Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu

Super Clausius-Clapeyron scaling of extreme hourly precipitation and its relation to large-scale atmospheric conditions

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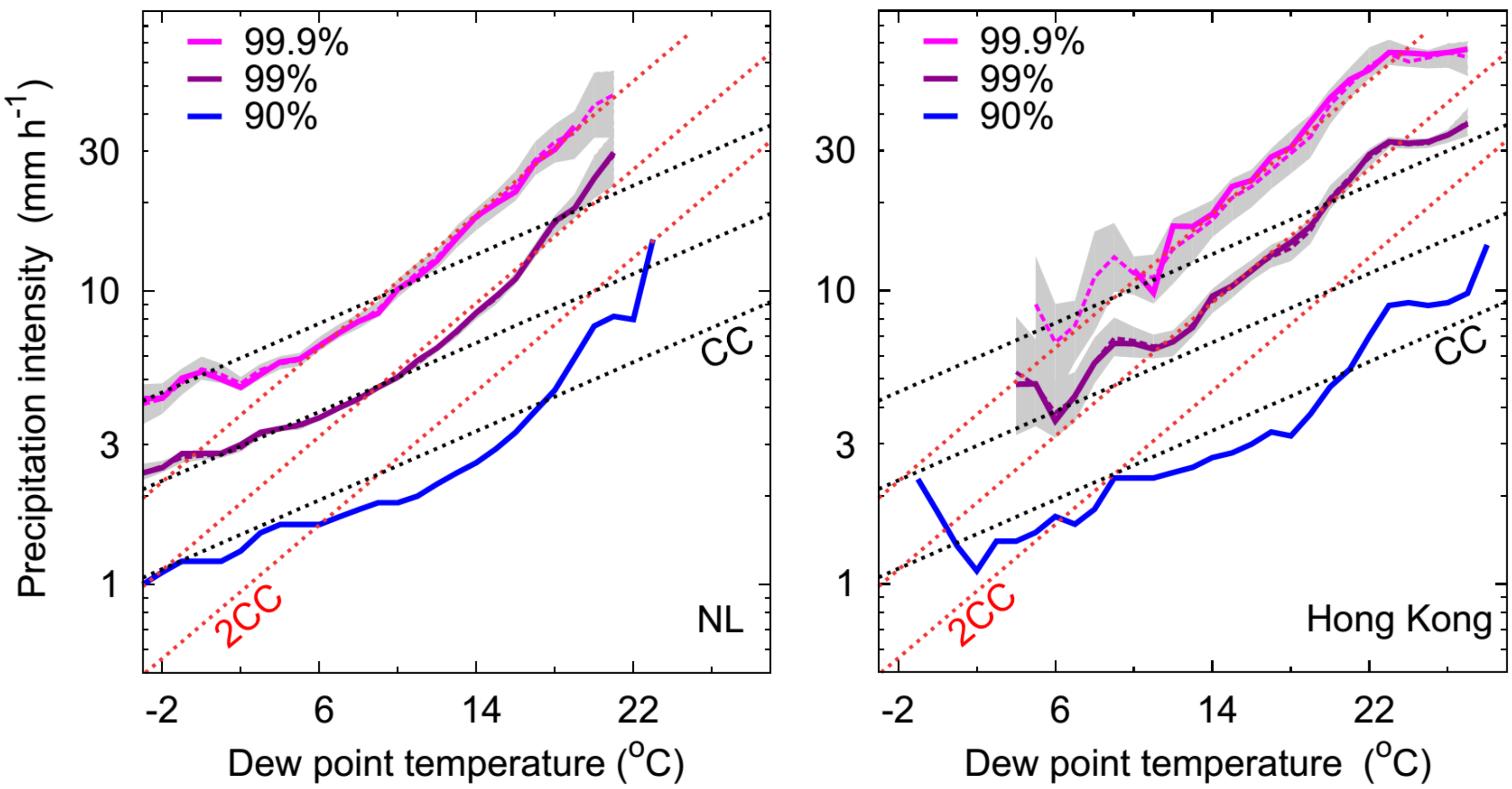
(journal of climate)

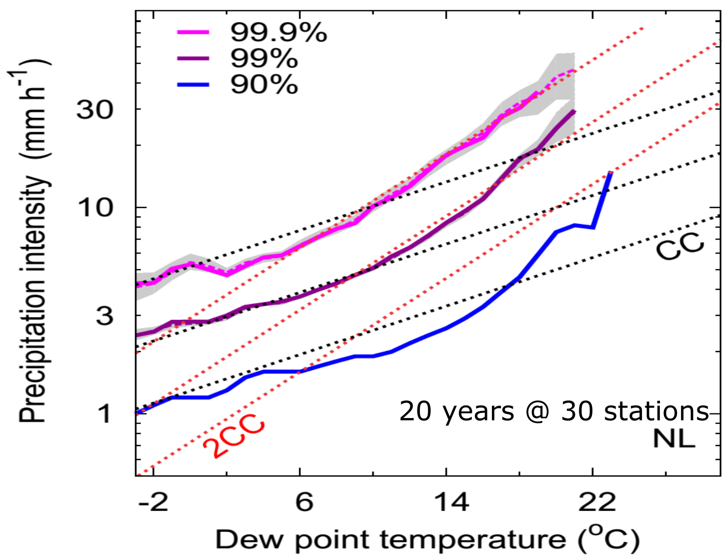
Scaling of hourly extremes with dew point temperature



Take dew point temperature 4 hour prior to precipitation event to minimize influence of cold & dry air due to downdrafts associated with heavy showers

Scaling of peak hourly precipitation from events

Data divided into “independent” events



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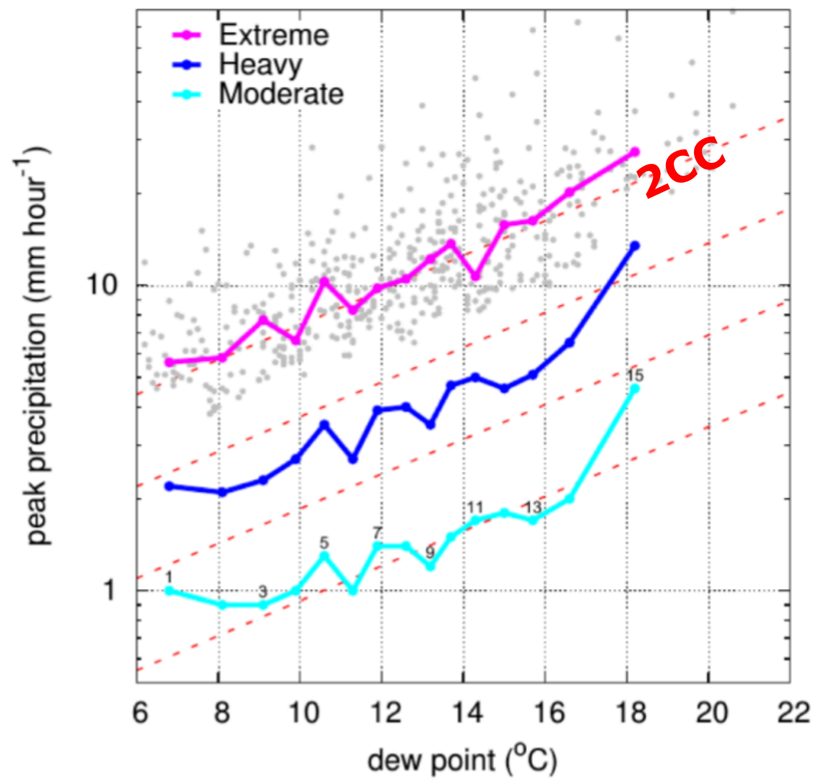
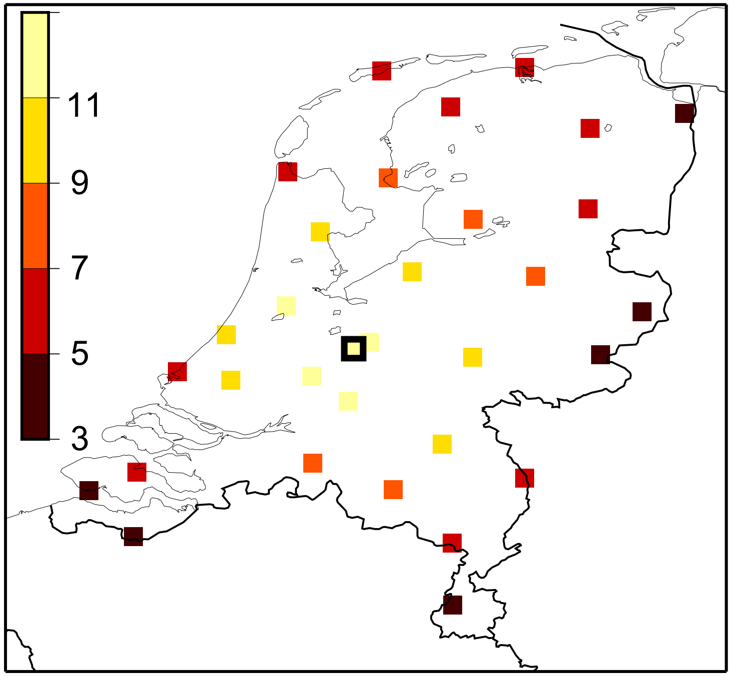
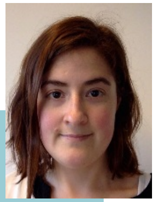


Only summertime, afternoon events

An event based analysis combining surface observation with re-analysis data



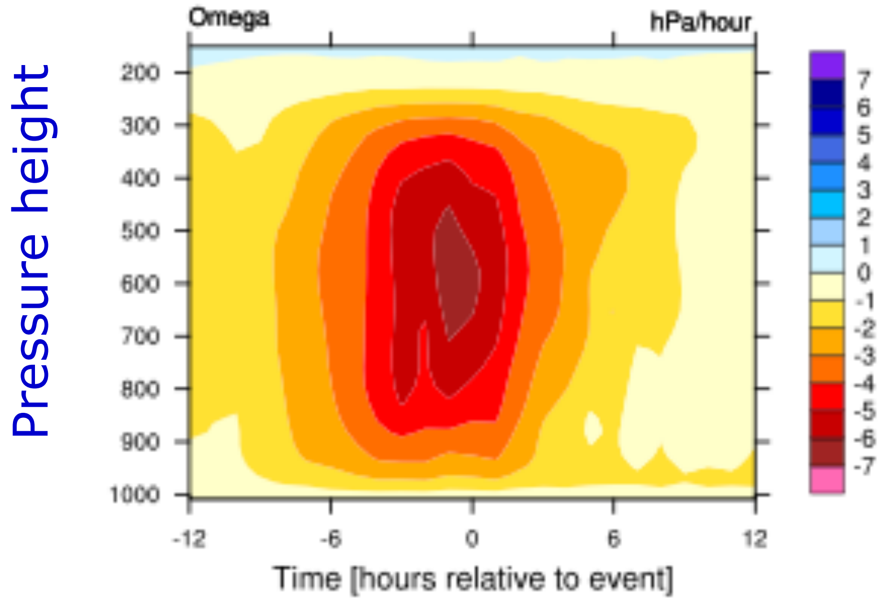
1. Events are precipitation measurement exceeding 0.1 mm that are connected in time and space (within a 70 km radius)
2. Combining surface observations with atmospheric conditions from a downscaling of ERA-interim reanalysis.



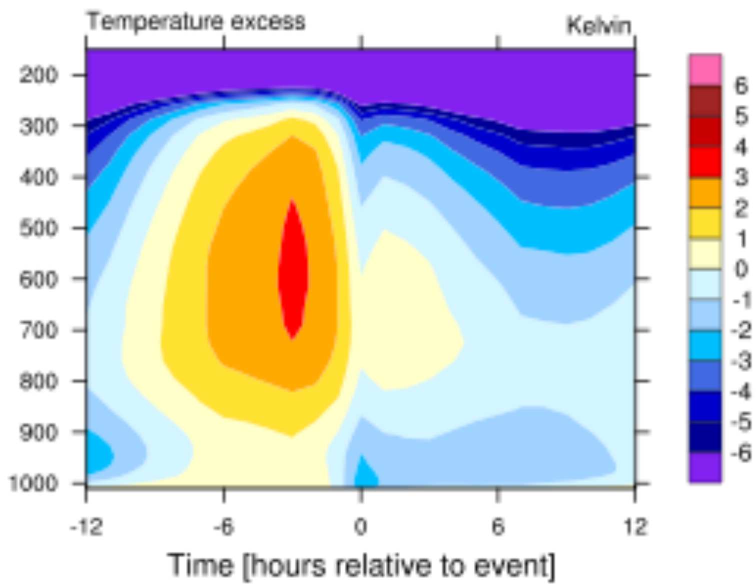
Method: see Loriaux et al, 2016: Peak Precipitation Intensity in Relation to Atmospheric Conditions and Large-Scale Forcing at Midlatitudes. *J. Geophys. Res. Atmos.*

Large-scale vertical motion (omega) and temperature excess updraft parcels

Omega



Temperature excess

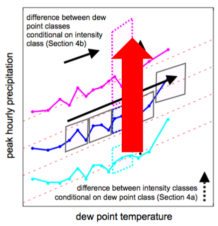


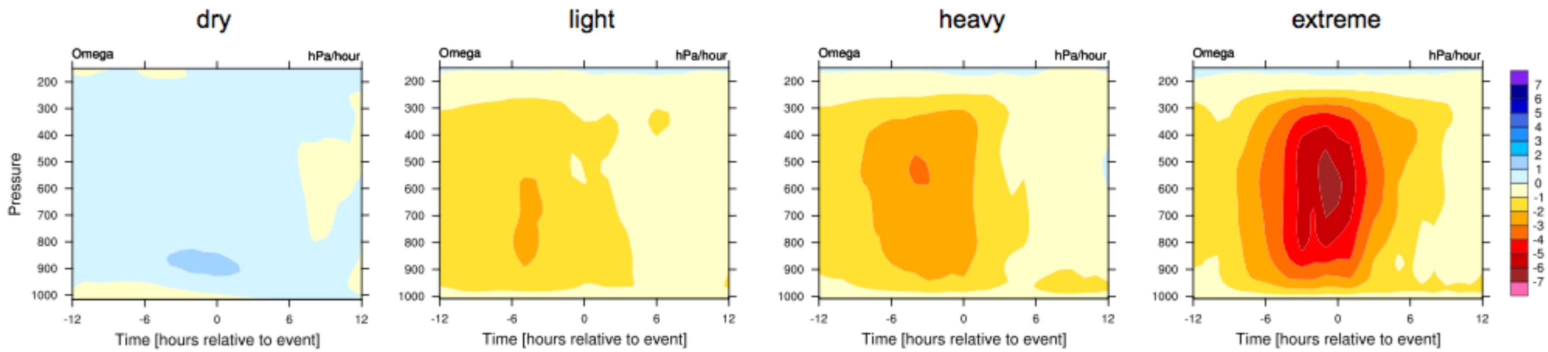
Time relative to occurrence of the hourly peak intensity of the shower

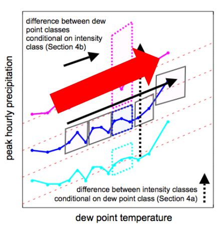
"Fuel supply: provides moisture to the precipitating area"

"Engine: measure instability of the atmosphere & strength local updrafts in convective clouds"

Large-scale vertical velocity (omega)

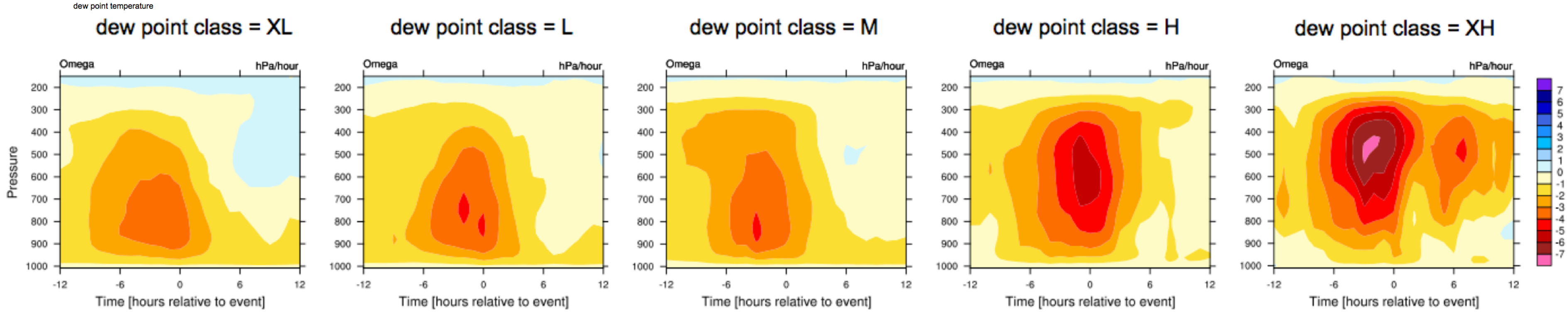




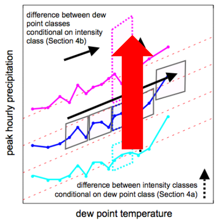


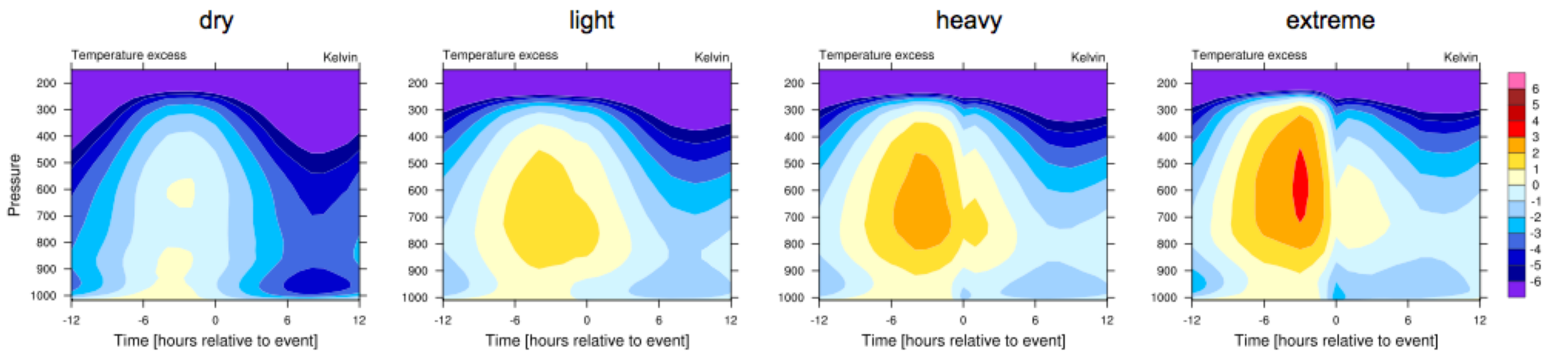
Most extreme events characterized by (much) larger large-scale vertical motions

Extreme events at (very) high humidity have larger rising motions

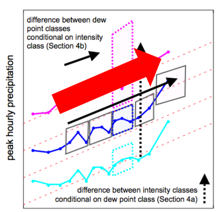


Temperature excess moist updraft

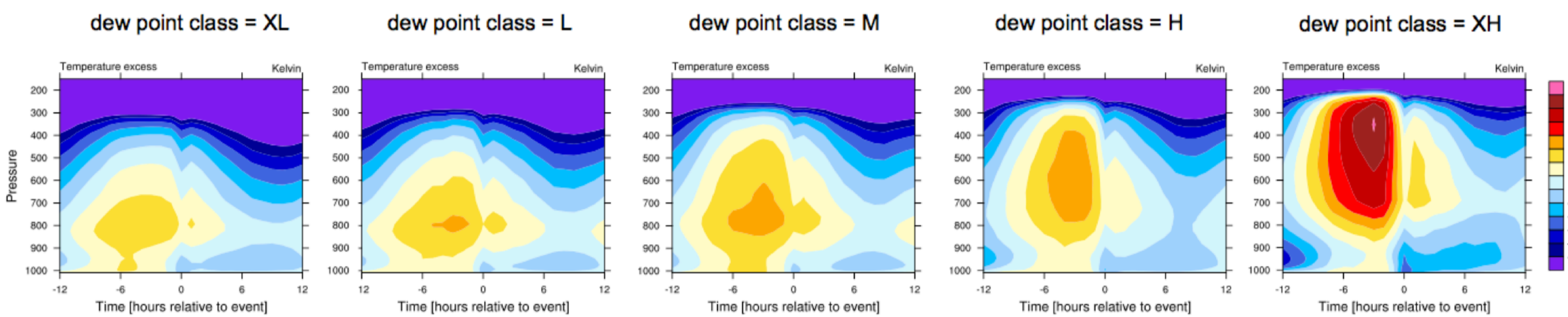




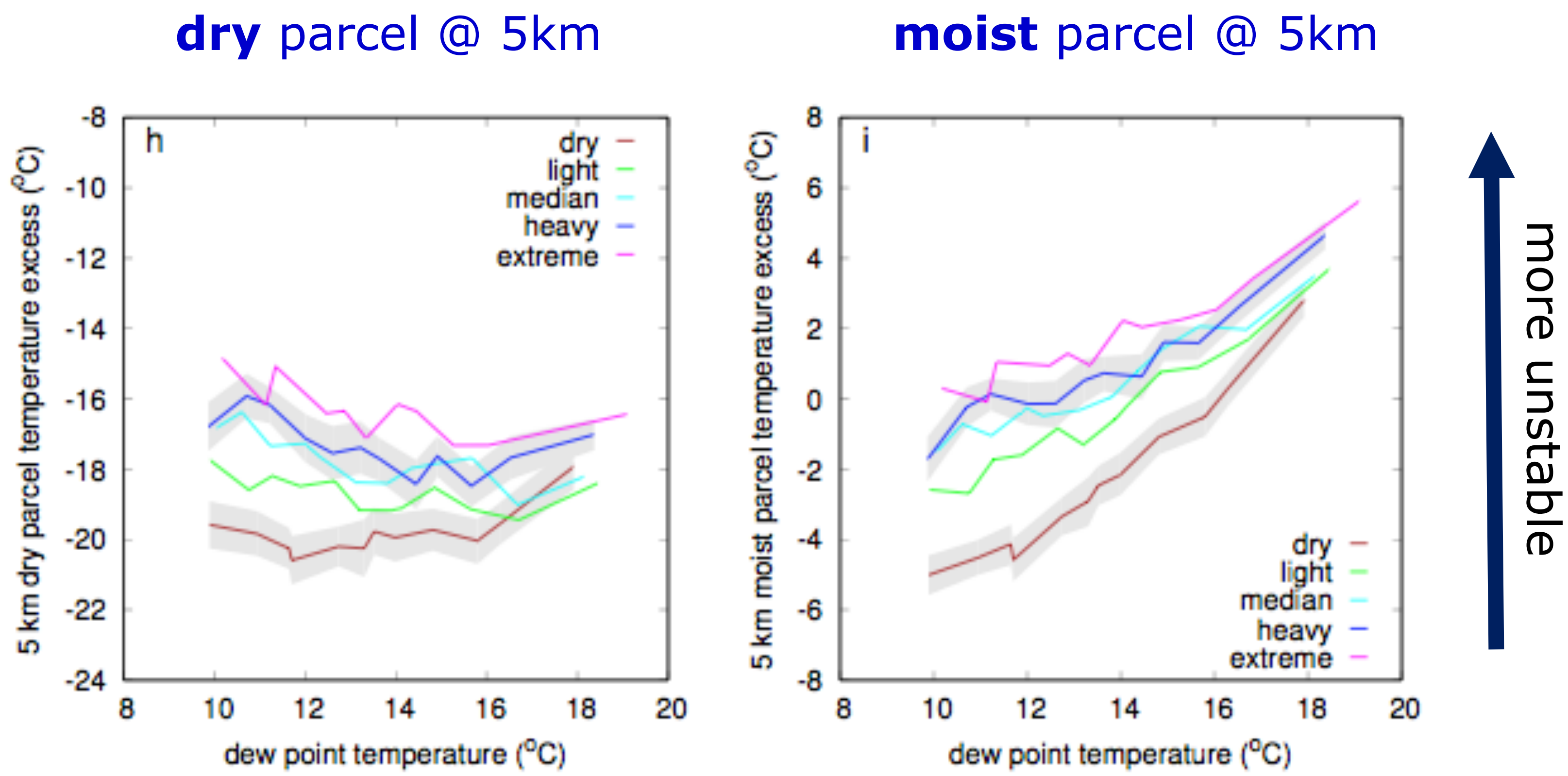
More intense events are characterized by larger instability



Instability and max. cloud top height increase rapidly for high humidity

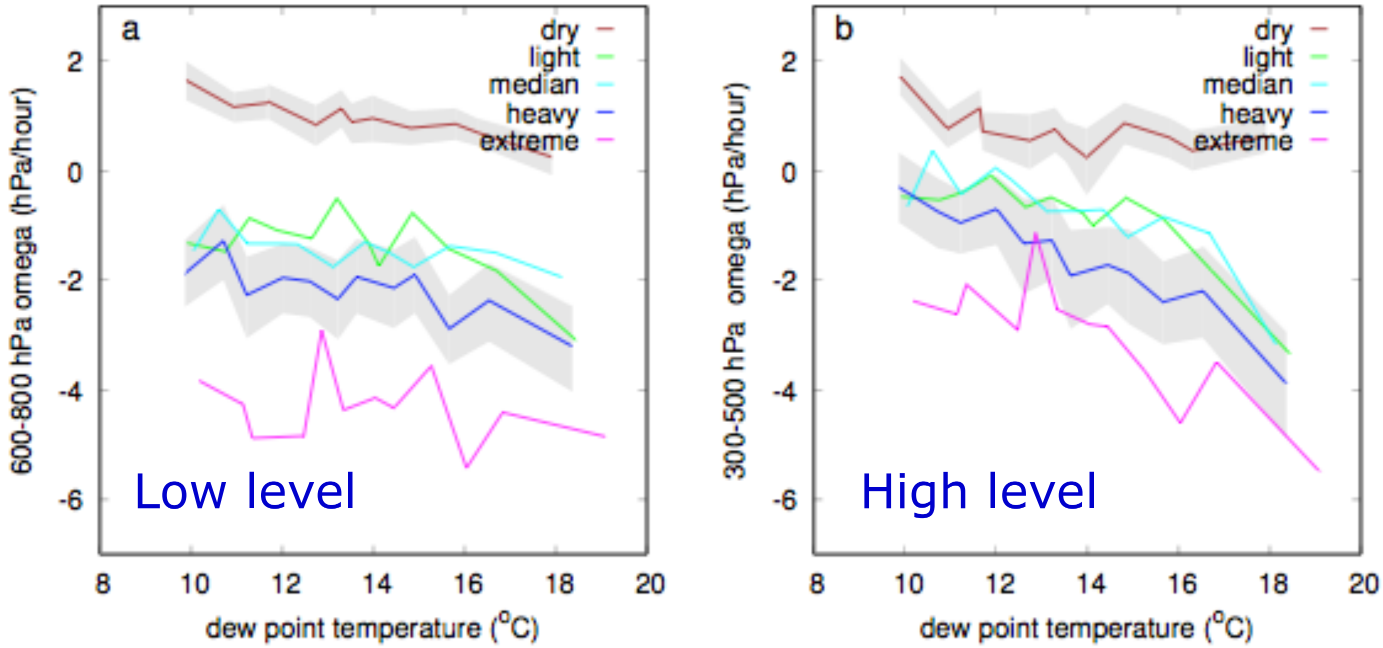


Increases in instability with surface dew point are primarily due to latent heat release



The most extreme events have larger omega and moisture convergence, which increases at high dew points

Average omega over Netherlands from 7 hours before until 2 hours after

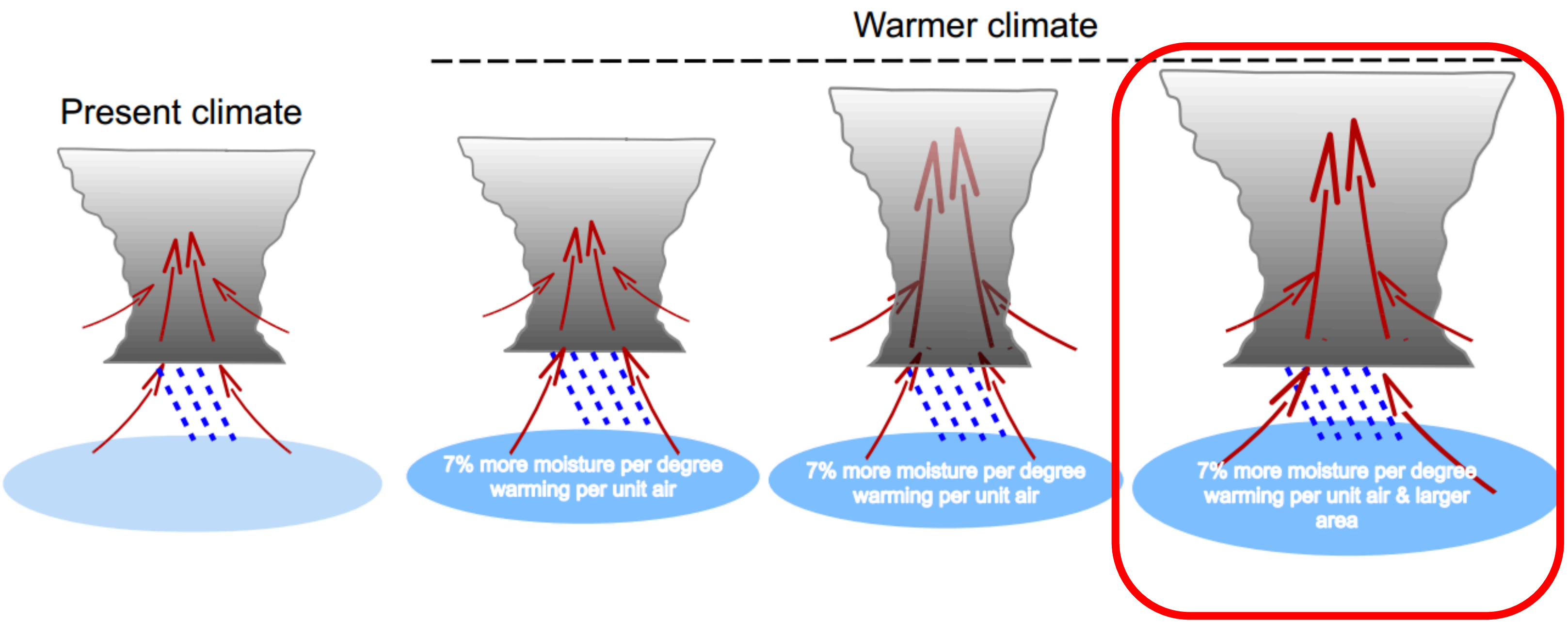


Increases in omega are likely due to latent heat release associated with convective activity (QG omega equation) – a positive feedback on moisture convergence

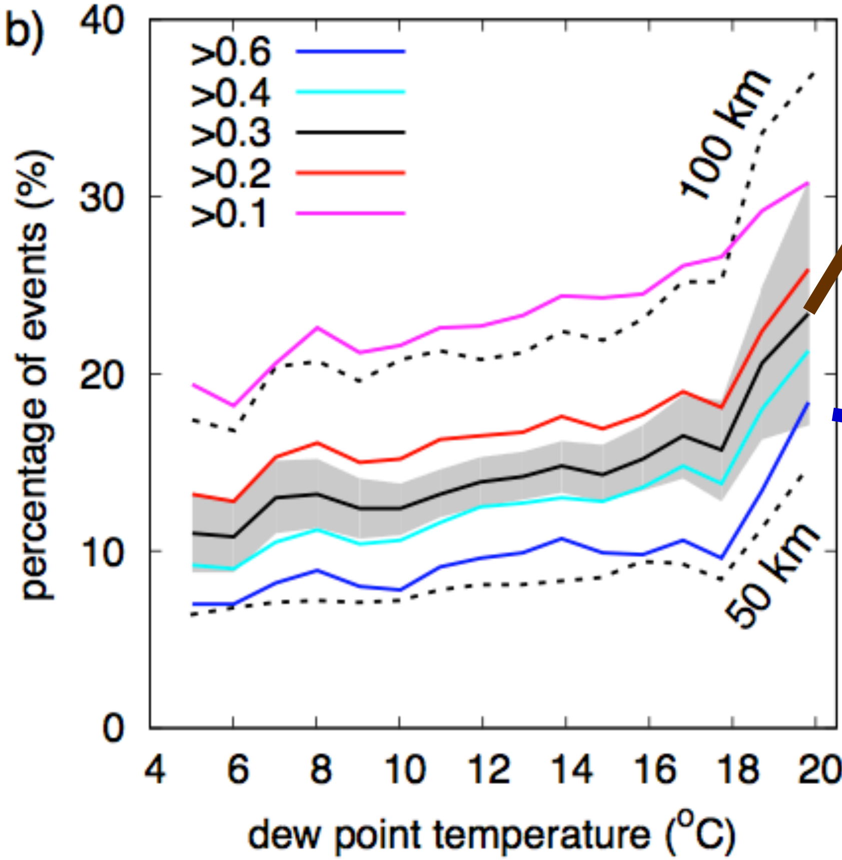
These results points at bigger and stronger convective clouds in a warming climate

as higher surface dew points lead to :

- stronger clouds updrafts and deeper clouds: more active clouds
- stronger large-scale moisture convergence: larger clouds systems (in particular for dew points above 15 degrees)



So, do we see bigger convective systems at high dew points?



Percentage of events that produced rain at at least 30 % of the stations (±10 stations)

Percentage of events that produced rain at at least 60 % of the stations (±20 stations)

Conclusions

Scaling of hourly precipitation with 14 % per degree appears to be related to:

- Increased instability (almost) entirely due to moisture effects (latent heating)

- At high dew points a feedback from the large-scale circulation

- Related to the large-scale feedback, an increase in cloud size

Paper accepted in Journal of Climate