Jet Propulsion Laboratory
California Institute of Technology

Ground-Based Diurnal Measurements of NO_2 and NO_3 in Support of SAGE-III/ISS Validation

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Objectives

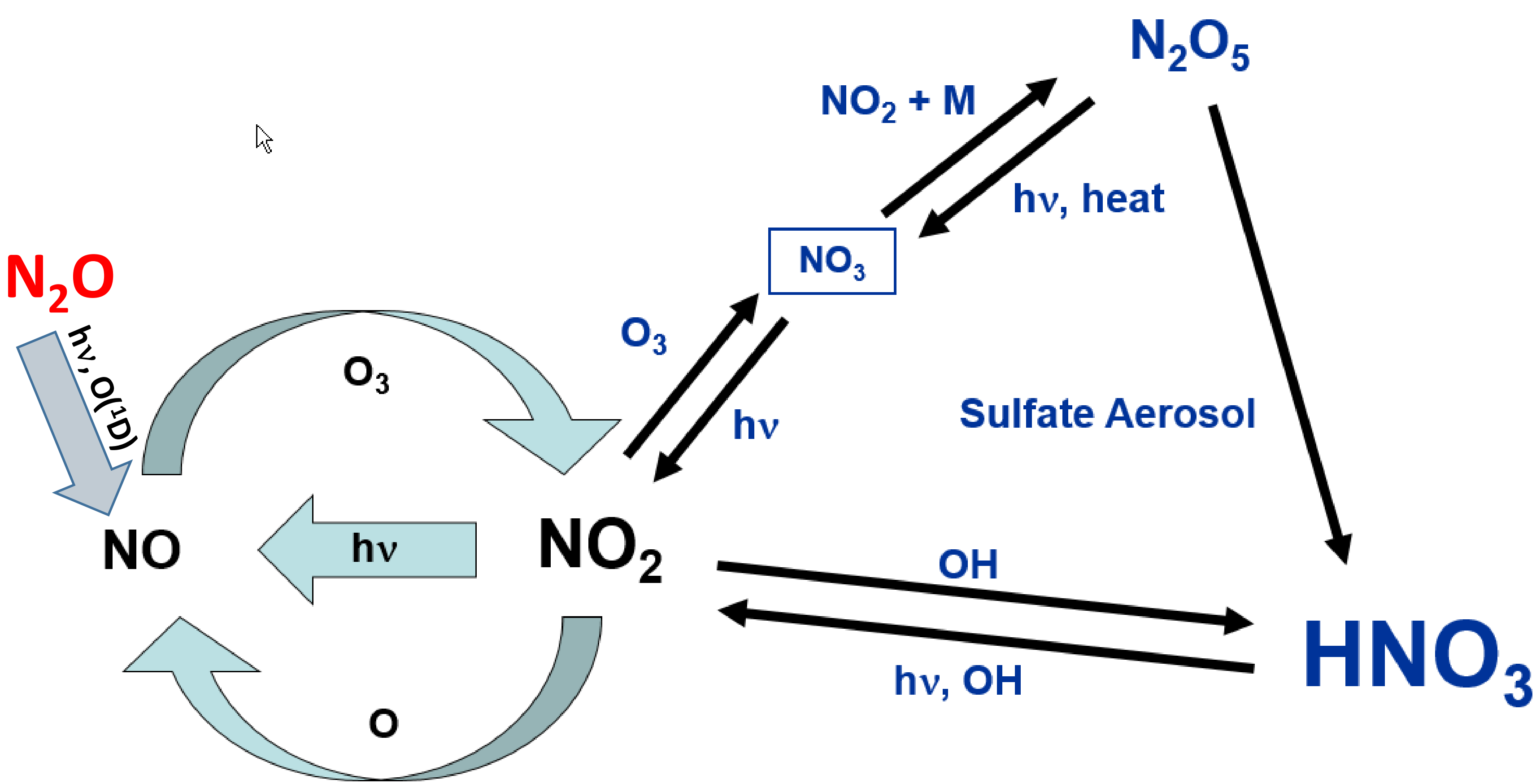
Objective 1: Obtain direct solar/lunar measurements of NO_3 and NO_2 from Table Mountain Facility in support of SAGE III/ISS validation.

Objective 2: Analyze comparisons with coincident SAGE III/ISS measurements and work with the algorithm and science teams to interpret the comparisons and incorporate improvements into retrieval algorithms.

Objective 3: Utilize in-situ measurements of NO_3 and N_2O_5 and chemical modeling to separate stratospheric and tropospheric partial columns.

Co-Investigators	
Thomas J. Pongetti, JPL	Data Acquisition/Analysis
King-Fai Li, UCR	1-D Modeling
Yuk L. Yung, Caltech	1-D Modeling
Steven S. Brown, NOAA	In-situ measurements

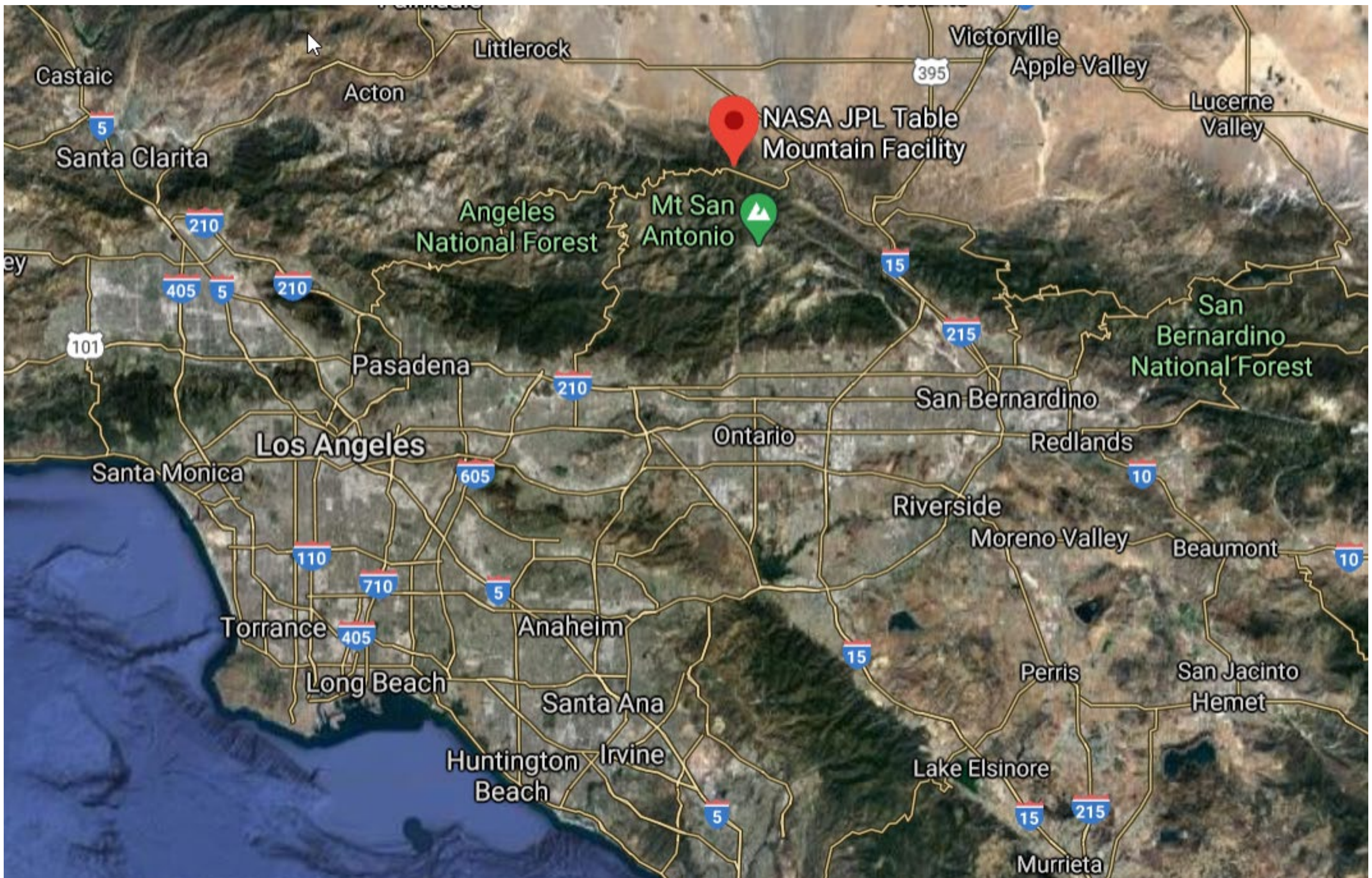
Key Processes in Stratospheric NO_x-NO_y Photochemistry



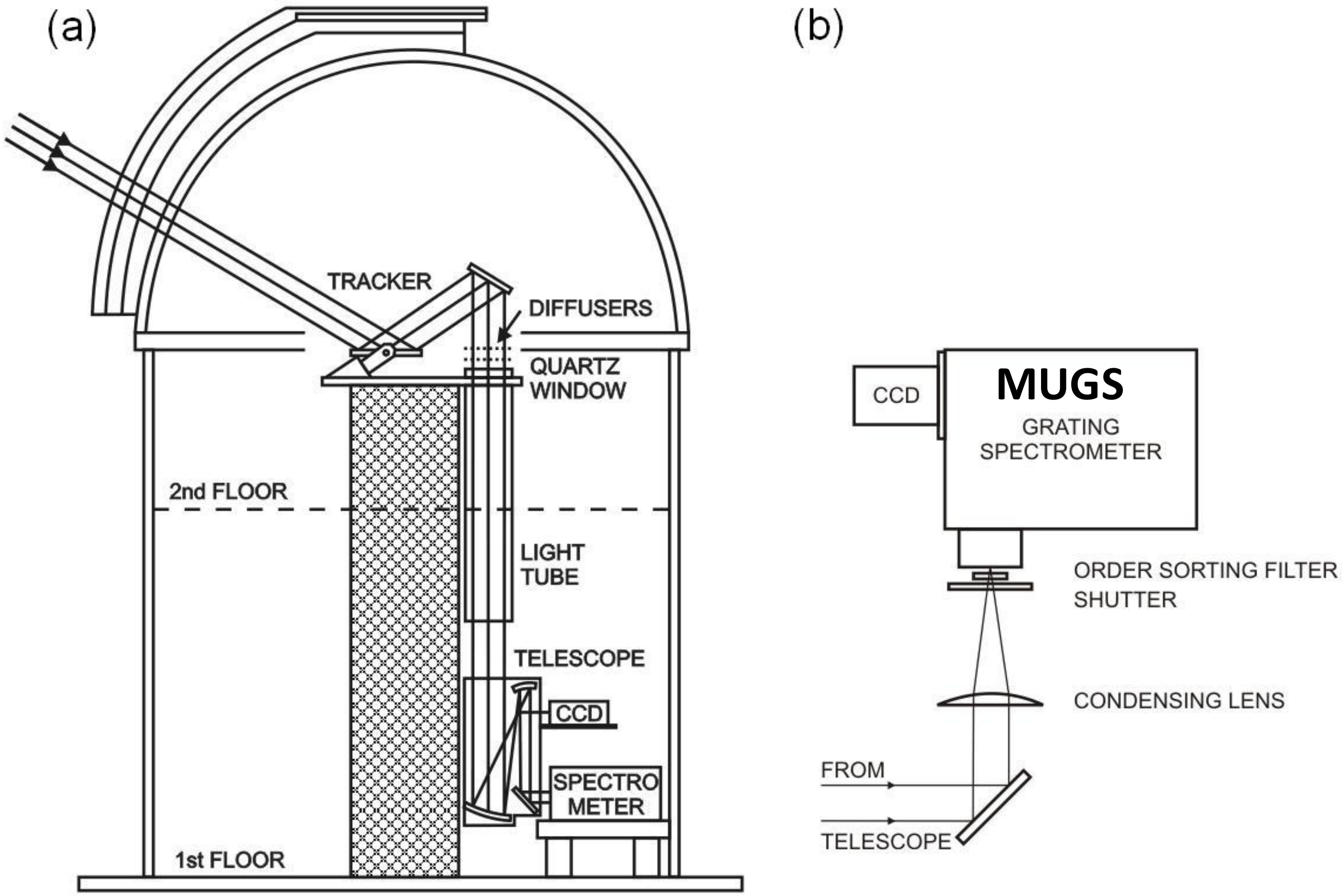
- Two pathways to HNO_3 formation:
  - Daytime (through OH + NO_2 + M reaction)
  - Nighttime (through N_2O_5 + sulfate aerosol reaction, NO_3-mediated

Ground-Based Measurements

Direct Solar and Lunar Spectroscopy at JPL Table Mountain Facility



UV-Visible Grating Spectrograph (MUGS) at JPL/Table Mountain Facility



Schematic of the instrument light path. (a) Light is collected by the primary of the heliostat (tracker) then through an off-axis telescope which also serves as a fine guider for the pointing system. (b) The light is directed through a condensing lens, shutter, order-sorting filter, and then into the spectrometer where it is dispersed and recorded by a CCD camera.

Correcting for Trace Gas Absorption in the NO_2 Reference Spectrum

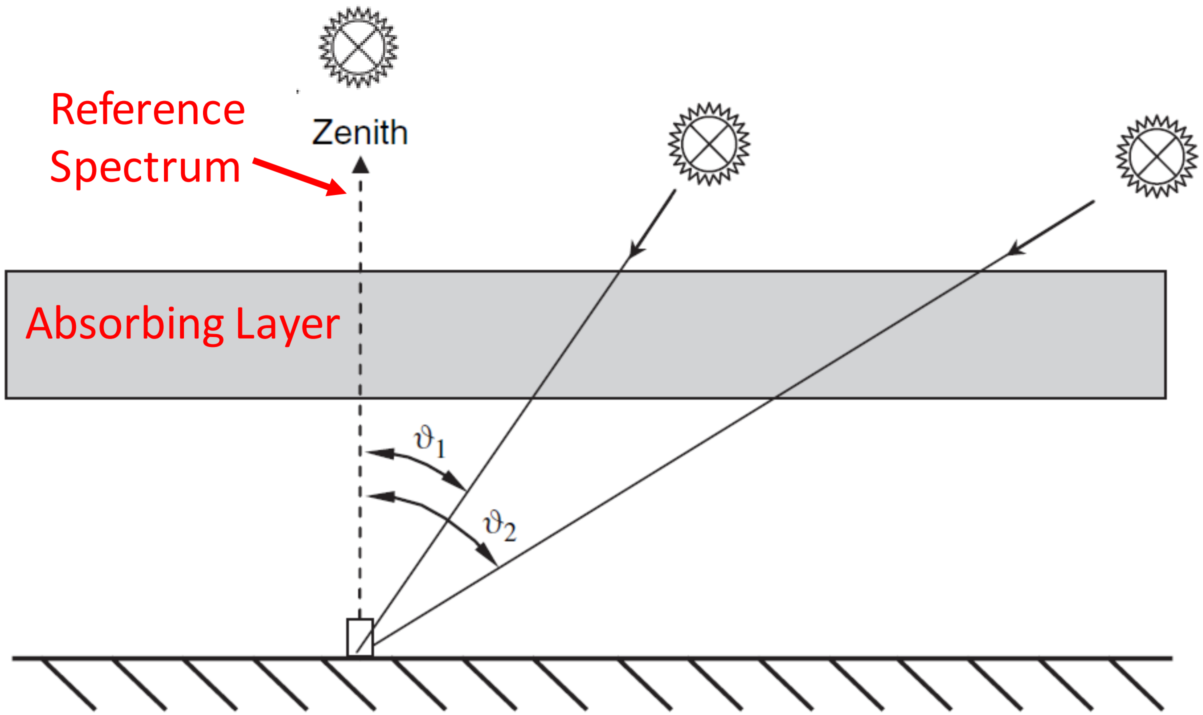
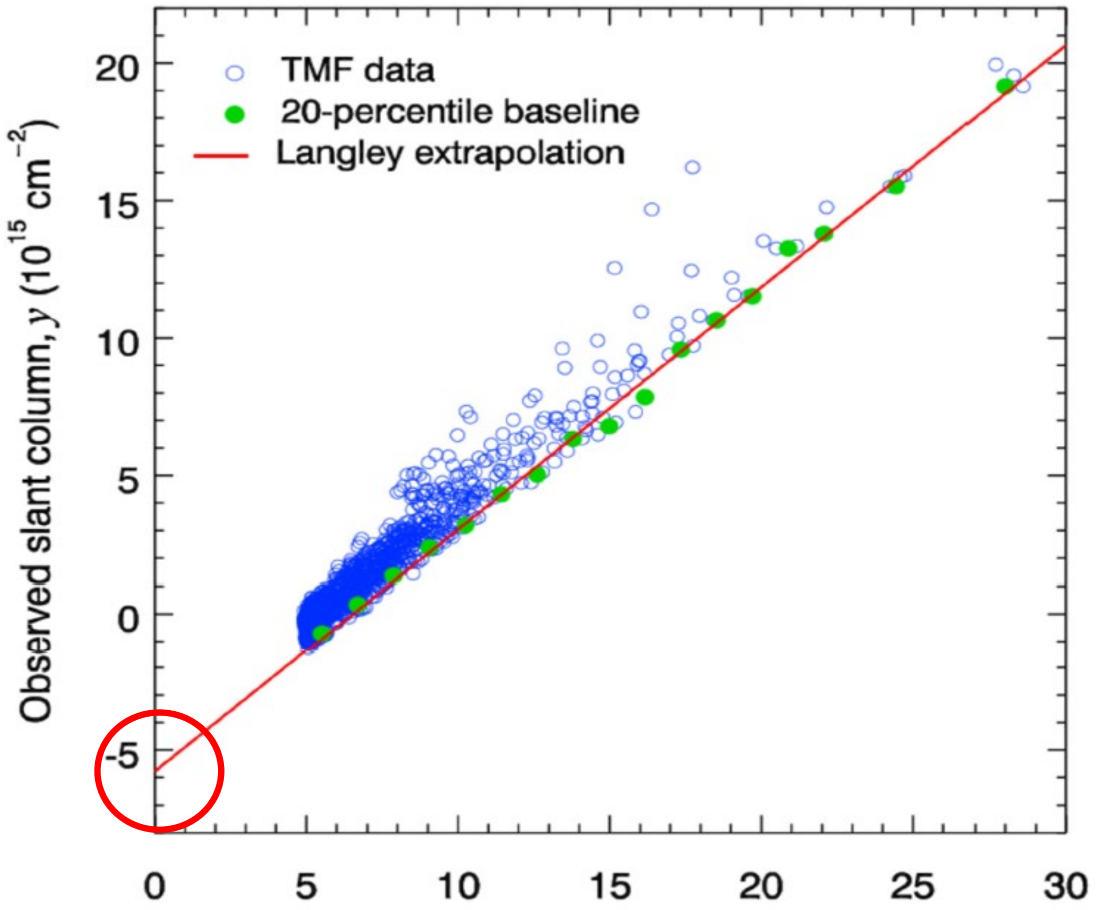


Fig. 9.1. Sketch of direct light observation geometries. In first approximation, the light path through a trace gas layer varies with $1/\cos\vartheta$ (ϑ = zenith angle of celestial body observed) From Stutz and Platt, *Differential Optical Absorption Spectroscopy* (2008)

- A *reference spectrum* is acquired near zenith to obtain a background solar spectrum
- The reference spectrum contains absorption(s) from the molecule(s) of interest.
- A *Langley Plot* is constructed to determine the slant column density in the reference spectrum.

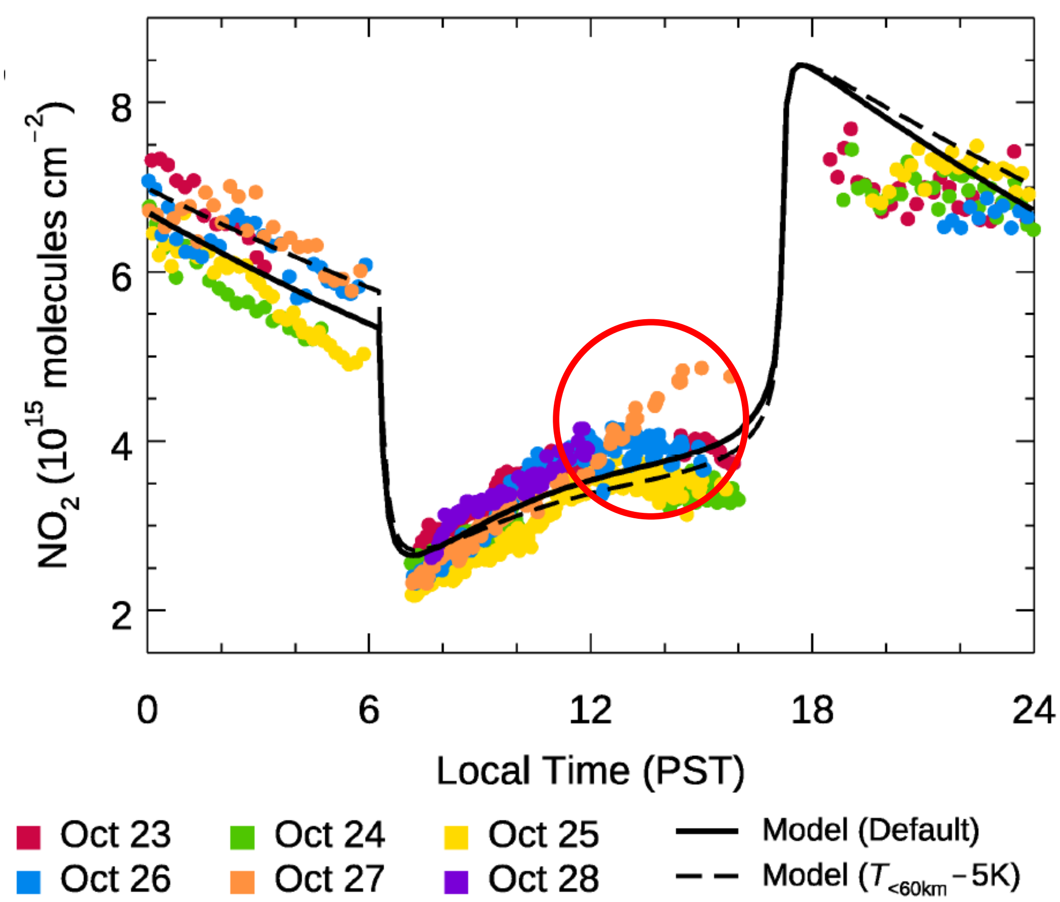
Modified Langley Extrapolation



Modeled slant column, *AMF_i x $VC_o(AMF)$ (10^{15} cm^{-2})*

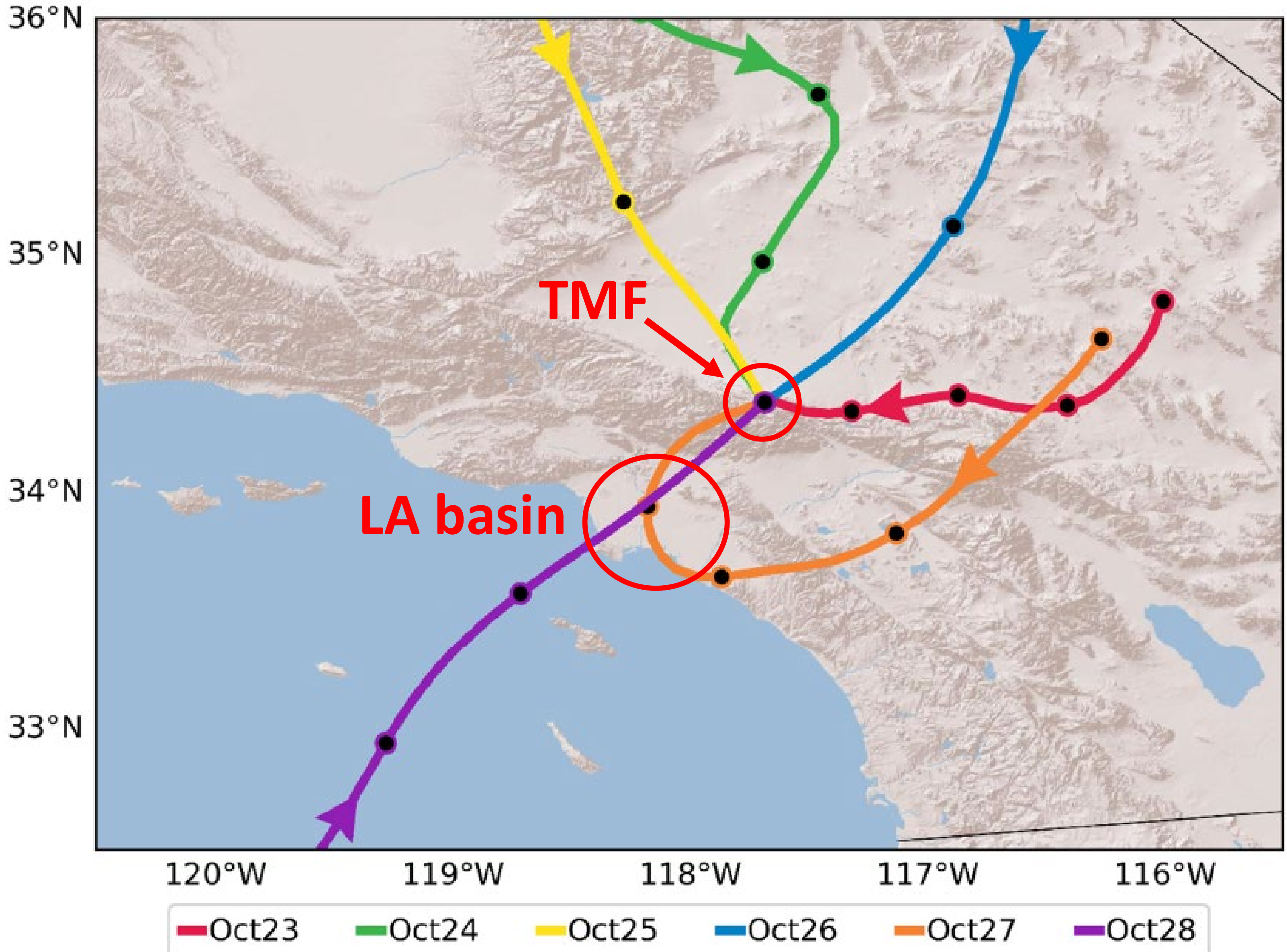
- X-axis is transformed from AMF_i to AMF_i x $VC_o(AMF)$ where the function $VC_o(AMF)$ is derived from the model's *a* priori time-dependence of NO_2
- This transformation results in the correct value of the reference column abundance as determined from the y-intercept

NO_2 Column Model-Measurement Comparison



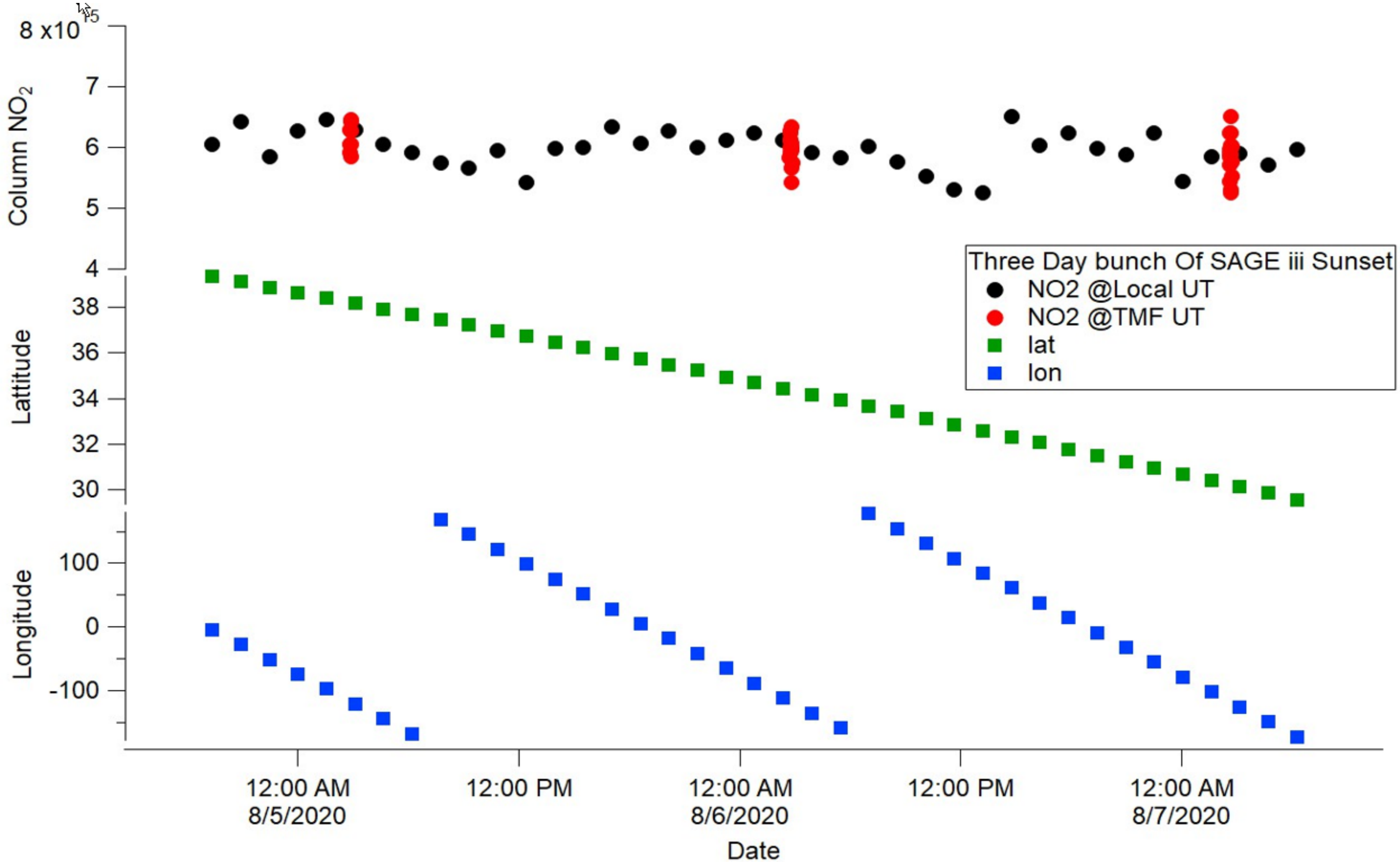
- NO_2 reference column using modified Langley method
- Overall agreement is excellent; First continuous night/day record
- MUGS cannot measure at the exact time of sunrise or sunset due to obstructions
- October 27 daytime data show influence of a polluted air mass

24 Hour Back-Trajectories Reaching TMF at 1500



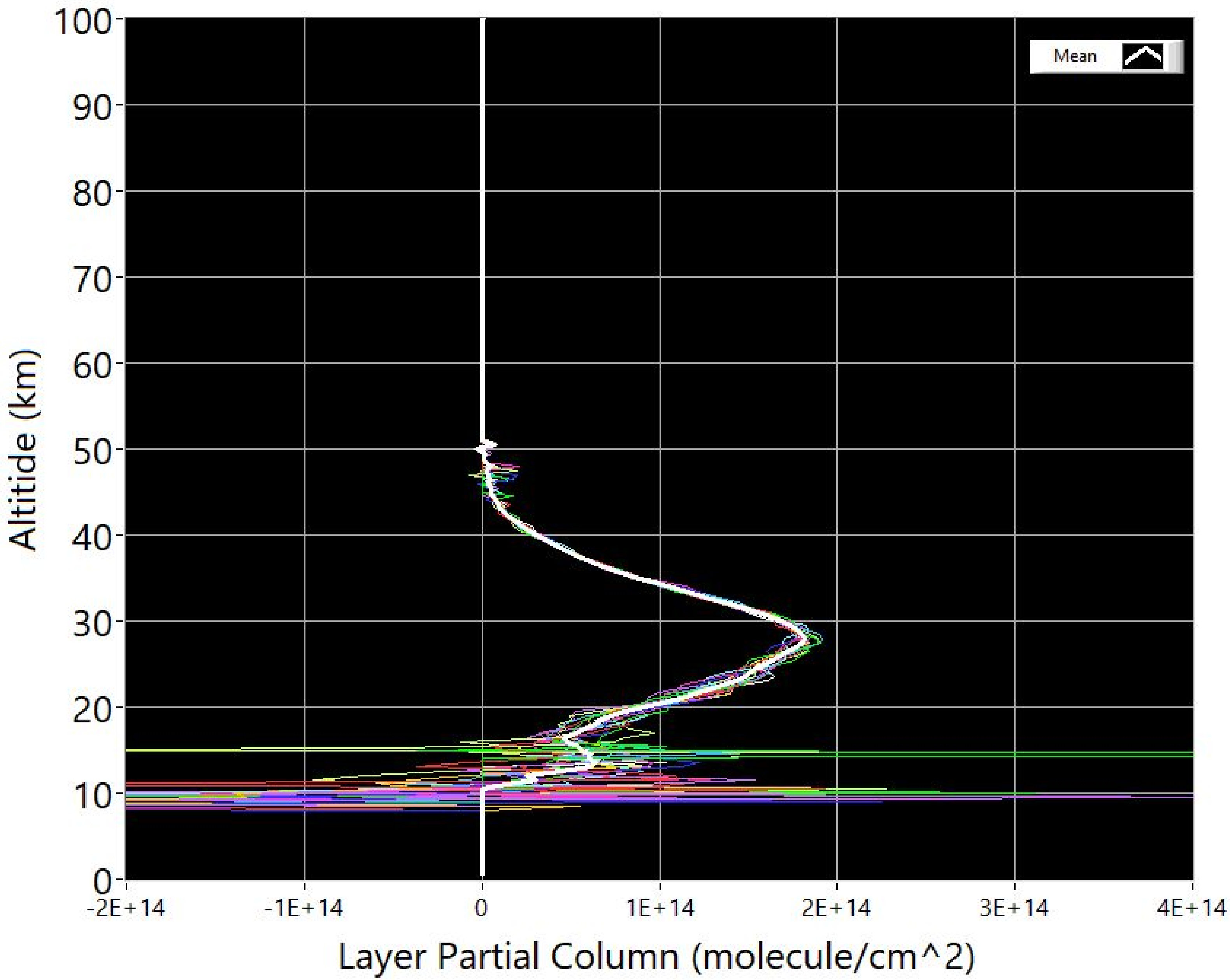
MUGS Comparisons with SAGE-III/ISS

SAGE-III/TMF Coincidences

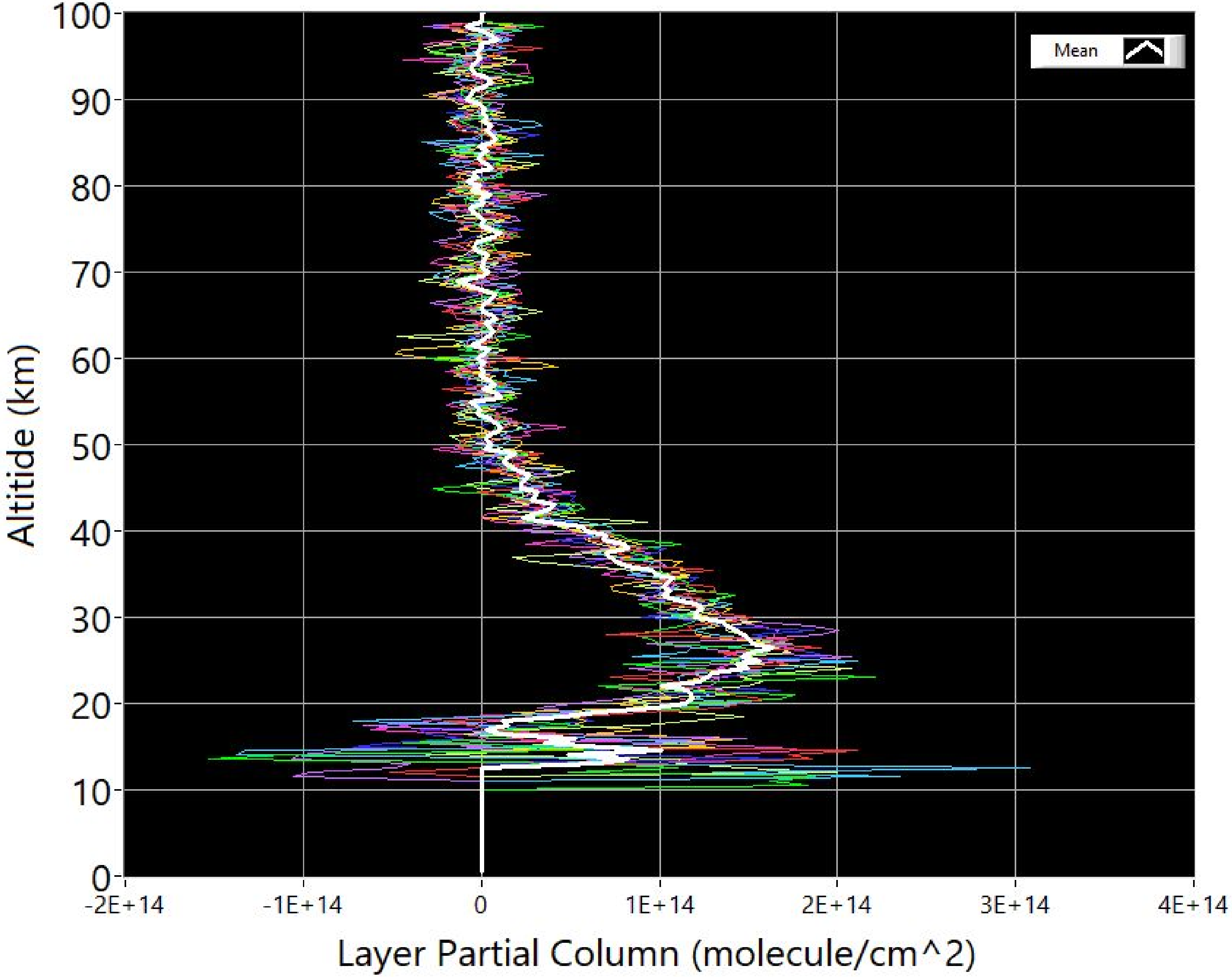


- Exact coincidences between SAGE-III and TMF are exceedingly rare
- We consider coincidences within a global zonal belt ± 5° latitude from TMF (34.4 °N)
- SAGE occultations at other longitudes are converted to TMF local time

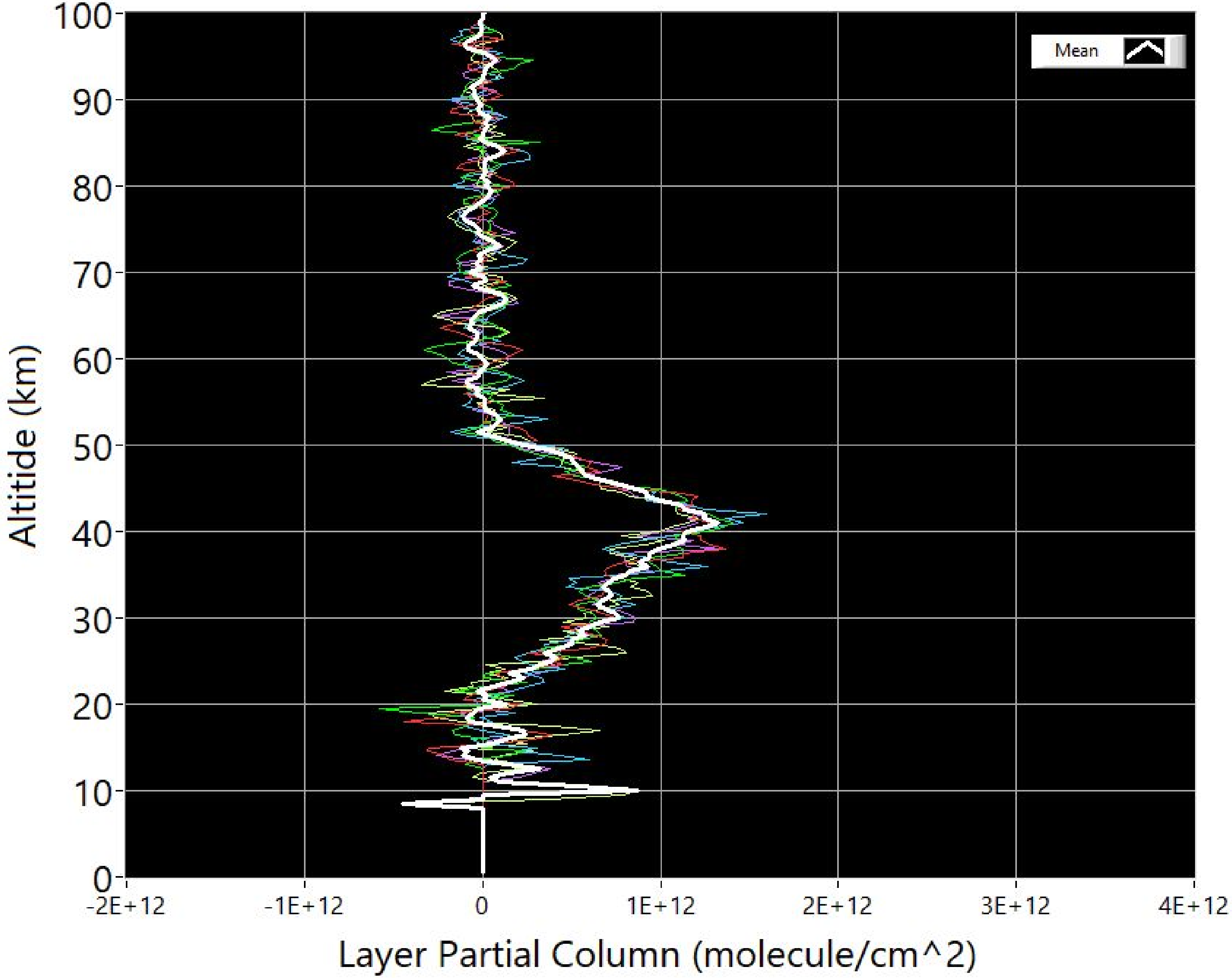
Typical SAGE-III Sunrise NO_2 Profiles (zonal average)



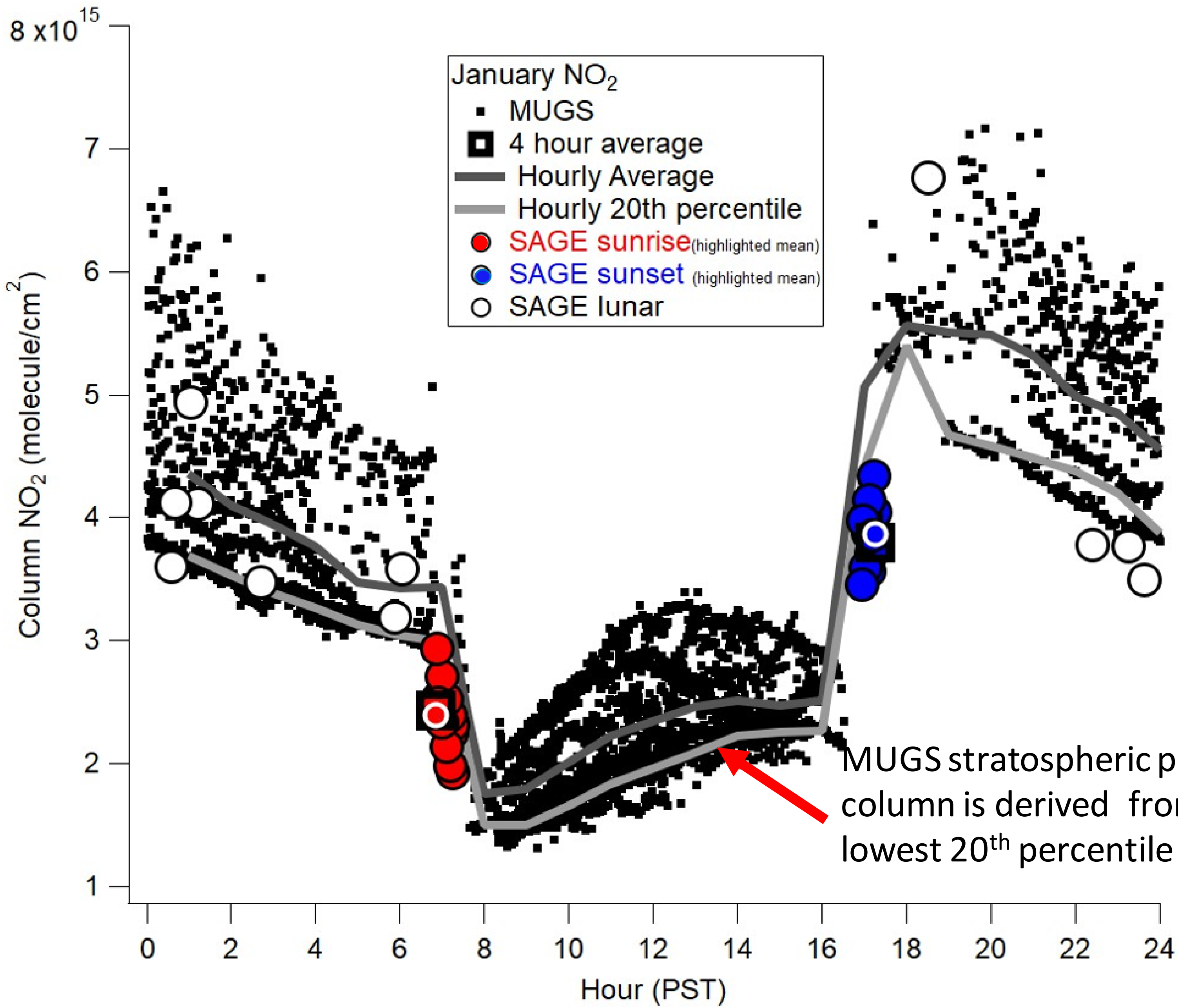
Typical SAGE-III Lunar NO_2 Profiles (zonal average)



Typical SAGE-III Lunar NO_3 Profiles (zonal average)

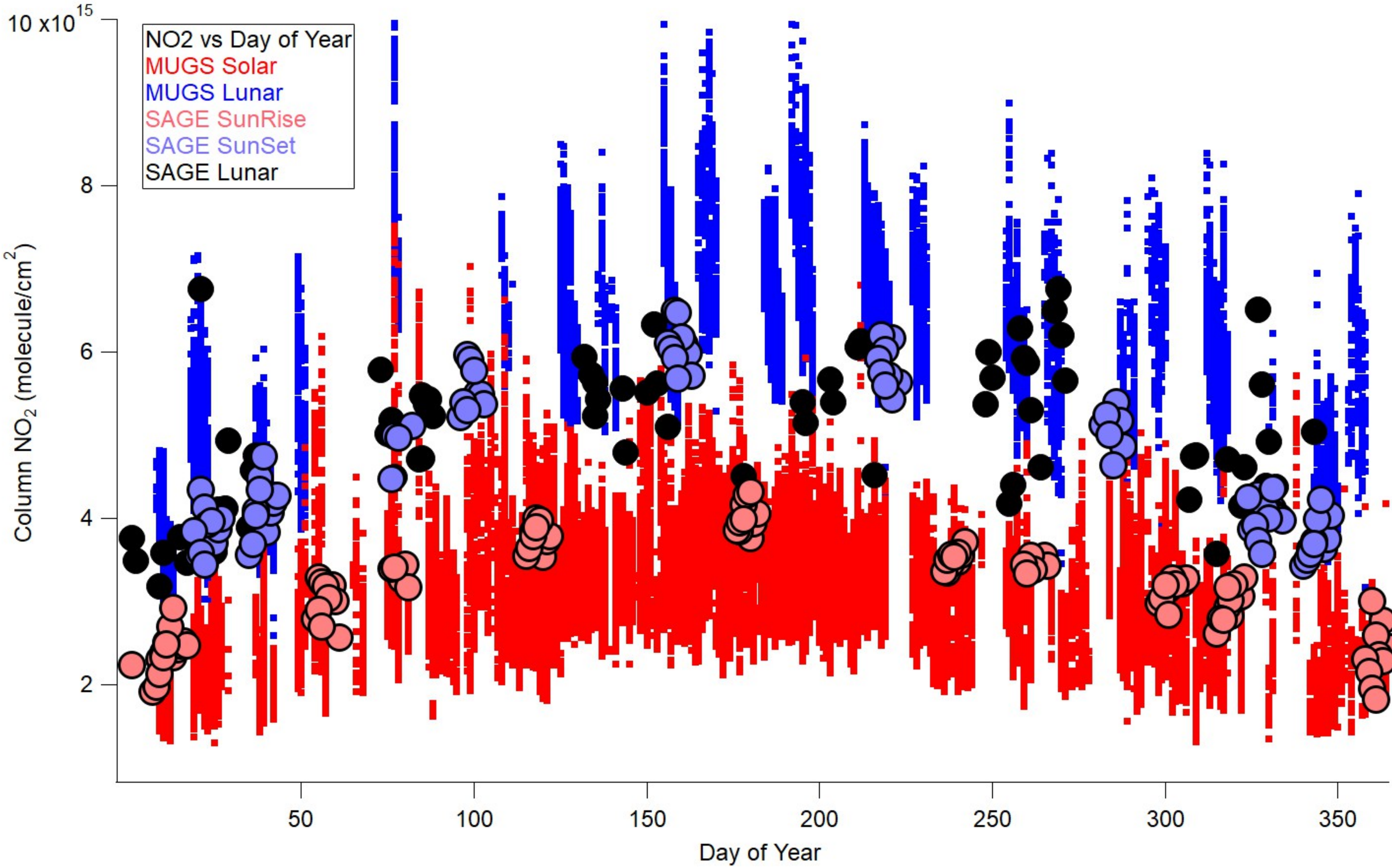


Example SAGE-MUGS NO_2 Comparison: January

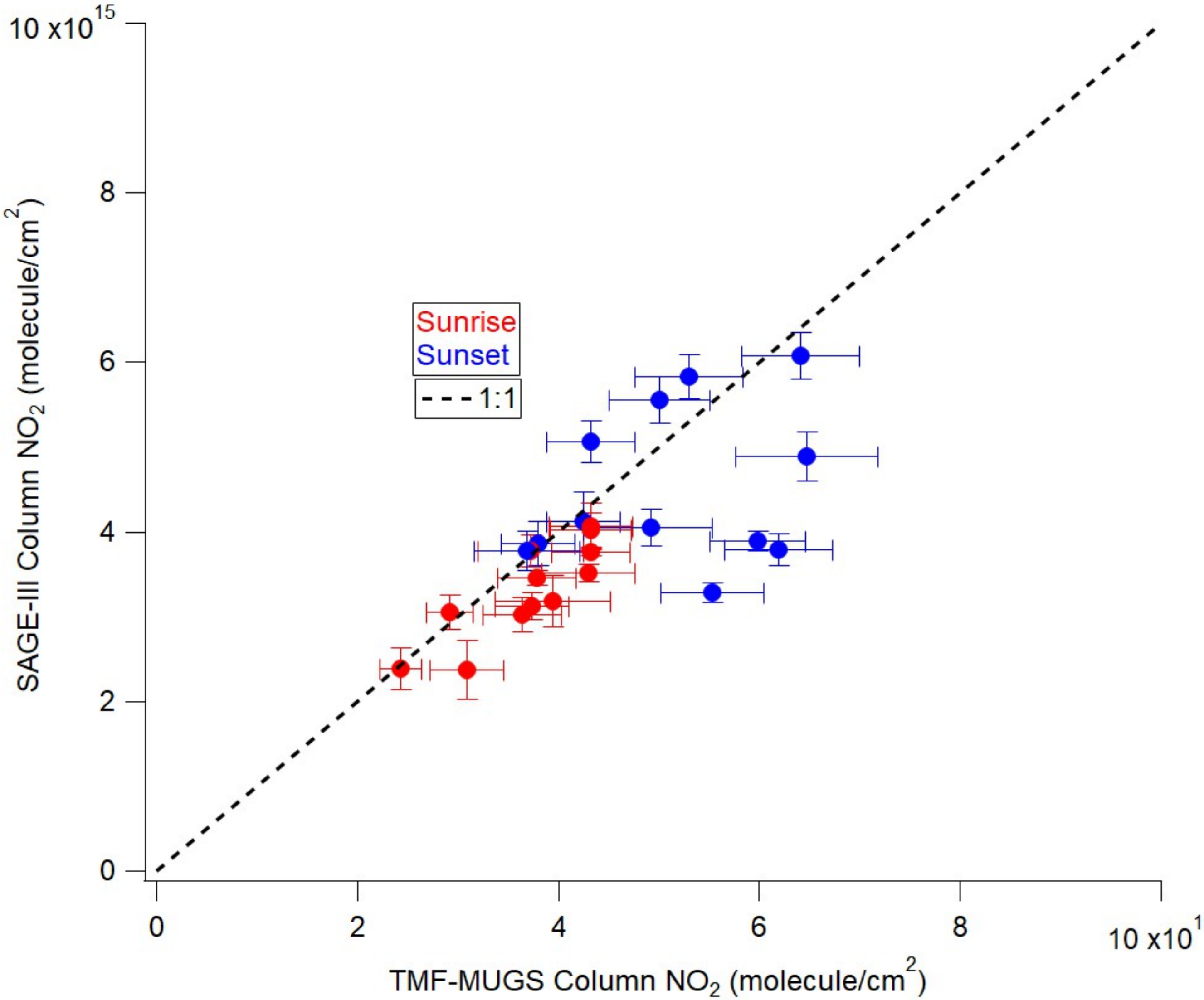


MUGS stratospheric partial column is derived from lowest 20th percentile

SAGE-MUGS NO_2 Comparison: year-over-year



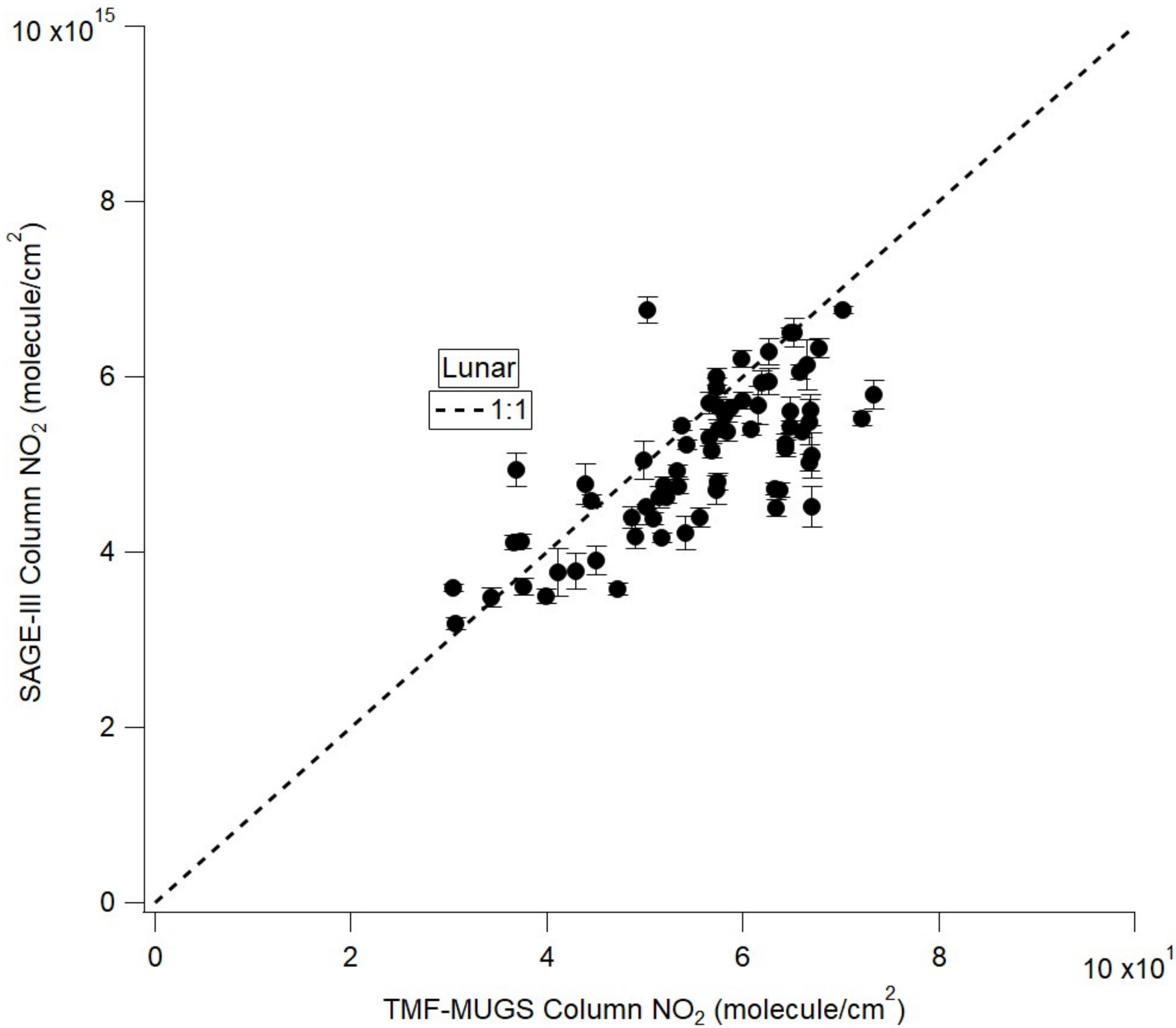
SAGE-MUGS NO_2 Correlation (Solar)



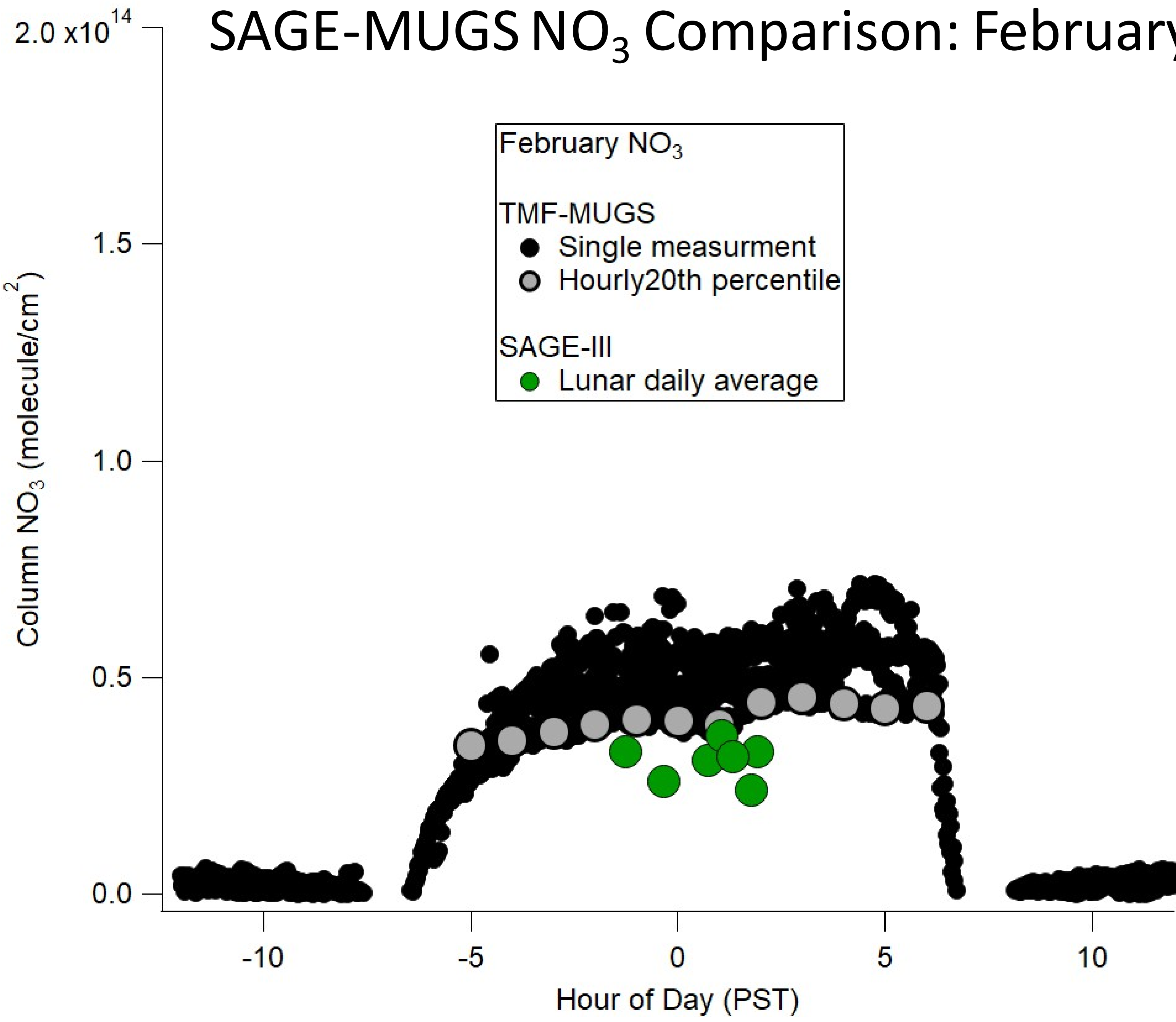
- Scatter plot between monthly averages of SAGE-III columns (z>15 km) and MUGS total columns (± 2 hours from sunset or sunrise, 20th percentile)

SAGE-MUGS NO_2 Correlation (Lunar)

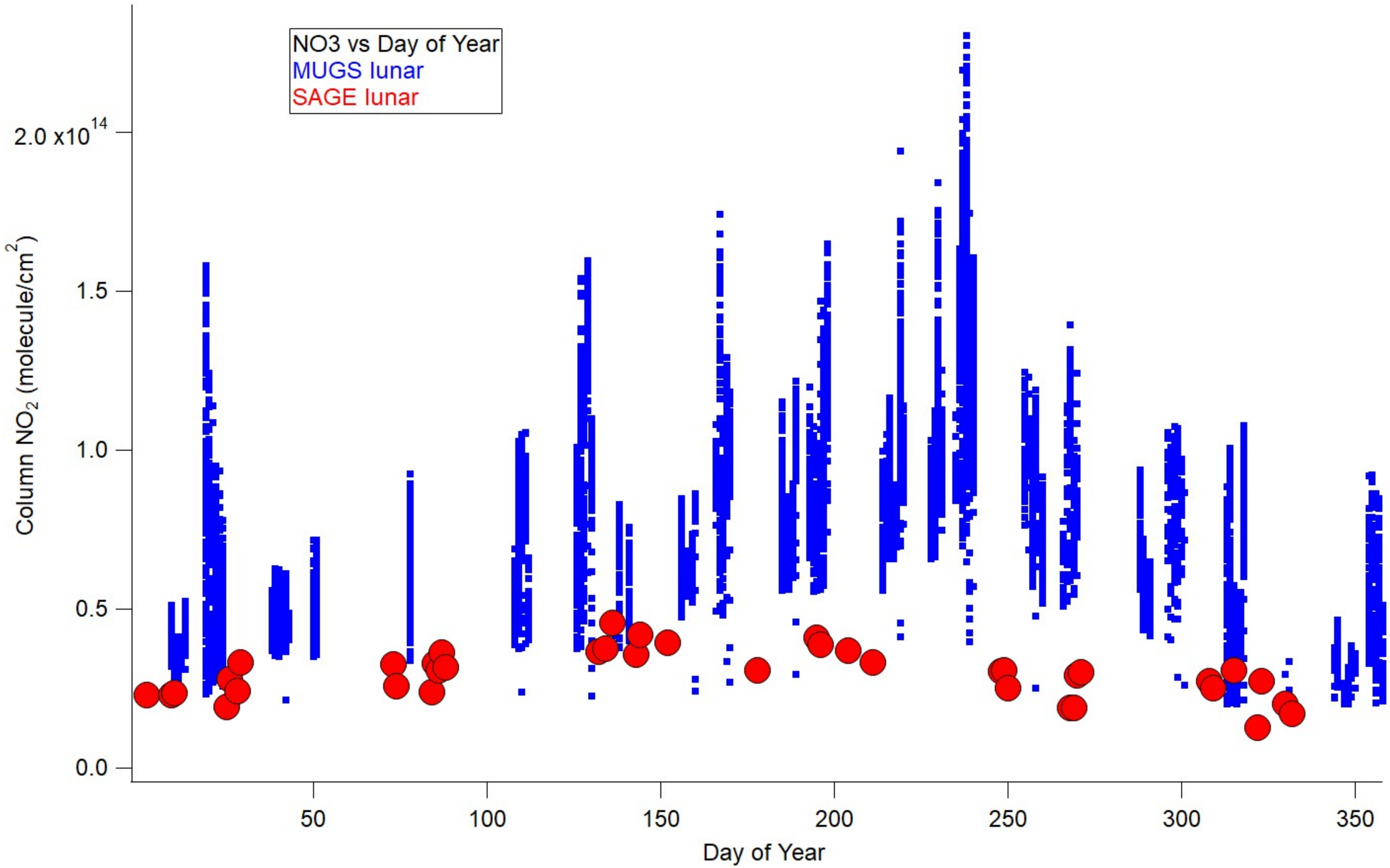
Note: Lunar NO_2 is a research product – not formally released



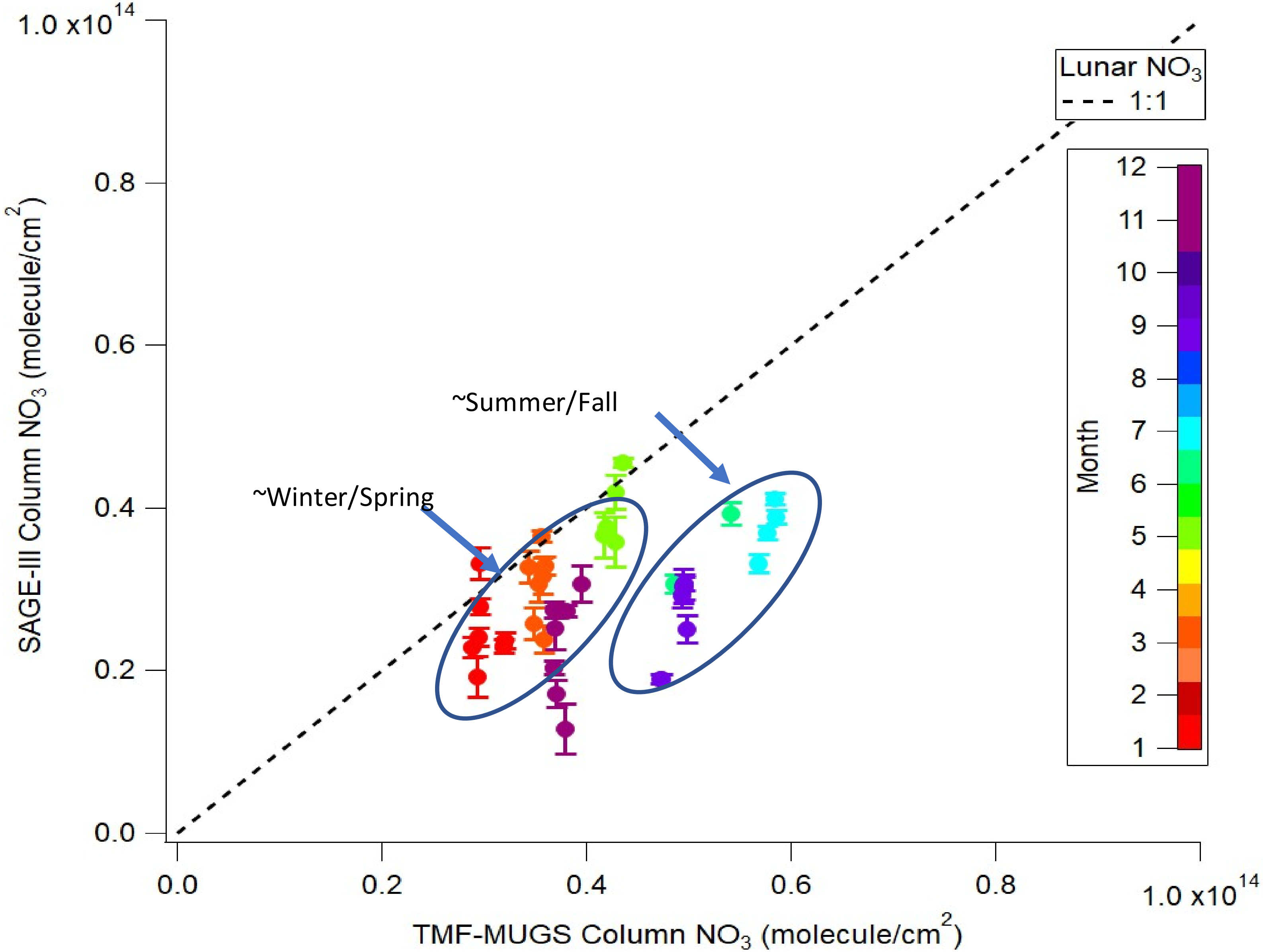
SAGE-MUGS NO_3 Comparison: February



SAGE-MUGS NO_3 Comparison: year-over-year



SAGE-MUGS NO_3 Correlation (Lunar)



Take-Home Points

- Ground-based TMF direct sun/moon total column measurements provide very good comparisons with SAGE-III/ISS stratospheric partial columns because:
    - High altitude (2.3 km) and remote location of TMF minimize PBL pollution contributions to the total column
    - Sorting methods are available to identify measurements (NO_2, NO_3) that contain significant tropospheric contributions.
    - 1-D model provides the nominal tropospheric partial column contributions
- *Preliminary* comparisons between MUGS and SAGE show good correlations for NO_2. NO_3 agrees well in winter/spring, less well in summer/fall
- *Future work* will focus on extending the ground-based climatologies, using the 1-D model for diurnal corrections, working with algorithm team on lunar NO_2 product including cross sections.