T-FORS: WP4- Tests and validation experiments

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Outline

- **HF Direction Finding system - GFP**
  - Mean of measurement
  - Results
- **NOSTRADAMUS HF OTH-R - ONERA**
  - Mean of measurement
  - Experiments configurations
  - Results

HF Direction finding system - GFP

Mean of measurement

- Highly sensitive antenna system
- Rod antennas installed in two 16/8 elements concentric circles
- For skywave with high bearing accuracy
- Used as a directional antenna in order to analyze the azimuth of arriving HF signals
- Located 30 km south from Cologne

Figure 1: Locations of Nostradamus and DF

Figure 2: DF array

HF Direction finding system - GFP

Results

Skywave propagation

- Using transmission from NCDXF/IARU International Beacon Project

Beacon callsign	Beam heading	Distance from DF
OH2B	34°	1781 km
CS3B	238°	2600 km

- OH2B is located in Helsinki, CS3B is located in Madeira → skywave propagation
- The DF measurements were filtered in differently narrow sectors to focus on the HF transmitting beacon of interest
- During a TID timeframe, the average squared deviation ($AvSQD_{TID}$) have been calculated in order to have a metric about the quality of the measurements. All the other measurements were used to compute $AvSQD_{NoTID}$.

HF Direction finding system - GFP

Results

Skywave propagation

- As JR055 (digisonde), is located in the DF-OH2B path, TID azimuth detected over JR055 are used

TID-Event	$AvSQD_{NO\ TID}$	$AZIM_{HF-B}$	$AVSQD_{TID}$	$AZIM_{TID}$	ΔAZIM	Degraded
03/10/2021	8.13	39.5	14.7	267	227.5	YES
06/10/2021	8.13	39.5	0.56	255	215.5	NO
06/10/2021	8.13	39.5	1.67	186	146.5	NO
07/10/2021	8.13	39.5	3.12	220	180.5	NO
08/10/2021	8.13	39.5	9.38	258	218.5	YES
10/10/2021	8.13	39.5	1.63	274	234.5	NO

Table 1: Values of average squared deviation for the beacon OH2B

Figure 3: Path between DF and OH2B beacon

HF Direction finding system - GFP

Results

Skywave propagation

- All degraded events are concentrated between 260° and 280° azimuth, at 45° respect the light of sight
- All degraded events are concentrated during the equinox

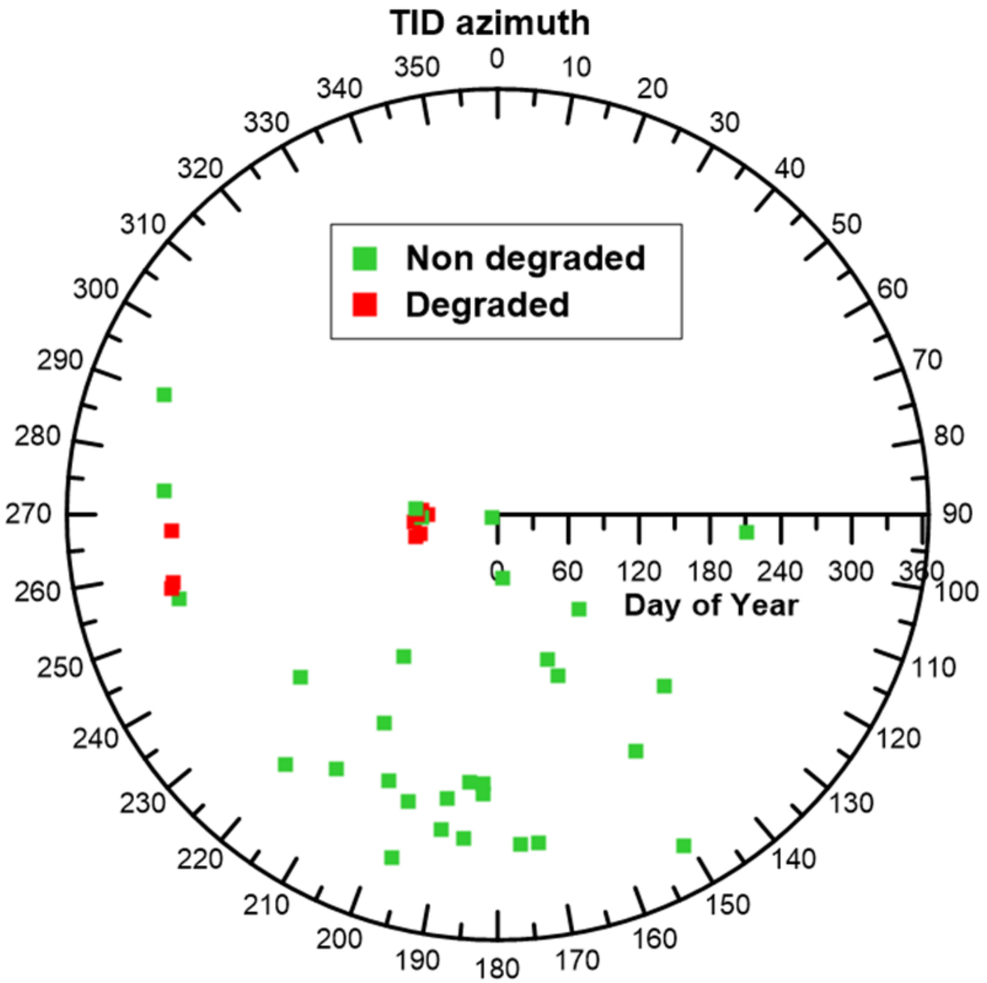

Figure 4: TID detections according to azimuth and day of year – measurements on OH2B beam

HF Direction finding system - GFP

Results

Skywave propagation

- All degraded events are concentrated in the morning sector. Solar terminator influence
- As we are looking high latitude area, the ionization is too weak at night to see any effects at DF system

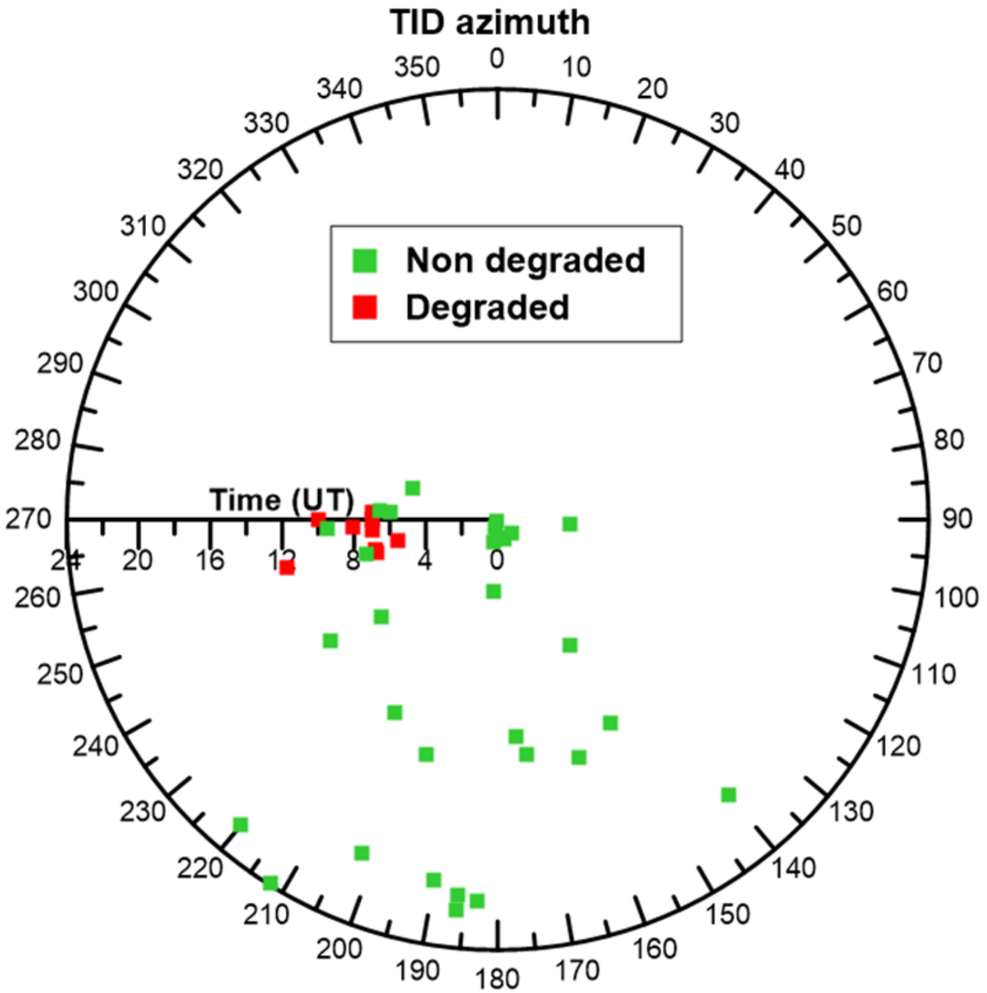

Figure 5: TID detections according to azimuth and UT – measurements on OH2B beam

HF Direction finding system - GFP

Results

Skywave propagation

- All degraded events are concentrated during the equinox
- Larger dispersion, most of the degraded events are under southward TID propagation

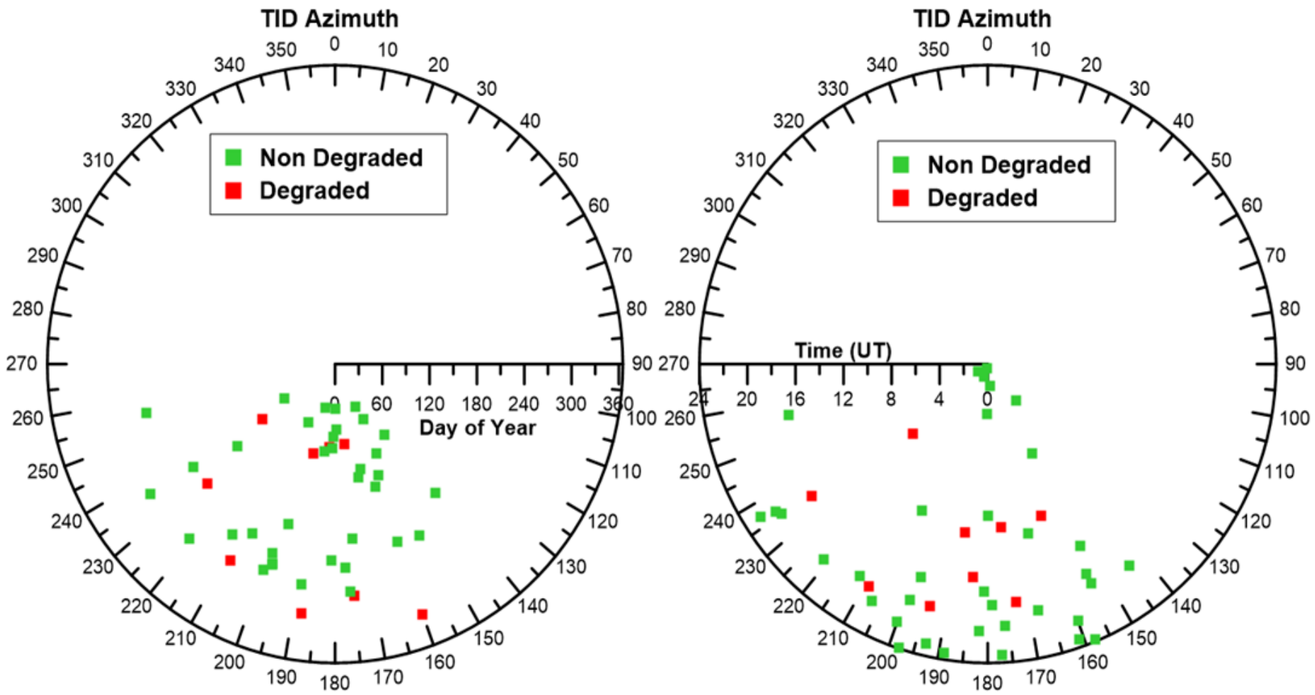

Figure 6: TID detections– measurements on CS3B beam

NOSTRADAMUS HF OTH-R

Mean of measurement

- Monostatic, surface array HF skywave system
- 288 bicone antenna elements distributed over the arms of a three-branch star
- Buried infrastructure to shelter the transmission and reception electronics
- Full digital system
- 360° coverage in azimuth
- Control of the beam in azimuth and elevation
- Located 80 km west from Paris

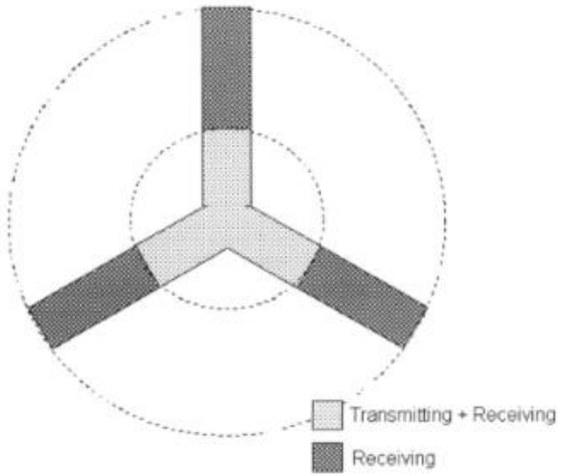

Figure 7: Repartition between transmiting and receiving antennas

Figure 8: Nostradamus array

Experiments configurations

Line of sight (LOS) propagation

- Detect at short ranges, directly inside the ionosphere the passage of disturbances
- Changing the frequency changes the depth of penetration into the ionosphere

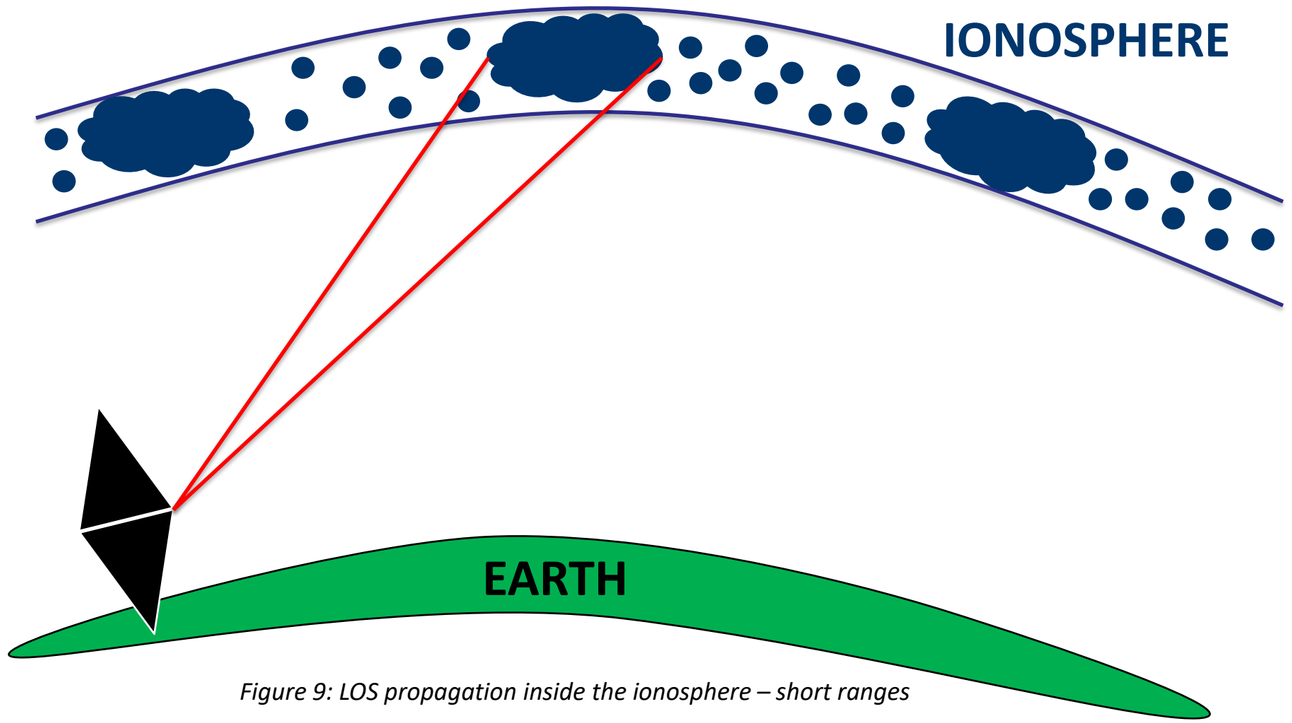

Figure 9: LOS propagation inside the ionosphere – short ranges

Experiments configurations

Skywave propagation

- Detect at medium ranges, to see amplitude/doppler variations on the ground clutter echo
- If the propagation channel is stable, ground clutter echo is located as 0 doppler and the coverage in ranges doesn't changes. All disturbances modify this state

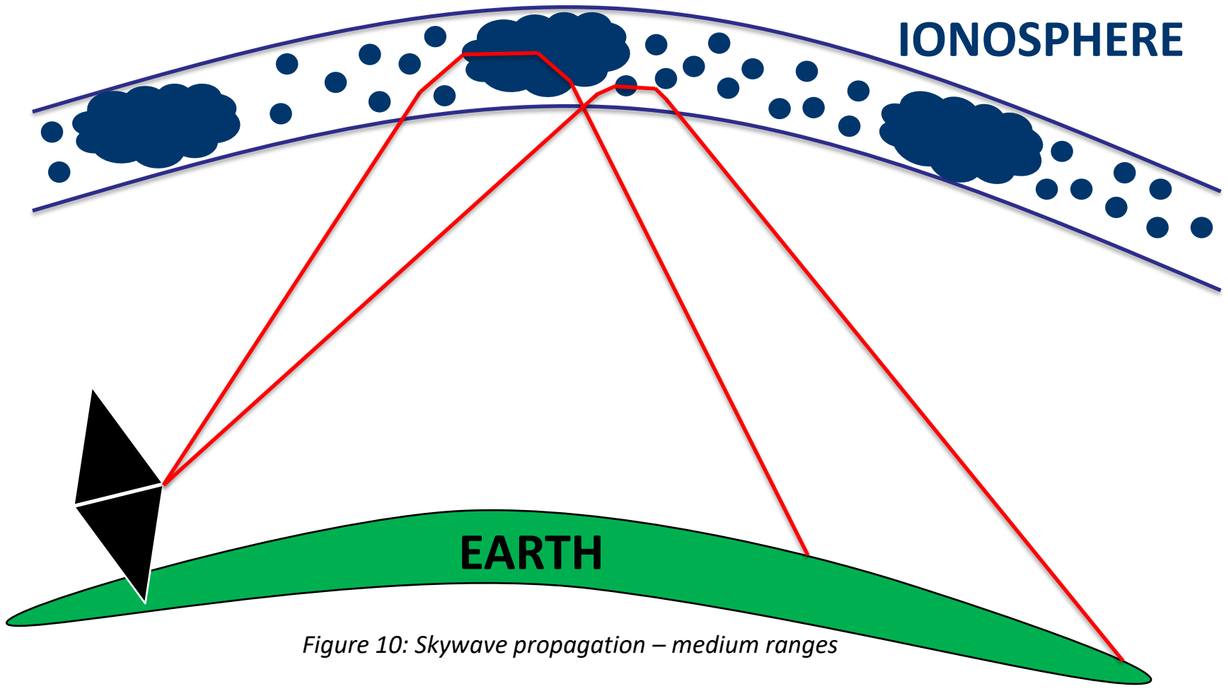

Figure 10: Skywave propagation – medium ranges

Experiments configurations

Parameters of the study

- For the two configurations we can study different parameters :
  - Start and end time
  - Intensity
  - Spatial extension
  - Velocity
- Signal analysis enables us to obtain RTI images where R is group-range, T is slow time and I is intensity

NOSTRADAMUS HF OTH-R

Examples

LOS propagation

- 5.12s integration time
- 358° azimuth
- 30° elevation
- 29th June 2011
- Starting time 21:28

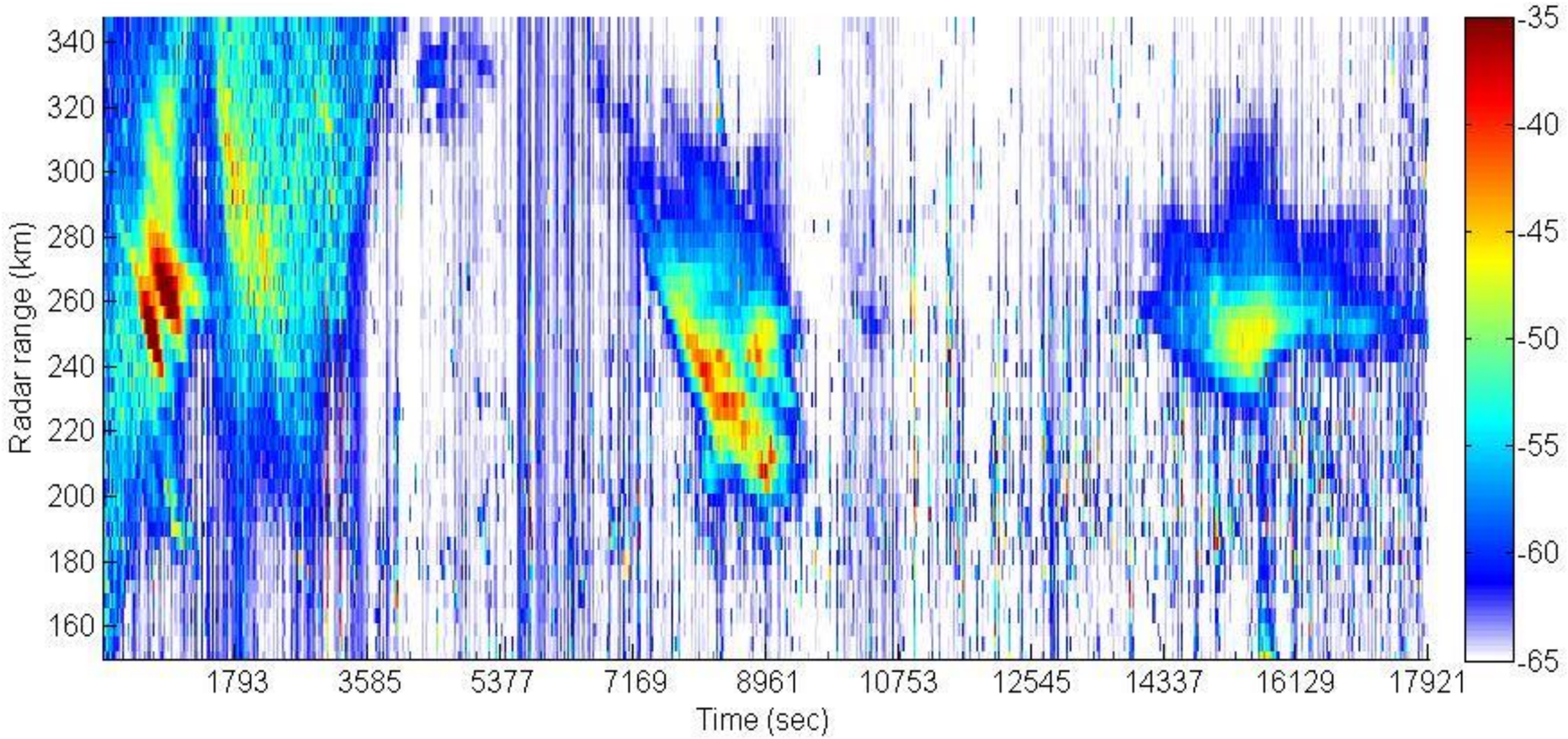

Figure 11: RTI image in LOS configuration

NOSTRADAMUS HF OTH-R

Examples

Skywave propagation

- 10.24s integration time
- 88° azimuth
- 25° elevation
- 10.598 MHz frequency
- 11th April 2012
- Starting time 10:40
- 1 hour and 54 minutes duration

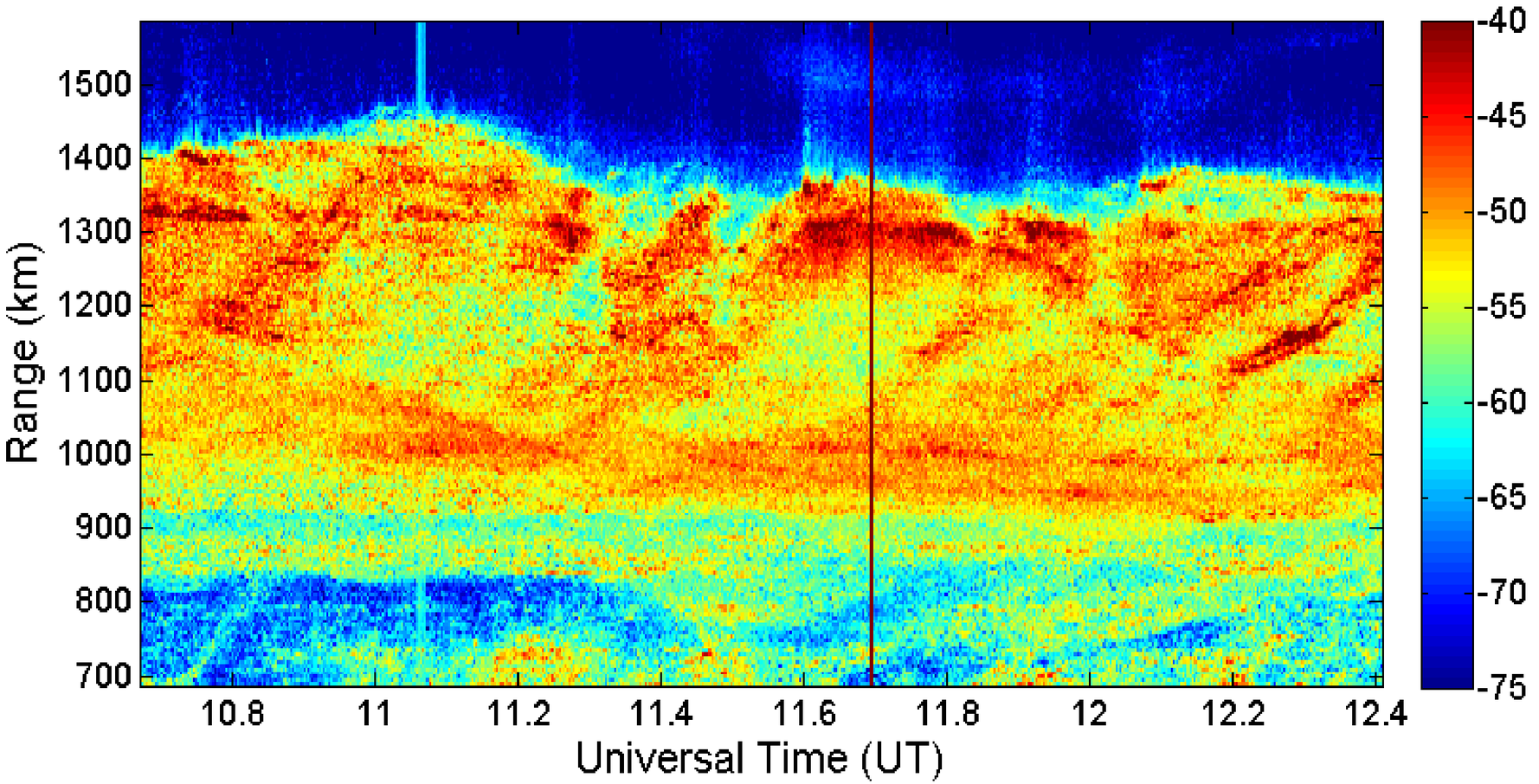

Figure 12: RTI image in skywave configuration

Thank you for your attention!

Acknowledgements

GIRO; Prof. Dr. Bodo Reinisch and Dr. Ivan Galkin; Dr. David Altadill, Observatori de l'Ebre (OE); Dipl.-Phys. Jens Mielich; NCDXF/IARU International Beacon Project; The Operators from the ionospheric observatory in Dourbes

Funded by the European Union

The T-FORS project is funded by the European Union (GA-101081835). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency (HaDEA). Neither the European Union nor the granting authority can be held responsible for them.