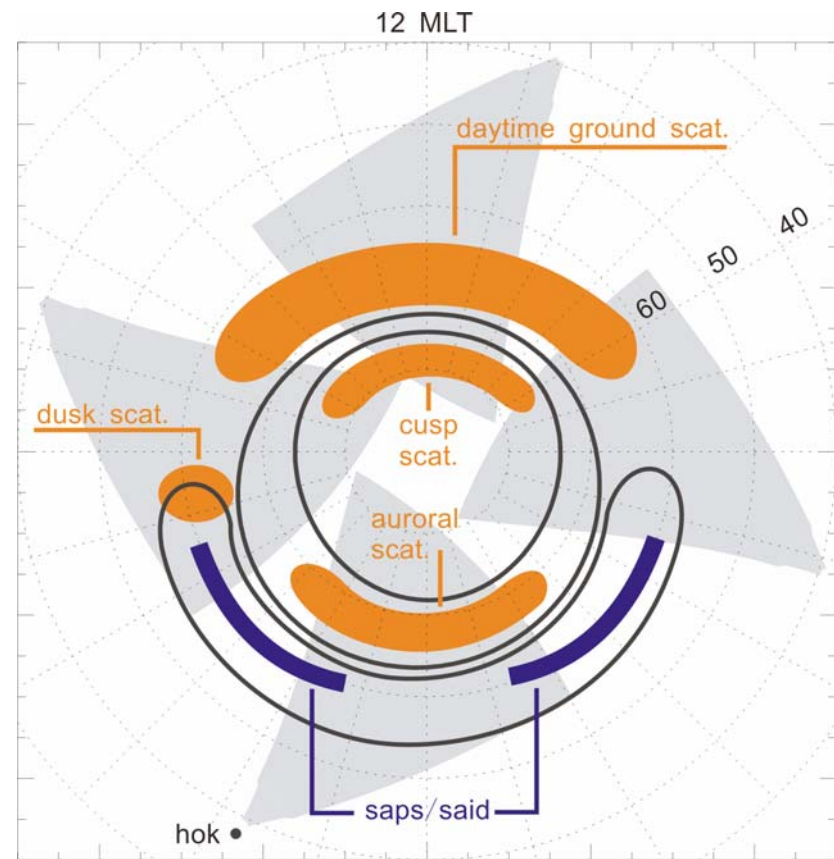


Dusk scatter echoes observed with mid-latitude SuperDARN radar in Hokkaido, Japan

It's a zoo of radar backscatter!

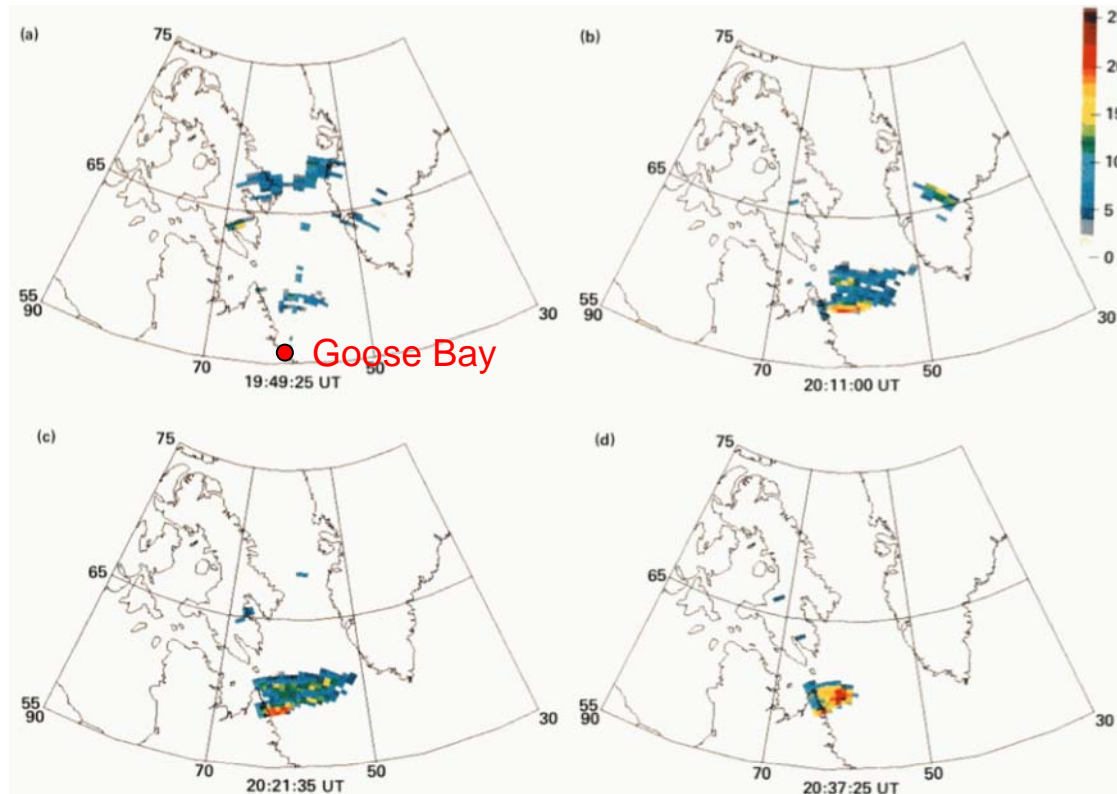
1. **daytime ground scatter**
(Ishida et al., 2008, Hayashi et al., XXXX)
2. **cusp scatter in disturbed cond.**
(Nishitani et al., XXXX, Hosokawa et al., XXXX)
3. **auroral scatter in disturbed cond.**
4. **dusk scatter echoes (DUSE)**
5. **saps / said**
(Kataoka et al., 2007, Ebihara et al., 2008, 2009)
6. **mid-latitude nighttime FAIs, QPE**
(Ogawa et al., XXXX; Suzuki et al., XXXX)
7. Es, meteor and PMSE?



K. Hosokawa and N. Nishitani

Dusk Scatter Echoes (DUSE) - An introduction

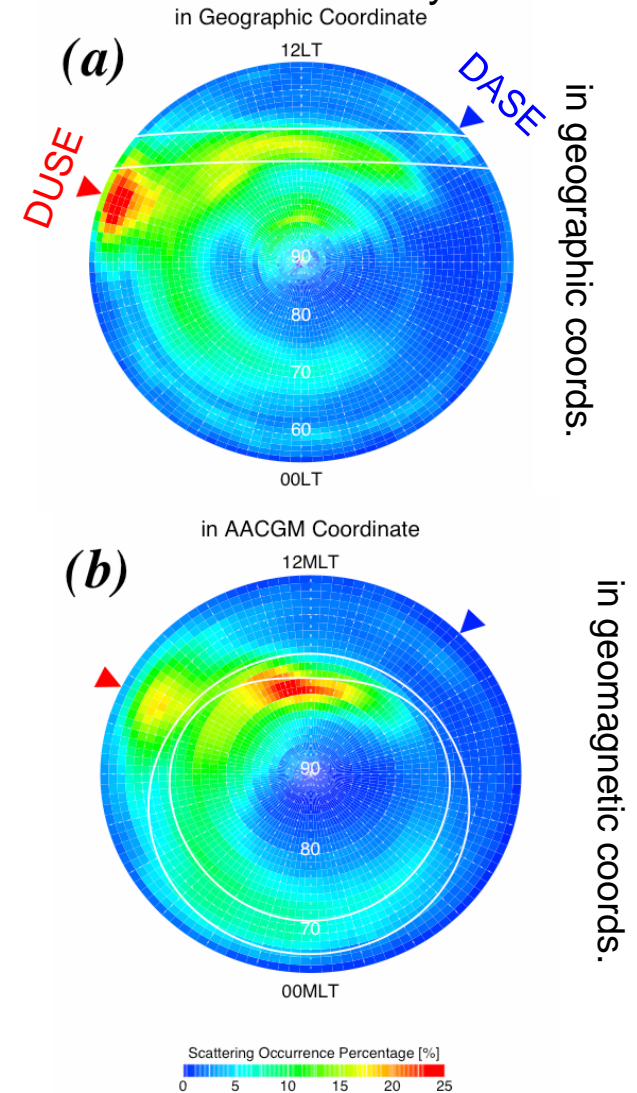
First observation with the Goose Bay HF radar



- appear at closer range gates **after local sunset**
- continue for approximately **1.5 hours**
- one of the most **prominent irregularities** in the high-latitude coherent HF radar observations

Ruohoniemi et al. (1988)

Statistical study



Hosokawa et al. (2001)

Generation of FAIs based on gradient-drift instability (GDI)

Linear growth rate of small-scale electron density irregularities based on GDI is maximized when the background plasma drift is parallel to the density gradient

Keskinen and Ossakow (1982)

Requirement:

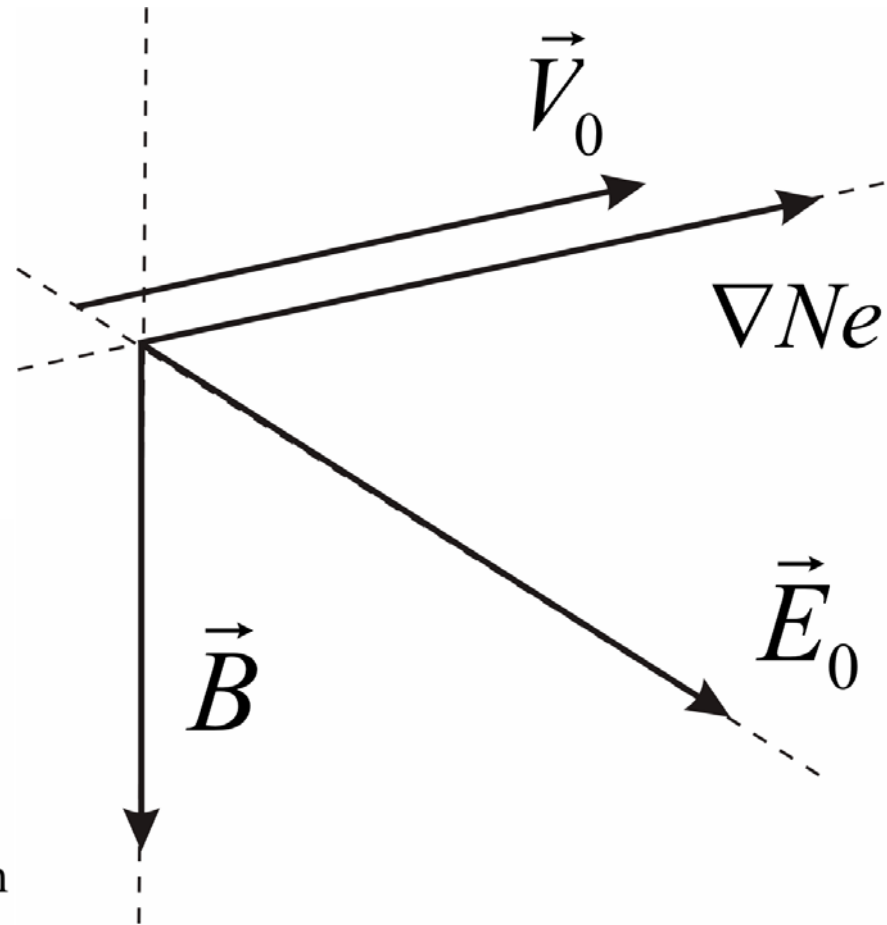
background plasma drift is parallel to the electron density gradient

(i.e. electric field is perpendicular to the electron density gradient)

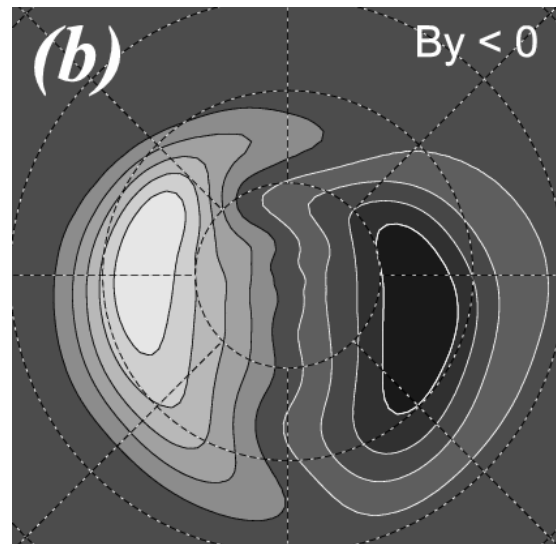
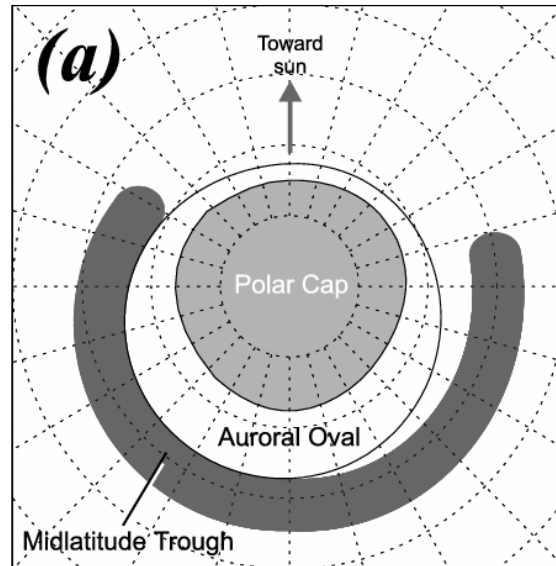
$$\gamma = \frac{V_0}{L} \quad : \text{growth rate}$$

$$V_0 = \frac{E_0}{B} \quad : \text{drift velocity}$$

$$L = \frac{Ne}{\nabla Ne} \quad : \text{density gradient scale length}$$

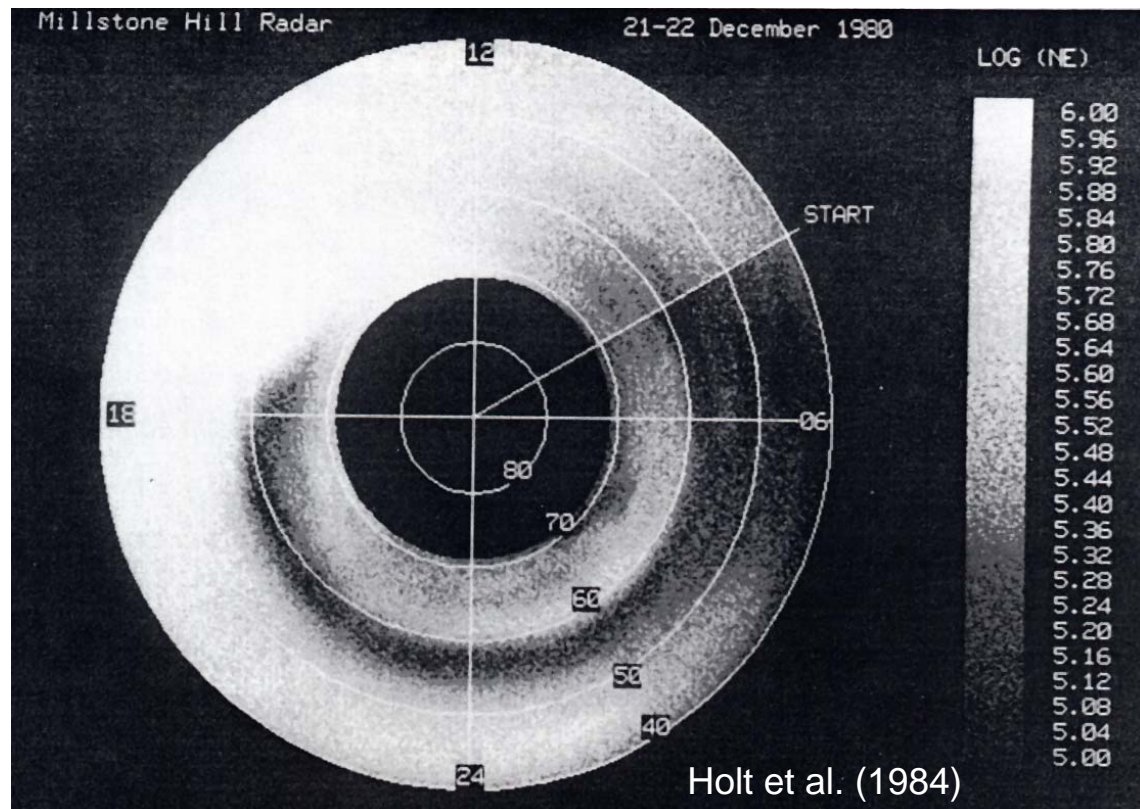


Large-scale structures in the subauroral ionosphere responsible for DUSE



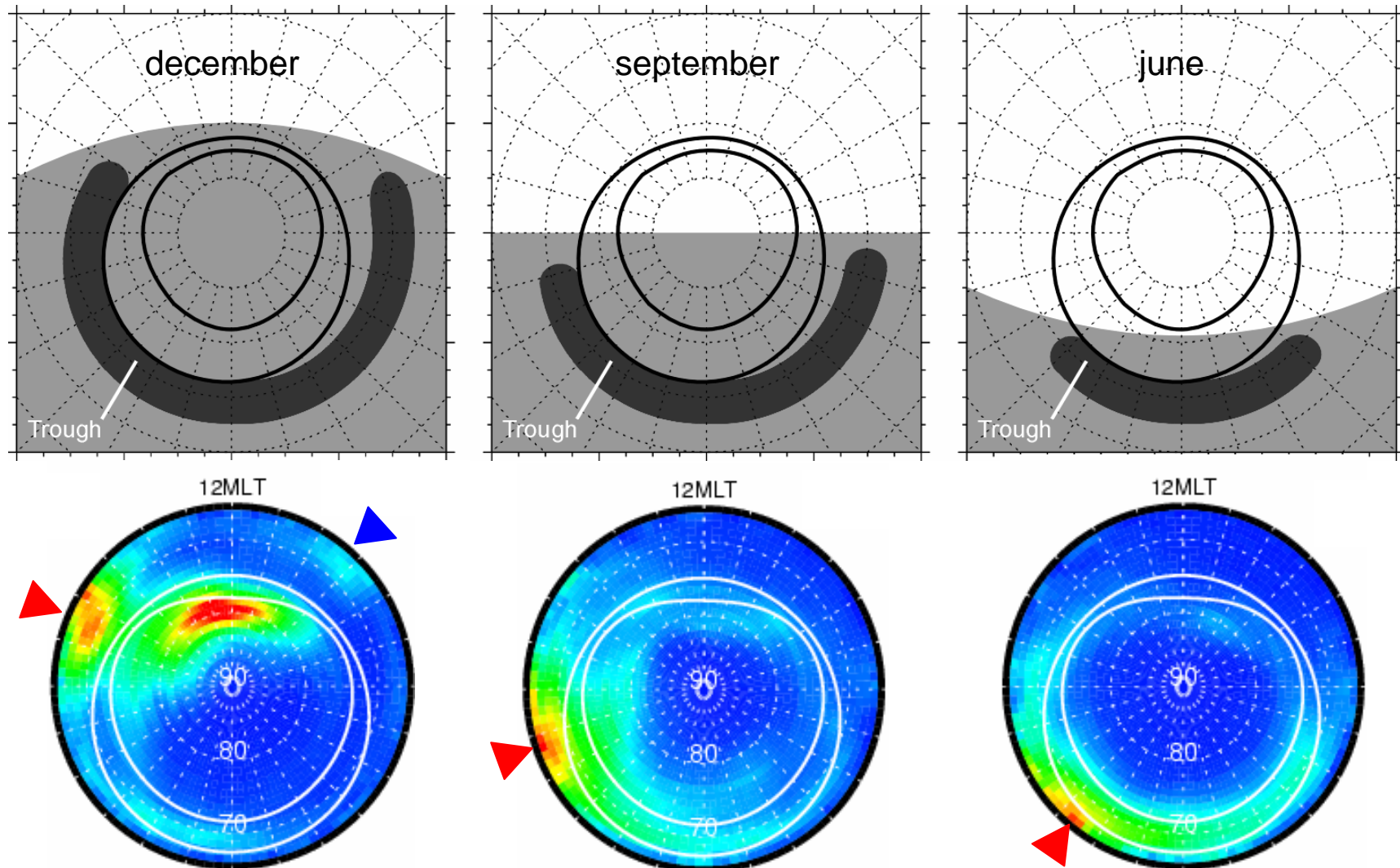
Combination of the **electron density gradient** and **ambient electric field** could generate irregularities

- **midlatitude trough** : electron density structure
- **westward return flow** : plasma drift (poleward E-field)



Seasonal variation of DUSE

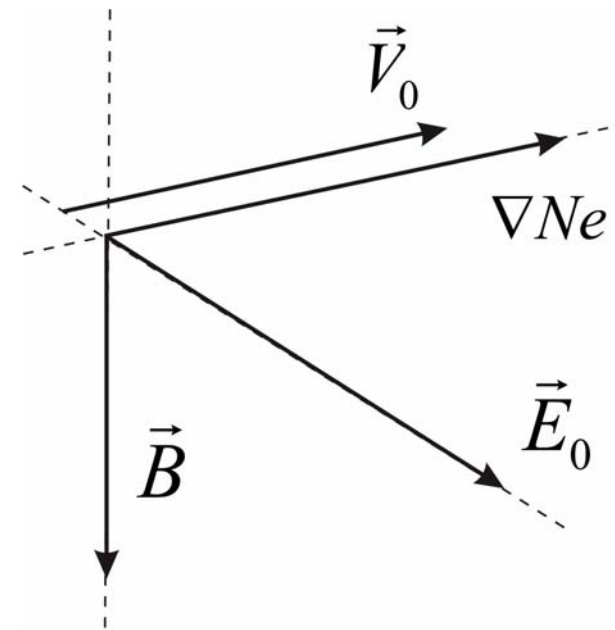
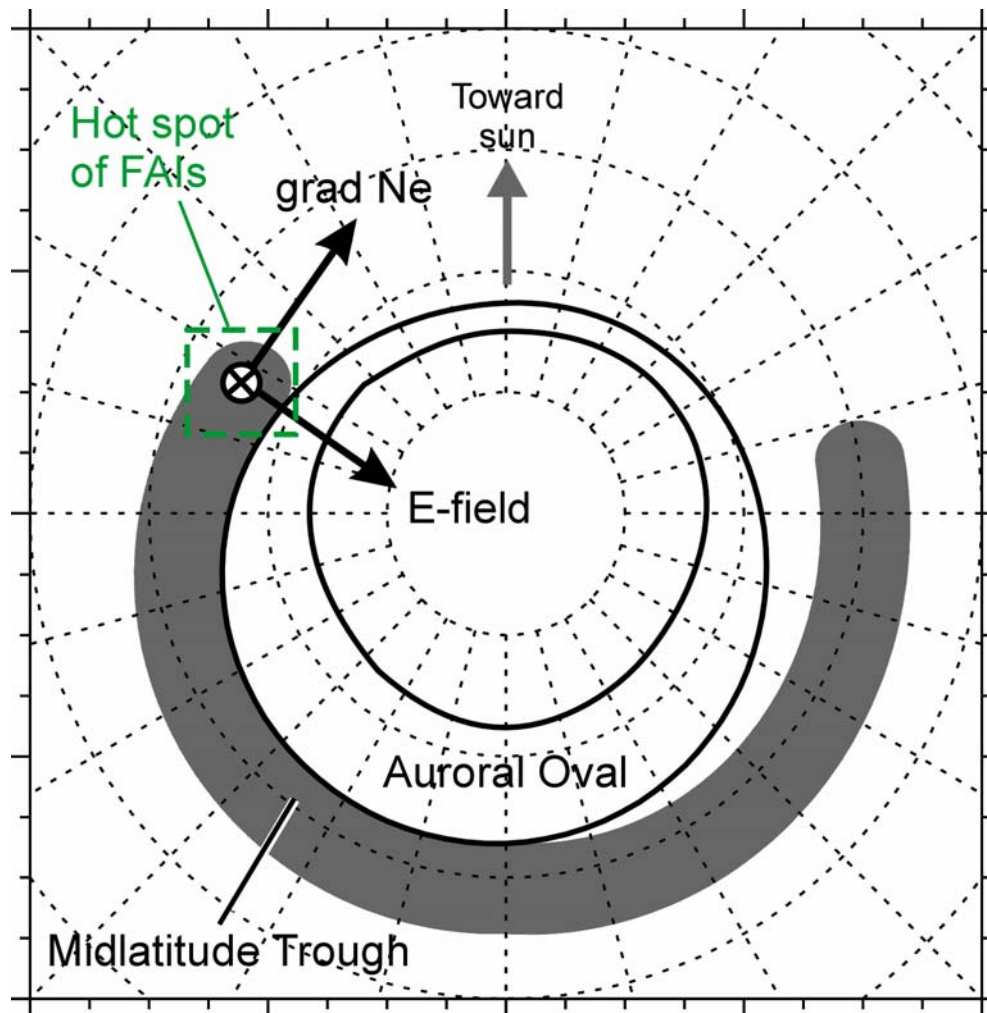
dusk scatters are always collocated with the sunward edge of trough.



Hosokawa et al. (2001)

Model based on gradient-drift instability (GDI)

Requirement: **background plasma drift is parallel to the electron density gradient**
(i.e. electric field is perpendicular to the electron density gradient)



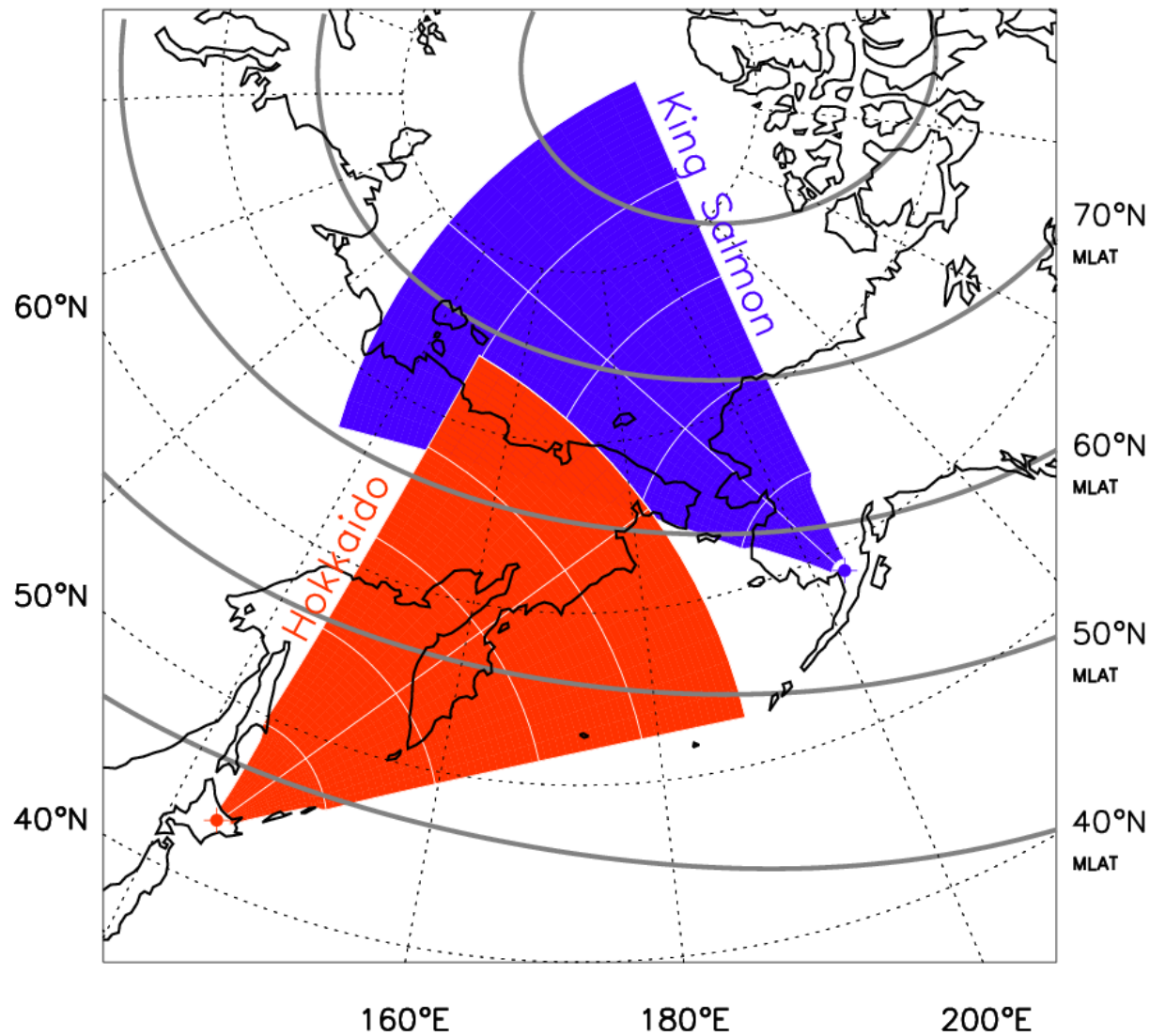
$$\gamma = \frac{V_0}{L} \quad : \text{growth rate}$$

$$V_0 = \frac{E_0}{B} \quad : \text{drift velocity}$$

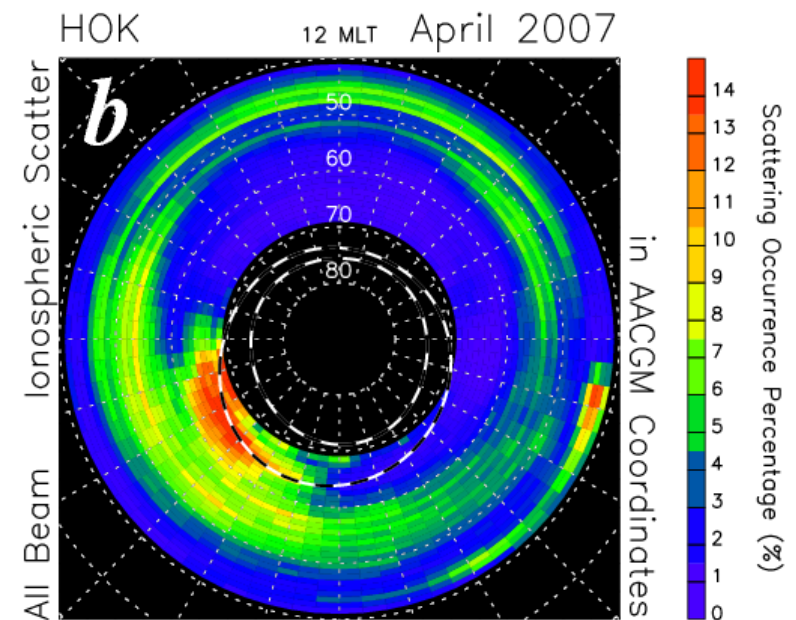
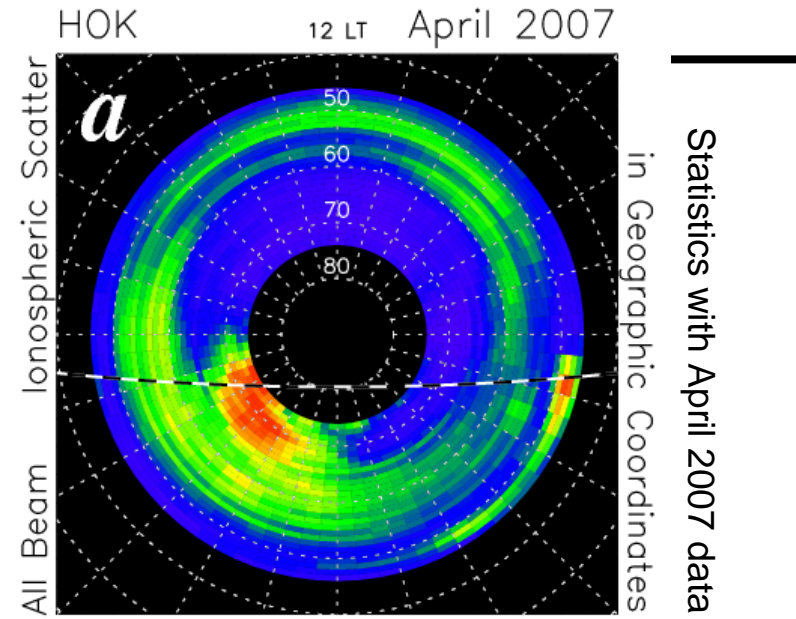
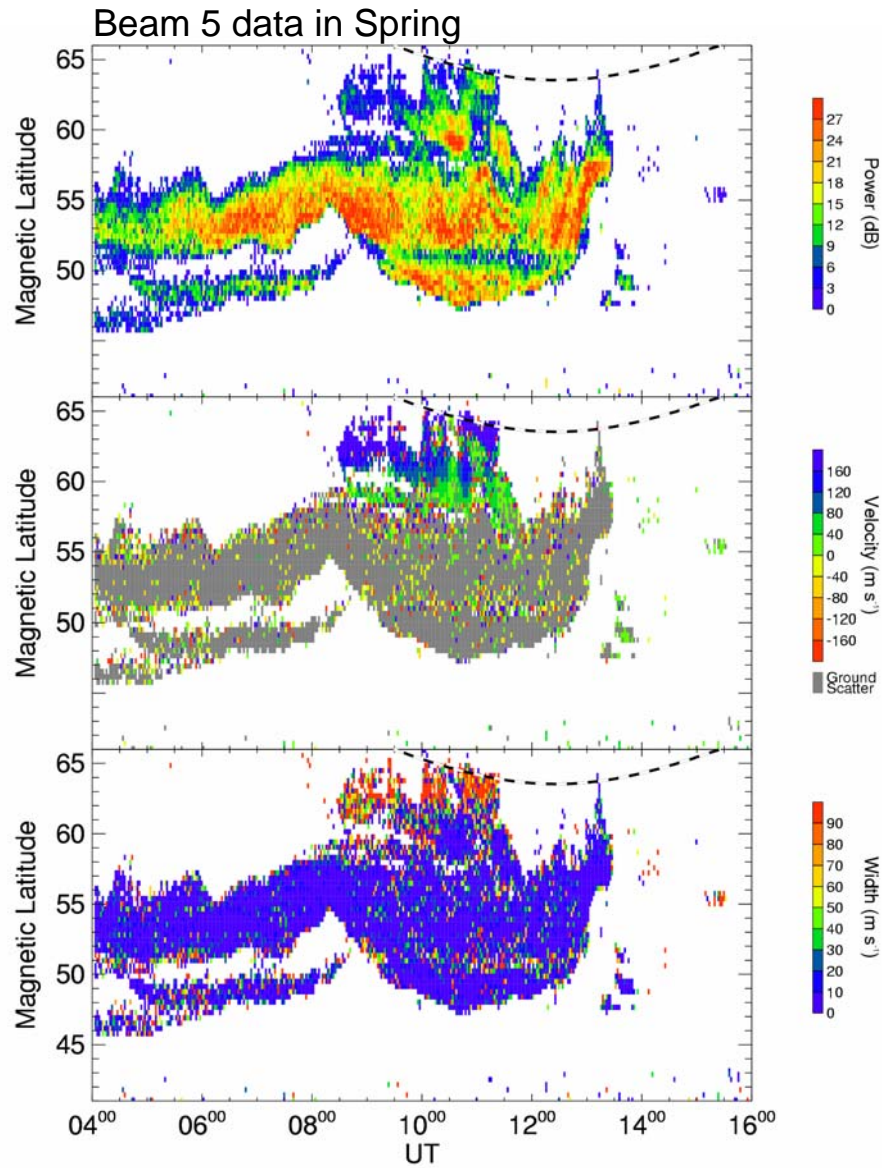
$$L = \frac{Ne}{\nabla Ne} \quad : \text{density gradient scale length}$$

Japanese radars in the Far-East

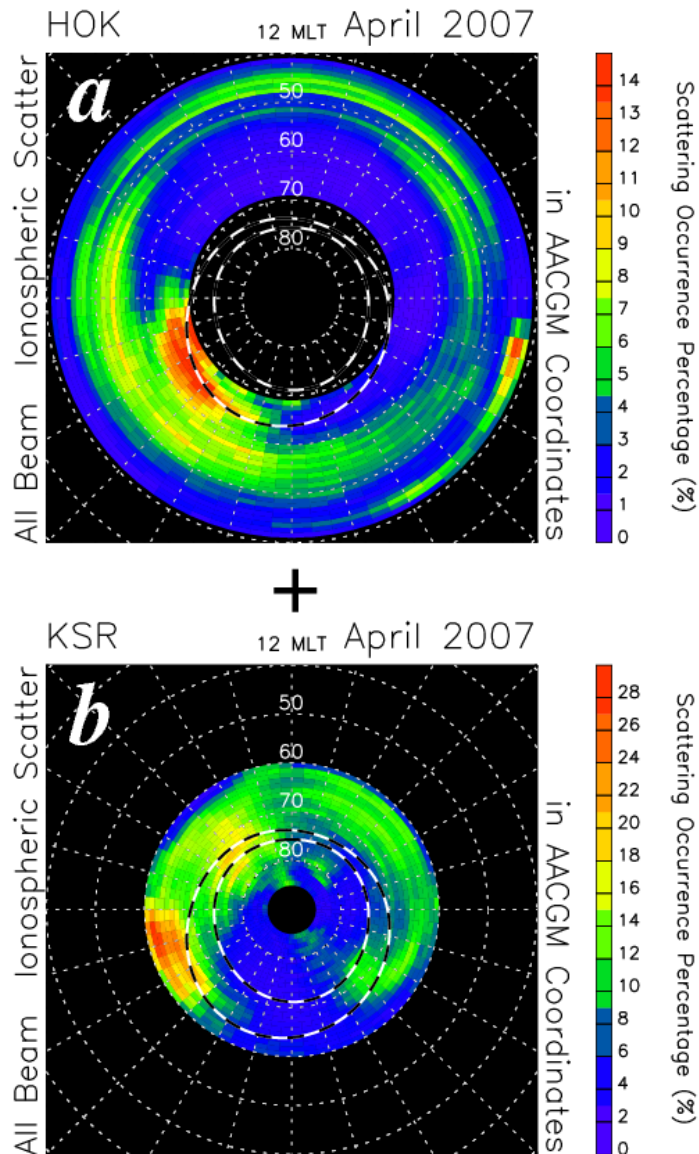
Seamless coverage of the subauroral ionosphere.



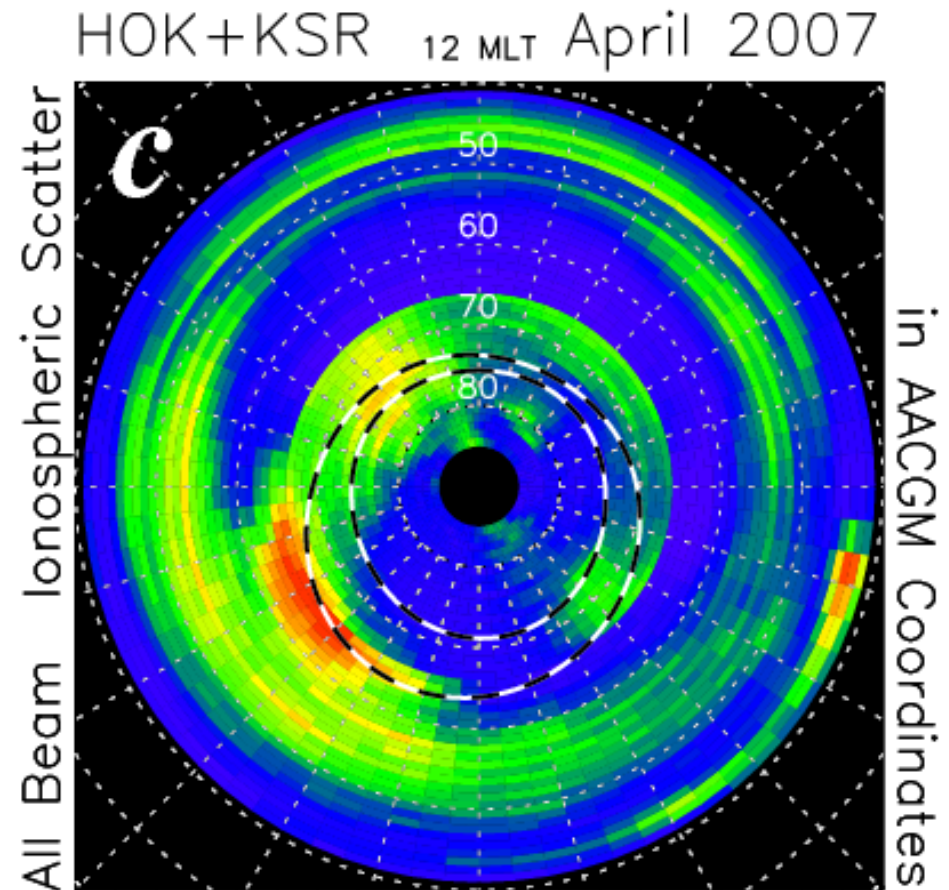
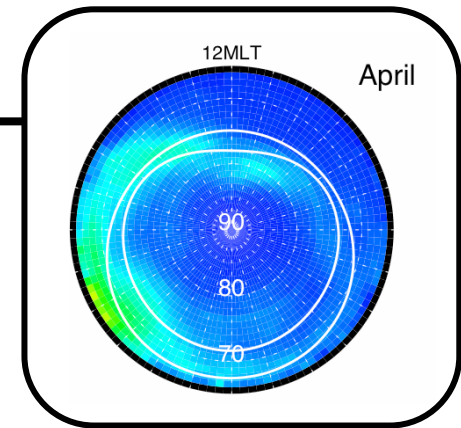
DUSE seen from Hokkaido

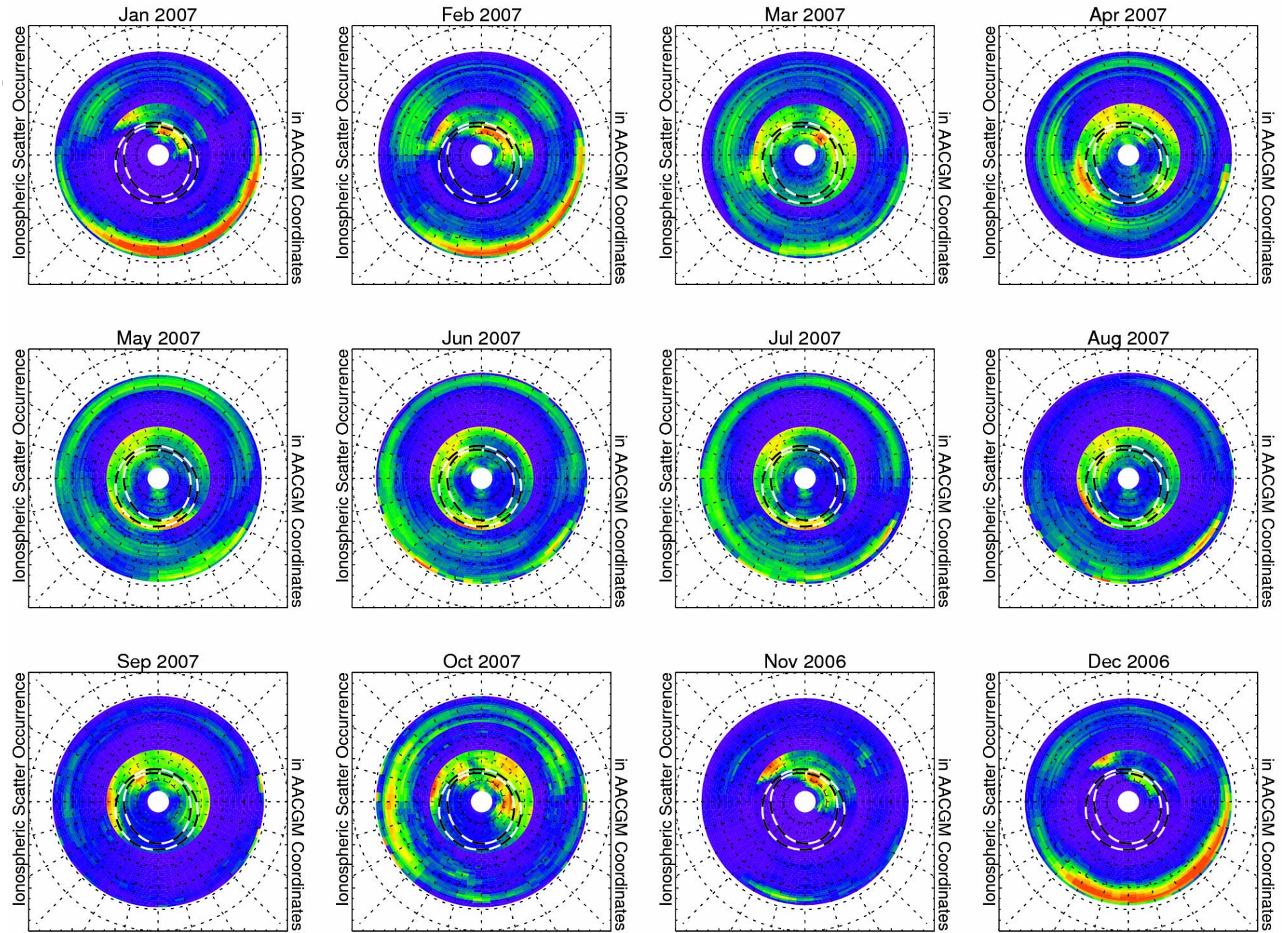


Combining data from the two radars

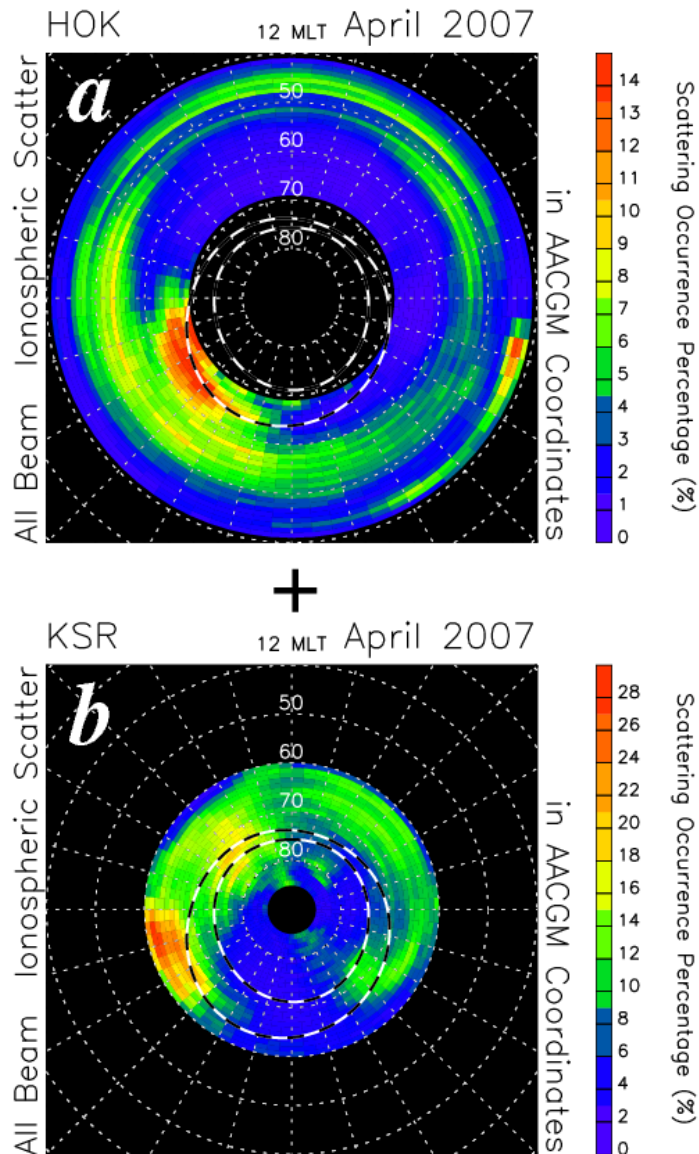


- Prominent DUSE activity equatorward of the oval.
- another peak is seen in the lower latitude part.

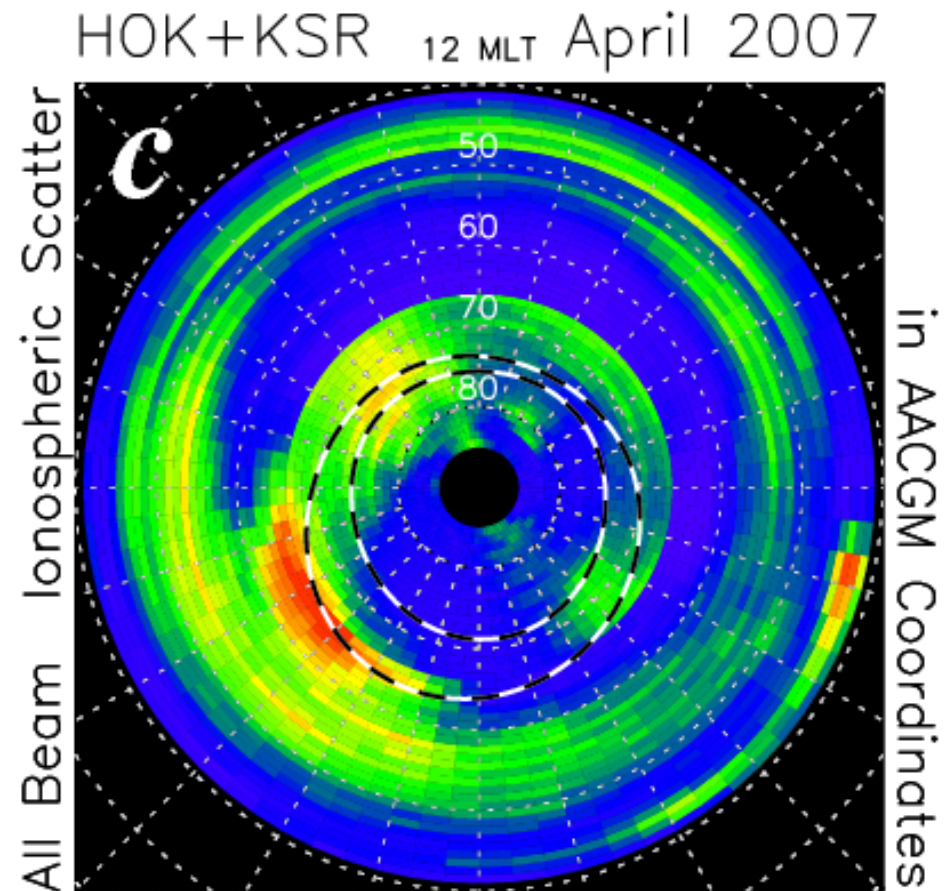
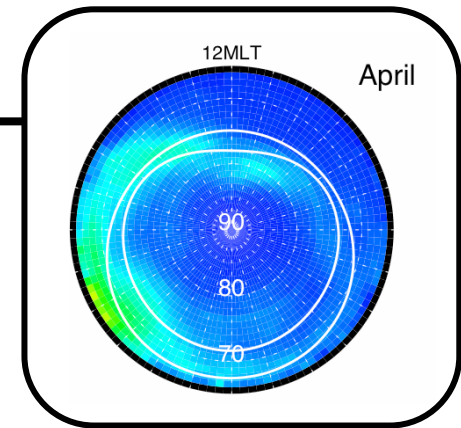




Combining data from the two radars



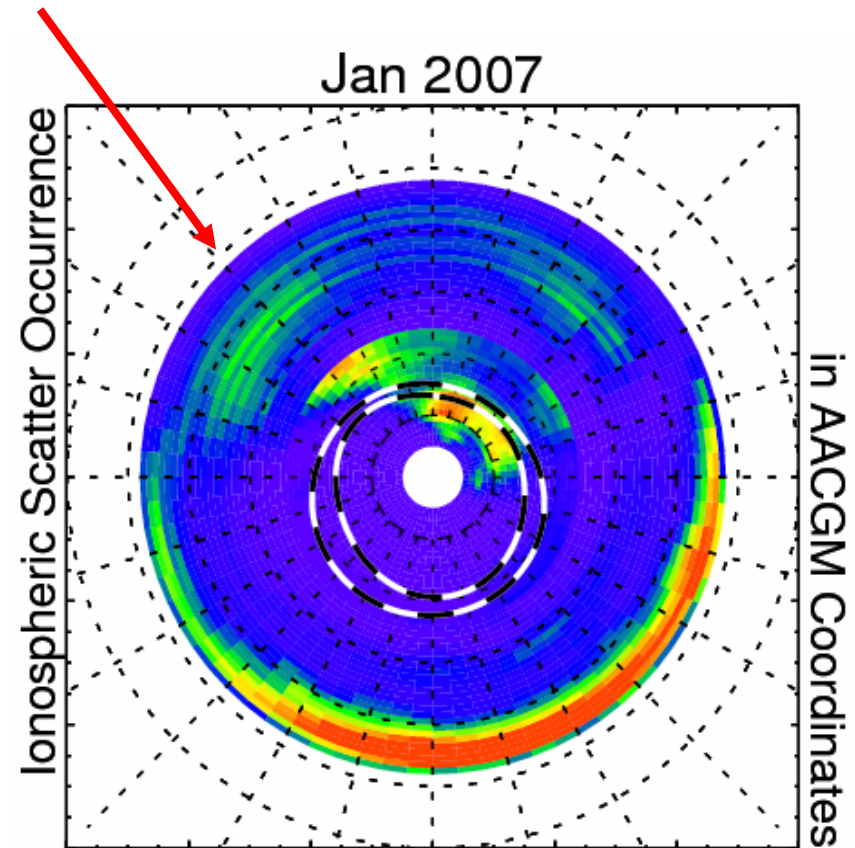
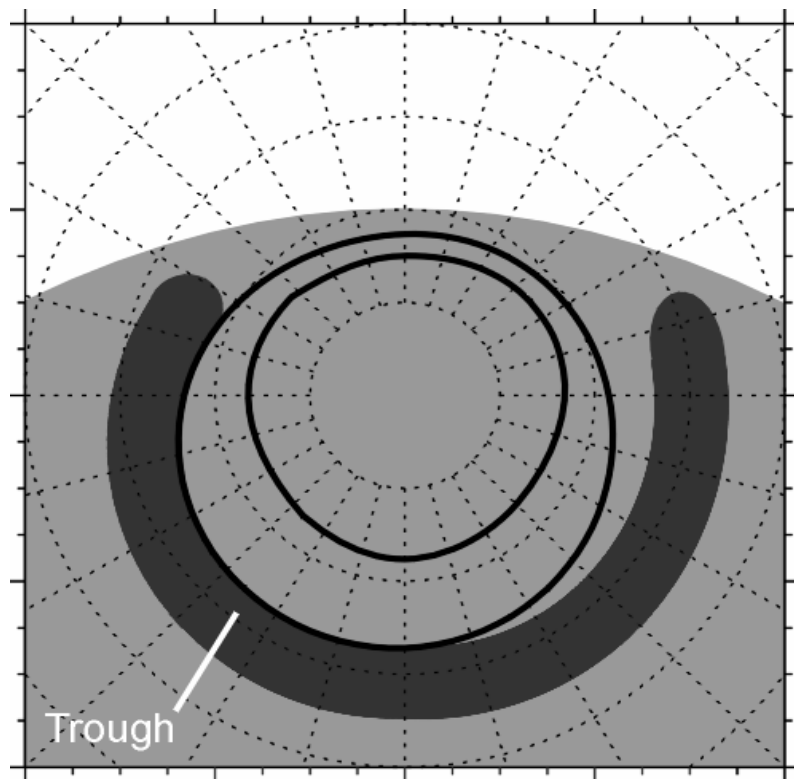
- Prominent DUSE activity equatorward of the oval.
- **another peak is seen in the lower latitude part.**



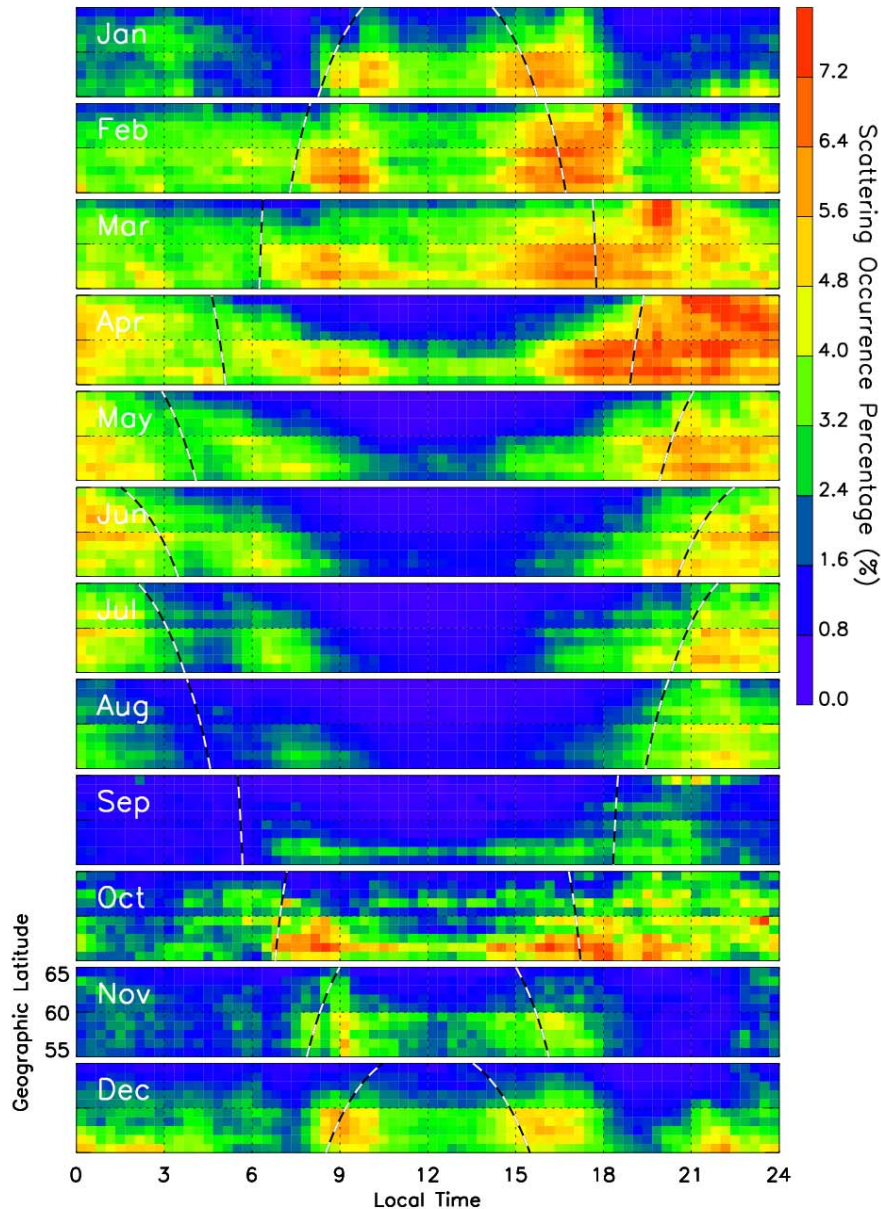
Lower latitude DUSE?

Another weak enhancement of backscatter occurrence rate is found ...

What is this?

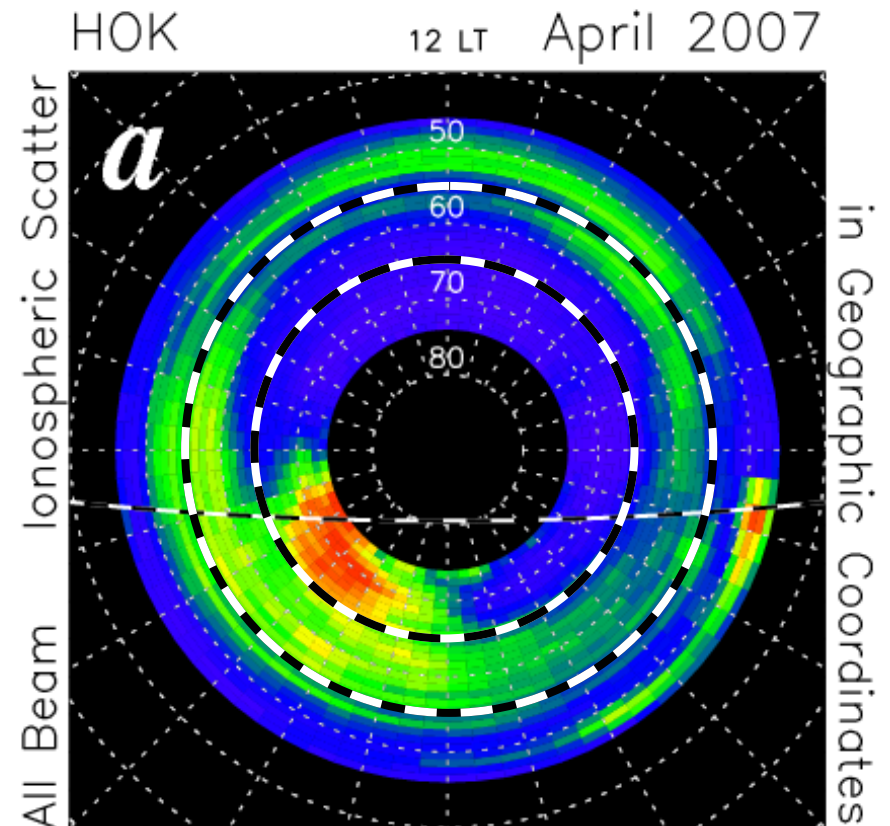


Lower latitude DUSE (LL-DUSE)



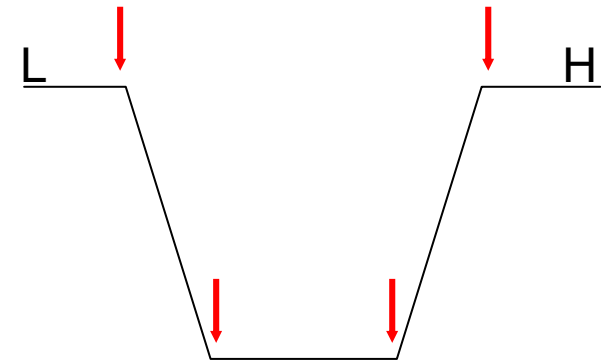
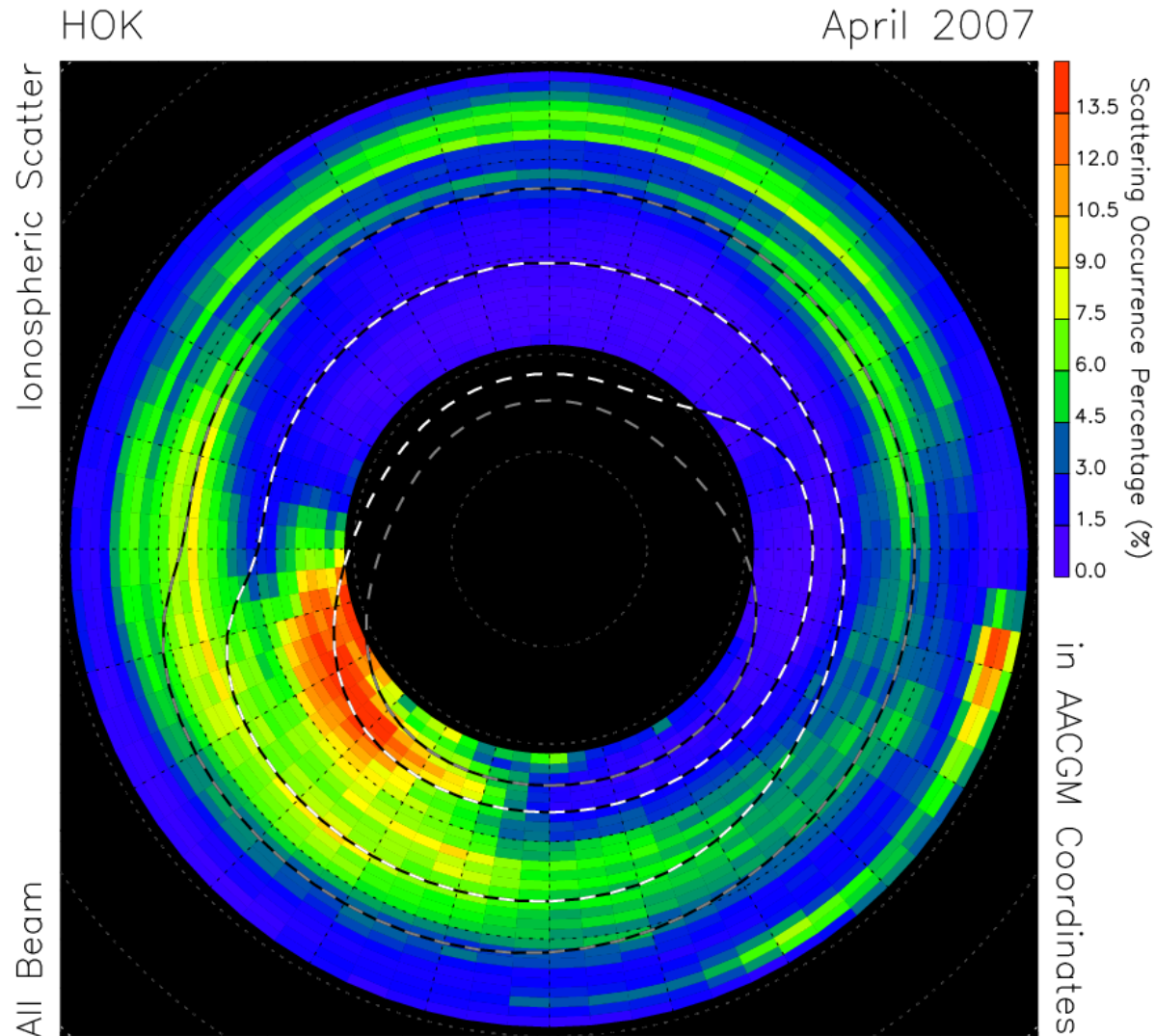
Local time where the lower latitude DUSE appear changes systematically probably according to the motion of the terminator.

But there exist considerable offset between the source of LL-DUSE and sunset.

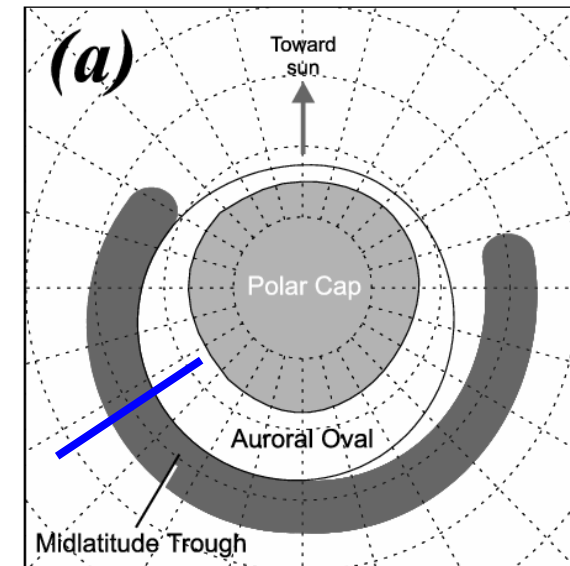


Comparing with the trough model

LL-DUSE seem to be collocated with the equatorward wall of the trough.

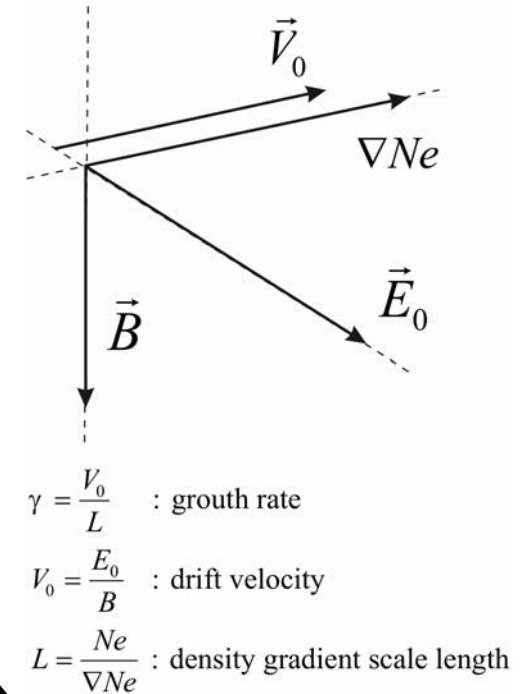
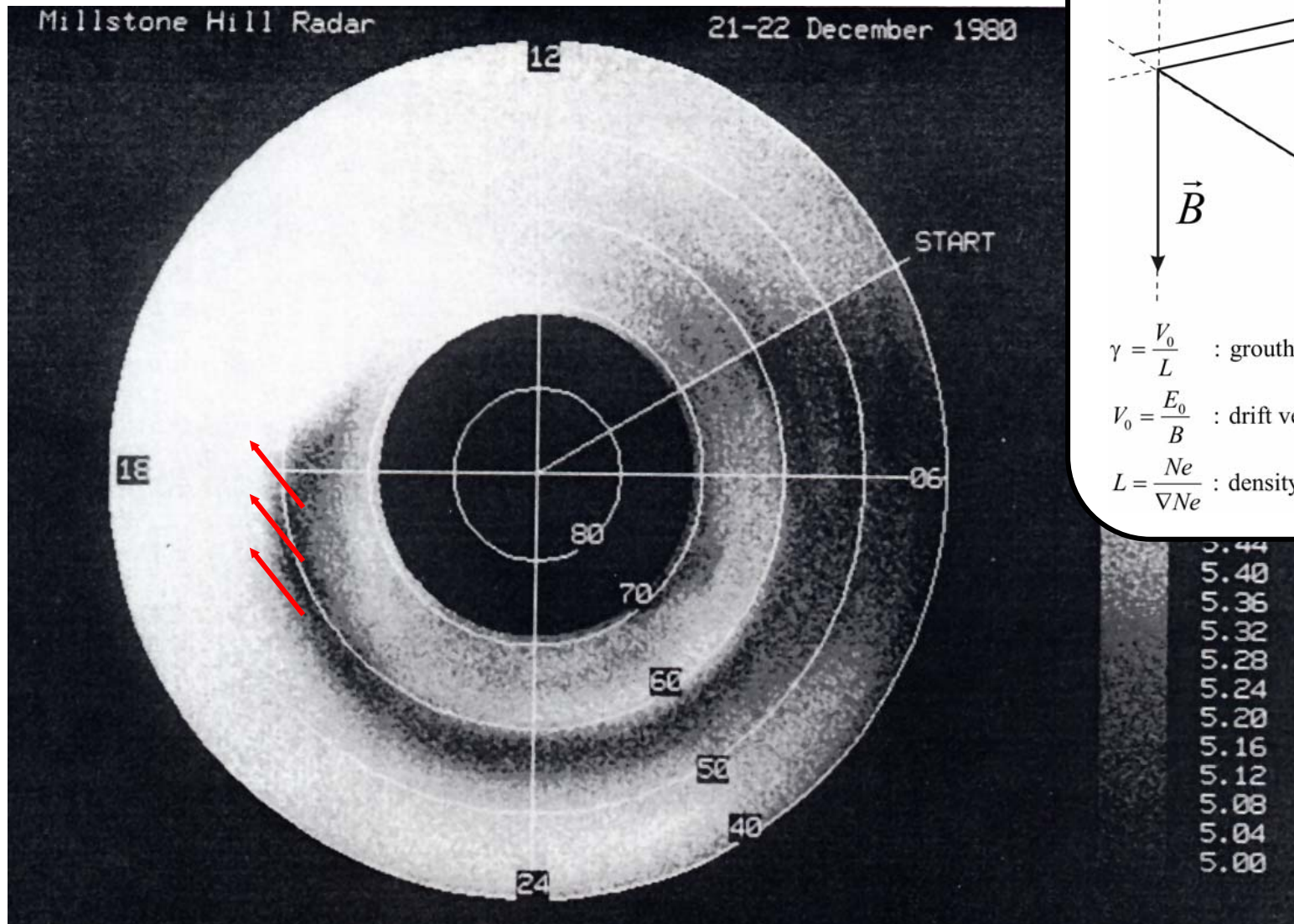


Halcrow and Nisbet (1977)



Generation of lower latitude DUSE

Equatorward flow (westward e-field) is needed...



Still considering ...

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courtesy of Tsugawa-san

Lower latitude DUSE

