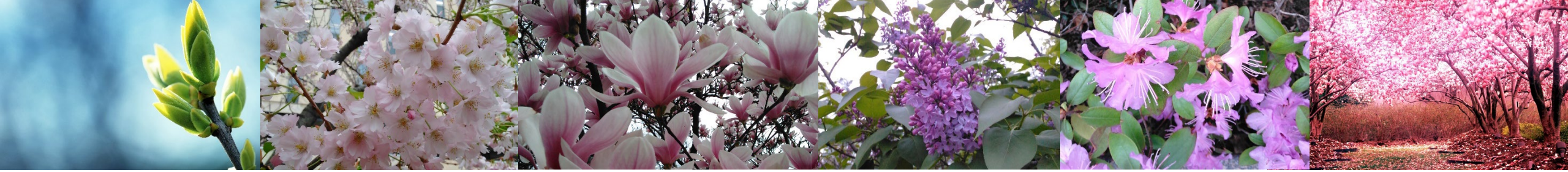

Northern hemisphere land-atmosphere feedback from prescribed plant phenology in CESM

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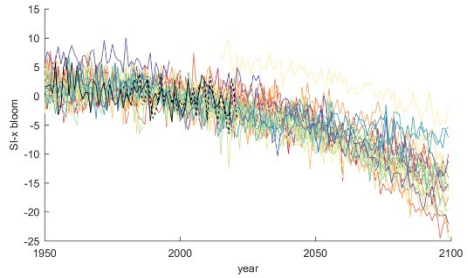
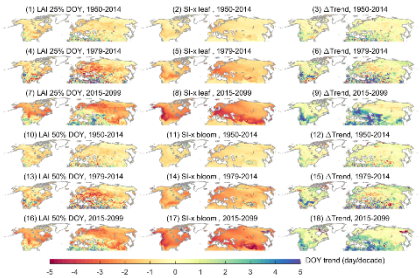
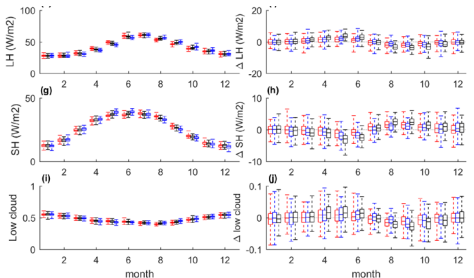
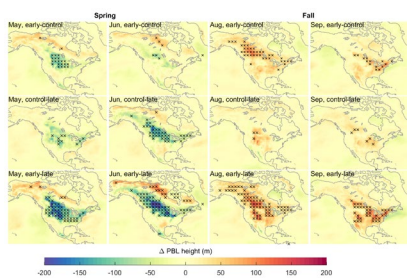
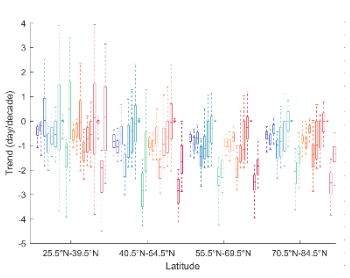
Li X., Ault, T. R., Richardson, A. D., Frolking, S., Herrera, D. A., Friedl, M. A., Carrillo, C. M., and Evans, C. P. (Under review). Northern hemisphere land-atmosphere feedback from prescribed plant phenology in CESM. *Journal of Climate*. Under review

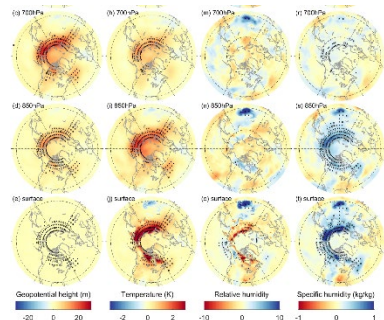








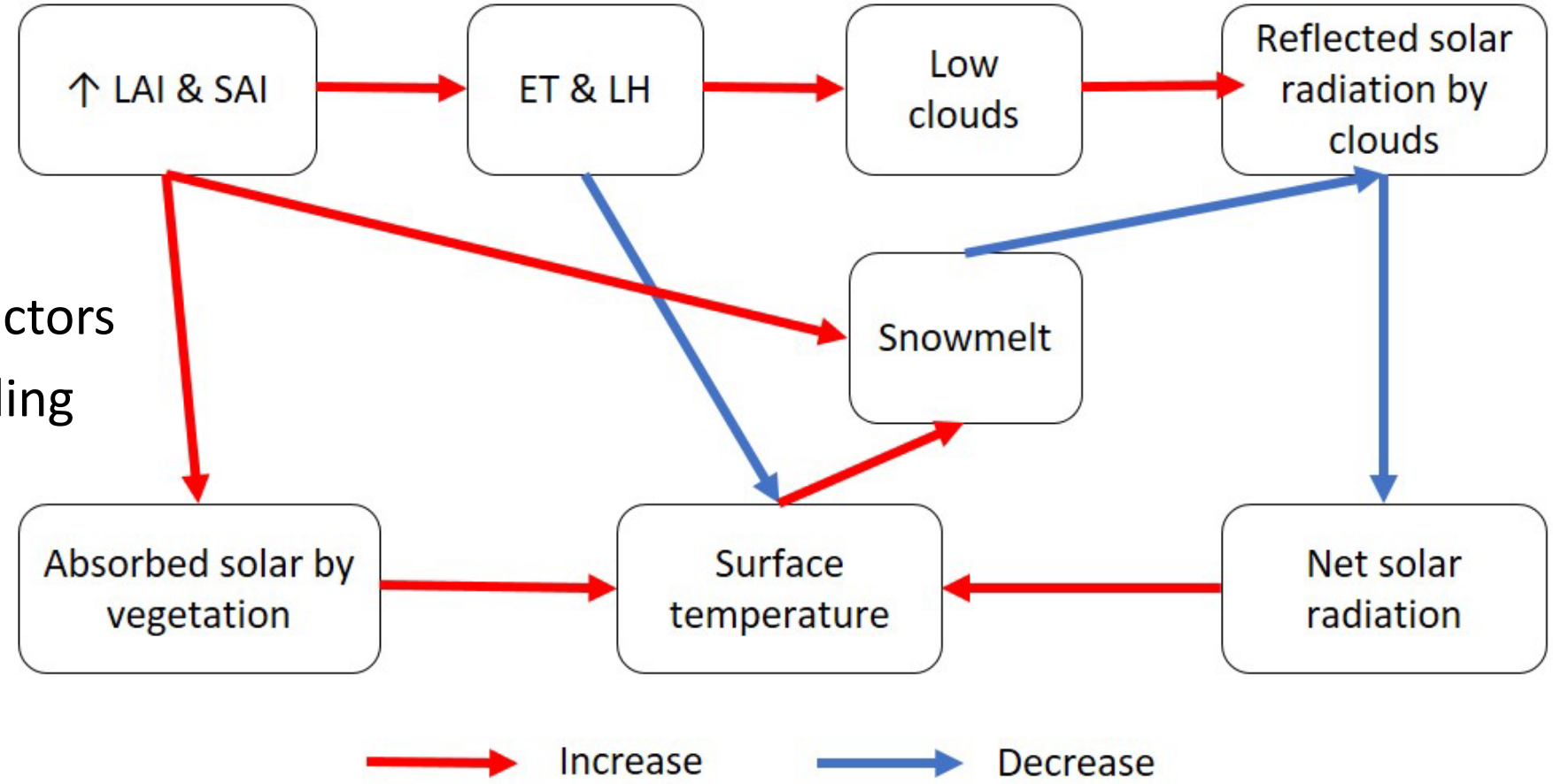




Phenology is important for both the carbon cycle and land-atmosphere coupling:

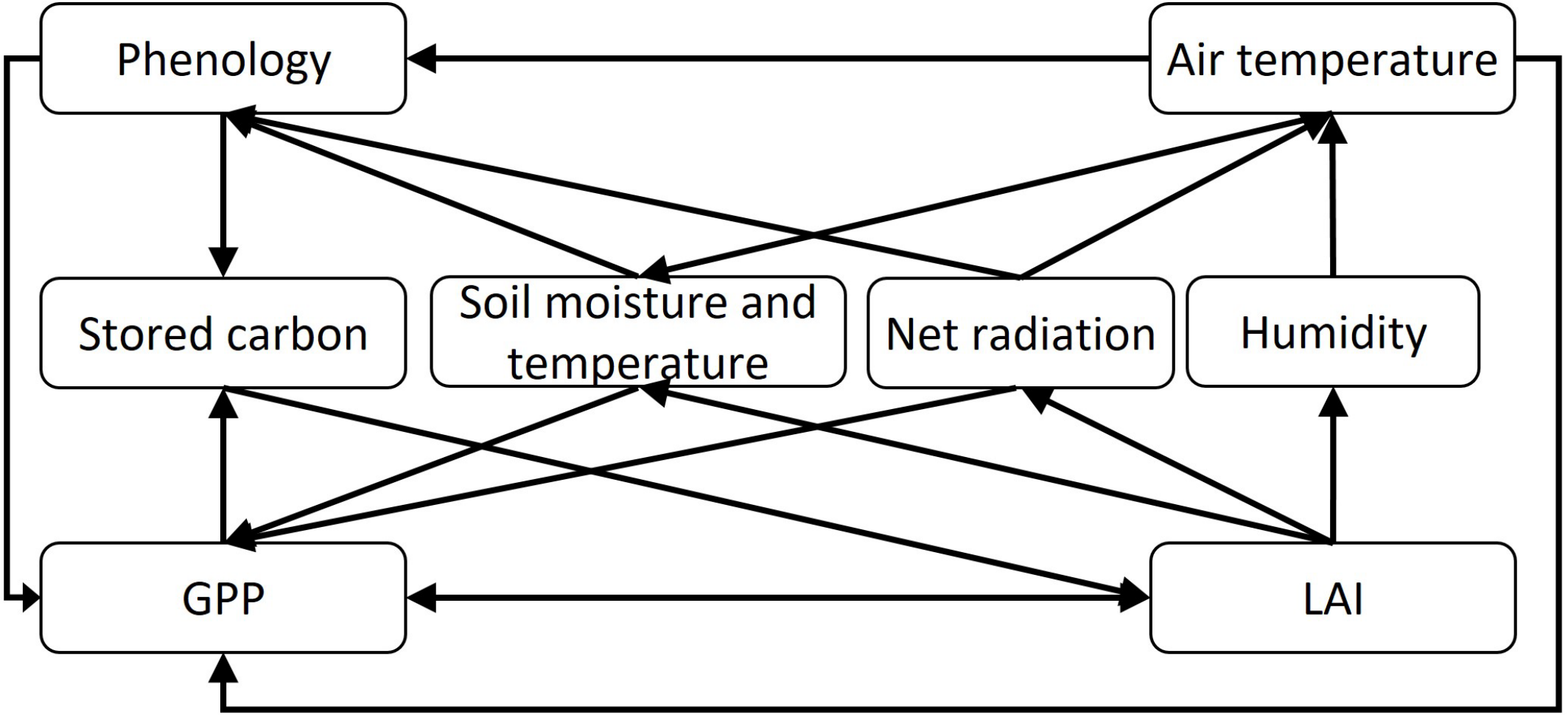
➢ Phenology modifies land-atmosphere coupling significantly at seasonal scale

- Directly influences energy and water exchanges;
- Indirectly changes cloud cover and albedo;
- Modulate controlling factors of land-atmosphere coupling

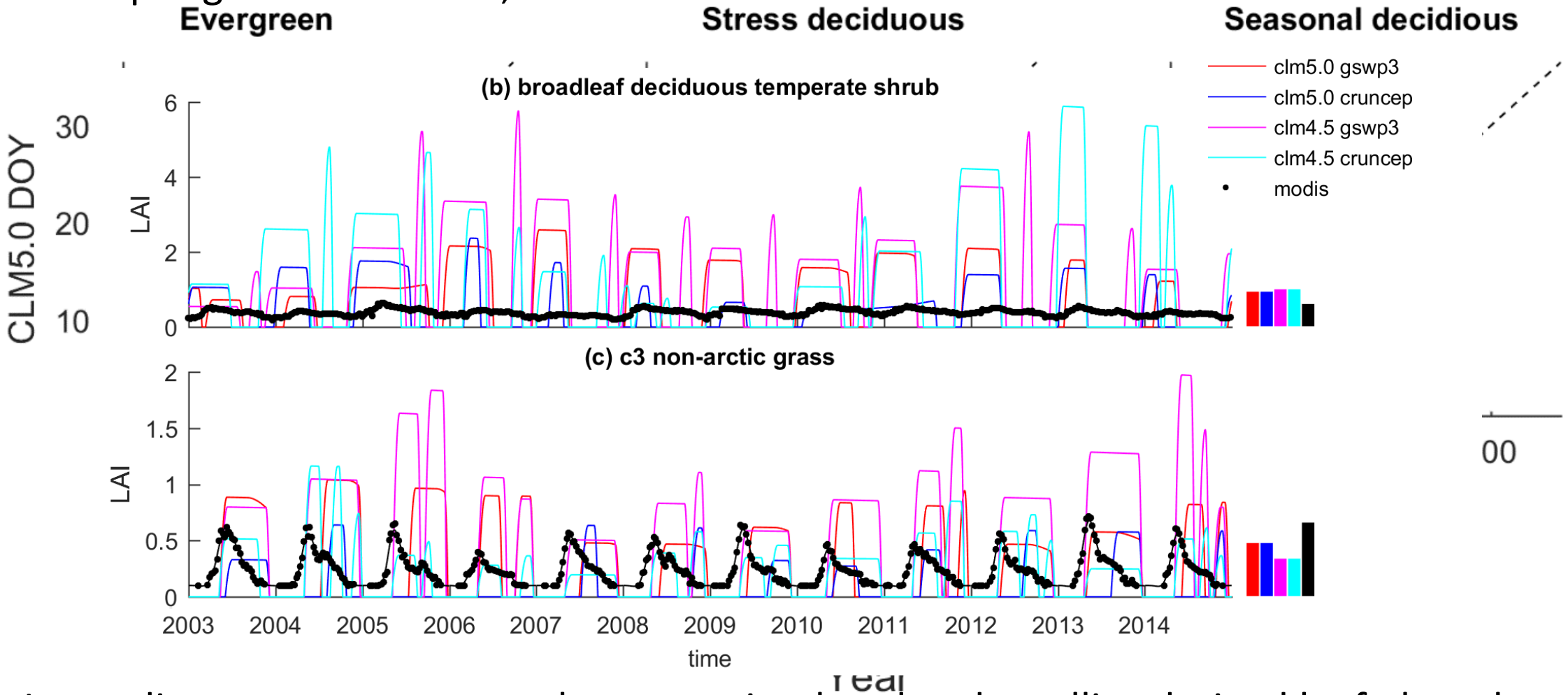


➢ Phenology influences primary production and the carbon cycle:

- Modulates growing season, leaf development, and primary production;
- Influences ecosystem structure and function.



- Phenology varies with the changing environment:
  - Interannual variability of spring onset can be as large as 14 days;
  - “Spring advancement”;



- Large disagreements present between simulated and satellite-derived leaf phenology

However, differences between model simulations and remote sensing derived records in LAI results in a relatively small bias in GPP (Li et al., 2022), so we wonder:

1. to what extent would phenology biases influence land-atmosphere coupling

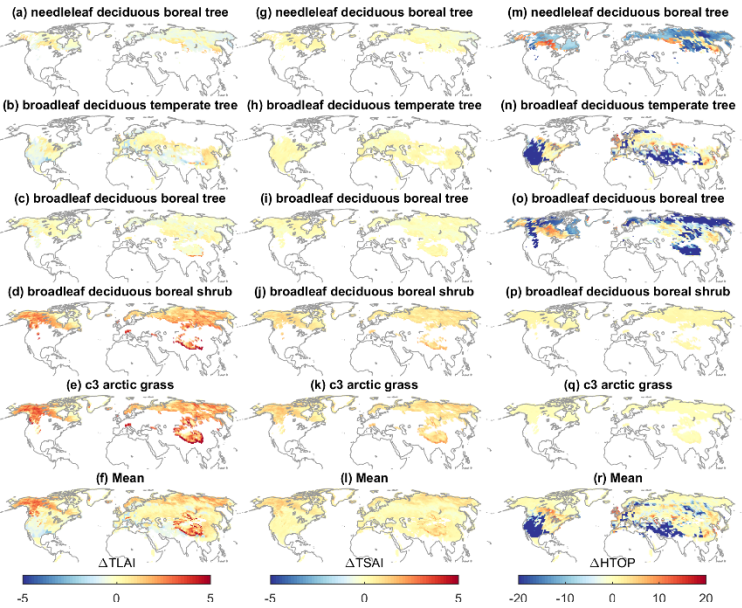
2. when, where, and what these influences are, and

3. which phenoPFT has the largest influences

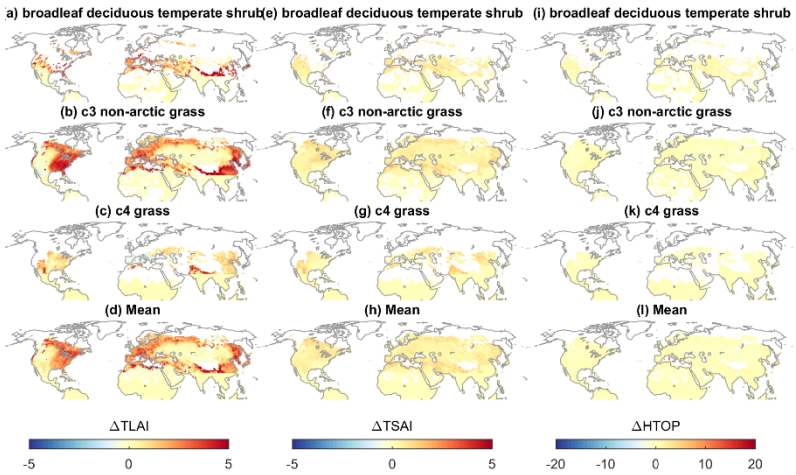
Methods:

- Run CLM5.0 BGC with GSWP3 historical forcing dataset

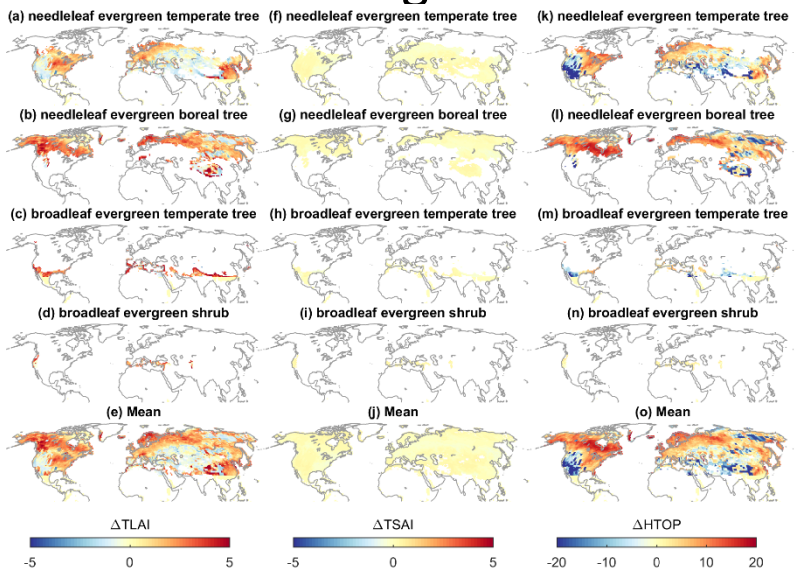
Seasonal deciduous



Stress deciduous



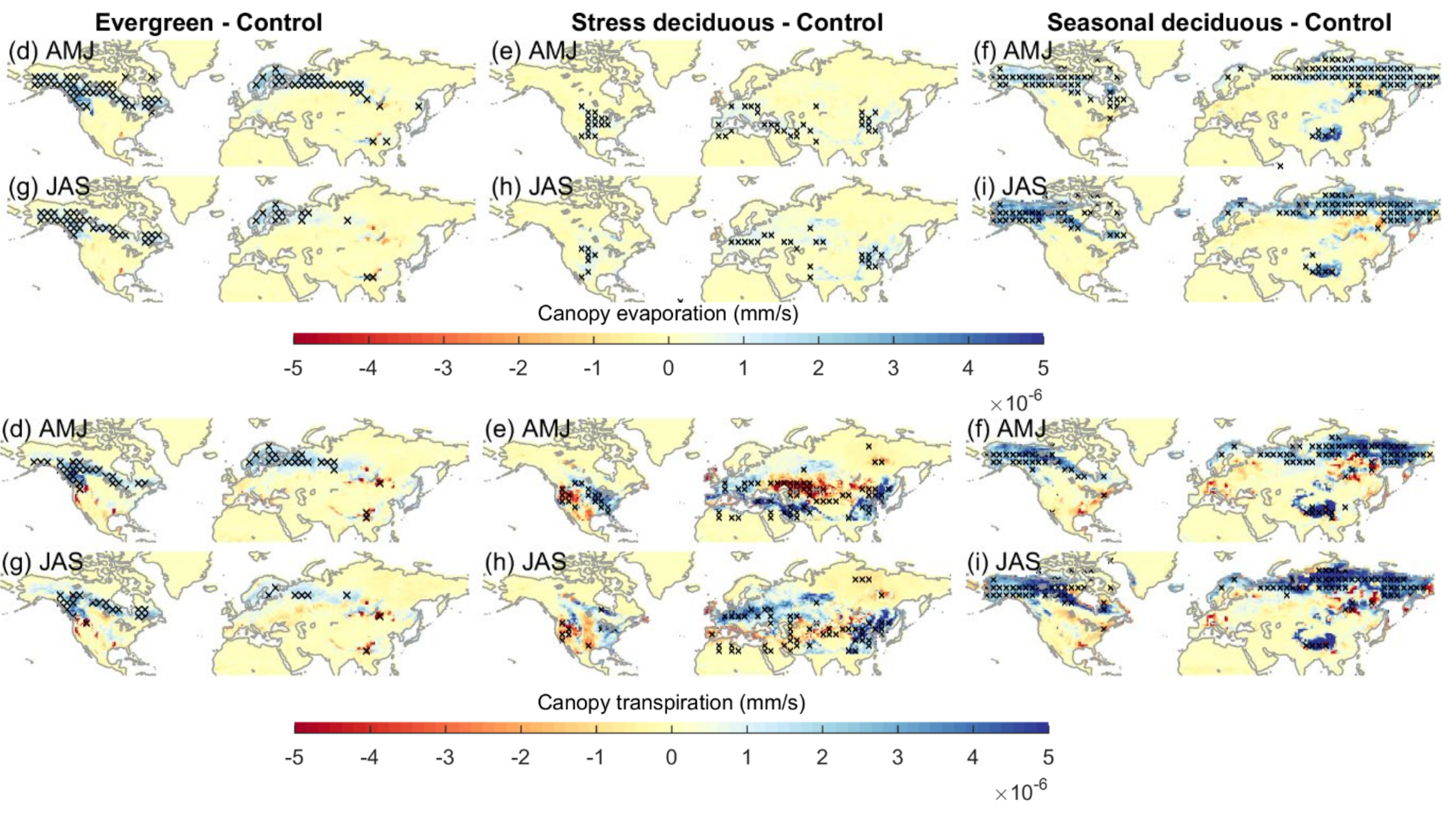
Evergreen



- Replace satellite phenology (SP) with CLM-simulated phenology in the Northern Hemisphere (North of 25N) for each phenology type and run for 100 years
  - Coupled land-atmosphere component configurations (F2000Climo): CAM6 + CLM5 SP
  - Climatological ocean conditions (HadSST 1995-2005 climatology)

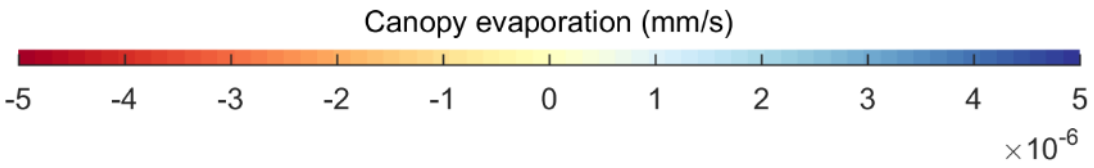
Results:

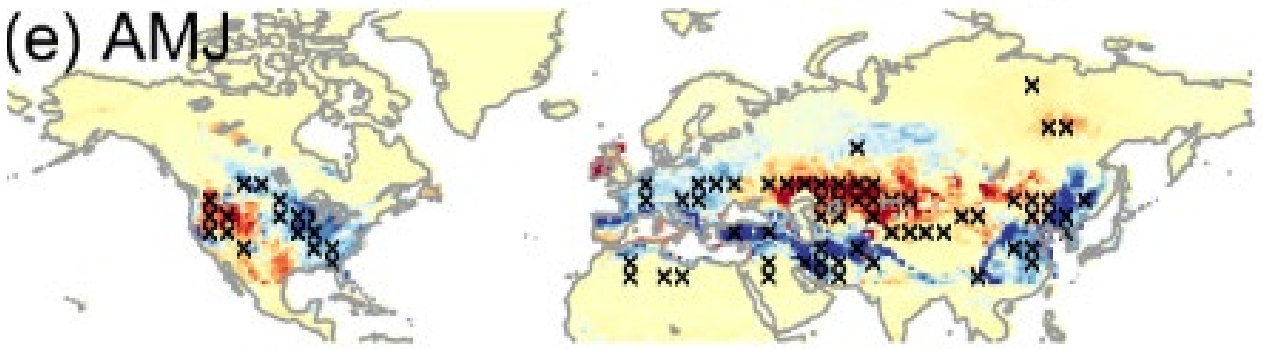
- Changes during the growing season
- Late-winter to spring changes in surface albedo and snow feedback
- Changes at interannual time scale and in the upper atmosphere

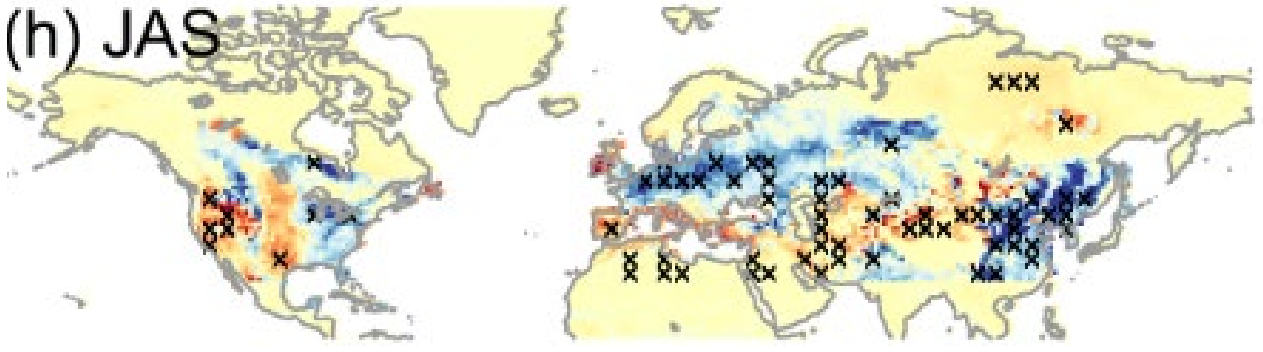

Evergreen - Control
Stress deciduous - Control
Seasonal deciduous - Control
(d) AMJ
(e) AMJ
(f) AMJ
(g) JAS
(h) JAS
(i) JAS
Canopy evaporation (mm/s)
-5 -4 -3 -2 -1 0 1 2 3 4 5
×10-6
(d) AMJ
(e) AMJ
(f) AMJ
(g) JAS
(h) JAS
(i) JAS
Canopy transpiration (mm/s)
-5 -4 -3 -2 -1 0 1 2 3 4 5
×10-6


(e) AMJ


(h) JAS


Canopy evaporation (mm/s)
-5
-4
-3
-2
-1
0
1
2
3
4
5
×10-6

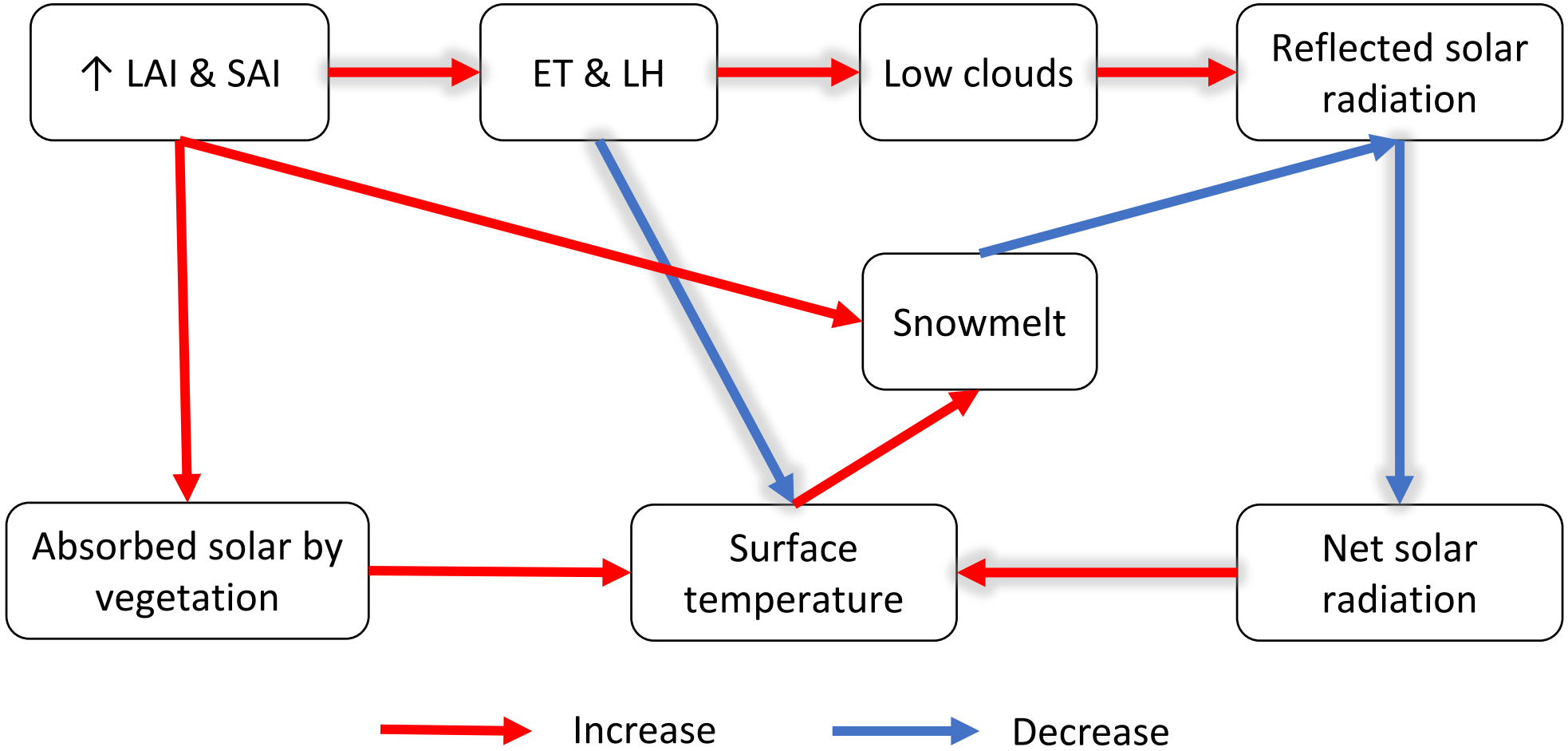

(e) AMJ

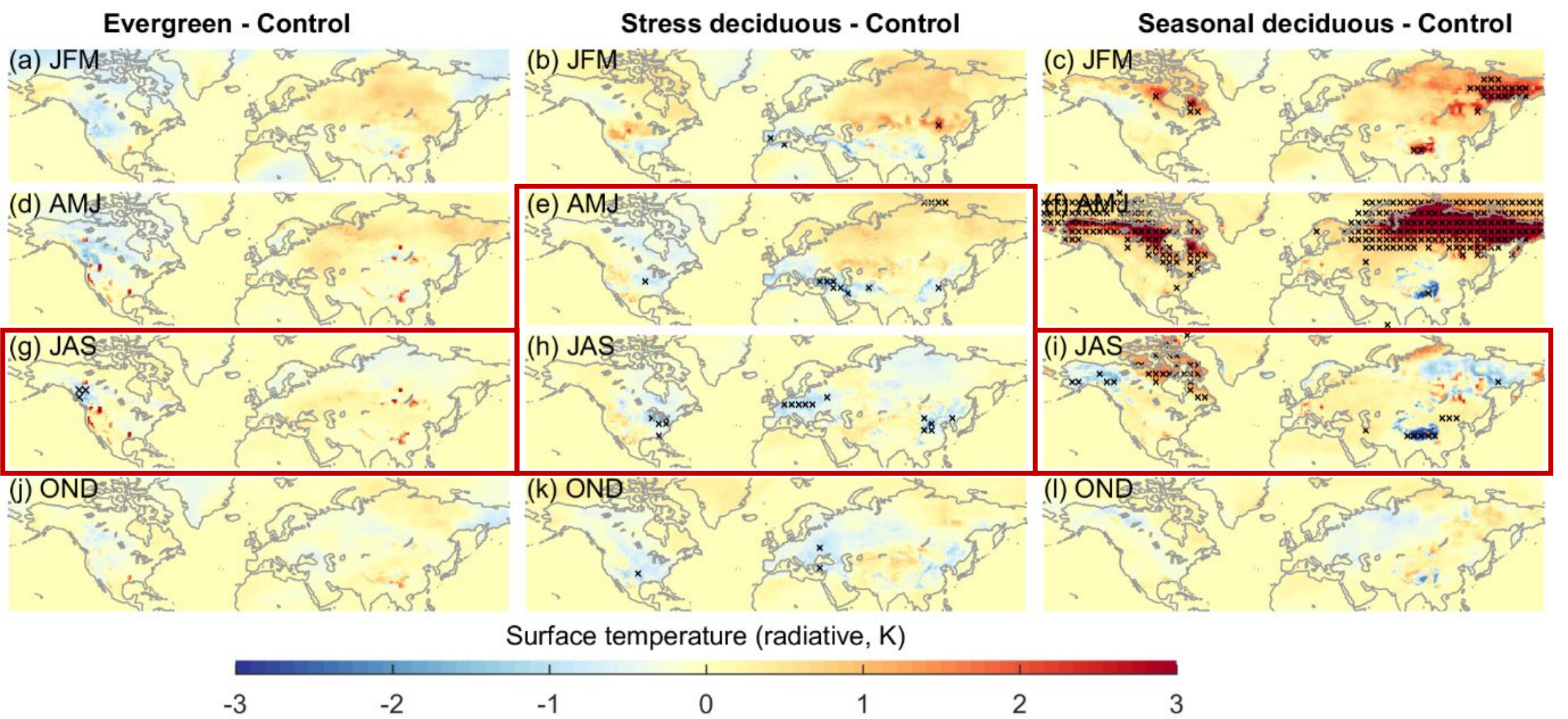

(h) JAS


Canopy transpiration (mm/s)
-5
-4
-3
-2
-1
0
1
2
3
4
5
×10-6

Results:

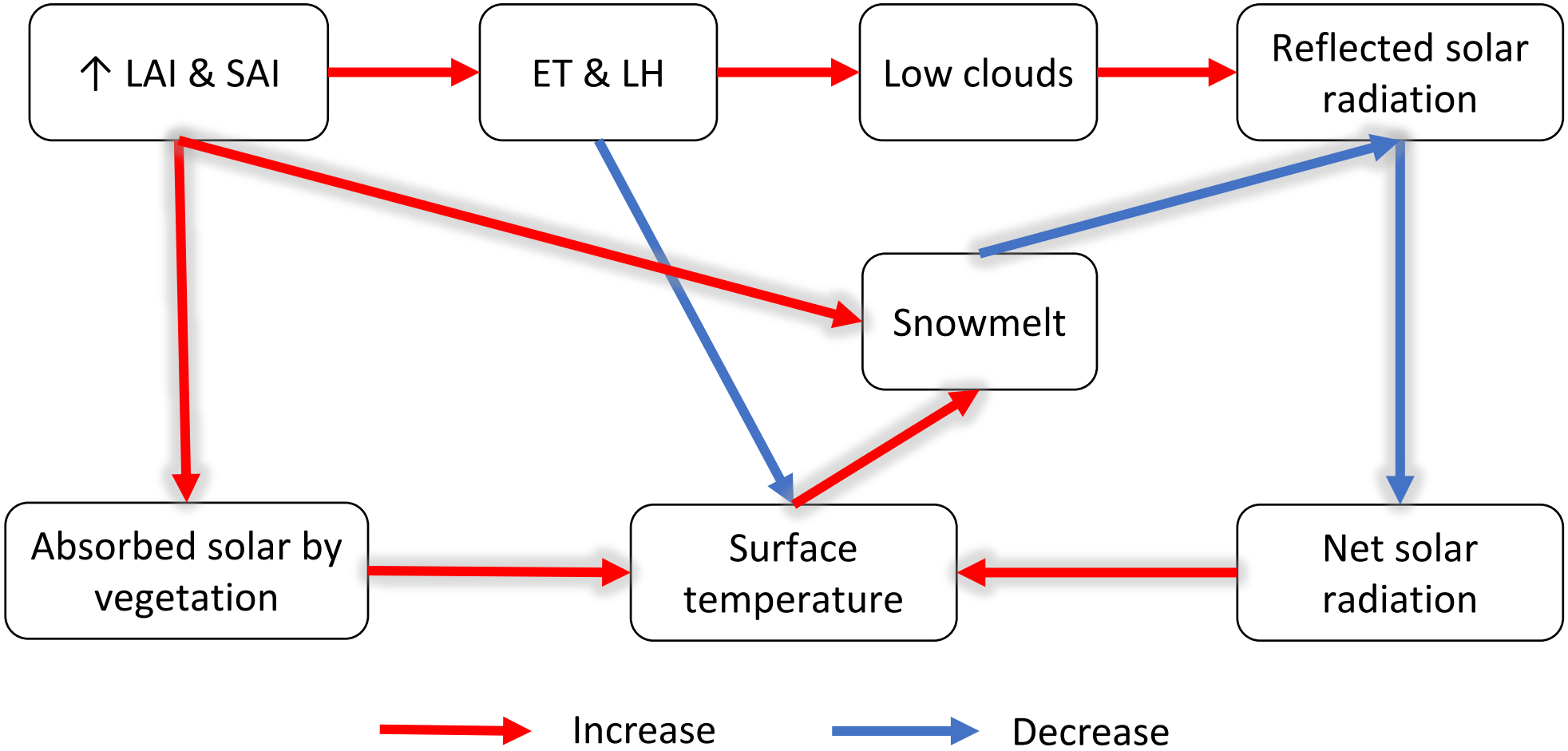
- Changes during the growing season
- Late-winter to spring changes in surface albedo and snow feedback
- Changes at interannual time scale and in the upper atmosphere

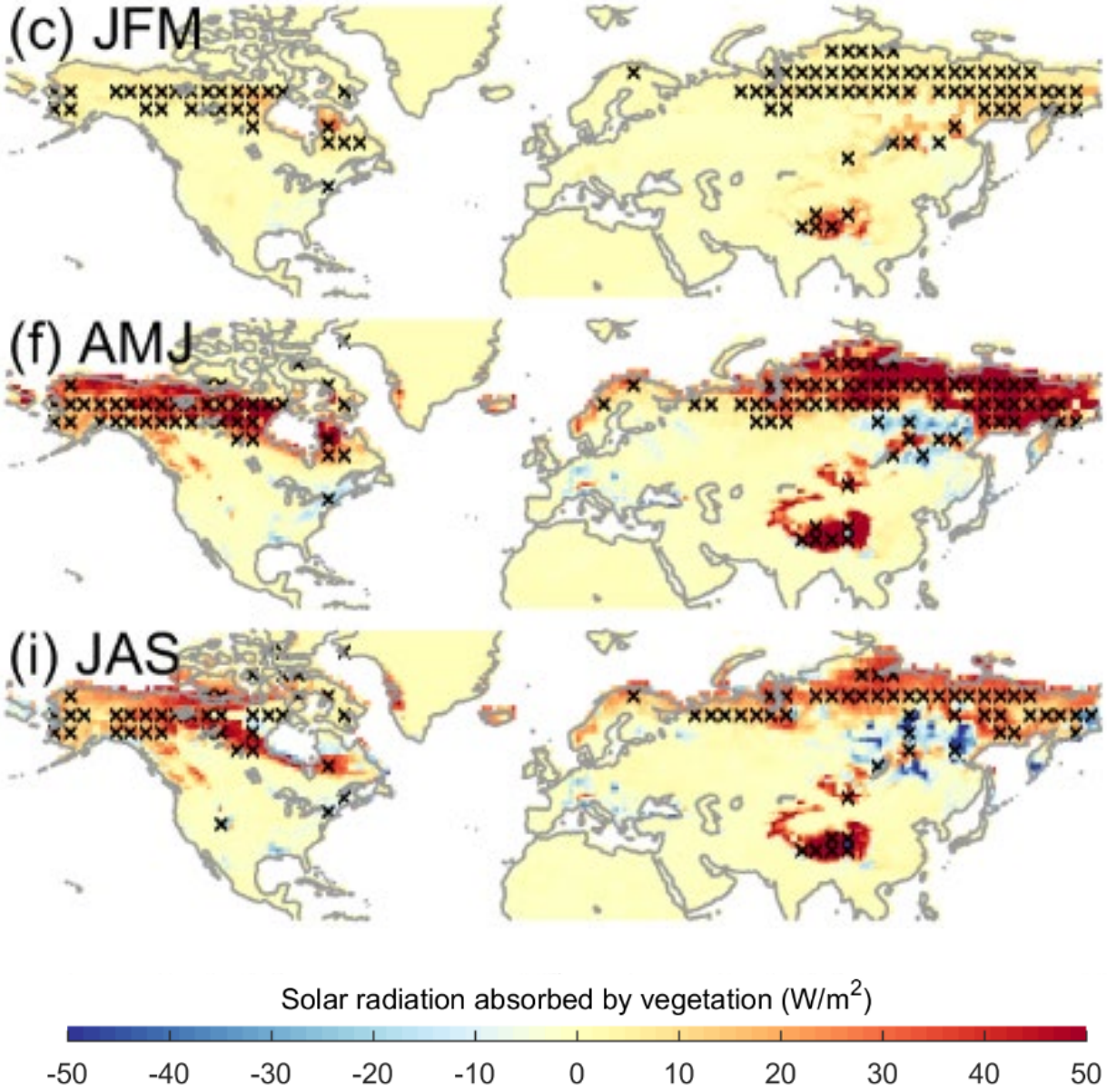


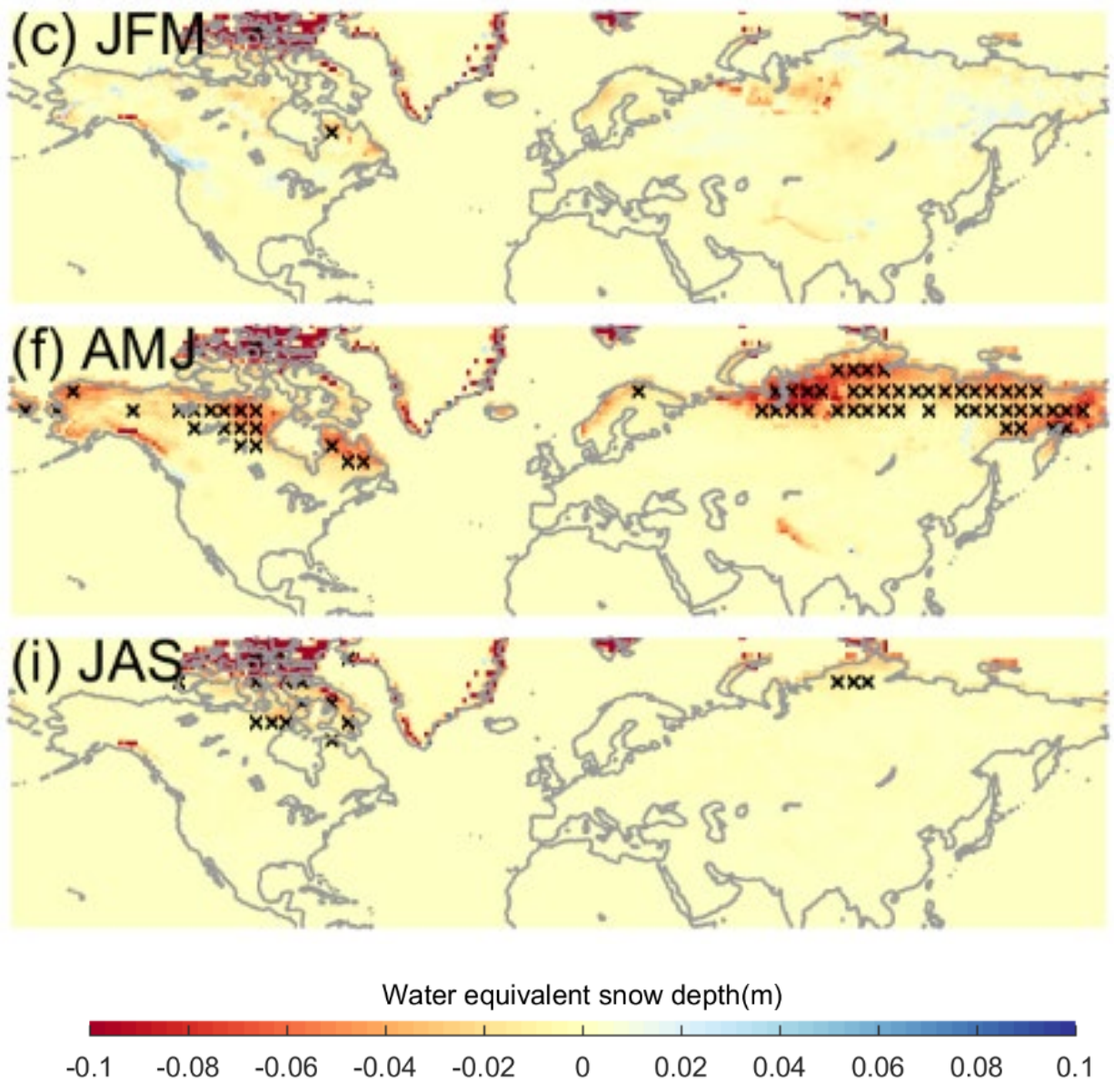

Evergreen - Control
Stress deciduous - Control
Seasonal deciduous - Control
(a) JFM
(b) JFM
(c) JFM
(d) AMJ
(e) AMJ
(f) AMJ
(g) JAS
(h) JAS
(i) JAS
(j) OND
(k) OND
(l) OND
Surface temperature (radiative, K)
-3
-2
-1
0
1
2
3

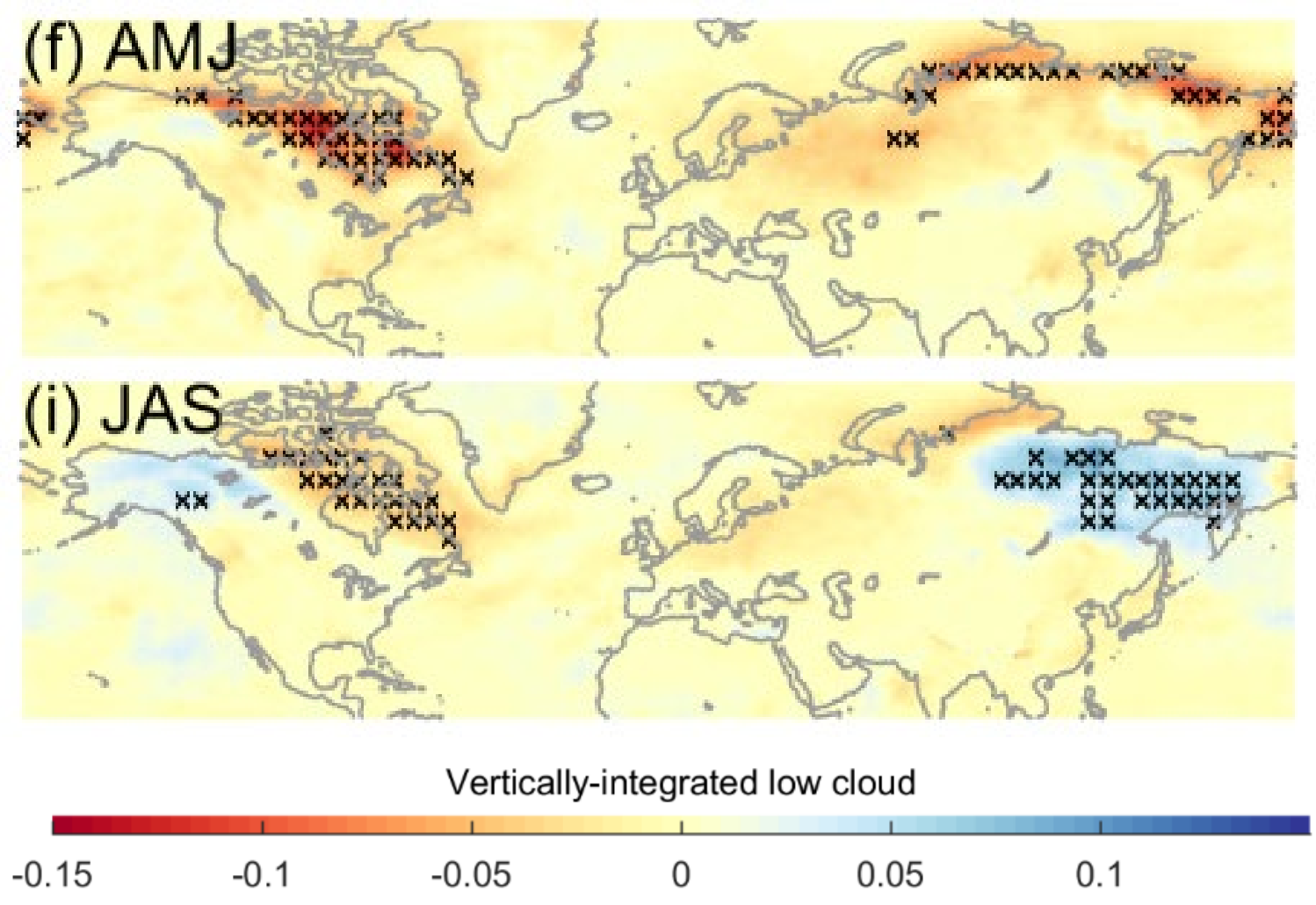
Results:

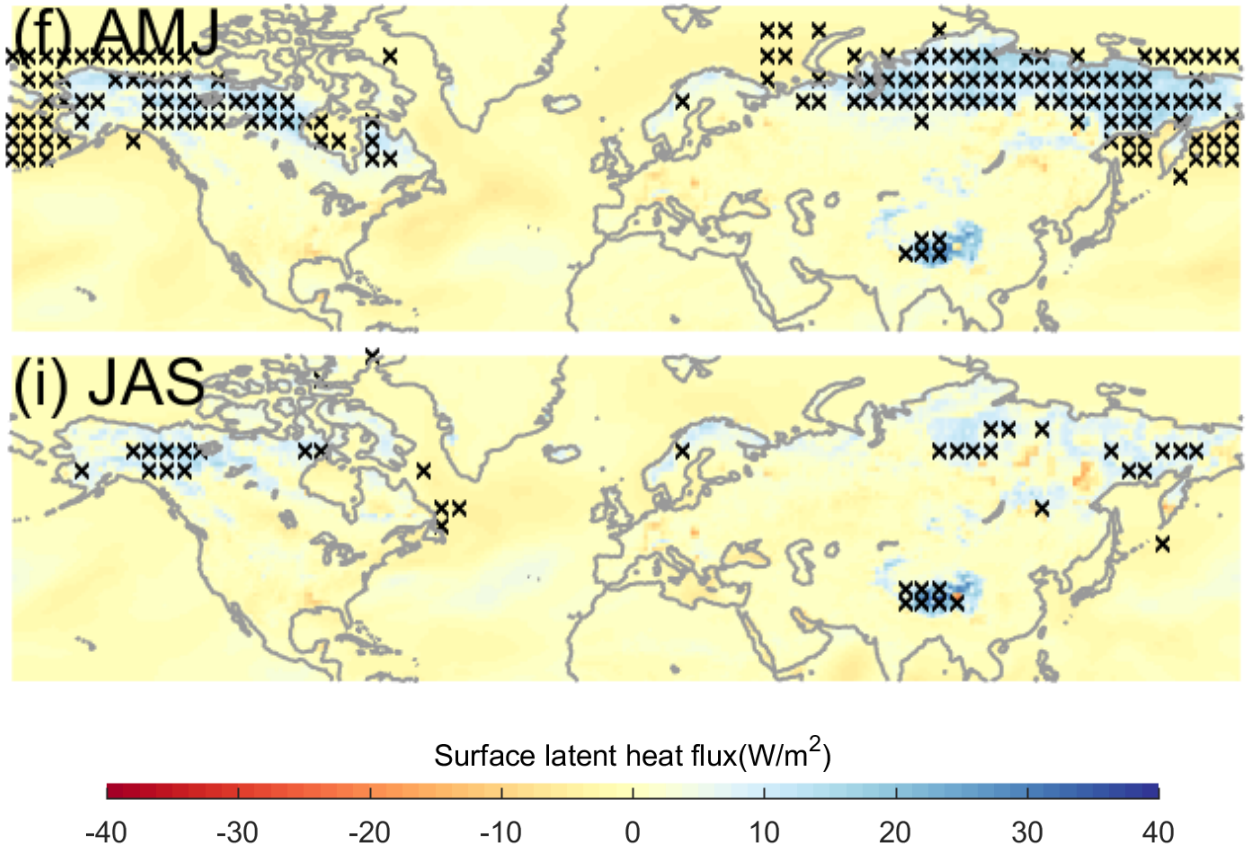
- Changes during the growing season
- Late-winter to spring changes in surface albedo and snow feedback
- Changes at interannual time scale and in the upper atmosphere

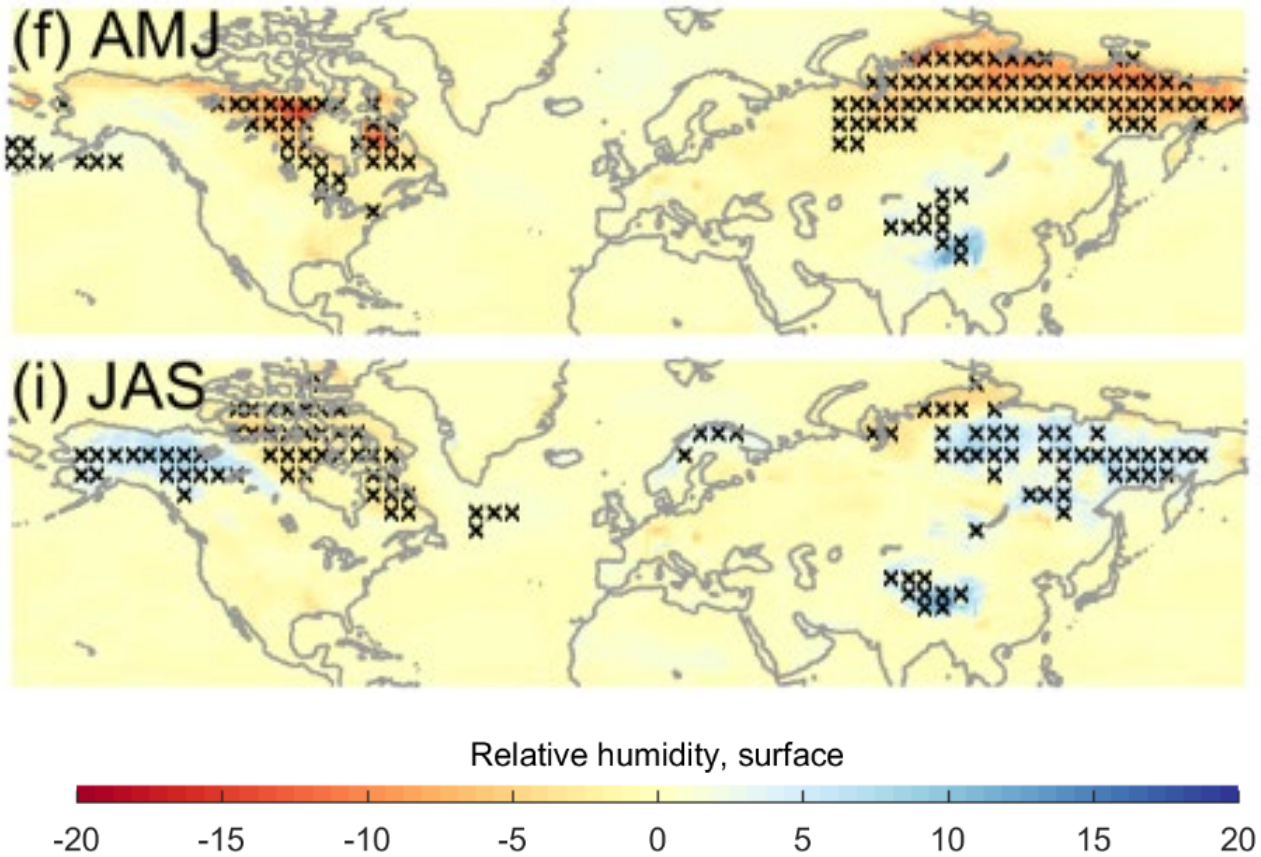


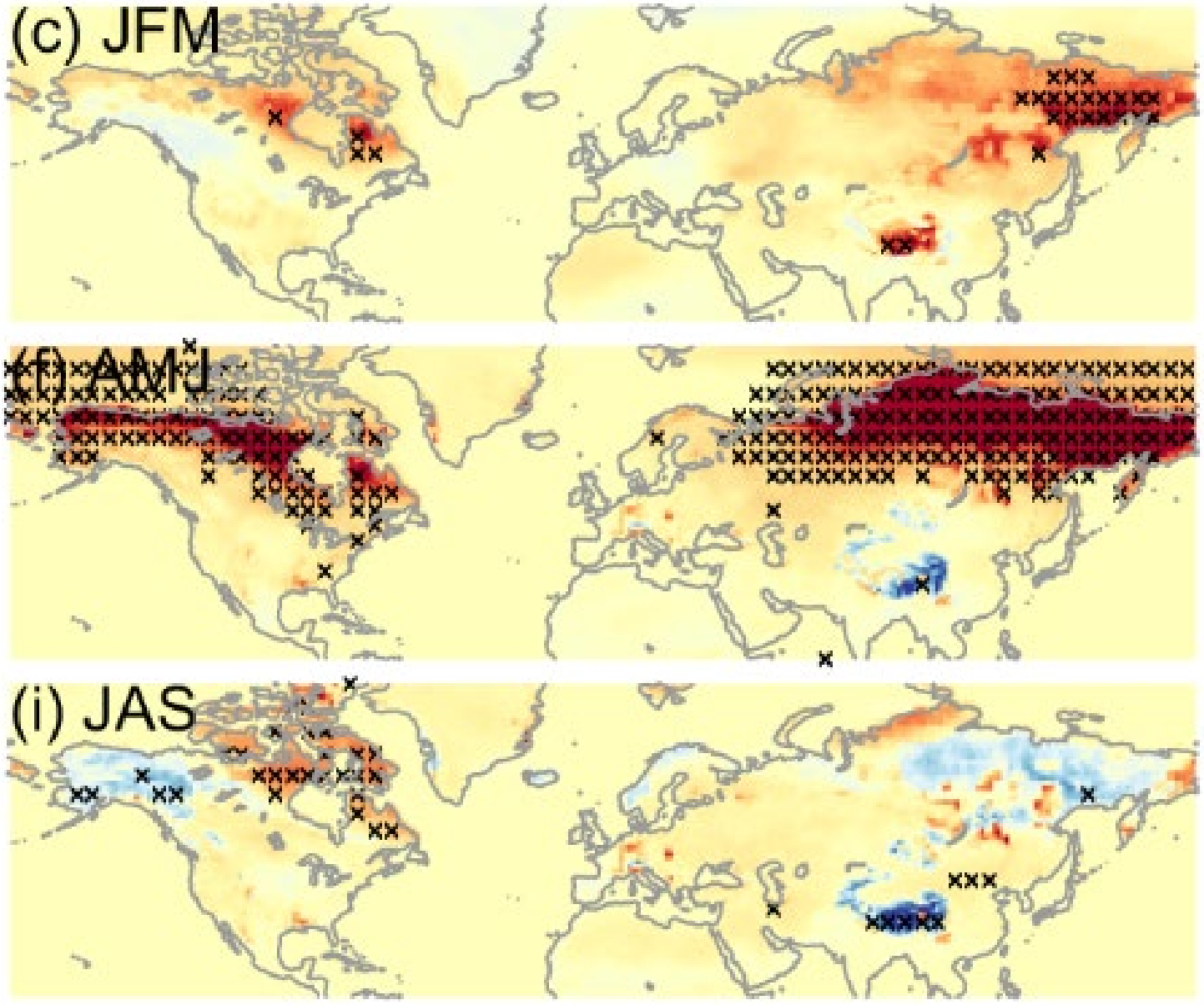

(c) JFM
(f) AMJ
(i) JAS
Solar radiation absorbed by vegetation (W/m^2)
-50 -40 -30 -20 -10 0 10 20 30 40 50


(c) JFM
(f) AMJ
(i) JAS
Water equivalent snow depth(m)
-0.1 -0.08 -0.06 -0.04 -0.02 0 0.02 0.04 0.06 0.08 0.1


(f) AMJ
(i) JAS
Vertically-integrated low cloud
-0.15
-0.1
-0.05
0
0.05
0.1

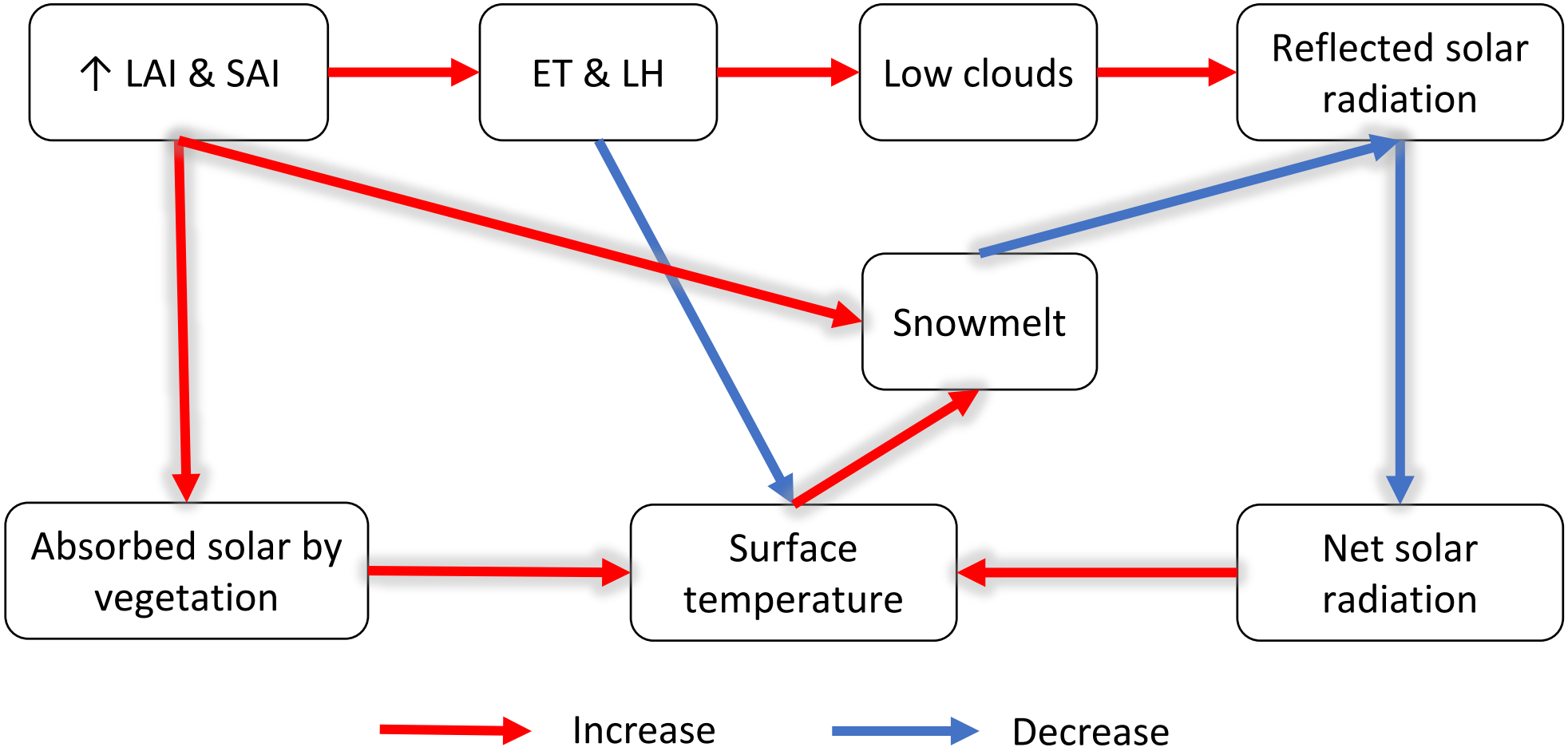

(f) AMJ
(i) JAS
Surface latent heat flux(W/m^2)
-40
-30
-20
-10
0
10
20
30
40


(f) AMJ
(i) JAS
Relative humidity, surface
-20
-15
-10
-5
0
5
10
15
20


(c) JFM
(f) AMJ
(i) JAS
Surface temperature (radiative, K)
-3
-2
-1
0
1
2
3

Results:

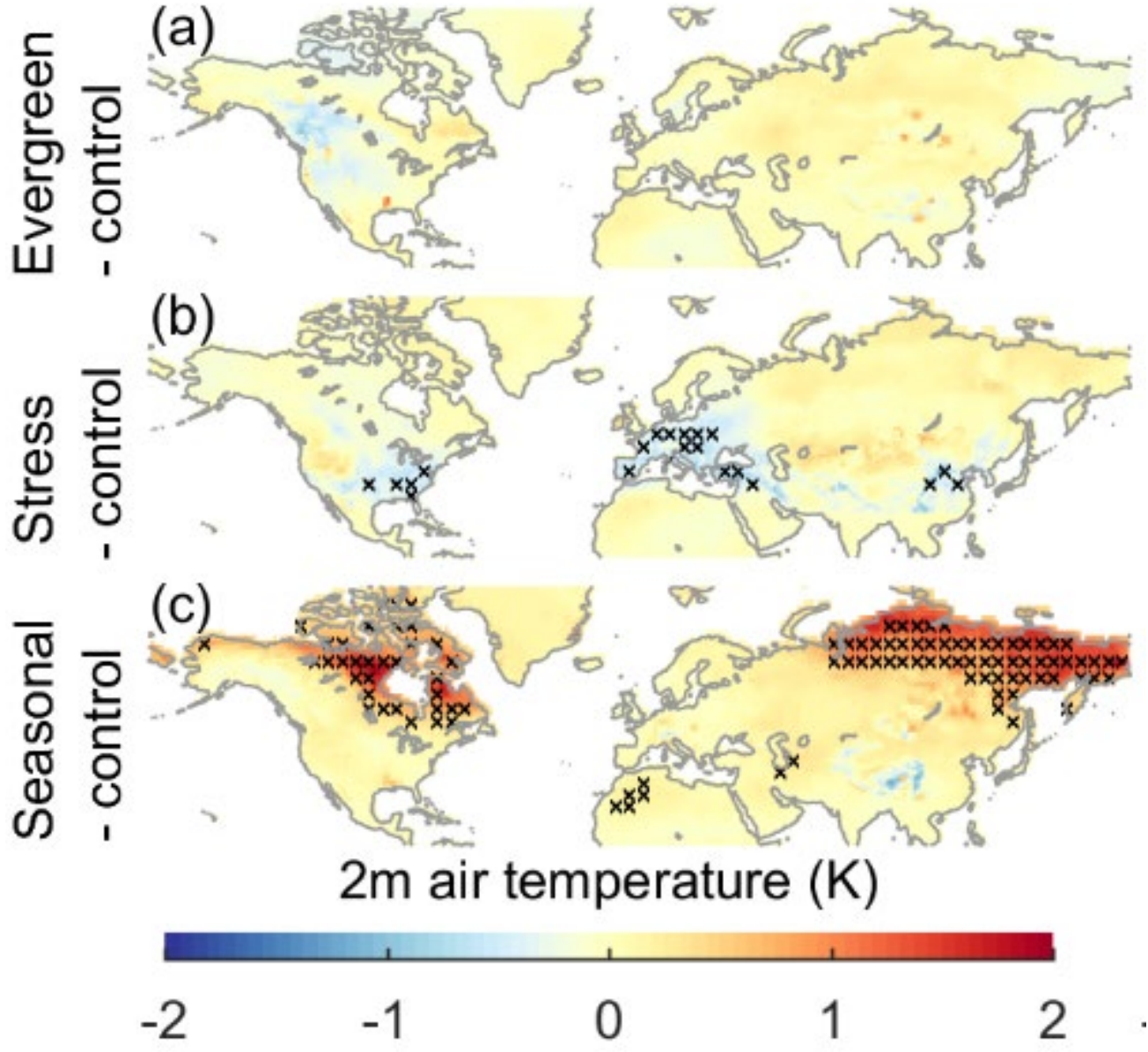
- Changes during the growing season
- Late-winter to spring changes in surface albedo and snow feedback
- Changes at interannual time scale and in the upper atmosphere



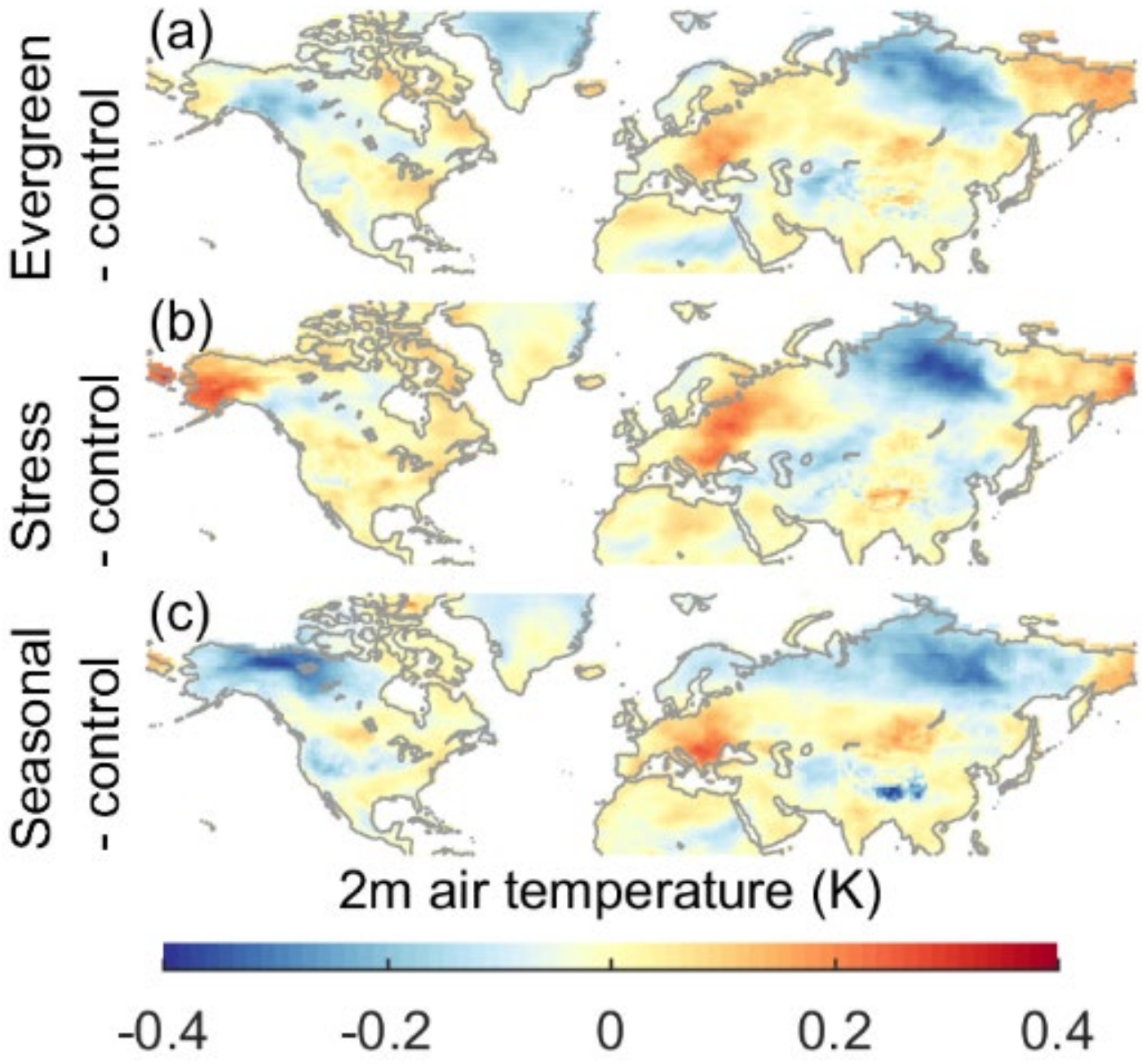
Results:

- Late-winter to spring changes in surface albedo and snow feedback
- Changes during the growing season
- Changes at interannual time scale

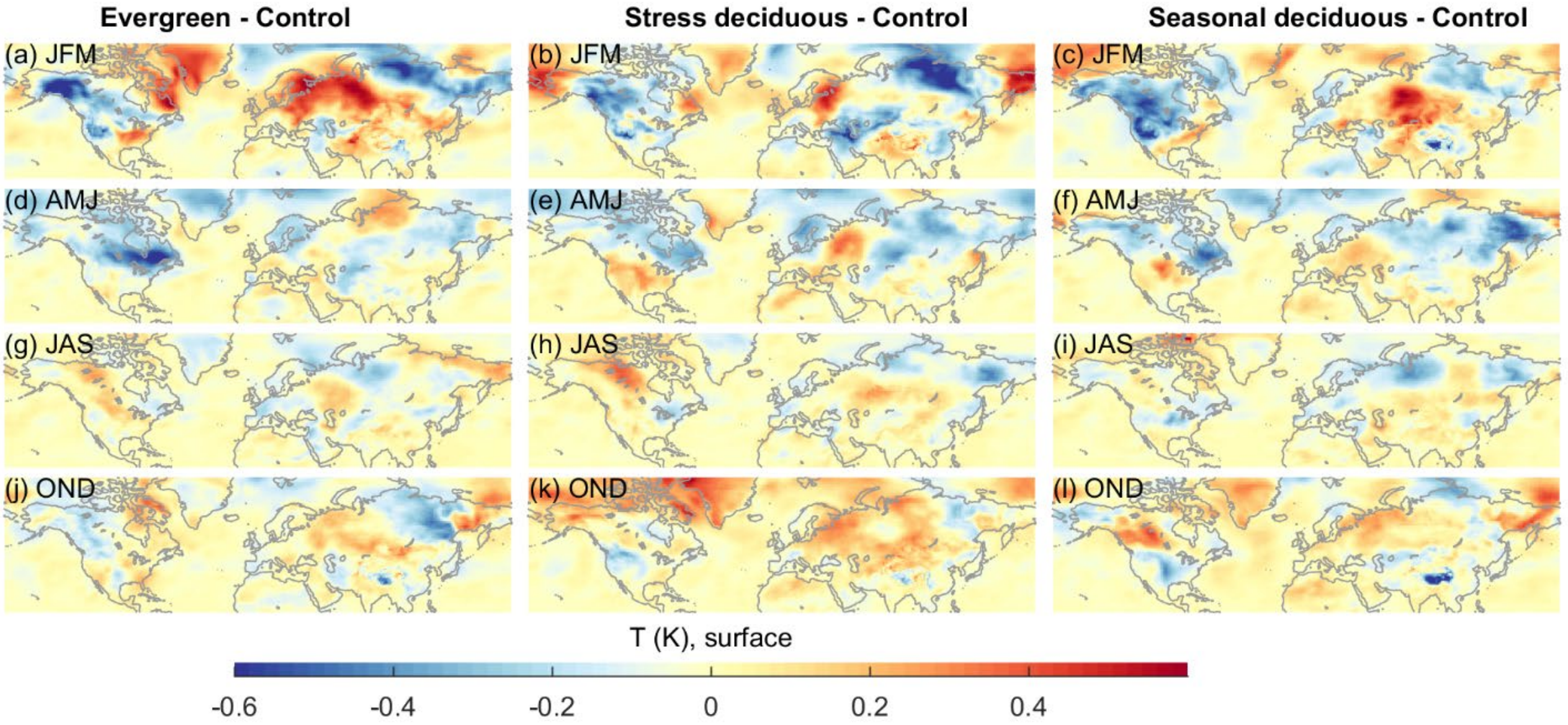
  and in the upper atmosphere



Changes in interannual variability



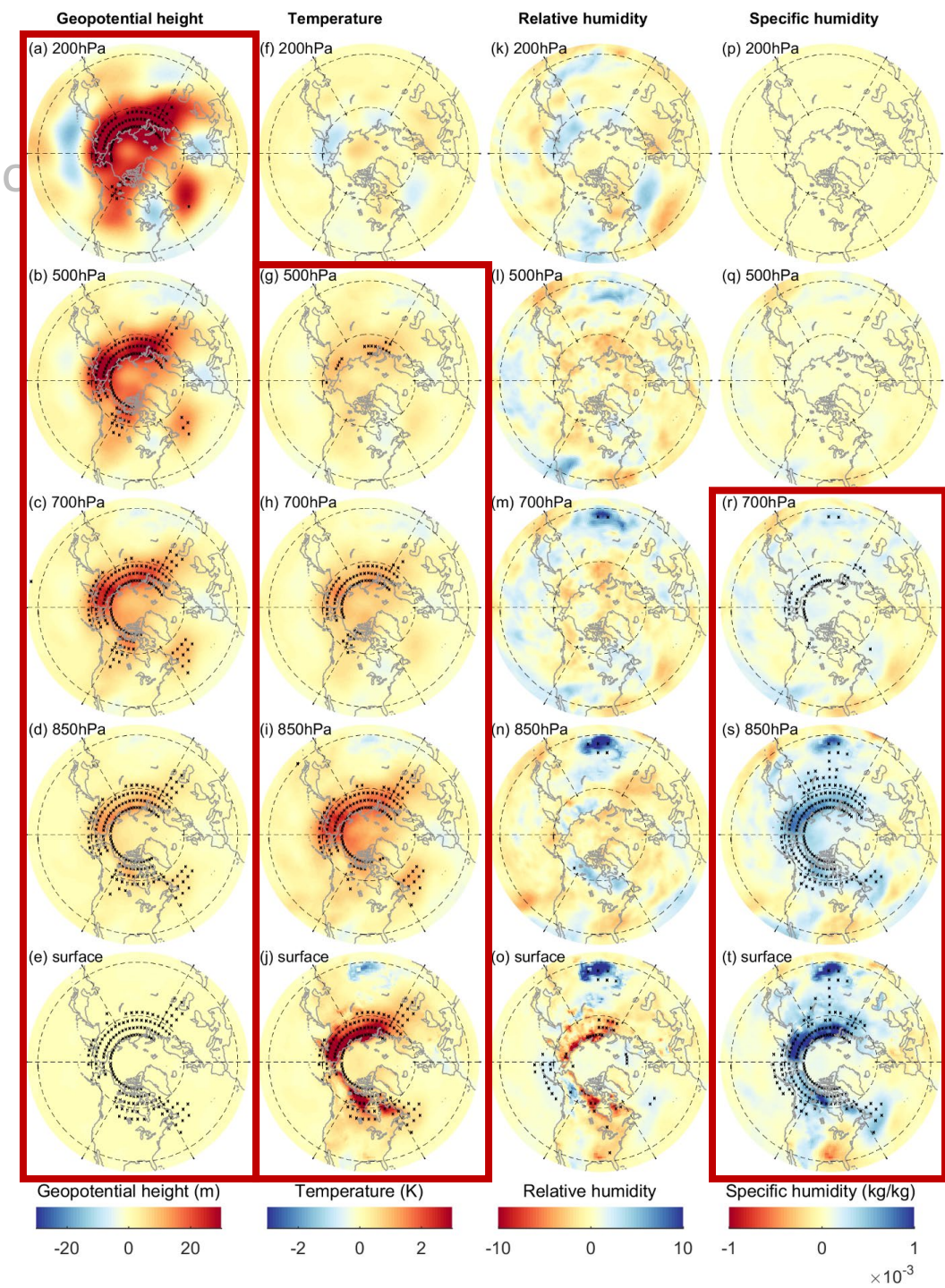
Changes in interannual variability



Results:

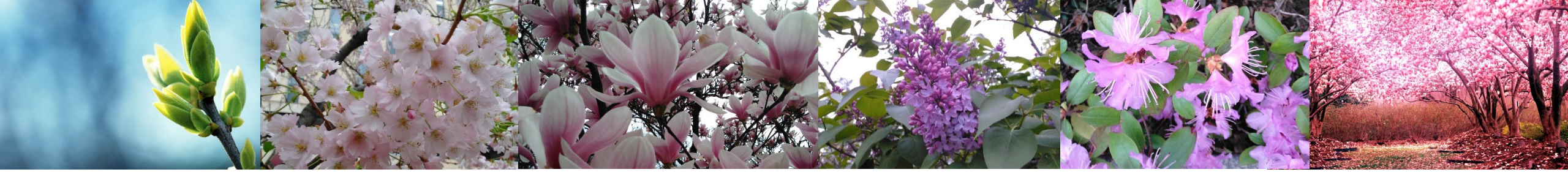
- Late-winter to spring changes in surface albedo and sno
- Changes during the growing season
- Changes at interannual time scale

  and in the upper atmosphere



Conclusions:

- phenology influences the land surface and land-atmosphere interactions through both direct influences on fluxes and momentum exchanges and indirect influences via snow-albedo feedback and cloud feedback;
- Influences induced by phenology discrepancies are the largest and most significant in seasonal deciduous phenology in the late winter to spring season, when temperatures in high latitude regions can increase over 3K at the surface and propagate to 500hPa or higher, potentially altering large-scale atmospheric circulations;
- Changes during the growing season depend on soil moisture availability and differ by phenology type, and plants in arid or semi-arid regions may face higher moisture stress and potentially shorter growing season;
- Discrepancies in phenology simulations not only affect the land surface and boundary layer, but can potentially influence the mean state of the upper atmospheric layers and large-scale circulation.



Thank you!

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References:

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Li, X., Melaas, E., Carrillo, C. M., Ault, T., Richardson, A. D., Lawrence, P., ... & Young, A. M. (2022). A comparison of land surface phenology in the Northern Hemisphere derived from satellite remote sensing and the Community Land Model. *Journal of Hydrometeorology, 23* (6)

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Funded by NSF Macrosystems Biology award (DEB-2017815; DEB-1702551) and NSF Career Award (AGS-1751535)