Spatial Uncertainty in Probabilistic Forecasts Lowers Perceived Risk and Likelihood of Precautionary Action

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SCREEN CAPTURE NOT ALLOWED

Low probabilities in forecasts lead to less precautionary action

- People are generally reluctant to insure against rare events with very small probabilities

  Botzen and van den Bergh (2012), Slovic et al. (1977), Schmidt (2016)

- People are unlikely to take precautionary actions to protect against extreme weather events, if probabilities are below 50%

  Joslyn and Savelli (2010), Kox et al. (2015), Morss et al. (2010)

- Small probabilities are generally not taken seriously enough

Deterministic forecasts are no alternative

- People **prefer** forecasts that communicate uncertainty information over forecasts that do not

  Morss et al. (2008)

- People **perform better** in decision-making tasks if they received probabilistic rather than deterministic forecasts

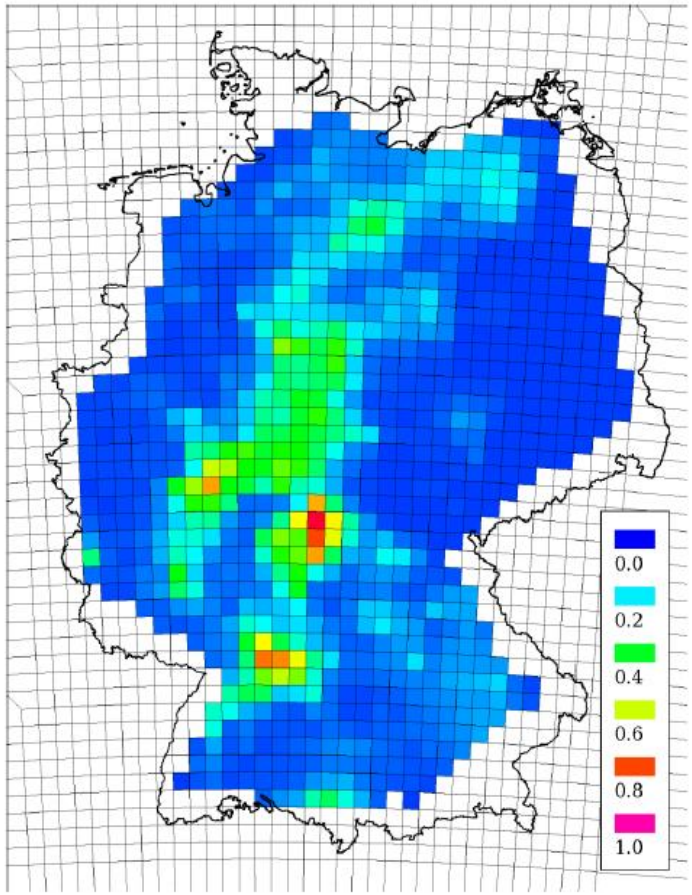
  Joslyn et al. (2007), Joslyn, & LeClerc (2013)

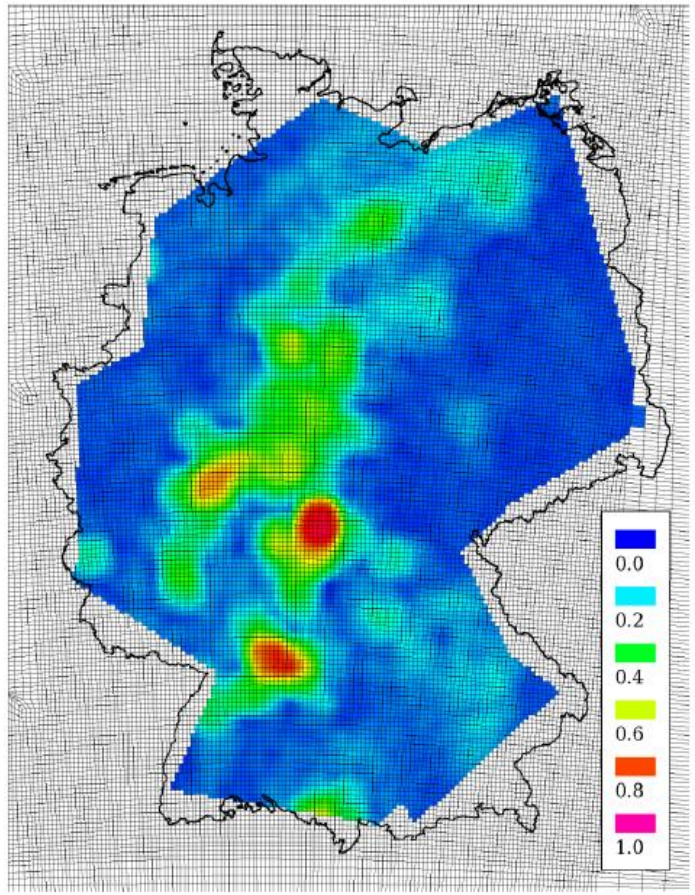
- People anticipate uncertainty in deterministic forecasts

  Joslyn and Savelli (2010), Morss et al. (2008)

One possible solution: widen forecast area

- Lowering forecast resolution increases probabilities

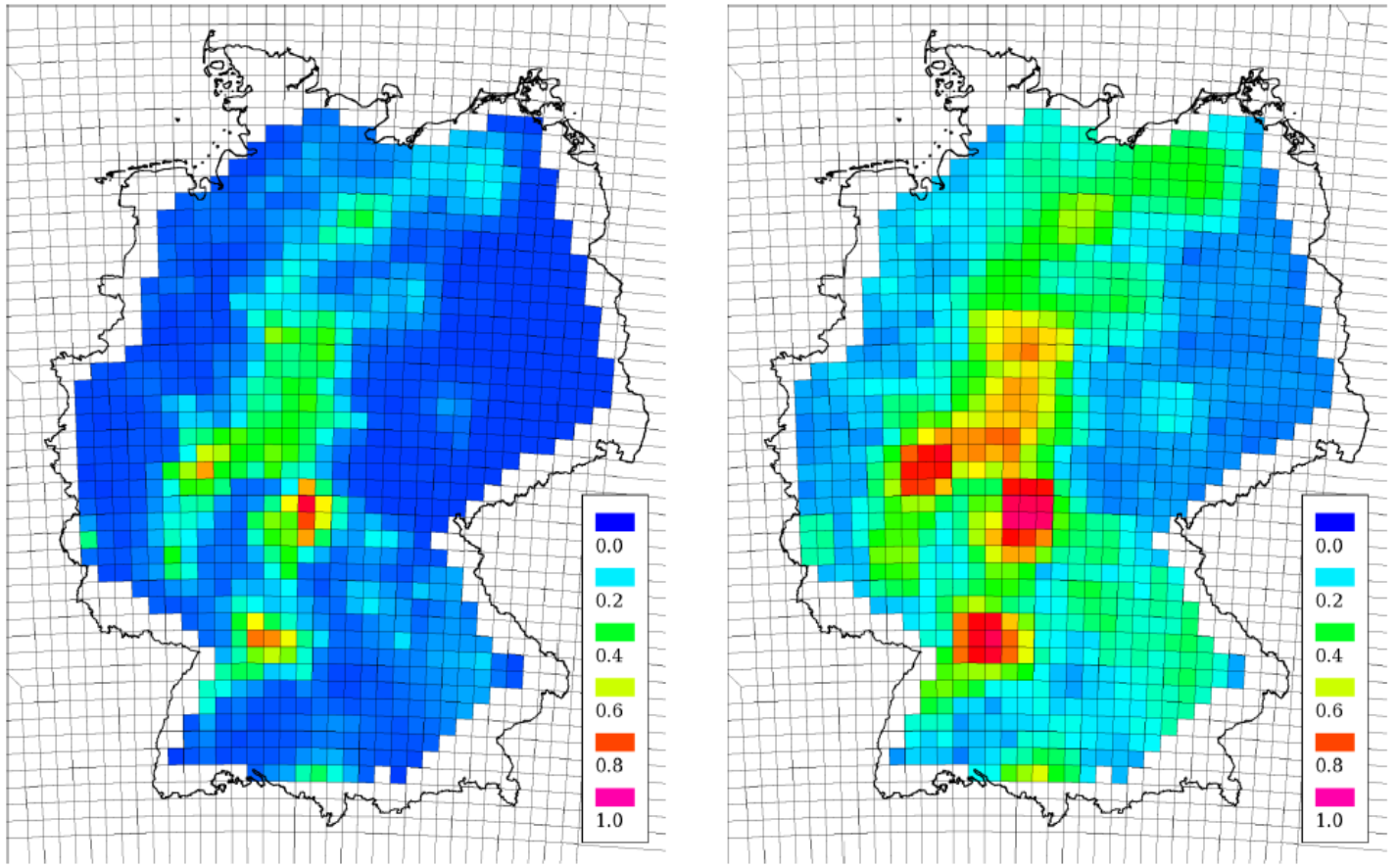




Courtesy Reinhold Hess (DWD)

Changing forecast resolution

- Lowering forecast resolution increases probabilities



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Changing forecast resolution

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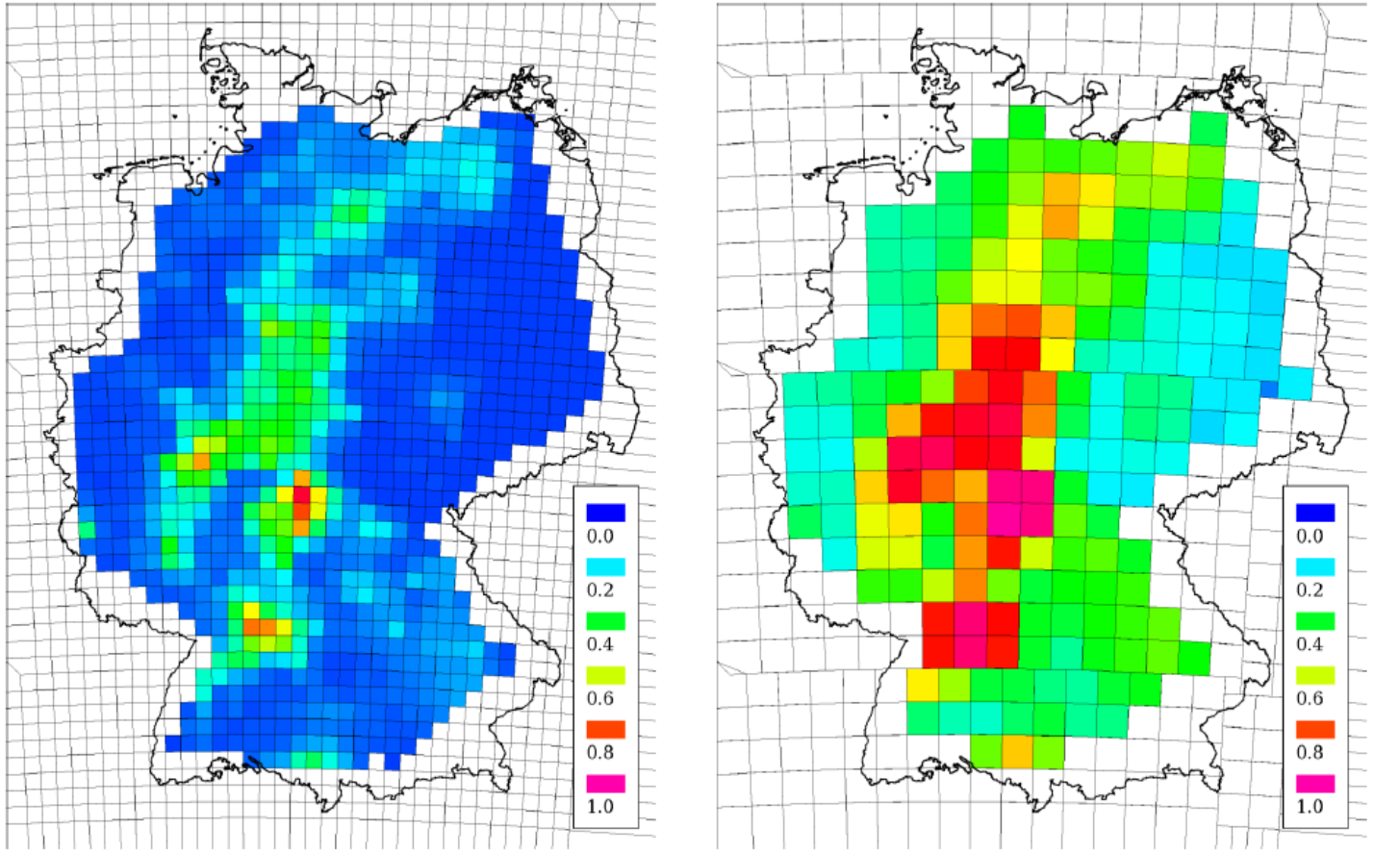

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Changing forecast resolution

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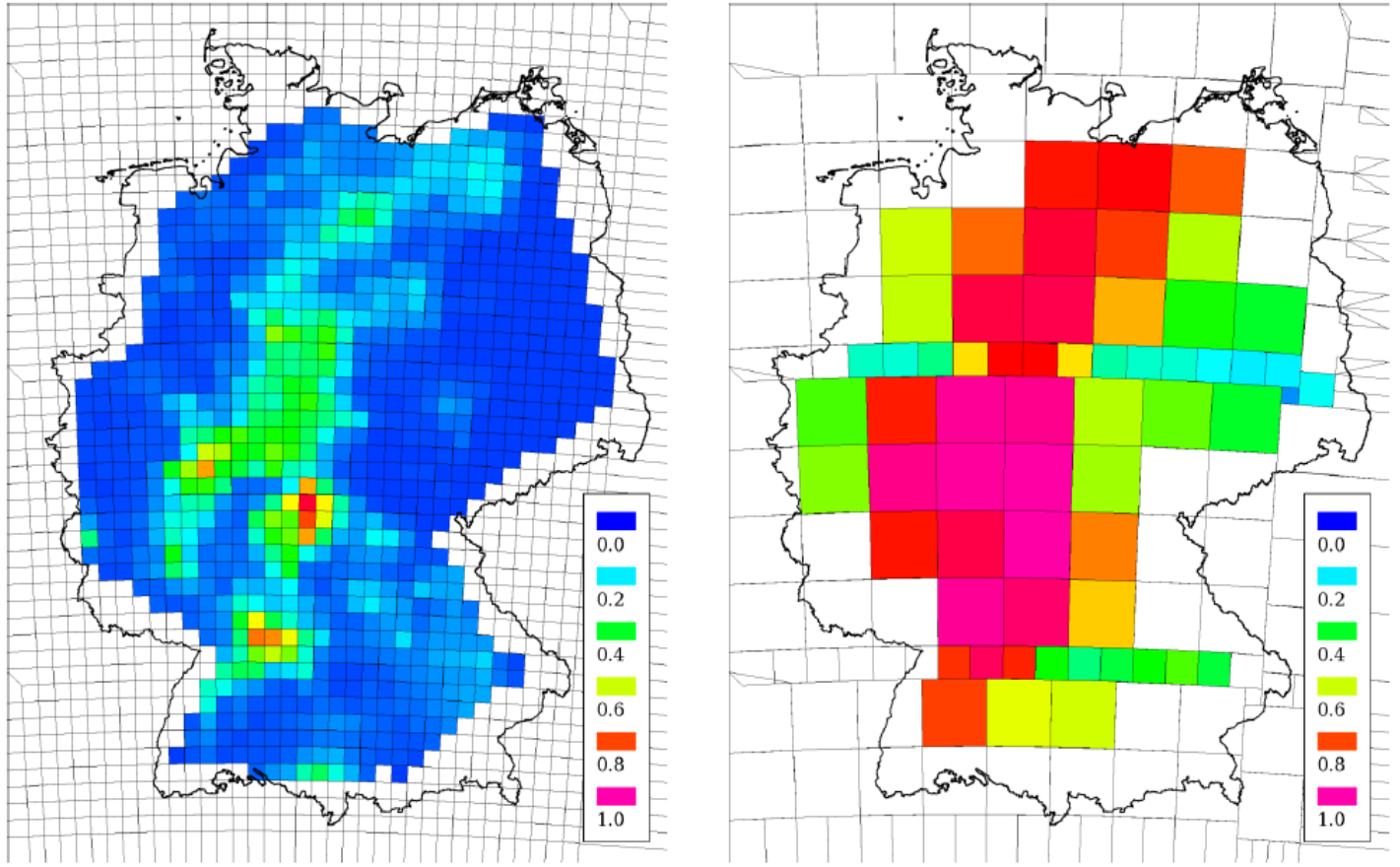
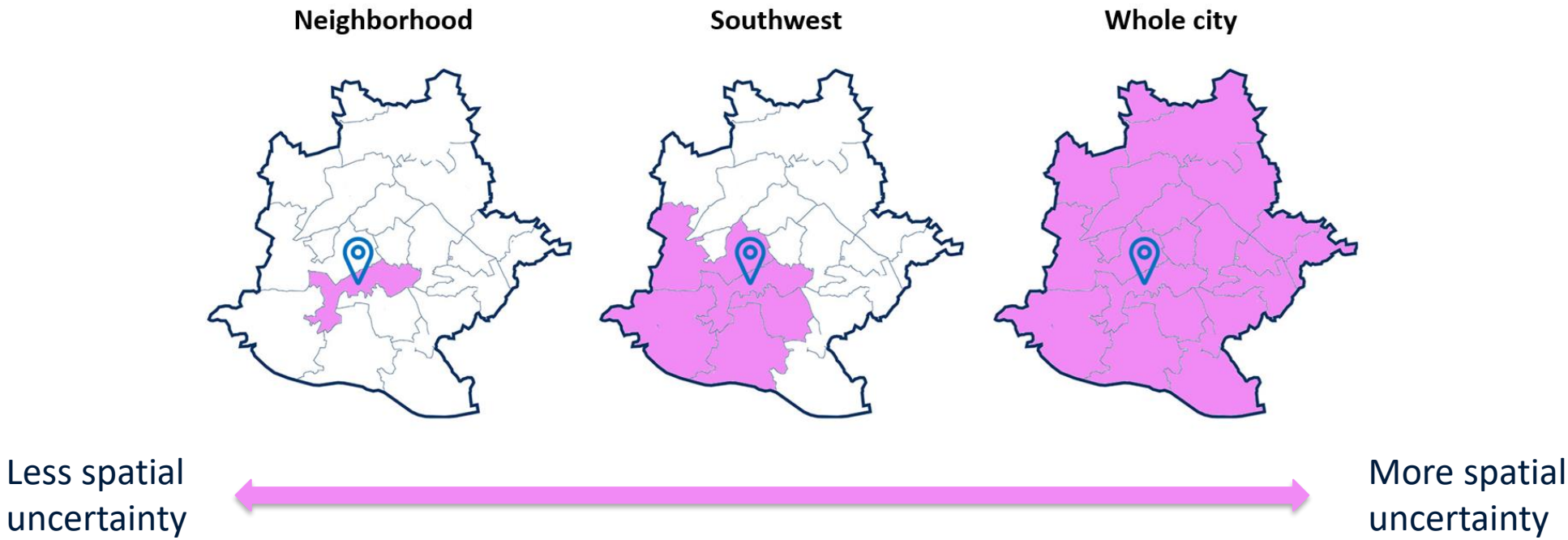


Courtesy Reinhold Hess (DWD)

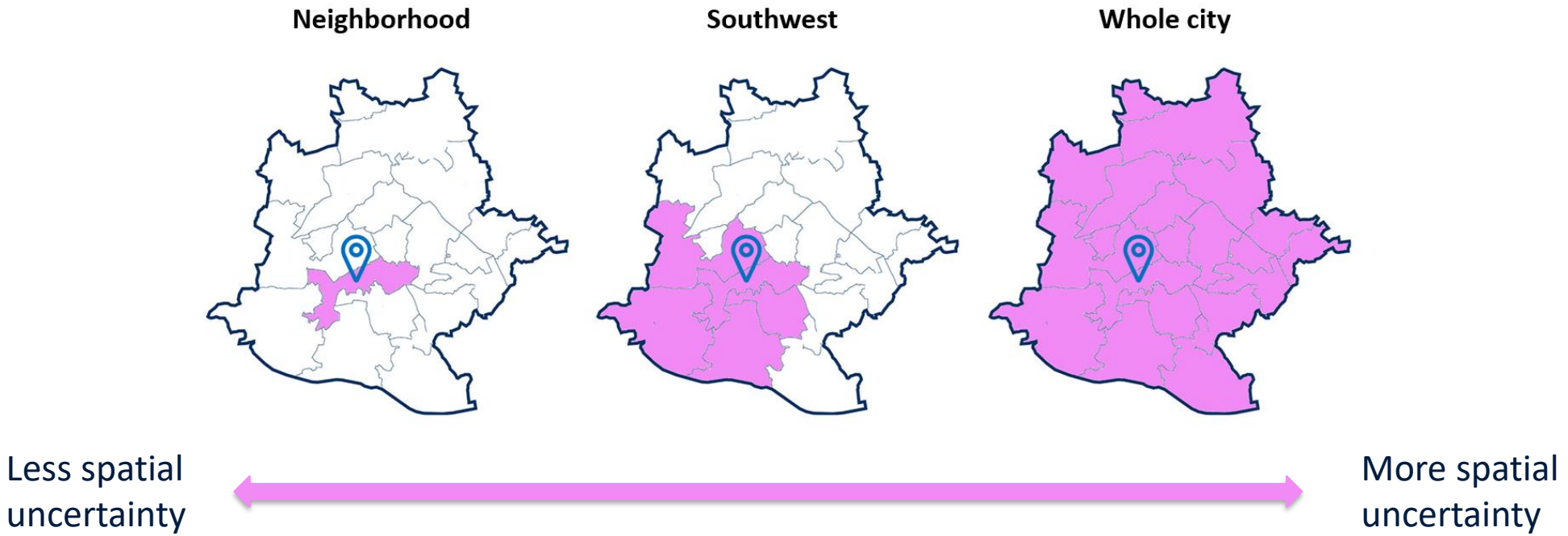
Lower forecast resolution, higher spatial uncertainty

- Wider forecast areas mean more uncertainty about where exactly in the forecast area the event could occur



Lower forecast resolution, higher spatial uncertainty

- However, the effect of spatial uncertainty should also depend on how forecast users interpret the **spatial reference class** of the forecast they receive



Lower forecast resolution, higher spatial uncertainty?

- However, the effect of spatial uncertainty also depends on how forecast users interpret the **spatial reference class** of the forecast they receive

- People following the interpretation that…

  - "There is a 30% chance of the event to occur **somewhere** (i.e., in at least one place) in the forecast area during the forecast period.

Somewhere -> spatial uncertainty

  - "**At any** one particular **point** in the forecast area (for example at your house) there is a 30% chance that the event will occur."

Any point -> no spatial uncertainty

Adapted from Murphy et al. (1980)

The probability–spatial uncertainty trade-off

Assuming there is in fact an effect of spatial uncertainty, lowering resolution should lead to a trade-off:

- Lower forecast resolution leads to **higher forecast probabilities**, which lead to higher risk perception and **more** precautionary activity

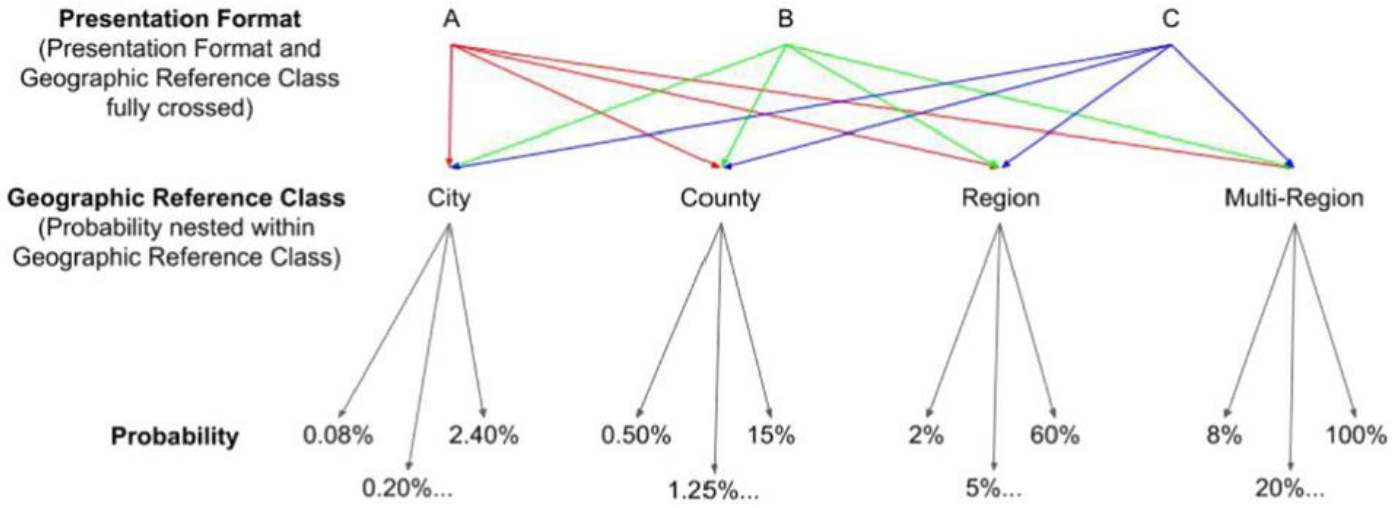
But

- Lower forecast resolution leads to **higher spatial uncertainty**, which leads to lower risk perception and **less** precautionary activity

The probability–spatial uncertainty trade-off

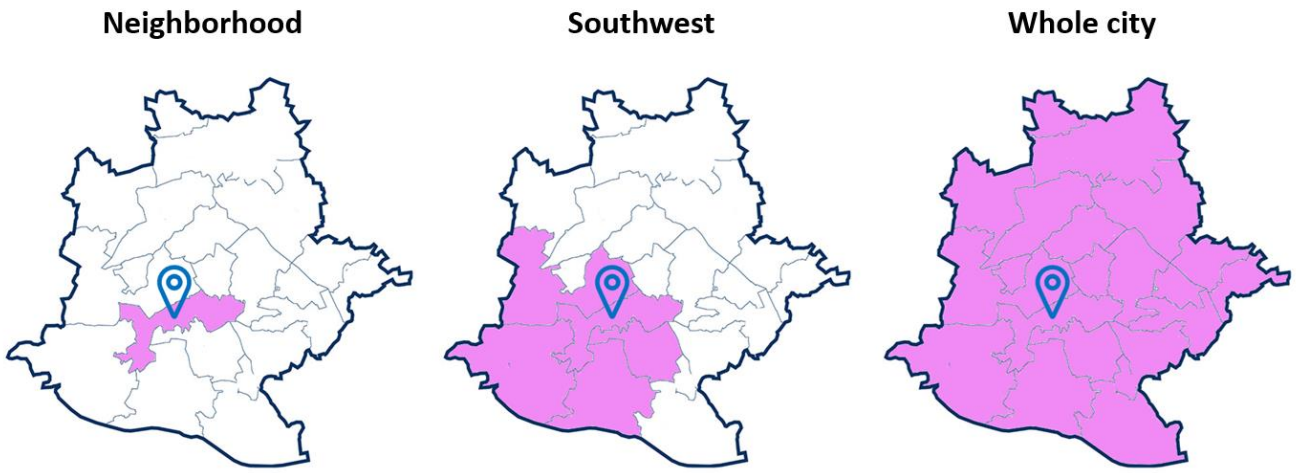
Shivers-Williams & Klockow-McClain (2020)

- Found that **lower** forecast resolution led to **increased** rates of precautionary action against a storm



Study design

- *N* = 149, within subject (2 tasks, 12 trials per task)
- Forecast resolution





- Probabilities

20 % - 30 % - 40% - 50%

Scenario and tasks

- Organizer of a small concert series
- Checking thunderstorm forecast day before event
- Need to avoid damages to people and equipment

- How likely is it that the event area is going to be hit? [in percent]

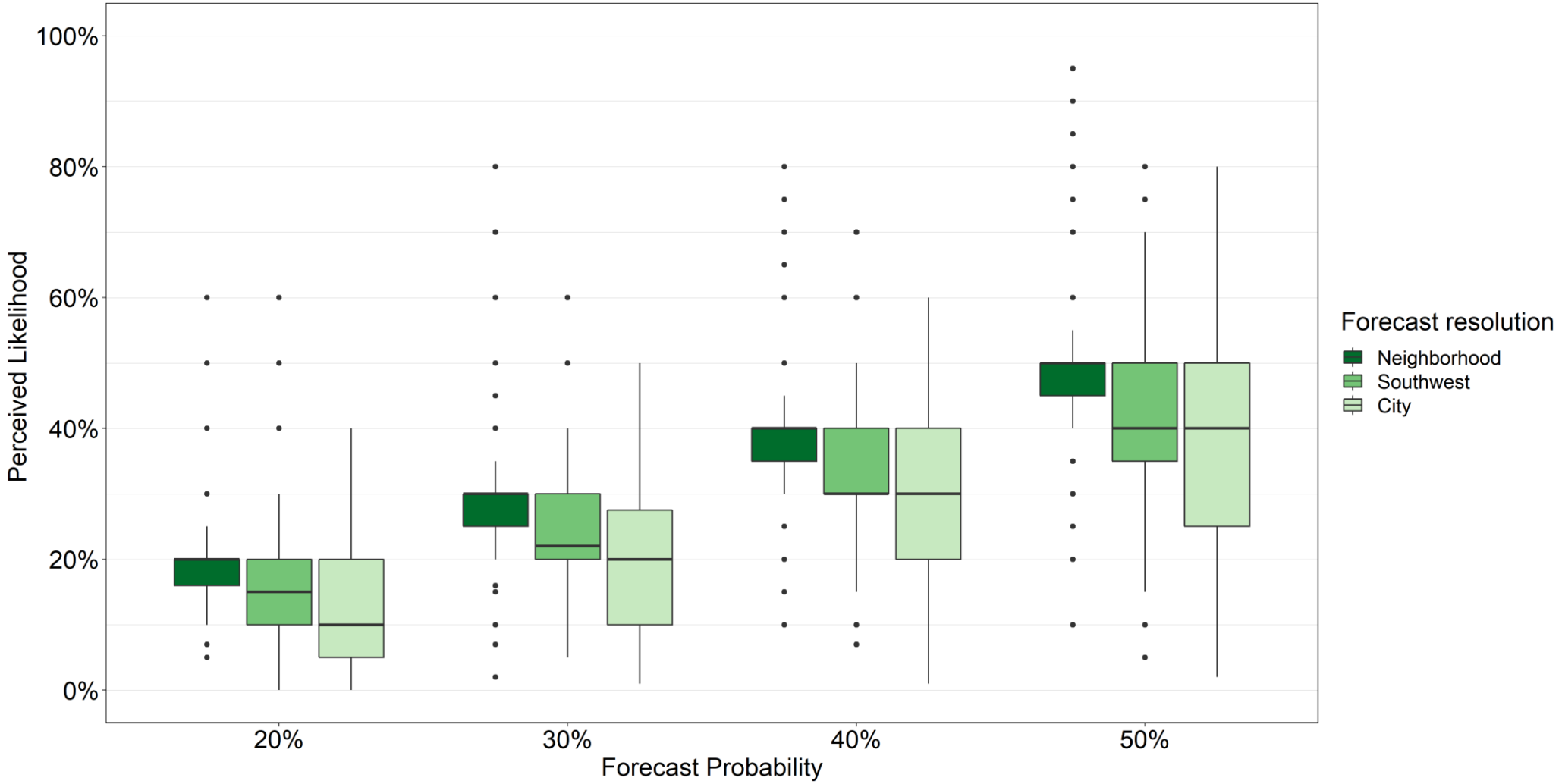
- Host or cancel the event?

- Interpretation of spatial reference class

	Hit by thunderstorm	NOT hit by thunderstorm
Host event	- 20.000	0
Cancel event	- 5.000	- 5.000



Results: Lower resolution, lower perceived risk



What does a 30% chance of thunderstorms in Stuttgart tomorrow mean?

"*At any* one particular *point* in Stuttgart (e.g., at the townhall) there is a 30% chance that thunderstorms will occur tomorrow, and a 70% chance that thunderstorms will not occur tomorrow."

"There is a 30% chance that thunderstorms will occur *somewhere* (i.e., in at least one place) in Stuttgart tomorrow, and a 70% chance that thunderstorms will occur nowhere in Stuttgart tomorrow."

adapted from Murphy et al. (1980)

What does a 30% chance of thunderstorms in Stuttgart tomorrow mean?

"*At any* one particular *point* in Stuttgart (e.g., at the townhall) there is a 30% chance that thunderstorms will occur tomorrow, and a 70% chance that thunderstorms will not occur tomorrow."

30% of participants

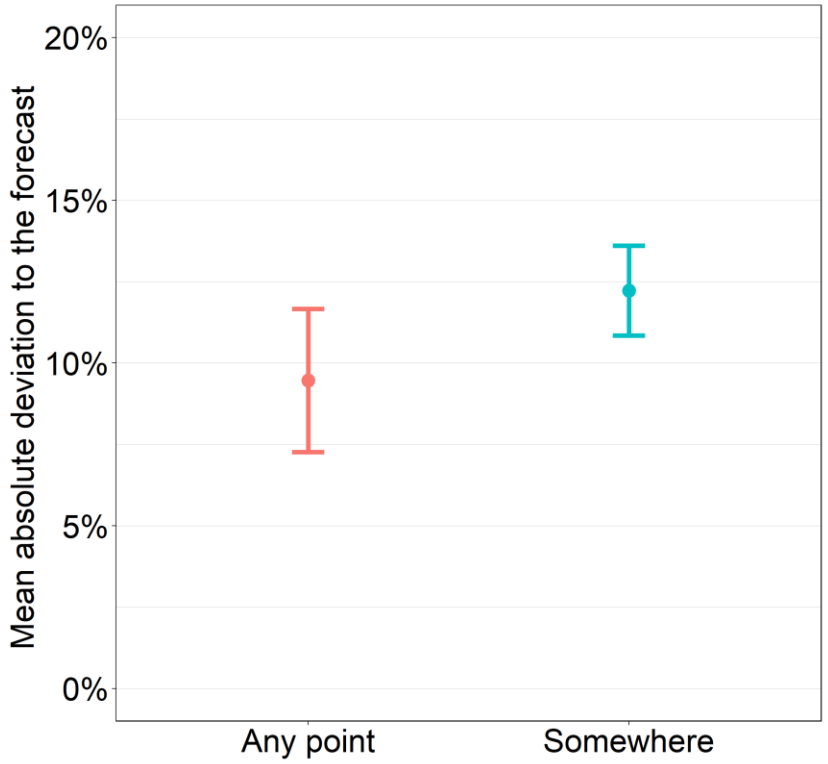
"There is a 30% chance that thunderstorms will occur *somewhere* (i.e., in at least one place) in Stuttgart tomorrow, and a 70% chance that thunderstorms will occur nowhere in Stuttgart tomorrow."

66% of participants

adapted from Murphy et al. (1980)

Mean absolute deviation

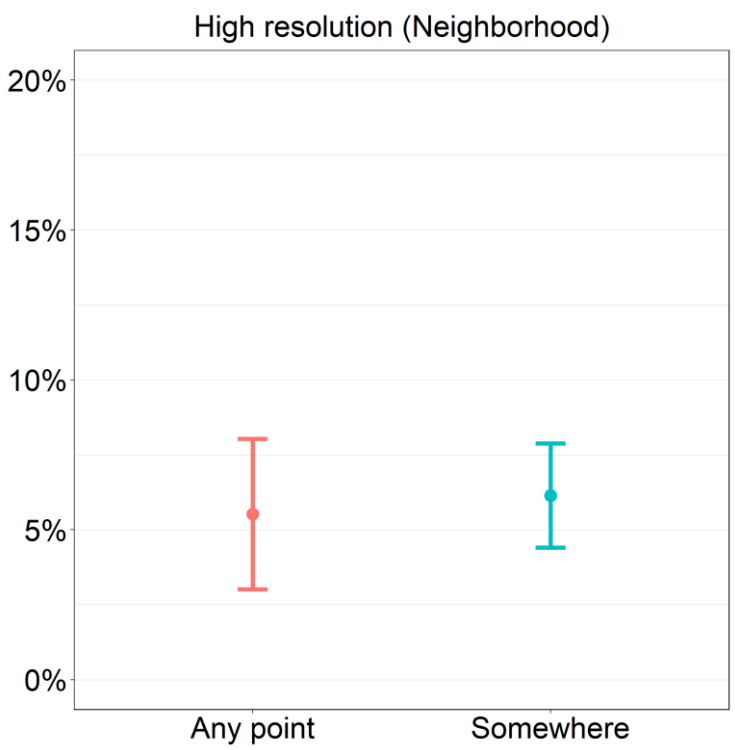
- Does the deviation of the perceived likelihood to be hit by rain from the forecasted probability differ between interpretation groups?

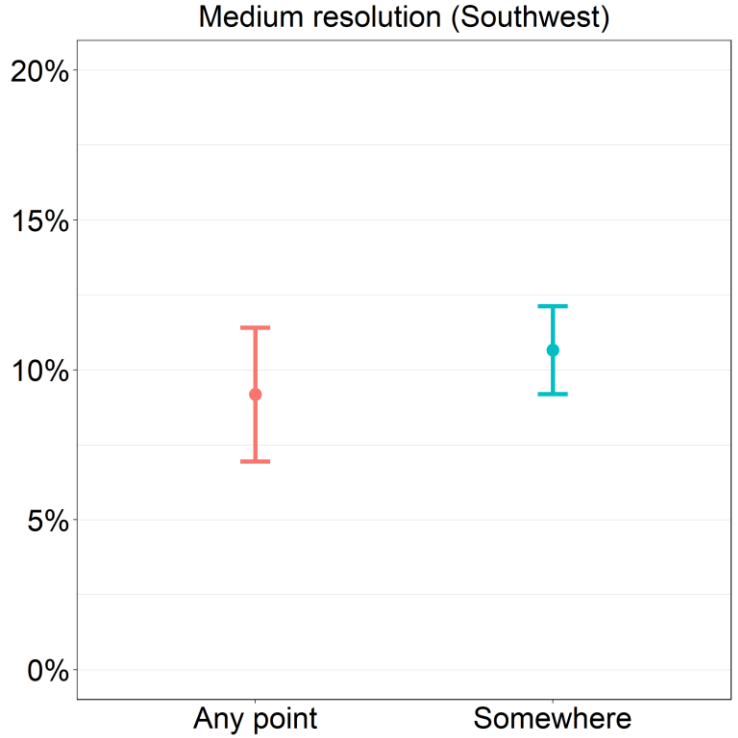


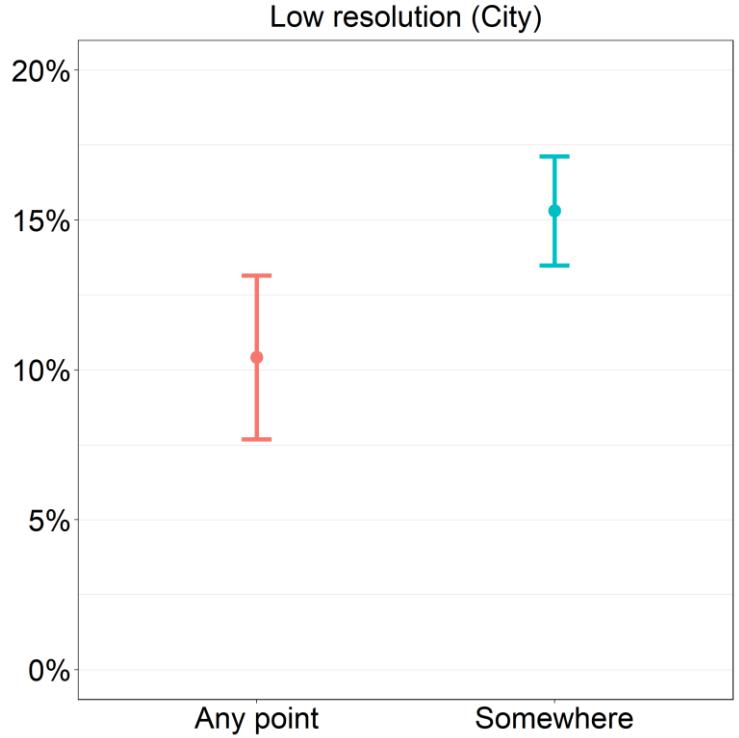
Overall, no significant difference between interpretations of the spatial reference class

Mean absolute deviation

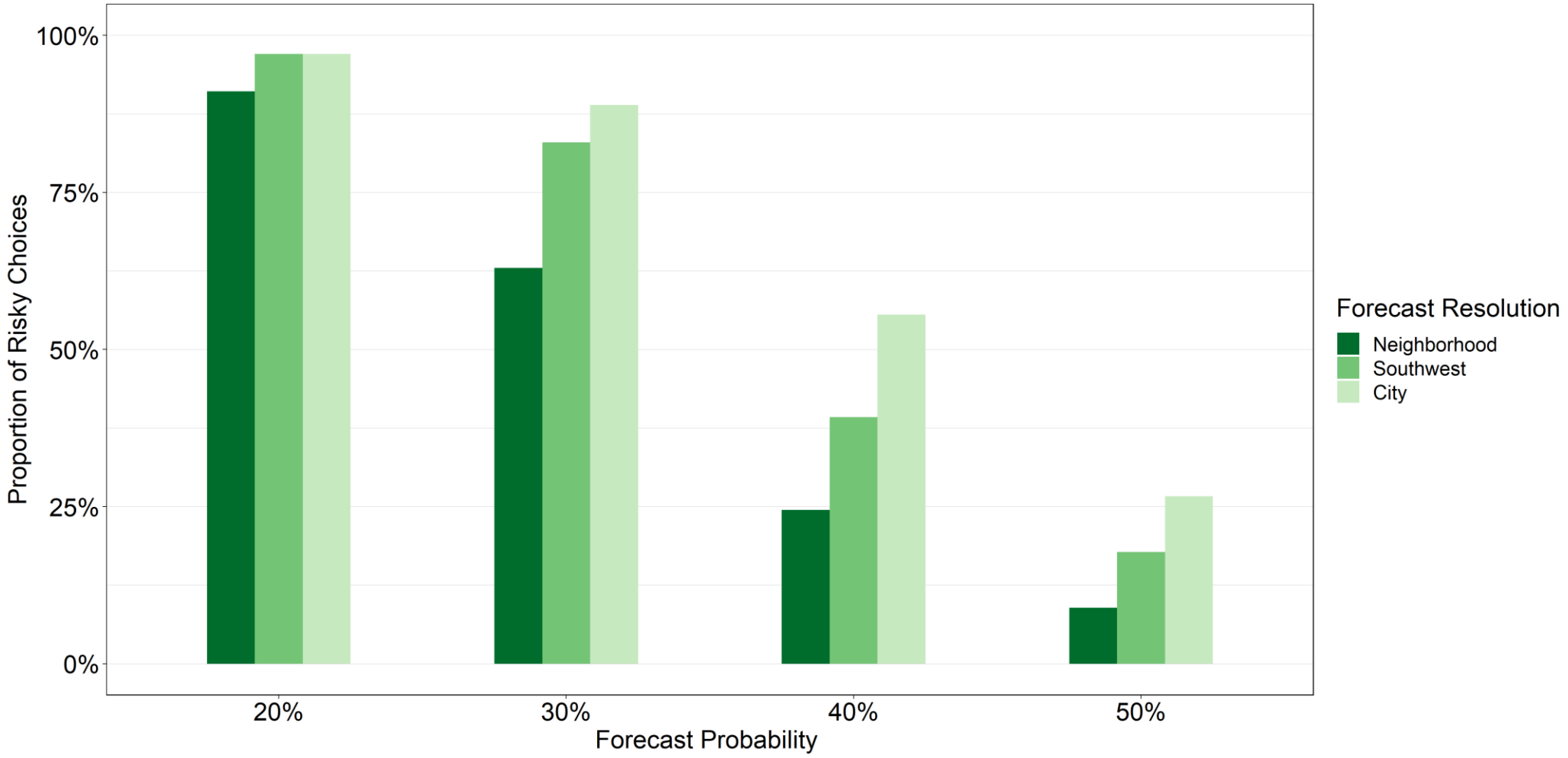
- We can note a trend of higher deviation for the somewhere interpretation with lower forecast resolution.







Lower resolution, less cancelations



Conclusion

- Lower forecast resolution **reduces** perceived risk
- Lower forecast resolution **reduces** likelihood to take precautionary action
- Interpretations of spatial reference class only **rough proxy** for observed risk perception and behavior
- Is there a **Sweet spot** in the **Trade-off** between lower forecast resolution and higher forecast probabilities?

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