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# Enhanced downward transport of thermospheric nitric oxide in a regionally-refined version of WACCM

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Earth system models with tops in the thermosphere have historically struggled to recreate the large nitric oxide (NO) mixing ratios in the high-latitude winter and spring mesosphere and stratosphere. Possible causes include missing sources of energetic particle precipitation, missing chemistry, and errors in the general circulation of the upper atmosphere. Additionally, transport by atmospheric waves that are ubiquitous near the mesopause could play a role in transporting the abundant thermospheric NO downward into the mesosphere and stratosphere. Typically, transport by waves that are not resolved by coarse resolution models is parameterized, and a potential source of the NO model-data bias. In this study, we resolve what would normally be subgrid-scale waves natively using a version of the Whole Atmosphere Community Climate Model with regional refinement (WACCM-RR). WACCM-RR resolves limited regions down to as far as 1/32° horizontally at a lower computational cost compared to global high-resolution models. Here we examine the distribution of NO in the upper atmosphere in a WACCM-RR simulation for the full year of 2010 employing 3 levels of refinement down to a 1/8° grid over the Continental US (1° outside of the regionally refined area). At the end of spring at mesopause heights, an increase of a factor of 2.5 is seen over the regionally refined area, which decreases to about a doubling during the summer months. This difference then increases again to around a factor of 2.5 at the end of summer and persists until the start of autumn. Since the additional wave-induced transport is not restricted to NO, other species are impacted (i.e., O, $O_3$, $CO_2$). The results point to the applicability of WACCM-RR for detailed investigations of wave-transport processes, and their impact on the dynamics and composition of the stratosphere-mesosphere-lower thermosphere system .

## Solicited or Contributed

Contributed

## Author list and affiliations

## Presenting author

Marcin Kupilas

**Primary authors:** KUPILAS, Marcin (University of Leeds); Prof. MARSH, Daniel (University of Leeds); Dr DAVIS, Nicholas (National Center for Atmospheric Research); LAURITZEN, Peter (National Center for Atmospheric Research); FENG, Wuhu (National Centre for Atmospheric Science); GARDNER, Chester (University of Illinois); GUARINO, Maria Vittoria (International Center for Theoretical Physics); PLANE, John (University of Leeds)

**Presenter:** KUPILAS, Marcin (University of Leeds)

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