

Interactive comment on “Mesospheric nitric oxide model from SCIAMACHY data” by Stefan Bender et al.

Anonymous Referee #1

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This paper uses mesospheric NO observations taken by the SCIAMACHY instrument between 2002 and 2012 to build a non-linear empirical model of NO number densities as function of time and geomagnetic latitude, driven by the AE index as proxy for energetic particle precipitation and the Ly- α index as proxy for the EUV and XEUV influences.

The presented empirical model is very useful for constraining or validating atmospheric models and complements other empirical models of NO that focus either on the lower thermosphere or on the stratosphere/lower mesosphere.

The paper is generally well written and the methodology is presented in a clear manner. However, the discussion of the obtained responses could be improved by consideration of the limitations of the empirical model. For instance, modeled responses are

interpreted as NO production rates (e.g., the AE response) which is an oversimplification since important physical mechanisms are not represented by the model (e.g., transport). Similarly, many of the discussed hemispheric asymmetries are most likely related to the use of geomagnetic coordinates (see specific comments below). This should be addressed before publication in ACP.

Specific comments:

p2 I4: This is misleading: SSWs cause reduced mesospheric descent (or even an upwards motion), not enhanced descent. You are referring to the strong downwelling that often occurs in the recovery phase of the SSW, typically associated with the formation of an elevated stratopause.

p2 I9: MIPAS upper atmosphere observations were carried out in the 40 - 170 km range, see Bermejo-Pantaleón et al, 2011 (doi:10.1029/2011JA016752).

p2 I19: I wouldn't say the most CCMs parametrize NO. Rather, some models (those that are not resolving the thermosphere) constrain NO at the models upper lid by observation-based parameterizations.

p3 I5: Is there any atmospheric model study that illustrates the effectiveness of NO_x photo-excitation as NO loss process? I would expect that N₂O formation via metastable N₂(A) + O₂ as discussed in Funke et al. 2007 and Sheese et al., 2016 is likely a more relevant source for upper atmospheric N₂O.

p3 I11-12: "NO is produced in dark conditions by particle precipitation at auroral latitudes, but is then depleted only by reacting with atomic nitrogen". I don't understand this sentence. NO is produced by particle precipitation at any illumination condition. NO loss is mostly occurring at sunlit conditions (photolysis of NO and subsequent reaction R5).

p3 I22: The semi-empirical model of Funke et al. does not only cover the stratosphere but also a significant part of the mesosphere.

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p4 I22: “We use two proxies to model the NO number densities, one accounting for the long-term eleven-year solar cycle and one accounting for the short term geomagnetic activity.” Isn’t one of these proxies related to solar irradiance variations and the other one related to energetic particle precipitation? Both of them exhibit short- and longterm variability. . .

p5 I1: “questioned” seems too strong to me. Hendrickxs et al. simply noticed “that the auroral electrojet index is a more suitable proxy”.

p5 I11: The choice of geomagnetic latitude as coordinate deserves some further discussion: Although production by EPP is linked to geomagnetic latitudes, mesospheric NO distributions are mostly ruled by illumination and (to some extend) by dynamics, both resulting in NO distributions organized in geographic latitudes.

p5 Eq3: What is the rationale behind omitting the harmonic term in the non-linear model? By doing so, seasonal variations not related to EPP remain unconsidered. Or, in other words, the model is forced to attribute any seasonal variation to EPP. In the same line, shouldn’t a life-time correction be considered also for the Ly-a part?

p6 I7: “accounts for the different lifetime at polar night compared to polar day. “ This could be phrased in a more general way, i.e., “. . .during winter and summer”.

p10 I2: The vertical shape of the Ly-a response is intriguing: Why is this response peaking at 70-75 km while NO production due to XEUV should increase with altitude?

p11 I4: The larger amplitude of the NH annual lifetime variation is likely a result of the use of the geomagnetic latitude grid (this variation is smeared out in the SH due to the geomagnetic pole offset).

p12, I4-11: Similarly, the smaller SH AE coefficients (and shorter lifetimes) are likely related to the choice of a geomagnetic grid.

p13 I2: The AE coefficients do not represent a NO production rate, they simply represent the NO response to AE perturbations. Note that transport and mixing processes

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are not considered by the empirical model, the latter being most likely responsible for the increased polar AE response around 70 km due to accumulation effects during the winter.

p14 l8: Note that the annually varying finite lifetime is only considered for the EPP-related part of NO.

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