全球变暖停滞现象的耦合模式模拟研究

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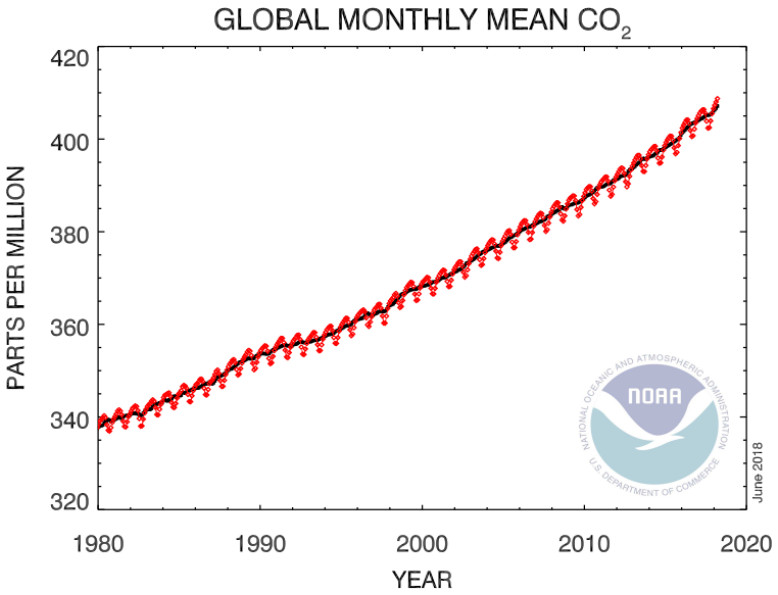
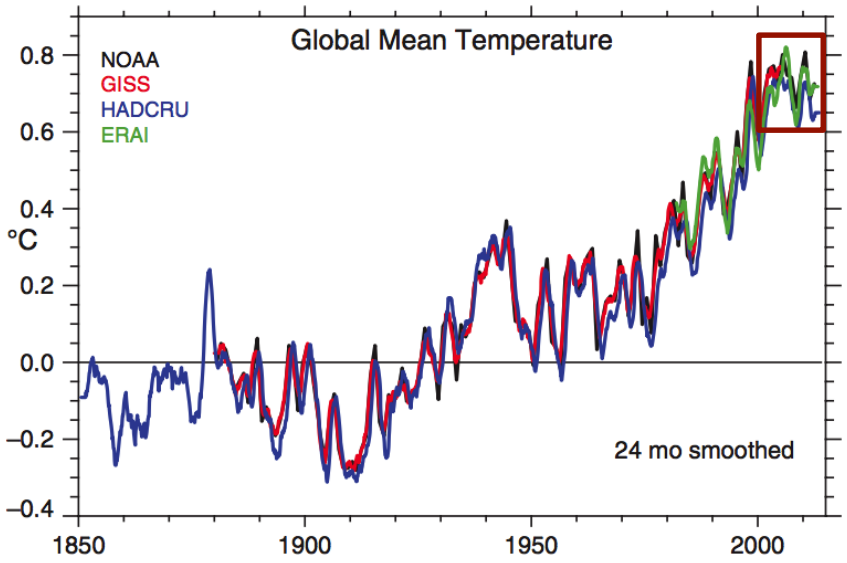
研究背景

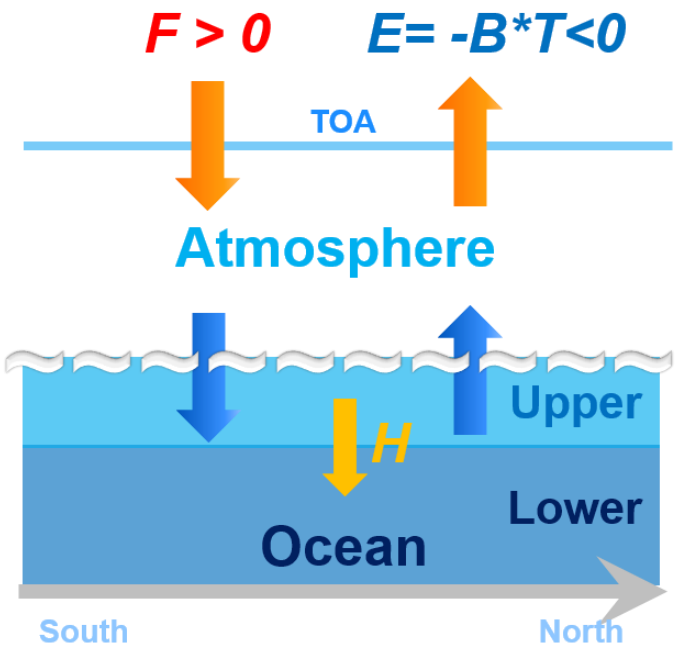


https://www.esrl.noaa.gov/gmd/ccgg/trends



Trenberth et al. (2013)

研究背景



$$C_1 \frac{dT_1}{dt} = F - BT_1 - \gamma(T_1 - T_2)$$

$$C_2 \frac{dT_2}{dt} = \gamma(T_1 - T_2)$$

Solomon et al. (2010), Kaufmann et al. (2011)

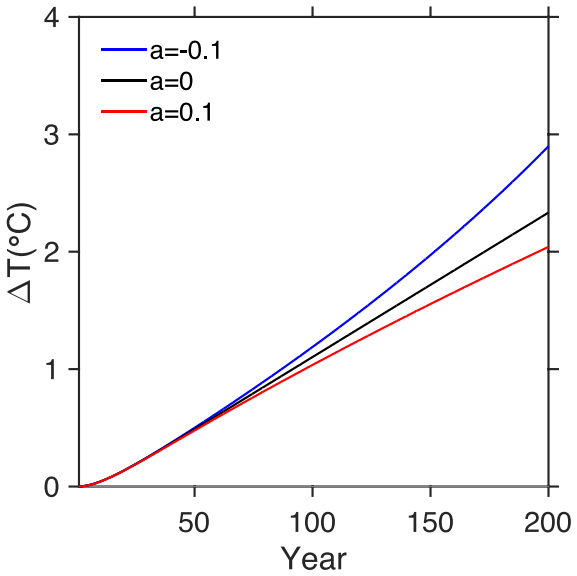
Gregory et al.(2015), Yoshimori et al.(2016)

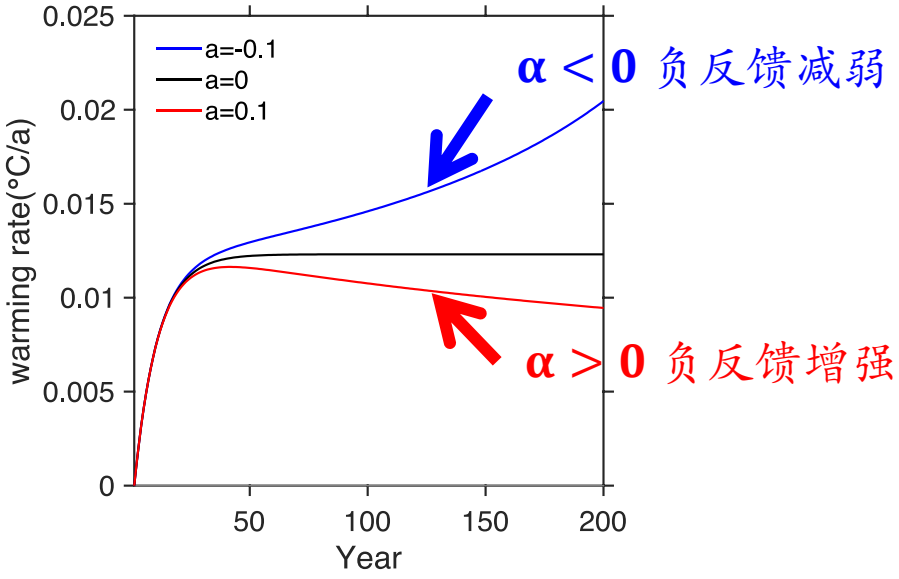
假说：气候反馈和海洋热量吸热的变化➔Hiatus (?)

研究背景

$$C\frac{d\Delta T}{dt} = \Delta F(t) - (B + \alpha\Delta T)\Delta T$$

$$\alpha\ (\mathrm{W}m^{-2}K^{-2}) \begin{cases} > 0, \text{负反馈增强} \\ = 0, \text{反馈率不变} \\ < 0, \text{负反馈减弱} \end{cases}$$





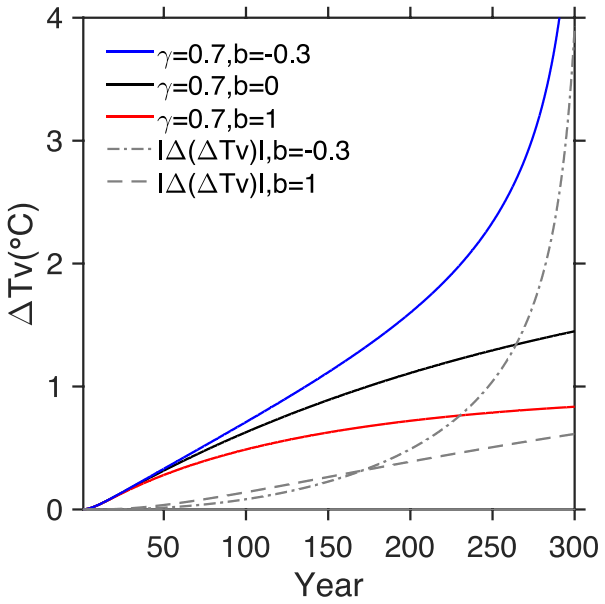
研究背景

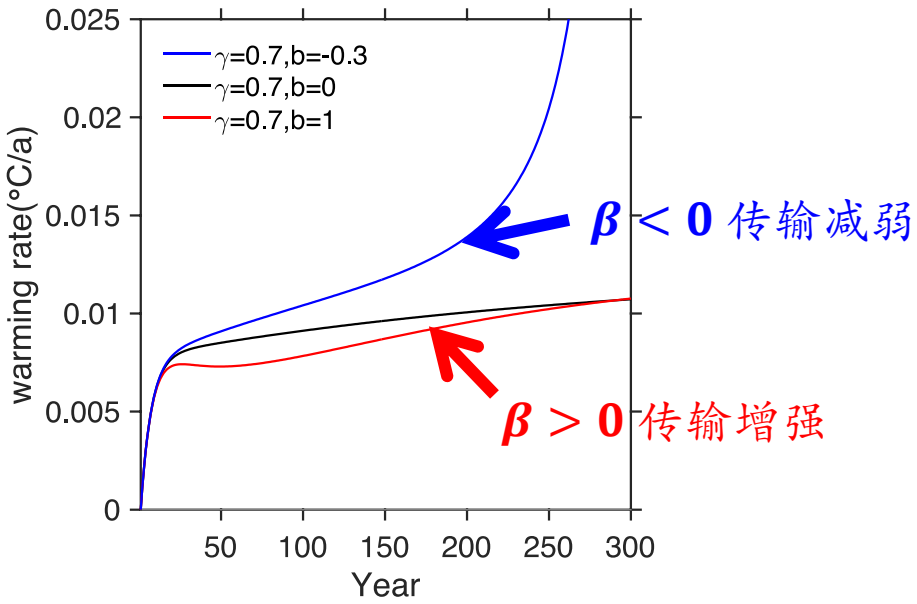
$$C_1\frac{d\Delta T_1}{dt}=\Delta F(t)-B\Delta T_1-(\gamma+\beta\Delta T_v)\Delta T_v;$$

$$C_2\frac{d\Delta T_2}{dt}=(\gamma+\beta\Delta T_v)\Delta T_v$$

$$\Delta T_v=\Delta T_1-\Delta T_2$$

$$\beta\ (\mathrm{W}m^{-2}K^{-2})\begin{cases}>0, \text{向下热量传输增强}\\ =0, \text{向下热量传输不变}\\ <0, \text{向下热量传输减弱}\end{cases}$$

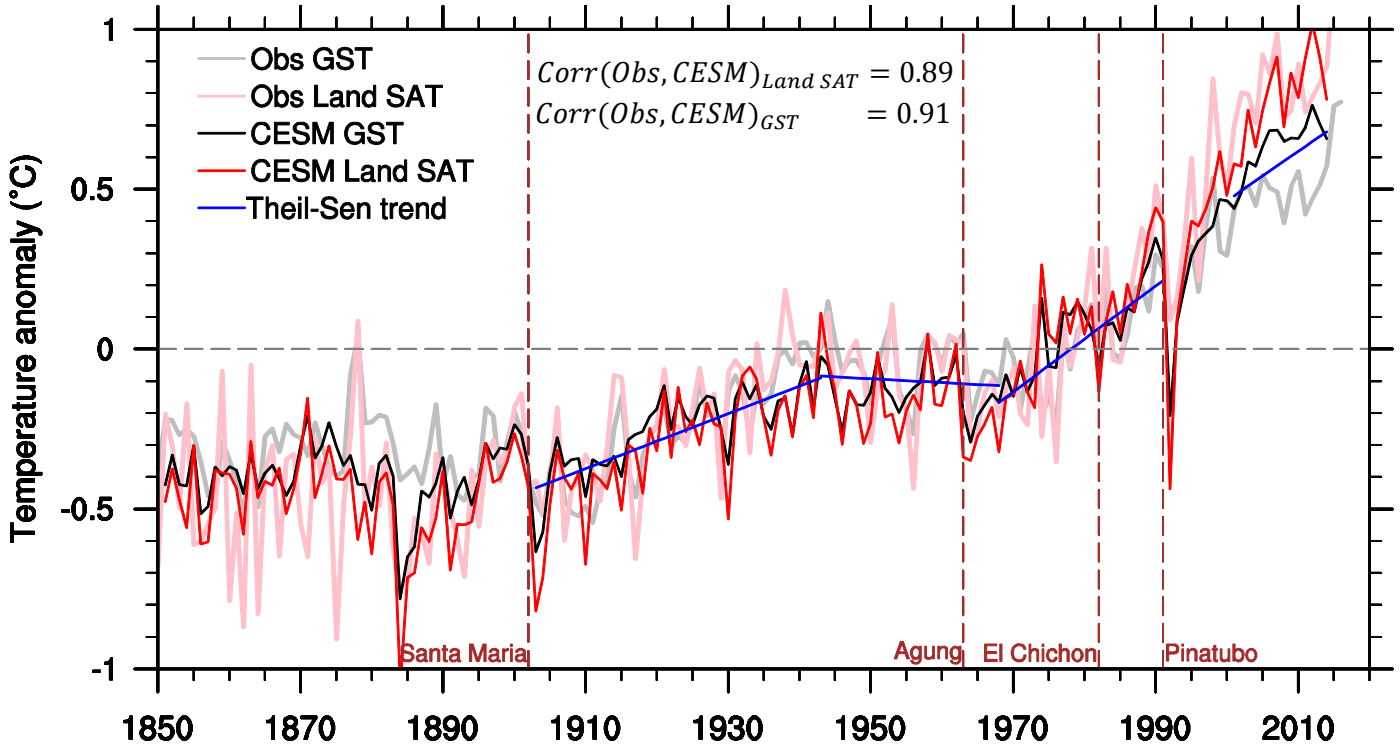




问题：

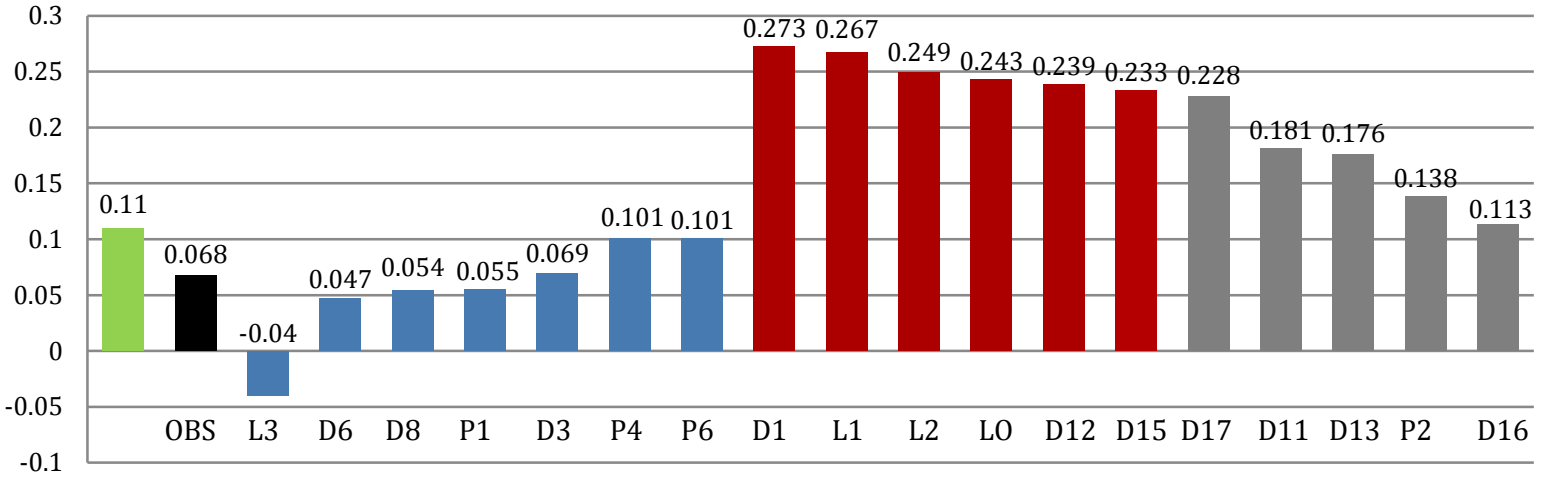
气候反馈和海洋热量吸收在现实世界里的变暖停滞中起到作用了吗？

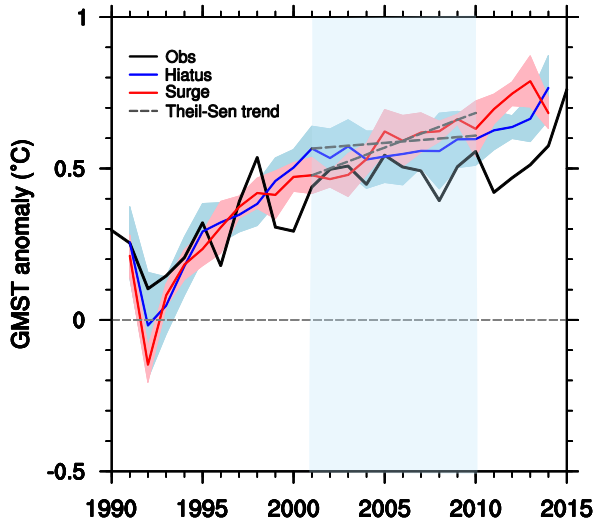
CESM历史强迫模拟与观测对比

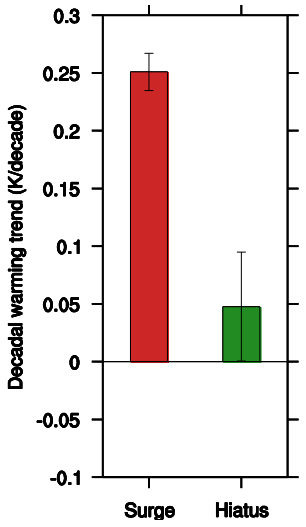


Hiatus组和Surge组增温率对比

表1 观测和18组集合实验中2001-2010年全球平均表面温度增温率(℃/decade)







增温率(℃/decade)

Obs: 0.068

Hiatus: 0.047

Surge: 0.229

图1 Hiatus和Surge组温度变化（左），两组2001-2010年增温率对比（右）

Hiatus组和Surge组气候反馈率对比

$$C\frac{d\Delta T}{dt} = \Delta F(t) - B\Delta T = \Delta TOA \text{ net radiation flux}$$

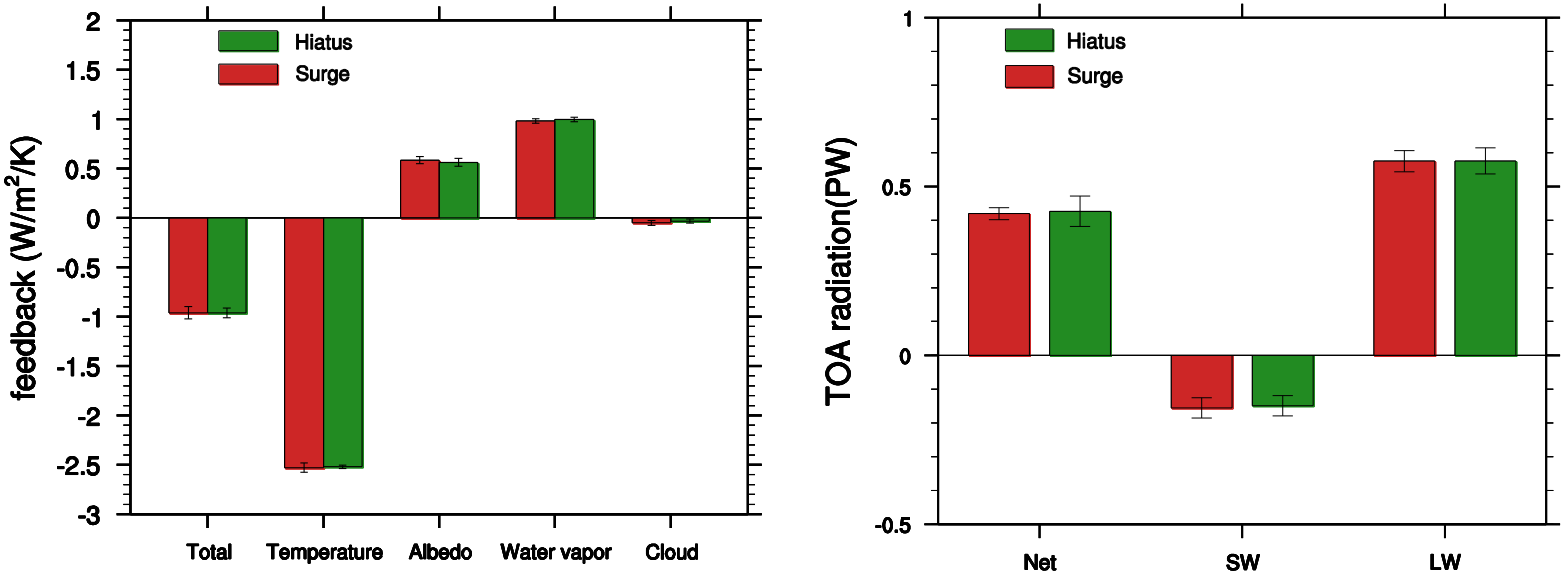


图2 Hiatus和Surge组2001-2010年气候反馈率（左），
大气层顶辐射通量变化趋势（右）对比

Hiatus组和Surge组海洋热含量（OHC）对比

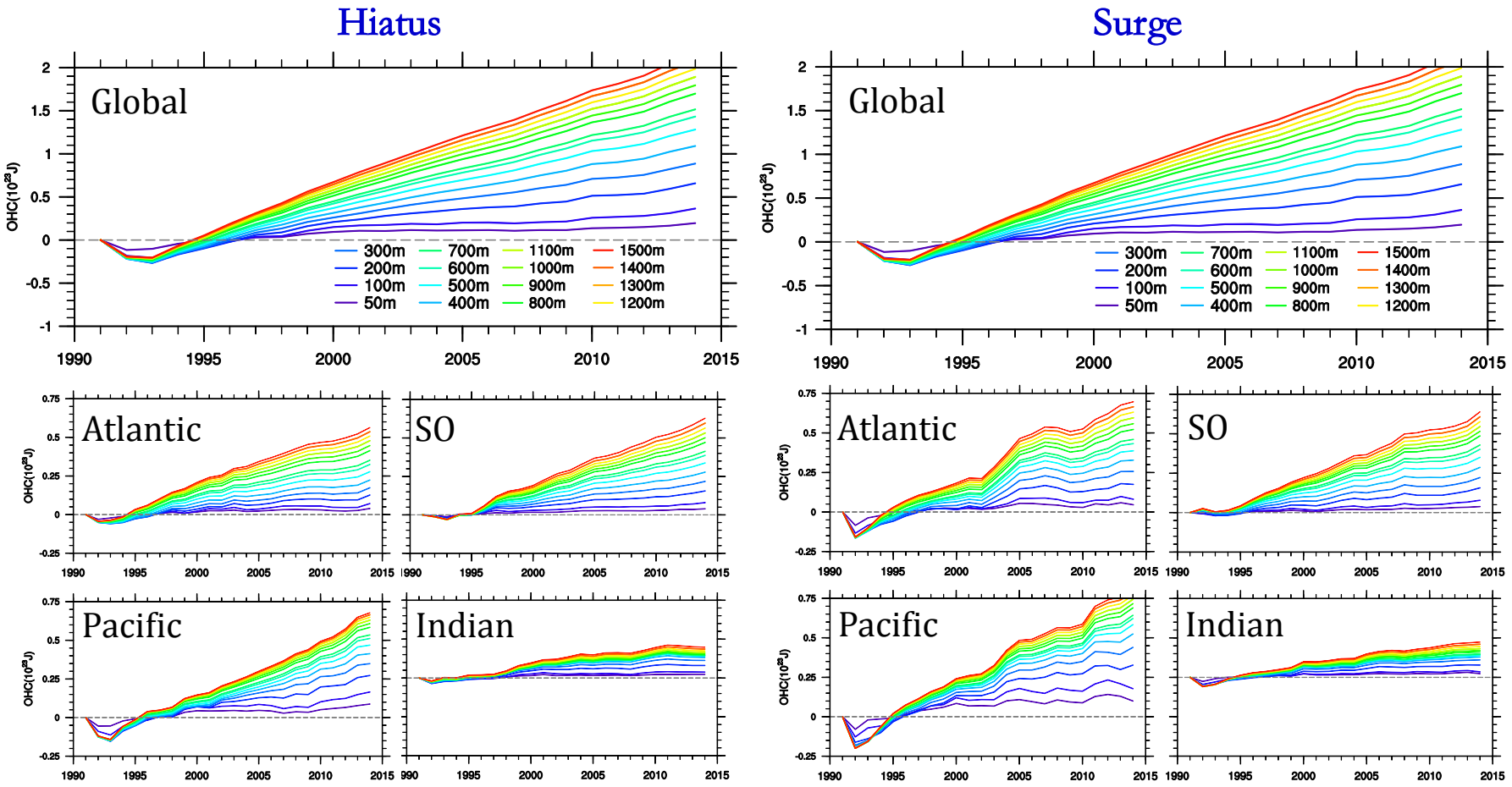


图3 Hiatus和Surge组全球海洋及四个洋盆从表层到50,100,~1500m的OHC

Hiatus组和Surge组海洋热含量（OHC）垂直分布对比

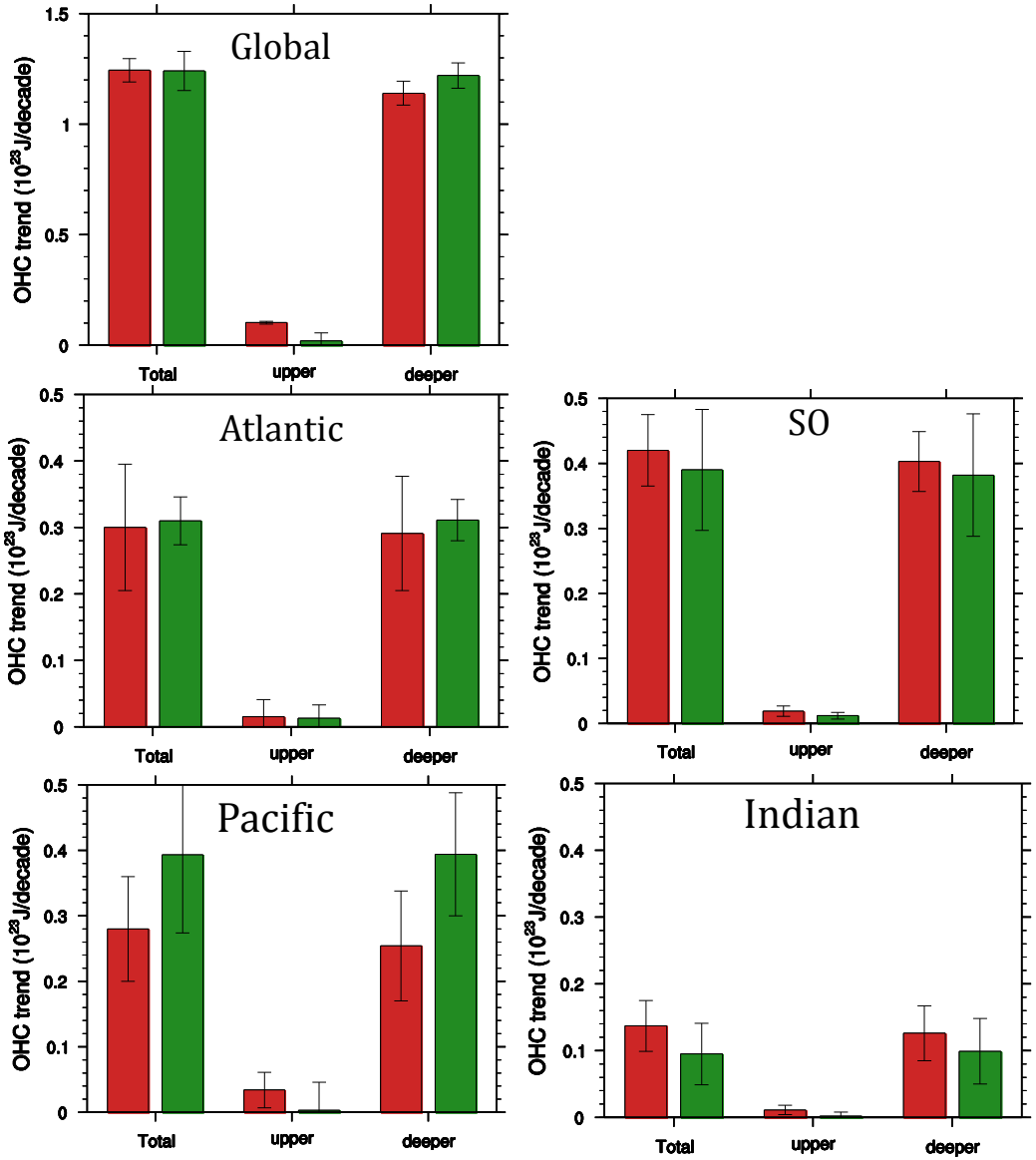
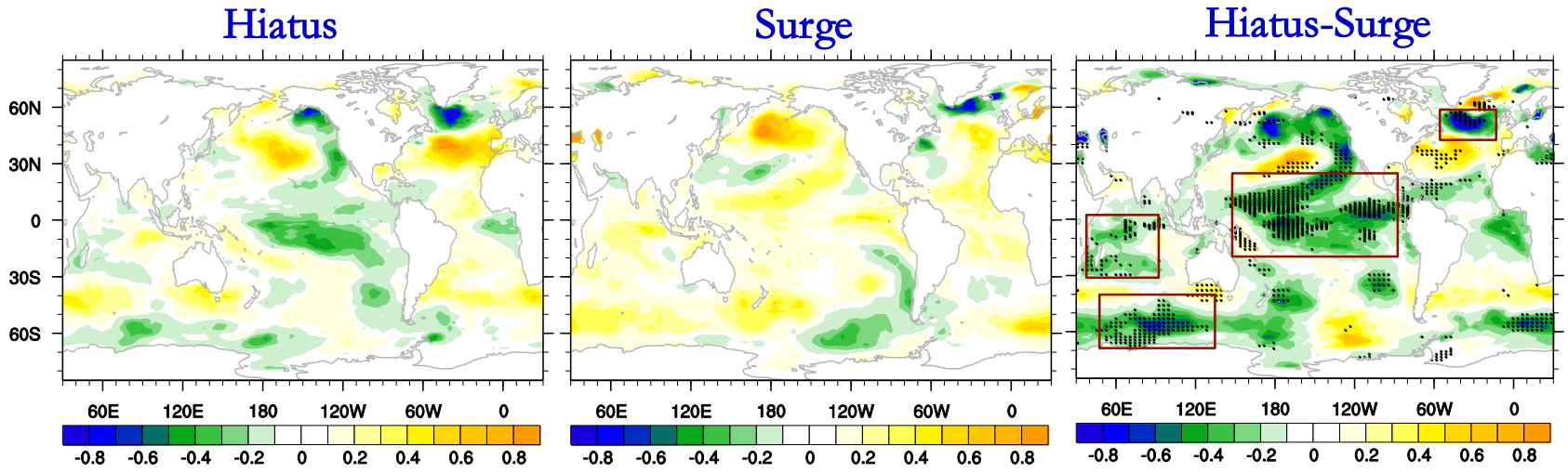
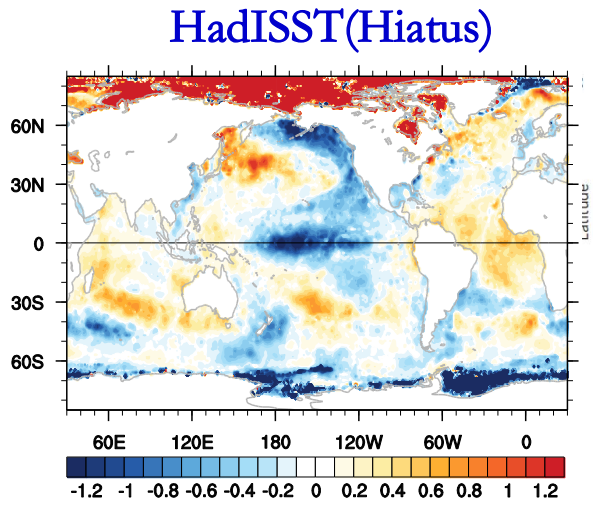
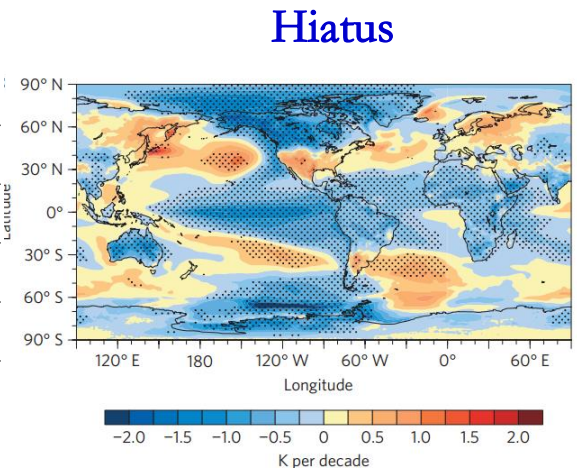


图4 Hiatus和Surge组海洋热含量分布对比，error bar为加减一倍标准差

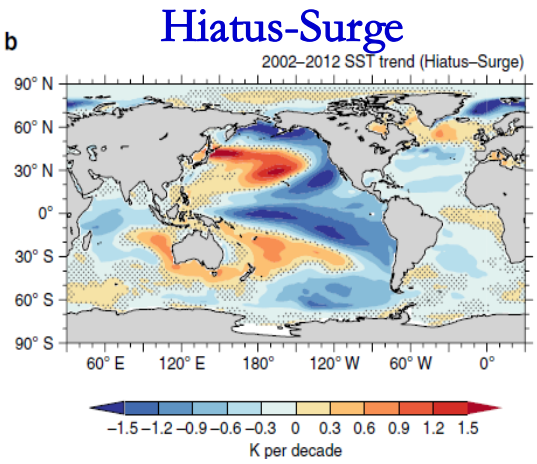
Hiatus组和Surge组SST 变暖趋势空间分布对比







Meehl et al. (2011)



Liu et al. (2015)

Hiatus组和Surge组各洋盆内部OHC分布对比

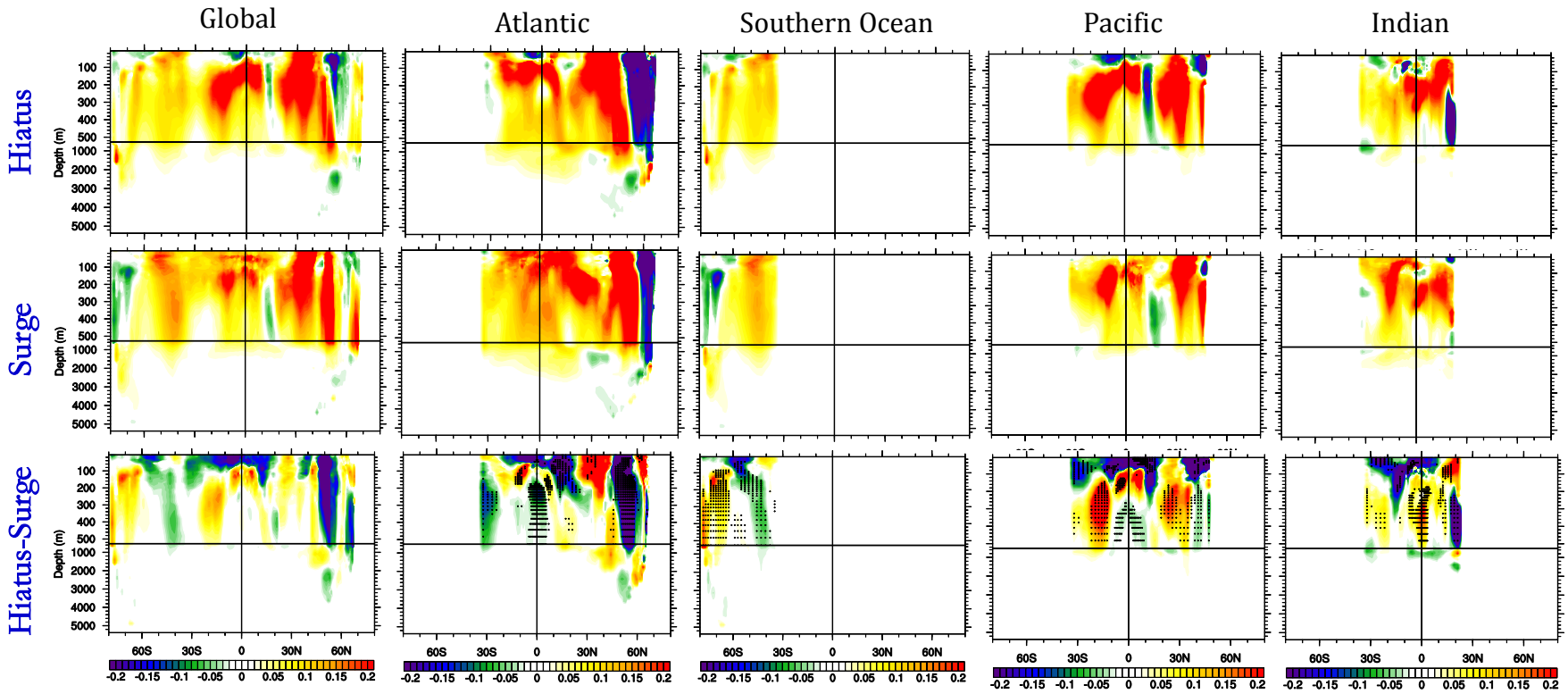
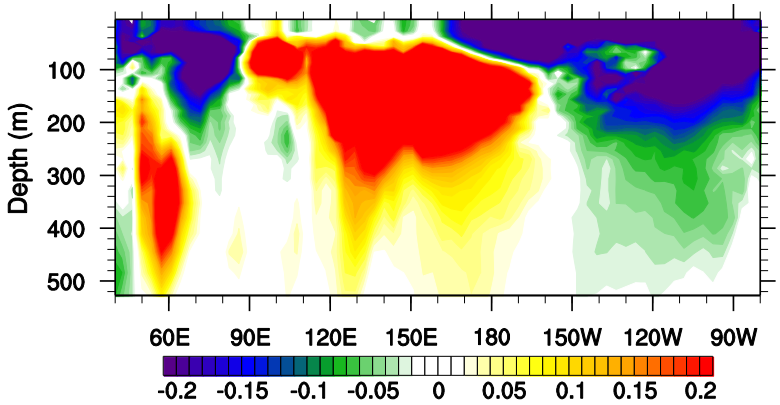
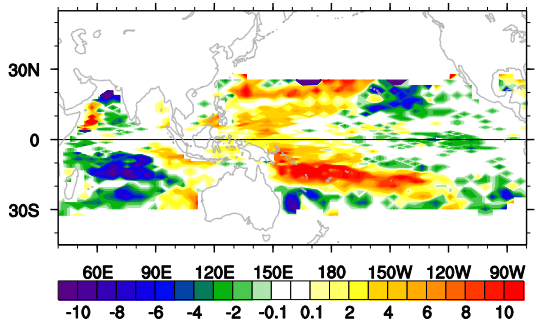


图5 Hiatus和Surge组2001-2010年全球及各洋盆纬向平均温度变化趋势及两组间的差异





Summary and Discussion

- Hiatus under linear heating
  - Possible
- New mechanisms
  - Enhancing **negative** climate feedback
  - Enhancing downward heat mixing (?) (Short)
  - Ocean circulation (? to be investigated)
- How to realize in real world?
  - Understanding climate feedback first!

LaCOAS

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Thanks