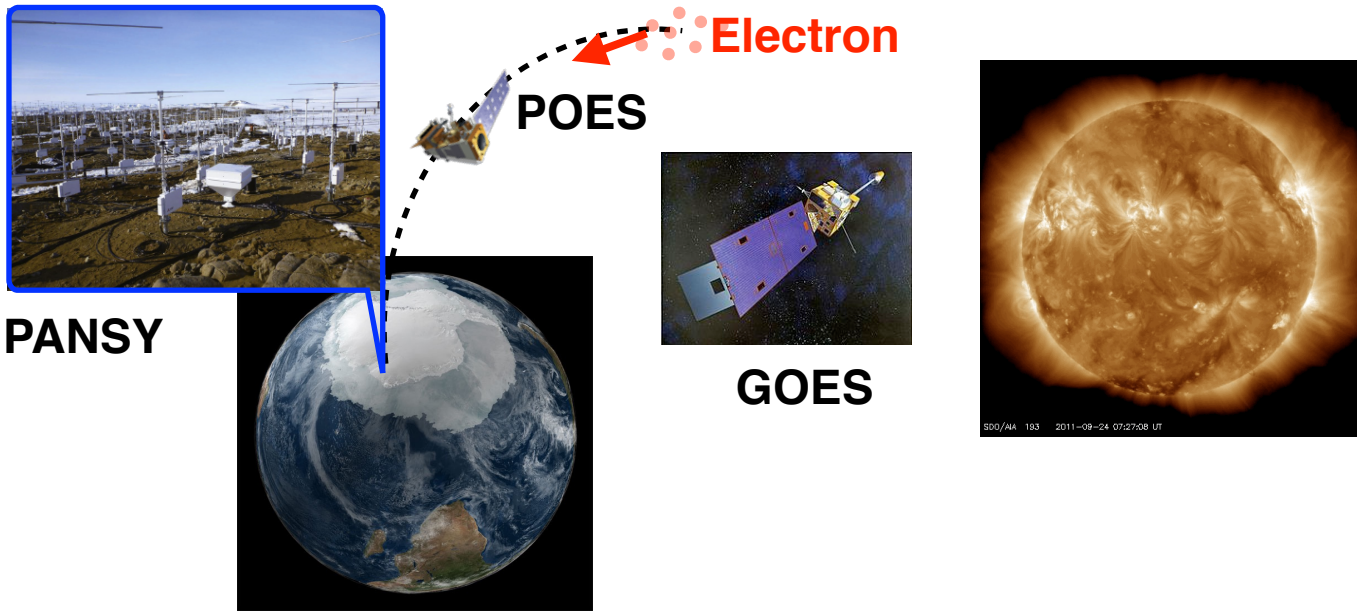
SCOSTEP-WDS Workshop
September 28-30, 2015

Energetic particle precipitations impacts on the mesosphere observed by the PANSY radar



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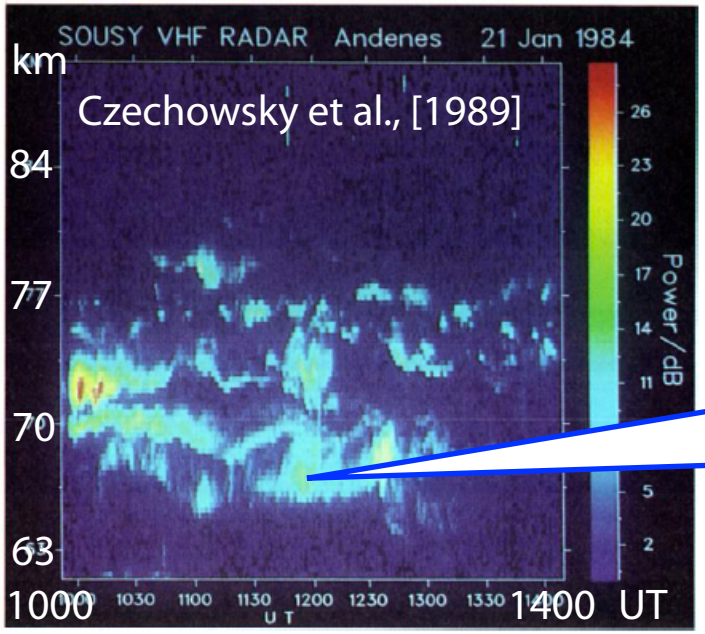
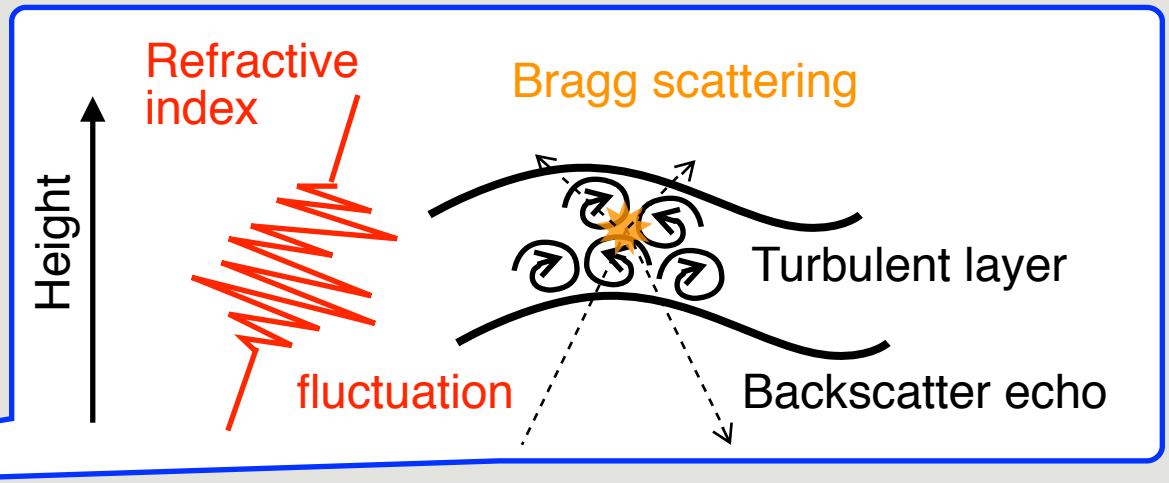
Outline

- ✓ Introduction
  - PMWE: What is Polar Mesosphere Winter Echo?
  - the PANSY radar: Dataset used in this study
- ✓ Event reports
  - St. Patrick's Day Event
  - the Summer Solstice 2015 Event
- ✓ Conclusions and future works

Polar Mesosphere Winter Echo

- ✓ Polar Mesosphere Winter Echo (PMWE)
  - – Mesosphere echo in the polar regions during non-summer period [e.g., *Ecklund and Balsley*, 1981]
    - Altitude: 60-80 km without well-defined peak
    - Local time: primarily confined to daytime



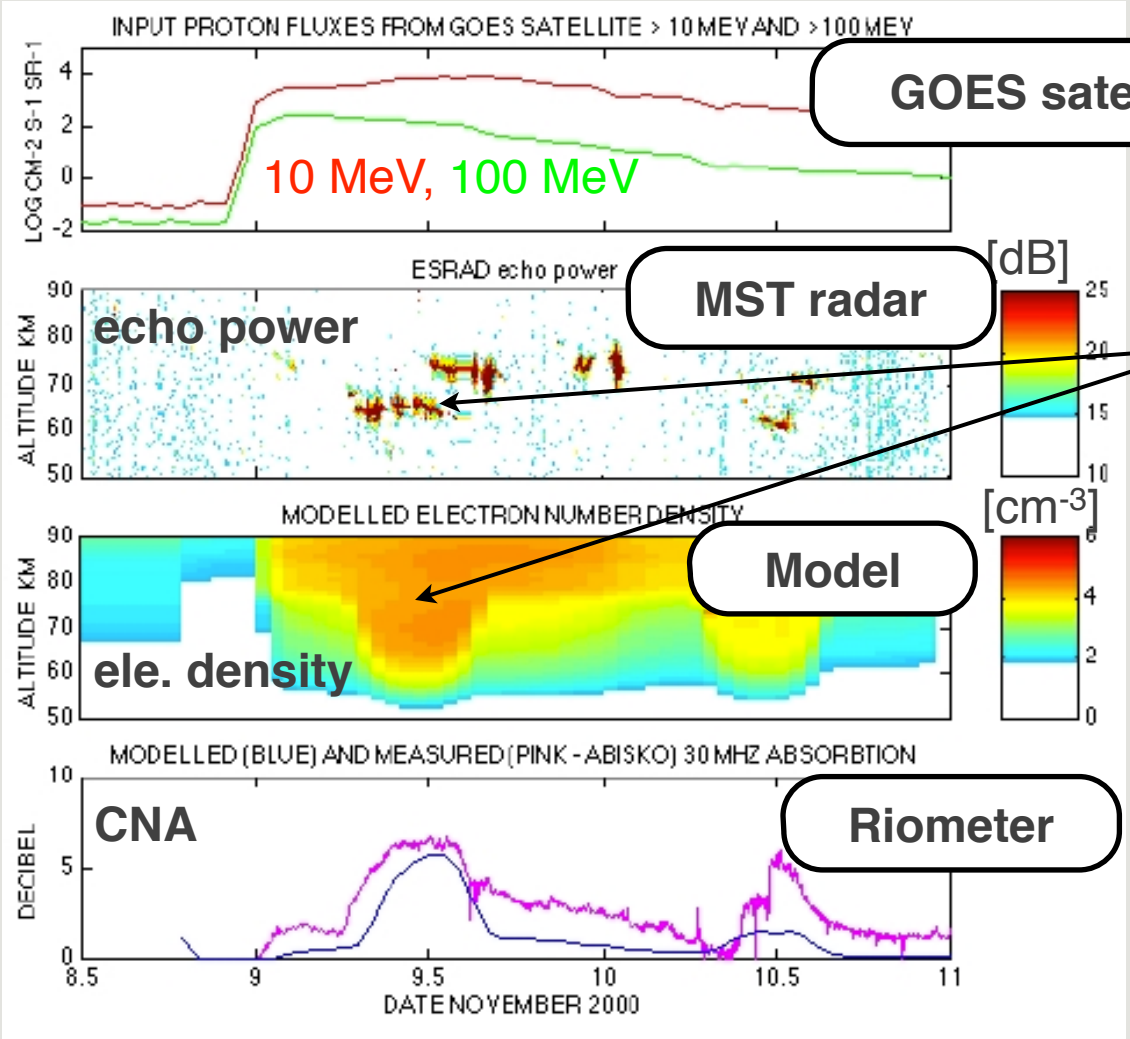


  - – Mean occurrence rate is only 2.9 % (Total 447.5 h) [*Zeller et al*. 2006]
    - This is partly because electron density in dark mesosphere is extremely low.
    - Good correlation to enhancement of electron density in D region due to Solar Proton Event (SPE) [*Kirkwood et al*., 2002]

Correlations to SPEs

- ✓ First report on mesospheric echo associated with Solar Proton Event
  - quasi simultaneous detection of **SPE** and **PMWE** (GOES and MST radar @ Esrange)

***Kirkwood et al.*, [2002]**



GOES satellite

MST radar

Model

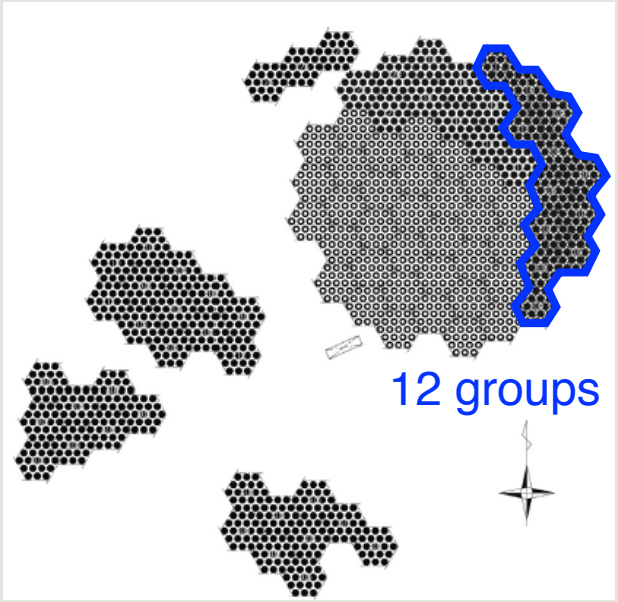
Riometer

Enhancement of electron density ($> 10^{10}$ m^{-3}) can be seen behind PMWE.

PMWE can be regarded as a proxy of ionization in the mesosphere due to SPE.

The PANSY radar

- ✓ However, observation of PMWE has been limited during period of SPEs
- ✓ PANSY (**P**rogram of the **AN**tarctic **SY**owa) [*Sato et al.*, 2014]
  - The largest MST radar in Antarctica
  - PMWE was identified for 110 days from March to September 2013, even during period without SPEs [*Nishiyama et al.*, 2015].
  - can be used as riometer in normal operation
- ✓ In this study, we used the data obtained from
  - March, 2015: the full-system operation by 55 antenna groups
  - June 2015: the 22% of the full-system.



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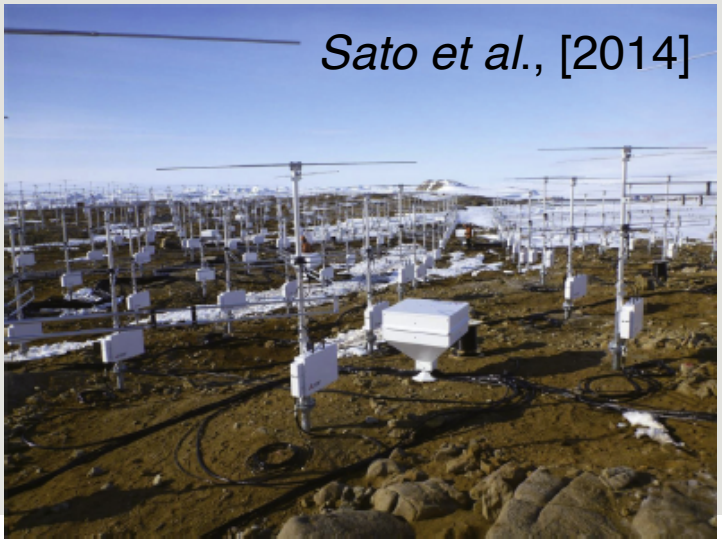
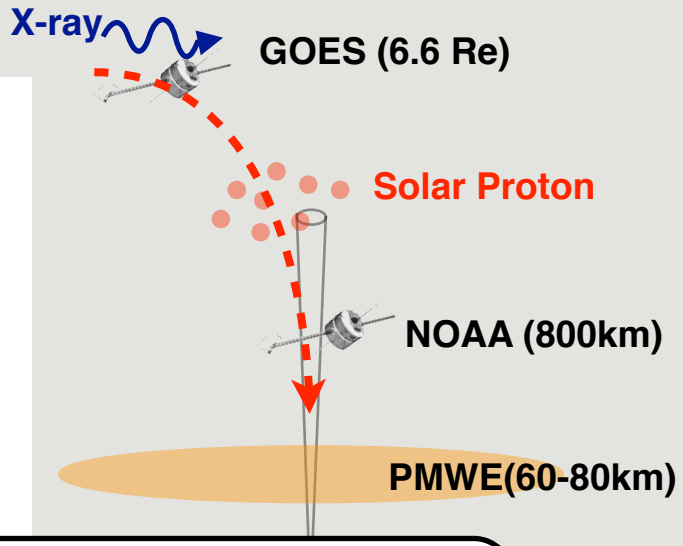


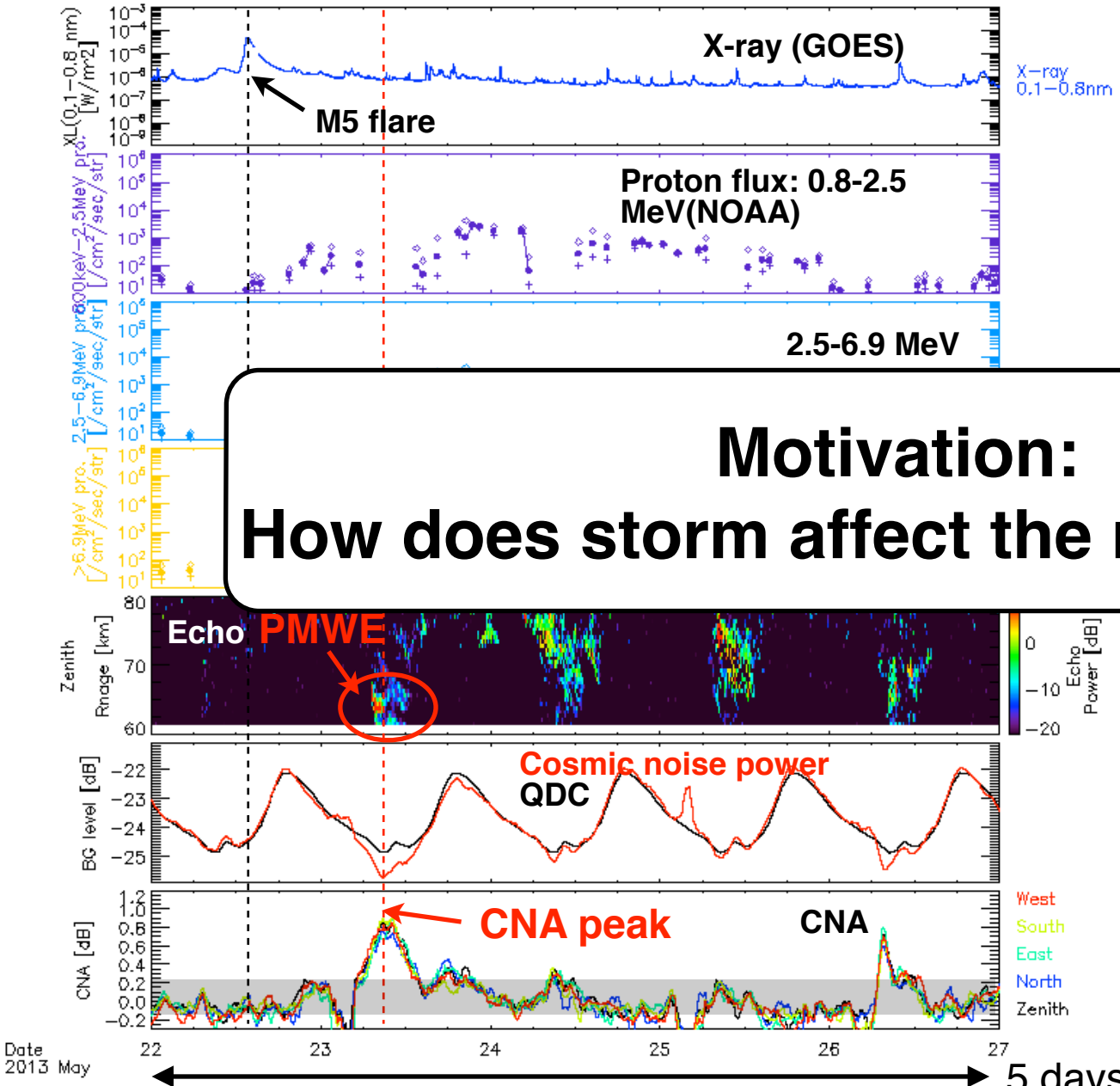
Table 1. Specification of PANSY radar

System	**Coherent Pulse Doppler Radar (Active phased array)**
Transmitted Frequency /	**47 MHz / 113 kW (full system 520 kW)**
Antenna aperture	**3,900 m² (full system 18,000 m²)**
Antenna	**228 (1045) Yagi-antennas with transmitter and receiver modules**
Receiver	**Multi-channel system composed of 12 (55) groups**

SPE: PMWE and CNA

✓ A case study during SPE on May 23, 2013





Motivation:
How does storm affect the mesosphere?

…n was …yowa.

=> Significant ionization in the lower mesosphere

Simultaneous observations of PMWE and CNA only using the PANSY radar

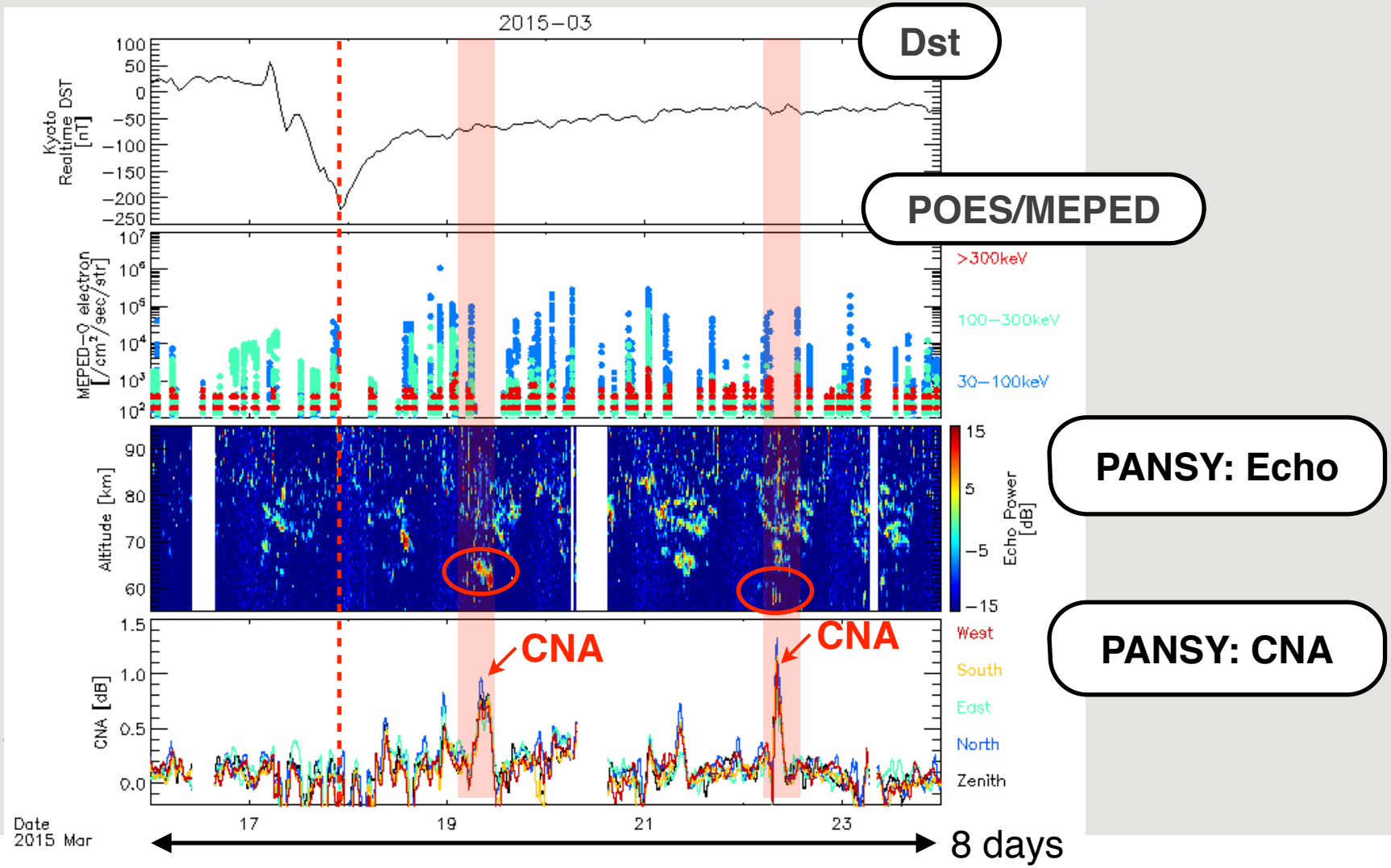
1) Sudden appearance of PMWE around 65 km

2) Strong absorption of cosmic noise (~0.8 dB)

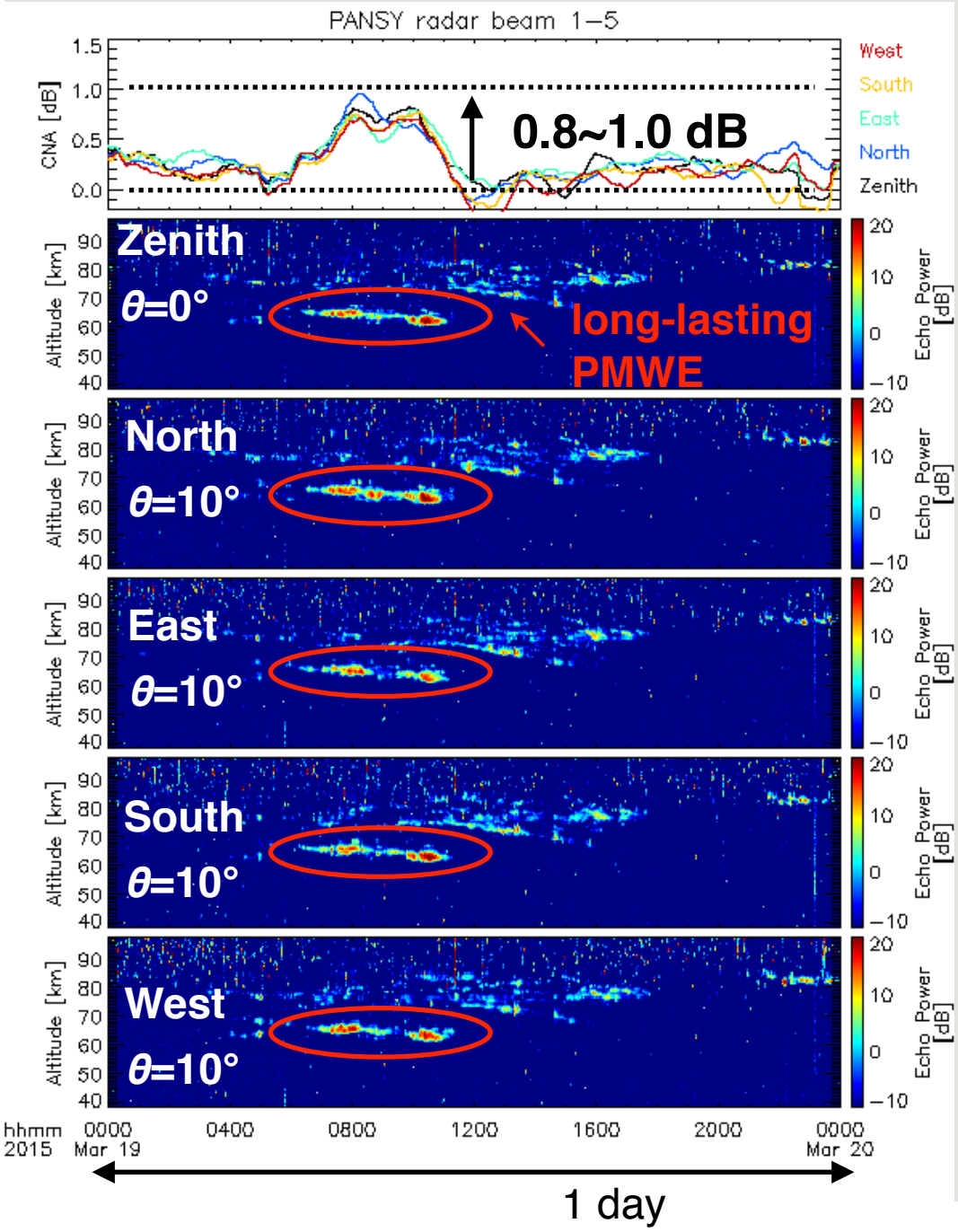
St. Patrick's Day Event

Overview

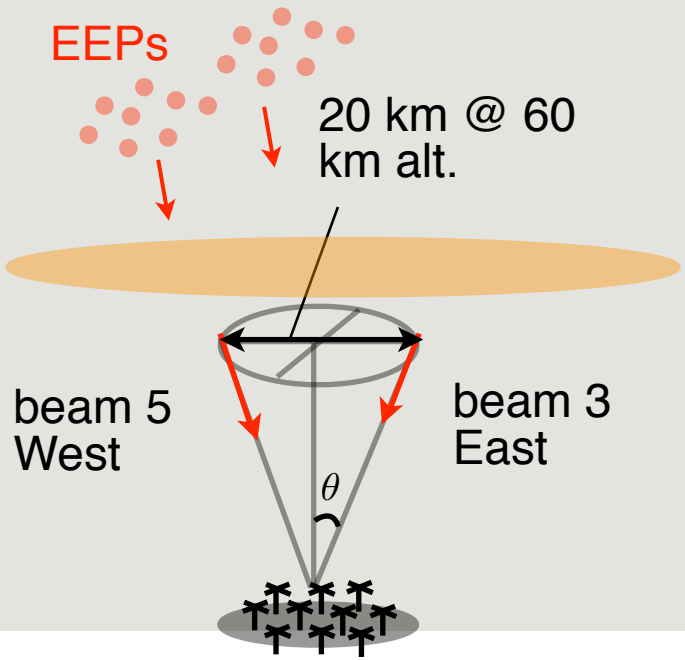
- ✓ During the period of the recovery phase
  - Increase in Energetic Electron Precipitations (EEPs) in the range of 30-300 keV were observed by POES/MEPES
  - Strong PMWE around 60 km altitude was accompanied by two enhancements of CNA.



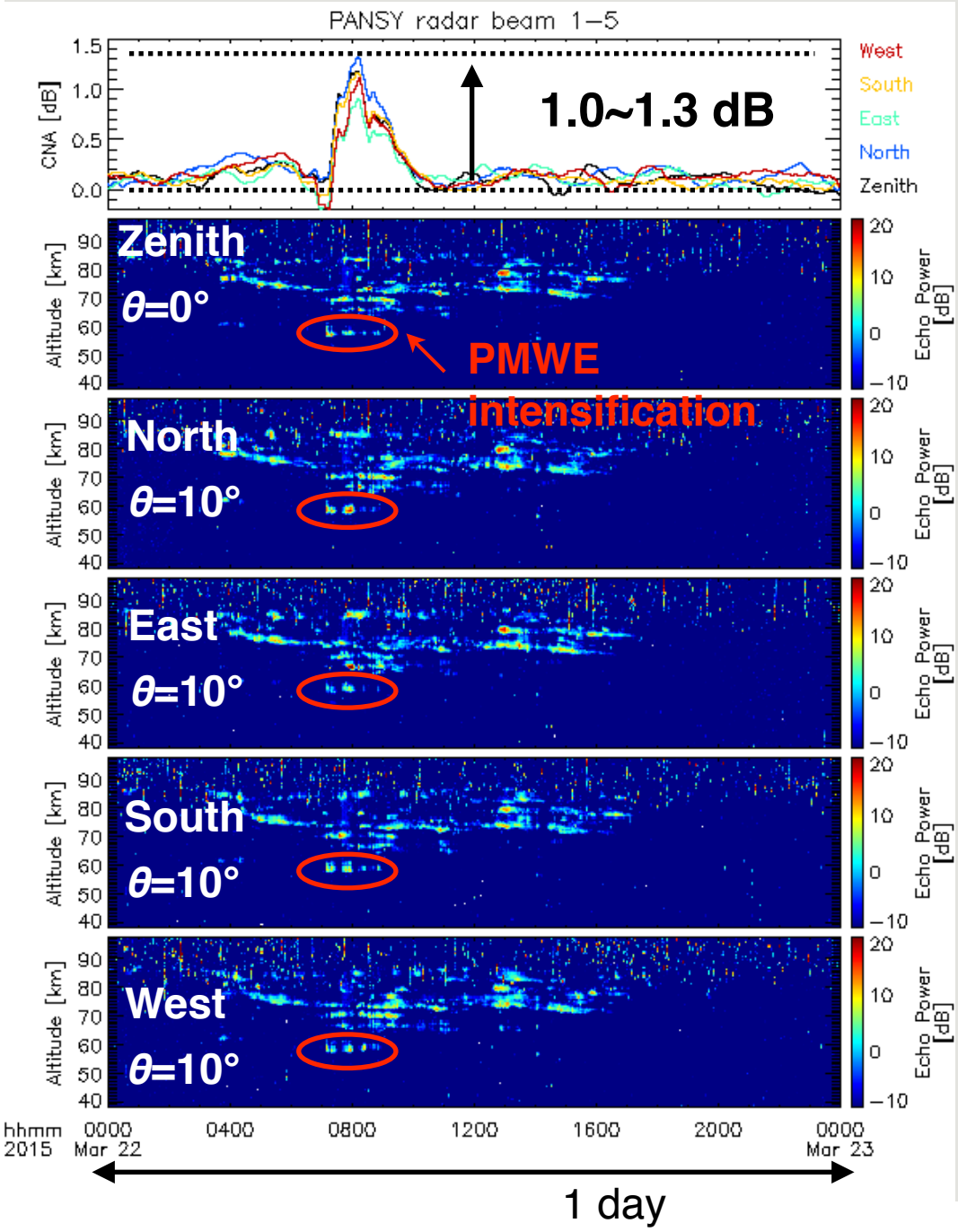
March 19, 2015



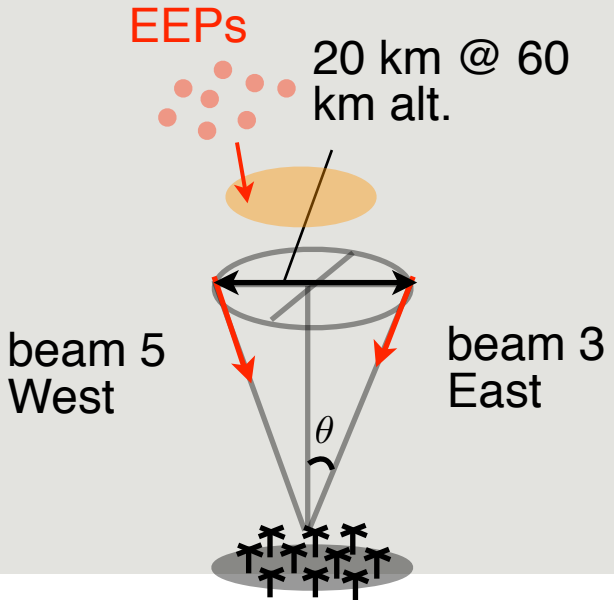
- ✓ March 19; Strong and long-lasting PMWE around 60 km altitude
  - with time duration about 5 hours
  - shows good correlations to temporal variations of CNA
- ✓ This result suggests strong ionizations occurred in wide area associated with continuous EEPs.



March 22, 2015



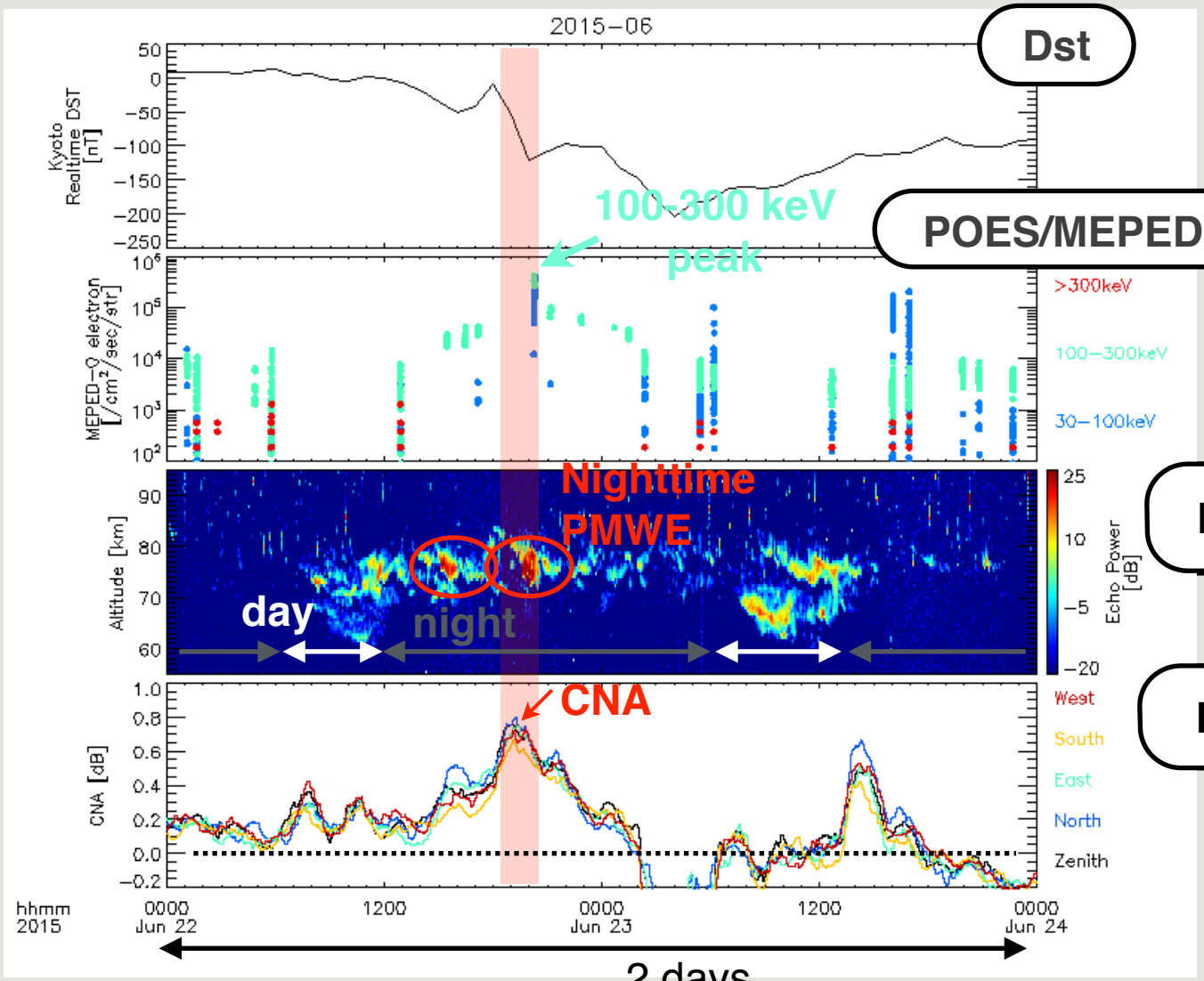
- ✓ March 22; Sporadic PMWE intensification below 60 km altitude
  - Backscattered echo power was relatively weak
  - It was accompanied by steep increase in CNA with larger amplitude
- ✓ This result may suggest that we observed temporal evolutions of ionizations in FOV associated with localized EEPs.



the Summer Solstice 2015 Event

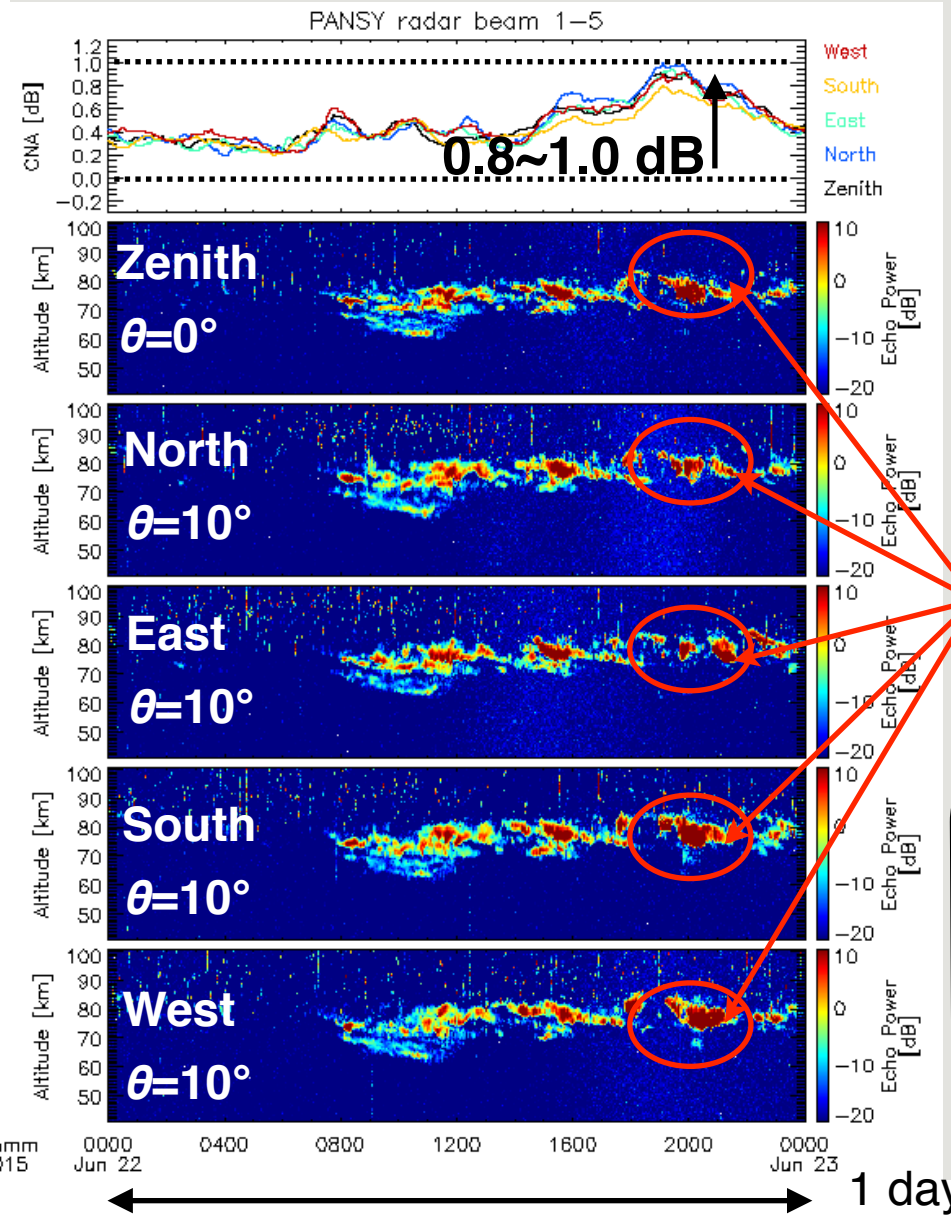
Overview

- ✓ During the period of the main phase
  - The peak EEP flux in 100-300 keV was observed.
  - At the same time, both “Nighttime PMWE” and CNA occurred.
- ✓
- –

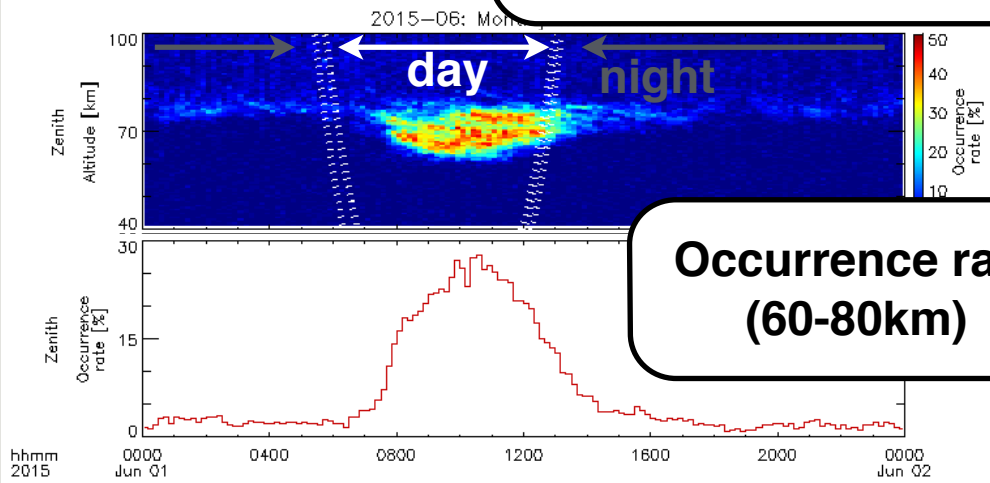


Nighttime PMWE

✓ Nighttime PMWE is less observed than daytime PMWE due to poor electron density in the mesosphere.



Monthly mean PMWE



Occurrence rate (60-80km)

Nighttime PMWE around 23 LT (20 UT)

EEP in 100-300 keV caused strong ionization around 70-80 km even in local midnight.

(production due to EEPs > loss due to recombination)

But, we must take SPE effect into account.

Summary

- ✓ We presented simultaneous PMWE and CNA observation during the two storms in order to demonstrate EPP impacts on the mesosphere.
- ✓ During recovery phase of St. Patrick's Day event,
  - March 19; Strong and long-lived PMWE around 60 km altitude with time duration about 5 hours.
  - March 22; Sporadic PMWE intensification below 60 km altitude accompanied by larger CNA than March 19.
- ✓ During main phase of the Summer Solstice 2015 event,
  - June 22; Strong "Nighttime PMWE", which implies unusual ionization in the mesosphere due to EEP, was observed at 70-80 km altitude.
- ✓ The differences of PMWE characteristics (duration, altitude, LT) among each event should be related to those of storms (magnitude, transport and loss process).

- ✓ Future works
  - We have to estimate electron density profile corresponding to each event using model to discuss about EPP impacts more quantitatively.