Characterization of Equatorial Ionosphere in South East Asia in the ERICA Project: a case study

EQUATORIAL IONOSPHERE CHARACTERIZATION IN ASIA

Lucilla Alfonsi,
Luca Spogli, Claudio Cesaroni, Domenico Di Mauro,
Rodrigo Romero, Fabio Dovis,
Gabriella Povero

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Motivations of the work

- **Southeastern Asia** is a very interesting area from the ionosphere monitoring point of view.
- The **ionosphere-magnetosphere coupling** presents features which differ from other geographical sectors.
- The **lack of extended networks of monitoring stations** makes peculiarities in Southeastern Asian ionosphere not exhaustively known and understood.

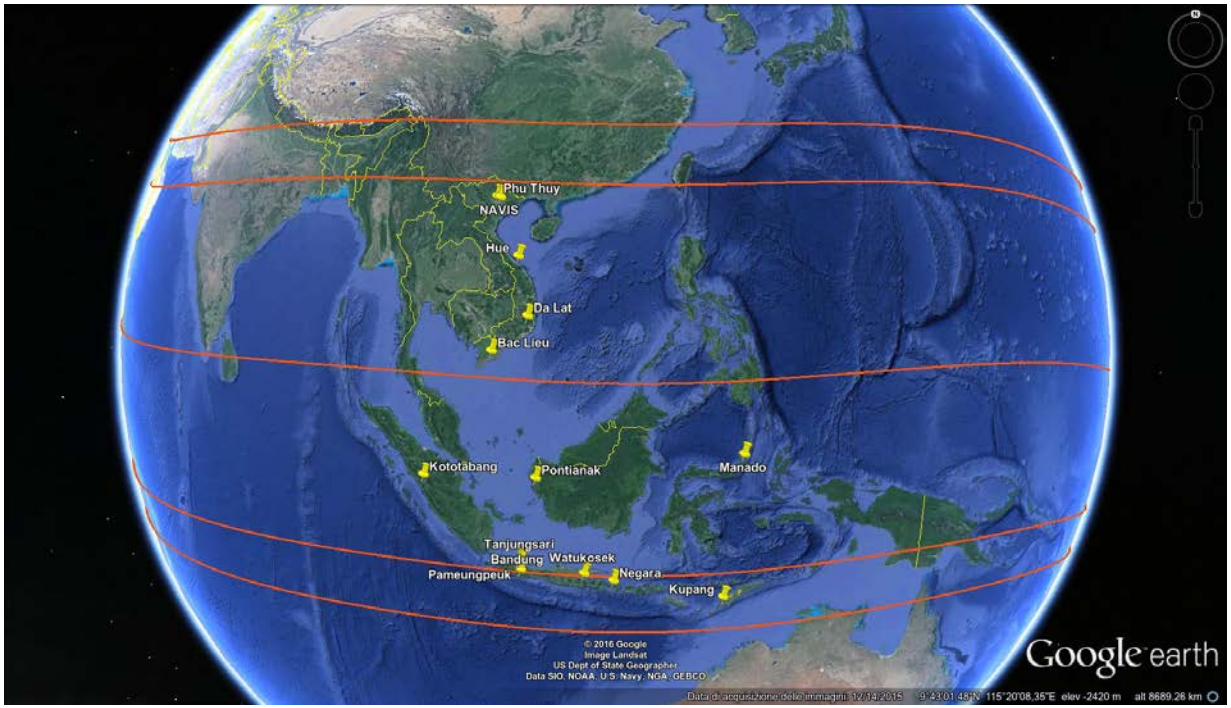
Objectives

- To characterize the ionospheric variability of the Equatorial Ionospheric Anomaly (EIA) in SEA, in particular the variation of the plasma electron density in the EIA southern and northern crests and over the dip equator identified by the Equatorial Ionospheric Trough (EIT)
- To conduct an **ad hoc measurement campaign** with ground-based instruments at the footprints of EIA and EIT in Vietnam and Indonesia
- To provide training to the South East Asian researchers involved in the project

Measurement Campaign

Full Network

Location	GNSS (50Hz)	Magneto meter	Ionosonde
Navis (Hanoi)	X		
Phu Thuy	X	X	
Hue	X		
Da Lat		X	
Bac Lieu	X	X	
Manado	X		
Kototabang		X	
Pontianak	X		X
Bandung	X		
Tanjungsari		X	
Pameungpeuk		X	
Watukosek		X	
Negara		X	
Kupang	X		X



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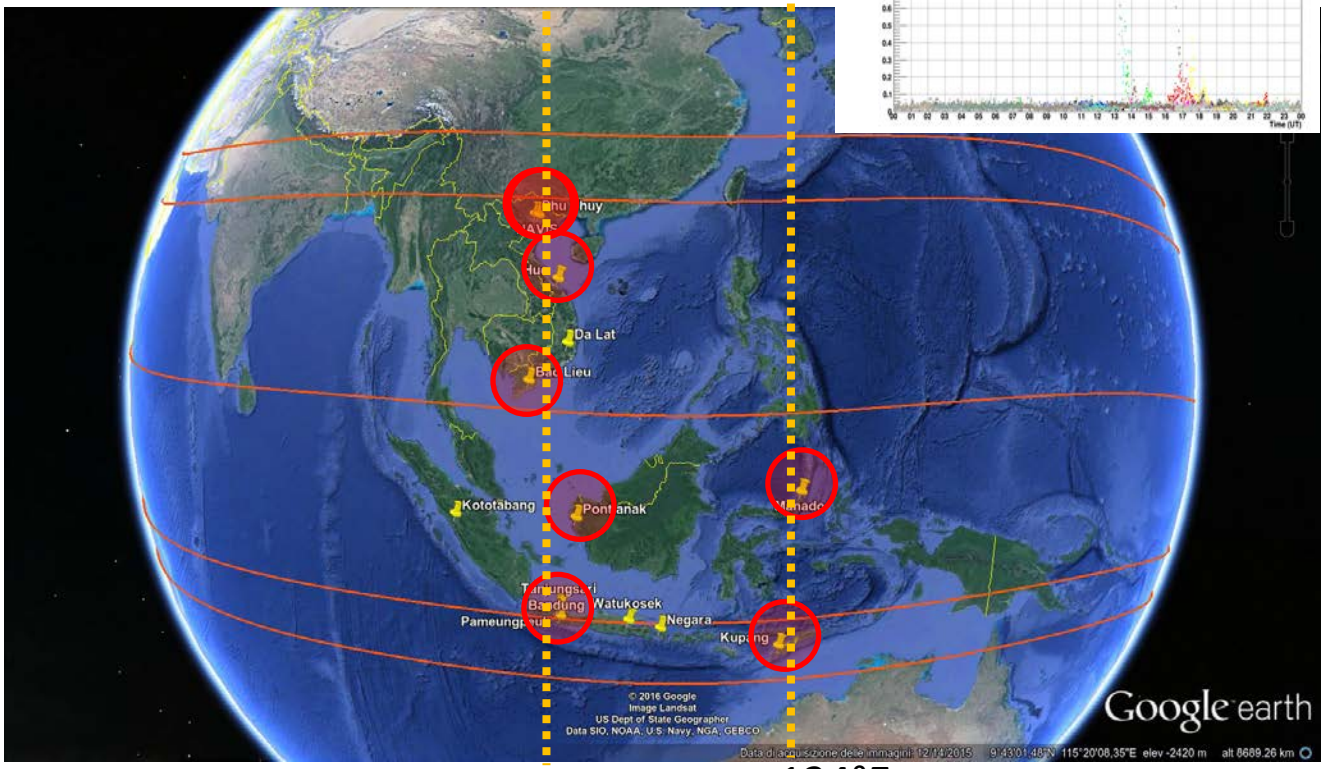
Pameungpeuk		X	
Watukosek		X	
Negara		X	
Kupang	X		X

GNSS



Examples of S4 time profile

Novatel Station6

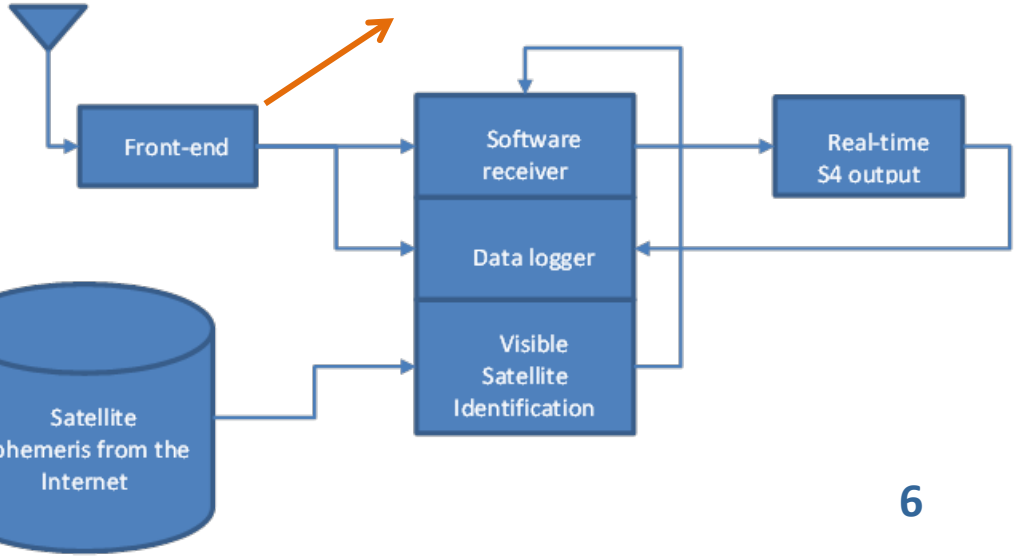
Novatel GSV4004

Software receiver

Measurement Campaign

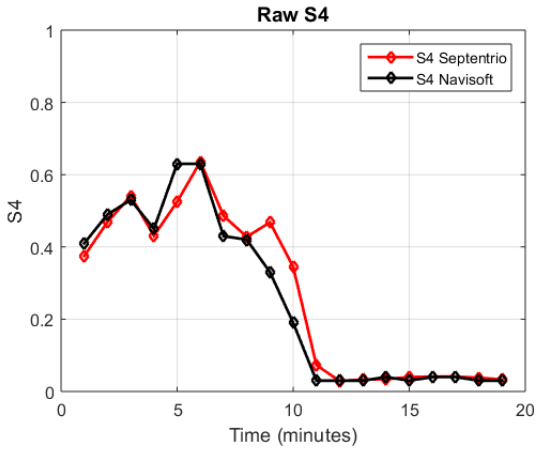
GNSS raw data was envisioned to complement the measurements obtained from co-located professional receivers in Vietnam and Indonesia.

- ✓ Front-end built with flexible configuration of frequency bands.
- ✓ Data processing by means of software receiver.
- ✓ Large amount of data (1minute=1GB). Data recorded only upon detection of scintillation indexes above a threshold.

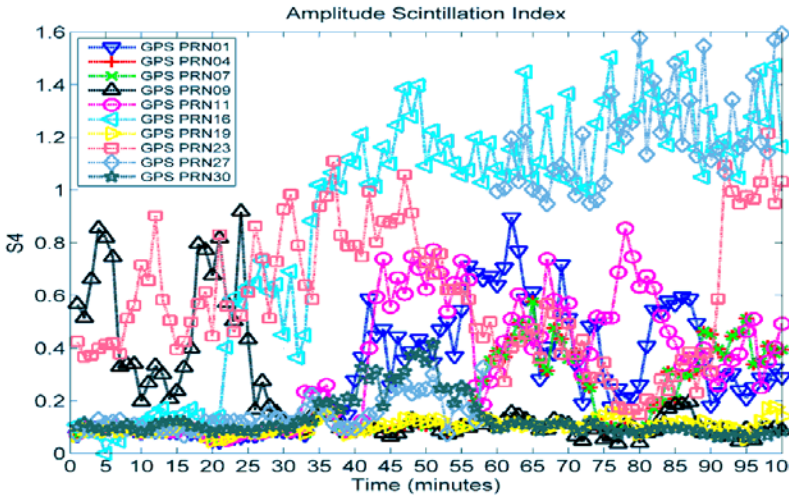


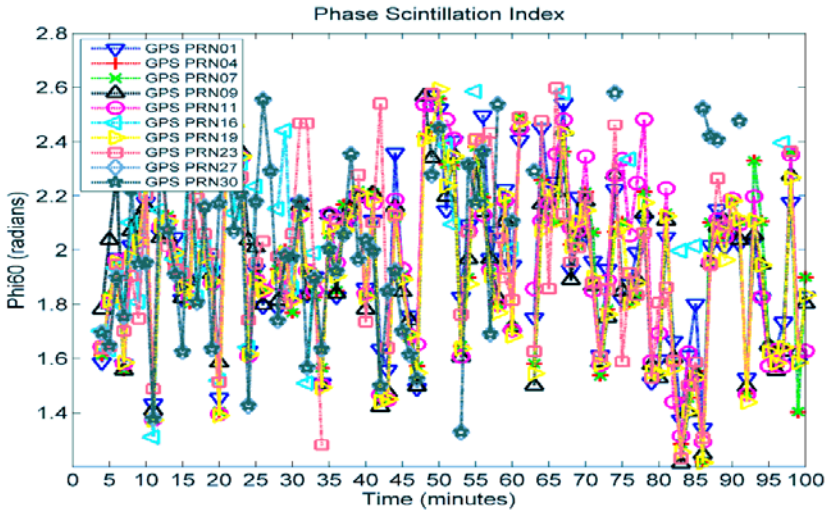
Measurement Campaign

- ✓ Scintillation estimations were initially validated against those of professional receivers.



- ✓ Performance of the complete setup was fully validated under scintillation activity over Hanoi.





Measurement Campaign

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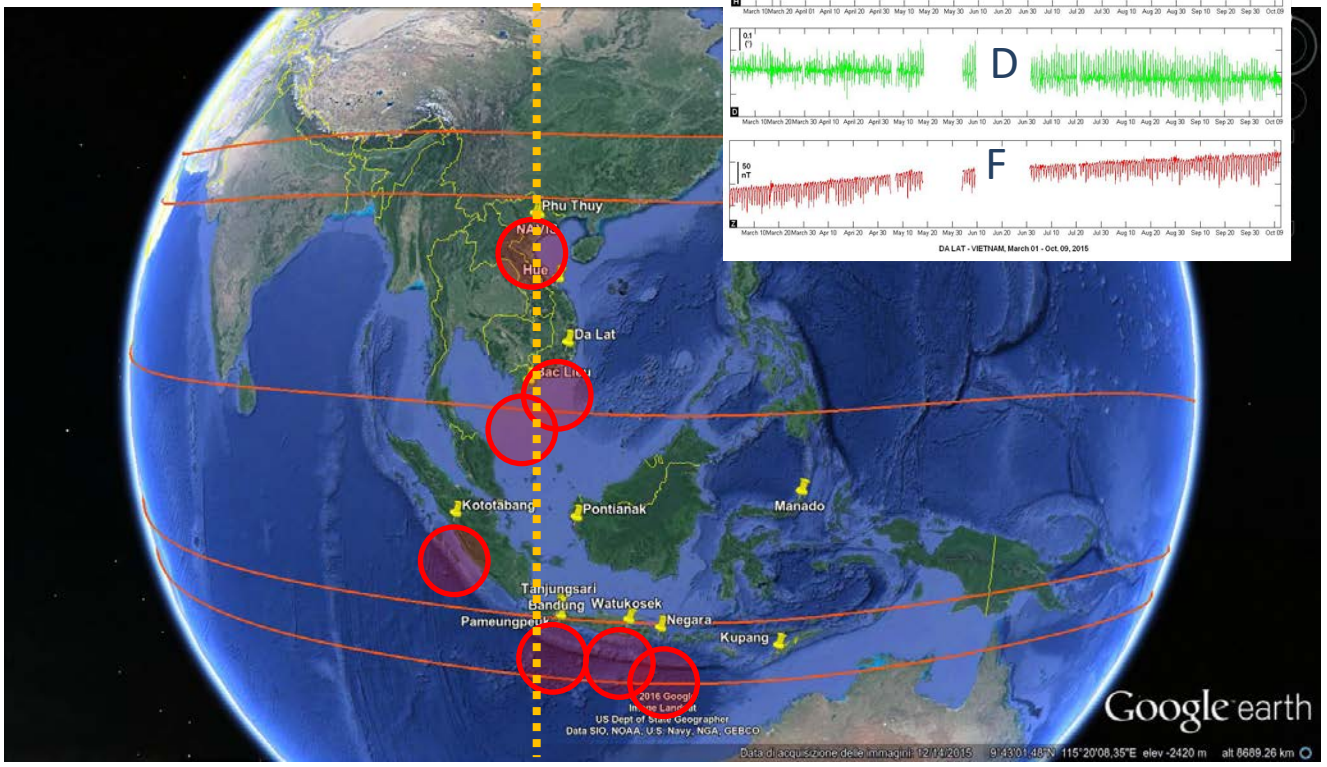
Pontianak	X		X
Bandung	X		
Tanjungsari		X	
Pameungpeuk		X	
Watukosek		X	
Negara		X	
Kupang	X		X

Magnetometers



106°E

Examples of dataset (Da Lat)

- Vector magnetometers for the recording of the field variations in the three-dimensions.
- Scalar magnetometers for the recording of F, the amplitude of the field.

*only variational data

Measurement Campaign

Full Network

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Negara		X	
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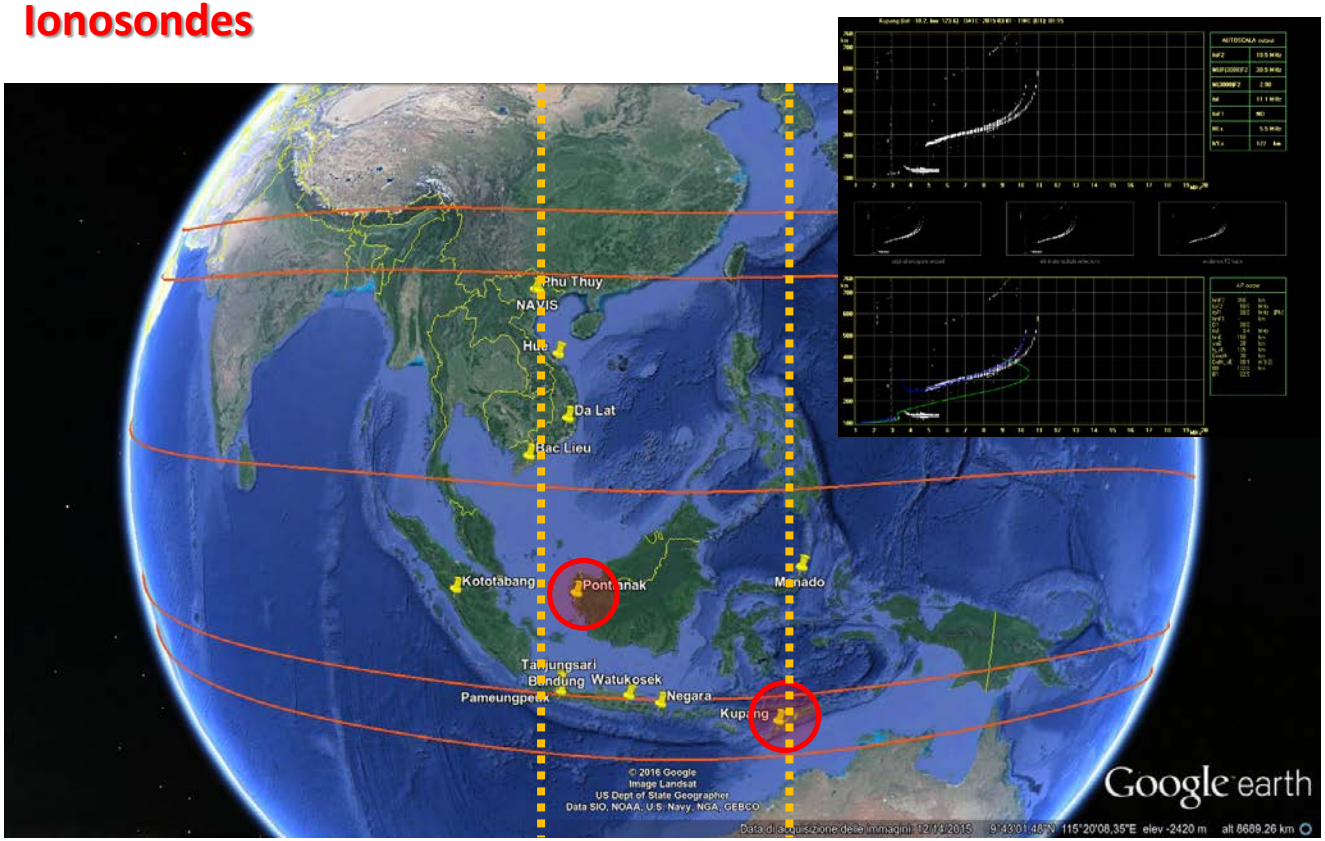
Ionosondes



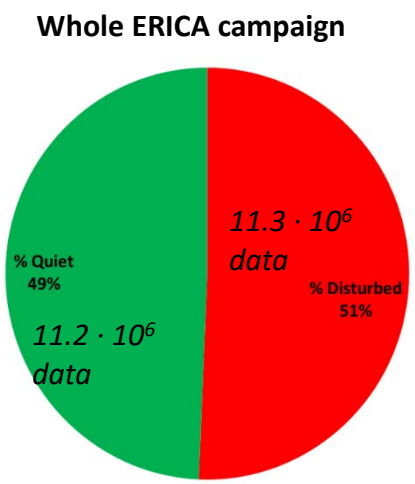
Examples of ionogram (Kupang)

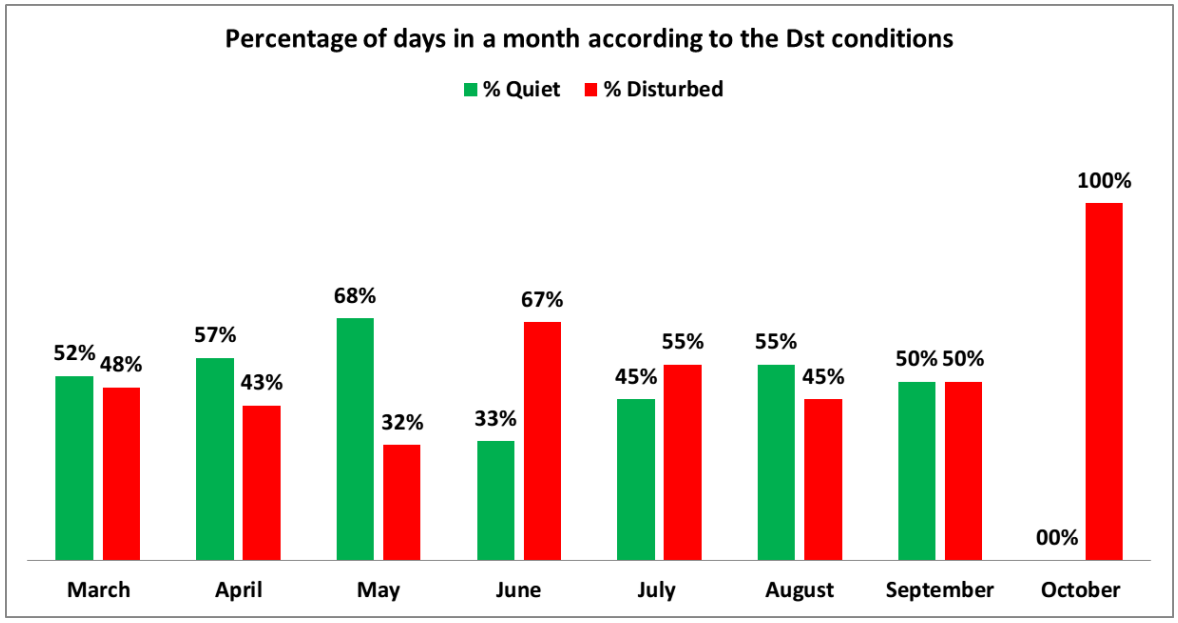
- Two Indonesian stations equipped with Canadian Advanced Digital Ionosondes (CADI)
- Sounding repetition rate of 15 minutes
- Sweeping frequency range from 1 to 20MHz

Analysis of collected data

Climatological assessment of the ionosphere

- **CLIMATOLOGY**: assessment of the general recurrent features of the ionospheric irregularities dynamics and temporal evolution on long data series
- GNSS grouped into quiet and disturbed conditions according to Dst index and local K index.
- A good balance in the number of days with quiet and disturbed conditions for reliable climatology was achieved.



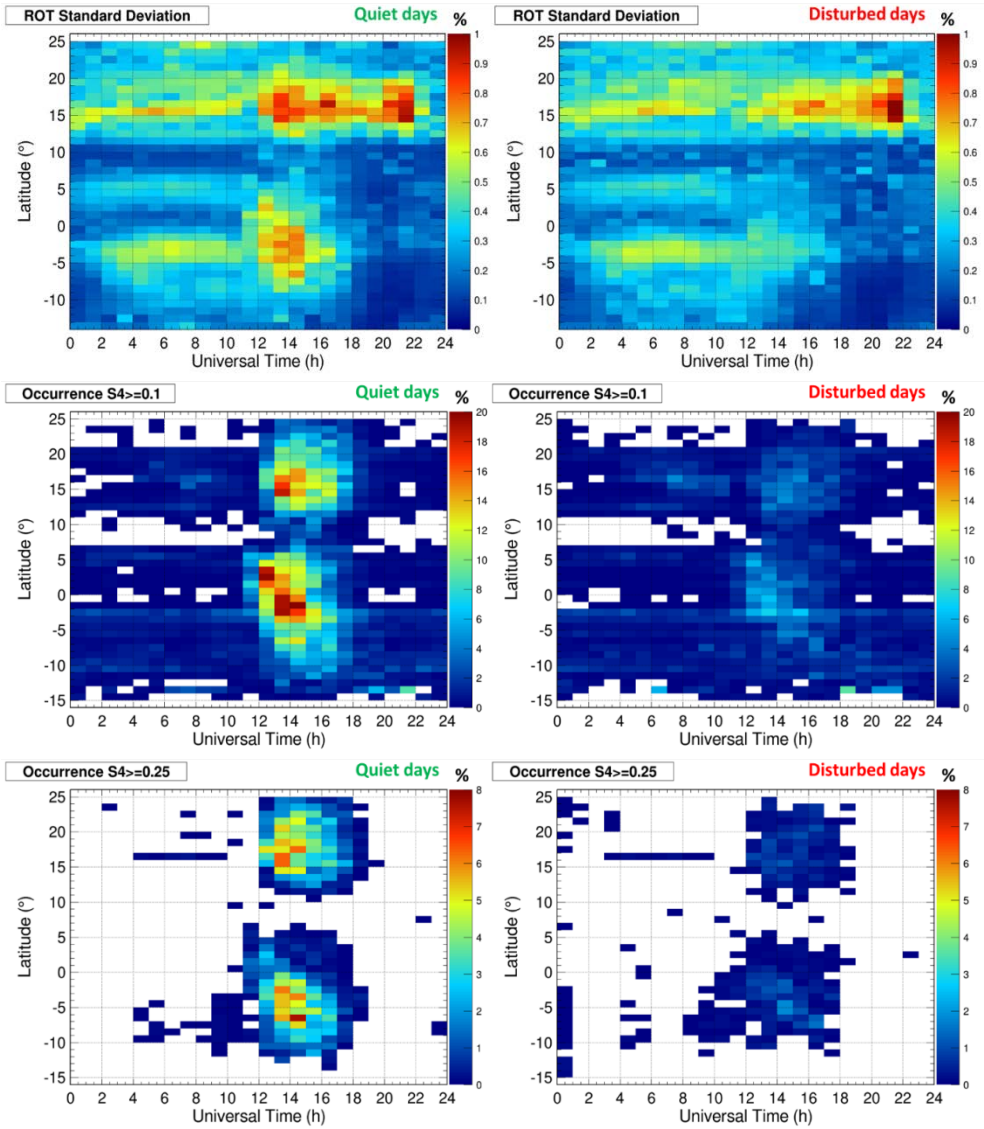


Analysis of collected data

Climatological assessment of the ionosphere

Ground Based Scintillation Climatology

- GBSC maps describe the variation of occurrence in geographic latitude and UT.
- Calculated over 1-minute interval, from all the satellites in view above 30° of elevation
- Thresholds are chosen in order to distinguish between different scintillation scenarios



Highlights

- Inhibition of the scintillation occurrence during post sunset hours
- Penetration of electric fields from auroral latitudes during storm periods may inhibit the formation of the two crests of the EIA
- Not all TEC spatio-temporal scales are effective in producing scintillation-leading irregularities in the ionosphere

Analysis of collected data

Climatological assessment of the ionosphere

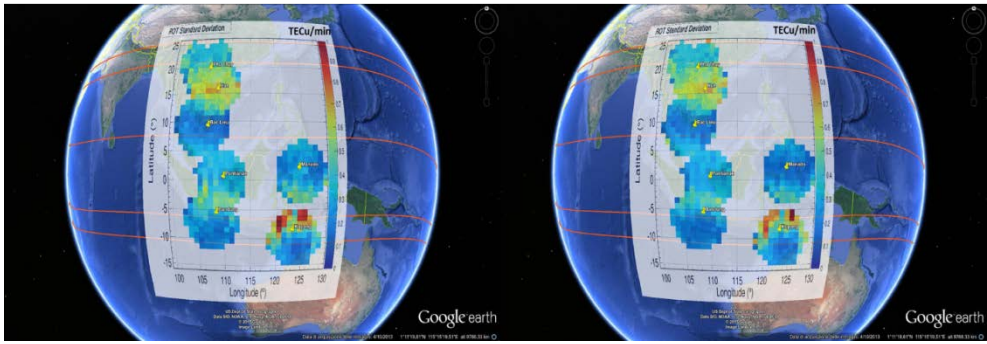
Ground Based Scintillation Climatology

- GBSC maps describe the variation of occurrence in geographic coordinates

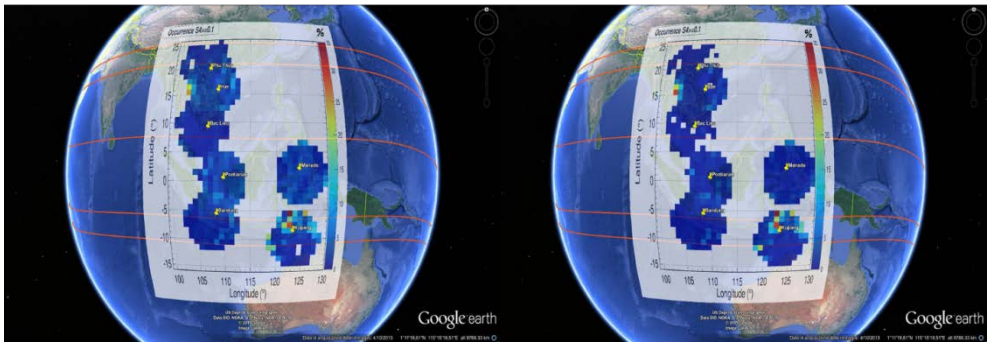
Highlights

- Inhibition of the scintillation occurrence during post sunset hours
- Dip equator and the ± 15°-20° magnetic parallels (orange curves) provide a clear portrait of the EIA crests and trough

Quiet days | Disturbed days



Quiet days | Disturbed days



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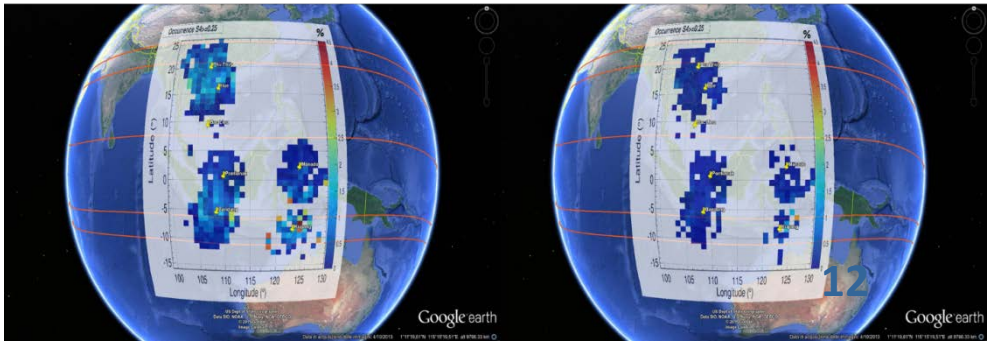
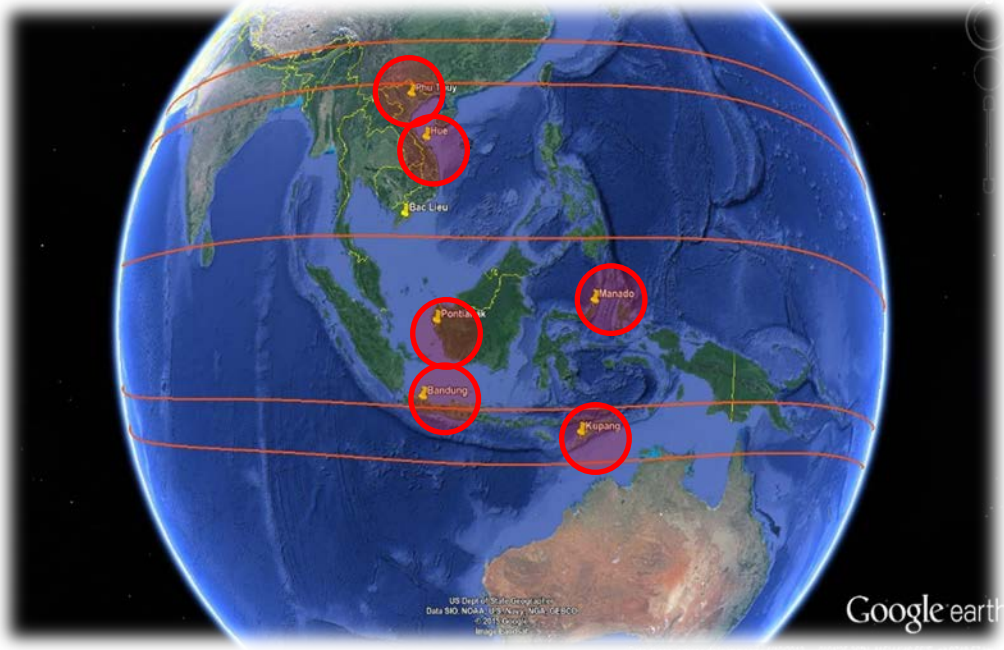
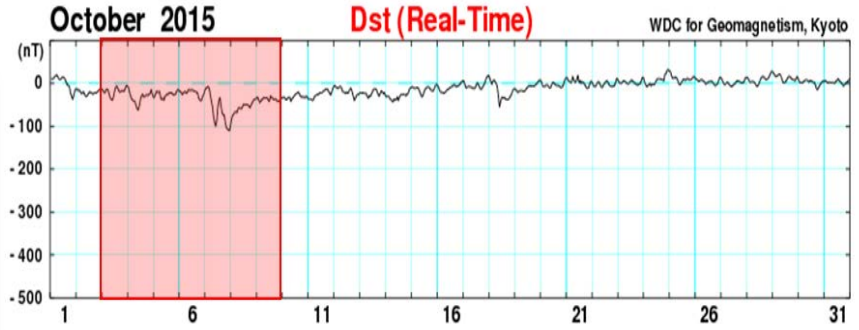


Analysis of collected data

The case of 03-09 October 2015



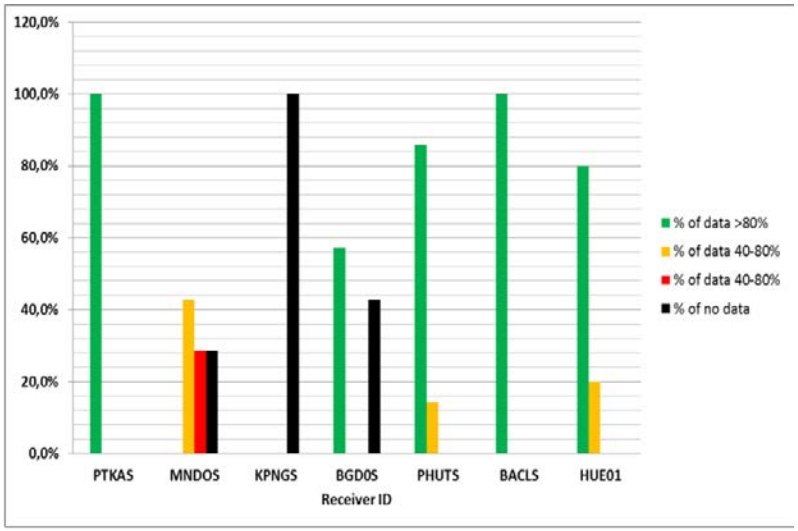


D_{st} variations show the occurrence of one moderate storm occurred on the 7th and 8th of October 2015.

flag	meaning	color
0	no data	
1	data < 40%	
2	data 40-80 %	
3	data>80%	

YY	MM	DD	PTKAS	MNDOS	KPNGS	BGD0S	PHUTS	BACLS	HUE01
2015	10	03	3	2		3	3	3	3
2015	10	04	3	1		3	2	3	3
2015	10	05	3	2		3	3	3	3
2015	10	06	3	1		3	3	3	2
2015	10	07	3				3	3	3
2015	10	08	3				3	3	3
2015	10	09	3	2			3	3	3

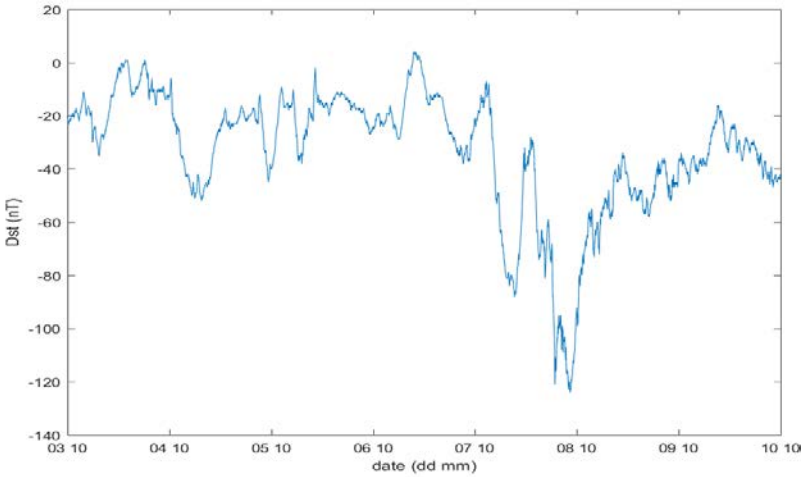
Storm days with x% of available GNSS data

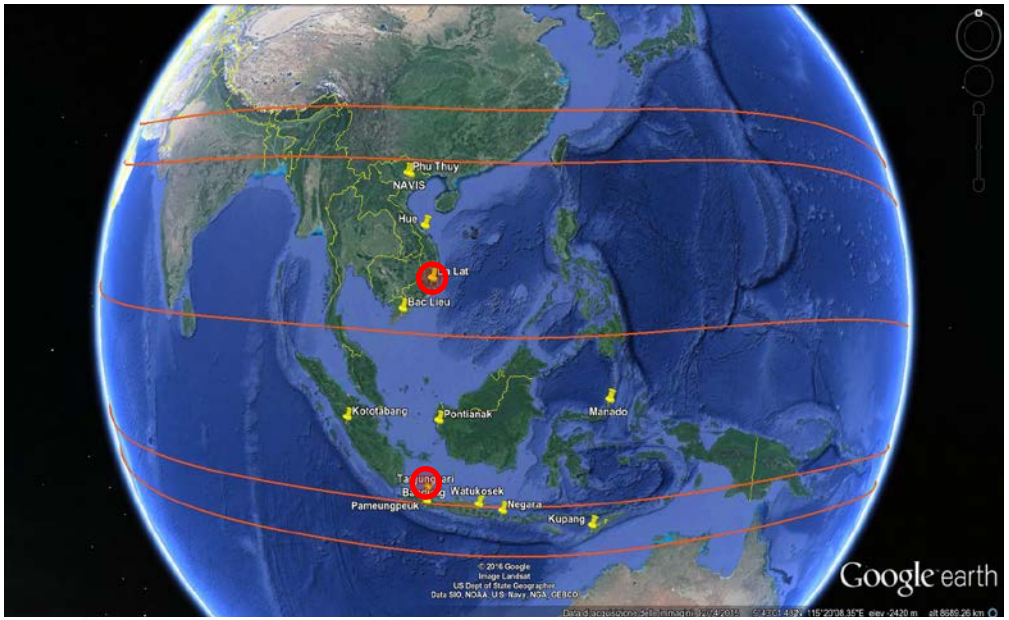


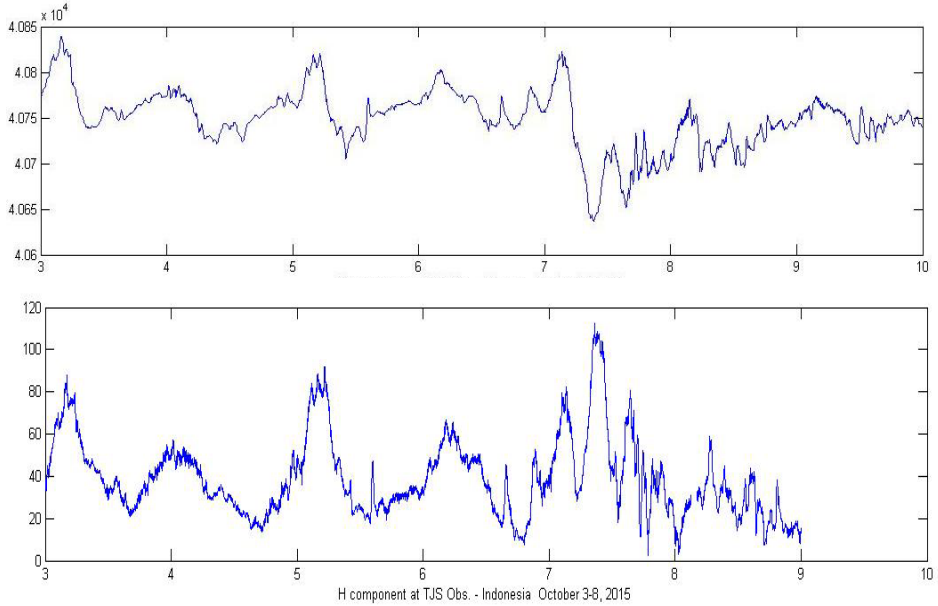
Analysis of collected data

The case of 03-09 October 2015

A series of geomagnetic moderate to strong storms occurred due to a glancing blow of a CME launched on 30 September and to exacerbated solar wind conditions due to a recurrent coronal hole on 7 October.



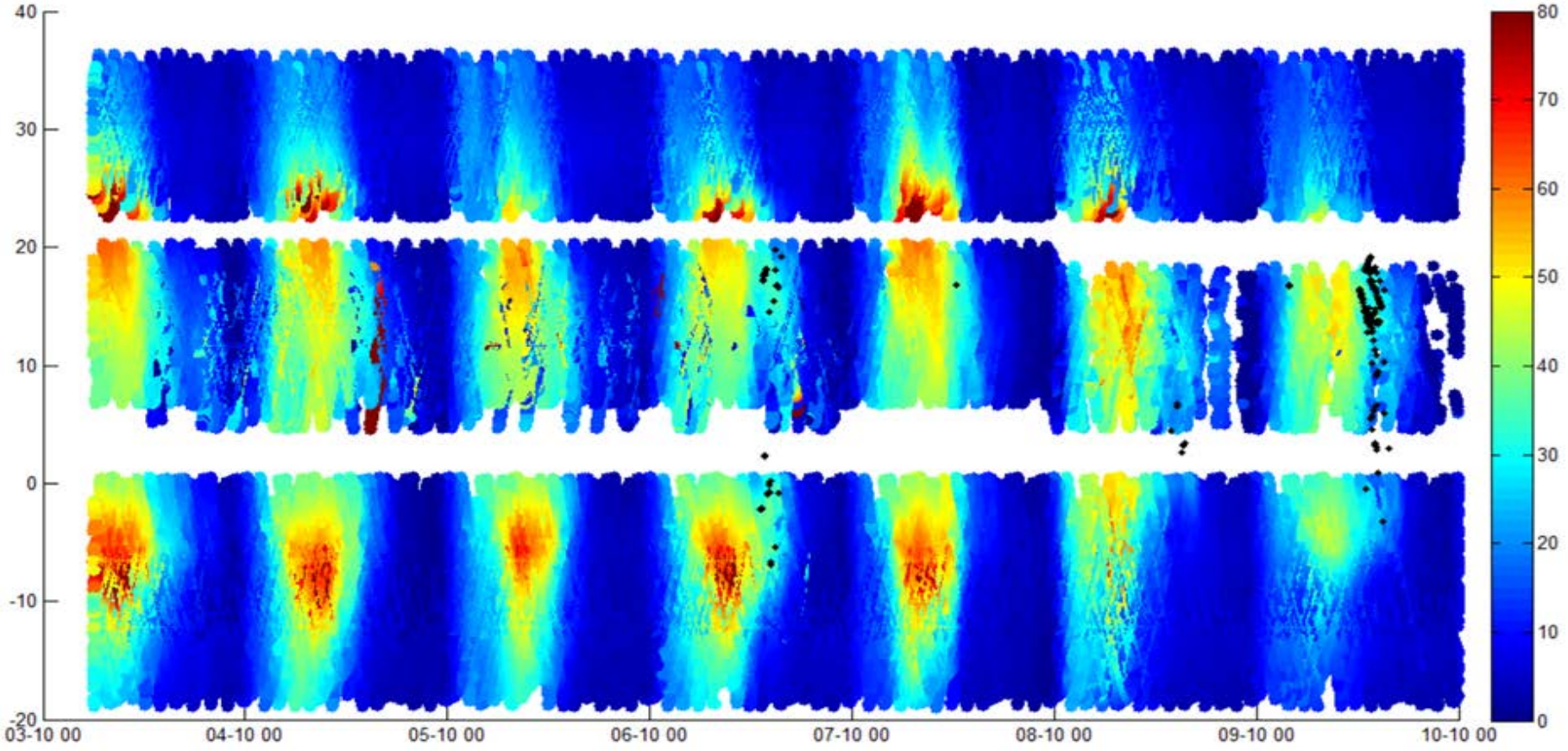




Analysis of collected data

The case of 03-09 October 2015

The calibrated VTEC mapped together with the scintillation occurrence shows the S4 inhibition on the 3rd, 4th, and 5th of October, an enhancement of S4 on the 6th October, a new decrease on the 7th October and the restart of the expected scintillation increase on the 8th and, mainly, on the 9th of October



Conclusions

- Crucial importance of **accessing regional data** to properly characterise the ionospheric environment for both climatological and weather assessment (SEA regions are unevenly covered by ionospheric and geomagnetic measurements)
- The twofold approach (ionospheric climatology plus deeper investigation of specific events) has proved to be effective in better understanding the local features of the ionosphere, although there are still open issues about ionosphere behaviour over SEA.
- Significant analysed phenomena:
  - inhibition of the formation of the two crests of the EIA
  - corresponding inhibition of the scintillation on L-band signals
  - asymmetry of the scintillation patterns between the northern and southern crests of the EIA

Thank you!

ERICA

EquatoRial Ionosphere Characterization in Asia

Lucilla Alfonsi

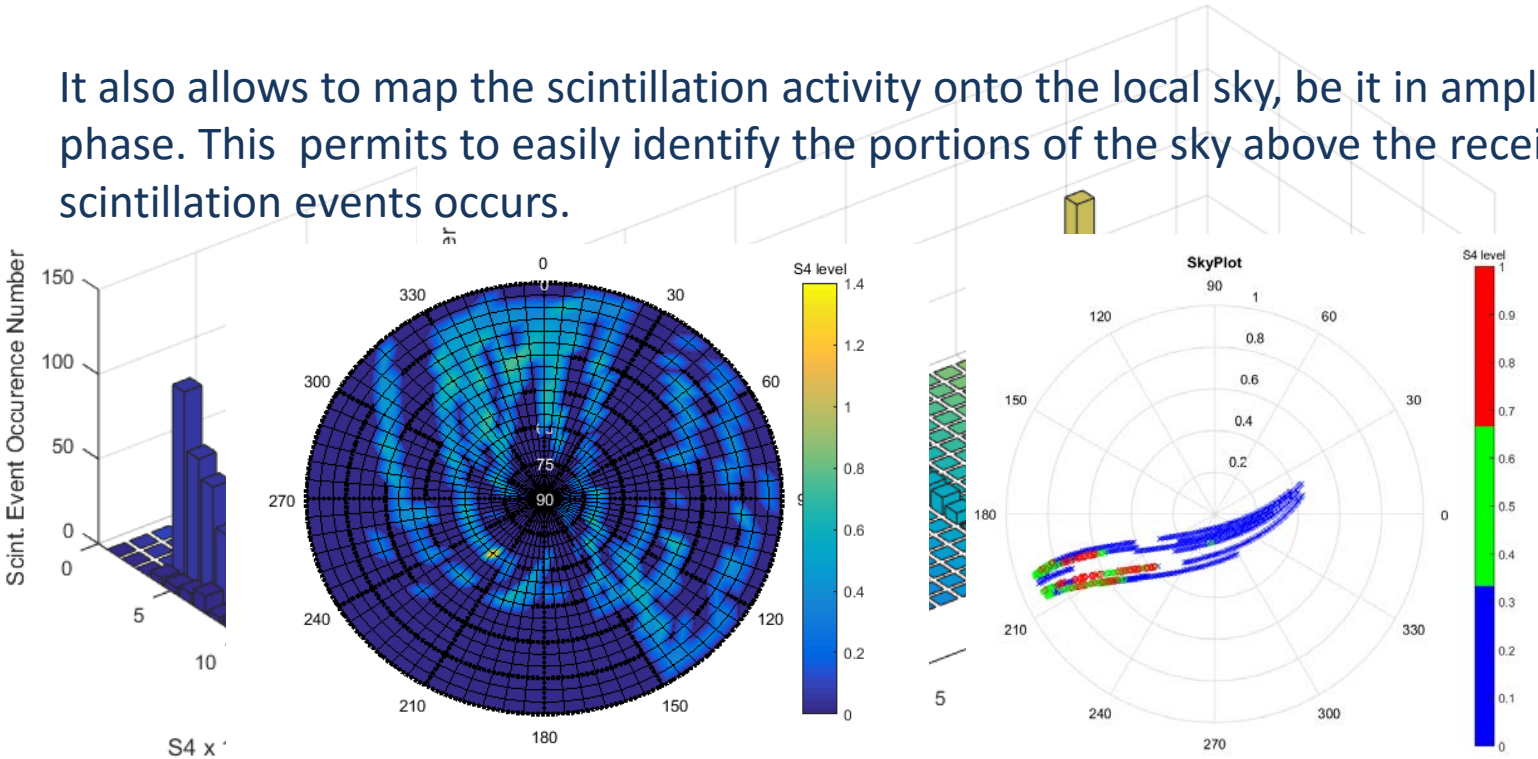
lucilla.alfonsi@ingv.it

www.ismb.it

Measurement Campaign

The developed graphical interface allows a quick snapshot of the scintillation activity of selected satellites during spans of hours, days, or even months.

It also allows to map the scintillation activity onto the local sky, be it in amplitude or phase. This permits to easily identify the portions of the sky above the receiver where scintillation events occurs.



Scintillation activity location
Statistical Analysis: S4 x Day
Statistical Analysis: S4 x PRN