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Can Solar Activities Influence Extreme Weather over Continental Portugal?

Stochastic Contrasts of Temperature and Precipitation with Sunspots and Cosmic Ray Intensity.

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The influence of solar variability on climate is currently uncertain. The primary reason for differing opinions on the subject derives from the fact that although numerous studies have demonstrated significant correlations between certain measures of solar activity and various climatic phenomena, the magnitude of the variable solar radiactive forcing reported in these studies is generally so small it is difficult to see how it could possibly produce climatic effects of the magnitude observed. Recent observations have indicated a possible mechanism via the influence of solar modulated cosmic rays on global cloud cover. Surprisingly the influence of solar variability is strongest in low clouds, which points to a microphysical mechanism involving aerosol formation that is enhanced by ionization due to cosmic rays. Since it is confirmed the average state of the Heliosphere is important for climate on Earth. The number of cosmic rays that reach the surface of the earth is influenced by a number of factors, which affect the number of particles that are detected: latitude, diurnal cycle, solar activity, Earth weather and altitude. The intensity of cosmic radiation is dependent on magnetic latitude. Since the sun is one of the primary sources for cosmic rays the daily rotations of the Earth and solar activity have significant impact on the number of cosmic rays which reach the surface of the Earth. Cosmic ray intensity as a function of various solar activities including sunspots and Heliospheric structure has been reported. Rapid

changes in cosmic ray intensity measurements have been attributed which result from solar flare and coronal mass discharges. Changes in local weather can also influence cosmic ray counters. Variation in cosmic ray also counts during thunderstorms, $i.e.$, strong atmospheric electric fields associated with thunderstorms have an effect on the propagation of cosmic ray particles. Besides, cosmic ray intensity is dependent on altitude. The purpose of this investigation is to determine the relationship between local extreme weather and cosmic ray intensity. Case study is realised considering some meteorological stations over Portugal mainland in the period of 1901-2000. We found statistically significant correlations between weather attributes and solar activity in the target period. Note that in this period special events with important volcanic eruptions and strong ENSO must be considered.

Supporters of solar effects theories counter by contending that various positive feedback mechanisms may amplify the initial solar perturbation to the extent that significant changes in climate do indeed result. In this summary, we highlight some of the recent scientific literature that demonstrates the viability of such solar linkages with extreme temperatures and precipitation. Hence, in this work we evaluate the existence of empirical evidence to support the hypothesis that solar variability is linked to the Earth's climate through regional-scale temperature and precipitation stochastic processes. One possible linkage to climate change is the sun's influence over the local flux of galactic cosmic rays via the fact that as the solar magnetic field gets stronger; fewer cosmic rays are able to penetrate to the inner solar system and Earth. Because the galactic cosmic rays cosmic rays contribute for ionizer air molecules in the lower atmosphere, they might play a role in processes like cloud formation. Recent studies have analysed the connection between galactic cosmic rays flux, solar activity, and climate on Earth. It was found that during the past 11.1-year solar cycle, Earth's cloud cover was more closely correlated with the galactic cosmic rays flux than with other solar activity parameters, such as solar radiance, the main energy emitted by the sun. Henrik Svensmark concludes that climate seems to be influenced by solar activity via the galactic cosmic rays and cloud connection. In other words, climate is partly affected by processes in deep space (*Physical Review Letters*, **81**, 5027-30, 1998). Controversy background may possibly be warranted by Fangqun Yu and Richard P. Turco (*Journal of Geophysical Research*, **106**, **D5**, 4797-4814, 2001). According to Tinsley (1996) lower atmospheric conductivity is primarily determined by the incoming cosmic ray flux. We have not discussed the physical processes which may be involved in the modulation of cloud factors by galactic cosmic rays as these lie beyond the scope of the present work, which is primarily concerned with empirical data. Several works have explored various possible effects on cloud formation and precipitation processes of ionisation by both galactic cosmic rays and energetic particles of solar origin. One suggestion is that cosmic rays striking dust particles in the air might help to trigger cloud formation perhaps thereby changing precipitation or temperature patterns or both. But how and which types of clouds might be formed, and their effects on climate or other environmental measures, remain too sketchy to draw reliable and quantitative conclusions. Currently, though, it is impossible to say with accuracy what causes the many newly discovered correlations between the cosmic ray by-products found in terrestrial reservoirs and ecosystem changes. That leaves forecasting future ecosystem change with rather large gaps in reliability. The effects here are rather subtle and appear to be limited to the dry season. The overall effect of the anthropogenic activities on annual and daily rainfall cycles is probably small and requires more study. Future research will use observed data for investigating the linkage between anthropogenic activities and the cloud-precipitation components of the water cycle. Using meteorological stations data from 1901-2000 we found evidence of a statistically reasonable relationship between cosmic ray flux, precipitation and absolute temperatures over Portugal Continental (at mid latitudes). Both weather variables vary by 15% during the solar cycle of the 1980's over the latitude band 37^oN-42^oN. Alternative explanations of the variation in these atmospheric parameters by changes in Tropospheric aerosol content, ENSO and volcanic eruptions could explain poorer statistical relationships. In the last 60 years the major forcing seems to have been changing solar luminosity, severe weather episodes coincide with a solar minimum. The exact mechanism remains unknown, but could have been increased cloudiness. Variations in precipitation potentially caused by changes in the cosmic ray flux have implications for the understanding of cloud and water vapour feedbacks.

The rainfall decreases are most pronounced in February just before the transition from wet to dry seasons in the Northern area of Portugal. In this transition period, the effects of land cover, such as evaporation, are not accelerated by large-scale weather disturbances that are common during some other season of the year. Small decreases in rainfall are observed for the southern regions in February and March, September and October; and relative decreases are also observed in the northern regions mainly after 1976, particularly in April. Furthermore, the rainfall increases are most pronounced in September and October during the final transition from dry to wet seasons in the Southern part of Portugal. Large variability in rainfall is also observed in the overall mainland Portugal, particularly in November and December. This research does not contradict that the Portuguese mainland south/north region experienced a shift in the onset of rainfall toward the morning/afternoon hours. The shift was likely initiated by the contrast in surface heating across the north and south regions. We can notice the reduction of warm-nights exceedances along the period. The main conclusion is that the average state of the Heliosphere can affect local Earth's climate, mainly for mid latitudes. Possibly, the Portuguese climate system is more sensitive to small variations in solar activity than generally believed!

Effectively, researchers consider that the solar wind, which becomes stronger during sunspot cycles, protects the earth from high-energy charged particles (cosmic rays) from outer space. These incoming cosmic rays may contribute to cloud formation, cooling the earth. Researchers are not sure how cosmic rays contribute to cloud cover, though there are some theories. The solar activity rises and falls with a period of about 11 years. The number of sunspots indicates the level of solar activity. Emissions of matter and electromagnetic fields from the Sun increase during high solar activity, making it harder for Galactic cosmic rays to reach Earth. The cosmic ray intensity is lower when solar activity is high and *vice-versa*. Currently the sunspots are decreasing and cosmic ray intensity is increasing. Recent analysis of monthly mean cloud data from the International Satellite Cloud Climatology Project uncovered a strong correlation between low cloud and the cosmic ray flux for extensive regions of the Earth with which new studies have been made related to geographical variation of the correlation between low cloud and predicted ionization level from cosmic rays. We suppose that, under the most favourable conditions, a reduction in low cloud cover combined with the direct forcing by solar irradiance could explain a significant part of the regional changing over Continental Portugal.