ON DELETION OF QUESTIONABLE ELECTRON DENSITY PROFILES RETRIEVED USING THE COSMIC RADIO OCCULTATION (RO) TECHNIQUE

By

Dr. P. S. Brahmanandam (Anand)

Research Center in Remote Sensing Techniques
for Atmosphere and Ionosphere Studies
&
Professor, Department of Physics
Madanapalle Institute of Technology and Science (MITS)
Madanapalle-517 325, Andhra Pradesh, India.
Email: dranandpsb@mits.ac.in
Google scholar: https://scholar.google.com/citations?hl=en&user=eYISJwgAAAAJ

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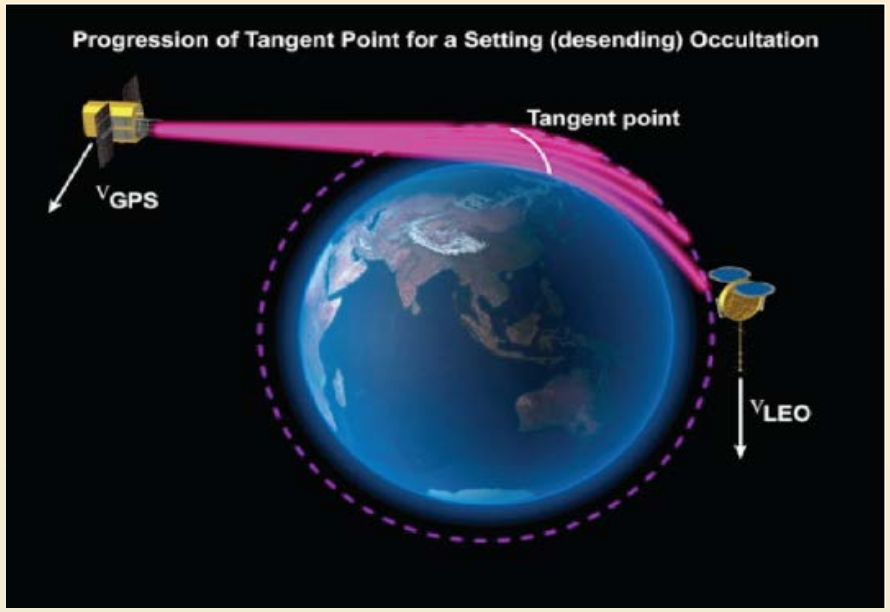
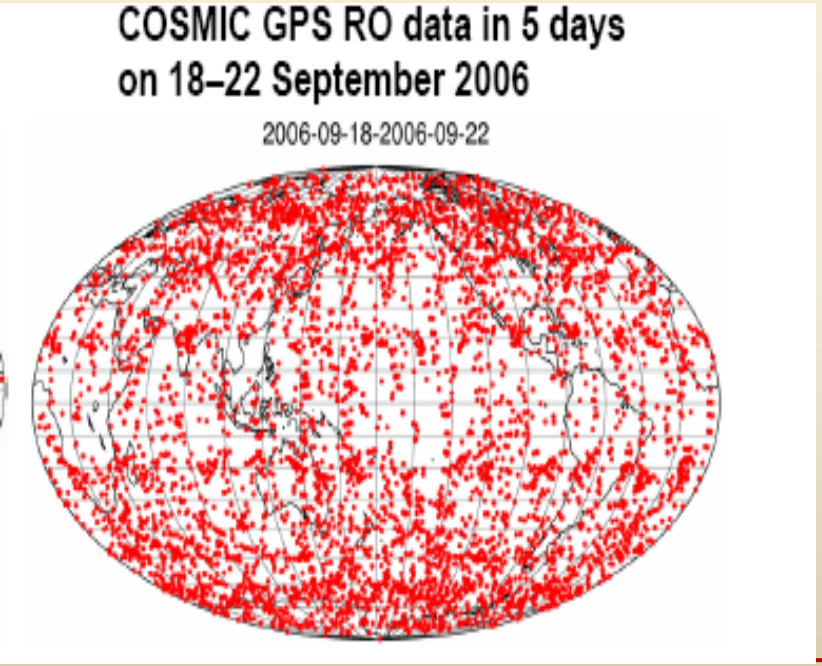
RADIO OCCULTATION CONCEPT

➢An occultation occurs when a GPS (GNSS) satellite rises or sets across the limb wrt to a LEO satellite.

➢ **A ray passing through the atmosphere is refracted due to the vertical gradient of refractivity (density).**

➢ During an occultation, the ray path slices through the atmosphere





COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate)

➢ Joint US-Taiwan mission & 6 LEO satellites launched on 15 April 2006

➢ Demonstrate “operational” use of GPS limb sounding with global coverage in near-real time

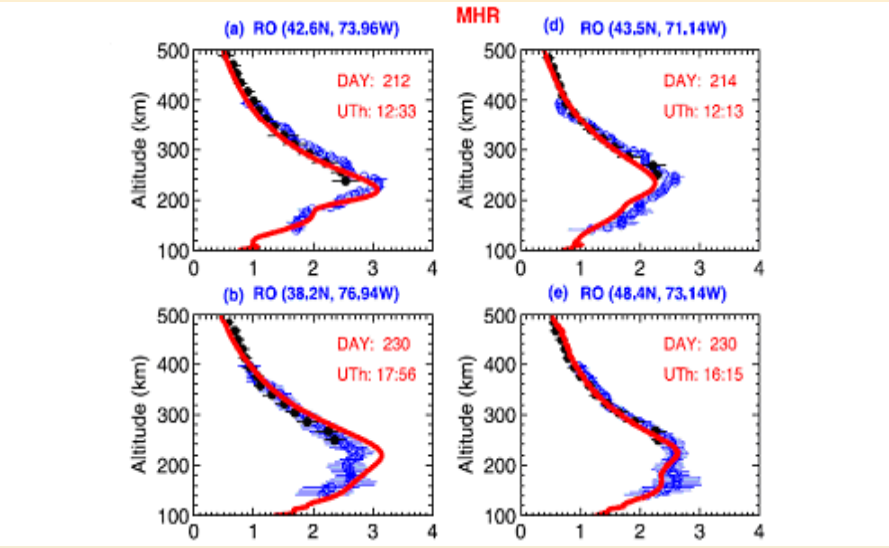
➢ web page: www.cosmic.ucar.edu

Comparisons between COSMIC RO EDPs & ground and model based EDPs

Figure shows comparisons of electron density profiles between COSMIC RO (solid lines) and Millstone Hill ISR (circles). Error bars are standard deviations for the ISR data over 1 hour [after Lei et al. 2007]

Approach: Radio occultation events with tangent points at the F2 peak height within 6° latitude and 6° longitude of the ISR data were selected

Observation: A good correspondence between them was found.



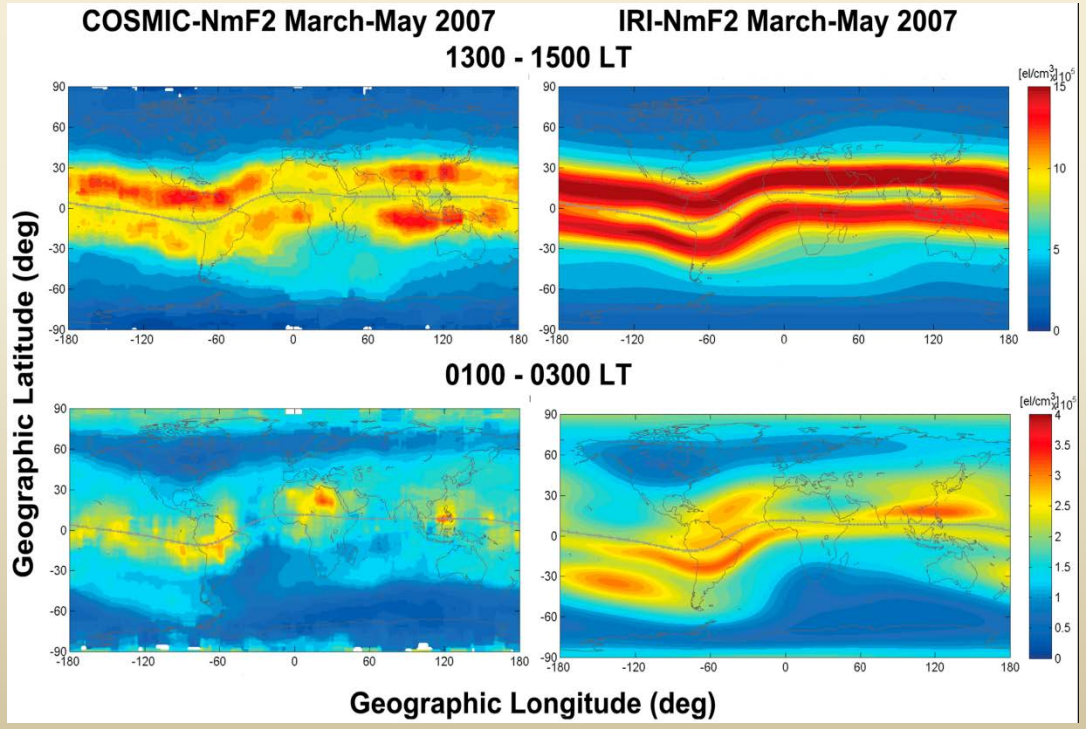
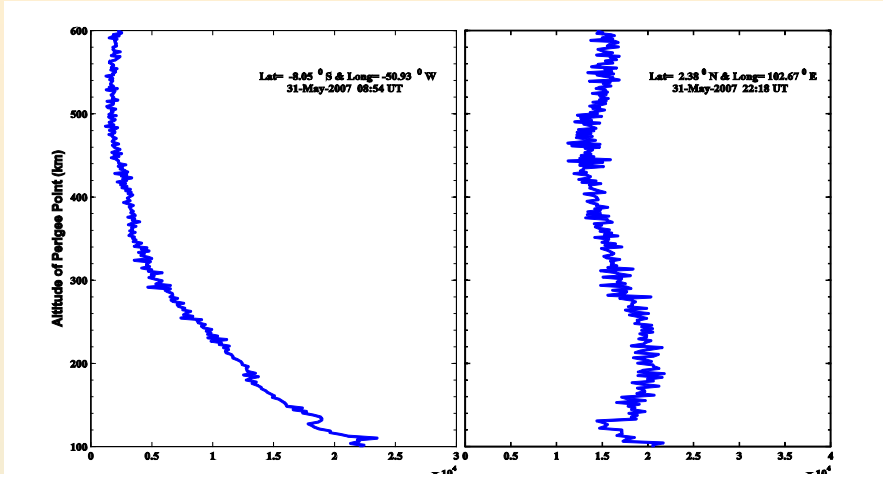


Figure shows global distributions of COSMIC and IRI NmF2 during daytime and nighttime March- May 2007 seasons, averaged between 1300 and 1500 LT (for daytime) and 0100 and 0300 LT (for nighttime) [after **Potula et al. 2011, JGR- Editor's Choice**].

Observation: A reasonable correspondence between them was found, with few exceptions

SPHERICAL SYMMETRY & FEW TYPICAL EXAMPLES OF QUESTIONABLE DENSITY PROFILES (QDP)

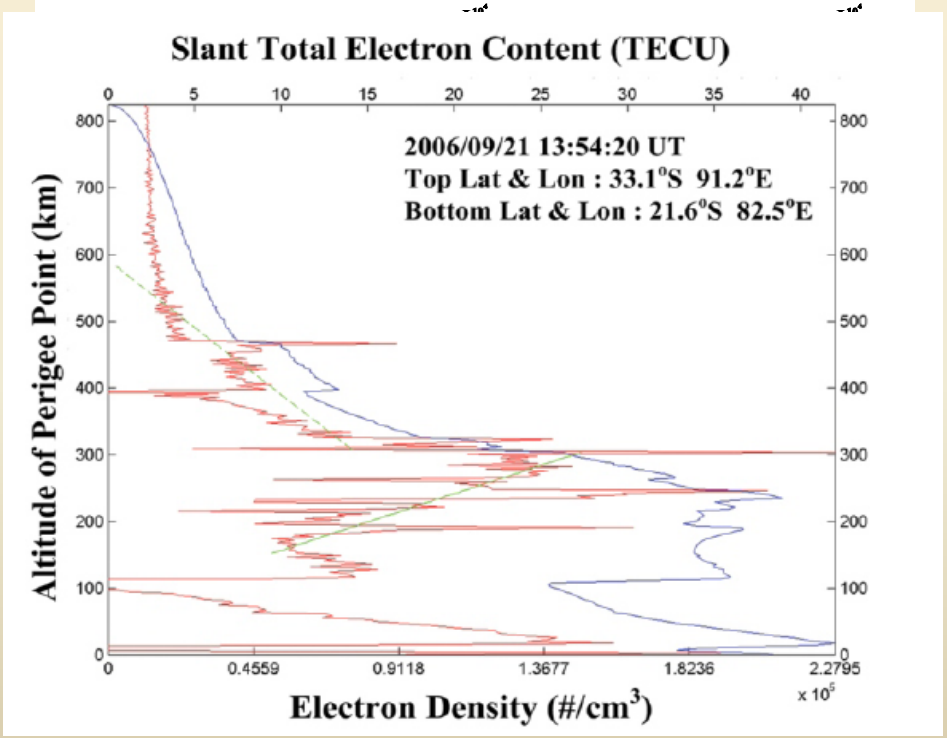
A crucial assumption -GPS RO technique - **Spherical symmetry** of atmosphere refractive at the locality of occultations, meaning that there is **no significant asymmetric *horizontal* variations.**



If no irregular electron density distributions in the GPS ray path, the occultation-retrieved electron density will be a smooth curve without random fluctuations superimposed on the curve.

However,

Due to the presence of ionospheric irregularities, the retrieved electron density profile will be highly fluctuating as shown.



Adopted methodology to relinquish QDP

RATIONALE:

Near-real time processed RO data –useful in data assimilation models

Decrease in either the data volume or data quality occurrence will have negative effects in both weather prediction and space weather monitoring

Due to the solar activity dependency of space weather occurrence, the negative effects of them on RO should be more significant during solar maximum years, and, hence more attentions should be paid by individual research groups

Our Approach:

Mean Deviation (MD) of electron density fluctuations and slope (or vertical gradient) of topside EDP.

$$MD = \sum_{i} \frac{\left| n_{ei} - \overline{n_{ei}} \right|}{N \overline{n_{ei}}}$$

N - Total data points in a profile

n_{ei} & $\overline{n_{ei}}$ measured background (obtained by taking 9-point running average of the measured electron density profile) electron densities at the i-th height

Farther the measured electron density deviates from the background value, the larger the magnitude of MD will be.

Statistics show majority of MDs appear in range between 0-1.5

TOPSIDE SLOPES

Positive gradient or nearly uniform distribution in the topside portion of the F-layer(above NmF2).

Topside slopes of density profiles are calculated by dividing the electron density profile with altitude in the height range between 420 and 490 km.

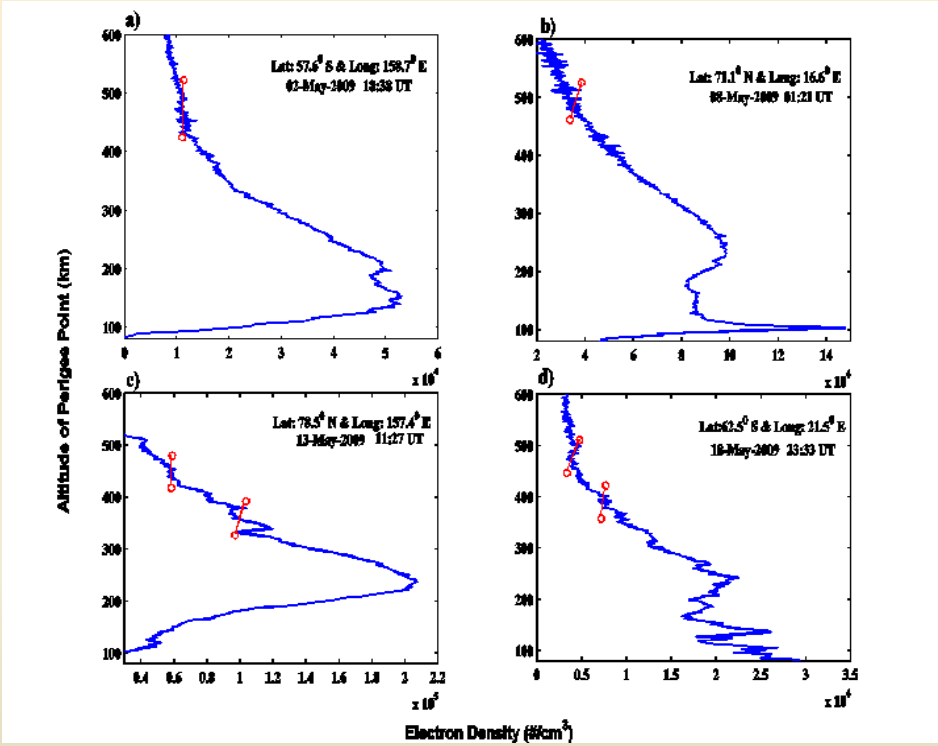
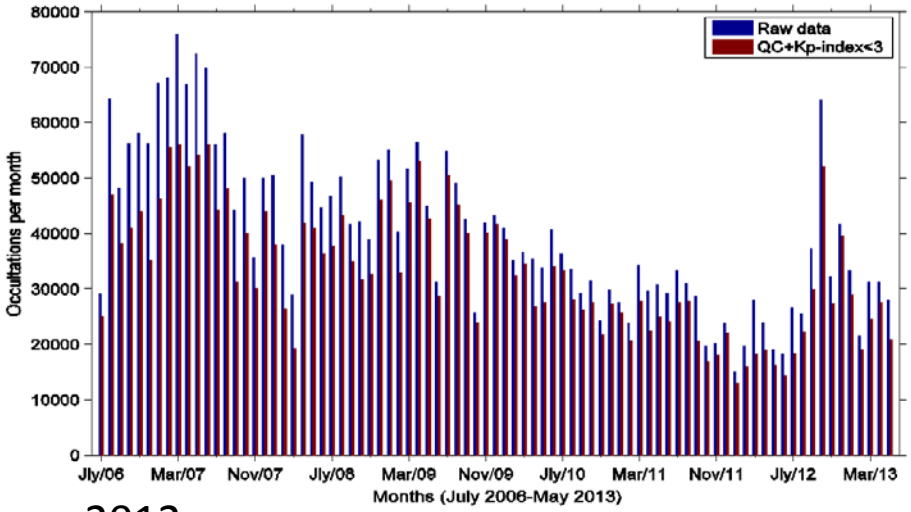


Figure shows different COSMIC electron density profiles with positive slopes at the topside ionosphere that are marked with red color dumbbell

Global features of mean deviations

Figure shows a bar graph, wherein the total number of COSMIC occultations before and after QC checks during July 2006 and May 2013 are presented



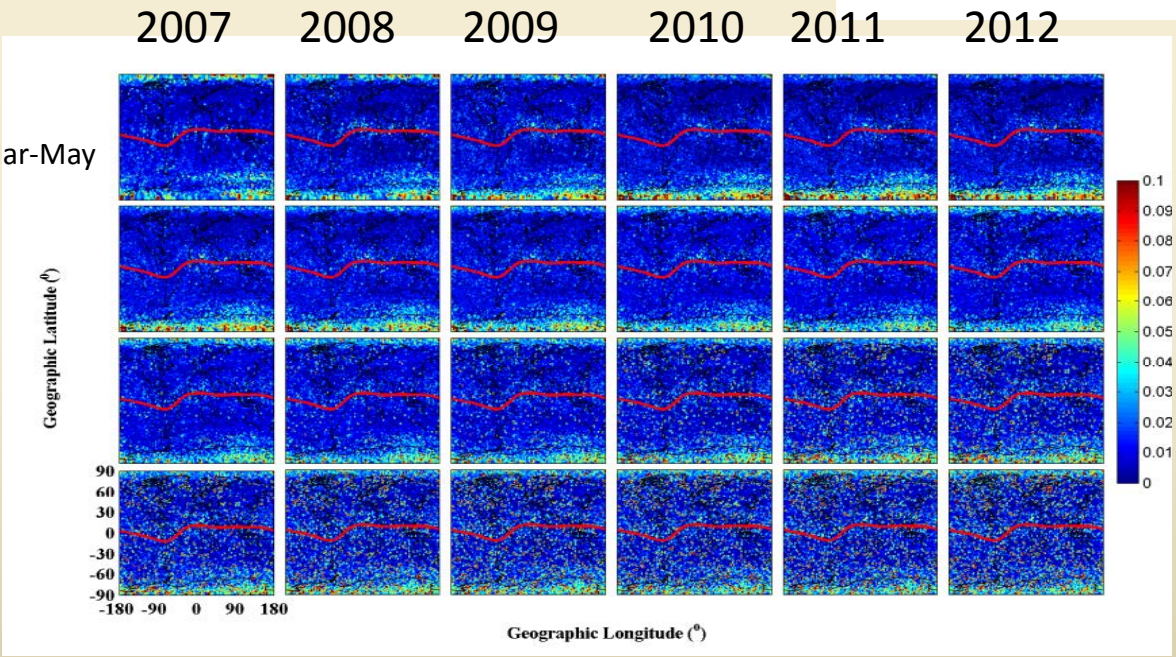


Figure shows global-seasonal variations of mean deviations of processed density profiles during different seasons between 2007 and 2012

Observation: a) Southern polar regions are associated with higher values during most of the seasons. This feature strongly suggests that the ionospheric electron densities in the southern polar region were much more irregular than those in the northern polar region

b) Increasing intensities wrt to increasing solar activity i.e. MDs show solar activity dependence.

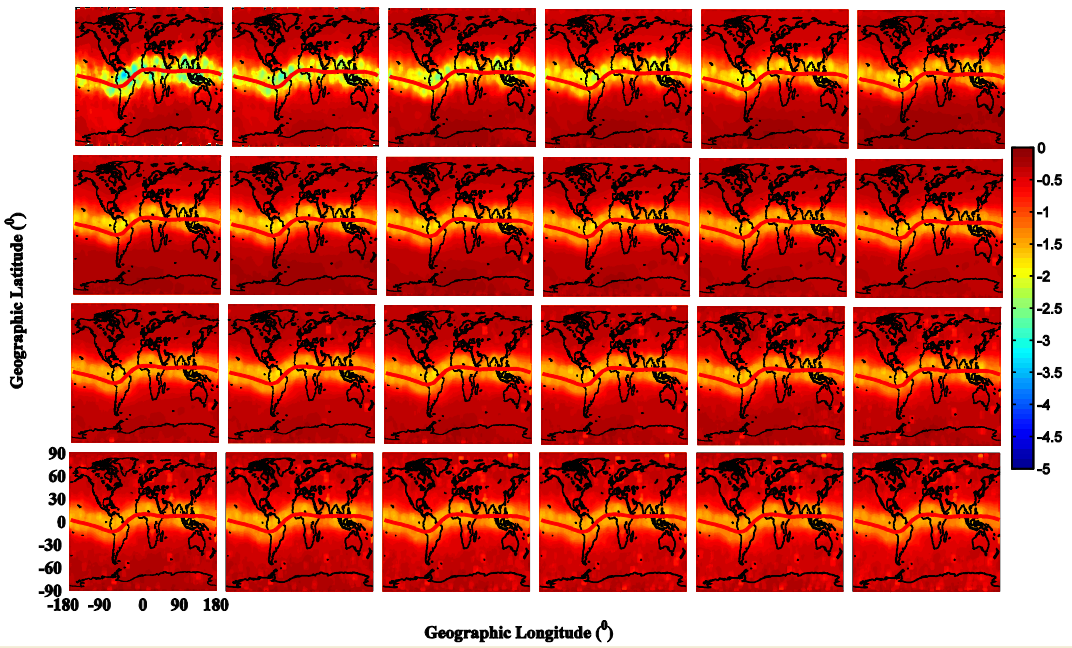


Figure shows global-seasonal variations of topside slopes of processed density profiles during different seasons between 2007 and 2012

Observation:

a) Pronounced variation within around $\pm 30^0$ latitudes and no such features are found above around $\pm 30^0$ latitudes during most of the seasons

b) No clear solar activity dependent (!)

TYPICAL COMPARISONS- UNPROCESSED & PROCESSED

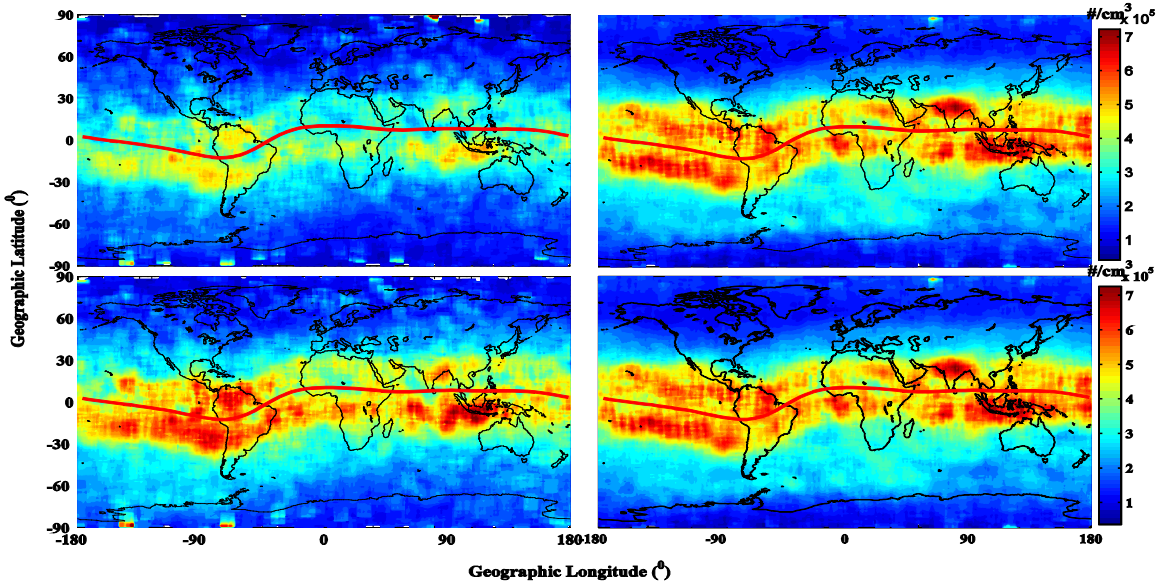
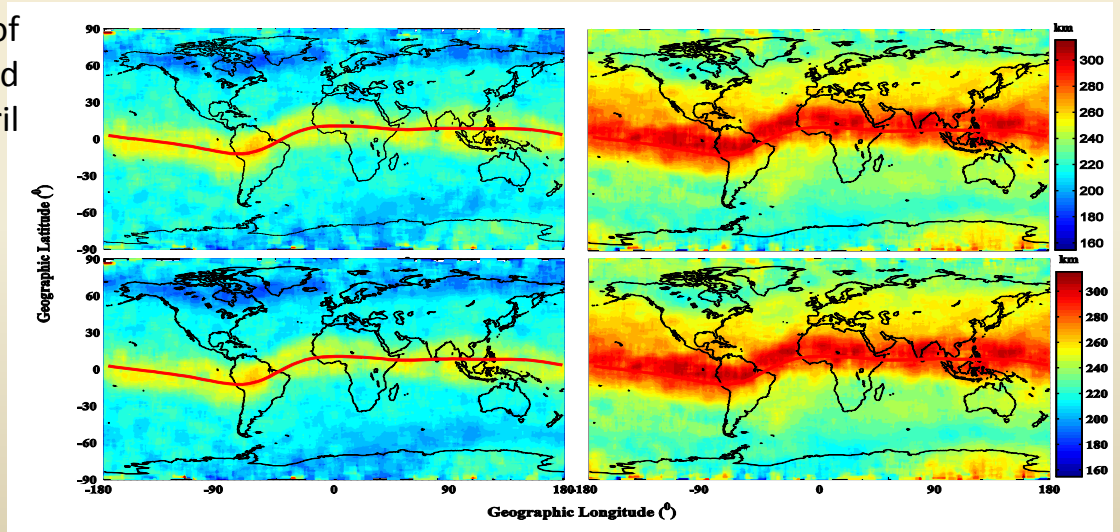


Figure shows global peak density variations of unprocessed (topside panels) and processed (bottom side panels) profiles for March and April 2009

Observation: EIA structures over the entire Pacific Ocean regions are not appearing for unprocessed profiles and the magnitudes associated with EIA structures at west and east side of African continent, over the south American continents and over the eastern part of Indian ocean are not comparable with processed density profile during March 2009

Figure shows global peak height variations of unprocessed (topside panels) and processed (bottom side panels) profiles for March and April 2009

Observation: No prominent differences were found, unlike peak densities.



CONCLUSIONS

- A mere, yet a powerful method, on the deletion of QDP of COSMIC RO technique is presented, which relies again on COSMIC own database rather than relying on any model or other ground-based data

- After the implementation of this innovative QC scheme, more than 581271 (~17%) questionable profiles were discarded during the 83 months study period (July 2006-May 2013).

- The plotted global trends of mean deviations and topside fluctuations have shown solar activity dependency and pronounced variations between around $\pm 30^0$ latitudes.

- Comparisons of peak electron densities between unprocessed and processed density profiles has shown remarkable differences in large-scale structures and magnitudes associated with them, which indicating that the electron density profiles being provided by COSMIC RO technique need to be used only after the deletion of questionable profiles.

- Though CDAAC do not filter QDP at present, it is anticipating that such efforts will be taken during its future missions such as COSMIC-2, which is going to be launched during the mid of 2016.

- However, in order to delete the so-called questionable profiles being provided by the COSMIC RO technique, our procedure may be helpful.

Thanks for your kind attention