

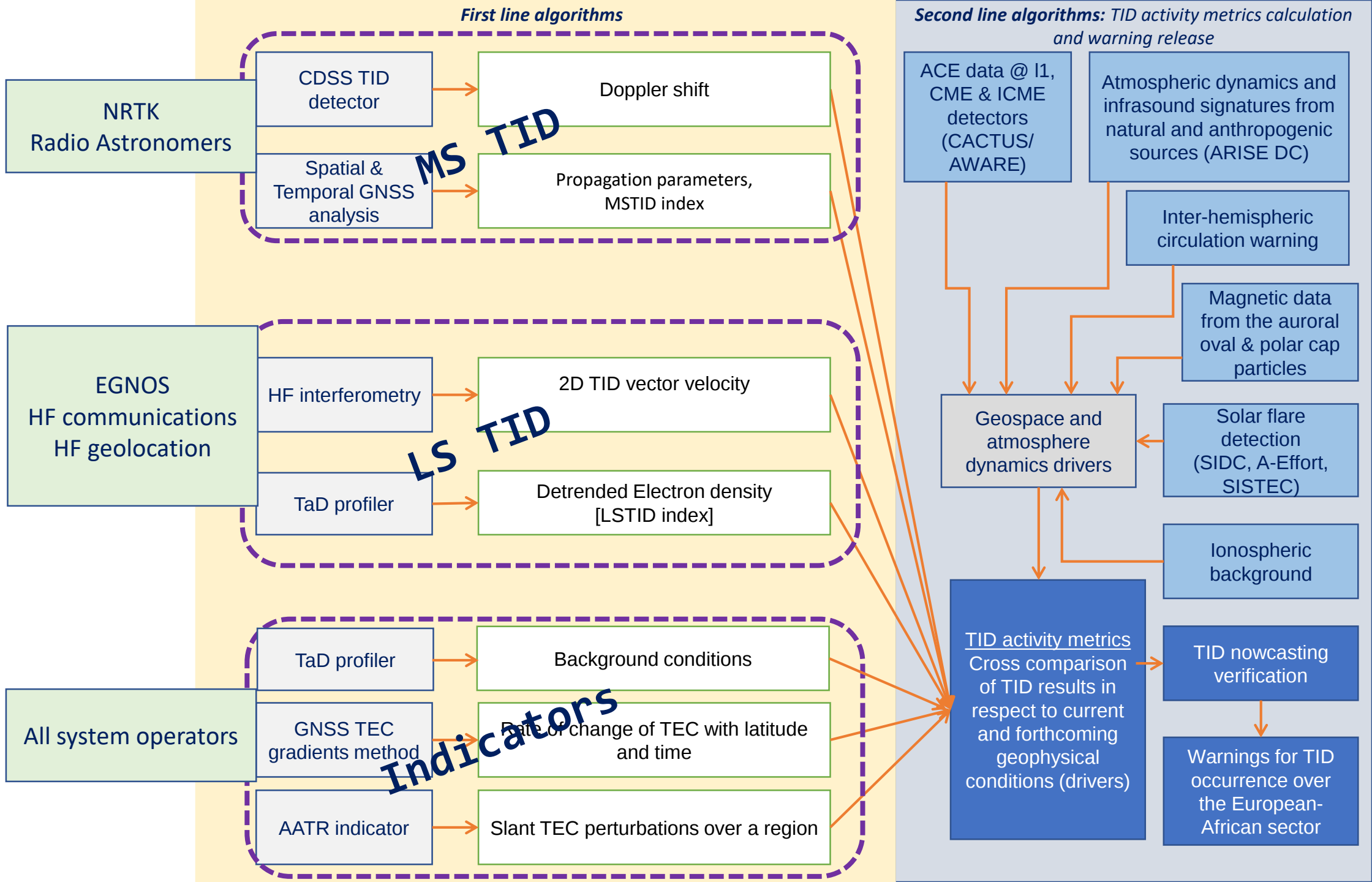
TID activity metrics in the TechTIDE service

Anna Belehaki

National Observatory of Athens



11 May 2022



Design phase for identification of drivers and additional parameters for the warning system

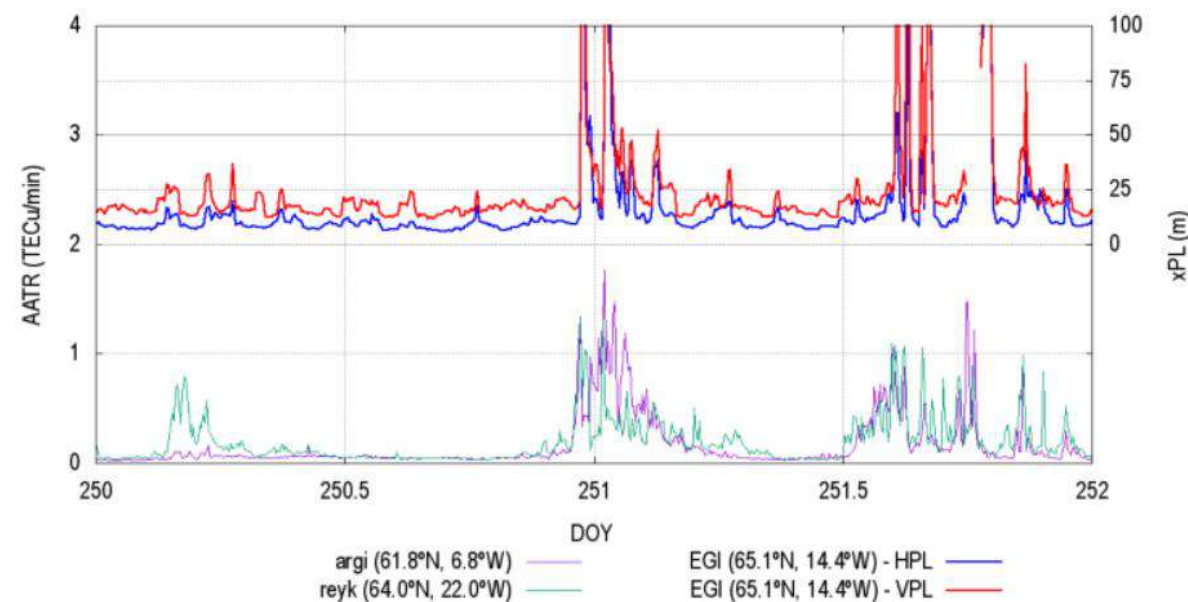
TID driver		Wave period	Horizontal phase velocity	Horizontal wavelength	Time of duration
Phenomenon	Characteristic/ calculations				
Geomagnetic storms – distinguish between CME and CCIR driven and between SSBC driven	IMF at L1 <i>Dst</i> , <i>Kp</i> , <i>aa</i> , <i>am</i> , and AE index, PCN/PCS as well as regional indices for the European sector	LSTIDs - up to 3h MSTIDs – 15-60 min	LSTIDs- 400–1000 m/s MSTIDs- 100 -250 m/s	LSTIDs -> 1000km MSTIDs- hundreds of km	depending on source up to several days
Troposphere - ionosphere coupling	Acoustic waves with frequency less than 1 Hz	Infrasound 1-5 min MSTIDs 15-25 min	For infrasound ~80 m/s For MSTIDs ~50 m/s	MSTIDs- tens to hundreds of km	several hours
super typhoons, hurricanes	Meteorological forecasts	8-30 min	100-220 m/s	160-270 km	several hours
Seismic activity	CDSS data and TEC maps	Infrasound up to 5 min; MSTIDs -15 min	Up to 780 m/s	At about 1000-5000 km from the epicentre	~1 h
Solar terminator	Astronomical calculations	~15 min to ~60 min	500 m/s (700 m/s) at SSMIN (SSMAX)	Up to 3600 km	1–2 h (time shift of about 1.5–2.5 h after the solar terminator appearance)
Eclipse	Astronomical almanac data	~60 min	~300 m/s	Hundreds km from the totality central path	Up to several hours

TID Activity scales Based on EGNOS performance degradation



TID driver	Number of analysed events	Magnitude of EGNOS availability degradation	Range of EGNOS availability degradation
CME	5	2 - high degradation 2 – moderate degradation 1 – low degradation	22.7% - 33.9% 8.7% - 12.0% 1.8%
CIR/CH HSS	25	23 – moderate degradation 2 – low degradation	5.4% - 15.7% 4.1% - 4.3%
SSBC	1	moderate degradation	6.8%

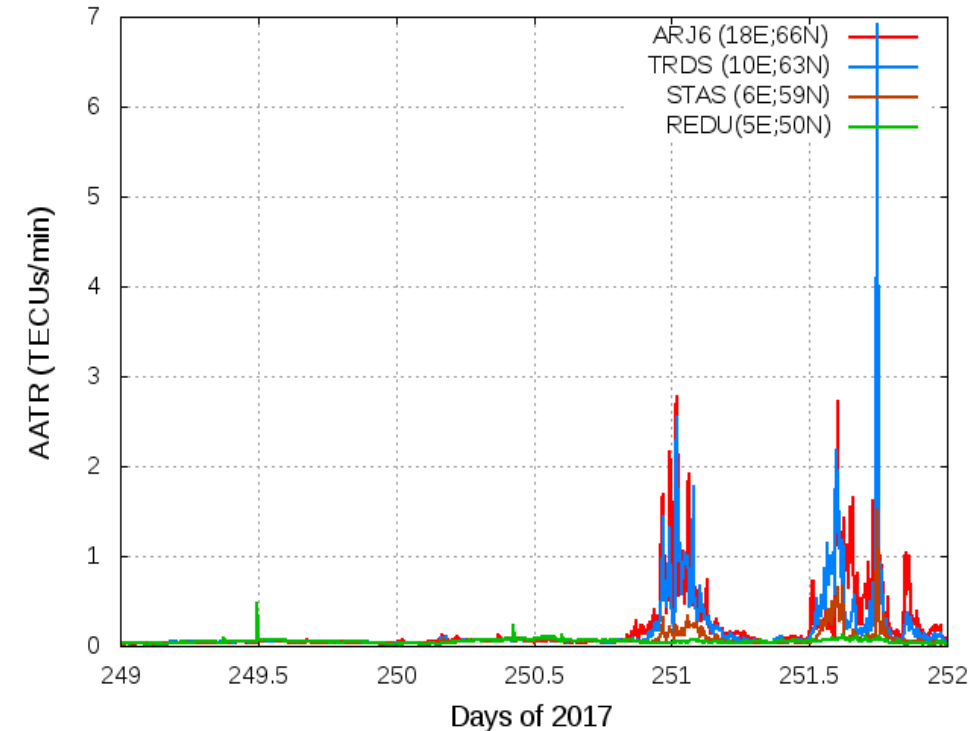
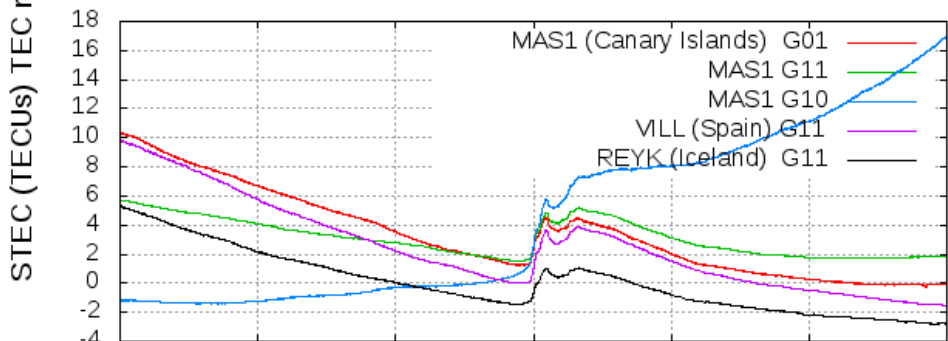
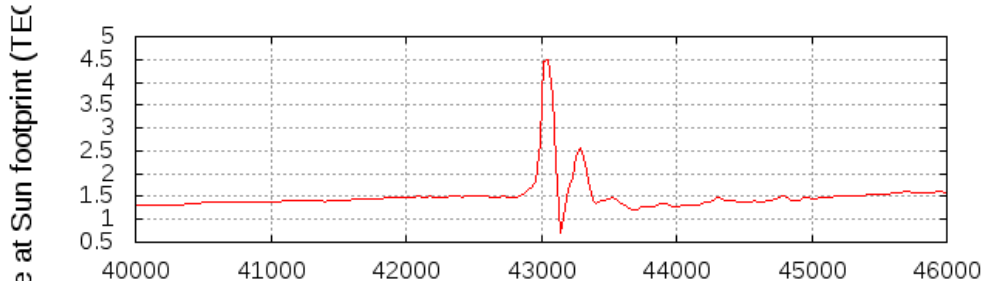
7 – 9 September 2017



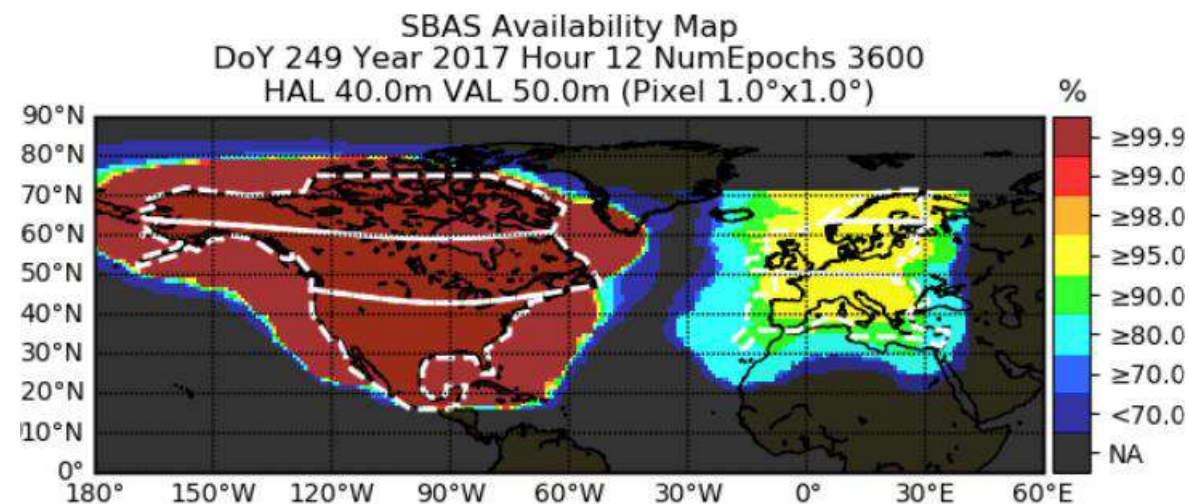
AATR can be used for defining ionospheric activity linked to the performance degradation of the EGNOS performance.

AATR color scale

Color	Scale	Activity
Green	from 0 up to 0.5 TECUs/min	normal/typical
Yellow	from 0.5 up to 1 TECUs/min	moderate
Red	higher than 1 TECUs/min	high



TID Activity scales
Compliance with solar and
geomagnetic disturbances

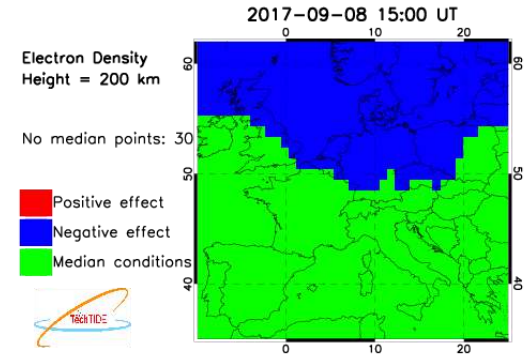
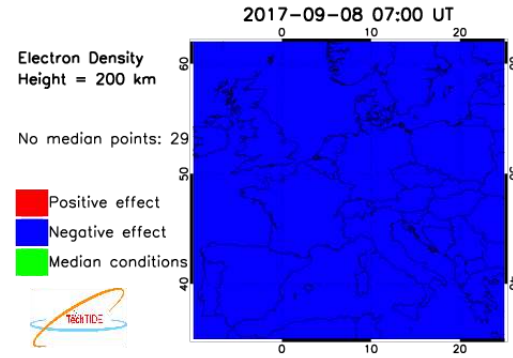
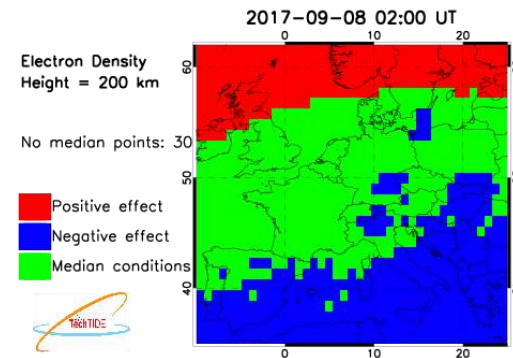
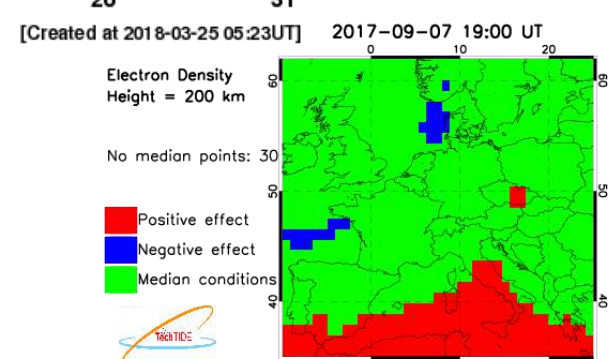
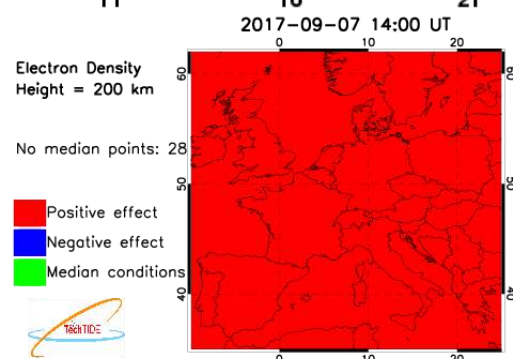
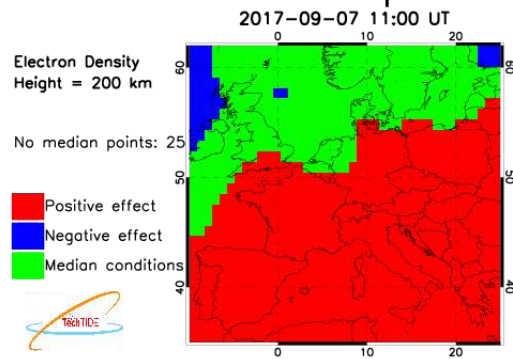


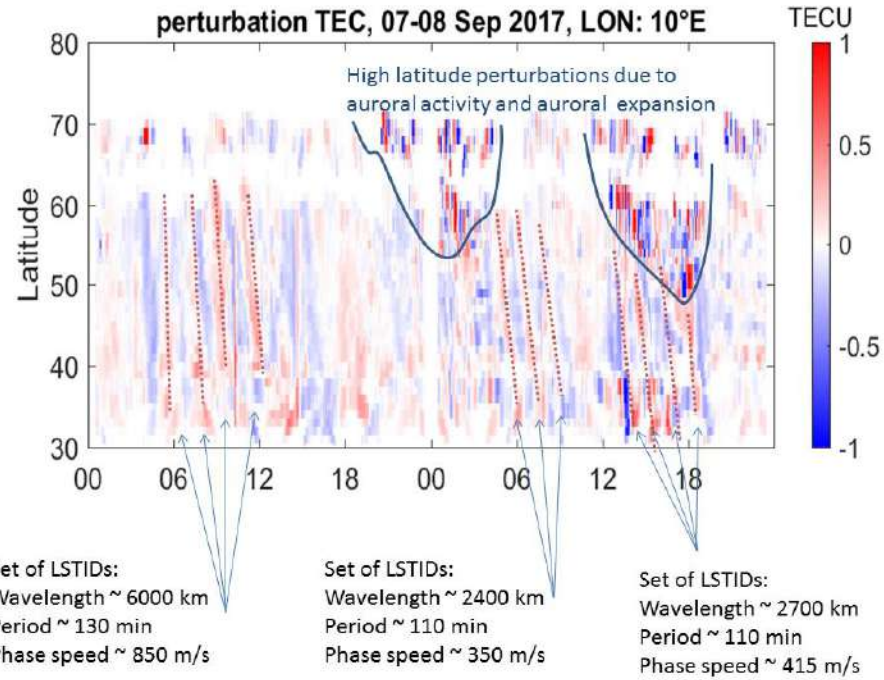
Sudden increase of the STEC for all satellites in view at noon
related to the solar flare of 6 September 2017 and Solar Flare
detection base on the GNSS TEC rate.



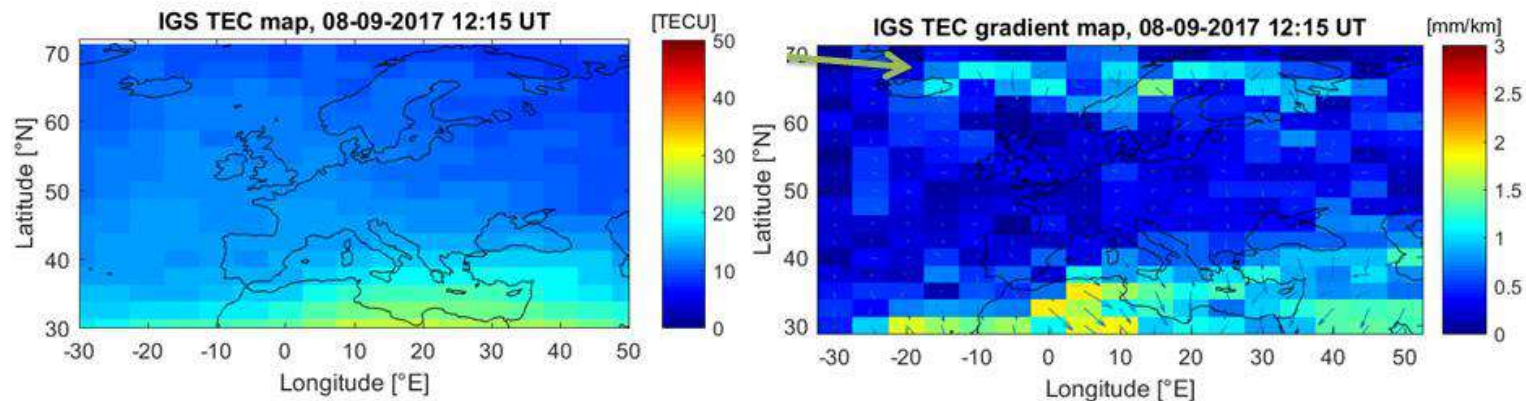
TID Activity scales

Compliance between AATR activity scales and background conditions



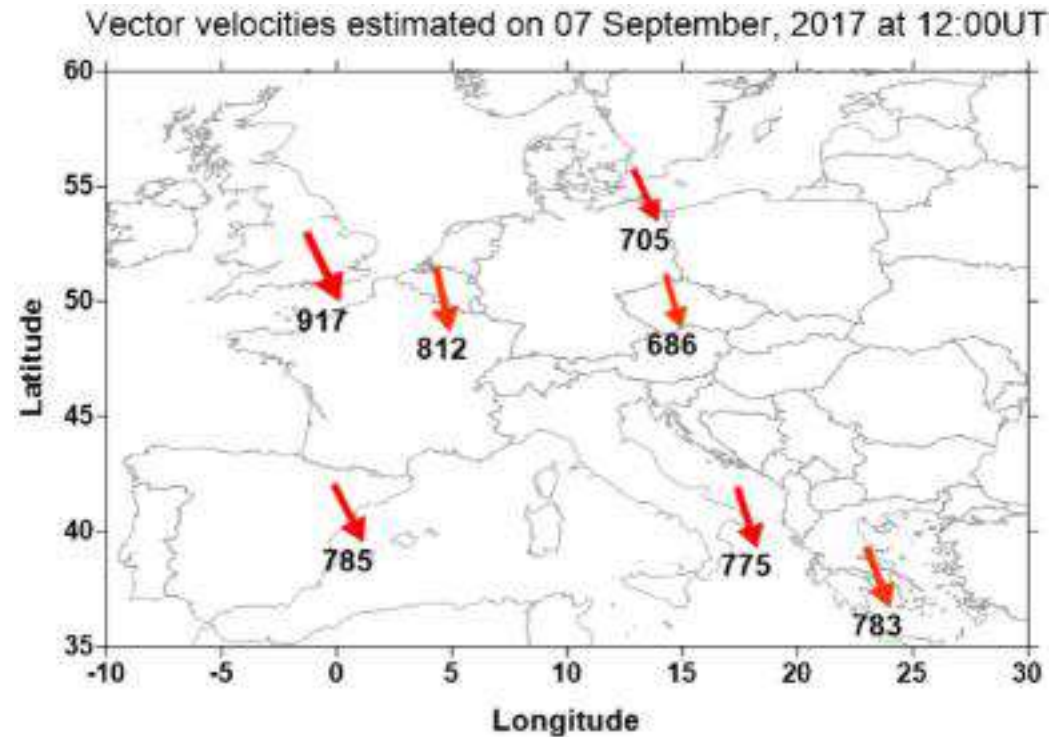
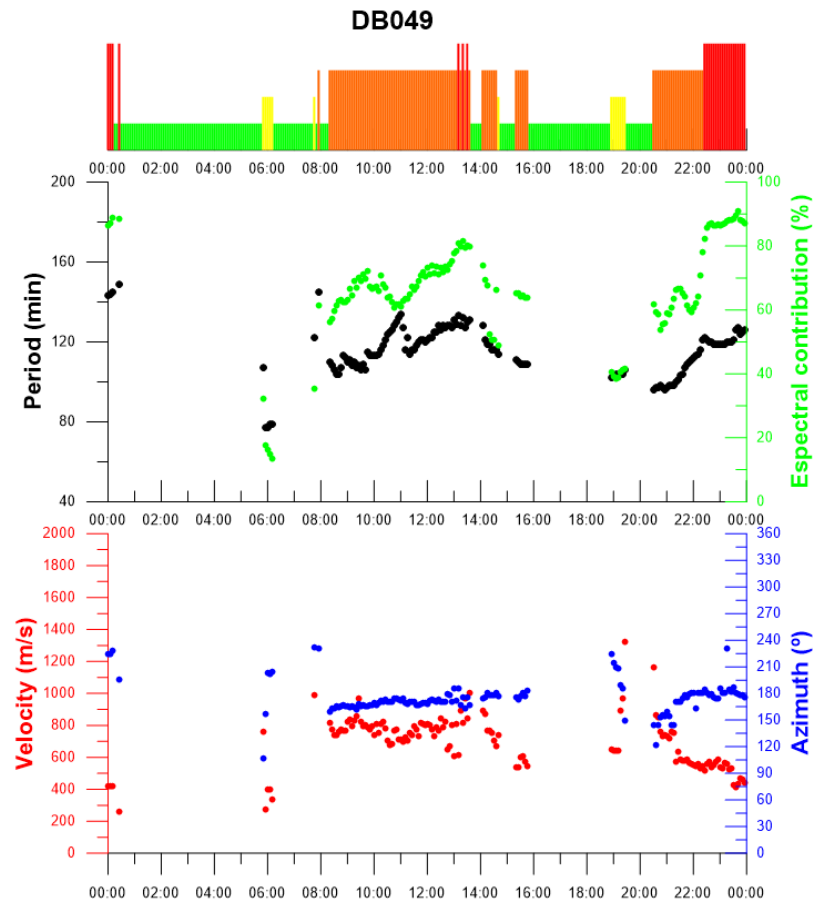


TID Activity scales
Compliance between
AATR and TEC gradient
activity scales





TID Activity scales Compliance between AATR and HF-INT activity scales



TID activity metrics

Method	Product	Characteristic/Parameter: Scales
GNSS TEC Gradient	<u>TEC gradient map:</u> Absolute value of the gradient (Amplitude) expressed in mm/km	<u> TEC Gradient Amplitude in high-latitudes (57-67°N) </u> : [< 1.2] Low [1.2, < 2] Medium [> 2] Strong
AATR Indicator	<u>Activity Index:</u> AATR expressed in TECU/min	<u>AATR</u> : [< 0.5] Low [0.5, <1] Medium [>1] Strong
Ionospheric Background Conditions Indicator	<u>Detection of background ionospheric activity including positive and negative ionospheric storm effects</u> Color coded maps of the deviation of the current electron density in respect with median electron density. - dNe < 1σ median conditions (green) - dNe > 1σ positive (red) - dNe < -1σ negative (blue)	<u>Ionospheric Background Activity conditions Characteristics:</u> - Median conditions are dominating: Green points > 80% - Positive conditions are dominating : Red points > 80% - Negative conditions are dominating : Blue points > 80% - Conditions tend to be disturbed: positive and negative points > median points - Conditions tend to be median: positive and negative points < median points

Method	Product	Characteristic/Parameter: Scales
HF-INT	<u>Detections of LSTID:</u> Period, Spectral Energy Contribution (SEC), Velocity, Direction of propagation	<u>SEC</u> : [<10%] Insignificant [10%, <65] Weak [65%, <80%] Moderate [>80%] Strong
LSTID index	<u>Detection of LSTID:</u> Perturbation in the local values of the electron density (RSD%) at specific altitudes (from 200 to 500 km) and specific geographic locations.	<u>RSD</u> : <100 LSTID index=0; No TID 100<RSD<300 LSTID index=1; Uncertain Conditions RSD>300 LSTID index=2; TID

Method	Product	Characteristic/Parameter: Scales
MSTID index	<u>Activity Index:</u> MSTID_idx expressed in m of LI (1 TECU=0.105 m of LI)	<u>MSTID_idx</u> : [<0.1] Low [0.1, <0.2] Medium [>0.2%] Strong NRTK: [<0.01] Quiet
CDSS-MSTID	<u>Detections of MSTID:</u> Period, Amplitude, Phase velocity, Direction of propagation	<u>Doppler shift</u> : [<0.06] Insignificant [0.06, <0.12] Moderate [0.12, <0.18] Strong

TID activity report:
Refreshed every 5 min

Possibility to issue an
alert based on user-
defined criteria

Most recent conditions: Median conditions are dominating @ 2022-05-09T15:15:00 UTC

View TID Activity | Reference Date: 2022-05-09T15:50:00 UTC

LSTID Detection	Date	Critical Characteristic	Current value of critical characteristics		Activity level	ACVICO
AATR	2022-05-08T11:15:00	AATR at any location	0.076	LOW	LOW	
GNSS TEC Gradient	2022-05-09T15:40:30	TEC gradient amplitude in high latitudes	1.513	MEDIUM	MEDIUM	
HF Interferometry (HF-INT)	2022-05-09T15:50:00	Spectral Energy Contribution	2		LOW	
HF TID	2022-05-03T02:07:00	Amplitude (in situ)	13.7		MEDIUM	
LSTID _{idx}	2022-05-09T15:20:00	Relative Std Dev of Ne	26.644		LOW	

MSTID Detection	Date	Critical Characteristic	Current value of critical characteristics		Activity level	ACVICO
CDSS	2022-05-09T14:00:00	Doppler shift detected in the Czechia network		NO DATA		
MSTID _{idx}	2022-05-08T11:20:00	MSTID _{idx} at any location	0.418	STRONG	STRONG	

Session

Integration and validation TID Detectors - CLUSTER room

12 May 2022, 11:00

[Prediction of Large Scale Travelling Ionospheric Disturbances based on Total Electron Content and Solar Wind observations](#)

Dr Claudia Borries (DLR)

[An ionospheric activity index for the identification of large scale travelling ionospheric disturbances \(LSTIDx\)](#)

Dr Ioanna Tsagouri (National Observatory of Athens)

[The AATR and MSTID indicators](#)

Dr Cristhian Timoté (UPC)

[Continuous Doppler sounding in the Czech Republic and its application to TechTIDE project](#)

Dr Jaroslav Chum (IAP, CAS)

[HF-Interferometry method to Traveling Ionospheric Disturbances detection](#)

Dr Antoni Segarra (Ebro Observatory)

[Multi-TID detection and characterization techniques at UPC-IonSAT.](#)

Alberto Garcia Rigo (UPC-IonSat)