

# NGEE-ARM-ASR Interactions

Focus on Coupled-System Processes

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# Shared Objectives

- **NGEE-Arctic**: “...improving climate model **predictions** through advanced **understanding** of **coupled processes** in Arctic terrestrial ecosystems.”
- **ARM**: “...improve the **understanding and representation**, in climate and earth system models, of clouds and aerosols as well as their interactions and **coupling** with the Earth’s surface.”
- **ASR**: “Quantify the interactions among aerosols, clouds, precipitation, radiation, dynamics, and thermodynamics to improve fundamental **process-level understanding**, with the ultimate goal to reduce the uncertainty in global and regional climate **simulations and projections**.”

***Coupled system understanding & predictive capabilities***

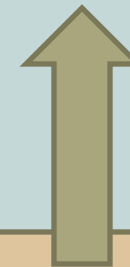
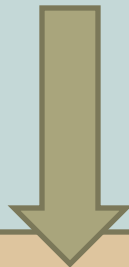
# Large-scale Feedbacks/Interactions

## Atmosphere

Large-scale & Locally-forced variability  
Net transport of moisture / heat into Arctic  
Gases impact large scale energy budget



*Energy fluxes*  
*Water fluxes*  
*Gas fluxes*



*Energy fluxes*  
*Water fluxes*  
*Gas fluxes*

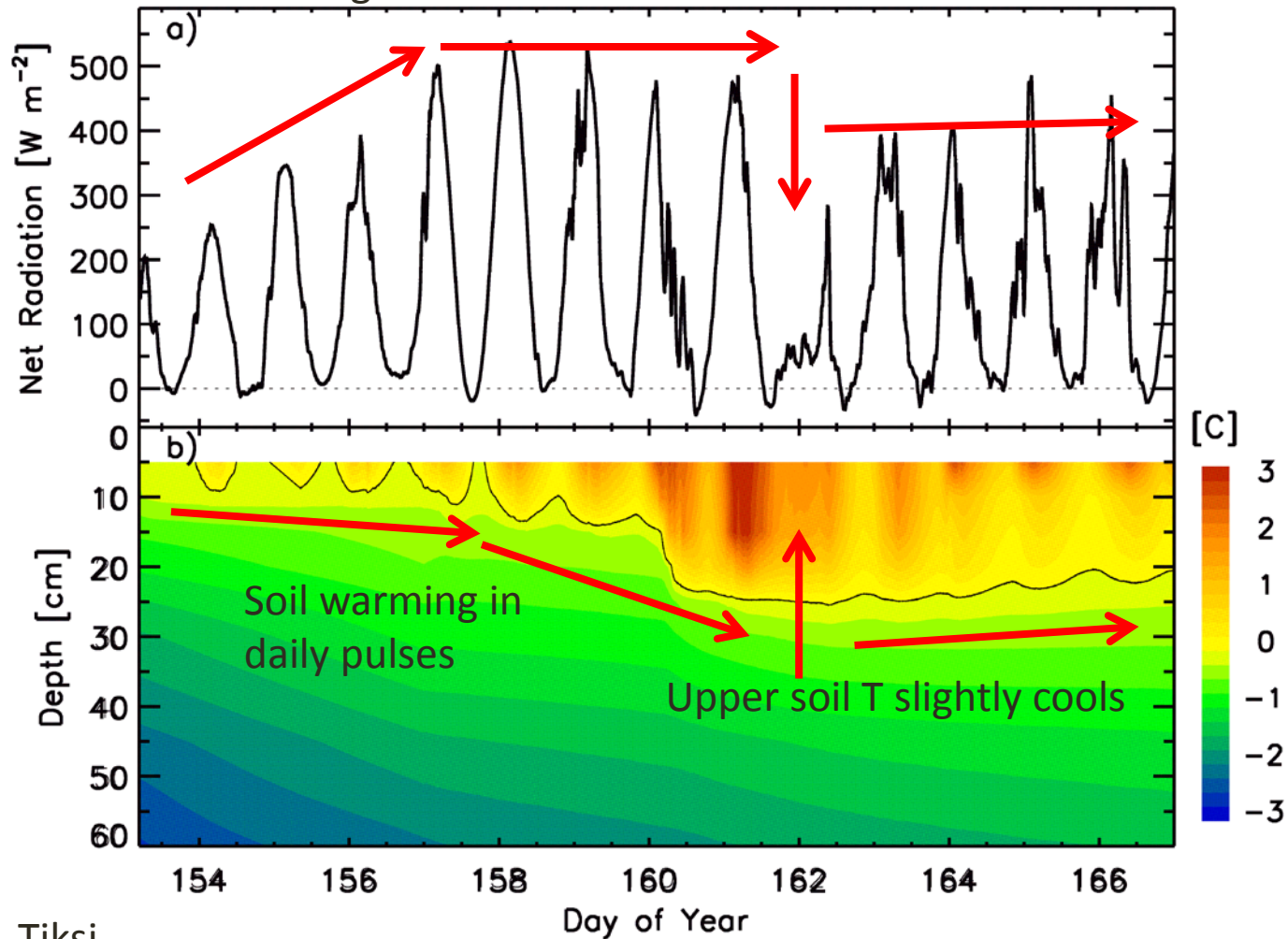
## Land surface / sub-surface

Locally-forced variability  
Carbon reservoir  
Change in moisture content  
Change in permafrost

# Atmosphere → Land

Snow melt decreasing albedo?

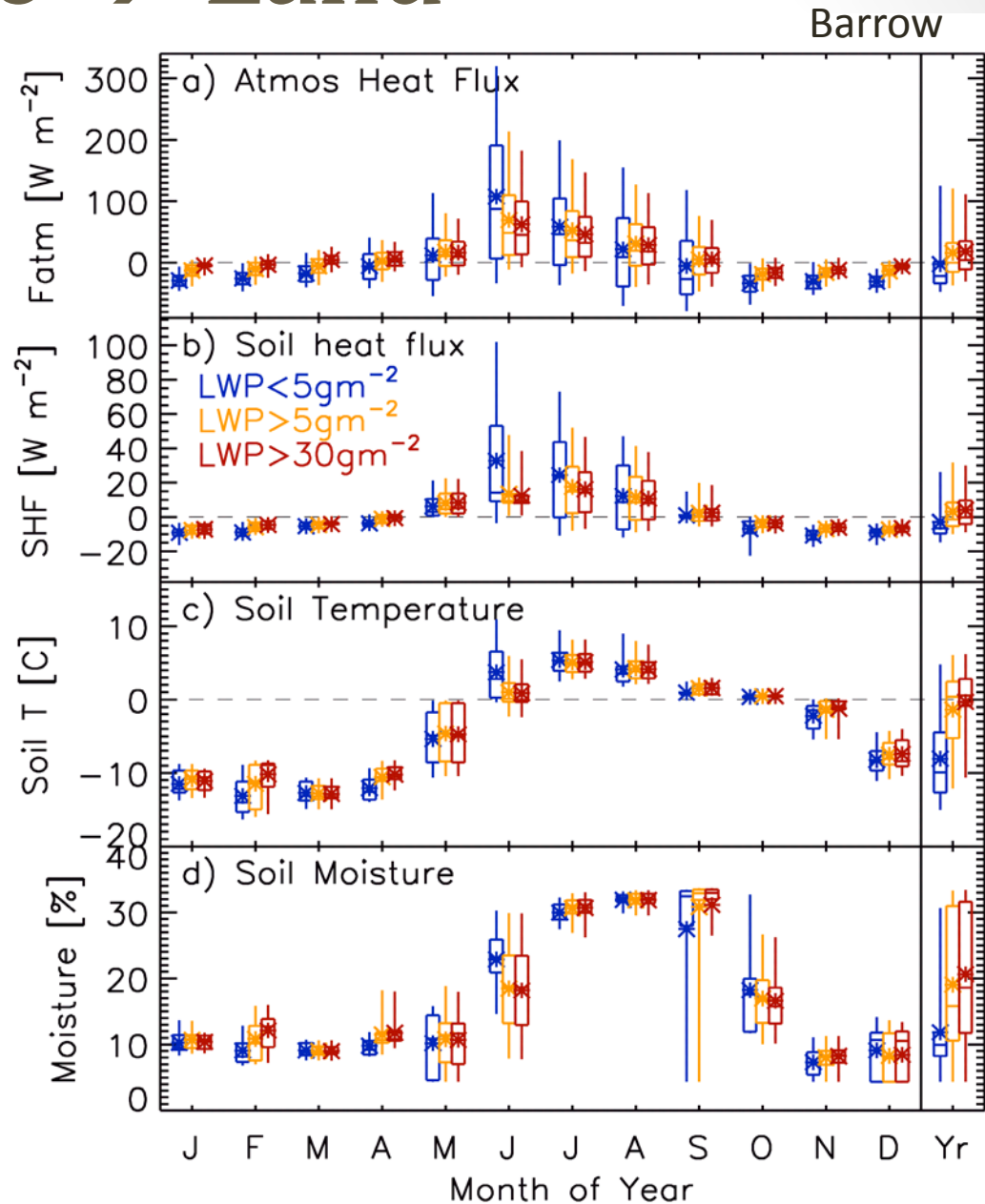
Clouds decrease net radiative flux



# Atmosphere → Land

- The surface energy budget (and net surface atmospheric heat flux) determine the flow of energy into the surface and sub-surface.
- These heat fluxes impact soil temperature and moisture, and can have implications for permafrost

**Conclusion:** Representing sub-surface processes requires characterizing and representing atmospheric energy fluxes.

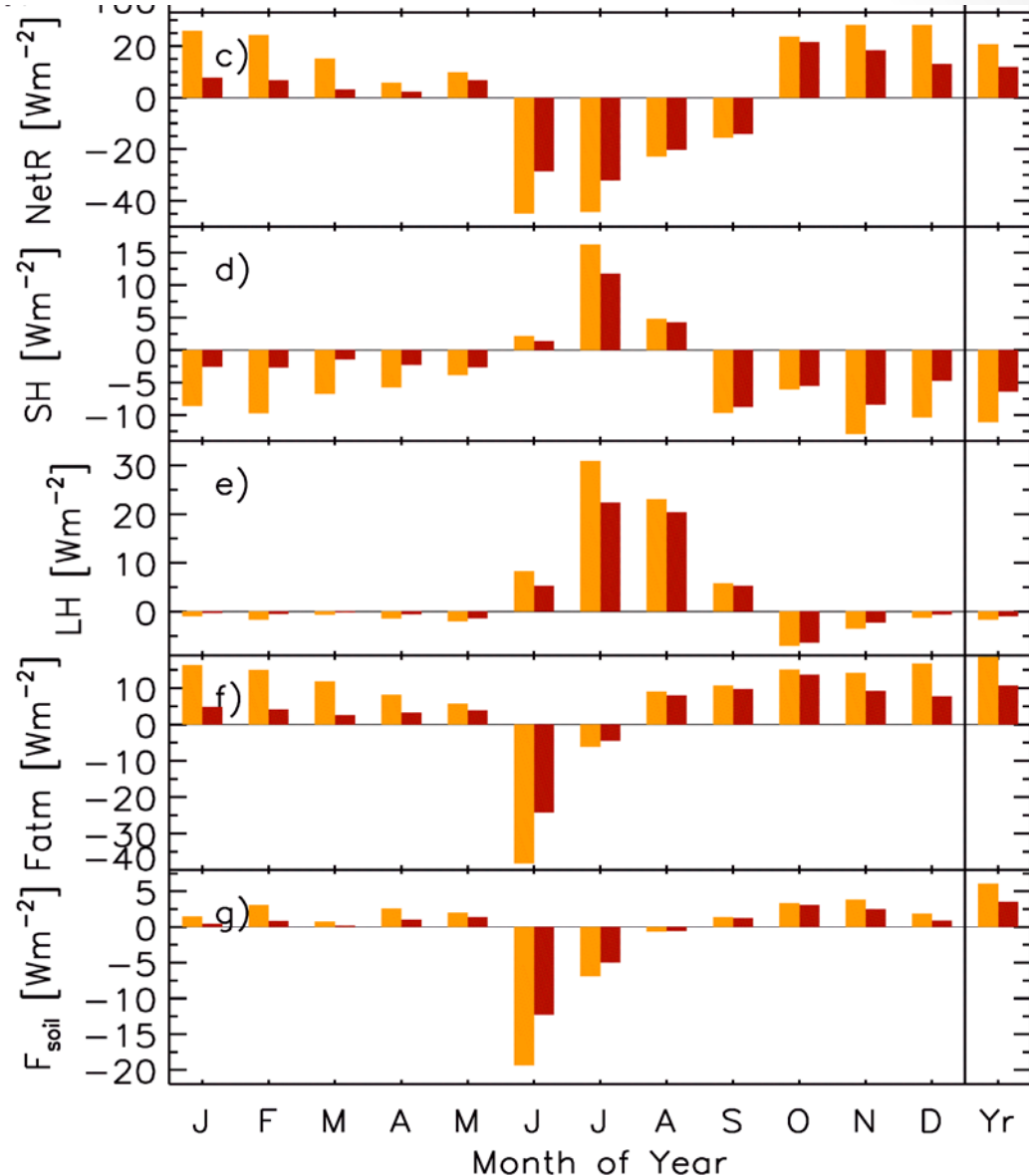


# Atmosphere → Land

Barrow

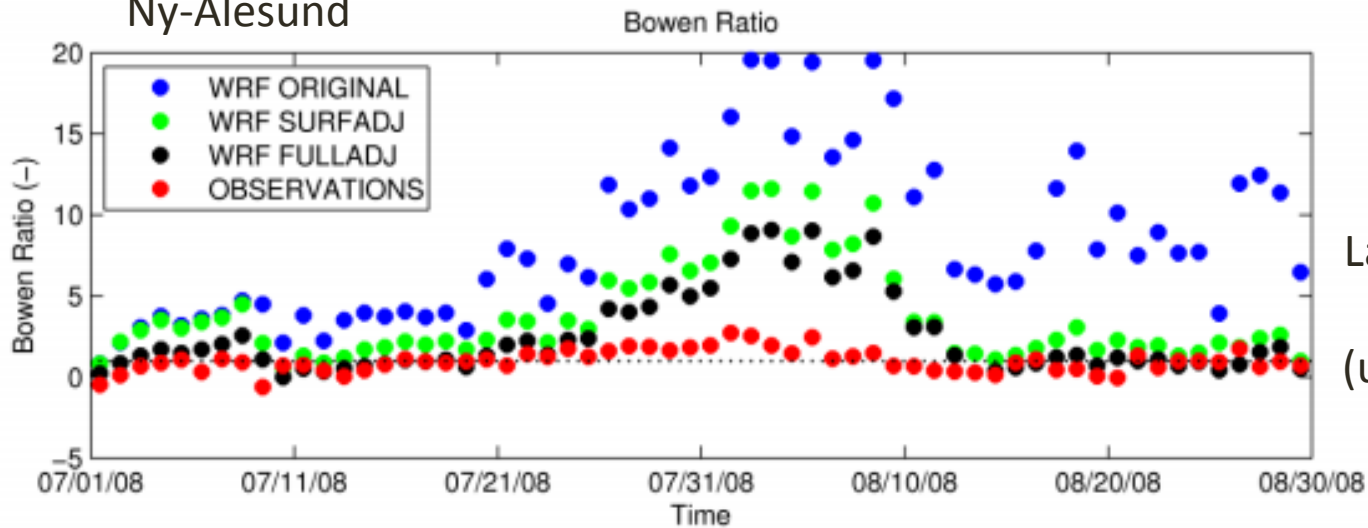
## Liquid clouds play a key role.

- Radiatively warm surface except in summer (JJAS)
- Turbulent flux response partially offsets radiative forcing
- Clouds cool surface (total atmos flux) only in June/July.
- Clouds weakly warm soil year round except for significant cooling in June/July.
- Clouds dampen the annual cycle.



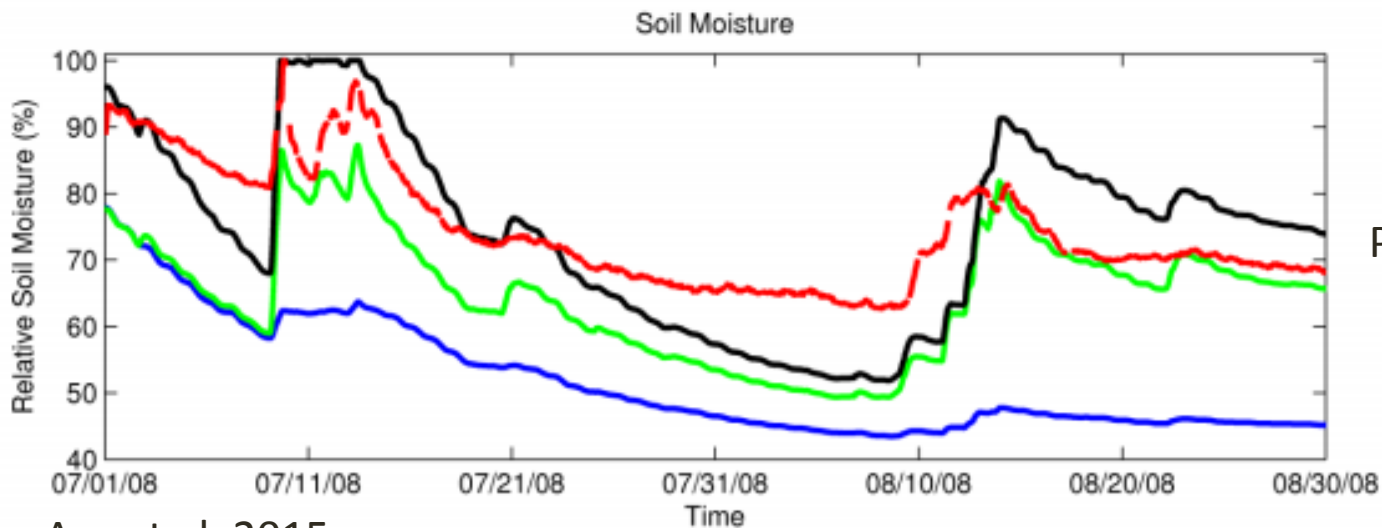
# Land → Atmosphere

Ny-Alesund



$$B = SH/LH$$

Large latent heat flux errors (underestimates)



Poorly modeled soil moisture (too dry)

# Understanding Coupled System

- Atmospheric fluxes impact timing, rate, and extent of soil temperature changes (and impact soil moisture).
- Land surface impacts turbulent heat fluxes into the atmosphere, affecting low level mixing and vertical fluxes of moisture, energy, etc.
- Terrestrial models often forced by atmospheric parameters from reanalyses, which struggle to represent Arctic BL, cloud, and surface fluxes.
- Coupled system allows interactions, understanding of co-variability, and eventually the improved ability to model how the atmosphere-terrestrial system evolves together



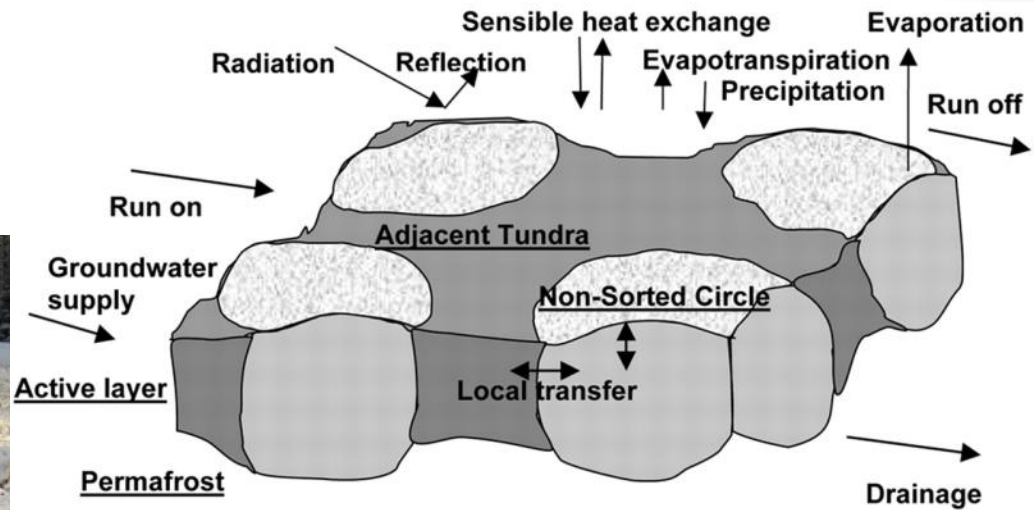
## Thoughts for moving forward:

- Study the links:

Atmos. processes  $\leftrightarrow$  Surface Energy Fluxes  $\leftrightarrow$  Soil processes

Can we obtain system closure?

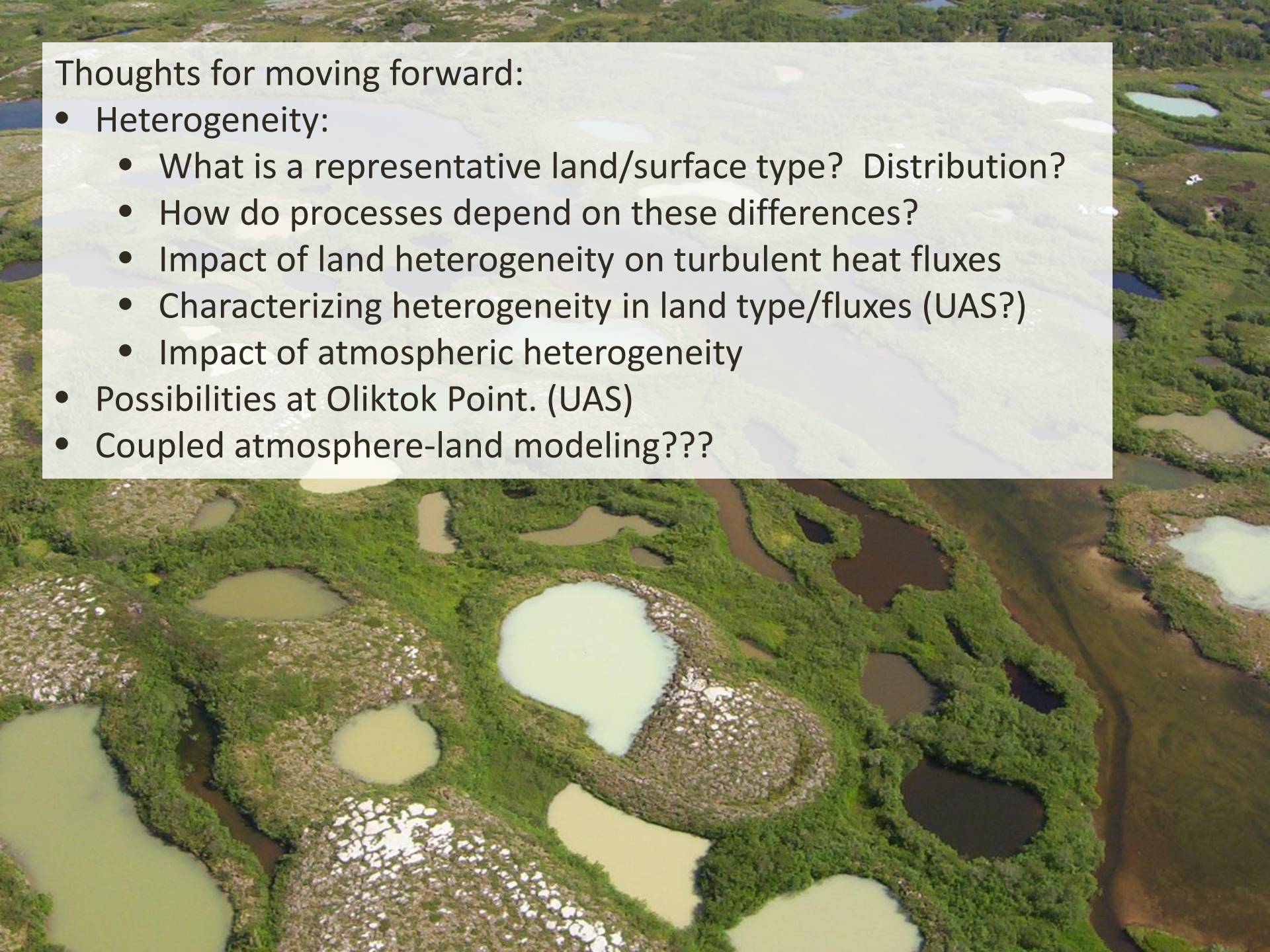
- How are precipitation and soil moisture processes related?





## Thoughts for moving forward:

- Heterogeneity:
  - What is a representative land/surface type? Distribution?
  - How do processes depend on these differences?
  - Impact of land heterogeneity on turbulent heat fluxes
  - Characterizing heterogeneity in land type/fluxes (UAS?)
  - Impact of atmospheric heterogeneity
- Possibilities at Oliktok Point. (UAS)
- Coupled atmosphere-land modeling???





# Opportunities

Building PanArctic Atmosphere-Surface Exchange Collaboration  
International Arctic Systems for Observing the Atmosphere (IASOA)

