Onset of F-region plasma plumes observed with the Equatorial Atmosphere Radar in Indonesia

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Equatorial Atmosphere Radar: EAR

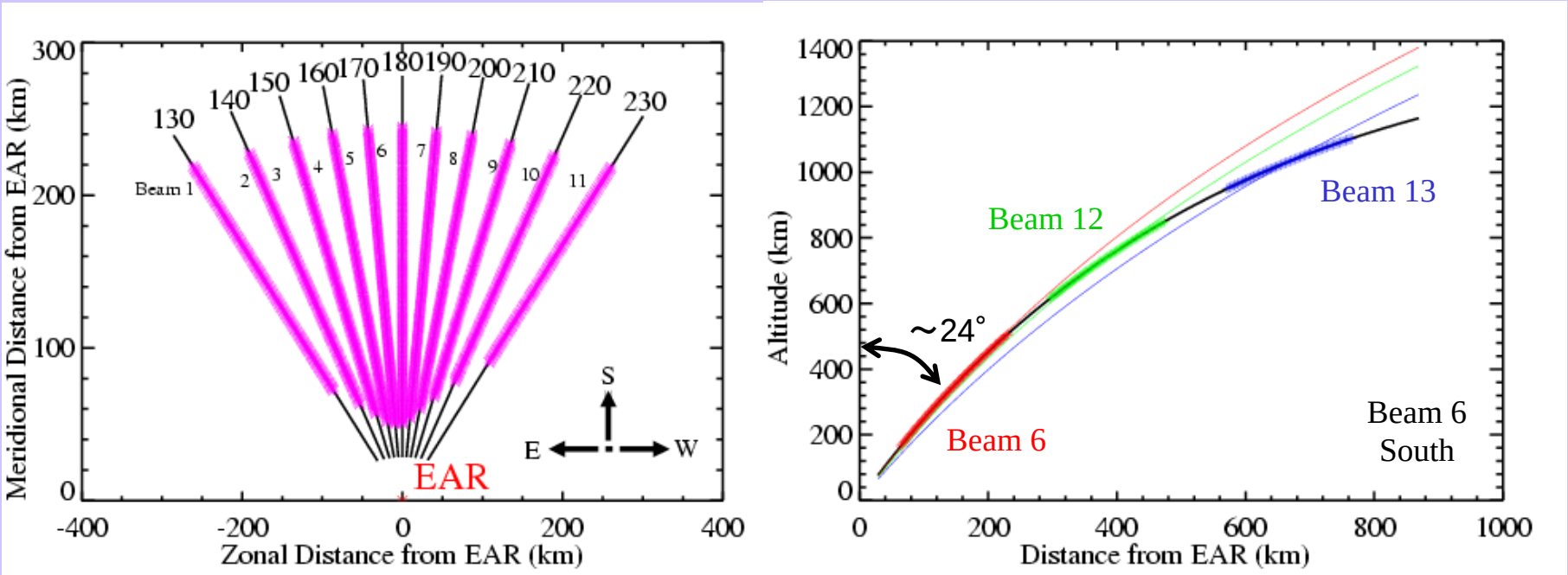
47MHz, Antenna array (110 m in diameter)

Bukittinggi, West Sumatra, Indonesia (0.20S, 100.32E; Dip lat. 10.36S; 865 m above sea level)

560 Yagi antennas, 100kW

EAR: ESF observation mode

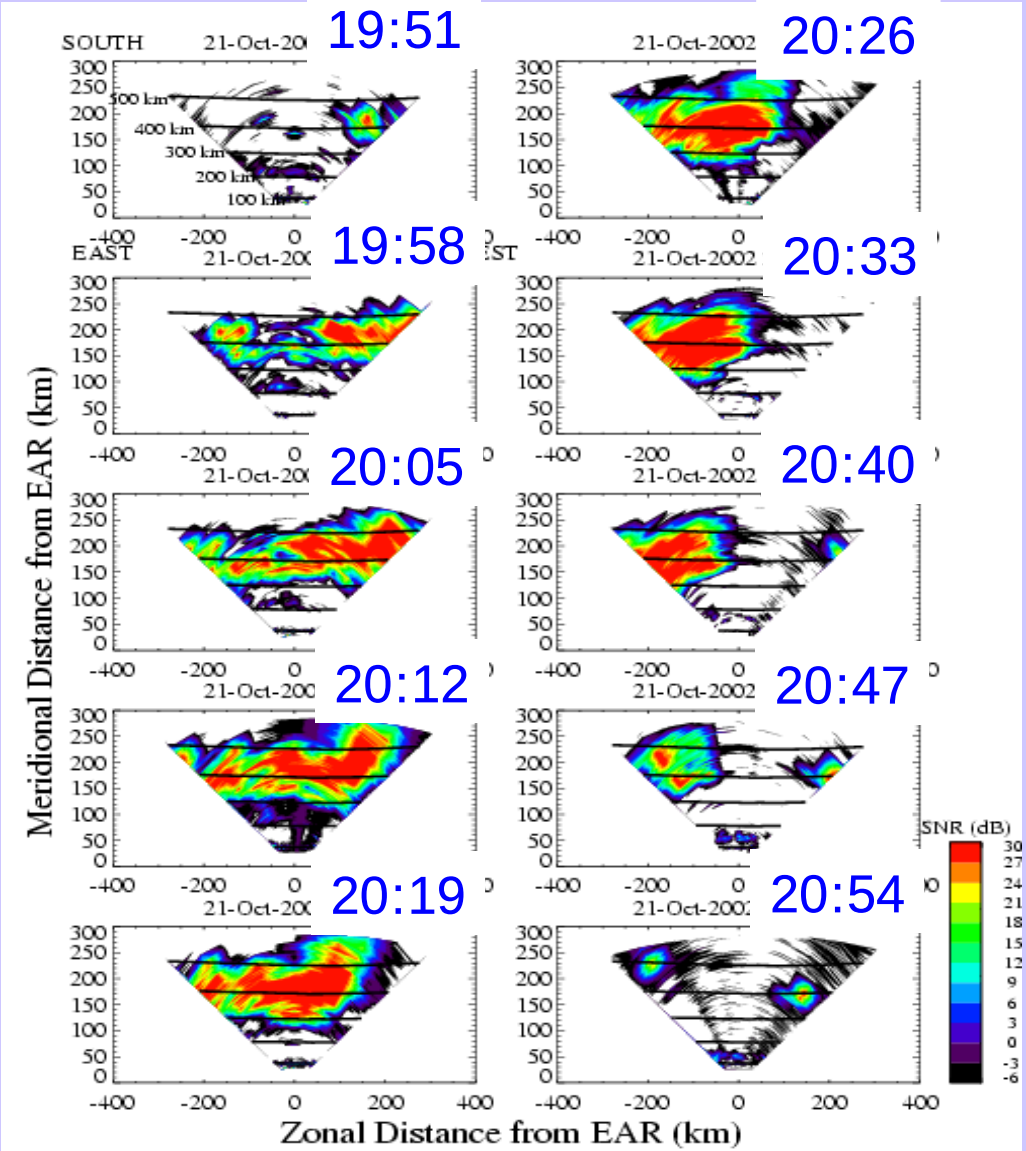
Fan shaped sector map

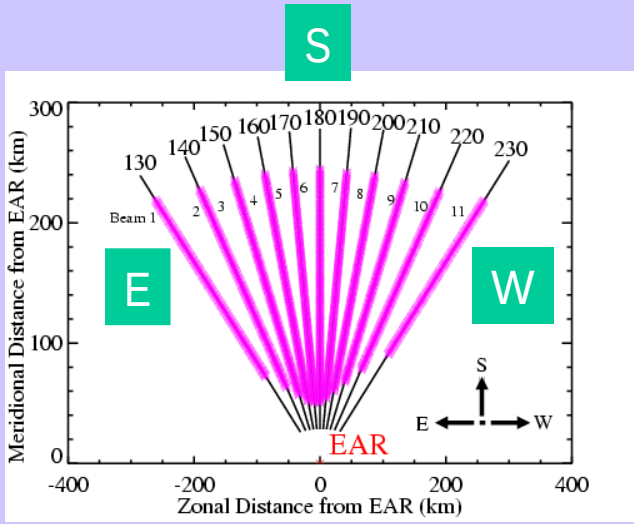


Time required for completing one sequence of observation from Beam 1 to 13 is approximately 140 sec.

Fukao et al., 2004

EAR: Spatial structure of bubble



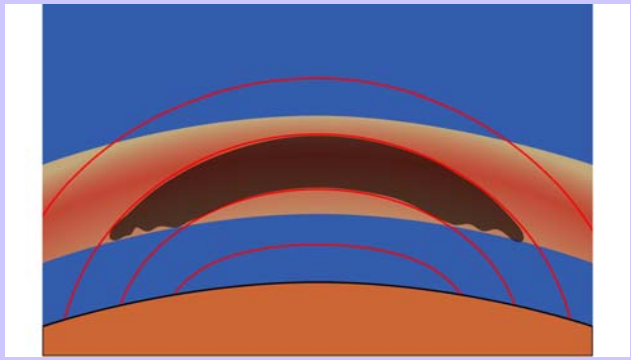


Fan shaped sector map

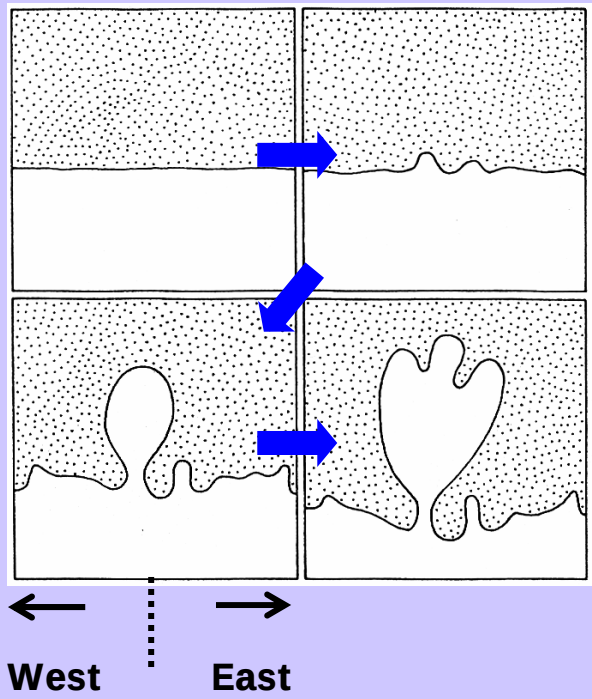
1951-2054 LT
October 21, 2002

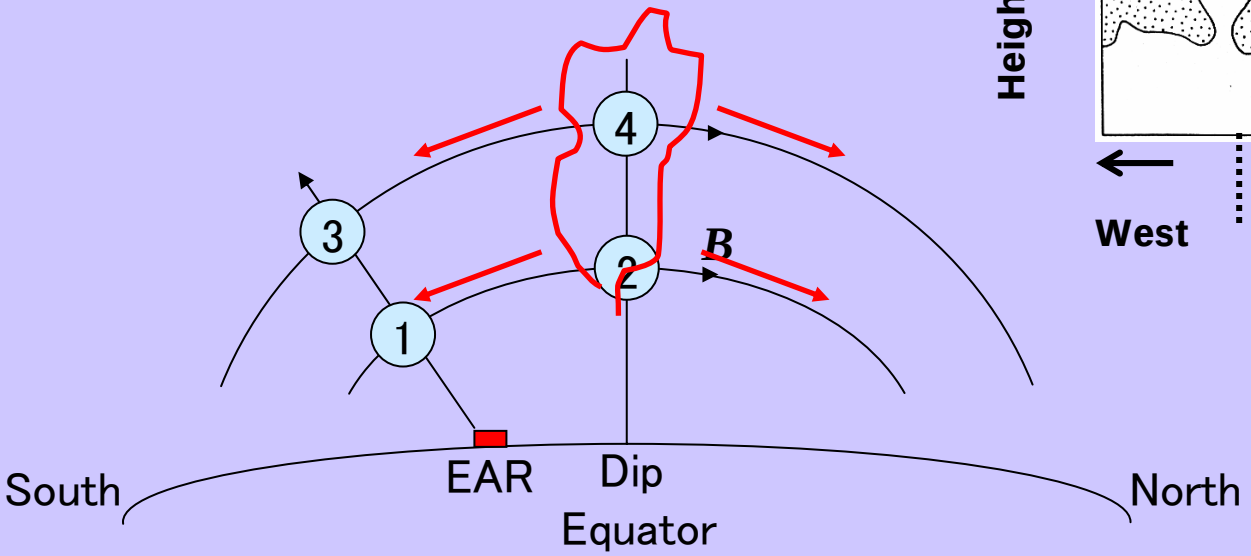
Plasma bubbles

Meridional cross section



Zonal cross section

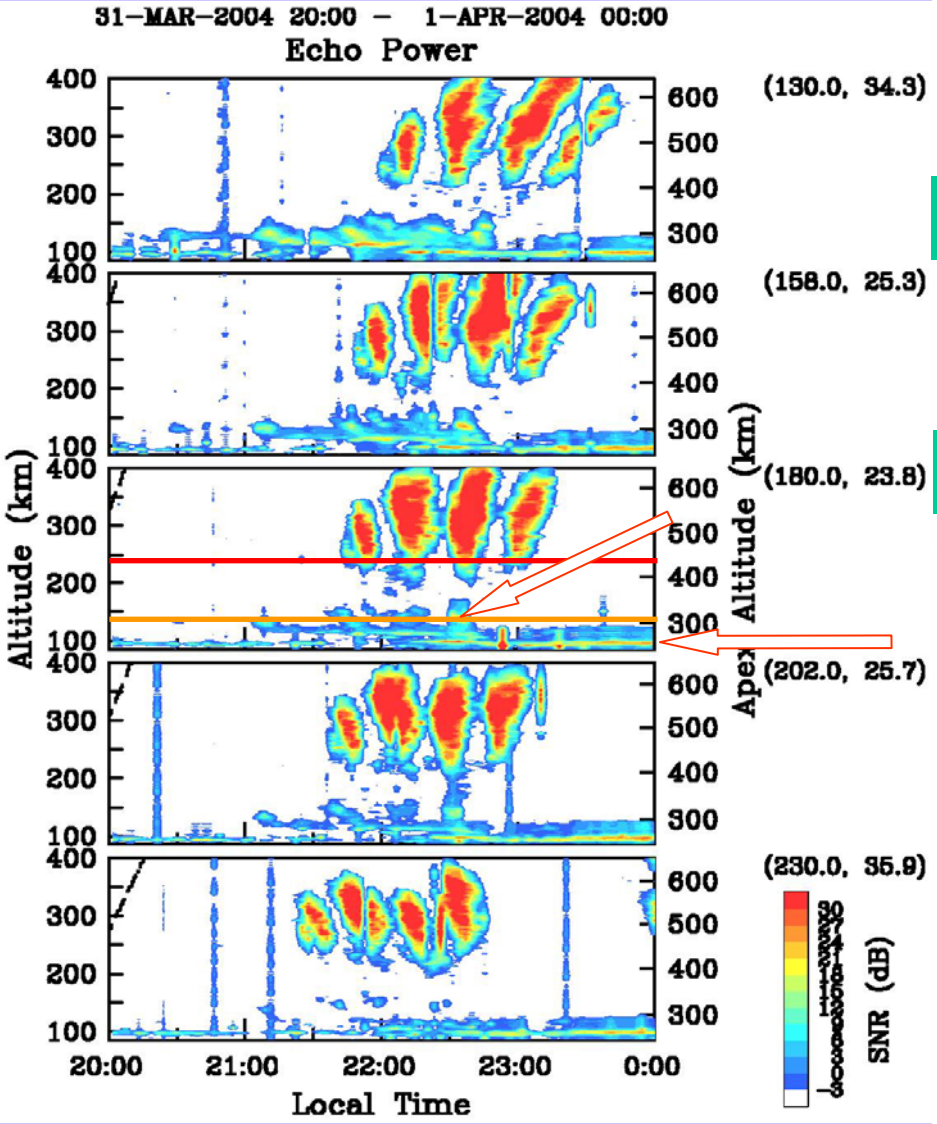




EAR Obs.	Dip Eq.
①: 100km	⇔ ②: 280km
③: 300km	⇔ ④: 520km

EAR: 10.36S dip lat

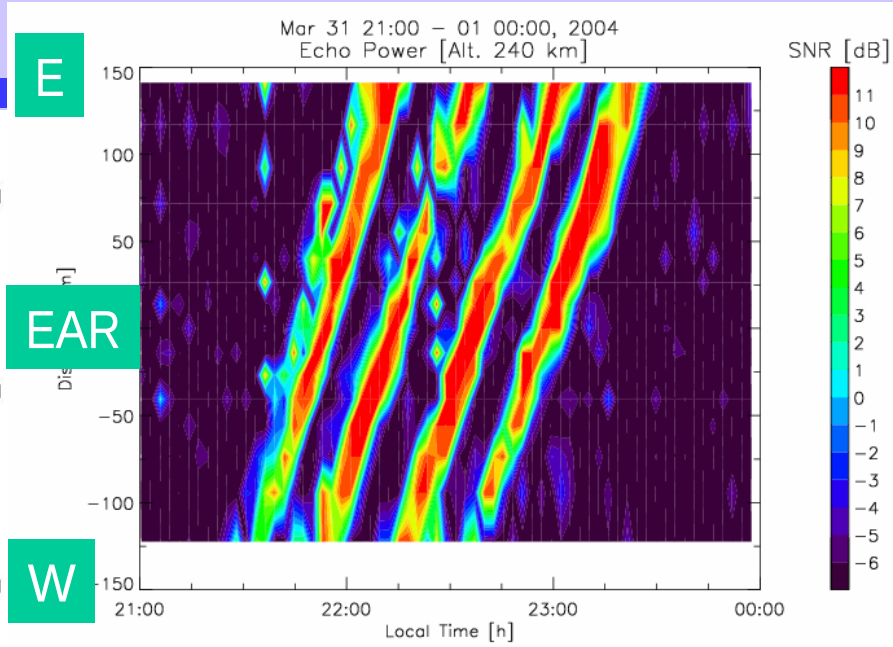
Valley region echoes

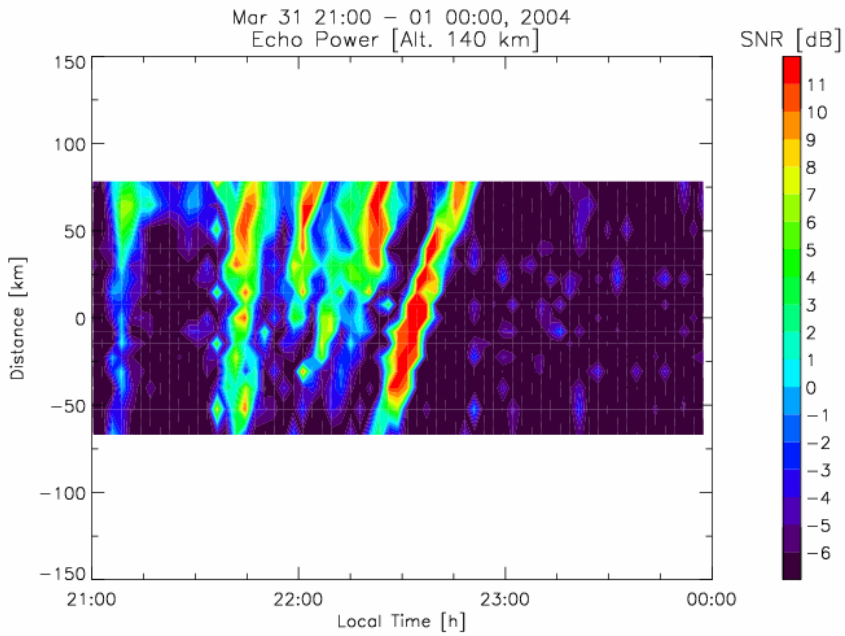


E

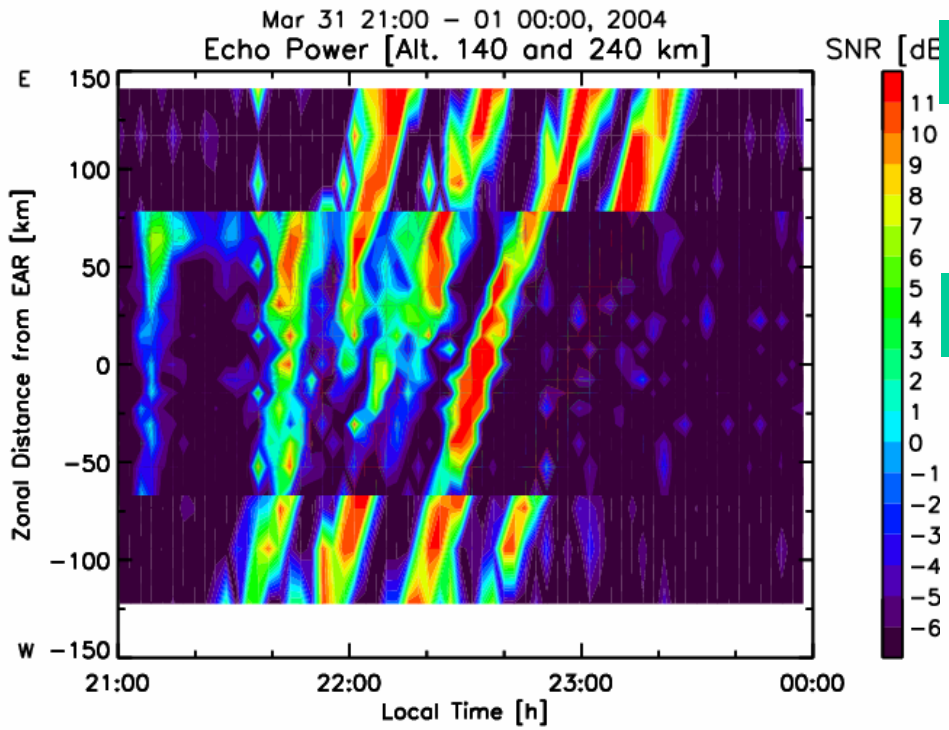
EAR

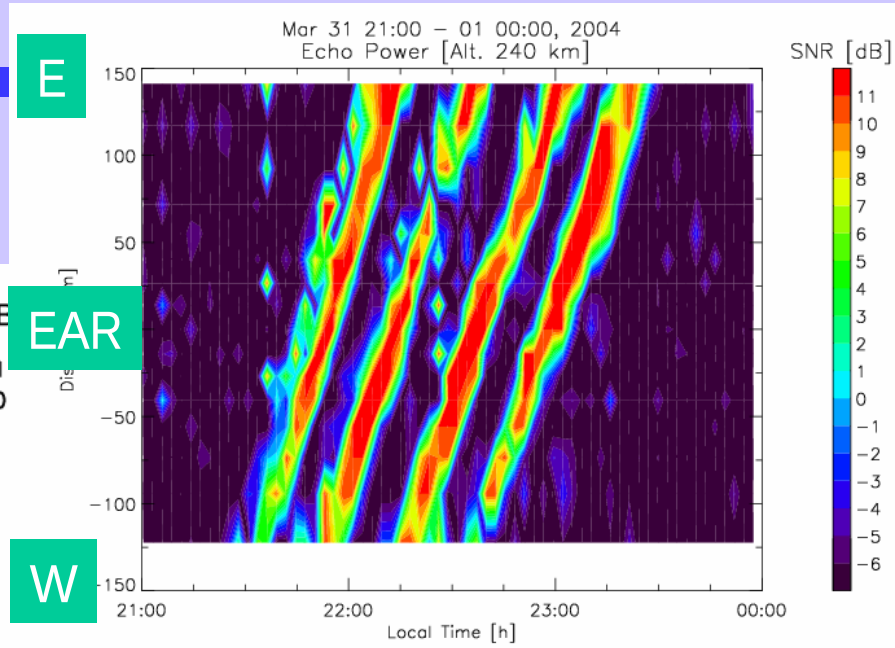
W

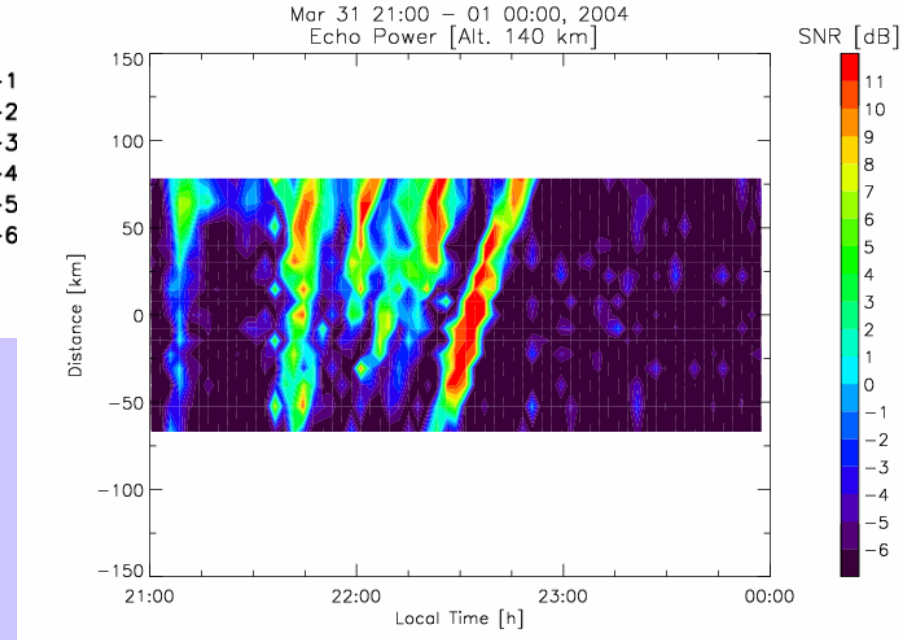




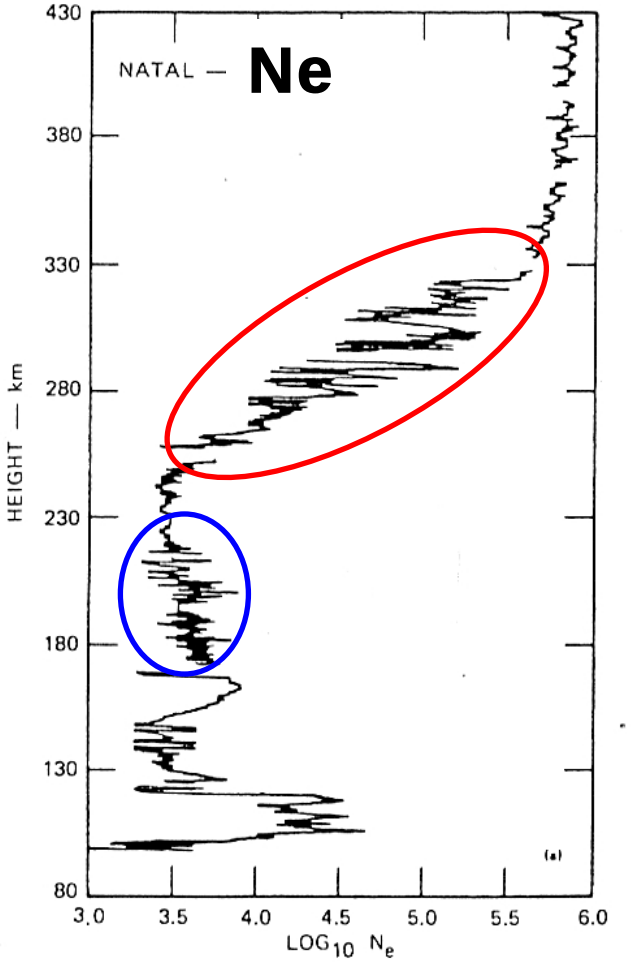
Valley region echoes

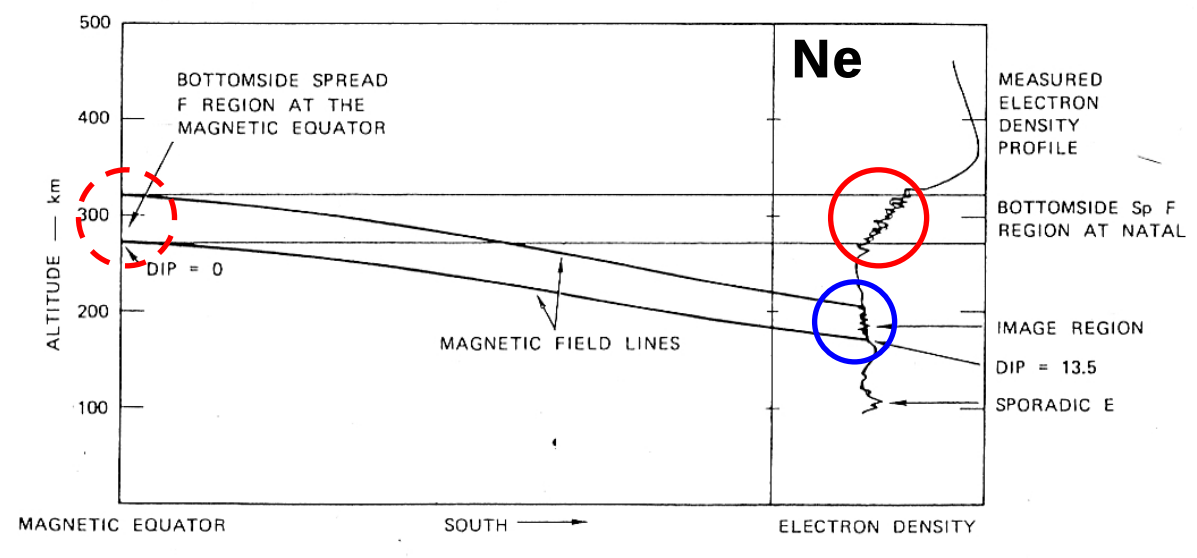






Formation of image structure





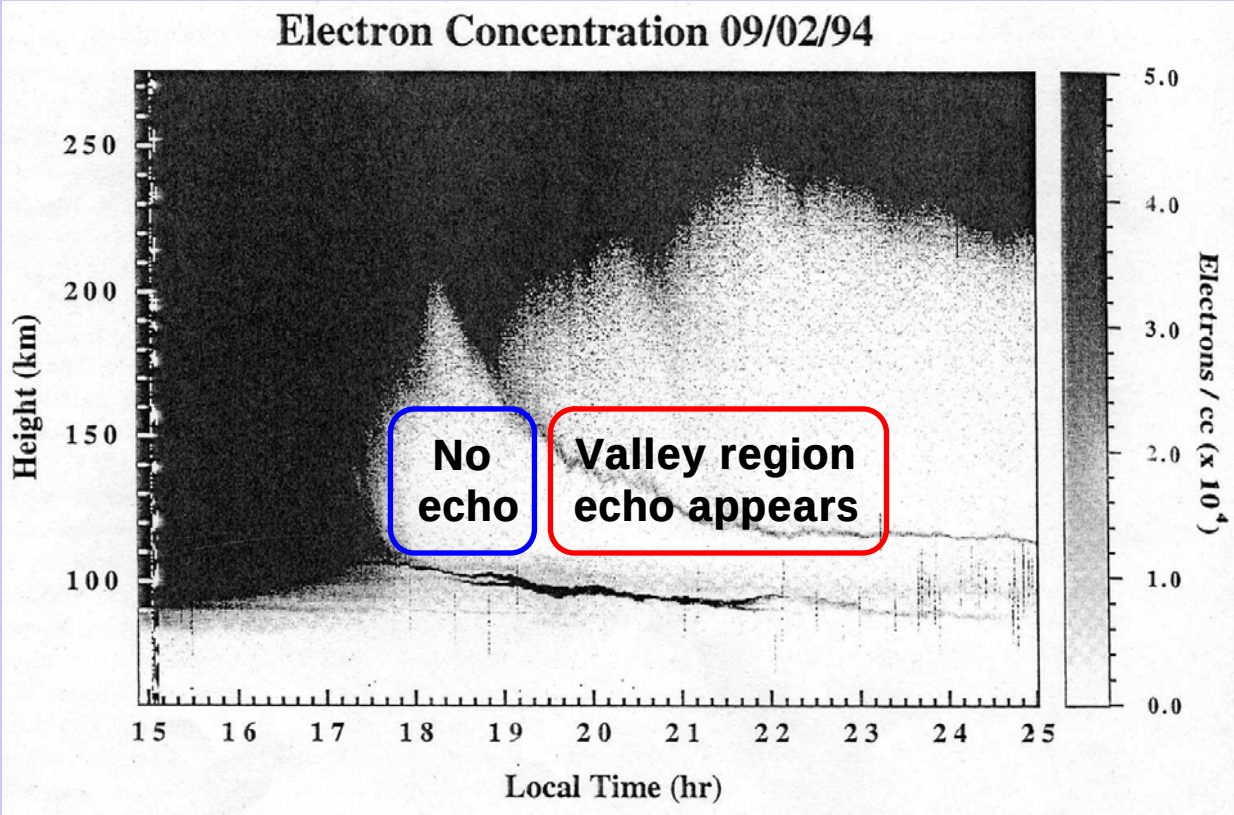
Rocket observation;
Vickrey et al., 1984

Bottom-side ESF structures at dip equator form their image in valley region at low latitude.

However, to explain the EAR echoes below 150 km,

- **background density is too low, and**
- **no echo is observed immediately after bubble occurrence.**

Intermediate Layer; plausible source



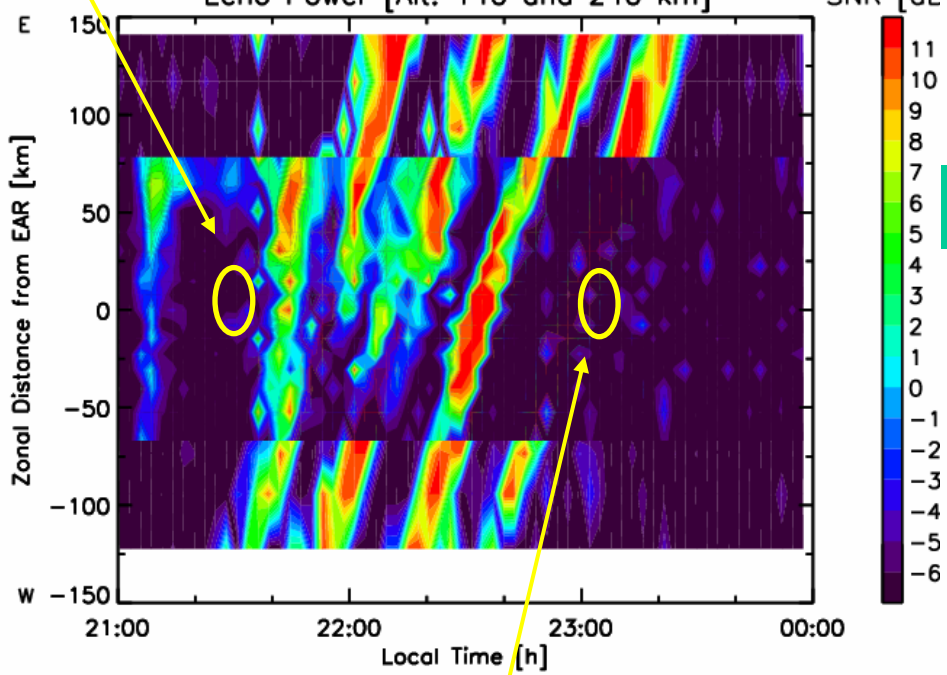
Arecibo ISR Observation; Mathews et al., 1997

Intermediate layers may supply enough density and density gradient in the valley region [Patra et al., 2002].

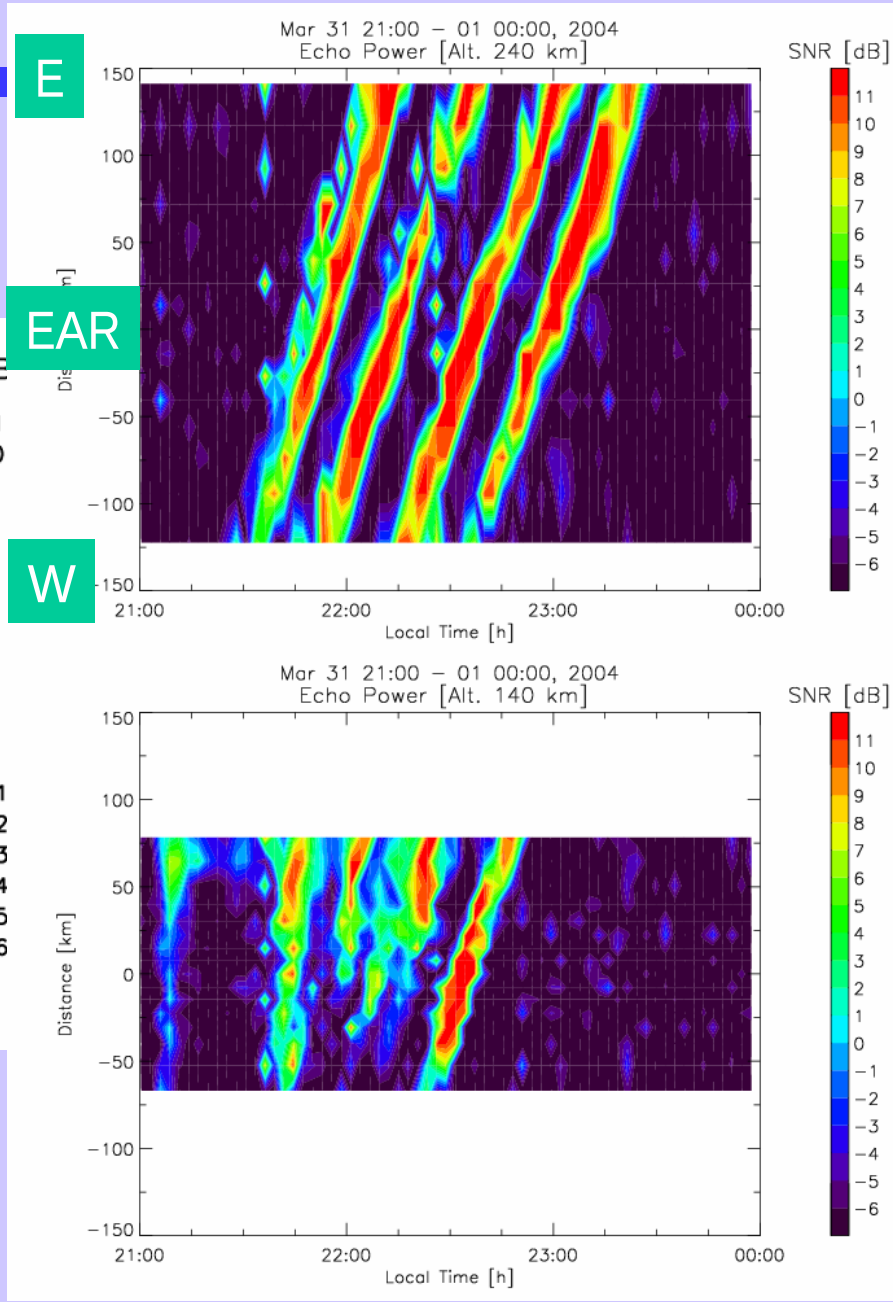
- (2, 4) mode of semidiurnal tide appears before midnight in low latitudes,
- being consistent with the occurrence of valley region echoes observed by EAR.

Valley region echoes

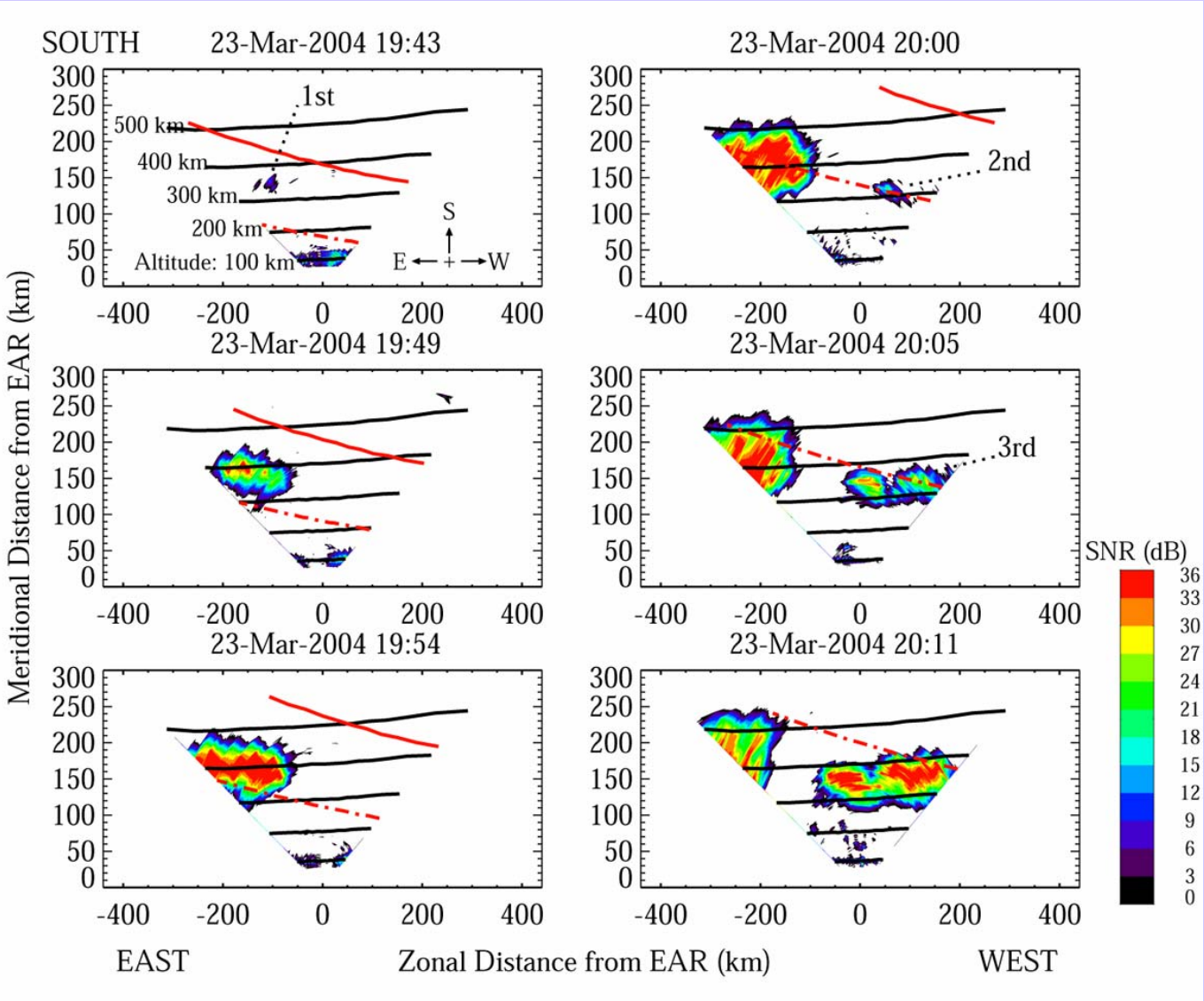
Bottomside spread F



No intermediate layer



Plumes born close to the sunset terminator

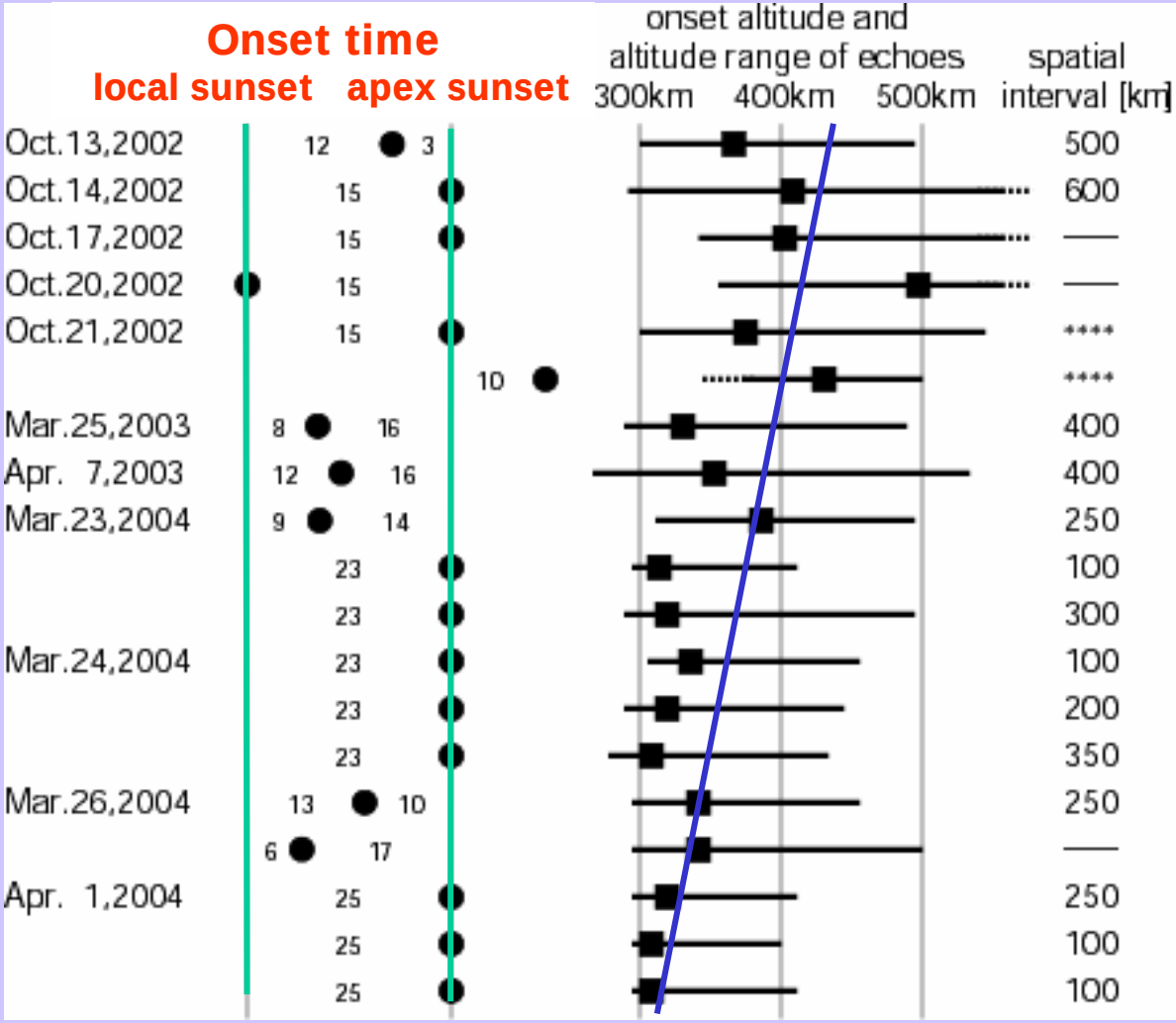


Sunset terminator over EAR

Apex sunset terminator

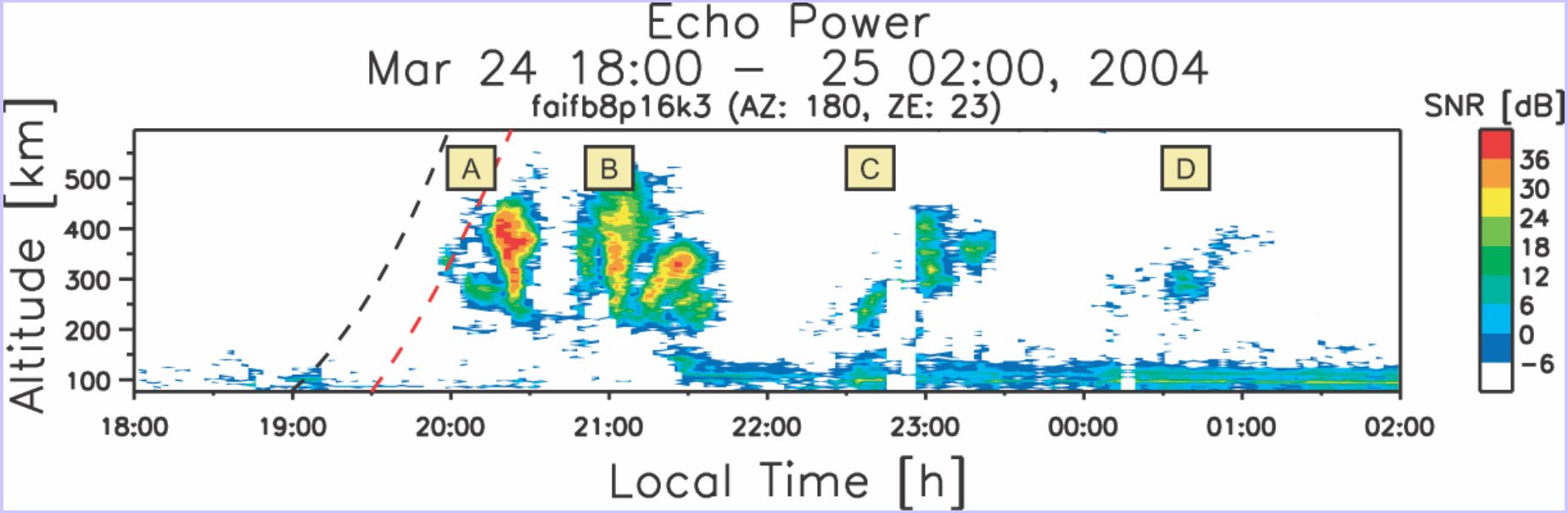
Onset time and altitude range of plume echoes

Yokoyama et al., 2004



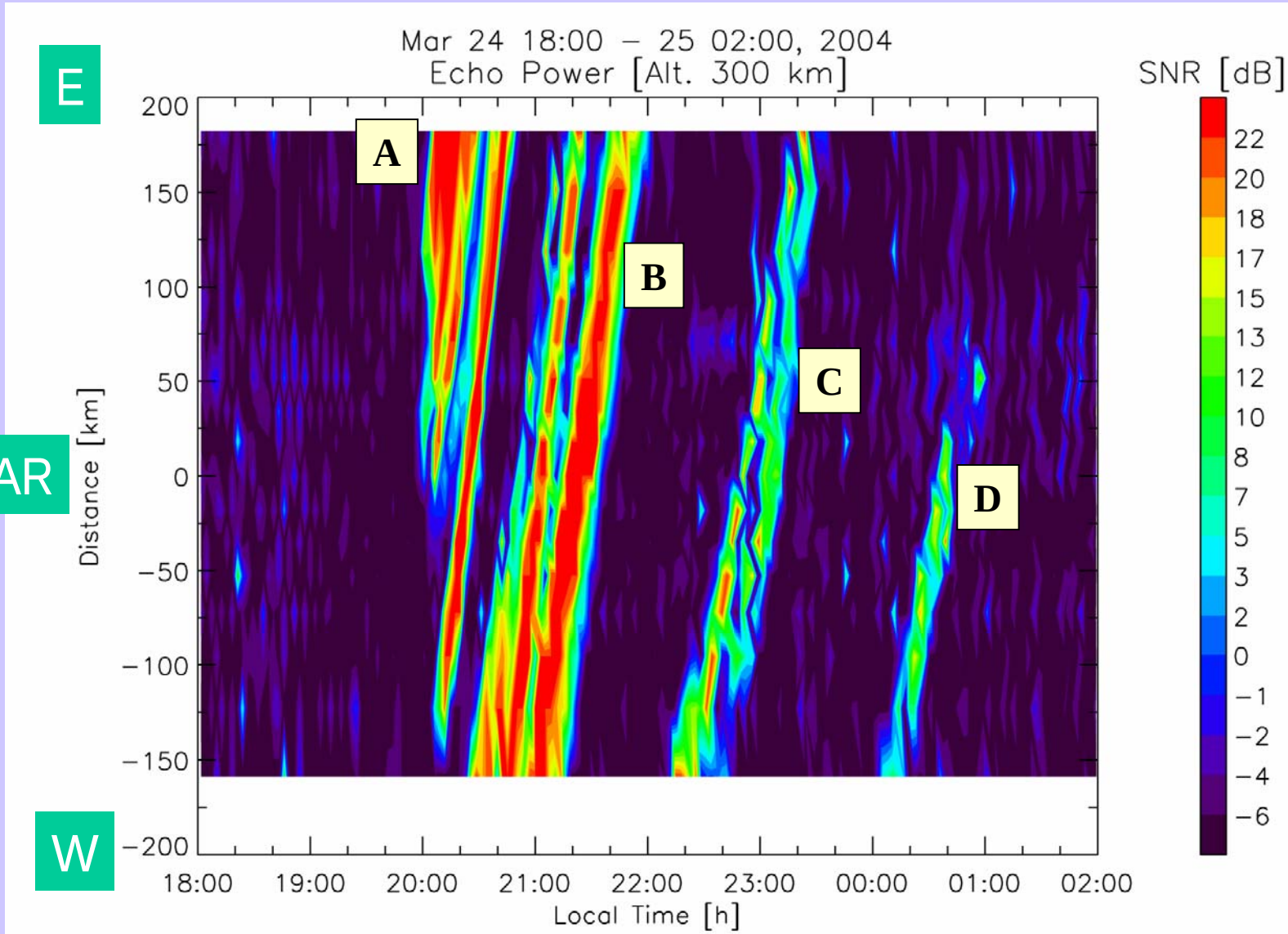
19 out of ～80 plumes were generated within the fan sector

Four plumes successively appear over EAR

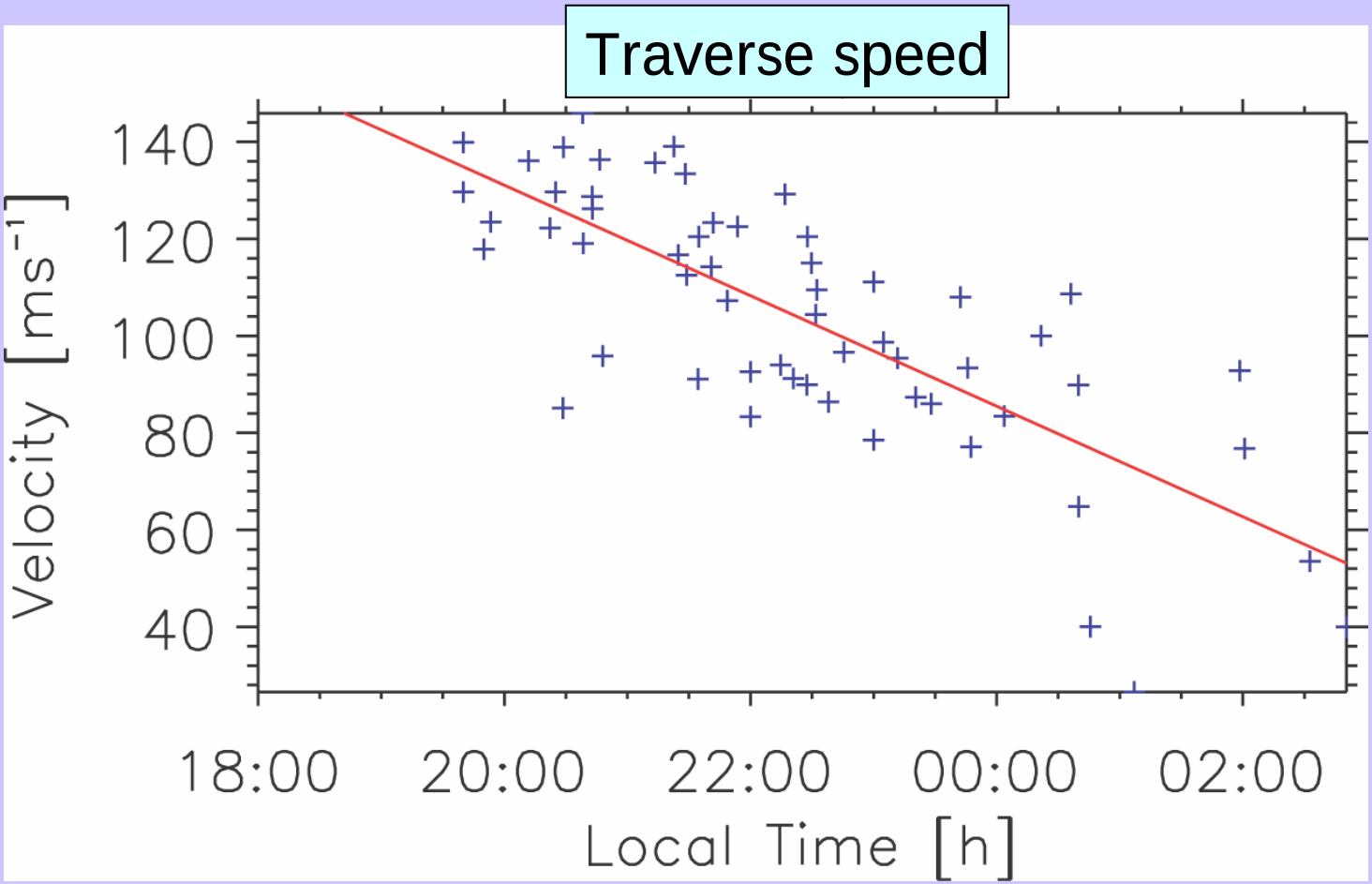


Plume A is generated over EAR, while plumes B-D are fossil bubbles drifted from the west.

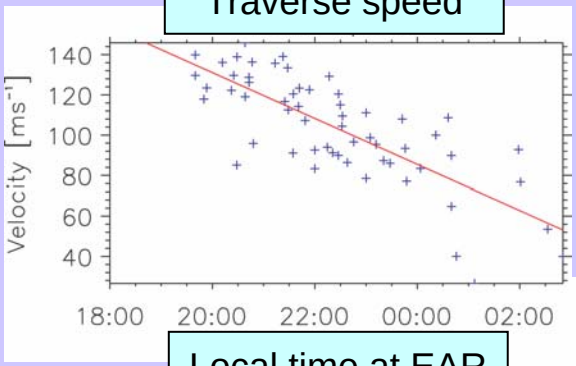
West-to-east traverse of plumes at 300 km



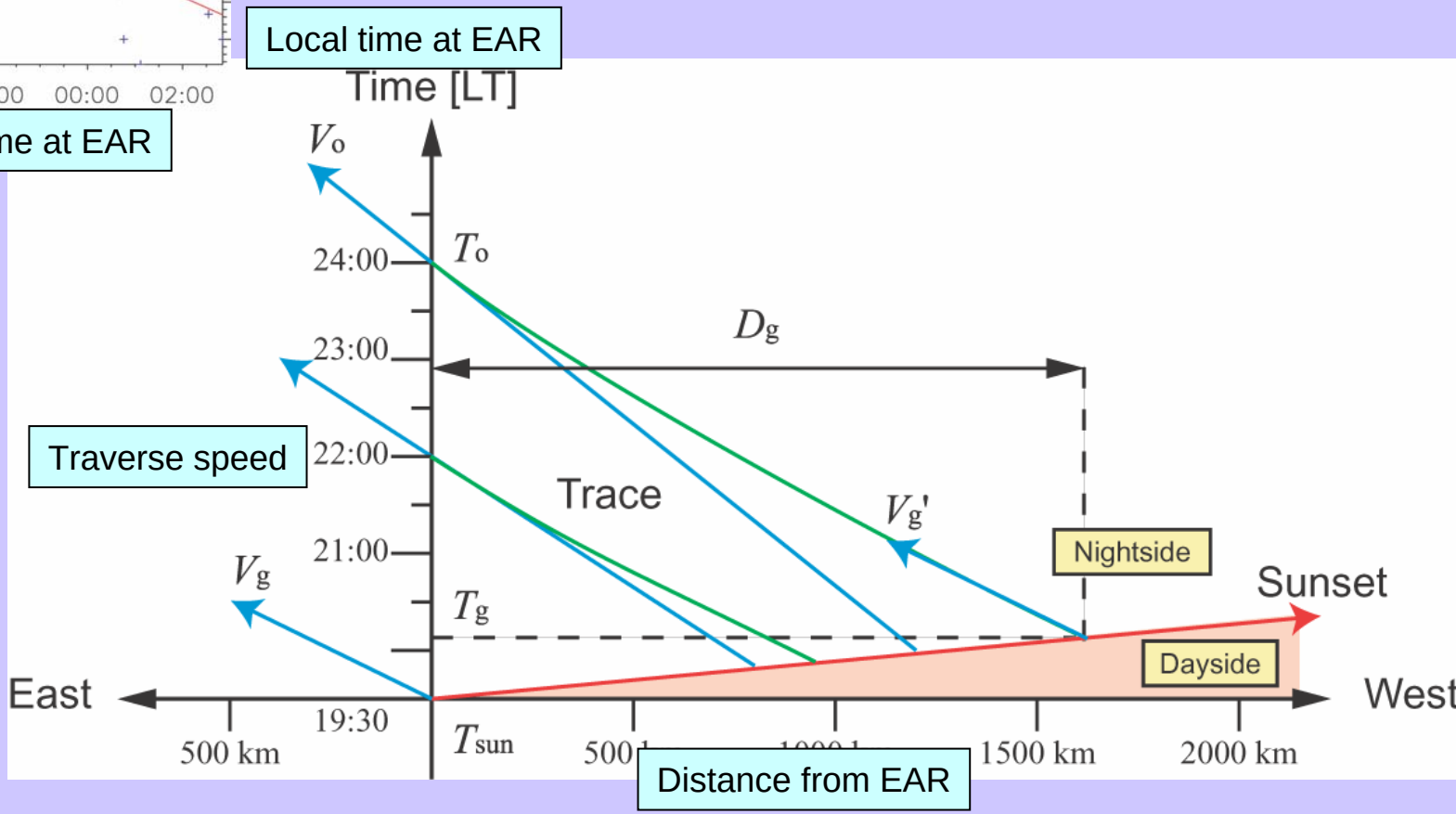
Zonal traverse speed of plumes



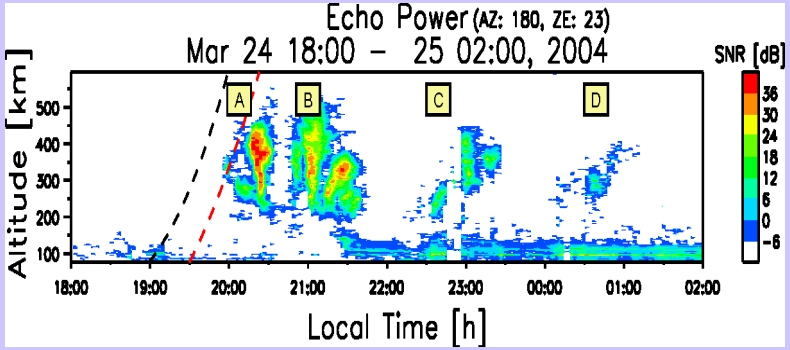
Trace plumes back to their onset places

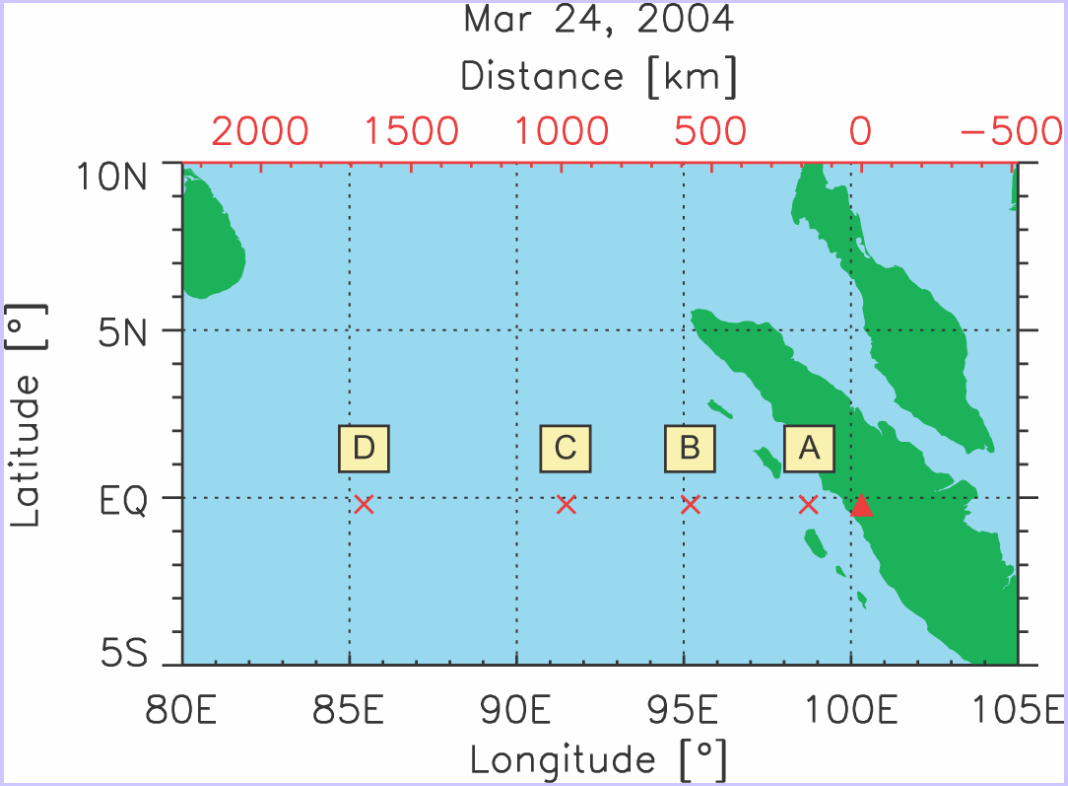


Considering that plumes are generated at the sunset time.



Onset place of the four successive plumes



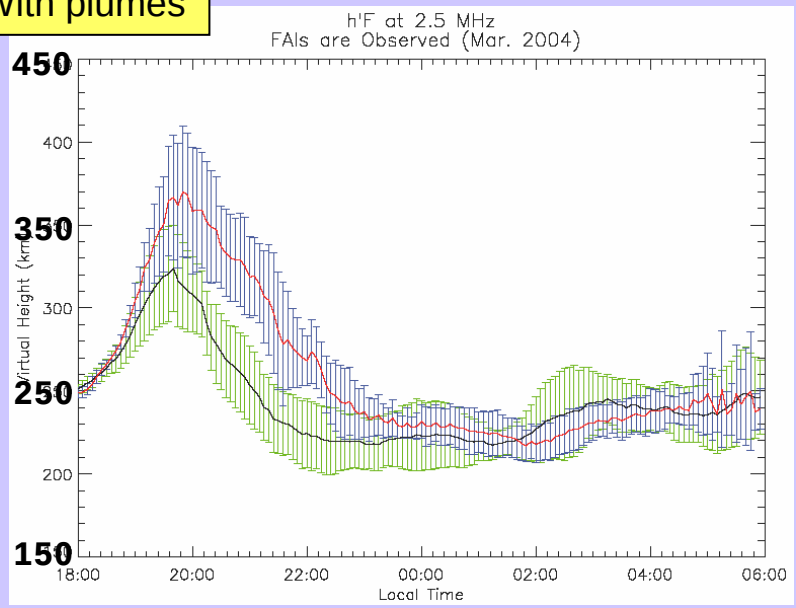


F-layer 2.5-MHz height observed by ionosondes

Plumes observed at 13 nights.

No plume observed at 6 nights.

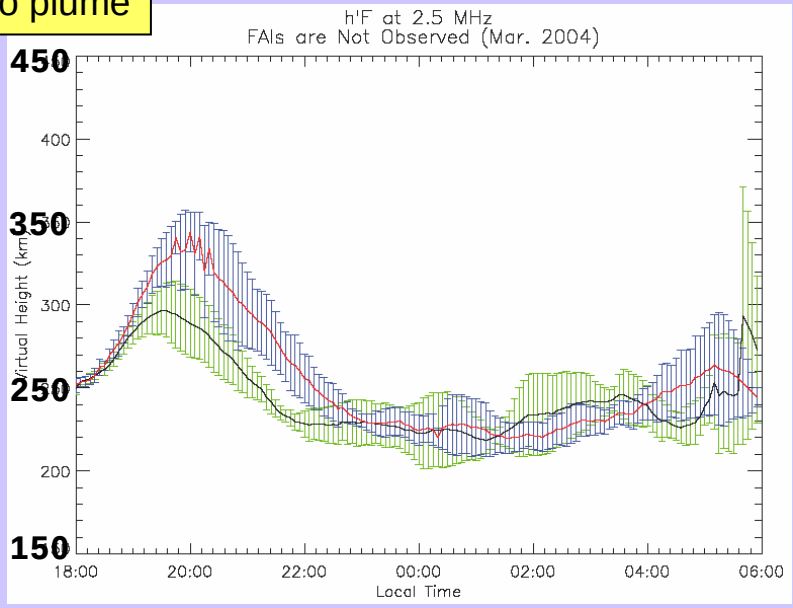
With plumes



Virtual height (km)

Local time

No plume



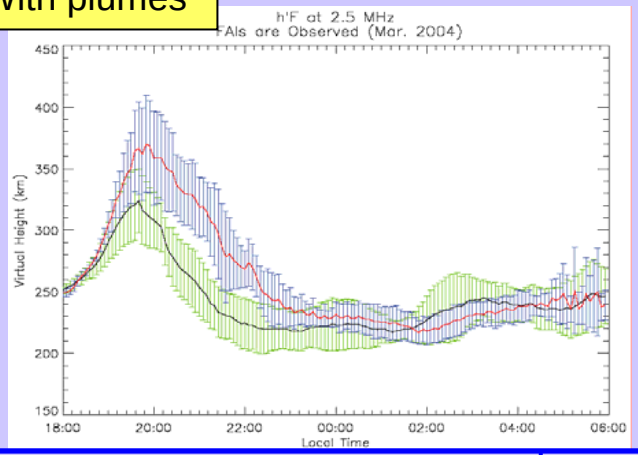
Local time

red: Chumphon (Geomagnetic equator)

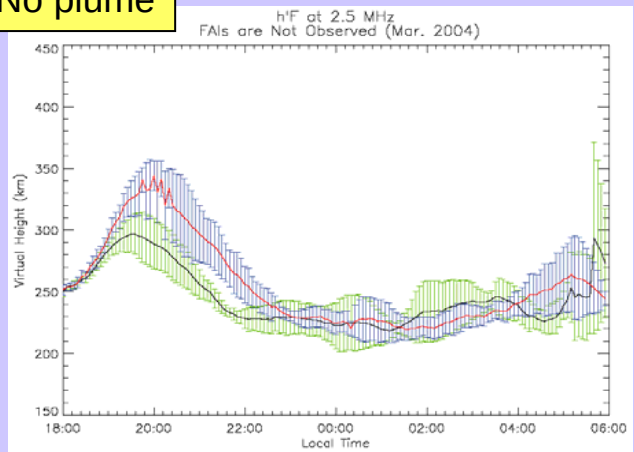
black: Kototabang (EAR site)

F-layer 2.5-MHz height observed by ionosondes

With plumes



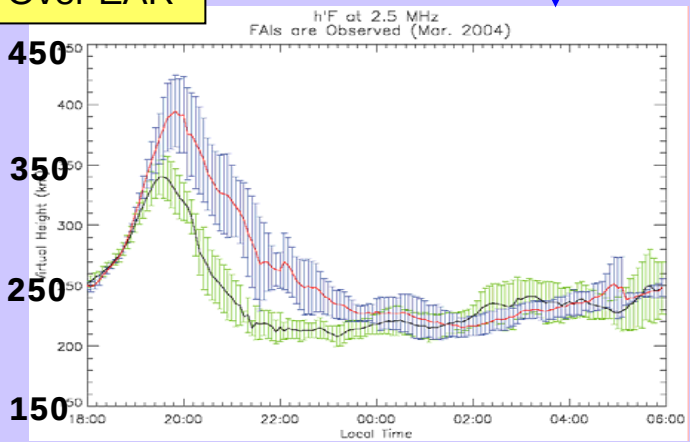
No plume



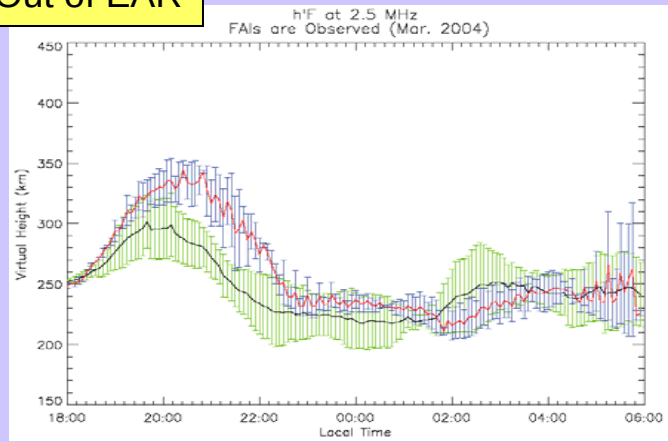
red: Chumphon (Geomagnetic equator)

black: Kototabang (EAR site)

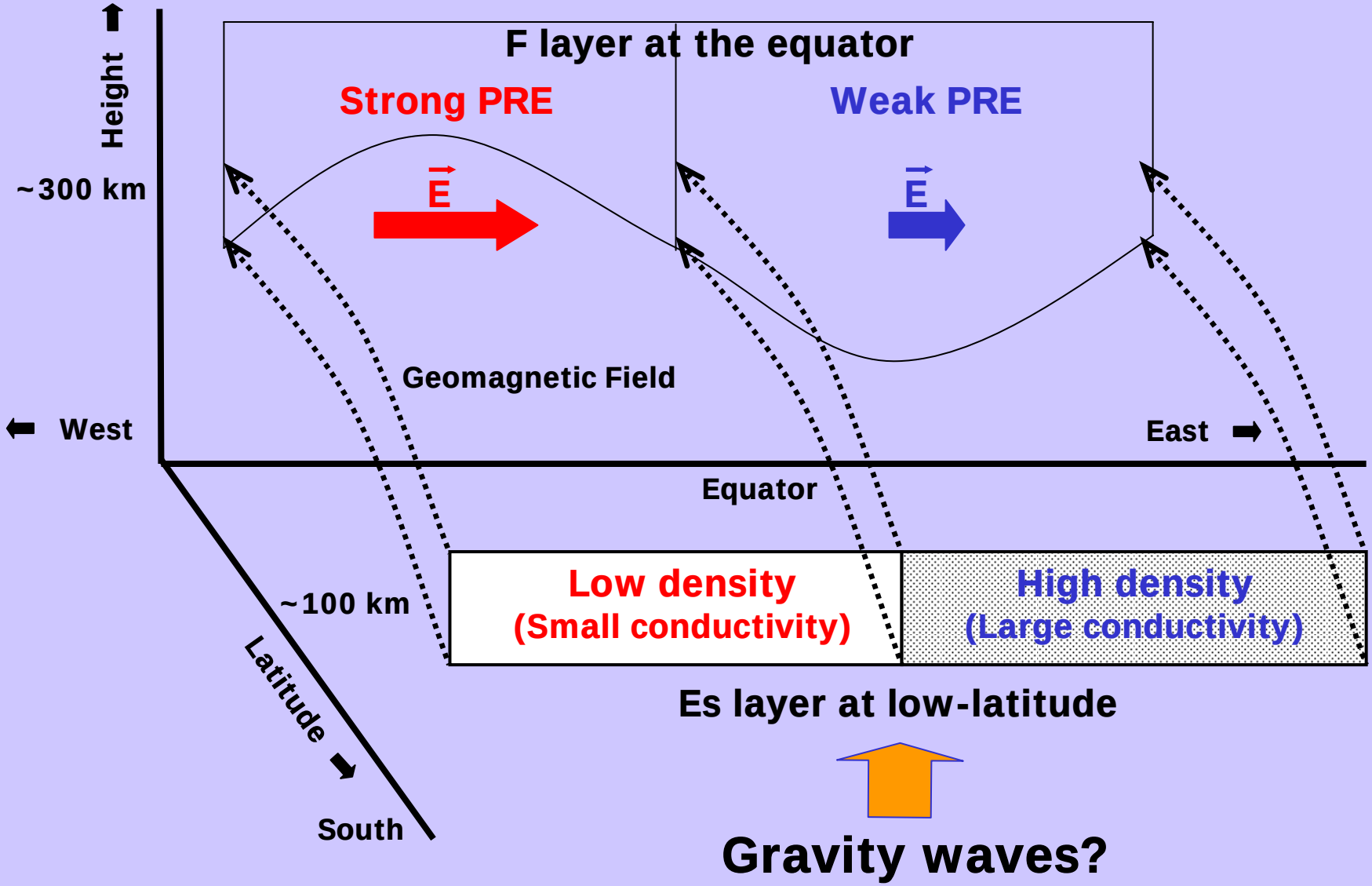
Over EAR



Out of EAR



Es layer inhomogeneity causes F layer modulation?



Concluding Remarks

- Plumes associated with equatorial plasma bubbles are generated, primarily at, and some before the apex sunset time.
- The ionosphere rises up to ~400 km in altitude when plumes are generated.
- Plumes are generated with spacing of several hundred km.
- Ionization density of Sporadic E layer may be modulated with a gravity wave of this wavelength, and intensify the prereversal enhancement.