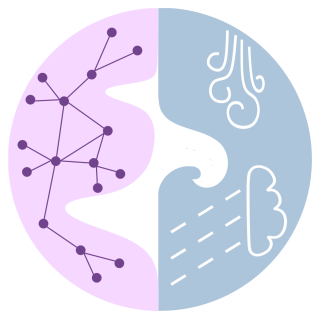
Journal Club MLCS
Resolving Sahelian thunderstorms improves mid-latitude weather forecasts

Gregor Pante & Peter Knippertz

Lea Elsemüller

November 25, 2020



Mesoscale convective system

- mesoscale convective system (MCS) = complex of thunderstorms
- summertime West African Sahel has the worldwide highest degree of thunderstorm organisation into long-lived, several hundred-kilometre elongated, fast propagating systems that contribute 90% to the annual rainfall
- MCS are misrepresented by convection parameterisations in numerical weather prediction and climate models
- negative implications for the simulated diurnal cycle and location of precipitation and, consequently, soil moisture and atmospheric circulation in the WAM region

What is convection?

"In meteorology, the term is used specifically to describe vertical transport of heat and moisture in the atmosphere, especially by updrafts and downdrafts in an unstable atmosphere. The terms "convection" and "thunderstorms" often are used interchangeably, although thunderstorms are only one form of convection. (...) However, convection is not always made visible by clouds.(...)"

Definiton from https://forecast.weather.gov/glossary

- current global weather prediction and climate models represent thunderstorms using simplified parameterisation schemes

$\rightarrow$ deteriorates the modelled distribution of rainfall from individual storms and the entire West African monsoon circulation

- Goal: overcome systematic failures in NWP over West Africa to get better results by increasing the model resolution over West Africa

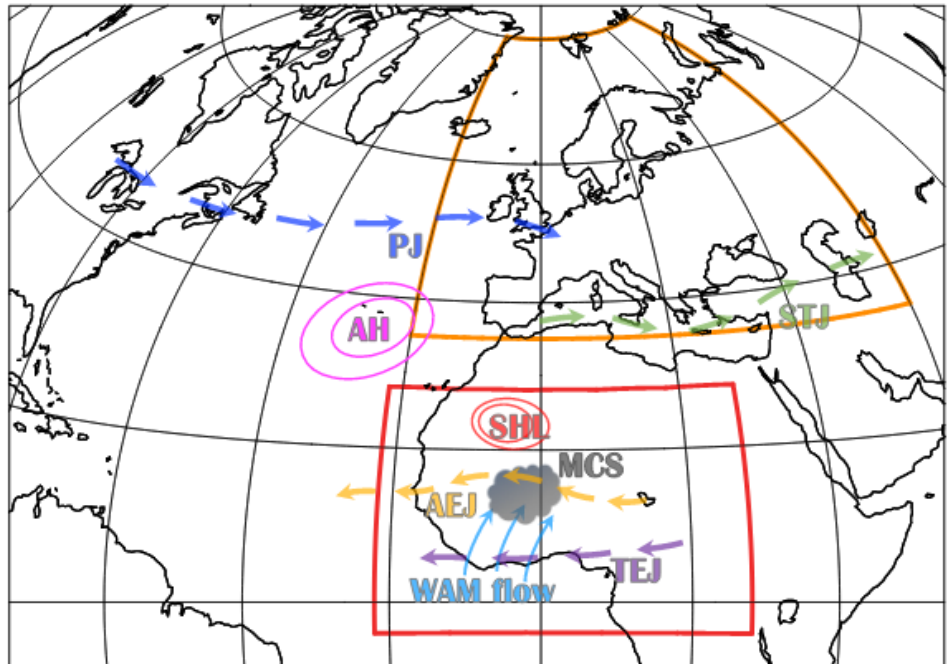
$\rightarrow$ allows to avoid convection parameterisation and yields to better representation of organised convection in the Sahel and of moisture within the monsoon system, ultimately improving 5–8-day tropical and mid-latitude weather forecasts

Short excursion into weather foecasts

- Model calculations are done for "domains" - large areas covering parts of (or even entire) continents, for which a complete forecast is calculated
- nesting: placing a higher resolution domain within a coarser, parent domain, useful for more accurate resolving of AOIs while still resolving surrounding
- two-way nesting: both domains are computed at the same time and completely interacting

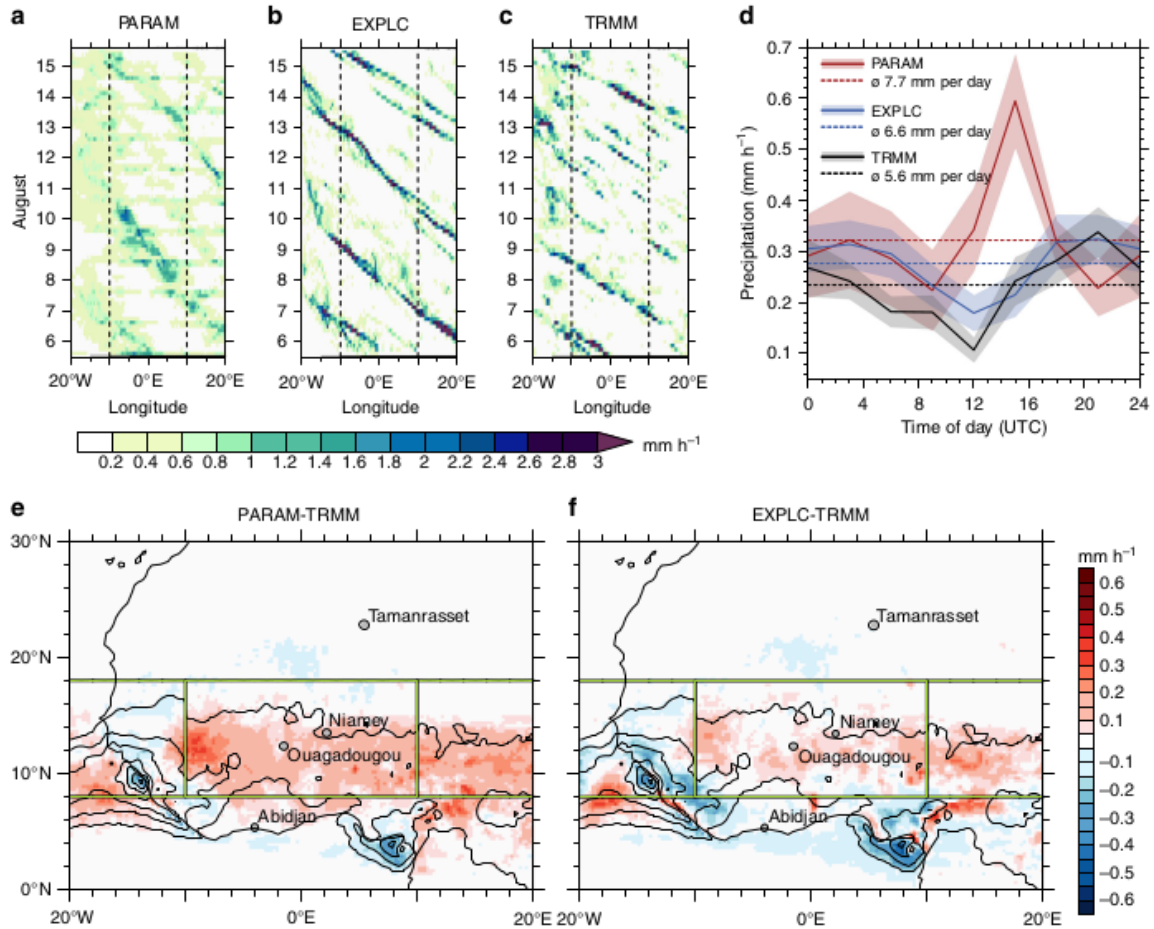
Method

- icon (Icosahedral Nonhydrostatic) model: global numerical weather prediction model which is used by the dwd
- Two-way nesting: exchange of information between different model domains through relaxation.
- two different simulations:
  - PARAM: Tiedtke–Bechtold convection parameterisation for the whole globe, operational set-up of the global ICON model with a two-way nesting domain only over Europe
  - EXPLC: additional two-way nesting domain over West Africa where the parameterisations for deep and shallow convection are turned off

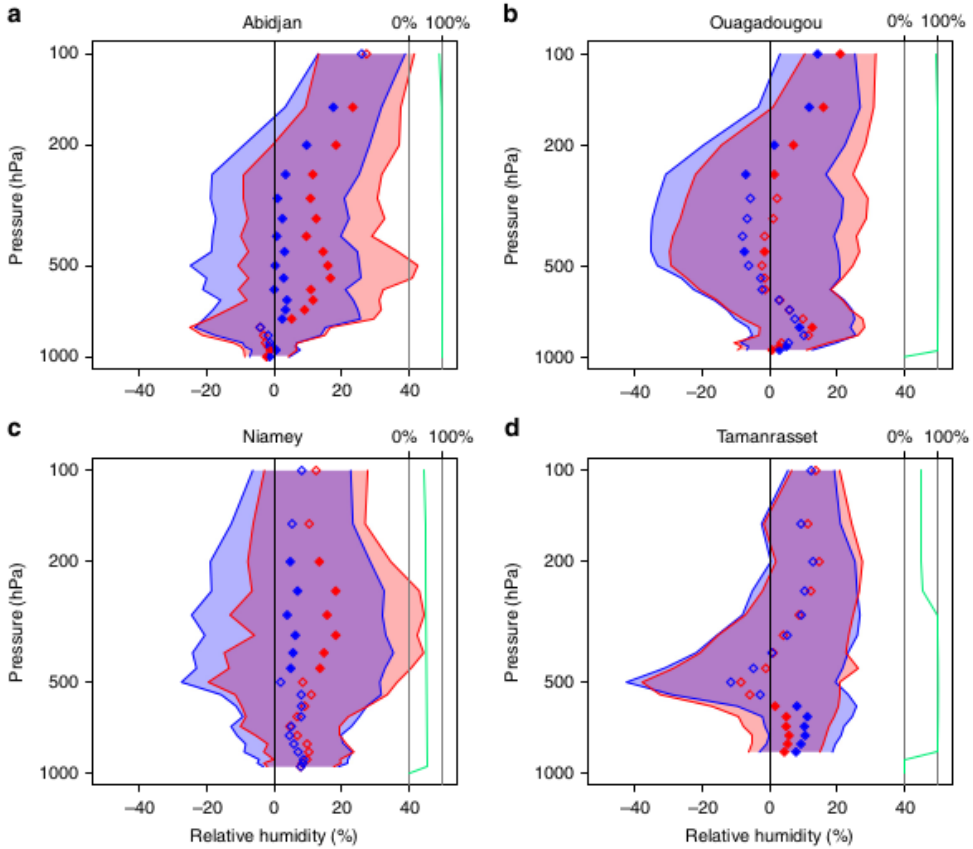


Model performance in simulating precipitation

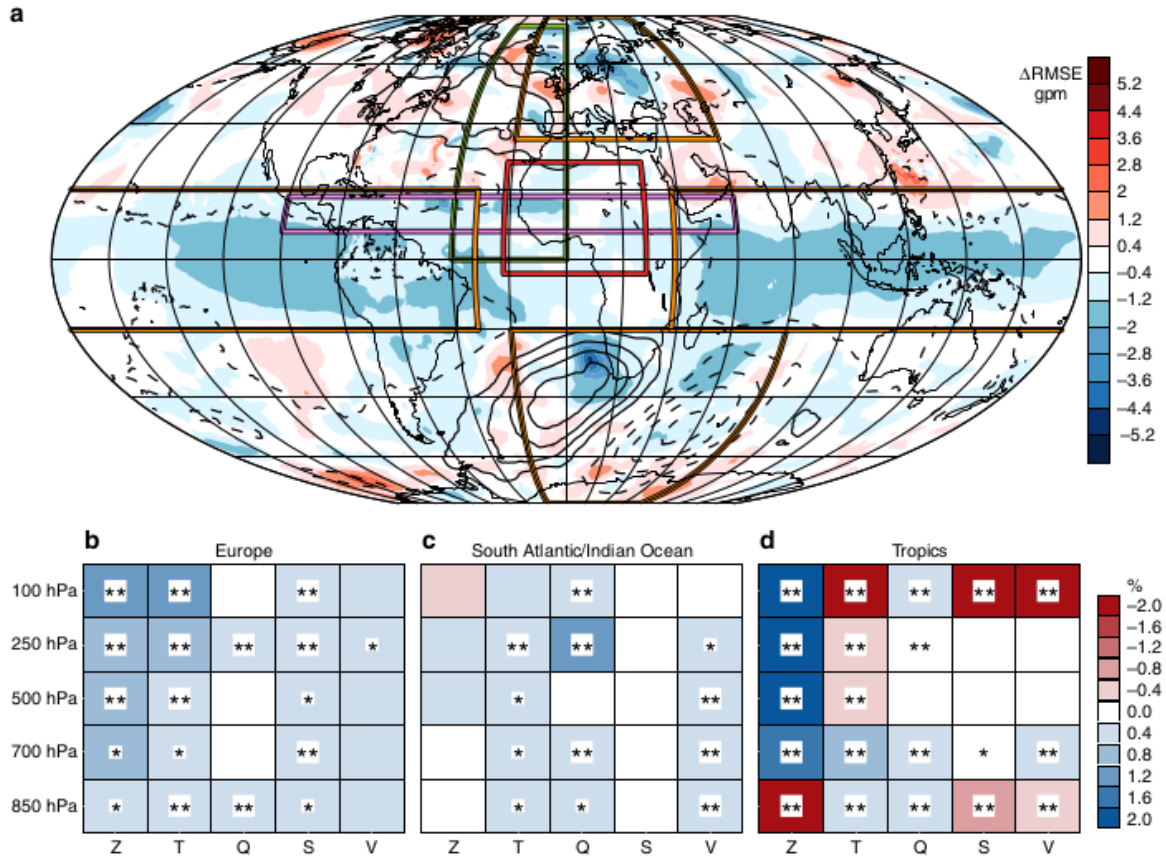
Impact of Sahelian MCSs on forecasts for West Africa



Model evaluation against radiosondes for relative humidity

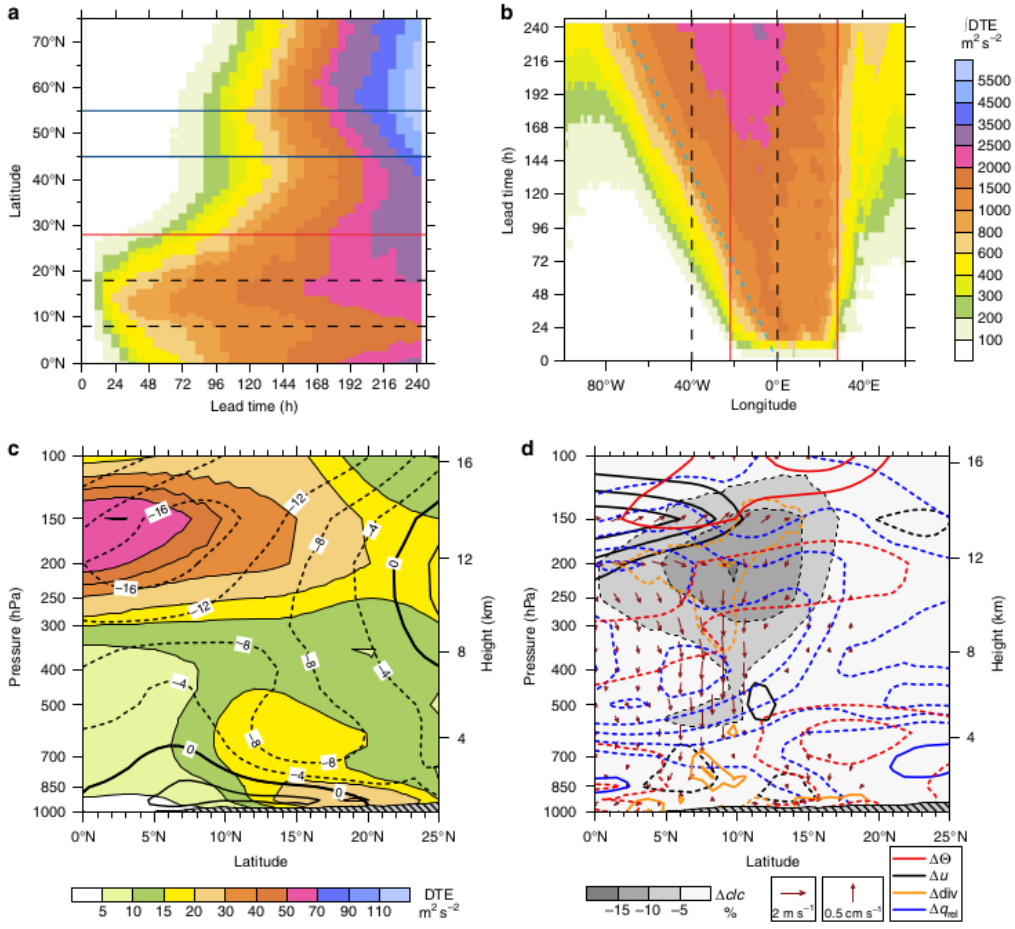


Impact of resolving Sahelian thunderstorms on global forecasts



geopotential (Z), temperature (T), specific humidity (Q), wind speed (S) and wind vector (V)

Mechanism connecting West Africa and remote regions



Conclusion

- explicitly resolving summertime Sahelian MCSs in the ICON model significantly impacts on forecast biases and errors over West Africa itself but also over remote regions in the tropics and extratropics, including Europe
- better representation of precipitation features and diurnal cycle over Sahel, overall improvement of the moist bias in ICON
- but: problems over southern parts of West Africa and with the Saharan boundary layer remain or even deteriorate

References

- Pante, G., & Knippertz, P. (2019). Resolving Sahelian thunderstorms improves mid-latitude weather forecasts. Nature communications, 10(1), 1-9.
- Dwd. ICON (Icosahedral Nonhydrostatic) Model. Retrieved November 24, 2020 from `https://www.dwd.de/EN/research/weatherforecasting/num_modelling/01_num_weather_prediction_modells/icon_description.html`
- Soriano, C., Jorba, O., & Baldasano, J. M. (2004). One-way nesting versus two-way nesting: does it really make a difference?. In Air pollution modeling and its application XV (pp. 177-185). Springer, Boston, MA.