Potential of TIMED/GUVI limb observations for medium-scale traveling ionospheric disturbances study at mid-latitudes
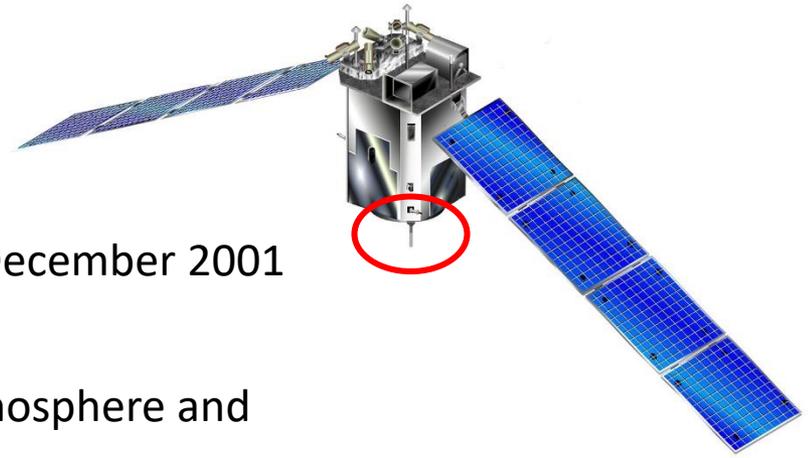
Gilles Wautelet, Benoît Hubert, Jean-Claude Gérard

LPAP, STAR Institute, Liège University (Belgium)

European Space Weather Week 16
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The GUVI instrument

- On-board NASA/TIMED spacecraft launched in December 2001

- 74° inclination at 625 km altitude (LEO)

- <u>Goal</u> : explore Earth's Mesosphere, Lower Thermosphere and Ionosphere (MLTI)

- Four instruments, among them : the Global UltraViolet Imager GUVI
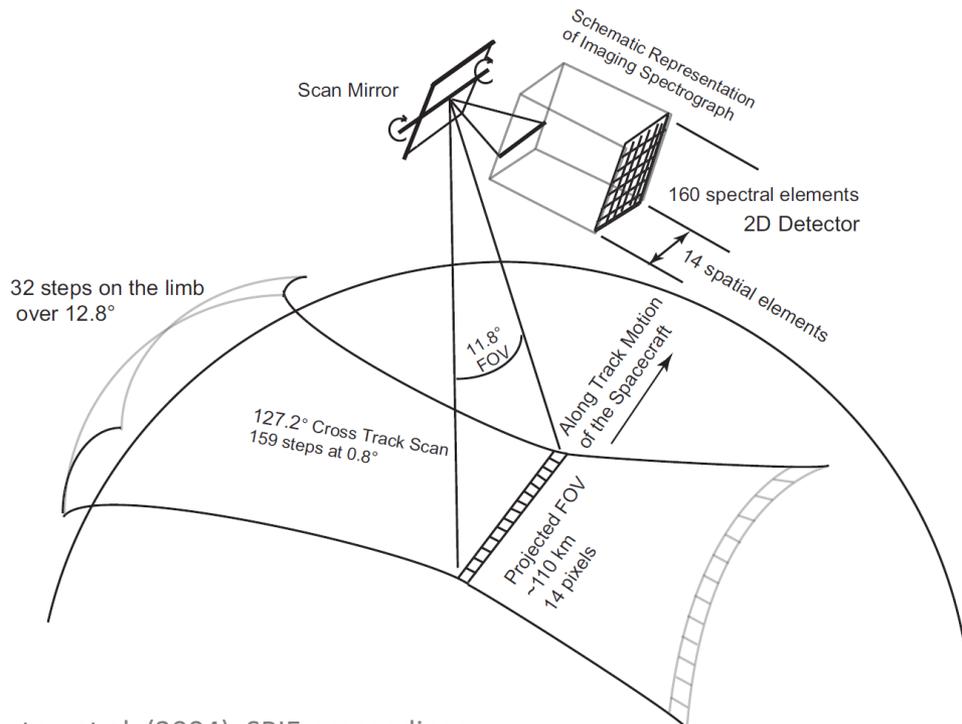
- Rotating mirror: scan every 15 s

- 14 spatial pixels (along-track)

- 32 pixels per limb profile

- Provides both limb and disk measurements

- 5 wavelengths: 1216, 1304, 1356, LBHS, LBHL

- Exposure time very short → need to enhance the SNR !

Improving GUVI L1B limb data (profiles)
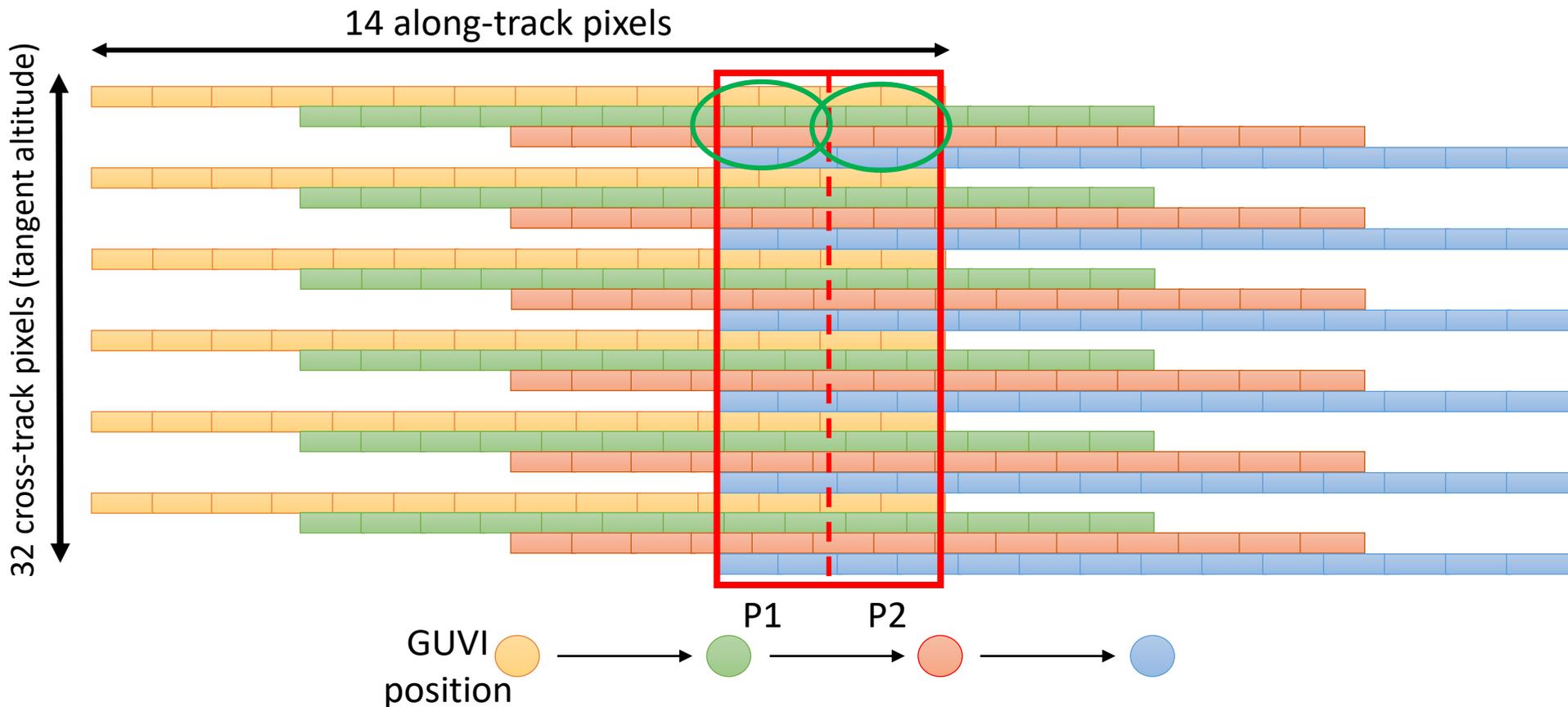
- 4 epochs can be superimposed to add pixel counts (or brightness in Rayleighs)
- 9 profiles into 1 super-profile
- 2 super profiles per epoch (P1 and P2)
- Number of counts x 9 → SNR x 300%

Methodology (1/2)

- Solar maximum period: 2002 to 2004

- Geomagnetically quietest days : 10 international Q-days per month

- Nighttime: SZA > 100°

- Selection of GPS stations around the magnetic equator (25°)

- <u>GPS processing</u>:

  ➢ L1/L2 Geometry-Free (GF) phase computation → « biaised » STEC

  ➢ Epoch-to-epoch time difference → dSTEC

  ➢ low-cut polynomial fitting to remove orbital and gradients trends → RodSTEC (rate of dSTEC)

  ➢ Fourier filtering for frequency range 5 – 60min (tuned for small and medium-scale TIDs)

http://www.igs.org/network
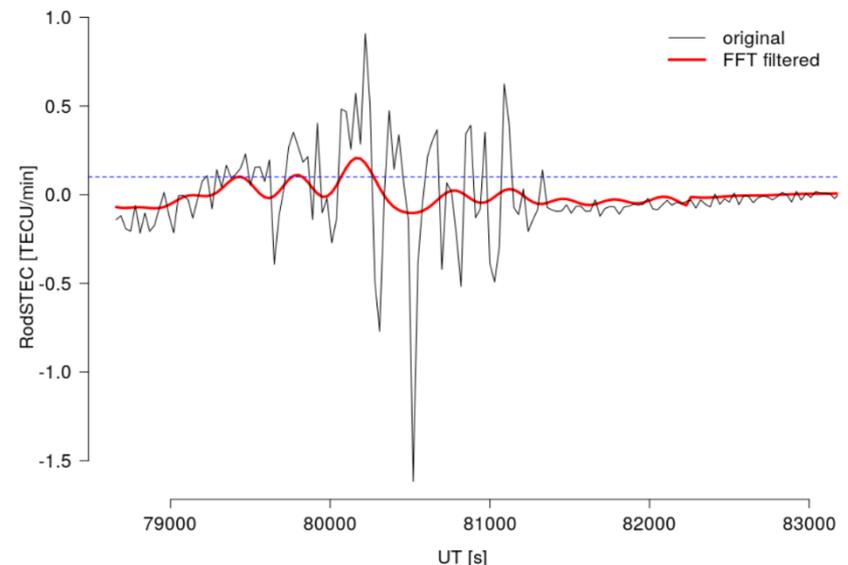
Methodology (2/2)

- ➤ 15-min Standard-Deviation of the Fourier-filtered RodSTEC time series ➜ $\sigma_{RodSTEC}$

- ➤ TID/irregularity detection by applying detection threshold in $\sigma_{RodSTEC}$. e.g. 0.3 TECU/min

- ➤ Mapping of Ionospheric Pierce Points (IPP) at 300 km ➜ geolocation

- GUVI processing

  - ➤ Consider tangent point (TP) location for altitude of 300 km

  - ➤ Retrieve all GUVI revolutions for detected TIDs/irregularities

  - ➤ Computing 2 super profiles per epoch in the 135.6 wavelength

- Matching conditions

  - ➤ Distance between TID/irregularity and GUVI < 1000 km

  - ➤ Time difference +/- 15 min

➡ **Coincidental GPS and GUVI data for irregularity/TID**

Example: irregularity @ low-lat

DOY 285/2003, Indian sector between 13:00 and 15:00 UTC
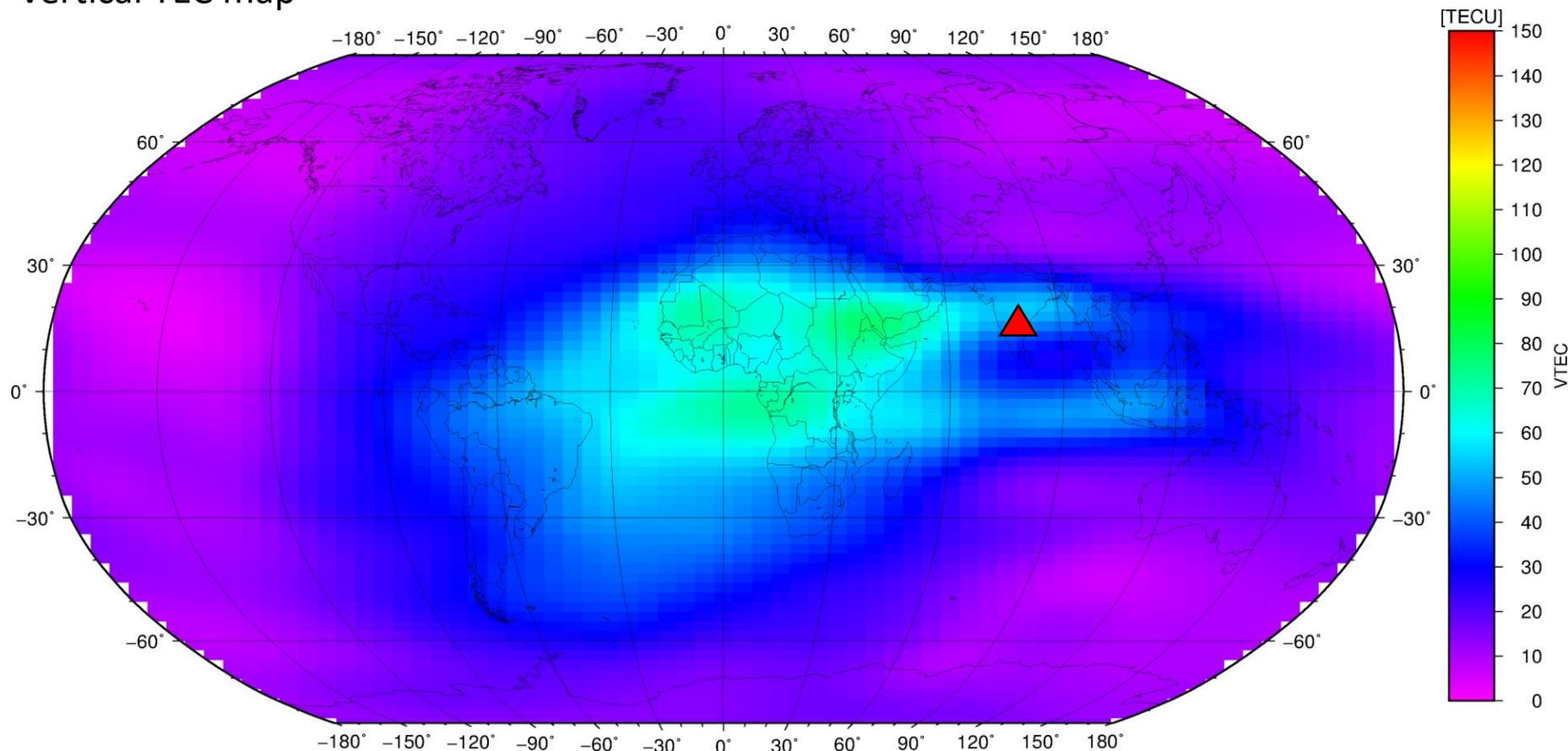
Vertical TEC map

13:00
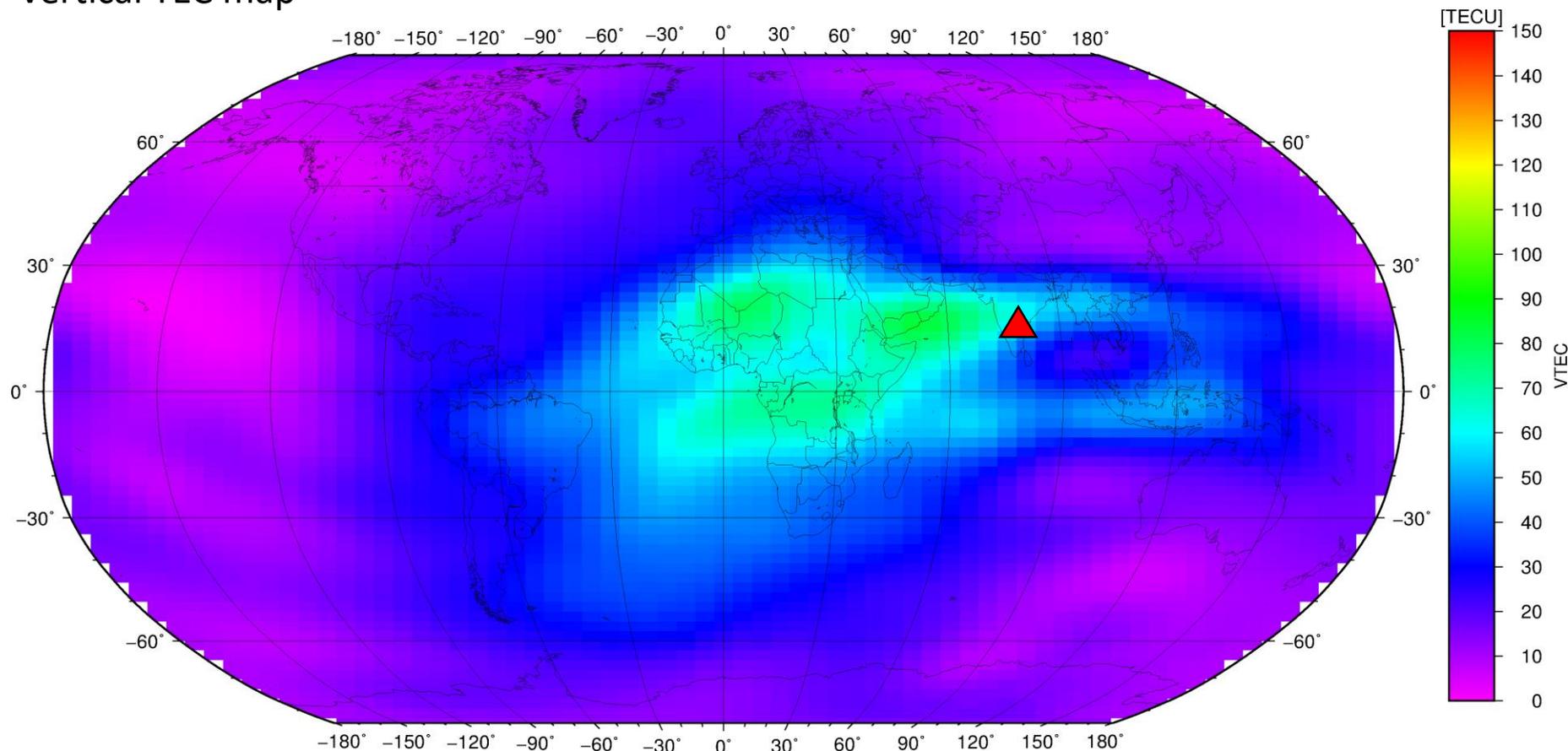
Example: irregularity @ low-lat

DOY 285/2003, Indian sector between 13:00 and 15:00 UTC
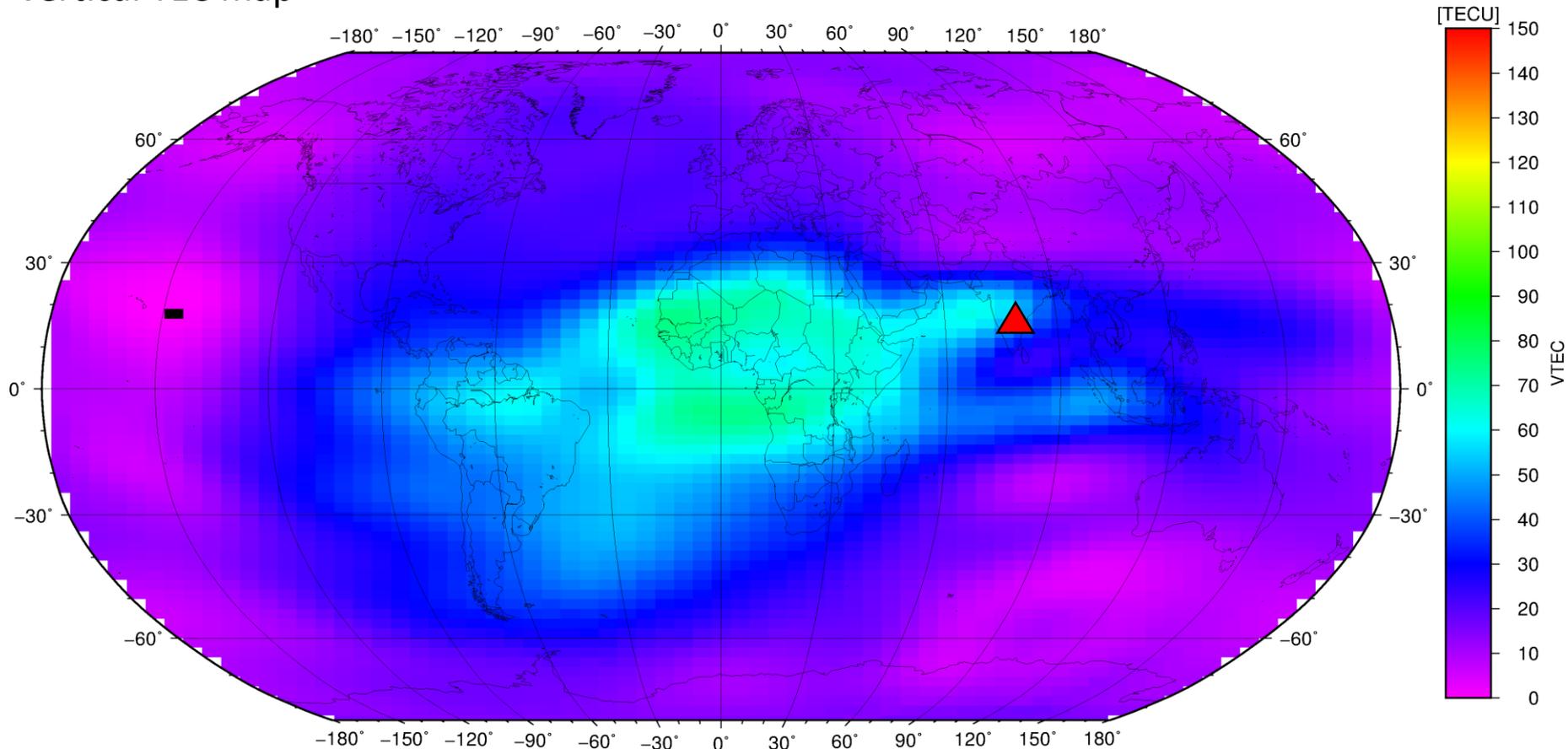
Vertical TEC map

14:00

Example: irregularity @ low-lat

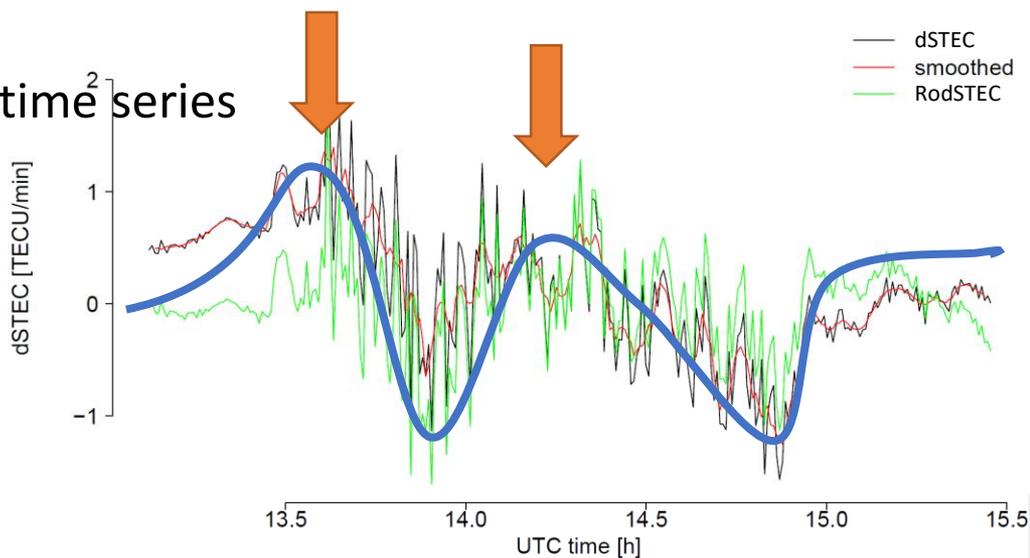DOY 285/2003, Indian sector between 13:00 and 15:00 UTC
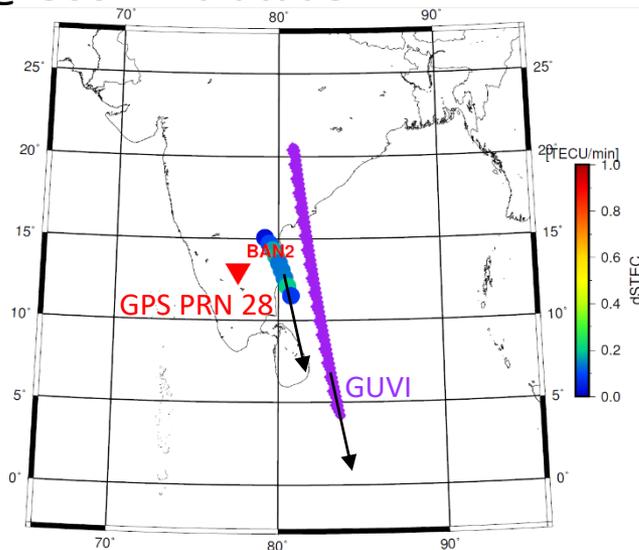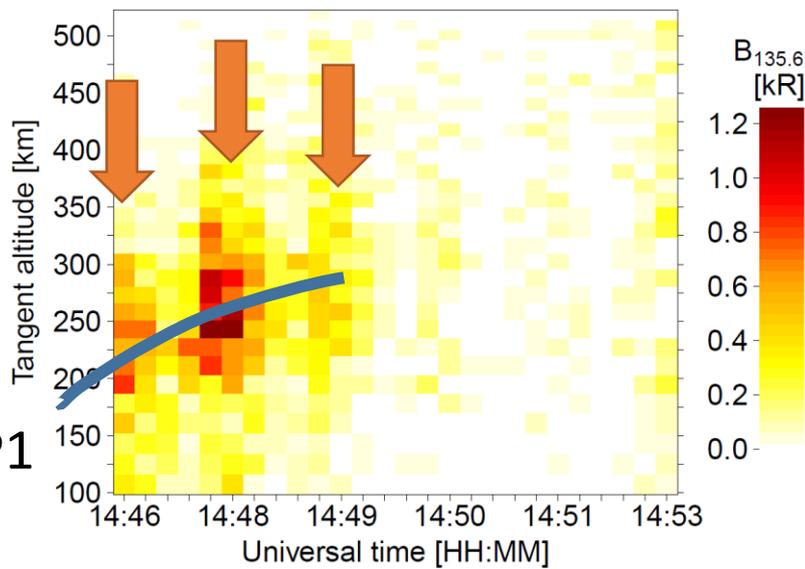
Vertical TEC map

15:00

Example: irregularity @ low-lat

DOY 285/2003, Indian sector between 13:00 and 15:00 UTC

GPS (Ro)dSTEC time series

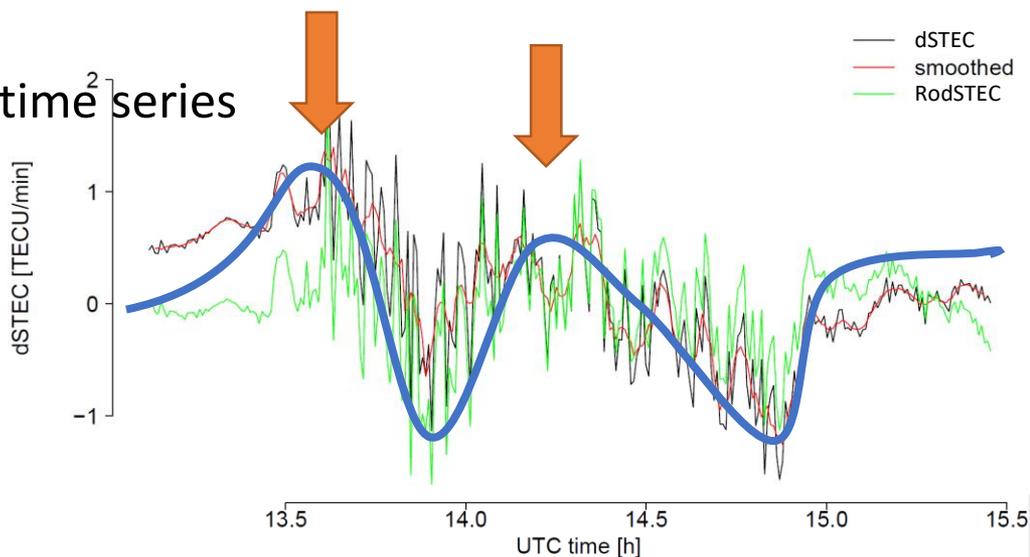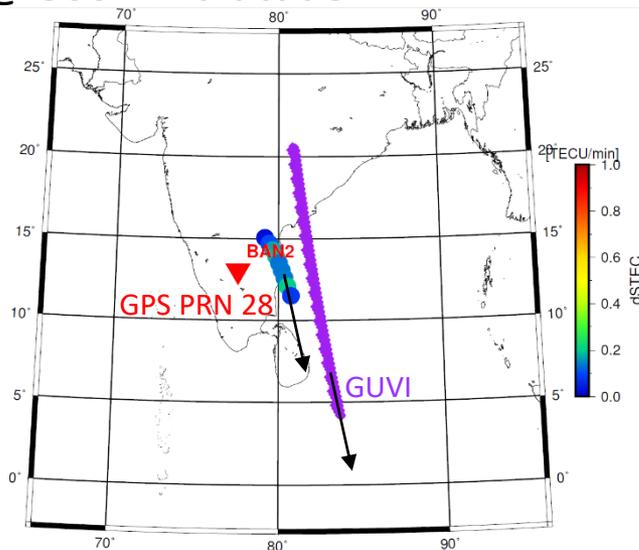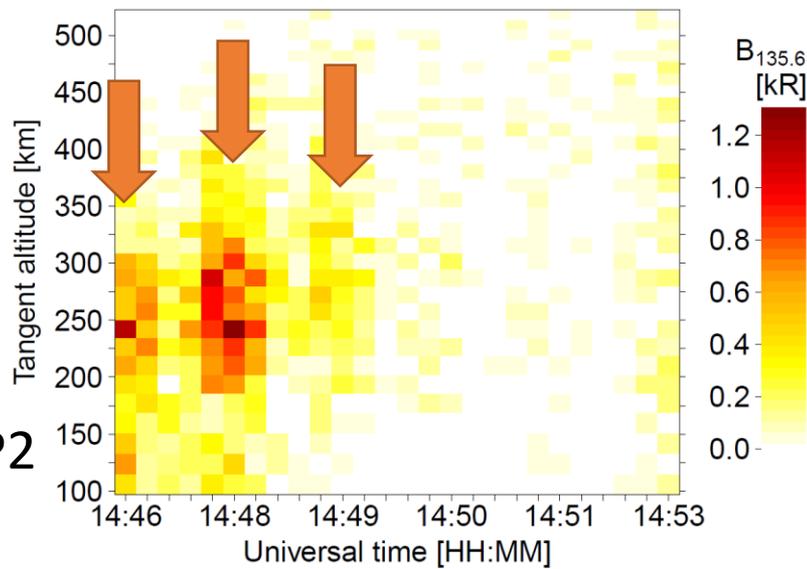GUVI and GPS data
@ 300 km altitude

GUVI keogram P1

Example: irregularity @ low-lat

DOY 285/2003, Indian sector between 13:00 and 15:00 UTC

GPS (Ro)dSTEC time series

GUVI and GPS data
@ 300 km altitude
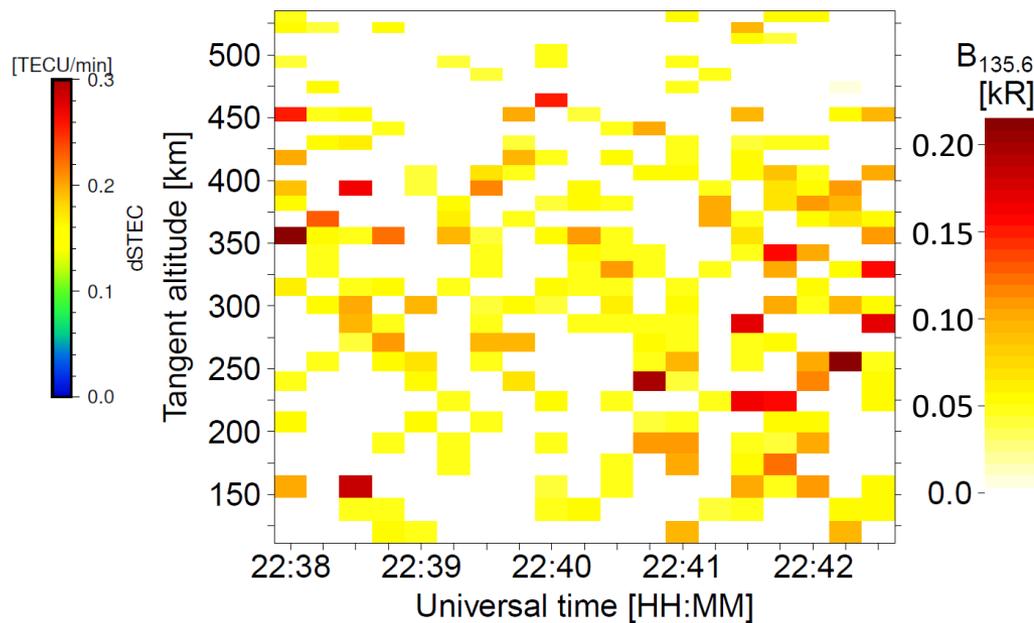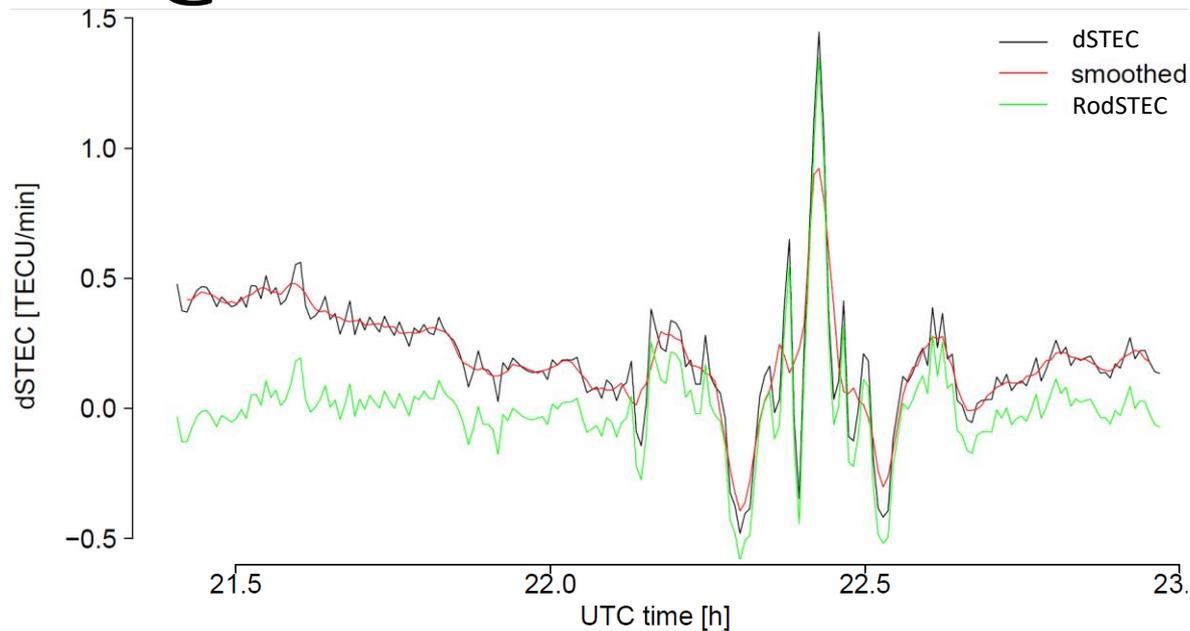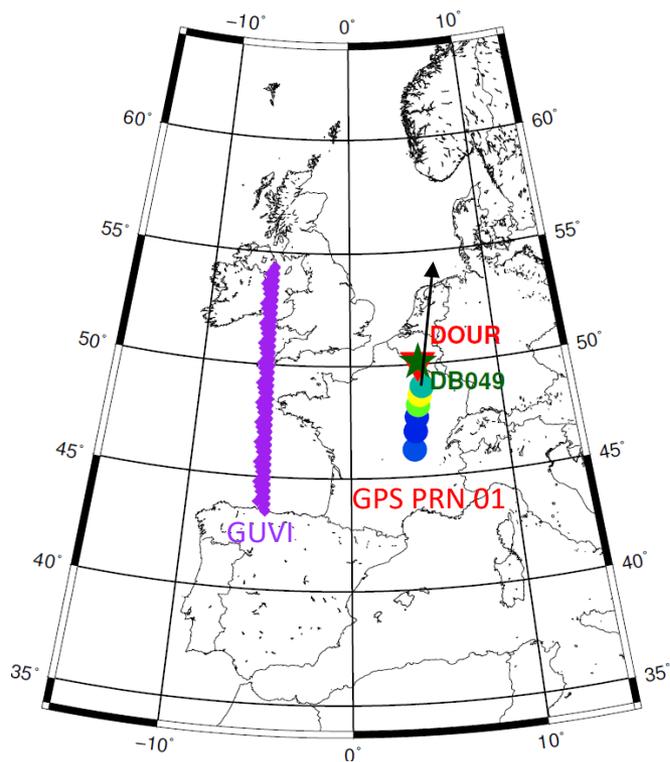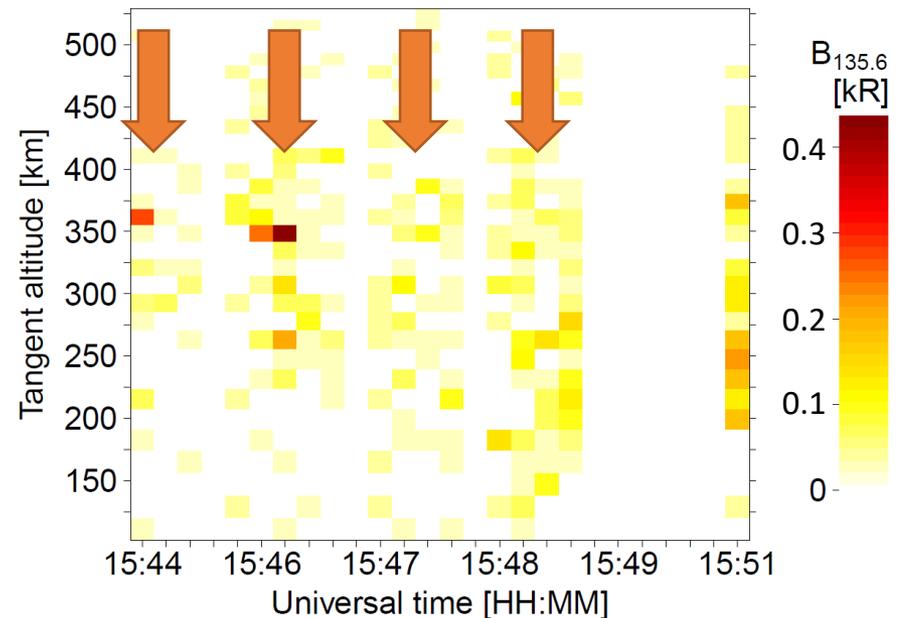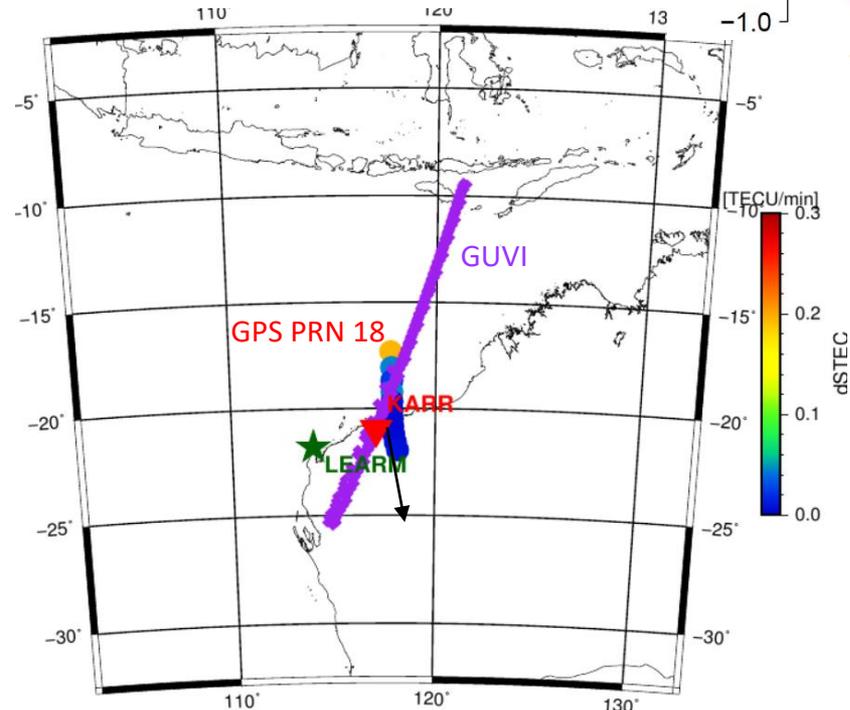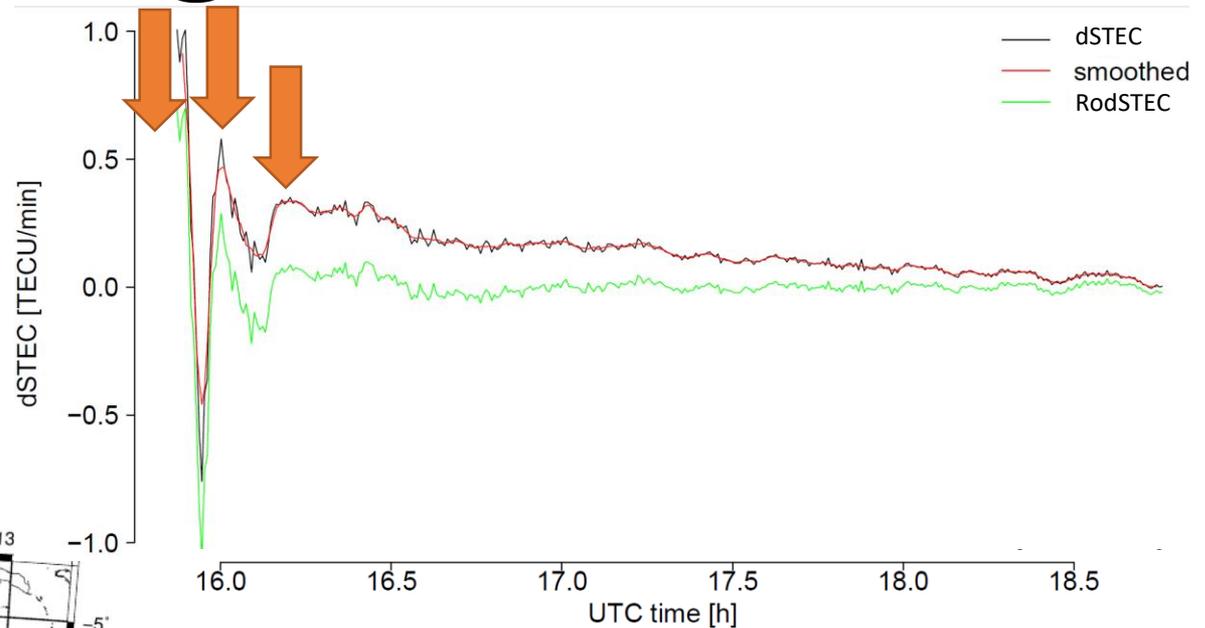
GUVI keogram P2

MSTID detection @ mid-latitude

DOY 029/2002 in
Dourbes (Belgium)

MSTID detection @ mid-latitude

DOY 072/2003 in
Karratha (Australia)

Conclusions and perspectives

- Development of GUVI super-profiles to enhance SNR

- Development of tools for irregularity detection using GPS and identification of coincidental GUVI – GPS data

- Equatorial features can be detected at limb. GUVI provides highly valuable data, complementary to GPS-TEC measurements

- Nighttime MSTIDs at mid latitudes are not detected due to weak SNR

- ICON mission will provide limb scans in 135.6 nm with much larger SNR:

Wautelet et al. (2019), JGR Space Physics
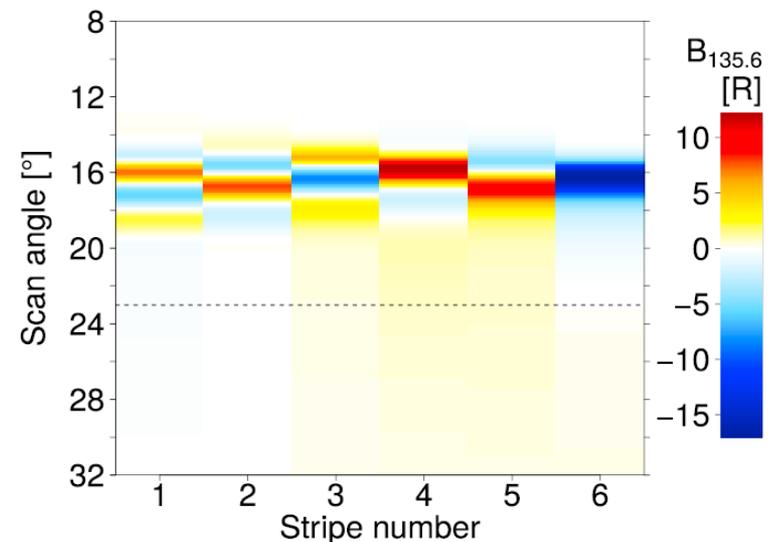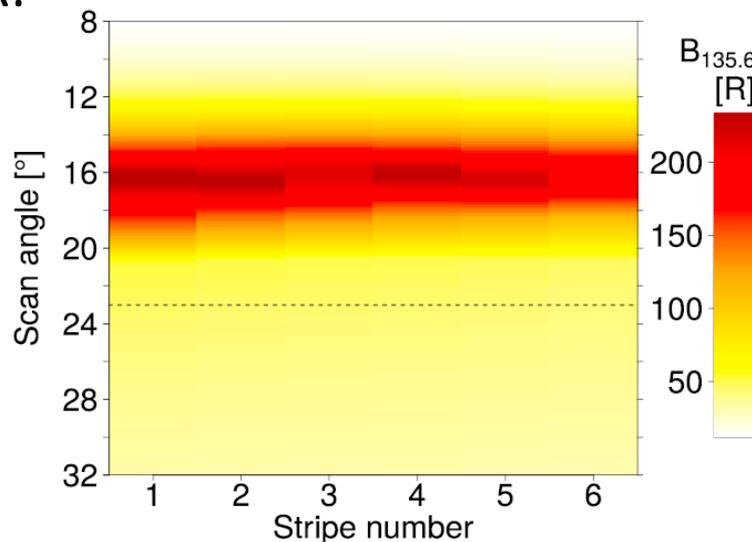
MSTID signature simulation in 135.6 nm as seen by ICON/FUV

Thank you !

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