# Sporadic E layer climatology derived from CHAMP, GRACE and COSMIC radio occultations: Initial results from GFZ Potsdam


C. Arras, J. Wickert, Ch. Jacobi*, S. Heise, G. Beyerle, T. Schmidt and M. Rothacher

GeoForschungsZentrum Potsdam, Department 1.1, Geodesy and Remote Sensing, Germany
* University of Leipzig, Institute for Meteorology, Germany


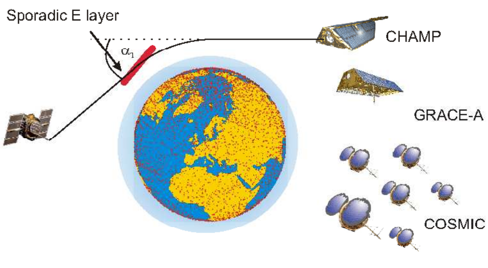


*Fig.1:* *GPS radio occultation scheme for detecting sporadic E-layers.*

## 1. Introduction

Sporadic E layers are patchy thin areas of enhanced electron density which appear mainly during daytime on the summer hemisphere. They cause strong fluctuations in GPS Radio Occultation (RO) signals. These disturbances are visualised in the analysis of the Signal to Noise Ratio (SNR) of the GPS L1 signal which has been measured onboard the CHAMP (launched in 2000), COSMIC and GRACE (data available since 2006) satellites. These satellites provide about 2500 globally distributed occultation measurements per day. Usually, the 50 Hz RO profiles are used for the derivation of neutral atmospheric parameters like temperature, pressure and water vapour content. But with a starting altitude of about 130 km above the Earth's surface the 50 Hz occultation data also contain more detailed information on the ionospheric fine structure. Therefore they are adequate to observe the spatial and temporal variation of sporadic E occurrence on a global scale. In total we analyzed 1,016,100 occultation profiles with 142,185 of them including sporadic E signatures. We present initial results of the derivation of sporadic E information from the multi-satellite GPS RO data set. We introduce first global climatologies of sporadic E occurrence with a high spatial resolution and the interannual variability of global sporadic E occurrence.

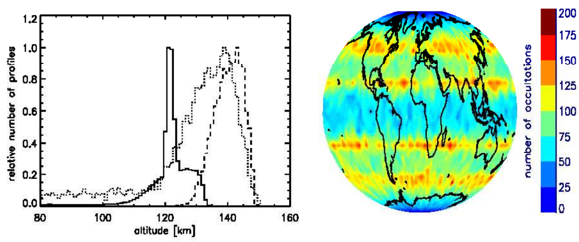


***Fig.2:*** ***left -*** *Distribution of maximum altitude of GPS RO data (50 Hz) from CHAMP (dotted), GRACE-A (dashed) and FORMOSAT-3/COSMIC (solid).*
***right -*** *Global data coverage of CHAMP + Grace-A + COSMIC occultations in summer (June, July, August) 2007 with a resolution of 5°x5°.*

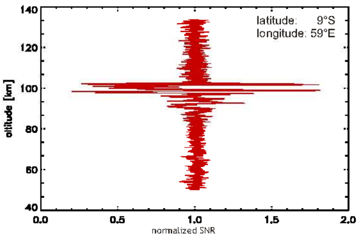


***Fig.3:*** *Example for a CHAMP/GPS RO measurement of the SNR with the signature of a sporadic E layer in an altitude of about 100 km on January 1, 2003.*

## 2. Detection of sporadic E layers

Because of their high iononization level and strong ionization gradients sporadic E layers have a considerable effect on radio wave communication which is used for their detection. GPS signals are modified related to the refractive index of the atmosphere which is only dependent on electron density in the ionosphere. Therefore, scintillations in GPS signals can directly be related to electron density fluctuations.

## 3. Interannual behavior

Fig. 4 shows the first long-term series of global sporadic E occurrence derived from CHAMP measurements. Sporadic E is mainly a summer phenomenon with strong variations in duration and latitudinal extension of the summer maximum. Occurrence rate maxima on the northern hemisphere are generally higher than on the southern hemisphere.

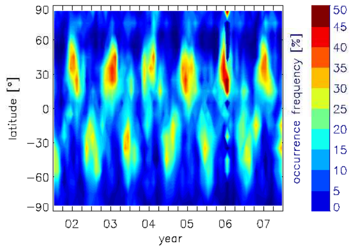


***Fig. 4:*** *Time series of monthly relative sporadic E occurrence rates in dependency of geographical latitude (10° resolution) measured by CHAMP between January 2002 and December 2007.*

## 4. sporadic E annual variation derived from CHAMP, GRACE and COSMIC radio occultation

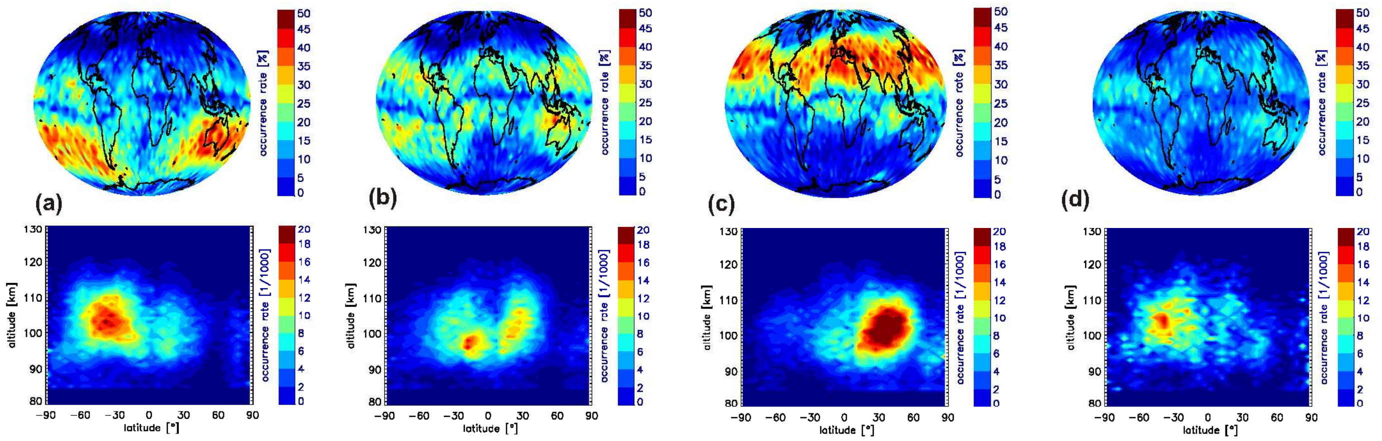


***Fig.5:*** *Seasonal behaviour of sporadic E layers detected with CHAMP, GRACE and COSMIC in a time intervall from December 2006 to November 2007 with a resolution of 5°x5°.* ***(a)*** *winter (December 2006, January 2007, February 2007),* ***(b)*** *spring (March, April, June 2007),* ***(c)*** *summer (July, August, September 2007),* ***(d)*** *autumn (September, October, November 2007). The upper row contains plots of global relative sporadic E occurence rates. In the lower panels the corresponing altitude/latitude cross-sections are shown.*

## 5. Conclusion and outlook

The CHAMP, GRACE-A and COSMIC satellites provide an excellent database to investigate irregularities in the lower ionosphere. In this study we analysed more than 1,000,000 occultation measurements with respect to the occurrence of sporadic E layers. With this huge dataset it is possible to visualize the global Es occurence with improved spatial resolution compared to prior studies.
Next steps will be to expand the climatologies to examine possible coupling processes of the detected irregularities with the neutral atmosphere and with the Earth's magnetic field.


**Contact:**

Christina Arras
GFZ Potsdam
Telegrafenberg, 14473 Potsdam, Germany
Email: arras@gfz-potsdam.de