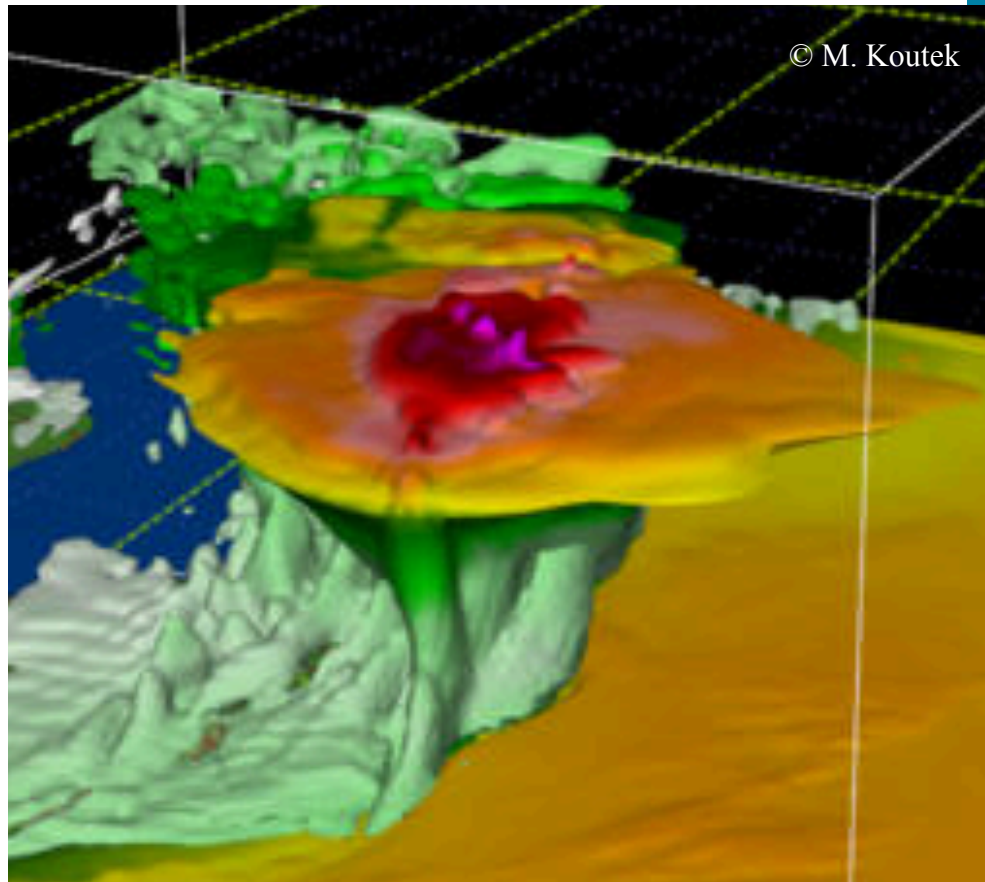




Royal Netherlands
Meteorological Institute (KNMI)
*Ministry of Infrastructure and the
Environment*



Simulation of the atmosphere: High resolution (short range) NWP

Sander Tijm
KNMI

13:01

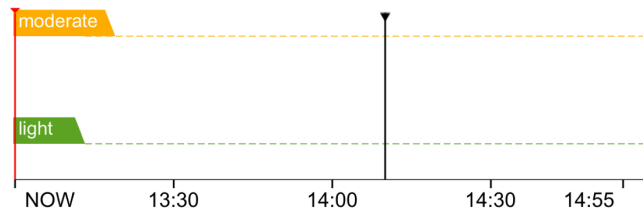
5G



14:10

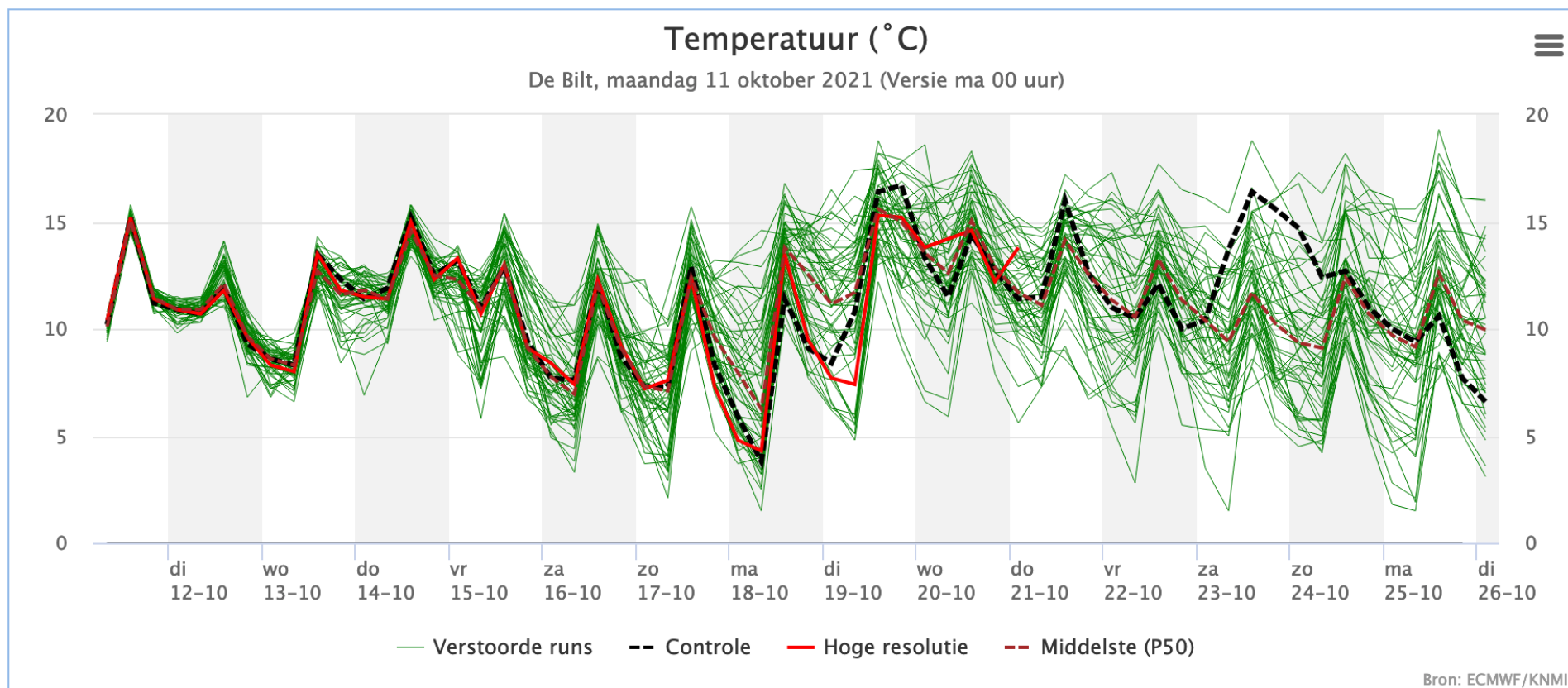


No precipitation 0 mm/h



De Uithof

- Weather
- Rain radar
- Weernieuws
- Wereldweer
- More





Intro

- IMAU->IMAU->KNMI (research, operations, international HIRLAM management, UWC-West management)
- History NWP
- History LAM NWP in Netherlands
- HARMONIE, setup, capabilities, EPS
- Verification and model problems, current research

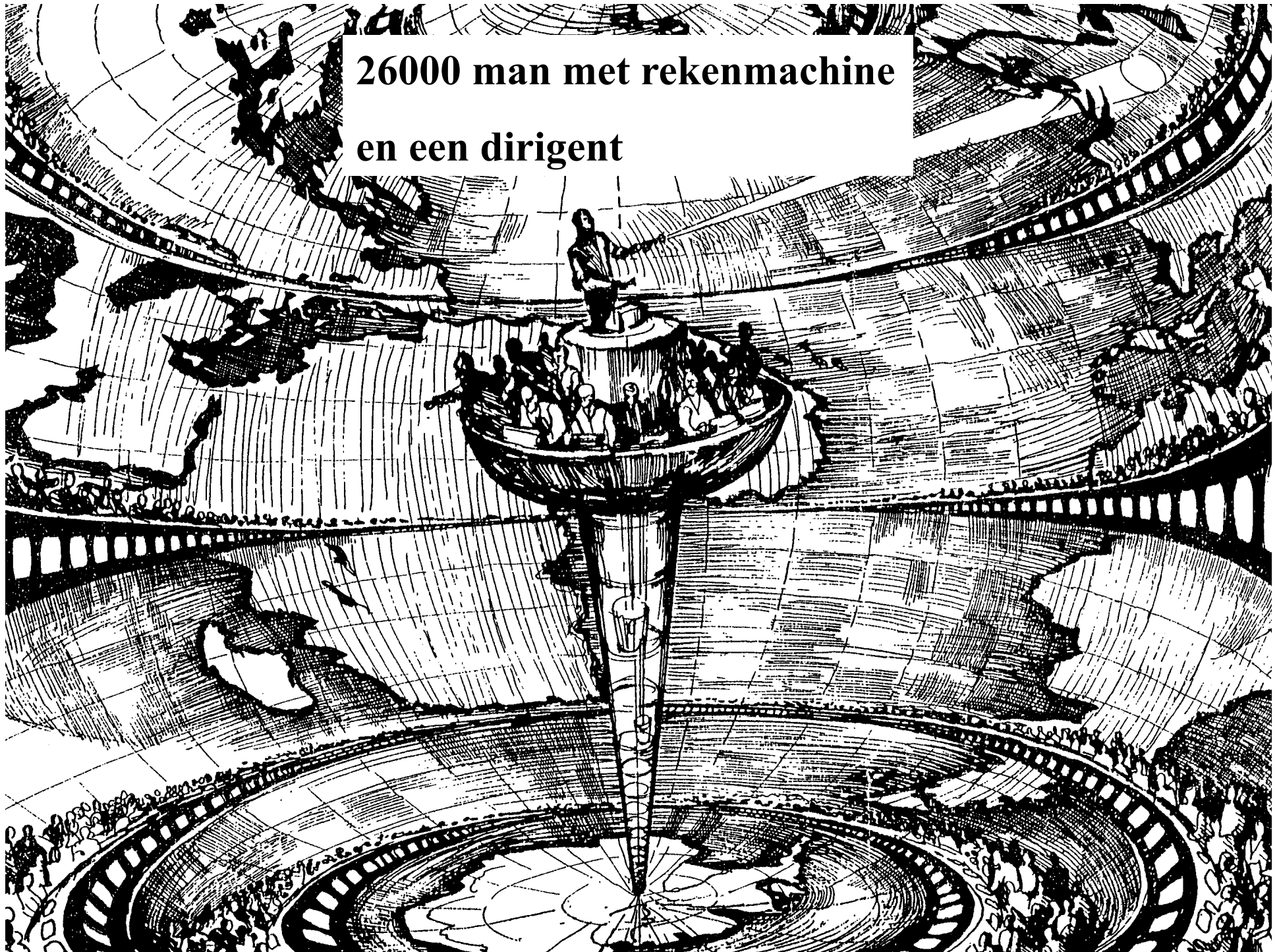


History Numerical Weather Prediction

- First ideas NWP by pioneer Lewis Fry Richardson (1920)
- First complete set of equations
- Huge amount of calculations
- Forecast contained very large errors



26000 man met rekenmachine
en een dirigent





1946-1950: Princeton-group

- Charney, de theoretician/synopticus
 - Fjortoft : de meteorologist
 - Von Neuman: mathematician
-
- Together they set up the first numerical weather prediction model



Computational power drives spatial resolution

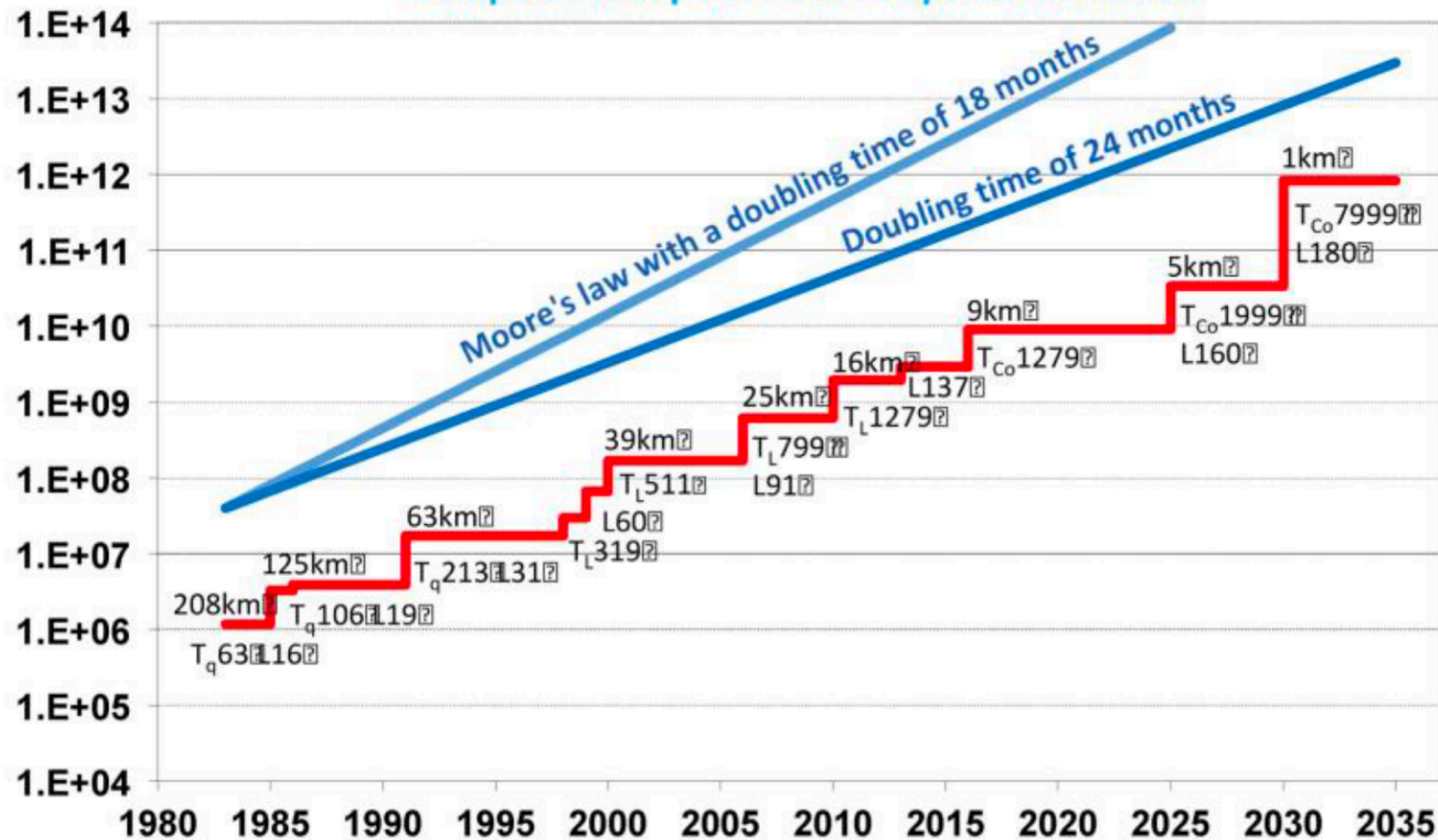
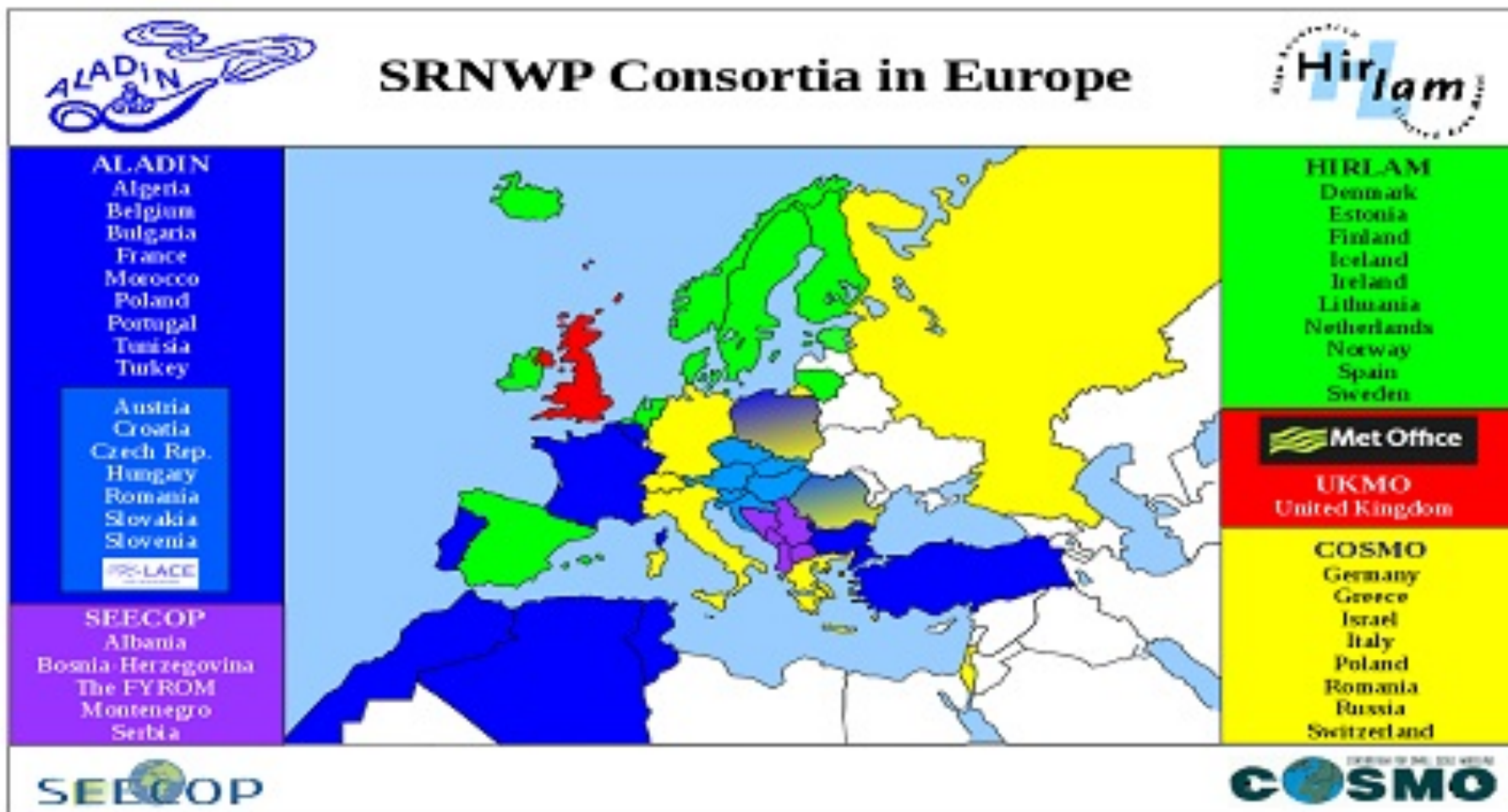


Figure 2. "Understanding grows only logarithmically with the number of floating point operations." (John P. Boyd). The progress in the degrees of freedom (vertical levels $\times$ grid columns $\times$ prognostic variables) of the ECMWF



History HIRLAM and HARMONIE

- Why limited area models?
- Hemelvaart storm 1983 -> improved representation of small scale systems necessary (ECMWF 200 km)
- Running model provides flexibility in setup, output, development of applications based on model
- First development of LAM
- KNMI starts cooperation with HIRLAM in 1986
- HIRLAM cooperation with ALADIN since 2006 for development of mesoscale model: HARMONIE-AROME





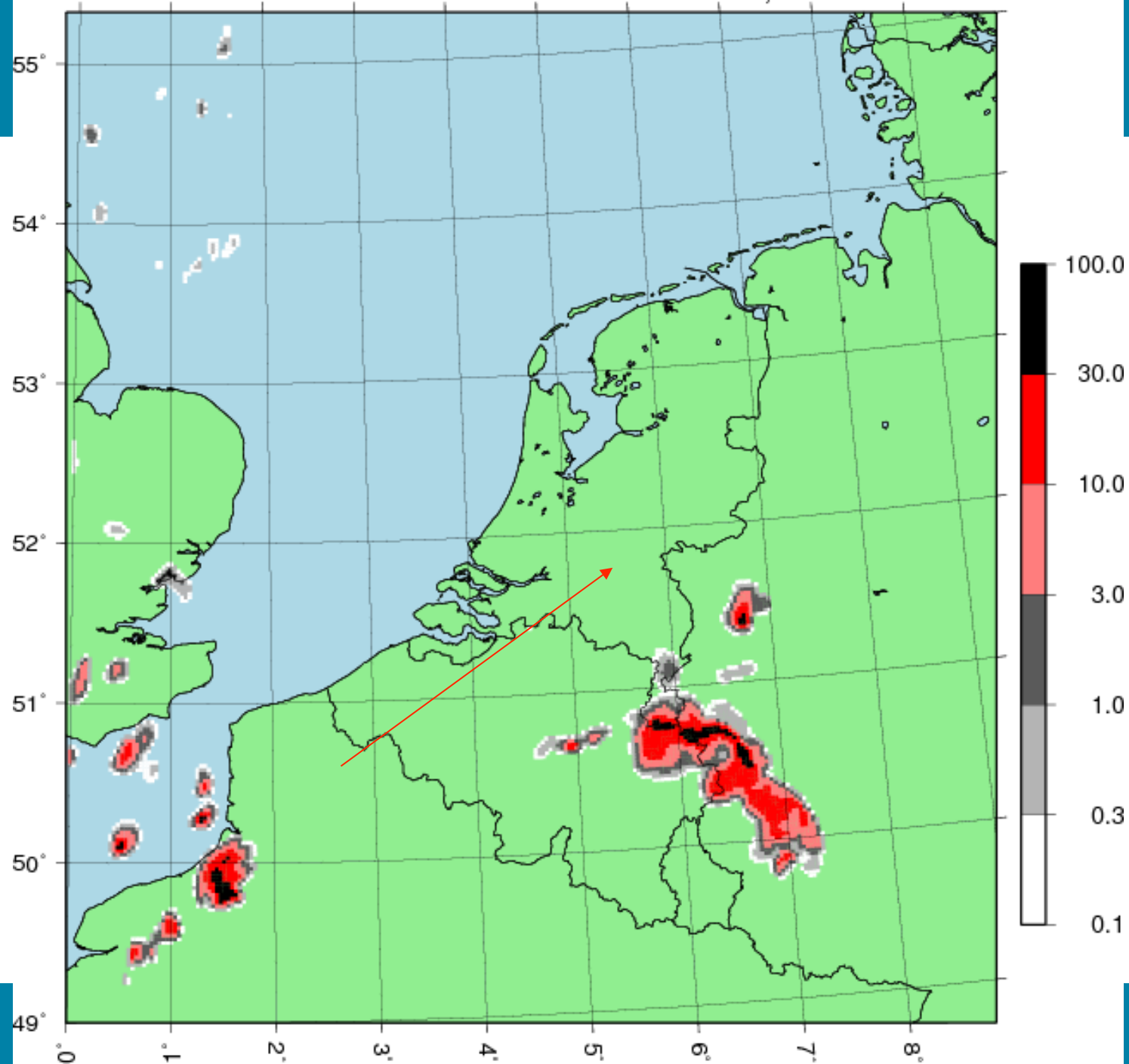
History HIRLAM and HARMONIE

- HIRLAM first operational at KNMI in 1993, 16 levels, resolution 55 km (EC 100 km)
- 1996: 55 km, 31 levels (EC 60 km)
- 2002: 22 km, 40 levels (EC 40 km)
- 2006: 11 km, 60 levels (EC 25 km)
- 2012: 2.5 km HARMONIE on smaller domain, 60 levels (EC 16 km)
- 2018: 11 member ensemble HARMONIE-AROME 2.5 km, 65 levels (EC 9 km, ens 18 km)
- 2023: cooperation with Denmark, Ireland, Iceland



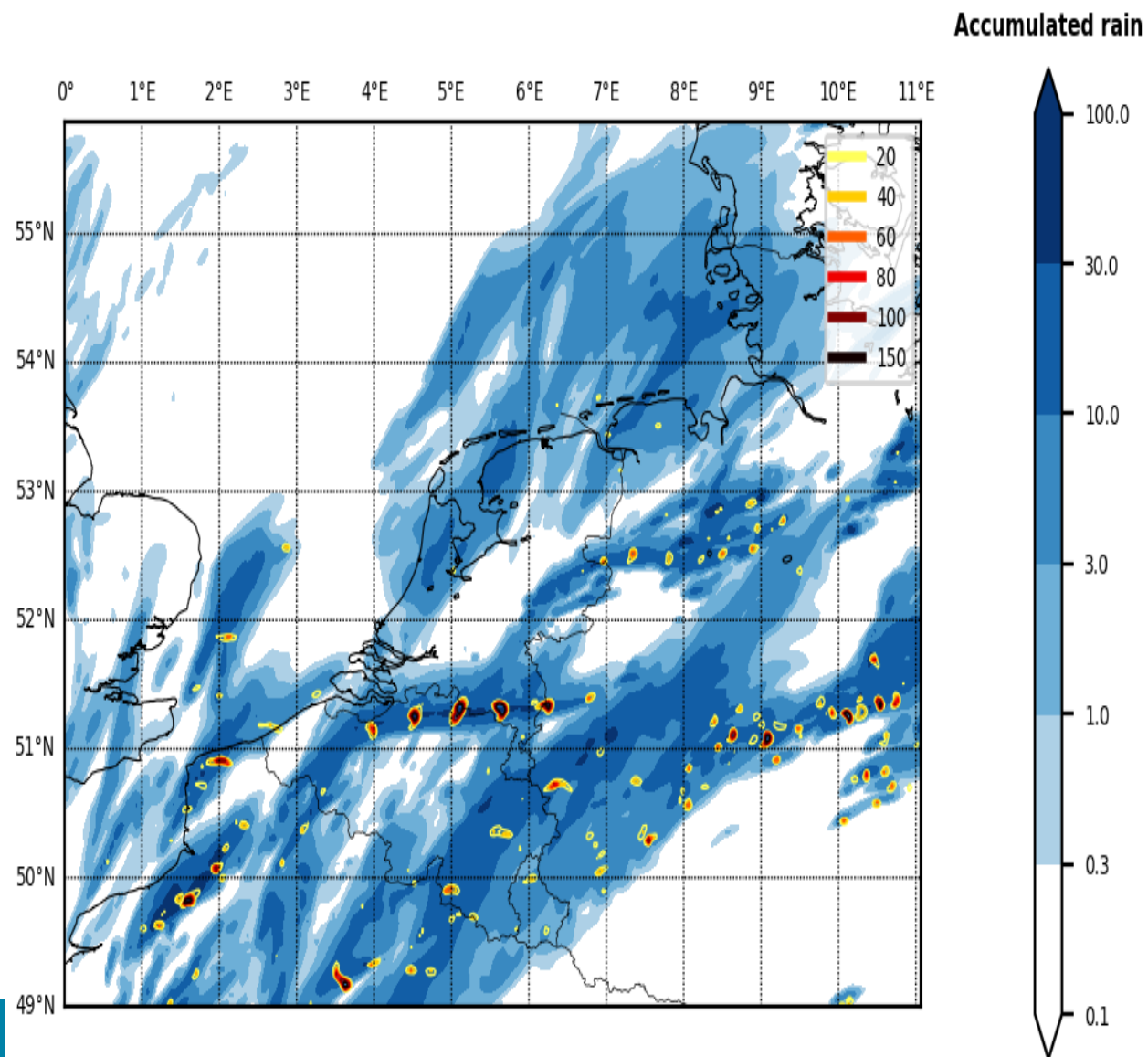
United
Weather
Centres

HARM36 Rainrate an 2014060800 val 09 – 06, 00 UTC





Accumulated rain with accumulated updraft helicity superimposed





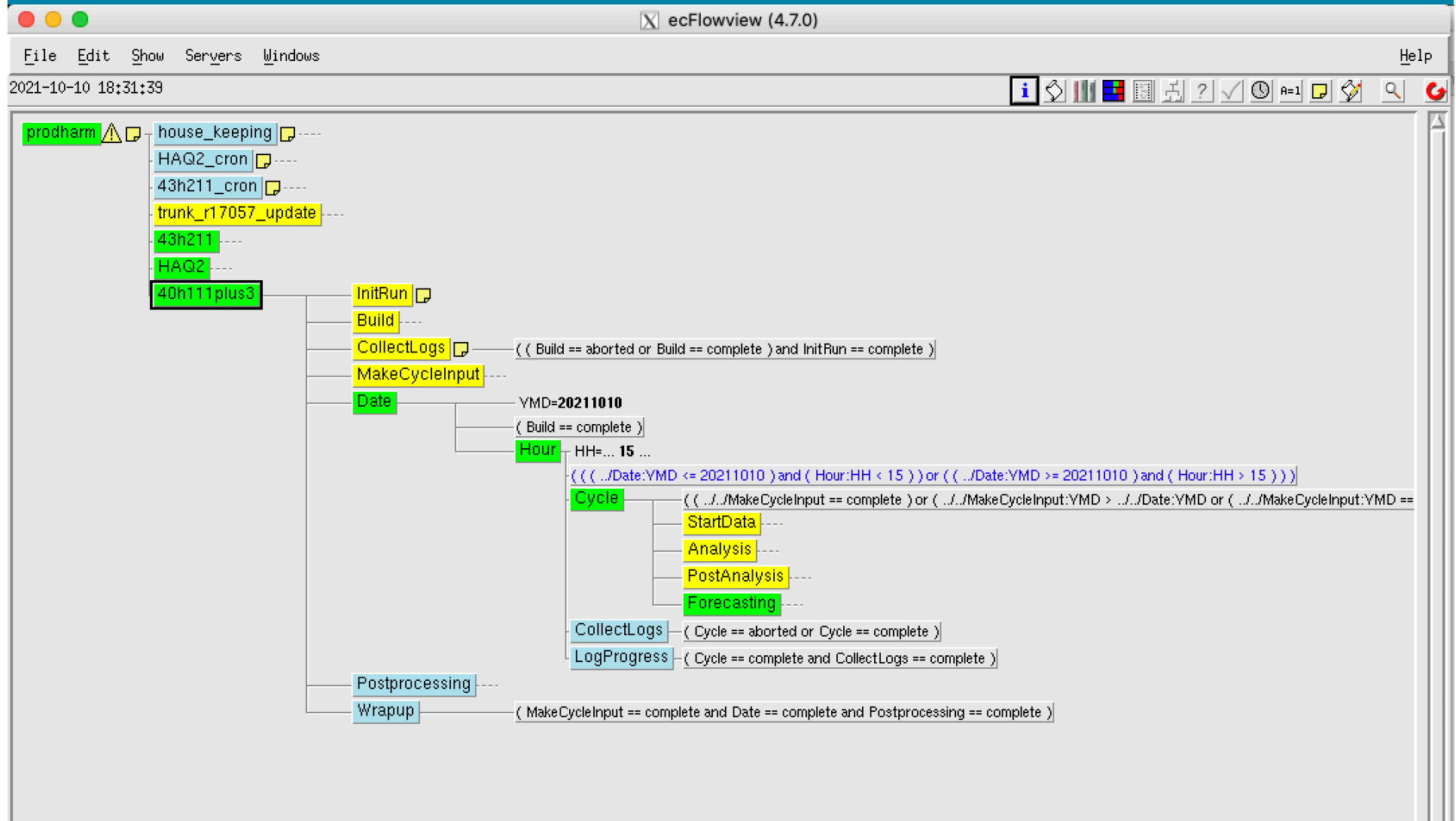
Content of NWP models

- System development
- Data Assimilation (initial conditions)
- Dynamics (advection, high resolution)
- Upper air physics
- Surface physics
- Ensemble predictions
- Postprocessing (output)
- Verification



Content of NWP models

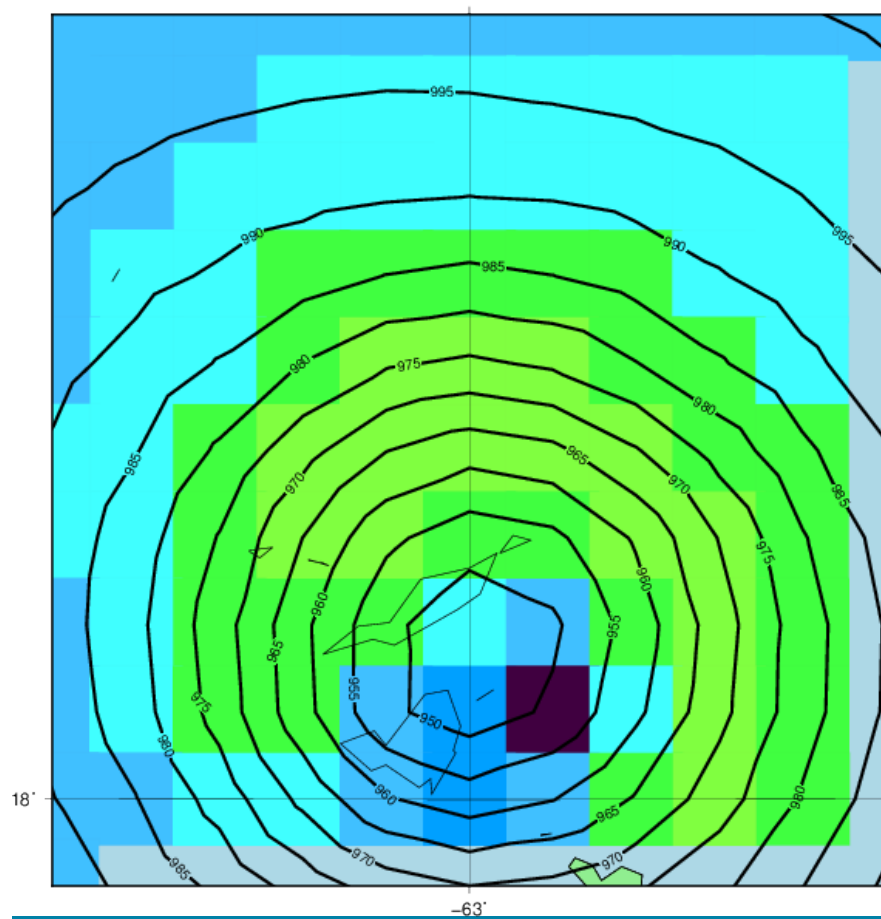
- System development
- Data Assimilation (initial conditions)
- Dynamics (advection, high resolution)
- Upper air physics
- Surface physics
- Ensemble predictions
- Postprocessing (output)
- Verification



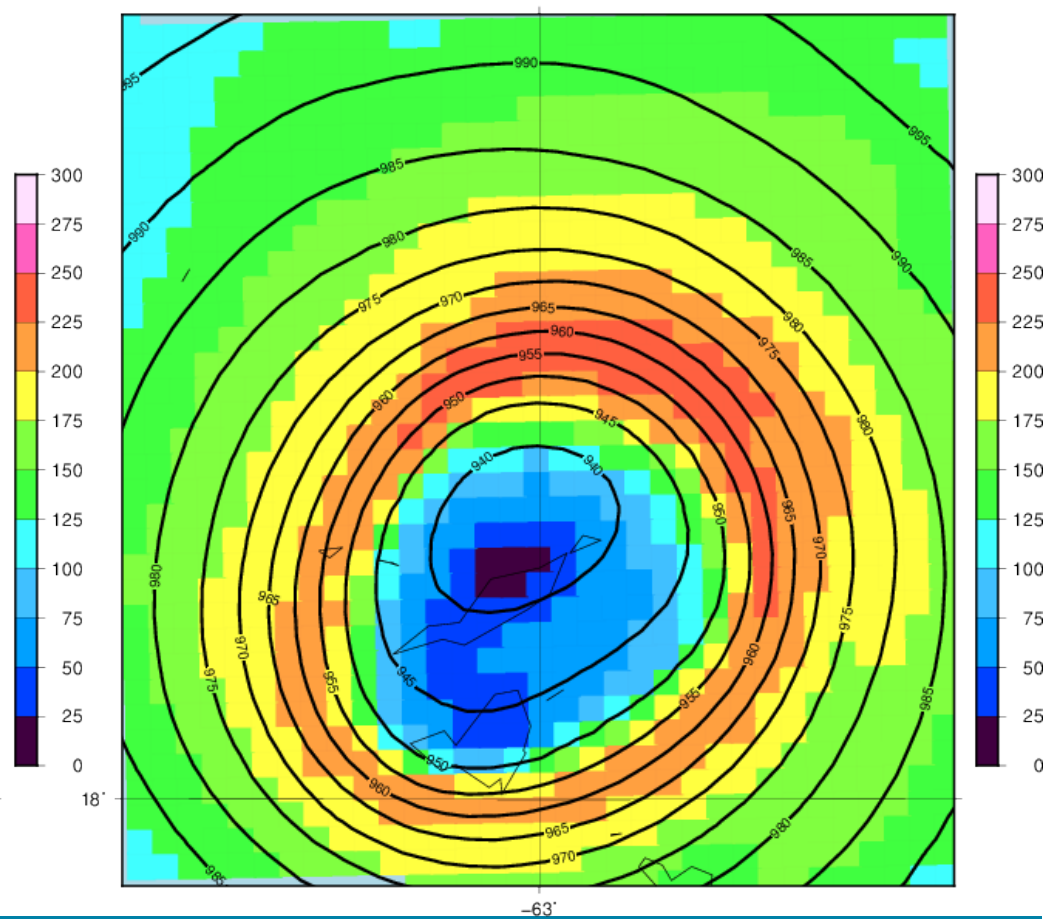


Why high resolution?

PMSL & wind ECMWF 2017090512 +25UTC



PMSL & wind HARMONIE 2017090512 +25UTC





Nieuws

Noodweer zorgt in korte tijd voor wateroverlast en schade

Frits van Otterdijk en Chantalle Donné - Geplaatst op dinsdag 29 juni 2021 - 22:56



Wateroverlast in Bunde.

Foto: Orange Media

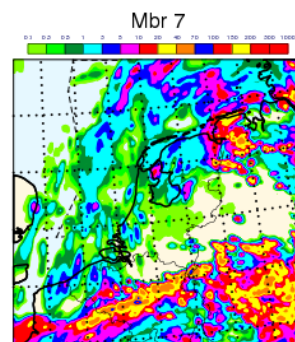
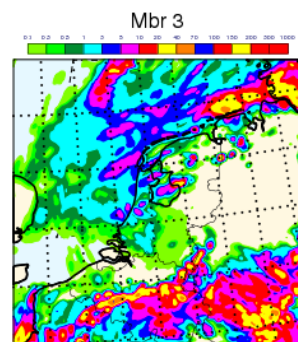
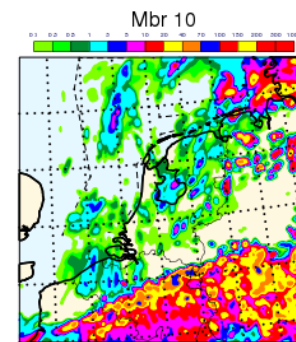
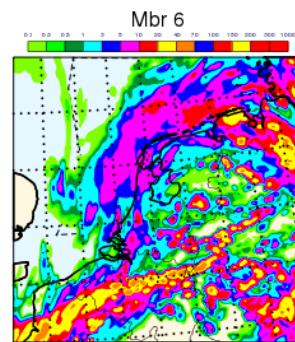
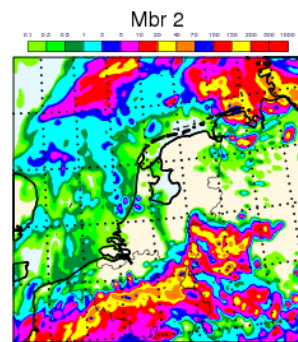
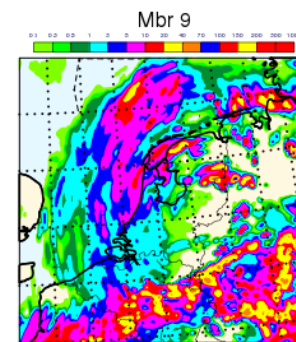
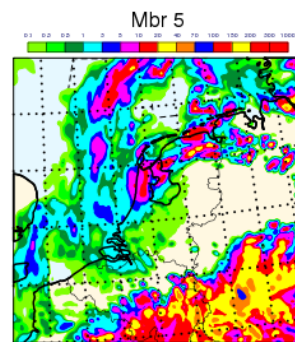
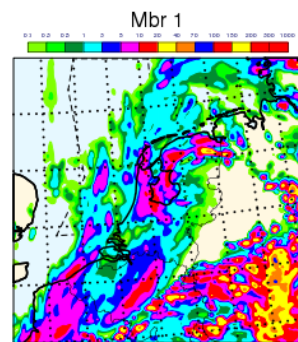
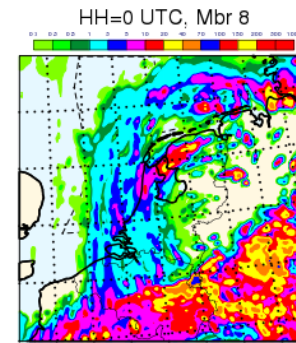
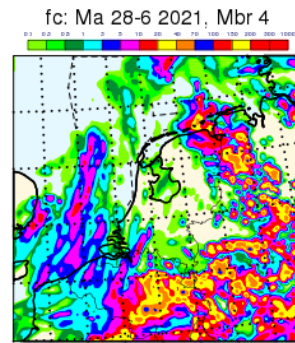
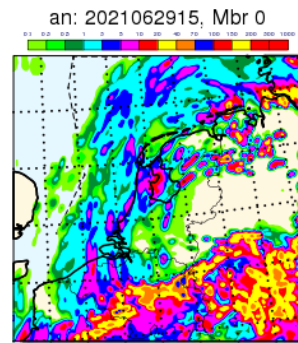


Buitenland

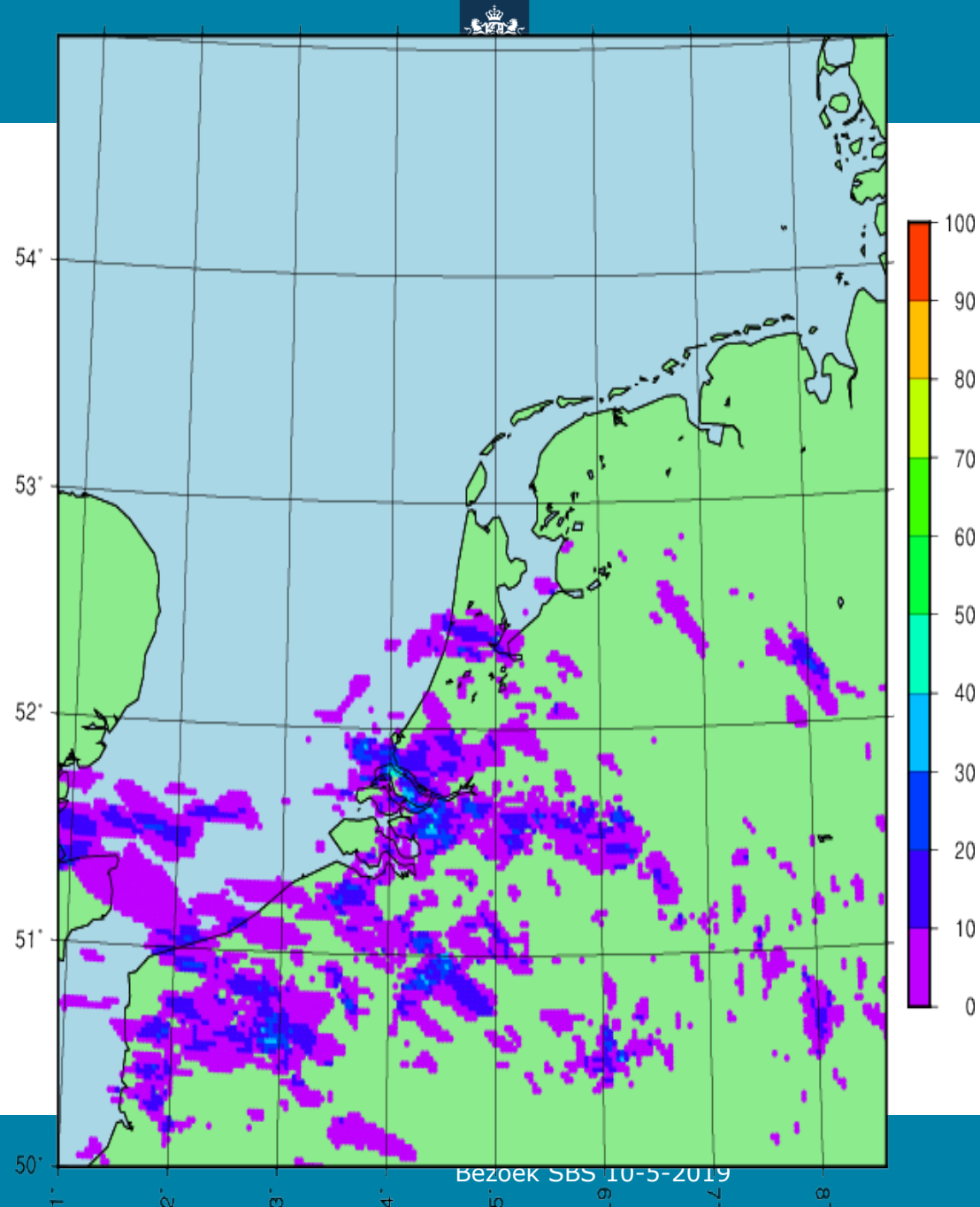
Noodweer Duitsland in beeld: overstromingen en gaten in de weg



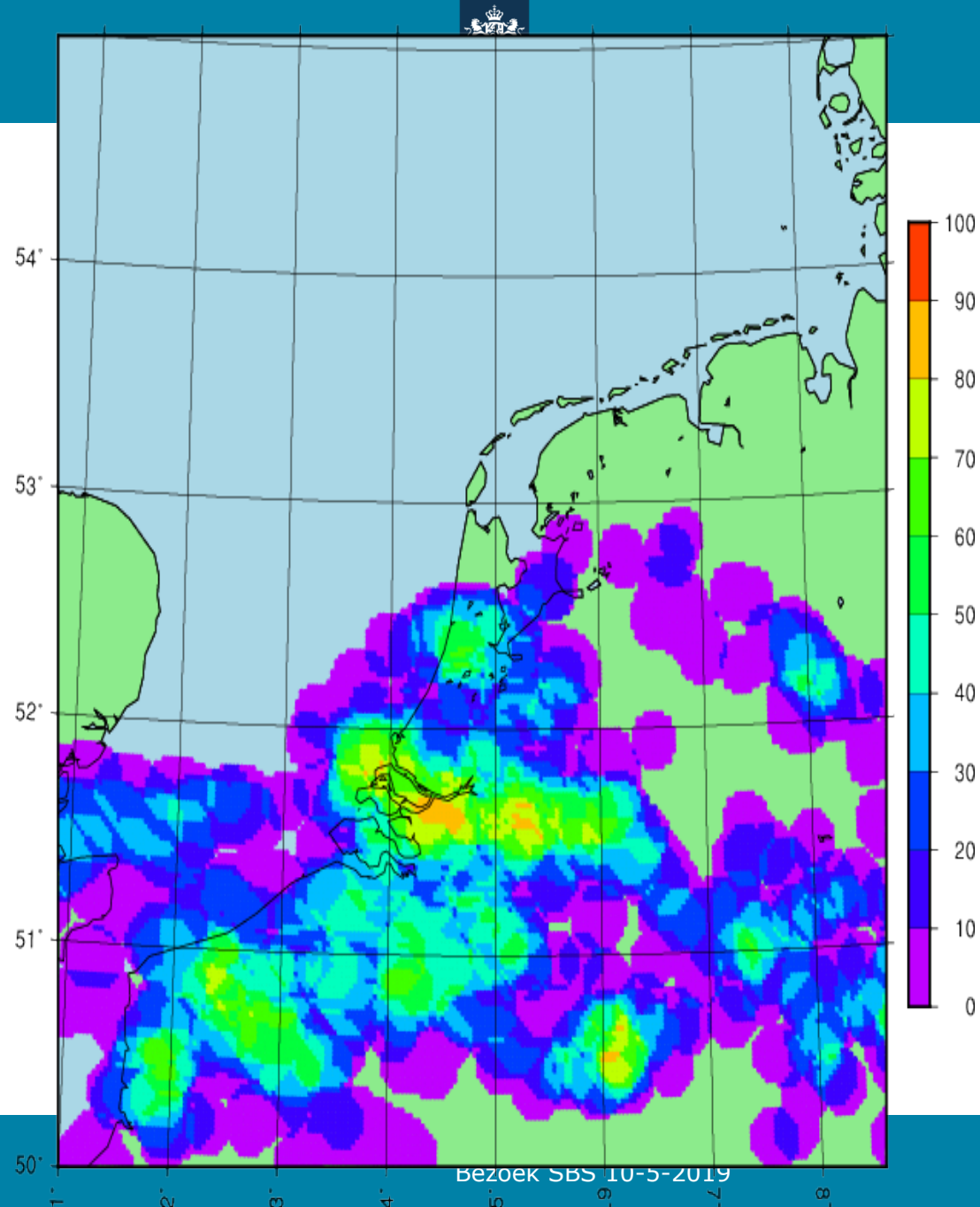
Verwoeste straten nadat noodweer over dorpen en plaatsen in Duitsland trok.



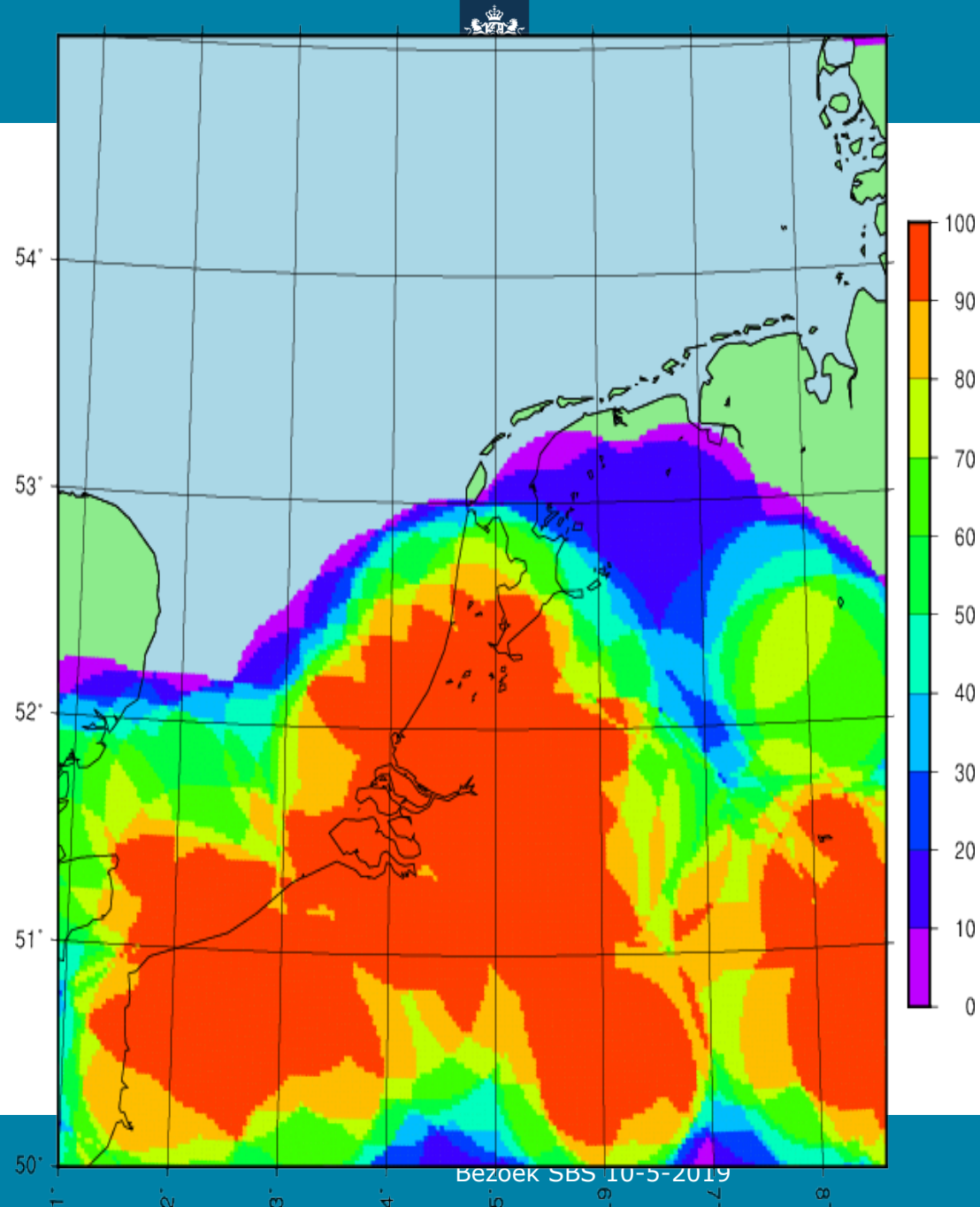
Why high
resolution EPS?



Upscaling
for better
warnings
on possible
extremes



Upscaling
for better
warnings
on possible
extremes

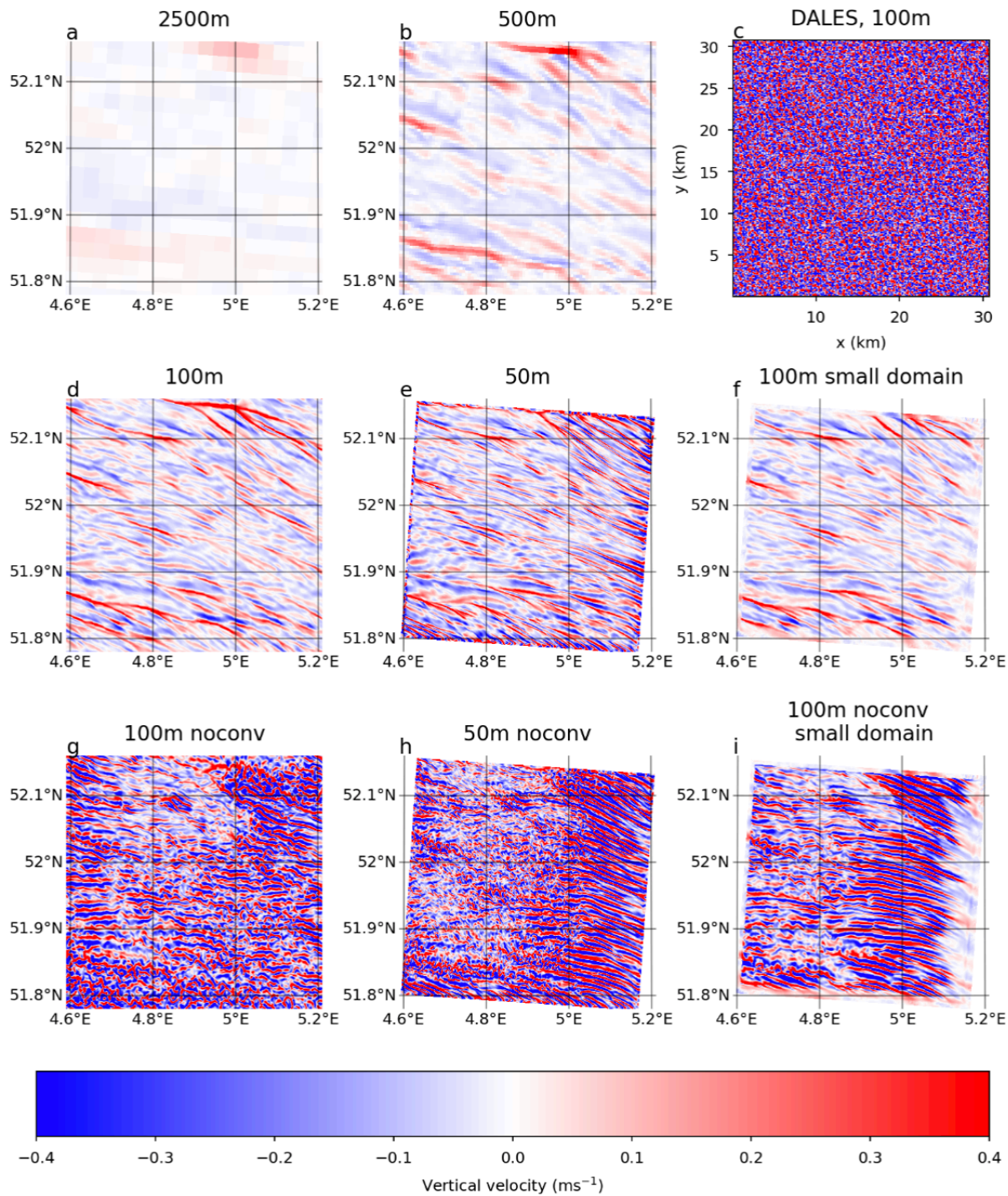


Upscaling
for better
warnings
on possible
extremes



New developments

- Work towards higher resolutions: 100-1000 metres
- Optimizing models for new computer architectures (mixed CPU/GPU)
- Optimizing models through the use of machine learning, replacing (parts of) physics through ML determined routines



Experiments at grid resolutions of 500, 100 and 50 m.

Strong impact of choices in physics.



HARMONIE-AROME student research at KNMI

2009-2010: Roos de Wit – lightning forecast from graupel

2015-2016: Nadia Bloemendaal – Surface fluxes and too high temperatures

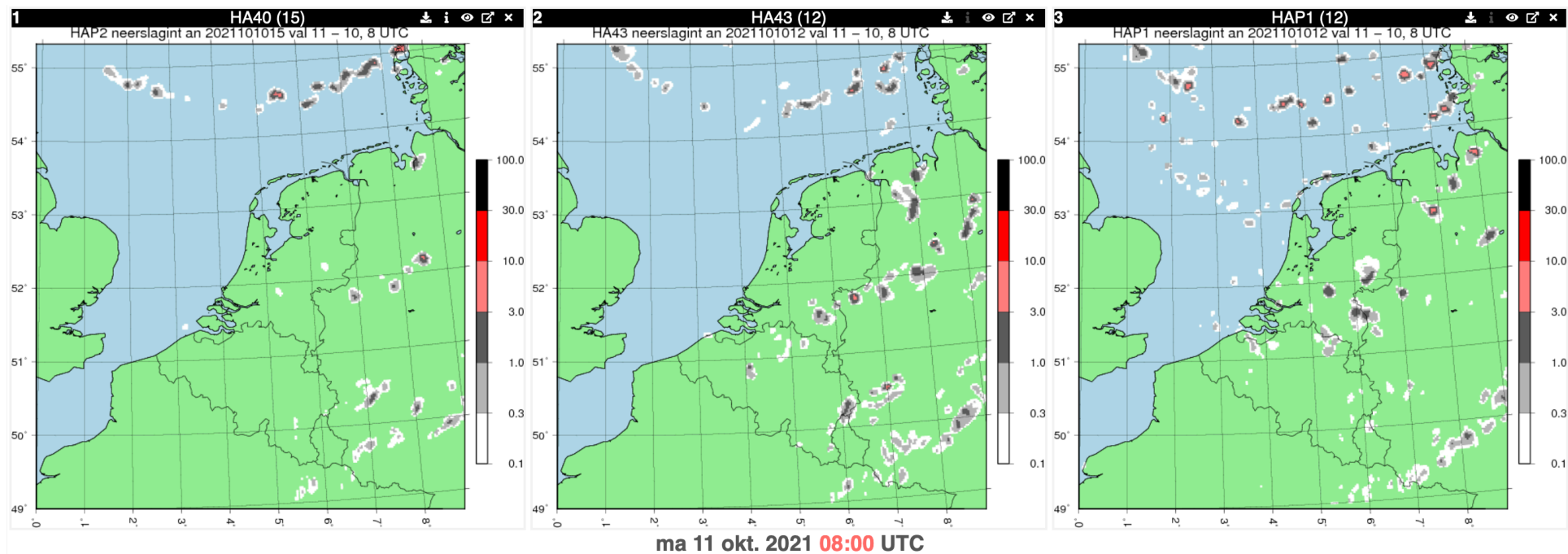
Pleun Bonekamp – Freezing rain forecasting

2018-2019: Bram van 't Veen – HARMONIE convection

2019-2020: Tosca Kettler – Fog forecasting in HARMONIE-AROME

Research topics:

- snow problems (not melting quickly enough, not covering surface enough for shallow snow layers)
- wind speed bias inland, yearly cycle (important for renewable energy)
- retuning of wind gusts (overestimation), microphysics and postproc.
- retuning of lightning parameterization (based on 2009 version)
- Missing showers





Regenradar Onweerradar Satelliet Regen en Wolken

Overige landen

ma 10:00



Afgelopen uur

Komende 2 uur

Komende 24 uur



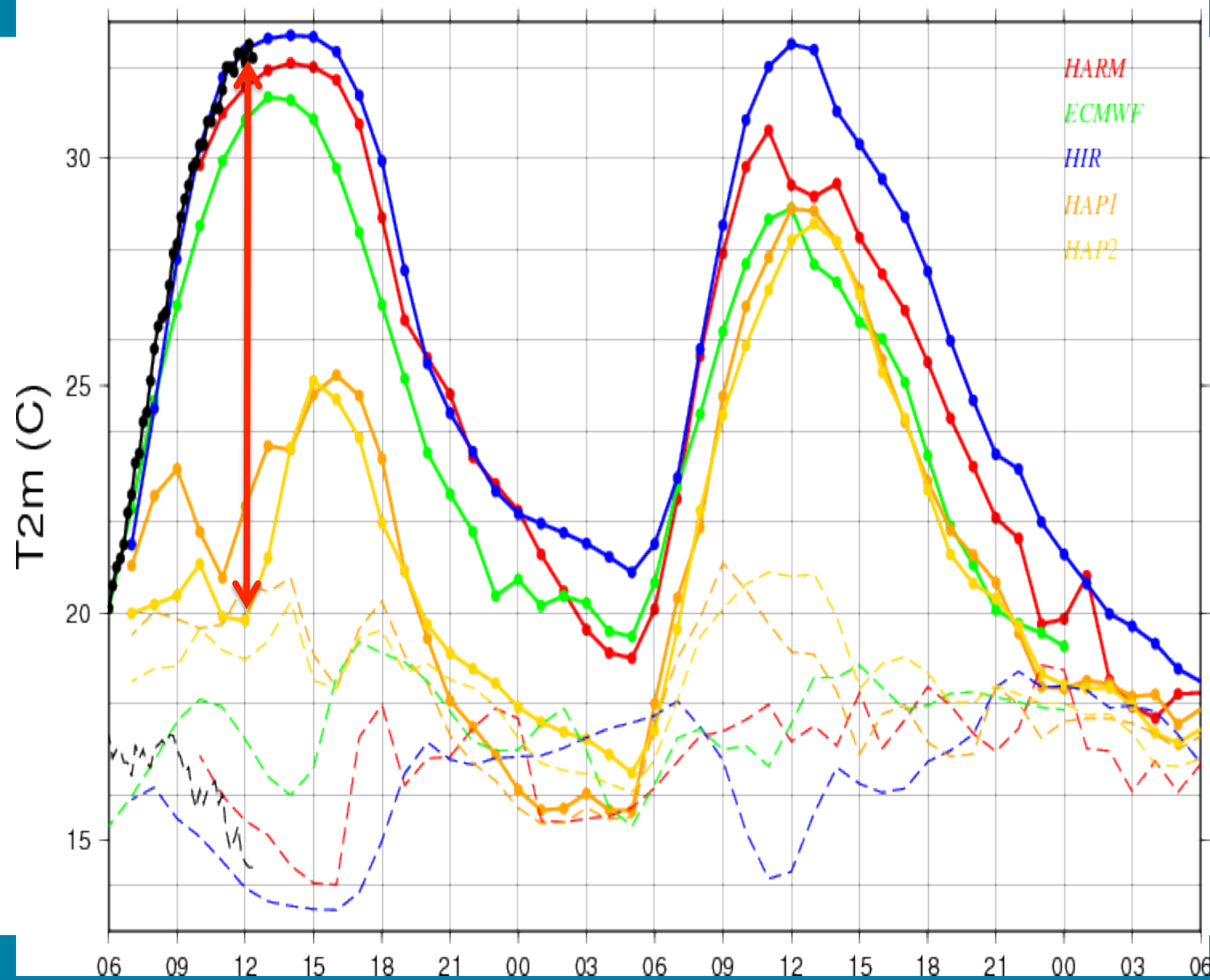
30

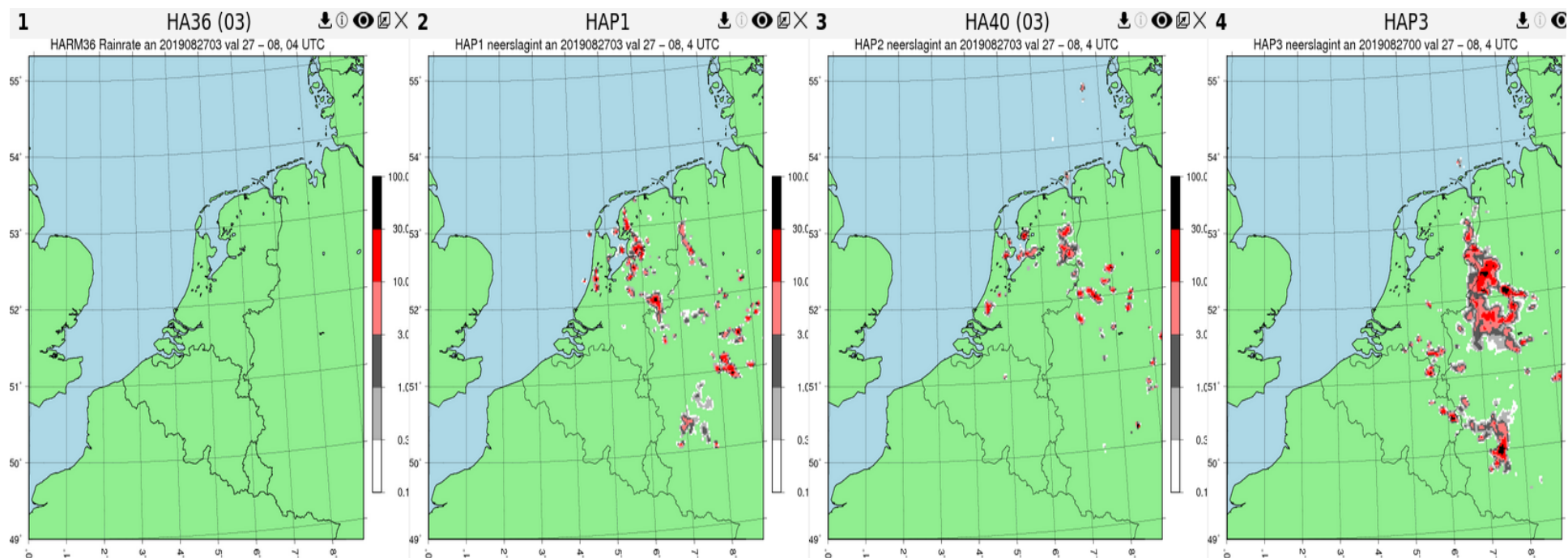


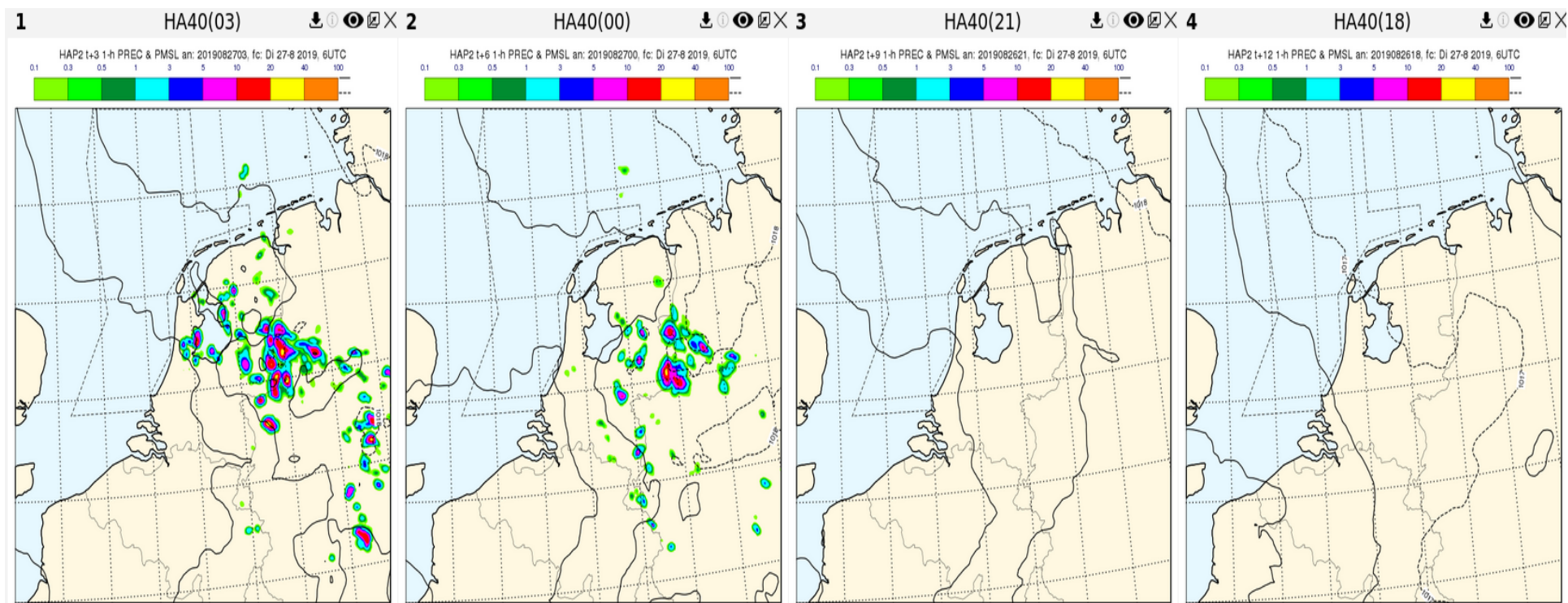


Shorter forecasts are always better?

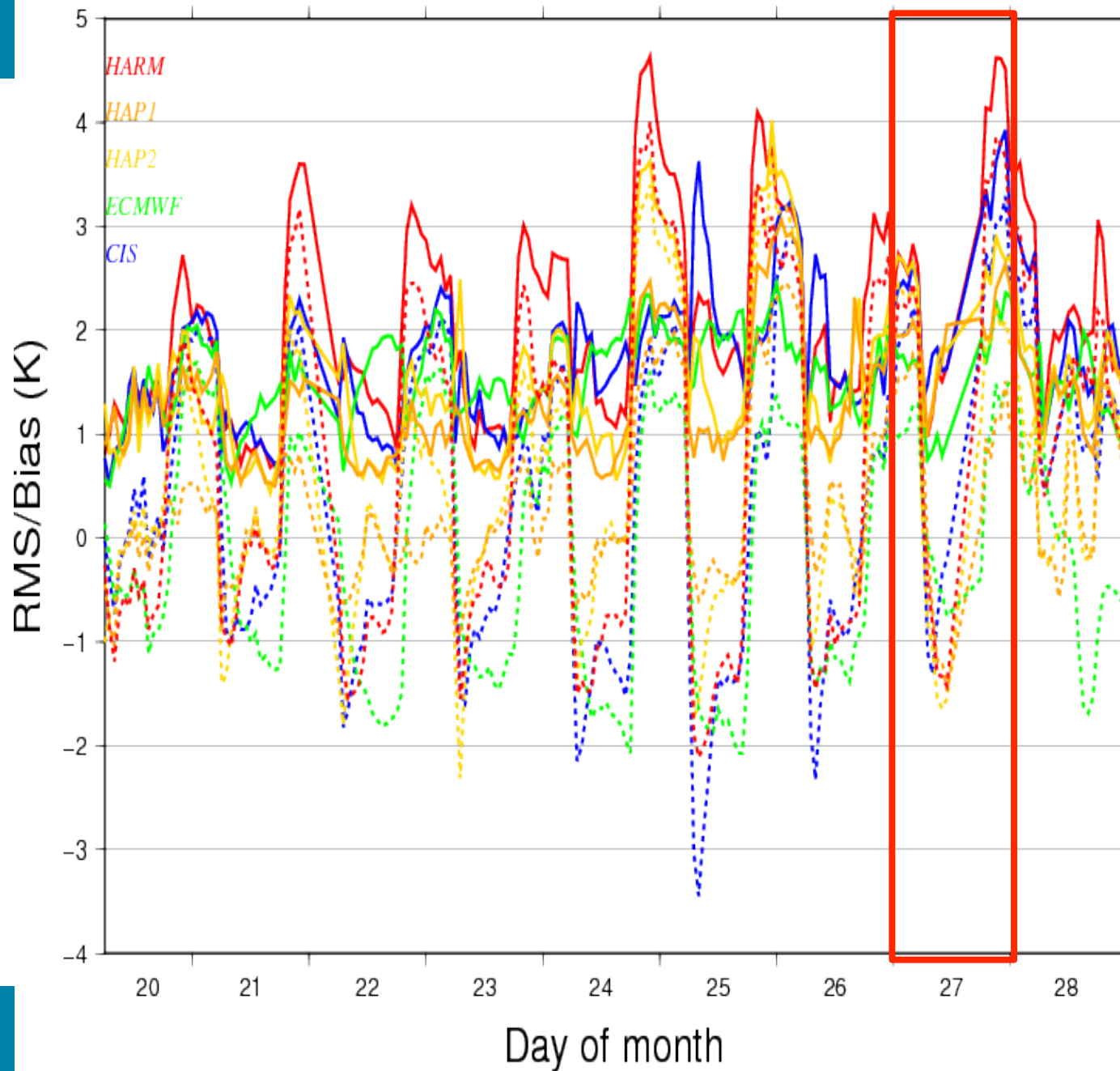
T2m & Td2m HARM(r,o) HIR(b) & EC(g) time series EHGG 2019082706



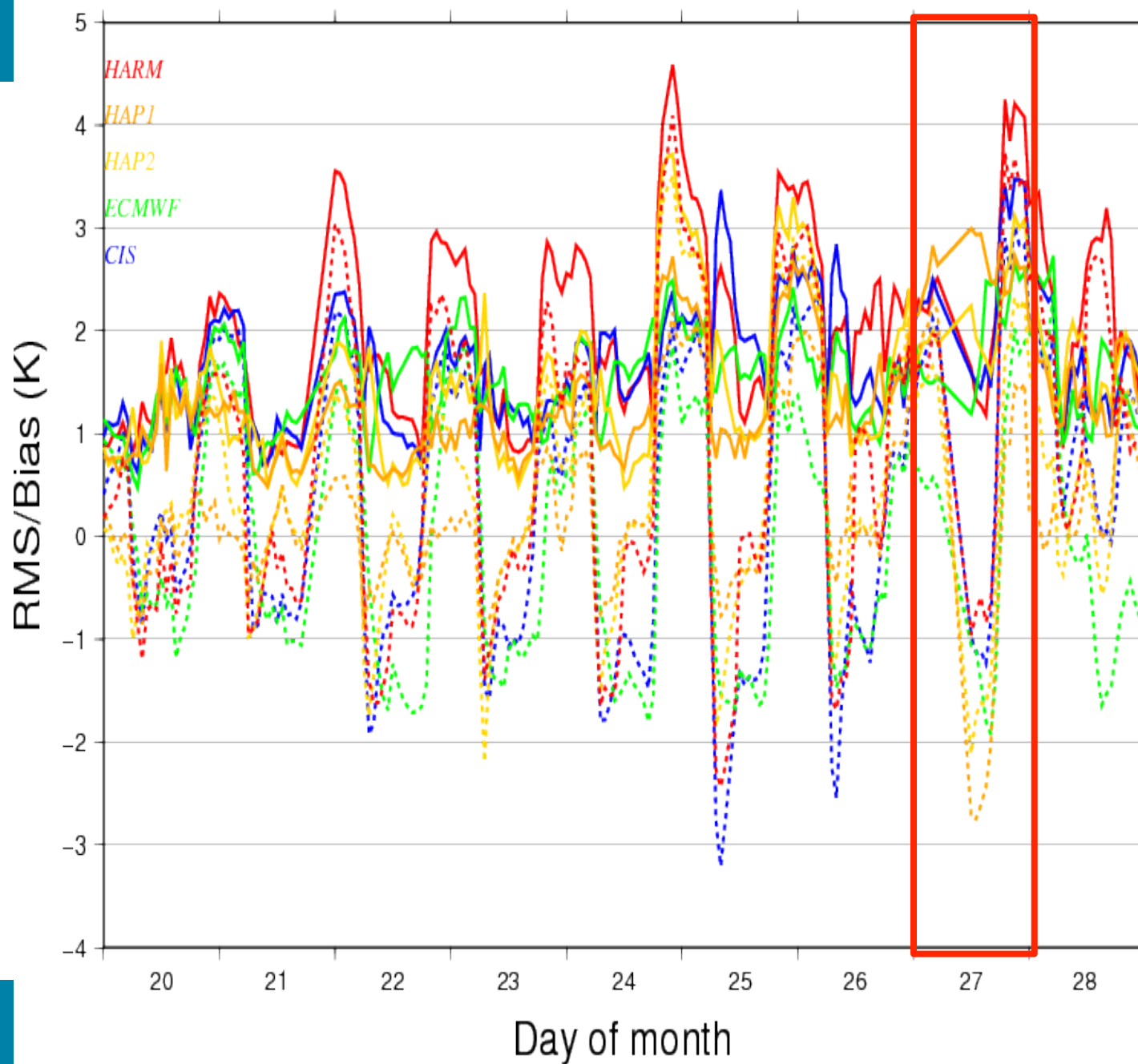




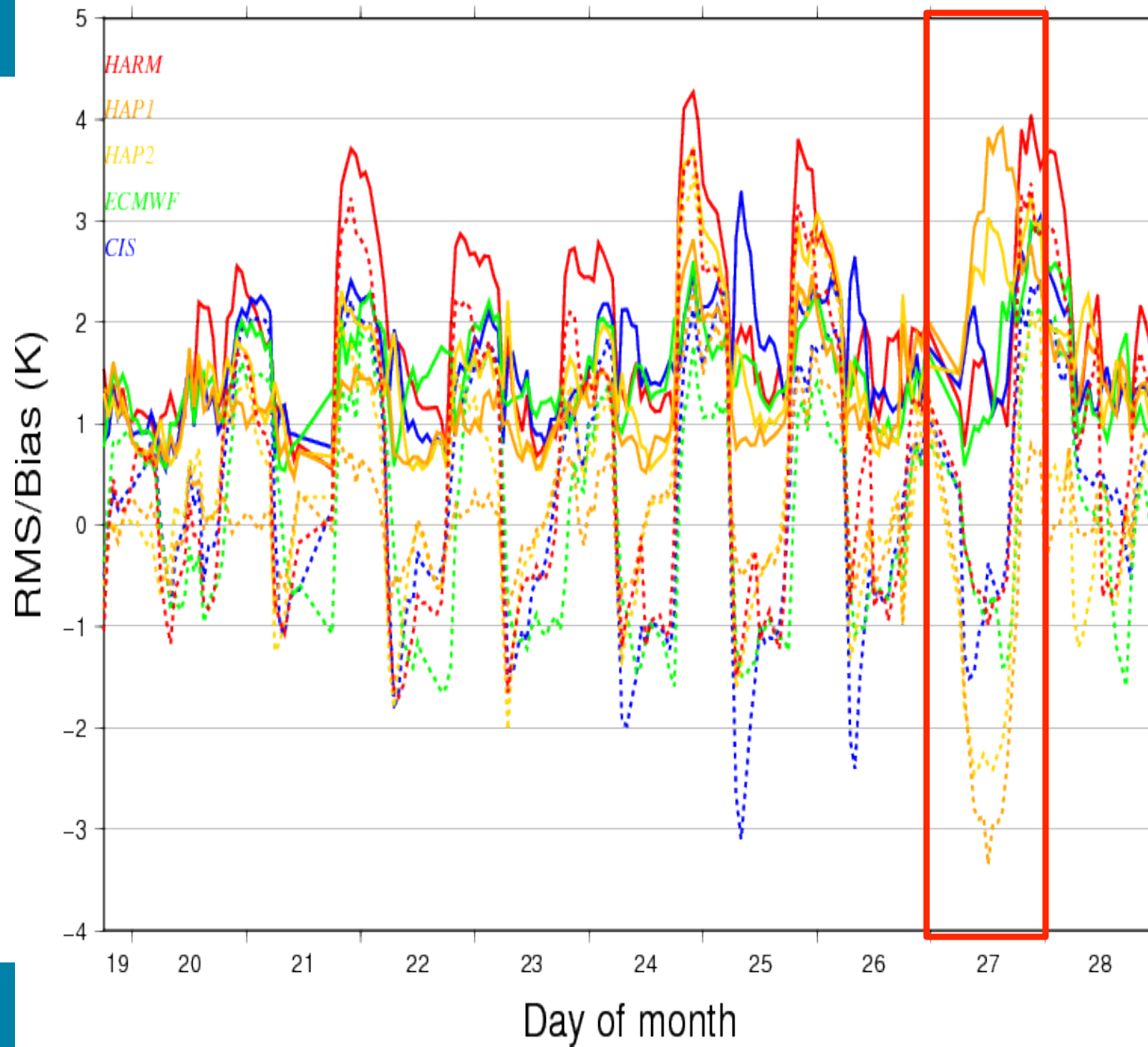
Verif T2m all NL, fr=30-36



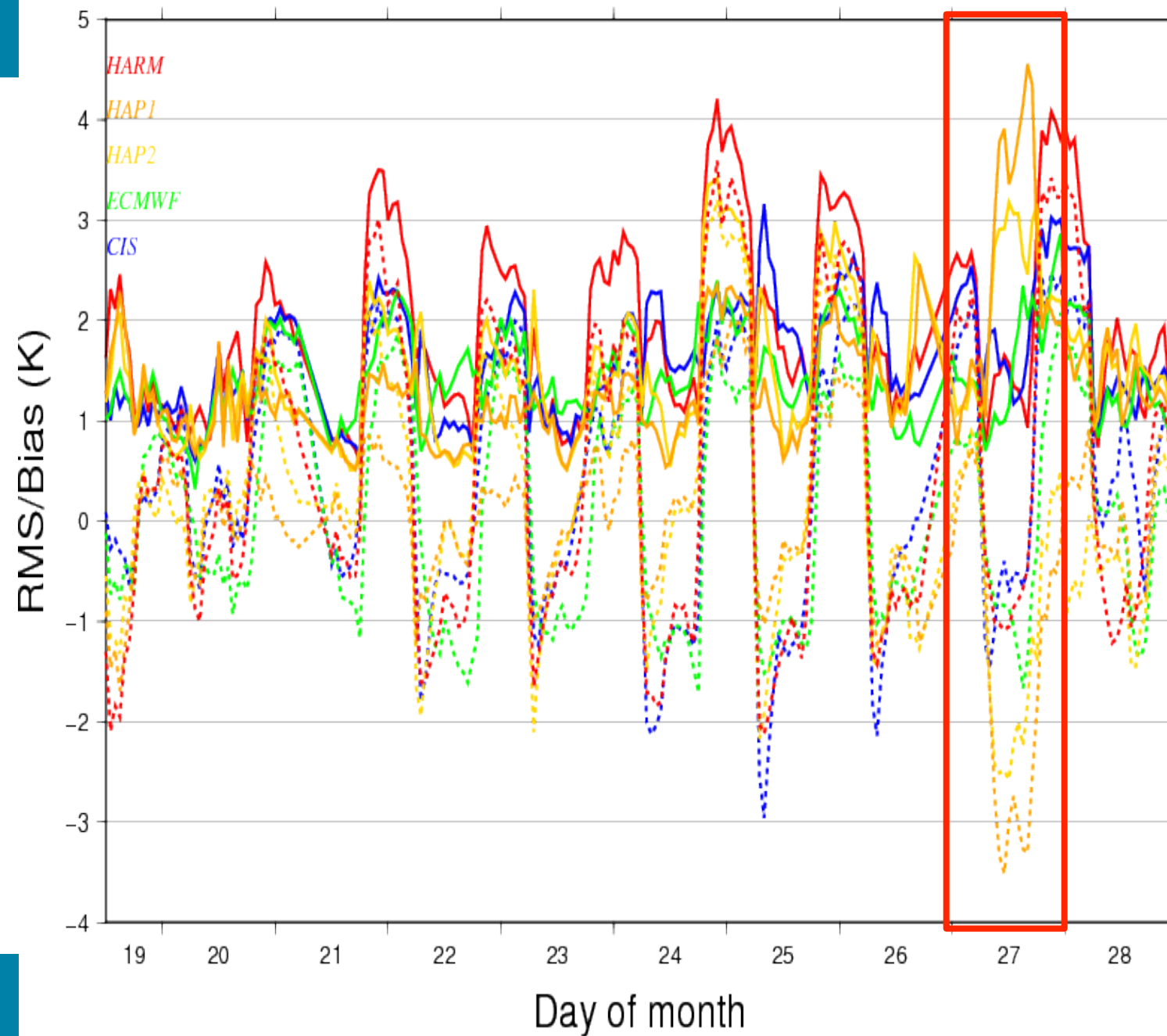
Verif T2m all NL, fr=24-30



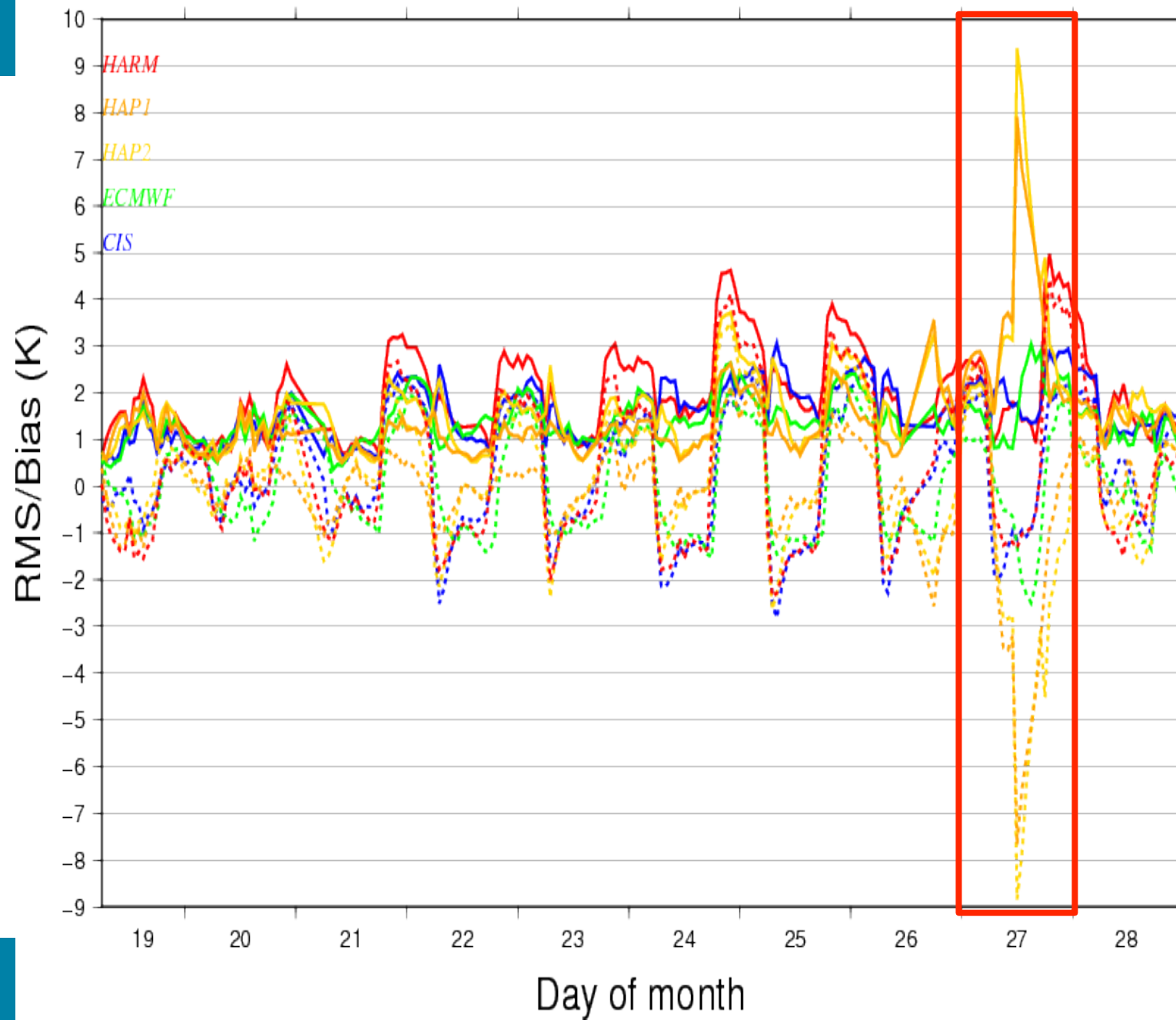
Verif T2m all NL, fr=18-24



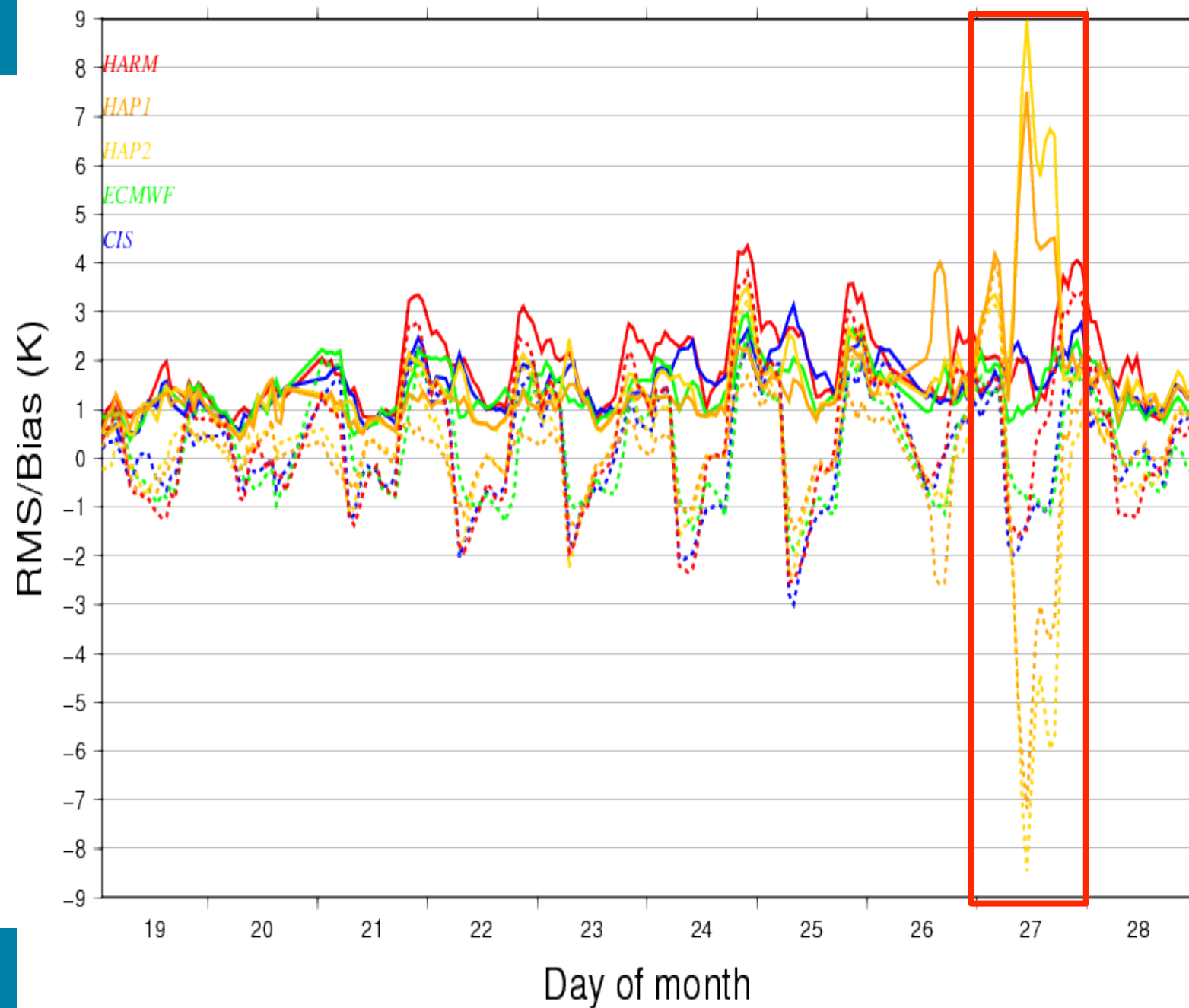
Verif T2m all NL, fr=12-18



Verif T2m all NL, fr=6-12



Verif T2m all NL, fr=0-6





HARMONIE-AROME student research at KNMI

2009-2010: Roos de Wit – lightning forecast from graupel

2015-2016: Nadia Bloemendaal – Surface fluxes and too high temperatures

Pleun Bonekamp – Freezing rain forecasting

2018-2019: Bram van 't Veen – HARMONIE convection

2019-2020: Tosca Kettler – Fog forecasting in HARMONIE-AROME

Research topics:

- snow problems (not melting quickly enough, not covering surface enough for shallow snow layers)
- retuning of wind gusts (overestimation), microphysics and postproc.
- retuning of lightning parameterization (based on 2009 version)