Deutscher Wetterdienst

DWD

On the choice of thresholds to give warnings

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Outline:

- Aim of the talk
- Warning process
- Importance of the threshold choice
- Examples
- Summary

Aim:

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Wetter und Klima aus einer Hand

Meteorological Centres

probabilistic forecasts of high impact events

Users

decision-making process: Do we take any action?

Probabilities → Yes / No forecast

Which is the best way of converting probabilities into binary forecasts?

Warning process:

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➔ Define the weather event to be forecast

Example: Probability that the wind is above 14m/s

$$\begin{cases} O=1, \text{ if } O \geq 14 m/s \\ O=0, \text{ if } O < 14 m/s \end{cases}$$

➔ Obtain a probabilistic forecast, *P*

➔ Define the warning criterion:

Choice of threshold.

$$\begin{cases} F=1, \text{ if } P \geq P_{th} \\ F=0, \text{ if } P < P_{th} \end{cases}$$

Warning process:

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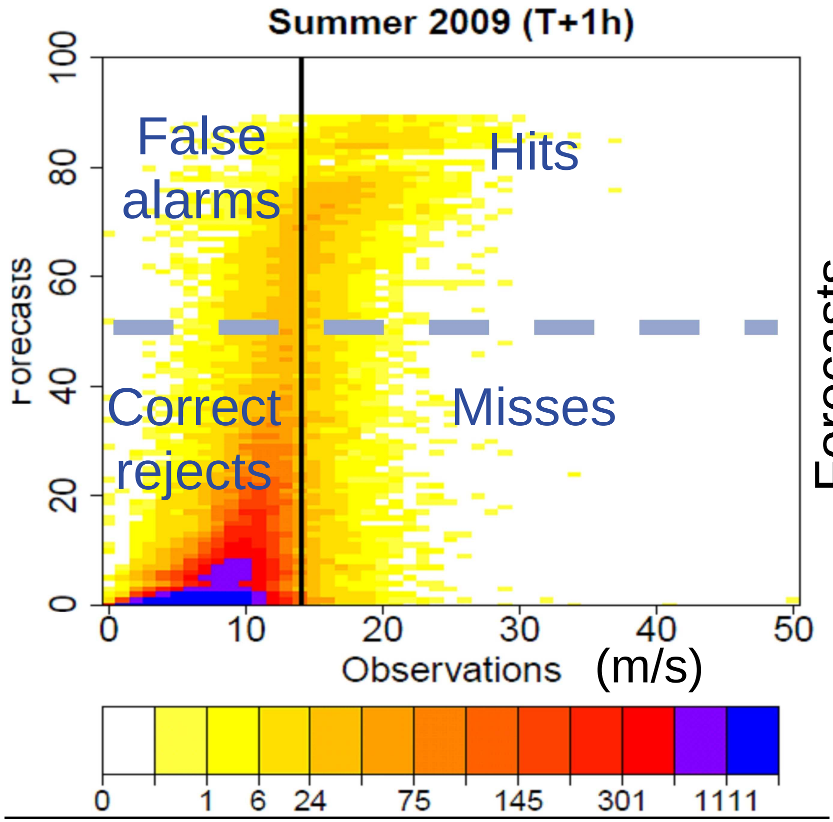

Observations

Forecasts	YES	NO	Total
YES	Hits (a) 5479 0.020	False alarms(b) 2615 0.0096	8094 0.0296
NO	Misses(c) 5966 0.022	Correct rejects(d) 257959 0.948	263925 0.970
Total	11445 0.042	260574 0.9576	272019 1

Warning process:

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$$\text{Base Rate} = \frac{a+c}{n} = P(O=1) = 0.042$$

$$\text{Frequency Bias} = \frac{a+b}{a+c} = \frac{P(F=1)}{P(O=1)} = 0.707 \quad \begin{cases} >1 \Rightarrow \textit{Overforecast} \\ =1 \Rightarrow \textit{Perfect} \\ <1 \Rightarrow \textit{Underforecast} \end{cases}$$

$$\text{Hit Rate (Prob.detection)} = \frac{a}{a+c} = P(F=1 \mid O=1) = 0.479$$

$$\text{False Alarm Ratio} = \frac{b}{a+b} = P(O=0 \mid F=1) = 0.323$$

etc.

Perfect case:

Frequency Bias = 1, False Alarm Ratio = 0, Hit Rate = 1

The scores vary if we change the threshold: P_{th}

but... how to get better scores and so use a "better threshold"?

Choice of threshold:

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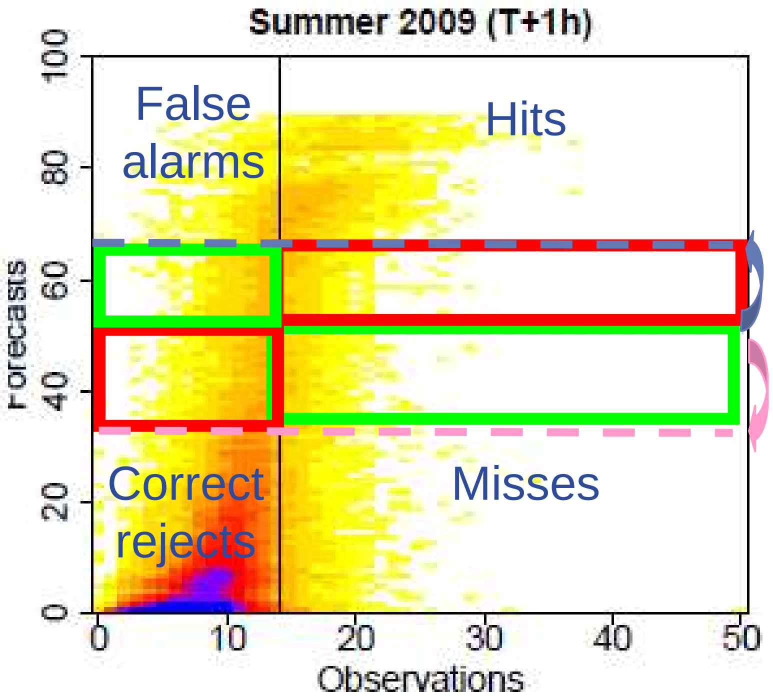

Increase P_{th} → the model says NO more. Less false alarms and less hits.

If the event does not happen, more correct rejects

If the event happens, more misses

Decrease P_{th} → the model says YES more.

Less misses but less correct rejections

If the event happens, more hits

If the event does not happen, more false alarms

Some scores will improve but others will get worse

Which is the compromise? It depends on the user priorities

Choice of threshold:

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- ➔ Some users penalize more the false alarms while others penalize more the misses.
- ➔ A decision making model can be used where all potential users of weather forecasts are characterized by a function of the costs and the losses.

Observations

Forecasts	YES	NO
YES	Mitigated Loss	Cost to prevent weather related damages
NO	Loss in case the user does not protect his operations	No Cost

Wind gusts:

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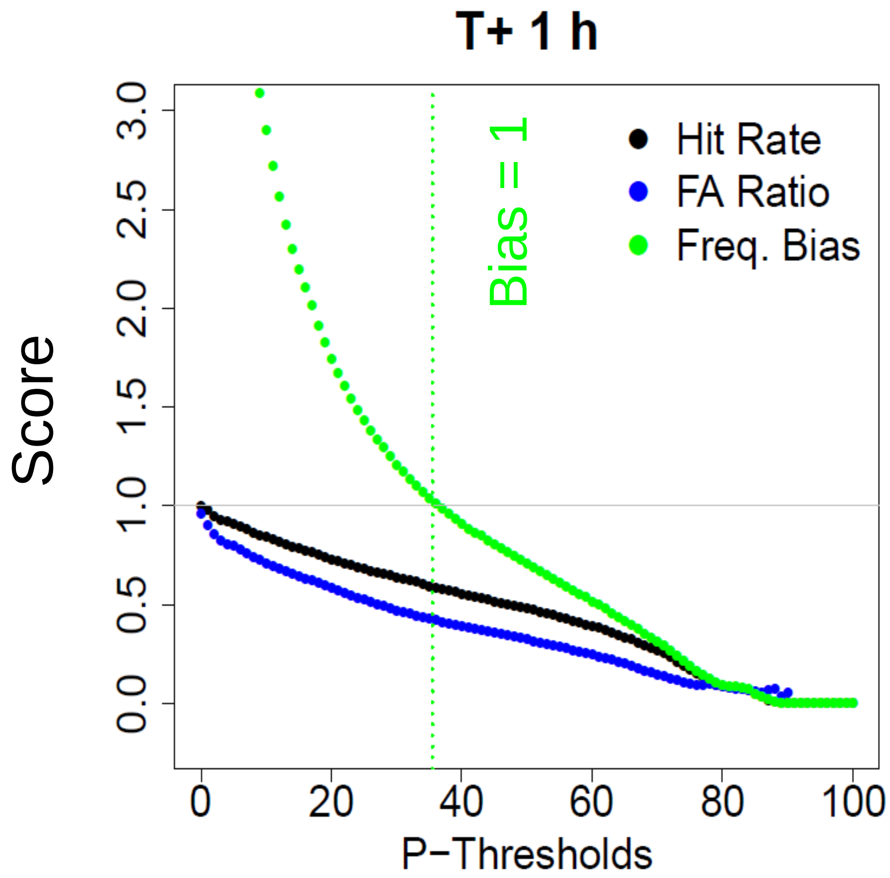
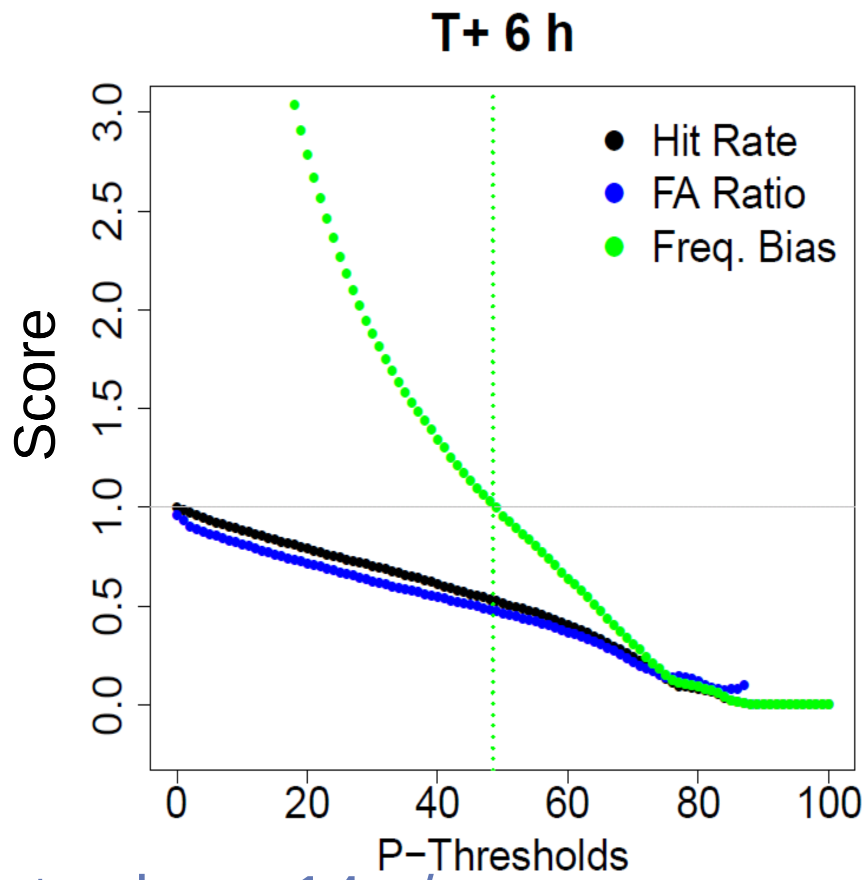
If Bias is 100%→ POD=60%, FAR=45%
If POD is 80%→ Bias=2, FAR=60%

The threshold varies with the





Probability of wind gusts above 14m/s

Choice of threshold:

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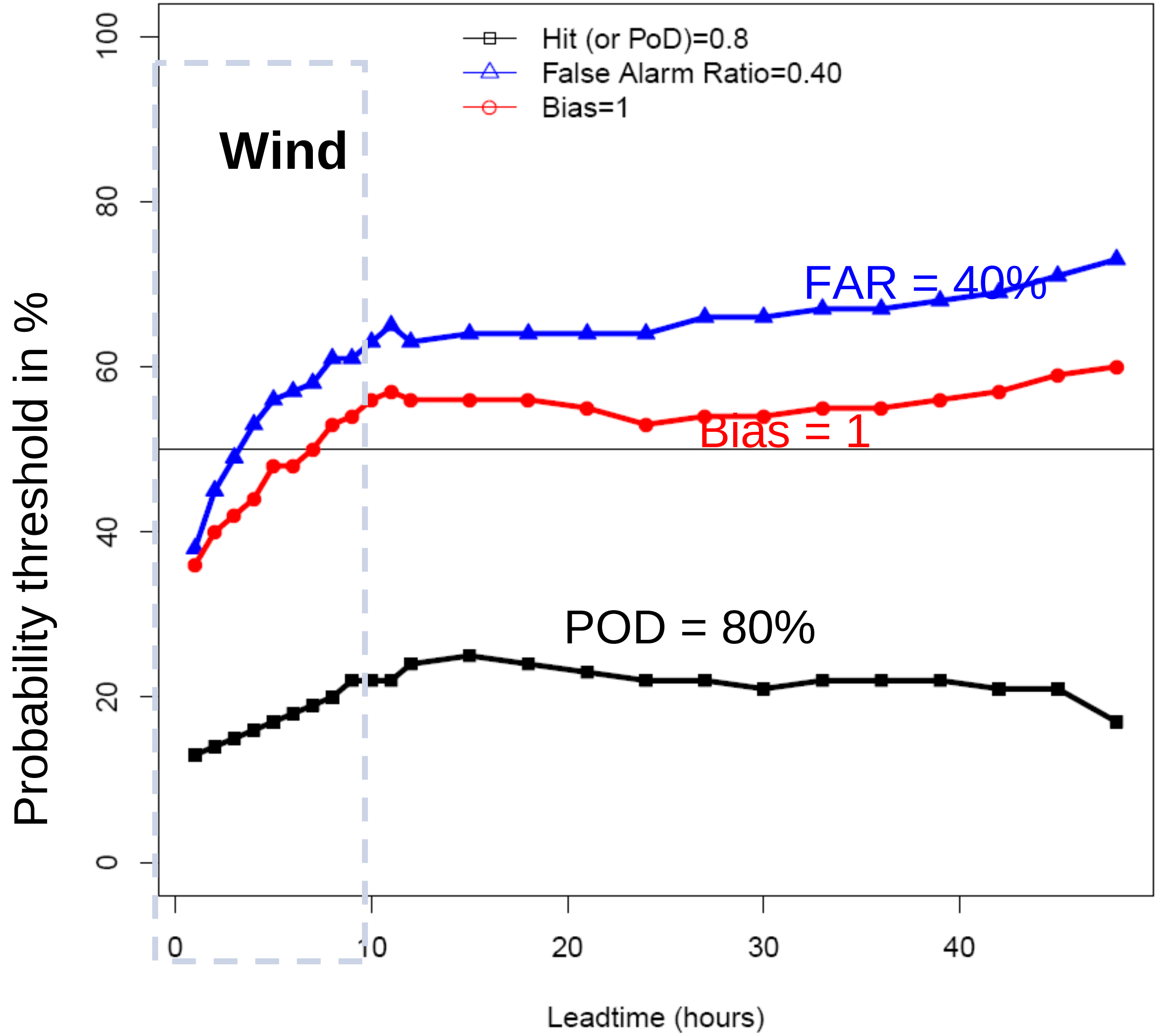
Probability thresholds vary depending on the chosen criterion

P_{th}



Thunderstorms:

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Thunderstorm in Summer 2009: Yes/No

$$\begin{cases} F = 1 \text{ if } P \geq 0.5 \\ F = 0 \text{ if } P < 0.5 \end{cases}$$

	Obs=YES	Obs=NO	Total
Forec YES	**2878** **p=0.0055**	**1702** **p=0.0033**	**4580** **p=0.0088**
Forec NO	**5825** **p=0.011**	**506893** **p=0.979**	**512718** **p=0.99**
Total	**8703** **p=0.016**	**508595** **p=0.983**	**517298** **p=1**

$$\text{Frequency Bias} = \frac{a+b}{a+c} = \frac{P(F=1)}{P(O=1)} = 0.526 < 1 \Rightarrow \text{Underforecast}$$

$$\text{Hit Rate (Prob.detection)} = \frac{a}{a+c} = P(F=1 \mid O=1) = 0.33$$

$$\text{False Alarm Ratio} = \frac{b}{a+b} = P(O=0 \mid F=1) = 0.37$$

Perfect case:
Frequency Bias=1,
False Alarm Ratio=0,
Hit Rate=1

Choice of threshold:

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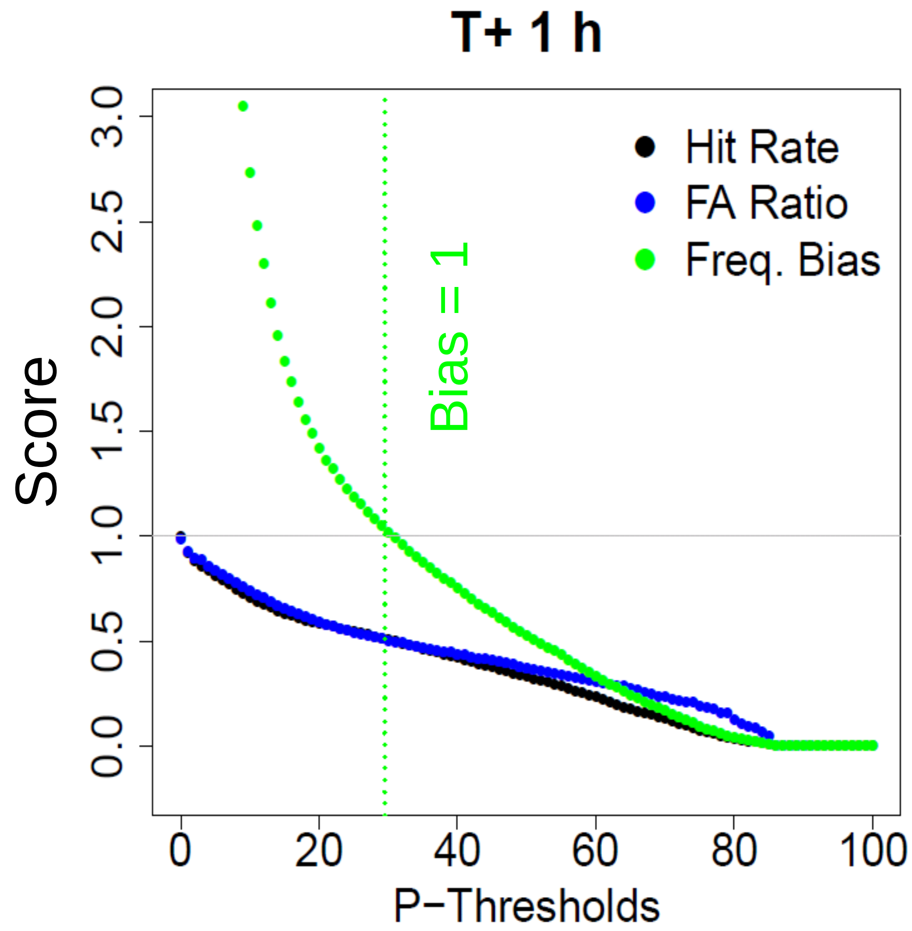
If Bias is 100%→ POD=50.7%, FAR=50.2%
If POD is 80%→ Bias=4.33, FAR=81.7%



Summary

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- ➔ A threshold needs to be chosen to convert probabilities into binary forecasts.
- ➔ The scores depend on the threshold.
- ➔ There is no score that represents all the information included in the contingency table, so there cannot be a „perfect“ threshold.
- ➔ Forecasters need to establish a criterion that depends on the event, lead time and user requirements.

Thank you!