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ROSA
Radio Occultation Sounder for Atmosphere

Use of ROSA data in Space Weather

Massimo Materassi (ISC-CNR Firenze)

Chicago, August 7-16, 2008

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Flying on board of Oceansat-2…

Contract: ASI-ISMB, ISMB/ASI N.I./006/07/0

ASI Agenzia Spaziale Italiana (Italian Space Agency)

ISMB Istituto Superiore "Mario Boella"

Chicago, August 7-16, 2008

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PLAN OF THE TALK

- The Oceansat-2 Mission.
- The ROSA receiver's concept.
- The ROSA-ROSSA scientific campaigns.
- Space Weather of the ionospheric vertical profiles.
- Space Weather of the topside-plasmaspheric TEC.
- Space Weather of the radio scintillation on limb-sounding links.
- Conclusions.

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PLAN OF THE TALK

- **The Oceansat-2 Mission.**

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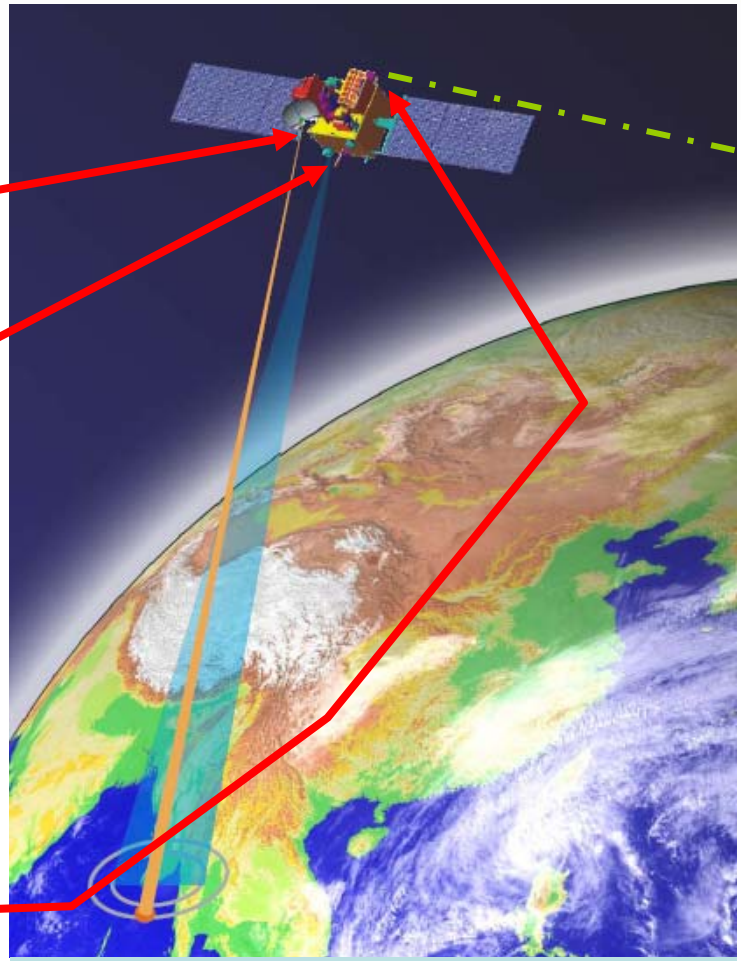
Oceansat-2: an Indian satellite dedicated for ocean research

Ku-band pencil beam scatterometer: wind vectors close to Ocean's surface

Ocean Colour Monitor (CCD camera): LAC (360 m) and GAC (4 km) modes to image Ocean's surface globally (in 4 ÷ 6 days) and in local detail

Radio Occultation Sounder of the Atmosphere (ROSA): amospheric profiles and data for space weather



Credits: from the announcement of opportunity "Indian Remote Sensing Satellite Oceansat-2 Mission" issued by ISRO

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PLAN OF THE TALK

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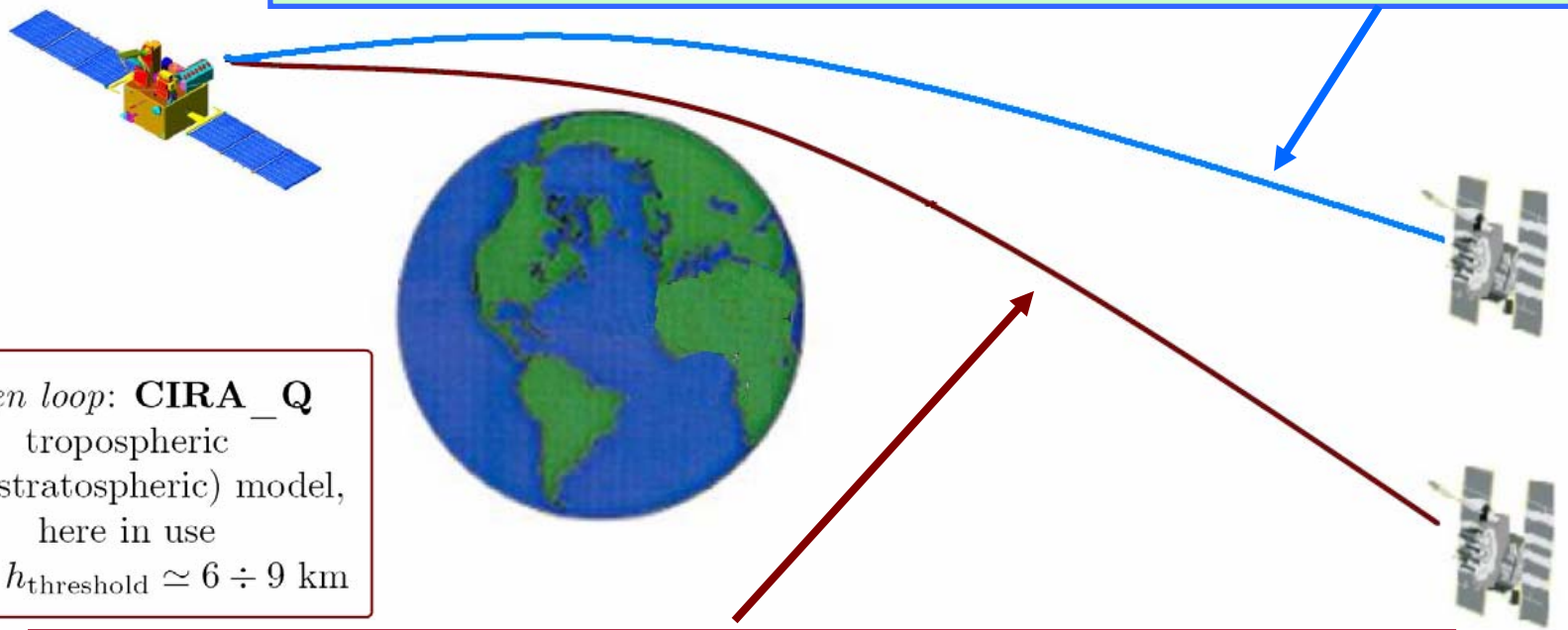
Tracking the signal in rising events: the ROSA open loop and closed loop configurations

$h > h_{threshold}$: the signal is regular enough to be tracked via the closed loop configuration of ROSA



Open loop: **CIRA_Q** tropospheric (and stratospheric) model, here in use up to $h_{\mathrm{threshold}} \simeq 6 \div 9$ km

$h < h_{threshold}$: the signal, strongly disturbed by water vapour, is tracked via an open loop configuration of ROSA

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The ground segment of ROSA 1/2

Table 1 – Details related to one-cycle OCEANSAT-2 ground visibility (2 days) from the two acquisition centres of Matera and Hyderabad

Start visibility	End visibility	Duration, s	GS
1 Jun 2006 12:03:47.97	1 Jun 2006 12:17:03.15	795.176	Matera
1 Jun 2006 13:45:33.87	1 Jun 2006 13:48:27.17	173.299	Matera
1 Jun 2006 18:07:06.70	1 Jun 2006 18:20:57.02	830.321	Hyderabad
1 Jun 2006 19:46:46.26	1 Jun 2006 19:57:22.52	636.256	Hyderabad
1 Jun 2006 20:01:04.11	1 Jun 2006 20:06:46.06	341.950	Matera
1 Jun 2006 21:33:52.52	1 Jun 2006 21:47:29.03	816.508	Matera
1 Jun 2006 23:12:17.80	1 Jun 2006 23:25:27.82	790.017	Matera
2 Jun 2006 06:24:44.03	2 Jun 2006 06:38:42.48	838.453	Hyderabad
2 Jun 2006 08:04:17.37	2 Jun 2006 08:14:36.08	618.711	Hyderabad
2 Jun 2006 09:37:30.71	2 Jun 2006 09:48:07.01	636.300	Matera
2 Jun 2006 11:14:24.61	2 Jun 2006 11:28:40.54	855.923	Matera

Data will be downloaded to the Space Geodesy Centre in Matera (Italy) and to the National Remote Sensing Agency in Hyderabad (India).

On the average, Oceansat-2 will be in view 6 times per day.

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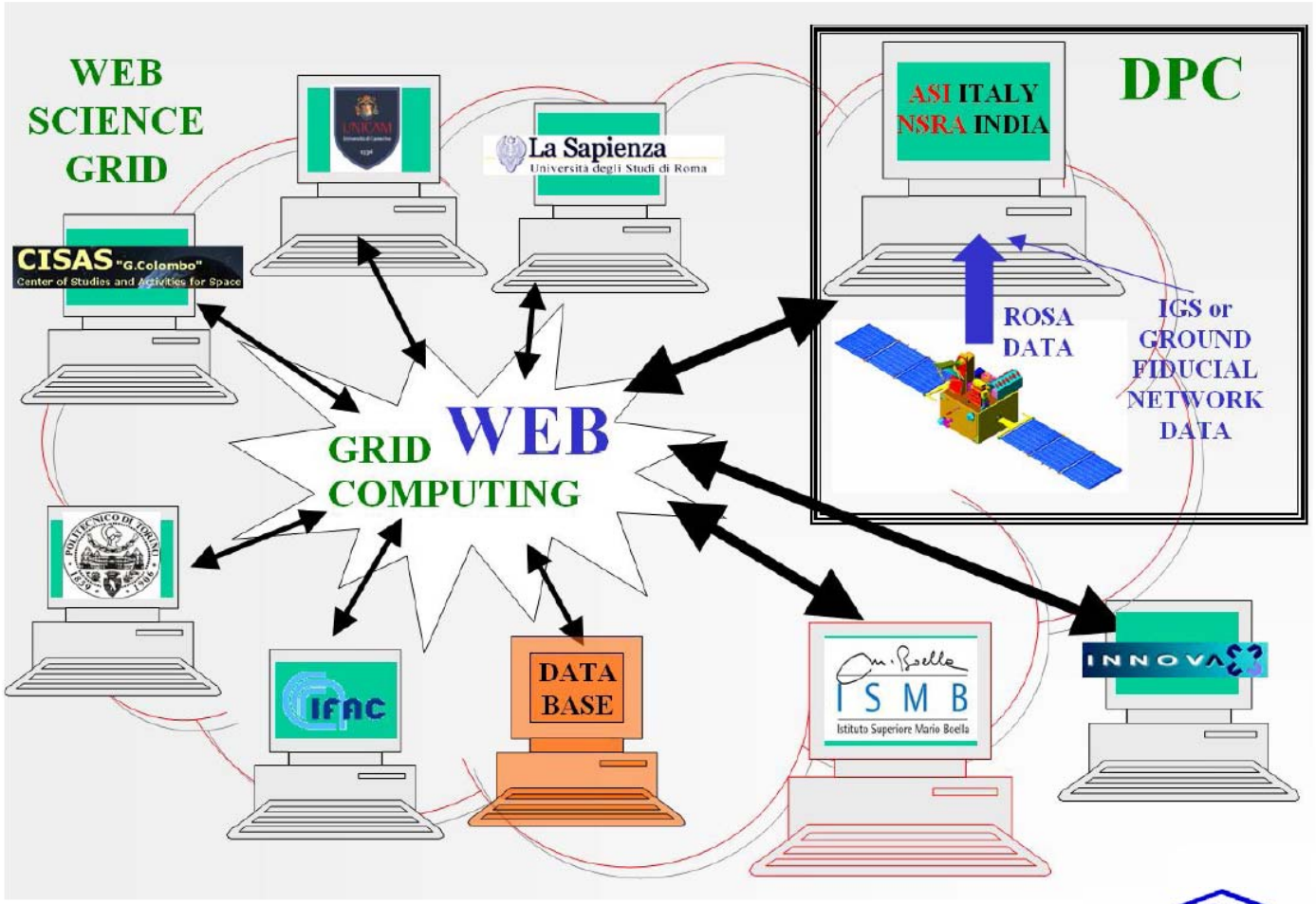
The ground segment of ROSA 2/2

The software of the ground segment is built up by Italian universities, research-technological institutes and an innovative industry. They will be all part of a web grid for data elaboration.



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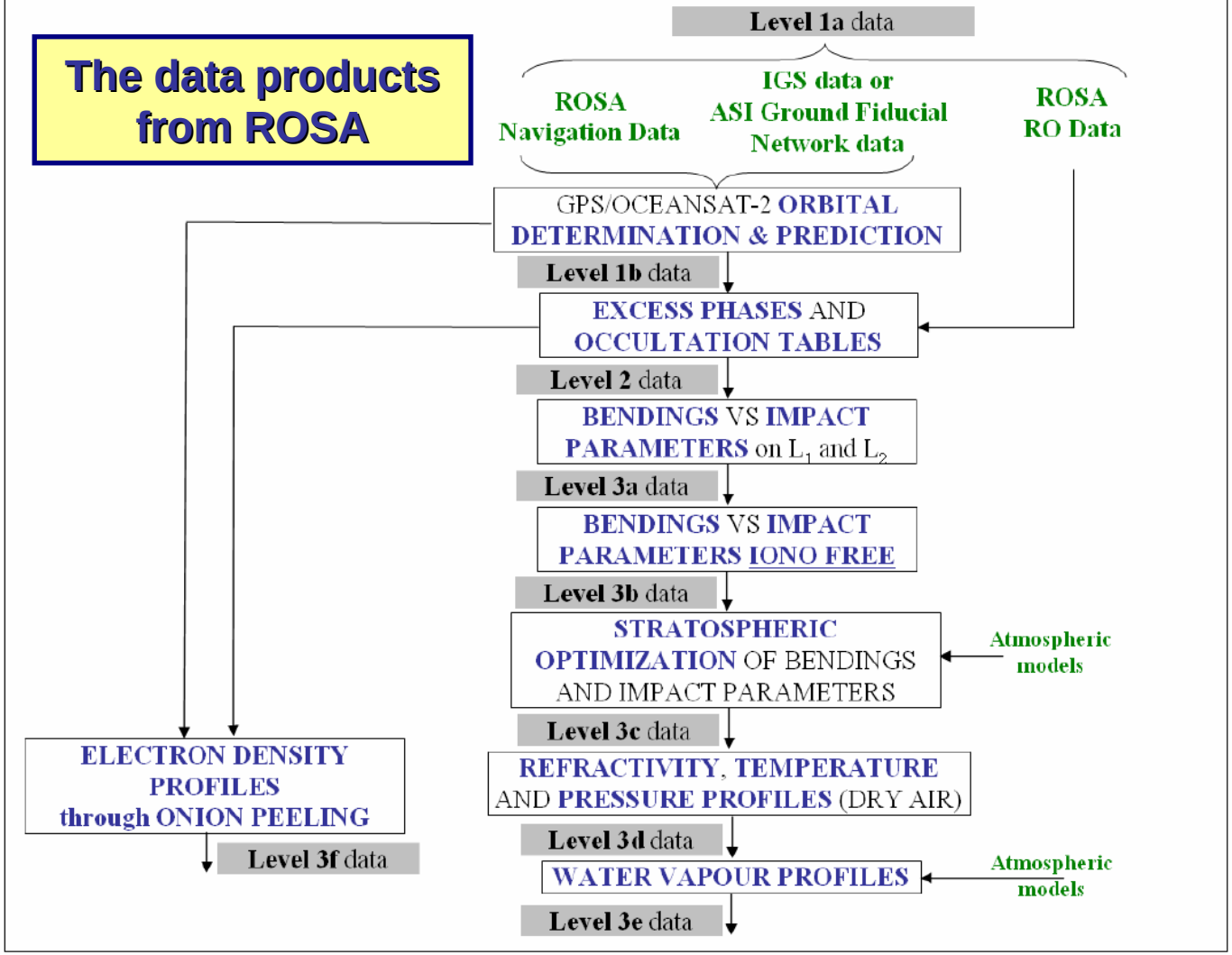
The data products from ROSA



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ROSA-ROSSA: ROSA Research and Operational Satellite and Software Activities

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Tropopause height and temperature, climatic studies, large scale water vapour analysis, RO vs LIDAR

La Sapienza — Università degli Studi di Roma

Assimilation of RO data into climatological and real time weather prediction models

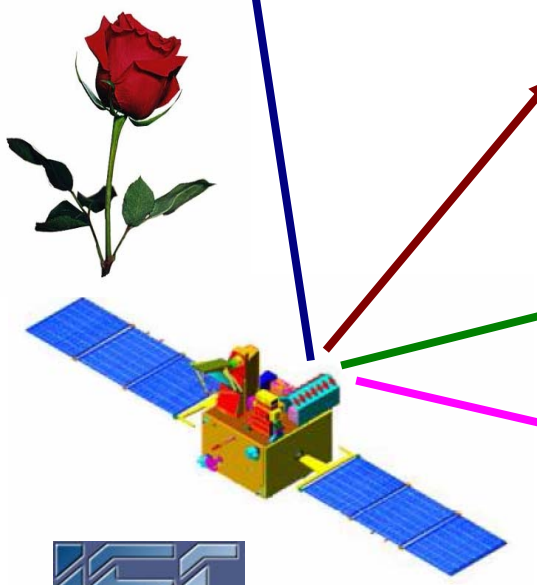
UNICAM

Assimilation of RO data into climatological and real time weather prediction models

POLITECNICO DI TORINO 1859 1906

Ionospheric 3D inversion via tomography

INNOVA



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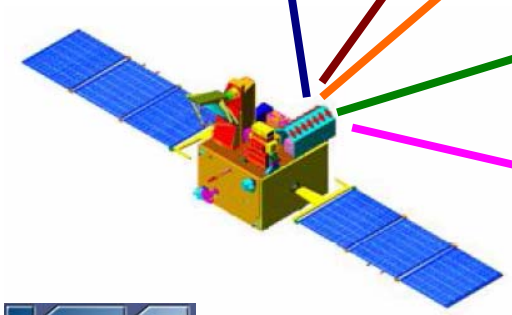
UNICAM

ISC — IFAC

POLITECNICO DI TORINO 1859 1906

INNOVA



Space weather via:

- **Ionospheric profile analysis;**
- **Topside-plasmasphere's TEC monitoring;**
- **Irregularity study via occultation links**

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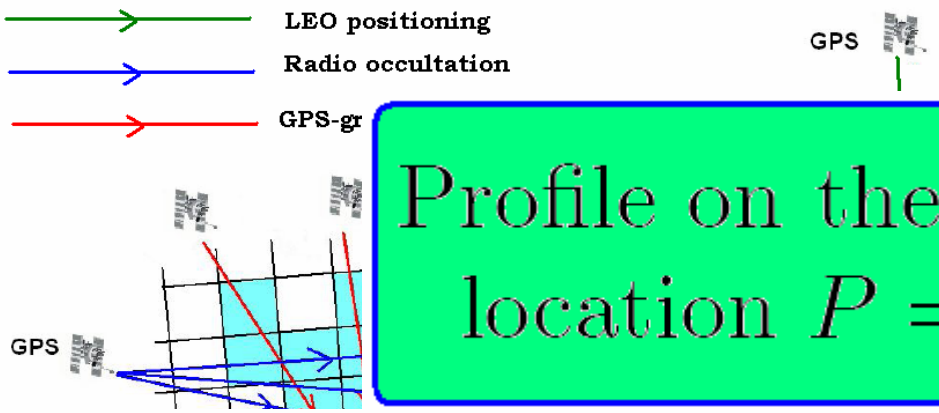
Ionospheric profiles from RO via MIDAS

(Multi Instrument Data Analysis System, developed by the University of Bath, UK)



Profile on the top of some location $P = (\vartheta_P, \varphi_P)$:

version
etermine the
lensity N_e in
on of interest
ion of total

$$N_e(P;h) = N_{e\mathrm{MIDAS}}(\vartheta_P, \varphi_P, h)$$

- **GPS-ground links: horizontal gradients;**
- **Radio occultation links: vertical gradients;**
- **GPS-LEO positioning links: topside and plasmasphere.**

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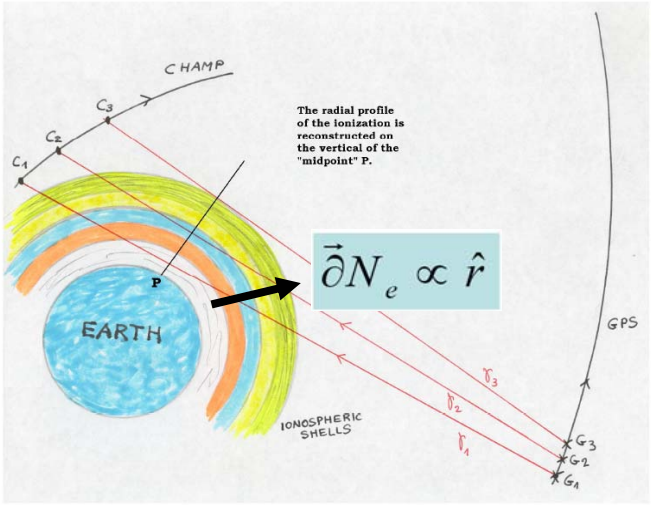
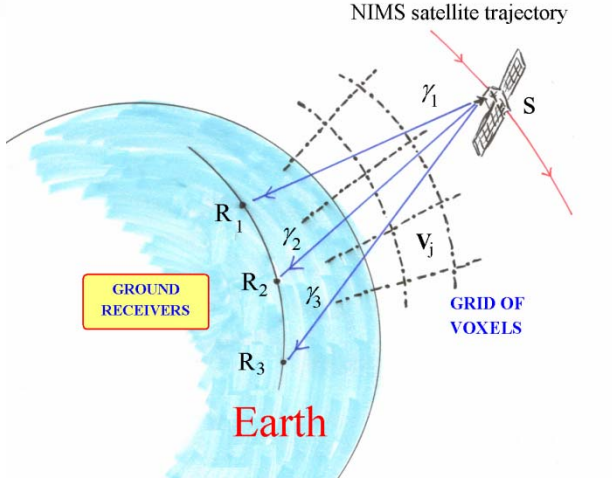
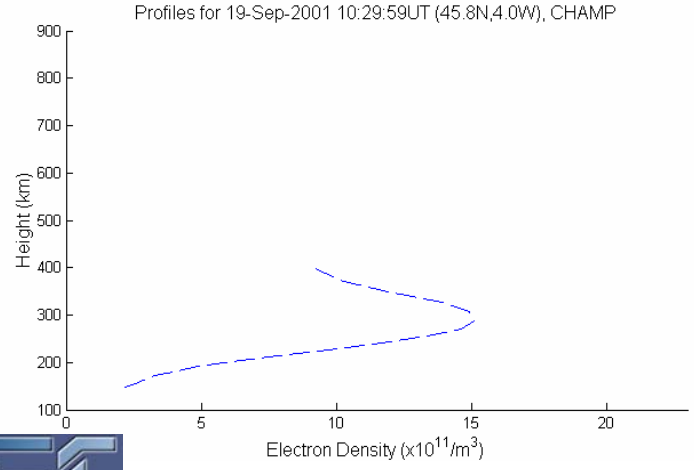
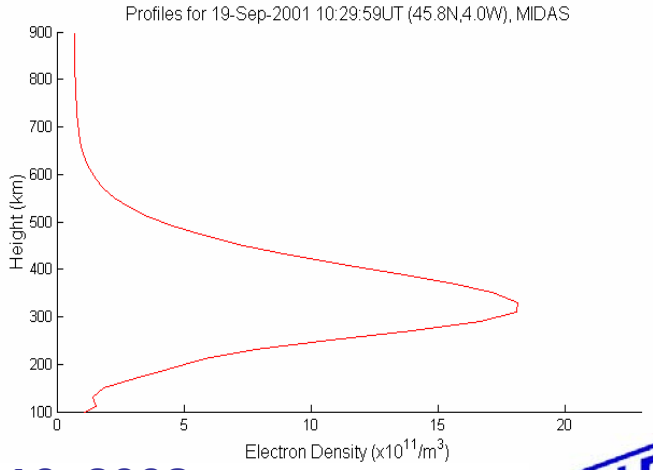
Tomography-onion peeling mutual "validation":









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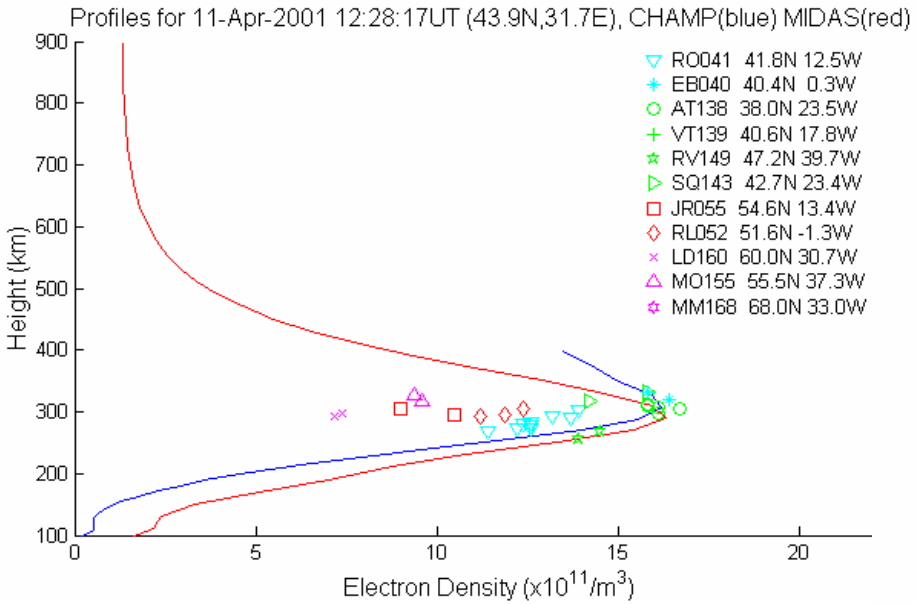
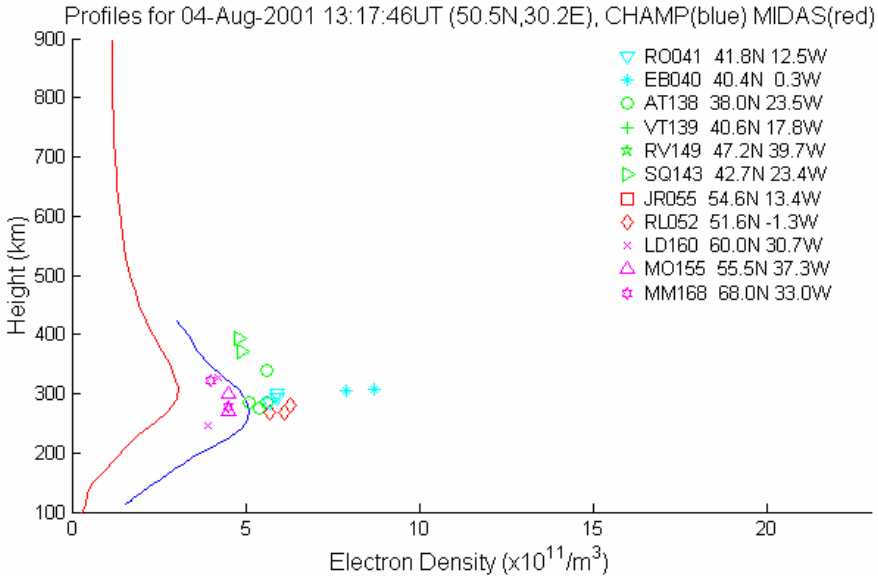
Tomography and onion peeling validation via data (e.g. ionosondes):





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Ionospheric profiles' Space Weather

• Collect ionospheric profiles $N_e(h)$ for different helio-geophysical conditions;

• Qualitative-freqency study: parametrize the profiles (e.g. N_{max}, h_{max}, H,…) and study the variability of parameters' distribution as a consequence of the different helio-geophysical conditions;

• Quantitative study: study the coupling between processes describing the Sun-Earth forcing and the profile parameter evolution via tools from information theory (e.g. mutual information and information transfer).

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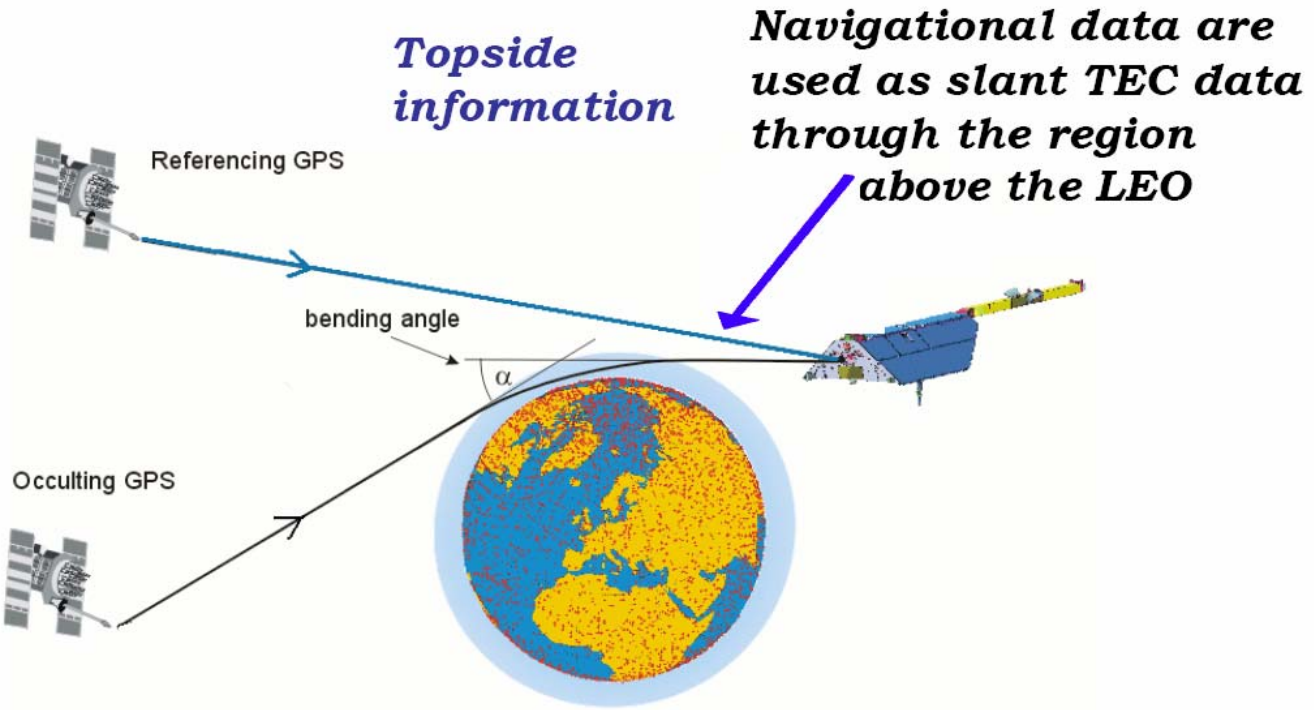
Topside-plasmasphere TEC may be obtained from "navigational data" of the LEO-spaceborn receiver, and put in relationship with helio-geophysical conditions.



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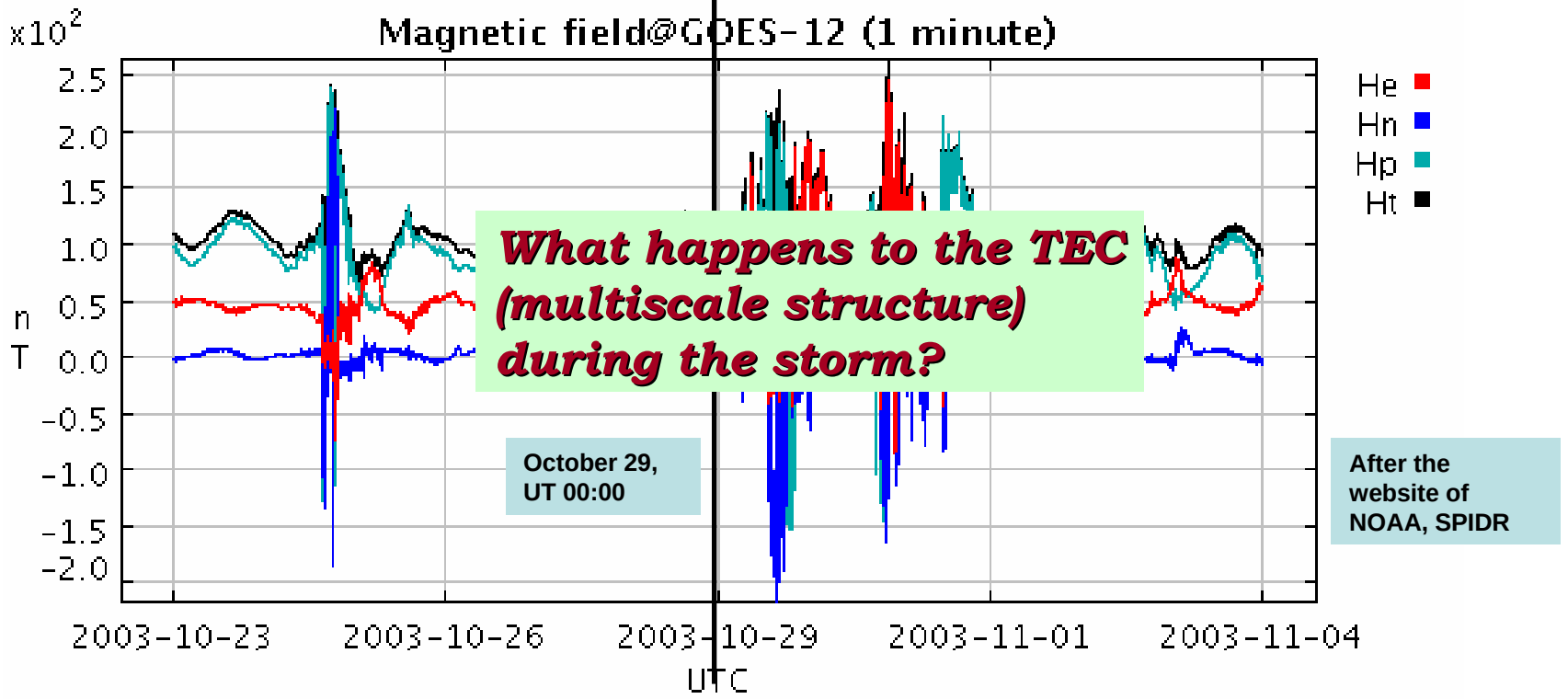
Space Weather of the small scale structures of the total electron content.

2003 Halloween Storm



What happens to the TEC (multiscale structure) during the storm?

October 29, UT 00:00

After the website of NOAA, SPIDR

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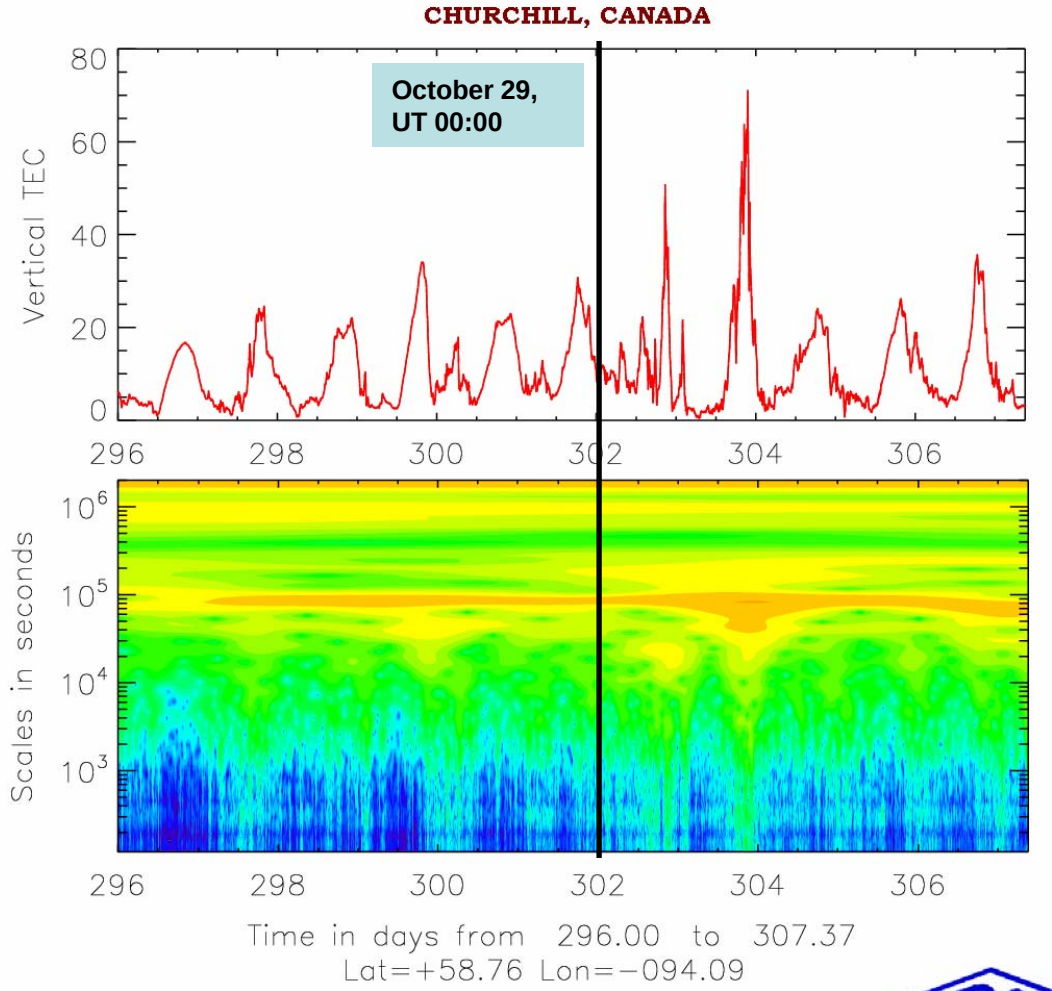
Space Weather of the TEC small scale structures.

During the storm period, the (ground) vertical TEC appears not only fluctuating with a stronger dynamic, but also more irregular at the small time scales.

The continuous wavelet analysis, is able to track the distribution of fluctuations at all the scales as functions of the time in a very detailed way.



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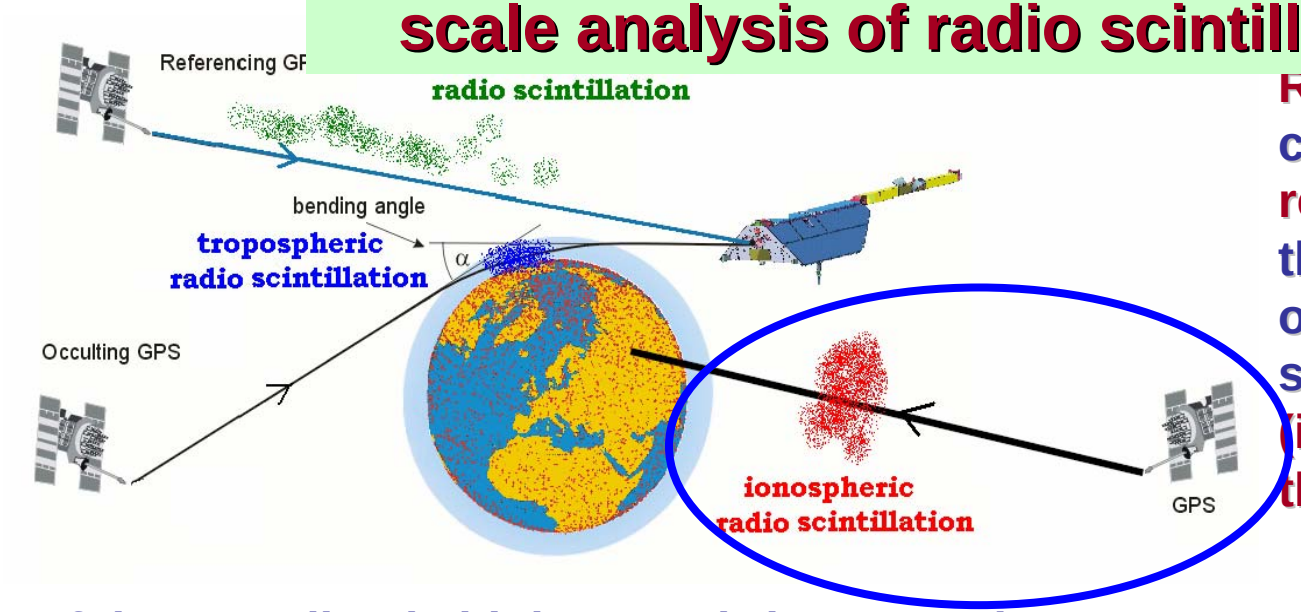
High sampling rate data from ground GPS scintillation receivers are the "playground" for practicing on multi-scale analysis of radio scintillation

de-

nose



Radio scintillation is caused by an irregular refractivity. Studying the radio-scintillation on a given link is studying the (integrated) effect of these irregularities.

If the sampling is high enough (e.g. 50 Hz), LEO + GPS data will allow for the comparison between the ionospheric and tropospheric irregularity effects in terms of radio scintillation.

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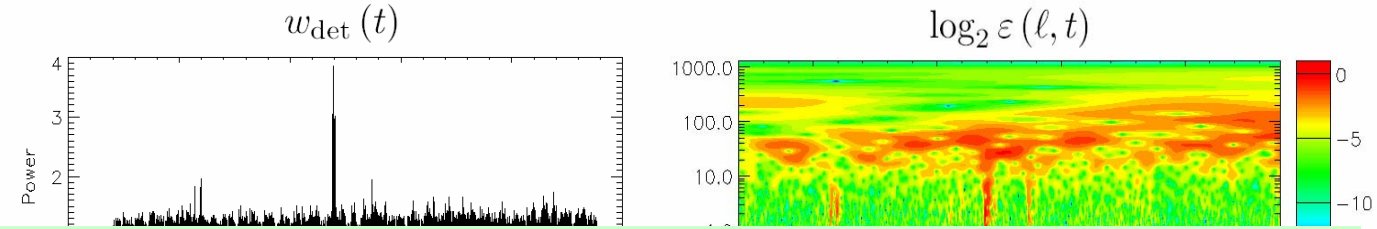
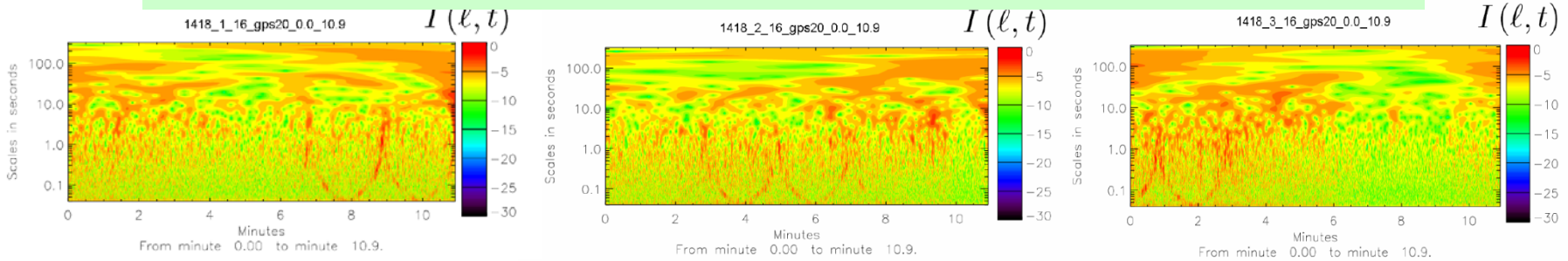
Radio scintillations are multi-scale and non-stationary.
Wavelet analysis will be the right tool to study them.



Multi scale analysis applied to radio data allows both to appreciate small scale features in the medium and to discriminate unwanted interference effects.

Wave … of a
sidera … tipath



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Opportunities given by the availability of data from the ROSA receiver in terms of Space Weather of the ionosphere (1/2):

- Assess quantitatively the role of radio-occultation in stochastic inversions of ionospheric data.

- Develop and refine non-tomographic profile retrieval techniques (advanced onion-peeling techniques).

- Monitor the variability of the ionospheric structure in the vertical direction in relationship with different Space Weather conditions.

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Opportunities given by the availability of data from the ROSA receiver in terms of Space Weather of the ionosphere (2/2):

- Monitor the topside-plasmaspheric TEC in relationship with different Space Weather conditions.

- Study the RO data via multi-scale analysis, to investigate the radial properties of ionospheric irregularities.

- Study the topside-plasmasphere data via multi-scale analysis, to investigate the topside-plasmaspheric irregularities (if any).

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Opportunities given by the availability of data from the ROSA receiver in terms of Space Weather – Weather interaction:

- The ROSA receiver will provide the community with data for both the ionospheric and the "lower" atmospheric science.
- The ROSA project has brought together physicists and engineers from the two fields.
- The ROSA-ROSSA community is a good chance for exchanging experiences, ideas and working to the investigation of how the "lower" atmosphere system is forced by the Sun-Earth interaction and reponds to it (non-antropogenic global change).
- Open our community to the worldwide community.

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Acknowledgements

• The Chairpersons of this Session for kindly inviting me to present this work.

• ASI for the support after the contract “Software for Oceansat2-ROSA”

• Dr Cathryn N. Mitchell (the Chairlady again!) for providing ground scintillation data and MIDAS.

• Dr Luigi Ciraolo for providing time series of vertical TEC data, and very useful discussions.

• Dr Paolo Spalla for the pleasure to work everyday with him.

• The Organizers of the present General Assembly and all the very kind people of the Staff.

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Thank you all
for your kind
attention...

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