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The thermospheric mass density anomaly al polar latitudes: a comparison of CHAMP and GRACE observations

G. Kervalishvili and H. Lühr
Germany (guram.kervalishvili@gfz-potsdam.de)

We present for the first time direct comparison of the thermospheric mass density anomaly observations at high latitudes obtained from the accelerometers on board the satellites CHAMP (at about 400 km altitude) and GRACE (at about 500 km altitude). A systematic survey of the anomalies is based on the statistical analysis of both spacecraft observation data during the 4 years (from 2002 through 2005), but only for calendar dates at which both satellite recordings are available. The comparison shows that at higher altitude, GRACE orbit, the anomalies are more pronounced and have about two times higher relative values than at the lower CHAMP orbit. The obtained results, presented in a geomagnetic latitude-magnetic local time (MLT) frame, look quite different in Northern and Southern Hemispheres. The median anomaly distribution in the Northern Hemisphere has a clear peak at about 12 MLT and between 70° and 80° geomagnetic latitude for both satellites. This peak location corresponds well to the statistical position of the dayside cusp region. However, noticeable difference is observed for the location of anomaly peak center, namely for GRACE it is shifted towards 13 MLT by about 40 minutes. Also GRACE shows a secondary smaller peak between 23 and 24 MLT and at about 70° geomagnetic latitude, which corresponds to the location of the nightside substorm region.
A completely different picture emerges in the Southern Hemisphere. For CHAMP observations, we can see the median anomaly distribution with two peaks, where the bigger one is spread out between 60° and 80° geomagnetic latitude and between 11 and 15 MLT, and a smaller one located between 60° and 70° geomagnetic latitude and between 22 and 23 MLT. Nevertheless, GRACE shows a little bit different picture of the peak anomaly distribution, which is spread out between 60° and 70° geomagnetic latitude and between 13 and 23 MLT.
One possible mechanism for creating density anomalies during geomagnetic storm time can be the ion upflow at high altitudes. Therefore a comparison of GRACE and DMSP (at about 830 km altitude) spacecraft observations during magnetic storms in the period from 2002 through 2005 with Dst < -100 nT are also presented. We have considered observations from the two spacecraft with almost the same UT and found good coincidences between mass density anomaly (GRACE) and upward ion velocity (DMSP). These coincidences can be separated into polar cap, dayside cusp and nightside auroral region with the following results:
a. Polar cap - mass density anomalies but no enhancement of ion velocity
b. Dayside Cusp - mass density anomalies and ion velocity enhancements in good agreement
c. Nightside auroral region - ion velocity enhancements but no mass density anomalies.
These conclusions apply for both Northern and Southern Hemispheres.