

Assessing high-latitude climate feedbacks using models and observations

Alex Hall

UCLA Dep't of Atmospheric Sciences

2003 SEARCH Open Science meeting

How would we measure climate feedbacks?

Climate sensitivity parameter

Change in net incoming shortwave with SAT

$$\lambda = \frac{dF}{dT_s} - \frac{dQ}{dT_s}$$

Change in outgoing longwave with SAT

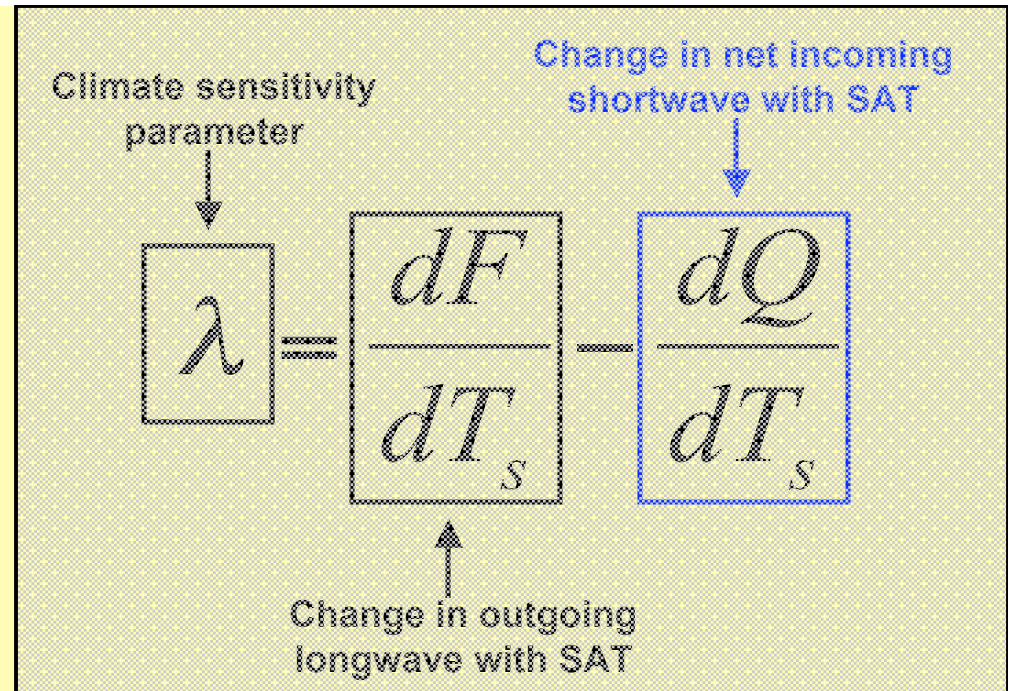
Barriers to measuring climate feedbacks based on the observed record

_The observed record contains both internally-generated variability and variations stemming from external forcing. If the feedback behaves differently in the internal variability context, the presence of internal variability could contaminate the statistics of the feedback in observed record (example: sea ice albedo feedback).

_Even if the observed record is dominated by variations stemming from external forcing, it may not be in equilibrium with the external forcing. The statistics of the feedback in the observed record would be contaminated if the feedback behaves differently in the context of transient climate change (example: southern hemisphere climate change).

Both of these barriers may be surmountable in the case of snow albedo feedback in the northern hemisphere.

We focus here on the contribution of surface albedo feedback to dQ/dT_s .

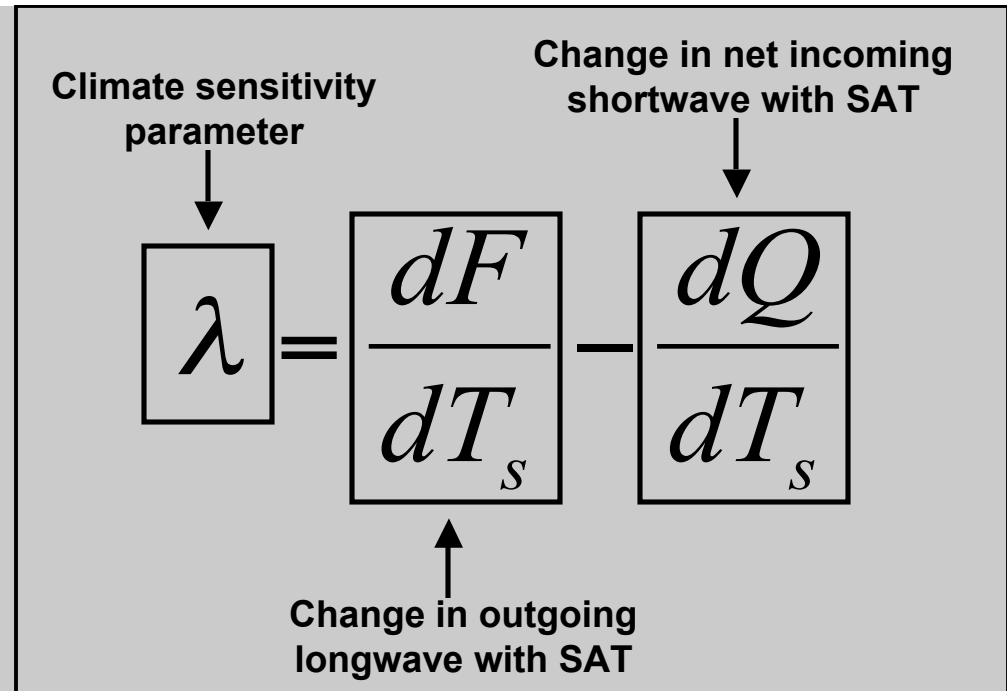


$$\left(\frac{\partial Q}{\partial T_s} \right)_{SAF} = \frac{\partial Q}{\partial \alpha_s} \cdot \frac{d\alpha_s}{dT_s}$$

change in solar radiation with surface albedo

change in surface albedo with SAT

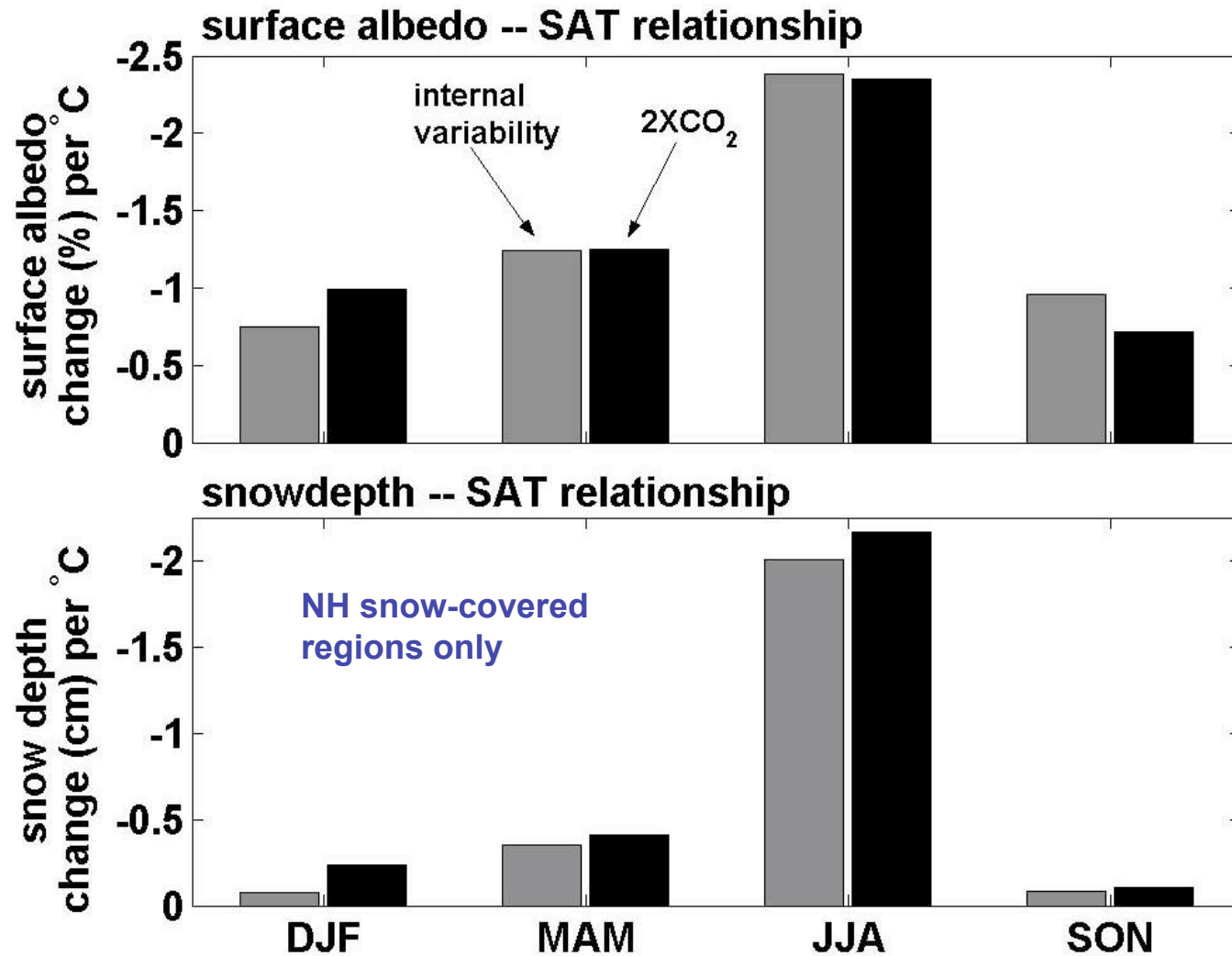
We focus here on the contribution of surface albedo feedback to dQ/dT_s .



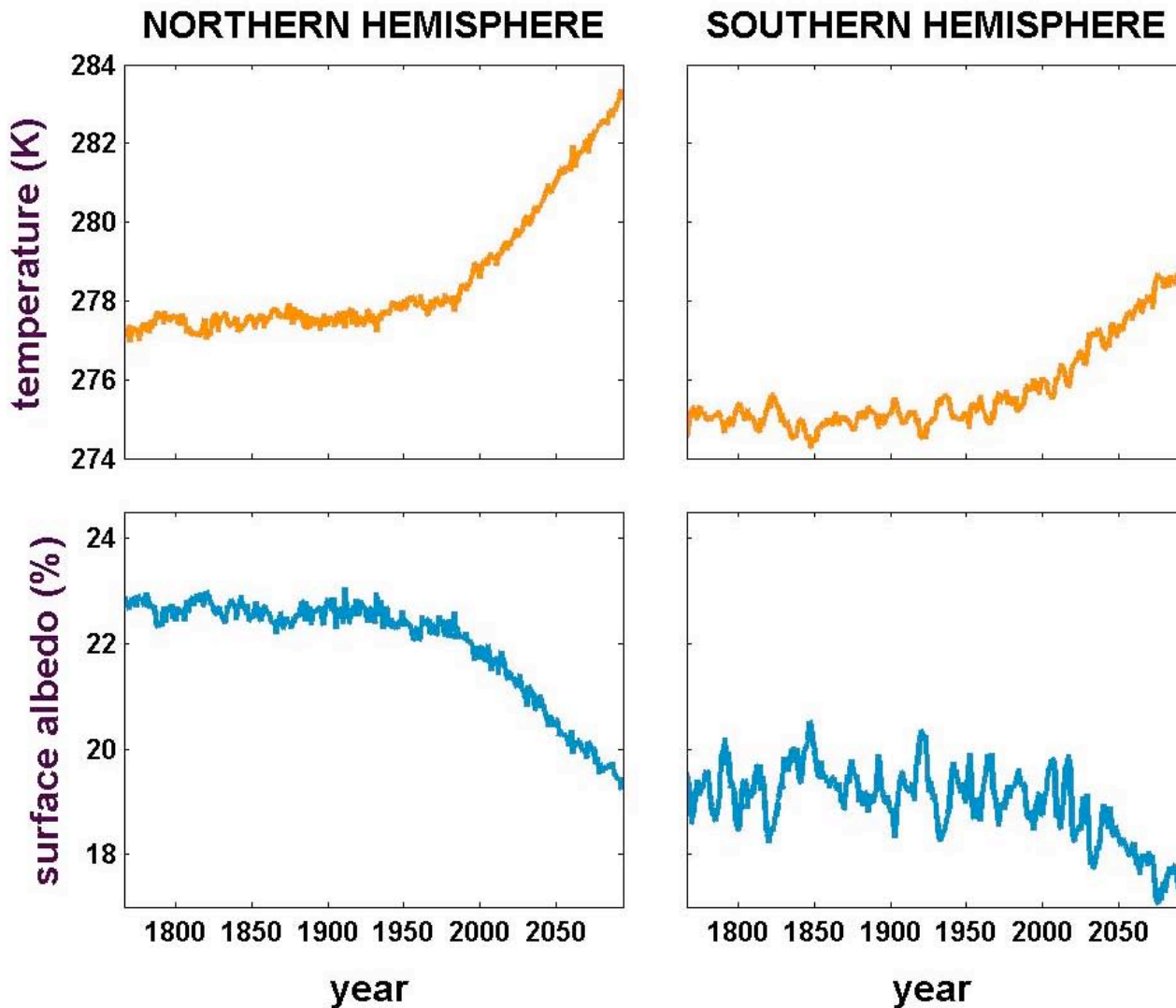
$$\left(\frac{\partial Q}{\partial T_s} \right)_{SAF} = \frac{\partial Q}{\partial \alpha_s} \cdot \frac{d\alpha_s}{dT_s}$$

change in solar radiation with surface albedo

change in surface albedo with SAT

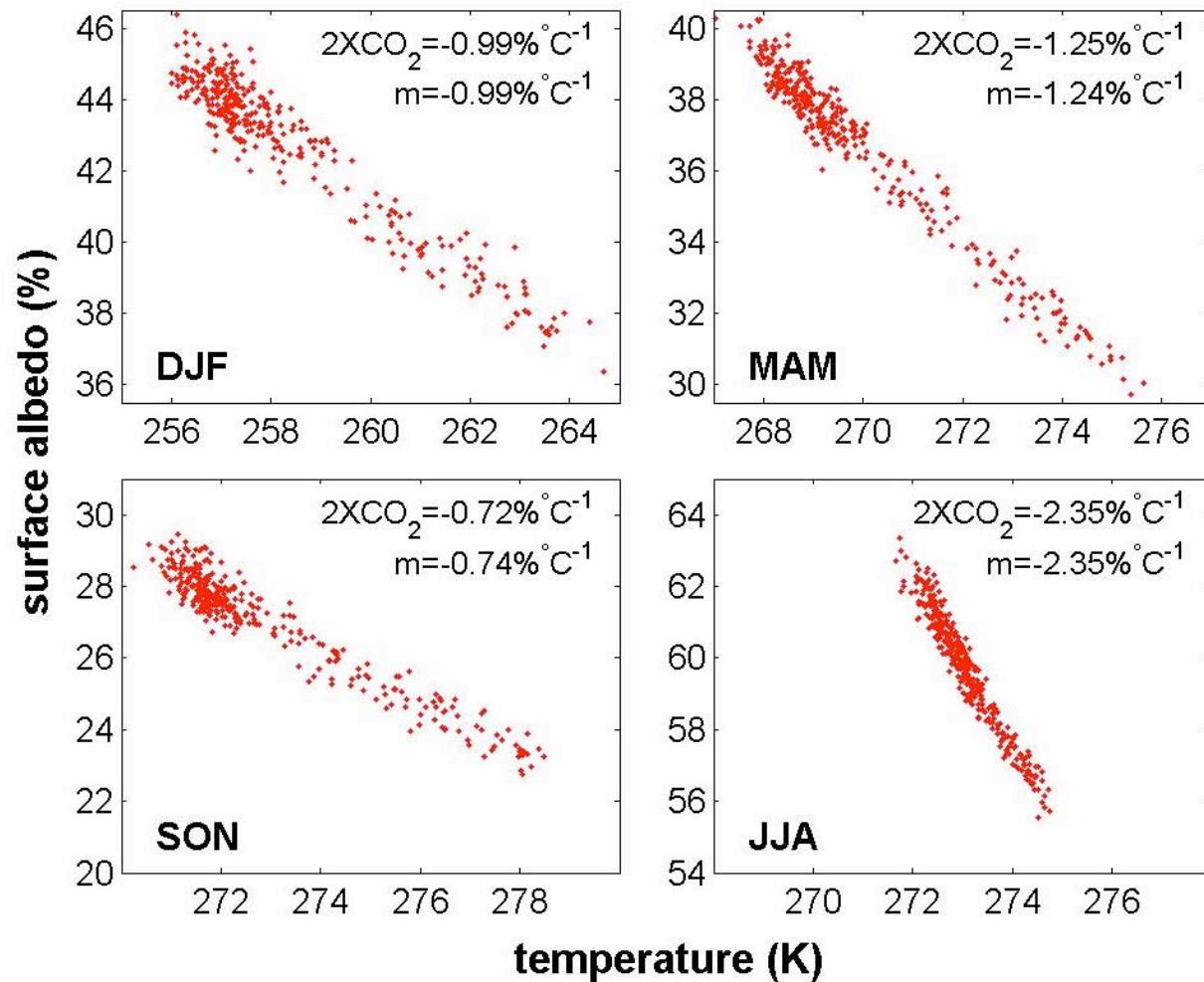


Snow albedo feedback behaves in a similar way in the equilibrium climate change and internal variability contexts.



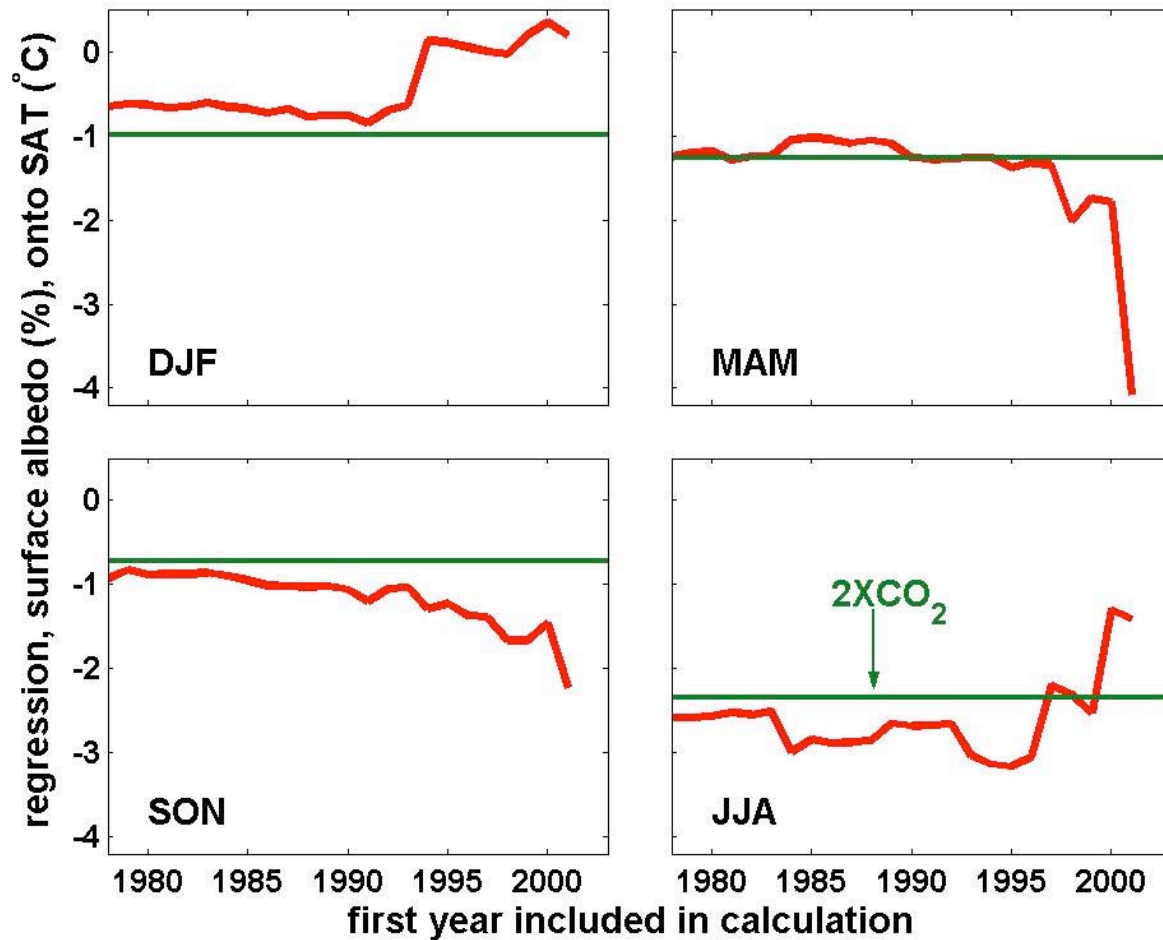
Time series of NH and SH extratropical **SAT** and **surface albedo** in a scenario run, where past and projected future changes in greenhouse gases and sulfate aerosols are imposed on the model. This run has a similar mix of internal variability and transient response to external forcing as the observed record.

Scatter plot of sfc albedo vs SAT in scenario run for NH snow-covered regions



The regression of surface albedo onto SAT in the scenario run agrees very well with the change in surface albedo divided by the change in SAT in the CO₂-doubling context.

sfc albedo—SAT regression in the scenario run for the satellite era



If the scenario run is any guide, it should be possible to measure snow albedo feedback in the equilibrium climate sensitivity context by examining data from the satellite era (1978-present).

Barriers to measuring climate feedbacks based on the observed record

_The observed record contains both internally-generated variability and variations stemming from external forcing. If the feedback behaves differently in the internal variability context, the presence of internal variability could contaminate the statistics of the feedback in observed record (example: sea ice albedo feedback).

_Even if the observed record is dominated by variations stemming from external forcing, it may not be in equilibrium with the external forcing. The statistics of the feedback in the observed record would be contaminated if the feedback behaves differently in the context of transient climate change (example: southern hemisphere climate change).

Both of these barriers may be surmountable in the case of snow albedo feedback in the northern hemisphere.

