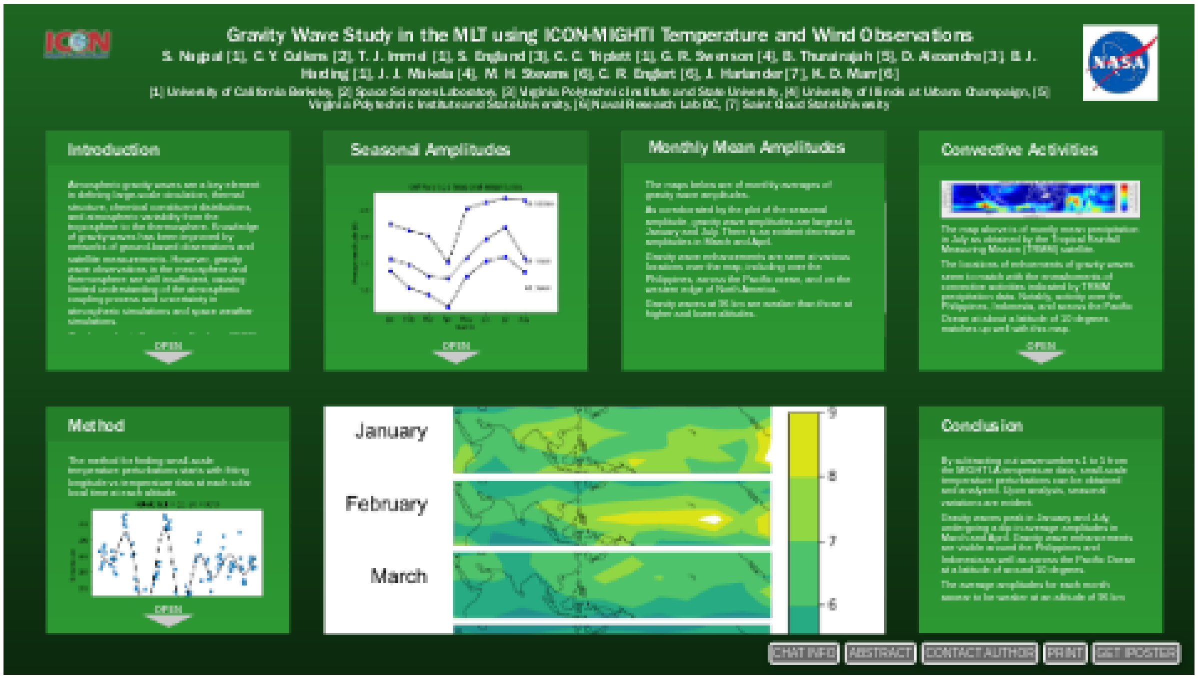
Gravity Wave Study in the MLT using ICON-MIGHTI Temperature and Wind Observations



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INTRODUCTION

Atmospheric gravity waves are a key element in defining large-scale circulation, thermal structure, chemical constituent distributions, and atmospheric variability from the troposphere to the thermosphere. Knowledge of gravity waves has been improved by networks of ground-based observations and satellite measurements. However, gravity wave observations in the mesosphere and thermosphere are still insufficient, causing limited understanding of the atmospheric coupling process and uncertainty in atmospheric simulations and space weather simulations.

The Ionospheric Connection Explorer (ICON) is a NASA-funded Heliophysics satellite was launched on October 10, 2019, at 9:59 p.m. EDT in order to take measurements at high altitudes.

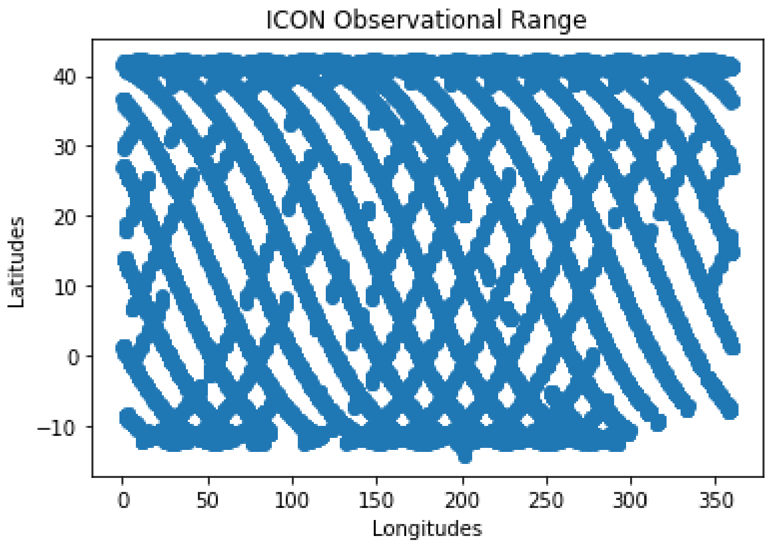


Fig. 1: ICON's Observational range

ICON measures over all longitudes and latitudes of range about 10S to 40N.

This poster uses temperature measurements collected by MIGHTI-A (Michelson Interferometer for Global High-resolution Thermospheric Imaging), an instrument aboard ICON.

SEASONAL AMPLITUDES

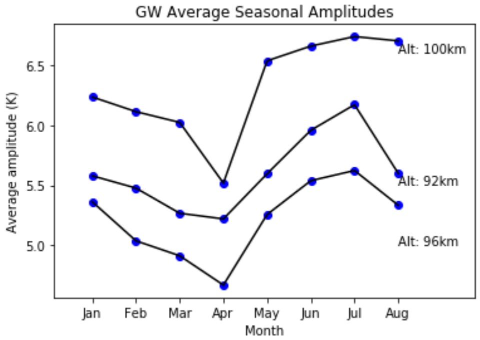


Fig. 6: Average seasonal amplitudes of gravity waves

The results of averaging gravity waves over ICON's observational range (latitudes 10S to 40N and all longitudes) are shown in Fig. 6. Similar seasonal variation peaks in gravity waves are visible in January and July at all altitudes.

Notably, amplitudes are lower at an altitude of 96 km and then get larger again.

MONTHLY MEAN AMPLITUDES

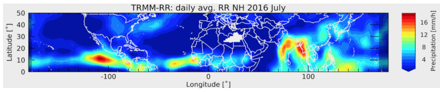
The maps below are of monthly averages of gravity wave amplitudes.

As corroborated by the plot of the seasonal amplitude, gravity wave amplitudes are largest in January and July. There is an evident decrease in amplitudes in March and April.

Gravity wave enhancements are seen at various locations over the map, including over the Philippines, across the Pacific ocean, and on the western edge of North America.

Gravity waves at 96 km are weaker than those at higher and lower altitudes.

CONVECTIVE ACTIVITIES



The map above is of montly mean precipitation in July as obtained by the Tropical Rainfall Measuring Mission (TRMM) satellite.

The locations of enhcements of gravity waves seem to match with the enmahcments of convective activities indicated by TRMM precipitation data. Notably, activity over the Philippines, Indonesia, and across the Pacific Ocean at about a latitude of 10 degrees matches up well with this map.

Further research is needed to determine whether a causal relationship exists between these convective activities and regions of heightened gravity wave activity.

METHOD

The method for finding small-scale temperature perturbations starts with fitting longitude vs temperature data at each solar local time at each altitude.

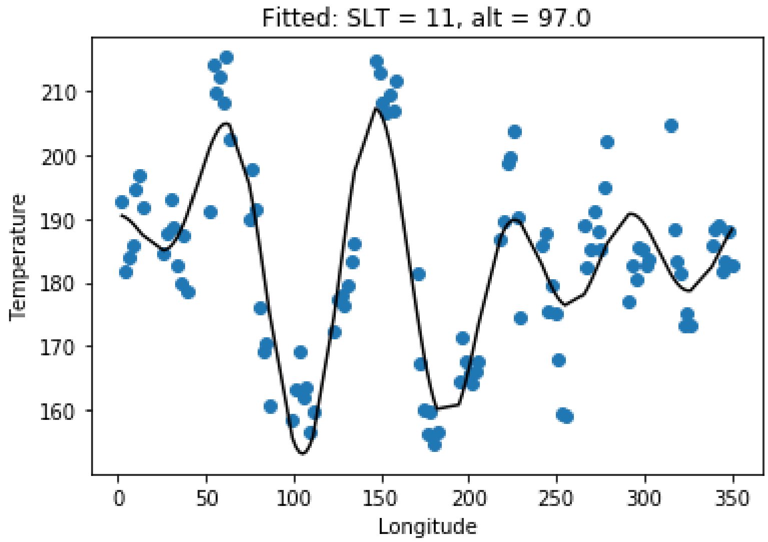


Fig 2: Fitted temperature data at SLT = 11 hr and altitude = 97 km.

Figure 2 for example, is the fitting of all the data within 30 minutes of solar local time 11 hours at an altitude of 97 km.

Perturbations are extracted by subtracting the large-scale waves (wavenumbers 1-5) from temperature data ($T' = T - T_{1\text{-}5}$). The residuals after fitting the data are the high-wavenumber temperature perturbations. We consider these perturbations as gravity waves in this work.

After repeating this process for all solar local times, the results can be combined to create contour plots of perturbations for all of the observed altitudes.

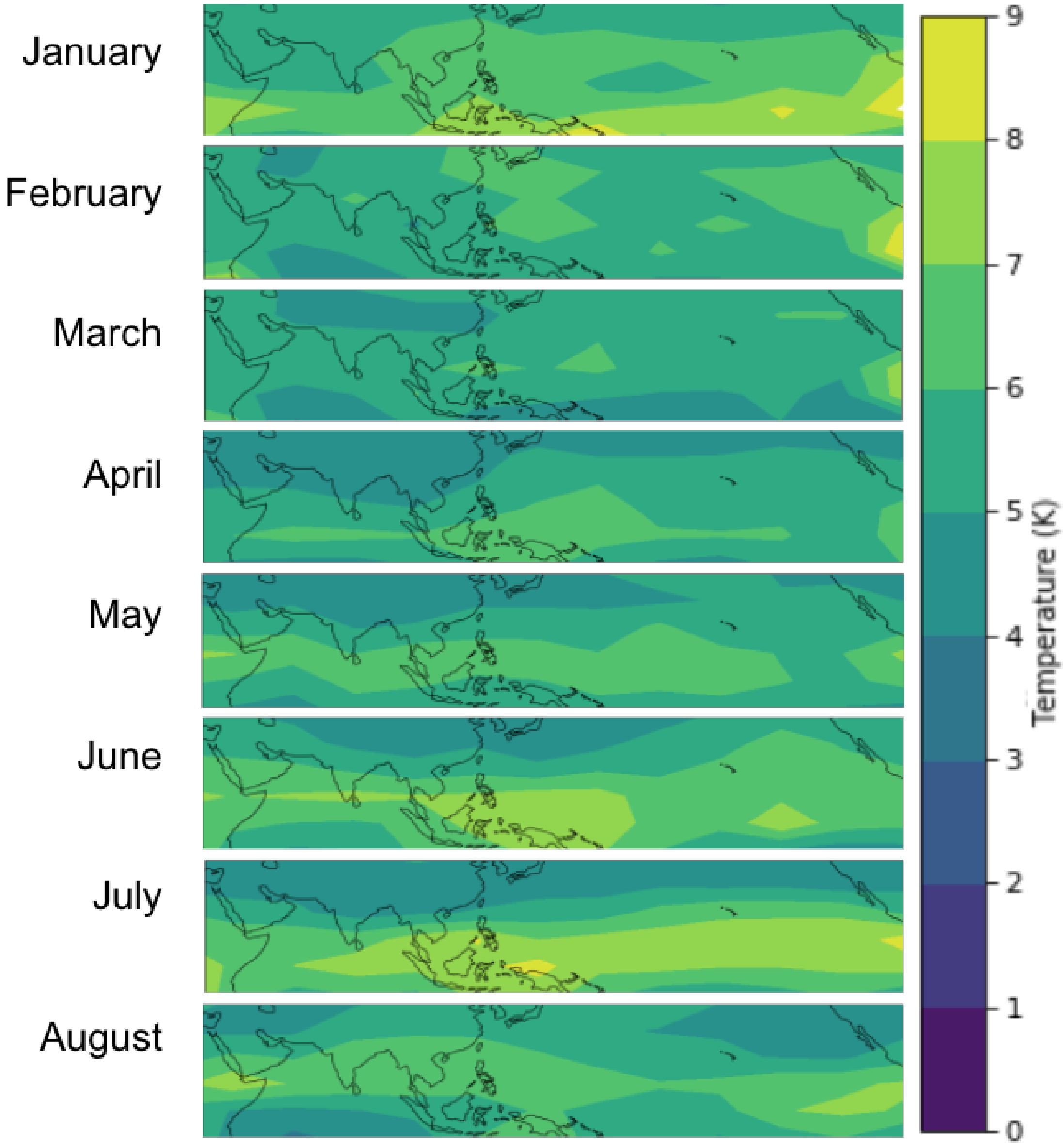


Figure 3. Monthly mean gravity wave amplitude (K) at 92 km from January to August.

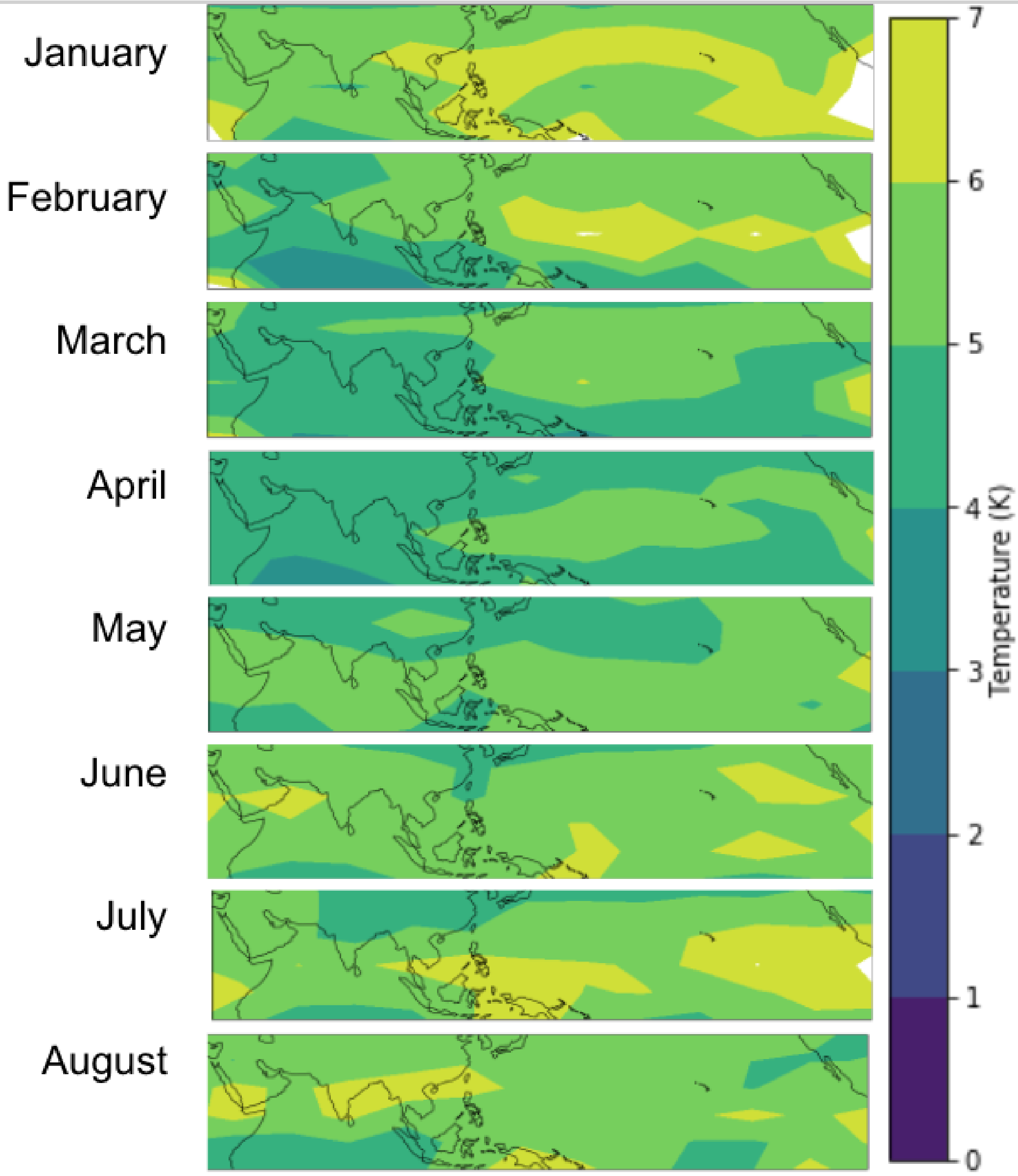


Figure 4. Monthly mean gravity wave amplitude (K) at 96 km from January to August.

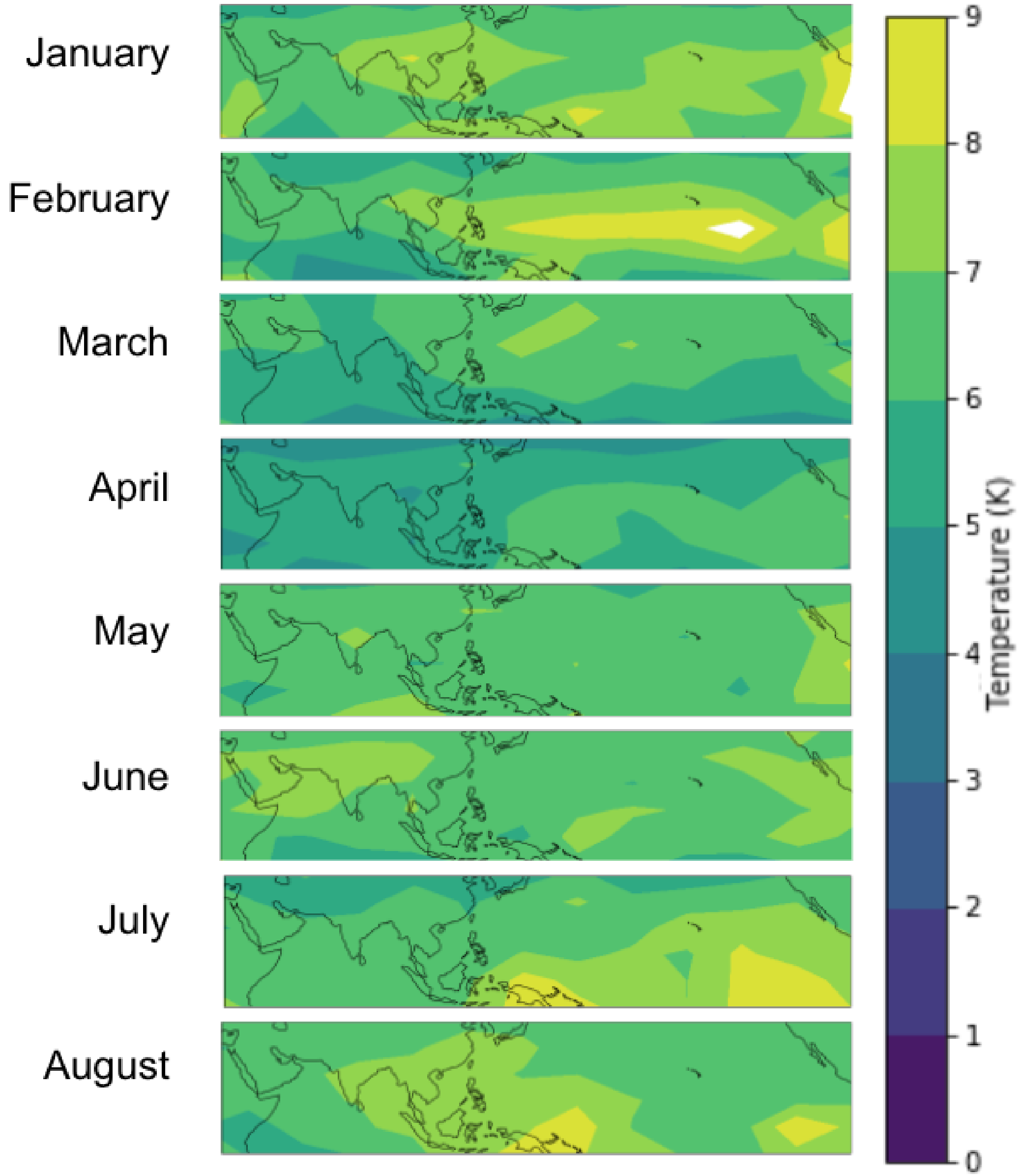


Figure 5. Monthly mean gravity wave amplitude (K) at 100 km from January to August.

CONCLUSION

By subtracting out wavenumbers 1 to 5 from the MIGHTI-A temperature data, small-scale temperature perturbations can be obtained and analyzed. Upon analysis, seasonal variations are evident.

Gravity waves peak in January and July, undergoing a dip in average amplitudes in March and April. Gravity wave enhancements are visible around the Philippines and Indonesia as well as across the Pacific Ocean at a latitude of around 10 degrees.

The average amplitudes for each month appear to be weaker at an altitude of 96 km compared to other measured altitudes.

ABSTRACT

Atmospheric gravity waves have important roles in driving atmospheric coupling processes from the lower atmosphere to the mesosphere, thermosphere, and ionosphere. NASA's Ionospheric Connection Explorer (ICON) satellite was launched on 10 October 2019 and has been observing atmospheric temperatures and winds in the latitude range of 10S-40N. Michelson Interferometer for Global High-resolution Thermospheric Imaging (MIGHTI) is one of the instruments on ICON measuring temperatures and winds. Using both temperature and wind measurements from ICON-MIGHTI observations, small-scale perturbations (< wavenumber 6) are extracted and analyzed in the altitude range of 90-105 km and are considered to be gravity waves in this work. Obtained gravity waves will be compared to other satellite observations including TIMED/SABER. Vertical profiles of ICON-MIGHTI winds and temperatures are further analyzed to study instabilities including Richardson numbers and Brunt Vaisala frequency. Relationship between these instabilities and gravity waves will also be briefly discussed in this work.