Abstract

The SABER/TIMED pressure and temperature, which are currently available in the SABER v2.0 database, were retrieved using radiances measured in the 15 μm CO_2 band in combination with the WACCM model CO_2 distribution.

We have developed a rigorous non-LTE, self consistent, two-channel, simultaneous retrieval of pressure, temperature and CO_2 density from SABER daytime broadband limb 15 and 4.3 μm radiances. Twelve years of simultaneous temperature/pressure/CO_2 profiles have been produced thus far in a post processing mode, where the two-channel methodology is applied to measured radiances. These new results for various latitudes and seasons as well as their comparisons with model results are for the first time displayed and discussed here. After proper validation these retrievals are supposed to replace currently available p, CO_2 (WACCM) and temperature data.

Results: exploratory view

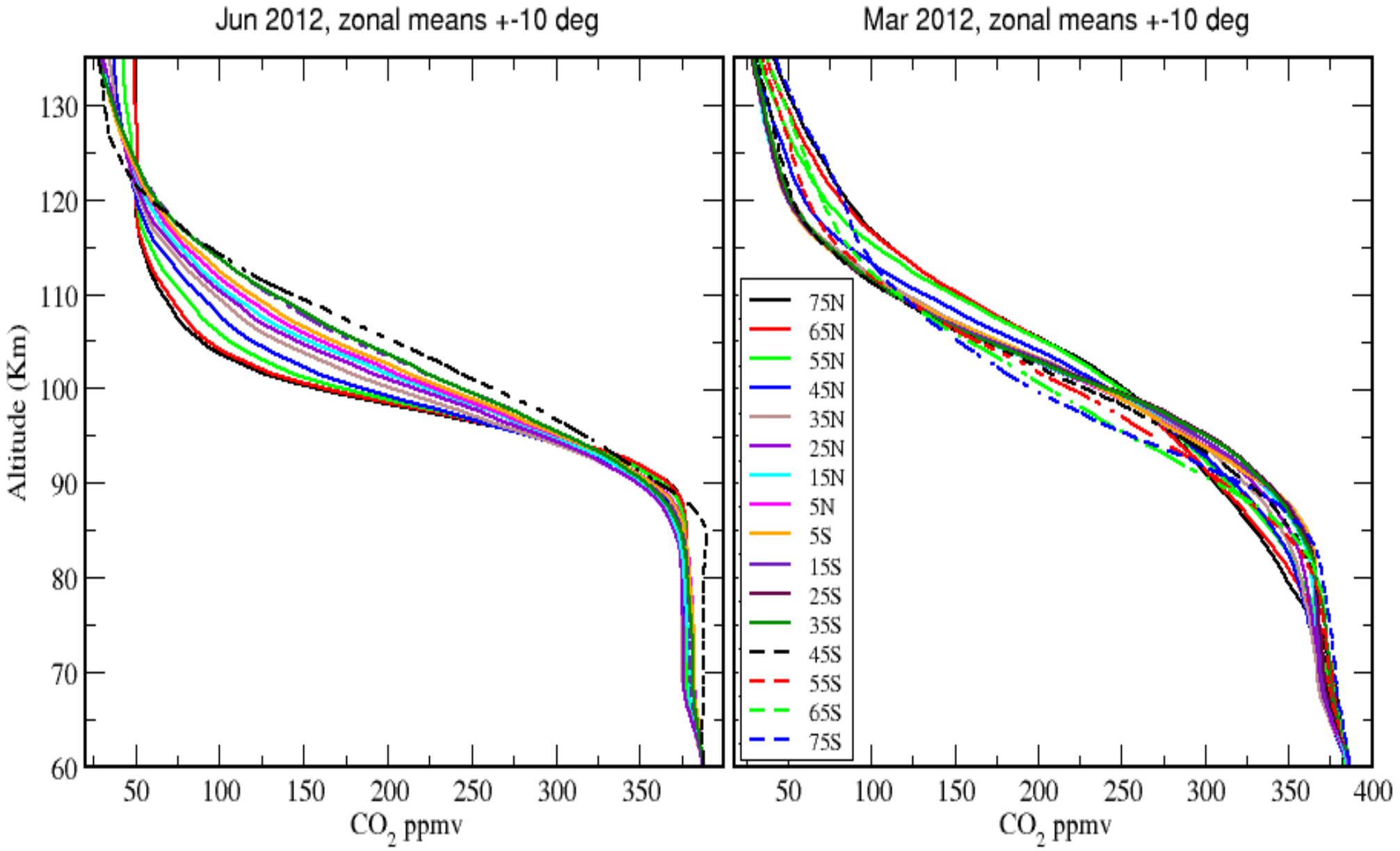
Details of new 2-channel retrieval algorithm

- *Algorithm*: non-LTE forward fit.
- Both T and CO_2 are fitted at all altitudes at once, with iterative switching between the channels (not "onion peeling")
- On average 6-10 iterations are needed.
- acceleration of convergence by accounting for the *downward shifting of signal sensitivity on limb* [Rezac et. al. 2011].

Optimized forward model:

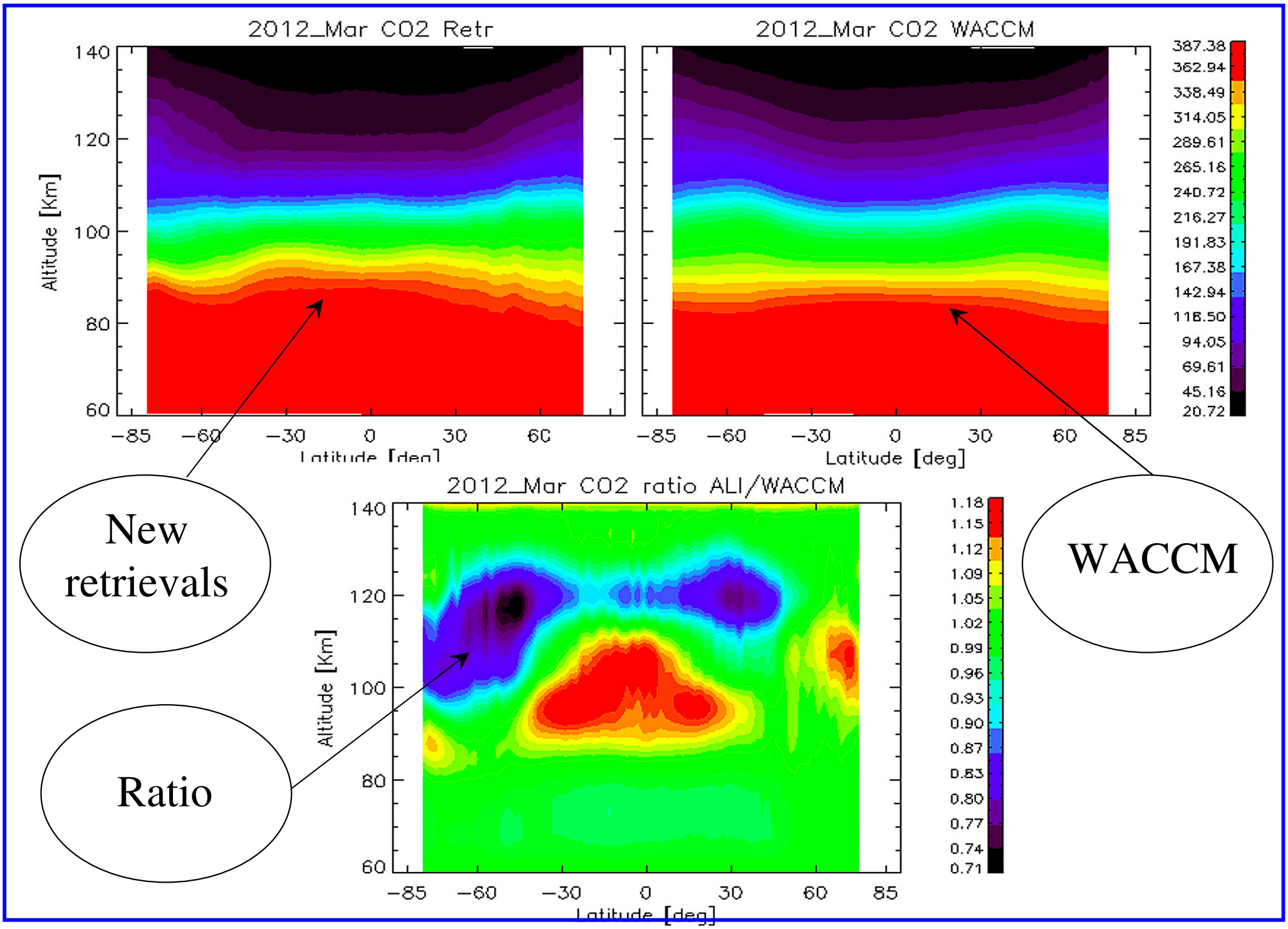
- 15 μm (Ch1, T retrieval): 36 bands; 4.3 μm (Ch7, CO_2): 25 bands (including earlier neglected FH, SH bands of 628 important up to ~65km).
- Limb radiance: LBL , line overlapping (important up to 80-87 km in Ch7 for equator and polar summer)
- non-LTE population updated at each iteration: ALI-ARMS/ODF code package [Feofilov and Kutepov, 2012] applied with RT optimized utilizing the opacity distribution functions (ODF) for both 15 and 4.3 μm transition (speed up factor of ~100 - 200).
- *Retrieval range:* T: 65-120 km, smooth transition to WACCM at 125-140 km; CO_2: 65-135 km, smooth transition into WACCM at 125 km.

Mean CO_2 (Lat-Alt), Equinox

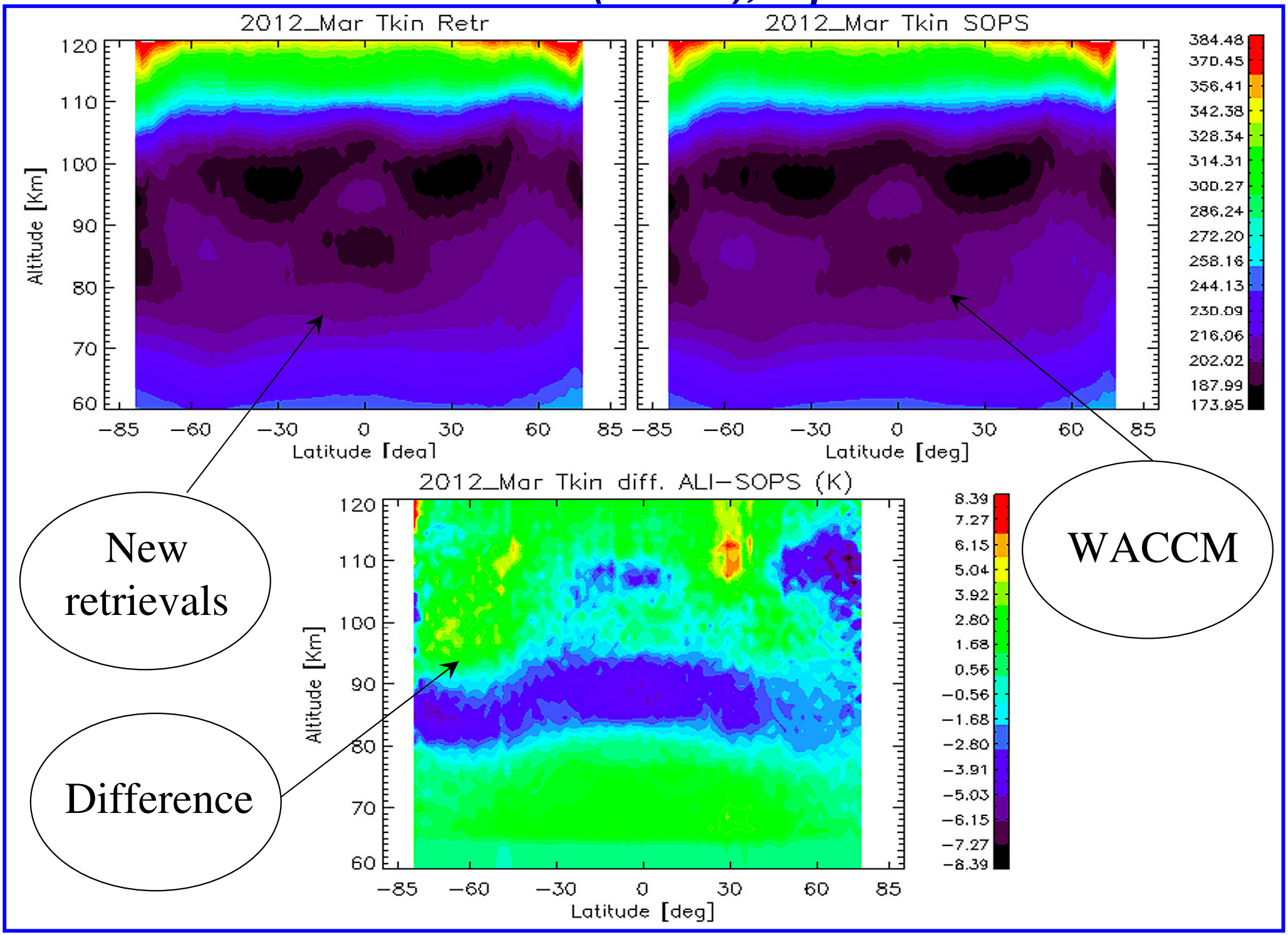


Significant difference in CO_2 profiles for polar summer and equinox: at polar summer CO_2 remains well mixed up to about 90 km

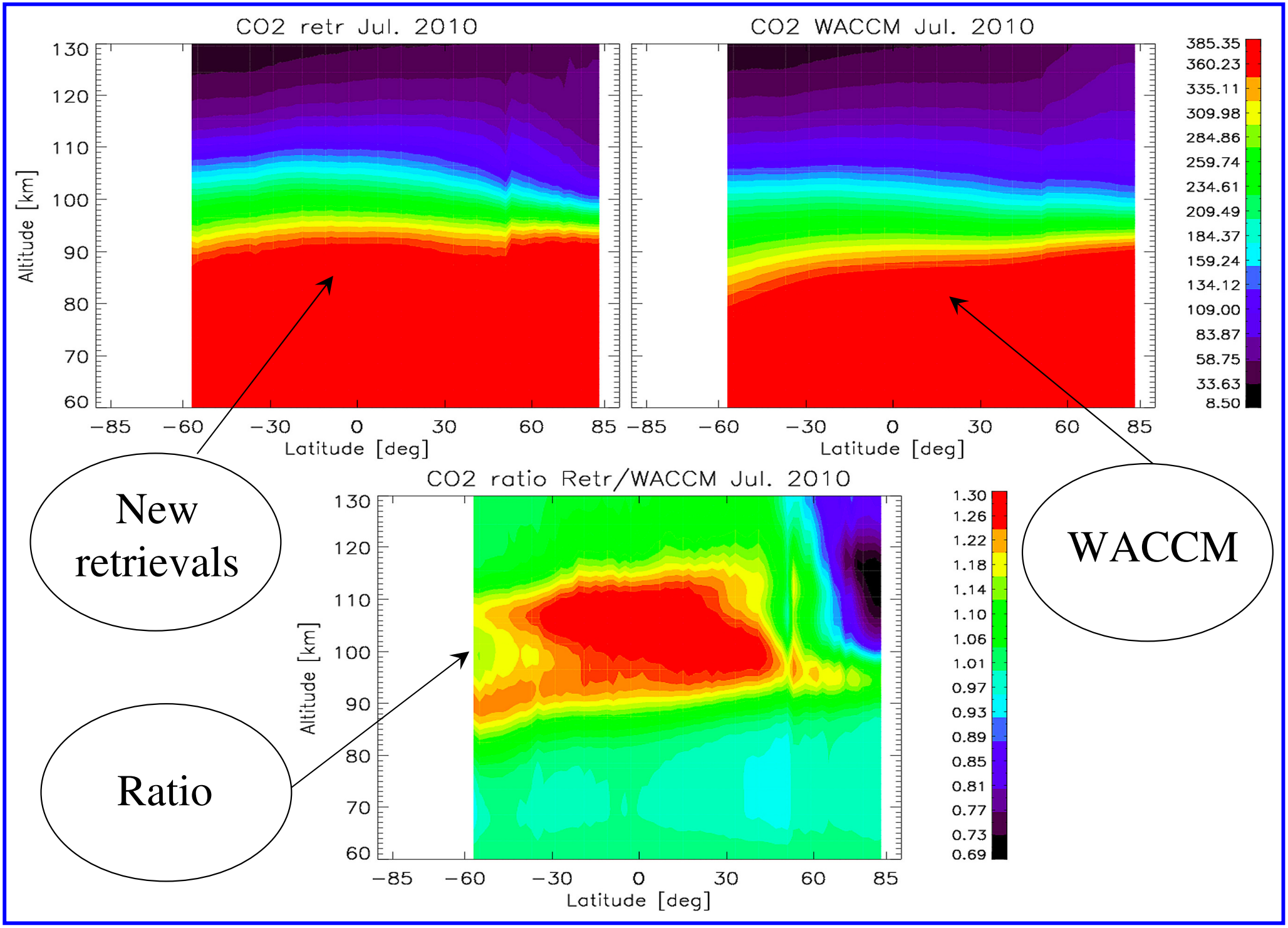
Mean CO_2 (Lat-Alt), Equinox



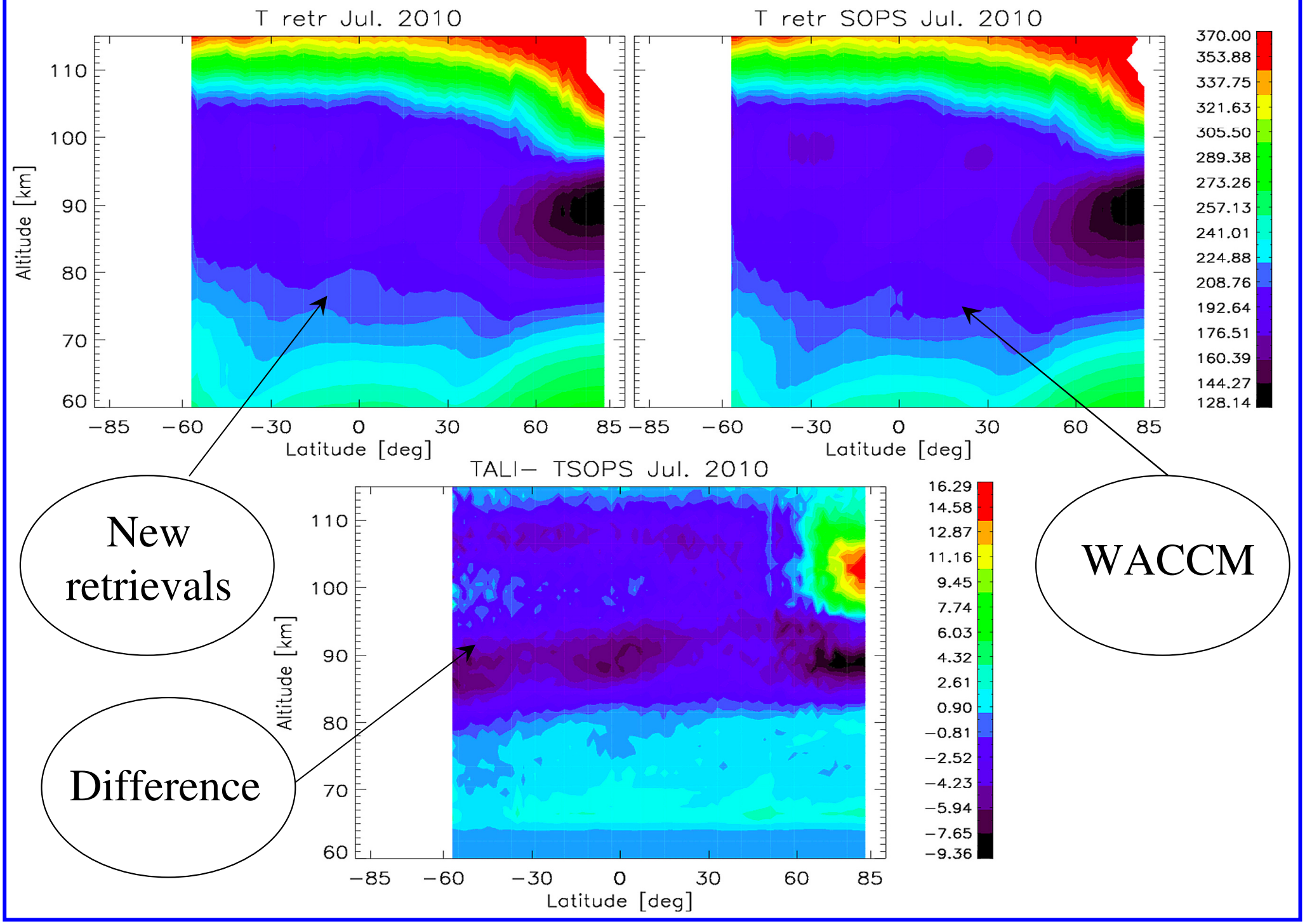
Mean T (Lat-Alt), Equinox



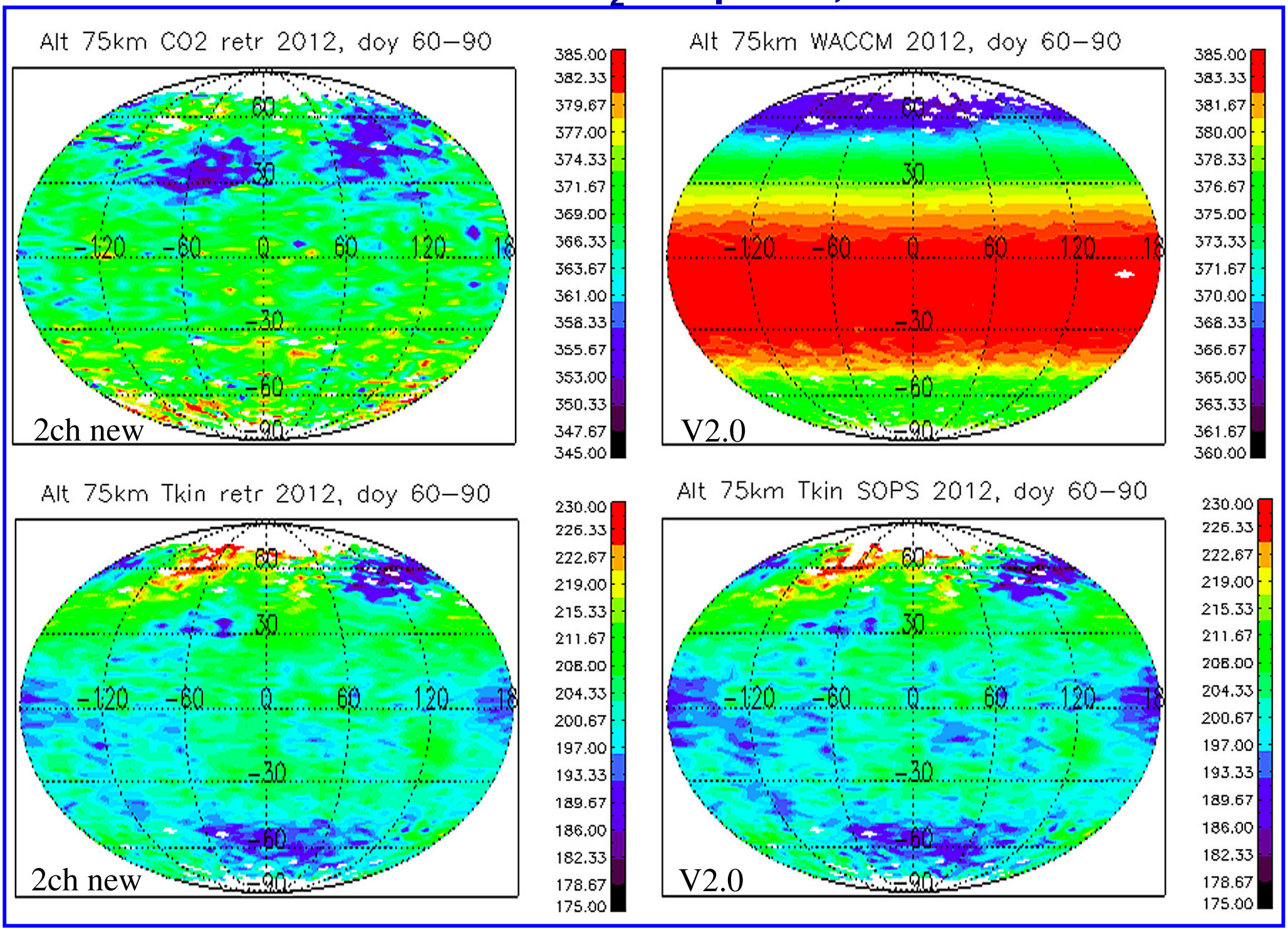
Mean CO_2 (Lat-Alt), NH Summer



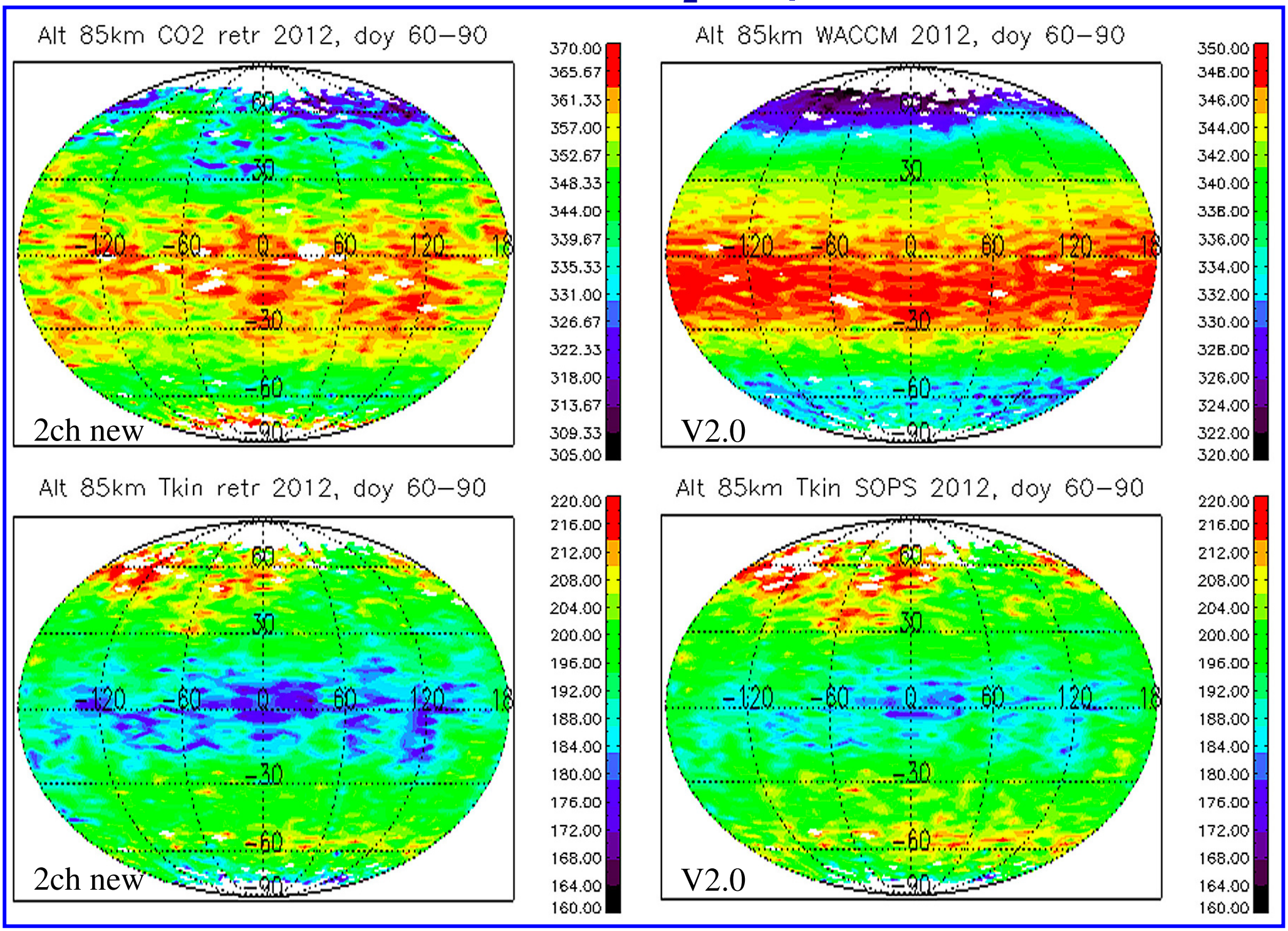
Mean T (Lat-Alt), NH Summer



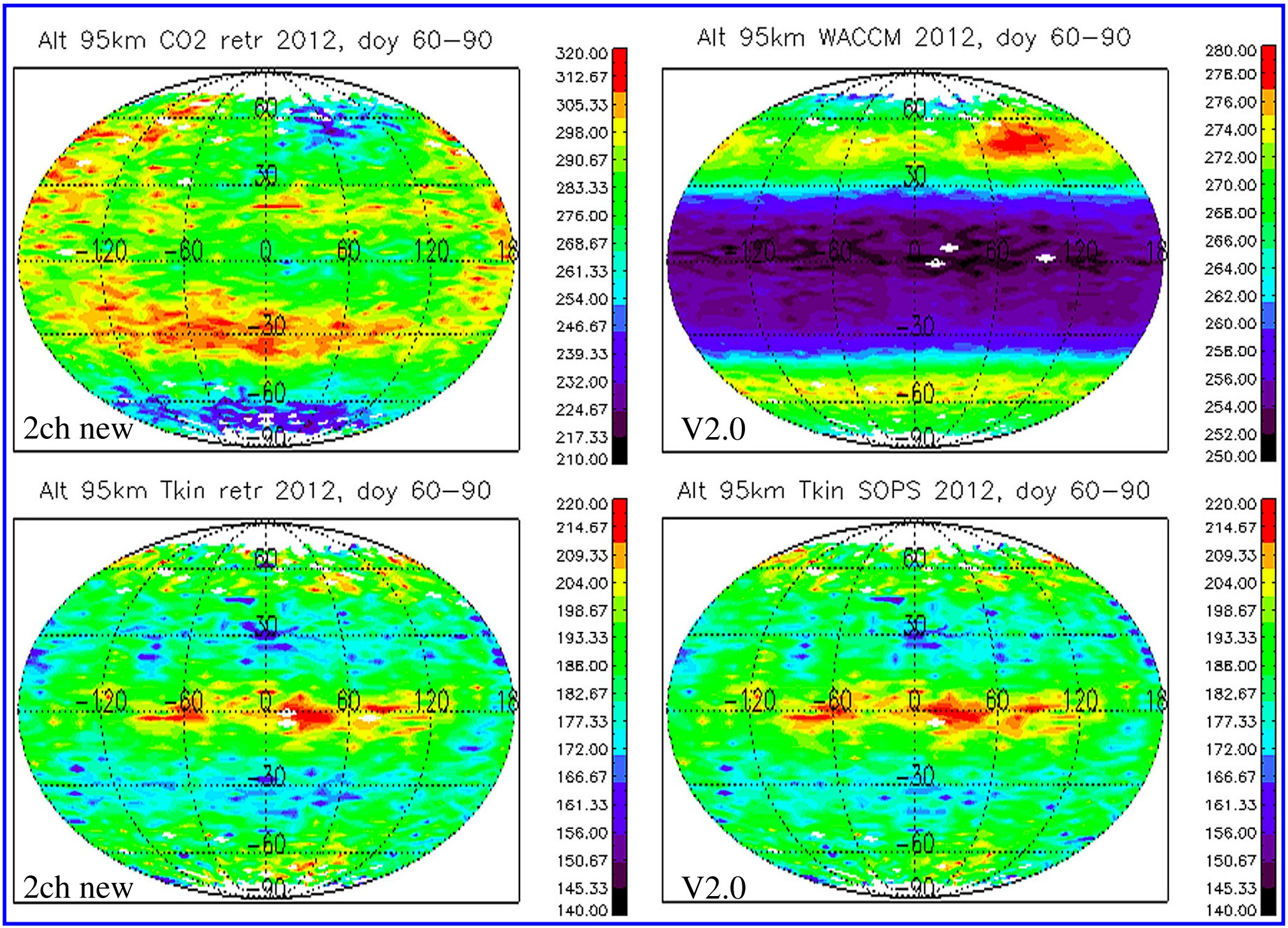
Global mean CO_2/T Equinox, 75 km



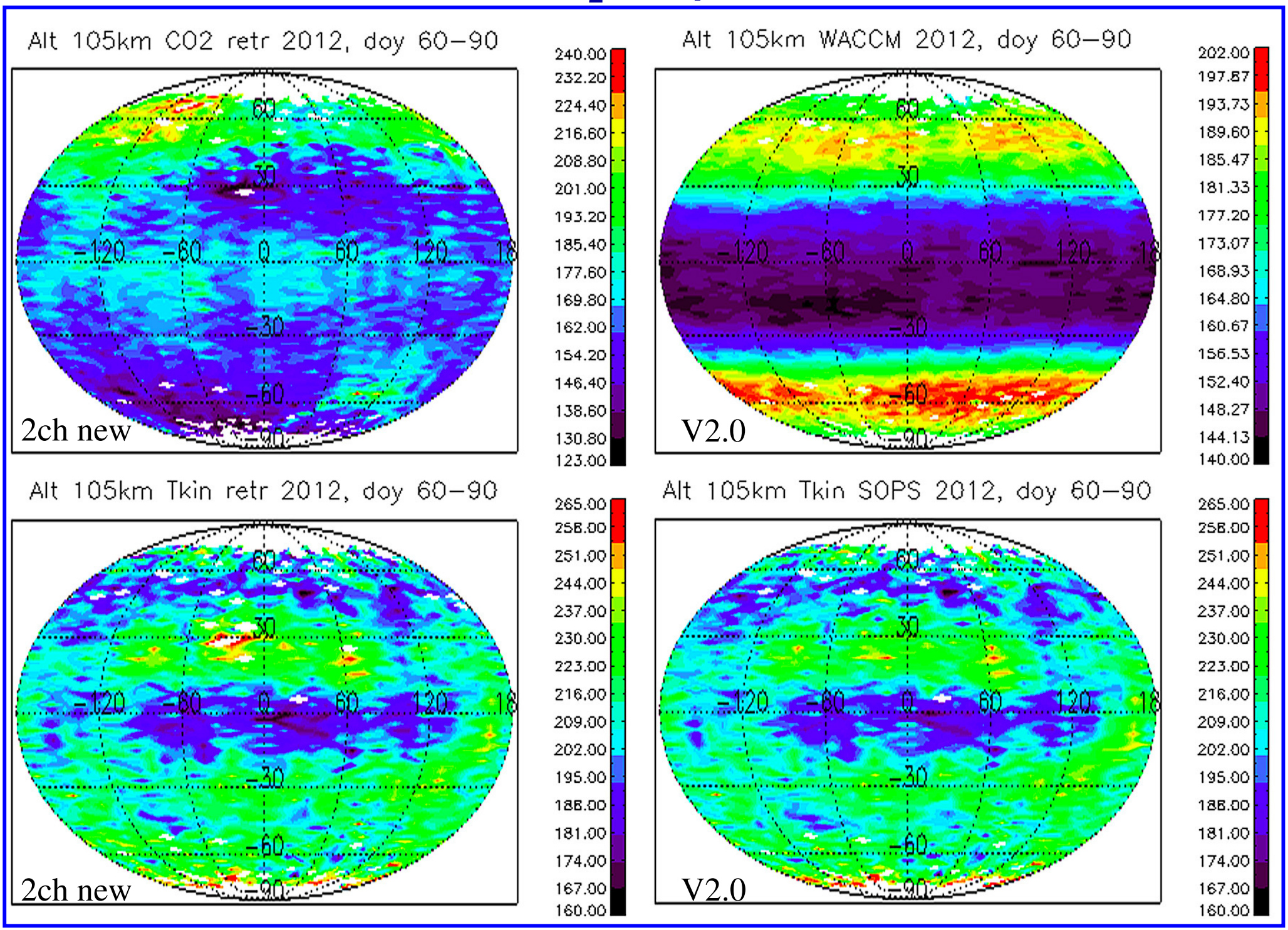
Global mean CO_2/T Equinox, 85 km



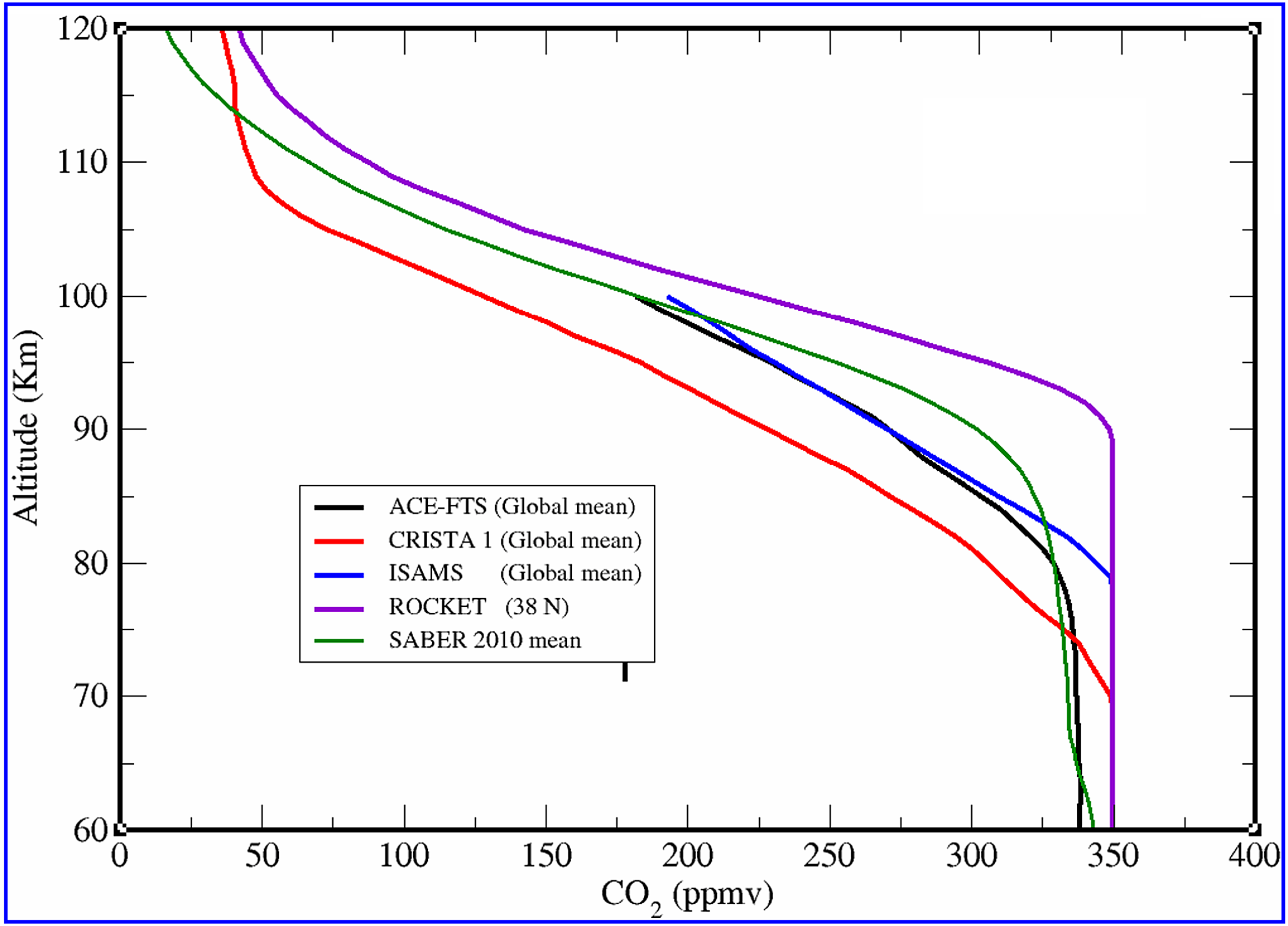
Global mean CO_2/T Equinox, 95 km



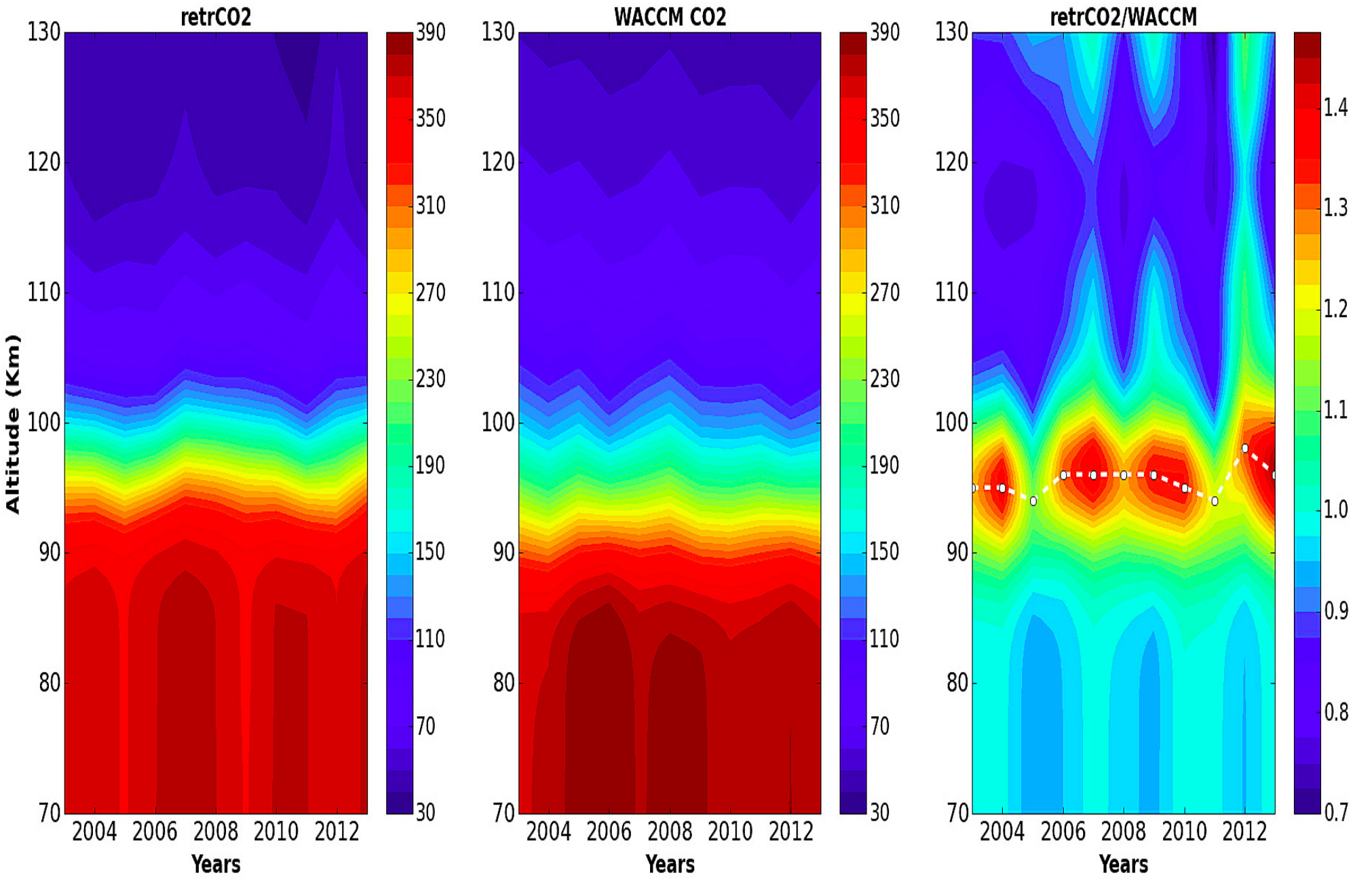
Global mean CO_2/T Equinox, 105 km



Global mean CO_2 scaled to ~ Rocket data at 60 km

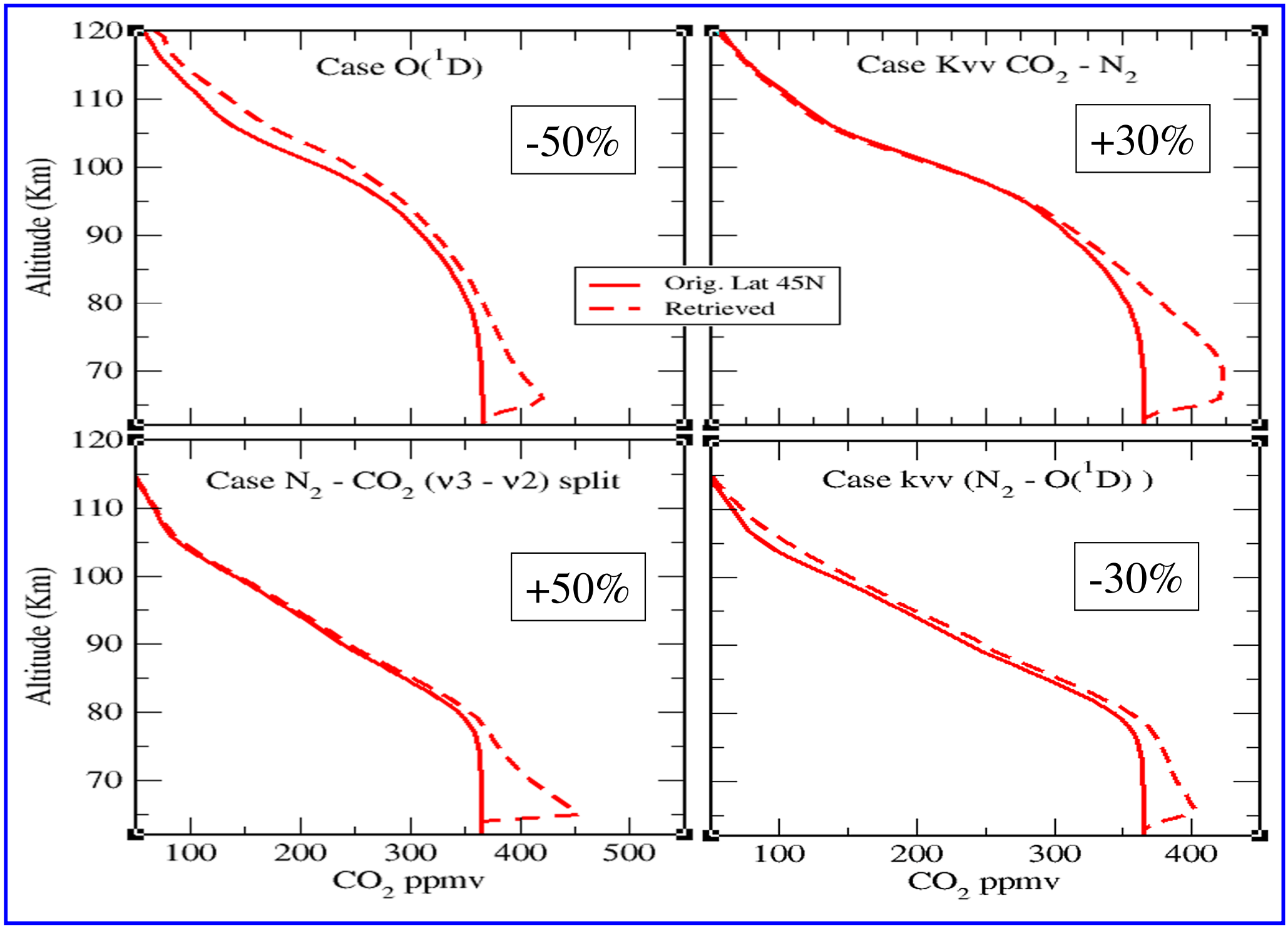


Long term and inter-annual CO_2 VMR behavior w.r.t. WACCM



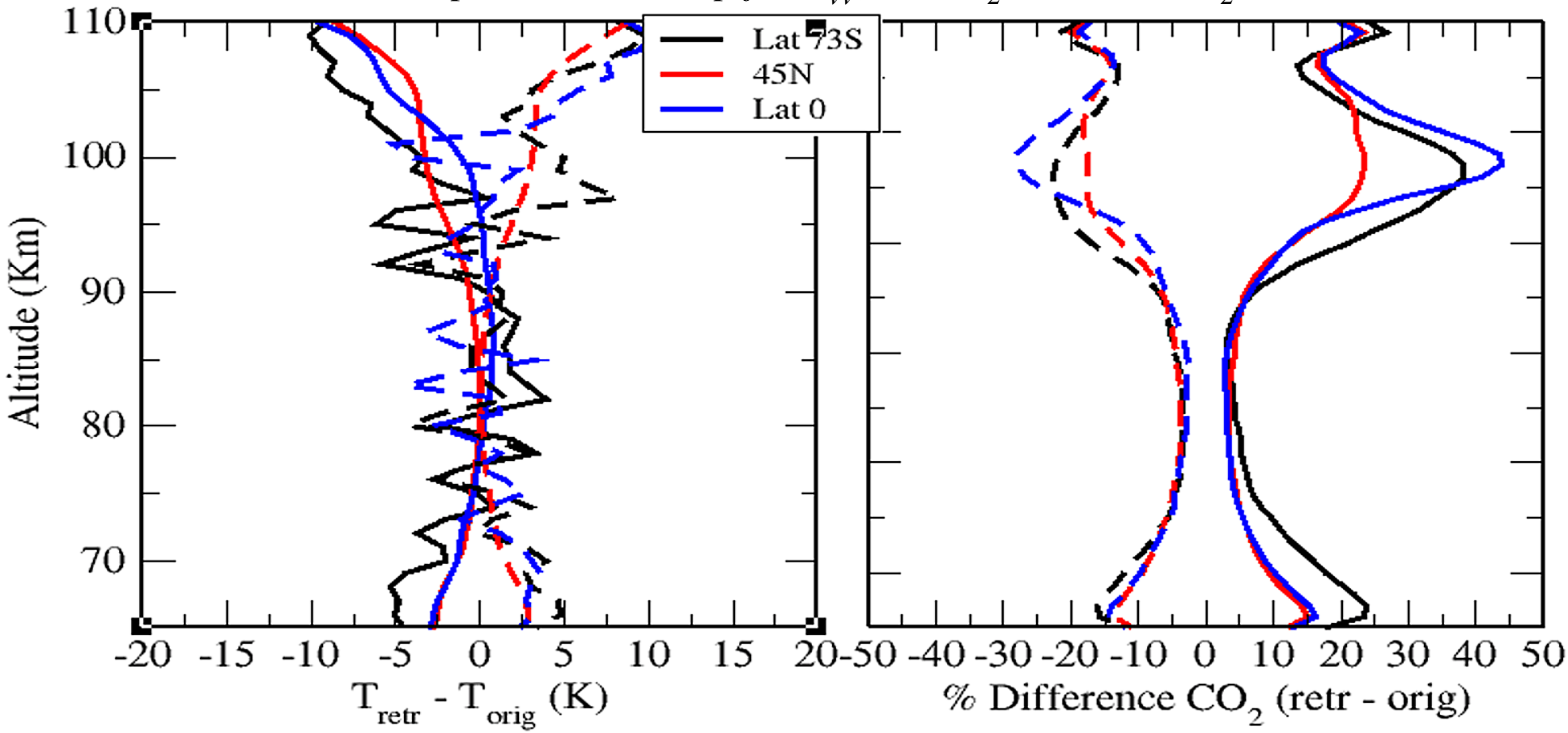
January, zonal mean at latitudes between 70-80 S for 2004-2013.

Retrieved CO_2 VMR bias response



Sensitivity and error analysis – single profile

Example of non-linear response of retrieved CO_2 to the O^1D.
Similar error patterns develop for $k_{vv}(O^1D\text{-}N_2)$ and $O^1D\text{-}N_2$ biases.



- Random errors for the daytime SABER measurements are negligible up to 130 km.
- Systematic errors are dominated by the collisional rates uncertainty and/or [N_2, O, O^1D]
- Only weak geomagn. activity events (Kp < 4) used to avoid NO+ contamination of rad.
- For a single 2-channel retrieval, the estimated total uncertainties are:
  - **T_{kin} profile**: 4K 65 – 90 km, 12 K from 90 up to 110 km and 30 K up to 120 km.
  - **CO_2 VMR**, 10% 65 – 90 km, 20% 90 – 110 km and 30% 110 – 130 km.

Conclusions

- Twelve years of simultaneous temperature/CO_2 profiles have been produced thus far where the two-channel methodology is applied to radiances that have been registered in altitude space.
- The seasonal behavior of newly retrieved CO_2 resembles in general that of WACCM, although differs from WACCM in some aspects, particularly in polar summer (well mixed up to ~90 km)
- New T obtained with the revised CO_2 is between 5–12 K colder in polar mesopause, mostly due to the well mixed CO_2 up to 90 km). In general, T distribution does not strongly differ from those of WACCM and/or current SABER product.
- The individual profile error budget is dominated primarily by systematic uncertainties: [O^1D, O^3P], $k_{vv}(N_2\text{-}O^1D)$.

Future work:

- Validation work, comparing to other available data inferred from measurements (ACE-FTS, SOFIE).
- Long term and inter-annual studies and comparison with global circulation model (WACCM).
- Speeding up of the inversion with data trained algorithms for potential future radiance calibration.