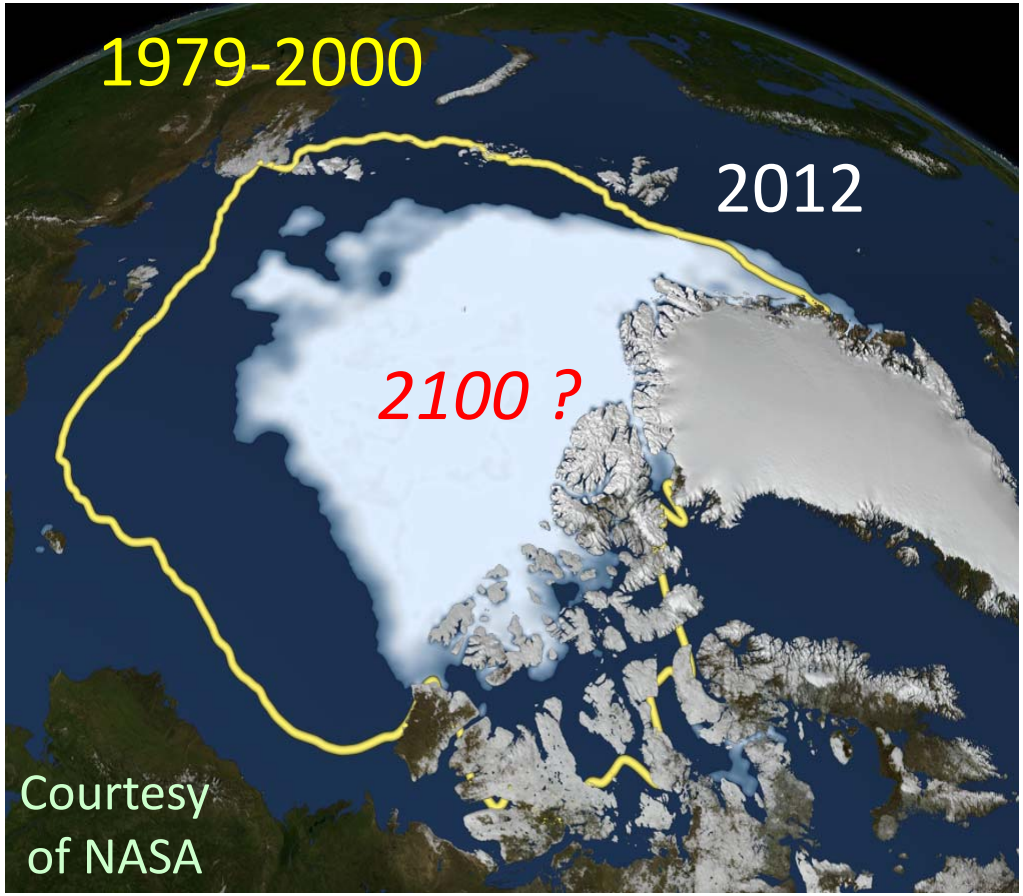
Modeling the Atmospheric Response to Arctic Sea Ice Loss

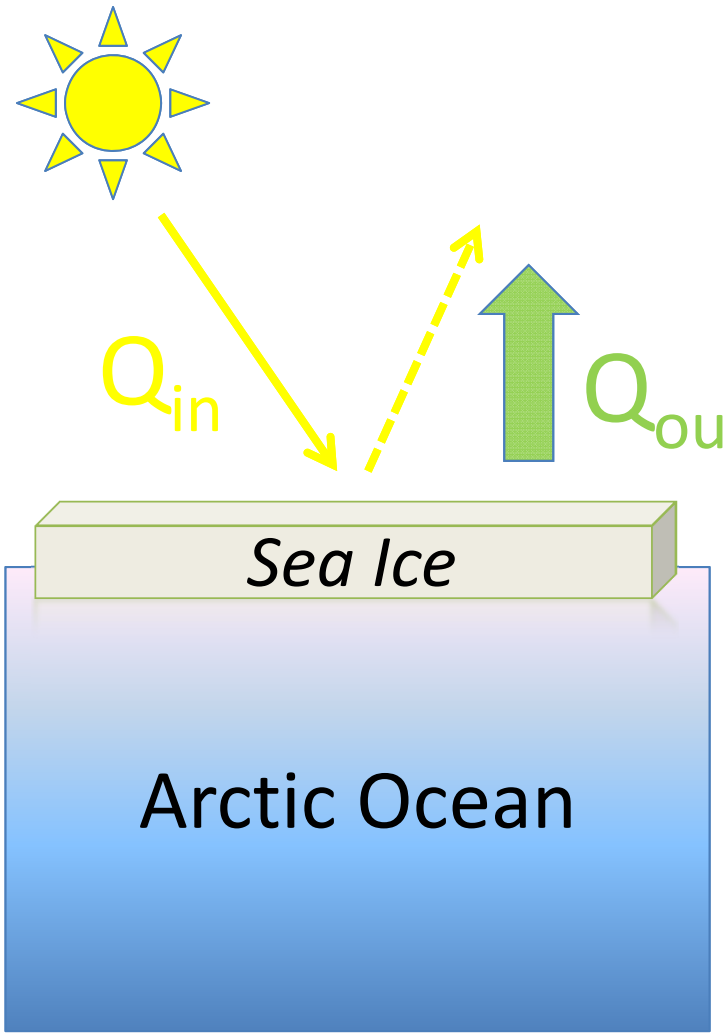


- Processes
- Impacts
- Uncertainties

Clara Deser (NCAR)

FAMOS 21 October 2014

Processes: Surface energy exchange



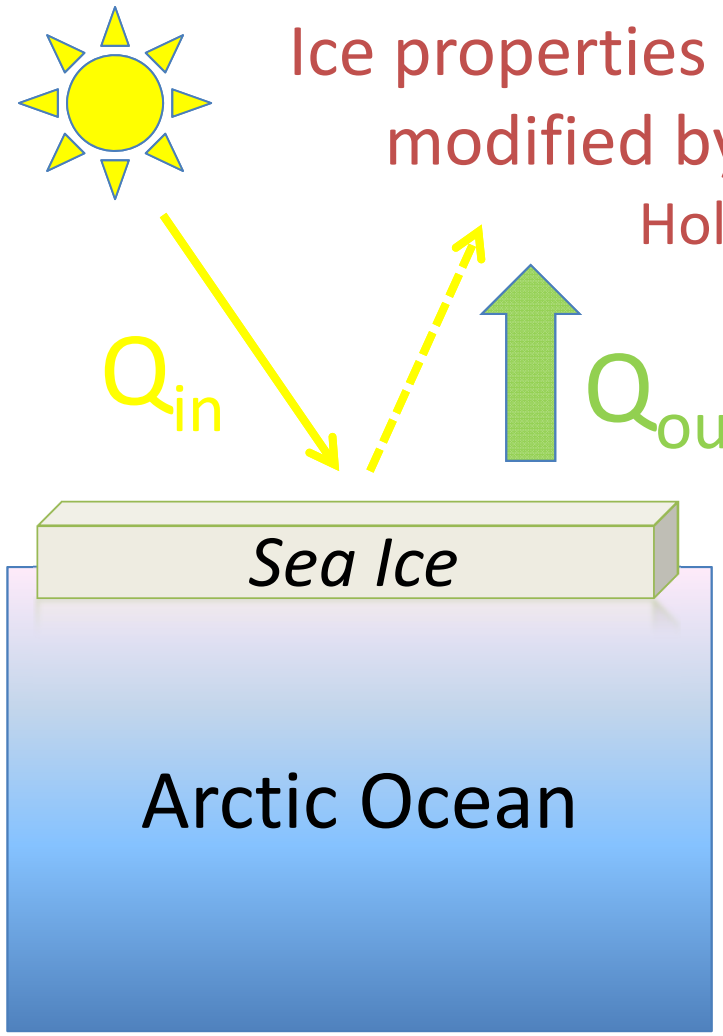
Q_{sw} **shortwave radiation**

Q_{lw} **longwave radiation**

Q_{sh} **sensible heat**

Q_{lh} **latent heat**

Processes: Surface energy exchange



Ice properties (albedo, emissivity, temperature) modified by ice age, thickness, snow, etc.

Holland et al. 2012 *J. Climate*

Q_{sw} **shortwave radiation**

$(1\text{-}albedo)\ Q_{in}$

Q_{lw} **longwave radiation**

$\varepsilon \quad \sigma T^4$

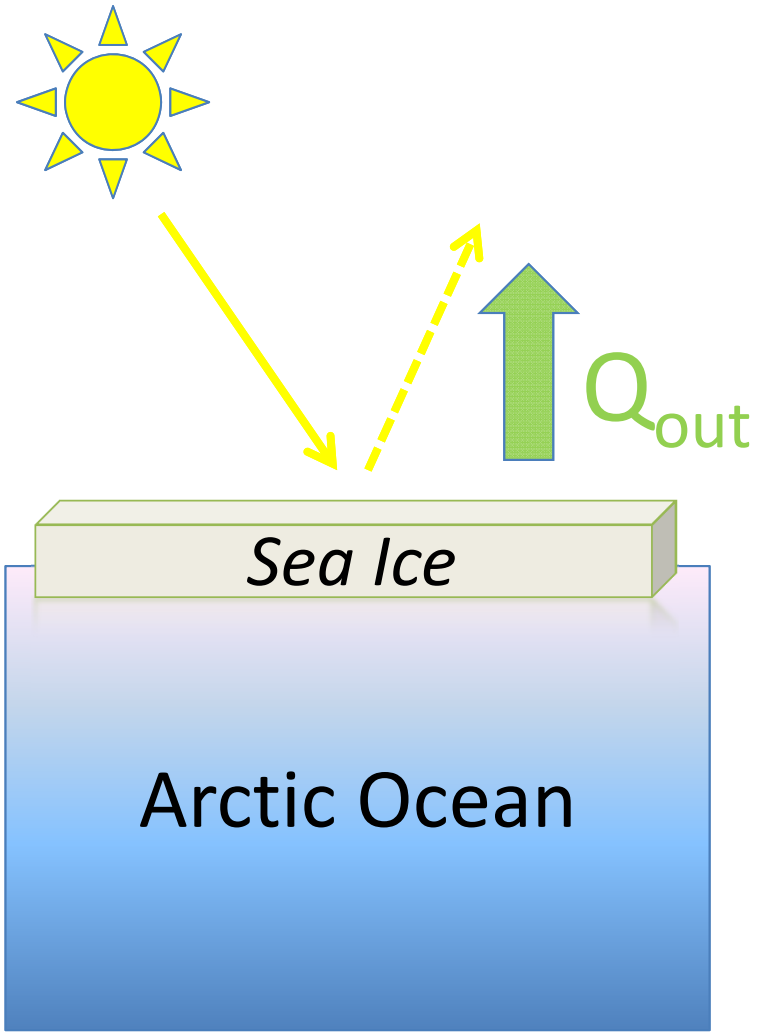
Q_{sh} **sensible heat**

$W\ (T - T_a)$

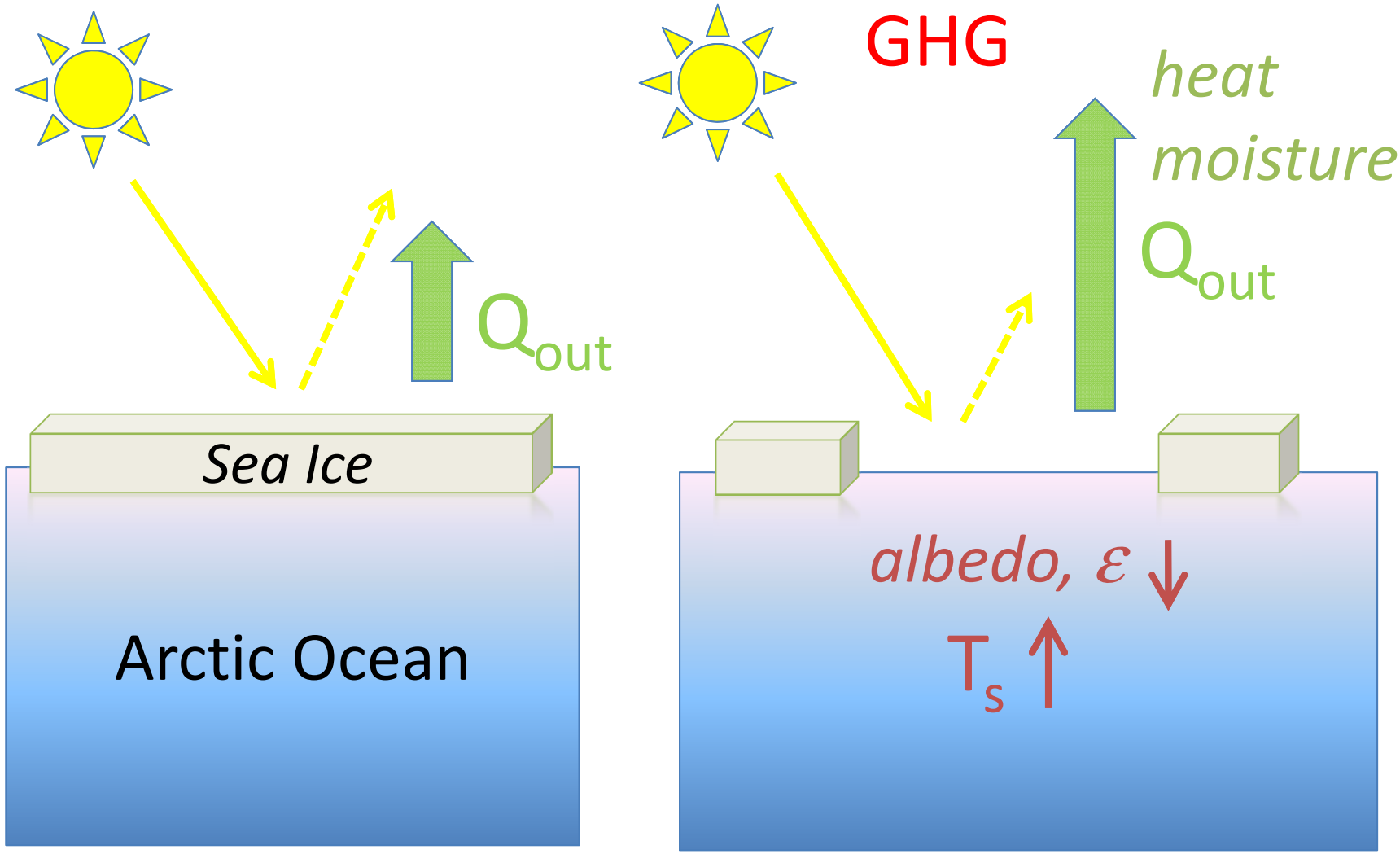
Q_{lh} **latent heat**

$W\ (q - q_a)$

Response of surface energy exchange to GHG-induced Arctic sea ice loss

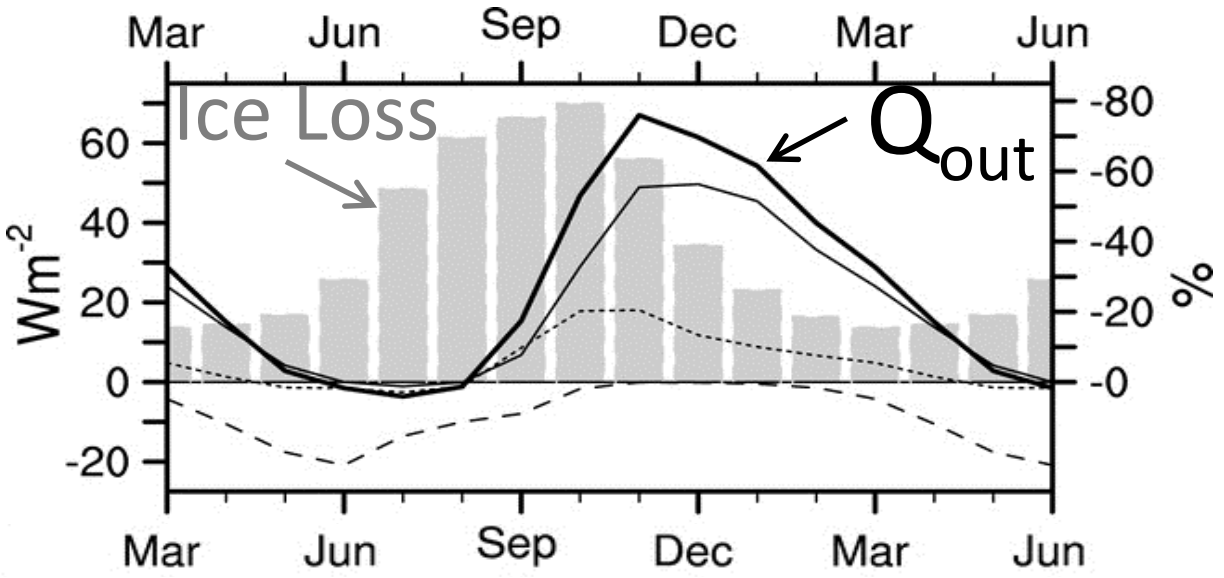


Response of surface energy exchange to GHG-induced Arctic sea ice loss



Coupled Climate Model Results

Response to late 21st century sea ice loss

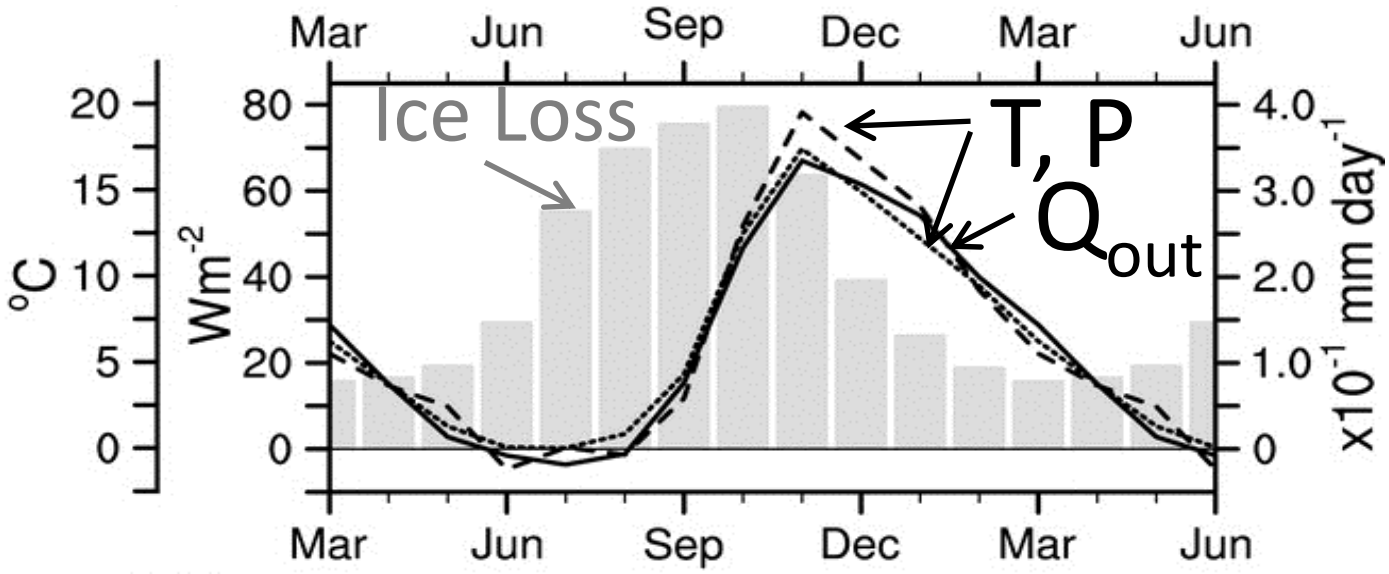


Delayed surface heat flux response

Deser et al., 2010 *J. Climate*

Coupled Climate Model Results

Response to late 21st century sea ice loss



Arctic T, P responses in phase with Q_{out}

Deser et al., 2010 *J. Climate*

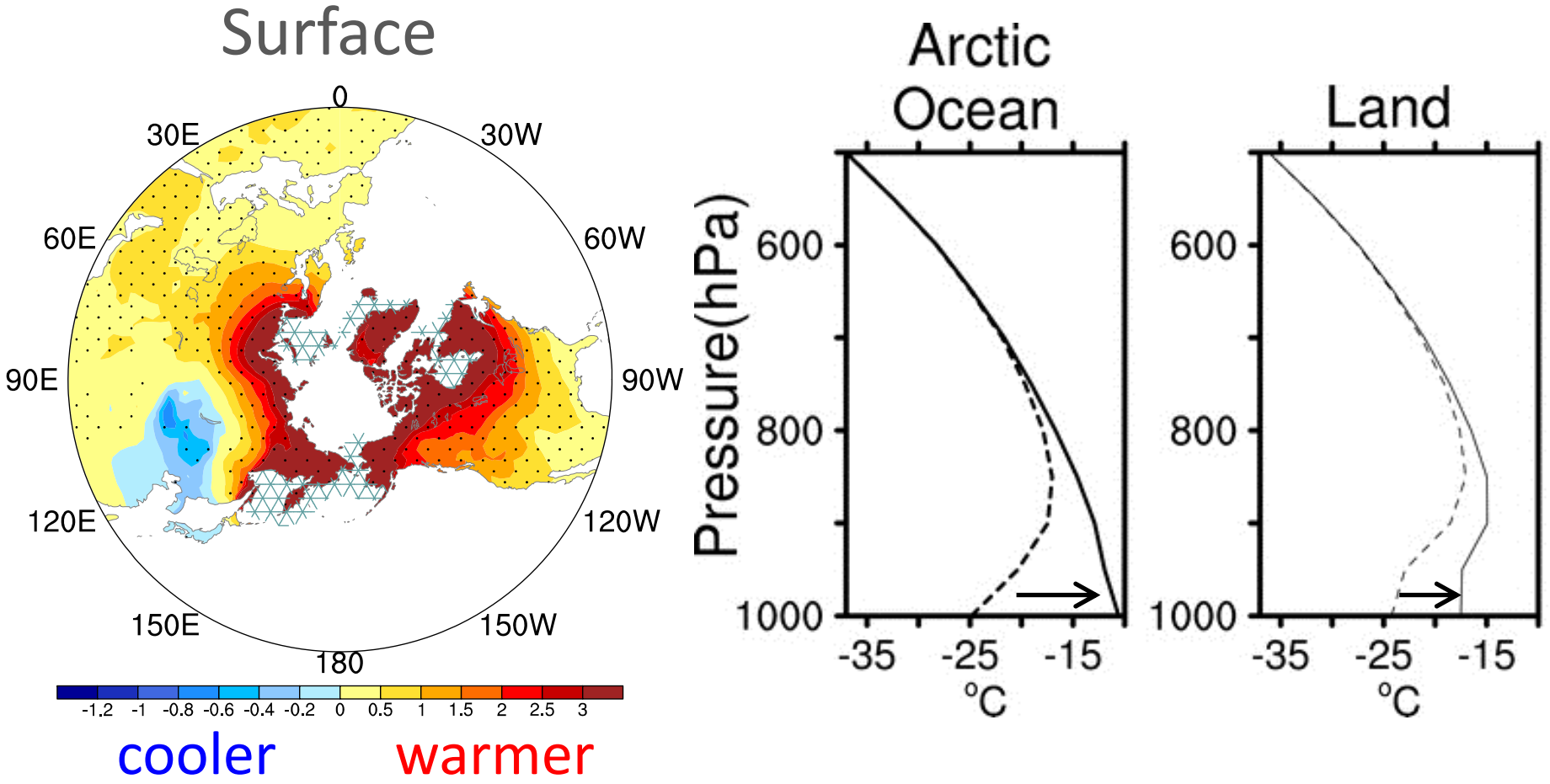
Terrestrial Impacts of Arctic Sea Ice Loss

Temperature

Precipitation

Circulation

Winter Air Temperature Response

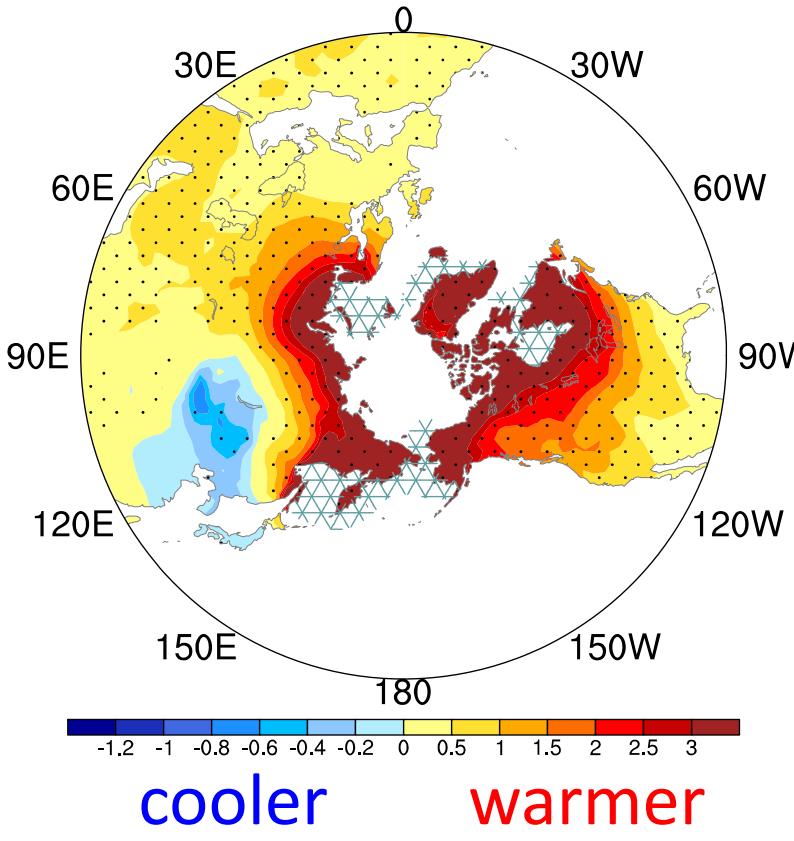


Poleward and surface amplified warming

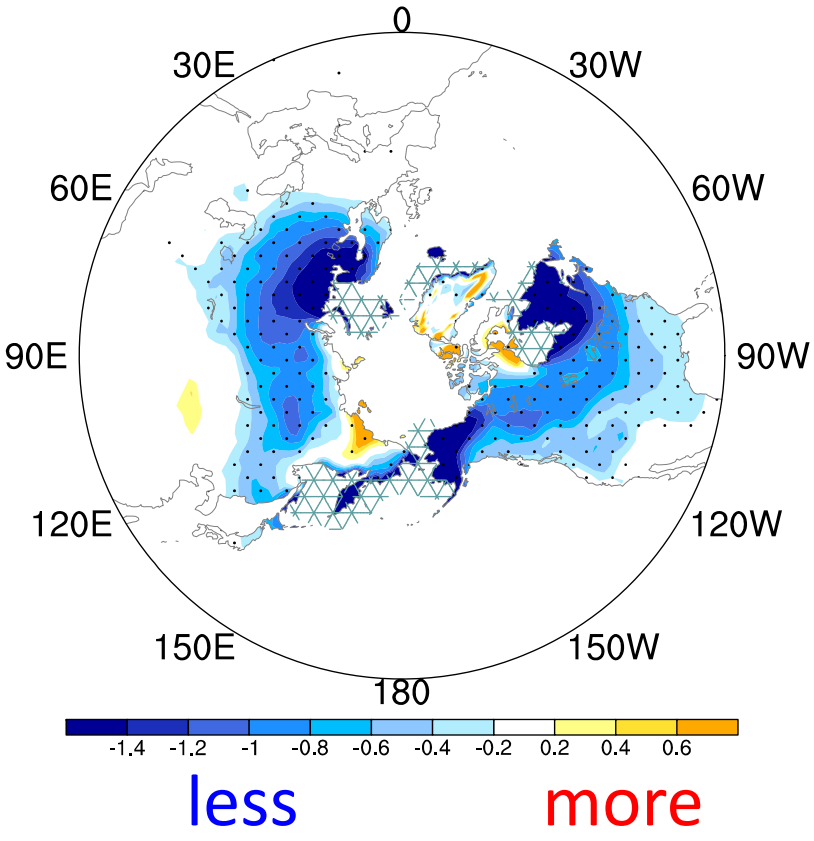
(Deser et al., 2010)

Winter Air Temperature Response

Mean



Daily variance

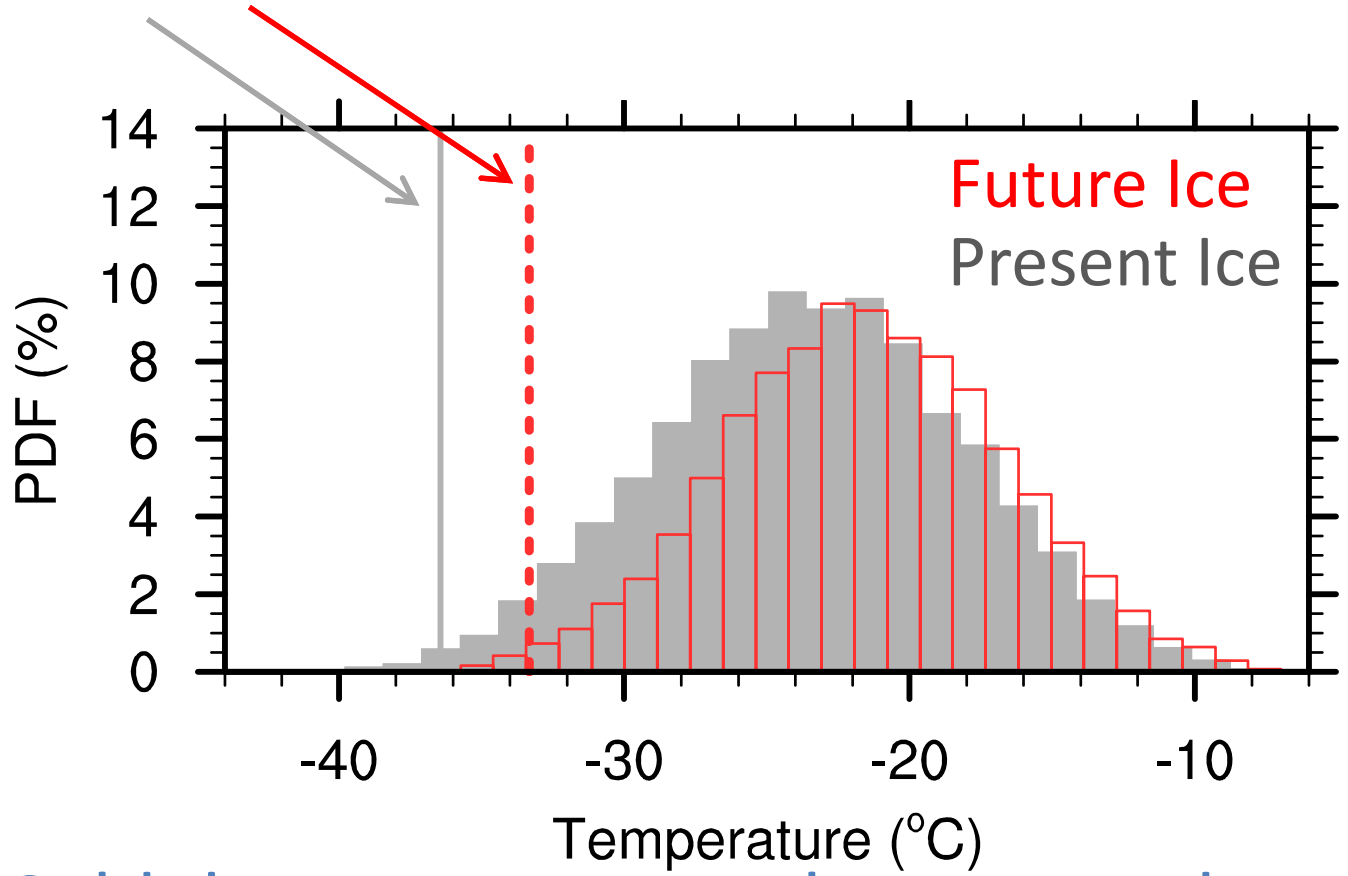


Less variability from day to day

Screen, Deser and Sun (submitted to BAMS)

Winter Air Temperature Response

Lowest 1% of days (cold extremes)



Cold days warm more than warm days

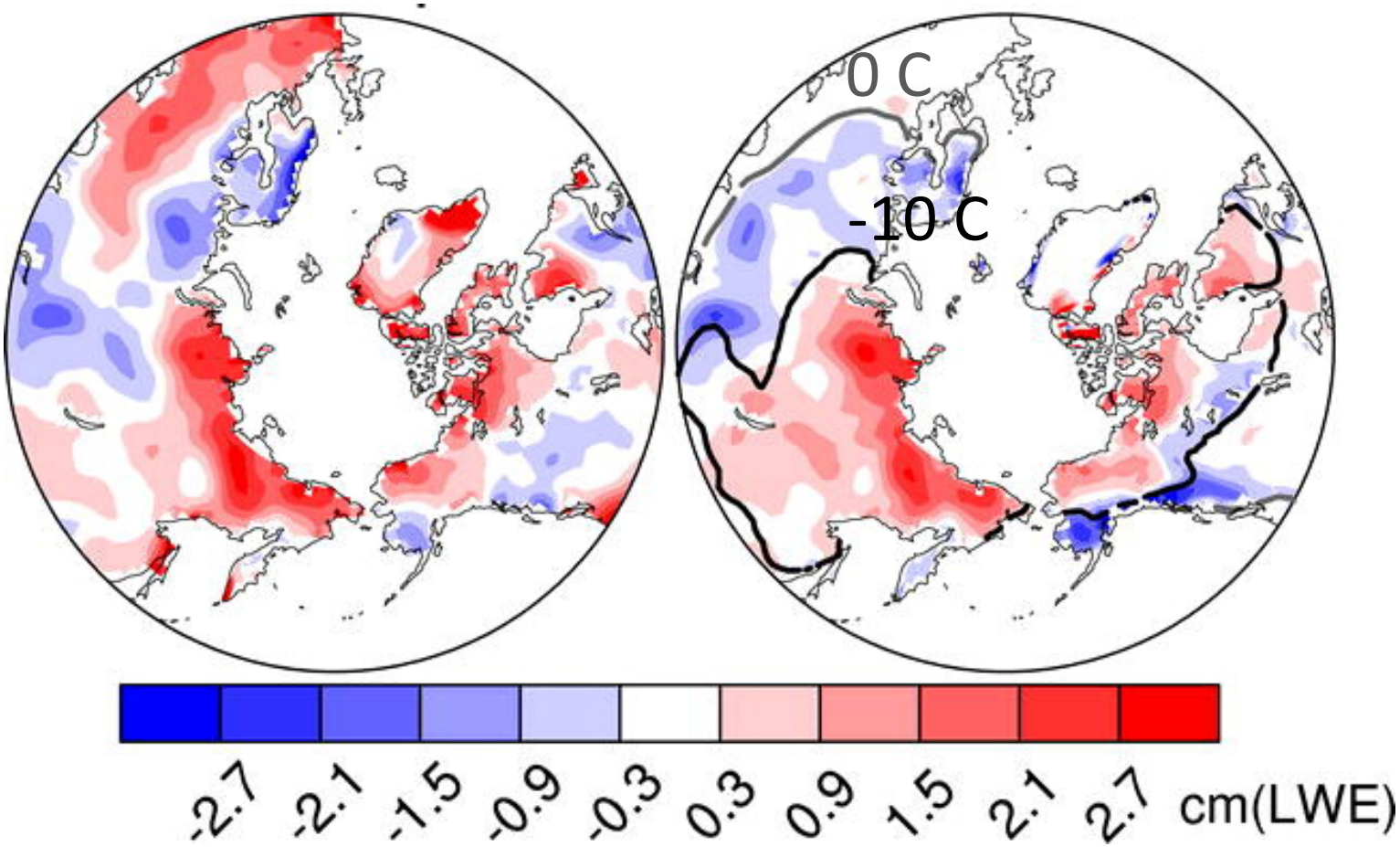
(reduced risk of cold extremes)

Screen, Deser and Sun (submitted to BAMS)

Winter Precipitation Response

Oct-Mar Accumulated Precip

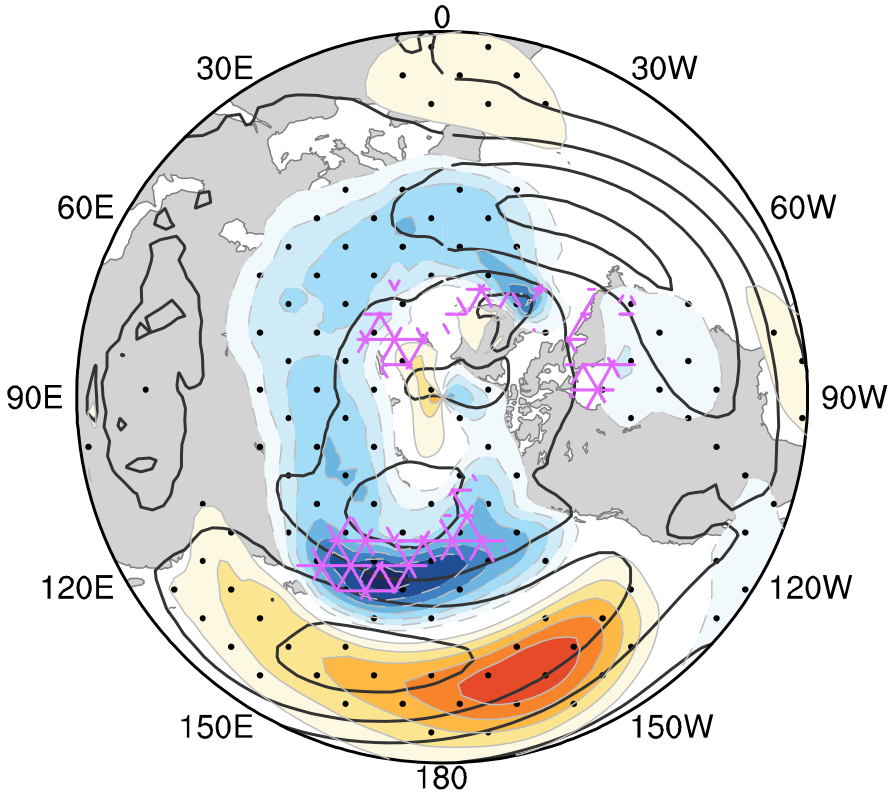
March Snow Depth



Deser et al., 2014 *J. Climate*

Winter Circulation Response

700 hPa



Zonal mean

100 hPa

1000 hPa

Zonal wind (positive = from the west)

Weakening and equatorward shift

Robust Impacts of Arctic Sea Ice Loss

- Near-surface warming north of ~ 30 N
- Increased Arctic precipitation
- Weakening/equatorward shift of the westerly winds (due to decreased ΔT)
- Decrease in variability

Uncertainties in the response to Arctic Sea Ice Loss

- Net surface heat flux: parameterizations, clouds, planetary boundary layer
- Circulation: strength relative to internal variability (Signal-to-noise)
  (e.g., Screen et al., 2013 *Climate Dynamics*)
- Stratosphere-tropospheric coupling, ocean-atmosphere feedbacks
  (e.g., Deser et al., 2014 *J. Climate*)