Decoding Hosing and Heating Roles in a Warming Climate

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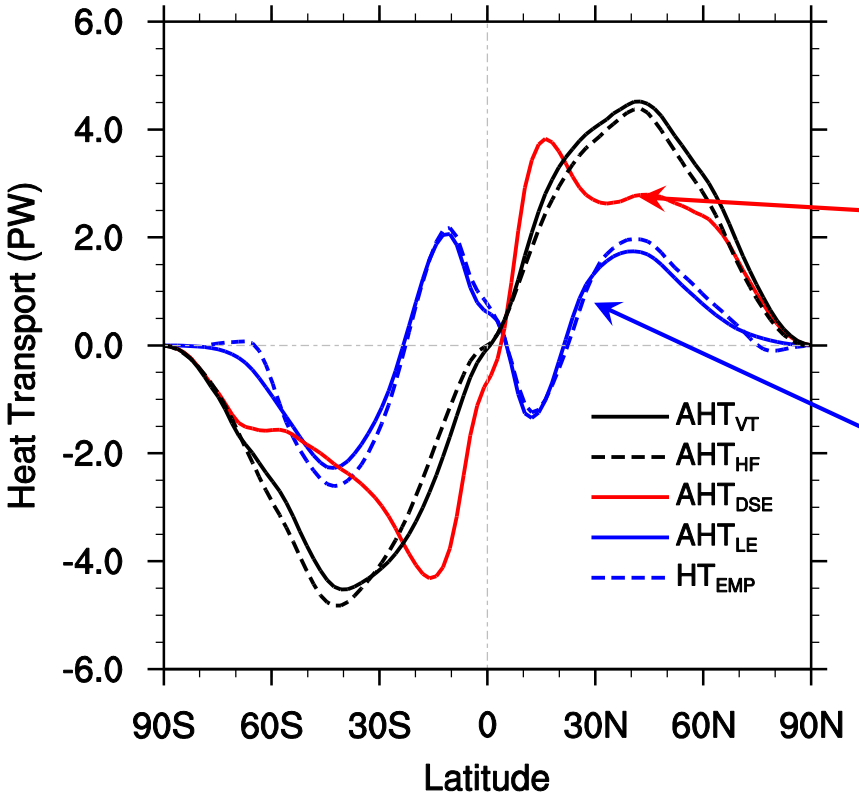
Atmosphere *Latent Heat* Transport

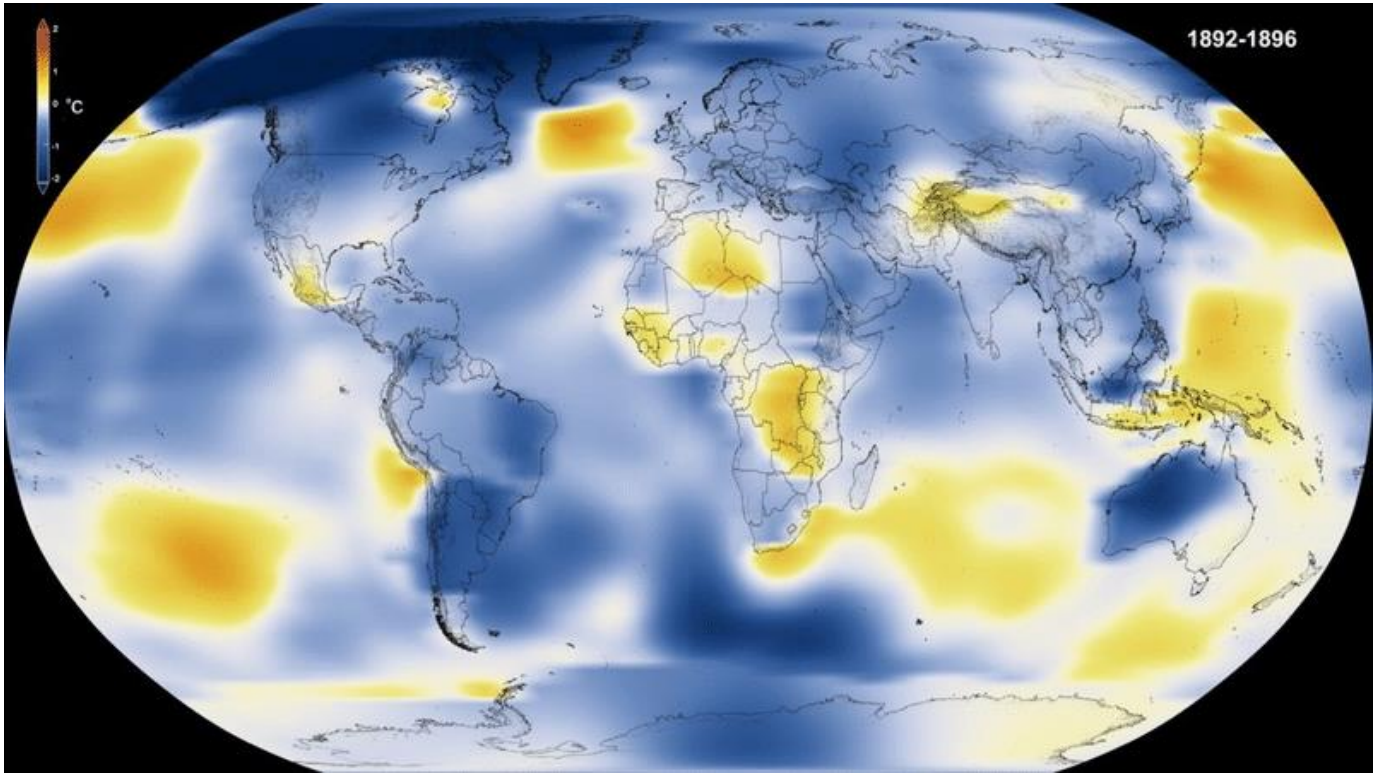


Dry Air

Latent Heat (water)

Yang et al. 2015: Decomposing the meridional heat transport in the climate system. *Climate Dynamics*.

A Warming Climate



NASA/GSFC/Scientific Visualization Studio
https://www.giss.nasa.gov/research/news/20170118/2016gistempupdateblack.gif

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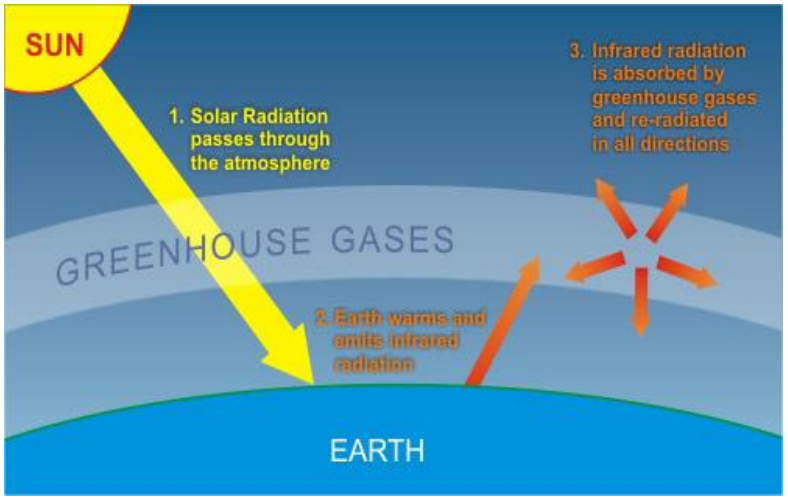
A Warming Climate

Resulted from

Heating



Hosing

Pictures from internet

Decoding Hosing and Heating Roles in a Warming Climate

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Water Role – A Fundamental

Lapse Rate

Dry Air: $\Gamma_d = g/c_p = 9.8$ °C/km

Wet Air: Γ_w = ... = 6-7 °C/km

30%

Latent Heat: Solid —334J/g→ Liquid —2260J/g→ Gas

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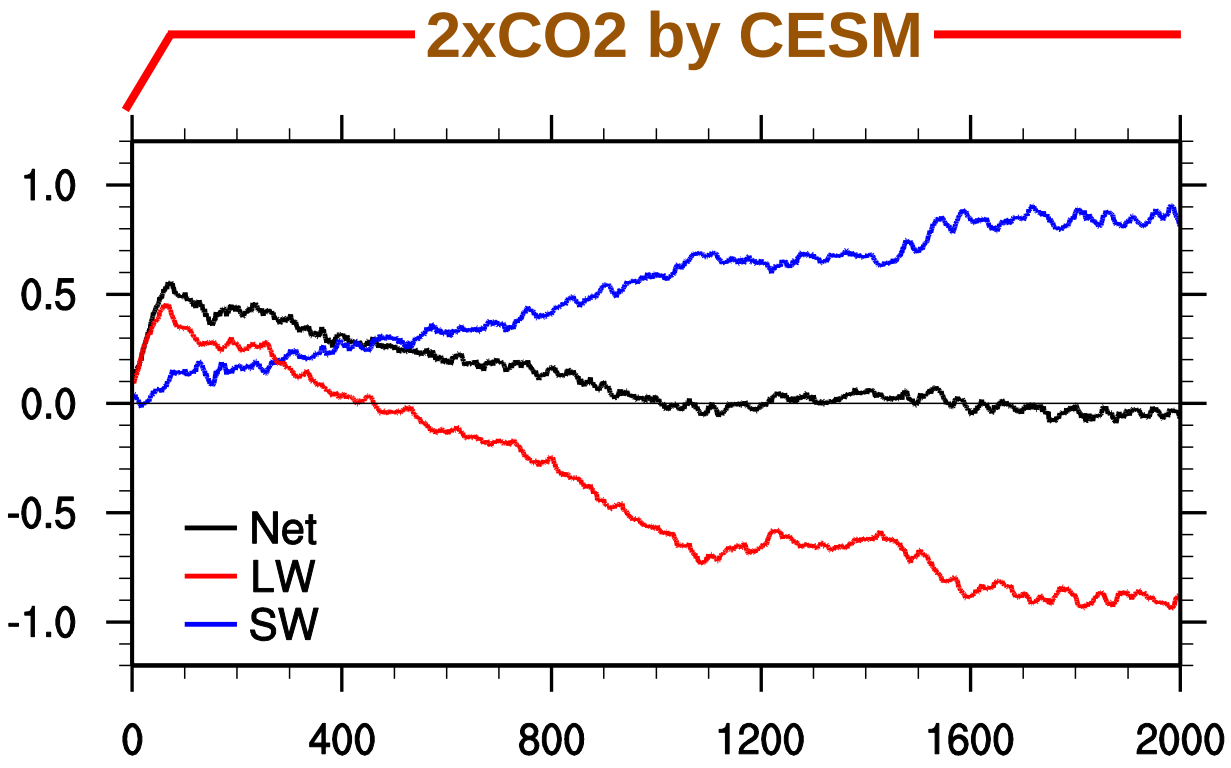
TOA Flux Change in a Warming Climate



NCAR CESM1.0 global warming experiments

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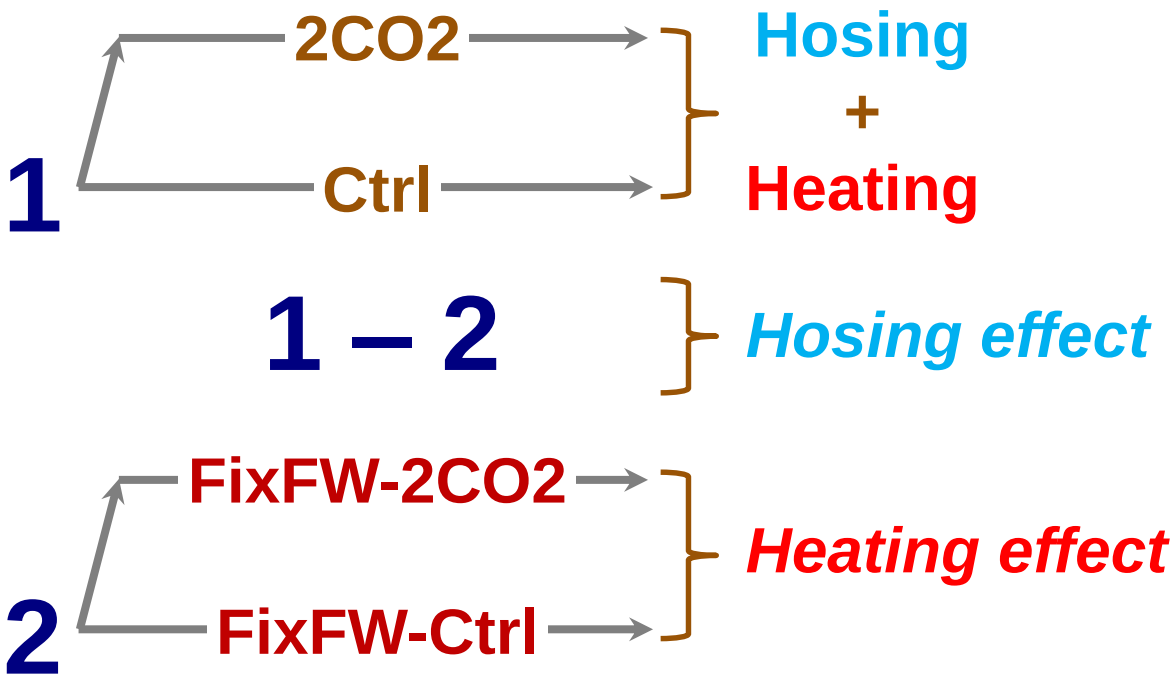
Separate *Hosing* and *Heating*



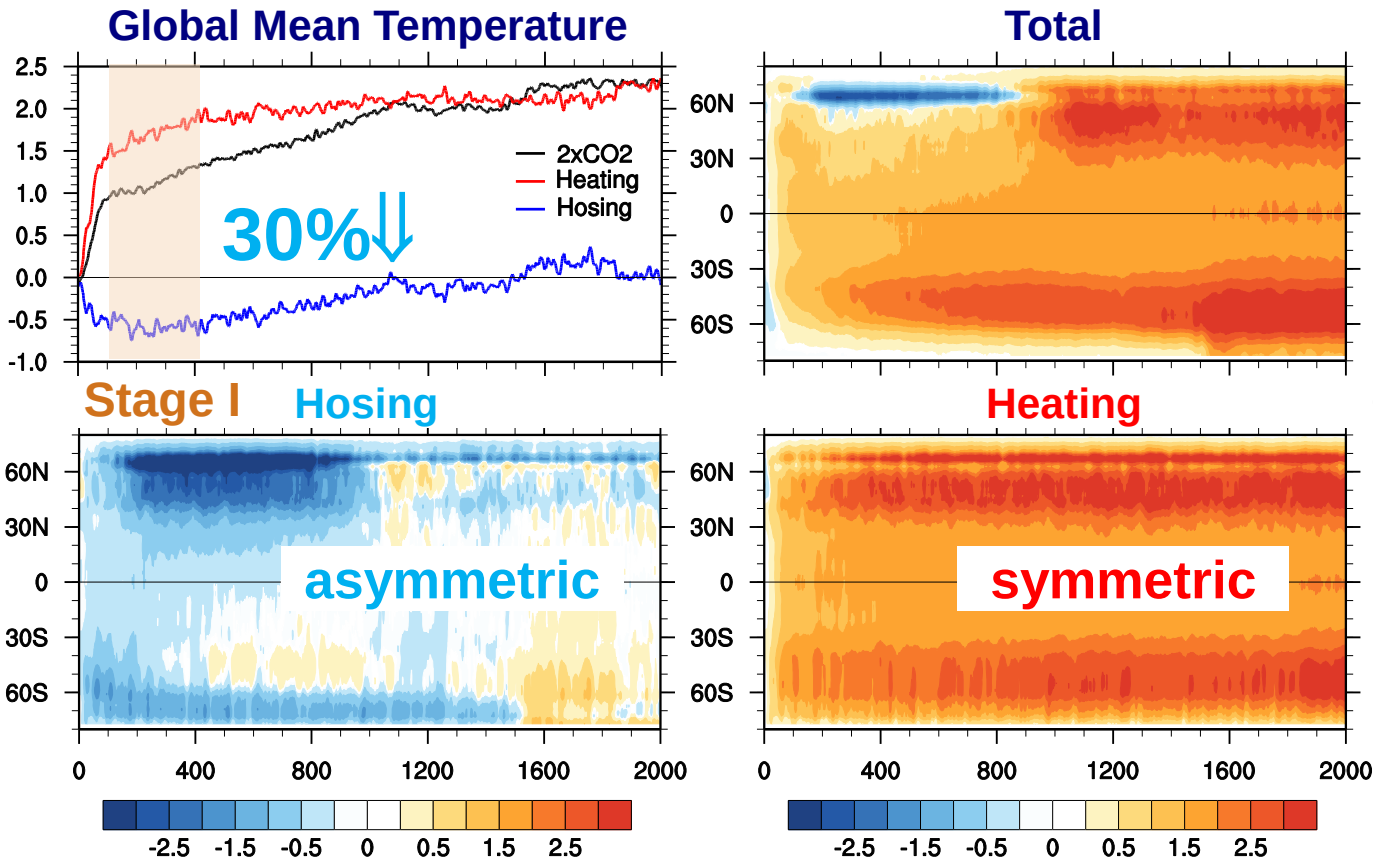
FixFW: fix net surface ocean flux

precipitation – evaporation

+ sea-ice melting

+ river runoff

Global *Temperature* Evolution



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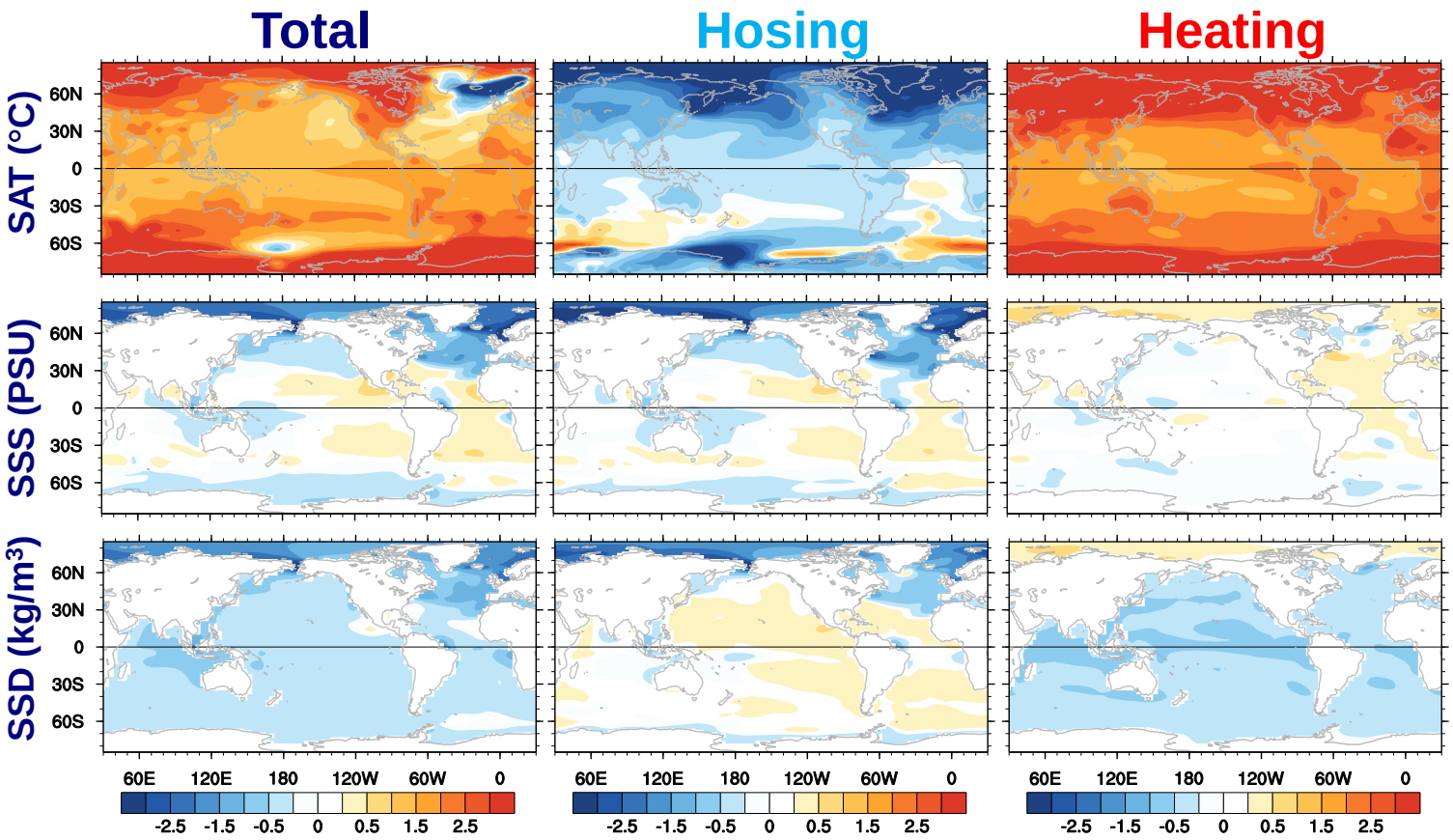
Stage I in Global Warming

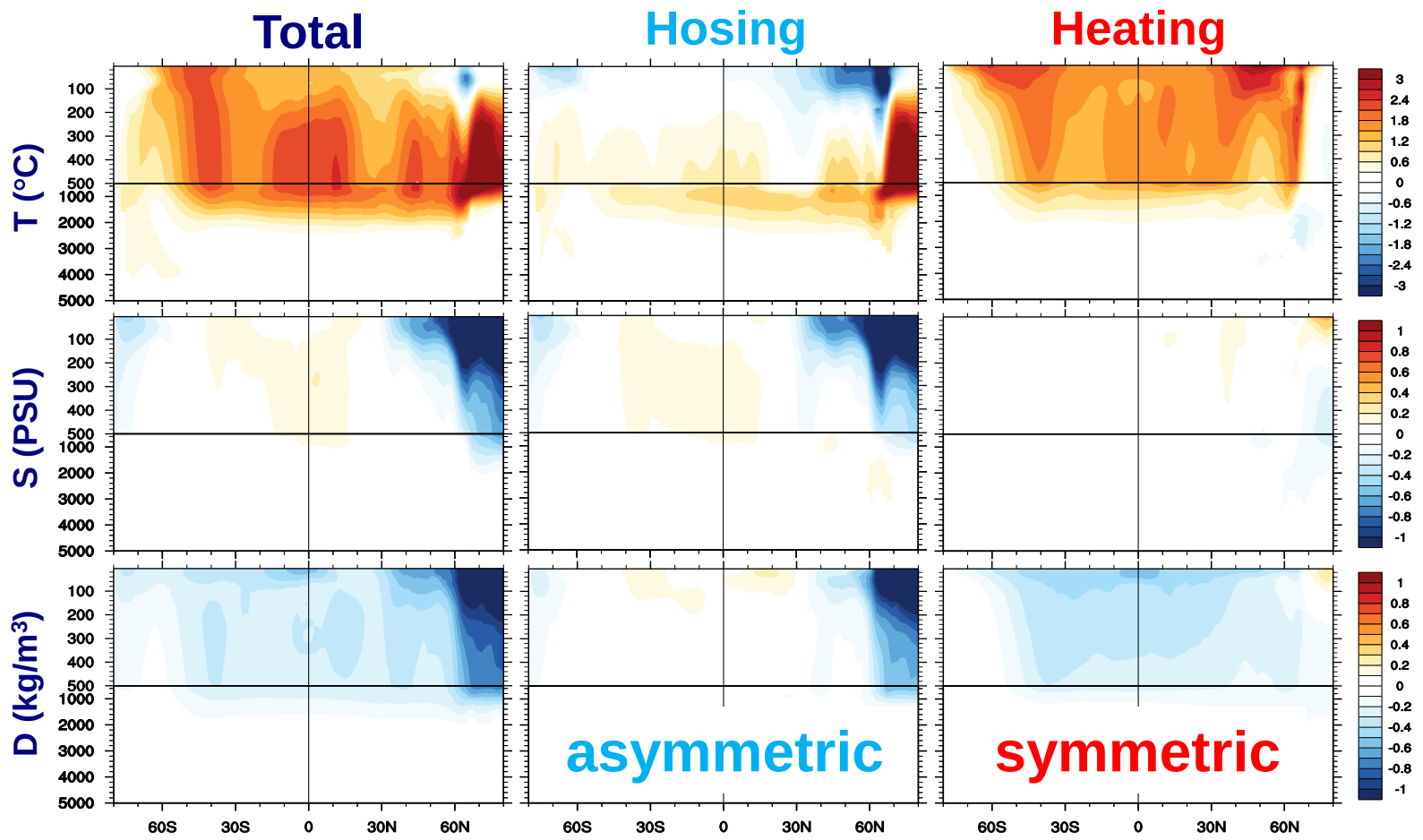
Most relevant to human beings

Surface Changes

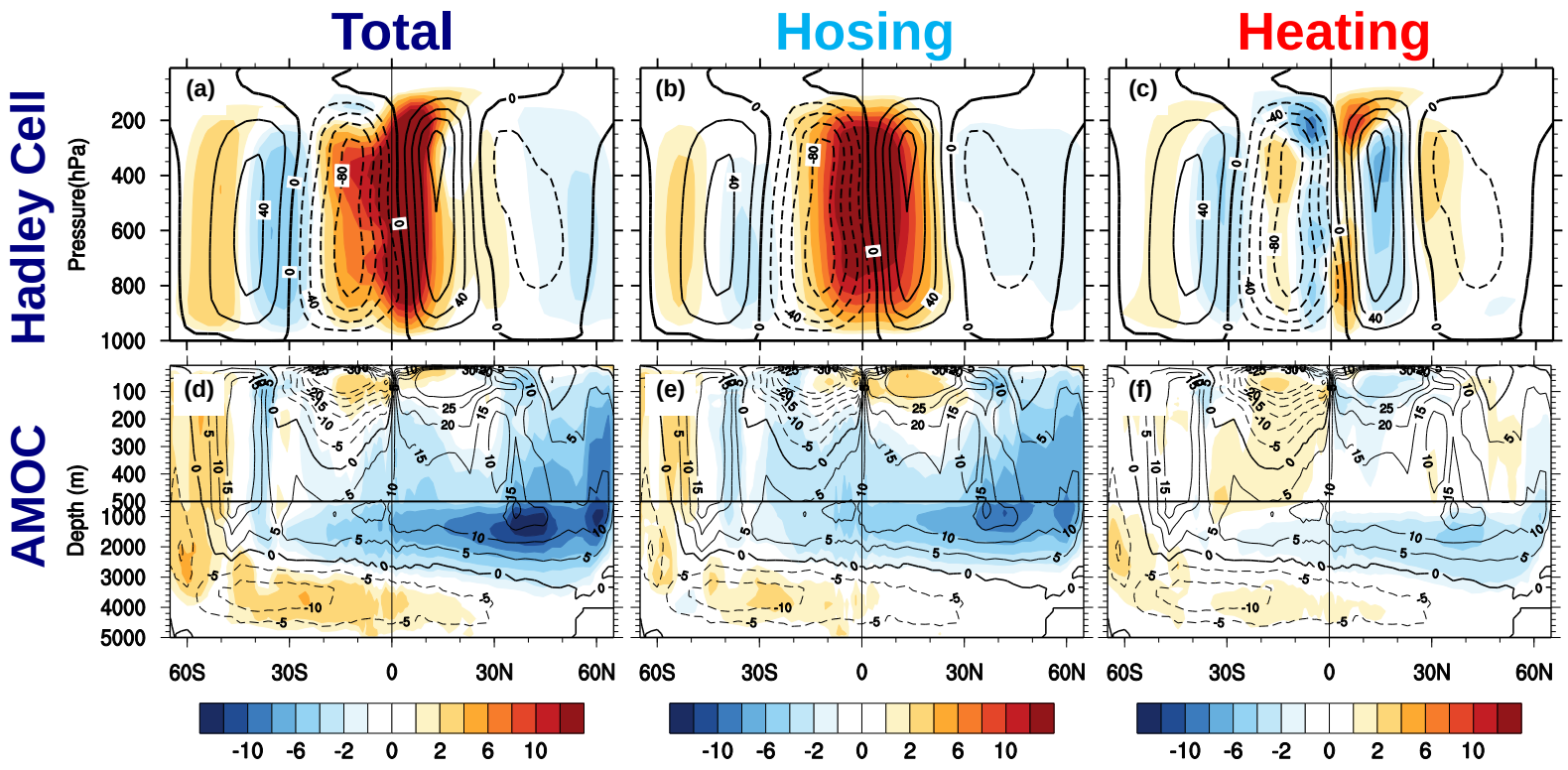


Freshwater results in cooling and freshening, asymmetric change

Ocean Changes



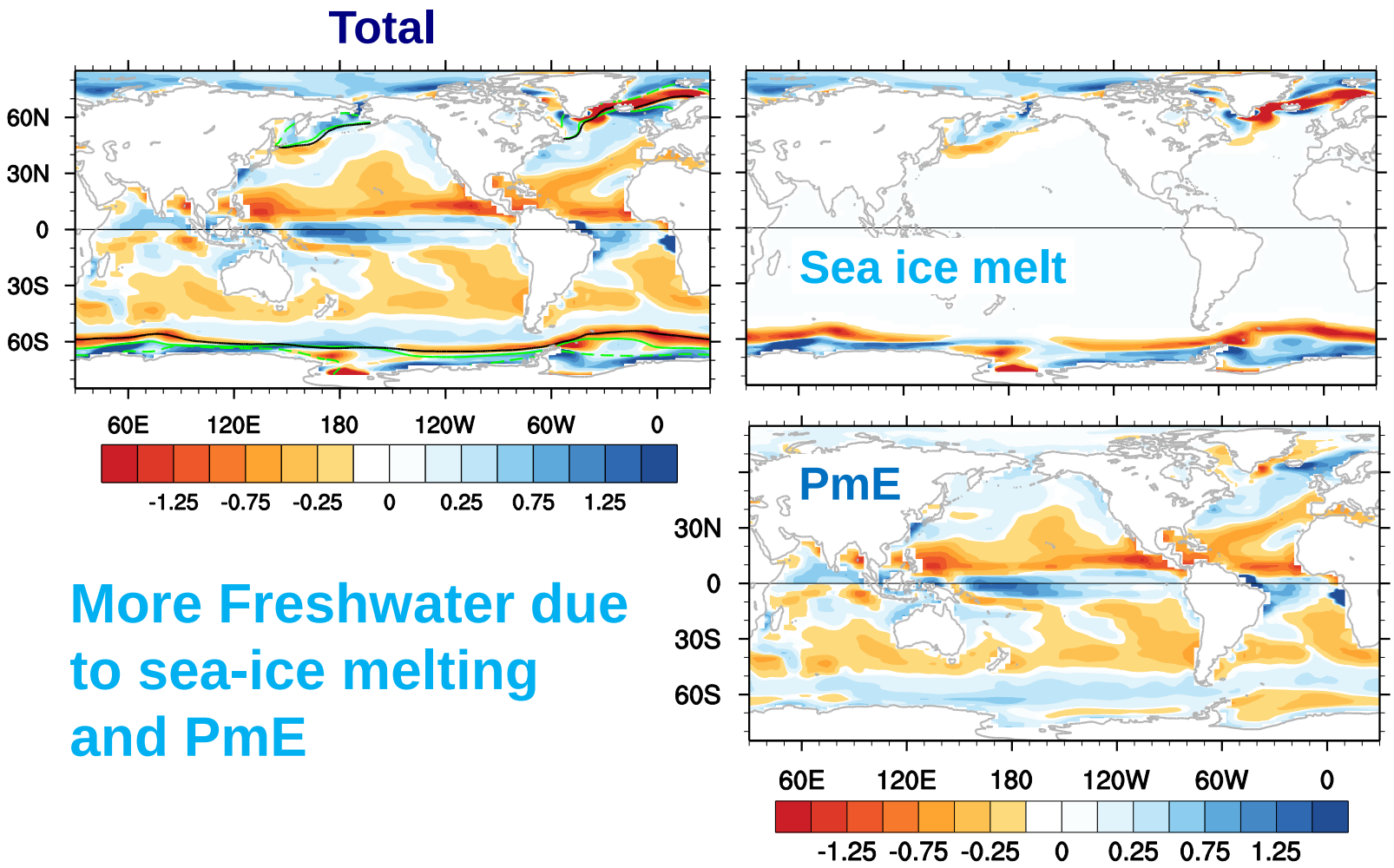
Atmosphere-Ocean *MOCs*



Hosing: HC and AMOC changes;

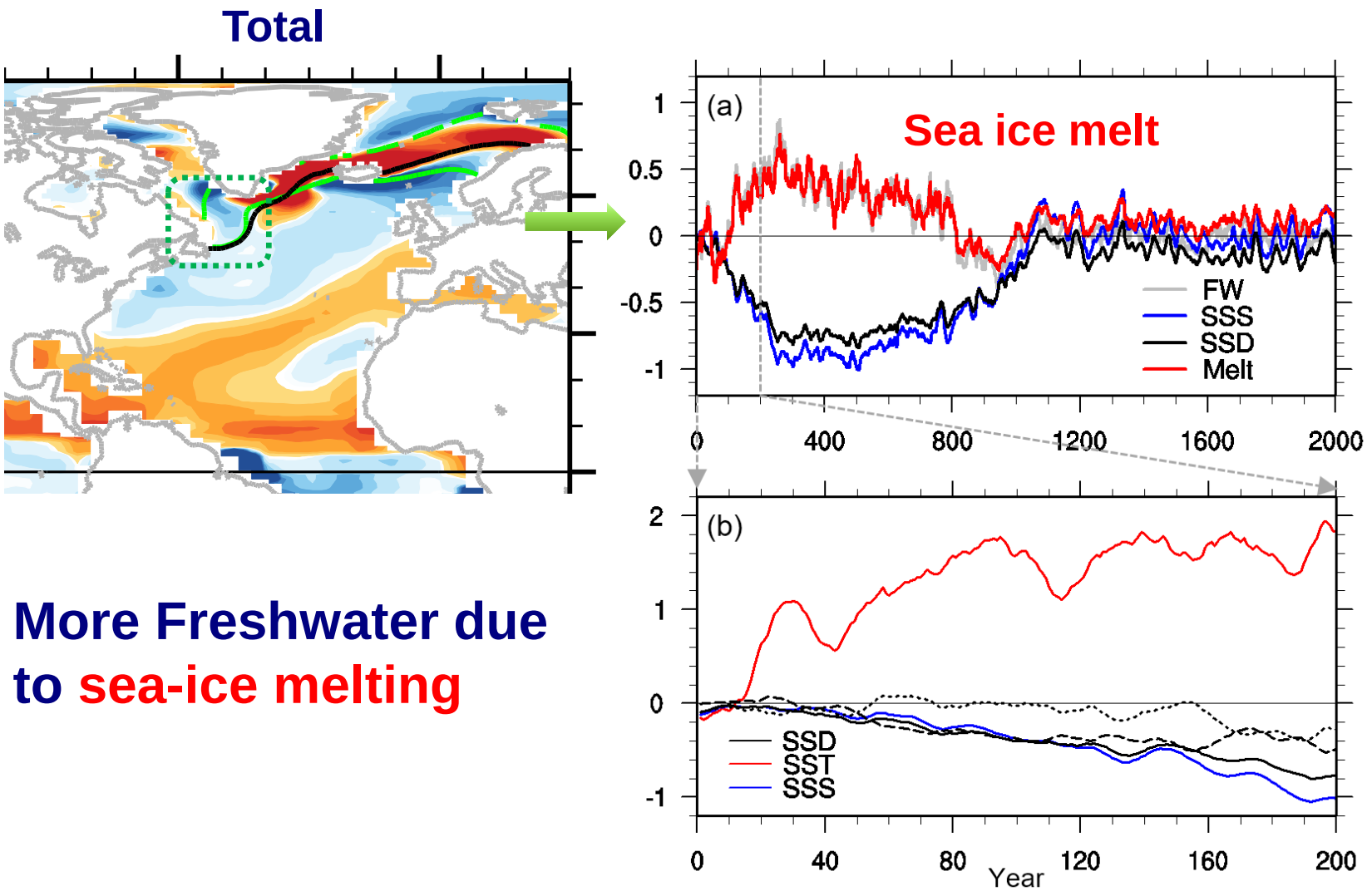
Heating: nearly unchanged

Global *Freshwater* Change



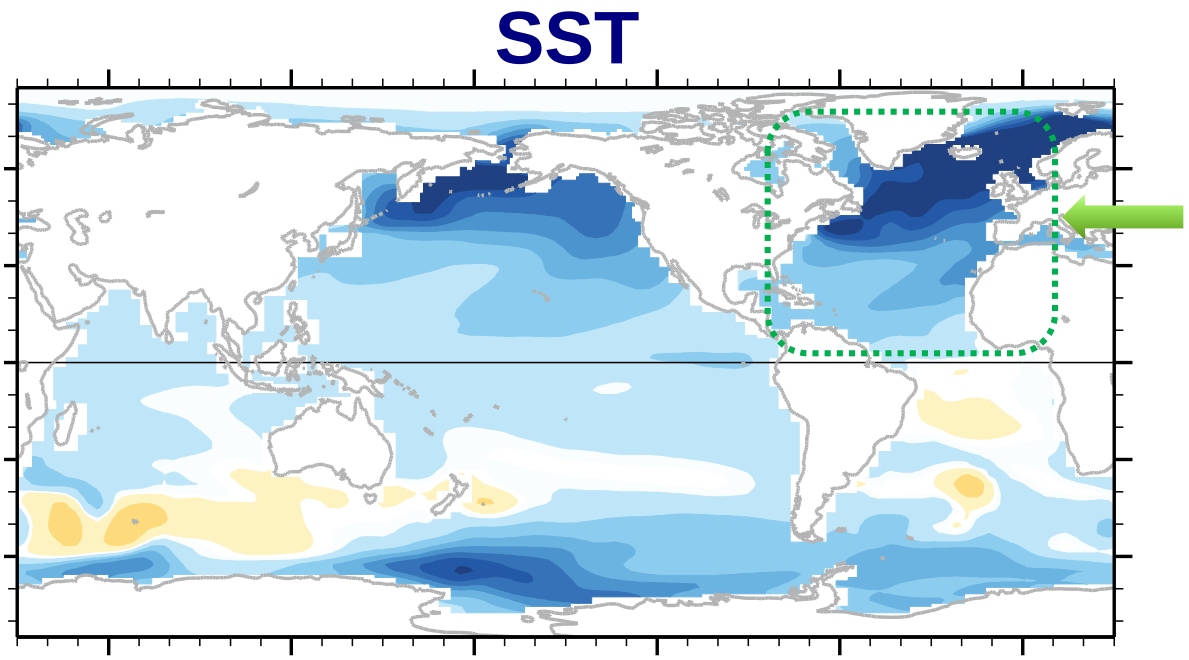
More Freshwater due to sea-ice melting and PmE

Freshwater Change in N. Atlantic



More Freshwater due to sea-ice melting

Mechanism of Hosing Cooling



- Freshwater ⇑
  - ➔ SSS ⇓
  - ➔ AMOC ⇓
- Cold water advection from Arctic ⇑

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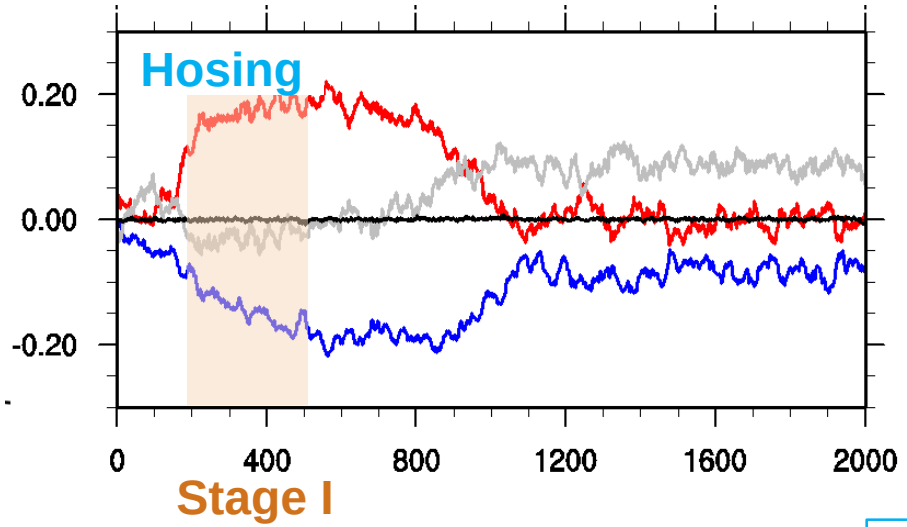
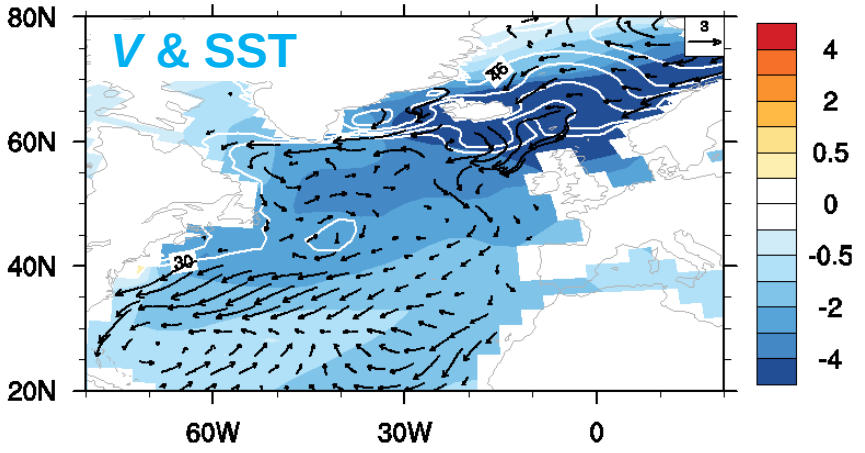
Mechanism of Hosing Cooling

North Atlantic





Cold water advection from Arctic ⇑

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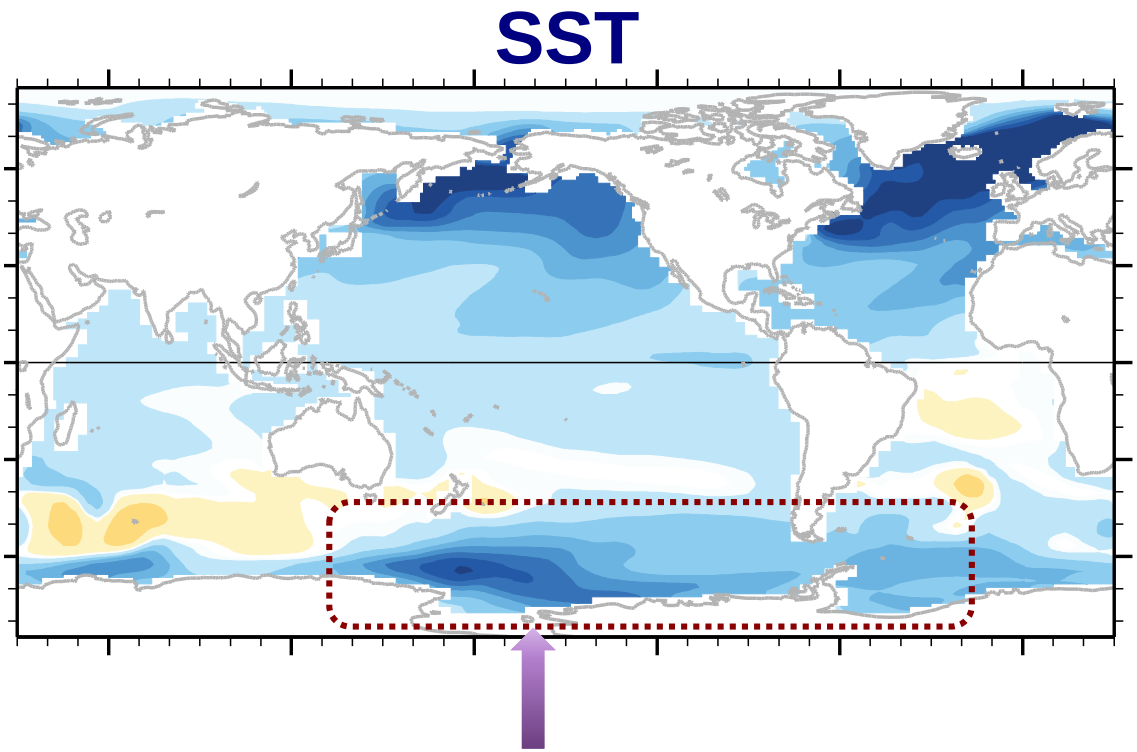
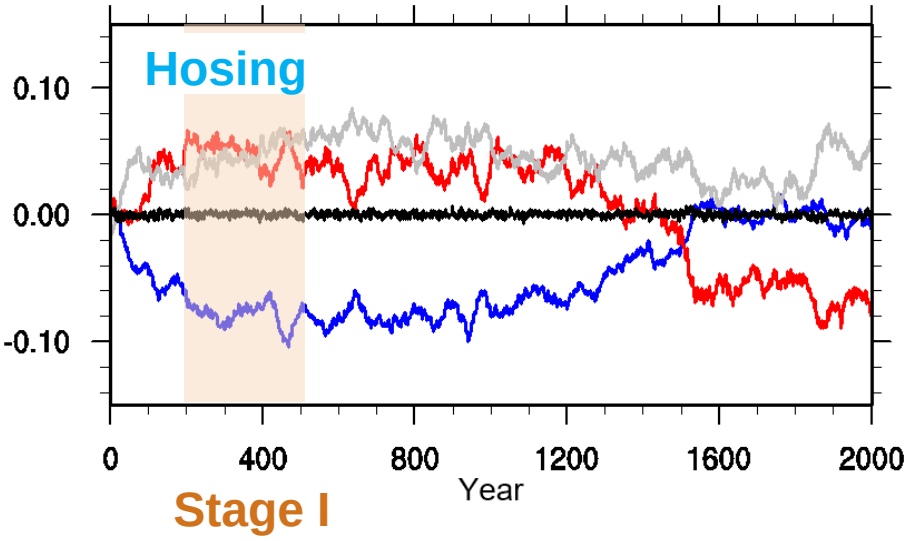
Mechanism of Hosing Cooling

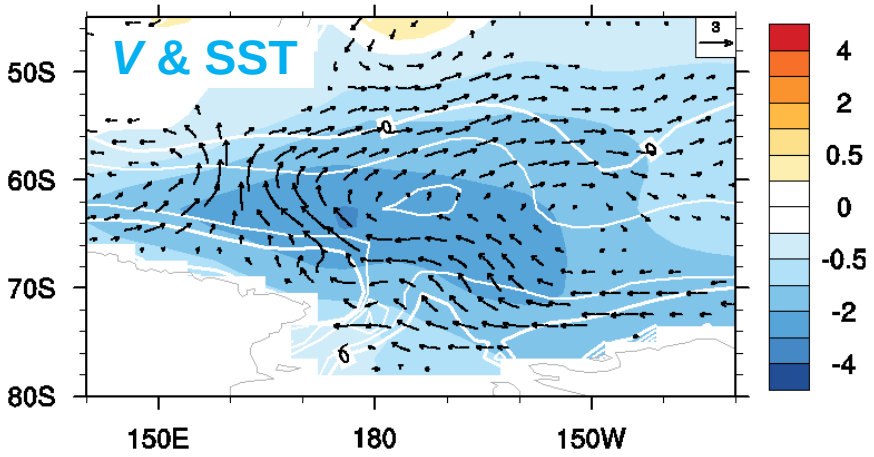


- Sea-ice melting ⇑ ➔ Northward Ekman flow ⇑ ➔ Ekman pumping ⇑

Mechanism of Hosing Cooling

Southern Ocean

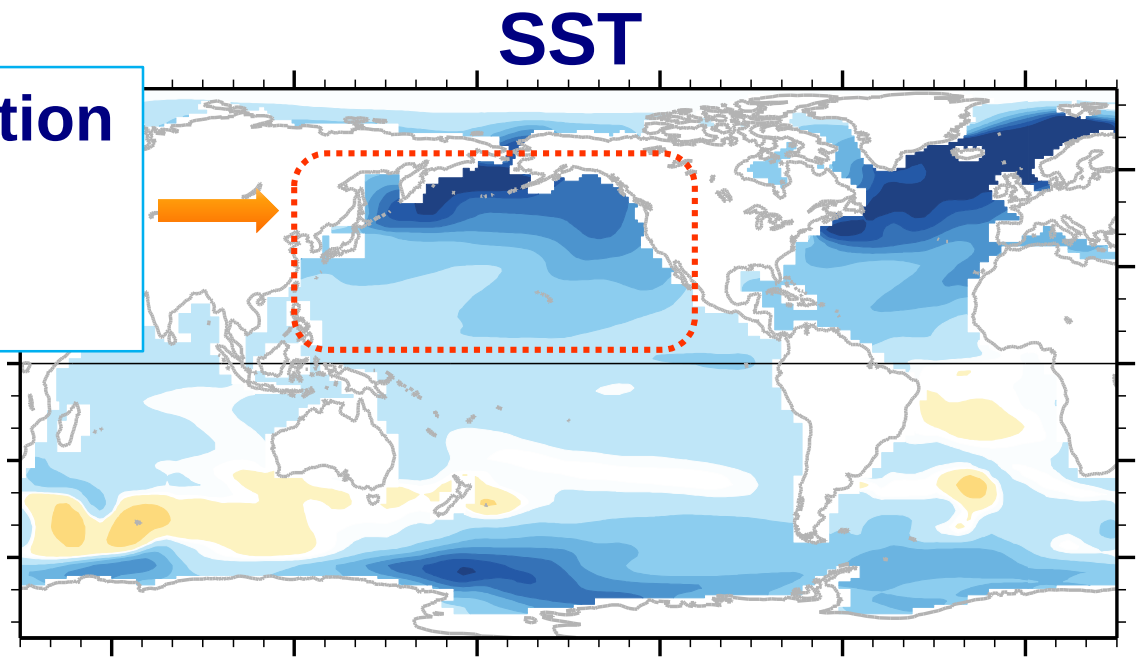




Sea-ice melting ⇑ ➔ Northward Ekman flow ⇑ ➔ Ekman pumping ⇑

Mechanism of Hosing Cooling

- Cold FW advection from Arctic ⇑
- SAT ⇓



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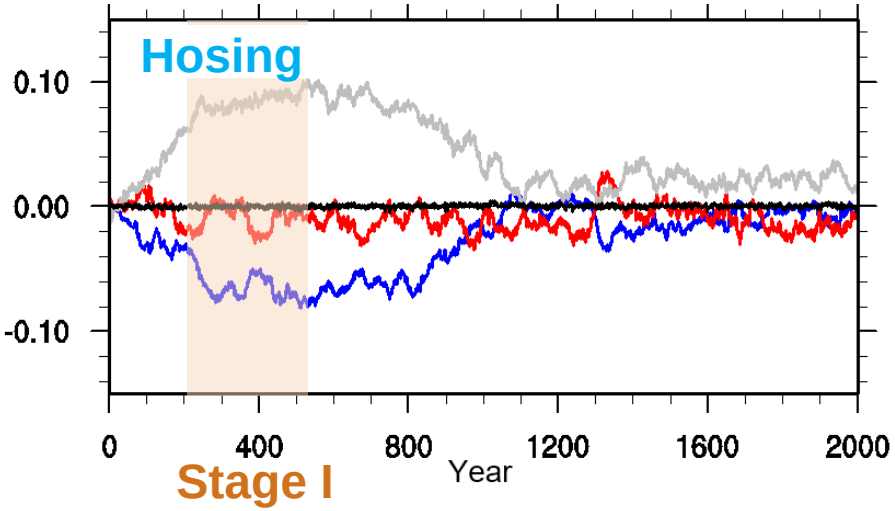
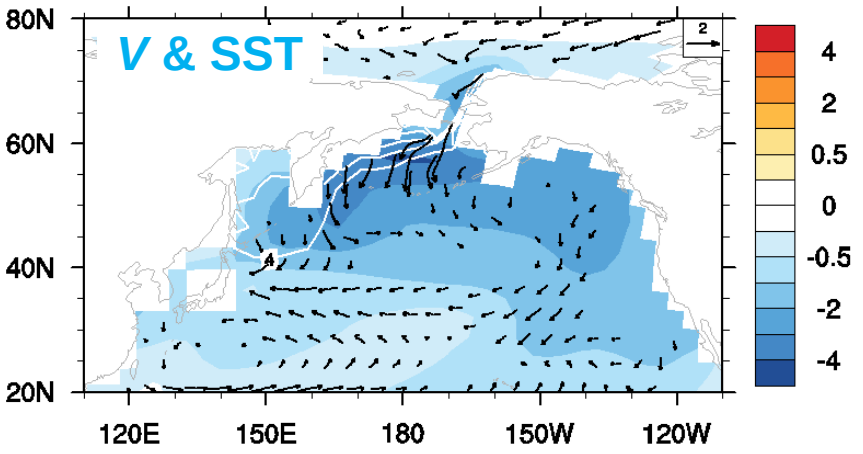
Mechanism of Hosing Cooling

North Pacific



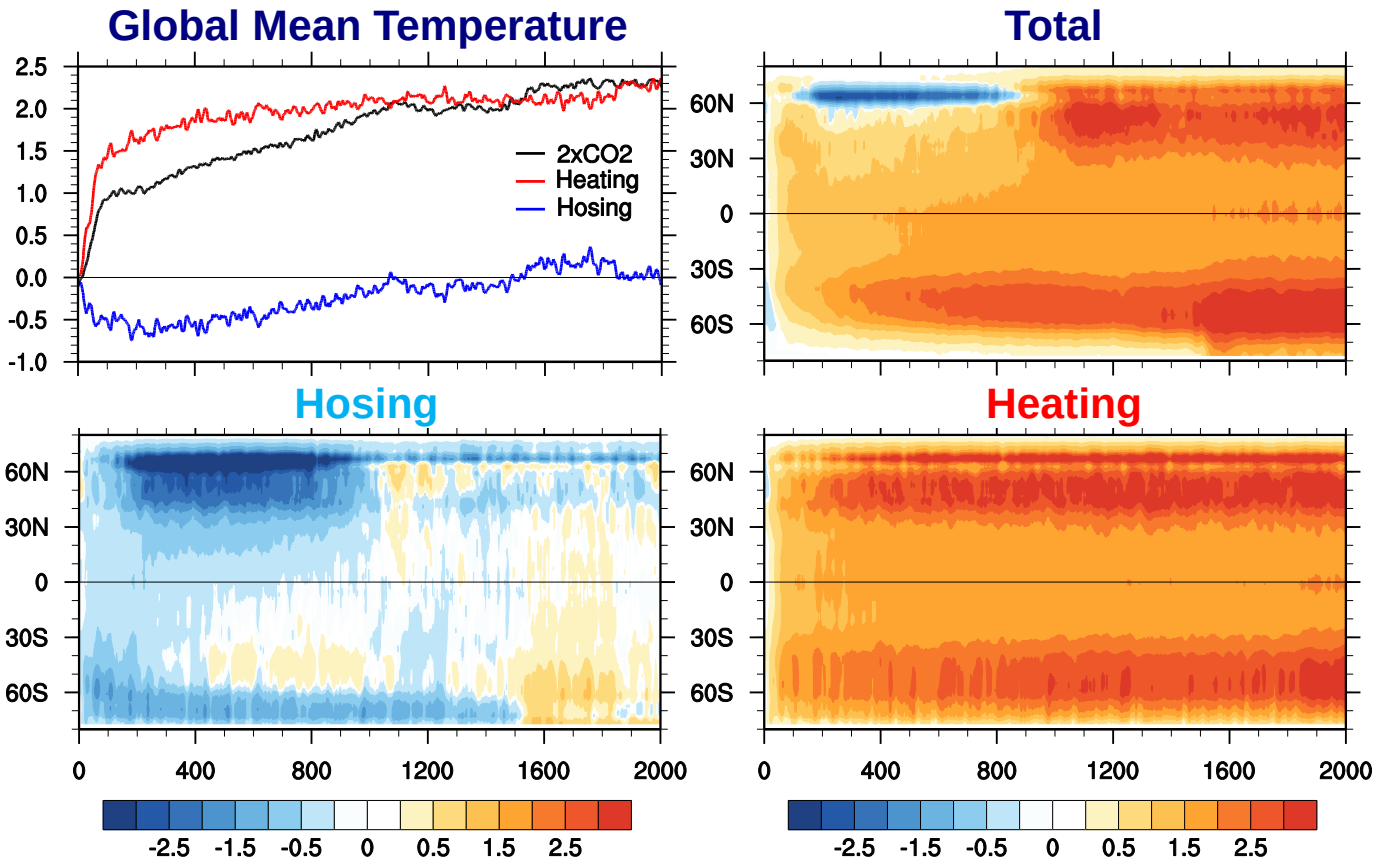


Cold FW advection from Arctic ⇑

Later stages in Global Warming …

Go to summary

Global *Temperature* Evolution



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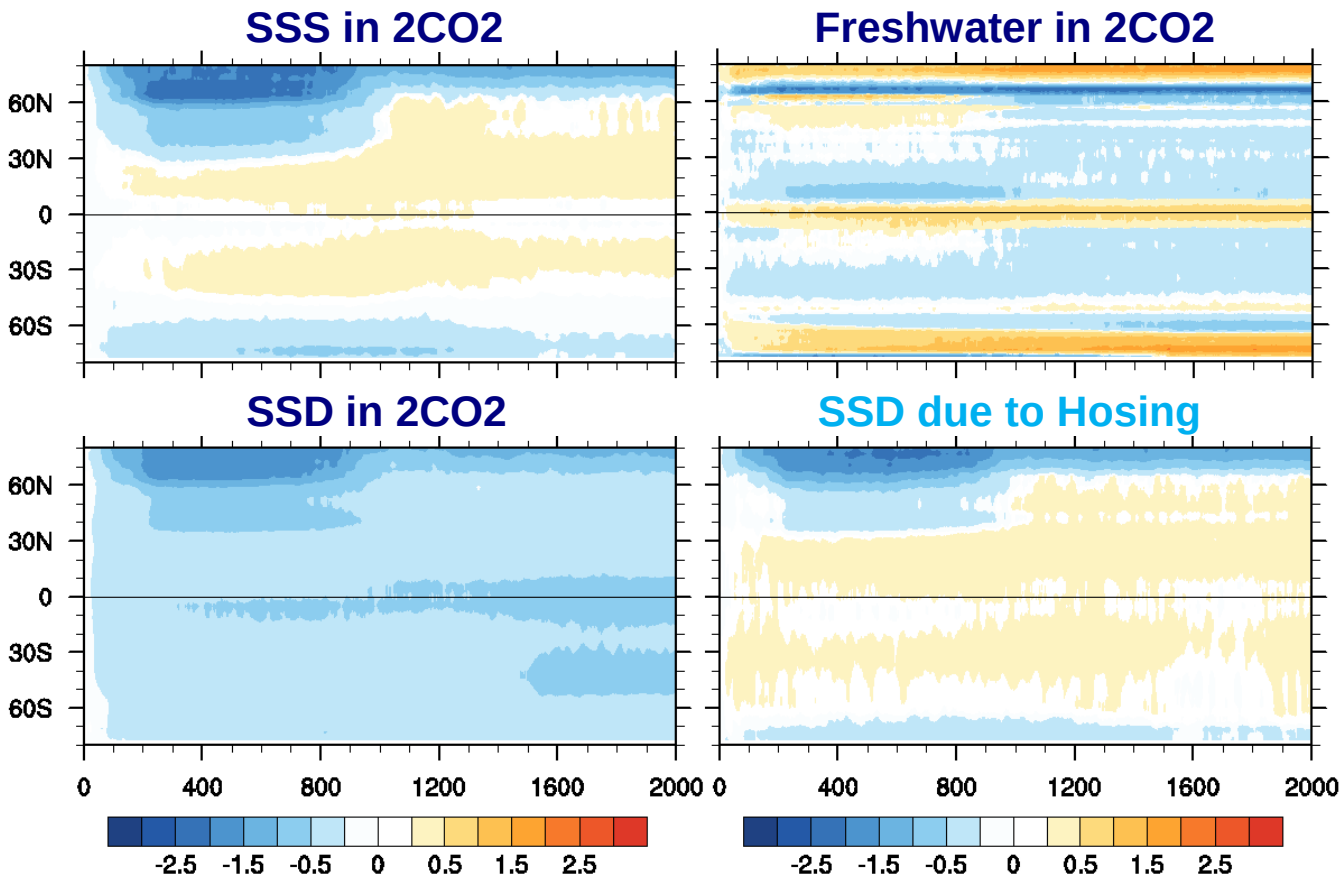
Evolution of *SSS, Freshwater, SSD*



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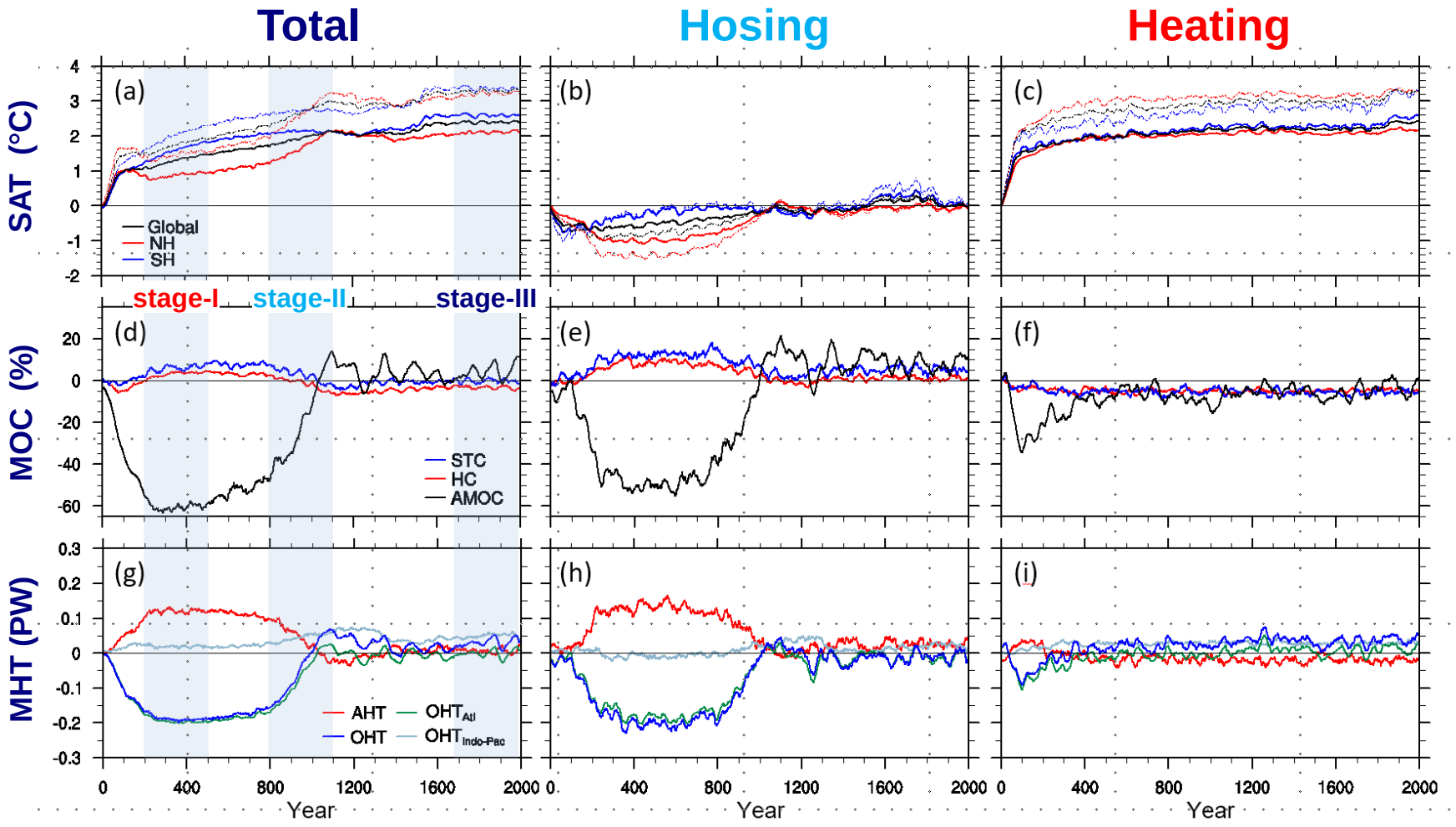
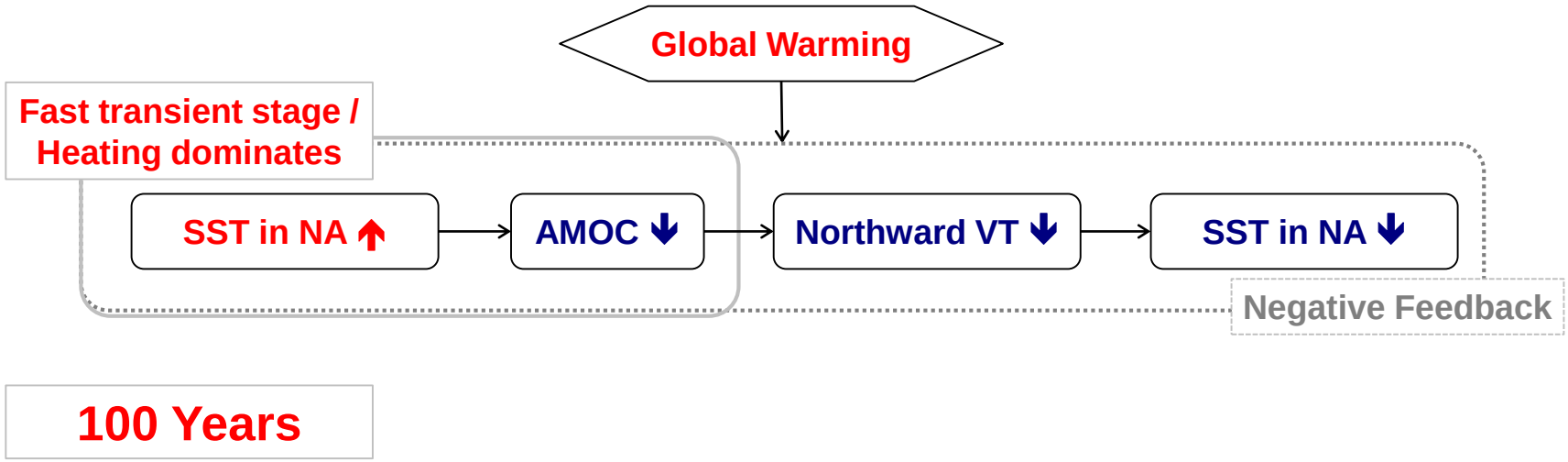
Evolution of *MOCs* and *MHTs*



Summary



100 Years

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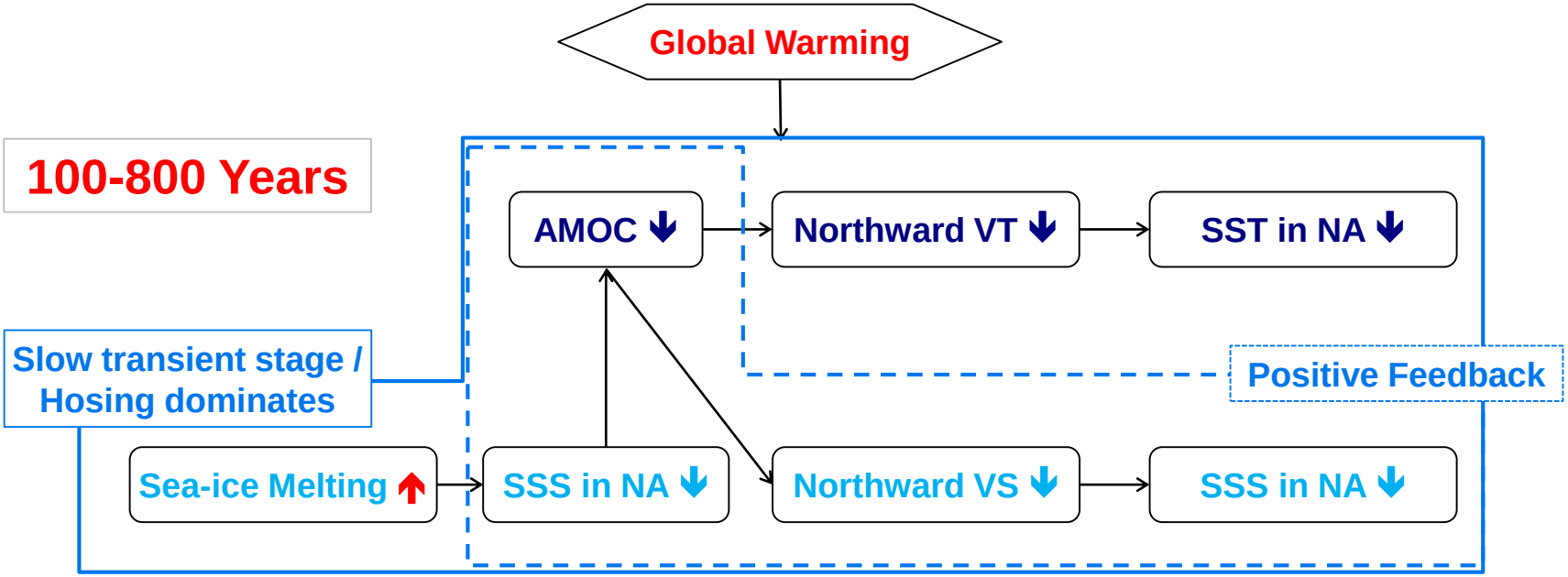
Summary



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Summary and Discussion

- Hosing: 30% cooling
  - Asymmetric changes
  - Arctic sea ice melting
  - AMOC ⇓ and HC ⇑
  - Baroclinic change in ocean T
- Heating: symmetric
  - Barotropic change in ocean T
  - Into the deep ocean
- More studies on different stages

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Thanks

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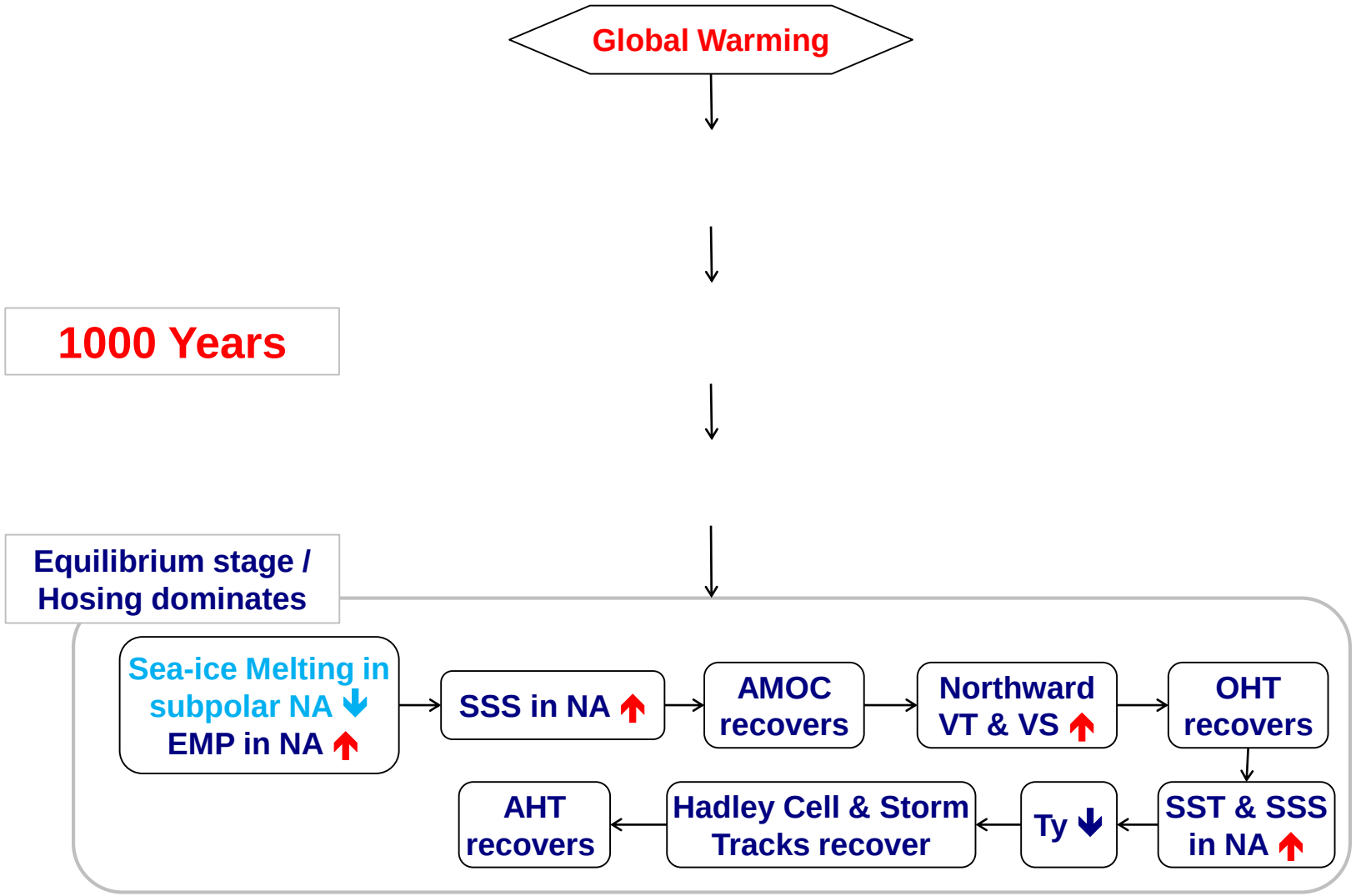
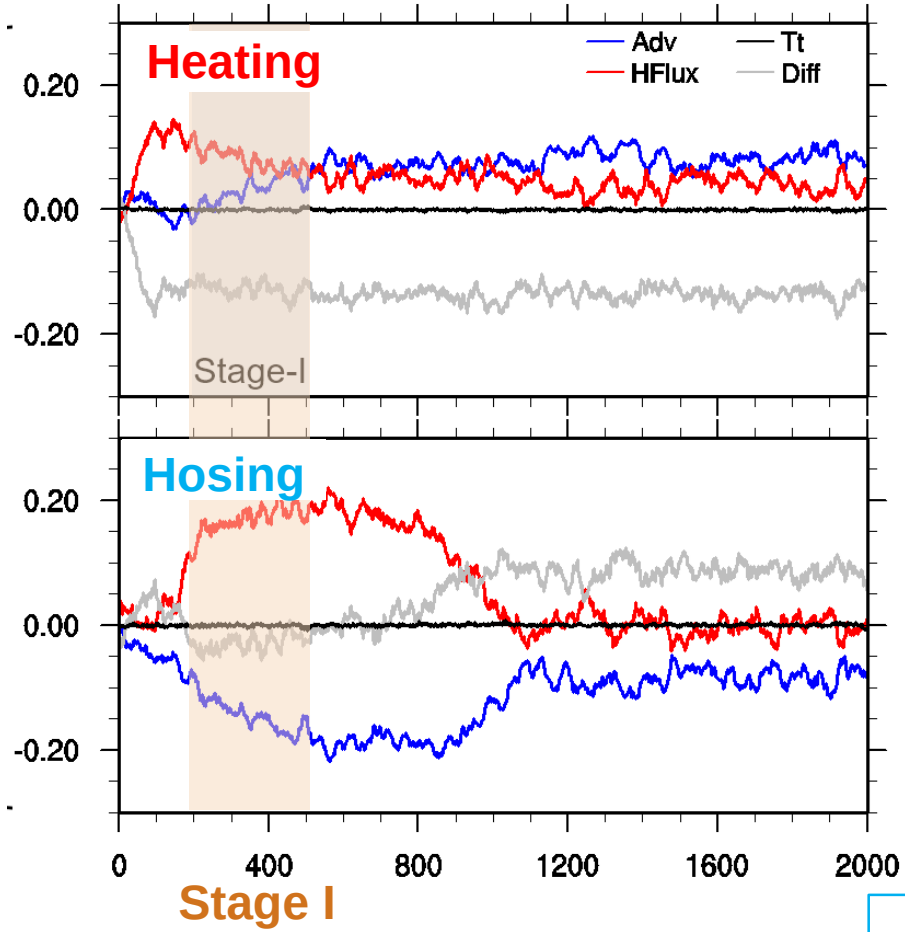
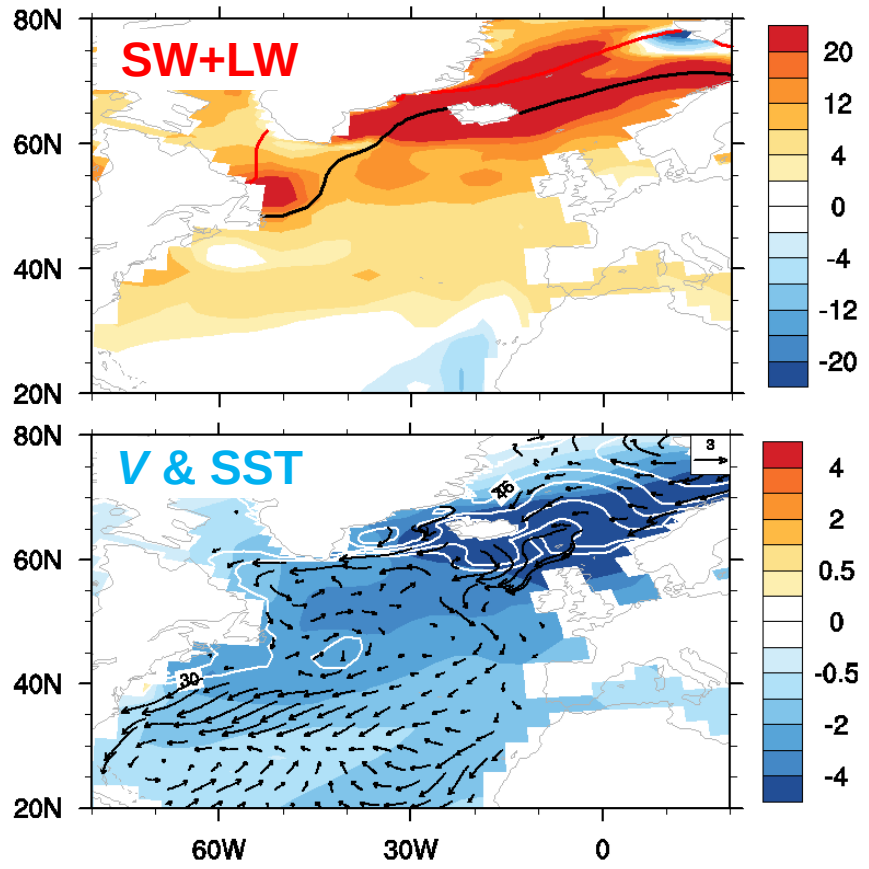
Summary


Global Warming
1000 Years
Equilibrium stage / Hosing dominates
Sea-ice Melting in subpolar NA ↓
EMP in NA ↑
SSS in NA ↑
AMOC recovers
Northward VT & VS ↑
OHT recovers
SST & SSS in NA ↑
Ty ↓
Hadley Cell & Storm Tracks recover
AHT recovers

Mechanism of Hosing Cooling

North Atlantic

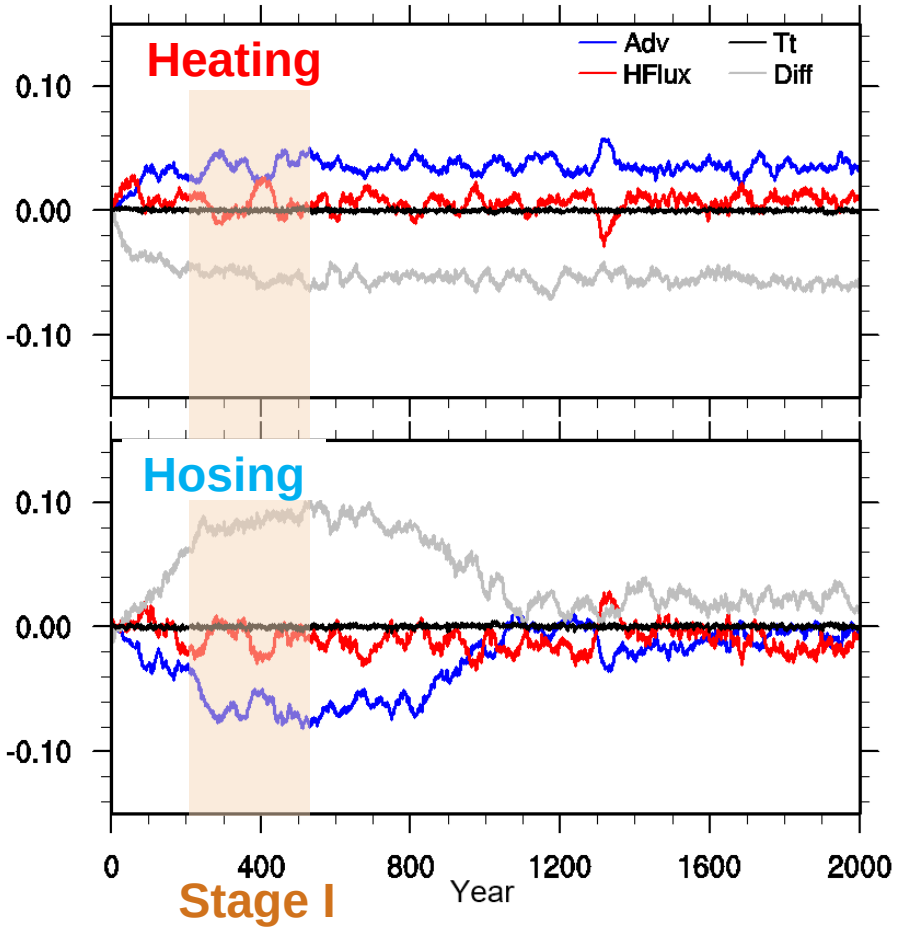


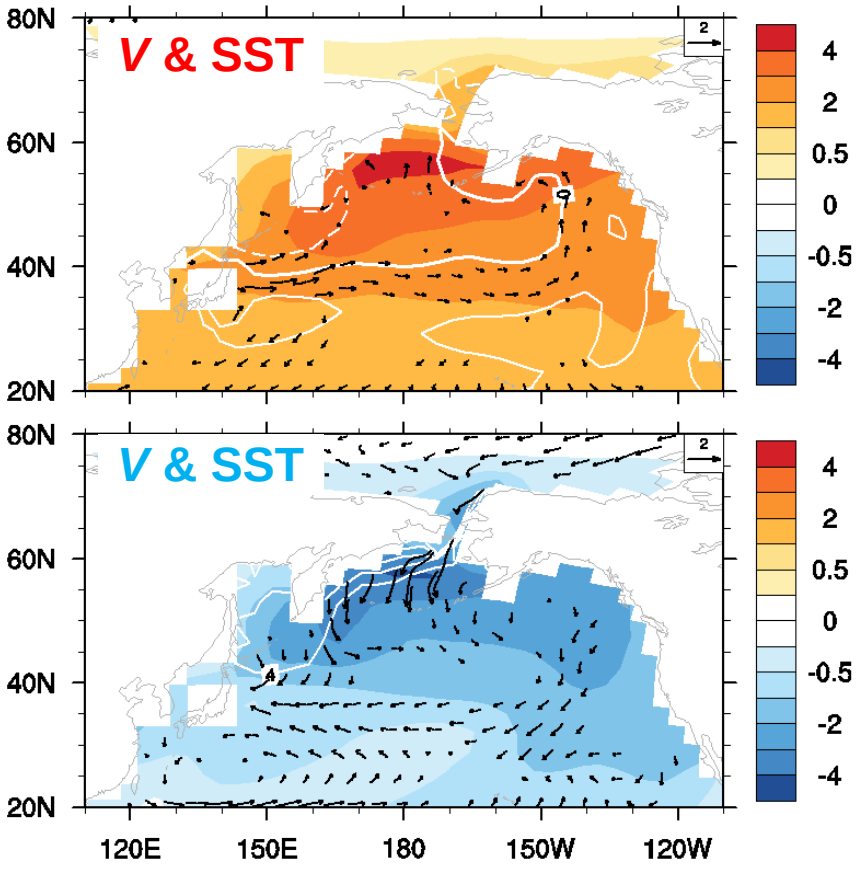


Cold water advection from Arctic ⇑

Mechanism of Hosing Cooling

North Pacific





Cold FW advection from Arctic ⇑

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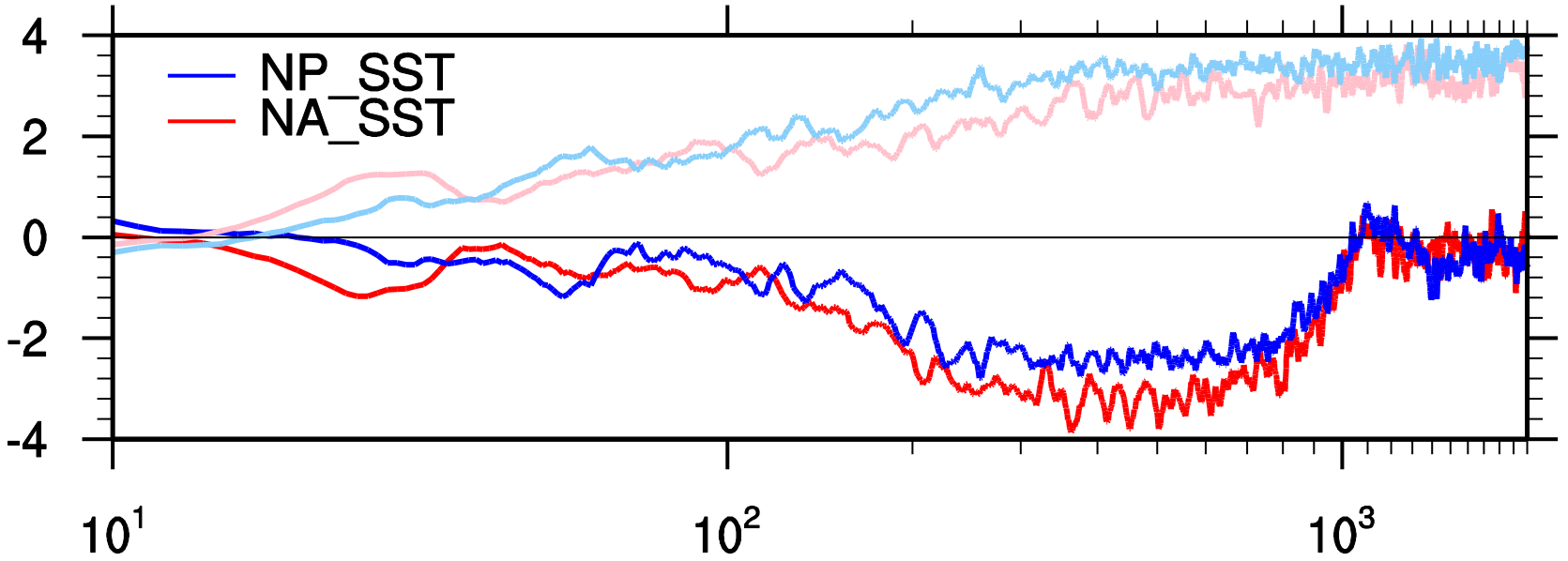
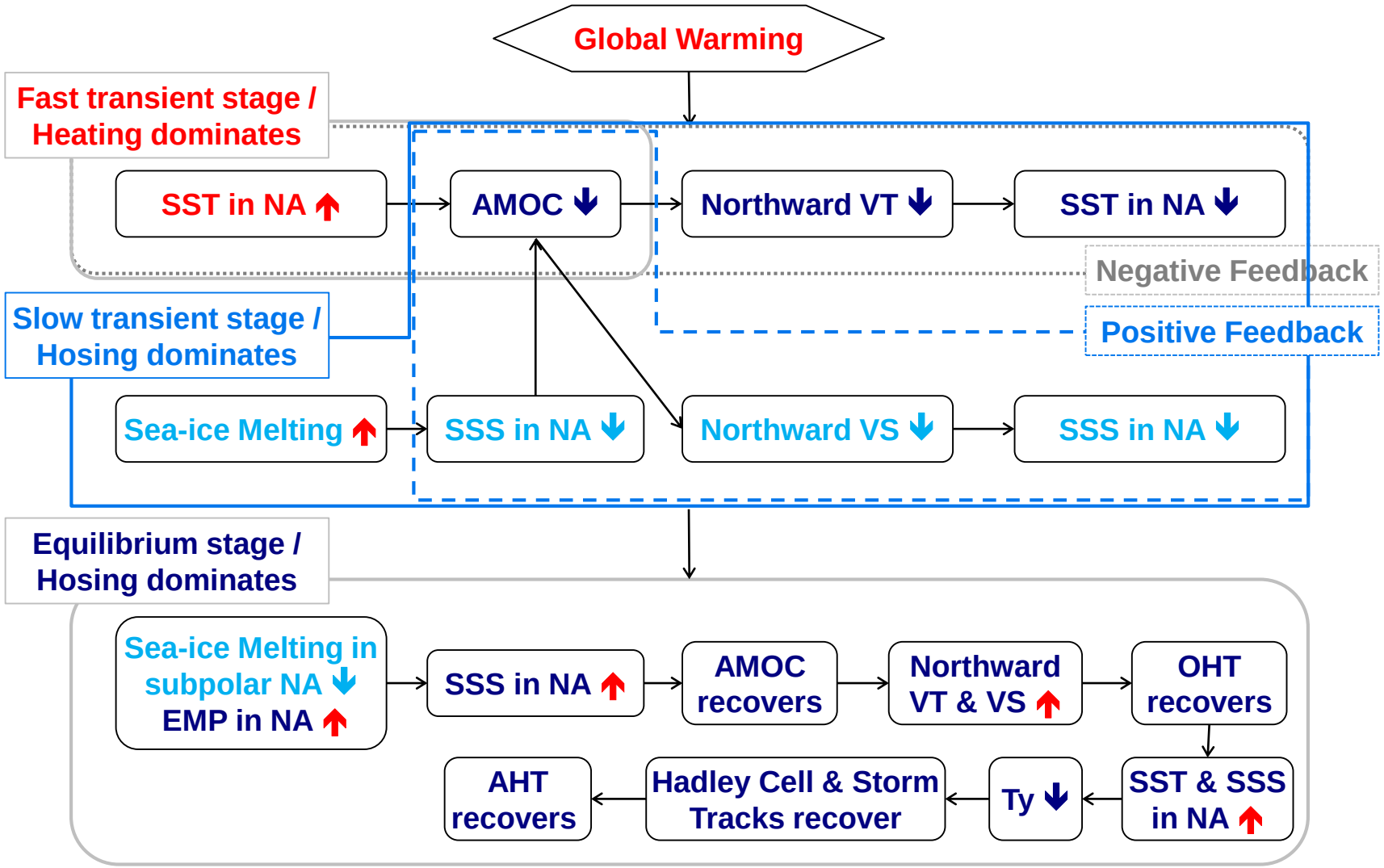
Relationship: N. Pacific and N. Atlantic

N. Pacific *lags* N. Atlantic by 5 years

Lag Corr. $(NA, NP)_{max} = 0.85$



Summary


Global Warming
Fast transient stage / Heating dominates
SST in NA
AMOC
Northward VT
SST in NA
Negative Feedback
Positive Feedback
Slow transient stage / Hosing dominates
Sea-ice Melting
SSS in NA
Northward VS
SSS in NA
Equilibrium stage / Hosing dominates
Sea-ice Melting in subpolar NA
EMP in NA
SSS in NA
AMOC recovers
Northward VT & VS
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SST & SSS in NA
Ty
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