Internal variability generating hiatus periods in high resolution simulations

PRIMAVERA: High resolution climate processes - 561

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1. Motivation

Introduction
There have been decades, such as the 2002-2009, where the observed global-mean SST showed zero or negative trends. It has been suggested that such periods are associated with periods of increased ocean heat uptake[1,2].

Research Questions What is the relationship between SST trends and ocean heat content at different depths arising solely from natural climate variability? What is the impact of atmospheric resolution?

Model Met office Hadley Centre Global Environment Model version 3 (HadGEM3-GC2)[3]. It includes the NEMO ocean model and CICE sea ice model at ORCA025 resolution (~30 km), coupled to the atmosphere UM model at N216 resolution (~60km) and N512 resolution (~30km).

Experiments 100 years long with constant present day forcing:
- Exp1-AtmLR with HadGEM2-Atmosphere N216, Ocean ORCA025
- Exp2-AtmHR with HadGEM2-Atmosphere N512, Ocean ORCA025

2. Sea surface temperatures

SST decadal trends arising from climate variability as big as 0.3 degK/decade in Exp1-AtmLR, weaker in Exp2-AtmLR (Fig 1).

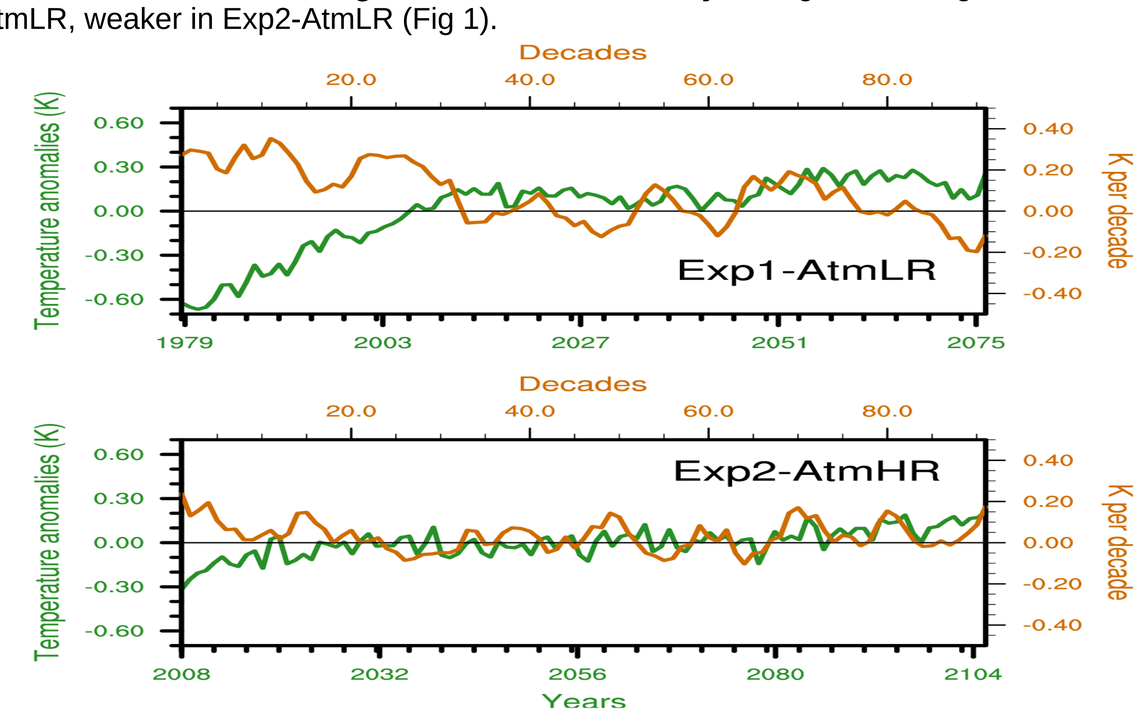

Fig 1: Global mean SST anomalies with respect to the 100-year means in K (green lines) and 10-year linear trends in SST for overlapping running decades (orange lines) in K/decade.

3. Composite trends of sea surface temperatures

Different patterns of SST warming In Exp1-AtmLR, the warming (cooling) decades are associated with a predominant warming (cooling) in the Southern Ocean, Tropical Pacific and Indian Ocean. In Exp2-AtmHR the warming (cooling) decades are associated mostly with a warming (cooling) in the tropical and northern Pacific. The Southern Ocean, whereas is not noticeably warmer in the warming decades, is colder (in South Pacific) in the cooling decades.

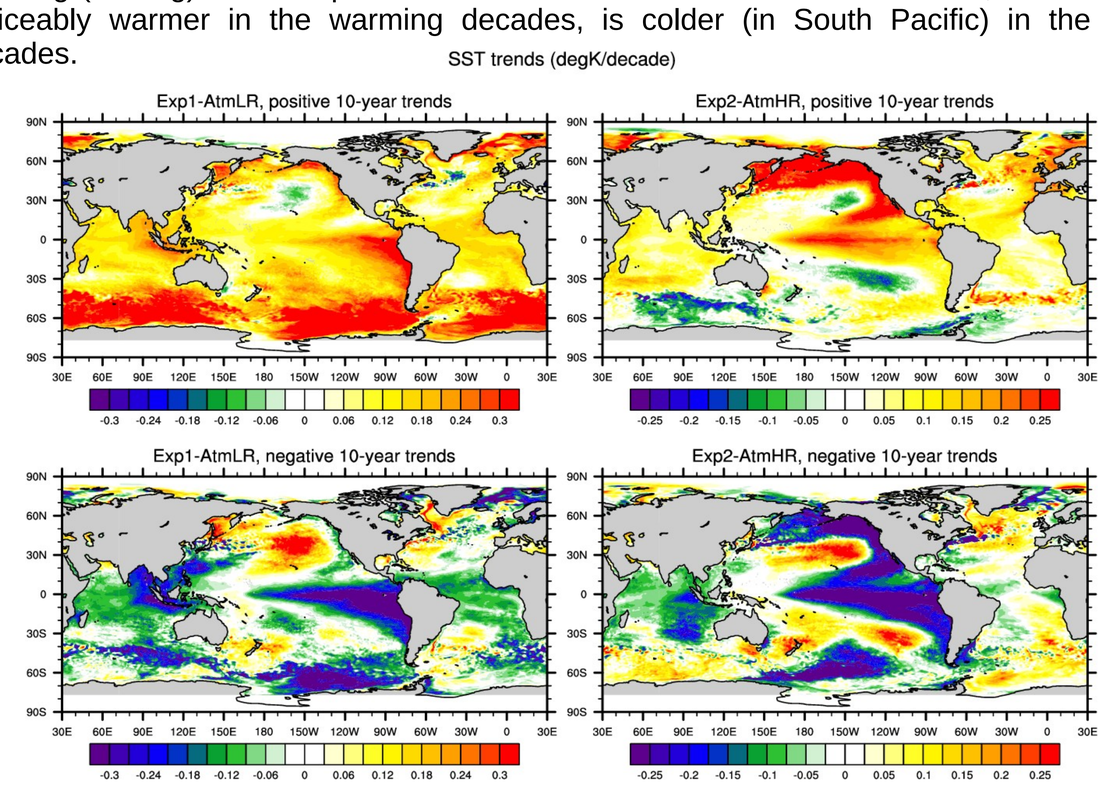

Fig 2: 10-year linear trends in SST in K/decade, for positive (top row) and negative (bottom) trend decades.

4. SST and ocean heat content

Global mean ocean heat content trends in the deeper ocean (>800m) correlates with the global mean SST trends in Exp1-AtmLR (Fig 3). In Exp1-AtmLR, warm (cold) SST trends are associated with a cooling (warming) of the Indian Ocean, mid-Atlantic, and, less so, Pacific Ocean, below 800m (Fig 4). Conversely, warm SST trends are associated with a warming of the Southern Ocean at all depths (Fig 4). In Exp2-AtmHR the link between SST trends and ocean heat content trends below 800m is noisier and less clear. This might imply different mechanisms at work in the two experiments, or perhaps insufficient OHC drift removal in Exp2-AtmHR (assumed linear here).

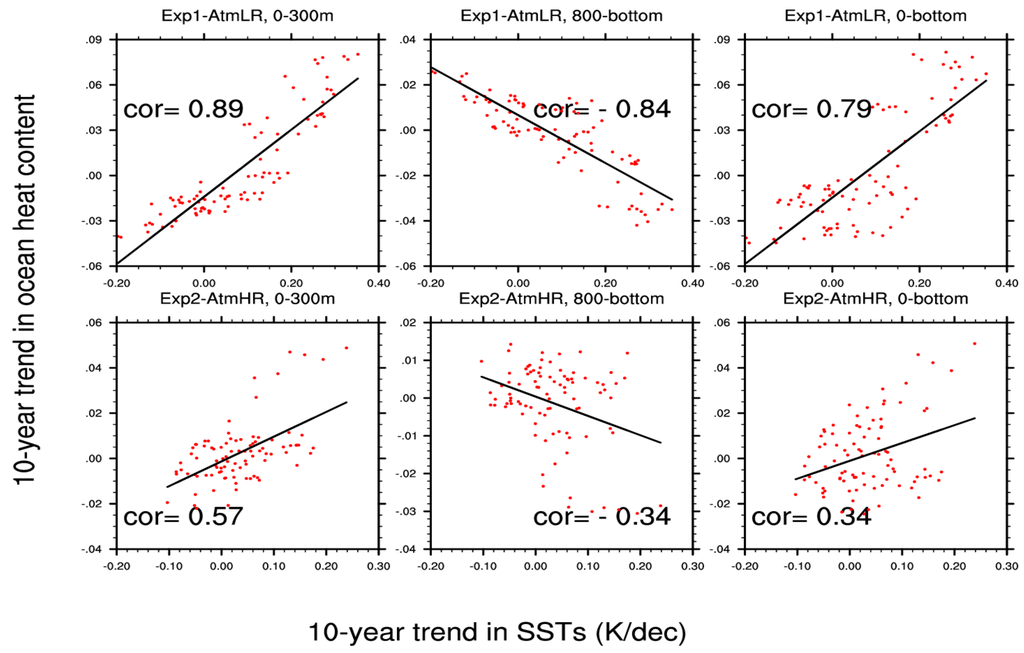

Fig 3: Correlation between global mean SST decadal linear trends (in K/decade) and global mean decadal linear trends in ocean heat content (in 10^{23} J/decade). We use here overlapping running decades for the 100-year period (91 decades). The ocean heat content drift has been assumed linear and removed.

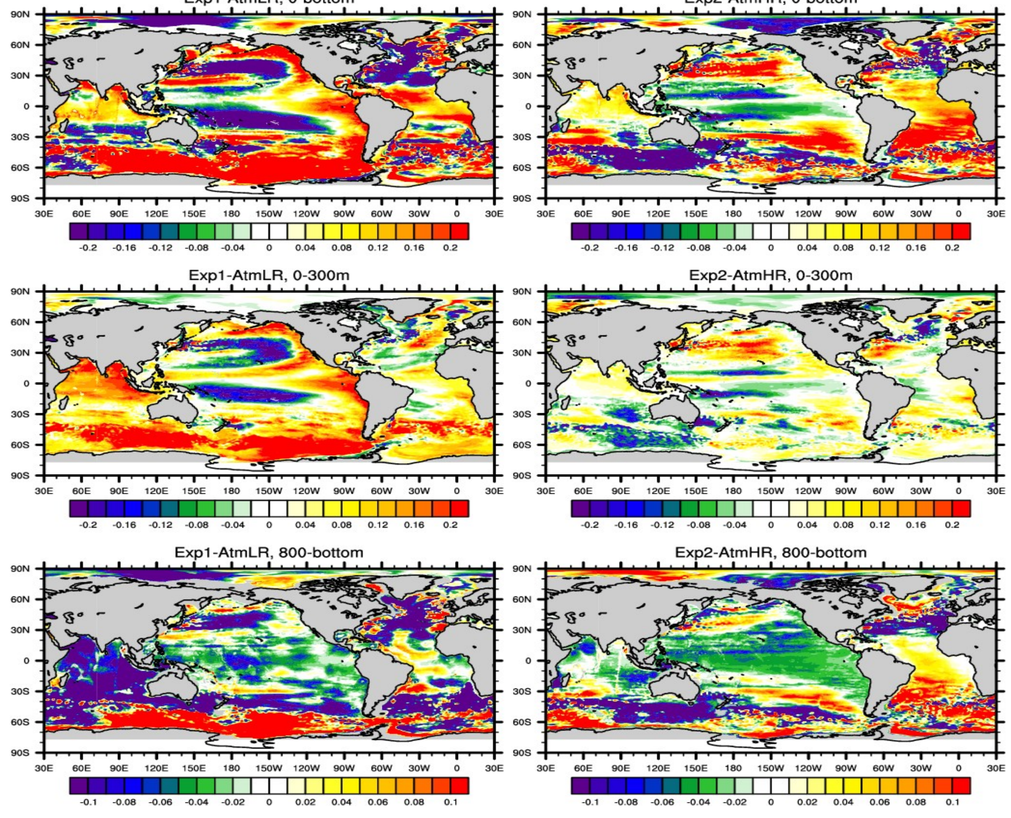

Fig 4: Regression coefficients between decadal linear trends in global mean SST (in K/decade) and decadal linear trends in ocean heat content (in 10^{12} J/m2/decade). We use here overlapping running decades for the 100-year period (91 decades)The ocean heat content drift has been assumed linear and removed.

5. Discussion and outlook

We explore the relationship between trends in SST and ocean heat contents at different depths in two experiments with the same high resolution in the ocean (~30km) but different atmospheric resolution. Preliminary findings show that:

1. Natural variability alone can generate large SST trends (up to 0.3K/decade)
2. The SST trends are associated with trends of the opposite sign in ocean heat content in the deeper (>800m) ocean, peaking in the Indian and in the Pacific Ocean.
3. Exp2-AtmHR does not seem to have the same relation with the deeper ocean heat content as in Exp1-AtmLR.
4. The different behaviour of the two experiments point to either insufficient drift removal of the ocean heat content in Exp2-AtmHR (assumed linear here), or different mechanisms that impact the SST trends.
5. Work in progress: explore mechanisms of heat uptake/redistribution.

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2. Watanabe, Masahiro, et al. "Contribution of natural decadal variability to global warming acceleration and hiatus." Nature Climate Change 4.10 (2014): 893-897.
3. Williams, K. D., et al. "The met office global coupled model 2.0 (GC2) configuration." Geoscientific Model Development 8.5 (2015): 1509-1524.