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# Climatic Cycles from Annual to Orbital Scale, their Origin and Stability

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We studied climatic cycles in North Italy during the Holocene and Late Pleistocene from luminescence of speleothems from Savi Cave near Trieste, N. Italy. We obtained 720 images of fluorescence and phosphorescence of speleothems from 10 caves from a S-N transept of Italy. We choose the best of them to produce high- quality records of environmental changes in Italy. Amongst all samples only speleothems (stalagmites and few flowstones) from Savi cave (North Adriatic coast near Trieste) were suitable for preparation of long high- resolution luminescence palaeoclimatic records. We dated a speleothem from cave Savi with 15 ICP-MS TIMS-U/Th dates form 1.317 to 16.484 kyrs B.P. with ($2\sigma$) error ranging from +/-97 to +/-480 years. We measured 3 paleoluminescence records (Stoykova et al., 2004) from this stalagmite:

The longest luminescent record covers last the 14430 $\pm$176 years ($2\sigma$ error) with a time step from 1.11 to 12.70 years.

We prepared also a composite record consisting of 81000 data points, which has been compiled from 39 overlapping scans (of 4800 data points each). It covers the last 5005.2 $\pm$140 years ($2\sigma$) (the upper 80 mm. of the sample) including several hiatuses. The resolution of the record varies from 9.9 days to 33.9 days.

The highest resolution composite record covers the last 2028 $\pm$100 years ($2\sigma$) (the upper 20 mm. of the sample) with several hiatuses. This composite record consists of 40106 data points and has been compiled of 16 overlapping scans (of 4800 data points each). It has resolution from 15.6 days to 19.9 days. It allows precise measurements of

the annual growth rate of the speleothem. It varies from 2.2 to 45.4 $\pm$0.5 microns/year from its mean value of 6.36 microns/year. Obtained record covers 2028 years taking into account hiatuses in the record. This record represents mainly the annual rainfall at the cave site.

We used the special real- space periodogramme analysis algorithm described in Shopov et al. (2002) to calculate the intensity of the cycles of the annual precipitation at the cave site. Resulting periodogramme demonstrates that the strongest cycles of the annual rainfall in the region of Trieste, Italy are with duration of about 300 and 55 years. Precipitation cycle with duration of 300 years has been detected by other authors as well but its origin is still unclear. We studied variations of the length of these cycles with time by evolutive power spectral analysis.

We used the same digital analysis to calculate the intensity of the cycles of the speleothem luminescence (representing cycles of solar radiation or air temperature). Obtained power spectra demonstrate that the strongest cycles of the soil temperature in the region of Trieste, Italy are with duration of about 11, 22 and 70 years. These are well known solar cycles, which drive temperature changes in some climatic regions. We studied variations of the length of these cycles with time by evolutive power spectral analysis.

We measured a luminescent speleothem record from Jewel Cave, South Dakota, US. It is still the only available experimental solar insolation proxy record with sufficiently long duration to reproduce the orbital variations. This record covers 89300- 138600 yrs B.P. with high resolution (34 years) and precision of measurements better than 1%. It reveals determination of millennial and century cycles in the record. The record has been dated by 6 TIMS U/Th dates with 2 sigma error of 0.8- 5.5 kyrs. This record exhibits a very rapid increasing in solar insolation at 139 kyrs +/- 5.5 kyrs (2 sigma error) responsible for the termination II. This increasing is preceding the one suggested by the Orbital theory with about 10 kyrs and is due to the most powerful cycle of the solar luminosity with duration of 11,5 kyrs superposed on the orbital variations curve. The Devils Hole 18- O record suggests that termination II happened at 140 +/- 3 kyrs. It follows precisely the shape of our experimental solar insolation record. So the Devils Hole record suggests, that the well known splitting and shifting of the glaciations relatively to the theoretical orbital variations curves appear to be result of solar luminosity variations

We measured also a luminescent solar insolation proxy record in a speleothem from Duhlata cave, Bulgaria. This record covers last 250 000 yrs with resolution 251- 445 years. It is dated by 4 TIMS U/Th dates and coinsides with the JC11 record in the frames of the dating error. This confirms, that both these records, from two sites 10

000 km apart represent solar insolation (which is global) rather that the local paleotemperature.

This solar insolation proxy record contains not only orbital variations, but also solar luminosity self variations, producing many cycles with duration from several centuries to 11500 years. The most powerful non- orbital cycle is 11500 years cycle (as powerful as the 23000 a. orbital cycle in our record). It was found previously to be the most intensive cycle in the delta C-14 calibration record and was interpreted to be of geomagnetic origin. Our recent studies suggest, that this is a solar cycle modulating the geomagnetic field. We found also cycles with duration of 6000, 4400, 3300, 2500, 2300, 1900 and 1460, years (in order of decreasing intensity) with amplitude ranging respectively from 16 to 4 % of the amplitude of the main orbital cycle presented in our record.

Known decadal and even century solar cycles have negligible intensity (100 times less intensive) relatively to this cycles. This millennial solar luminosity cycles can produce climatic variations with intensity comparable to that of the orbital variations. Solar luminosity and orbital variations both cause variations of solar insolation affecting the climate by the same mechanism.