Nighttime medium scale traveling ionospheric disturbances in southern hemisphere using FORMOSAT-2/ISUAL 630.0 nm airglow images

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ISUAL Viewing Geometry

- Altitude: \( \sim 891 \) km
- Orbit: Polar, Sun-synchronize
- Orbital plane: \( 98.99^\circ \)
- Period: 14 rev/day
- Field of view: \( 20^\circ \times 5^\circ \)
- Filter: 630.0 nm
- Band-width: 7 nm

Thermospheric 630.0 nm emission from the O\(^{1}D\) sate

OH emission within the ISUAL band width of 70Å

FOV includes two emissions, O\(^{1}D\) 630.0 nm and portions of OH bands.

(Chern et al. JASTP, 2003)
**ISUAL Observation**

Satellite scans between 2100-2200 LT

Tangent plane at about 30° E (~2 hour earlier local time)

Bright regions of airglow in ISUAL images

Raw Image

Tangent projection

O\(^1\)D

OH(9-3)
Medium scale traveling ionospheric disturbances in ISUAL viewing geometry

- Frontal structures of localized bands of density perturbation in F-region, exhibiting preferential azimuthal alignment and propagation characteristics.
  - In the Northern Hemisphere, MSTID’s appear to be aligned in the northwest – southeastward direction and propagate southwestwards.
  - In the Southern hemisphere, the MSTID’s have northeast – southwestward alignment and propagate northwestwards.

- Coupled Perkins and Es-layer instability

ISUAL takes limb images of 630.0 nm airglow, Viewing to the East from the orbit.
MSTID in ISUAL image
MSTID fluctuations in ISUAL measurements

Alternate regions of bright and less bright intensity results from MSTID within the ISUAL viewing geometry.

MSTID fluctuations in the altitude-latitude map of 630.0 nm intensity by merging all individual measurements along the orbit.
Intensity perturbation by MSTID

• There is a considerable overlap in the volume sampled by successive images along the orbit.

• Average of such overlapping pixels, after spatially aligning, are used to generate a background image.

• The intensity perturbation by MSTID is then obtained by removing the background from the corresponding image.
The intensity perturbation from each pixel is projected to the latitude and longitude corresponding to the altitude of the emission peak.

- 630.0 nm emission arises from a narrow layer centered around 250 km altitude.
Many ISUAL observations show such azimuthally aligned intensity perturbations in the southern hemisphere.

In the southern hemisphere, the MSTID alignment and the ISUAL line-of-sights are parallel, while they could be perpendicular in the northern hemisphere.

SAMI2 ionosphere model is used to simulate the MSTID observations in ISUAL viewing geometry.

SAMI2 model is used to simulate the MSTID observation for the ISUAL viewing geometry.

- Different alignment angle of wave fronts
- MSTID fluctuations at different longitudes along the line-of-sights.
Simulations with different MSTID orientations

MSTID could be better observed in ISUAL images when the wave fronts are suitably aligned with the line-of-sight geometry.

- More observations in the southern hemisphere
ISUAL images MSTID fluctuations when the disturbance is near the tangent plane.
Space based imaging of global MSTID occurrence in southern hemisphere

Such intensity perturbation in ISUAL observations are used to investigate MSTID characteristics in the southern hemisphere.
MSTID occurrence peaks in winter months
Least during equinox
Asia/Oceana region: maximum in June solstice;
Pacific/American region: maximum December solstice
Wavelength

- Mostly in the range 150-300 km.
- A small percentage > 400 km

Orientation

- MSTID orientation ranges between 20-60°
- Majority of the events are within 30-50°

The growth of Es-layer instability maximizes when the normal to the wave fronts have an orientation of 45° or less.

The distribution of orientation angle indicates the coupling of Es-layer instability with F-region and support the Perkins instability.
Conclusions

• With suitable wave front orientation, space based airglow observations could be used for global MSTID observations.

• The distribution of the observed MSTID orientation indicates that Es- and F layer coupling might play important role in the MSTID generation.

• Peak MSTID occurrence in winter months might indicate coupling from conjugate hemisphere.

THANK YOU
MSTID simulation

- Vertical displacements in electron density resulting from the polarization electric field associated with MSTID (Shiokawa et al., JGR, 2003; Otsuka et al., AG, 2013) are introduced in SAMI2 electron density within the volume sampled by ISUAL viewing geometry.
- The 630.0 nm emission with MSTID fluctuations is simulated, and the intensity is integrated along the line-of-sights to reproduce the observations.
ISUAL observation

SAMI2 electron density with MSTID fluctuations, projected to ISUAL viewing geometry.

Simulated 630.0 nm intensity corresponding to the ISUAL observation