

*Selected Abstracts:***28-R. Peters, D. und D. Waugh, Influence of barotropic shear on the poleward advection of upper tropospheric air, *J. Atmos. Sci.*, **53**, 3013-3031, 1996.**

The characteristics of the poleward advection of upper-tropospheric air are investigated using meteorological analyses and idealized numerical models. Isentropic deformations of the tropopause during Northern Hemisphere winter are examined using maps of Ertel's potential vorticity together with contour advection calculations. Large poleward excursions of upper-tropospheric air are observed during Rossby wave breaking events. These "poleward" breaking events occur in regions of diffluence (over the eastern Atlantic Ocean–Europe region, and over the eastern Pacific Ocean–North America region), and the evolution of the tropospheric air depends on the local, meridional shear: in anticyclonic (or weak cyclonic) shear the tropospheric air tilts downstream, broadens, and wraps up anticyclonically, whereas in cyclonic shear the tropospheric air tilts upstream, thins, and is advected cyclonically. The role of ambient barotropic flow is further examined by considering the flow in two numerical models: a planar, equivalent-barotropic, contour dynamics model and a simplified general circulation model. In both models, the variation of the poleward wave breaking with the zonal and meridional shear is consistent with that in the analyses.

**102-R. Karpechko, A.Y., P. Hitchcock, D.H.W. Peters, A. Schneidereit, 2017. Predictability of downward propagation of major sudden stratospheric warmings, *QJRMS* 2017, DOI: 10.1002/qj.3017**

Major sudden stratospheric warmings (SSWs) are striking phenomena of wintertime stratospheric circulation usually defined as a reversal of zonal mean circulation from westerlies to easterlies. SSWs often have significant impact on tropospheric circulation and cause anomalies in surface climate lasting for up to 2 months. For this reason, dynamics and predictability of SSW receive considerable attention. It is however well-known that not all SSWs cause significant, long-lasting impact on the troposphere. In order to explain differences in tropospheric impacts following SSWs, several reasons have been previously proposed, including differences in type of SSW (split or displacement), persistence of stratospheric anomalies, preconditioning of the tropospheric circulation, and whether or not SSW was accompanied by a planetary wave reflection in the stratosphere. Here we address the predictability of tropospheric impacts by SSWs by seeking early precursors of the impacts. We separate midwinter SSWs into two groups: those which are followed by significant, long-lasting impacts on the tropospheric circulation (defined in terms of anomalous Northern Annular Mode) and those not followed by significant anomalies in the annular mode. We show that SSWs characterised by a more negative Northern Annular Mode index in the lower stratosphere around 150 hPa and enhanced wave activity propagation to the stratosphere during the first few days following the central date have a larger probability of being followed by tropospheric impact, both in reanalyses and in climate model runs. These anomalies play a more important role in the subsequent downward propagation of the signal to the troposphere than the type of SSW: whether it is a split or a displacement, or absorptive or reflective SSW. We propose that using these anomalies as precursors of tropospheric impacts of SSW can enhance climate predictability.

**106-R. Peters, D.H.W., A. Schneidereit, A.Y. Karpechko, Enhanced Stratosphere/Troposphere Coupling During Extreme Warm Stratospheric Events with Strong Polar-Night Jet Oscillation, *Atmosphere* 2018, **9**, 467; doi:10.3390/atmos9120467**

Extreme warm stratospheric events during polar winters from ERA-Interim reanalysis and CMIP5-ESM-LR runs were separated by duration and strength of the polar-night jet oscillation (PJO) using

a high statistical confidence level of three standard deviations (strong-PJO events). With a composite analysis, we demonstrate that strong-PJO events show a significantly stronger downward propagating signal in both, northern annular mode (NAM) and zonal mean zonal wind anomaly in the stratosphere in comparison with non-PJO events. The lower stratospheric EP-flux-divergence difference in ERA-Interim was stronger in comparison to long-term CMIP5-ESM-LR runs (by a factor of four). This suggests that stratosphere–troposphere coupling is stronger in ERA-Interim than in CMIP5-ESM-LR. During the 60 days following the central date (CD), the Arctic oscillation signal was more intense during strong-PJO events than during non-PJO events in ERA-Interim data in comparison to CMIP5-ESM-LR runs. During the 15-day phase after CD, strong PJO events had a significant increase in stratospheric ozone, upper tropospheric zonally asymmetric impact, and a regional surface impact in ERA-Interim. Finally, we conclude that the applied high statistical threshold gives a clearer separation of extreme warm stratospheric events into strong-PJO events and non-PJO events including their different downward propagating NAM signal and tropospheric impacts.

**107-R. Schneidereit, A. and D.H.W. Peters, Long-Term Wintertime Trend of Zonally Asymmetric Ozone in Boreal Extratropics During 1979–2016, *Atmosphere* 2018, 9, 468; doi:10.3390/atmos9120468.**

Strong zonally asymmetric ozone (ZAO) changes are observed in the boreal extratropics for winter. During the TOMS (Total Ozone Mapping Spectrometer) period (1979–1992) the decrease of zonally asymmetric total ozone (ZATO) was twice as large as the observed zonal mean total ozone trend over Europe in January mainly caused by ultra-long wave transport. Recent studies have demonstrated that the ozone evolution reveals three different quasi-bidecadal trend stages: (i) Decline, (ii) leveling, and (ii) healing. This study focuses on the ZAO structure in boreal extratropics and on ozone transport changes by ultra-long waves during winter months. ERA-Interim data together with a linearized transport model are used. During the healing stage ZATO increases significantly over the North Atlantic/European region for January. The ZATO increase (healing stage) and ZATO decrease (decline stage) are caused by different monthly mean ozone transport characteristics of ultra-long planetary waves over the North Atlantic/European region. Furthermore, the vertical advection (ageostrophic transport) of ozone versus its horizontal component dominates in the lower and middle stratosphere during the healing stage. It is hypothesized that these ageostrophic wind changes are mainly caused by a wave train directed northeastwards which seems to be directly linked to the Arctic warming.

**111-R. Mani Sivakandan, Dieter H.W. Peters, Günter Entzian, Long-term oscillations and trends of the mesosphere derived from 60 Years of standard phase-heights measurements over Europe: An update, *JASTP* 261 (2024) 106274. <https://doi.org/10.1010/j.jastp.2024.106274>.**

The time series of standard phase-height (SPH) and plasma scale-height (PSH) have been updated from a 60-year long-radio-wave measurement of the broadcasting station Allouis (France, 162 kHz). The signal was received at Kühlungsborn (54° N, 12° E, Mecklenburg, Northern Germany). The statistical analysis of the SPH series shows a significant overall trend with a decrease of 116 m/decade indicating a subsidence of the long-radio wave reflection height of about 700 m. With consideration of a stratopause altitude trend (-70 m/decade) follows an overall mesospheric shrinking of about 300 m over Western Europe. As expected the time series of SPH shows in its spectrum dominant modes which are typical for the solar cycle, ENSO and for QBO bands indicating solar and lower atmospheric influences. Solar cycle and ENSO (-QBO)-like band-pass show a growing increase of SPH up to 1987, followed by a decrease afterward. We found a strong reduction in the amplitude of the solar cycle band due to the weak solar cycle 24, but an increase in the ENSO band. For summer months during solar minimum years, and without stratopause altitude

trend, a thickness temperature trend of the mesosphere is significant with a trend value of  $-0.47 \pm 0.43$  K/decade. The long-term solar variability and the stratopause altitude trend were excluded to determine a more realistic intrinsic mesospheric thickness temperature trend. The overall cooling of the intrinsic mesospheric temperature during 60 years of observation is in the order of 3 K. The long-term solar variability including the decreasing maximum of last solar cycle, and the stratopause altitude trend have to be excluded in order to determine an intrinsic mesospheric temperature trend, which may be caused by greenhouse gas increase in the middle atmosphere.

**112-R. Mani Sivakandan, Dieter H.W. Peters, Jens Mielich, Toralf Renkwitz, Ralph Latteck, and Jorge L. Chau, Comparison of interannual oscillations in the F, E, and D-region ionosphere using longterm ground-based measurements, 2024 submitted to JGR Atmosphere.**

This comprehensive study focuses on interannual oscillations from 1 to 25 years in the F, E, and D region ionosphere. By leveraging long-term (1960-2018) continuous ground based ionosonde and phase height measurements in northern Germany, we have identified the peak periods and temporal variations of these oscillations using advanced analysis techniques such as Lomb-Scargle periodogram, wavelet, and coherence analysis to the detrended, and deseasonalized data. Our investigation also includes an in-depth analysis of solar proxies (F10.7cm and  $L\alpha$ ) to gain insights into the underlying sources of these oscillations. Our results strongly indicate that solar forcing is pivotal in driving oscillations with periods longer than 7 years in the F, E, and D region ionosphere. Furthermore, we have uncovered that the oscillations observed in ENSO-like and QBO-like periods are influenced by solar forcing through ionization and lower atmospheric variability through vertical coupling at different time intervals.

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