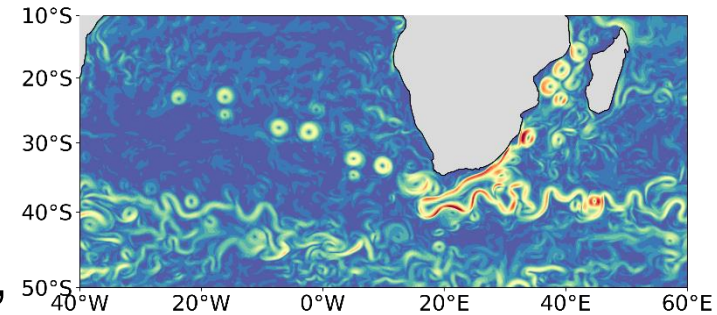


Stratospheric Ozone Recovery Slows Down Future Agulhas Leakage Increase due to Climate Change

Ioana Ivanciu, Arne Biastoch, Katja Matthes,
Sebastian Wahl, Jan Harlass



GEOMAR Helmholtz Centre for Ocean Research Kiel

Presenting author



Ioana Ivanciu

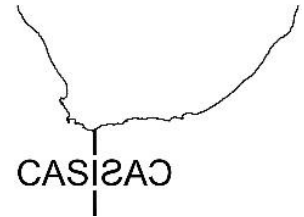
Doctoral Candidate

GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

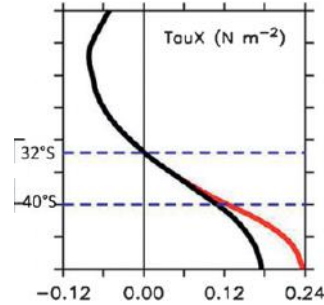
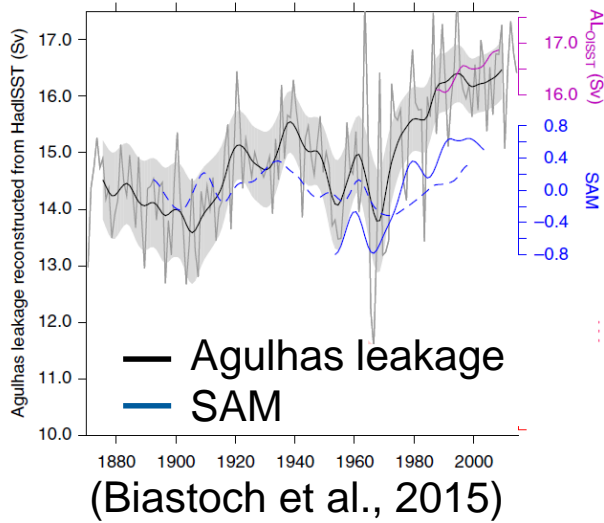
iivanciu@geomar.de

Ivanciu, I., Matthes, K., Biastoch, A., Wahl, S., and Harlaß, J.:
Twenty-first century Southern Hemisphere impacts of ozone
recovery and climate change from the stratosphere to the ocean,
Weather Clim. Dynam. Discuss., in review.

<https://doi.org/10.5194/wcd-2021-43>

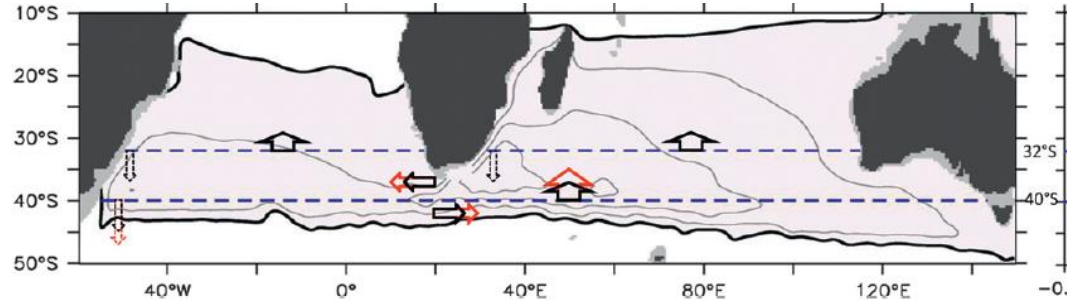


Motivation: westerlies changes alter the Agulhas leakage



Durgadoo et al., showed that strengthening the westerlies increases the wind stress curl over the Indian Ocean, resulting in more Agulhas leakage.

(Durgadoo et al., 2013)



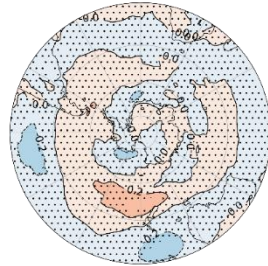
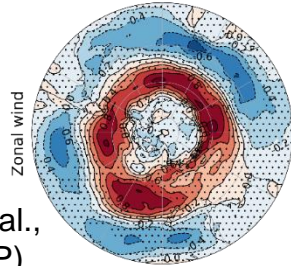
The Agulhas leakage increased in the second half of the 20th century in response to the poleward intensification of the westerlies.

Past westerlies strengthening driven by O₃ depletion, but O₃ recovers during the 21st century

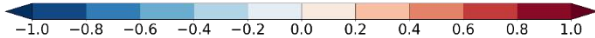
Past westerlies change (m s⁻¹)

O₃

GHGs



(Ivanciu et al., 2021, ACP)



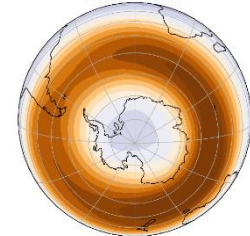
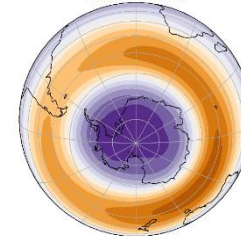
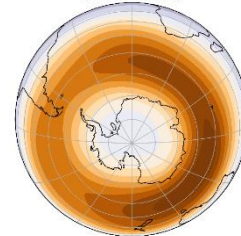
Past poleward intensification of the westerlies driven mainly by O₃ depletion, with GHGs playing secondary role.

Spring TCO (DU)

1960-1969

1990-1999

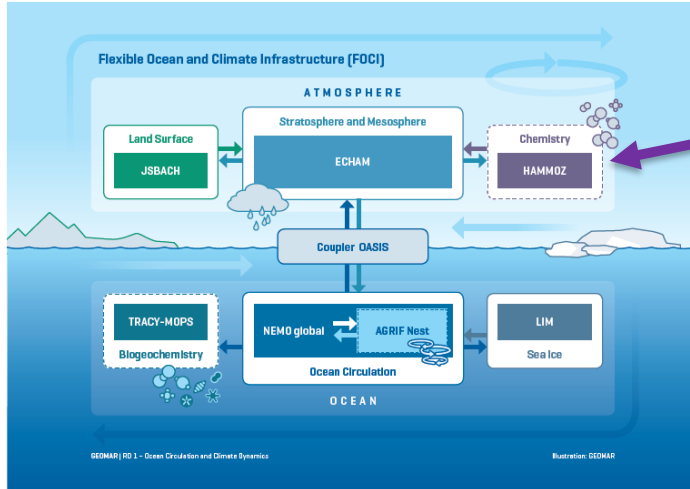
2060-2069



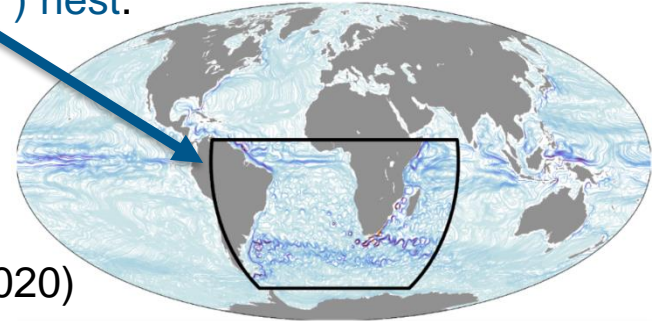
O₃ hole peaked in the 1990s and is expected to recover during the 21st century.

How will the Agulhas leakage respond to the continuous increase in GHGs as the O₃ hole recovers?

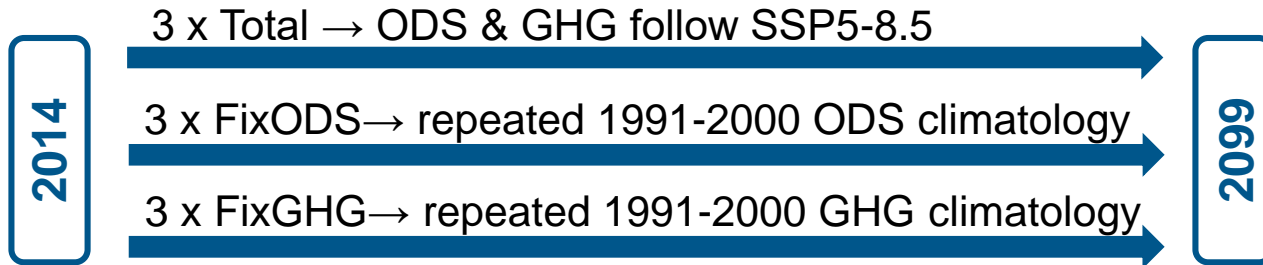
Model Simulations



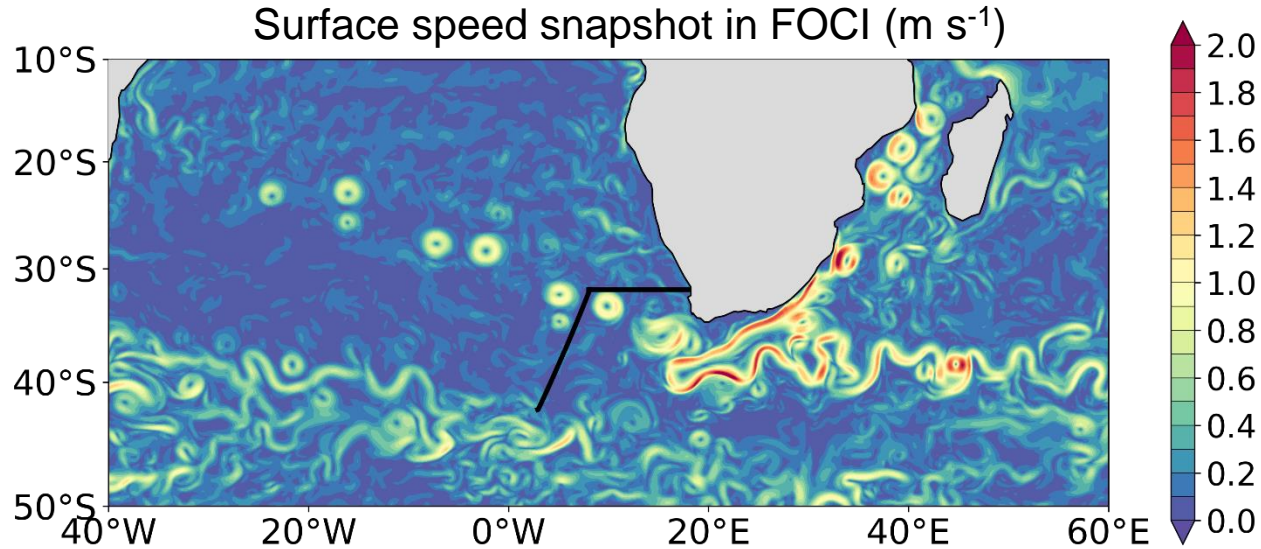
Ensembles of single forcing simulations with the coupled climate model FOCI, including **interactive ozone chemistry** and **high resolution (0.1°) nest**.



(Matthes et al., 2020)

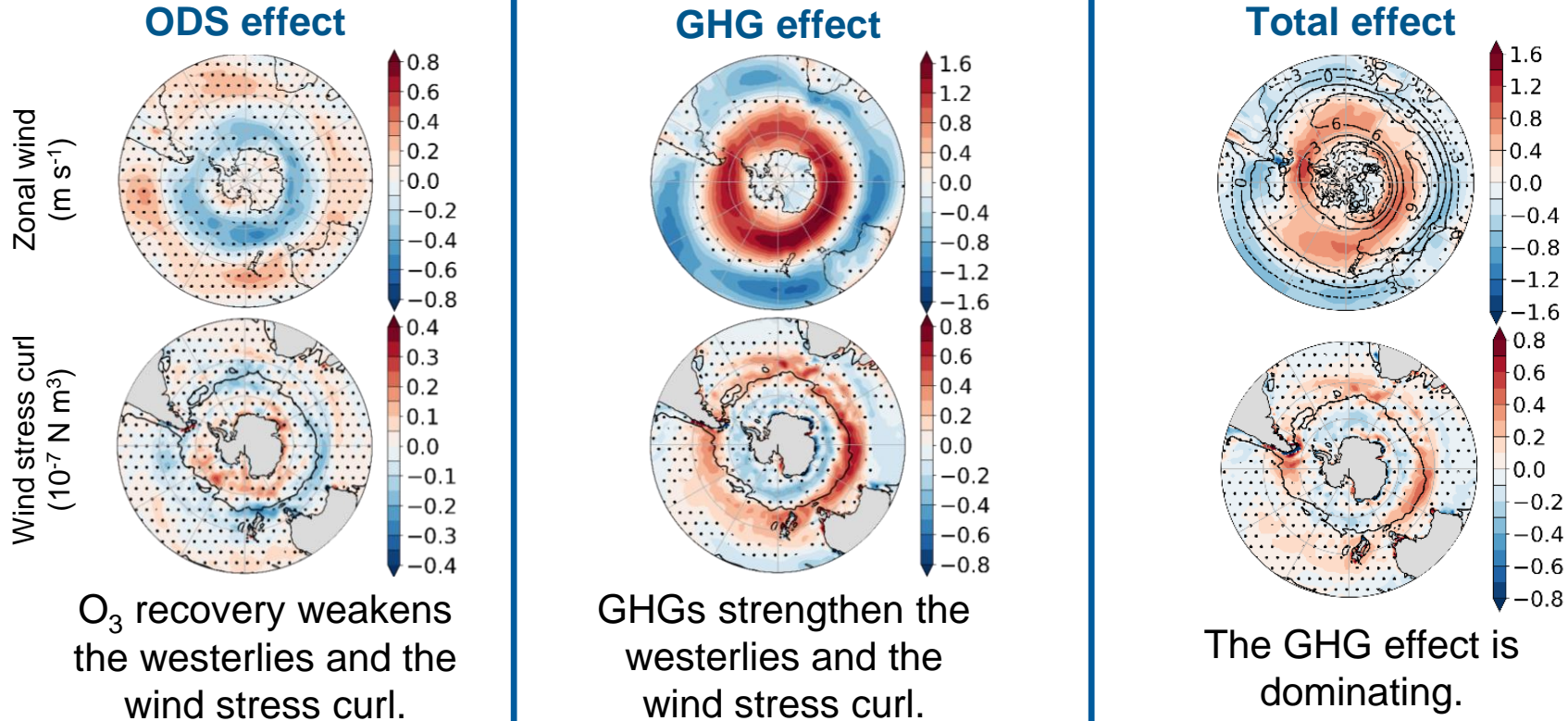


Agulhas leakage calculation



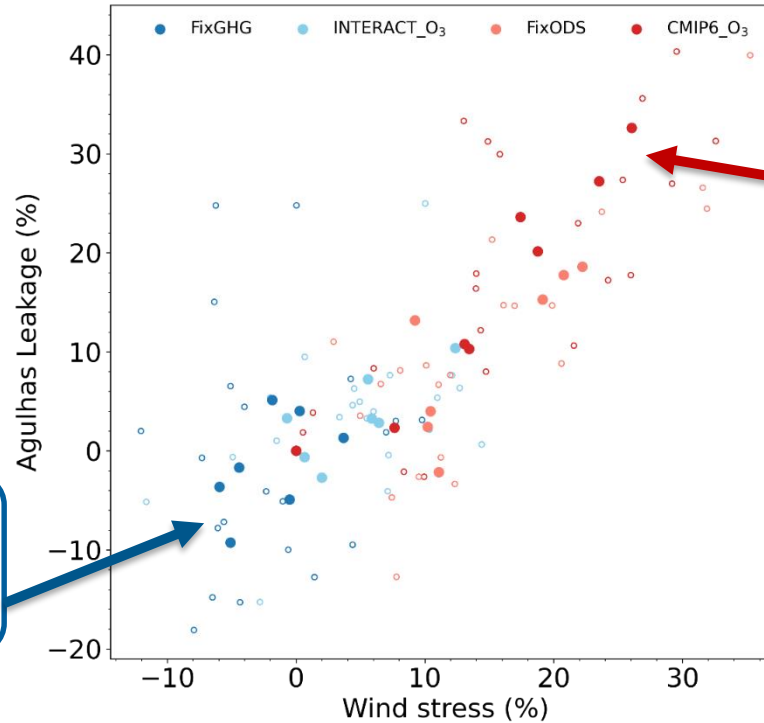
- ARIANE lagrangian particle tracking software (Blanke and Raynaud 1997).
- Particles seeded across the Agulhas Current at 32°S.
- Each particle is assigned a fraction of the total Agulhas Current volume transport.
- Agulhas leakage = particles crossing the Good Hope section within 5 years.

How are the westerly winds changing in the future?



Are westerlies and Agulhas leakage changes related in FOCI?

- Single simulation
- Ensemble mean

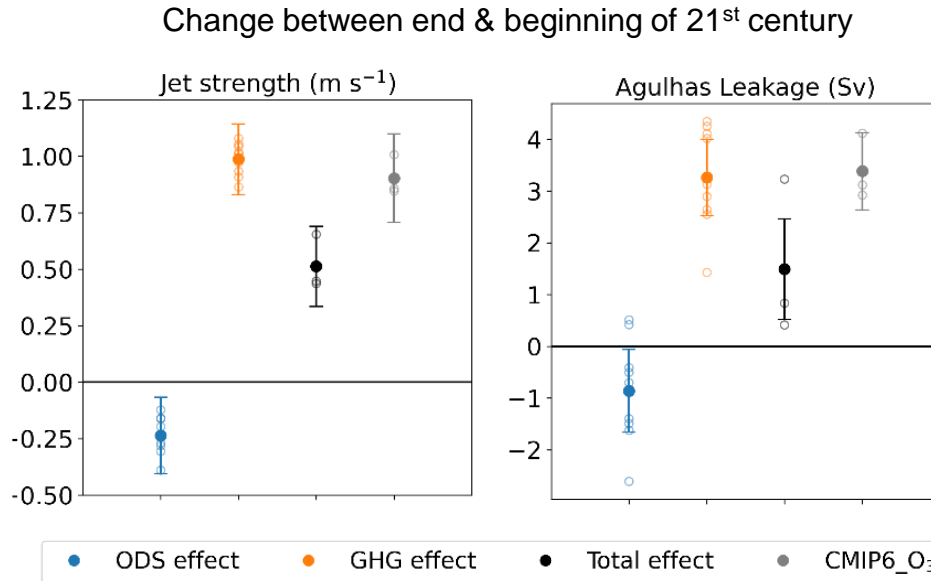


Agulhas leakage increases for stronger westerlies

Agulhas leakage decreases for weaker westerlies

FOCI captures the relationship between the westerly winds and Agulhas leakage.

O₃ recovery mitigates the GHG impact on Agulhas leakage



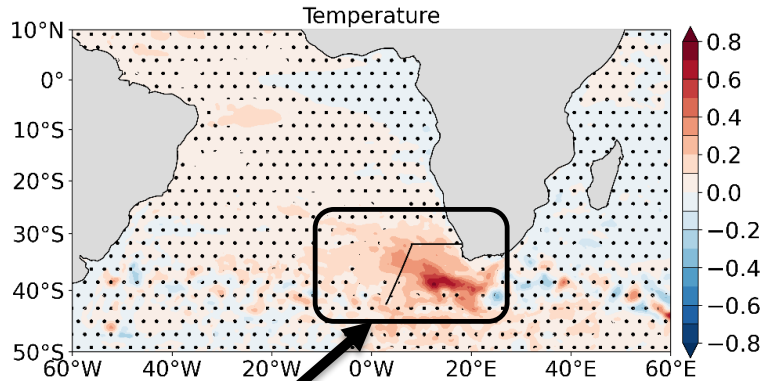
Stronger westerlies due to increasing GHGs drive an increase in Agulhas leakage.

Weaker westerlies due to O₃ recovery drive a decrease in Agulhas leakage.

Overall increase in Agulhas leakage, but weaker than in the absence of O₃ recovery.

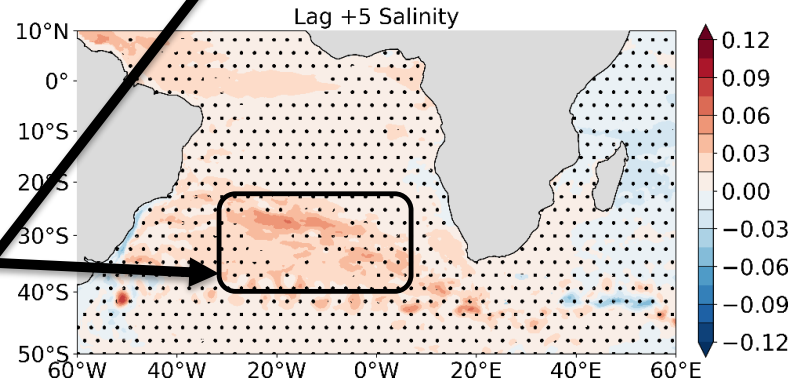
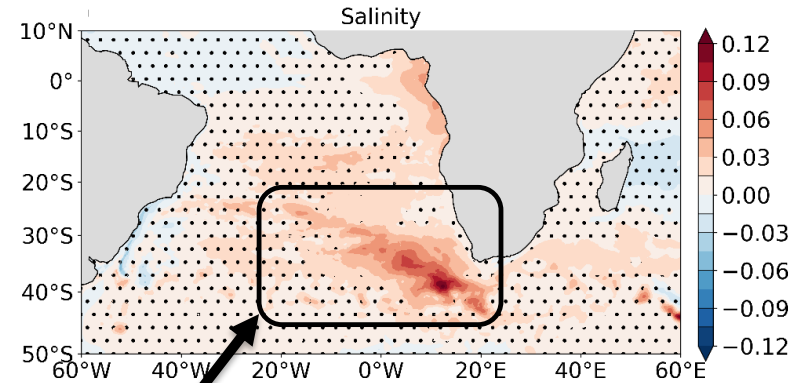
How does an increased Agulhas leakage affect the S. Atlantic?

Decadal composites of 11 high Agulhas leakage periods → upper 1000m T & S.

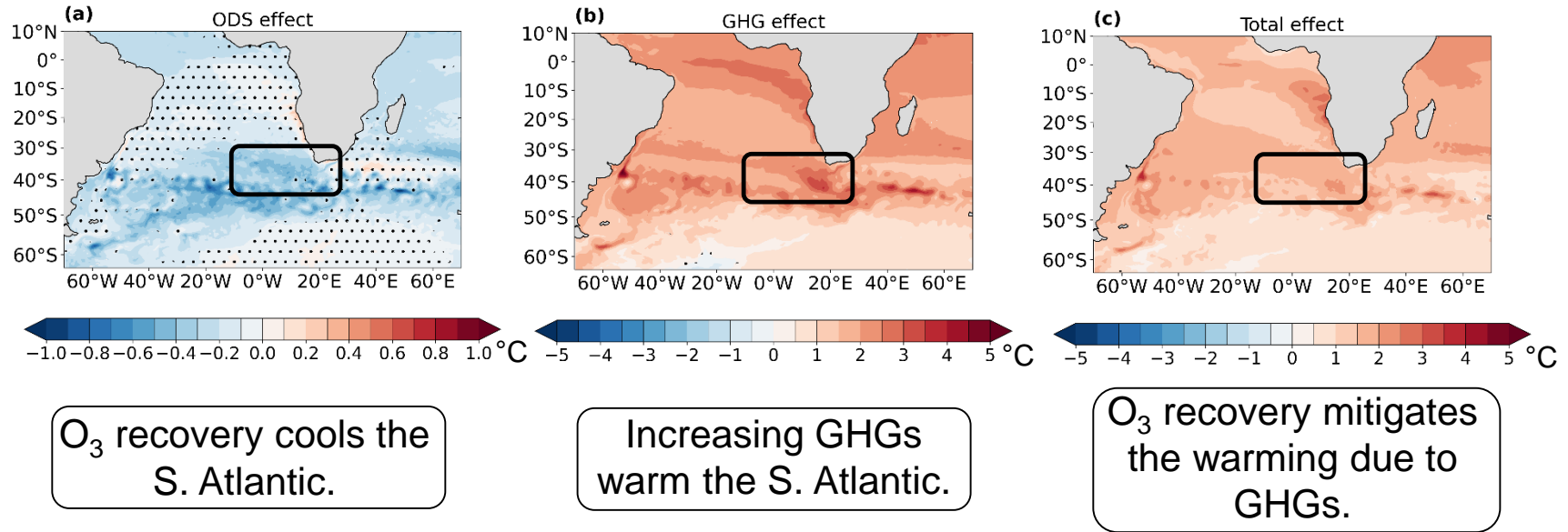


Warm anomalies propagating northwestward.

Salty anomalies propagating northwestward, persistent 5 years later.



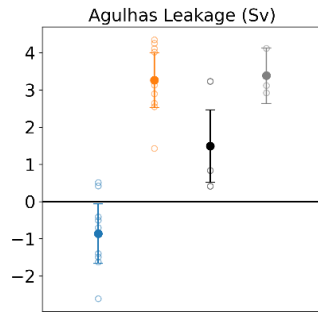
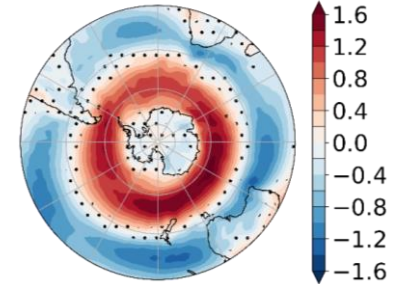
South Atlantic SST changes during the 21st century



Agulhas leakage changes affect the S. Atlantic SST, but their impact cannot be clearly distinguished from the impact of other circulation changes (e.g. Ekman transport & pumping).

Summary

GHGs continue to strengthen the westerly winds and the associated wind stress curl over the Indian Ocean, while O₃ recovery weakens the westerlies and the wind stress curl.



The Agulhas leakage increase in response to GHGs is mitigated by the decrease in response to O₃ recovery.

The increased Agulhas leakage leads to warm and salty anomalies in the upper 1000 m, which contribute to the thermohaline changes experienced by the S. Atlantic.

