Global and regional hydrologic cycle impacts of forestation

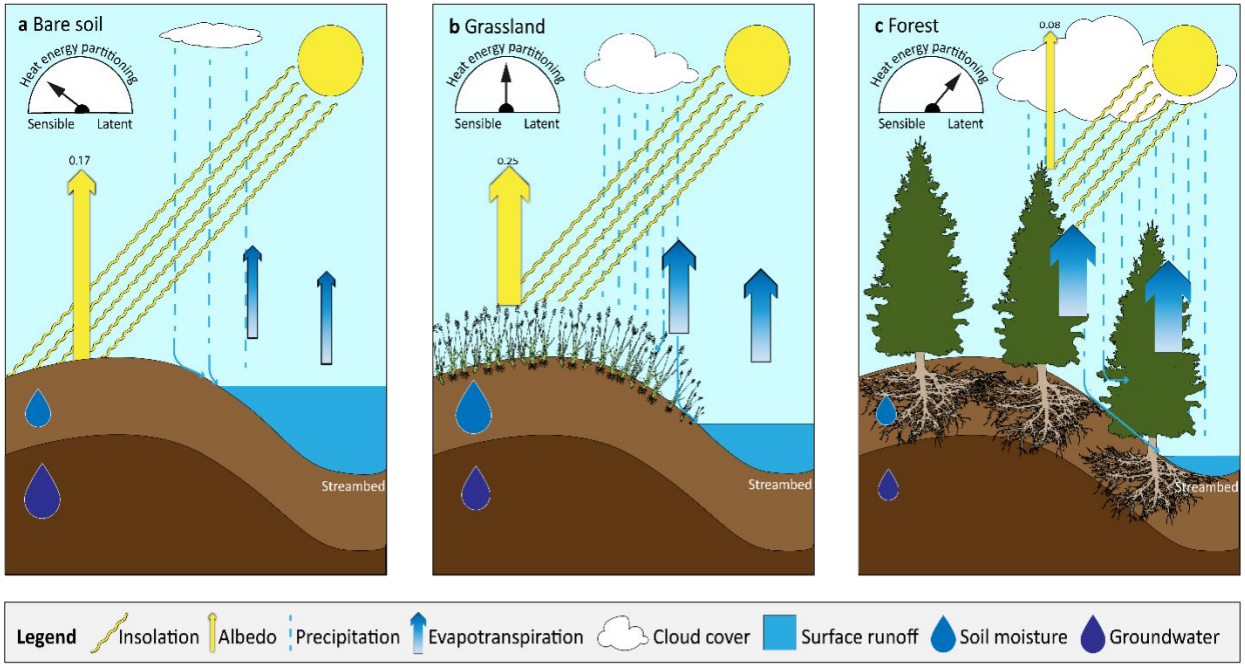
Christine Leclerc (leclerc@sfu.ca)
Dr. Kirsten Zickfeld, and Dr. W. Jesse Hahm
Department of Geography, Simon Fraser University

Why forestation's hydrologic cycle impacts matter

1. Many national commitments to reduce emissions under *The Paris Agreement* include forestation
2. Form of carbon dioxide removal
3. Tree-hydrologic cycle interaction

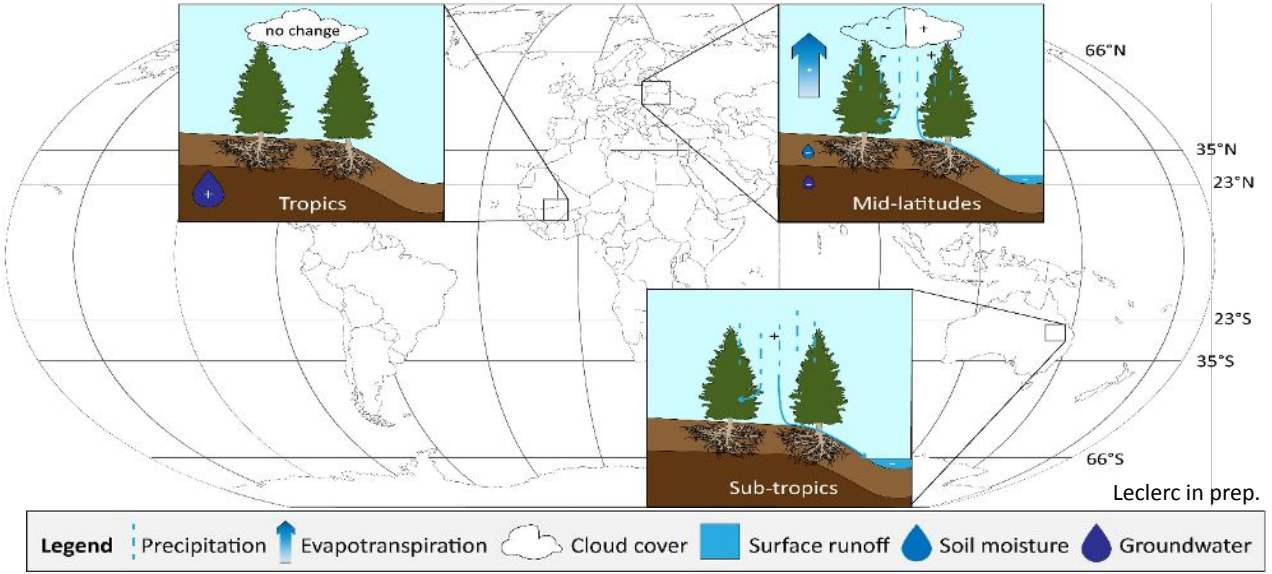
Alan Murray-Rust | Afforestation project in England

Biophysical effects of forestation



Leclerc in prep.

Forestation impacts on key hydrologic cycle variables



Leclerc in prep.

Knowledge gaps

Little comprehensive regional study of forestation's hydrologic *cycle* impacts

Hydrologic *cycle* impacts little studied for tropics and sub-tropics

Modelling studies of forestation's soil moisture impacts are rare

Research question

How will globally significant forestation impact the hydrologic cycle at global and regional spatial scales and an annual temporal scale?

Methods | Modelling framework

1. Model type justification
2. CMIP6 simulations:
    - Baseline (ScenarioMIP ssp370)
    - Forestation (LUMIP ssp370-ssp126Lu)
3. Variables in full study:
    - Precipitation*
    - Evapotranspiration*
    - Cloud fraction
    - Surface runoff*
    - Soil moisture*
    - Groundwater runoff

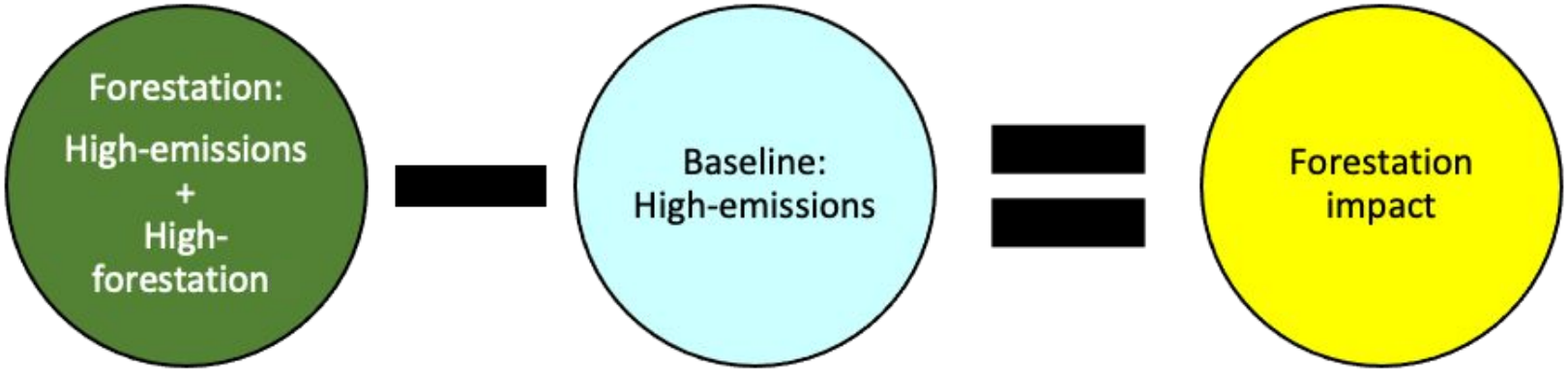
Results presented here are for variables with *

Methods | Models used

1. For hydrologic cycles variables:
   - ACCESS-ESM1-5
   - CanESM5
   - CESM2
   - GFDL-ESM4
   - MIROC-ES2L
   - MPI-ESM1-2-LR
   - NorESM2-LM
   - UKESM1-0-LL

2. For tree cover change:
   - ACCESS-ESM1-5
   - CanESM5
   - CESM2
   - GFDL-ESM4
   - MPI-ESM1-2-LR
   - UKESM1-0-LL

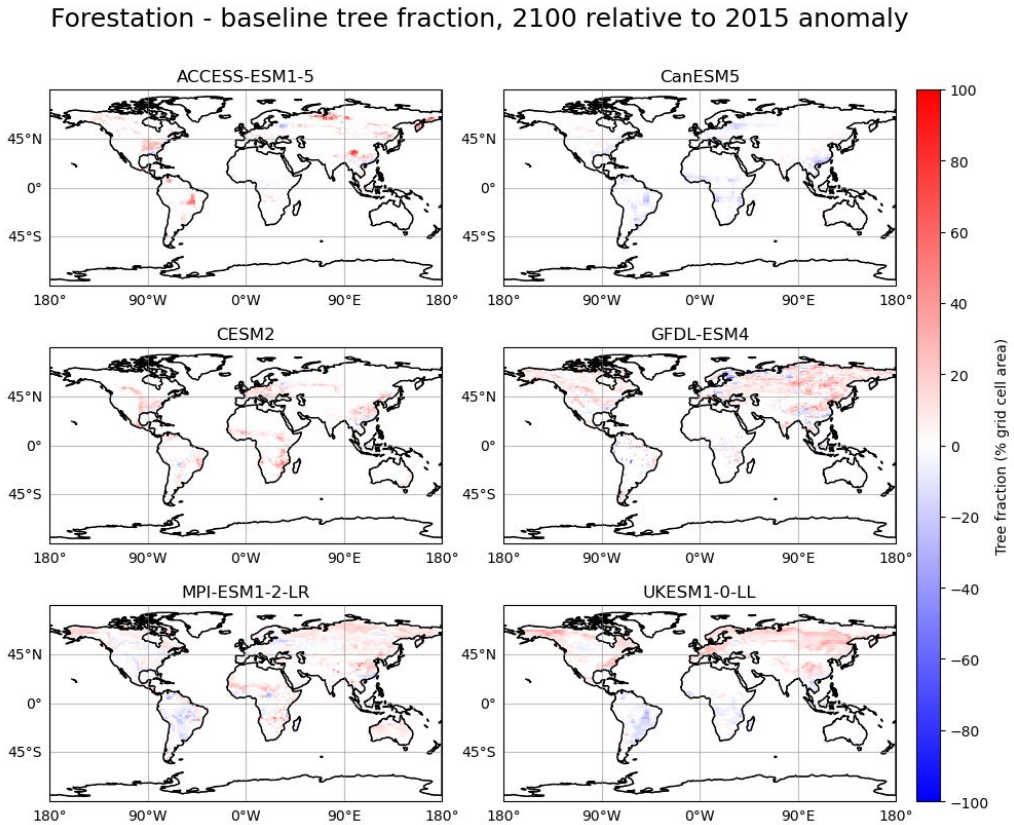
Methods | Experiment design



ssp370 is a high emissions pathway, spp126 is a high forestation pathway, and ssp370-ssp126Lu combines high emissions with high forestation land use.

Tree cover change 2015-2100

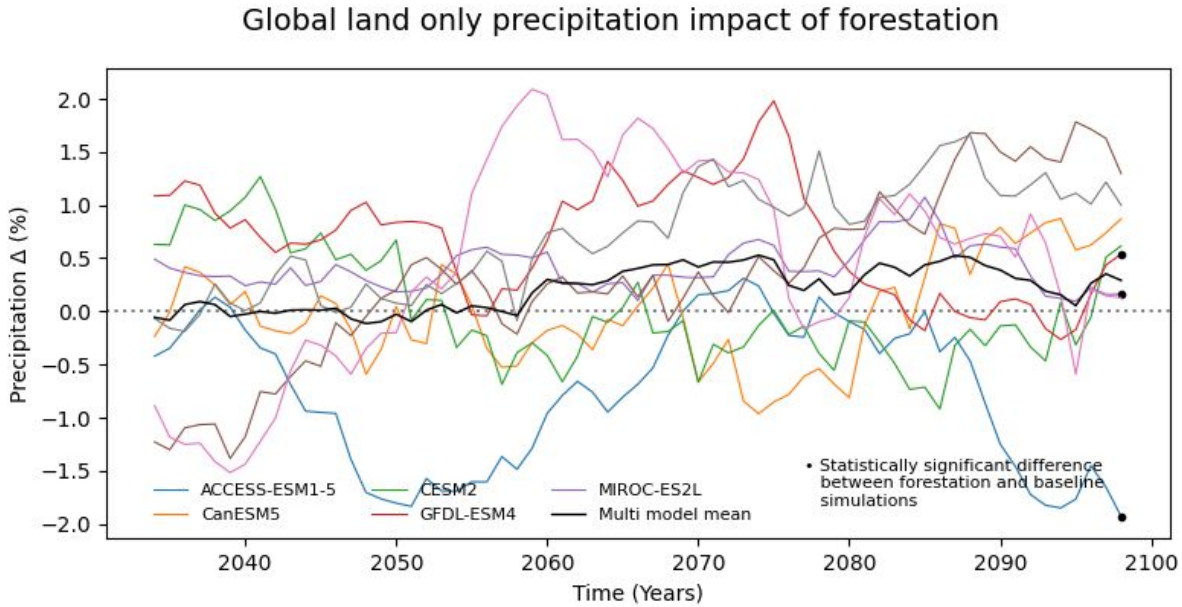
- Red = areas of tree fraction ↑ for ssp126
  compared to ssp370
- Blue = areas of tree fraction ↓ for ssp126
  compared to ssp370
- In ssp126, reforestation happens mainly in the Congo, China, and the eastern United States



Leclerc in prep.

Key findings Global

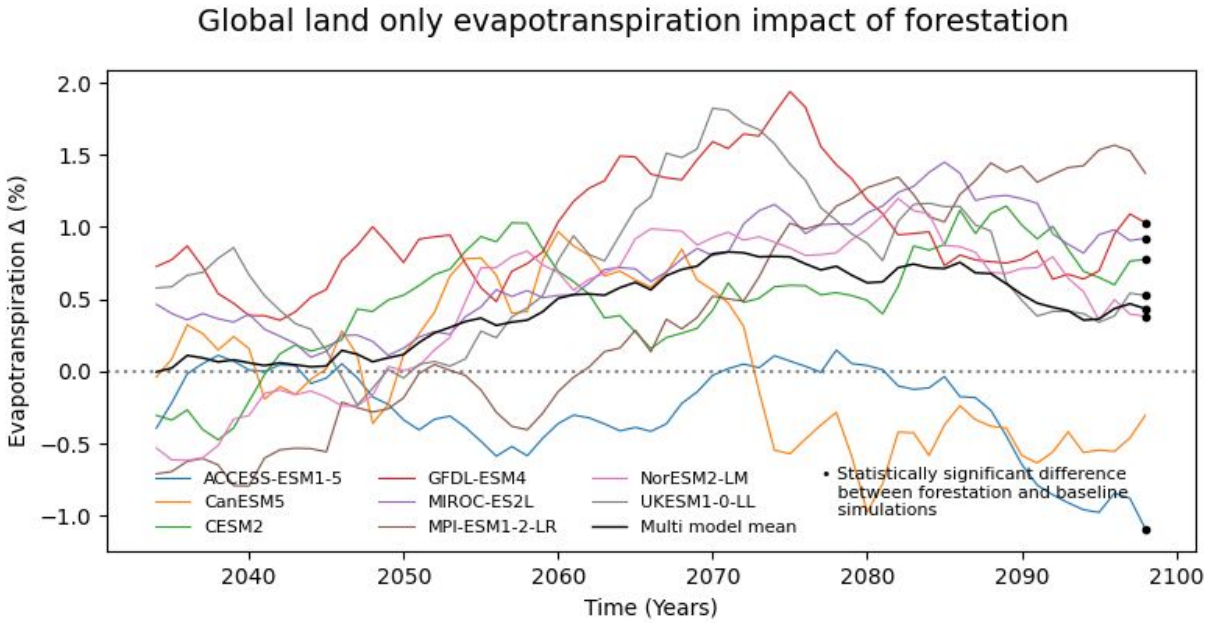
Multi-model mean precipitation change due to forestation is not statistically significant



Leclerc in prep.

Key findings Global

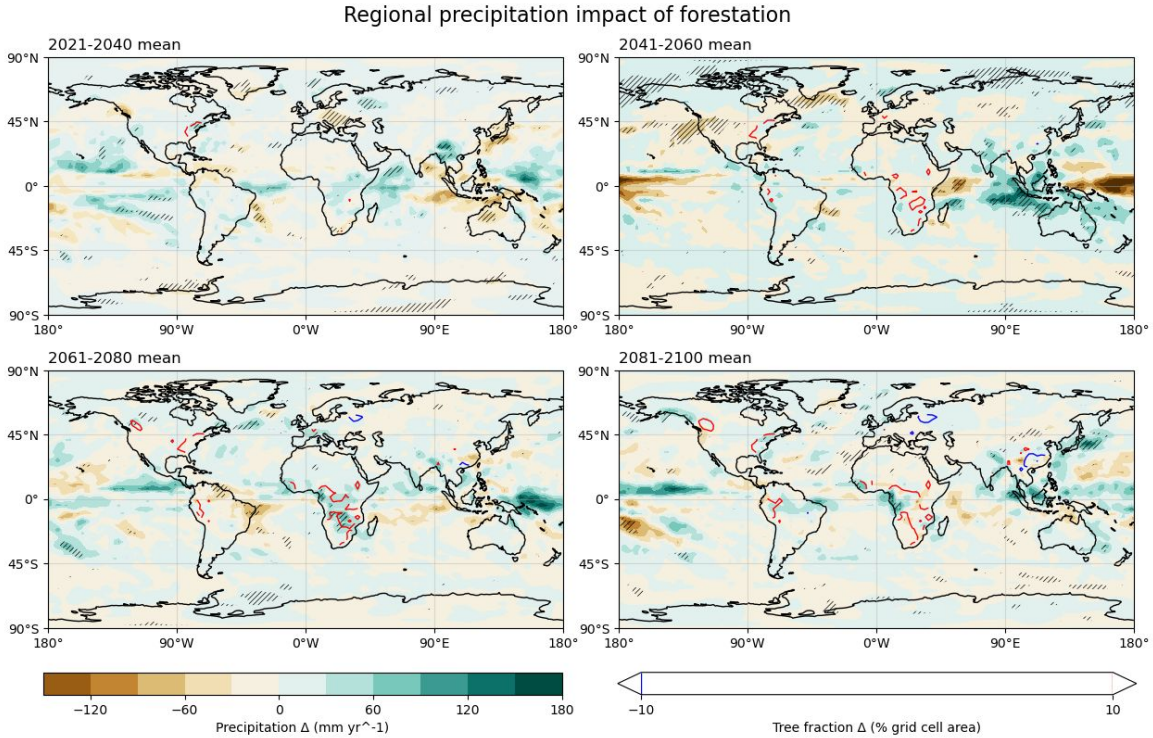
Multi-model mean evapotranspiration change due to forestation is statistically significant



Leclerc in prep.

Key findings Regional

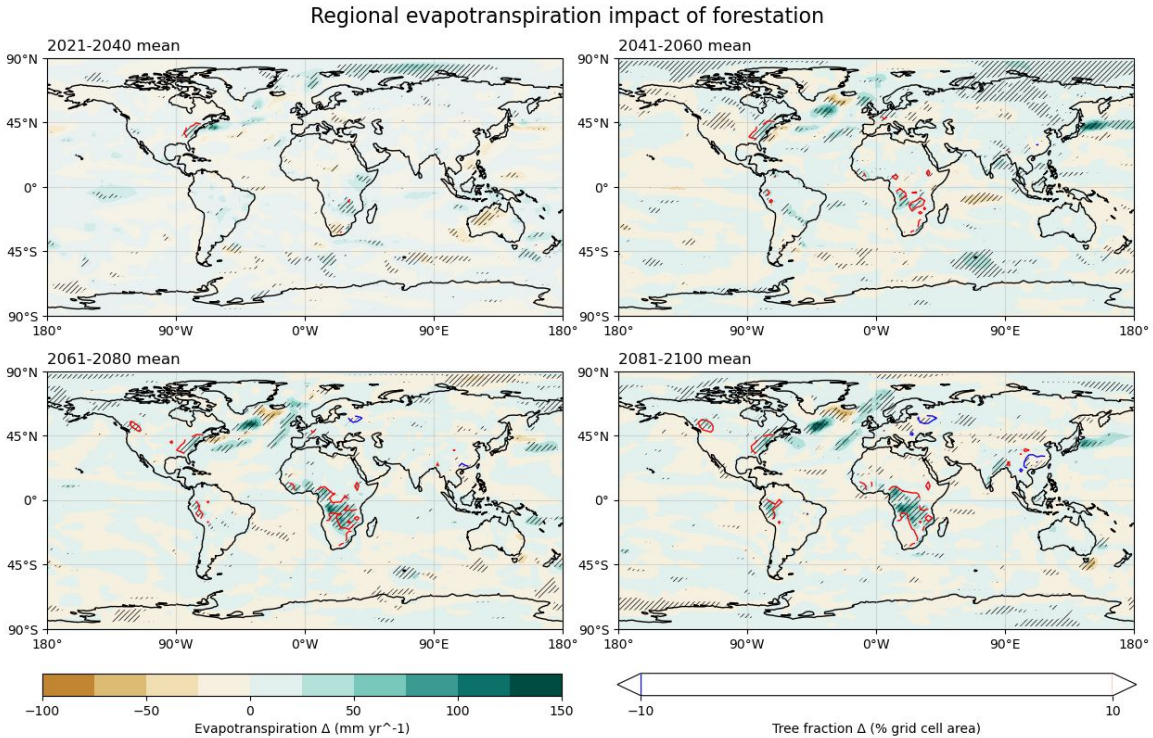
Precipitation, evapotranspiration, and soil moisture show statistically significant change for all time periods in study



Leclerc in prep.

Key findings Regional

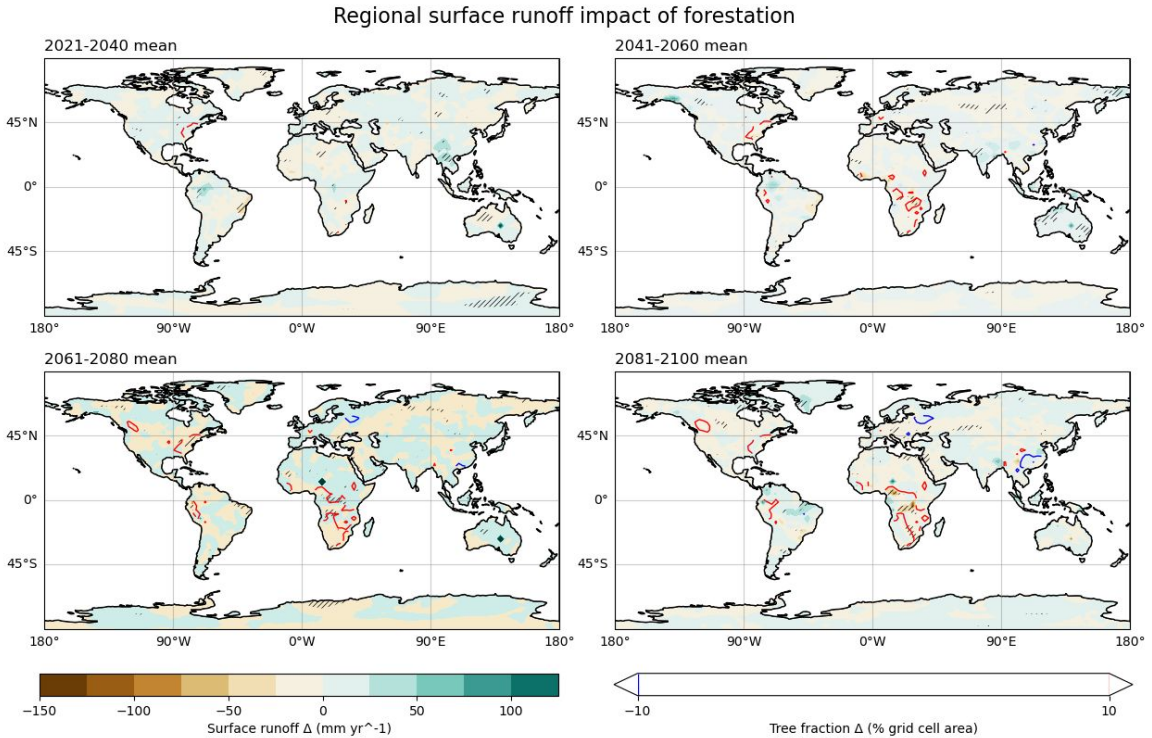
Evapotranspiration has the most regions of statistically significant change over areas of tree cover change



Leclerc in prep.

Key findings Regional

Surface runoff shows very few regions with statistically significant change



Leclerc in prep.

Discussion | Global

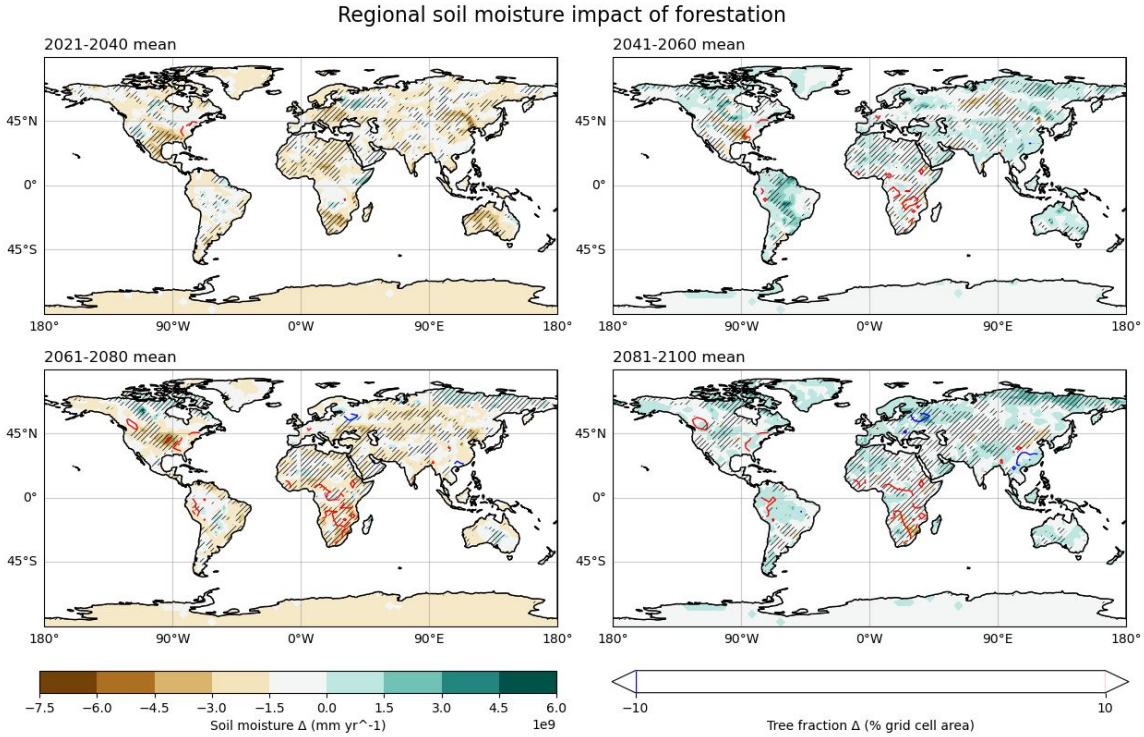
1. Evapotranspiration change is statistically significant
2. Globally, precipitation and surface runoff change are not statistically significant

Conclusions

1. Evapotranspiration change is statistically significant and may result in soil moisture change
2. Impacts are not limited to where trees are planted
3. The signal-to-noise ratio has potential to be increased

Key findings Regional

Statistically significant change is widespread for soil moisture, including over areas where forestation occurs



Leclerc in prep.

Thank you.

CLIMATE
Research Lab

SFU SIMON FRASER UNIVERSITY

Dr. Kirsten Zickfeld
Dr. W. Jesse Hahm
Pierre Etienne Banville, Tom Markland, Takuma Mihara, Dr. Marzieh Mortezapour, and my family

NSERC
CRSNG