Spectral analysis of luni-solar signal in daily meteorological data at Prague-Klementinum 1775 to 2011

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Linkages between lunar synodic cycle and select types of meteorological parameters have been suggested in previous studies. In important papers it was demonstrated that extreme precipitation events occur more frequently on the third to fifth day after syzygies. The effect is sometimes called Bowen's signal and similar lunar or semi-lunar modulation was later found also in ozone concentrations, sunshine, thunderstorm frequencies and in global temperatures observed by polar orbiting satellites. In our earlier papers we tried to analyse the possibility that the effect is transient in relation to solar activity. We confirmed the long-term quasi-periodical nearly-parallel changes in expression of lunar signal in 14 century-long daily precipitation series across Europe. The prevailing periods seemed to be similar to 22-year Hale solar magnetic cycle but there was no clear evidence and other similar celestial cycles could not be excluded.

A unique set of uninterrupted daily precipitation data from Prague-Klementinum since 1804, published by the Czech Hydrometeorological Institute, was available. In this study we also made use of a related dataset of daily mean cloudiness that dates back as far as 1775. The cloud cover has been observed in a subjective way but we think its reliability is relatively good. In the case of precipitation we also examined the series of days with daily amount exceeding 10 mm.

The data were divided into epochs of synodic months and superposed for 5 or 11 years with a step of one year. We get six sets of mean 29-day synodic signals containing 198-204 records for precipitation and 227-233 records for cloudiness. The temporal occurrence of lunar variation was defined as correlation coefficient ψ between semi-lunar cosine function (period $4\pi/29.53$), emulating the Bowen's signal, and the mean signals.

The coefficients ψ drawn against time created quasi-periodical charts ranging over more than two centuries. The impression of the ever-changing picture of synodic signals was given also by 3D-visualization by Surfer 10.4 surface maps. After removing both short and long-term variations of ψ using a band-pass filter (cut-off periods 4 and 64 years) we calculated the power spectra by FFT that were afterwards smoothed with a running mean of 3 data points.

A periodicity of 23 years - indicating solar influence - is prominent in the power spectra of cloudiness both for 5 and 11-year superposition and also in the case of the two precipitation series limited to 10 mm daily amounts, but is not present in the general precipitation series. The latter express important peaks in their power spectra near 18 years what might support the idea about the role of lunar Saros cycle of 18.6 years.