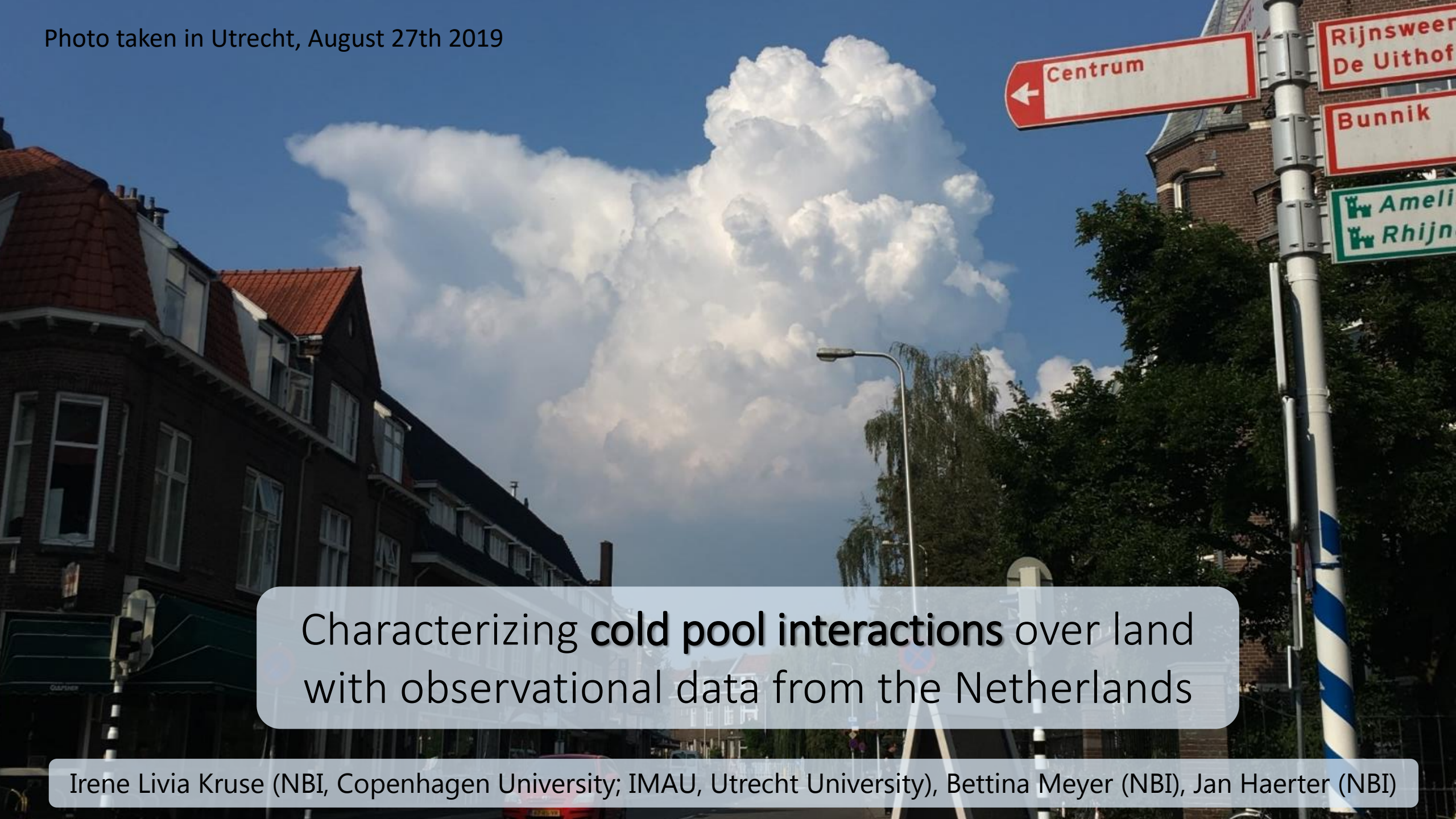


Photo taken in Utrecht, August 27th 2019

Characterizing **cold pool interactions** over land with observational data from the Netherlands

Irene Livia Kruse (NBI, Copenhagen University; IMAU, Utrecht University), Bettina Meyer (NBI), Jan Haerter (NBI)

What is the role of cold pools within atmospheric convection?

Cold pools (evaporatively cooled downdrafts originating from convective rain clouds) can interact with their environment and with one another, at times triggering new convection.

Characterizing these interactions with the use of observations may be a key step towards deeper understanding into the role of cold pools in the spatial organization of convection.

Cold pool triggering of new convection:

Dynamic lifting mechanisms	*Thermodynamic mechanisms*
• Interaction with environmental wind shear • Collision with other cold pools	• Accumulation of moisture in outer ring leading to higher buoyancy

e.g. Mesoscale Meteorology in Midlatitudes (Markowski, Richardson 2010), ch. 5.3: Outflow Boundaries; Feng et al. 2015 https://doi.org/10.1002/2014MS000384; Tompkins 2001 https://doi.org/10.1175/1520-0469(2001)058<1650:OOTCIL>2.0.CO;2; Torri et al. 2015 https://doi.org/10.1002/2015GL063227

Why study **observations** of cold pools over **land**?

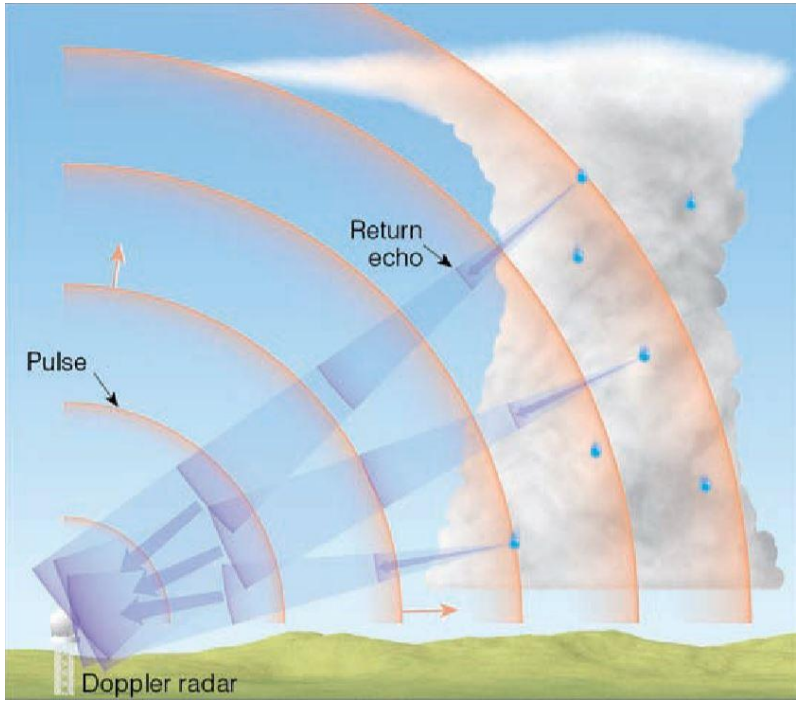
- To validate cold pool properties derived from numerical **simulations**
- To complement observational campaigns conducted over **oceans**
- To find **observational evidence** of cold pool collisions/triggering of convection

Location of study: The Netherlands

(bonus: flat topography, which reduces the topographical triggers of new convection)

How can we observe cold pools?

Doppler radar (Herwijnen radar)



16 scanning angles

REFLECTIVITY
(shows rain intensity of generating rain cells but also provides direct visualization of gust fronts at times)

BASE VELOCITY
(shows the radial velocity of suspended particles)

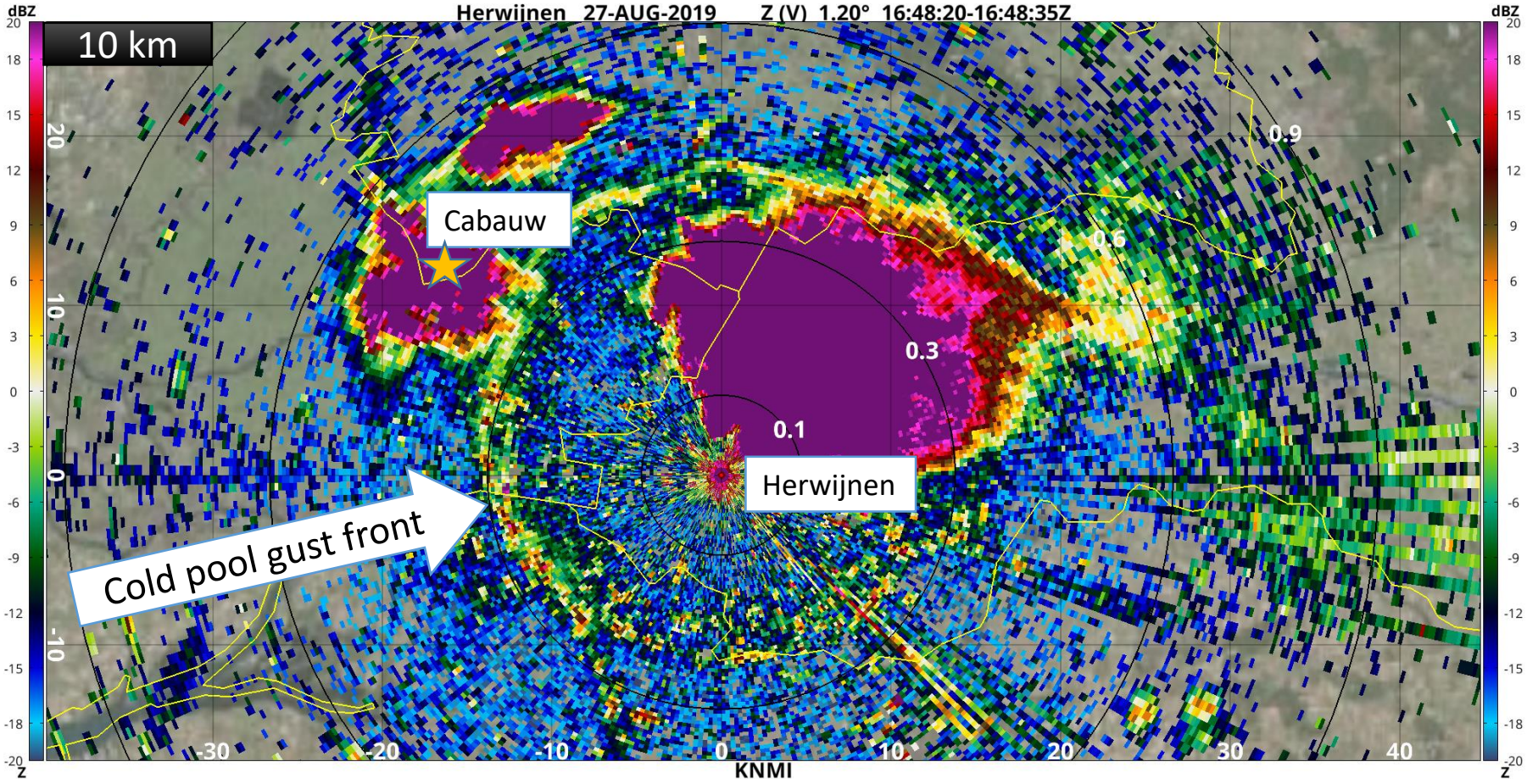
Tower time series (212m Cabauw tower)

6 heights + surface

TEMPERATURE
WIND SPEED
MOISTURE (SH, RH)
HEAT FLUXES (SHF, LHF)

Note: All data provided by KNMI

Example of radar reflectivity image of **one cold pool case**



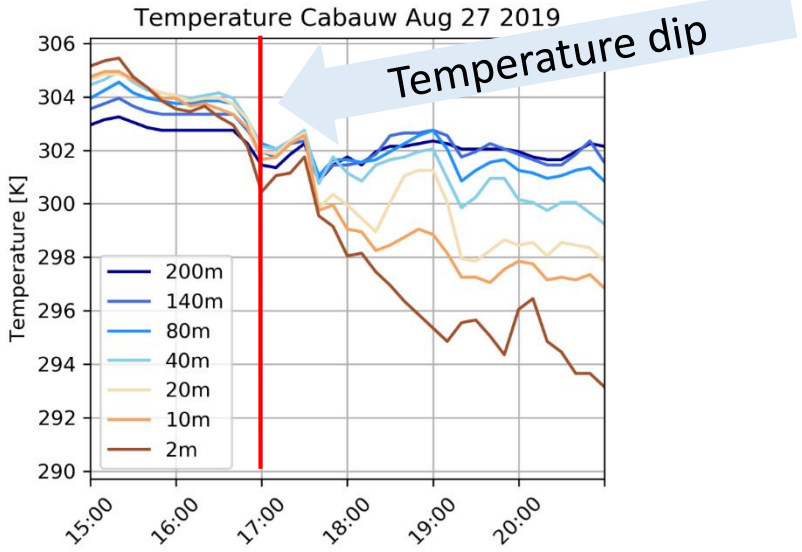
”seen” by the radar because of dust and/or insects brought aloft in the convergence zone

Full time-evolution including base velocity: https://vimeo.com/414159231

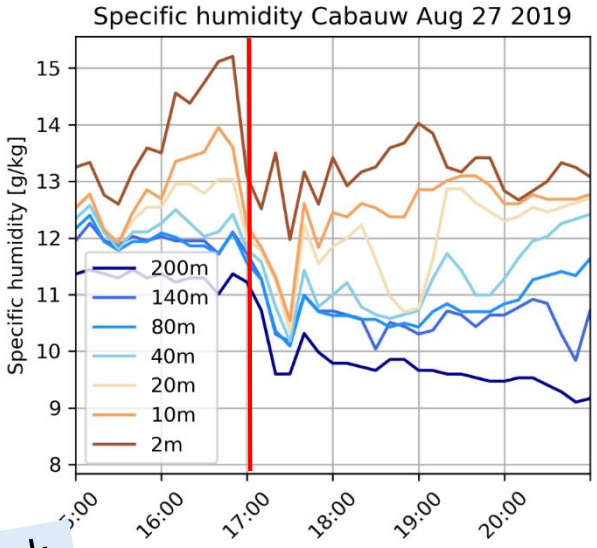
Visualized with NLradar viewer by Bram van’t Veen

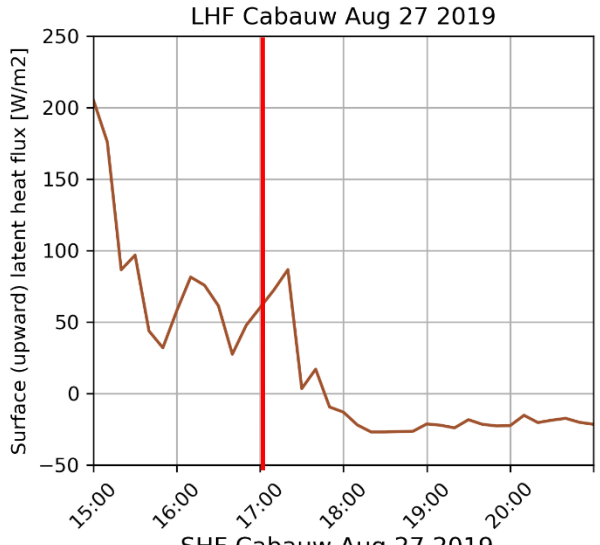
Example of 10-min tower time series during **one cold pool case**

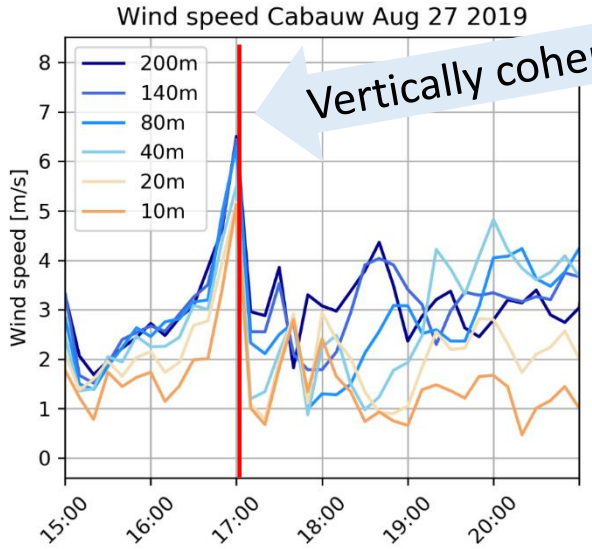
(red line indicates when the gust front "hits" the tower in the radar image)



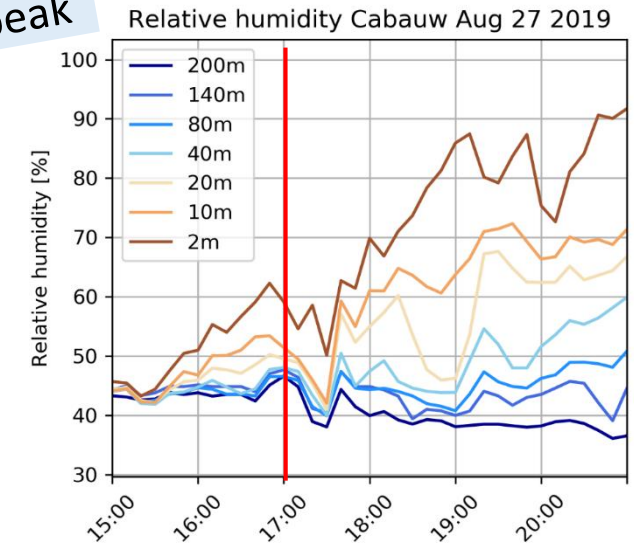
Temperature dip

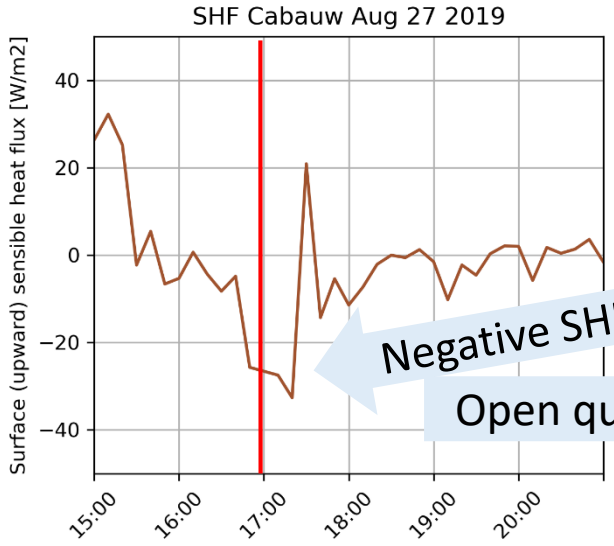






Vertically coherent wind peak





Negative SHF?

Open question

Expansion of study to **multiple cases**

Development of algorithm to detect cold pools from Cabauw time series

To identify passing cold pool gust fronts in Cabauw timeseries of temperature and wind speed, an algorithm was developed considering surface temperature dips (adapted from *De Szoeke et al. 2017* https://doi.org/10.1175/JAS-D-16-0264.1) and in addition, the vertically coherent wind signal seen throughout the 6 tower levels at the time of a gust front.

Cold pool identification criteria in algorithm:

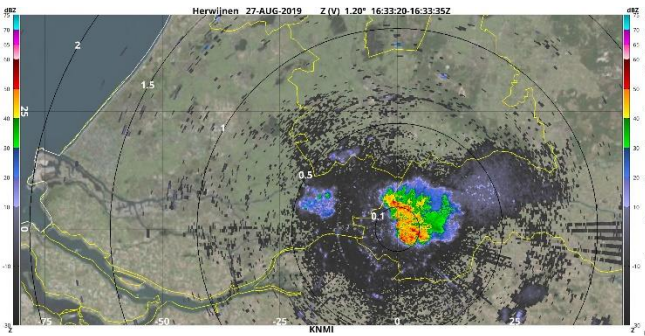
TEMPERATURE DIP (K) > 1.5 + multi-height WIND PEAK (m/s) > 4σ = COLD POOL!

(where σ is the standard deviation of height-summed daily wind fluctuations from the centered 2 hour mean)

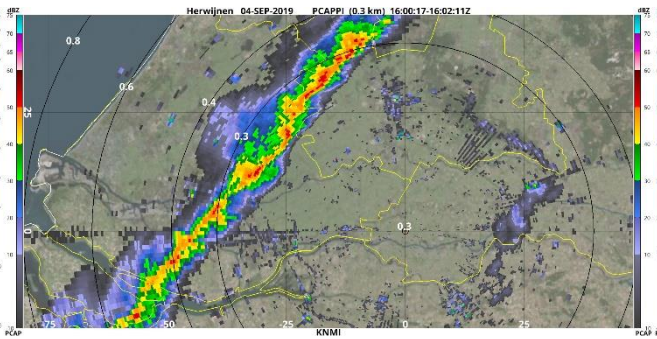
Work in progress

Applying the algorithm to Cabauw timeseries of the summer of 2019 (May-September), 34 «cold pools» have been found, and have been investigated with the Herwijnen radar imagery.

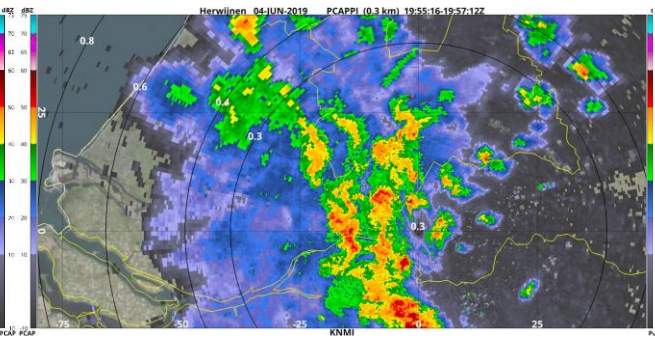
When observing the reflectivity imagery, the origin of *all* the detected «cold pools» can be classified visually into 4 groups:



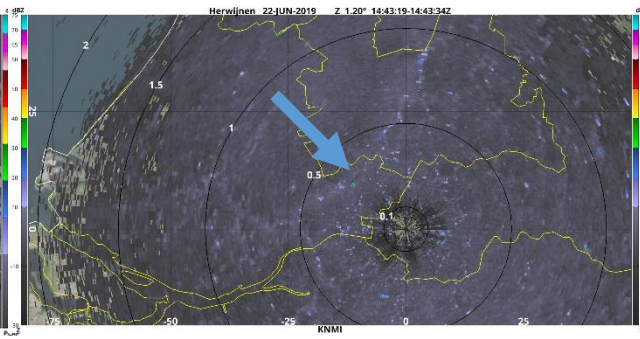
Isolated «popcorn» convection



«Squall line» organized convection



Mesoscale convective systems



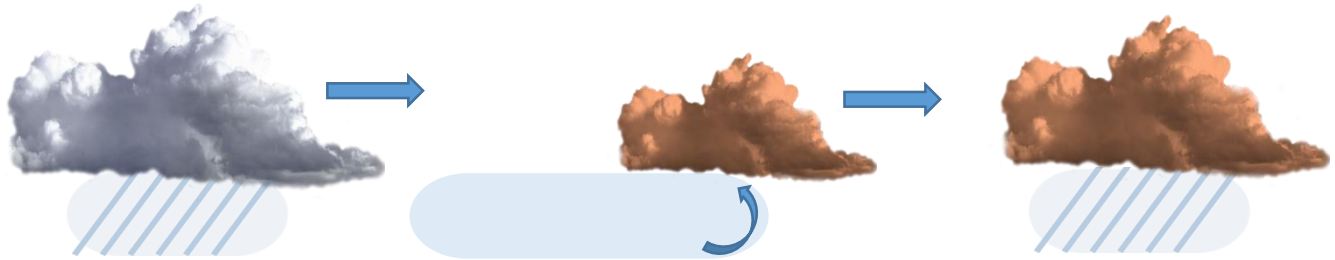
Unidentified origin: reflectivity «lines» corresponding with wind peaks and temperature dips but no nearby rain event

Visualized with NLradar viewer by Bram van't Veen

Final message and outlook

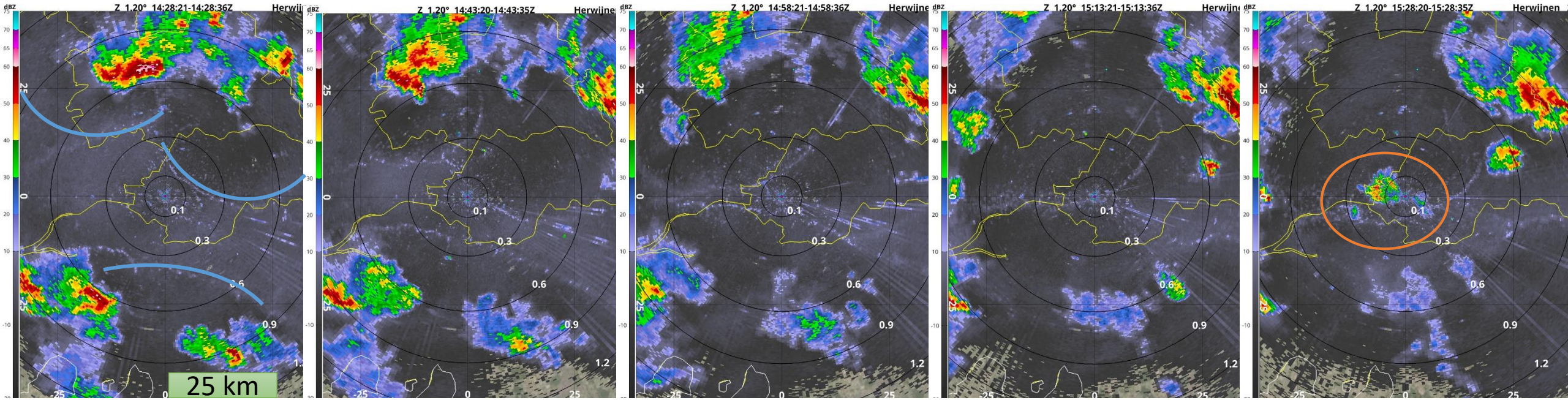
The combination of tower measurements and radar imagery allows to verify an algorithm that can detect cold pools from point measurements in different weather conditions.

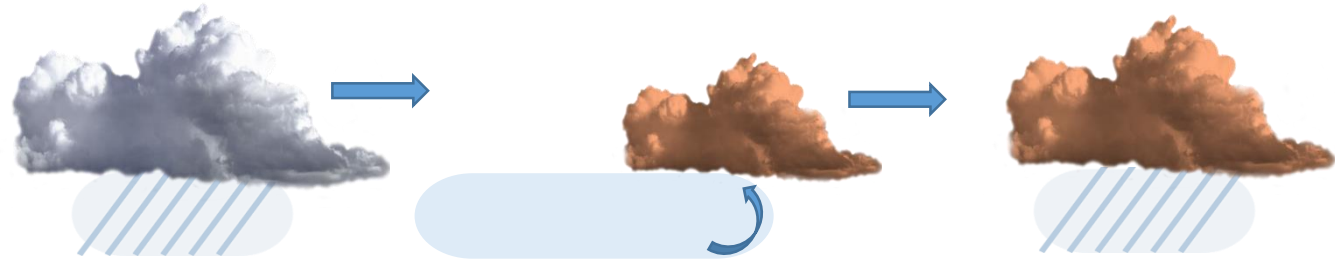
Starting with the isolated «popcorn» cases, we aim to find a link between generating rain cell and cold pool spreading velocities, and potentially linking this to properties of cold pool-triggered rain cells.



Final message and outlook

Sequence showing a cold pool collision + triggered rain cell in radar reflectivity





Stay tuned for results!

Visualized with NLradar viewer by Bram van't Veen