To Warn or not to Warn: That is the risky question! Perspectives on uncertainty in weather warnings.

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4) Hans-Ertel-Centre for Weather Research (HErZ)

Weather forecasts are:

useless

wrong

- For gusts,10-20% misses – mostly severity underestimated
- 90% of wind warnings too high (1, 2, 3 Bft)
- every 2nd thunderstorm

popular

- 3rd most frequently accessed category of web sites

Outline of my talk

- Guide to better decisions to mitigate impact and spead up recovery with less costs
- Can we reliably estimate the degree of wrongness ?

Need to be well:

- communicated
- understood
- used

Transdisciplinary project WEXICOM

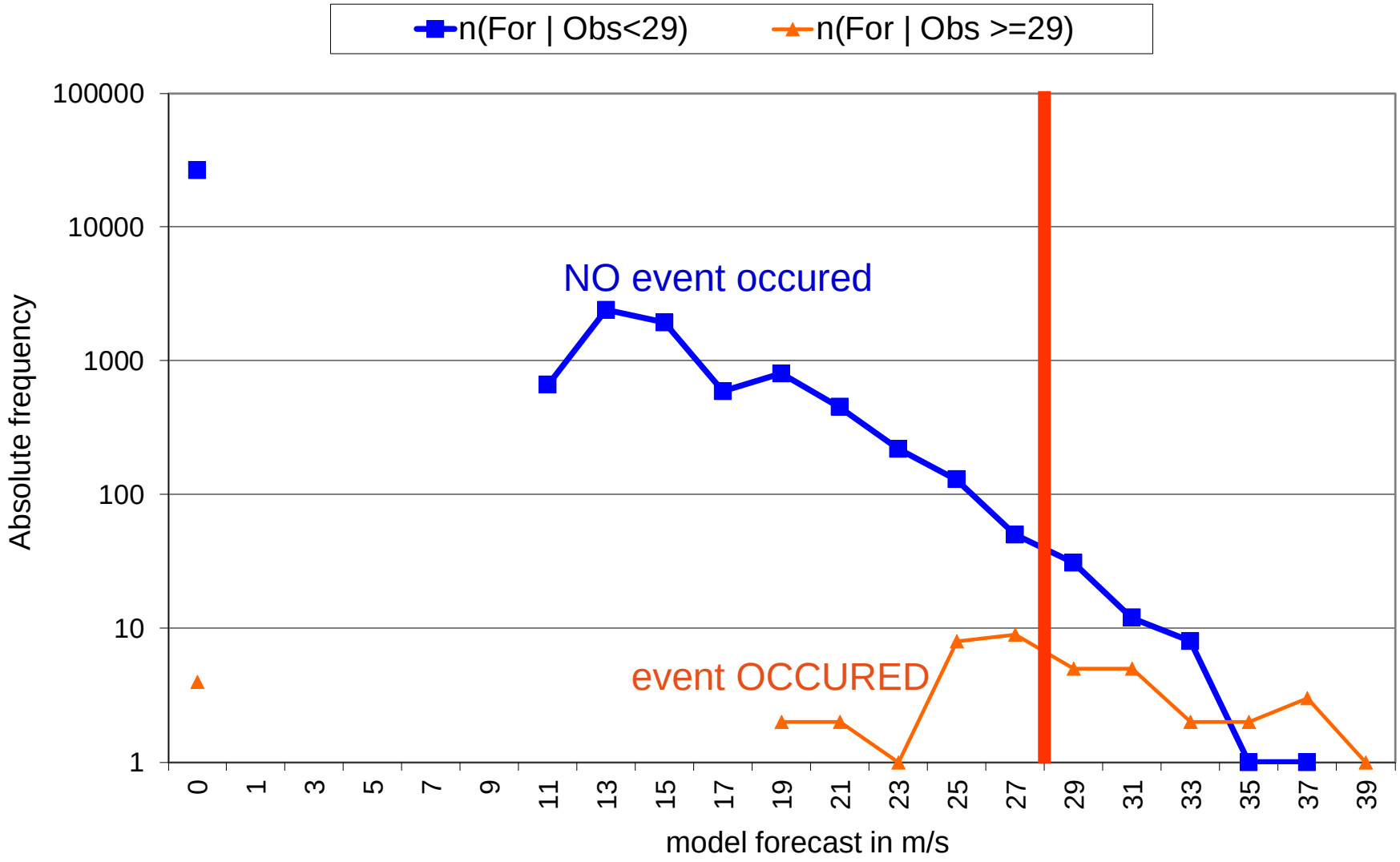
- **WEXICOM**: **W**eather warnings: from **EX**treme event **I**nformation to **COM**unication and action
- transdisciplinary project of meteorologists, social and behavioural scientists and users mainly from emergency operations
- Methods: surveys, interviews, stakeholder workshops, direct observations of emergency operations, impact modeling
- part of the „Hans-Ertel-Centre for Weather Research“ (HErZ), which is a collaboration between DWD and german universities and research institutions

Decision to WARN

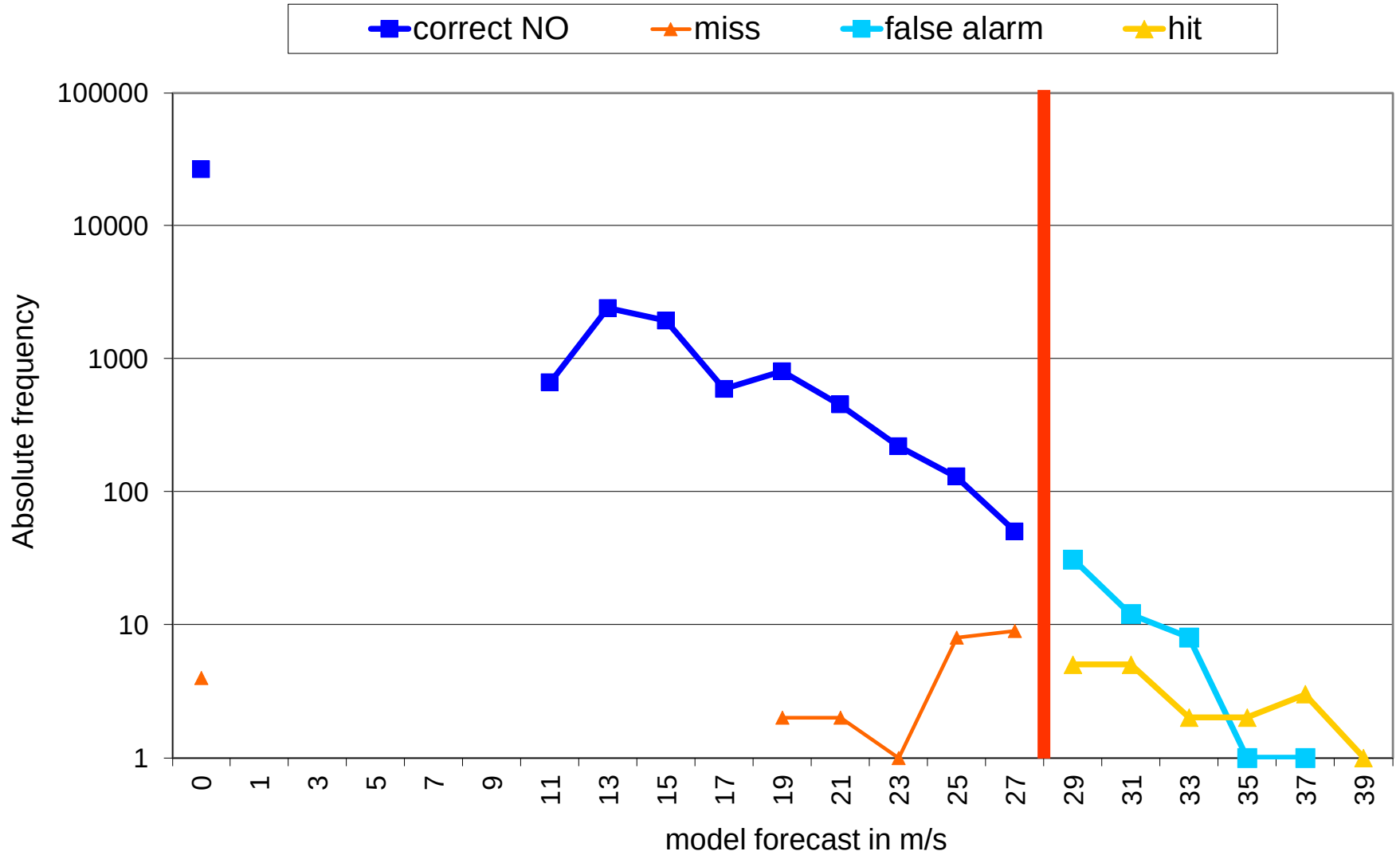
Example:

- One event: violent storm: >= 29 m/s (11 Bft)
- COSMO-EU model gust forecasts

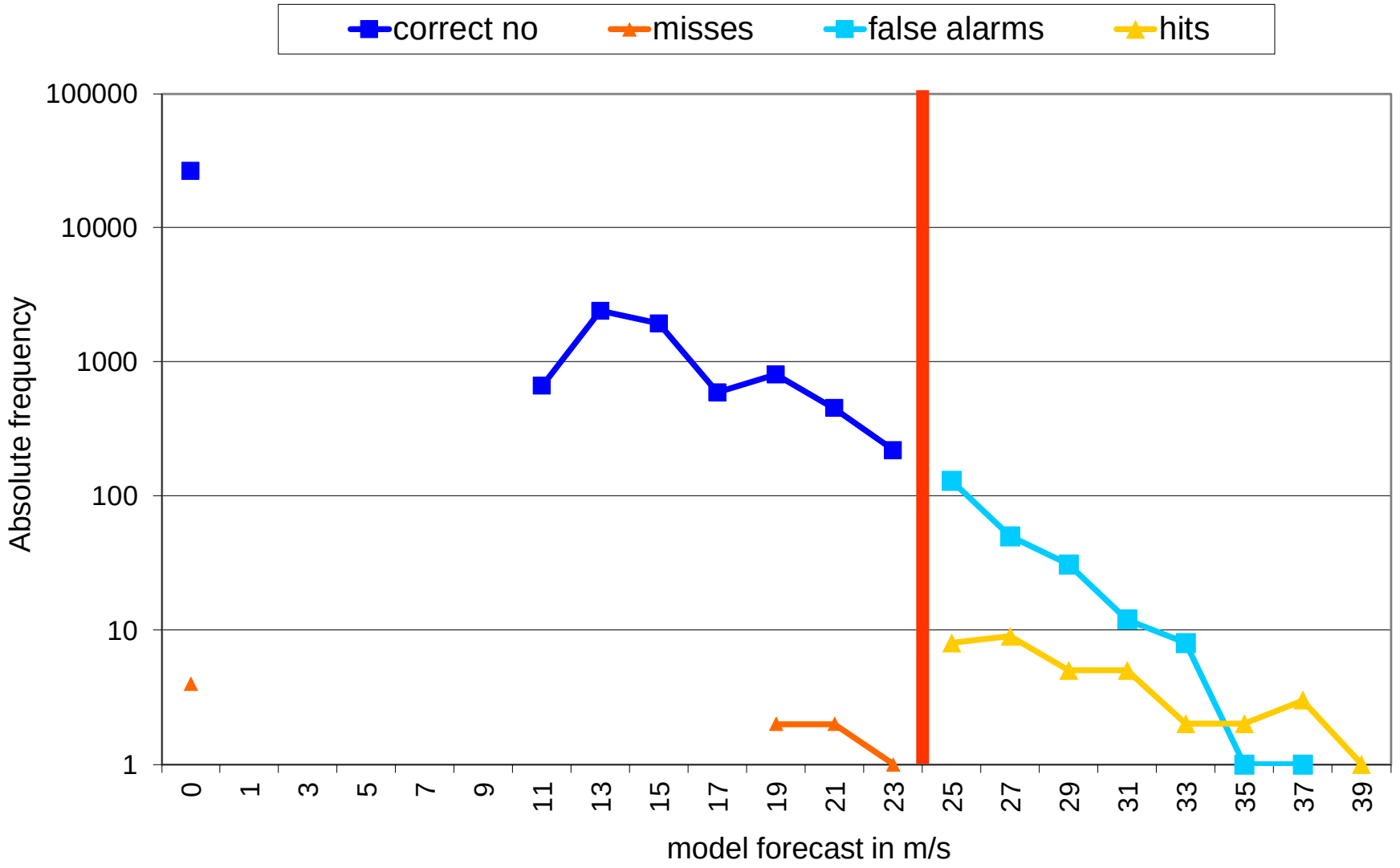
Discriminability



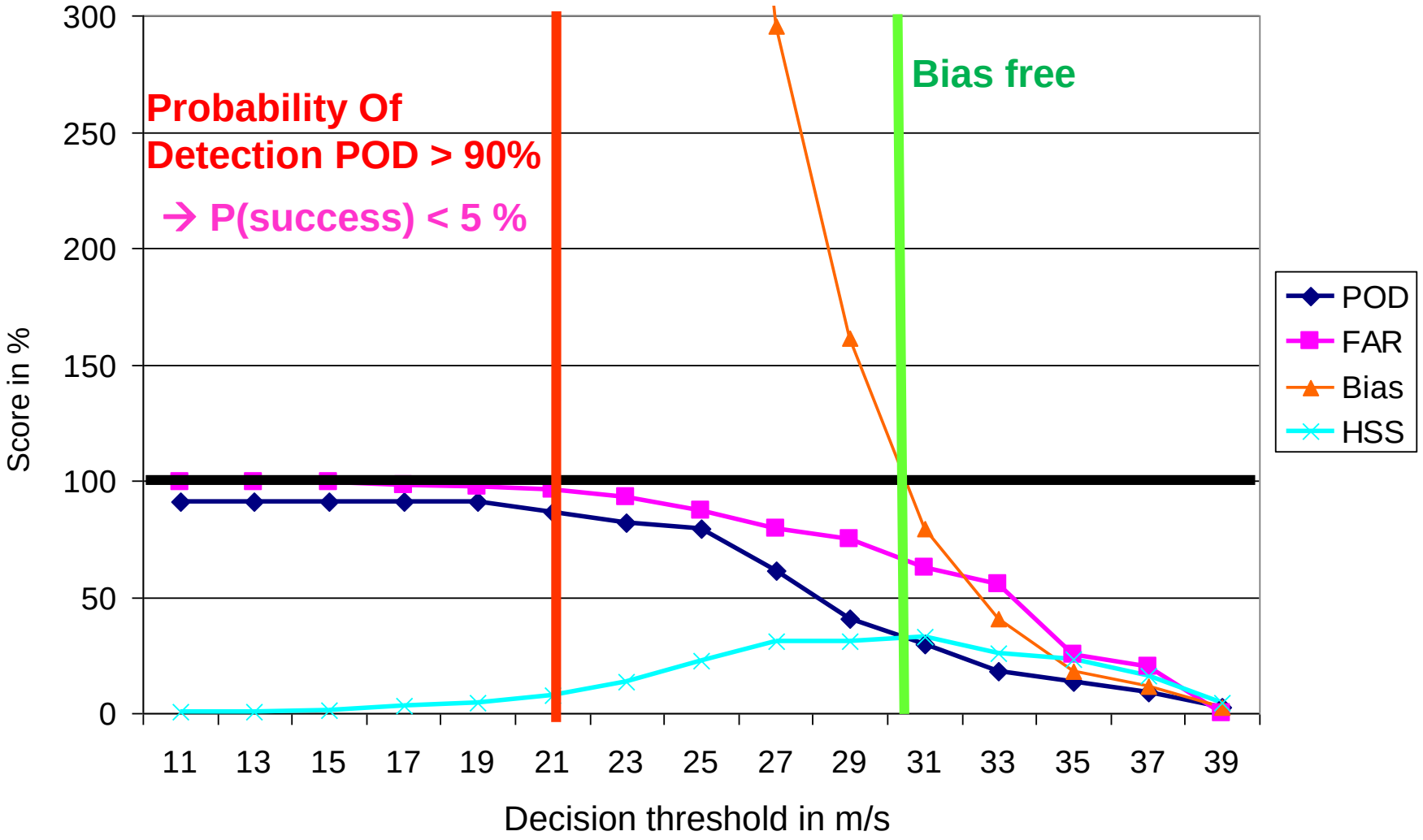
Discriminability



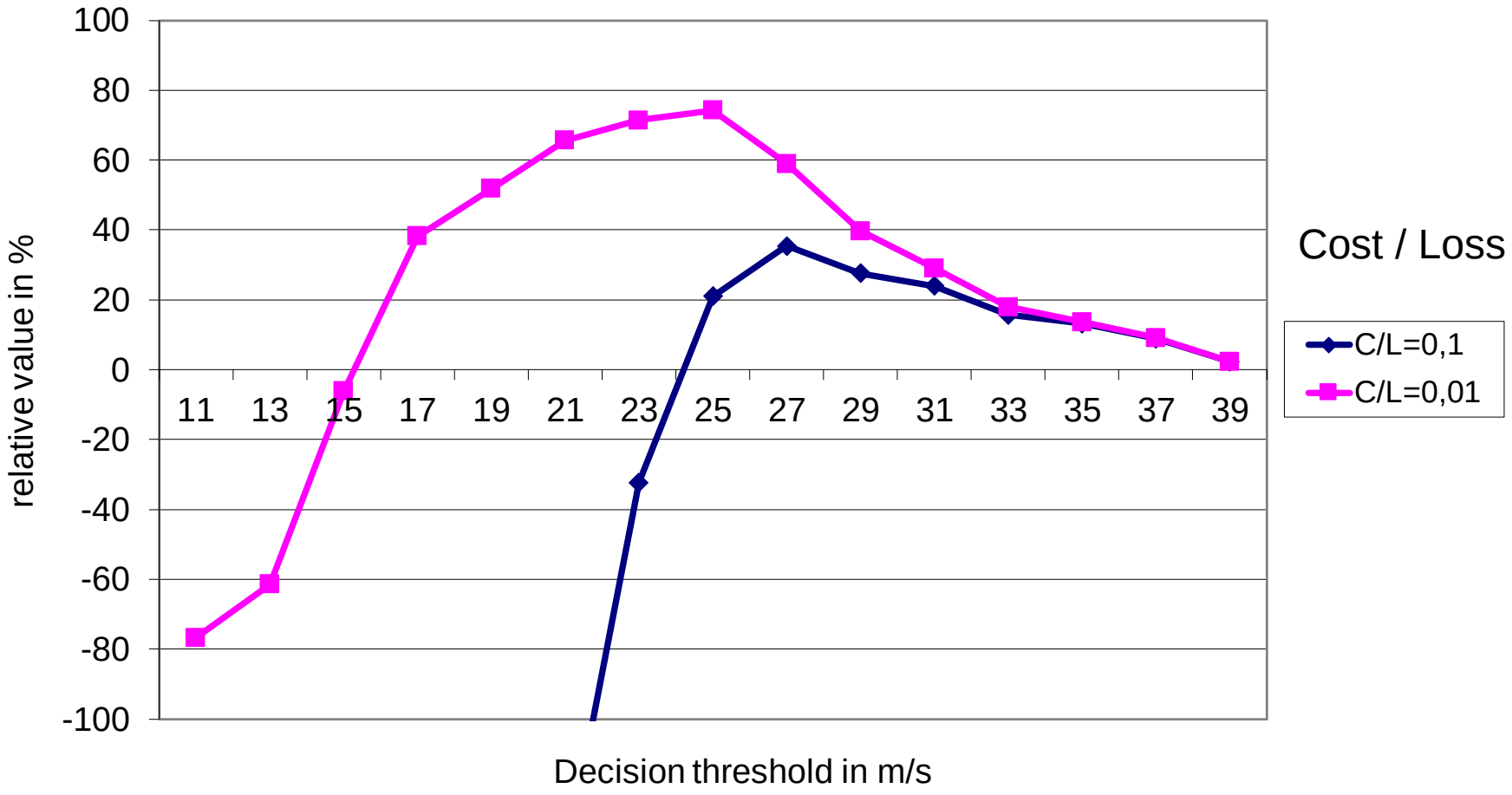
Discriminability



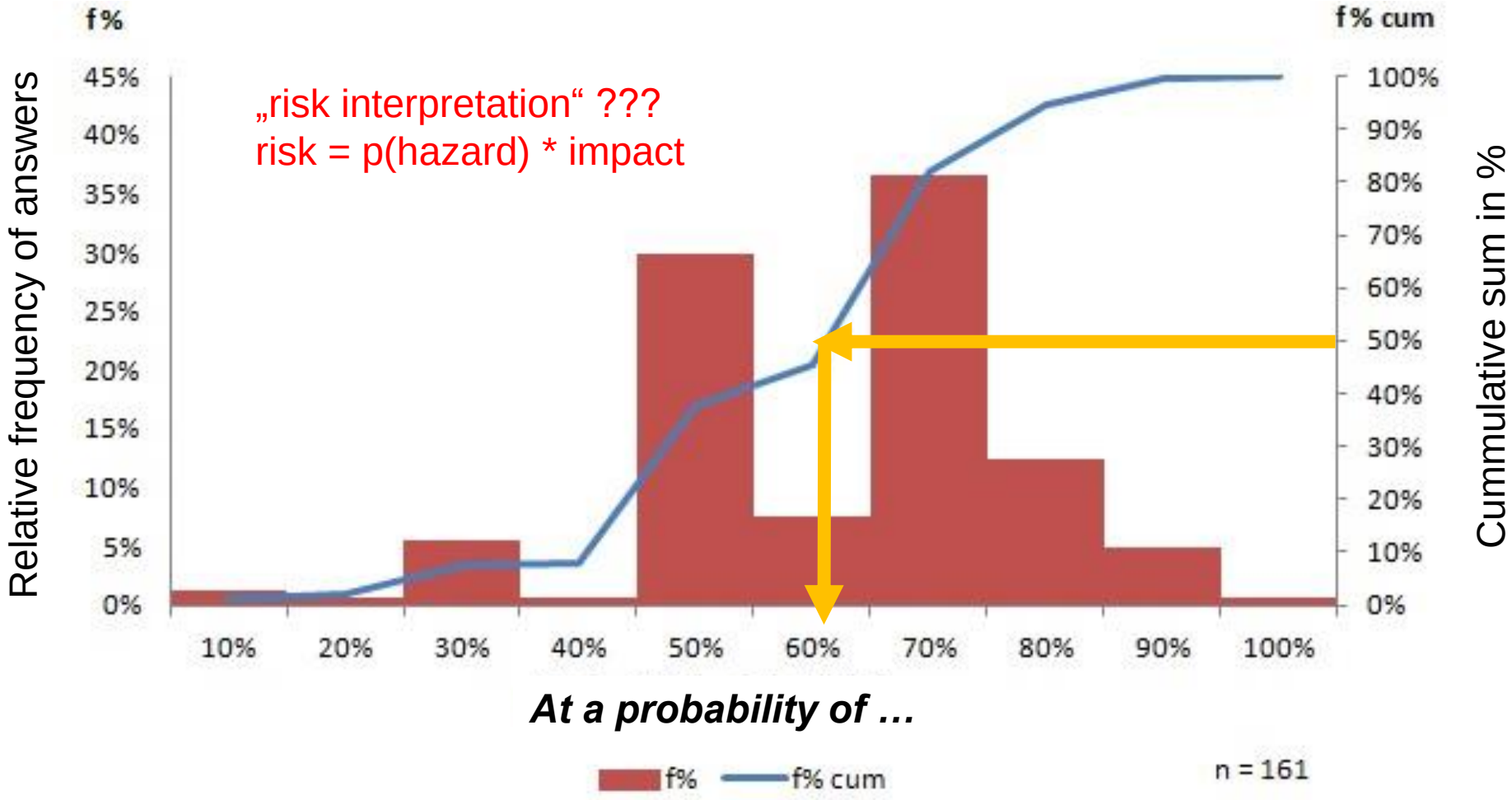
Score dependance on decision threshold



Forecast value relative to climatological forecast



Survey: "At which probability threshold would you start action?"



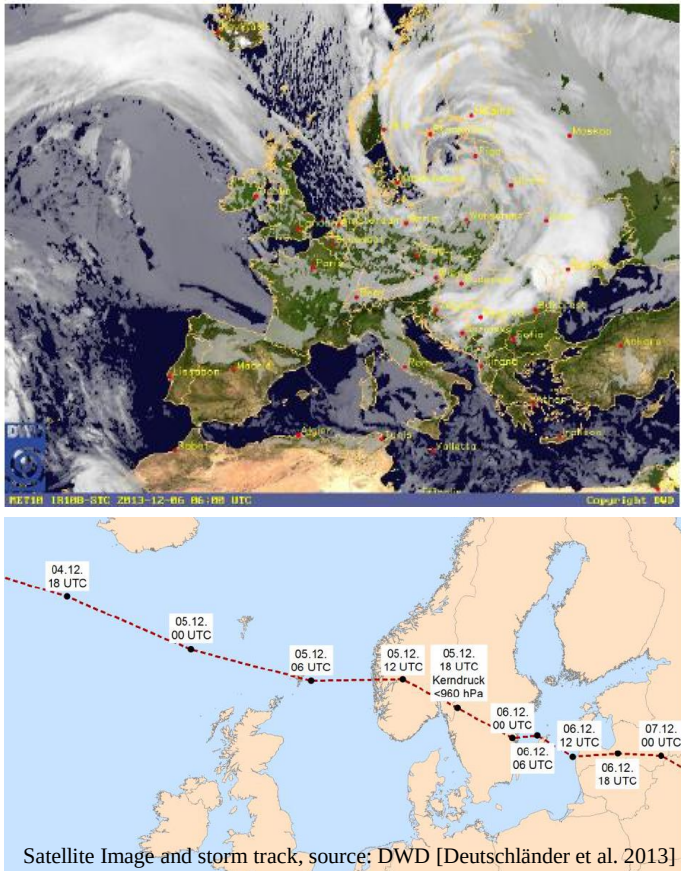
From a survey with emergency managers.

Kox, T.; Gerhold, L. & U. Ulbrich (2014): Perception and use of uncertainty in severe weather warnings by emergency services in Germany. Atmos. Res.158-159, 292-301.

STORM XAVER 5./6.12.2013

- Storm CHRISTIAN hit Northern Germany six weeks before XAVER (underestimated, 14 people killed, estimated economic losses in Germany: 300 to 400 million Euro [GDV 2014]
- Storm XAVER was **not unexpected**: weather models gave first hints 5 days prior to the event
- Strong winds and great damage on the British Isles: (e.g. collapse of cliff destructed several houses)
- At least 10 people died in Europe due to the storm
- Estimated economic losses in Germany: 100 to 200 million Euro [GDV 2014]

[Deutschländer et al. 2013; Kox et al. 2015; Kunz et al. 2013]



Satellite Image and storm track, source: DWD [Deutschländer et al. 2013]

The Berlin weather situation

- Highest wind speeds 26 m/s (10 Bft)
- first severe weather alert was issued by the DWD on 1 December
- Increased to a severe weather warning (violent storm, 29 m/s, 11 Bft) on the day of the storm (5th Dec)

Media

- XAVER generated extensive media coverage
- Comparisons with the 1962 Hamburg storm surge (about 340 fatalities)

Storm effects in the city of Berlin

- No casualties or major losses were reported

[Kox et al. 2015]

Hamburg Storm Surge
[Source: Gerhard Pietsch 1962]

Direct observation of Berlin fire brigade control center during the storm (Kox et al. 2015)

- Only few weather related incidents (Firefighter: „*We have less to do than on a normal Thursday night*"), Warnings successful? (self-destroying-prophecy)
  - Well planned preparatory actions by fire brigade?
  - Effect of the extensive media coverage (hype)?
- A survey was already planned in the research project and scheduled for May 2014
- Thus, a question regarding XAVER was included in the questionnaire

Popular internet meme after the event

[Source: Dionysos1988, wikimedia]

Study Design and Sample Characteristics

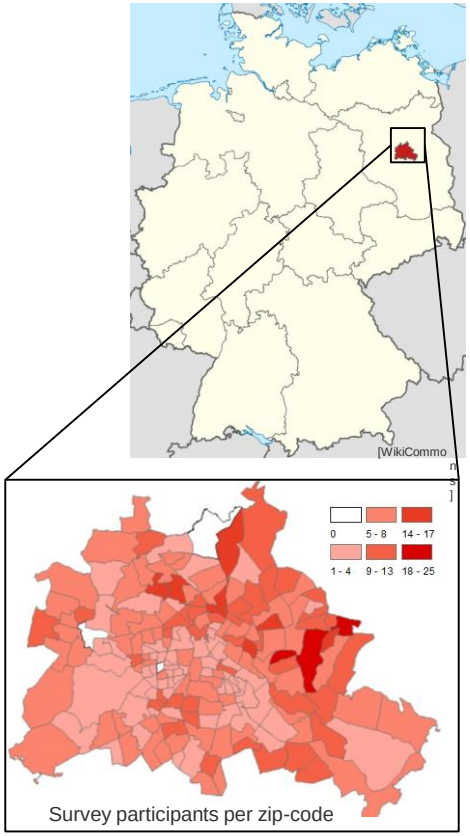
How?

- Online survey
- 20 questions (media use, confidence in weather forecasts, uncertainty and risk perception, prior experience with severe weather, believes and values…)

Who?

- Population of Berlin, Germany
- Age 18- 90, mean 42,5
- n = 1342
- Mostly well educated (40% college entrance qualification)
- 52% men, 48% women
- 82% rent their home
- 77% are living for >10 years in Berlin

Kox et al. 2015, in preparation



People's memory of the storm & their decision based on the warning

	Frequency	Percent
A) I do not remember the storm.	197	14.7
B) I do remember the storm, but I have no memory of my actions due to the warnings.	391	29.1
C) I did not take any specific action due to the warning.	428	31.9
D) I took the following protective measures…	326	**24.3**
	1342	100

- secure property (e.g. closing windows),
- move car to safer place,
- leaving work place earlier than usual,
- switching from car to public transport,
- cancelling planned activities in the evening,
- avoiding staying outdoors,
- increased attention,
- following news and weather reports with more interest,
- …

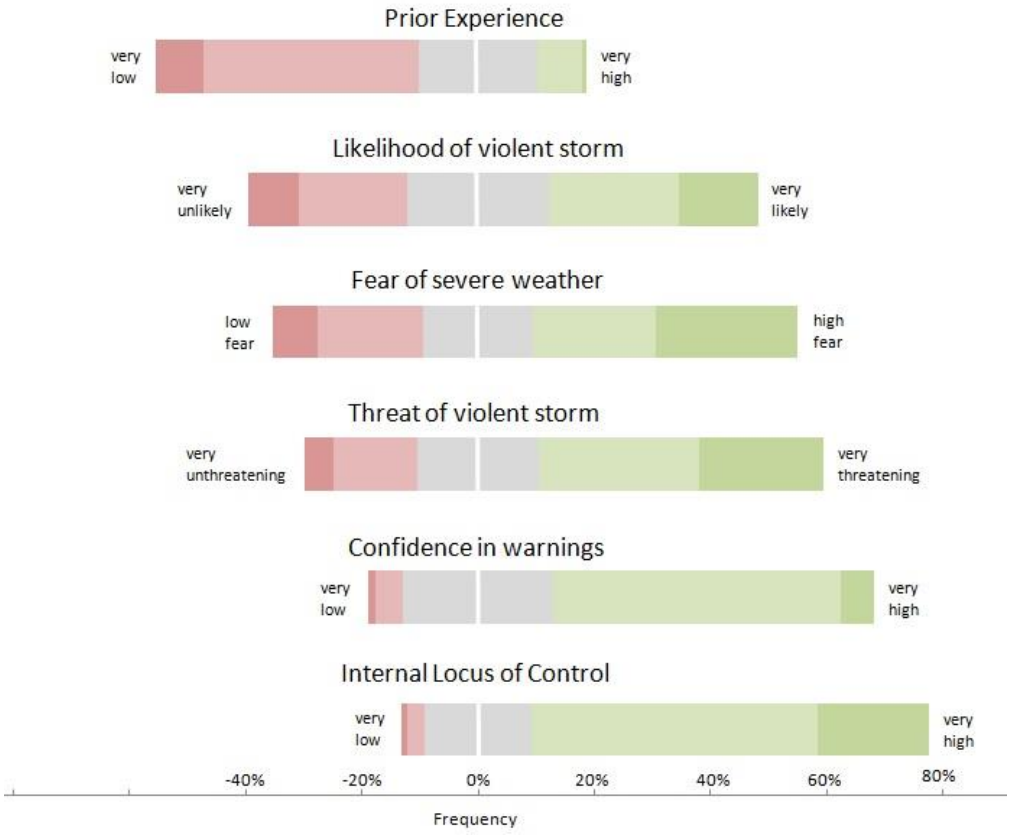
[Kox, Heisterkamp, Ulbrich, 2015]

Criteria Affecting People's Decision to Take Protective Action

No systematic deviance was found with respect to socio-demographic and socio-economic variables…

- age,
- education,
- income,
- or housing status.

- Affective variables such as fear of severe weather and confidence in weather forecasts showed a significant effect on people's decision to take protective action
- Contrary, high experience of natural hazards did not necessarily lead to action
- Strong confidence in weather forecasts and a high level of internal locus of control seems to be an important driver for protective action



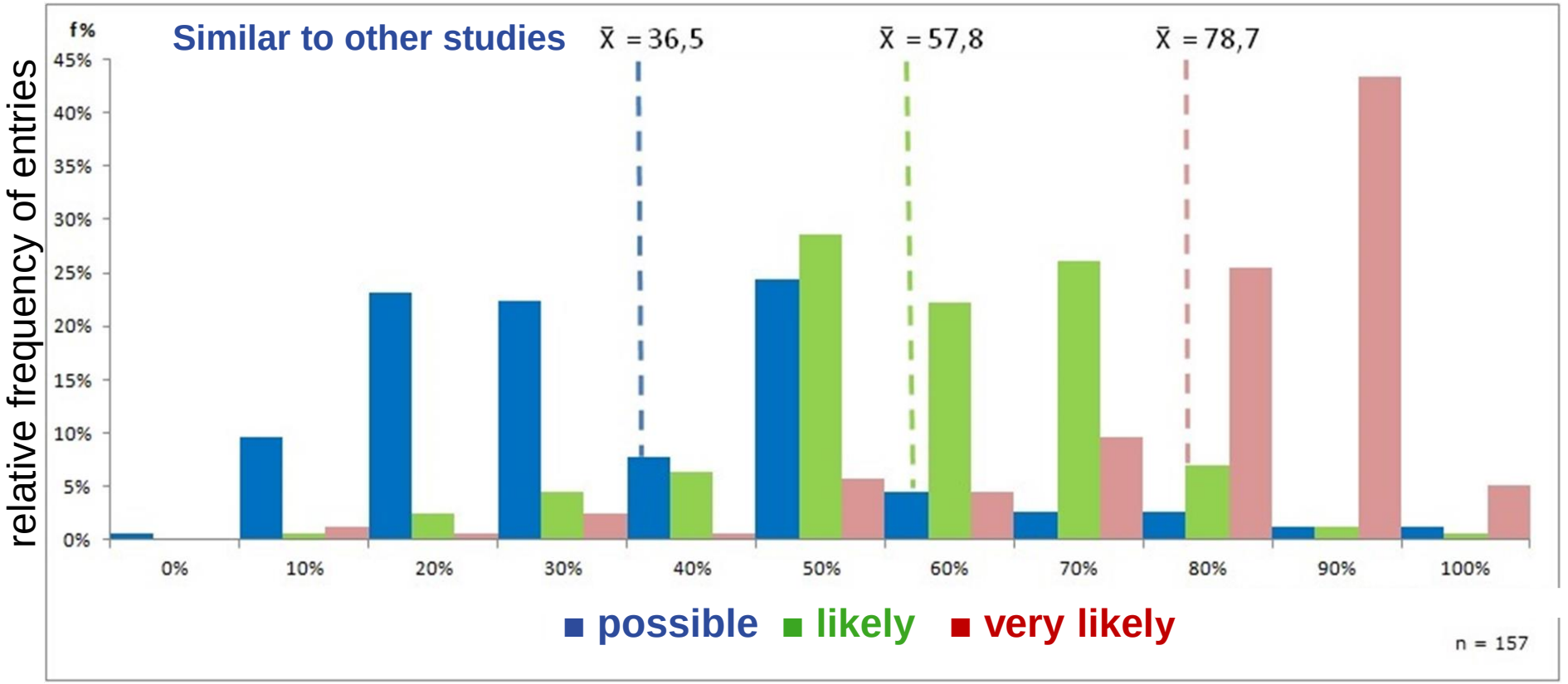
Diverging stacked bar chart of impact of risk perception on decision to act on the storm warning, n=326

Recommendation: tailor warnings to address individual risk tolerances

Open Questions: as self-responsibility is an important driver for protective action, how to address specific subgroups of the population, who might be limited in their actions

Numerical association of verbal probability statements by emergency managers

Question: *"Imagine, the DWD states the advent of a storm for your area for the next day as 'possible', 'likely' or 'very likely'. Which of the following probability terms would you associate with this prediction?"*



Kox, T.; Gerhold, L. & U. Ulbrich (2014): Perception and use of uncertainty in severe weather warnings by emergency services in Germany. Atmos. Res.158-159, 292-301.

1. Can human forecasters estimate warning uncertainty ?
2. How well is this done in verbal terms ?

- probabilistic short range (T+36h, in 6h-intervals) forecast
- for warning events (gusts, occurence of thunderstorms)
- for Berlin (900 km^2) or larger area of Berlin+Brandenburg (30.000 km^2)

3 different forecasts:

- human forecaster**:** from regional office in Potsdam
  - **1) numerical** estimate (deliberately produced for our project)
  - **2) textual** (operational text issued 4 times a day)
- **3) WarnMOS:** Warning Model Output Statistics
  - based on the global models GME and IFS
  - includes latest observations

*Pardowitz, Kox, Göber, Bütow, 2015: Human estimates of warning uncertainty: Numerical and verbal descriptions. MAUSAM, **66**, 625-634*

19 counties within Berlin+Brandenburg: 30.000 km²

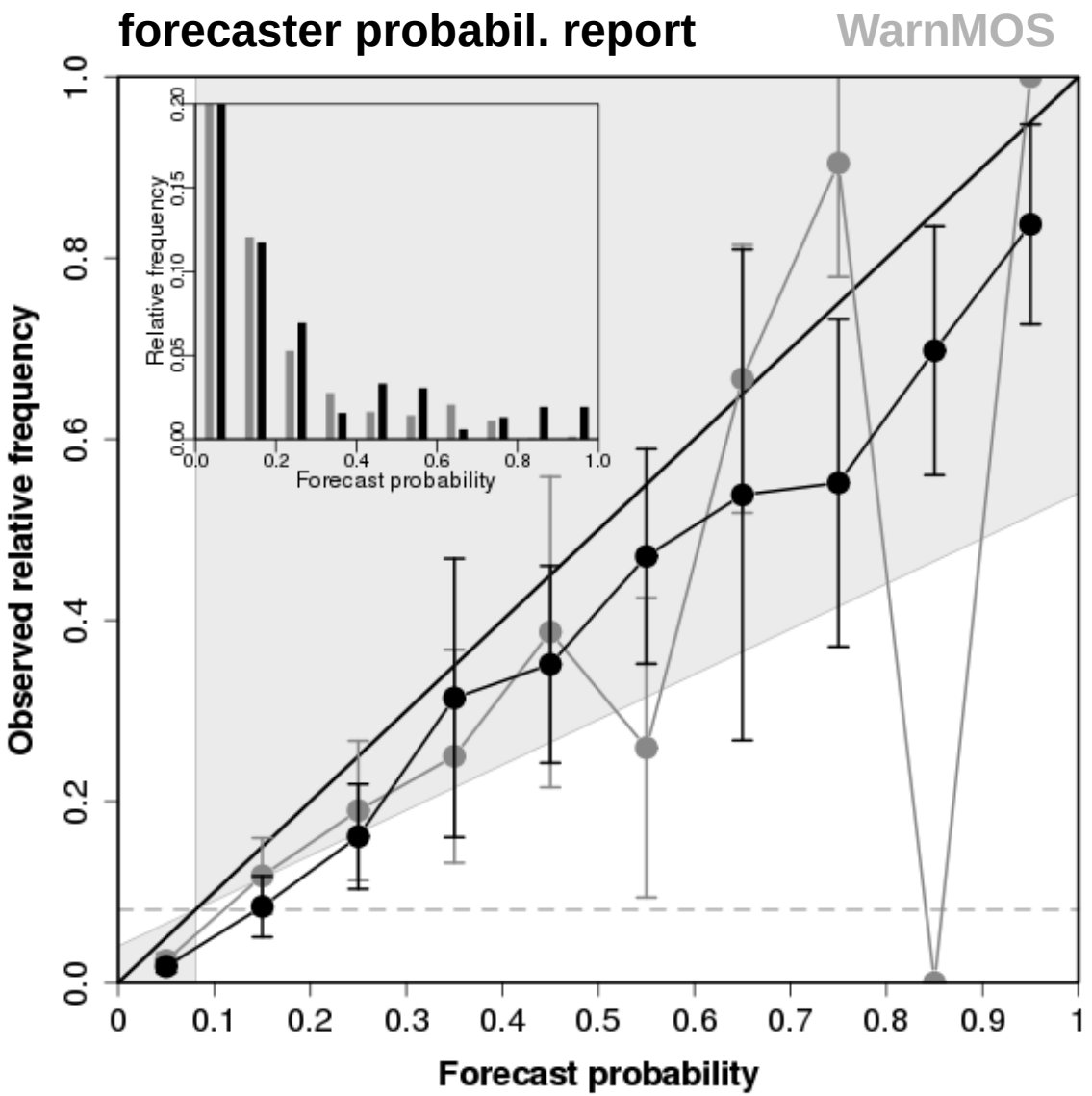
Berlin: 900 km²

Source: http://de.wikipedia.org/wiki/Brandenburg#mediaviewer/Datei:Brandenburg,_administrative_divisions_-_de_-_colored.svg

wind gusts ≥ 14 ms (7 Bft)

human vs machine

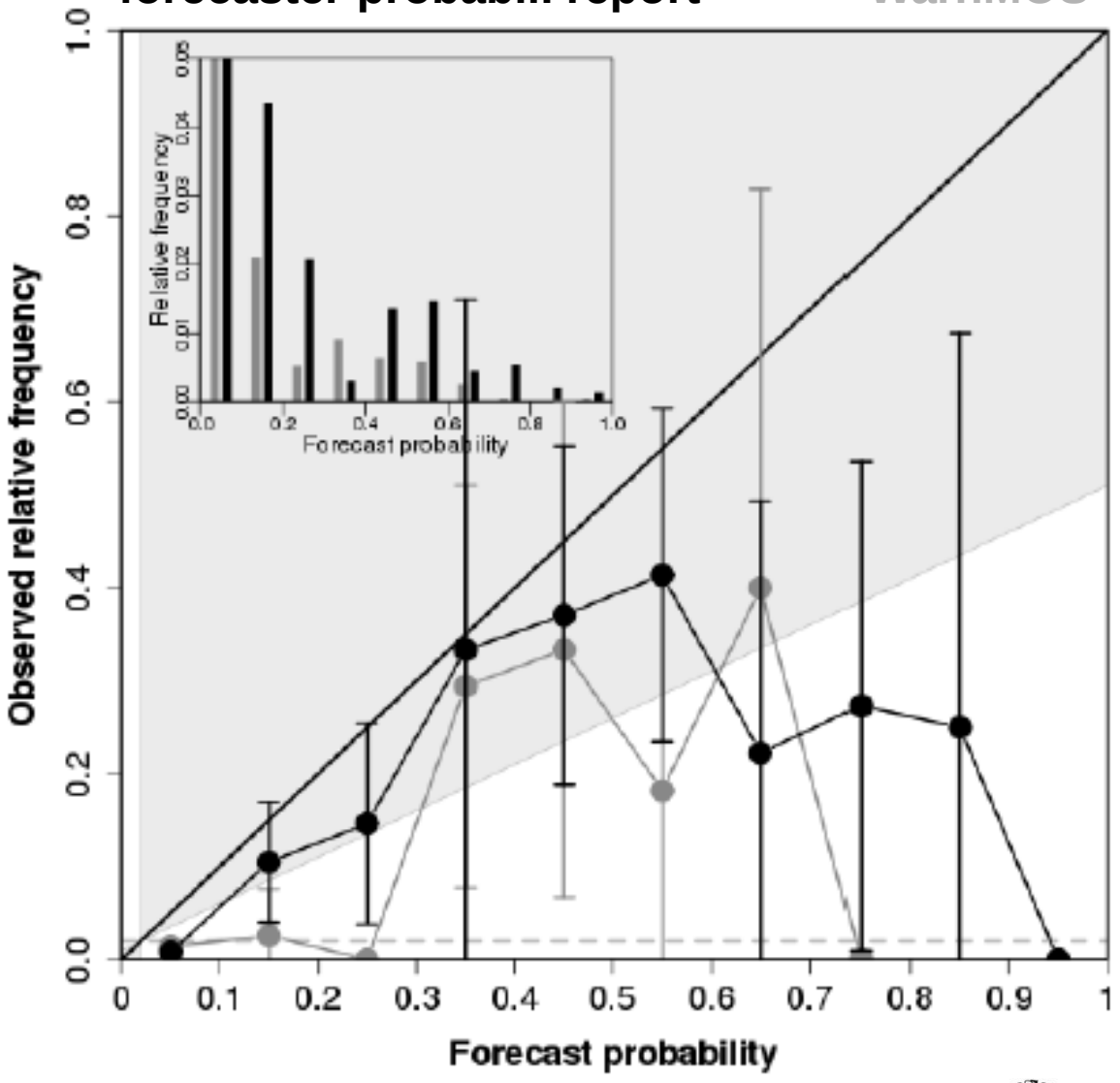
- reliability similar
- Brier Skill Score = 16 %



thunderstorms
human vs machine

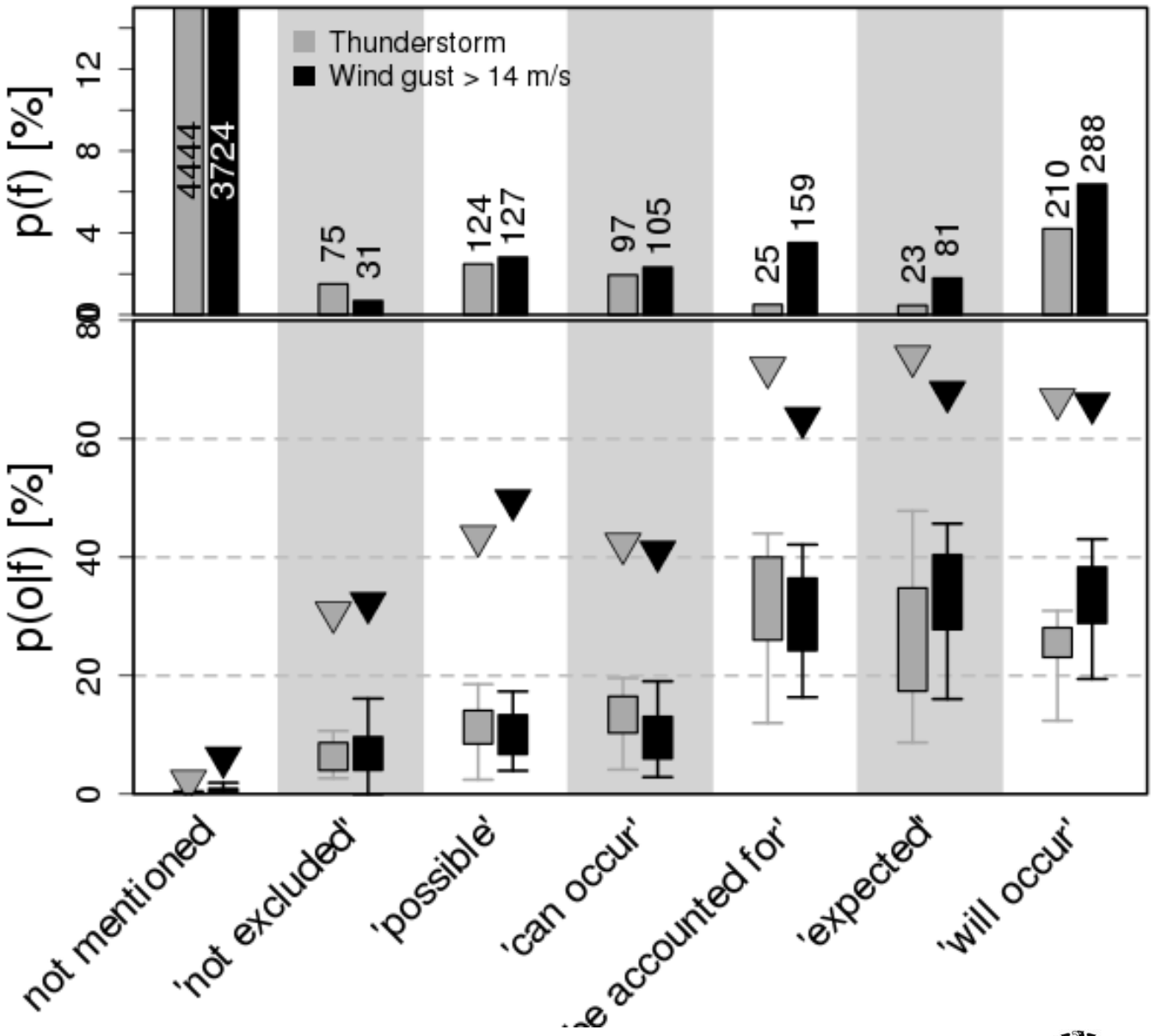
- reliability similar
- Brier Skill Score =6 %

forecaster probabil. report WarnMOS



P(usage)

P(obs given terms)



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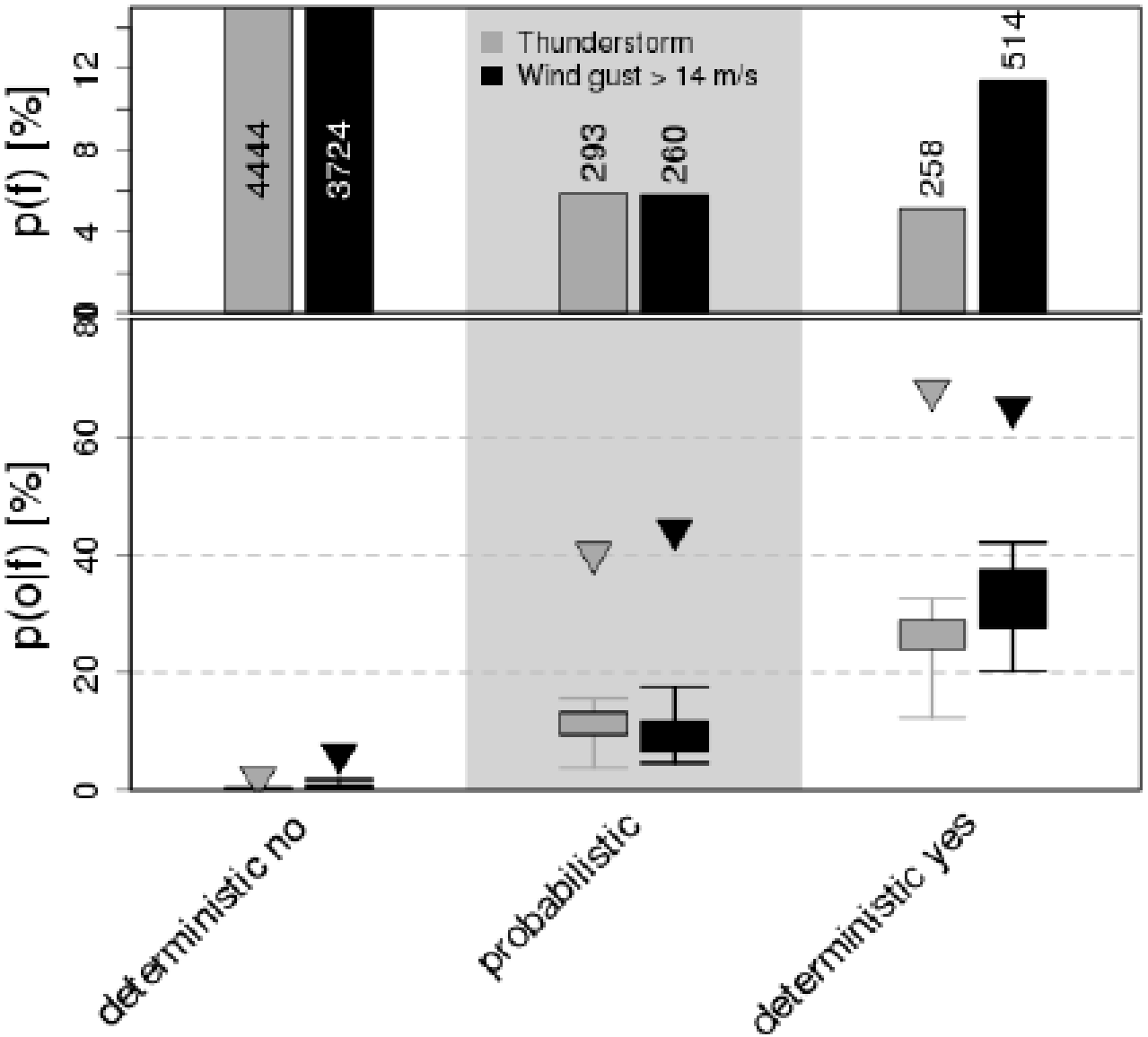
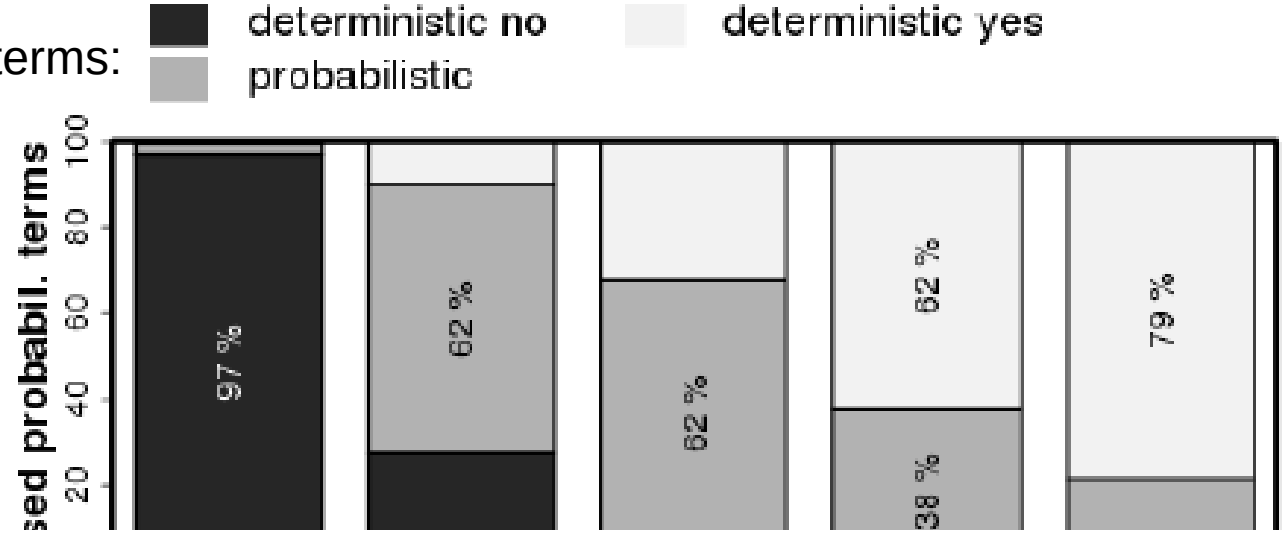
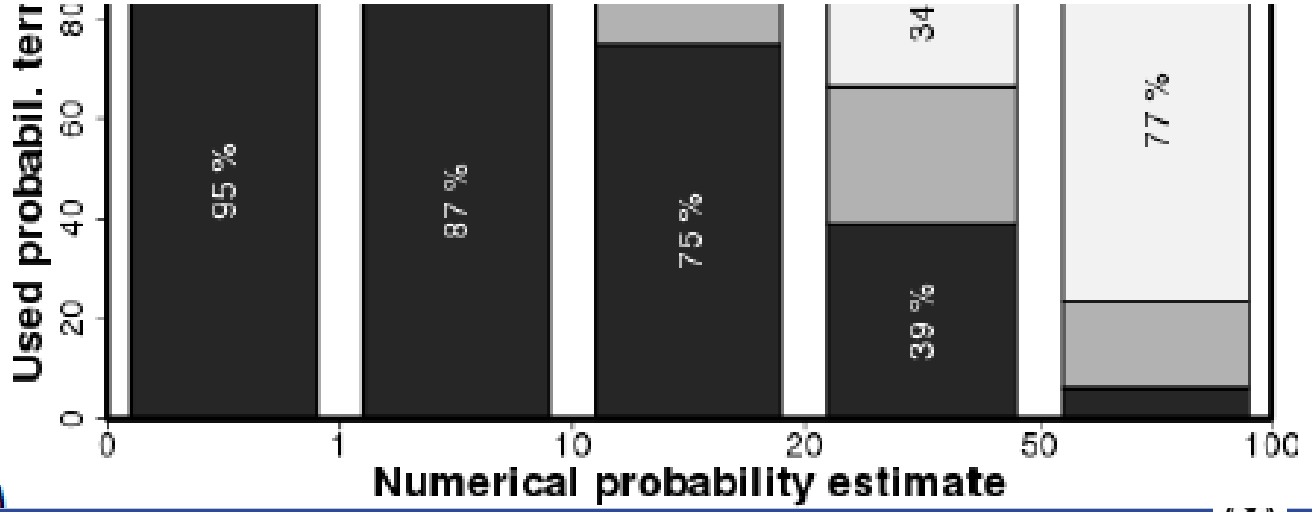


Categories of verbal terms:



thunderstorms

"stronger" words for thunderstorms → points to forecasting of risk rather than uncertainty alone



gusts

Conclusions

- Users are interested in „risk“ forecasts, whereas meteorologists can provide forecasts of the probability of hazards → potential for confusion → transdisciplinary approaches essential
- human forecasters can estimate warning uncertainty reliably
- minimise overlap and vagueness of terms to describe uncertainty by restricting oneself to only a few terms
- reduce underspecificity by sharply delineate categories and specification of relationship between words and numbers