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Inter-hemispheric comparison of the ionosphere-plasmasphere system from multi-instrumental/model approach.

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Context

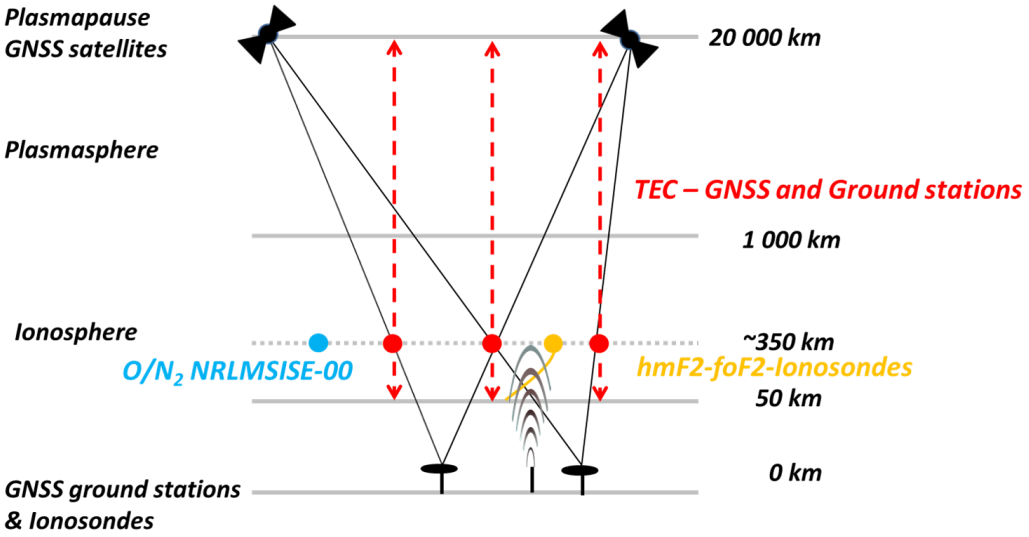
BEZA-COM project (NRF/BELSPO): Interhemispheric Comparison of the Ionosphere-Plasmasphere System. 2019-2021

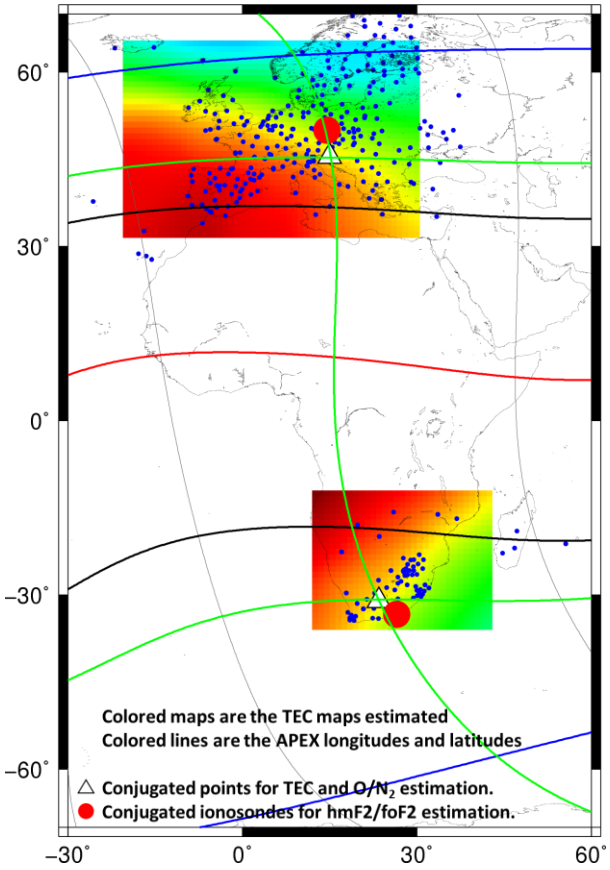
"What are the differences in the inter-hemispheric conjugacy between the ionosphere and that in the lower, middle and upper atmospheres, and what causes those differences?"

From : Kennicutt, et al., 2015 - A roadmap for Antarctic and Southern Ocean science for the next two decades and beyond*, International Steering Committee of the Scientific Committee on Antarctic Research (ISC-SCAR) , *Antarctica Science.

Here : Inter-hemispheric comparison of TEC, hmF2/foF2, O/N_2 based on data/model

Concept





TEC data (15-20 years)

IONEX maps. 2003-2018 for South Africa, 1998-2018 for Europe. Sampling rate 15 min. Grid resolution 0.5°x0.5°

Ionosondes data (hmF2 anf foF2, 15-23 years)

Grahamstown (SA) 1996-2019. Sampling rate : hourly to 15 min. Průhonice (CZ) 2004-2019. Sampling rate : hourly.

O/N_2 data (18 years)

2000-2018 data from NRLMSISE-00 model (Picone et al. 2002) output of O/N_2 at 350 km altitude. Sampling rate : 1 minute.

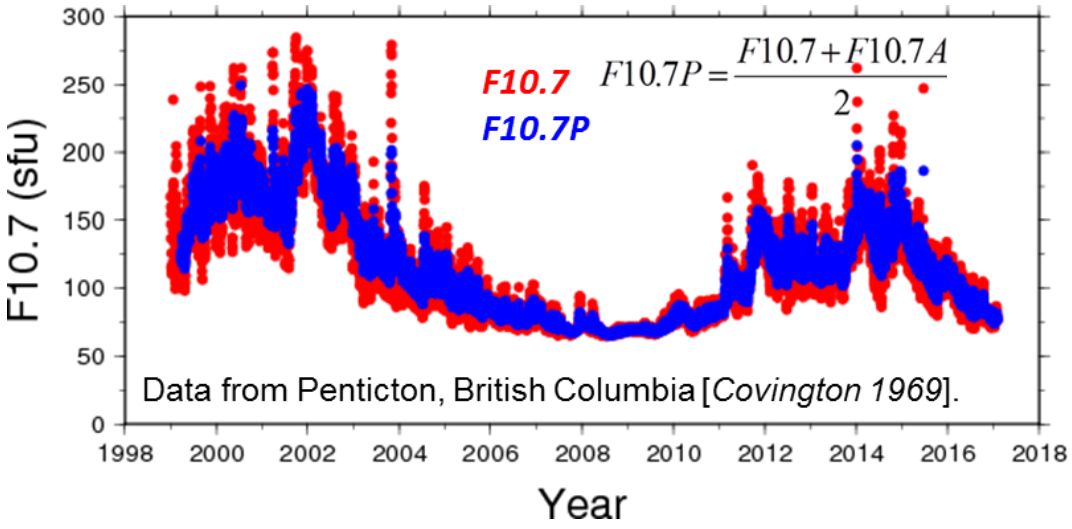
Data extraction

E90° N-S 40° in Geomag. Coord. (APEX, Richmond 1995)

Empirical models for comparison

Empirical models based on F10.7P index (~ EUV emission from the Sun)

The data sets is then employed to constrain an empirical model to predict the vTEC, hmF2, foF2, and O/N_2 at a given time and location from F10.7P solar index in entrance using a least-square adjustment.



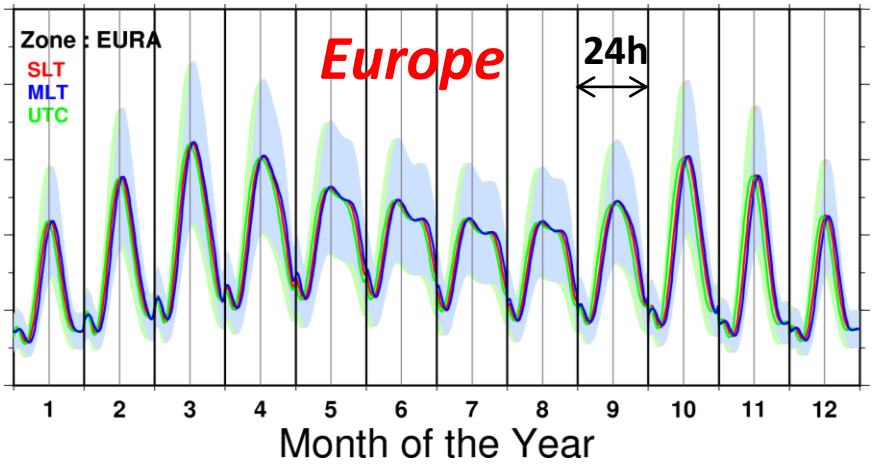
To minimize the differences between the modelled and observed TEC we considered:

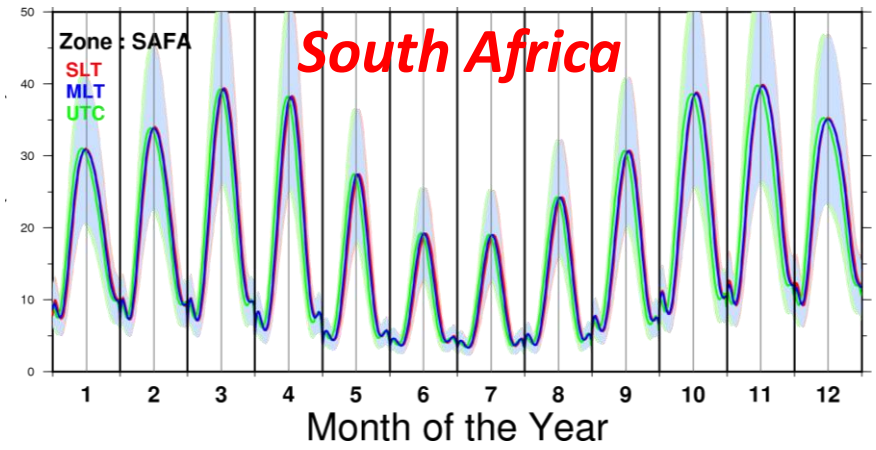
- An eight-order polynomial function between the parameter and F10.7P

$$TEC\ (or\ hmF2\ or\ foF2\ or O/N_2) = F10.7P \sum_{i=0}^{i=8} (\alpha_i t^i + \beta)$$

- A discretization with respect to the month of the year.

How to read the next slides ?



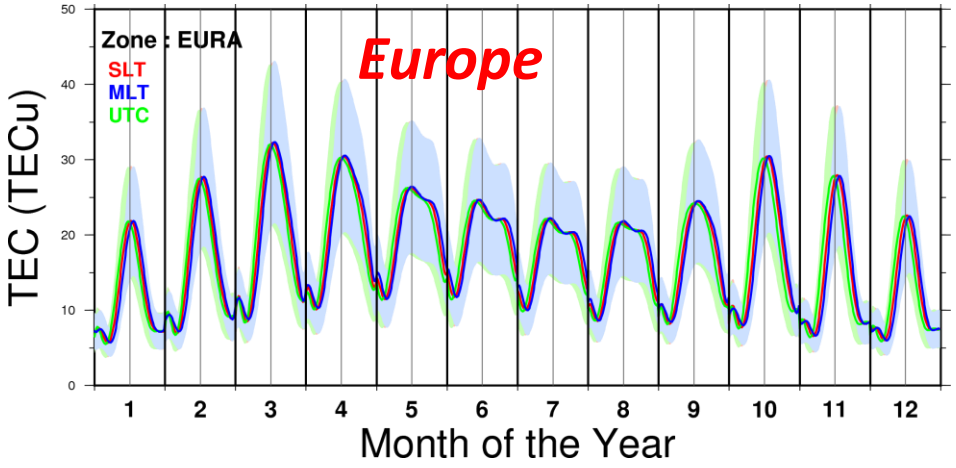


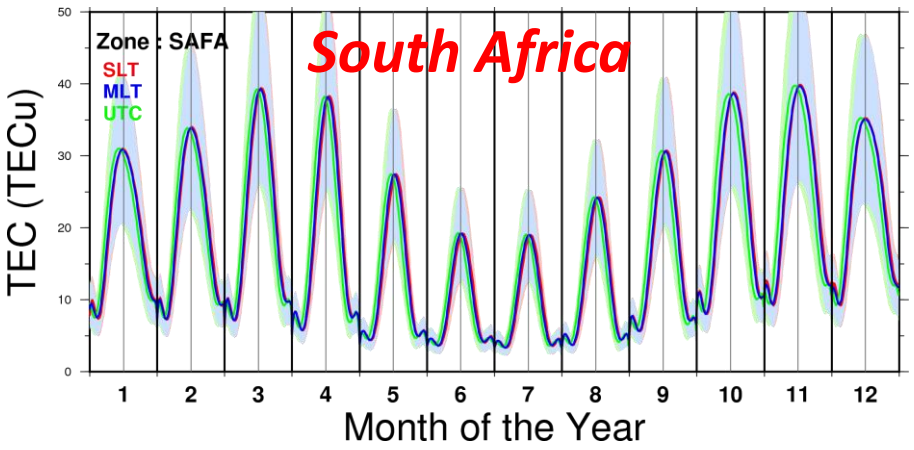
Monthly climatological behavior *of the quantity considered (TEC, hmF2, foF2 or O/N_2) for different time definitions: Solar local time (SLT, red), Coordinated Universal Time (UTC, green) and Magnetic Local Time (MLT, bleu). The grey line is the noon for the difference time definitions.*

The colored lines are the daily variability of the quantity for medium solar activity level (F10.7P = 120 sfu). The spread of the colors stands for low and high solar activity (F10.7P= 80 and 160 sfu respectively).

All the interpretation in the next slides are for a medium solar activity level : F10.7P = 120 sfu

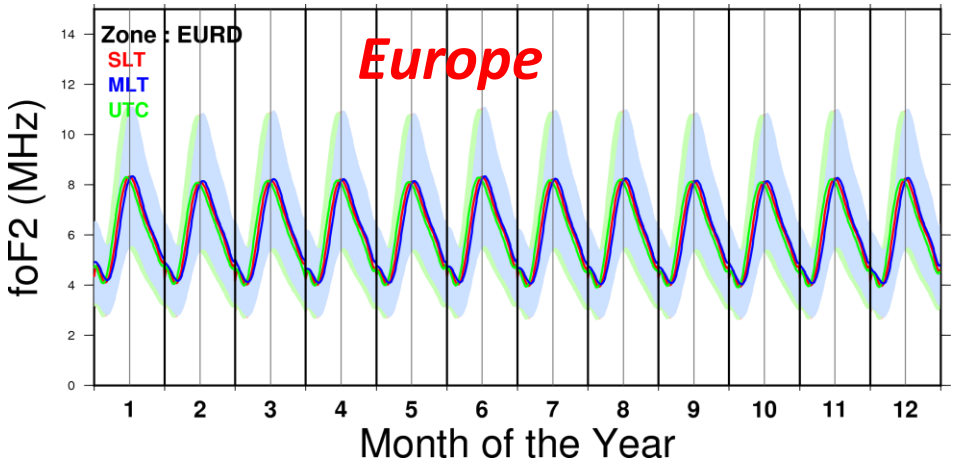
Inter-hemispheric TEC comparison

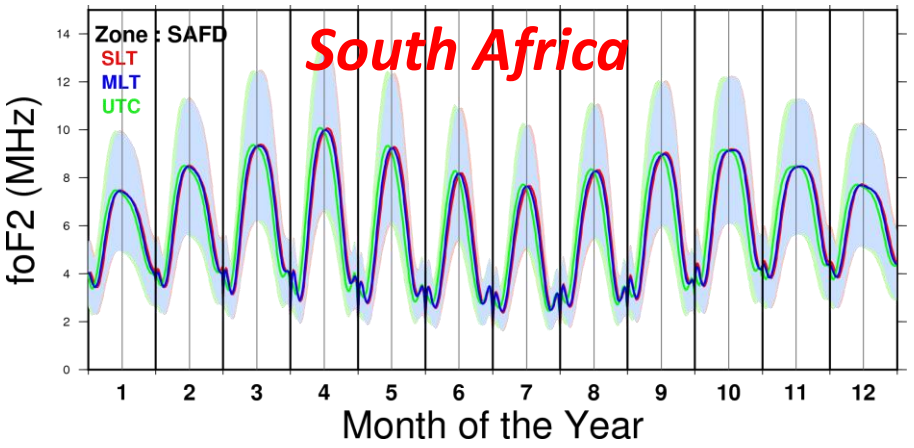




- ✓ The TEC shows different max. and min. values for the two hemispheres. This is mainly due to the solar zenith angle and geographic latitudes differences of the two localizations considered.
- ✓ For a mean solar activity level, the maximum TEC is around 40 TECu over South Africa during equinoxes, and 32 TECu over Europe.
- ✓ The amplitude of the daily variation is more pronounced over the Southern hemisphere.
- ✓ The double crest around noon is present during summer period over Europe (North hemisphere) while it is not visible over South Africa.

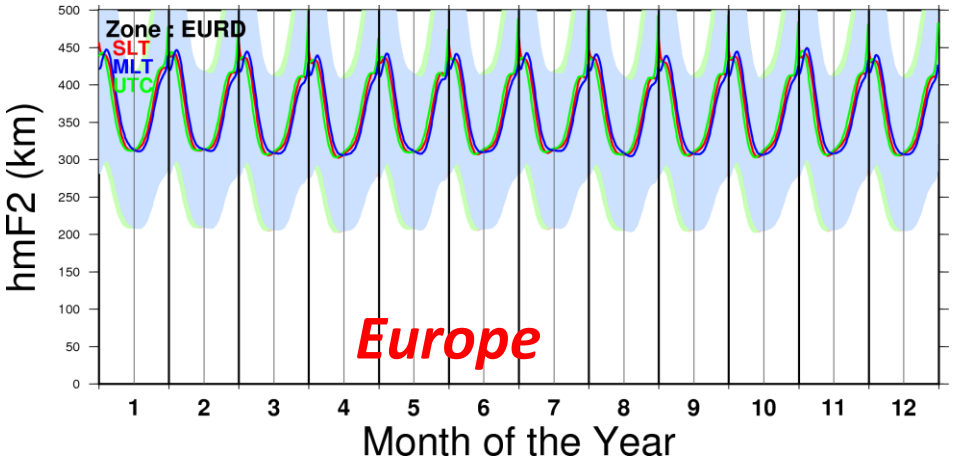
Inter-hemispheric foF2 comparison

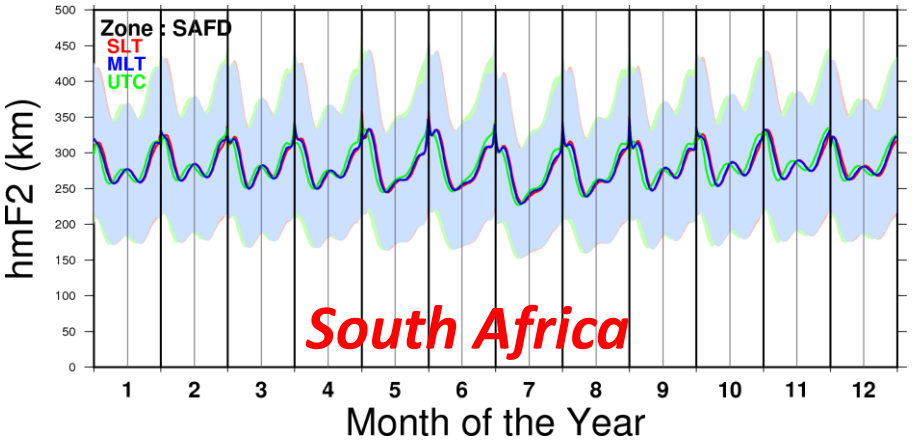




- ✓ The foF2 shows different max. and min. values for the two hemispheres. There is no clear annual variation for the European region compare to South Africa
- ✓ For a mean solar activity level, the maximum foF2 is around 10 MHz over South Africa during equinoxes, and 8 MHz over Europe.
- ✓ The amplitude of the daily variation is more pronounced over the Southern hemisphere.
- ✓ The double crest around noon is not present during summer period over Europe (North hemisphere) nor South Africa.

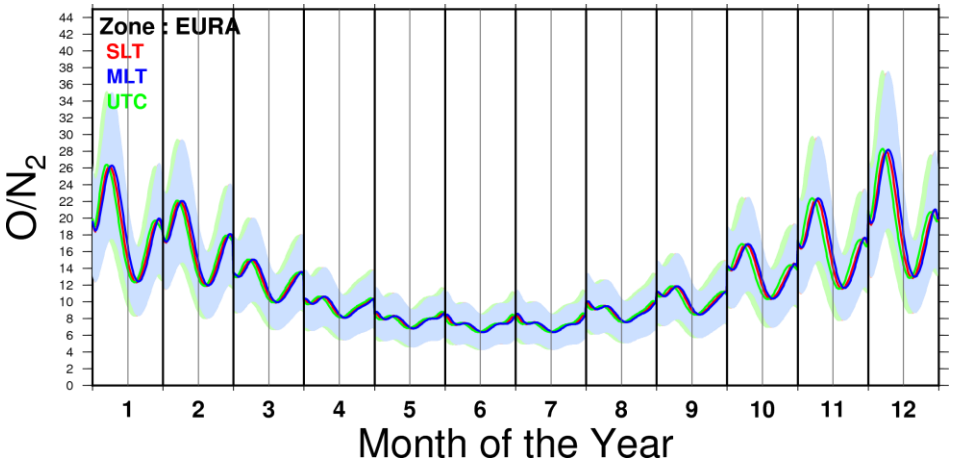
Inter-hemispheric hmF2 comparison

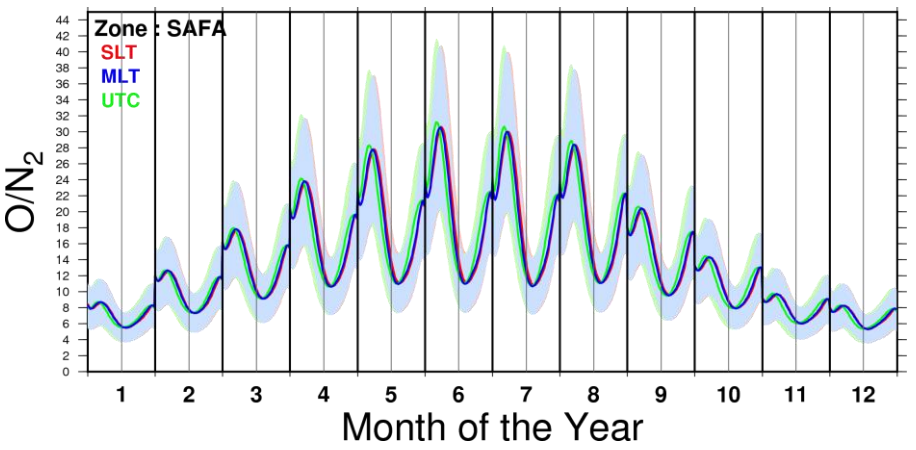




- ✓ The hmF2 shows different max. and min. values for the two hemispheres. This is mainly due to the solar zenith angle and geographic latitudes differences of the two localizations considered.
- ✓ There is no change of the hmF2 during the year for both hemispheres
- ✓ For a mean solar activity level, the mean hmF2 is around 300 km over South Africa and 400 km over Europe.
- ✓ The amplitude of the daily variation is more pronounced over the Northern hemisphere.

Inter-hemispheric O/N_2 comparison





- ✓ The maximum of the O/N_2 is more or less the same ($O/N_2 \approx 30$) during the at 06:00 (UTC, LMT, SLT) in the Southern hemisphere and the Northern hemisphere during their respective winter seasons.
- ✓ The minimum O/N_2 (i.e. during hight solar zenith angle at noon) is the same for the two hemispheres ($O/N_2 \approx 6$).
- ✓ The amplitude of the variation is more pronounced over the Southern hemisphere.

Summary and conclusions

	Similarities	Differences	
		Europe	South Africa
TEC	Annual variation Maximum at local noon	Double crest Max: 32 TECu Min: 5 TECu	More daily amplitude Max: 40 TECu Min: 3 TECu
foF2	Maximum at local noon	No annual variation Max: 8 MHz Min: 4 MHz	Annual variation Max: 10 MHz Min: 2 MHz
hmF2	No annual variation Minimum at local noon	Max: 450 km Min: 300 km	Max: 320 km Min: 250 km
O/N_2	Annual variation Maximum at 06:00 UTC Max : 30 Min : 6		More daily amplitude

- ✓ This study use long-term data sets (> 15 years) to study the coupling between the TEC, foF2, hmF2 and O/N_2 at two conjugated localization in the Northern and Southern hemispheres.
- ✓ The differences in the TEC annual variation seem to the O/N_2 compare to the foF2 and hmF2 parameters for the annual variation.
- ✓ The daily maximum and minimum TEC values, are however linked to the foF2 variations, which is more pronounced over the Southern hemisphere compare to North.
- ✓ The next step is to estimate the plasmaspheric contribution by using Radio occultation data.