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Efficiency of cold pool outflows in dust emission: central Saharan observations from Fennec

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The Fennec project has, for the first time, provided high quality high resolution instrument observations of the remote central Saharan atmosphere. Fennec Supersite 1 at Bordj-Badji Mokhtar (BBM) in south-west Algeria is located very close to the boreal summer global dust maximum and is an ideal location from which to investigate dust production mechanisms. A detailed analysis of observations taken during the 2011 intensive observation period (IOP) allows the dust to be partitioned by emission mechanism. Cold pool outflows are the most important mechanism, responsible for up to 65% of the dust during the IOP, followed by low level jets (LLJs) and dry convective plumes. This ranking is maintained whether the partitioning is done using lidar backscatter, nephelometer scattering or uplift potential. It is also consistent with aerosol optical thickness (AOT) measurements: the dustiest cold pool AOTs are always 3.0 or over, the dustiest LLJ AOTs are between 1.0 and 2.0 and the dustiest dry convective plume has an AOT of 1.25.

The reason cold pool outflows raise more dust than the other two mechanisms is examined further. For locally emitting dust events, there is a positive correlation between lidar backscatter and wind speed at BBM as expected, but it is not particularly strong ($r=0.4688$, $p<0.1$). If the points are decomposed by mechanism, then only LLJ-induced emission and dry convective plumes display a positive correlation between backscatter and wind speed. This suggests that cold pools are able to raise more dust at lower wind speeds than dry convection or LLJ-induced emission. In other words, cold pools are more efficient at raising dust.

The explanation for this efficiency is not due to the strength of the vertical wind component: cold pools are not associated with stronger vertical winds than LLJs or dry convection. However, the explanation may lie in the direction of the vertical wind component: most cold pool events are associated with a stronger downward than upward component of the vertical wind, while LLJ-induced emission is associated with a stronger upward component. Furthermore, all of the cold pool events with the highest nephelometer scattering peaks are associated with a stronger downward component of vertical wind.

If the direction of the vertical wind component is an important control on dust emission, it has important implications. Station wind observations using only wind vanes and cup anemometers do not provide three-dimensional wind measurements. Shear velocity (u^*), a common metric used for calculating thresholds for erosion and sediment transport, does not take it into account. Model parameterizations of uplift are often based around u^* and also do not account for the direction of vertical wind. Data from BBM suggest that these emission schemes may have missing processes.