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How important are atmospheric depressions and nocturnal low-level jets for North African dust emission?

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Nocturnal low-level jets (NLLJs) and atmospheric depressions are known to generate wind speeds sufficient for dust emission in North Africa, but their relative importance is not well quantified. This work presents the first climatology of dust emission associated with theses phenomenon based on ERA-Interim data from the European Centre for Medium-Range Weather Forecasts. Depressions are detected as minima in the geopotential height at 925 hPa with a tracking algorithm. NLLJs are identified with a new automated detection algorithm. The results of the identification are connected with dust emissions from a dust model driven by 10m-winds from ERA-Interim.

The findings highlight that atmospheric depressions are associated with 55 % of the dust emission in the annual and spatial mean. Regions south of the Atlas Mountains in spring and wide areas of North Africa during summer have contributions of up to 90 %. Lee cyclogenesis causes favourable conditions predominantly in spring while the heat low over West Africa dominates the climatology in summer.

Migrating cyclones that live for more than two days are rare and associated with 4 % of the dust emission annually and spatially averaged. Maximum contributions of cyclones to dust emission are 25 % over eastern North Africa in spring. This result suggests that few depressions forming near the Atlas Mountains undergo the development to a long-lived and moving cyclone. Even though their total contribution to dust emission is small, the emission intensity is large. The climatological mean of the emission flux is exceeded by a factor of four to eight during cyclones. The presence of soil moisture during cyclones suppresses 10 % of the dust emission. The daytime fluxes are three to five times larger than at night.

NLLJs are wind speed maxima at night that build at a few 100 m above the surface. Annually and spatially averaged, NLLJs form in 29 % of nights. Single regions and seasons, e.g. the Bodélé Depression in winter and the margins of the Saharan heat low in summer, have frequencies of up to 80 %. The NLLJ contribution to the dust emission amount is 15 % annually and spatially averaged. Specific regions and seasons show NLLJ contributions of up to 60 %. The largest dust emission associated with NLLJs is found during the mid-morning when the surface inversion decays.

In conclusion, atmospheric depressions, migrating cyclones and NLLJs are important for North African dust emission. This climatology enables a process-based evaluation of meteorological drivers of dust emission in atmospheric models that contributes to reducing uncertainty.