Doing Space Weather

by using ground-based optical instruments in the polar region

Keisuke Hosokawa
University of Electro-Communications, Tokyo

in collaboration with

Kazuo Shiokawa and Yuichi Otsuka
Solar-terrestrial Environment Laboratory, Nagoya University, Nagoya

Yasunobu Ogawa
National Institute of Polar Research, Tokyo

Takuya Tsugawa
National Institute of Information and Communications Technology, Tokyo

True-colour all-sky auroral images from Tromsø, Norway
“Space weather” and “polar ionosphere”
What is the SW impact of ionosphere?

Satellite communication environment is dependent on the status of the ionosphere.

Occurrence of ionospheric scintillation

GNSS (Global Navigation Satellite System)

Pos. error

Total Electron Content (TECU = 10^{16} m^{-2})

Delay in Range (m)

Delay Time (10^{-9} sec)

1.0

10.0

100.0

0.1

1.0

10.0

0.33

3.3

1

10

100

Ionosphere

Electron density enhancement

Plasma irregularities

Ionospheric scintillation

Positioning error

Kintner, 2008
Optical observations in the polar region

- Tromsø (MLAT ~69°)
- Resolute Bay (MLAT ~83°)
- Auroral oval
A magnetic storm on Dec 15, 2006

- X class flare and **CME** on Dec 13, 2006
- Shock arrived at ACE on Dec 14, 2006
- Increased magnetic field ~20 nT
- Increased solar wind density and speed
- Large magnetic storm (min $D_{st}$ -146 nT)
TEC enhancements in the polar cap

Resolute Bay
MLAT ~ 83°

TEC data from Resolute Bay

10-20 TECU enhancements

December 15, 2006
Dense plasma stream in the polar cap

OL 630.0 nm  0324 37s UT

TEC data from Resolute Bay

10-20 TECU enhancements

18MLT  24MLT

Abs Value

sun
dusk
Dense plasma stream in the polar cap

Hosokawa et al., 2009, 2010
Optical observations in the polar region

10-20 TECU enhancements

TEC data from Resolute Bay
Scintillation in the auroral region

![Graph showing Dst index and scintillation indices over January 2012.](image)

- **Amplitude Scintillation: S₄ index**
- **Phase Scintillation: σφ index**

Jan 22, 2012
○ : direction of GPS satellites

The size of ○ indicates the magnitude of $\sigma_\phi$

5 hours of all-sky images during a magnetic storm on January 22, 2012
Ionospheric scintillation vs aurora display

Almost one-to-one correspondence between scintillations and auroral appearance
Summary

Space weather impacts of the ionosphere on the GNSS systems during storms:

1. Polar cap region: dense plasma plume induces positioning errors
2. Auroral region: aurora causes scintillation of the navigation signals

Ground-based optical instruments help us to better understand these impacts.