



# Effect of High-Latitude Surface Forcing on the Tropics and Southern Hemisphere

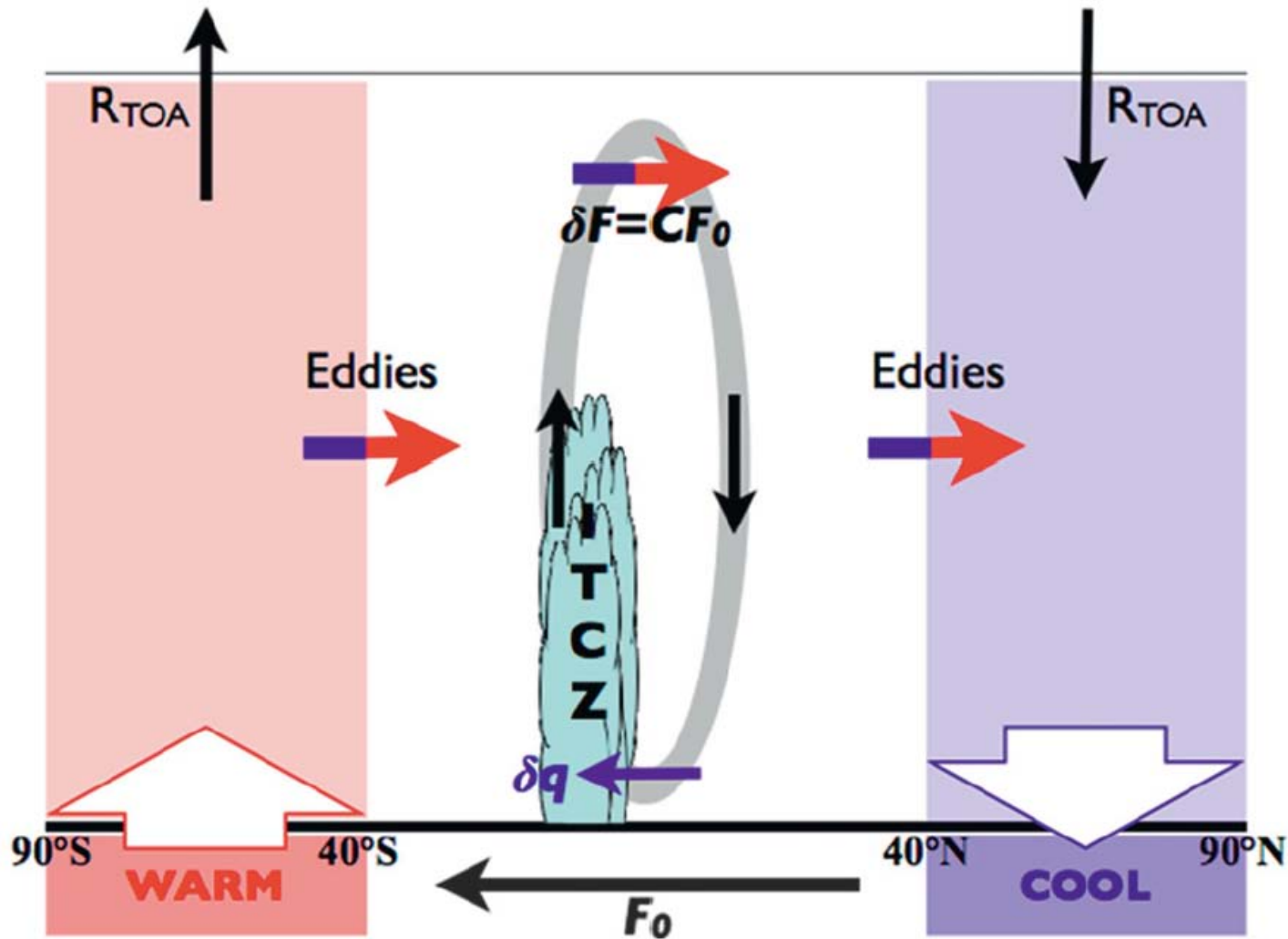
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Bonfils, Shihyu Lee, and Bill Riley

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Community Earth System Model Workshop  
Breckenridge, CO, June 20-23, 2011

# Can changes at high latitudes affect the tropics and opposite hemisphere?

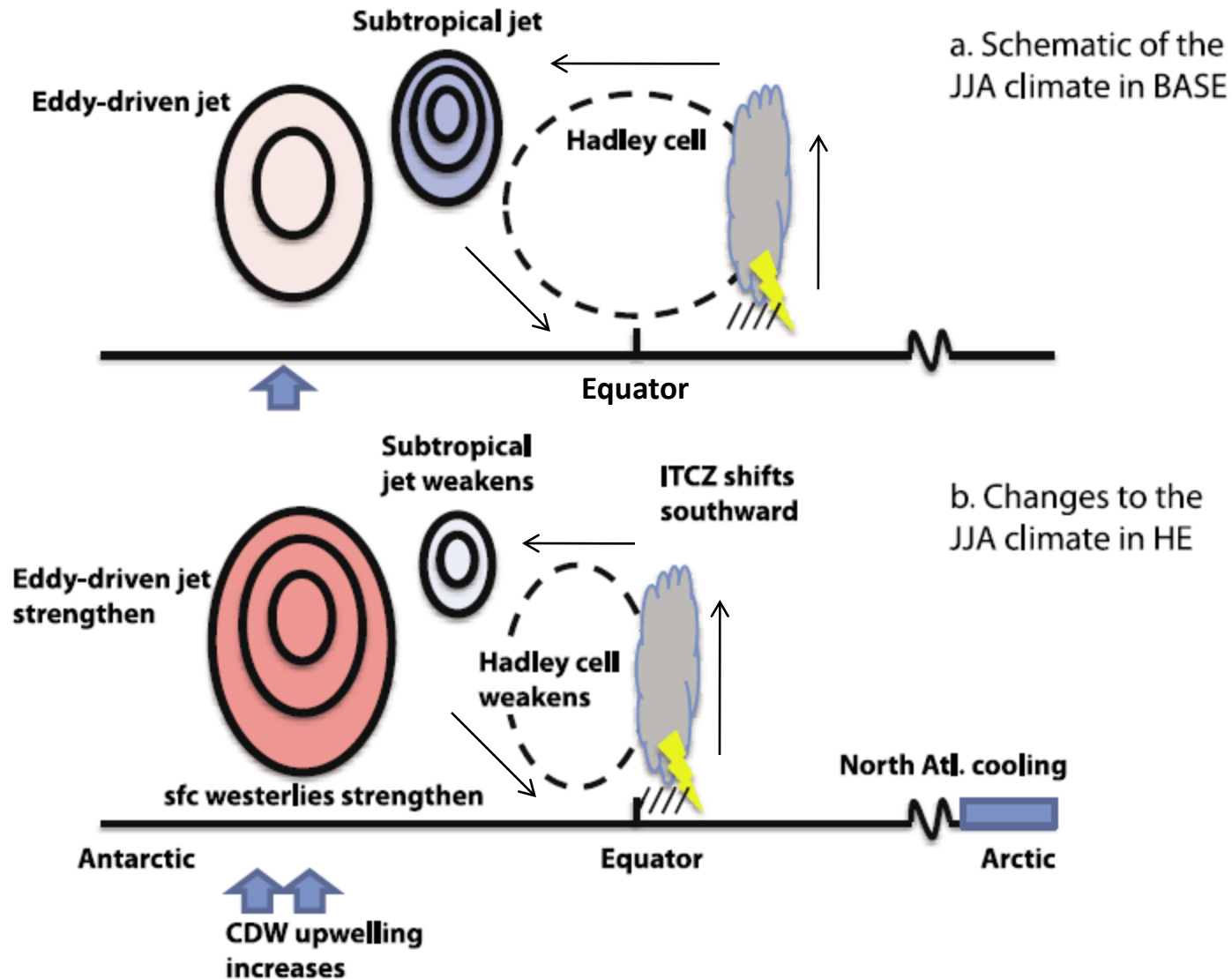
- Possible mid- and high-latitude changes of interest for climate change & paleoclimate:
  - Thermohaline shutdown in the North Atlantic
  - Changes in forest cover
  - Changes in land ice or seasonal snow cover
  - Changes in lake or wetland area
- Mechanisms: oceanic heat transport, albedo, Bowen ratio, and seasonal thermal inertia

# Thermohaline shutdown could shift the ITCZ southward.



From Kang et al., 2009, *J. Atm. Sci.*

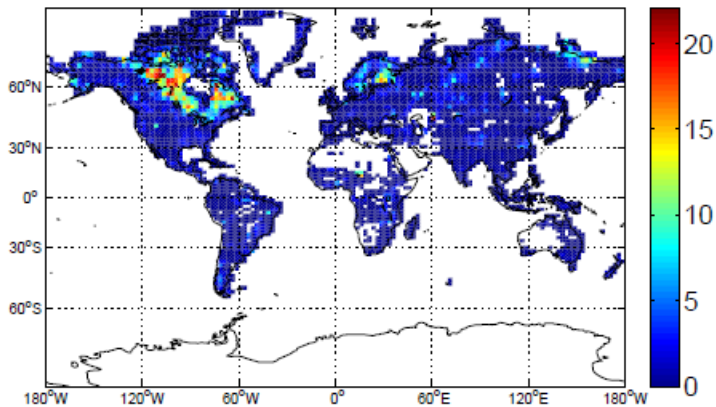
Accompanying increases in Southern Ocean westerlies could increase atmospheric CO<sub>2</sub> (20 – 60 ppm).



From Lee et al., 2011, *Paleoceanography*

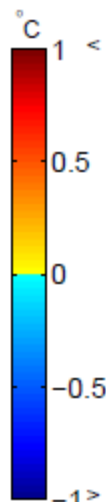
# Does Boreal lake distribution affect the Southern Hemisphere?

Conservative estimate of missing lake area in CLM

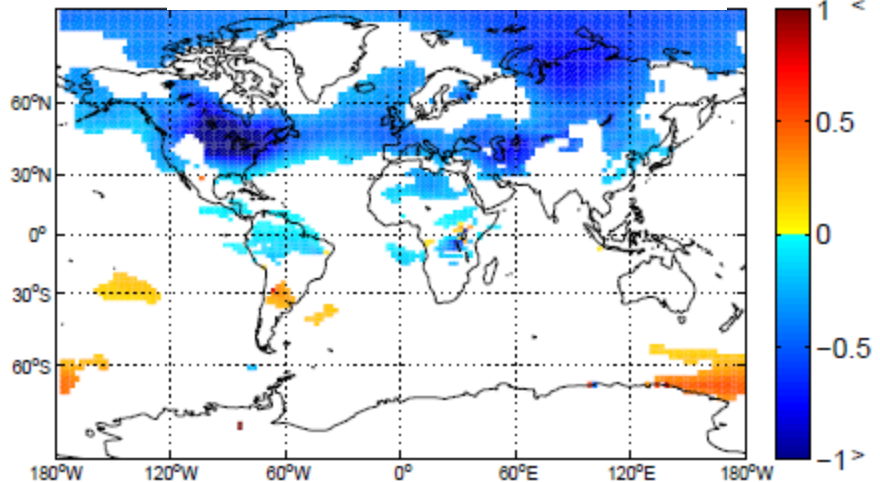


JJA 850 hPa temperature changes from adding lakes

Realistic area– CLM default



Realistic – no lake area

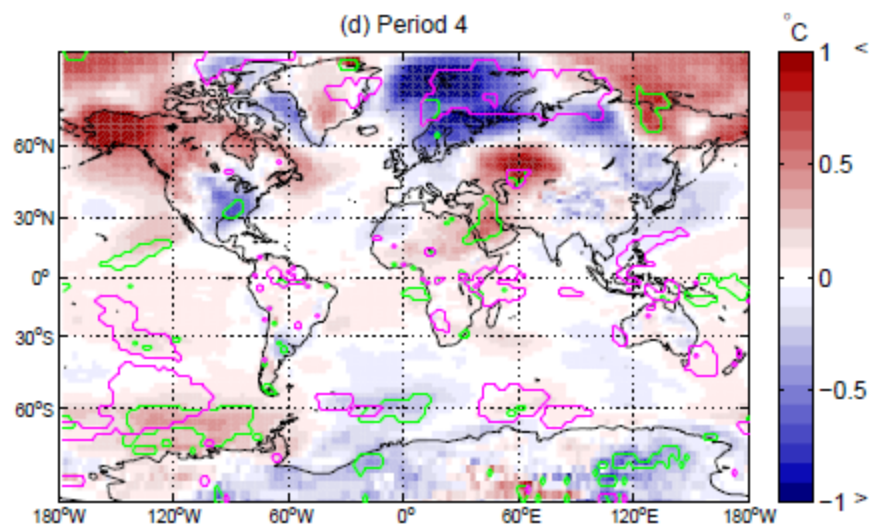
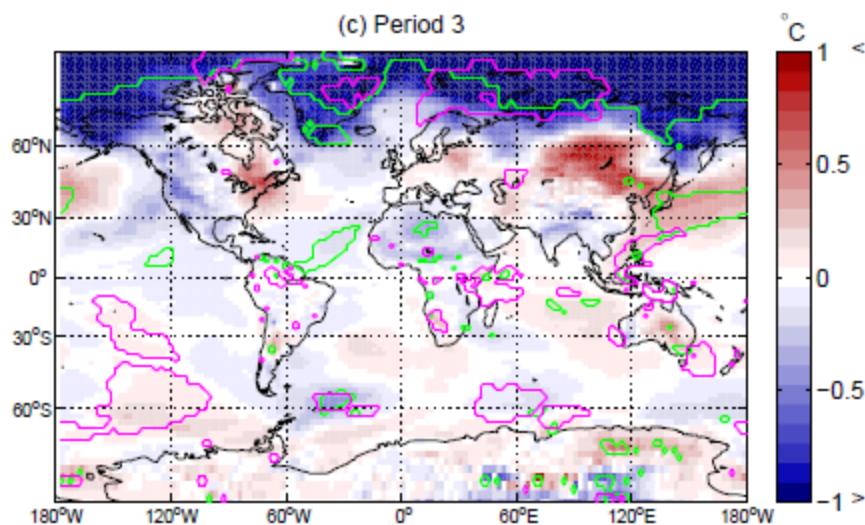
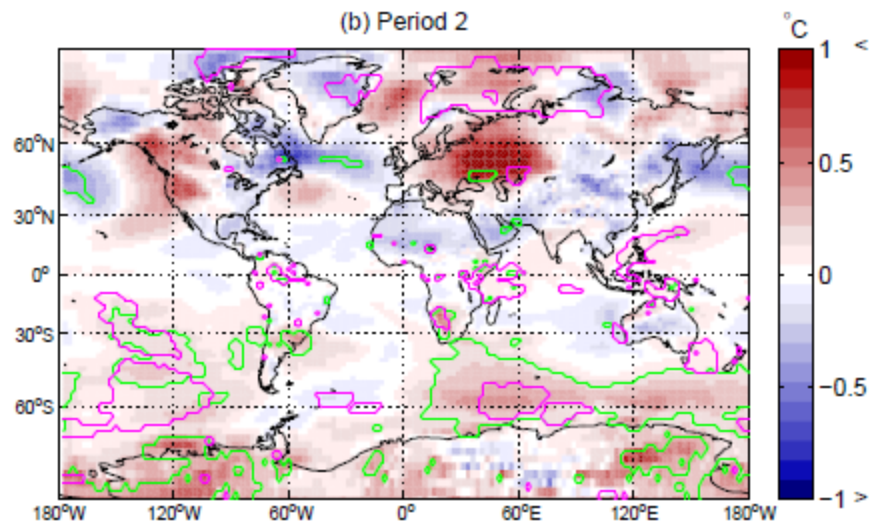
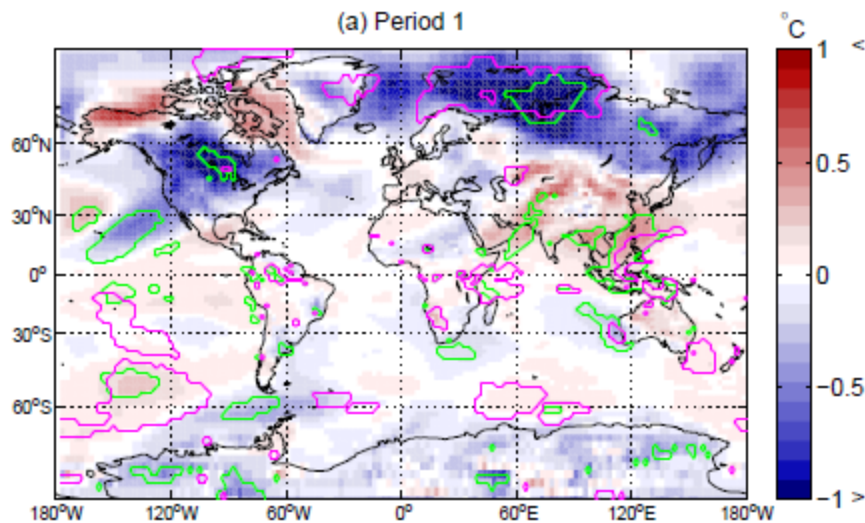


# Temporal and spatial autocorrelation complicates the interpretation of remote changes.

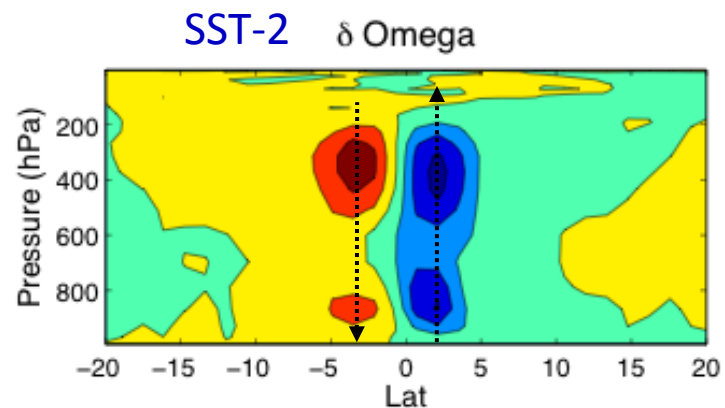
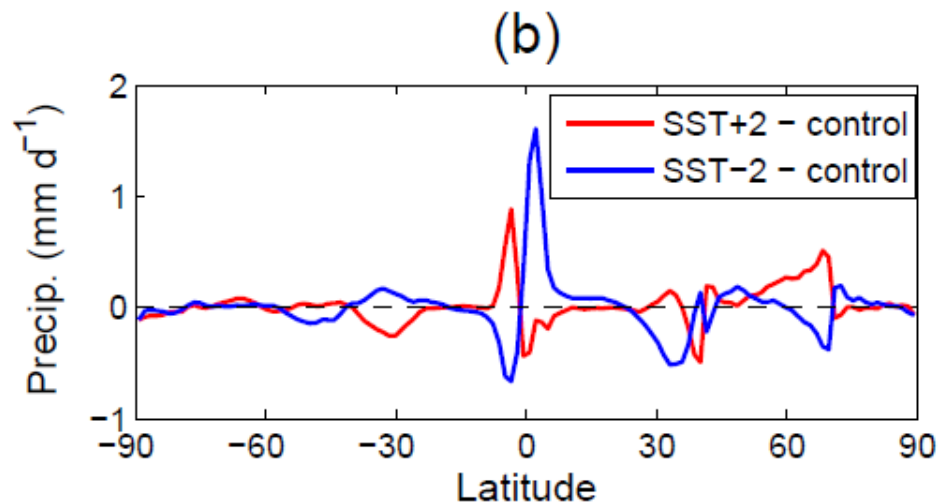
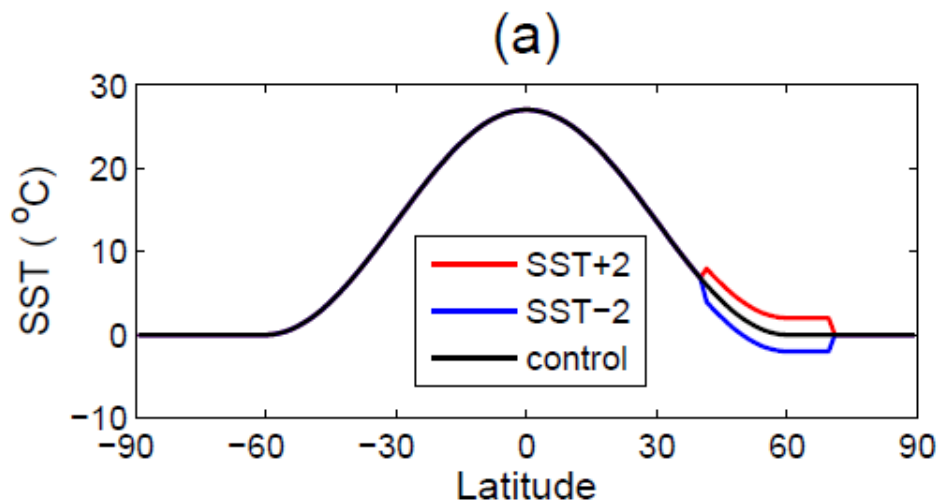
DJF changes from adding lakes

significant for overall 180-yr simulation

significant for 45-yr sub-period

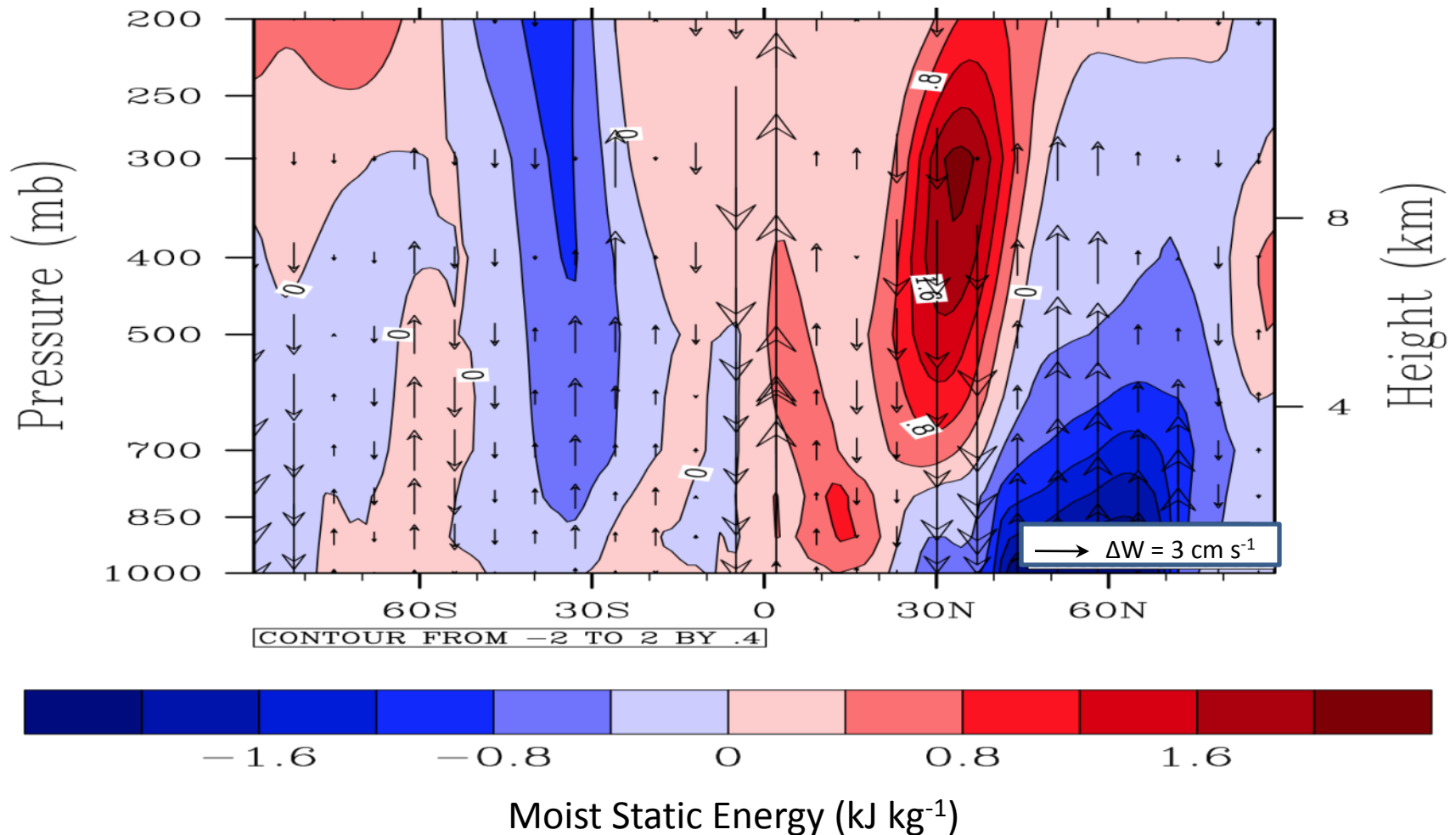


# Aqua-planet experiment with fixed SSTs mimics effects of lakes in JJA (**SST-2**) and SON (**SST+2**)



- With high-lat cooling, the ITCZ shifted northward. The NH Hadley Cell strengthened and the SH Hadley Cell weakened.
- Opposite of previous experiments!

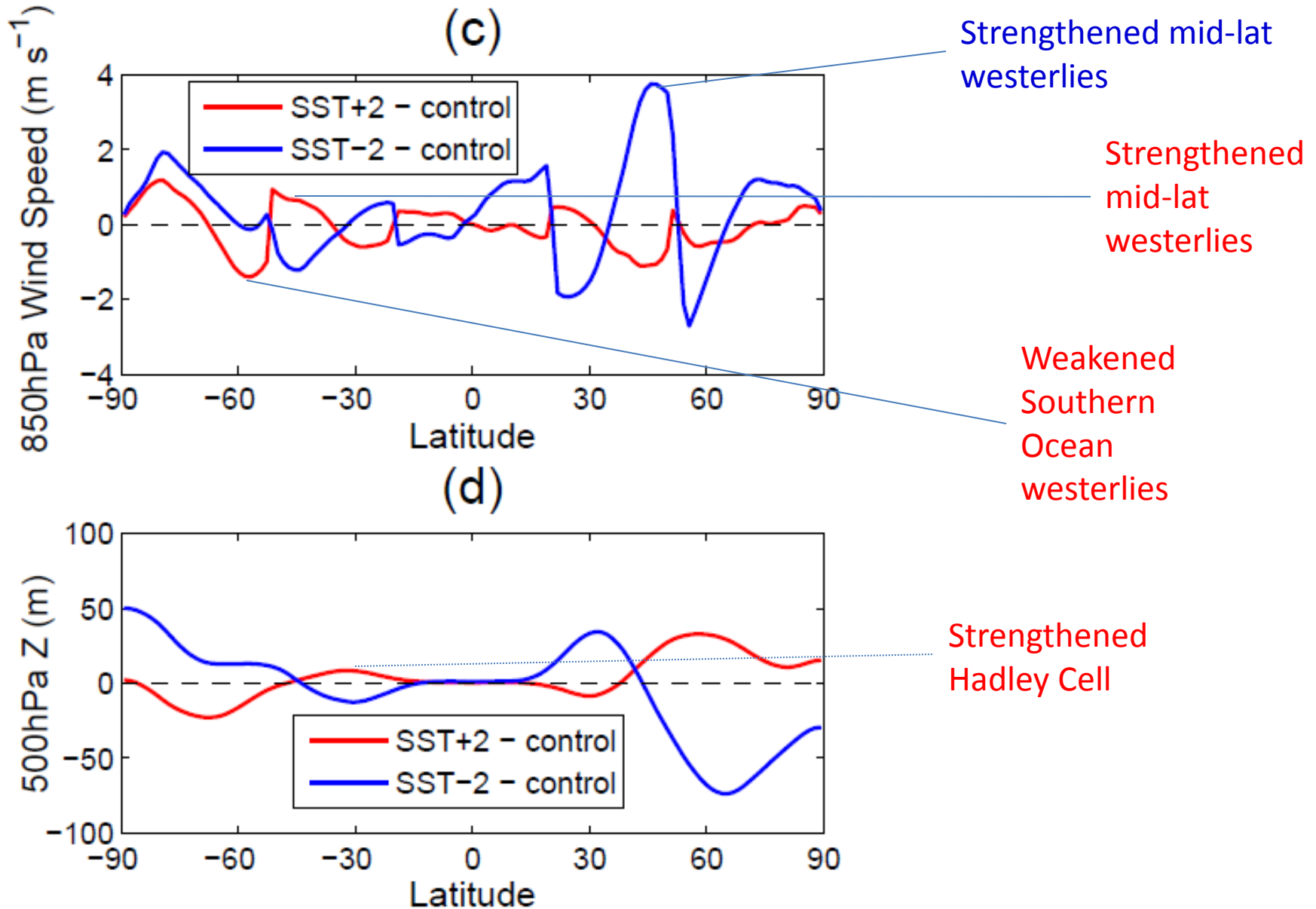
# Changes driven by mid-lat temperature gradient and shifts in NH moist energy transport?



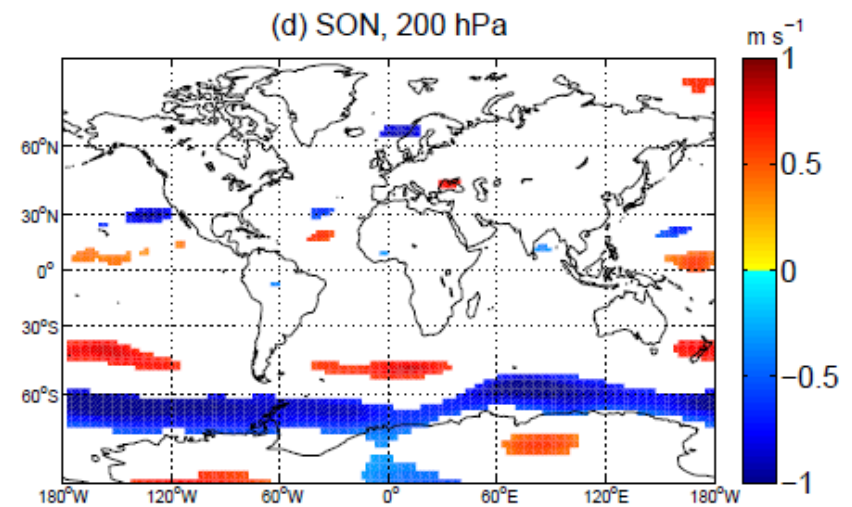
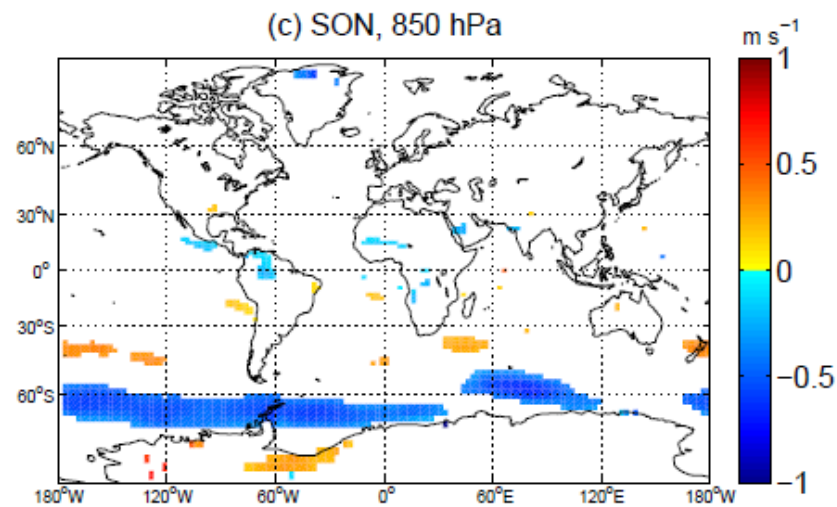
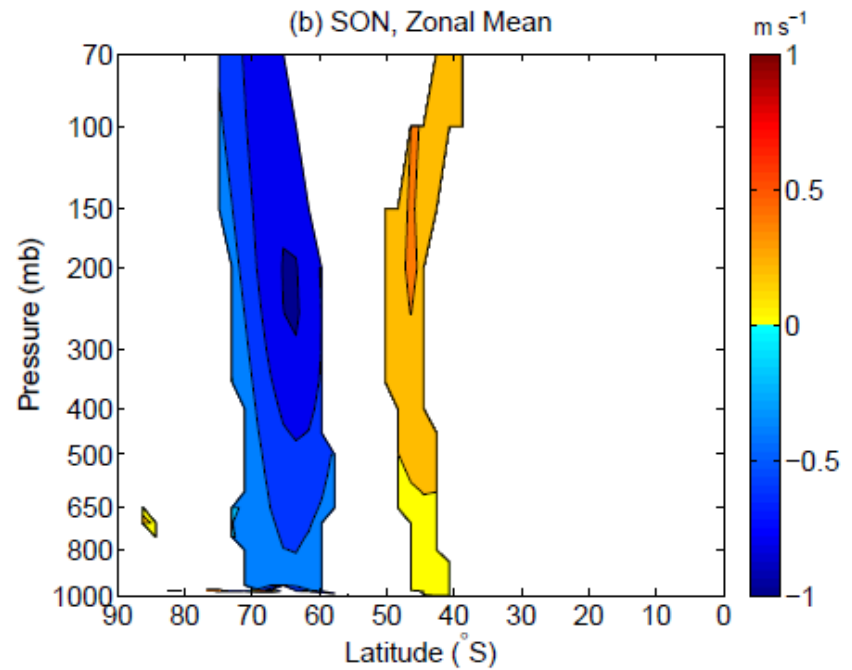
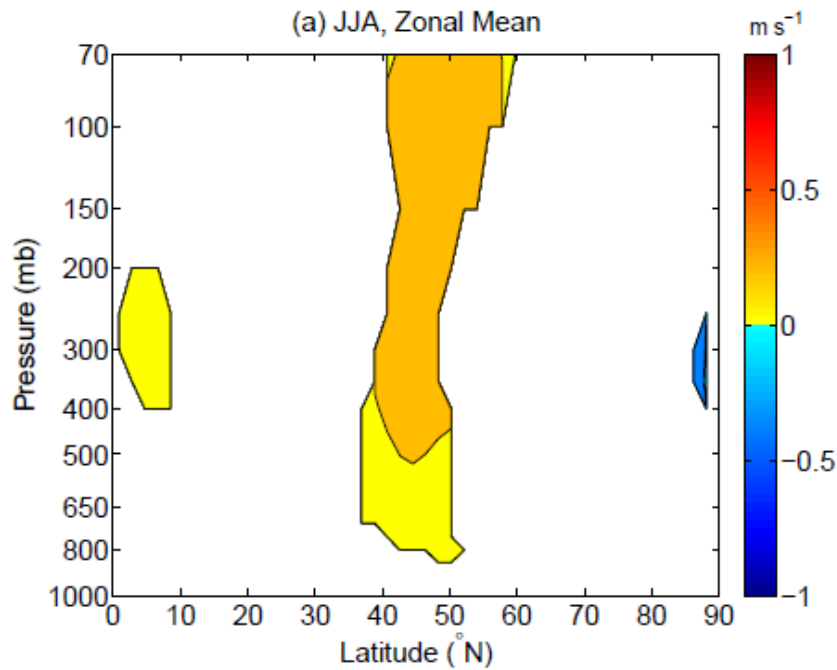
SST-2



# Changes in zonal winds included SH shifts in **SST+2**.



# Similar changes occurred when adding lakes.



# Contrasting mechanisms of remote change

- Fixed SSTs
  - Open energy budget
  - Like land surface change in albedo or sub-surface energy storage
  - Primarily seasonal changes may not affect SSTs
- Slab or active ocean
  - Closed energy budget (except TOA balance)
  - Like ocean circulation change
  - Long-term changes allow SSTs to adjust

# Conclusions

- Even relatively small NH extra-tropical changes can cause significant changes in tropical and SH atmospheric circulation.
- The direction of shifts in the ITCZ and SH circulation resulting from a NH surface cooling (or warming) may depend on the details of the forcing causing the temperature change.

# Acknowledgements & References

- Discussion with Sarah Kang and Bill Collins
- Support from the US DOE and LBNL

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