Imaging Science Contributions to Space Weather Research Using Geomagnetic Conjugate Point Observations: Latitude Coupling—North and South America and Europe-Africa

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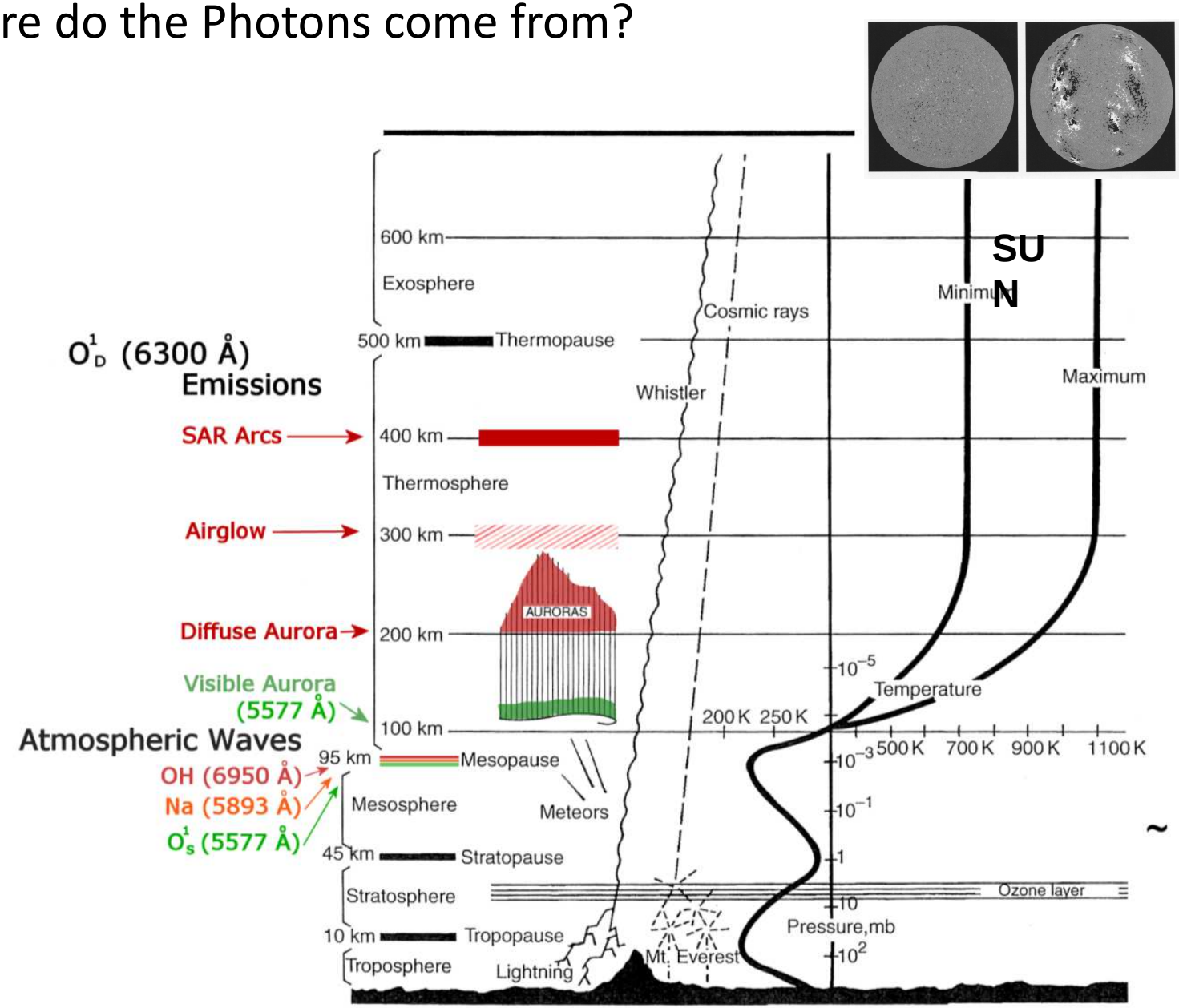
Outline

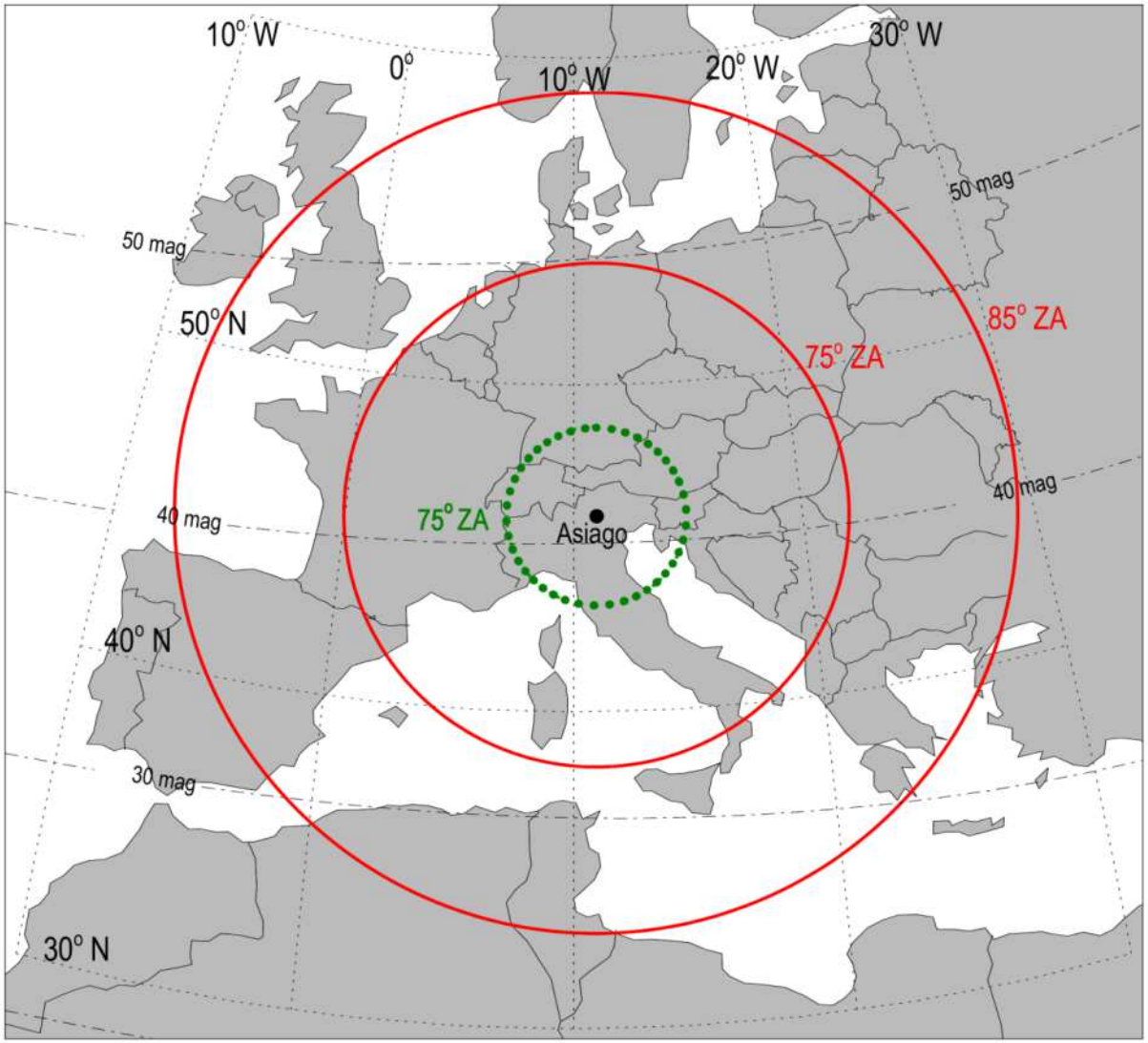
- Overview of All-Sky-Imaging
  - Single Site Observations
    * Stable Auroral Red (SAR) arcs
    * Upward coupling: Mesosphere-Ionosphere

- Conjugate Point Science
  - New insights into a single source of disturbance encountering different seasonal “receptor” conditions.
    * SAR arcs
    * MSTIDs
    * ESF

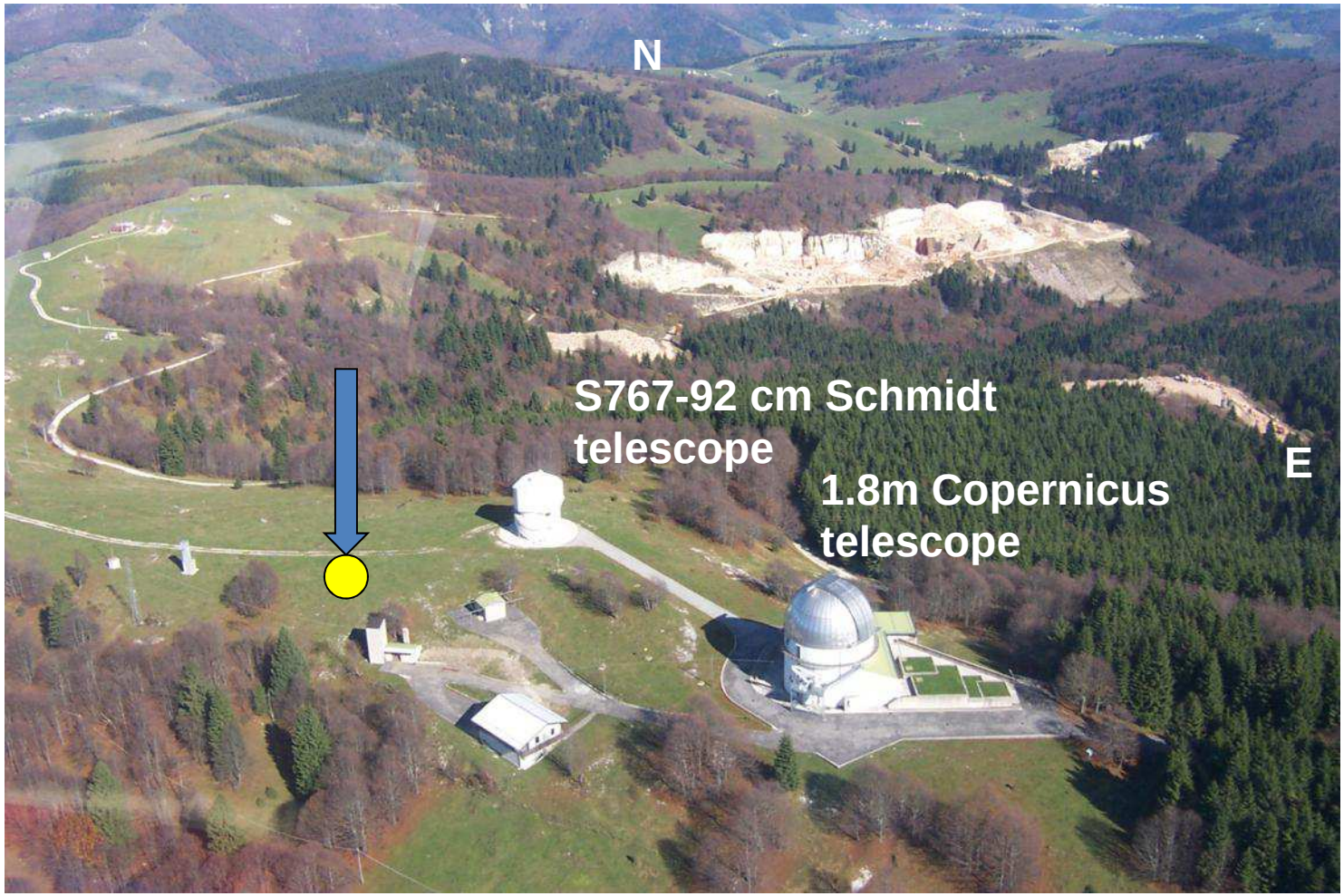
Where do the Photons come from?



Horizon of ASIAGO in the different spectral bands



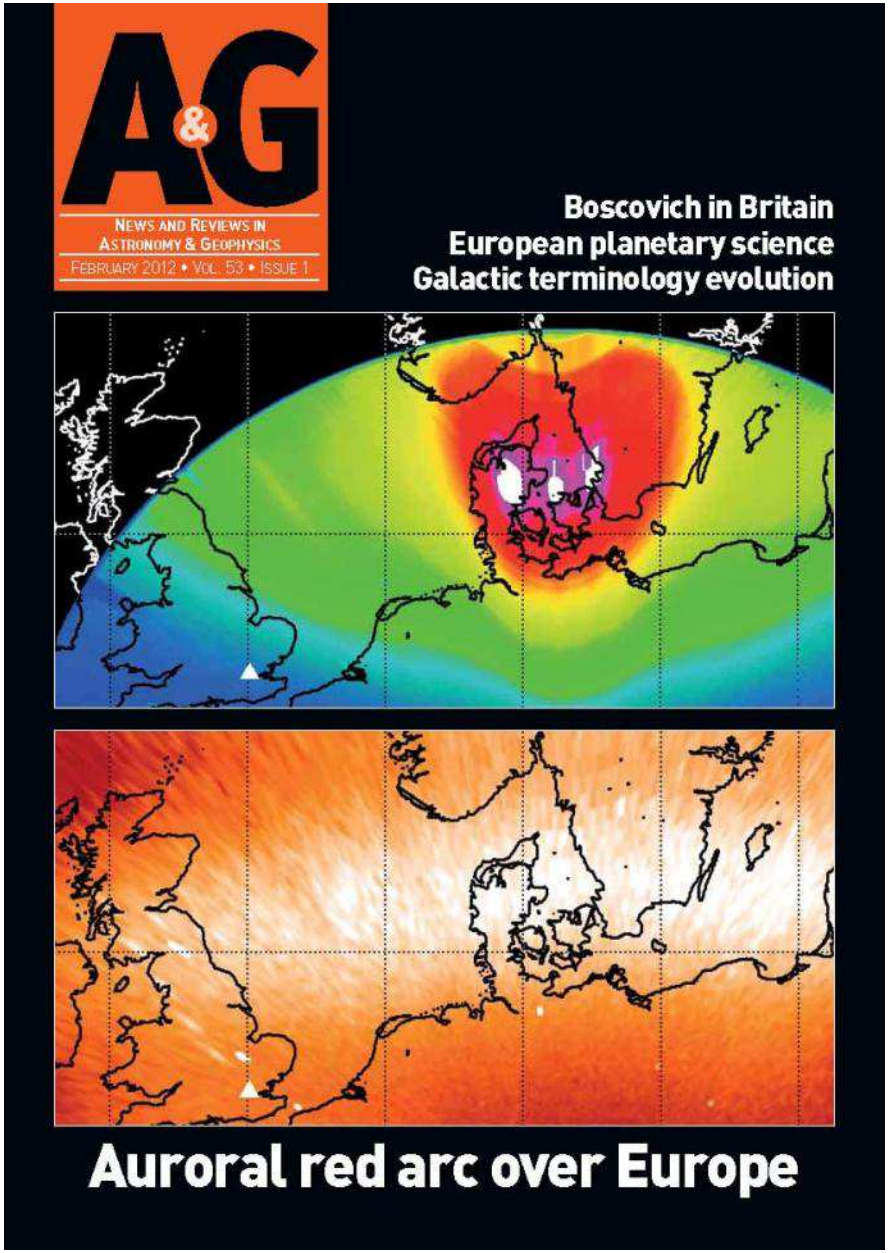
ASIAGO location at Cima Ekar



Housing

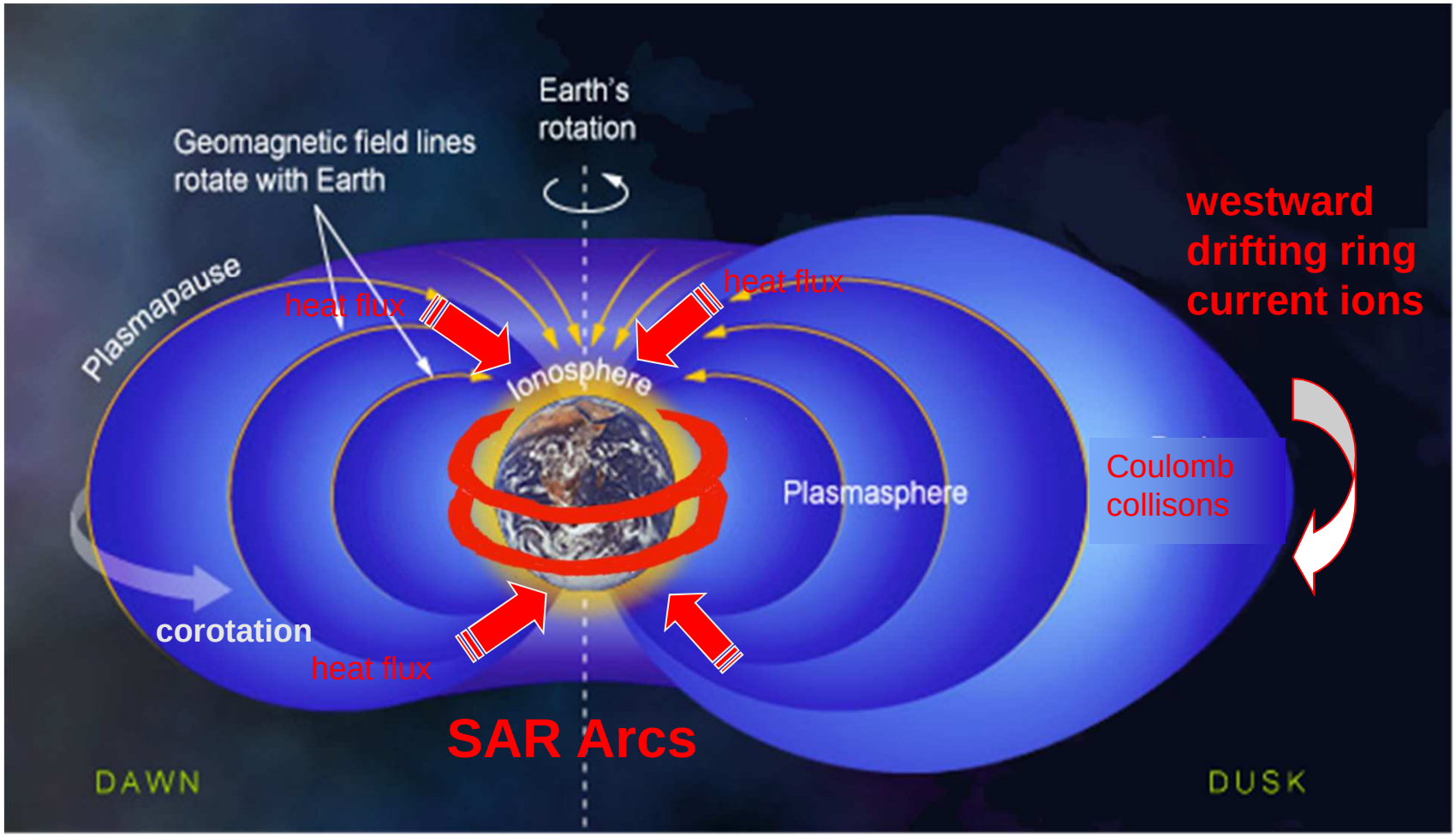
The BU camera is lodged in a small container, which has been equipped with temperature and humidity controls, and safety devices. Two telescopes can be sited inside the container. The glassy domes are permanently open. Only occasional maintenance operations are required by the Observatory technical staff.

The A&G cover (Feb 2012)



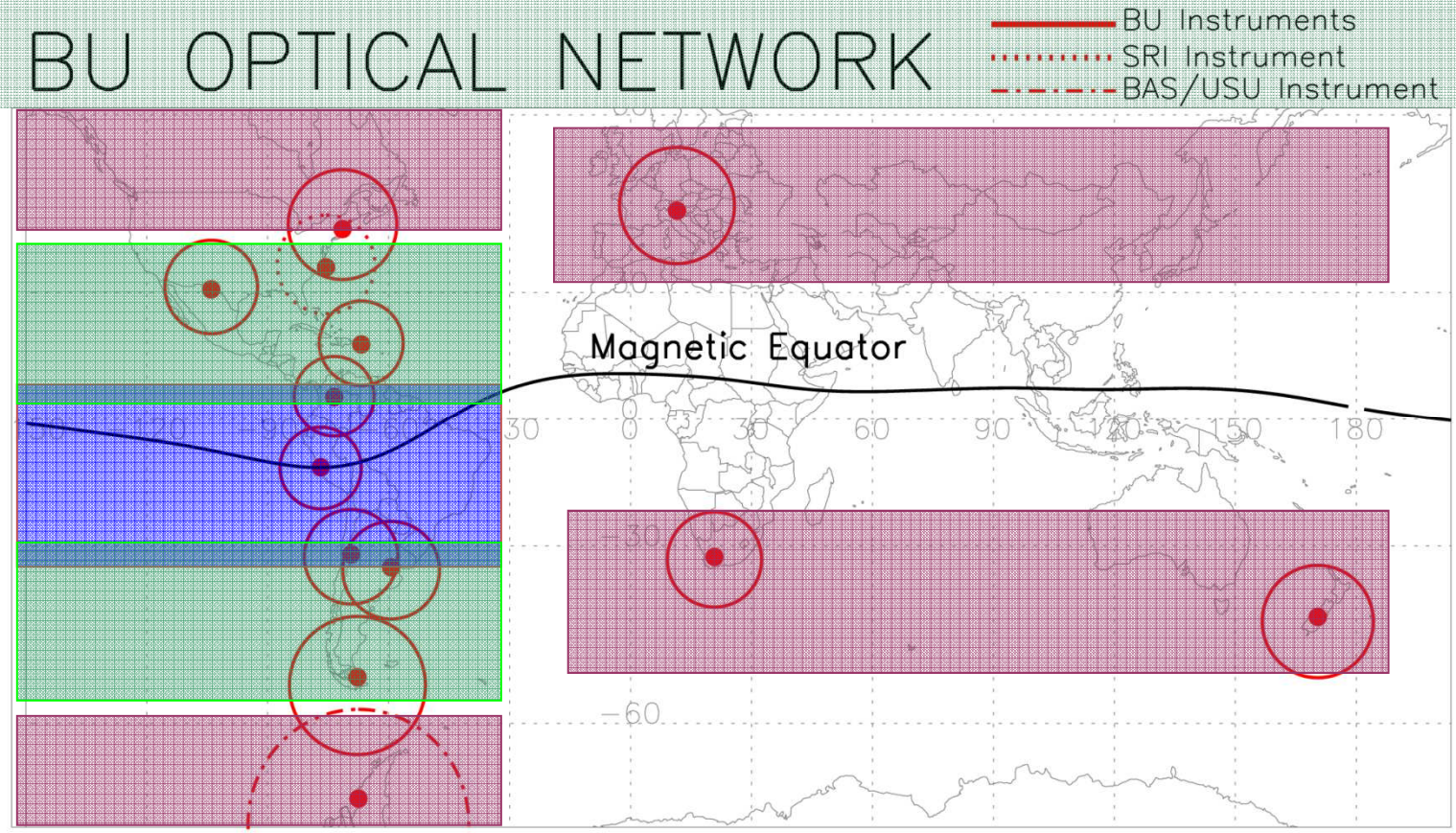
SAR: Stable Auroral Red arcs

Formation of SAR Arcs



Networks of All-Sky-Imagers (ASIs) for ITM System Science

BU OPTICAL NETWORK



1. Equatorial and low latitude Ionosphere (from magnetic equator to the crests of the Appleton Anomaly). *ESF and MSTIDs, effects on trans-ionospheric radio signals using GPS and optical diagnosis.*

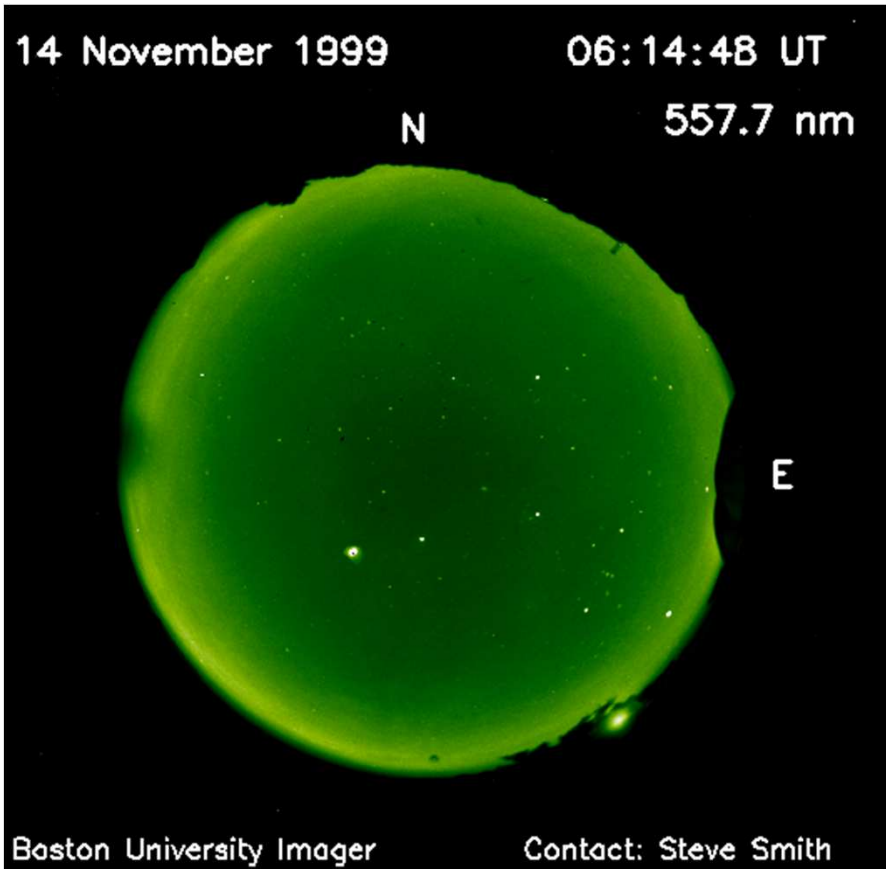
2. Mid latitude Ionosphere (poleward from Anomaly crests to ~ ± 40 mag lat). *Nighttime MSTIDs, E and F region coupling.*

3. Sub-auroral Ionosphere (latitudes below auroral ovals). *Stable auroral red (SAR) arcs (magnetic activity effects that transfer magnetospheric ring current energy into the I-T system)*

4. Mesospheric Dynamics *(above mountains, coastal & oceanic sites)*

MLT Gravity Waves and M-T Dynamical Coupling Processes

Mesospheric Bores

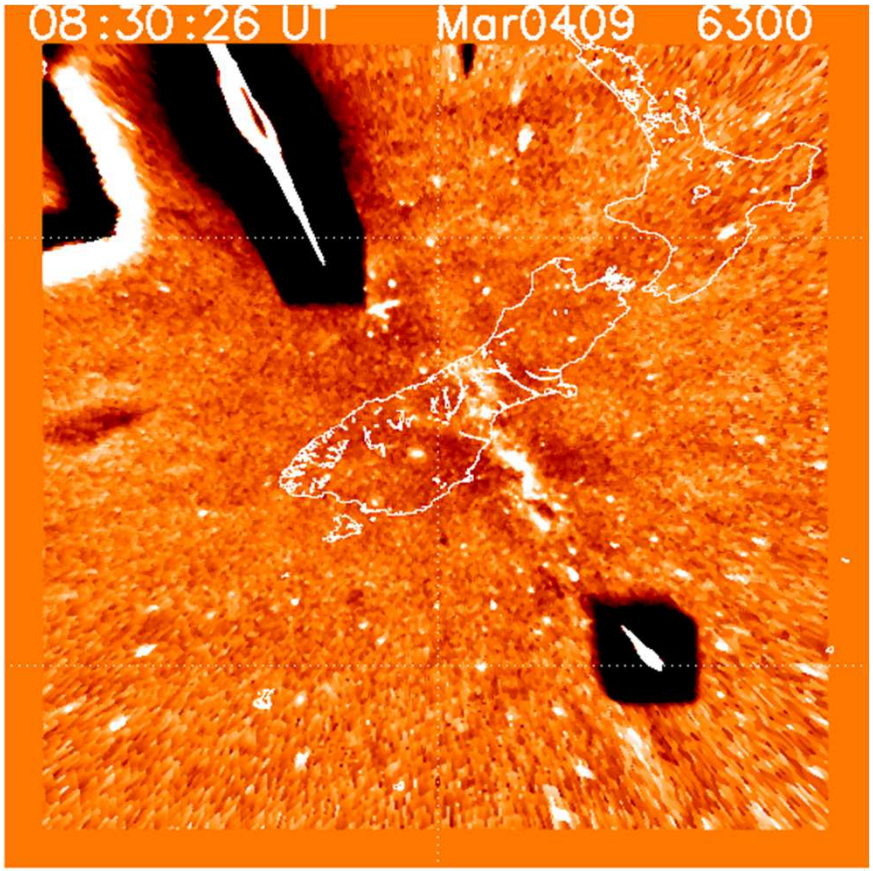


McDonald Observatory, Texas 14 November 1999

Large mesospheric bore disturbance in the 557.7 nm emission. Naked–eye visibility (Smith et al., 2003 JGR).

Indicated presence of stable temperature inversion layer near 90 km altitude spanning over 1100 km.

Secondary GW's in Thermosphere



Mt. John Observatory, New Zealand 4 March 2009

Secondary thermospheric GW's in 630.0 nm emission generated from breaking GW's in the MLT (Smith et al., 2013 JGR).

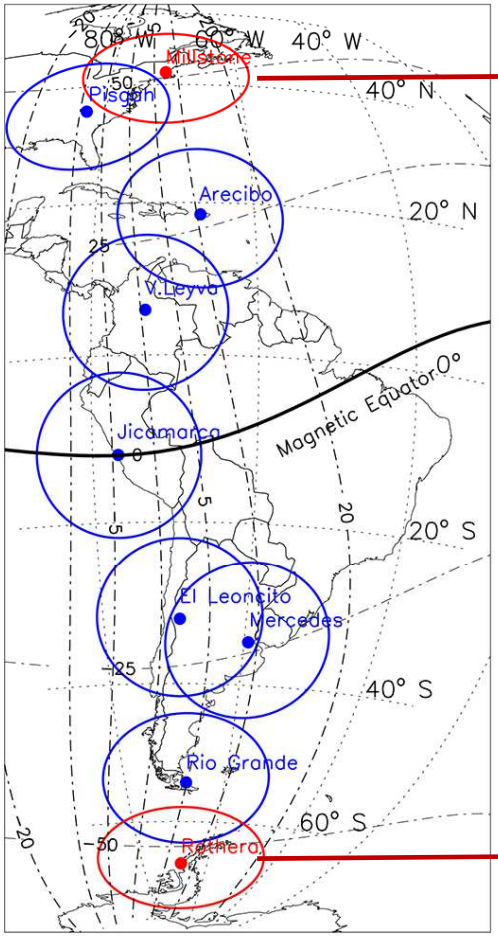
- **Strong SE-ward waves 9:00-12:30UT** **Two simul. wave sets**
- **Weaker NW-ward waves 9:00-10:30UT** **prop. in opp. dirs**.

Clear example of dynamical coupling between mesosphere and thermosphere.

Boston University All-Sky-Imagers

Geomagnetic Conjugate Science Feature: Stable Auroral Red (SAR) Arcs

1 June 2013



Millstone Hill 01:39:16 UT

Rothera 00:02 UT

6300 Å Images

Similarities

- Both SAR Arcs at L= 2.74 R_e
- Same Separations from Diffuse Aurora

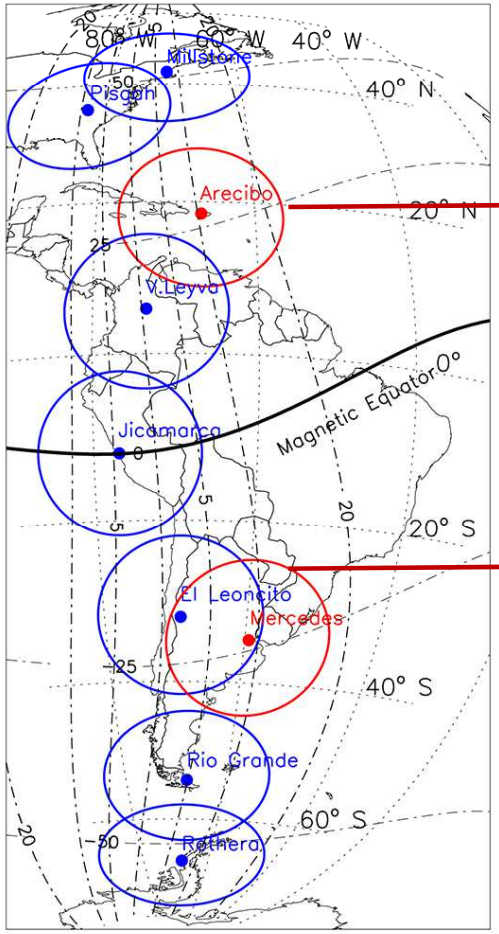
Differences

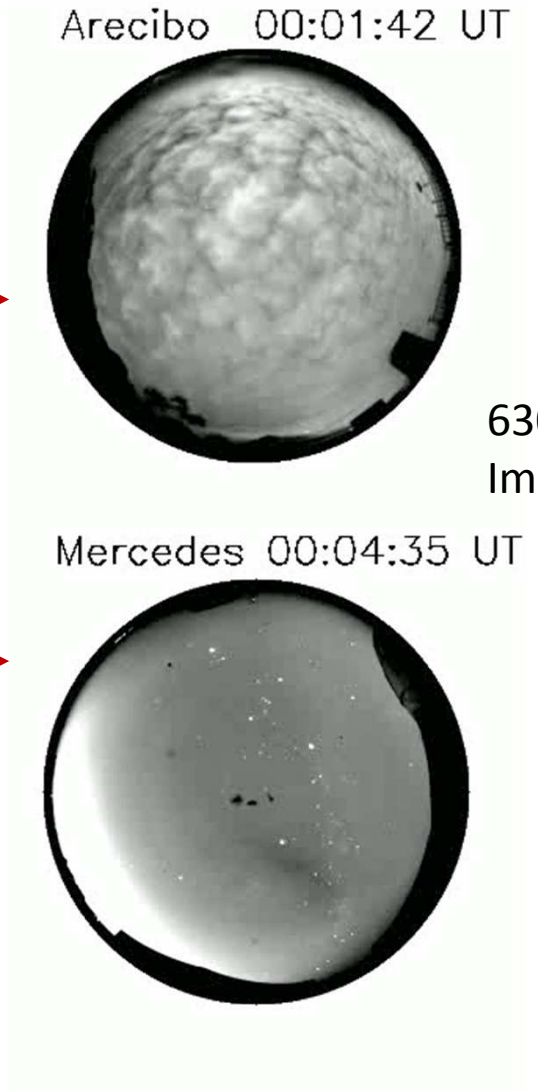
- Small scale structures along arcs
- Brighter in Southern Hemisphere
- Latitude gradients stronger in South

Boston University All-Sky-Imagers

Geomagnetic Conjugate Science Feature: Medium Scale Travelling Ionospheric Disturbances

9 Feb 2013





6300 Å Images

Similarities

- MSTIDs travel westward & equator-ward in both hemispheres: SW in north, NW in south
- Wave Crests & Troughs linked by same field lines

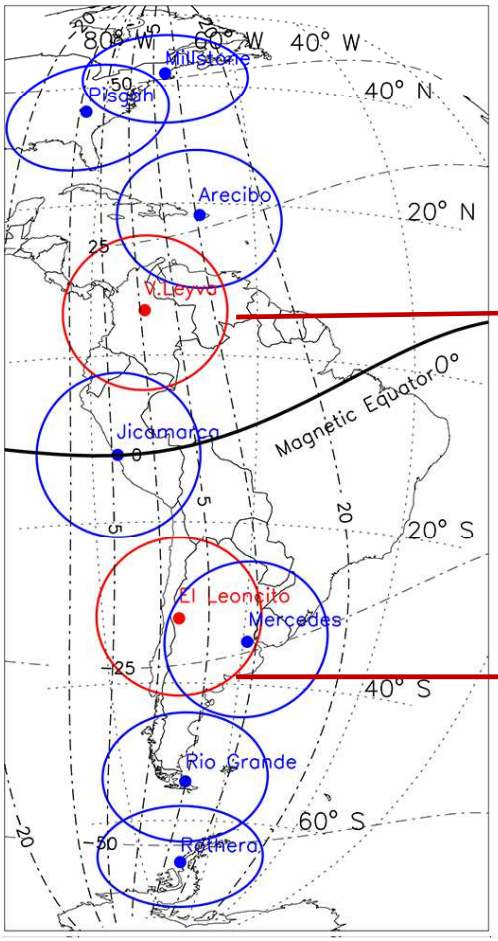
Differences

- Background airglow brighter in Summer (Southern) hemisphere
- Crest-to-trough brightness ratio higher in Winter (Northern) hemisphere
- Ionospheric radar data only available in Northern hemisphere

Boston University All-Sky-Imagers

Geomagnetic Conjugate Science Feature: Airglow Depletions showing trans-equatorial Plasma Instabilities

18 November 2014



Villa de Leyva 00:19:48 UT

7774 Å Images

El Leoncito 00:20:06 UT

Similarities

- Coherence of broad temporal & spacial occurrence patterns
- Broadly consistent zonal (E→W) drift patterns

Differences

- Fine structuring stronger in Southern hemisphere
- Bright-to-dark contrast greater in Winter (Northern) hemisphere
- Zonal drift patterns affected by South Atlantic magnetic field anomaly

Summary

- First network of All-Sky-Imagers poised to contribute to studies of upper atmosphere phenomena linked by common electro-dynamical mechanisms along same geomagnetic field lines

- Upcoming NASA missions (ICON and GOLD) will focus attention on N-S hemisphere effect with high resolution provided by ASI networks

- Opportunities for international collaborations.

The first use of coordinated ionospheric radio and optical observations over Italy: Convergence of high and low latitude storm-induced effects

C. Cesaroni[1]*, L. Alfonsi[1], M. Pezzopane[1], M. Mendillo[2], J. Baumgardner[2], C. Martinis[2], J. Wroten[2], M. Lazzarin[3] and G. Umbriaco[3]

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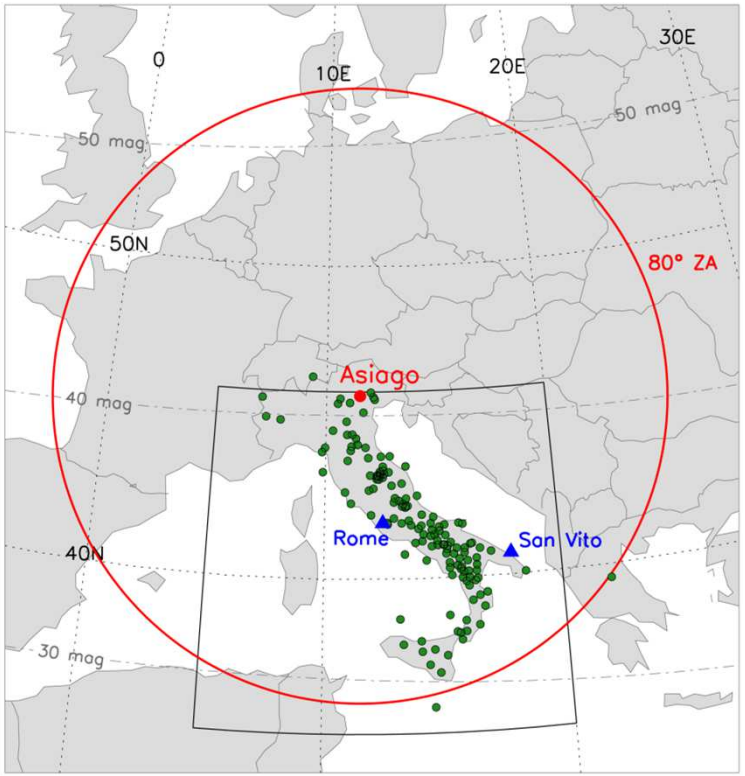
[2]Center for Space Physics, Boston University, Boston, MA, 02215, USA.

[3]Department of Physics and Astronomy, University of Padova, Italy.



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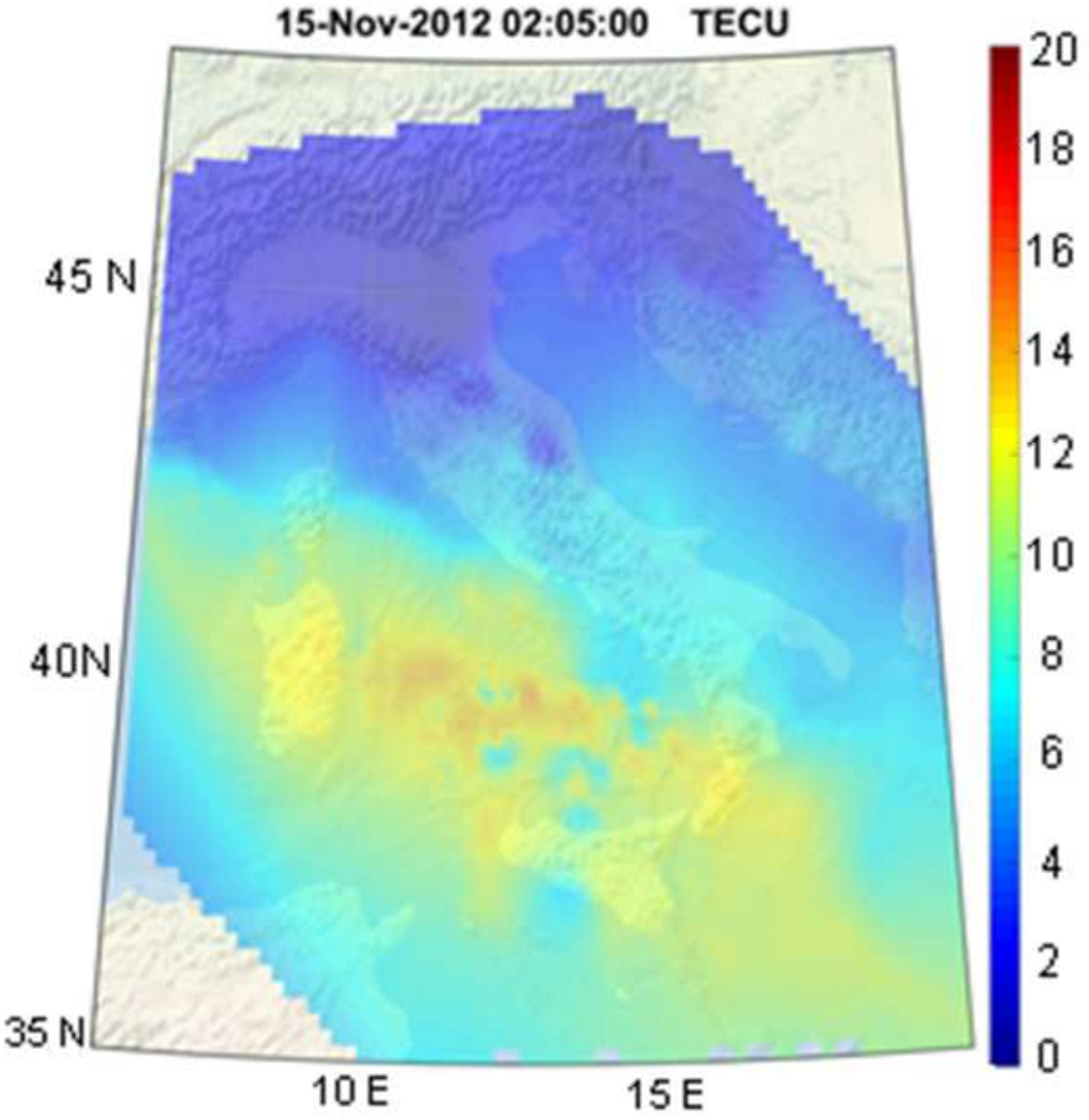
Ionospheric Total Electron Content (TEC) from RING Network



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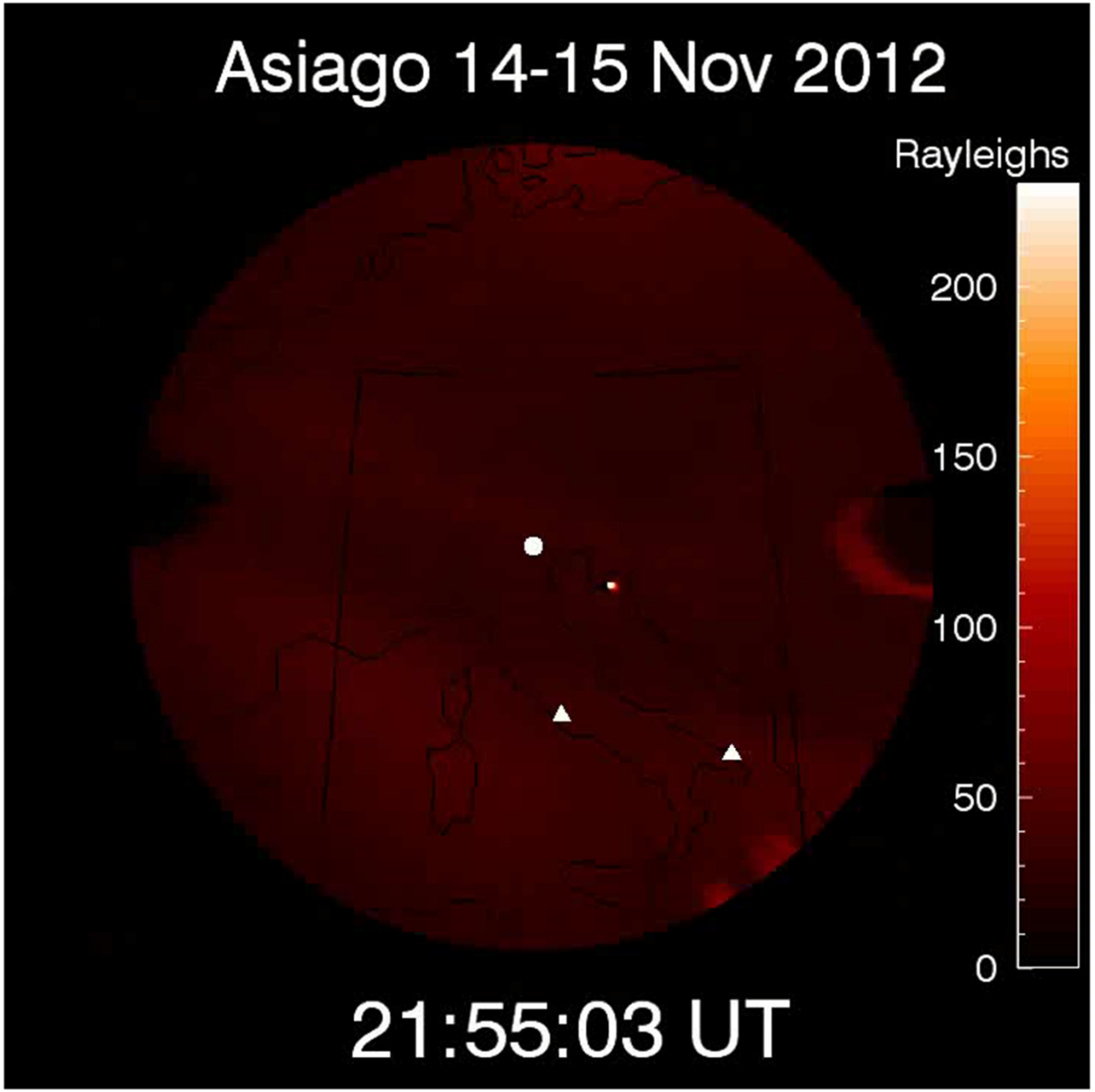

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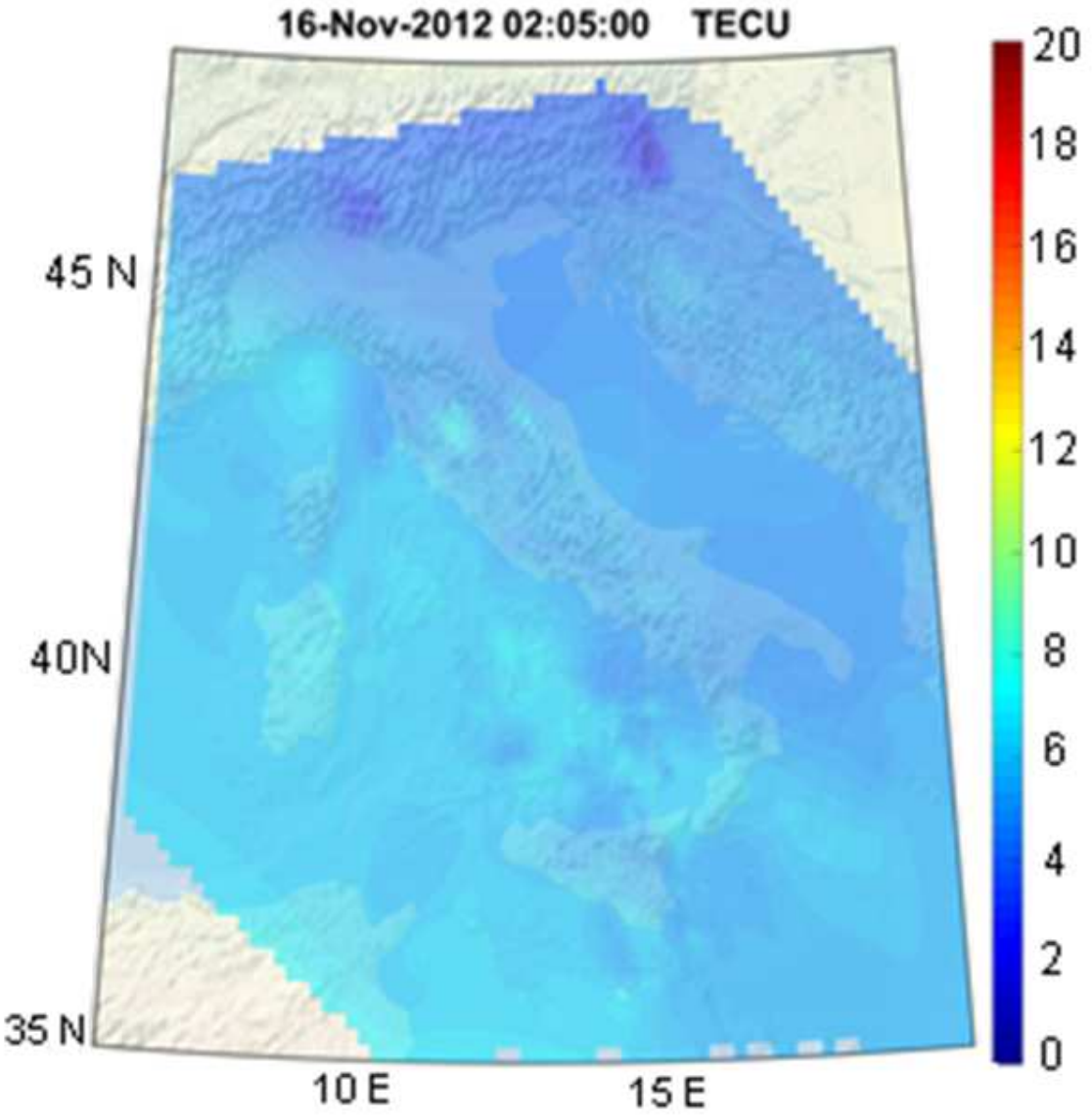

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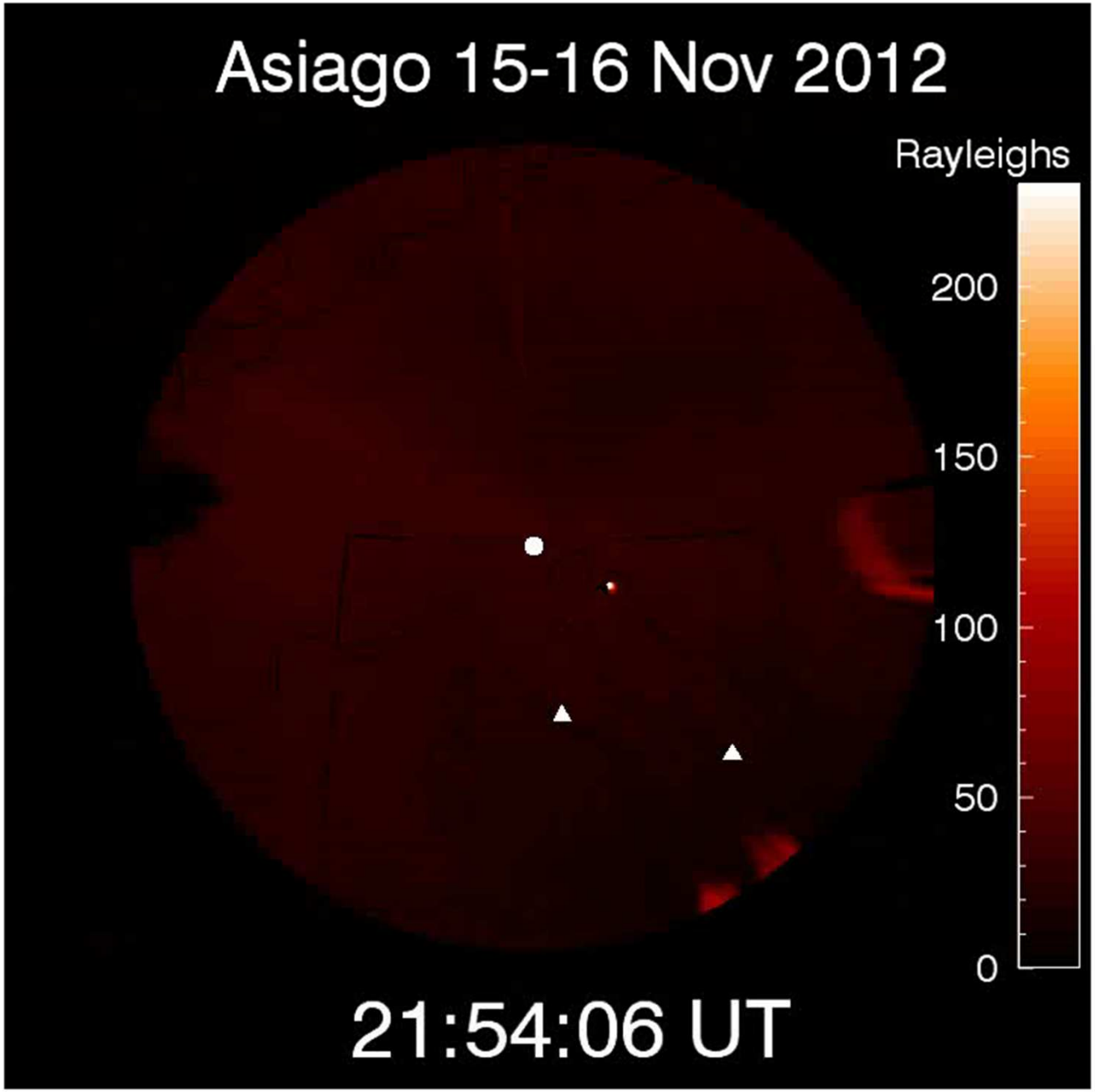

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Findings

- Persistent enhancements to the SW in F-layer ionization and airglow attributed to an unusual poleward excursion of low latitude storm-time ionospheric morphology.

- High-latitude brightness wave in 630.0 nm airglow traveling from NE to SW encountered, but could not cross, the pre-existing stationary enhancement in the SW.

- Empirical Mode Decomposition of single station vertical Total Electron Content data linked the airglow wave to a Large Scale Travelling Ionospheric Disturbance.

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All BU imaging data available on website.

Collaborations Welcome!