Impacts of High Spectral-Resolution Coupling of NIR Snow Reflectance Between ESM Atmospheric and Cryospheric Components

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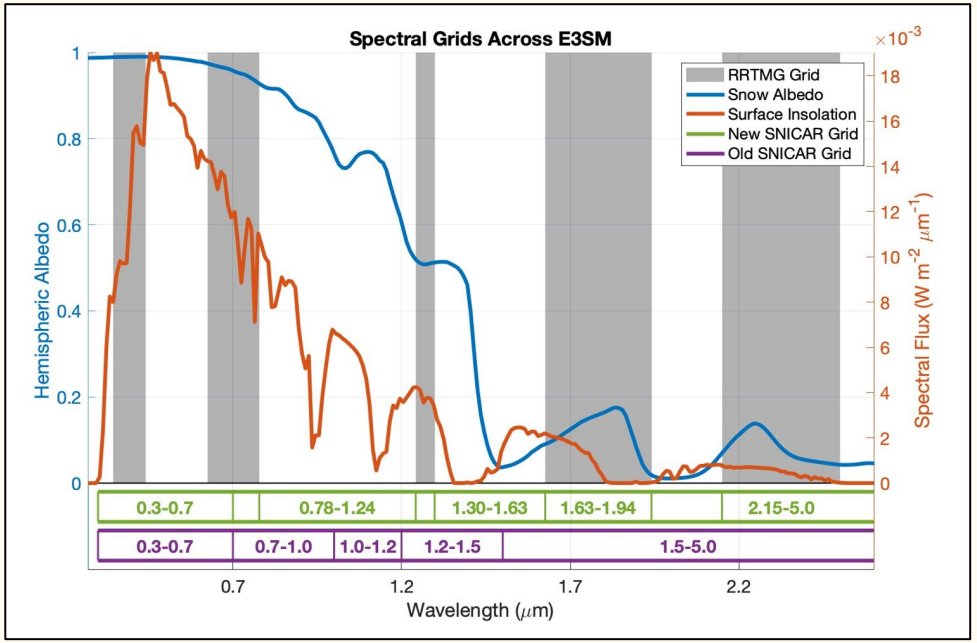
Overview

Solar radiation resolved with inconsistent spectral grids across components of Earth system models:

- Atmospheric Model - 14 Bands
- Cryospheric Model - 5 Bands
- Coupler - 1 VIS and 1 NIR

This study addresses inconsistent, coarse spectral grids that produce biases in absorbed solar radiation at the surface and lower atmosphere



Unify NIR Atmosphere & Surface Spectral Resolutions

Push atmospheric spectral NIR fluxes through coupler to compute mean NIR flux

Employ high resolution atmospheric spectral grid over snow in surface component

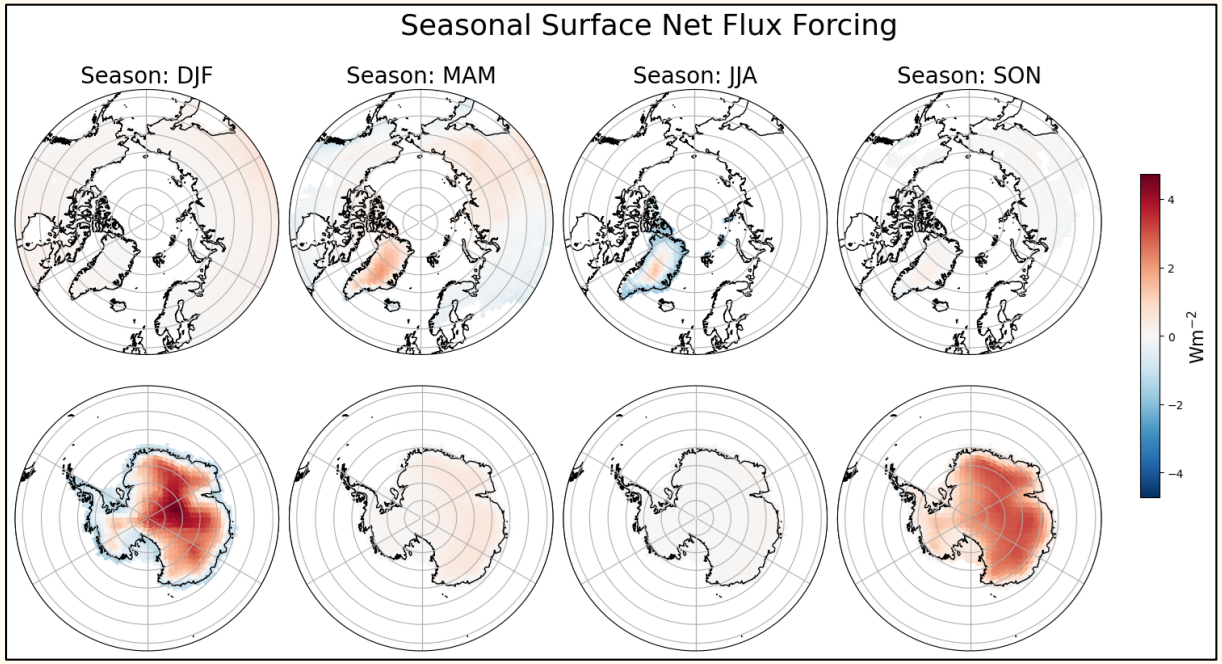
Bonus: Atmosphere “sees” high-resolution, dynamic, surface spectral albedo

Forcing due to Full Coupling of NIR Albedos

Darkens or brightens cryospheric surfaces:

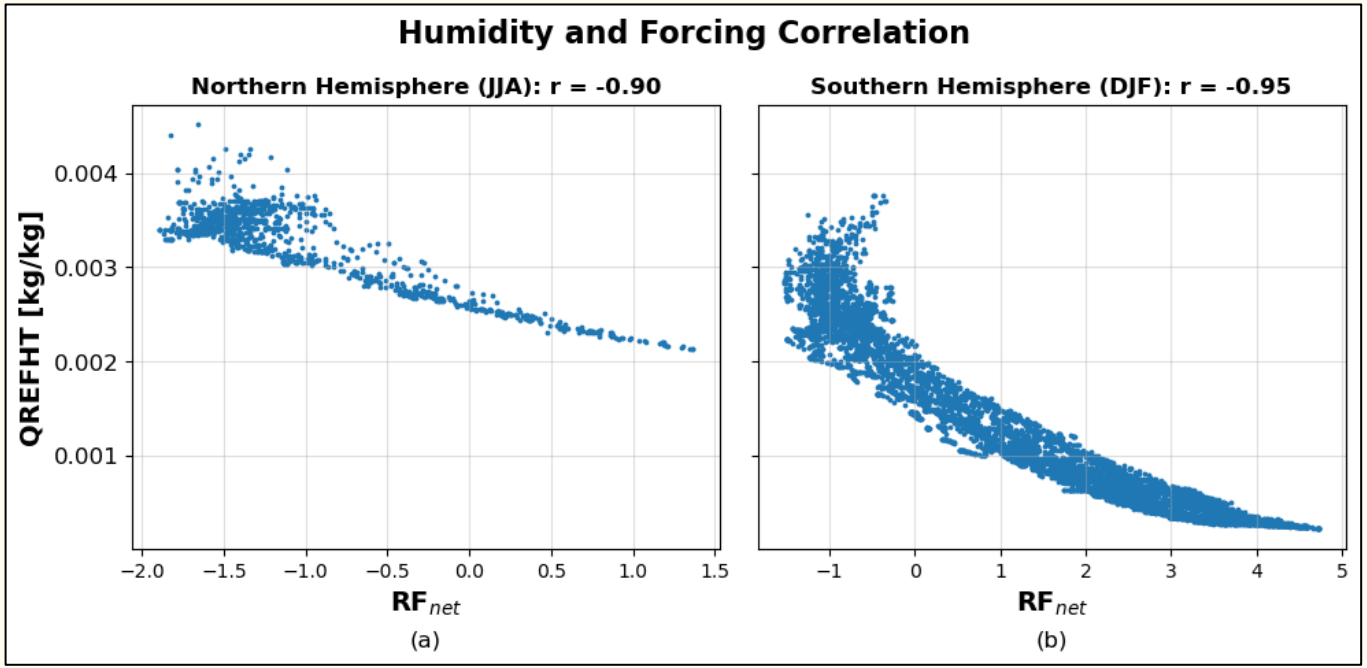
Darkening within Antarctica in summer

Brightening primarily around coasts of Antarctica and Greenland



Humidity Modulates Forcing Sign and Magnitude

Full NIR coupling tends to darken/brighten surface when atmosphere is drier/moister than profile used to construct fixed weights



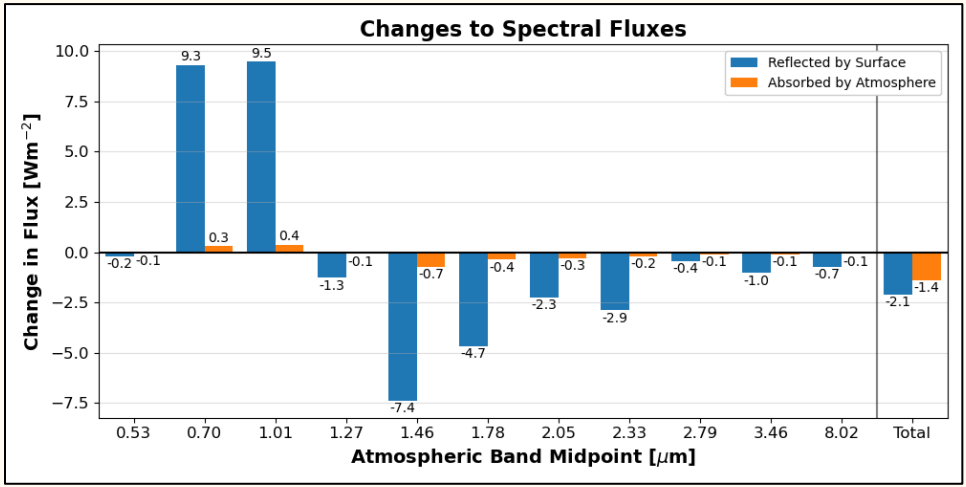
Results - Climate Response - Atmosphere

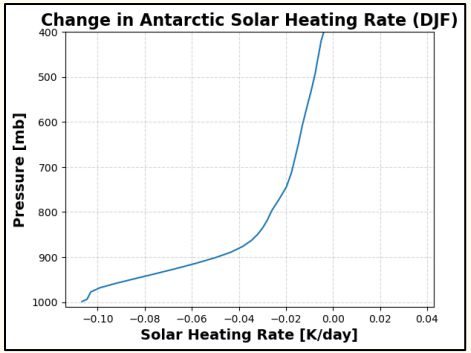
Redistribution of solar fluxes

- Increases solar flux reflected into atmospheric bands transparent
- Decrease in reflected flux sensitive to absorption

→ Cooling of the atmosphere

Cooling rates show good agreement with offline estimates by Tolento et al., 2024 (1.47 Wm^{-2})





Summary

Full NIR coupling of solar radiation between atmosphere and snow-covered land:

- Reduces surface & atmosphere heating biases
- Induces a surface net flux forcing ranging from -1.9–4.7 Wm^2 relative to control two-band schemes
- Lowers reflectance of longer wavelength NIR bands, thereby reducing atmospheric warming rates