Geophysical Research Abstracts
Vol. 21, EGU2019-6630-2, 2019
EGU General Assembly 2019

Arctic Amplification from Space: Analyzing the Ice-Cloud Feedback with 35 years of ESA Cloud_cci AVHRR Radiation Flux and Cloud Climatologies

Daniel Philipp (1), Martin Stengel (1), and Bodo Ahrens (2)

(1) Deutscher Wetterdienst, Satellite-based Climate Monitoring, Offenbach am Main, Germany, (2) Insitute for Atmospheric and Environmental Sciences, Goethe University, Frankfurt am Main, Germany

Arctic surface warming is about twice the global average, known as Arctic Amplification [Vaughan et al., IPCC, 2013]. Amplifying feedback mechanisms with sea ice as a centerpiece are assumed to cause this phenomenon, highlighting the Arctic as very vulnerable to global climate change. Despite a variety of existing studies that focus on Arctic cloud trends, their vertical profile, the relation with sea ice, and finally the contribution of the Ice-Cloud (IC) feedback to Arctic Amplification, there are still controversial results. Differences arise primarily due to difficulties in passive instrument cloud detection over sea ice (e.g. Liu et al., AMS JCLI, 2010) and lacking knowledge of Arctic atmospheric profiles. 35 year state-of-the-art satellite-based Climate Data Records (CDRs) generated within the framework of the ESA Cloud_cci project [Stengel et al., ESSD, 2019] are used to present (1) cloud cover and surface Cloud Radiative Forcing (CRF) changes over the Arctic, (2) assess its relation and causality with declining sea ice and (3) discuss impacts on future climate with the focus on the IC feedback. As a highlight, causality between clouds and sea ice is – first ever to our knowledge – assessed with Granger Causality (GC) which offers valuable advantages compared to often used cross-correlation. Sensitivities of CRF to cloud cover changes have been quantified. Autumn months (Sept.-Nov.) are characterized by excessive sea ice loss and an amplified surface warming [Serreze et al., The Cryosphere, 2009]. In our study we find extensive positive low-level cloud cover (Cloud Fractional Cover; CFC) trends over the Arctic ice pack for October and November with an amplitude of up to about +10% per decade. On contrary, summer months (incl. September) do not show significant low-level cloud trends despite strong Sea Ice Concentration (SIC) trends. Statistically significant anti-correlations between SIC and low-level CFC are observed in October and November in the marginal ice zone, indicating an association between SIC and low-level CFC. The GC analysis revealed a strong causal relation between SIC and low-level CFC where the influence of SIC on low-level CFC is stronger than vice-versa. The analysis of ERA-Interim reanalysis data suggests that low-level CFC is impacted by SIC through surface-atmosphere coupling via turbulent surface fluxes of heat and moisture. These fluxes are enhanced over newly ice-free ocean in melting zones in October and November, destabilizing the atmosphere which in turn fosters cloud formation. The lack of summer and September cloud response is likely to be due to small atmosphere-ocean temperature gradients in this period of the year limiting turbulent surface fluxes. Because the net CRF at the surface is positive (dominant longwave heating) in October and November, the surface heating also shows a trend of locally up to about $+8$ Wm^{-2} per decade. This additional heating has certainly the capability to increasingly hinder sea ice recovery and therefore formation of perennial ice. All in all, the positive IC feedback seems clearly evident in the analyzed satellite data with the strength to contribute a major part to Arctic Amplification.