Validation of CHAMP Electron Density and Electron Temperature Data with Corresponding Data from the Arecibo Incoherent Scatter Facility

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1 INTRODUCTION

Incoherent scatter data from Arecibo have been used to verify the electron temperature and electron density data measured onboard CHAMP with the planar Langmuir probe. The radar data are well suited for such a comparison, since for so-called WORLD DAYS profiles of T_e (and N_e) are routinely measured between about 200 and 600 km altitude. In principle CHAMP passes the Arecibo area twice a day, but with quite variable distances from the radar scattering volume. We selected 150 overpasses on 63 days between September 2001 and July 2006 covering distances up to 2000 km, for which the data are available from the MADRIGAL data base.

2 LOCATION

Arecibo vicinity (see Fig.1): Subsequent CHAMP passes are about 23° in longitude($\approx$ 1.5h) apart. Thus we have at least two overpasses per day near Arecibo. The actual number of overpasses depends on the distance criterion (green circles). Within a radius of 1000 km we have ≈ 5 overpasses in 4 days as a long term average. The CHAMP cruising altitude decayed from about 430 km in 2001 to about 360 km in 2006.

3 VARIATION

Fig.2 shows a typical example of the daily variation of Te over Arecibo at three altitudes: Every day the electron temperature over Arecibo shows a steep increase between about 9 and 12 UT (4:30 - 7:30 LT) due to sunrise. The shape of the curve depends weekly on season. During this increase, which corresponds of course also to a large longitudinal gradient, the Arecibo and the CHAMP T_e may show a large difference, depending on CHAMP's location. We had to omit 5 overpasses from the data base due to this effect.
We calculated relative differences of electron density and electron temperatures as measured by CHAMP and Arecibo:

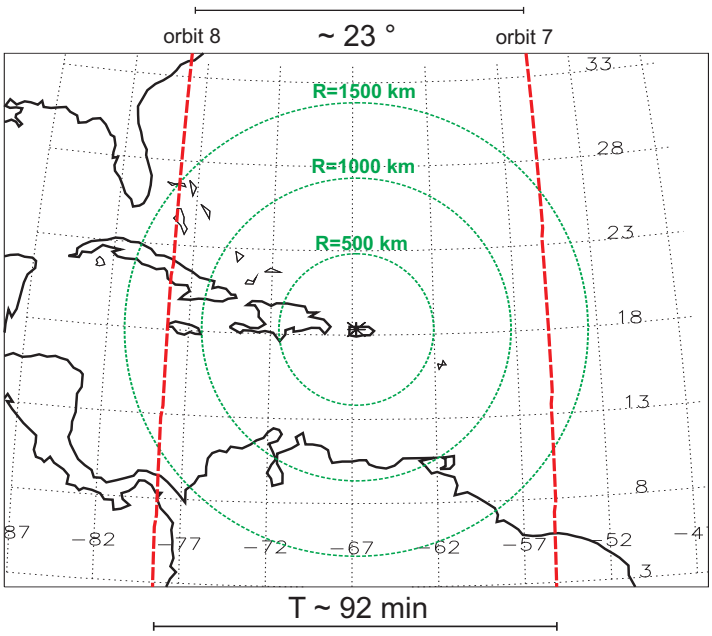

Figure 1: Arecibo location.

$$\mathrm{rd}(N_e) = \frac{N_e(\mathrm{CHAMP}) - N_e(\mathrm{Arecibo})}{(N_e(\mathrm{CHAMP}) + N_e(\mathrm{Arecibo}))/2} \quad (1)$$

$$\mathrm{rd}(T_e) = \frac{T_e(\mathrm{CHAMP}) - T_e(\mathrm{Arecibo})}{(T_e(\mathrm{CHAMP}) + T_e(\mathrm{Arecibo}))/2} \quad (2)$$

In the following we use the indicated relative differences rather then the absolute difference of N_e and T_e directly.

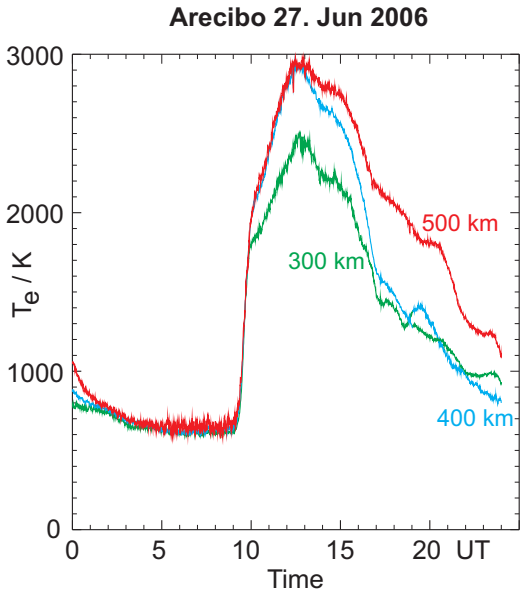

Figure 2: Variation of electron temperature.

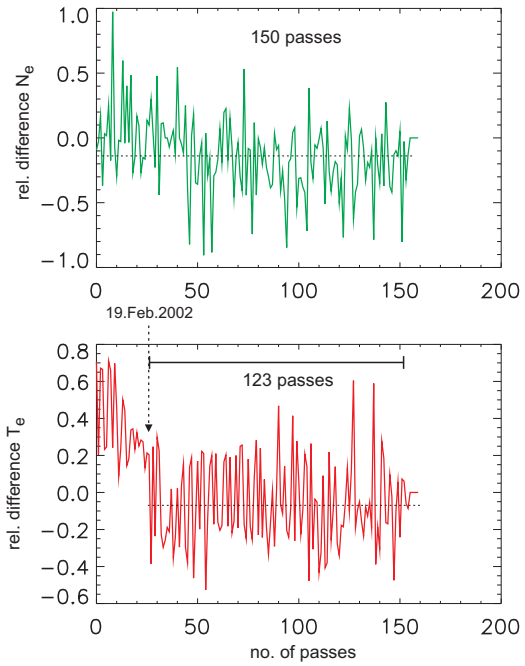

Figure 3: Relative differences between CHAMP and Arecibo.

In Fig.3 the relative differences are plotted just one after the other (more or less versus time) for all avaliable overpasses. Large systematic deviations can be seen, particularly in T_e (lower panel) for the 2001 and early 2002 data. On 19. Febr. 2002 the Langmuir Probe was re-calibrated, thus we discarded all 2001 data in the following. The effect is less pronounced but still visible in N_e (upper panel). 123 overpasses were left for the study within a range of 2000 km.
In Fig.4 we examine the scatter (standard deviation) and offset of the relative differences as a function of distance of CHAMP from the radar scattering volume. We are aware that a distance of 2000 km is too large, since considerable gradients, particularly in N_e can occur (this is evident from the strong variation of the offset

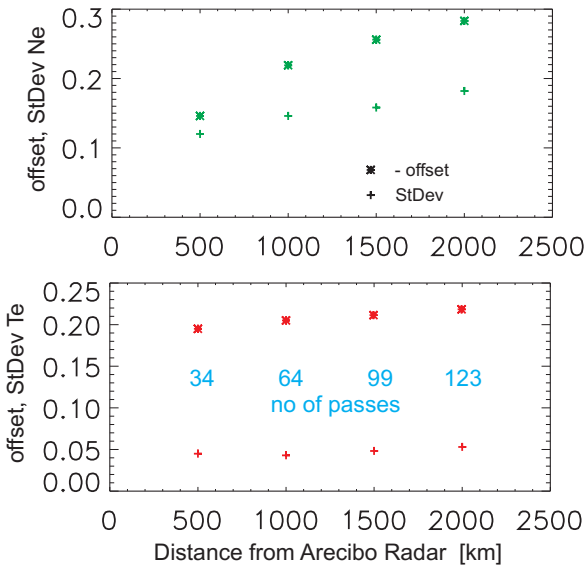

Figure 4: Scatter of results vs. separation distance.

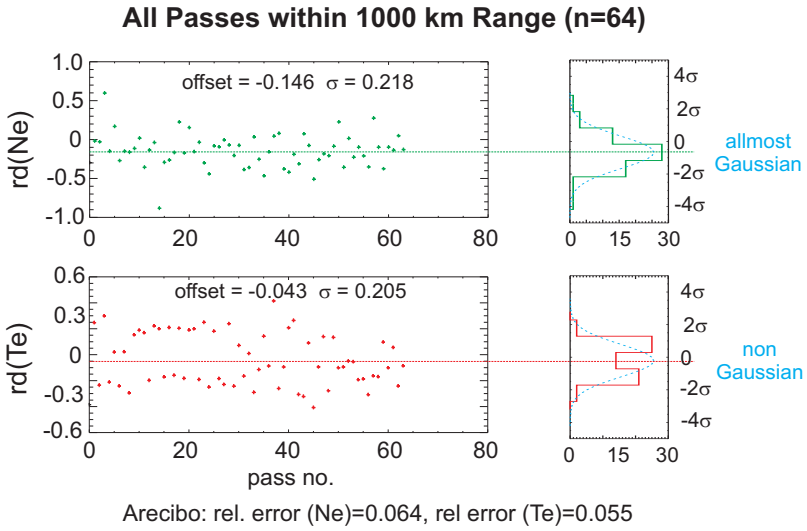

Figure 5: Scatter of relative differences.

of N_e, upper panel). Our choice of allowable distance, below 1000 km in the following, is a compromise between possible gradients and a sufficient number of overpasses. The distance was always measured at the CHAMP cruising altitude for which N_e and T_e have been interpolated from the profiles measured with the radar.
In Fig.5 the relative differences of N_e and T_e are given. The relative error in N_e and T_e from the Arecibo measurements indicate that they are only responsible for about 30% of the scatter. For N_e the relative differences are almost Gaussian distributed, but for T_e the distribution (in terms of standard deviation σ) is double humped. The reason for this behaviour is explained in the next figure.
Fig.6 show the relative differences for T_e as a function of daytime. We can tentatively plot a parabola through

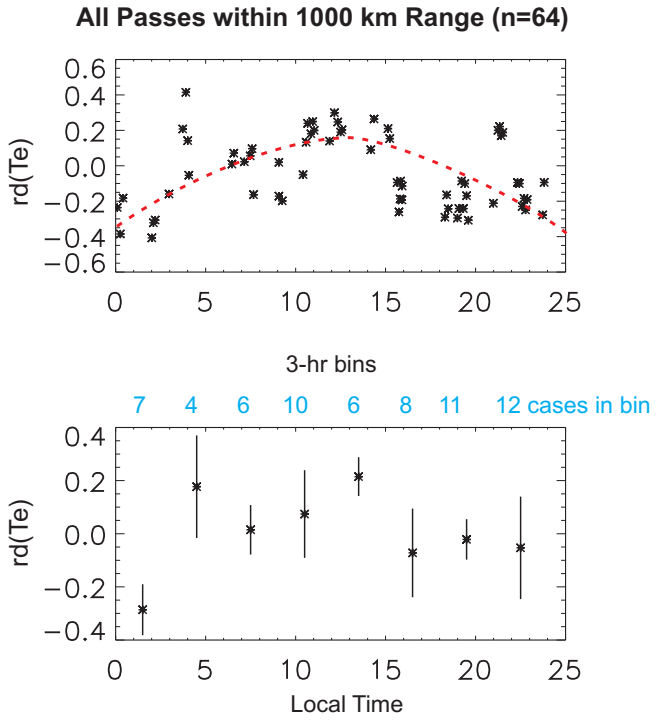

Figure 6: Relative differences as a function of daytime.

the points indicating that the offset is positive (T_e(CHAMP) higher than T_e(Arecibo)) during daytime, but negative (T_e(CHAMP) lower than T_e(Arecibo)) during night time. More quantitatively this is seen when we combine the data in 3-hr bins (lower panel). This diurnal difference is probably a result of spacecraft charging through photo electrons during daytime which affects the determination of T_e from the log-slope of the current voltage curve of the Langmiur probe. Data from more overpasses may allow another re-calibration of T_e.

4 SUMMARY

- The re-calibration of the Langmiur probe on 19. Feb. 2002 clearly improved the overall agreement of the electron temperature.
- CHAMP - N_e: $> 15\%$ lower than at Arecibo, but rd(N_e) almost Gaussian distributed,
- CHAMP - T_e: $> 10\%$ higher then at Arecibo during daytime, $> 20\%$ lower during nighttime, perhaps caused by satellite potential changes,
- no dependence of rd(N_e) and rd(T_e) on geomagnetic activity was found.

Data from more overpasses are needed to improve the statistics.