

Climate Change in HadCM3

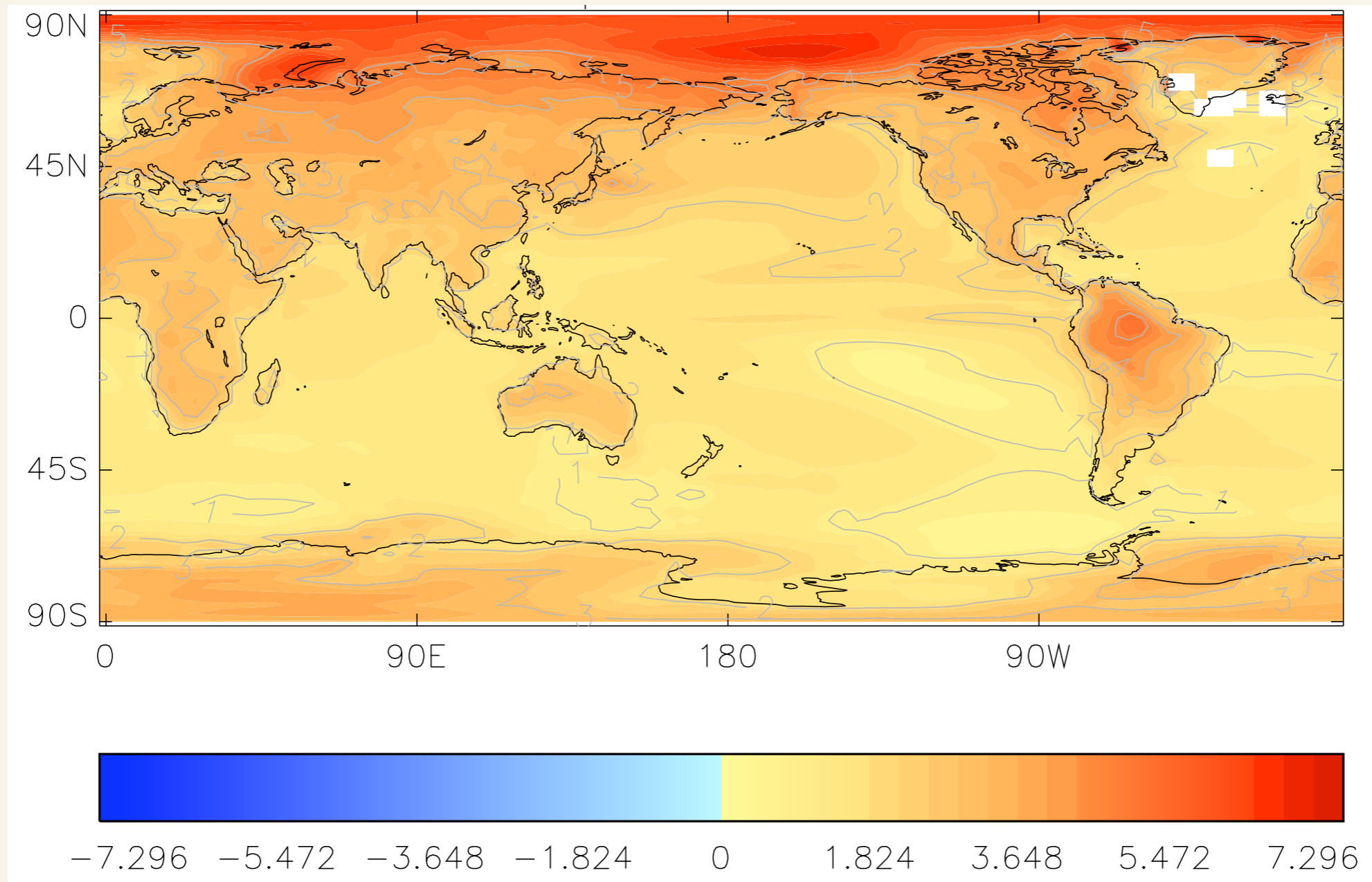
Chris Brierley

Chapa Club - 21/06/06

Increase in CO₂

- ~ A climate forcing leads to a change in the energy balance of earth.
- ~ Earth responds by changing its characteristics.
- ~ Largest method of doing this is a change in temperature.

Surface Air Temperature

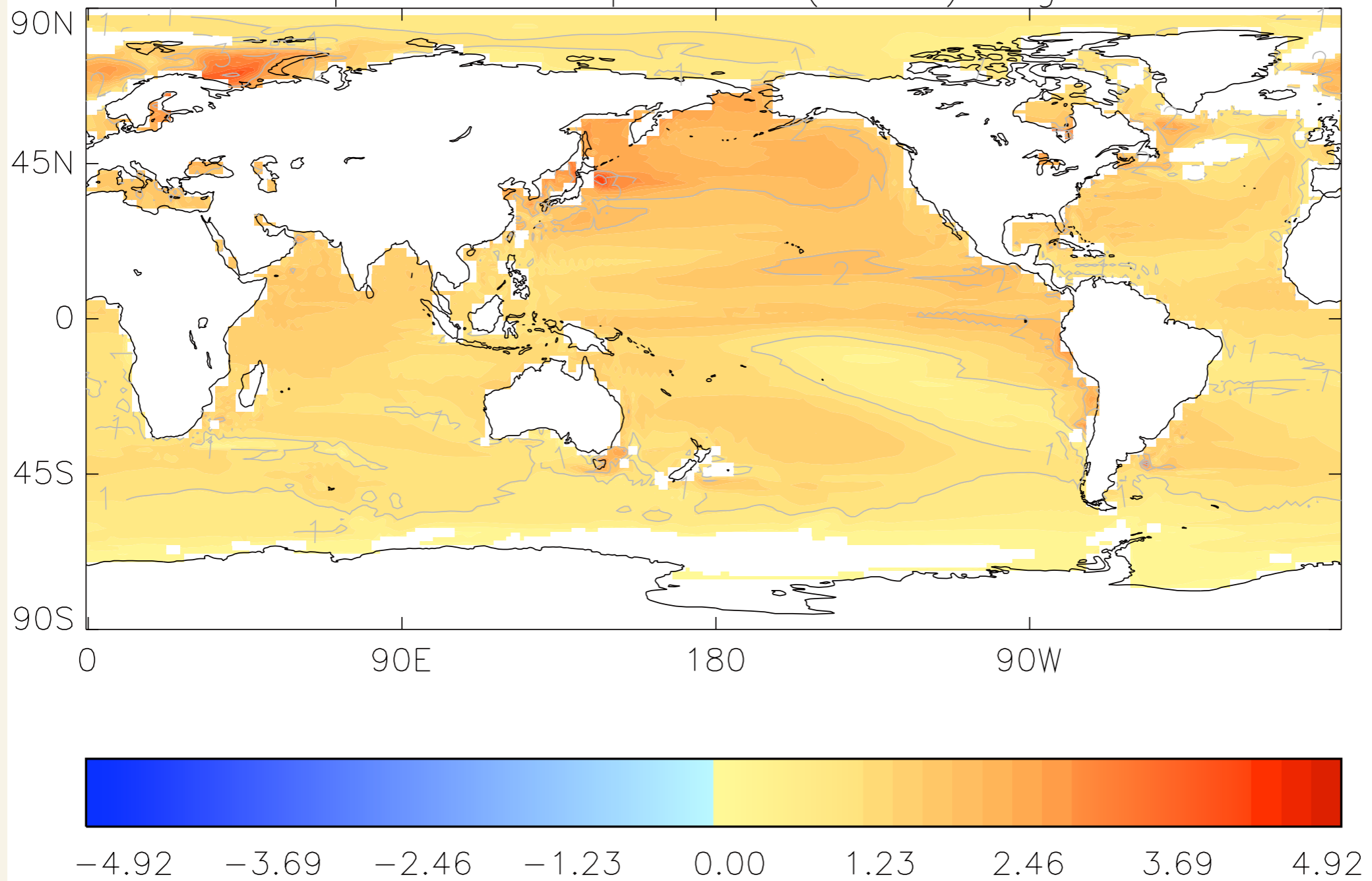


White is not significant

Surface Air Temp.

- ~ Significant increase in temp everywhere.
- ~ Maximum in Arctic (Arctic Amplification)
- ~ Land warms more than ocean (c.f. COWL pattern)
- ~ Smallest warming in Southern Ocean/North Atlantic - both areas of strong vertical heat transports in the ocean.
- ~ Large warming in Amazon Basin (not found in all models).

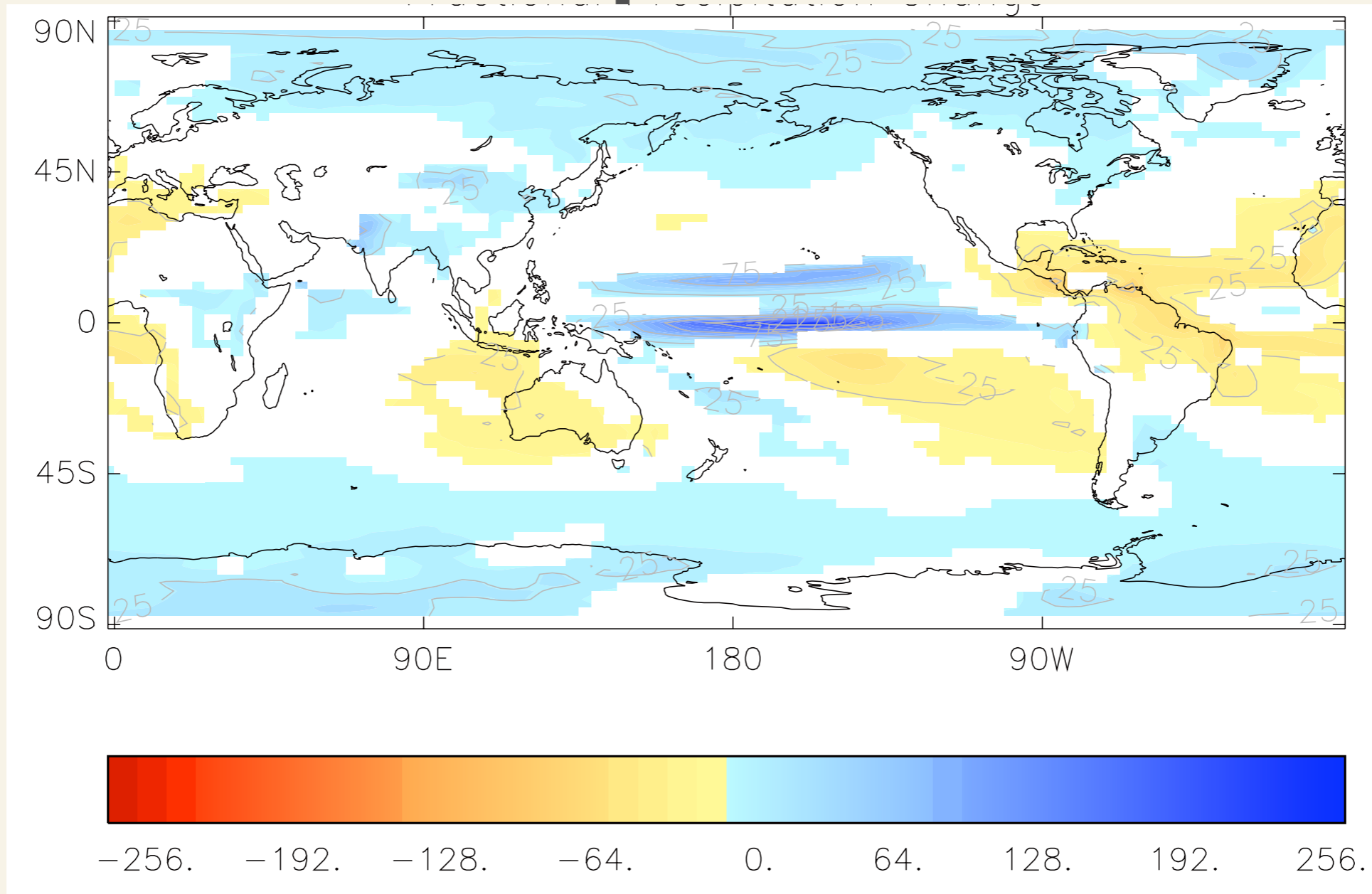
Sea Surface Temps



Sea Surf. Temps

- ~ Similar structure to SAT pattern.
- ~ Don't see same size warming in Arctic, because sea-ice forms a barrier in winter (Barents Sea has little sea-ice in winter).
- ~ Preferential warming to eastern side of equatorial Pacific and western side of Indian.
- ~ Shallowing of equatorial thermocline.

Precipitation

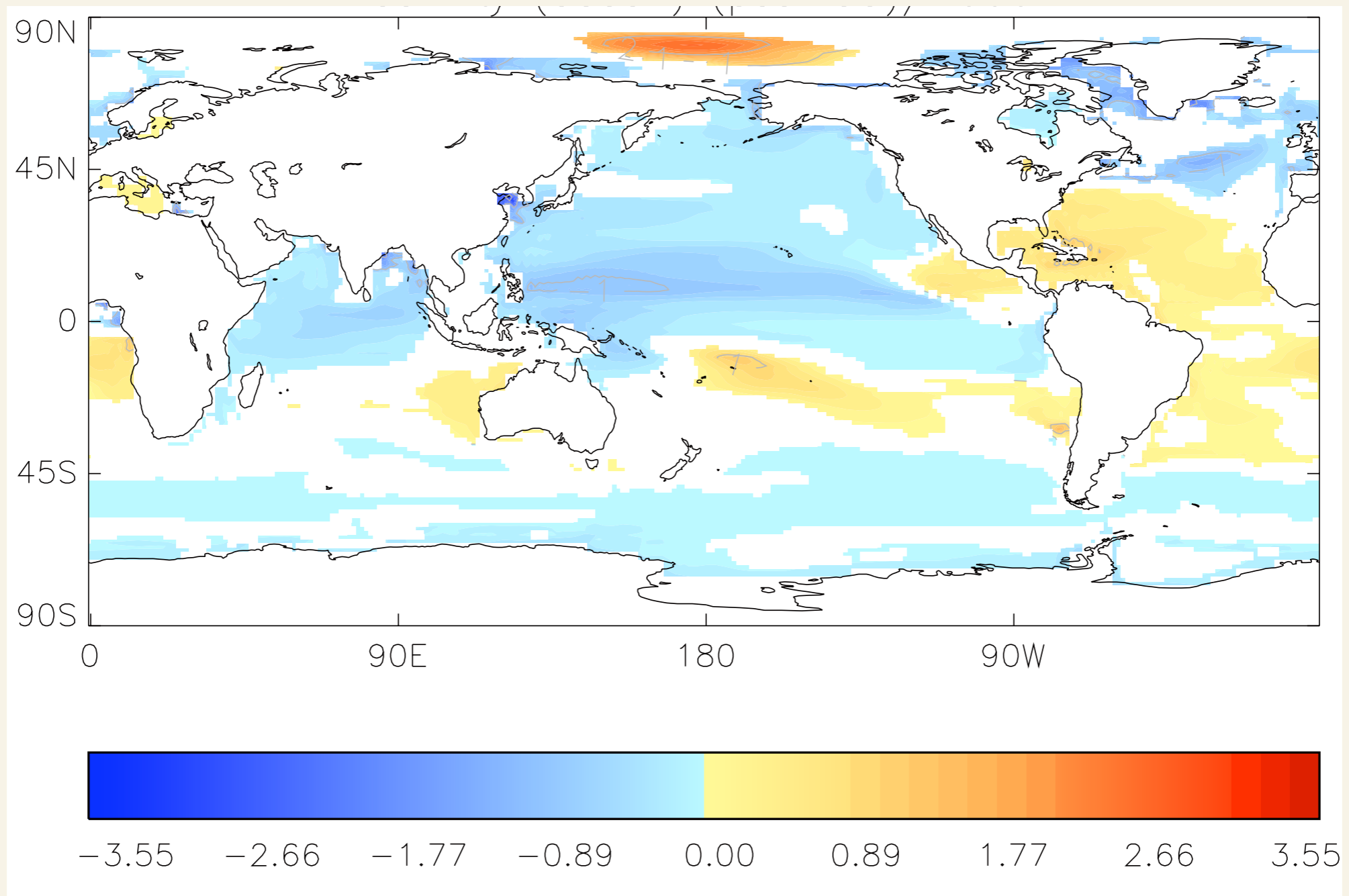


Change as a fraction of initial rainfall

Precipitation

- ~ Increase in extra-tropics and decrease in tropics
- ~ Relating to enhanced moisture transport of warmer air.
- ~ Northward shift of ITCZ (Northern hemisphere warms more than Southern).
- ~ Increase in rainfall in equatorial Pacific, and decrease over Amazon (similar to El Nino).
- ~ Due to warmer SSTs in E Eq. Pacific.

Sea Surface Salinity

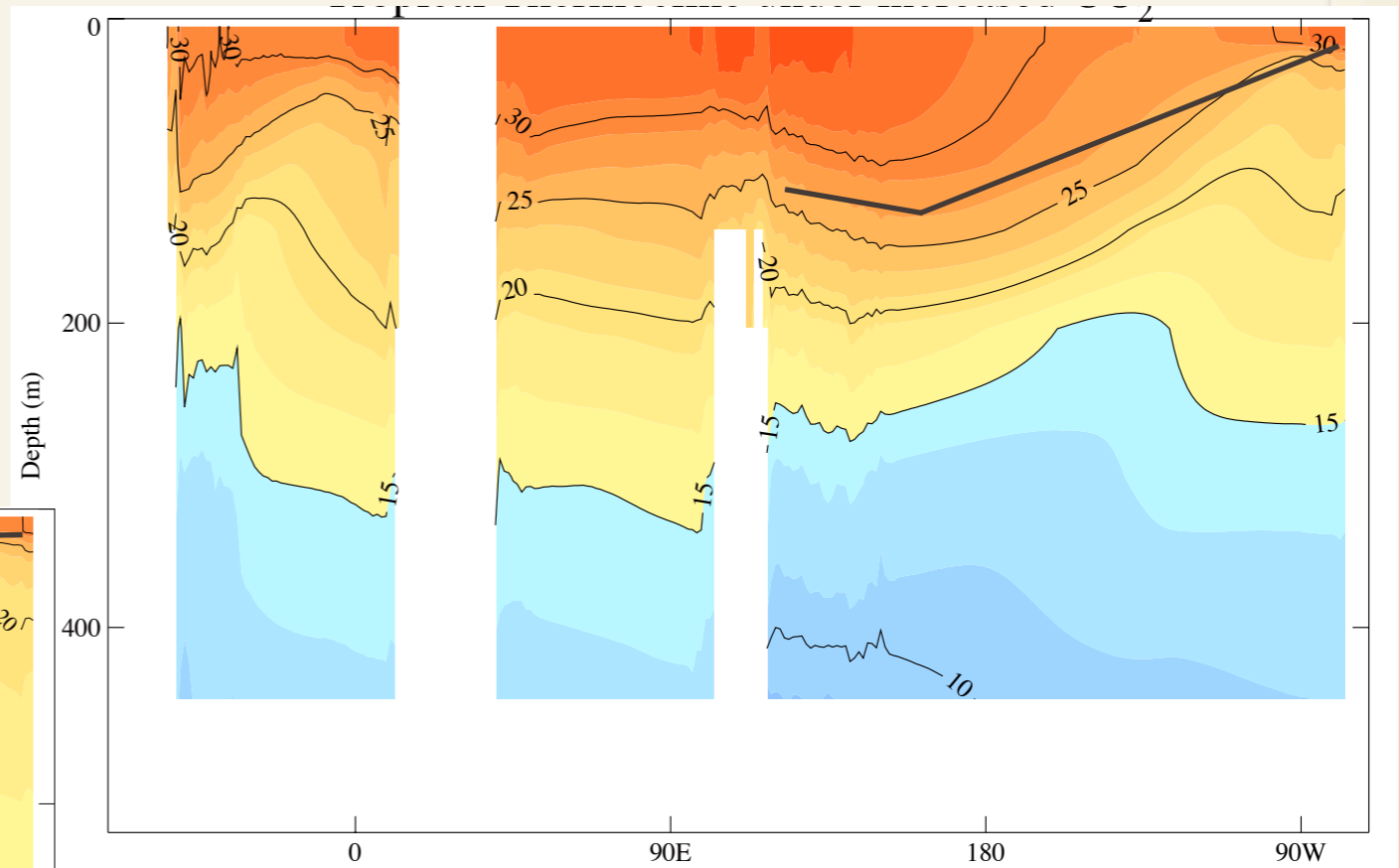
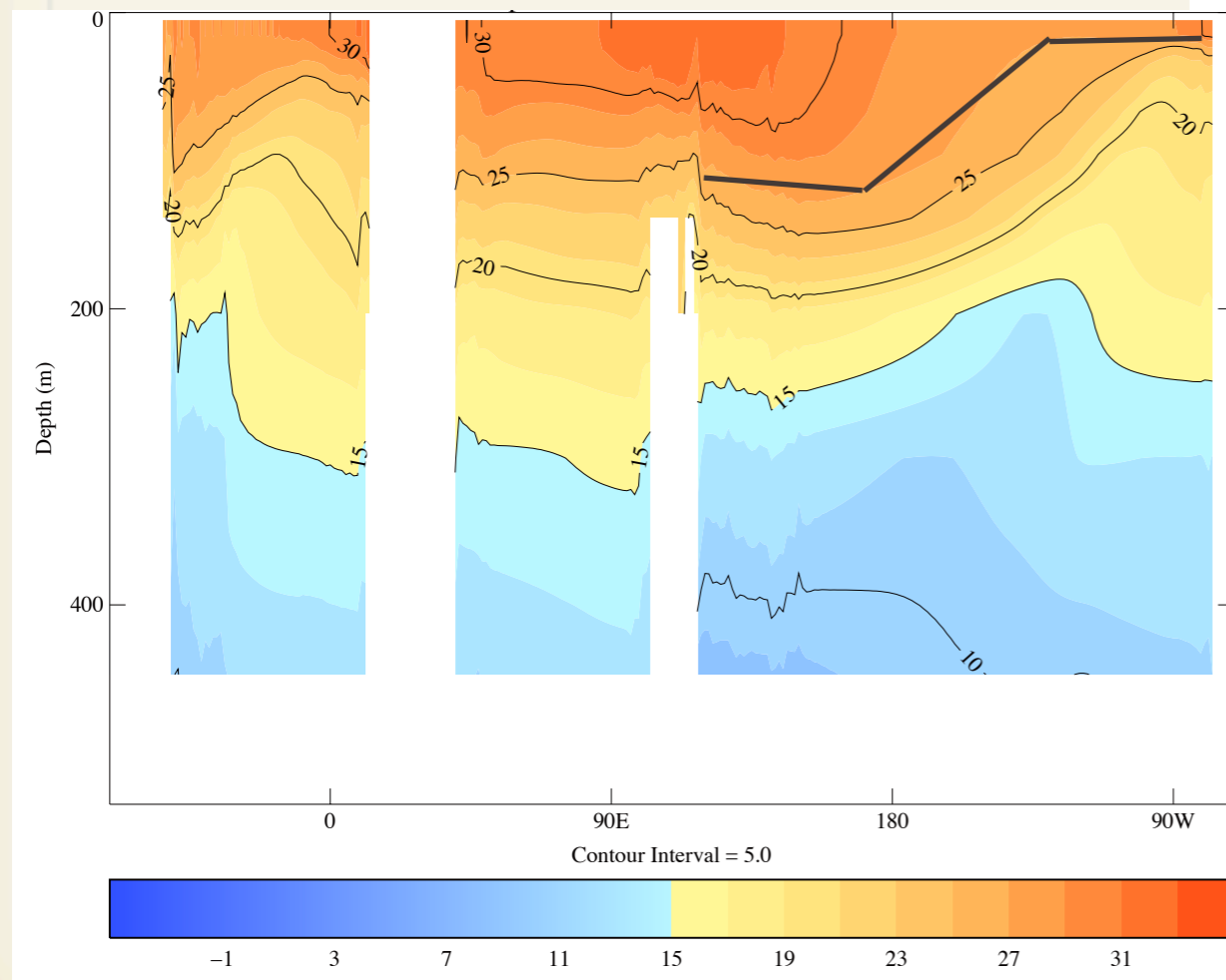


SSS

- ~ Echoes parts of precipitation pattern.
- ~ Salinification of equatorial Atlantic.
- ~ Freshening of North Atlantic - effects on Thermohaline circulation.
- ~ Strong salinity changes in East Siberian Sea (which I don't understand)

Tropical Thermocline

Before



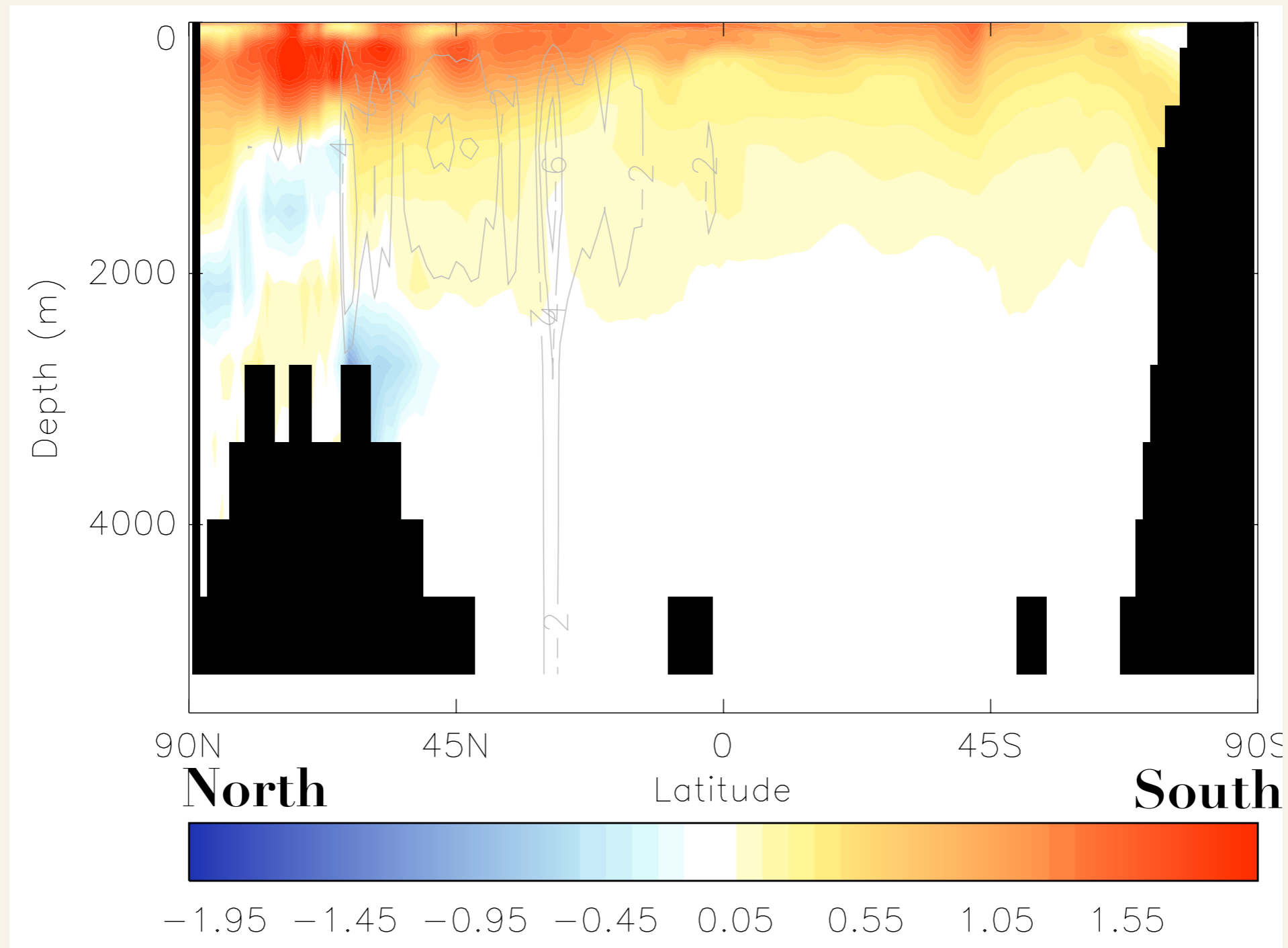
After

No Significance testing

Eq. Pacific Response

- ~ Same amount of heat flux goes into mixed layer; so the thin bit heats more.
- ~ Warm pool *expands* eastwards (rather than *shifting* eastwards as in El Nino)
- ~ Sends Kelvin waves east - causing anomalous descent over Amazon.
- ~ Suppresses convection there, allowing more solar radiation onto surface
- ~ Hence Amazon preferentially warms. (carbon feedbacks enhance this)

Thermohaline Circ.



Colour = Temp change (K), white is “no change”,
Contours = circulation change in Sv

THC

- ~ Temperature increase doesn't percolate to depths of ocean in 70 yrs.
- ~ Circulation partly driven by sinking in North Atlantic.
- ~ Warming and freshening of surface increases stratification - capping convection.
- ~ Reduction of ~ 4 Sv (20-30%), but exact value uncertain due to high natural variability.

HadCM3 References

~ Climate Change

- ~ SRES Scenarios - T. C. Johns, J. M. Gregory, W. J. Ingram, C. E. Johnson, A. Jones, J. A. Lowe, J. F. B. Mitchell, D. L. Roberts, D. M. H. Sexton, D. S. Stevenson, S. F. B. Tett, M. J. Woodage, 2003, *Clim. Dyn.*, Vol. 20., pp. 583-612
- ~ Model Uncertainty - M. Collins, B. Booth, G. Harris, J. Murphy, D. Sexton and M. Webb, 2006, *Clim. Dyn.*, DOI 10.1007/s00382-006-0121-0
- ~ HadCM3 vs. HadCM2 - K. D. Williams, C. A. Senior and J. F. B. Mitchell, 2001, *J. Clim.*, Vol. 14, pp. 2659-2674.
- ~ Plus, of course, the IPCC.

~ Model Description

- ~ Ocean - C. Gordon, C. Cooper, C. A. Senior, H. Banks, J. M. Gregory, T. C. Johns, J. F. B. Mitchell, R. A. Wood, 2000, *Clim Dyn*, Vol 16, pp 147-168.
- ~ Internal Var. - M. Collins, S. F. B. Tett and C. Cooper, 2001, *Clim. Dyn.*, Vol 17, pp 61-81
- ~ Atmos. - V. D. Pope, M. L. Gallani, P. R. Rowntree, R. A. Stratton, 2000, *Clim. Dyn.*, Vol. 16., pp 123-146
- ~ HadCM2 - T. C. Johns, R. E. Carnell, J. F. Crossley, J. M. Gregory, J. F. B. Mitchell, C. A. Senior, S. F. B. Tett, R. A. Wood, 1997, *Clim. Dyn*, Vol. 13, pp 103-134