

Comparison of the IRI-2007 Topside Electron Density with CHAMP and COSMIC/Formosat-3 Data

C. Mayer and N. Jakowski
 German Aerospace Center (DLR), Institute of Communications and Navigation, D-17235 Neustrelitz, Germany
 Christoph.Mayer, Norbert.Jakowski@dlr.de

Abstract

Reported are results of a comparison of the topside electron density of the IRI-2007 model with data obtained from the CHAMP and the COSMIC/Formosat-3 satellite missions.

Starting from 2001 we have collected on average 15 tomographic reconstructions of the topside electron density every day using GPS data of the zenith-viewing antenna onboard CHAMP. These data sets form the basis of a comparative study with IRI-2007 topside data. While this long-term data basis enables us to study solar cycle dependent effects in the upper ionosphere/plasmasphere, the electron density profiles derived from COSMIC/Formosat-3 offer an up to now unprecedented temporal and spatial resolution with up to 2500 profiles per day.

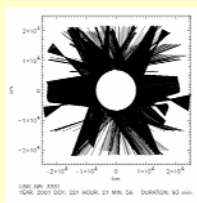
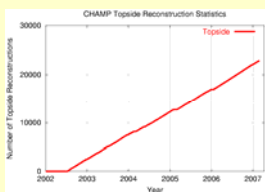
As more and more of the COSMIC satellites approach their design orbits in about 800km height, the upper part of the electron density profiles can provide valuable information about the transition region between the ionosphere and the plasmasphere. Starting from F2-layer height we compare the results with the IRI-2007 model.

Data basis

1. Topside GPS CHAMP

Data Assimilation [1]

- Grid adapted to geographic/geomagnetic coordinates
- Background Model: PIM 1995 [2]
- Iterative multiplicative assimilation algorithm



Each day we obtain 15-16 topside reconstructions

Data is collected during a full revolution of CHAMP. The distribution of links projected onto the orbit plane is shown above.

2. COSMIC Electron Density Profiles [3]

COSMIC – Constellation Observing System for Meteorology, Ionosphere, Climate
 FORMOSAT-3 – Taiwan's Formosa Satellite Mission #3

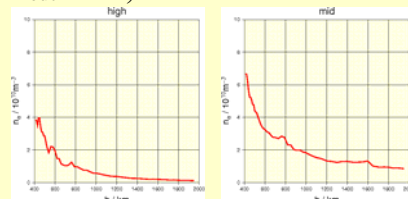
- Taiwan/USA (UCAR, NSF, NASA, USAF, NOAA/NSPO, ONR)
- Launch: April 15, 2006
- 6 Satellites, FM1-FM6, height: 600-800km
- Up to 2500 IRO/day
- >700,000 IRO total
- COSMIC Data Analysis and Archive Center CDAAC

<http://cosmic-io.cosmic.ucar.edu/cdaac/index.html>

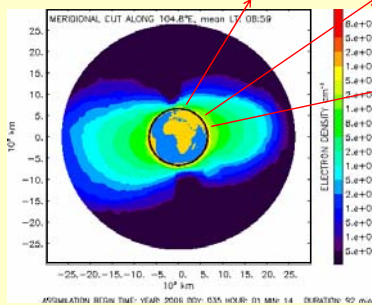
Method of comparison:

$$\text{relative difference} = \text{median} \left(\frac{\text{measurement} - \text{model}}{\text{model}} \right)$$

Vertical electron density profiles between 400km and 2000km height are extracted from the 3D-Reconstructions made from CHAMP topside GPS measurements at latitudes $-80^\circ, -60^\circ, \dots, 0^\circ, \dots, 60^\circ, 80^\circ$ along the CHAMP orbit.



CHAMP topside reconstruction for 2006-035 01:15 UTC.



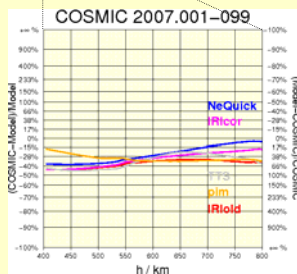
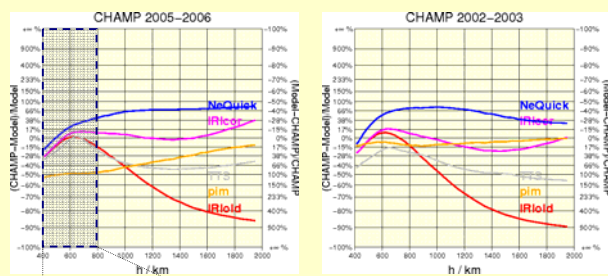
The shown electron density profiles are taken from the 100° meridian, as indicated by the arrows.

The compression of the plasmasphere on the day-side is visible.

IRI2007 Model Topside options [4]:

- old IRI topside (IRIold)
- new IRI topside (IRIcor)
- NeQuick
- TTS (Tršková, Truhlík, Šmilauer) [5]

Results: COSMIC/CHAMP vs Model:



Since we have CHAMP topside data starting from 2002, we are able to perform the comparison for different levels of solar activity:

- 2002-03: $80 < F_{10.7} < 250$, 125,931 profiles
- 2005-06: $70 < F_{10.7} < 120$, 85,354 profiles

The COSMIC profiles have a maximal height of ca. 800km. The number of profiles ranges from 228,718 at 400km to 65,841 at 800 km.

Although the number of profiles is comparable to the number of extracted CHAMP topside profiles, a period of only 99 days is covered while for CHAMP we use several years of data.

Results: CHAMP vs Model

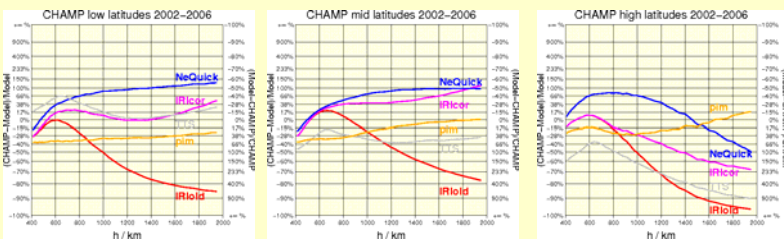
The plot on the right side shows a comparison of CHAMP with IRI-2007 topside models and with the PIM model.

On the left (right) axis deviations of measurements (models) relative to the models (measurements) can be read off.

We perform the comparison for different latitude ranges:

- Low latitudes: $\text{abs}(\text{lat}) < 30^\circ$
- Mid latitudes: $30^\circ < \text{abs}(\text{lat}) < 50^\circ$
- High latitudes: $\text{abs}(\text{lat}) > 70^\circ$

From 2002-2006 we have extracted 290,225 profiles in total, that is 64484, 64497, and 96746 profiles in high, mid, and low latitudes.



Conclusions:

- We have compared vertical electron density profiles obtained from CHAMP topside tomography with the IRI-2007 model.
- The four topside models implemented within IRI-2007 show a different behaviour. The model IRIcor shows the best fit to the data.
- The largest deviations occur at high latitudes and under high solar activity conditions.
- In addition we have compared COSMIC ionospheric radio occultation profiles to IRI-2007 with similar results but less statistics.

Acknowledgements:

We gratefully acknowledge the provision of COSMIC data by CDAAC. This work has been financially supported by the German State Government of Mecklenburg-Vorpommern under the Grant V230-630-08-TIFA-334.

References:

- [1] Heise et al., GRL, 29, No. 14, 44-1, 2002
- [2] Daniell, et al., Radio Sc., 30 (5), 1995
- [3] <http://cosmic-io.cosmic.ucar.edu/cdaac/index.html>
- [4] <http://nssdcftp.gsfc.nasa.gov/models/ionospheric/iri>
- [5] Truhlík, et al., Adv. Space Res., 33 (6), 2004