



# Losun svifryks frá gatnakerfinu á höfuðborgarsvæðinu - ferlar og líkan

*Particulate Matter Emissions from the Street System in the Capital Region - Processes and Models*

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# Happy Studded Tire Day, Iceland!

1<sup>st</sup> of November

It is now legal to drive with studded tires on your vehicle.



Image source: <https://commons.wikimedia.org/wiki/File:Spikereifen.JPG>



Image source: <https://ak0.picdn.net/shutterstock/videos/20825950/thumb/1.jpg>

for now

# Particulate Matter (PM; í. Svifryk)

- ◆ Particulate Matter, or PM, refers to microscopic airborne solid or liquid particles.
- ◆ Subdivided by size
  - ◆  $PM_{10}$  = Particles  $< 10 \mu\text{m}$  in diameter
  - ◆  $PM_{2.5}$  = Particles  $< 2.5 \mu\text{m}$
- ◆ No type of environmental pollution poses a greater threat to human health (WHO)

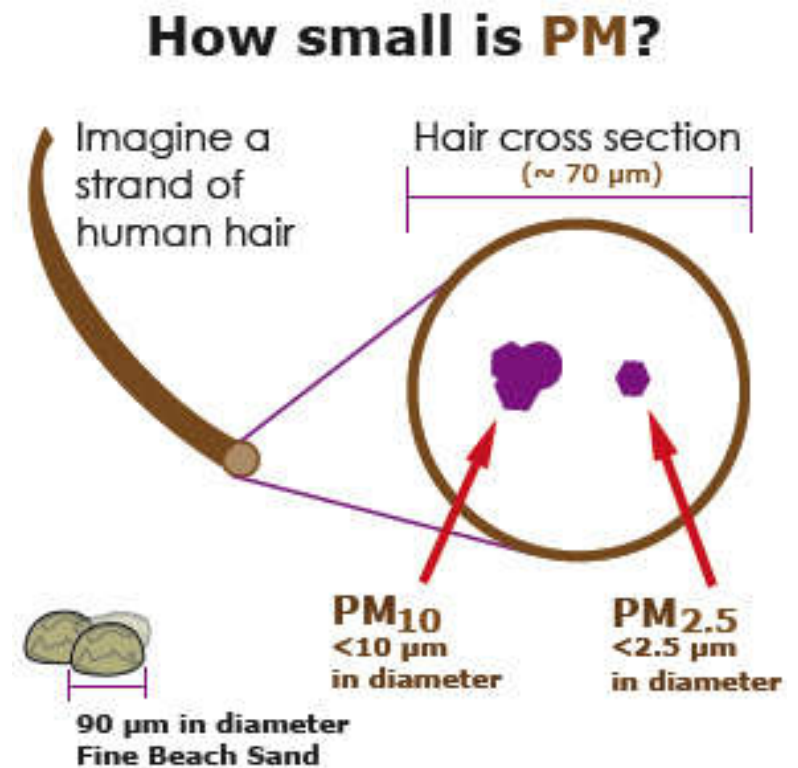


Image source: <https://www.downwindersatrisk.org/2017/07/new-harvard-study-there-is-no-safe-level-of-exposure-to-smog-or-particulate-matter/>



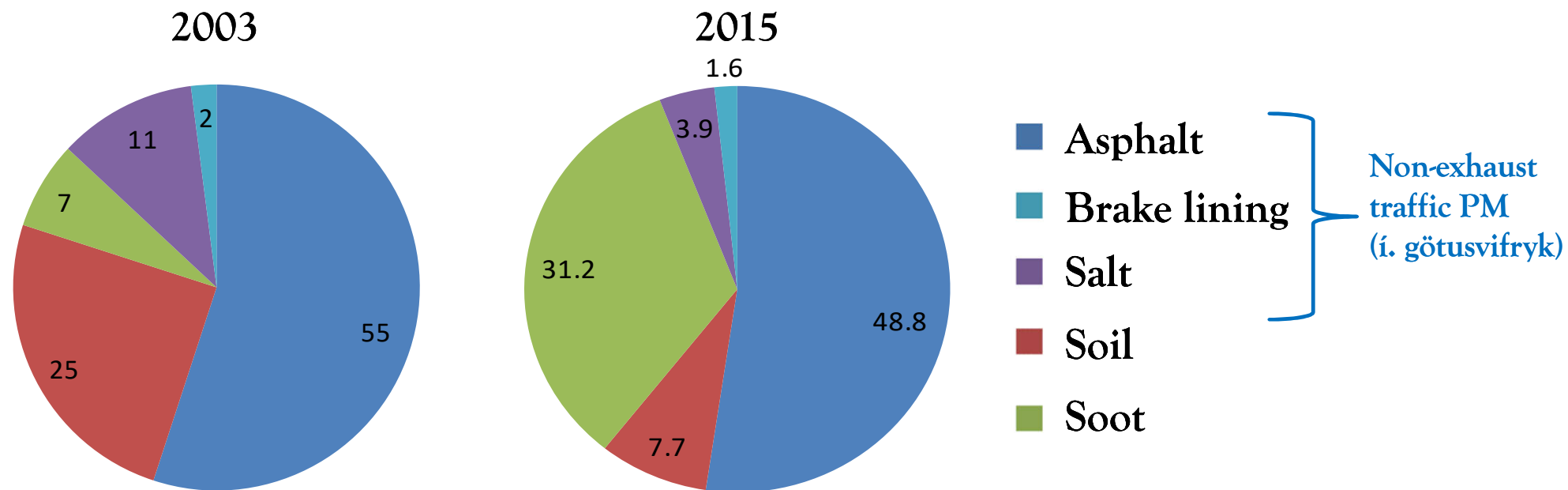
# Health Effects of Particulate Matter

- ◇ Premature mortality and morbidity, mainly related to respiratory and cardiovascular diseases (WHO, 2013).
- ◇ Estimated that 80 premature deaths occur in Iceland due to PM pollution [+ <5 due to NO<sub>x</sub> & O<sub>3</sub>] (*Hreint loft til framtíðar 2017*)
- ◇ Children are especially at risk (WHO, 2013).
  - ◇ Pollution reduces lung development, health problems, poorer academic performance, ...
- ◇ Morbidity relates to the occurrence of illness and years lived with a disease or disability (EEA, 2019), leading to decreased living quality and increased time away from work → social monetary loss





# Non-exhaust traffic emissions comprise of 50% of Particulate Matter



# NORTRIP

## NOn-exhaust ROad TRaffic Induced Particle emission modelling

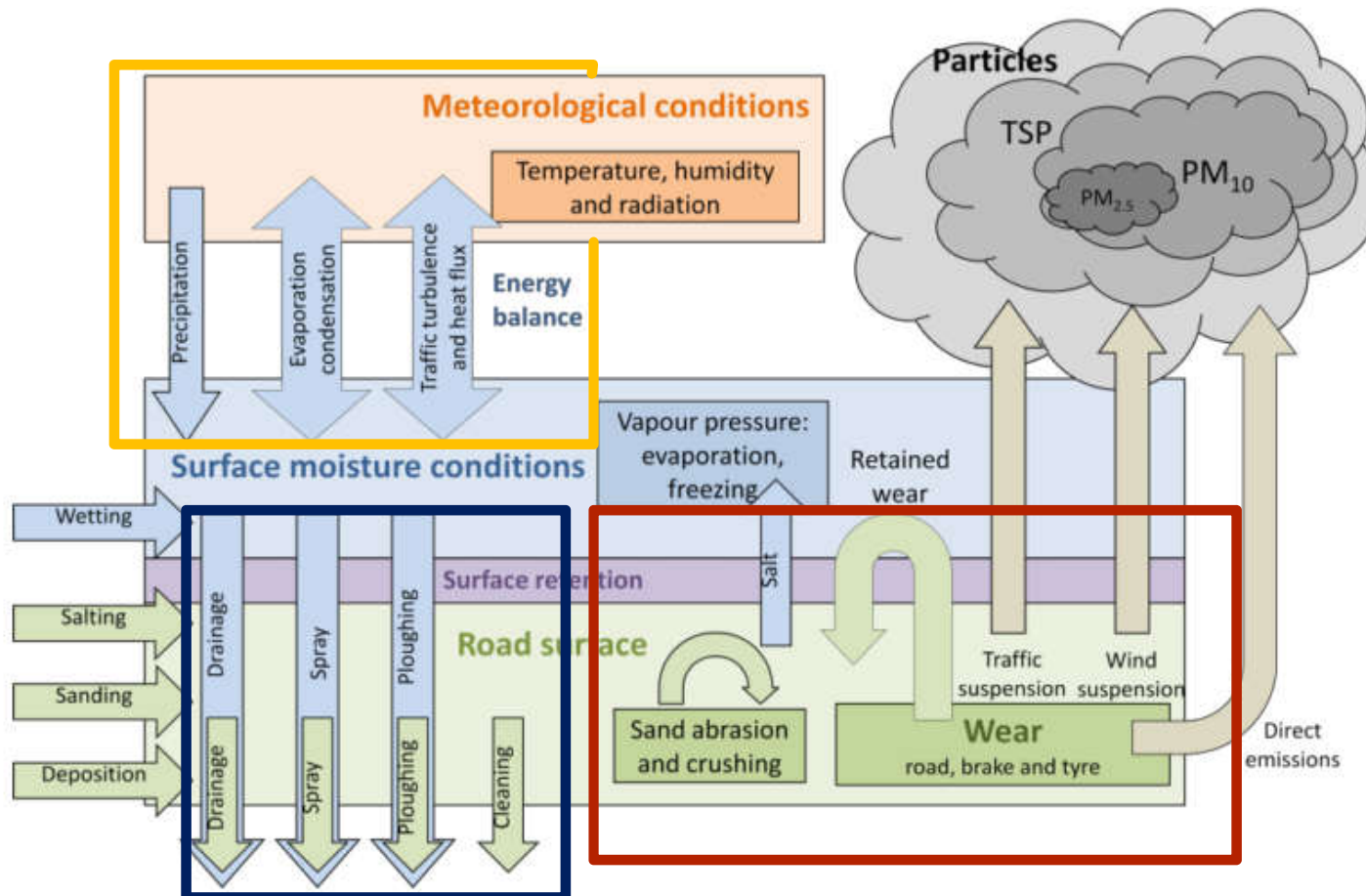
### Process Based Emissions Model

#### Road Dust

- ◇ Sources
  - ◇ Wear (road, brakes, tires)
  - ◇ Abrasion/crushing
- ◇ Sinks
  - ◇ Drainage, spray, ploughing, cleaning

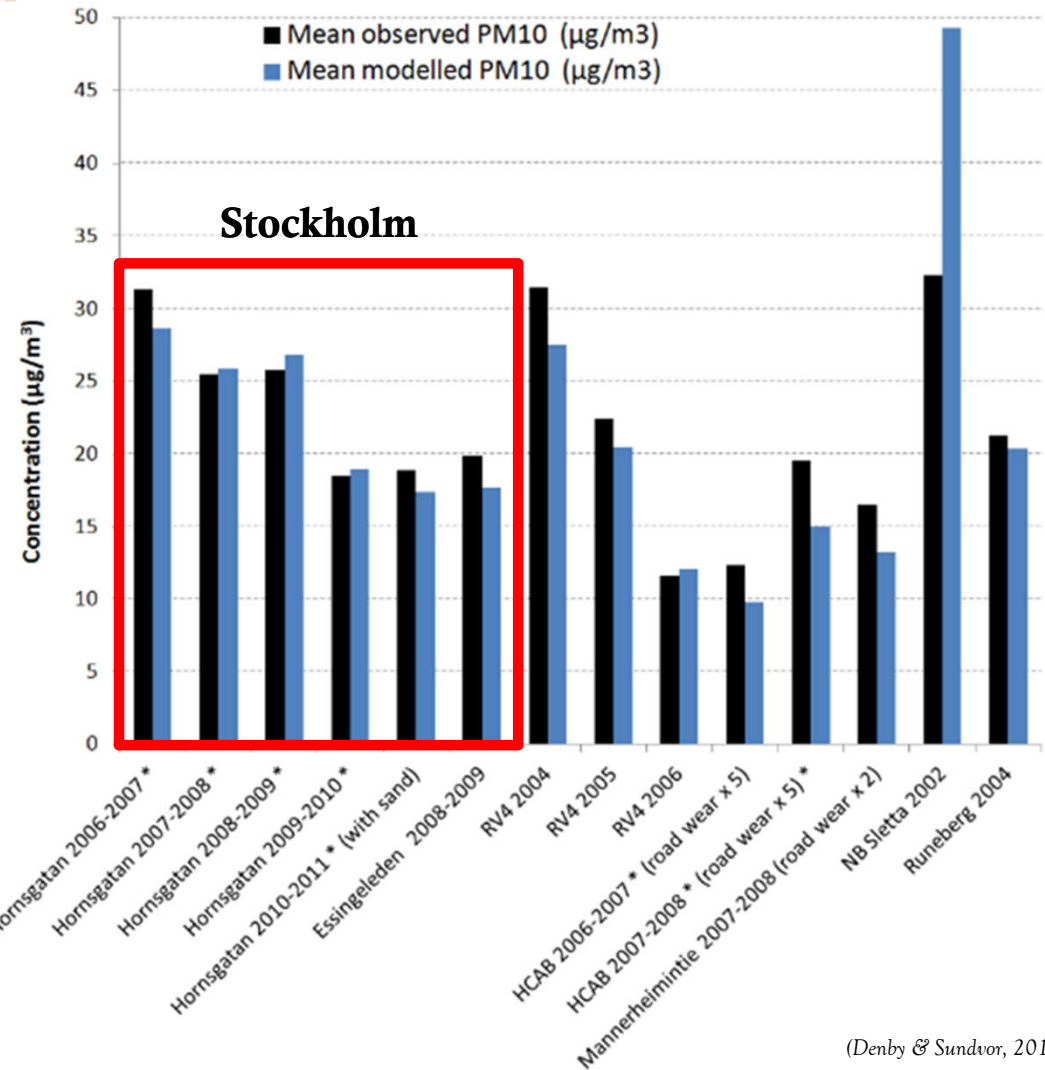
#### Road Moisture

- ◇ Energy Balance
  - ◇ Evaporation/condensation
  - ◇ Sources and sinks



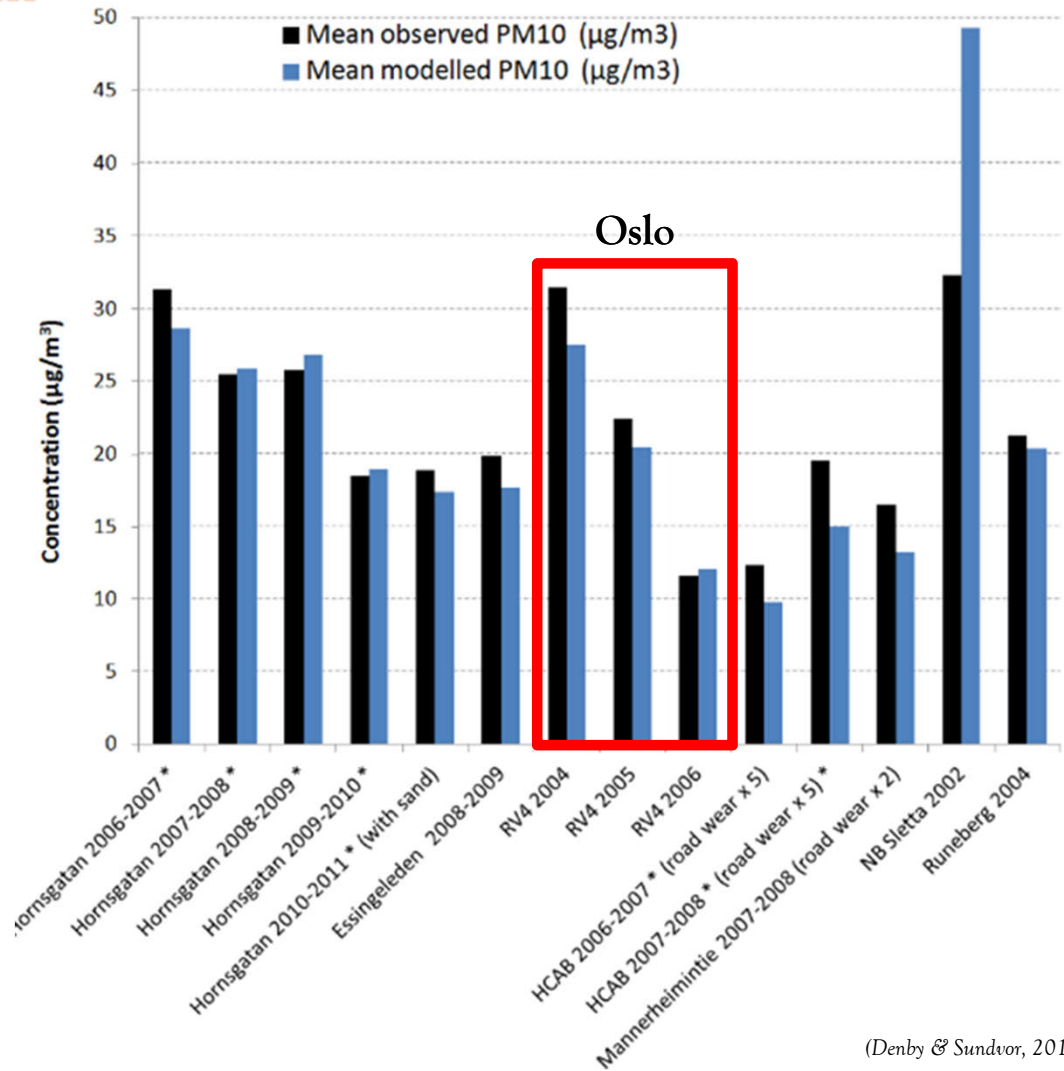
# NORTRIP in Stockholm

- ◆ Model run with observed road moisture data
- ◆ Satisfactory representation of PM concentrations at two sites, although one of them displayed large wintertime discrepancies.



# NORTRIP in Oslo

◆ Model captured well annual reduction in PM associated with speed limit reductions



# NORTRIP at Grensás 2012 & 2016



Period	Daily mean correlation $R^2$	Mean PM <sub>10</sub> observed (net)	Mean PM <sub>10</sub> modelled (net)
2012 - all year (FHG*)	0.03	11	8.8
2012 - April - May (FHG)	0.29	12.2	8.8
2012 - June- July (FHG)	0.03	12.8	5.1
2012 - Nov. - Dec. (FHG)	0.07	12.5	9.7
2016 - all year (FHG)	0.06	12.0	5.1
2016 - all year (KOP*)	0.00	14.0	6.7

\* background stations: FHG - Fjölskyldu-og Húsdúragarðurinn / KOP - Kópavogur Dálsmari

- ◇ Martina Stefani, a former HÍ student and current specialist at Umhverfisstofnun.
- ◇ Site: Intersection of Grensásvegur and Miklabraut.
- ◇ Conclusions:
  - ◇ Model captures the order of magnitude of the mean PM<sub>10</sub>
  - ◇ More research needed to understand processes and peaks



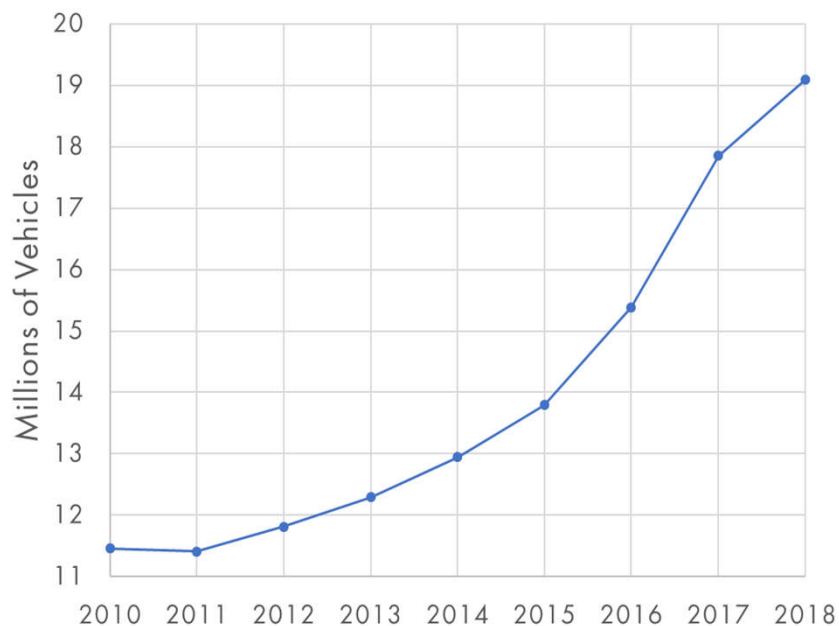




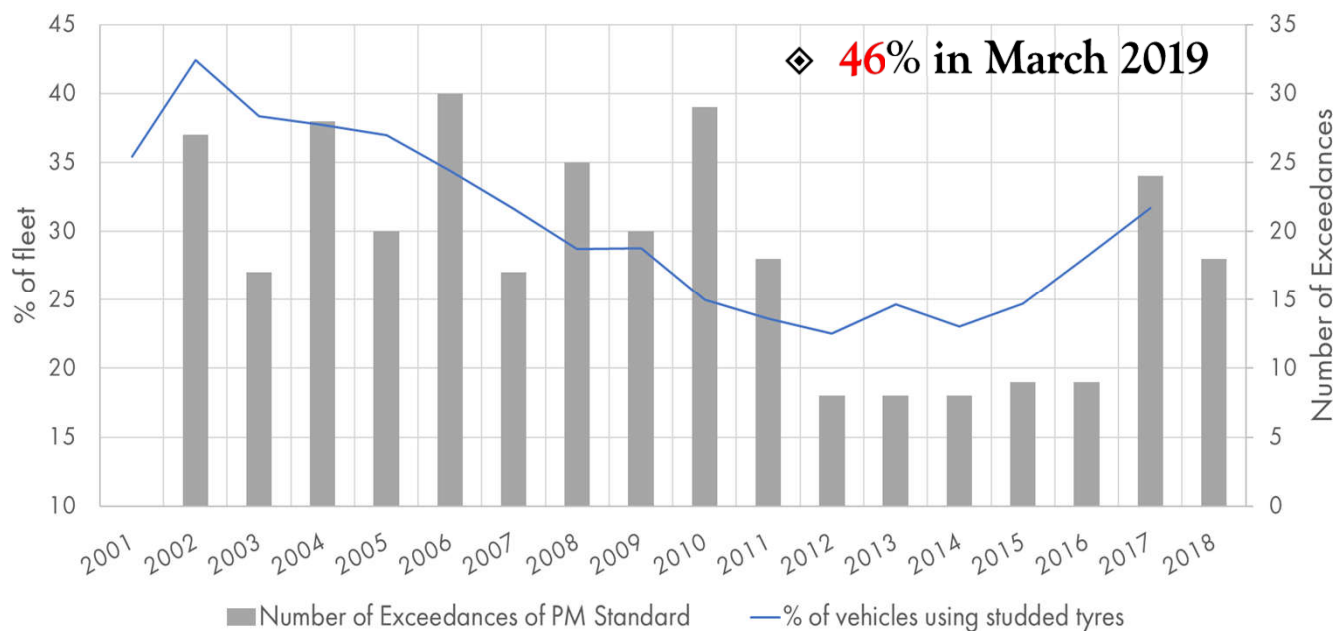
# Alarming Traffic and PM<sub>10</sub> Trends 2014-2018

- ◆ Traffic increased **46** % 2014 to 2018
- ◆ More traffic, more PM<sub>10</sub>
- ◆ 32% of the vehicle fleet used studded tyres 2017; up from 24%
- ◆ More PM exceedances occurred during higher use of studded tires

Annual Traffic at Kaupþún



Vehicles using studded tyres & PM exceedances since 2001





# Objectives

- ◆ Improve our understanding of the complex processes that cause PM exceedances
  - ◆ Focus: road wetness and studded tires
- ◆ Find the best abatement strategies for road dust.

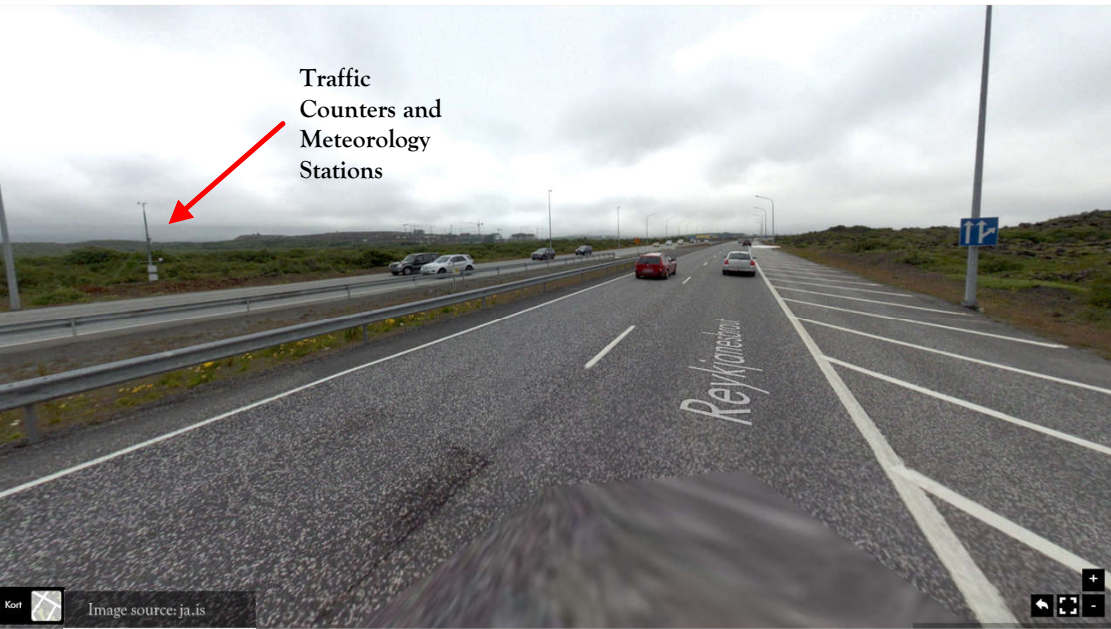


Image source: Vilhelm Gunnarsson, *Iceland Magazine*

*Less  
of  
this!*



Image source: *Iceland Monitor*, [https://icelandmonitor.mbl.is/news/news/2015/06/02/pm10\\_pollution\\_high\\_today/](https://icelandmonitor.mbl.is/news/news/2015/06/02/pm10_pollution_high_today/)



# Site: Kauptún, Garðabær

## ◇ Traffic Counts

- ◇ 18,9 million vehicles in 2018
- ◇ Average of approx. 52.000 vehicles per day
- ◇ 7.9% considered heavy-duty

## ◇ Continuous data for 2017-present

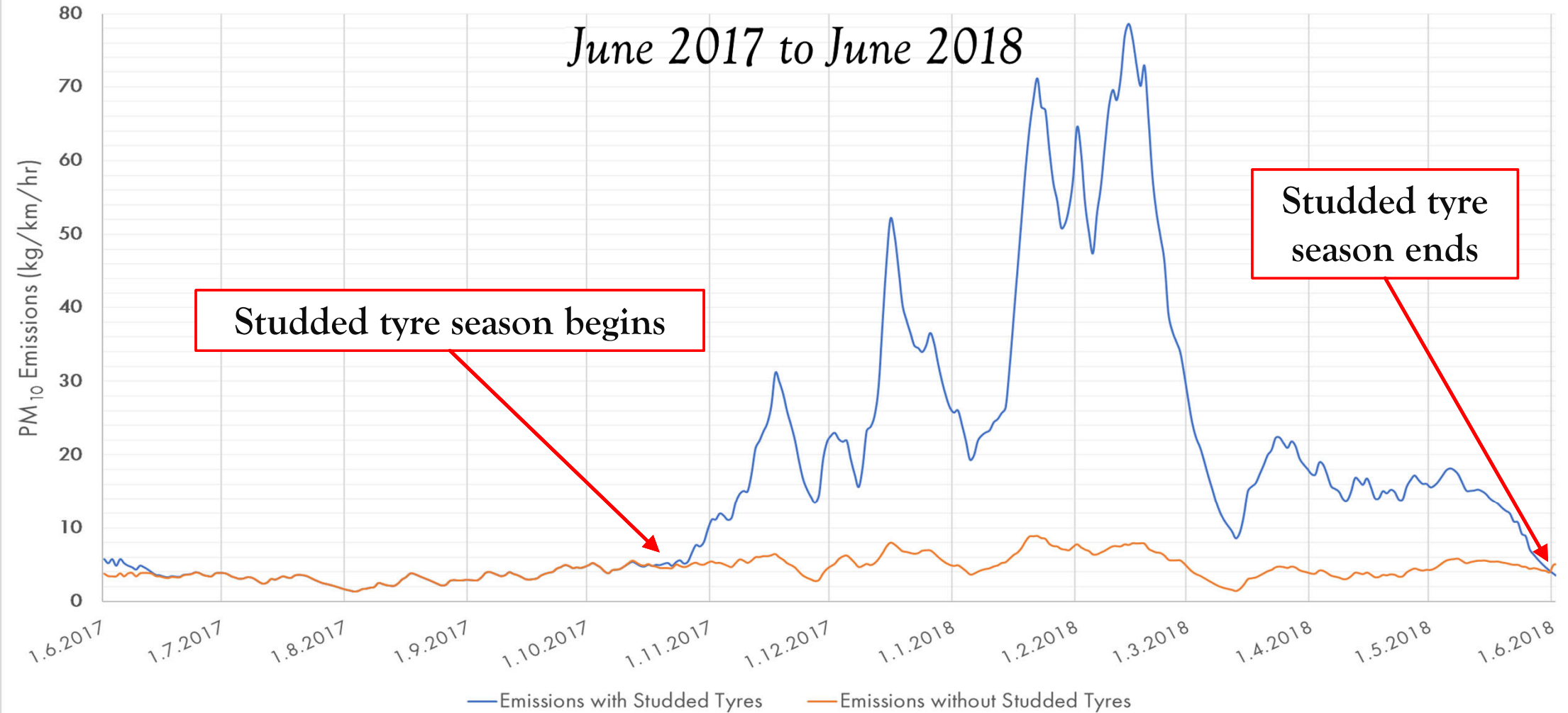
- ◇ Meteorology
- ◇ Road surface conductivity
- ◇ Road surface temperature

Data Source: Vegagerðin and Veðurstofan



# Modelled Emissions with & without Studded Tires

June 2017 to June 2018





# Road Wetness

- ◇ Lowers *resuspension*
- ◇ But, increases *wear rate*

## Affects modeled processes:

- ◇ Surface retention
- ◇ Surface dust mass sinks from drainage and spray
- ◇ Salt dilution
- ◇ Reduction of road and tyre wear due to ice

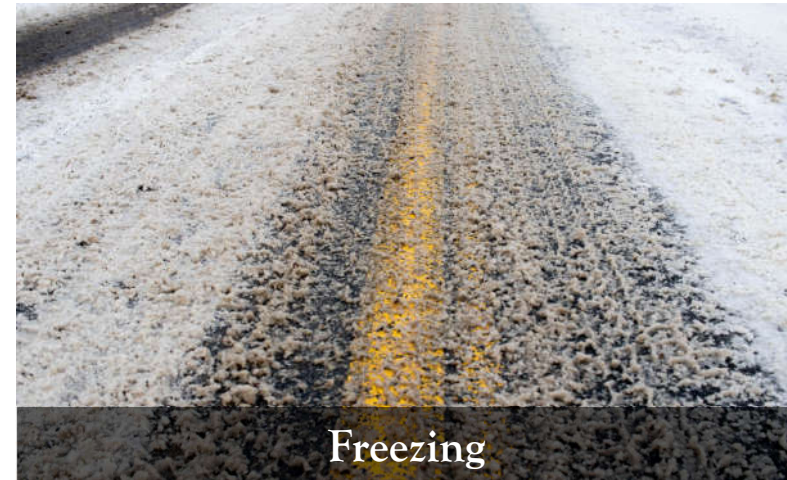


Image source: Johanna, Camping Iceland Blog, <http://www.campingiceland.com/iceland-driving-safety-tips-road-trip>



Image source: Pjetur, Iceland Magazine

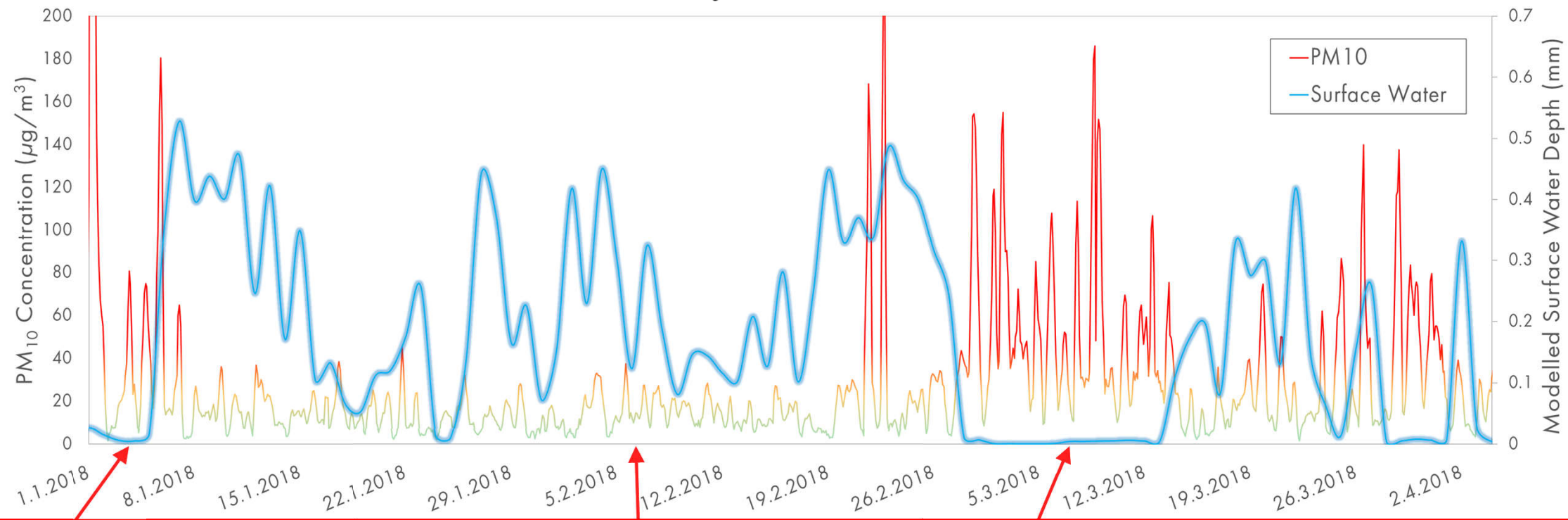


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# Rolling 6-hour Average of PM<sub>10</sub> at Grensás vs. Modelled Road Wetness

January – March 2018



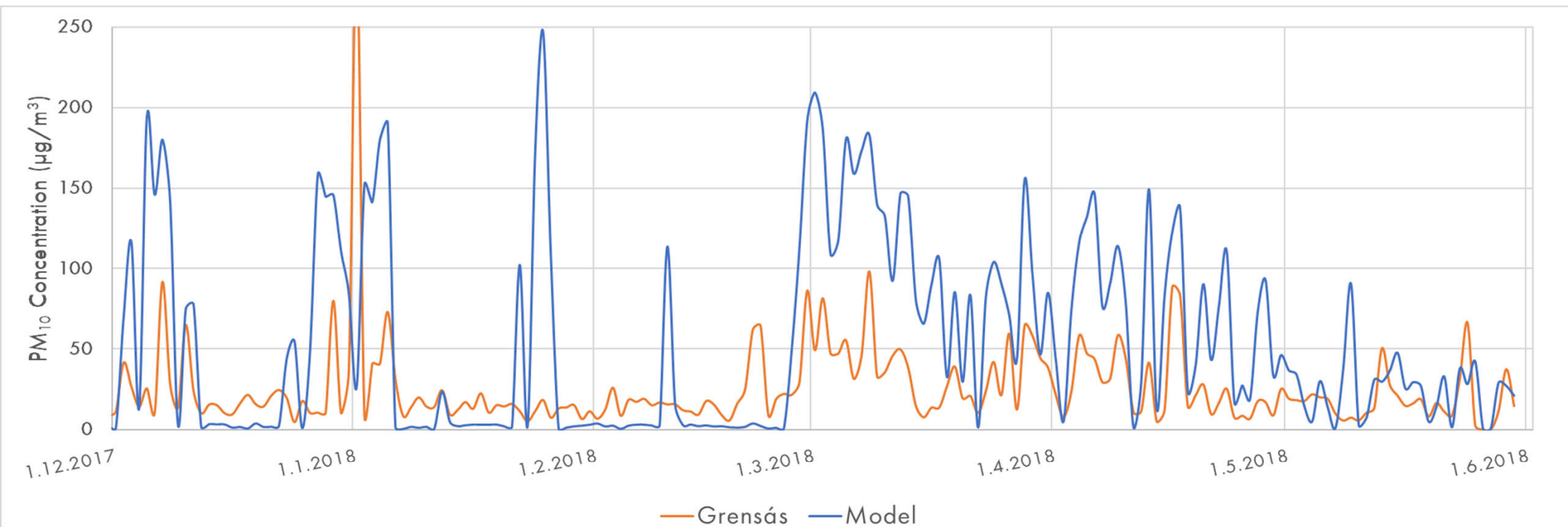
Very dry conditions coupled with fireworks on New Year's day 2018 caused dust levels to skyrocket.

Low PM<sub>10</sub> is recorded during prolonged period of wet roads for most of January and February.

During a two-week period of unseasonal dryness, PM<sub>10</sub> and PM<sub>2.5</sub> levels rose sharply, causing multiple exceedances of US and EU air quality standards.

# Measured vs. Modelled Daily PM<sub>10</sub>

1. December 2017 – 31. May 2018



A model run for the Kauptún site for the period from 1. June 2017 to 31. May 2018 shows some correlations ( $R^2 = 0.37$ ) with measured data at Grensás station, but these sites are considerably different, and these results are strictly preliminary.



# Conclusions

- ◆ Reykjavík is undergoing an alarming change in traffic that contributes to increased exceedances of particulate matter health safety limits.
- ◆ NORTRIP model quantifies studded tires as a significant dust generation mechanism.
- ◆ Dust accumulated on the ground is emitted when the road dries up.
- ◆ Next steps:
  - ◆ Expand and improve model inputs
  - ◆ Must account for salting, background and observed air quality data
  - ◆ Analyze observed data at Kauptún and Strandaheiði
  - ◆ Run scenarios with different vehicle speeds, road surfaces, fraction of studded tyres
  - ◆ Use of denser asphalts





## Acknowledgements

*Takk fyrir!*

- ◇ Martina Stefani, Umhverfisstofnun
- ◇ Bjarni Már Gauksson, Vegagerðin
- ◇ Nicolai Jónasson, Vegagerðin
- ◇ Björn Jónsson, Vegagerðin
- ◇ Ragnhildur G. Finnbjörnsdóttir, Umhverfisstofnun
- ◇ Anna Rut Arnardóttir, Háskóli Íslands
- ◇ EFLA
- ◇ Vegagerðin
- ◇ Reykjavíkurborg
- ◇ Umhverfisstofnun
- ◇ Veðurstofa





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## Location 2: Strandaheiði, Reykjanesbraut

- ◆ Traffic Counts
  - ◆ 5,75 million vehicles from June 2017 to May 2018
  - ◆ Average of approx. 15.700 vehicles per day
  - ◆ 6.2% considered heavy-duty
- ◆ Similar data availability as Kauptún

Strandarheiði - austur      Veðrið kl. 14:10      ANA 1 m/s 4°C



Kl. 14:23:02 - sun. 27. okt. 2019      Image source: Vegagerðin

# Non-exhaust traffic emissions generation

## Direct Mass Loading

- ◇ Road wear
  - ◇ Bitumen and aggregates types
  - ◇ Influenced by road wetness, surface temperature, asphalt composition, vehicle speed, meteorology
- ◇ Tire wear
  - ◇ Frictional energy between the rubber and road
  - ◇ Type of rubber, vehicle weight, asphalt characteristics, vehicle speed, studded tires
- ◇ Brakes wear
  - ◇ Higher generation at areas of frequent braking; traffic lights, junctions, corners, etc

## Indirect Mass Loading

- ◇ Resuspension of road dust
  - ◇ Influenced by wind, vehicles, and road wetness
- ◇ Emissions from vegetation, industry, and salting

