Royal Netherlands
Meteorological Institute
Ministry of Infrastructure
and Water Management

HARMONIE-AROME physics developments

EWGLAM/SRNWP meeting 2019

Sander Tijm

Overview

- Turbulence
- Shallow convection
- Radiation
- Microphysics
- High resolution

Overview

- Convection
- Convection
- Convection
- Convection

- And time permitting:

- Surface exchanges

Convection challenges HARMONIE-AROME

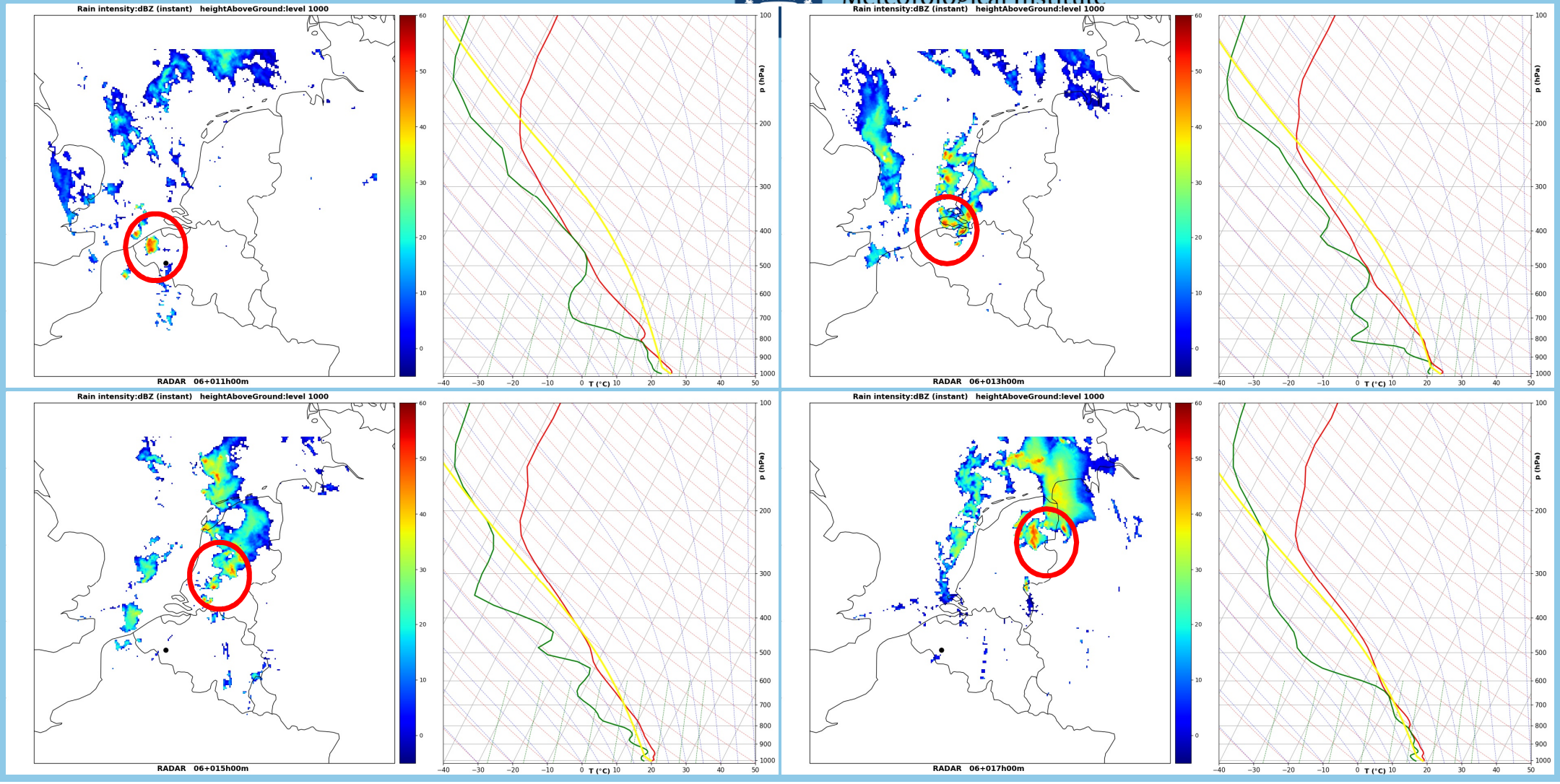
- Problems with convection
  - No initiation near end of heating period
  - Surface problems (drying out)
  - Shallow convection, no showers in specific conditions
  - Nighttime convection not developing
  - Convection dying out too quickly
  - Not enough weakly precipitation areas near convection

- Climatological weakness, big unphysical hammer necessary for EPS (same for low clouds)

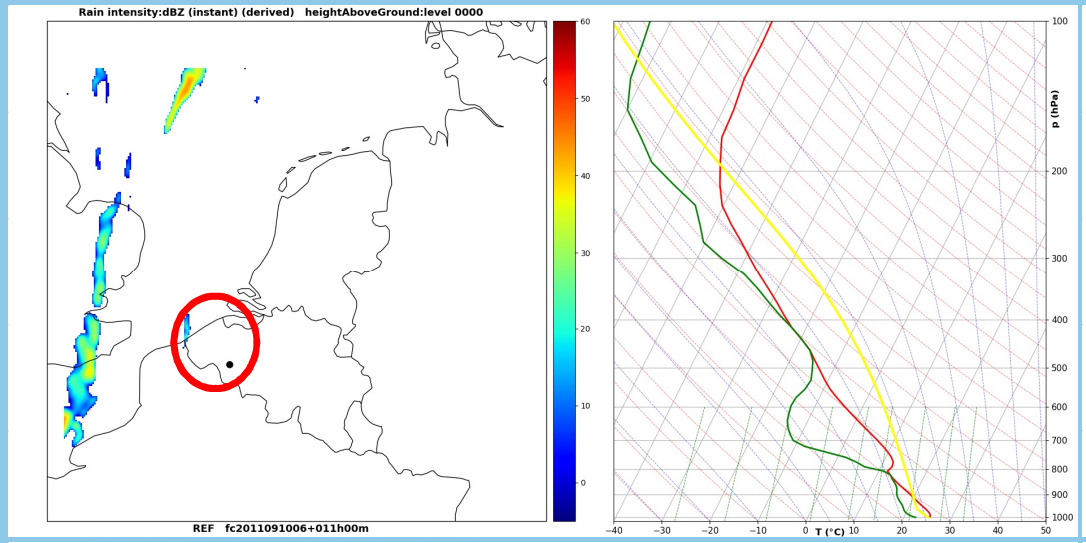
Convection 1 (Bram van 't Veen)

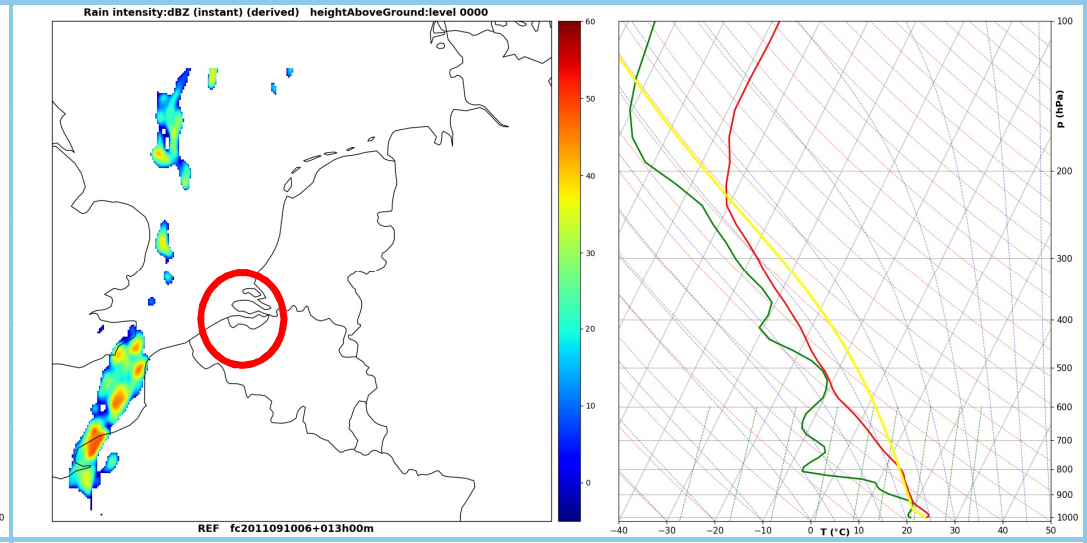
- Detailed analysis of supercell case
- Supercell that develops in older HARMONIE-AROME does not in most recent release. Cold start from ECMWF analysis, no difference from DA, clean comparison
- Reason: Turbulence? Shallow convection? Surface? Microphysics?

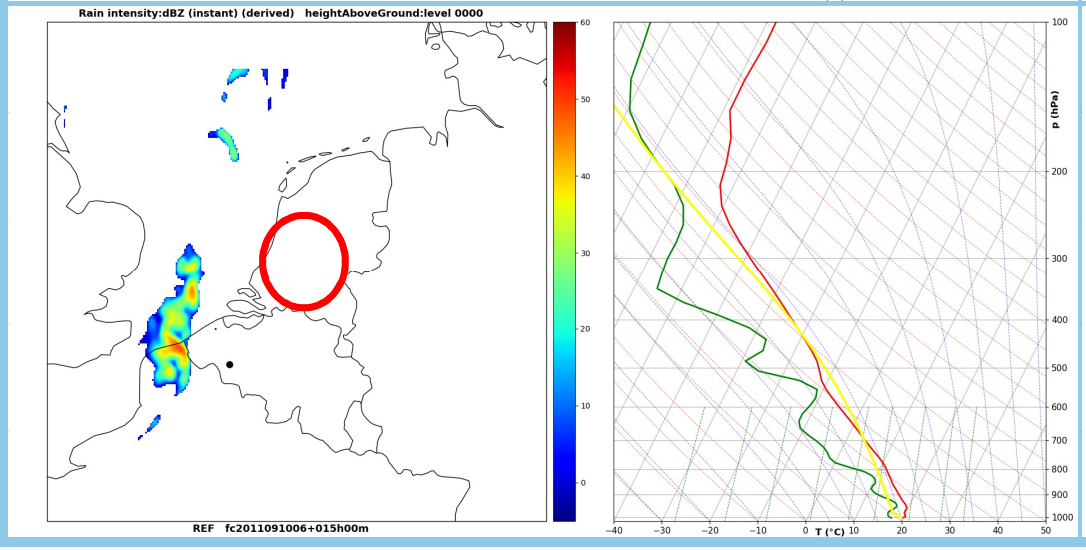
2011-09-10, supercell case

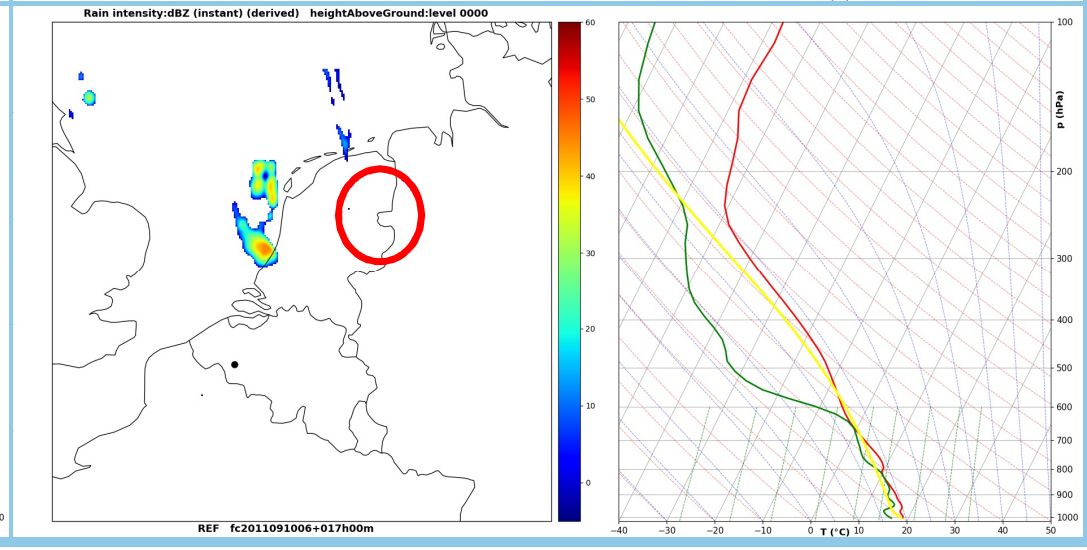


Latest HARMONIE-AROME

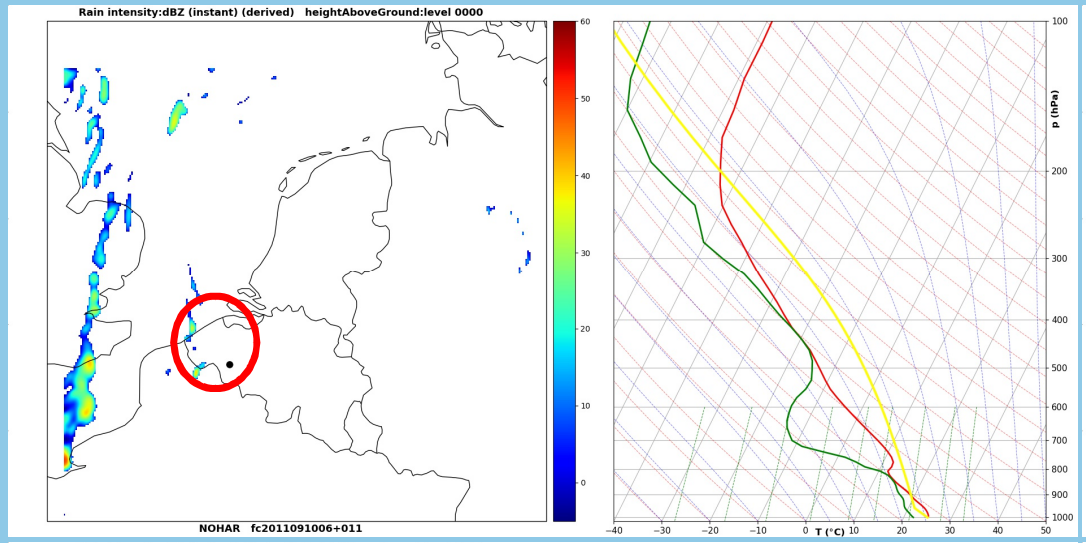


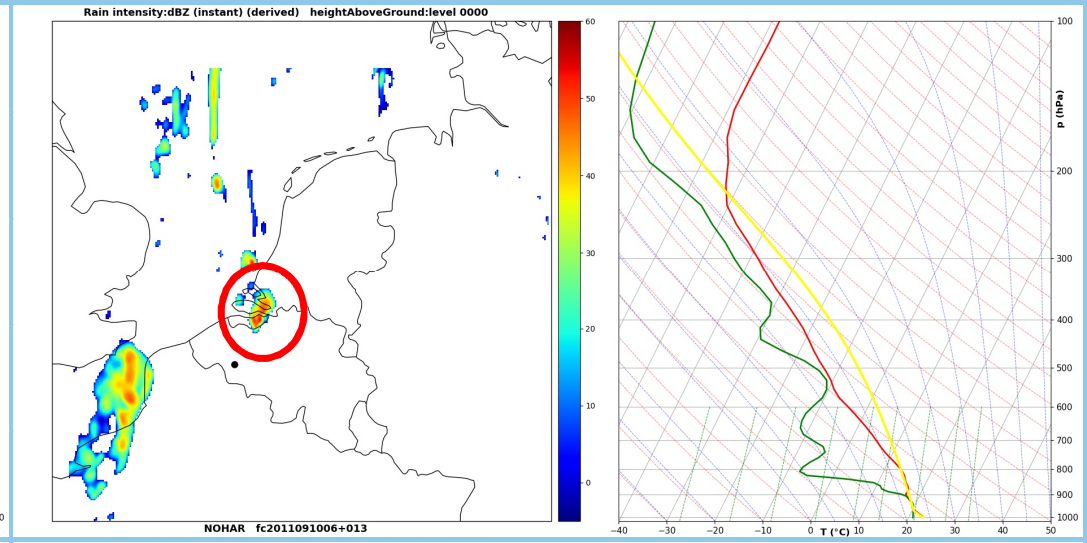


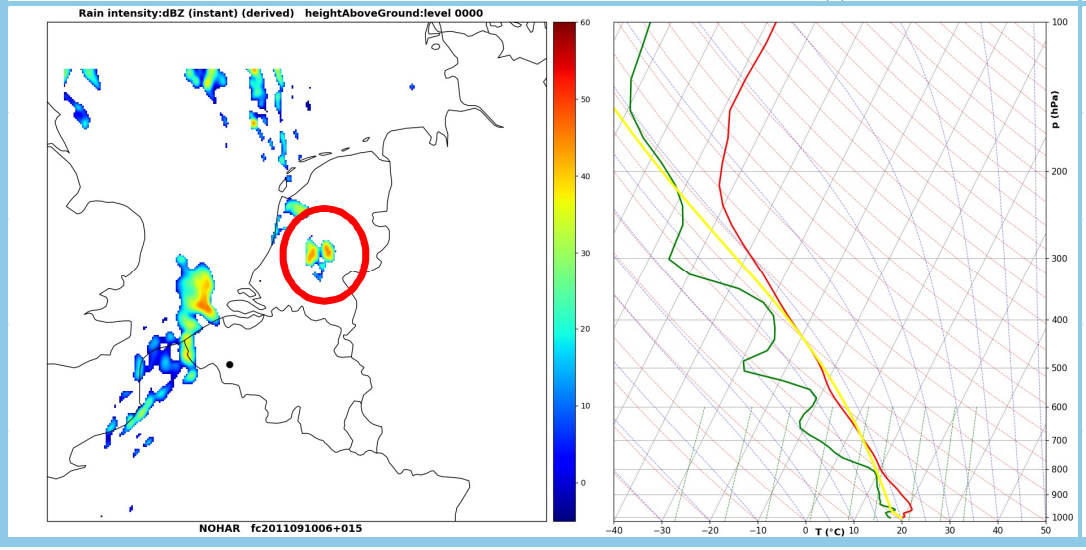


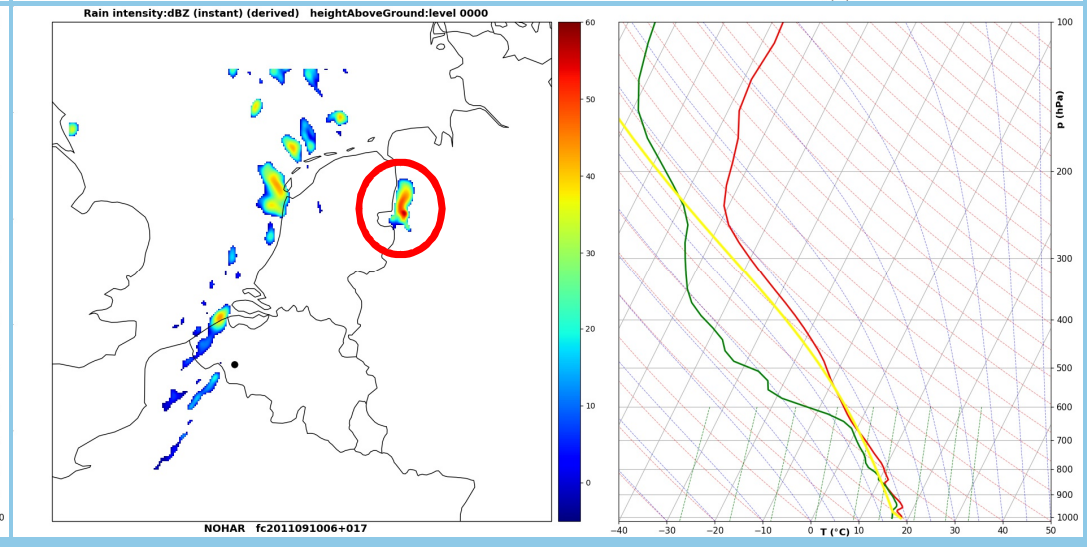


Older physics settings

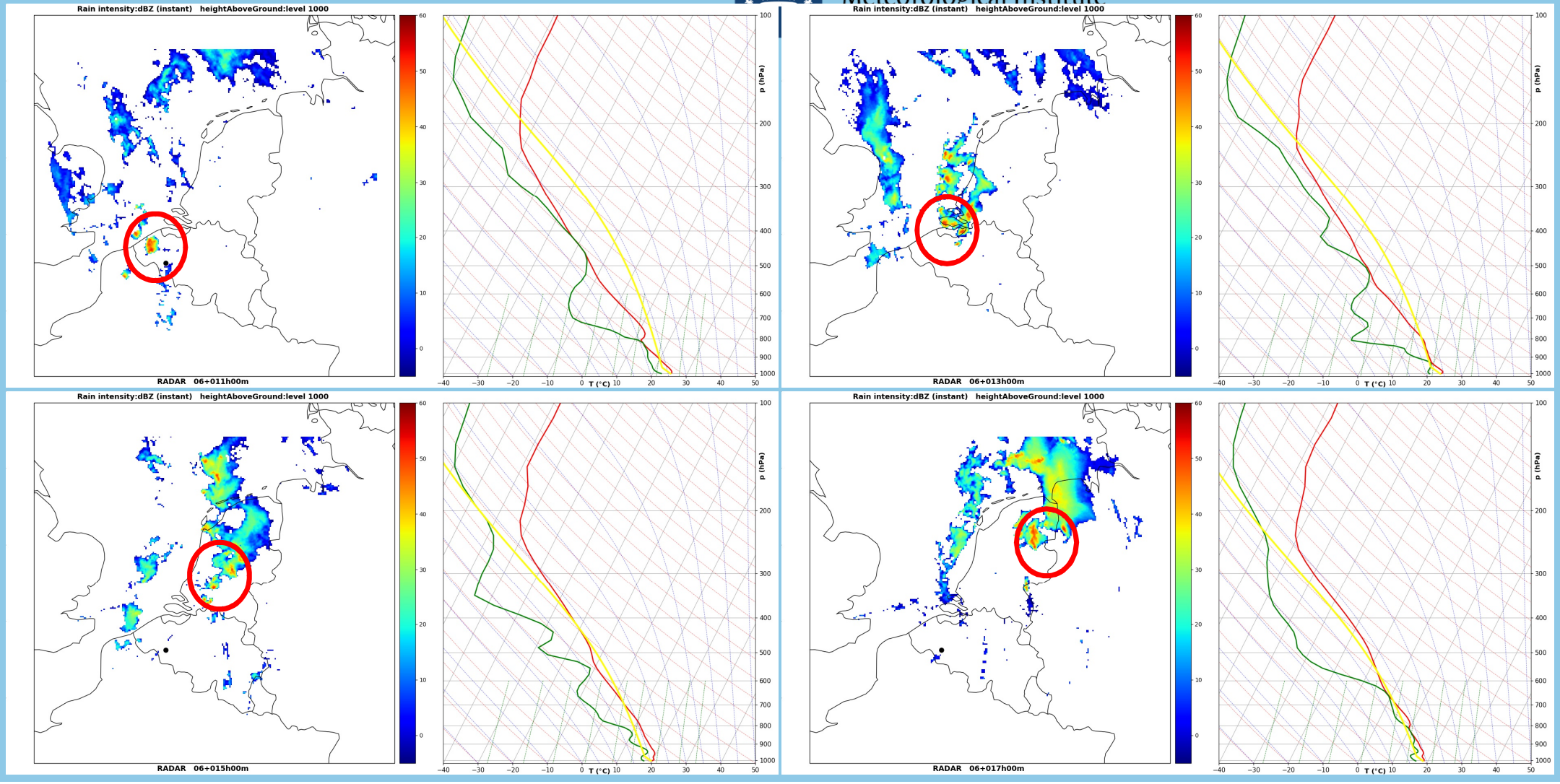




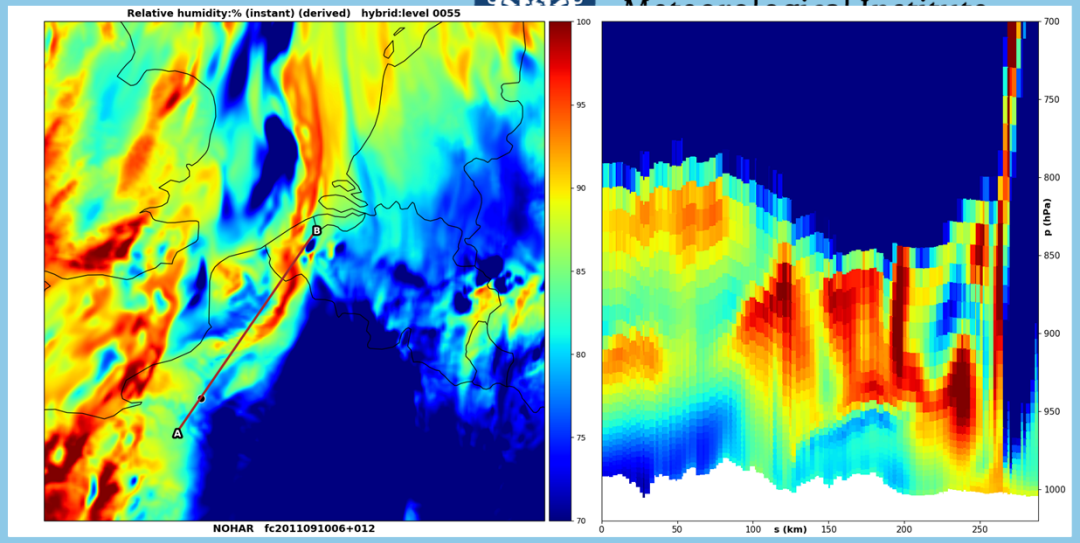




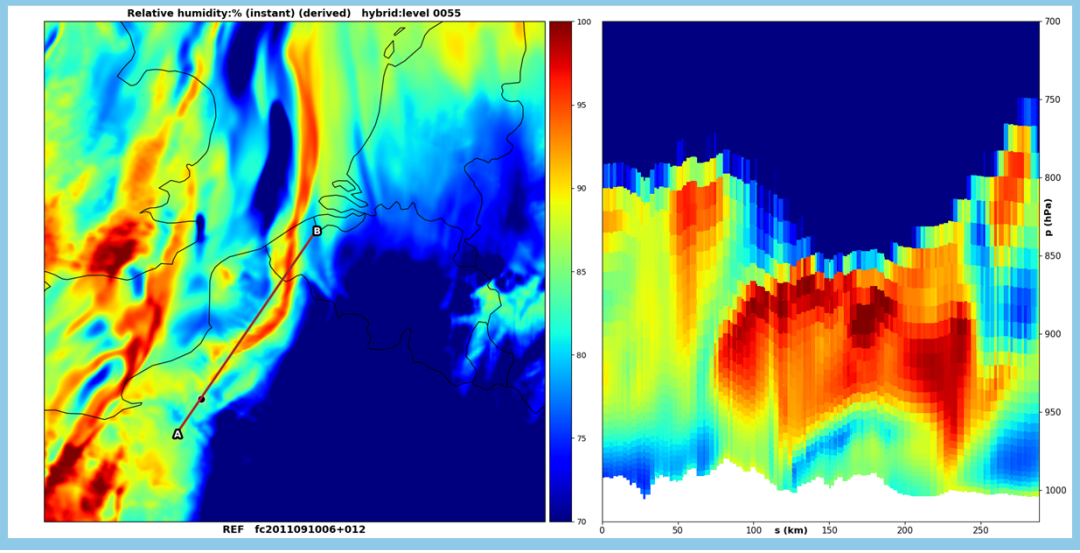
2011-09-10, supercell case



Relative humidity



Old physics



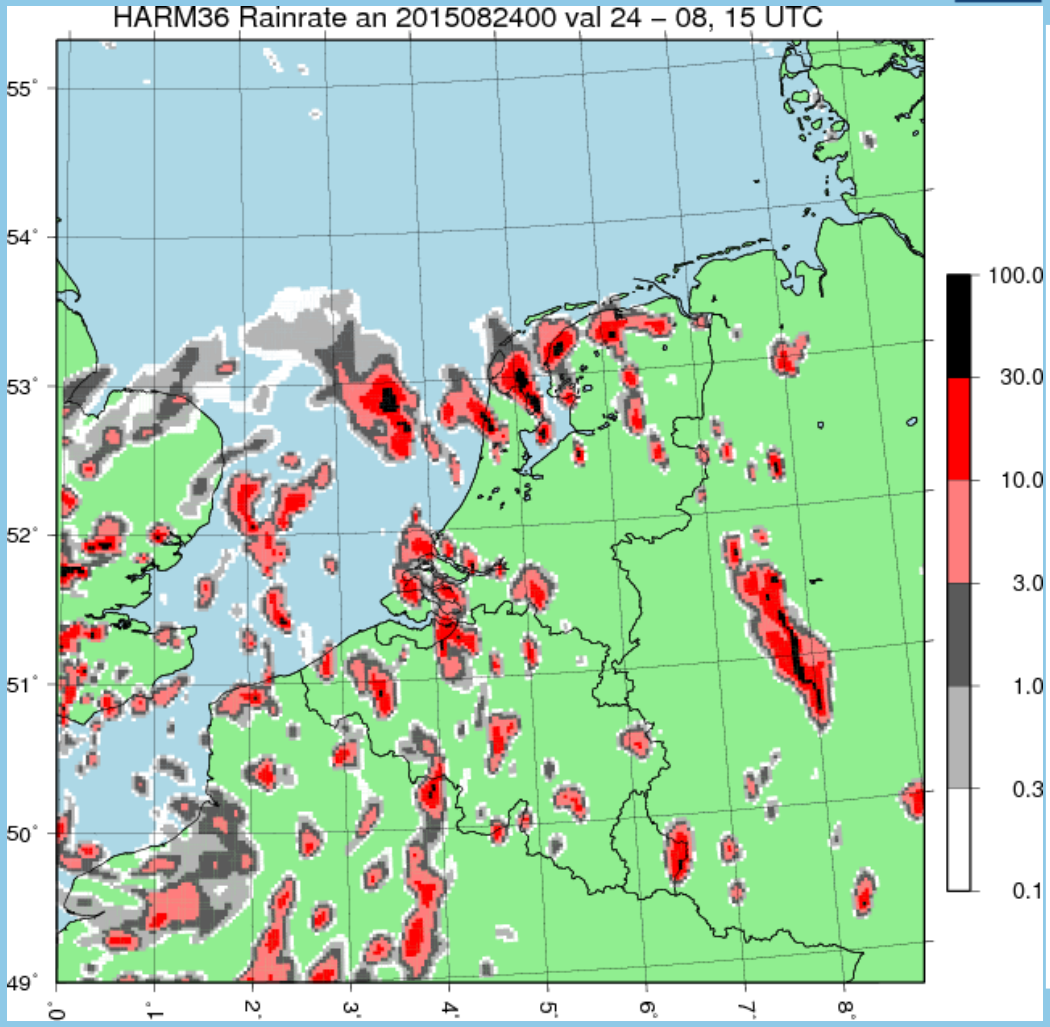
Reference

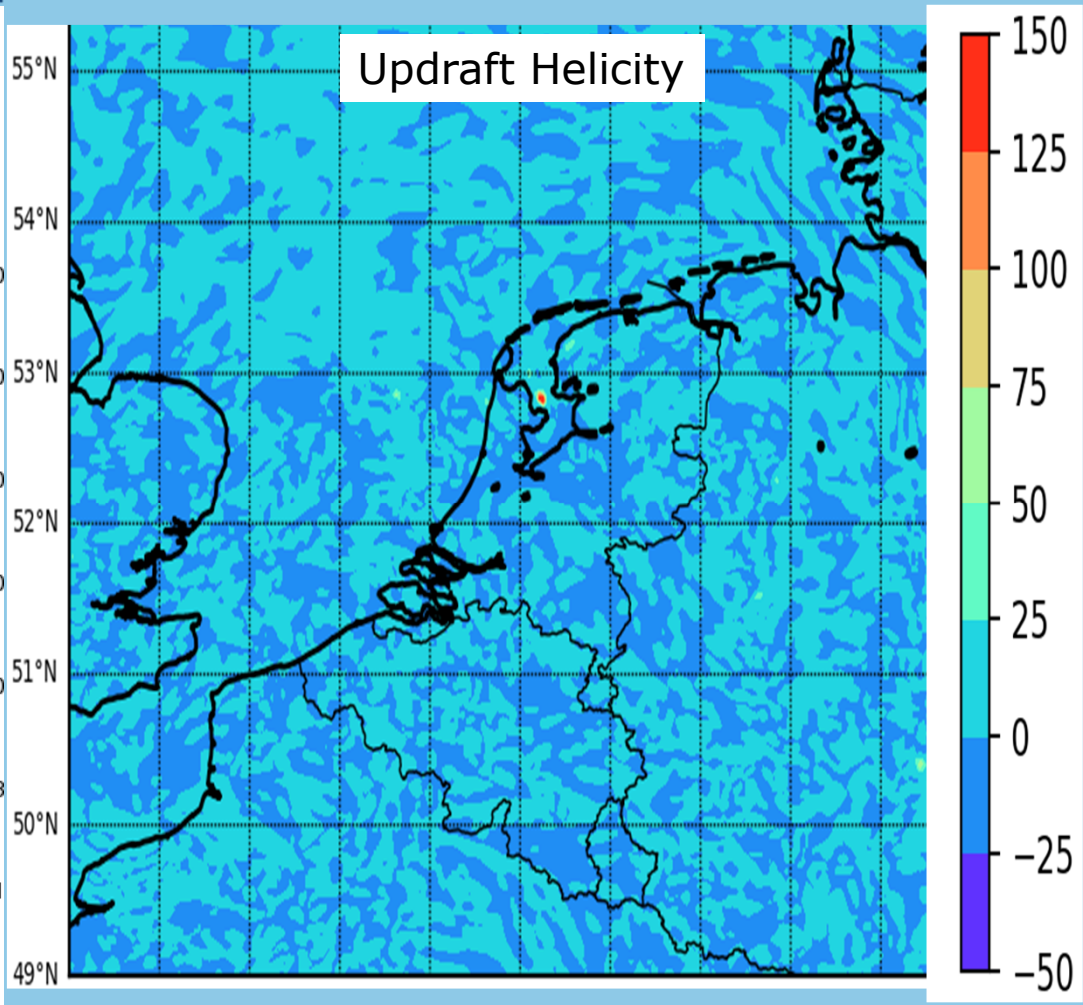
Convection 1 (Bram van 't Veen)

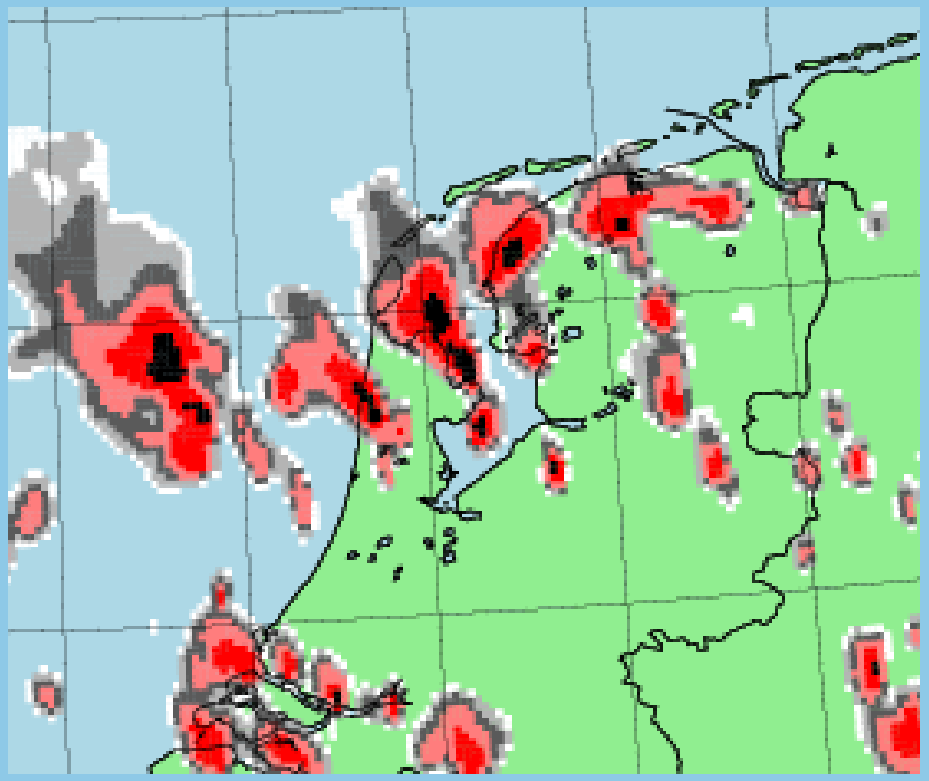
- Detailed analysis of supercell case
- Supercell that develops in older HARMONIE-AROME does not in most recent release
- Reason: Turbulence? Shallow convection? Surface? Microphysics?
- Boundary layer becoming too dry: Mixing in free atmosphere and stable layers reduced for CY43, also positive for low clouds

Convection 2: Updraft Helicity (Amélie Sterlé)

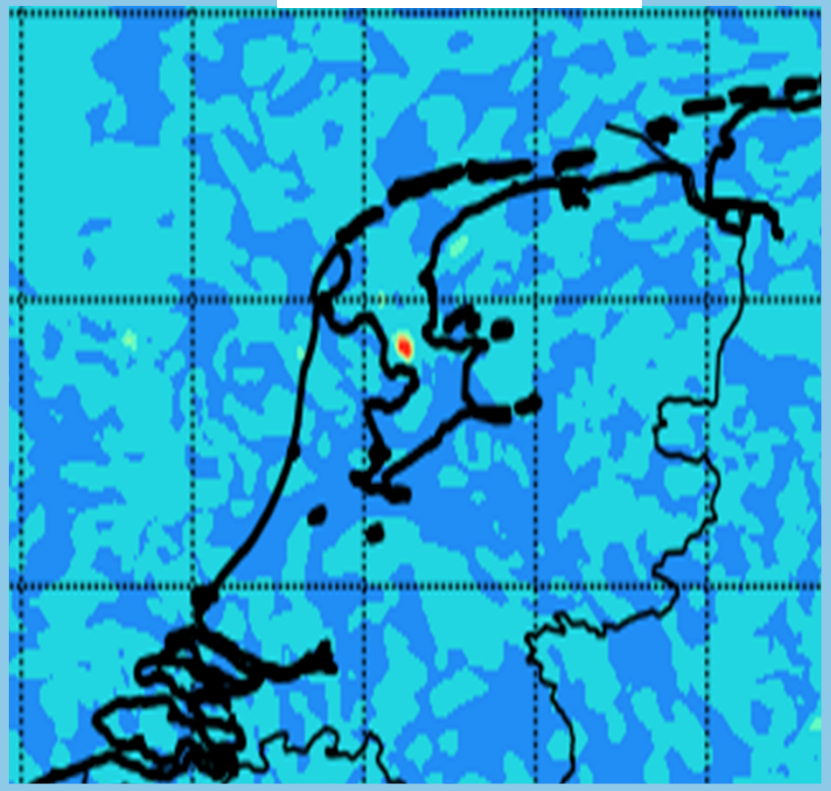
- HARMONIE-AROME at 2.5 km too coarse to resolve meso-vortex and tornadoes
- Storm relative helicity in convection parameterizing models indicator of possibility of tornadoes
- Convection permitting models resolve meso-vortex partially
- Updraft helicity highlights rotating columns


HARM36 Rainrate an 2015082400 val 24 – 08, 15 UTC
55°
54°
53°
52°
51°
50°
49°
0°
1°
2°
3°
4°
5°
6°
7°
8°
100.0
30.0
10.0
3.0
1.0
0.3
0.1

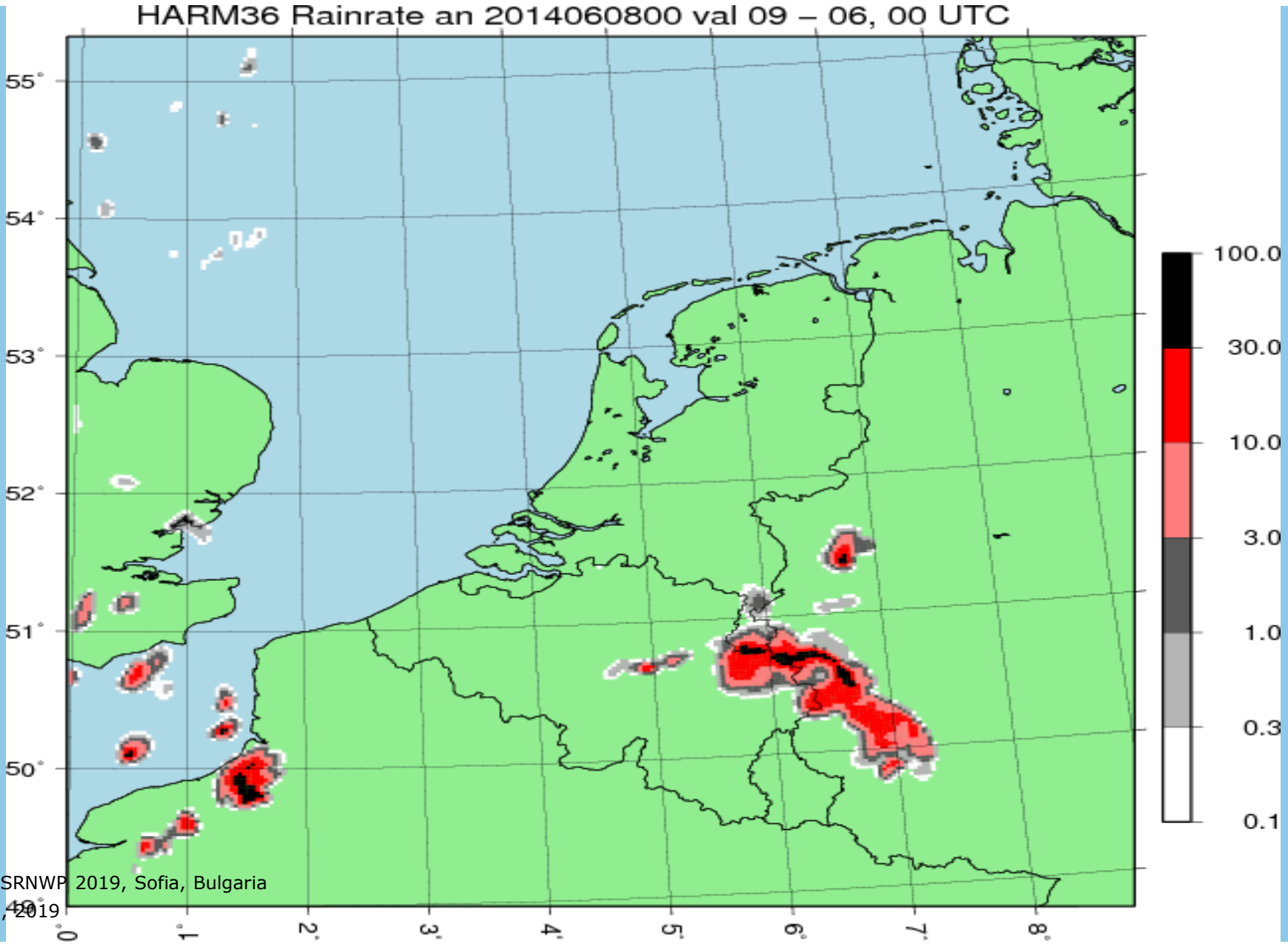

Updraft Helicity
55°N
54°N
53°N
52°N
51°N
50°N
49°N
150
125
100
75
50
25
0
−25
−50

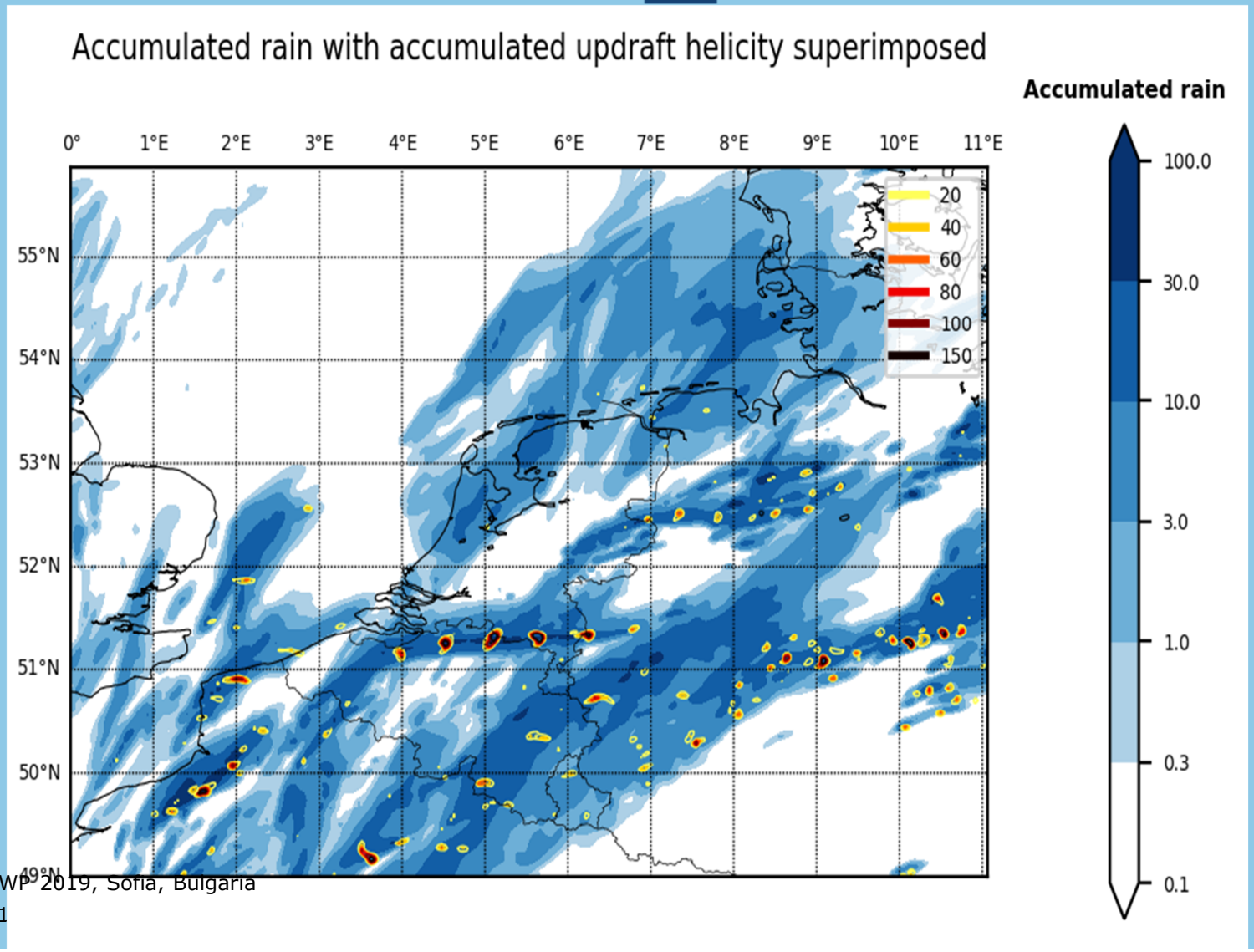


Updraft Helicity



Updraft Helicity


HARM36 Rainrate an 2014060800 val 09 – 06, 00 UTC
55°
54°
53°
52°
51°
50°
49°
0°
1°
2°
3°
4°
5°
6°
7°
8°
100.0
30.0
10.0
3.0
1.0
0.3
0.1


Accumulated rain with accumulated updraft helicity superimposed
Accumulated rain
0°
1°E
2°E
3°E
4°E
5°E
6°E
7°E
8°E
9°E
10°E
11°E
55°N
54°N
53°N
52°N
51°N
50°N
49°N
20
40
60
80
100
150
100.0
30.0
10.0
3.0
1.0
0.3
0.1

Convection 3 (Bram van ‘t Veen)

- Comparison of radar precipitation and model reflectivity
- Initially study over Europe
- Problem with inhomogeniety of radars
- Problem with wave length of radars
- -> Study of convection over USA

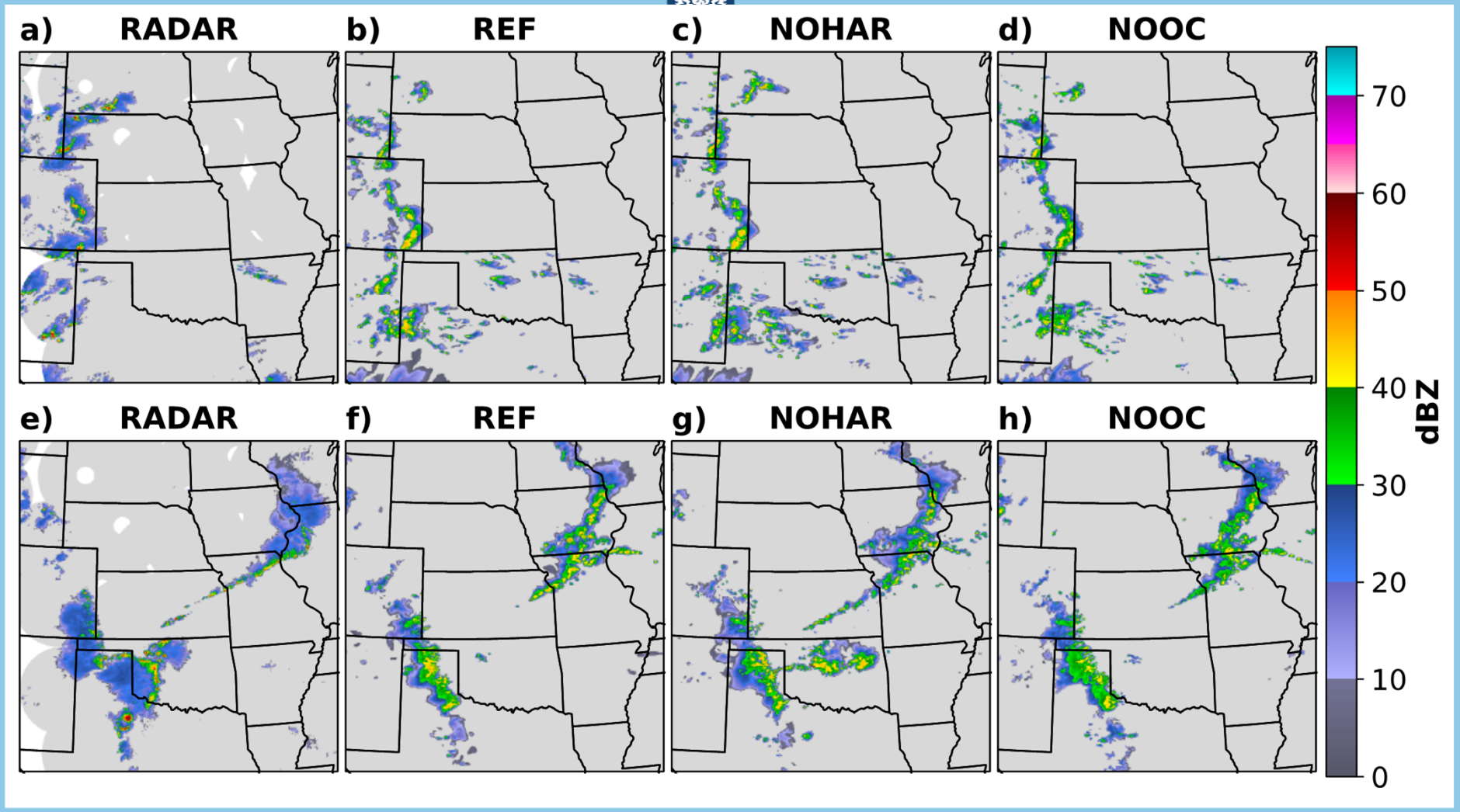
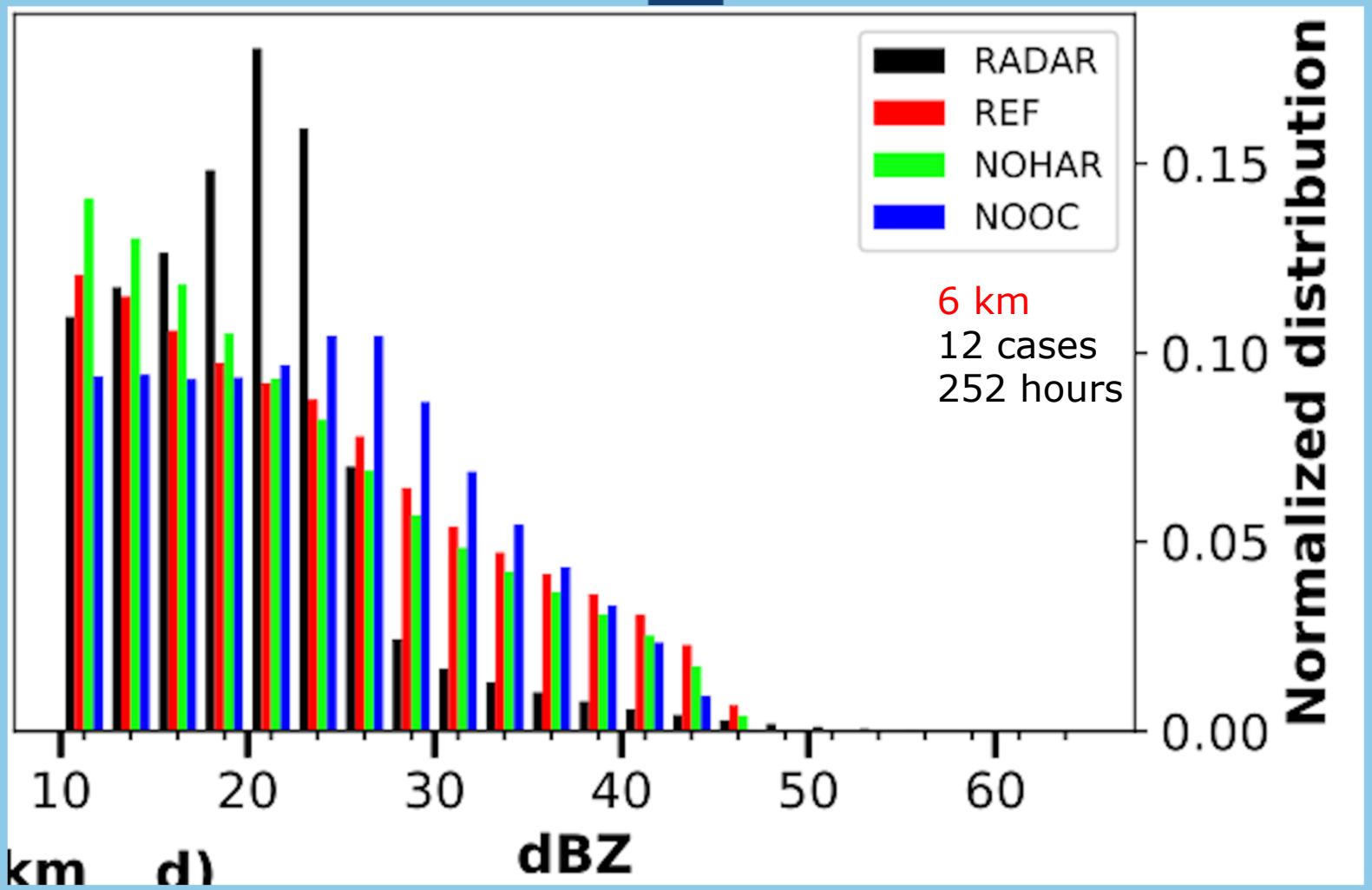
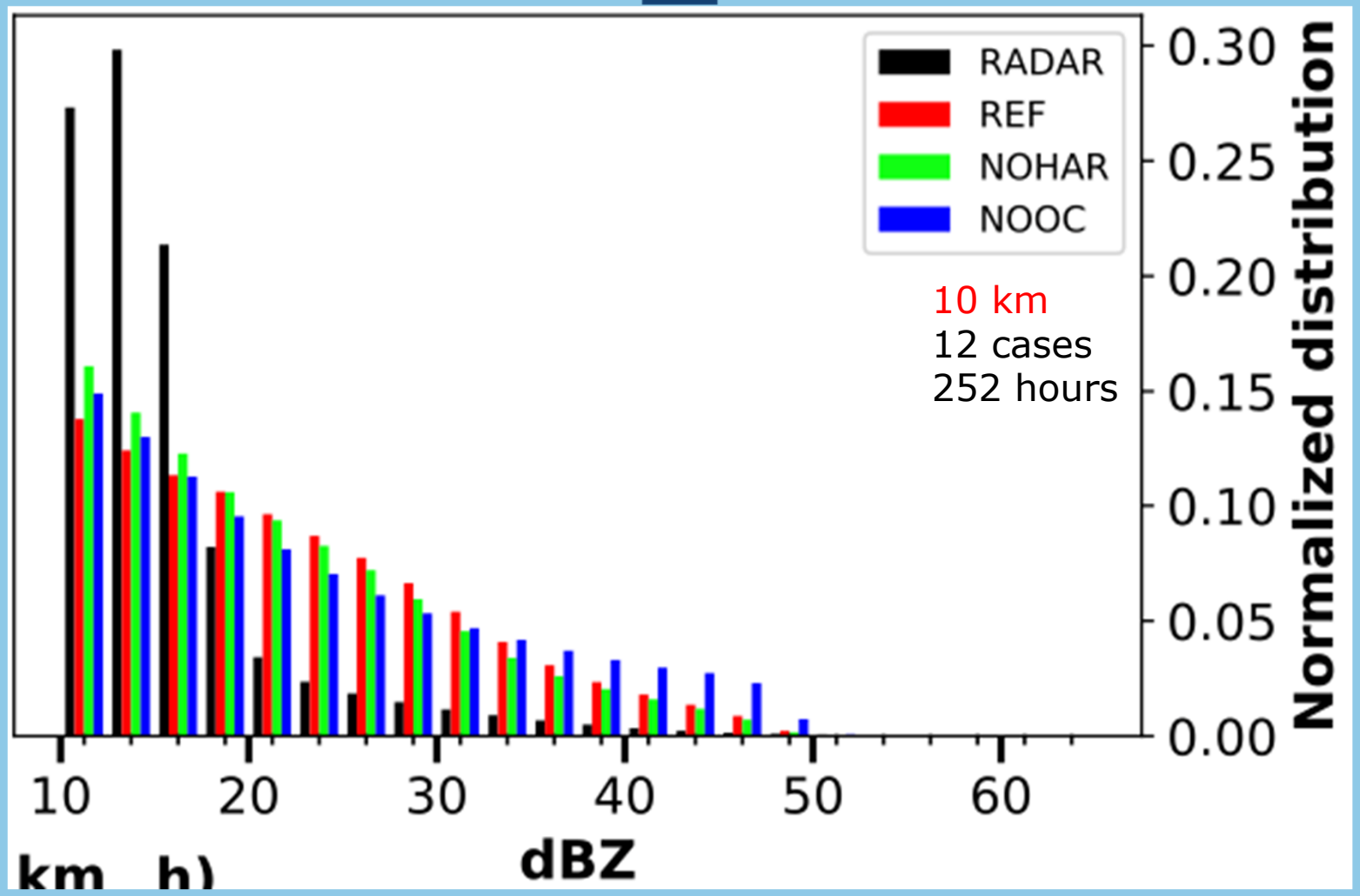


Figure 6.3: As in figure 6.1, but for (b-d) 2019-06-02, 12Z, and (f-h) 2019-06-15, 15Z.


RADAR
REF
NOHAR
NOOC
6 km
12 cases
252 hours
0.15
0.10
0.05
0.00
Normalized distribution
10
20
30
40
50
60
dBZ
km d)


RADAR
REF
NOHAR
NOOC
10 km
12 cases
252 hours
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Normalized distribution
10
20
30
40
50
60
dBZ
km h)

Convection 3 (Bram van 't Veen)

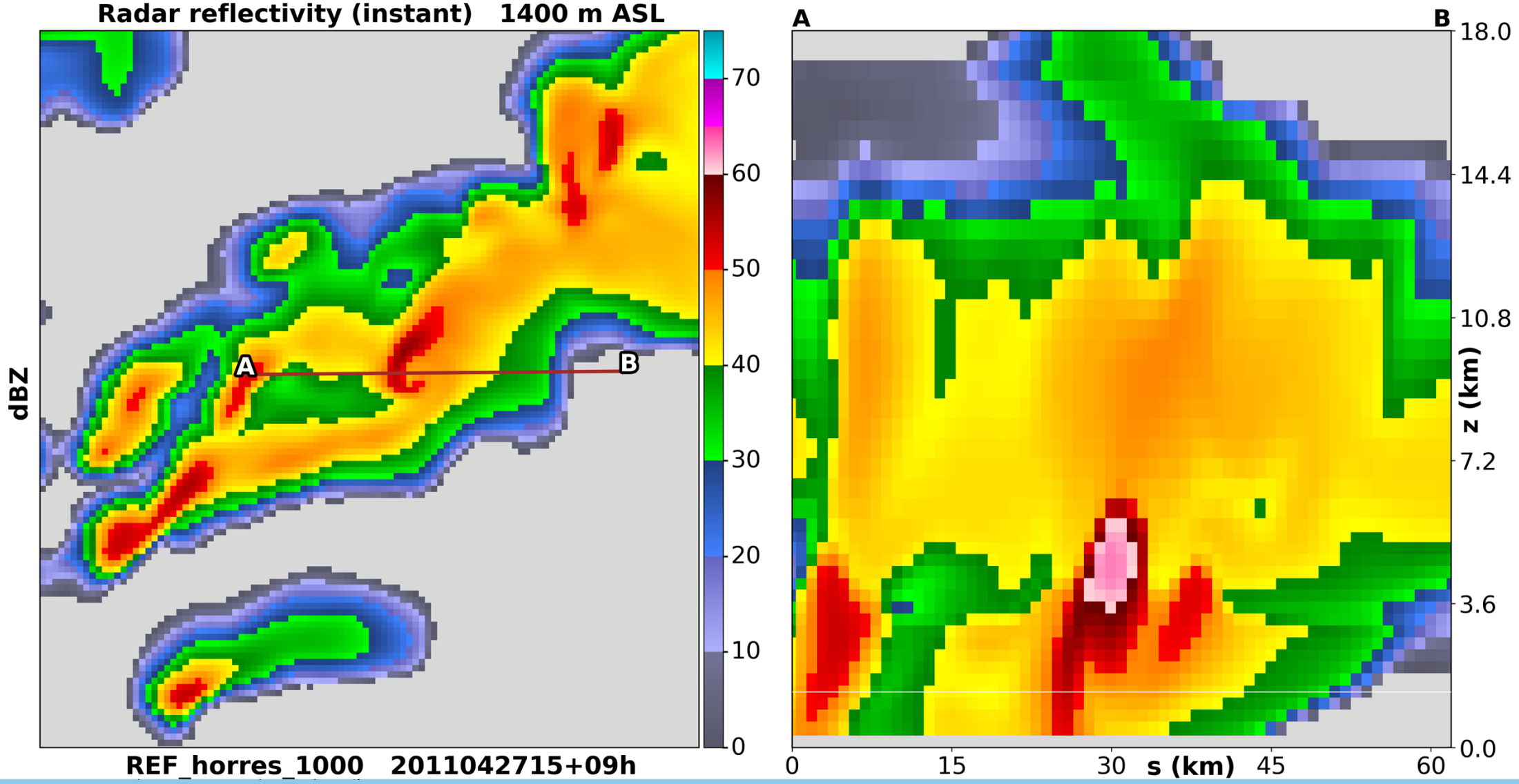
- Precipitation reaches too high
- Too large areas with intense precipitation
- Too small areas with light precipitation
- Work necessary on microphysics

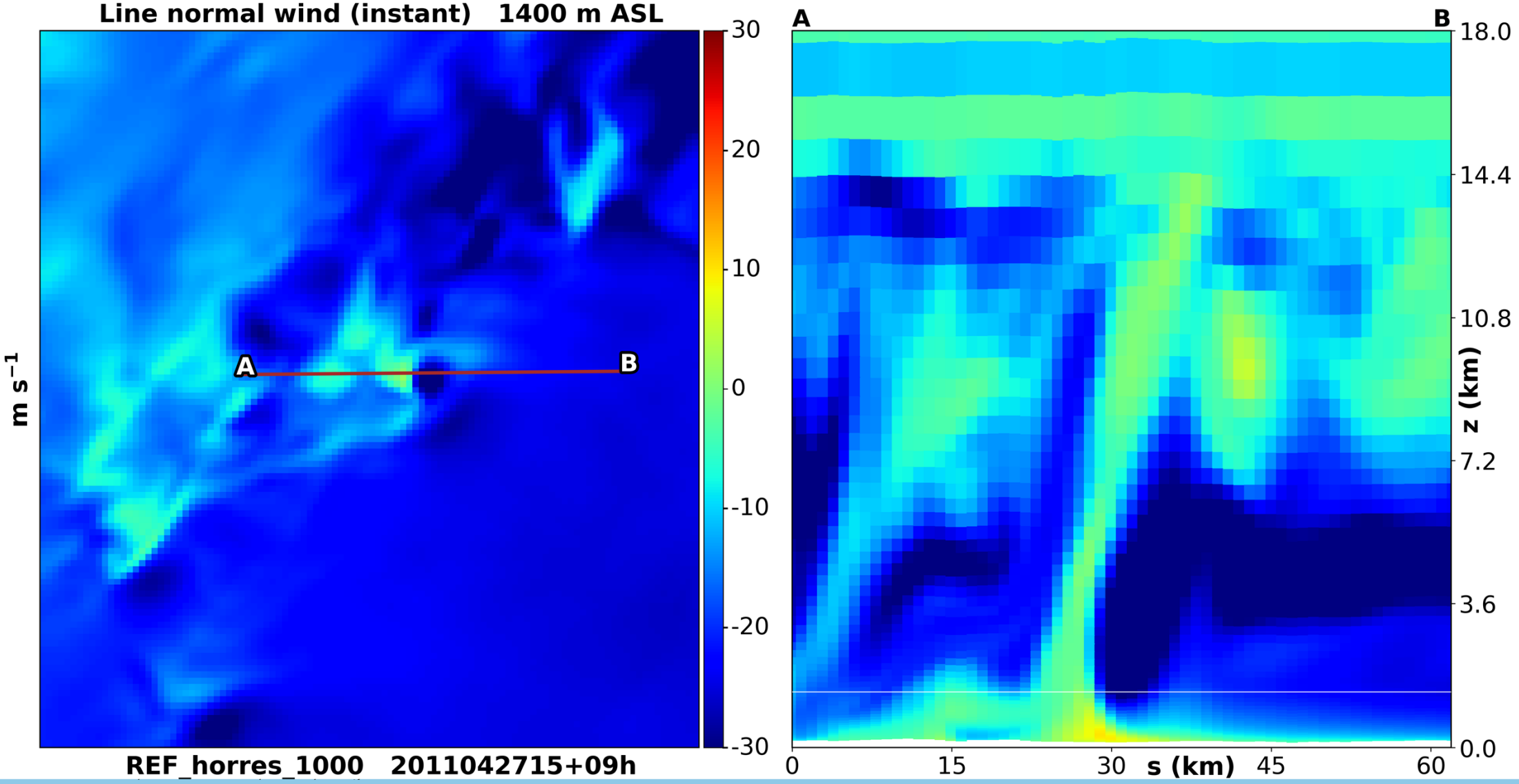
Tornadoes in HARMONIE-AROME?

To study resolution dependence of microphysics also runs at 1 km

For microphysics (distribution of precipitation) resolution is not so important

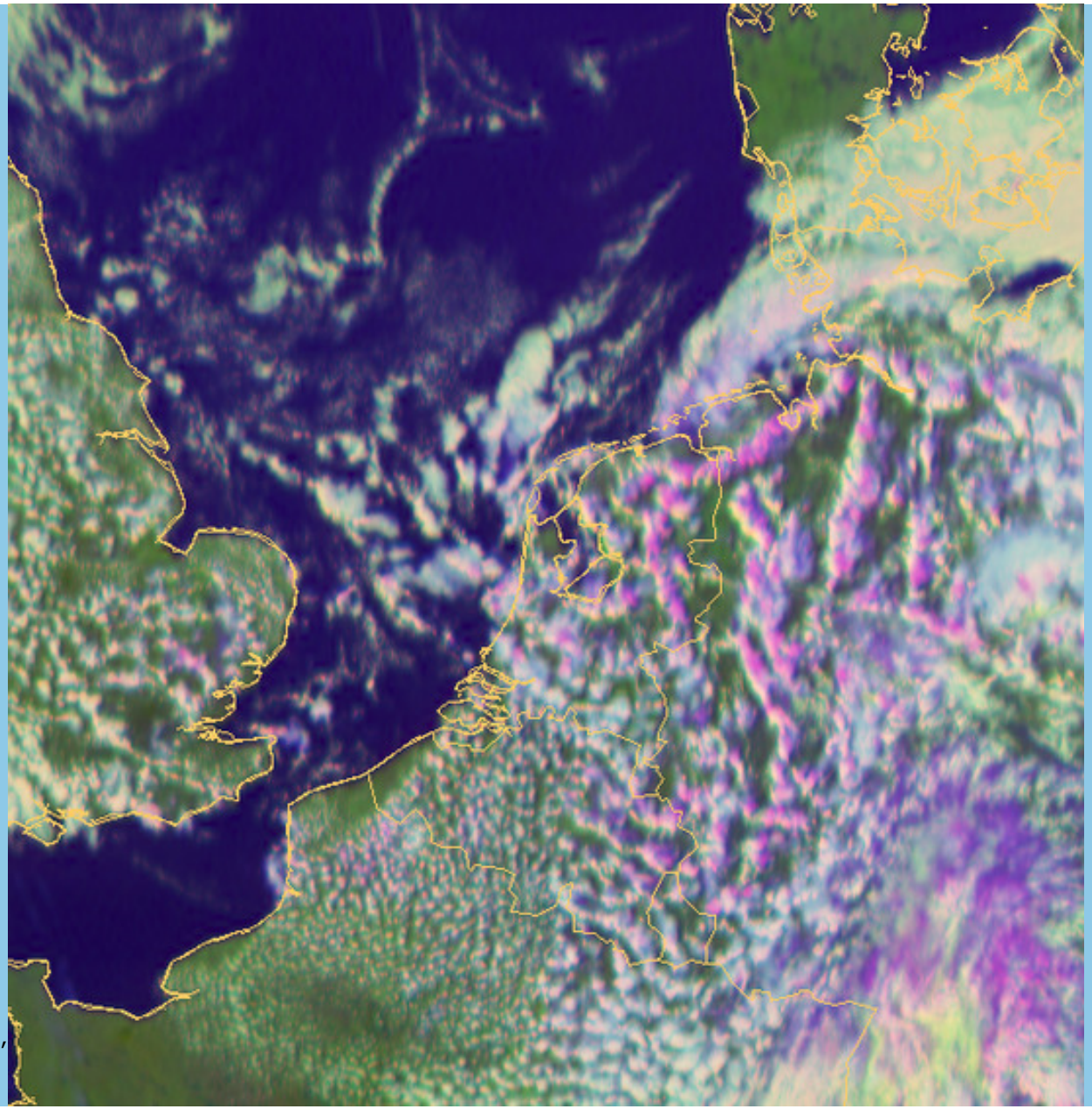
But meso-vortices start to develop in HARMONIE-AROME in tornado outbreak case

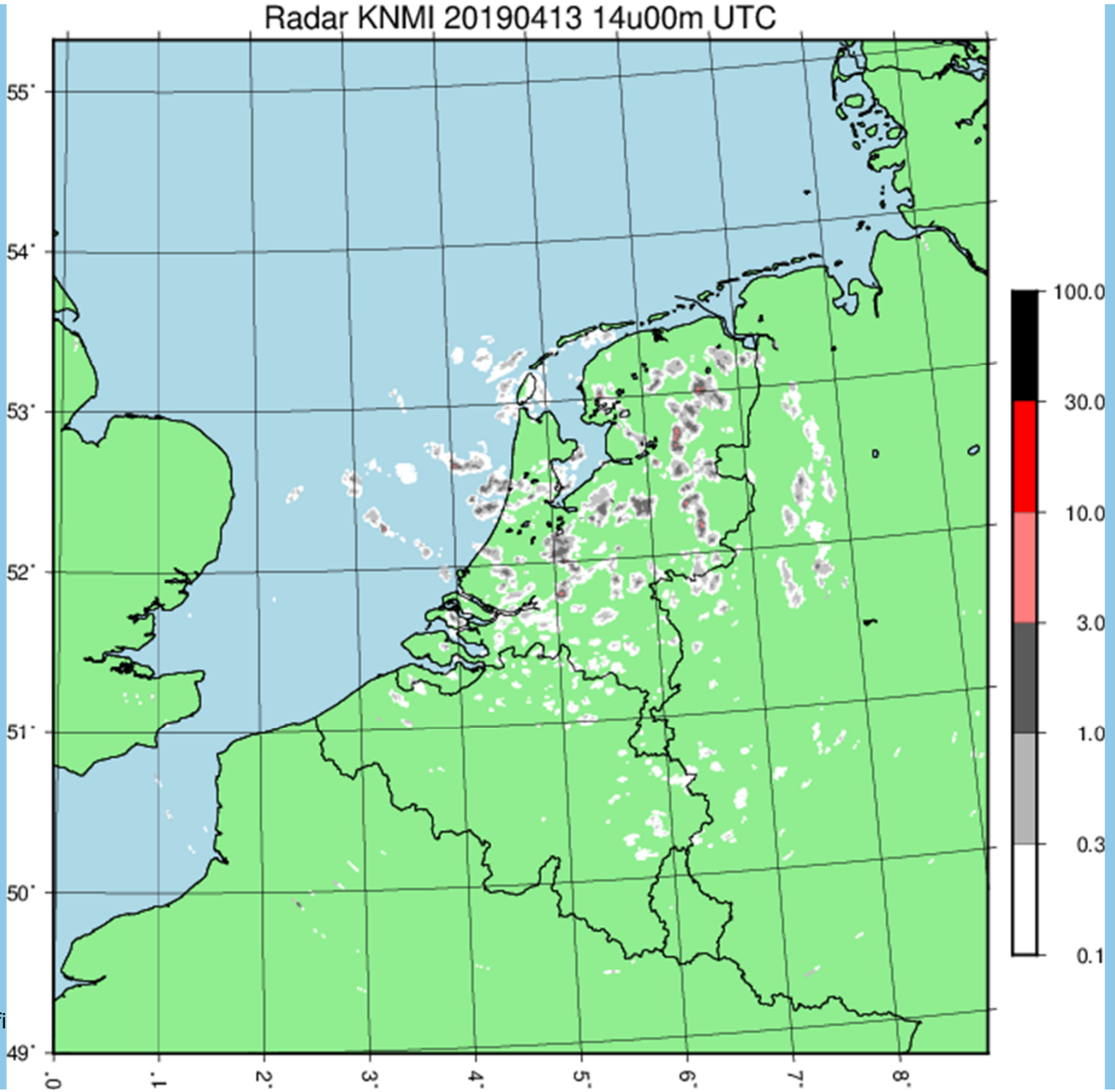

Radar reflectivity (instant) 1400 m ASL
A
B
dBZ
70
60
50
40
30
20
10
0
REF_horres_1000 2011042715+09h
A
B
18.0
14.4
10.8
7.2
3.6
0.0
z (km)
0
15
30
s (km)
45
60

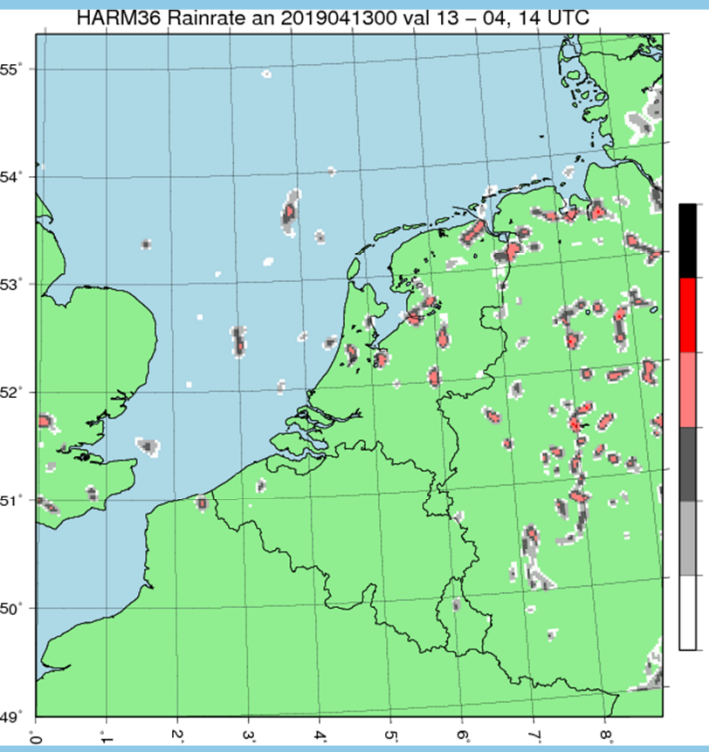

Line normal wind (instant) 1400 m ASL
A
B
m s^{-1}
30
20
10
0
-10
-20
-30
REF_horres_1000 2011042715+09h
A
B
18.0
14.4
10.8
z (km)
7.2
3.6
0.0
0
15
30
s (km)
45
60

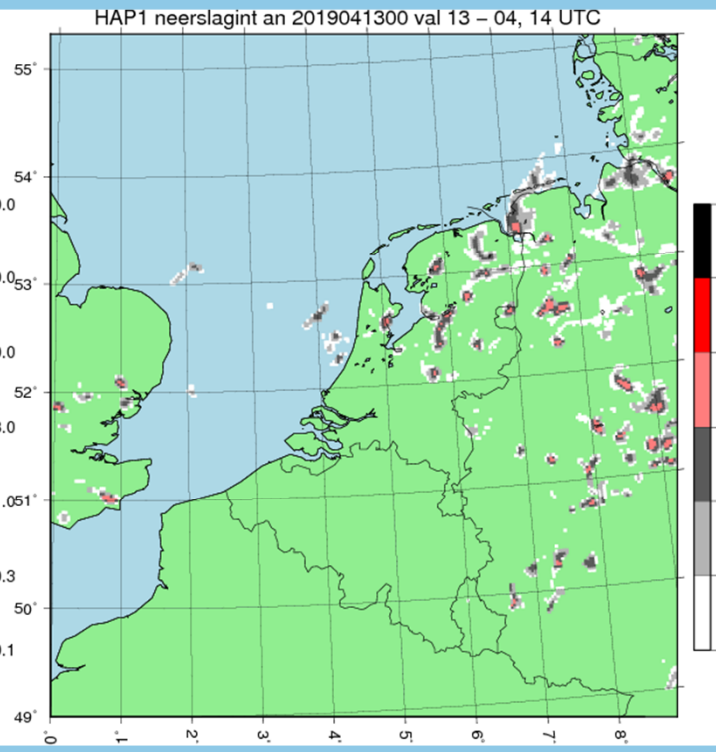
Convection 4: Shallow convection

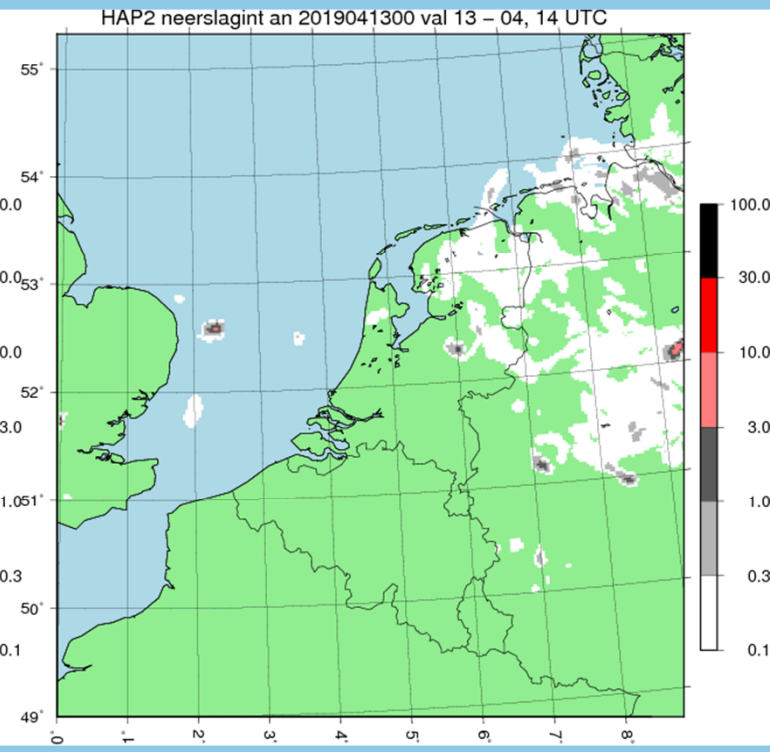
- Showers with cloud tops between -5°C and -15°C not resolved by HARMONIE-AROME
- Convection stays within shallow convection scheme
- Shutting down shallow convection scheme gives more showers, but not enough organization into open cells.

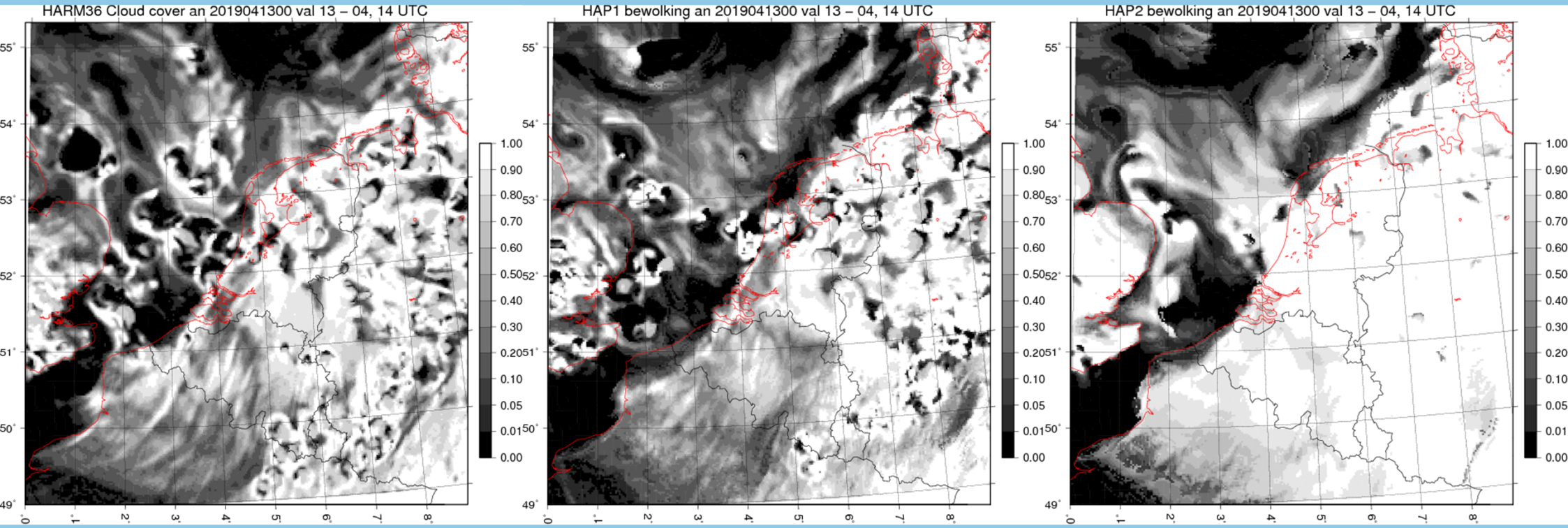



Radar KNMI 20190413 14u00m UTC
55°
54°
53°
52°
51°
50°
49°
.0
.1
2°
3°
4°
5°
6°
7°
8°
100.0
30.0
10.0
3.0
1.0
0.3
0.1


HARM36 Rainrate an 2019041300 val 13 – 04, 14 UTC
55°
54°
53°
52°
51°
50°
49°
100.0
30.0
10.0
3.0
1.0
0.3
0.1


HAP1 neerslagint an 2019041300 val 13 – 04, 14 UTC
55°
54°
53°
52°
51°
50°
49°
100.0
30.0
10.0
3.0
1.0
0.3
0.1


HAP2 neerslagint an 2019041300 val 13 – 04, 14 UTC
55°
54°
53°
52°
51°
50°
49°
100.0
30.0
10.0
3.0
1.0
0.3
0.1


HARM36 Cloud cover an 2019041300 val 13 – 04, 14 UTC
HAP1 bewolking an 2019041300 val 13 – 04, 14 UTC
HAP2 bewolking an 2019041300 val 13 – 04, 14 UTC
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.05
0.01
0.00

Convection challenges HARMONIE-AROME

- Problems with convection
  - No initiation near end of heating period
  - Surface problems (drying out)
  - Shallow convection, no showers in specific conditions
  - Nighttime convection not developing
  - Convection dying out too quickly
  - Not enough weakly precipitation areas near convection

One parameter with big impact

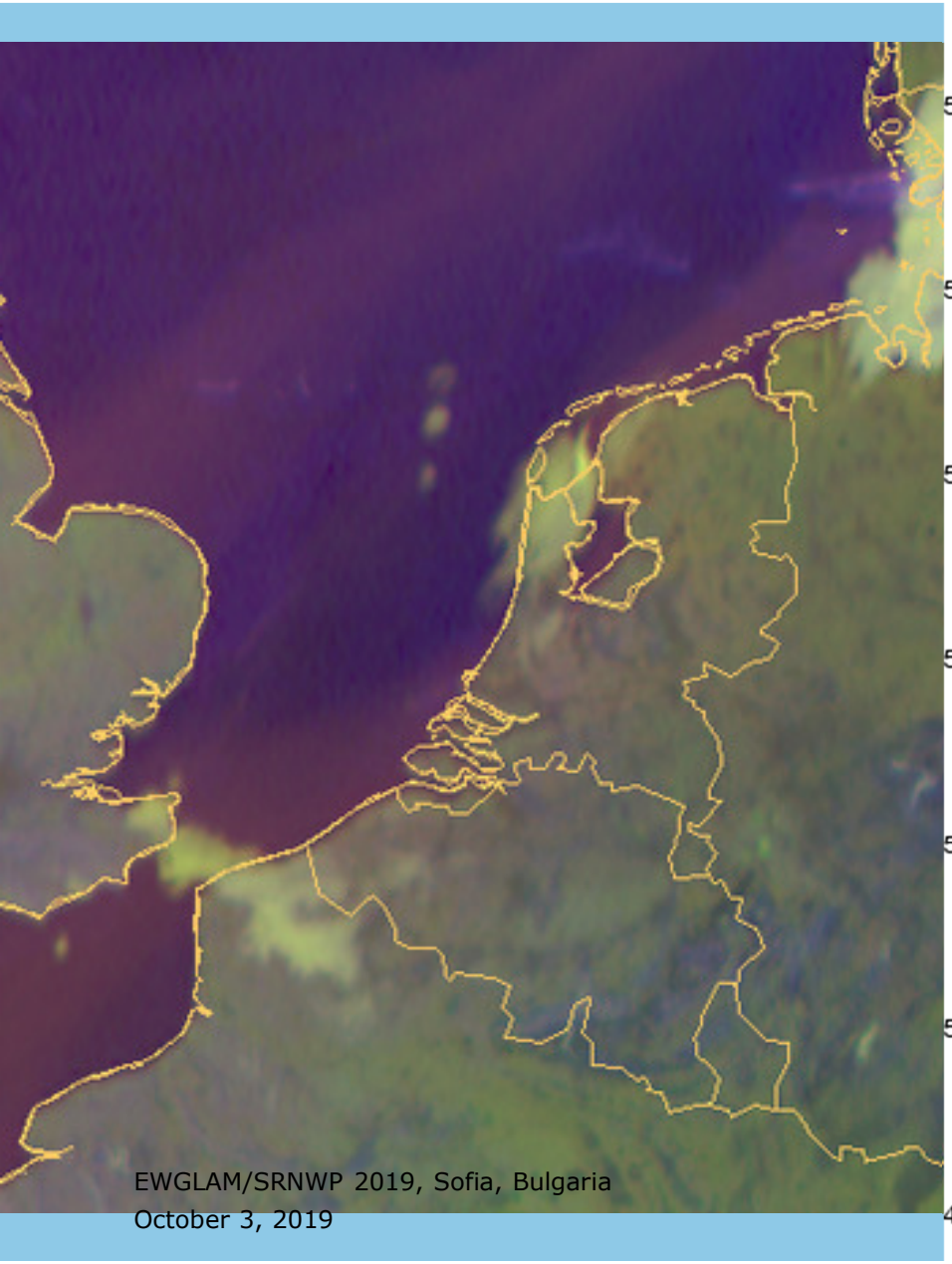
HARMONIE-AROME uses parameter that determines maximum stability used in calculation of exchange at the surface

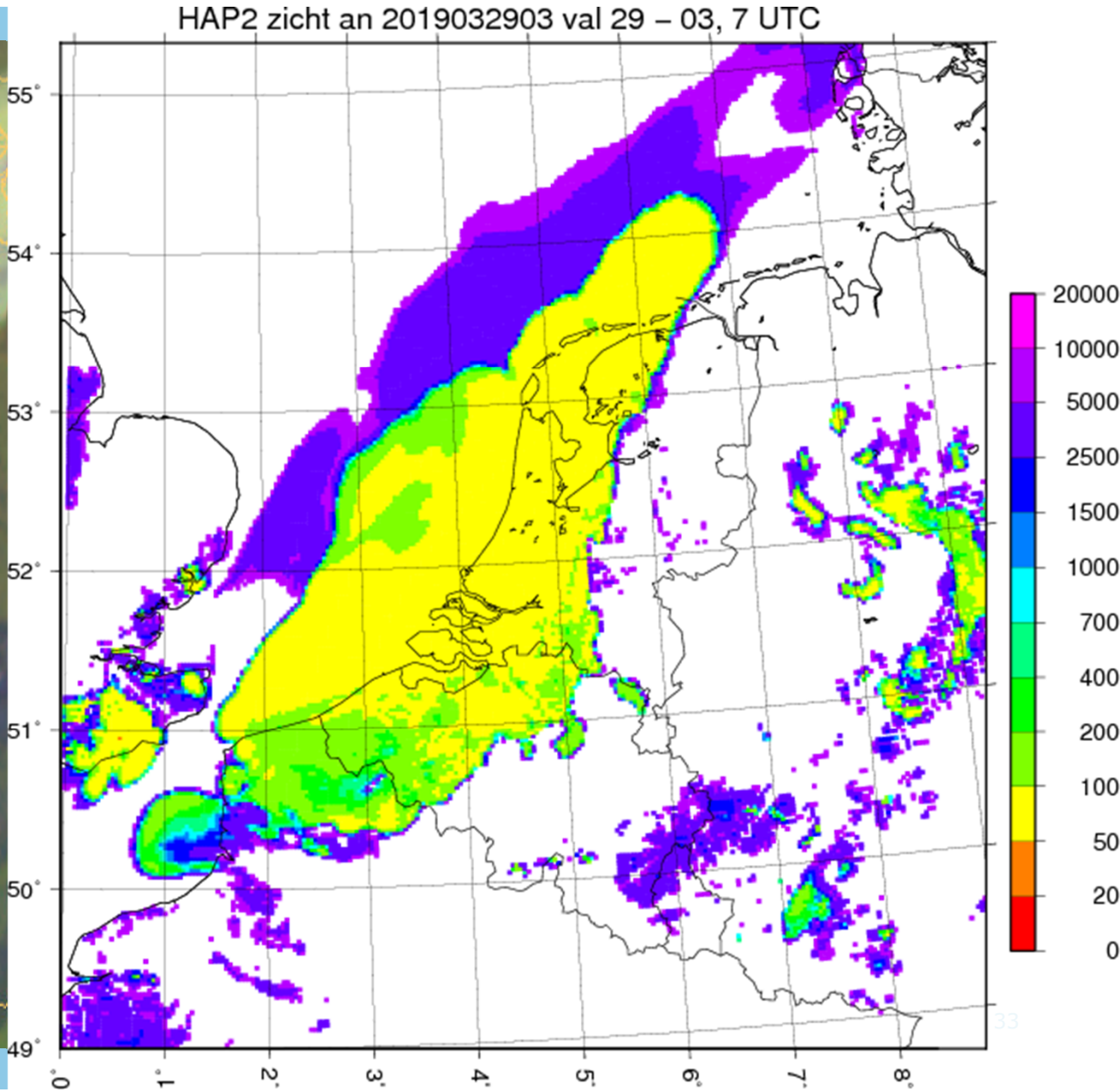
XRIMAX = 0.0

Neutral stability maximum

Introduced when canopy scheme was used in HARMONIE-AROME

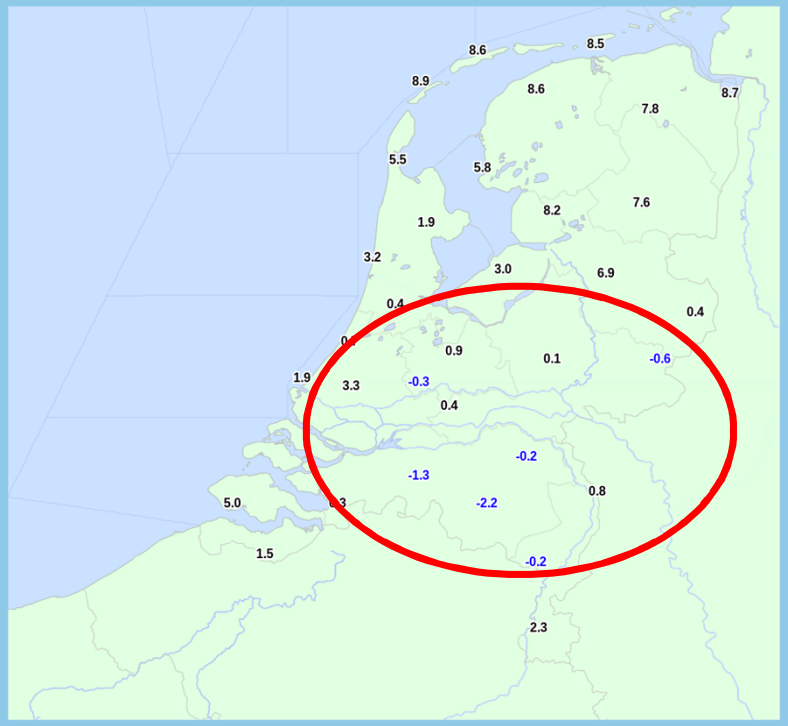
Canopy scheme is not used anymore…….

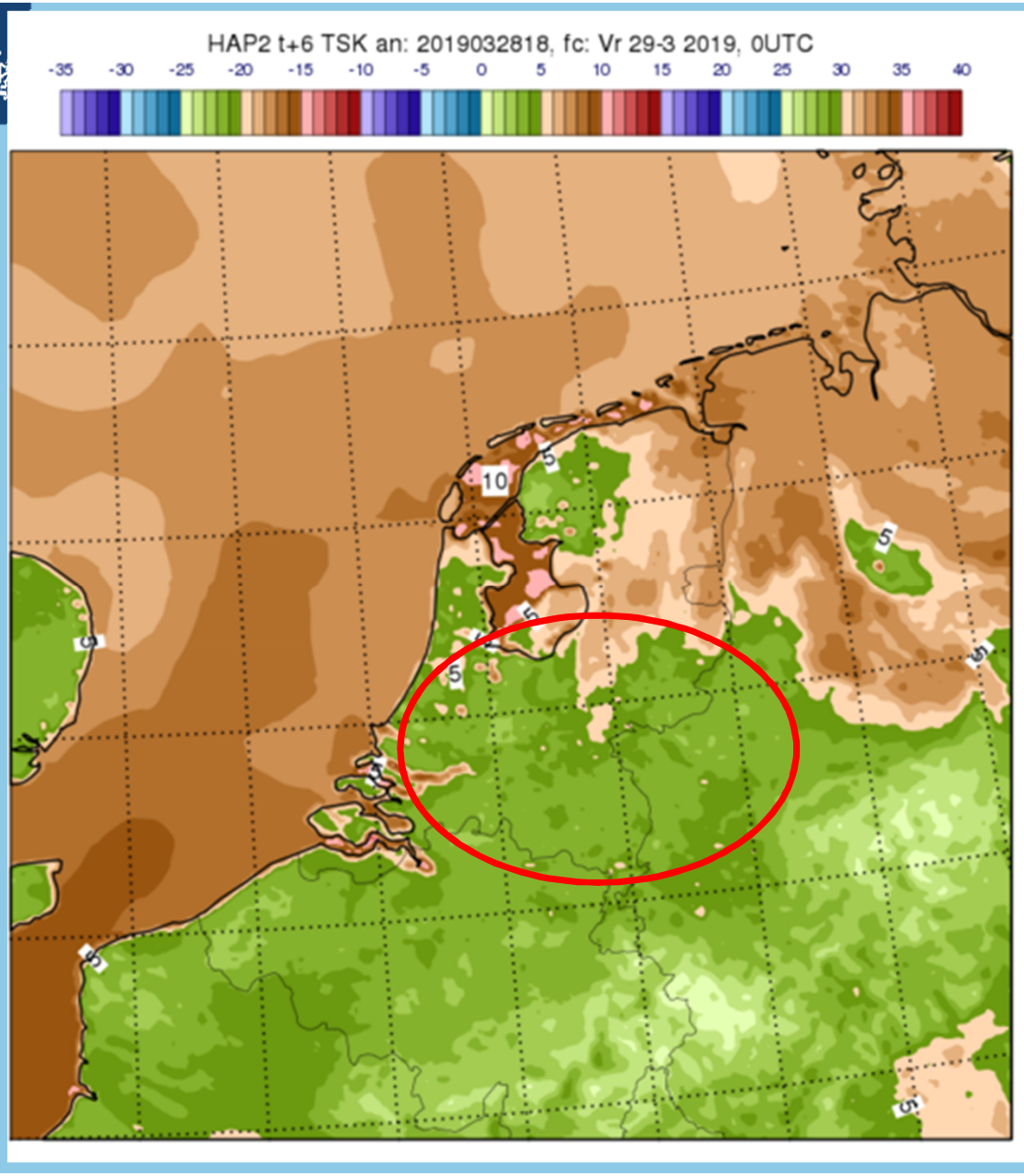


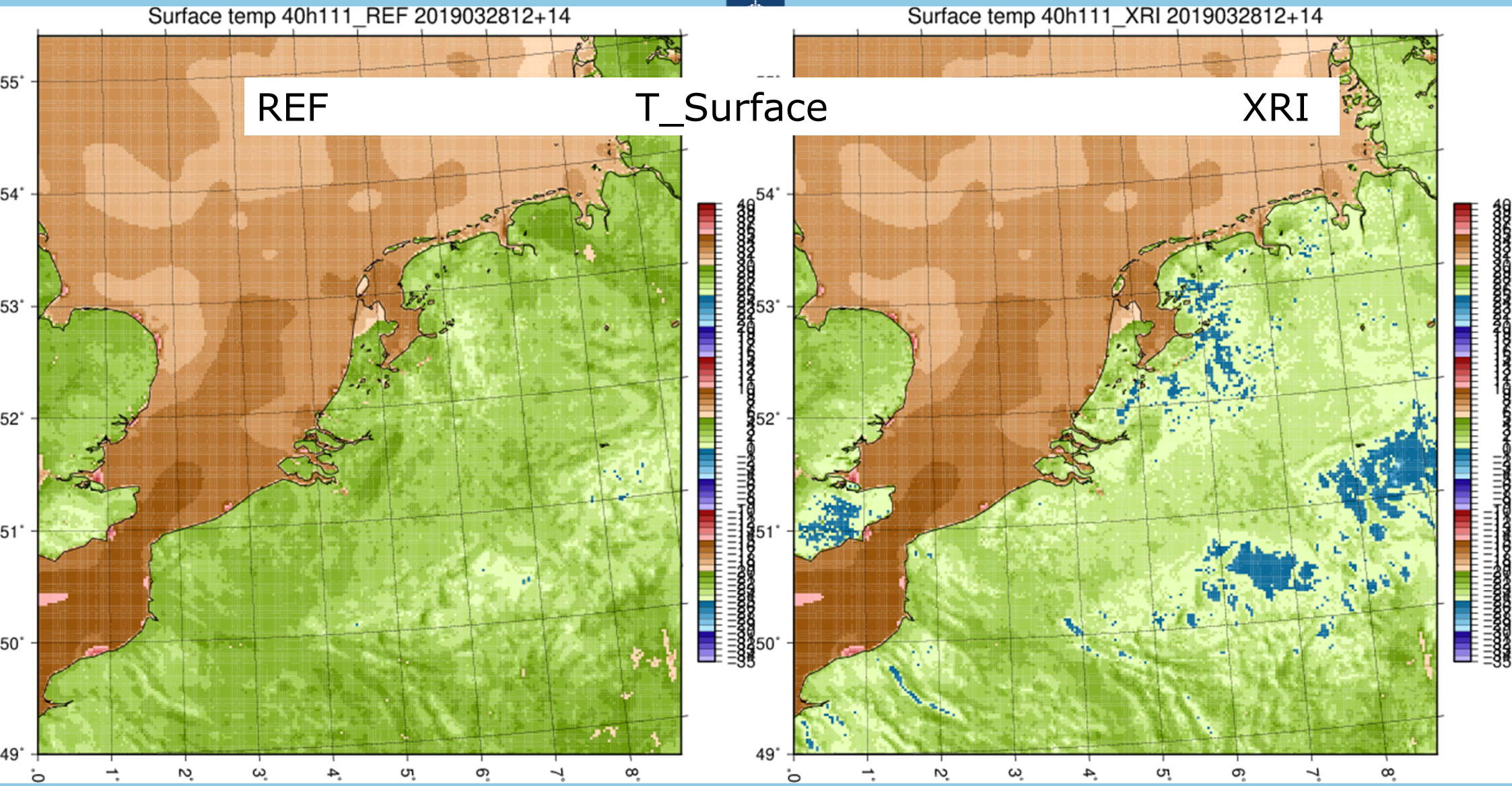

HAP2 zicht an 2019032903 val 29 – 03, 7 UTC
55°
54°
53°
52°
51°
50°
49°
0°
1°
2°
3°
4°
5°
6°
7°
8°
20000
10000
5000
2500
1500
1000
700
400
200
100
50
20
0

Surface fluxes, impact on stable boundary layer

- Impact XRIMAX on T_surf and fog formation?



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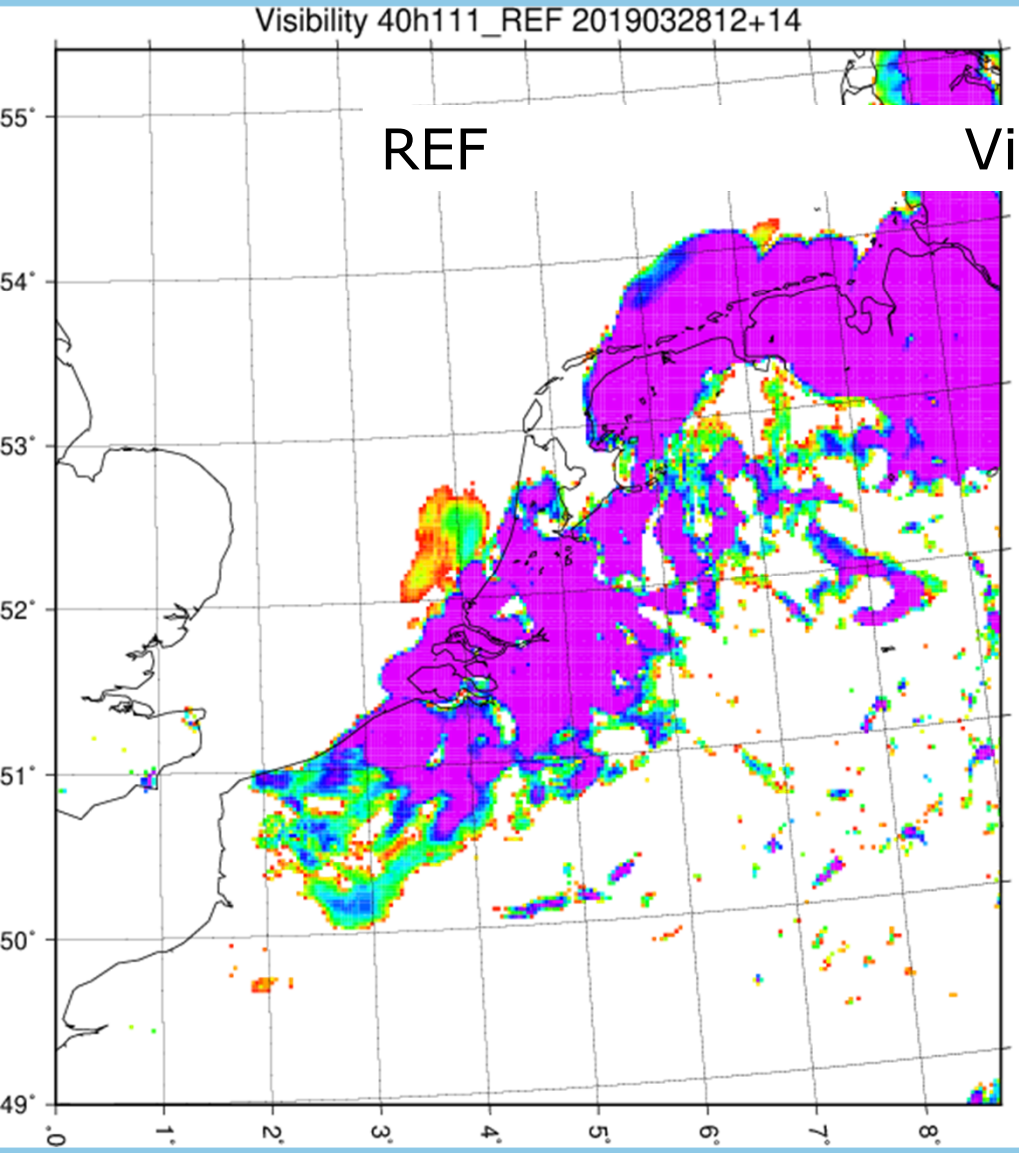
Surface temp 40h111_XRI 2019032812+14
REF
T_Surface
XRI

Visibility


Visibility 40h111_REF 2019032812+14
REF
55°
54°
53°
52°
51°
50°
49°
0°
1°
2°
3°
4°
5°
6°
7°
8°
5000
4750
4500
4250
4000
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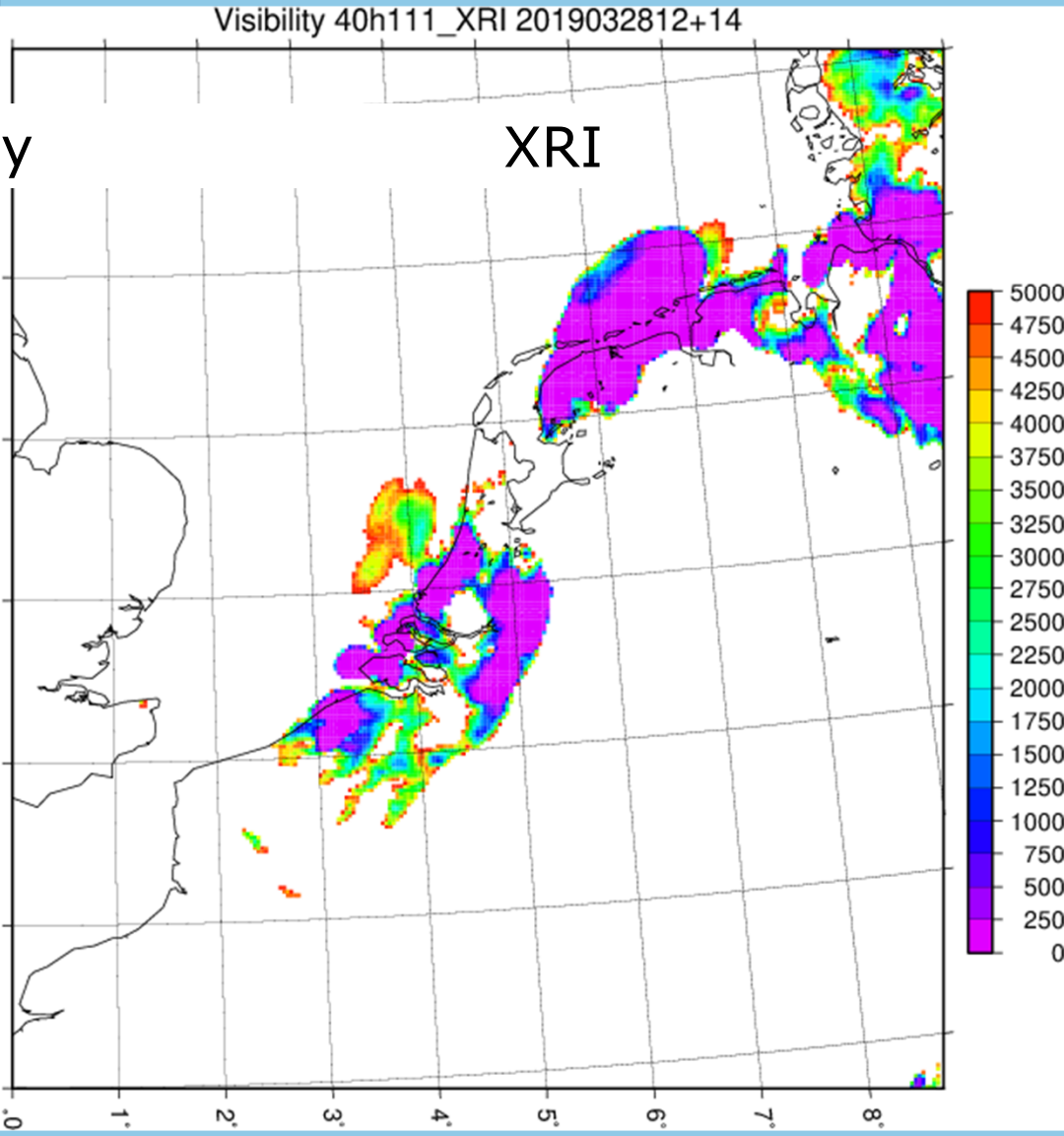
2500
2250
2000
1750
1500
1250
1000
750
500
250
0


Visibility 40h111_XRI 2019032812+14
XRI
54°
53°
52°
51°
50°
49°
0°
1°
2°
3°
4°
5°
6°
7°
8°
5000
4750
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
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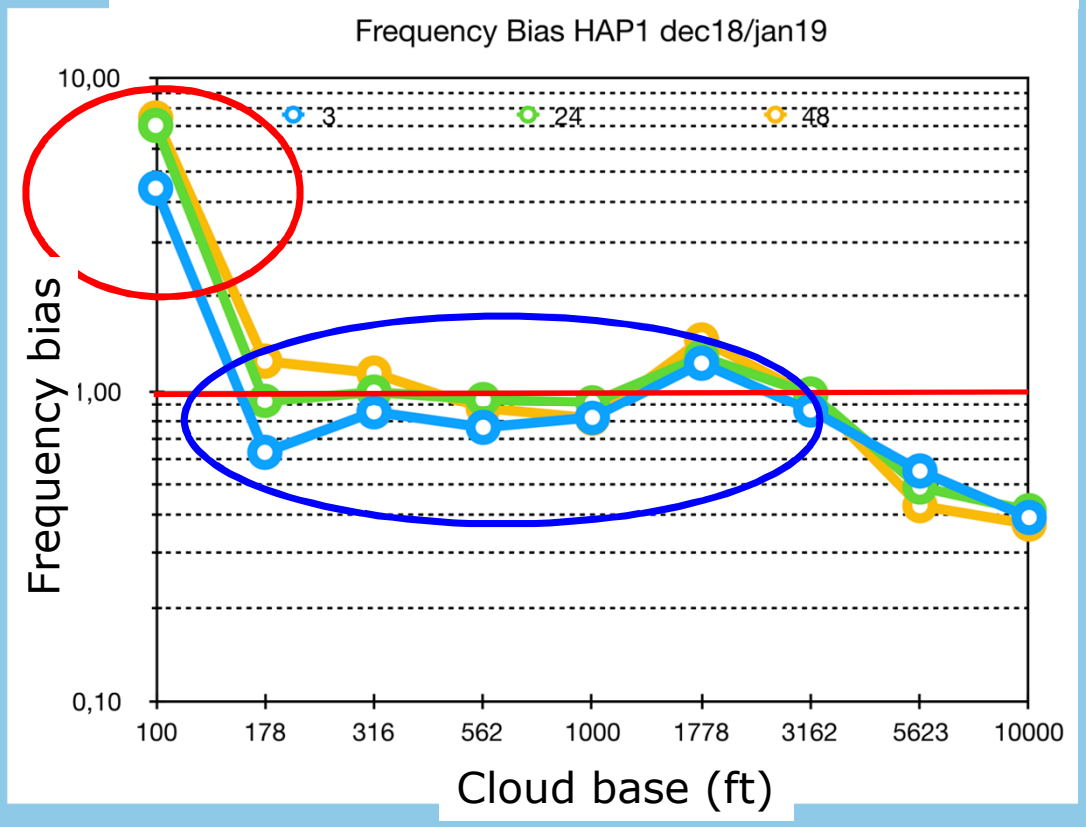
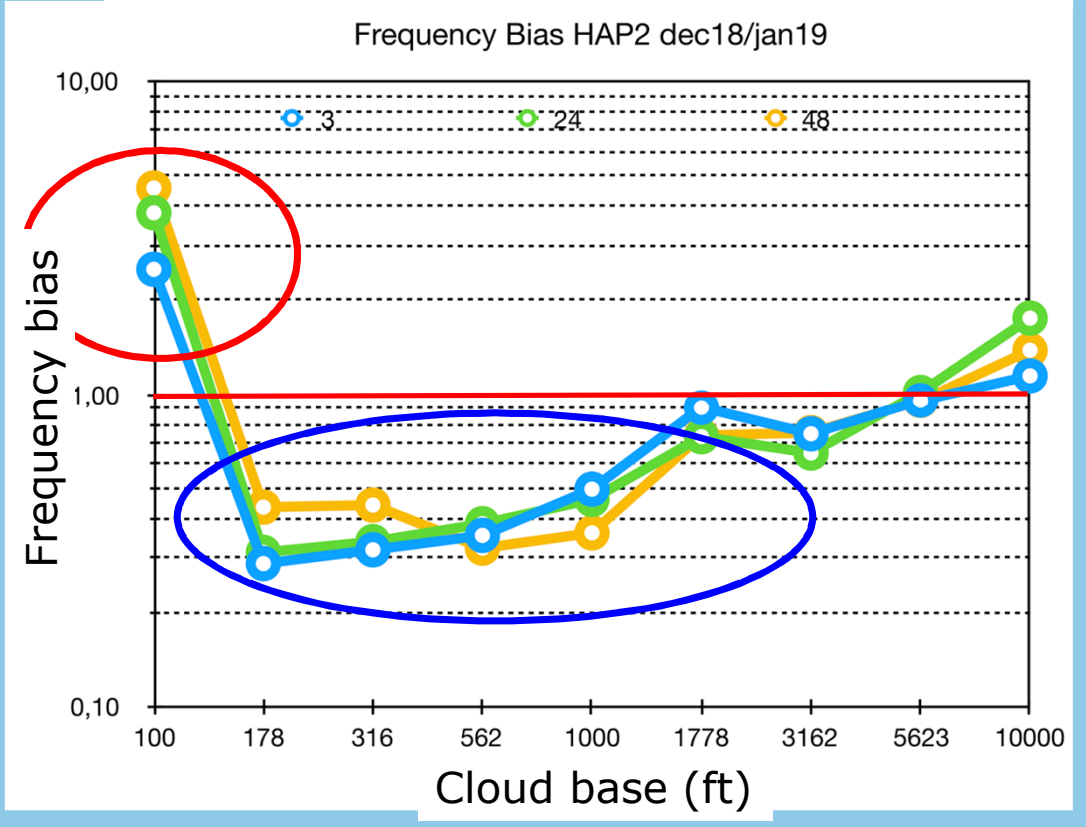
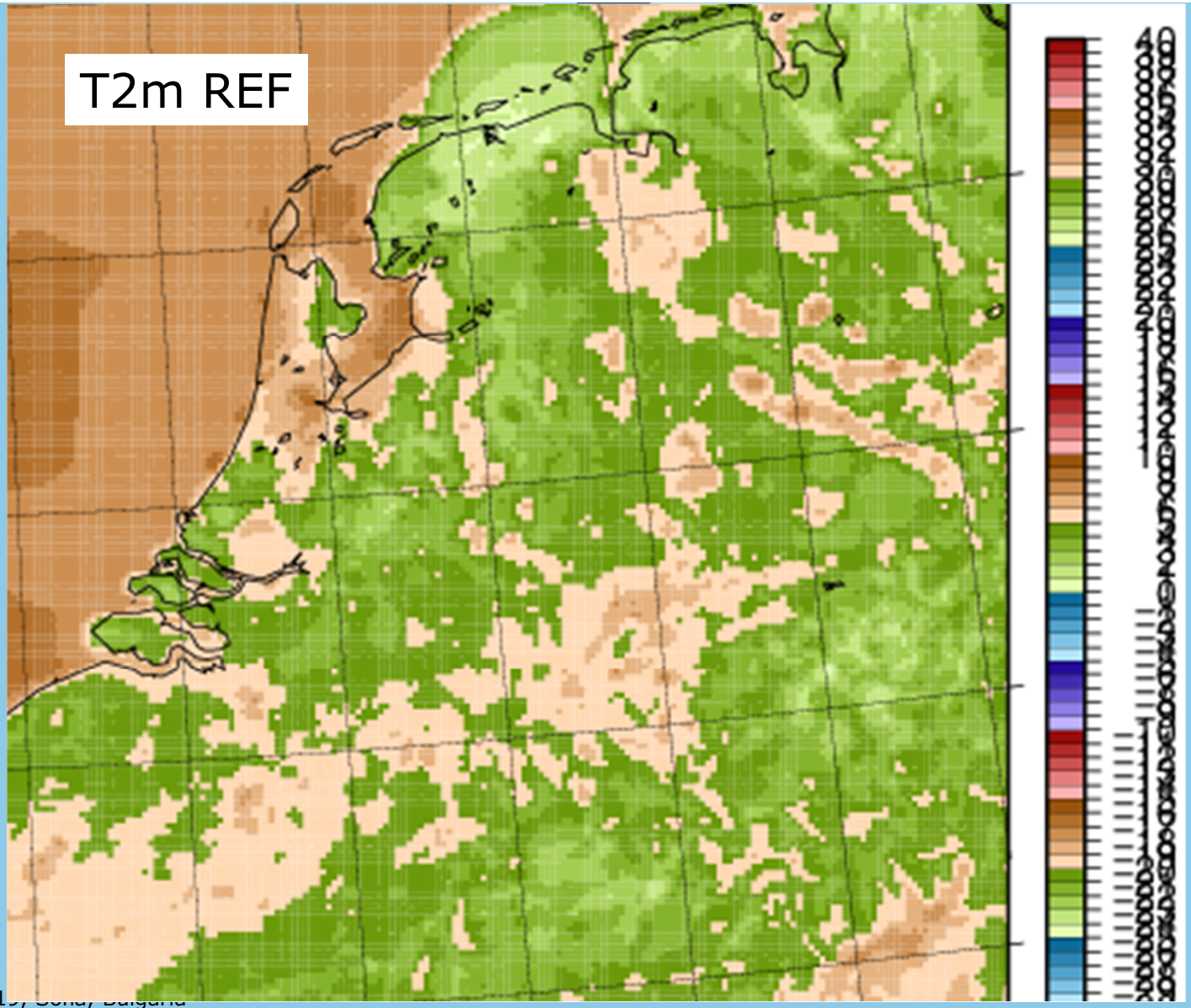
1250
1000
750
500
250
0

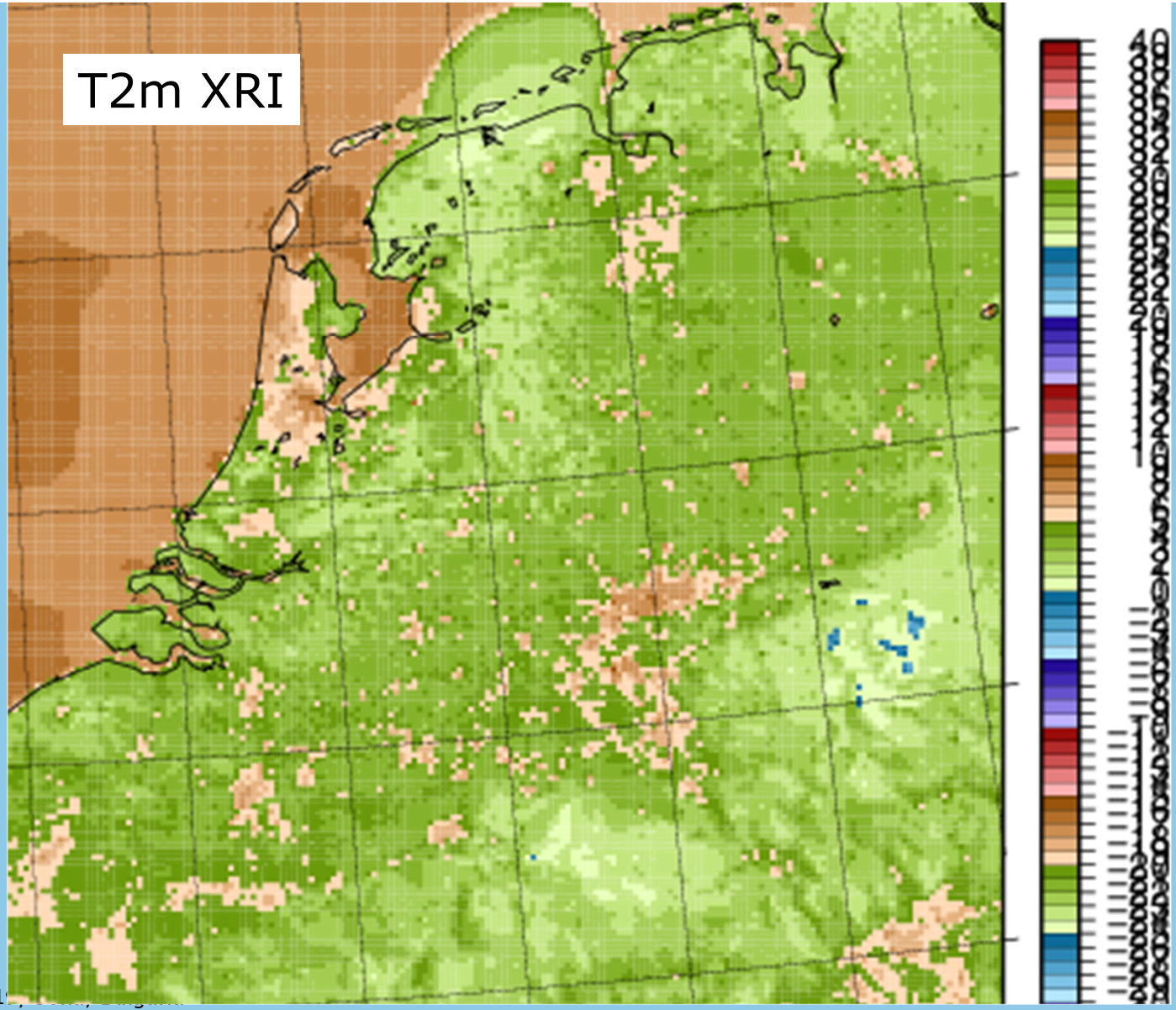
40h1.2tg2, NOHARATU
64 122 356 697 1830 1966 3560 3943 595

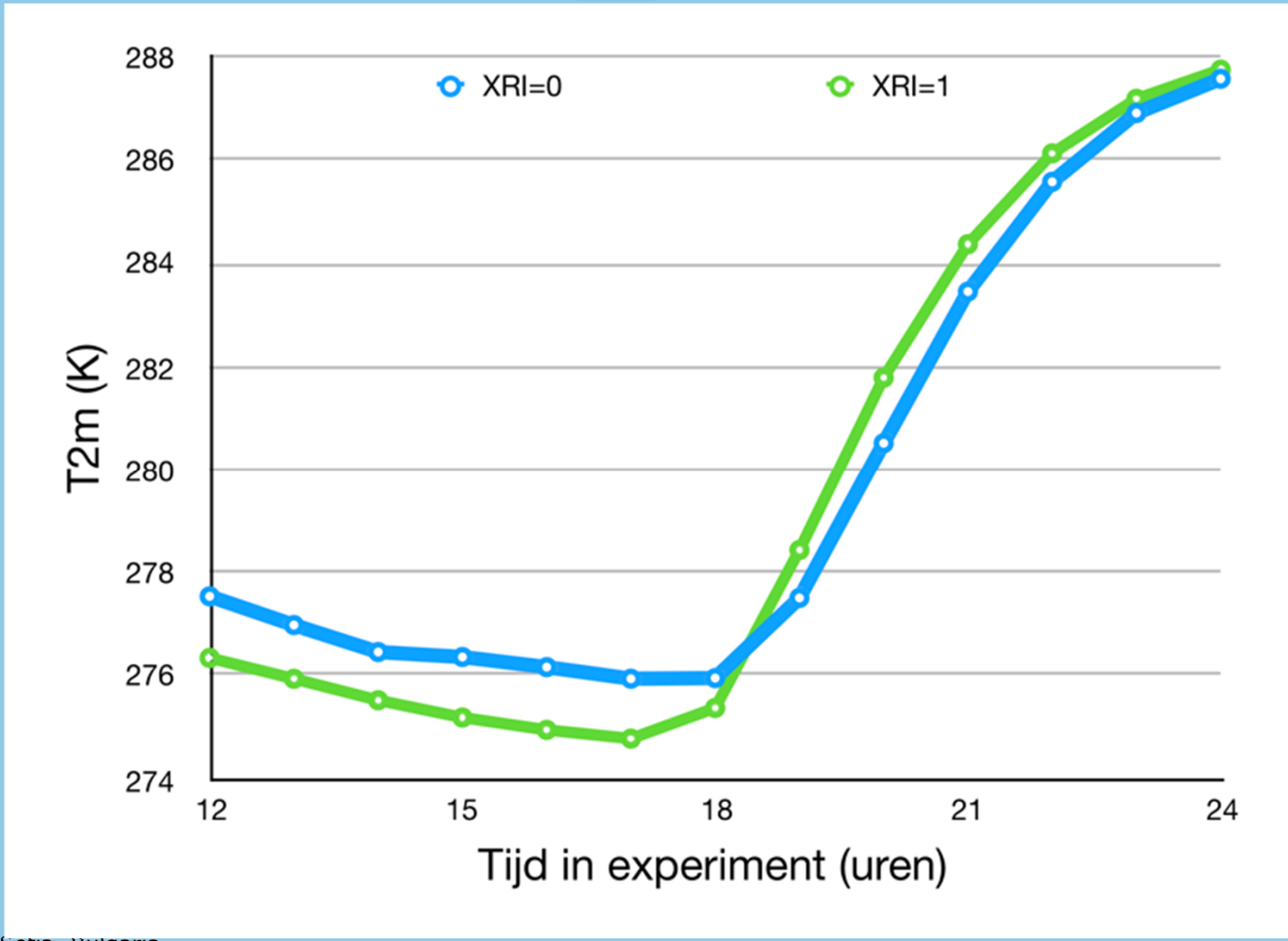


40h1.1.1
64 122 356 697 1830 1966 3560 3943 595




T2m REF


T2m XRI


XRI=0
XRI=1
288
286
284
282
280
278
276
274
T2m (K)
12
15
18
21
24
Tijd in experiment (uren)