

Nitric Oxide Cooling and Concentrations Derived from SABER

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• Motivation and Objective:

- Nitric Oxide :
 - Is a thermostat of the thermosphere.
 - plays important role in regulating the energy budget in the thermosphere.
- Long term precise datasets of NO cooling and NO concentration are of great important.
- Objective:
 - Derive the NO cooling from SABER measurements by using new unfiltered factor.
 - Derive the NO concentration from SABER NO cooling and MSIS simulations.

• Introduction:

- Energy
 - is input to the system externally from the Sun.
 - is also input from the atmosphere below.
- Between 100 km and 200 km is the “heat sink” region.
- Emission and escape of infrared radiation is the only mechanism that the Earth’s surface and atmosphere lose thermal energy to space.
- O, NO, CO₂ are three major radiators in Earth’s atmosphere.
- CO₂ and NO radiative cooling are the major cooling mechanism that cool the thermosphere between 100 km and 200km.

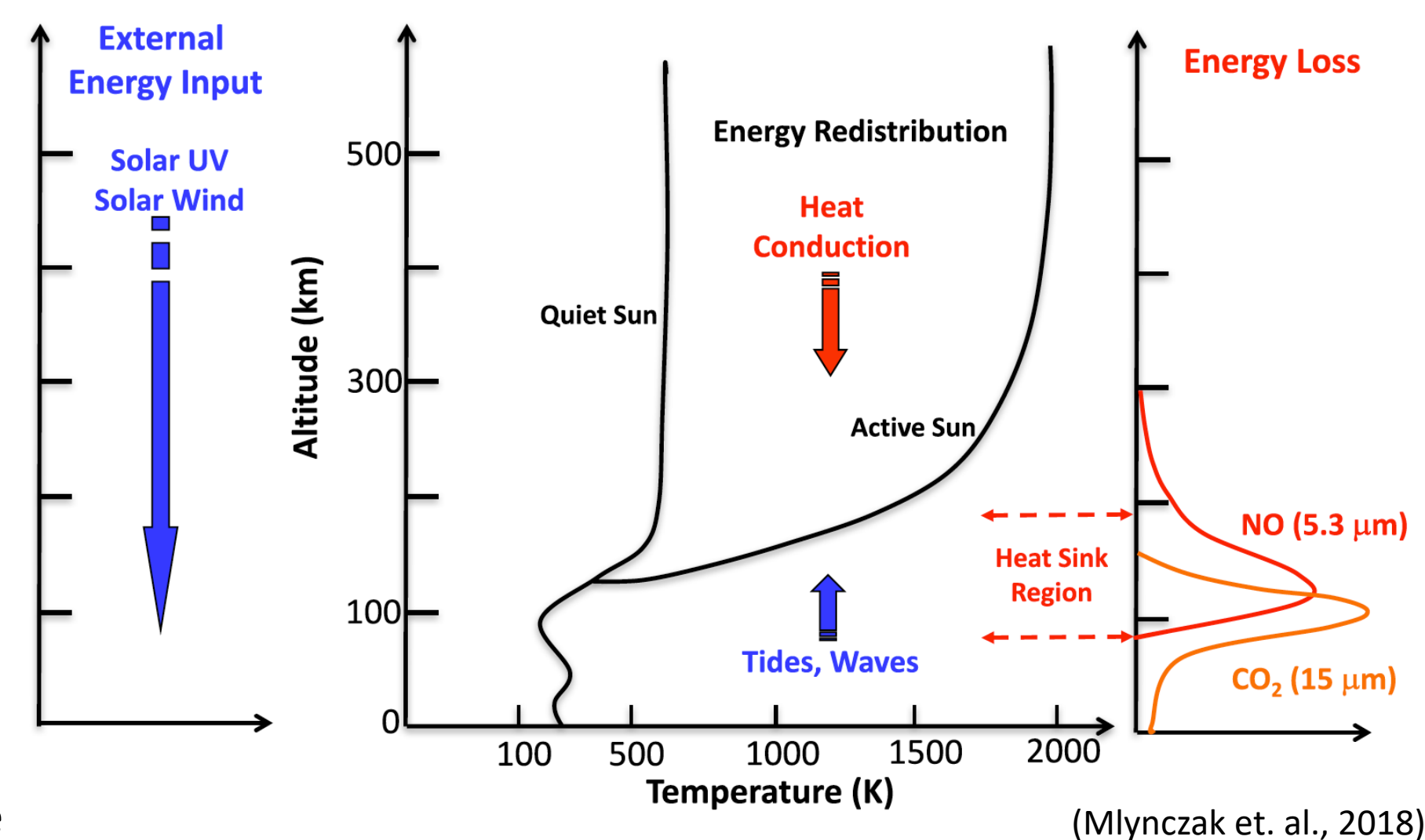


Figure 1 Conceptual overview of the thermosphere thermal structure and its energy budget.

• Background:

- Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite
 - Launched on 7 December 2001
 - Into a 74.1° inclination orbit at 630 km altitude
 - A period of 1.6 hours.
- Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument:
 - Scans the Earth’s limb from 400 km to the hard surface.
 - Measures profiles of infrared limb radiance in a spectral interval.
 - Encompasses ~60% of the emission lines from NO bands of 1 to 0, 2 to 1, and 3 to 2.

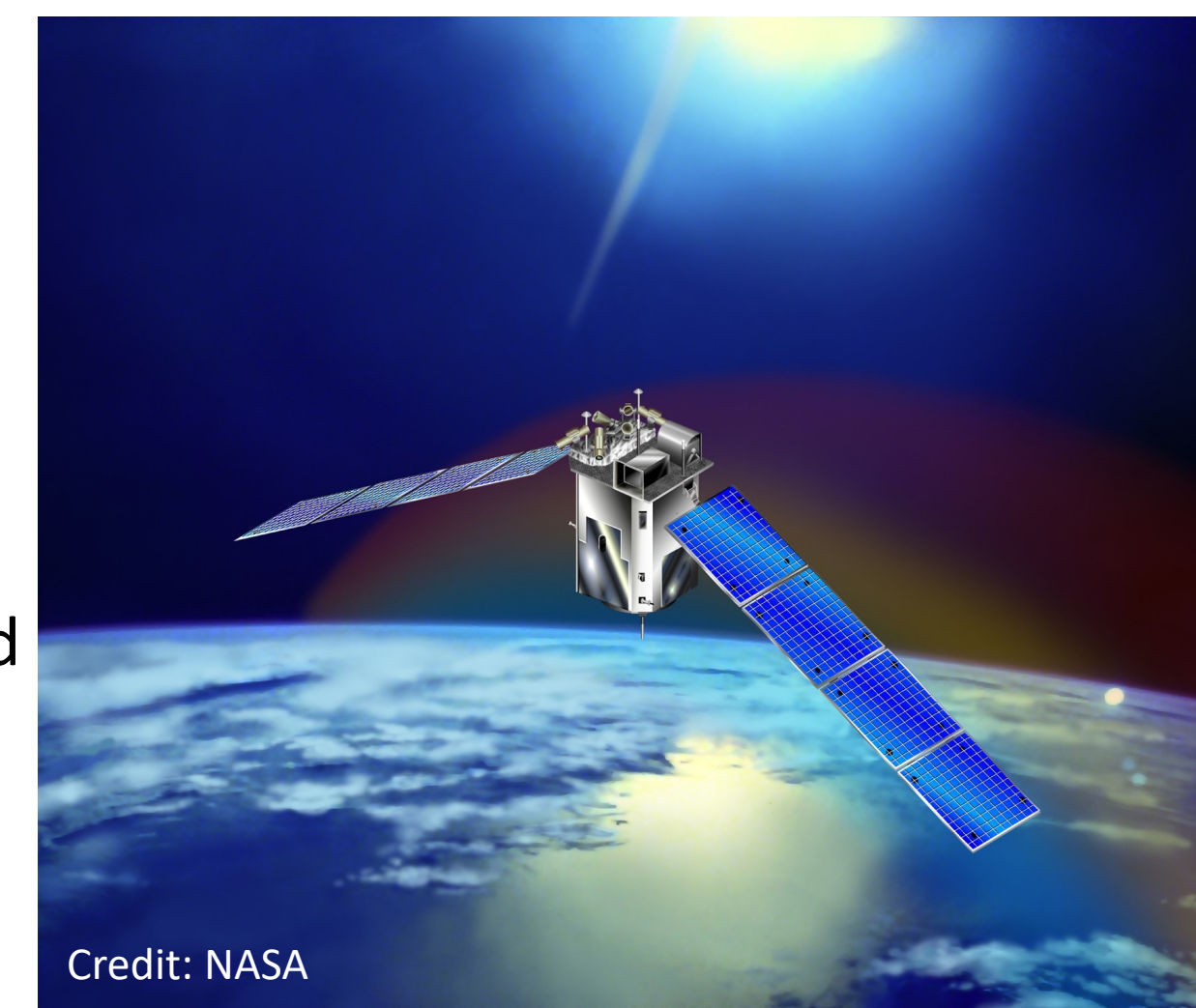


Figure 2 TIMED satellite and SABER instrument

- (Russell et al., 1999)
- SABER NO cooling

$$V(z) = I(z) \times U(z)$$
 Where $I(z)$ is the in-band measurements, $U(z)$ is the ‘unfiltered factor’, and $V(z)$ is the full band NO cooling, z is altitude.
- SABER NO Concentration

$$n(NO) = \frac{V}{A_{10}} \times \left[\frac{A_{10} + k_O n(O) + k_{O_2} n(O_2)}{R_{01} + (k_O n(O) + k_{O_2} n(O_2)) \times \exp(-2700/T)} \right]$$

V is emission rate/NO cooling. Derived from SABER
 R_{01} is radiative recitation rate. Derived from MSIS 2.0 simulations
 $n(O), n(O_2)$ are number densities of O, O_2 . Simulated by MSIS 2.0
 T is neutral temperature. Simulated by MSIS 2.0
 $A_{10} = 13.3 \text{ s}^{-1}$, representing the transition probability of $NO(v=1) \rightarrow NO(v=0) + h\nu_{5.3\mu m}$;
 $k_O = 4.2 \times 10^{-11} \text{ cm}^3 \text{ s}^{-1}$ (Hwang et al., 2003), is the vibrational relaxation rate of $NO(v=1)$ by collisions with O ;
 $k_{O_2} = 2.4 \times 10^{-14} \text{ cm}^3 \text{ s}^{-1}$ (Murphy et al., 1975), is the vibrational relaxation rate of $NO(v=1)$ by collisions with O_2 ;

• Road Map:

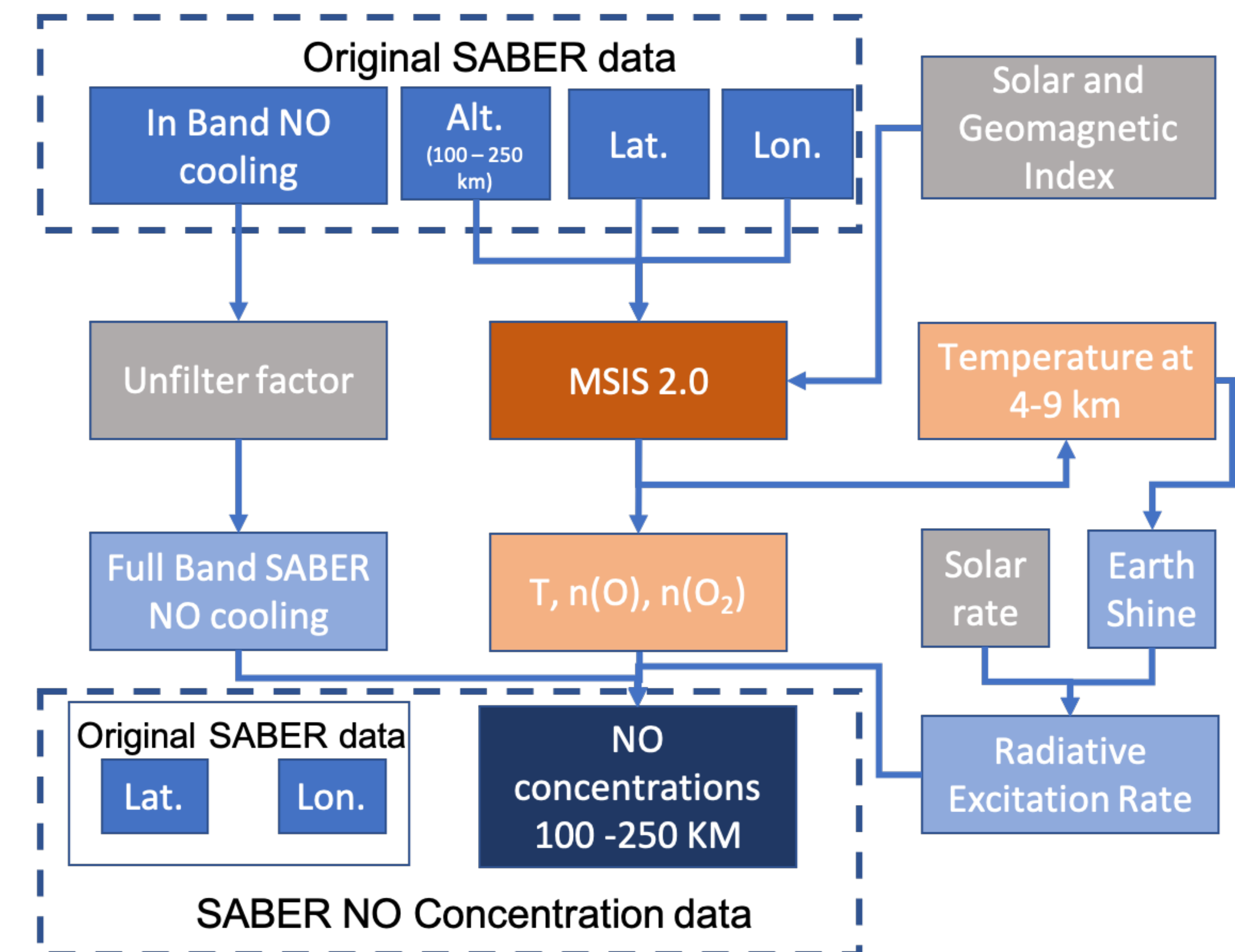


Figure 3 Process of deriving the unfiltered SABER NO cooling and SABER NO concentration data

• Results: NO Cooling

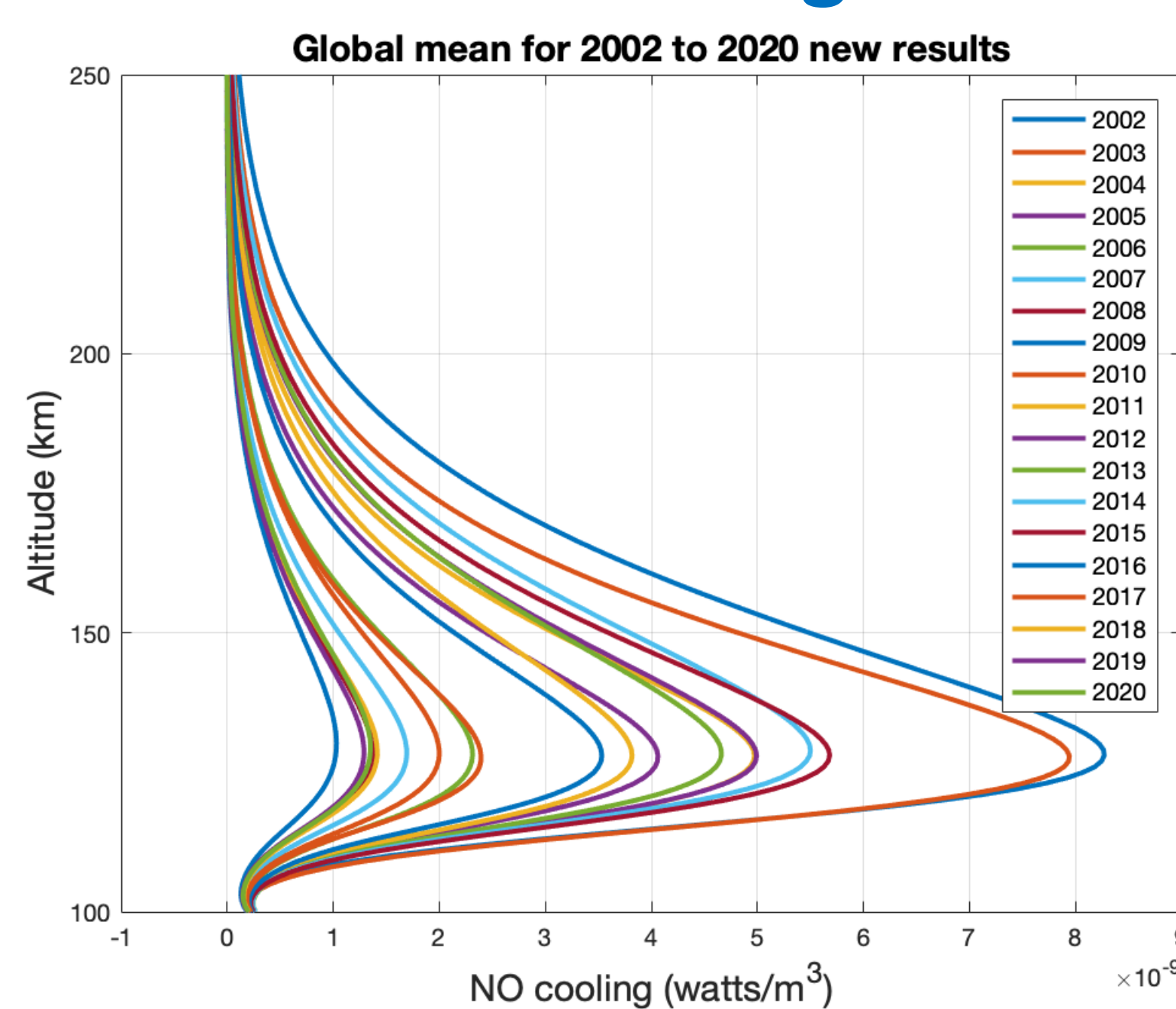


Figure 4 (a) Global Annual Mean of Newly Derived SABER NO Cooling

NO Concentration

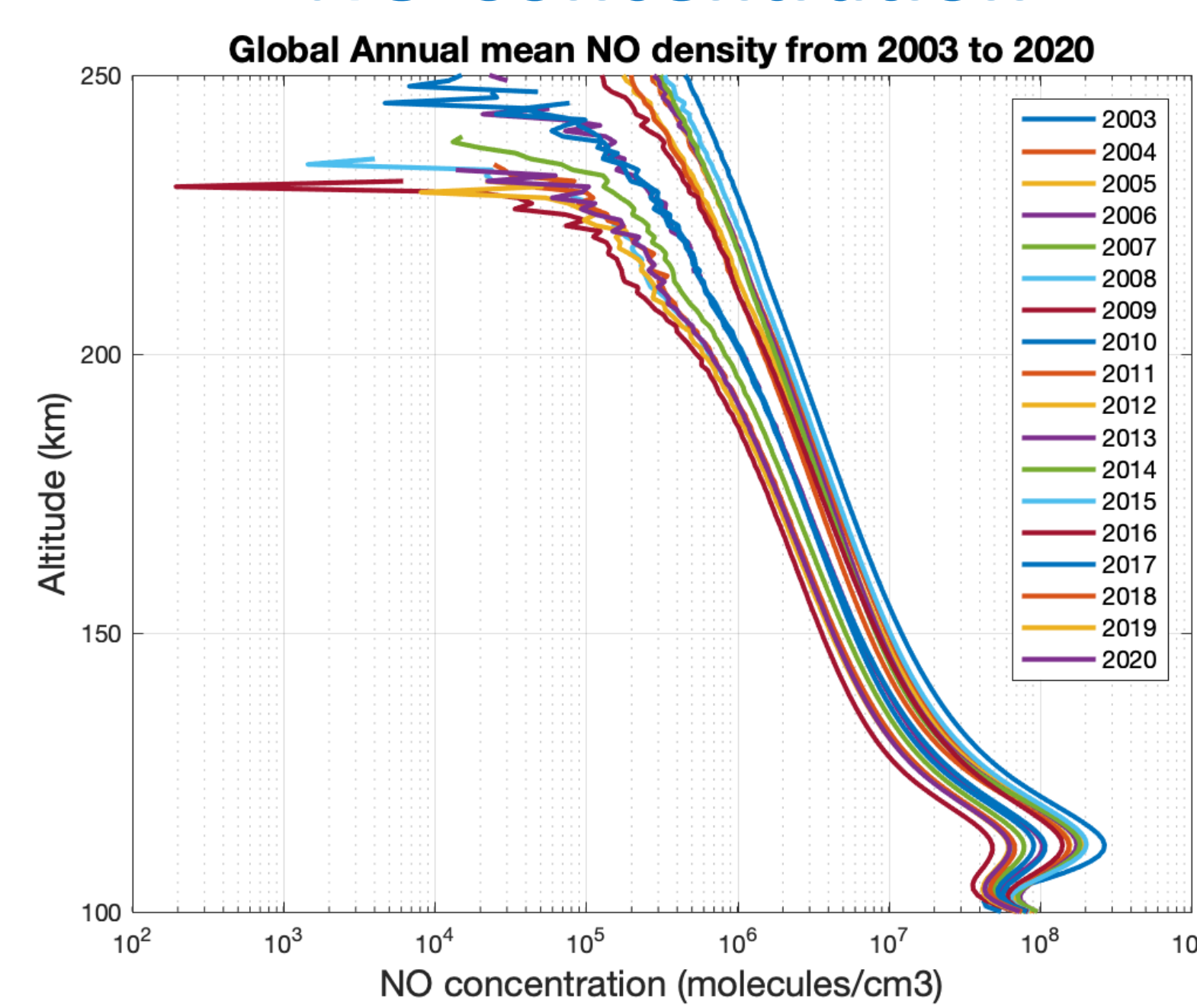


Figure 4 (c) Global Annual Mean of SABER Derived NO Concentration

Comparison

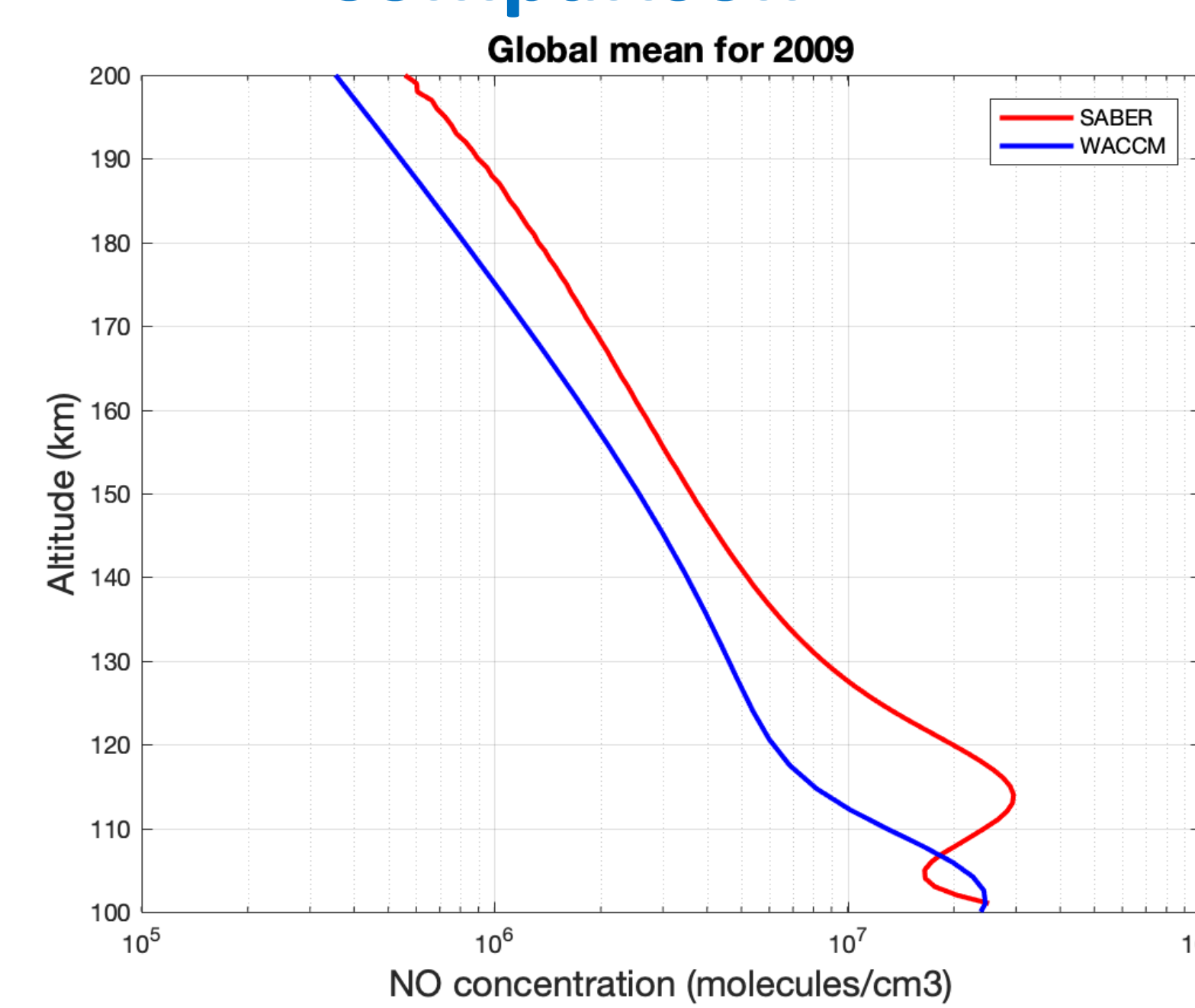


Figure 4 (e) Comparison of NO Concentration between SABER and WACCM-x simulations for 2009

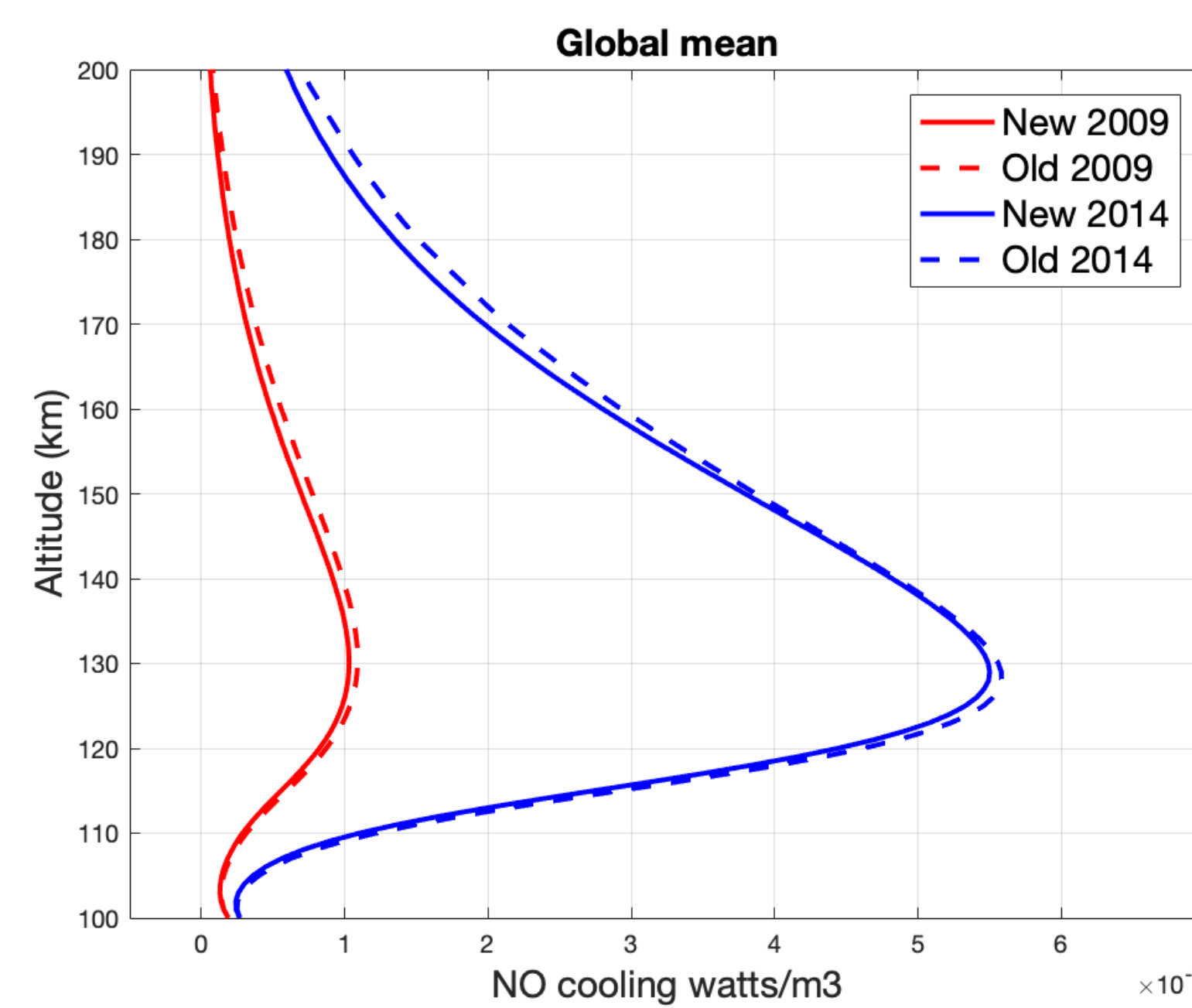


Figure 4 (b) Comparison of Newly Derived SABER NO Cooling and Currently Available Data for Solar Maximum Year 2014 and Solar Minimum Year 2009

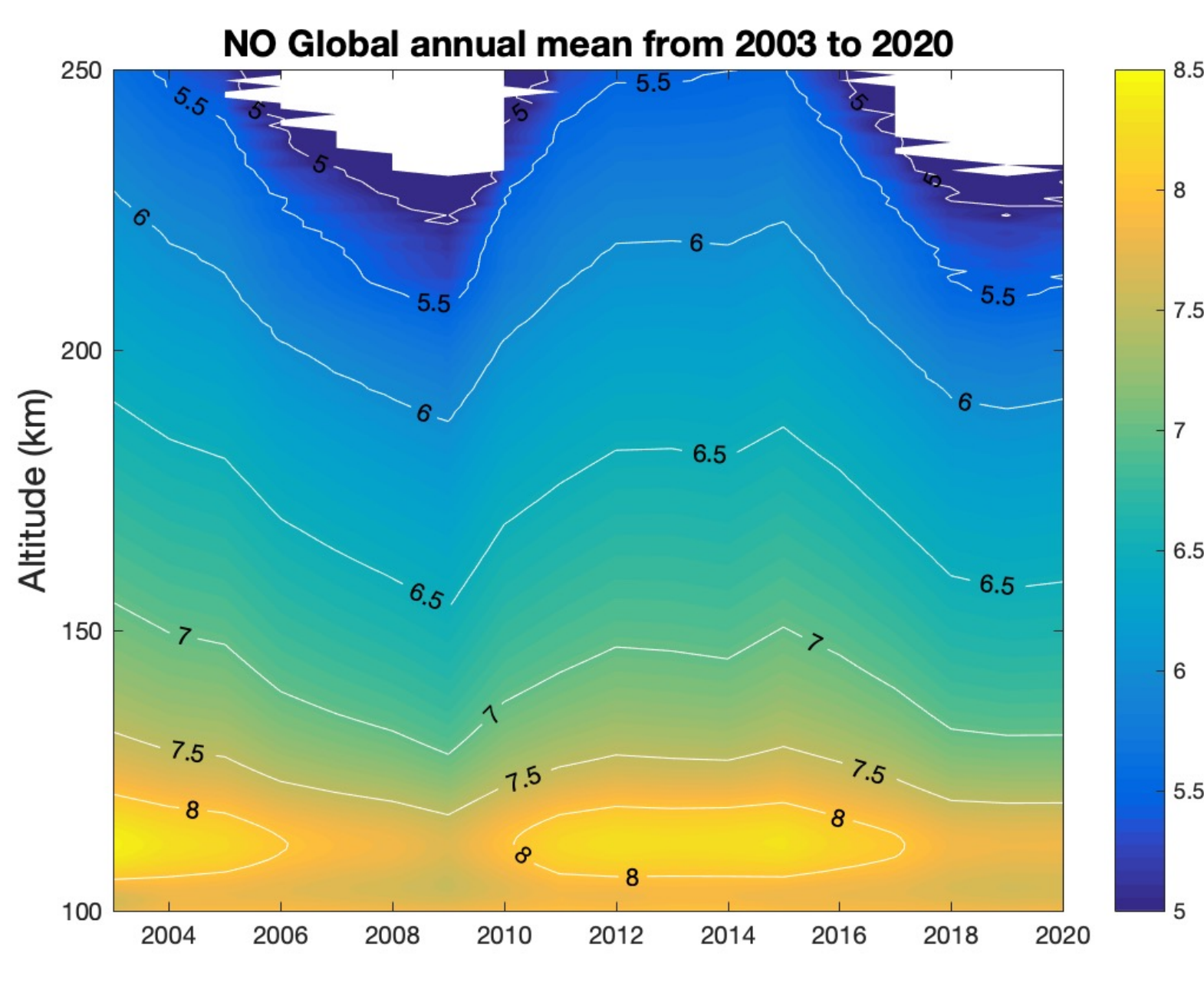


Figure 4 (d) NO Concentration Global Annual Mean as a Function of Year

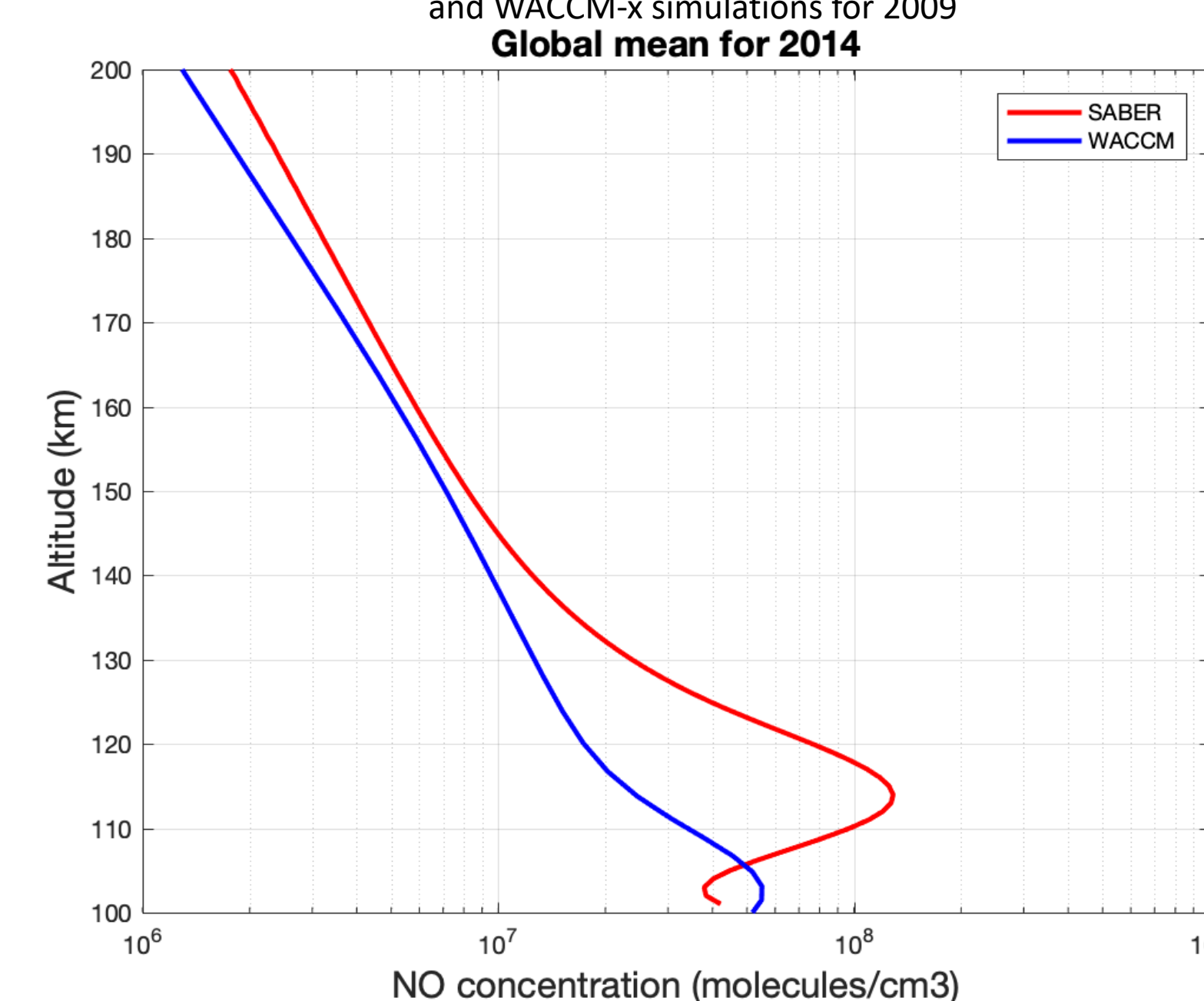


Figure 4 (f) Comparison of NO Concentration between SABER and WACCM-x simulations for 2014

• Summary:

- NO cooling and NO concentration are derived from SABER measurements with the NEW unfiltered factor and MSIS 2.0 simulations.
- The newly derived NO cooling profiles are smaller than the old NO cooling profiles as expected.
- The difference between the newly derived NO cooling and the old NO cooling profiles are smaller during solar maximum year (2014) than during solar minimum year (2009).
- The NO concentration is peak at ~ 110 km as expected.
- The NO concentration and the upper limit of the NO concentration data are varying with the solar cycle.
- SABER NO concentration is larger than SD-WACCM simulation for both 2009 (solar minimum year) and 2014 (solar maximum year) below 200 km.

• Next Step:

- Compare SABER NO concentration data to NOEM simulations
- Conduct error analysis of the SABER NO concentration data.

• Acknowledgement:

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• Reference:

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