Geophysical Research Abstracts
Vol. 18, EGU2016-209, 2016
EGU General Assembly 2016

Multi-decadal changes and predictions over the Southern Hemisphere Polar region: role of the stratospheric representation in CMIP5 models

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In the last decades, the strong ozone hole at Southern Hemisphere (SH) polar latitudes has been responsible of a long-term lower stratospheric cooling that seasonally superimposes to the GHG cooling, affecting summertime circulation from the stratosphere to the surface. In the troposphere, the ozone-induced cooling implies a poleward shift of the mid-latitude jet and projects onto the positive phase of the Southern Annular Mode (SAM) at the surface affecting also oceanic circulation and temperature by variations in wind stress at the ocean surface and in the oceanic Ekman transport. The SAM positive phase projects onto Sea Surface Temperature (SST) colder anomalies around most of Antarctica and warmer anomalies around the west side of Antarctic Peninsula and at mid-high latitudes, contributing to accelerate initially the upper branch of the Atlantic Meridional Overturning Circulation (AMOC) in opposition to the weakening induced by global warming.

We demonstrate that a proper representation of the stratospheric processes in climate models is the key ingredient to fully capture multi-decadal climate changes in the SH and to make more reliable future predictions. We perform a multi-model analysis assessing to which extent a limited representation of stratospheric processes in the Coupled Intercomparison Project Phase 5 (CMIP5) models leads to biases in the representation of simulated SH stratospheric, tropospheric and surface changes on multi-decadal time scales. All these same changes are analyzed for future scenarios with projected increase of GHGs and ozone recovery. We investigate also the relationship between the SAM positive phase and the SST summertime trends and possible effects on the oceanic circulation for the different model classifications.