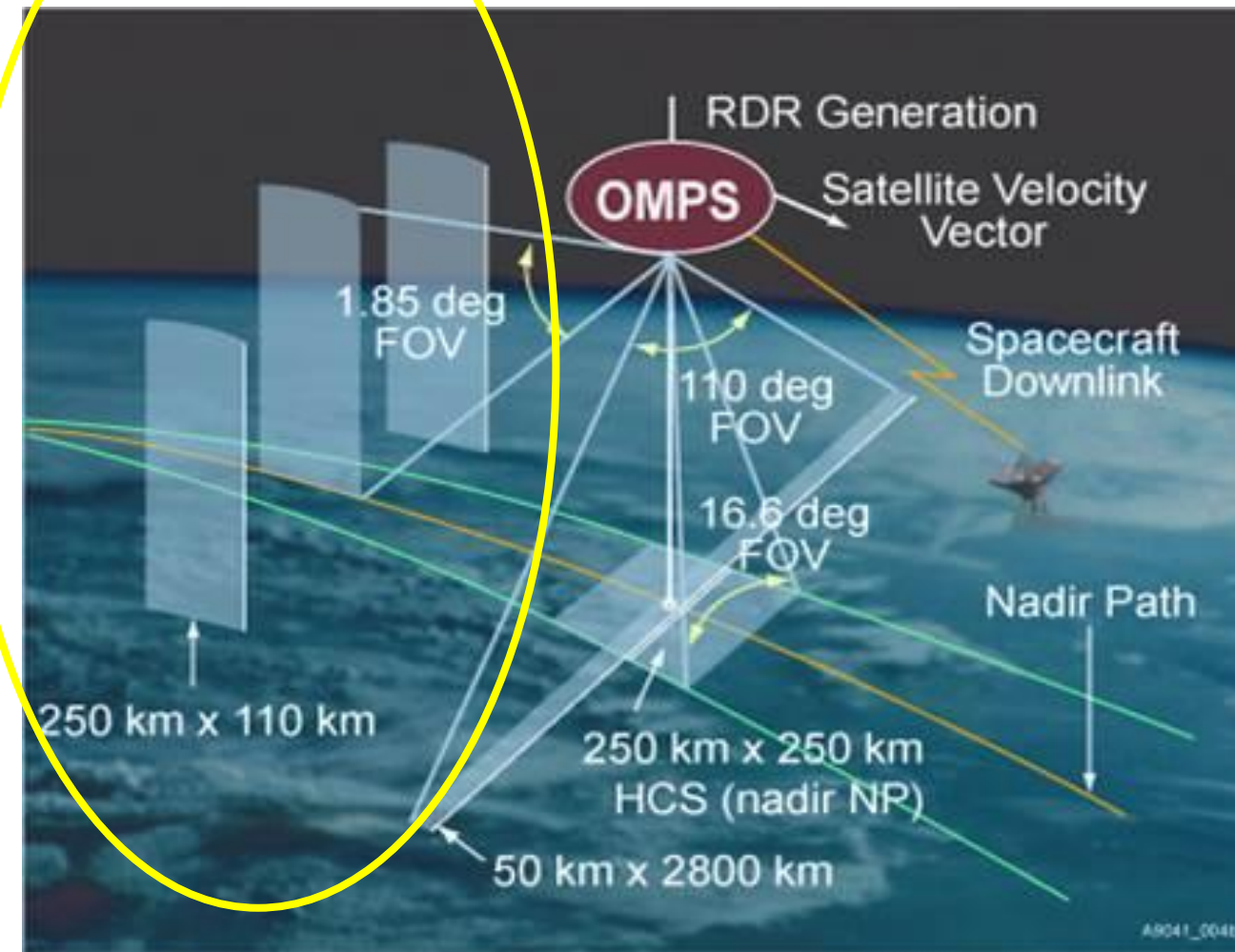
²NASA Goddard Space Flight Center (GSFC)

³Science and Technology Corporation (STC)

Poster A52Q-1209, AGU Fall Meeting, Chicago, IL 12-16 December 2022

- Ozone Mapping and Profiling Suite (OMPS) Limb Profiler (LP) launched on Suomi NPP satellite on 28 October 2011
- Limb scatter measurements are made looking backward along the orbit track with three slits (center, $\pm 4.25^\circ$ to each side = 250 km separation at tangent point)
- Hyperspectral CCD collects simultaneous data over 0-80 km altitude (1 km sampling) and 290-1000 nm (spectral resolution = 1-35 nm)
- Initial requirement of cloud detection is to establish lower boundary for termination of ozone and aerosol retrievals

Introduction

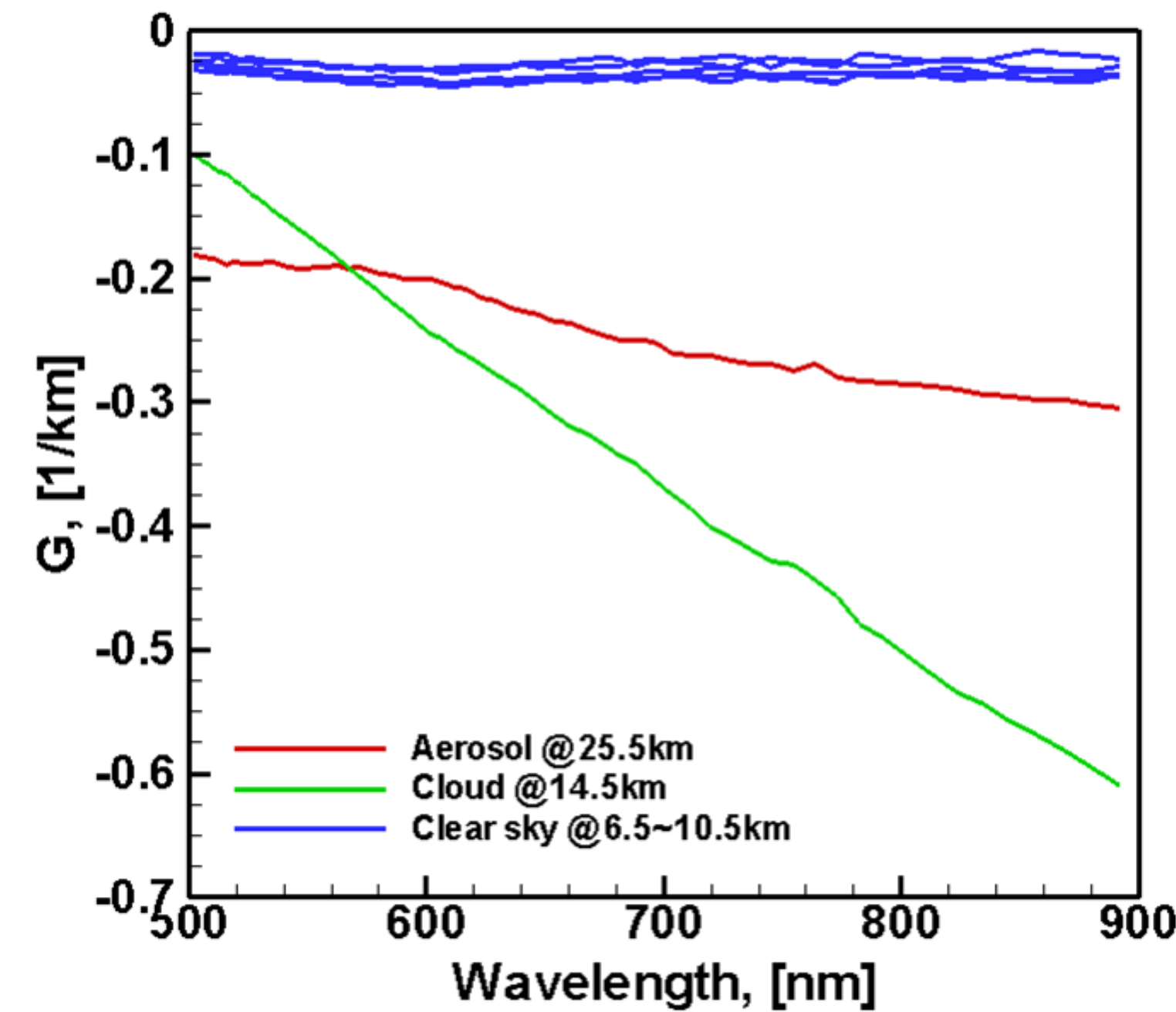


Cloud Detection

- Chen et al.* [2016] algorithm uses vertical gradient and spectral dependence of radiance (675 nm, 869 nm) to identify cloud top:

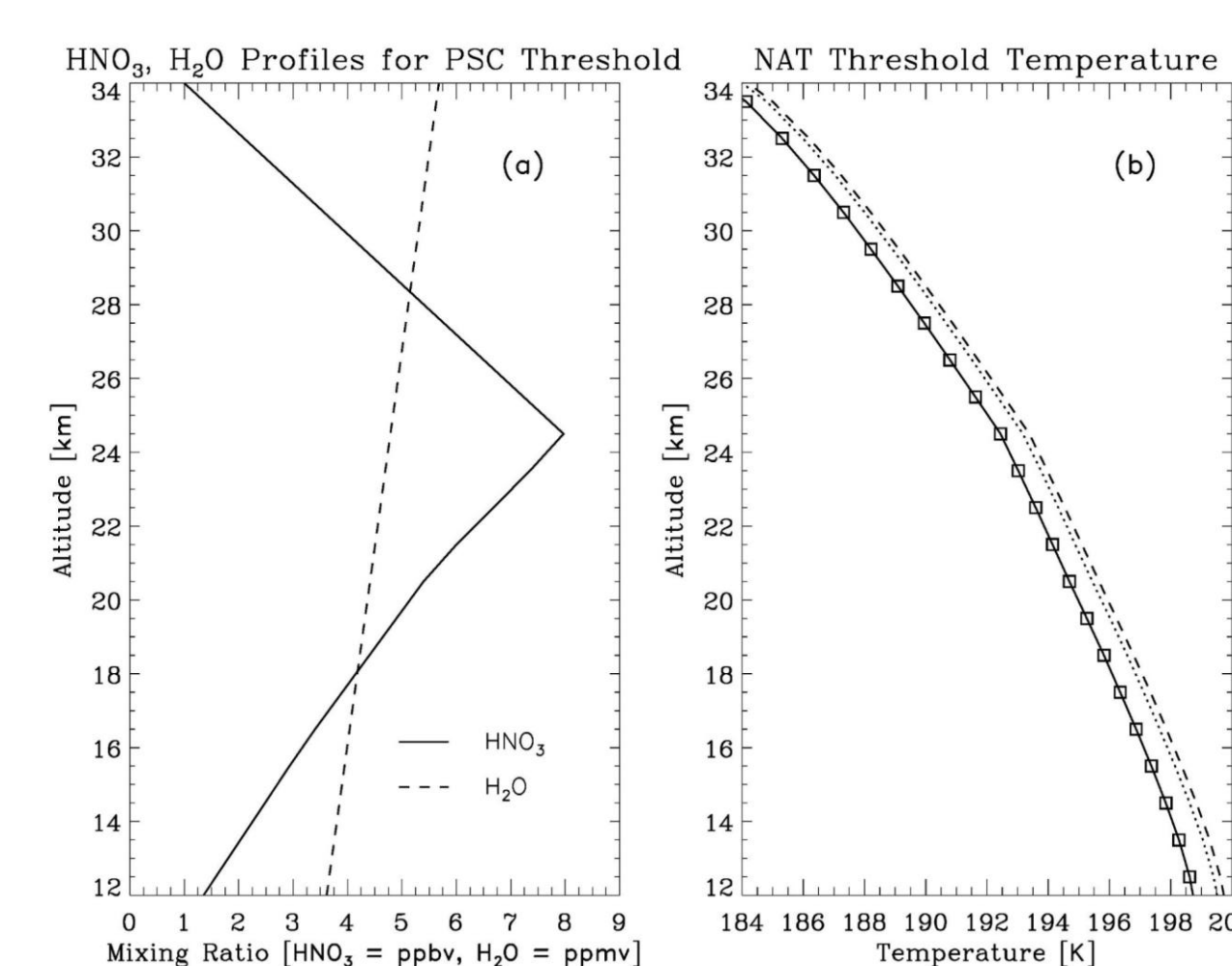
$$\ln R(z) = \frac{\partial \ln I(675 \text{ nm}, z)}{\partial z} - \frac{\partial \ln I(868 \text{ nm}, z)}{\partial z}$$

- Assume that water ice clouds (*green*) have steeper difference in gradient than aerosols
- Establish threshold (radiance ratio > 0.15) to identify cloud



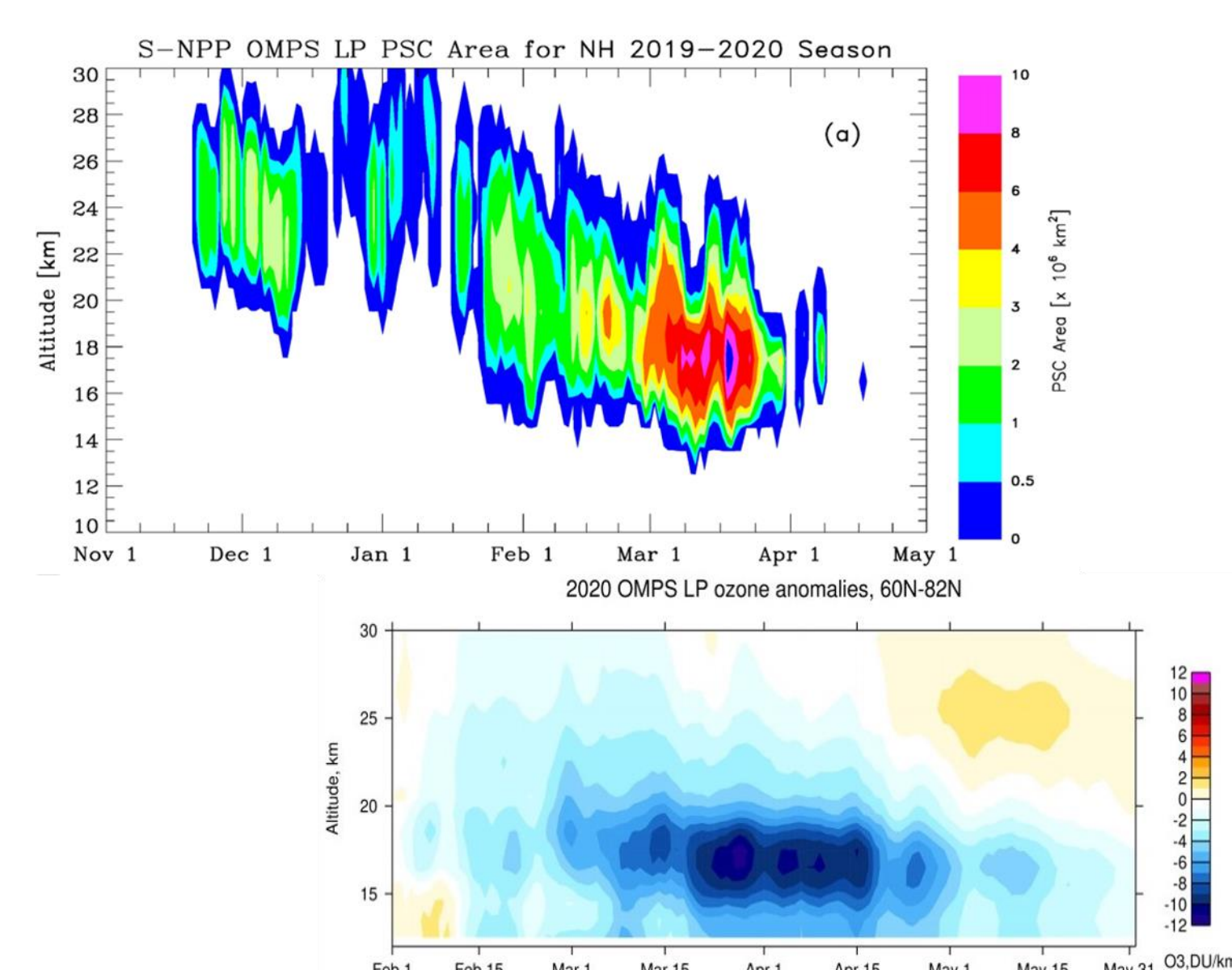
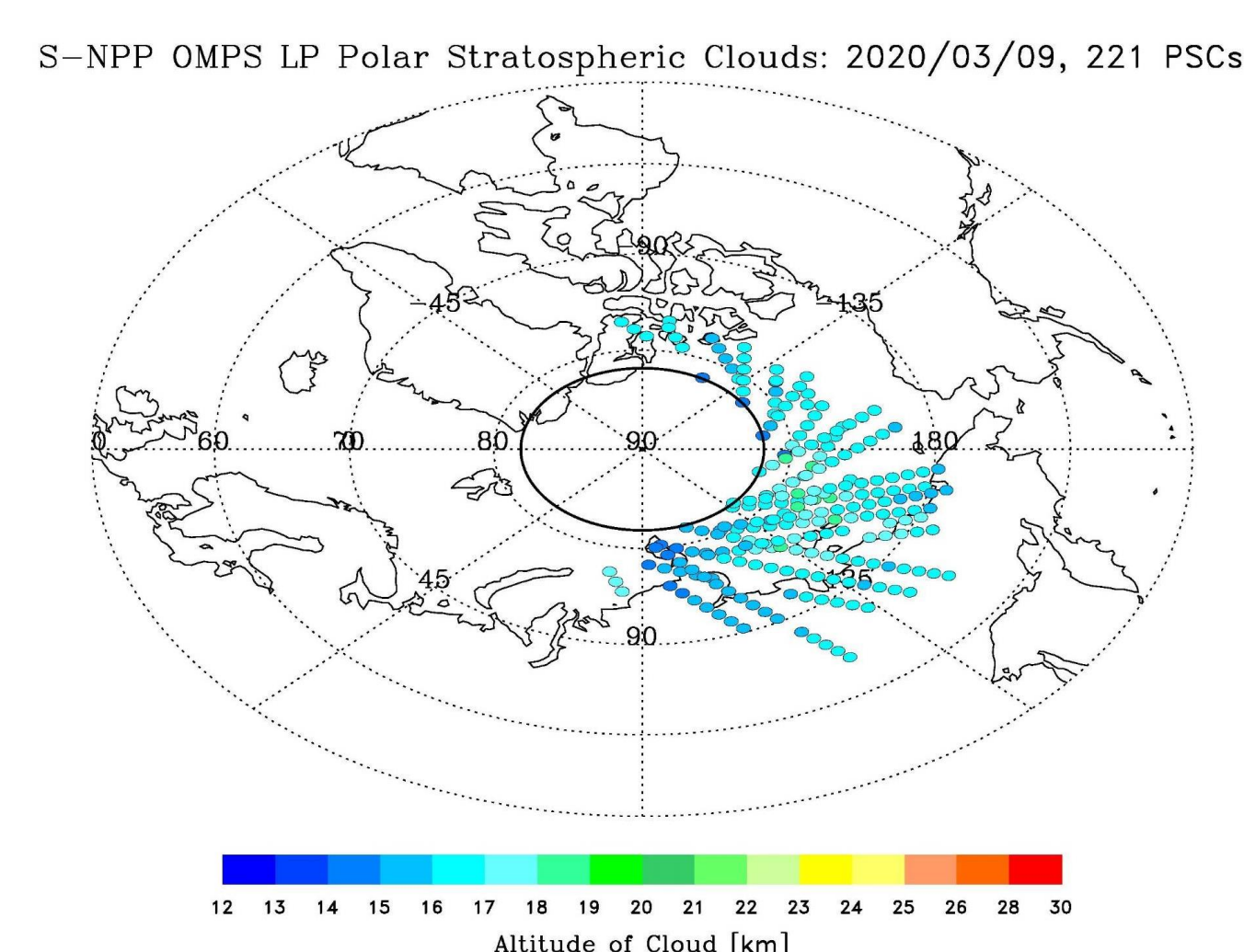
PSC Identification

- Require $Z_{\text{cloud}} > (Z_{\text{tropopause}} + 2 \text{ km})$ to limit cirrus contamination [defines “high cloud”]
- Calculate threshold temperature profile for nitric acid trihydrate (NAT) particles using seasonal average H_2O and HNO_3 mixing ratio profiles[*left*] derived from MLS observations.
- This T_{NAT} threshold profile [*right*] is insensitive to exact mixing ratio values (*dotted line* = $2 \cdot \text{HNO}_3$, *dashed line* = $1.2 \cdot \text{H}_2\text{O}$).



Current Results

- Regional distribution with preferred locations
- Calculate area by allowing additional clouds for $T < T_{\text{NAT}}$ below LP cloud altitude
- Variations agree with ozone depletion for strong NH 2019-2020 season

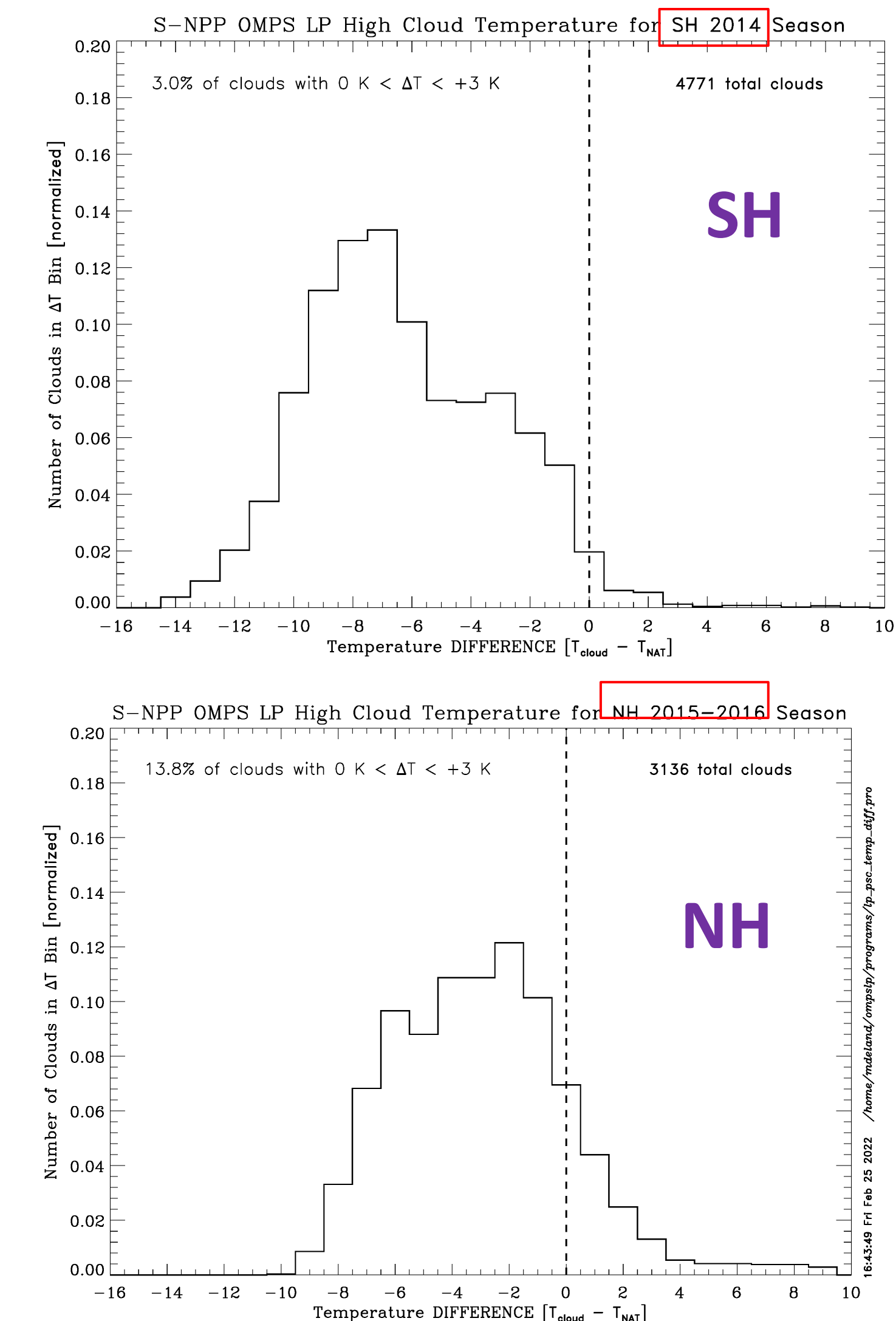


DeLand et al. [2020], *Geophys. Res. Lett.*

Do LP PSC results agree with expectations based on current mechanisms?

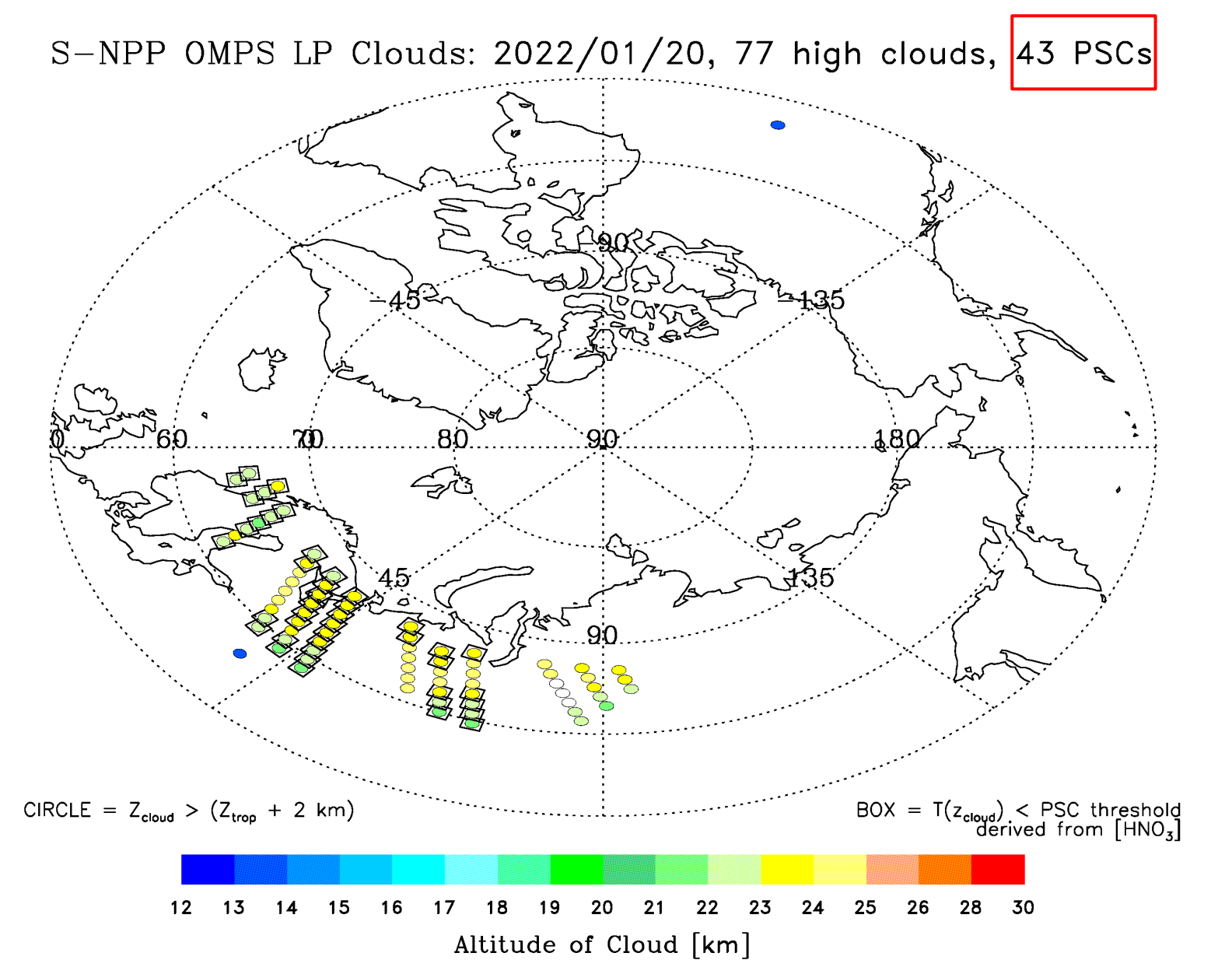
Distribution of High Cloud ΔT Values

- Calculate difference between T_{cloud} and T_{NAT} for all high clouds
- Identify fraction of cases with ΔT between 0 K and +3 K
- SH seasons typically have ~3000-7000 high clouds, peak ΔT well below T_{NAT} (-7 K for this season)
- Small tail with positive ΔT (< 3%)
- NH seasons typically have ~500-3500 high clouds, broader shape to distribution (peak $\Delta T \approx -2 \text{ K}$ for this season)
- More cases with positive ΔT (10-15%), including cases above +3 K



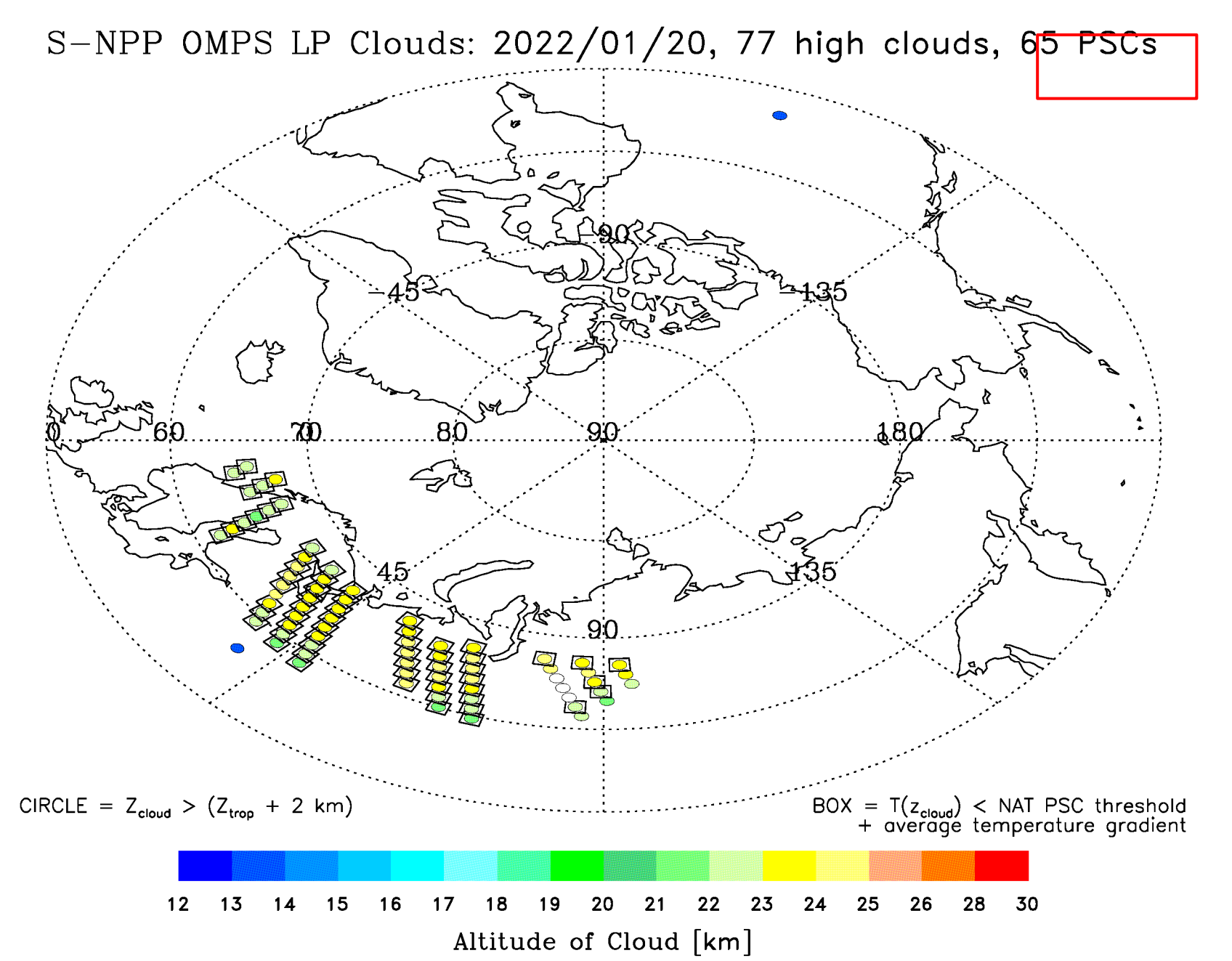
Assignment of Cloud Altitude

Standard Algorithm



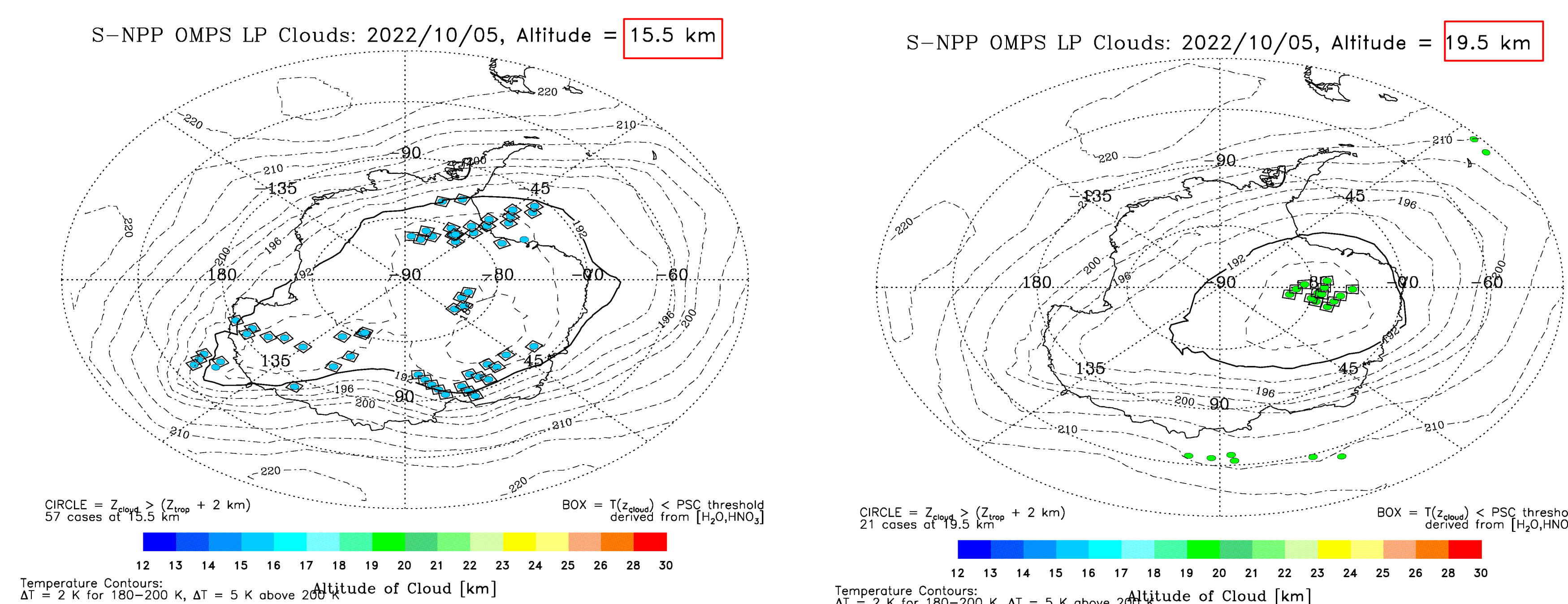
- Some clusters of NH high clouds show gaps in PSC identification
- Examine temperature profile and gradient
- Typical value of $\Delta T/\Delta z$ at PSC altitude is +3 K/km
- Extended region of “cold” temperatures below PSC altitude
- Temperature differences for non-PSC clouds [events 165, 170] are less than +3 K
- Cloud altitude is fairly close to temperature minimum
- LP cloud height assignment is quantized to 1 km steps
- Apply $\Delta T/\Delta z$ adjustment to PSC temperature threshold identification
- New PSCs fill in spatial gaps from previous result

Revised Algorithm

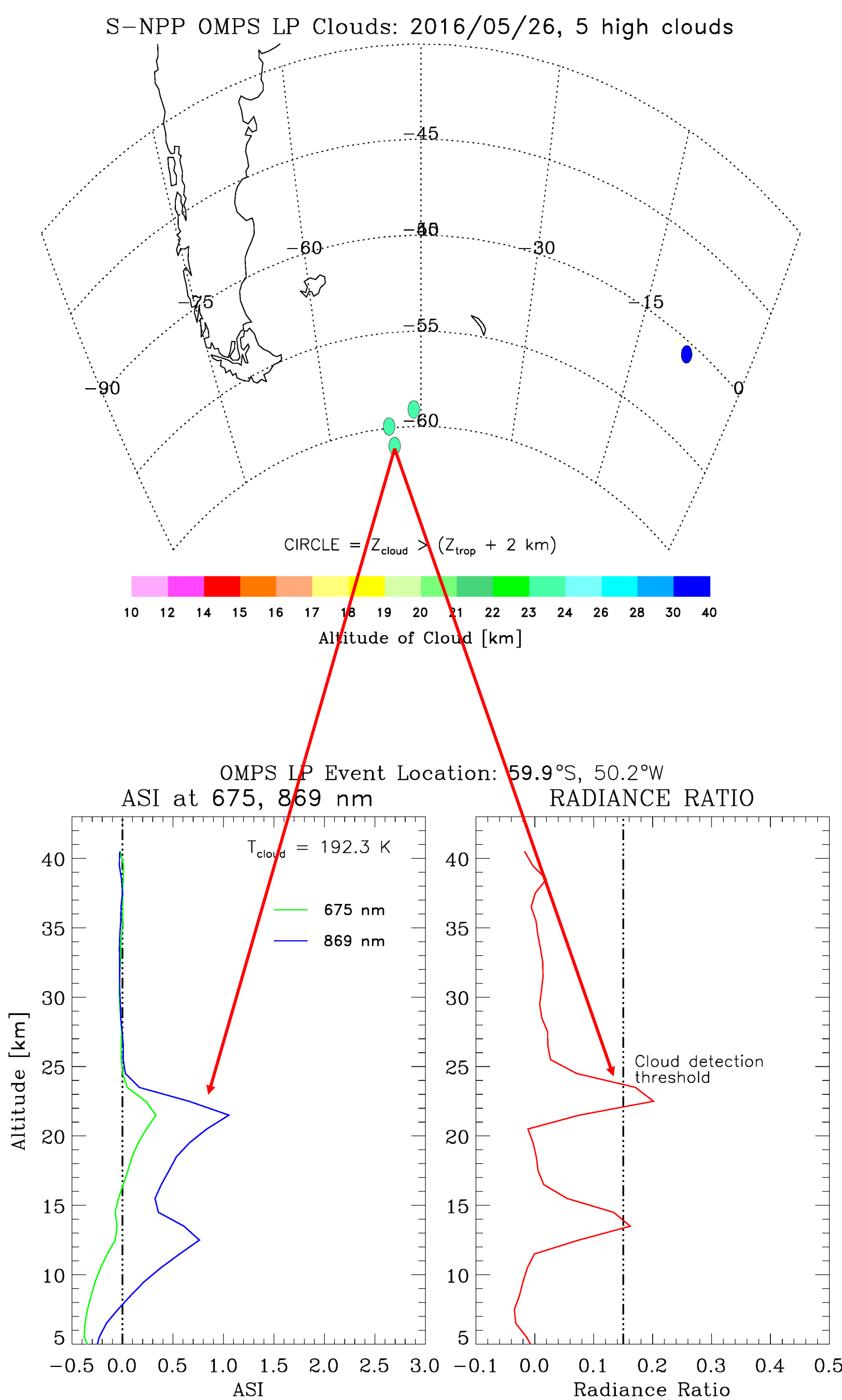


Distribution vs. T(z) Profile

- PSC distribution at specific altitude is consistent with GMAO temperature contours at same altitude
- Need to update NAT threshold calculation to use observed H_2O , HNO_3 (particularly within vortex) to validate composition and detection



Identification of Out-of-Season PSCs



- LP identifies high clouds at low SH latitudes (30°-60°S) in all seasons
- Look at date in May 2016 with multiple high cloud detections near South America
- Examine profiles of radiance with “clear-sky” component removed, cloud detection index for validation
- Filter out cases where South Atlantic Anomaly (SAA) particles hit CCD
- Good case:** Difference in radiance gradient (*left panel*) gives peak in radiance ratio (*right panel*). Temperature at cloud altitude is close to NAT formation threshold.

Future Plans

- Revise NAT threshold calculation to use observed H_2O , HNO_3 profiles from MLS
- Review causes for not identifying PSC within cold region (Radiance ratio threshold? Error in $T(z)$?)
- Validate PSC detections that appear to exceed formation threshold
- Extend analysis to new LP instrument on NOAA-21 (launched 11/10/2022)

Acknowledgments

- Funding provided by NASA grant 80NSSC21K1965