Occurrence characteristics of subauroral rapid plasma flows observed by the SuperDARN Hokkaido East HF radar

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SAPS

SAPS (Sub-Auroral Polarization Stream) Foster and Burke (2002)

Westward rapid plasma flow occurs in subauroral region.

Because ExB drift of ion lead to SAPS, it may be observed as a large electric field and is called Sub-Auroral Electric Field (SAEF) . Karlsson et al. (1998)

Generation mechanism of SAPS

Anderson et al. (1993)

Pederson conductivity Σ_P is large in electron precipitation region, and small Σ_P in trough.

Large electric field is generated in order to flow the Region2 ionospheric current.

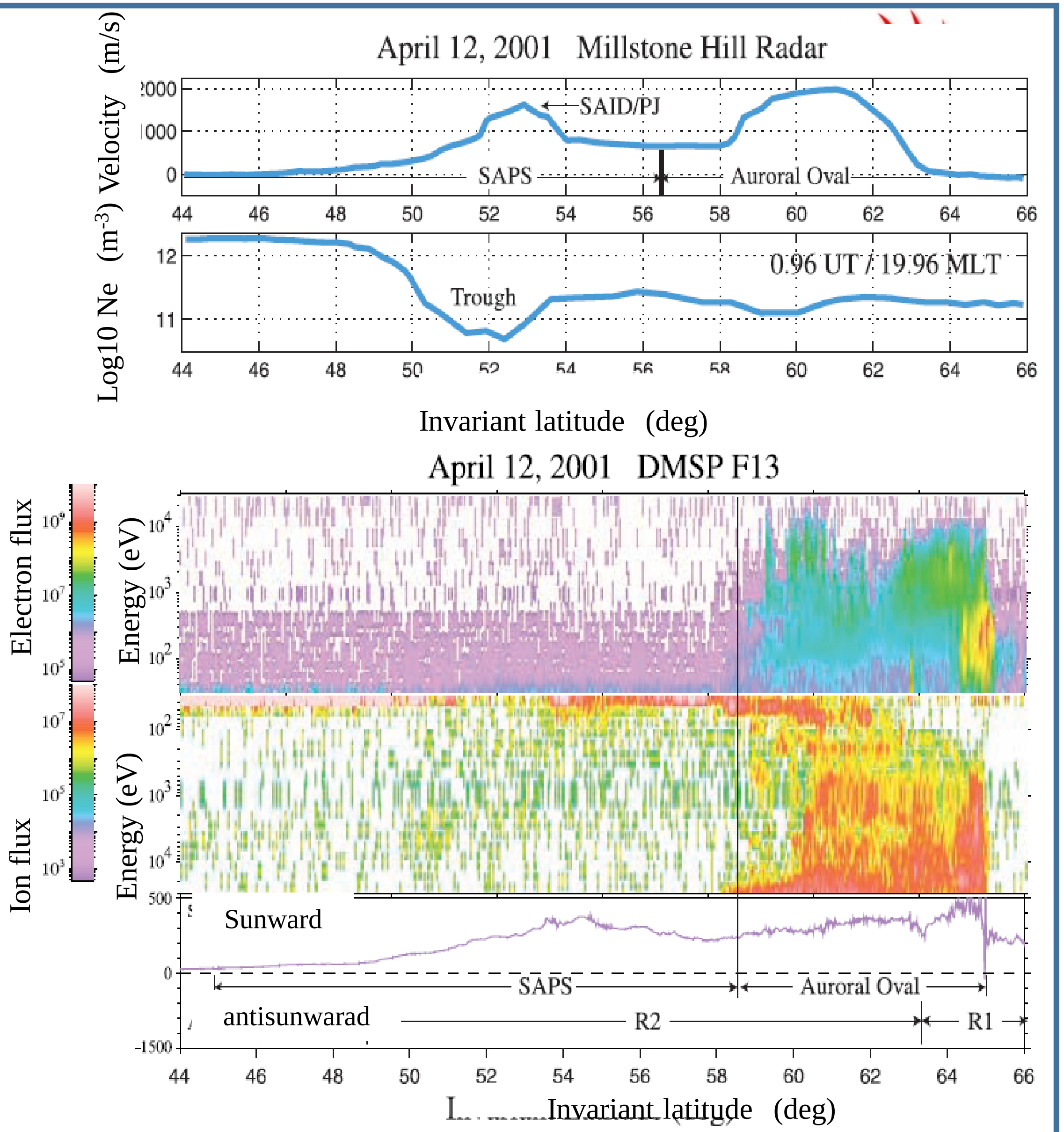

Fig.1. top : Correlation between SAPS and electrons
bottom : SAPS and Foster and Burke (2002)

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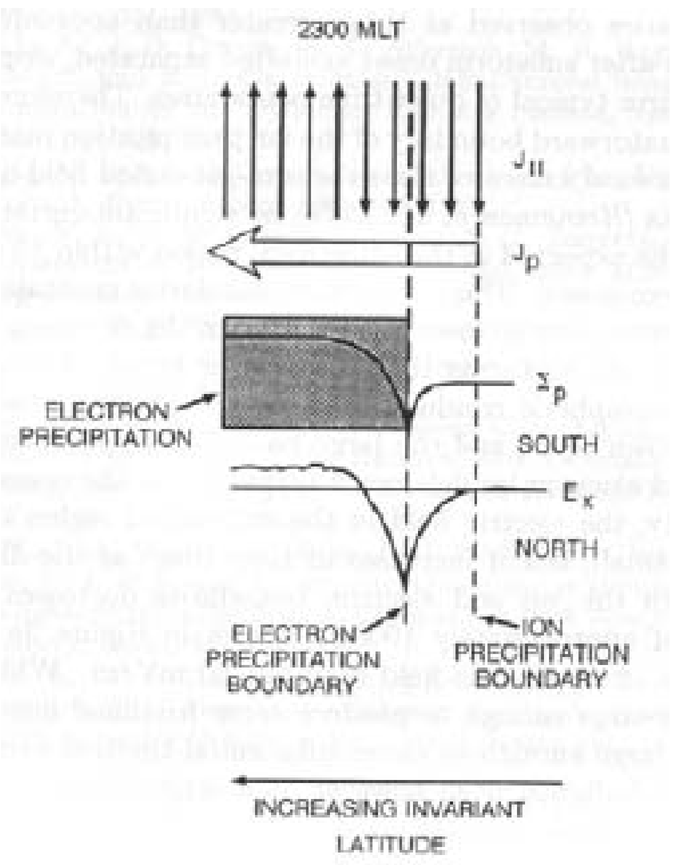

Fig.2. Anderson et al. (1993)

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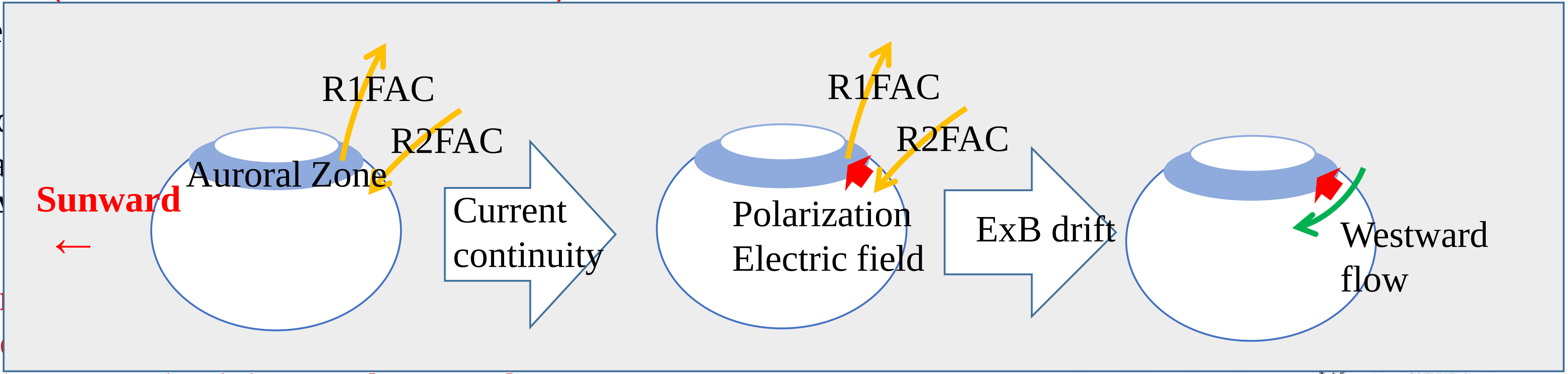

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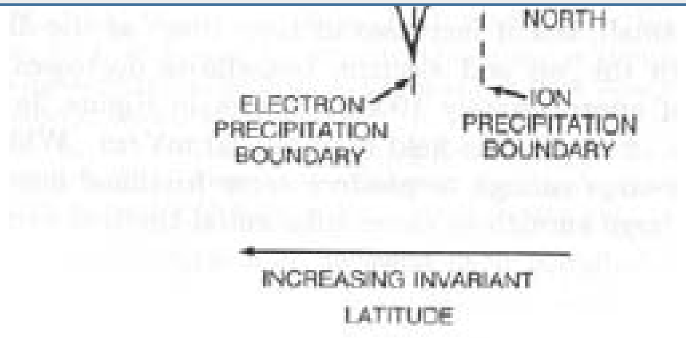

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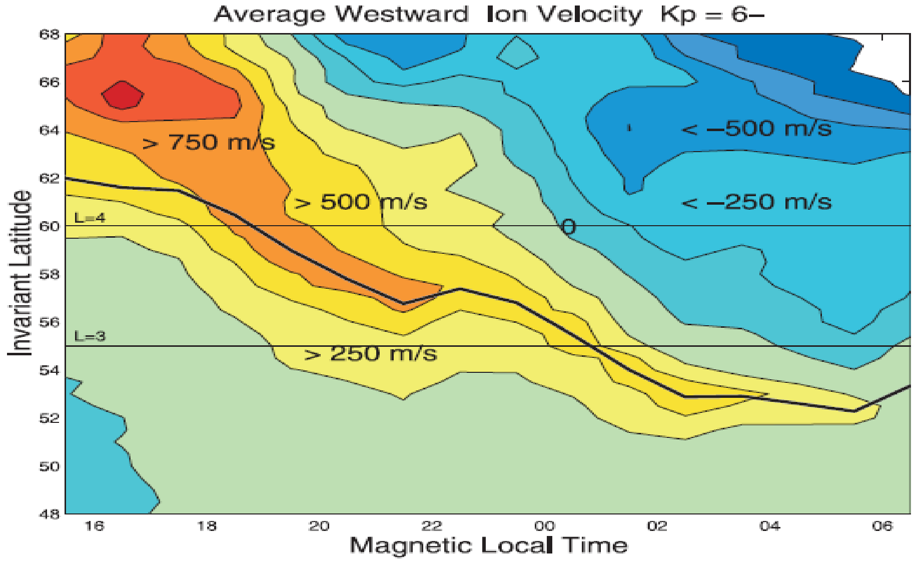
Previous works

・As occurring MLT progress, the speed becomes slow, and SAPS shifts to lower latitudes.
Foster and Vo. (2002)

・Positions of SAPS are highly correlated with Dst index.
Kataoka et al. (2009)

There are still some open questions to be answered.
→We conduct a statistical study on SAPS using the Hokkaido East HF radar data for about 8 years.



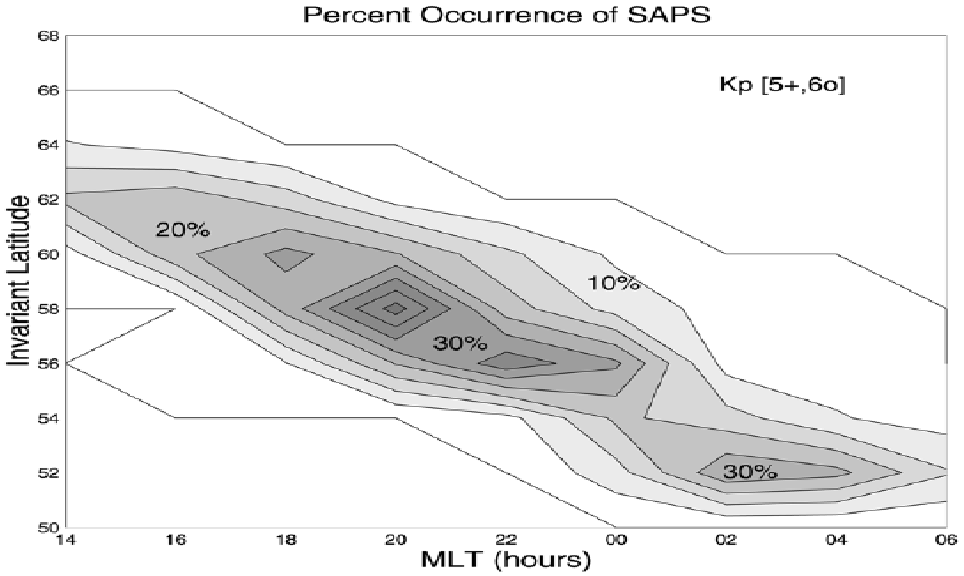


Fig.3. Relation MLAT and velocity of SAPS against for MLT
Foster and Vo (2002).

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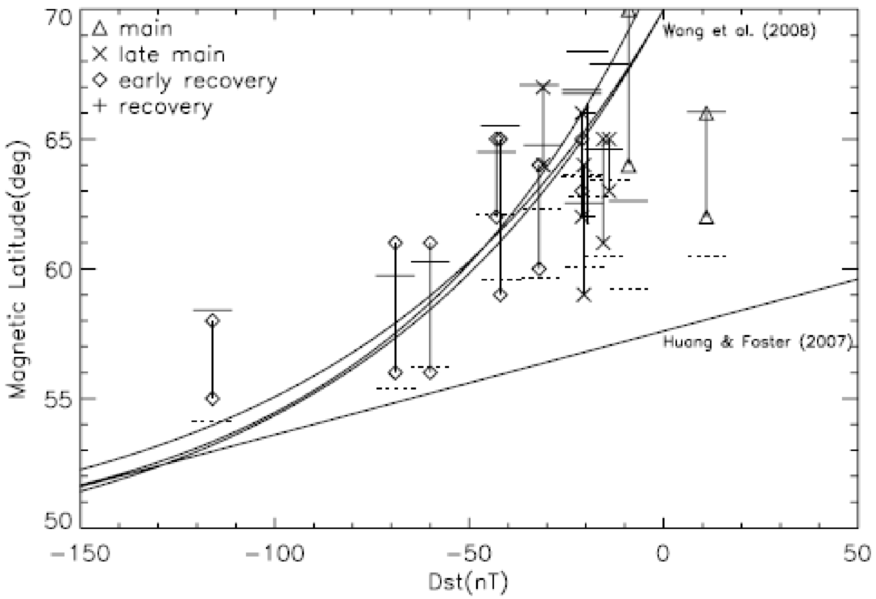


Fig.4. Latitude dependence by Dst index
Kataoka et al. (2009)

There are still some open questions to be answered.
→We conduct a statistical study on SAPS using the Hokkaido East HF radar data for about 8 years.

Research topic

Q. The slower speed limit of SAPS.

The slower speed limit of SAPS have not been defined so far.

Because previous works used only (very) fast flows for the statistics.

Flow of this study

1. Checking the events of westward flows including the SAPS
   by using a wide range of background conditions..
   Westward speed >10.0 m/s MLAT 40~70°
2. To distinguish subauroral region from auroral oval at that time.
3. Get the data of flow speed and MLAT, SYM-H every 30 minutes.
4. Investigating correlation between flow speed and MLAT-Dst dependence.

Positions of SAPS → Depends on Dst index

The flows whose positions depend on Dst → SAPS

$$\mathrm{MLAT} = 49^\circ + 23e^{Dst/69.5}$$
$$\mathrm{MLAT} = 48^\circ + 22e^{Dst/80.5}$$
$$\mathrm{MLAT} = 49^\circ + 21e^{Dst/80.5}$$

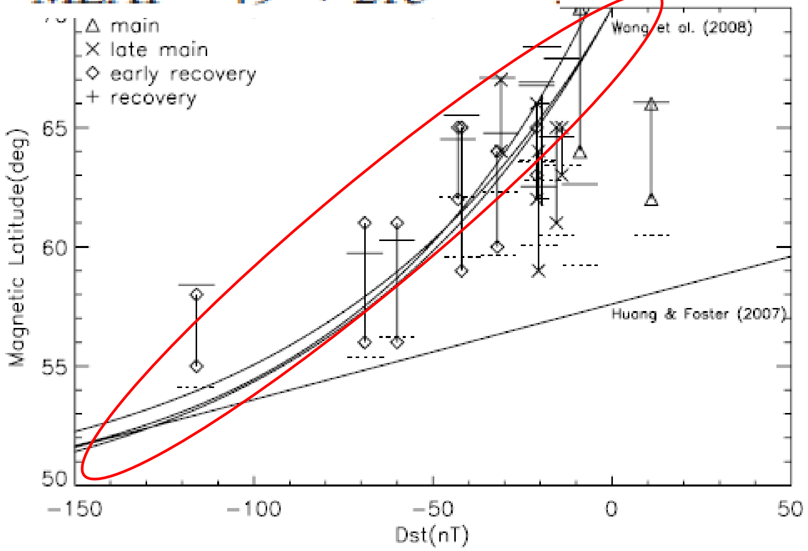


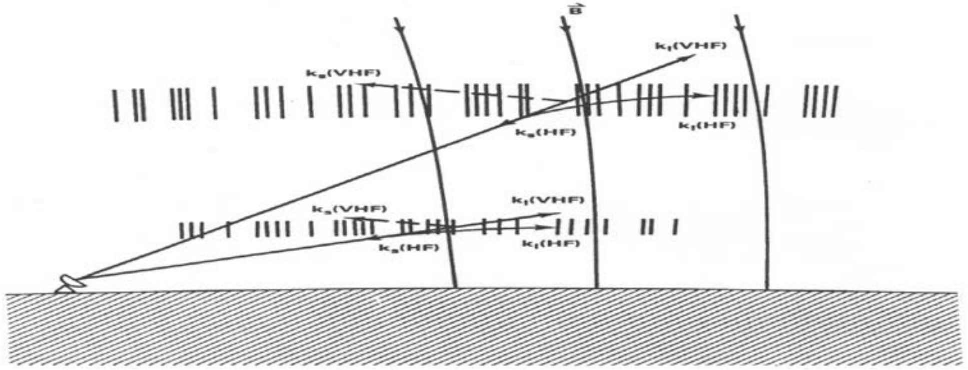
Fig.4. Latitude dependence by Dst index Kataoka et al. (2009)

Hokkaido East HF radar

This radar can observe the region of lower latitude than any other SuperDARN radars.

- MLAT:36.46° , MLON -145.34°
- Frequency 8~20 MHz

It measures Bragg scattering due to irregularity of electron density in the ionosphere. Considering the Doppler effect, we estimate Doppler velocity from obtained data.



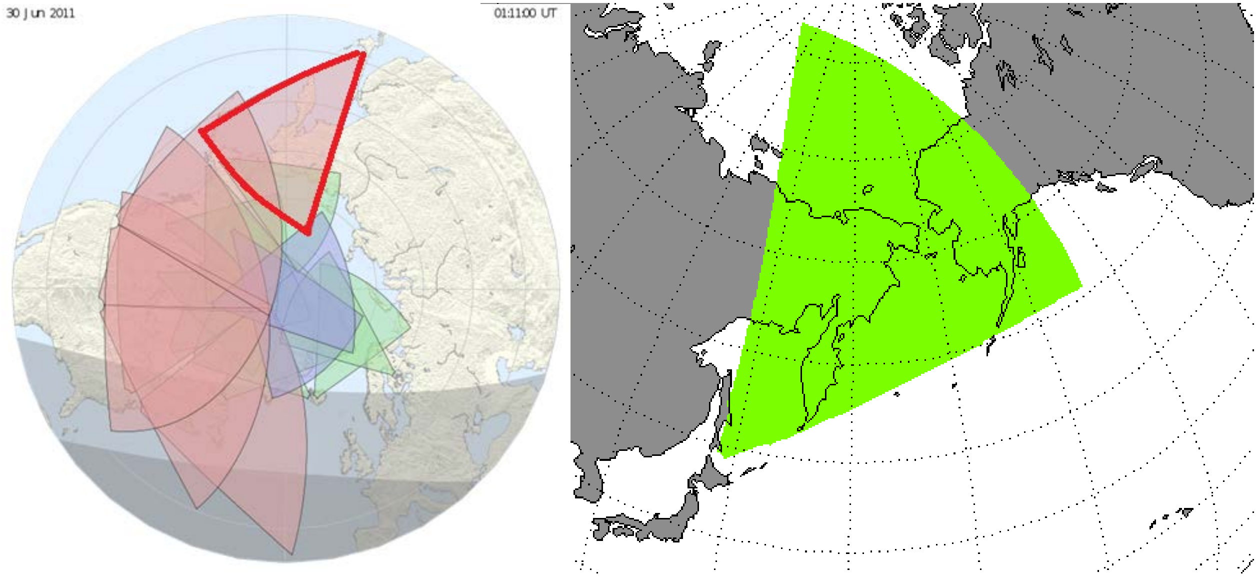


Fig.5. Picture and LOS of the Hokkaido East HF radar.

Data select

3. Get the data of flow speed and MLAT, SYM-H every 30 minutes.

1. Checking the events of westward flows including the SAPS.
2. To distinguish subauroral region from auroral oval at that time.

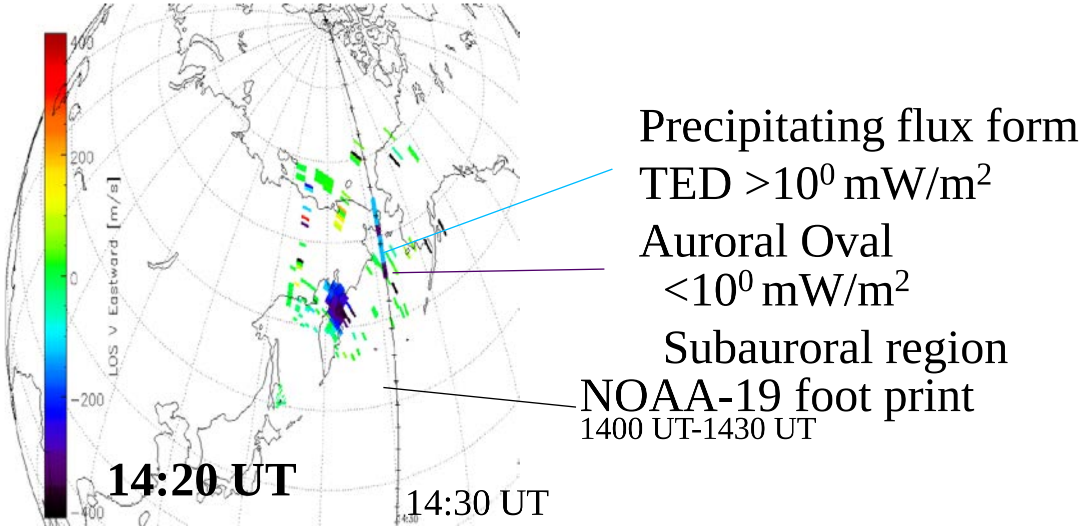


Fig 6. Precipitating flux obtained from TED on NOAA satellite, and LOS speed obtained from the Hokkaido HF radar. (2012/07/15)

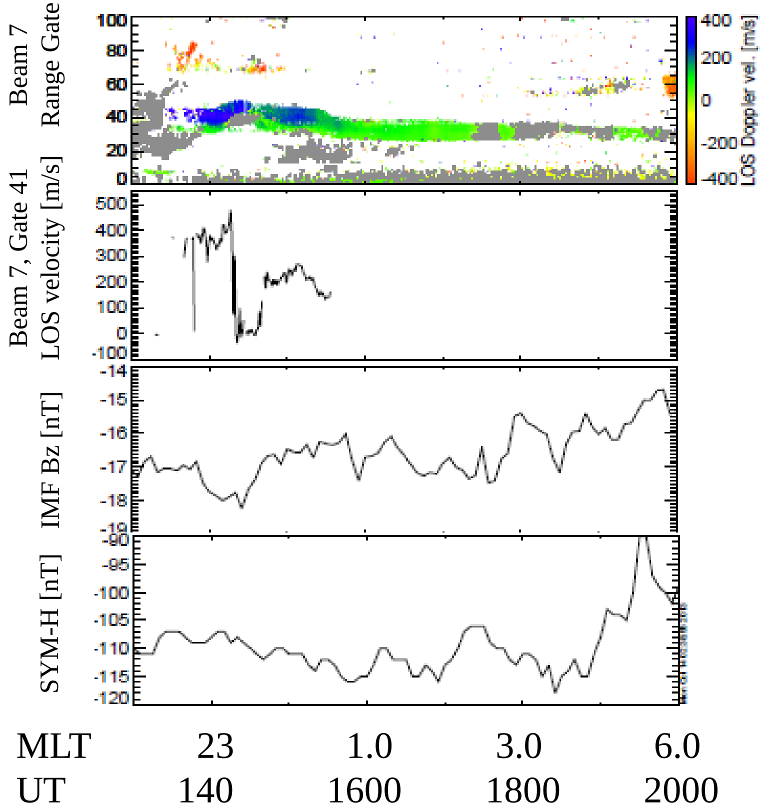


Fig 7. Data of 2012/07/15
(from top) Doppler velocity, LOS velocity, IMF Bz, AL index and SYM-H.

Result

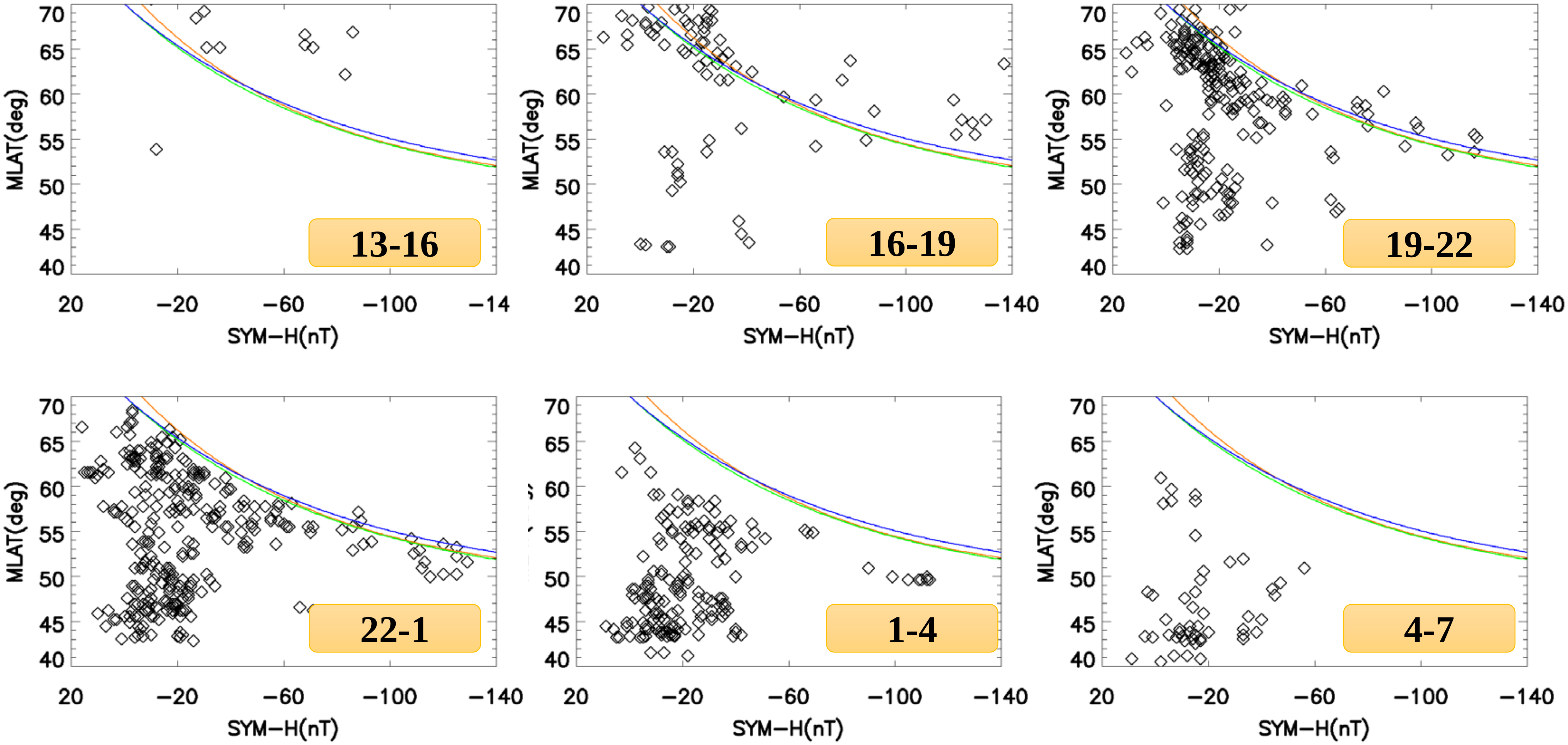
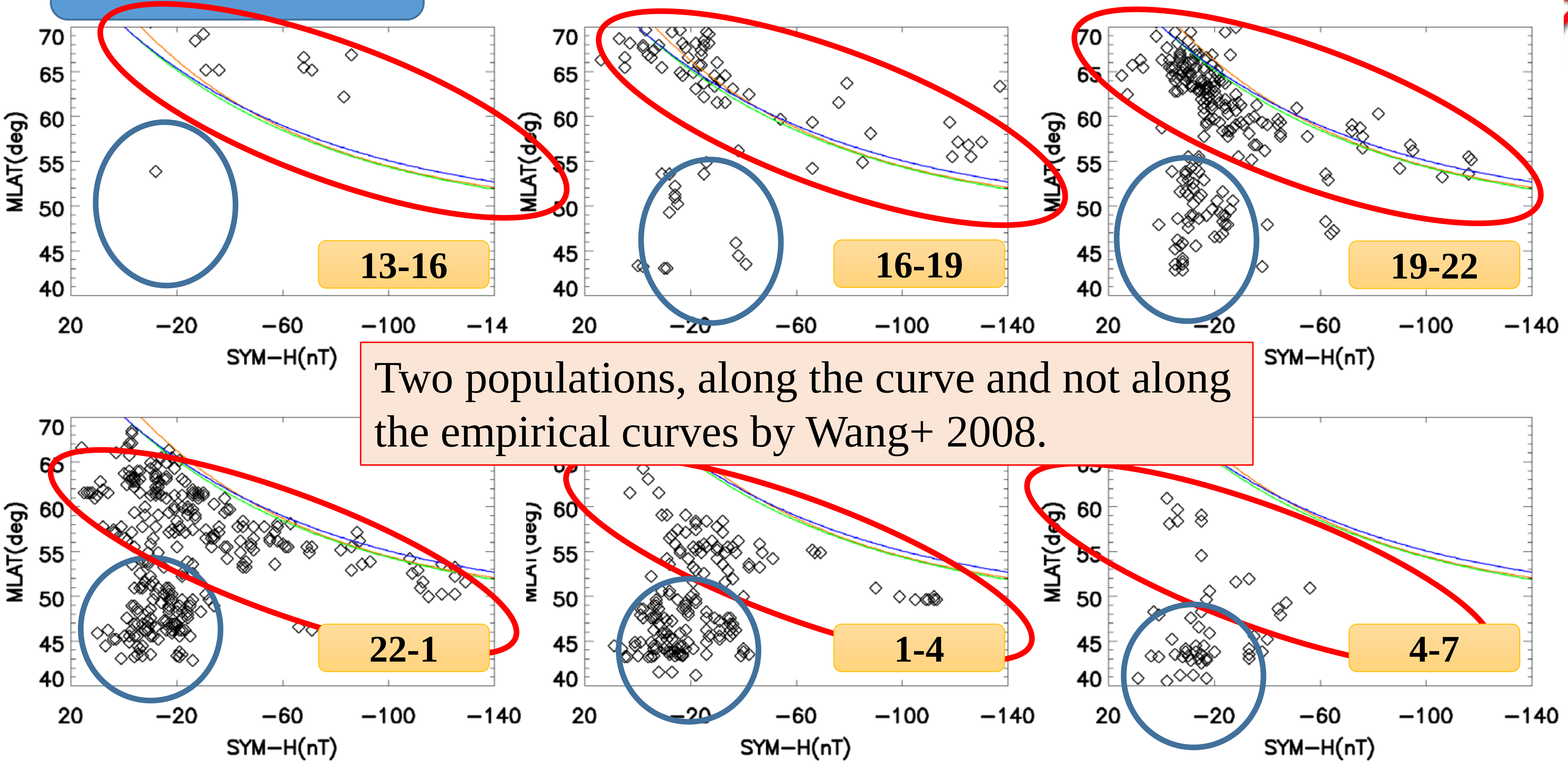


Fig.8. Dst index and occurred position for each MLT with Wang's formulas.

Result



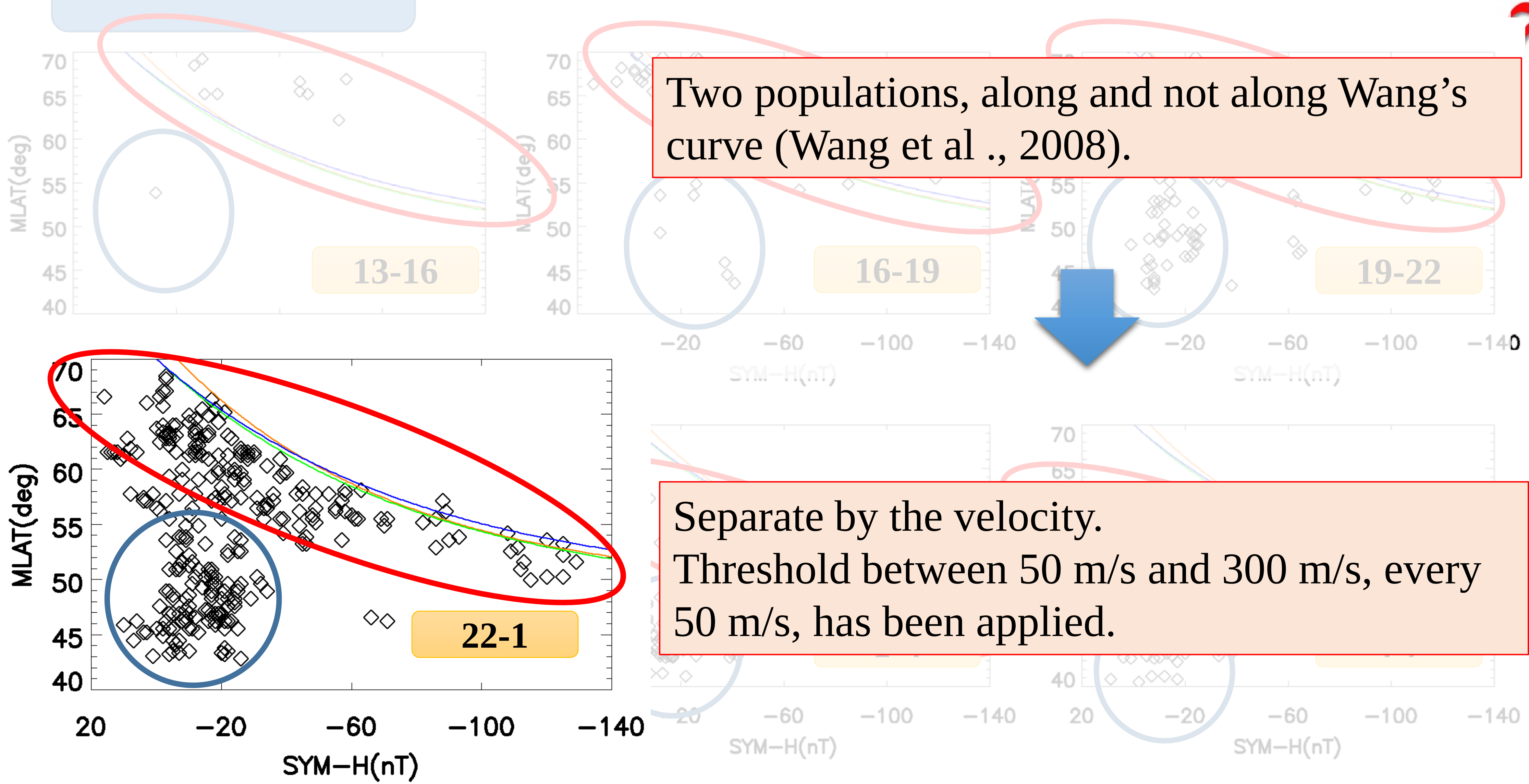
Two populations, along the curve and not along the empirical curves by Wang+ 2008.

Fig.8. Dst index and occurred position of each MLT with Wang's formulas.

Result

Two populations, along and not along Wang’s curve (Wang et al ., 2008).

Separate by the velocity.
Threshold between 50 m/s and 300 m/s, every 50 m/s, has been applied.



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Result

22-1 MLT

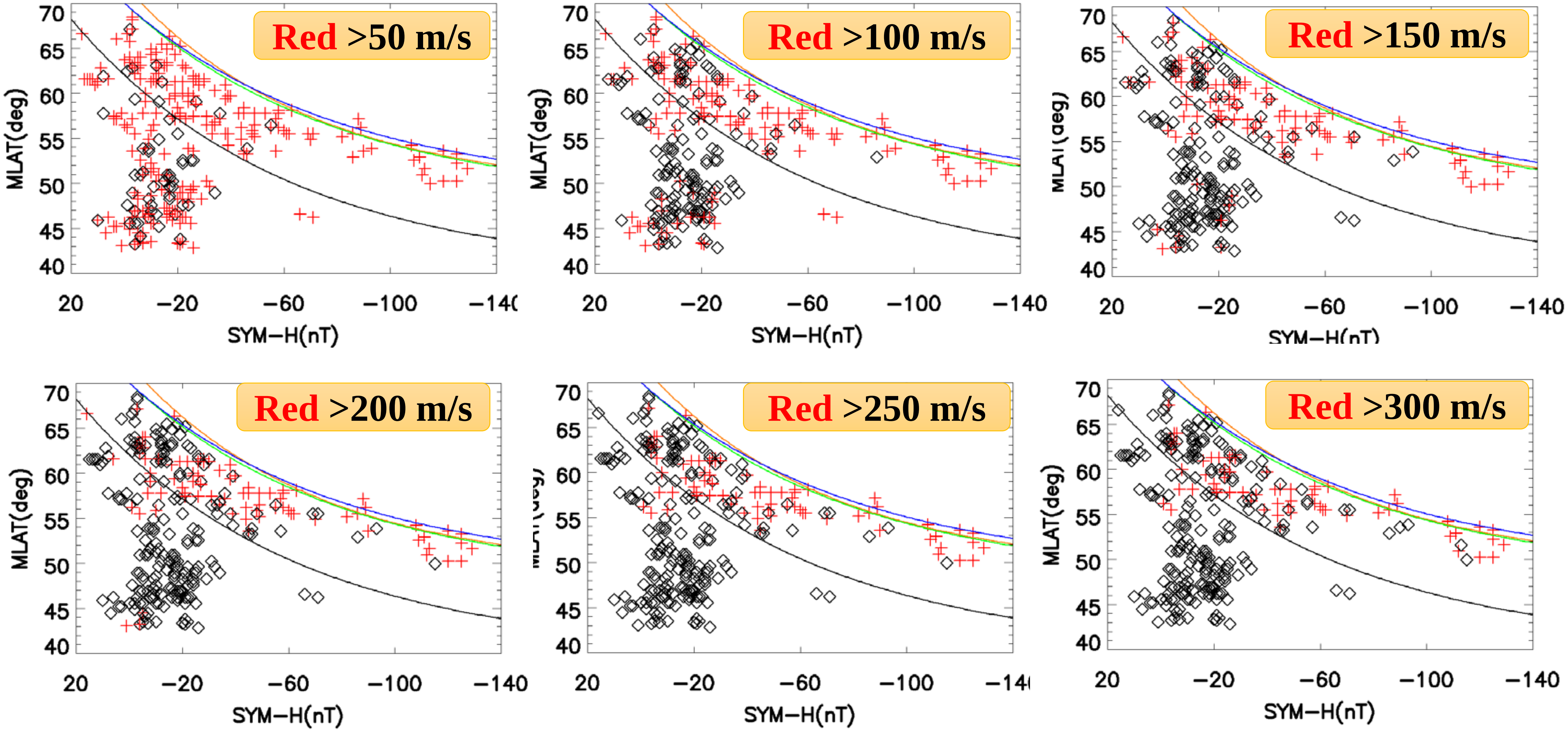
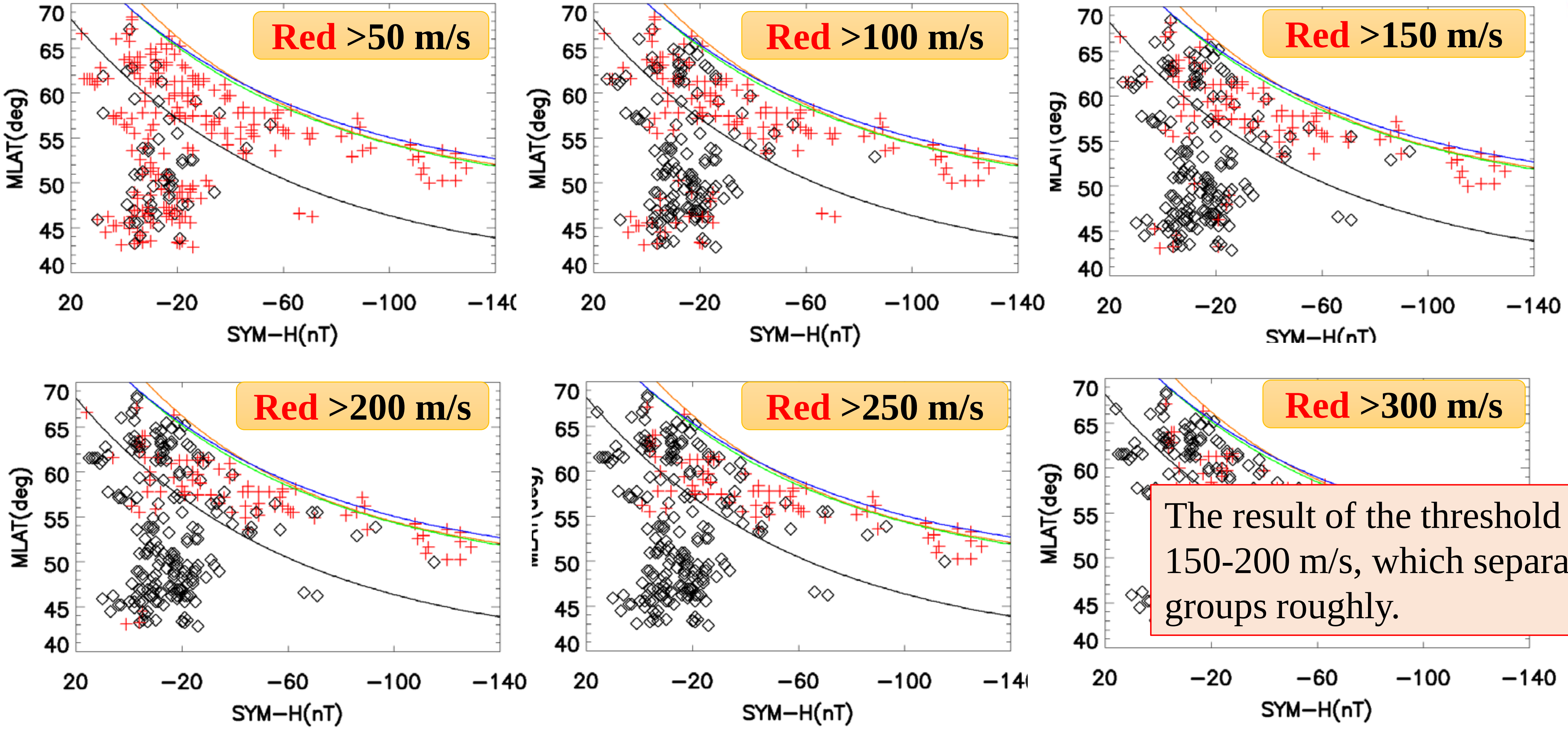


Fig.9. The Results separated by speed.(22-1 MLT)

Result

22-1 MLT



The result of the threshold is 150-200 m/s, which separate two groups roughly.

Fig.9. The Results separated by speed.(22-1 MLT)

Statistical test

For each MLT bin, we separated all events into the two groups faster/slower than a velocity threshold. Then, we examined the percentage of the faster events that satisfy the latitude threshold. The latitude threshold is determined by Foster and Vo [2002] for Kp=7 . The faster event percentage was evaluated with various velocity thresholds.

The percentage reaches asymptotically ~80-100%, when the threshold is ~150-200 m/s.

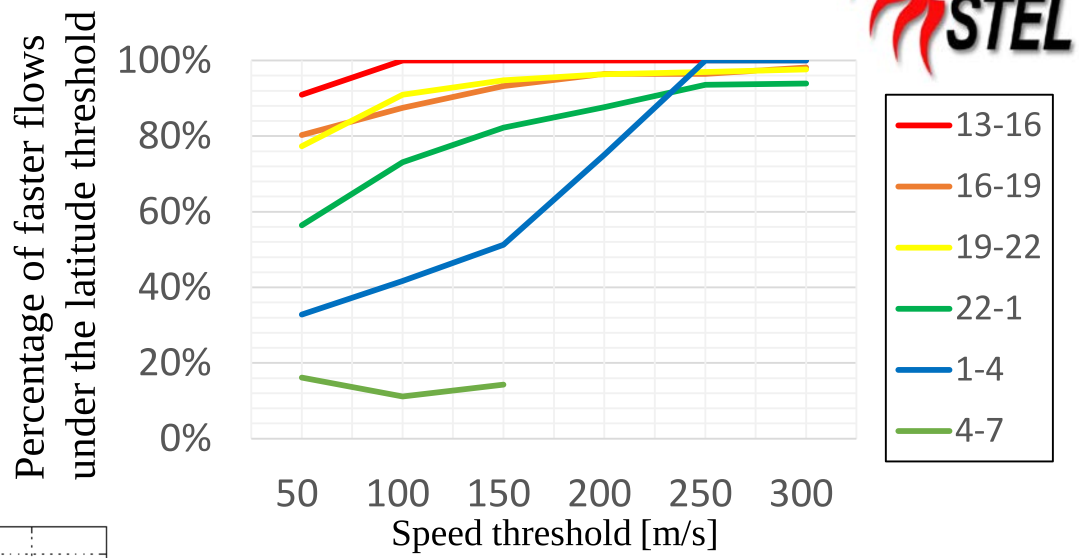


Fig 12. The result of statistical test

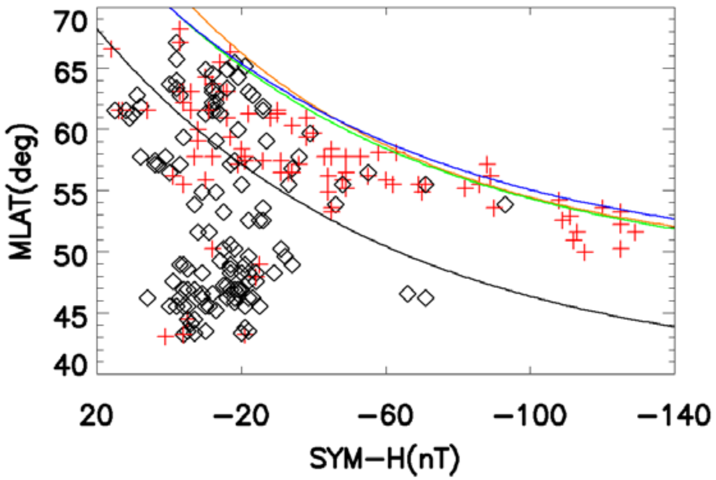


Fig 10. Example of a statistical test
(22-1 MLT threshold is 150 m/s)

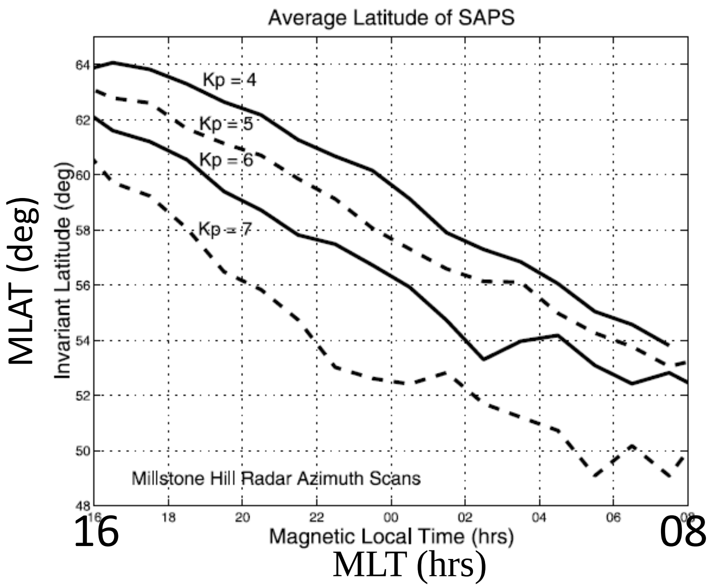
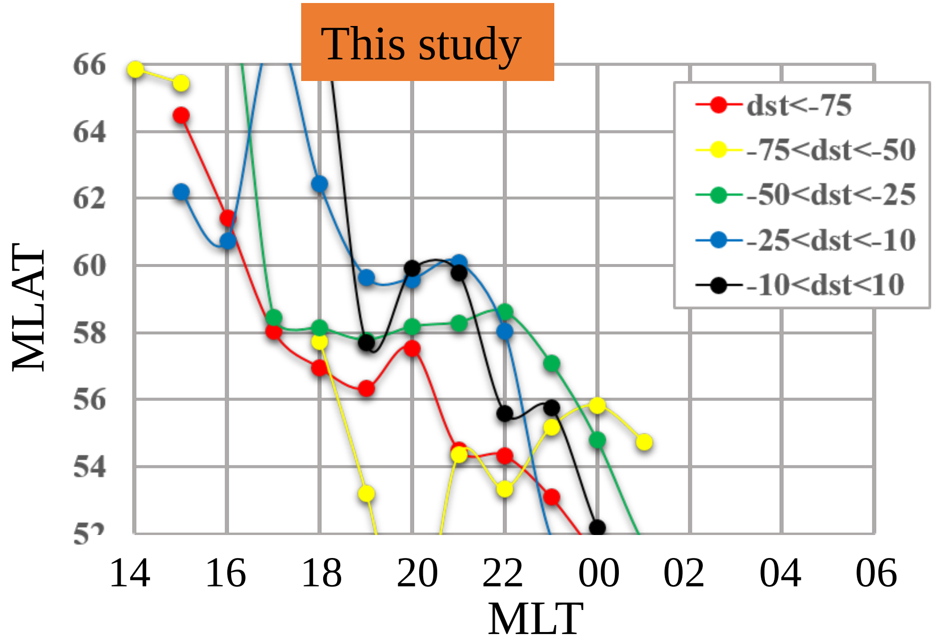


Fig 11. MLAT dependence of MLT with Kp (Foster and Vo, 2002.)

Table 1. The latitude threshold

MLT [h]	13-16	16-19	19-22	22-1	1-4	4-7
MLAT[°]	61	58	55	54	52	50



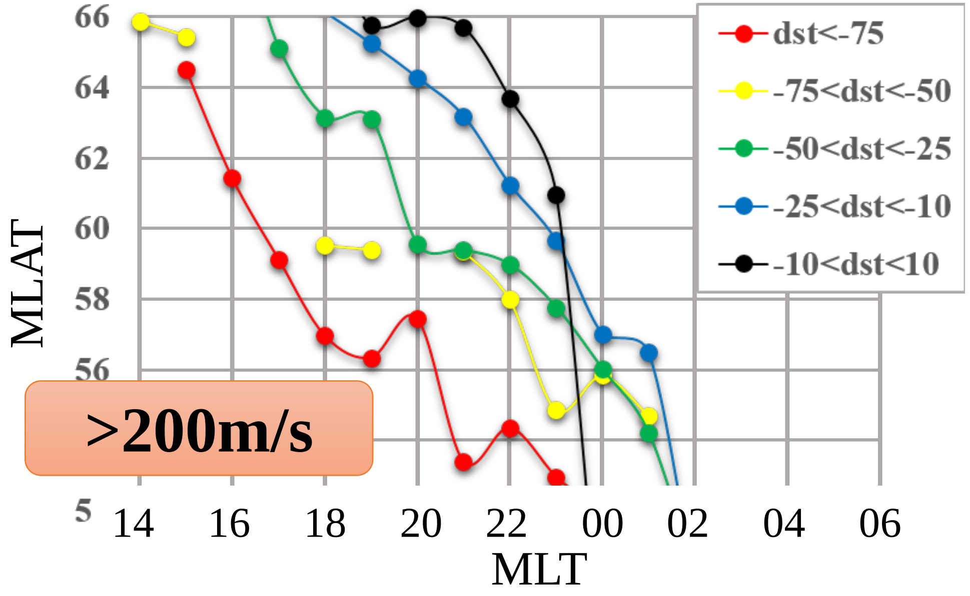


Fig.15. Relationship of MLAT and MLT of each Dst index.
top: no threshold, bottom: threshold of > 200 m/s.

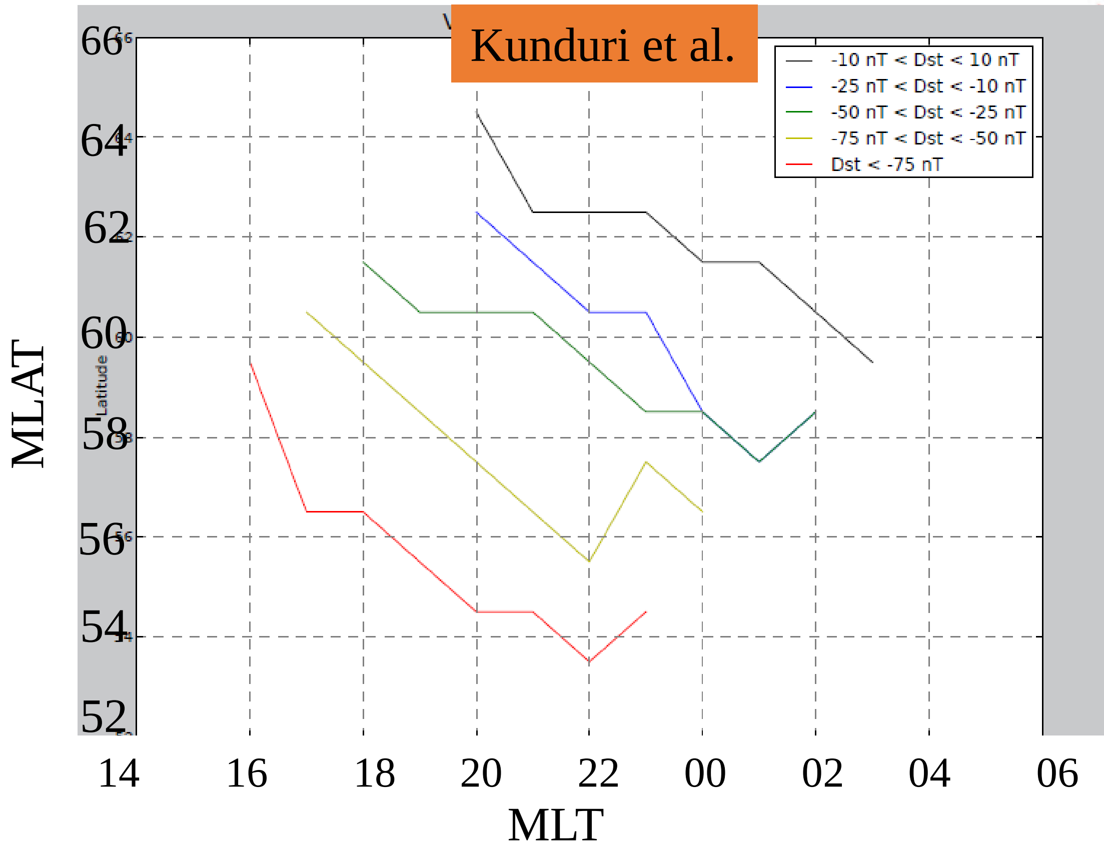


Fig.16. Relationship of MLAT and MLT of each Dst index
B. Kunduri et al., AGU FALL Meeting 2013.

The difference of relationship between MLAT and MLT for each Dst index is easily identifiable by applying threshold of > 200 m/s .

Q. The slower limit of SAPS.

→The slower limit of SAPS is 150-200 m/s.

Discussion and Conclusion

Q. <u>The slower limit of SAPS.</u>

We classified westward flows by their velocity.

Faster flow than 150-200 m/s → As Dst decreases, their positions toward lower latitude.

Slower flow than 150-200 m/s → Their positions are not dependent on Dst index.

→**<u>The lowest limit of SAPS speed is ~150-200 m/s.</u>**

- The slower flows are mid latitude F region echo(Fukao et al., 1988).
- This result gives a minimum electric field which generates SAPS.

→**<u>A minimum electric field is 6-8 mV/m</u>**

- This electric field contribute to investigate mechanism of Feedback instability.

Future Work

- To confirm whether SAPS is generated when minimum electric field. And checking the situation at that time.

→ Investigating factor of generating SAPS.

STEL