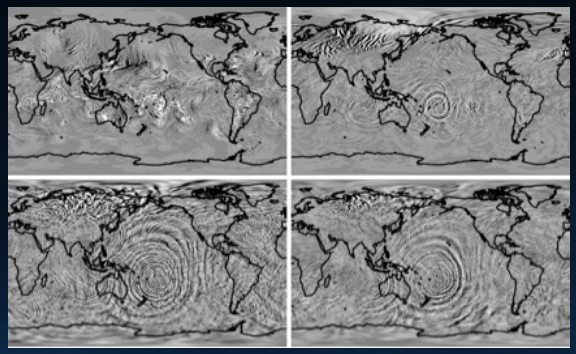
When Lower Atmosphere Waves Invade the Upper Atmosphere

The Earth's upper atmosphere is known to be dramatically driven by energy inputs from above, through solar and geomagnetic inputs. At the same time energy from Earth's weather systems in the troposphere propagate upwards.

How Earth's terrestrial and space weather systems interact is not well understood. A new paper published in *Space Weather*, reviews research on how energy from Earth's lower atmosphere affects variability in the upper atmosphere. The author, Han-Li Liu from the National Center for Atmospheric Research High Altitude Observatory in Boulder, Colorado, found that weather nearer to Earth's surface could produce up to 35% of the variability seen in the uppermost layer of the atmosphere, the thermosphere. The thermosphere is also co-located with most of the charged area of Earth's atmosphere known as the ionosphere.



A model simulation illustrates how gravity waves kicked off by a cyclone east of Australia build as they travel toward space. The simulation was created using a high-resolution version of the Whole Atmosphere Climate Model (WACCM). Credit: Hanli Liu, NCAR.

This thermosphere-ionosphere system, known as the TI, is highly variable. Variability in the TI can directly impact our spacecraft and Earth's technological infrastructure down below. Low Earth orbiting Spacecraft, such as the international space station, orbit in the TI. Atmospheric drag occurs in the TI, affecting not only spacecraft but debris. The radio and GPS signals we rely on for navigation and communication propagate through the TI.

Much of the variability seen in the TI is through changes in solar irradiance, and is also a result of how solar activity interacts with Earth's magnetic field. Scientists started paying special attention to periods of variability in the TI that weren't influenced by space weather, looking for information on how Earth's lower atmosphere might affect conditions higher up. After reviewing the research, Liu attributes any variability seen in the TI not due to space weather to atmospheric waves from the troposphere.

These atmospheric waves include tides, planetary waves, gravity waves, and acoustic waves. Recent studies have shown that these waves, both directly and indirectly, affect TI wind, temperature, and compositional structures; the TI circulation pattern; neutral and ion species transport; and the ionospheric wind dynamo, which generates ionospheric currents and changes in ionospheric density. Whether or not these atmospheric waves propagate upward depends on the wind and temperature conditions in the troposphere.

The NASA Heliophysics next-to-launch ICON mission will take remote and in situ measurements of the TI region, providing observations needed to better understand the whole system. ICON will investigate the continuous interactions between solar forcing and Earth's weather systems that drive extreme and unpredicted variability in the near-space environment.