Coordinated, optical, radio, and magnetic investigations of wave dynamics in the daytime upper atmosphere

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Introduction

- Various processes occurring in the upper atmosphere are affected by electrodynamical and neutral wave dynamics.

- Lower - equatorial upper atmospheric regions are highly dynamically coupled.

- Optical method of investigation is one of the effective means to study the neutral dynamical behaviour of the upper atmosphere

- To investigate the daytime neutral behaviour, optical dayglow emissions (Oxygen **557.7 nm**, **630.0 nm** and **777.4 nm**) from a low-latitude station (Hyderabad, India, 17.36^0 N, 78.4^0 E, MLAT = 9^0 N) have been used for this study.

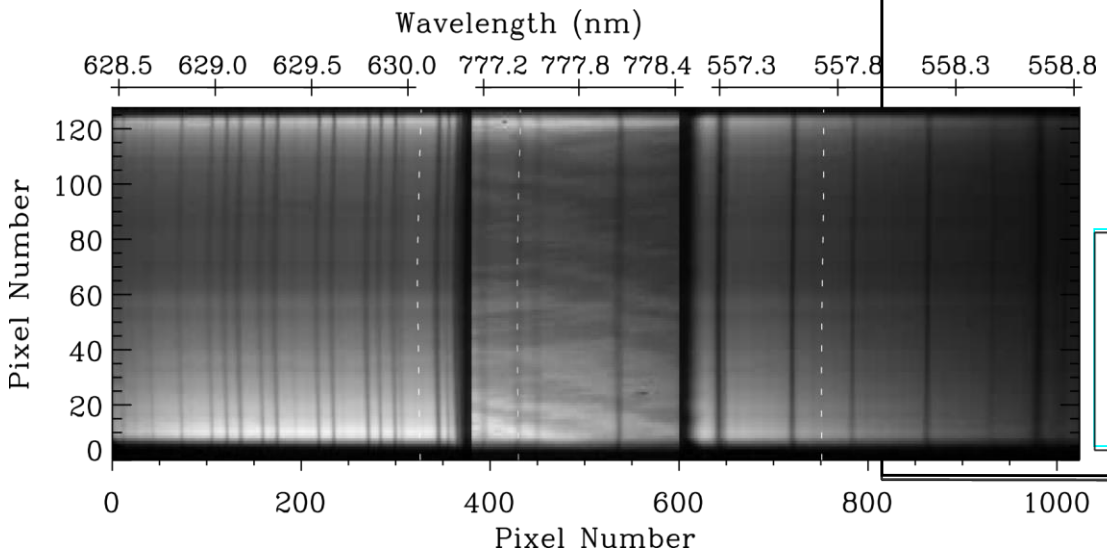
Multiwavelength Imaging Spectrograph using Echelle - grating (MISE)

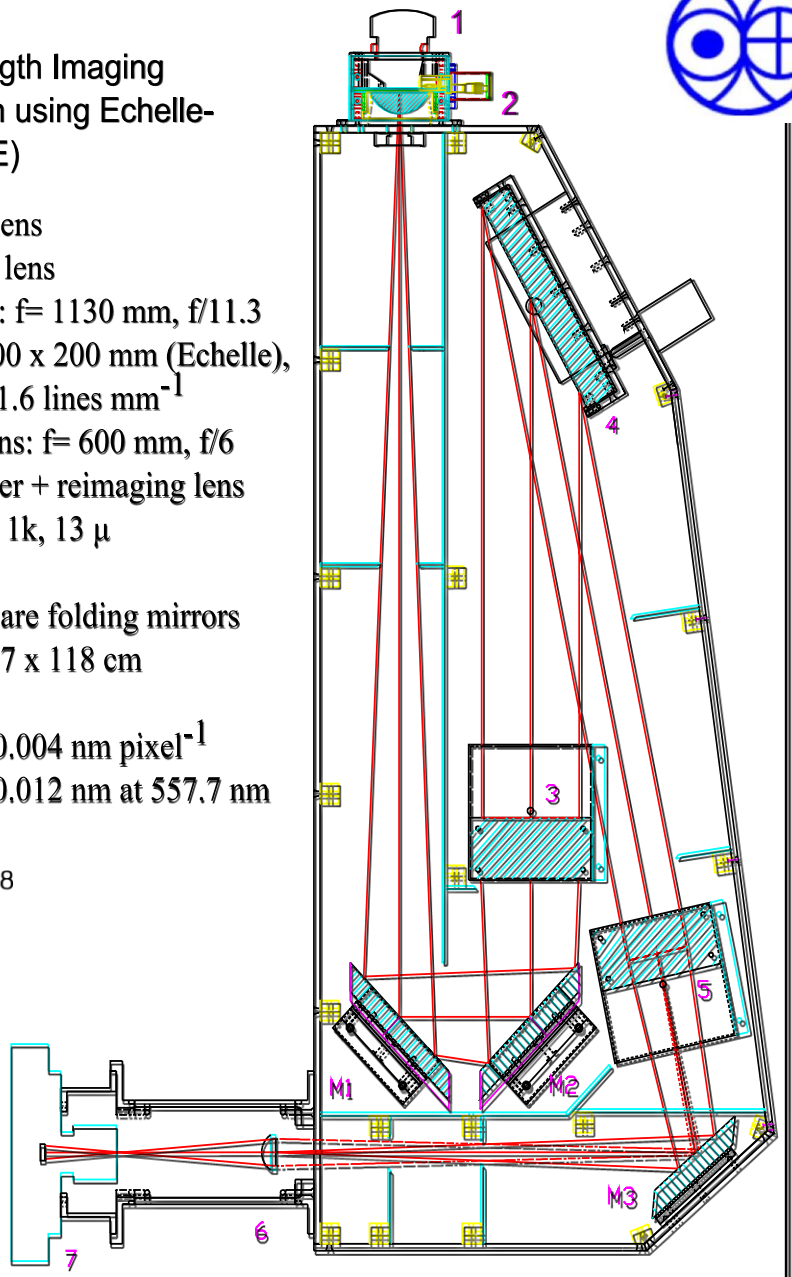
Multiwavelength Imaging Spectrograph using Echelle-grating (MISE)

1. Objective lens
2. Slit + field lens
3. Collimator: f= 1130 mm, f/11.3
4. Grating: 100 x 200 mm (Echelle), 31.6 lines mm^{-1}
5. Imaging lens: f= 600 mm, f/6
6. Mosaic filter + reimaging lens
7. CCD: 1k x 1k, 13 µ

M1, M2, M3 are folding mirrors
Dimension: 77 x 118 cm

Dispersion= 0.004 nm $pixel^{-1}$
Resolution= 0.012 nm at 557.7 nm





Pallamraju et al., (2013), JASTP

Commissioning of MISE

- **JNTU, Hyderbad**
  (17^0N, 80^0E; 8.7^0N Mag. Lat)
  PRL's optical aeronomy observatory

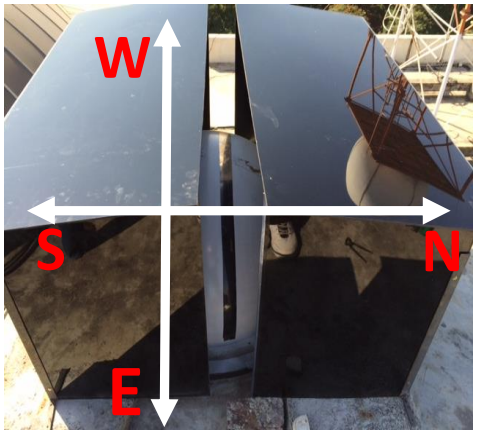
- Initially, MISE was commissioned with its slit oriented along the magnetic meridian (N-S).

- Later, the slit alignment was changed to **East-West** direction

- At present data collection is continuing in **continuous mode**

Installation of dome in east-west direction

MISE: A view from inside the laboratory



Top side view of dome with hood

Production mechanism of the emissions

577.7 nm

Production of $O(^1S)$

$$O + e_{ph} \rightarrow O(^1S) + e^-$$
$$O_2 + h\nu \rightarrow O(^1S) + O$$
$$O_2^+ + e_{th} \rightarrow O(^1S) + O$$
$$O + O + M \rightarrow O(^1S) + O + M$$

Loss of $O(^1S)$

$$O(^1S) \rightarrow O(^1D) + h\nu\ (557.7nm)$$
$$O(^1S) + N_2/O_2 \rightarrow O(^3P) + N_2/O_2$$

630.0 nm

Production of $O(^1D)$

$$O + e_{ph} \rightarrow O(^1D) + e^-$$
$$O_2 + h\nu \rightarrow O(^1D) + O$$
$$O_2^+ + e_{th} \rightarrow O(^1D) + O$$
$$O(^1S) \rightarrow O(^1D) + h\nu\ (557.7nm)$$

Loss of $O(^1D)$

$$O(^1D) \rightarrow O(^3P) + h\nu\ (630.0\ nm)$$
$$O(^1D) + N_2/O_2 \rightarrow O(^3P) + N_2/O_2$$

777.4 nm

Production of $O(^5P)$

$$O^+ + e \rightarrow O(^5P)$$

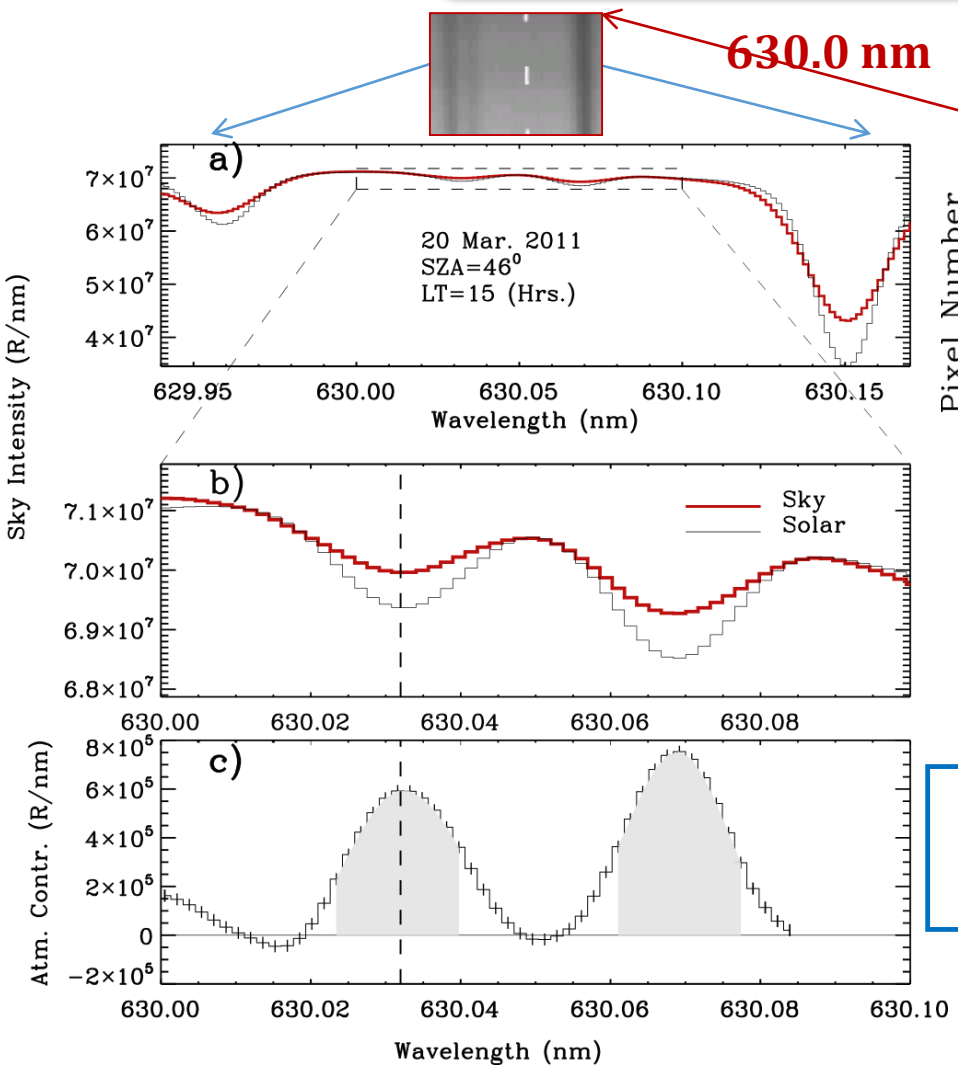
Loss of $O(^5P)$

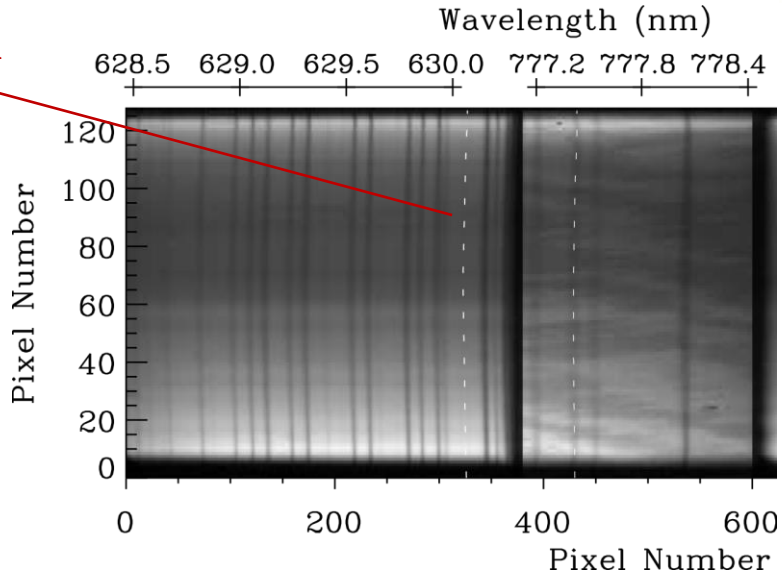
$$O(^5P) \rightarrow O(^5S) + h\nu\ (777.4\ nm)$$

Altitudes of emission (Approx)

OI 557.7 : ~130 km
OI 630.0 : ~230 km
OI 777.4 : ~300 km

Analysis Methodology





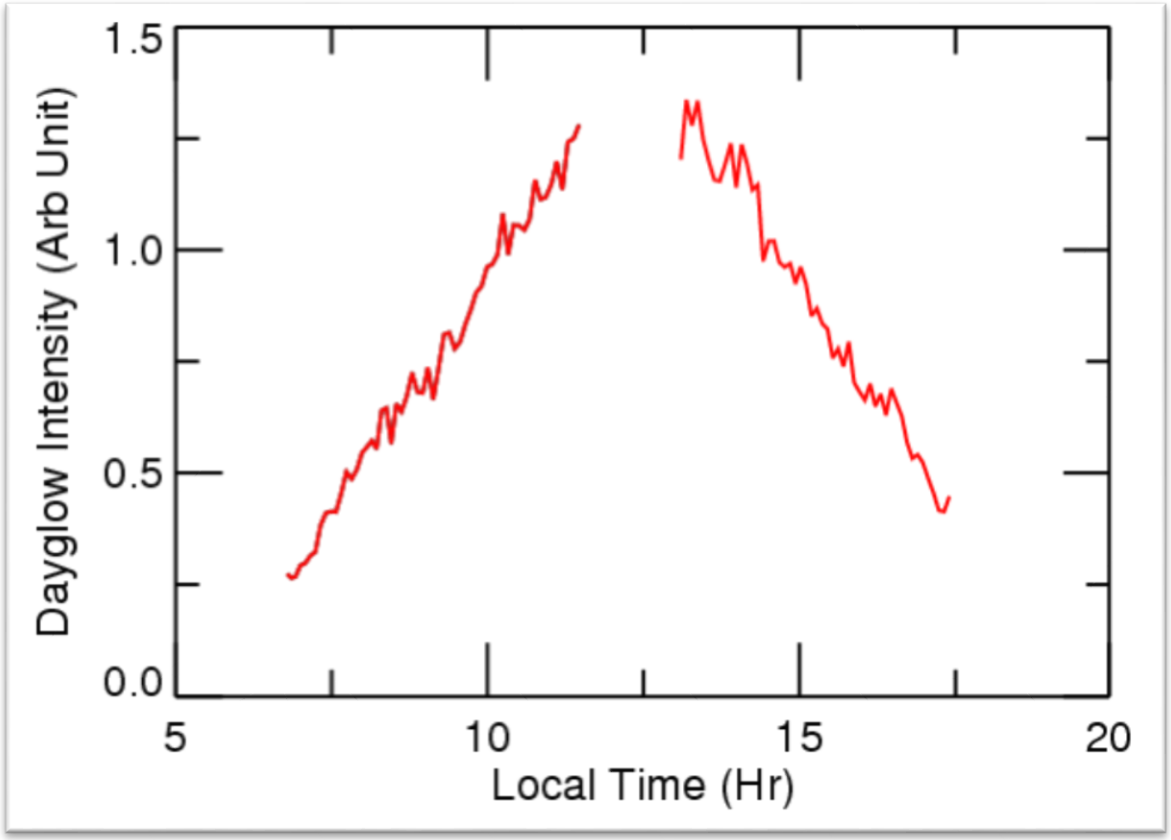
Dayglow=Total contribution –
Scattering contribution (Ring Effect)

$$RE = Total\ integrtaed\ counts\ in\ DG\ line \times \frac{Line\ strength\ of\ a\ Fraunhofer line}{Line\ strength\ of\ DG\ line}$$

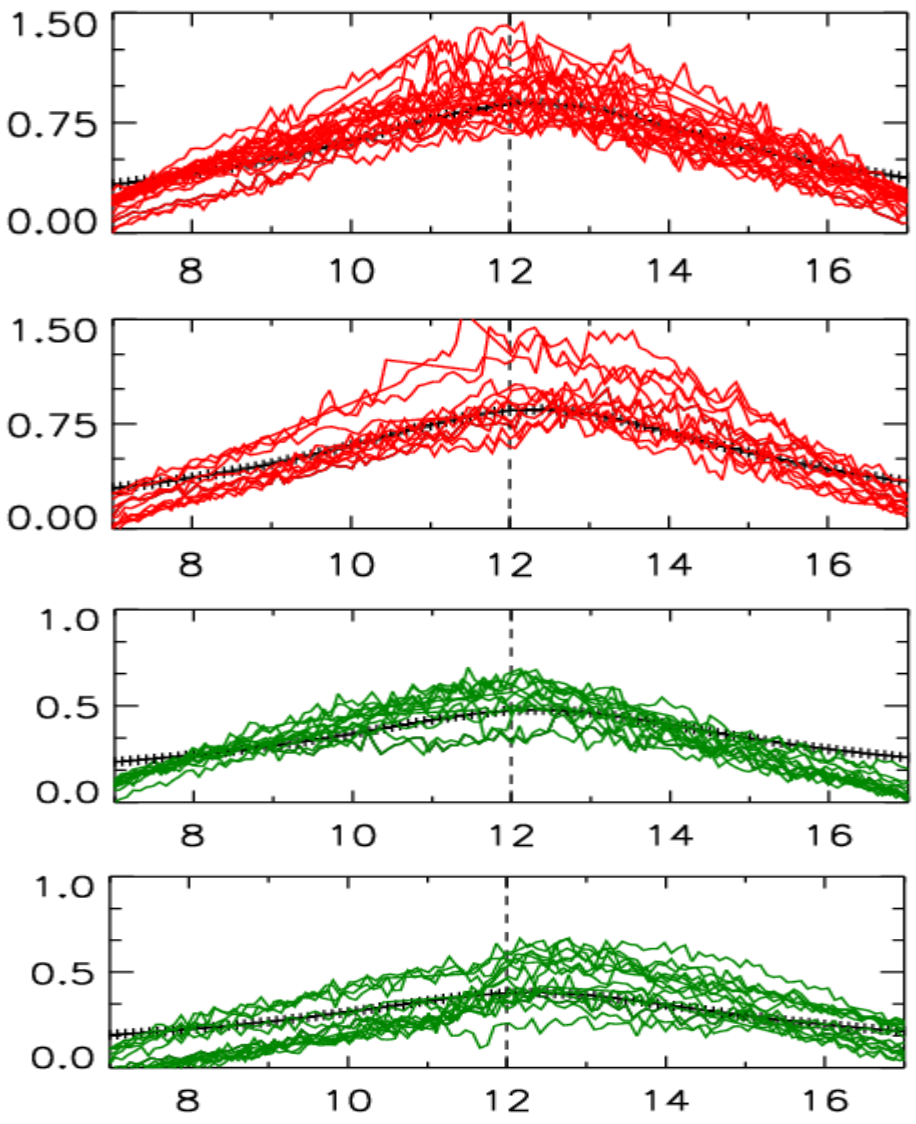
Pallamraju et al., 2013, JASTP

Line strength=Normalized Depth X Half Width

Diurnal variations of dayglow intensity



Different combination of days showing symmetric and asymmetric behaviour both in 630.0 nm and 557.7 nm



Dec 2013 – Feb 2014

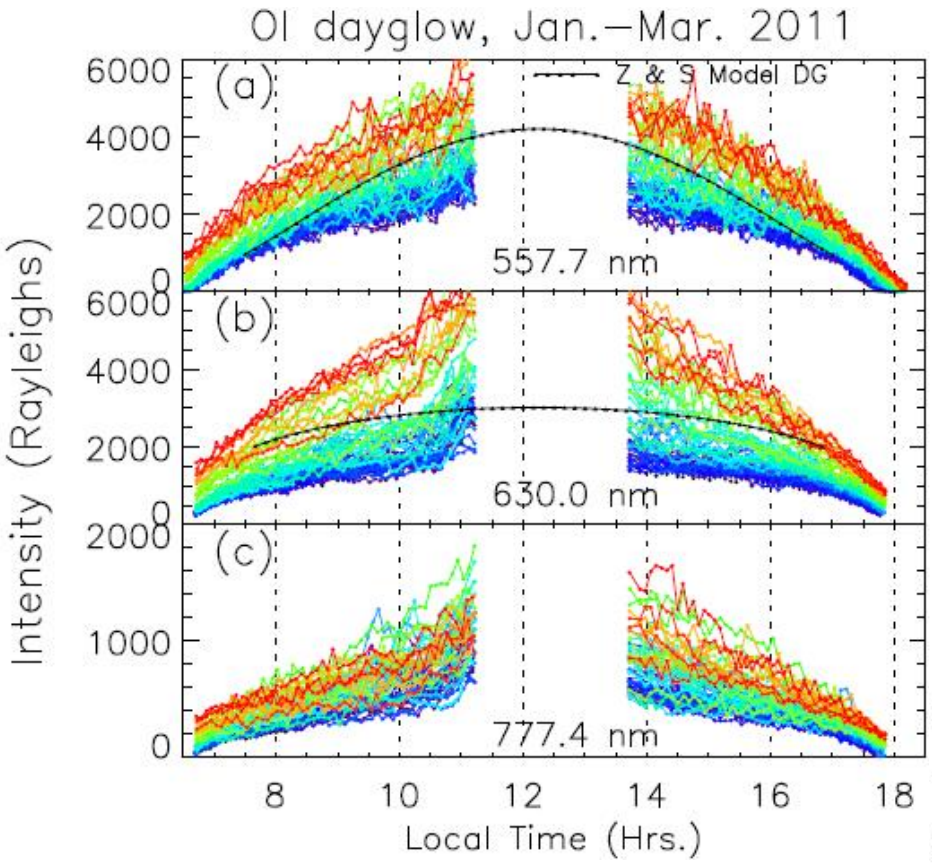
Symmetric

Asymmetric

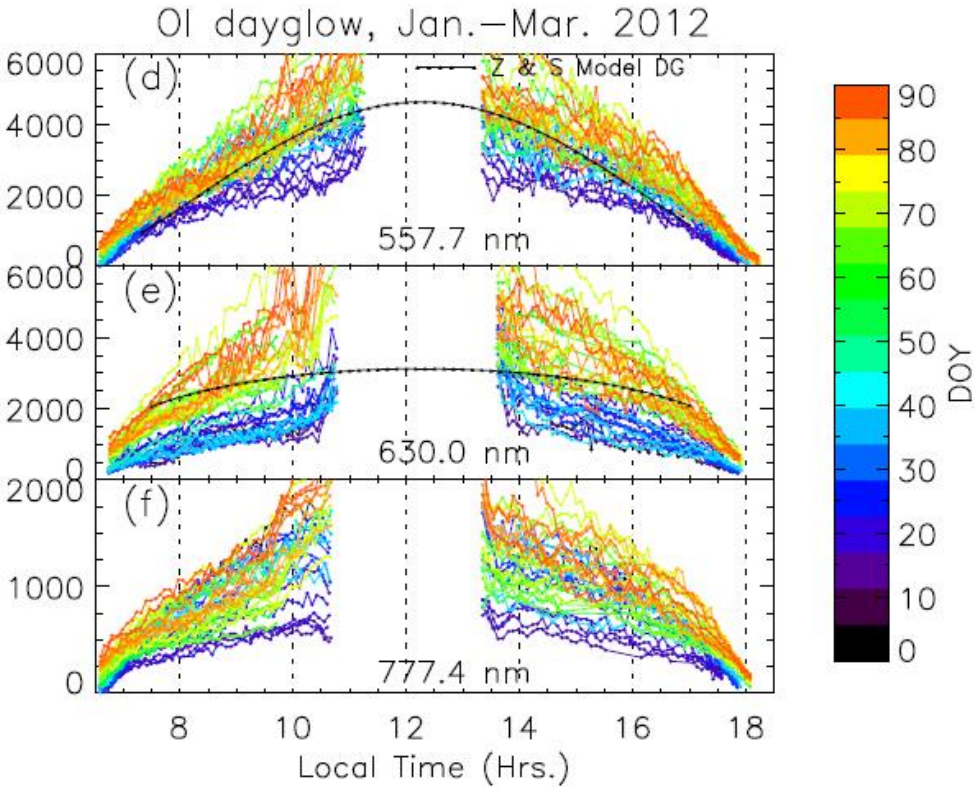
Symmetric

Asymmetric

- Notice the peak in the afternoon in asymmetric days
- Spread in the emission intensities in the afternoon is greater than the pre-noon.
- Emissions from multiple alts. behaving in a similar fashion – common source



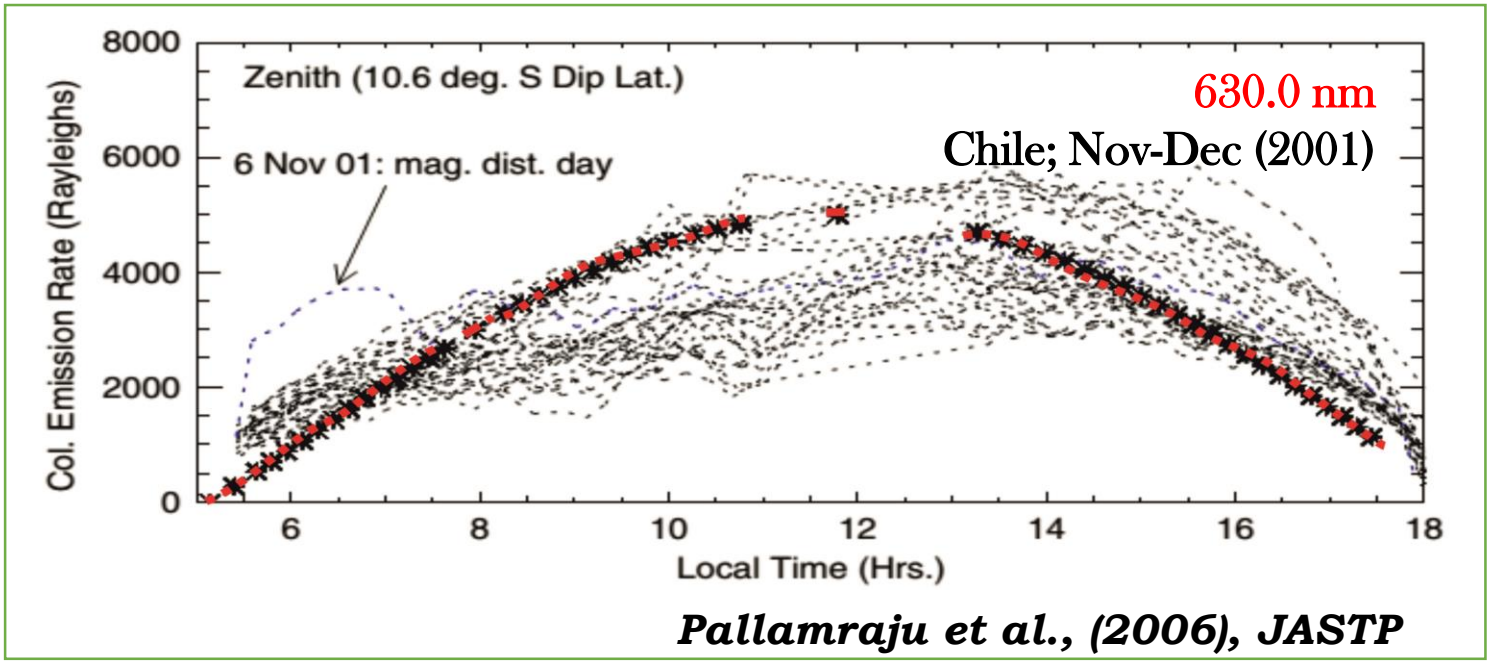
- ✓ OI 557.7 nm dayglow intensities for different days are shown. Empirical model of Zhang and Shepherd (2005, JGR) is also shown.
- ✓ OI 630.0 nm dayglow is compared with the Zhang and Shepherd Empirical model (2004, GRL)



- ➢ The day to day variability is prominent in the measurements.
- ➢ Significant altitudinal variability in emissions in all the daytime emissions may be noted.
- ➢ Peak intensities found ~ noontime.

- During low-solar activity epoch 2010 – 2013, such “asymmetric” behaviour in emission intensities was not seen.

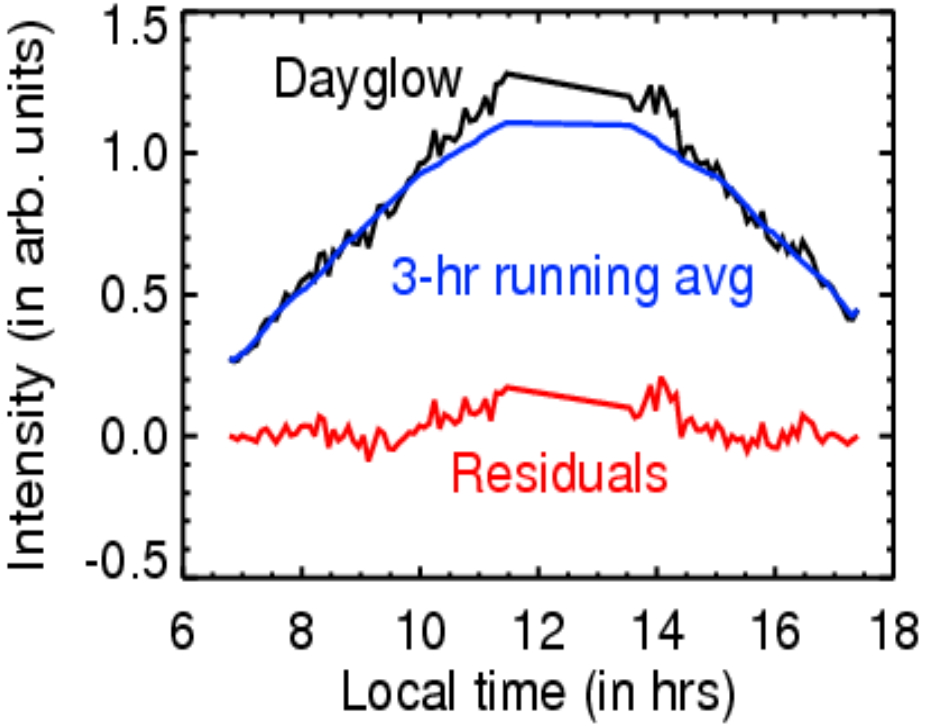
- However, asymmetric behaviour was seen during high solar activity epochs of 2001 and 2014.

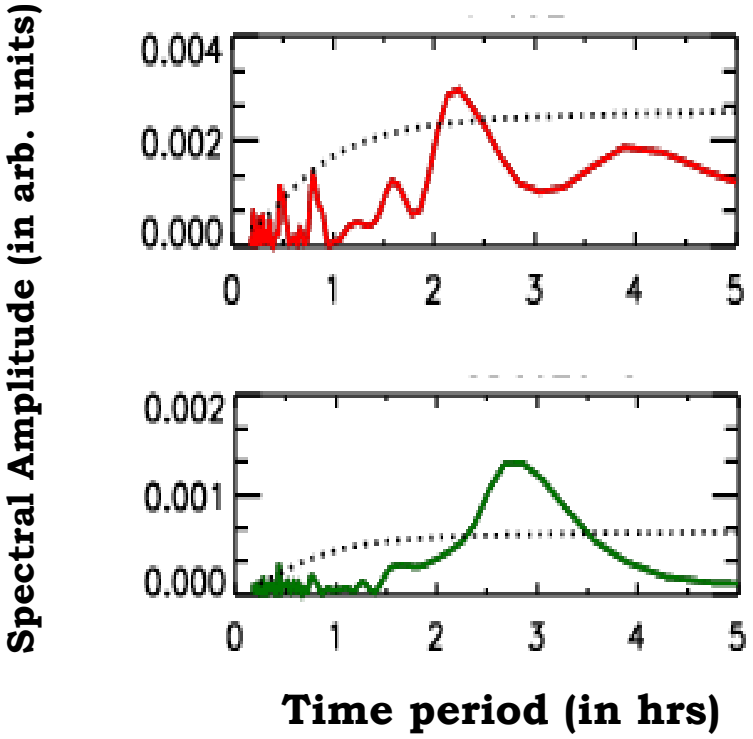


❖ The ‘asymmetric’ behaviour in emissions is due to:

- neutral dynamics
- Electrodynamics
- or both !

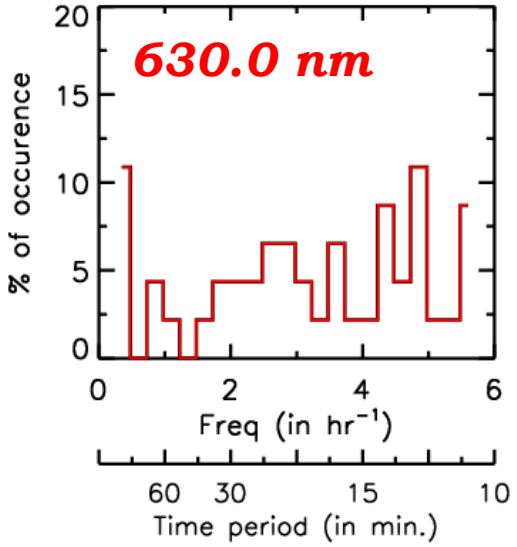
Periodogram analysis of dayglow intensities at both 630.0 nm and 557.7 nm and EEJ carried out

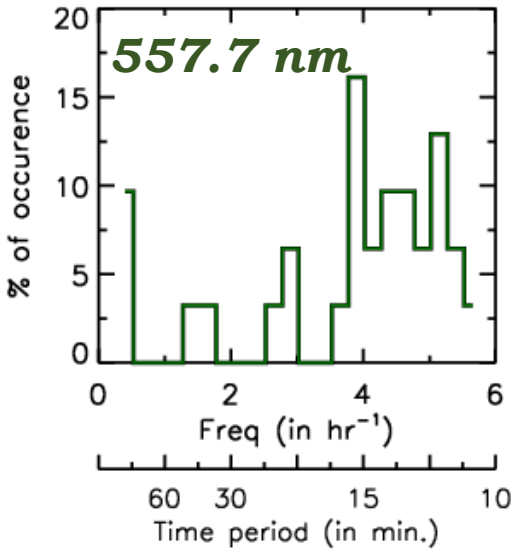


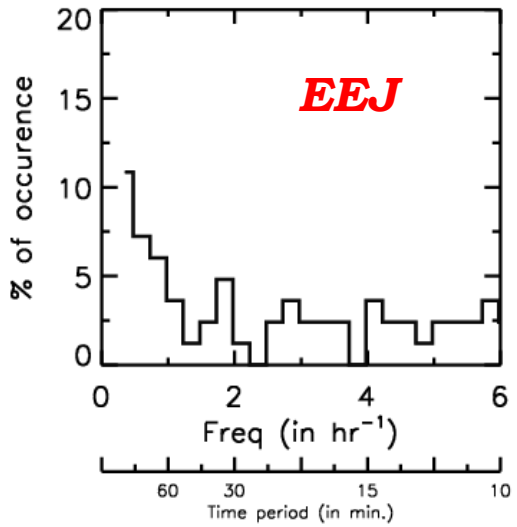


Gravity wave analyses

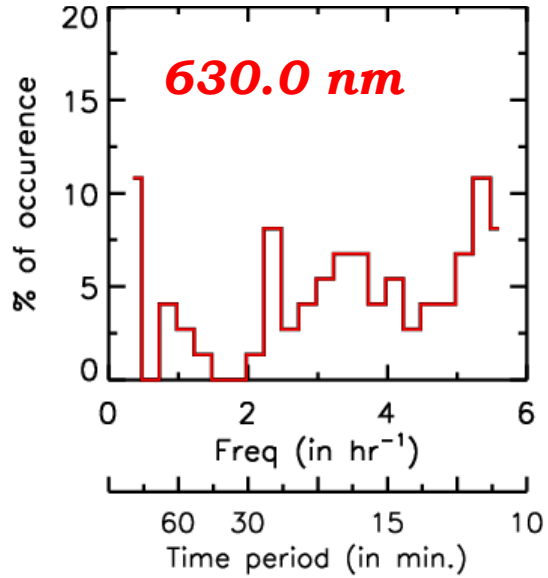
Days showing asymmetric behaviour

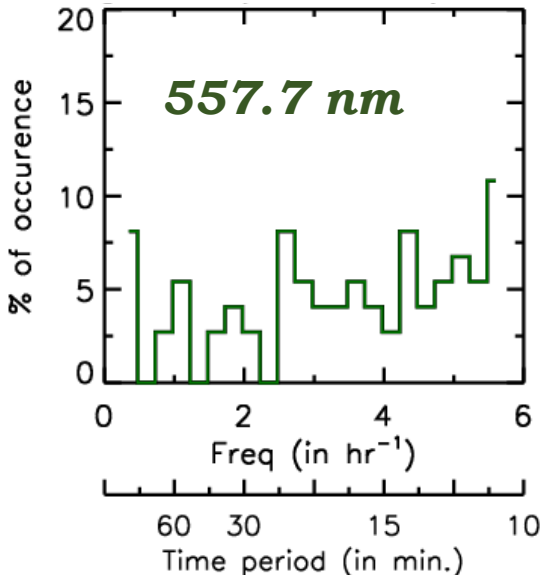


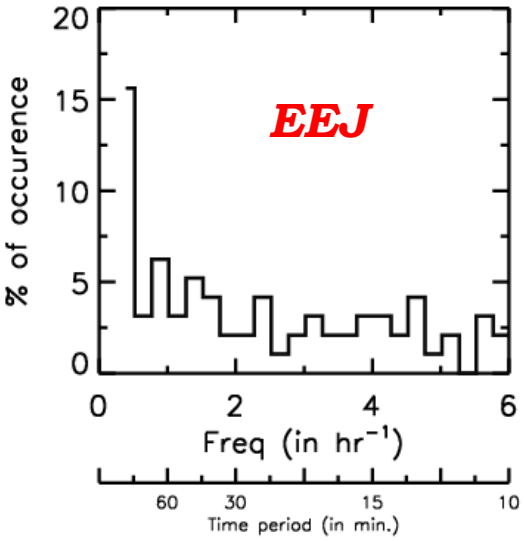




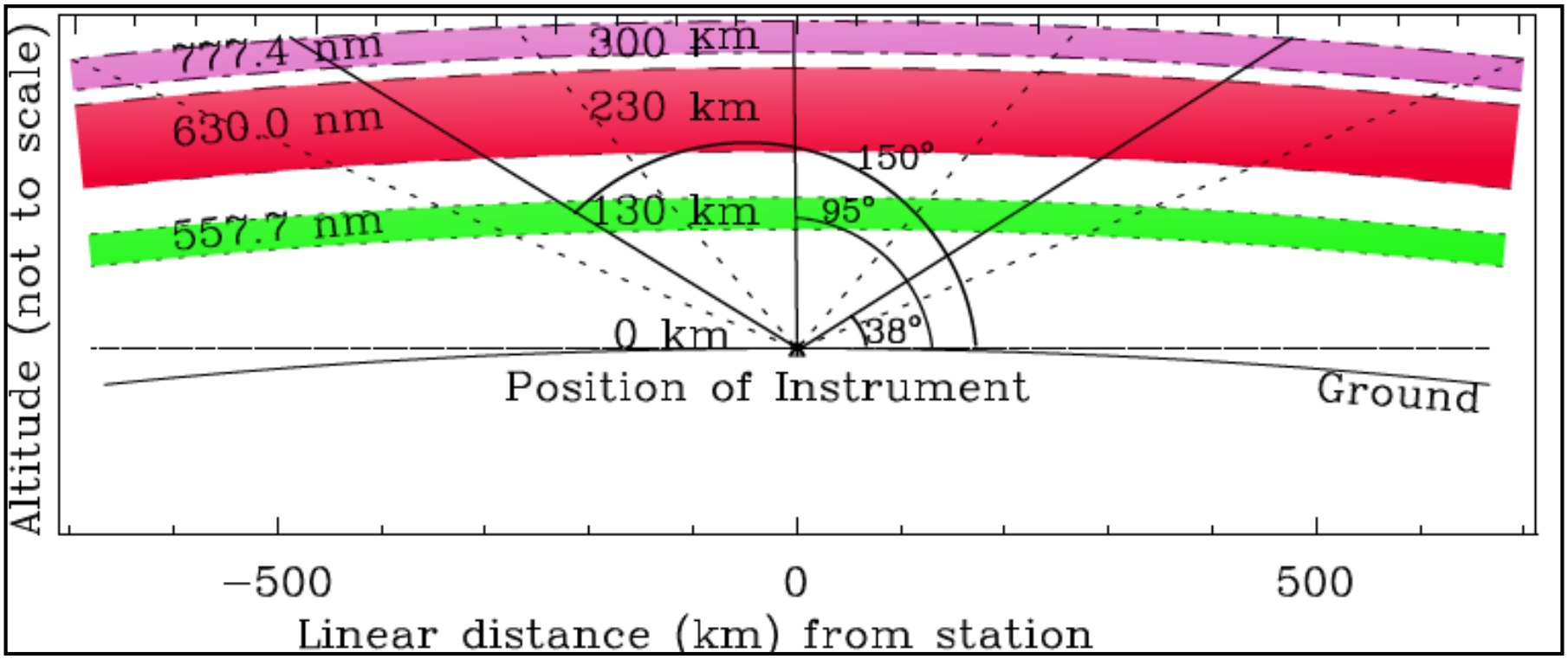
Days showing symmetric behaviour





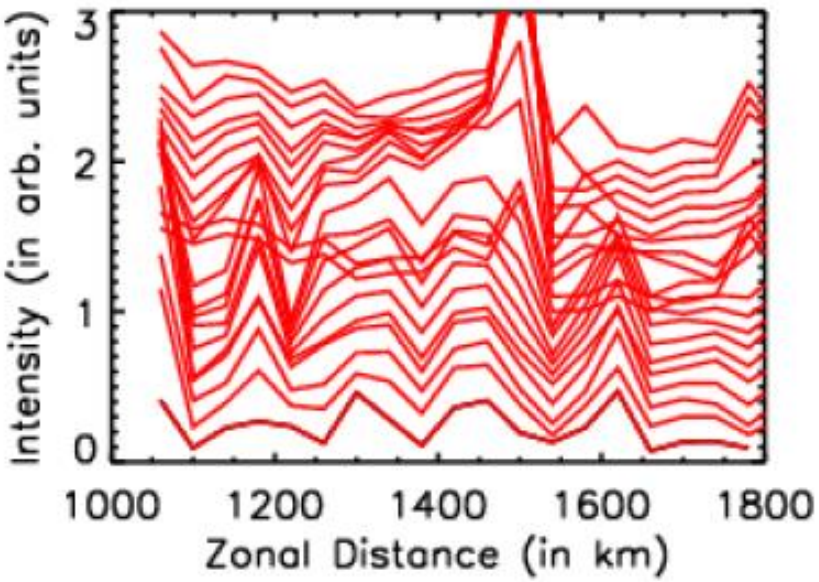


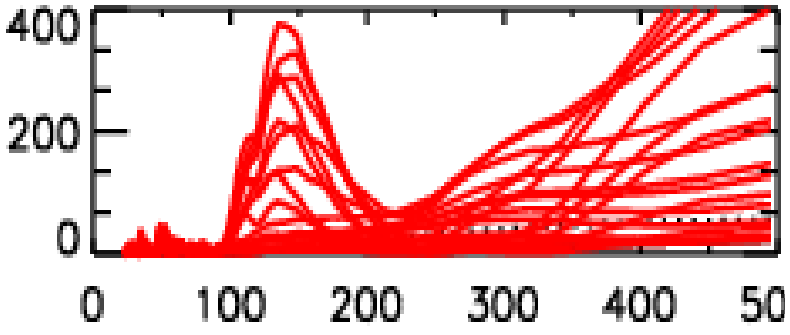
MISE has a large FOV

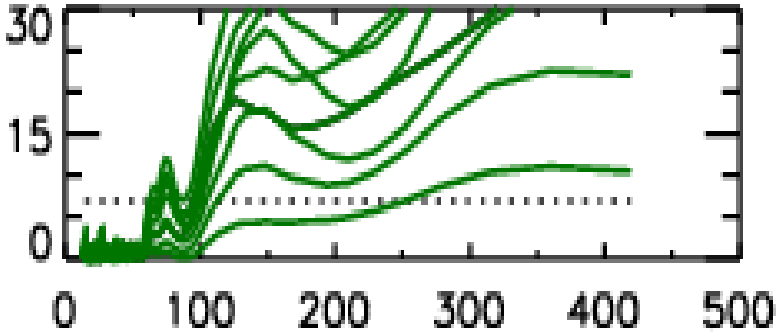


Schematic of the view directions for all the three dayglow emissions measured is shown above.

Scale size spectral analysis of dayglow intensities at both 630.0 nm and 557.7 nm



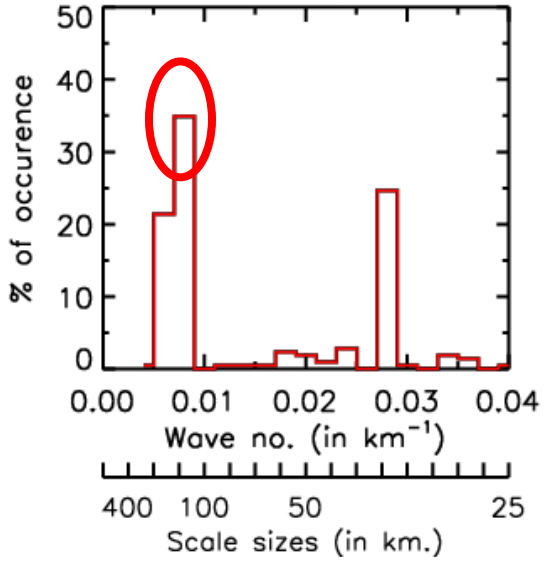




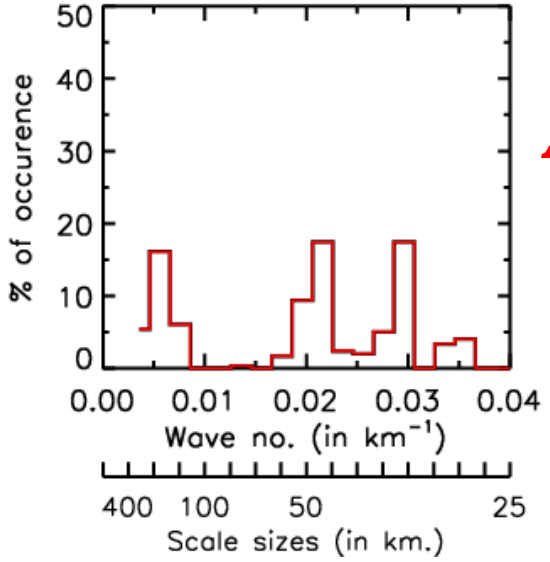
Scale size analyses (630.0nm)

Days showing asymmetric behaviour

Forenoon

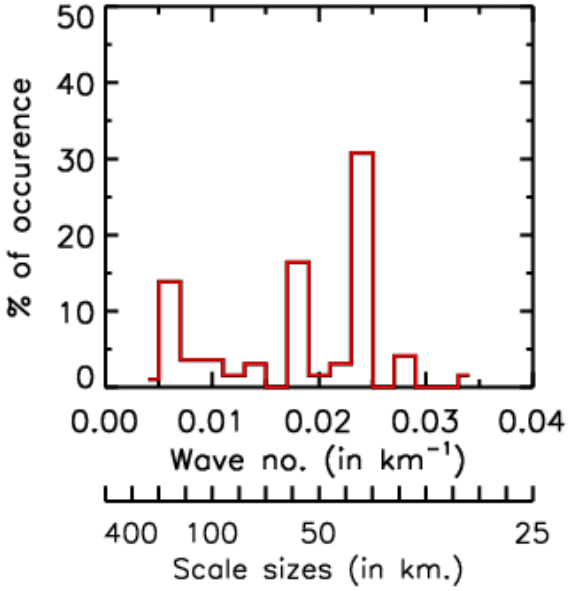


Afternoon

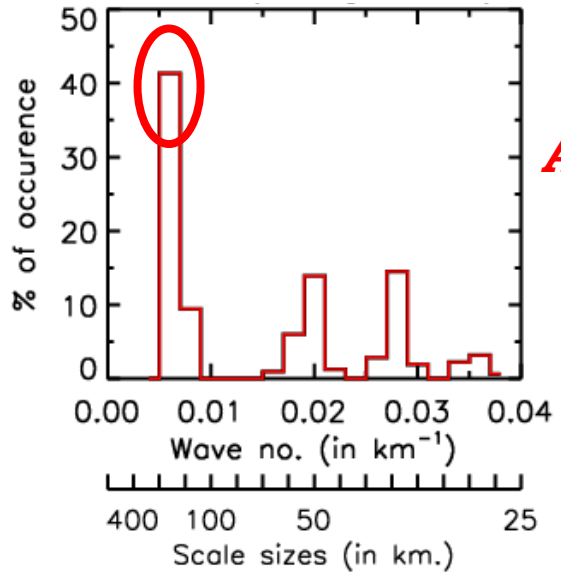


Days showing symmetric behaviour

Forenoon



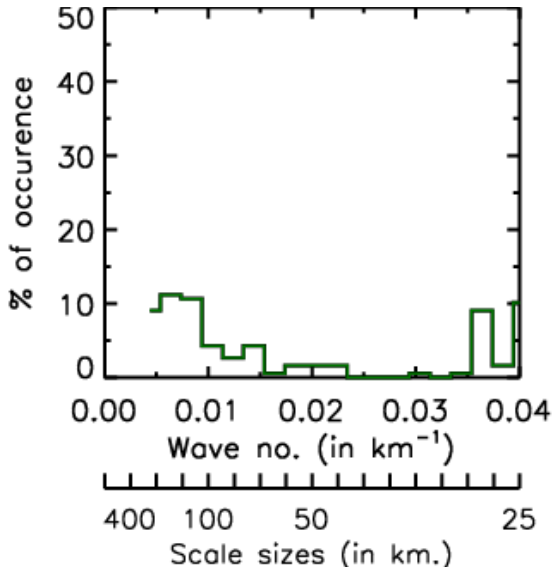
Afternoon



Scale size analyses (557.7 nm)

Days showing asymmetric behaviour

Forenoon



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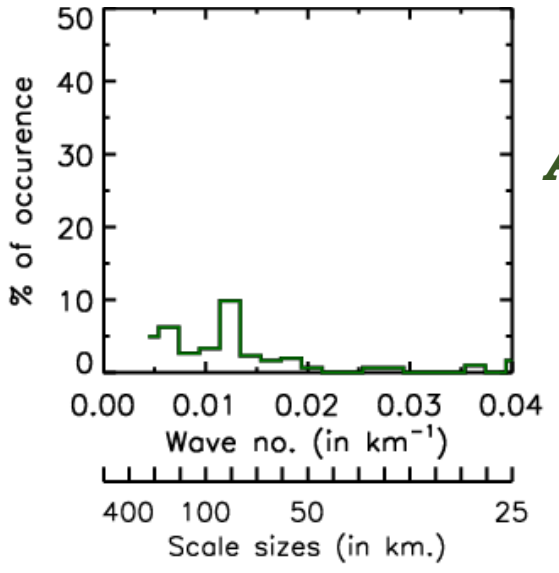
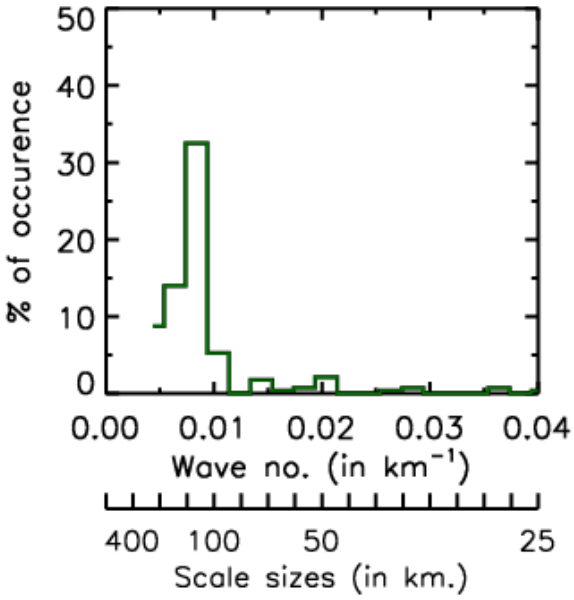
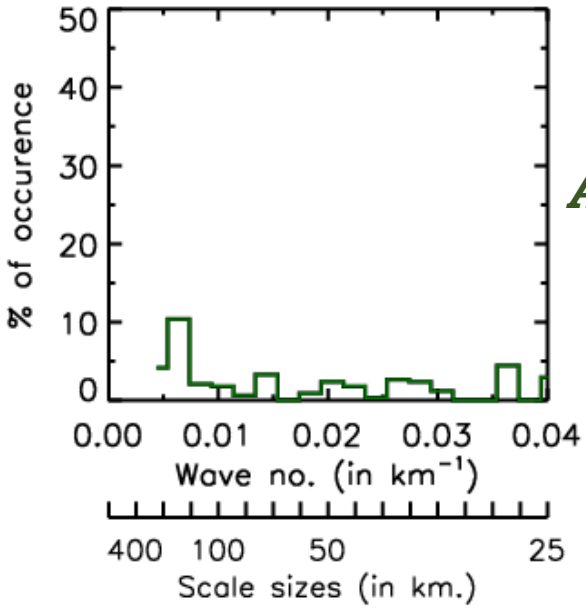


Days showing symmetric behaviour

Forenoon



Afternoon



Summary

- Daytime neutral atmospheric optical emissions at different altitudes show different diurnal behaviour that varies from day to day.

- Time periods in both emissions as well as EEJ don't show any significant variation in the symmetric and asymmetric days.

- Further, the zonal scale-sizes show varying behavior in the forenoon vs. afternoon during days with symmetric/ asymmetric behavior.

Thank you…