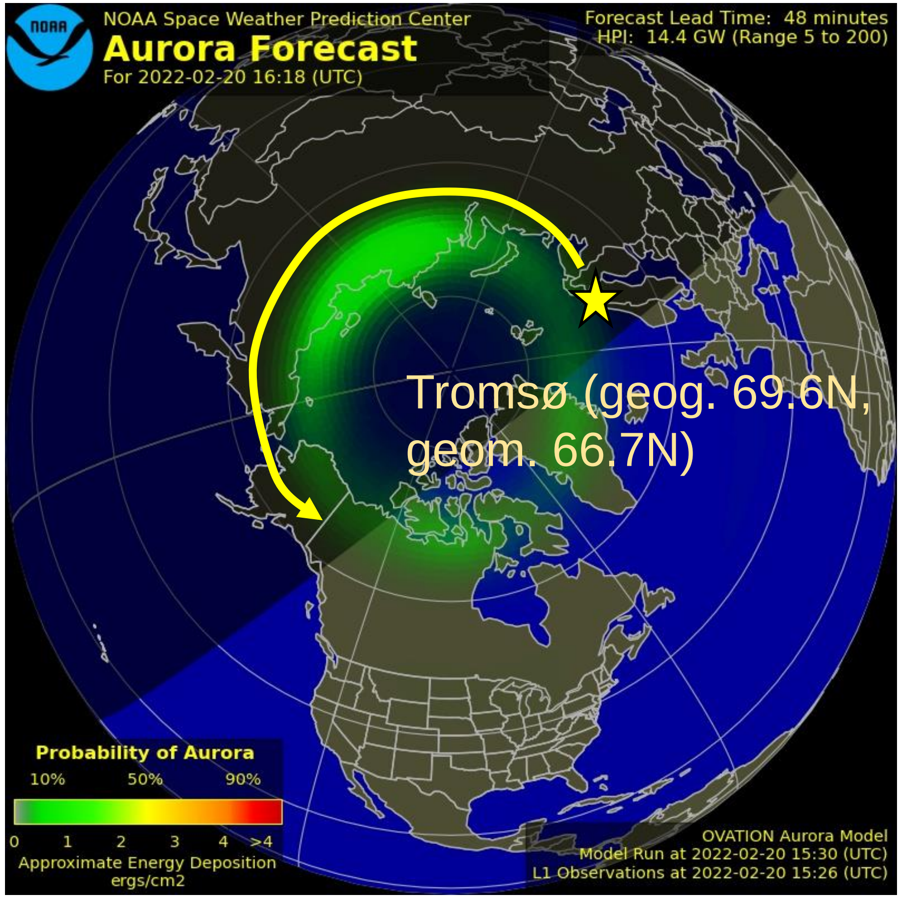
地磁気静穏時のサブオーロラ帯における熱圏風加速

Thermospheric wind acceleration in the subauroral region during quiet periods



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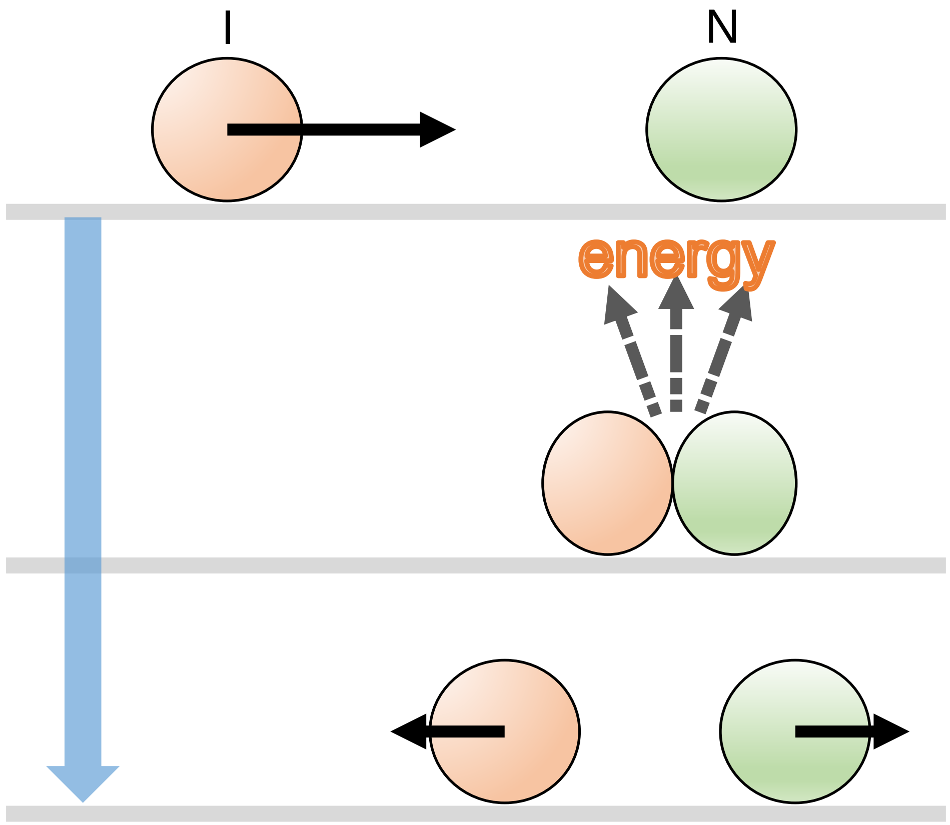
Ionosphere

VERY LOW IONIZATION RATE

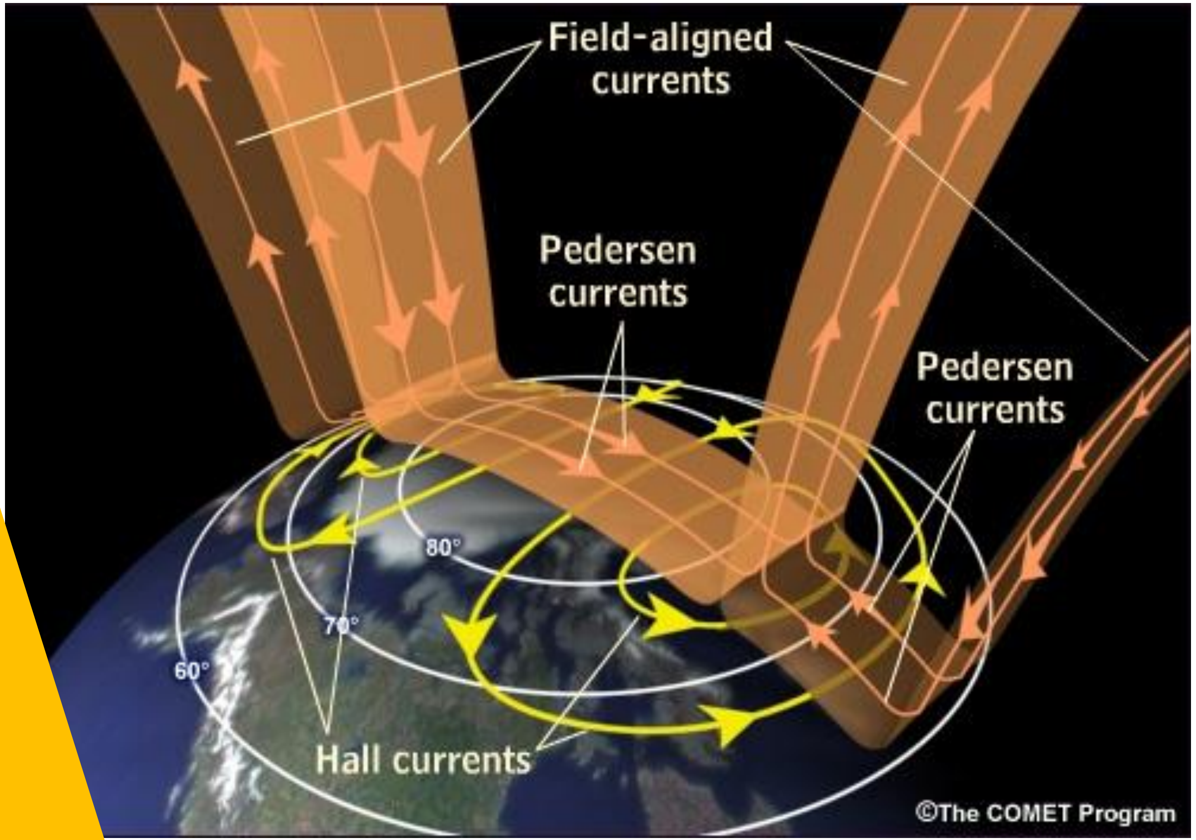
Particle collisions

particle COLLISIONS
between NEUTRALS
and IONS



Ion drag & Joule heating

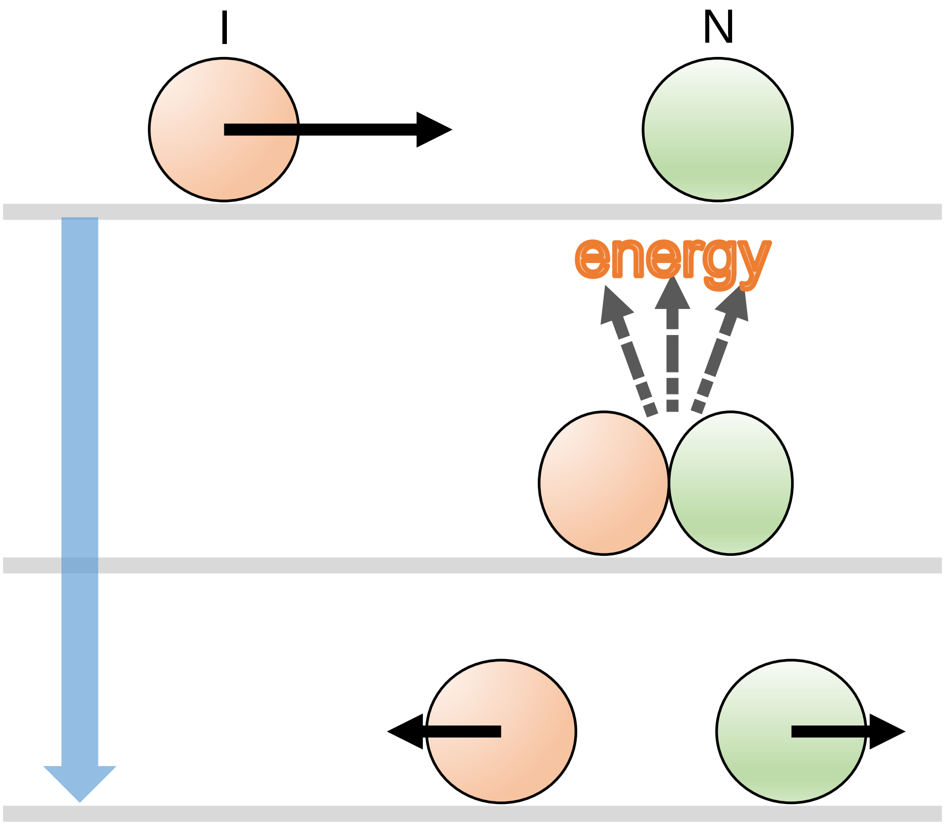
ENERGY CONVERSION



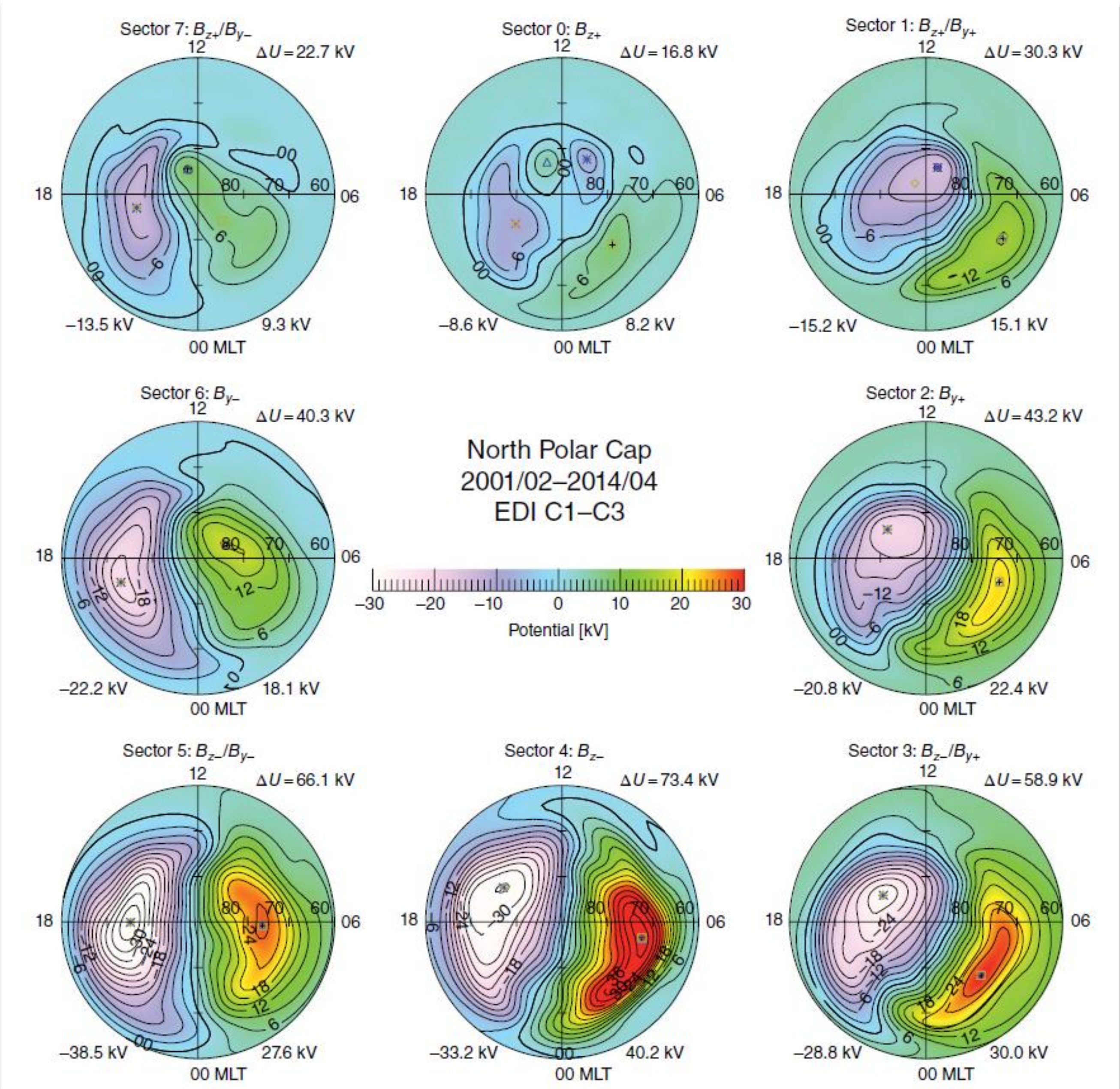
Ionospheric plasma kinetic energy is converted to kinetic energy of the thermospheric neutrals (ion drag) and thermal energy of the neutrals (Joule heating).

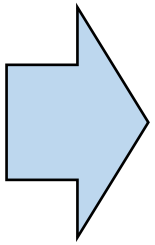
Particle collision is important

particle COLLISIONS between NEUTRALS and IONS



Ionospheric convection





Thermospheric wind

Förster+, AGU Monograph 2017

high-lat thermospheric wind : dusk/dawn cell structure

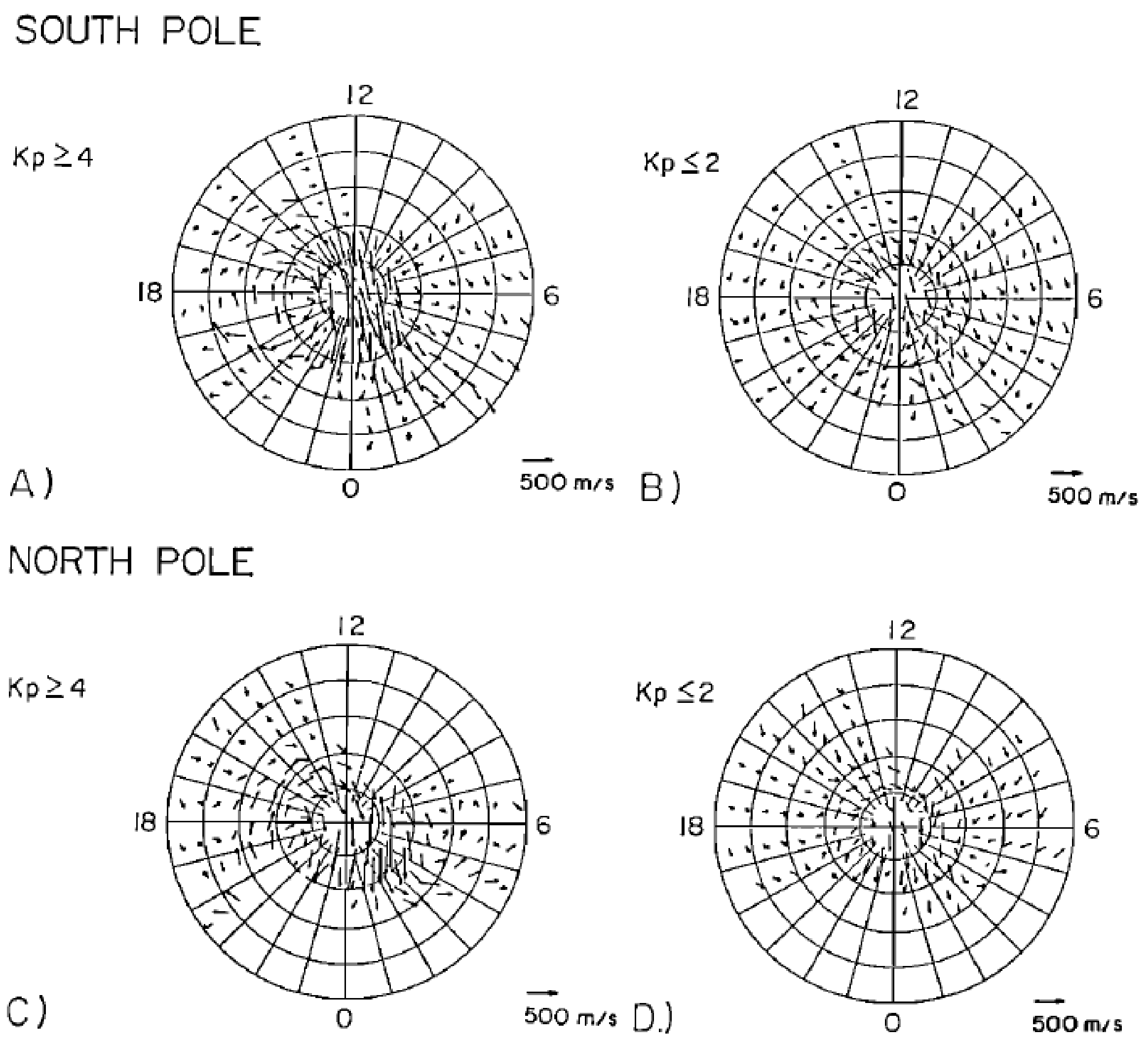


Fig. 1. Mean vector wind field for six months of neutral wind data (November 1981 through January 1982 and November 1982 through January 1983) from the DE 2 spacecraft plotted in geomagnetic latitude and magnetic local time. (*a*) Southern hemisphere mean vector wind field for conditions of $Kp \geq 4$. (*b*) Southern hemisphere mean vector wind field for conditions of $Kp \leq 2$. (*c*) Northern hemisphere mean vector wind field for conditions of $Kp \geq 4$. (*d*) Northern hemisphere mean vector wind field for conditions of $Kp \leq 2$. The outer circle is at $\pm 40°$, depending on the hemisphere.

McCormac+ JGR 1987

DE 2 wind statistical analysis
NH in winter, SH in summer
(1981/Nov-1982/Jan & 1982/Nov-1983/Jan)

SH: dusk cell alone for both Kp
NH: dusk is always dominant

similar results from South Pole FPI
Hernandez+ GRL 1990

"The influence of the dawn cell of ion convection on the neutral circulation is usually less apparent and sunward neutral velocities in the morning auroral zone are generally smaller in magnitude than those in the evening sector."

McCormac, GRL, 1985

Effect of Coriolis force

high-lat thermospheric wind

IMF By dependency of the wind

peak polar-cap wind at dusk/dawn side for negative/positive By

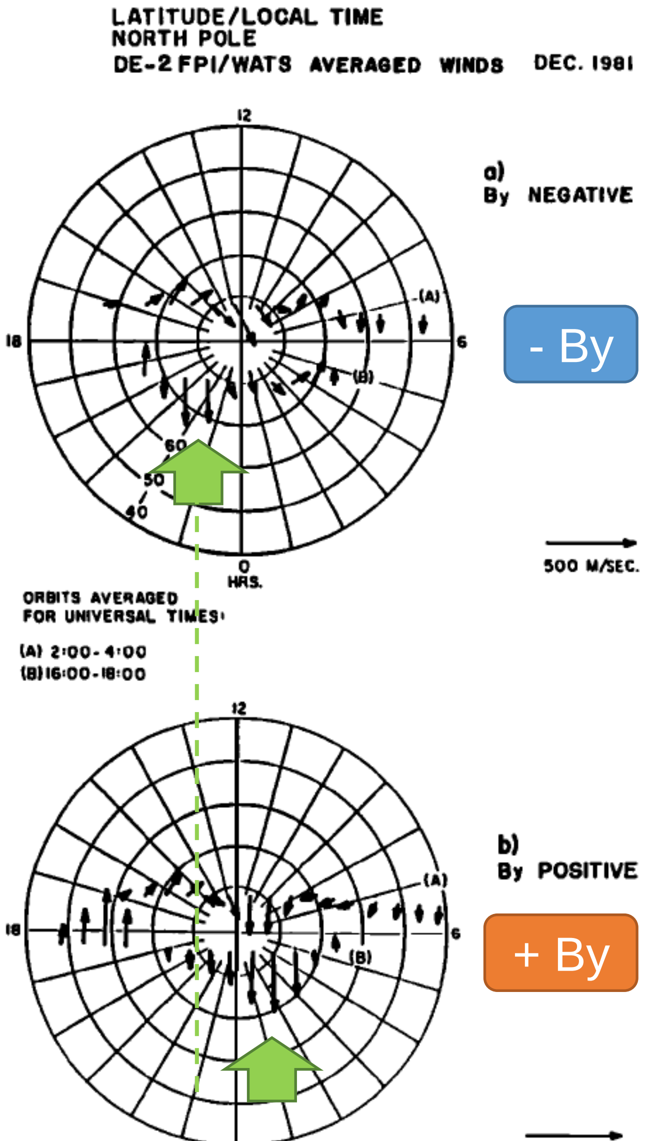


Fig. 1. Average neutral wind vectors for December 1981 plotted in geomagnetic polar coordinates (magnetic latitude and local time) obtained for the specified UT intervals with a) B_y negative and b) B_y positive.

McCormac+ GRL, 1985

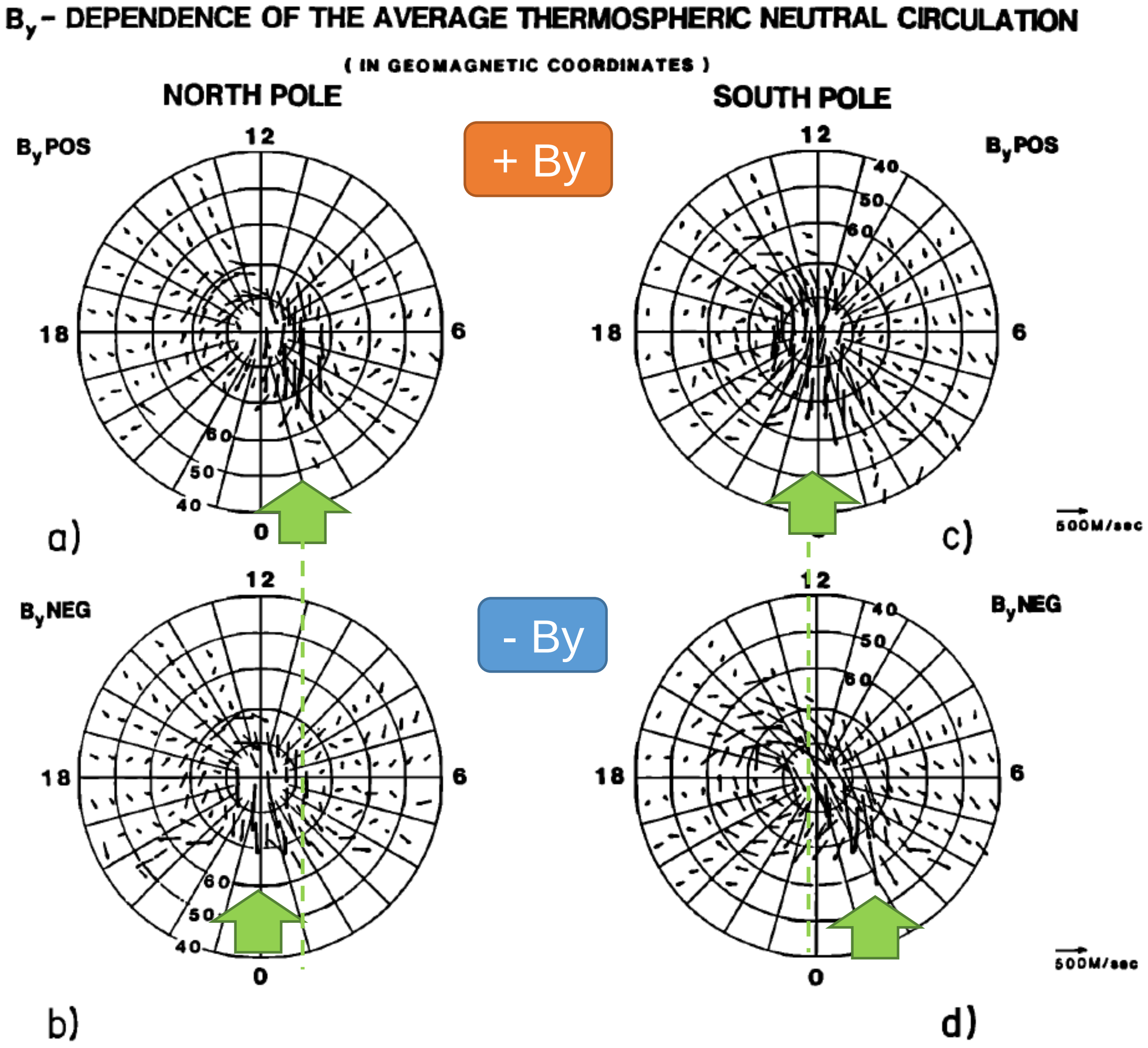
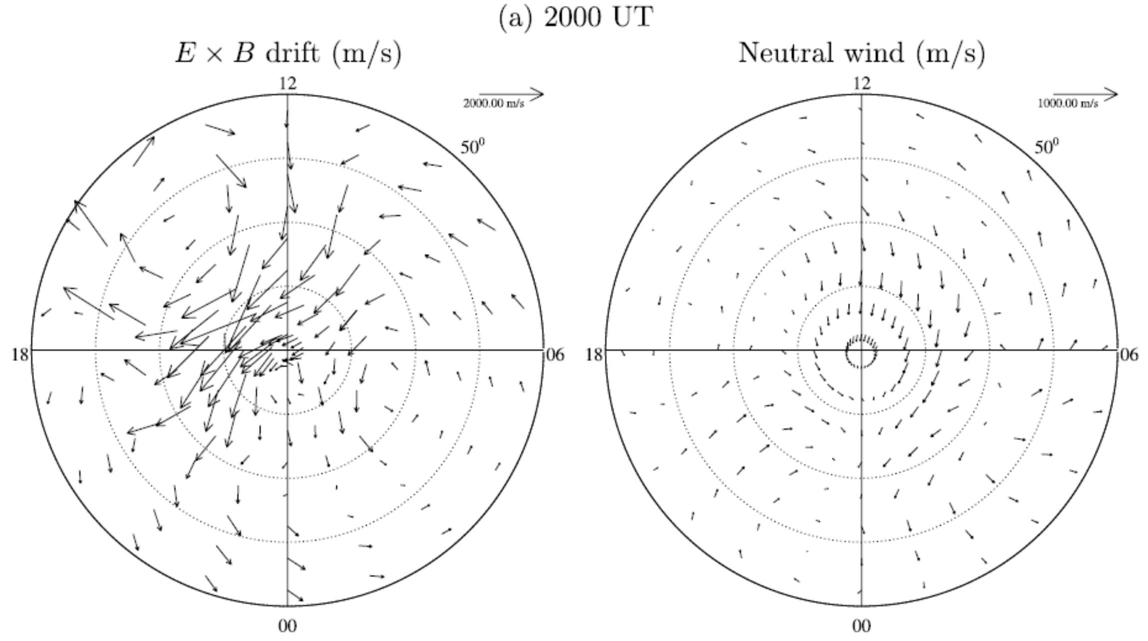


Fig. 16. Averaged thermospheric neutral wind measurements for (a) north pole B_y positive, (b) north pole B_y negative, (c) south pole B_y positive, and (d) south pole B_y negative. Data collected between November 1981 and January 1982 and between November 1982 and January 1983 were averaged according to the sign of the B_y component of the IMF and plotted in geomagnetic polar coordinates (magnetic latitude and magnetic local time). The outer circle of each polar dial is at 40° geomagnetic latitude. The figure is from *Thayer et al.* [1987].

Thayer+, AnGeo, 1987

similar results from UCL TGCM simulation: Rees+, PSS, 1986

high-lat thermospheric wind : deviations from **quiet**



NCAR TIEGCM with AMIE outputs

Deviations from the quiet condition do not clearly show sunward neutral winds…

Deng+, JGR 2009

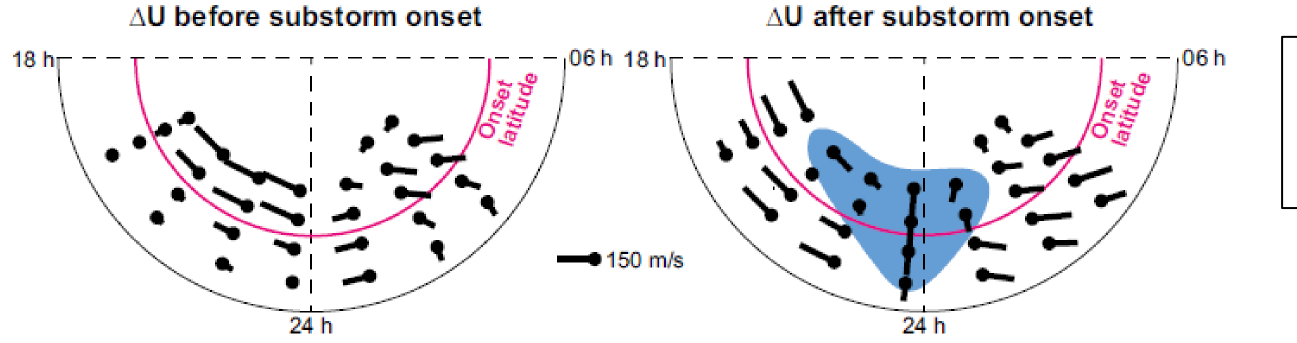


Figure 9. Illustration of substorm-associated wind disturbances before substorm onset (left) and after it (right) in the polar plot. The arrows at the earliest MLT corresponds to Type 1 wind disturbance, the second earliest to Type 2, etc. Because there was only one type of wind disturbance in the postmidnight sectors, Type 6 should apply to a large area in this MLT range and was hence shown twice. The magenta curve marks the onset latitude. The blue shaded region indicates where the zonal component of the substorm-associated wind disturbance is directed oppositely to the two-cell circulation. MLT, magnetic local time.

Statistics of SDIs' wind around substorm onset

Sunward flow is enhanced after substorm onset. **U** in the blue hatch is opposite to **Vi.** Analysis of 4 SDIs in AK but single FOV mode. Complicated definition of the "background wind."

Zou+, JGR 2021

Scientific objective

Baseline of the wind

A successful way of estimating wind acceleration would be calculation of difference from the quiet-time wind. But **what is the “quiet-time wind”?** Is modeled wind reliable? Is limitation of, for example, “Kp < 3” good enough?

A weak but significant input

Quiet-time measurements may give a new insight to investigate mechanisms working in the M-I-T coupled system, which might be masked by many simultaneous processes during geomagnetically disturbed periods.

HWM14

AGU PUBLICATIONS

Earth and Space Science

RESEARCH ARTICLE
10.1002/2014EA000089

Key Points:
- The horizontal wind model has been updated
- New data fill observational gaps
- Empirical specifications are consistent with ionospheric models

Supporting Information:
- Figures S1–S3
- Software S1

Correspondence to:

An update to the Horizontal Wind Model (HWM): The quiet time thermosphere

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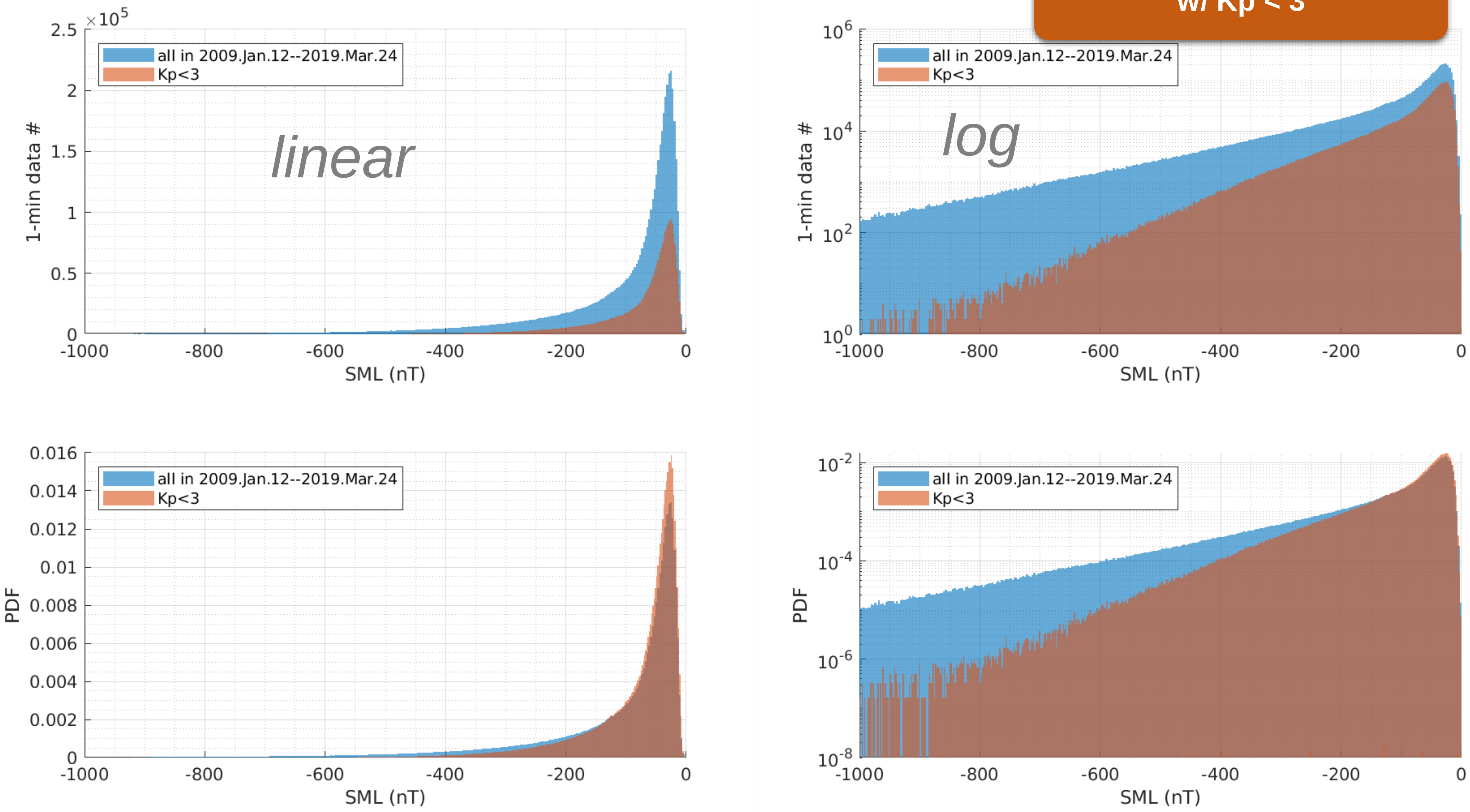
constant for all observations and chosen to reflect both the measurement uncertainties and the random geophysical variability not representable by the empirical formulation. Data corresponding to geomagnetically quiet conditions (local 3 h $Kp < 3$) are used in the parameter estimation. The first iteration is started with $\mathbf{m}_n$ and $\mathbf{S}_n^{-1}$ equal to zero and performed using evenly distributed pseudo observations from both HWM93 and a multiyear TIEGCM model run. As described in *Drob et al.* [2008], these pseudo data are included as soft constraints in data-free regions to damp spurious artifacts toward reasonable values, thus making higher model resolution possible for the majority of the model space where observational coverage is good.

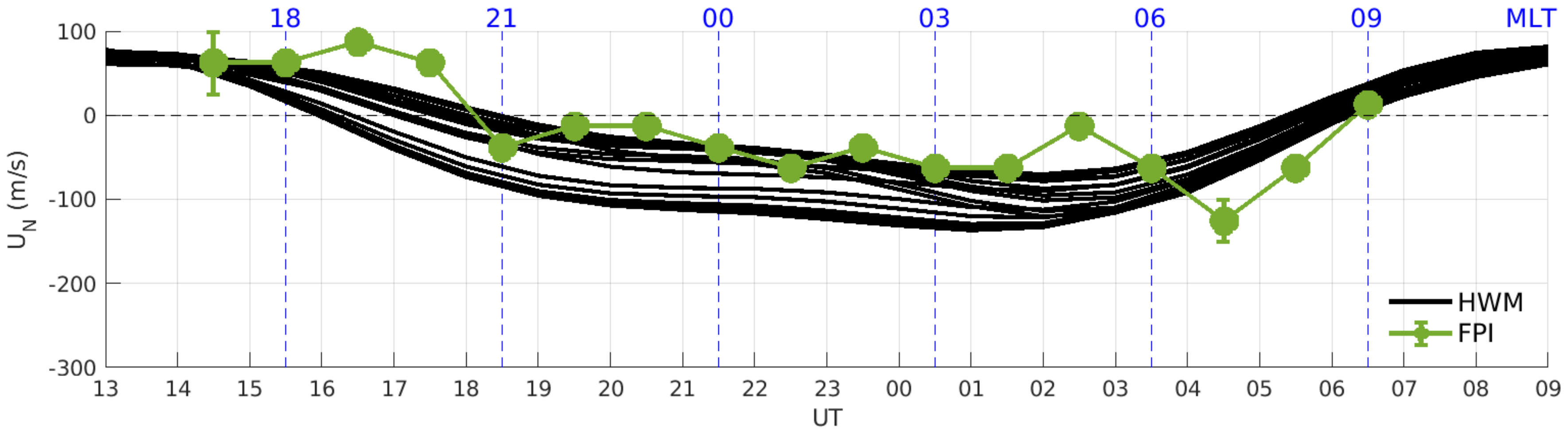
Statistics of SML: "Kp<3" is quiet?

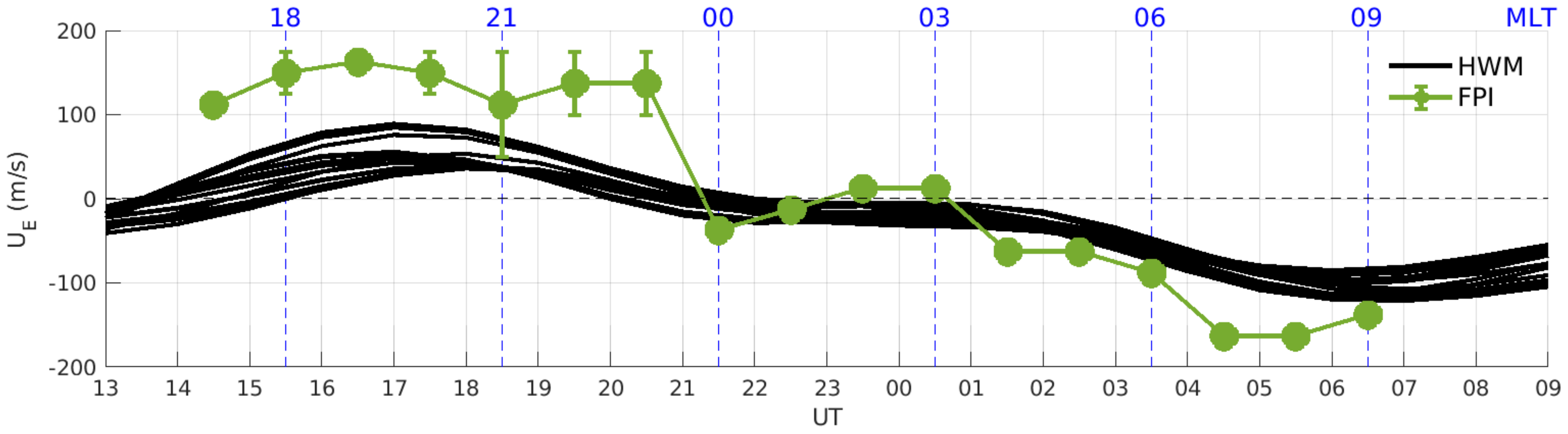
all in 2009.Jan – 2019.Mar

w/ Kp < 3



quiet HWM14 vs statistical FPI quiet-time wind





Baseline of the wind

In terms of the thermospheric wind at F-region altitude, **the baseline wind should be carefully decided**. Simple applications of, for example, limitation of Kp<3 or HWM14 model would be insufficient.

A weak but significant input

- **Dusk-side westward acceleration gradually grows up (probably) by substorm onset**.
- For relatively shorter time, the westward acceleration would quit and turn to be **eastward acceleration after MLT midnight.**
- **Eastward acceleration would last in the morning sector.**
- These zonal-wind behavior is similar as the ionospheric convection, although it would be squeezed or Tromsø was relatively **located in the subauroral region**.
- **Southward acceleration would be dominant** through the night but late morning MLT.