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Development and validation of the European Cluster Assimilation Techniques run libraries

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EGU General Assembly 2012, Vienna, Austria, 22-27 April 2012

Abstact *The European Commission funded the European Cluster Assimilation Techniques (ECLAT) project as a collaboration of five leader European universities and research institutes. A main contribution of the Finnish Meteorological Institute (FMI) is to provide a wide range global MHD runs with the Grand Unified Magnetosphere Ionosphere Coupling simulation (GUMICS). The runs are divided in two categories: Synthetic runs investigating the extent of solar wind drivers that can influence magnetospheric dynamics, as well as dynamic runs using measured solar wind data as input. Here we consider the first set of runs with synthetic solar wind input. The solar wind density, velocity and the interplanetary magnetic field had different magnitudes and orientations; furthermore two F10.7 flux values were selected for solar radiation minimum and maximum values. The solar wind parameter values were constant such that a constant stable solution was archived. All configurations were run several times with three different (-15°, 0°, +15°) tilt angles in the GSE X-Z plane. The result of the 162 simulations named so called "synthetic run library" were visualized and uploaded to the homepage of the FMI after validation. Here we present details of these runs.*

No	n [cm^{-3}]	V_x [km/s]	B_x [nT]	B_y [nT]	B_z [nT]	F10.7 min tilt angles [°] -15	0	+15	F10.7 max tilt angles [°] -15	0	+15
1	15	400	+3	0.3	-15						
2	15	400	+3	0.3	+15						
3	15	400	+3	0.3	-6						
4	15	400	+3	0.3	+6						
5	15	400	+3	-15	0.3						
6	15	400	+3	-6	0.3						
7	15	600	+3	0.3	-15						
8	15	600	+3	0.3	+15						
9	15	600	+3	0.3	-6						
10	15	600	+3	0.3	+6						
11	15	600	+3	-15	0.3						
12	15	600	+3	-6	0.3						
13	7	400	-3	+15	0.3						
14	7	400	+3	0.3	-15						
15	7	400	+3	0.3	+15						
16	7	400	+3	0.3	-6						
17	7	400	+3	0.3	+6						
18	7	400	+3	-15	0.3						
19	7	400	+3	+15	0.3						
20	7	400	+3	-6	0.3						
21	7	600	-3	+6	0.3						
22	7	600	+3	0.3	-15						
23	7	600	+3	0.3	+15						
24	7	600	+3	0.3	-6						
25	7	600	+3	0.3	+6						
26	7	600	+3	-15	0.3						
27	7	600	+3	-6	0.3						

Table 1: *Description of the completed GUMICS4 runs: **Original parameters.** Original parameters with ConstBx0. Nonzero IMF components. Nonzero IMF components and +5° tilt in YZ plane. Nonzero IMF components and zero B_x.*

ECLAT gallery

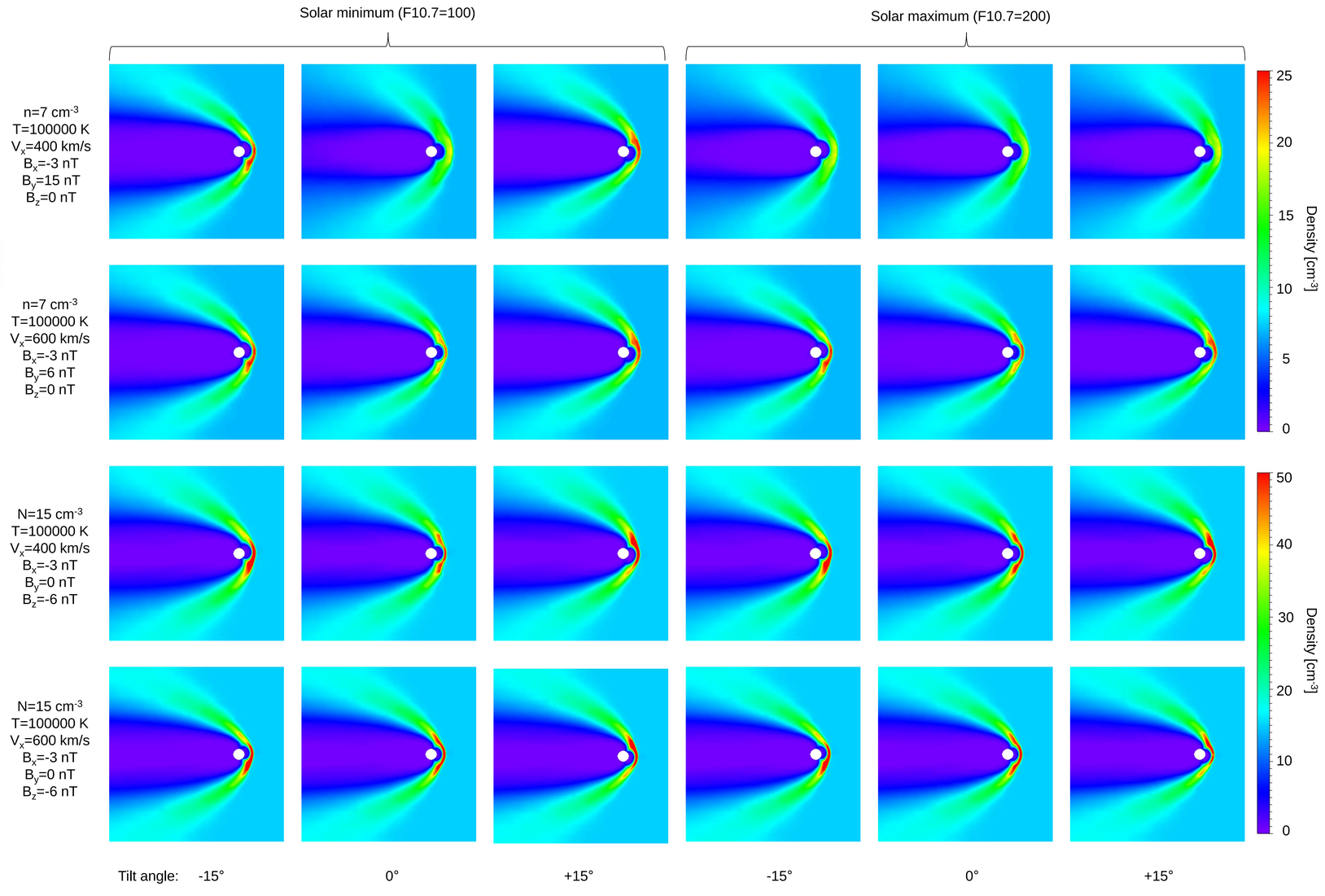

Figure 3: *ECLAT run library: various GUMICS-4 simulation results based on different input solar wind speed, density and Interplanetary Magnetic Field orientations. All solar wind parameters were used six times with three tilt angles (-15°,0°,+15°) and two solar radiation flux (F10.7) values at 2800 MHz (100 or 200 in solar flux units (10^{-22}W m^{-2} Hz^{-1})).*

GUMICS-4 simulations

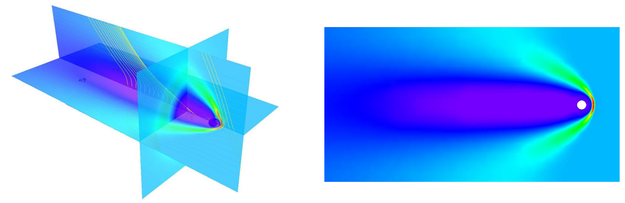

Figure 1: *3D (left) and 2D (right) visualisations of GUMICS-4 simulation results. The size of the simulation box are X_{GSE}=[220,-30]R_{Earth} and Z_{GSE}=[-63,63]R_{Earth}.*

Grand **U**nified **M**agnetosphere **I**onosphere **C**oupling **s**imulation is a global 3D MHD simulation of the plasma environment of the near-Earth space (Figure 1; Janhunen et al., 2012). The magnetosphere is coupled to the ionosphere and the code runs on UNIX/Linux systems. It is controlled by a two hours long solar wind input file (B_x, B_y, B_z, V_x, V_y, V_z,T, n) and its configuration file (tilt, F10.7 flux, etc.). All units are in SI (m,m/s,m^{-3} and K) and in GSE. The time is given in seconds relatively from zero. 27 combinations were selected (B: 6nT,14nT, B_x -3nT, +3nT; V_x 400km/s, 600km/s; density 7cm^{-3}, 14cm^{-3}; temperature 100000K). The system needs one hour for initialization. Three tilt angles were selected (-15°, 0°, +15°) in the GSE X-Z plane and 0° in the GSE X-Z plane.

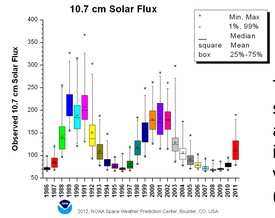

Figure 2: *F10.7 solar flux variability from 1986 to 2011. .*

Two F10.7 flux values (100, 200) were selected according to solar minimum and maximum (Figure 2). So the 27 input files x 3 tilt angles x 2 F10.7 flux values = 162 runs were completed (Table 1; Figure 3).

GUMICS validation using empirical relations

Lobe magnetic field | Plasma sheet pressure | Magnetopause

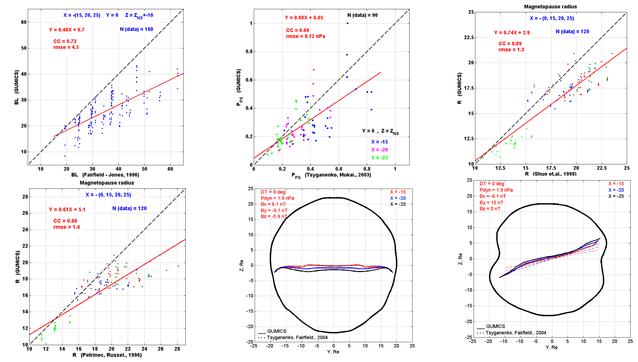

Figure 4: *The ECLAT runs were validated by different empirical methods*

Various empirical methods were applied: Lobe magnetic field: X=-(15,20,25);Z=Z_{NS}+10;Y=0 (Fairfield, Jones., 1996; Tsyganenko., 2000). Magnetopause position: X=-(0,15,20,25), nose (Shue et.al., 1998;Petrinec,Russel.,1996). Ionospherical potential (Ruohoniemi, Greenwald,1996). Tail plasma sheet pressure; X=-(15,20,25);Y=0;Z=Z_{NS} (Tsyganenko, Mukai., 2003). Tail neutral sheet shape: X = -(15, 20, 25); (Tsyganenko, Fairfield., 2004). Dayside magnetic field compression (Shue et. al., 2011). Field aligned currents R1 (Papitashvili et. al., 2002). Penetration By IMF into the magnetotail (Figure 4).

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Acknowledgements The ECLAT project was funded by the European Union, the Grant Agreement number is 263325. The work of Gábor Facskó was supported by the OTKA grant K75640 of the Hungarian Scientific Research Fund.