Perturbations of Global Wave Dynamics During Stratospheric Warming Events of the Solar Cycle 24

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Solar Cycle 24 (2009-19): Summary of SSW events

During the SC-24 there were 8 Arctic (major and minor) SSW events and single minor Antarctic SSW. *Goncharenko and collaborators* (2009-13) examined influence of SSW on the ionosphere-thermosphere-mesosphere (ITM) plasma and dynamics.

The Whole Atmosphere (WA) models constrained by NWP analyses (0-40 km) can predict the observed perturbations of dynamics and plasma in the ITM.

This paper highlights the key features of the perturbed global wave dynamics induced by Arctic and Antarctic warming events employing two WA models: WACCM-X and WAM with GEOS-5 meteorology of NASA/GMAO.



Arctic winter 2013:T-ZM, T-PW1, T-PW2 observed by MLS EOS Aura (top) and WACCMX-GEOS5 (bottom)



12-hr Tide Energy Anomaly and its Dominance over 24-hr and 8-hr after SSW onsets: WACCM-X/GEOS5

(b) EPV, 2010-01-28, PT=800K

(a) EPV, 2009-01-23, PT=800K

SW2 Temperature Amplitudes at 105 km: SABER and WACCM-X/GEOS-5 (2009, 2010, 2012, 2013)

Both, WACCMX/GEOS5 simulations and the 60-day composite SABER temperature tidal analysis dosplay the growth of SW2 amplitudes

Global maps (150 km) of 12-hr, 24-hr and 8-hr NS-wind amplitudes: after SSW-2013 (Jan 16) and 30-day averaged

During 2013 (last row) simulations and data do not display 2-day oscillations.

January 2012: Simulated Variability of NS-Winds (60 km =>130 km, from PW to tides) at MU/MF and IS radars

2019 Antarctic (Sep 5-17) and Arctic (Dec 25-Jan 1) SSW events

SW2 Temperature Amplitudes (~105 km) WACCMX/GEOS5 and SABER analysis (60-day SABER diagnostics x 1.3 to match colors)

Simulated TEC and TEC anomalies that span SSW days along 20°S (mlat); the enhanced TEC variability occur after (around) onsets of SSW.

Uncertainties in Predictions of Tidal Dynamics (SW2 and DW1 at ~150 km) by WAM and WACCM-X with GEOS-5 meteorology

The large discrepancy between two WA models (WAM and WACCM-X) in the thermosphere (see limits on colorbars) highlights needs to use new NASA ICON and GOLD instruments and evaluate WA models exploring the thermosphere DA schemes for tidal dynamics.

Concluding Remarks

- During the SC24, the WA simulations of nine SSW events demonstrate enhancements of tidal variability with the growth of the 12-hr tide and its dominance over the 24-hr and 8-hr in the E-region of ITM.
- The SABER/TIMED tidal analysis confirms predictions of WA models below 110 km with growth of SW2 after major and minor SSW. The IS and MU/MF radars also display qualitative agreements with WA wind predictions.
- The MLT tropical radar winds display the quasi 2-day wave signatures during SSW (2009, 2010, 2012, except 2013). This feature is well predicted by WACCMX and WAM with meteorology of GEOS-5 (NASA/GMAO).
- Below ~110 km two US WA models with GEOS-5 meteorology can reproduce the tidal and planetary wave perturbations during SSW. *The WACCM-X tides is ~20-40% less than the tides simulated by WAM.*
- In the domain of 130-180 km the discrepancy between WA models is increased; The NASA ICON and GOLD observations of composition, winds and temperature will be critical data to verify and constrain WA models.