Future projections in the climatology of five low-level jets across different CORDEX domains

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Introduction and objective

- A low-level jet (LLJ) is a wind maximum in the first vertical 1.5 km of the atmosphere [1]. They are important as they carry moisture and have the ability to modulate rainfall patterns.
- The strength and location of five low-level jets (Monsoon Low-Level Jet [MLLJ], Caribbean Low-Level Jet [CLLJ], West African Westerly Jet [WAWJ], Great Plains Low-Level Jet [GPLLJ] and South American Low-Level Jet [SALLJ]) are examined in three periods: 1) historical (1995-2014); and under the RCP8.5 emissions scenario 2) mid-future (2041-2060); and 3) far future (2080-2099).

Methodology: RegCM4, CORDEX Domains and LLJs considered in this study

- Simulations were performed using a regional climate model, RegCM4 [2] at a spatial resolution of 25 km. These simulations were driven by three GCMs, which provide a range of climate sensitivities in the CMIP5 program [3], and the other, a generally good performance over multiple CORDEX domains [4].

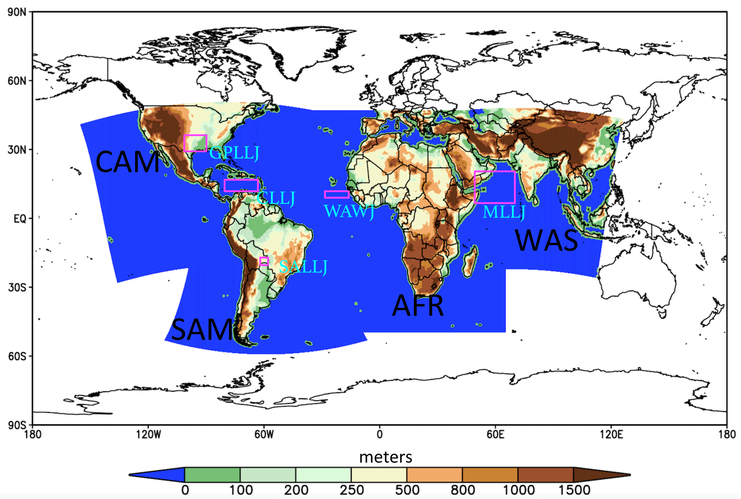

Figure 1. Multiple CORDEX domains showing topography and location of the low-level jets analyzed in this study. The monsoon low-level jet (MLLJ), Caribbean Low-Level Jet (CLLJ), West African Low-Level Jet (WALLJ), Great Plains Low-Level Jet (GPLLJ) and South American Low-Level Jet (SALLJ).

Three GCMs considered per CORDEX domain

CAM Domain:- HadGEM2-ES, MPI-ESM-MR and GFDL-ESM2M

SAM Domain:- HadGEM2-ES, MPI-ESM-MR and NorESM1-M

AFR Domain:- HadGEM2-ES, MPI-ESM-MR and NorESM1-M

WAS Domain:- MPI-ESM-MR, MIROC5 and NorESM1-M

How well does RegCM4 represent the LLJ strength and location?

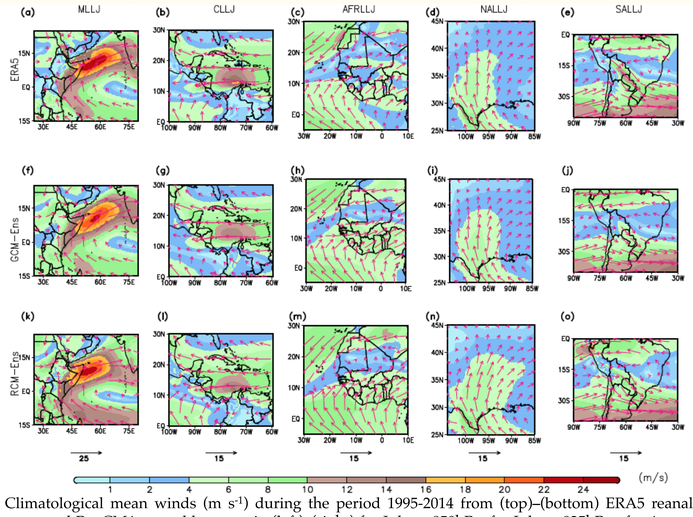

Figure 2. Climatological mean winds (m s^{-1}) during the period 1995-2014 from (top)–(bottom) ERA5 reanalysis, GCMs ensemble mean and RegCM4 ensemble mean, in (left)–(right) for July at 850hPa, for July at 925hPa , for August at 925hPa, for June at 925hPa, and for June at 700hPa shown over the LLJs regions considered in this study. Wind magnitude shown as shaded and direction as vector.

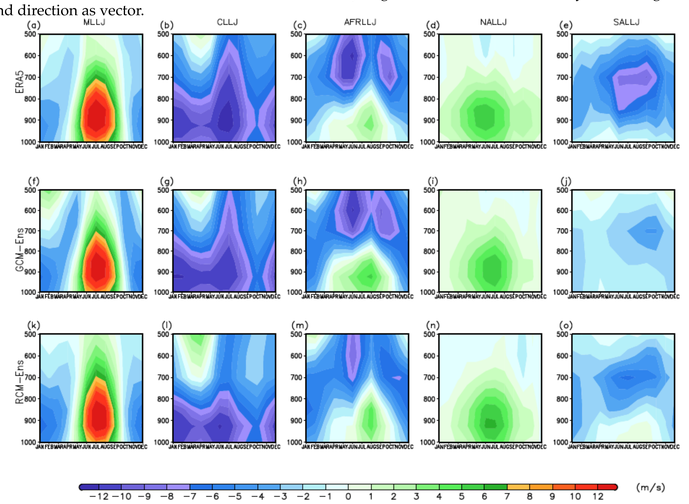

Figure 3. Annual cycle of the vertical (1,000–500 hPa) profile of wind components (m s^{-1}) for ERA5 reanalysis (top row), GCMs ensemble mean (middle row) and RegCM ensemble mean (bottom row), in zonal wind average over the monsoon low-level jet (50–70°E, 5–20°N), zonal wind average over the Caribbean Low-Level Jet (80–70°W, 12.5–17.5°N), zonal wind average over the West African Low-Level Jet (15–25°W, 8–11°N); meridional wind average over the Great Plains Low-Level Jet (103–95°W, 28–34°N); and meridional wind average over the South American (63–61°W, 17–17.75°S). Negative values refer to easterly and northerly winds. All the above fields are calculated for the reference (1995-2014) period.

Summary

- RegCM4 captures the low level jet regions well across different CORDEX domains. It also improves the representation (strength and location) of LLJs in most of the regions considered in this study.
- Mixed regional responses in LLJs is noticed in RCP85 scenario e.g. the MLLJ and WALLJ show a northward shift in the far future, while the CLLJ and SALLJ show a westward expansion.

Future spatial and vertical changes in LLJs in terms of their location and strength

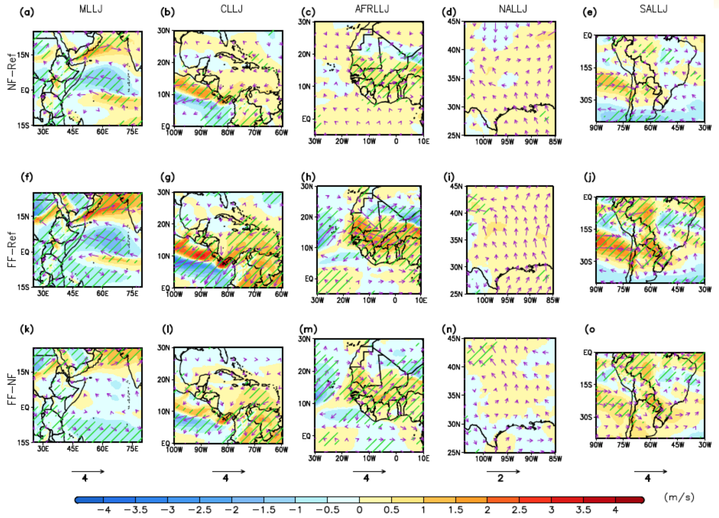

Figure 4. Changes in RegCM4 ensemble mean winds under the RCP8.5 scenario: (top)-(bottom) difference between 2041–2060 and 1995–2014 periods, difference between 2080–2099 and 1995–2014 period, and difference between the 2080–2099 and the 2041–2060 period, for each LLJs arranged similar to Figure 2. Oblique lines represent areas where the changes are significant at 95% level.

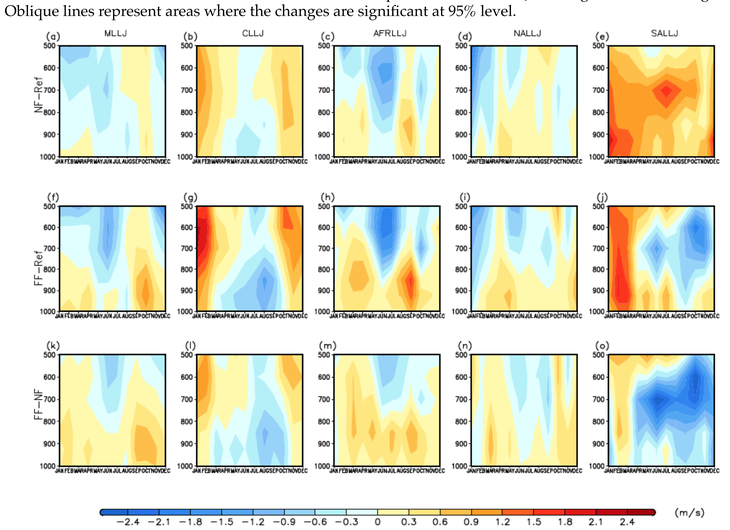

Figure 5. Annual cycle of the vertical changes in RegCM4 ensemble mean wind components (depending upon LLJ) under the RCP8.5 scenario: (top)–(bottom) difference between 2041–2060 and 1995–2014 period, difference between 2080–2099 and 1995–2014 period, and difference between 2080–2099 and 2041–2060 period for each LLJs arranged similar in Figure 3.

References

[1] Blackadar, A.K. (1957). *Bull. Am Meteorol*. Soc 38:283–290
[2] Giorgi, F., et al. (2012). *Clim. Res.*, 52, 7-29
[3] Taylor, K.E. (2012). *Bull. Am Meteorol*. Soc, 78, 485-498.
[4] Elguindi, N., et al. (2014). *Climatic Change*, doi: 10.1007/S10584-013-0935-9
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