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Non-stationary Relationship between Cloud Radiative Forcing and Sea Ice Concentration in the Arctic Ocean during Summer

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1. Introduction

The summer extent of the Arctic sea ice cover has been declining for the past few decades. There are several possible cause of the dramatic Arctic sea ice loss. Earlier work has eatablished the general impact on ice extent of warming trends, changes in atmospheric circulation, increased export of older ice out the Fram strait, low clouds, advection of ocean heat from the pacific and North Atlantic, and enhanced solar heating of the ocean. recent study suggests that absorbed solar radiation at the top of the atmosphere in early summer plays an precursory role in determining the Arctic sea ice concentration in late summer. Since clouds are so intimately involved in the Arctic surface radiation budget, it is necessary to more clearly understand how they interact with radiation. In this study, we have examined changes in the relationship between surface cloud radiative forcing(CRF) and sea ice concentration(SIC)/surface temperature surface temperature (TS) in the Arctic Ocean during summer (June-July -August-September).

2. Date and Methods

The monthly observation data of shortwave (SW) and longwave (LW) CRFs, SIC and TS were obtained over the Arctic Ocean (North of 70°N) from the Extended AVHRR Polar Pathfinder (APP-x) product for the period of 1982–2012. Because the definition of cloud fraction different varies in different models and observations, we use the SW and LW CRFs. Ramamathan et al. (1989), the surface SCFs is defined as :

$$\mathrm{SCFs} = (\mathrm{SW}\downarrow - \mathrm{SW}\downarrow_{cs})\cdot(1-\alpha) + (\mathrm{LW}\downarrow - \mathrm{LW}\downarrow_{cs})$$

where the subscripts cs indicates clear-sky fluxes and α is the surface albedo. The first and second term on the right hand side of the equation represent the cloud influence on the solar and the infrared radiation, respectively. Vavrus (2006) suggests that new formular, by removing the surface albedo effects. In this study, SW SCFs and LW SCFs is defined as :

$$\mathrm{SW\ SCFs} = \mathrm{SW}\downarrow - \mathrm{SW}\downarrow_{cs}$$
$$\mathrm{LW\ SCFs} = \mathrm{LW}\downarrow - \mathrm{LW}\downarrow_{cs}$$

This formular makes the change in CRF a more useful measure of cloud feedback. We separate SCFs into SW SCFs and LW SCFs to compare its effects.

3. Results

We found that the relationship between CRF and SIC/TS changed over time. The negative (positive) correlation between SW CRF (LW CRF) and SIC has become stronger over the Pacific sector of the central Arctic since the late 20th century. This indicates that the cloud radiative effect by LW radiation has been reduced, whereas that by

SW radiation has increased over the Pacific sector of the Arctic Ocean. In addition, the impact of LW CRF to SIC has increased over the marginal sea areas. Similar relationship is also found in the TS data. This recent change in the relationship based on the satellite observation is not reproduced in current climate models. Rather, most models tend to overemphasize the cloud radiative effect by LW radiation on SIC/TS during summer.

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