

(photo: 2007/02/22)

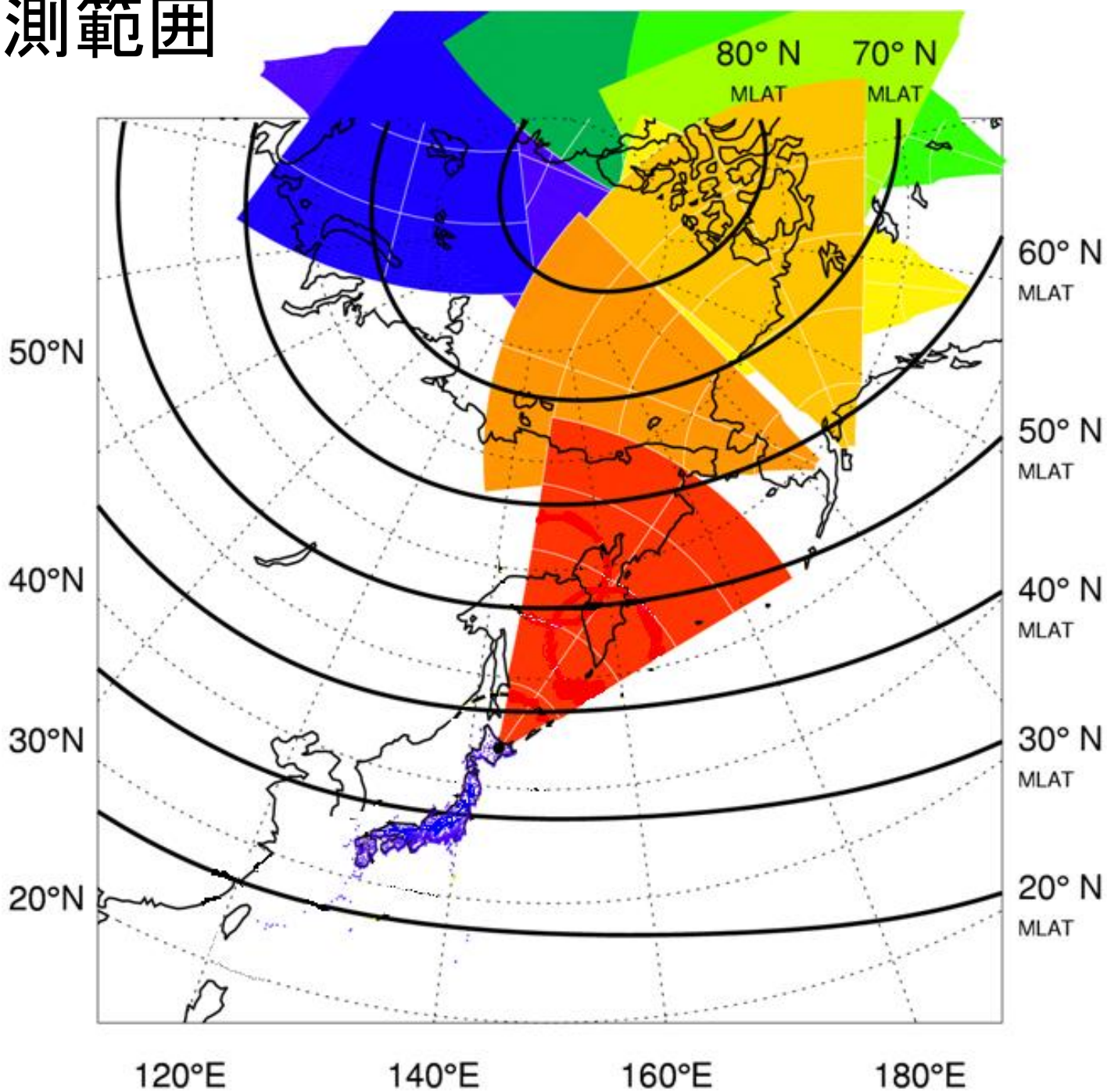
# 2006年12月15日に 北海道-陸別HFレーダーとGEONETで 観測された大規模伝搬性電離圏擾乱

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細川敬祐(電通大)、齊藤昭則(京大理)、  
北海道-陸別HFレーダー研究グループ

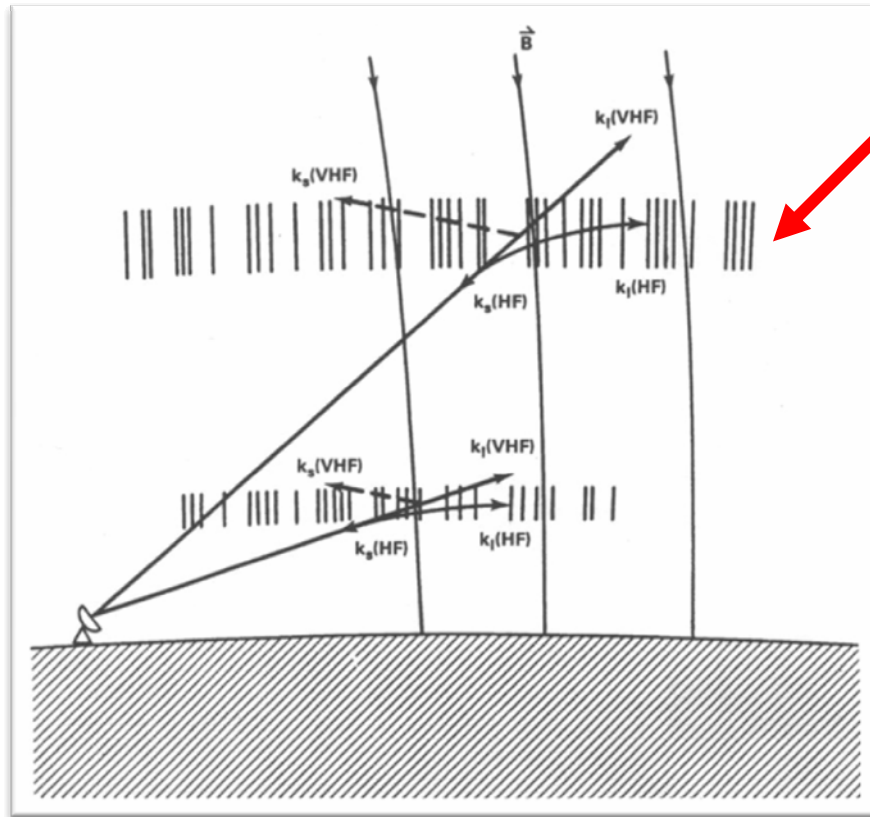
# 研究目的

- 2006年11月、STE研は北海道にHFレーダーを設置
- 2006年12月15日にHFレーダーとGPSのTEC(全電子数)データからLSTID（大規模伝搬性電離圏擾乱）に相当する変動が観測された。
- LSTIDについて、近年は、GPSのTECデータから解析されていたが、北海道HFレーダーの設置により、さらに緯度方向において広い観測が可能となった。
- これらの観測結果からLSTIDについて解析することで、新しい知見が得られることが期待できる。

# 觀測範圍



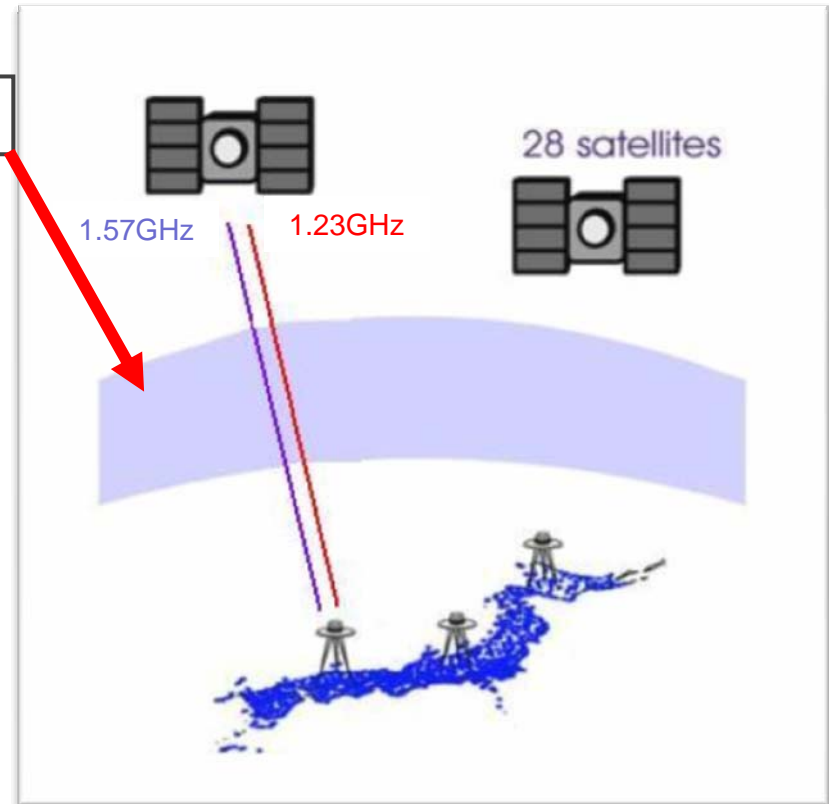
# 観測機器 (HFレーダーとGPS)



Greenwald et al.

返ってくる電波の周波数の違いから電離圏の電子の視点方向の速度を測定

電離圏



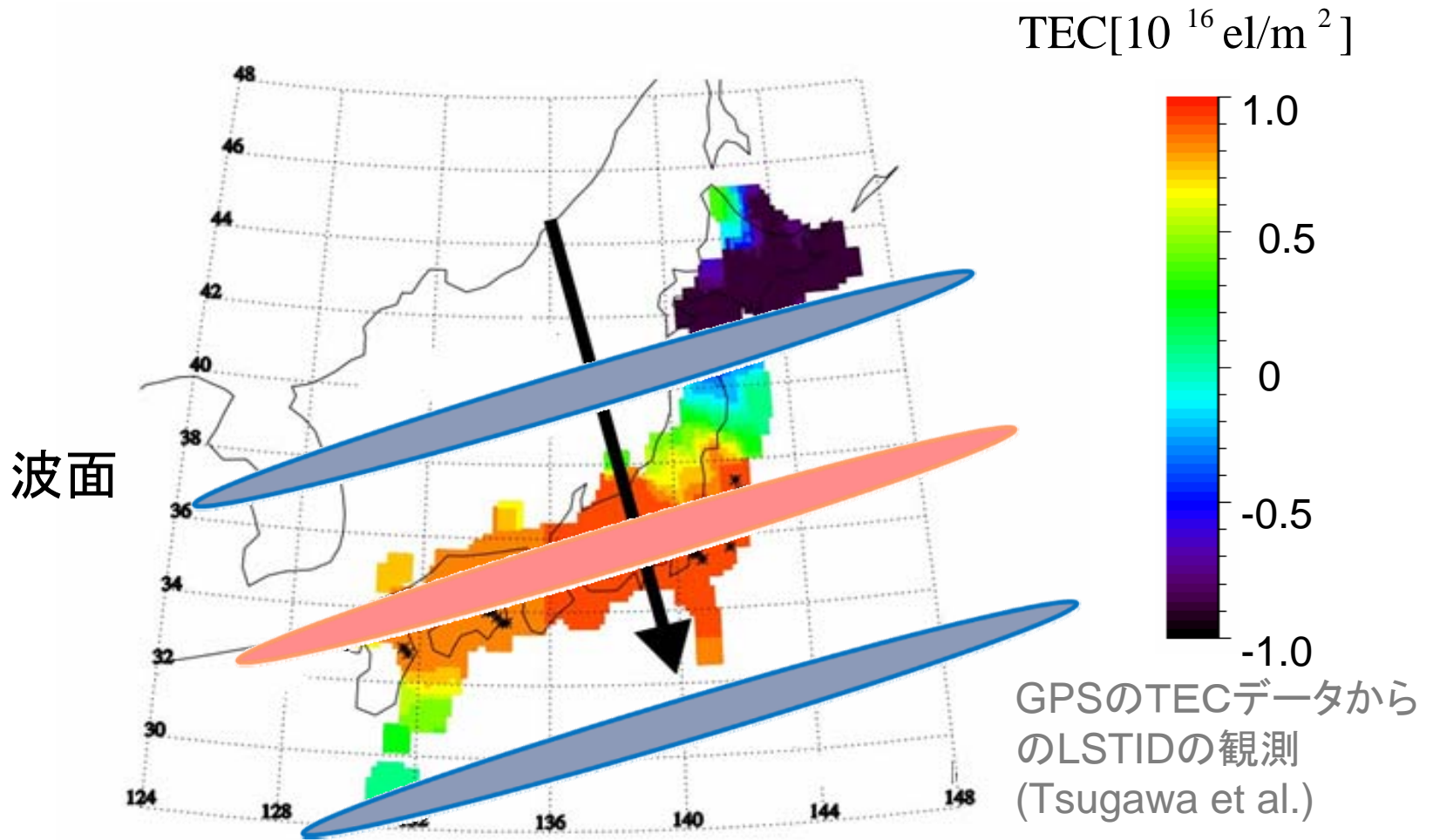
Tsugawa et al.

GPSの2周波の位相差を利用してパス上の全電子数(TEC)を測定



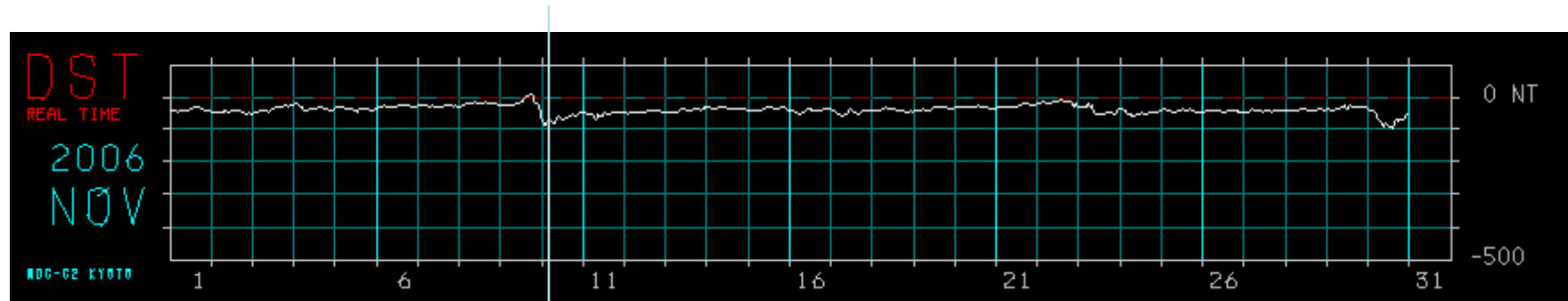
# 大規模伝搬性電離圏擾乱の特徴 [Hunsucker, 1982]

(LSTID: Large-Scale Traveling Ionospheric Disturbances)

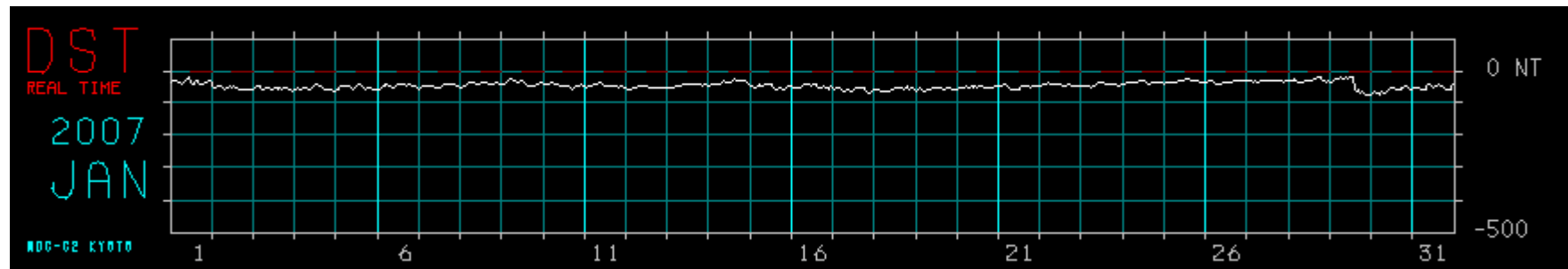
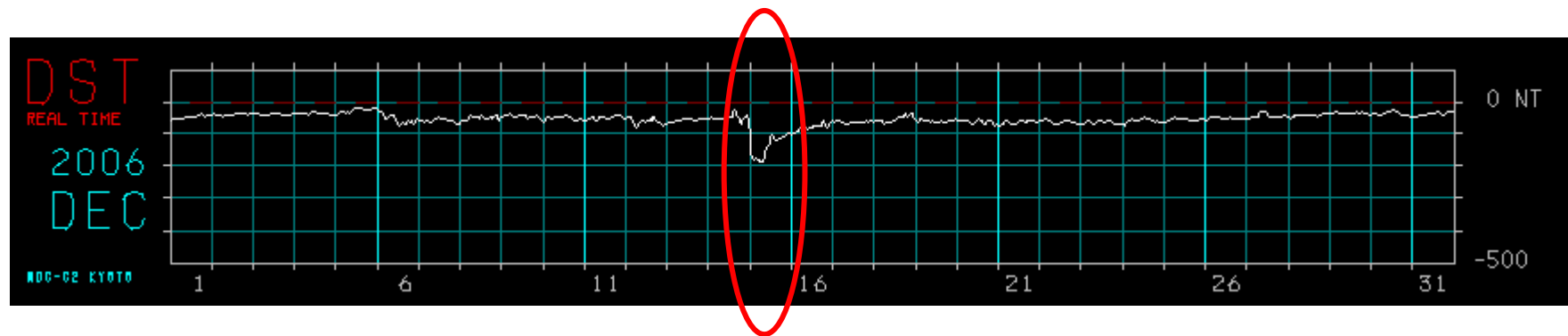


- 水平波長 1000km以上
- 位相速度 数100m/s - 1000m/s
- 周期 30分- 3時間
- TEC変動の振幅 10 - 20 %

# 運用開始後3ヶ月間(2006/11-2007/01) Dst index



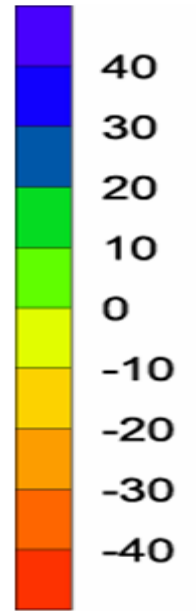
運用開始



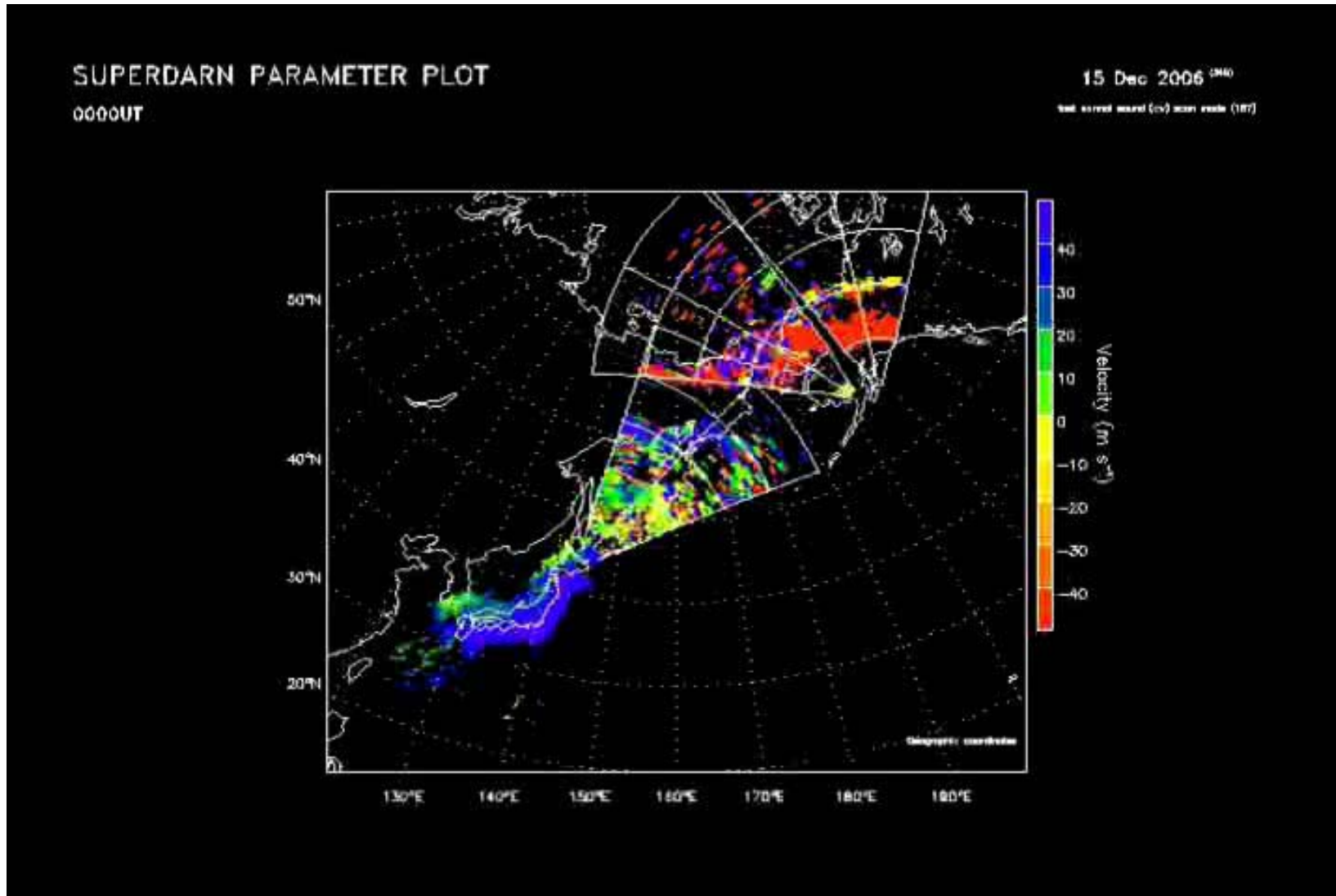
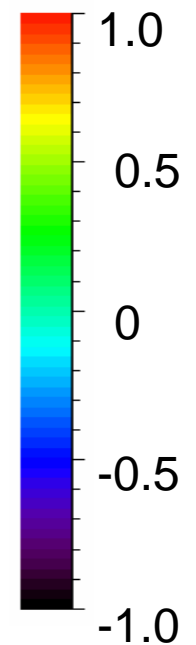
# 観測結果

2006/12/15  
0030-0230 UT  
0930-1130 LT

Velocity[m/s]



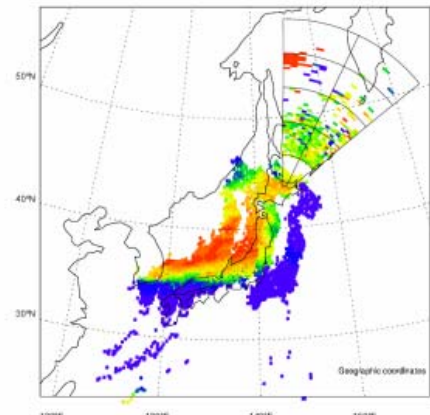
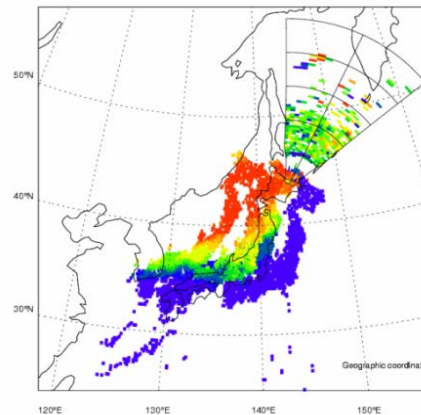
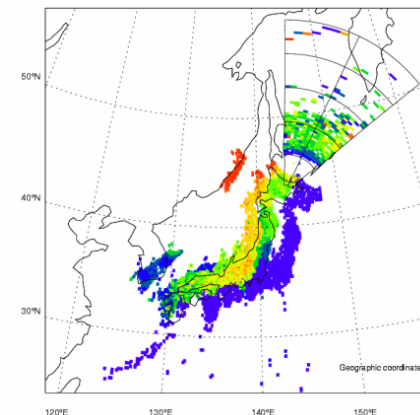
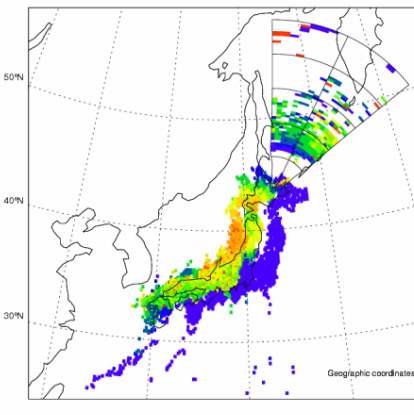
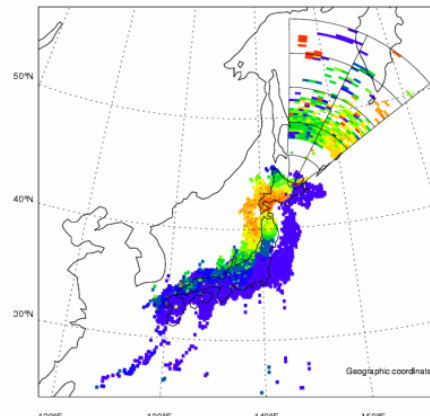
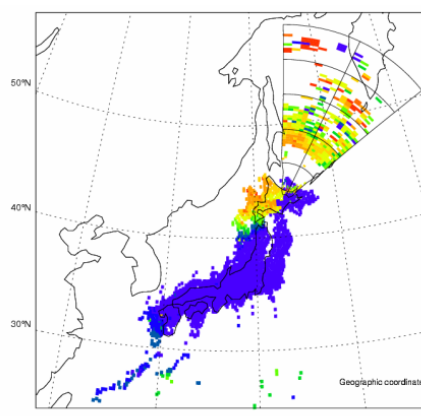
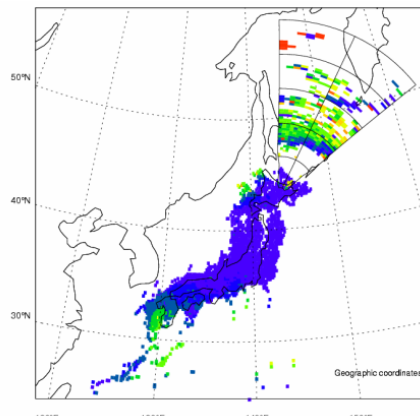
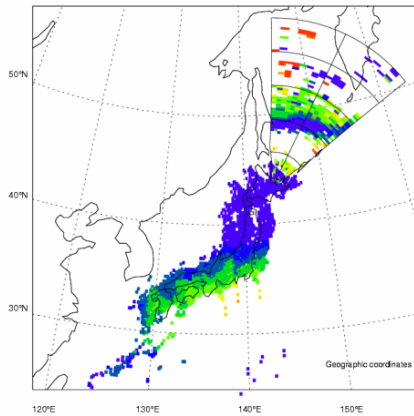
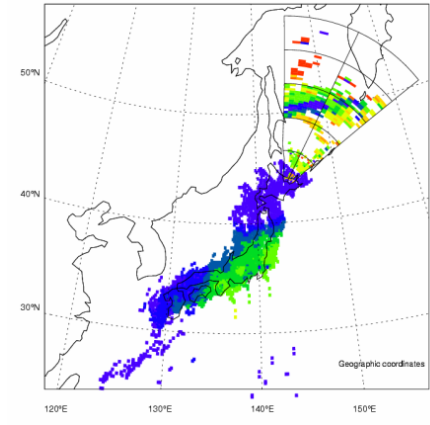
TEC[ $10^{16}$  el/m<sup>2</sup>]



# 南向きに伝搬する変動

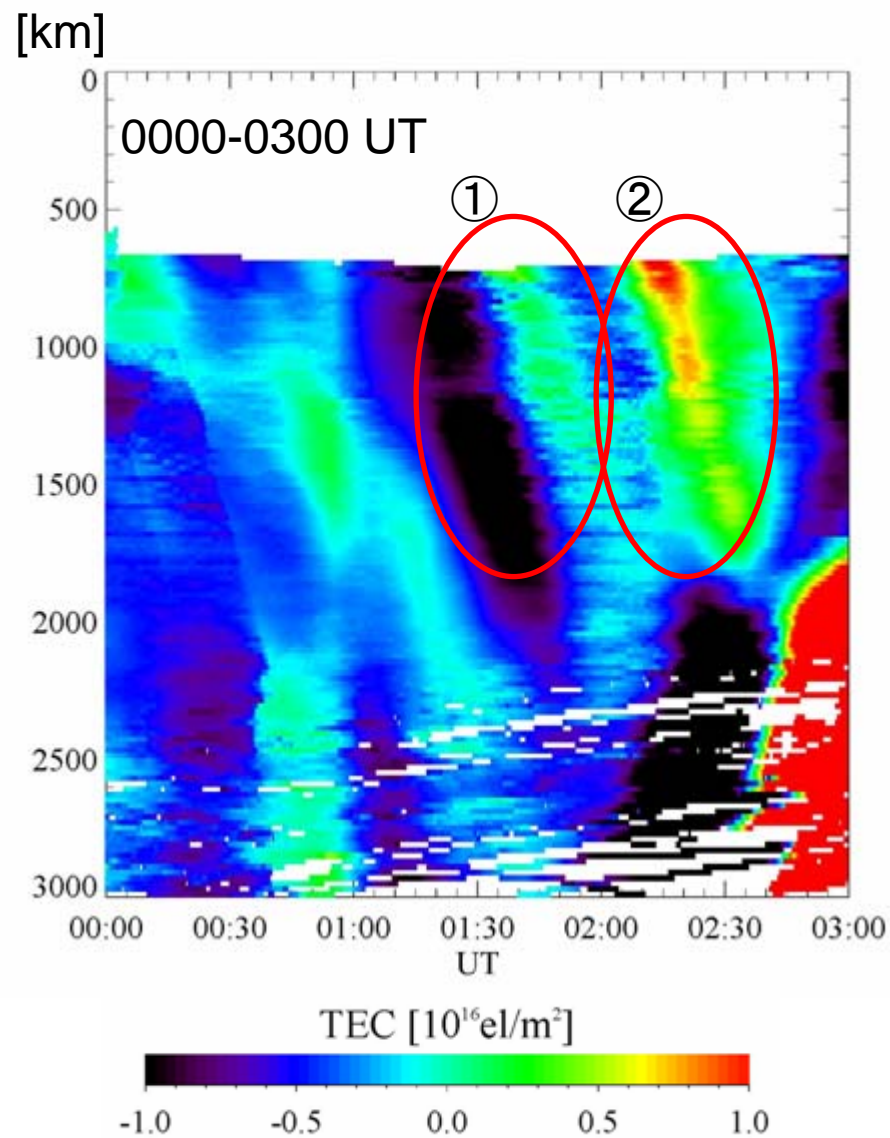
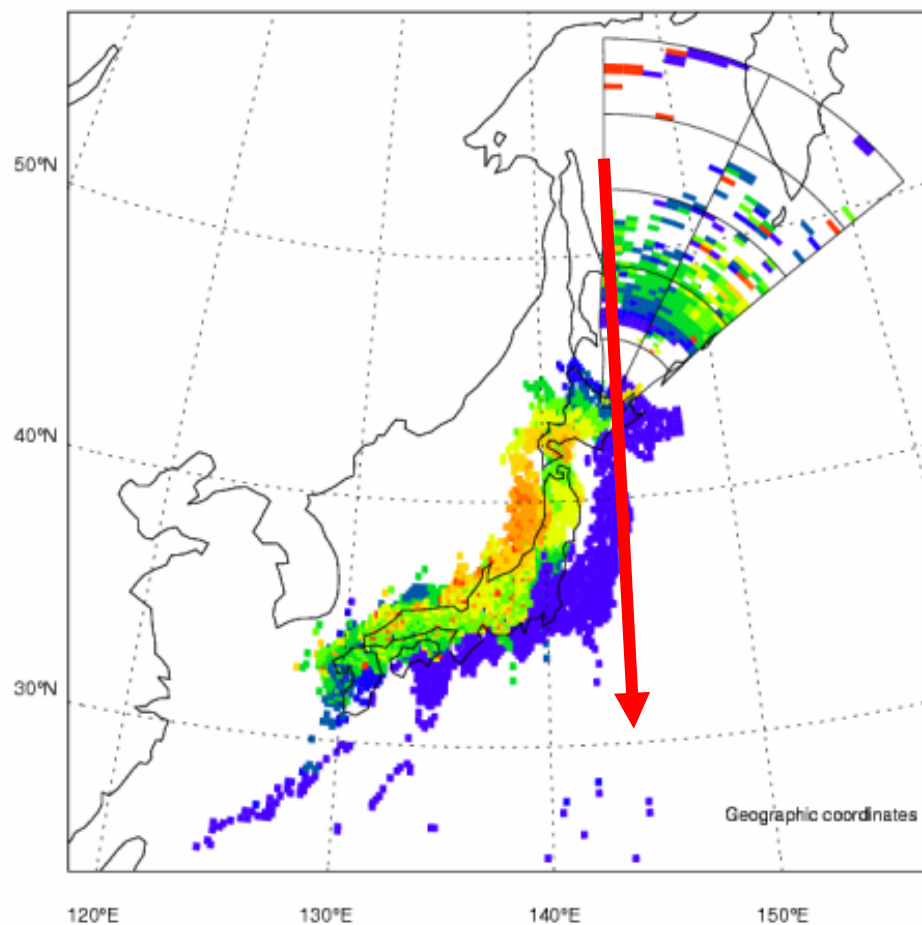
0110-0230 UT  
1010-1130 LT

SuperDARN : Doppler velocity  
GPS : TEC



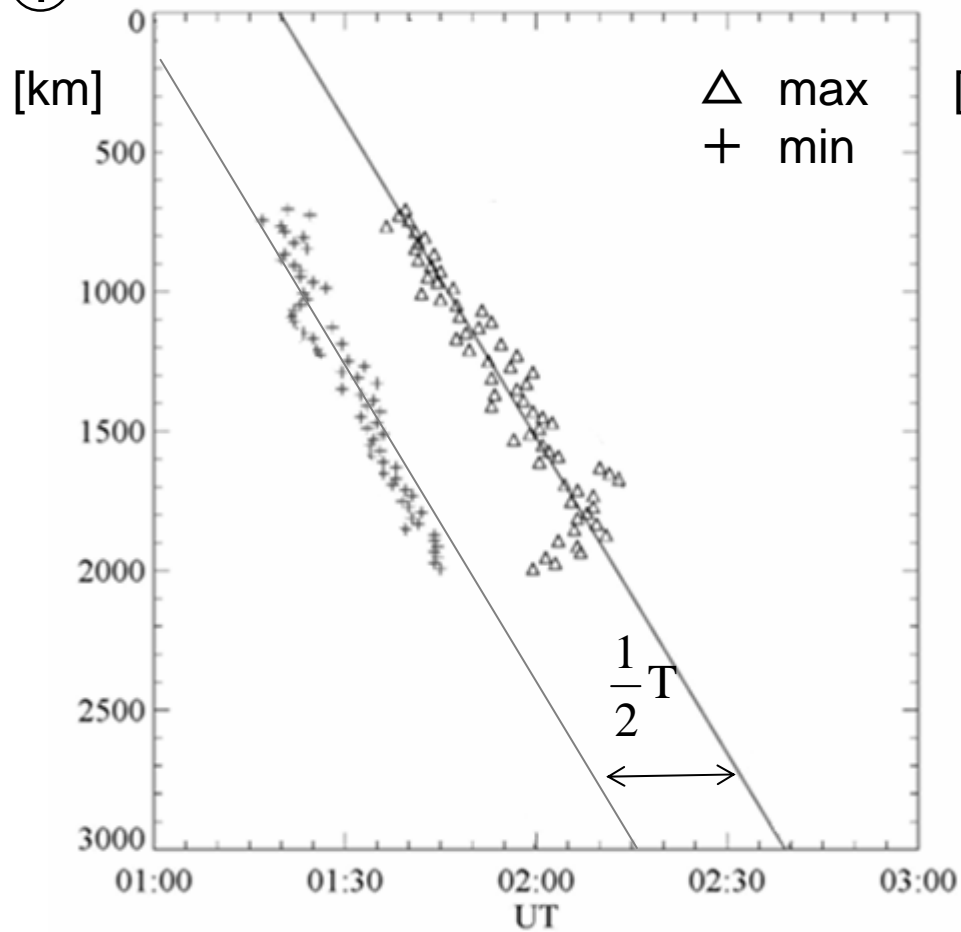


# 伝搬方向に沿った軸のGPSのTEC変動



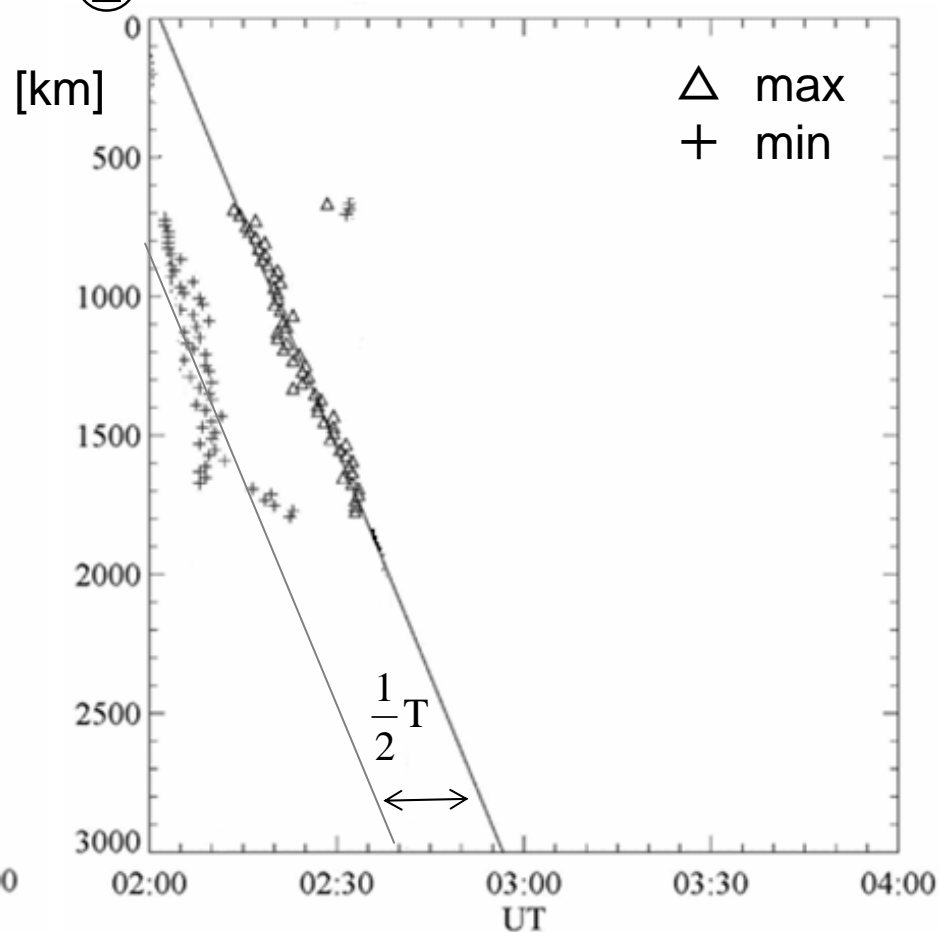
# 2つの南向きに伝搬する変動

①



伝搬速度 : 629 m/s  
 周期 : 47 min  
 波長 : 1773 km

②



伝搬速度 : 908m/s  
 周期 : 32min  
 波長 : 1743km

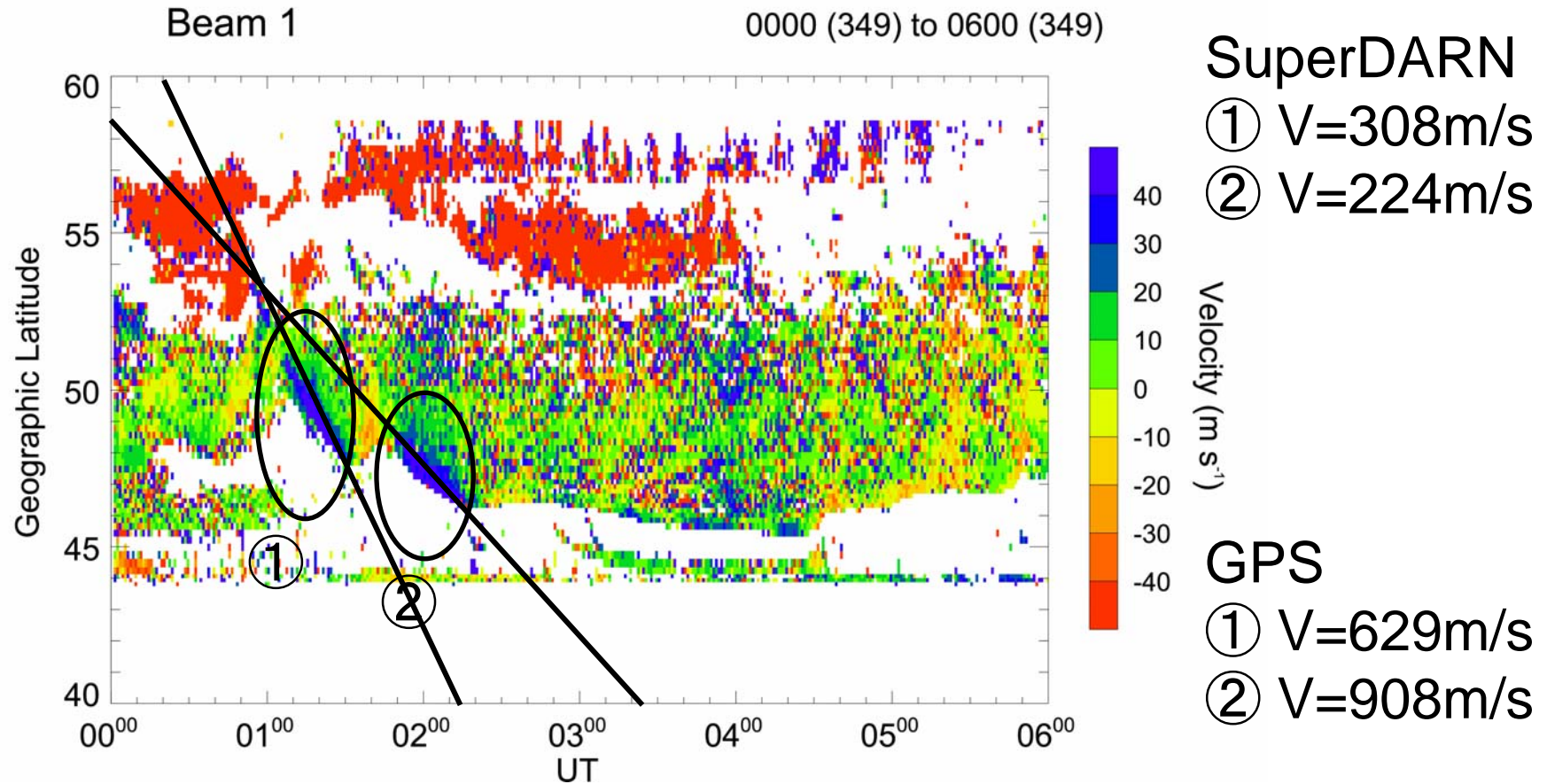
# 2006/12/15 SuperDARN

SUPERDARN PARAMETER PLOT

Hokkaido: vel

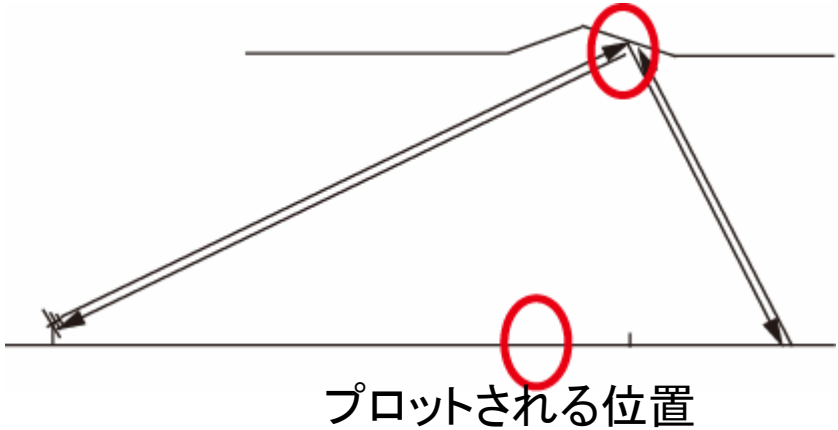
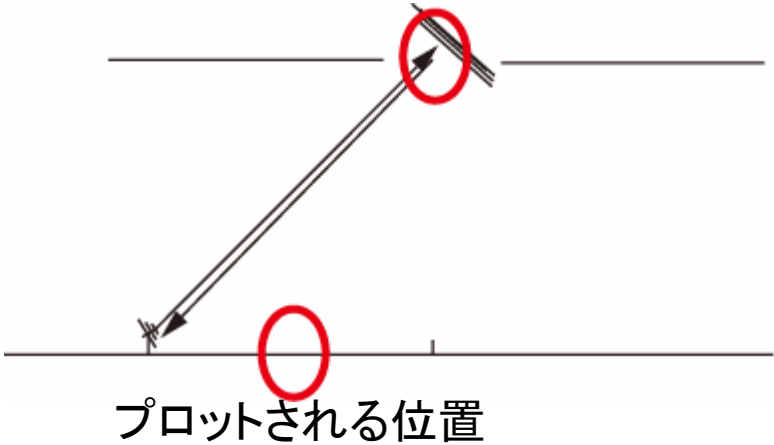
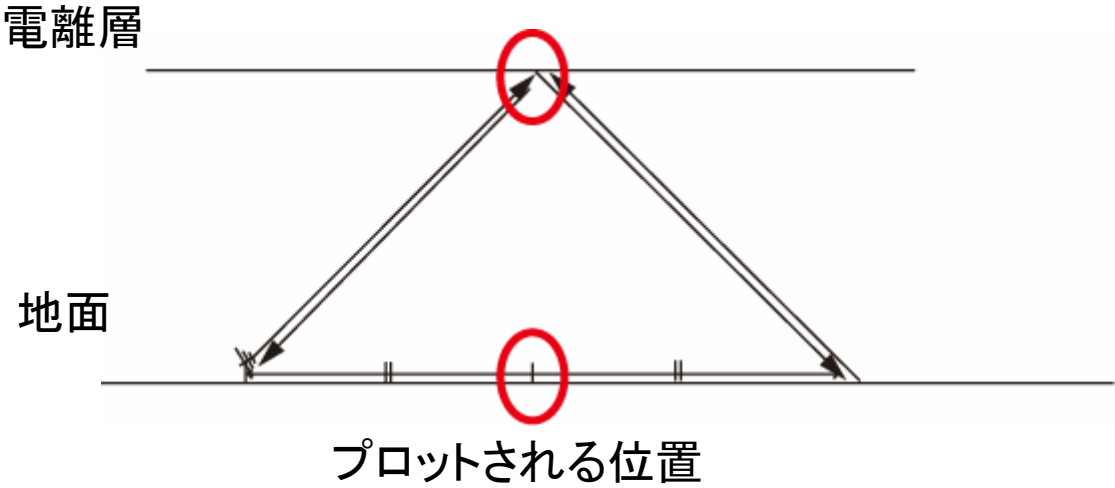
15 Dec 2006

fast normal (cw) scan mode (151)



Beam 1 横軸: 00 -06 UT 縦軸: 地理緯度  
(09 -15 LT)

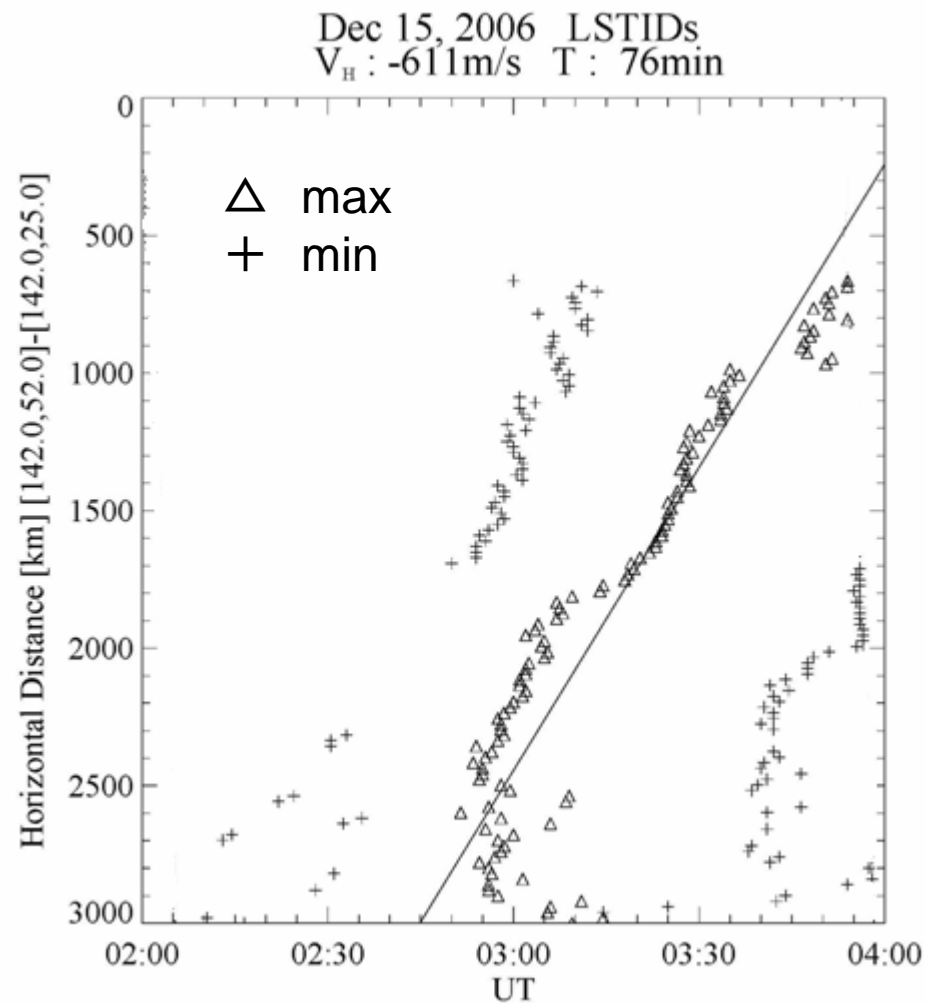
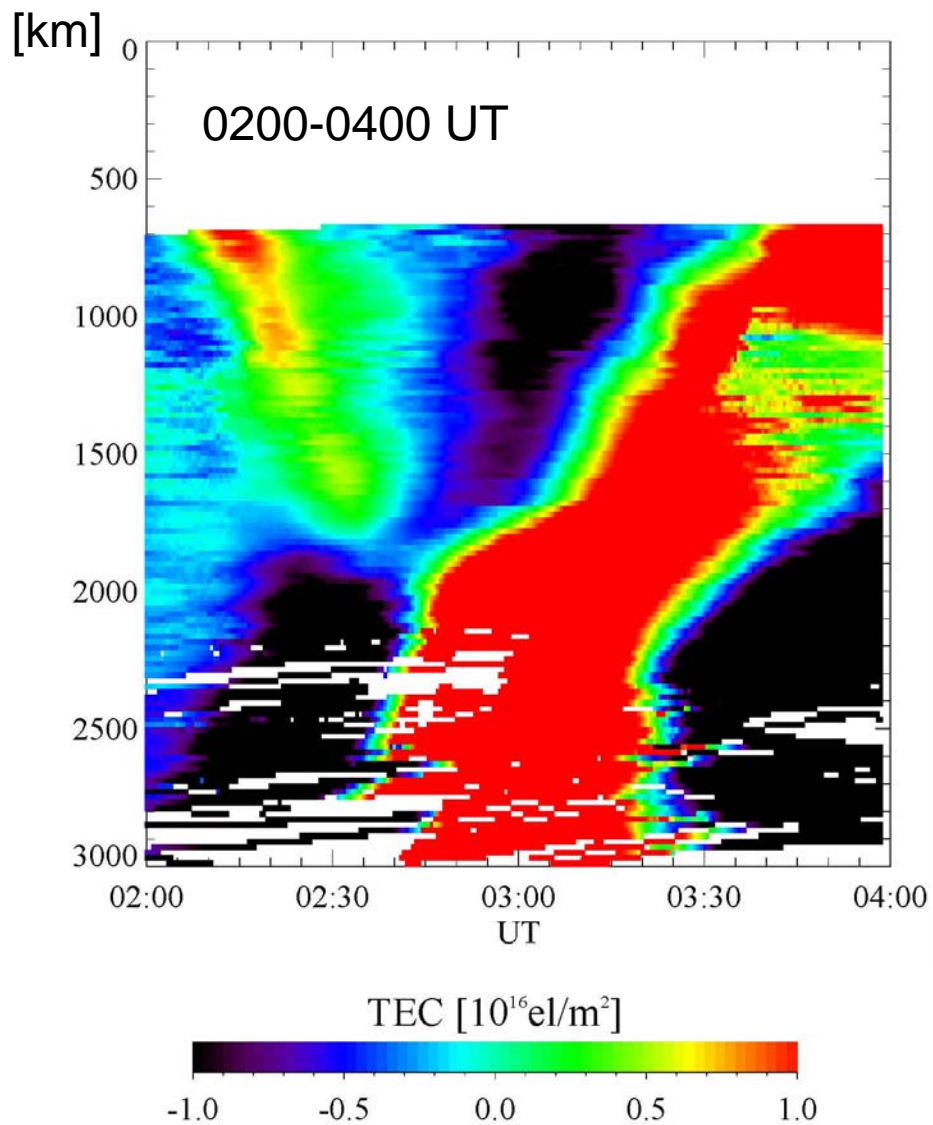
# 電波のエコー



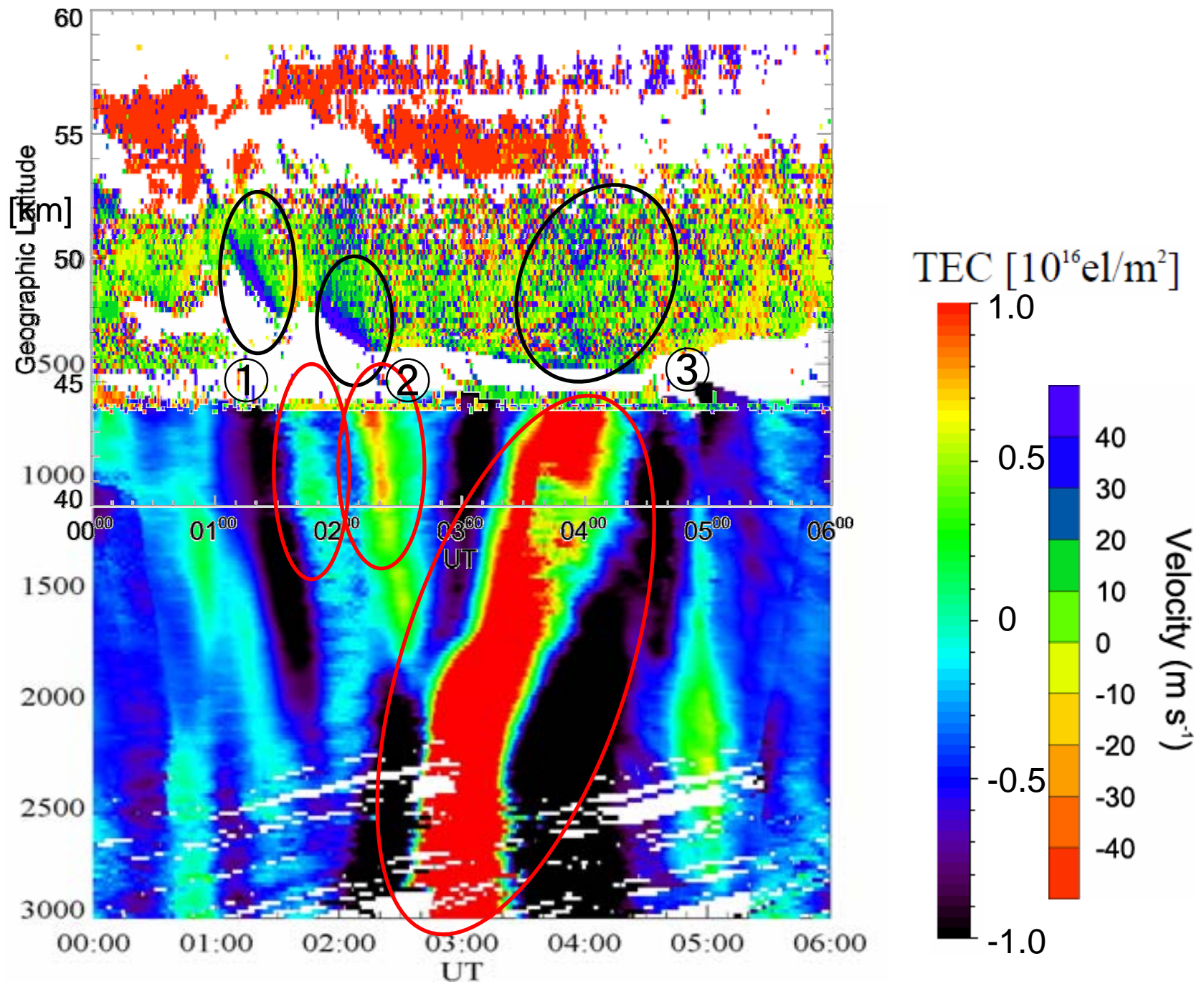
電離層に凹凸があるとプロットされる位置がずれる

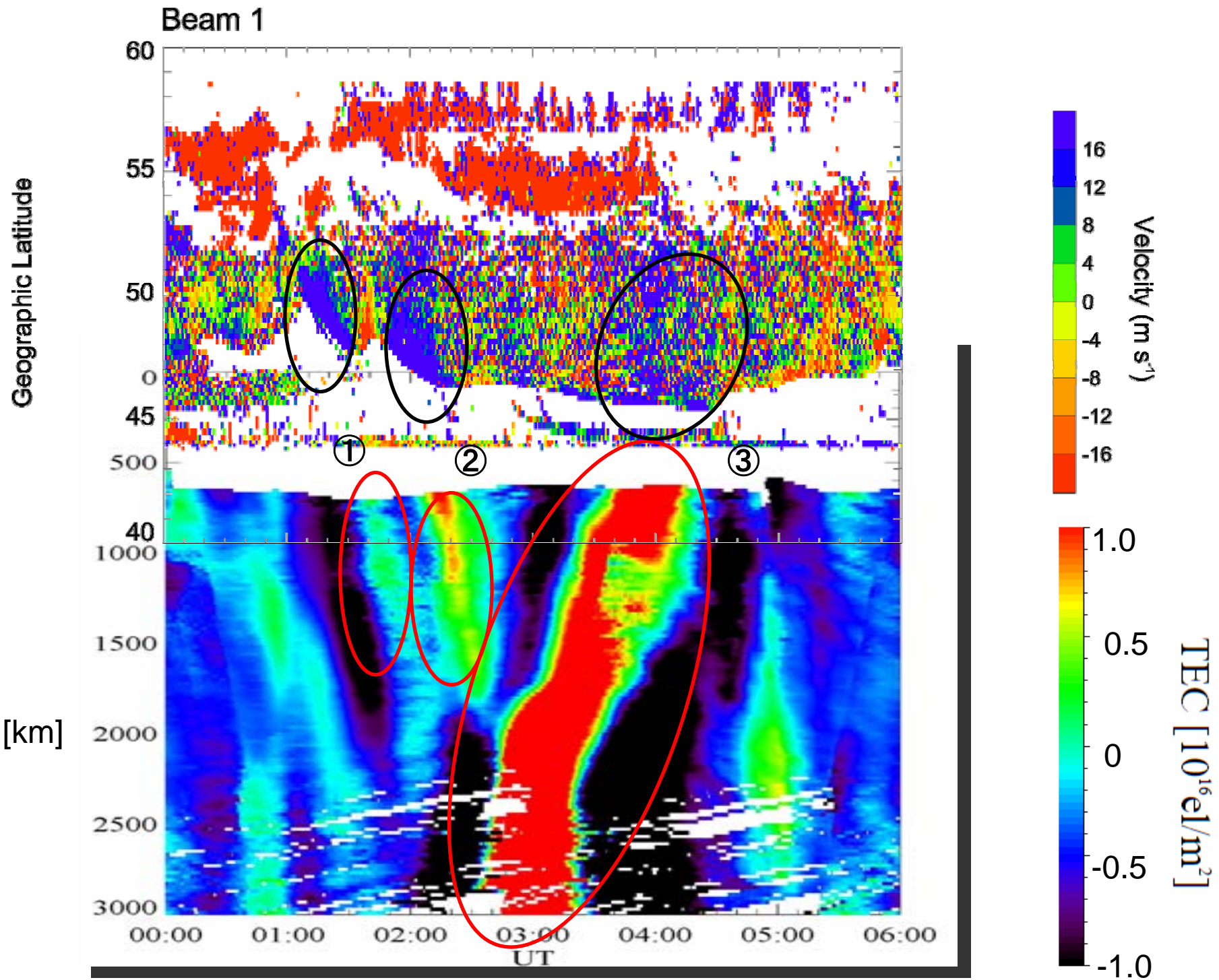






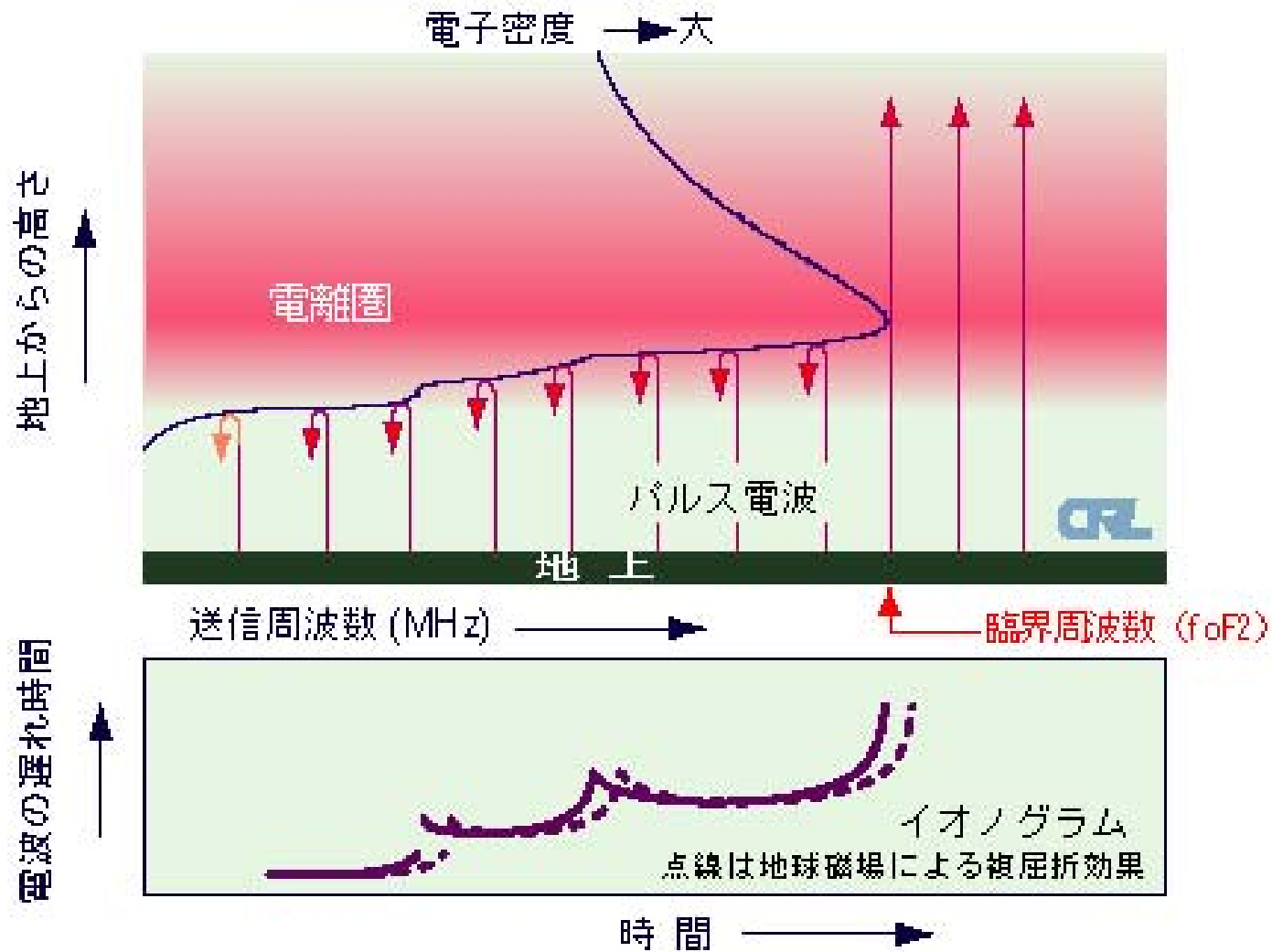
伝搬速度 : 北向きに611m/s  
 周期 : 76分  
 波長 : 2786km







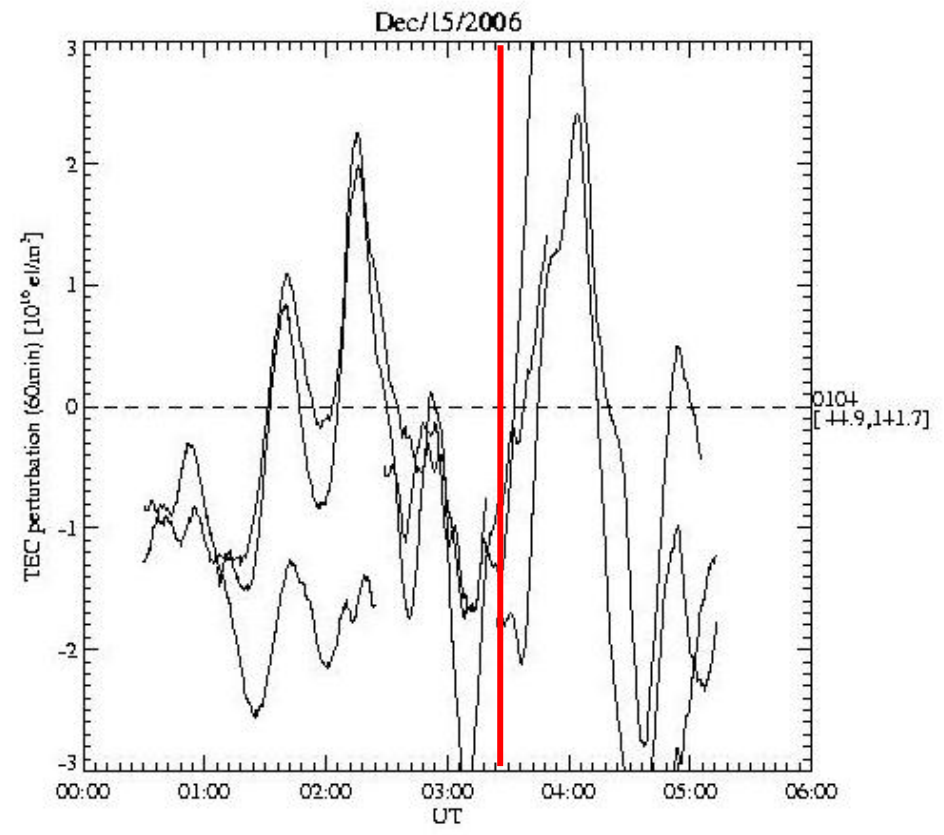
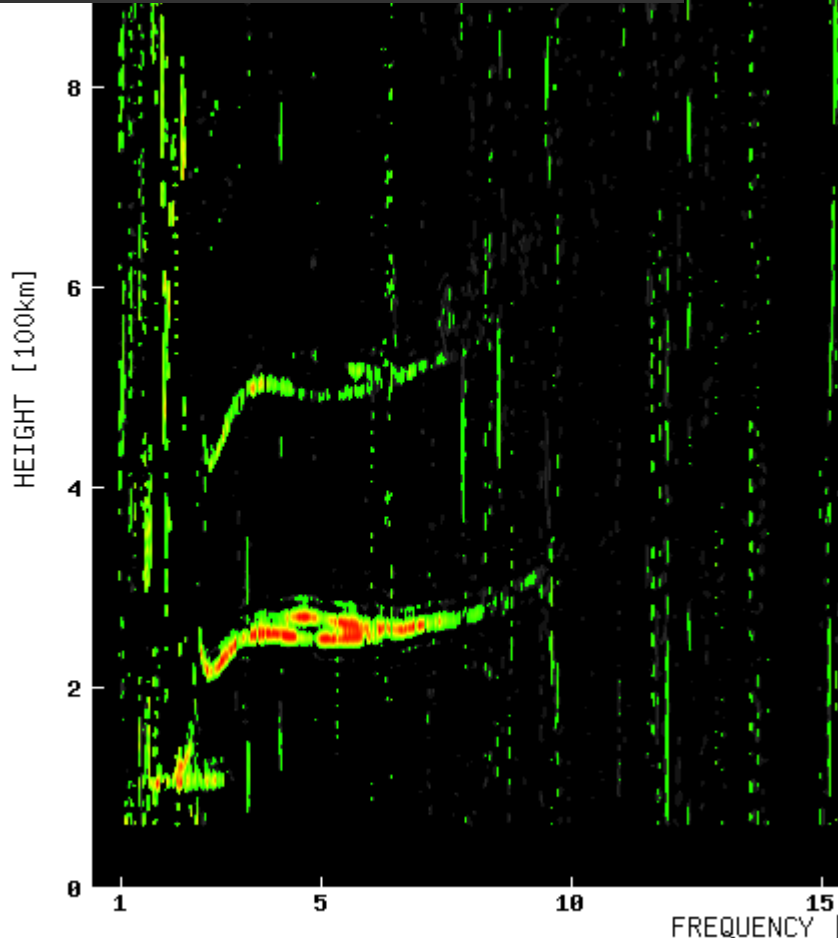
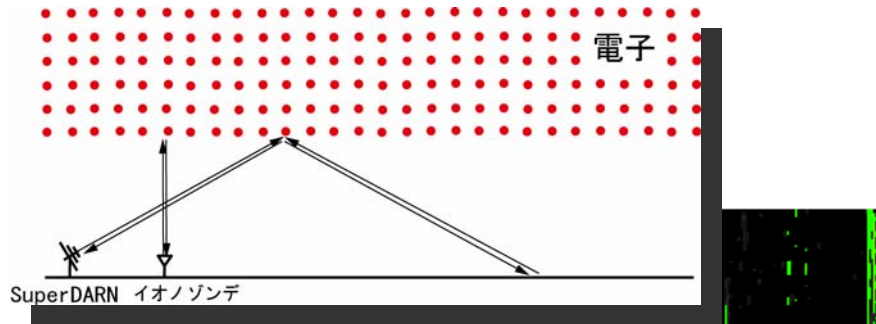
# 電離圏の電波観測 (イオノゾンデ)



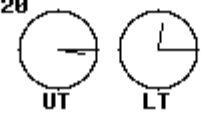
$$f_0F2 \cong 8.98 \times \sqrt{n_{\max}} [Hz] \quad n_{\max}: \text{最大電子密度} [m^{-3}]$$

電離圏の高さと最大電子密度がわかる。

0315 UT

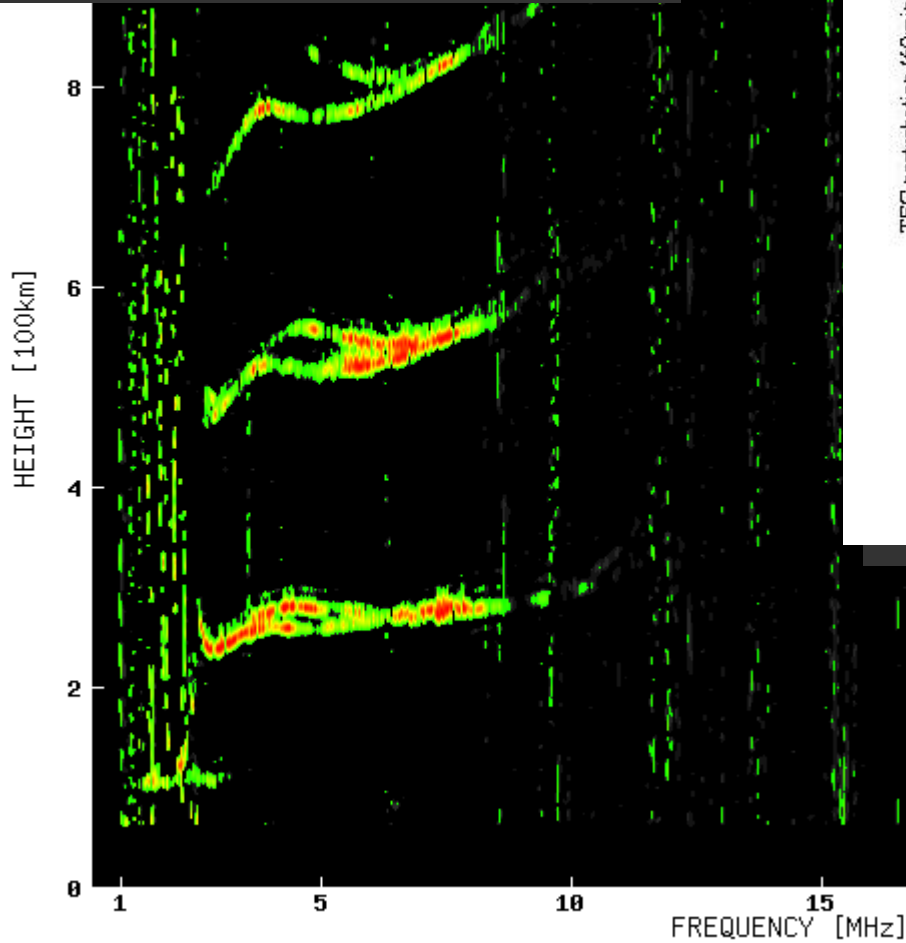
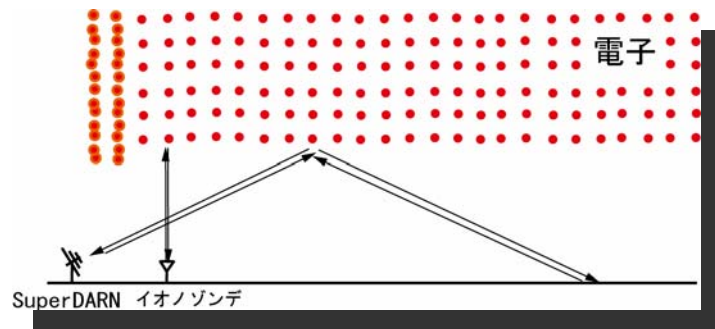


Wakkanai 2006/12/15 03:15:00 UT  
2006/12/15 12:15:00 LT

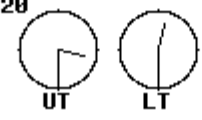
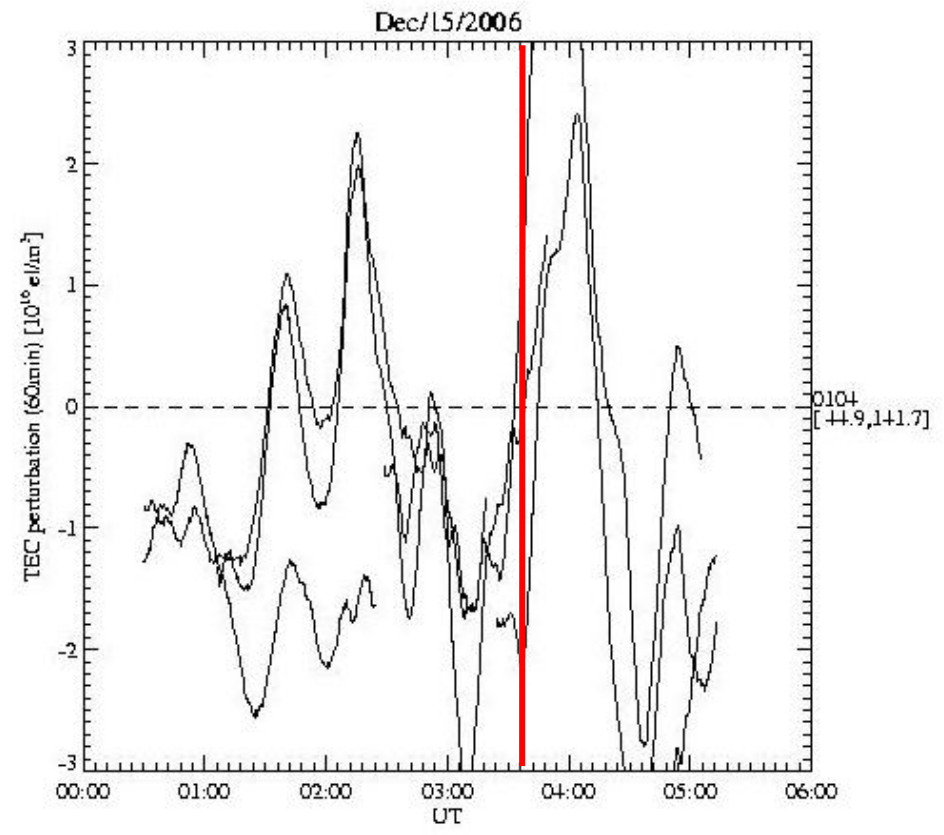




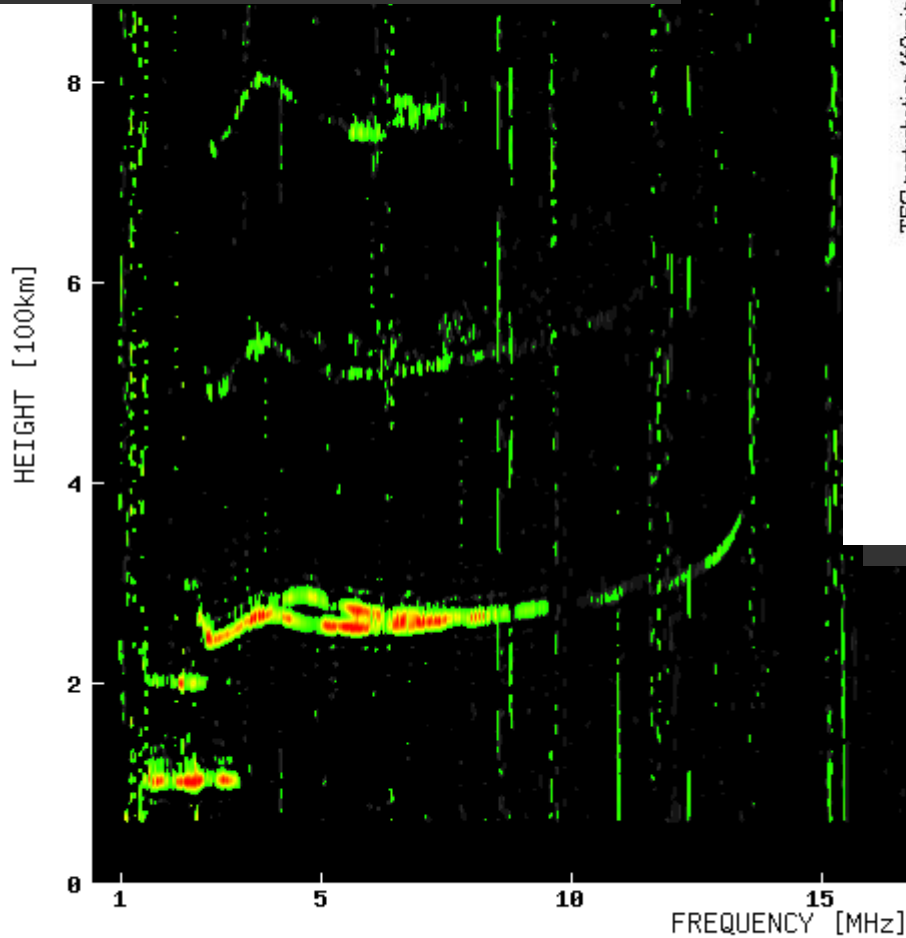
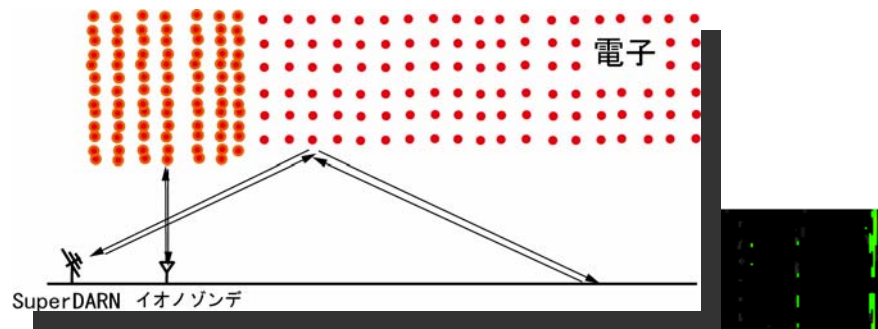
0330 UT



Wakkanai 2006/12/15 03:30:00 UT  
2006/12/15 12:30:00 LT

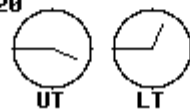
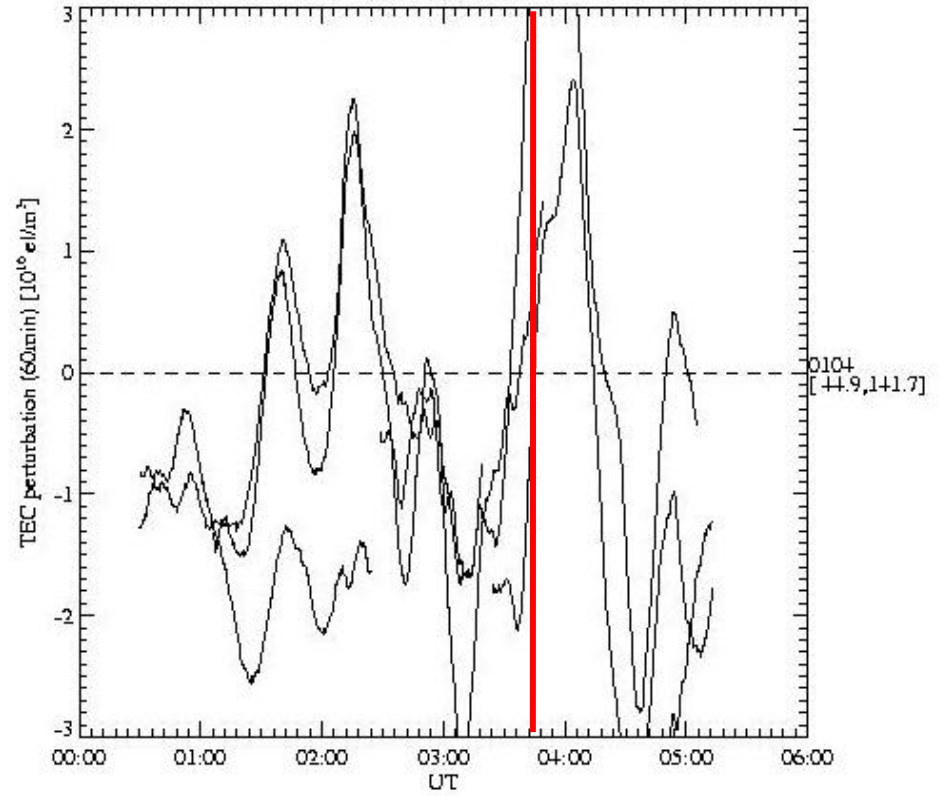


0345 UT

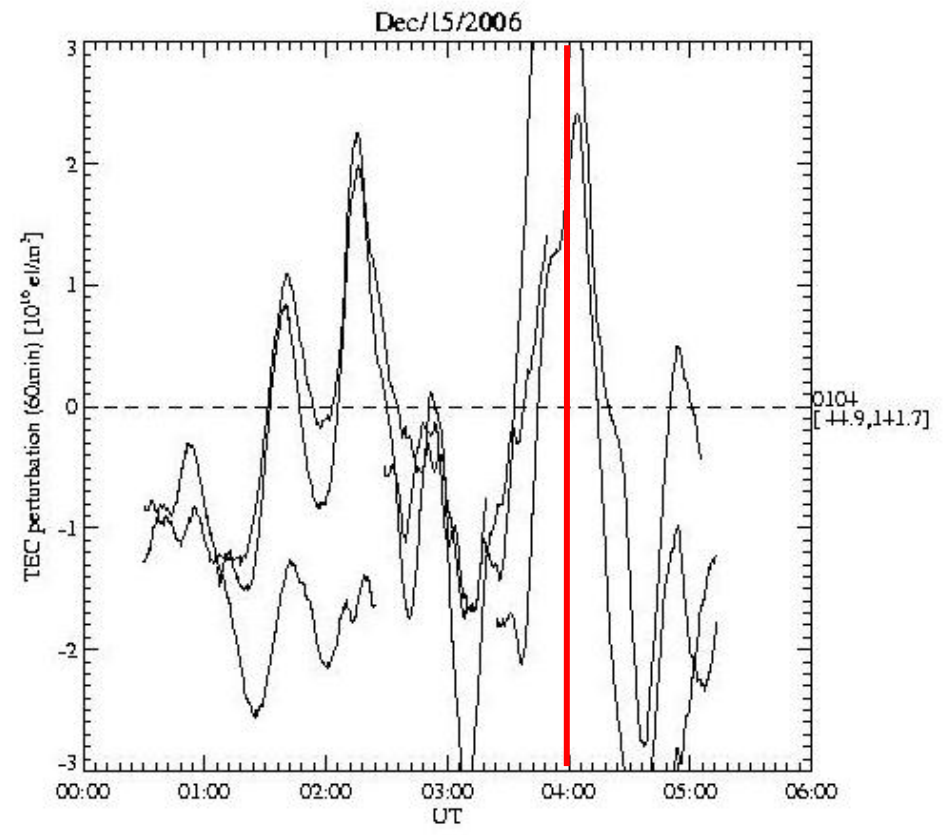
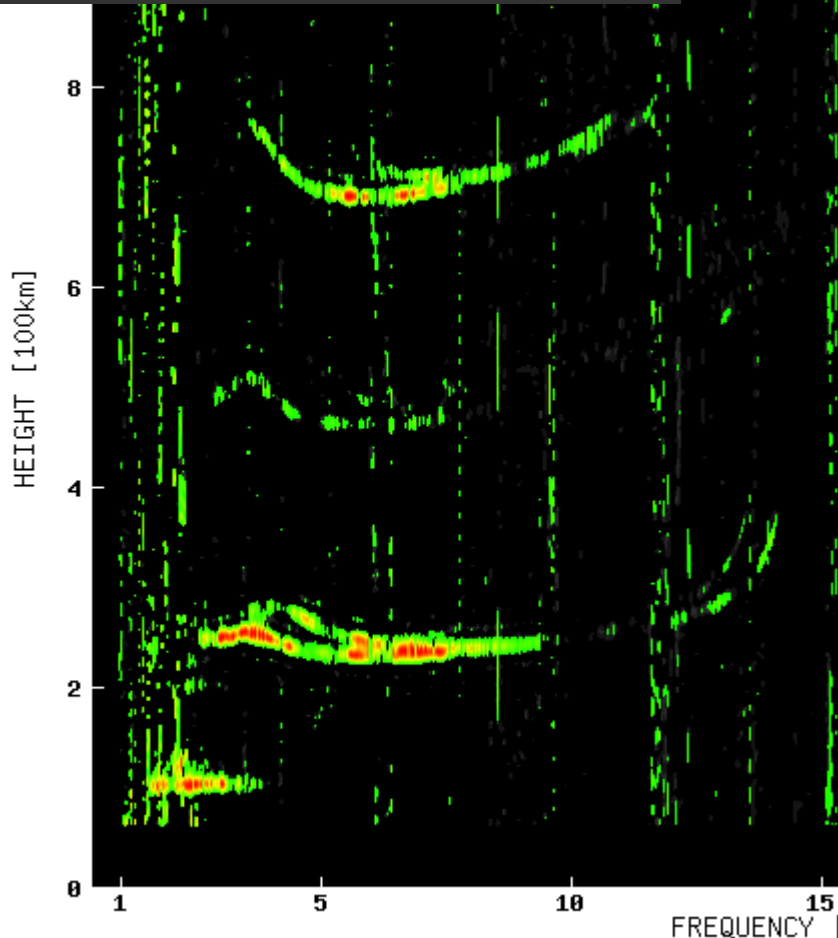
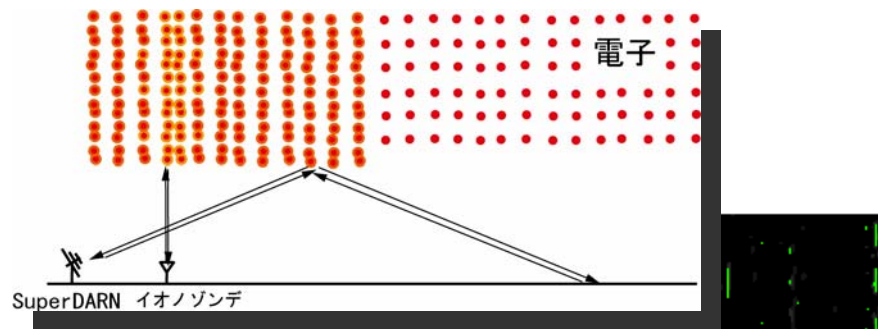


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2006/12/15 12:45:00 LT

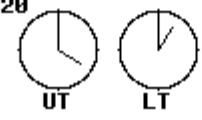
Dec/15/2006



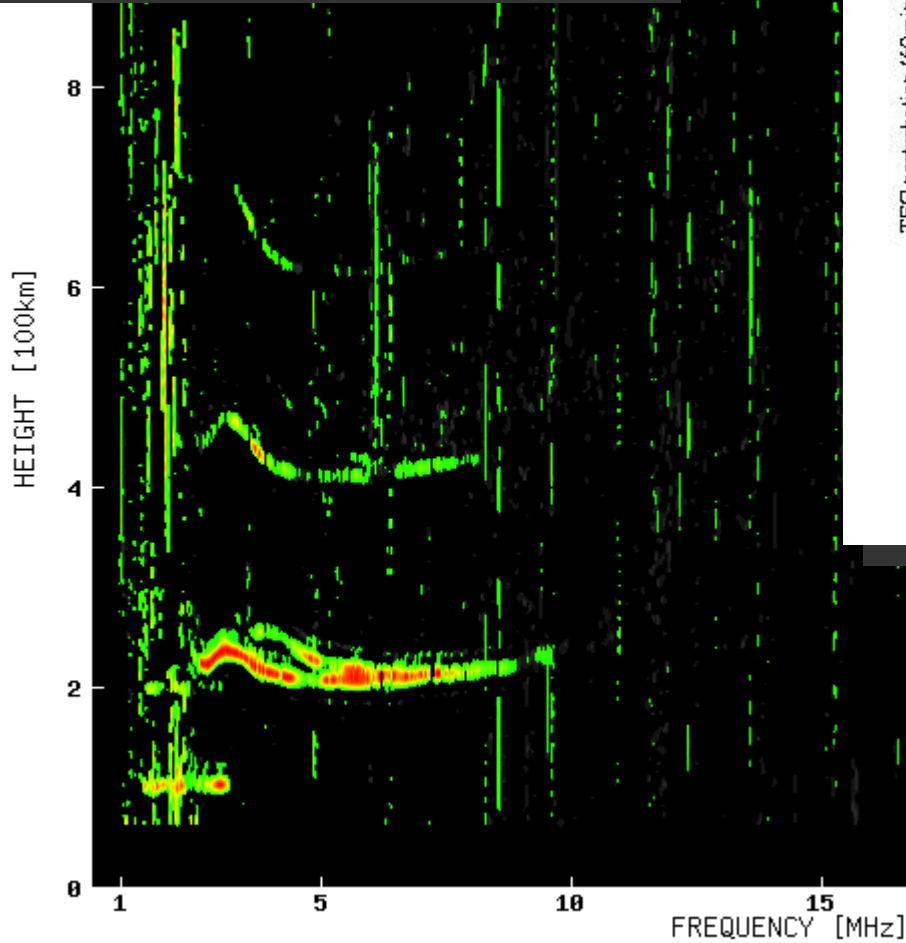
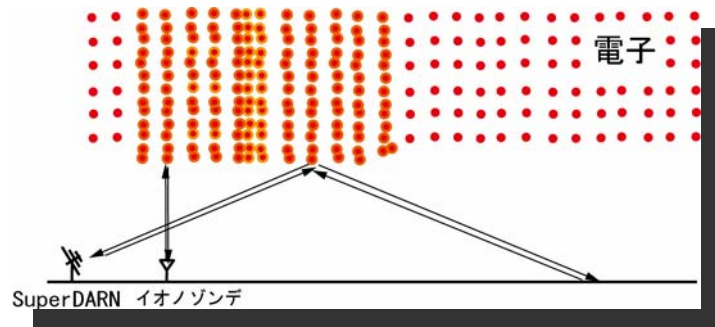
0400 UT



Wakkanai 2006/12/15 04:00:00 UT  
2006/12/15 13:00:00 LT

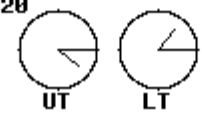
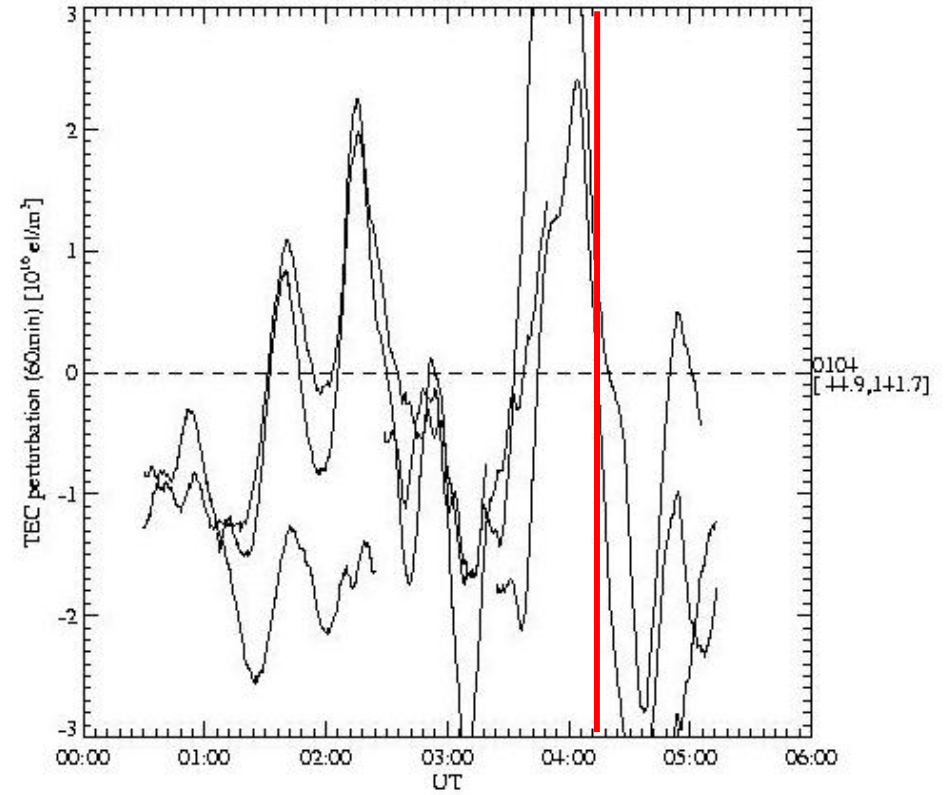


0415 UT

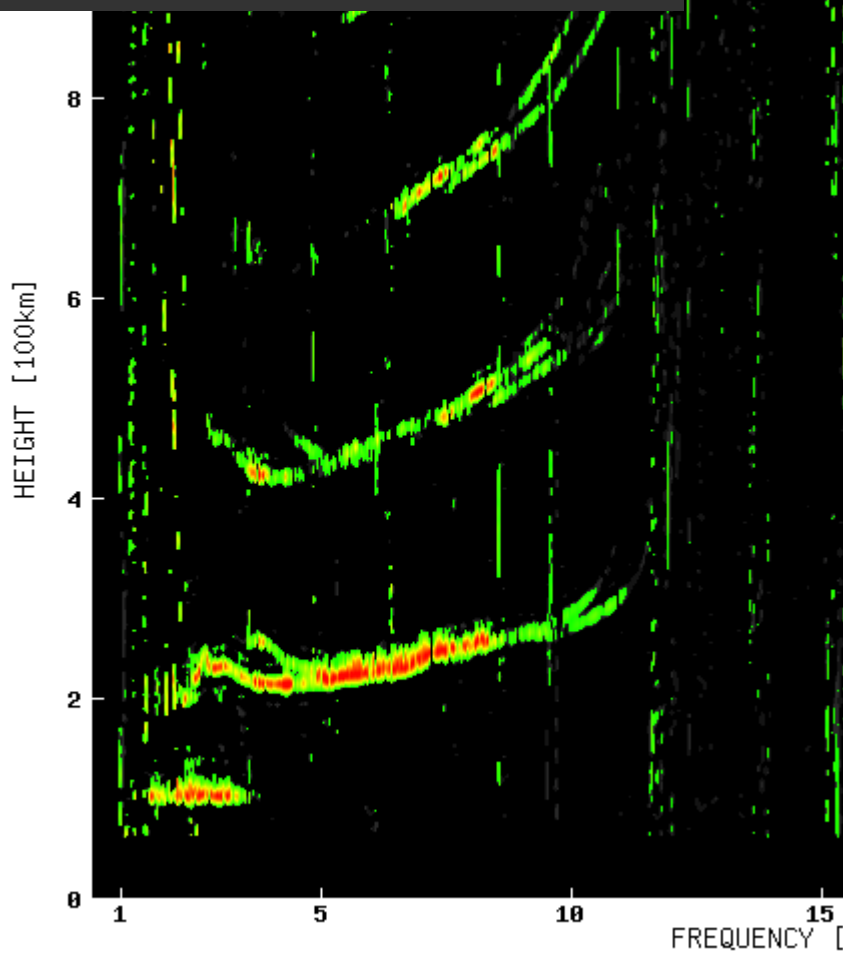
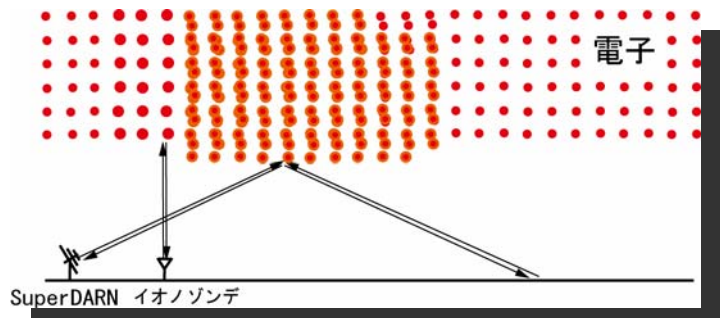


Wakkanai 2006/12/15 04:15:00 UT  
2006/12/15 13:15:00 LT

Dec/15/2006

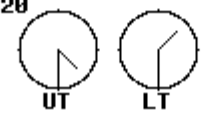
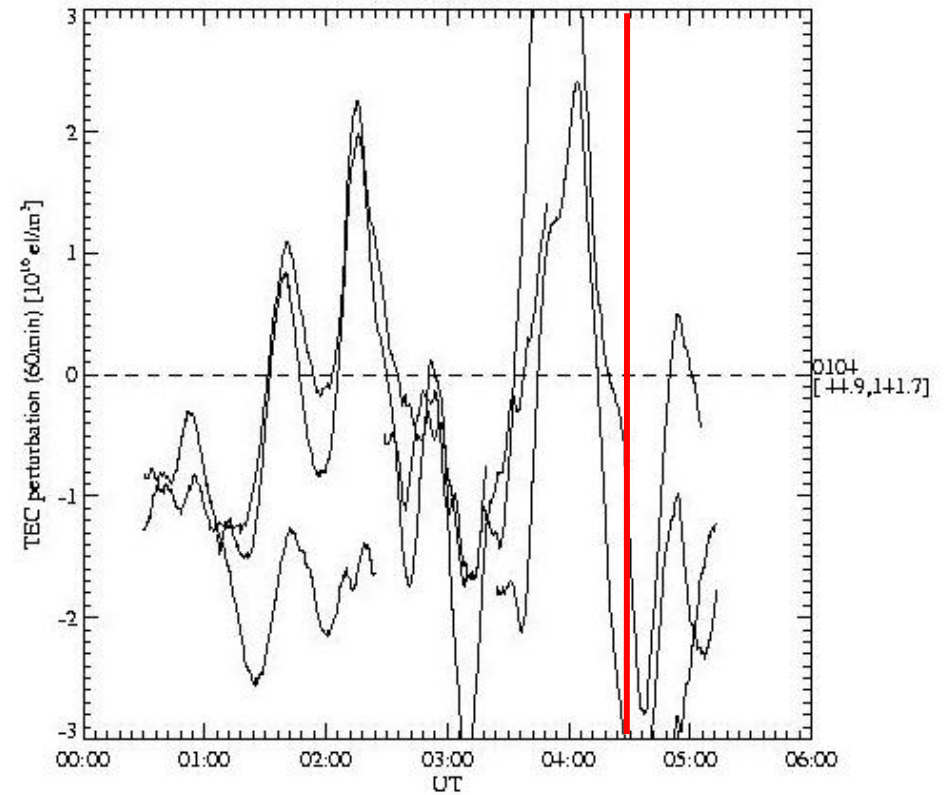


0430 UT



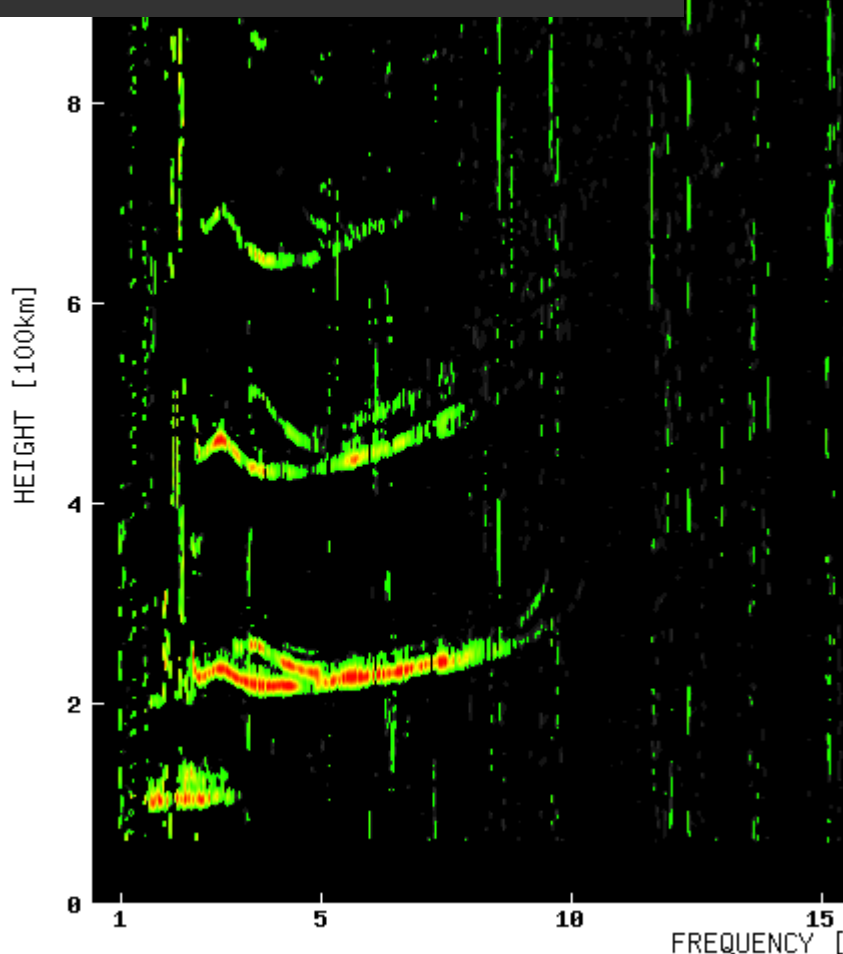
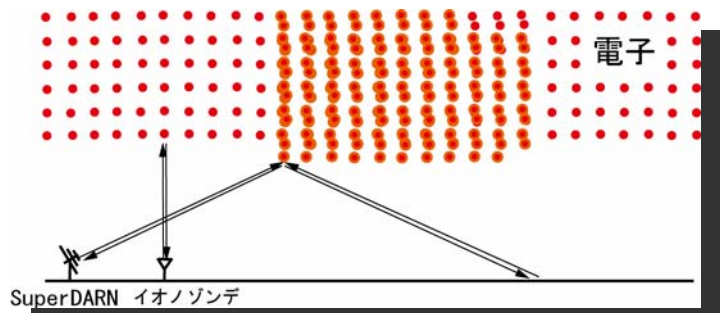
Wakkanai 2006/12/15 04:30:00 UT  
2006/12/15 13:30:00 LT

Dec/15/2006



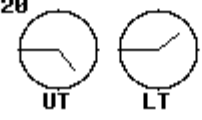
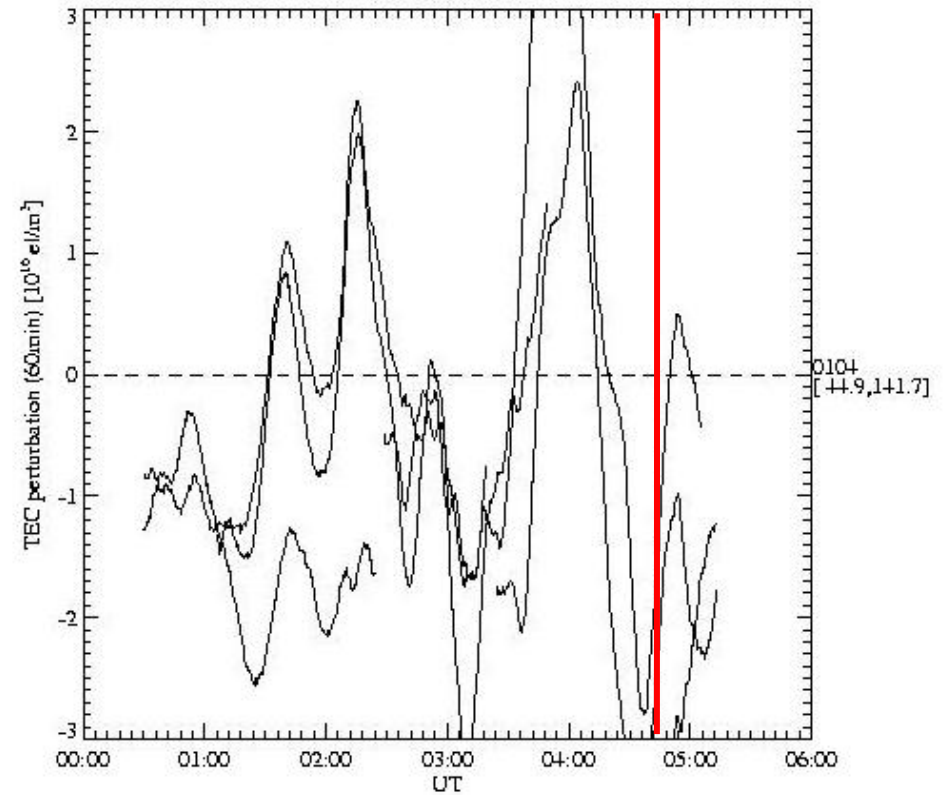


0445 UT



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2006/12/15 13:45:00 LT

Dec/15/2006



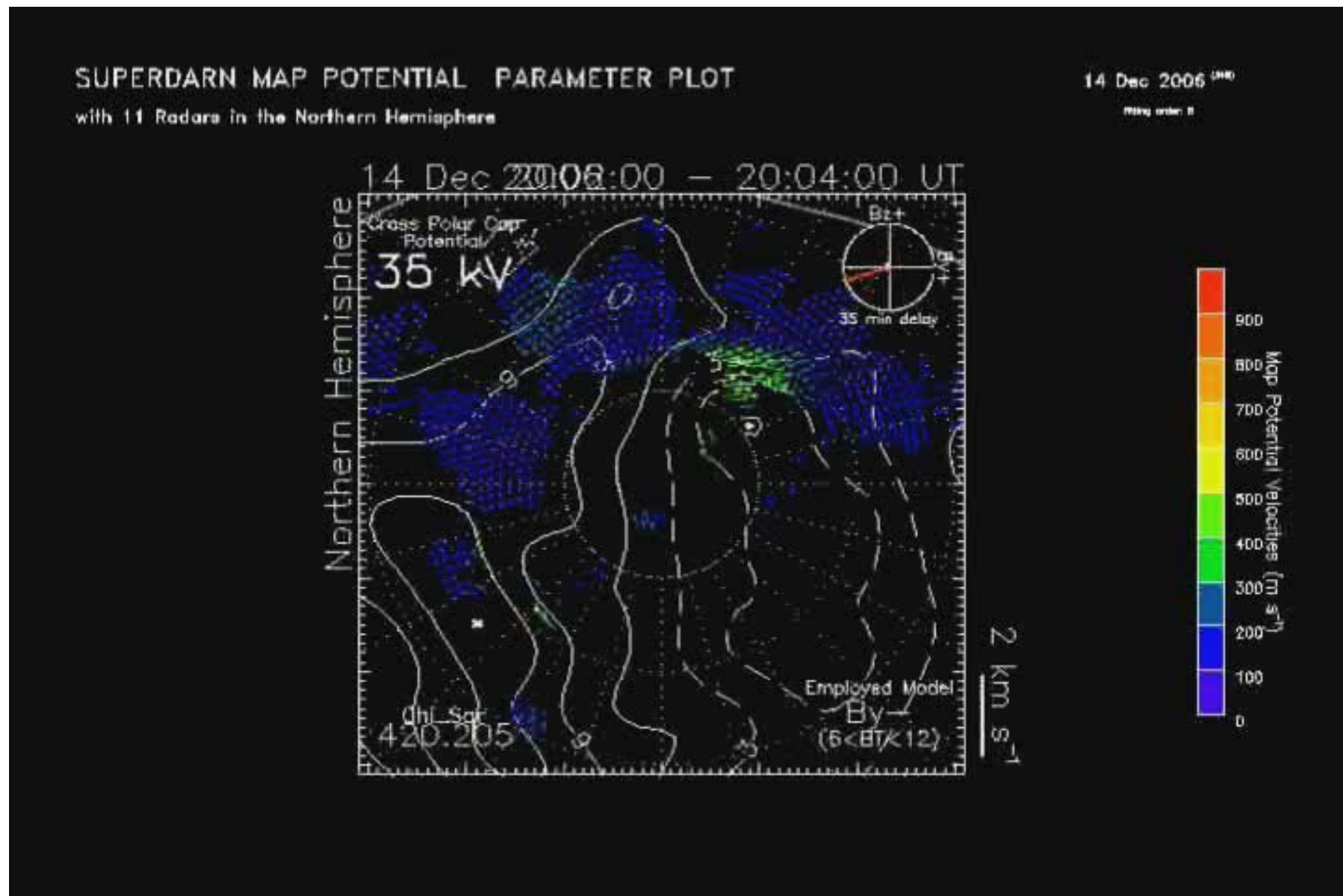
# まとめと課題

- 北海道HFレーダーとGEONETにより、同時に低中緯度を観測することが可能となった。
  - 2006年12月15日に南向きに伝搬する変動と、北向きに伝搬する変動が観測された。
  - 南向きに伝搬する変動は、伝搬速度、周期、波長は今までのLSTIDの例にほぼ一致した。
  - 北向きに伝搬する変動は、TECの値は比較的大きく、SuperDARNとイオノグラムのデータから電離層の高度を下げる特徴があったと考えられる。
- 
- 極域のポテンシャルマップ

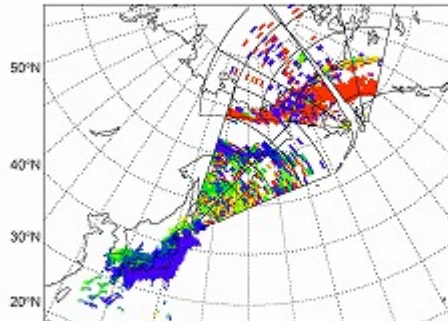
# ポテンシャルマップ

2006/12/14-15

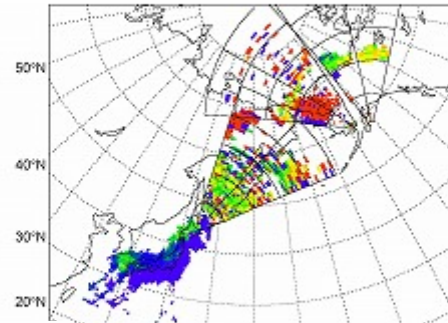
2000-0200 UT



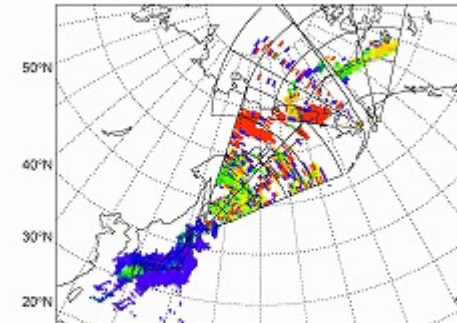
SUPERDARN PARAMETER PLOT  
0000UT



SUPERDARN PARAMETER PLOT  
0015UT

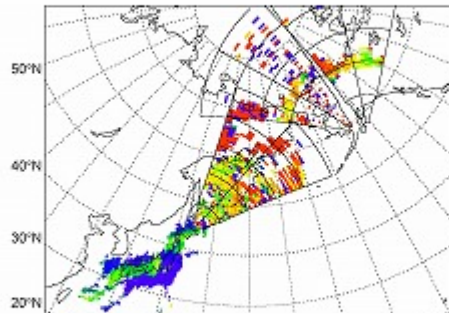


SUPERDARN PARAMETER PLOT  
0030UT

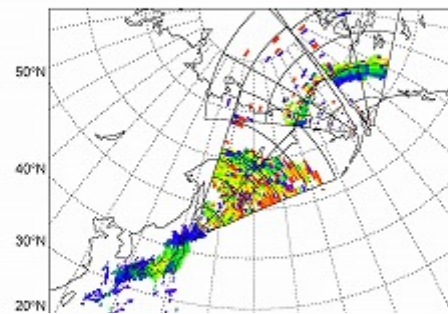


15 Dec 2001  
fast normal sound (p/s) sec

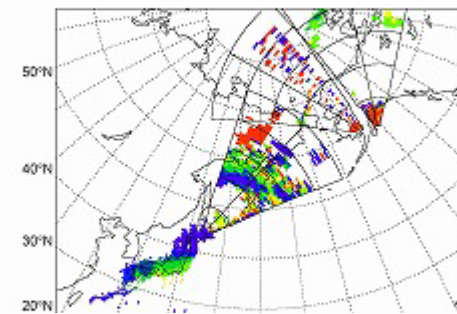
SUPERDARN PARAMETER PLOT  
0045UT



SUPERDARN PARAMETER PLOT  
0100UT

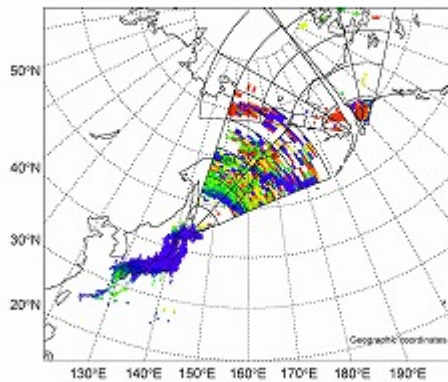


SUPERDARN PARAMETER PLOT  
0115UT

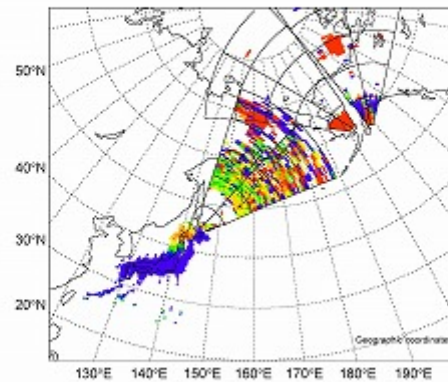


15 Dec 2001  
fast normal sound (p/s) sec

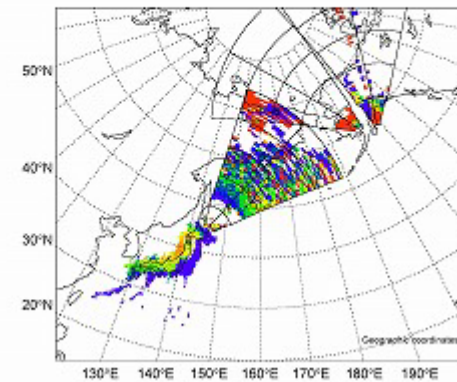
SUPERDARN PARAMETER PLOT  
0130UT



SUPERDARN PARAMETER PLOT  
0145UT



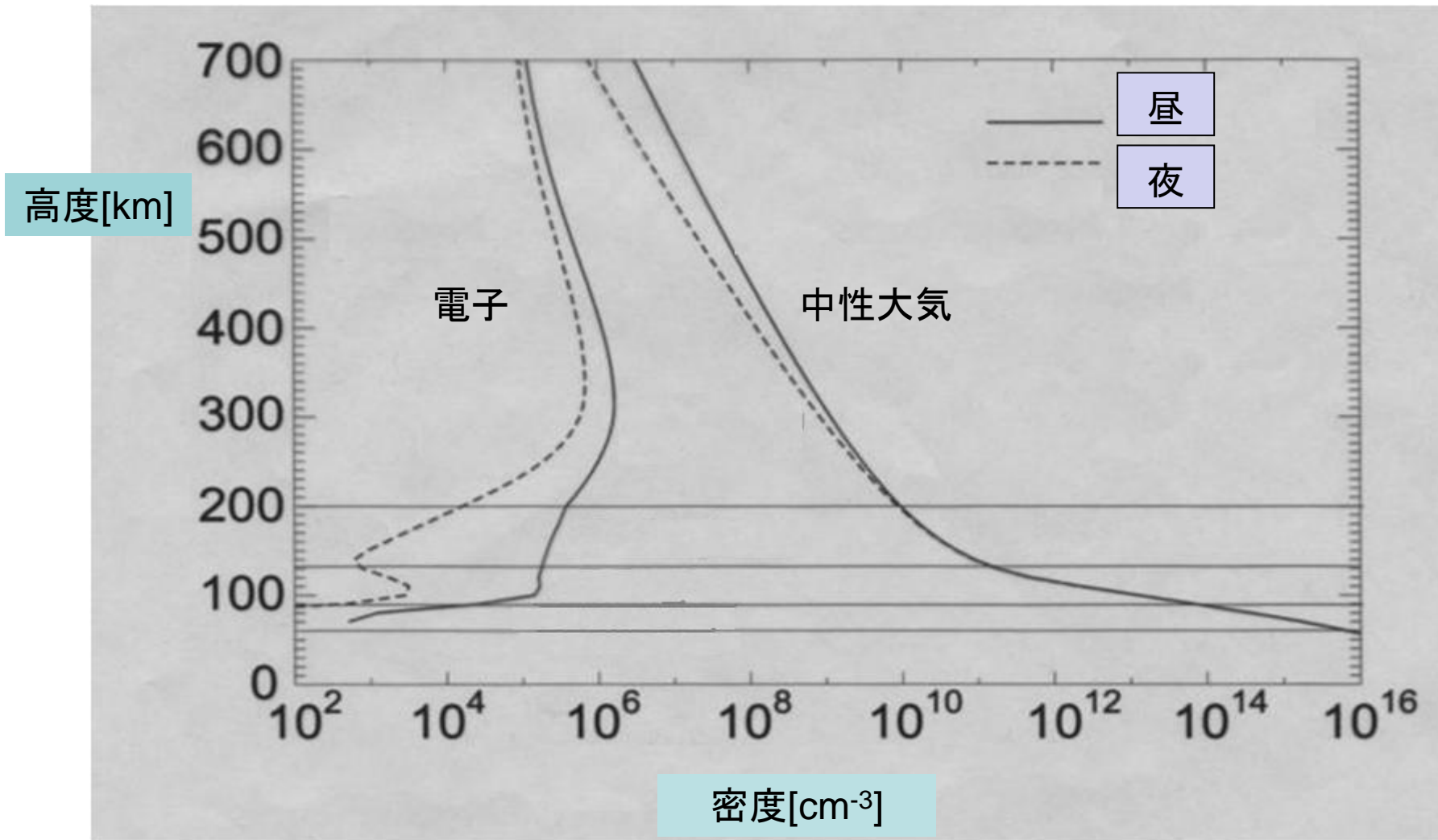
SUPERDARN PARAMETER PLOT  
0159UT



15 Dec 2001  
fast normal sound (p/s) sec

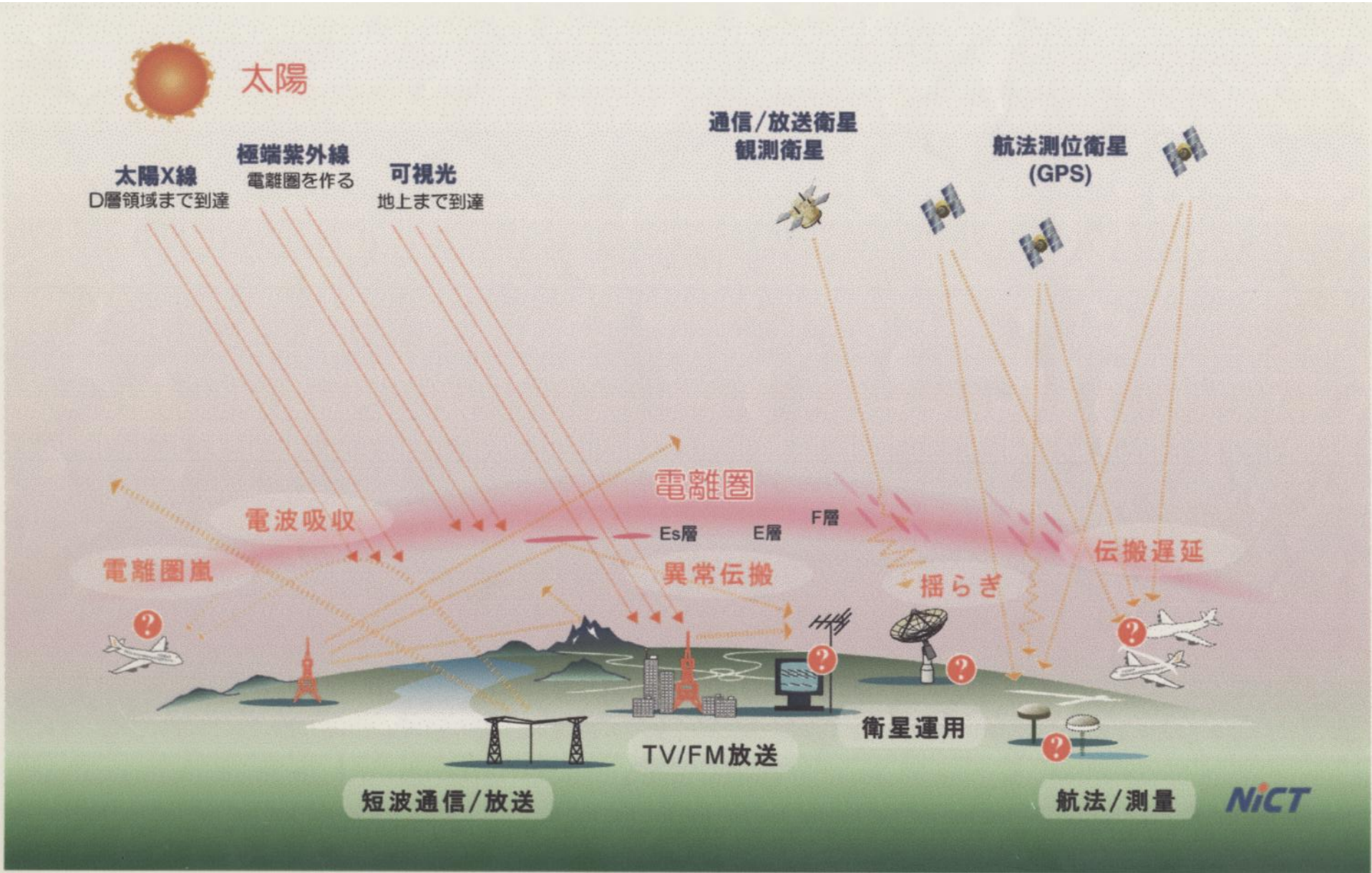


# 研究背景—電離圏



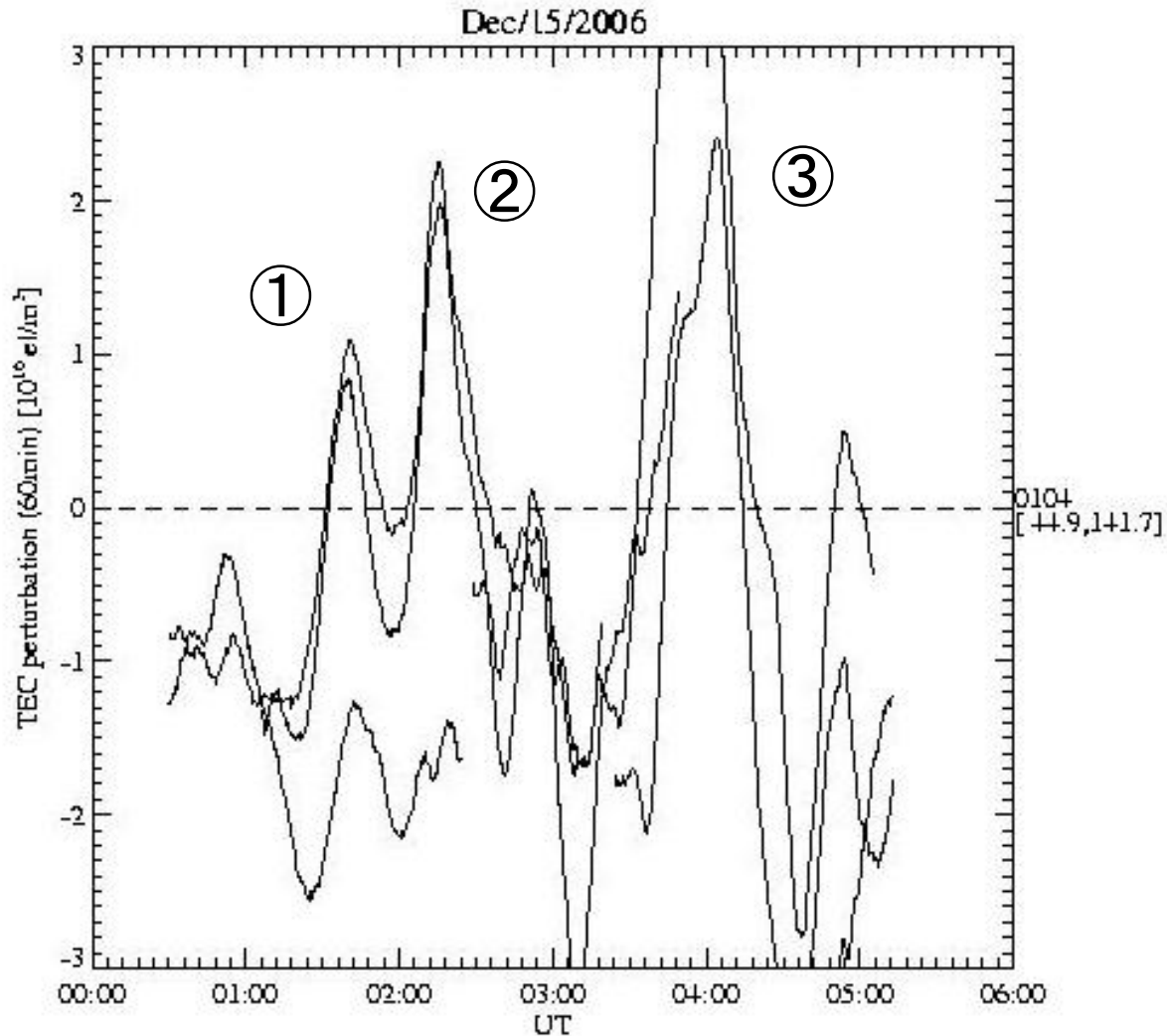
電離圏は電波の伝搬にいろいろ影響を与えるだけでなく、宇宙環境を決めるうえで重要な働きをしている。

# 電離圏の擾乱により及ぼす影響

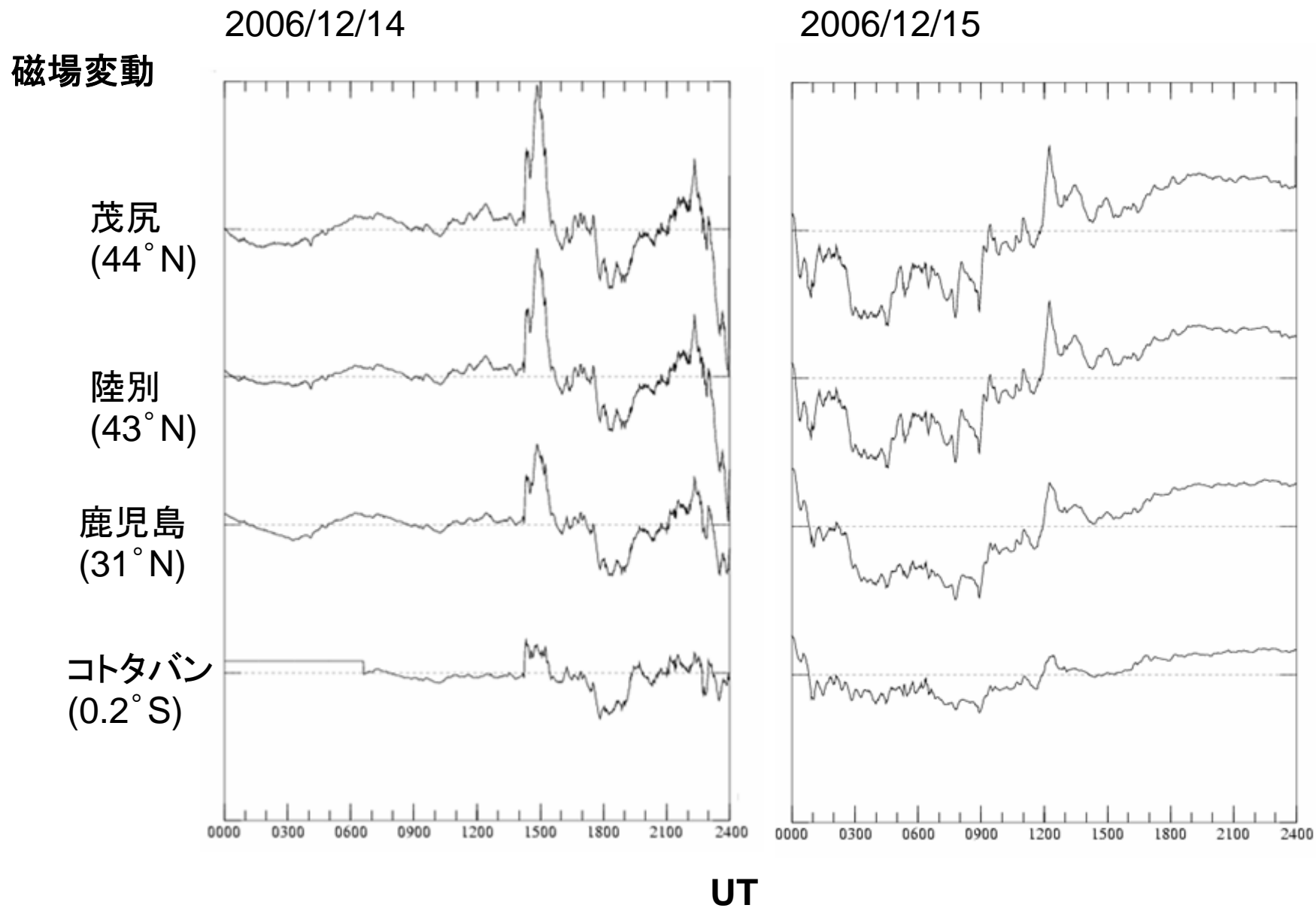


# 稚内でのGPSデータ TEC変動値(60分以下の変動成分)

2006/12/15  
0000-0600 UT  
0900-1500 LT

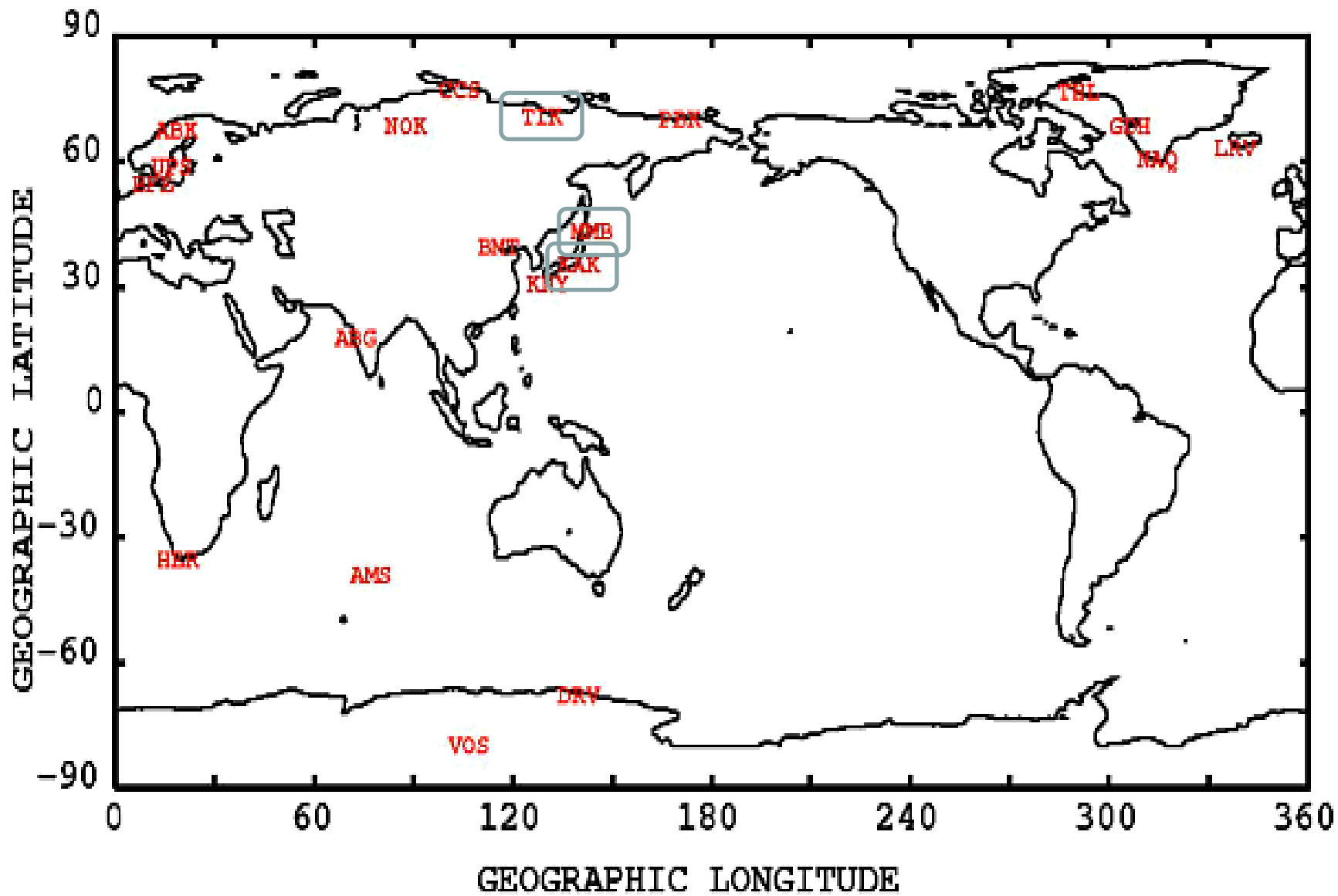


# 磁気座標210度の地磁気観測データ(H成分)

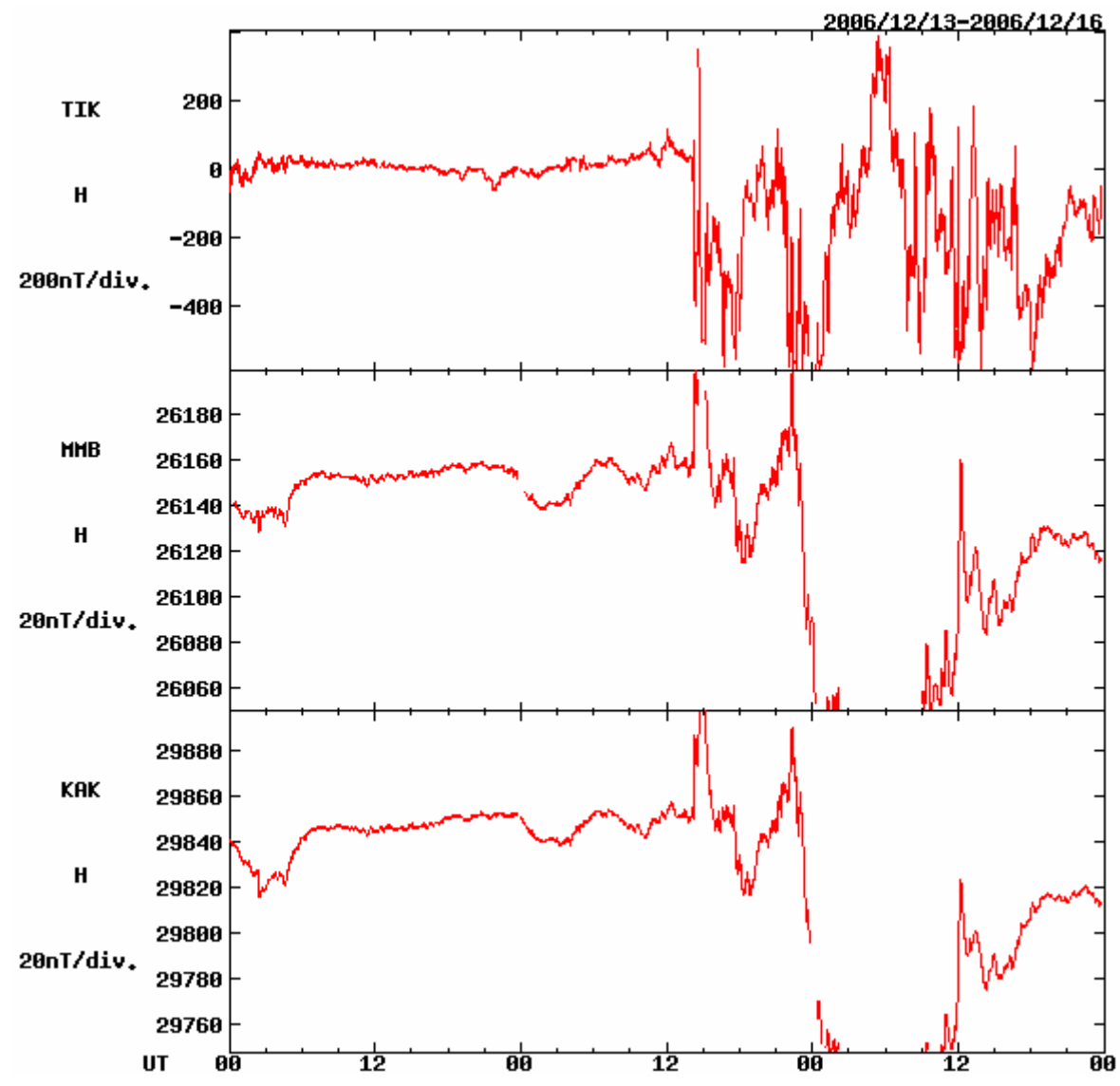




# Quicklook Map

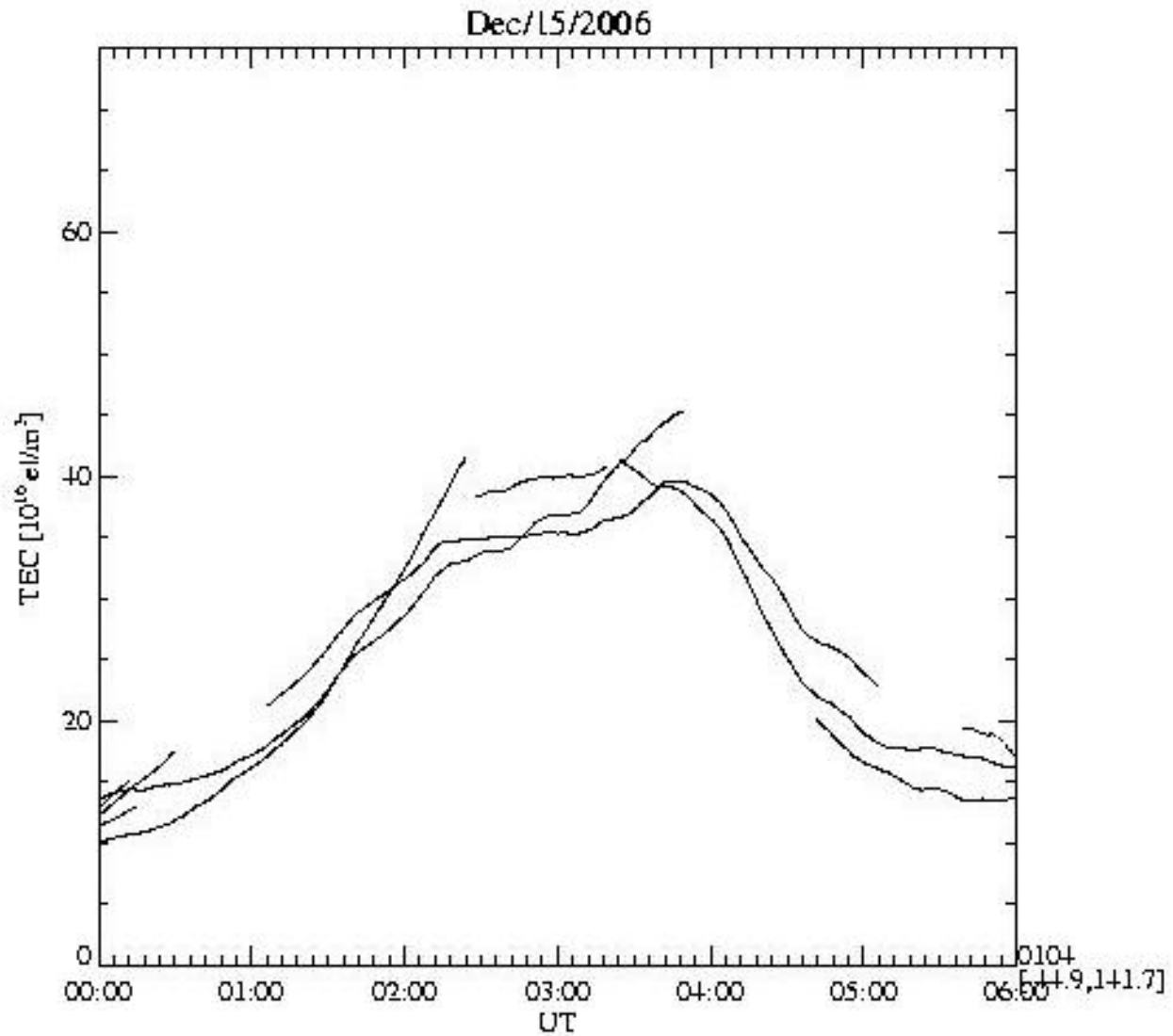


# 地磁気データ H成分



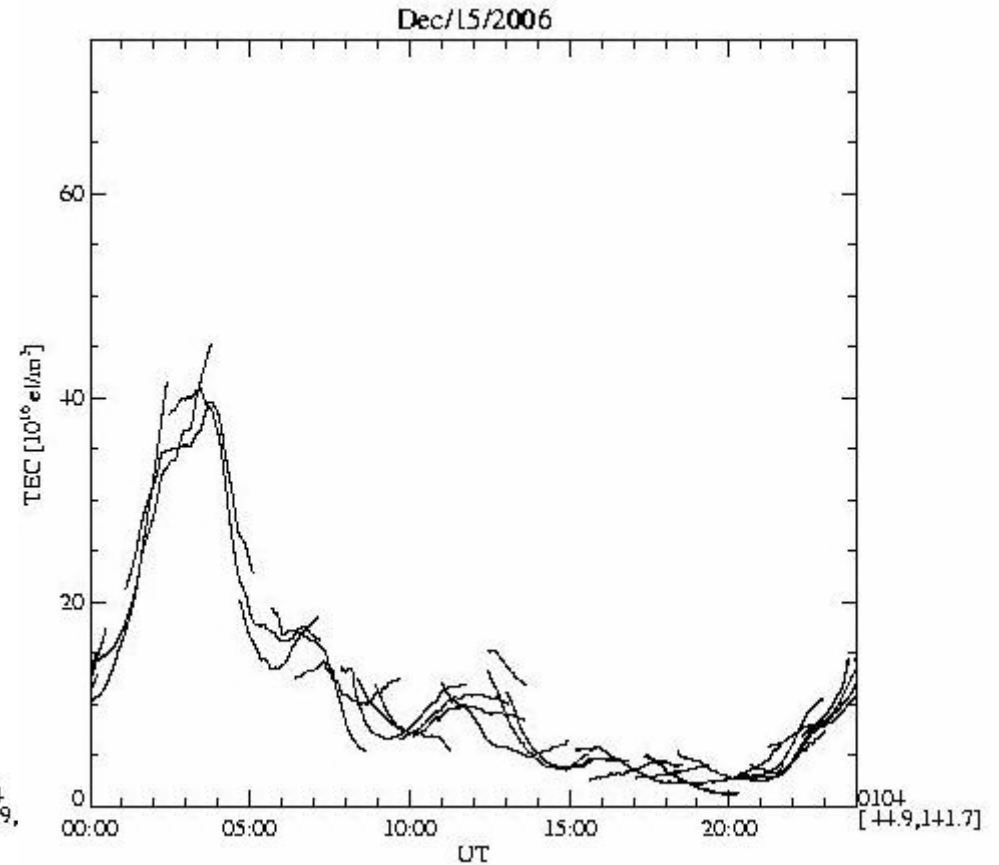
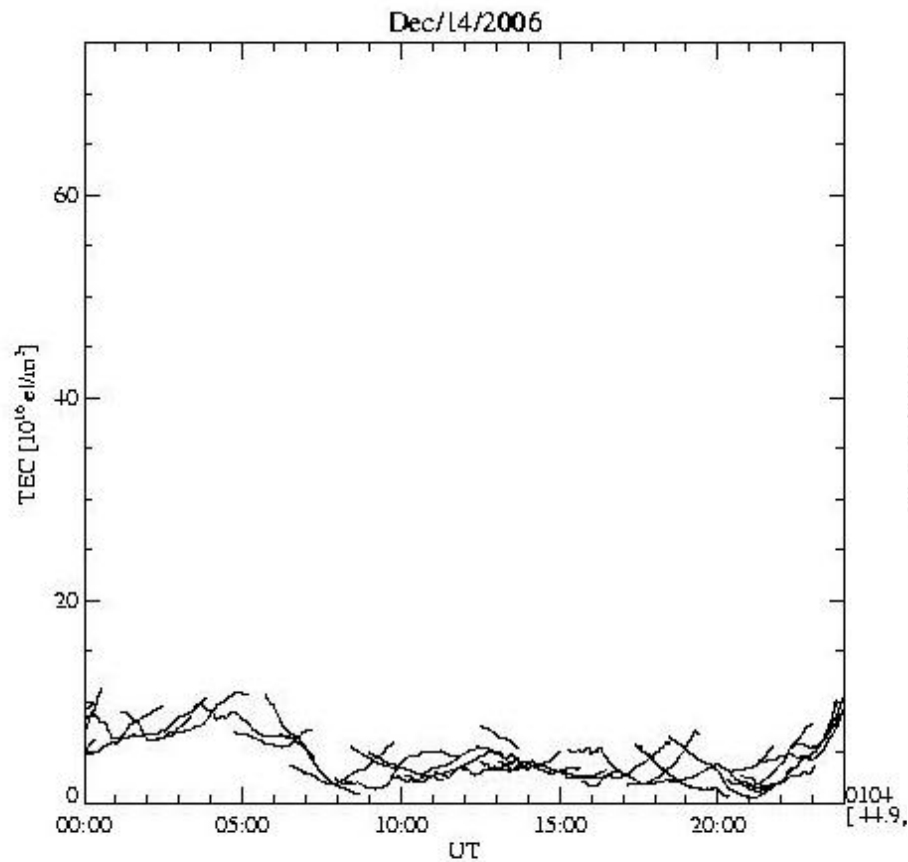
# 稚内でのGPSデータ TEC絶対値(推定値)

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0900-1500 LT



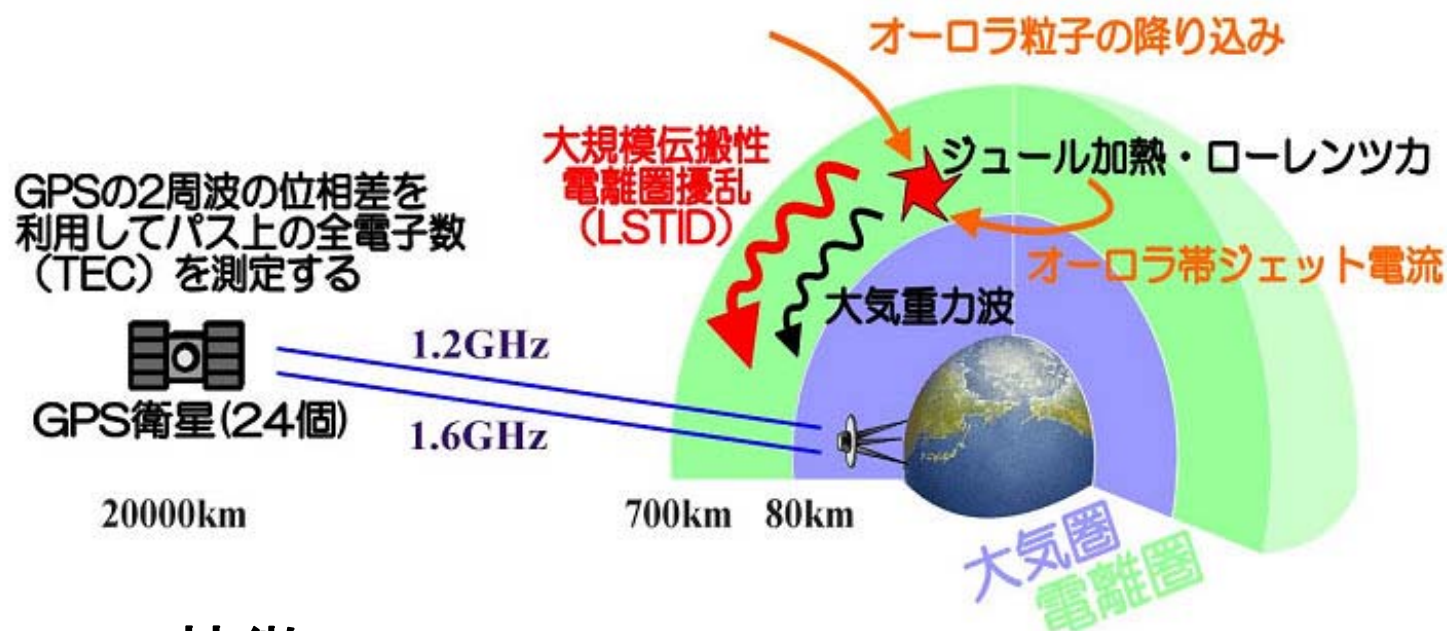
# 稚内でのGPSデータ TEC絶対値(推定値)

2006/12/14-15  
0000-2400 UT  
(LT=UT+09)



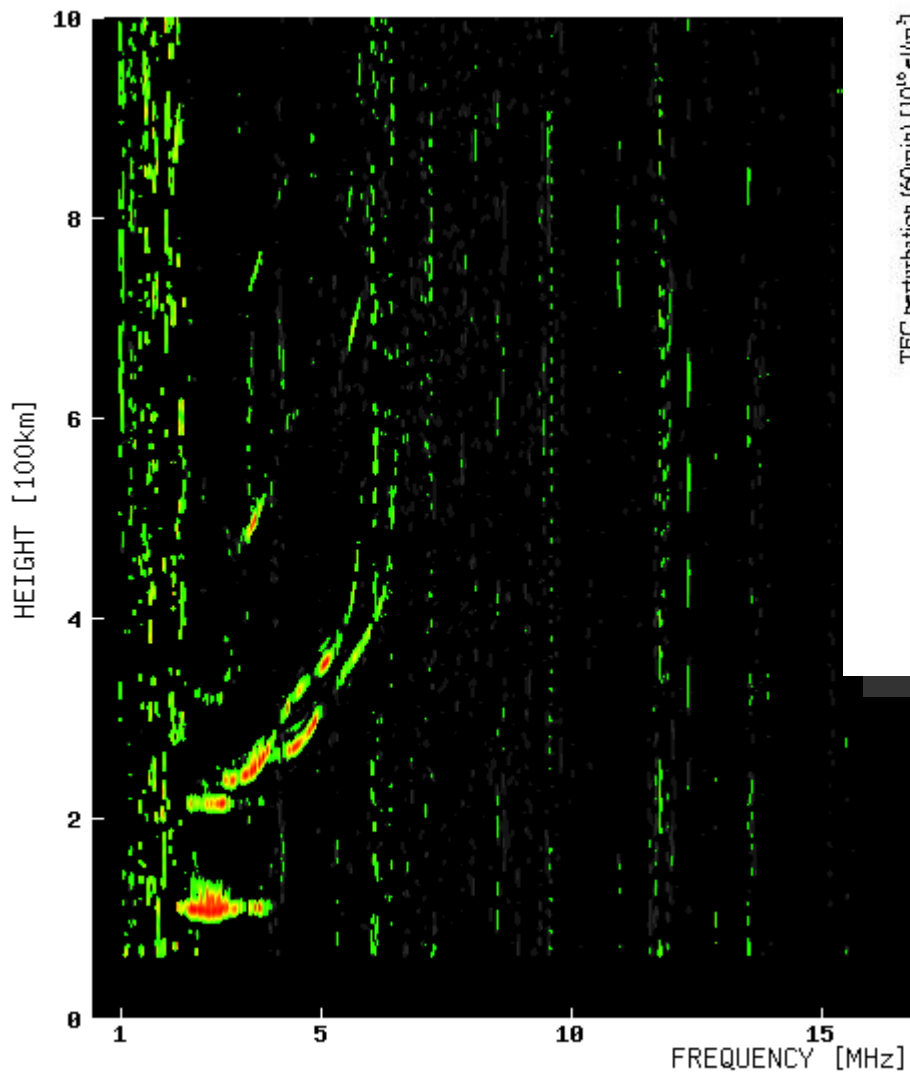


# GPSを利用した大規模伝搬性電離圏擾乱 (Large-Scale Traveling Ionospheric Disturbances: LSTID) の研究

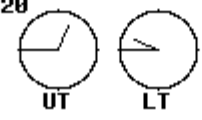
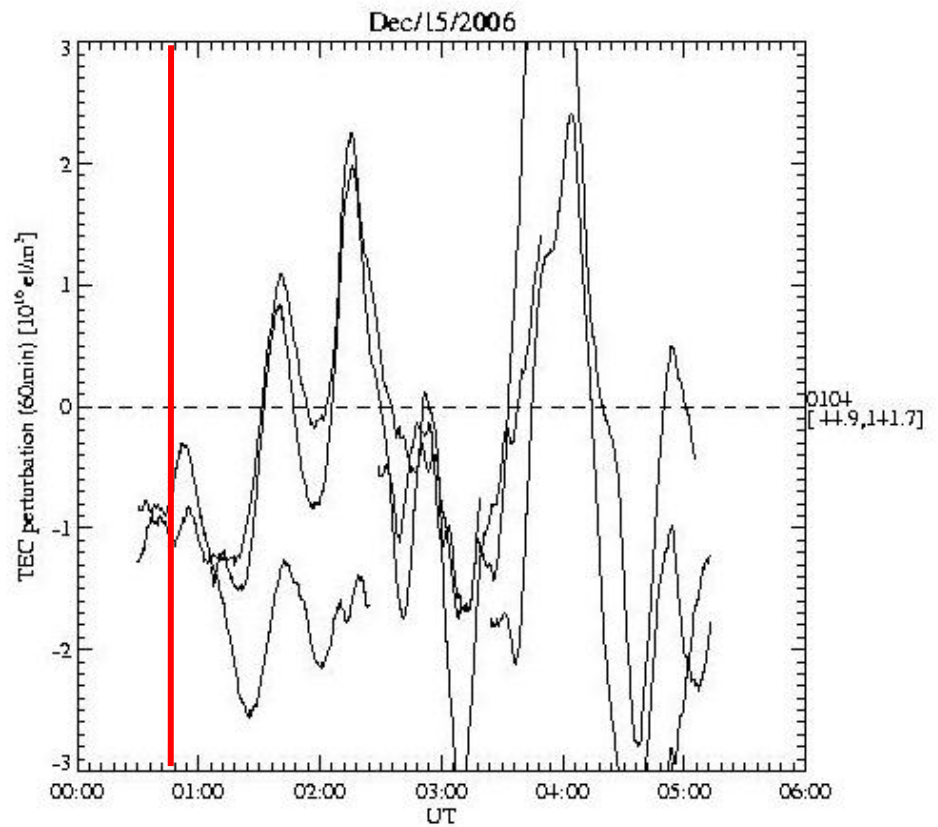


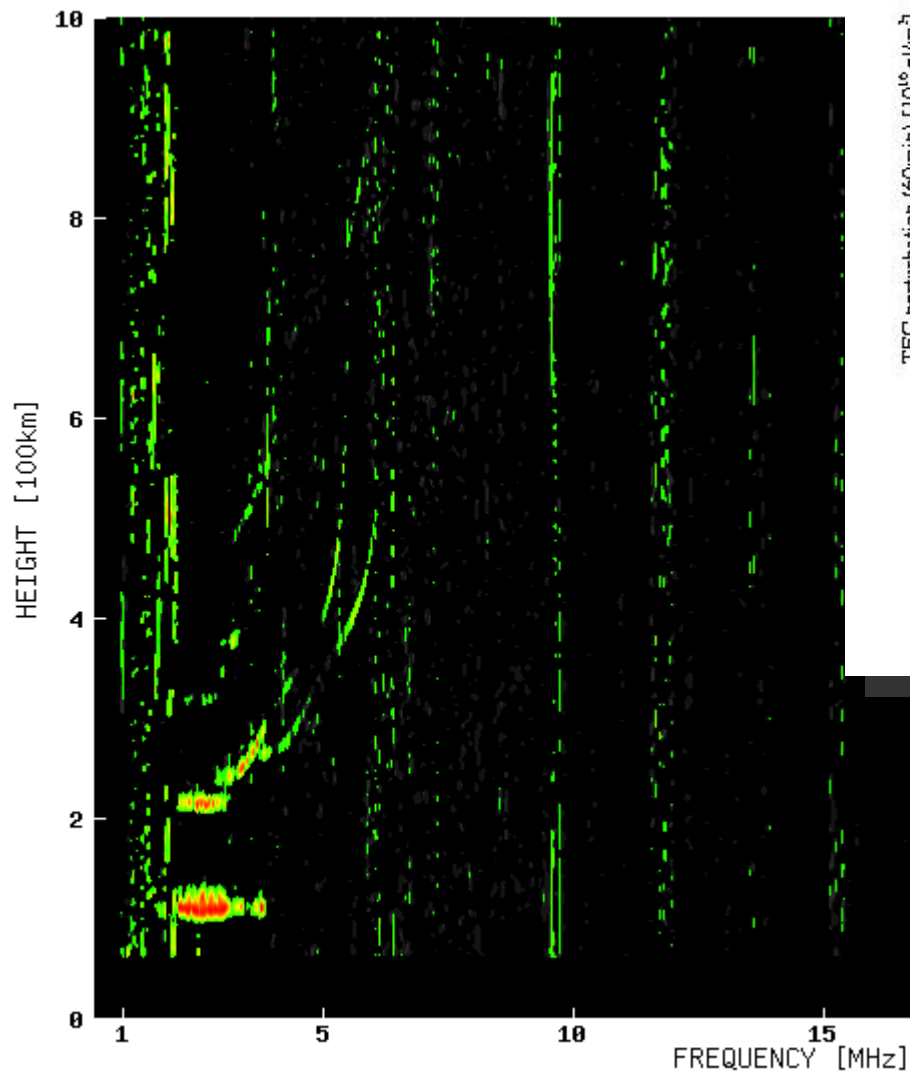
## LSTIDの特徴 [Hunsucker, 1982]

- 水平波長 1000km以上
- 位相速度 数100m/s - 1000m/s
- 周期 30分- 3時間
- TEC変動の振幅 10 - 20 %

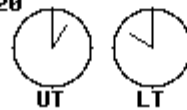
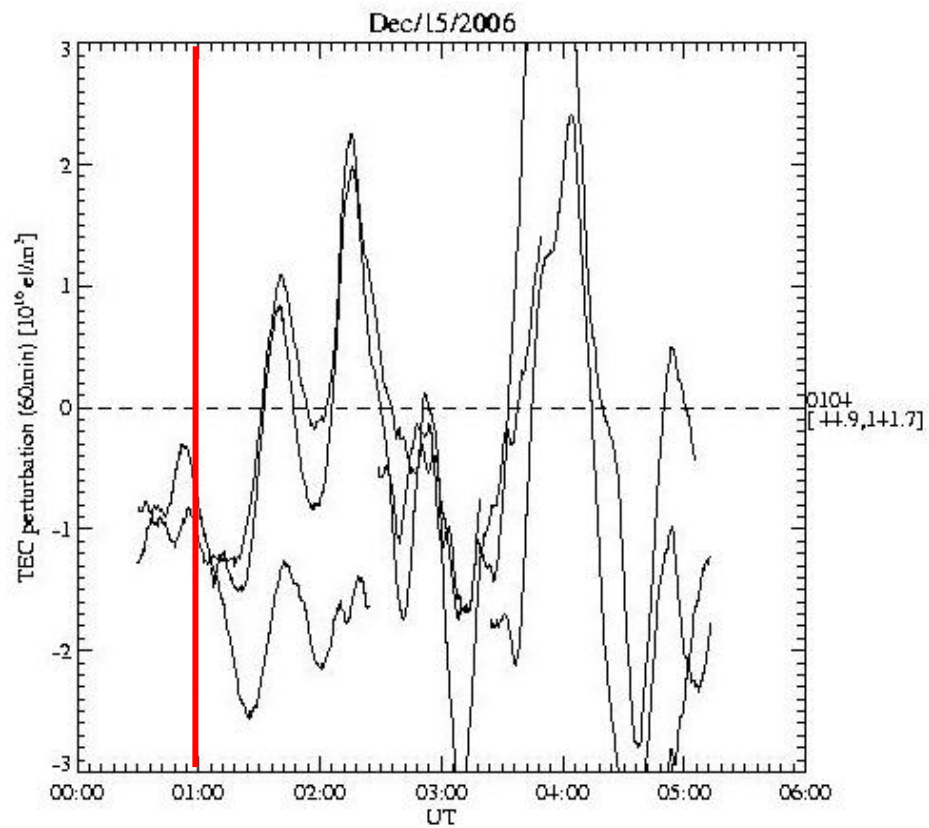


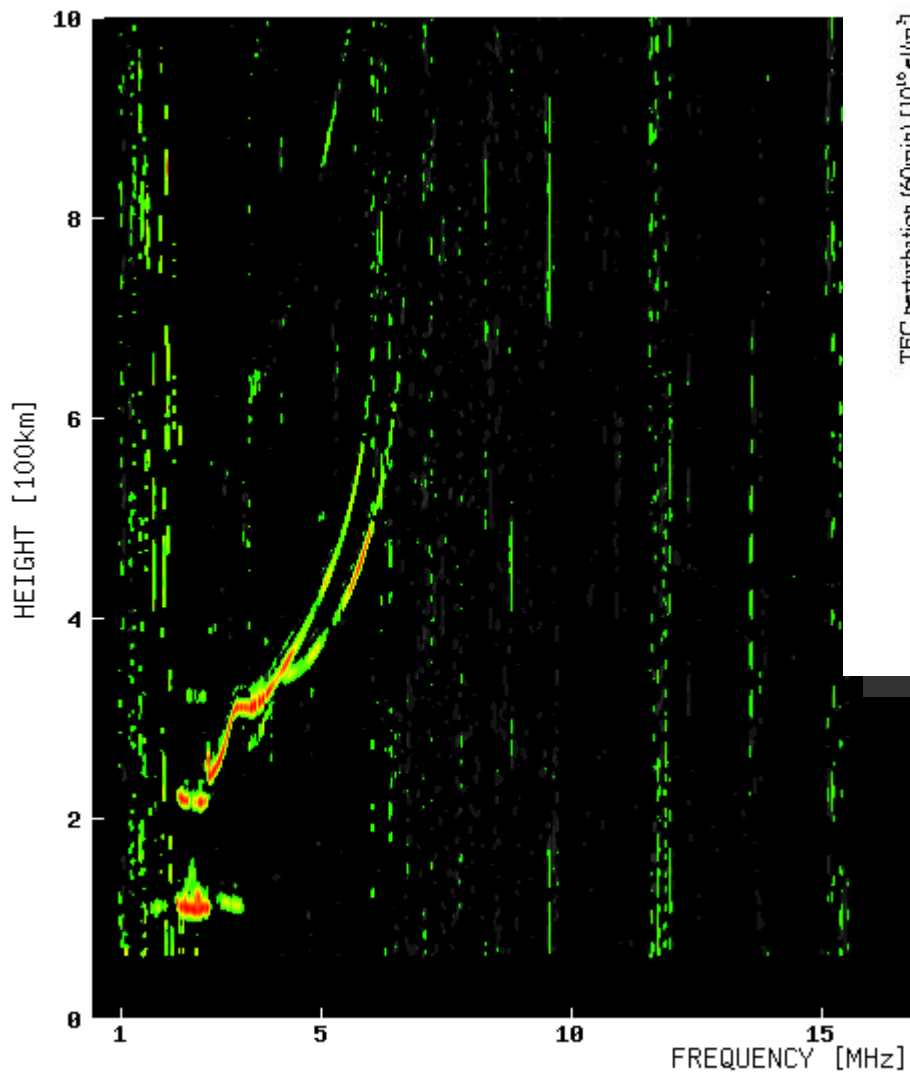
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 2006/12/15 09:45:00 LT



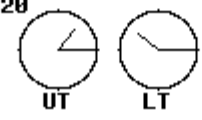
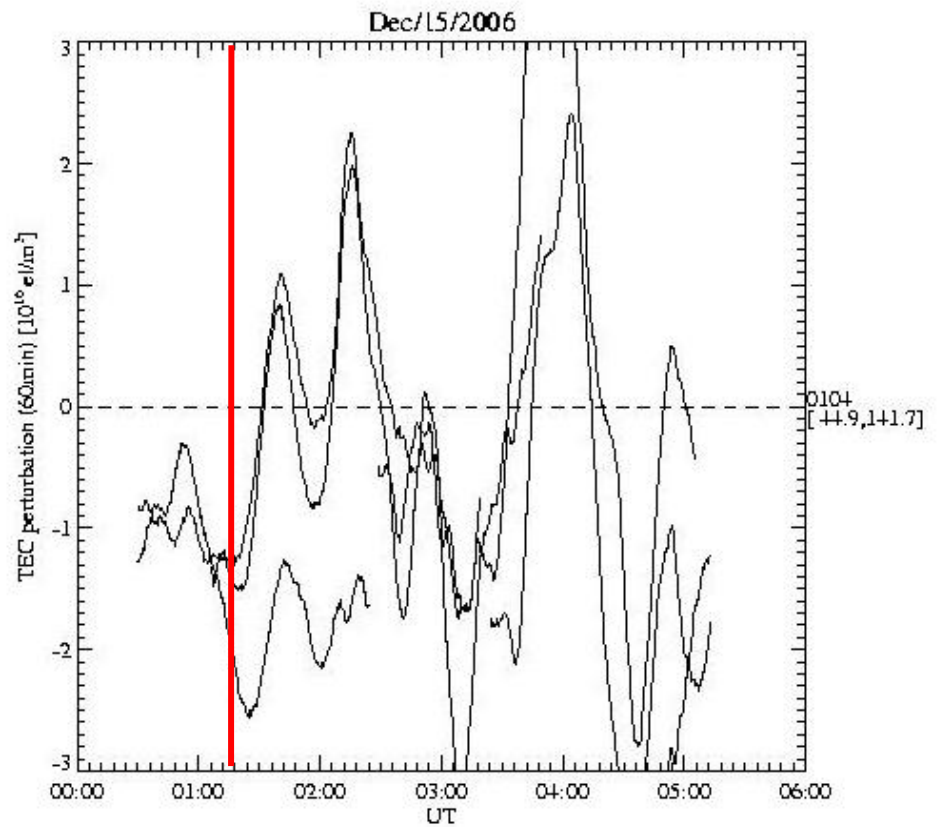


Wakkanai 2006/12/15 01:00:00 UT  
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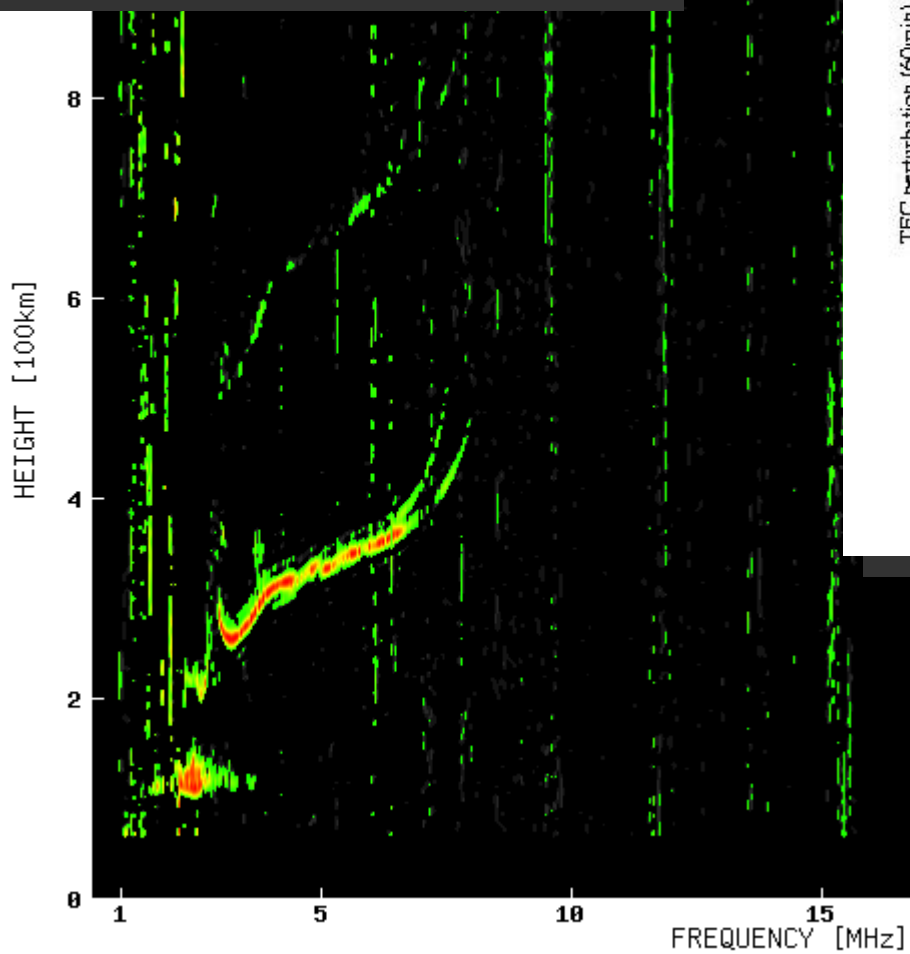
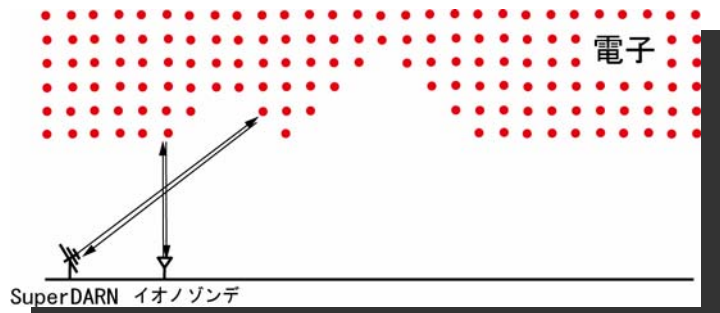




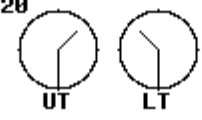
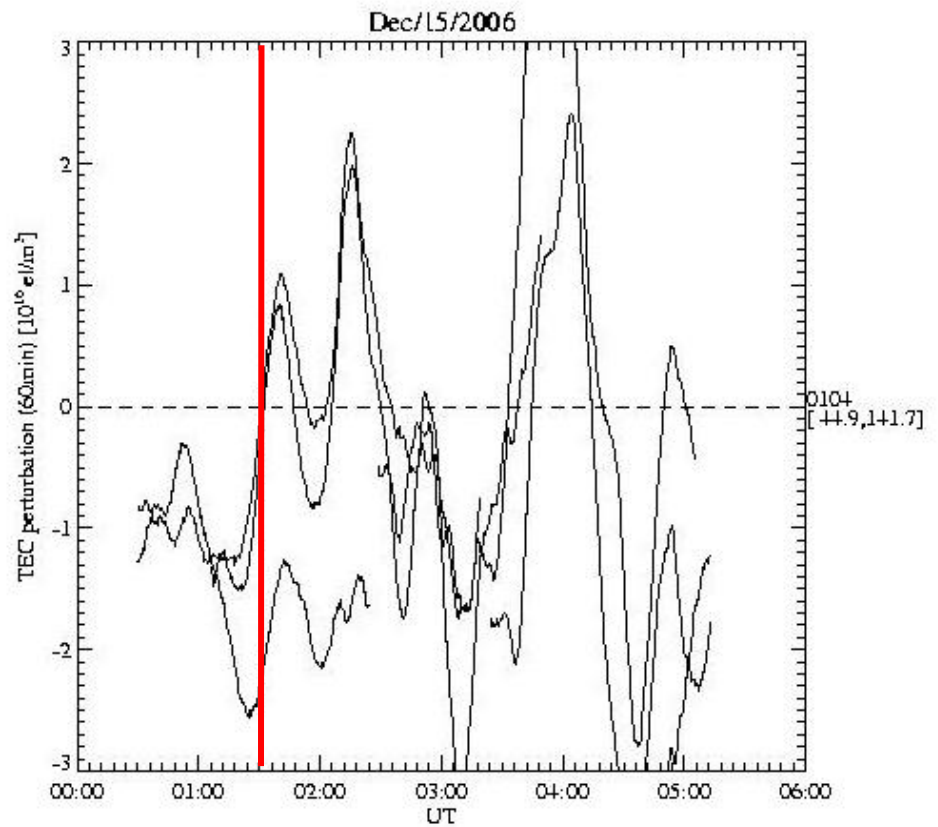
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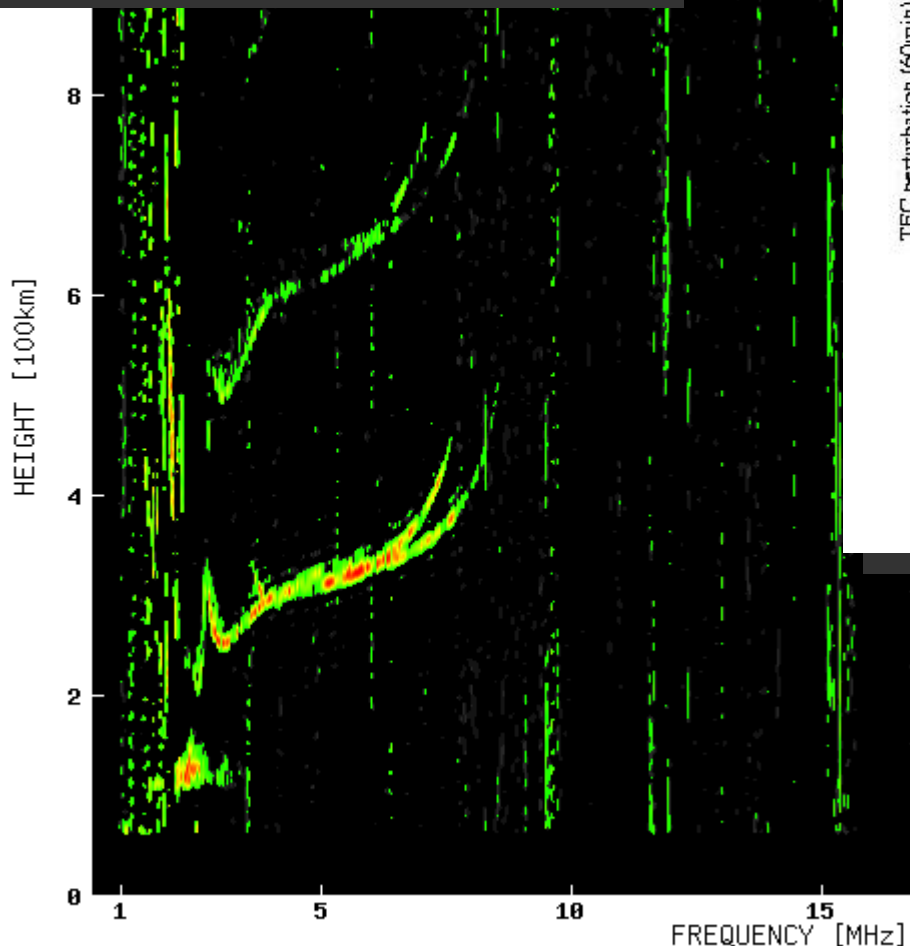
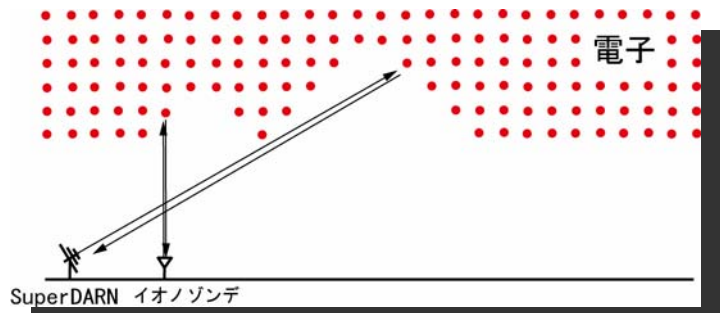




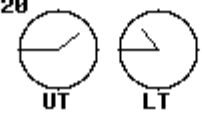
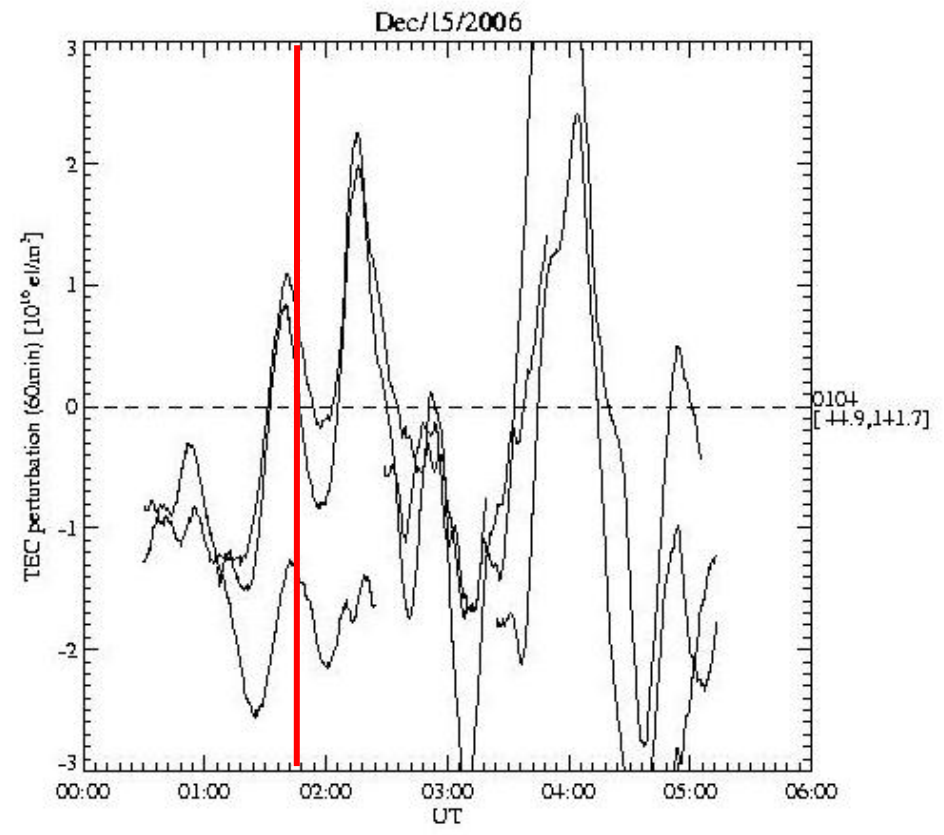


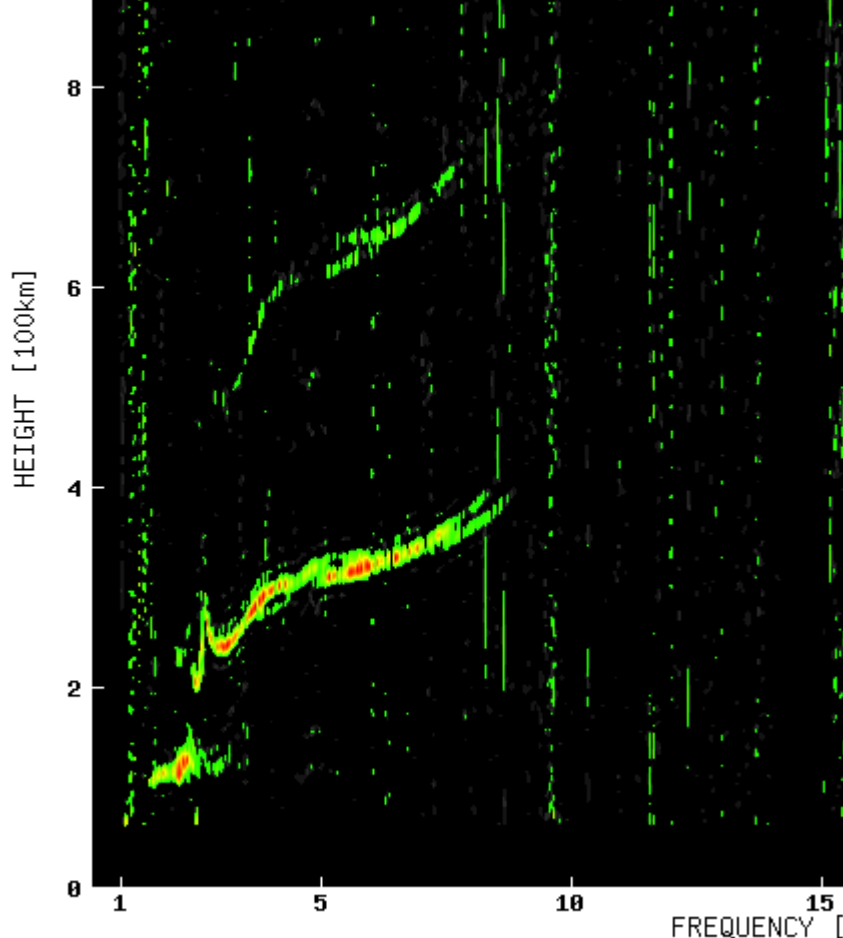
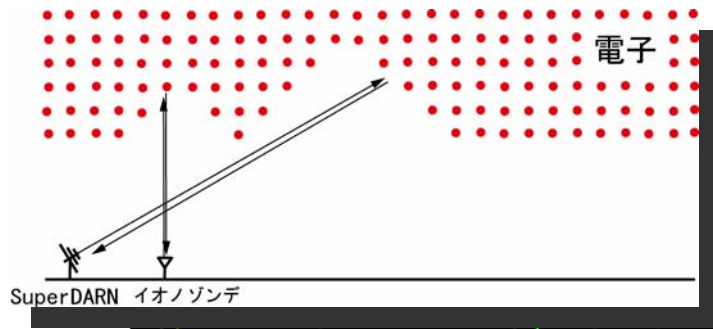
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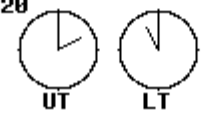
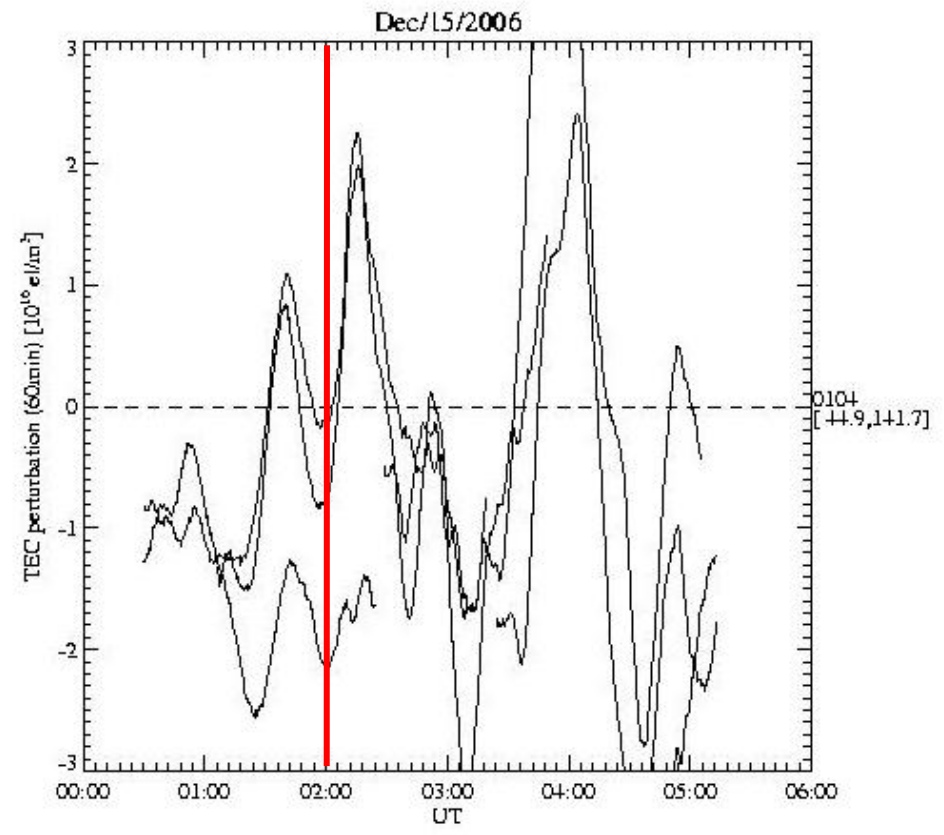


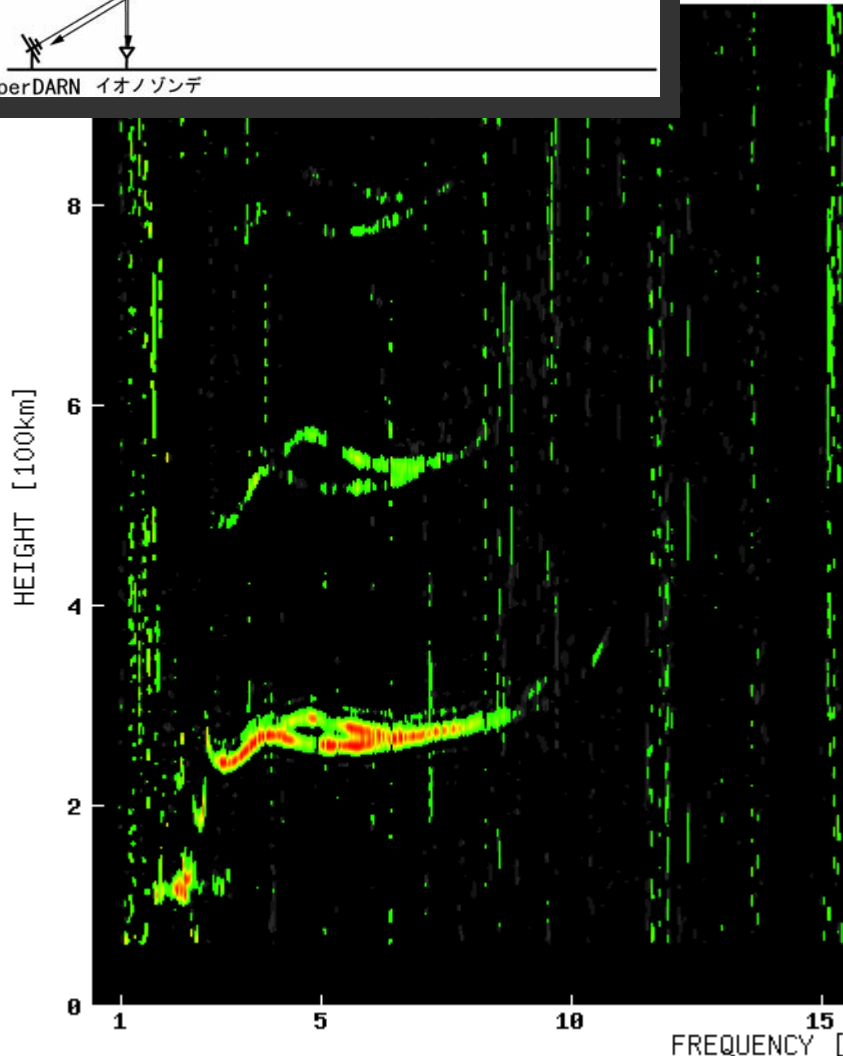
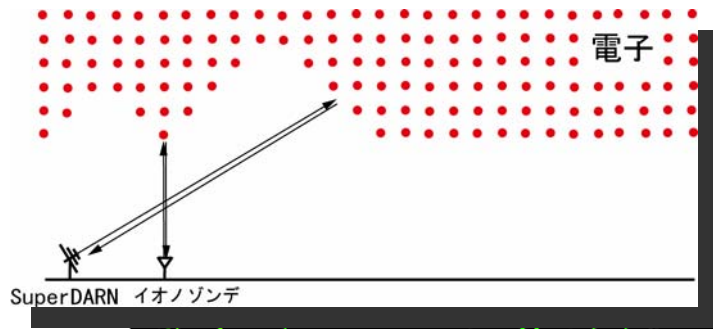
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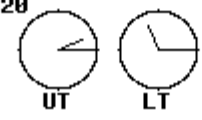
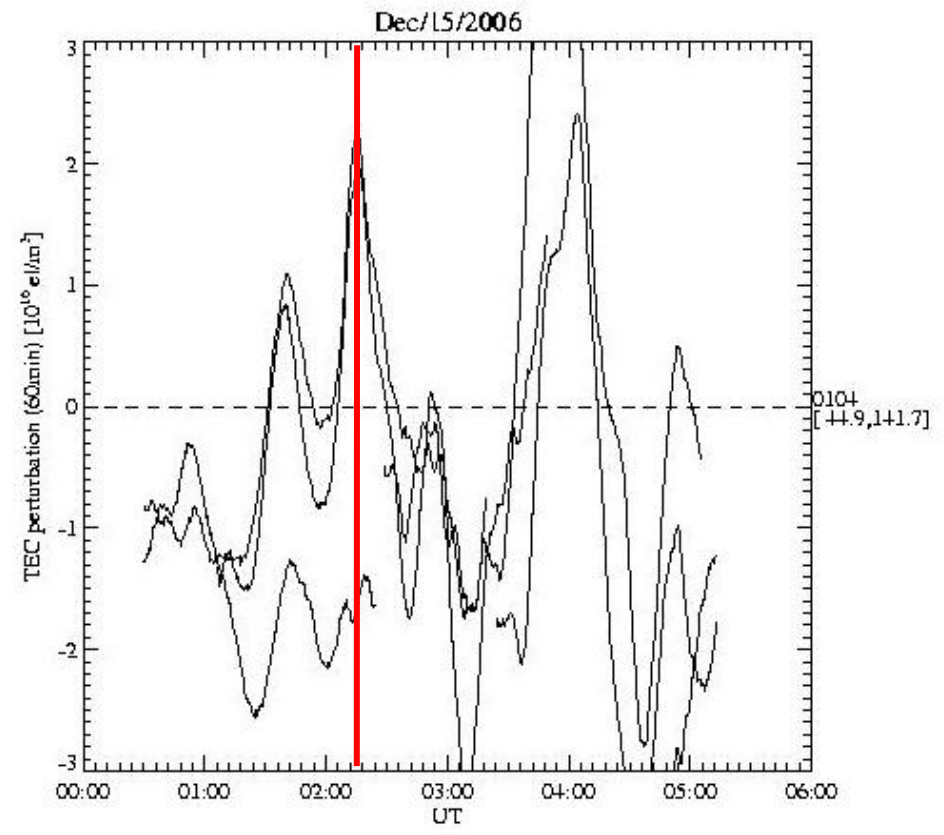


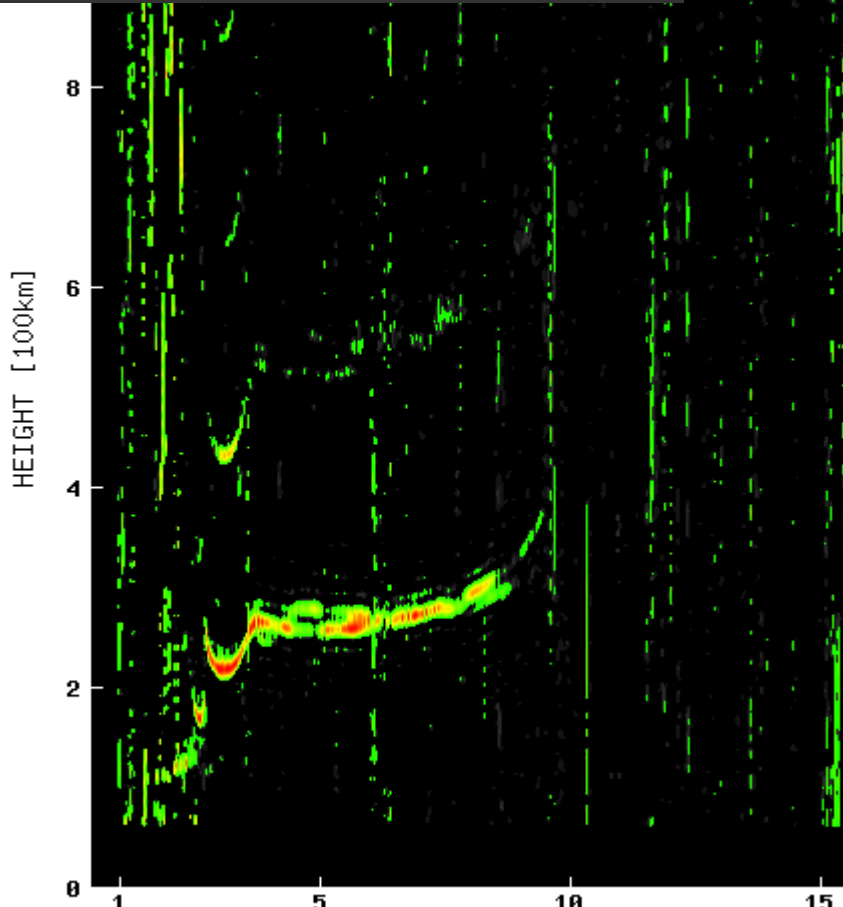
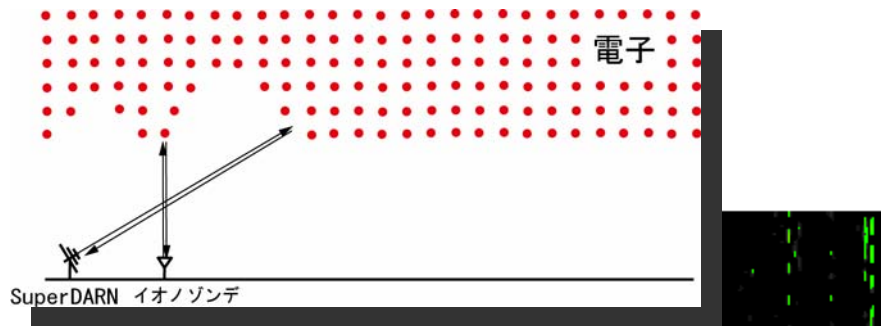
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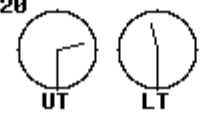
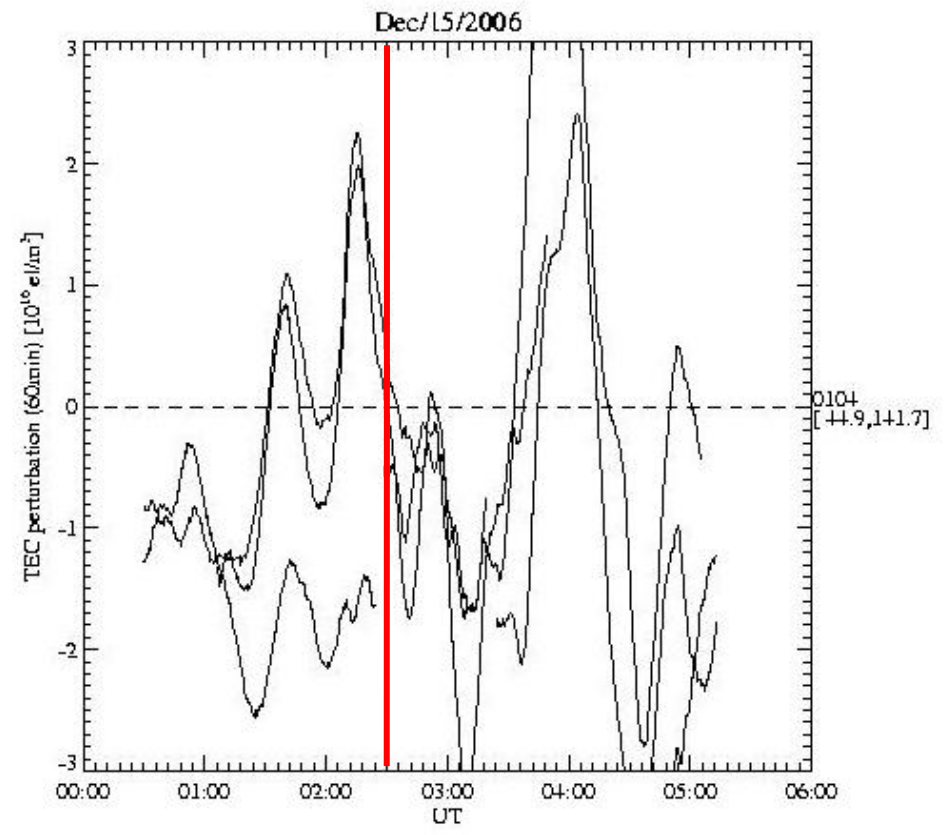


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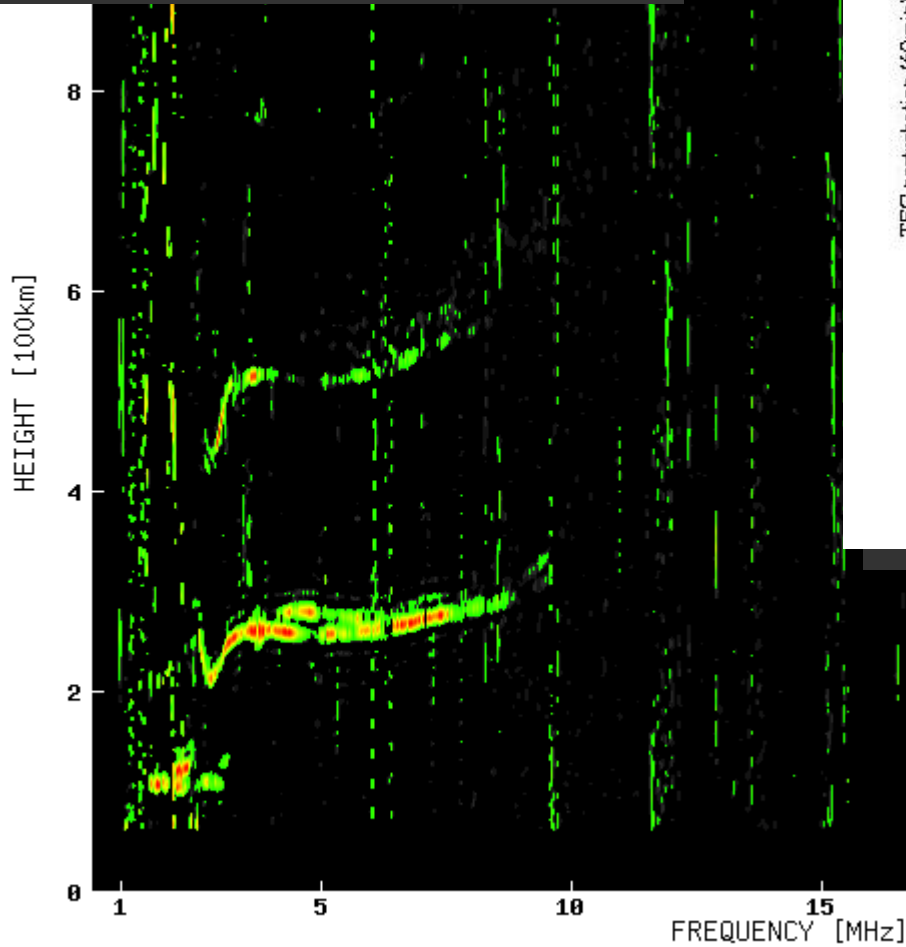
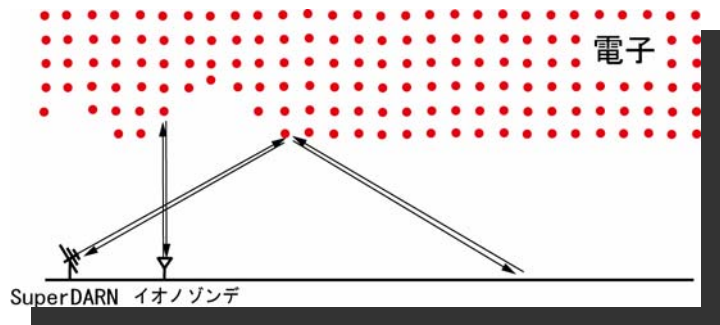




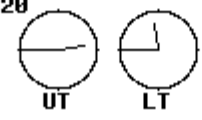
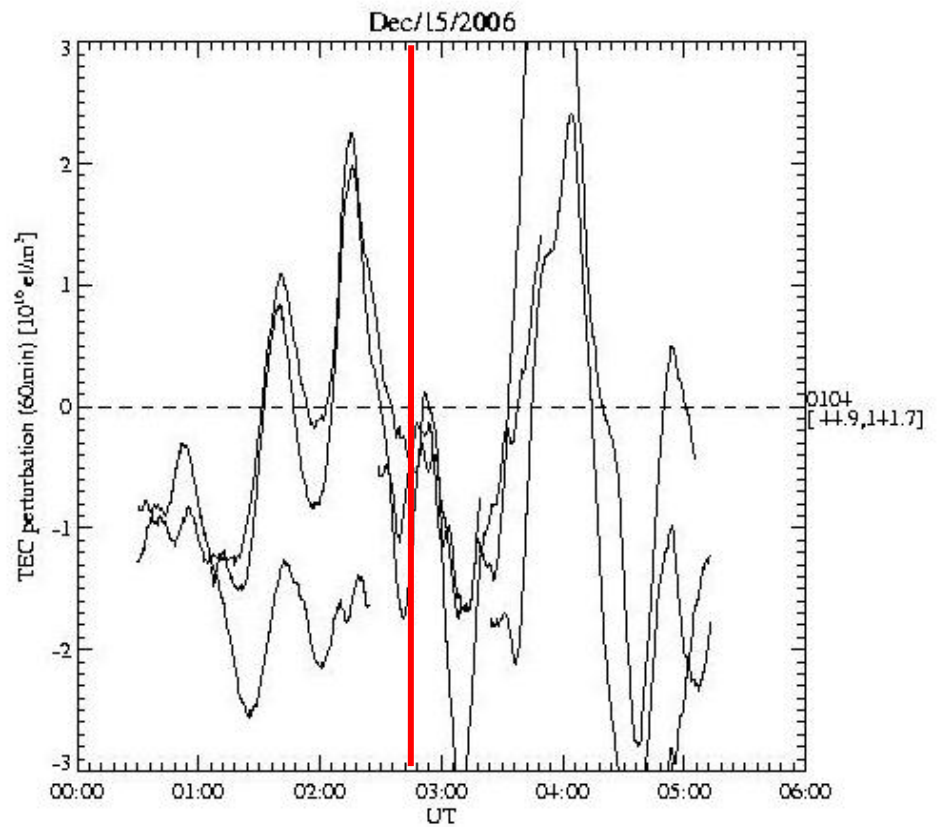
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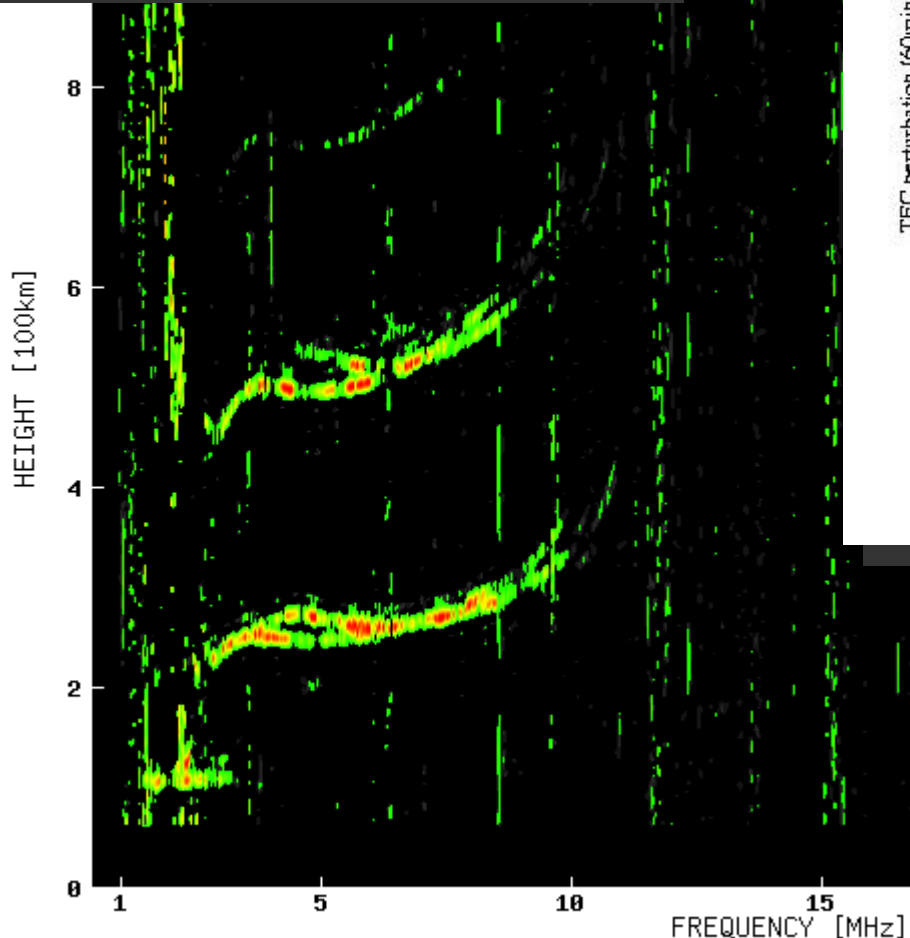
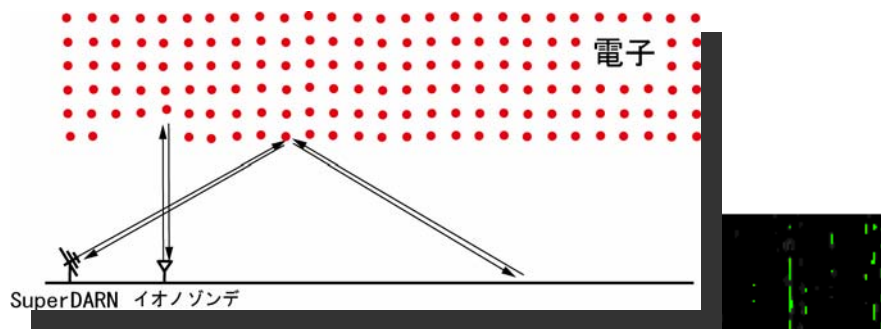




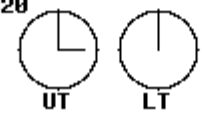
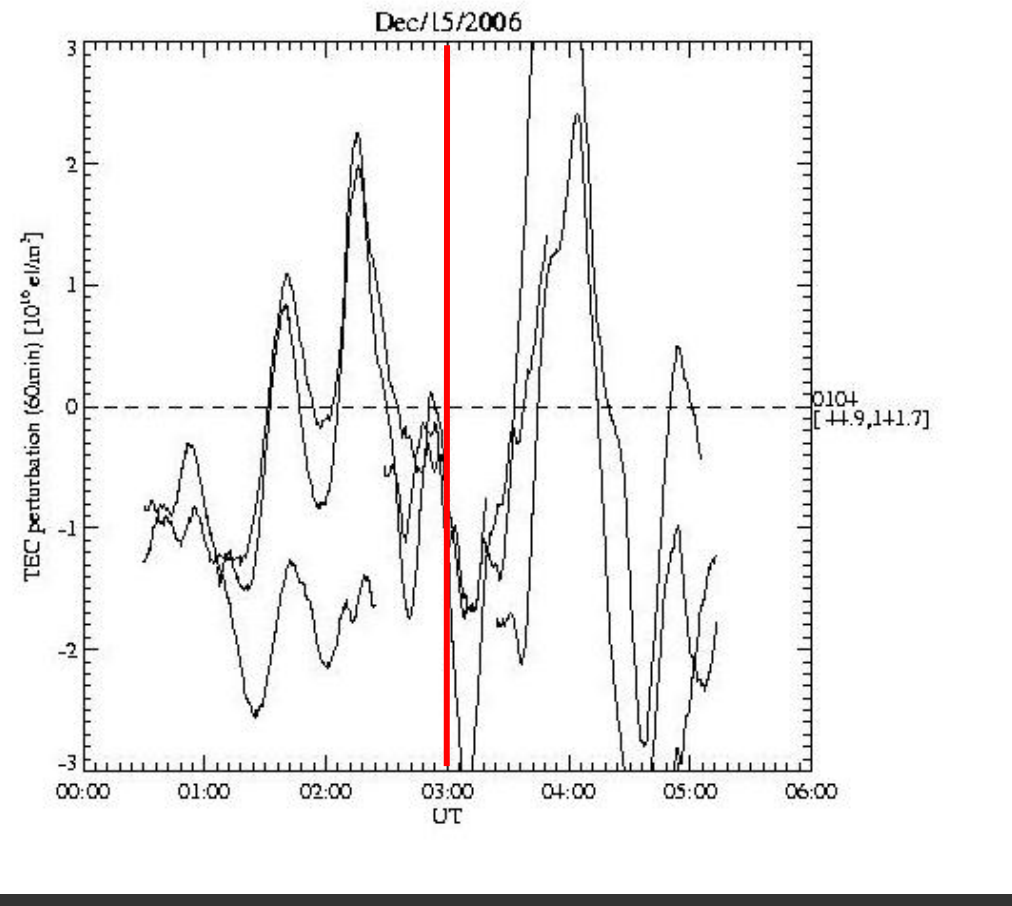


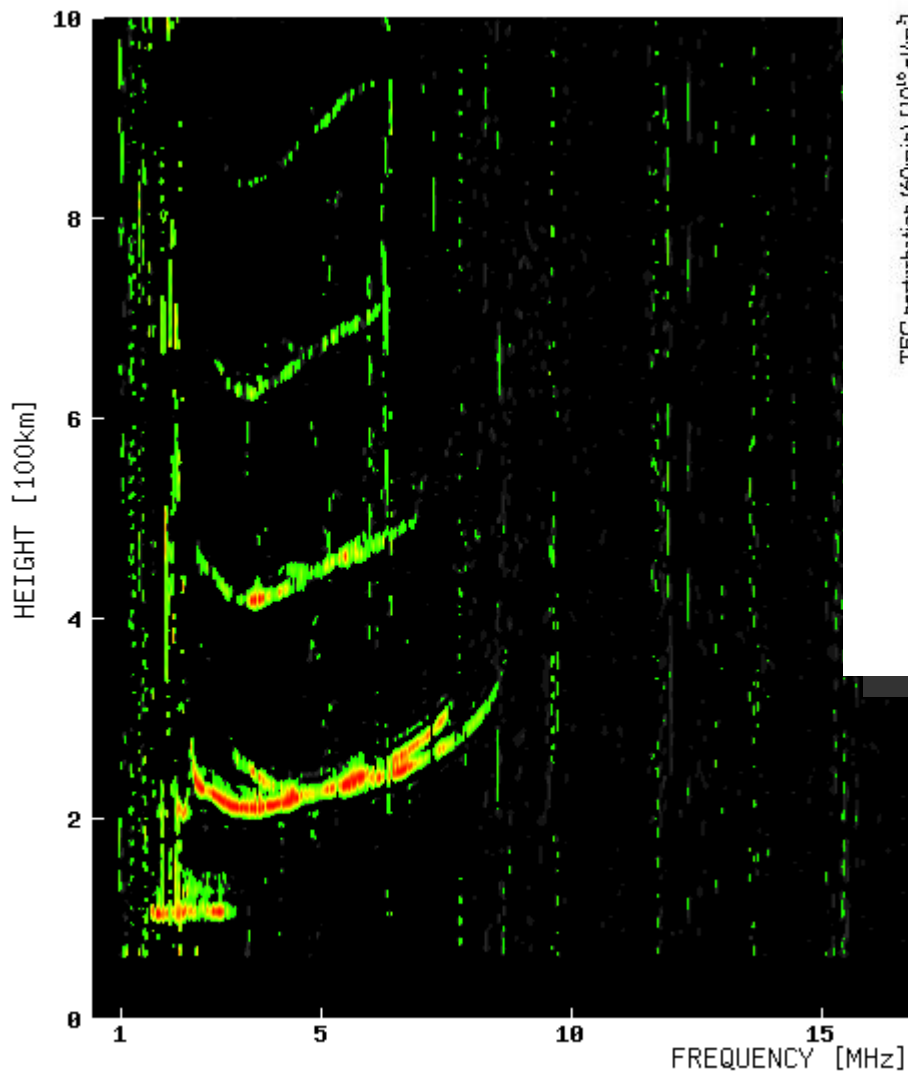
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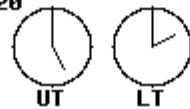
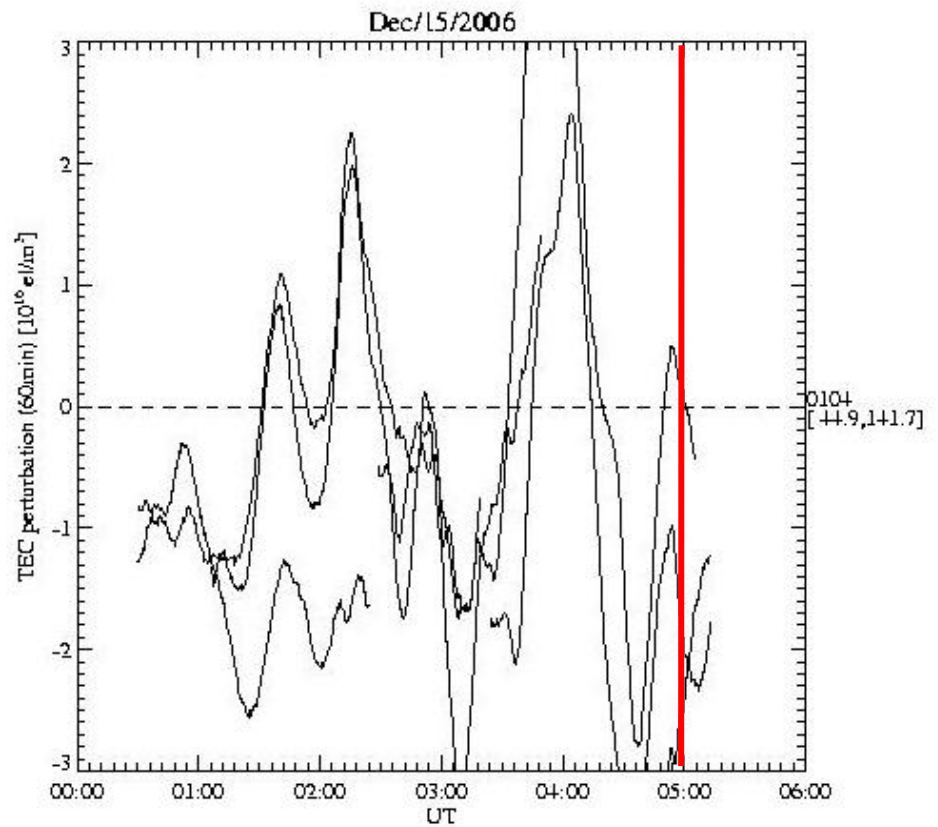


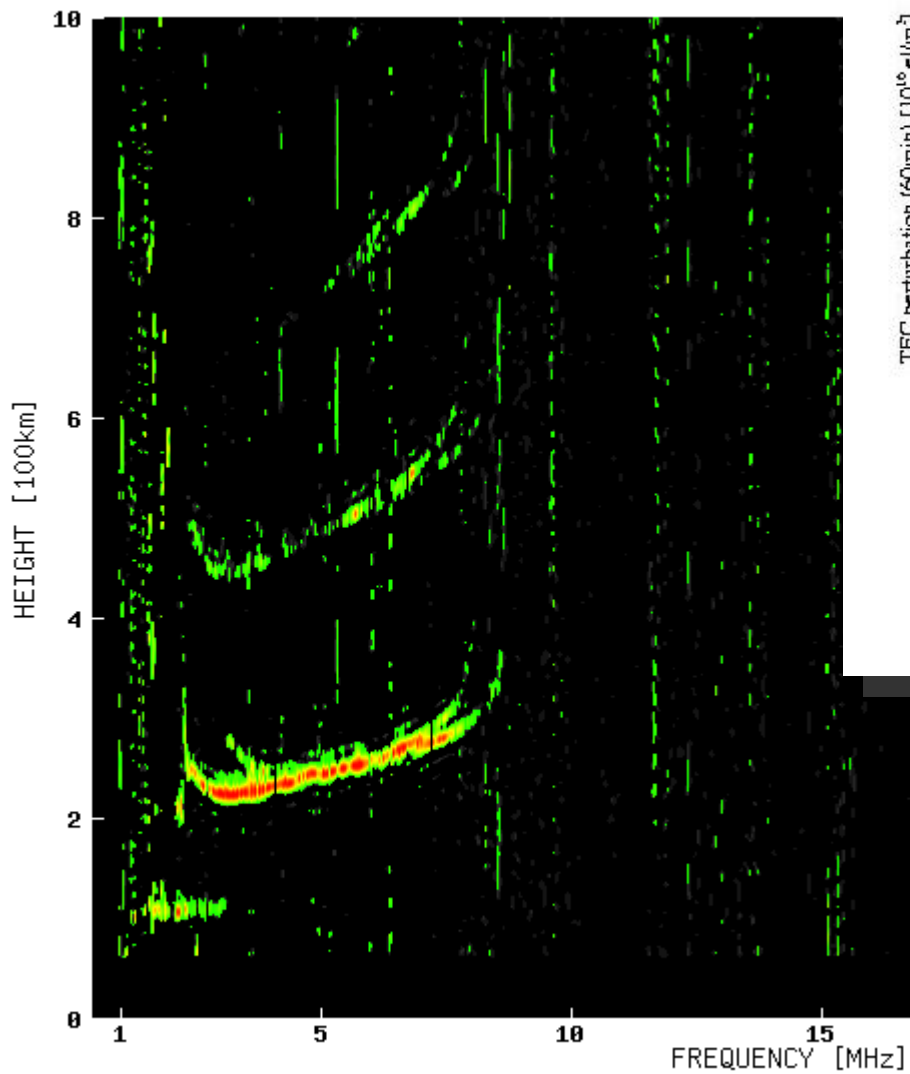
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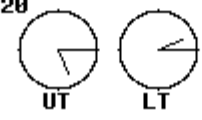
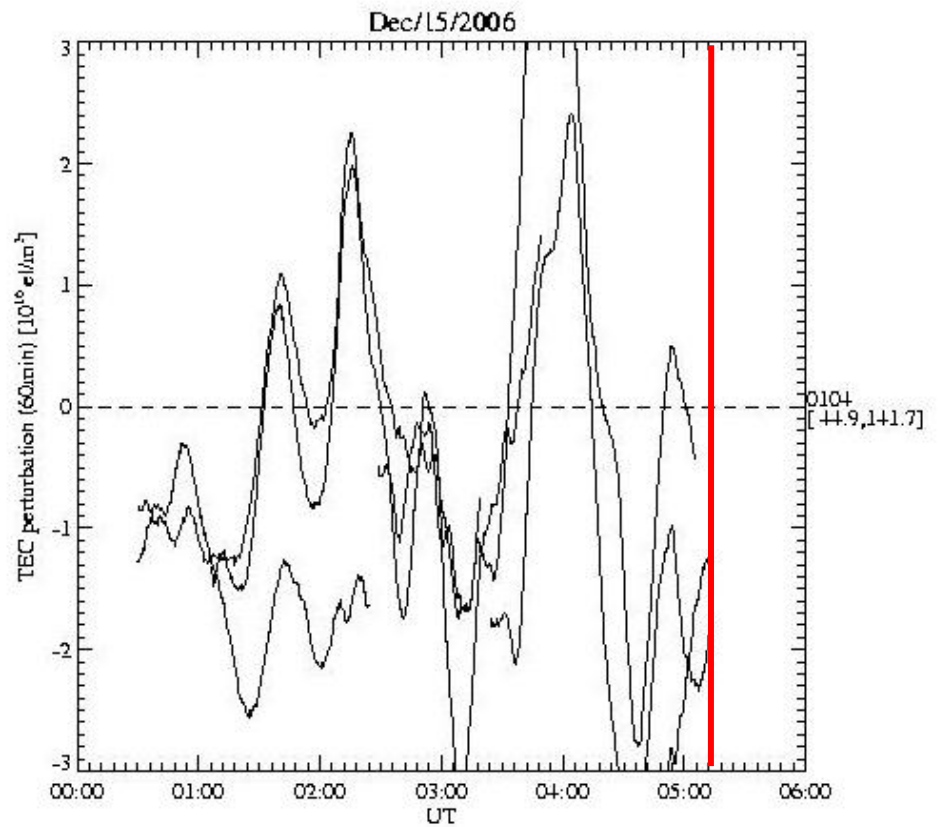


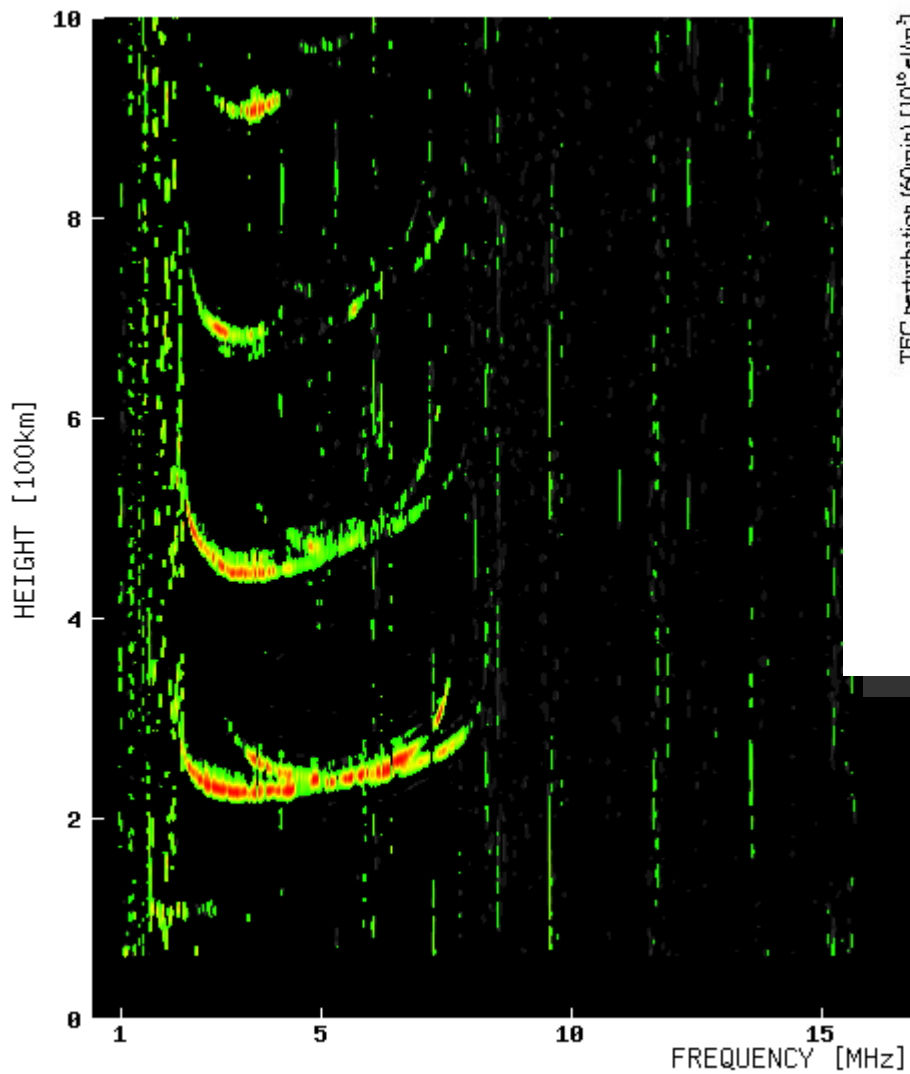
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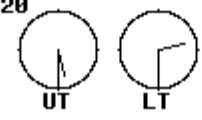
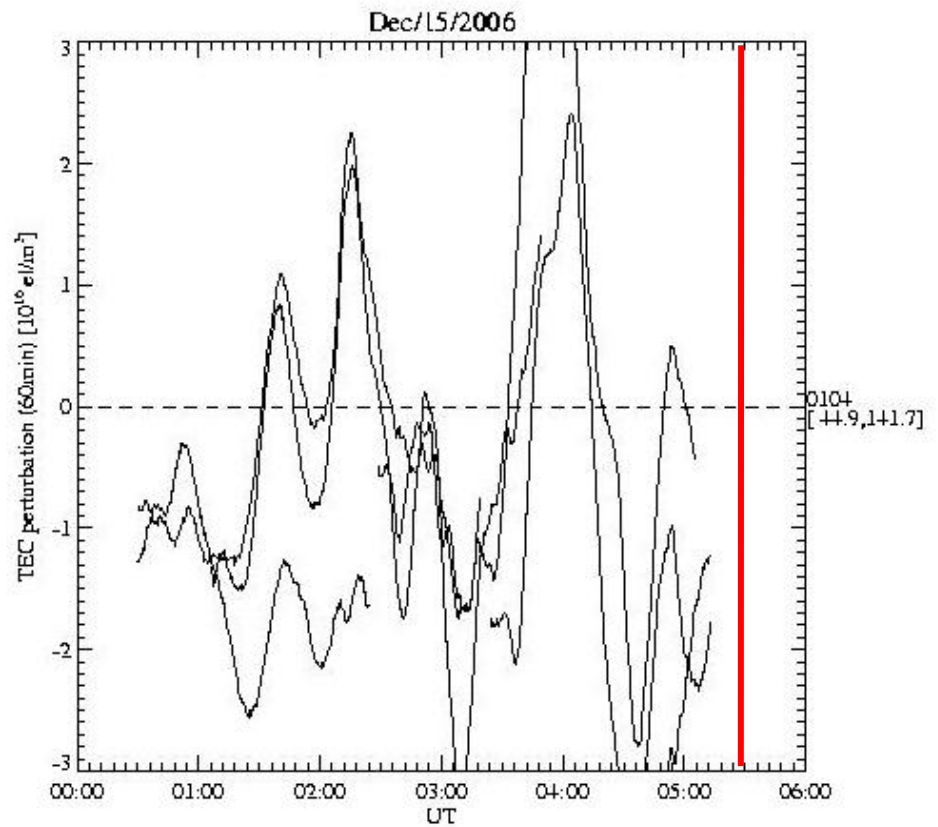


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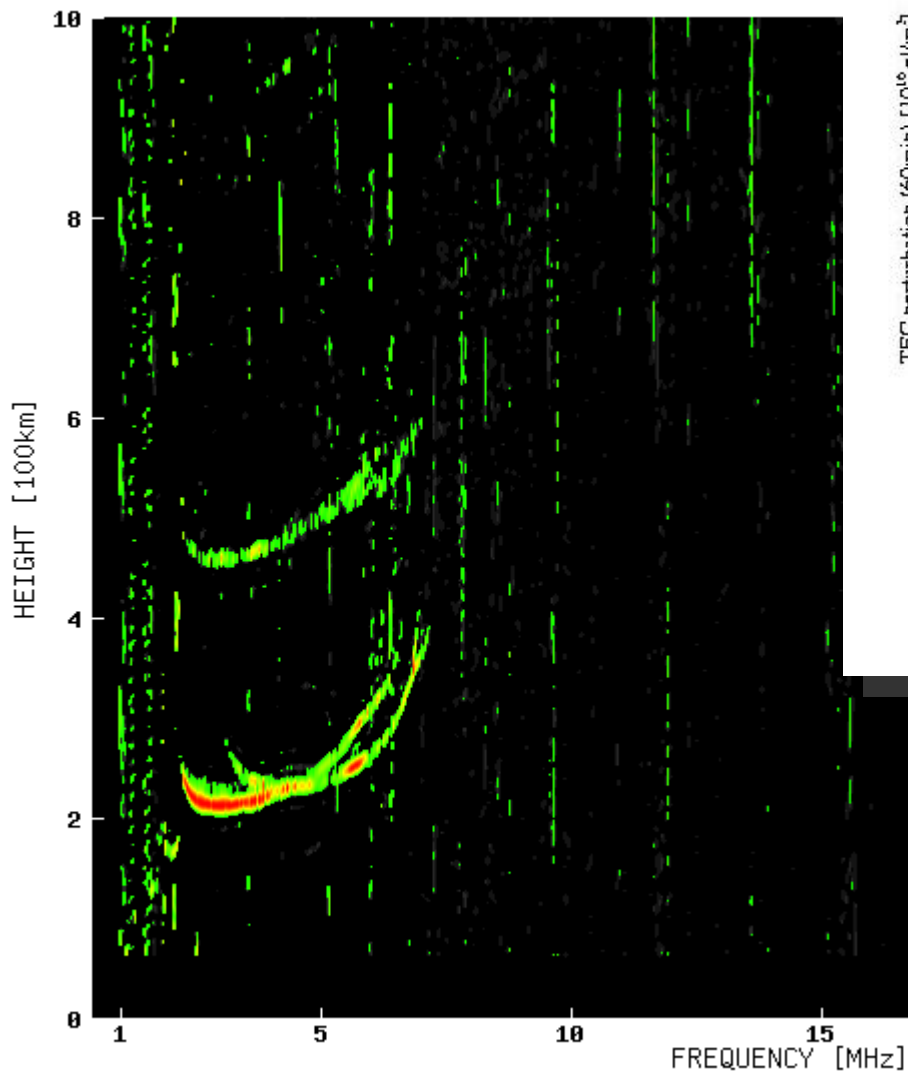




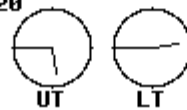
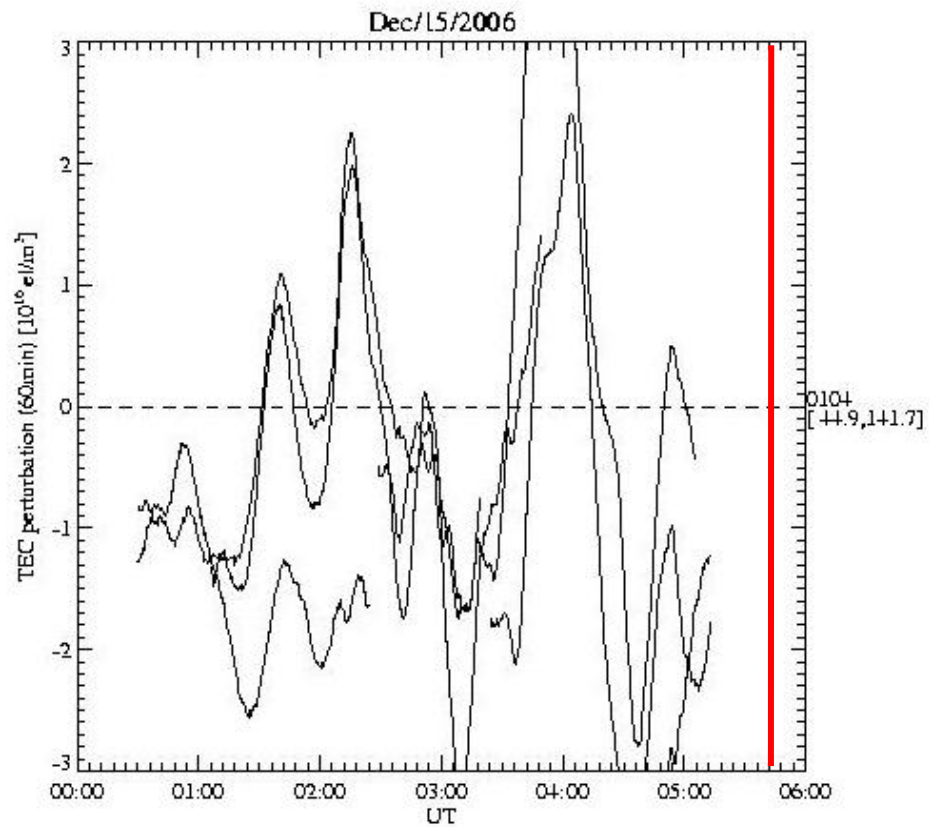
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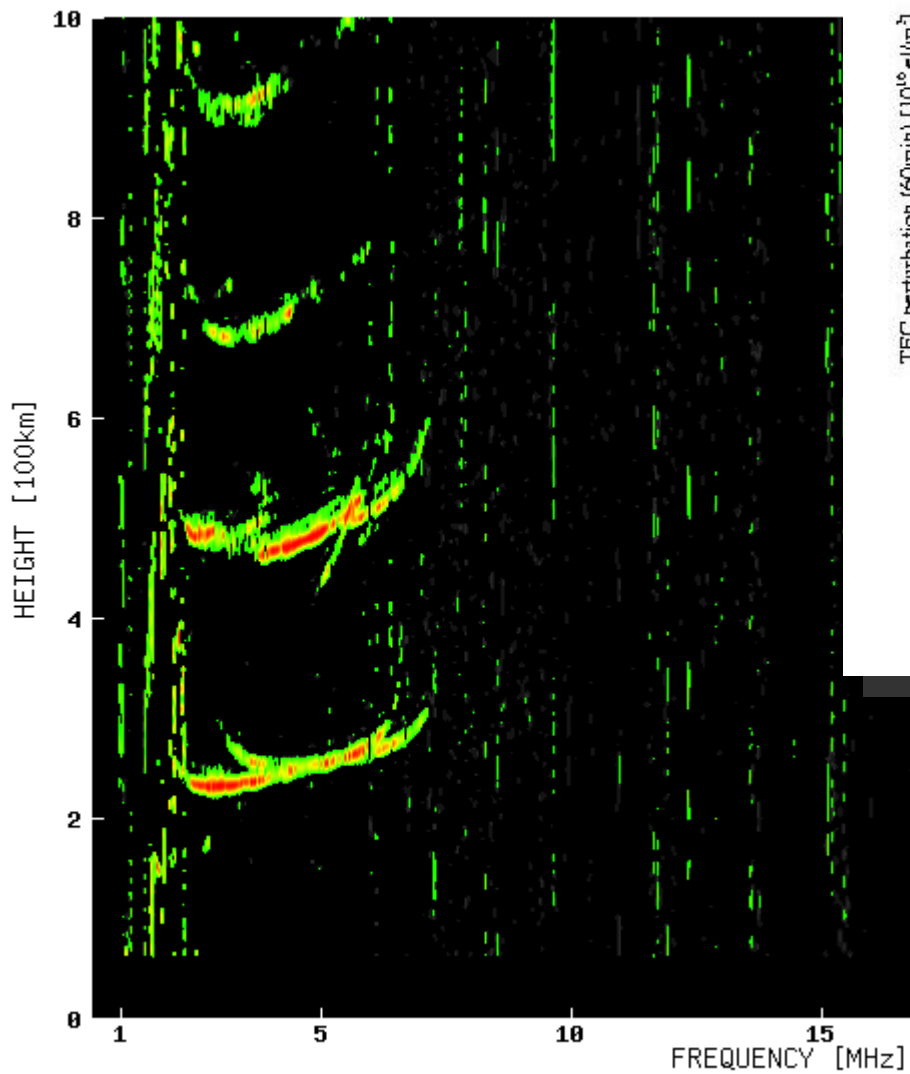






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Dec/15/2006

