What sets the position of the ITCZ?



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Inter-hemispheric asymmetries in climate



- 1. Discuss role of Atlantic MOC carrying heat northward across the equator -- argue this results in ITCZ being displaced north of the equator
- 2. Mechanisms of MOC variability on decadal timescales
 - -- emphasize 'gyre wobbles' induced by stochastic wind forcing in middle latitudes
 - -- may lead to decadal shifts in ITCZ (in models)
- 3. Conclusions

Schematic of thermohaline circulation of the Ocean



Review by Marshall and Speer, 2012

Upper Cell emanating from the north (Atlantic) Lower Cell from the south (around Antarctica) Complex, 3-D circulation extending from pole to pole

Results in inter-hemispheric asymmetries in climate

Atlantic carries roughly 1/2 PW heat northward across the equator



Suppose that at the equator

$AHT + OHT \simeq 0$

If OHT > 0 at equator, due to Atlantic's MOC, then AHT < 0 to compensate.

Atmosphere achieves this by shifting ITCZ north of the equator



Earth-like Aqua-planets





ITCZ



Earth-like Aqua-planets

Drake



ITCZ

-80 Ρ

-60

-40

-20



In present climate there is a small 0.2 PW net (A+O) northward transport of heat across the equator

Precipitation (mm/dav)



If this transport was achieved by atmosphere, ITCZ would be south of equator!

ITCZ is 'pushed northward' by OHT

 $AHT + OHT \gtrsim 0$

OHT > 0

and so, atmospheric heat transport must be southward

AHT < 0



<u>because</u>

Atlantic MOC carries heat northward across the equator

Implicit in work of Zhang and Delworth, 2005

So, can decadal variability in the Atlantic MOC induce decadal shifts in the position of the ITCZ?

Variability of MOC - in two coupled climate models



Tulloch and Marshall, J. Climate, 2012



Q-factor of oscillation is about '2' - there is some predictability

Stochastically forced by the wind cf Griffies and Bryan, 1997



Precip anomaly associated with a 3 sigma AMOC event



How large is the ITCZ shift?



Donohoe et al, 2012

Summary

- 1. Distinctive feature of ocean's MOC is that it carries significant amounts of heat across the equator
- 2. Association between ITCZ and AHT at equator is established

e.g. papers by Kang, Frierson, Chiang, Held, Donohoe....., and others

Here, gone one step further to argue that, at the equator:

AHT + OHT \simeq 0

OHT > 0 and so AHT < 0

i.e. ocean's MOC 'pushes' the ITCZ north of the equator

see Zhang and Delworth (2005), Frierson et al (in preparation) and work presented here

3. Decadal variability in MOC can induce decadal variability in position of the ITCZ.

but 'small' effect

Many discussions with

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