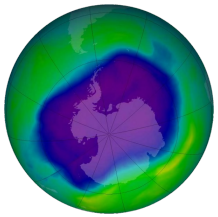
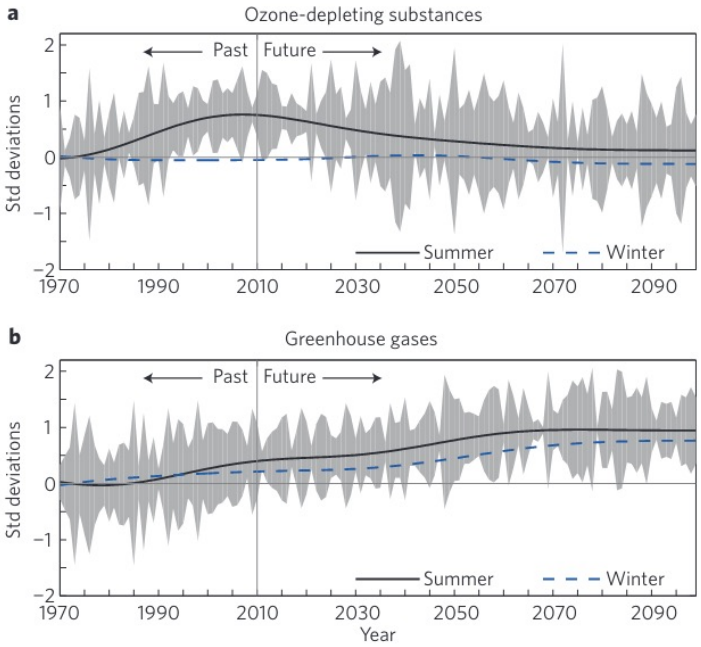
The Evolving Relative Role of Stratospheric Ozone and Greenhouse Gasses in Modifying the Southern Ocean Carbon Sink from 1950 to 2100

Tereza Jarníková, Corinne Le Quéré, Colin Jones, Steven Rumbold

Changing polar climate due to ozone depletion and greenhouse gas emissions



SAM index timeseries



Thompson et al 2011

- Historically, ozone depletion increased the SAM index → stronger and more southerly winds, especially in summer

- Ozone is recovering, but GHG emissions are expected to continue increasing winds, year-round

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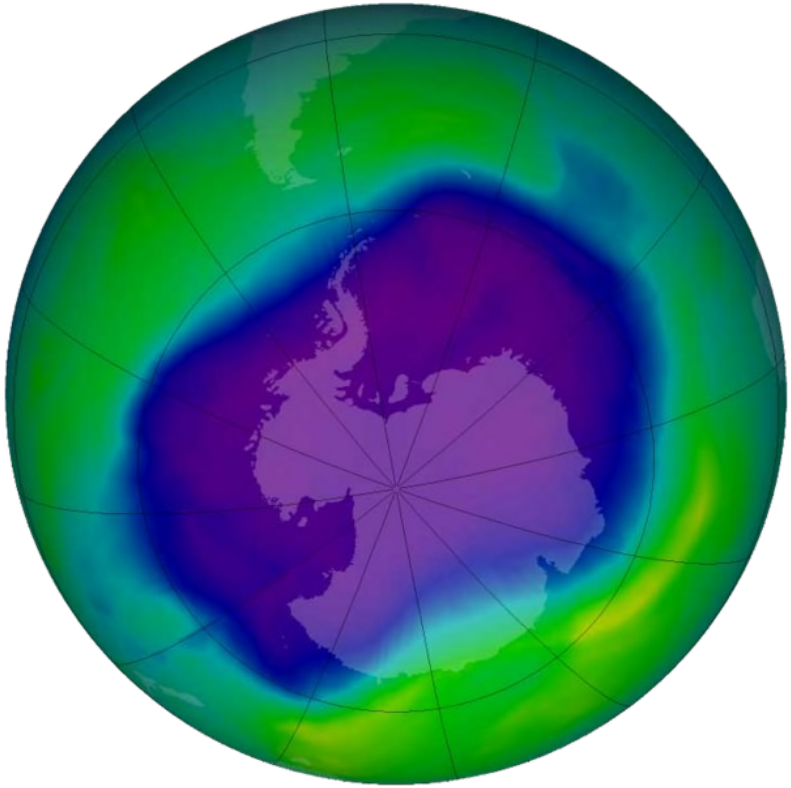

1. How are the Southern Ocean wind patterns projected to change over the coming century under different ozone and SSP scenarios?

2. What are the effects of changing wind patterns on the physical ocean sea state?

3. What are the relative controls on the carbon flux?

Experimental Design

A combination of 3 ozone and 2 GHG scenarios, UKESM1, 1950-2100

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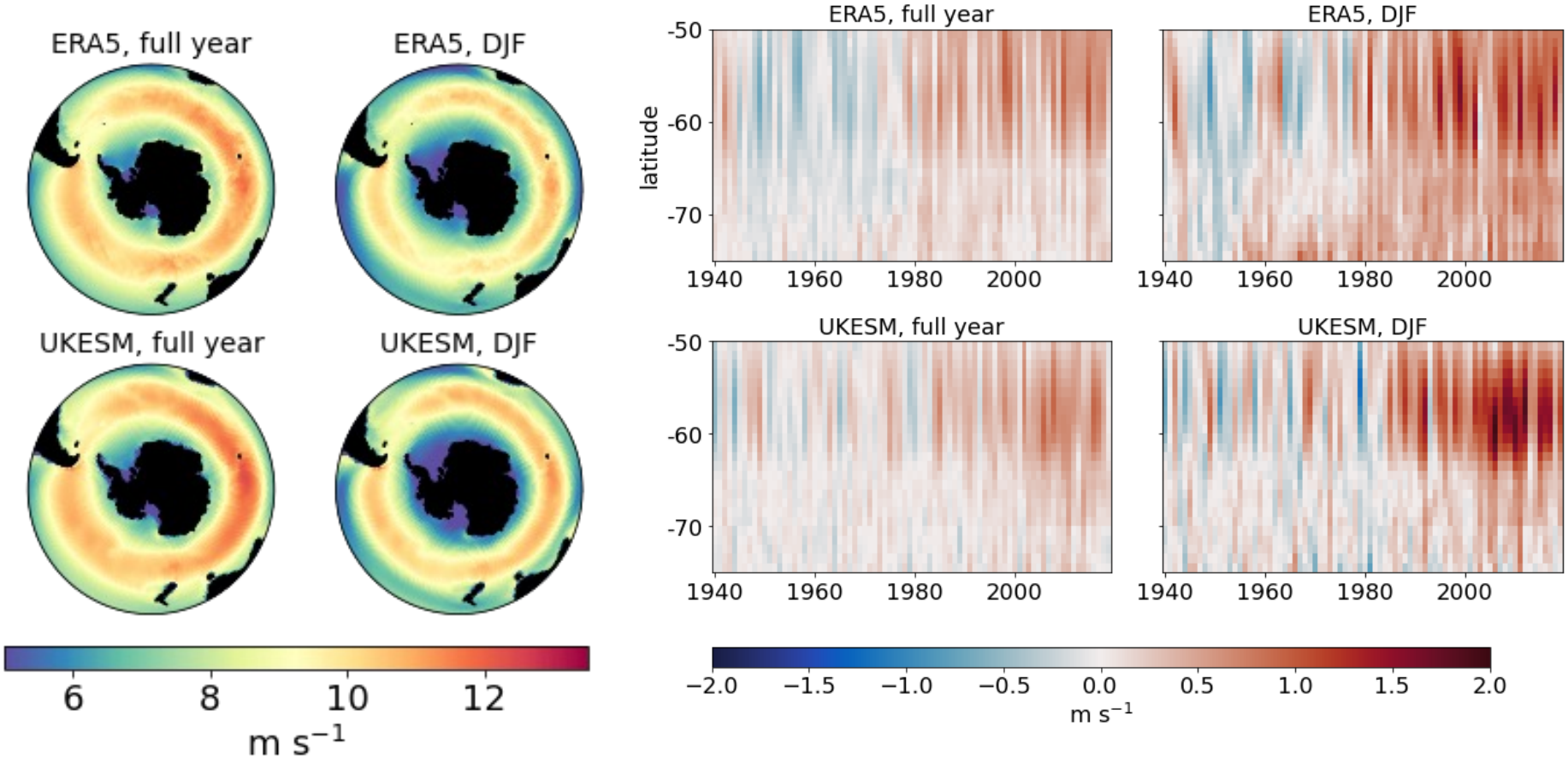
What are the major physical controls on the Southern Ocean carbon sink, and how will they change due to GHG emissions and ozone depletion?

quantity	expected effect of ozone depletion on quantity	expected effect of atmo. GHG increase on quantity	expected effect of quantity change on CO2 sink (↓: sink decrease)
wind velocity (WINDS)	↑	↑	↓(↑)
sea surface temperature (SST)	↓(↑)	↑	↓(↑)
mixed layer depth (MLD)	↑	↓	↓↑
overturning (OT)	↑	↑(↓)	↓

Can we learn from the UKESM1 winds?
Yes, they perform well against the ERA5 reanalysis



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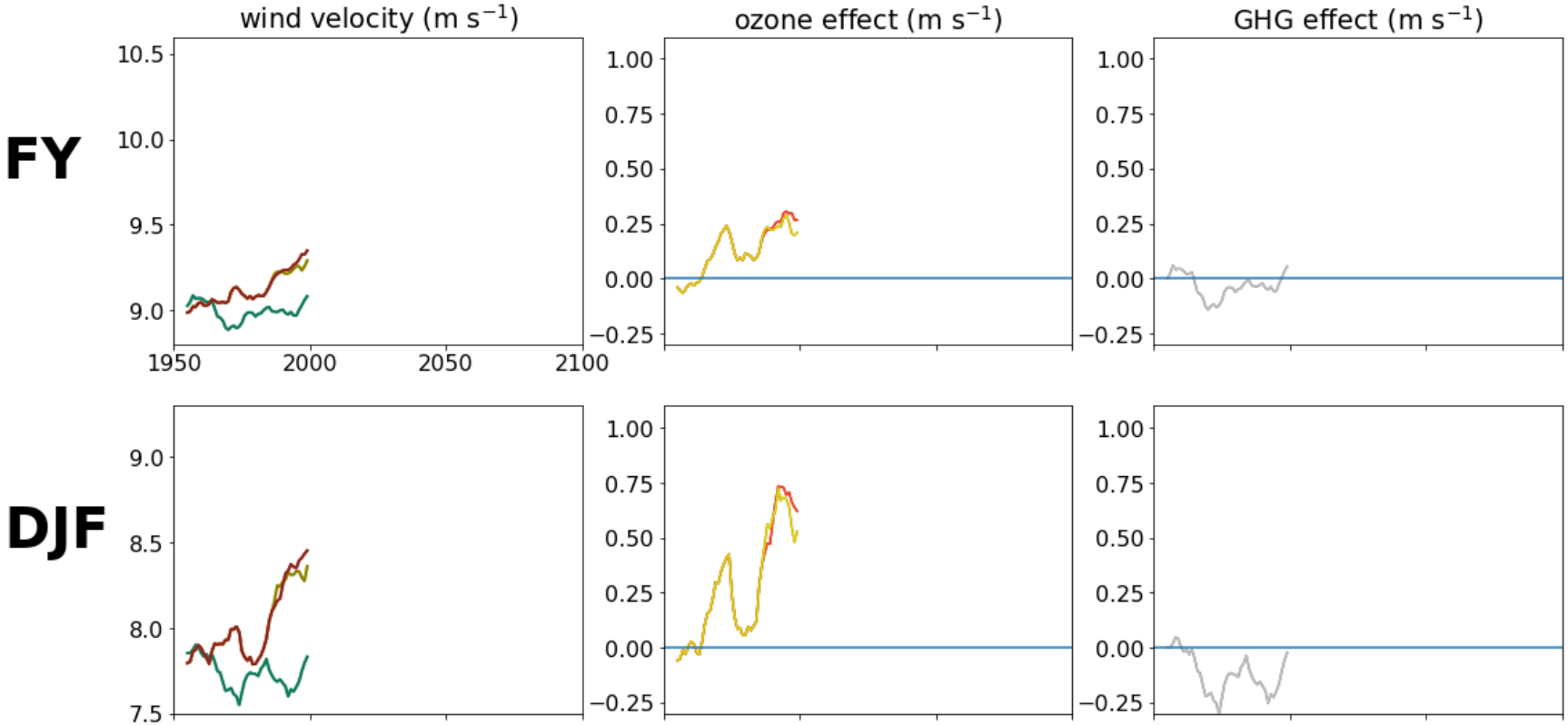
Ozone and GHG effect on wind speed, 1950-2100



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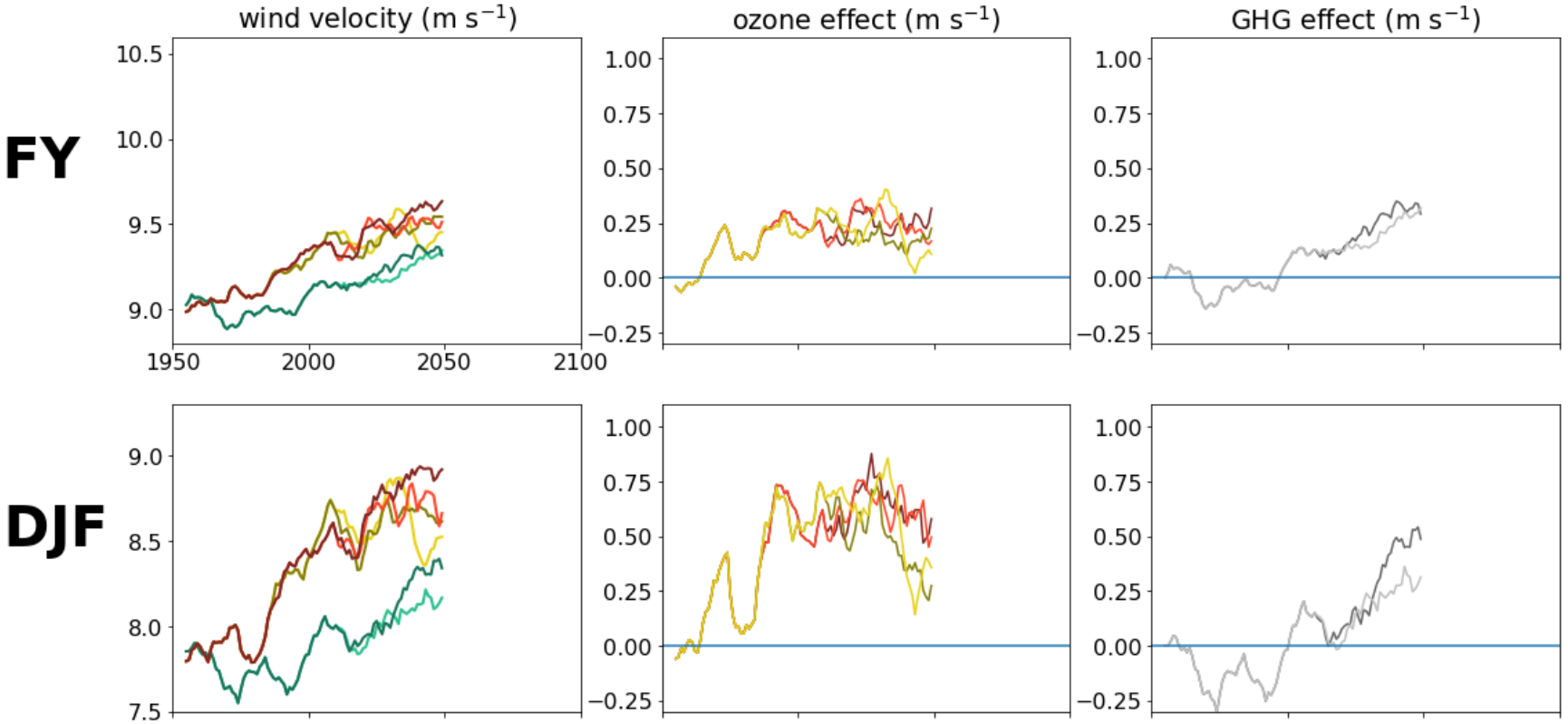

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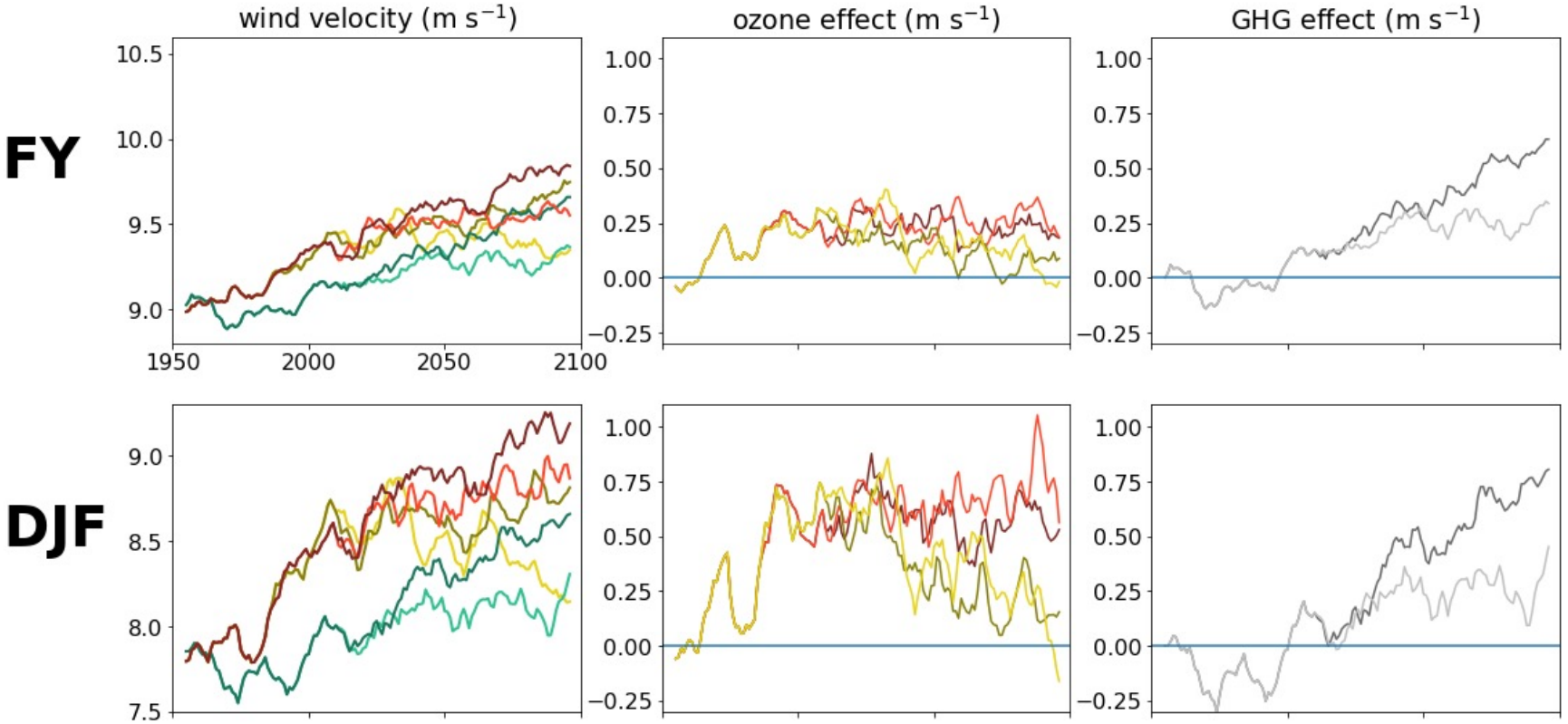

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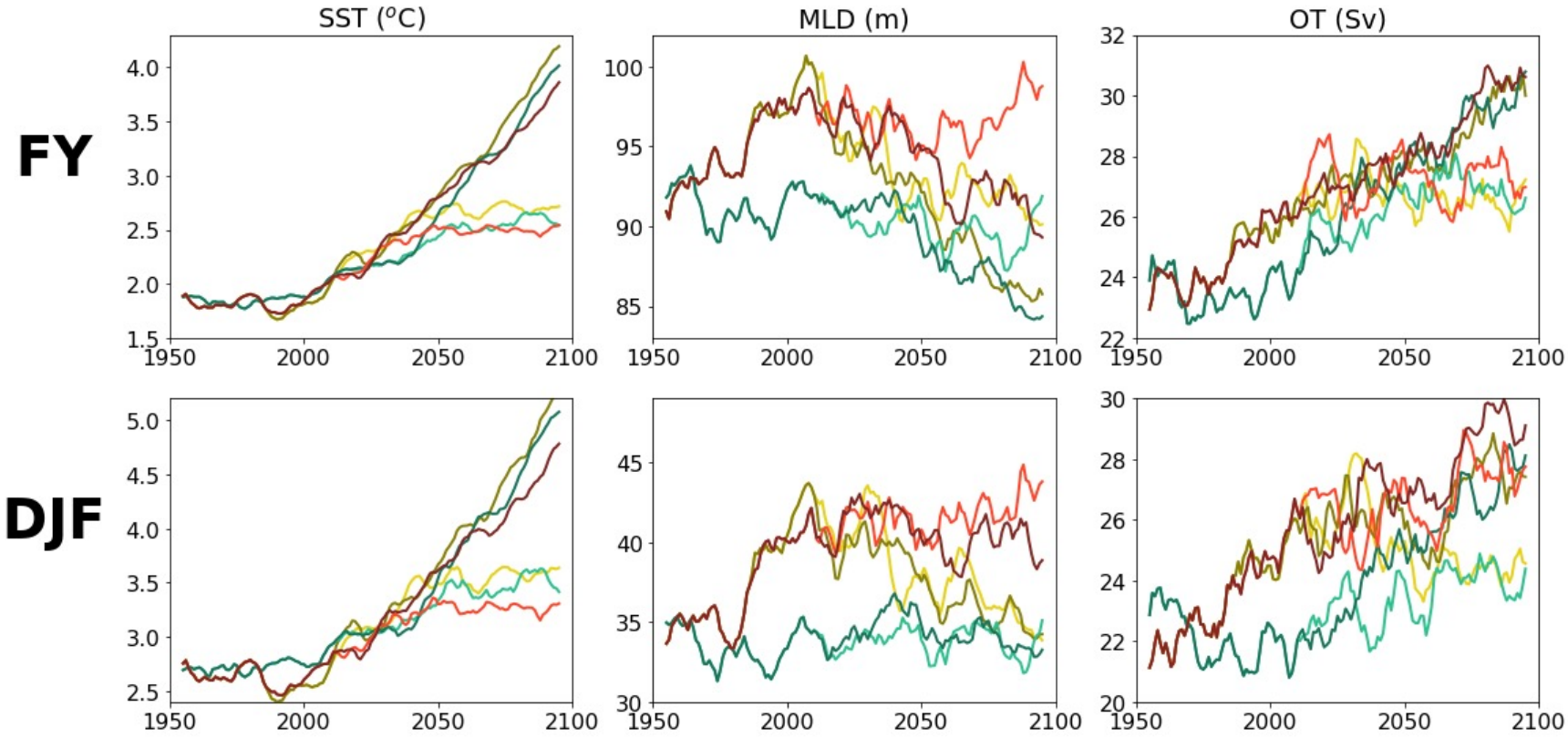

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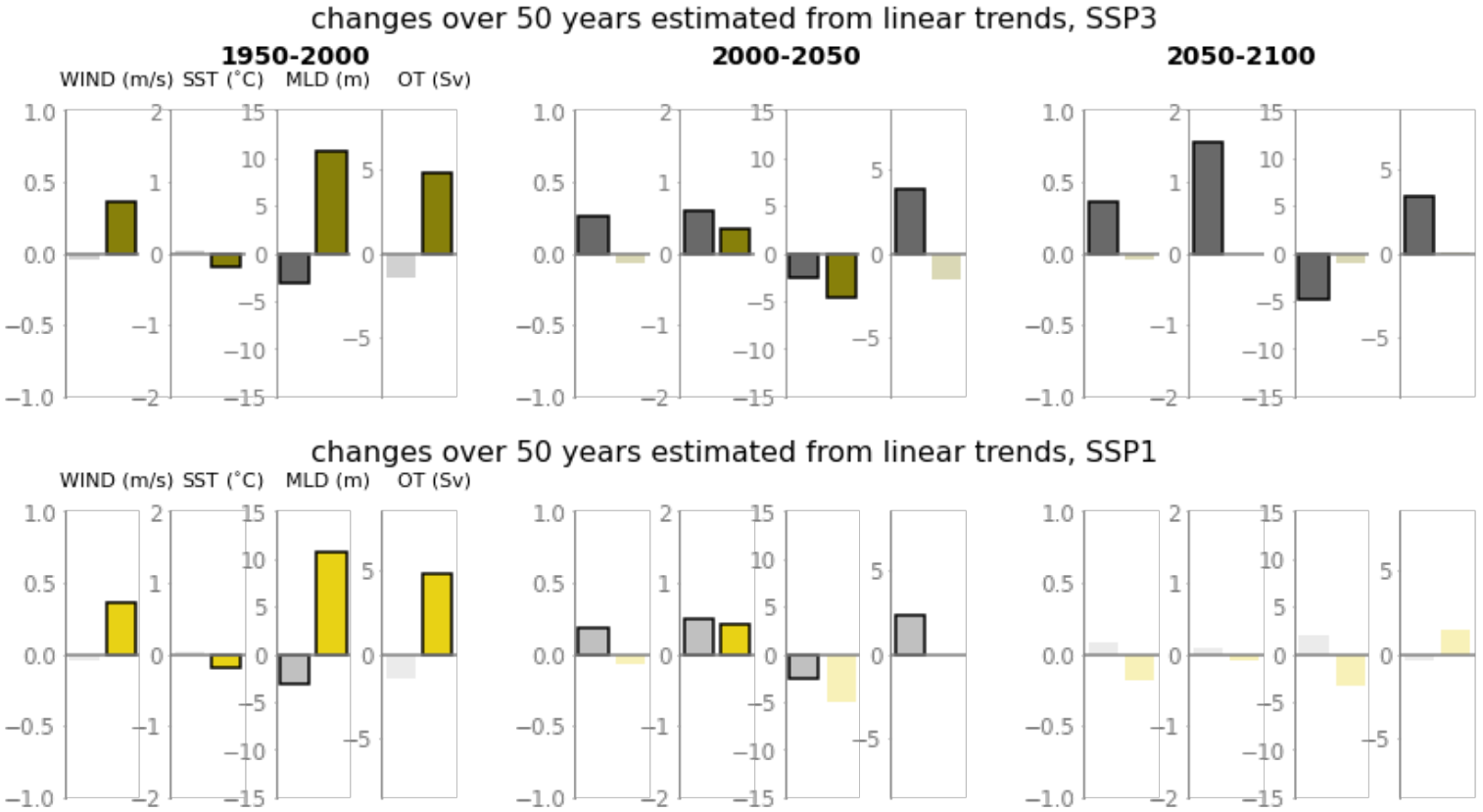

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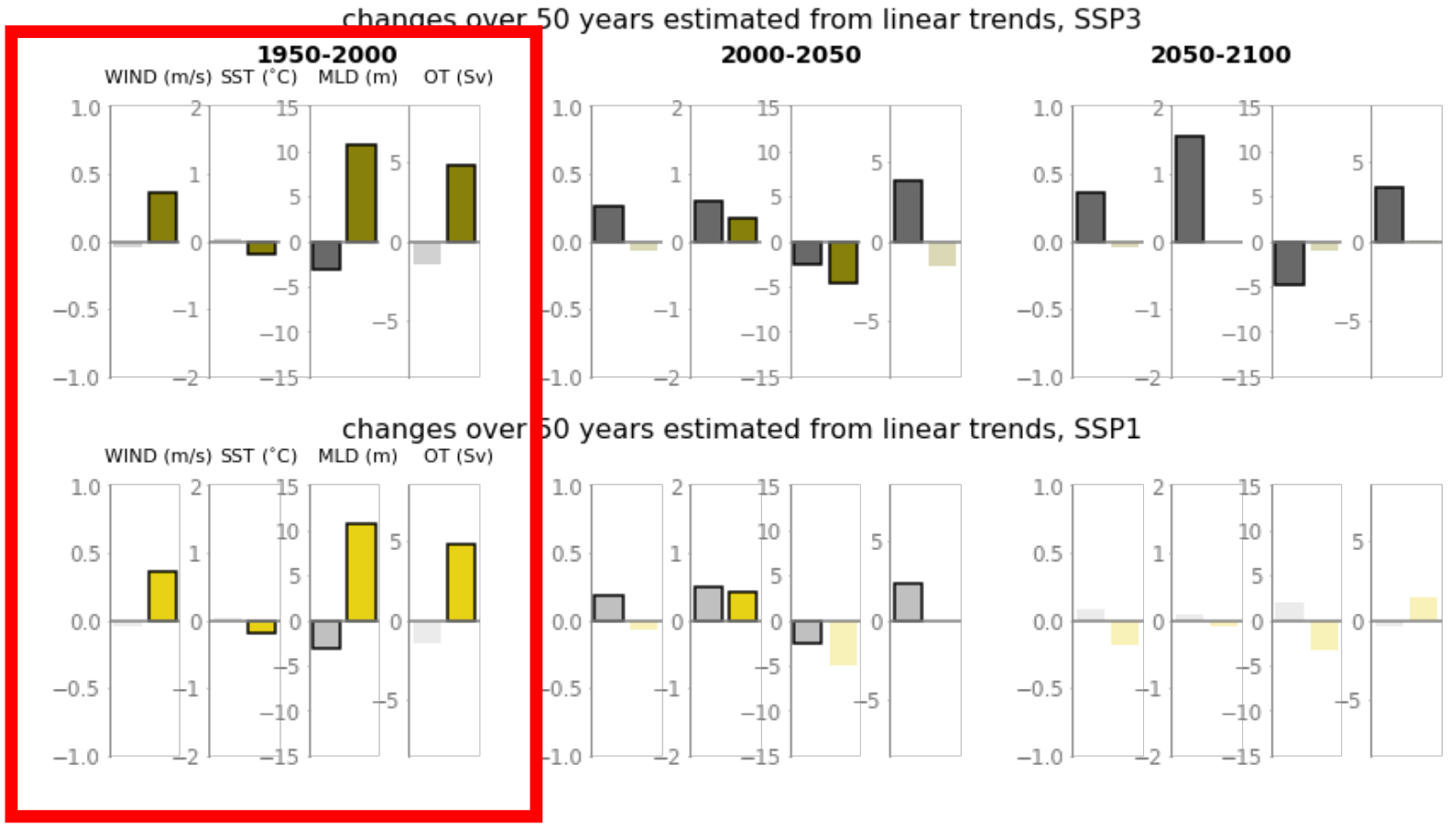

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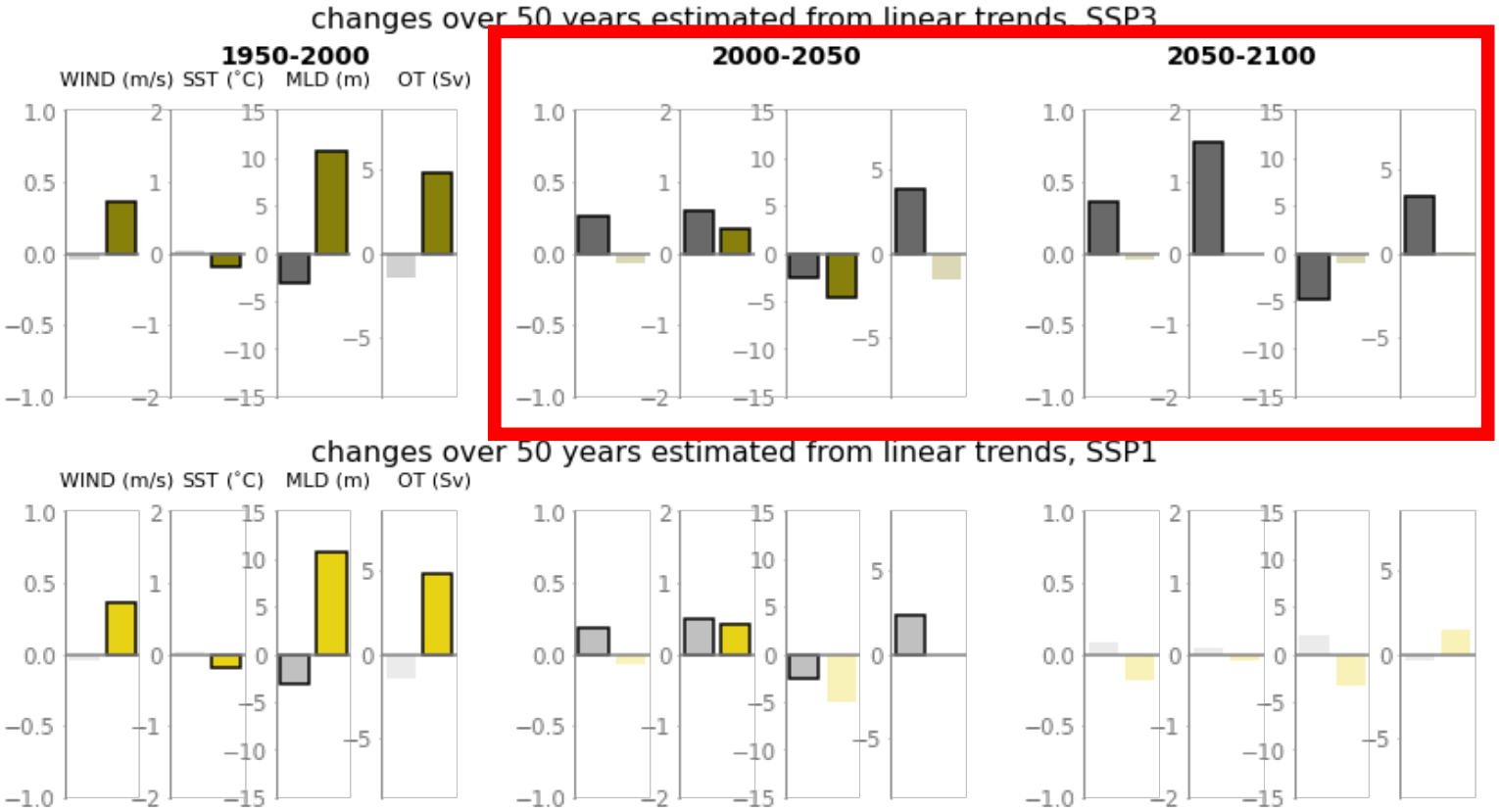

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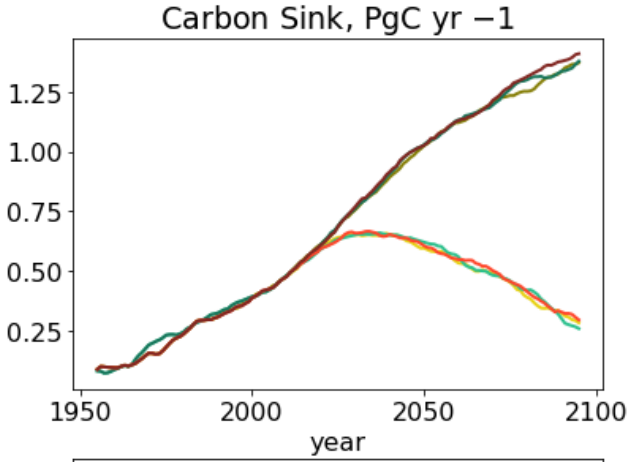

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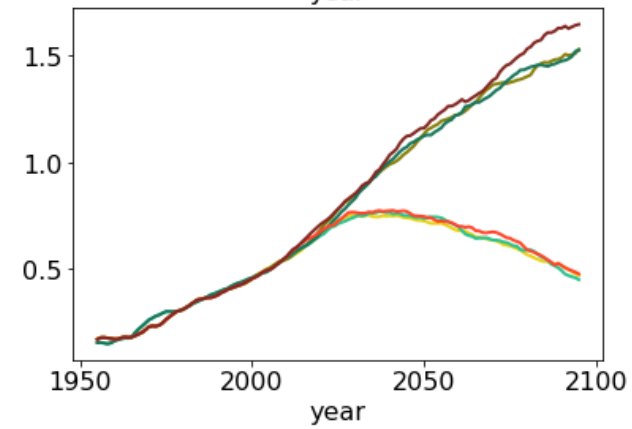

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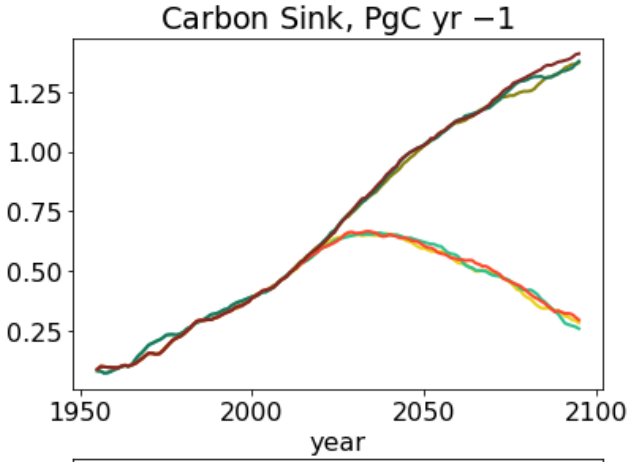

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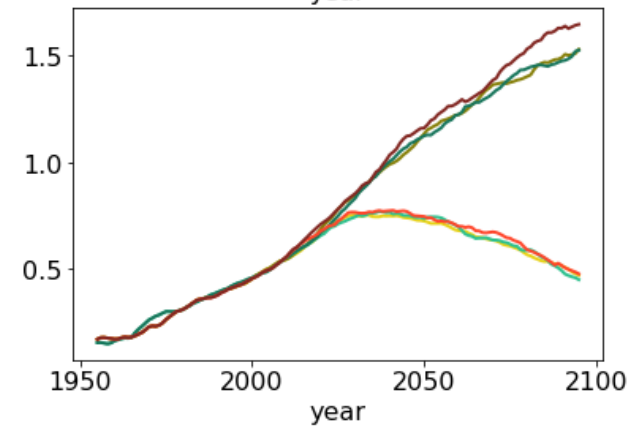

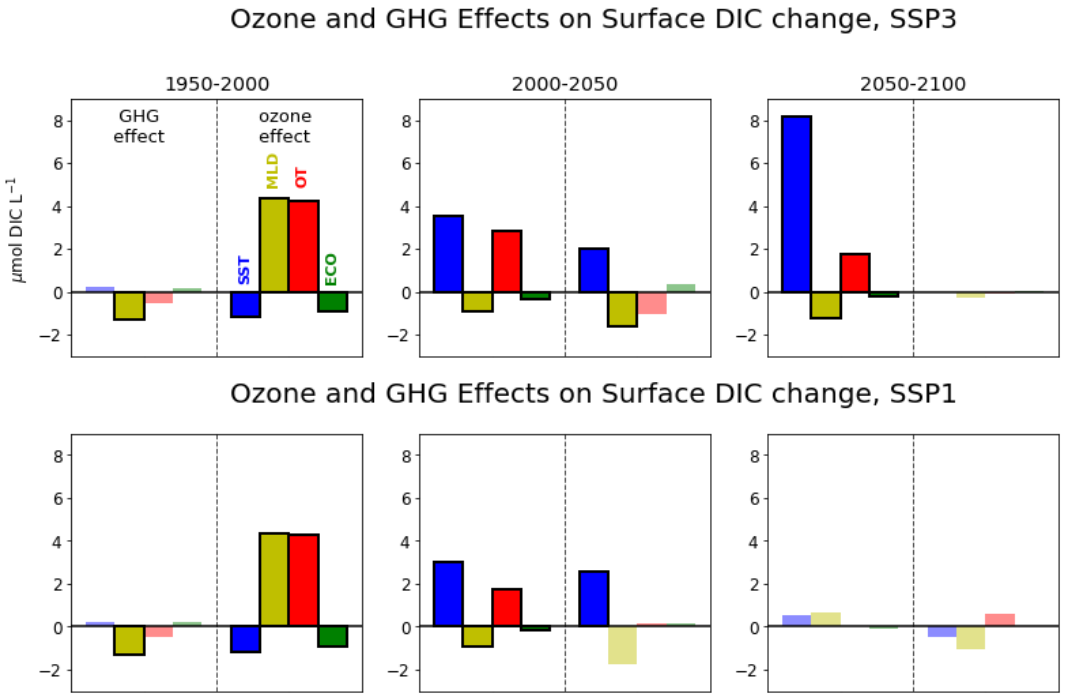

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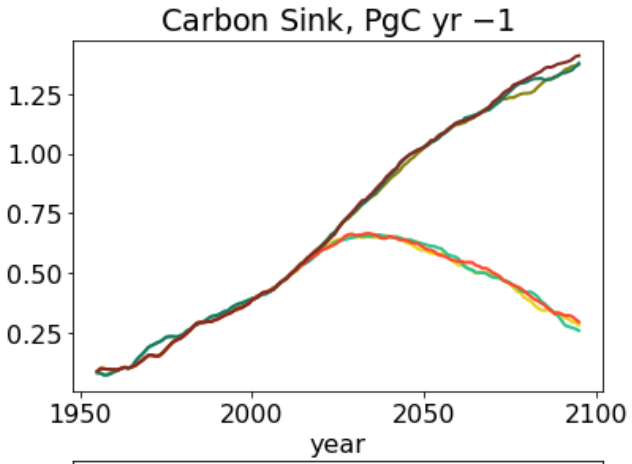

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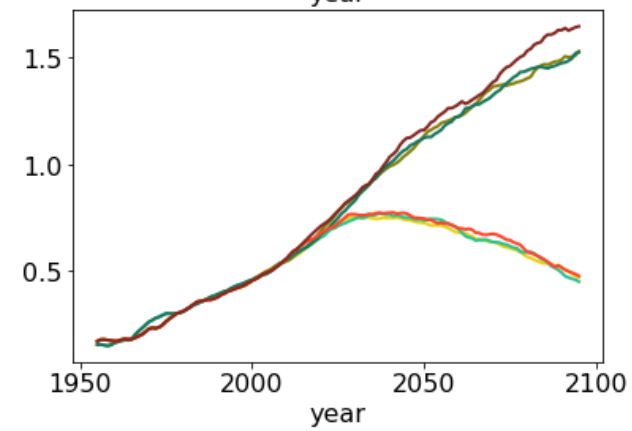

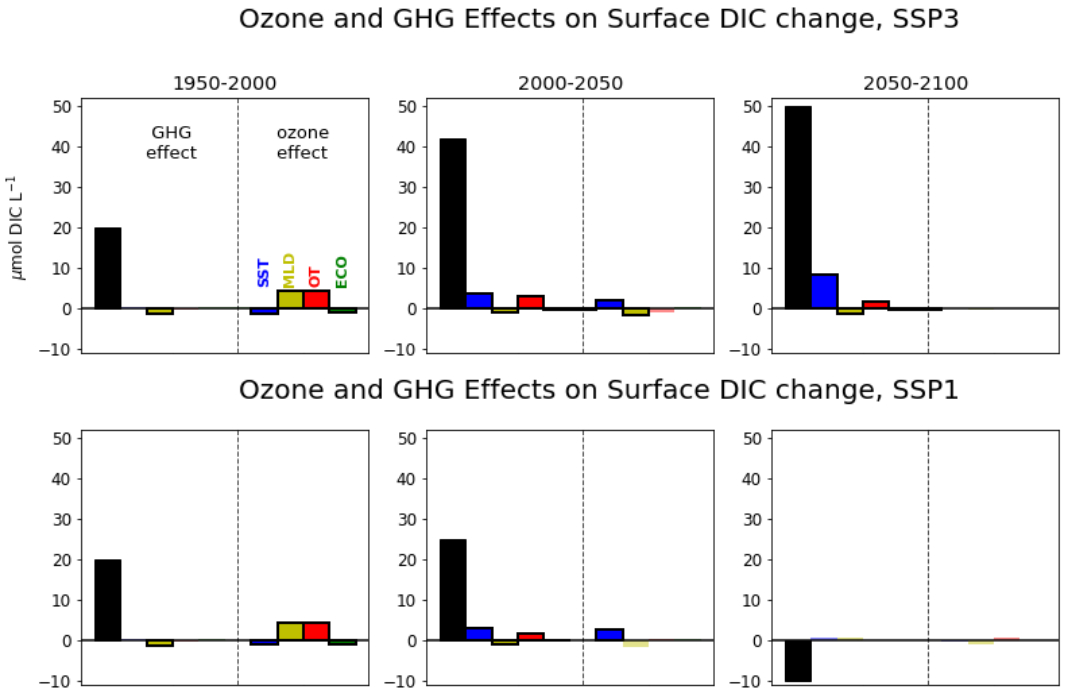

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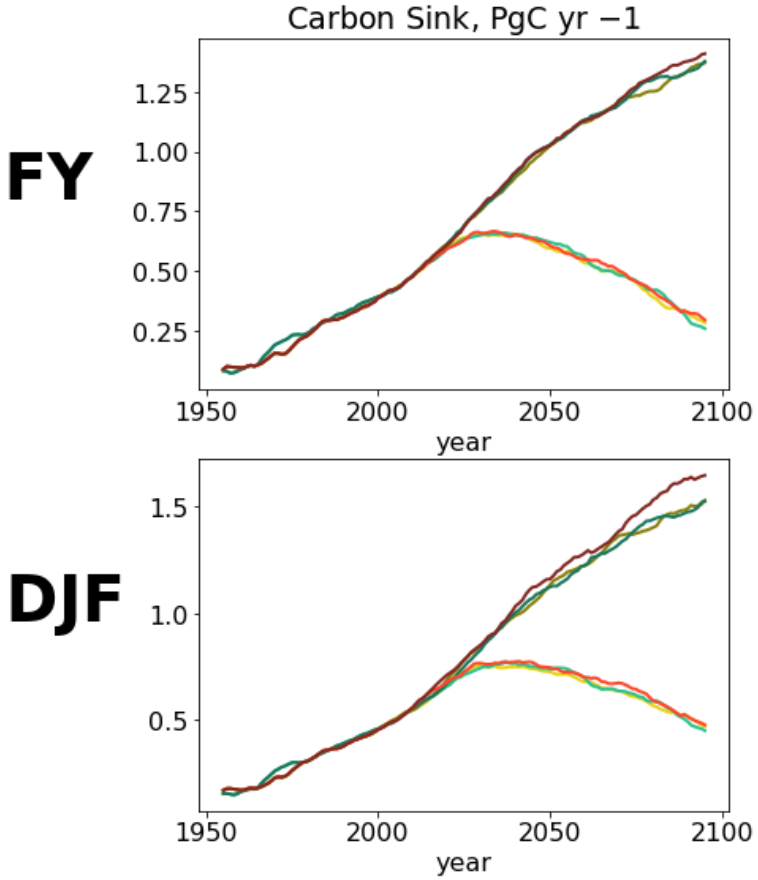

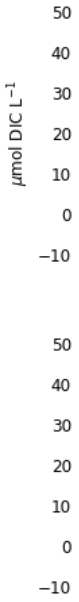

Summary

1. Both ozone and GHG act to modulate the winds and physical oceanographic conditions
2. There is a shift controls from ozone dominance to GHG dominance over the course of the 21st century
3. Non-CO2 effects are important, especially the thermal effect, but for the CO2 sink are secondary to the atmospheric CO2 effect

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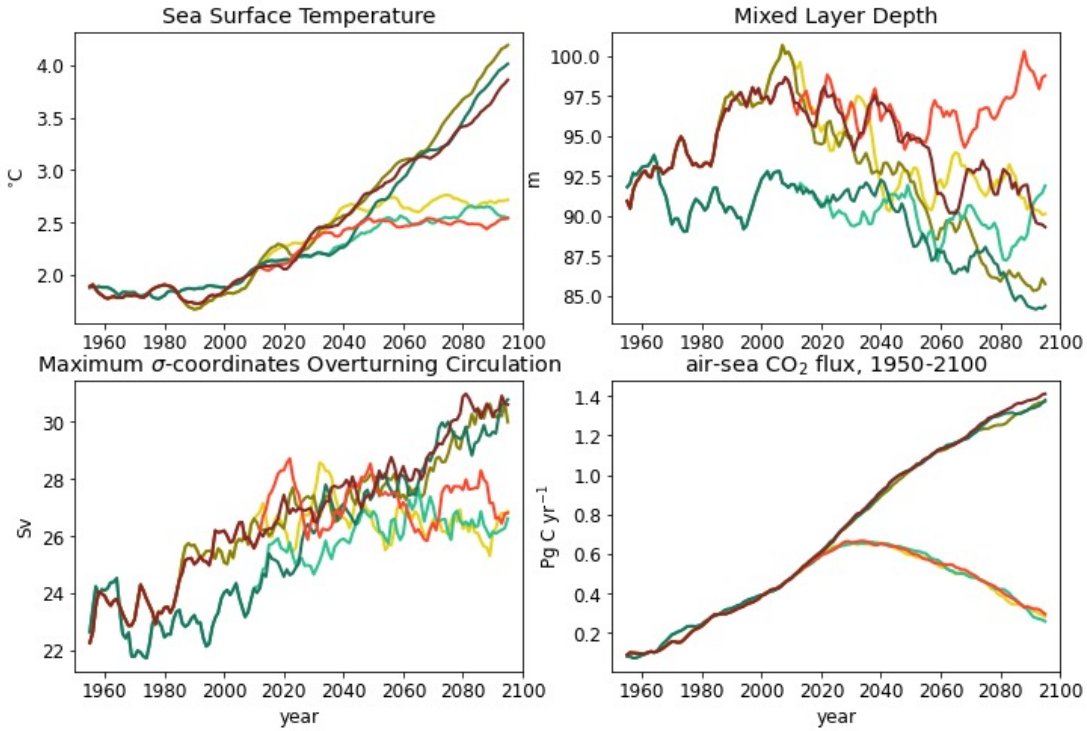
RANDOM OTHER SLIDES BEGIN HERE



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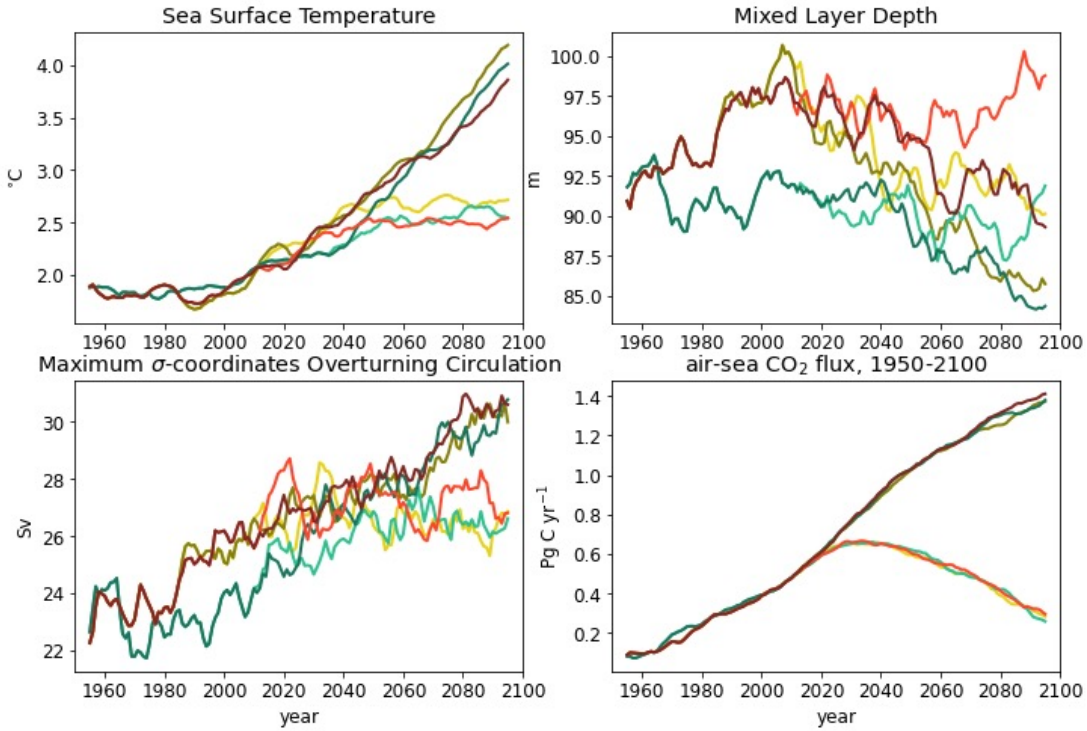

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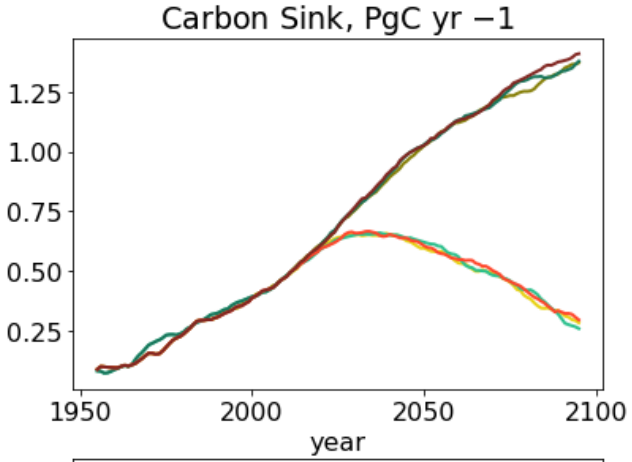

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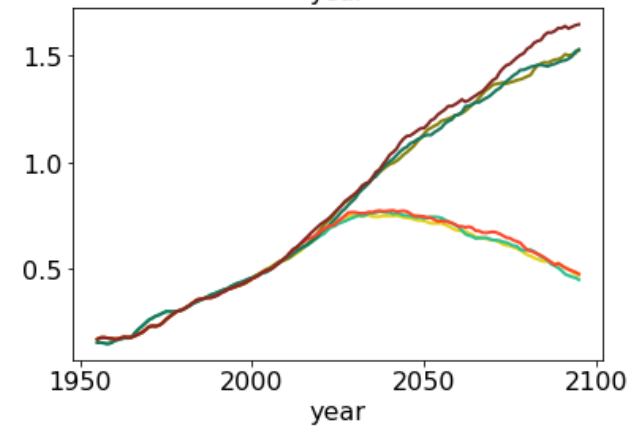

quantity	Mechanism of change
sea surface temperature (SST)	CO_2 solubility change with temperature (~4% pCO2 / degree)
mixed layer depth (MLD)	Changes in near-surface DIC gradient
overturning (OT)	Changes in delivery of deep DIC to surface

A back of the envelope calculation: of non-CO_2 effects the thermal effect is most important, but non-CO_2 effects are dwarfed by the atmospheric carbon signal.