

# Use of fuzzy methods in verification and comparison of high resolution forecasts (first tests)

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Fuzzy verification methods applied for comparison of high resolution precipitation

Data used in experiment:

ALADIN Numerical Weather Prediction (13.5 km spatial resolution) output

Standard metrics employed in verification and used for comparison of high resolution forecasts

False alarm rate  $F = \frac{false \ alarms}{correct \ rejections + false \ alarms}$  False Alarm Ratio  $FAR = \frac{false \ alarms}{hits + false \ alarms}$ 

AROME Numerical Weather Prediction (2.7 km spatial resolution) output Verified field

precipitation (6h, 12h, 24h cumulation)

### Thresholds:

0.0, 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0 [mm/24h]

### Precipitation intervals:

0.0 - 0.1, 0.1 - 0.2, 0.2 - 0.5, 0.5 - 1.0, 1.0 - 2.0, 2.0 - 5.0, 5.0 - 10.0, 10.0 - 20.0, 20.0 - 50.0, above 50.0 [mm/24h]

## Scales and domain characteristics:



Example of the different scales of the neighborhood surrounding the grid box of interest:

1km, 10km, 15km, 25km, 45km, 85km, 165km

Proportion Correct hit rate  $PC = \frac{hits + correct \ rejections}{N}$ 

#### Threat Score





#### Equitable Threat Score



### Results

(examples)

		F minimumcoverage cum 24h								_	F	minin	numco	overaç	ge	cum 24h					
165km	NaN	0.38	0.50	0.25	80.0	0.12	0.04	0.00	0.00	0.00	165km	0.00	0.00	0.07	0.03	0.00	0.07	0.03	0.00	0.00	0.00
85km	NaN	0.47	0.39	0.18	80.0	0.12	0.04	0.03	0.00	0.00	85km	0.00	0.00	0.10	0.10	0.04	0.11	0.04	0.03	0.00	0.00
45km	NaN	0.47	0.35	0.29	0.12	0.12	0.04	0.03	0.00	0.00	45km	0.00	0.07	0.11	0.11	0.07	0.11	0.04	0.03	0.00	0.00
25km	NaN	0.40	0.38	0.30	0.08	0.08	0.04	0.03	0.00	0.00	25km	0.07	0.03	0.15	0.15	0.04	0.07	0.04	0.03	0.00	0.00
15km	NaN	0.33	0.38	0.33	0.09	0.08	0.04	0.03	0.00	0.00	15km	0.12	0.03	0.16	0.19	0.04	0.07	0.04	0.03	0.00	0.00
10km	NaN	0.33	0.38	0.37	0.09	0.04	0.04	0.03	0.00	0.00	10km	0.12	0.04	0.12	0.21	0.04	0.04	0.04	0.03	0.00	0.00
1km	NaN	0.33	0.38	0.37	0.09	0.04	0.04	0.03	0.00	0.00	1km	0.12	0.04	0.15	0.20	0.04	0.04	0.04	0.03	0.00	0.00
	0.0	0.1	0.2	0.5	1.0	2.0	5.0	10.0	20.0	50.0		0.0	0.1	0.2	0.5	1.0	2.0	5.0	10.0	20.0	50.0
thresholds [mm/24h] precipitation intervals [mm/24h														ŀh]							
	FAR minimumcoverage cum 24h									FAR minimumcoverage cum 24h											
165km	and a strength of the state	and the second second																			
1000000	0.00	0.32	0.61	0.55	0.29	0.50	0.50	NaN	NaN	NaN	165km	0.00	NaN	1.00	1.00	NaN	0.67	1.00	NaN	NaN	NaN
85km	0.00	0.32	0.61 0.39	0.55 0.36	0.29 0.29	0.50 0.50	0.50 0.50	NaN 1.00	NaN NaN	NaN NaN	165km 85km	0.00 0.00	NaN NaN	1.00 1.00	1.00 1.00	NaN 1.00	0.67 0.75	1.00 1.00	NaN 1.00	NaN NaN	NaN NaN
85km 45km	0.00 0.00 0.00	0.32 0.40 0.40	0.61 0.39 0.33	0.55 0.36 0.46	0.29 0.29 <mark>0.38</mark>	0.50 0.50 0.50	0.50 0.50 0.50	NaN 1.00 1.00	NaN NaN NaN	NaN NaN NaN	165km 85km 45km	0.00 0.00 0.00	NaN NaN 1.00	1.00 1.00 0.60	1.00 1.00 0.75	NaN 1.00 1.00	0.67 0.75 0.75	1.00 1.00 1.00	NaN 1.00 1.00	NaN NaN NaN	NaN NaN
85km 45km 25km	0.00 0.00 0.00 0.00	0.32 0.40 0.40 0.32	0.61 0.39 0.33 0.33	0.55 0.36 0.46 0.46	0.29 0.29 <mark>0.38</mark> 0.29	0.50 0.50 0.50 0.40	0.50 0.50 0.50 0.50	NaN 1.00 1.00 1.00	NaN NaN NaN NaN	NaN NaN NaN NaN	165km 85km 45km 25km	0.00 0.00 0.00 0.10	NaN NaN 1.00 1.00	1.00 1.00 0.60 0.80	1.00 1.00 0.75 0.67	NaN 1.00 1.00 0.50	0.67 0.75 0.75 0.67	1.00 1.00 1.00	NaN 1.00 1.00 1.00	NaN NaN NaN NaN	NaN NaN NaN

	F			multievent			cum 24h					F			multievent			cum 24h			
165km	NaN	0.67	0.69	0.63	0.61	0.36	0.21	0.07	0.00	0.00	165km	0.71	0.60	0.73	0.68	0.63	0.38	0.21	0.07	0.00	0.00
85km	NaN	0.67	0.44	0.53	0.39	0.16	0.07	0.03	0.00	0.00	85km	0.47	0.48	0.38	0.44	0.44	0.19	0.07	0.03	0.00	0.00
45km	NaN	0.33	0.44	0.42	0.30	80.0	0.04	0.03	0.00	0.00	45km	0.24	0.24	0.31	0.32	0.22	80.0	0.04	0.03	0.00	0.00
25km	NaN	0.33	0.38	0.37	0.09	0.04	0.04	0.03	0.00	0.00	25km	0.12	0.04	0.15	0.20	0.04	0.04	0.04	0.03	0.00	0.00
15km	NaN	0.33	0.38	0.37	0.09	0.04	0.04	0.03	0.00	0.00	15km	0.12	0.04	0.15	0.20	0.04	0.04	0.04	0.03	0.00	0.00
10km	NaN	0.33	0.38	0.37	0.09	0.04	0.04	0.03	0.00	0.00	10km	0.12	0.04	0.15	0.20	0.04	0.04	0.04	0.03	0.00	0.00
1km	NaN	0.33	0.38	0.37	0.09	0.04	0.04	0.03	0.00	0.00	1km	0.12	0.04	0.15	0.20	0.04	0.04	0.04	0.03	0.00	0.00
	0.0	0.1	0.2	0.5	1.0	2.0	5.0	10.0	20.0	50.0		0.0	0.1	0.2	0.5	1.0	2.0	5.0	10.0	20.0	50.0
thresholds [mm/24h]												reci	ipita	atio	n int	terv	als	[mr	/24	h]	
FAD multiplicate sum 24h												FAD		manulti	au ont			246			

	FAR		_	multievent			cum 24h					FAR			multievent			cum 2	24h		
ōkm	0.00	0.32	0.46	0.55	0.70	0.69	0.86	1.00	NaN	NaN	165km	0.52	0.79	0.86	0.81	0.89	0.77	0.86	1.00	NaN	NaN
ōkm	0.00	0.32	0.35	0.50	0.60	0.50	0.67	1.00	NaN	NaN	85km	0.47	0.80	0.77	0.73	0.86	0.62	0.67	1.00	NaN	NaN
ōkm	0.00	0.20	0.35	0.50	0.58	0.33	0.50	1.00	NaN	NaN	45km	0.31	0.86	0.80	0.80	0.86	0.40	0.50	1.00	NaN	NaN
ōkm	0.00	0.21	0.33	0.54	0.29	0.20	0.50	1.00	NaN	NaN	25km	0.20	1.00	0.80	0.83	0.50	0.33	1.00	1.00	NaN	NaN
ōkm	0.00	0.21	0.33	0.54	0.29	0.20	0.50	1.00	NaN	NaN	15km	0.20	1.00	0.80	0.83	0.50	0.33	1.00	1.00	NaN	NaN
)km	0.00	0.21	0.33	0.54	0.29	0.20	0.50	1.00	NaN	NaN	10km	0.20	1.00	0.80	0.83	0.50	0.33	1.00	1.00	NaN	NaN

### Fuzzy verification methods adopted for experiment

- Upscaling useful forecast resembles the observations when averaged to coarser scales.
  Matching strategy neighborhood observation vs neighborhood forecast.
- Minimum coverage useful forecast predicts the event over a minimum fraction of the region of interest. Matching strategy neighborhood observation vs neighborhood forecast
- Multi-event contingency table useful forecast predicts at least one event close to an observed event. Matching strategy — single observation vs neighborhood forecast.
- Area-related RMSE useful forecast has similar distribution of intensities as the observations. Matching strategy neighborhood observation vs neighborhood forecast.
- Conditional square root of RPS useful forecast has a high probability of matching the observed value. Matching strategy single observation vs neighborhood forecast.
- Practically perfect hindcast useful forecast resembles one that would have been issued by a forecaster given perfect knowledge of the observations beforehand. Matching strategy single observation vs neighborhood forecast.
- Pragmatic useful forecast has a high probability of detecting events and non-events.



The presence of the extremal values of indicators in tables (obtained in tests) imply strong consistency for precipitation forecasts given by both models. In other words, output of the lower resolution model ALADIN and model AROME which covers more subtle features (because of the denser grid) are not the same but very similar. These were preliminary tests thus further study is needed.

Matching strategy — single of observation vs neighborhood forecast.

- Fractions skill score useful forecast has similar frequency of forecast events and observed events. Matching strategy neighborhood observation vs neighborhood forecast.
- Fuzzy logic useful forecast is more correct than incorrect. Matching strategy neighborhood observation vs neighborhood forecast.

Ebert E. E., 2008, Fuzzy verification of high-resolution gridded forecasts: a review and proposed framework, *Meteorol. Appl.*, **15**, 51–64;



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