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Influence of synoptic weather patterns on solar irradiance variability in Europe

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Solar radiation is important for many aspects of existence on Earth, including the biosphere, the hydrological cycle, and creatures living on the planet. Previous studies have reported decadal trends in observational records of surface shortwave (SW) irradiance around the world, too strong to be caused by varying solar output. These observed decadal trends have been dubbed "solar dimming and brightening" and are believed to be related to changes in atmospheric aerosols and cloud cover. Because the observed solar variability coincides with qualitative air pollution histories, the dimming and brightening have become almost synonymous with shortwave attenuation by anthropogenic aerosols. However, there are indications that atmospheric circulation patterns have influenced the dimming and brightening in some regions, e.g., Alaska and Scandinavia. In this work, we focus on the role of atmospheric circulation patterns in modifying shortwave irradiance.

An examination of European SW irradiance data from the Global Energy Balance Archive (GEBA) shows that while there are periods of predominantly decreasing ($\sim$1970-1985) and increasing ($\sim$1985-2007) SW irradiance, the changes are not spatially uniform within Europe and in a majority of locations not statistically significant.

To establish a connection between weather patterns and sunshine, regression models of SW irradiance are fitted using a daily classification of European weather called Grosswetterlagen (GWL). The GWL reconstructions of shortwave irradiance represent the part of the solar variability that is related to large scale weather patterns, which should be effectively separated from the influence of varying anthropogenic aerosol emissions.

The correlation (R) between observed and reconstruced SW irradiance is between 0.31 and 0.75, depending on station and season, all statistically significant ($p<0.05$, estimated with a bootstrap test).

In central and eastern parts of Europe, the observed decadal SW variability is poorly represented by the GWL models, but in northern Europe, the GWL model recreates observed decadal solar variability well. This finding suggests that natural and/or anthropogenic variations in circulation patterns have influenced solar dimming and brightening to a higher degree in the north than in the rest of Europe.