

Forecasting extreme meteorological events over complex topography

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Outline

- **How to target the EPS on rare events**
 - Extreme Forecast Index (**EFI**) a verification
 - Processing by ANN (Artificial Neural Networks)
 - COSMO LEPS

Conclusions

„Rescaling / downscaling“ techniques for extreme events



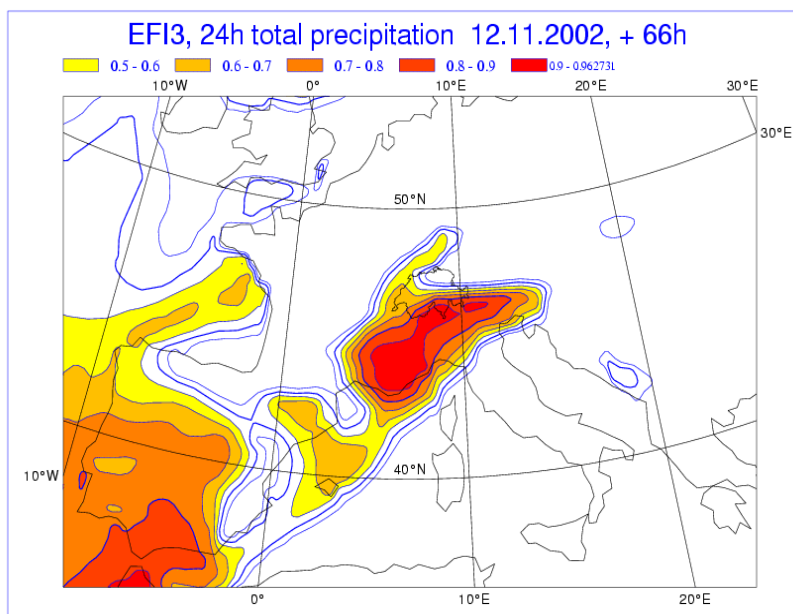
EFI rescale with respect to model climate

Artificial neural Network (**ANN**)

pattern recognition of extreme situations with respect to a given meteorological parameter (precipitation)

LEPS downscale ensemble with a LAM

1/ EFI verification and guidance



ECMWF Extreme Forecast Index

$$EFI_n = (n + 1) \int_0^1 (p - F_f(p))^n dp$$

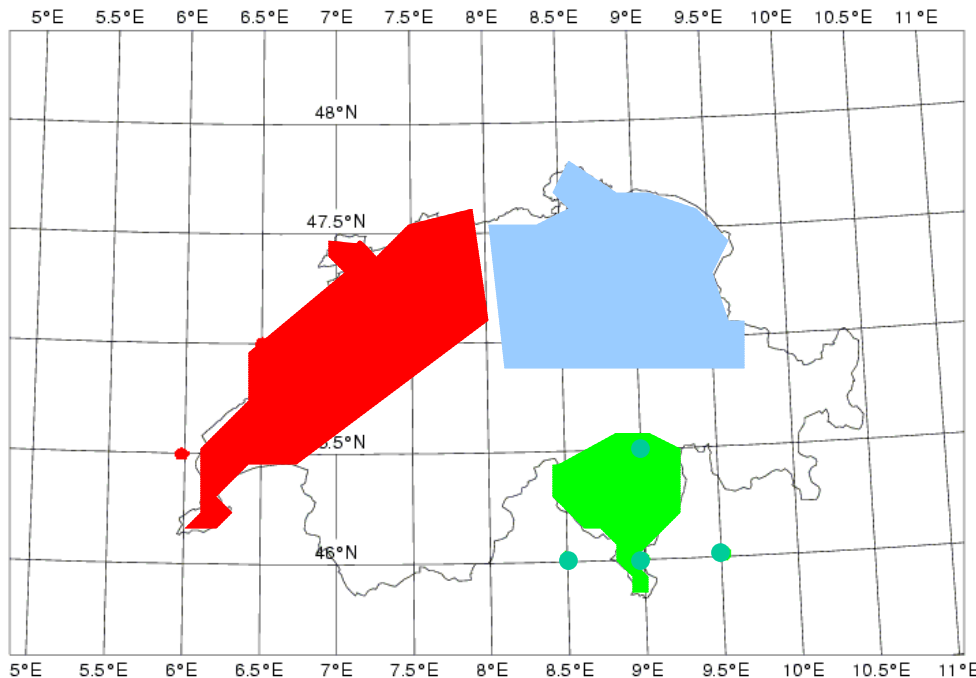
- **EFI values – fct quantity?**
- **Forecaster guidance**

EFI verification

Verification parameters



- ◆ Precipitations and wind gusts (nov.2001-apr.2003)
 - Predictands: 2nd max prec. / 24h of climatological regions (W, E, S)
 - Predictors: EFI max over regions



- ◆ Thresholds
 - >20 mm/24h
 - >50 mm/24h
 - 75 km/h

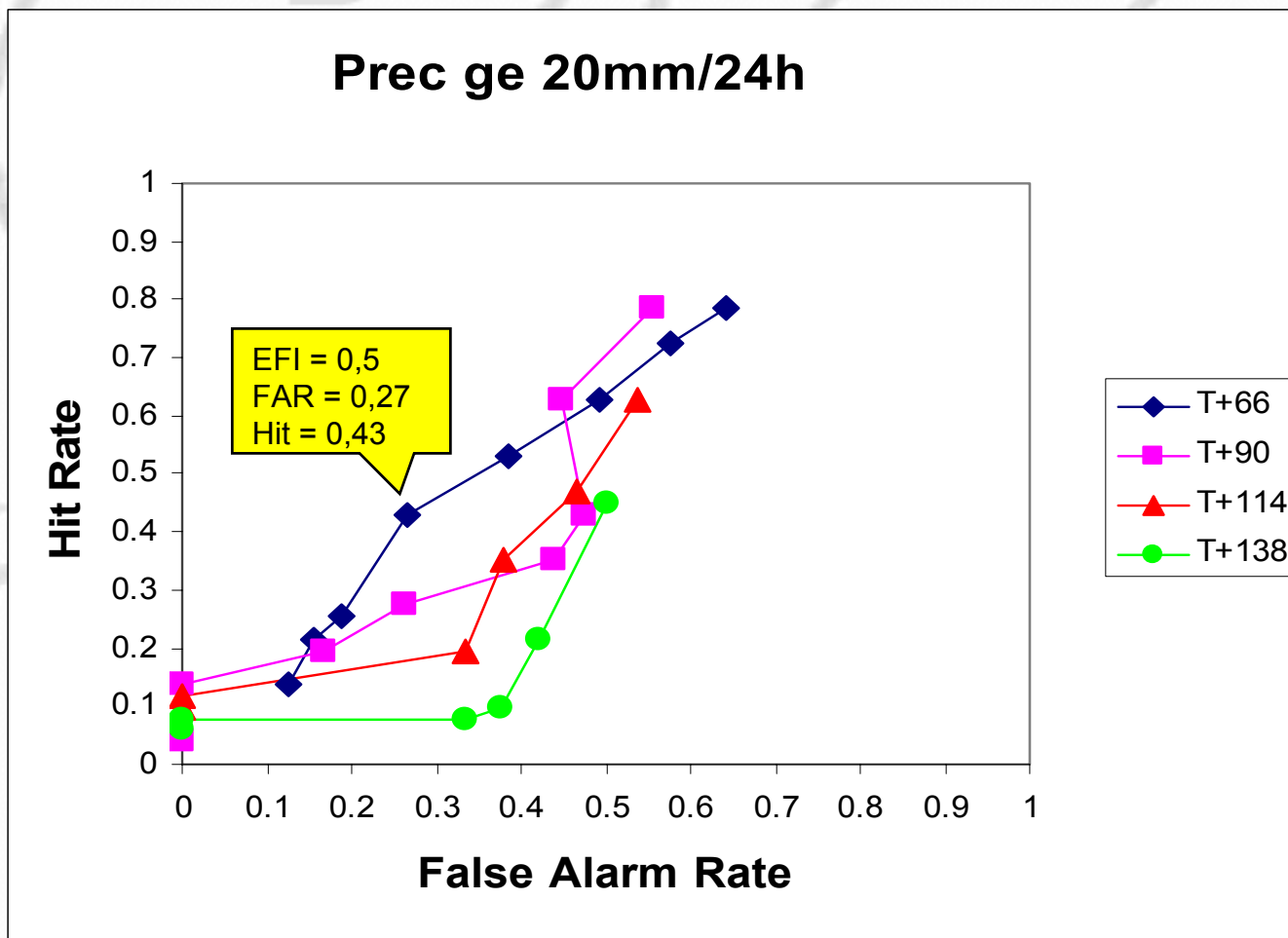
Verification: scores



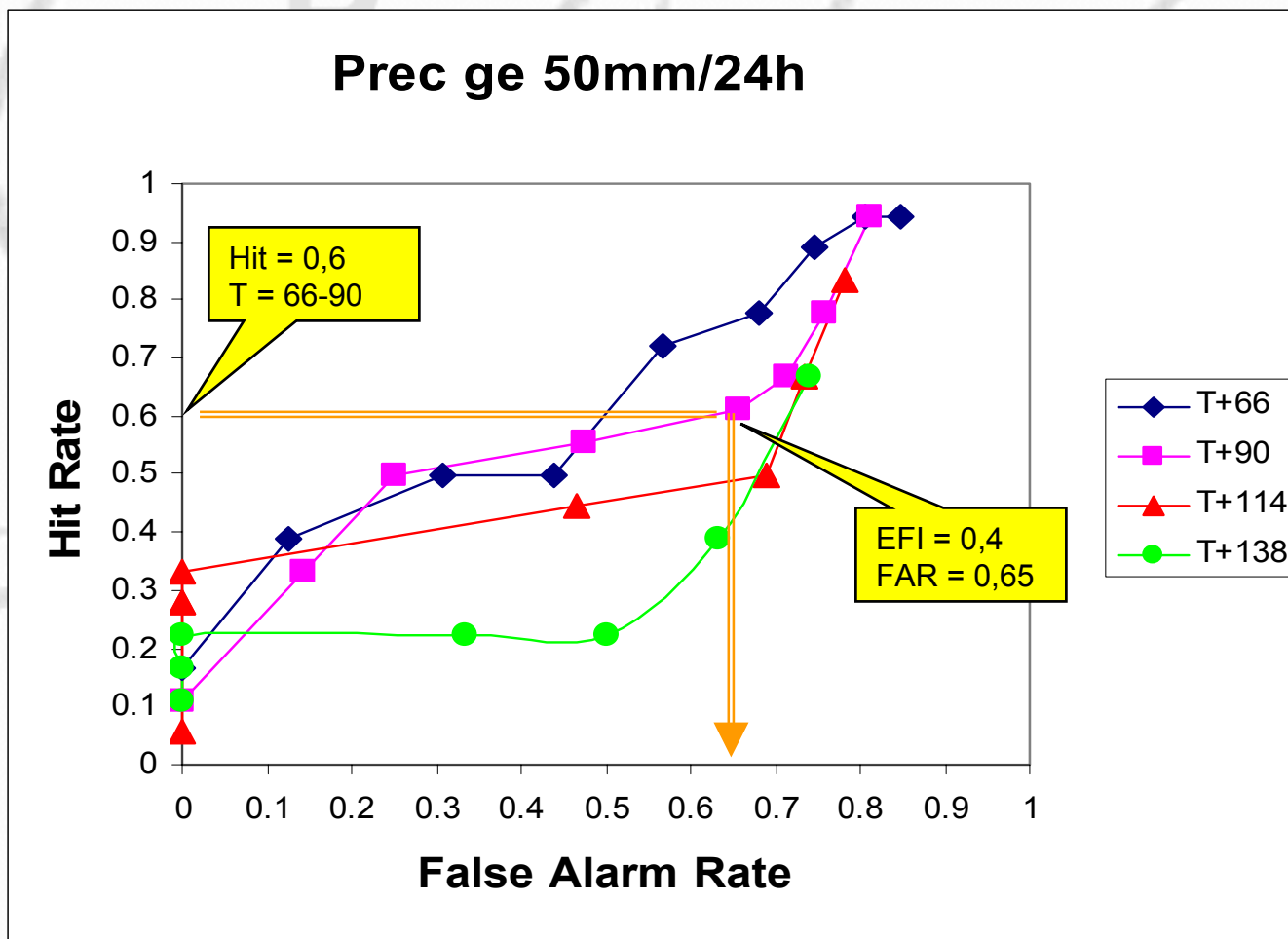
Event	Observed	Not Observed
Forecasted	A	B
Not Forecasted	C	D

- **Event forecasted : EFI gt given value**
- **Hit Rate = $A / (A+C)$**
- **FAR = $B / (A+B)$**

Precipitations : Switzerland South



Precipitations : Switzerland South



Forecaster guidance



T+42-66h

Hit=0.6

	Prec ge 10mm		Prec ge 20mm		Prec ge 50mm	
	EFI	FAR	EFI	FAR	EFI	FAR
West	0.2	0.2	0.2	0.6		
South	0.3	0.3	0.3	0.5	0.5	0.5

Gust ge 75km/h

Hit=0.5

	T+36-60h		T+60-84h		T+84-108h		T+108-132h	
	EFI	FAR	EFI	FAR	EFI	FAR	EFI	FAR
West	0.3	0.7	0.3	0.5	0.2	0.7	0.2	0.8

2/ Recognition of extreme events with Artificial Neural Network



Unsupervised training

- Self Organising Map (SOM) = classification of weather patterns irrespective of the predictand (precipitation)
- Interpretation in terms of weather elements made in a second step: probability to exceed some threshold for each element of the classification



B

Supervised training

- The predictors and the predictand (precipitation) have to be shown simultaneously to the network
- ***Feed Forward Neural Network (FFNN)*** shown here

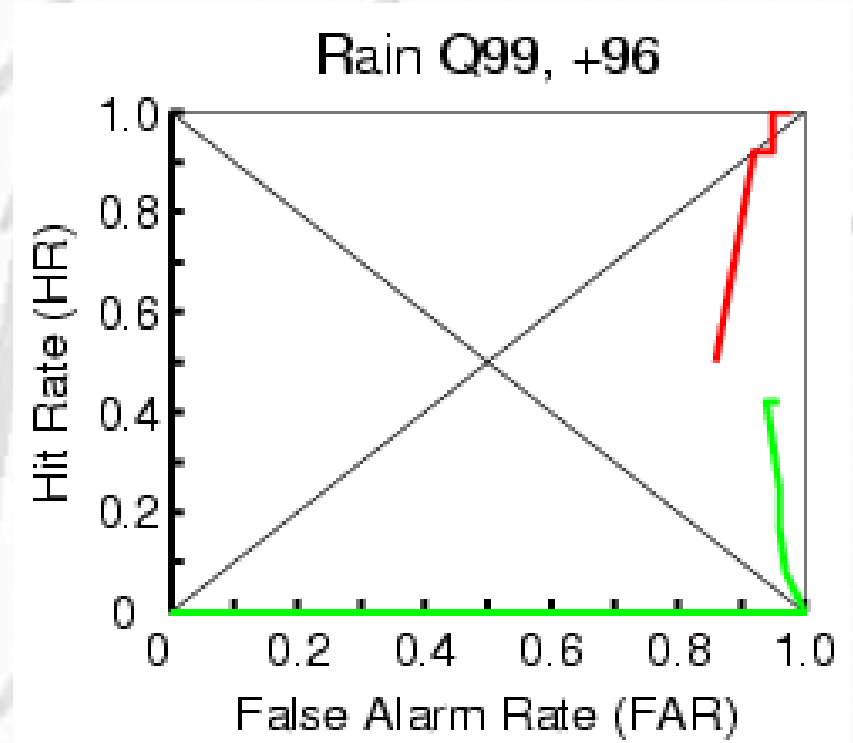
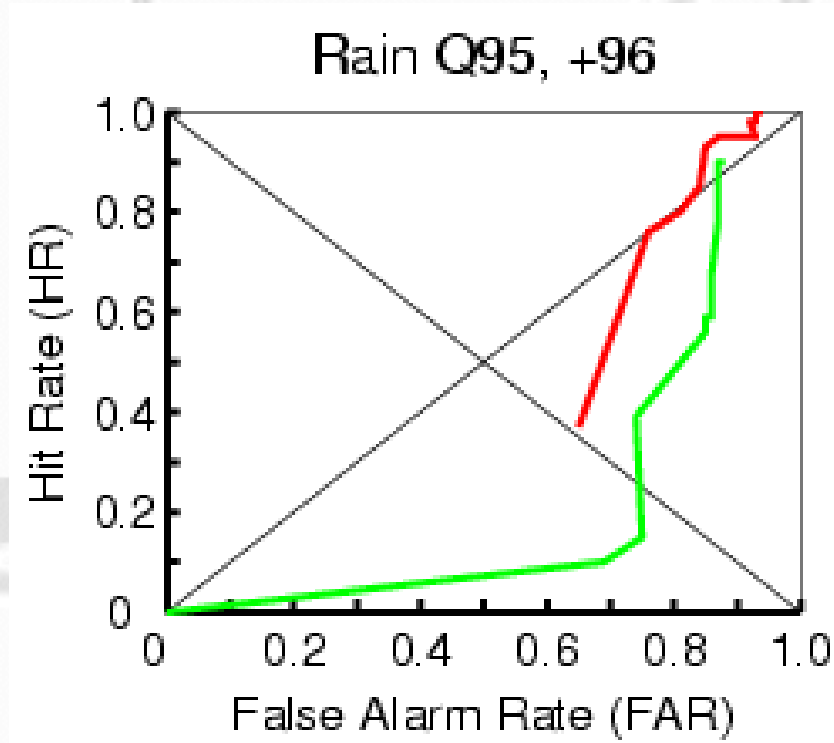
H

Predictors = upper air



Set	850 hPa	700 hPa	500 hPa	input features
A_L, A_H	T	-	Z	200
B_L, B_H	T	R	W, Z	400
C_L, C_H	R, T, U, V	R, Z	R, T, W, Z	1000
D_L, D_H	R, T, U, V	R, T, U, V, W, Z	R, T, W, Z	1400
\tilde{C}_L, \tilde{C}_H	first 250 PCA components of C_L, C_H			250
\tilde{D}_L, \tilde{D}_H	first 250 PCA components of D_L, D_H			250

Perf. prog based on ANN upper air to forecast rainfall in Lugano



- SOM (unsupervised)
- FFNN (supervised)

Predictors = upper air + precipitations

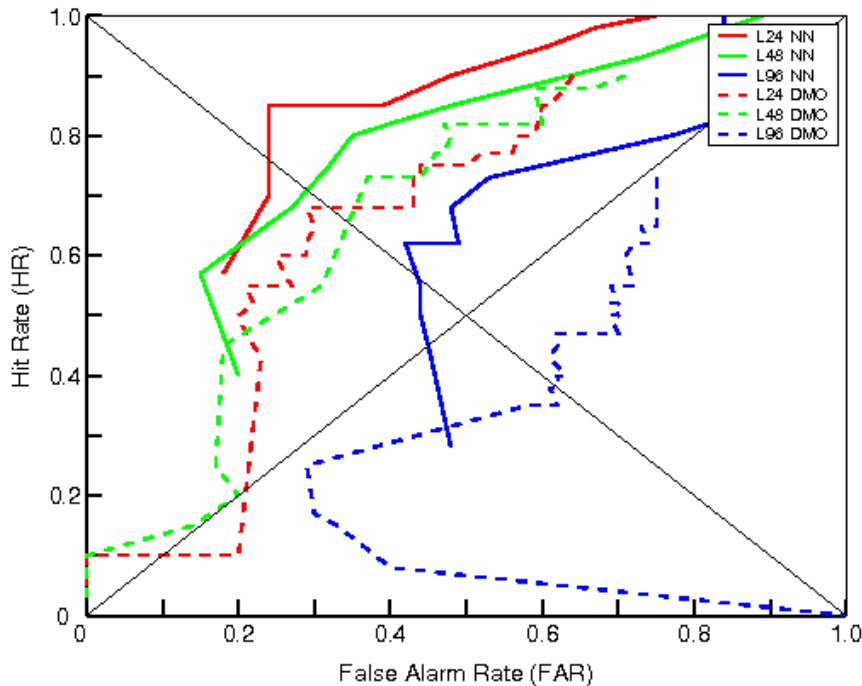
- New classification by supervised learning adding the DMO precipitations as predictors
- Work done on the ECMWF T511
- Use DMO precipitation with the simple rescaling:

Event predicted when DMO $rr > 10\text{mm}$,
20mm, 30mm,...

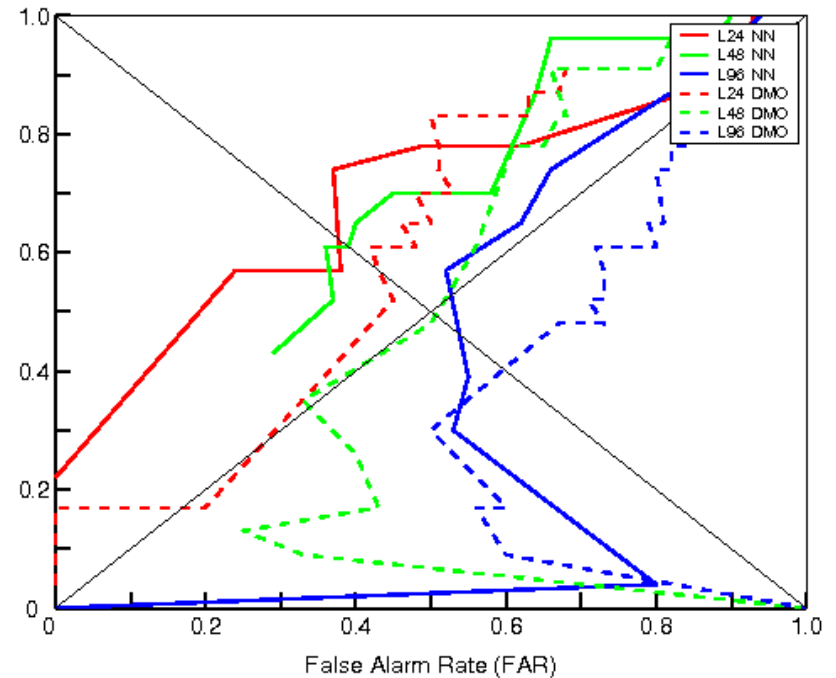
ANN upper air + precip DMO

Rainfall Lugano

Rain ≥ 10.0 mm/24h

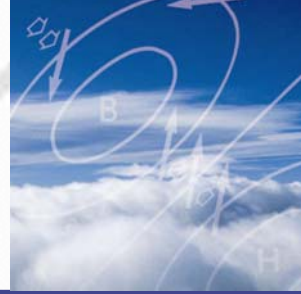


Rain ≥ 20.0 mm/24h



- Rescaled DMO (T511) T+24, T+48, T+96
- FFNN + precip DMO T+24, T+48, T+96

Training set: data from 1.6.1998 to 31.5.2001,
 Validation set: data from 1.6.2001 to 31.5.2002



3/ The COSMO LEPS

LEPS

- downscale ensemble with a LAM

November 2002 flooding, 14-16th November

- Low over western Mediterranean
- Southerly current over the Alps
- Over 100 mm/day south of the Alps (classical)
- Geneva: 92 mm in one day (14th) **Very exceptional**

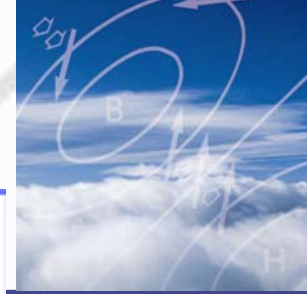
14.11.2002



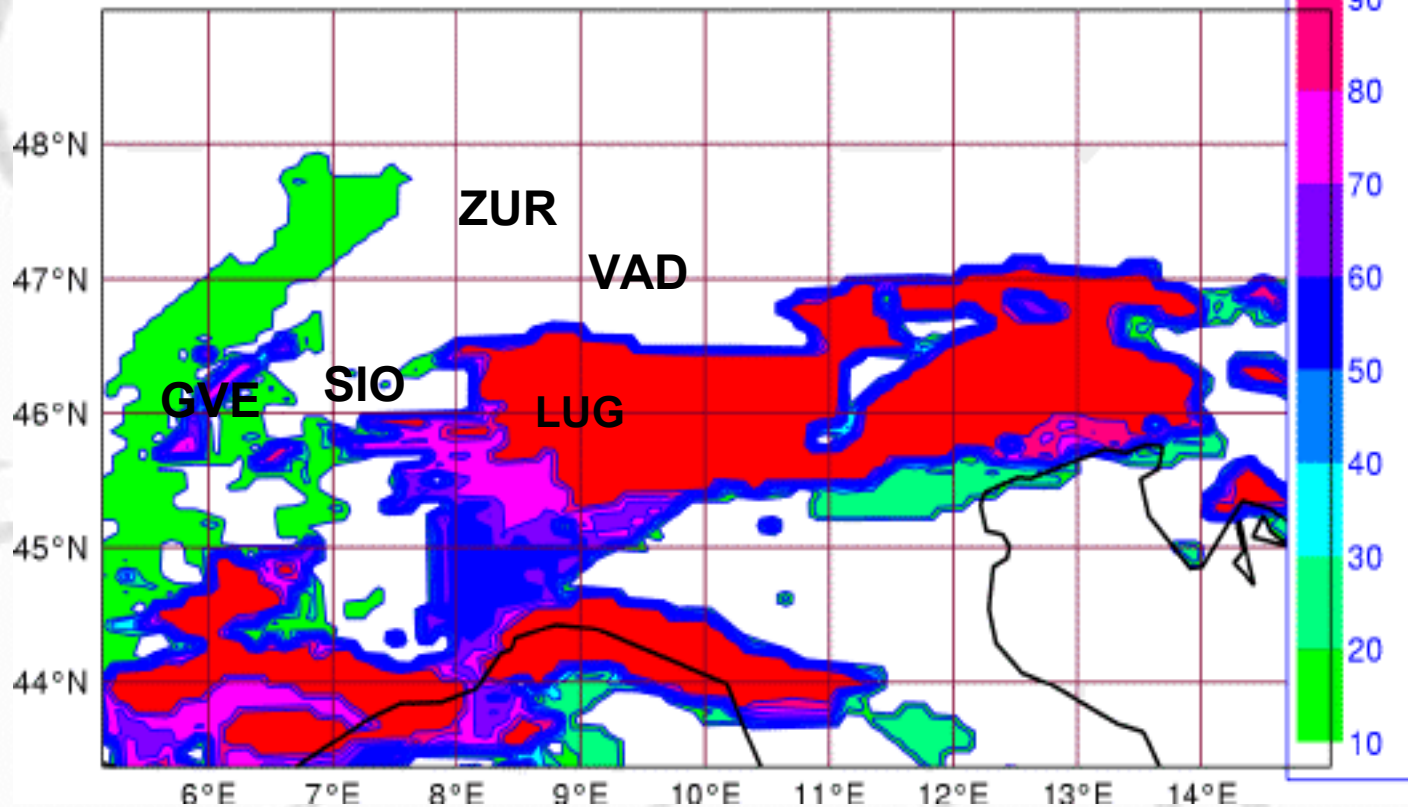
TP050 RRSS Niederschlag; Tagessumme (konv.Periode: 0540-0540 Folgetag) (0.1 mm)

.....
SHA 119
BAS 304 GUT 48
RUE 246 LAE // TAE 70
FAH 474 KLO 98 STG 66
BUS 152 REH 94 SMA 40 HOE //
CHA 245 WYN 230 WAE 45 SAE 105
CDF 544 NAP 106 LUZ 52 VAD 171
NEU 355 BER 226 PIL 64 GLA 195
FRE 651 PAY 309 ALT 246 CHU 347
PLF 191 INT 45 ENG 113 WFJ 128 SCU 504
MLS 51 JUN // GUE 72 DIS 794 DAV 225
DOL 766 PUY 468 ABO 100 GRH 243 PIO 1123 HIR 1765 SAM 767
CGI 870 AIG 132 MVE 59 ULR 572 ROE 1101COM 1041SBE 1359 COV 530
GVE 926 SIO 65 VIS 40 CIM 792 ROB 800
FEY 92 OTL 1230MAG 2037
EVO 24 ZER 164 LUG 637
GSB 906 SBO 710
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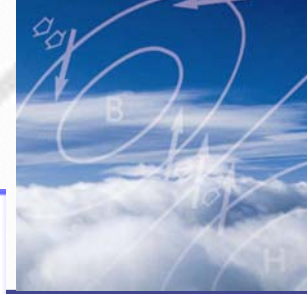
LEPS rr>20 mm, 14.11.2002 12z – 15.11.2002 12z



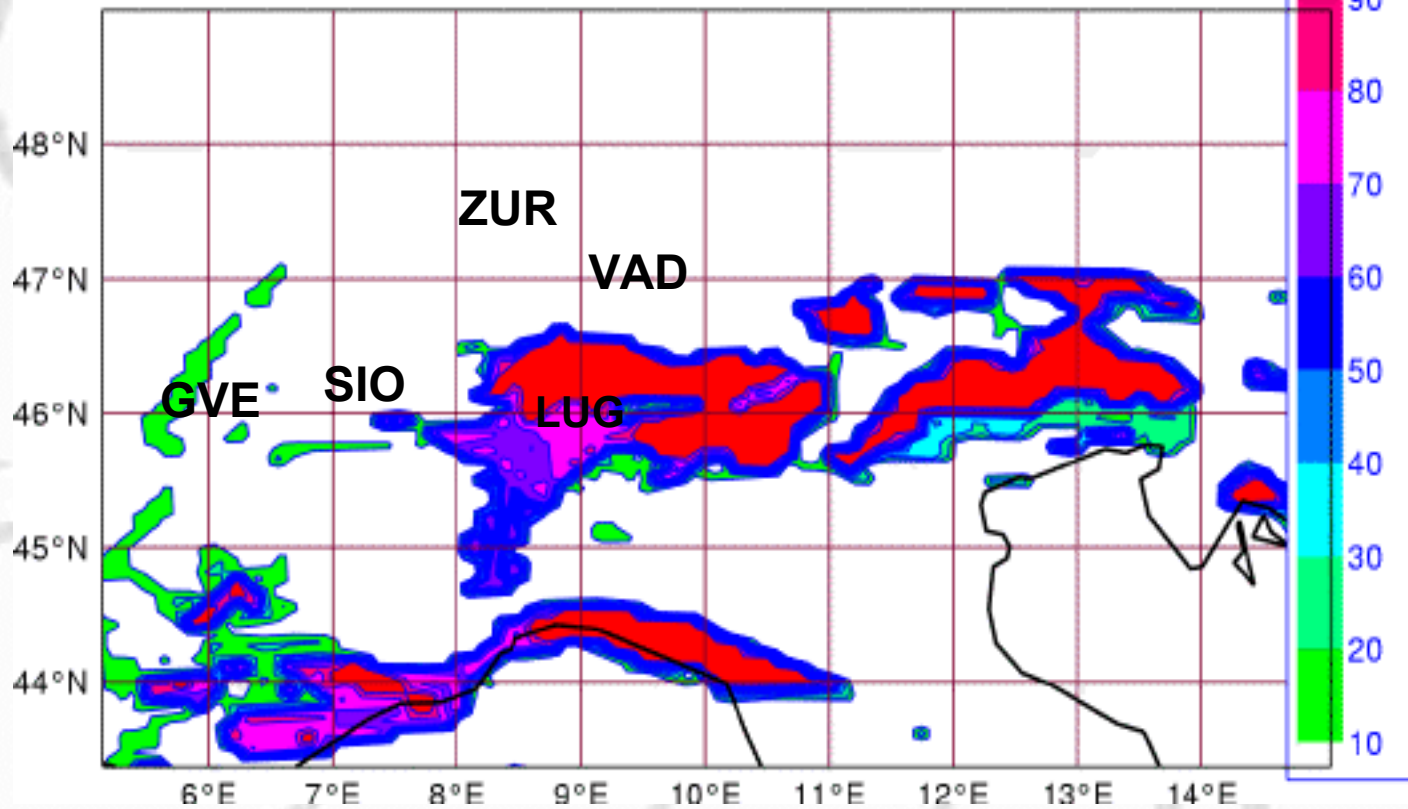
Tuesday 12 November 2002 12UTC ECMWF EPS Probability Forecast I-(48-72) VT: Friday 15 November 2002 12UTC
Surface: total precipitation >0.200 10³ mm



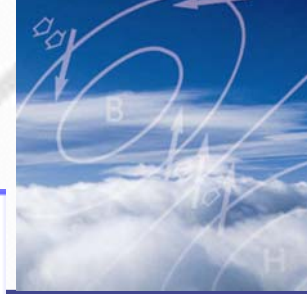
LEPS rr>50 mm, 14.11.2002 12z – 15.11.2002 12z



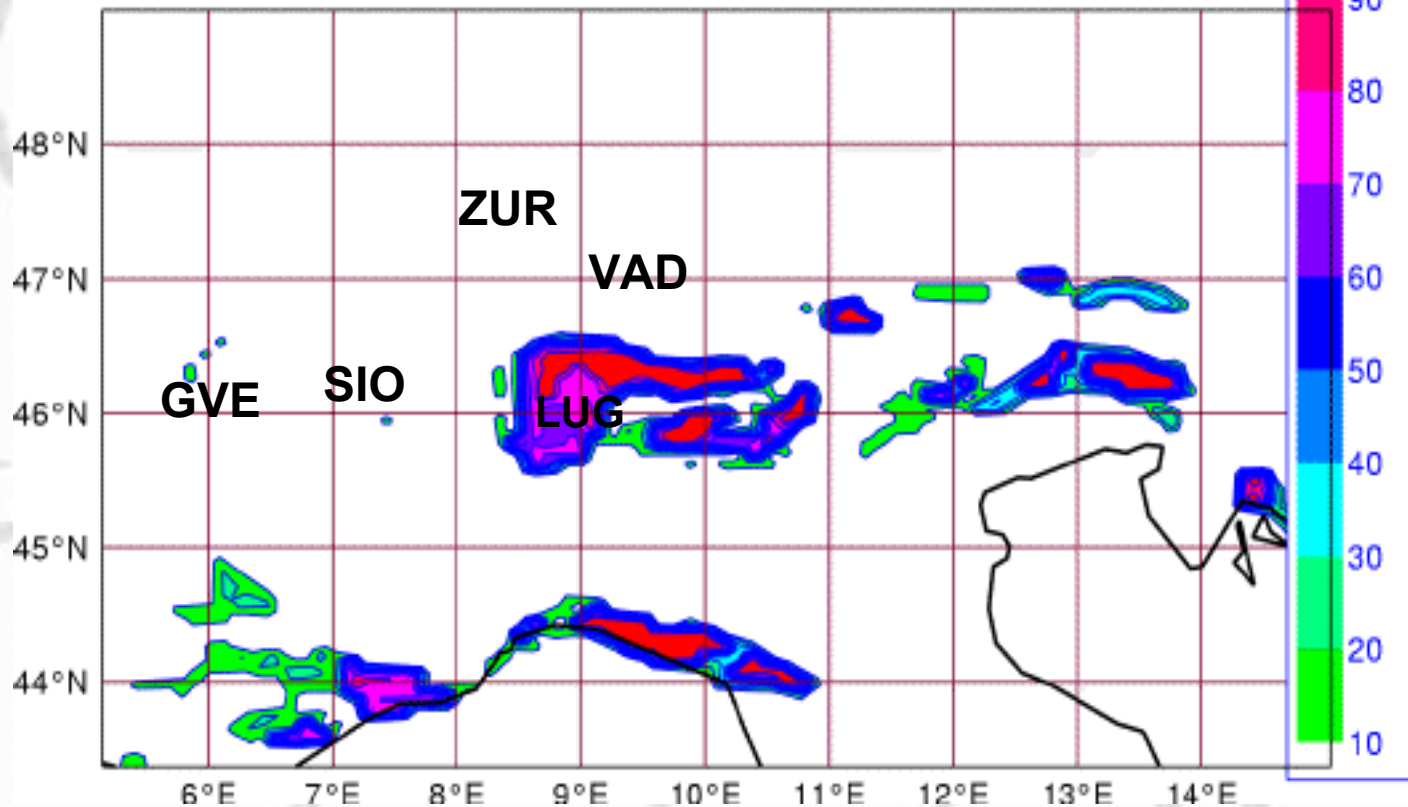
Tuesday 12 November 2002 12UTC ECMWF EPS Probability Forecast I+(48-72) VT: Friday 15 November 2002 12UTC
Surface: >0.500 10¹ mm



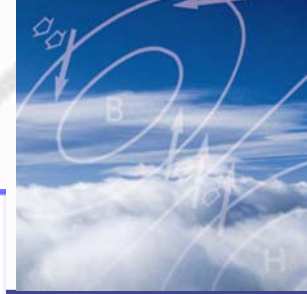
LEPS rr>100 mm, 14.11.2002 12z – 15.11.2002 12z



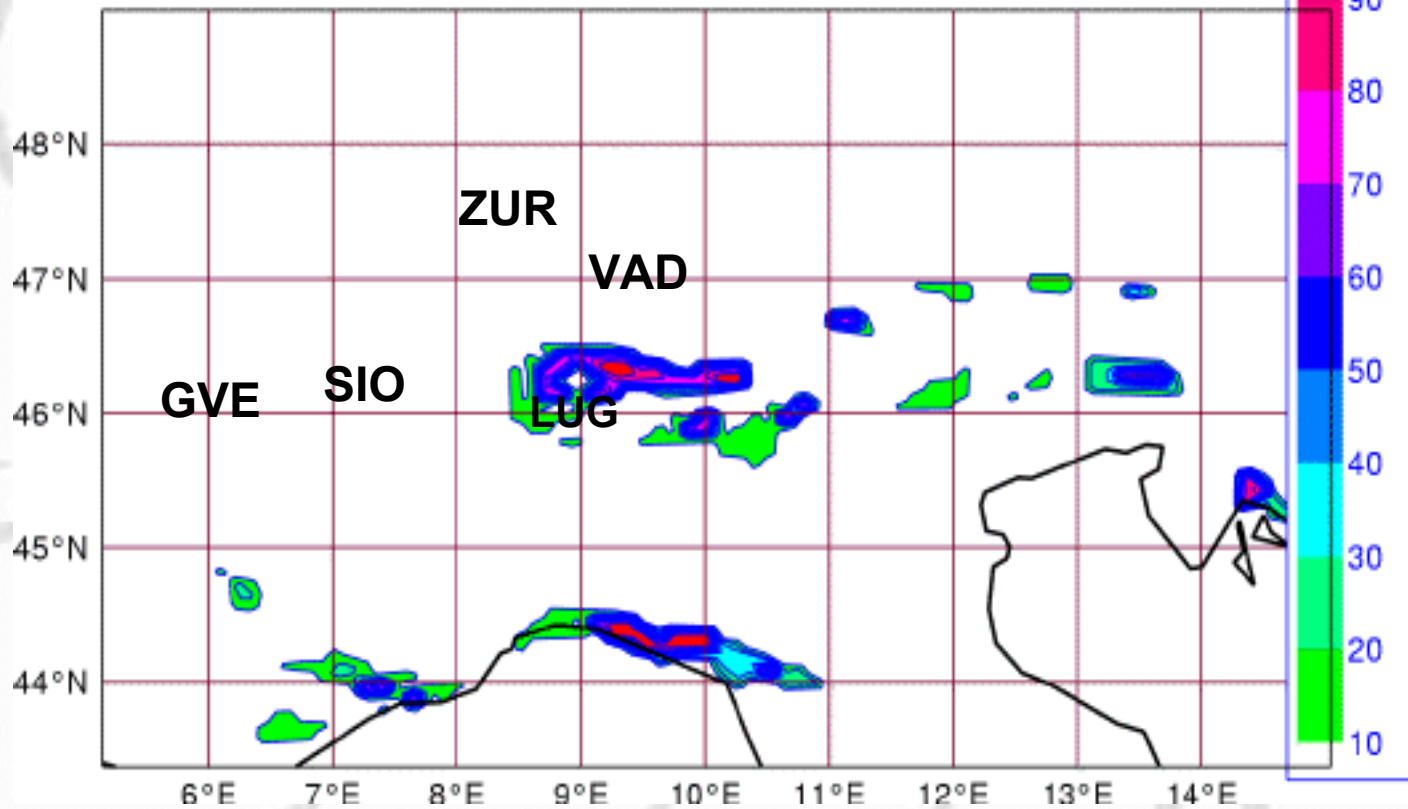
Tuesday 12 November 2002 12UTC ECMWF EPS Probability Forecast I+(48-72) VT: Friday 15 November 2002 12UTC
Surface: >0.100 10¹ mm



LEPS rr>150 mm, 14.11.2002 12z – 15.11.2002 12z



Tuesday 12 November 2002 12UTC ECMWF EPS Probability Forecast I+(48-72) VT: Friday 15 November 2002 12UTC
Surface: >0.150 10¹ mm



Conclusions

- Forecasting of rare events requests special treatment
- Downscaling / rescaling EPS or Deterministic fct
- Hit rate is usable
- False Alarm Rate can be optimised, but remains high
- DMO, EFI, LEPS, ANN have each their own qualities
- Educating the weather service on these methods

Thank you

