Atmospheric centers of action over oceans in the Southern Hemisphere: Possible changes in the 21st century from CMIP6 model simulations

Mokhov I.I.[1,2], Osipov A.M.[2], Chernokulsky A.V.[1]

[1]A.M. Obukhov Institute of Atmospheric Physics RAS
[2]Lomonosov Moscow State University
mokhov@ifaran.ru

An analysis of possible changes of the atmospheric centers of action (ACA) in the Southern Hemisphere under global warming was carried out. We used the results of simulations with climate models of the CMIP6 ensemble with the SSP5-8.5 scenario for the 21st century. The quality of the ACAs simulations was evaluated by comparison of the CMIP6 historical scenario with the ERA5 reanalysis data (https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5) for the base period 1981-2005.

The areas corresponding to each of the analyzed ACAs were identified similar to (Mokhov et al., 2020). Within the area corresponding to ACA, the mean sea level pressure Pc was determined with increased or decreased pressure for anticyclonic or cyclonic conditions, respectively (see also (Mokhov et al., 2018; Mokhov et al., 2021). The ACA intensity was characterized both by the pressure at sea level in the ACA region Pc and by the corresponding pressure drop Ic relative to the mean hemispheric pressure P_H at the sea level. We also analyzed the relative changes in the ACA intensity Ic = Ic/δIc - when normalizing Ic to the corresponding standard deviations (SD) δIc.

Two model ensembles were analyzed separately, i.e., all CMIP6 models that provide information on sea-level pressure (53 models and their versions), and selected models that best simulate both sea-level pressure field and intensity of ACAs (similar to (Mokhov et al., 2022)).

Table 1. Intensity Ic [hPa] of ACAs in the Southern Hemisphere for winter and summer from simulations with selected 11 CMIP6 ensemble of climate models (under the historical scenario) and by ERA5 reanalysis data for the base period 1981-2005. The standard deviations (SD) of the ACA intensity are given in parentheses. The corresponding estimates for the selected models are given in square brackets.

ACA Seasonal Mean Intensity (hPa)	Winter (JJA)		Summer (DJF)	
	Reanalysis	CMIP6 models	Reanalysis	CMIP6 models
South Pacific High	7.2 (±1.5)	8.5 (±1.6) [8.1 (±1.5)]	9.8 (±1.0)	9.6 (±0.9) [9.7 (±0.9)]
South Atlantic High	9.2 (±0.9)	11.4 (±1.0) [10.9 (±1.0)]	7.9 (±0.6)	8.3 (±0.7) [8.2 (±0.7)]
South Indian (Mascarene) High	11.3 (±1.2)	13.2 (±1.1) [13.0 (±1.0)]	8.7 (±0.7)	8.8 (±0.7) [8.7 (±0.7)]
South Pacific Low	-20.7 (±4.0)	-17.3 (±3.9) [-17.9 (±3.7)]	-18.3 (±2.8)	-17.6 (±2.7) [-17.5 (±2.6]
South Atlantic Low	-15.8 (±0.9)	-13.6 (±1.6)) [-14.3 (±1.6)]	-13.5 (±1.0)	-12.7 (±1.1) [-13.1 (±1.1)]
South Indian Low	-17.8 (±1.3)	-16.6 (±1.8) [-16.9 (±1.8)]	-12.4 (±1.1)	-12.0 (±1.1) [-12.3 (±1.1)]

Table 1 presents intensity Ic of ACAs over oceans in the Southern Hemisphere for winter and summer from simulations with CMIP6 ensemble of climate models and by ERA5 reanalysis data for the base period 1981-2005.

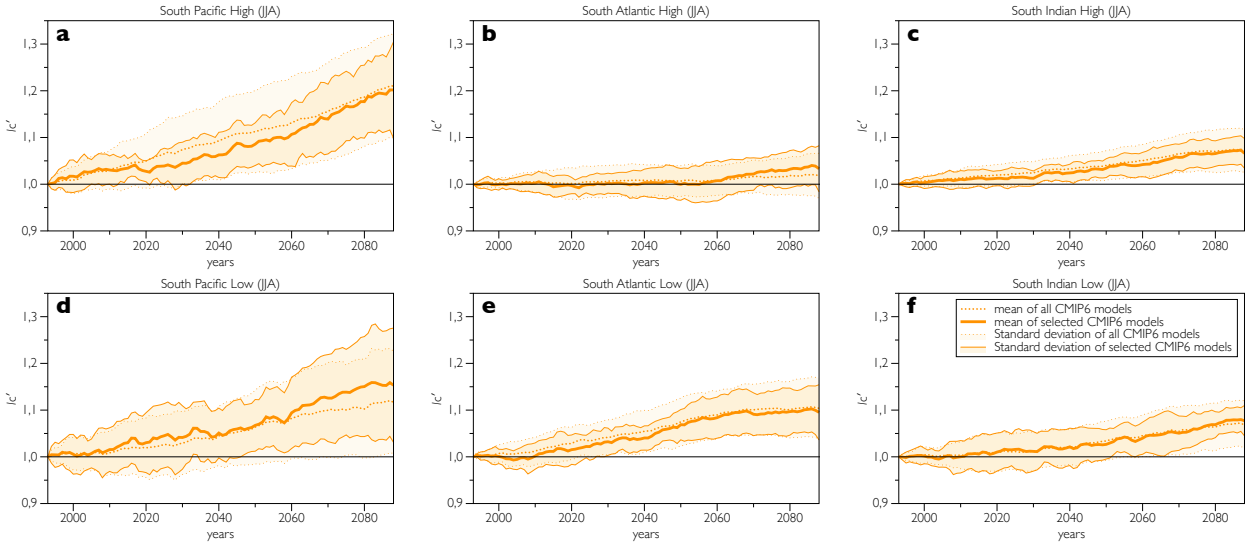

Figure 1. Changes in the winter (JJA) ACA intensity (normalized to SD for the base period 1981-2005) in the Southern Hemisphere from simulations with CMIP6 models under the SSP5-8.5 scenario. Here: (a) South Pacific High, (b) South Atlantic High, (c) South Indian (Mascarene) High, (d) South Pacific Low, (e) South Atlantic Low, (f) South Indian Low. SD ranges relative to 30-year moving averages are shaded, mean value for the ensemble is shown as well. Two ensembles are shown: the ensemble for the selected models is shown with solid lines, the ensemble with all CMIP6 models is shown with dashed lines (and paler shading),

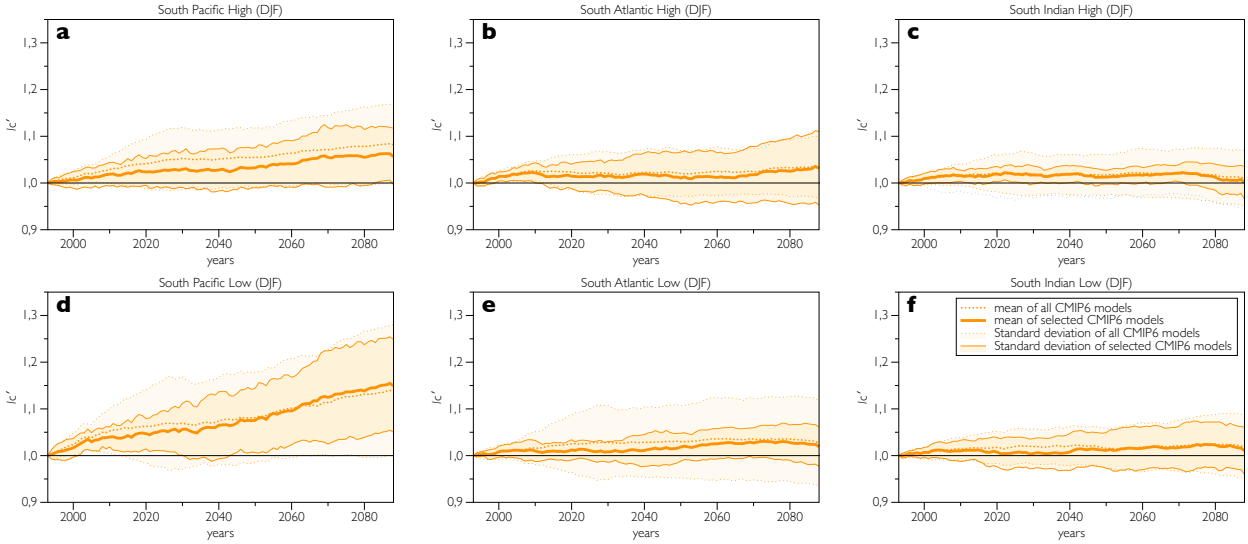

Figure 2. Same as Figure 1 but for changes in the summer (DJF).

According to ensemble simulations with CMIP6 models all analyzed ACAs over oceans in the Southern Hemisphere are intensified as a whole in the 21st century under scenario SSP5-8.5.

References

Mokhov I.I., Chernokulsky A.V., Osipov A.M. Changes in the characteristics of atmospheric centers of action. In: Intense Atmospheric Vortices and Their Dynamics. Ed. By I.I. Mokhov, M.V. Kurgansky, O.G. Chkhetiani. Moscow, GEOS, 2018, 398-403. (In Russian)

Mokhov I.I., Chernokulsky A.V., Osipov A.M. Atmospheric centers of action in the Northern and Southern Hemispheres: Features and variability. Rus. Meteorol. Hydrol., 2020, **45** (10), 749–761.

Mokhov I.I., Chernokulsky A.V., Osipov A.M. Atmospheric centers of action in the Northern and Southern Hemispheres: Tendencies of change in the 21st century from model simulations. Research Activities in Earth System Modelling, E. Astakhova (ed.), 2021, Rep. 51, 7, 11-12.

Mokhov I.I., Osipov A.M., Chernokulsky A.V. Atmospheric centers of action in the Northern Hemisphere: Current features and expected changes in the 21st century based on simulations with the CMIP5 and CMIP6 ensembles of climate models. Doklady Earth Sciences, 2022, **507** (2), 1132–1139.