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# A comparison of LPIM-COSMIC and IRI(CCIR) F2 peak parameters determinations

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## Outlook of the presentation

Objective of this work:

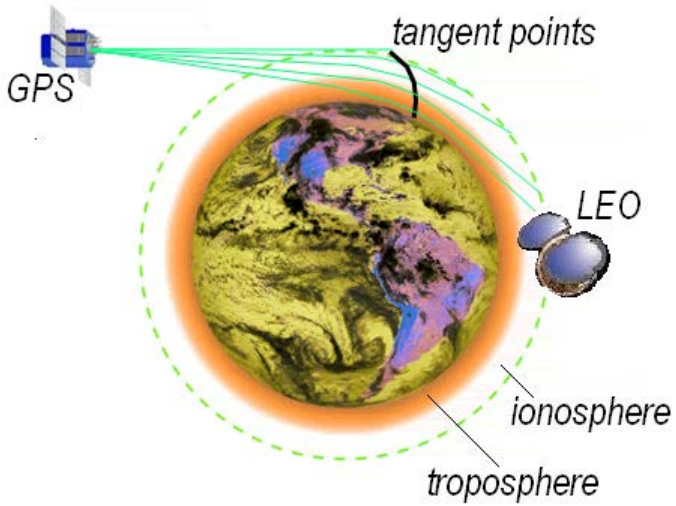
*Assimilate COSMIC/FormoSat3 electron density profiles into the LPIM(3D) via the estimation of the F2-peak parameters. This contribution presents comparisons between the obtained results and the values given by IRI(CCIR).*

- I. COSMIC / FormoSat3 mission and radio occultation profiles
- II. Retrieving the F2 peak parameters with LPIM
- III. General variables of the problem.
- IV. Comparisons between C/F3 and IRI F2 peak parameters values
- V. Conclusions

# I. COSMIC / FormoSat3 mission and radio occultation profiles

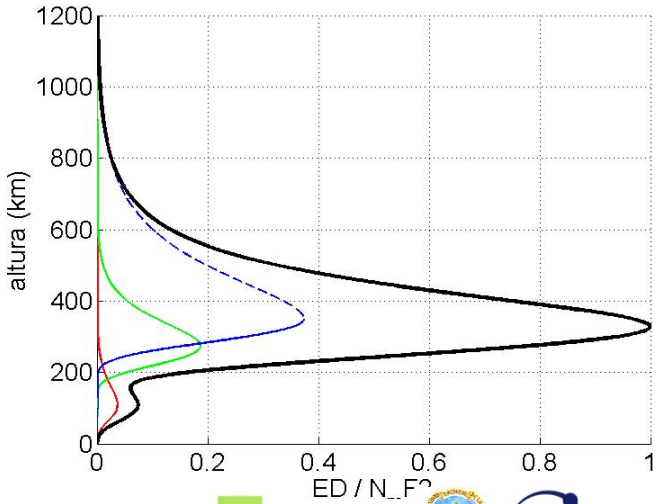
## About the mission

- COSMIC / FORMOSAT-3 (Constellation Observing System for Meteorology/Formosa Satellite Mission 3) joint project between the National Space Organization (NSPO) of Taiwan and the UCAR of the USA.
- The mission consists of six micro-satellites that were launched on April 2006, into circular orbits with an altitude of ~800 km, with a separation of 30° in longitude between orbital planes.
- Based on Radio Occultation (RO) inversion techniques, the mission team provides electron density profiles in the ionosphere, temperature profiles in the stratosphere, and temperature and water vapor profiles in the troposphere.
- The dataset used in this work was downloaded from the Data Analysis and Archival Center (CDAAC) database (http://cdaac-www.cosmic.ucar.edu/cdaac/index.html), at the University Corporation for Atmospheric Research (UCAR).



# II. Retrieving the F2 peak parameters with LPIM(3D)

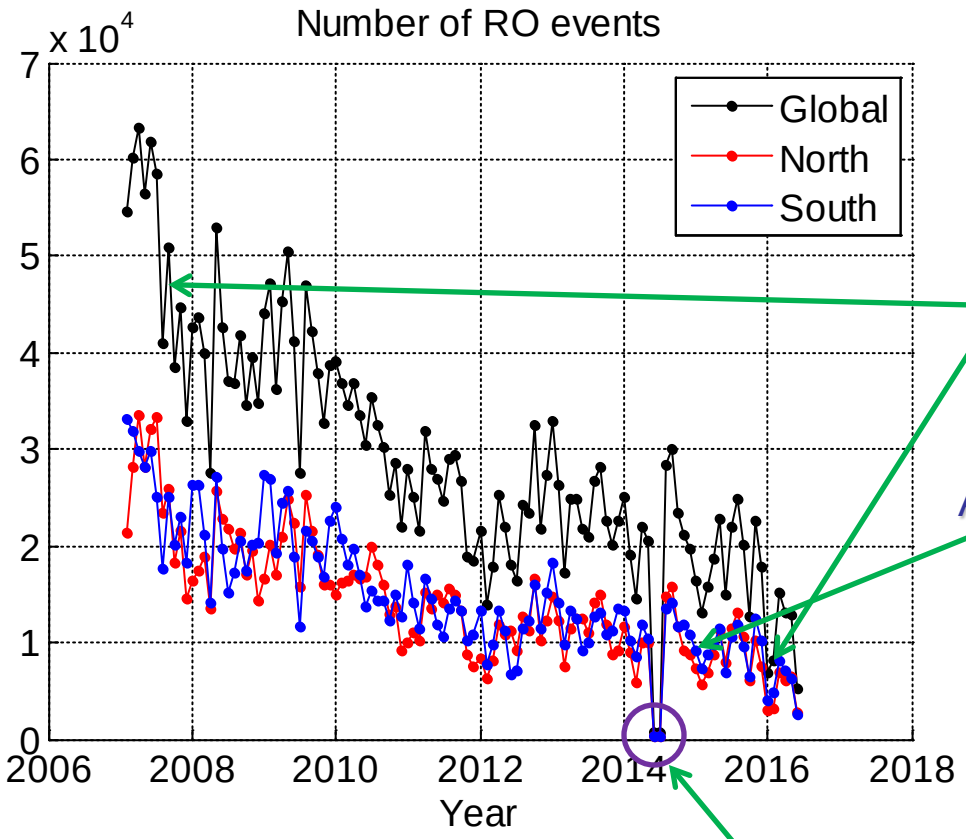
- Each COSMIC/F3 electron density profile was individually fitted to the La Plata Ionospheric Model (LPIM) obtaining a pair (NmF2,hmF2) for each profile.
- LPIM uses 3 a-Chapman layers to represent the electron density as function of the height in the E, F1 and F2 layer, and a vary-Chapman function in top-side.
- LPIM is parameterized as a function of the electron density, height, and scale height of the F2 layer.
- A re-weighted Least Squares algorithm is used for down-weighting unreliable data (occasionally, entire ROP) and for retrieving the model parameters and their variances.
- This procedure assigned negligible weights (lower than one tenth of the unity of weight) to approximately 20% of the data (including complete ROP).




*Brunini C, Azpilicueta F, Nava B. A technique for routinely updating the ITU-R database using radio occultation electron density profiles. J. Geod,* 10.1007/s00190-013-0648-x, 2013

## III. General variables a) number of RO events temporal evolution

The monthly number of events is reducing systematically with time.

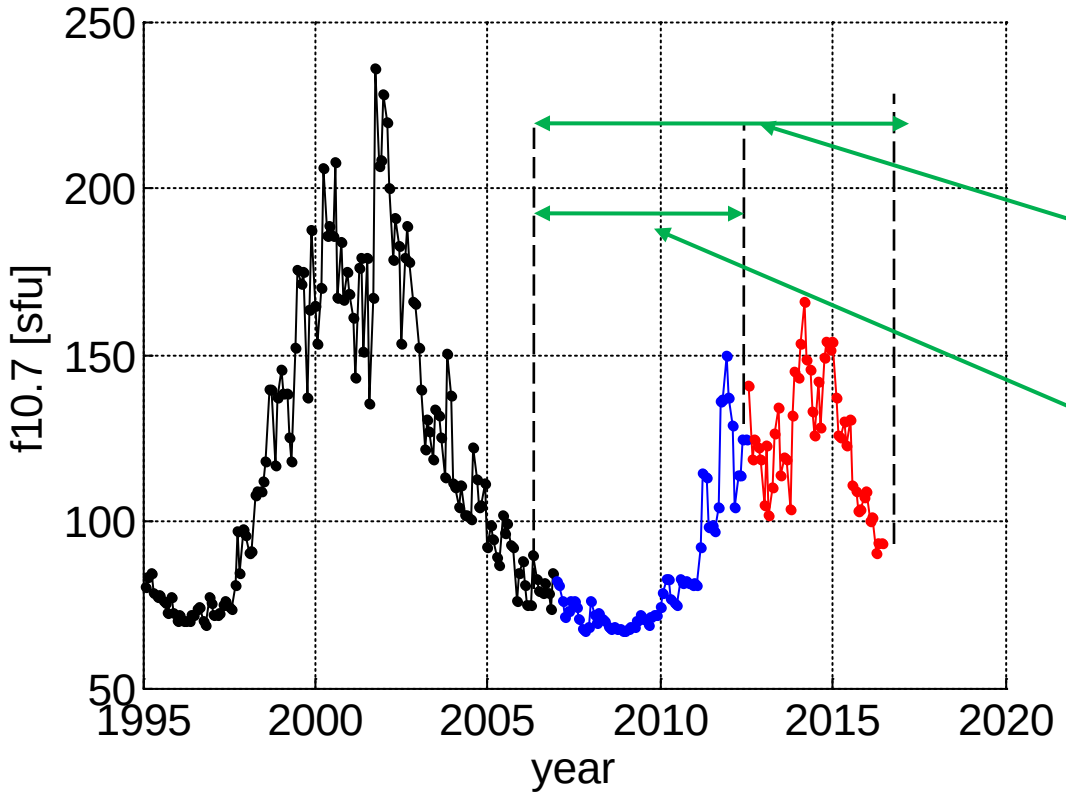



A factor of 4 between 2007 and 2016

Affects similarly both modip hemispheres

2 months with data problems

## III. General variables: b) Solar activity evolution




2007-2016.5 – Present work

2007-2012.8 – Previous work*

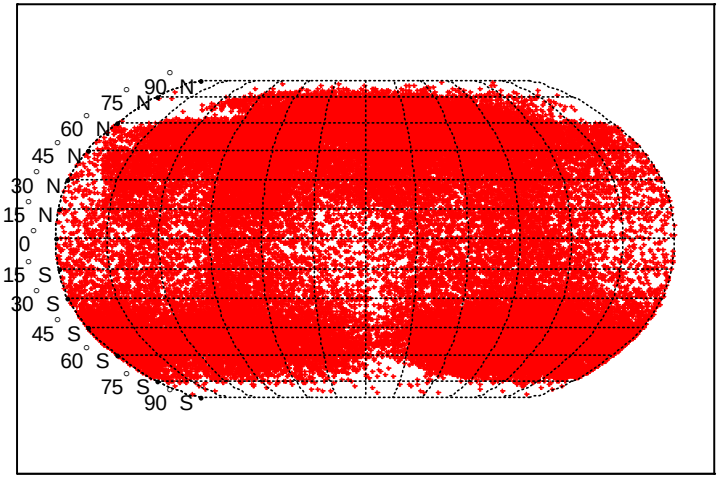
- 2007-2016.5 – Complete C/F3 data series covering the last minimum and maximum.
- Last maximum was relatively low when compared to the previous one.

*Azpilicueta F., D. Altadill, C. Brunini, J.M. Torta, E. Blanch, *' A comparison of LPIM-COSMIC F2 peak parameters determinations against the IRI(CCIR)',* ASR, doi: 10.1016/j.asr.2014.08.008, 2015.

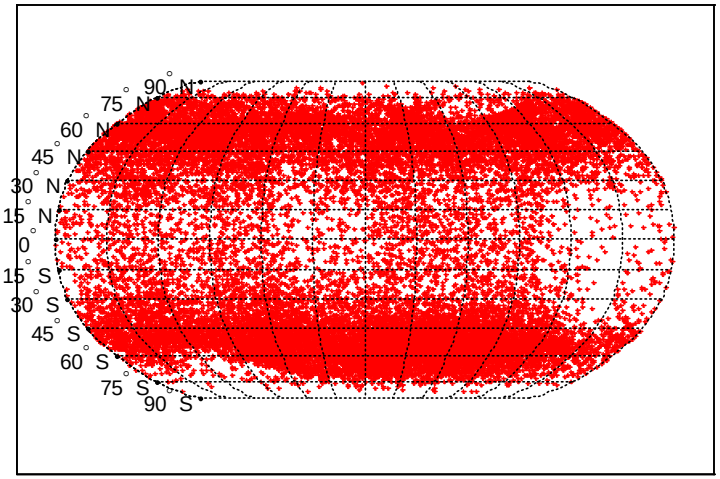
## III. Gral. Variables: c) spatial distribution of the RO events

Instead of using the geographic system, the maps are represented in Local Time – modip. The Sun is always over the central meridian

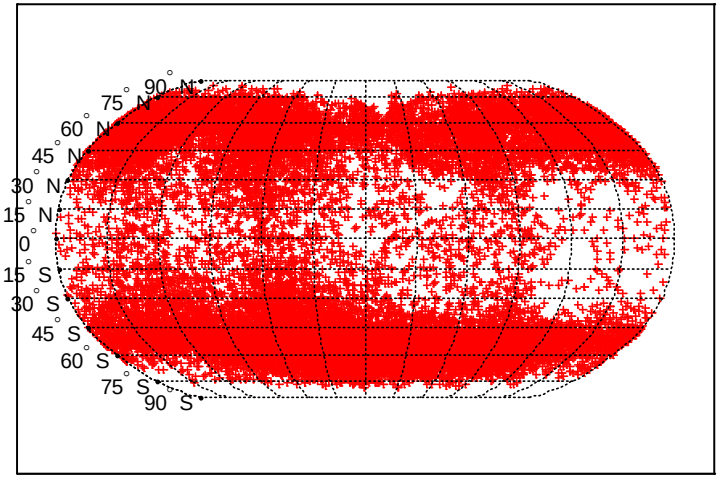
2007 - March - RO events in LT-modip



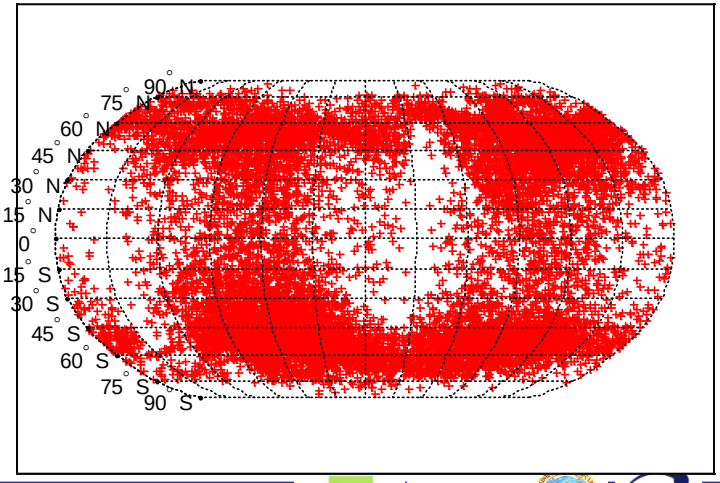

2012 - March - RO events in LT-modip




2014 - March - RO events in LT-modip

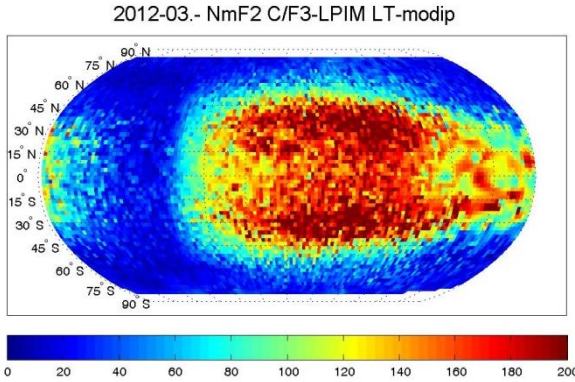


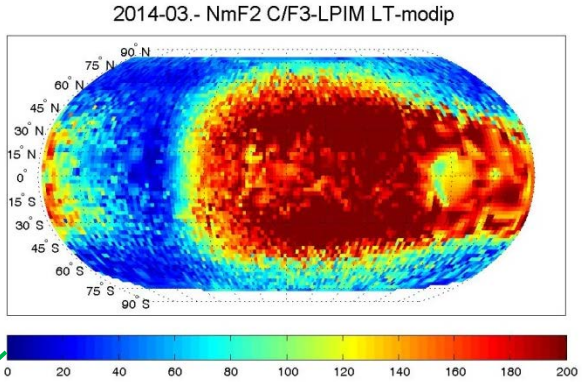

2016 - March - RO events in LT-modip

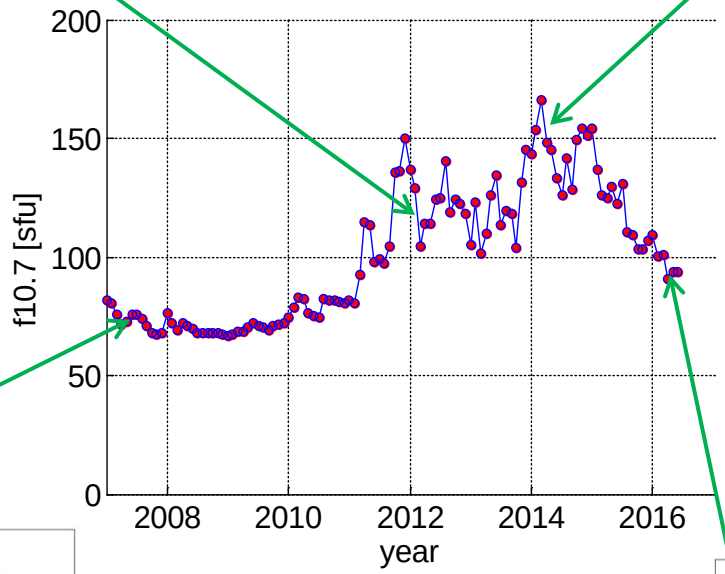


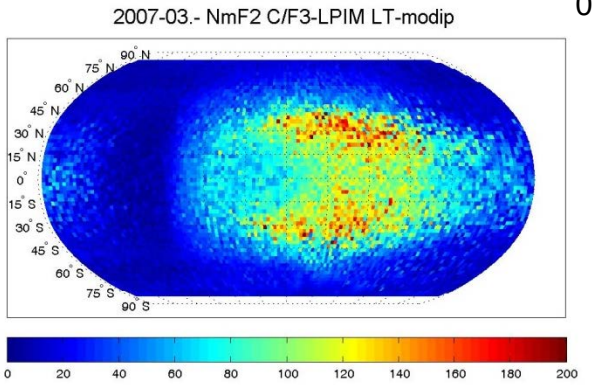
# Example of NmF2 – C/F3-LPIM

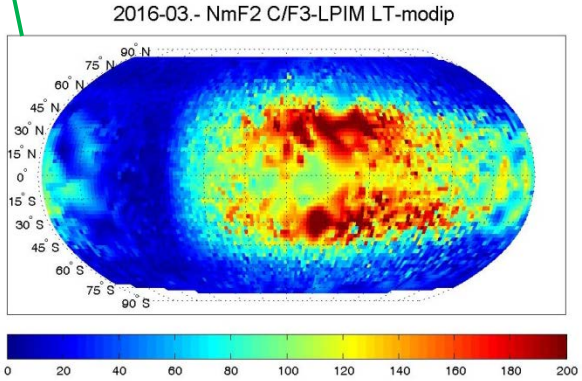
## Local Time – modip



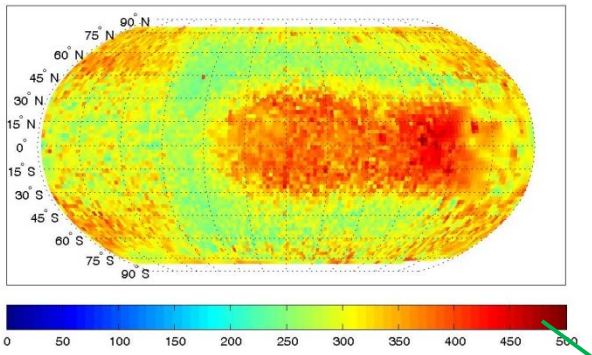



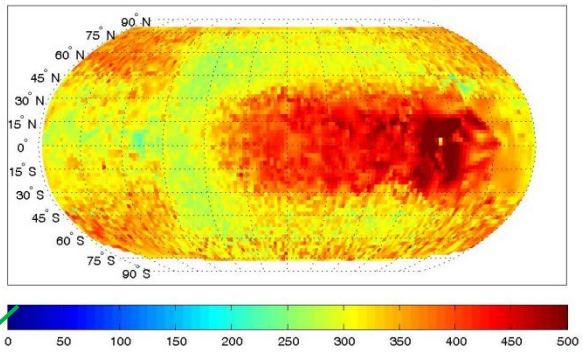



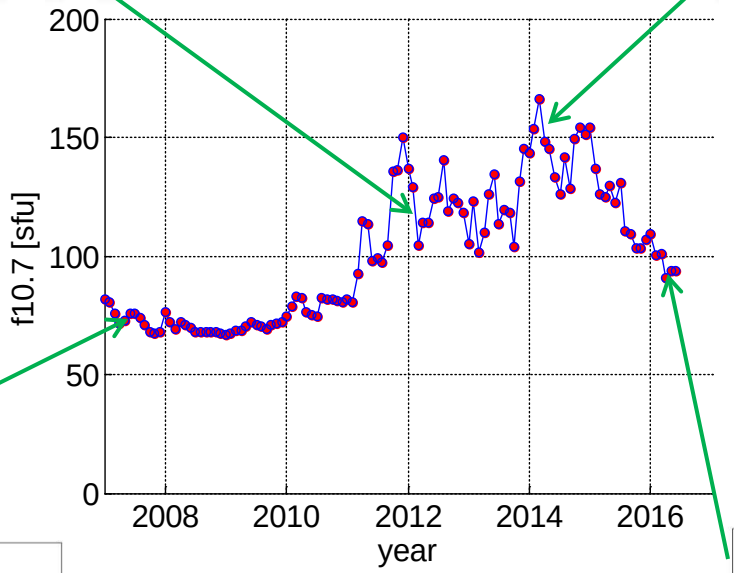



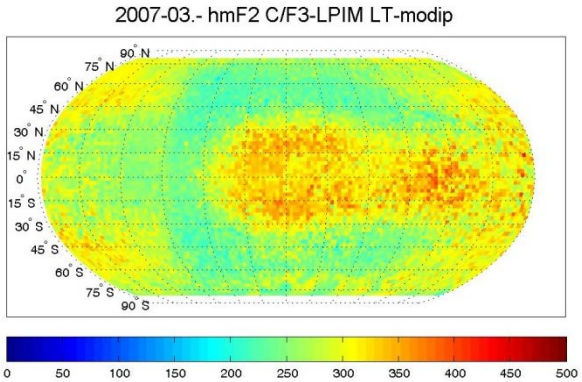
# Example of hmF2 – C/F3-LPIM

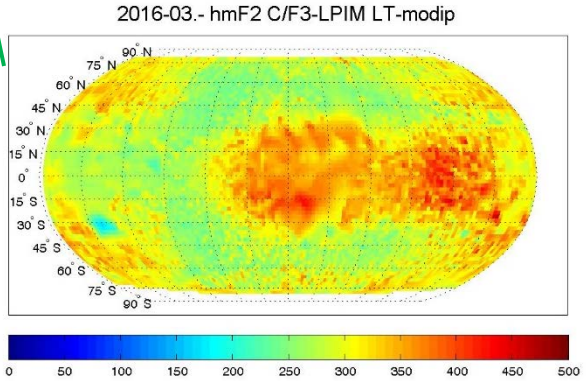
## Local Time – modip



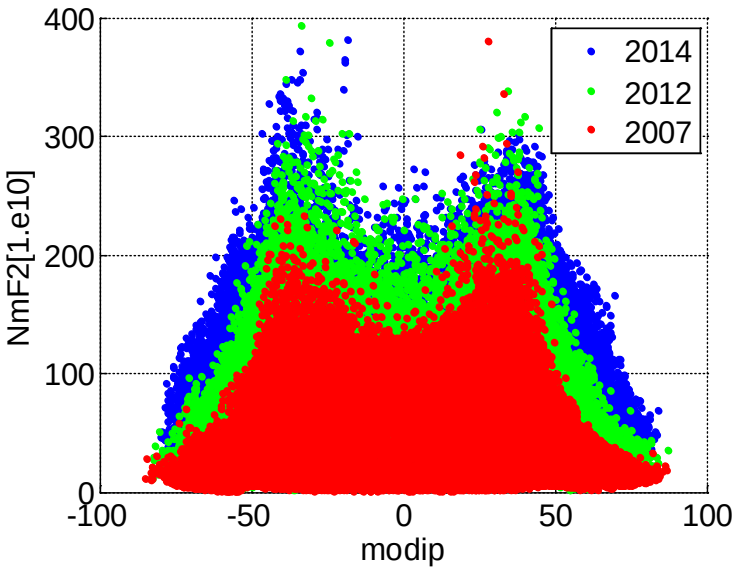



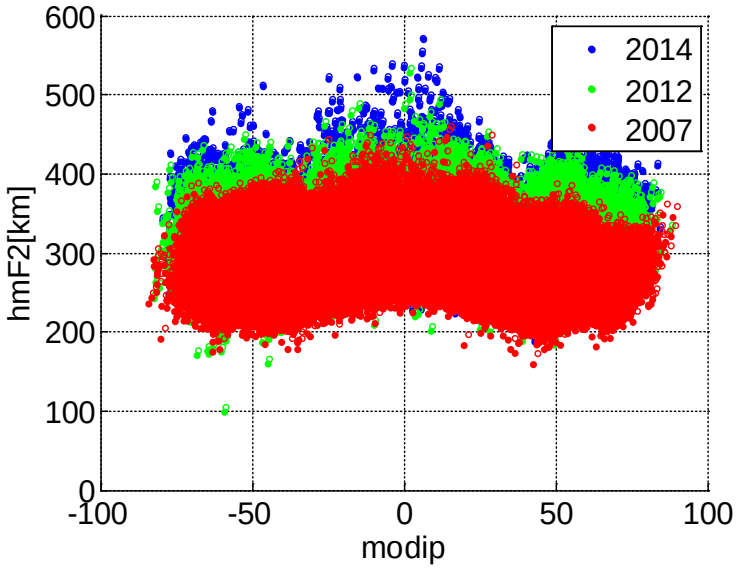



# Examples of Nm and hm LPIM-COSIMC determinations

NmF2 - March



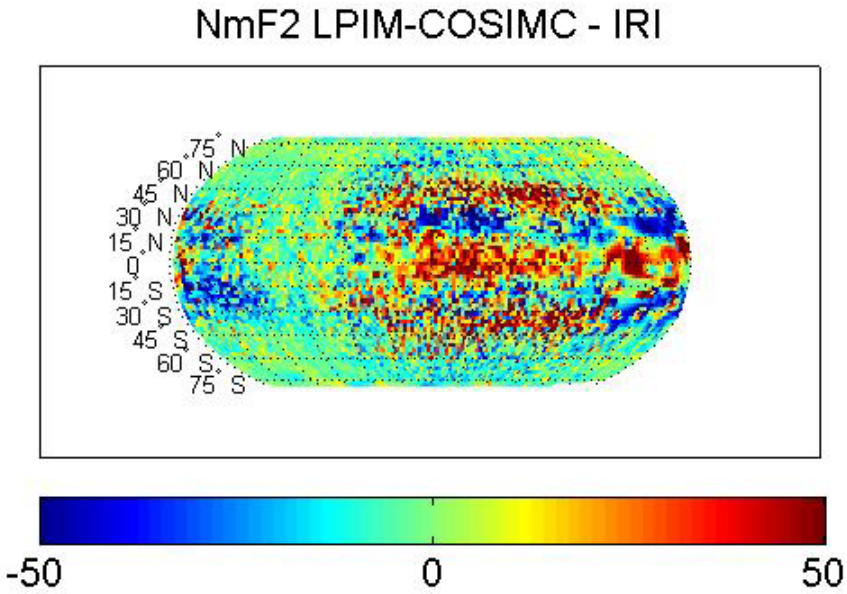

hmF2 - March

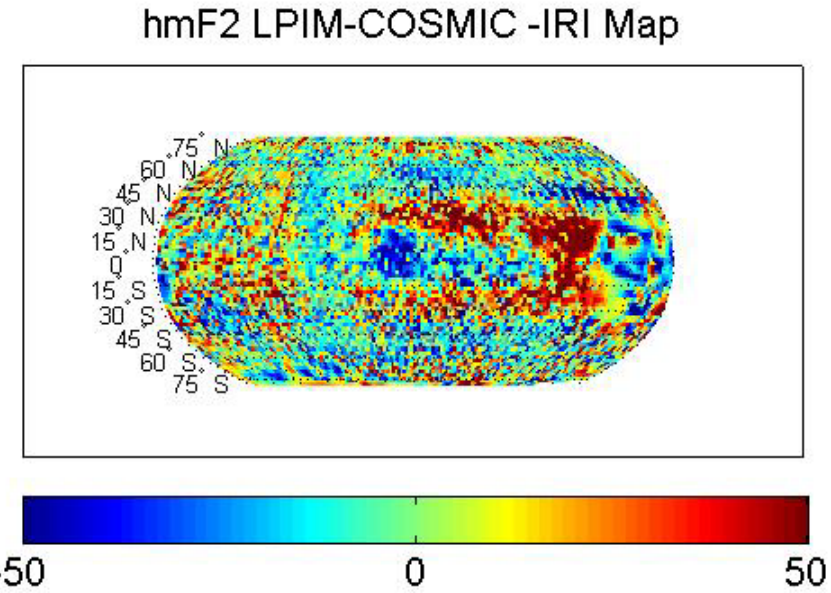


# III. Comparison between IRI and C/F3 peak parameters

## Examples of maps of LPIM – IRI

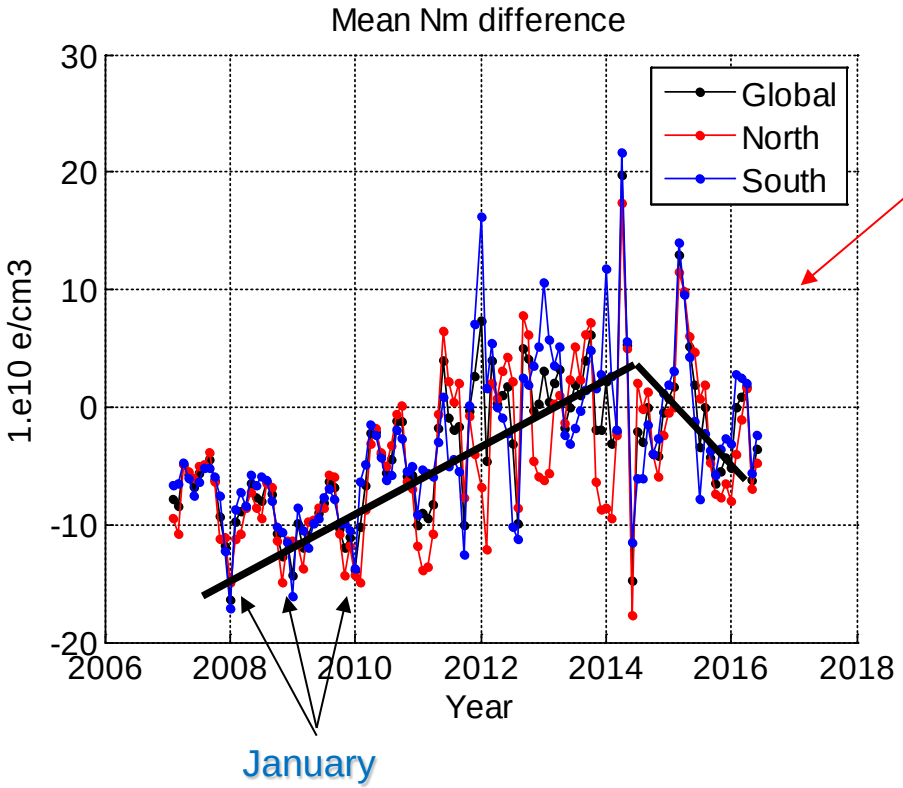
March 2012



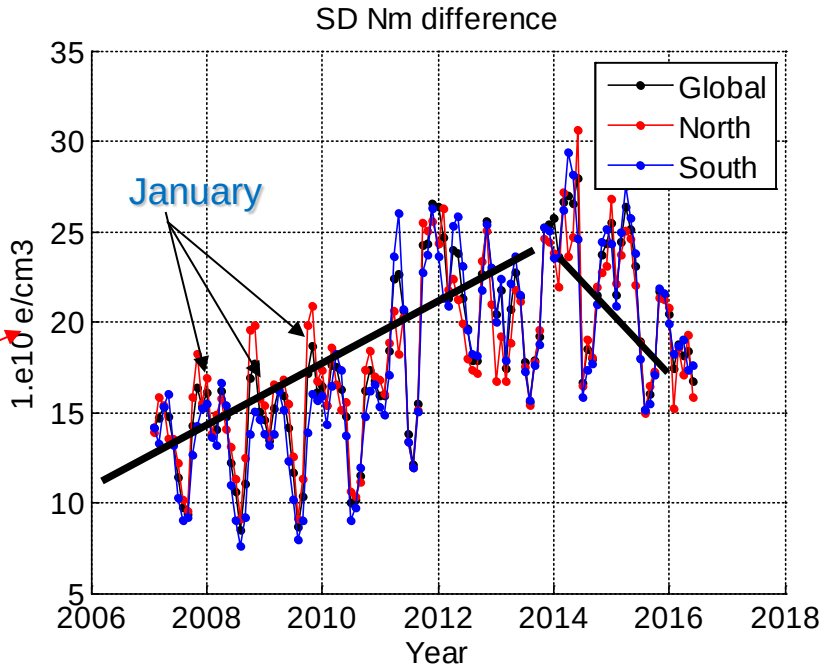

Local Time – modip

## III. a Evolution of the Nm monthly mean difference

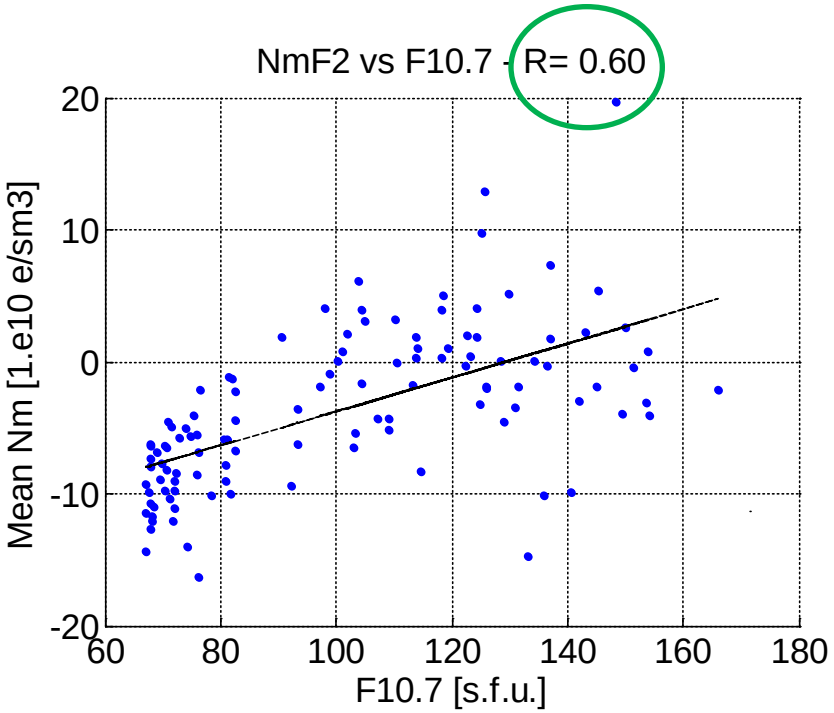


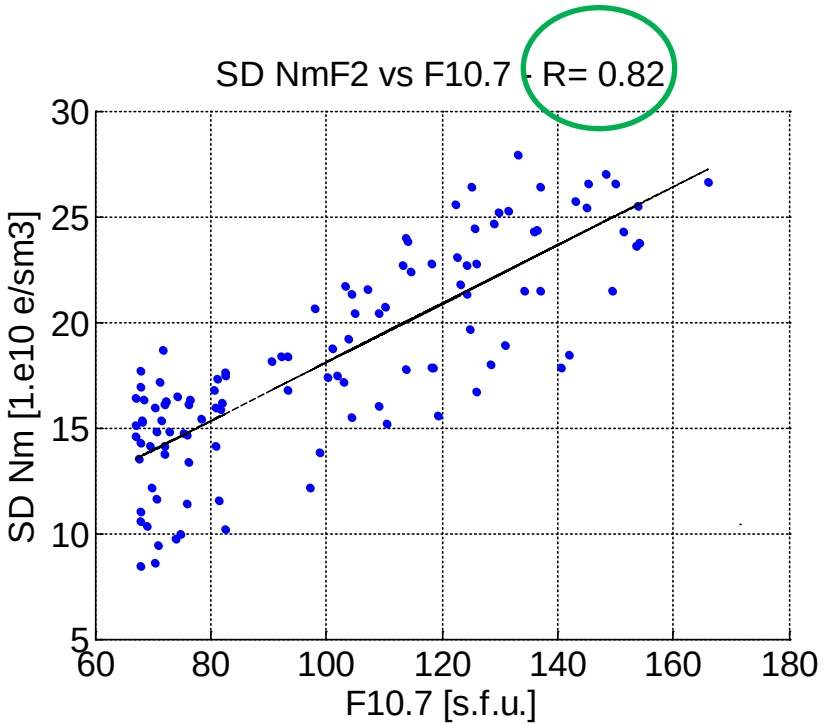

Climatological part

Meteorological part

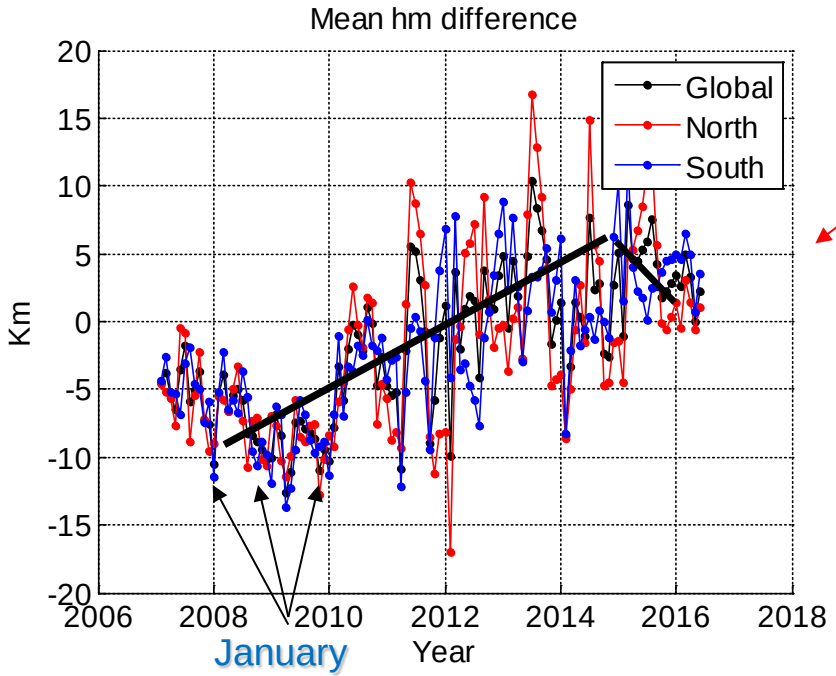


## III.b Effect of the Solar activity on Nm differences

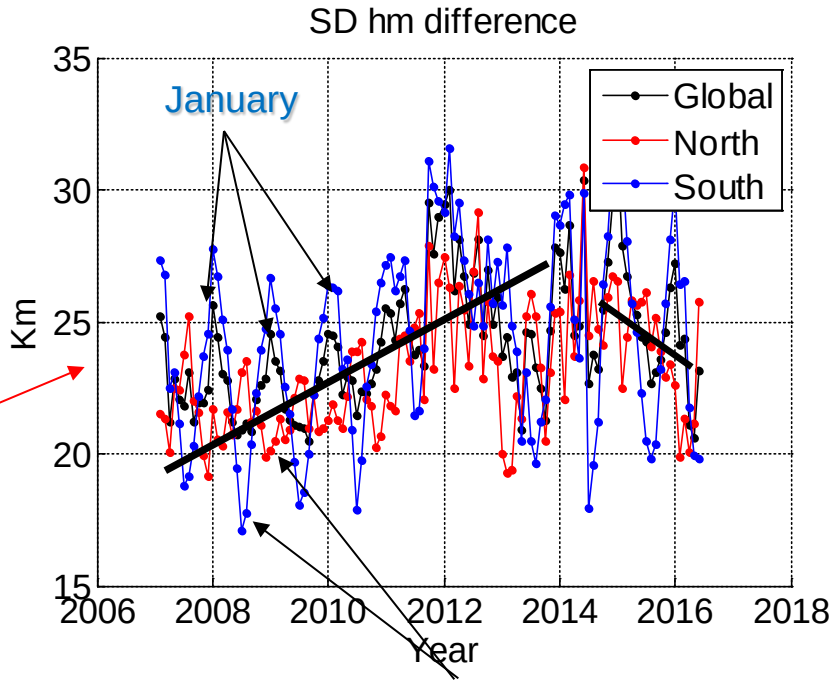


## III.c Evolution of the hm monthly mean difference



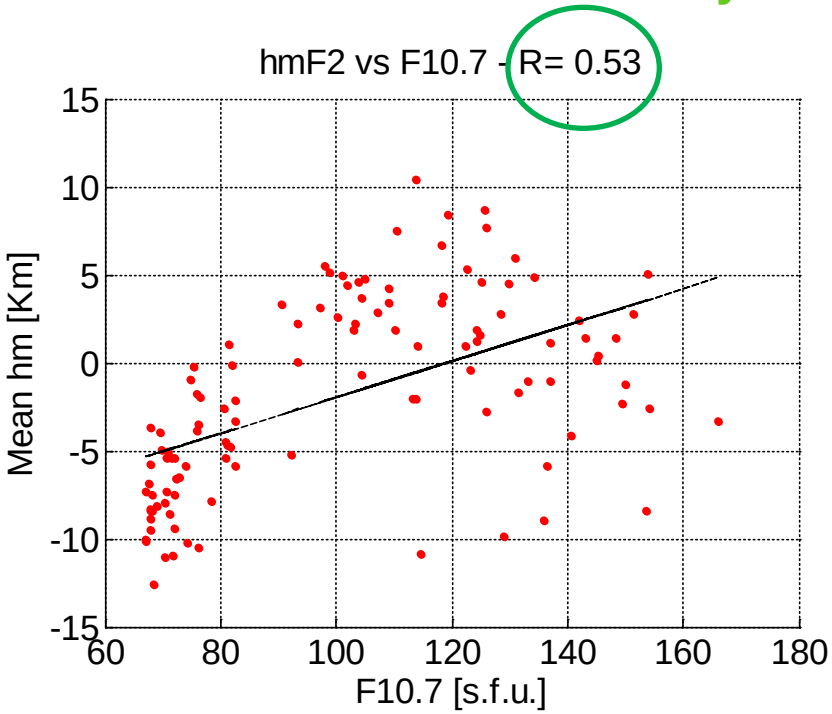

Climatological part

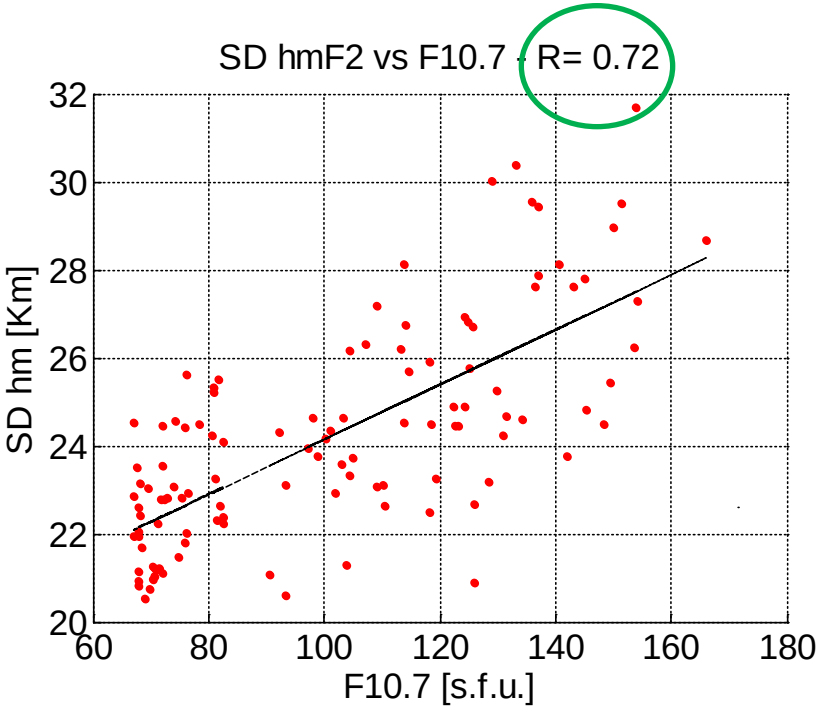



Meteorological part

North and South are in phase opposition

## III.d Effect of the Solar activity on the hm differences



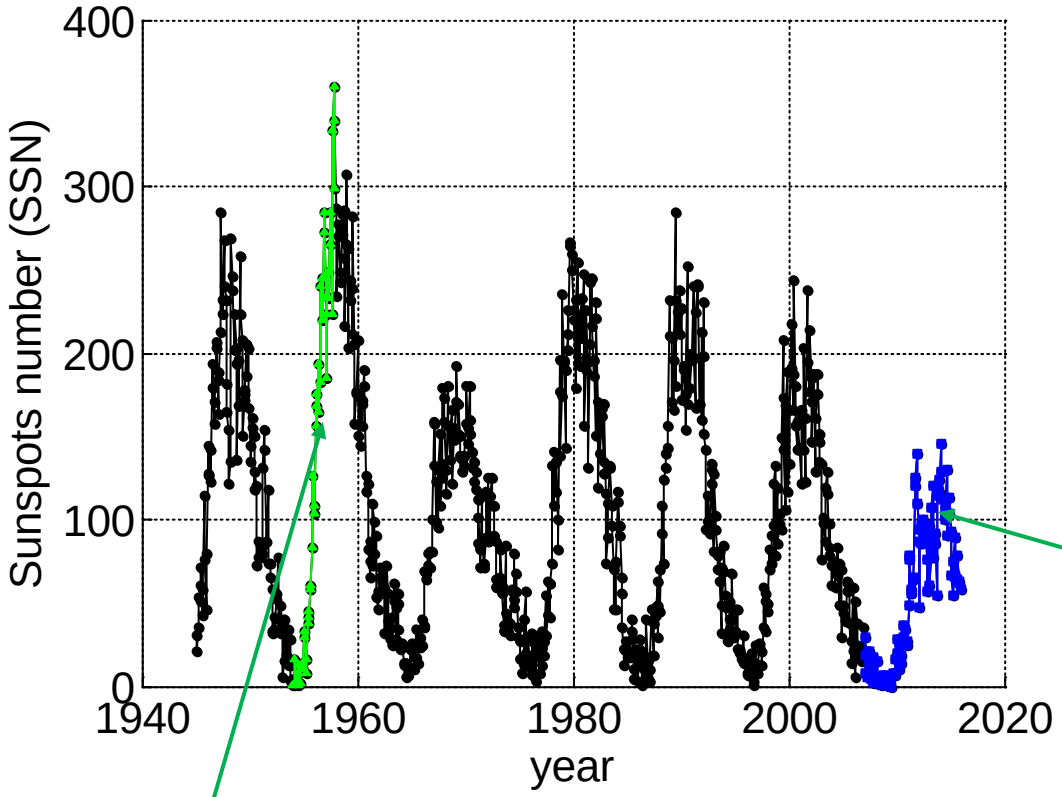
## IV. Conclusions

- The mean difference observed between LPIM-COSMIC and IRI are compatible with the differences between IRI and other models and data sourced (for example IRI and EBRO). In other words there is no clear evidence of a systematic bias between LPIM-COSMIC and IRI.
- Taken LPIM-COSMIC as the reference, the annual and semi-annual signals could indicate in both mean and SD (but mainly in SD), a lack of capability prediction of IRI.
- The mean difference (climatological part) does not present any systematic difference with a neglecting variation range from -10 to 10 km. This could be interpreted as a double verification: from one side the LPIM-COSMIC data are well determined and from the other IRI provides a good climatologic representation of the hm.
- The SD indicates that the inability of the IRI to model meteorological part of the problem could be in the range from -30 to 30 Km. The behavior over the Southern modip hemisphere is worse.
- The solar activity level enlarge the mean difference of both parameters (correlations of 0.6).
- The statistics most affected by the solar activity are the SD. This is understandable because the IRI was not developed with climatologic purposes.

I want to thank:

- for your attention.
- COSMIC/FormoSat3 mission for the profiles database (http://www.cosmic.ucar.edu/).
- Dr. B. Navan, Prof. S. Radicella, and Dr. P. Doherty for their kind invitation to participate on this Symposium.
- ICTP and Dr. Sharafat Gadimova from the United Nations Office for Outer Space Affairs (UNOOSA) for supporting my travel and stay here.

## III. General variables: c) SSN historical data series

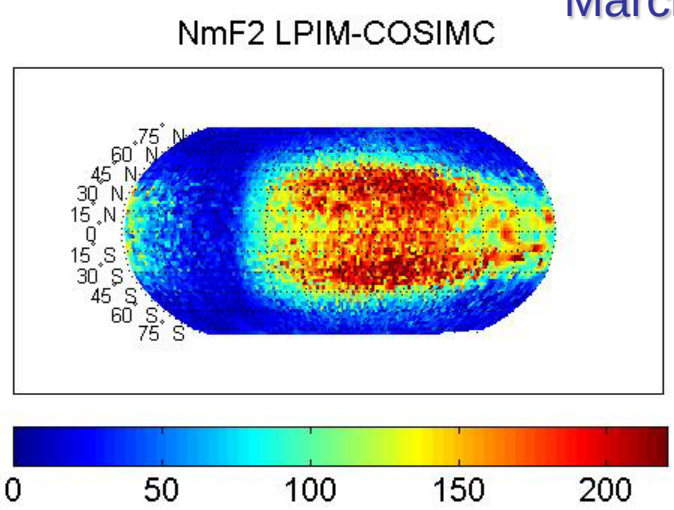


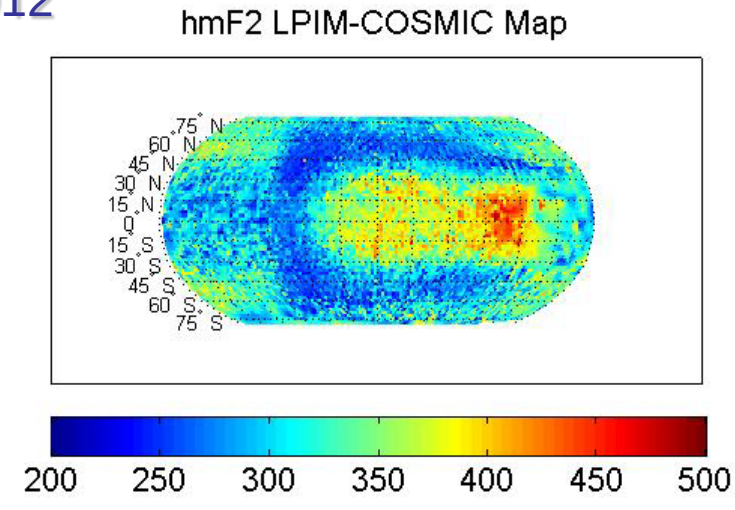

Present work

Period used for determining the CCIR coefficients

## II.a Examples of Nm and hm LPIM-COSIMC in LT-modip

### March 2012




### March 2007