Manuscript ID: egusphere-2023-1749

Interactive comment on "Sharp increase of Saharan dust intrusions over the Western Mediterranean and Euro-Atlantic region in February-March 2020–2022 and associated atmospheric circulation." ***by Cuevas-Agulló et al.***

Reply to Diana Francis

1. In a previous work we have identified atmospheric rivers as a main driver for this kind of Saharan dust intrusions. Would be good to see a discussion in this paper on this and how the identified atmospheric circulation is different/similar to it: https://www.sciencedirect.com/science/article/pii/S0169809521005159

Thanks, Dr Diana Francis, for the suggestion. The two intense episodes of Saharan dust transport during February 2021 were associated with Atmospheric Rivers (ARs), which were proposed as a potential driver of (moist) dust events in Europe by Francis et al. (2022). This study has been cited in the revised version of the manuscript. We have also included a short paragraph in Section 3 of the revised manuscript summarising the following points:

1. According to Francis et al. (2022), the majority (~78%) of AR days coincided with strong to extreme dust events, but only ~18% of the dust episodes co-occurred with AR events. For the revised version of the manuscript, we have re-assessed this relationship by using our catalogue of February-March dust events over the western Euro-Mediterranean and ARs, identified visually as long and narrow structures with vertically integrated water vapour higher than 20 Kg m^{-2} (Gimeno et al., 2014). The results confirm that less than one-third of the dust events of 2003-2022 concurred with ARs (see two examples in Figure R1.1). This linkage is even weaker when dust days are considered (~17% of the dust days with an AR in 2020-2022). This probability is like that reported by Francis et al. (2022) and lower than that obtained by conditioning on blocking (~50%), suggesting that the latter exerts a more significant control. Despite this, we agree that ARs might play an important role in the wet deposition of dust, as was the case during some of the extreme events analysed in the manuscript (and in Francis et al., 2022). Therefore, in the revised manuscript, we encourage additional studies to address the similarities and differences between dry and wet dust events.
2. We believe that ARs are fully independent of the atmospheric circulation drivers considered in our manuscript (cut-off lows and blocking). Indeed, the synoptic analyses

of the two case studies described by Francis et al. (2022) show a wavy jet with either a ridge over central Mediterranean or an omega block over central Europe, both accompanied by troughs over its western and/or eastern flanks, which typically evolve into cut-off lows. This high-low pressure configuration is consistent with that reported in the submitted manuscript (see Figure 6) and with the underlying drivers considered therein (blocking and cut-off lows). It also resembles the composites for Mediterranean ARs described in Lorente-Plazas et al. (2019). The reviewed literature suggests that northwestern African cut-off lows are modulated by the large-scale flow blocking (Nieto et al., 2007), with the southerly flow in between promoting ARs (Lorente-Plazas et al., 2019) and the advection of Saharan dust (Francis et al., 2022). The influence of blocking on ARs. For example, Benedict et al. (2019) found that North Pacific blocking modulates AR probabilities along the North American west coast. The effect of the large-scale flow configurations on AR occurrence and landfall has also been addressed in other studies. For example, Pasquier et al. (2018) found that during blocking-like weather regimes (WRs), such as Scandinavian blocking, the probability of AR landfall increases over the western Mediterranean and northern Africa. In contrast, cyclonic zonal flow (ZO) favours AR landfalls at comparatively higher latitudes, which is consistent with Figure 5 of the submitted manuscript. From this perspective, ARs could be considered a consequence (or a coupled element) of the enhanced meridional flow instigated by the high-low pressure dipole. This has been briefly stated in the revised text.

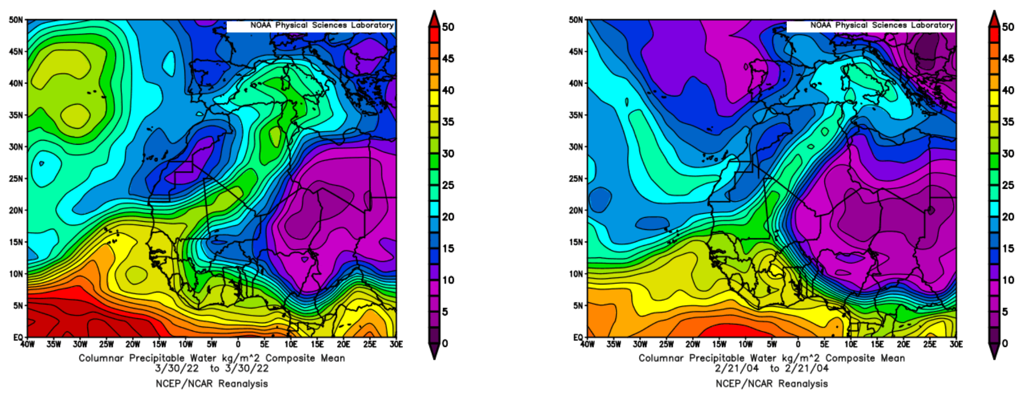

Figure R1.1: Examples of daily snapshots ARs diagnosed from vertically integrated water vapour from the NCEP/NCAR reanalysis: 30 March 2022 (left) and 21 February 2004 (right).

References

Benedict, J. J., Clement, A. C. and Medeiros, B.: Atmospheric blocking and other large-scale precursor patterns of landfalling atmospheric rivers in the North Pacific: A CESM2 study. Journal of Geophysical Research: Atmospheres, 124, https://doi.org/10.1029/2019JD030790, 2019.

Francis, D., Fonseca, R., Nelli, N., Bozkurt, D., Picard, G., Guan, B.: Atmospheric rivers drive exceptional Saharan dust transport towards Europe, Atmospheric Research, 266, 105959, https://doi.org/10.1016/j.atmosres.2021.105959, 2022.

Gimeno, L., Nieto, R., Vázquez, M. and Lavers, D.: Atmospheric rivers: a mini-review. Frontiers in Earth Science, 2, https://doi.org/10.3389/feart.2014.00002, 2014

Lorente-Plazas, R., Montavez, J. P., Ramos, A. M., Jerez, S., Trigo, R. M. and Jimenez-Guerrero, P.: Unusual atmospheric-river-like structures coming from Africa induce extreme precipitation over the western Mediterranean Sea. Journal of Geophysical Research: Atmospheres, 125, e2019JD031280, https://doi.org/10.1029/2019JD031280, 2020.

Nieto, R., L. Gimeno, L. de la Torre, Ribera, P., Barriopedro, D., García-Herrera, R., Serrano, A., Gordillo, A., Redaño, A. and Lorente, J.: Interannual variability of cut-off low systems over the European sector: The role of blocking and the Northern Hemisphere circulation modes, Meteorol. Atmos. Phys., 96, 85–101, https://doi.org/10.1007/s00703-006-0222-7, 2007.

Pasquier, J. T., Pfahl, S. and Grams, C. M.: Modulation of atmospheric river occurrence and associated precipitation extremes in the North Atlantic Region by European weather regimes. Geophysical Research Letters, 46, 1014–1023, https://doi.org/10.1029/2018GL081194, 2019.