# Observation of traveling ionospheric disturbances with ICON ultraviolet imagers

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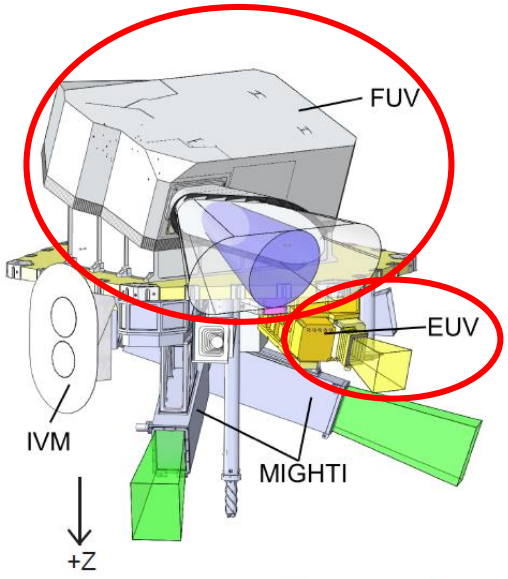
# Medium-Scale Traveling Ionospheric Disturbances (MSTIDs)

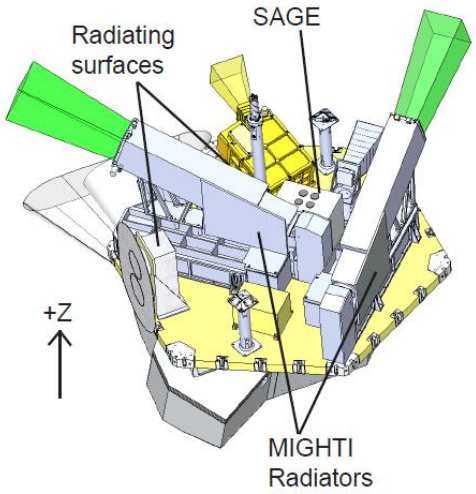
- Wave-like fluctuation of neutral/ion/electron density in the ionosphere
- Vertical transport of momentum and energy from the lower atmosphere
- Horizontal wavelength: 100 – 1000 km
- Period: 12 min – 1h
- Horizontal phase velocity: 50 – 300 m/s
- Two main types:

→ Classical: *Ne* variations due to the passage of an Atmospheric Gravity Wave (AGW) generally propagating upwards

→ Non-classical: *Ne* variations due to an oscillating electric field (electrodynamic coupling between Es and F layers)

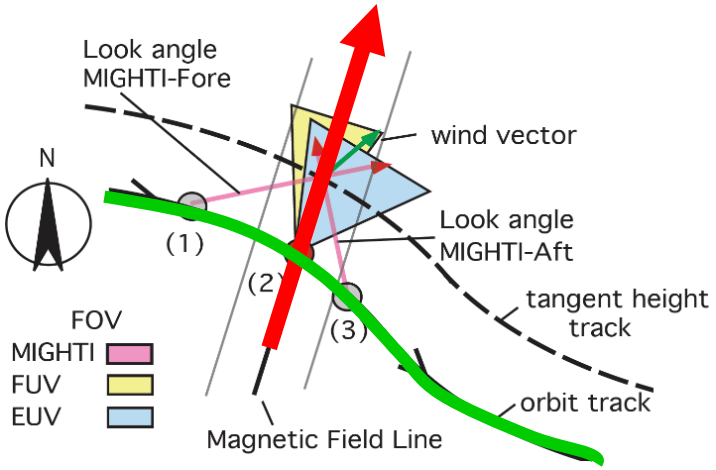
# The ICON mission




Credits : Immel et al. (2012)

- ICON = Ionospheric CONection Explorer
- Goal : understand the ionospheric variability study by studying the connection between ionosphere and weather / space-weather
- Circular orbit, 27° inclination at 575 km altitude
- Four instruments, two of them in UV : EUV and FUV which are co-aligned with a vertical field of view of 24°




Credits : Immel et al. (2012)

# ICON Ultraviolet instruments

## Far Ultraviolet Imager (FUV)

- Two detectors at 135.6 and 155 nm for OI and $N_2$ LBH-band respectively
- Measure $O^+$ altitude profile (**nighttime**)
- Measure $[O]/[N_2]$ altitude profile
- Time resolution: 12 s

## Extreme Ultraviolet Imager (EUV)

- Emission at 83.4, 61.7 and 58.4 nm for OII (opt. thick), OII (opt. thin) and He respectively
- Measure $O^+$ altitude profile (**daytime**)
- Time resolution: 12 s

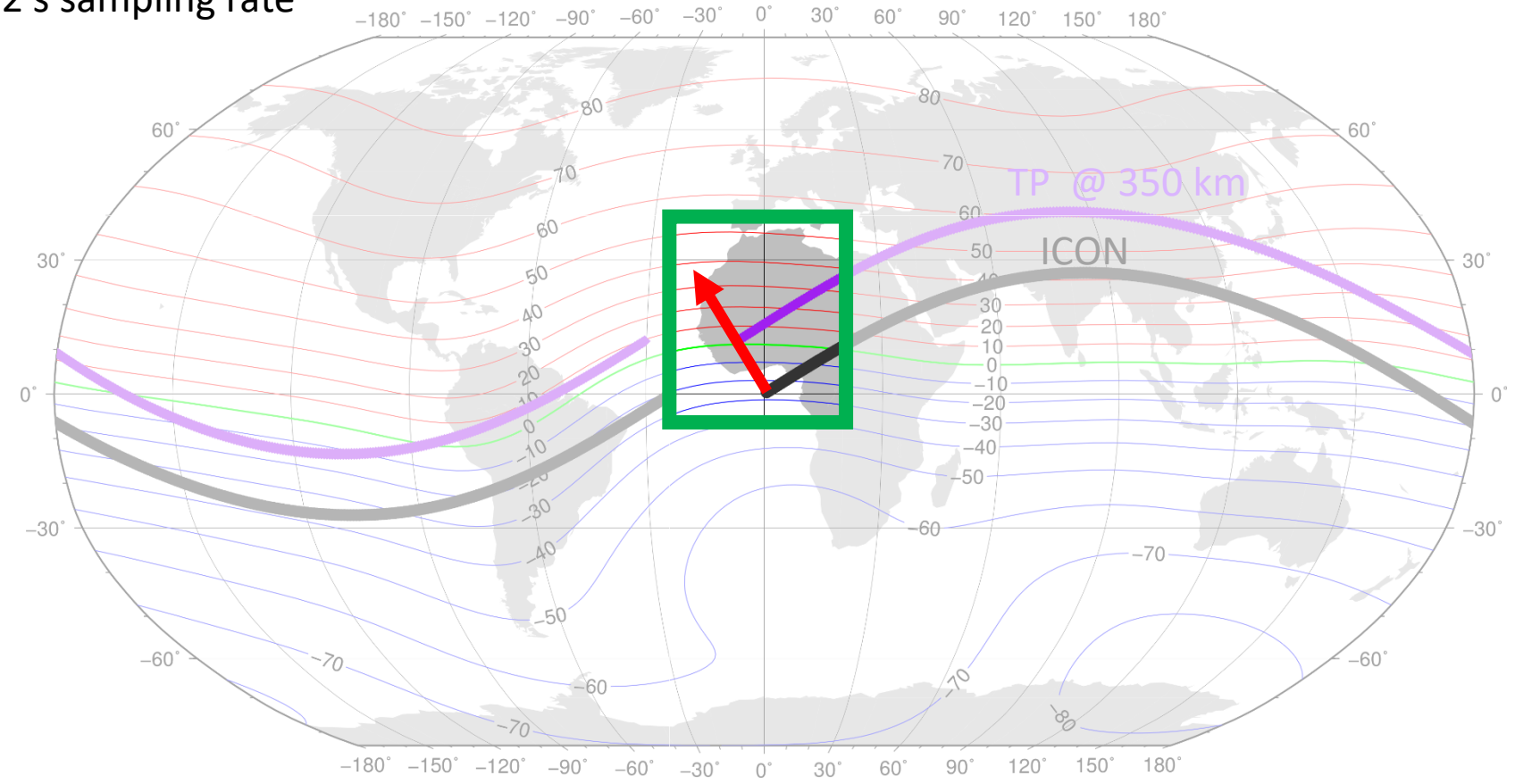
→ Product Level-1: Line-of-sight integrated brightness

Product Level-2: Inverted values (profiles)

**??? Will ICON UV instruments be able to observe MSTIDs ???**

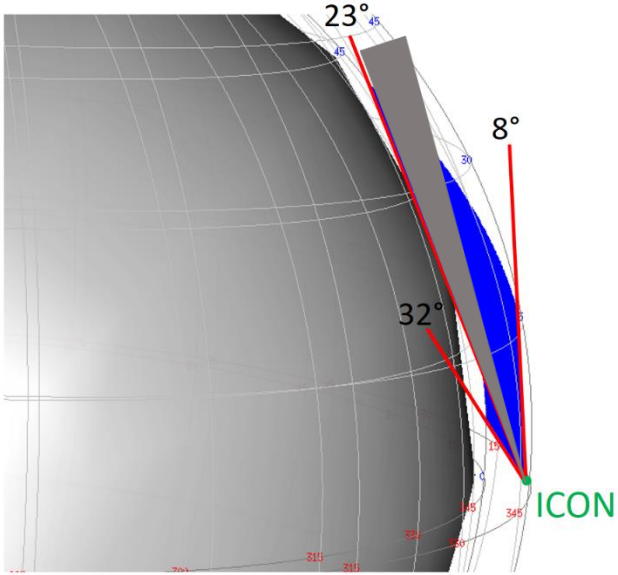
# Simulation: ICON and standard ionosphere

- Ionosphere (IRI-2016) and geomagnetic field (IGRF12) on a grid: 0.5° x 0.5° x 5 km
- ICON orbit, starting from 0°/0° and FUV/EUV field of view perpendicular to ICON's orbit track
- 12 s sampling rate



# Simulation: ICON and standard ionosphere

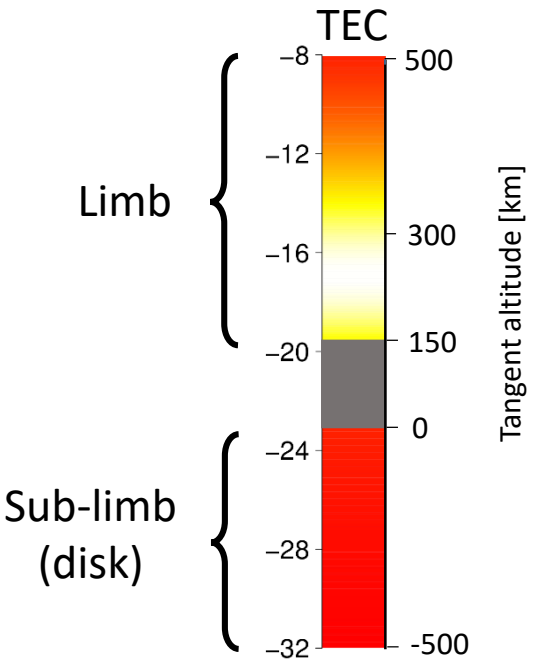
- Ionosphere (IRI-2016) and geomagnetic field (IGRF12) on a grid: 0.5° x 0.5° x 5 km
- ICON orbit, starting from 0°/0° and FUV/EUV field of view perpendicular to ICON's orbit track
- 12 s sampling rate
- For each scan: computation of intersections of the 256 lines-of-sight (LoS) with voxels




Hypothesis: Ionosphere transparent to airglow emission
→ $O^+$ density LoS integration becomes TEC

Level-1 product simulation:

- TEC for each of the 256 LoS (angles from 8 to 32° below local horizontal)
- « Grey zone » for positive tangent altitudes < 150 km ($O_2$ absorption and mis-modeling of ionosphere)

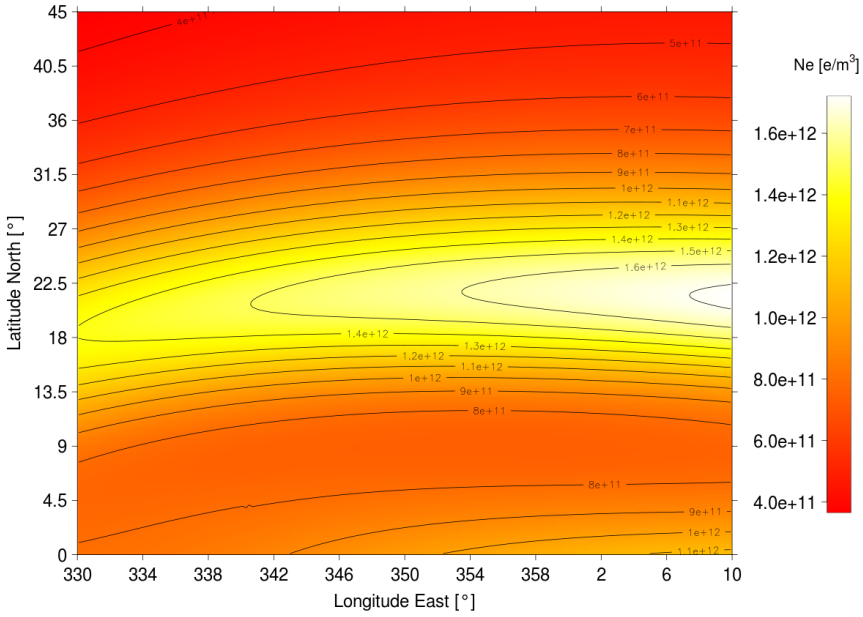


# Simulation: a classical MSTID

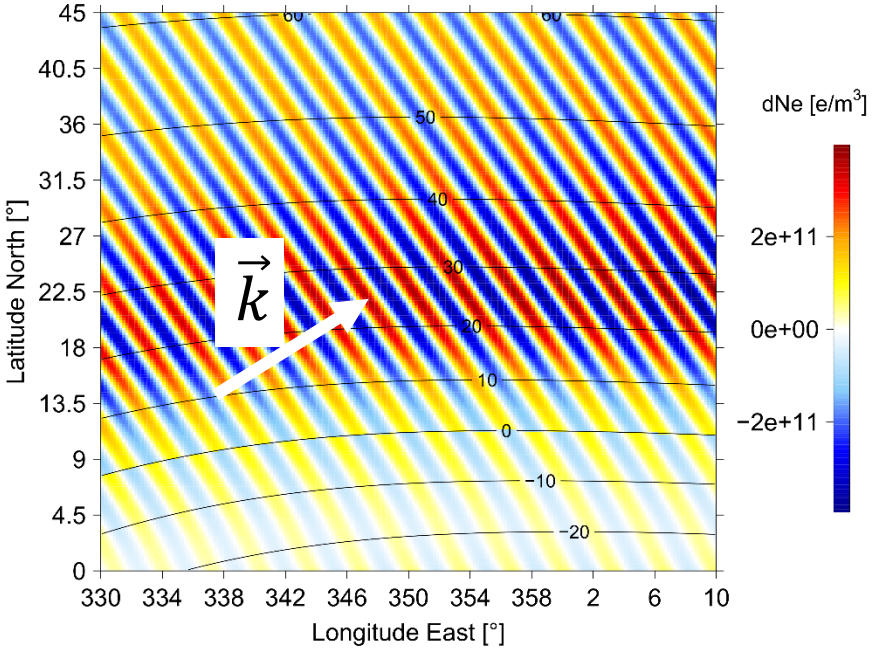
- Period: 25 min
- Horizontal wavelength: 300 km
- Vertical wavelength: 165 km
- Upwards propagation

- Horizontal phase velocity: 46 m/s
- Vertical phase velocity: 84 m/s
- Plane wave approximation
- Maximum amplitude: 15% of the TEC background

## IRI background




## MSTID

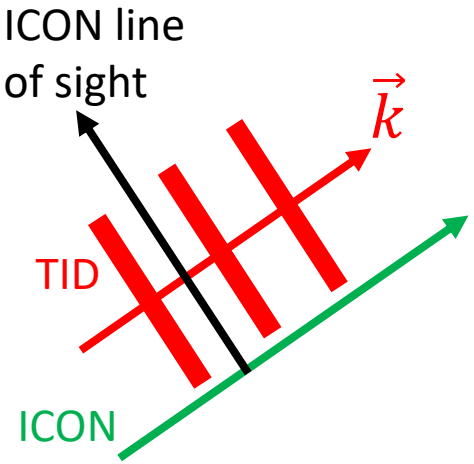


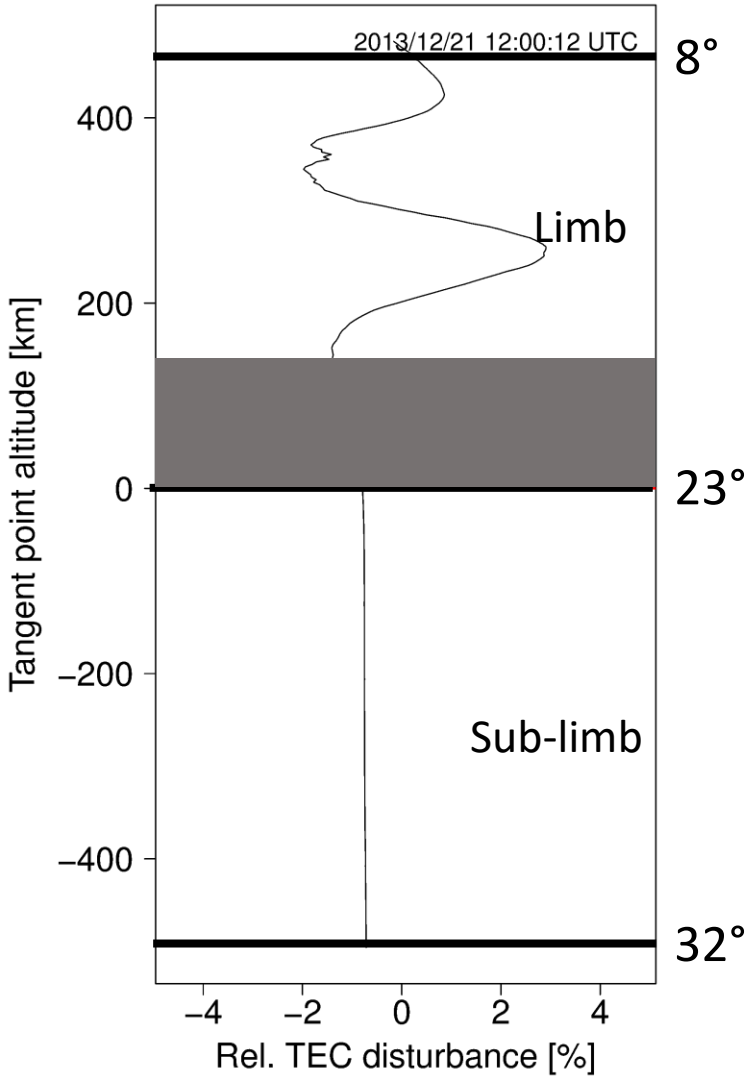
# How ICON sees the TID (1/2)

## Propagation azimuth : 63°

→ $\vec{k}$ along ICON orbit

→ $\vec{k}$ perpendicular to ICON line-of-sight



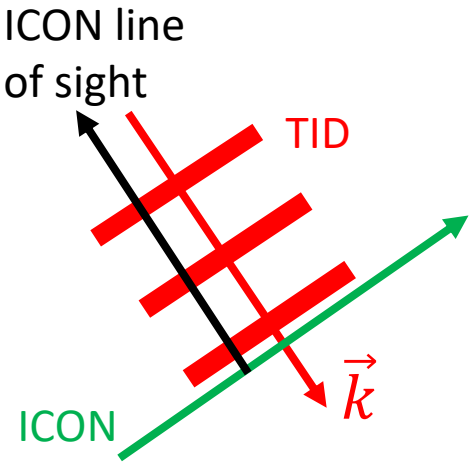

Successive scan of crests and troughs (max and min)
→ Moderate to strong signature

# How ICON sees the TID (2/2)

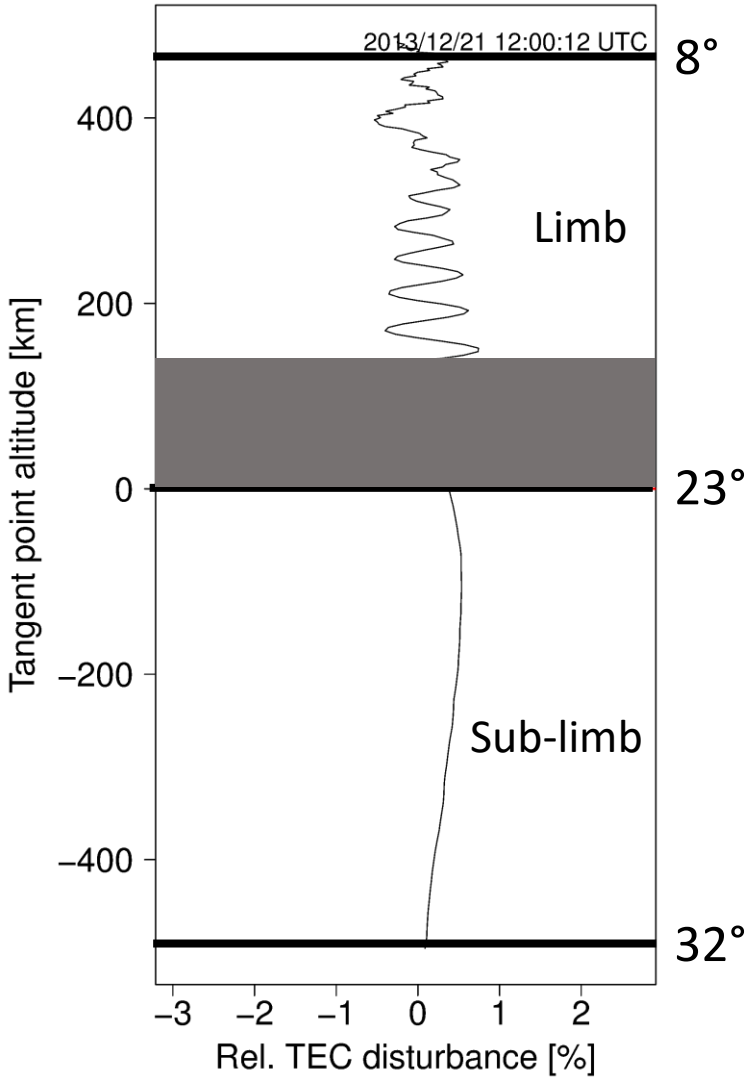
## Propagation azimuth : 153°

→ $\vec{k}$ perpendicular to ICON orbit

→ $\vec{k}$ anti-parallel to ICON line-of-sight



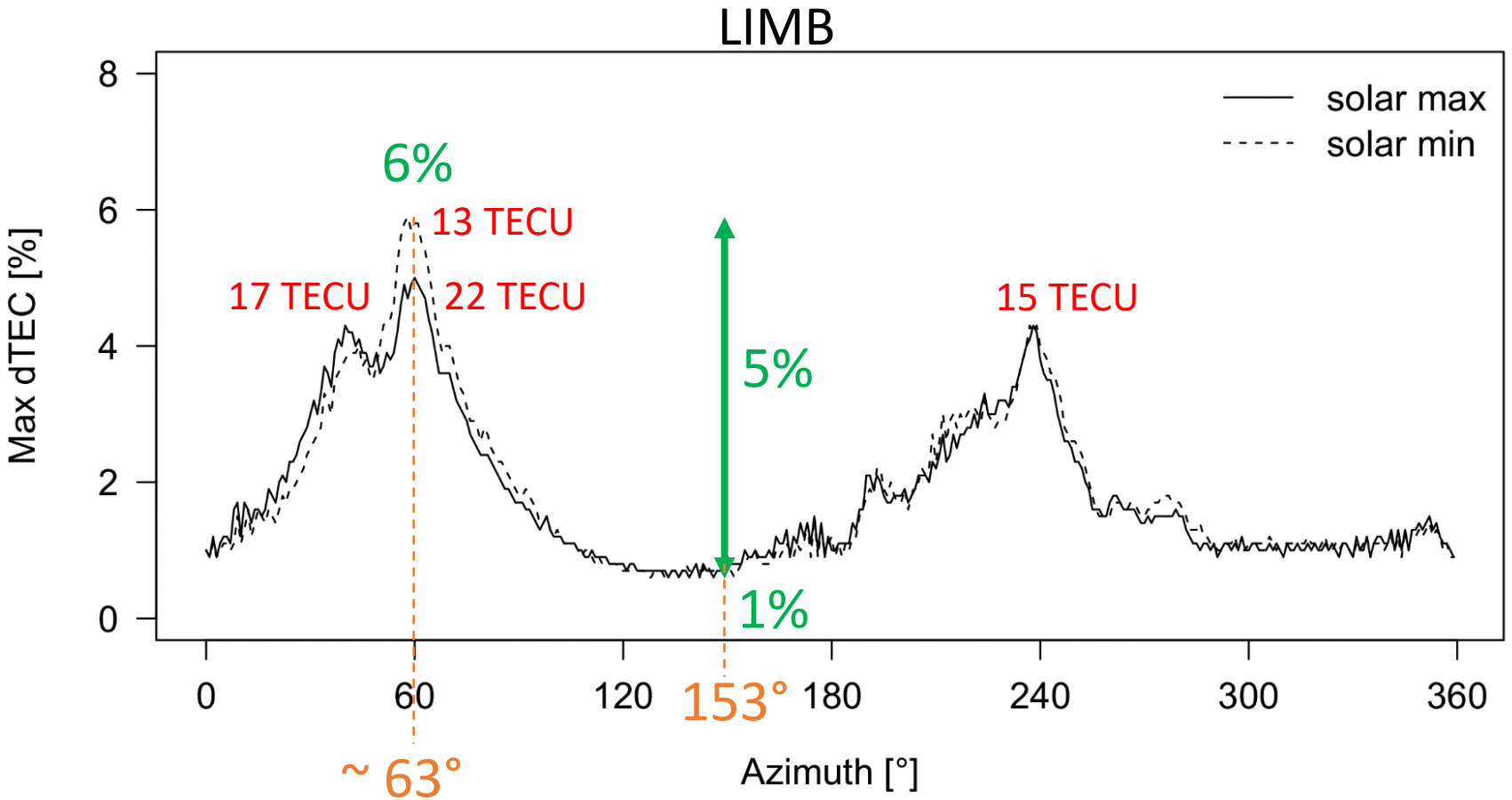

Crests and troughs (max and min) compensate
→ weak signature



# Influence of azimuth: limb region

Relative [%]
Absolute [TECU]

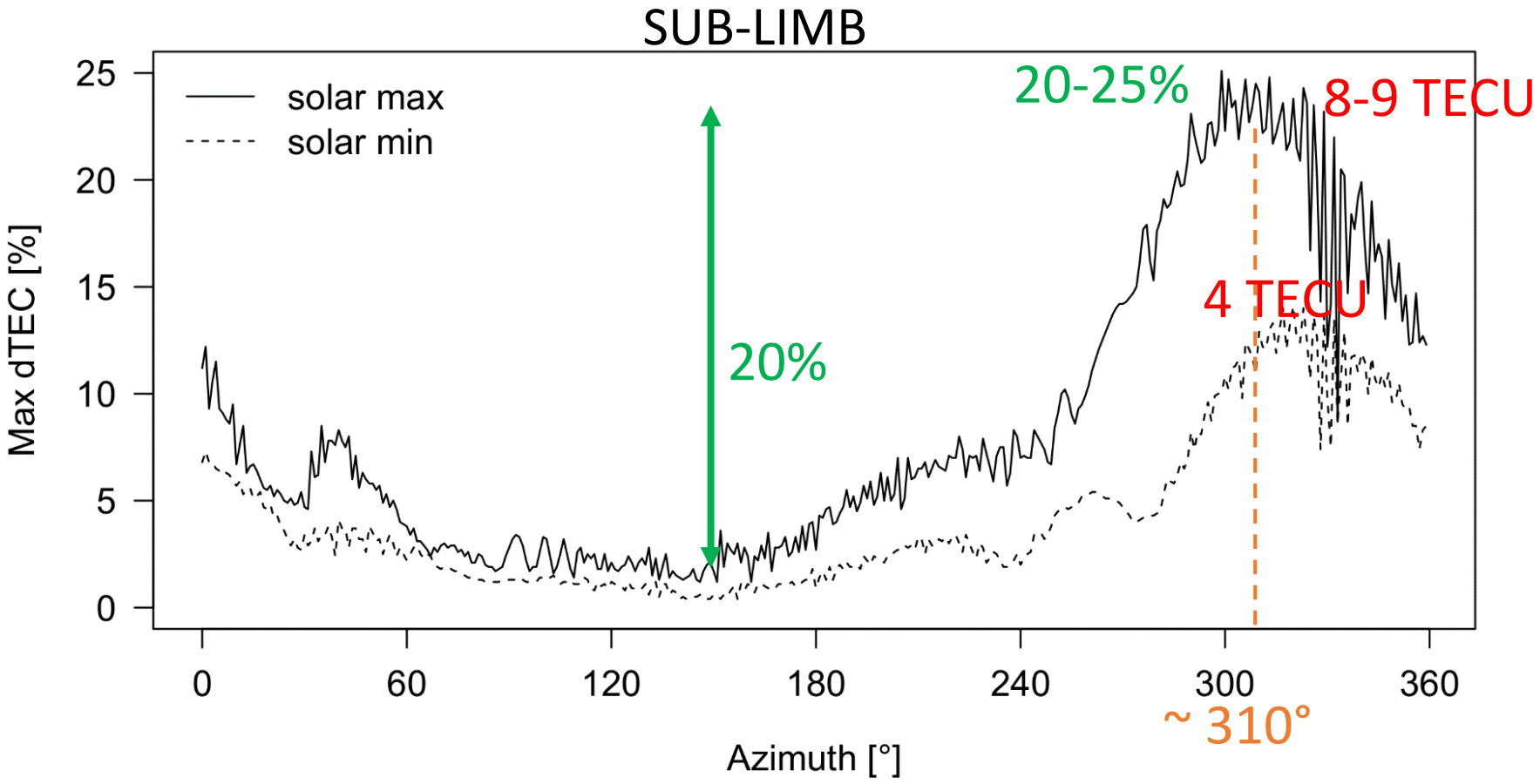
Period = 25 min
Hz wavelength = 300 km
Winter solstice at 12:00 LT



# Influence of azimuth: sub-limb region

Relative [%]
Absolute [TECU]

Period = 25 min
Hz wavelength = 300 km
Winter solstice at 12:00 LT



# Conclusions and perspectives

- Development of a simulation tool: IRI background + TID
- TID detection strongly depends on TID/ICON relative orientation
- The optimal relative orientation is different for limb and sub-limb regions
- For a 15% *dNe* and in the best case, TEC relative deviation is 6% for limb and around 20% for sub-limb

- Keogram analysis to infer propagation parameters
- Make use of the imaging capability of FUV to assess the spatial structure of the TID
- Inclusion of radiative transfer for daytime to simulate airglow brightness (instead of TEC)

Thank you !

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