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Two pathways of decadal ENSO variability in modulating long-term global carbon cycle

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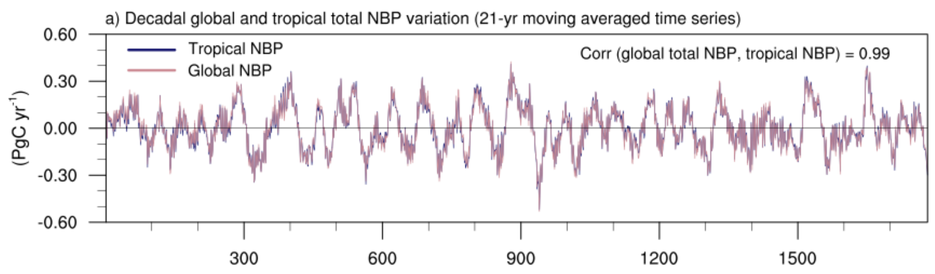
Introduction

The **El Niño–Southern Oscillation (ENSO)** drives **interannual global carbon cycle variability** by affecting terrestrial ecosystem *via* atmospheric teleconnection. The ENSO-like SST pattern has significant decadal variability and the ENSO characteristic changes on decadal time scales. It is expected from the strong relation between ENSO and global carbon cycle on interannual timescales that **such decadal behaviors of ENSO naturally modulate the global carbon cycle on decadal timescales**

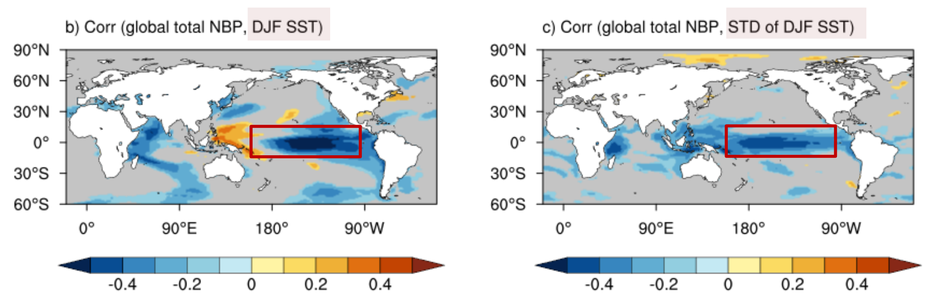
Study Purpose : how and how much decadal ENSO variability affects global carbon cycle on decadal time scales?

Data : CESM1-LE, Long-term fully coupled control simulation under pre-industrial condition

Relationship between ENSO and carbon cycle on decadal time scale



✓ Decadal variability of Net Biome Productivity (NBP)
✓ Important role of tropical ecosystem on carbon cycle variability



✓ Strong **negative** correlation between decadal ENSO variability and terrestrial carbon flux

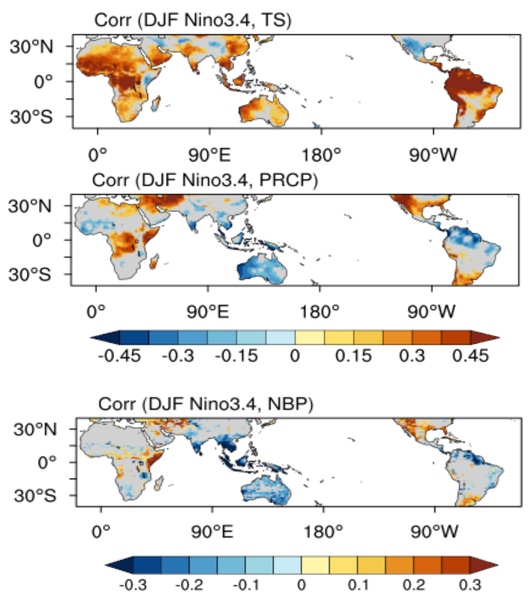
Pathway 1 : Decadal tropical Pacific SST variability

On interannual time scale

[El Nino years]
Warm & Dry
Reduced net productivity
Carbon release to ATM

[La Nina years]
Cold & Wet
Increased net productivity
Carbon uptake from ATM

On decadal time scale



Decadal **SST** variability
(Warm / Cold)

↓

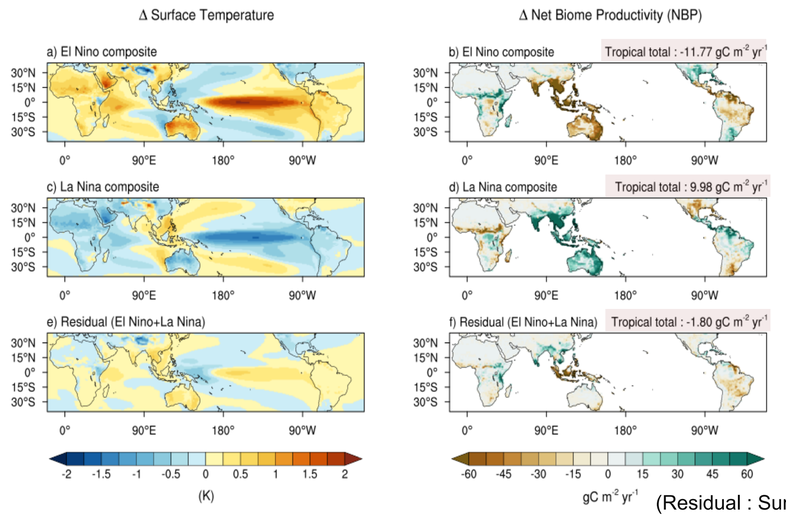
Long-term changes in **temperature/precipitation**
(Warm & Dry / Cold & Wet)

↓

Decadal **NBP** variability
(Negative / Positive NBP)

Pathway 2 : ENSO asymmetry & decadal ENSO amplitude modulation

Asymmetric terrestrial carbon flux due to ENSO asymmetry



[El Nino events]
Carbon Loss

V

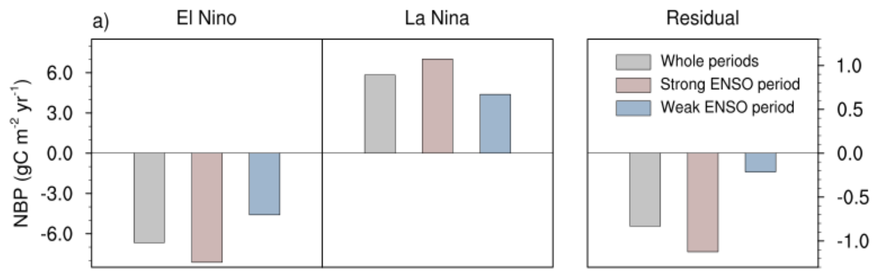
[La Nina events]
Carbon Uptake

Negative Residual NBP

(Residual : Sum of El Nino and La Nina composite)

✓ Residual NBP effects can be reflected to the mean state.

Residual NBP variability induced by ENSO amplitude decadal modulation can generate decadal NBP variability.



Greater ENSO Amplitude
↓
Greater Residual NBP

✓ Decadal changes in residual NBP generate decadal variation of terrestrial carbon flux, especially in EQA and AMZ.

Summary

✓ There are two pathways, which can explain about 36% of the decadal variations in global carbon cycle.
✓ First, climate change induced by decadal ENSO-like SST variability regulate terrestrial productivity on decadal time scale.
✓ Second, decadal changes in asymmetric terrestrial biosphere's response to ENSO, resulted from decadal ENSO amplitude modulation, generate decadal variability of carbon flux.

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