On the Relative Role of Clouds in the Decadal Changes of Solar Radiation

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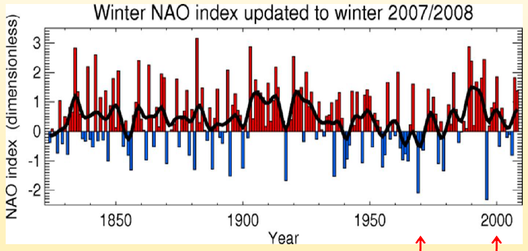
Time Series of NAO Winter Index



Osborn et al., 1999

Period of study is dominated by a strengthening of the positive phase of the NAO

1970 2000

Introduction and Methodology

This study aims at quantifying the most important factors for the decadal variations in the surface shortwave downward radiation. With reports describing global variations of this radiation parameter using surface and satellite-derived measurements, emphasis has recently been placed on regional studies to further understand the mechanisms that are contributing to the local changes in solar radiation. Analysis of this radiative parameter is performed on surface observations in Europe from the Global Energy Balance Archive (GEBA) from 1970 through 2000. Because cloud cover is one of the major contributors for the variability of solar radiation, we assess the relative role of this factor. The effect of cloud cover on surface shortwave downward radiation is evaluated through generalized linear models where these two factors act as covariates. Denoted by Y^j and C^k the time series $Y^j = (Y^j_{1,DJF}, Y^j_{1,MAM}, Y^j_{1,JJA}, \ldots, Y^j_{n,MAM}, Y^j_{n,JJA}, Y^j_{n,SON})$, $C^k = (C^k_{1,DJF}, C^k_{1,MAM}, C^k_{1,JJA}, \ldots, C^k_{n,MAM}, C^k_{n,JJA}, C^k_{n,SON})$, of solar radiation at station j and of cloud cover at station k. Also, n = 26 years for 1971-1996 has been chosen because solar radiation and cloud cover are both available only within this period. The statistical model used here is a multiple linear regression: $Y^j \sim \text{Normal}(\mu, \sigma)$, $\mu = \beta_0 + \beta_1 C^k + \beta_2 DJF + \beta_3 MAM + \beta_4 JJA + \beta_5 T$. Seasonal variations in solar radiation are taken into account by using 4 indicator variables: DJF, MAM, JJA, and SON, which are equal to 1 in the corresponding season of each year and 0 otherwise. A linear trend term T is included.

Data

Solar Radiation-Global Earth Balance Archive (GEBA) maintained at ETH, Zurich, Switzerland

- Global radiative fluxes at the Earth's surface with a total of 1600 stations and over 250,000 monthly mean values
- Annual standardized anomalies are computed from averaging monthly mean values for 1970-2000

Cloud Cover

- Carbon Dioxide Information Analysis Center (CDIAC)
- Seasonal means of cloud cover co-located with the GEBA solar radiation measurements are used from 1971-1996

NAO

- National Center for Atmospheric Research (NCAR) in Boulder, Colorado
- Difference in normalized sea level pressure (SLP) between Ponta Delgada, Azores and Stykkisholmur/Reykjavik, Iceland for 1970-2000

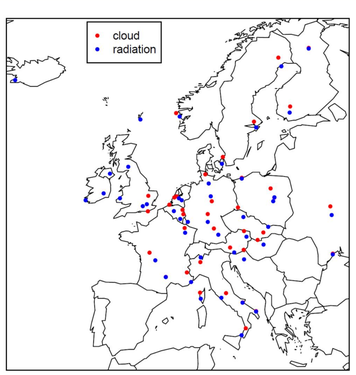


Figure 1. Location of solar radiation stations from GEBA (blue) and cloud cover (red).

Spatial Dependence of the Cloud Cover Effect on Solar Radiation during 1971-1996

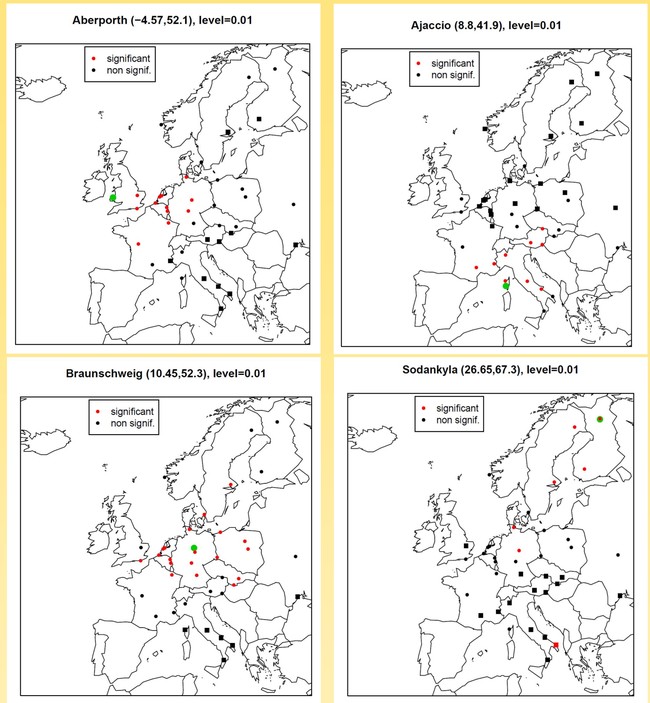


Figure 2. Cloud cover has a positive (negative) effect on the solar radiation measured at the green dot station (see plot title for coordinates and name of location) for all cloud measurement stations represented by a circle (square). Significant values at the 1% confidence level are plotted in red.

Spatial Dependence of the Cloud Cover Effect on Solar Radiation during 1971-1996

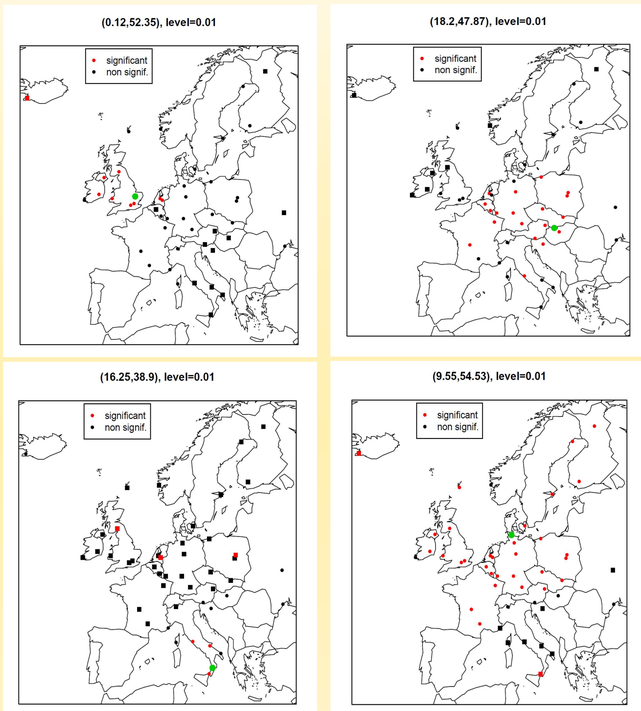


Figure 3. Cloud cover at the green dot station (see plot title for coordinates) has a positive (negative) effect on the solar radiation measured at all stations represented by a circle (square). Significant values at the 1% confidence level are plotted in red.

Conclusions

- **A high degree of spatial coherence is found for the effect of cloud cover on the solar radiation**
- **Cloud cover from stations located close to the solar radiation measurement site has a statistically significant positive effect**
- **Cloud cover from stations located remotely far from the solar radiation site has a statistically significant negative effect**
- **There exists a decoupling of the effects of cloud cover on solar radiation between Central and Southern Europe possibly due to the NAO circulation**