The LMD-MGCM (thermosphere-ionosphere)

HELIOSARES meeting

Paris, 28 February 2014

Outline

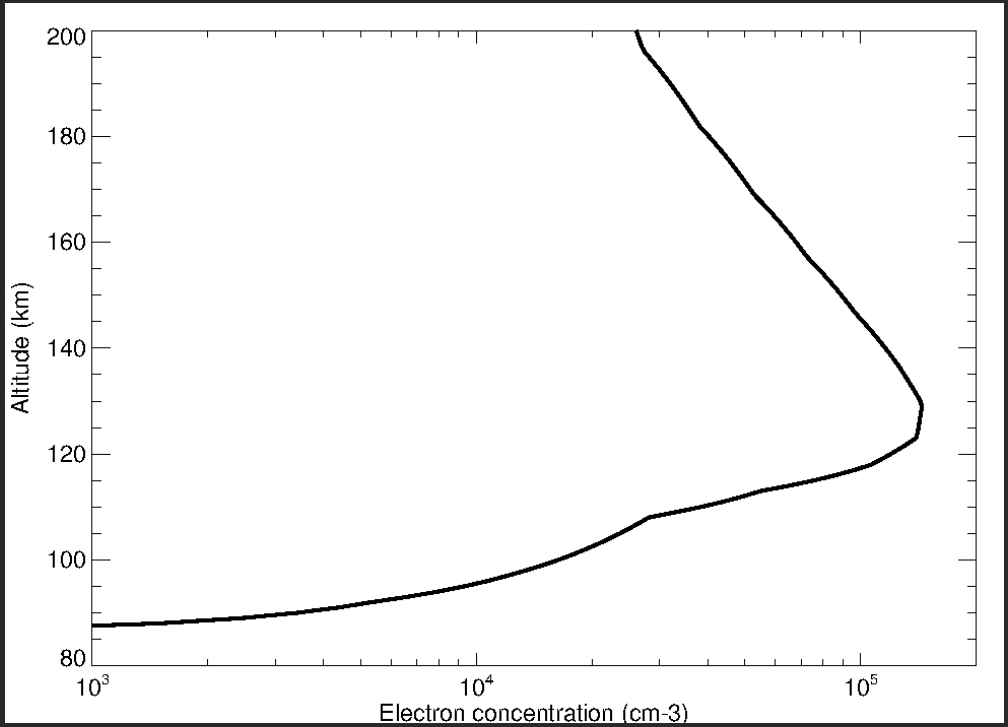
- State of development
- Results
  - Validation
  - Post-terminator ionosphere
  - Thermospheric/ionospheric variability
- Future developments/studies

State of development

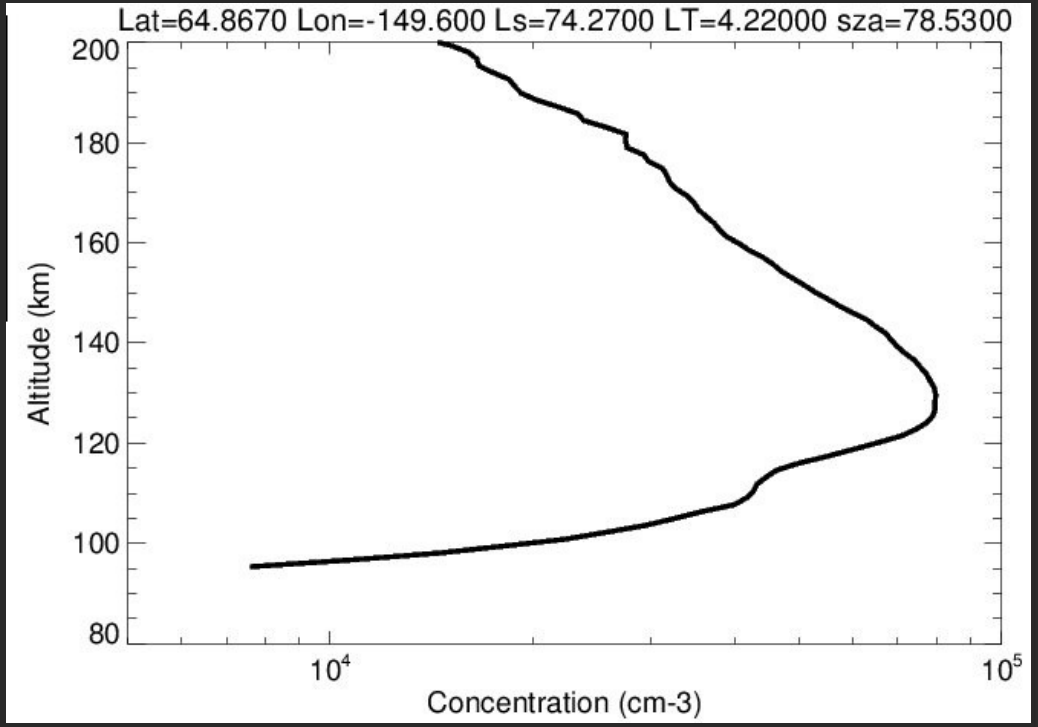
- Thermosphere/ionosphere model fully developed
  - Improvements included within HELIOSARES
    - Coupling of ions with general circulation
    - Updated CO2 photoabsorption cross sections
    - Secondary ionization parametrized using Nicholson et al. 2009
    - New chemical reactions, important for H, added
    - Reaction rates reviewed and updated
    - Reaction rates read from external file
    - Day-to-day observed variability of the EUV solar flux

State of development

Typical electronic profile



GCM, sim.



MGS, obs.

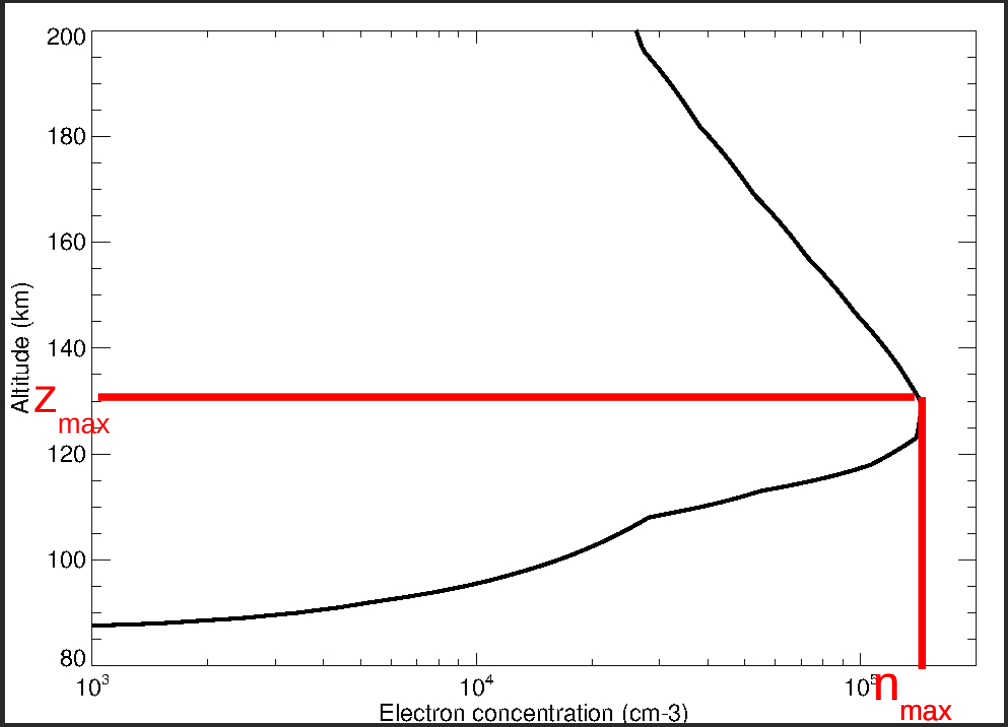
State of development

- Objectives in HELIOSARES fulfilled, with some extra additions
- HELIOSARES Task 3.1: ionospheric developments
  - Coupling with the neutrals ✓
  - Secondary ionization issues ✓
  - X-ray effects (?)
  - Validation ✓
- HELIOSARES Task 3.3.2: inputs for exospheric and magnetospheric models
  - 3D description of thermosphere/ionosphere at 4 seasons for SMAX and SMIN

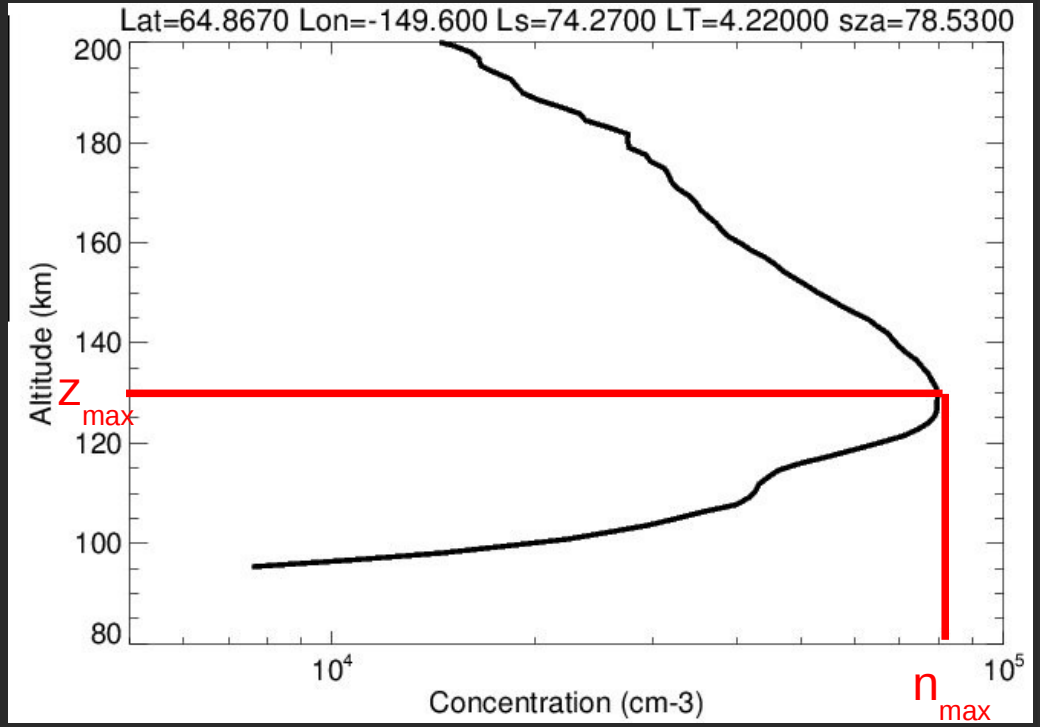
Results: validation

- Comparison with MGS RSS observations
  - Data span MY24-MY27
- Latest version of LMD-MGCM
  - All ionospheric developments
  - Other GCM improvements (NLTE 15 um cooling)
- Simulations covering the observing periods
  - Observed dust load
  - Observed day-to-day variability of UV solar flux
- Results interpolated to same time and location of each MGS ionospheric observation

Results: validation



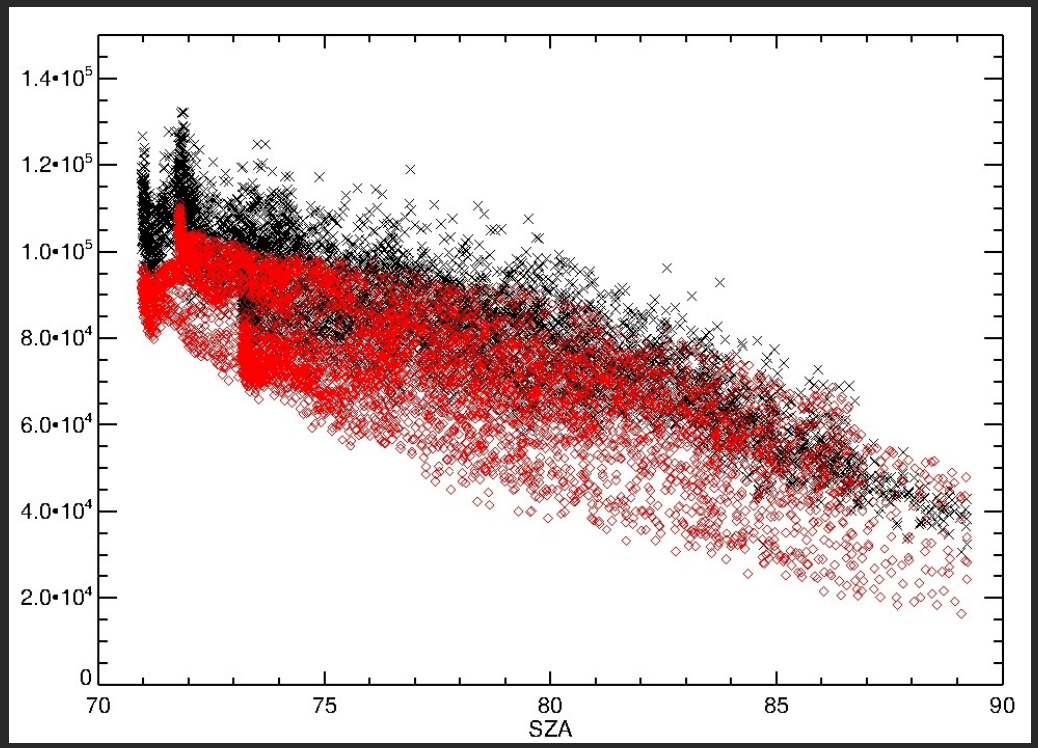
GCM, sim.

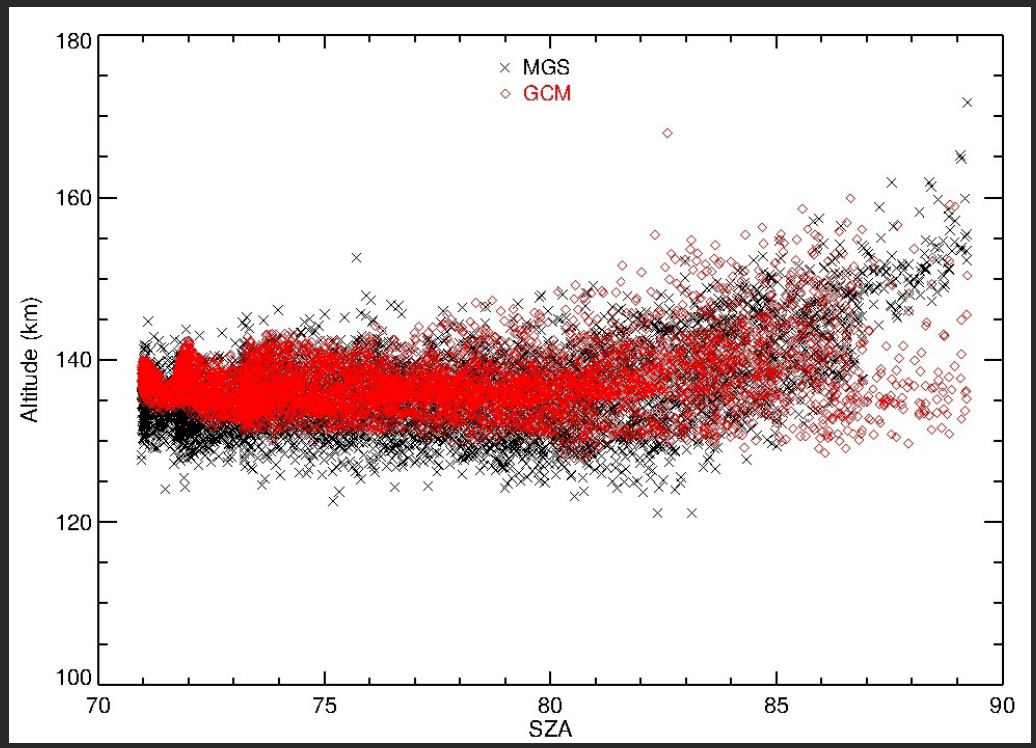


MGS, obs.

Results: validation

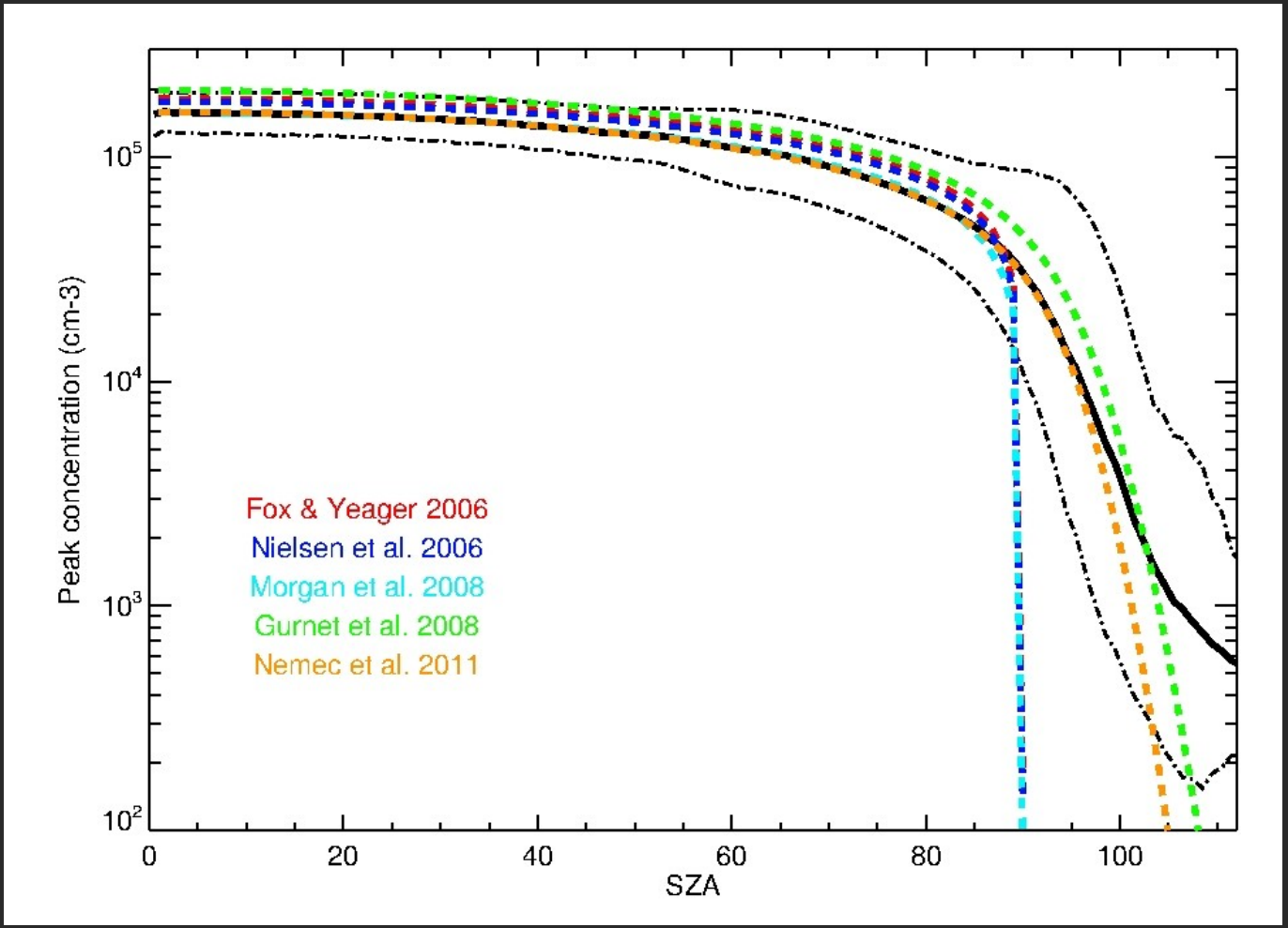
Comparison for the full MGS dataset





- Average diff. peak electronic conc: 13.6%
- Average diff. peak altitude: 1.1 km

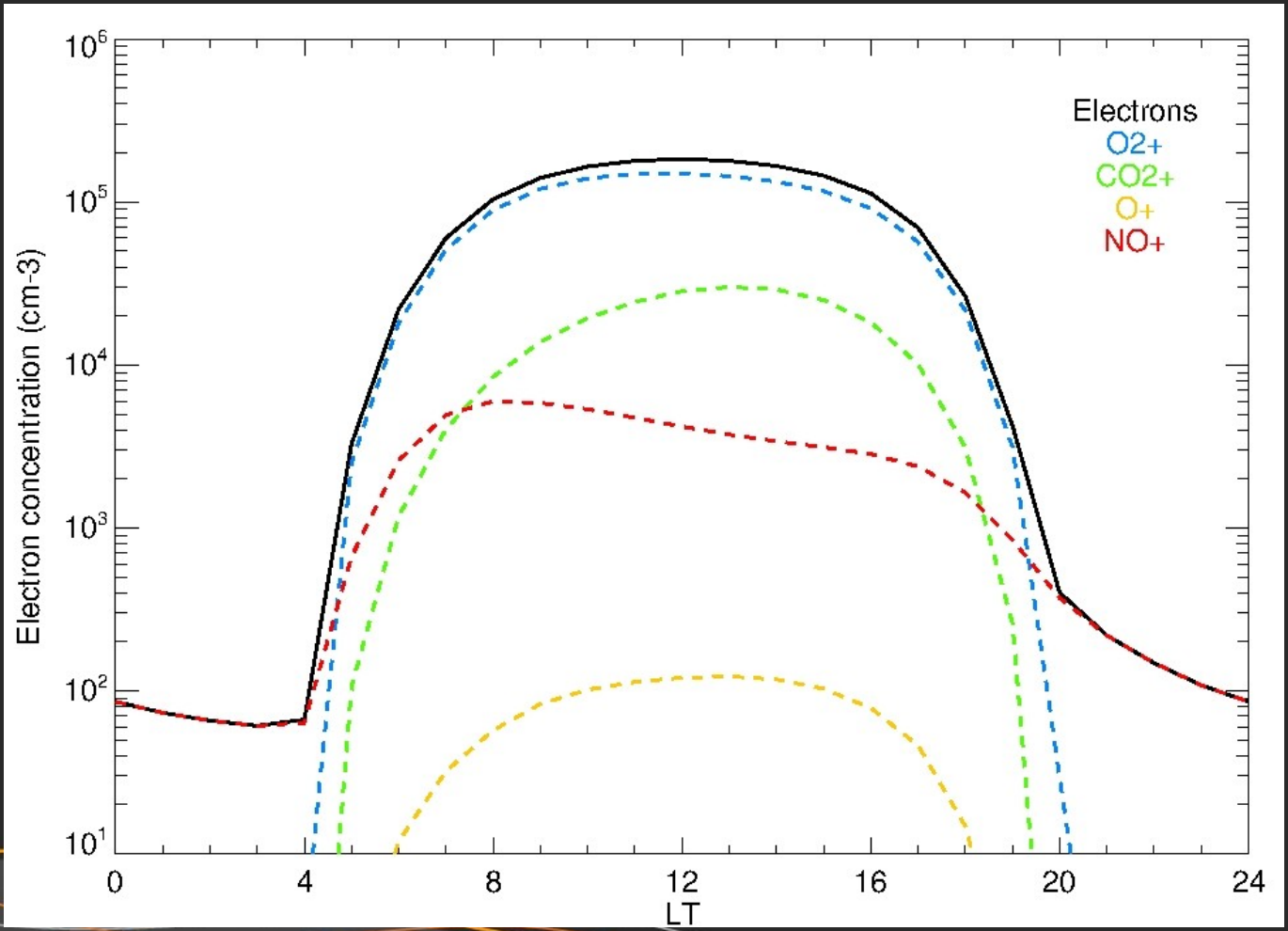
Results: validation (MARSIS)



- Good agreement up to SZA≈100
- Above SZA≈100 fits to the data are not valid

Results: post-terminator ionosphere

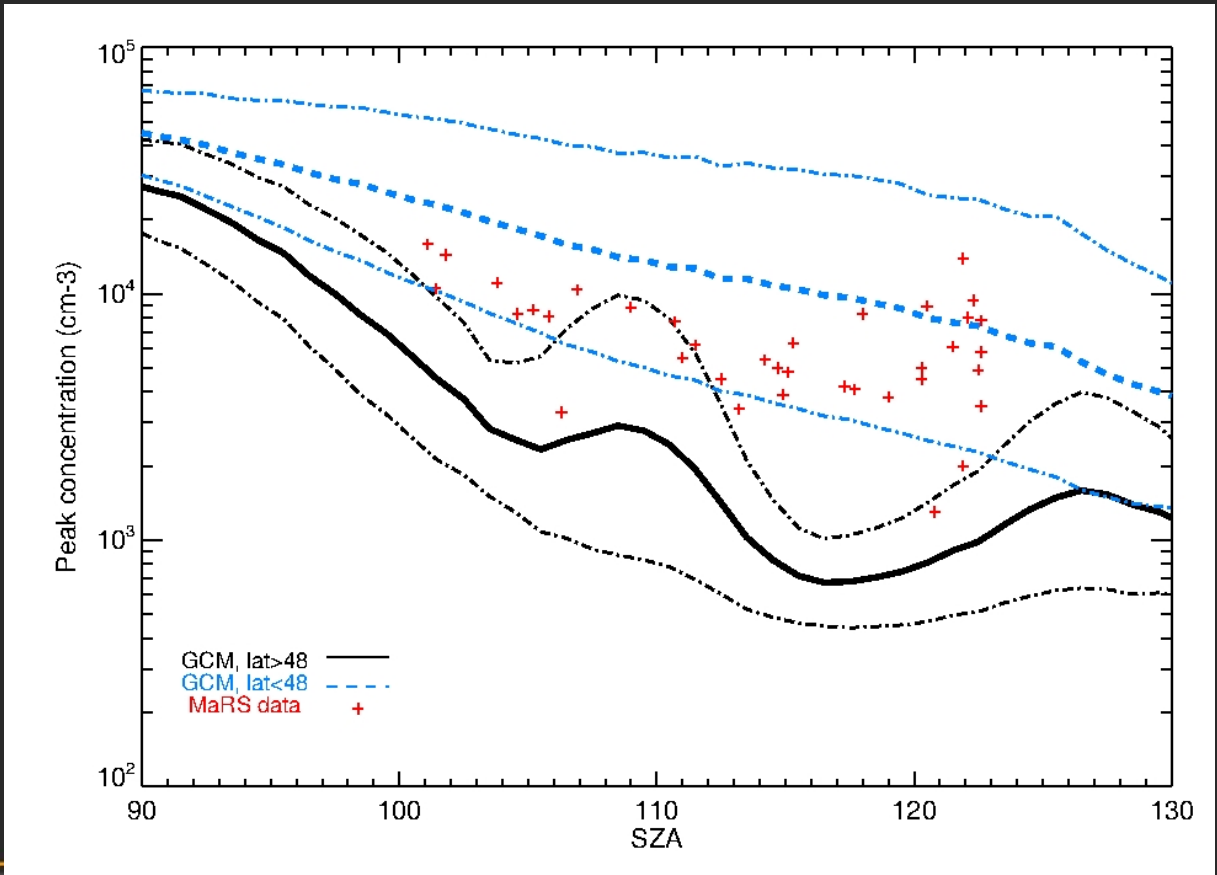
LT variability and ionospheric composition (120 km)



O2+ CO2+ NO+ O+

Results: post-terminator ionosphere

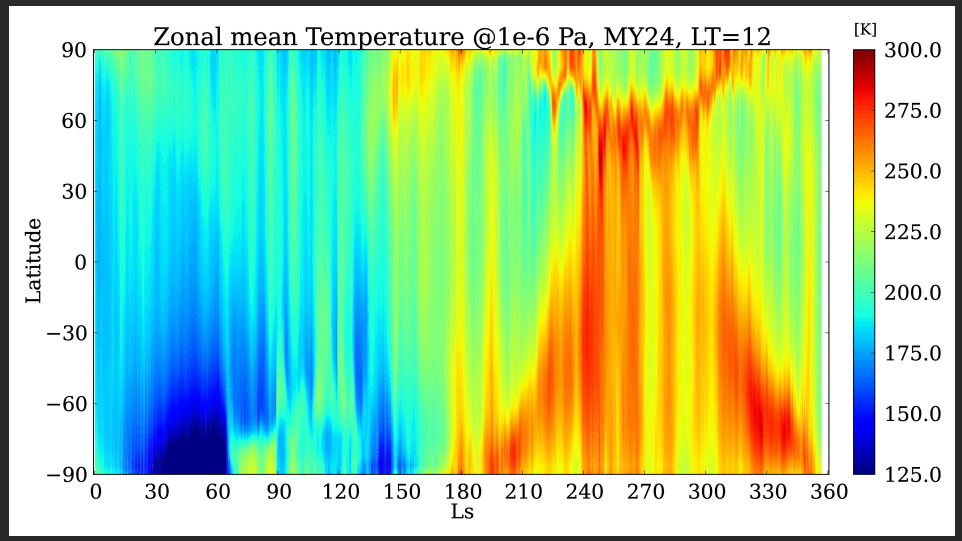
Comparison with MaRS data (Withers et al. 2013)



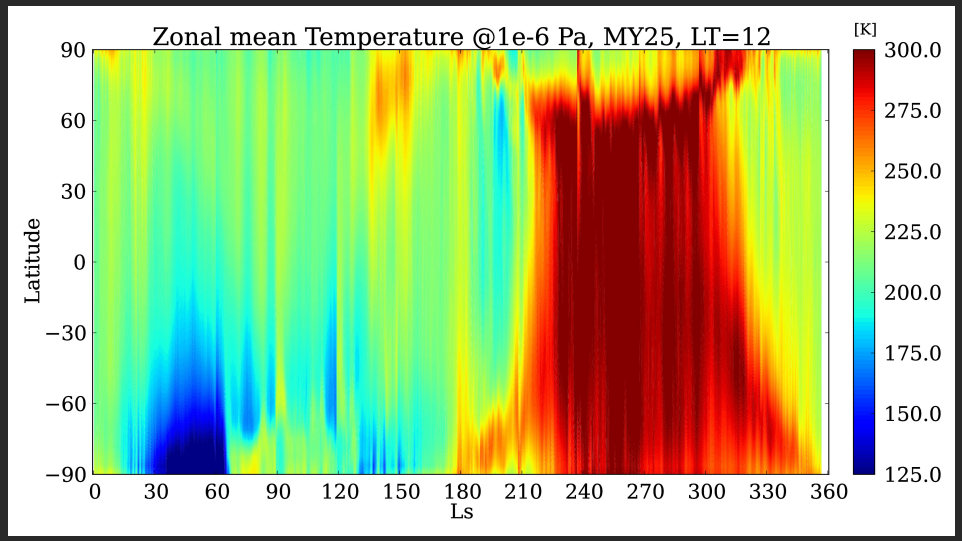
- Plasma dynamics could improve agreement ?

Results: 7 MYs climatology

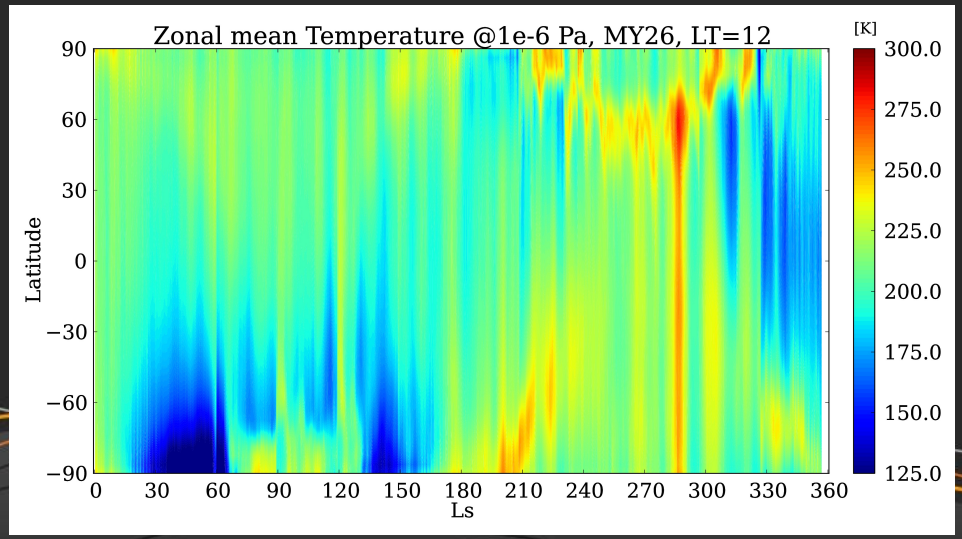
MY24



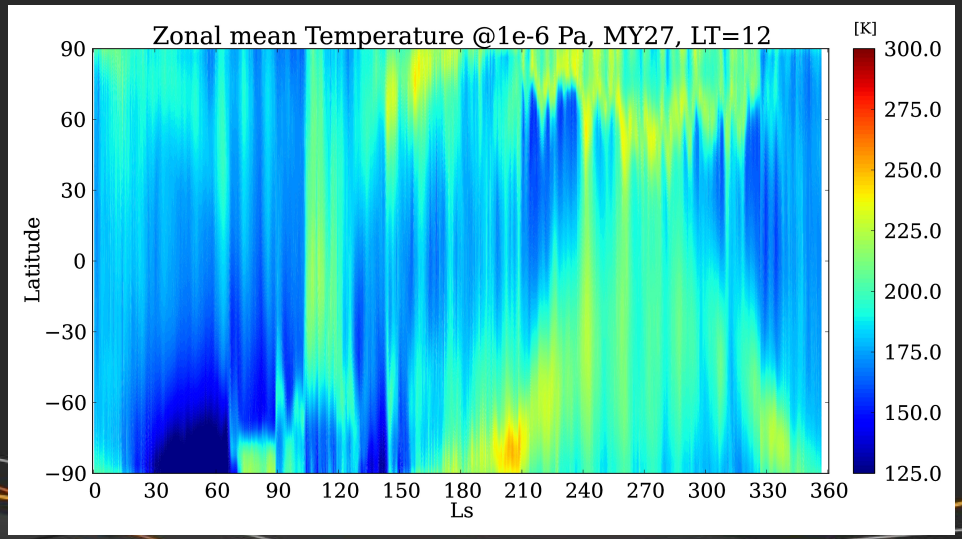
MY25



MY26

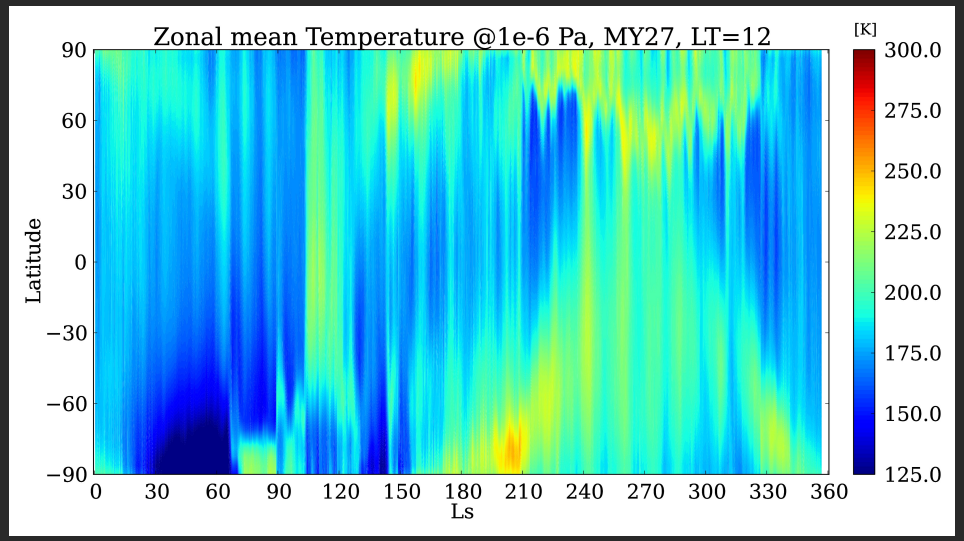


MY27

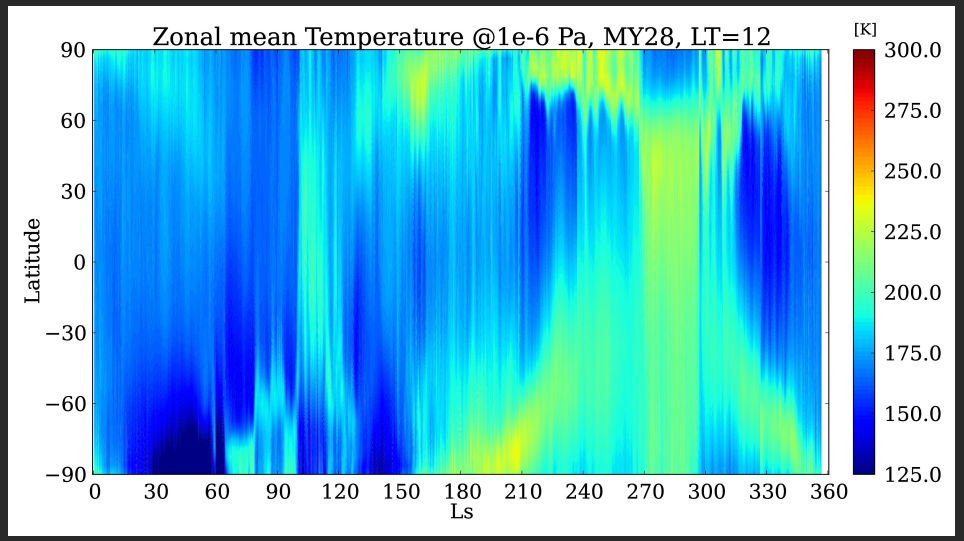


Results: 7 MYs climatology

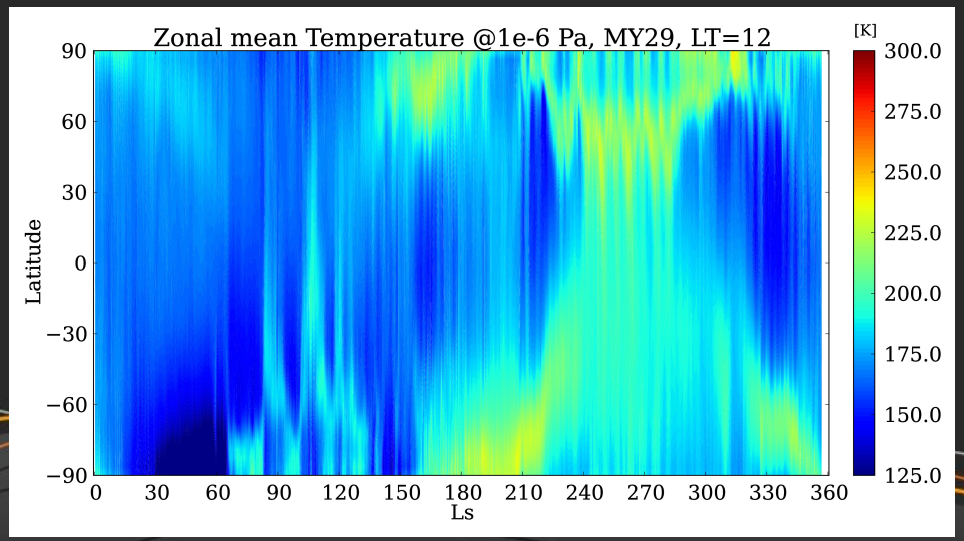
MY27



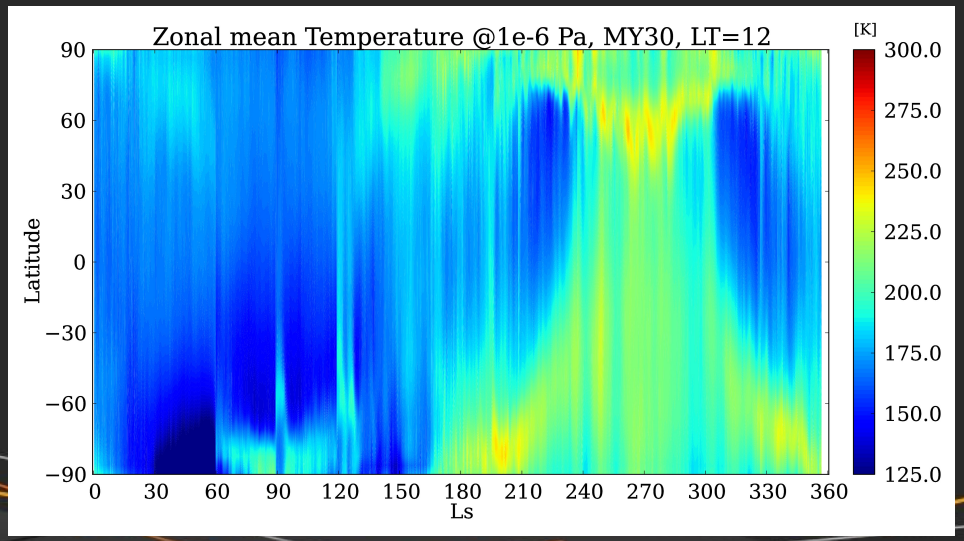
MY28



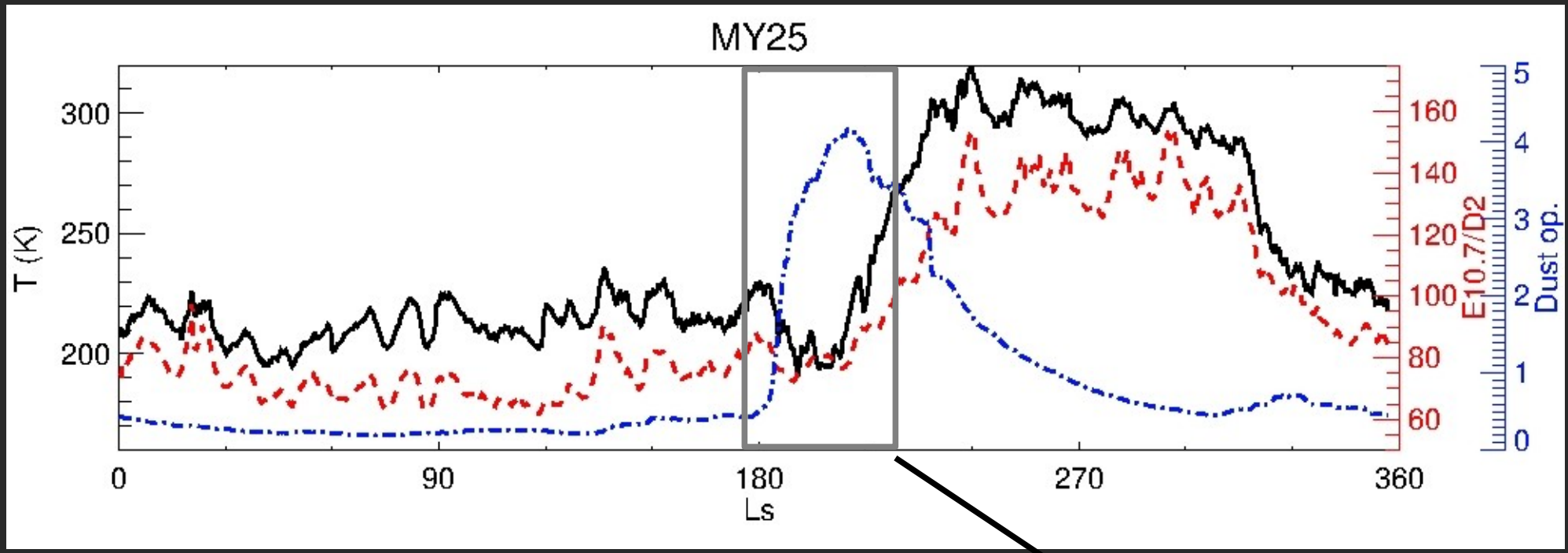
MY29

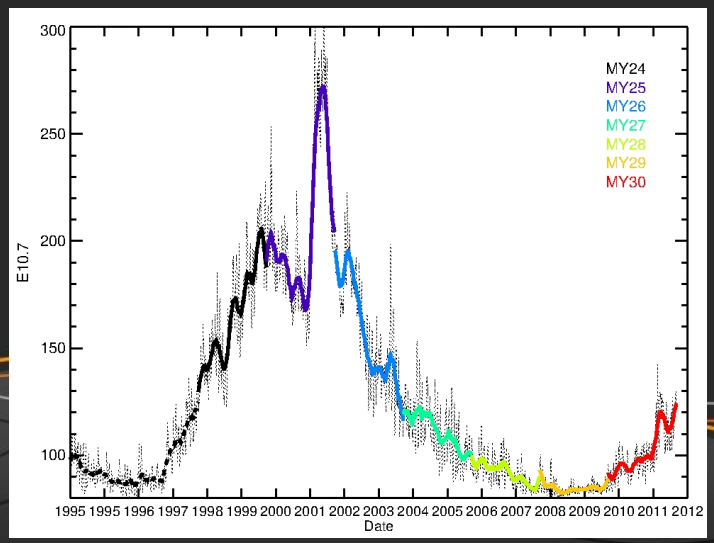


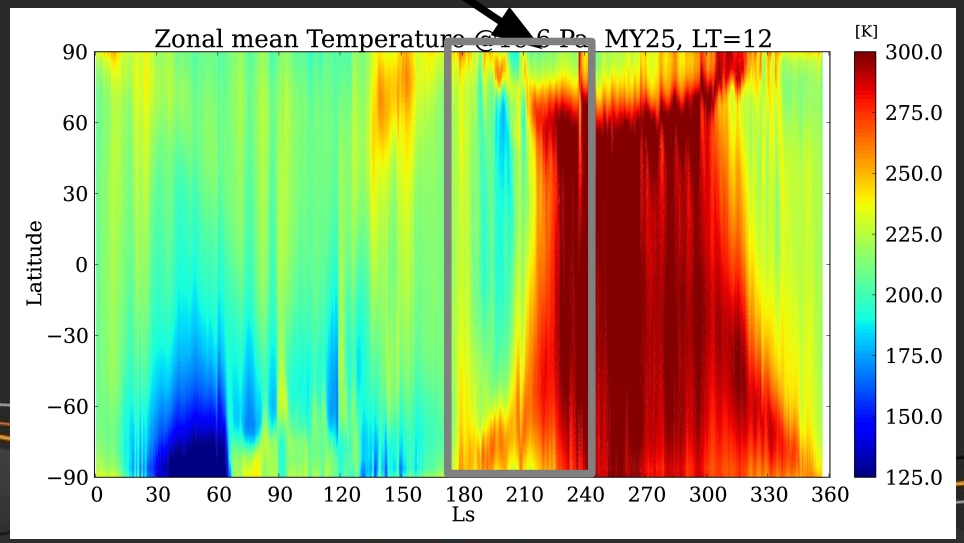
MY30



Results: 7 MYs climatology







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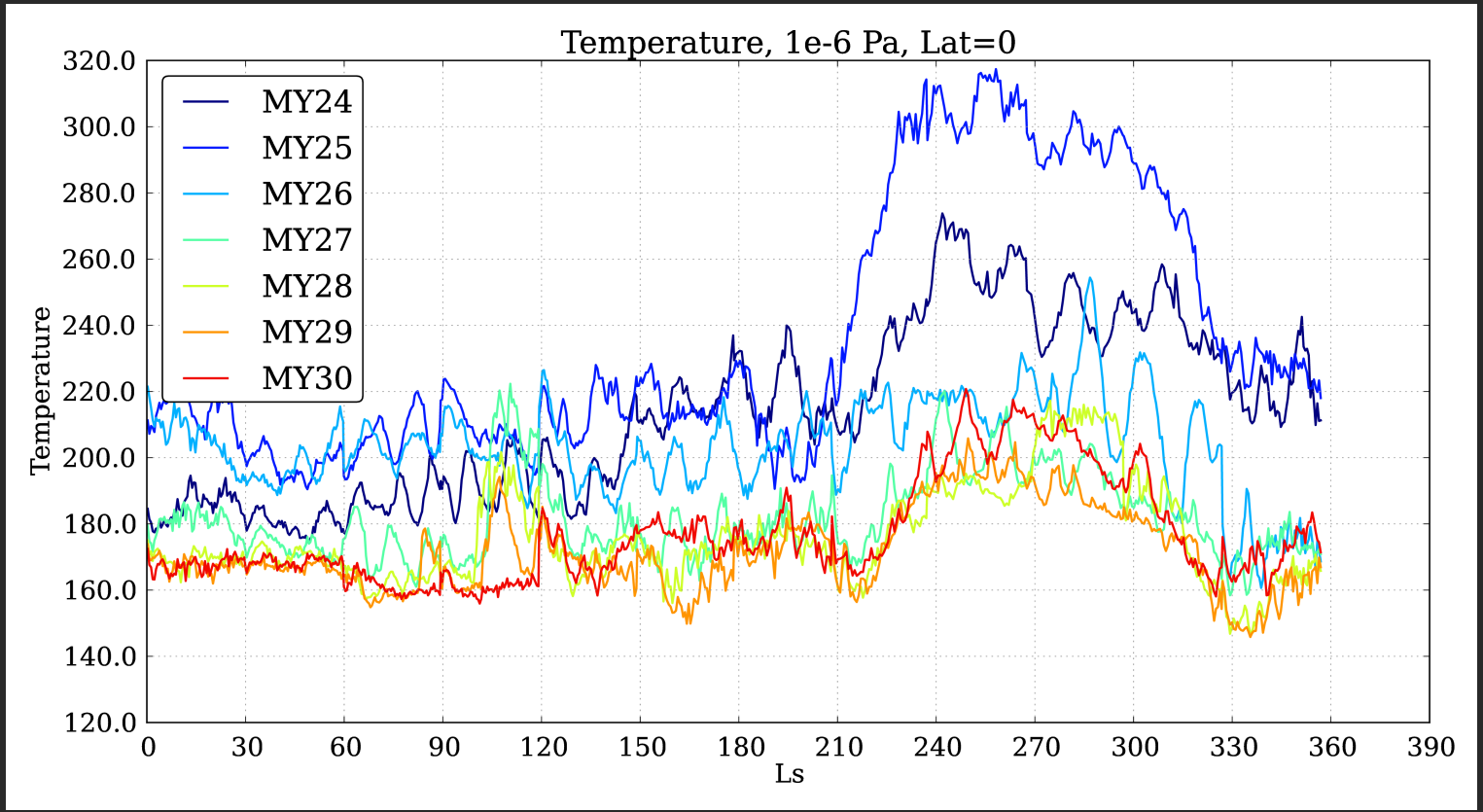
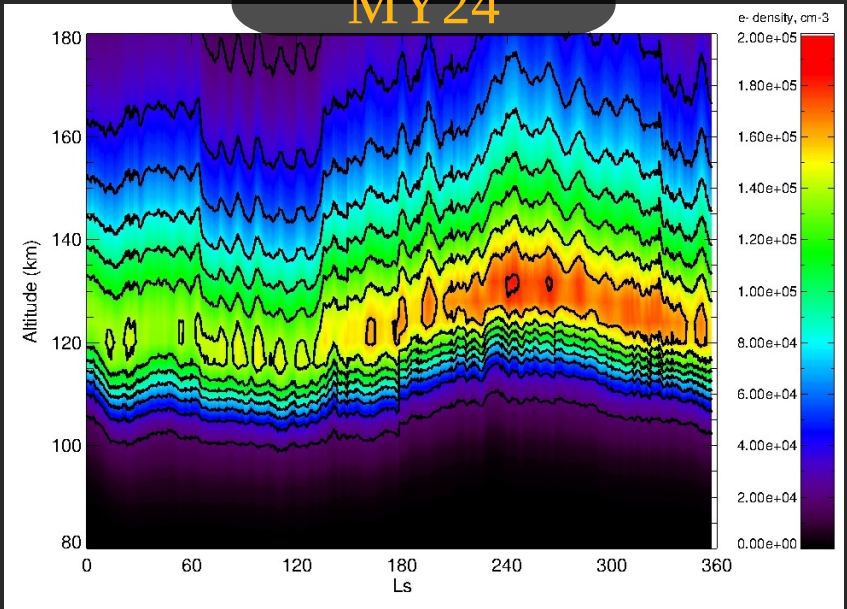


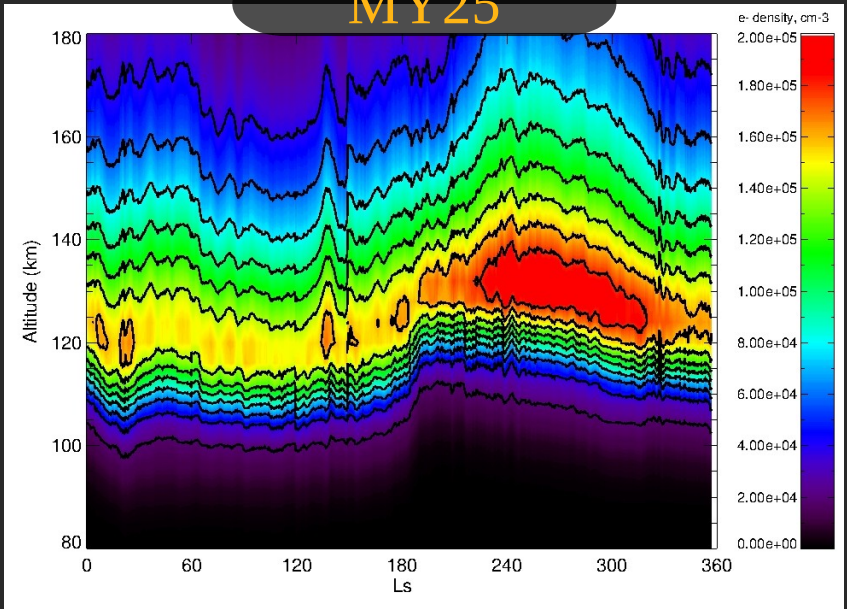
- Interannual variability ranges from about 50 K during first half of the year to about 140 K at the perihelion season

Results: 7 MYs climatology

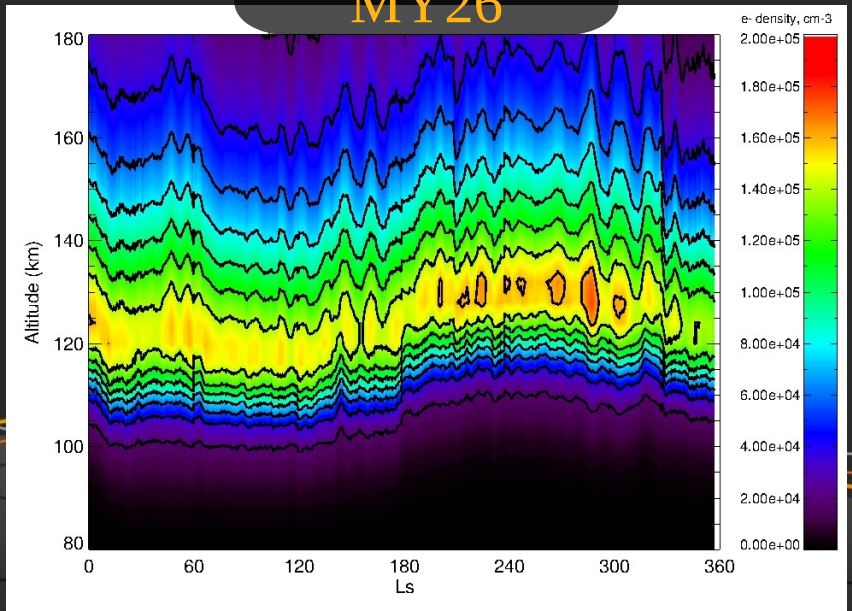
MY24



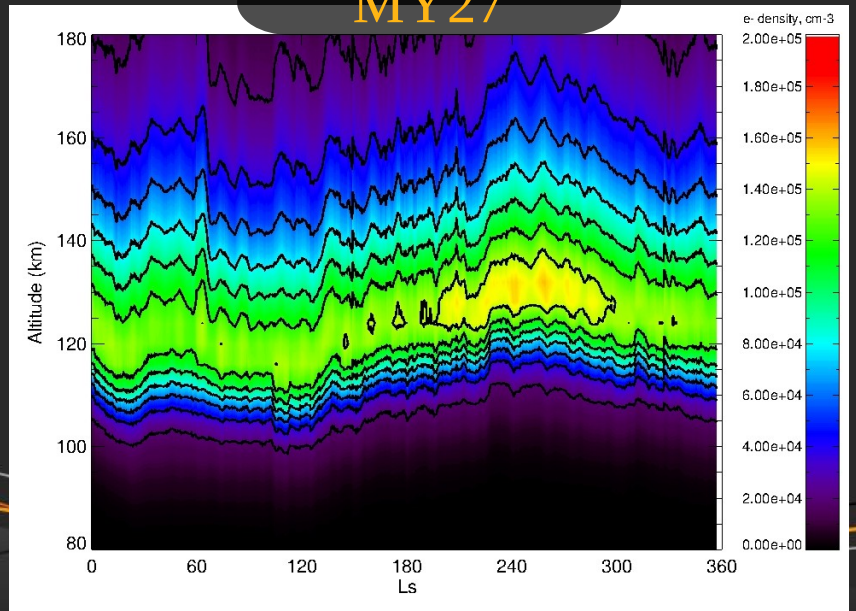
MY25



MY26



MY27



Future work

- Publish, publish, publish...
  - Post-terminator ionosphere ?
  - Ionospheric climatology ?
- Add ionospheric reactions important for H
- Refine description of x-rays
- Photoelectrons (important for airglow) ?