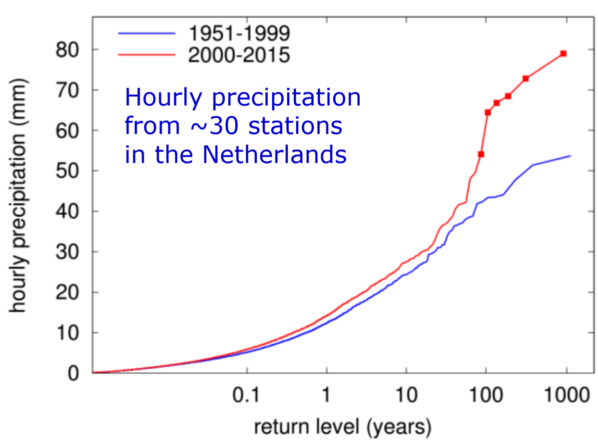
Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu

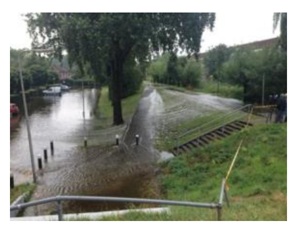
RESPONSE OF HOURLY PRECIPITATION EXTREMES TO CLIMATE PERTURBATIONS: RESULTS FROM A MESOSCALE MODEL

Geert Lenderink

J. Attema and J. Loriaux, E. van Meijgaard

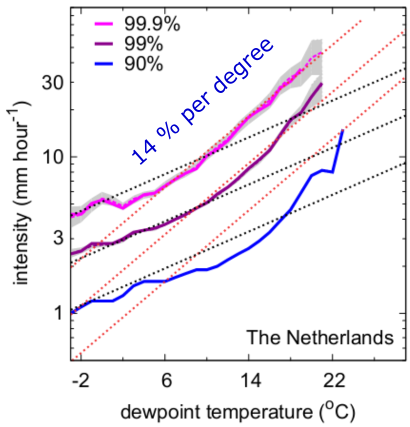
The last years the Netherlands experienced extreme precipitation



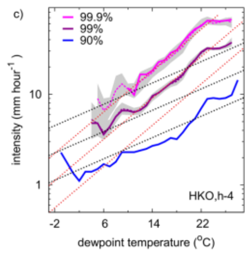


Relation between extremes and warming from observations

Data 30 stations in NL



Data Hong Kong



Explains the observed increase in hourly extremes (+15%) in the Netherlands

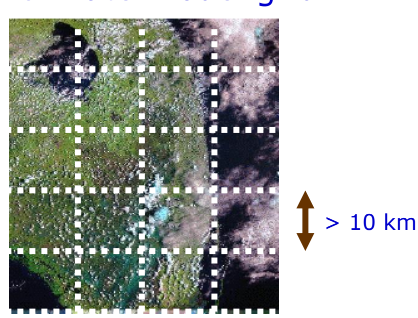
In Deltas in climate change context: change dewpoint ~ change temperature

www.knmi.nl/samenw/regioklim
Lenderink et al. HESS, 2011

These extremes are caused by organized mesoscale convective systems (MCS)

a real convective cloud

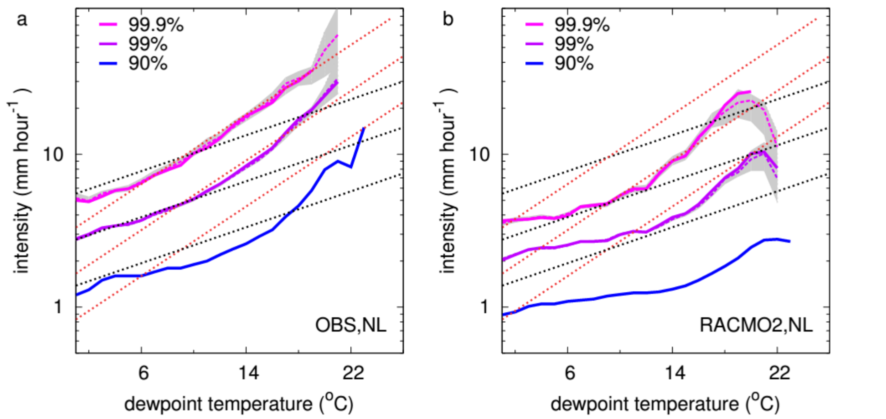
a climate model grid



Mesoscale convective systems are unresolved
(at best partly resolved) in present-day climate models

Climate models underestimate relation between precipitation intensity and moisture

Station observations | **Regional climate model @12km**



dewpoint temperature ~ absolute humidity

Latest revolution in weather prediction mesoscale models

Mesoscale models
- 2-3 km resolution
- use non-hydrostatic dynamics (i.e. explicitly predict vertical motions)
- resolve largest convective motions in the atmosphere.

"Convective clouds in mesoscale models look like real clouds"

Applications of mesoscale models in climate research

- These models are computationally very expensive to run
- Only short time periods (10 years) on small domain (1000x1000 km^2) can be simulated
- Only a few studies have been published so far


nature climate change

LETTERS

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Heavier summer downpours with climate change revealed by weather forecast resolution model

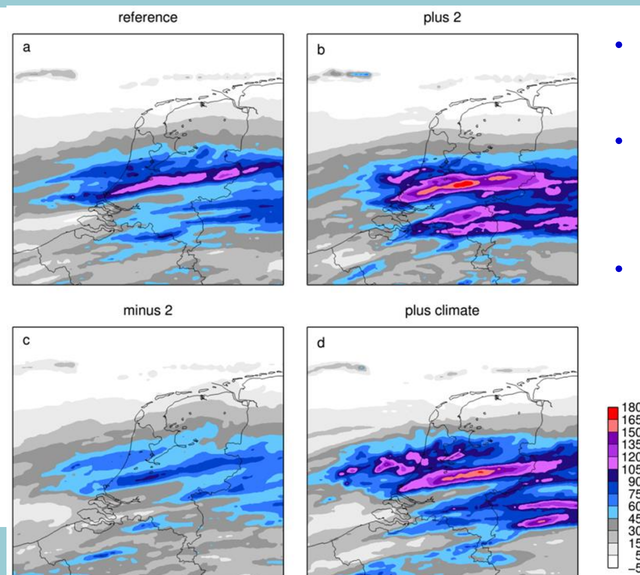
Elizabeth J. Kendon[1*], Nigel M. Roberts[2], Hayley J. Fowler[3], Malcolm J. Roberts[1], Steven C. Chan[3] and Catherine A. Senior[1]

The future analogue approach

1. Select cases based on observed extremes: 12 cases
2. Run a control simulation with re-analyis boundaries
3. Re-run cases for different perturbations for initial fields, boundaries + surface conditions:
   - "plus 2": 2 degrees warming & unchanged relative humidity
   - "minus 2": 2 degrees cooling & unchanged relative humidity
   - "plus climate": perturbation in temperature & relative humidity derived from a climate integration @ 2 degrees global warming

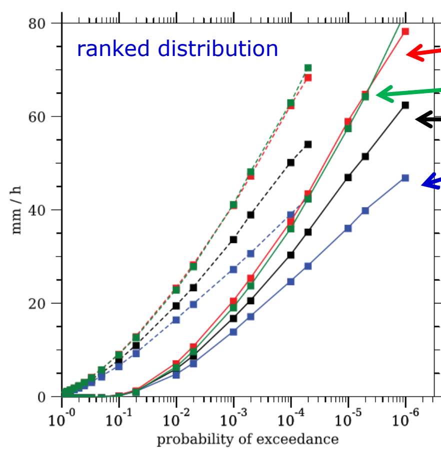
How much rain would fall if the same event (same meteorological conditions) would occur in a warmer (or cooler) climate ?

An example for the "Hupsel" event
2-day precipitation sum



- Perturbed runs similar to reference run
- Warmer runs display larger precipitation amounts
- Colder run, less precipitation

Combined statistics of 12 cases



2 degrees warmer ("plus 2")

"plus climate"

reference

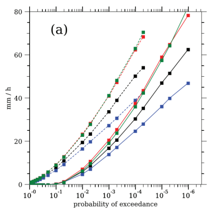
2 degrees colder ("minus 2")

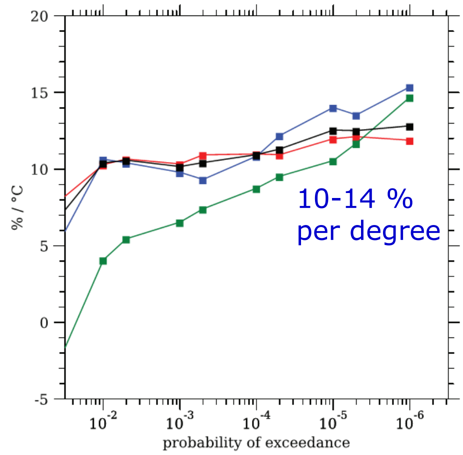
Based on pooling all hourly data from all grid points of the model

more extreme

Combined statistics of 12 cases

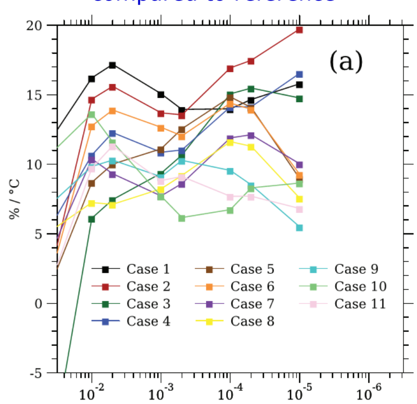
Estimate change
per degree temperature
compared to reference



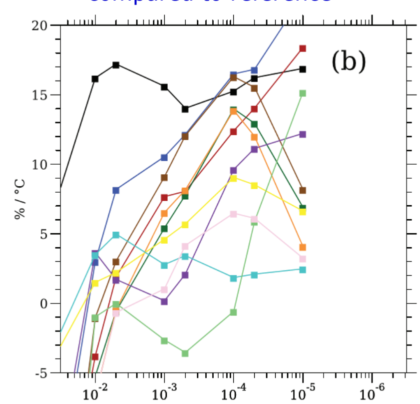


But large differences between cases ....

"plus 2" and "minus 2"
compared to reference



"plus climate"
compared to reference



Conclusions

1. Observations of (sub)hourly precipitation extremes give ~12-14 % per degree warming
2. Climate models (strongly) underestimate this dependency for the high temperature range
3. By perturbing a mesoscale model we can successfully create “future analogues” of present-day extremes
4. From these perturbation we get ~ 12 % per degree average over 12 cases (yet with a large inter-case spread)
5. More info: Attema et al. ERL 2014; www.knmi.nl/samenw/regioklim