Dust Mobilization due to Density Currents in the Atlas Region: Observations from the SAMUM Field Campaign

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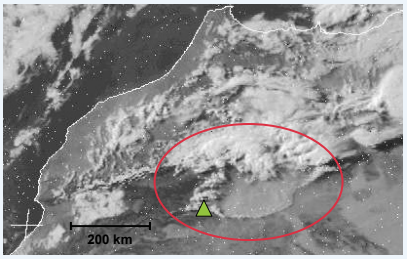
Outline

- The Saharan Mineral Dust Experiment (SAMUM; www.tropos.de/samum) first field campaign took place in southern Morocco between 11 May and 10 June 2006.
- Ground-based in-situ and remote sensing measurements were performed at two locations: Ouarzazate airport (30°53'N, 6°54'W) and Tinfou (30°15'N, 5°37'W).
- Overarching aim of SAMUM is a better quantification of the radiative impact of airborne desert dust.
- Here we present results of additional investigations on the meteorological conditions for dust mobilization during the SAMUM field campaign.
- Usually dust is mobilized by large-scale frontal systems or numerous small-scale dust devils.
- This study focuses on a little investigated meso-scale mechanism: density currents driven by evaporational cooling of convective precipitation in mountainous regions.

An Exemplary Case Study

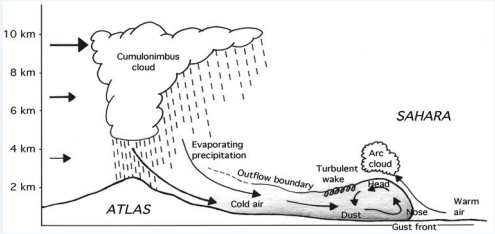
- Around 18:15 UTC on 31 May the SAMUM team at the Tinfou site observed the quick approach of a shallow 'lobe' of dust filled air from the northeast.
- The shape and propagation of the 'dust front' as seen from the side (left) and front (bottom) are reminiscent of a density current. → Mechanism
- Note the shallow arc clouds 'riding' on top of the dusty air.

Satellite View



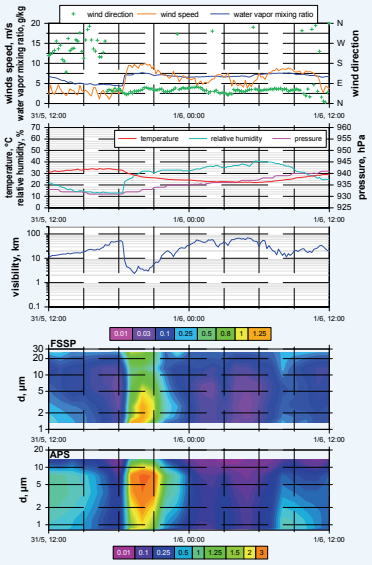
- The Meteosat Visible image at 18 UTC, 31 May 2006 shows intense convection over the Moroccan Atlas and Anti-Atlas chains.
- Evaporation of precipitation creates a 'cold pool' that quickly spreads southward into the Sahara with a convex leading edge characteristic of density currents.
- The Tinfou site (green triangle) is just ahead of the dust front at this time.

Mechanism

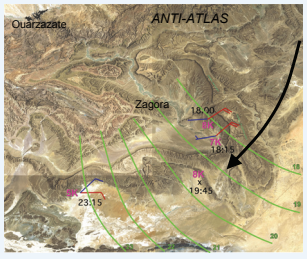


1) Development of deep convection over the Atlas
2) Blowing-off of cloud tops by upper-level winds
3) Generation of a cold pool at midlevels due to evaporation of precipitation in the dry and hot desert air
4) Density differences to the environment cause pressure gradients and a quick spreading of the cold air
5) Further acceleration along the topographic gradient
6) Strong winds at the leading edge raise dust and high turbulence mix it through a deep layer
7) Lifting of warm air ahead of the leading edge results in condensation and the formation of arc clouds

Station Observations



- Ground based observations at the Tinfou site show abrupt changes during the passage of the dust front:
  → increase in relative humidity and water vapor mixing ratio
  → increase in wind speed to 10 m/s
  → wind direction changes from SW to NE
  → decrease in temperature by 3°C
  → increase in pressure by 4 hPa
  → decrease in visibility from 50 to 3 km
  → increase in aerosol concentration, mainly for particles of 5 µm diameter
- Observed changes are consistent with the proposed mechanism, even though temperature and pressure changes are relatively weak at the northwesternmost part of the density current.
- Visibility and aerosol measurements show a duration of the event of only a few hours.



Frontal Analysis

- The IMPETUS project (www.impetus.uni-koeln.de) provided us with meteorological station data from their network in southern Morocco.
- The adjoining figure shows the passage of the dust front at three IMPETUS stations and the Tinfou site (times in UTC are given in black).
- Barbs indicate wind direction and speed before (blue) and after (red) the frontal passage. The dew point jumps at the front (in °C) are given in magenta.
- The slow propagation speed of ~20 km/h is consistent with the observed small temperature differences. → Station Observations

Conclusions

- The SAMUM field campaign in southern Morocco in May/June 2006 provides unique observational data to study mechanisms of dust mobilization in the Atlas region.
- The presented observations point to an important role of density currents driven by evaporational cooling of convective precipitation over the Anti-Atlas for the generation of strong and turbulent near-surface winds necessary for dust mobilization.
- Other such events are currently investigated and climatological studies based on IMPETUS data are envisaged.
- The proposed mechanism is most likely relevant for other mountainous parts of the Sahara like the Ahaggar, Aïr or Tibesti, and might therefore be a key in understanding dust emissions from northern Africa during summer in general.

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