

Interactive comment on “Atmospheric QBO and ENSO indices with high vertical resolution from GNSS radio occultation temperature measurements” by Hallgeir Wilhelmsen et al.

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AC2

We thank the reviewer for helpful questions and comments. Please find our responses below.

C1

Major comments

Comment 1: “In the stratosphere, the temperature-QBO might be related to the QBO in vertical wind. It would be nice if the authors would explain the physical relationships between the temperature anomalies and other anomalies.

What are the basic reasons for the occurrence of the temperature anomalies?”

Response 1: The main connection between QBO winds and temperature, T , is expressed through Eq. (1),

$$\frac{\partial \bar{u}}{\partial z} = -\frac{R}{H\beta} \frac{\partial^2 T}{\partial y^2}, \quad (1)$$

where \bar{u} is the zonal wind speed, z is the log-pressure height, R is the gas constant, H the nominal scale height, β is the latitudinal derivative of the Coriolis parameter, and y is latitude.

Centered on the equator, with meridional scale L , Eq. (1) can be approximated as

$$\frac{d\bar{u}}{dz} \sim \frac{R}{H\beta} \frac{T}{L^2}. \quad (2)$$

The relationship between the zonal winds and the temperature anomalies around the equator is therefore proportional to the vertical gradient of the zonal winds. See e.g., Randel et al. (1999, [https://doi.org/10.1175/1520-0469\(1999\)056<0457:GQCDFU>2.0.CO;2](https://doi.org/10.1175/1520-0469(1999)056<0457:GQCDFU>2.0.CO;2)), or Baldwin et al. (2001, <https://doi.org/10.1029/1999RG000073>).

We added to page 2, line 3:

“The atmospheric temperature anomalies are proportional to the vertical gradient of the zonal winds (Randel et al., 2001; Baldwin et al., 2001), which makes it possible to investigate the QBO through temperature anomalies.”

C2

Minor comments:

Comment 2: “Introduction: I am missing the discussion of existing literature about the ENSO effects in the stratosphere. Do you see such an effect in your ENSO indices at stratospheric altitudes?”

Response 2: We added several references to the introduction, see response to Comment 3 from Referee #1, RC1, and have some additional discussion about this in response to Comment 1 from Referee #3, RC3.

Comment 3: Page 3, line 24: “... from from May 2001”.

Response 3: One “from” removed.

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