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Spatial distribution of the polar thermospheric wind acceleration and importance of the 2D measurement

Shin-ichiro Oyama

ISEE, Nagoya U., Japan

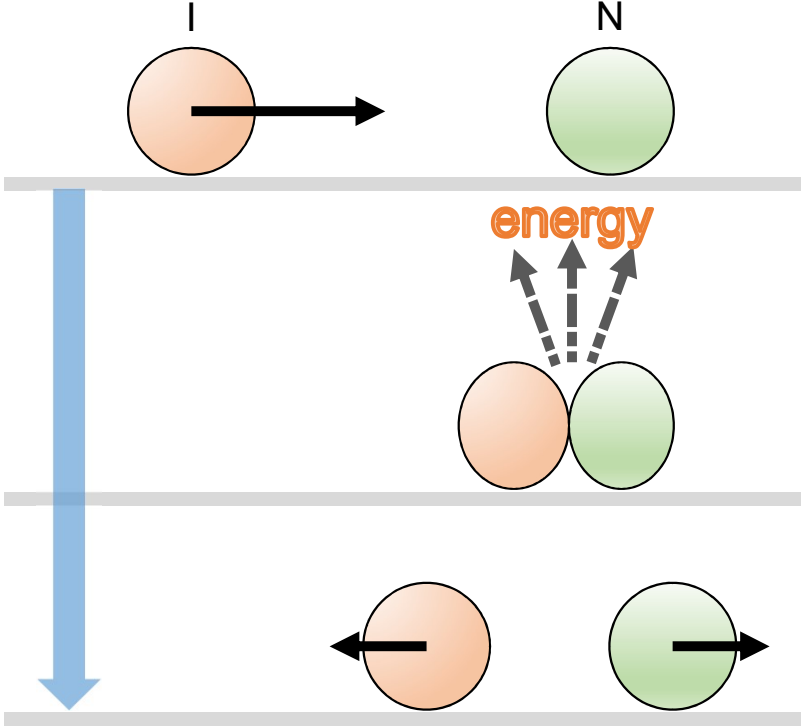
U. Oulu, Finland

NIPR, Japan

VERY LOW
IONIZATION RATE

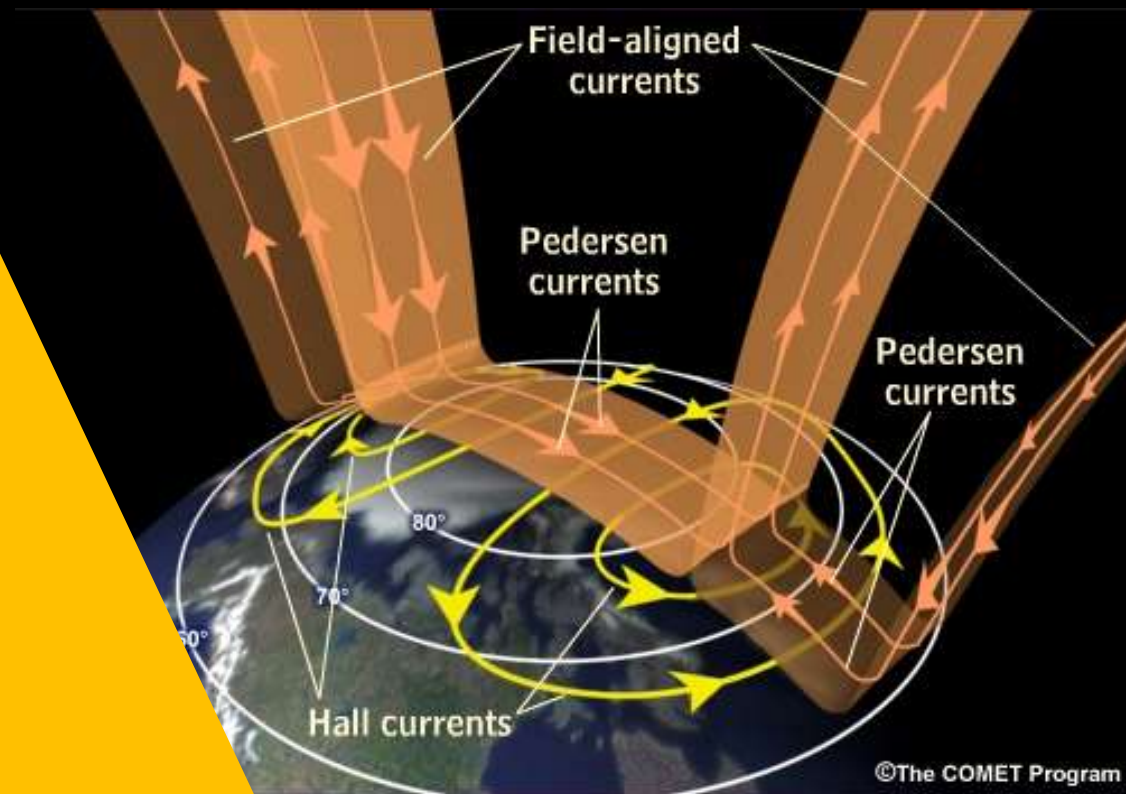


particle COLLISIONS
between NEUTRALS
and IONS



ENERGY CONVERSION

Ionospheric plasma kinetic energy is converted to kinetic energy of the thermospheric neutrals (**ion drag**) and thermal energy of the neutrals (**Joule heating**).



Measurement of the ionosphere and the thermosphere is essentially important.

$$m_i n_i v_{in} (\mathbf{V} - \mathbf{U})$$

momentum transfer rate per unit volume from ions to neutrals

$$\frac{m_i}{3k_B} (\mathbf{V} - \mathbf{U})^2$$

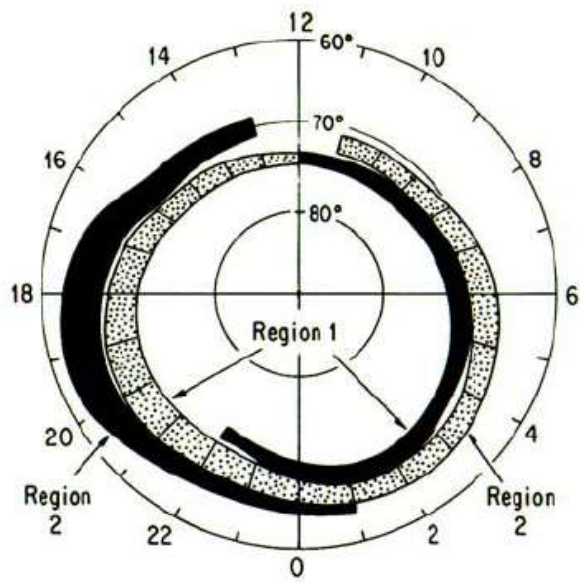
Ion temperature increase by friction between ions and neutrals



Photo: Thomas Ulich

Global Pattern

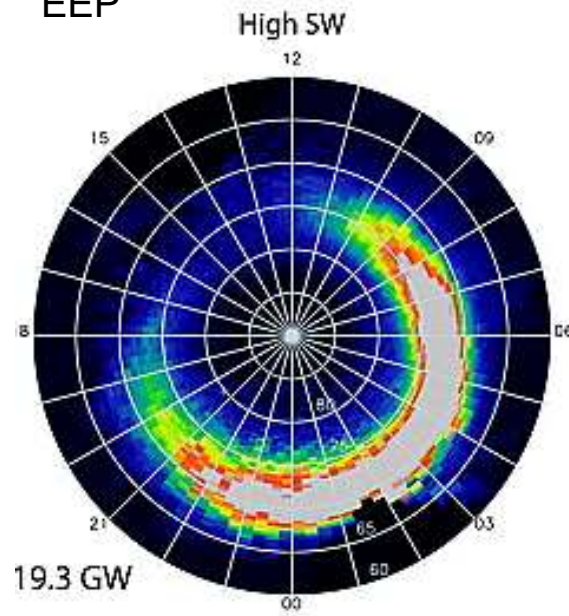
FAC



- Current into ionosphere
- Current away from ionosphere

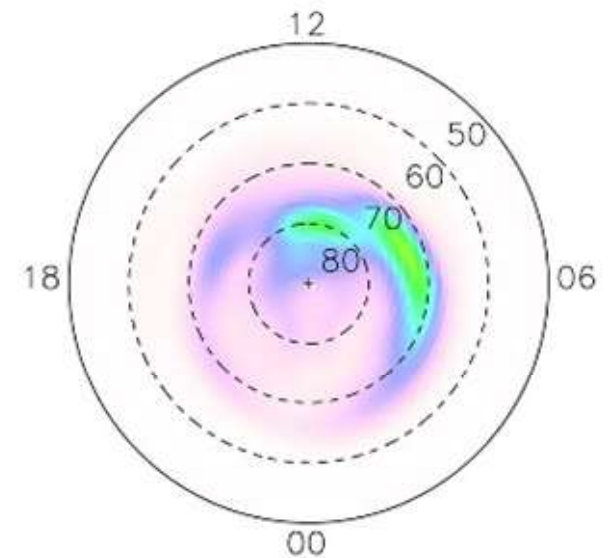
Iijima and Potemura, JGR, 1976

EEP



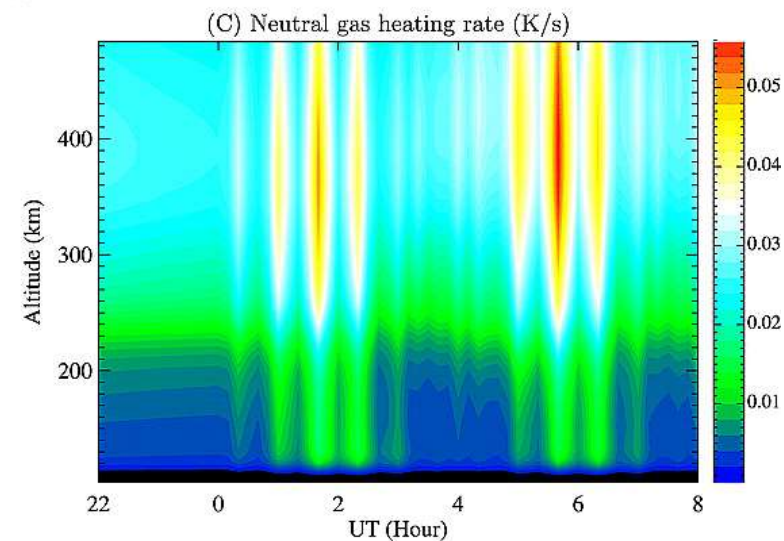
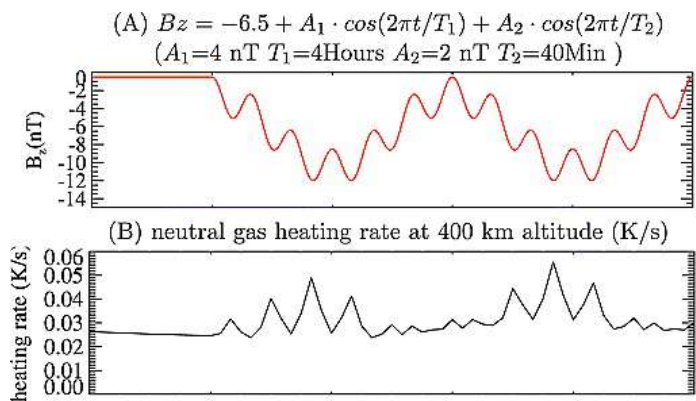
Newell+, JGR, 2010

Qj



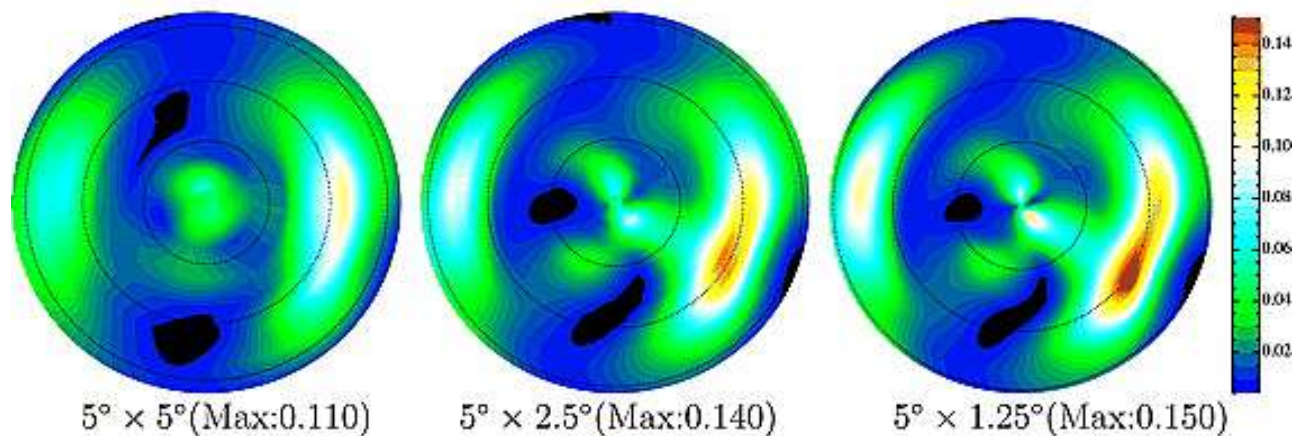
Billet+, JGR, 2018

Scale Coupling: Ionosphere

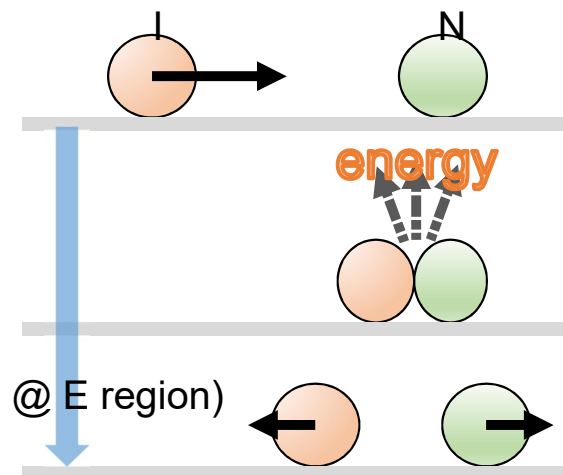


Deng & Ridley, JGR, 2007

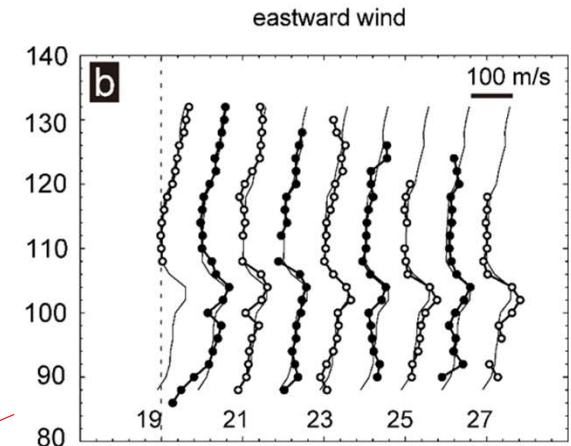
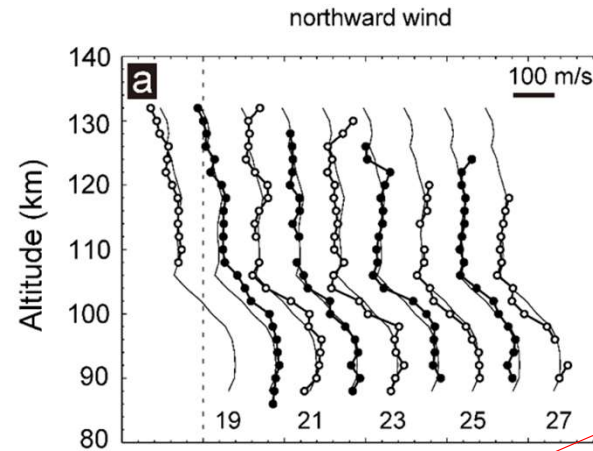
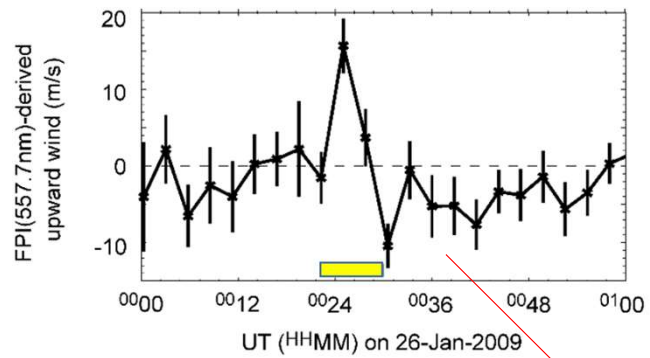
Neutral gas heating rate with different spatial resolution (K/s)



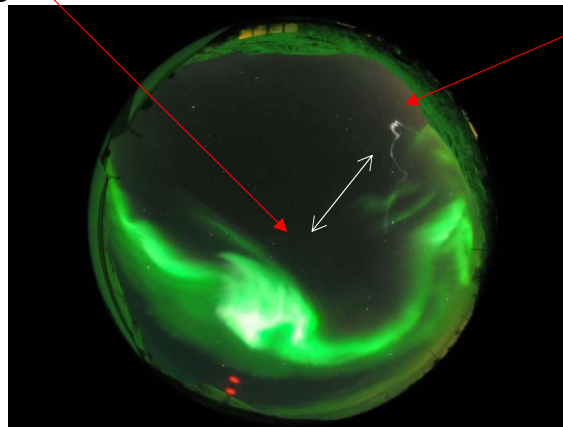
- Codrescu+, GRL, 1995
- Crowley & Hackert, GRL, 2001
- Matsuo+, JGR, 2003
- Oyama+, AnGeo, 2010 (10 Hz \rightarrow Ti @ E region)



Fine structures in the thermosphere



FPI@Tromsø



TMA

~170 km apart

Oyama+, JGR, 2017

Q: What does the thermospheric response look like relative to aurora?

Measurements

Allsky camera

- ✓ Longyearbyen (NIPR)
- ✓ Tromsø (ISEE, NIPR)

Magnetometer

- ✓ IMAGE chain
- ✓ Local AL index (IL) was calculated separating region into the 3 parts (T1-3)

FPI

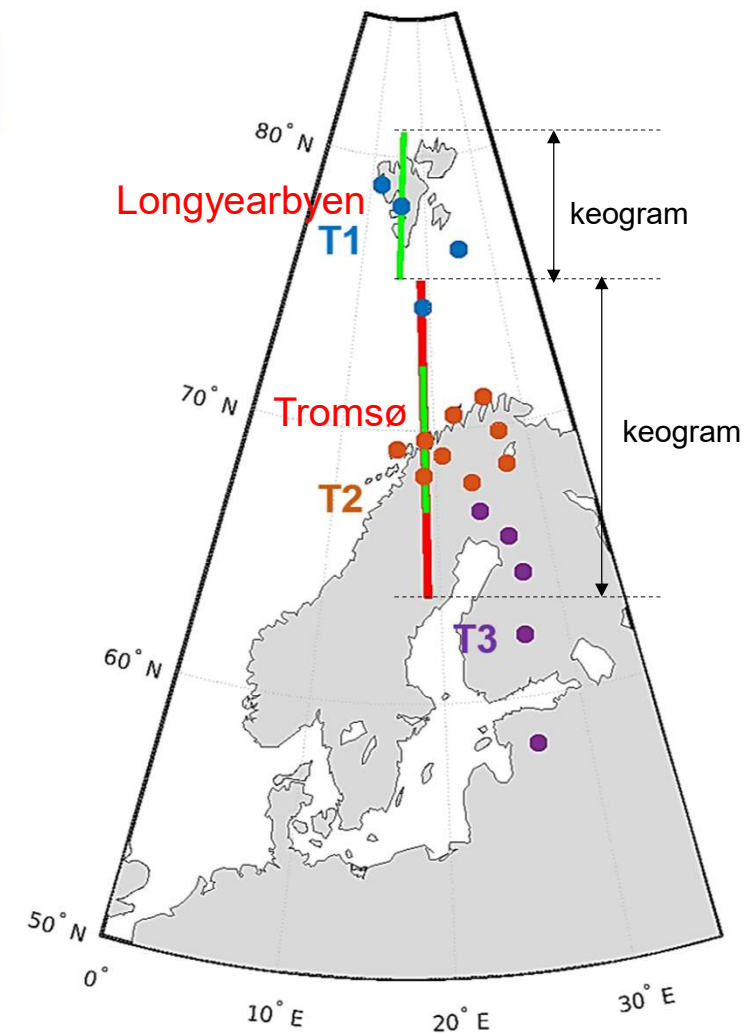
- ✓ Tromsø, 630 nm

Geomagnetic activity

- ✓ focus on very quiet periods
- ✓ most of the time, $k_p = 0-1$, sometimes 2, at most 3.

Event

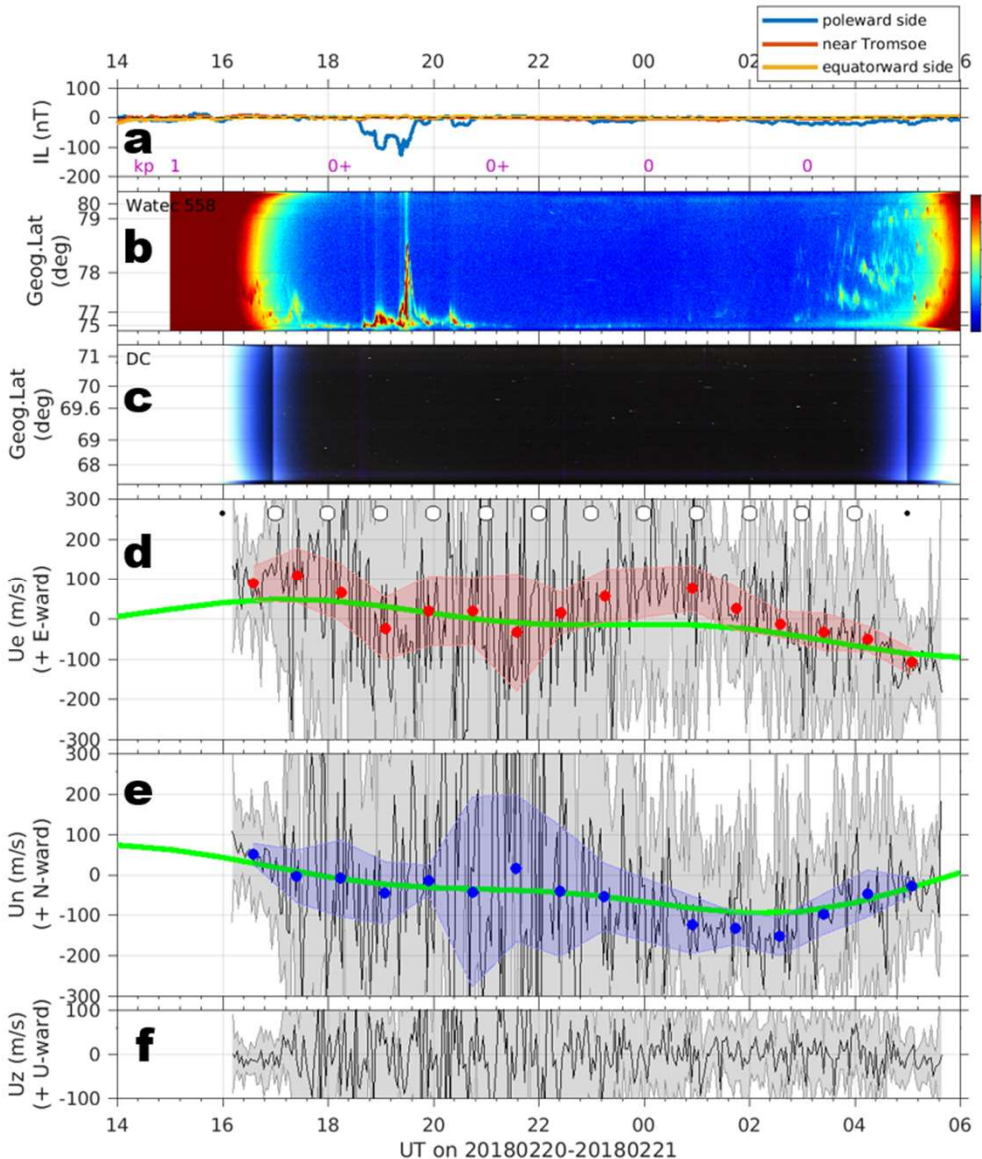
- ✓ 6 events in total; but present a part
- ✓ 2018/02/11-12: quietest night --> baseline of the wind





Very quiet condition but some aurorae at north of Tromsø by ~500 km away.

FPI (630 nm) wind was accelerated westward soon after appearance of the aurora in the evening or in the dusk ionospheric convection cell.



IL index

keogram at Longyearbyen

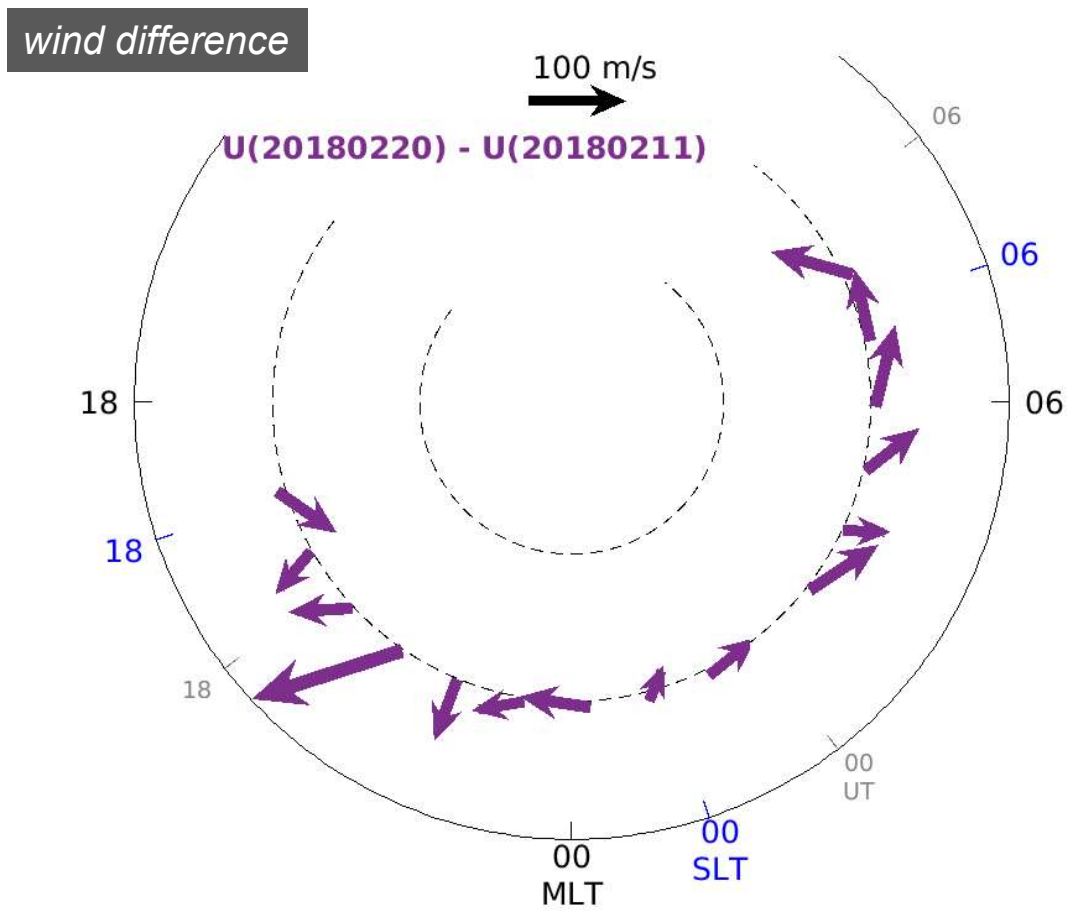
keogram at Tromsø

FPI (630nm) zonal wind
black: original
dot: 50 min integration
green: HWM14

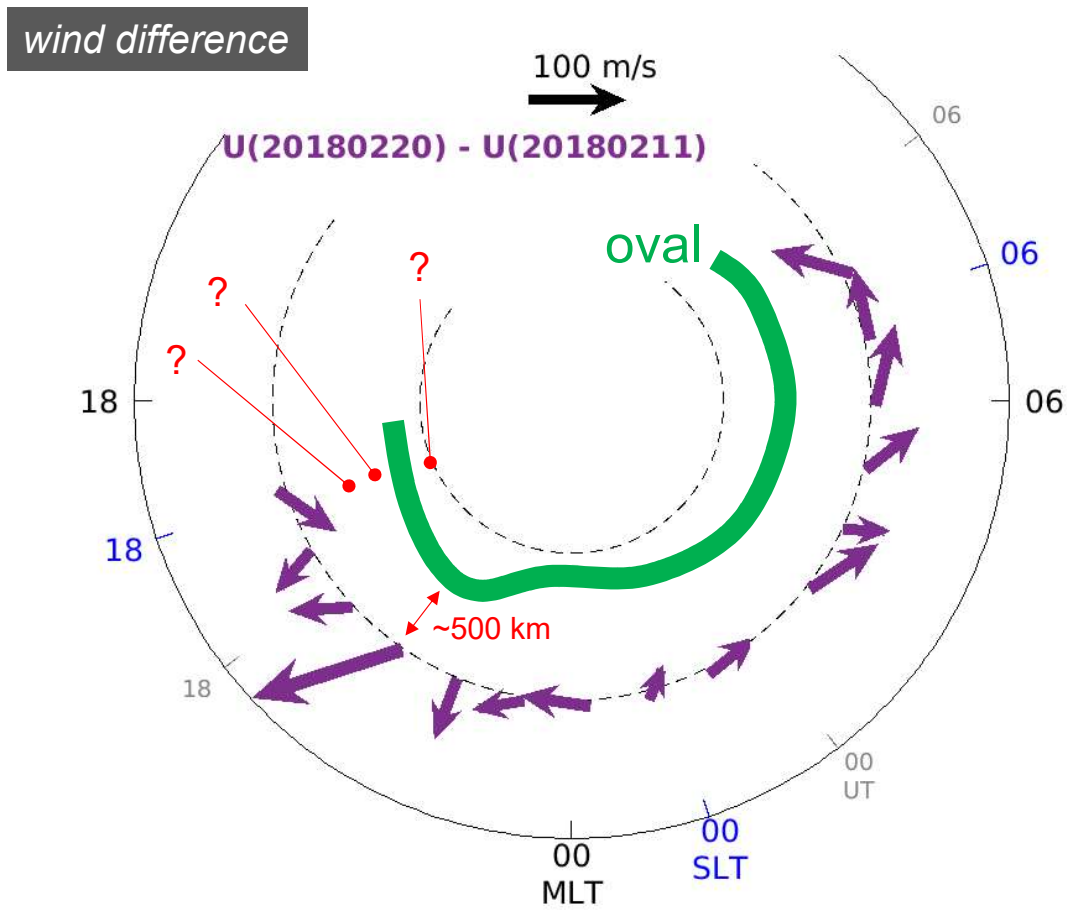
FPI (630nm) meridional wind
black: original
dot: 50 min integration
green: HWM14

FPI (630nm) vertical wind

Winds in the thermosphere



Winds in the thermosphere

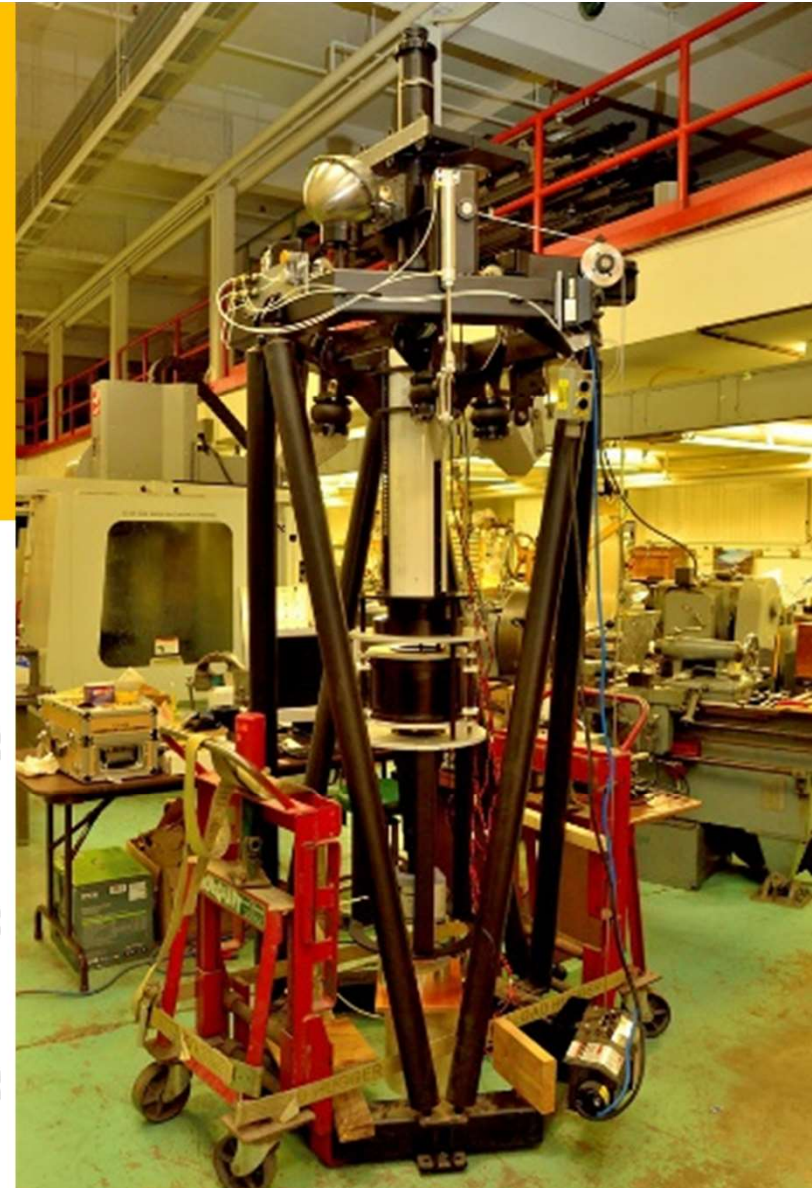
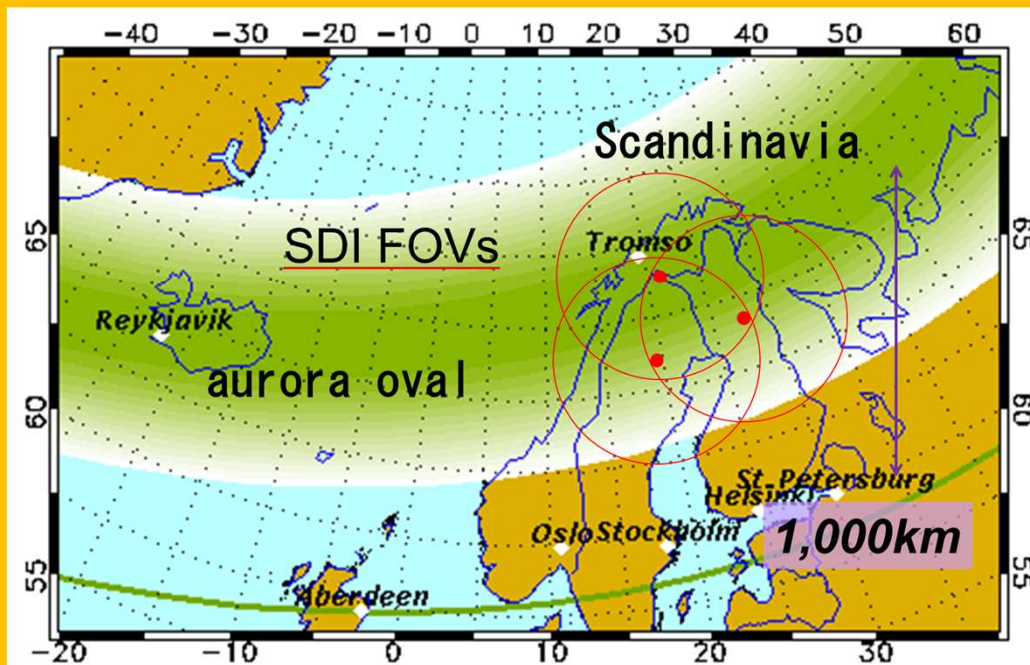


SDI

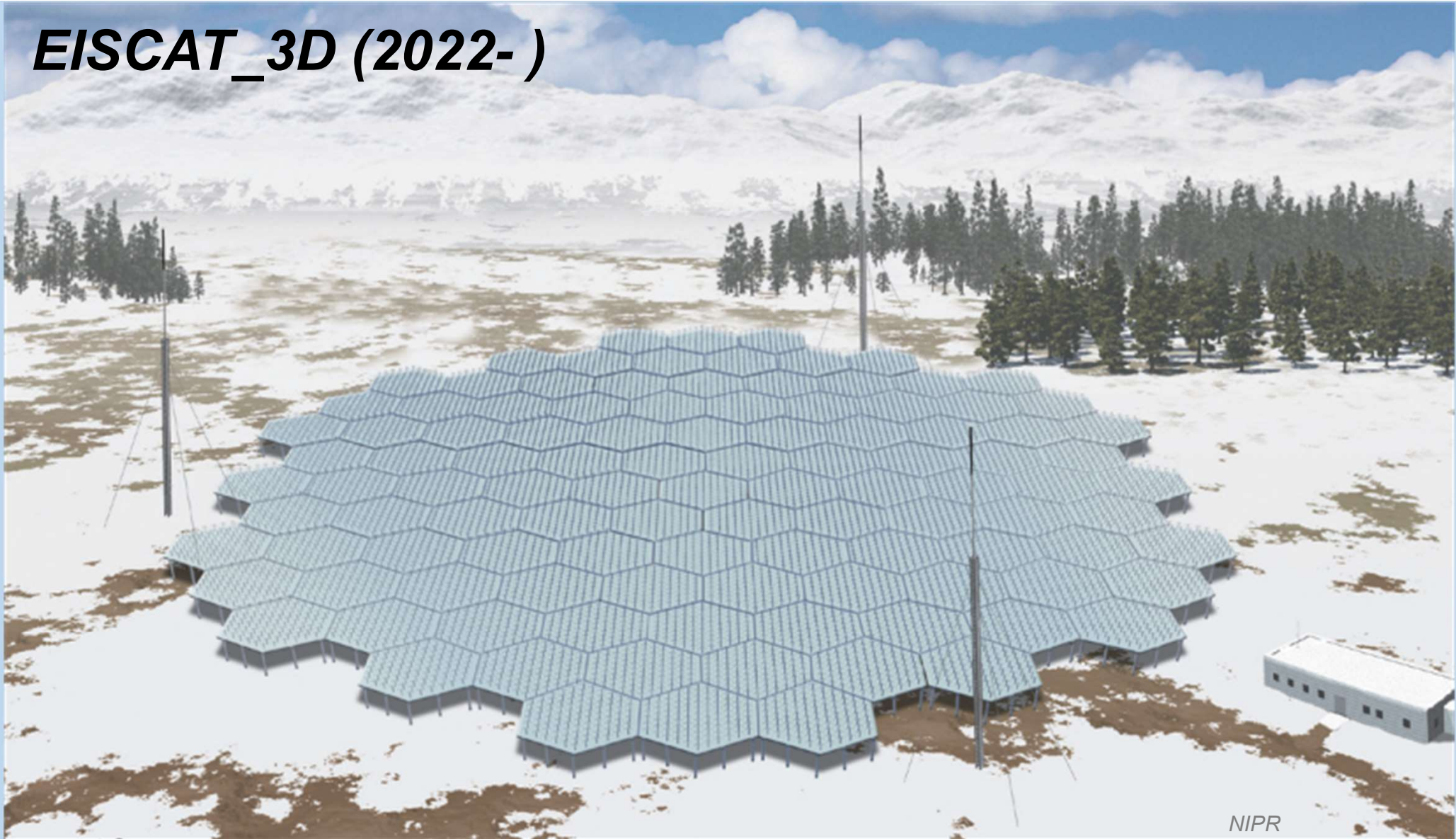
Scanning Doppler Imager is a ground-based Fabry-Perot Doppler spectrometer, operating in an all-sky imaging mode with a separation scanned etalon to resolve Doppler spectra.

SDI observes 630nm, 558nm and OH nightglow and auroral emissions in the upper (~240 km) and lower (90-150 km) thermosphere and mesosphere (~90 km), respectively.

Combining multiple SDIs, we can obtain the 2D map of the three-component wind vector and the temperature

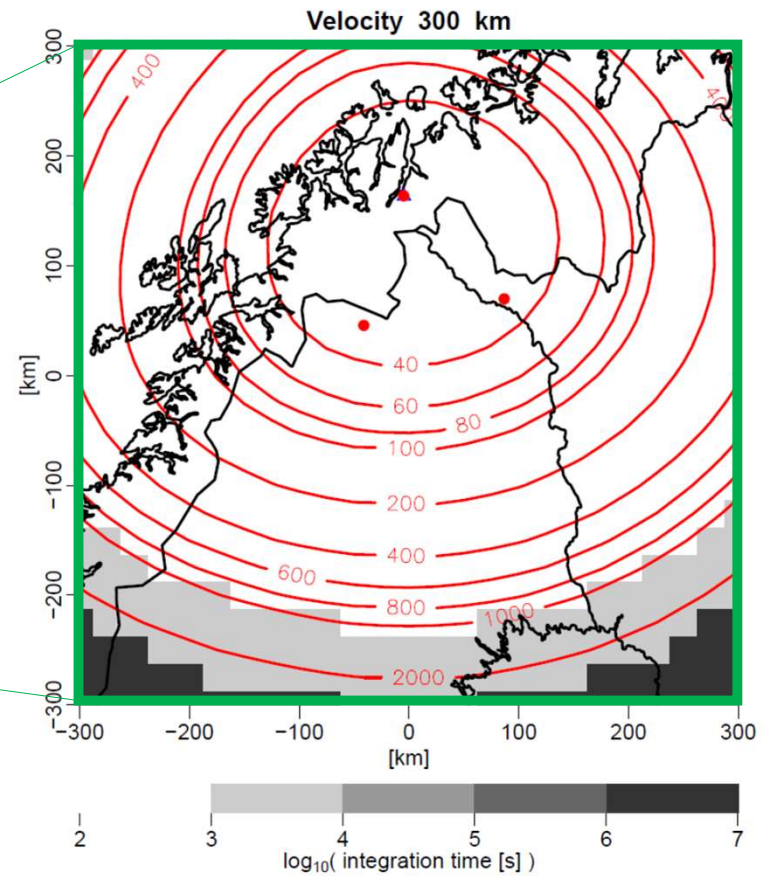
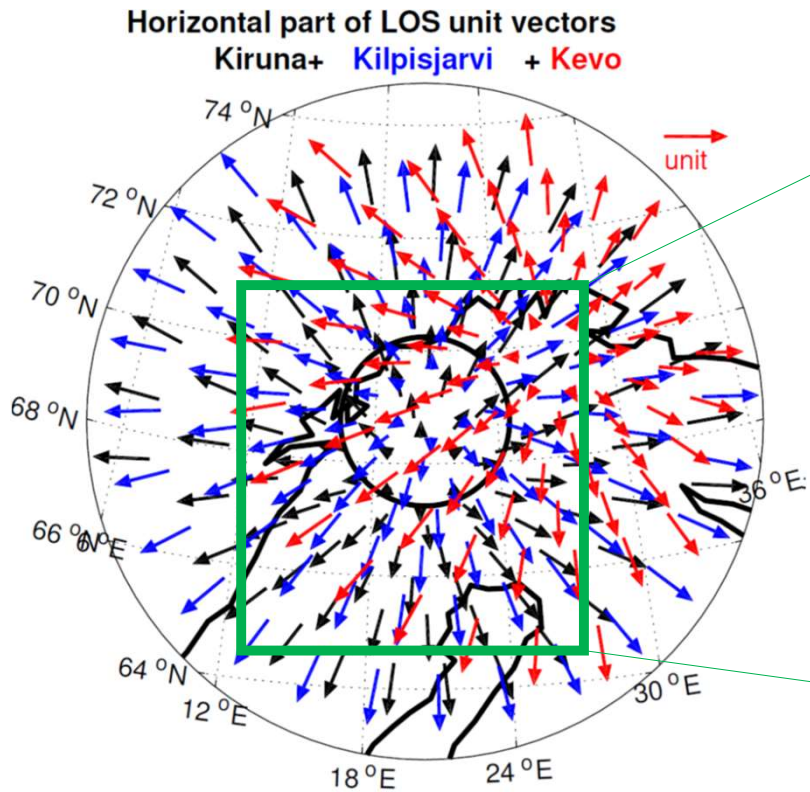


EISCAT_3D (2022-)



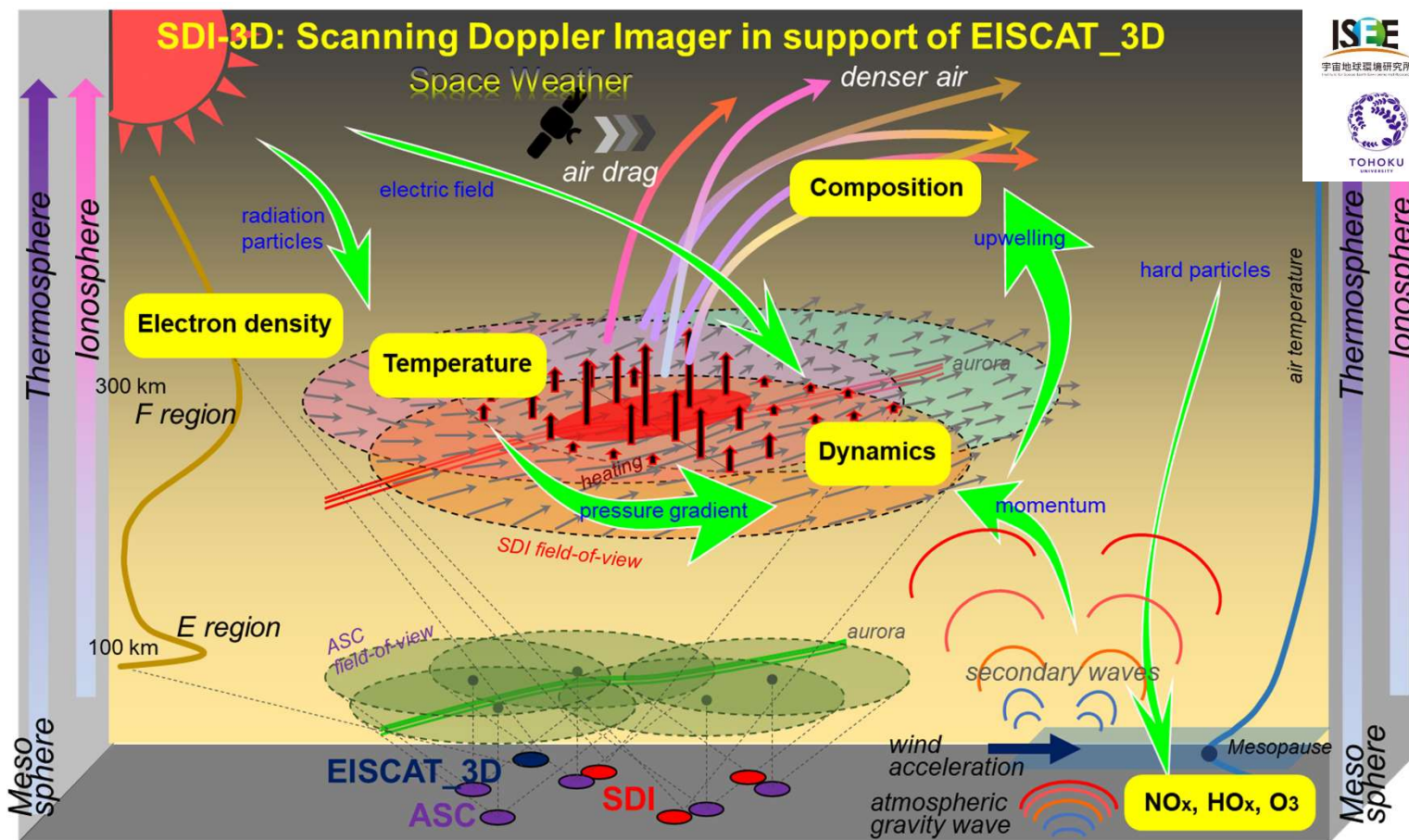
NIPR

FOV of 3 SDIs + EISCAT_3D



SDI-3D project

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by Shin-ichiro Oyama