Royal Netherlands
Meteorological Institute
*Ministry of Infrastructure
and Water Management*

HARMONIE-AROME Forecast Model progress 2020

Sander Tijm

Workplan:

Boundaries

(Low) Clouds: Wim de Rooy
Convection (initiation, shallow open cell, deep convection)
Radiation and aerosols: Laura Rontu
Aerosols and microphysics: Daniel Martin, Oskar Landgren
Stable PBL/Fog

MUSC

Postprocessing

High Resolution

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Convection (deep convection)

Boundaries

Postprocessing

Fog (Tosca Kettler)

Fog already a problem since first HARMONIE-AROME version in 2012.

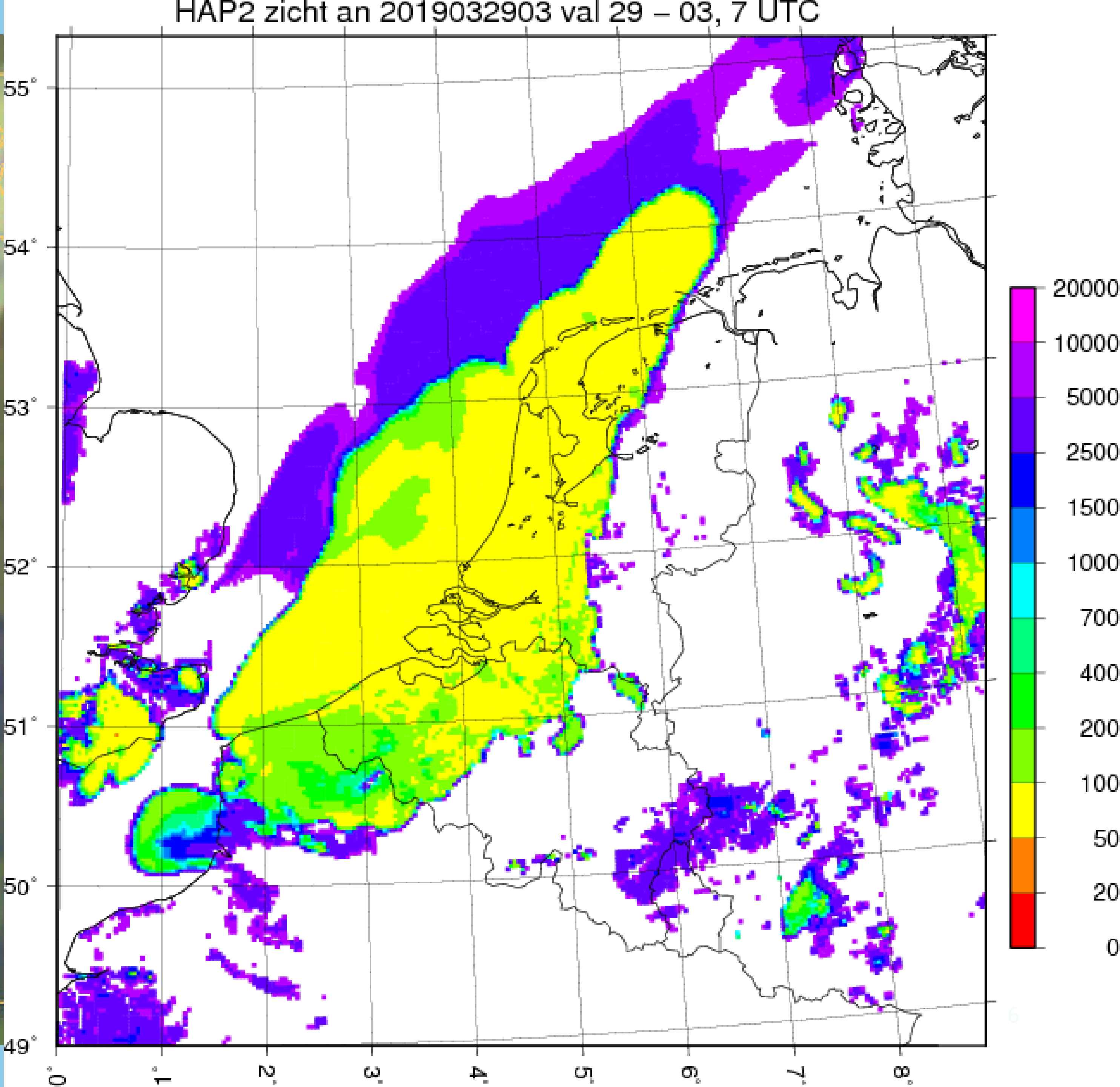
Too large fog extent

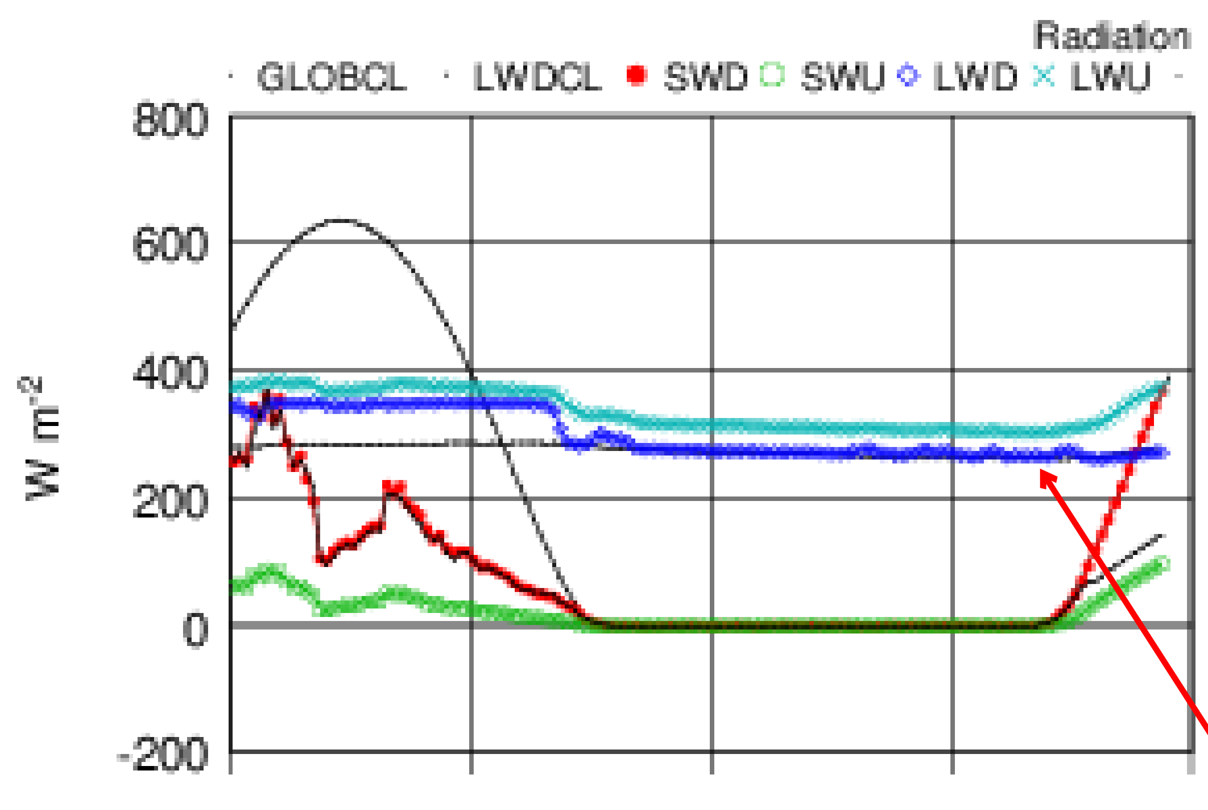
Fog cools too much over sea

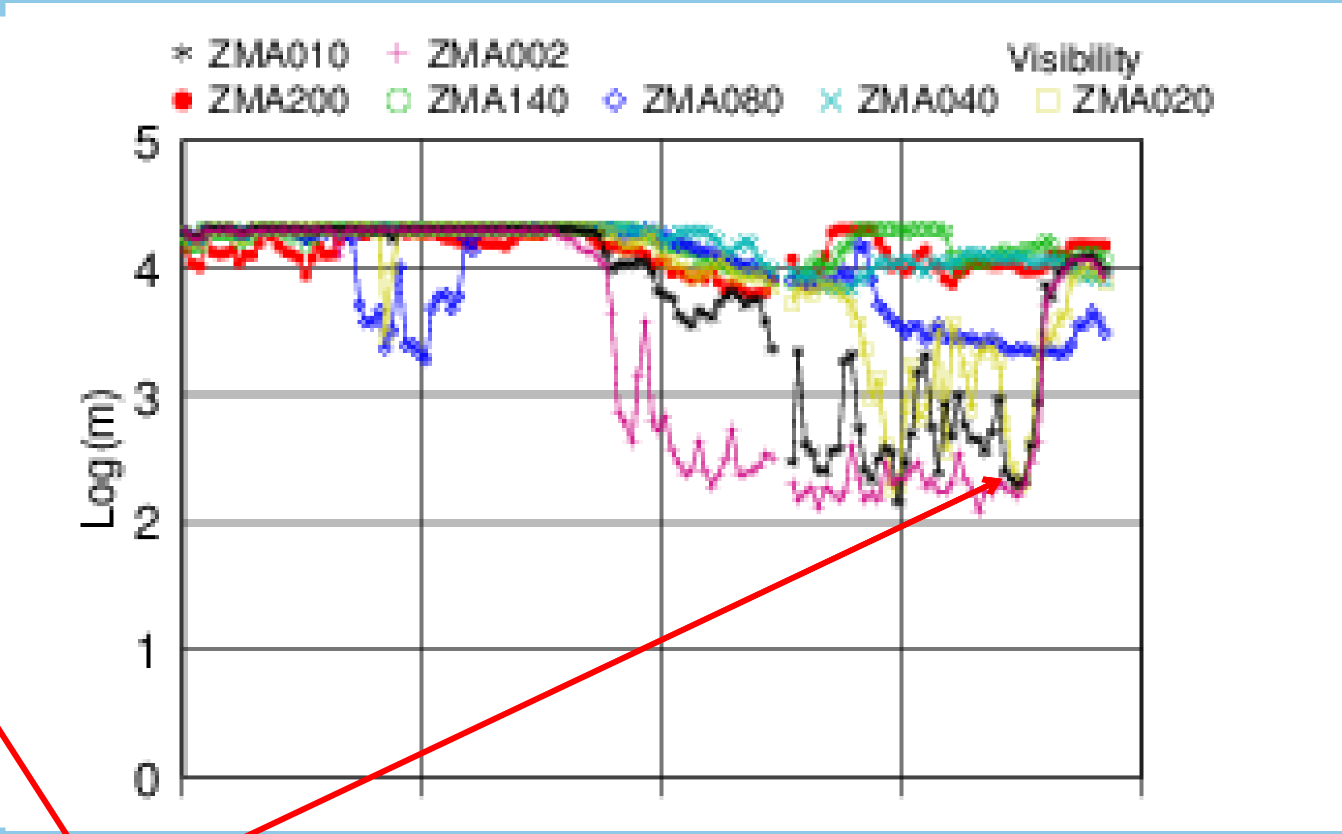
Too dense fog, too much cloud water in fog (Paris fog campaign: mostly less than 0.06 g/kg*, at start of fog, HARMONIE-AROME up to 0.45 g/kg)

Study of 3D case 28/29-03-2019, setup of 1D case in MUSC

*:*M. Mazoyer et al.: Experimental study of the aerosol impact on fog microphysics, Atmos Chem Phys, 2019*

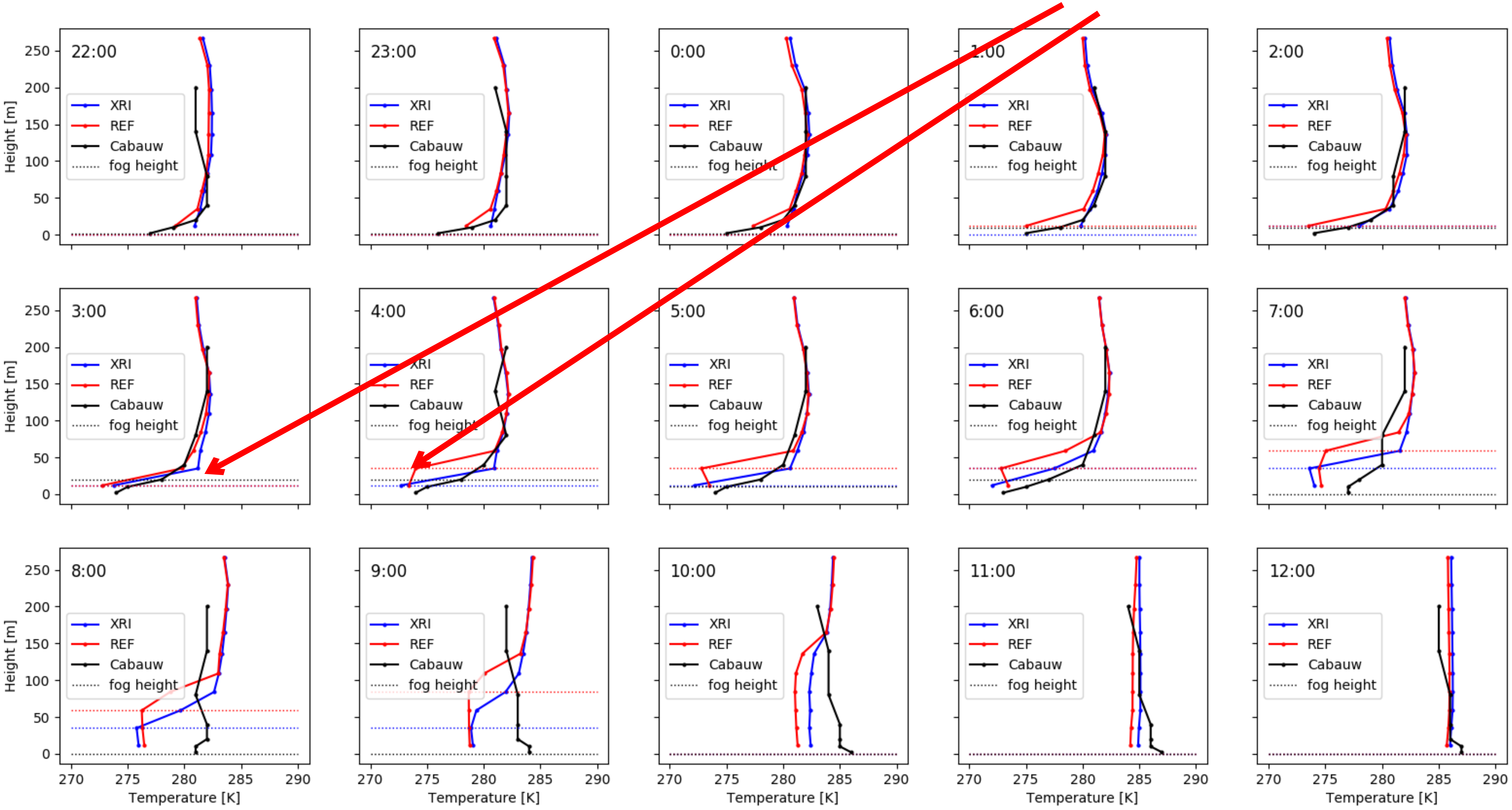

HAP2 zicht an 2019032903 val 29 – 03, 7 UTC
55°
54°
53°
52°
51°
50°
49°
0°
1°
2°
3°
4°
5°
6°
7°
8°
20000
10000
5000
2500
1500
1000
700
400
200
100
50
20
0





Fog depth 10-20 m, no impact on downwelling longwave radiation

Fog layer of 25m already starts to cool from the top, 5K in one hour



MUSC (Whelan, Gleeson, Outten)

MUSC 1-D version (actually 4 columns) of HARMONIE-AROME/AROME/ALARO

New version has been made by Eoin Whelan en Emily Gleeson (Met-Eireann)

Contains Cycle 43.

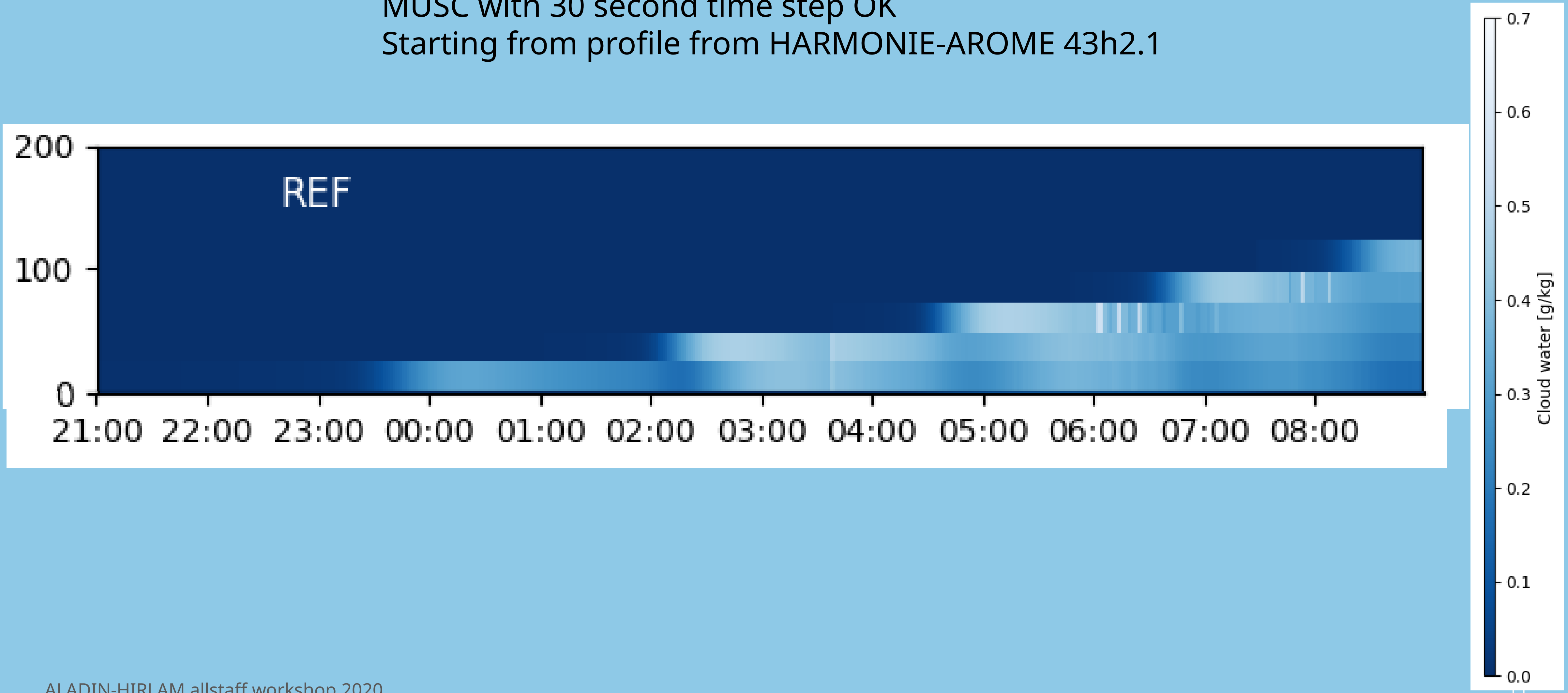
Description of:

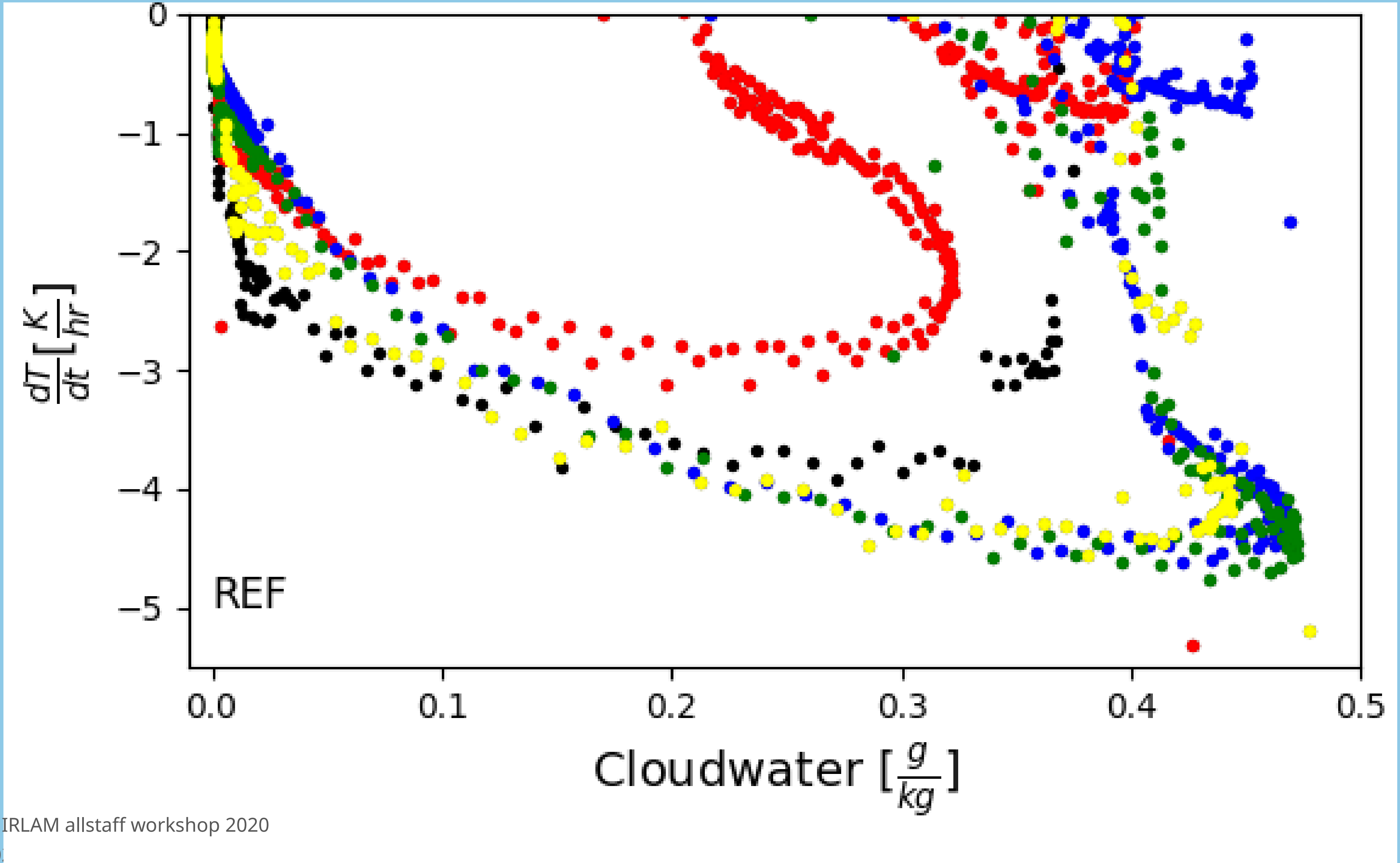
- Setup of MUSC
- Run MUSC
- MUSC output
- Creating MUSC input

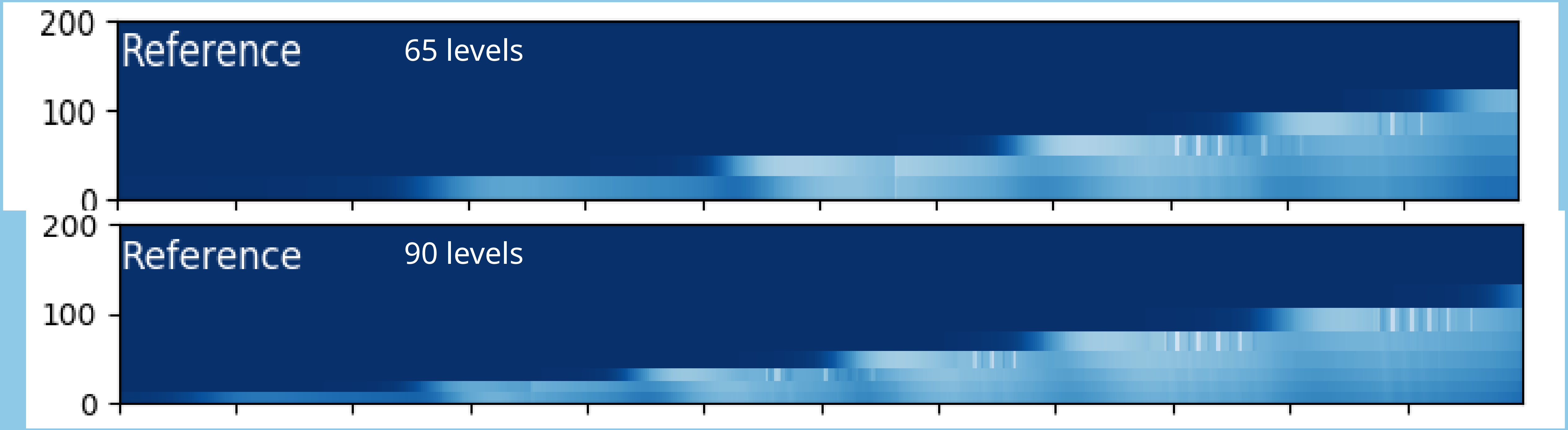
Latest development: Stephen Outten (Met.no) built a MUSC version in a virtual machine. Easy to set up in only a few hours!

https://hirlam.org/trac/wiki/HarmonieSystemDocumentation/MUSC

MUSC with 30 second time step OK
Starting from profile from HARMONIE-AROME 43h2.1




REF
Cloudwater [g/kg]
dT/dt [K/hr]
0
−1
−2
−3
−4
−5
0.0
0.1
0.2
0.3
0.4
0.5


200
Reference
65 levels
100
0
200
Reference
90 levels
100
0

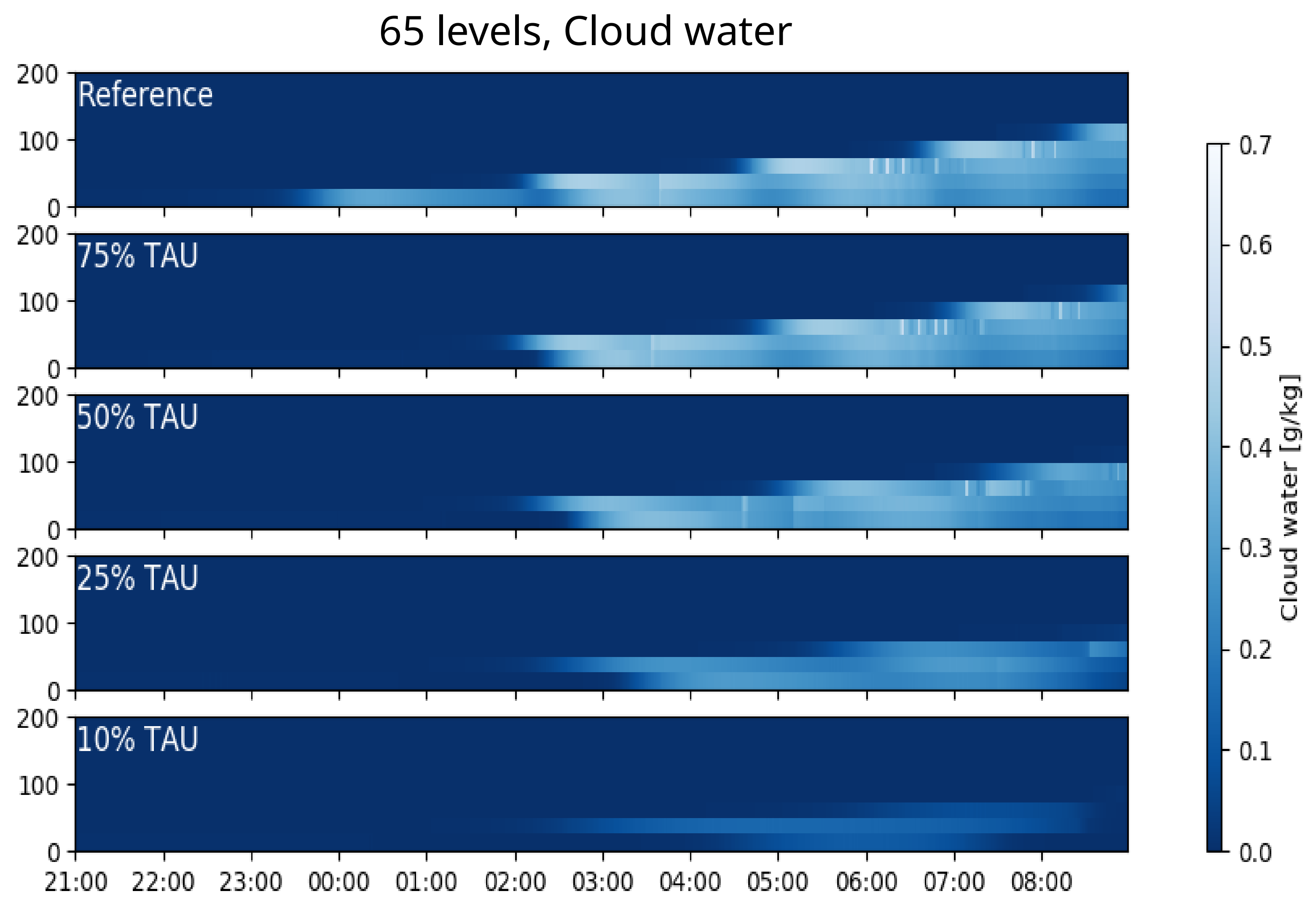
First results MUSC

Fog cools very quickly, up to 5 K/hr

90 layers does not solve problem in this case

CY43 has later development and smaller horizontal extent of fog, evaporation?

Chicken and egg question, cloud water causing too strong impact of longwave radiative cooling or longwave radiation causing too strong cooling leading to too much cloud water? Or both?

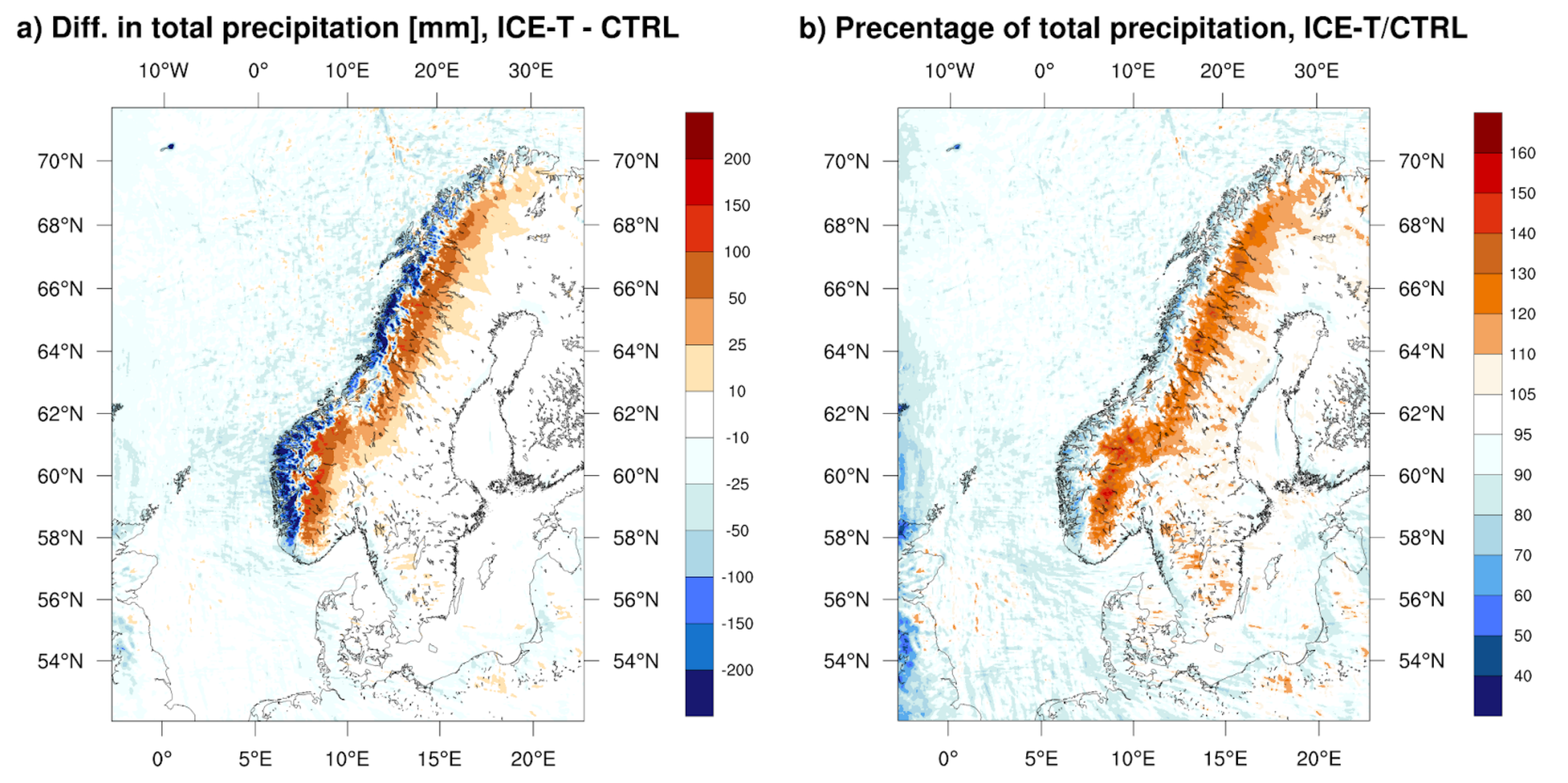

65 levels, Cloud water
Reference
75% TAU
50% TAU
25% TAU
10% TAU
200
100
0
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
Cloud water [g/kg]
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

Thompson scheme (Jenny Engdahl)

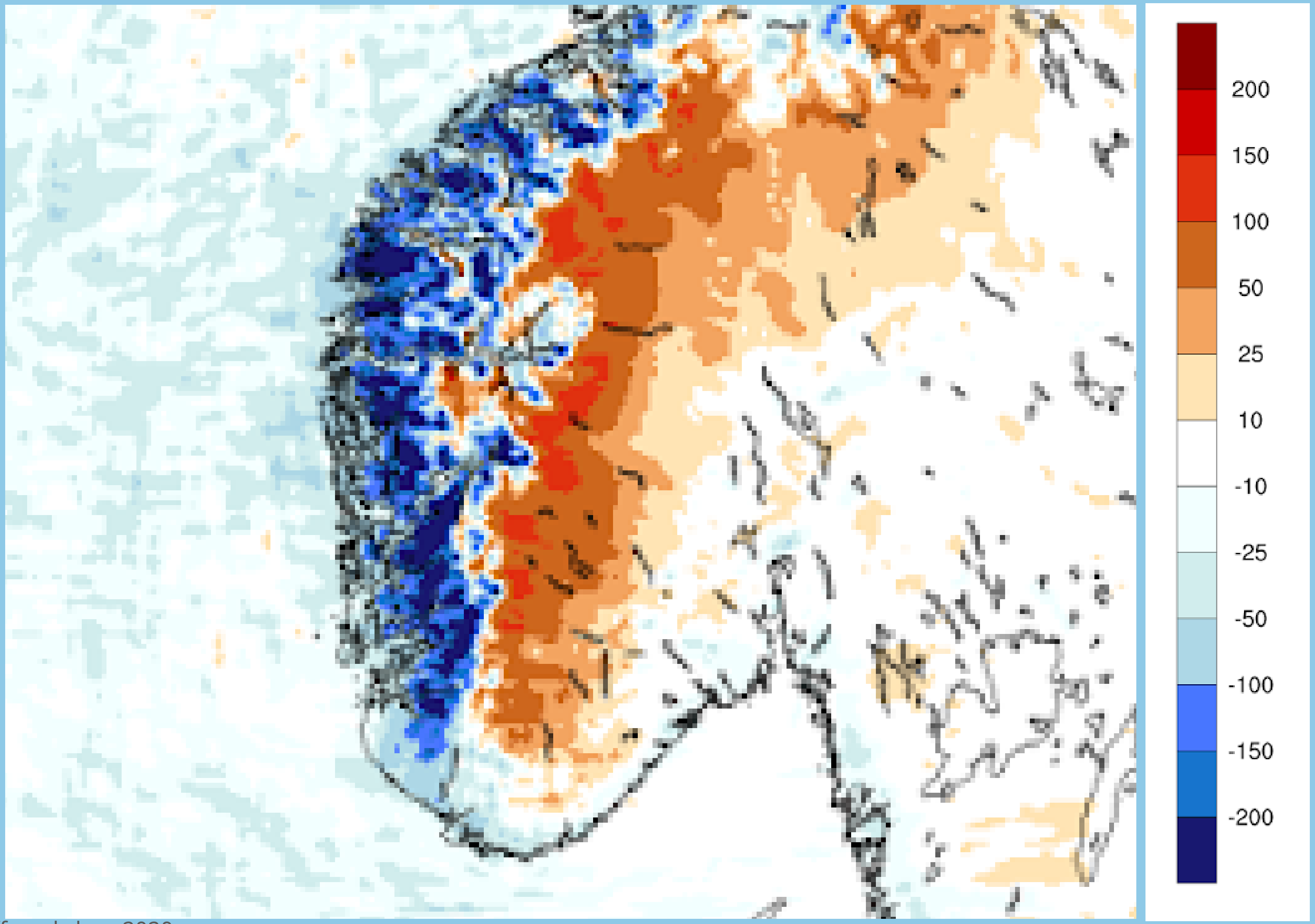
Thompson scheme elements implemented in ICE-3

Introduced to improve forecast of icing due to supercooled clouds on power lines

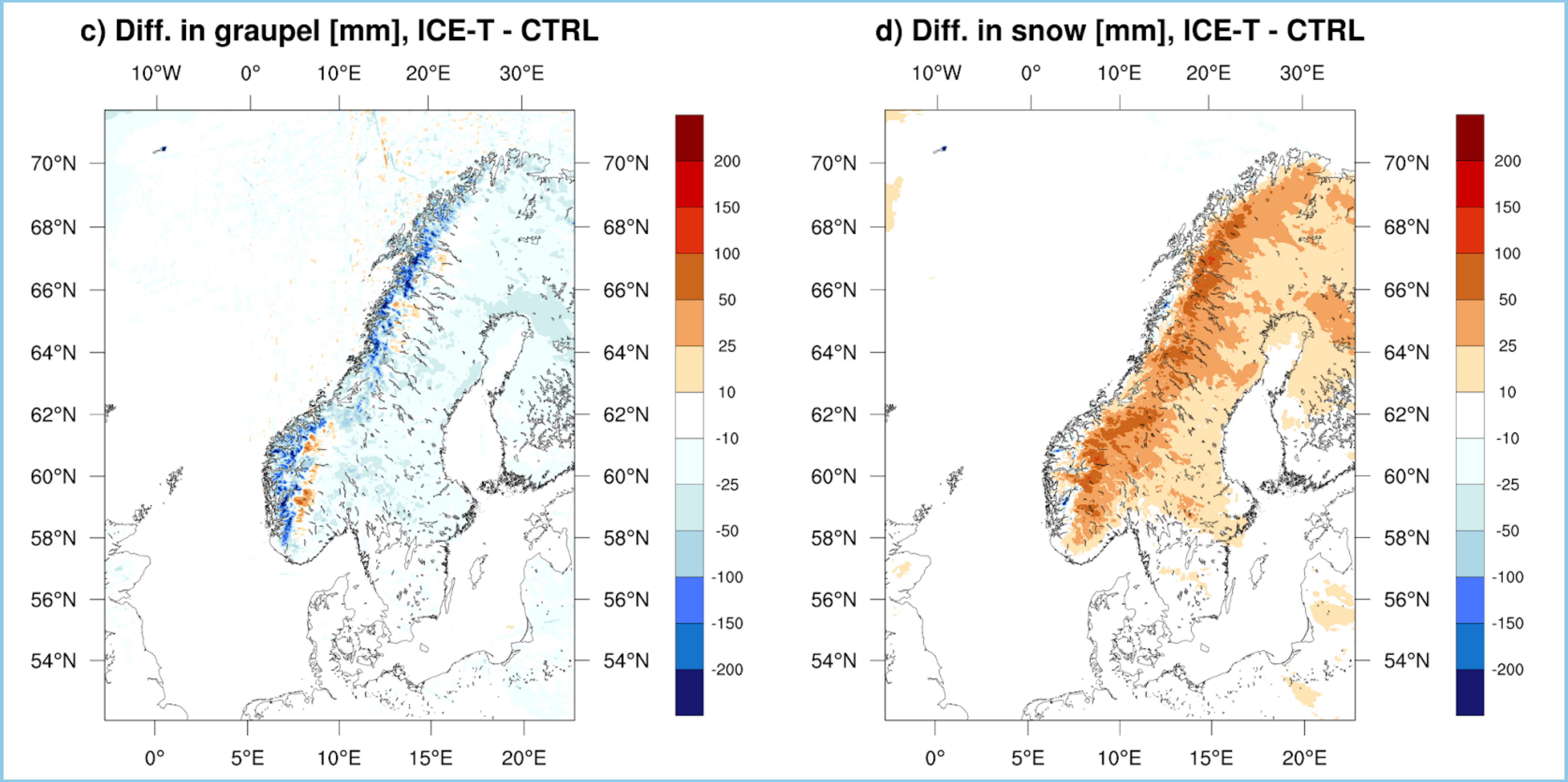
Significantly impacts the division of precipitation between snow and graupel, which has a big impact on the precipitation in mountainous areas.



a) Diff. in total precipitation [mm], ICE-T - CTRL
b) Precentage of total precipitation, ICE-T/CTRL
10°W
0°
10°E
20°E
30°E
70°N
68°N
66°N
64°N
62°N
60°N
58°N
56°N
54°N
5°E
15°E
200
150
100
50
25
10
-10
-25
-50
-100
-150
-200
160
140
130
120
110
105
95
90
80
70
60
40



200
150
100
50
25
10
-10
-25
-50
-100
-150
-200


c) Diff. in graupel [mm], ICE-T - CTRL
d) Diff. in snow [mm], ICE-T - CTRL
10°W
0°
10°E
20°E
30°E
70°N
68°N
66°N
64°N
62°N
60°N
58°N
56°N
54°N
5°E
15°E
200
150
100
50
25
10
-10
-25
-50
-100
-150
-200

Boundaries (Colm Clancy)

Initially AROME-AROME coupling

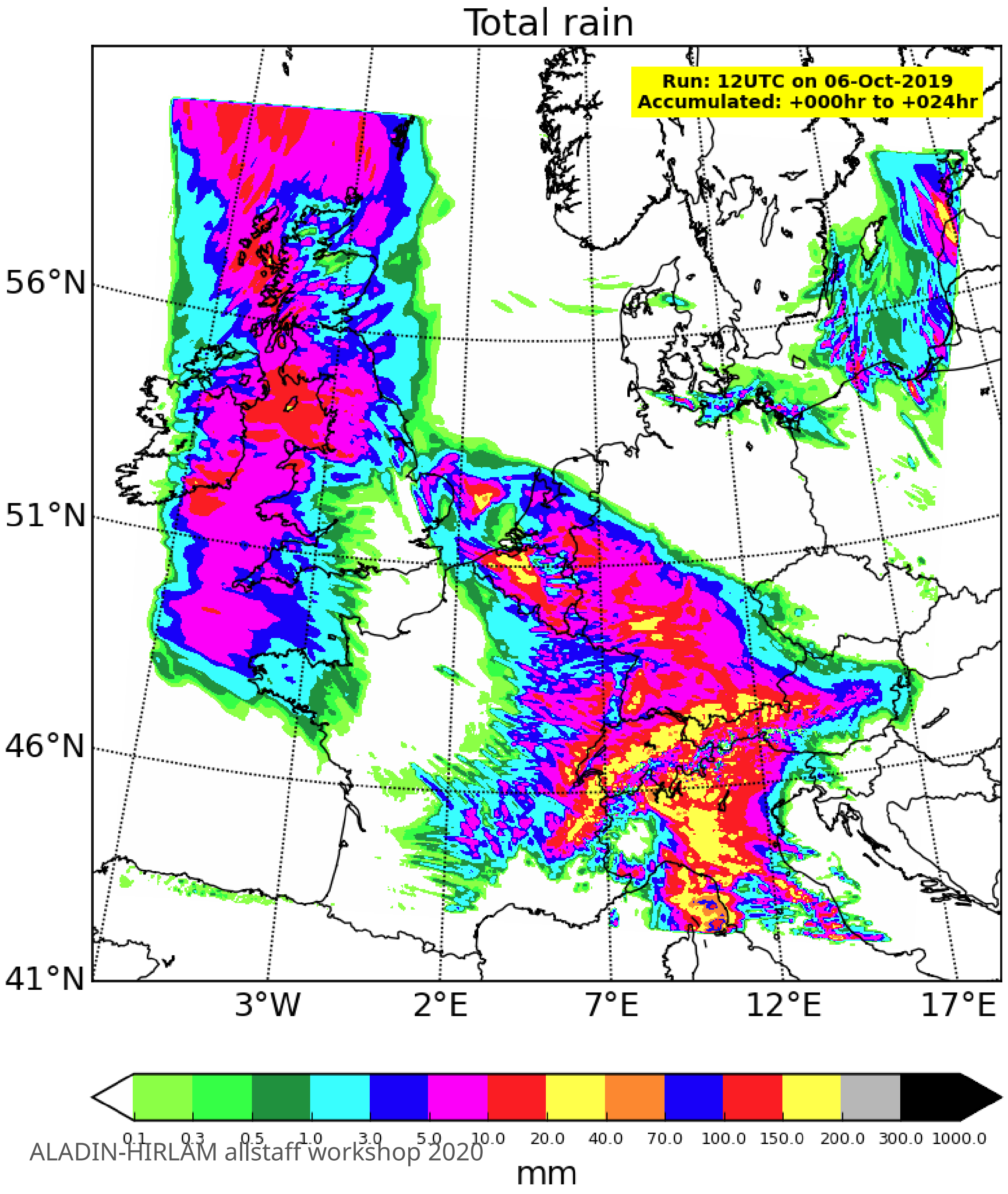
Small impact of coupling cloud water/ice in addition to specific humidity

Larger impact (almost no large scale precipitation spinup) when rain, snow and graupel are coupled

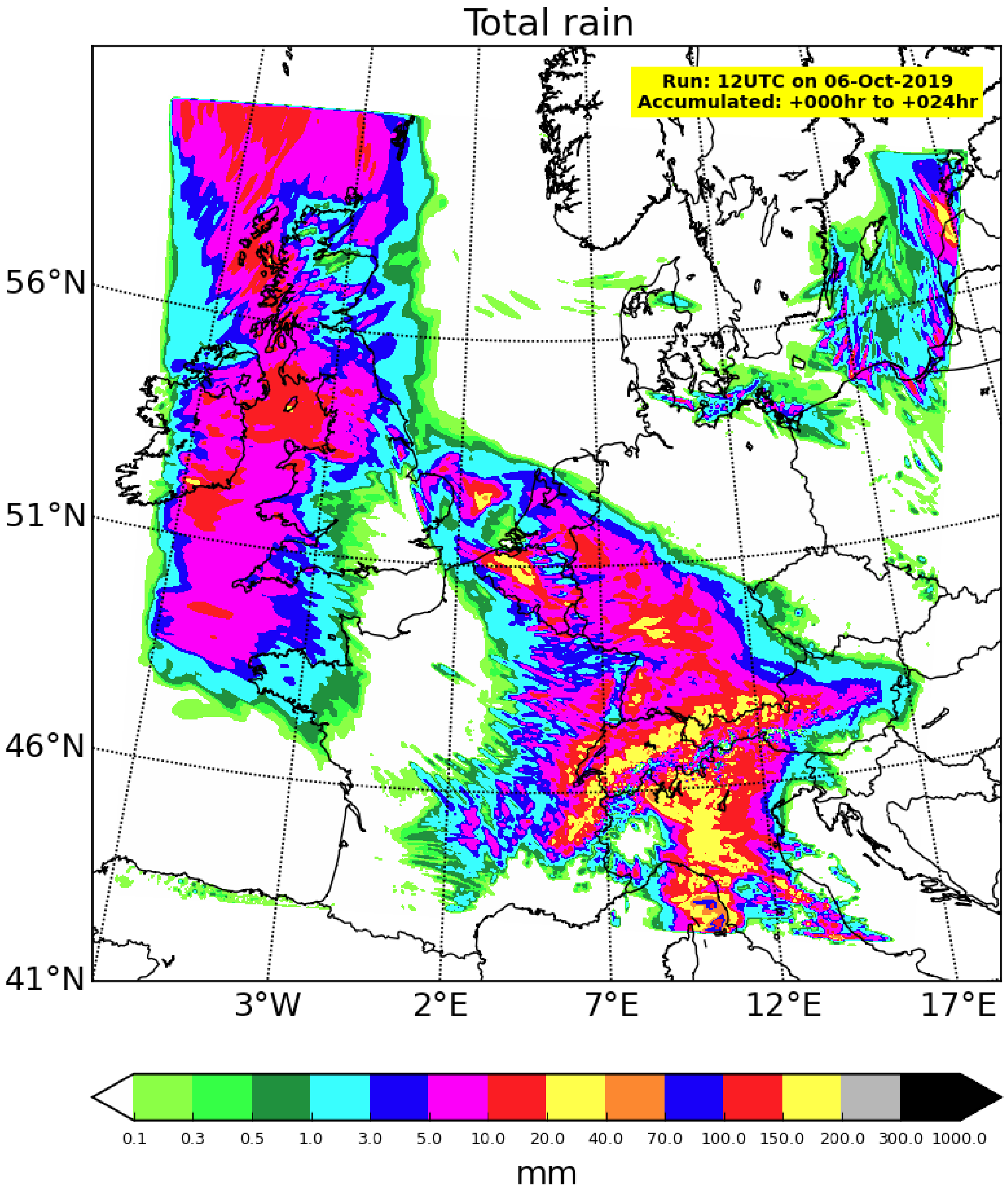
Similar impact found in IFS-AROME coupling of cloud water/ice as AROME-AROME coupling

Looking further into coupling of IFS large scale rain and snow

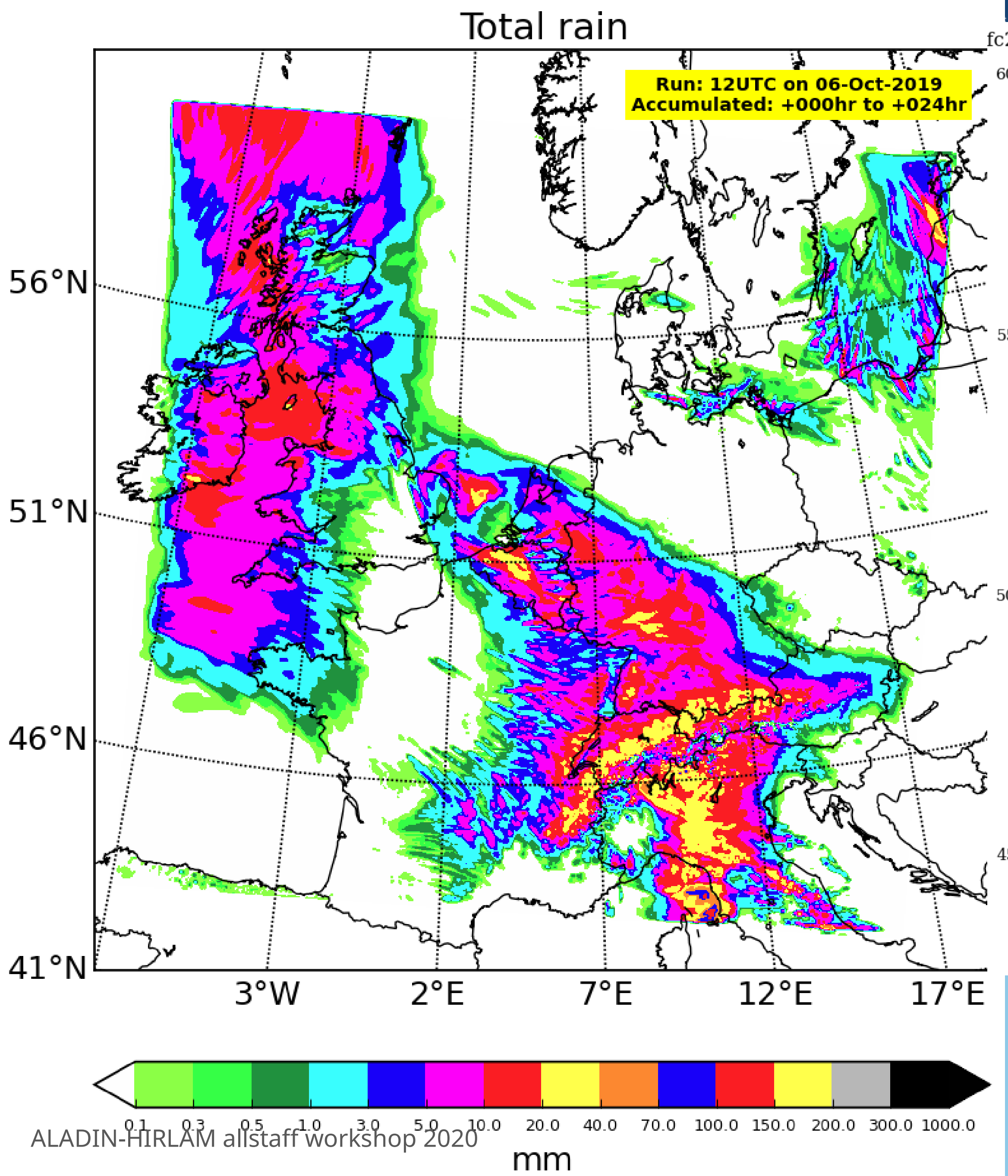
Different impact for convection (other placement) and large scale precipitation (quicker start from boundary).

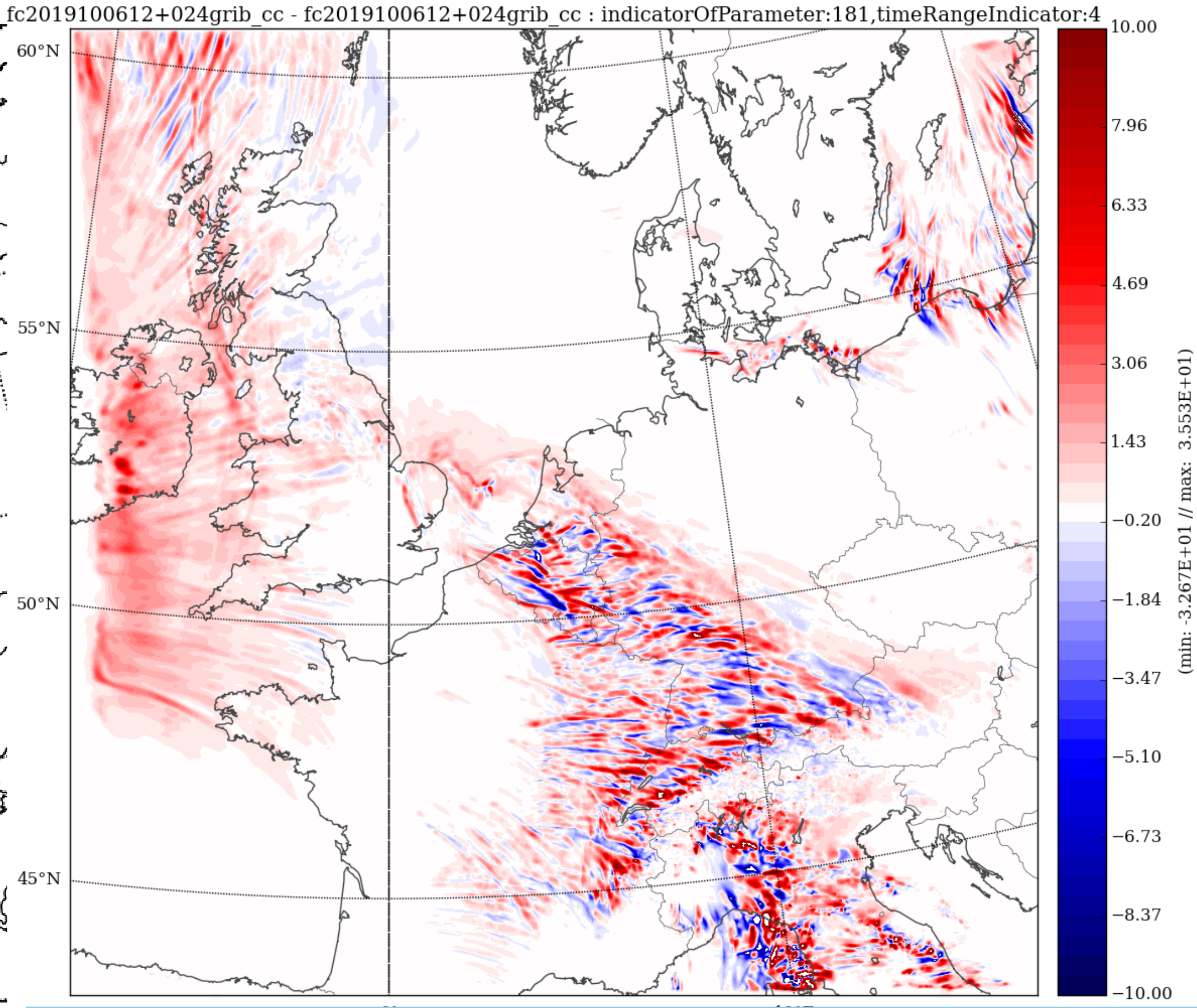


Total rain
Run: 12UTC on 06-Oct-2019
Accumulated: +000hr to +024hr
56°N
51°N
46°N
41°N
3°W
2°E
7°E
12°E
17°E
0.1 0.3 0.5 1.0 3.0 5.0 10.0 20.0 40.0 70.0 100.0 150.0 200.0 300.0 1000.0
mm



Total rain
Run: 12UTC on 06-Oct-2019
Accumulated: +000hr to +024hr
56°N
51°N
46°N
41°N
3°W
2°E
7°E
12°E
17°E
0.1 0.3 0.5 1.0 3.0 5.0 10.0 20.0 40.0 70.0 100.0 150.0 200.0 300.0 1000.0
mm


Total rain
Run: 12UTC on 06-Oct-2019
Accumulated: +000hr to +024hr
56°N
51°N
46°N
41°N
3°W
2°E
7°E
12°E
17°E
0.1
0.3
0.5
1.0
3.0
5.0
10.0
20.0
40.0
70.0
100.0
150.0
200.0
300.0
1000.0
mm


fc2019100612+024grib_cc - fc2019100612+024grib_cc : indicatorOfParameter:181,timeRangeIndicator:4
60°N
55°N
50°N
45°N
10.00
7.96
6.33
4.69
3.06
1.43
−0.20
−1.84
−3.47
−5.10
−6.73
−8.37
−10.00
(min: -3.267E+01 // max: 3.553E+01)

Updraft Helicity (Amélie Sterlé)

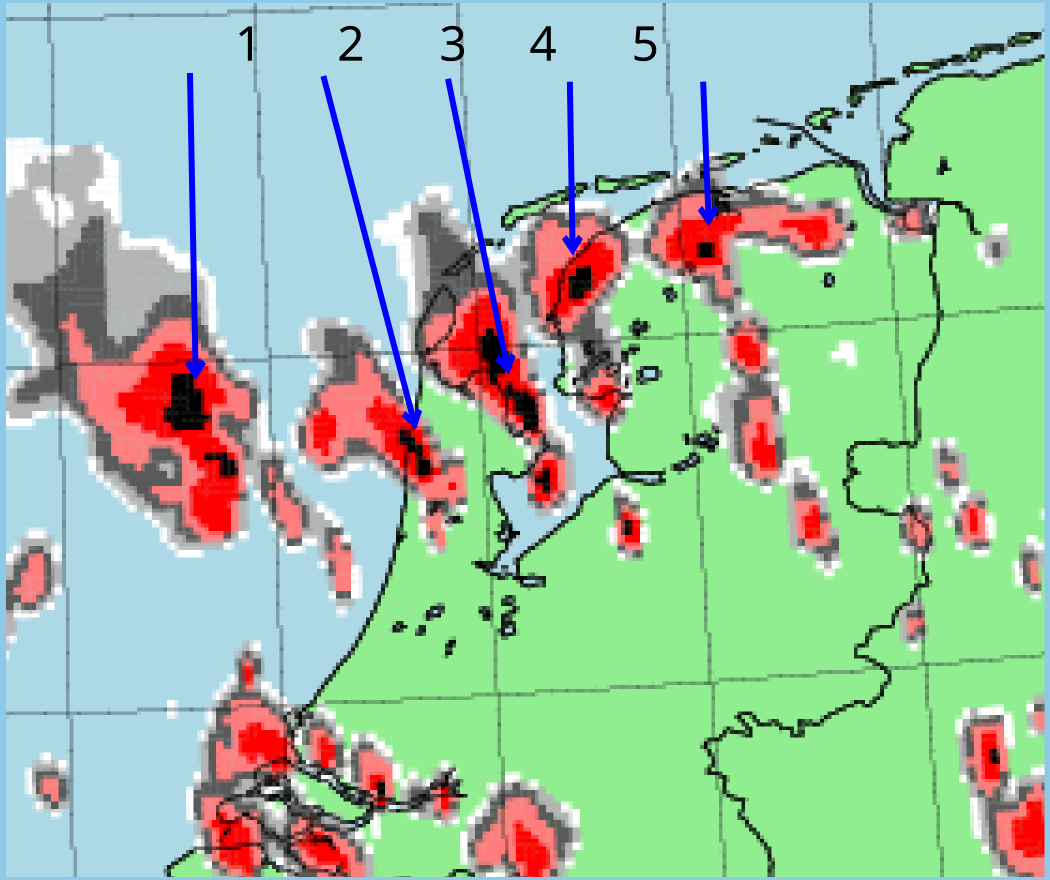
- HARMONIE-AROME at 2.5 km too coarse to resolve meso-vortex and tornadoes

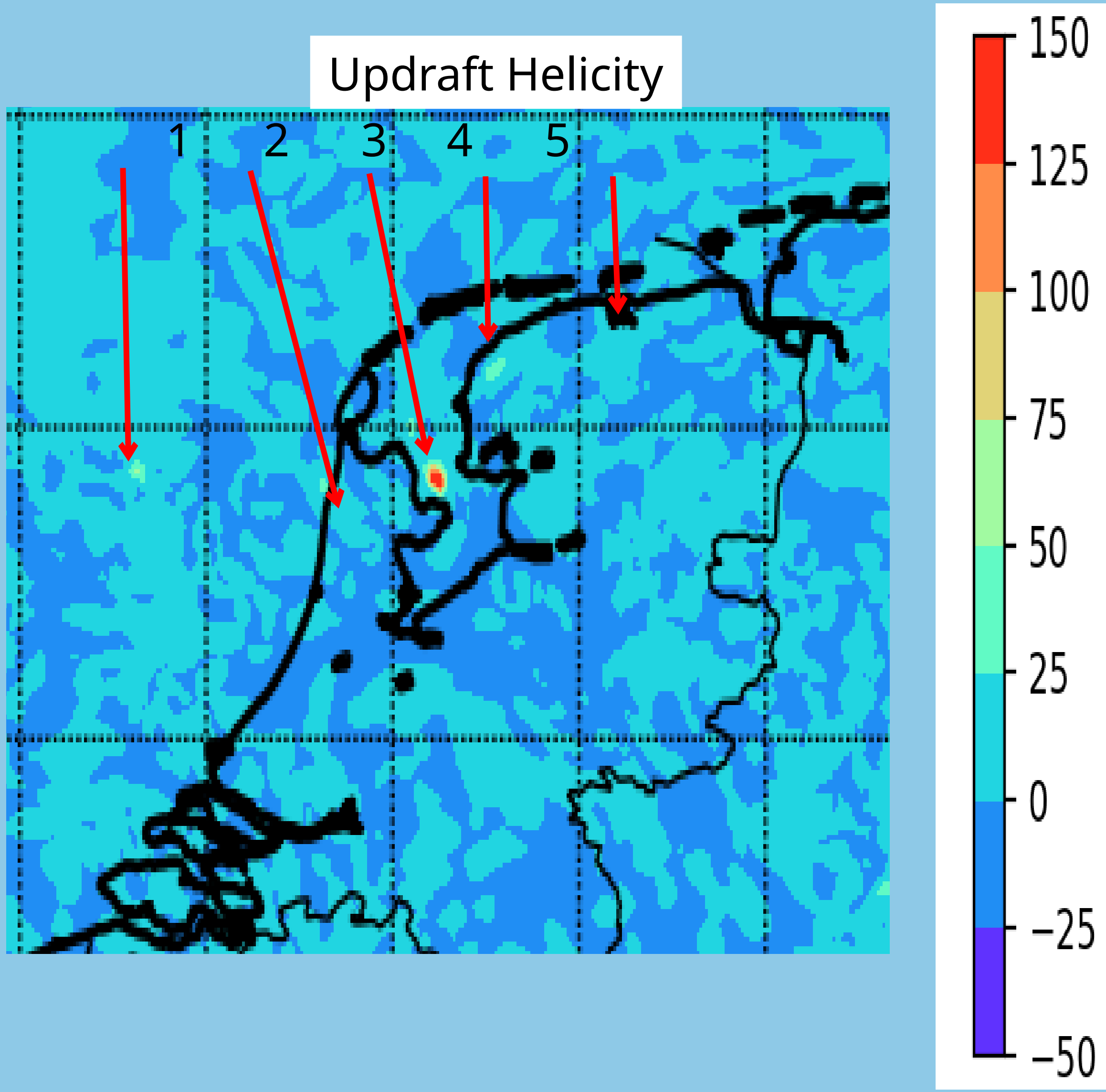
- Storm relative helicity in convection parameterizing models indicator of possibility of tornadoes

- Convection permitting models resolve meso-vortex partially

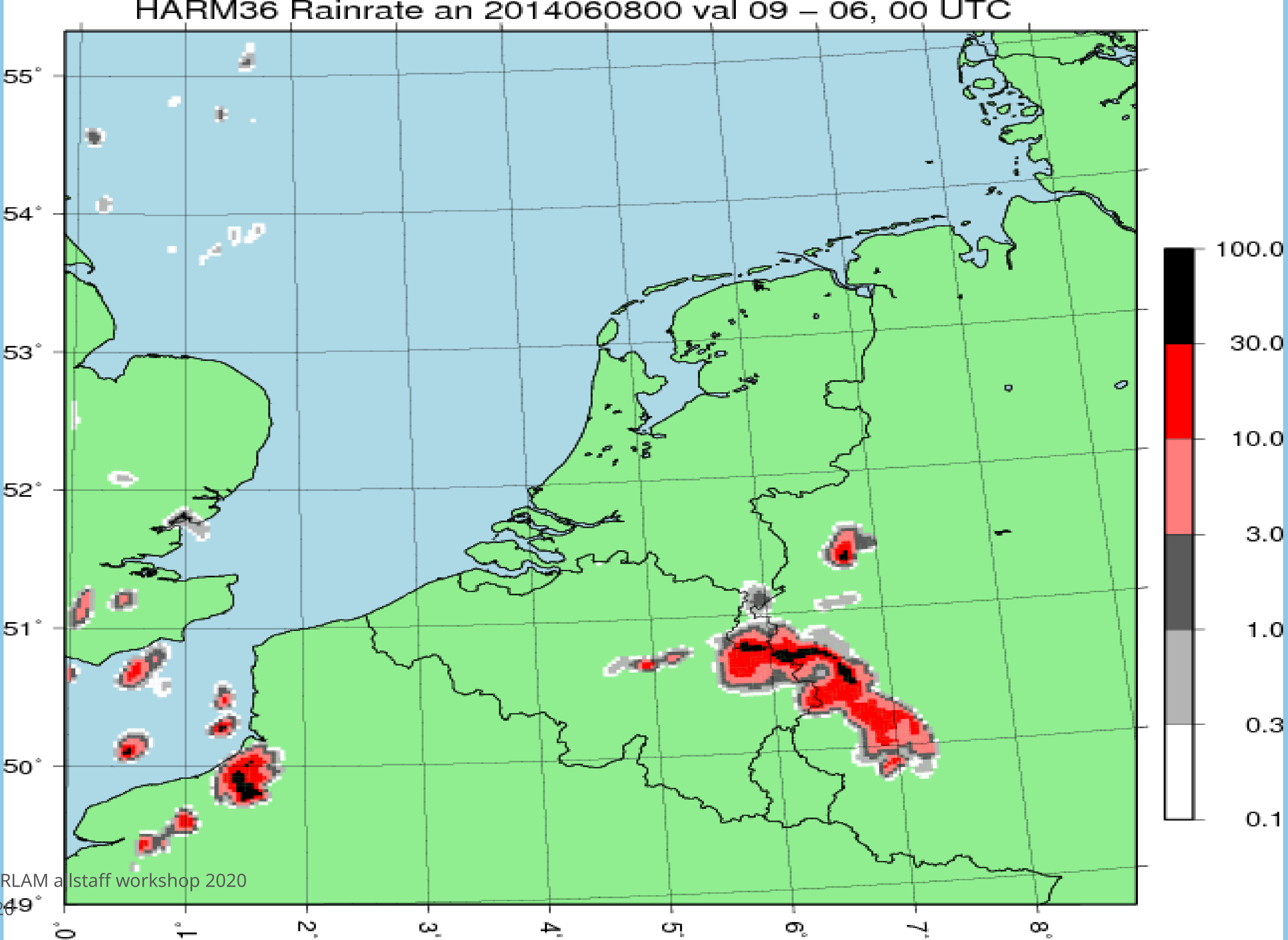
- Updraft helicity (UH) highlights rotating columns

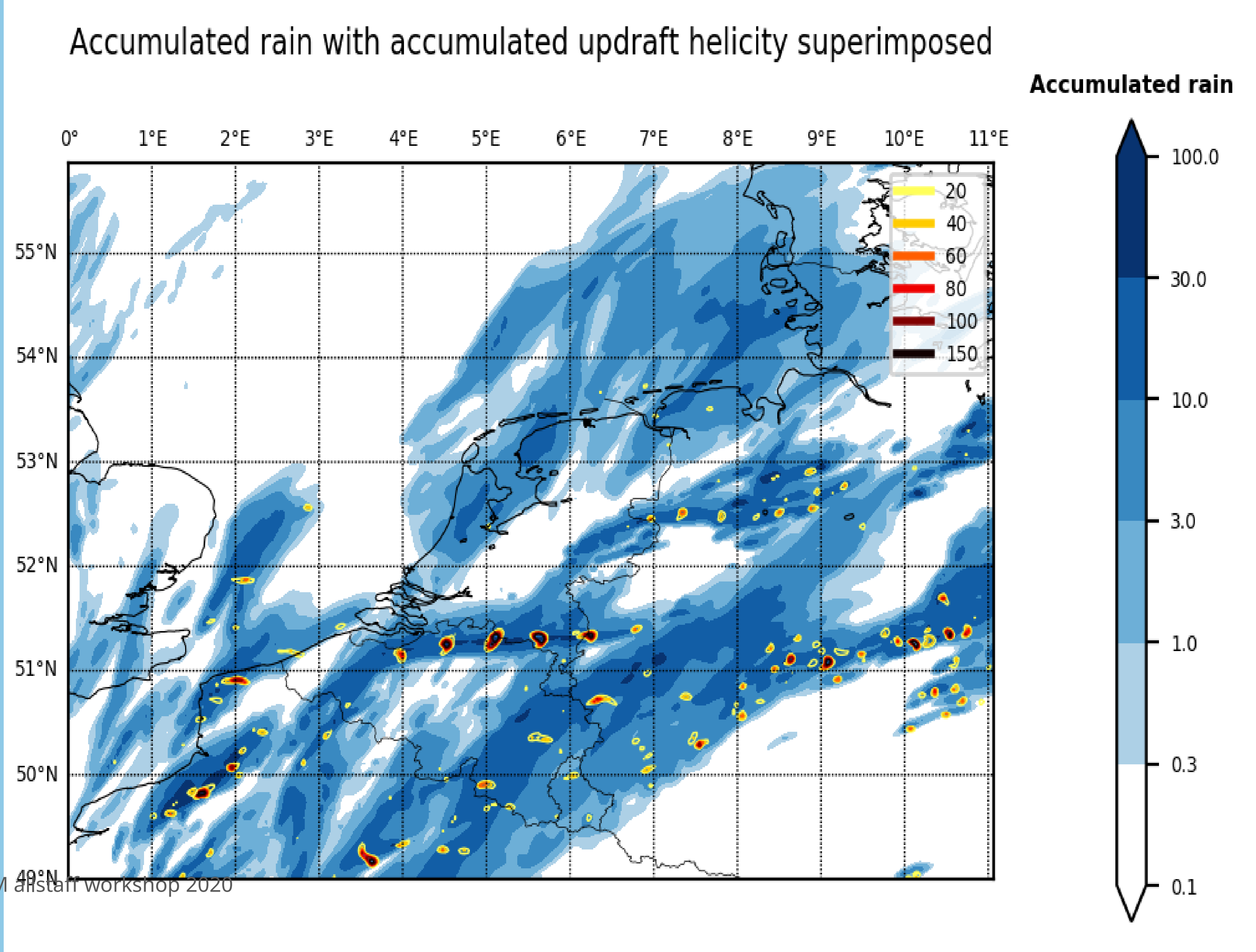
- UH = integral of (vorticity * vertical velocity)
- 850->500 hPa (850, 700, 600, 500 hPa)


1
2
3
4
5


Updraft Helicity
1
2
3
4
5
150
125
100
75
50
25
0
−25
−50

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

Conclusions

Fog problems better understood, now some handles to work on improvement

MUSC more flexible and easier to use

Thompson scheme gives strongly different precipitation distributions in mountainous areas, may help with underestimation of precip in valleys

Including all hydrometeors at boundaries necessary to reduce spinup of precipitation at boundary

Postprocessing of Updraft Helicity may help in forecasting of tornadoes