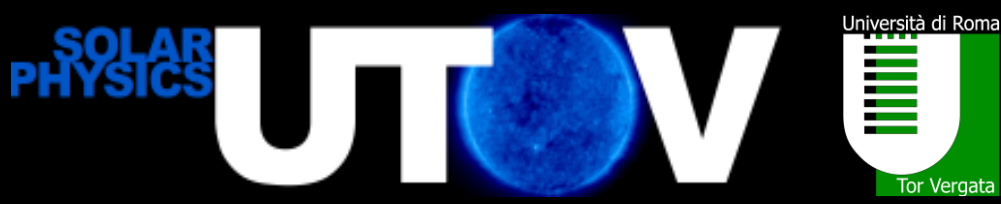


Analysis of solar activity impact on thermospheric density during ESA GOCE mission



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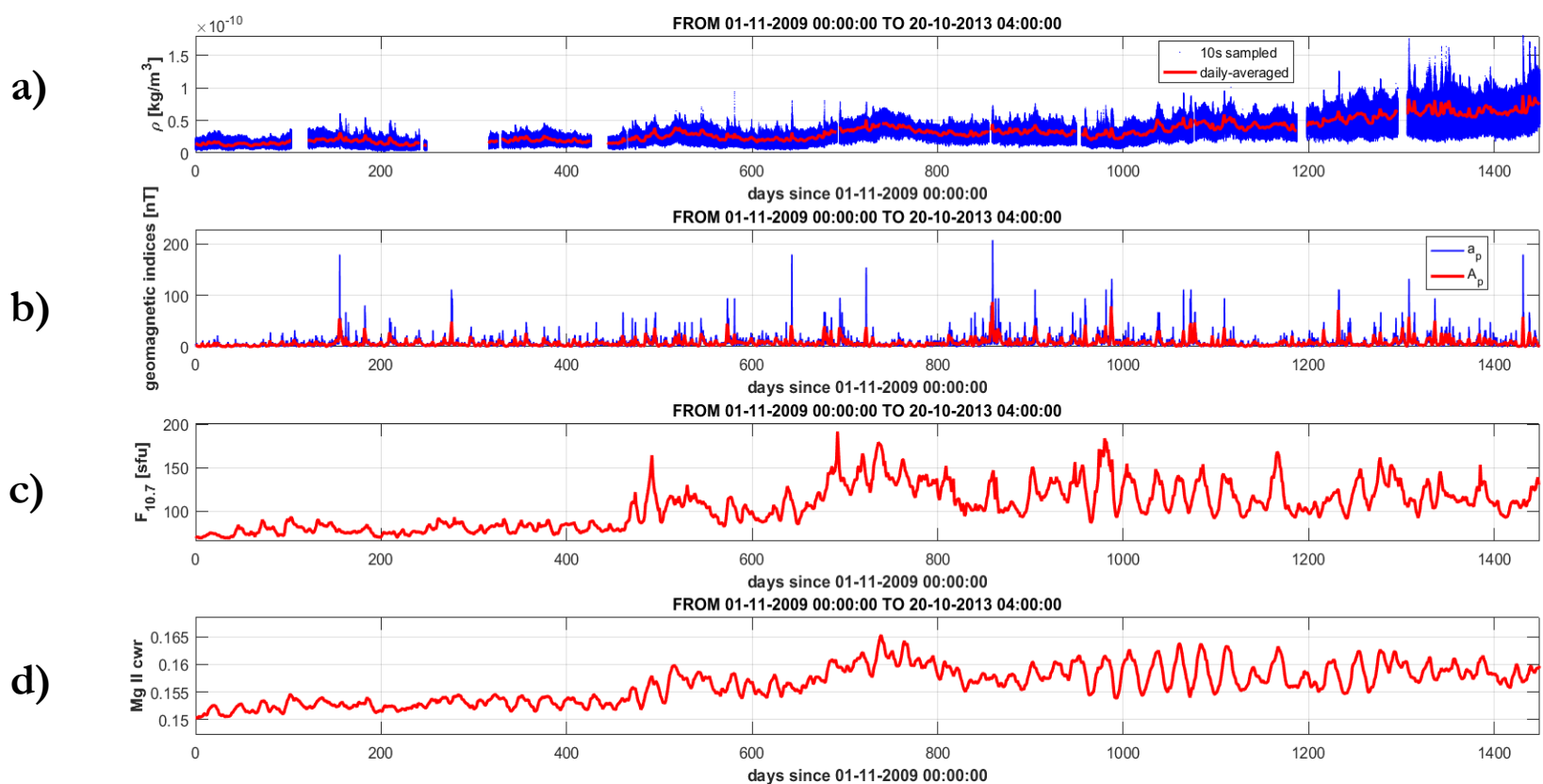
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Abstract

The impact of solar activity on thermospheric density during ESA's gravity mission GOCE (17 March, 2009 - 11 November, 2013, rising phase of solar cycle 24) has been investigated using different solar indices. Thermospheric densities at a mean altitude of 254 km, derived from the high-precision accelerometers on board the GOCE satellite, represent a unique low-altitude dataset. Solar activity indices such as the F10.7 flux, the Mg II core-to-wing ratio and the Ap geomagnetic index in the period of GOCE mission have been firstly examined in time and their correlations with GOCE thermospheric density have been studied. Then, solar indices have been analysed through the Empirical Mode Decomposition (EMD), a technique best suited in analysing non-stationary and non-periodic time signals. After extracting the individual components (IMFs) from the solar indices, thermospheric density have been reconstructed and compared with the GOCE dataset. The preliminary results presented in this work suggest how significant advantages may be gained using the Mg II index and EMD method in describing the solar-thermospheric connection.

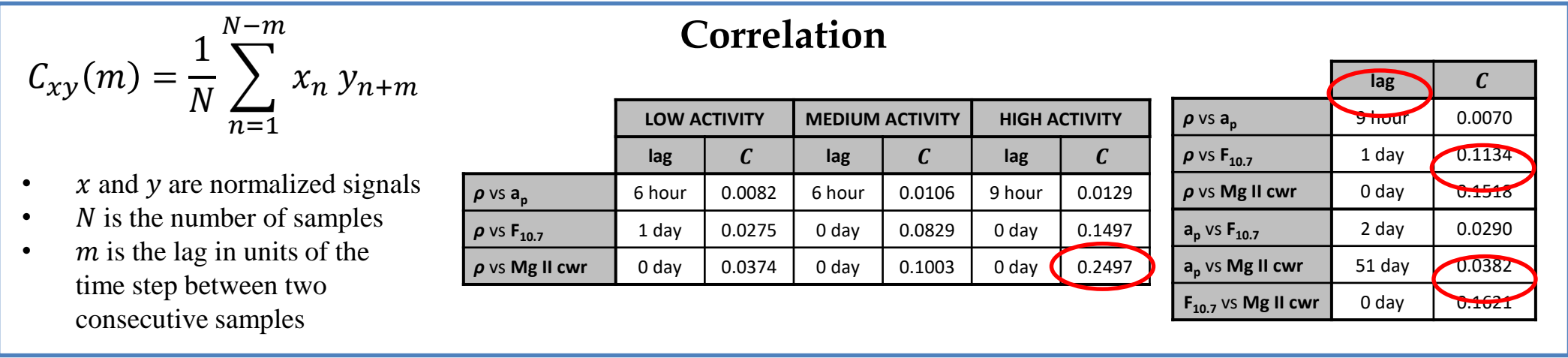
GOCE (Gravity field & steady-state Ocean Circulation Explorer)

- Drag-Free Attitude and Orbit Control System to maintain altitude constant
- on-board ultra-sensitive accelerometers used to create dataset of **10s** sampled thermospheric density at 260 km altitude (*Eelco Doornbos et al.* of TU Delft [1]) available at ESA GOCE Archive (**01/11/2009 -20/10/2013**)
- the satellite was operated until few hours before destruction into the atmosphere.
- very high uncertainty (half an orbit) in the location of re-entry up to few hours before due to the highly variable level of solar and geomagnetic activity

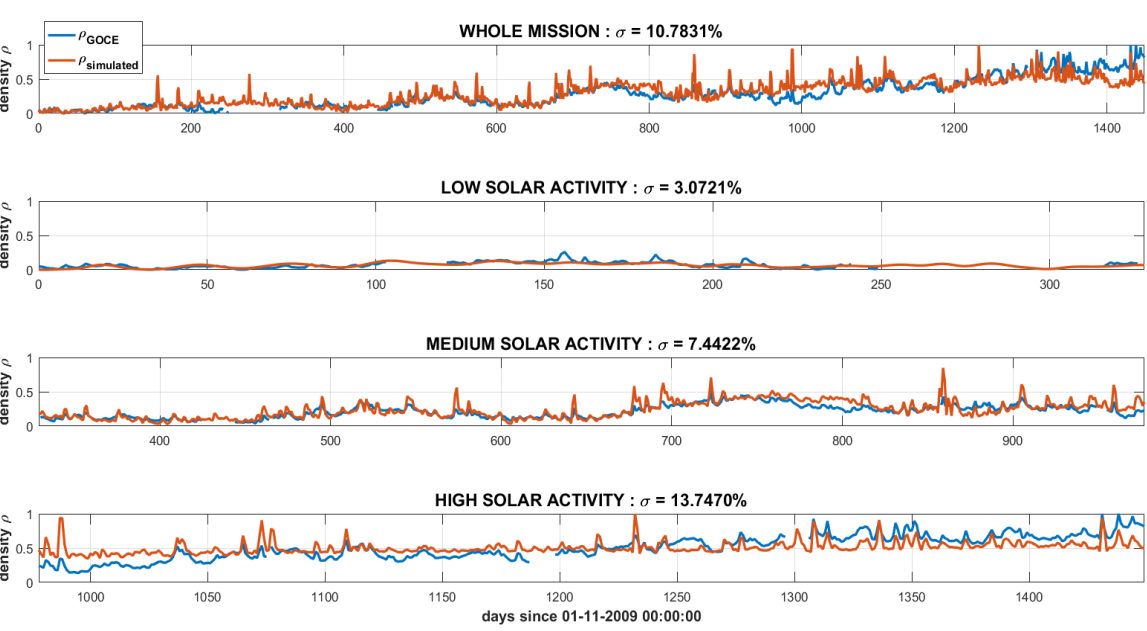
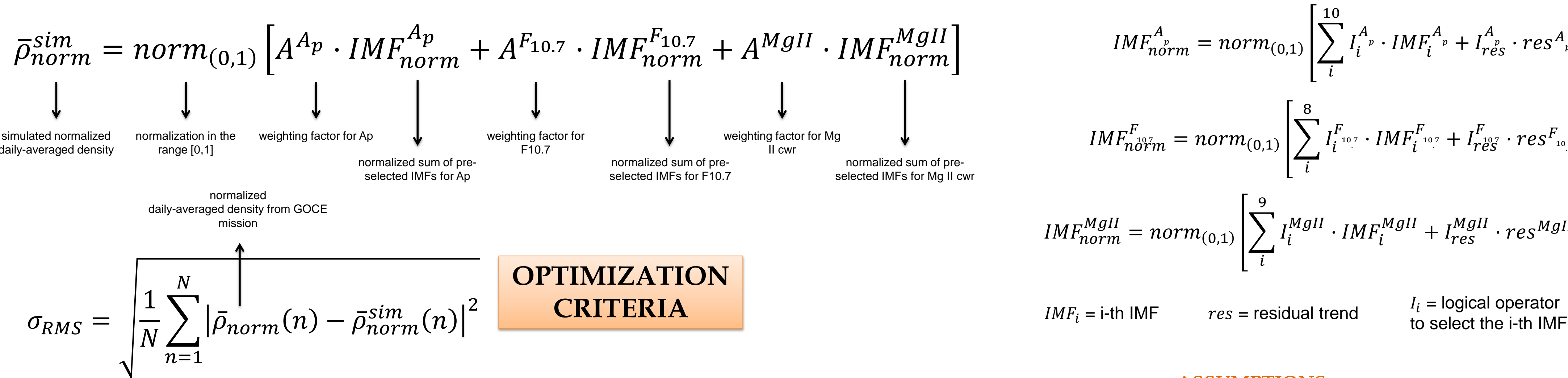


a) Atmospheric density vs time (both 10 s sampled and daily averaged) during GOCE mission; **b)** Geomagnetic index a_p and daily-averaged geomagnetic index A_p vs time during GOCE mission (signal spikes are removed by interpolation)

1. Thermospheric density is badly-correlated with geomagnetic index and well-correlated with solar flux indices (especially with Mg II cwr)
2. The thermospheric response to a_p impulsive changes is within 6 to 9 hours
3. Impulsive variations of a_p , as well as long-term evolution of F10.7 and Mg II cwr are well reflected in the thermospheric density



Recreate thermospheric density time profile from Intrinsic Mode Functions and the residual trends of solar indices EMD



	σ_{RMS} [%]	index	1	2	3	4	5	6	7	8	9	10	res	A
whole mission	10.78	A_p	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0.3005
		Mg II				✓							✓	2.0232
low solar activity	3.07	A_p									✓	✓	✓	2.3317
		Mg II				✓		✓	✓				✓	4.0793
medium solar activity	7.44	A_p	✓	✓	✓	✓	✓							0.5406
		Mg II				✓		✓	✓				✓	3.5154
high solar activity	13.75	A_p	✓	✓	✓	✓	✓	✓	✓	✓				0.3113
		Mg II							✓				✓	2.1352

Conclusions

Whole mission: good representation of long-term evolution (except for medium to high solar activity period) over-estimation of peaks; **Low solar activity:** very good representation both for long-term evolutions and peaks; **Medium solar activity:** good representation of long-term evolution over-estimation of peaks; **High solar activity:** no satisfactory representation of long-term evolution (over-estimation and under-estimation) good representation of peaks (except for initial over-estimation).