Project: **987**

Project title: **The role of the South Atlantic Anticyclone in the Tropical Atlantic climate variability**

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During the year, our attention was focused on four topics:

1. The analysis of the Benguela Low Level Jet (BLLJ), one of the components of the South Atlantic Anticyclone using the coupled runs with the AFR domain. The BLLJ contributes to the generation of the South Eastern Tropical Atlantic biases. The BLLJ is one of the most important mesoscale features in the region and shape of the climate of the regional climate in the Eastern South Atlantic. The strong coastal upwelling there associated to the Benguela eastern boundary current (EBC) makes the ocean along the coast of this region one of the most productive ecosystems in the world.
   We analyse one of our 25 km horizontal resolution uncoupled ROM simulation which cover the 1980-2014 period, to describe the characteristics of the BLLJ. We found that the Benguela coastal low-level jet is characterized by intense winds that occur around 400 m above sea level, within or at the top of the marine atmospheric boundary layer. This coastal jet is an important mesoscale feature in the Namibia and Angola coastal areas, since it is present virtually all year round, with differences in frequency of CLLJ occurrence and location. The near-surface wind speeds from ROM and a set of Africa-CORDEX simulations are evaluated, with a good performance in representing the wind speed at 10 m height in both cases. The Benguela CLLJ is characterized by two local maximums of frequency of occurrence at around 26oS and 17.5oS. During austral summer, the jet has a frequency of occurrence of about 60% and it is located in its southern cores around 26oS. During autumn and winter, the frequency of occurrence decreases to nearly half, and migrates equatorward. During spring, the jet has a frequency of 45%, and is found at the northern core17.5oS. The jet wind speed is higher in the south core but is found at higher altitudes in the north core. Also, the seasonal cycle of momentum budget defines well the seasonality of BLLJ frequency of occurrence.

2. Using the same simulations, we also characterized for the first time in a high resolution coupled simulation (25 km AFR domain) the Canarian Low level Jet. The North African coastal low-level jet (NALLJ) lies over the cold Canary current and is synoptically linked to the Azores Anticyclone and to the continental thermal low over the Sahara Desert. Although being one of the most persistent and horizontally extended coastal wind jets, this is the first high resolution modelling effort to investigate the NALLJ climate. The ROM and the CORDEX-Africa simulations are

extensively evaluated showing a good ability to represent the surface winds. The NALLJ shows a strong seasonal cycle, but, unlike most coastal wind jets, e.g. the California one, it is significantly present all year round, with frequencies of occurrence above 20%. In spring and autumn, the maxima frequencies are around 50%, and reach values above 60% in summer. The location of maximum frequency of occurrence migrates meridionally from season to season, being in winter and spring upwind of Cap-Vert, and in summer and autumn offshore the Western Sahara. Analogously, the lowest jet wind speeds occur in winter, when the median is below 15 m/s. In summer, the jet wind speed median values are ~20 m/s and the maxima are above 30 m/s. The jet occurs at heights ~360 m. A momentum balance is pursued disclosing that the regional flow is almost geostrophic, dominated by the pressure gradient and Coriolis force. Over the jet areas the ageostrophy is responsible for the jet acceleration.

3. We have studied the impact of climate change in the characteristics of the Benguela low level jet with the help of an uncoupled and coupled simulations with ROM. These simulations are carried out with a 25 km horizontal resolution. In general, the coupled simulation displays the best performance in representing the present time near-surface wind speed and improves the known warm bias of sea surface temperature (SST) in the Benguela EBC region. The Our analysis of the projected changes of the BCLLJ climate towards the end of the 21st century (2070-2099) according to the RCP8.5 emissions scenario are analysed, following the RCP8.5 emissions scenario. Ashows an increase in the frequency of BCLLJ occurrence is projected along the southern area, in all most seasons, with higher changes in the coupled simulation (between 6 and 8%) and an intensification of the jet wind speed. We found that the The southerly shift of the South Atlantic high-pressure system intensifies the flow offshore the west coast of South Africa, and a sharpening of the land-sea thermal contrasts leads to an increase of the BCLLJ frequency of occurrence and an intensification of the jet wind speedthis changes are related to a southerly shift of the South Atlantic high-pressure system, which intensifies the flow offshore the west coast of South Africa, and causes a sharpening of the land-sea thermal contrasts. However, during spring, associated the decrease in near-surface wind speed due to warmer SSTs, the BCLLJ frequency of occurrence and jet wind speed are reduced.
4. The North African Coastal Low-Level Jet (NACLLJ) is a semi-permanent feature offshore the north western African coast, linked to the cold nearshore upwelling of the Canary Eastern Boundary Current system. Its main synoptic drivers are the Azores Anticyclone over the ocean and the inland Sahara thermal low. The coastal jet events occur in one of the world's most productive fisheries region, thus the evaluation of the effects of global warming in its properties is imperative. This study proposes an analysis of the annual and intra-annual attributes of the NACLLJ for two time periods 1976-2005 (historical) and 2070-2199 (future), resorting to coupled

and uncoupled atmosphere-ocean simulations with the ROM model, as well as near surface offshore wind speed from the CORDEX-Africa ensemble. The future simulations follow the RCP8.5 greenhouse gas emissions scenario. Overall, the ROM coupled simulation presents the best performance in reproducing the present-climate near surface wind speed, offshore northwest Africa, compared to the remaining RCM simulations. The higher SST resolution in the coupled simulations favours much localised colder upwelling strips near the coast and consequently stronger jets. In future climate, a small increase in the surface wind speed is projected, mainly linked to the regions of coastal jet presence. The NACLLJ is projected to be more frequent and intense, encompassing larger areas. An increase of the jet seasonal frequencies of occurrence is projected for all seasons, which is larger from spring to autumn (up to 15, 16 and 22% more frequent, respectively). However, in some offshore areas the winter NACLLJ persistency is likely to double, relatively to present-climate. Higher inter-annual variability is also projected for the future NACLLJ seasonal frequencies. The strengthening of the coastal jet speeds is also significant, between 5 and 12% in all seasons. Additionally, the jet's diurnal cycle shows an increase in jet occurrence across the day, particularly in the mid and late afternoon.

Table 1 summarizes and labels each one of the NAT and AFR experiments, according to horizontal resolution, precipitation parameterization and whether it is coupled or not.

Exp. No.	Atmosheric Horiz.Res (km).	Description
AFR25C	25	Coupled, ERA-I forcing
AFR25C	25	Coupled, MPI-ESM forcing, 1976-2005
AFR25C	25	Coupled, MPI-ESM forcing, 2070-2099
AFR25U	25	Uncoupled, ERA-I forcing
AFR25U	25	Uncoupled, MPI-ESM forcing, 1976-2005
NAT25U	25	Uncoupled, MPI-ESM forcing, 2070-2099

References

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