Karlsruhe Institute of Technology

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

High-resolution mineral dust modeling

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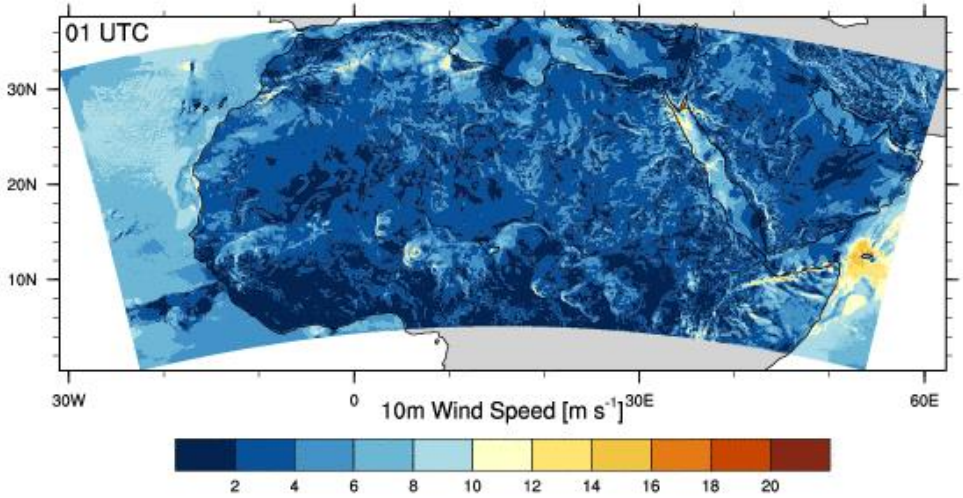
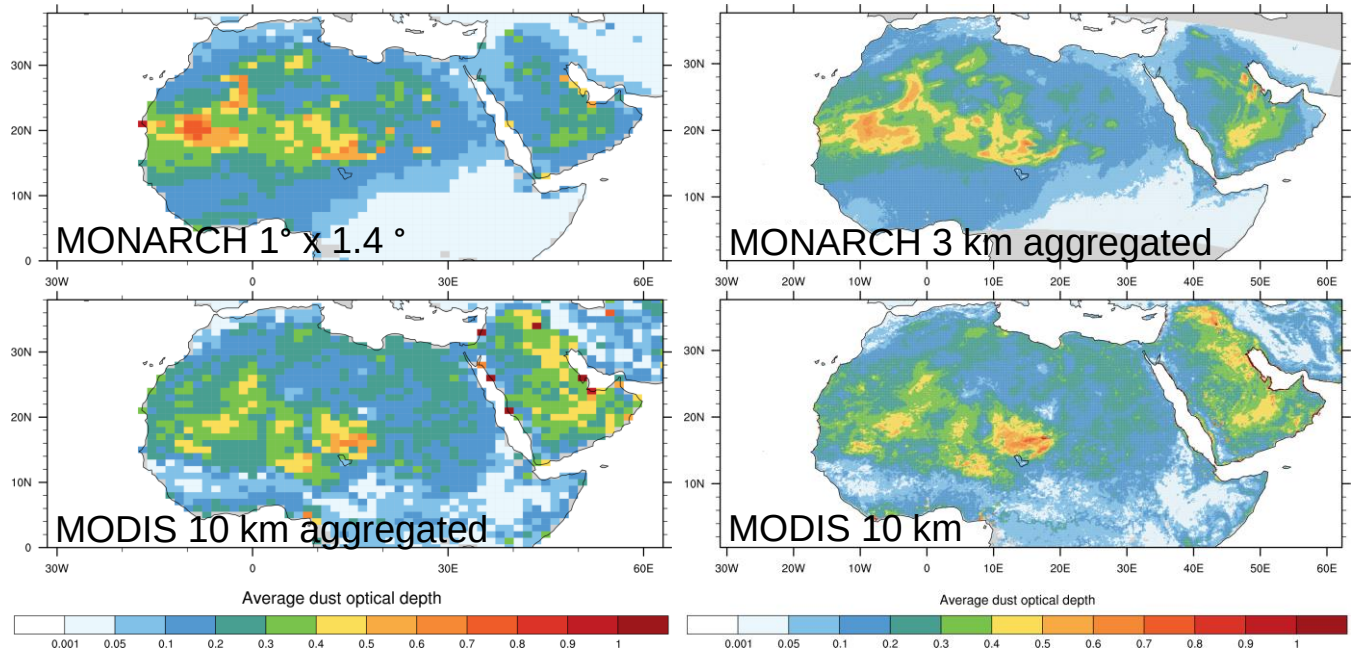
Storm-resolving modeling



- Explicit representation of deep convection and associated storms, e.g. haboobs
  - ➢ *How much do dust patterns change compared to coarse resolution runs?*
  - ➢ *How realistic are the simulated haboobs?*

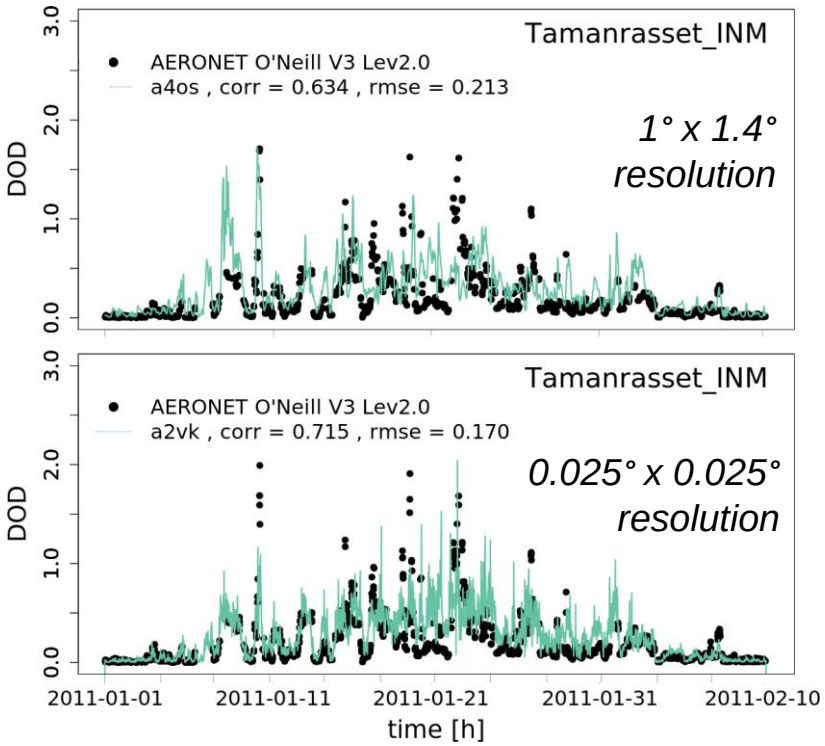
- **MONARCH** (Multiscale Online Nonhydrostatic AtmospheRe Chemistry) model (*Perez et al.*, 2011; *Klose et al.*, 2021)
- Simulation year **2011** at ~ **3 km** horizontal resolution
- Including online dust simulation (*Shao*, 2004 parameterization)

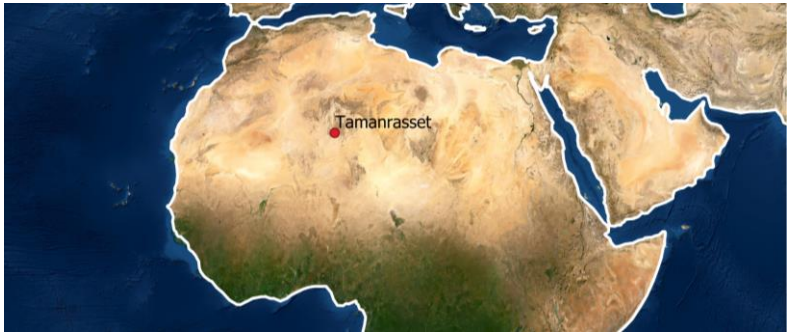
Dust optical depth (DOD)



- Dust optical depth from MODIS Deep Blue (Aqua)
- All-sky model DOD co-located with observations
- Very good agreement between MONARCH and MODIS at both resolutions
- Results of both runs are largely consistent.
- Increased DOD at higher resolution in the Arabian Peninsula

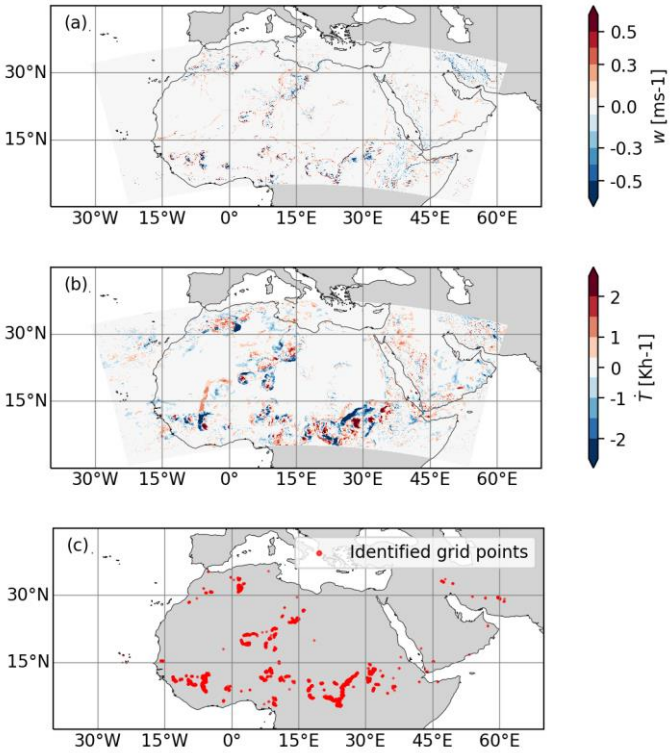
AERONET dust optical depth





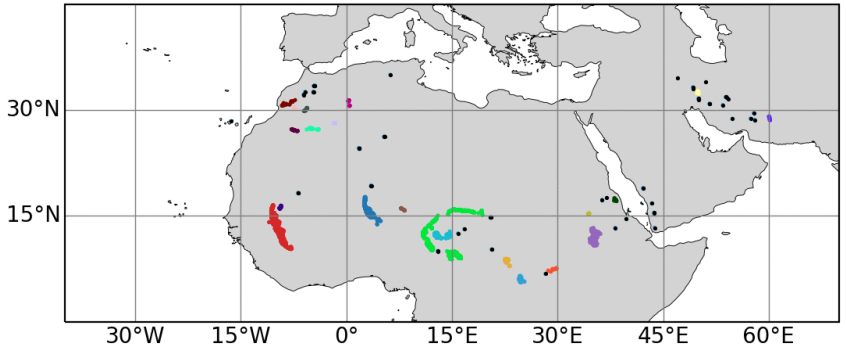
- Overall dust patterns change surprisingly little (cf. previous slide)
- Individual stations see increased DOD during summer, likely due to haboobs

Haboob identification and tracking algorithm

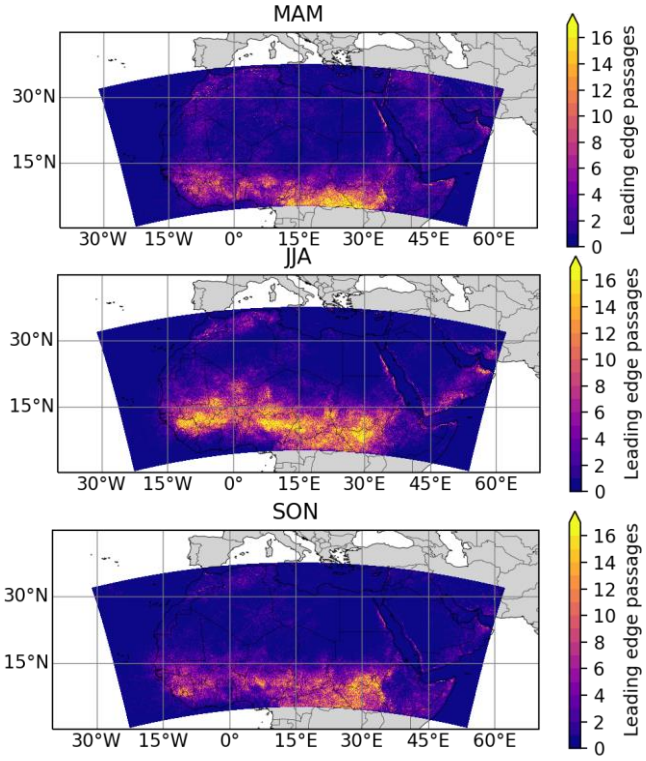


Unser et al., in prep.:

1. **Identification of haboob-associated grid points** based on meteorological criteria (Pantillon et al., 2015, 2016):
   - temperature tendency anomaly at 925 hPa < -1 K h^{-1}
   - abs(vertical wind speed at 850 hPa) > 0.5 m s^{-1}
2. **Clustering to individual haboobs**
3. **Temporal linking based on estimated travel distances**

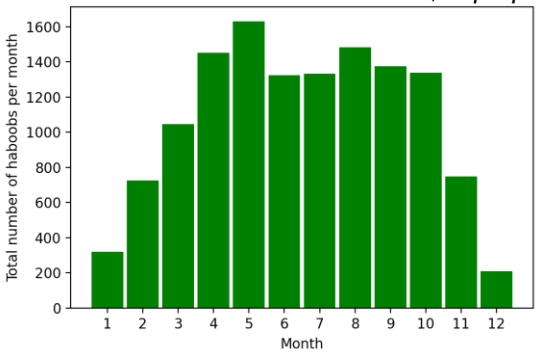


Statistical properties of (potential) haboobs



- Most **haboob leading edge passages** in southern North Africa, where vegetation cover prevents dust entrainment.
- Overall too many haboobs identified, as **not all are dust-laden**.
- Results show that **dust-criteria are in addition to the widely-used purely meteorological criteria necessary** for haboob identification.

Unser et al., in prep.



- New tracking algorithm facilitates the **automated identification and statistical analysis** of haboobs from model simulations

Thank you!

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- Storm-resolving modeling provides insights into the **impact of meso-scale phenomena** on the dust cycle
- **Novel haboob tracking algorithm** allows to characterize haboob statistics
- Continued investigation of **impact of haboobs on the dust budget**

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