Surface winds along the eastern boundary upwelling systems in future climate scenarios

René Garreaud (rgarreau@dgf.uchile.cl) and Mark Falvey (falvey@dgf.uchile.cl)
Department of Geophysics, Universidad de Chile

In this work we describe and interpret global-scale surface wind changes between present day conditions (baseline time slice: 1970-1999) and those projected for the end of the 21st century under the A2 IPCC scenario (A2 time slice: 2070-2099), with emphasis on the four major EBUS (Benguela, California, Canary and Humboldt). Evaluation of these changes are a key step to predict the regional environmental impacts of global climate change -linked to anthropogenic greenhouse gas increases- upon EBUS. Our primary dataset are the output from 21 coupled Global Circulation Models (GCM) integrations performed for the IPCC 4th Assessment Report.

Figure 1 shows the multimodel, A2 minus BL differences of annual mean sea level pressure (ΔSLP) and surface winds ($\Delta \mathbf{V}_s$). A particularly strong and consistent signal among the models is an increase in SLP along the poleward flank of the subtropical anticyclones (maximum at about 40° of latitude), modest changes at tropical latitudes, and a decrease at higher latitudes. This pattern has been linked with both an expansion of the Hadley circulation and a poleward shift of the extratropical storm tracks.

The low-level winds along the EBUS are in an ageostrophic balance between the meridional pressure gradient and the friction. Therefore, the ΔSLP pattern leads to enhanced equatorward flow along the EBUS at subtropical latitudes (maximum at about 30° of latitude). The increase of upwelling-favourable winds is particularly marked and persist year round off the coast of south-central Chile, where $\Delta \mathbf{V}_s \sim \Delta v_s \sim 1$ m/s. Along the Canary and Benguela systems the changes are weaker ($\Delta v_s \sim 0.5$ m/s) and encompass an smaller area, but still persist year round. Off California, enhanced equatorward flow is restricted to boreal spring.

The coupled GCMs don't show a consistent change in the depth of the ocean mixed layer along the EBUS, therefore we can infer that the projected increase in upwelling-favourable, equatorward flow will tend to cool these coastal regions. Enhanced ocean eddy-activity (also forced by the stronger winds) can extend this cooling effect farther into westward. Indeed, the geographic pattern of projected surface air temperature change (ΔSST) shows minimum warming over the EBUS, particularly off south-central Chile, where the ΔSST of about 1°C is only half of the zonal average ΔSST at the same latitude. For the same region, we also found a good correspondence between the "anomalous regional cooling" and the increment of the local equatorward flow in individual models.

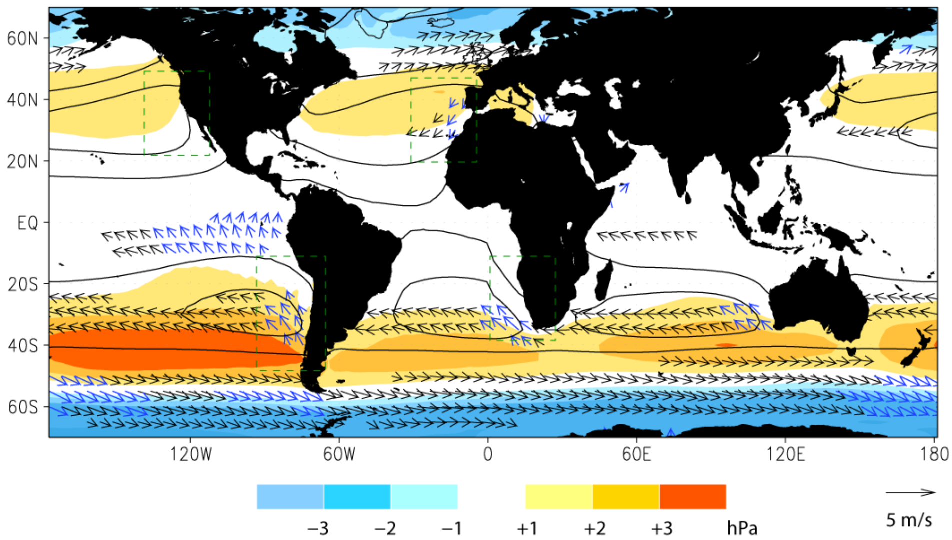

Figure 1. Multimodel average change (A2-BL) in the annual mean sea level pressure (shaded) and surface winds (vectors). Solid lines are the mean 1012 and 1017 hPa isobars in BL.