

Analysis of Storm-Time Patterns in Topside Electron Density Reconstructions based on CHAMP Data

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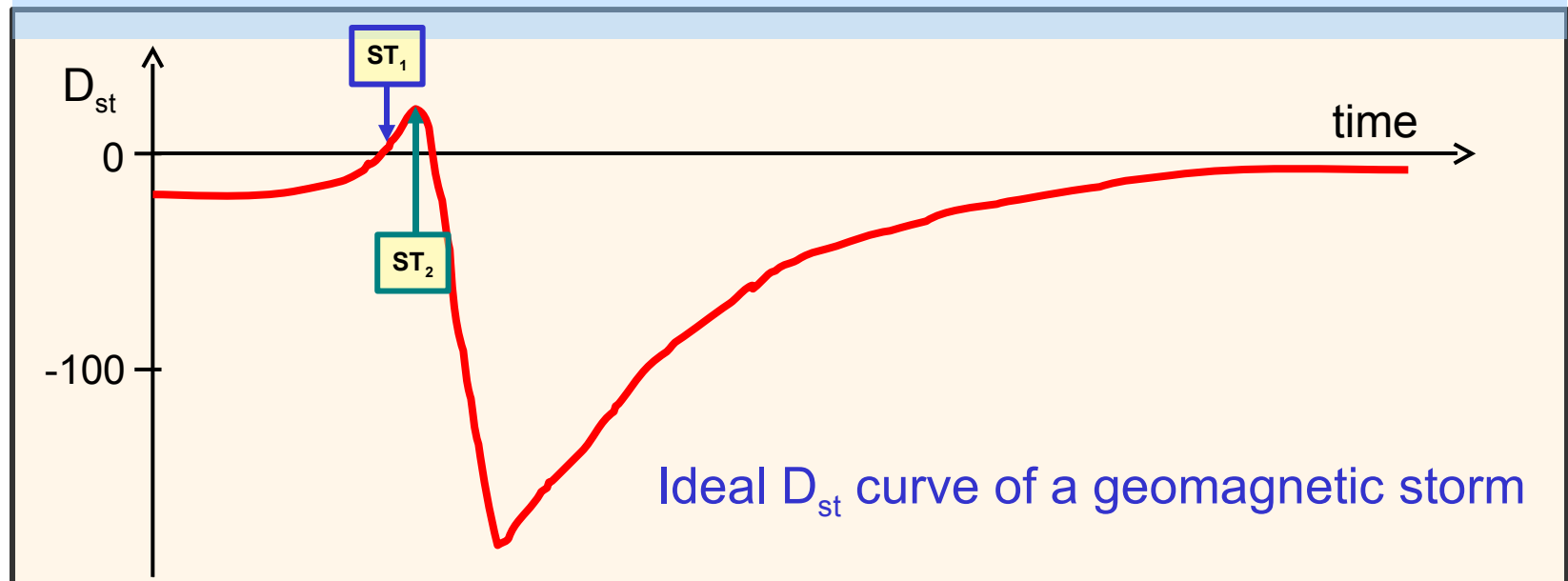


Outline

- **Storm Onset Definition(s)**
- **CHAMP Topside Sounding**
 - The CHAMP Satellite
 - TEC Derivation
 - Plasmasphere Data Assimilation
- **Storm-Time Epoch Analysis**
- **Conclusions and Outlook**

Geomagnetic Perturbations

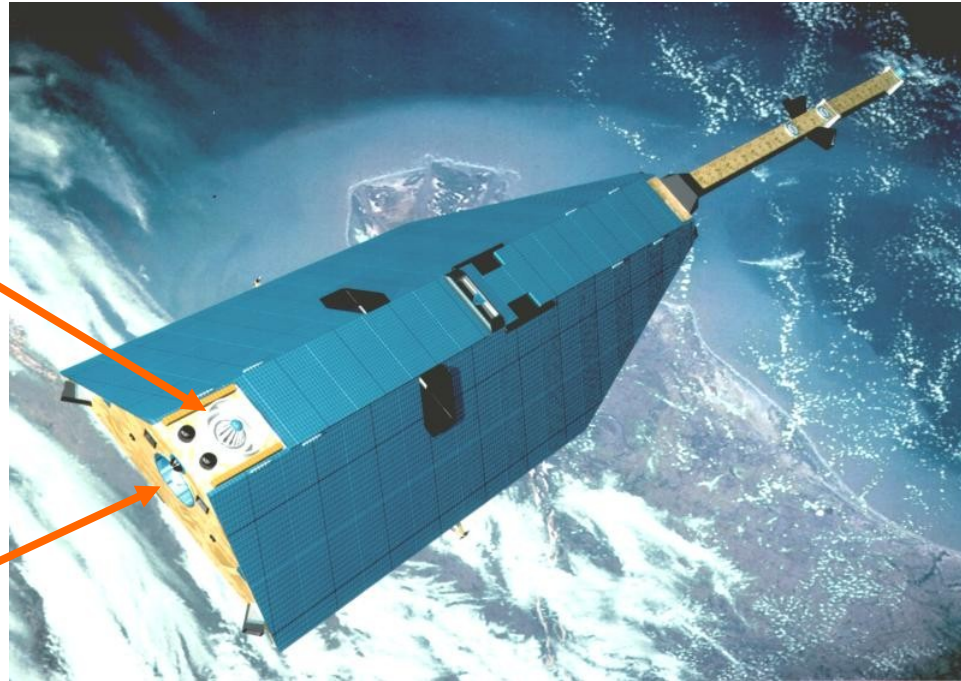
- We use the D_{st} index to detect geomagnetic perturbations
- Perturbations are characterised by large negative D_{st}
- There is no unique definition for the time of storm onset
- We use
 - D_{st} maximum (ST_2)
 - steepest positive D_{st} gradient (ST_1)



The CHAMP Satellite

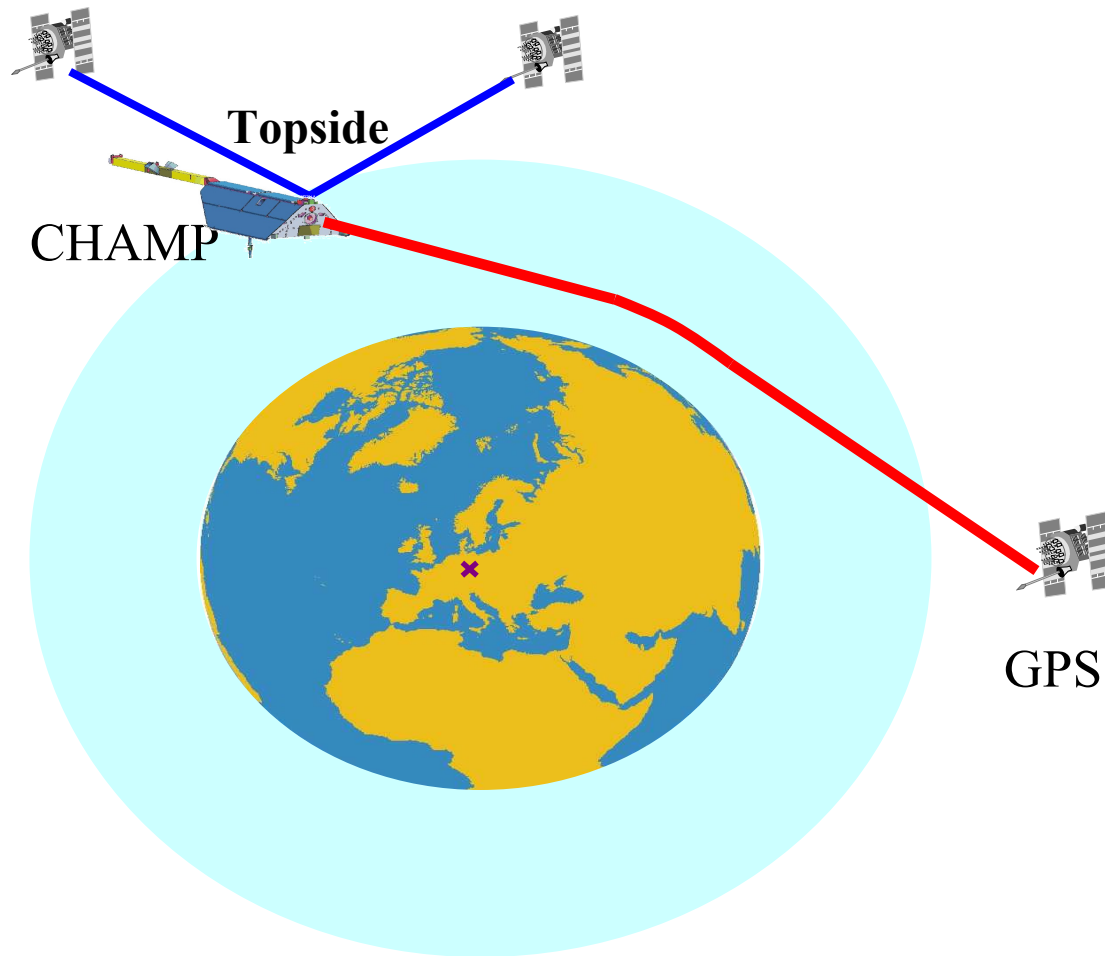
**GPS Zenith
antenna**

**GPS Occultation
antenna**



- Launch: 15 July 2000, $i = 87^\circ$, $h = 450$ km
- Now: $h \approx 350$ km

Topside sounding with CHAMP

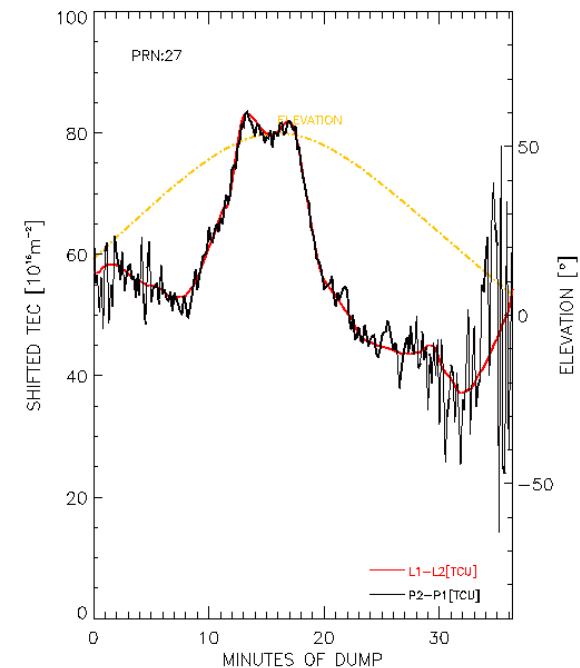


Derivation of TEC (zenith antenna)

- Compute TEC from Carrier Phases
- Assumption: straight ray path
- Determine bias
- Perform TEC Calibration

$$P_2 - P_1 = K \frac{f_1^2 - f_2^2}{f_1^2 f_2^2} TEC + dq + dQ + \varepsilon$$
$$L_1 - L_2 = K \frac{f_1^2 - f_2^2}{f_1^2 f_2^2} TEC + \varepsilon_{off}$$

RELATIVE TEC FROM SHIFTED CARRIER-PHASES



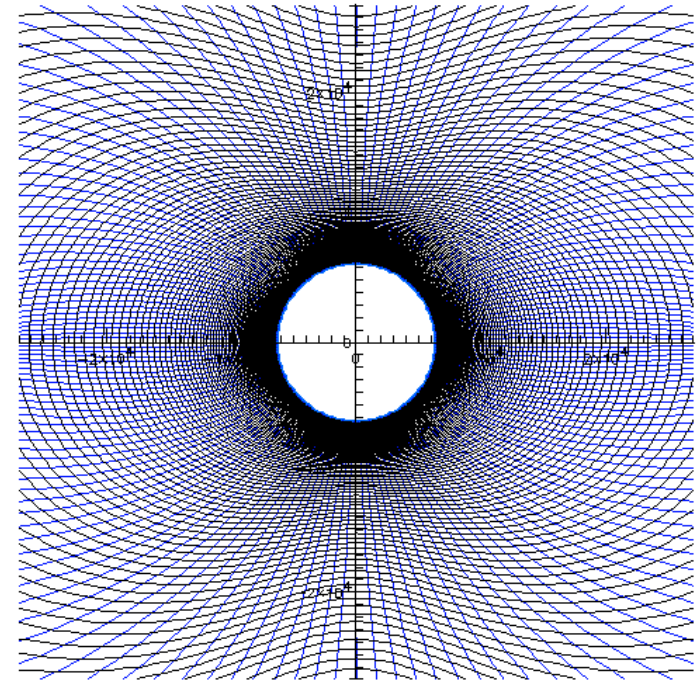
Plasmasphere Data Assimilation/1

- Idea: Inversion of

$$TEC = \sum_{i \in Voxels} \Delta s_i \bullet n_i$$

- Use of an „adapted“ Voxel structure

- Start assimilation with Model input
(PIM Model)



Plasmasphere Data Assimilation/2

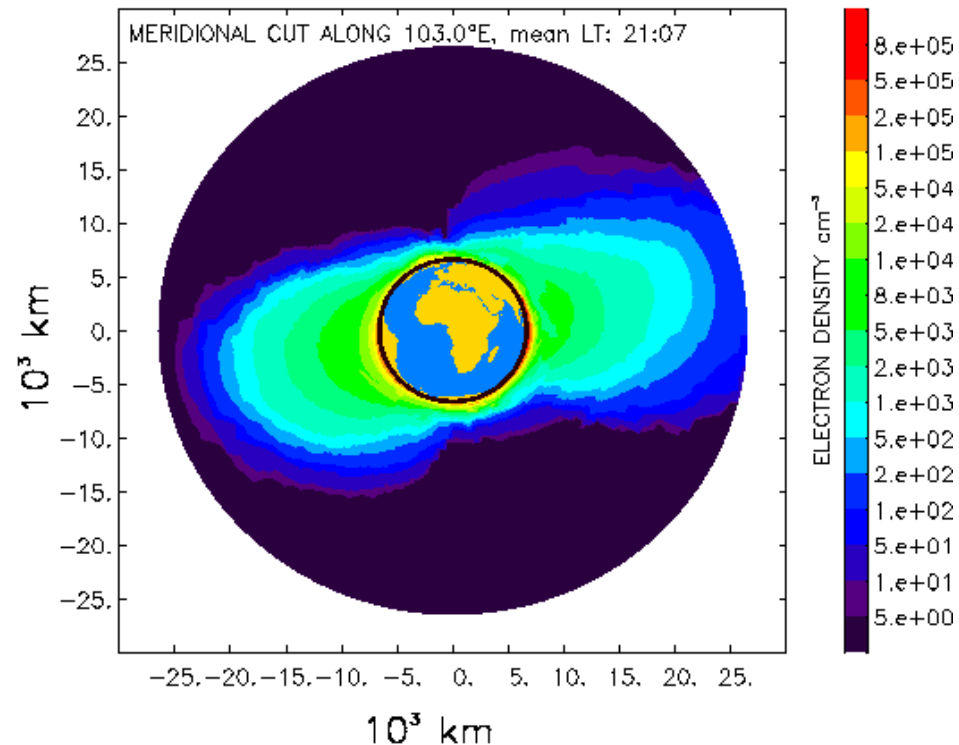
CHAMP Topside Electron Density Reconstruction

ASSIMILATION BEGIN TIME : 2005-005 13:31UTC
DURATION : 90 min

electron density in plane
of CHAMP revolution

● 15-16 3D maps/day

● Plots: <http://w3swaci.dlr.de>



Heise et al., GRL, 29, No. 14, 44-1, 2002





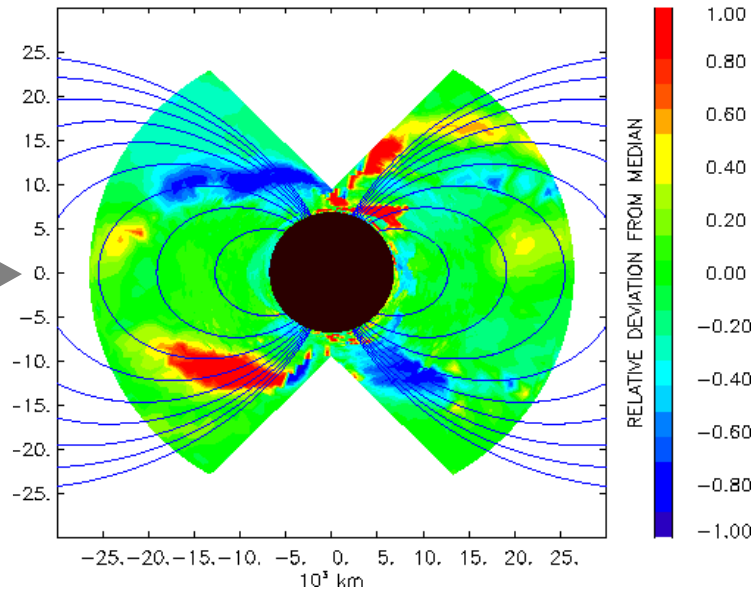
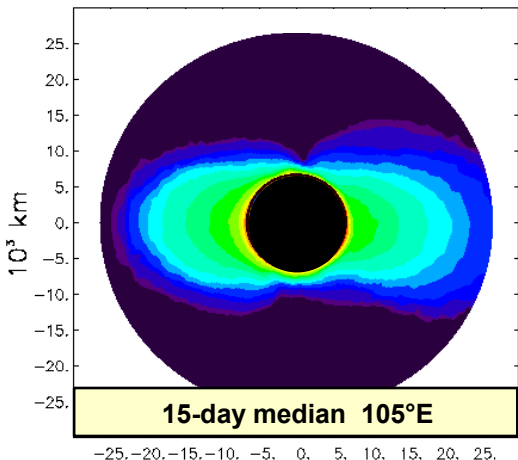
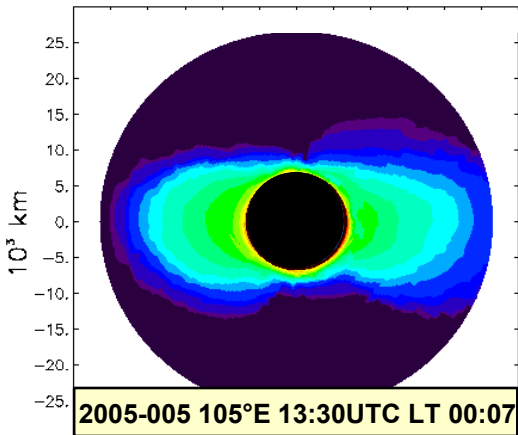
Storm-Time Epoch Analysis/1

- **Extract 2D electron density maps in CHAMP orbit plane**
- **Transform latitude -> geom. latitude (using dipol model)**
- **Compute 15-day medians every 7.5° longitude**
- **Compute difference maps wrt to the corresponding 15-day medians**
 - **abs** $x - x_m$
 - **rel** $(x - x_m)/x_m$
 - **log** $\log(x/x_m)$
 - **rel2** $(x - x_m)/(x + x_m)$
- **Compute the average of difference maps with the same storm time**

Storm-Time Epoch Analysis/2

Characterization of difference plot:

$$\Delta n^+ = \sum_{i|n_i > 0} n_i a_i / \sum_{i|n_i > 0} a_i, \quad \Delta n^- = \sum_{i|n_i < 0} n_i a_i / \sum_{i|n_i < 0} a_i$$

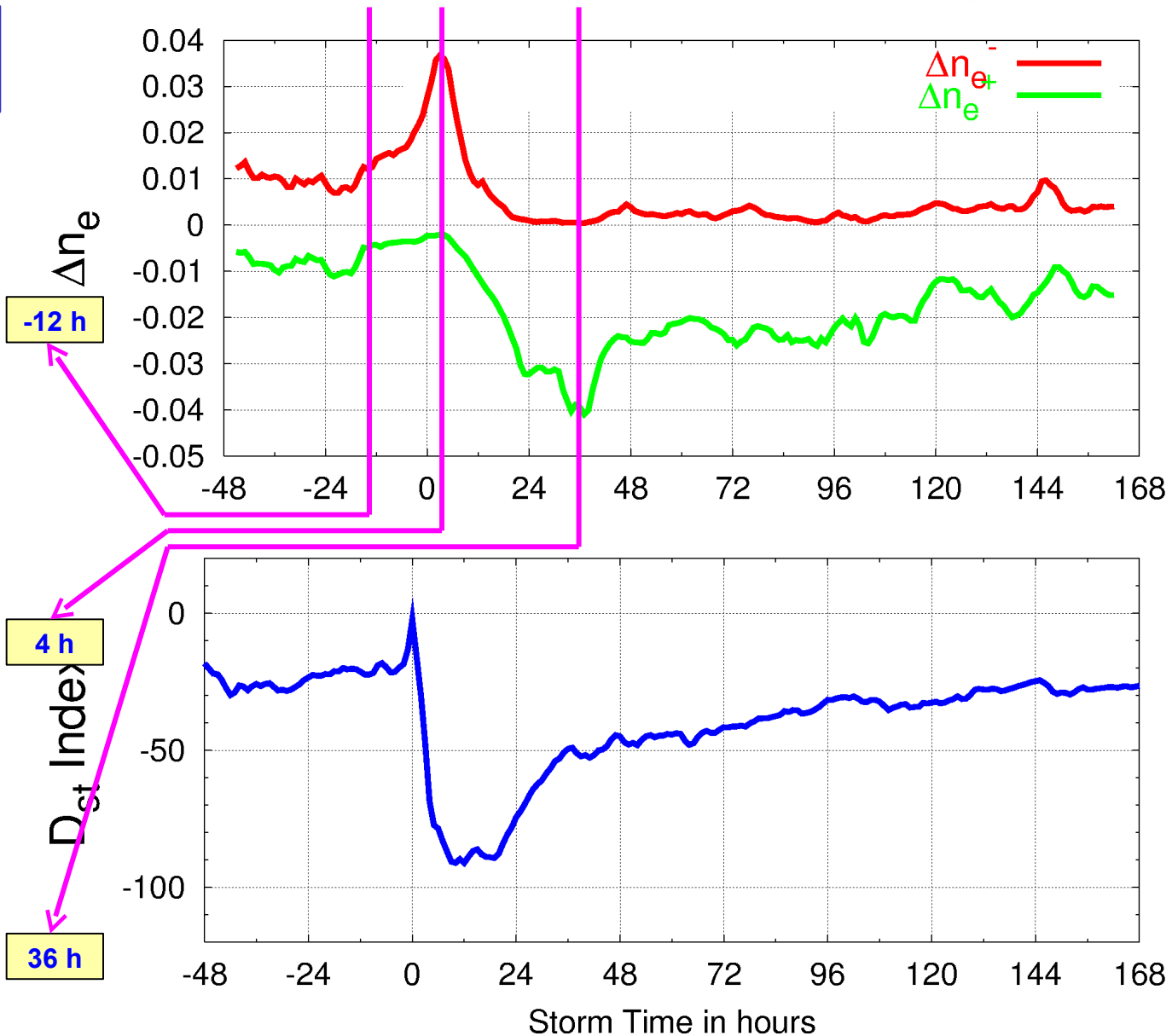
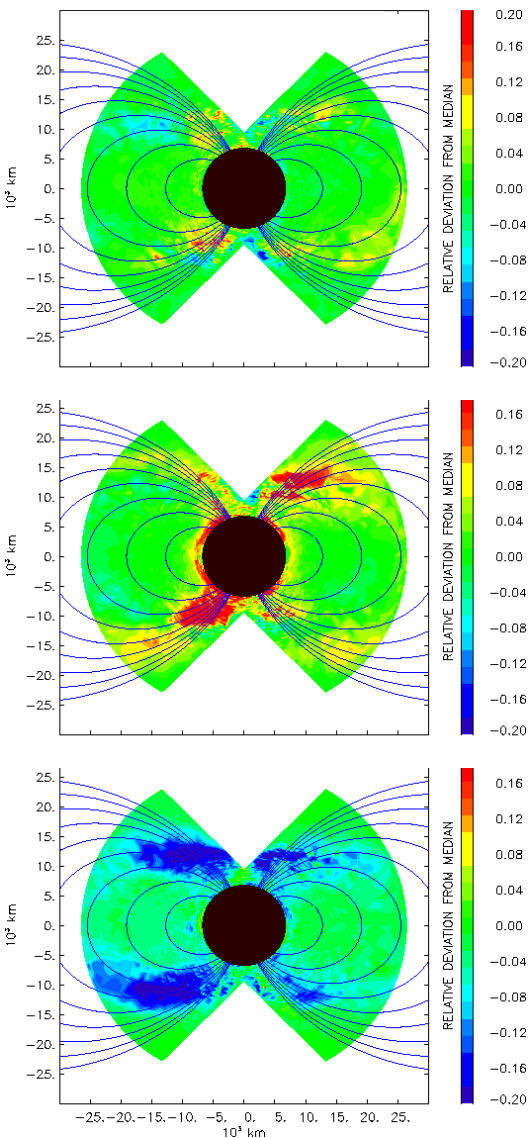


$$\Delta n^+ = +0.11$$

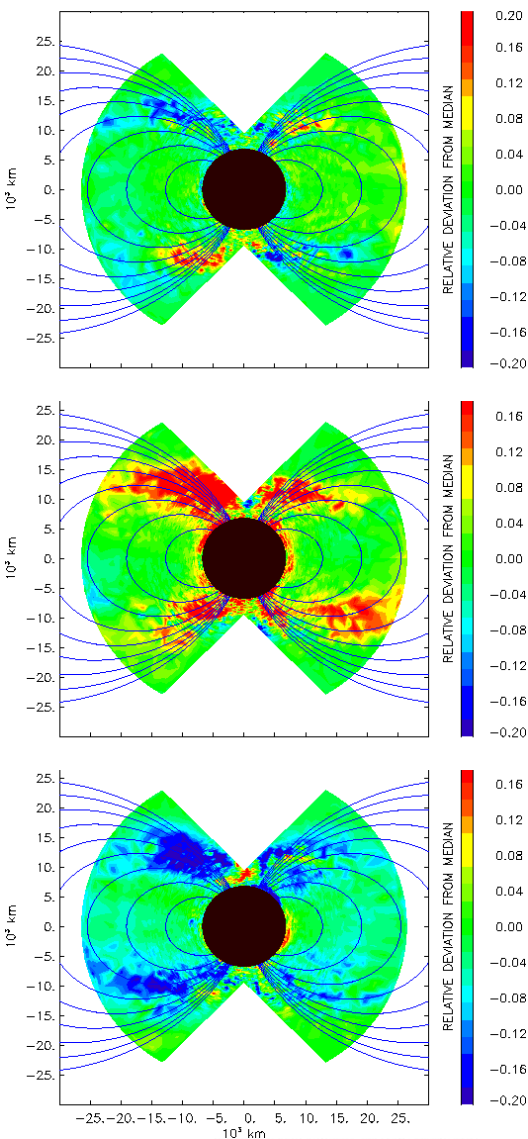
$$\Delta n^- = -0.08$$

relative deviations with respect to the corresponding 15-day median

Databasis: 40 Storms
Apr 2003 – Dec 2005



Databasis: 18 Storms
Aug 2002 – Dec 2005



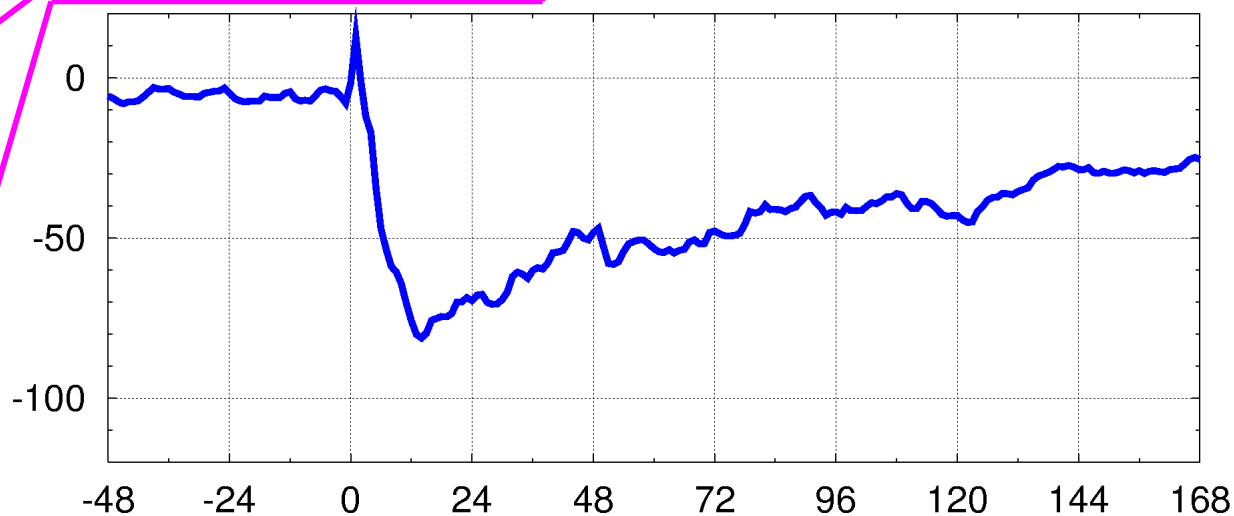
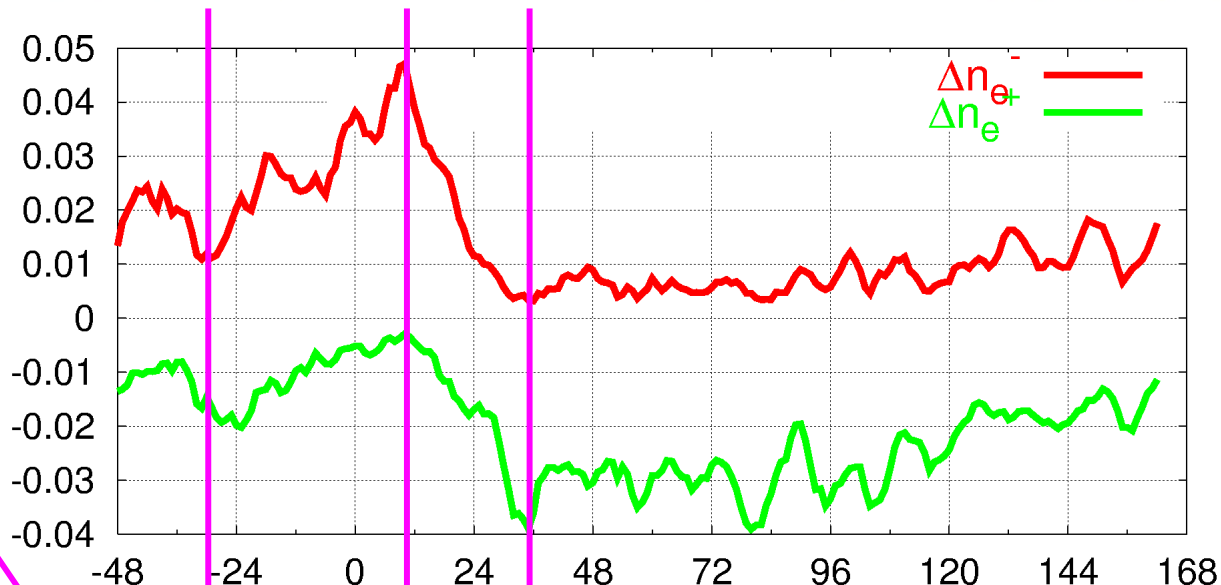
Δn_e

-30h

10h

35h

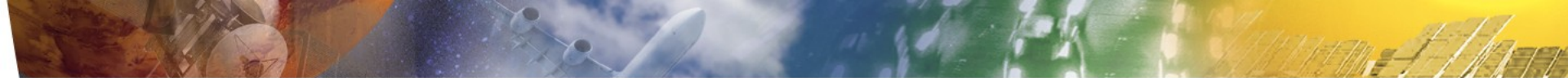
D_{st} Index



Storm Time in hours

Conclusions and Outlook

- GPS topside sounding onboard CHAMP can be effectively be used to study the space- and time-dependence of dynamic processes in the plasmasphere
- Observations:
 - There is a positive phase in the plasmasphere after D_{st} onset
 - followed by a negative phase peaking ca. 36h after D_{st} storm onset
 - Recovery (refilling of plasmasphere) takes place within 8 days
- To get more detailed insight into physical proccesses, better statistics is needed
- Future: comparison with ground-based storm studies
- Future: more data input: SAC-C, COSMIC, GRACE, TerraSAR-X,...





Plasmasphere Data Assimilation/2

Electron Density in plane
of CHAMP revolution

- 15-16 3D maps/day
- Plots: <http://w3swaci.dlr.de>

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