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Titolo: Evidence of the climate control of strong seismicity in the Italian Apennines through groundwater recharge

Abstract
This paper explores the possibility that the destructive earthquakes occurring along the Apennine Chain in Italy are systematically triggered by groundwater recharge. The focus is on multi-year transitions towards phases of wet climate rather than on short-term heavy rainfall occurring in a few days or seasonally. The analysis takes into consideration the earthquakes with moment magnitude Mw≥5.8 occurred since 1901. Their time distribution is compared with the fluctuations of the self-calibrated Palmer Drought Severity Index (scPDSI), an indicator of soil moisture, here assumed to be a proxy for groundwater recharge. It is found that the scPDSI evolved through six main oscillations lasting from 11 to 25 years and that, with one exception, the strongest earthquake in each phase is placed within two years from the maximum of soil moisture. Based on a statistical test for pairs of point processes, such a coincidence indicates a significant synchrony between the two phenomena. In particular, the two strongest earthquakes of the study period (1915, Marsica earthquake, and 1980 Irpinia-Basilicata earthquake, with moment magnitude Mw 7.1 and 6.8, respectively) occurred exactly in the year of two of the largest peaks of scPDSI. The connection between wet climate conditions and the occurrence of strong earthquakes is further investigated by comparing the time distribution of Mw≥6.1 historical earthquakes occurred since 1200 AD with the evolution of the Great Aletsch Glacier in Switzerland, representative of water accumulation at the continental level. Even in this case the earthquakes clustered during time periods of increased precipitation and lower water evaporation, corresponding to the extreme phases of the Little Ice Age. The agreement of the results at different time scales and using different climate indexes leads to postulate a significant and systematic role of groundwater recharge in the triggering of large earthquakes along the Apennines. It is also suggested that the earthquakes might be triggered by pore-pressure propagation, where the necessary hydraulic continuity is made possible by the intersection of the shallow karst structures with the seismogenic faults.

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