Probabilistic Nowcasting: Insight into a global-based and an object-based approach

4th RealPEP Project Meeting

Ricardo Reinoso-Rondinel, Martin Rempel, Markus Schultze, Silke Trömel, and Clemens Simmer

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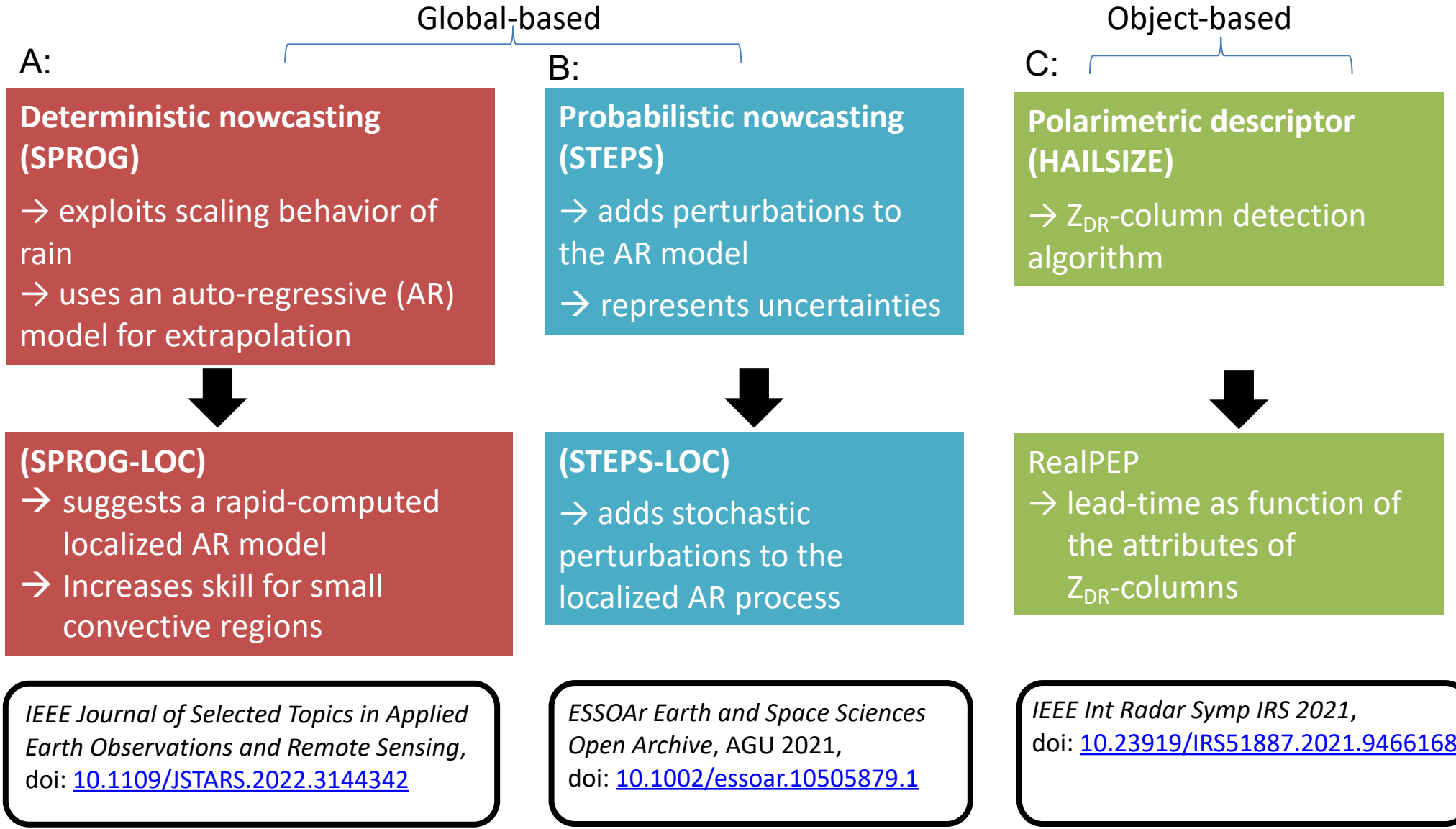
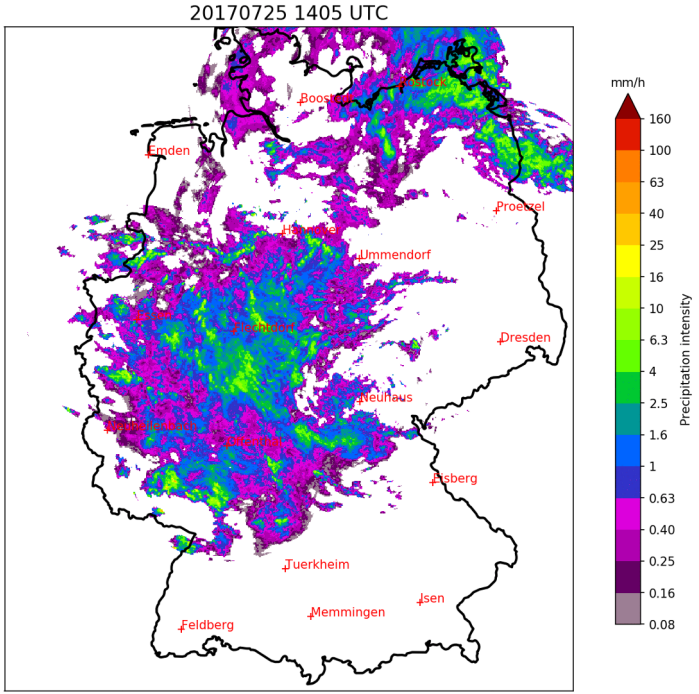

Global-based
Object-based
A:
B:
C:
Deterministic nowcasting (SPROG)
→ exploits scaling behavior of rain
→ uses an auto-regressive (AR) model for extrapolation
Probabilistic nowcasting (STEPS)
→ adds perturbations to the AR model
→ represents uncertainties
Polarimetric descriptor (HAILSIZE)
→ Z_{DR}-column detection algorithm
(SPROG-LOC)
→ suggests a rapid-computed localized AR model
→ Increases skill for small convective regions
(STEPS-LOC)
→ adds stochastic perturbations to the localized AR process
RealPEP
→ lead-time as function of the attributes of Z_{DR}-columns
IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, doi: 10.1109/JSTARS.2022.3144342
ESSOAr Earth and Space Sciences Open Archive, AGU 2021, doi: 10.1002/essoar.10505879.1
IEEE Int Radar Symp IRS 2021, doi: 10.23919/IRS51887.2021.9466168

Global-based nowcasting

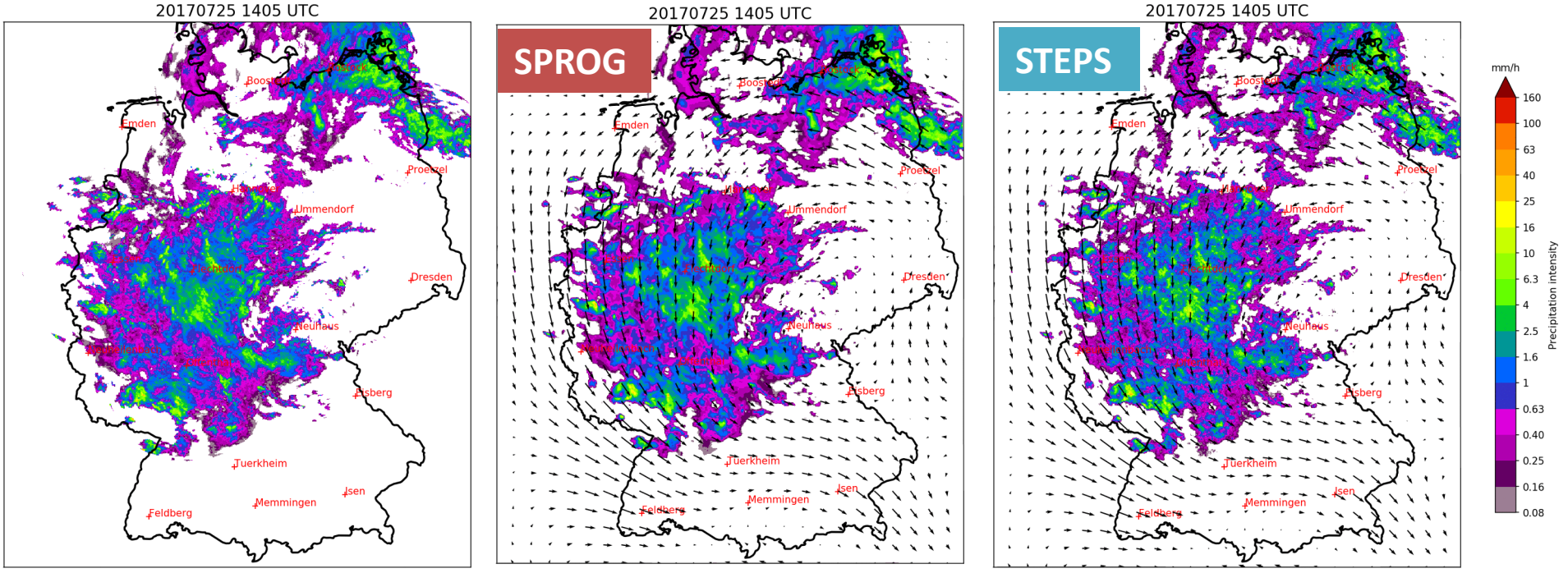
Observation of Precipitation



Global-based nowcasting

Observation of Precipitation

Nowcasting of Precipitation



Optical-flow
AR(1) extrapolation model

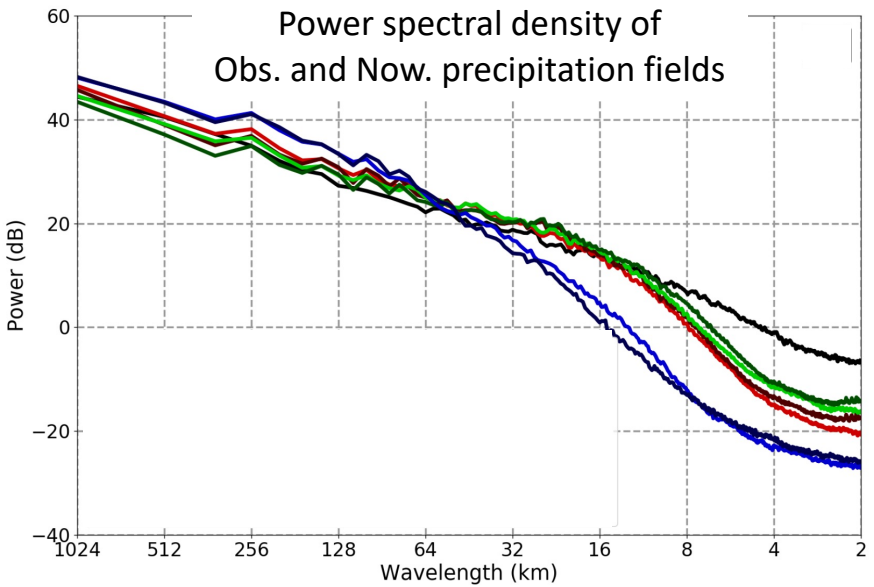
Stochastic perturbation of the
AR(1) extrapolation model

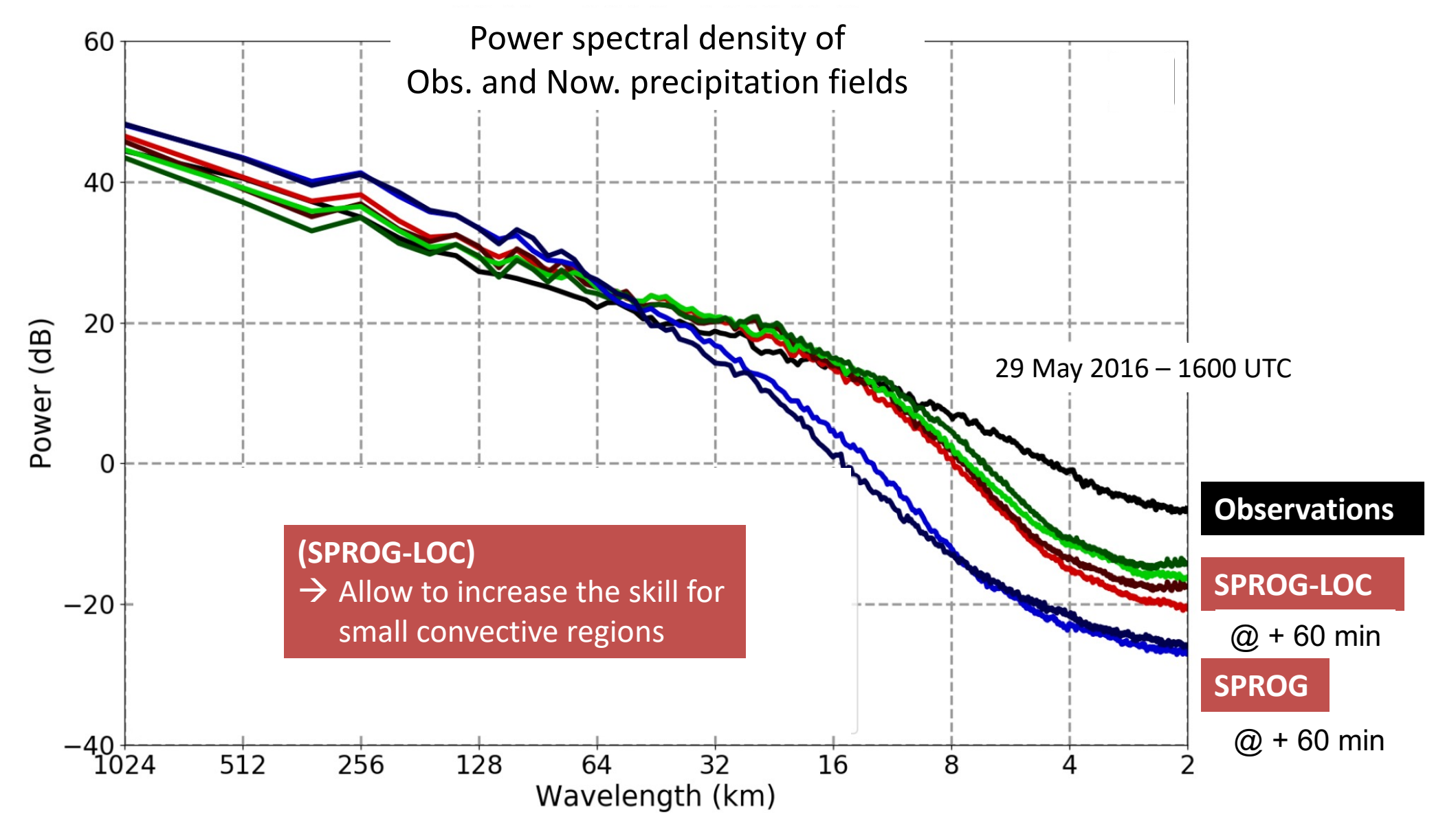
A: SPROG → SPROG-LOC

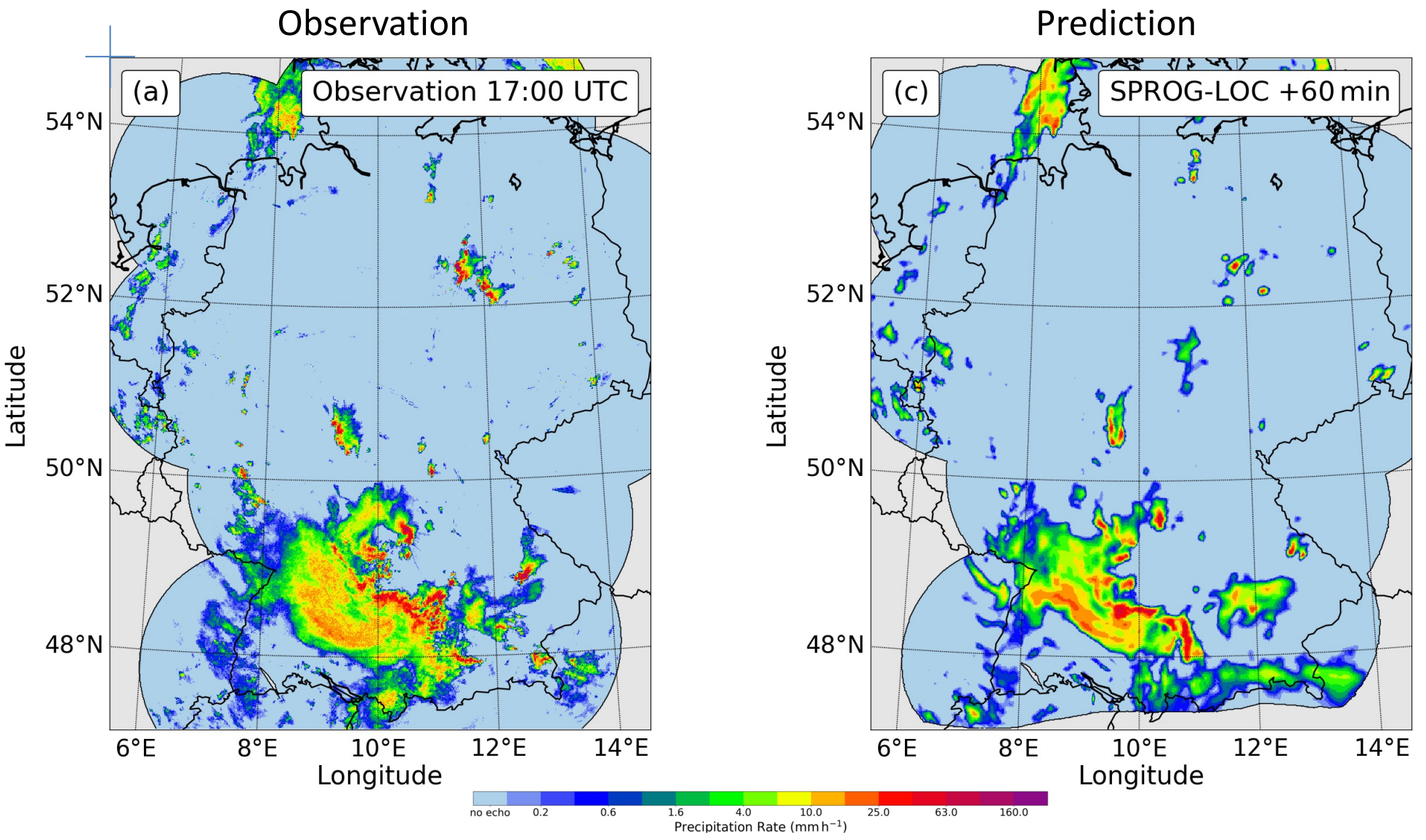
(SPROG-LOC)

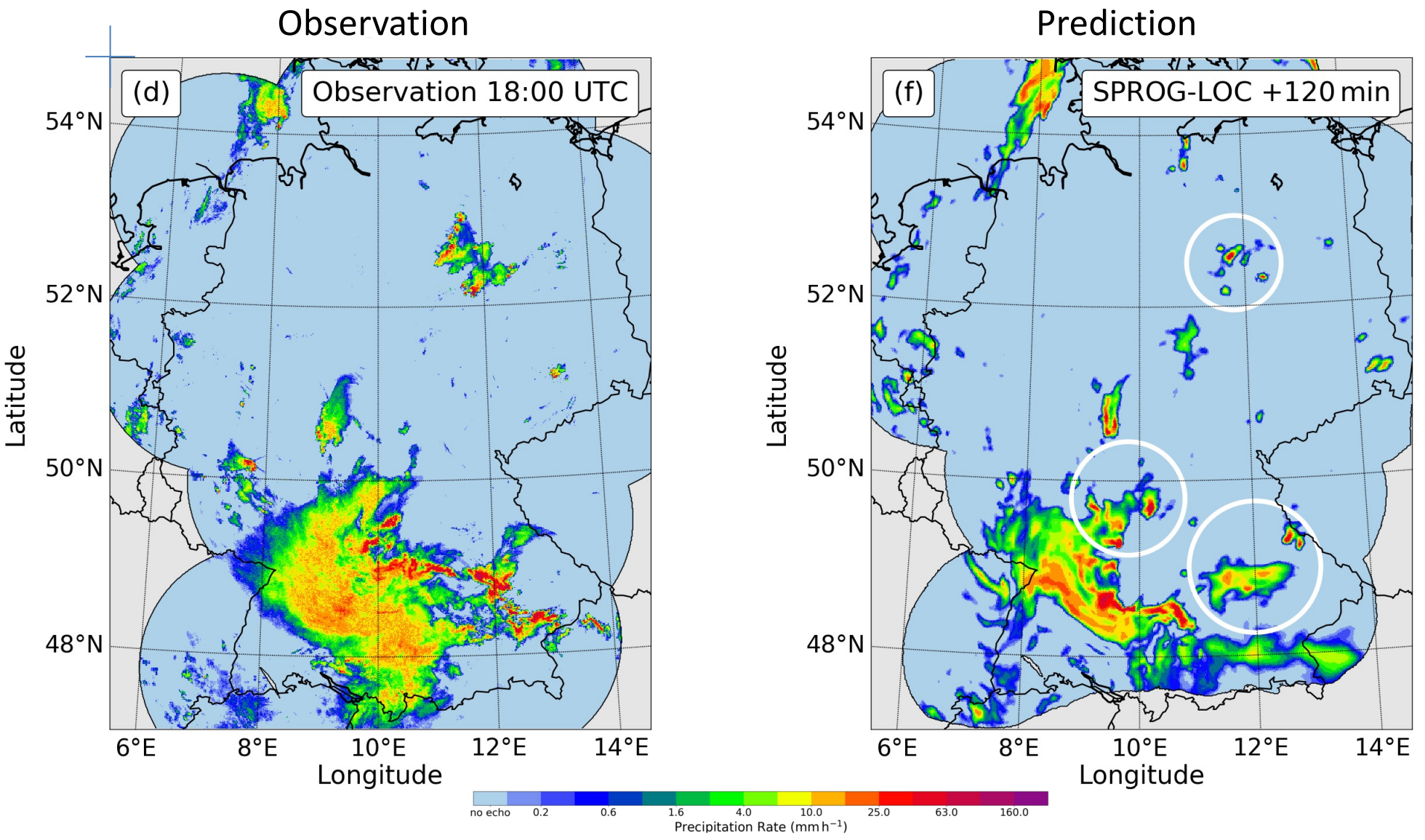
→ A rapid-computed spatially localized AR model

→ The auto-regression is controlled by 2-D coefficients (adaptive filtering)



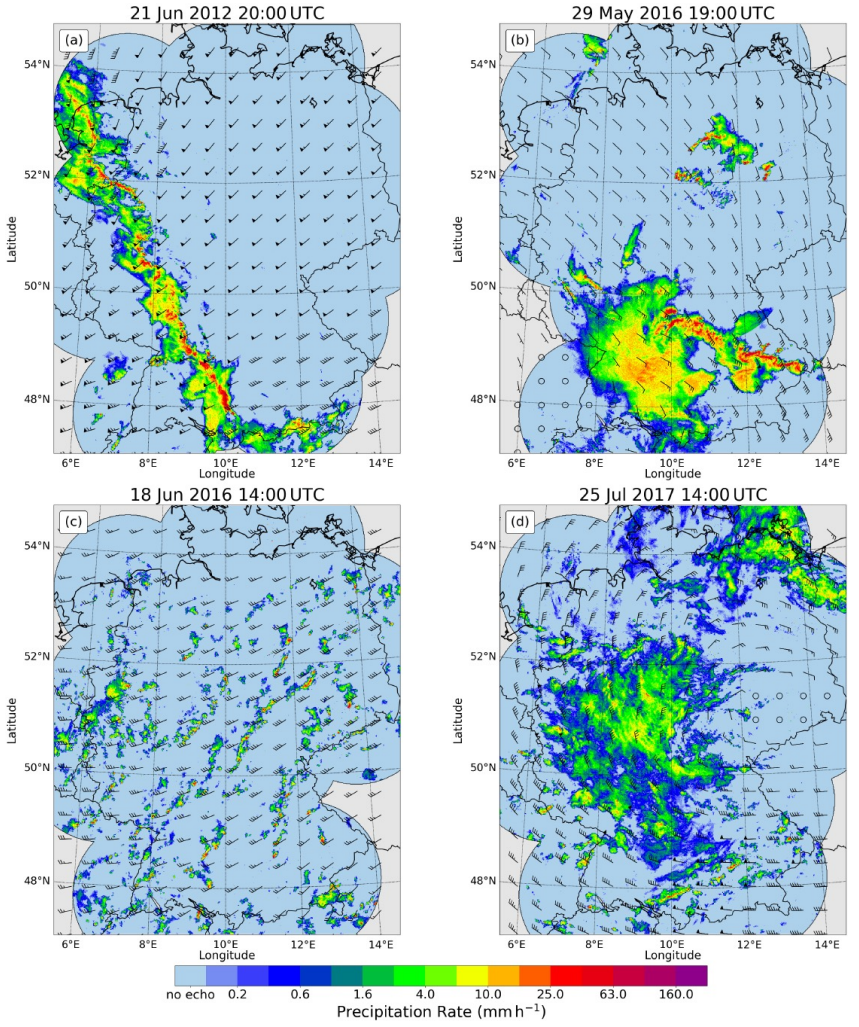

Power spectral density of
Obs. and Now. precipitation fields
29 May 2016 – 1600 UTC
Power (dB)
60
40
20
0
−20
−40
1024
512
256
128
64
32
16
8
4
2
Wavelength (km)
(SPROG-LOC)
→ Allow to increase the skill for small convective regions
Observations
SPROG-LOC
@ + 60 min
SPROG
@ + 60 min


Observation
Prediction
(a)
Observation 17:00 UTC
(c)
SPROG-LOC +60 min
54°N
52°N
50°N
48°N
Latitude
6°E
8°E
10°E
12°E
14°E
Longitude
no echo
0.2
0.6
1.6
4.0
10.0
25.0
63.0
160.0
Precipitation Rate (mm h^{-1})

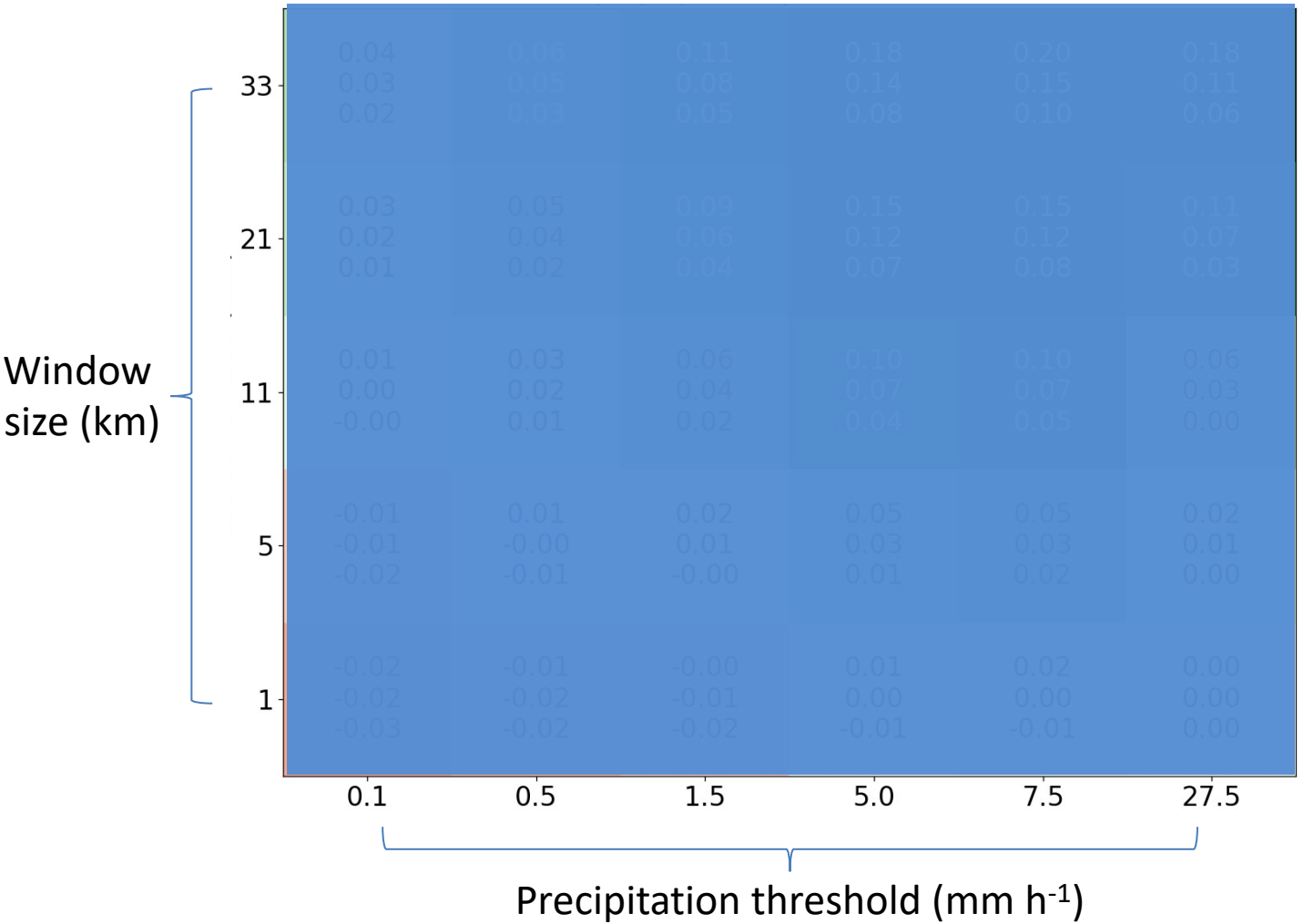

Observation
Prediction
(d)
Observation 18:00 UTC
(f)
SPROG-LOC +120 min
54°N
52°N
50°N
48°N
Latitude
6°E
8°E
10°E
12°E
14°E
Longitude
no echo
0.2
0.6
1.6
4.0
10.0
25.0
63.0
160.0
Precipitation Rate (mm h^{-1})

Evaluation of the SPROG-LOC model

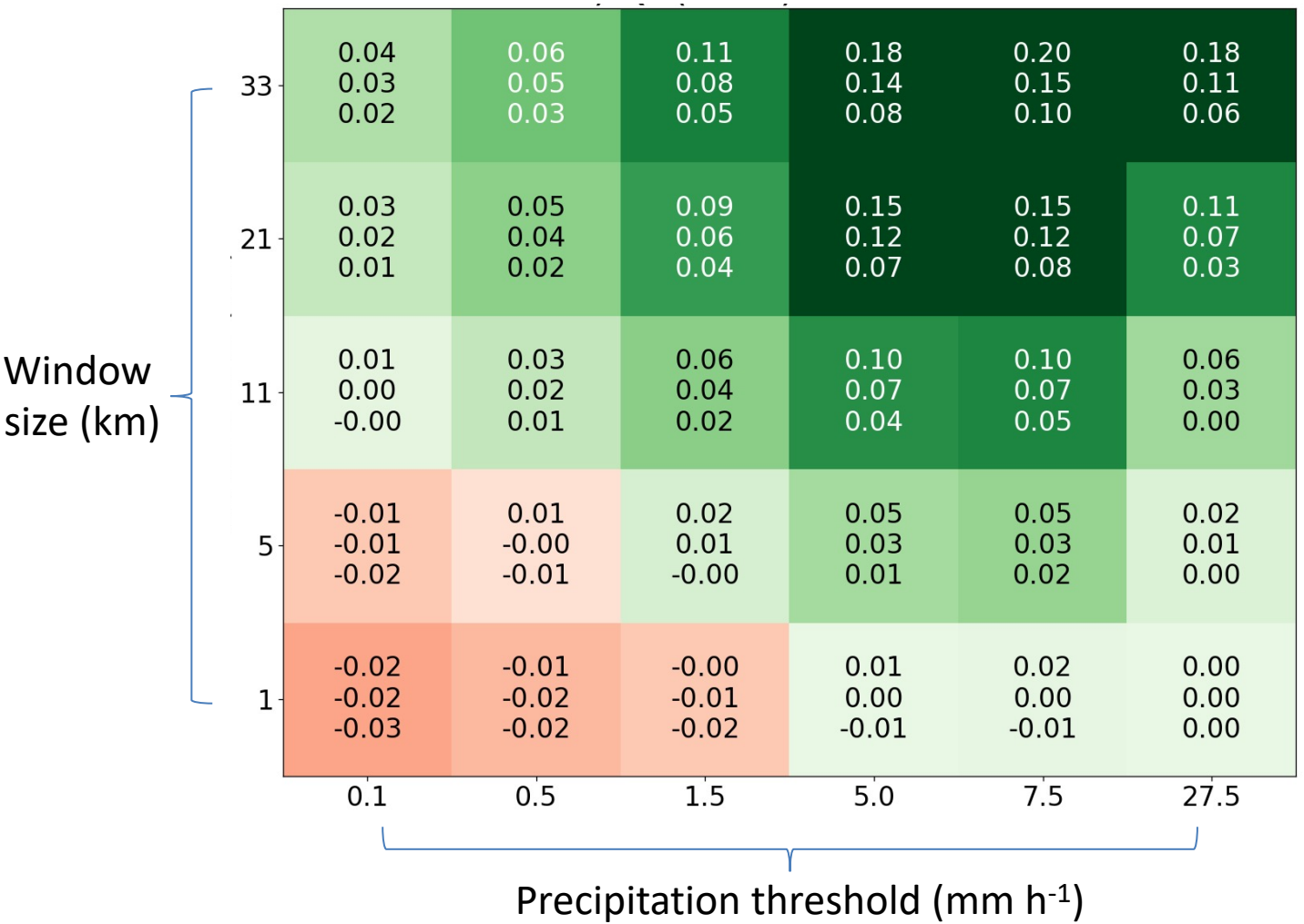
Event	Date
E1	21 Jun 2012
E2	20 Jun 2013
E3	06 Aug 2013
E4	29 May 2016
E5	01 Jun 2016
E6	04 Jun 2016
E7	18 Jun 2016
E8	25 Jun 2016
E9	19 Jul 2017
E10	25 Jul 2017



Evaluation of the SPROG-LOC model



Evaluation of the SPROG-LOC model



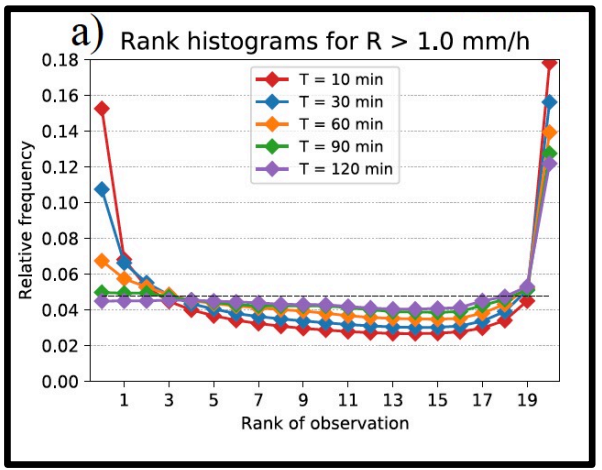
Q1, Q2, and Q3 of CSI(SPROG-LOC) – CSI(SPROG) at 60 min lead-time

B: **STEPS** → **STEPS-LOC**

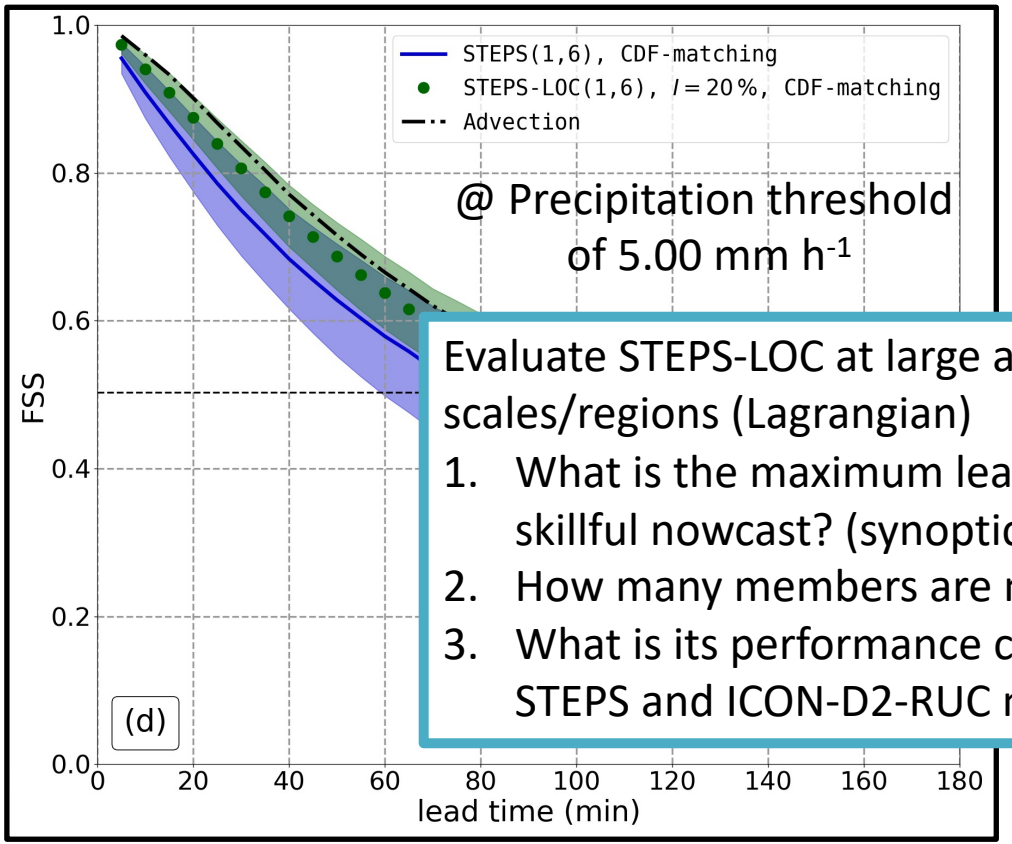
To what degree are uncertainties well represented?

(STEPS-LOC)→ adds stochastic perturbations to the localized AR process

RealPEP event on 19 July 2017



Ensemble members are not dispersive enough in convection

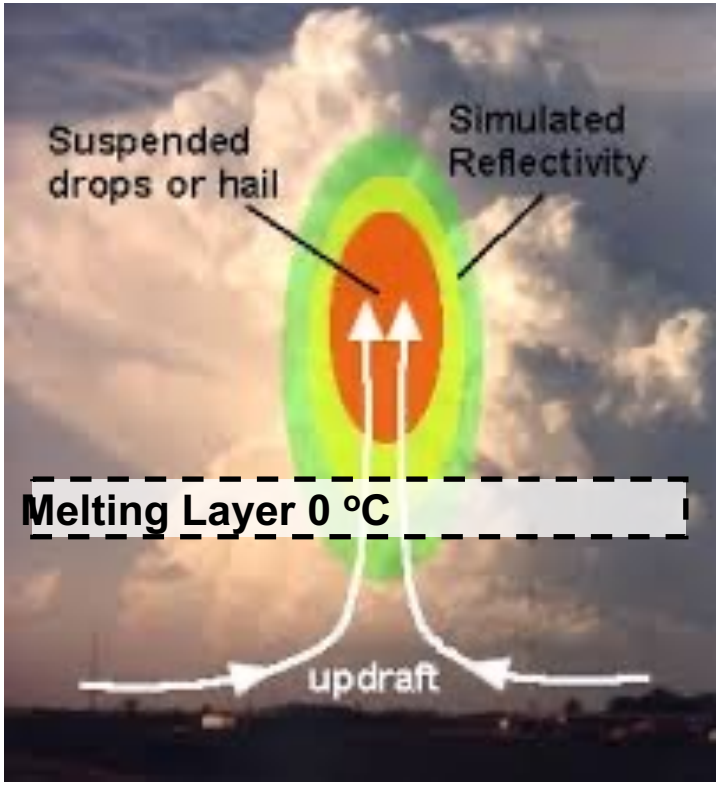


Evaluate STEPS-LOC at large and small scales/regions (Lagrangian)

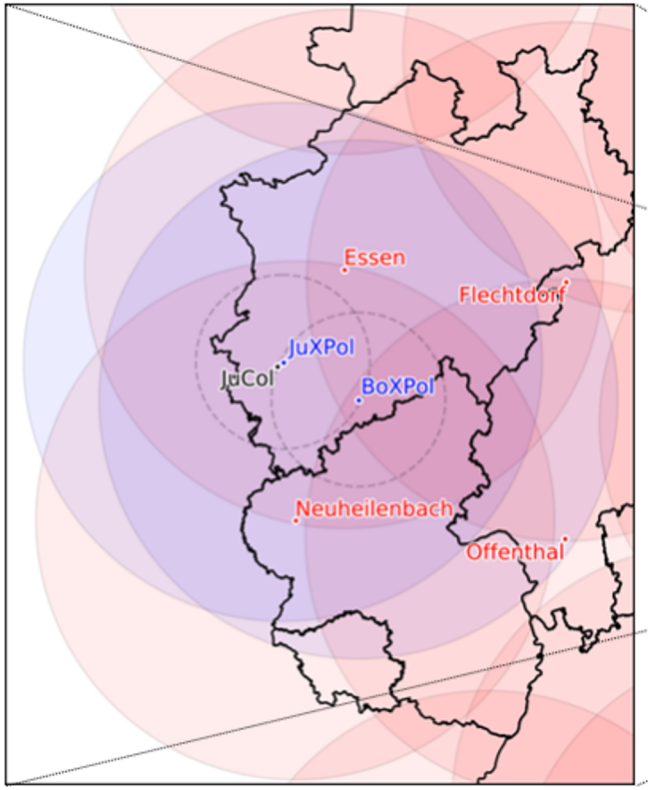
1. What is the maximum lead-time to obtain skillful nowcast? (synoptic situation)
2. How many members are needed?
3. What is its performance compared to the STEPS and ICON-D2-RUC models? (hourly)

C:

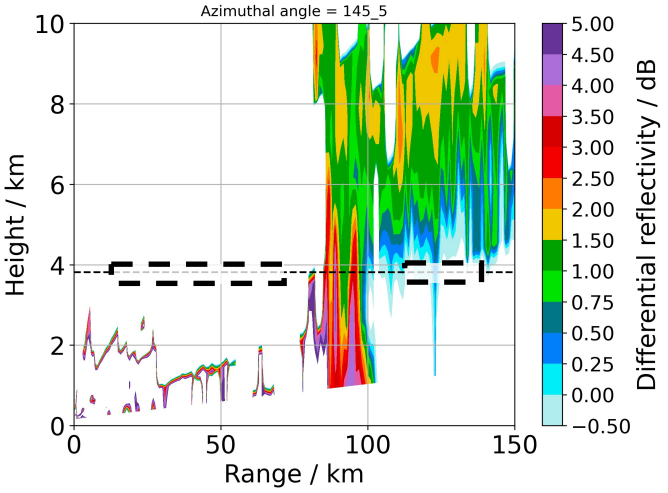
HAILSIZE (ZDR-Columns) → RealPEP (ZDR-Columns)

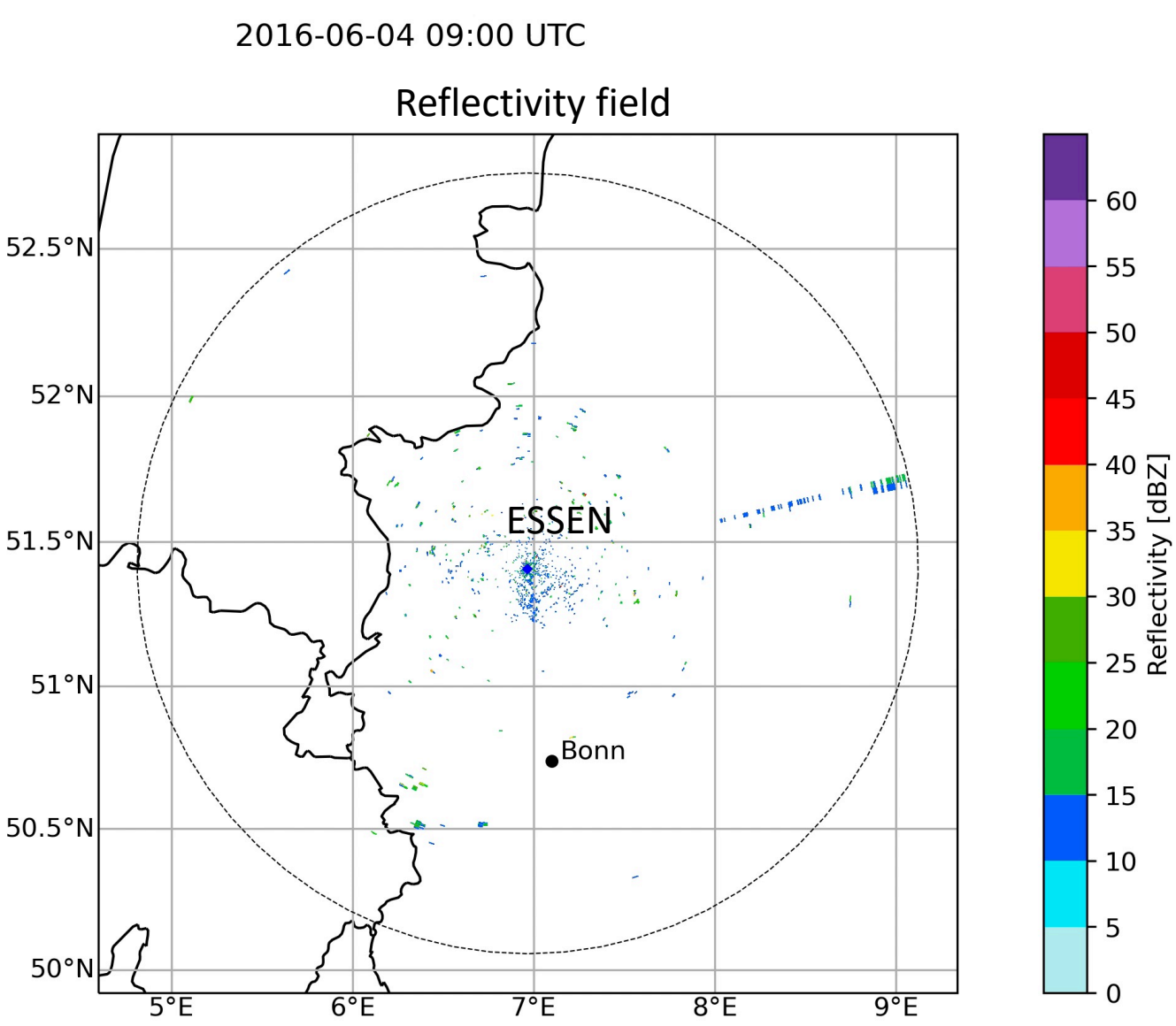


https://www.noaa.gov/

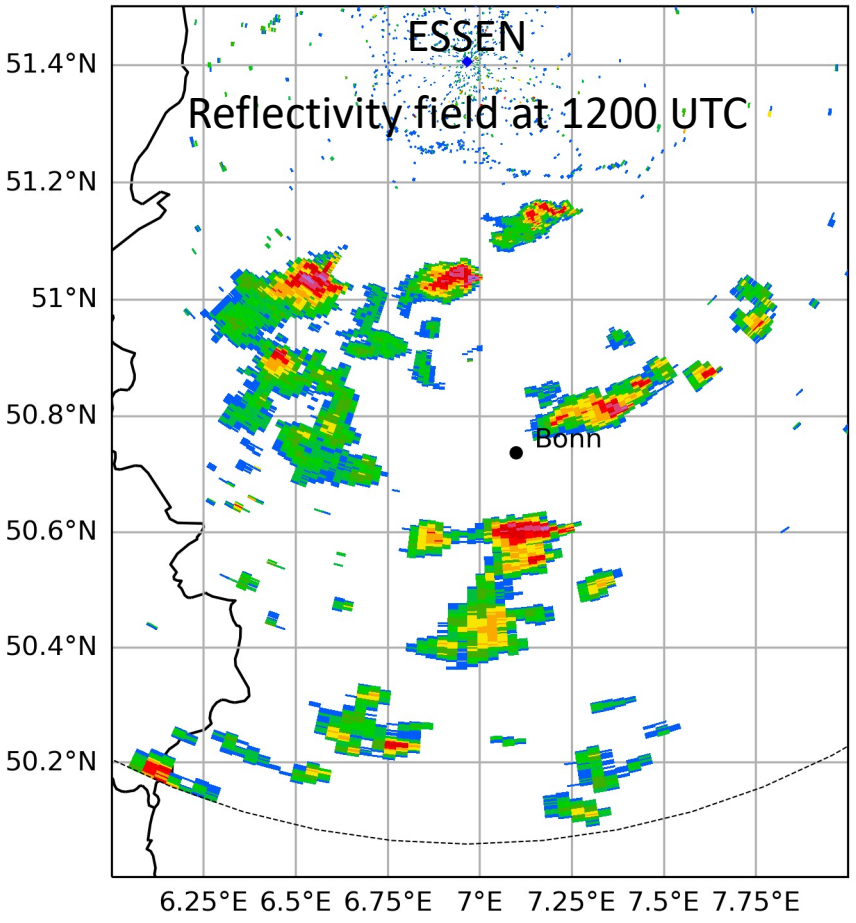


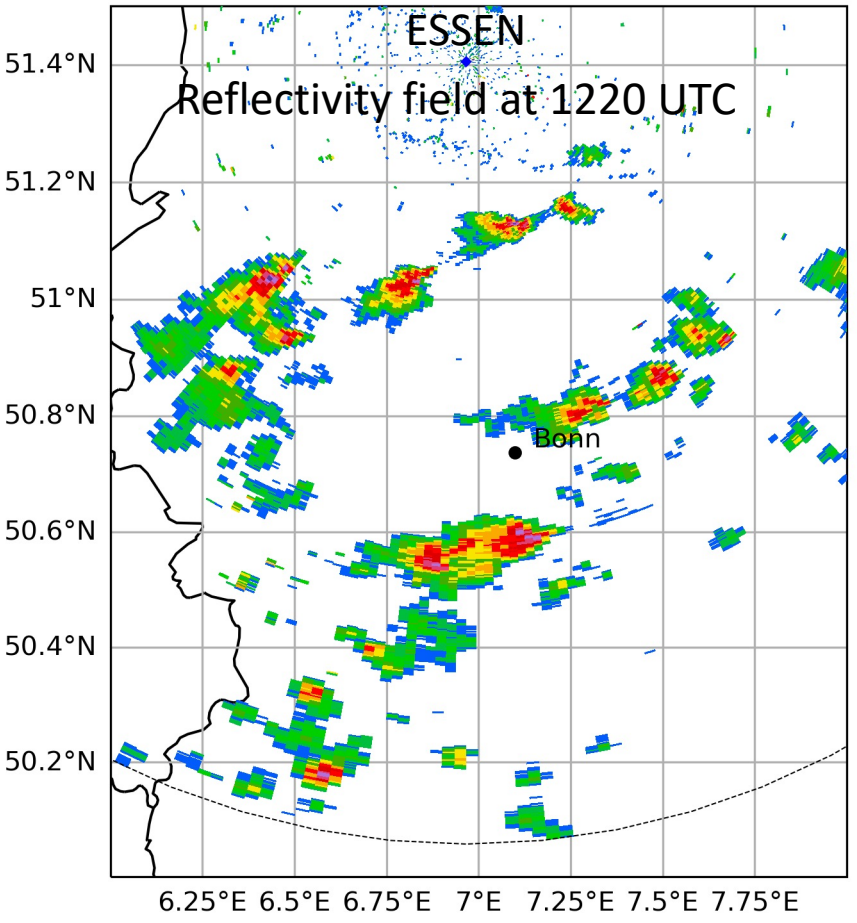
Interpolated vertical structure of Differential Reflectivity



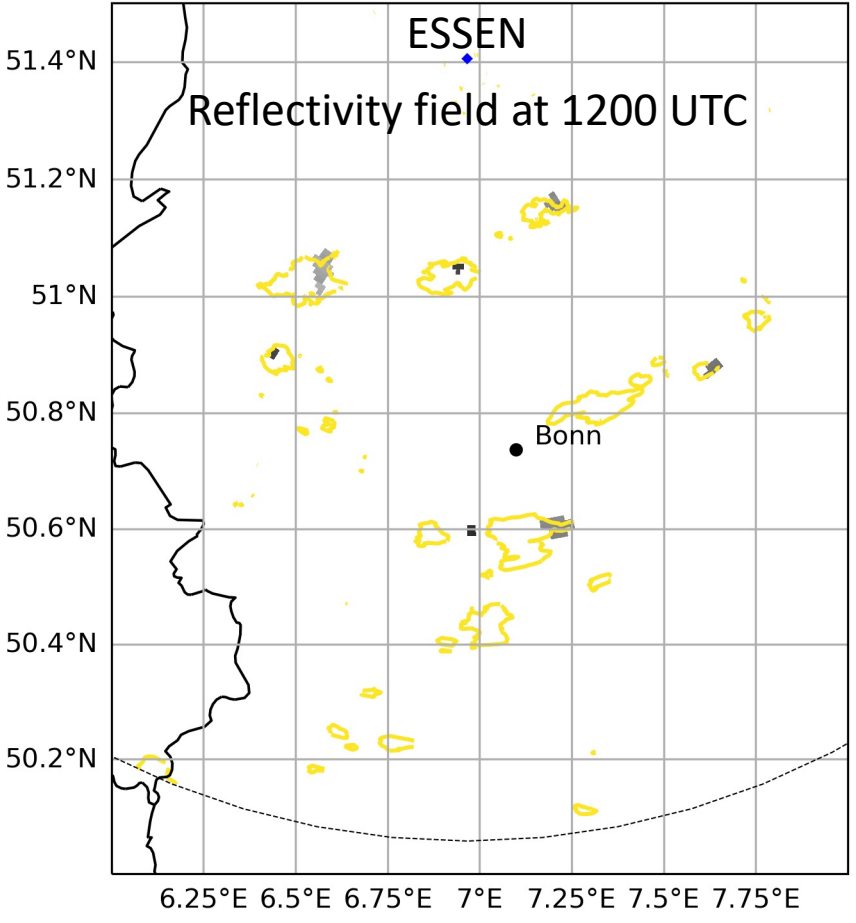

2016-06-04 09:00 UTC
Reflectivity field
ESSEN
Bonn
52.5°N
52°N
51.5°N
51°N
50.5°N
50°N
5°E
6°E
7°E
8°E
9°E
60
55
50
45
40
35
30
25
20
15
10
5
0
Reflectivity [dBZ]

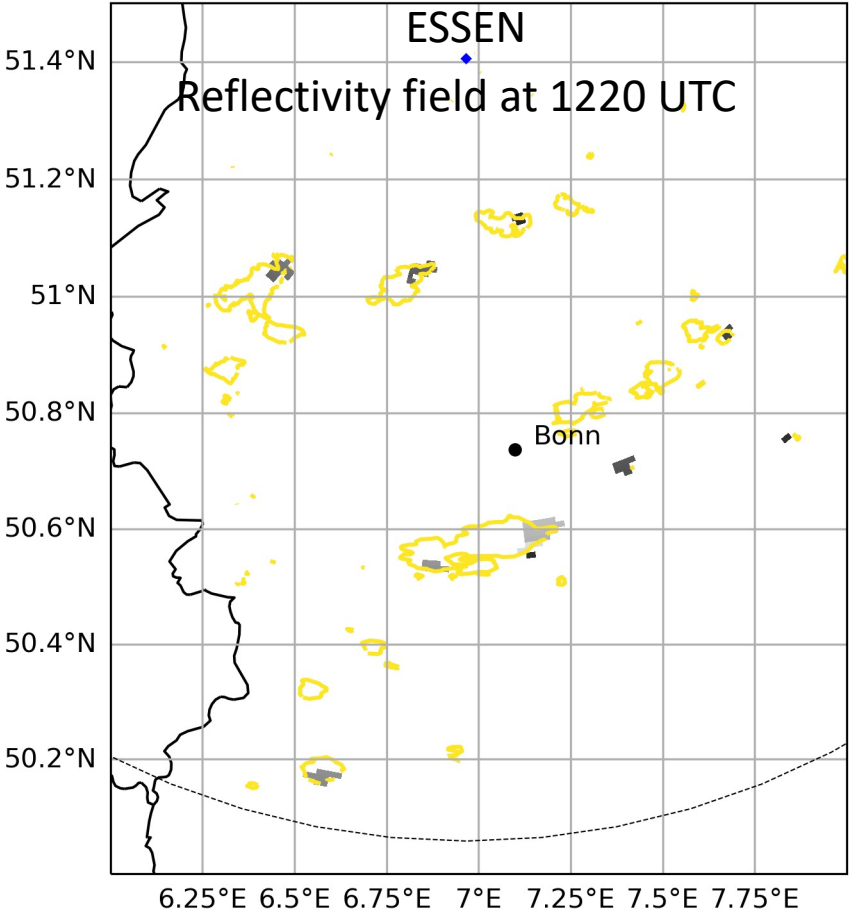
Detection of ZDR-Columns associated with precipitation



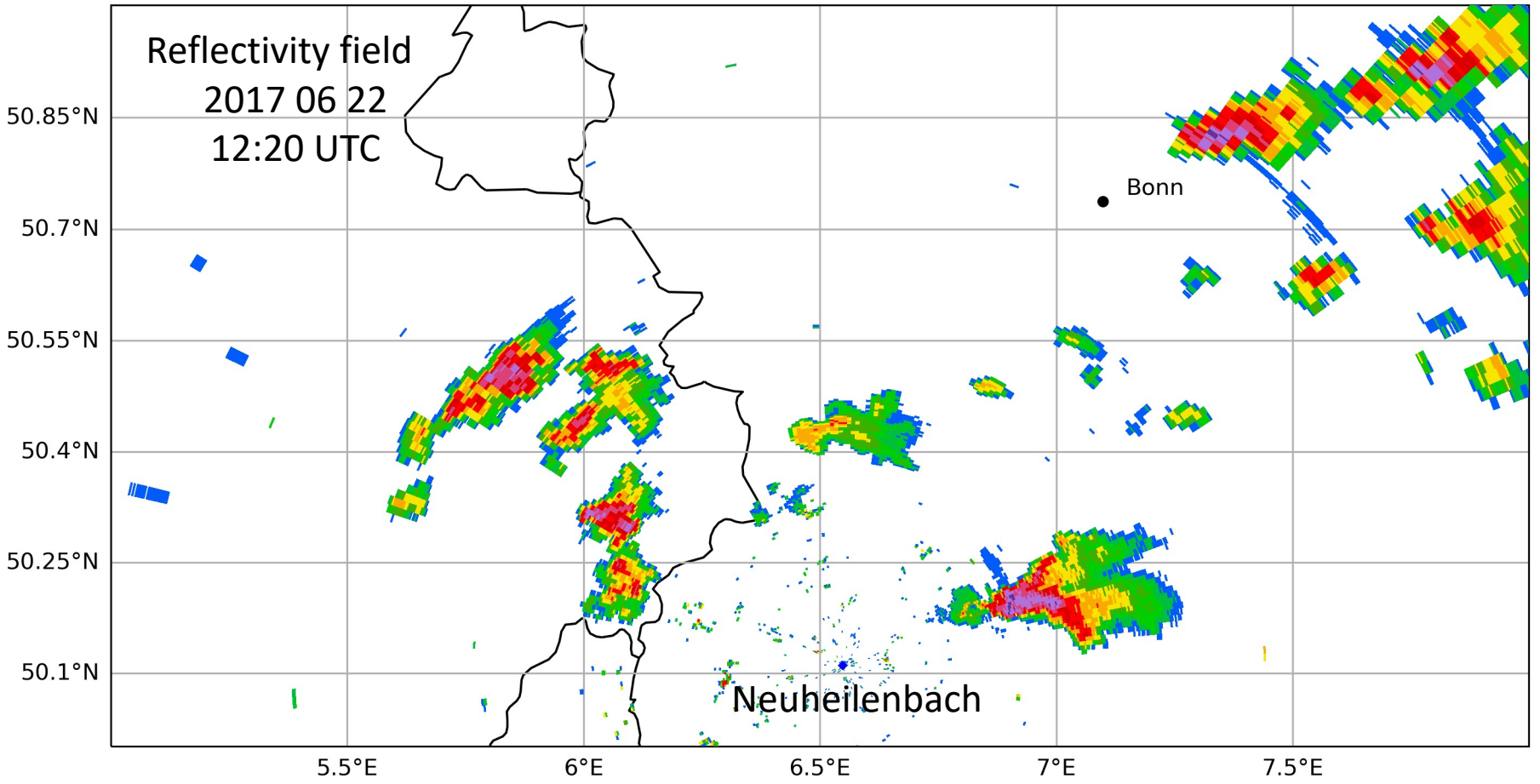


Detection of ZDR-Columns associated with precipitation

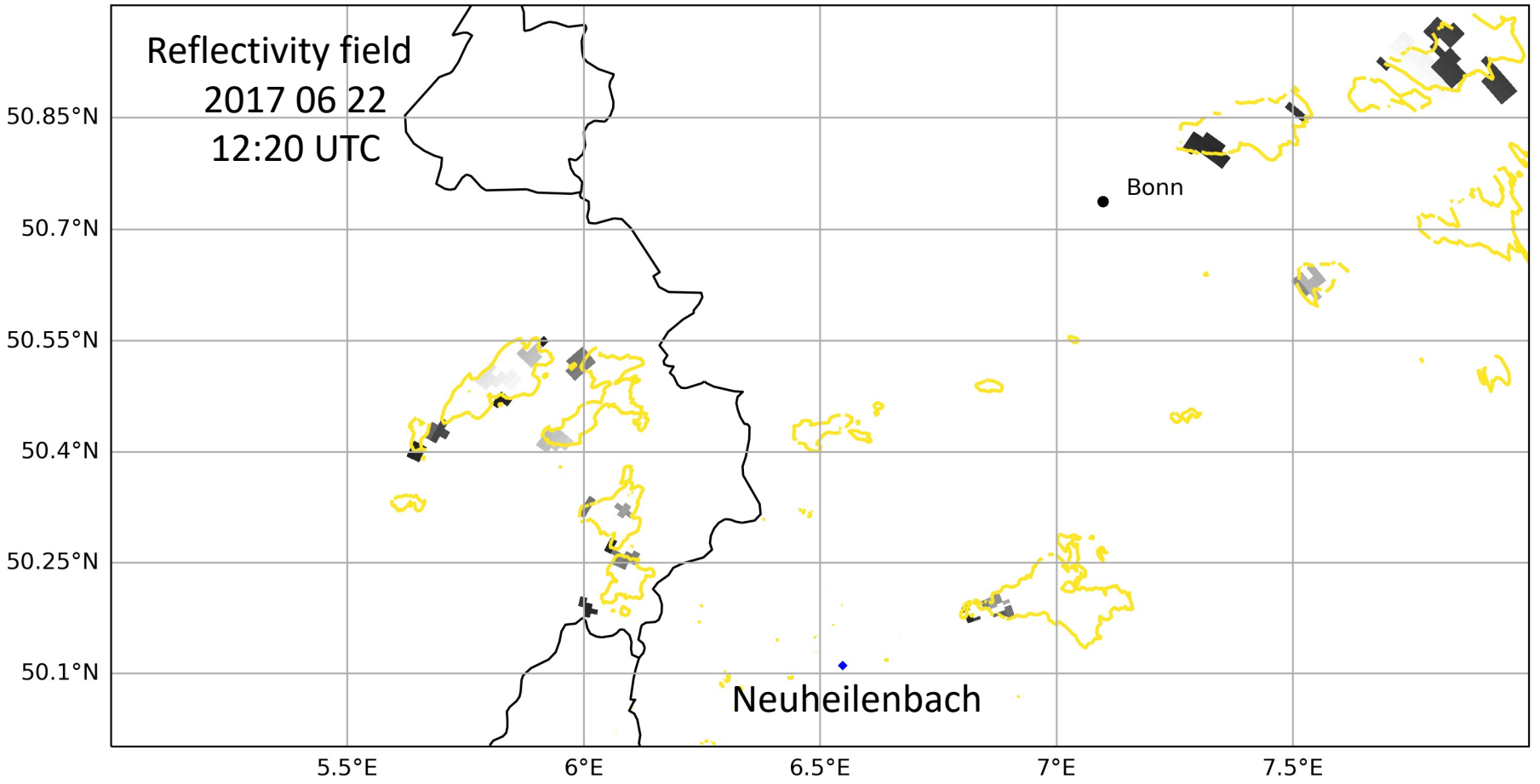




Detection of ZDR-Columns associated with precipitation

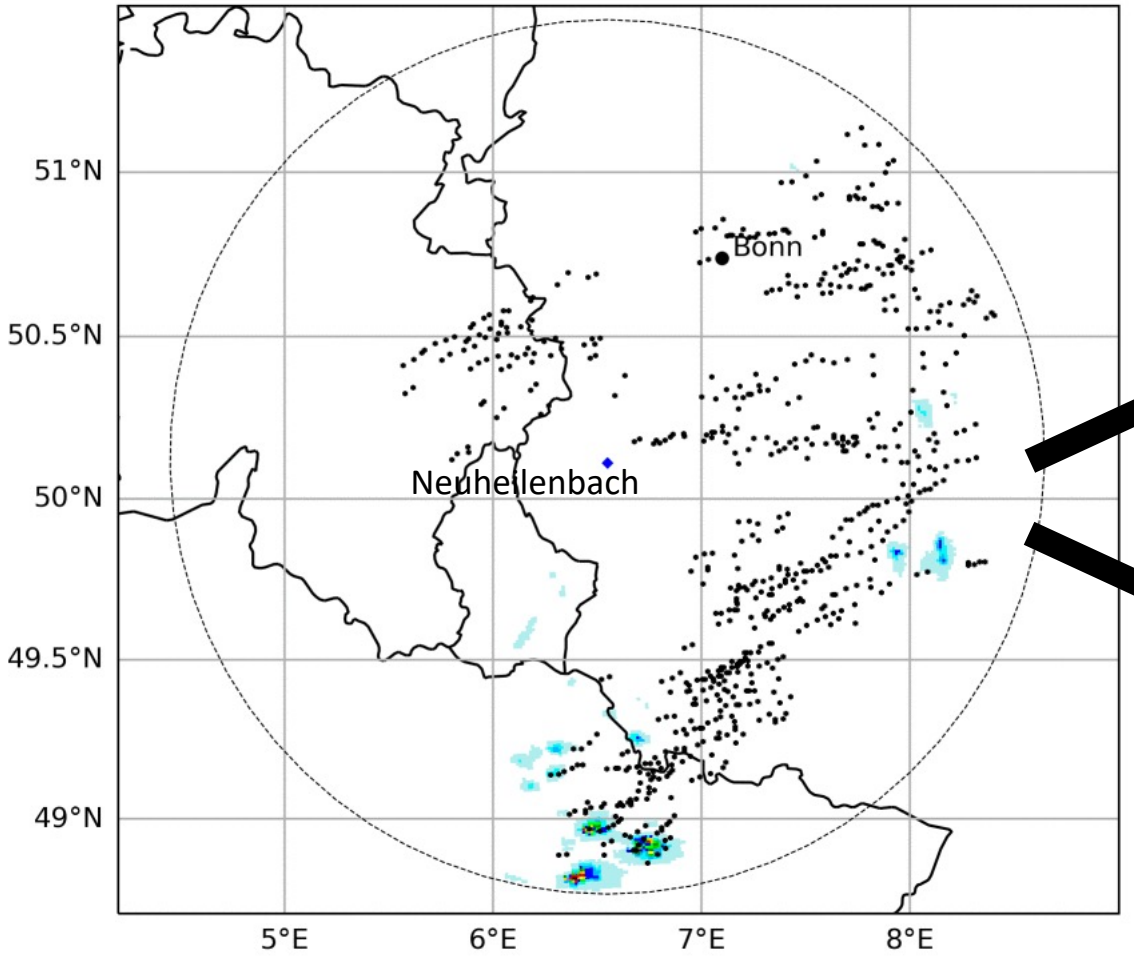


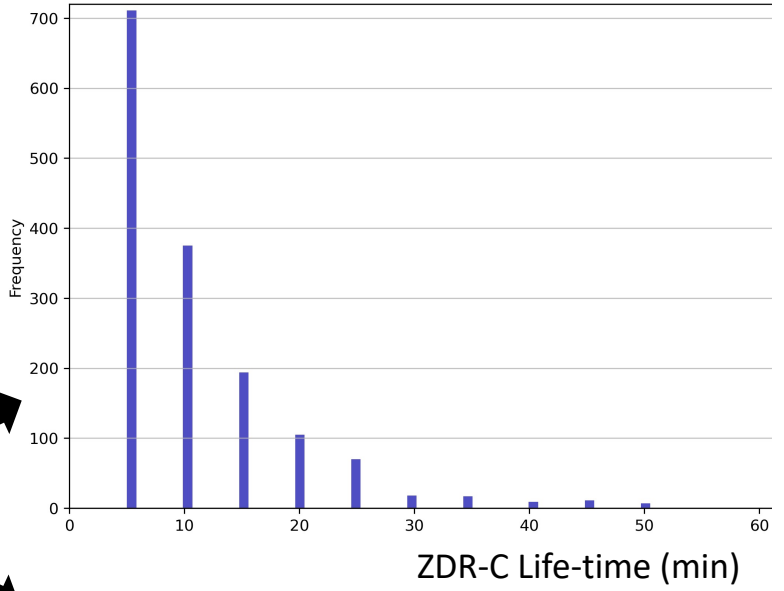
Detection of ZDR-Columns
associated with precipitation

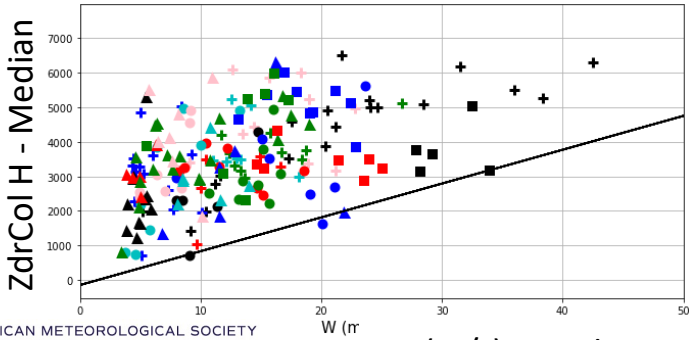


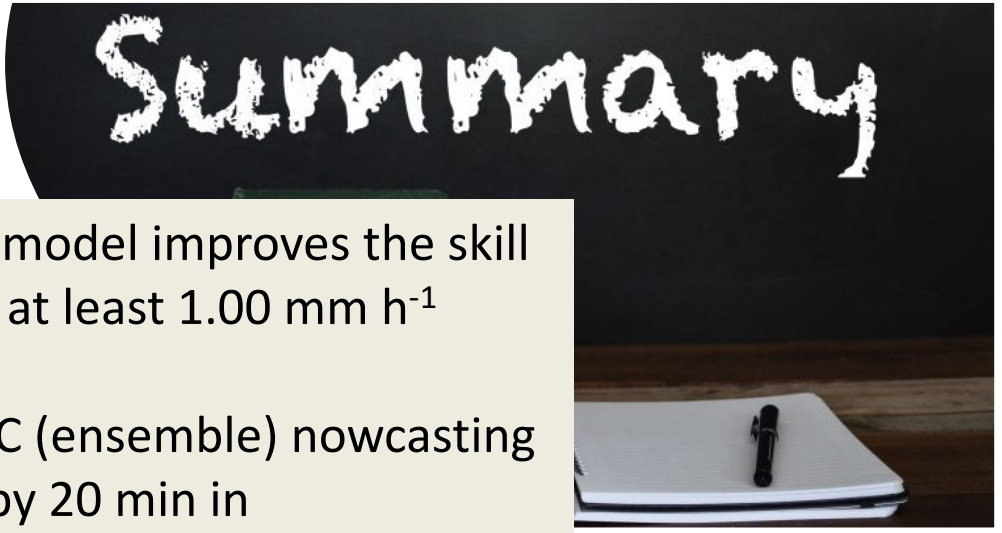
Tracking of ZDR-Columns associated with precipitation

2017-06-22 11:00 UTC







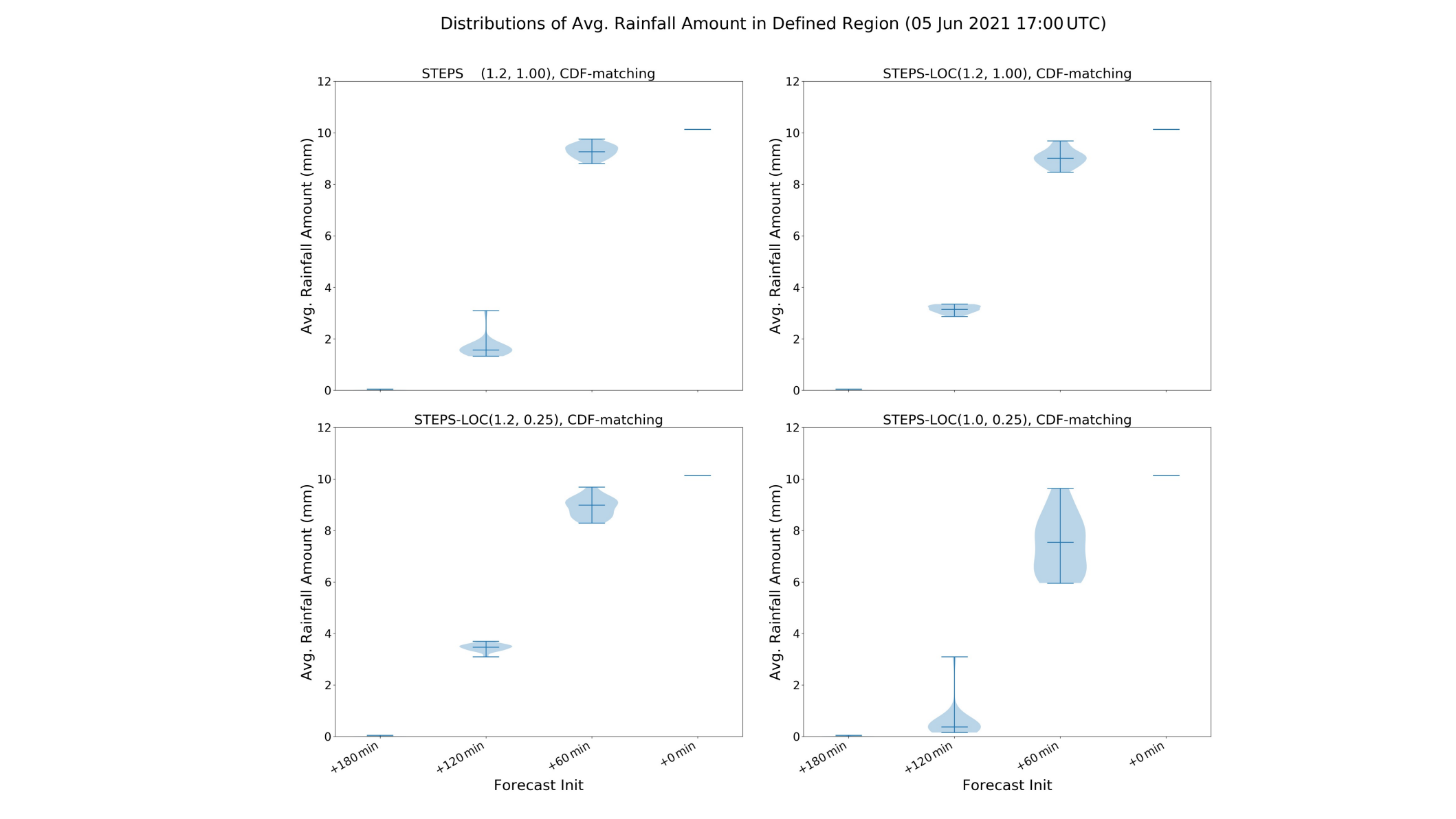


1. The SPROG-LOC (deterministic) nowcasting model improves the skill w.r.t SPROG mainly in precipitation areas of at least 1.00 mm h^{-1}

2. Preliminary results shows the the STEPS-LOC (ensemble) nowcasting model increases the lead-time w.r.t. STEPS by 20 min in moderate/convective precipitation areas.

3. Preliminary results on the identification and tracking of ZDR-Columns show a spatial-temporal consistency with precipitation fields.

4. Next: Include ZDR-C and CI properties in the SPROG-LOC/STEPS-LOC models.


Distributions of Avg. Rainfall Amount in Defined Region (05 Jun 2021 17:00 UTC)
STEPS (1.2, 1.00), CDF-matching
STEPS-LOC(1.2, 1.00), CDF-matching
STEPS-LOC(1.2, 0.25), CDF-matching
STEPS-LOC(1.0, 0.25), CDF-matching
Avg. Rainfall Amount (mm)
0
2
4
6
8
10
12
+180 min
+120 min
+60 min
+0 min
Forecast Init