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An empirical radar data quality function for the COSMO LHN

Andrea Rossa, Franco Laudanna Del Guerra
ARPA Veneto, Centro Meteorologico di Teolo, Italy

Daniel Leuenberger
MeteoSwiss

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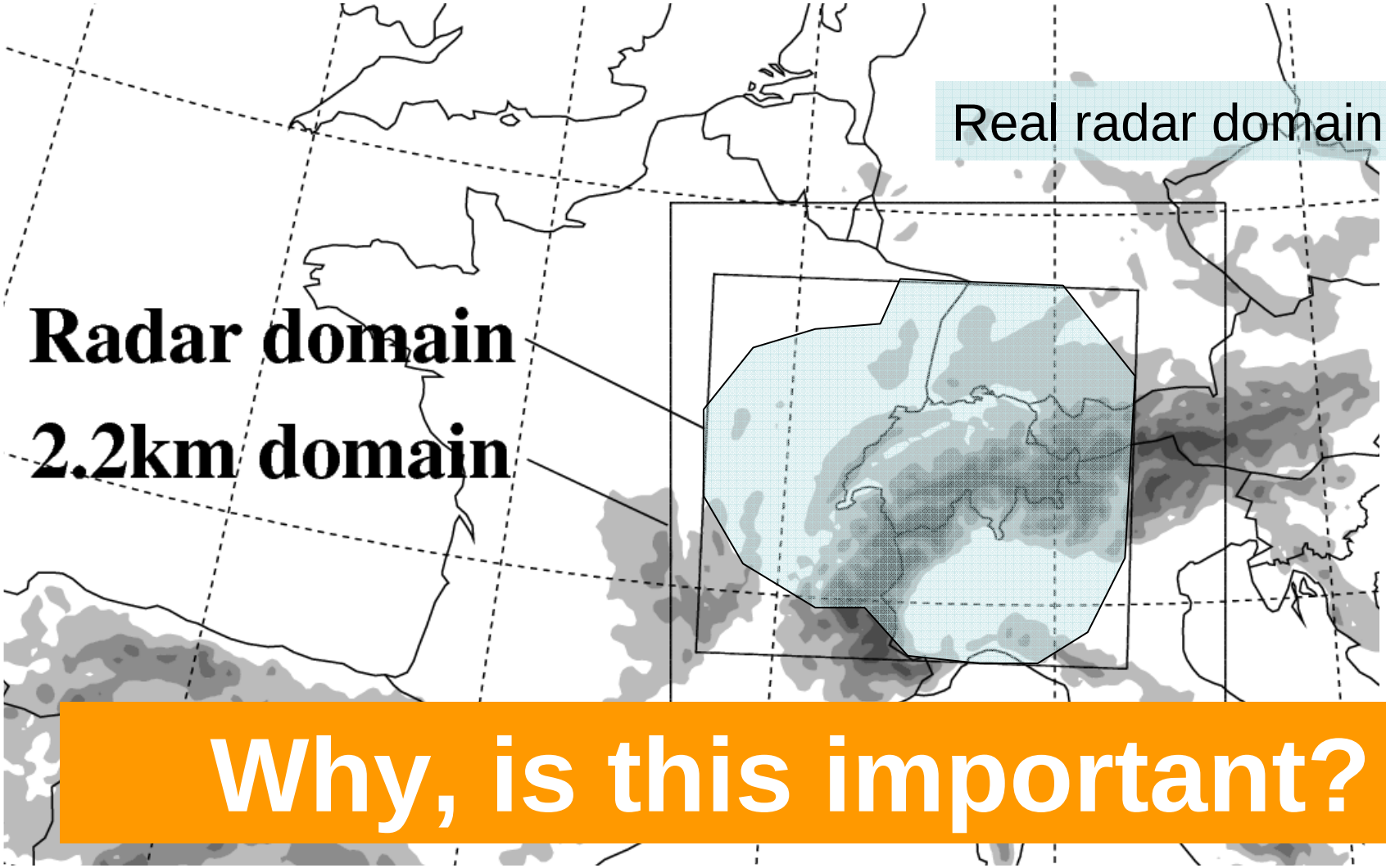
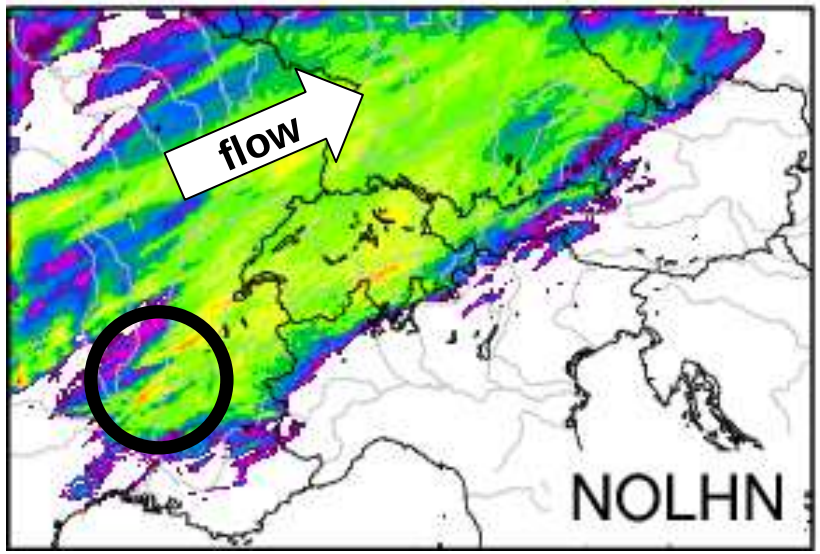
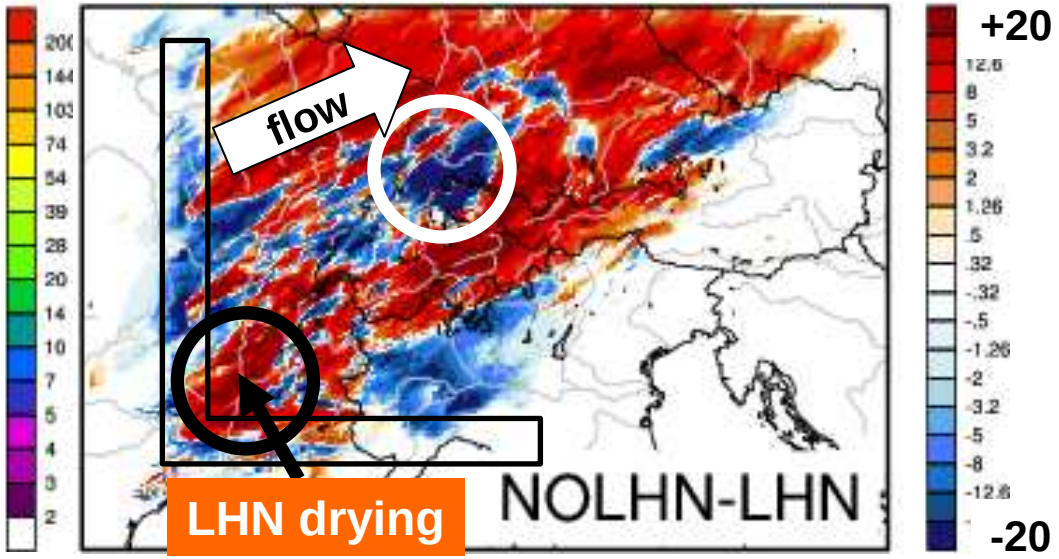
Radar data assimilation at MeteoSwiss

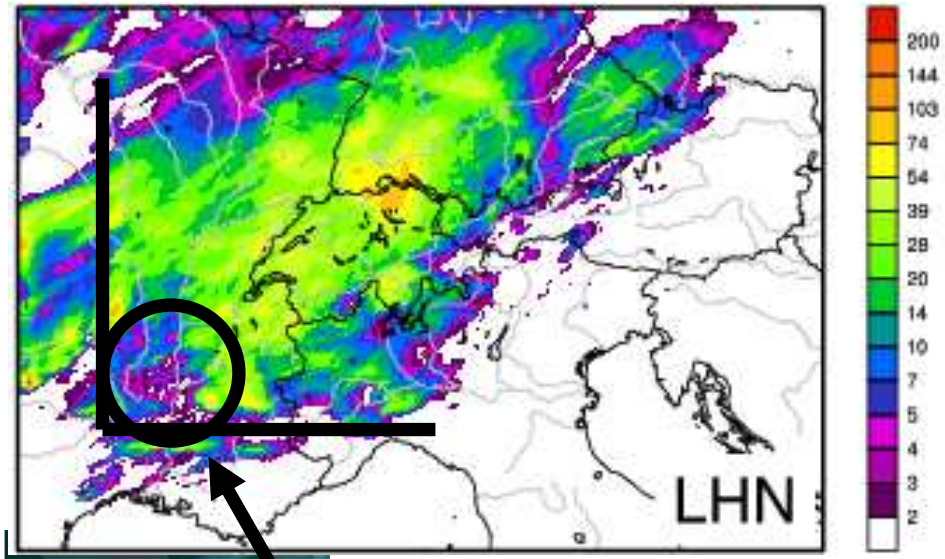


Why, is this important?

Well, it SEEMS important: 48h accumulation, SRN

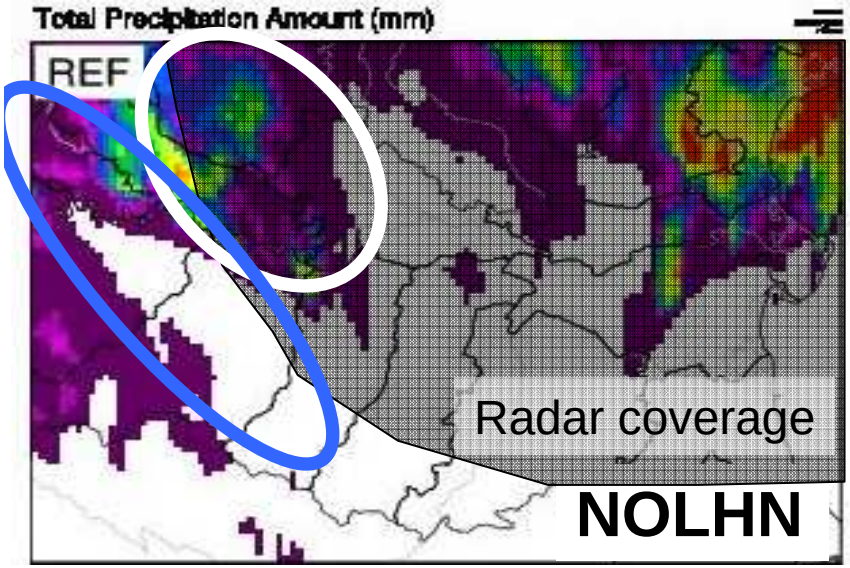


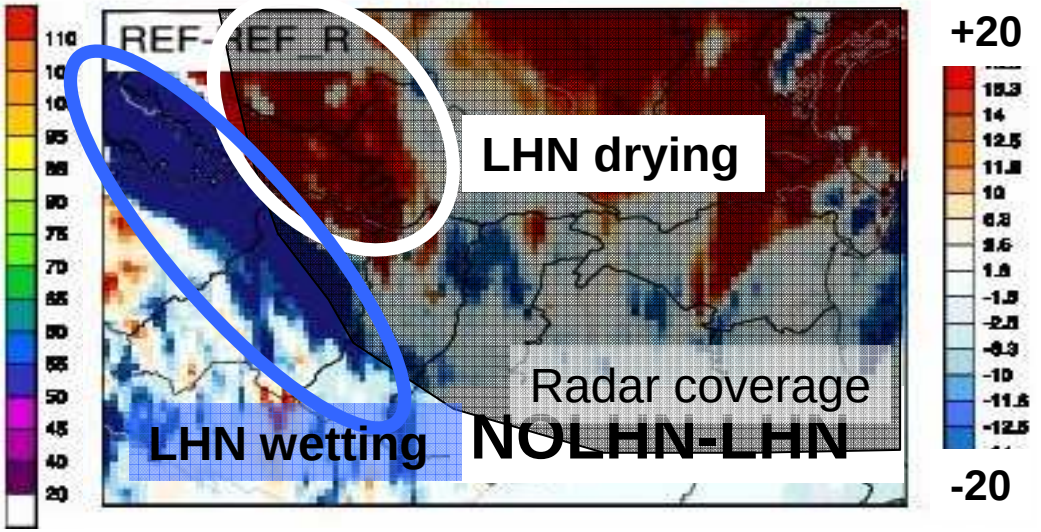


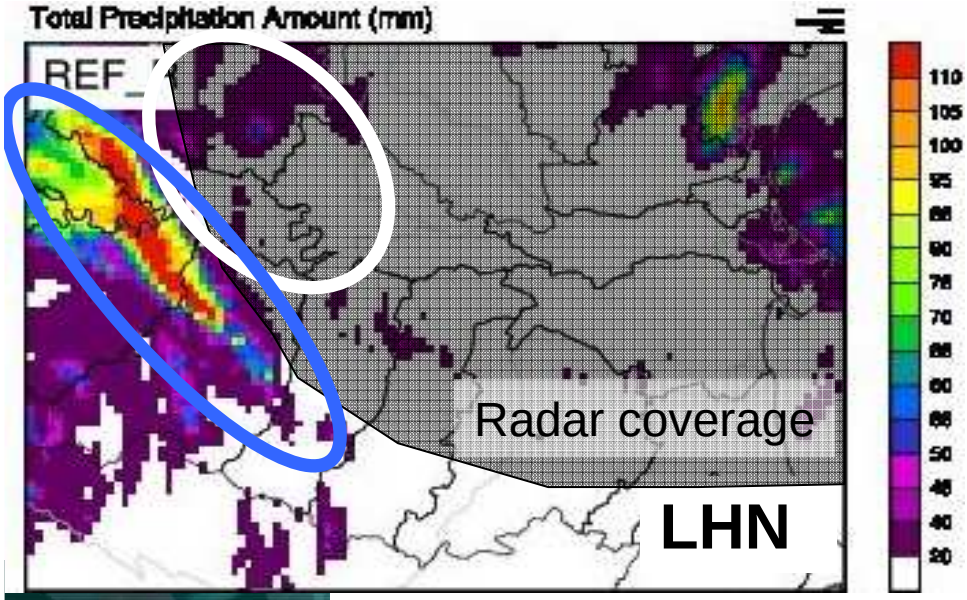


- **Evident artifacts at border**
- **LHN drying**
- **Significant downstream effects**

Well, it SEEMS important: 48h accumulation, ARPAV







- LHN drying
- LHN wetting outside radar domain, this time upstream

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What could be the problem: where radar 'blind'

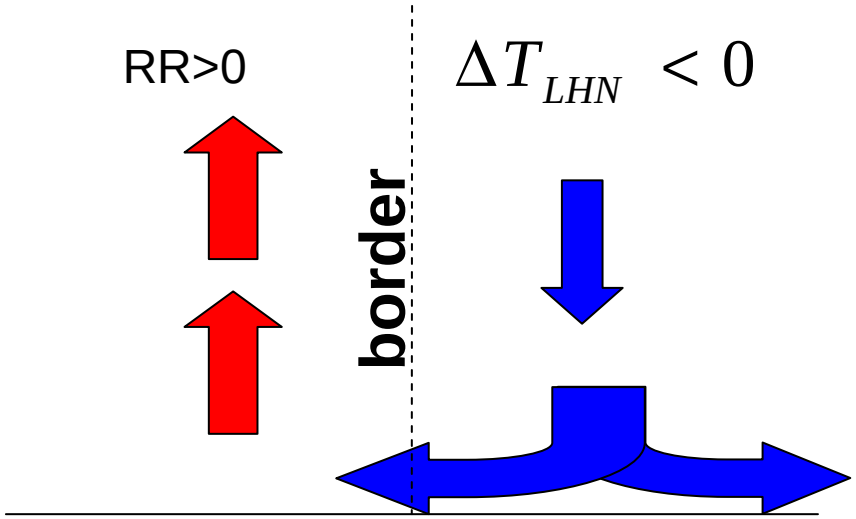
LHN

$$\Delta T_{LHN} = (f - 1) \cdot \Delta T_{LH_{\mathrm{mod}}}, \quad f = \frac{RR_{rad}}{RR_{\mathrm{mod}}}$$

$RR_{rad} = 0$

$\Delta T_{LHN} < 0, RR_{\mathrm{mod}} > 0$ → cooling

Cooling → subsidence & low-level divergence → **trigger precip**



$RR_{rad} = 0, RR_{\mathrm{mod}} > 0$

How can this be overcome?

LHN – the real story:

$$\Delta T_{LHN} = (f - 1) \cdot \Delta T_{LH_{\mathrm{mod}}}, \quad f = \frac{RR_{ana}}{RR_{mo}}$$

Analysed rain rate:

$$RR_{ana} = w \cdot RR_{rad} + (1 - w) \cdot RR_{mo}$$

Observation weight:

$$w = w(x, y, t) \qquad w \in [0,1]$$

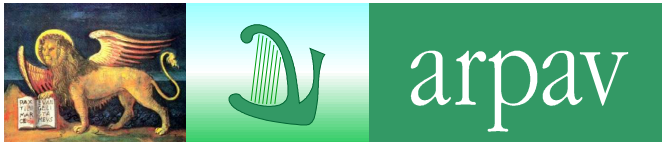
Build a radar data quality function:

→ high weight where radar 'good'

→ Low weight where radar 'modest'

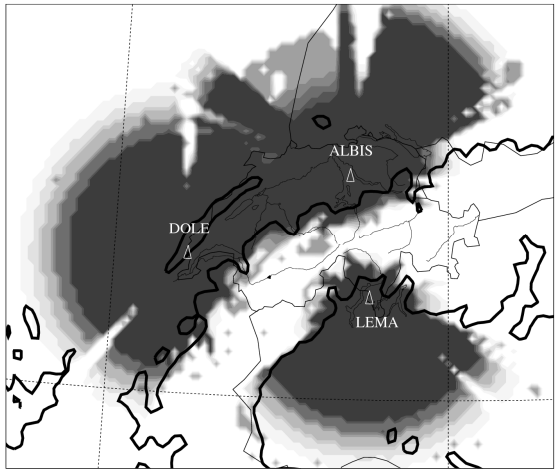
→ Zero weight where radar 'blind' or sees clutter

→ Simple to determine, easy to update, 'smooth'



Empirical radar data quality description

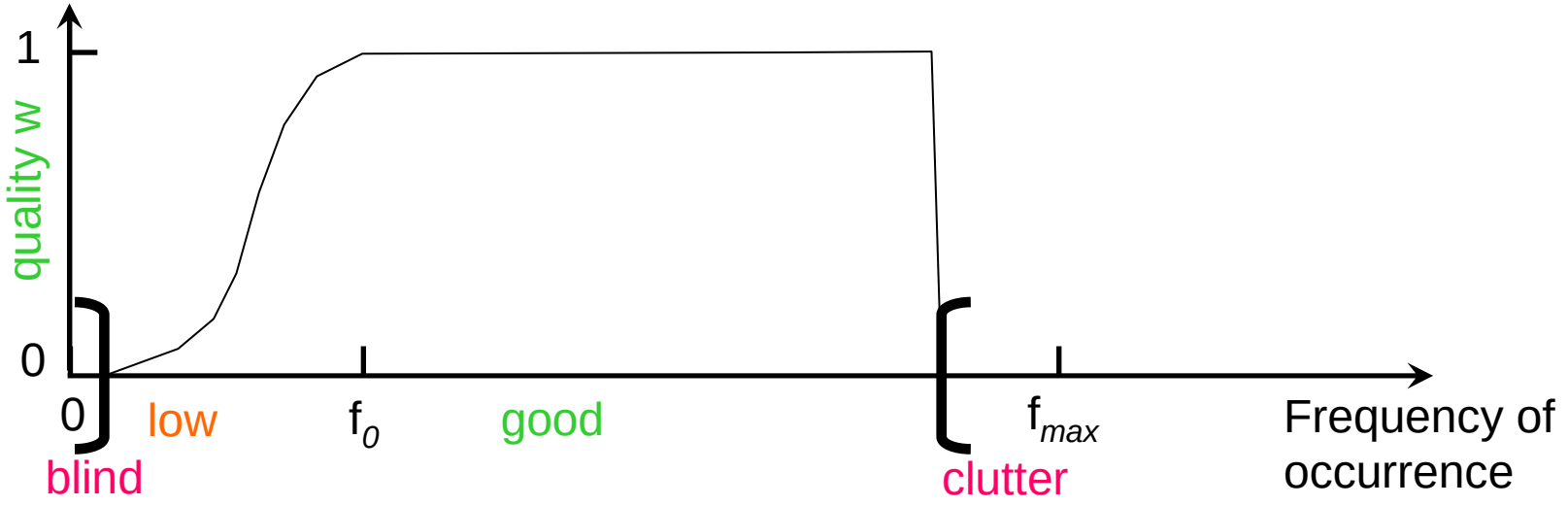
- **Geometrical visibility → assumes constant beam propagation**
- **Joss/Germann: long term accumulation similar to geometrical visibility**



- **Novel approach: long term frequency of occurrence**

Empirical radar data quality description (1)

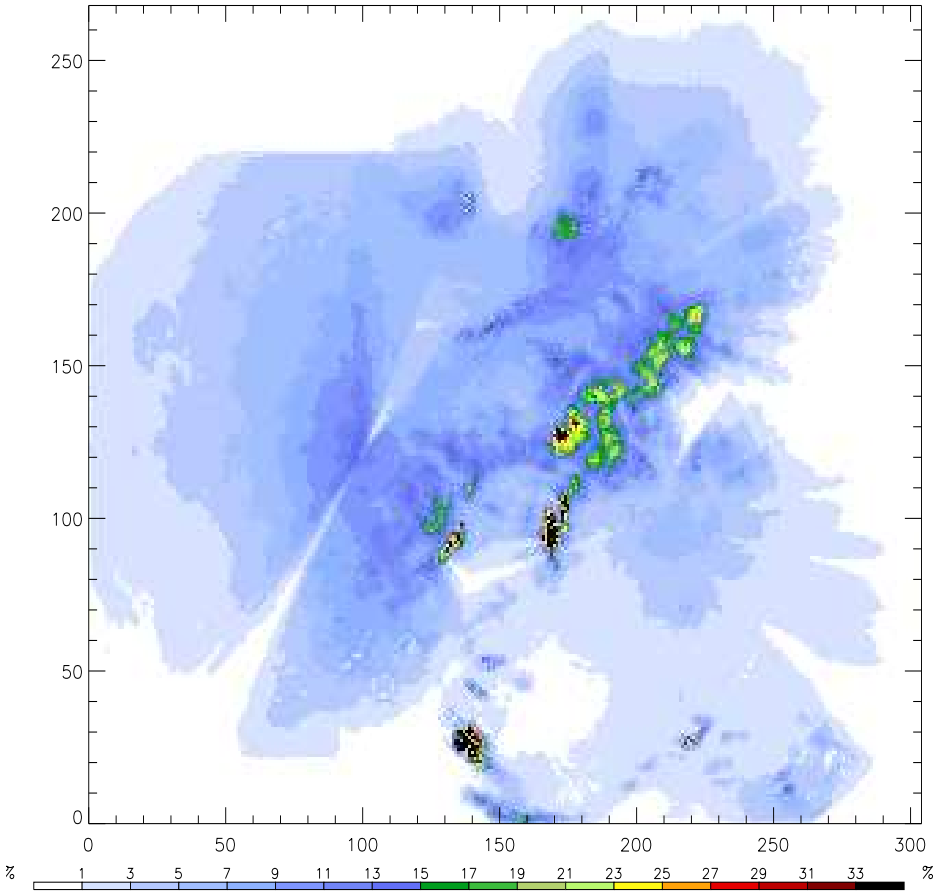
- long term frequency of occurrence: pixels which are
  - Always silent → radar blind
  - Always talking → probably clutter
  - Frequently seen → good quality
  - Rarely seen → low quality
- Assumes homogeneous long term precip occurrence patterns



Empirical radar data quality description (2)

- **Length of period such that:**
  - **Not depend too much on single events**
  - **Reflect seasonal differences**
  - **Found that 1 month is short, 3 months better**
- **Absolute numbers depend on:**
  - **precipitation climatology**
  - **Radar sensitivity**
  - **Scan strategy**
- **Tuning necessary for each radar composite**

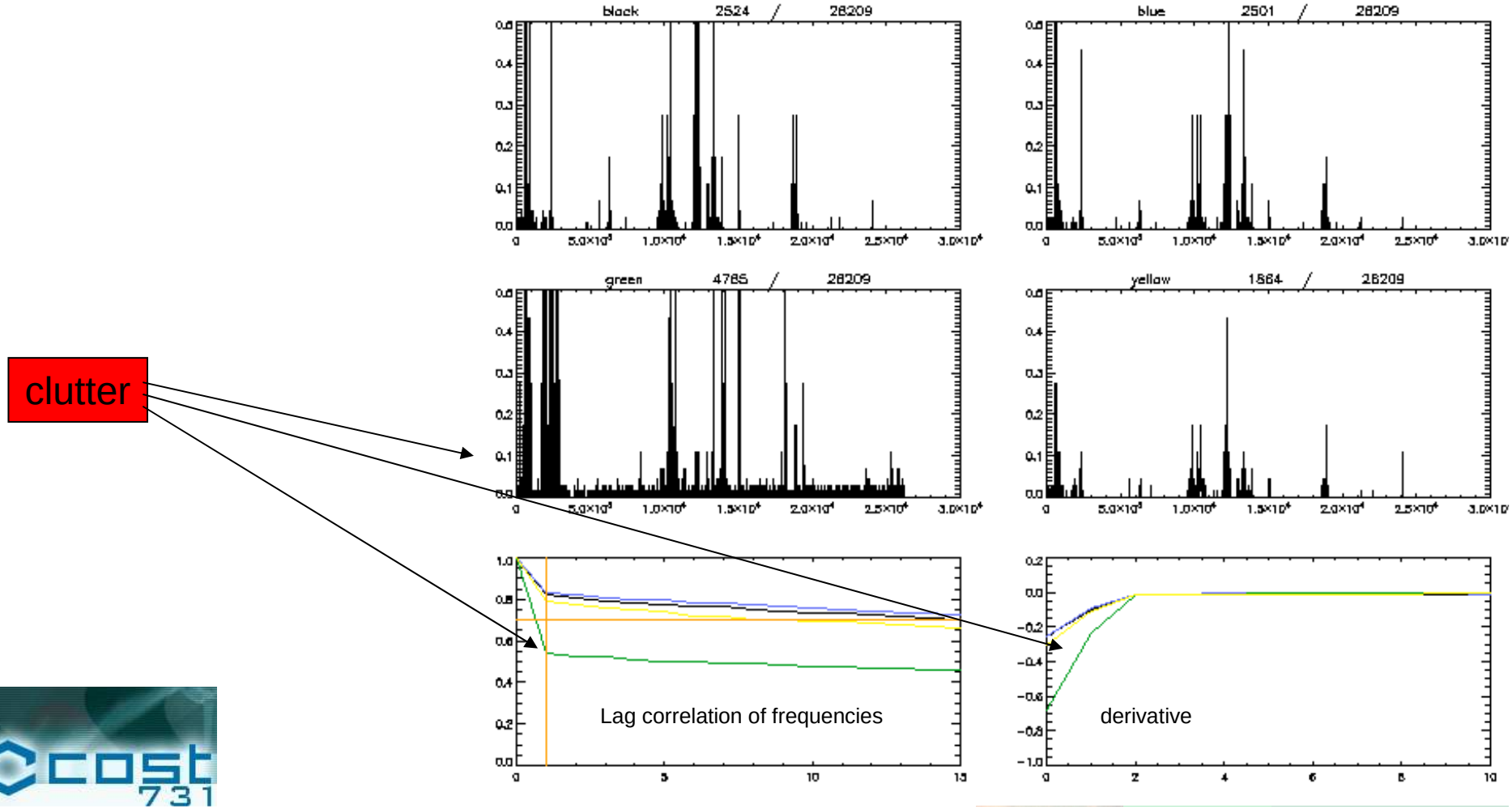
Frequency of occurrence in %



100% = about 9000 times in 1 month

Rest clutter identification: analyze time series

- **Clutter pixels are ‘talkative’ and rare: beyond 0.98-0.99 percentile**
- **Analysis of time-series of them (3 months periods)**
- **Plot of lag-correlation and derivatived of it.**

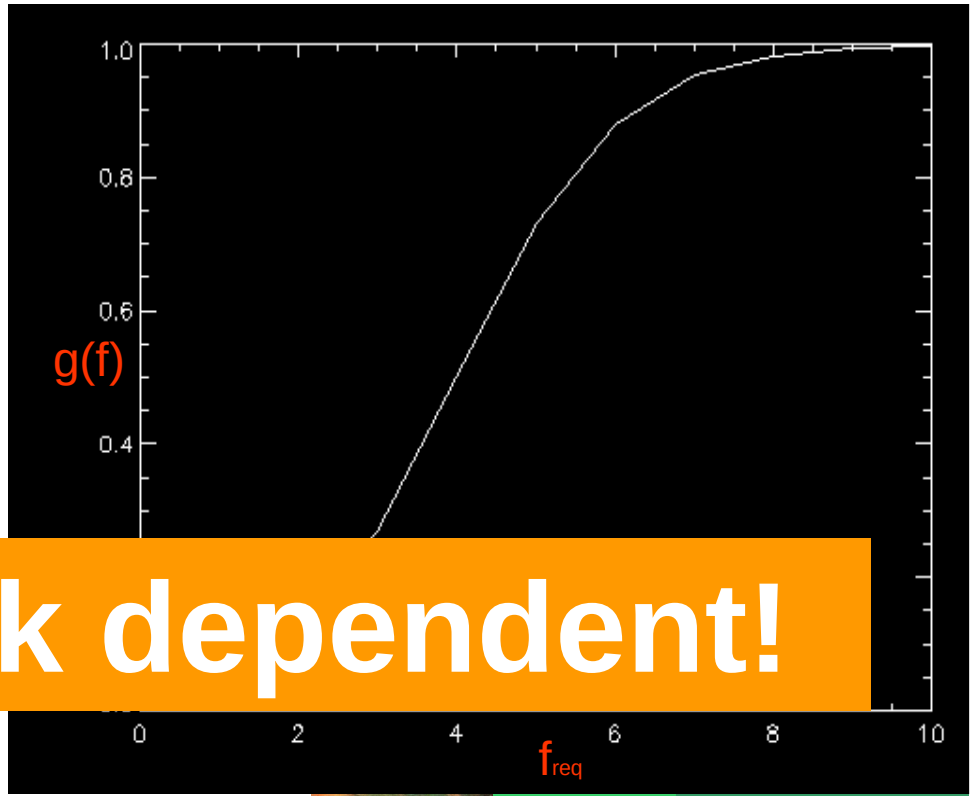


Construction of the quality function

$$w(x,y) = \begin{cases} 0 & \text{For rest clutter pixels over 0.99 percentile} \\ g(f) & \text{For pixels under the value of } f_0 \\ 1 & \text{Elsewhere} \end{cases}$$

f_0 tuning parameter: has been set to 7% for SRN (evaluation of reasonable range behaviour)

$$g(f) = \frac{-1}{1 + e^{((10 * freq) \div 7) - 4)}} + 1$$



Radar-network dependent!

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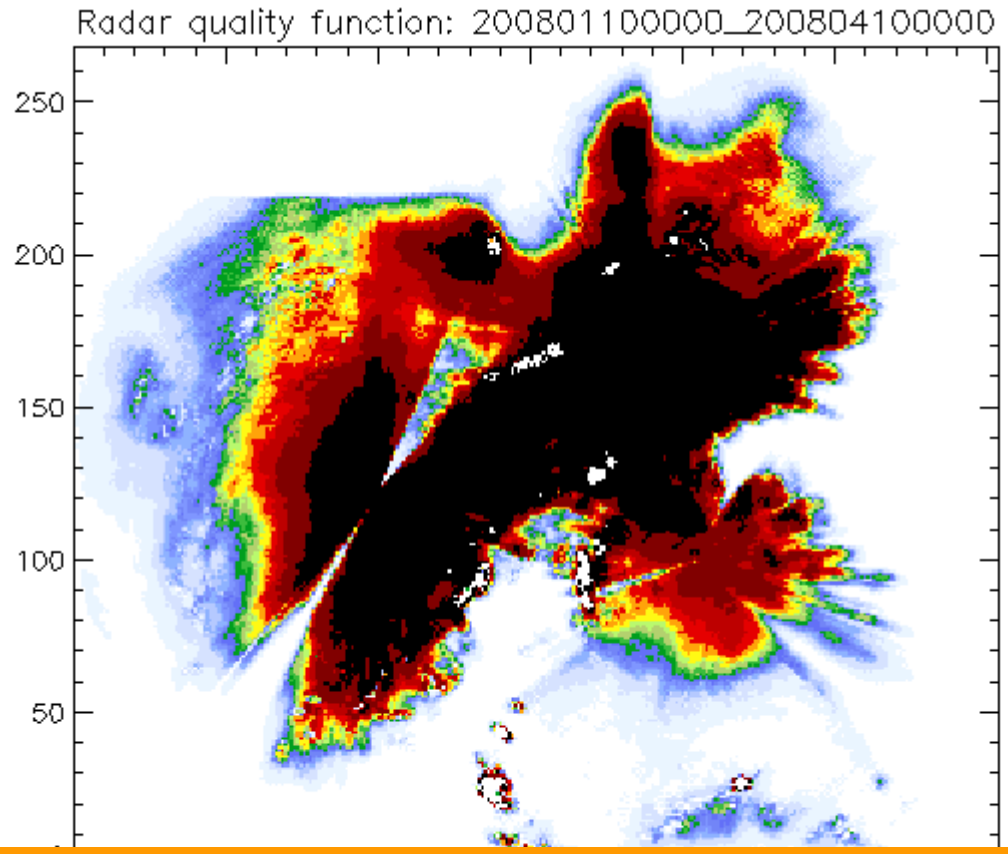
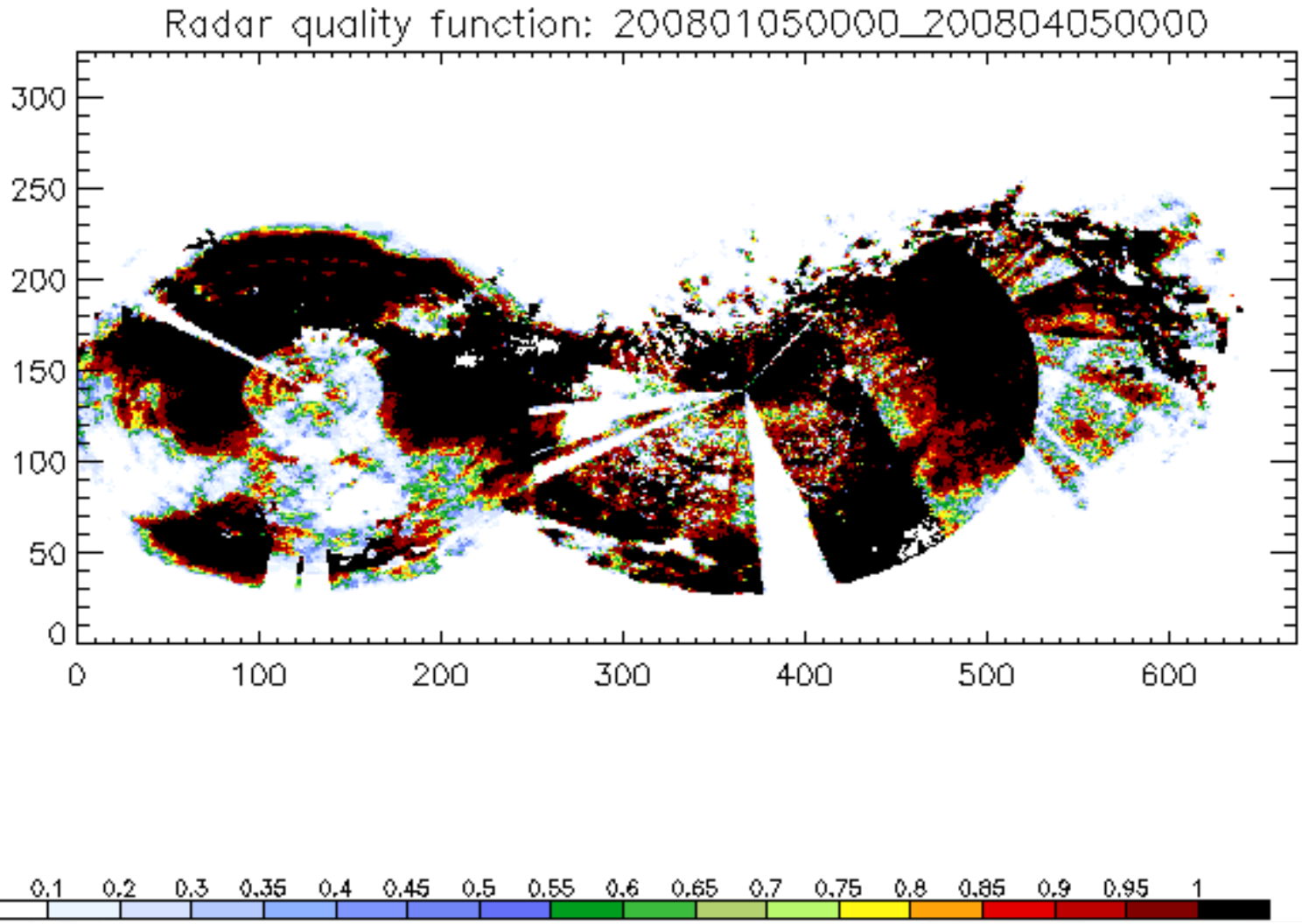
Finally ...

An example of w for the Swiss radar network:
3-month period, moved in 1-day steps

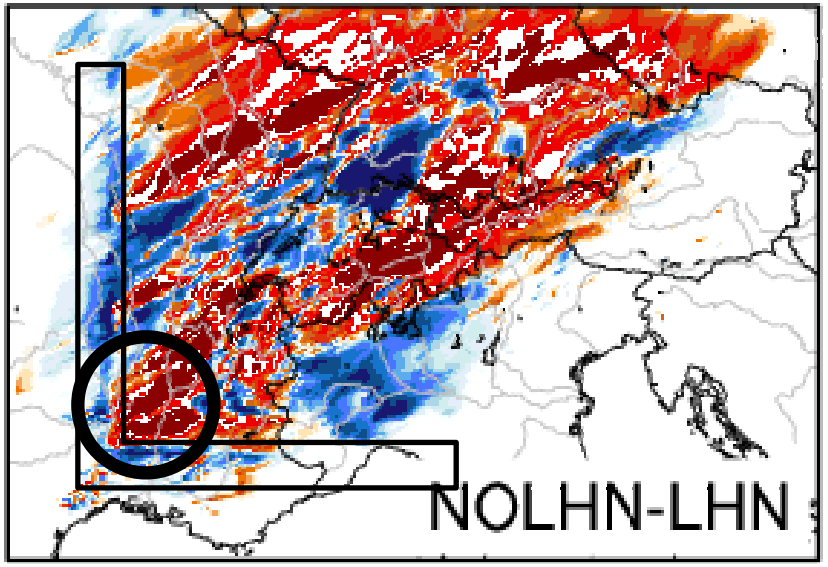


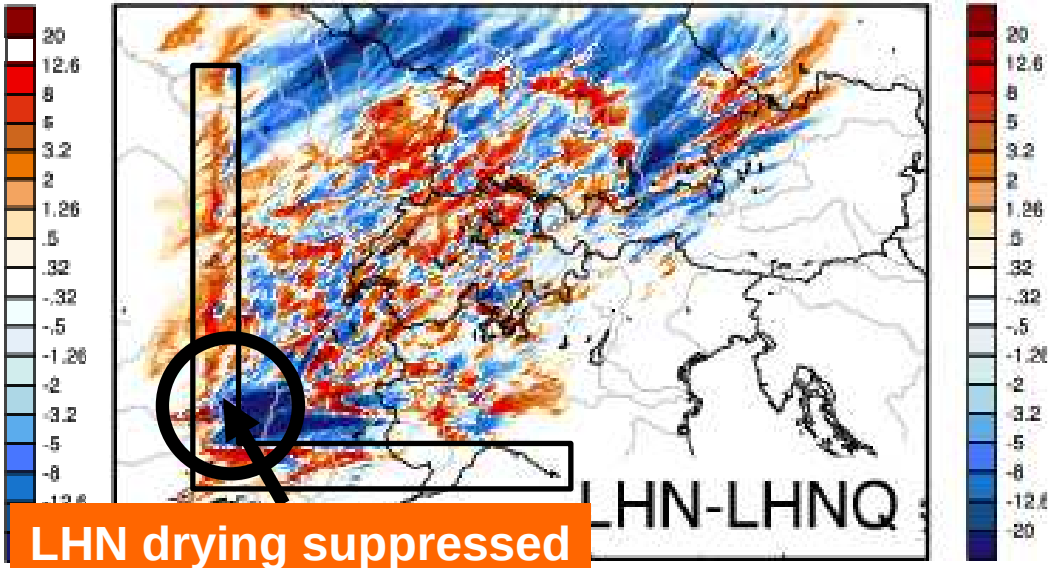
Plausible structure!

An example of w for the Veneto radar network:
3-month period, moved in 1-day steps

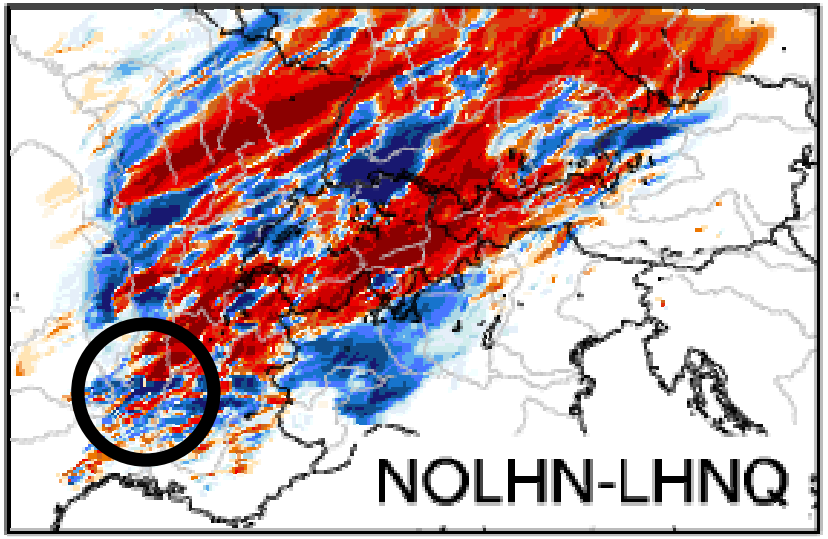


Impact of quality function on LHN: SRN





LHN drying suppressed



- Reduction of artifacts at border
- LHN drying (obviously) removed
- downstream effects somewhat reduced

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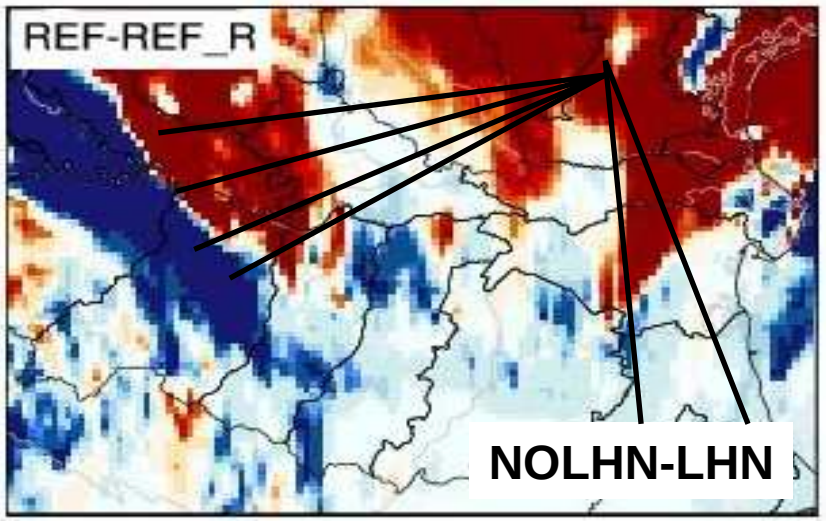
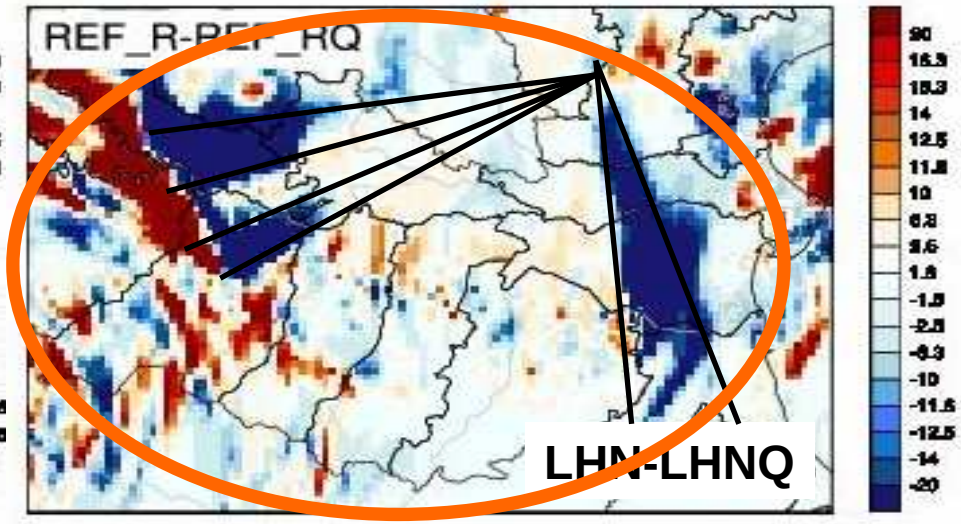
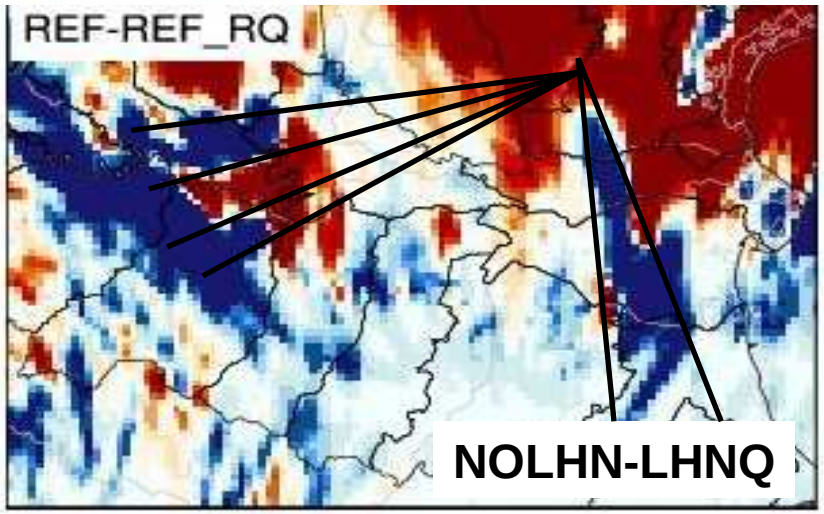
Impact of quality function on LHN: ARPAV

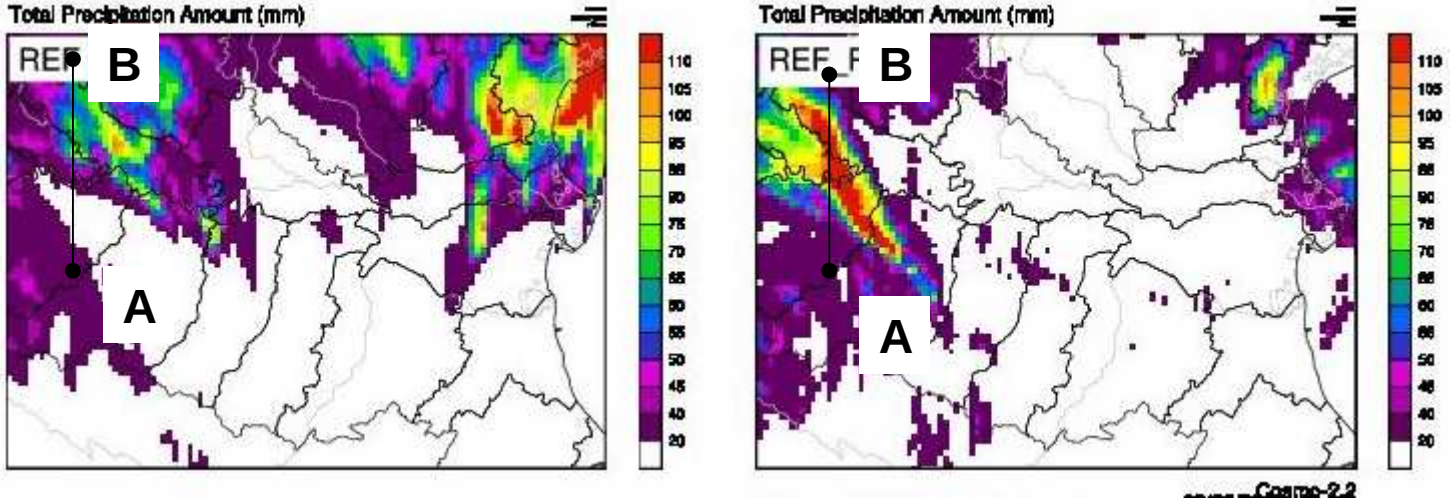


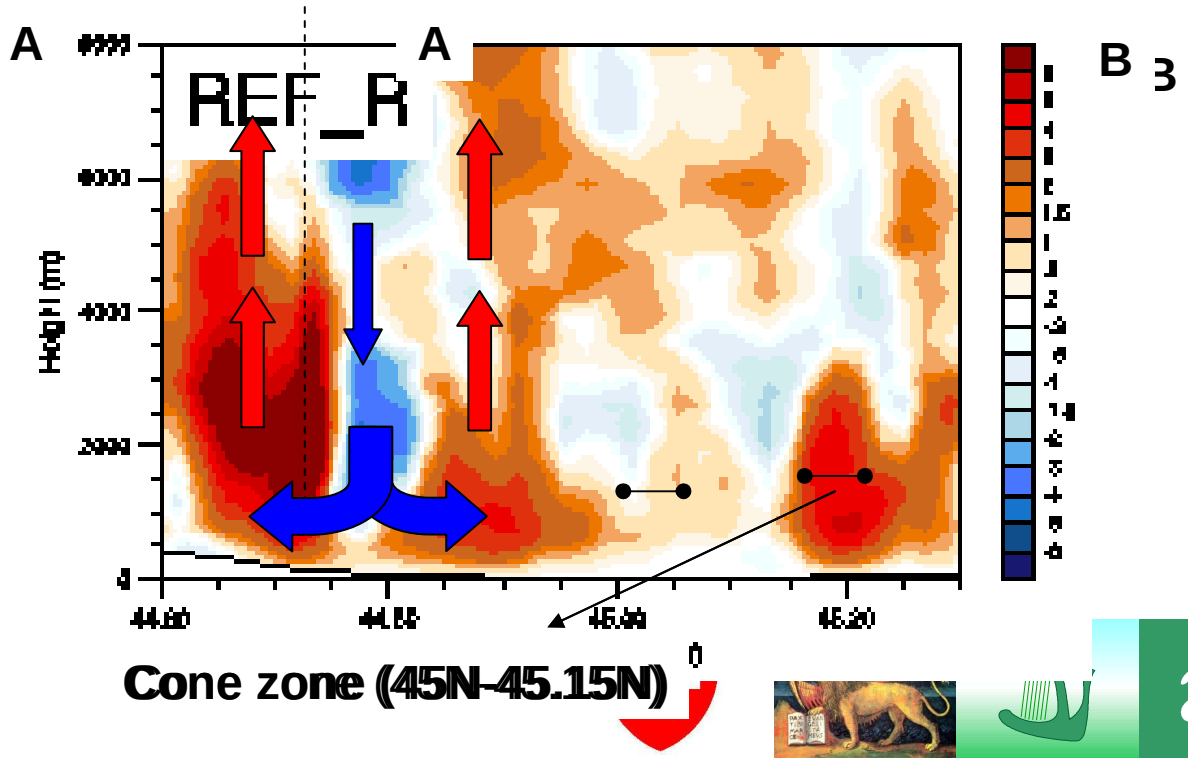




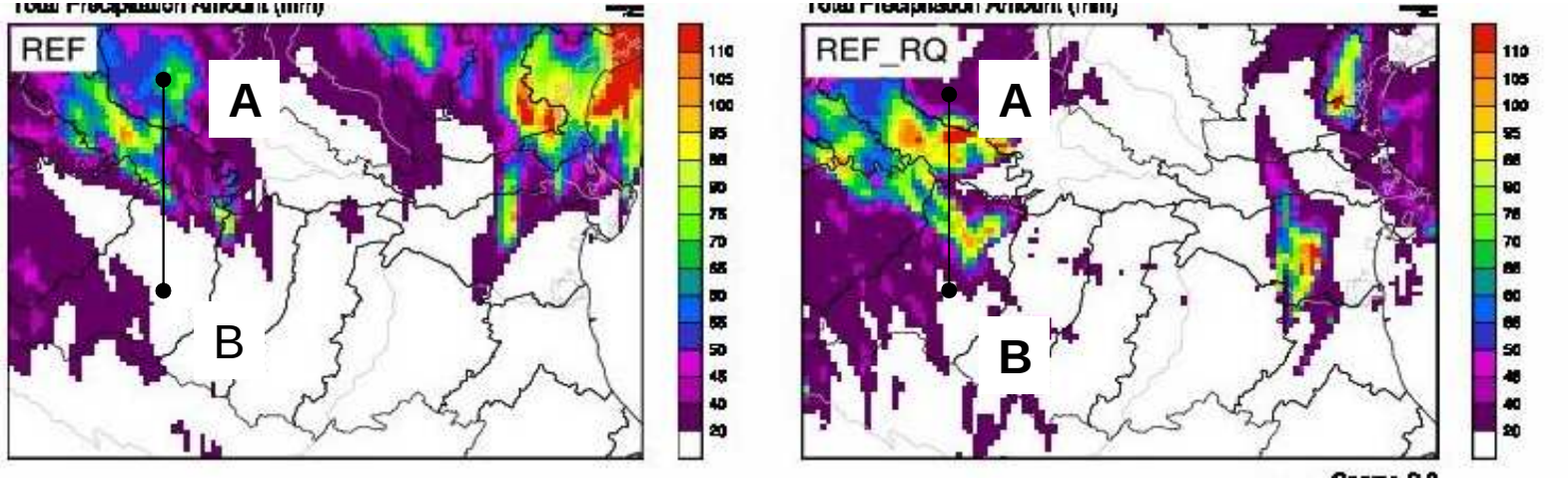
- **Clear effect in the cones where radar is ‘blind’**
- **LHN drying (obviously) removed**
- **LHN wetting (less obviously) removed**

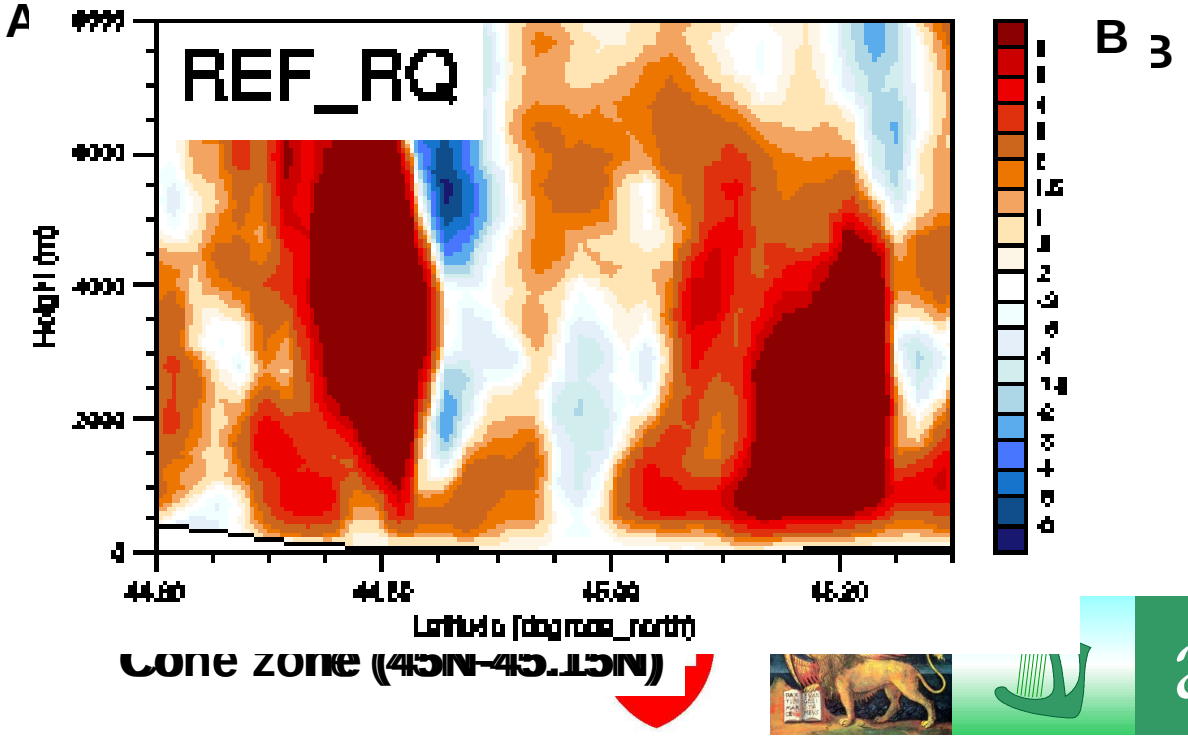
Integrated vertical velocity ...





Integrated vertical velocity ...





Core zone (45N-45.15N)

Discussion

Empirical radar data quality function is proposed

- **Conceptually simple and easy to construct**
- **Avoids artifacts and systematic errors from non-suitable radar data → QPF verification**
- **gives model more weight, but if model wrong, it stays wrong!**
- **If model correct, radar does not degrade → likely to be more important for widespread rain**

Outstanding questions and future work

- Document seasonal variability of quality function
- Performs more case studies and evaluate test chain
- Look at cases where model is good
- How to handle missing radars?
- What is the impact on the free forecasts (test chain results)