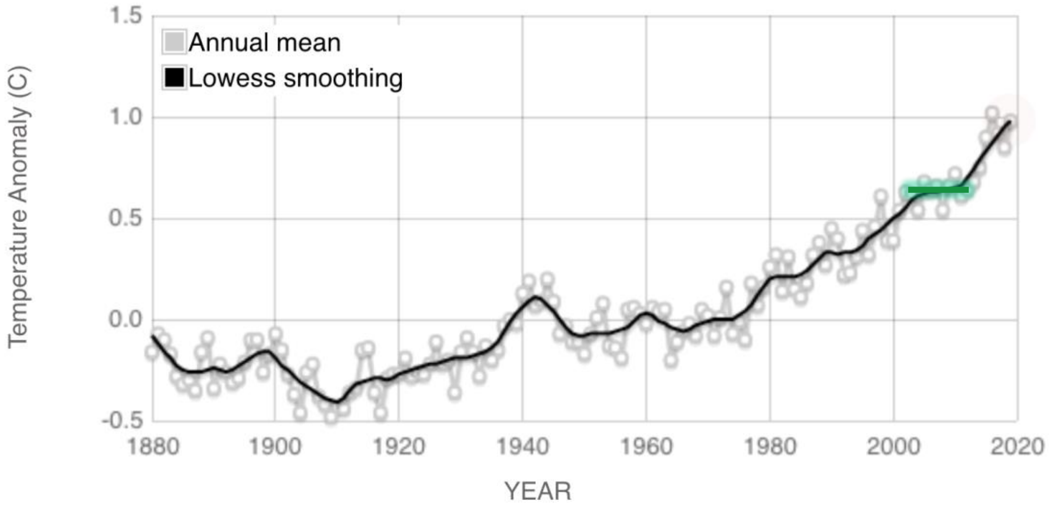
探究年代际自然变率和AMOC对全球增温趋势的调节机制



汇报人：　杨千姿

指导老师：杨海军 教授

2020年12月31日

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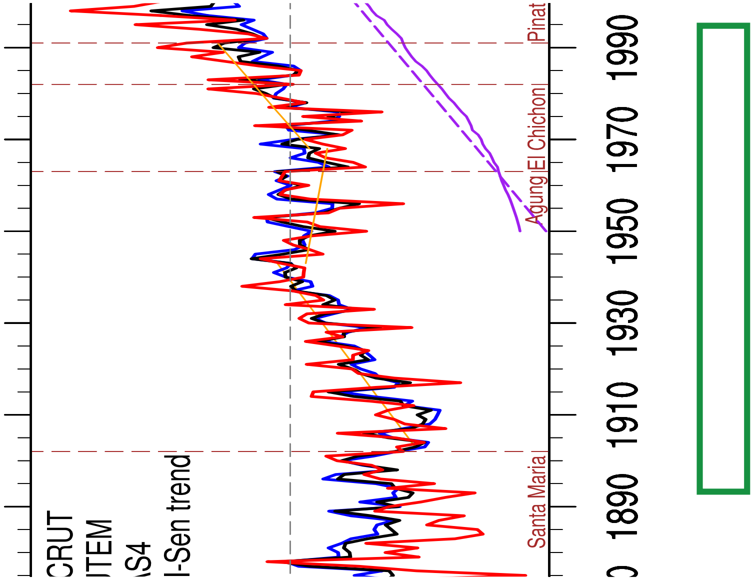
科学问题

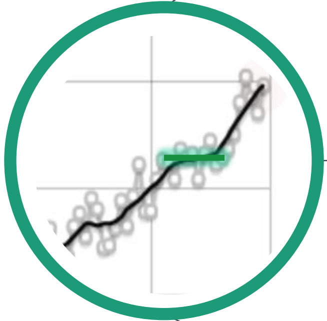
- 增暖减缓为何发生？

Global Warming Hiatus/Slowdown



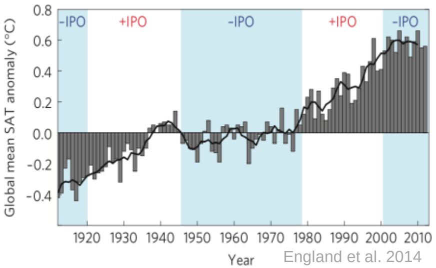
温室气体增多真的能造成全球增温吗？

前人研究进展



1 地球能量并未增加?

太阳活动、火山喷发、人为气溶胶等降温作用不足以抵挡温室效应

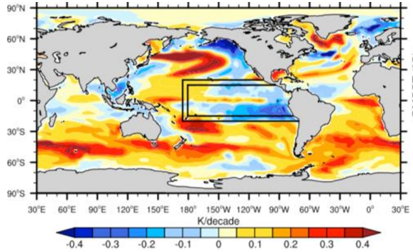


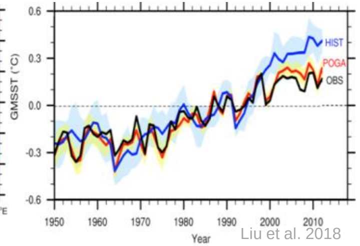
England et al. 2014

2 自然变率？PDO负位相?

增暖减缓期与PDO负位相对应

“Pacemaker”试验提高对GMST模拟效果





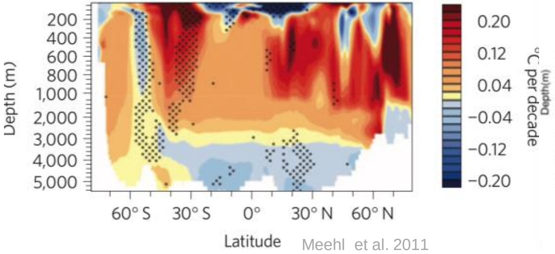
Liu et al. 2018

3 "Missing heat"在深海?

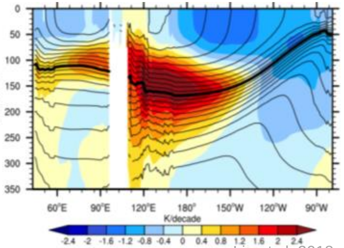
大西洋、南大洋垂直热量再分配

印度洋、太平洋水平热量再分配

与自然变率和AMOC变化有关



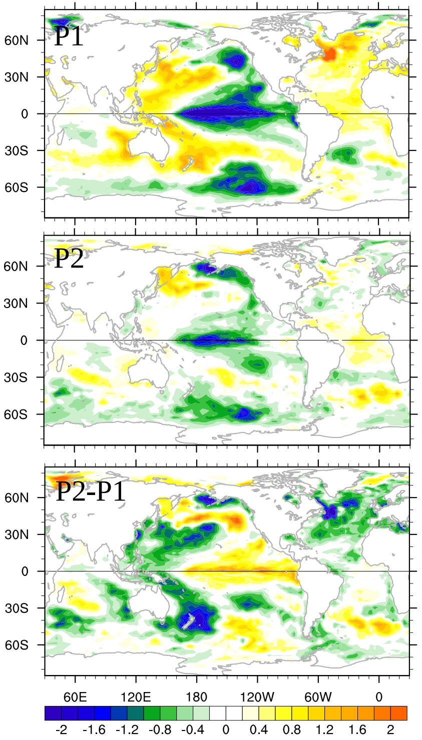
Meehl et al. 2011



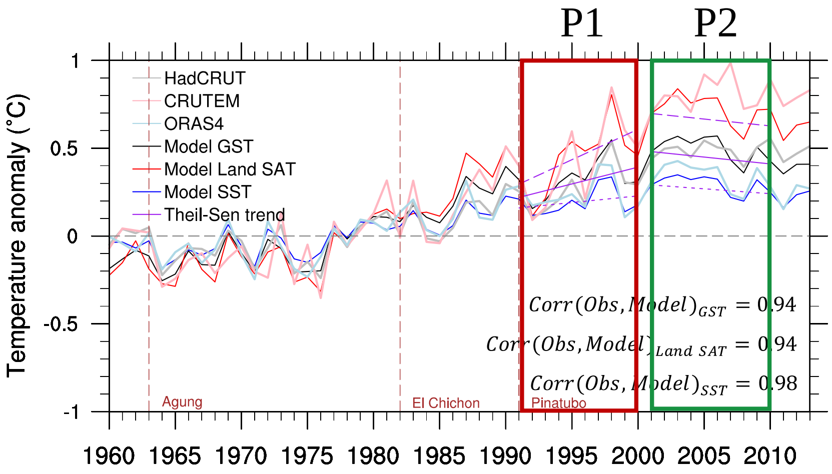
Liu et al. 2018

研究方法

观测资料ORAS4

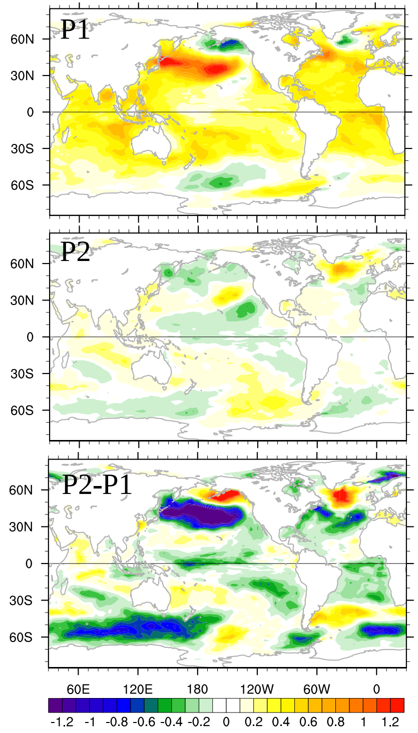


Warming trend (°C/10年)



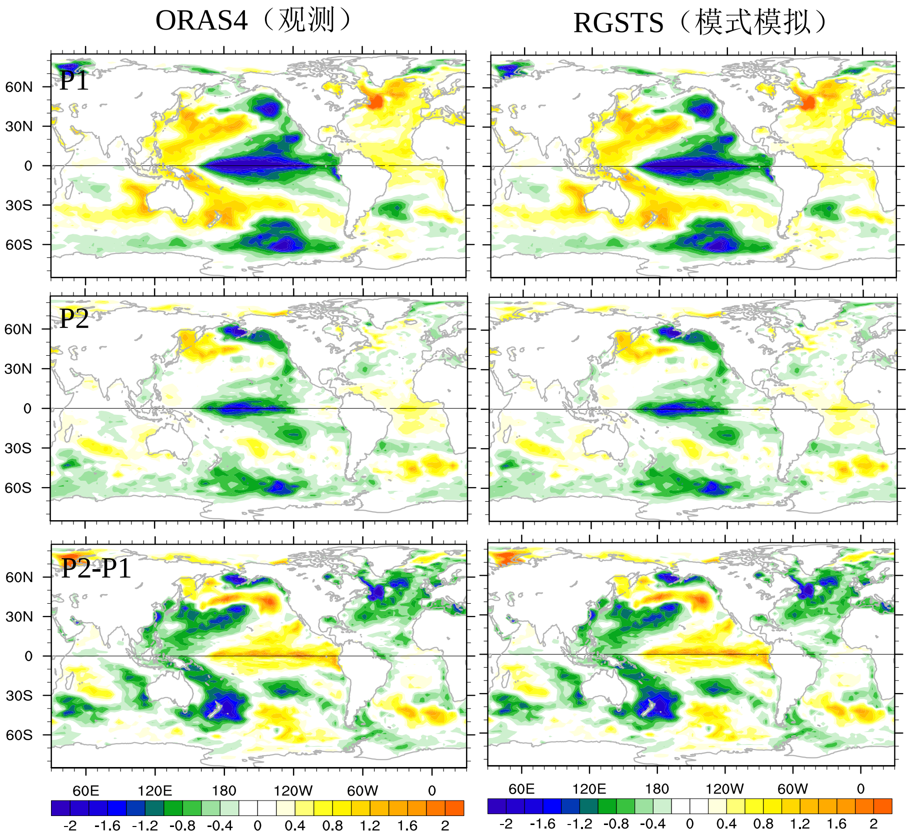
Restoring Global SST and SSS(RGSTS)

历史强迫模拟（HIS）



Warming trend (°C/10年)

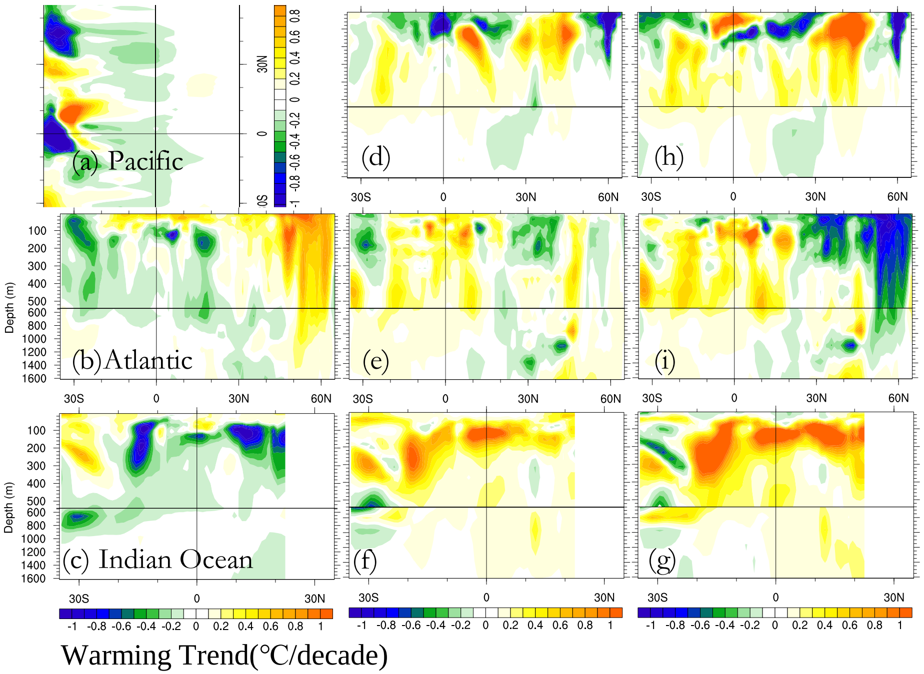
研究成果—表层海温模拟效果



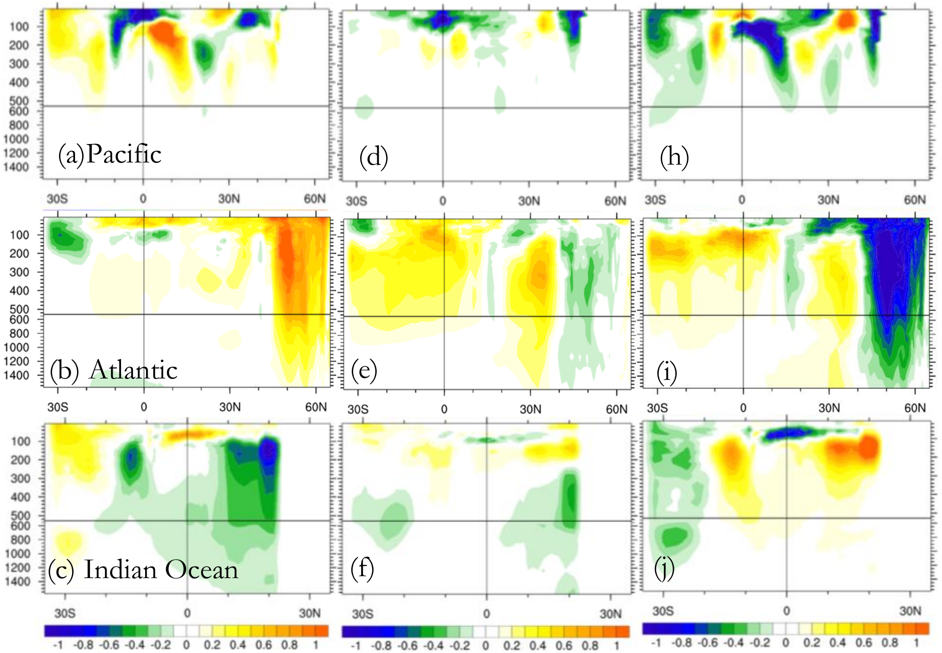
Warming trend (°C/10年)

研究成果—深层海温模拟效果

ORAS4（观测）



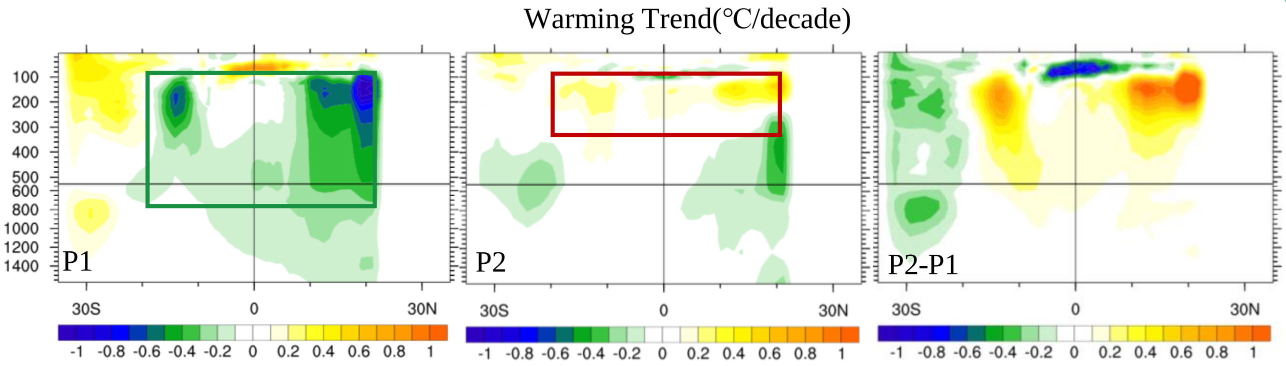
RGSTS（模式模拟）



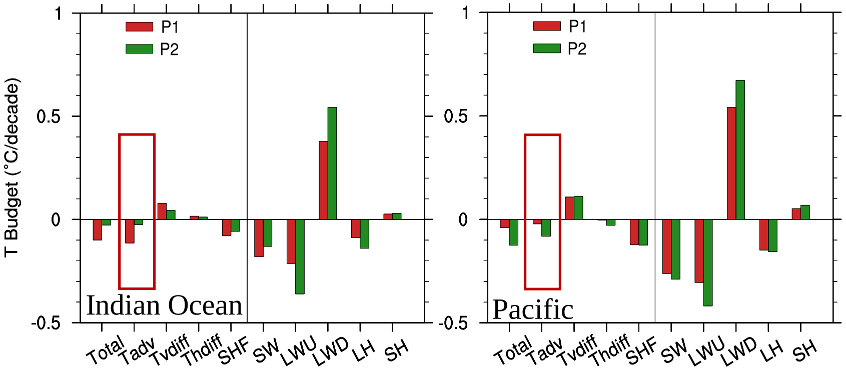
结论1

西太平洋、印度洋、北大西洋对增温停滞都有贡献。停滞期间，更多的热量集中在印度洋100-700米、大西洋中低纬100-1000米热量分布不均。

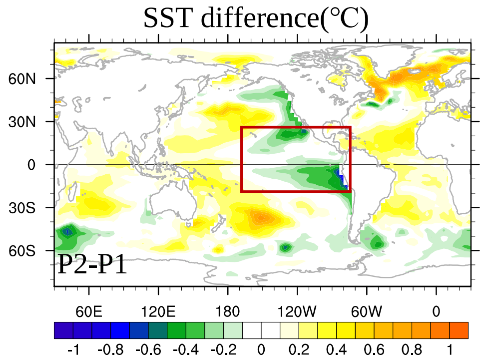
研究成果—印度洋

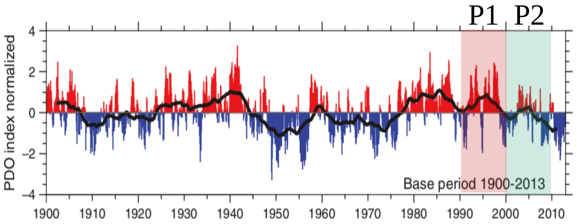


$$\frac{\partial T}{\partial t} = -\left(u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} + w\frac{\partial T}{\partial z}\right) + A_{\mathrm{H}}\nabla^2\mathrm{T} + \frac{\partial}{\partial z}\kappa\frac{\partial T}{\partial z} + \text{Heat Flux}$$

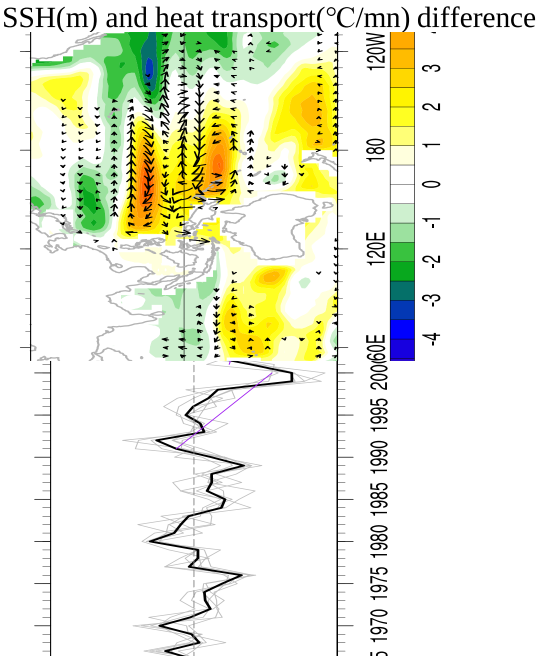


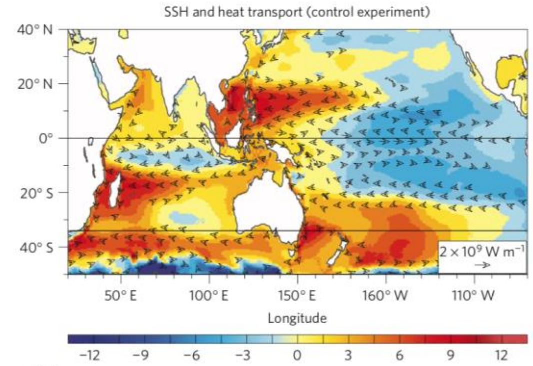
研究成果—印度洋P2热量更多的原因

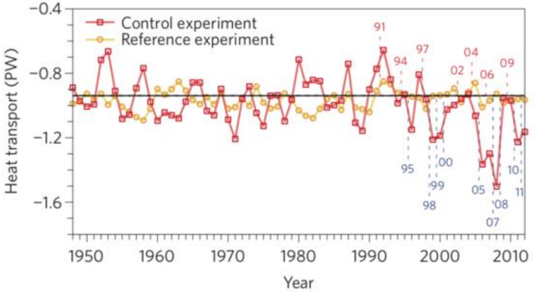




Trenberth and Fasullo, 2013

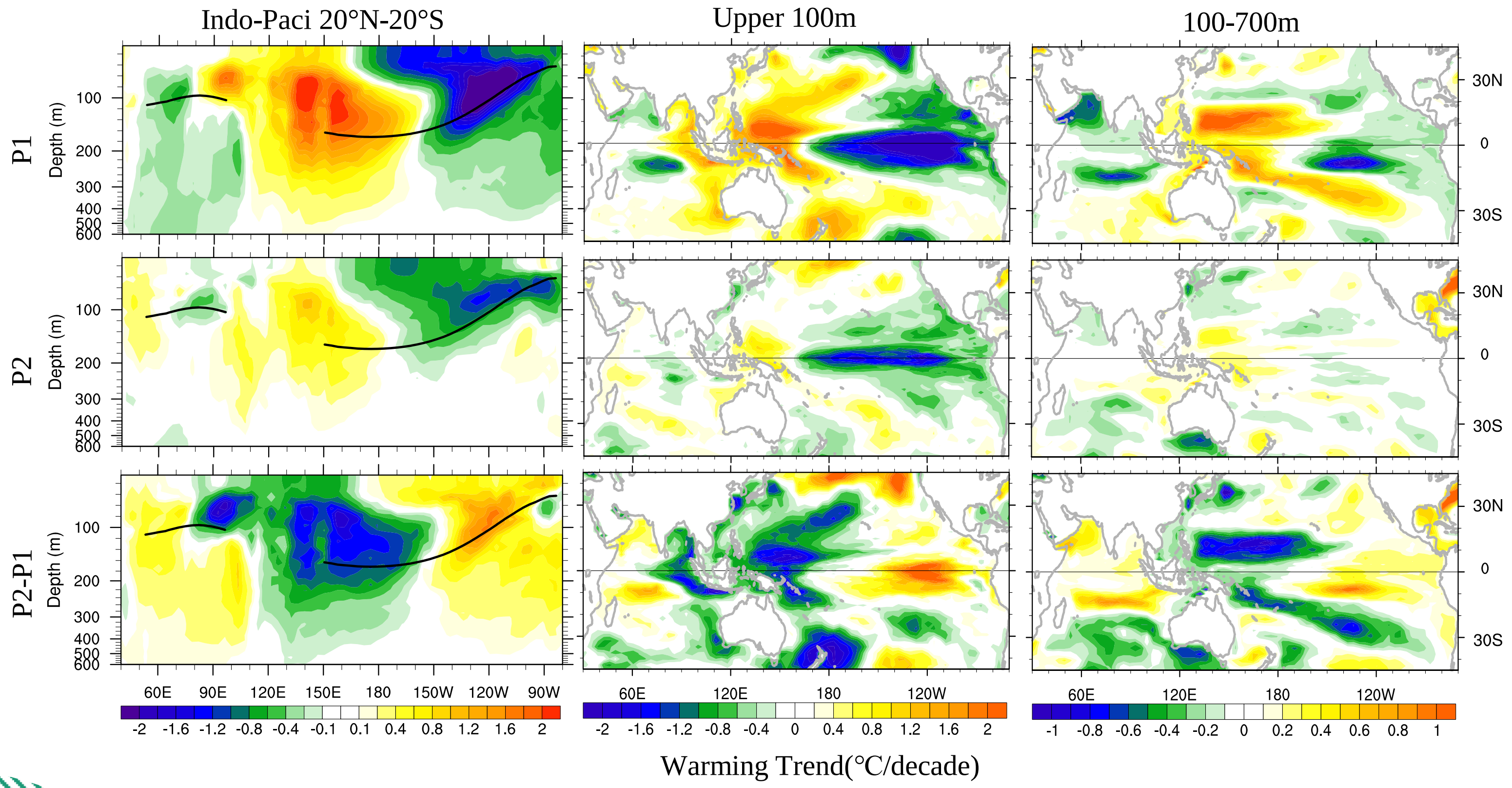




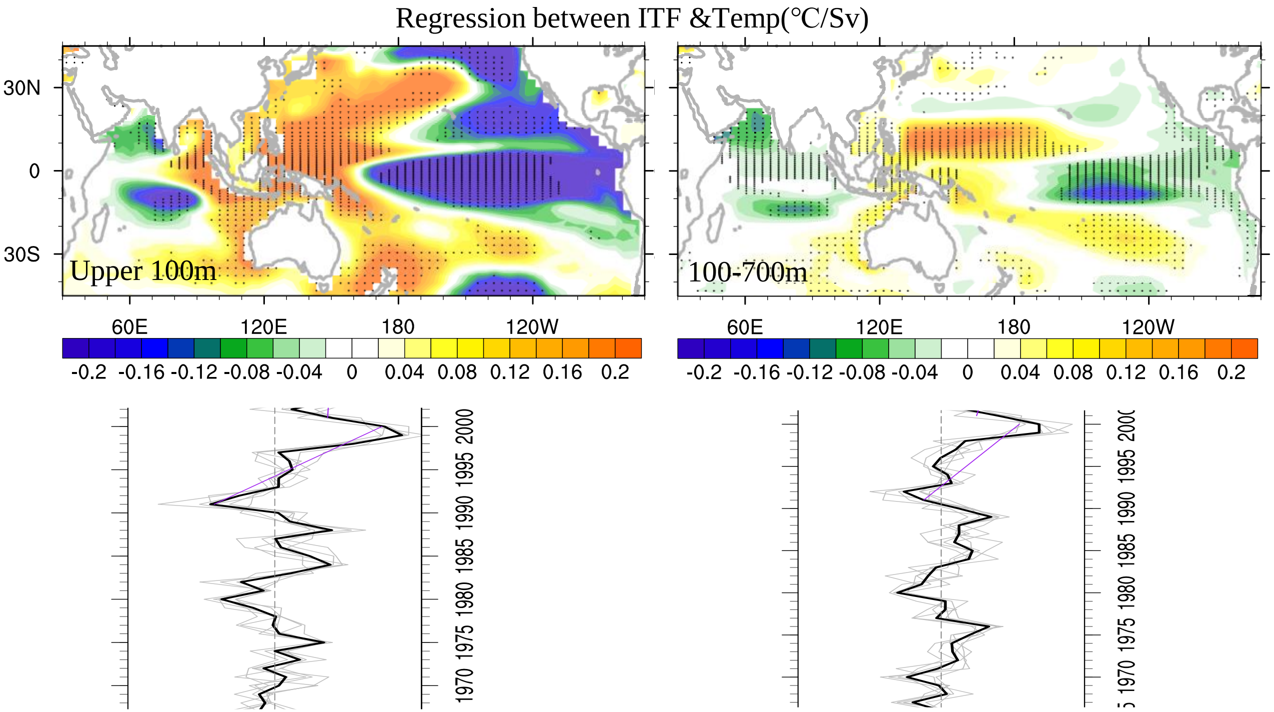


Lee et al.2015

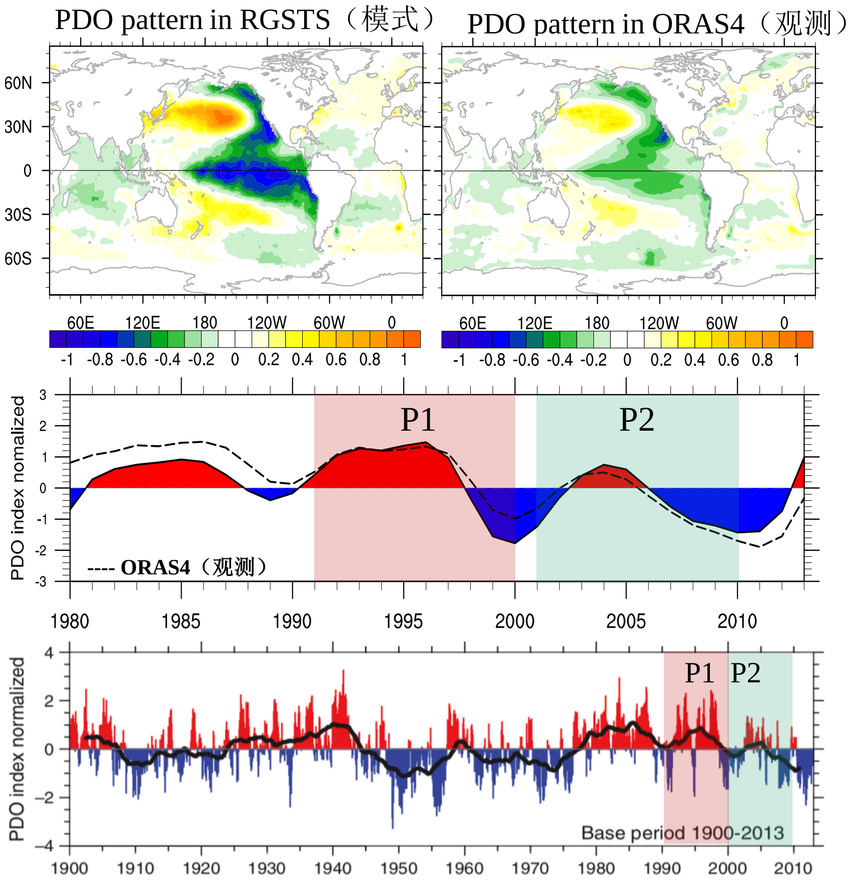
研究成果—印度洋P1热量更少且东西分布不均



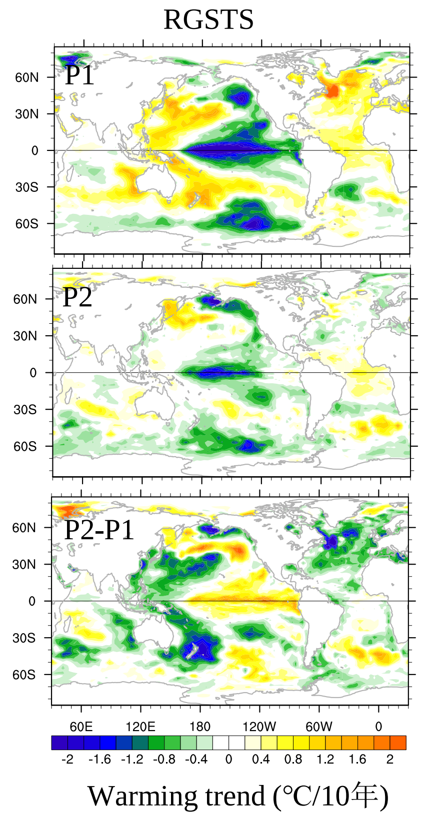
研究成果—西印度洋P1热量更少的原因



研究成果—西印度洋P1热量更少的原因

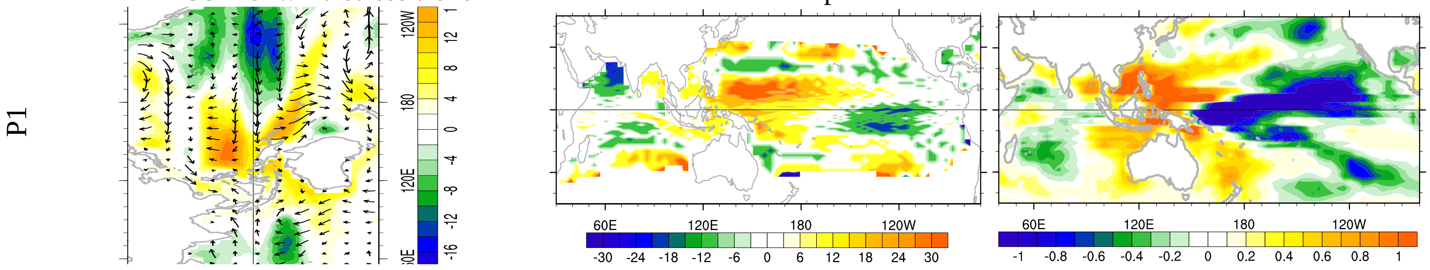


Trenberth and Fasullo, 2013



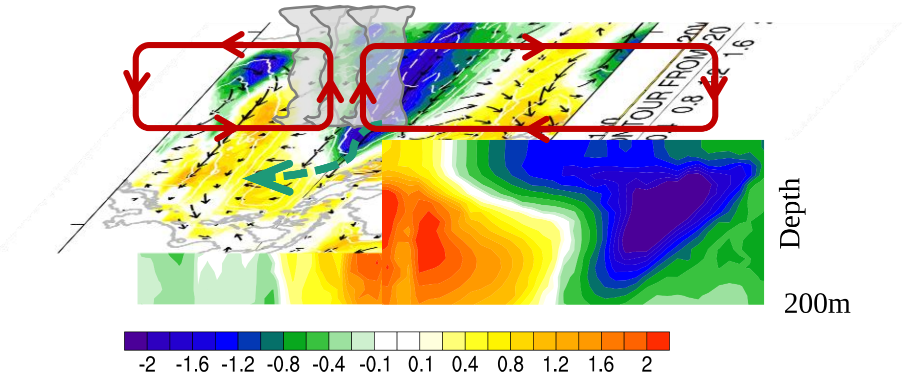
研究成果—西印度洋P1热量更少的原因

SSH & wind stress trend　　Thermocline depth trend　　PmE trend



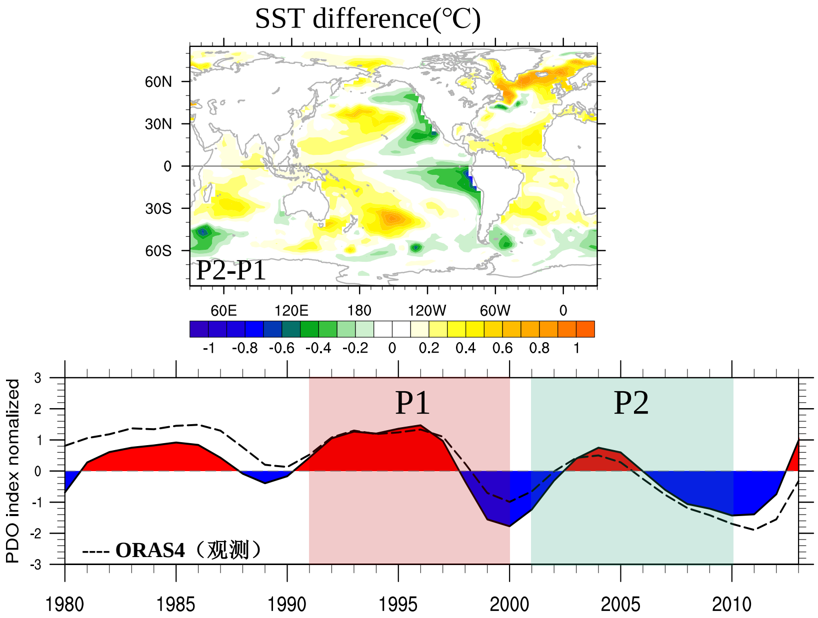
m/decade & dyne/cm²/decade　　m/decade　　kg/m²/s/decade

Schematic of temperature change rate in P1



研究成果—印度洋对增暖停滞的贡献机制

1



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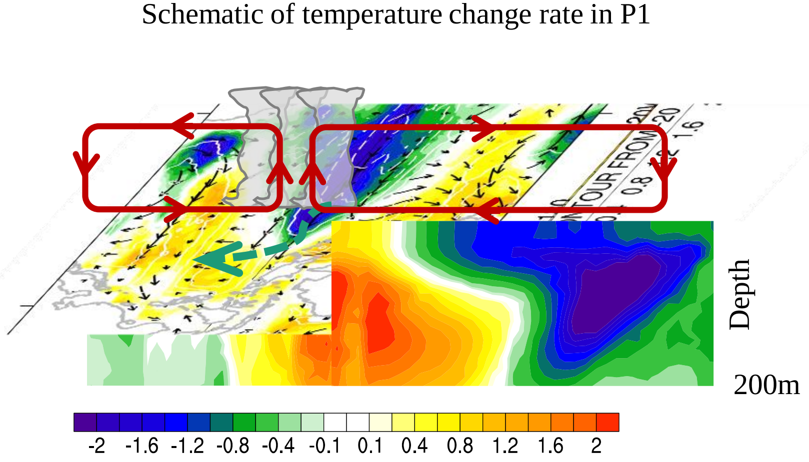


1. 增暖停滞期间（P2）太平洋呈**PDO负位相**，ITF增强，使印度洋次表层储存热量增多。

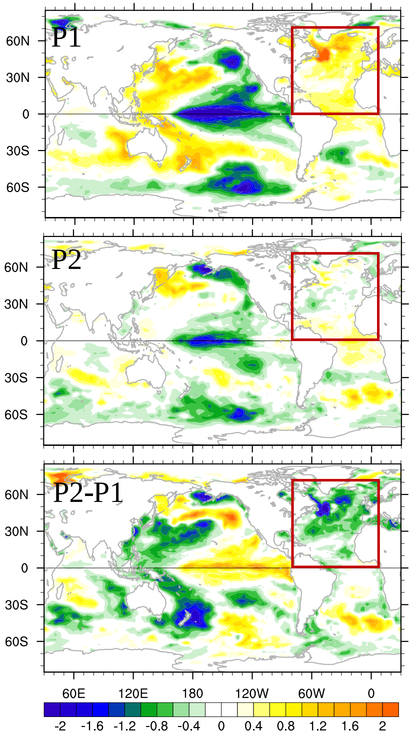
结论2

NEW

2. 快速增温期（P1）**PDO正位相向负位相转变**，沃克环流增强，局地海气耦合导致西印度洋次表层100-700米热量减少。

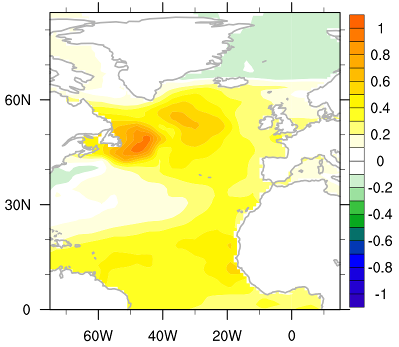
研究成果—大西洋表层机制

RGSTS（模式模拟）

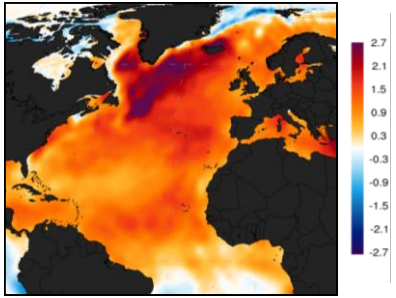


Warming trend (°C/10年)

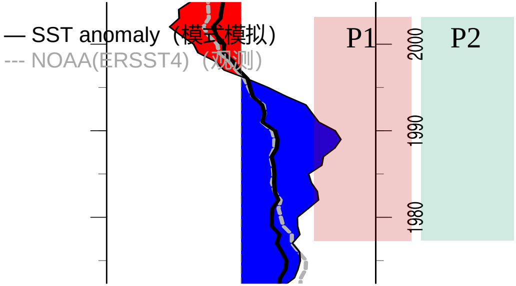
AMO pattern in RGSTS

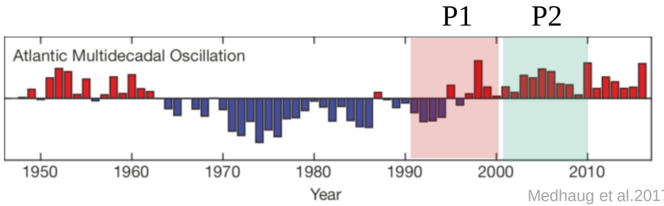


Atlantic Multidecadal Oscillation



Wikipadia



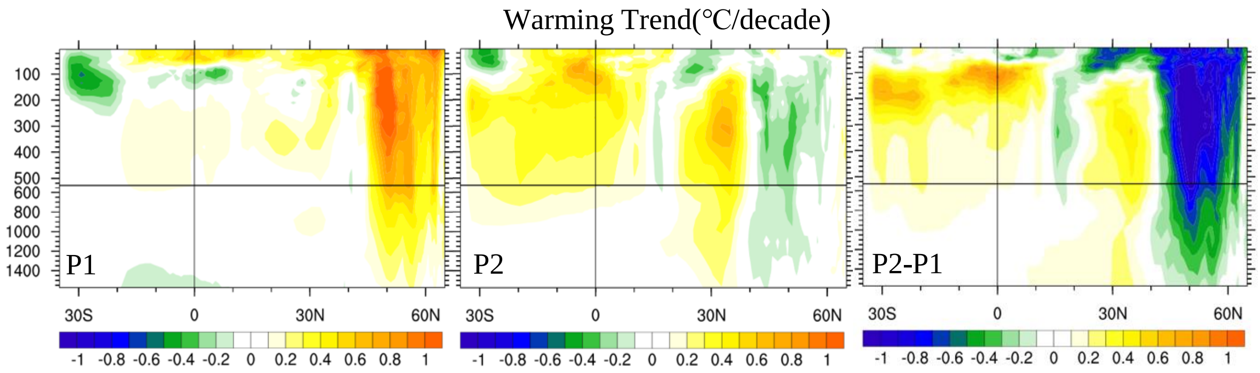


Medhaug et al.2017
Data from NOAA

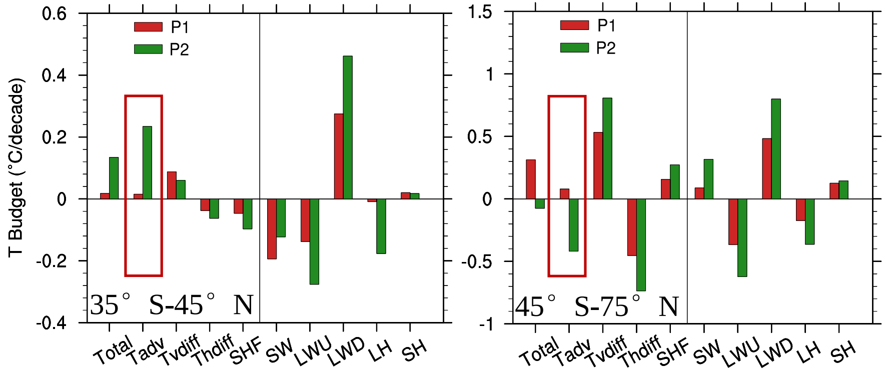
结论3

北大西洋SST变化趋势与AMO位相转变有关

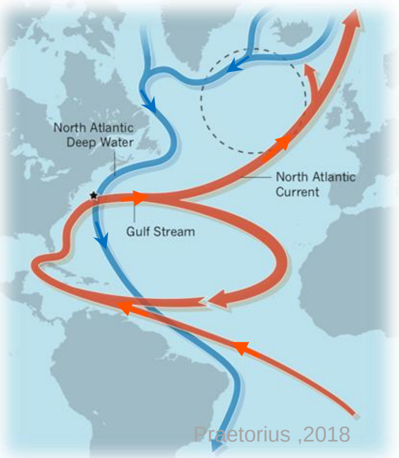
研究成果—大西洋次表层热量经向分布不均的机制

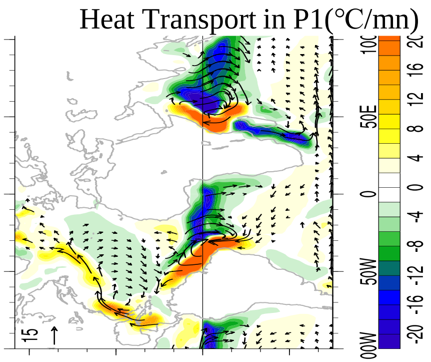


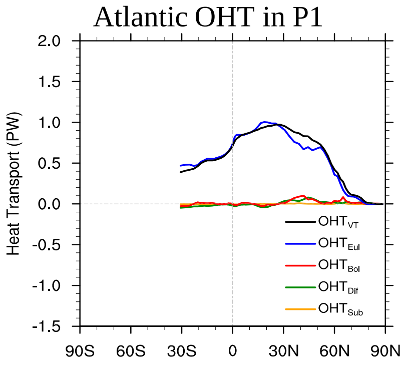
$$\frac{\partial T}{\partial t} = -\left(u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} + w\frac{\partial T}{\partial z}\right) + A_H\nabla^2 T + \frac{\partial}{\partial z}\kappa\frac{\partial T}{\partial z} + \text{Heat Flux}$$

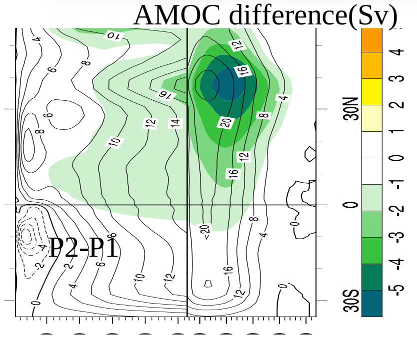


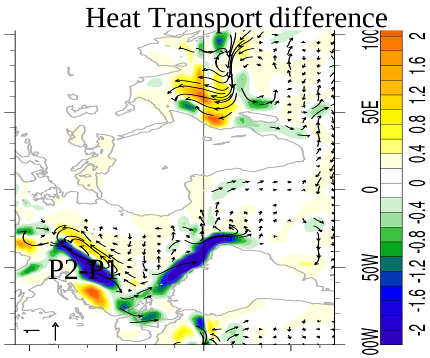
研究成果—大西洋次表层热量经向分布不均的机制

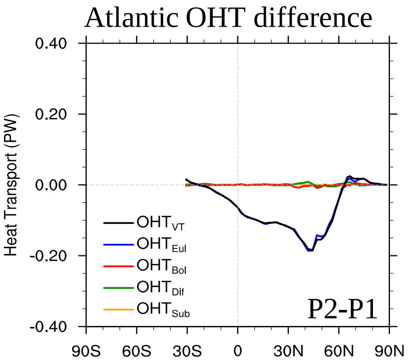






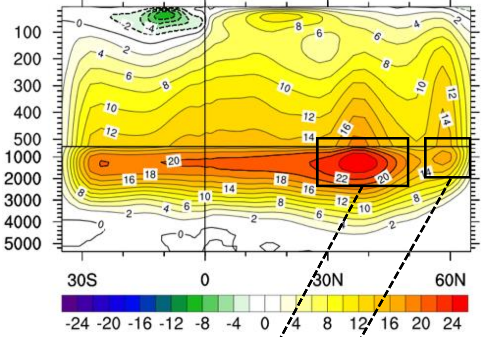




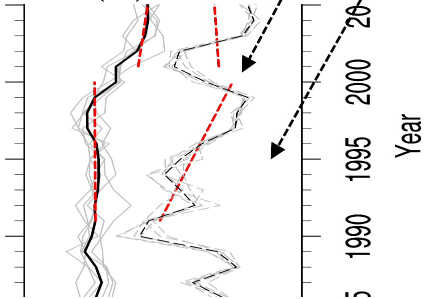


研究成果—大西洋AMOC的变化

AMOC in RGSTS(模式模拟，单位：Sv)

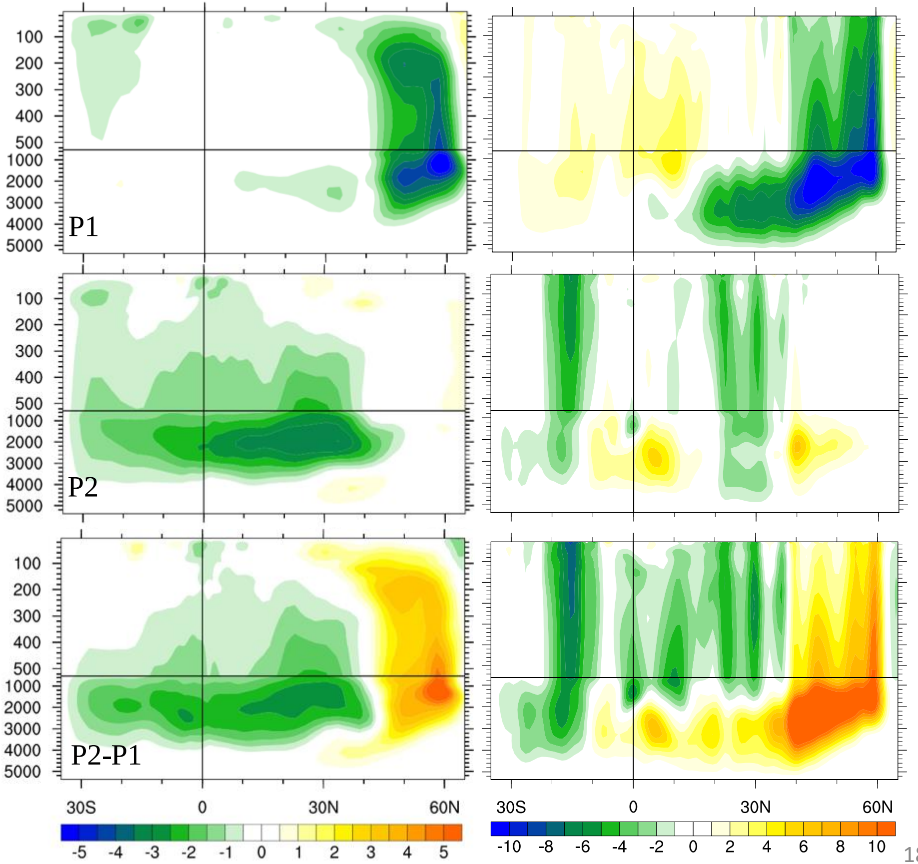


AMOC Index(Sv)

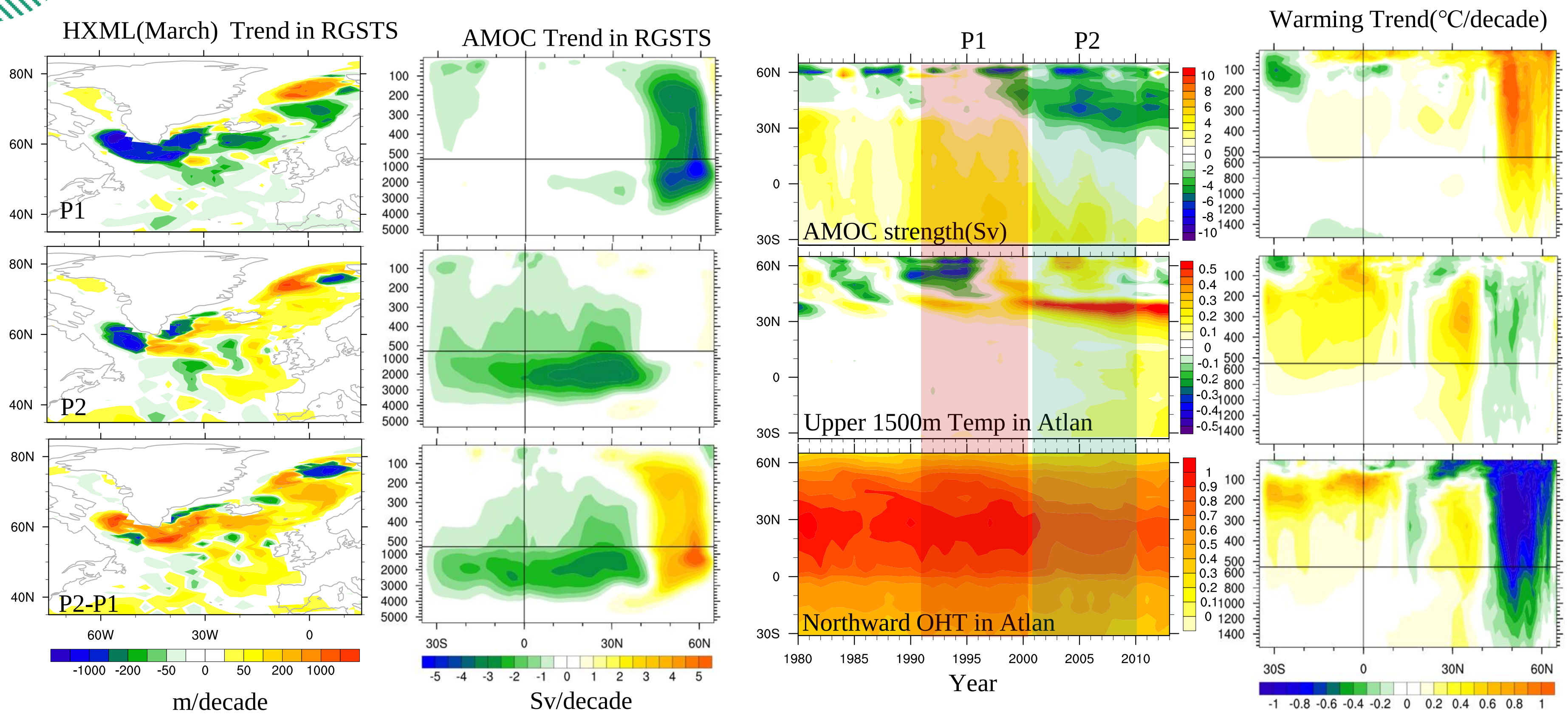


AMOC Trend in RGSTS（模式）

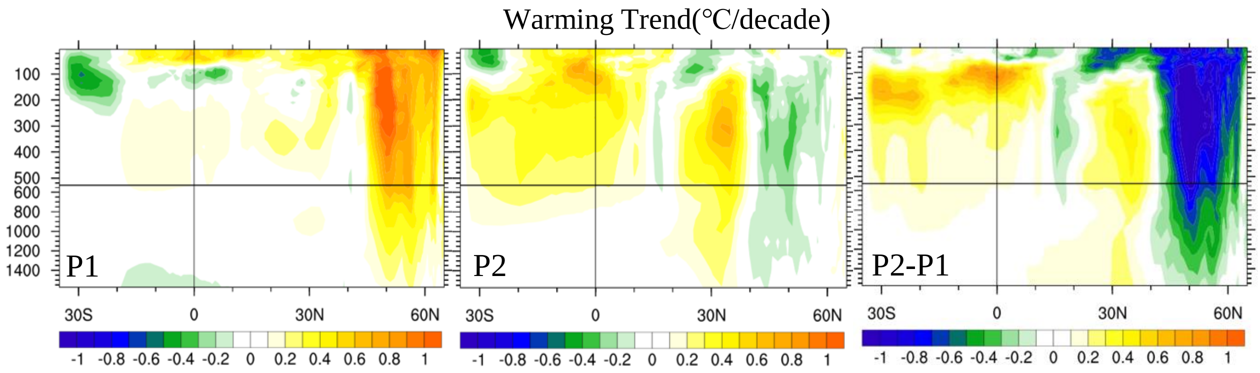
AMOC Trend in ORAS4 （观测， Sv/decade）



研究成果—大西洋AMOC变化对热量分配的影响



研究成果—AMOC对增暖停滞的贡献机制



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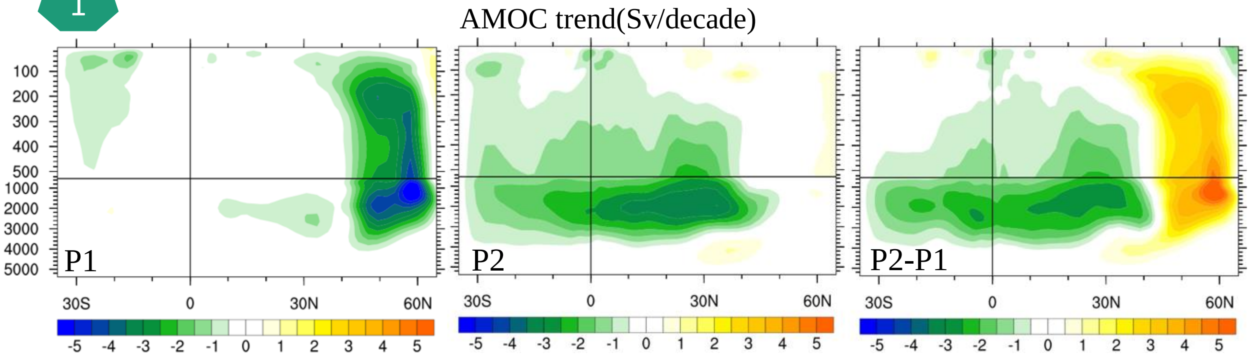

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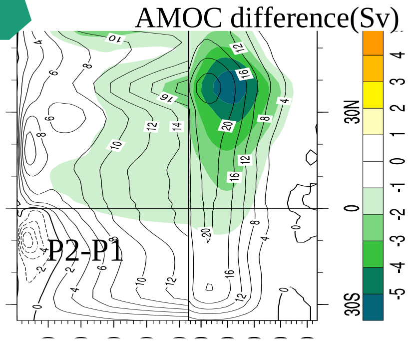
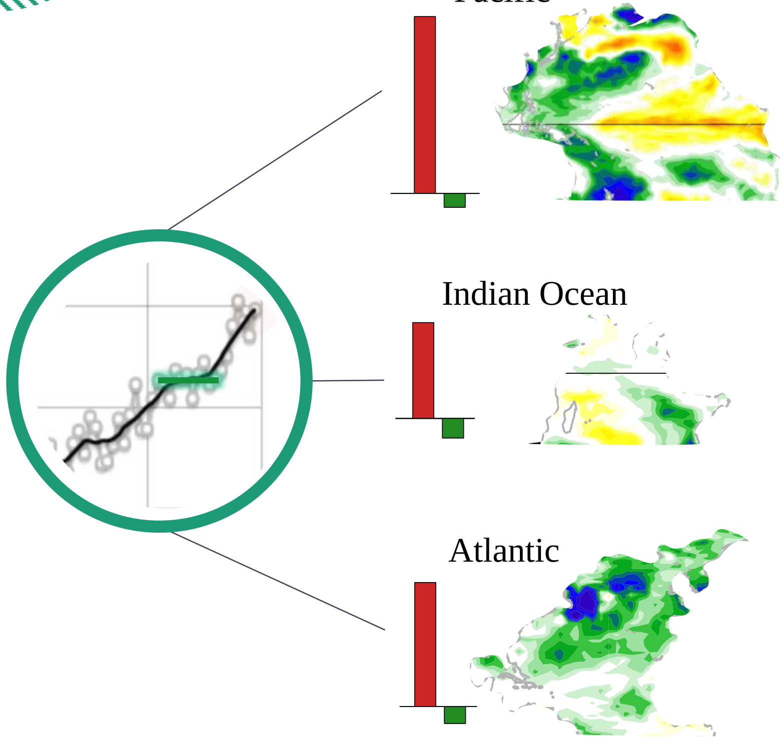


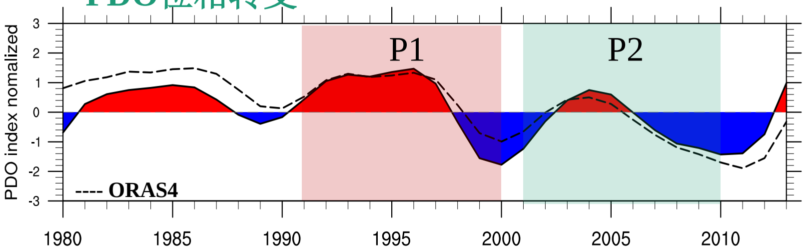
结论4

1.快速增温期（P1）深水形成逐渐减弱，使高纬度深层热量减少，且减弱信号逐渐南传。
2.增暖停滞期间（P2）AMOC减弱，OHT减弱，使中低纬度储存热量增多。

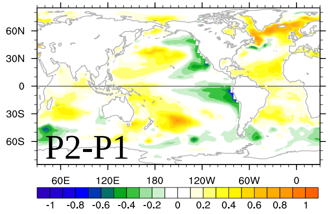
结论与展望—Hiatus（P2）-Surge（P1）



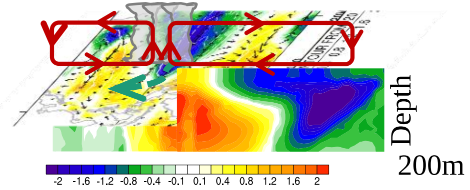
PDO位相转变



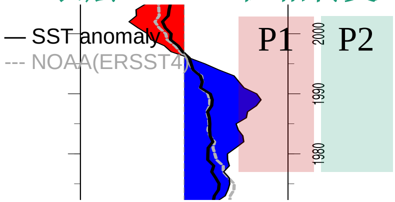
P2：PDO负位相→ITF↑



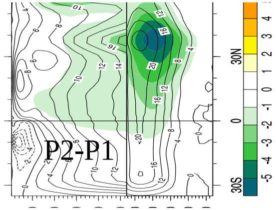
P1：PDO位相转变 NEW



表层：AMO位相转变 NEW



次表层：AMOC↓→OHT↓



结论 年代际自然变率对年代际增温趋势有调节作用。

结论与展望

- 全球变暖背景下BJC能够发生，是系统局地能量平衡的内在要求。BJC帮助维持气候系统稳定性。BJC通过大尺度经圈环流变化而实现。AMOC的变化由北大西洋淡水演变控制。
- 西太平洋、印度洋、大西洋对增温停滞都有贡献。停滞期间，更多的热量集中在印度洋100-700米、大西洋100-1000米。
- 增暖停滞期间太平洋呈PDO负位相，ITF增强，使印度洋次表层储存热量增多。快速增温期PDO正位相向负位相转变，沃克环流增强，局地海气耦合改变次表层热量分配状态。
- 北大西洋SST变化趋势与AMO位相转变有关。增暖停滞期间AMOC减弱，OHT减弱，使中低纬度储存热量增多。快速增温期深水形成逐渐减弱，并减弱信号逐渐南传，改变次表层热量分配状态。
- 年代际自然变率对年代际全球温度变化趋势有调节作用。印度洋局地海-气耦合、大西洋AMOC影响海洋热量分配。

1 AMO与AMOC变化关系

2 AMOC变化原因

3 大洋之间的联系

4 气候反馈和海洋垂直热量传输过程

参考文献

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Thank you for your attention!

Q&A