

Models for weather-related traffic variations and accident probabilities on roads

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OSA2.1 Reducing weather risks to transport: air, sea and land

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Introduction

In a previous study:

- Modelling weather-related road-accident probabilities without explicit consideration of traffic volume

[Becker et al \(2020\)](#)

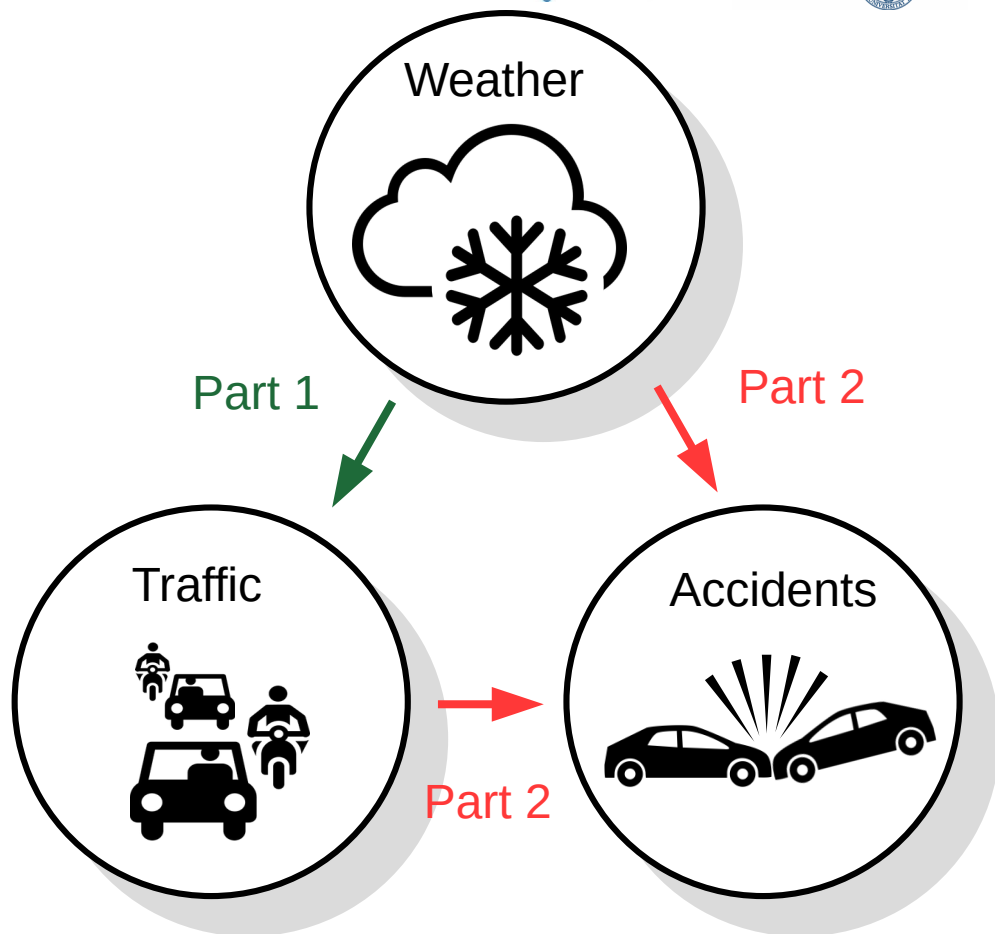
In the present study:

Part 1 - traffic model

- Modelling weather impacts on traffic volume

Part 2 - accident model

- Modelling weather impacts on accident probabilities with explicit consideration of traffic volume



Data



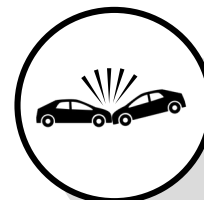
Weather data

- RADOLAN
 - Radar-based precipitation
- ERA5 reanalysis
 - temperature
 - Cloud cover
 - Wind gusts



Traffic data

- >1000 traffic stations (source: Federal Highway Research Institute)
- Federal roads and highways
- Hourly counts of
 - Motorbikes
 - Cars
 - Vans
 - Trucks



Accident data

- Police reports of heavy road accidents (source: German Federal Statistical Office)
- Information about
 - Date and time
 - Location (district)
 - Accident type
 - Speed limit
 - ...

Part 1 - Traffic model

Model description

- Poisson regression models for hourly counts of different vehicle types at each traffic station
- Models with (MET) and without (NO-MET) meteorological predictor variables

Predictor variables for NO-MET models

- Hour of the day
- Day of the week
- Month of the year
- Holidays

Predictor variables for MET models

- Variables of NO-MET models
 - Daily maximum temperature
 - Hourly precipitation sum
 - Daily average total cloud cover
 - Daily maximum wind gust
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- Stepwise selection of predictor variables based on cross-validated mean squared error (MSE)
 - Mean squared error skill score (MSESS) is used to quantify the improvement of predictive skill of MET compared to NO-MET

Part 1 - Traffic model

Skill scores for different vehicle types

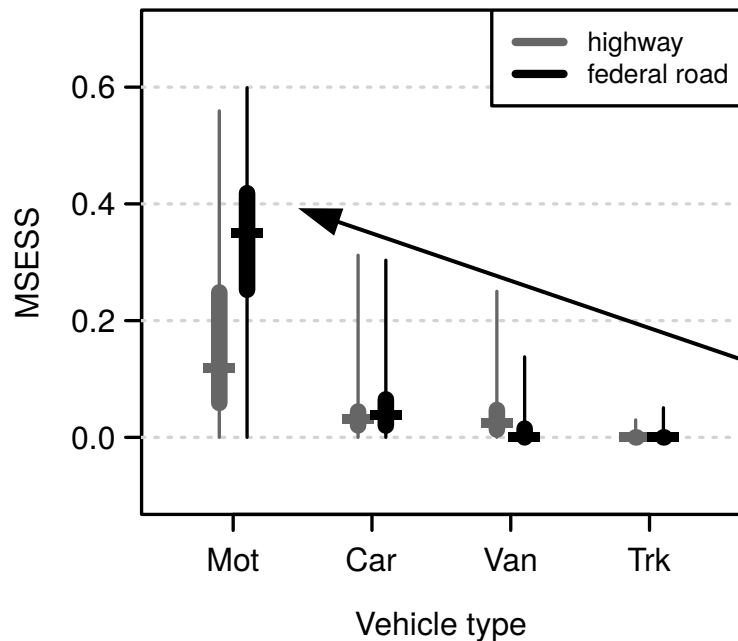
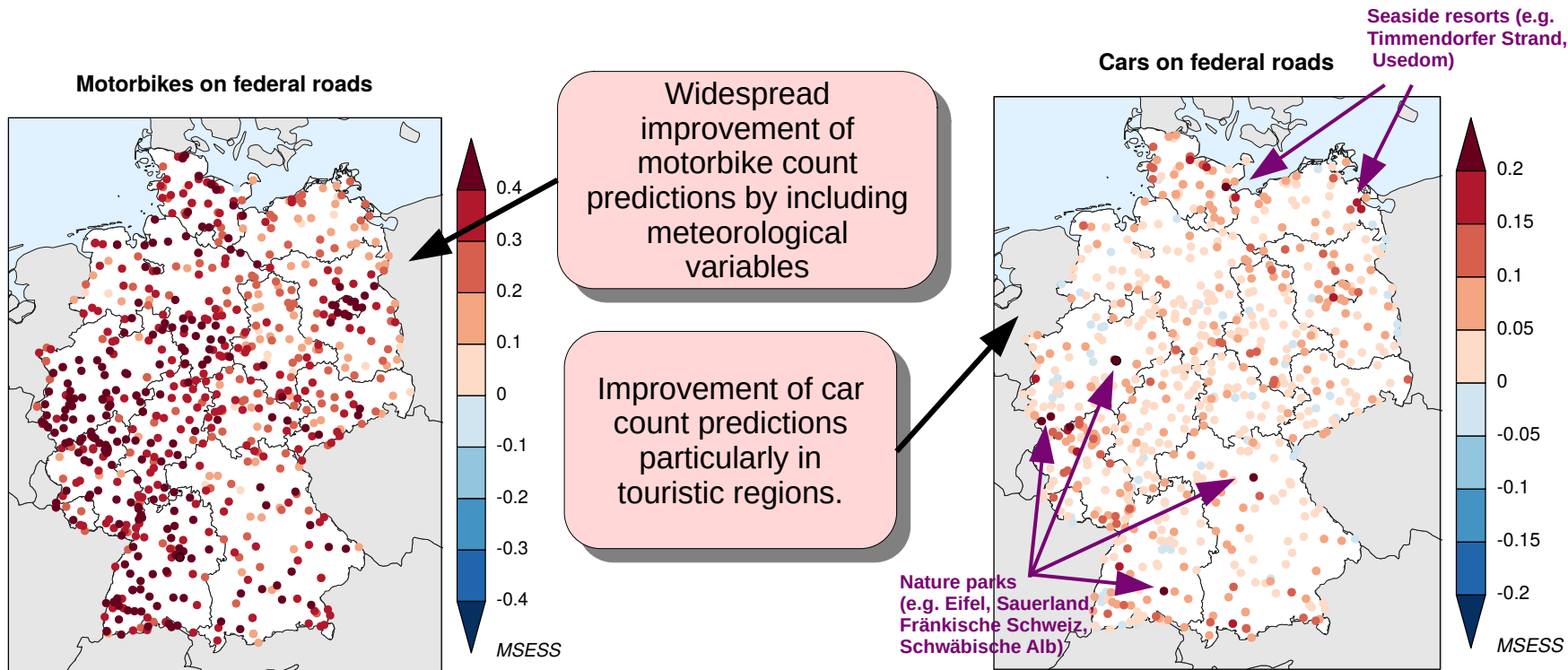


Fig. 1: Distributions of mean squared error skill scores (MESS) at different stations. MESS indicates the improvement of vehicle count predictions by including meteorological predictors in the models.

Predictions of hourly motorbike counts at federal roads show the largest improvement, when meteorological predictors are added to the models.

Part 1 - Traffic model

Skill scores – spatial distribution



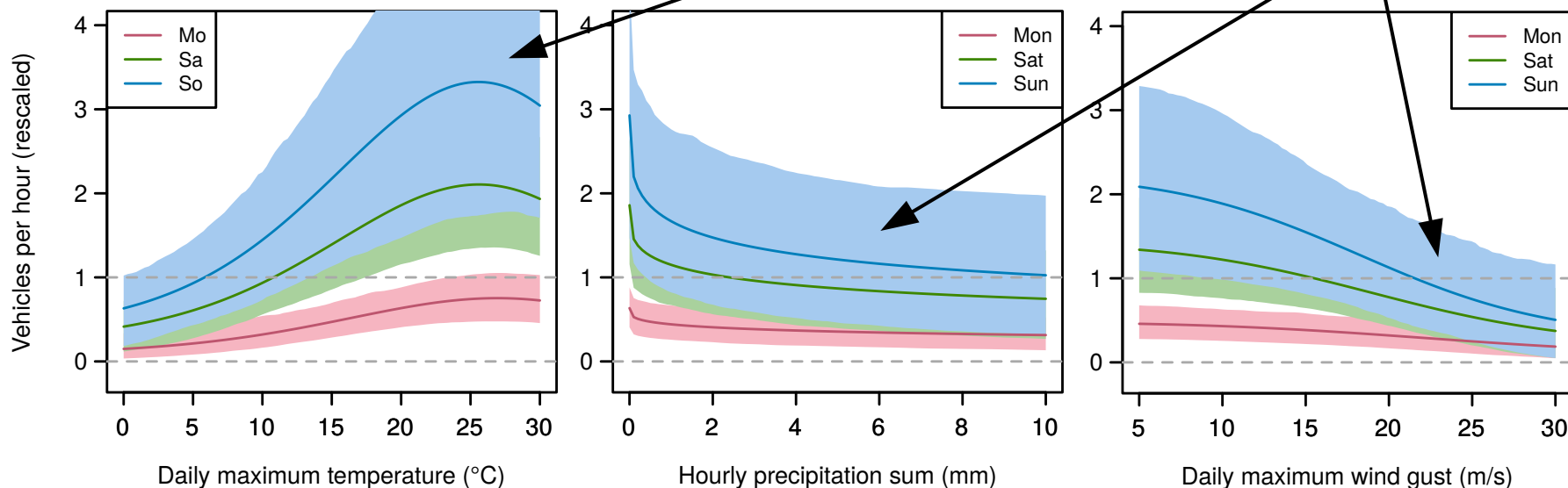
Part 1 - Traffic model

Functional relationships

- Influence of different meteorological parameters on hourly motorbike counts based on the MET models

On Sundays at about 25°C the highest motorbike counts occur.

Precipitation and high wind speeds lead to a reduction of motorbike volume by more than 50%.



Part 2 – Accident model

Model description

- Logistic generalized additive models are used to model hourly accident probabilities in German administrative districts

Simplified model formula

- $p \sim s(p_{\text{dis}}) + s(\text{traf}) + \text{te}(\text{precip}, \text{temp})$

Predictor variables

- p : hourly accident probability
- traf : hourly traffic counts
- p_{dis} : average accident probability in the district
- temp : Surface temperature
- precip : hourly precipitation sum

Smoothing terms

- $s()$ indicates a smoothing function of a single variable
- $\text{te}()$ indicates a multidimensional smoothing of more than one variable, accounting for variable interactions

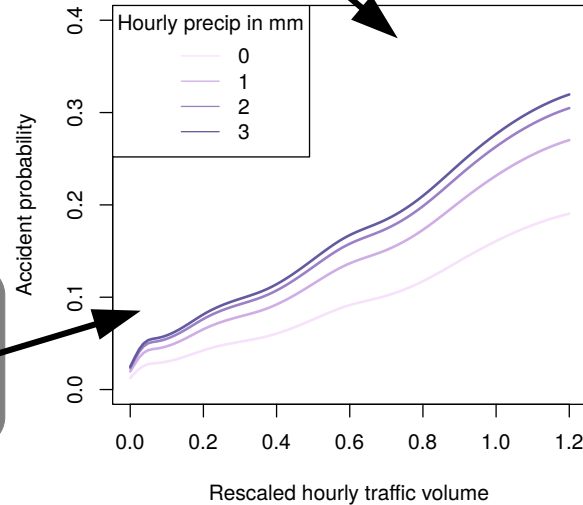
Part 2 – Accident model

Functional relationships

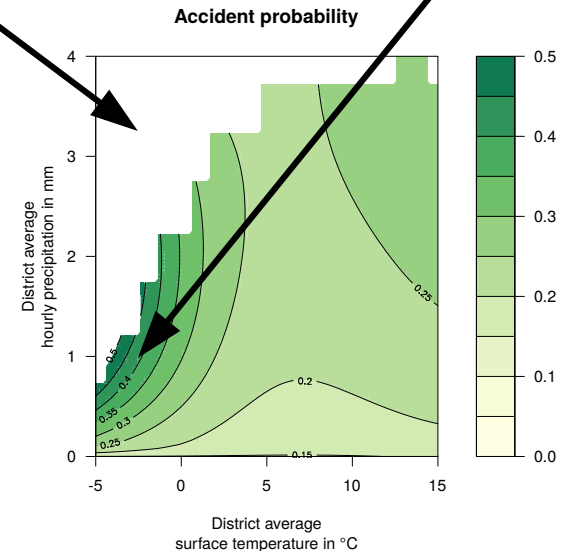
$$p \sim s(p_{\text{dis}}) + s(\text{traf}) + \text{te}(\text{precip}, \text{temp})$$

p_{dis} allows to distinguish
between different
administrative districts

Accident probability
increases with traffic
volume



Precipitation in combination
with temperatures below
0°C leads to the highest
accident probabilities.

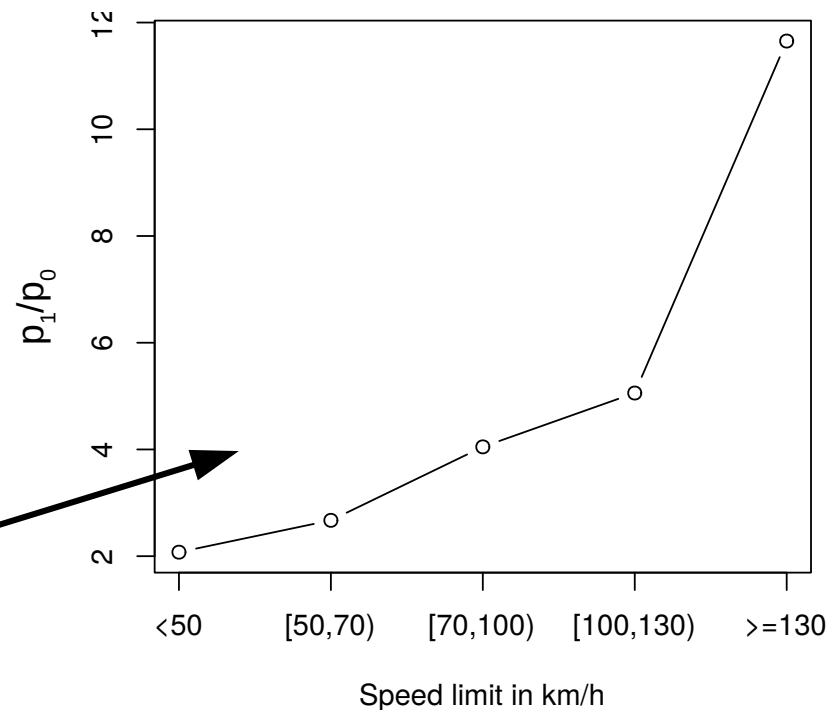


Part 2 – Accident model

Influence of snow and speed limit on accident probability

- p_0 : accident probability at temp=3°C and precip=0 mm/h
- p_1 : accident probability at temp=-3°C and precip=1 mm/h
- p_1/p_0 : factor by which accident probability increases during snow conditions
- p_1/p_0 is computed separately for different speed limits

The factor by which accident probability increases during snow conditions is larger at higher speed limits



Summary

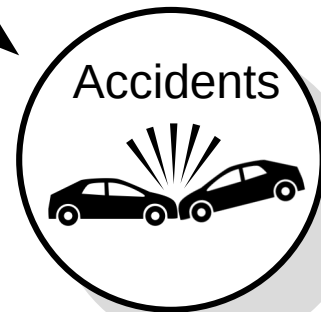
- Including meteorological variables in Poisson regression models improves the prediction of hourly traffic counts
- In case of motorbikes on federal roads the improvement is up to 60%



- Snow conditions increase accident probabilities
- The increase is larger at higher speed limits
- At >130 km/h the accident probability is 12 times larger during snow conditions



- Hourly traffic counts can be used to model accident probabilities



References

- Becker, N., Rust, H. W., & Ulbrich, U. (2020). **Predictive modeling of hourly probabilities for weather-related road accidents.** *NHESS*, 20(10), 2857-2871.
DOI: <https://doi.org/10.5194/nhess-20-2857-2020>