How do cold pool driven winds intensify extreme precipitation in mid-latitudes?

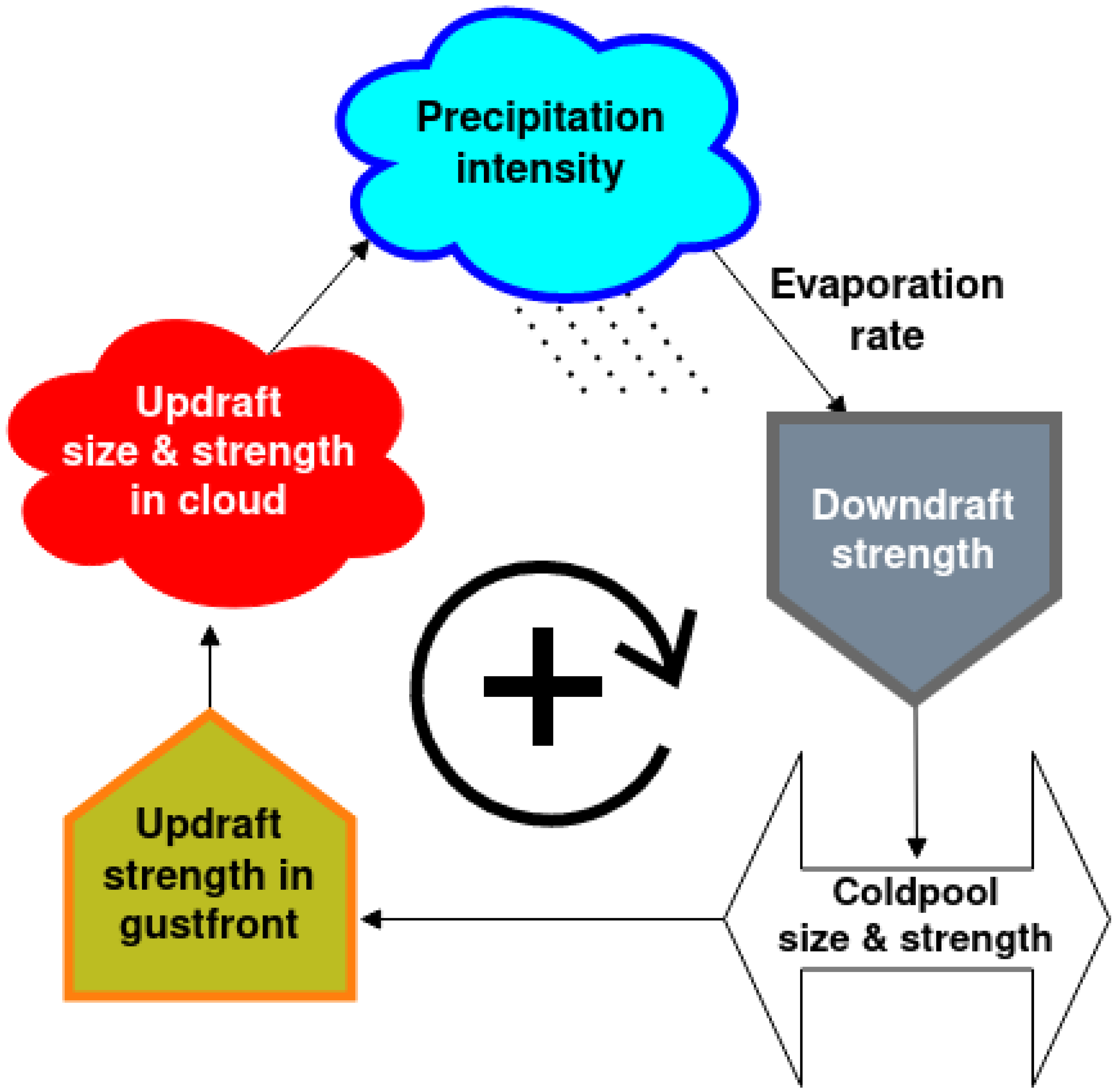
Research focus

How intensification of the dynamics leads to an increase of precipitation intensity beyond the usual Clausius Clayperon (CC) scaling for short timescales of 5 minutes.

Case description

- Idealised extreme precipitating case over the Netherlands at 52°N with large scale uplifting applied.
- We use the Dutch Atmospheric Large Eddy Simulation (DALES) to explore the sensitivity of the updrafts, the cold pool dynamics and the resulting precipitation intensity to warming. The 'warm' and 'cold' scenarios have +/- 4 K offsets with constant relative humidity.
- Prescribed surface fluxes following a diurnal cycle. Radiative cooling is also prescribed.
- Domain has grid spacing 200m horizontal and 240 layers with increasing vertical spacing.
- More details in *Lochbihler et al. JGR: Atmos, 2019*

Conceptual feedback loop



Snapshot of wind structure and precipitation

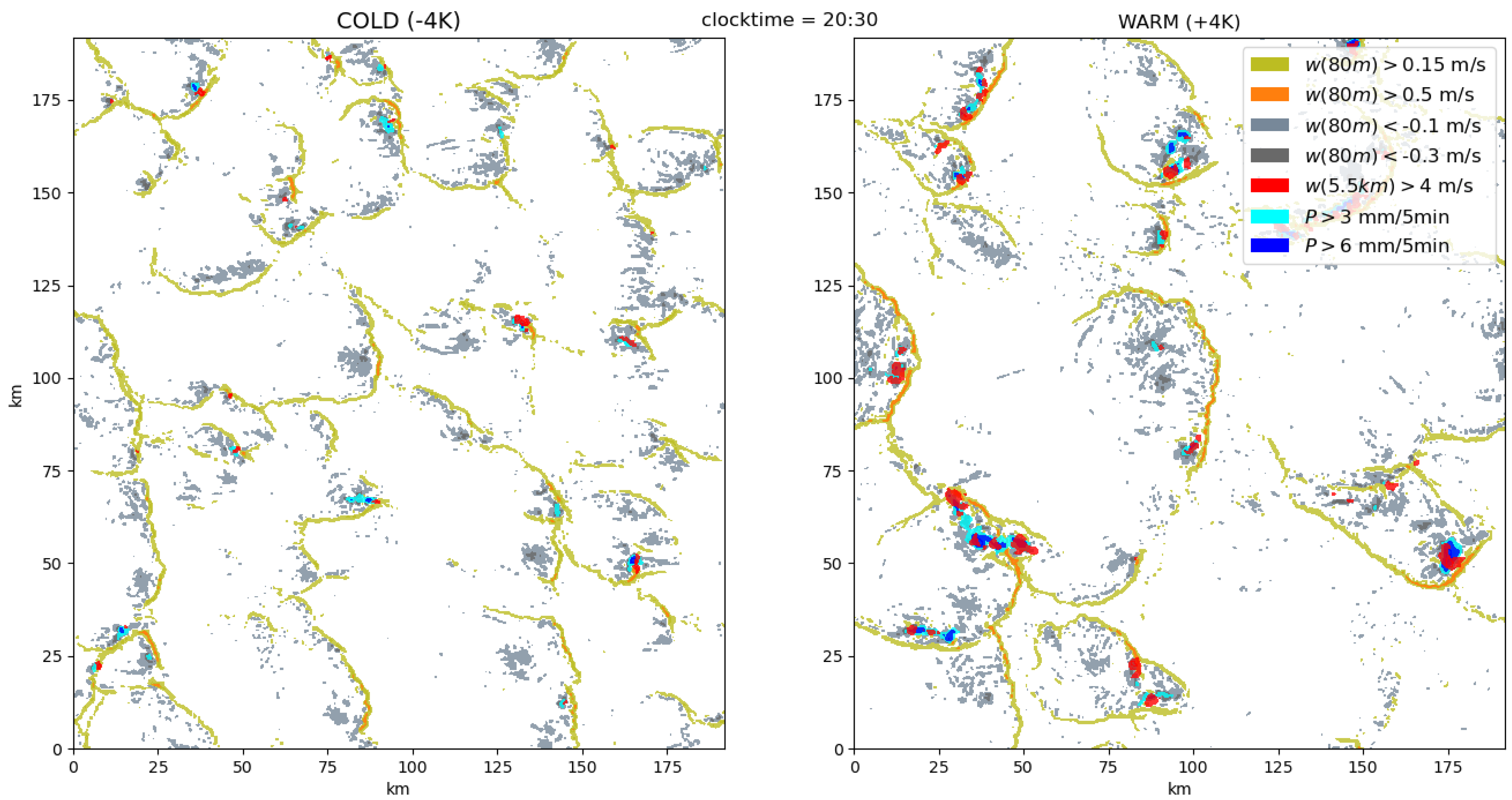


Figure: Cold versus warm scenario comparison, with a total of 8 K offset. Vertical winds near the surface (80m), the in-cloud updrafts (5.5 km) and the precipitation rate at the surface (0 m) are shown in colors matching with the depiction of the conceptual feedback loop.

What changes with warming

- The atmosphere holds more moisture.
- Precipitation intensifies.
- As precipitation falls, it cools the downdrafts by increased evaporation, creating a larger lateral density difference.
- Downdrafts spread out near the surface into bigger cold pools.
- Updrafts at the cold pool outflow boundary are stronger.
- Updrafts in the clouds accelerate more due to increased latent heat conversion.
- Stronger updrafts intensify precipitation closing the feedback loop.

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References:

Lochbihler et al., JAMES, 2021

Haerter and Schlemmer, GRL, 2018