

# Weather and Train Disruptions in Sweden 2011-2019

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# Background



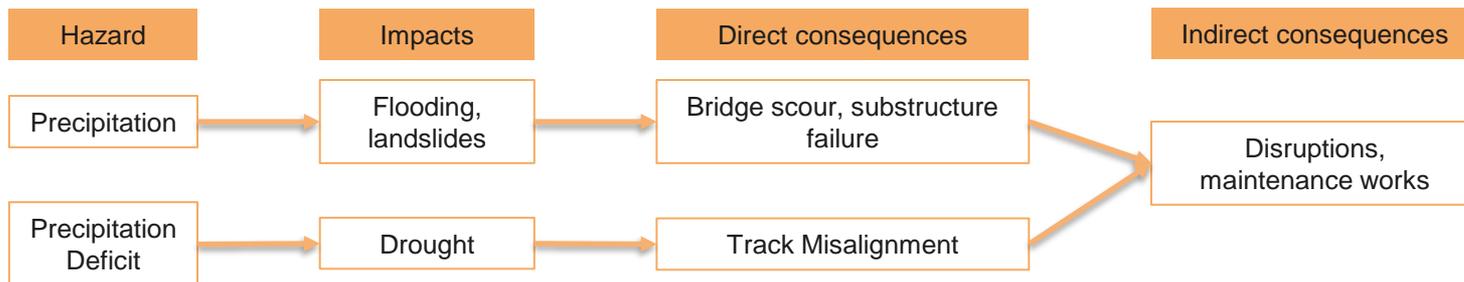
(Ferranti, et al., 2021)



# Background



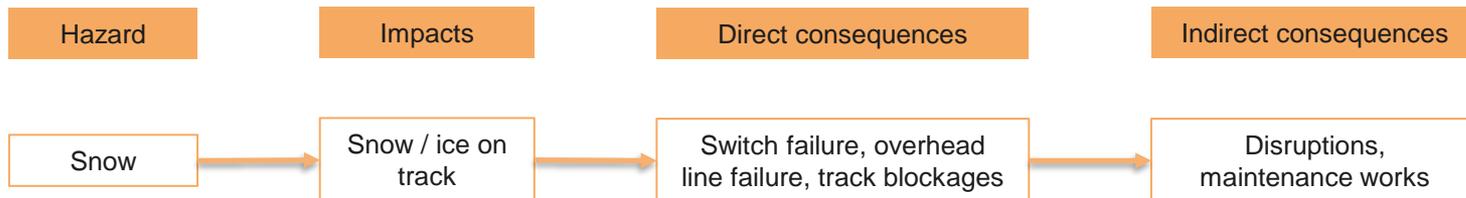
(The Globe and Mail, 2021)



# Background



(Palin et al., 2021)



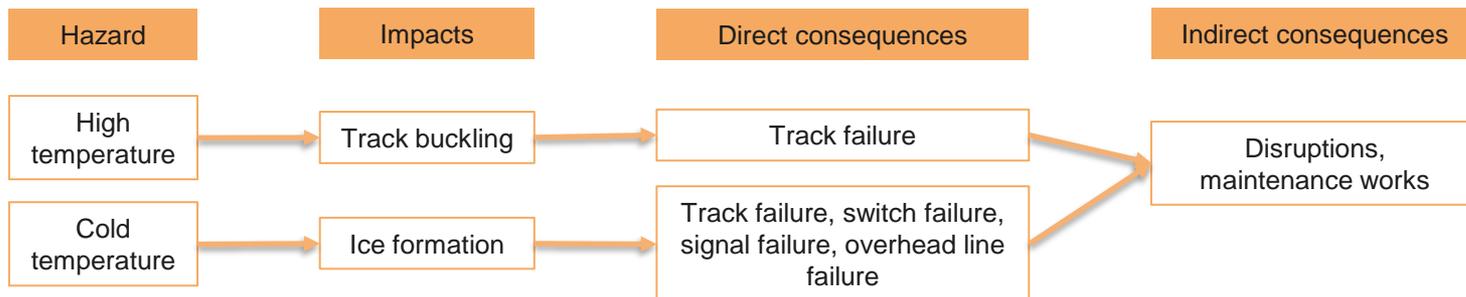
# Background



(Palin et al., 2021)



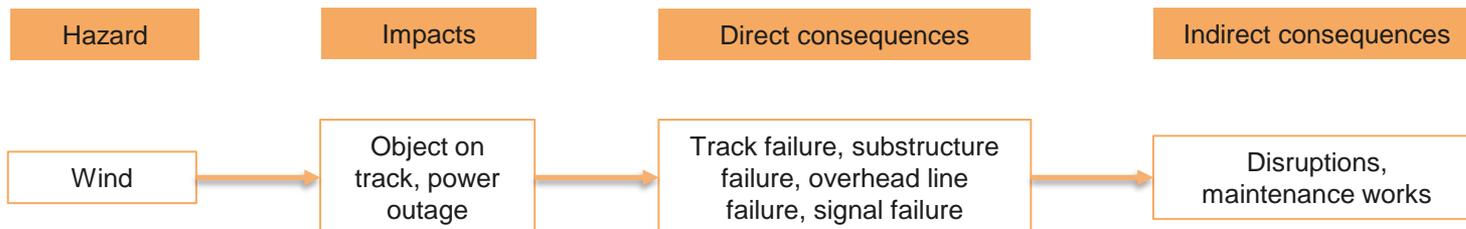
(Palin et al., 2021)



# Background



(Network Rail, 2022)



# Background

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**Location:** Swedish railway network between 2011-2019

**Aim:** to analyse the past effects of weather on railway disruptions in Sweden (i.e. cancellations or large delays) and consider how these may change along with changing climate conditions.

**Data sources:** Weather data (snow depth, precipitation, temperature, & wind speed) from SHMI & Railway operations data from Trafikverket

# Data & Method

## Weather Data

Weather Variable and Unit	Number of Observations	Observation Frequency	Number of Weather Stations
Average Snow Depth (m)	505,317	Daily	217
Average Temperature (C)	692,773	Daily	241
Average Precipitation (mm)	778,131	Daily	312
Max Wind Speed (m/s)	10,938,298	Hourly	153

Algorithm was created to match the coordinates of each train station to the nearest weather station on a day-by-day basis

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## Railway Operations Data

100 million registered arrivals at stations

### Disruptions

- Cancelled
- Delayed >60 minutes

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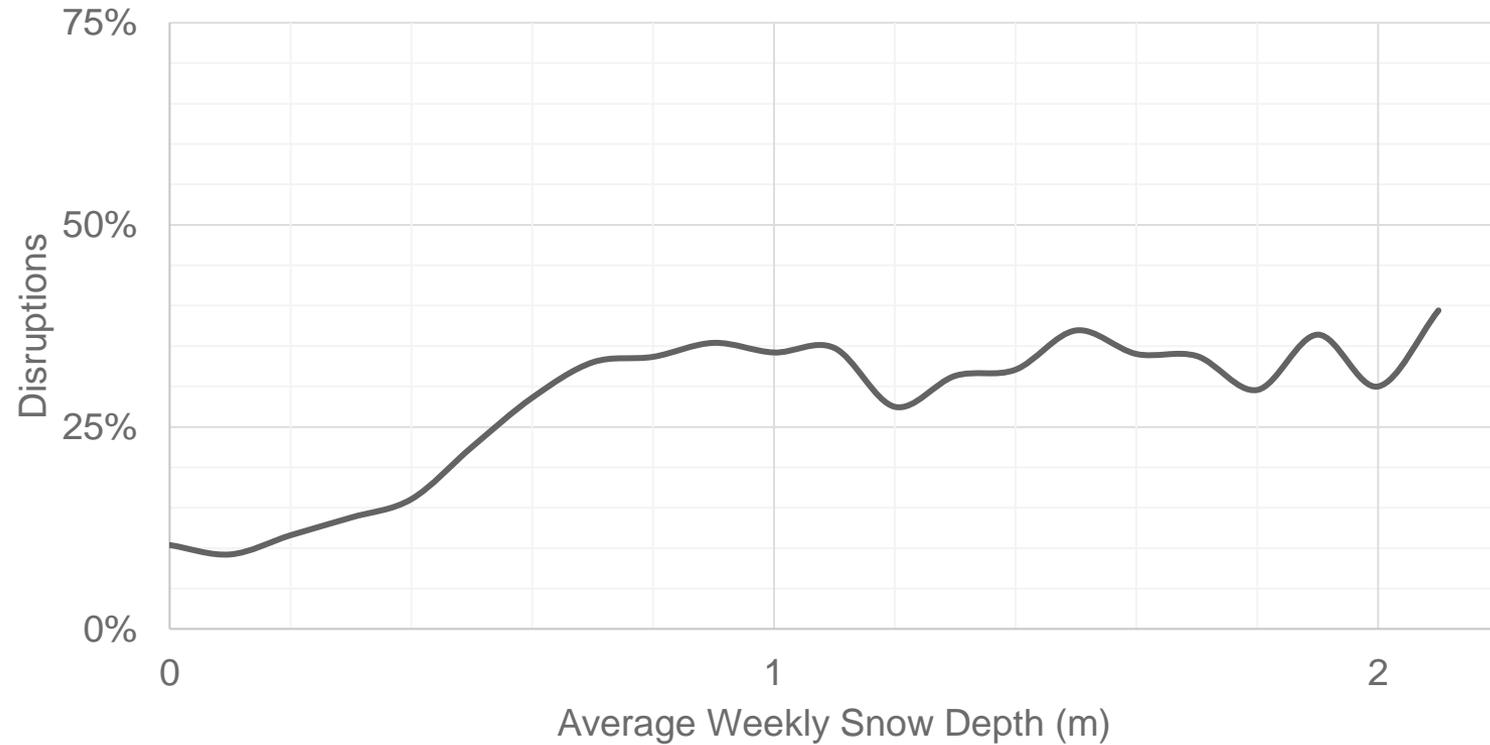
100 million registered arrivals at stations

### Disruptions

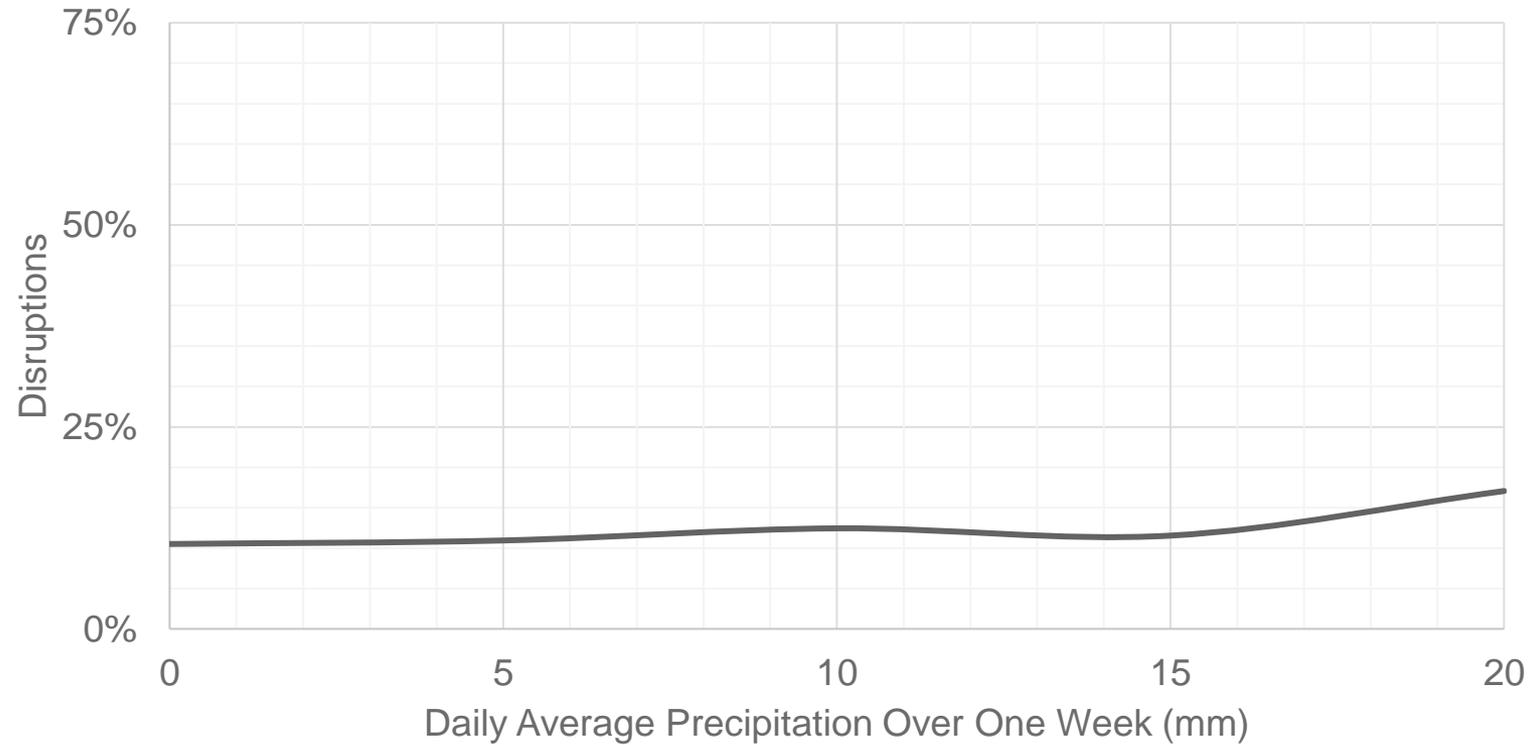
- Cancelled
- Delayed >60 minutes

Aggregated both data sets on a weekly basis to determine the disruptions shares for each weather variable

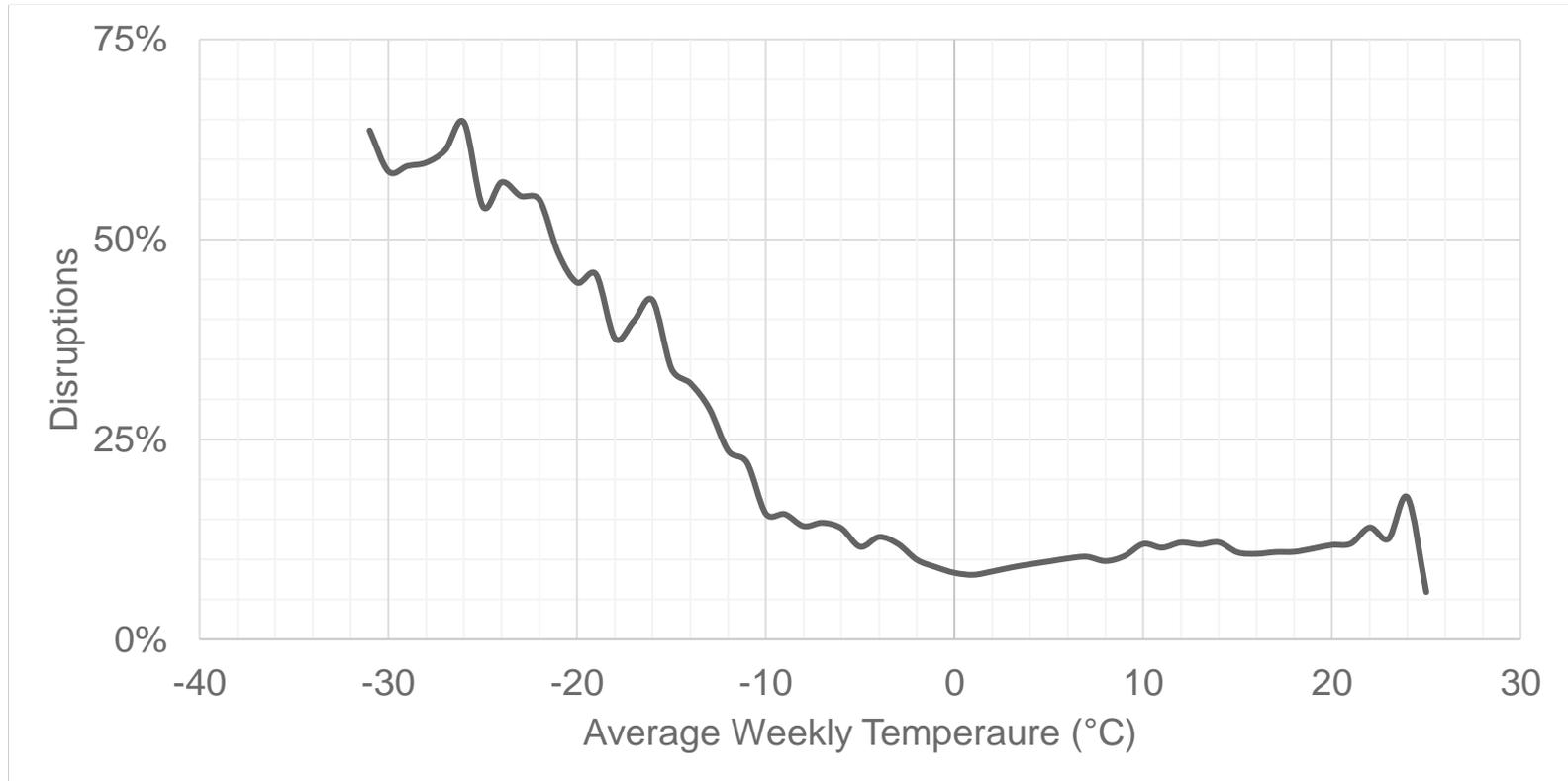
# Results



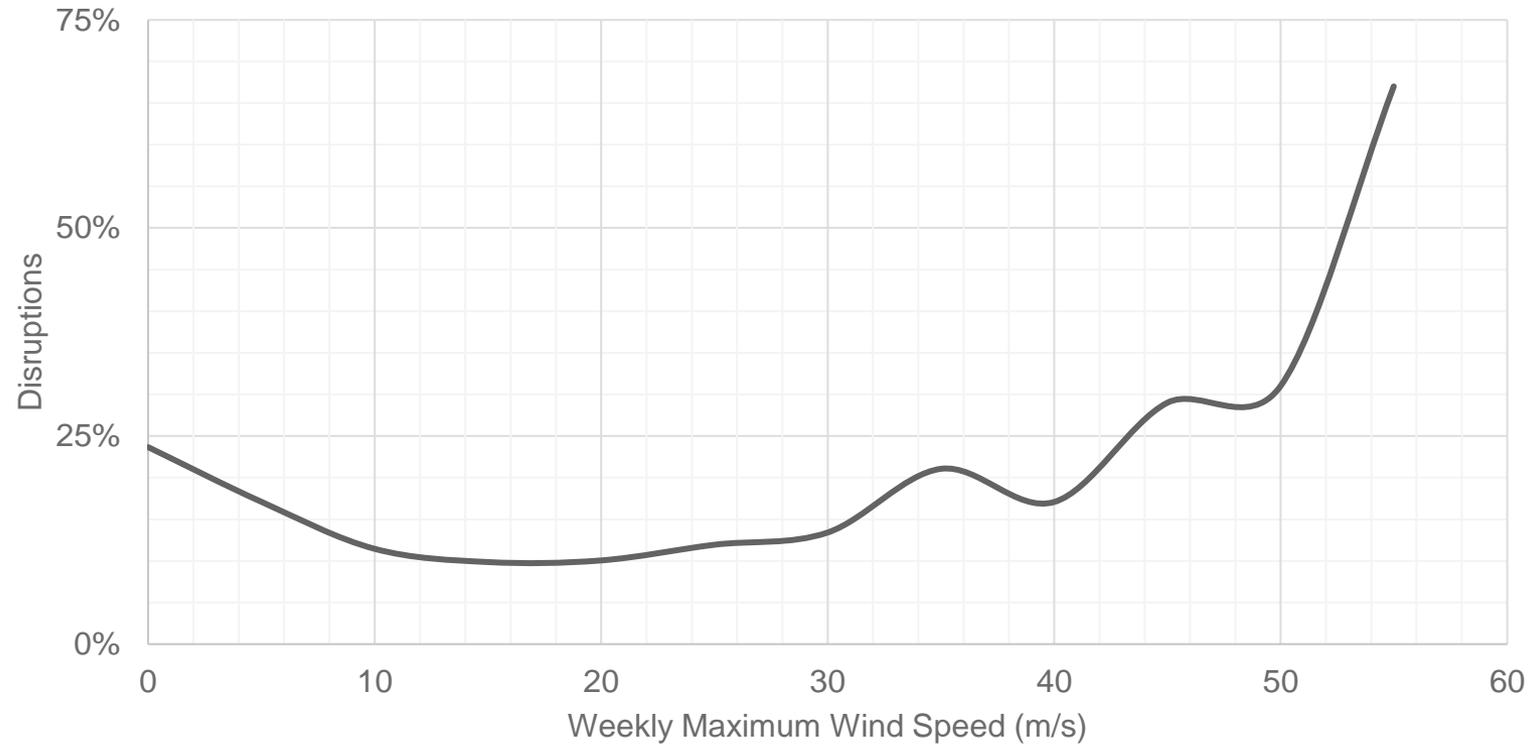
# Results



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# Discussion and Conclusions

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## Future Implications due to Climate Change



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**Precipitation:** Increase & more in the winter compared to summer (Lindgren et al., 2009; Thaduri et al., 2021)



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## Future Implications due to Climate Change

**Precipitation:** Increase & more in the winter compared to summer (Lindgren et al., 2009; Thaduri et al., 2021)

**Temperature:** Increase (Thaduri et al., 2021)

# Discussion and Conclusions

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## Future Implications due to Climate Change

**Precipitation:** Overall increase & more in the winter compared to summer (Lindgren et al., 2009; Thaduri et al., 2021)

**Temperature:** Increase (Thaduri et al., 2021)

**Wind:** More challenging to estimate (Thaduri et al., 2021)

Thaduri A., Garmabaki A. & Kumar U. (2021) Impact of climate change on railway operation and maintenance in Sweden: A State-of-the-art review. *Maintenance, Reliability and Condition Monitoring*, 1(2), pp. 52-70.

Lindgren, J., Jonsson, D.K. & Carlsson-Kanyama, A. (2009) Climate Adaptation of Railways: Lessons from Sweden, *European Journal of Transport and Infrastructure Research*, 9(2), pp. 164-181.



# Discussion and Conclusions

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- Current vulnerability to extreme weather is expected to increase as climate changes
  - Regional differences across Sweden
- If the frequency of disruptions is going to be reduced, then adaptation measures will have to be taken to reduce the risks of extreme events
  - Understanding the past patterns is one crucial piece to understanding the vulnerability to extreme weather
- **Future Research Directions:** More quantitative approaches to understanding future effects of climate change on railways & development of adaptation strategies

# THANK YOU!

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