The background of the slide is a composite image of Earth from space. The top half shows a dark, star-filled sky. The middle section shows the curved horizon of the Earth with a thin, glowing green aurora. The bottom half shows a view of Earth from space, with city lights visible as bright yellow and orange spots against the dark surface of the planet.

# Nightglow Brightens Horizons for Nighttime Imagery

**Steven D. Miller**

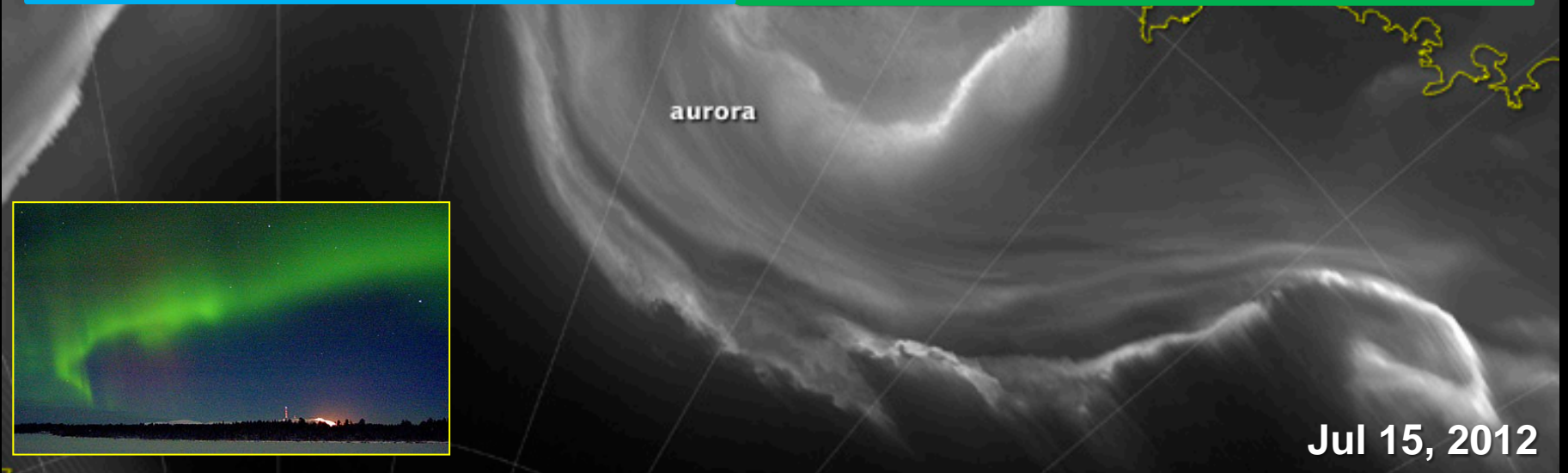
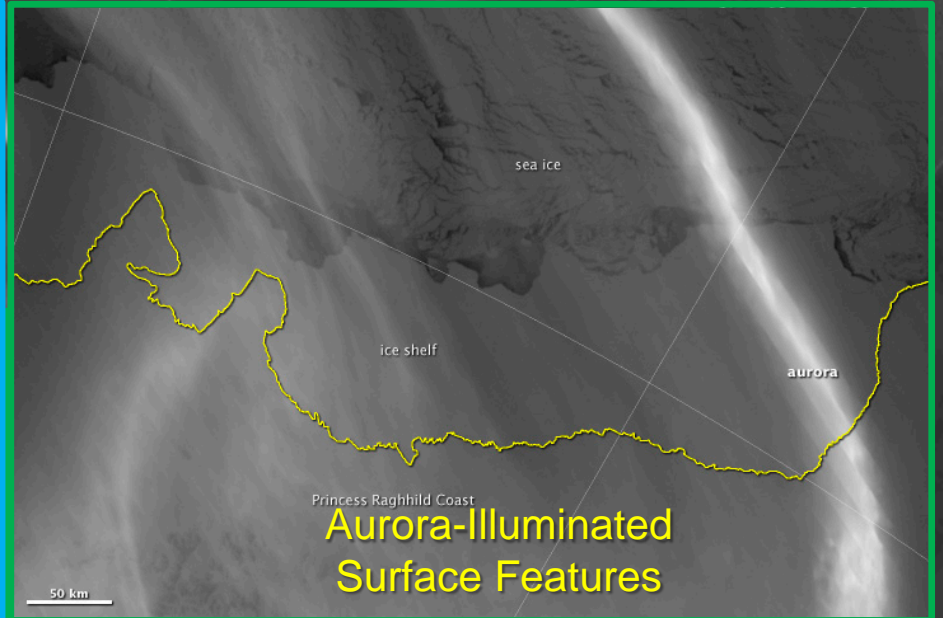
***Cooperative Institute for Research in the Atmosphere  
Colorado State University, Fort Collins***

**93<sup>rd</sup> Annual Meeting  
American Meteorological Society  
Austin, TX**

**8 January 2013**



# Aurora: Moonless Night



Jul 15, 2012

# The International Space Station's View of Nocturnal Light Sources



*Courtesy: NASA Johnson Space Center*

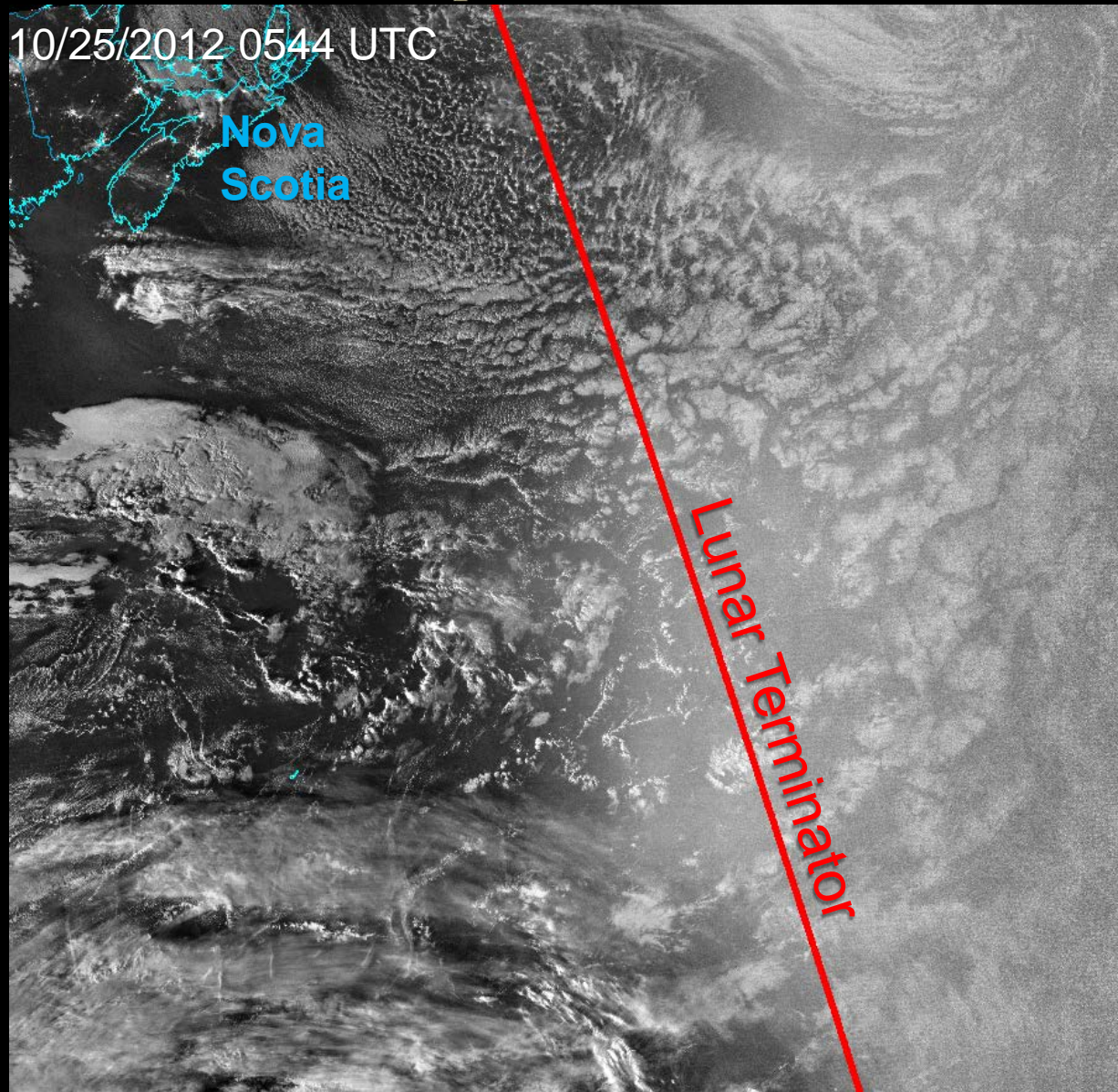
# A So-Called 'Dark' Night...



**Discovery:** The Day/Night Band is sensitive enough to detect and use these light sources for visible imagery *on completely moonless nights!*



# Clouds Beyond 'Moonset'

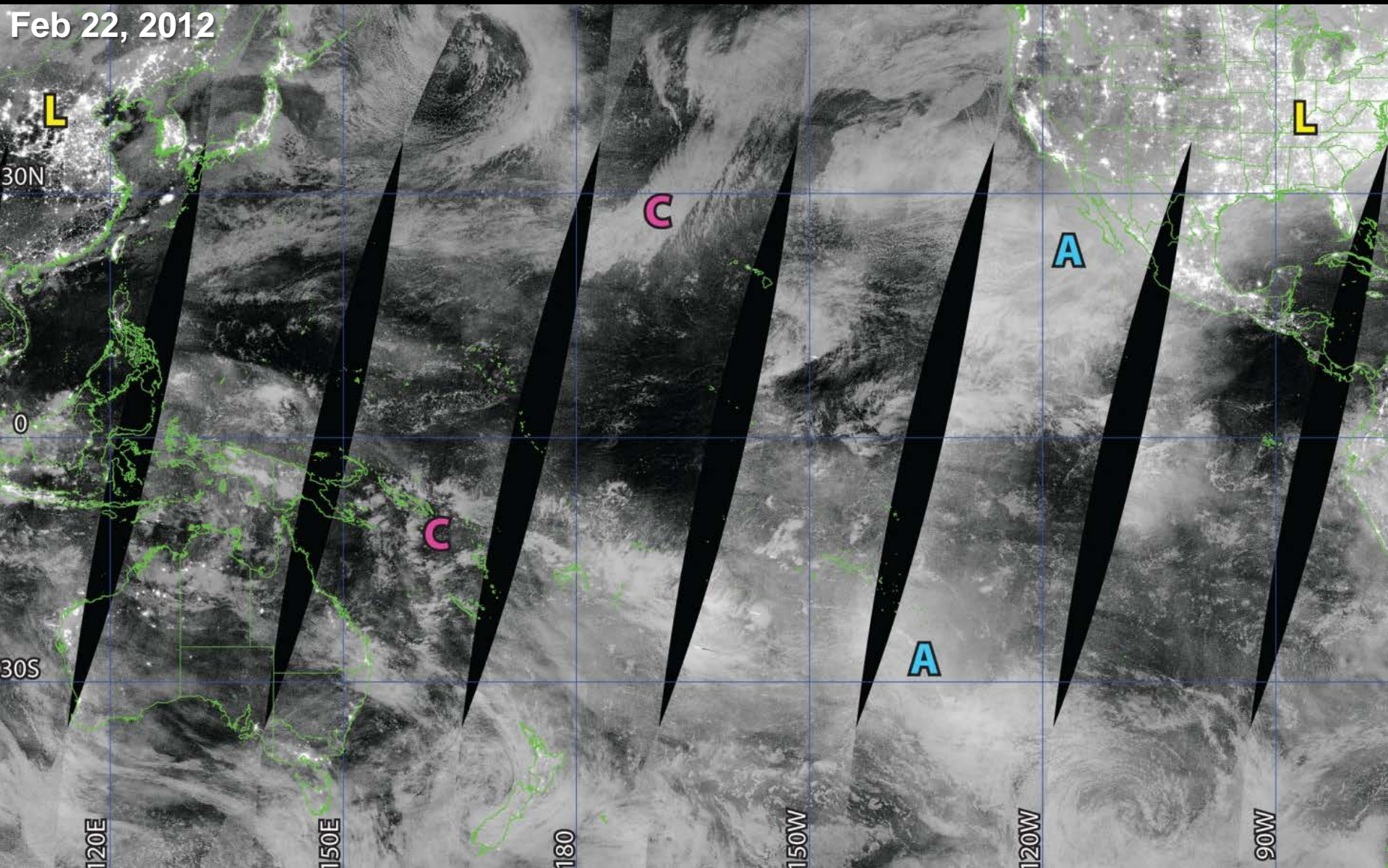


*Courtesy: W. Straka and K. Strabala, SSEC/CIMSS*



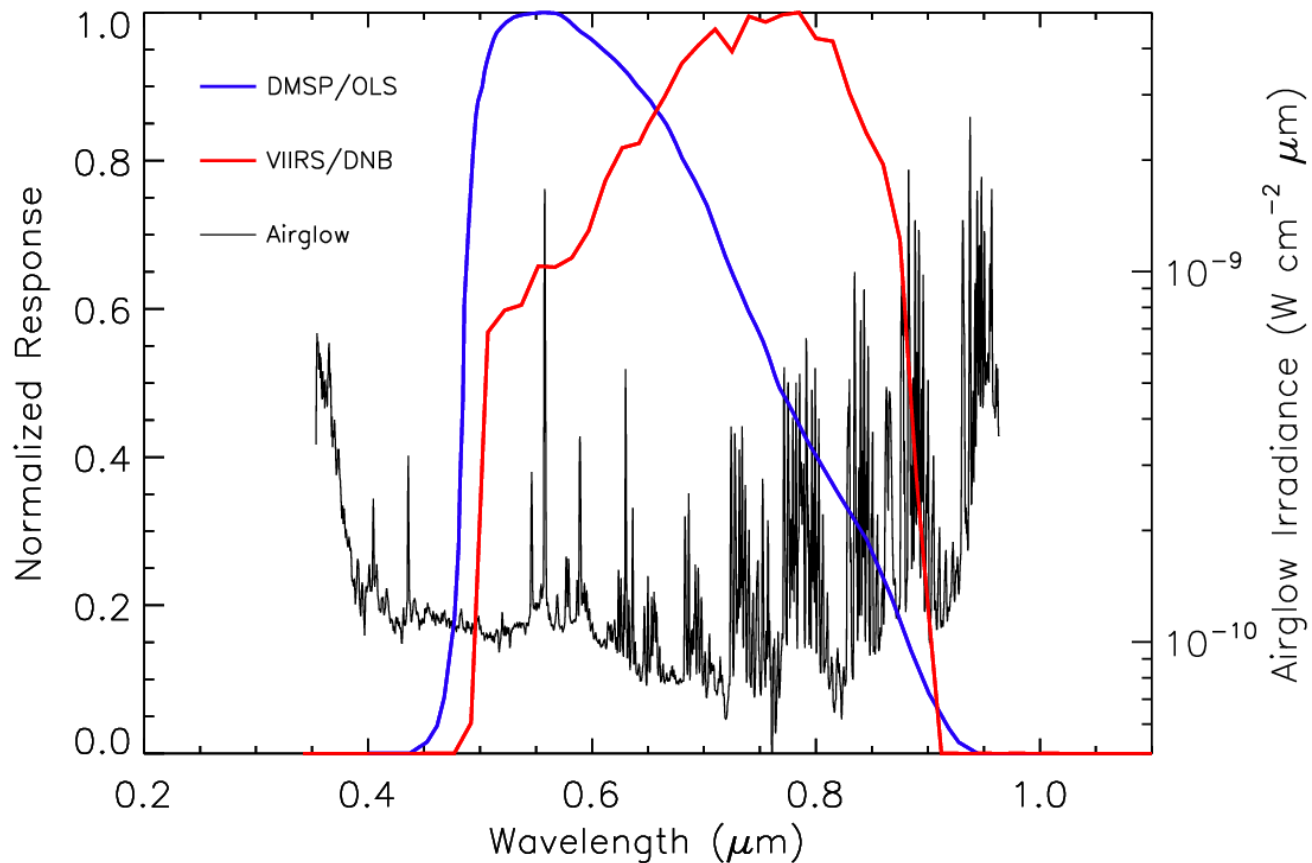
# ~1:30 AM Over the Pacific: *New Moon*

Feb 22, 2012





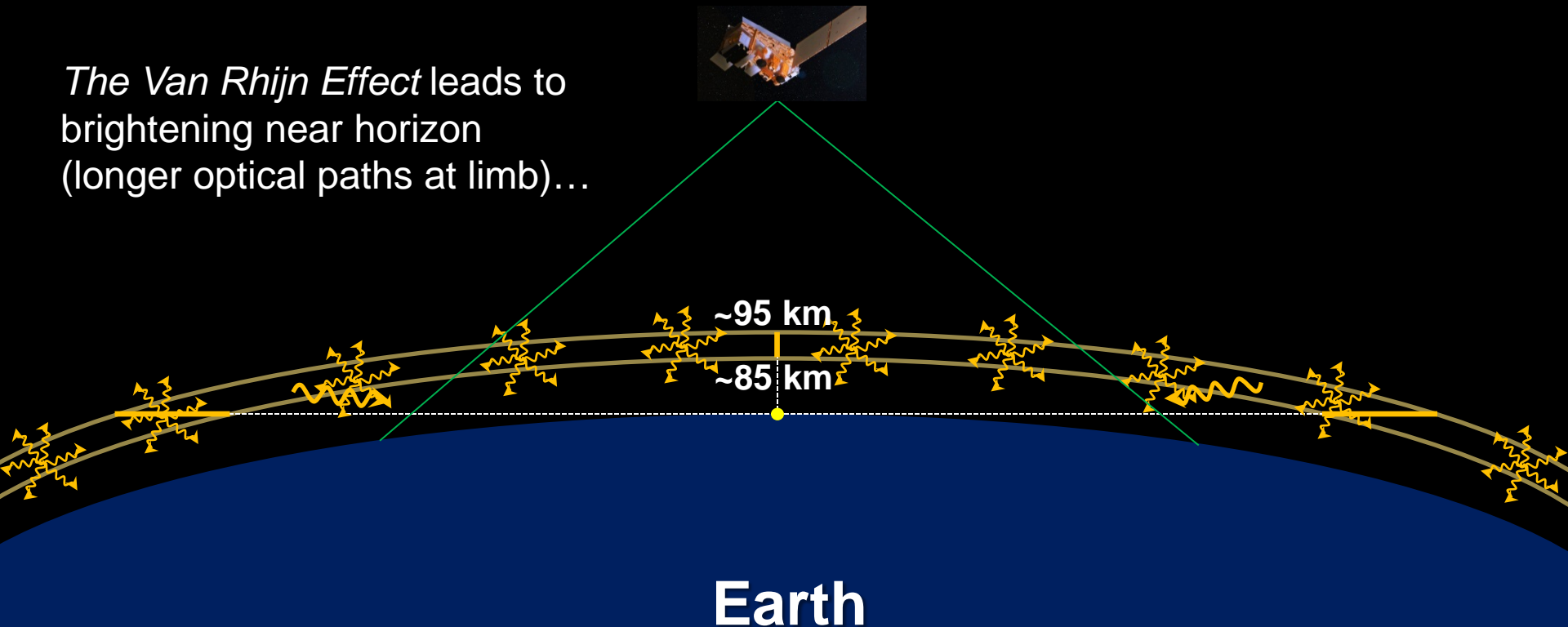
# Illumination Sources & Sensor Response



# The Nightglow Emission Source

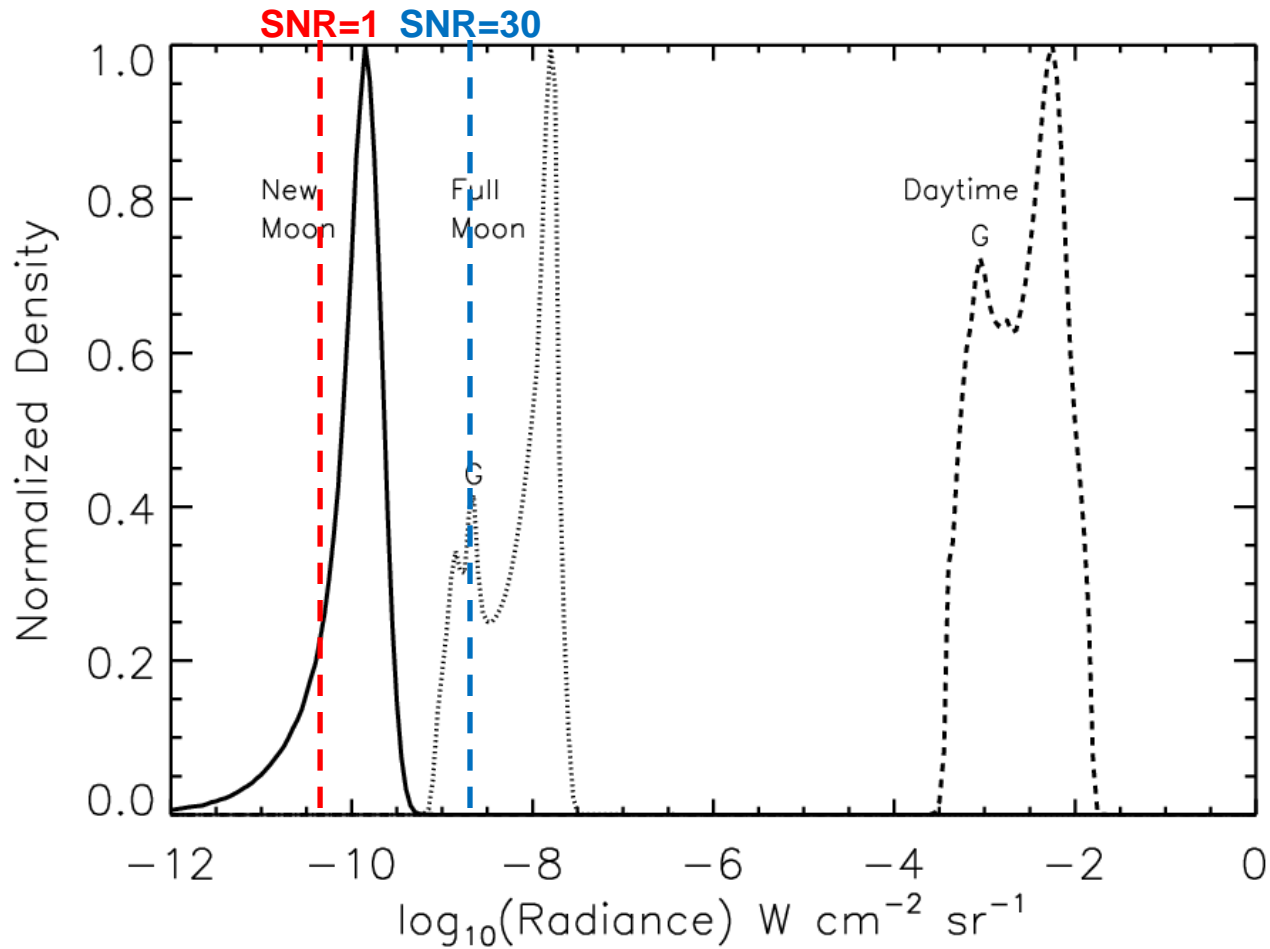
- Nightglow → chemiluminescence in upper-atmospheric gases
  - Vibrationally excited Hydroxyl ( $\text{OH}^*$ ; reactions between  $\text{O}_3$  and atomic Hydrogen), atomic & molecular Oxygen, Sodium and Nitrogen, among others
  - Brightest emissions in ~10 km thick layer near the mesopause (85-95 km)
  - Strong correlation with temperature and atomic Oxygen mixing ratio
  - Highly variable emissions across space & time

*The Van Rhijn Effect* leads to brightening near horizon (longer optical paths at limb)...



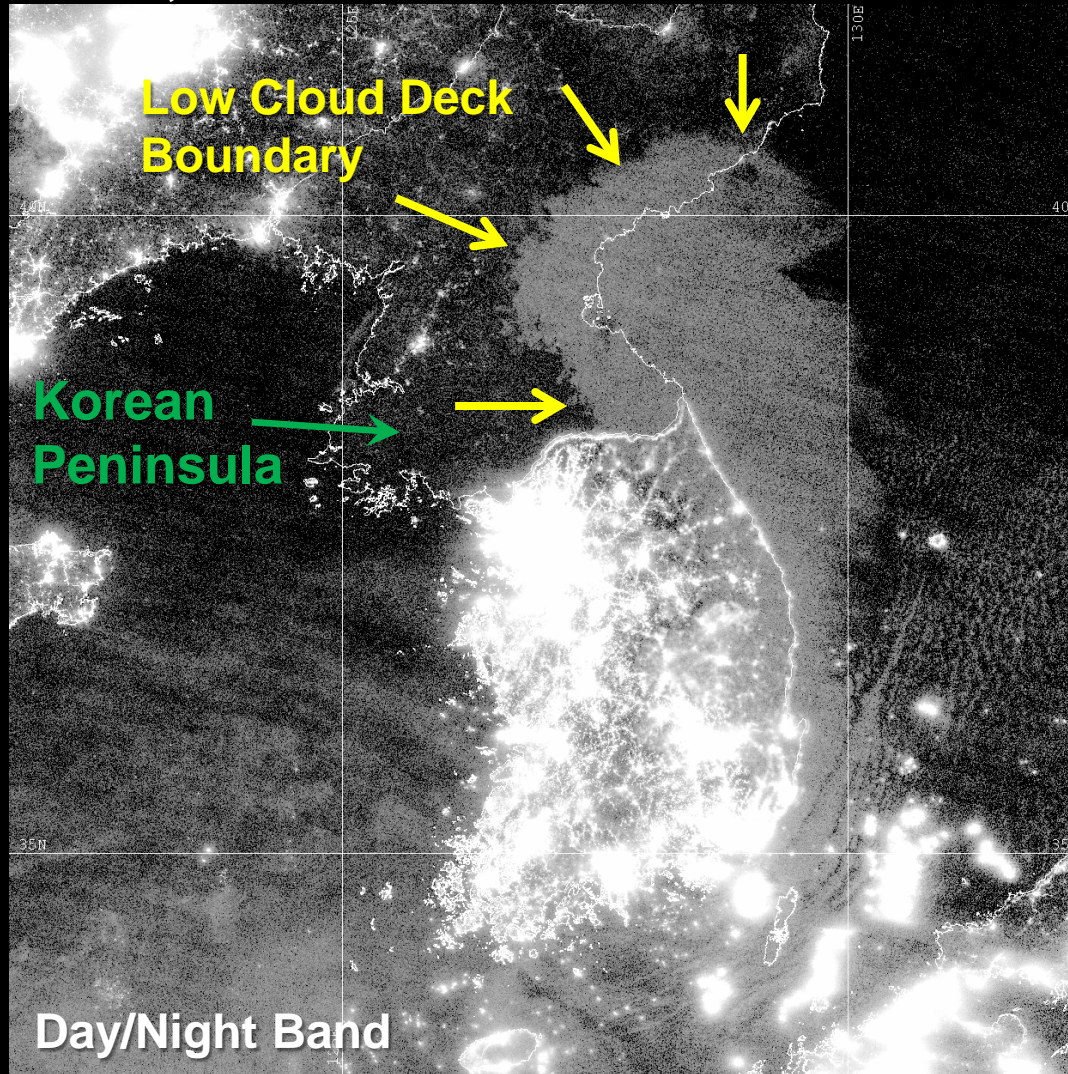


# Radiance Distribution



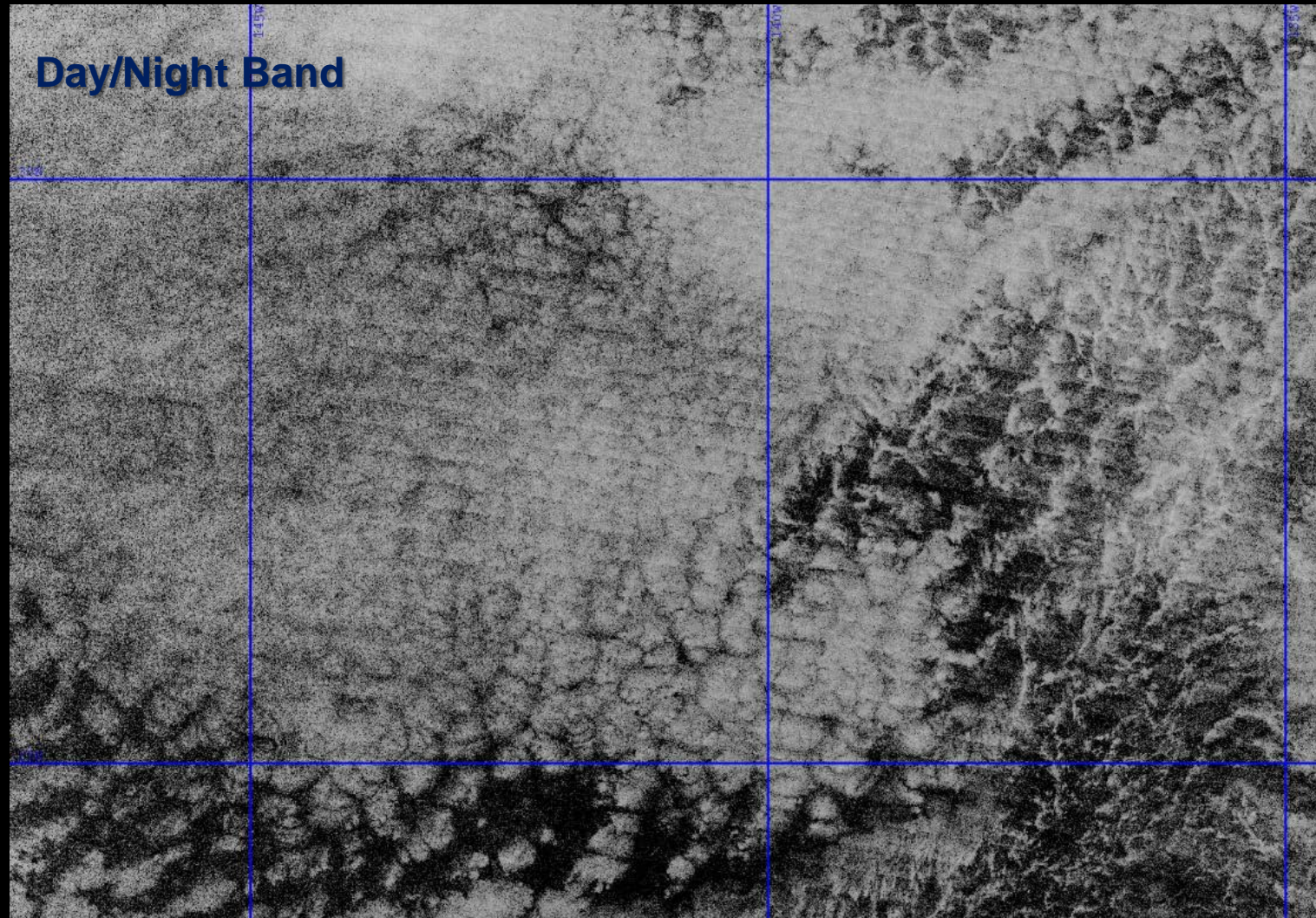
# Low Clouds & Fog Sensitivity

Feb 23, 2012





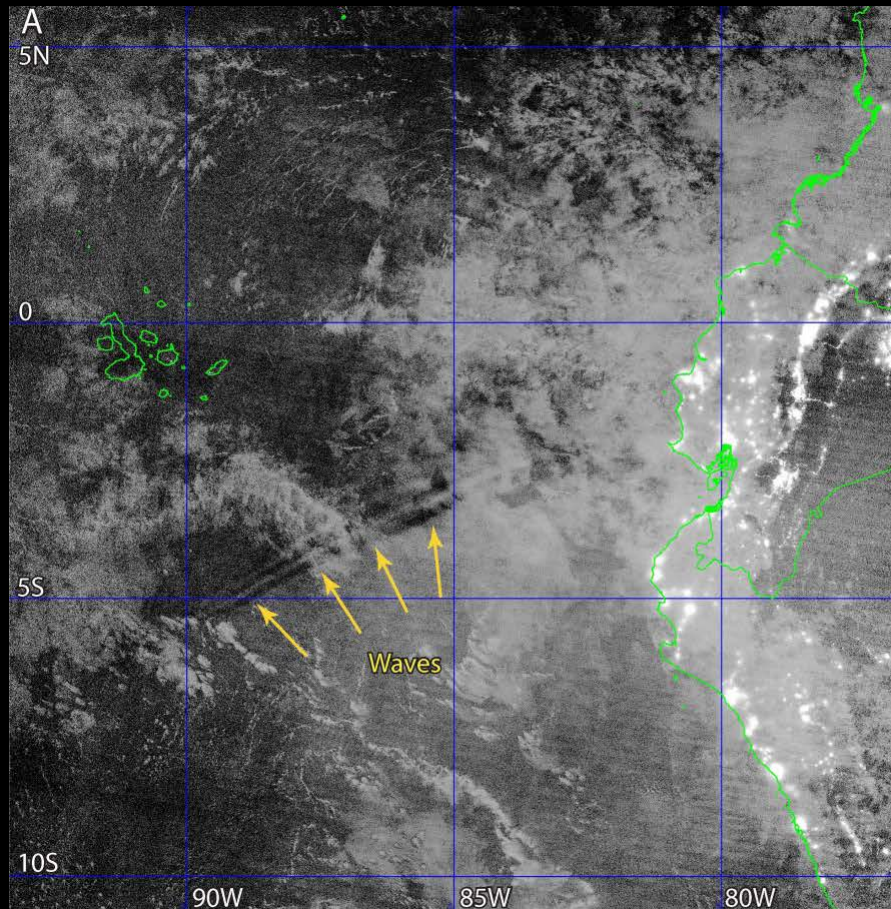
# Improved Low Cloud Structure



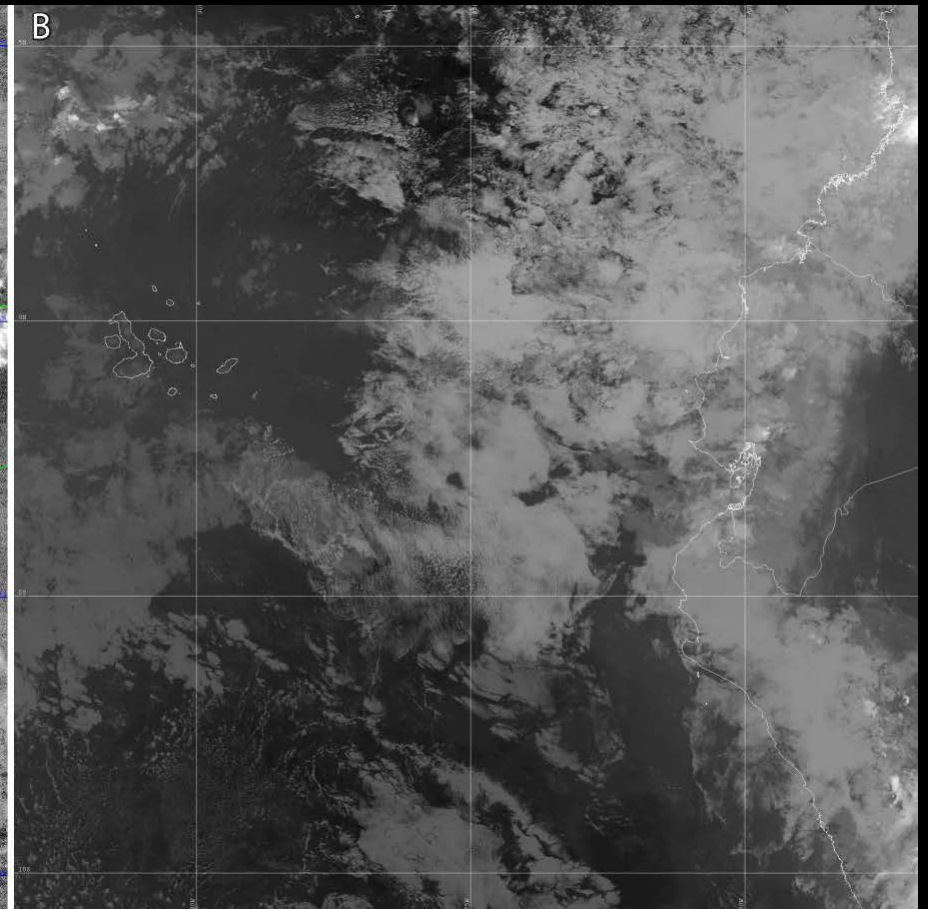


# Nightglow Waves

Day/Night Band



Thermal Infrared



→ Provides a top-down, synoptic scale perspective on coupling between lower & upper atmosphere...



# Thunderstorm Forcing



# Implications of the Discovery...

- A form of visible sensing exists on *all* nights.
- Reflectance and emission from diffuse light sources.
- Still exploring the information content; challenges and opportunities...a new research frontier!
- Improved sensitivity to lower atmosphere and surface environmental parameters.
- Direct observation of lower/upper atmospheric coupling (nightglow waves).

## *Open Access Article:*

Miller, S. D., *et al.*, 2012, *Proc. Nat. Acad. Sci.*, 109(39), 15706-15711.