CASISAC

Changes in the Agulhas System and its Impact on Southern African Coasts

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In Short

- The Agulhas System is a key element of the global overturning circulation
- The coastal distribution of sea level is strongly determined by regional processes
- Explicitly simulated atmospheric CO_2 and ozone allow to decipher the impact of changes in the westerlies on ocean circulation

The Agulhas current system is an important player in the global overturning circulation. On its way along the southern African coast, the Agulhas current transports waters south towards the tip of the continent, where it turns back into the Indian Ocean, shedding eddies that enter the Atlantic Ocean, carrying warm and salty waters from the Indian Ocean.

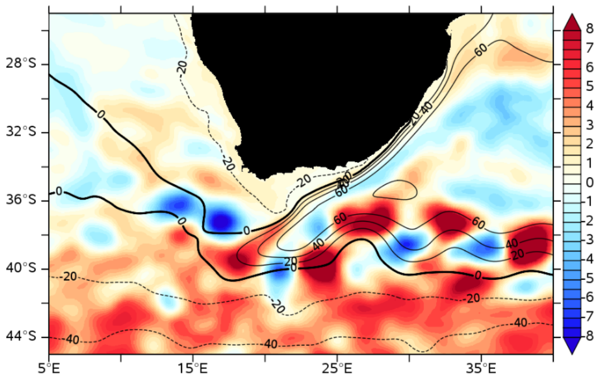

Figure 1: *Long-term mean (1960-2009) Sea Surface Height (contours and linear trend (shading) from INALT20.L46. Mean SSH contours depict the way of the Agulhas Current, its retroflection and the corridor in which Agulhas rings enter the Atlantic Ocean. The trend pattern shows sea level rise along southern African coasts and emphasizes the high spatial variability.*

This transport is highly variable on temporal and spatial scales and is subject to climatic changes [1]. The main focus in CASISAC is set on different influencing factors acting on the Agulhas system, particularly the impact of global warming on Southern Hemisphere wind systems. The observed and prognosed changes in the Agulhas system lead to a warming of surface waters and thus have a direct influence on the regional climate along the Atlantic rim, specifically in southern Africa. In particular, changes in the distribution and amounts of rain are important for the supply of drinking water and agriculture, but also they pose a threat through extreme events. We will simulate the impact of a changing Agulhas system on the regional climate in southern Africa. Ocean currents are also closely related to the distribution of the sea level, potentially expanding or compensating the global sea level rise. Changes in the distribution and height of surface wind waves come in addition. The already diagnosed and for the future prognosed regional distribution of the sea level along the southern African coastlines will be assessed (Figure 1). The combination of all effects, changing rain amounts and resulting river outflow, sea level rise and wind waves, are key quantities for the regional impact on southern African coasts. In CASISAC we aim at evaluating their vulnerability under global warming.

To assess the aforementioned processes, resolving ocean eddies is mandatory. We employ a series of nested model configurations [2] with resolutions of 1/20° (INALT20) and 1/10° (INALT10x) in the South Atlantic and western Indian Ocean embedded in global grids at 0.25° and 0.5° horizontal resolution, respectively.

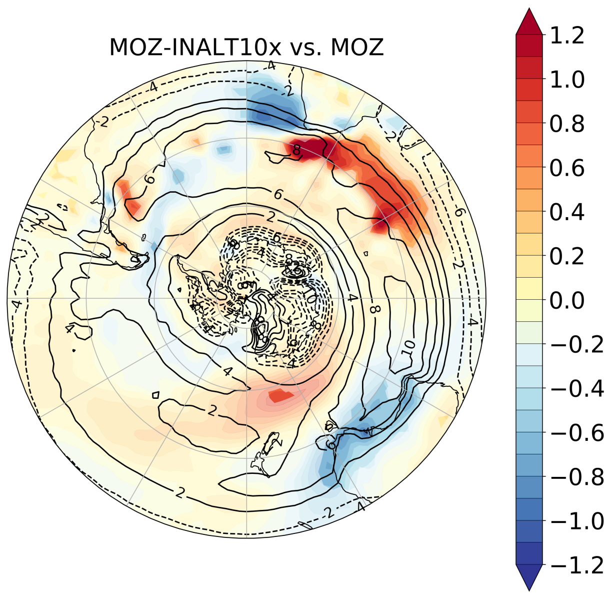

Figure 2: *Difference in 10 m zonal winds (1958-2013) for June-July-August between FOCI-MOZ-INALT10x and FOCI-MOZ (color shading; transparent colors not significant at the 95% level). Contours (interval 2 m/s) show the climatological zonal winds from the FOCI-MOZ-INALT10x*

Coupled ocean-atmosphere experiments with interactive atmospheric chemistry provide insights on

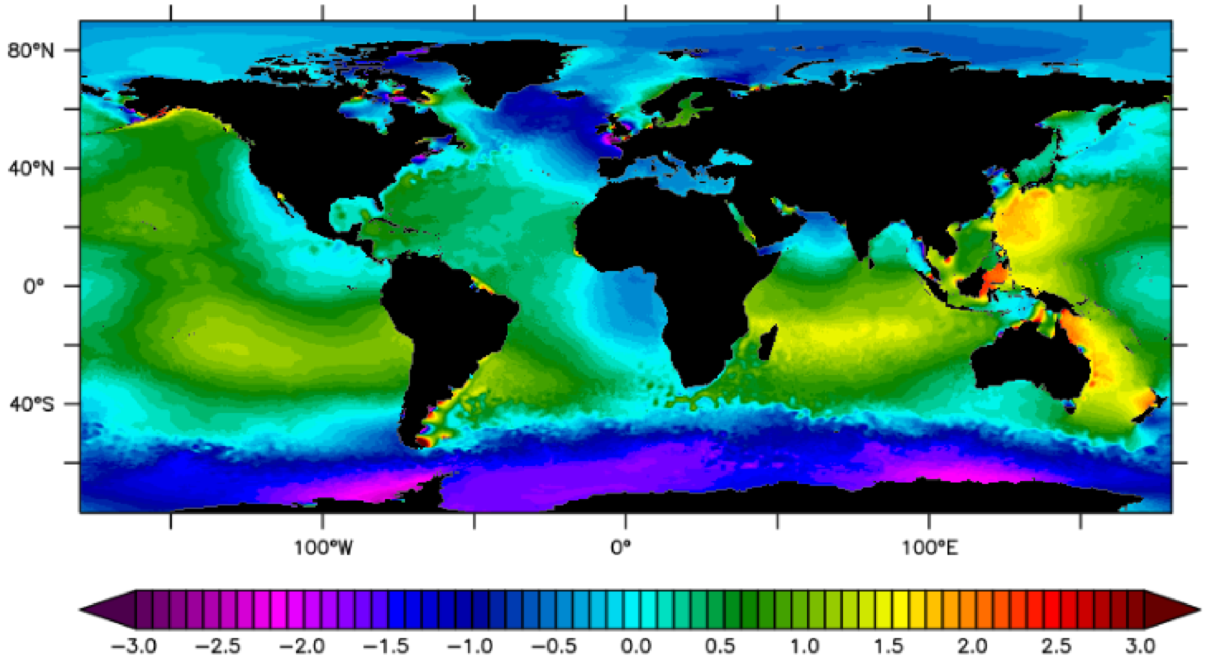

Figure 3: *Snapshot of Sea Surface Height anomaly from a simulation in INALT20.L46 with tidal forcing. Wave propagation along the coasts strongly influence sea level variability affecting their vulnerability.*

the impact of increasing CO_2 and a potential recovery of the Antarctic ozone hole on the Southern Hemisphere westerlies and thereby the Agulhas System. With the high resolution in the ocean (FOCI-INALT10x) the representation of e.g. sea surface temperatures improves compared to a coarser resolved version of the model (FOCI). We now see a combined effect in the atmosphere of including atmospheric interactive chemistry (MOZ) and the high resolution ocean (FOZI-MOZ-INALT10x) that manifests only in austral winter. The Southern Hemisphere westerly winds are enhanced on their equator-ward side at the tip of South Africa and in the western part of the Indian Ocean. This wind intensification is felt throughout the atmosphere up to the stratopause and improves the representation of the stratospheric westerly jet in the model (Figure 2). In future experiments we will examine the individual influences of ozone depleting substances and greenhouse gases on the Southern Hemisphere westerlies. Their projected evolutions are expected to counteract each other leading to high uncertainty in projections of future climate. Results from our coupled experiments are used by our partners at Helmhltz-Zentrum Geesthacht, GmbH as boundary conditions for their regional high resolution climate model simulating the influence of Agulhas dynamics on precipitation variability over southern Africa.

Hindcast experiments in INALT20 under prescribed atmospheric forcing over the past six decades will enable us to analyse multi-decadal variability and already ongoing changes in the Agulhas system and their regional and global scale effect. In these experiments we explicitly simulate tides that generate basinscale waves which accumulate along the coasts (Figure 3) and therefore strongly influence sea level variability there. Our partners at Universities of Siegen and Kiel will use sea surface height data from these model experiments to understand decadal variability and sea level variations along the southern African coasts and further for statistical downscaling of wind waves.

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More Information

[1] Biastoch, A. et al., *Nature Communications* **6**, 10082 (2015). doi:10.1038/ncomms10082

[2] Schwarzkopf, F. U. et al., *Geoscientific Model Development* (2019). doi:10.5194/gmd-2018-312

Project Partners

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