

# Coordinated Ground- and Space-Based Observations of Atmosphere-Ionosphere Coupling

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Thanks to:

- Guiping Liu, *UC Berkeley*
- Thomas Immel, *UC Berkeley & the ICON team*
- Richard Eastes, *U. Central Florida & the GOLD team*
- Qihou Zhou, *Miami University*
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- Geetha Ramkumar, *Vikram Sarabhai Space Center*
- Larisa Goncharenko, *MIT Haystack Observatory*

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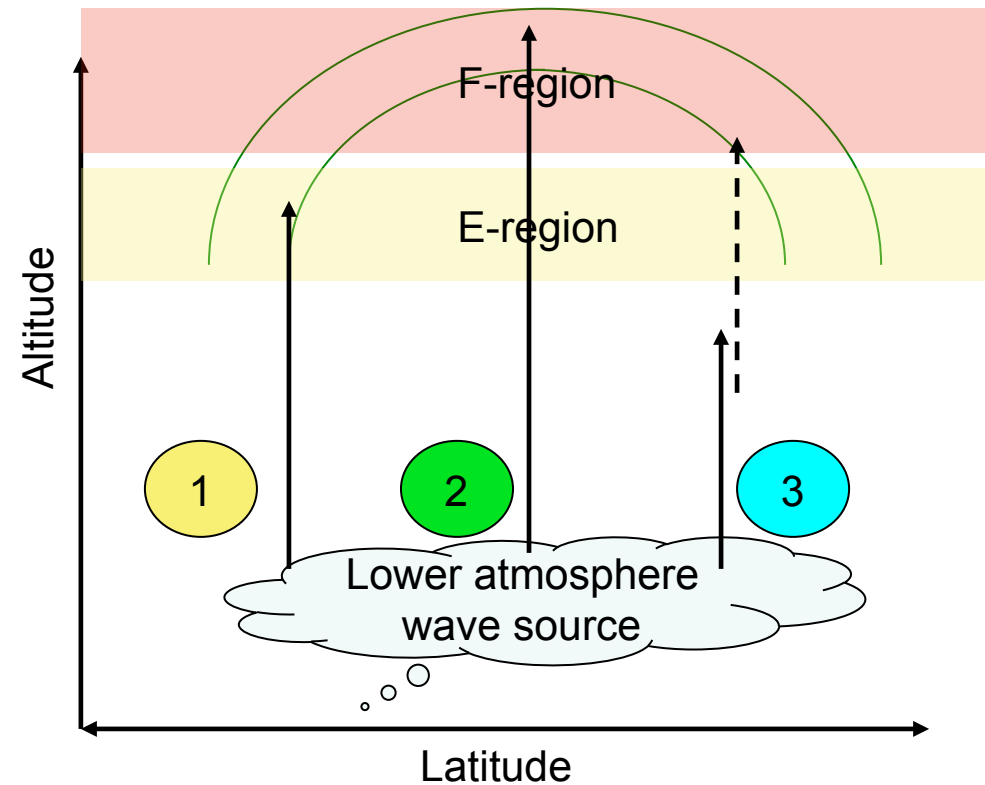


## Outline:

1. Goal
2. The URSI World Day Campaign – An example of what can be done now
3. The Planetary-Wave Signature in the Atmosphere
4. The Corresponding Signature in the Ionosphere
5. Coupling these two Regions
6. The ICON and GOLD Explorer missions

**Goal:** Determine the path by which planetary-wave signatures reach the F-region.

1. Via modulation of the E-region dynamo
2. Via direct propagation to the F-region
3. Via a secondary wave or wave interaction



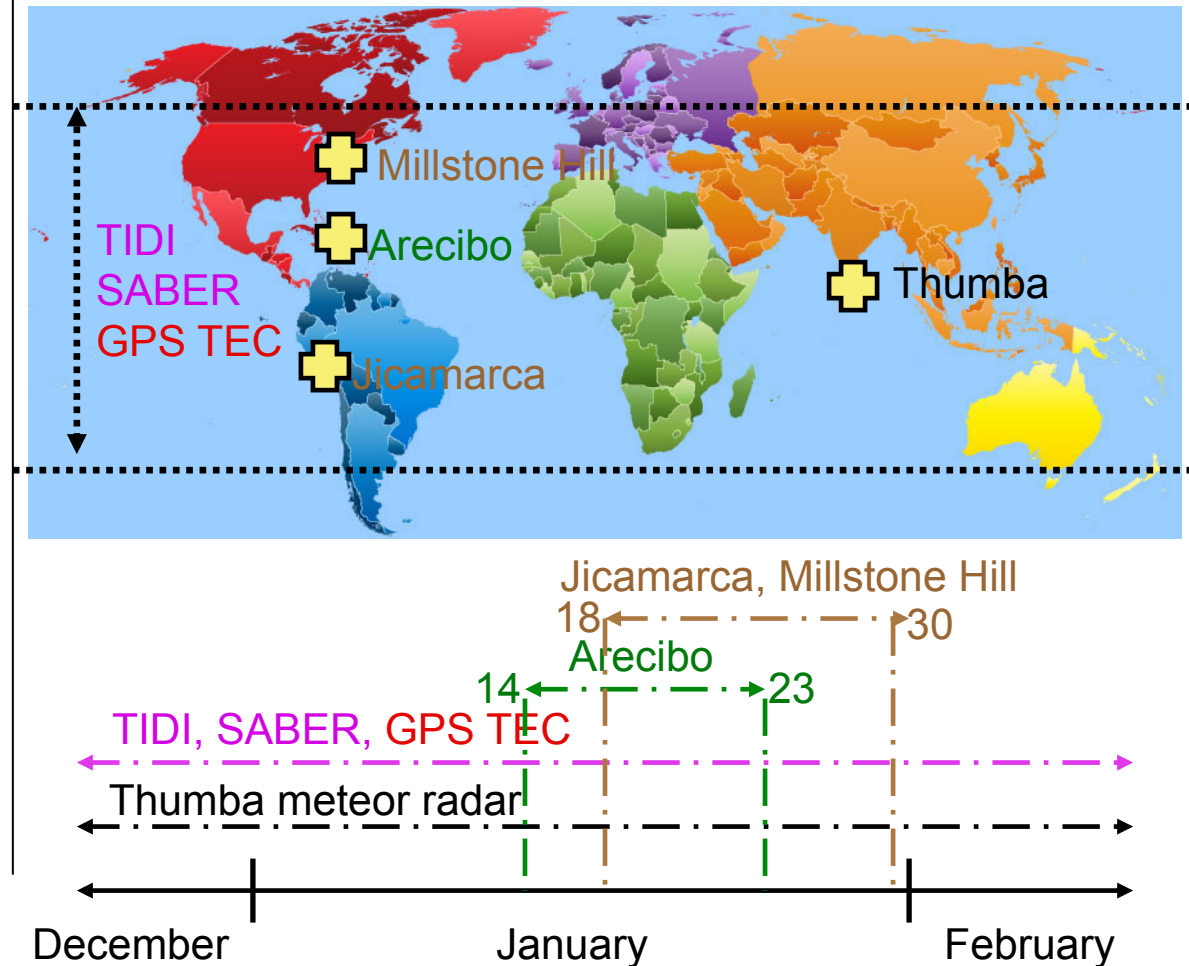
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## URSI World Day Campaign, January 2010



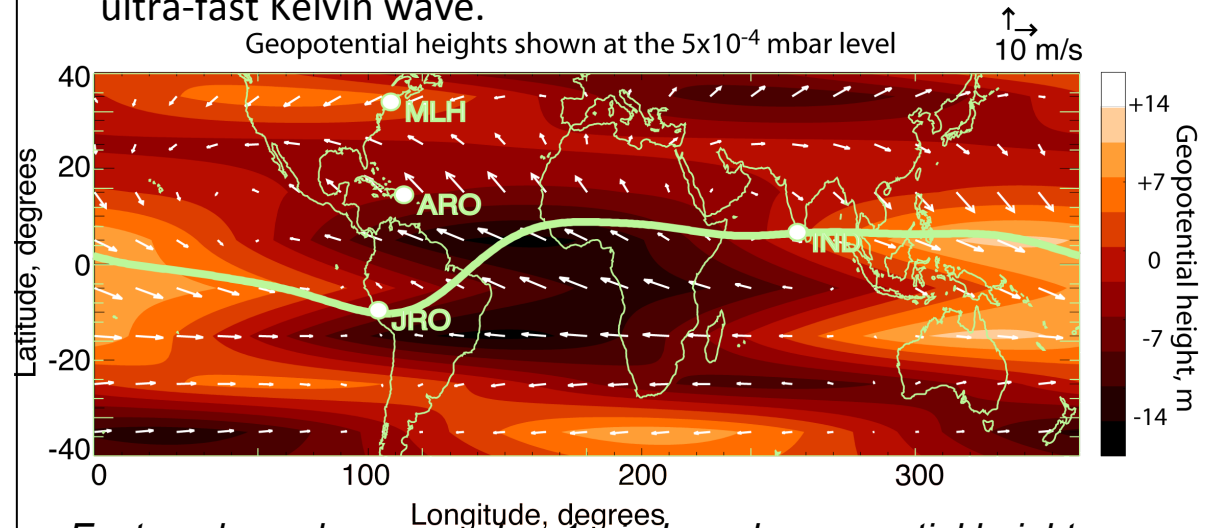
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We can also combine the TIDI and SABER data and reconstruct the horizontal structure (at a snapshot in UT). This, along with the parameters below confirm this is an ultra-fast Kelvin wave.



*Eastward zonal wavenumber-1 winds and geopotential heights from TIDI and SABER at 95 km, after England et al. (2012)*

Period	2.5 - 3.5 days
Vertical wavelength	40 km
Latitudinal range	$\pm 20^\circ$
Zonal wavenumber	Eastward, number 1
Maximum amplitude	10K, 20 m/s
Maximum altitude	105 - 110 km

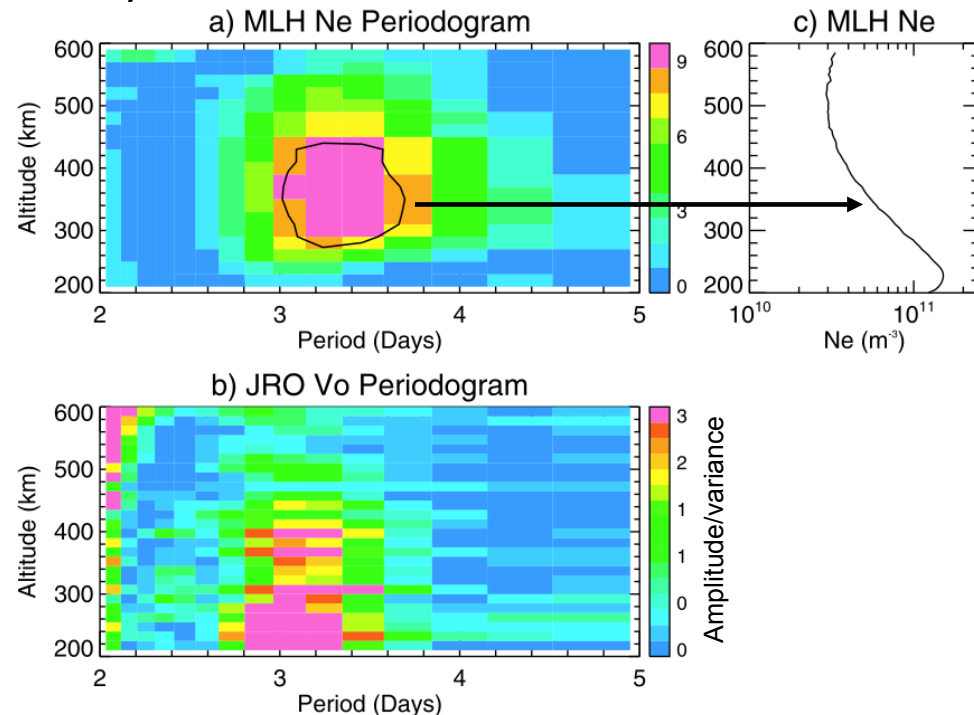
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The ISRs at Jicamarca and Millstone Hill provide details of the ionospheric response - its motion and density as a function of altitude.



**Top** - Lomb-Scargle periodogram of the electron density observed by Millstone Hill ISR over 18-30 January.

**Bottom** - As top, but for the vertical drifts at Jicamarca. After Liu et al. (2012).

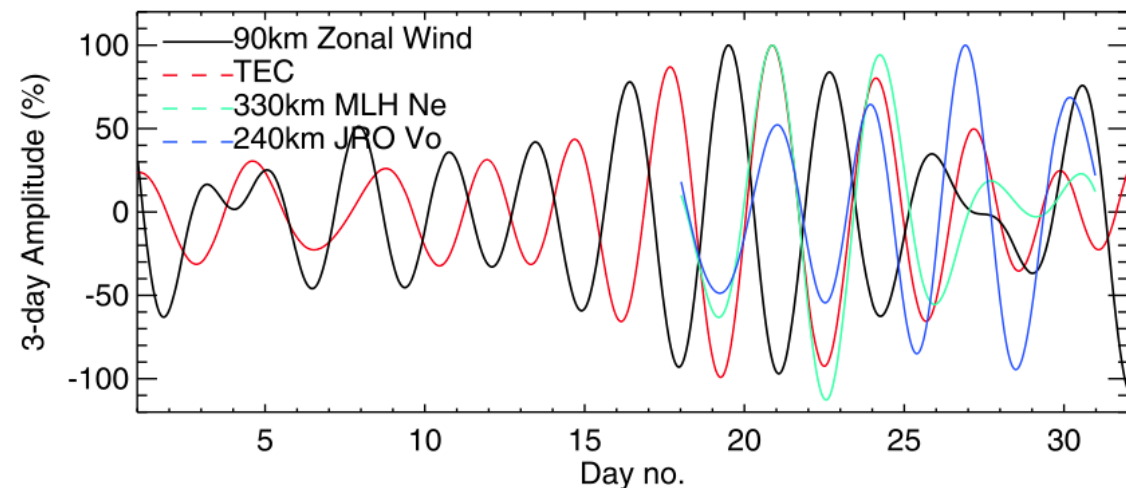
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Examining the timing of the driver seen in the atmosphere and the responses in the ionosphere we see the kind of phase & timing agreement that is **indicative** of a causal relation between the 3-day wave and the ionospheric response.



*Timing of the 3-day signatures seen in the mesospheric winds (black), IGS TEC (red), electron density at MLH (green) and vertical drifts at Jicamarca (blue). After Liu et al. (2012).*

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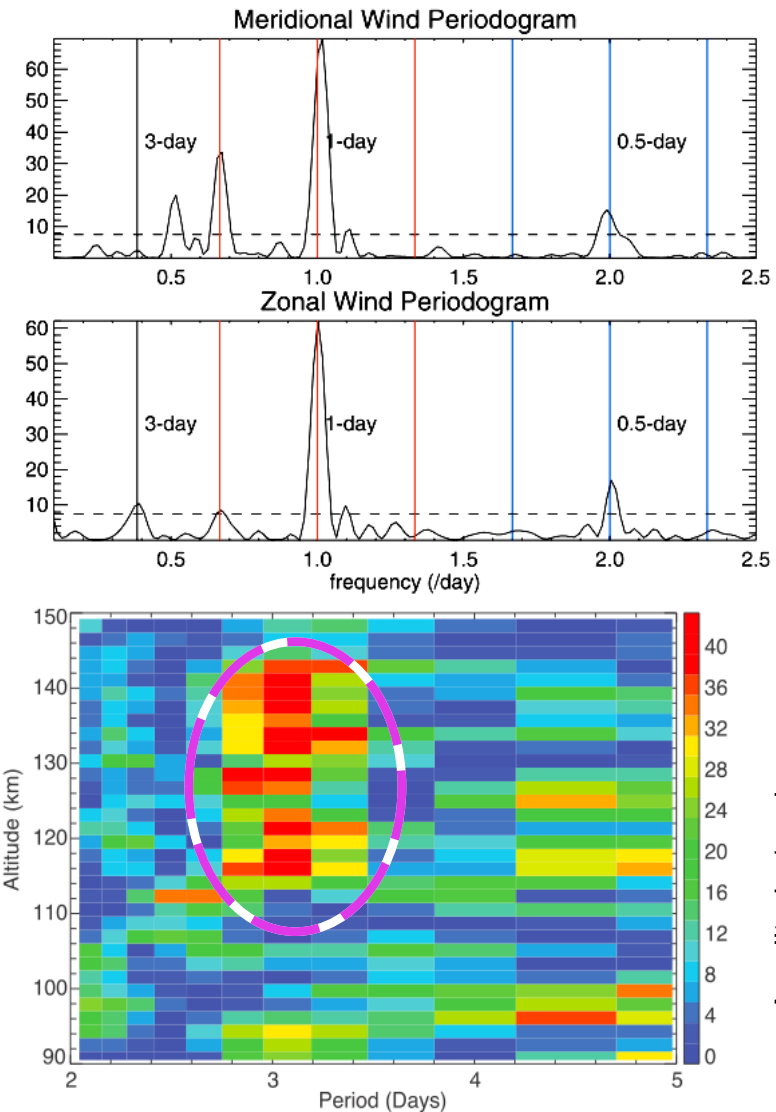


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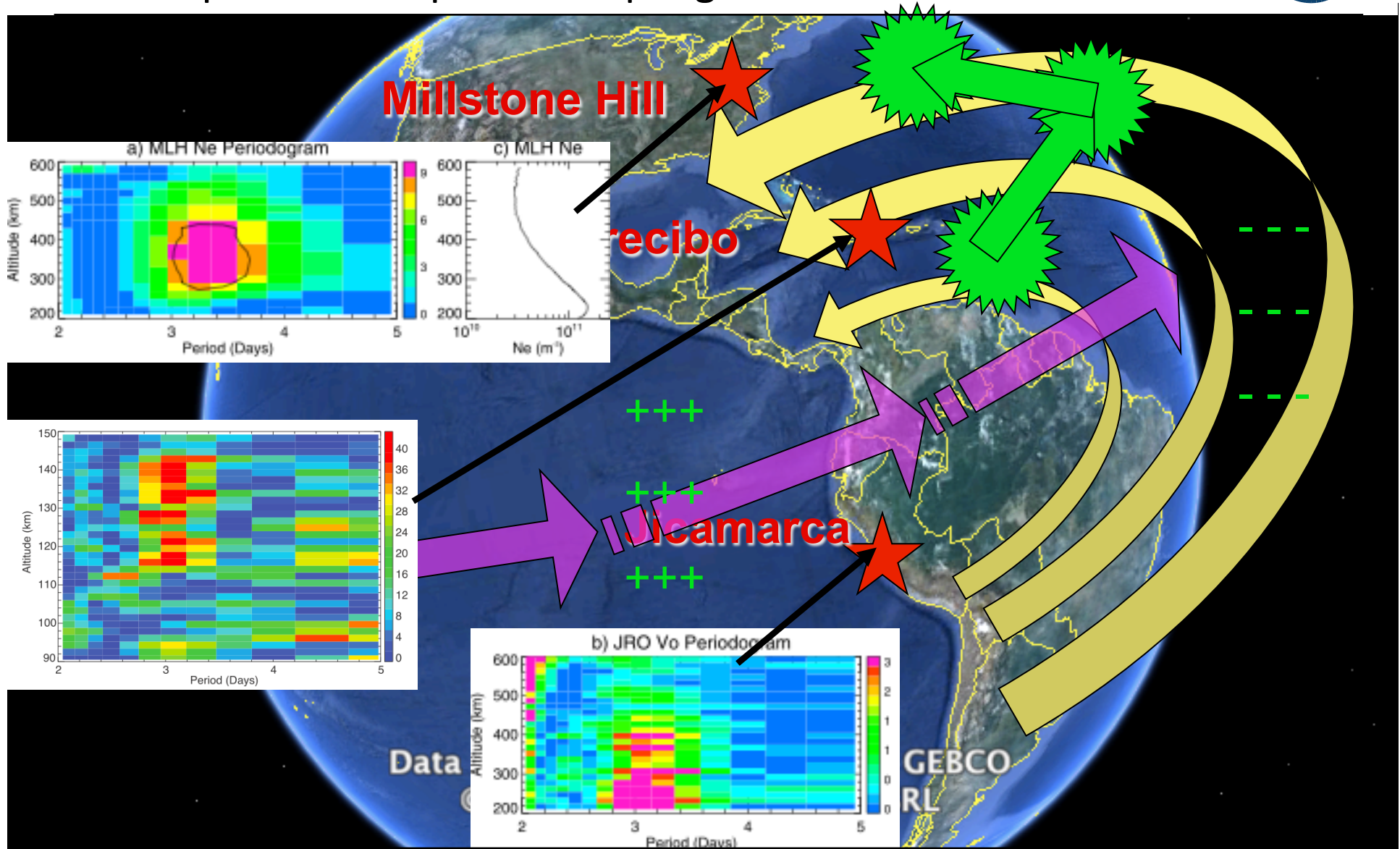
Spectra of meridional and zonal winds at Thumba at 98 km

Lomb-Scargle periodogram of the diurnal tidal winds observed by Arecibo from 90-150 km





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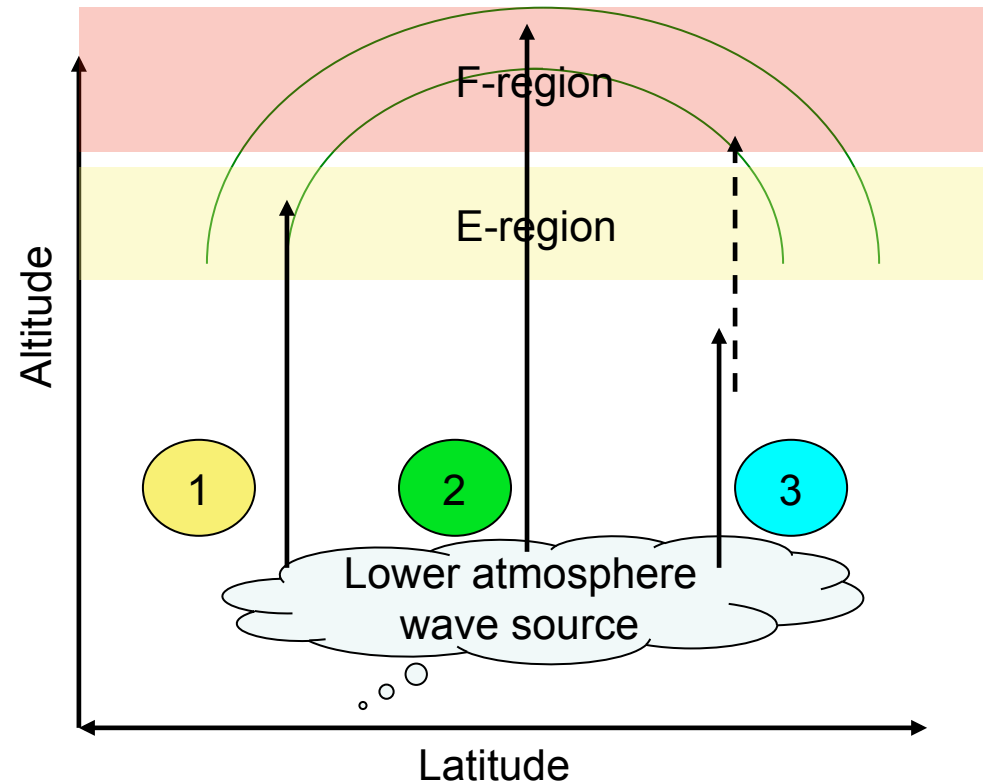


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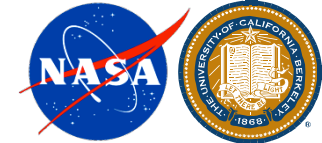
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- For this one case study we believe we have identified the coupling mechanism
- This identification relied on wind observations at E-region altitudes
- These are available from Arecibo for only a few days/year

# The NASA 2013 Explorer Missions: ICON and GOLD



The 2 new NASA Explorer Missions will both provide new & complimentary observations of this region.

The Ionospheric Connection (ICON) is designed to observe **atmospheric waves** at thermospheric altitudes & the **ionospheric response**.

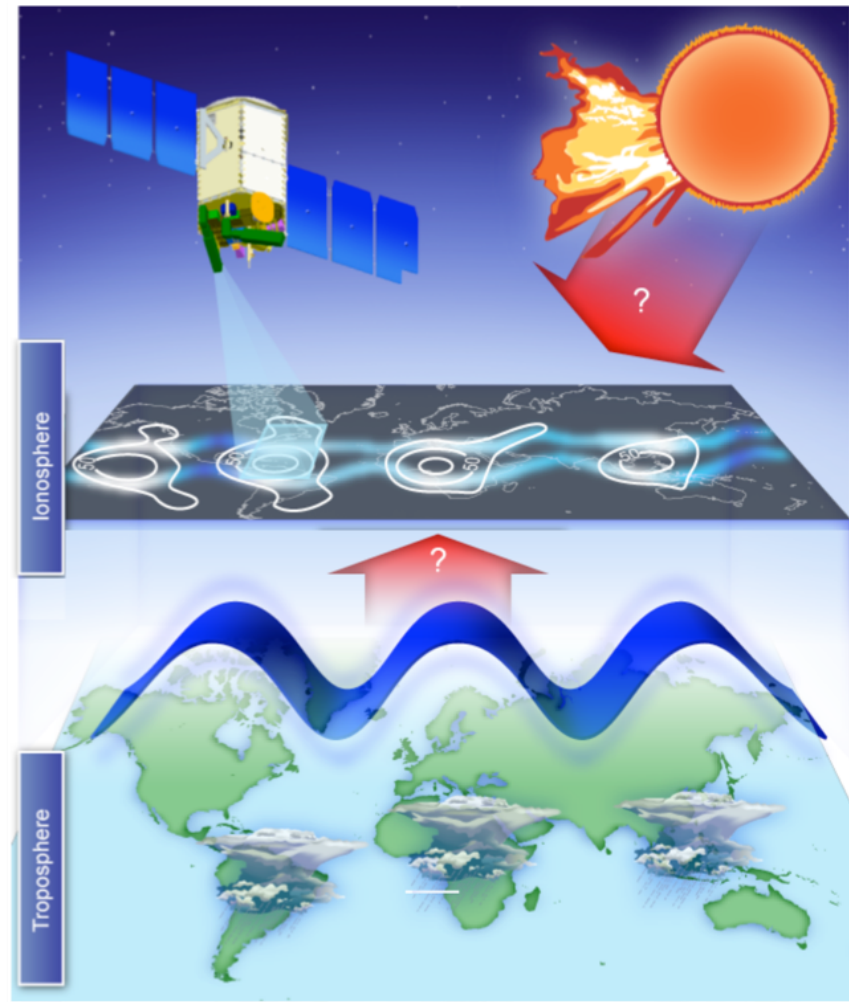
ICON carries 4 instruments:

Naval Research Lab – MIGHTI Neutral **winds and temperatures**

UC Berkeley – FUV **Neutral composition** and **nighttime plasma density**

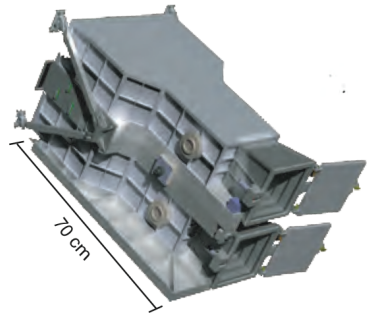
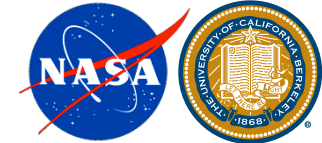
UC Berkeley - EUV **daytime plasma density**

UT Dallas – IVM *in situ* **plasma motion**



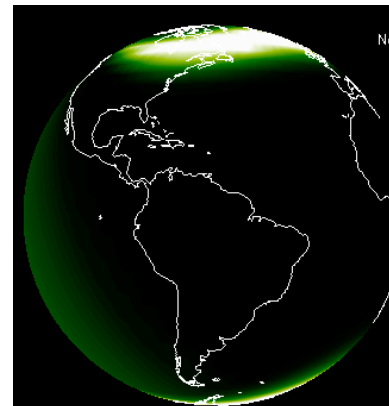
More information: <http://icon.ssl.berkeley.edu>

# The NASA 2013 Explorer Missions: ICON and GOLD

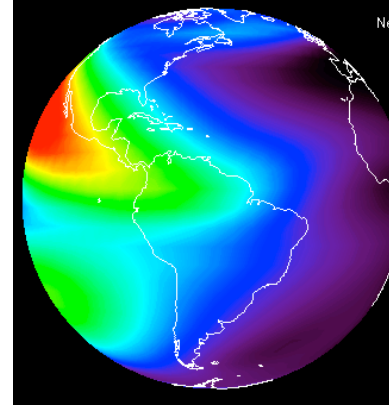
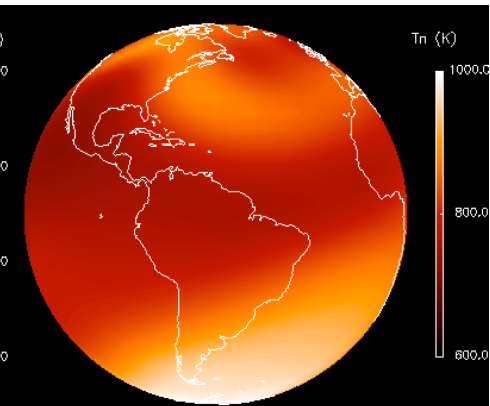


- Global-scale Observations of the Limb and Disk (GOLD) is a mission of opportunity (instrument) that will fly in geostationary orbit.
- GOLD is an imaging spectrograph that can observe FUV emissions at high spectral resolution.
- From these, GOLD can determine atmospheric and ionospheric parameters.

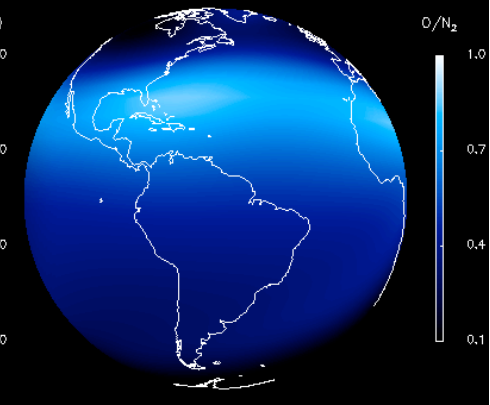
**E-region Electron  
Density (~110 km)**



**Neutral Temperature  
(~160 km)**

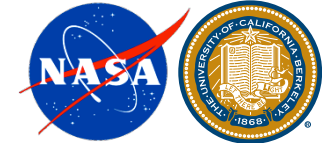


**F-region Electron  
Density (~300 km)**



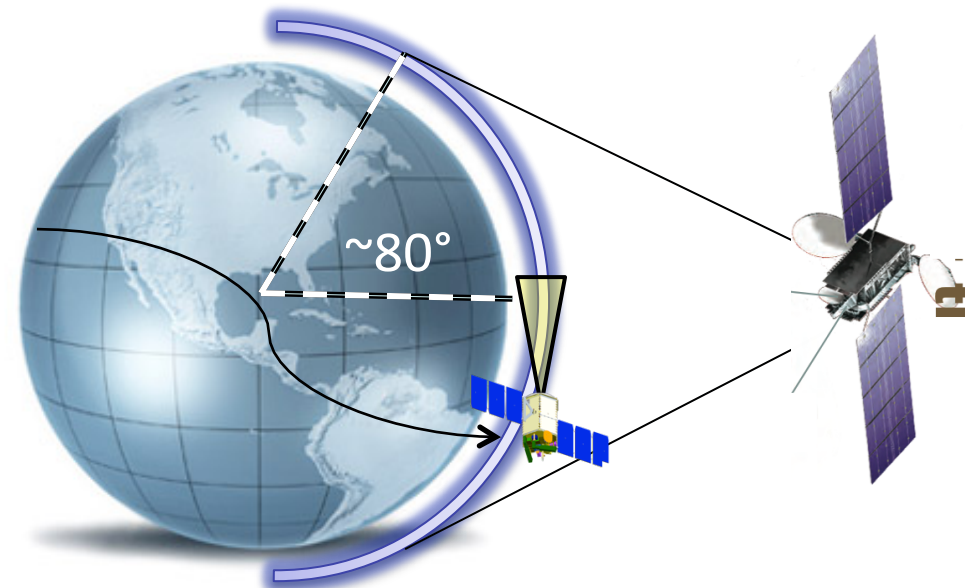
**O/N<sub>2</sub> Ratio  
(~160 km)**

# The NASA 2013 Explorer Missions: ICON and GOLD



## ICON and GOLD together:

- As ICON flies it observes altitude profiles of winds, ion densities and ion drifts *in situ* while GOLD images the thermosphere and ionosphere from a geostationary orbit.
- Both missions will operate at the same time: ICON launch 2017, GOLD launch 2018.
- We are organizing an AGU session to solicit community input for a strategy on how to use these missions, in addition to other ground-based and space-based observations and models, to address major science questions in our field.
- AGU SA014 - New Missions in the Thermosphere-Ionosphere.



*Combined ICON and GOLD observations will open the door to a range of new and innovative science investigations that no one mission can do alone.*