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Towards advanced sunspot-based indices and solar forcing proxies

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Most long-term solar irradiance and activity proxies are based on the international sunspot index series, Ri, as it is by far the longest direct record of solar activty. However, for recent years, other standard integrated-flux indices at our disposal (F10.7, MgII, HeII, Lyα) definitely lead to better proxies, in particular for the UV-X spectral irradiance. Here, we want to explore how more detailed information down to the level of individual sunspot groups can lead to multiple sunspot-based proxies that track better different kinds of recent solar indices and measured fluxes. By deliberately relying only on sunspot information, such improved proxies will allow the reconstruction of solar parameters over the distant past, thus enabling studies of secular variations of the solar forcing on the Earth atmosphere.

For this purpose, we can use existing multi-decade sunspot catalogs. However, the latter have multiple limitations in time coverage, recorded parameters and homogeneity. In a first approach, we use the Debrecen Photoheliographic Data (DPD), based on a few ground-based observatories and SOHO data, and the USAF/Mount Wilson catalog built by the Solar Optical Observing Network (SOON). Using those data sets, we can illustrate how the information from parallel catalogs can be merged to form a much more comprehensive record of sunspot groups. After filtering out invalid features, we find a 96.5% match between the DPD and USAF sunspot group entries. Currently in progress, this merging work will lead to the most comprehensive sunspot group catalog for the 1986 – 2010 period.

Using this catalog as a testbed, we then evaluate the importance of each sunspot group parameter for the reconstruction of a few fundamental reference indices (Ri, F10.7,MgII) relevant to the coupling between the chromospheric UV irradiance and the Earth's ionosphere. Using data mining techniques, we identify the relevant or redundant parameters and we explore how different target indices require different combinations of parameters and the inclusion of delayed responses. In the process, we derive some hints regarding a possible recent bias in the Ri index affecting the exceptionally long declining phase of the last solar cycle. This offers an occasion to compare the recent long-lasting solar minimum to similar long minima in the past sunspot record.