Radiation in ACME
To explore issues ACME is facing associated with radiation, and possible improvements

Philip Cameron-Smith,
ACME meeting, Summer 2017 (Bolger Center)
Radiation affects Atm, Land, Ocn, Ice
Radiation is still uncertain
Key points:

High-resolution surface radiation, temperature, precipitation, humidity, winds are likely to be important drivers of surface processes, especially in the Arctic.

Topography and microtopography controls on surface radiation budgets have large potential impacts in permafrost landscapes (next slide).
CO₂ feedbacks

Climate feedbacks

Permafrost and wetlands feedbacks

(Fig 6.20, IPCC AR5, WG I, 2013)
What does “high-resolution ESM gridcell” mean for the Arctic?

Image credits: Jiafu Mao, Salil Mahajan, Michele Thornton
Observations illustrate interactions among terrain, vegetation distribution, and snow. Surface radiation plays an important role in these interactions.
Terrain and Microtopography

Vegetation

Snow

Surface Hydrology

Terrain and Microtopography

Subsurface Thermal-Hydrology

Soil Biogeochemistry
Detailed studies in several Arctic tundra watersheds on Alaska’s Seward Peninsula (NGEE-Arctic)
Teller watershed: 2.3 km$^2$

HUC-12 containing the Teller watershed: 140 km$^2$
Impact of surface heterogeneities on land surface fluxes and states in simulations using an uncoupled, hyper-resolution land surface model

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June 2, 2017
Research objectives

Local surface topographic features (e.g. slope, aspect), as well as, non-local topographic features (e.g. terrain shading, sky view factor), impacts total amount of solar radiation reaching the Earth’s surface. Yet, the ACME land model assumes a flat Earth with an unobstructed view of sky.

1. How does surface heterogeneities due to soils, vegetation cover, and topography impact coarse-scale surface fluxes and states?

2. What is the relative impact of various sources of surface heterogeneities on coarse-scale surface fluxes and states?
Methodology

- Sources of heterogeneities
  1. Soils (POLARIS30)
  2. PFT (MODIS)
  3. Surface elevation (GTOP30)

- ALM is modified to account for effects of topography (slope and aspect) on downwelling solar radiation

- Surface dataset created at 1km horizontal resolution

- Each watershed was driven by $1 \times 1$ CRUC forcing dataset

- Simulation length was 20-years

- Surface dataset contained 100% naturally vegetated land

- Watersheds
  1. Rio Grand headwaters watershed, CO
  2. Snake headwater watershed, Wyoming
Following set of ALM simulations were performed:

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<tr>
<th>Code</th>
<th>Soil</th>
<th>PFT</th>
<th>Surface elevation</th>
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Rio Grande Headwaters
Rio Grande Headwaters: Monthly $R_{\text{shortwave}}$

![Graph of Rsdown: Mean](image)

![Graph of Rsdown: Standard dev](image)
Rio Grande Headwaters: Monthly sensible heat flux

SH: Mean

SH: Standard dev
Rio Grande Headwaters: Monthly latent heat flux

LH: Mean

LH: Standard dev

[\text{Wm}^{-2}]
Conclusion

- Surface heterogeneities have **negligible** impact on domain average fluxes and states.
- Surface heterogeneities **lead to spatial variability** in simulated fluxes and states.
Conclusion

• Sub-gridscale Land heterogeneity will affect climate response.
• Correlated land-use with snow affects the mean response.