A Synthetical Estimation of Northern Hemisphere Sea-ice Albedo Radiative Forcing and Feedback between 1982 and 2009

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Introduction

The decreasing surface albedo caused by continuously retreating sea ice over Arctic plays a critical role in Arctic warming amplification. An accurate quantification of the Arctic SIAF is essential for understanding the physical mechanisms of accelerated sea ice loss and assessing the underlying evolution of Arctic warming amplification.

Different estimates and conflict conclusions from previous studies

- Flanner et al (2011) found NH SIRF decreased 0.22 W m^{-2} from 1979 to 2008, yield a NH SIAF of 0.28 W m^{-2} K^{-1}.
- Pistone et al (2014) estimated the change in NH SIRF is 0.43 W m^{-2}, yield a global SIAF of 0.31 W m^{-2} K^{-1}.
- Flanner et al. (2011) also indicated that CMIP3 models substantially underestimated the SIAF because of the slower decline of model simulated sea ice.
- After data analysis and comparison, Dessler (2013) indicate there is no evidence GCMs underestimate surface albedo feedback.

Objectives

- Estimate the change in NH SIRF and SIAF in the past three decades with satellite-retrieved long-term surface albedo product.
- Find out what causes the difference between previous studies and try to reconcile their disagreement.
- Evaluate the performance of reanalysis on assessment of change in NH SIRF and SIAF.

Data

Table 1. Global satellite albedo products used in this study.

datasets		Source	Resolution	Frequency	Temporal coverage
Albedo Products	CLARA-A1	AVHRR	0.25°	Monthly	1982–2009
	ERA-Interim	Reanalysis	0.25°	Monthly	1982–2009
	MERRA	Reanalysis	0.67° × 0.50°	Monthly	1982–2009
TOA Flux	CERES SSF	CERES	1.0°	Monthly	2000–2009
Sea Ice	NSIDC SIE	SMMR/DMSP	25 Km	Weekly	1982-2009
Surf T	GISS Surf T	Simulated	2.0°	Monthly	1982-2009
Cloud Fraction	CERES SSF	CERES	1.0°	Monthly	2000–2009
	CLARA-A1	AVHRR	0.25°	Monthly	1982–2009

Results

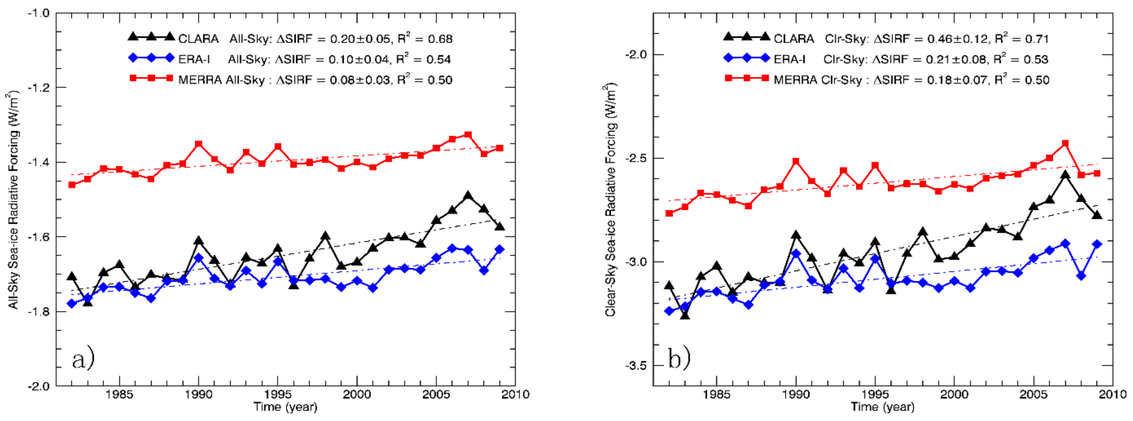

Fig. 1. Northern Hemisphere sea ice radiative forcing (SIRF) averaged over two radiative kernels and the estimated changes of SIRFs from 1982 to 2009 for (a) all-sky and (b) clear-sky.

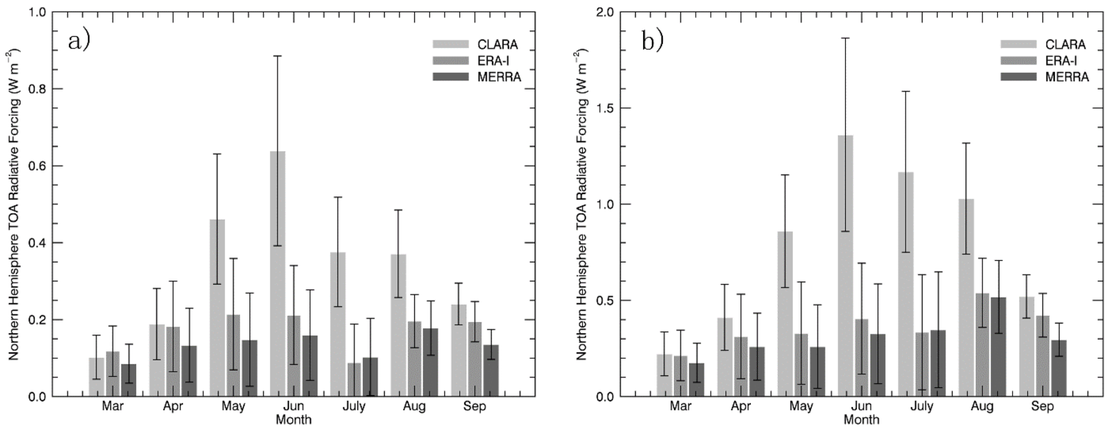

Fig. 2. Monthly changes in NH sea ice radiative forcing from 1982 to 2009 for (a) all-sky and (b) clear-sky

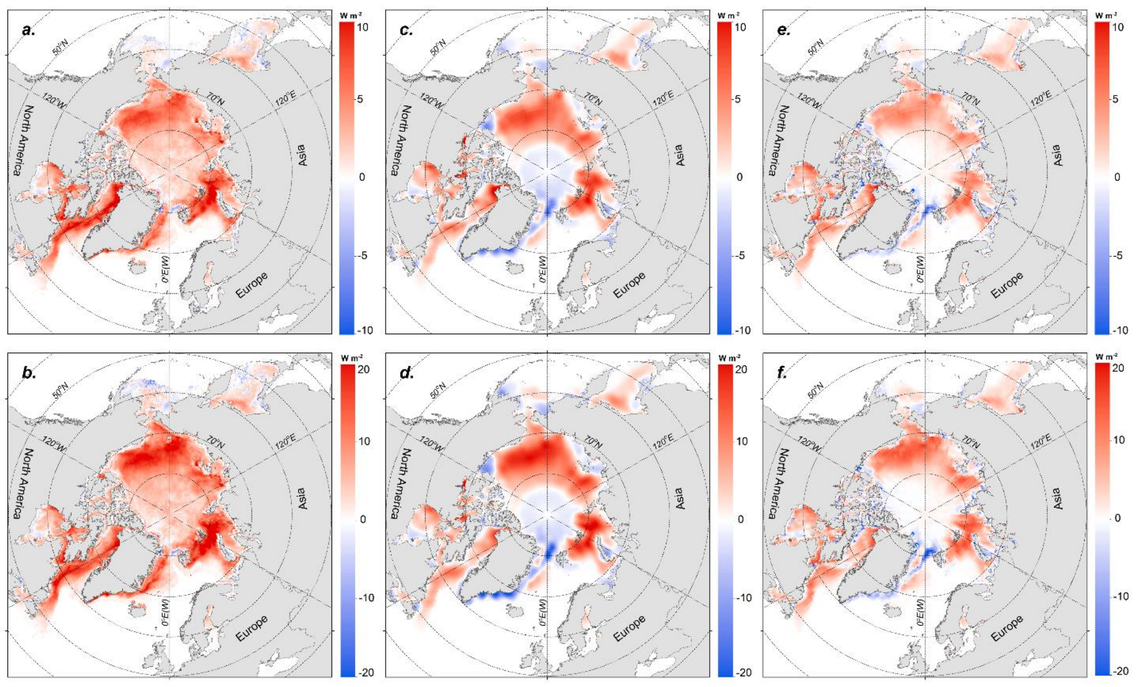

Fig. 3. Spatial distribution of changes in sea ice radiative forcing from 1982 to 2009 for (a) CLARA all-sky, (b) CLARA clear-sky, (c) ERA-Interim all-sky, (d) ERA-Interim clear-sky, (e) MERRA all-sky, (f) MERRA clear-sky .

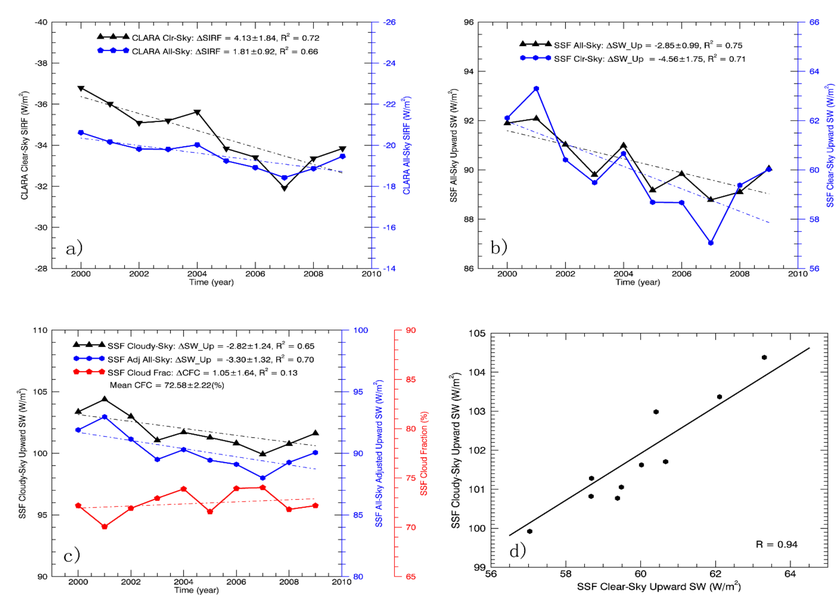

Fig. 3. Annual mean (a) CLARA SIRF; (b) CERES SSF TOA Upward SW Flux; (c) SSF cloudy-sky SW, adjusted all-sky SW Flux and cloud fraction. Subfigure (d) is the scatter plot of cloudy-sky and clear-sky upward SW flux.

Table 2. Northern Hemisphere (NH) and global sea ice albedo feedback (SIAF).

SIAF (W m^{-2} K^{-1})	Before Adjustment		After Adjustment	
	NH	Global	NH	Global
CLARA	0.25	0.19	0.42	0.31
ERA-I	0.13	0.09	0.19	0.14
MERRA	0.10	0.07	0.16	0.12

Conclusions

- With radiative kernel method, an estimated 0.20 ± 0.05 W m^{-2} SIRF has decreased in the Northern Hemisphere (NH) from 1982 to 2009, yield a sea-ice albedo feedback (SIAF) of 0.25 W m^{-2} K^{-1}.
- Further data analysis indicates that kernel method is likely to underestimate the change in all-sky SIRF. By applying an adjustment with CERES-based estimate, the change in all-sky SIRF over NH was corrected to 0.33 ± 0.09 W m^{-2}, yield a SIAF of 0.42 W m^{-2} K^{-1} for NH and 0.31 W m^{-2} K^{-1} for the entire globe.
- Relative to satellite surface albedo product, two popular reanalysis products - ERA-Interim and MERRA, severely underestimate the change in NH SIRF in melt season (May to August) during last three decades.

References

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- Dessler, A., 2013: Observations of Climate Feedbacks over 2000–2010 and Comparisons to Climate Models. *Journal of Climate*, **26,** 333-342.
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