An index to describe global ionospheric variability using satellite-borne solar EUV measurements

C. Unglaub[1], Ch. Jacobi[1], G. Schmidtke[2], B. Nikutowski[1,2], R. Brunner[2]

[1]University of Leipzig, Institute for Meteorology, Stephanstr. 3, 04103 Leipzig, Germany
[2]Fraunhofer IPM, Heidenhofstraße 8, 79110 Freiburg, Germany

Summary

Primary ionisation of major ionospheric constituents is calculated from SolACES and TIMED-SEE solar EUV measurements in the wavelength range 16-135 nm, and number densities of the background atmosphere taken from the NRLMSIS-E climatology. From the calculated ionisation rates, a global EUV-TEC index is derived, which describes the ionospheric response on solar EUV and its variability from the last solar maximum to date. The index is compared against global mean ionisation values taken from TEC maps. The index describes global TEC variability better than other indices like F10.7 do. The EUV-TEC index may be used for scientific research, and to describe the ionospheric effects on radio communication and navigation systems.

Data and calculation of the EUV-TEC Index

Daily TIMED/SEE solar EUV fluxes, and some additional spectra from SolACES. Wavelength range from 16-135nm is used.

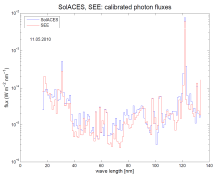


Fig. 1: Example of SolACES and TIMED/SEE spectra.

Global mean background atmosphere from NRLMSISE-00

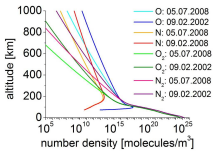


Fig. 2: Daily mean NRLMSISE-00 number densities at 0°E, 0°N of four atmospheric gases for different solar activities

Model to calculate primary ionisation

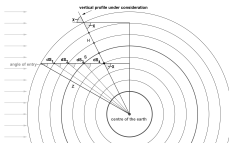
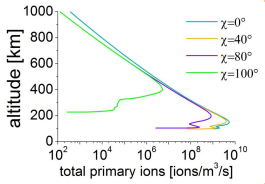


Fig. 3: Sketch of absorption/ionisation calculation for a specific point with given zenith angle.

Fig. 4: Example (15.04.2005) of primary photo-ionisation profiles for different zenith distances.



Global mean ionisation provides EUV-TEC index. Comparison with F10.7 and global mean IGS TEC.

Conclusions

From solar EUV spectra, global mean primary ionisation rates have been calculated on a daily basis. This provides an index - EUV-TEC -, which to a certain degree describes the influence of solar variability on the ionosphere. Comparison of the index variability with that of global mean TEC provided by GPS measurements show that the index is strongly correlated with TEC, although it performs only slightly better than indices based on EUV flux directly. In particular, the index is able to partly represent the seasonal global TEC cycle during solar minimum, which is not present in other indices used for solar variability description. In particular, for representing ionospheric variability, the new index performs better than the frequently used F10.7 radio flux.

Acknowledgements:

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Contact, information and data:

Christoph Jacobi
Institut für Meteorologie, Universität Leipzig, Stephanstr. 3, 04103 Leipzig
Email: jacobi@uni-leipzig.de

Results

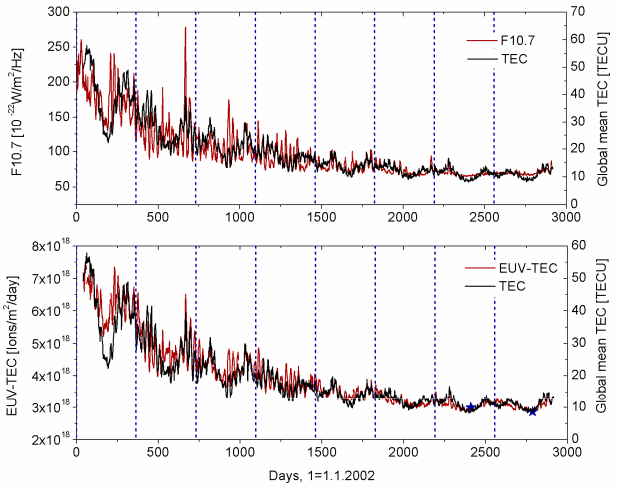

Fig. 5: Time series of daily EUV-TEC indices and global mean TEC (upper panel) and time series for global mean TEC index and F10.7 solar radio flux (lower panel) during 2002 to 2009. Few SolACES data are shown as blue stars.

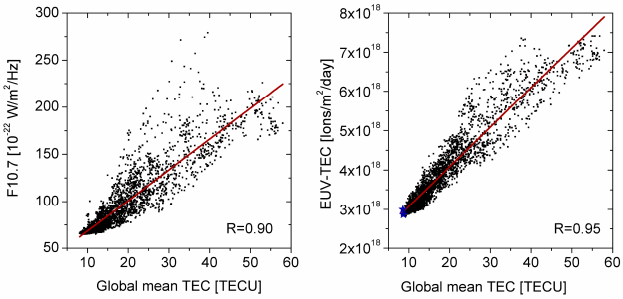

Fig. 6: EUV-TEC index (left panel) and F10.7 (right panel) vs. global mean TEC during 2002 to 2009. Few SolACES data are shown as blue stars.

Different time scales

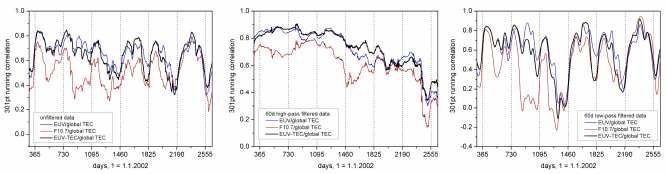

Fig. 7: 301 pt running correlation of global mean TEC vs. EUV energy flux, F10.7, and EUV-TEC. Left panel: original daily data. Middle panel: 60 days high-pass filtered data. Right panel: 60 days low-pass filtered data (Lanczos filter, 100 weights). The weaker correlation during winter seasons is due to the semiannual TEC variation not driven by EUV.

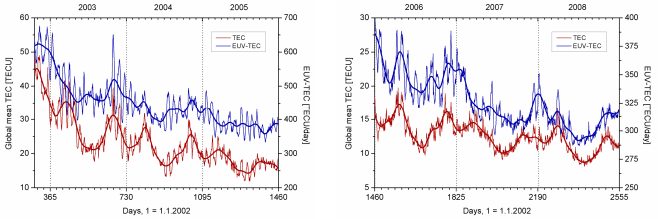

Fig. 8: Global mean TEC and EUV-TEC index for high/moderate (left panel) and low (right panel) solar activity. The thick solid line represents 60 days low-pass filtered data (Lanczos filter, 100 weights). During solar minimum TEC is dominated by the seasonal cycle, including the semiannual oscillation not driven by EUV variations.

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