Trends in solar radiation and cloud over the North Atlantic sector in the last four decades: drivers and physical processes

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Analyses of time evolutions in absorbed solar radiation (ASR) at the top of atmosphere, surface shortwave (SW) radiation and cloud cover, based on satellite observations and three reanalyses, show some consistent decadal trends over the North Atlantic sector in the last four decades. These trends show a strong seasonality with large changes in boreal spring and summer, characterized by increases in ASR and surface SW and decreases in cloud cover from 1980s to 2000s. These changes show consistent spatial patterns among different data sets over both North America and Europe although they are less so over the North Atlantic. A set of timeslice attribution experiments using an atmospheric general circulation model (AGCM) forced with prescribed changes in sea surface temperature/sea ice extent (SST/SIE), anthropogenic greenhouse gases (GHG) concentrations and anthropogenic aerosol (AA) emissions all together, or separately, to assess the roles of different forcings on these observed solar radiation and cloud trends. Model responses to all forcing changes reproduce main observed features over Europe and North America, including the seasonality, suggesting a dominant role of external forcing on recent trends. Individual forcing experiments indicate that recent decadal changes in surface SW radiation over North America and Europe are very likely and predominantly driven by AA emission changes with additional influence of SST/SIE and GHG changes. Responses in surface SW radiation to AA emission changes are strongly modulated by aerosol-radiation interactions and partly by changes in cloud fraction. Responses in surface SW radiation to SST and GHG changes are dominantly due to cloud cover changes.