Task 3.6:
Verification applications (spatial) to HIW - Comparative verification of NWC and NWP using spatial verification methods (SINFONY)

Today:
Extension of object-based verification of NWC and NWP towards "gridded objects" and ensemble forecasts

AWARE report

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Progress since last AWARE report

- Try to switch to R-package “sf“ (simple features) since it provides more functionality in simple calculations and plotting

  Calculation of MMI based on polygons in “sf” more than **50% faster** than in previous version (“raster”)

- Provide some statistical output of matched objects, i.e., those objects with a total interest > x, where 0 ≤ x ≤ 1

  SOON Output available but no analysis done yet

- At the moment, a real-time test system of “Sinfony” (Seamless integrated forecasting system) is running (NWP, nowcasting, combination of products, 20+1 members each), so there is a lot of new data for further verification tests

  Only few days with complete data are ready

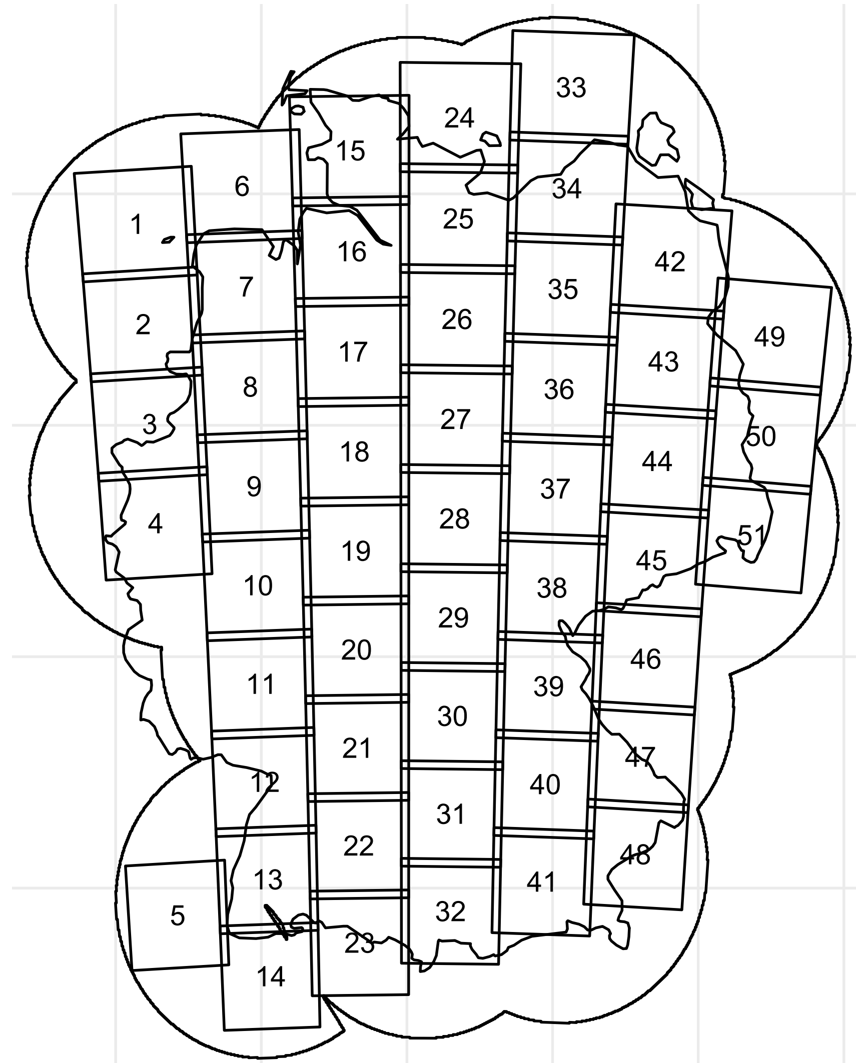
- Note: Since June 2020, there is a new colleague focussing on object-based verification only. This leads to some delay in further results because of induction period

  That‘s me 🙂

- Introduction of **“gridded objects”**

Introduction of “gridded objects”

- ➔ For **small-scale convective events** it is unnecessary to compare all objects all over Germany with each other
- ➔ Divide region of German radar composite into **51 grid boxes** with edge lengths of about 100 km and assign objects according to their **centroid position**
- ➔ **Overlap of 10%** of the boxes allows objects to belong to more than one box *(better more overlap? tests ongoing!)*
- ➔ Calculation of **MMI for each box** separately
- ➔ **MMI for entire domain** can be calculated additionally



(Un-)resolved issues

- Many parameter settings → tuning necessary
- Problem "no objects" (MMI not defined) more frequent with smaller grid boxes
  - Solution: set MMI to missing value and

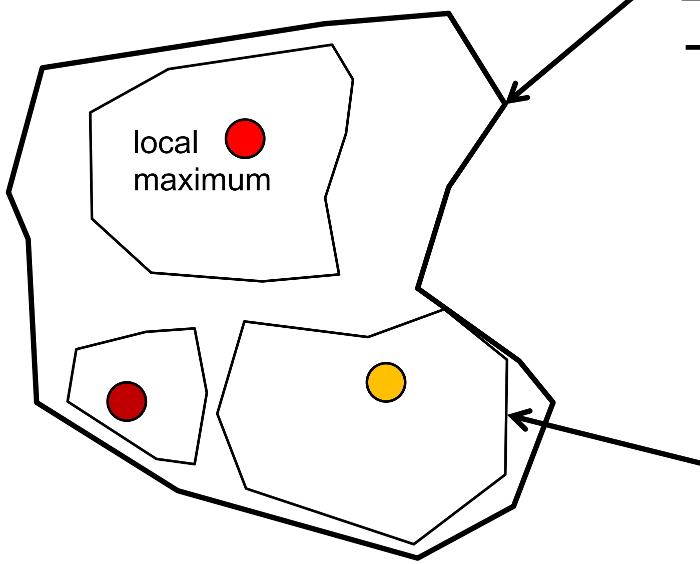
$$\text{count boxes} \begin{cases} \text{with 0 objects in both the observations and forecasts} \rightarrow \text{good} \\ \text{with 0 objects in either the observations or forecasts} \rightarrow \text{bad} \end{cases}$$

- Still unclear, how to adapt to Ensemble forecasts
  - Idea: Calculate MMI for each member separately and calculate mean etc.
  - Idea: Calculate "probabilistic objects" (Flora et al., 2019, WAF) and then get MMI from different probability ranges
- How to get number of "correct negatives" for object-based contingency tables
  - Idea: look-up-tables based on climatology for "expected" number and size of objects depending on current weather situation

Identification of convective cells

In-House product: KONRAD3D (convective evolution in radar products)

A **2D cell** for each radar & each elevation



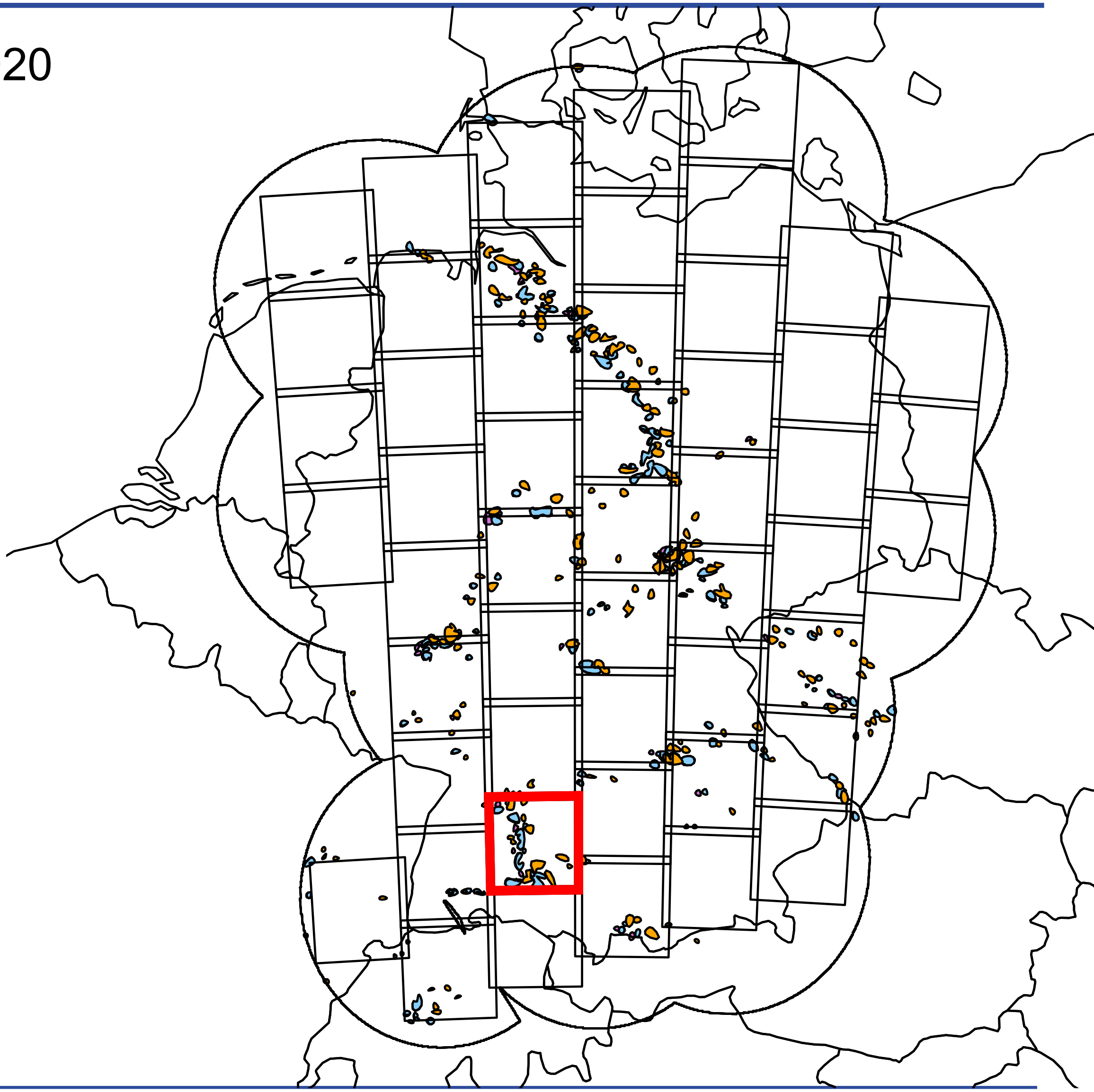
Basic thresholding:
→ here: **35 dBZ**

Adaptive thresholding:
A subcell has a min-max difference of at least **7 dBZ**

- **3D cells** by combination
- Applied to both, observations and simulations
- Note, the entire identification process is more complex

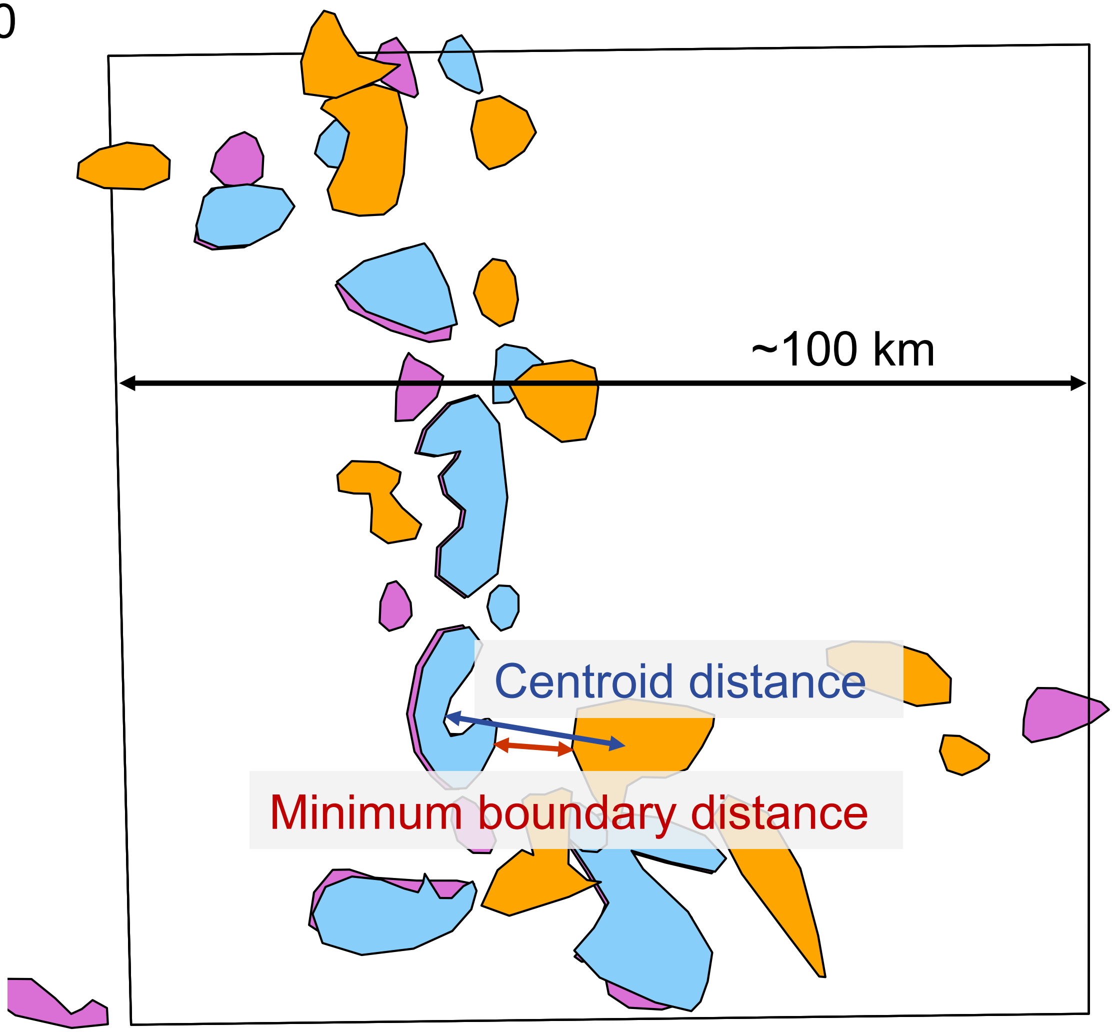
Example of KONRAD3D objects

- Preliminary data for 3 June 2020
  - Observation 13:05
  - Nowcast for 13:35
  - Observation 13:35
- Divide domain into grid boxes
  - **“Gridded objects”**



Example of KONRAD3D objects

- Preliminary data for 3 June 2020
  - Observation 13:05
  - Nowcast for 13:35
  - Observation 13:35
- Attributes of interest
  - Centroid distance
  - Minimum boundary distance
  - Area ratio
  - Intersection area ratio
- Compare all nowcasted with all observed objects



Fuzzy logic algorithm

- "Interest" I
  - $I_{i,j} = c_i \, w_i F_{i,j}$

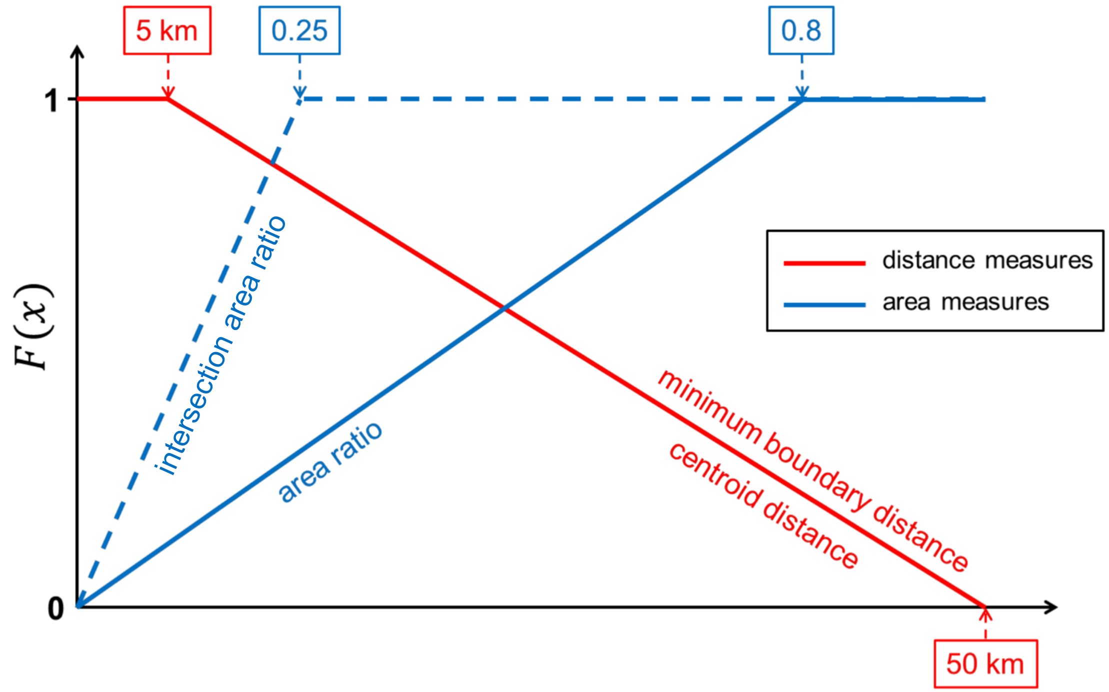
    i attribute index

    j object pair index

    c confidence function

    w weight of attributes

    F interest function

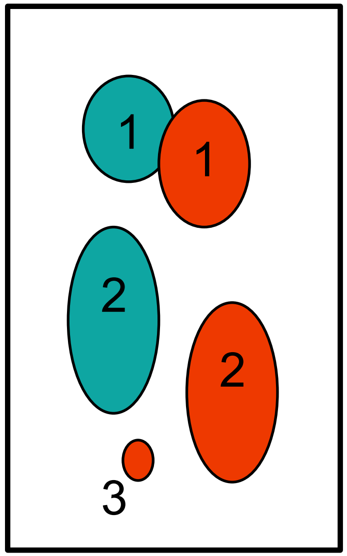


Attribute	Weight	Confidence	f_{min}	f_{max}
Centroid distance	28%	Area ratio	10 km	100 km
Minimum boundary distance	40%	1	5 km	50 km
Area ratio	19%	1	0.0	0.8
Intersection area ratio	13%	1	0.0	0.25

“Total Interest” and “MMI”

Combine the ”Interest” $I_{i,j}$ of attribute i and object pair j with weights w_i and confidence functions c_i **for each attribute** to the **“Total Interest”** $\boldsymbol{TI_j}$ for all object pairs

$$\boxed{TI_j = \frac{\sum_{i=1}^{M} I_{i,j}}{\sum_{i=1}^{M} c_i w_i}}$$



forecast
observation

“Total Interest” - matrix

observed objects

forecast objects

	1	2	max:
1	0.90	0.75	0.90
2	0.50	0.80	0.80
3	0.40	0.55	0.55
max:	0.90	0.80	

0.80 (MMIF)

0.85 (MMIO)

$$\text{median}(0.9, 0.8, 0.55, 0.9, 0.8) = \underline{0.8}$$

→ Median of Maximum Interest (MMI)

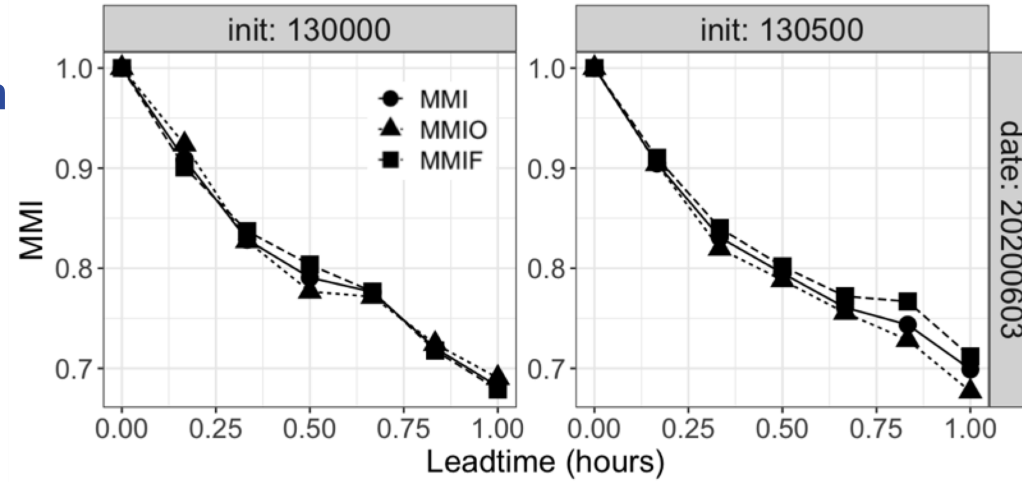
(Davis et al., 2009, WAF)

Visualisation

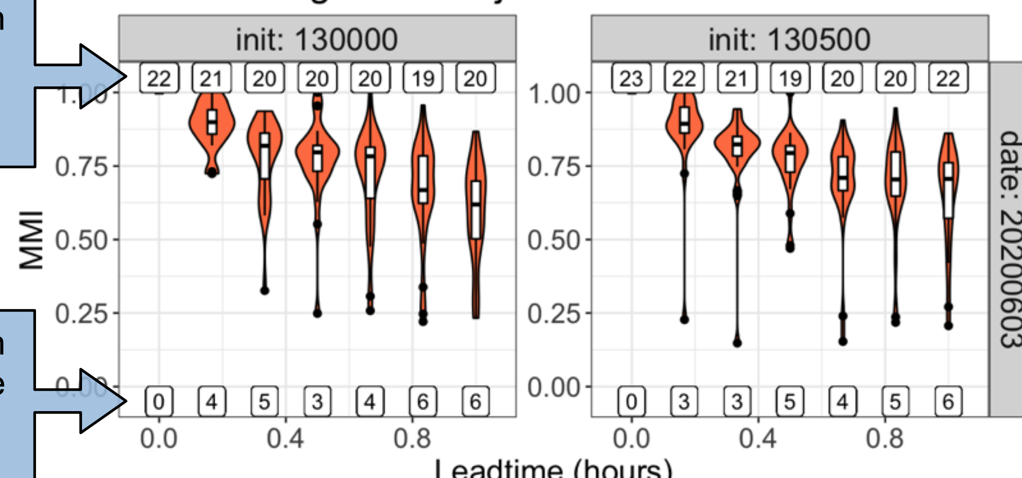
- ➔ Extended R-Shiny application **plots single grid boxes separately** or the **entire domain**

- ➔ Additionally a **combined violin-/box-plot** shows the probability density and the distribution of the scores of all grid boxes

Whole domain



Combined gridded objects



number of boxes with 0 objects in both the observations and forecasts 👍

number of boxes with 0 objects in either the observations or the forecasts 👎

Gridded objects

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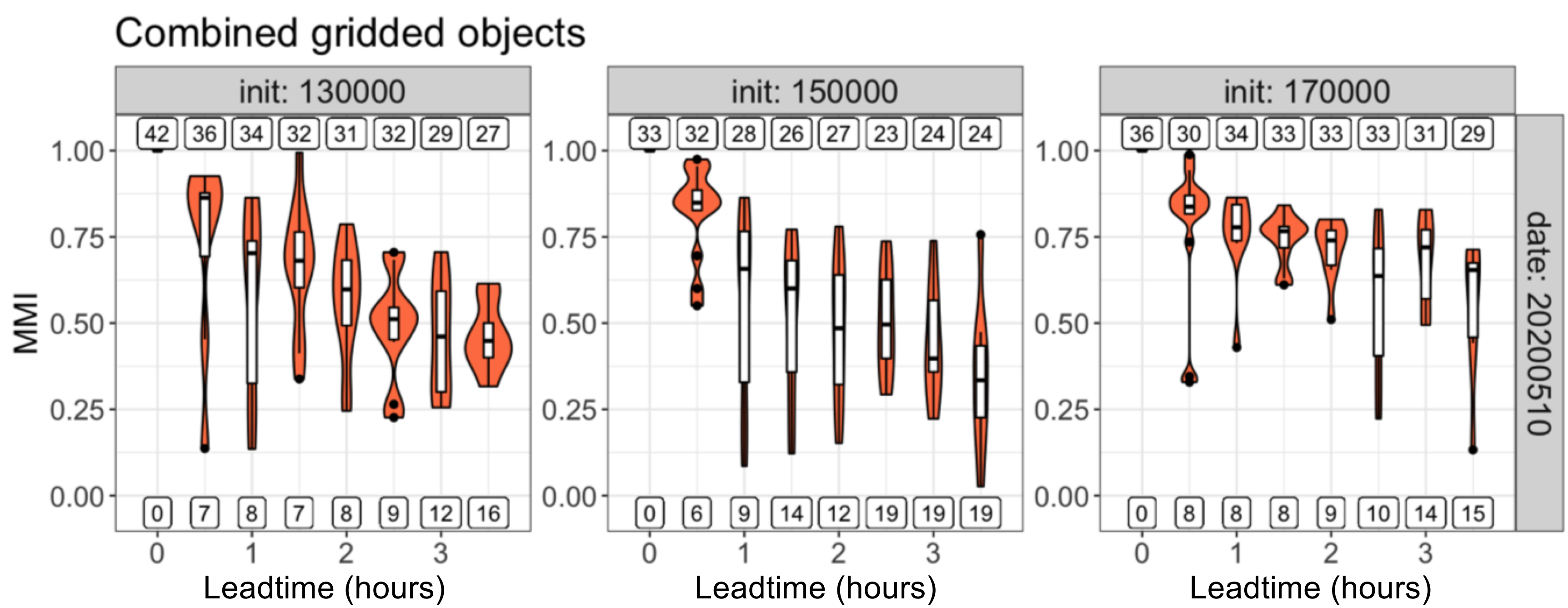
Wetter und Klima aus einer Hand

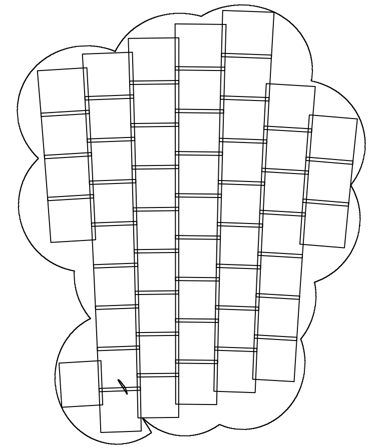
- Example data for 10 May 2020
- Three initialisation time steps at 13, 15, 17 UTC and a lead time of 3.5 hours
- 13 UTC: 42 of 51 boxes have no objects
- 15 UTC: more boxes with objects; fast decrease of MMI
- 17 UTC: slower decrease of MMI → not so many new objects developing?!

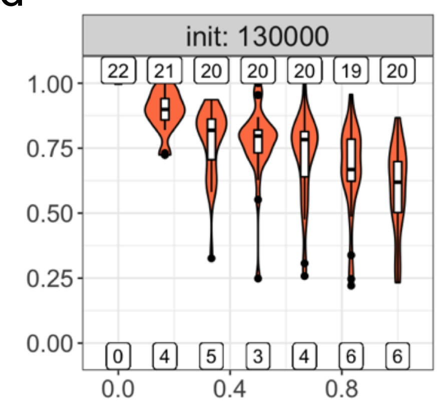


SINFONY

Conclusion

- Implementation of R-package **"simple features (sf)"**
  - Very time-efficient
- Fuzzy logic algorithm for calculation of "Total Interest" and **"Median of Maximum Interest" (MMI)** implemented in R-package for object-based verification
- Scores can now be calculated for **"gridded objects"**, i.e., the subdivision of the German radar composite into 51 grid boxes
- New diagram showing the **distribution of scores** over the grid boxes adds information to the plot of the MMI of the entire domain, e.g., number of boxes with no objects



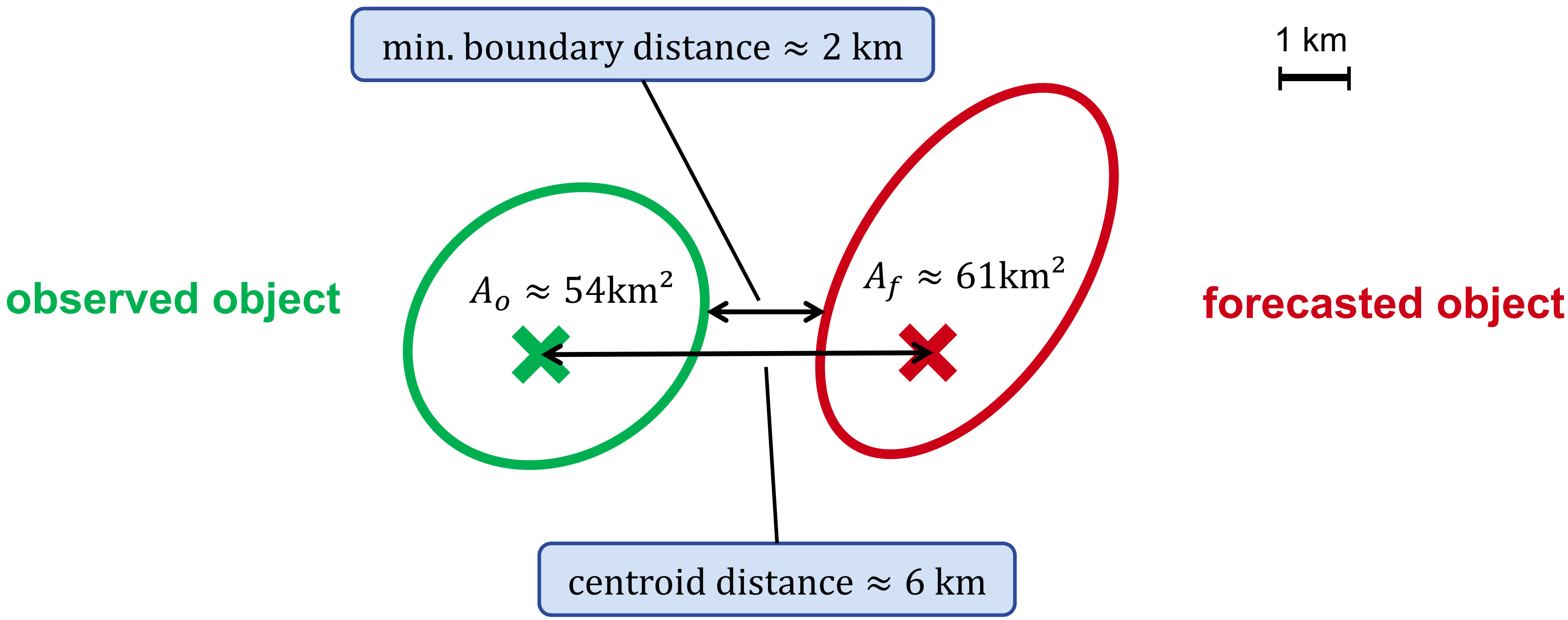


<u>Future work / unresolved issues:</u>

- Compute and analyse **statistics for matched objects**
  - "direction of displacement", "intersection area ratio", …
- Adapt to **ensemble forecasts**
- Determine number of **correct negatives**

Appendix

Calculate the attributes of an object pair



$$\text{area ratio} = \frac{\min(A_o, A_f)}{\max(A_o, A_f)} \approx 0.88$$

$$\text{intersection area ratio} = \frac{A_{int}}{\text{mean}(A_o, A_f)} = 0$$