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Newly Discovered Nightglow Emission in the Mesosphere: Iron Oxide

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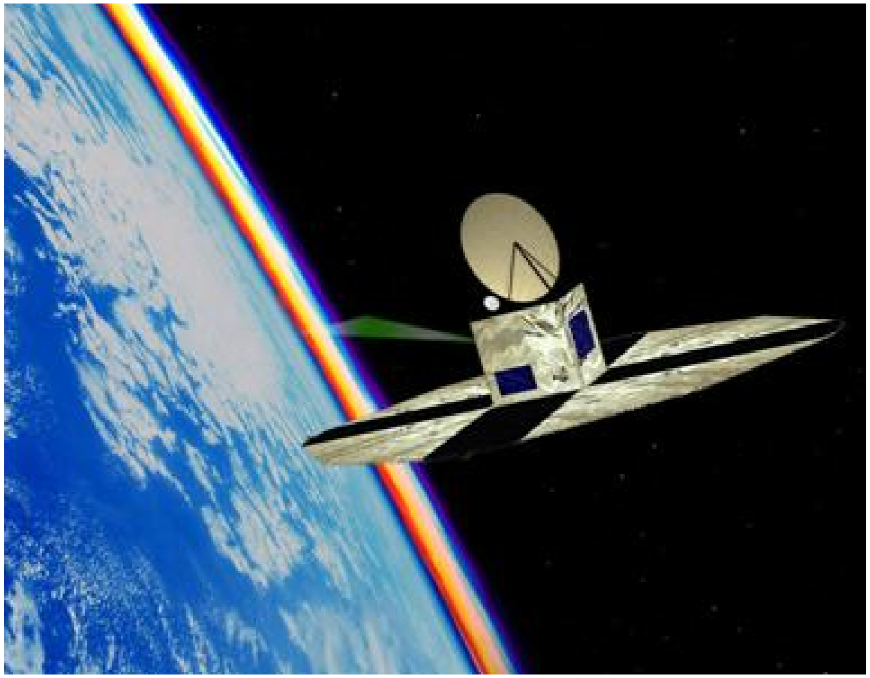
Overview

- Satellite observations: OSIRIS/ODIN data
- Ground-based observations: ESI/Keck II data
- Temporal variability
- Model comparisons
- Conclusions

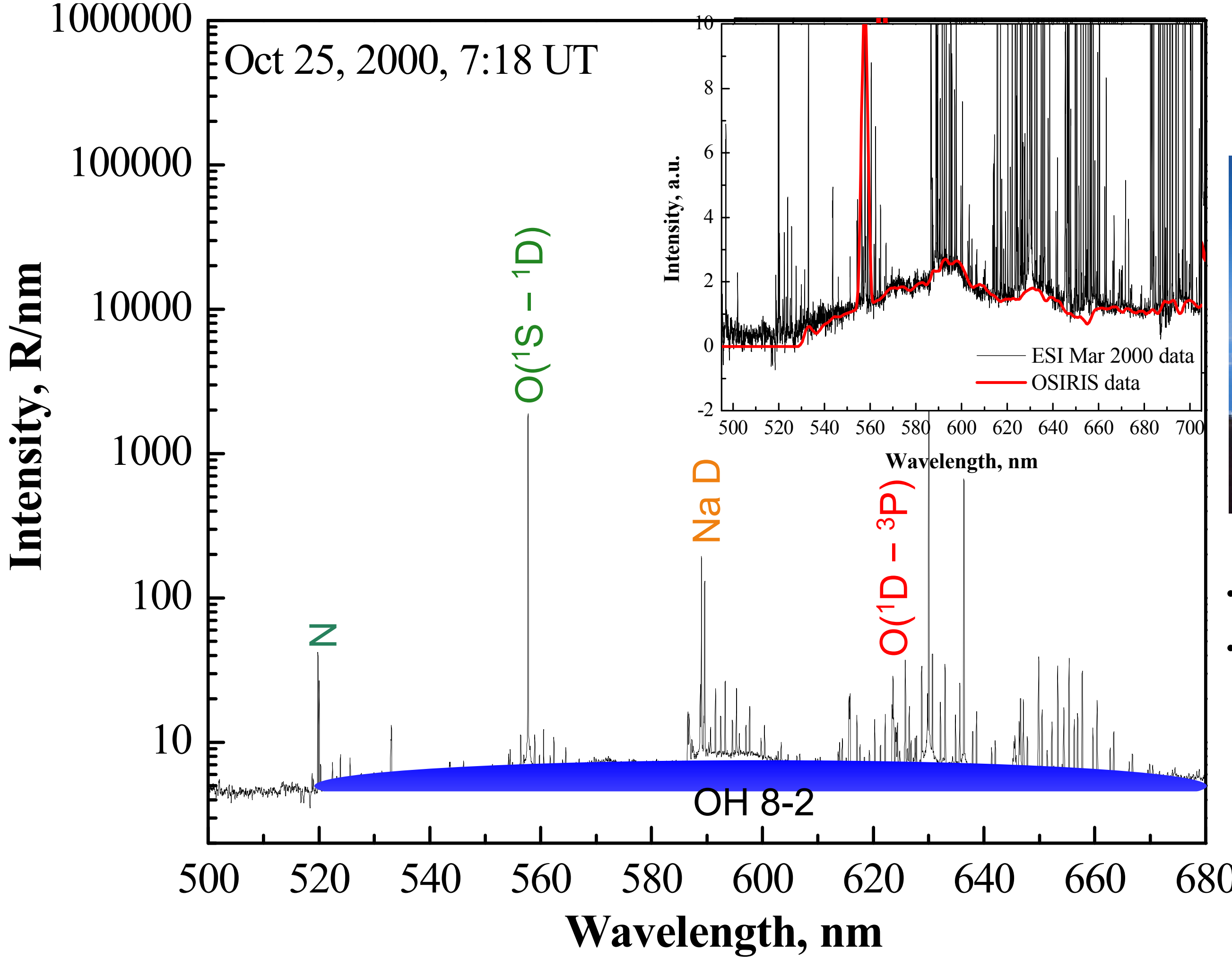
Satellite Observations OSIRIS/Odin

- Limb-scanning OSIRIS imaging spectrograph on ODIN produces vertical profiles between 75-105 km.
- Jenniskens et al. [2000] observed a similar feature in the 550-650 nm region in a Leonid meteor persistent train.



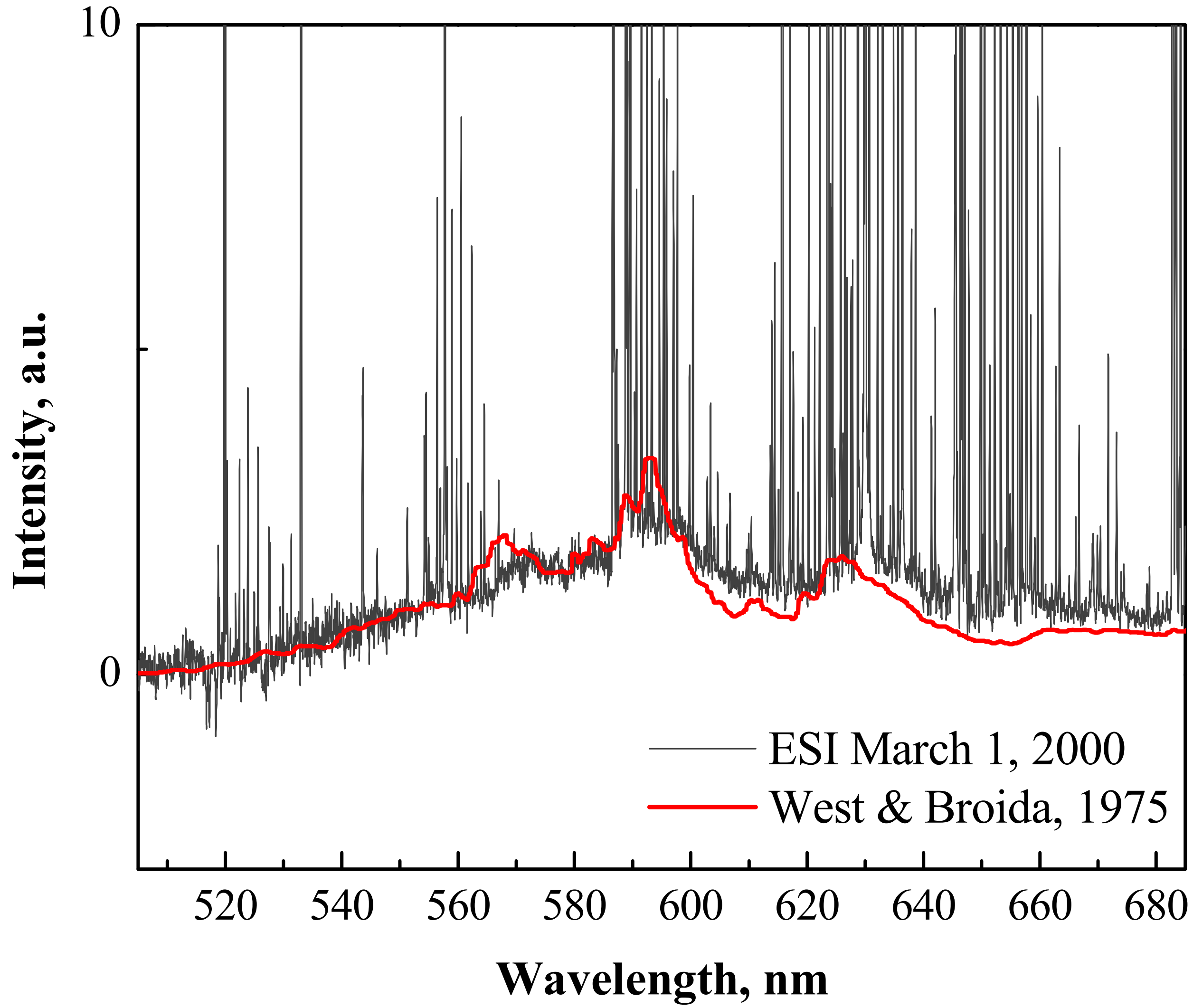
Evans, W. F. J., R. L. Gattinger, T. G. Slanger, D. V. Saran, D. A. Degenstein, and E. J. Llewellyn (**2010**) *Discovery of the FeO orange bands in the terrestrial night airglow spectrum obtained with OSIRIS on the Odin spacecraft,* **Geophys. Res. Lett.,** 37, L22105, doi:10.1029/2010GL045310.

Ground-based Observations: Sky Spectra from ESI/Keck II



- Intermediate Resolution
- 390-1100 nm

Assigning the Continuum-like Feature to FeO* Orange Arc Bands



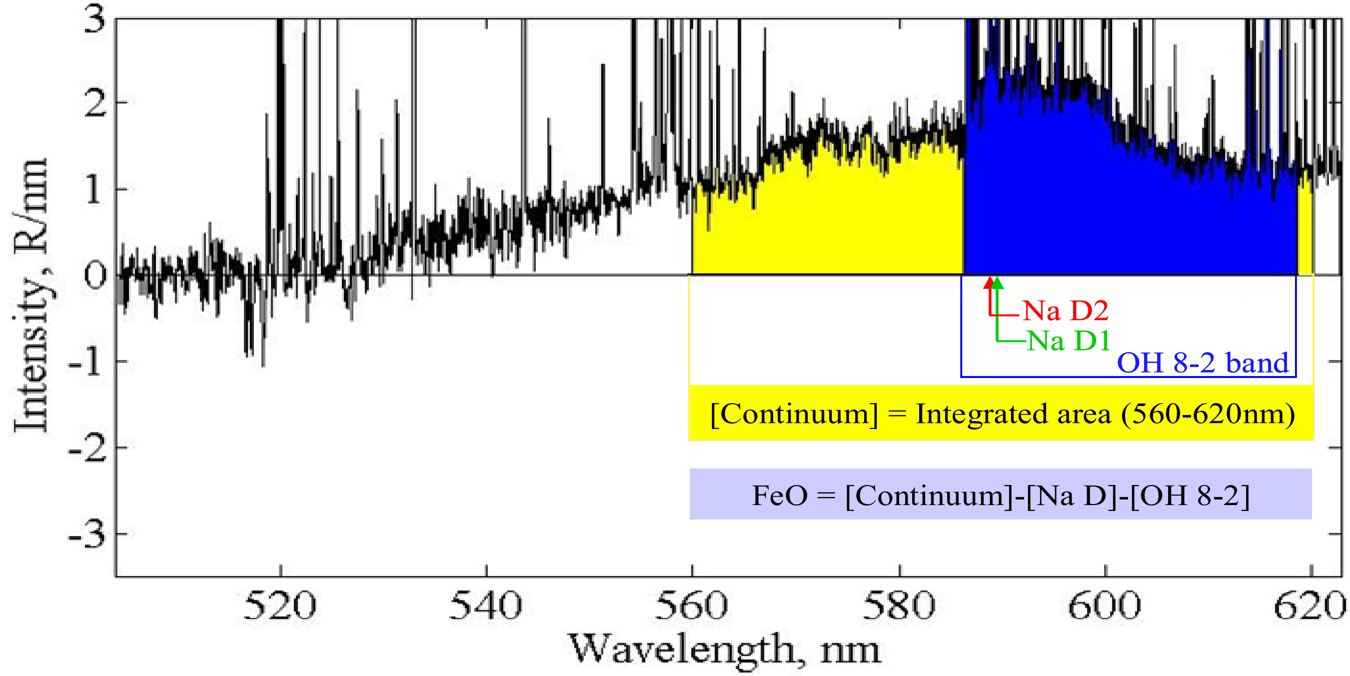
Source of FeO^* in the Mesosphere

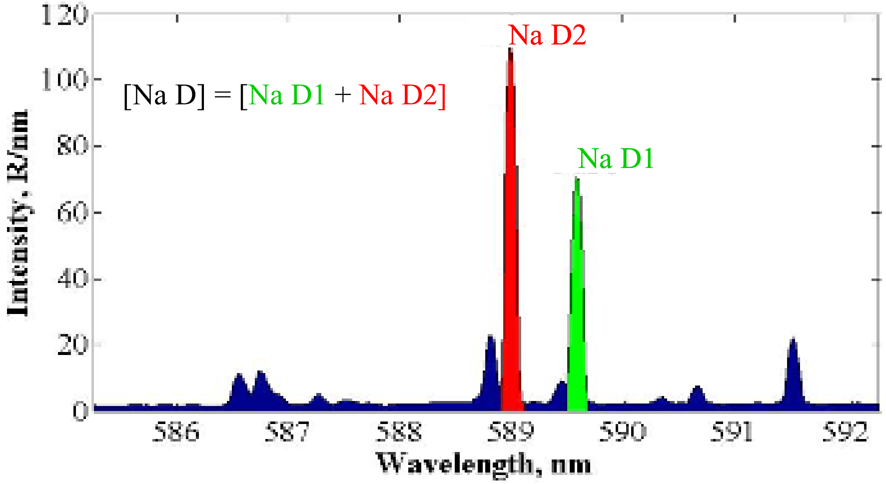
- The Fe layer in the mesosphere results from meteoric ablation.
- FeO^* [$D^5\Delta$, $D'^5\Delta$ etc] is formed by the reaction between Fe and O_3.
- Orange arc bands from D–X and D´–X transitions
- FeO^* radiative lifetime is very short ~ 260-590 ns [*West and Broida*, 1975; Son et al., 2000].

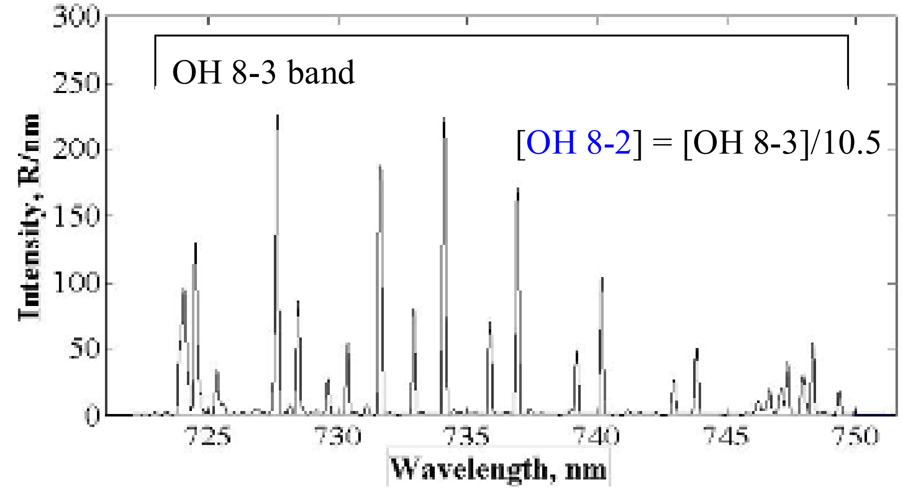
Data Analysis

- **GOAL:** Temporal behavior of FeO* emission, along with its possible correlation with the nearby Na and OH Meinel band emissions.
- **DATA:** 5 nights in March, 2000 and 4 nights in October, 2000, 30 min integration time.
  - intensity and wavelength calibrated and also corrected for airmass, integration time, and slit width.
- **ISSUES:** Presence of the oxygen green and red lines, as well as several OH Meinel bands.
- **WAVELENGTH REGION**: Current analysis is restricted to 560-620 nm for subtraction of the Na D and OH 8-2 intensities and excludes the strong atomic oxygen lines.

FeO Intensity Estimations





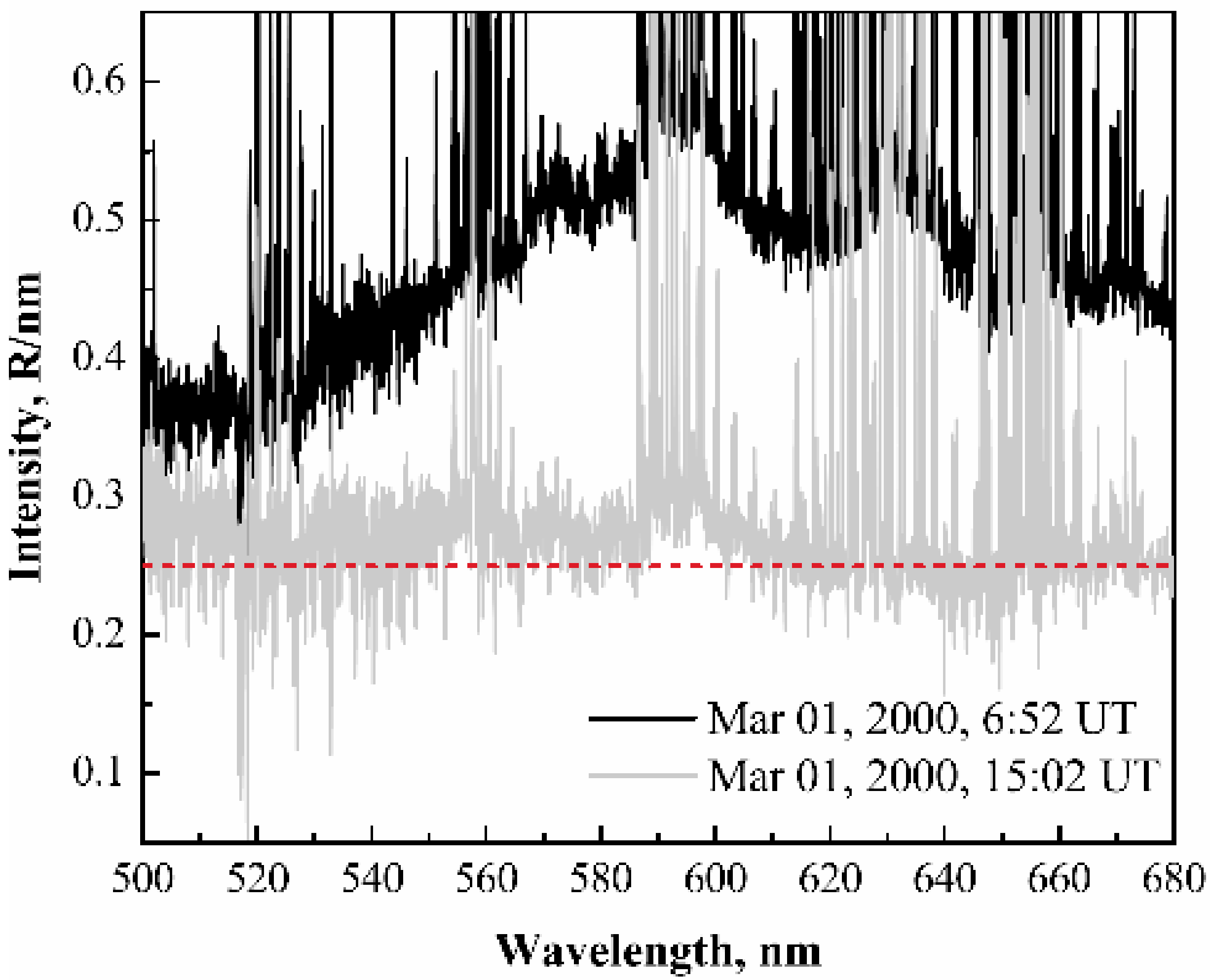


Ozone Dependence of FeO*, Na and OH Emissions

- The three main emitters in the wavelength region 560-620 nm, FeO*, Na*, OH* are linked by the fact that their formation depends on O_3.
  - $Fe + O_3 \rightarrow FeO^* + O_2$ (1)
  - $Na + O_3 \rightarrow NaO + O_2$ (2)
  - $NaO + O(^3P) \rightarrow Na^* + O_2$ (3)
  - $H + O_3 \rightarrow OH^*(\upsilon = 6\text{-}9) + O_2$ (4)
- Mesospheric Na and Meinel OH bands tracers for mesospheric dynamics and chemistry.

Temporal Variability

- Variability in the FeO* intensity could be due to changes in the concentrations and/or altitudes of its sources, Fe & O_3.

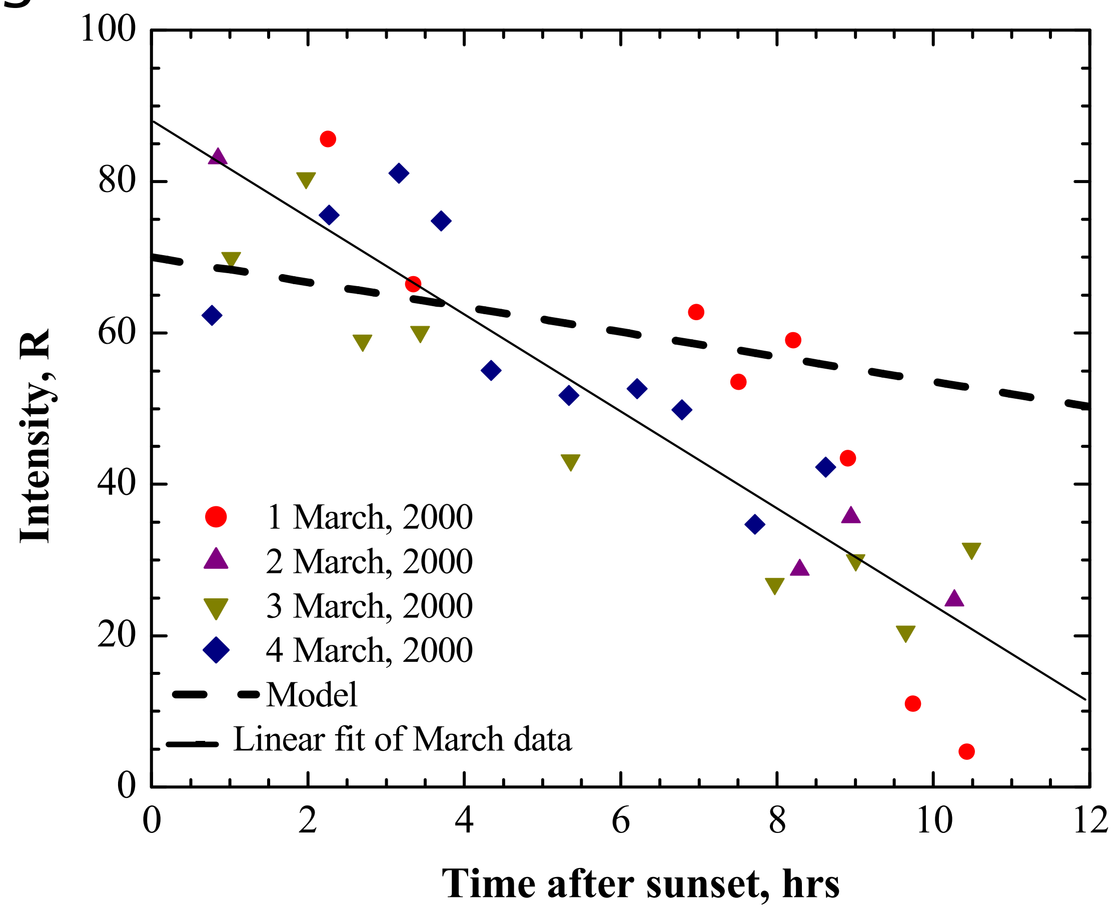


FeMOD Model

- FeO emission intensity at 20°N (ESI/ Keck II's latitude) was modeled using the time-resolved FeMOD.
- FeMOD is 1-dimensional (1-D), 65-110 km, height resolution of 0.5 km model that describes the iron chemistry in the MLT.
- The peak of the FeO* emission layer is at 89.5 km, ~ 2.5 km above the Fe layer.
- Modeled altitude profile of the emission closely resembles that from OSIRIS/Odin observations.

Model & Data Comparison

- The model (dotted line) underestimates this decrease, only predicting ~ 20% decrease over the night.



Model results courtesy Prof. JMC Plane

Conclusions

- Emission from excited FeO (FeO^*) has recently been identified in the terrestrial nightglow.
- Based on comparisons between astronomical sky spectra, OSIRIS/Odin data, meteor trains, and laboratory experiments.
- A quasi-continuum between 540-680 nm, peaking near 595 nm.
- Model does not capture the temporal variability of data, seasonal trends at play.
- More research is needed in nightglow observations as well as collocated Fe Lidar measurements to help determine the origin of such variability.

Significance of FeO*

- FeO* emission is an important contributor to the terrestrial nightglow.
- Possible tracer for mesospheric dynamics and atmospheric waves.
- The reaction of Fe and O_3 is the primary loss for atomic Fe in the mesosphere.
- Validation of models of the gas-phase and heterogeneous chemical reactions associated with meteoric metal species.
- Insight into meteor ablation studies.
- Misidentification by astronomers of this continuum-like feature such as light pollution.

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