

Unraveling driving forces for the Arctic surface albedo reduction since the 1980s



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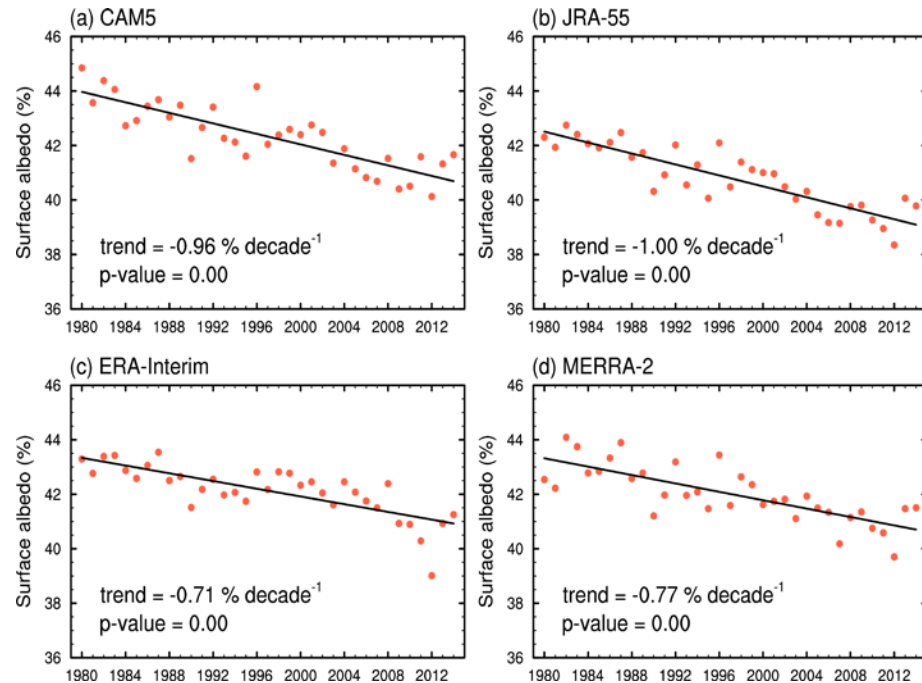
Proudly Operated by **Battelle** Since 1965

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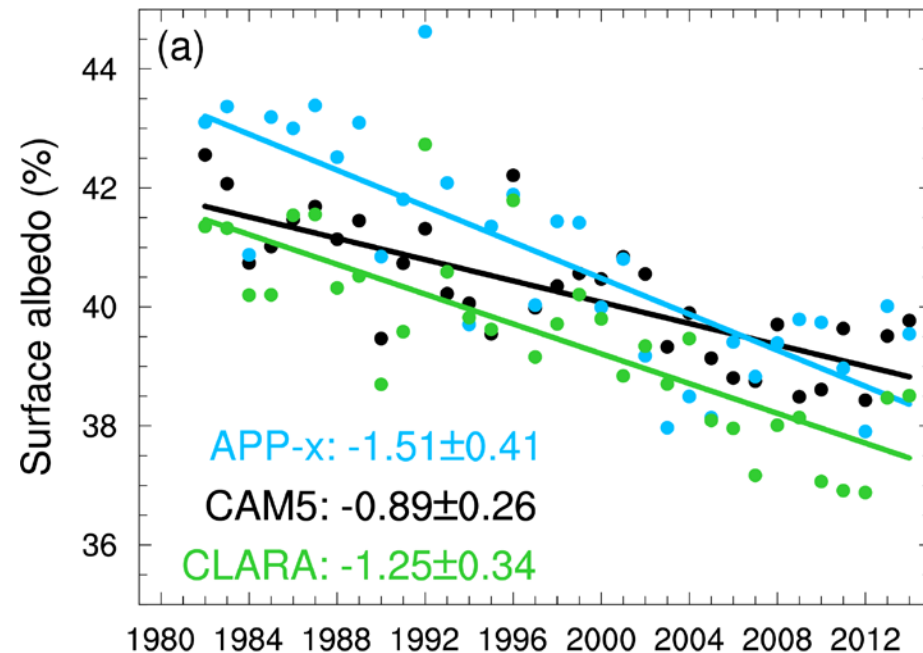
¹=PNNL, ²=U of Washington, and ³=U of Wisconsin-Madison

- Arctic amplification (AA): the faster warming of the Arctic compared to the rest of world.
- Positive surface albedo feedback plays an important role in AA.
- What's the primary contributor to Arctic albedo reduction?
- Model & Data: CAM5 simulation, reanalysis and satellite products.

Annual mean surface albedo



Mar-Sep mean surface albedo



Surface albedo trend attribution

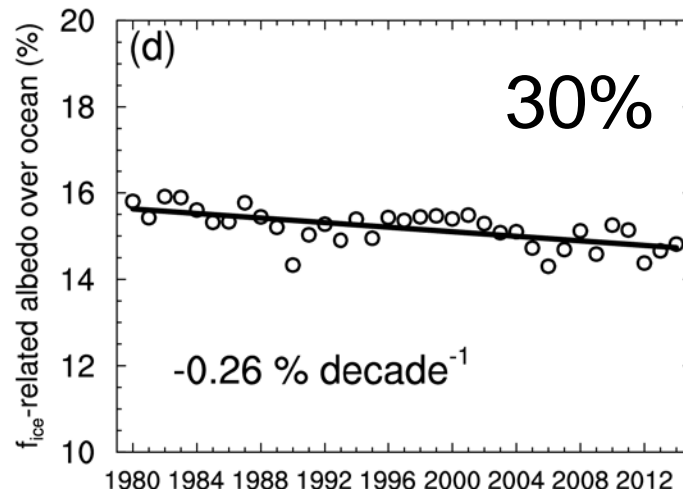
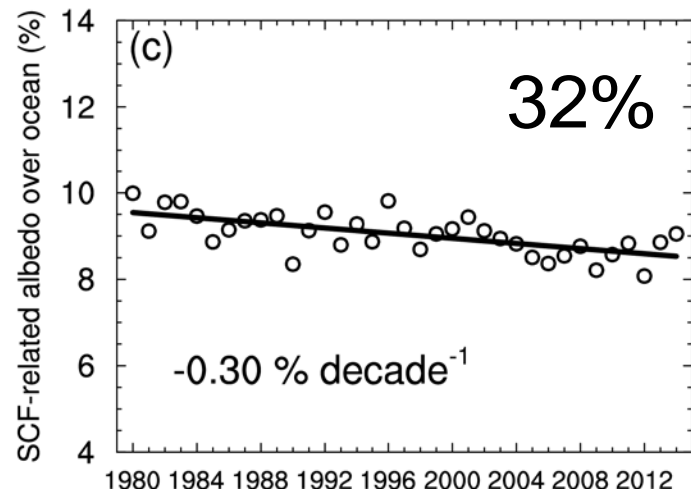
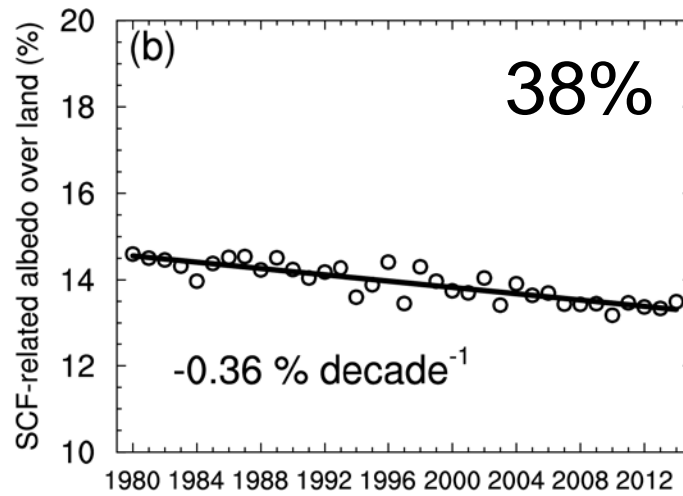
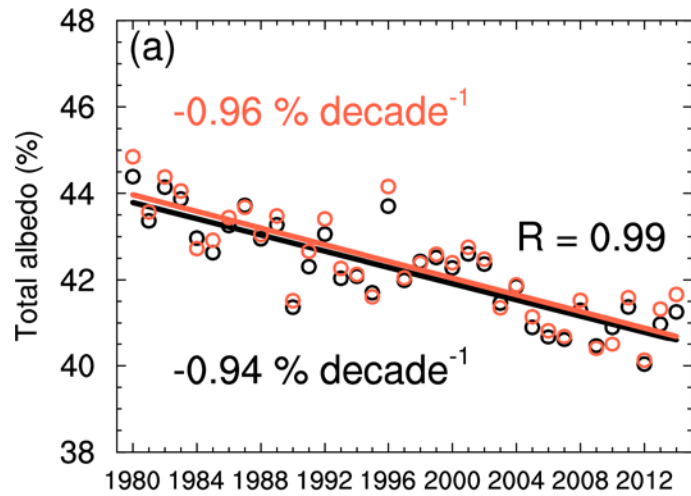
Result based on a surrogate model



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$$\alpha = SCF \cdot f_{land} \cdot \alpha_{land}^{snow} + (1 - SCF) \cdot f_{land} \cdot \alpha_{land} + (1 - f_{land} - f_{ice}) \cdot \alpha_{ocean} + SCF \cdot f_{ice} \cdot \alpha_{ice}^{snow} + (1 - SCF) \cdot f_{ice} \cdot \alpha_{ice}$$



- The physically based surrogate model (black) can reproduce the surface albedo decreasing trend over the Arctic from **CAM5**.
- 38% is attributed to snow cover fraction (SCF) decrease over land.
- 32% is attributed to SCF decrease over sea ice.
- 30% is attributed to sea ice fraction retreat.

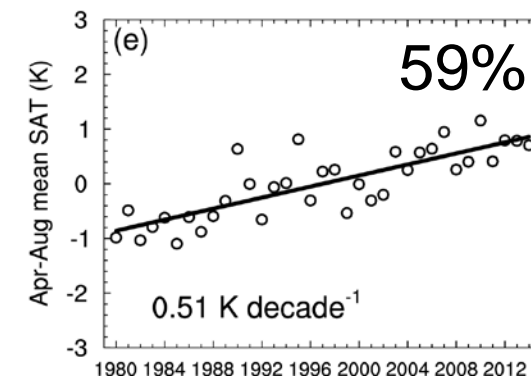
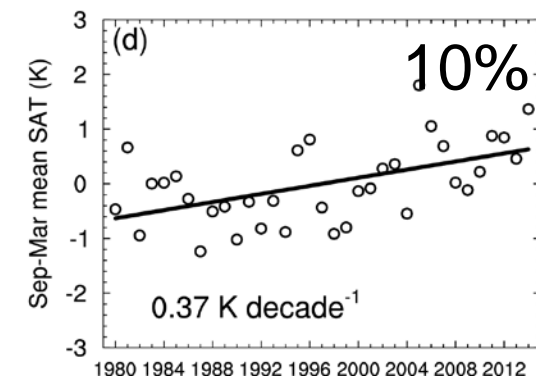
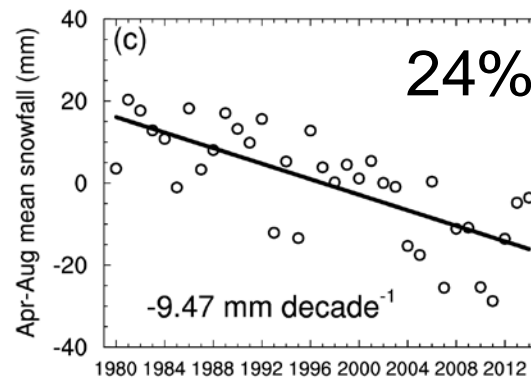
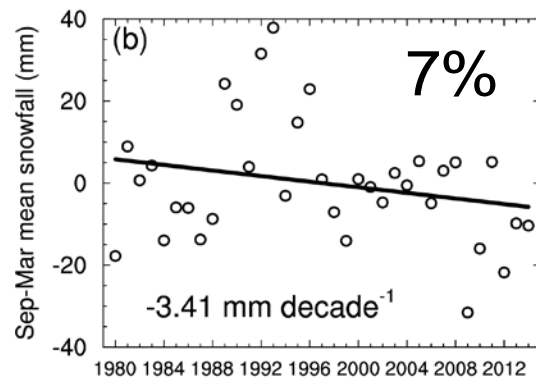
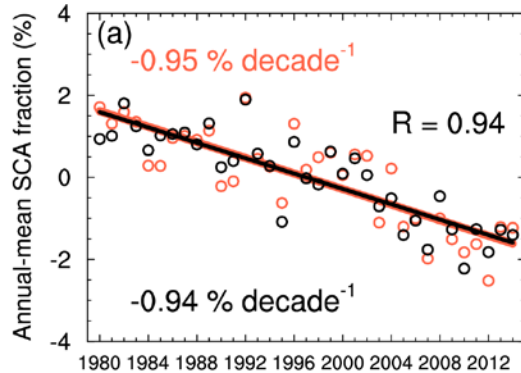
Attribution of snow cover fraction changes



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Result based on multiple linear regression analysis



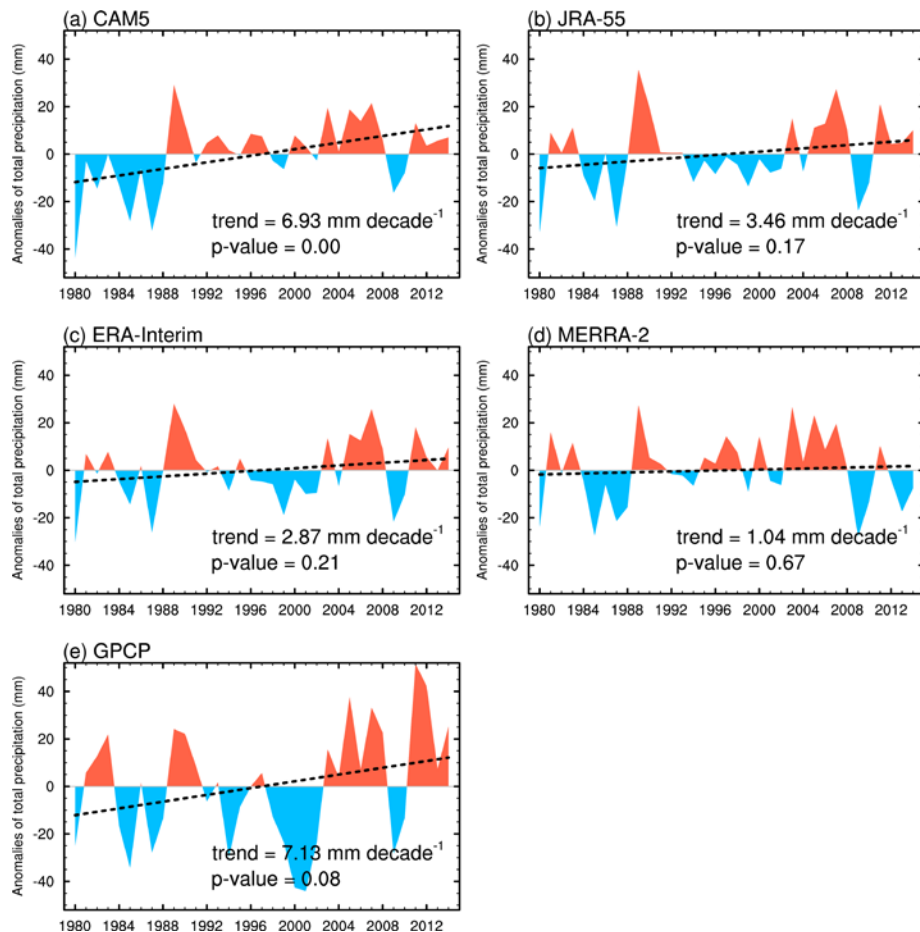
- The multiple linear regression equation can reproduce the snow cover area (SCA) decreasing trend, suggesting that the variation in SCA fraction can be fully explained by surface air temperature (SAT) and snowfall.
- The decreasing trend of SCA fraction is largely determined by the increase of SAT (69%) and decrease in snowfall (31%) over the Arctic, especially during the snow-melting season (Apr-Aug).

Zhang, R., et al. (2019). Unraveling driving forces explaining significant reduction in satellite-inferred Arctic surface albedo since the 1980s. *PNAS*, 116, 48, 23947-23953.

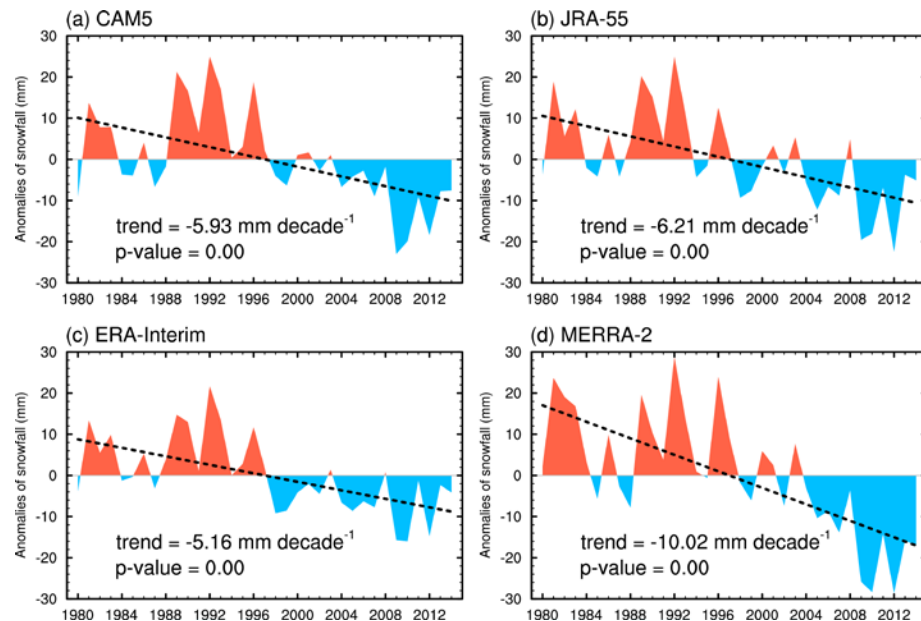
Summary & Future work

- ❖ The reduced snow cover fraction, driven by surface warming and declining snowfall, explains 70% of the observed reduction in the Arctic surface albedo.

Annual mean total precipitation



Annual mean snowfall



- Reanalysis cannot capture the significant precipitation trend, but CAM5 can.
- What's the reason? Moisture sources?