Warning verification
-
issues and approaches

Martin Göber

Department Weather Forecasting
Deutscher Wetterdienst DWD
E-mail: martin.goeber@dwd.de

Summary

Users of warnings are very diverse and thus warning verification is also very diverse.

Each choice of a parameter of the verification method has to be user oriented – there is no „one size fits all“.

Disposition
Q & A (pproaches)

1. Information about warning verification (5)
2. Characteristics of warnings (10 minutes)
3. Observations: which, sparseness, quality, thresholds (10)
4. Matching of warnings and observations (15)
5. Measures (10)
6. interpretation of results, user based assessments (20)
7. Comparison of warning guidances with warnings (15)

Issue: state of available information

19 out of 26 students answered (at least 1 question)
= 73 % answer rate

3. Are there documents in your service which lay down the rules in warning verification (or which generally describe how warning verification is done)?		Response Percent	Response Count
Yes		33.3%	6
No		44.4%	8
don't know		22.2%	4
	answered question		18
	skipped question		1

Issue: state of available information

- Warning verification is hardly touched in the „bibles“, i.e.: Wilks statistics textbook; Jolliffe/Stephenson‘s verification book; Nurmi‘s ECMWF „Recommandations on verification of local forecasts“; THE JWGV web-page, some mentioning in Mason‘s consultancy report.
- Yet lots of the categorical statistics can be used, although additional care is needed.
- It‘s very difficult to find information on the web or otherwise about the NMS‘ procedures – exception: NCEP‘s hurrican and tornado warnings.
- What is clear: compared to model verification it is **surprisingly diverse**, because it should be (often is) **driven by diverse users**.
- One document has quite a lot of information concentrated on user-based assessments: WMO/TD No. 1023 *Guidlines on performance assessment of public weather services.* (Gordon, Shaykewich, 2000). http://www.wmo.int/pages/prog/amp/pwsp/pdf/TD-1023.pdf

Information sources

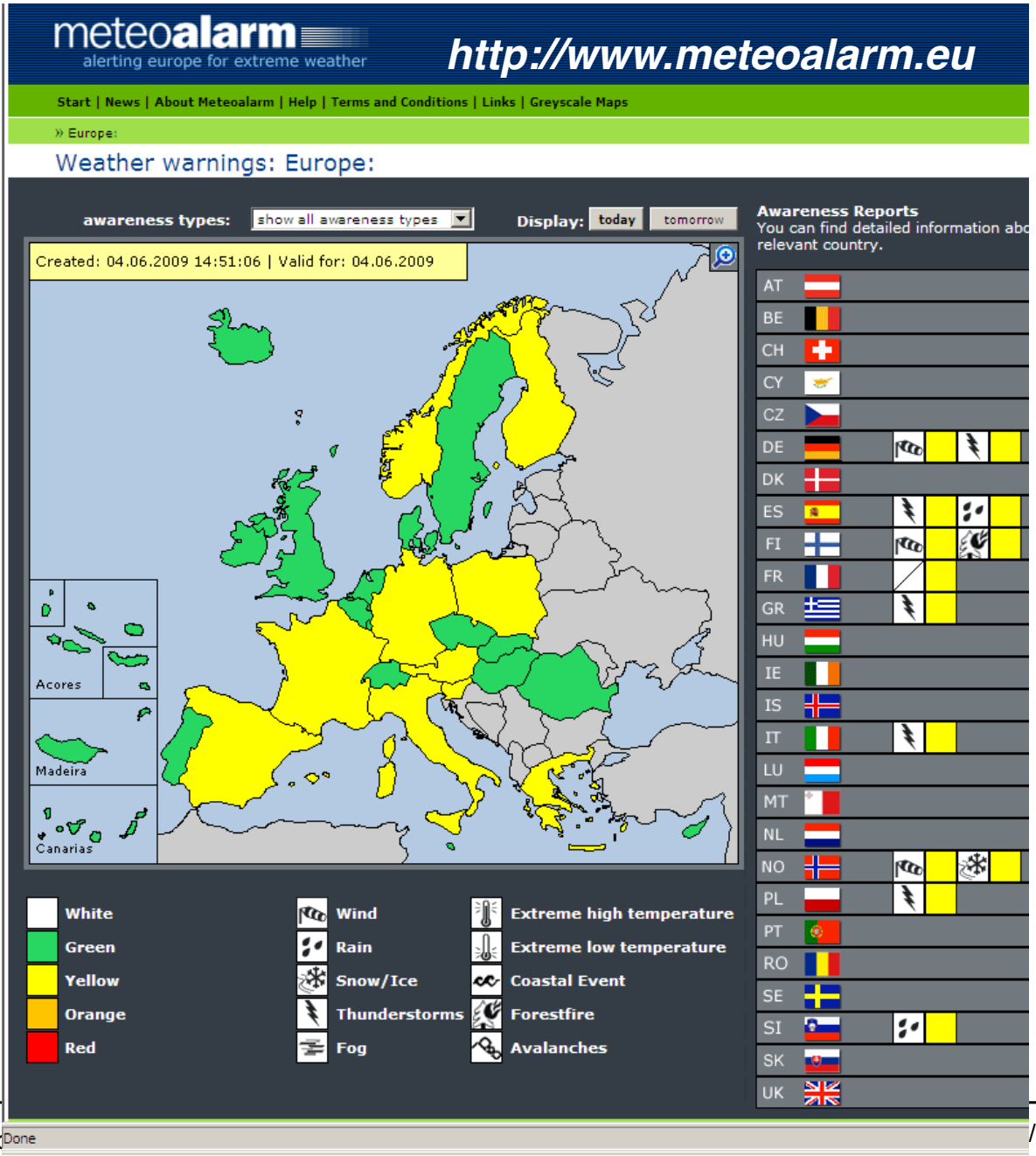
Presentation based on (partly scetchy) information from NMS of 10 countries (Thanks!):

- Austria
- Botswana
- Denmark
- Finland
- France
- Germany
- Greece
- Switzerland
- UK
- USA

Warnings

European examples of warnings

http://www.meteoalarm.eu


meteoalarm
alerting europe for extreme weather
http://www.meteoalarm.eu
Start | News | About Meteoalarm | Help | Terms and Conditions | Links | Greyscale Maps
» Europe:
Weather warnings: Europe:
awareness types:
show all awareness types
Display:
today
tomorrow
Created: 04.06.2009 14:51:06 | Valid for: 04.06.2009
Acores
Madeira
Canarias
Awareness Reports
You can find detailed information abo
relevant country.
AT
BE
CH
CY
CZ
DE
DK
ES
FI
FR
GR
HU
IE
IS
IT
LU
MT
NL
NO
PL
PT
RO
SE
SI
SK
UK
White
Green
Yellow
Orange
Red
Wind
Rain
Snow/Ice
Thunderstorms
Fog
Extreme high temperature
Extreme low temperature
Coastal Event
Forestfire
Avalanches
Done

Warnings

Yellow:

1. The weather is potentially dangerous. The weather phenomena that have been forecast are not unusual,
2. but be attentive if you intend to practice activities exposed to meteorological risks.
3. Keep informed about the expected meteorological conditions and do not take any avoidable risk.

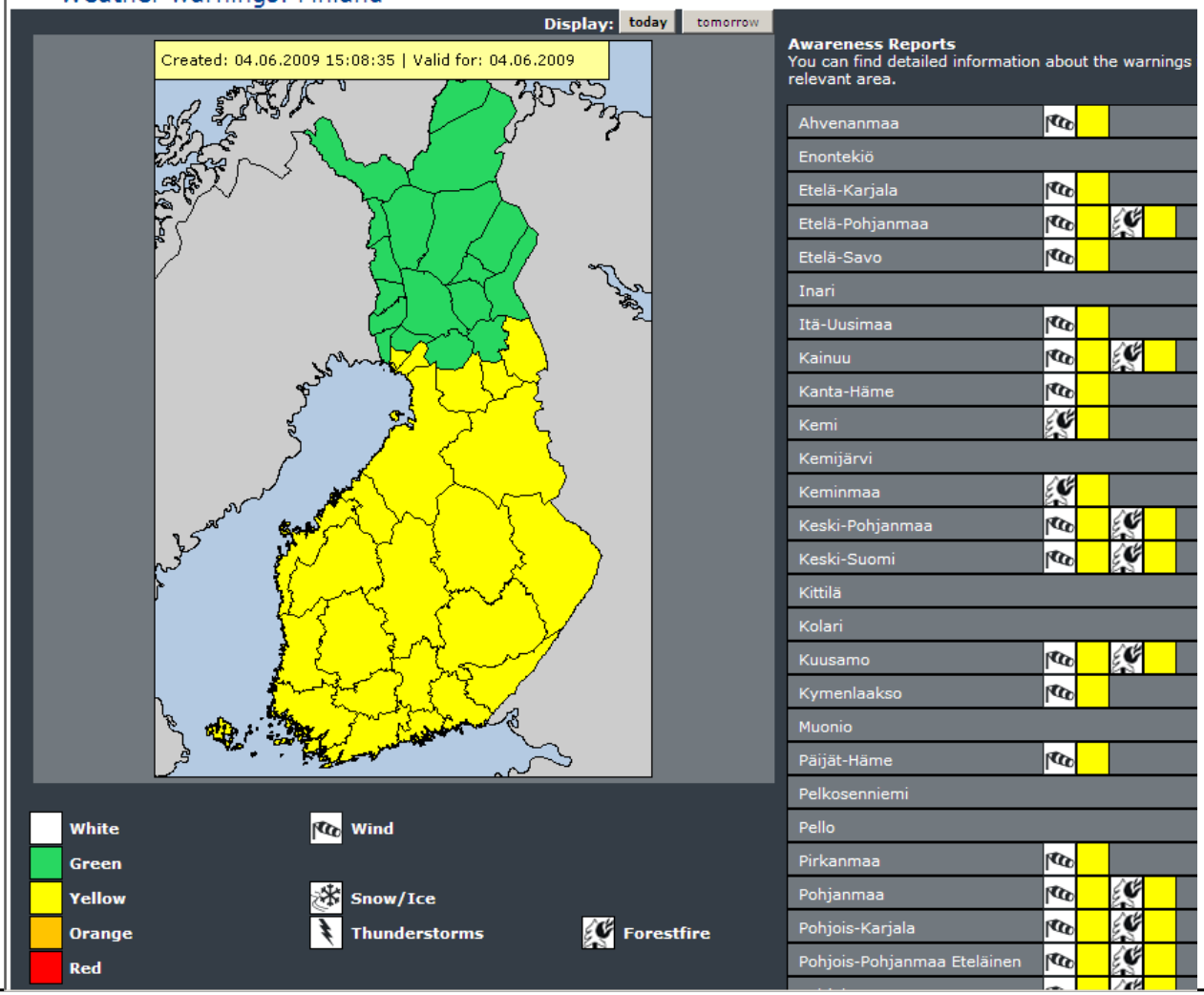
Orange:

1. The weather is dangerous. Unusual meteorological phenomena have been forecast.
2. Damage and casualties are likely to happen.
3. Be very vigilant and keep regularly informed about the detailed expected meteorological conditions. Be aware of the risks that might be unavoidable. Follow any advice given by your authorities.

Red:

1. The weather is very dangerous. Exceptionally intense meteorological phenomena have been forecast.
2. Major damage and accidents are likely, in many cases with threat to life and limb, over a wide area.
3. Keep frequently informed about detailed expected meteorological conditions and risks. Follow orders and any advice given by your authorities under all circumstances, be prepared for extraordinary measures.

Warnings



Paradigm shift in 21st ct:

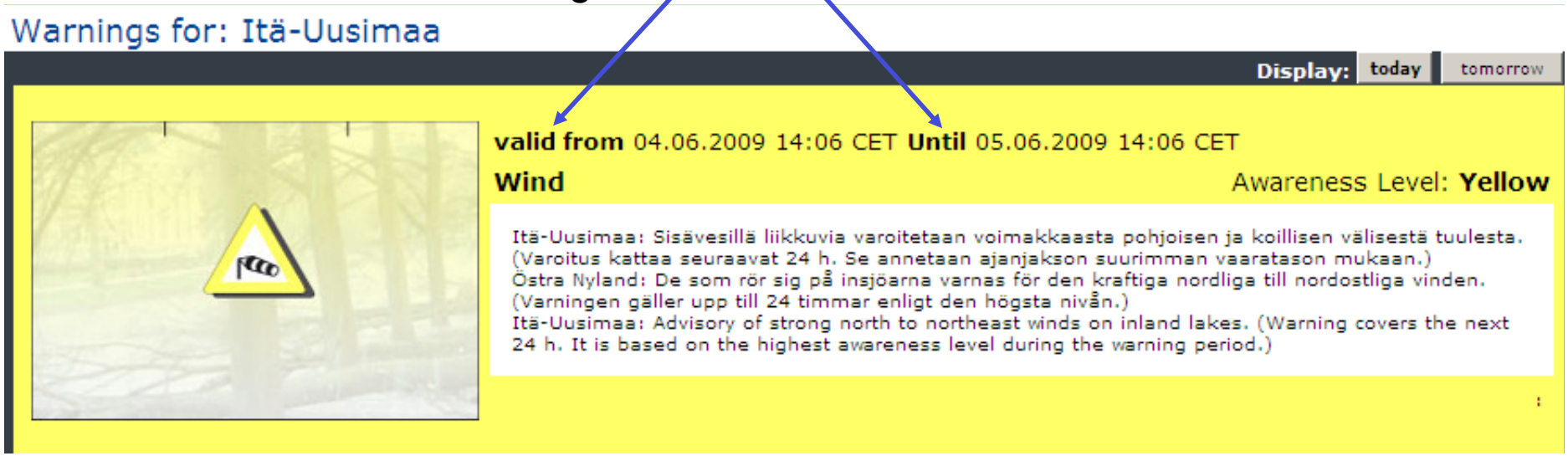
many warnings issued on a small, regional scale

Warnings

1. What are the spatial scales on which warnings are issued and/or verified in your country? Check all that apply.				
	issued	verified	verification rate	Response Count
cities	100.0% (10)	60.0% (6)	60 %	10
counties	100.0% (4)	50.0% (2)	50 %	4
provinces	100.0% (12)	58.3% (7)	58 %	12
whole country	88.9% (8)	77.8% (7)	88 %	9
			answered question	19
			skipped question	0

Warnings

2 additional free parameters
when to start: **lead time**
how long: **duration**



These additional free parameters have to be decided upon by the forecaster
or
fixed by process management (driven user needs)

Warnings

2. What is the required lead time for warnings for areas of different size? Check all that apply.

	cities	counties	provinces	whole country	Response Count
don't know	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0
less than 1 hour	**100.0% (2)**	50.0% (1)	0.0% (0)	0.0% (0)	2
1 hour	**50.0% (1)**	**50.0% (1)**	0.0% (0)	0.0% (0)	2
2 hours	**100.0% (2)**	0.0% (0)	0.0% (0)	0.0% (0)	2
3 hours	0.0% (0)	0.0% (0)	0.0% (0)	**100.0% (1)**	1
6 hours	33.3% (1)	**66.7% (2)**	33.3% (1)	33.3% (1)	3
half a day	**50.0% (2)**	25.0% (1)	25.0% (1)	**50.0% (2)**	4
1 day	22.2% (2)	33.3% (3)	**66.7% (6)**	55.6% (5)	9
2 days	12.5% (1)	37.5% (3)	62.5% (5)	**87.5% (7)**	8
don't know	40.0% (2)	40.0% (2)	**60.0% (3)**	40.0% (2)	5
				answered question	**18**
				skipped question	**1**

grey highlighting: highest value in each row%

tendency: larger scale, larger lead time

Issue: physical thresholds

Warnings:

- clearly defined thresholds/events, yet some confusion since either as country-wide definitions or adapted towards the regional climatology
- sometimes multicategory ("winter weather", thunderstorm with violent storm gusts, thunderstorm with intense precipitation)

Observations:

- clearly defined at first glance
    - yet warnings are mostly for areas → undersampling
    - "soft touch" required because of overestimate of false alarms
        - use of "practically perfect forecast" (Brooks et al. 1998)
        - allow for some overestimate, since user might be gracious, as long as something serious happens
        - probabilistic analysis of events needed

Issue: physical thresholds

gust warning verification, winter

”one category too high, is still ok, →no false alarm”

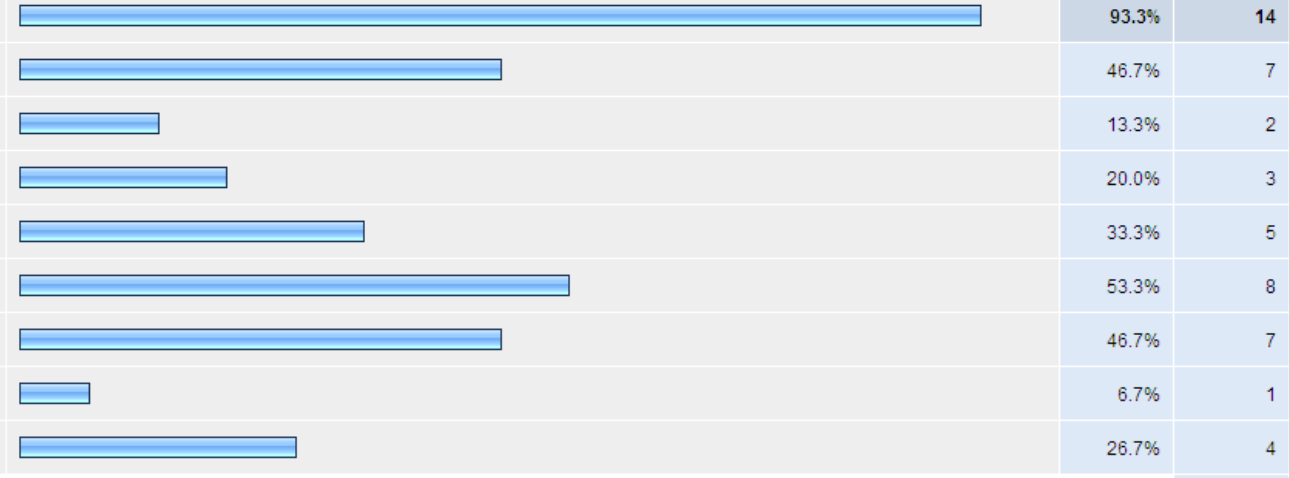
“severe”

	observed gusts in m/s or Bft							absolute frequ.	FAR	soft FAR	differ ence
	<14	14-17	18-24	25-28	29-32	33-37	>38				
	0-6	7	8-9	10	11	12	>12				
warnings											
no warning	**561834**	5244	300	1	0	0	0	567379			
near gale	66927	**19312**	1810	10	0	0	0	88059	0,59		
gale	23850	22227	**11036**	262	21	1	0	57397	0,75	0,37	0,37
storm	1295	2231	3557	**391**	52	3	0	7529	0,91	0,44	0,47
violent storm	207	577	1052	251	**80**	11	2	2180	0,96	0,84	0,12
hurrican force	136	208	414	118	37	**7**	1	921	0,99	0,95	0,04
extreme hurrican f.	0	0	0	0	0	0	**0**	0			
absolute frequency	654249	49799	18169	1033	190	22	3	723465			

“severe”

Issue: observations

4. What kind of observations do you use to verify warnings? Check all that apply.



	Response Percent	Response Count
synoptical observations	93.3%	14
metars	46.7%	7
non-meteorological networks	13.3%	2
lightning	20.0%	3
radar	33.3%	5
satellite	53.3%	8
media reports of damages	46.7%	7
spotters	6.7%	1
other eye witness reports	26.7%	4
Hide replies Other (please specify)		4

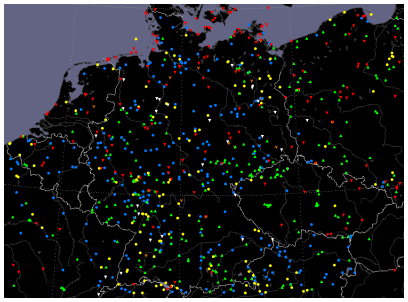
1.	AIREPS	Fri, Jun 5, 2009 9:42 AM	Find...
2.	I don't know how they verify warnings (is a forecaster's task and I'm workning on numerical models). I think they don't have any formal procedure to verificate warnings.	Thu, Jun 4, 2009 9:57 PM	Find...
3.	PM10 for yellow dust AWS	Thu, Jun 4, 2009 5:01 PM	Find...
4.	Agriculture and Hidrology reports	Thu, Jun 4, 2009 12:25 PM	Find...

	answered question	15
	skipped question	4

Issue: observations

5. How do you deal with the sparseness of the observations, i.e. how many observations (in the area and/or time interval) do you require to have been above a threshold for saying an "event has occured"? How do you deal with the quality of the observations? Check all that apply.			
	yes	no	Response Count
single obs above threshold sufficient	**50.0% (6)**	**50.0% (6)**	12
single obs slightly below threshold already sufficient	33.3% (3)	**66.7% (6)**	9
more than one obs needed	**86.7% (13)**	13.3% (2)	15
data are automatically quality controlled	40.0% (4)	**60.0% (6)**	10
data are manually quality controlled	**83.3% (10)**	16.7% (2)	12
		answered question	**16**
		skipped question	3

Issue: observations



What:

- standard: SYNOPS
- increasingly: lightning (nice! :), radar
- non-NMS networks
- additional obs from spotters, e.g. European Severe Weather Database ESWD

Data quality:

- particularly important for warning verification
- “skewed verification loss function”: missing to observe an event is not as bad as falsely reporting one and thus have a missed warning
- multivariate approach strongly recommended (e.g. no severe precip, where there was no radar or satellite signature)

Issue: data formats

Warnings:

- all sorts of ASCII formats, yet trend towards xml

Observations:

- "standard chaos"
- additional obs from spotters, ASCII, ESWD

Raw ASCII data (Selected event: F4 Pforzheim tornado, Germany, 10 July 1968)

INFO|10|V01.40|3|QC2|EYEWTN LIT NWSP TV WXSVC WWW|TorDACH V1.6.00, tordach.org/de, de@tordach.org; D. Fuchs, Promet 4'81, 8-10 ==> Monatl. Witterungsber. DWD;; Monatsarbeit der Wetterdienst-Referendarausbildung, 1978, 56 S.;; Pers. comm. 2000; R. Nestle, Meteor. Rdschau. 22 (1969), 1-3; Becht H. P., Stadtarchiv Pforzheim, pers. comm. (1998); Fulks, H.W., 1969: A synoptic review of the Pforzheim tornado of; 10 July 1968. 2nd Wea. Wing Tech. Bull, Air Wea. Service, US Air Force,; April 1969, 26-43.|1|Nikolai Dotzek, ESSL|20051231

TIME&PLACE|19|1968|07|10|WED|20|30|1H|DE|BW|Ittersbach, Pforzheim|||48.9055|08.5270|HILLS|RURAL|RURAL URBAN

TORNADO|23||4|8|DMGTEXT||FNLOBS|NOSVTCSOBS||||20|35||1000|W-E|DM:150M|170kFm||300|2|Same cell as T7/F3 tornado at Sarrebourg, Eschbourg, Hagenau#

Issue: matching warning and obs

Largest difference to model verification !

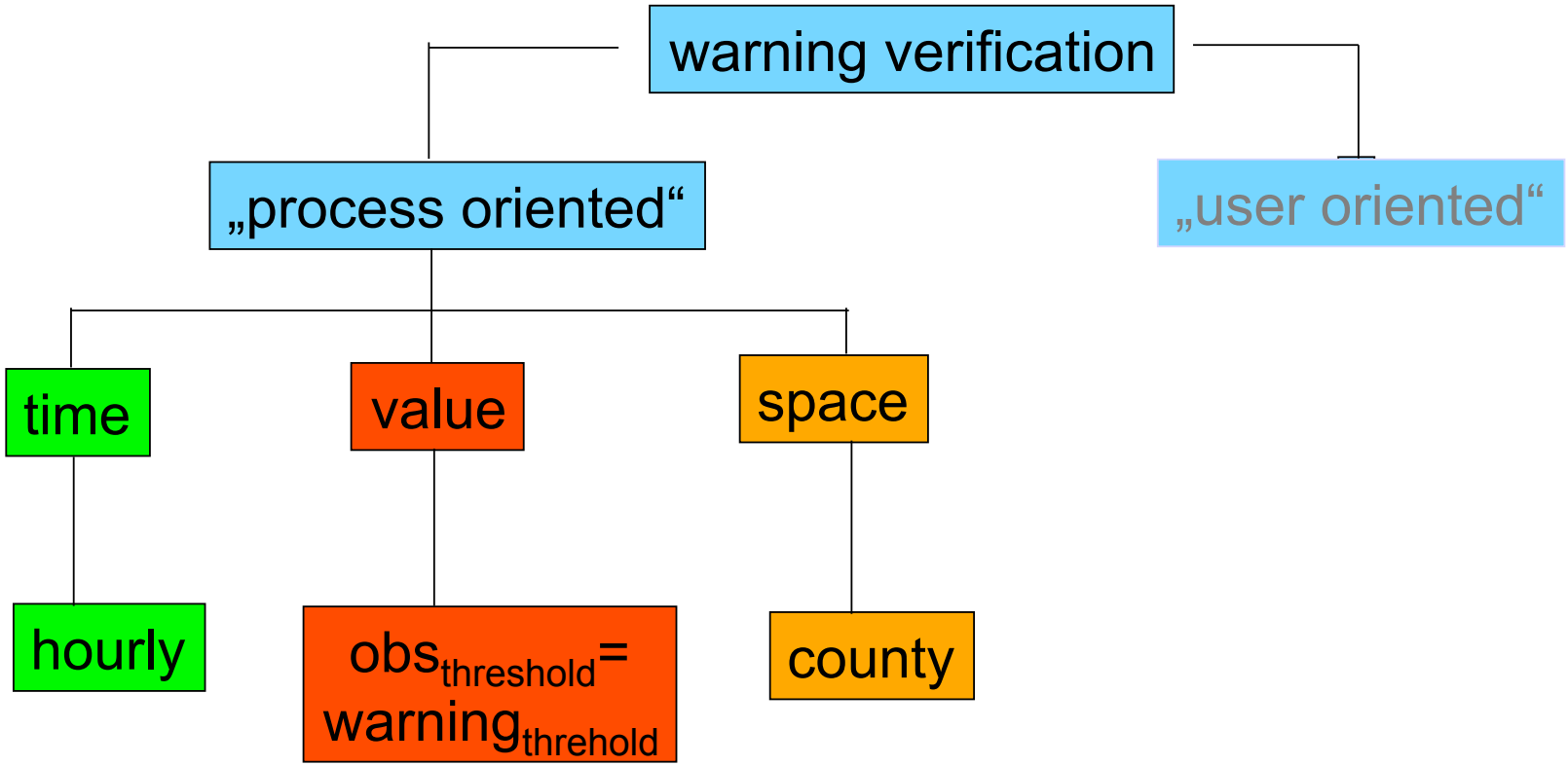
temporal

- hourly (SYNOPS), e.g. NCEP, UKMO, DWD as “process oriented verification”
- “events”:
  - warning and/or obs immediately followed by warning
  - obs in an interval starting at first threshold exceedance (e.g. UKMO 6 hours before the next event starts)
  - even “softer” definition: as “extreme events”
- thus size of sample N varies between a few dozens and millions !
- lead time for a hit: desired versus real; 0, 1, … hours ?

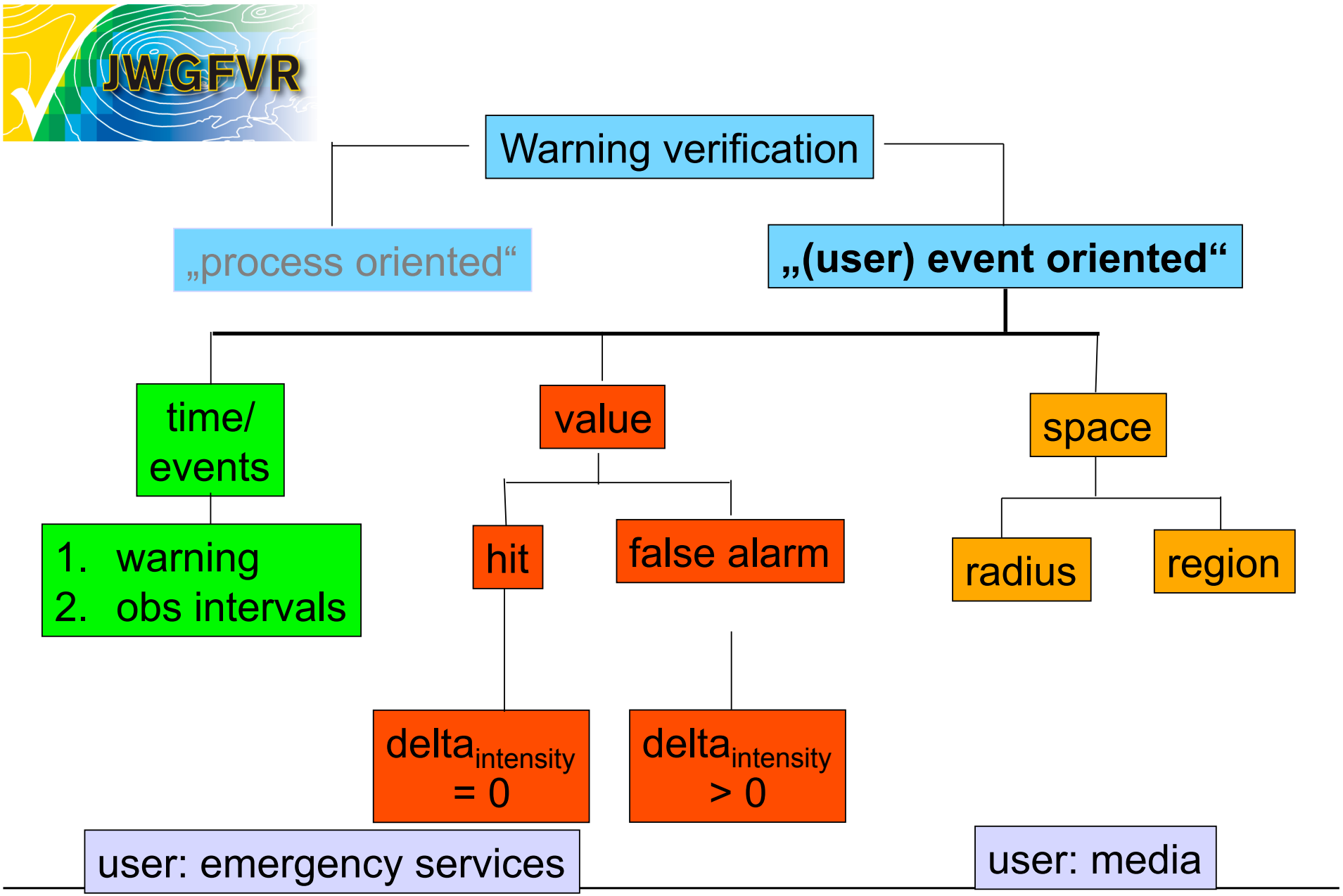
Issue: matching warning and obs

temporal

6. How do you match observations and warnings ? What is the actual lead time (as opposed to officially desired) which you require to count a warning as a "hit"?			
	yes	no	Response Count
on hourly basis	20.0% (1)	**80.0% (4)**	5
on three hourly basis	50.0% (3)	**66.7% (4)**	6
as "events"	**81.8% (9)**	18.2% (2)	11
lead time of at least 1 hour	**50.0% (2)**	**50.0% (2)**	4
lead time of least 2 hours	40.0% (2)	**60.0% (3)**	5
lead time of 2 or more hours	**75.0% (6)**	25.0% (2)	8
		answered question	**16**
		skipped question	3



user: operational control („single voice“)


JWGFVR
Warning verification
„process oriented“
„(user) event oriented“
time/
events
value
space
1. warning
2. obs intervals
hit
false alarm
radius
region
delta intensity
= 0
delta intensity
> 0
user: emergency services
user: media

Issue: matching warning and obs

hit

								hourly, "process oriented" verification	"event oriented" verification
time	15	16	17	18	19	20	21		
observation			1					1 hit	1 hit
warning		1	1	1	1			3 false alarms	
time of issue		X							

miss (too late)
or
hit (still useful)

								hourly, "process oriented" verification	"event oriented" verification
time	15	16	17	18	19	20	21		
observation		1						1 miss (or hit)	1 miss
warning		1	1	1				2 false alarms	
time of issue		X							

hit
+
false alarm (too long)

								hourly, "process oriented" verification	"event oriented" verification
time	15	16	17	18	19	20	21		
observation			1					1 hit	1 hit (including 1 false alarm)
warning		1	1	1	1	1		2 false alarms	
time of issue		X							

Issue: matching warning and obs

Largest difference to model verification !

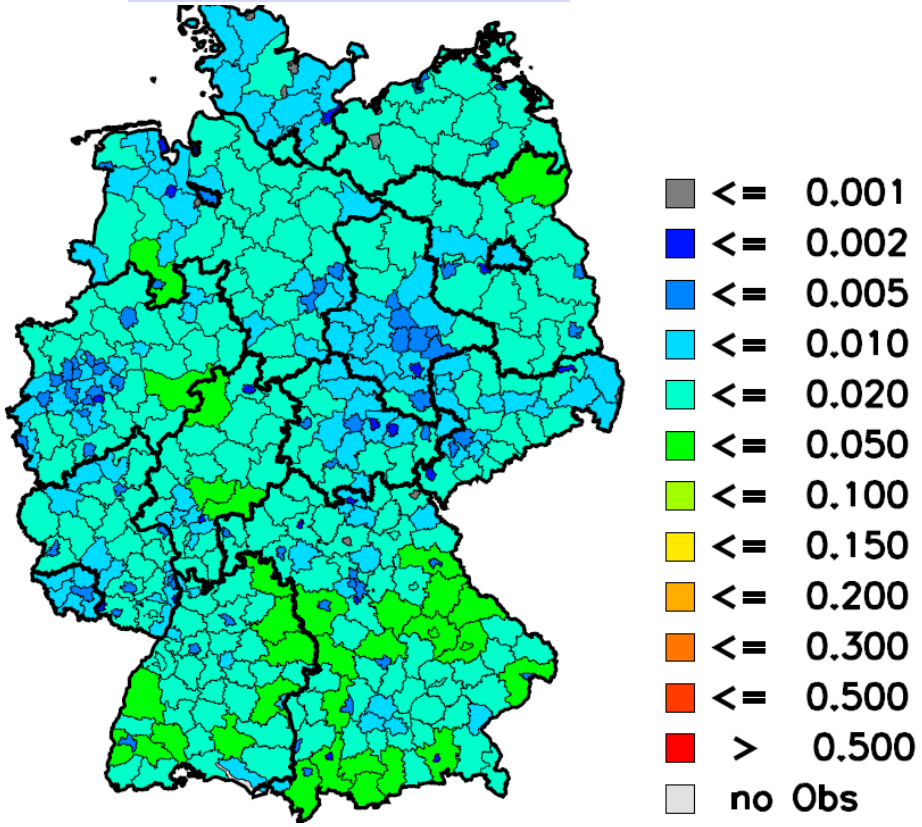
spatial

- sometimes “by-hand” (e.g. Switzerland, France)
- worst thing in the area
- dependency on area size possible
- “MODE-type” (**M**ethod for **O**bject-based **D**iagnostic **E**valuation)

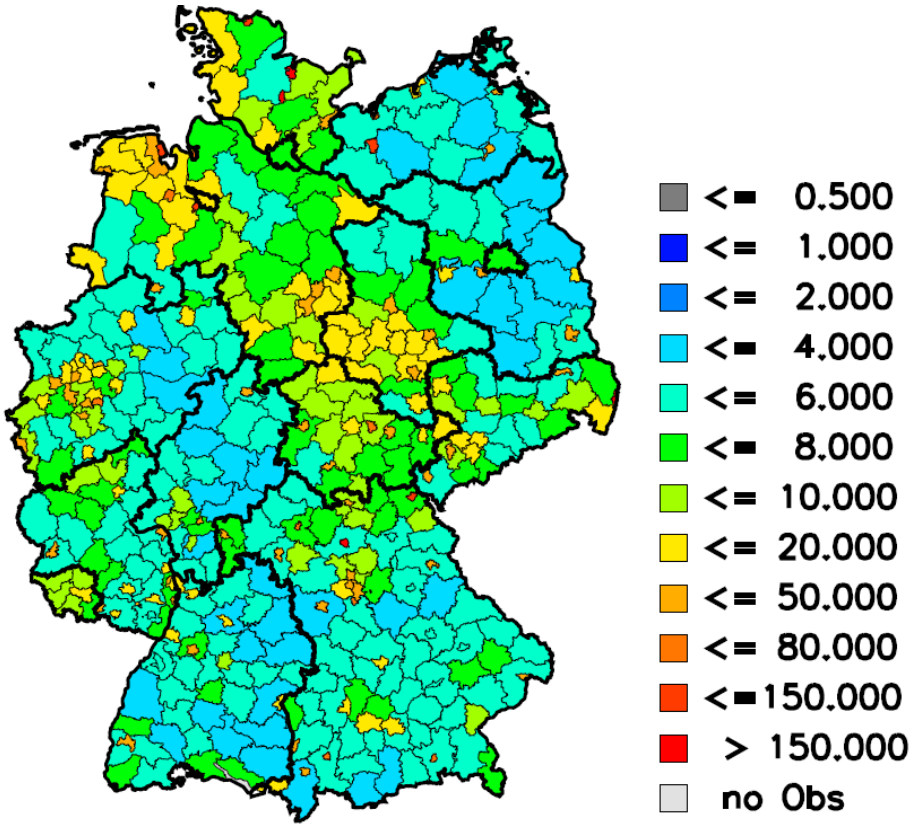
Issue: matching warning and obs

Thunderstorms

Base rate / h



bias



Issue: measures

Finley dataset, 1884

Tornado forecast	Tornado observed		
	Yes	No	fc Σ
Yes	28	72	100
No	23	2680	2703
obs Σ	51	2752	2803

Issue: measures

7. Which measures do you use to summarise the quality ? Check all that apply.

	Response Percent	Response Count
hit rate (= probability of detection)	83.3%	10
false alarm rate (percentage of falsly warned non-events)	58.3%	7
false alarm ratio (percentage of false warnings)	25.0%	3
TS (threat score)	50.0%	6
ETS (equitable threat score)	8.3%	1
HSS (Heidke skill score)	41.7%	5
HKS (Hansen-Kuippers score = TSS True skill score)	16.7%	2
ROC	16.7%	2
metric taking costs and losses explicitely into account	8.3%	1
Hide replies Other (please specify)		4

1. Dont now	Fri, Jun 5, 2009 9:42 AM	Find...
2. I don't know if they compute any of these measures	Thu, Jun 4, 2009 9:57 PM	Find...
3. W don't use any of deal above, but we use another criteria (for example, Obukhov criteria).	Thu, Jun 4, 2009 4:39 PM	Find...
4. odds ratio	Thu, Jun 4, 2009 12:24 PM	Find...

	answered question	12
	skipped question	7

Issue: measures

Finley dataset, 1884

Tornado forecast	Tornado observed		
	Yes	No	fc Σ
Yes	28	72	100
No	23	2680	2703
obs Σ	51	2752	2803

- "everything" used (including Extreme Dependency Score EDS, ROC-area)
- POD (view of the media: "something happened, has the weather service done it's job ?")
- FAR (view of an emergency manager: "the weather service activated us, was it justified ?"
- threat score frequently used, since definition of the no-forecast/no-obs category problematic
- no-forecast/no-obs category can be defined by using regular intervals of no/no (e.g. 3 hours) and count how often they occur
- "F-measure"

$$F_\beta = (1+\beta^2) * \frac{POD * (1-FAR)}{\beta^2 * POD + 1 - FAR}$$

"After years of study we ended up in using the value 1.2 for β for extreme weather…."

Issue: “Interpretation” of results

8. Do you have performance targets for warnings and are there consequences because of the results?

	Response Percent	Response Count
yes	23.1%	3
no	76.9%	10
Hide replies Other (please specify)		1

1. i am not sure — Fri, Jun 5, 2009 9:43 AM Find...

	answered question	13
	skipped question	6

Issue: “Interpretation” of results

Performance targets:

• extreme interannual variability for extreme events

• strong influence of change of observational network; “if you detect more, it’s easier to forecast” (e.g. after NEXRAD introduction in the USA)

Case studies

• remain very popular, rightly so ?

Significance

• only bad if you think in terms wanting to *infer* future performance, ok if you just think *descriptive*

• care needed when extrapolating from results for mildy severe events to very severe ones, since there can be step changes in forecaster behaviour taking some C/L ratio into account

Issue: “Interpretation” of results

Consequences

- changing forecasting process
  - e.g shortening of warnings at DWD dramatically reduced false alarm ratio based on hourly verification almost without reduction in POD
  - creating new products (probabilistic forecasts)

Issue: user-based assessments

9. Do you do user based assessments? What questions do you ask?

	Response Percent	Response Count
yes	50.0%	7
no	50.0%	7
Hide replies Other (please specify)		3

1. i am not sure	Fri, Jun 5, 2009 9:43 AM	Find...
2. Snow depth critical for traffic, hydrological risk	Thu, Jun 4, 2009 9:57 PM	Find...
3. Did you have sufficient lead time? Did you take any precautions? Was the infomation useful?	Thu, Jun 4, 2009 12:35 PM	Find...

answered question	14
skipped question	5

Issue: user-based assessments

- important role, especially during process of setting up county based warnings and subsequent fine tuning of products, given the current ability to predict severe events
- surveys, focus groups, user workshops, public opinion monitoring, feedback mechanisms, anecdotal information
- presentation of warnings to the users essential
- “vigilance evaluation committee” (Meteo France /Civil Authorities)
- typical questions:
    - Do you keep informed about severe weather warnings?
    - By which means?
    - Do you know the warning web page and the meaning of colours?
    - Do you prefer an earlier, less precise warning or a late, but more precise warning?
    - ……

Comparing warning guidances and warnings

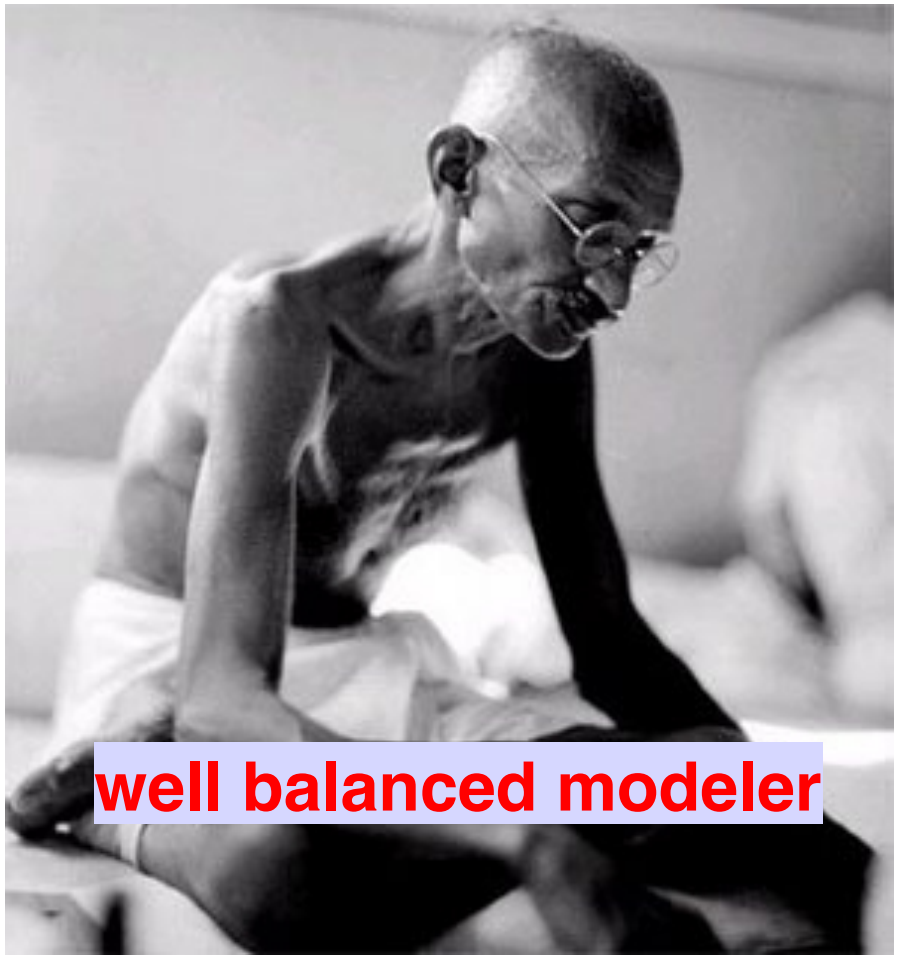
Example here, gust warnings

- Warning guidance: ”Local model gust forecast” (=mesoscale model)
- warning: human (forecaster)

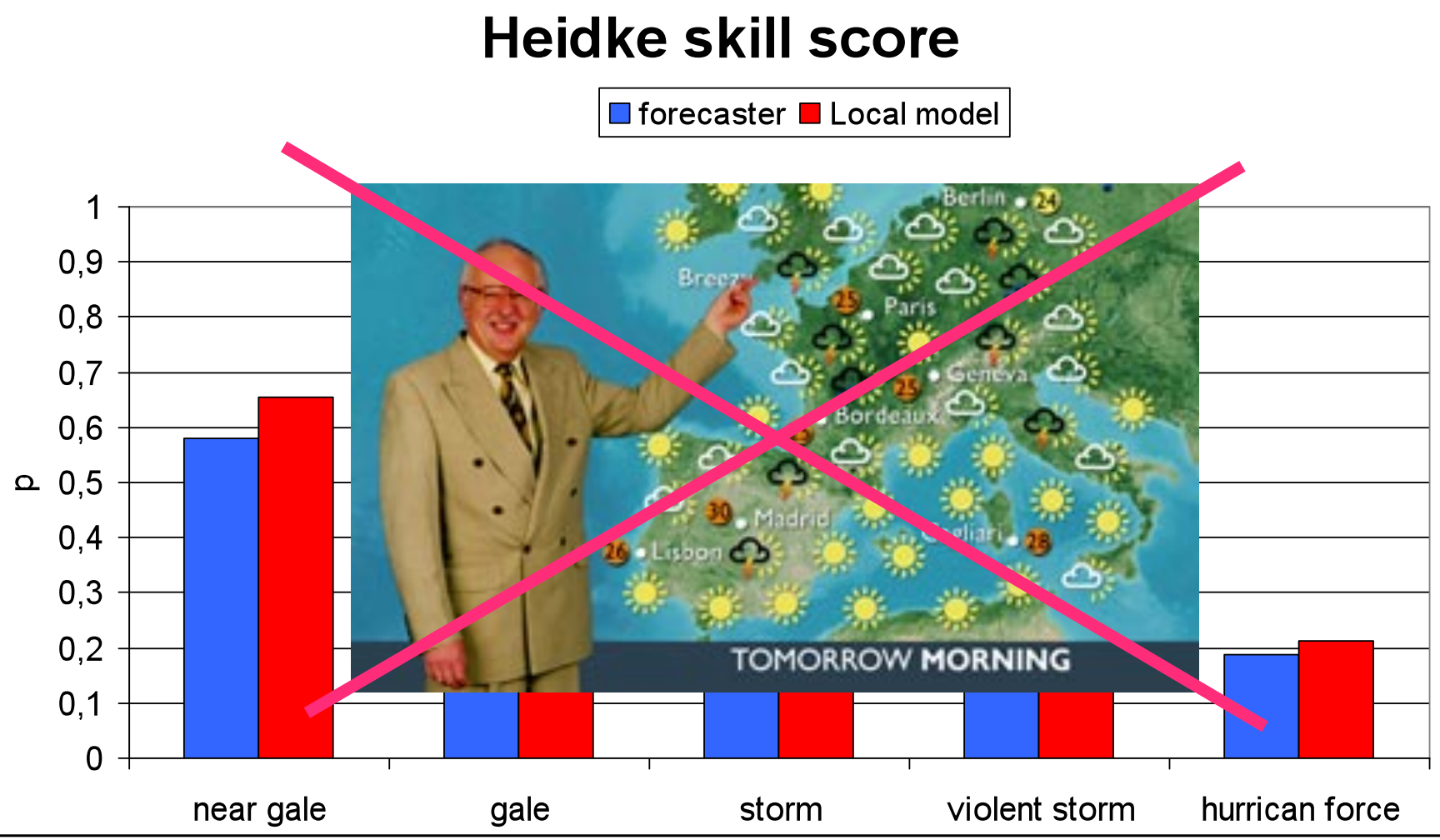
Comparing warning guidances and warnings

10. Do you compare warning guidance systems with warnings?		Response Percent	Response Count
no		46.7%	7
model guidances		53.3%	8
statistical products		20.0%	3
expert systems		13.3%	2
	answered question		15
	skipped question		4

Comparing warning guidances and warnings

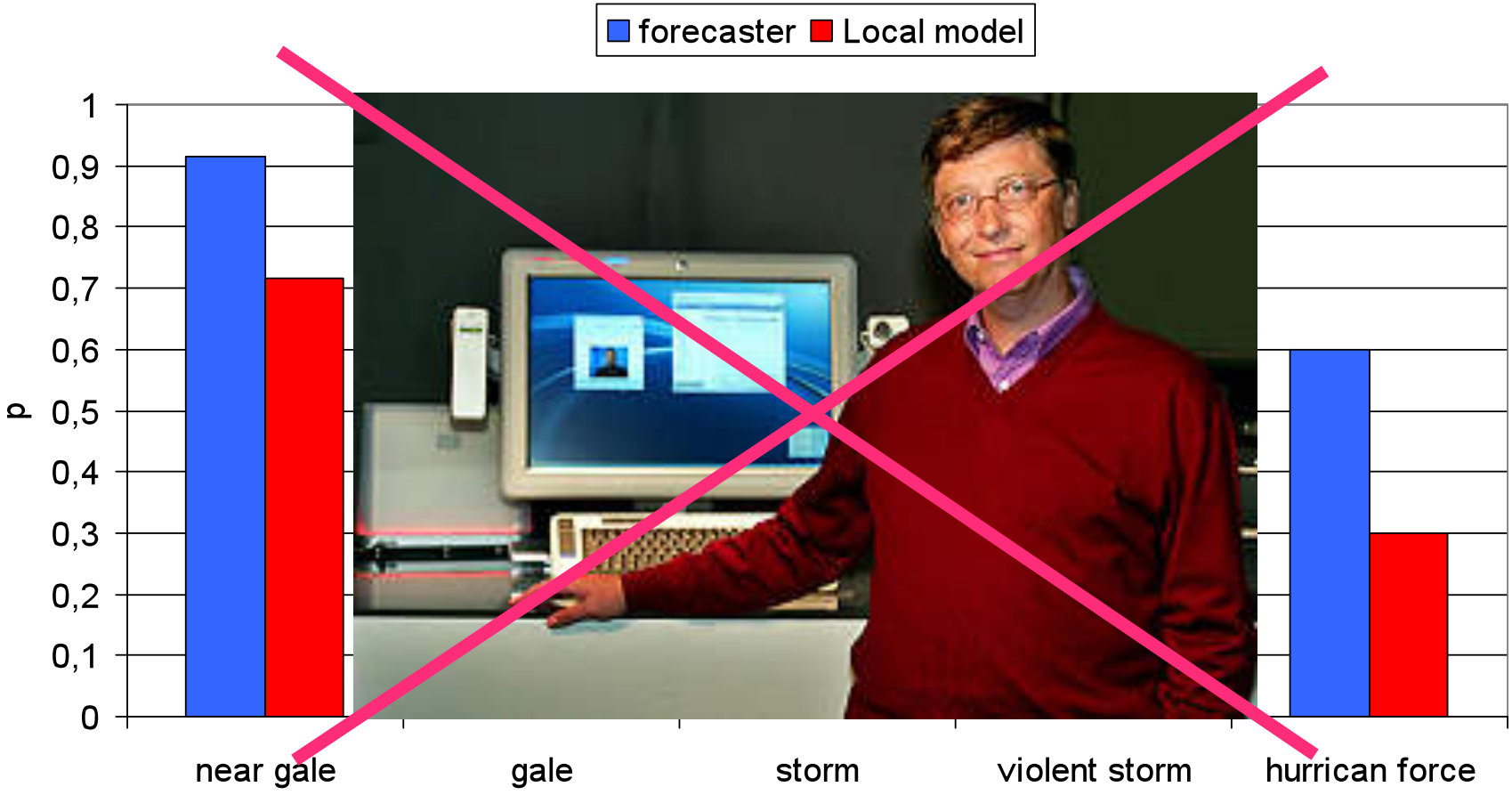


Issue: Comparing warning guidances and warnings



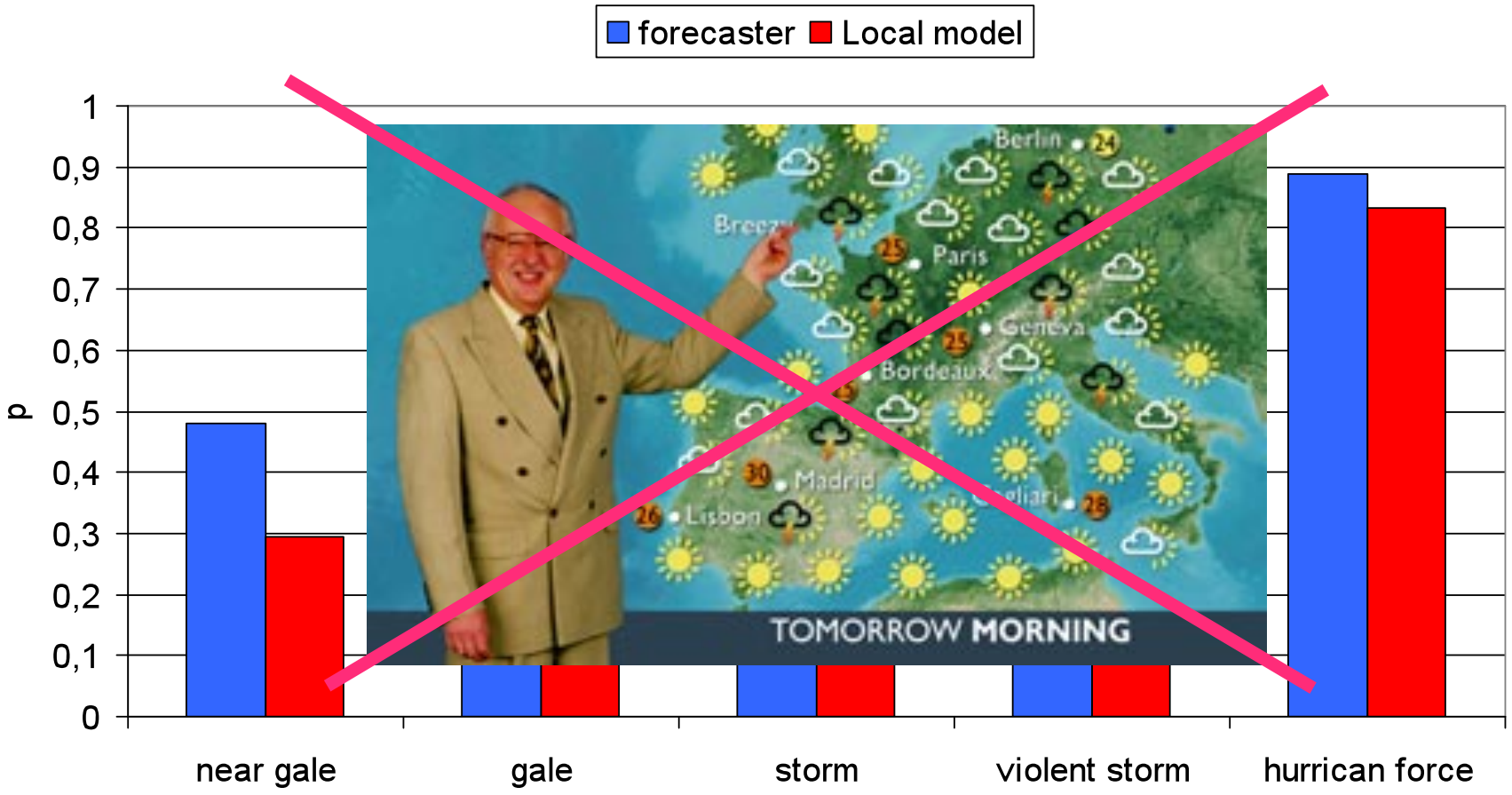
Issue: Comparing warning guidances and warnings

hit rate

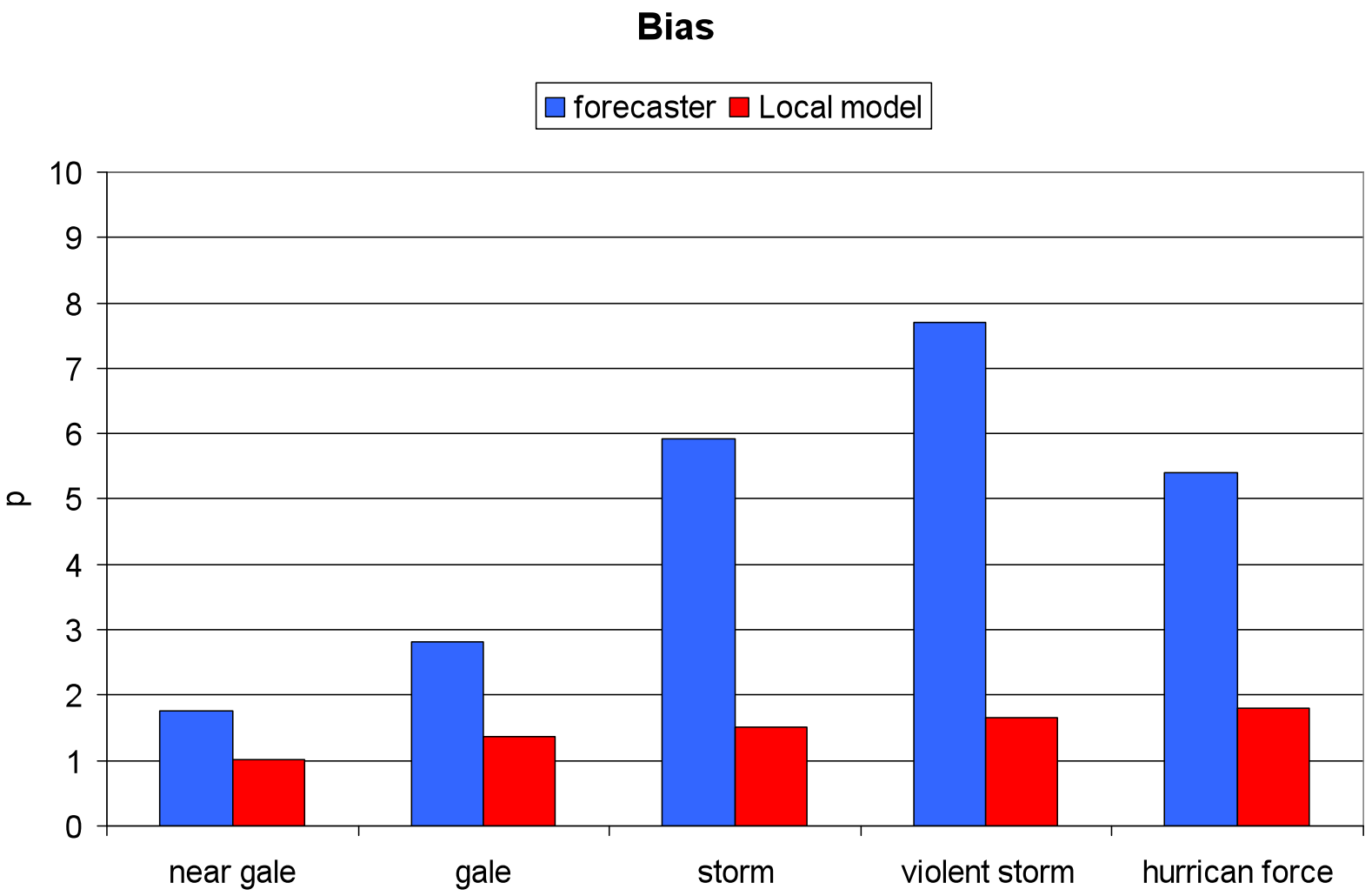


Issue: Comparing warning guidances and warnings

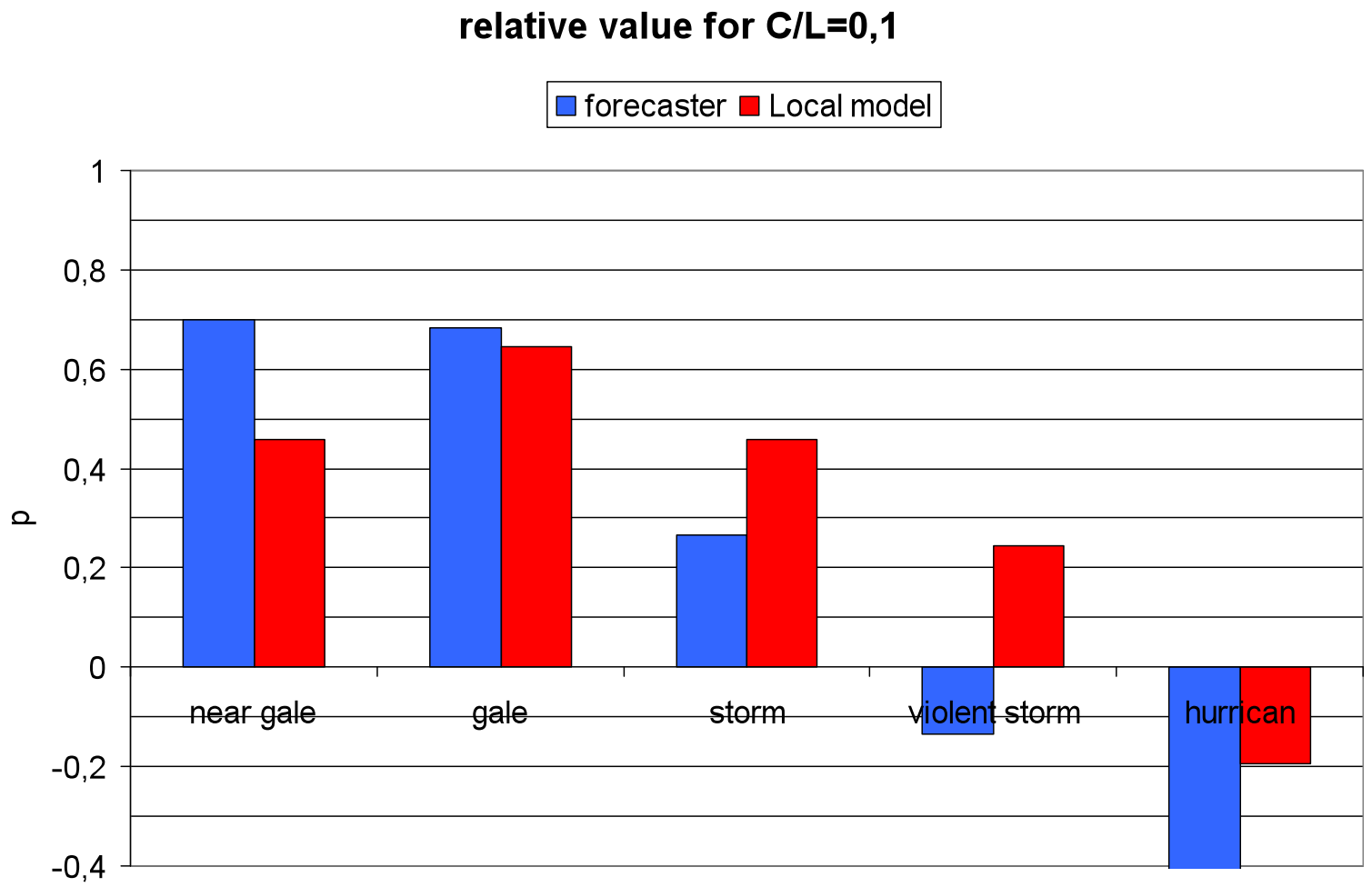
false alarm ratio



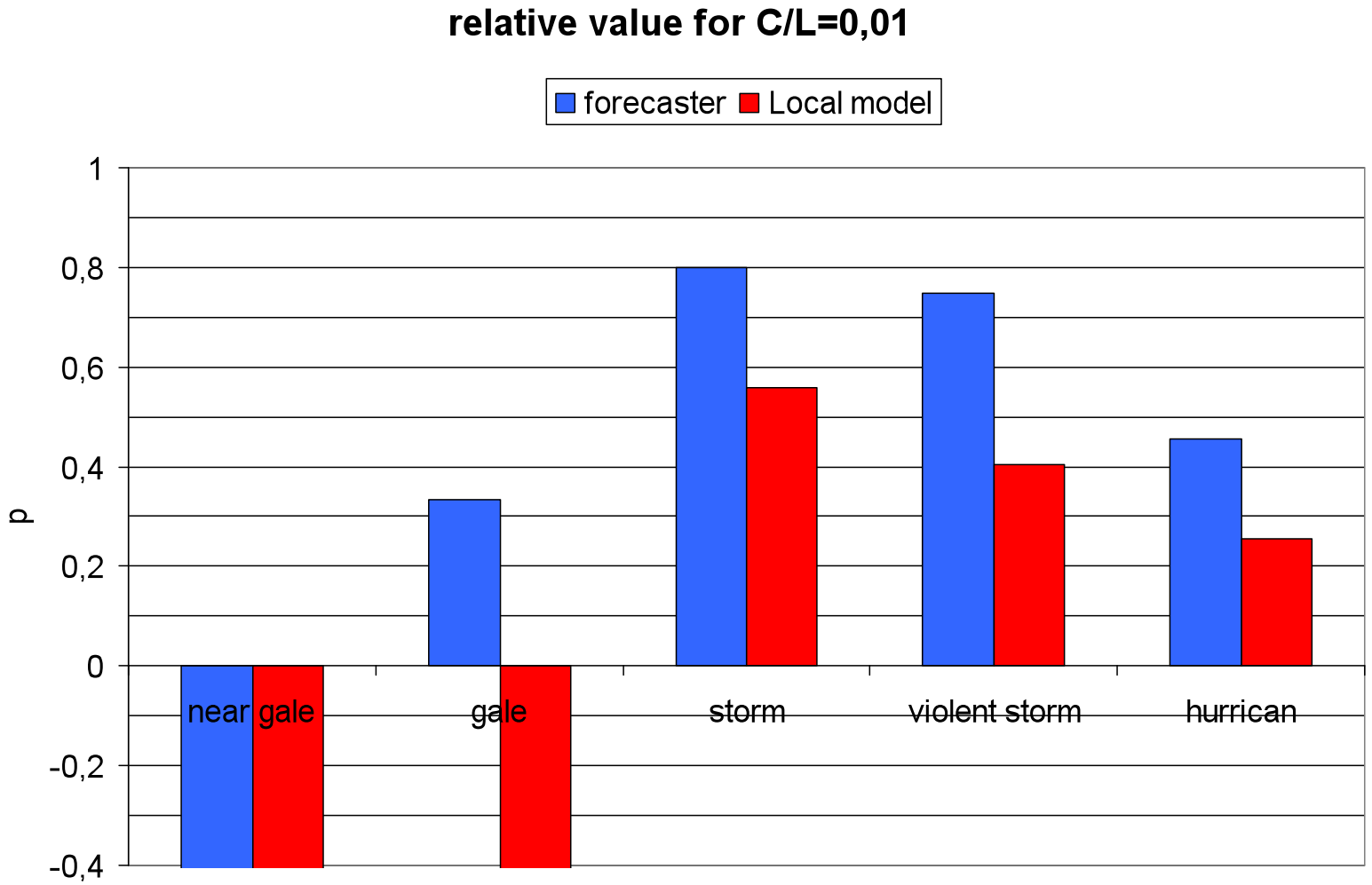
Issue: Comparing warning guidances and warnings



Issue: Comparing warning guidances and warnings



Issue: Comparing warning guidances and warnings



Issue: Comparing warning guidances and warnings

very different biases
→comparison of apples and oranges

But is there a way of ”normalising”,
so that at least the **potentials** can be compared ?

Issue: Comparing warning guidances and warnings

Re-calibration
„model bias = forecaster bias“
cdf(model) = cdf(forecaster)

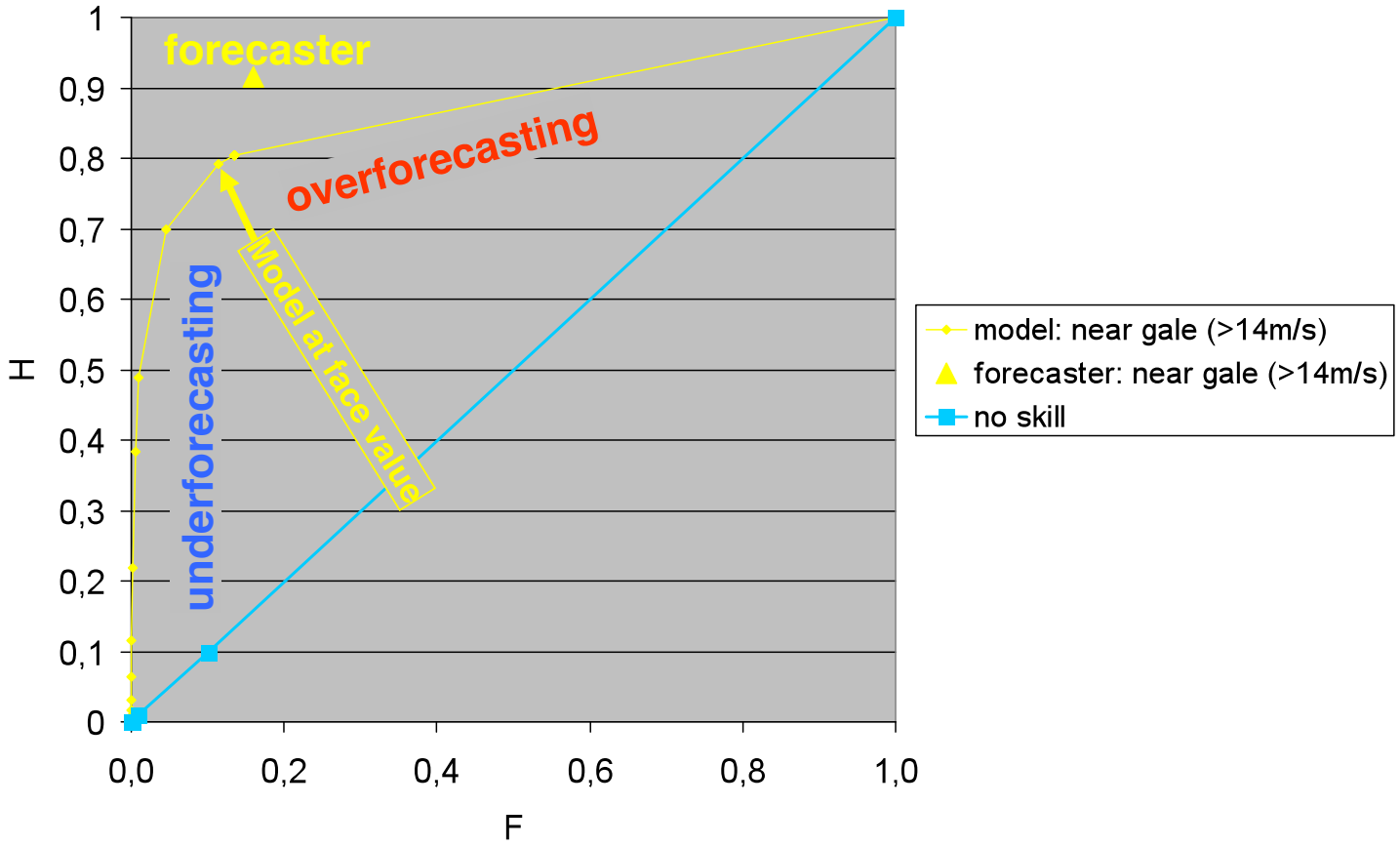
model in m/s ----> „model gust interpretation for warnings “

13	---->	14	(near gale)
16	---->	18	(gale)
22	---->	25	(storm)
25	---->	29	(violent storm)
30	---->	33	(hurricane force)

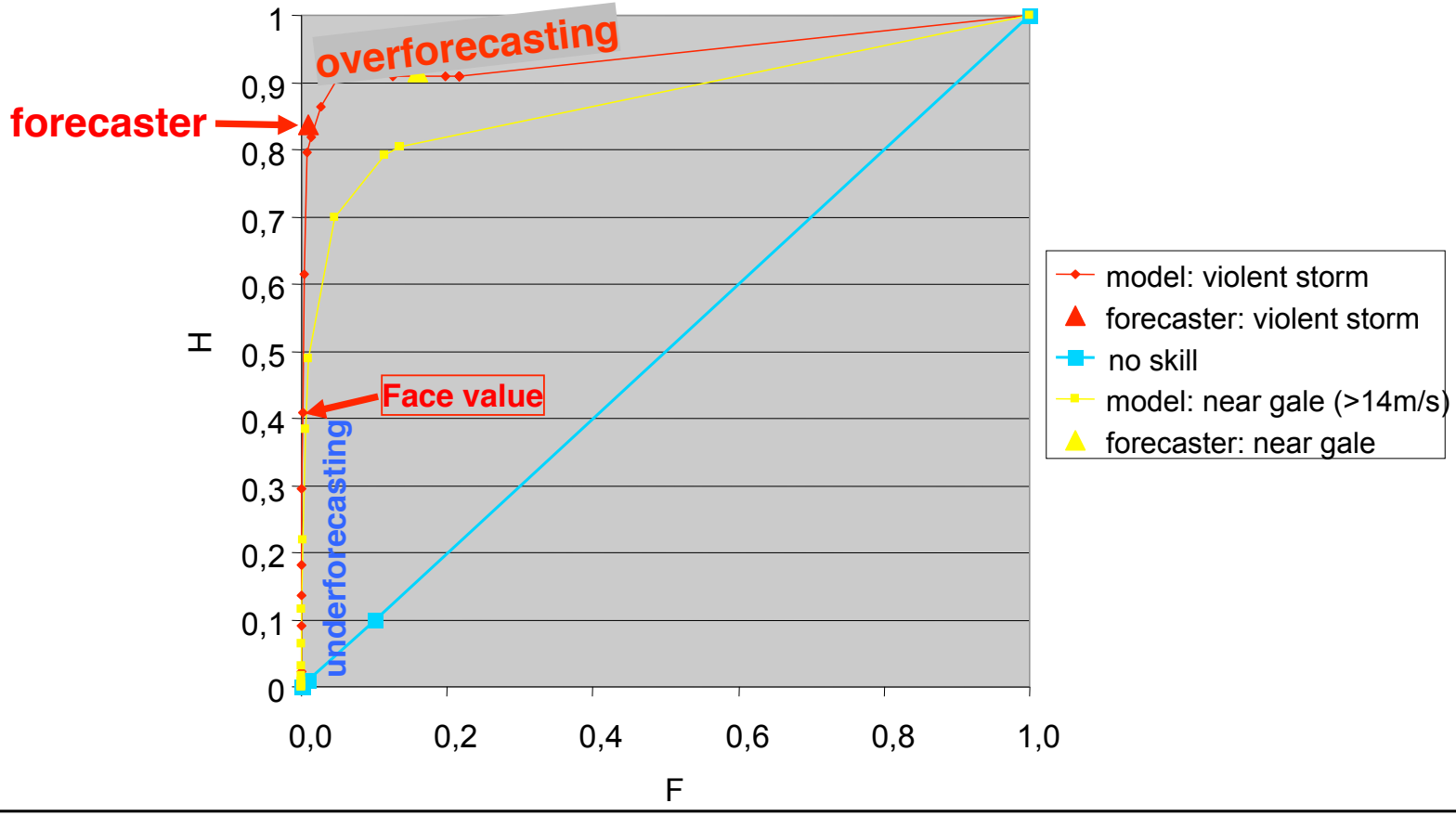
Verification of heavily biased model ? **Quite similar to forecaster !**

Issue: Comparing warning guidances and warnings

Relative Operating Characteristics (ROC)



Issue: Comparing warning guidances and warnings



Issue: Comparing warning guidances and warnings

Conclusions for comparative verification man vs machine

End user verification: verify at face value

Model (guidance) verification: measure potential

Summary

Users of warnings are very diverse and thus warning verification is also very diverse.

Each choice of a parameter of the verification method has to be user oriented – there is no „one size fits all“.

Can we warn even better ?

Fink et al.: Nat. Hazards Earth Syst. Sci., 9, 405–423, 2009

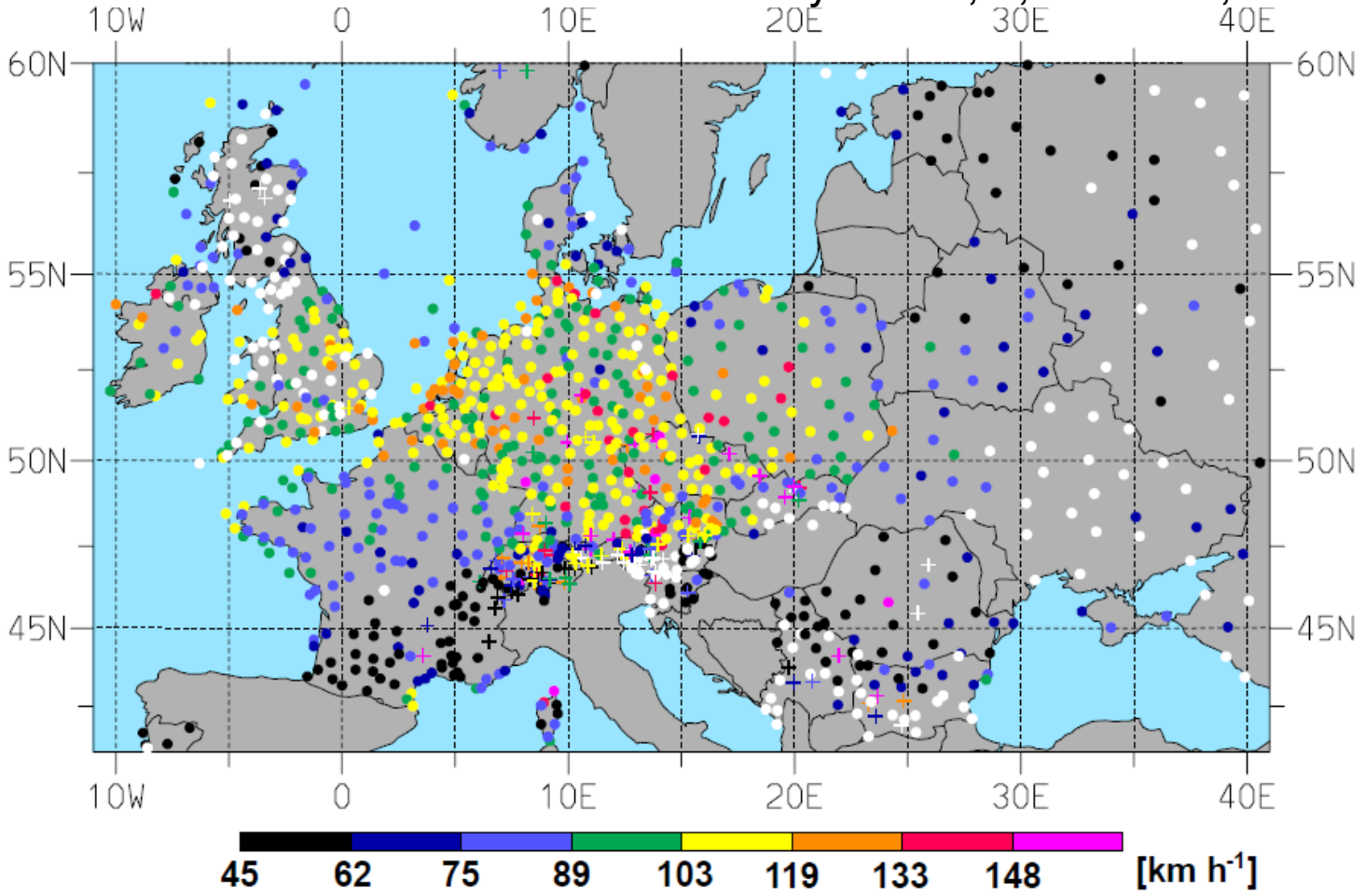


Fig. 6. Maximum wind gusts (in km h^{-1}) at different synoptic stations reported during the period from 00:00 UTC 17 January to 18:00 UTC 19 January 2007. Dots (crosses) delineate lowland (mountain) stations. Lowland stations possess an altitude lower than 800 m a.s.l. White symbols denote stations where no wind gusts were observed or reported.