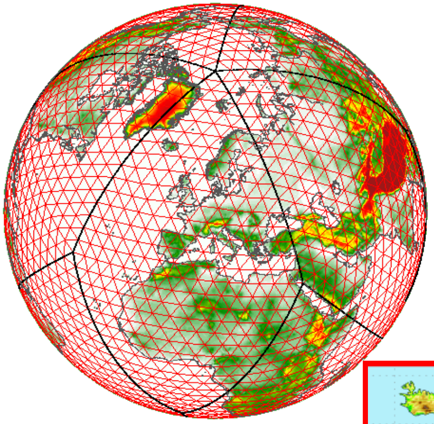
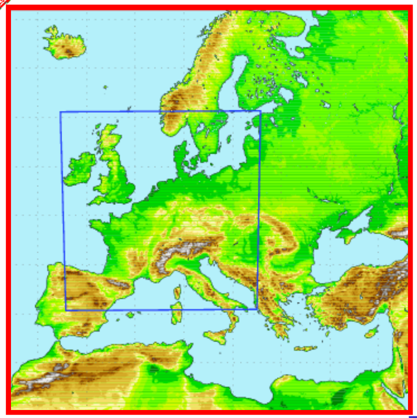
Some experiences collected during verification of precipitation forecasts using fuzzy techniques and some minor remarks concerning categorical verification

Ulrich Damrath

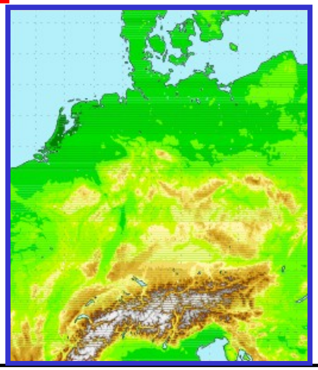
Deutscher Wetterdienst



GME



COSMO-EU

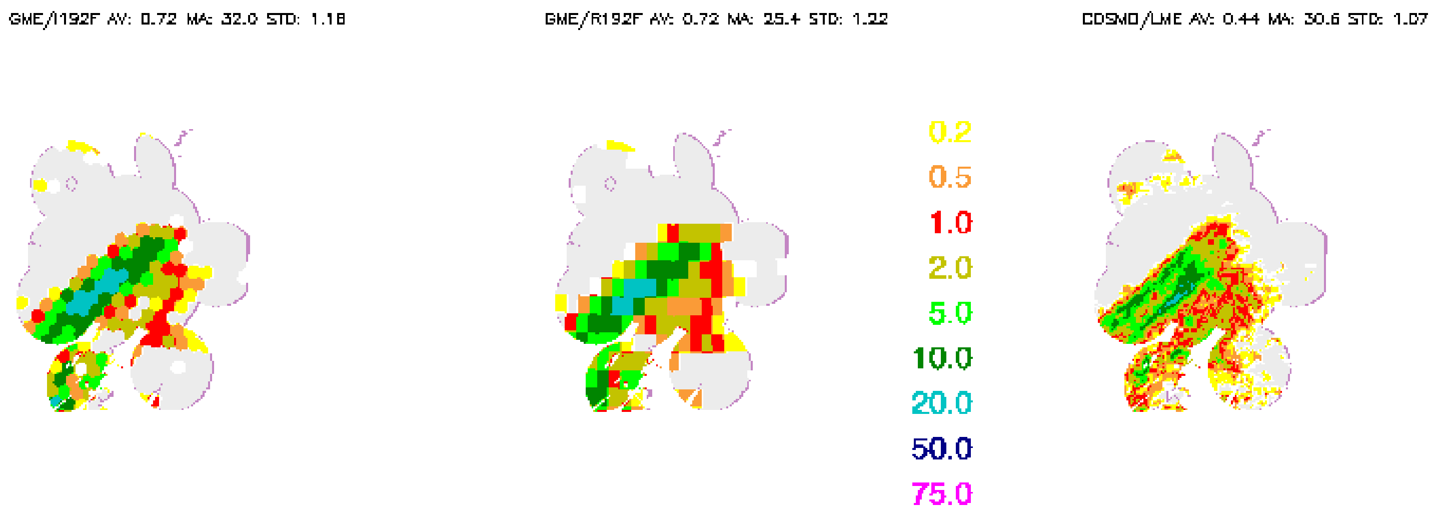


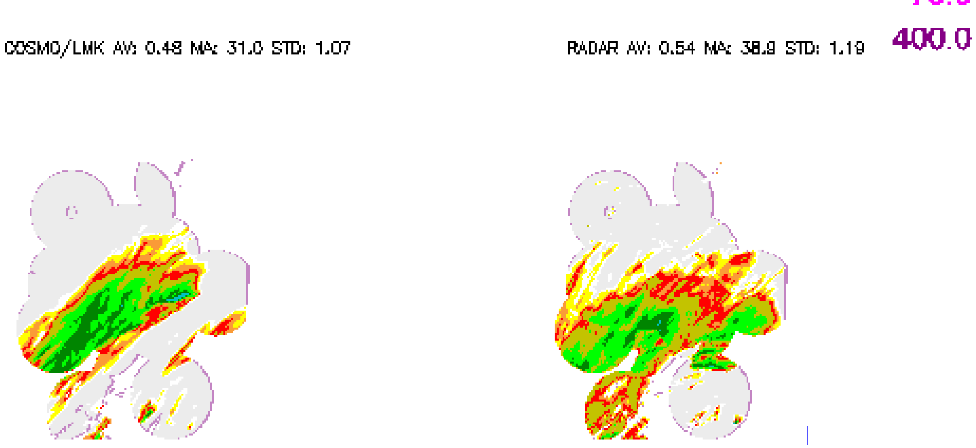
COSMO-DE

GME (Global)
~ 15 millions gridpoints
24h-forecast in 15 minutes
dx ≈ 40 km, 368642 GP, 40 L
hydrostatic

COSMO-EU (Europe)
~ 17 millions gridpoints
24h-forecast in 20 minutes
dx ≈ 7 km, 665x657 GP, 40 L
non hydrostatic

COSMO-DE (Germany)
~ 10 millions gridpoints
21h-forecast in 20 minutes
dx ≈ 2.8 km, 421x461 GP, 50 L
non hydrostatic





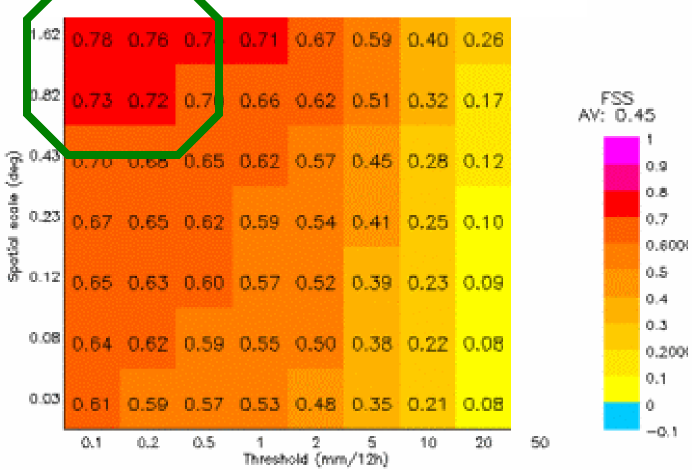
Basic data

(example with some missing observations)

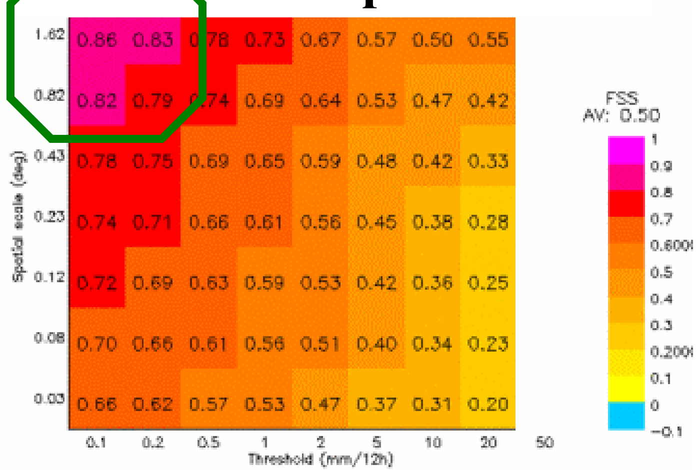
Forecasts of precipitation Start: 19.07.2007 00 UTC W=18–06

Deutscher Wetterdienst

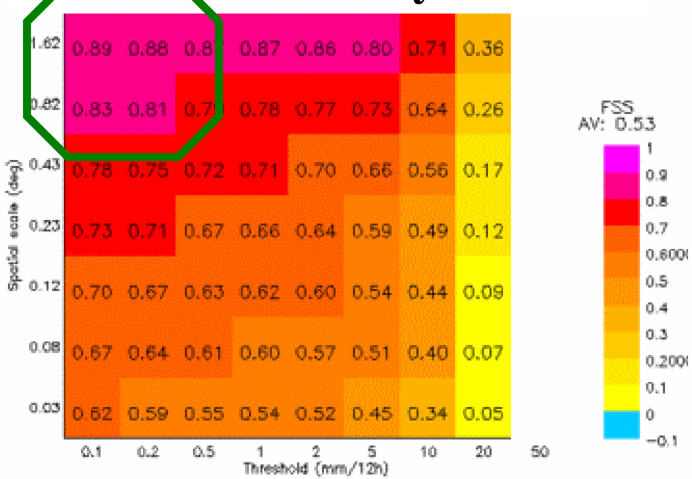
Global



Europe

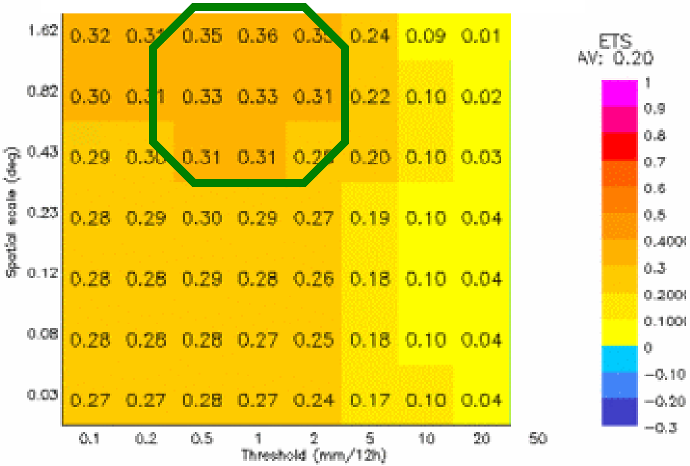


Germany

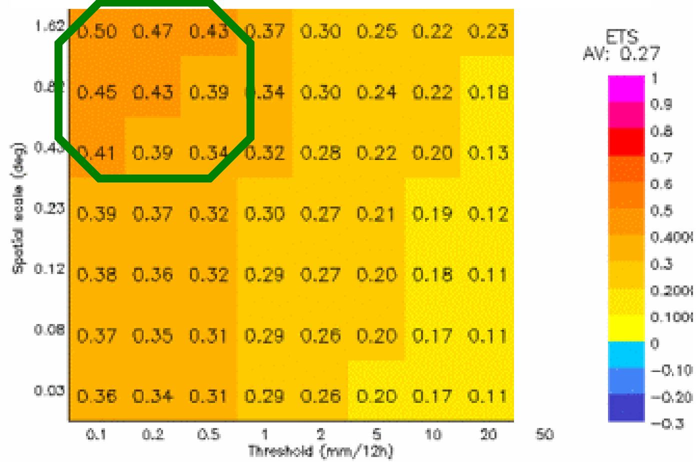


Fractions skill score for forecasts of GME, COSMO-EU and COSMO-DE for August 2008, forecast time 06-18 hours

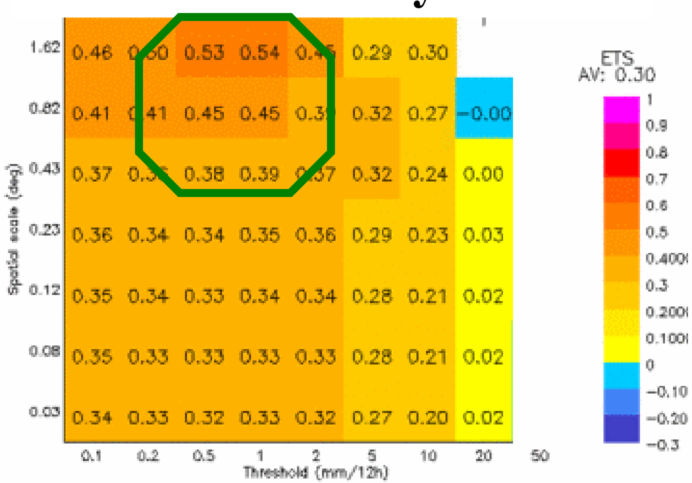
Global



Europe

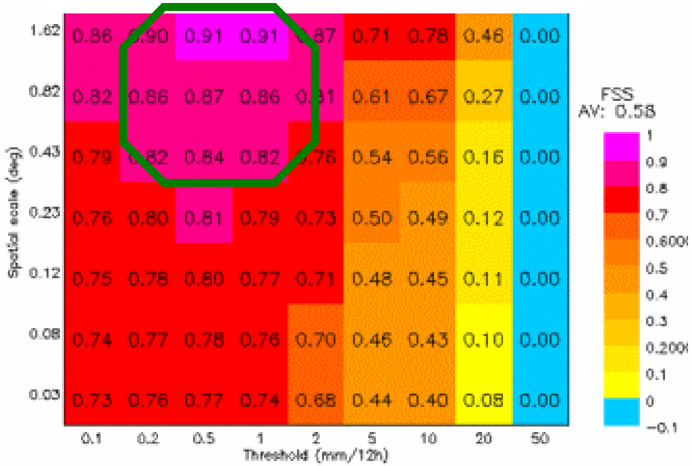


Germany

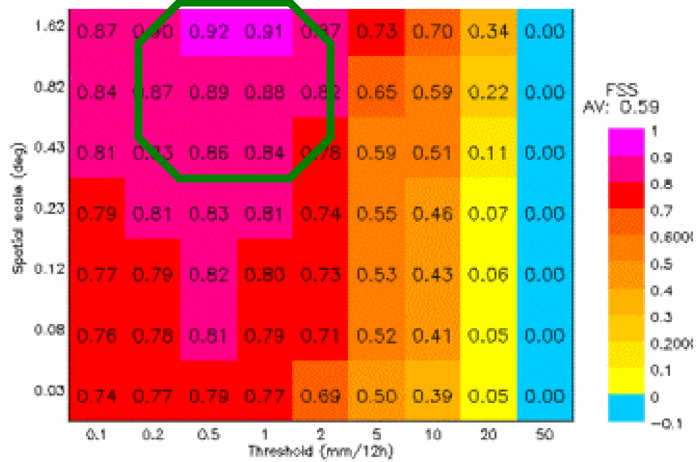


ETS upscaling for forecasts of GME, COSMO-EU and COSMO-DE for August 2008, forecast time 06-18 hours

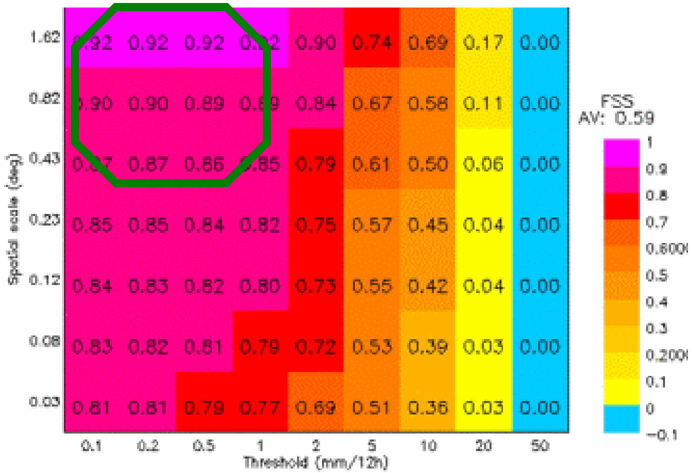
Global



Europe

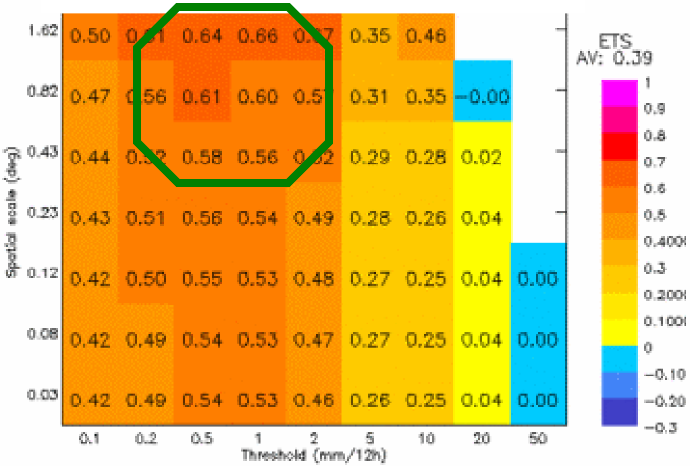


Germany

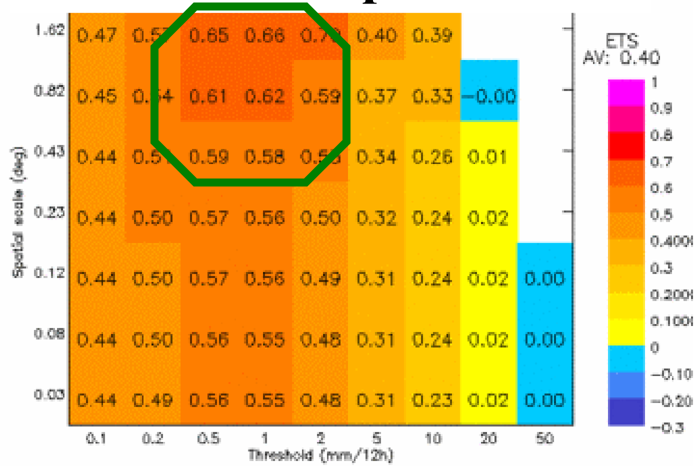


Fractions skill score for forecasts of GME, COSMO-EU and COSMO-DE for January 2009, forecast time 06-18 hours

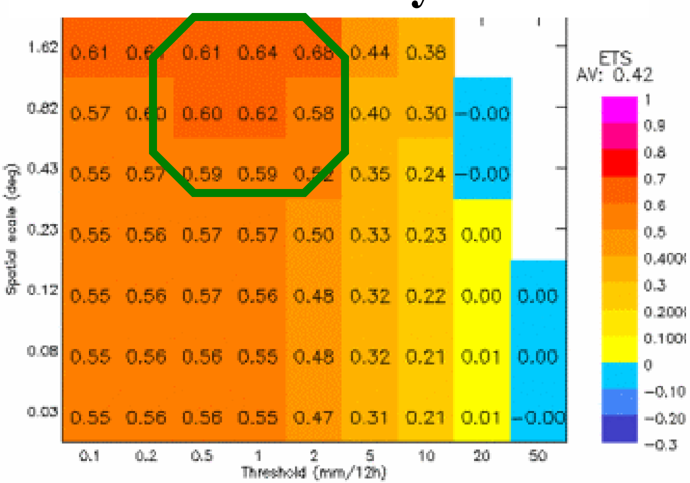
Global



Europe

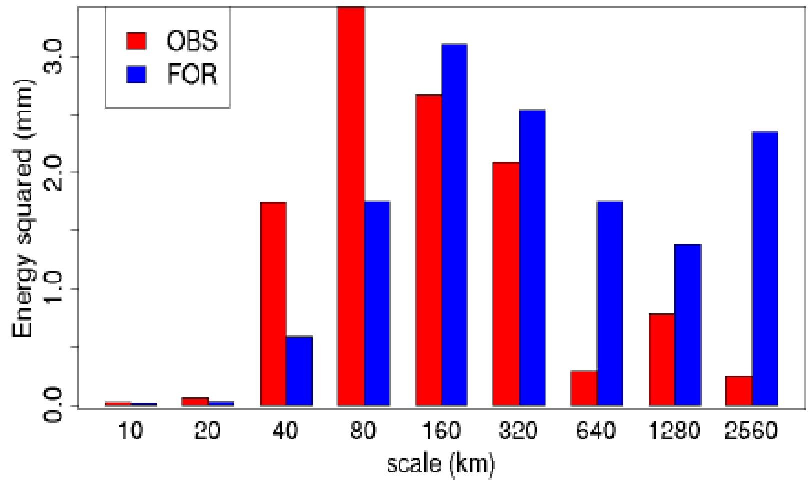


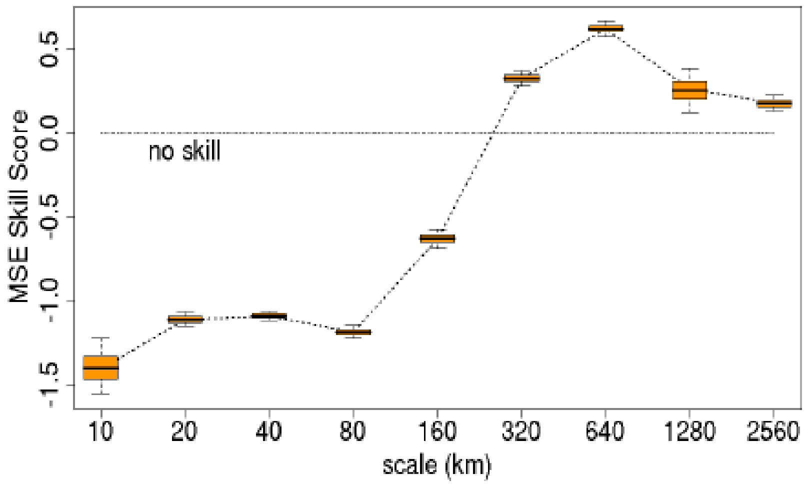
Germany



ETS upscaling for forecasts of GME, COSMO-EU and COSMO-DE for January 2009, forecast time 06-18 hours

... yet another score





Verification

on different scales, but only **where obs are available**

B. Casati's

energy squared Skill Score

1. Energy squared:

$$En^2(X) = \overline{X^2}$$

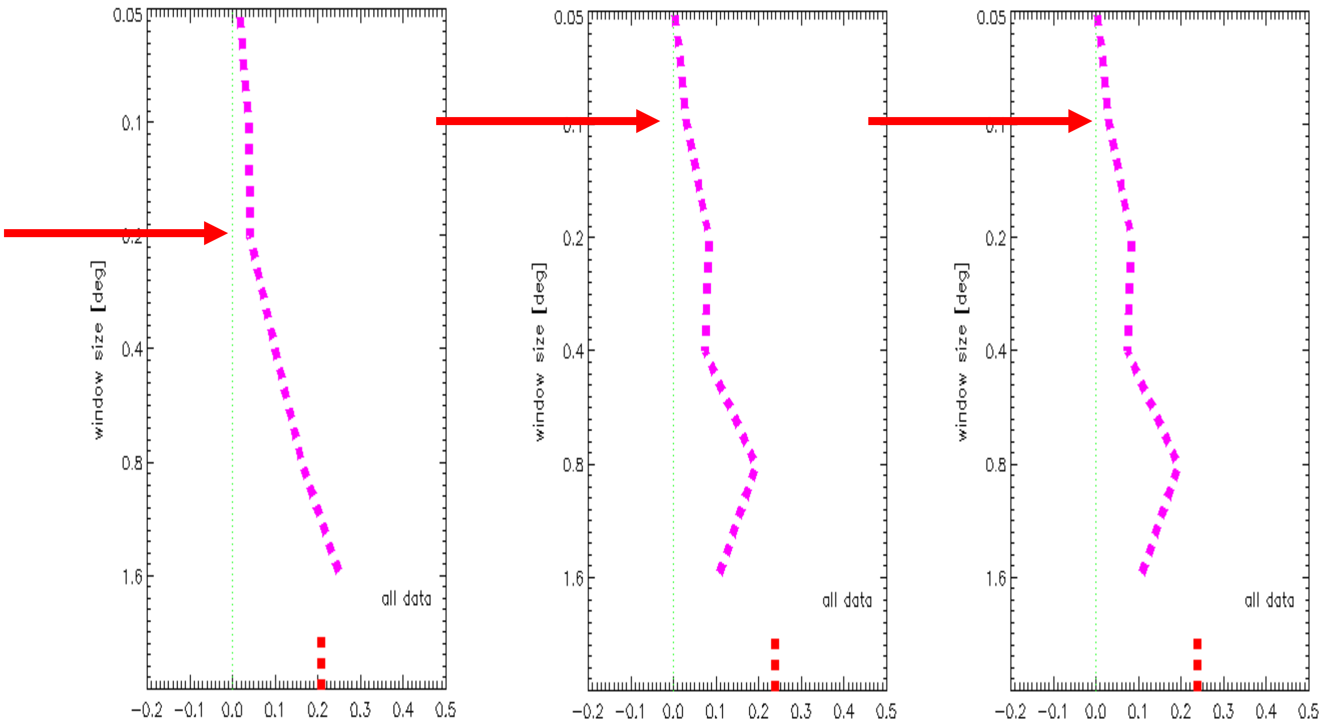
Measures the quantity of events and their intensity at each scale => BIAS, scale structure

2. MSE Skill Score:

$$1 - \frac{2 MSE(Y, X)}{En^2(X) + En^2(Y)}$$

X

Modification by U. Damrath in order to have a similar structure as for the FSS



Modified energy squared score for forecasts of GME(left), COSMO-EU(center) and COSMO-DE(right) for January 2009, forecast time 06-18 hours, horizontal: skill score, vertical: window size, red mark: skill for all scales

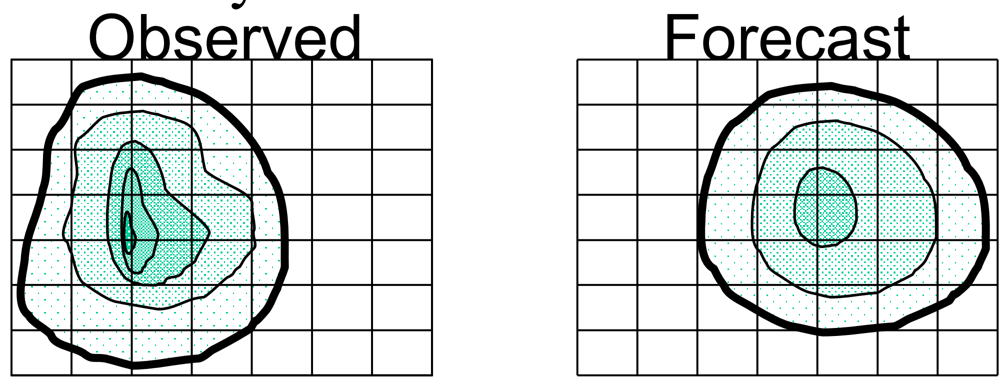
About consistency and inconsistency

- Forecasters are interested in consistent model forecasts.
- But due to growing of errors during forecast time forecasts consistency cannot be expected concerning all properties of the forecasted fields!
- Inconsistency: Differences between forecasts that are valid for the same time concerning different properties of the forecasted fields (properties of the pattern, values at special points of interest, extreme values, ...)
- Differences between the forecasted fields concerning
  - phase,
  - amplitude
  - and the remaining part

Entity-based QPF verification (rain "blobs")
by E. Ebert (BOM Melbourne)

Verify the *properties* of the forecast rain system against the *properties* of the observed rain system:

- location
- rain area
- rain intensity (mean, maximum)



CRA error decomposition

The total mean squared error (MSE) can be written as:

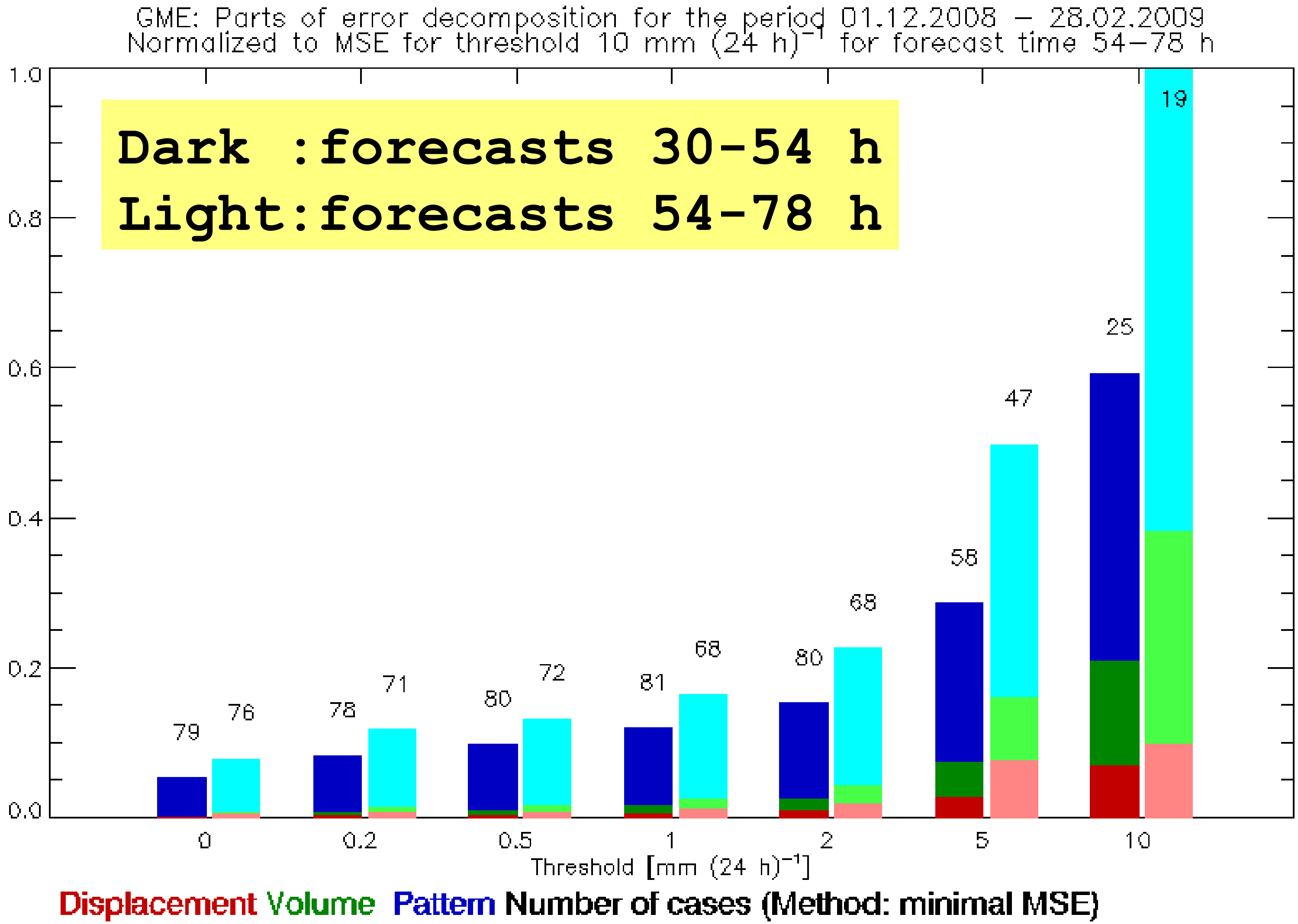
$$MSE_{total} = MSE_{displacement} + MSE_{volume} + MSE_{pattern}$$

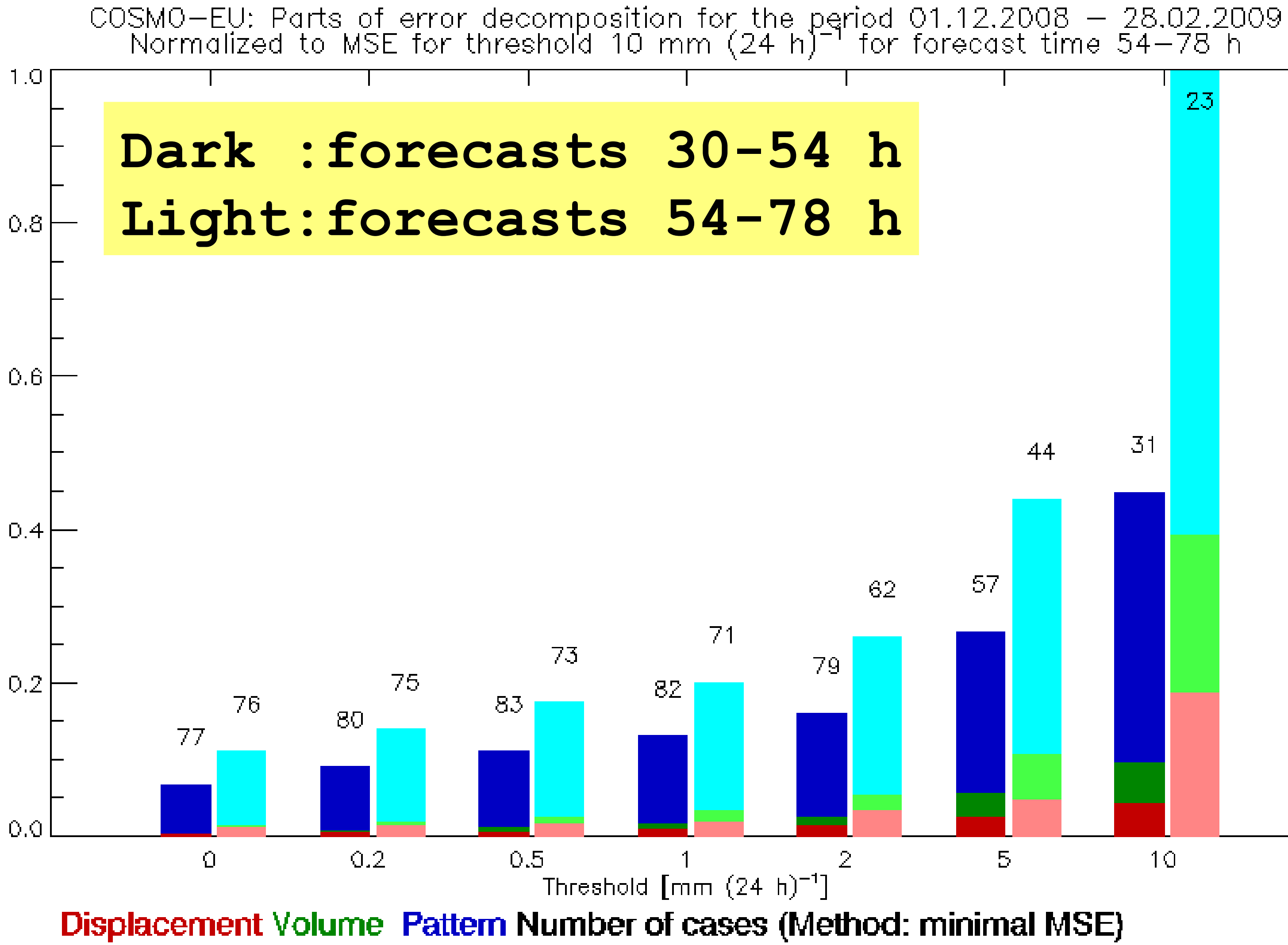
Configuration for the current study:

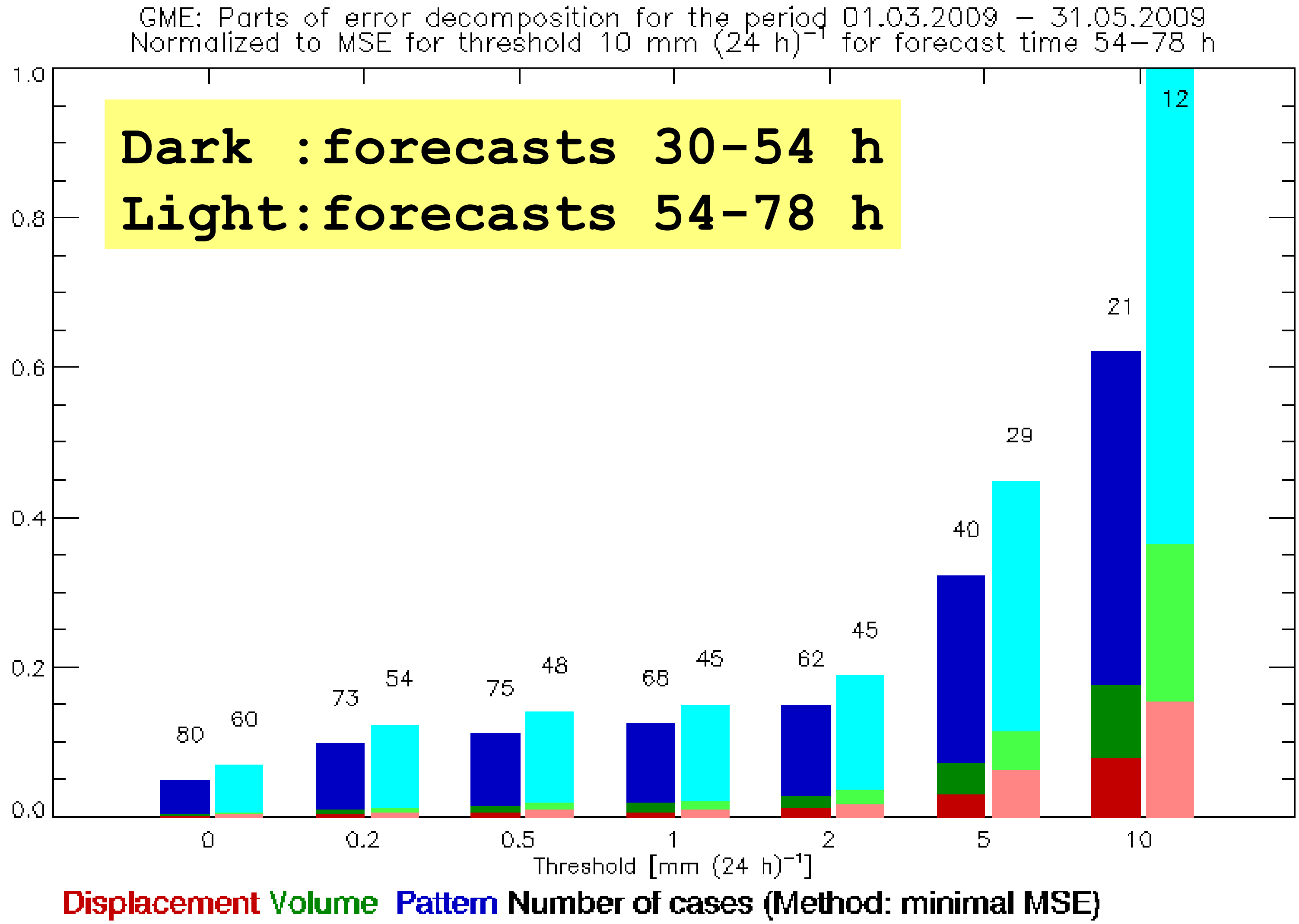
- "Observations": forecasts: 06-30 hours

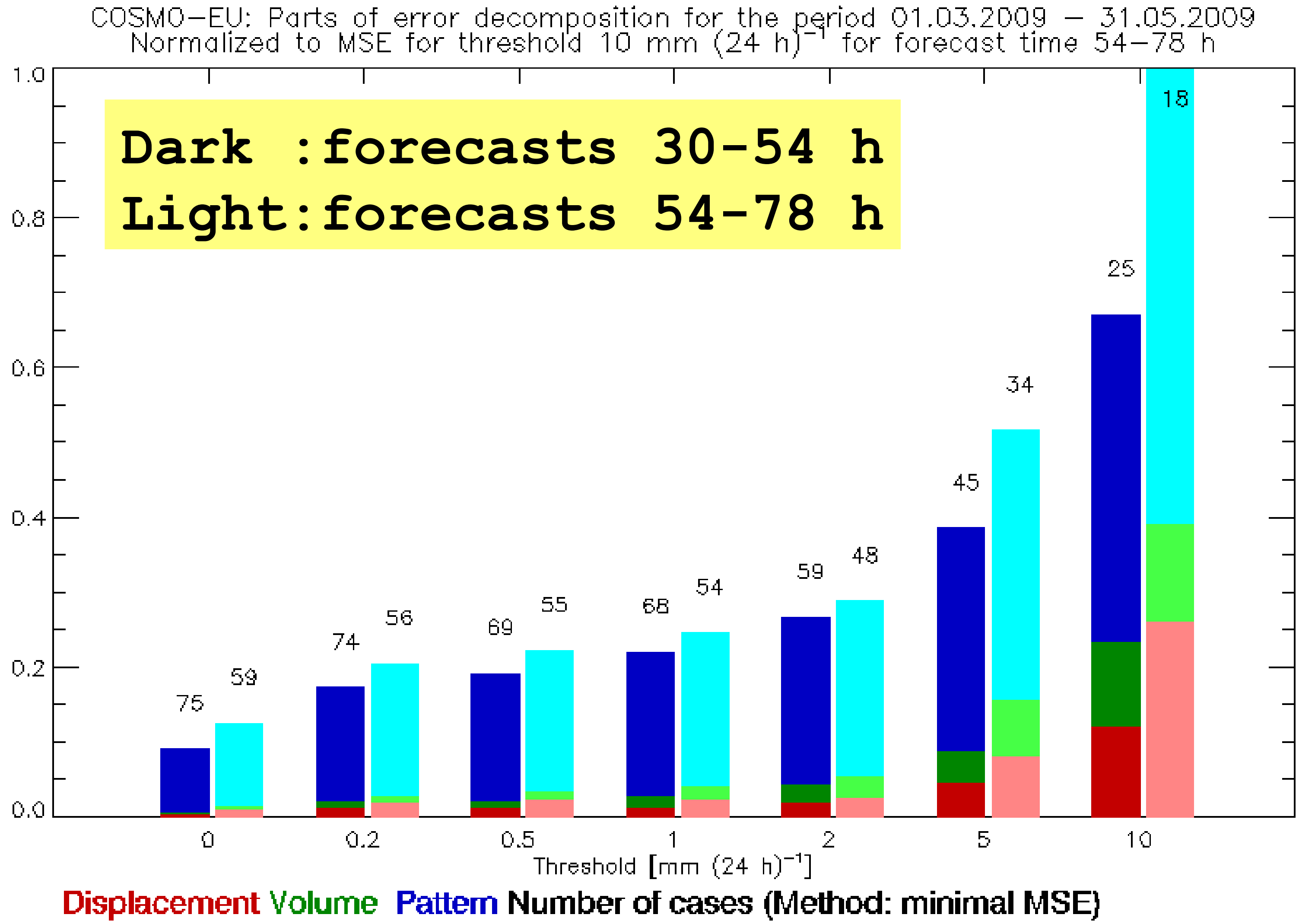
- Forecasts : forecasts: 30-54 hours and

forecasts: 54-78 hours


GME: Parts of error decomposition for the period 01.12.2008 – 28.02.2009
Normalized to MSE for threshold 10 mm (24 h)$^{-1}$ for forecast time 54–78 h
Dark :forecasts 30-54 h
Light:forecasts 54-78 h
1.0
0.8
0.6
0.4
0.2
0.0
79
76
78
71
80
72
81
68
80
68
58
47
25
19
0
0.2
0.5
1
2
5
10
Threshold [mm (24 h)$^{-1}$]
Displacement Volume Pattern Number of cases (Method: minimal MSE)


COSMO–EU: Parts of error decomposition for the period 01.12.2008 – 28.02.2009
Normalized to MSE for threshold 10 mm (24 h)⁻¹ for forecast time 54–78 h
Dark :forecasts 30-54 h
Light:forecasts 54-78 h
1.0
0.8
0.6
0.4
0.2
0.0
77
76
80
75
83
73
82
71
79
62
57
44
31
23
0
0.2
0.5
1
2
5
10
Threshold [mm (24 h)⁻¹]
Displacement Volume Pattern Number of cases (Method: minimal MSE)


GME: Parts of error decomposition for the period 01.03.2009 – 31.05.2009
Normalized to MSE for threshold 10 mm (24 h)$^{-1}$ for forecast time 54–78 h
Dark :forecasts 30-54 h
Light:forecasts 54-78 h
1.0
0.8
0.6
0.4
0.2
0.0
80
60
73
54
75
48
68
45
62
45
40
29
21
12
0
0.2
0.5
1
2
5
10
Threshold [mm (24 h)$^{-1}$]
Displacement Volume Pattern Number of cases (Method: minimal MSE)


COSMO–EU: Parts of error decomposition for the period 01.03.2009 – 31.05.2009
Normalized to MSE for threshold 10 mm (24 h)$^{-1}$ for forecast time 54–78 h
Dark :forecasts 30-54 h
Light:forecasts 54-78 h
1.0
0.8
0.6
0.4
0.2
0.0
75
59
74
56
69
55
68
54
59
48
45
34
25
18
0
0.2
0.5
1
2
5
10
Threshold [mm (24 h)$^{-1}$]
Displacement Volume Pattern Number of cases (Method: minimal MSE)

I have a friend.

He often says:
With your precipitation forecasts you are never right.

If your forecast is „*yes*" then it *never* rains!
But it rains if your forecast is „*no*"!

So what to do?
Say: „You are a fool!" and lose the friend?
Or : Accept his opinion and prove that this is wrong in terms that he is able to understand.

A possible solution: Take the opposite of the given forecasts as a reference forecast and check the result.

The traditional contingency table:

```
FC: yes OB: yes: hits
FC: no  OB: yes: misses
FC: yes OB: no : false alarms
FC: no  OB: no : zeros
```

The traditional ETS:

$$ETS = \frac{hits - reference(hits)}{hits + misses + false\,alarms - reference(hits)}$$

$$reference(hits) = \frac{(hits + misses) * (hits + false\,alams)}{hits + misses + false\,alarms + zeros}$$

The „opposite“ ETS:

$$reference(hits) = misses$$

$$ETS_{opp} = \frac{hits - misses}{hits + false\,alarms}$$

Properties:

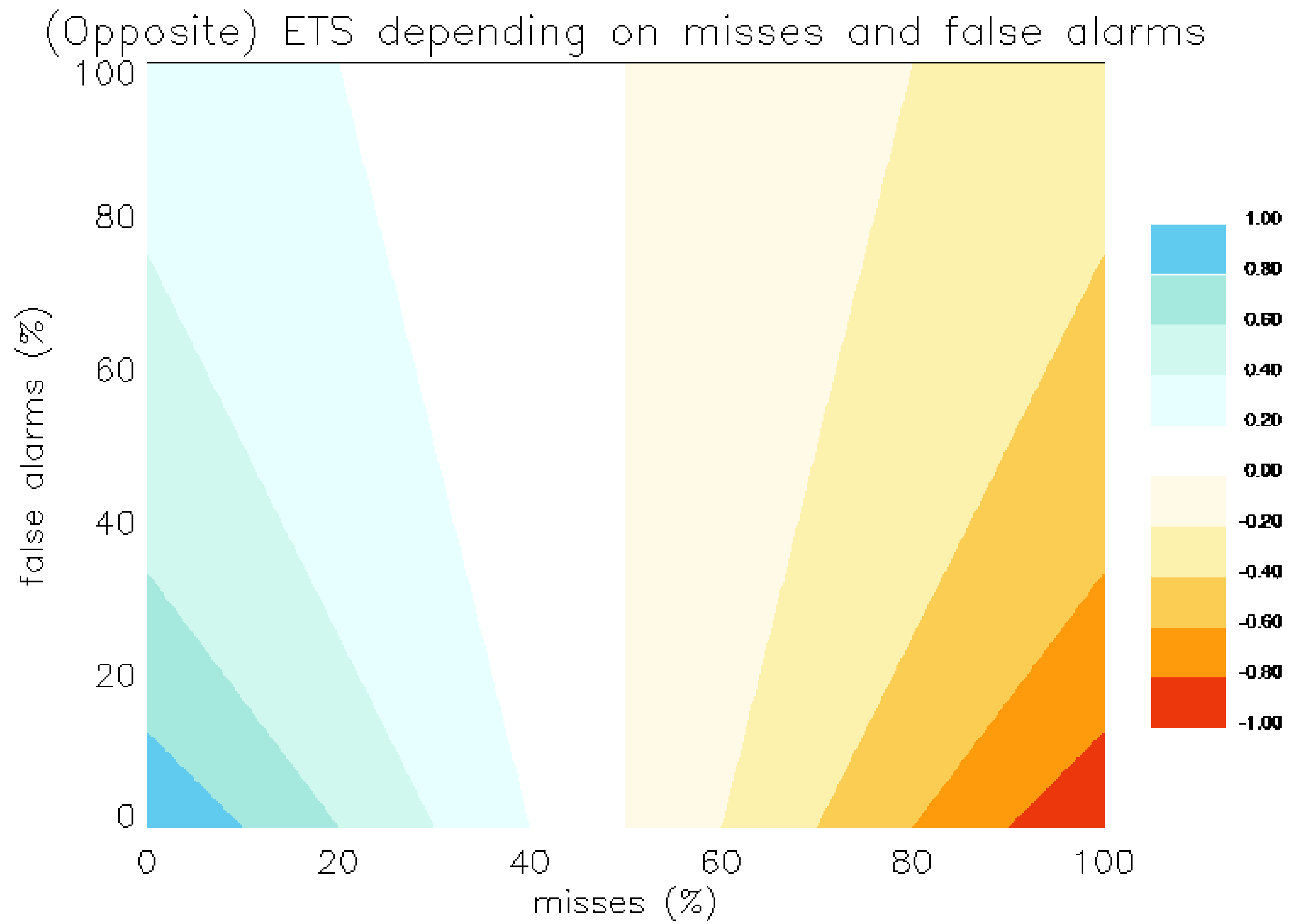
hits=100% misses=0 ETS_{opp}:=+1

hits=misses ETS_{opp}:= 0

hits=0:false alarms=50%

misses=50% ETS_{opp}:=-1

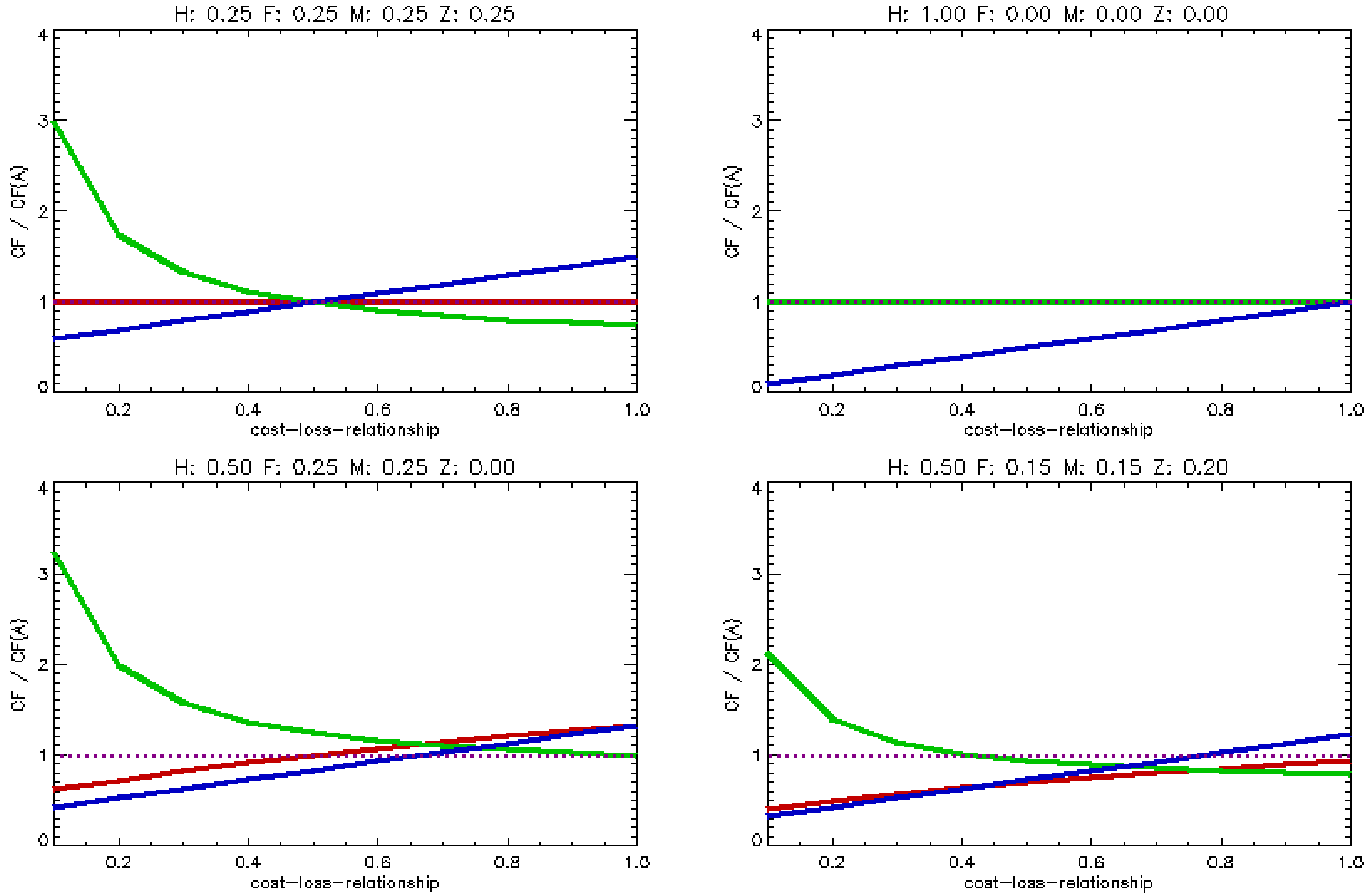
misses=0: ETS_{opp}:=1-FAR


(Opposite) ETS depending on misses and false alarms
false alarms (%)
misses (%)
0
20
40
60
80
100
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00

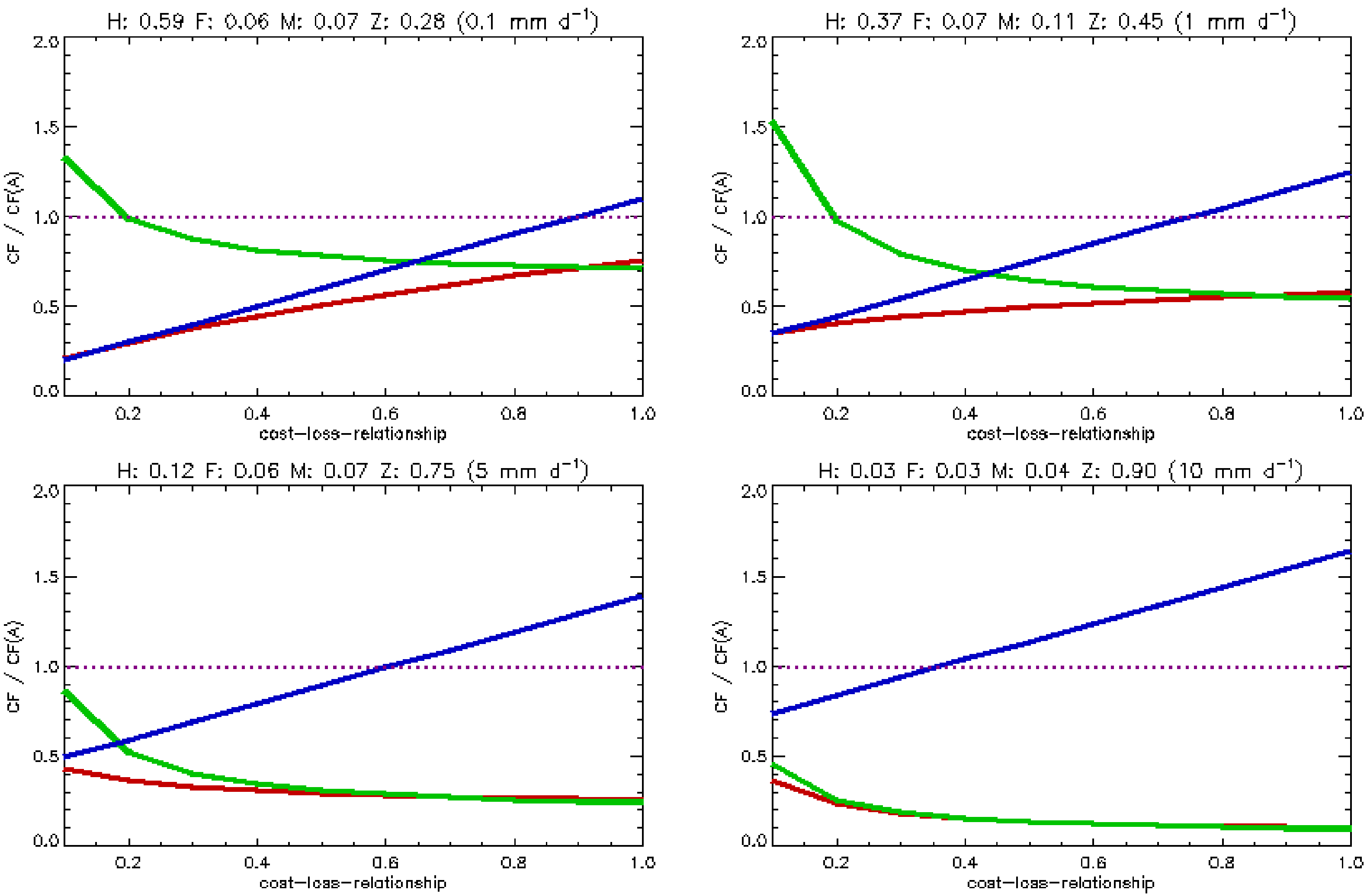
A simple look on the value of forecasts

```
FC: yes OB: yes: H (C)
FC: no  OB: yes: M (L)
FC: yes OB: no : F (M)
FC: no  OB: no : Z
-----------------------------------------
COSTS with cost-loss-relationship CR=C/L:
using forecasts : CF=(H+F)*C+M*L
never protect   : CN=(H+M)*C
ever  protect   : CE=(H+M+F+Z)*C
use the opposite: CO=(Z+F)*C+H*L
```

Deutscher Wetterdienst



Alternative forecasts: use the opposite ever protect never protect



Alternative forecasts: use the opposite ever protect never protect

Summary

- „Fuzzy“-verifications explains objectively what can be seen in many daily charts.
- Consistency of QPF for different forecast times depends mainly on precipitation amount.
- „Say the opposite!“ as a reference for scores will help your critical friends (or customers) stay friends (or customers).

Thank you for your attention!
Are there any questions?