

## **Mesosphere-Lower Thermosphere Planetary and Tidal waves structure over the Southern Hemisphere using SANA E and Halley SuperDARN HF RADAR**

By Perfect Chifoto

Email: [perfectpeechifoto@gmail.com](mailto:perfectpeechifoto@gmail.com)

Supervisor: Prof. Sivakumar Venkataraman

Co-supervisor: Dr. Nkanyiso .B Mbatha

# Objectives

- Investigating the contribution of Planetary waves in MLT dynamics.
- Verifying if there is a wave – wave interaction between planetary waves and tidal waves with the mean flow.
- Extracting the type of waves and wave periods dominant during the occurrence of minor Sudden Stratospheric Warming.

# Instrumentation and Data Analysis Techniques

- Sanae & Halley Super Dual Auroral Radar Network (SuperDARN) data
- National Centre for Atmospheric Research (NCEP/NCAR) Re-analysis Data
- United Kingdom Meteorological Office (UKMO) Data Assimilation

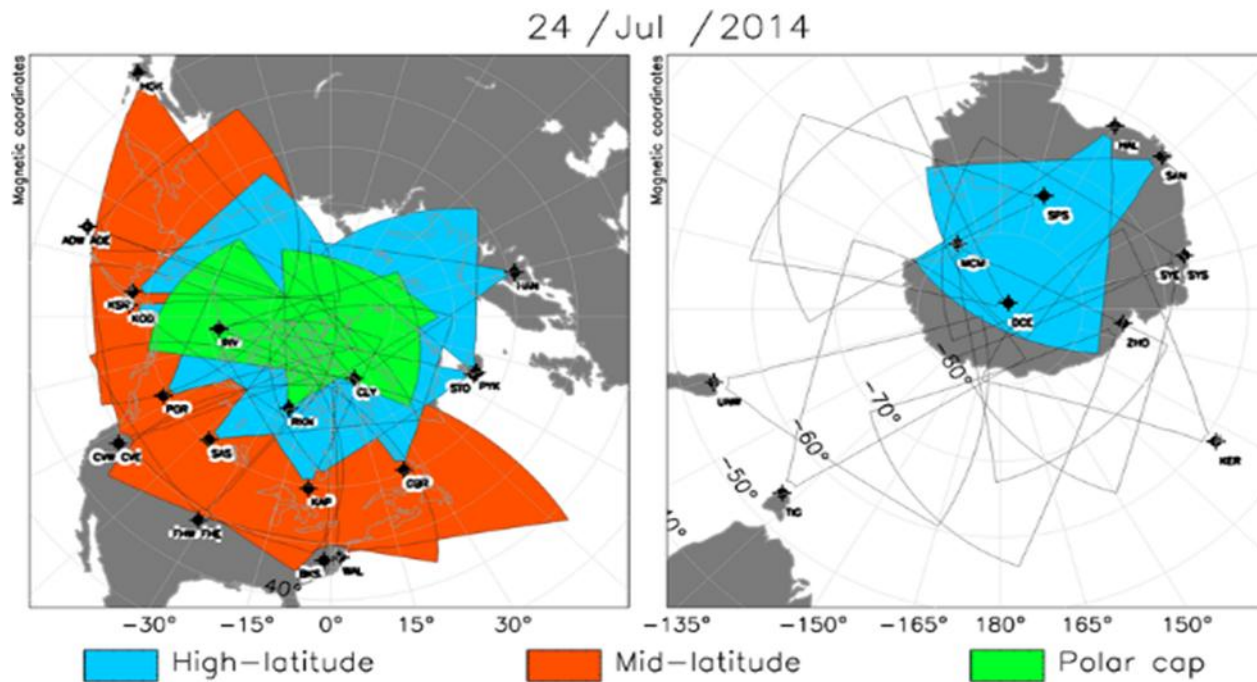
## Fourier Transform

$$X(\omega) = \int_{-\infty}^{\infty} x(t)e^{-i\omega t} dt$$

## Wavelet Transform, Morlet wavelet

$$\psi(t) = e^{-(t/c)^2} e^{i2\pi f_0 t}$$

# Schematic diagram showing SuperDARN radar network geo-locations and their field of view.



# Complex Demodulation

❖ is a technique used to extract the local amplitude and phase of a periodic non-stationary signal. In general, it is implemented by multiplying a given time series by a complex sinusoid ( $e^{-j\omega dt}$ ) where  $j = \sqrt{-1}$  and  $\omega$  is the demodulation frequency, and then pass the result through a low pass filter, Priestly (1981)

❖  $x(t) = \sum_{j=1}^m X_j(t) \exp(i\omega t) + Z(t)$

✓ Demodulated signal

❖  $x(t) = \frac{1}{2} X(t) \exp[i\phi(t)] + \frac{1}{2} X(t) \exp[-i(2\omega t + \phi(t))] + Z(t) \exp(i\omega t)$

✓ filter is applied to remove frequencies at or above the frequency  $\omega$

❖  $x'(t) = \frac{1}{2} X'(t) \exp(i\phi't)$

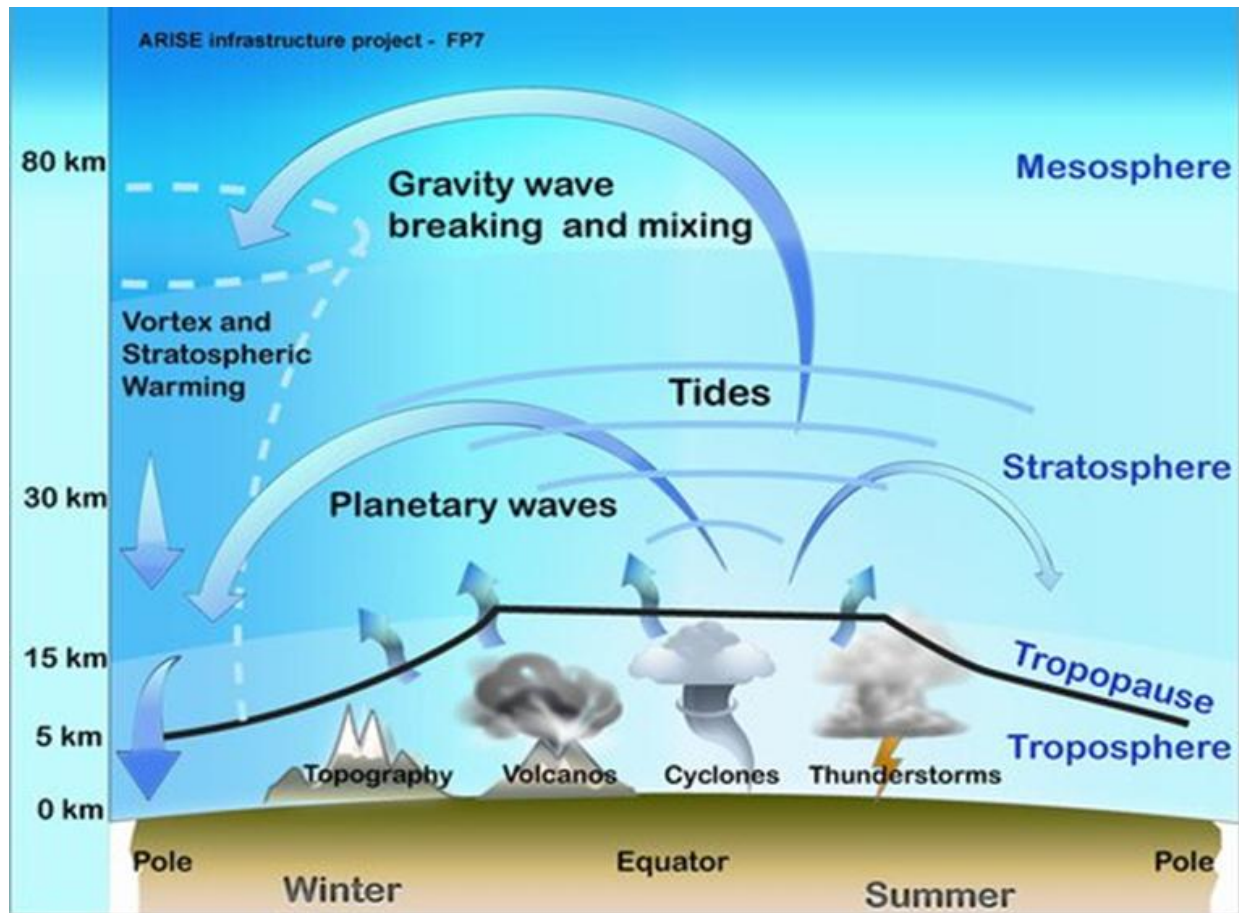
# Planetary Waves

- ❖ Planetary waves (or Rossby waves) are excited due to the meridional gradient of potential vorticity. They have periods of two to several days and have one or more longitudinal peaks around the globe.
- ❖ Planetary waves are forced modes generated in the troposphere by wind flow over continental scale topography, continent-ocean heating contrasts, nonlinear interactions among transient tropospheric wave disturbances, cyclones and thunderstorms, (Holton, (1975); Volland, (1988); Forbes, (1995) and Mbatha, (2012).

## Tidal Waves

- ✓ Atmospheric tidal waves (or commonly referred as tides) are generated because the atmosphere is periodically heated by the Sun.
- ✓ Tidal waves are separated into three types, namely (diurnal ~24 h, semidiurnal ~12 h tides and terdiurnal ~8 h) however, this study focuses only on diurnal tides (DT) and semidiurnal tides (SDT).

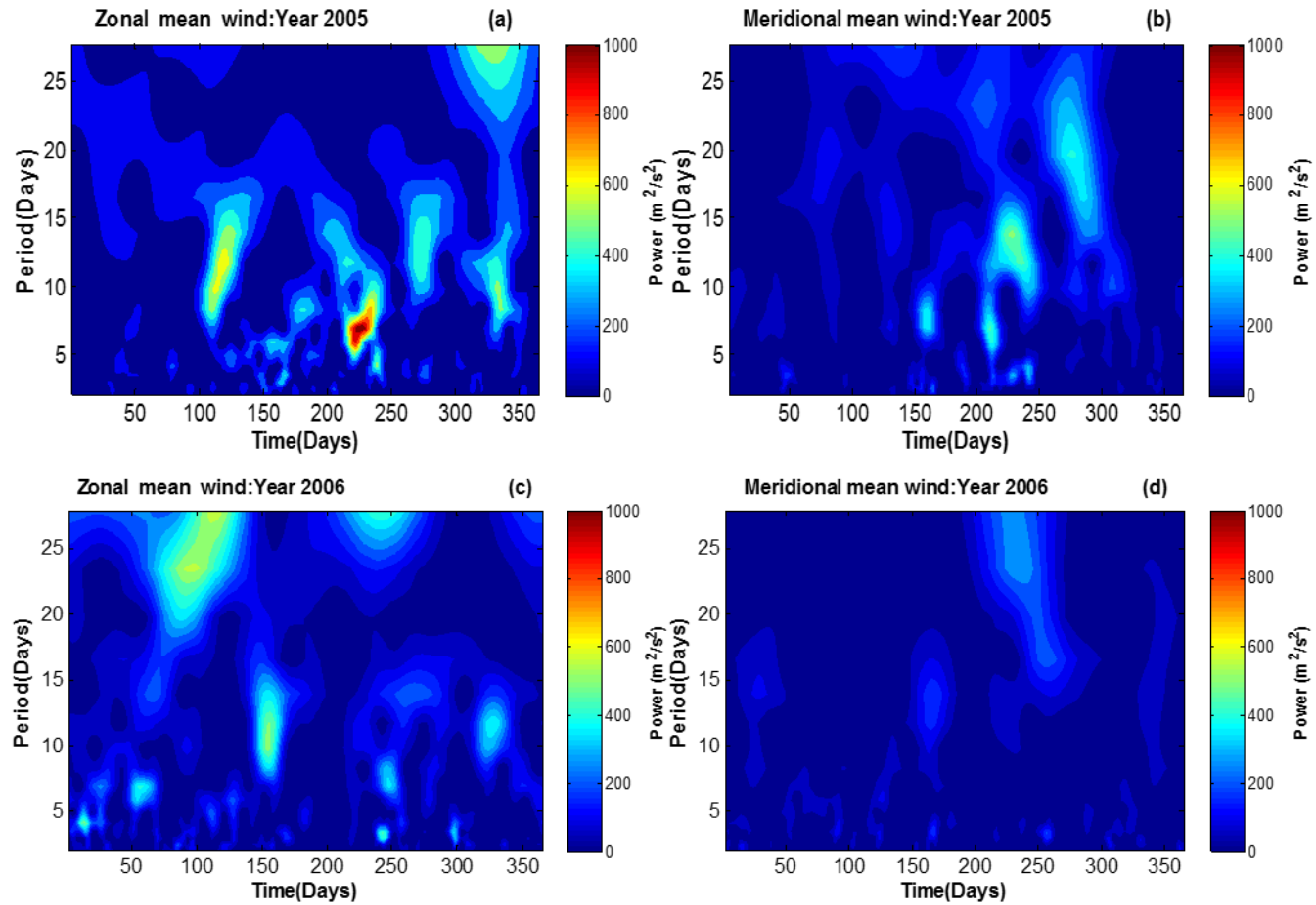




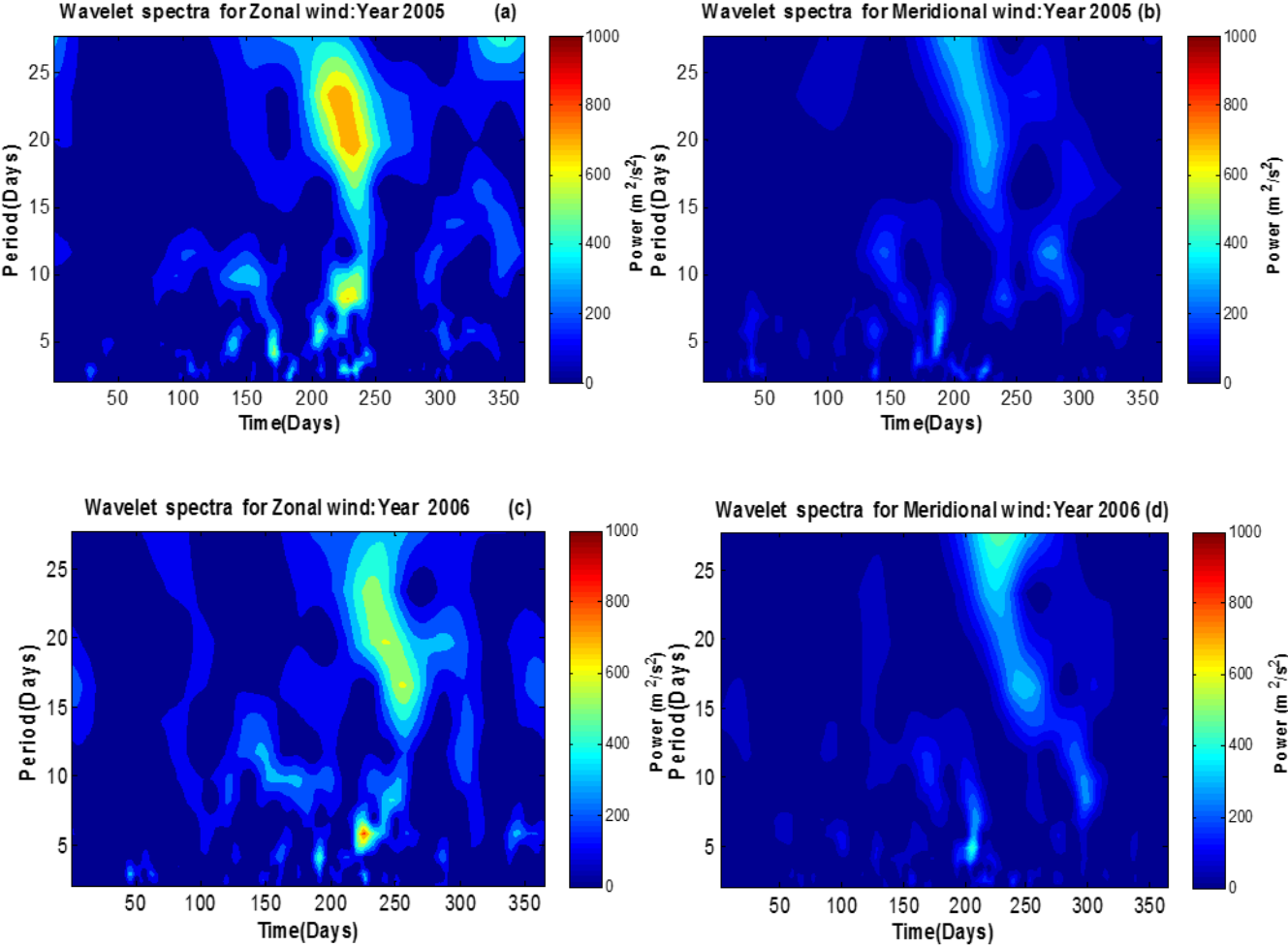
Dynamics of the troposphere-stratosphere-mesosphere exchanges including the contribution of gravity waves and planetary waves (source: <http://arise-project.eu/atmospheric-dynamics.php>).



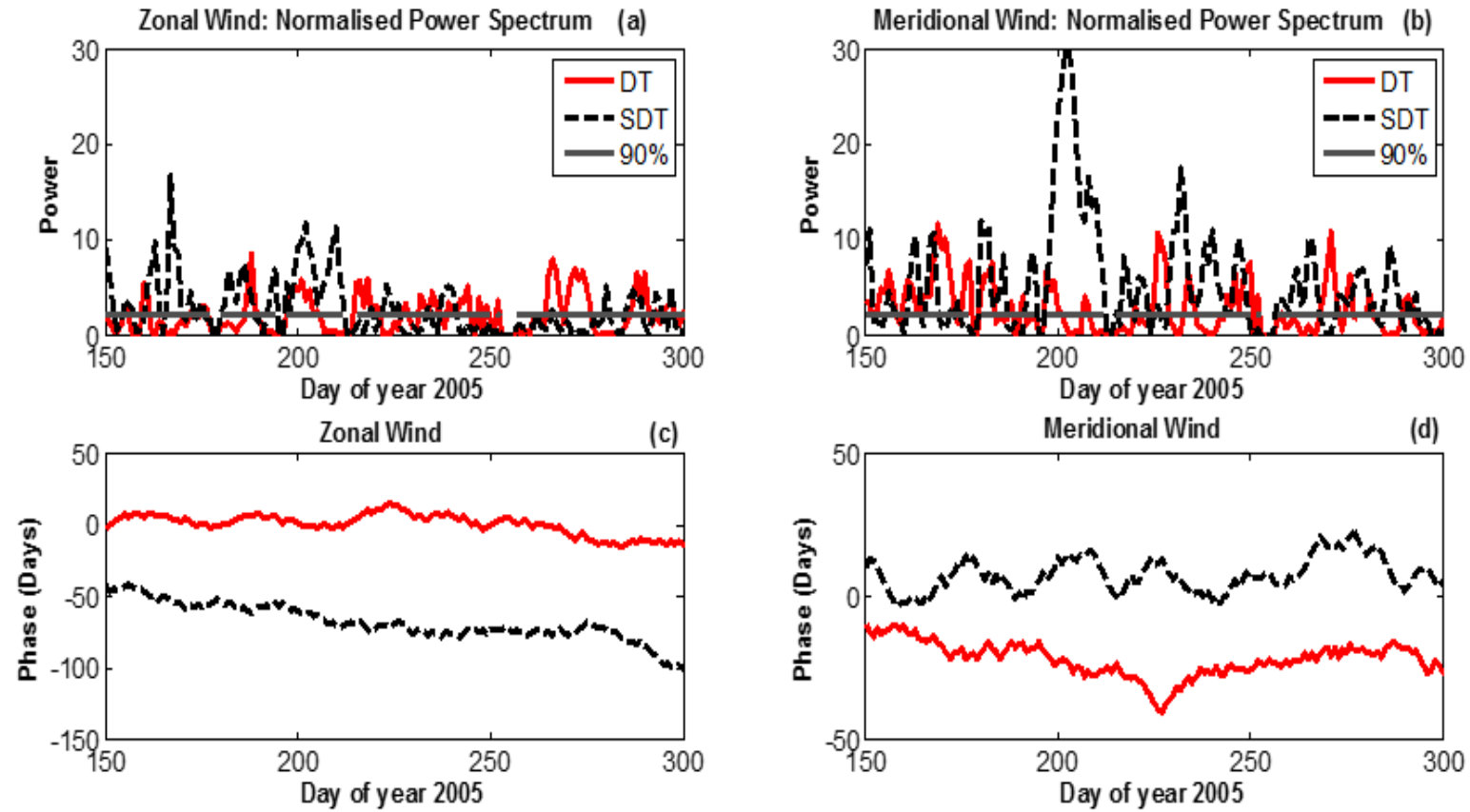
# SANAE Super DARN HF radar wind at ~94km.

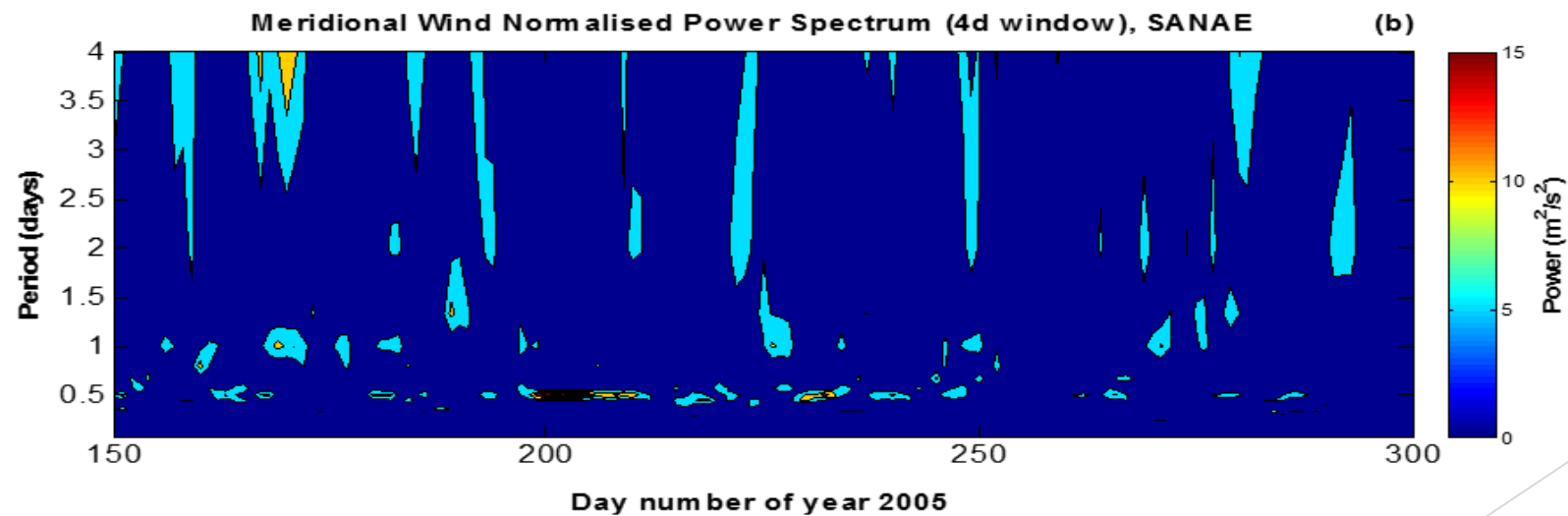
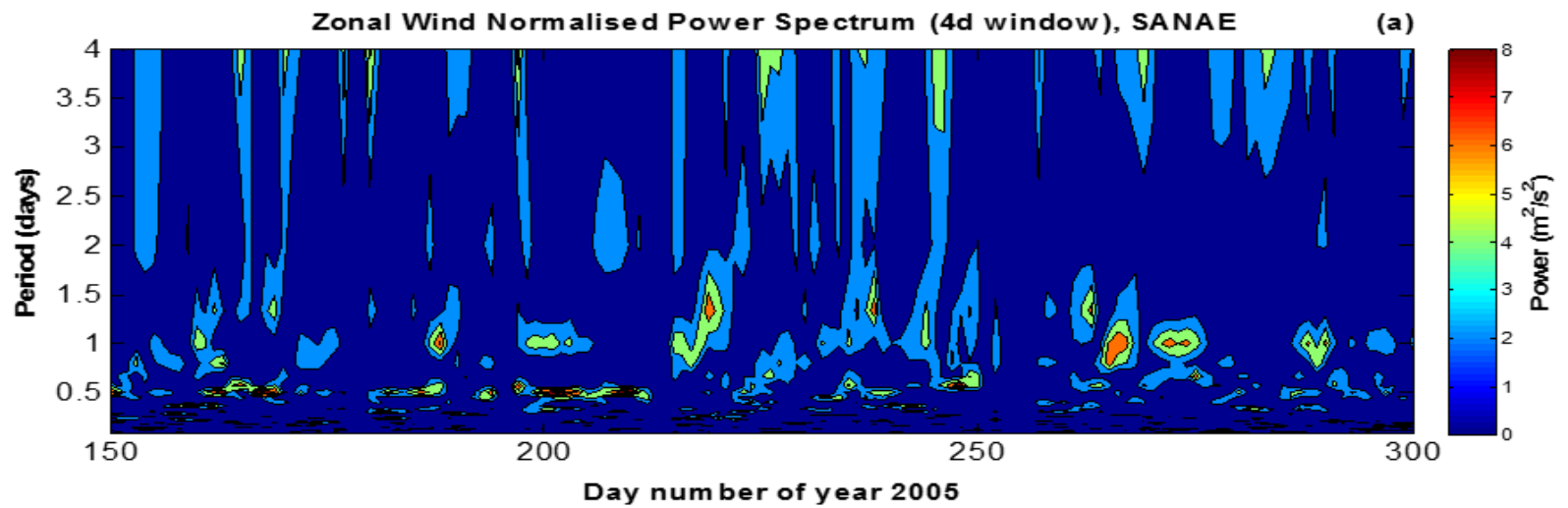


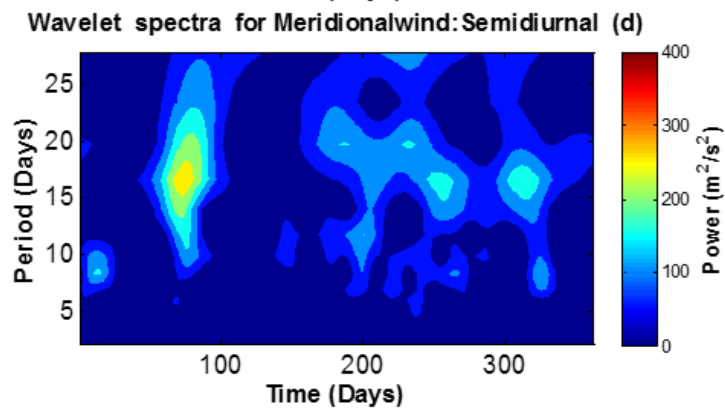
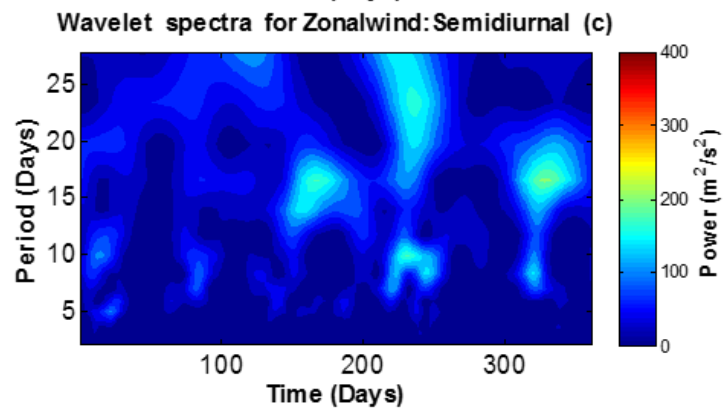
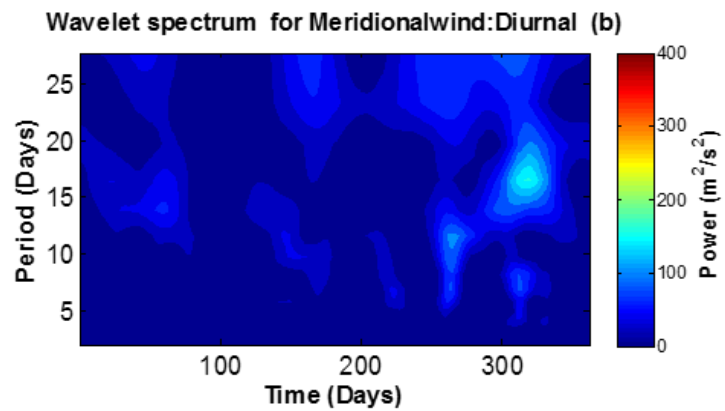
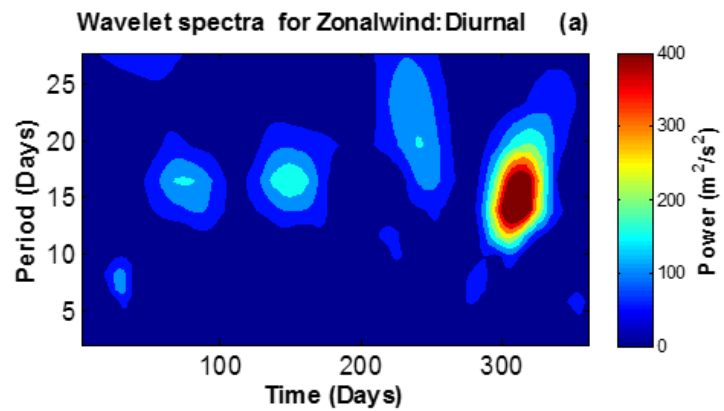
# Halley Super DARN HF radar wind at ~94 km



# Diurnal and Semidiurnal Tides



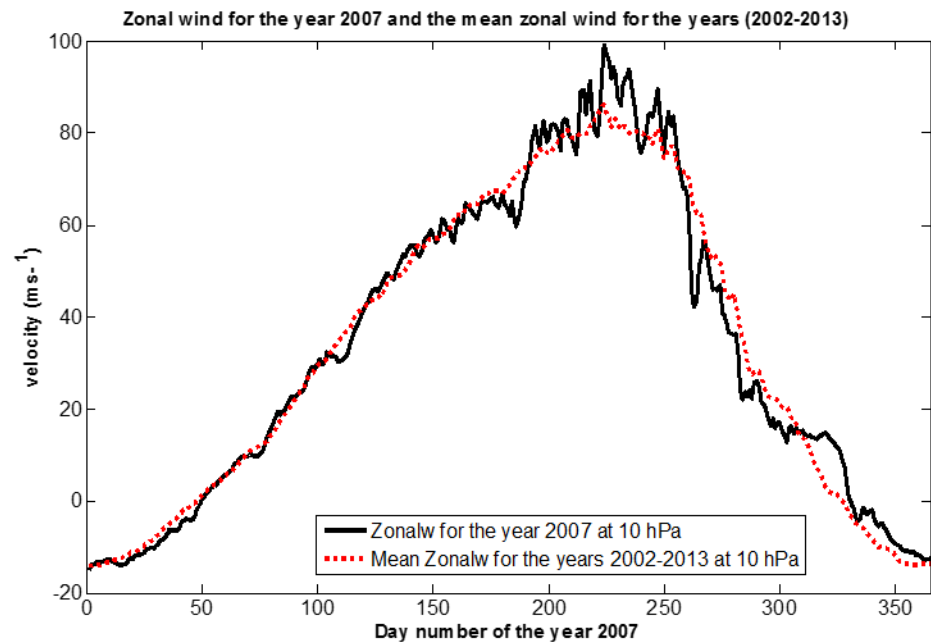




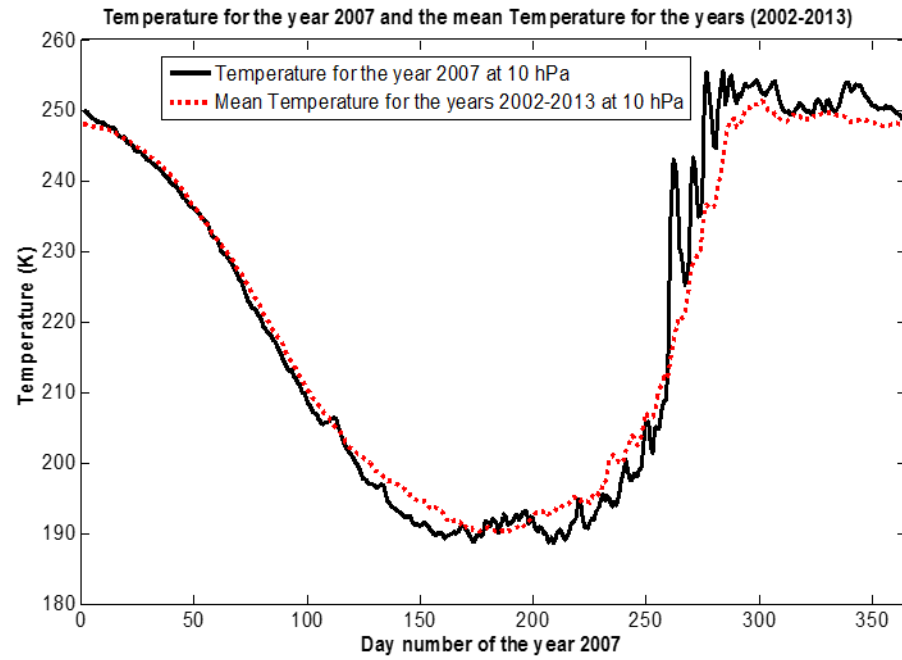
SANAE HF radar at ~94 km.

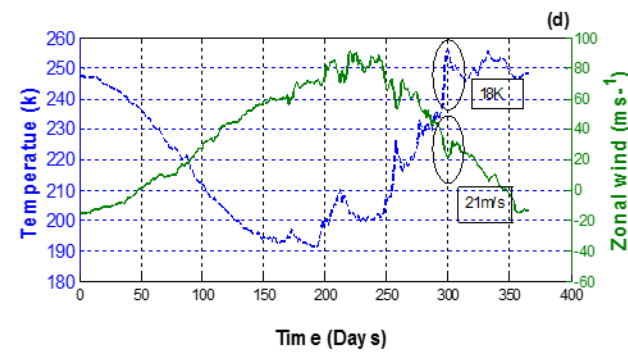
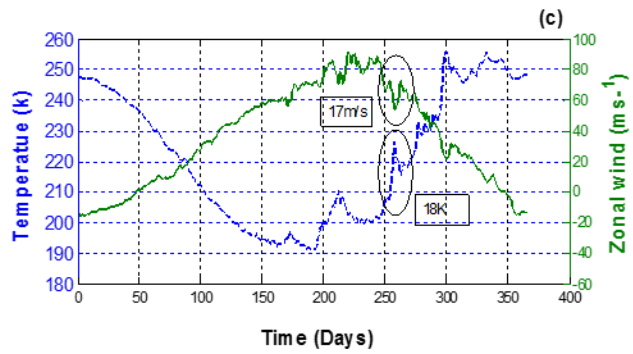
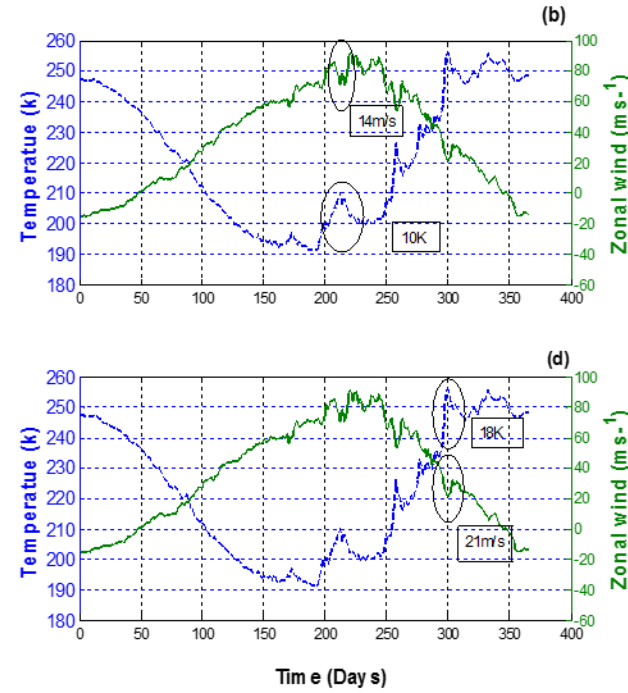
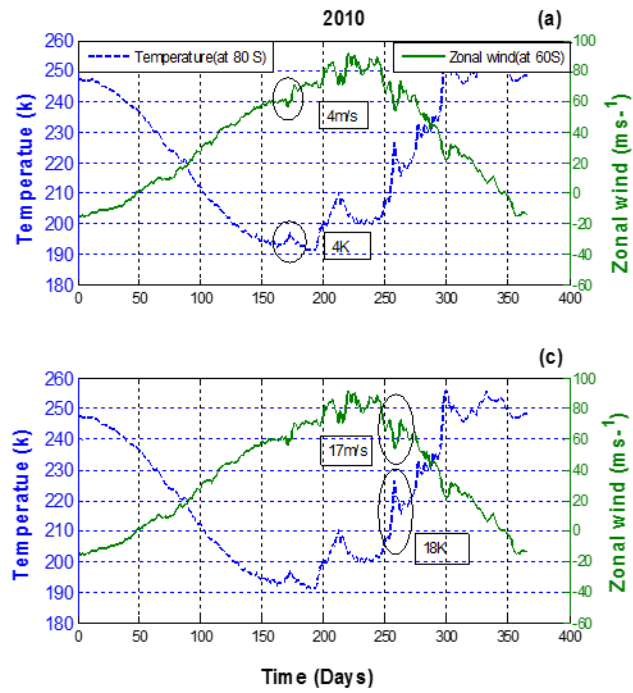
## Sudden Stratospheric Warming (SSW)

- ✓ There are four different types of SSW namely, minor SSW, major SSW, Canadian warming, and final Warming.
- ✓ According to World Meteorological Organisation (WMO), a major SSW occurs if the latitudinal mean temperature at 10 hPa or below increases abruptly pole ward from 60° latitude with an associated wind circulation reversal.
- ✓ If the process occurs but does not lead to a complete reversal of wind circulation, it is classified as a minor SSW.







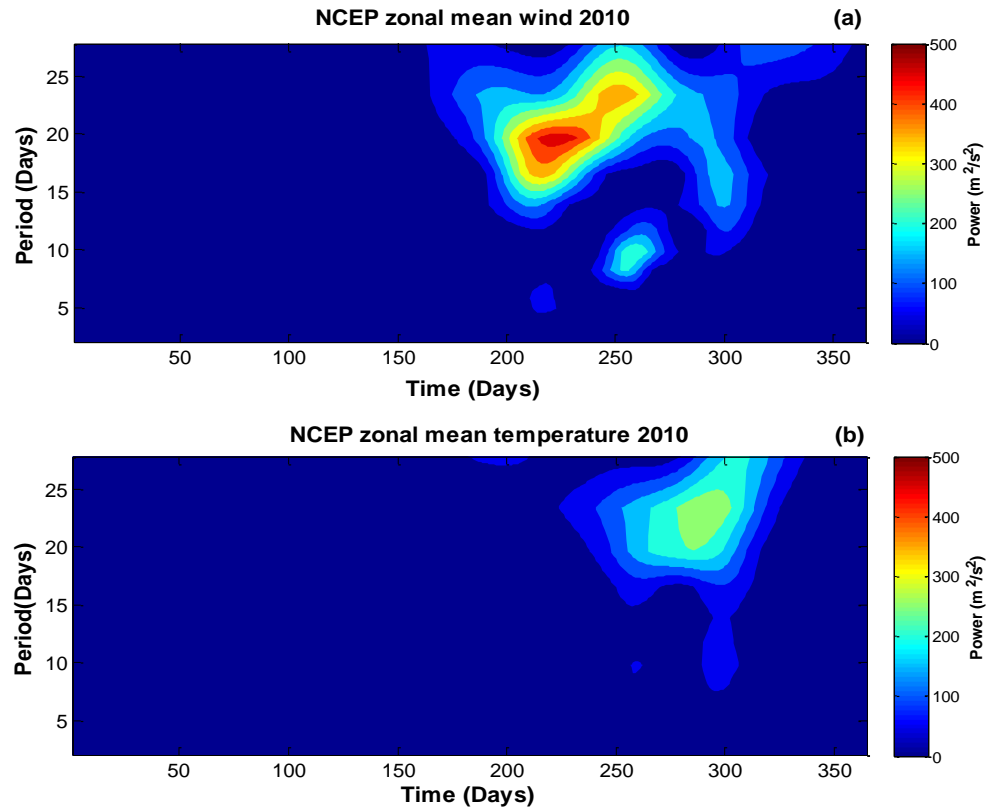


zonal mean wind at 60° S (solid line) and temperature at 80° S (dotted line) from NCEP reanalysis

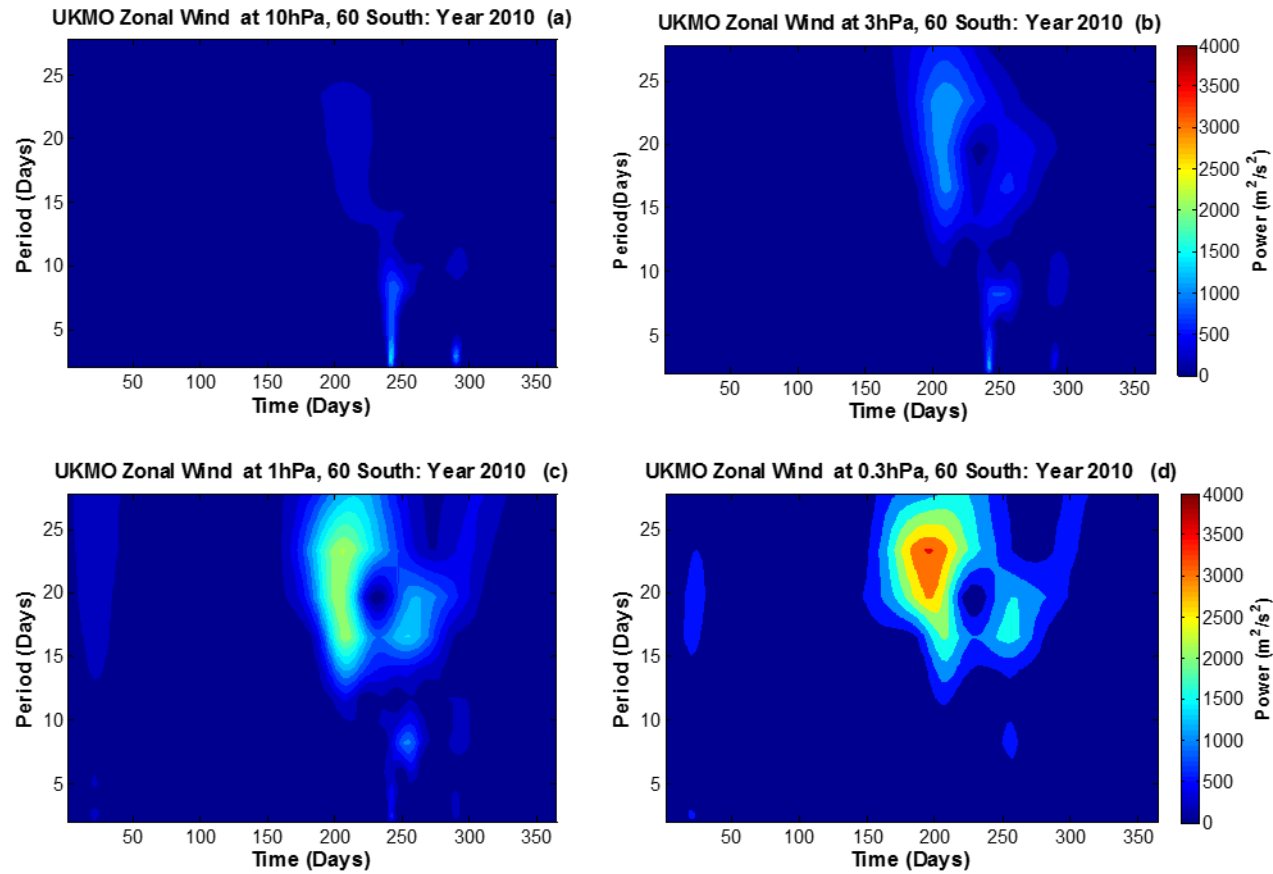
Start Day	End Day	Duration	Magnitude of $\Delta$ Velocity (m/s)	Magnitude of $\Delta$ Temperature (K)
165	175	10	4	4
195	226	31	10	18
253	263	10	17	18
294	302	8	21	18*(Final Warming)

- all minor SSW events occurred after the same duration of time had elapsed hence an average common period of approximately 42 days was estimated.

# Planetary Wave Activity during Minor Sudden Stratospheric Warming



Wavelet spectra for zonal mean wind at  $60^\circ\text{S}$  and temperature at  $80^\circ\text{S}$  at 10 hPa using NCEP reanalysis data



Wavelet spectra for UKMO zonal mean zonal wind for the year 2010

# Summary

- ❖ **The investigation shows the interaction between planetary waves and tides which could have caused minor Sudden Stratospheric Warming events**
- ❖ **The evidence of long period planetary waves during minor SSW events suggest the presence of quasi 10, 16 & 20 day waves.**

END

THANK YOU!!!!!!!!!!!!

