

PMSE Overshoot Effect and Aspect Sensitivity by EISCAT VHF tri-static radar



[1]



[2]

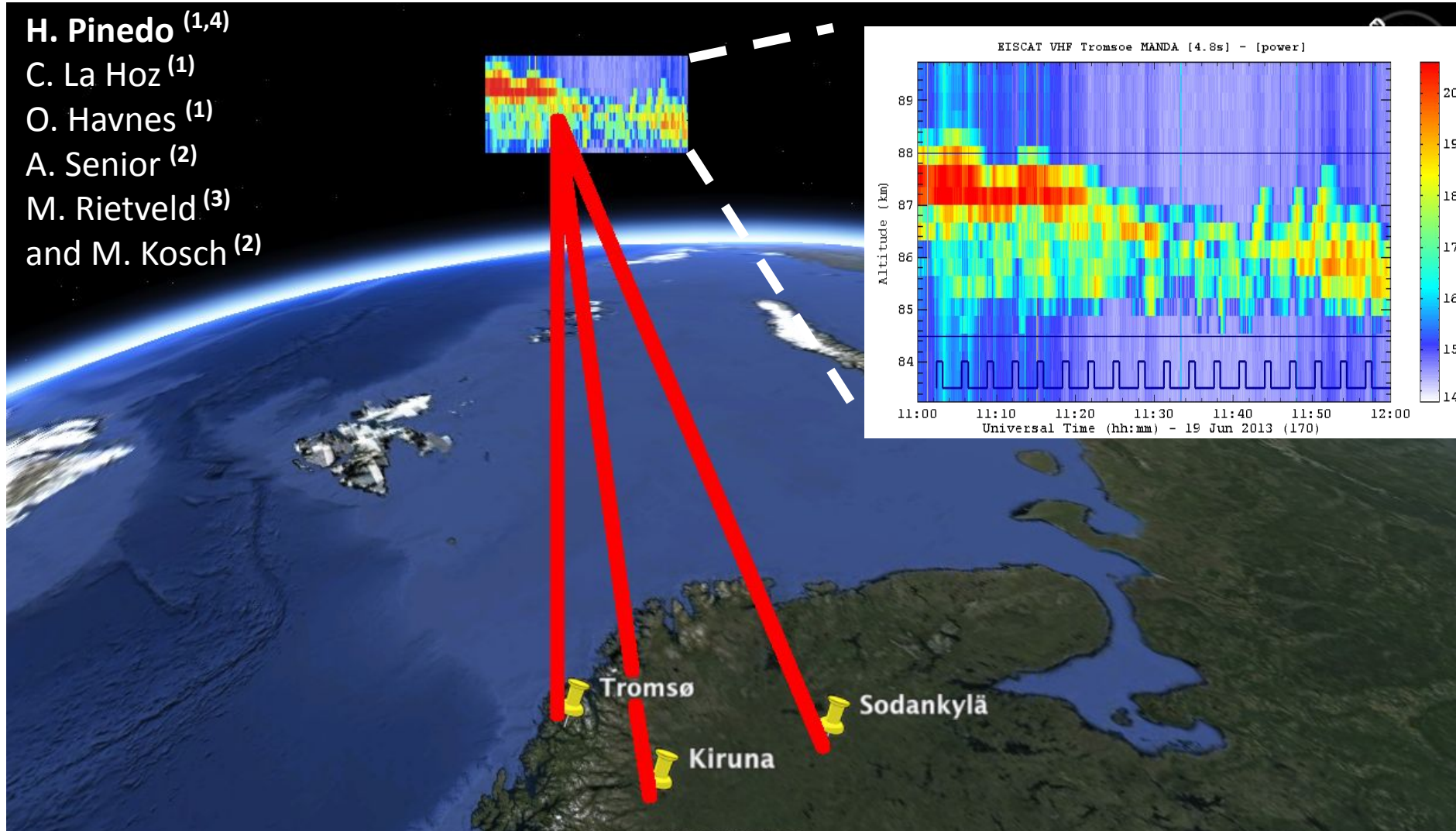


[3]

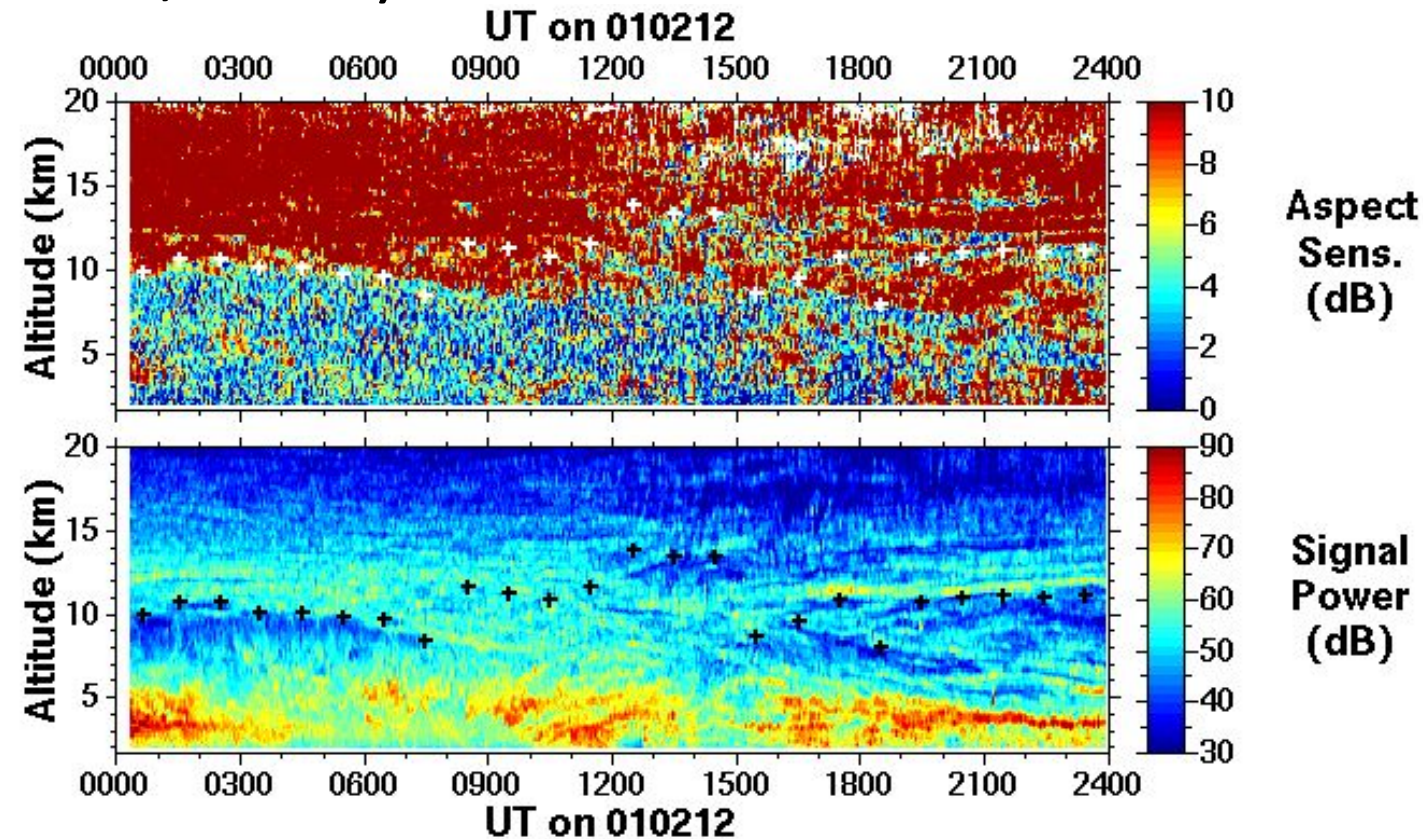


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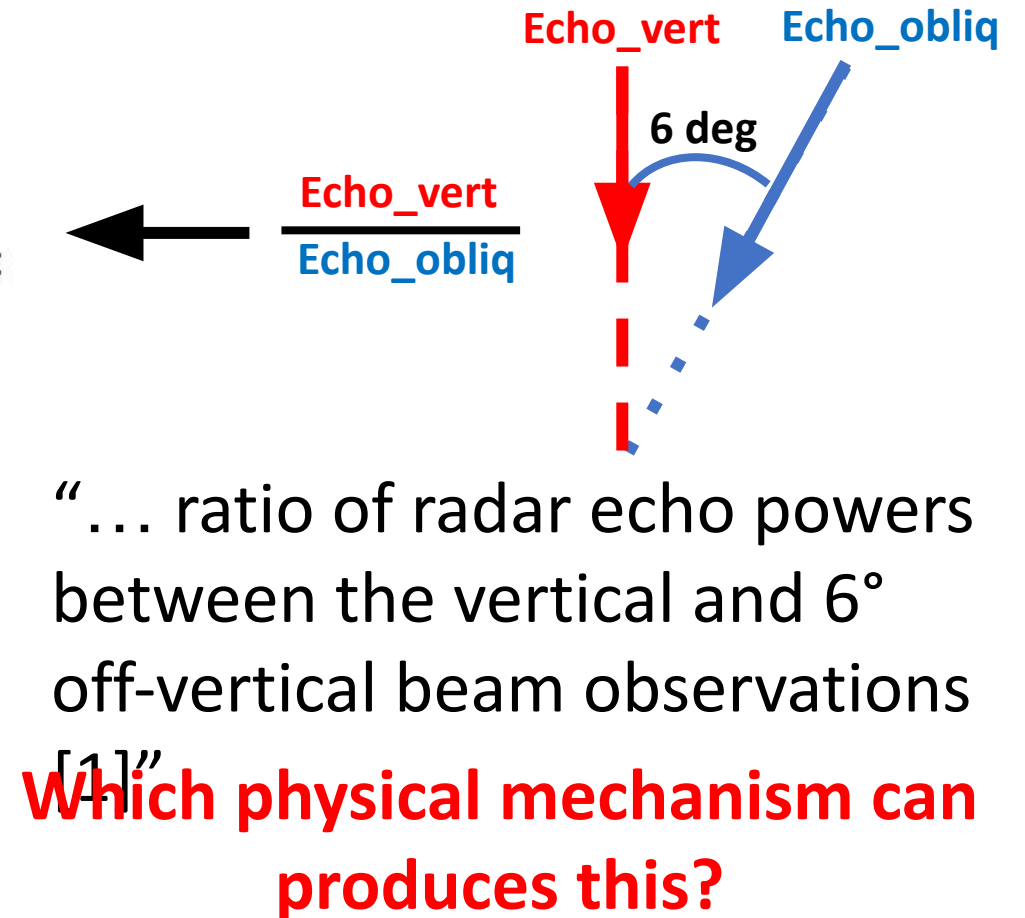
[4]



In Woodman and Chu (1988) was cited that “**MST radar echoes are aspect sensitive**, i.e. the echo power depends on antenna beam pointing angle, and are much larger when the antenna is directed to the vertical (Gage and Green, 1978; Rottger and Liu, 1978, Fukao et al., 1979)”.



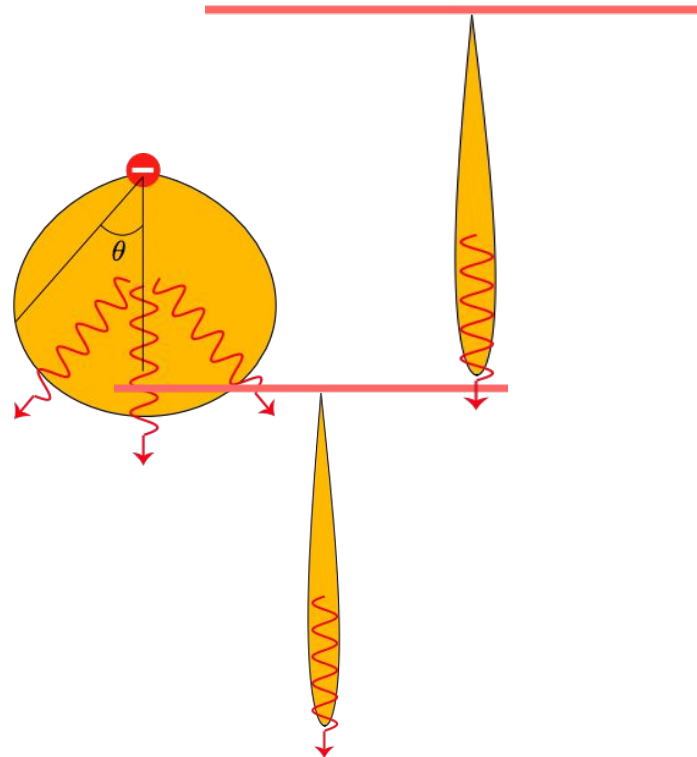
Source: [1] https://mst.nerc.ac.uk/descr_asp_sens.html



Which physical mechanism can produces this?

- **anisotropic turbulence** [Gage and Balsley, 1980; Doviak and Zrnic, 1984]
- **partial reflection** [Rottger and Liu, 1978]
- **fresnel scattering** [Gage et al., 1981].
- **Aspect sensitivity** can be used to **identify the presence of turbulence.**

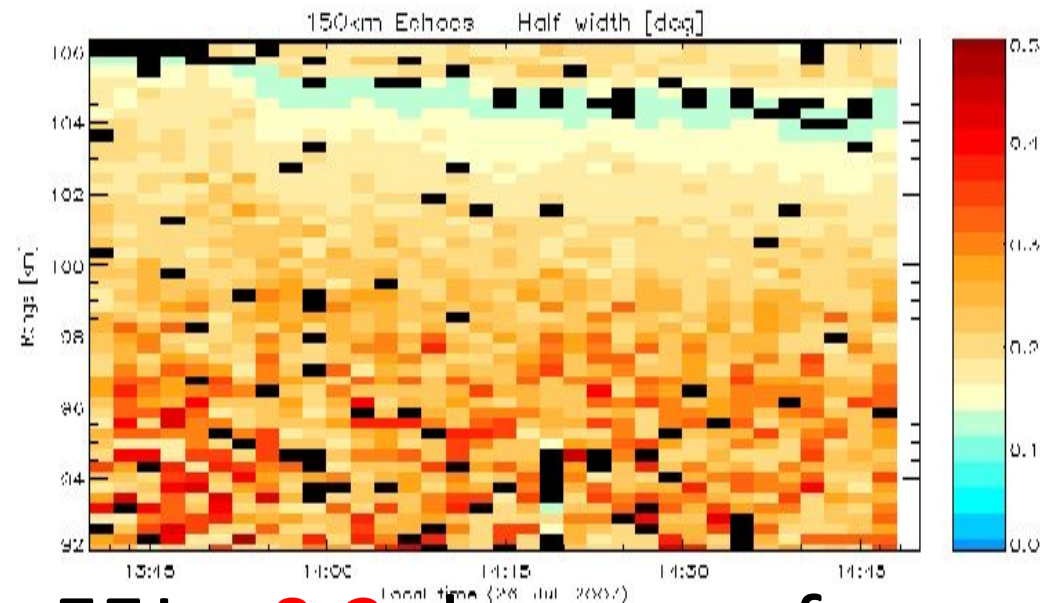
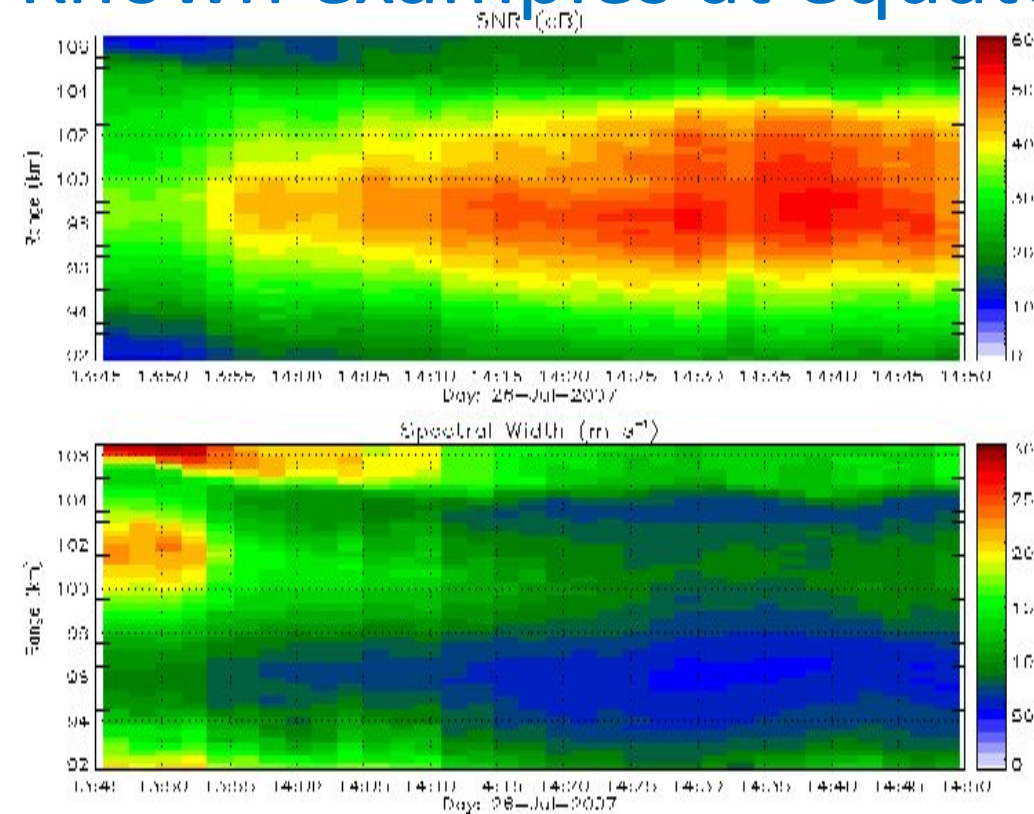
“narrow anisotropic turbulence is responsible for the aspect sensitivity of the radar echoes”
[Woodman and Chu, 1988]



“Proposed models predict different functional shapes in the angular dependence of the backscattered power as a function of angle” (Woodman and Chu, 1988)

- **anisotropic turbulence** -> elliptical shape of the angular dependence
 - **partial reflection**
 - **fresnel scattering**
- } -> specular in nature

Known examples at equatorial latitudes



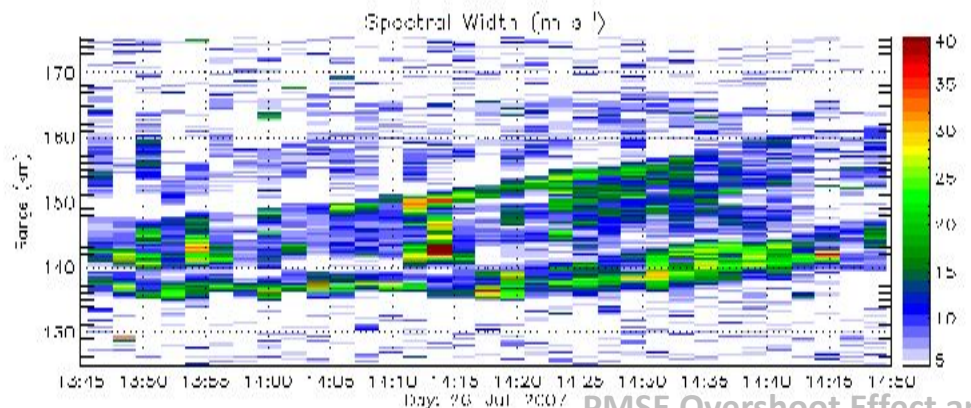
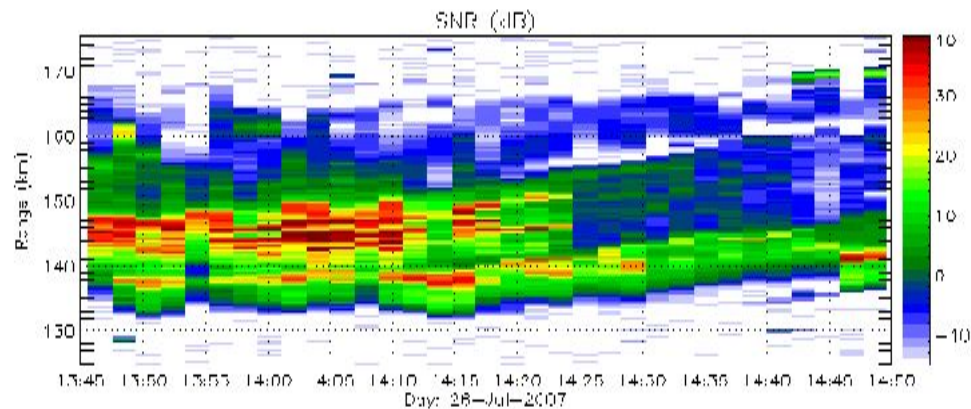
EEJ ~ 0.2 degrees of aspect angle

(Results by Pinedo et al. presented in URSIGA 2008)

“Proposed models predict different functional shapes in the angular dependence of the backscattered power as a function of angle” (Woodman and Chu, 1988)

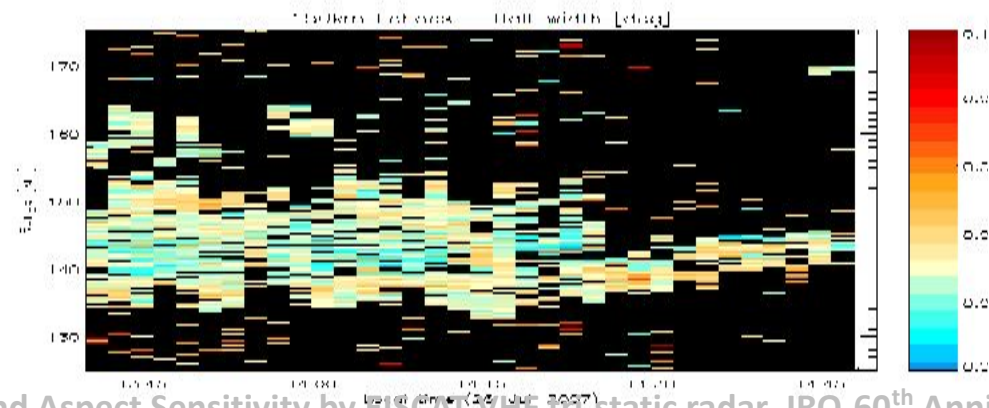
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Known examples at equatorial latitudes



150 km echoes $\sim 0.02!$ degrees of aspect angle

(Results by Pinedo et al. presented in URSIGA 2008)

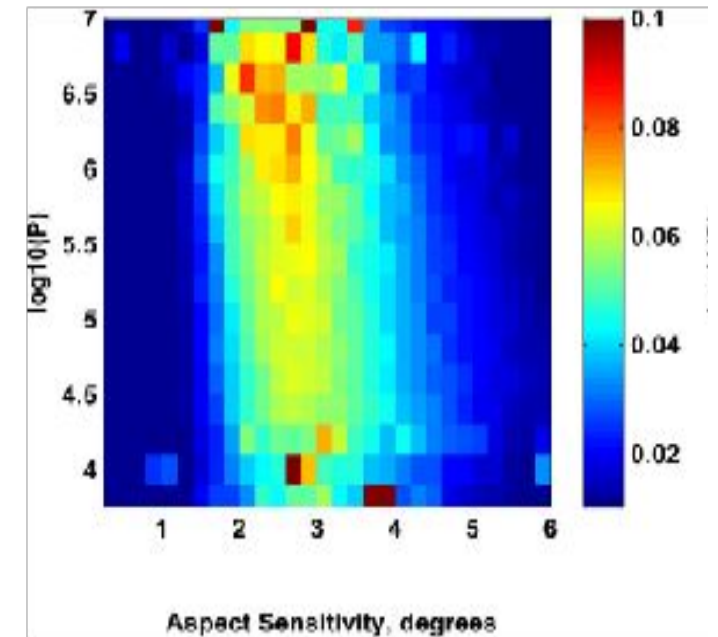
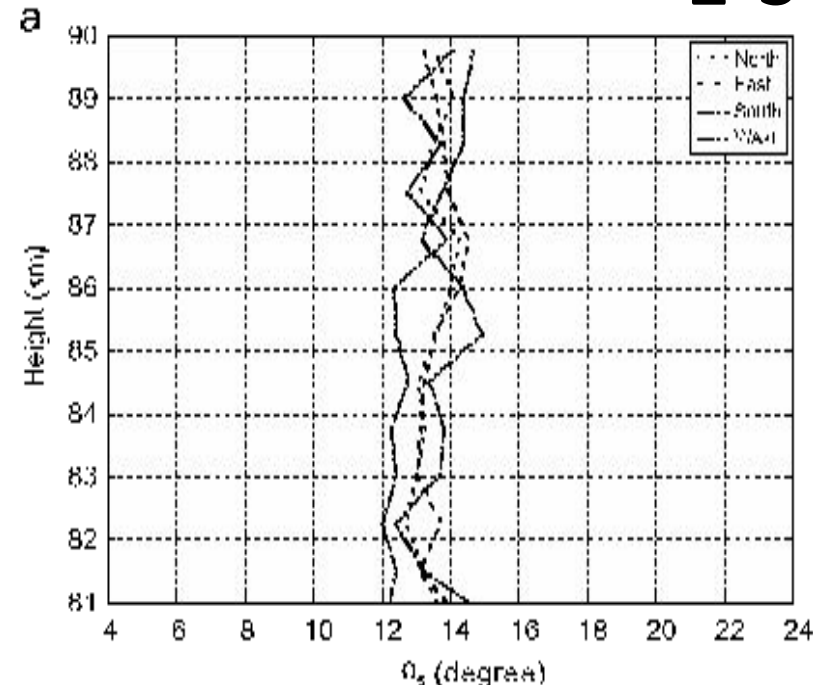


“Proposed models predict different functional shapes in the angular dependence of the backscattered power as a function of angle” (Woodman and Chu, 1988)

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Examples at polar latitudes

Polar Mesosphere Summer Echoes
~ 2-3 and ~ 10 degrees

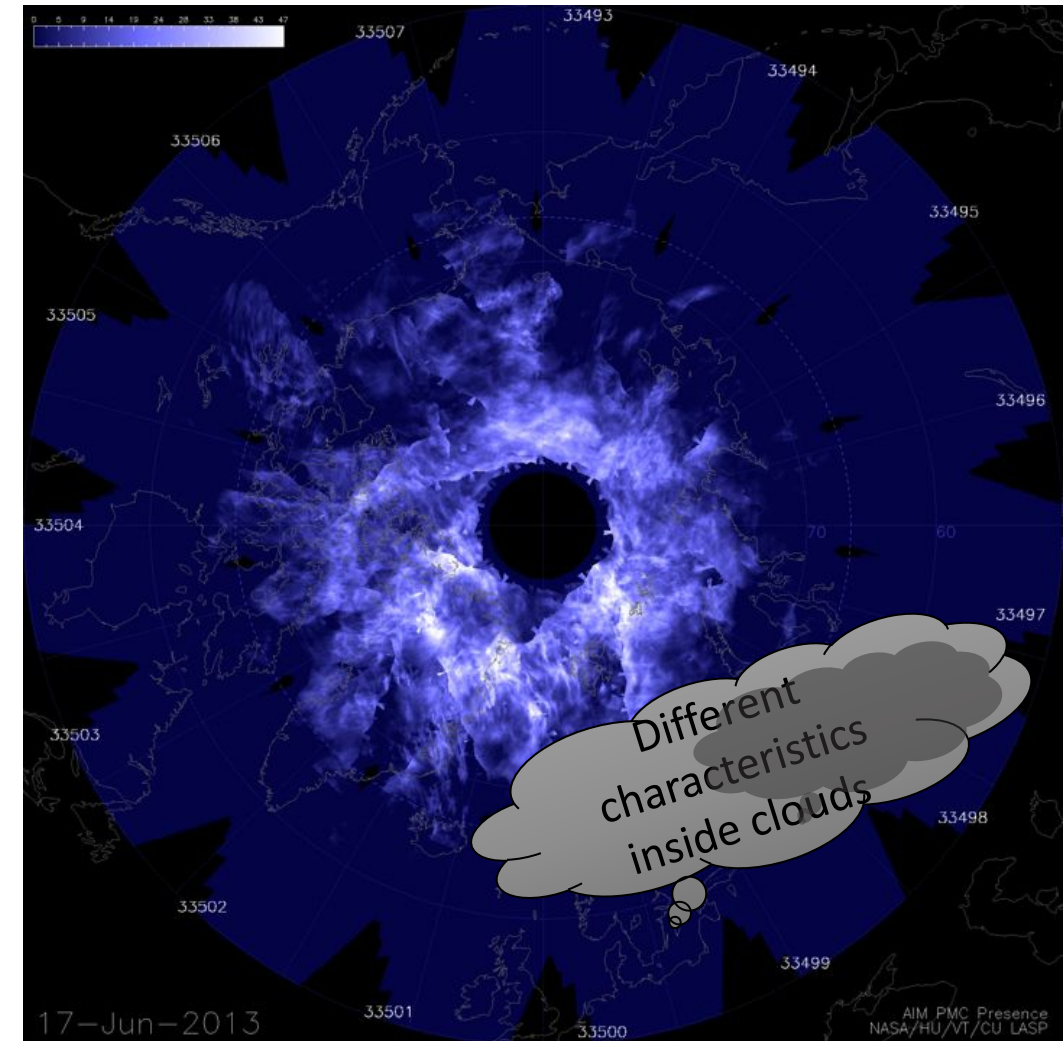
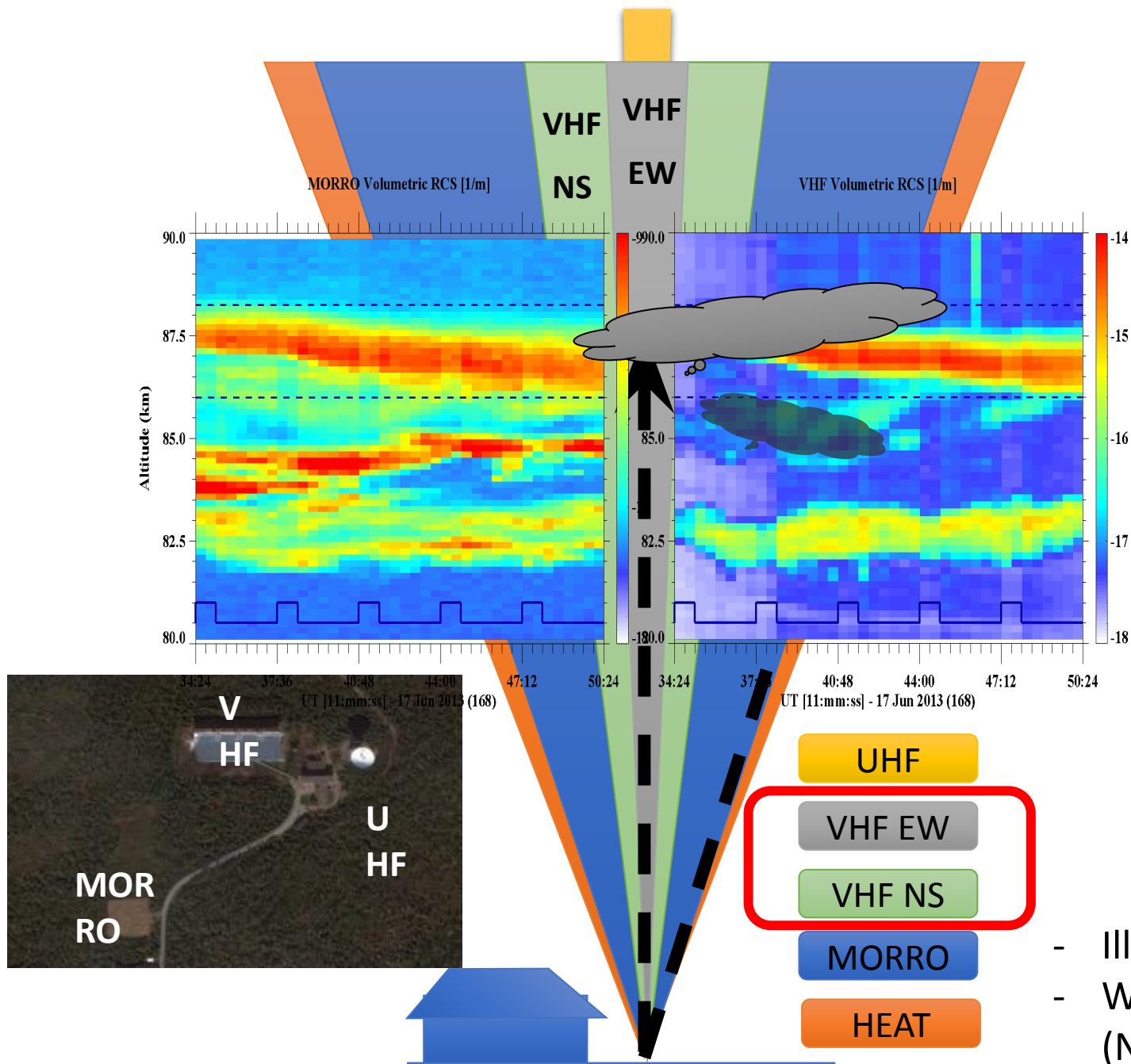


MST radar ~ 50 MHz
(Huaman and Balsley, 1998)

MST radar ~ 50 MHz
(Swarnalingam et al., 2010) 1998-2009 data

MST radar ~ 50 MHz
(Smirnova et al., 2010) 1997-2010 data

PMSE: different illuminated volumes

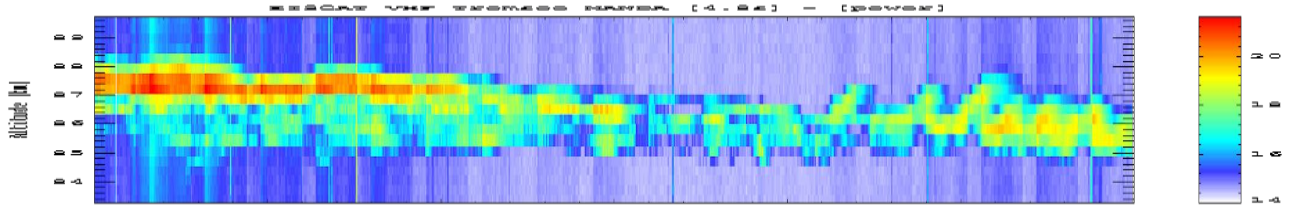


- Illuminated volume not full filled with PMSE struct.
- Wide angle antenna beam from typical MST radars (Not the case for EISCAT VHF Tri-static system measuring Mesosphere of aprox. 1 degree)

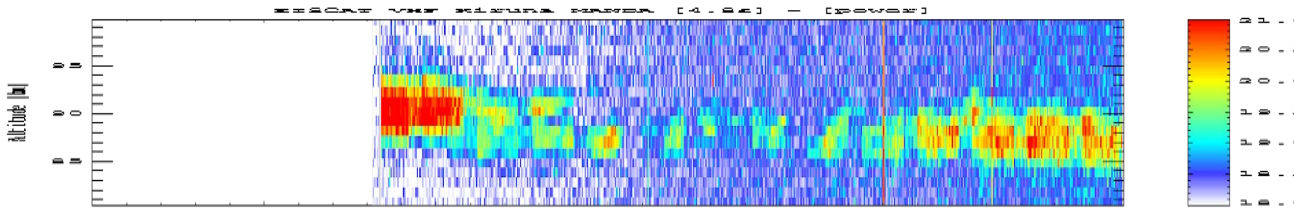
1. Motivation for tristatic measurements

Geometry

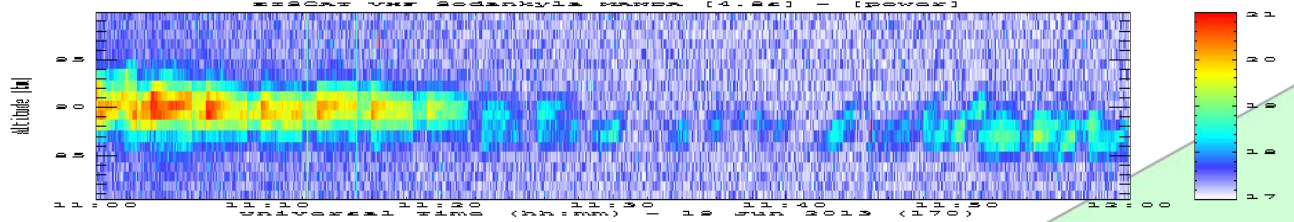
T



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Sodankylä, Kiruna & Tromsø Tri-static Measurements

More than 60 degrees!
Aspect sensitive

69°

85km

aprox 200 km



Kiruna

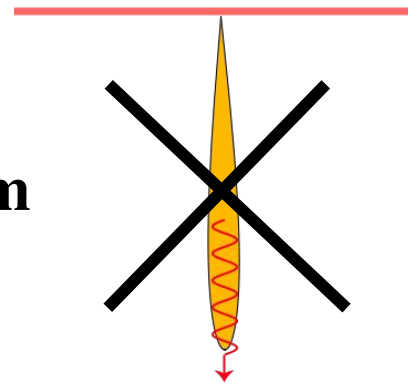


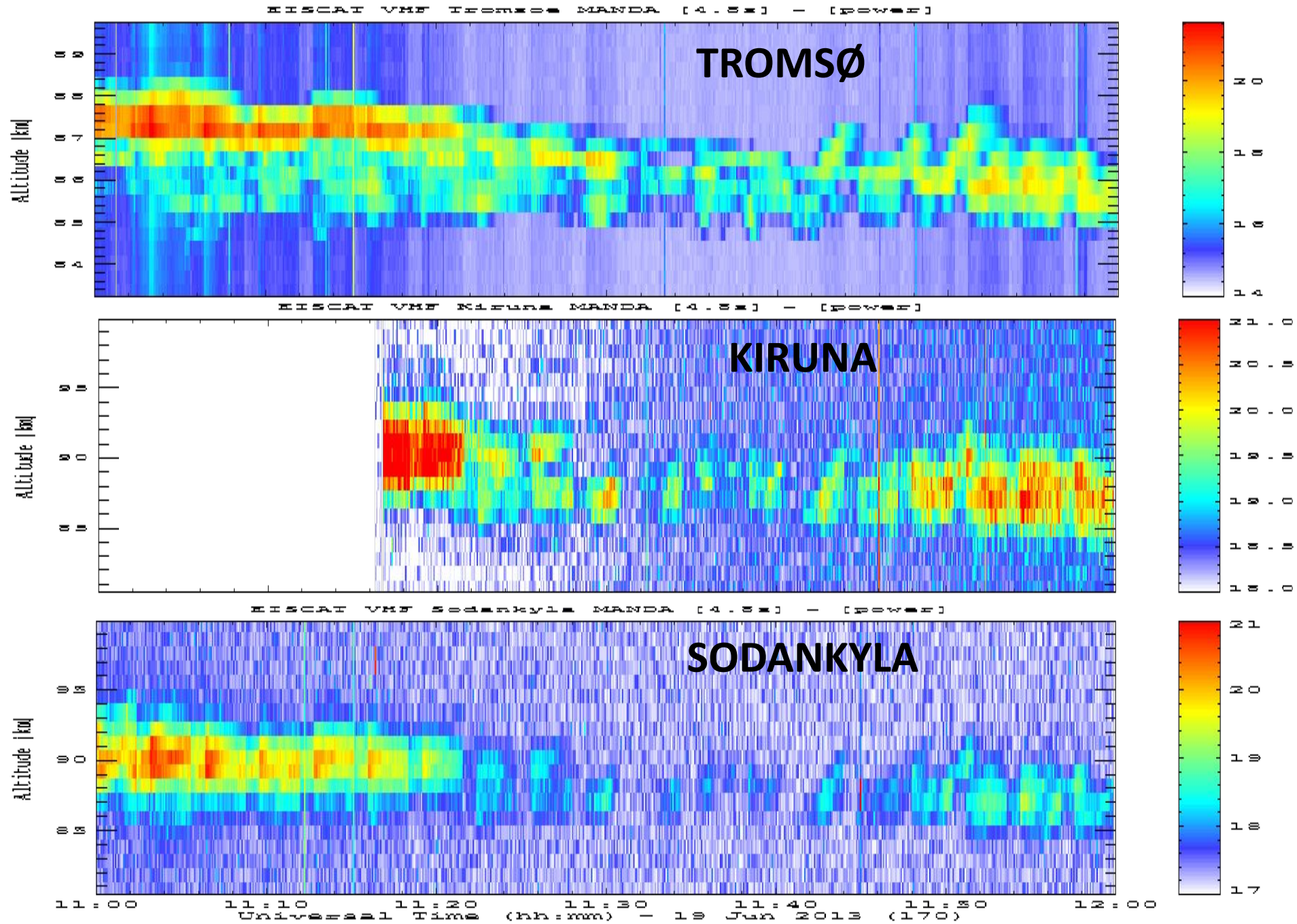
Sodankylä

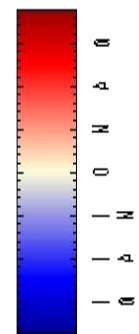
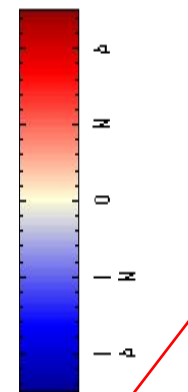
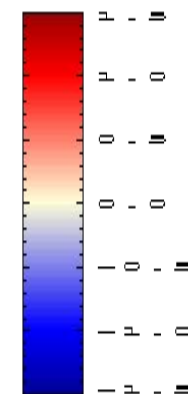
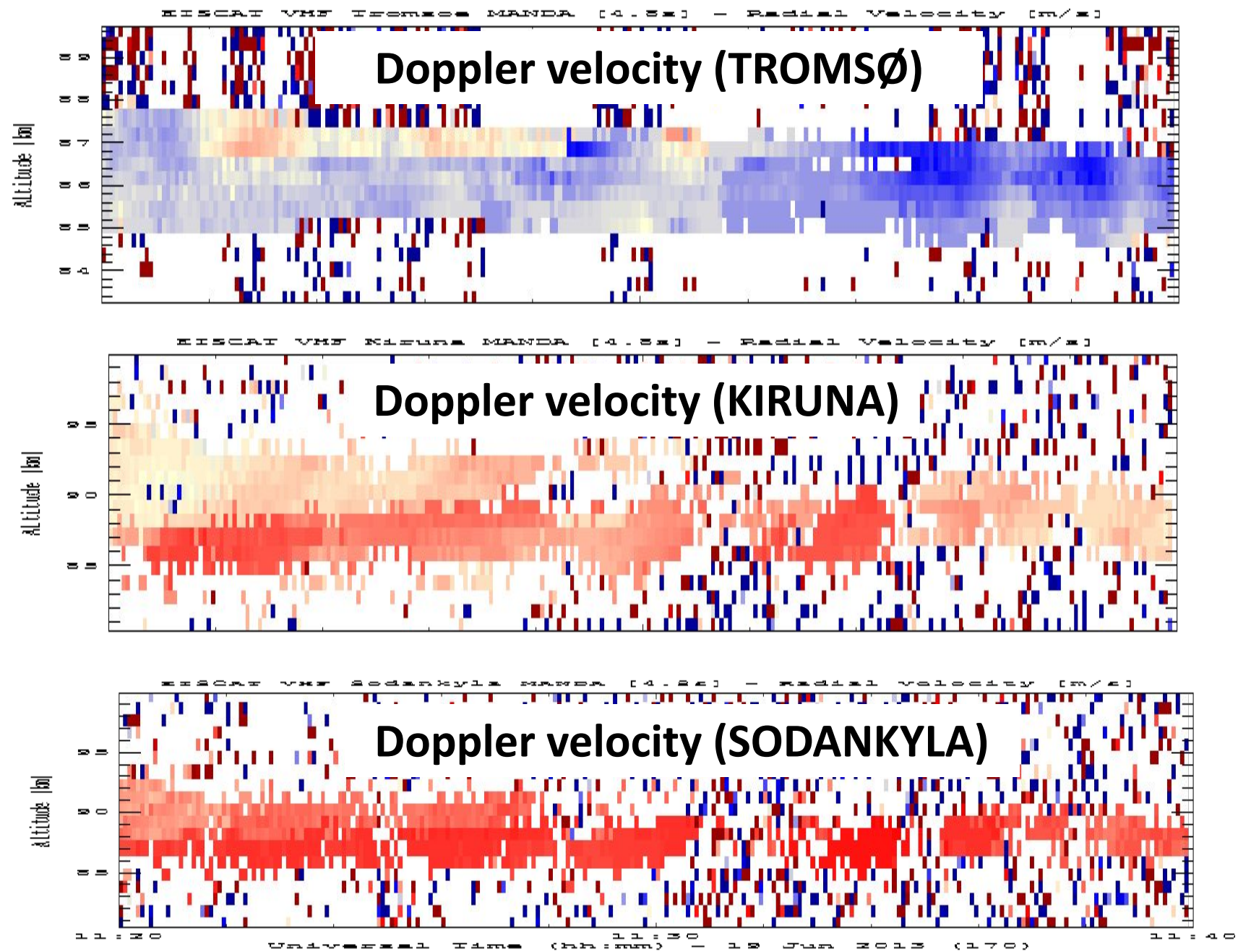
aprox 388 km



Tromsø

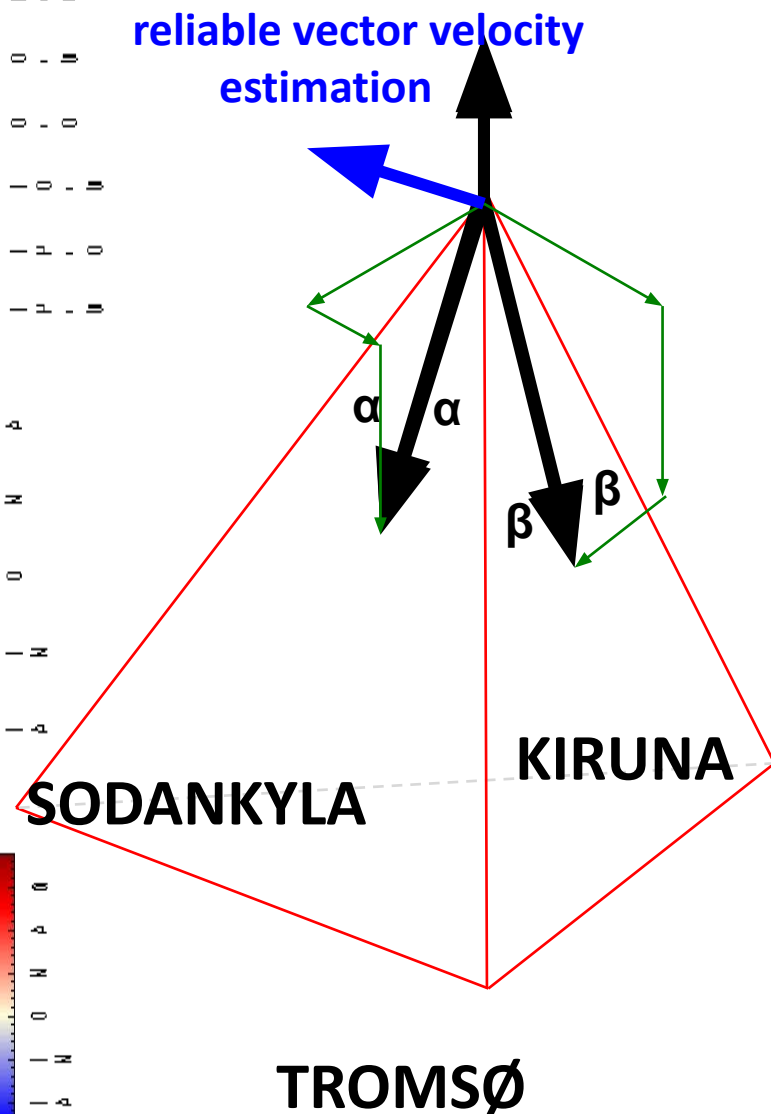






Tri-static PMSE

reliable vector velocity estimation



Conclusions

Aspect sensitivity

- Null aspect sensitivity at 224 MHz, i.e. near isotropic scatter (~ 69 deg)
- Present aspect sensitivity discrepancy **is an ongoing research work**

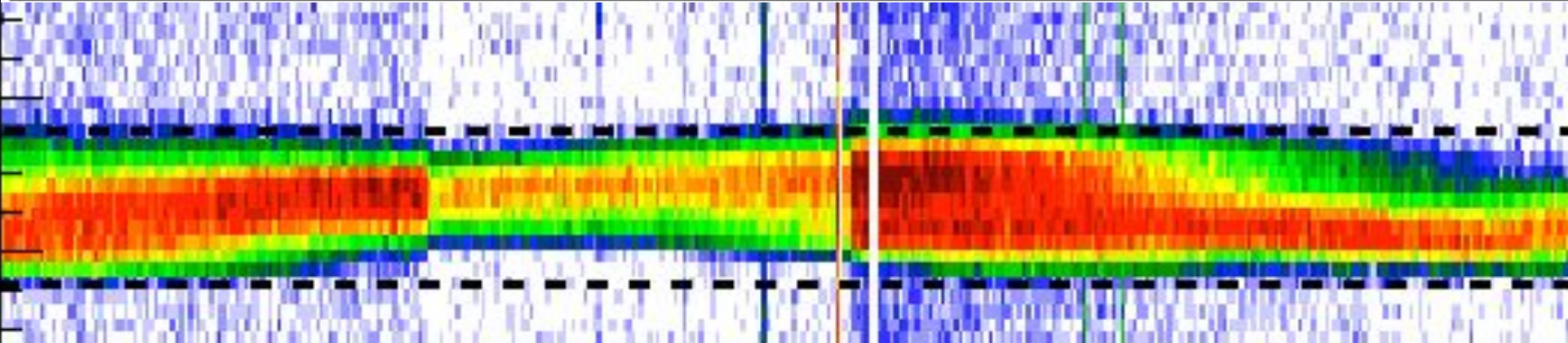
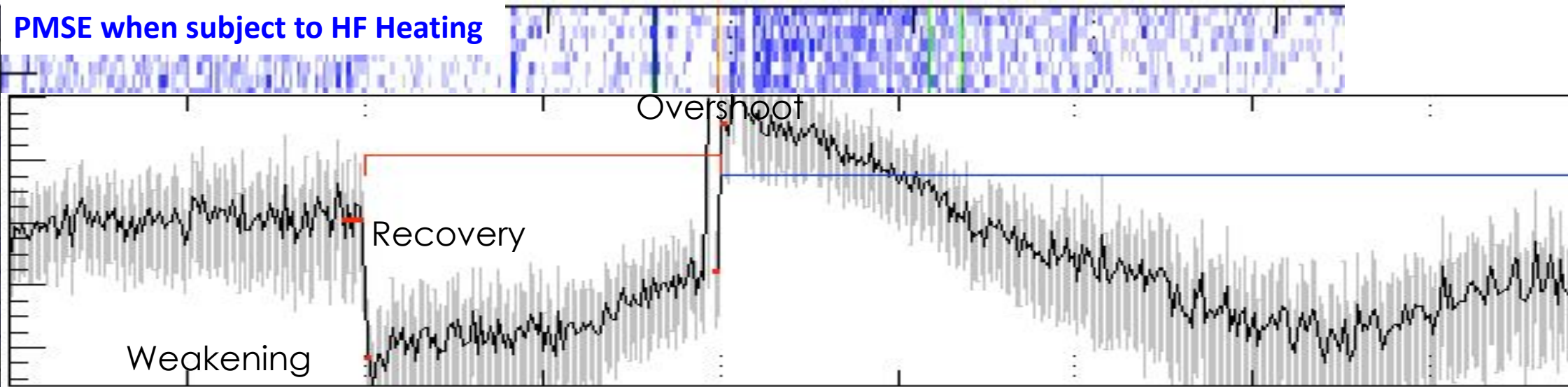
Vector velocity

- PMSE has **good SNR** as for getting **good estimates** of vector velocity.
- Geometry can provide more reliable vector velocity estimates.
- Ongoing work: **momentum flux**, verify the **wind reversal**.

Multi-wavelength analysis

- Contributing with **two (2) more wavelengths** from the remote sites, no significant difference from the current VHF wavelength, but anyway it adds more info.

PMSE when subject to HF Heating

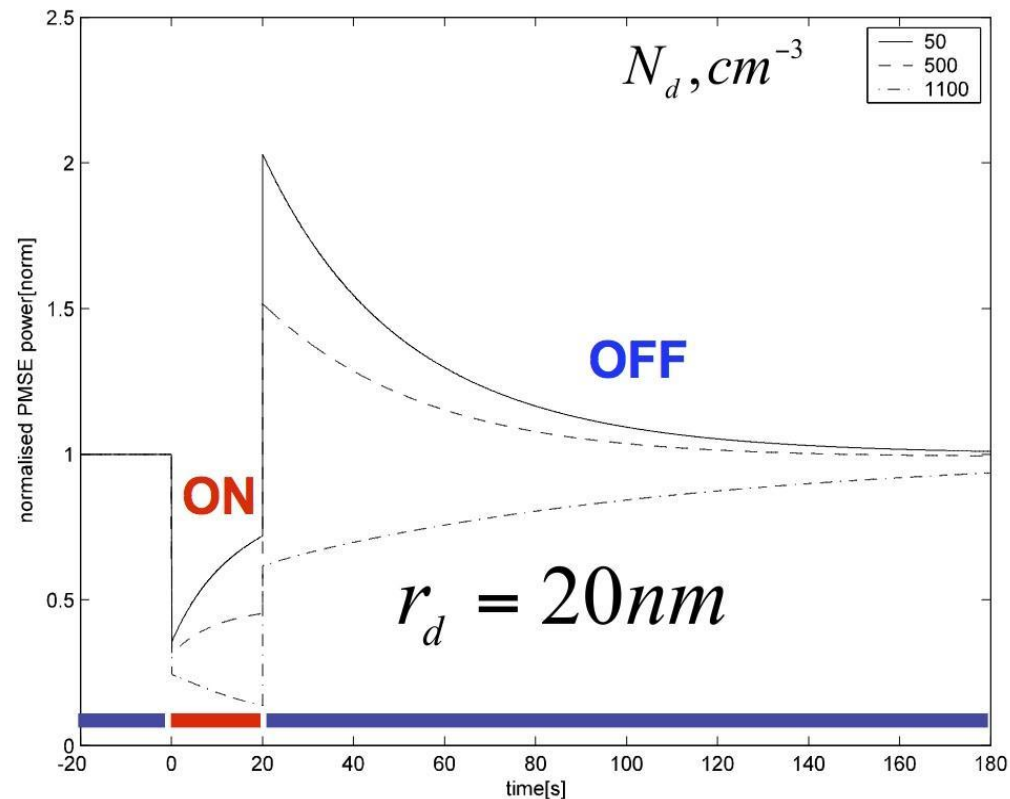


The overshoot effect on PMSE

Theory originally proposed and measured by **Havnes 2004 / Havnes et al. 2003**

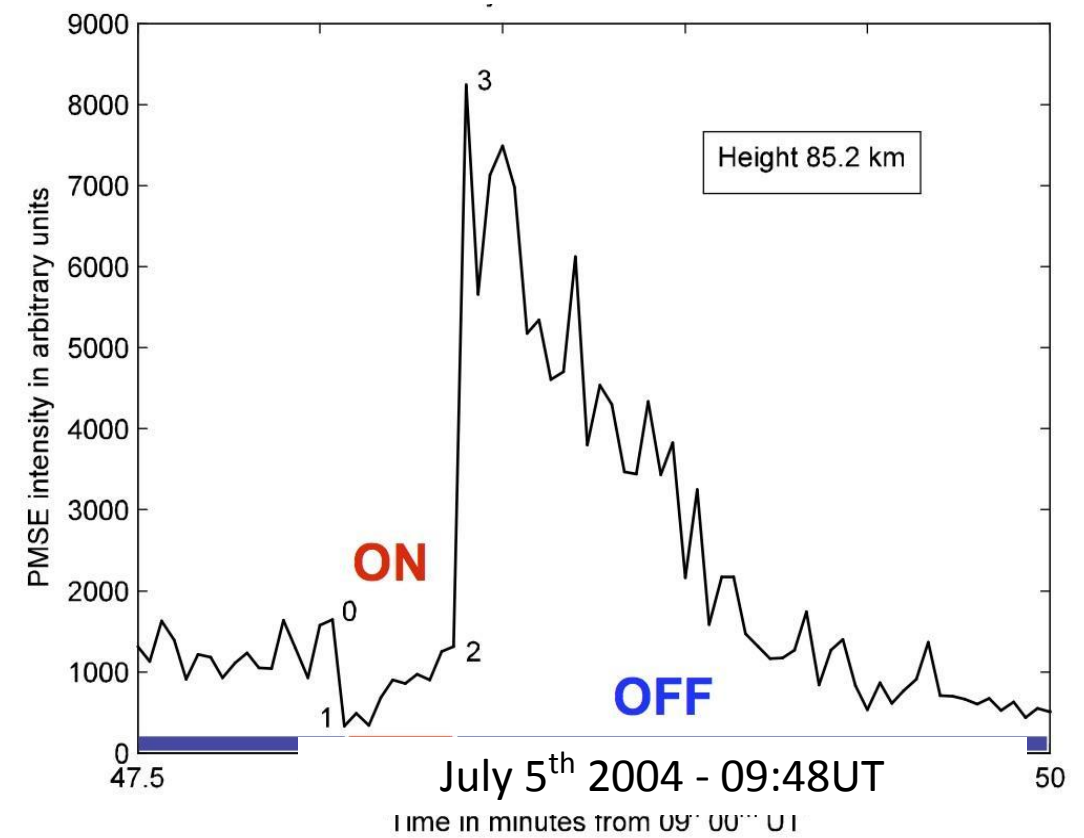
Plots corresponds to recent data from 2013

PMSE heating modulation



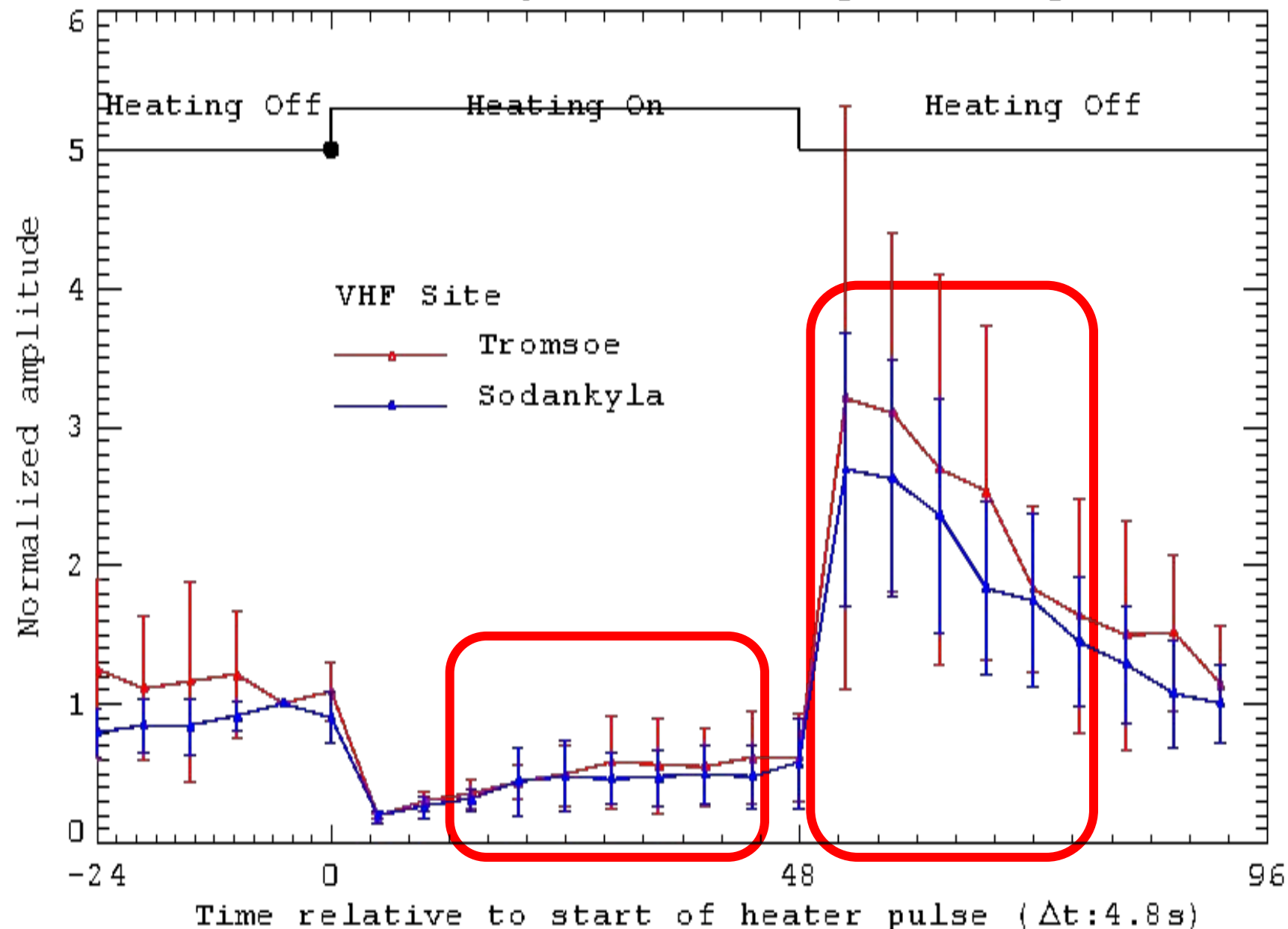
Mahmoudian et al. (2011), Biebricher et. al (2005)
Havnes et. al (2003)

**Theoretical prediction using
dusty plasma theory**



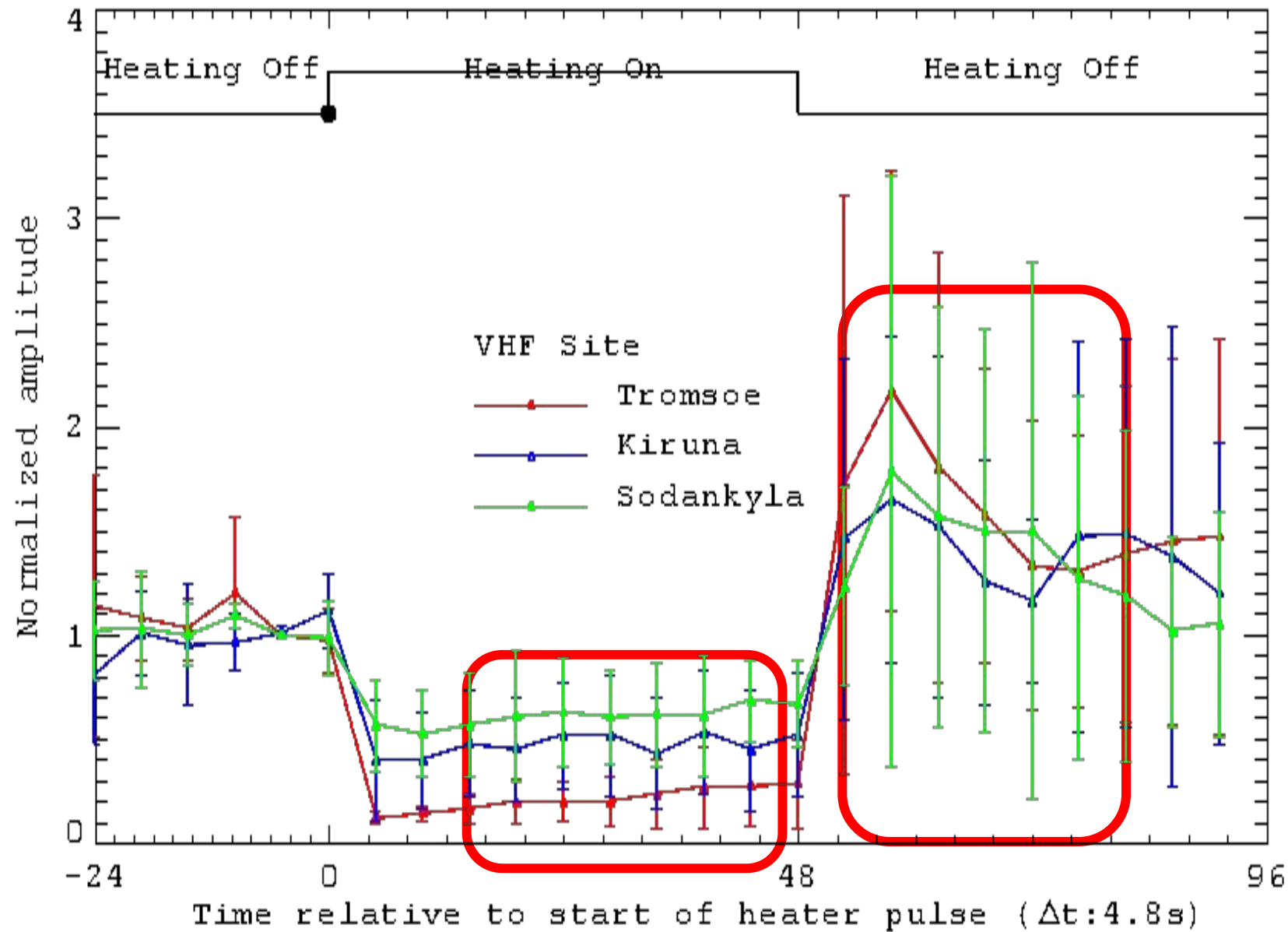
Experimental observation

VHF Tristatic - epoch and range averages PMSE



19 Jun 2013 (170) - From : 11:00:00 to : 11:20:00

VHF Tristatic - epoch and range averages PMSE



19 Jun 2013 (170) - From : 11:40:00 to : 12:00:00

Conclusions

Aspect sensitivity

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Heating modulation

- PMSE **weakening** and **overshoot effect** in the three sites.
- Evaluate the **possible site-differences** of **normalized** PMSE weakening level.

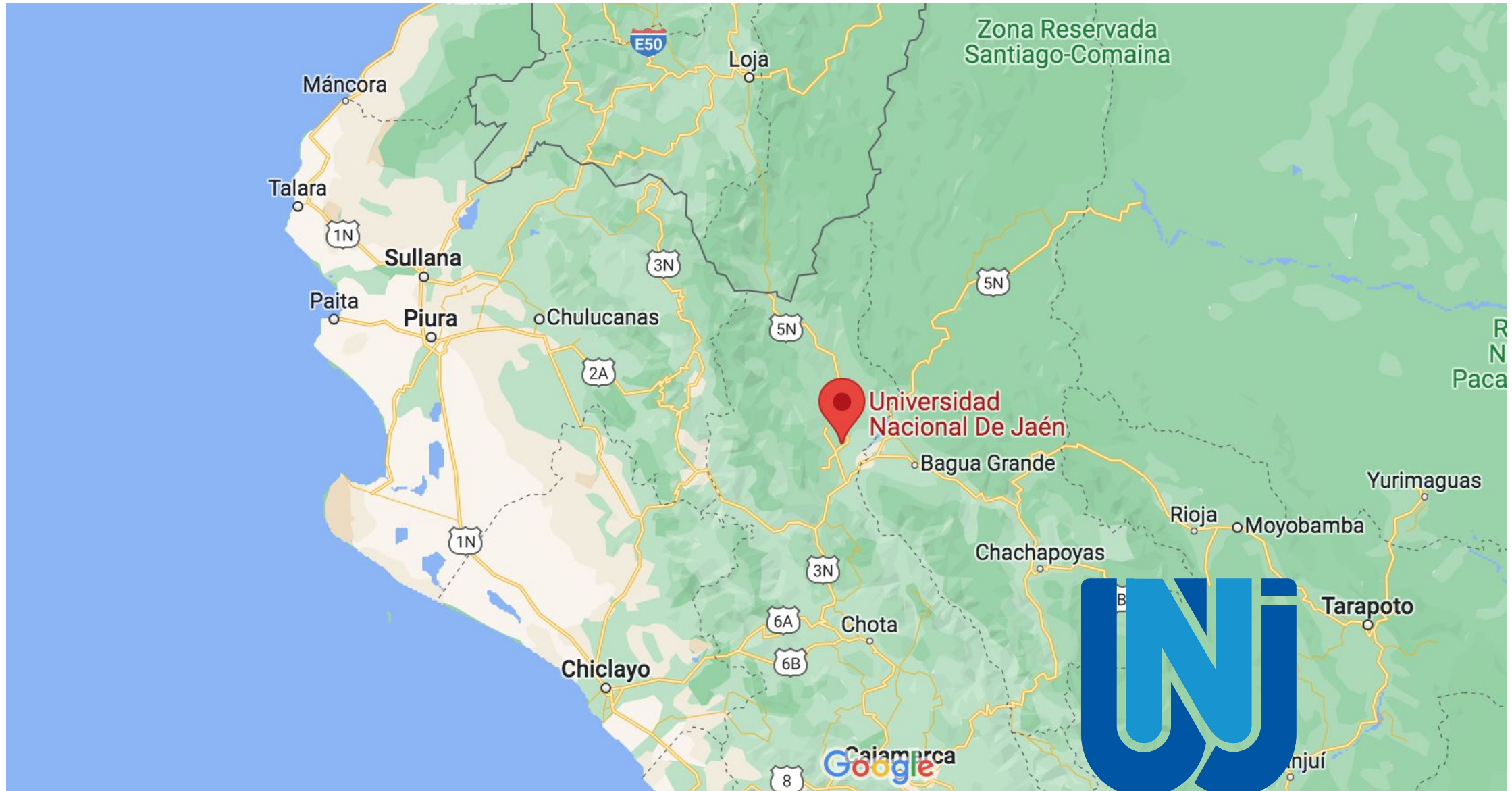
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