Albedo decrease caused by vanishing Arctic sea ice
Observational determination using CERES

Kristina Pistone
Ian Eisenman and V. Ramanathan
CERES Science Team meeting
Scripps Institution of Oceanography
30 October 2013
The Arctic sea ice is shrinking

http://nsidc.org/data/seaice_index/archives/
Decreasing ice area reduces albedo

- Amount of incoming solar radiation reflected back to space
- White surfaces reflect more; dark surfaces absorb more sunlight
- Ice albedo feedback
- Albedo of ice itself will change seasonally or with other factors
- Clouds are white
Seasonal cycle of ice albedo

- Cold snow
- Melting snow
- Pond formation
- Pond drainage
- Pond evolution
- Freezeup
- Open water
Our Question:

• How much does the albedo of the Arctic change as the ice retreats?
• How much extra energy does this mean for the Arctic?
• Are there any compensating effects to mitigate the albedo decrease?
Observational Data

• Shortwave radiation (0.3-5\(\mu\)m), 1°x1° resolution data from CERES Terra SSF Ed 2.6

• NSIDC: sea ice concentration measured from microwave satellites (SSM/I) since 1979
  – Monthly-averaged data, coincident with CERES from March 2000 through December 2011
Albedo tracks with sea ice decrease
Add EP spline fit, one panel here.
central Arctic (80–90N) ice albedos

- **Range of \( \alpha_s \) from SHEBA**
- **SHEBA mean \( \alpha_s \)**
- **\( \alpha_{s,l} \) from CERES**

The graph shows the albedo percentage over months from March to September, with significant fluctuations.
Increase in Arctic SW heat flux 1979-2011

• The decrease in albedo of 4% corresponds to an increase of $6.4 \pm 0.9 \text{ W/m}^2$ in absorbed solar radiation over the Arctic Ocean (1979-2011).
  – $0.43 \pm 0.07 \text{ W/m}^2$ over NH
  – $0.21 \pm 0.03 \text{ W/m}^2$ averaged over the globe, approx 25% the magnitude of CO$_2$ forcing during this period

• Compared with previous studies and models:
  – Perovich et al 2007: 5.6 W/m$^2$ into Arctic Ocean
  – Flanner et al 2011: 0.22 W/m$^2$ (0.15-0.32 W/m$^2$) for NH
  – CCSM4: lower measured trend, but $\delta \alpha/\delta I$ is consistent
Conclusions

• Independent datasets strongly corroborate one another

• Arctic albedo under cloudless conditions has decreased from 37% to 31% between 1979 and 2011; total-sky albedo decreased from 52% to 48% during the same period. This is larger than previous estimates.

• While GCMs underestimate ice retreat, the ice-albedo feedback appears well-captured.
Questions?