Project Details

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Project Title:
Solar influence on climate variability on centennial time scales

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Summary:
We propose a study addressing the LWS Sun-Climate Theme strategic objective to deliver the understanding of how and to what degree variations in the solar radiative and particulate output contribute to changes in global and regional climate over a wide range of time scales. Our investigation is focused on the role of the solar Centennial Gleissberg Cycle (CGC) in producing global and regional climate change. The CGC is characterized by a 90-100 year variation in the amplitude of the 11-year cycle accompanied by a corresponding variation in the intensity of geomagnetic activity. The extreme sunspot and geomagnetic minima during the recent sunspot cycle 23/24 transition can be understood as part of a CGC series of minima that also occurred in the beginnings of 18th, 19th and 20th centuries. These minima have been associated with cold winters in the Northern Hemisphere and the CGC has now been identified as operating at least 80% of the time during the last 1,500 years. The low-frequency nature of the CGC enhances the influence of solar variability on climate due to the engagement of oceans. This study of solar influence on climate at time scale intermediate between decadal and millennia scales is now possible and timely due to availability of high-resolution climate records and the development of adaptive data analysis methods.

Objectives: We will carry out empirical studies of climate response to solar forcing on the centennial time scale using advance data analysis methods and compare our results with those expected on the basis of the mechanisms that have been suggested for solar influence on climate. The effect of the CGC forcing of climate is expected to be seen primarily in regional patterns rather than in global changes. To trace the solar connection we will relate selected climate change records with the century-long records of solar variability seen in sunspots, geomagnetic activity, solar irradiance reconstructions and a millennium long record of low-latitude auroras, the best available markers of solar variability on centennial time scale. We will carefully investigate the role of the centennial climate change during the 19th and 20th centuries for which we have detailed and abundant data sets. Climate change during the 20th century has been increasingly caused by anthropogenic (CO2) forcing but the 19th, 18th and earlier centuries were less affected by it and solar forcing should be dominating. A comparison of these century-long climate histories can lead to improved understanding of the difference of climate responses to solar and to anthropogenic forcing. Well-dated volcanic contributions produce short-term effects and will easily be taken into account. The CGC response at earlier times and in specific Earth s regions will also be investigated.

Expected Significance: The regional and global effects of the CGC have received little attention until now. The investigation of CGC role in climate change is expected to validate and to expand our understanding of mechanisms of solar influence on climate. The major mechanisms include the solar effects on the annular modes coupled with the stratosphere-troposphere interaction, the solar irradiance effect on tropical oceans, and the influence of cosmic ray modulation of clouds. The CGC is expected to produce much stronger effects on climate relative to the decadal solar cycle because due to the thermal inertia of the ocean the whole atmosphere-ocean climate system is fully engaged. We expect strong regional effects. A comparison of the climate changes during the most recent CGC (1910 through 2010) and earlier CGCs will permit better estimates of the relative contribution of solar versus anthropogenic forcing.

The proposal team is confident it will achieve the objectives quoted above due to a long-term expertise in working with long-term solar, geomagnetic and climate data with an excellent record of publications in this field.

Publication References:

Summary: no summary

Reference: Feynman, J.; Ruzmaikin, A.; (2014), The Centennial Gleissberg Cycle and its association with extended minima, Journal of Geophysical Research: Space Physics, Volume 119, Issue 8, pp. 6027-6041, doi: 10.1002/2013JA019478

Summary: no summary

Reference: Ruzmaikin, Alexander; Feynman, Joan; (2015), The Earth's climate at minima of Centennial Gleissberg Cycles, Advances in Space Research, Volume 56, Issue 8, p. 1590-1599, doi: 10.1016/j.asr.2015.07.010