Applications of spatial methods in COSMO (in the framework of INSPECT PP)

Anastasia Bundel (1), Flora Gofa (2) and many other COSMO colleagues:

Dmitry Alferov (1), Elena Astakhova (1), Petra Baumann (4), Dimitra Boukouvala (2), Ulrich Damrath (3), Pierre Eckert (4), Flora Gofa (2), Alexander Kirsanov (1), Xavier Lapillonne (4), Joanna Linkowska (5), Chiara Marsigli (6), Andrea Montani (6), Anatoly Muraviev (1), Elena Oberto (7), Maria Stefania Tesini (6), Naima Vela (7), Andrzej Wyszogrodzki (5), and Mikhail Zaichenko (1), André Walser (4)

(1) RHM (a.bundel@gmail.com), (2) HNMS, (3) DWD, (4) MCH, (5) IMGW-PIB, (6) ARPA-SIMC, (7) ARPA-PT

ICCARUS, 28 February 2018, DWD, Offenbach-am-Main, Germany

WG5

Spatial methods

Filtering methods

- **Neighborhood**
  (Ebert, 2008)
- **Scale Decomposition**
- **DIST method**

Displacement methods

- **Features-based**
  - ✓Contiguous Rain Area (CRA) (Ebert and McBride, 2000)
  - ✓Method for Object-based Diagnostic Evaluation (MODE) (Davis et al., 2006)
  - ✓ Structure, Amplitude, Location (SAL) (Wernli et al., 2008)
- **Field deformation**

Spatial methods in COSMO

INTERP -> INSPECT -> INSPECT follow-on?

INTERP: studied the filtering methods, in particular, the neighborhood method.

FSS and upscaling ETS scores were identified as most useful.

Spatial methods

Filtering methods

Many √ √ • **Neighborhood** (Ebert, 2008)

√ • **Scale Decomposition**

√ √ • **DIST method**

Displacement methods

- **Features-based**
  - ✓ Contiguous Rain Area (CRA) (Ebert and McBride, 2000) √ √
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- **Field deformation**

By now, almost all the categories of spatial methods are applied by INSPECT participants

WG5

INSPECT outcomes, 1

- **Reruns of deterministic and ensemble forecast systems performed for MesoVICT test cases (ARPAE-SIMC, MCH, RHM)**
- **Scripts for running neighborhood, CRA, and SAL methods using free SpatialVx package available at WG5 repository (HNMS, IMGW-PIB, RHM), including processing gridded observation data**

INSPECT outcomes, 2

- **Several ways of compact visualization of neighborhood, CRA and SAL methods proposed (DWD, MCH, RHM).**

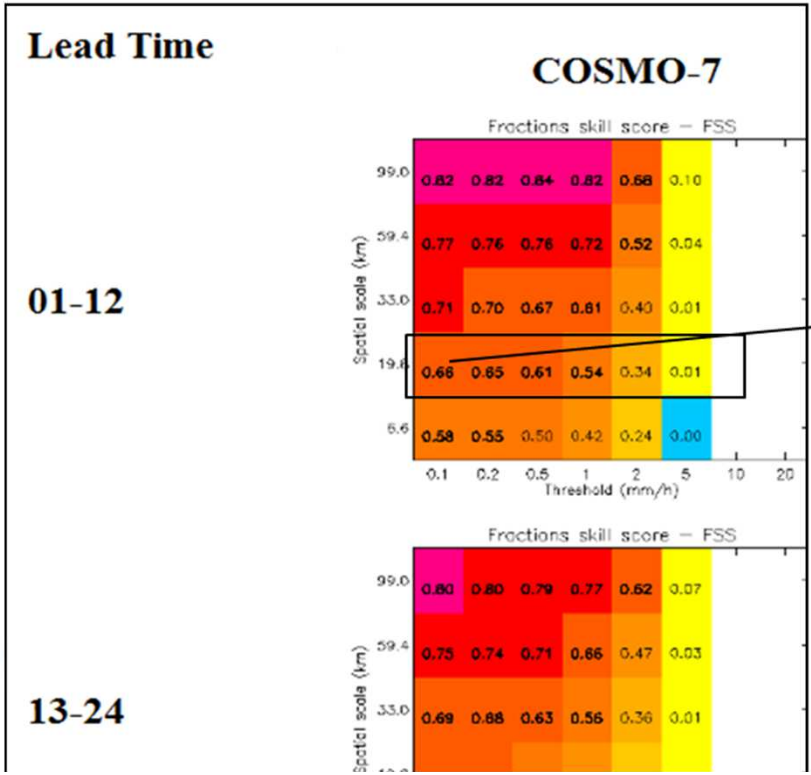
  Especially for neighborhood scores, such a framework can be implemented as part of the Common Verification activity.

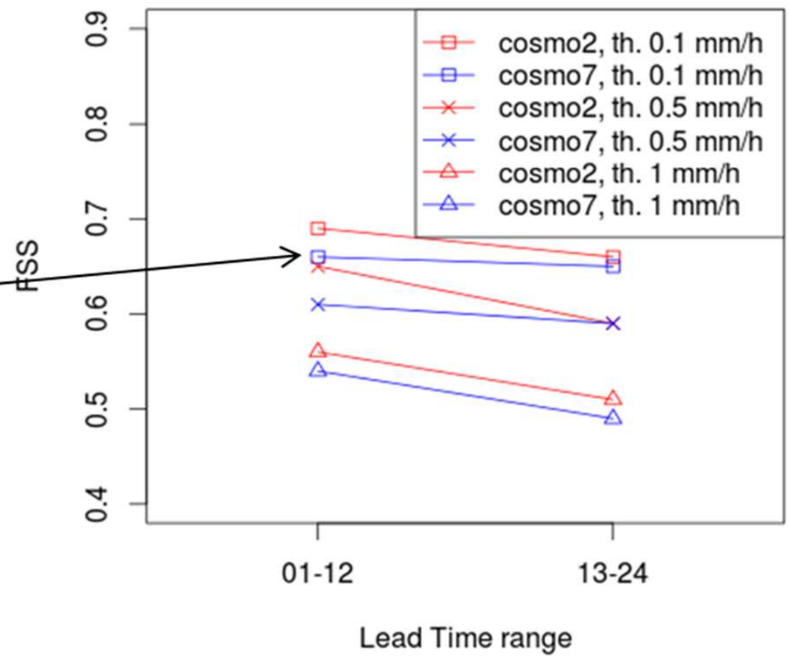
Compact visualization of scores, MCH

- **To select a single meaningful scale and to show the score as a function of lead time for selected thresholds.**

  FSS for two models for the scale 19.6 km which roughly corresponds to the size of a warning region in Switzerland:

MAM2015



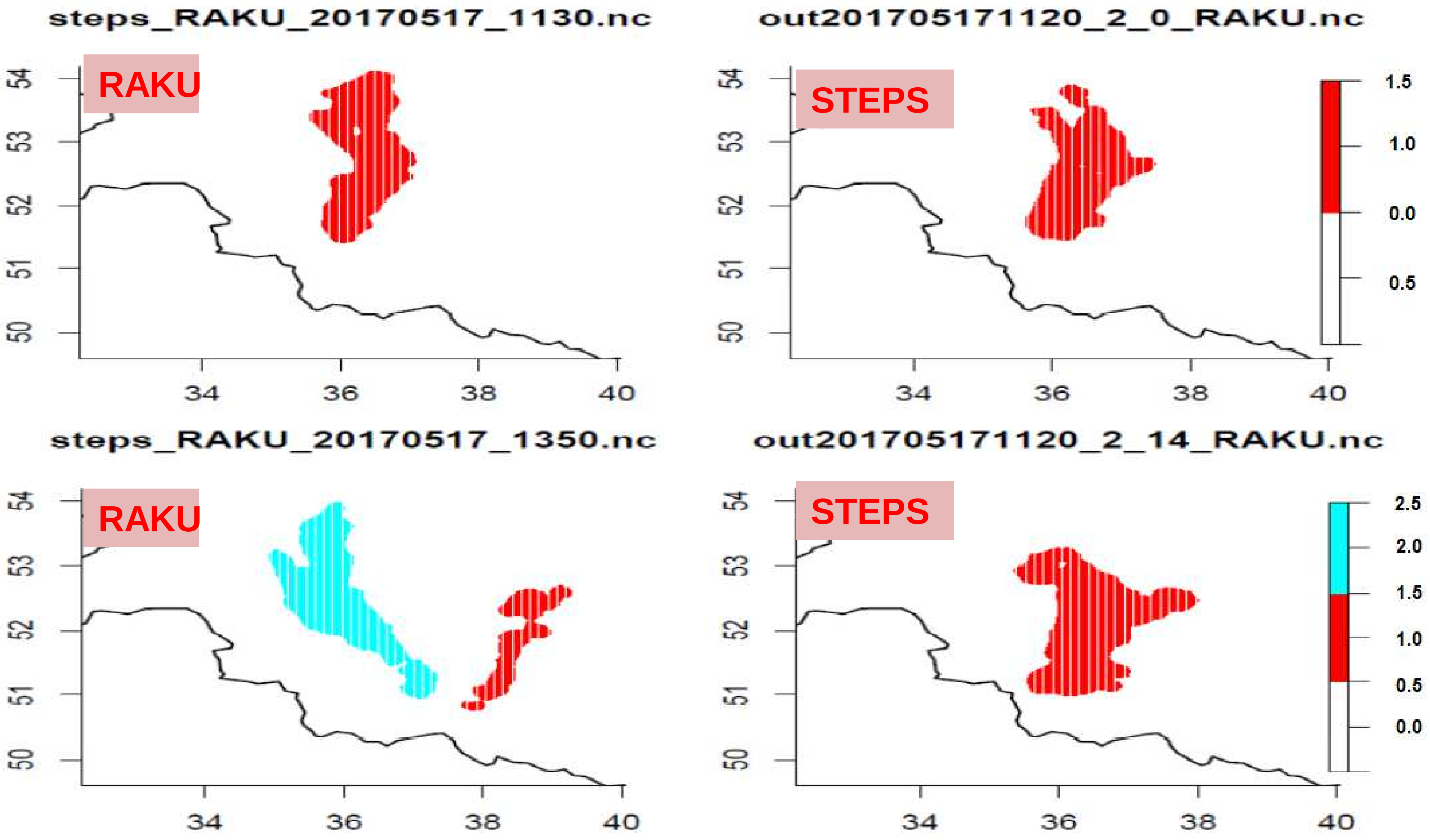


Aggregated CRA scores for STEPS nowcasting at RHM (Anatoly Muraviev)

- Verification period May-September 2017
- 9 radars in Central Russia, ~1100x1300 km
- Forecasts for large intense precipitation areas only are analyzed, ~300 cases
- 10 min time step until 3 h

WG5

SpatialVx: first и last objects



Object recognition and matching

R-SpatialVx, CRA
STEPS forecast: Radar RAKU 20170517_1120

R-SpatialVx craer output

ilead	x_shift	y_shift	MSE.total	.shift	.displ	.volume	.pattern
1	1.89	-10.49	0.4387	0.6986	-0.2599	0.0000	0.6986
2	2.83	-11.04	0.6058	1.0097	-0.4040	0.0002	1.0096
3	0.34	-10.44	0.7205	0.8957	-0.1753	0.0024	0.8933
4	-1.41	-13.42	1.2529	1.3553	-0.1024	0.0074	1.3479
5	-5.91	-12.93	1.7393	1.7697	-0.0304	0.0140	1.7557
6	4.20	-18.01	0.9870	1.2413	-0.2543	0.0044	1.2369
7	3.50	-13.52	0.9584	1.0873	-0.1288	0.0014	1.0859
8	2.36	-6.45	1.0874	1.0787	0.0087	0.0001	1.0787
9	3.24	-7.06	1.1609	1.1567	0.0042	0.0002	1.1565
10	5.49	-6.60	1.2815	1.2475	0.0340	0.0013	1.2463
11	6.65	-7.82	1.2953	1.2648	0.0305	0.0026	1.2622
12	10.41	-14.45	1.3093	1.1718	0.1375	0.0036	1.1682
13	11.33	-16.40	1.3937	1.2378	0.1559	0.0085	1.2293
14	-13.02	-12.33	2.3734	2.4361	-0.0627	0.0008	2.4353
15	-16.07	-14.96	2.6149	2.7596	-0.1446	0.0010	2.7586

Such CRA tables are aggregated over the whole period May-September 2017 !

Statistics of CRA object longitude shift

RAKU: CRA x_shift statistics OVER SITUATIONS

lead	min	q25	med	mean	q75	max
1	-15.280	-7.620	-2.680	-0.609	3.990	16.730
2	-23.480	-9.408	-2.505	-1.519	5.140	18.240
3	-25.920	-9.505	-5.345	-3.125	0.588	30.640
4	-33.920	-9.970	-0.940	-0.467	6.923	32.660
5	-50.030	-17.730	-5.530	-6.011	7.145	32.350
6	-43.530	-19.230	-4.490	-1.933	18.115	30.640
7	-44.900	-19.790	0.800	-2.318	13.760	41.780
8	-44.210	-13.613	-2.990	-2.133	10.455	41.160
9	-48.090	-12.640	-8.150	-5.302	10.428	27.000

Critical shift value* empirically defined as *35 km

***Red* : shifts for all objects don't exceed the critical value**

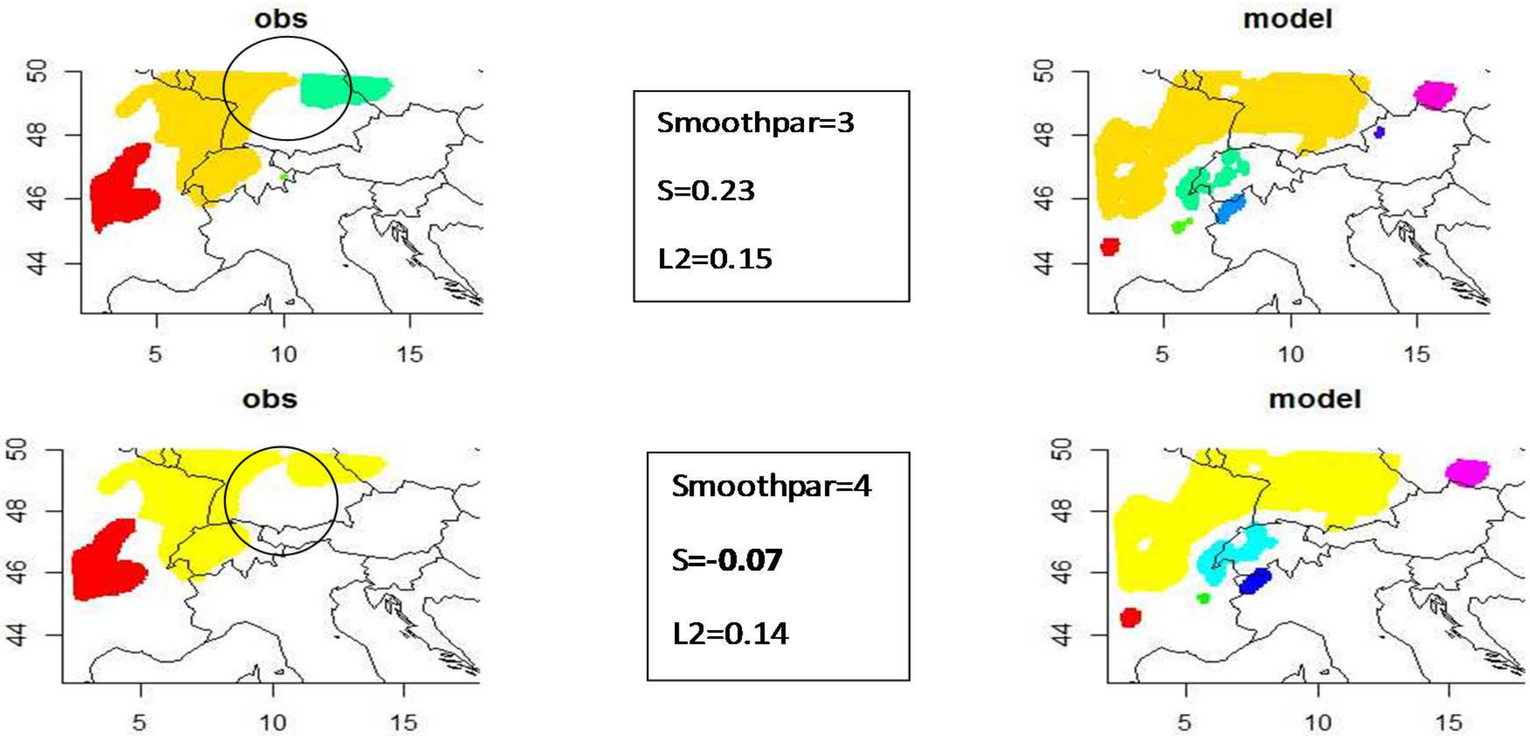
***Green*: shifts for not less than 50% of objects don't exceed the critical value (until 90 min lead time)**

Systematic shifts and other CRA error components can be determined in such a way.

INSPECT outcomes, 3

- **Recommendations as to using different options (smoothing, cut-off small objects, different matching criteria, and so on) for different situations (HNMS, RHM, IMGW-PIB, ARPAE-SIMC)**

An example: Influence of smoothing degree (by Dimitra Boucouvala)



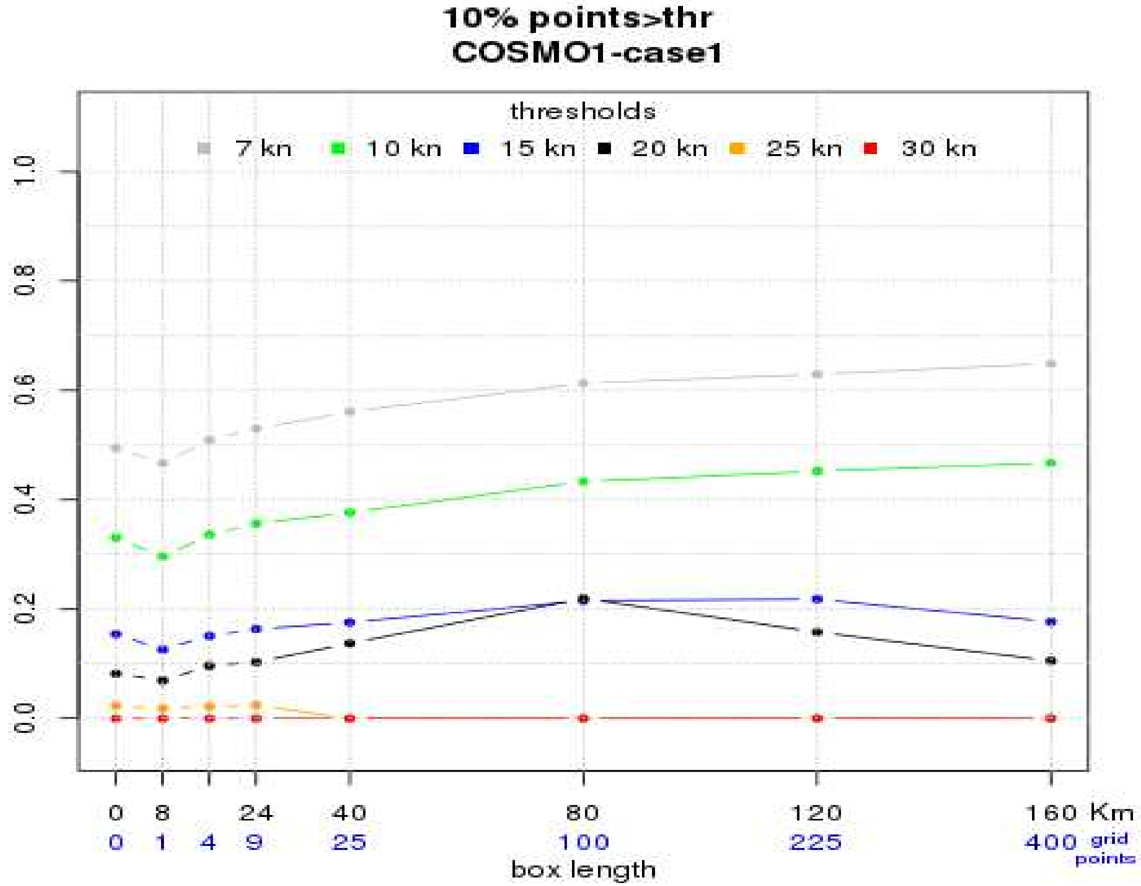
INSPECT outcomes: DIST applied to wind (M.S. Tesini)

The representative value of the box:

- **Wind speed: the median, 90th percentile**
- **Wind direction: as a first step the values were binned into 8 category (N, NE, E, SE, S, SW,W,NW). Then the most populated category was taken as representative for the direction in the box**

WIND SPEED Threat score, MesoVICT case 1, Cosmo-1

The event is defined here as “10% of points exceeding a predefined threshold”



COSMO-1 nearest grid point perform better than the aggregation on 8 Km box. Is the wind too local? Is it only an unlucky case?

Conclusions of Maria Stefania:

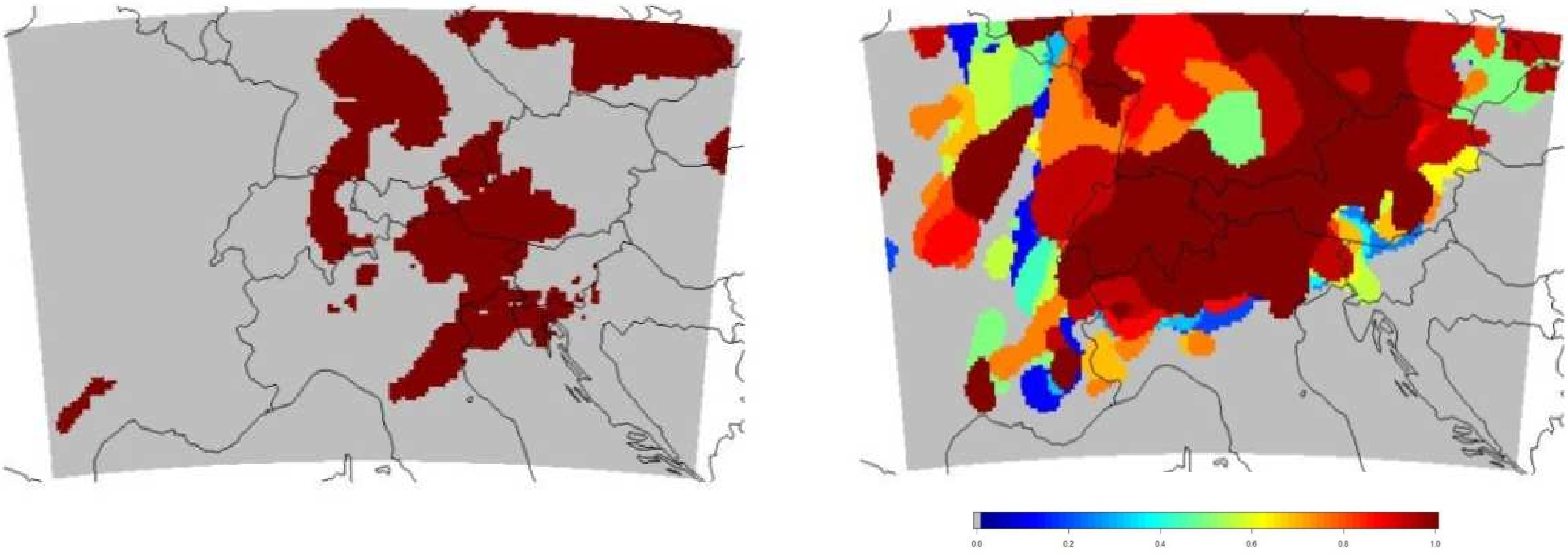
- First results on DIST application to wind were not found very satisfactory:
  - Maybe representative values should be chosen differently
  - The verification period was very short
  - maybe wind is too local and the aggregation has is benefit only if the “box” were chosen differently, maybe taking into account of the orography (valley,…)
- But before giving up some other test are needed:
  - For other MesoVICT cases
  - Looking to the geographical distribution of the scores
  - Using the JDC original observation (one of the main advantages of DIST was to deal with sparse point observations…)

INSPECT outcomes, 4.
Ensemble applications and observation uncertainty

- Sensitivity of COSMO-LEPS forecast skill to the verification network:
  application to MesoVICT cases (ARPAE-SIMC)
- Research on applying CRA to ensembles (RHM)
- Research on SAL applied to EPS includes comparison of objects in fields of probability (Radanovics et al, 2015, 2017) with consideration (if available) of observation uncertainty, for MesoVICT data (Dimitra Boucouvala, HNMS)

SAL (D. BOUCOUVALA): WHEN UNCERTAINTY IS APPLIED TO THE MODEL DOMAIN ONLY -

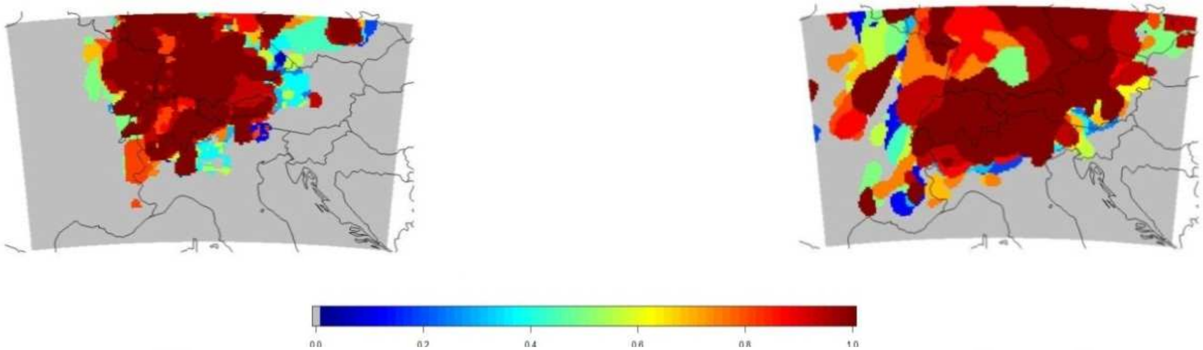
Only the objects of probability 1 can be compared to the observation objects



Probabilities of 3h precipitation > 2mm for observations (left) and LEPS (right). 21/06 12UTC. The color scale is the probability range

S parameter will reflect only the object size and not sharpness in this case

WHEN UNCERTAINTY IS APPLIED ALSO TO OBSERVATIONS (IN THIS CASE 16 MEMBERS OF VERA ENSEMBLE)



Probabilities of 3h precipitation threshold > 2mm for VERA ensemble (left) and LEPS (right) (21/06 12h)

Objects of probability =1

S=0.37, A=0.6, L=0.1

Objects of probability = 0.5

S=0.65, A=0.5, L=0.05

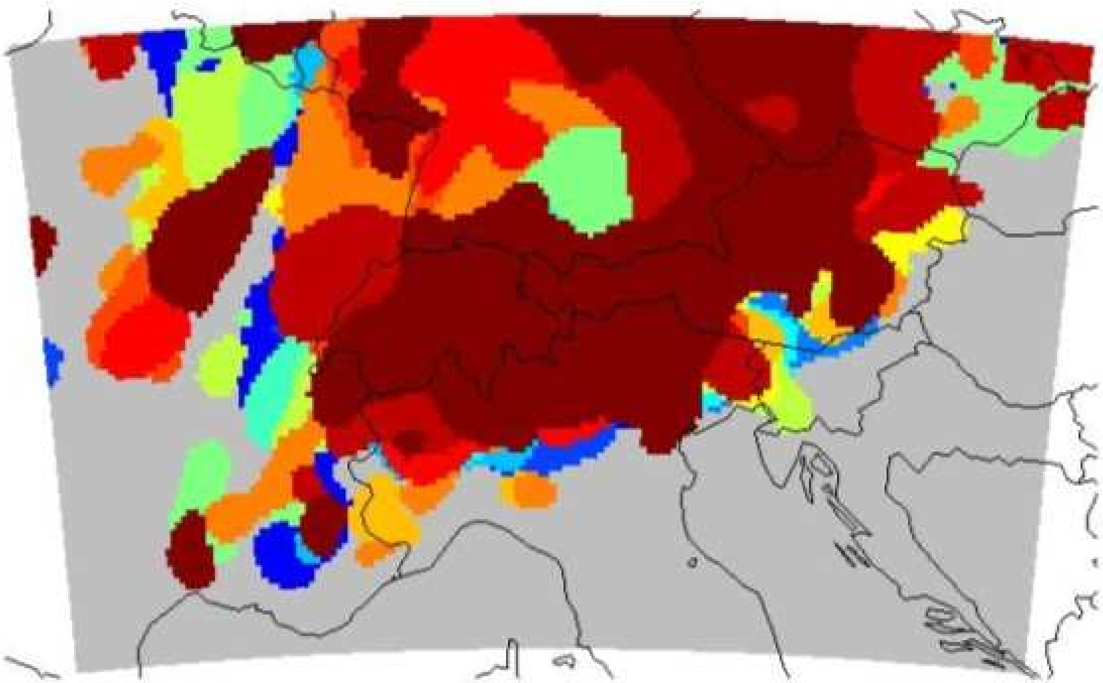
Thus, if we want to assess probabilities of objects less than 1 (could be important for different applications!), the only reasonable way is to include observation uncertainties. But the objects can be too large!

Possible INSPECT follow-on

- Further applications to ensembles
- Further research on introducing observation uncertainty
- Focus on HIW

Perspectives of applying spatial methods in COSMO

- Processing “terabytes of data”, in particular, for nowcasting, calculation efficiency will be of utmost importance!
- Spatial methods in the APSU and C2I PPs
- More user-specific variables (relation to WG4!), exploration of non-standard observations



THANK YOU
FOR YOUR ATTENTION !