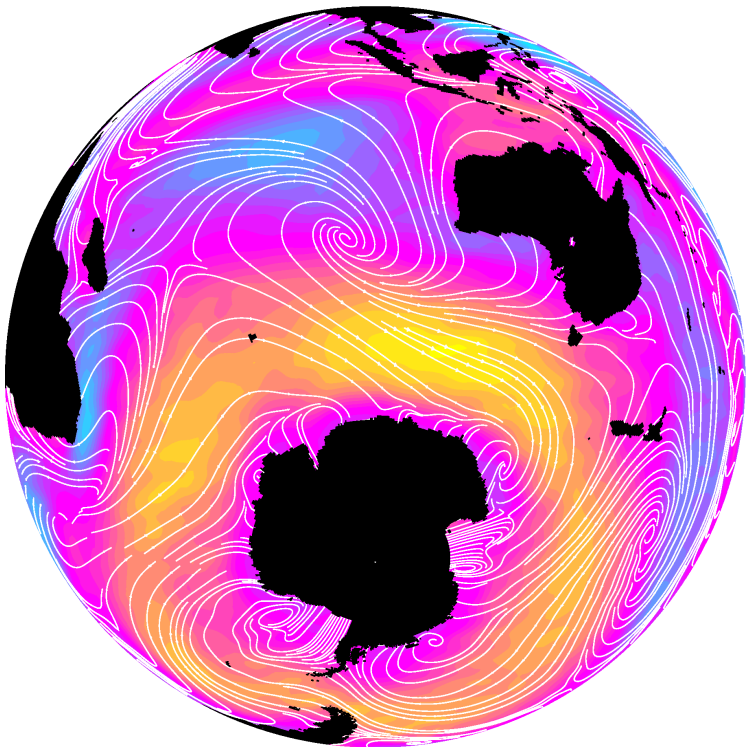
Wind induced changes in the ocean carbon sink



Neil Swart John Fyfe Oleg Saenko

Canadian Centre for Climate Modelling and Analysis, Environment Canada

Ocean carbon and heat uptake workshop
14 December 2014

Environment Canada Environnement Canada

Canada

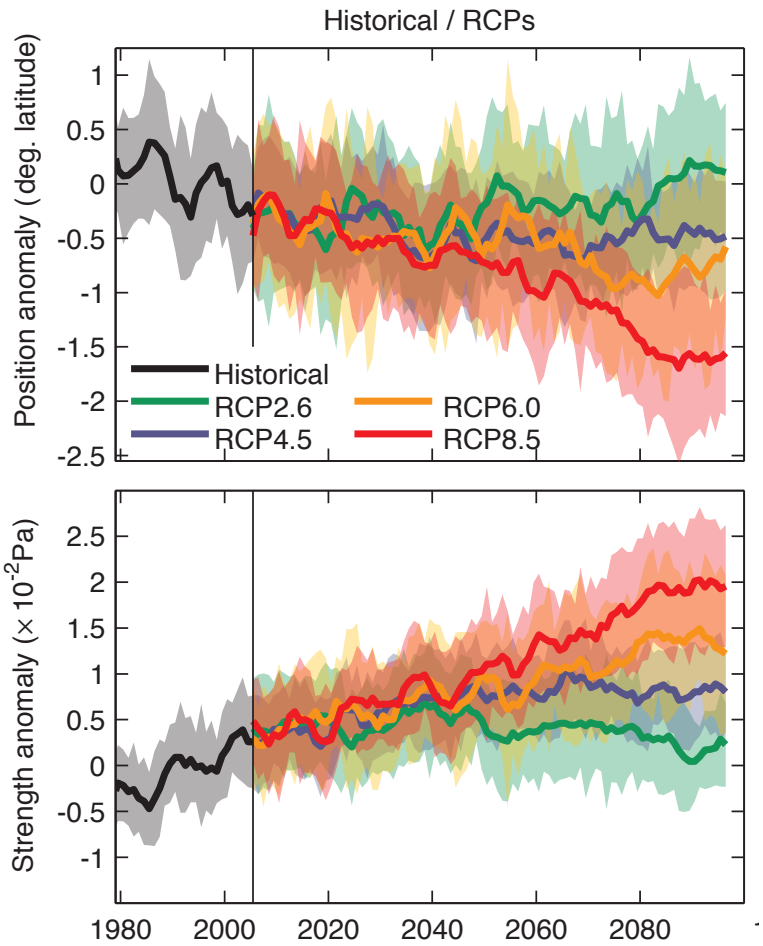
Overview

Metrics and uncertainties

1. *Observed* and *simulated* changes in the SH westerlies.
2. Ocean carbon uptake in an OBGCM driven by specified winds, with uncertainties due to...
   - model parametrization of mesoscale eddies.
   - poorly constrained winds.

Historical and future changes

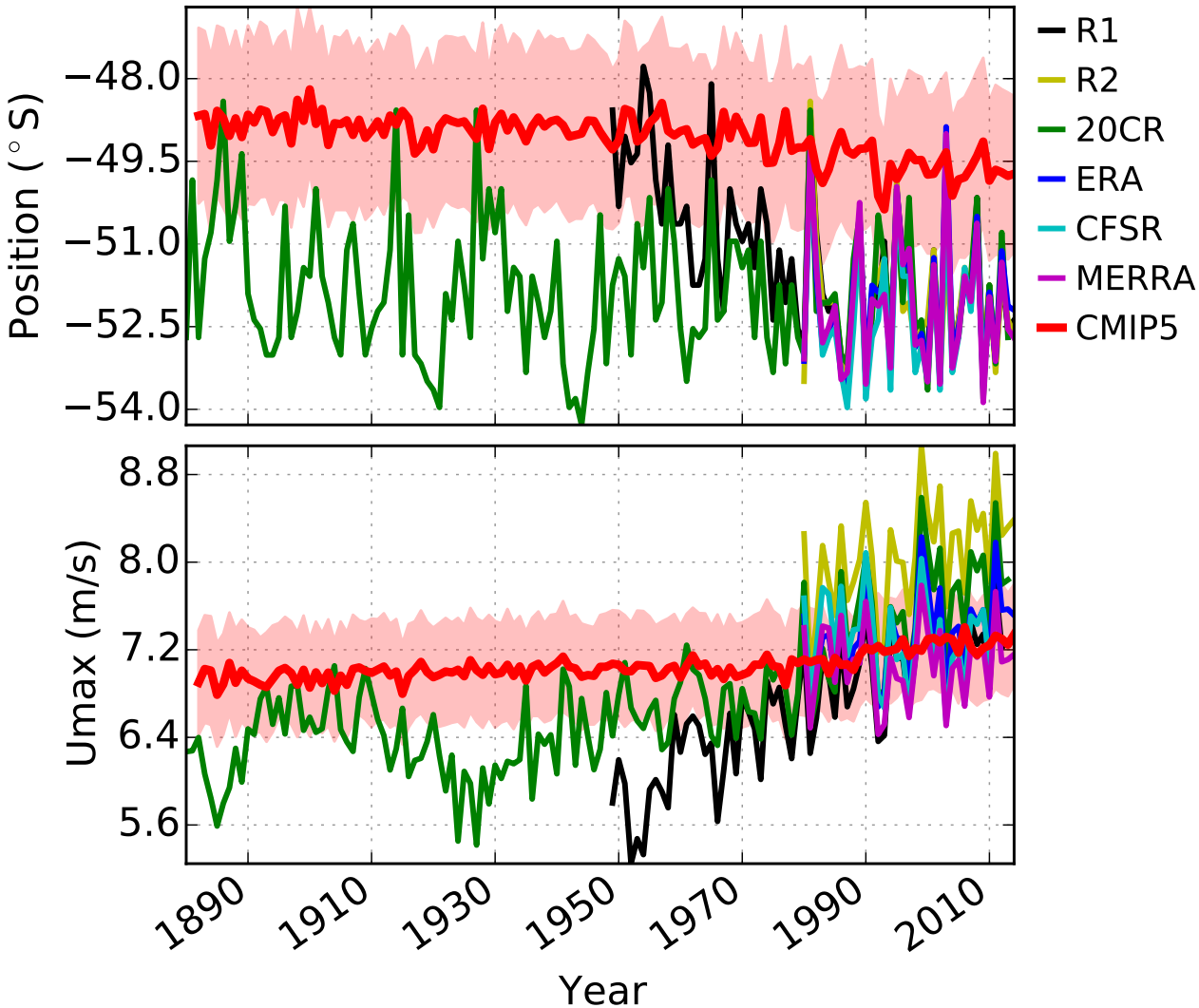
CMIP5 jet position and strength



N. C. Swart and J. C. Fyfe (Aug. 2012a), Observed and simulated changes in the Southern Hemisphere surface westerly wind-stress, *Geophys. Res. Lett.*, **39.**

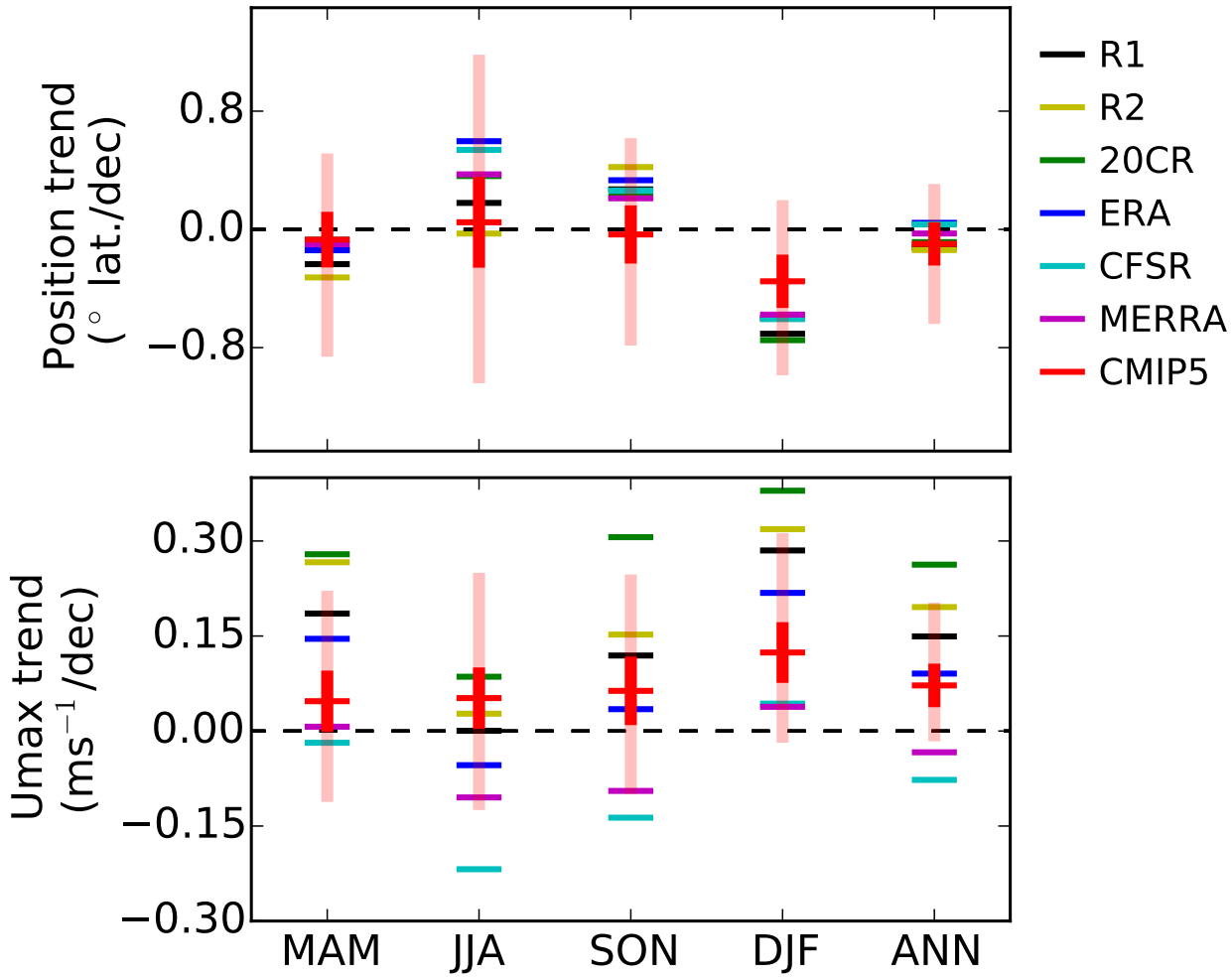
Historical changes

CMIP5 vs 6 reanalyses



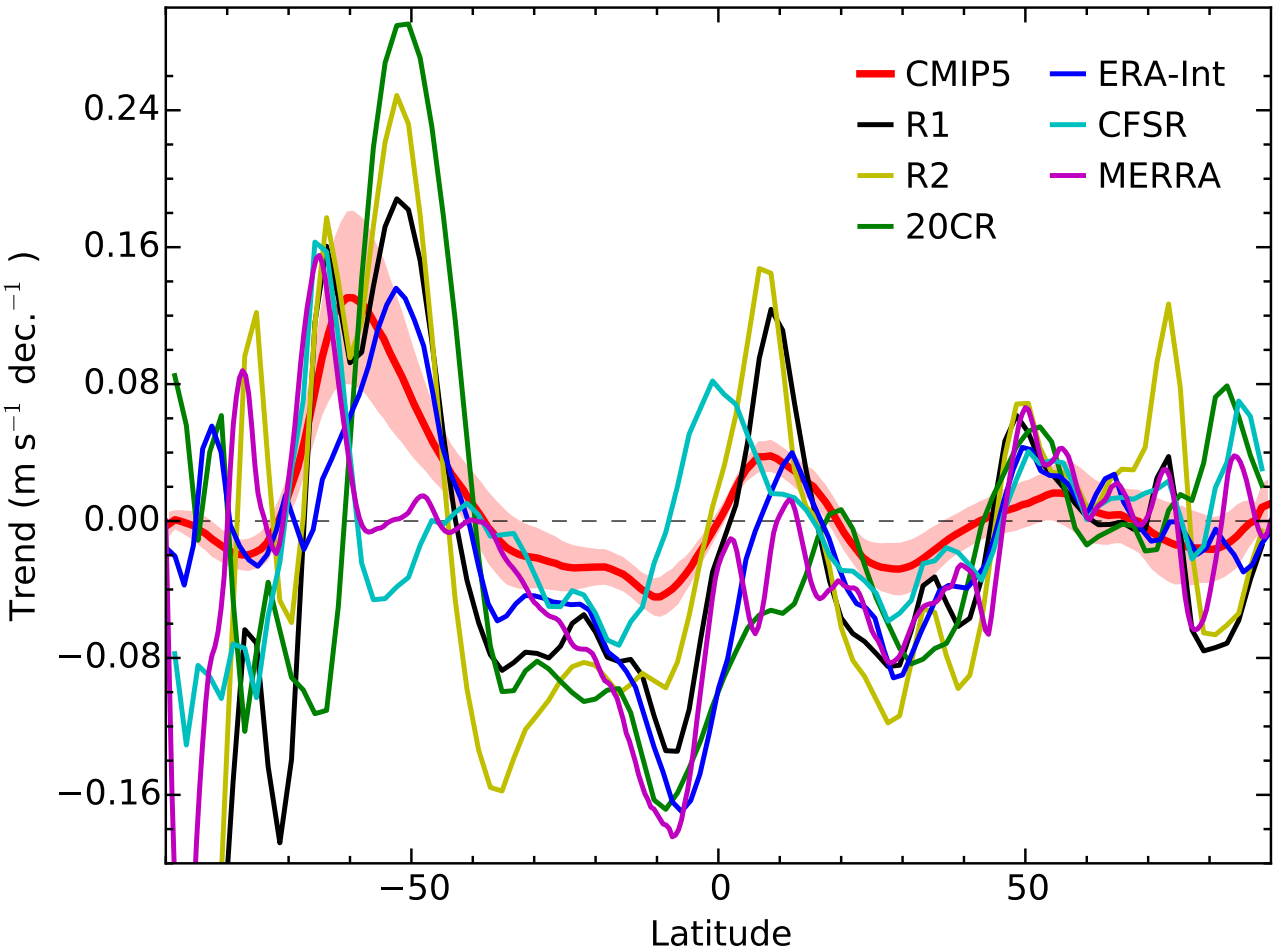
Historical trends (1979-2010)

CMIP5 vs reanalyses



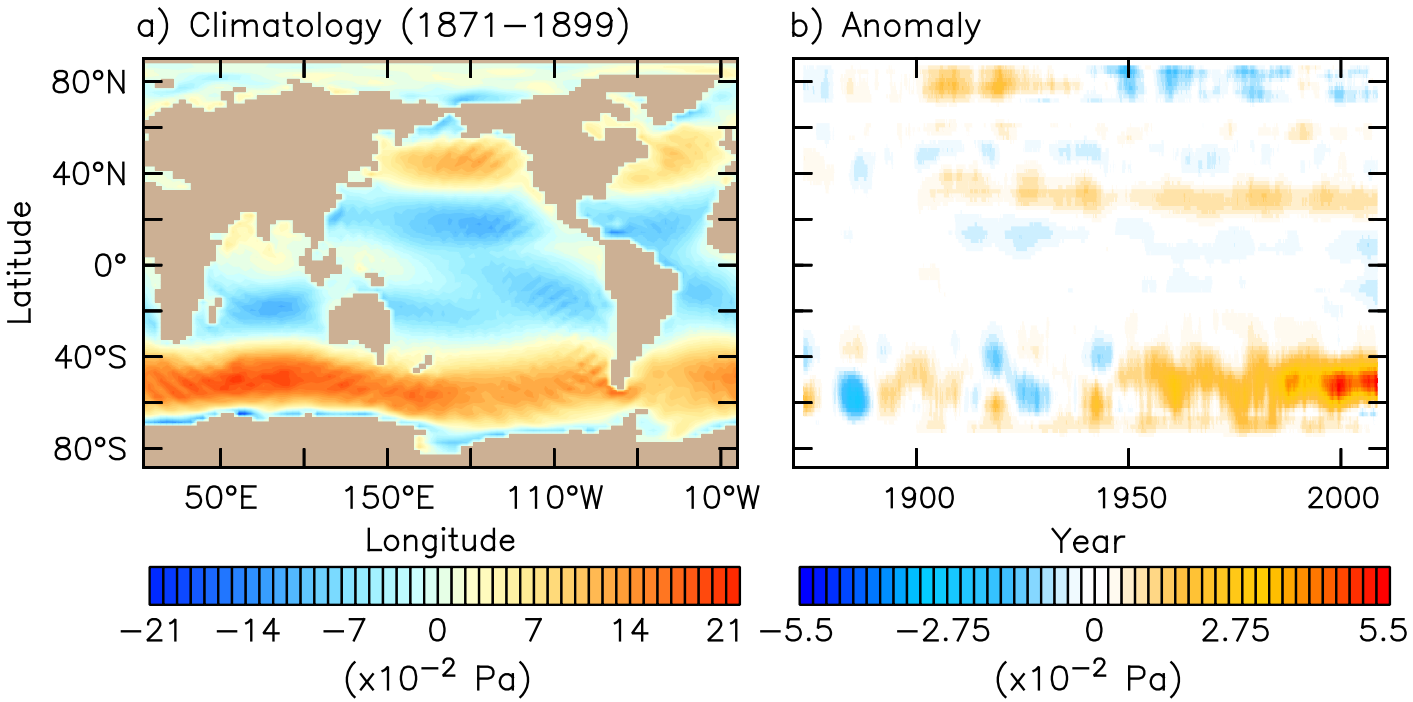
Historical trends (1979-2010)

Zonal mean trends in u10m



Carbon uptake in an OBGCM
forced with 20CR winds

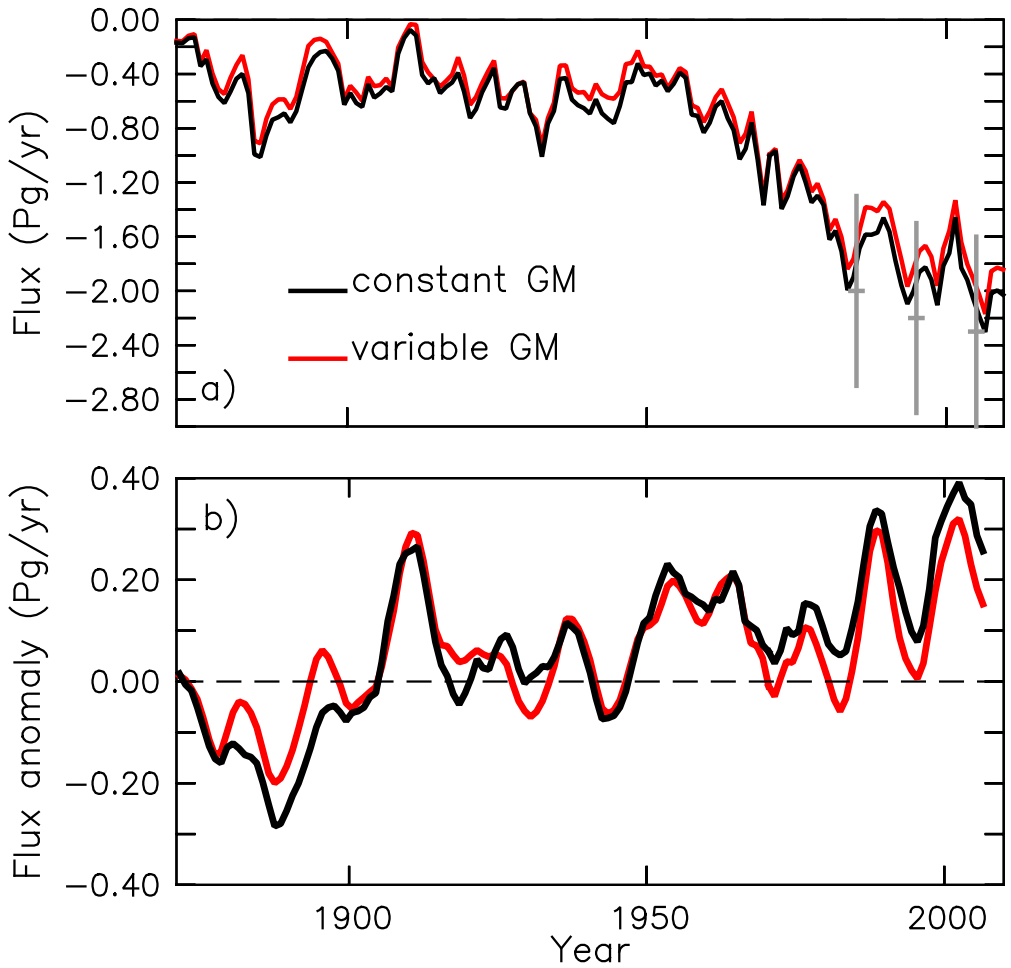
20CR winds → UVic ESCM → Ocean carbon uptake



N. C. Swart et al. (2014), Wind-driven changes in the ocean carbon sink, *Biogeosciences*, **11.**,

Carbon uptake in an OBGCM

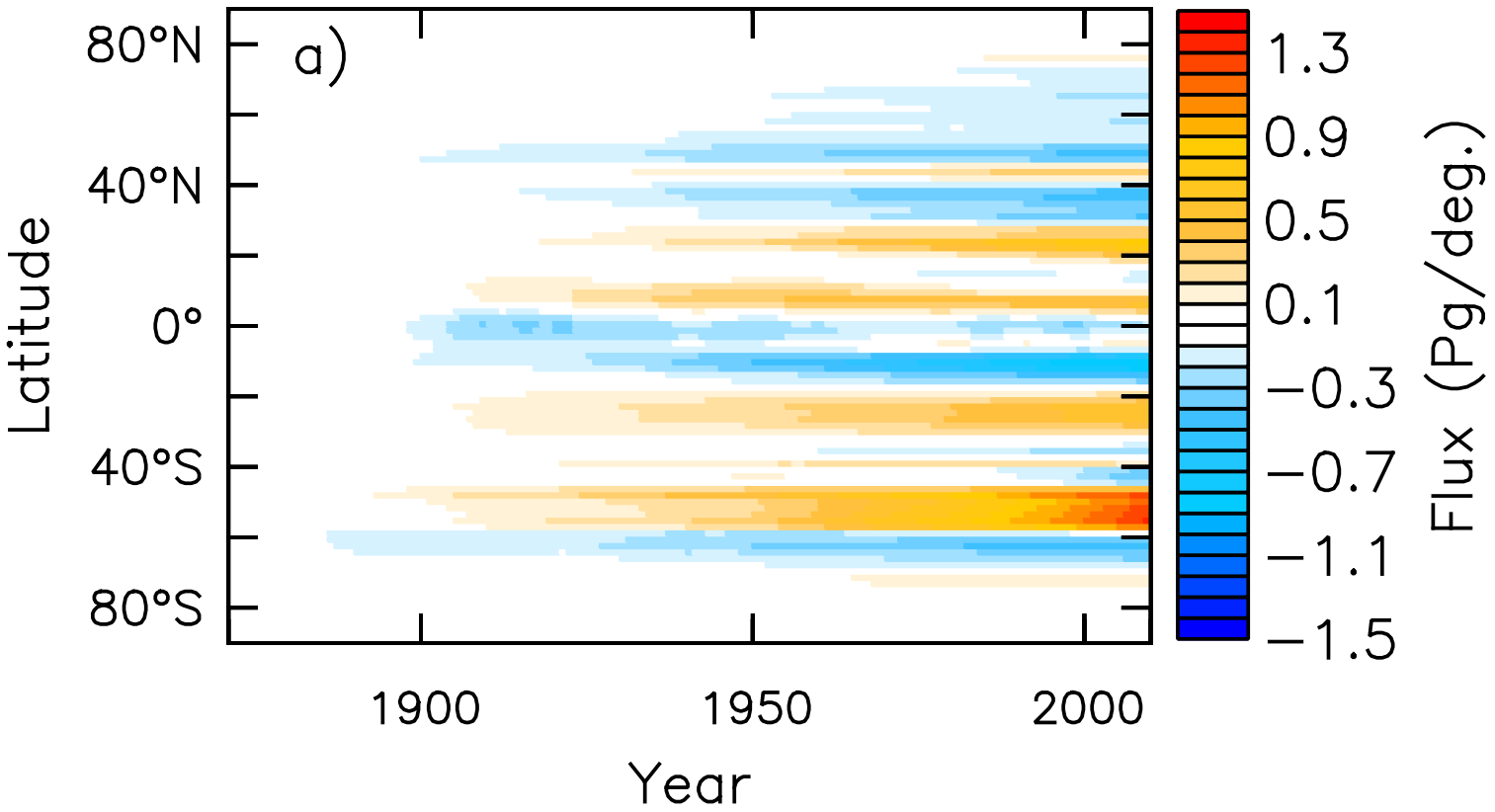
Net global carbon flux and wind feedback



N. C. Swart et al. (2014), Wind-driven changes in the ocean carbon sink, *Biogeosciences*, **11.**,

Carbon uptake in an OBGCM

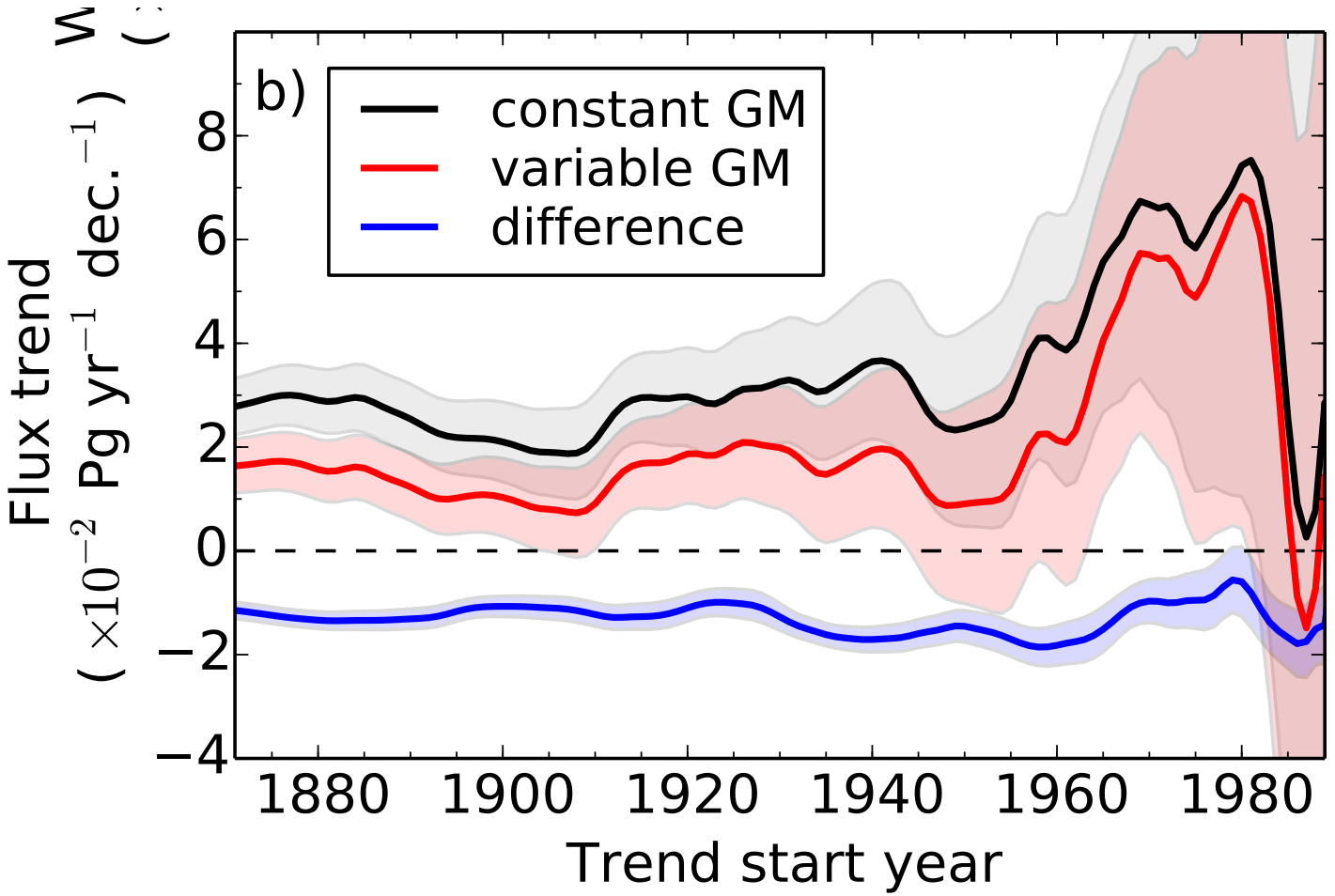
Wind induced flux anomaly



N. C. Swart et al. (2014), Wind-driven changes in the ocean carbon sink, *Biogeosciences*, **11.**,

Carbon uptake in an OBGCM

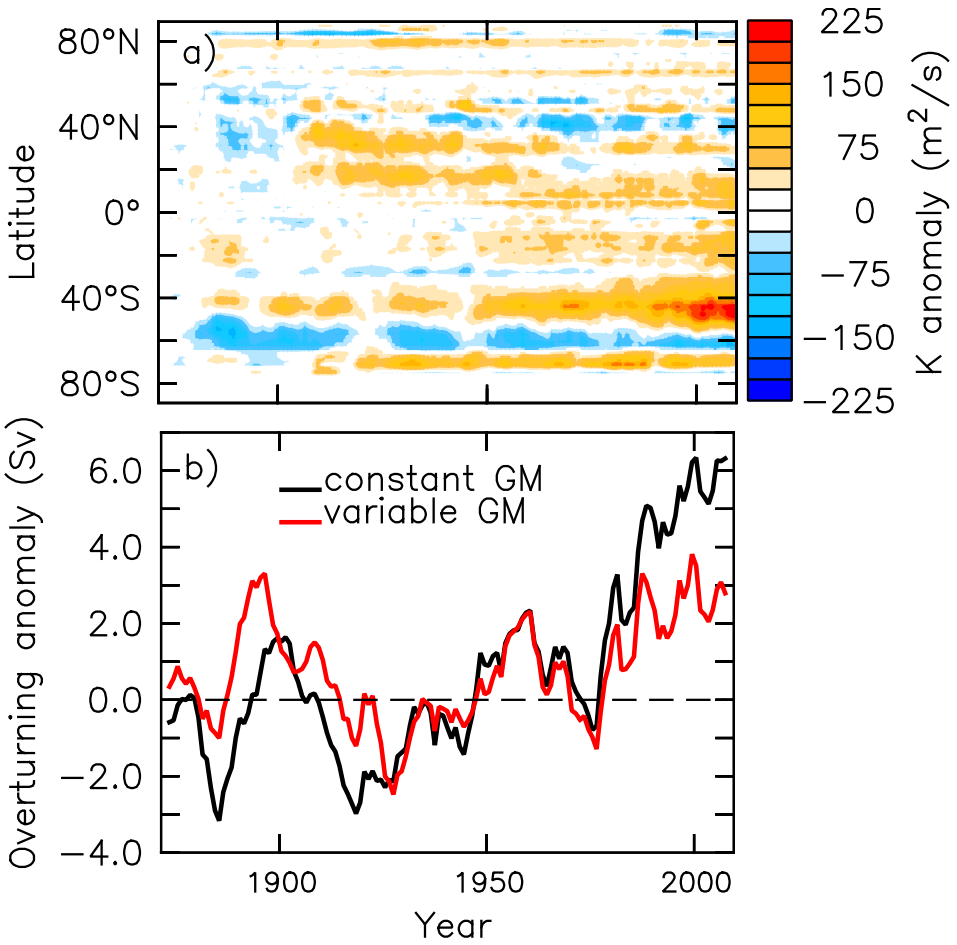
Wind induced trends in Southern Ocean surface flux



N. C. Swart et al. (2014), Wind-driven changes in the ocean carbon sink, *Biogeosciences*, **11.**,

Carbon uptake in an OBGCM

Changes in eddy diffusivity and MOC

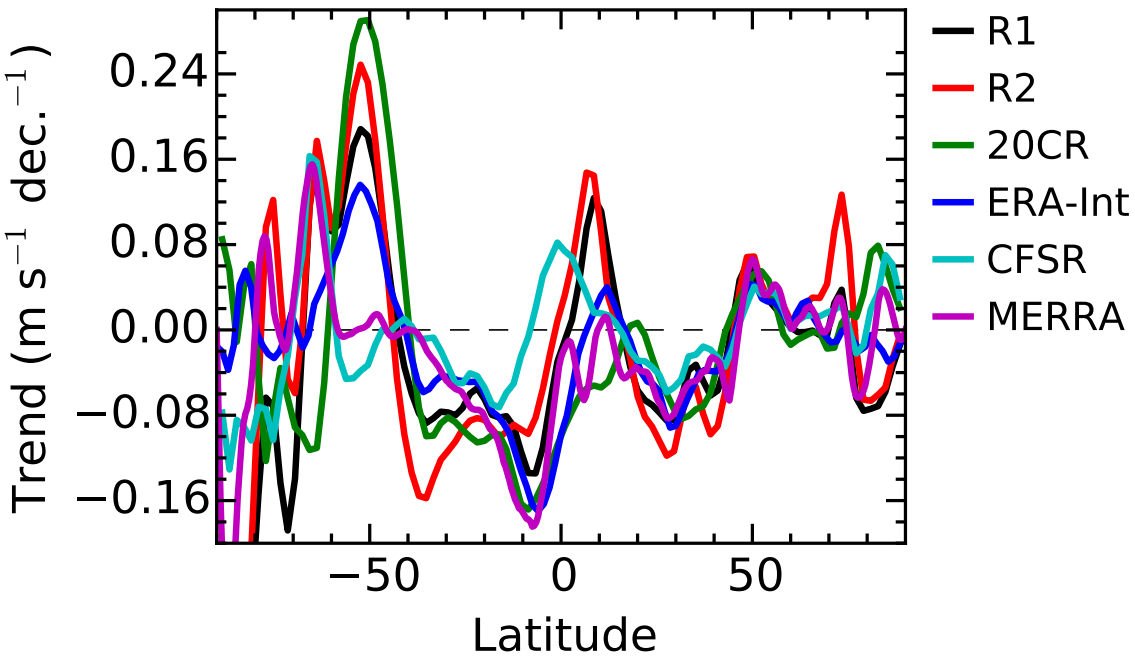


N. C. Swart et al. (2014), Wind-driven changes in the ocean carbon sink, *Biogeosciences*, **11.**,

Carbon uptake in an OBGCM

Uncertainty in reanalysis winds

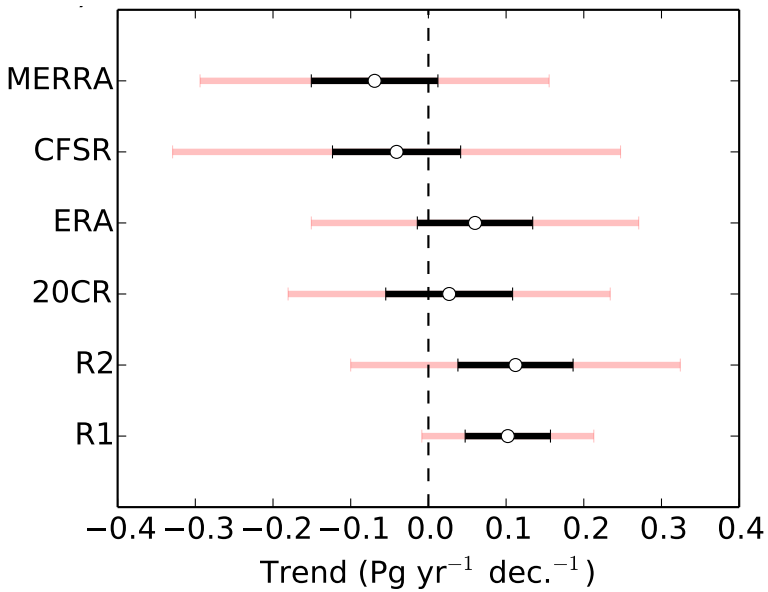
6 Reanalyzes winds → UVic ESCM → Ocean carbon uptake

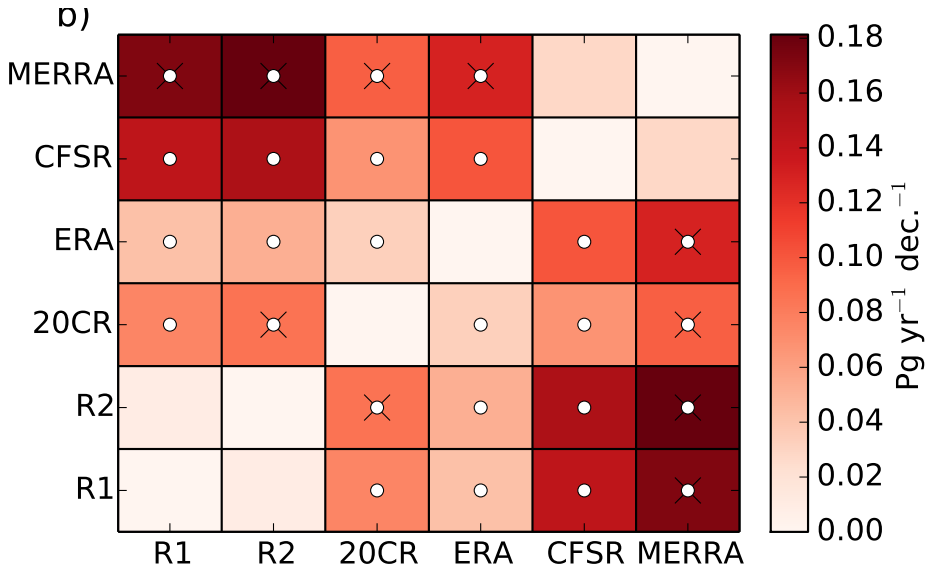


N. C. Swart et al. (2014), Wind-driven changes in the ocean carbon sink, *Biogeosciences*, **11.**,

Carbon uptake in an OBGCM

Effect of reanalysis wind uncertainty on carbon uptake trends

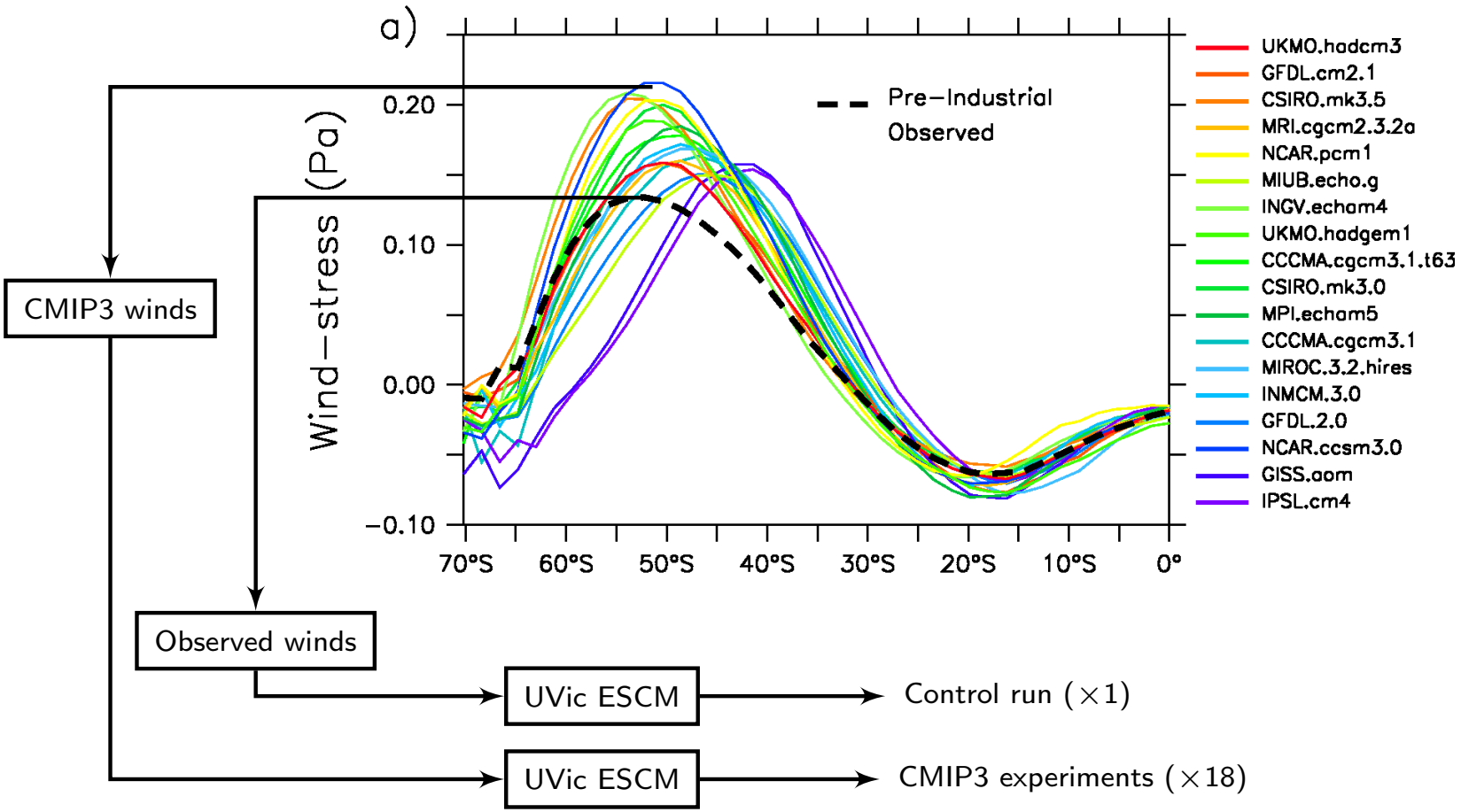




N. C. Swart et al. (2014), Wind-driven changes in the ocean carbon sink, *Biogeosciences*, **11.**,

Carbon uptake in an OBGCM

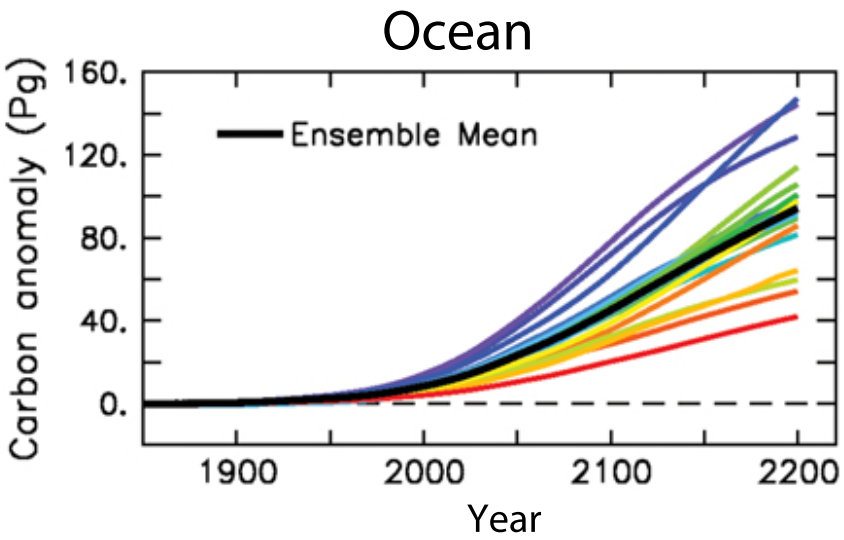
The bias in CMIP3 pre-industrial winds

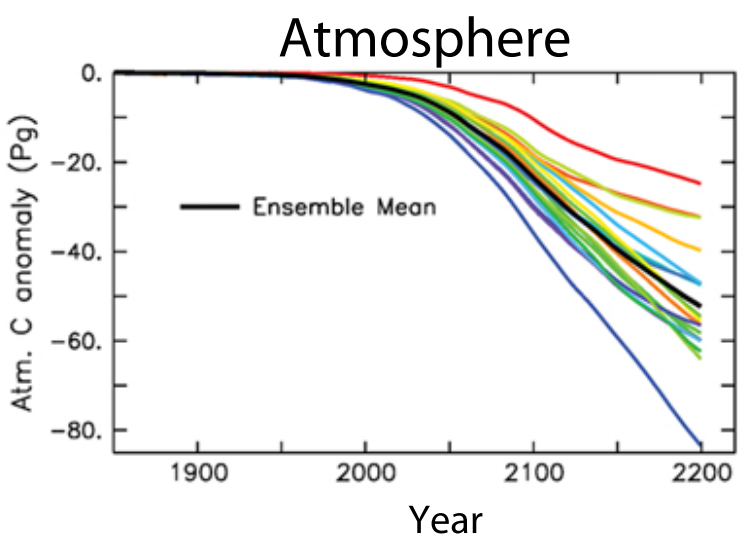


N. C. Swart and J. C. Fyfe (Jan. 2012b), Ocean carbon uptake and storage influenced by wind bias in global climate models, *Nature Clim. Change*, **2.**

Carbon uptake in an OBGCM

The effect of CMIP3 wind-stress biases on ocean carbon

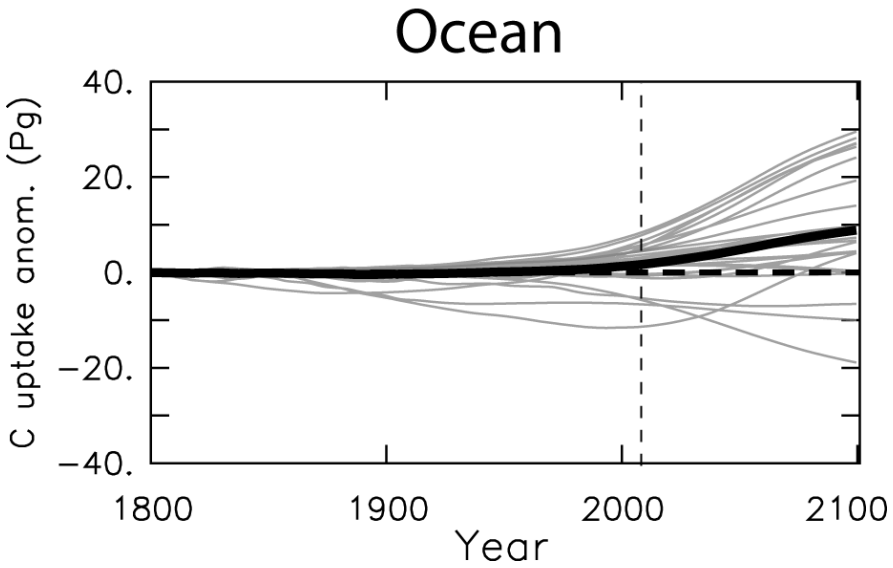




N. C. Swart and J. C. Fyfe (Jan. 2012b), Ocean carbon uptake and storage influenced by wind bias in global climate models, *Nature Clim. Change*, **2.**

Carbon uptake in an OBGCM

The effect of CMIP5 wind biases on ocean carbon



Conclusions

1. Intensifying westerlies reduce ocean carbon uptake, but...
2. **observed** and **simulated** changes in the westerlies are highly uncertain.
   - OBGCM estimates of ocean carbon uptake depend on choice of forcing.
   - Carbon uptake differences in CMIP ESMs stem partly from wind spread.
3. the wind feedback is sensitive to the eddy parameterization scheme in coarse resolution models.