Holistic winter maintenance model

Markus Hoffmann
Head research group road asset management
Institute of Transportation Sciences, TU Vienna
markus.hoffmann@tuwien.ac.at

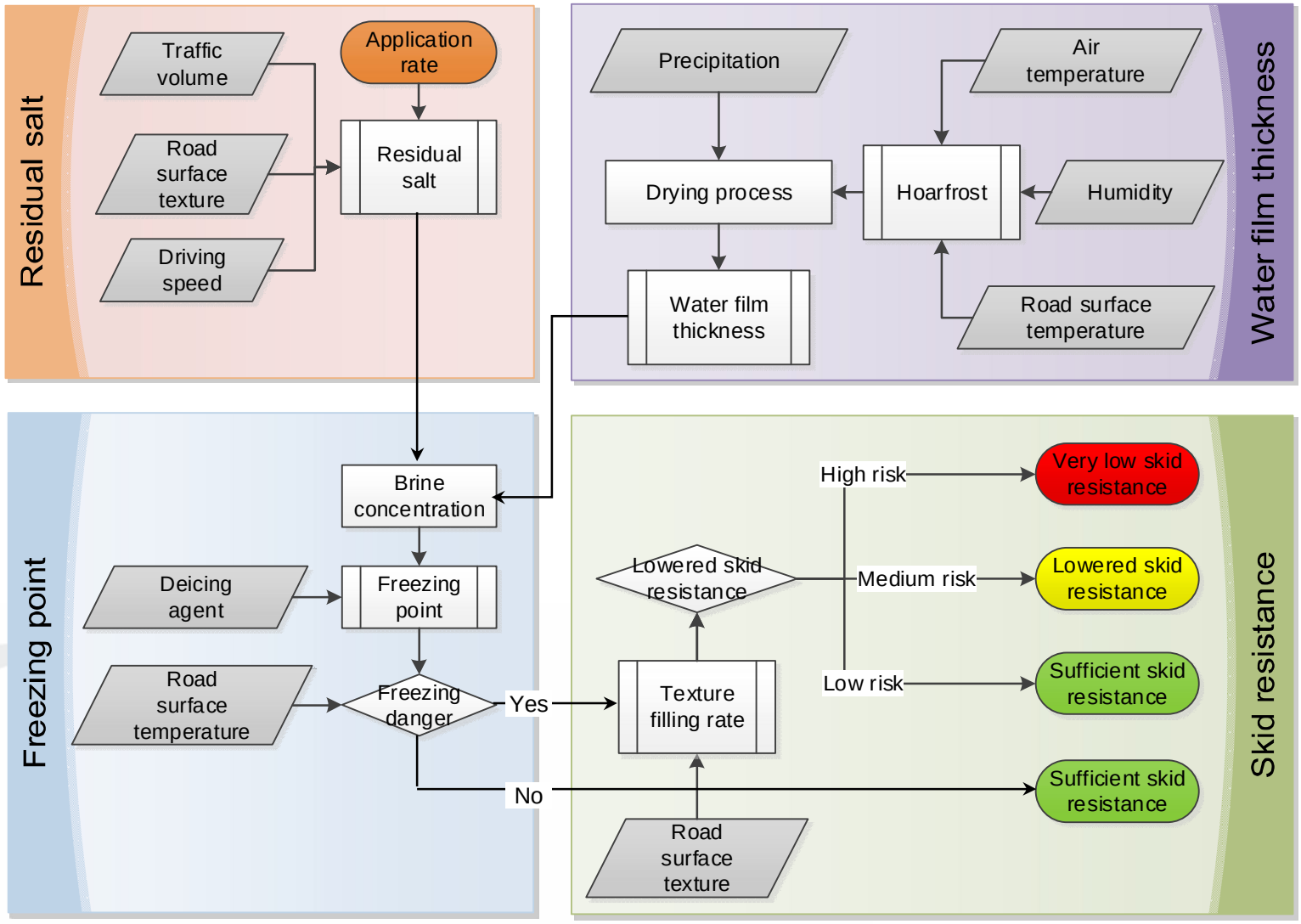
Peter Nutz & Ronald Blab
Institute of Transportation Sciences,
TU Vienna

0. CONTENT

1. Overview holistic winter maintenance model

Figure 1:

Schematic overview winter maintenance model @ TU Vienna



2. Salt application rates and residual salt

- Typical application rates between 5 to 40 g/m^2
- Results show initial salt losses of around 60%
- Further losses related to traffic & surface conditions

Figure 2: *Initial salt losses after application within the first 10 minutes*

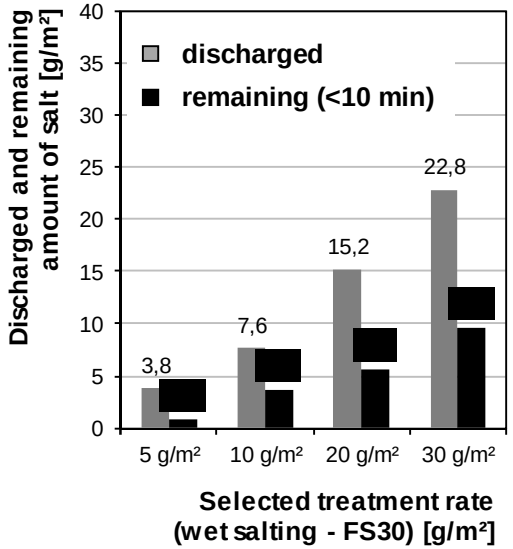
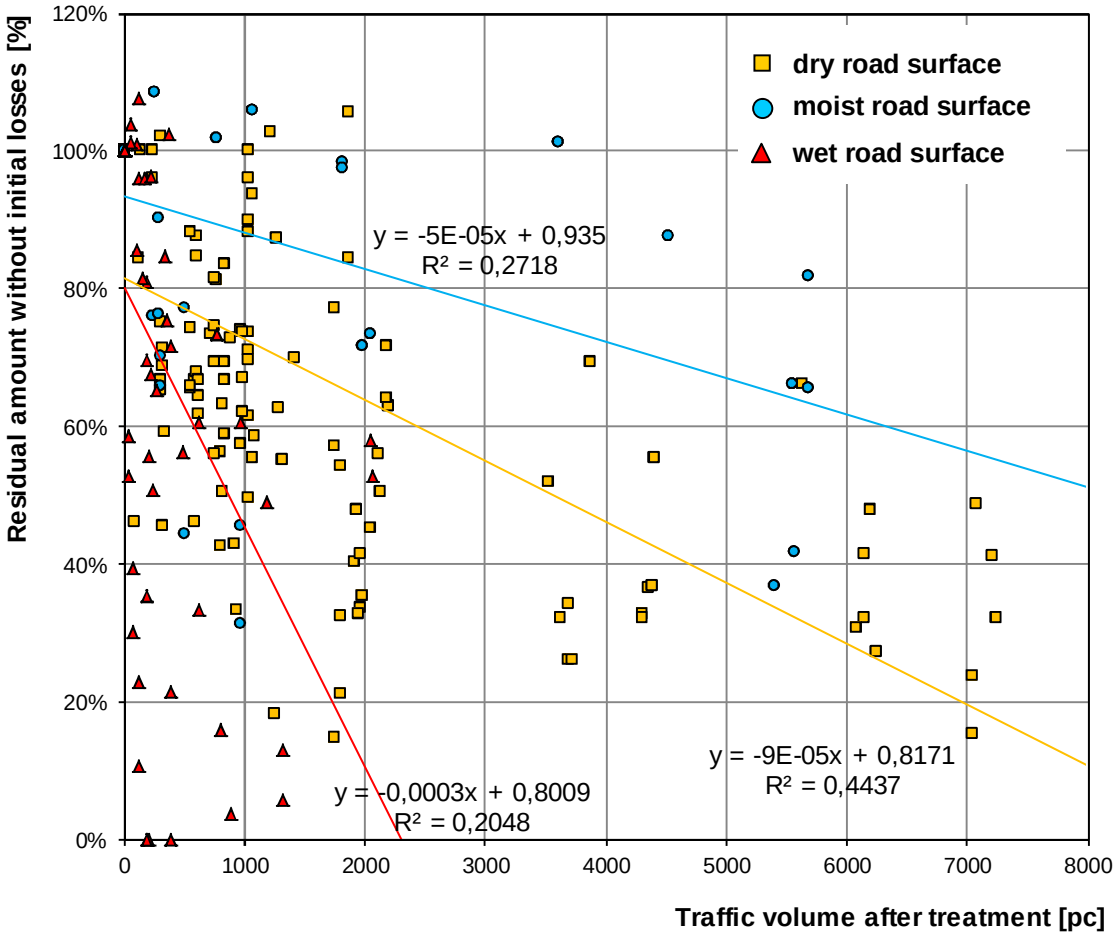
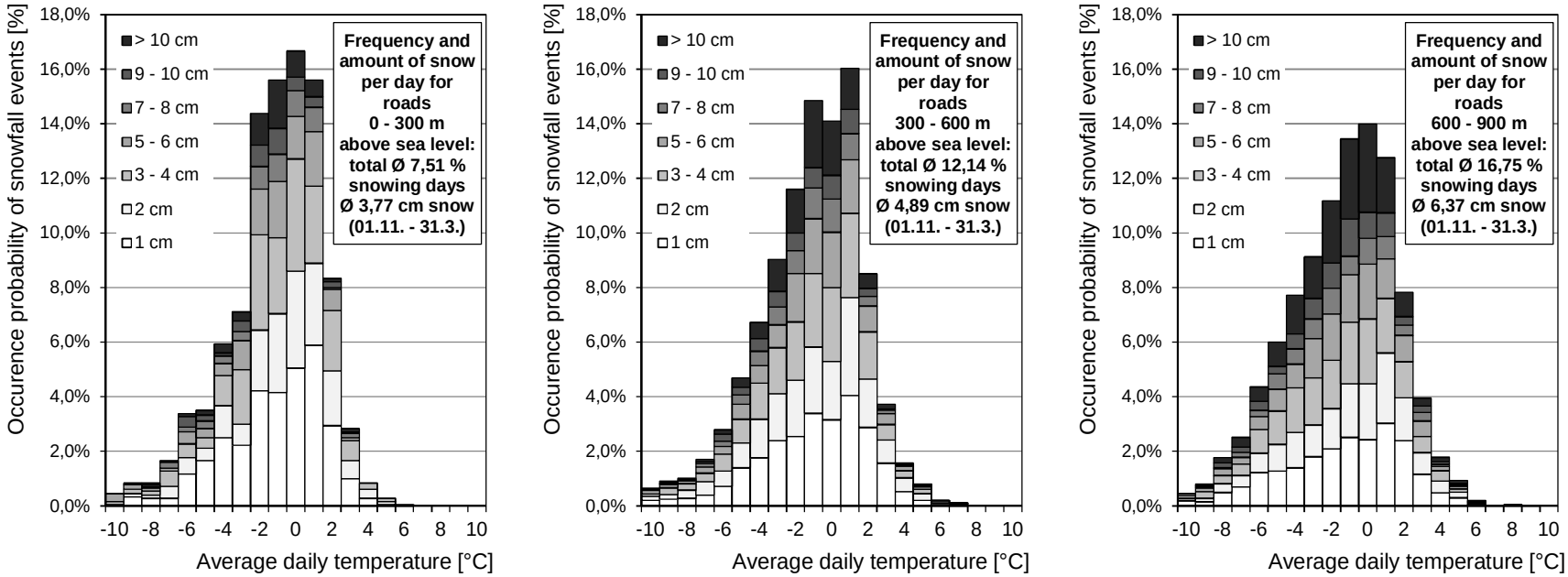


Figure 3: *Residual salt on the road depending on traffic volume and road surface conditions after initial losses*



3. Weather forecasts and snowfall events

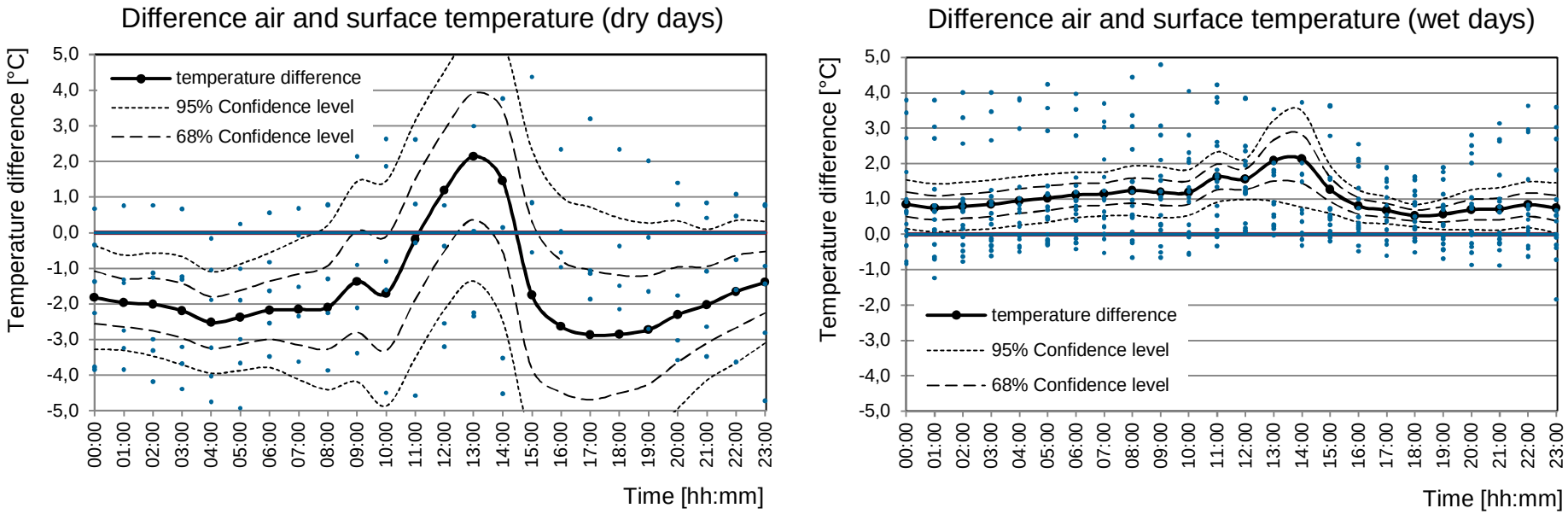
Figure 4: *Probability of snowfall events and total amount of snow per day depending on height above sea level and temperature in Austria*



- Majority of snowfall events in Austria between -4 to +2°C
- In average 11 (<300m), 18 (<600m) and 25 (>600m) snowfall days per year
- Still large deviations between prediction and measurements of events
- For details see *NUTZ, P. et. al. (2014); "Sensor based adaption of treatment strategies"*

4. Air and road surface temperatures

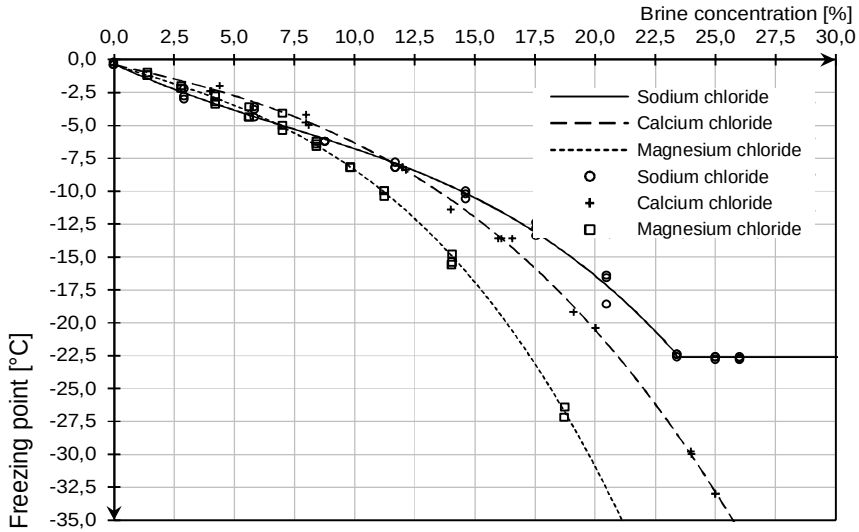
Figure 5: *Difference of air and pavement surface temperature on dry (unclouded) and wet (clouded) days*



- Predictions of air temperature somewhat accurate – surface temperature with large deviation
- Therefore real-time sensor measurement necessary for winter maintenance model
- For details see findings in *NUTZ, P. et. al. (2014); "Sensor based adaption of treatment strategies"*

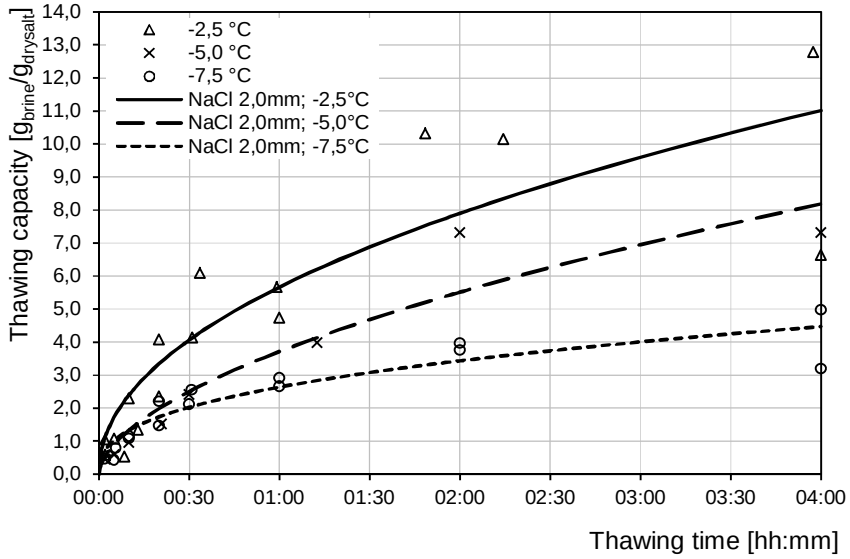
5. Freezing point and thawing capacity

Figure 6: *Freezing point diagram for different brine concentrations of sodium chloride, calcium chloride and magnesium chloride*



- Freezing point depends heavily on brine concentration
- Sodium chloride under normal circumstances cost-efficient

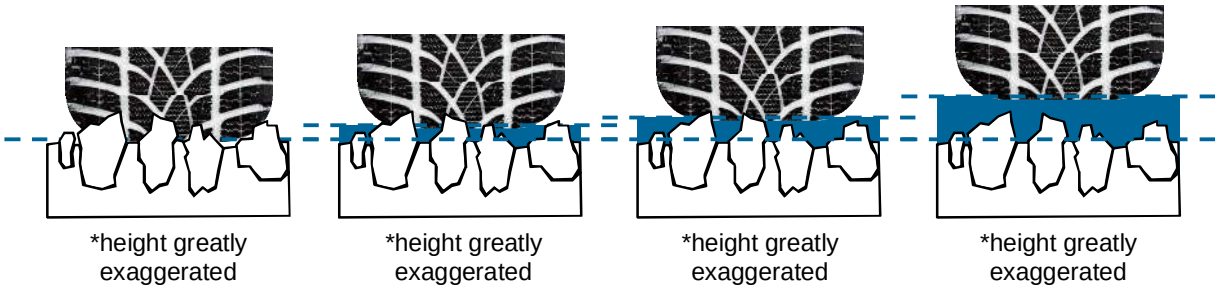
Figure 7: *Thawing capacity of sodium chloride for temperatures -2.5°C, -5.0°C and -7.5°C for a grain size of 2.0 mm to 3.15 mm*



- grain size, temperature and concentration of brine important
- Thawing and freezing processes take time, start fast and become slower
- More details in *NUTZ, P. et. al. (2014); „New test procedures for solid and liquid deicer“*

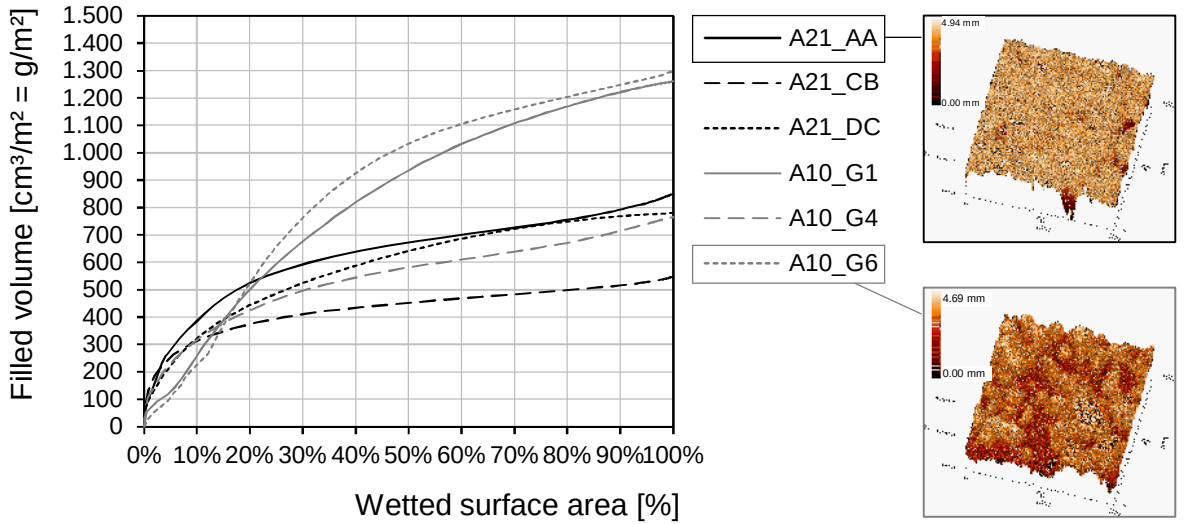
6. Pavement surface texture and skid resistance

Figure 8: *Reduced contact area tire-road due to filled texture volume with freezing precipitation*



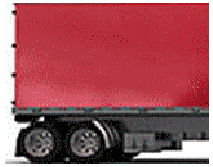
- Intermediate medium and contact area are crucial for resulting skid resistance

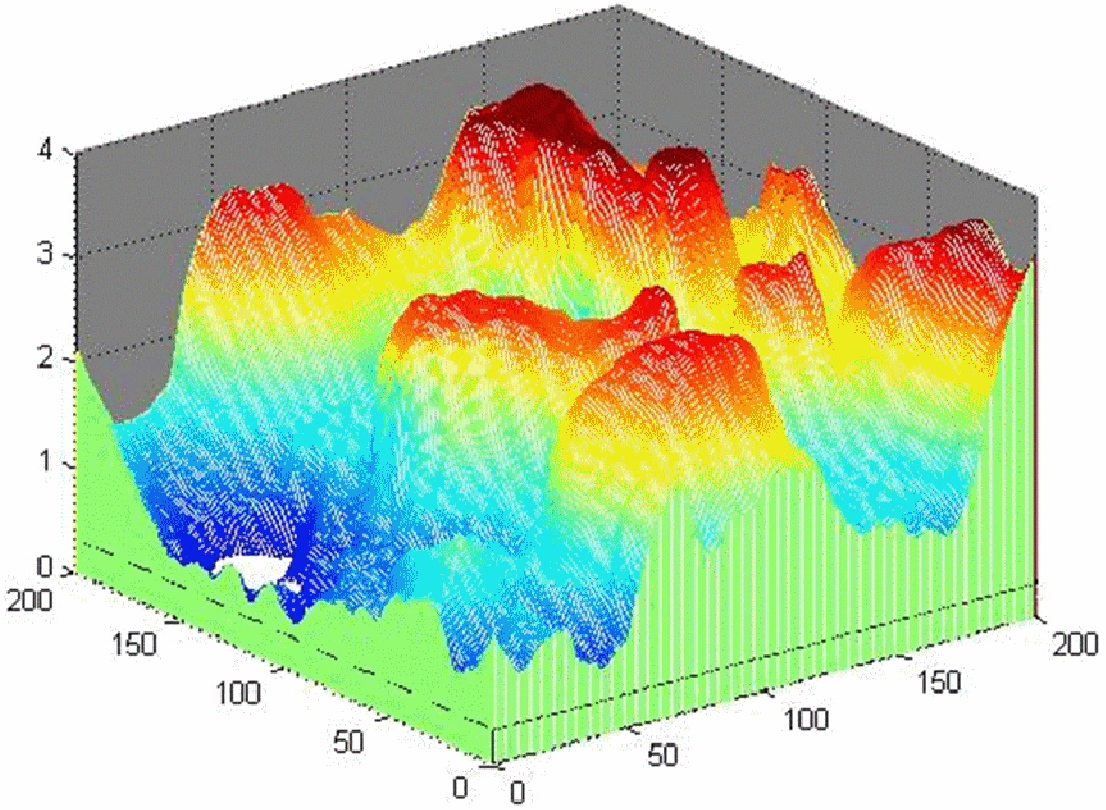
Figure 9: *Correlation: filled volume – wetted surface for 6 sample cores. with topography laser scans of cores A10_G6 (asphalt) and A21_AA (concrete)*



- Time to treatment depends heavily on surface texture
- At a certain filling rate a sudden loss of skid resistance can be observed

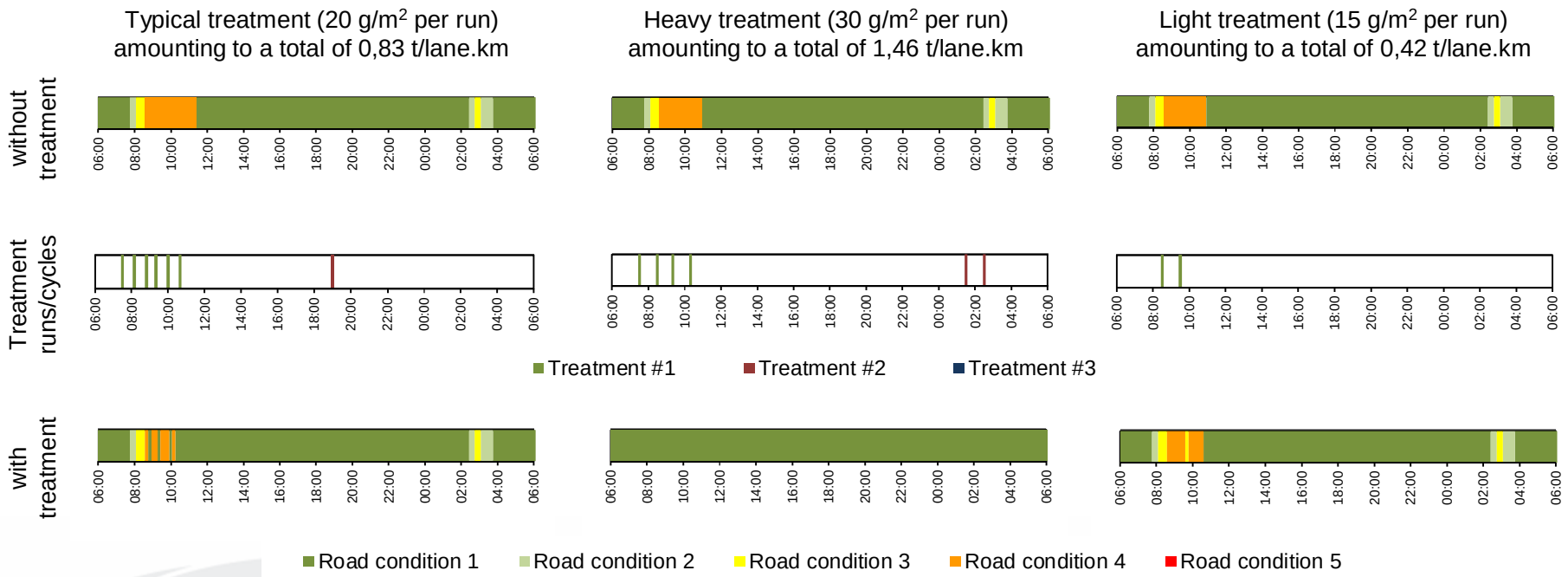
7. Speed and braking distances





8. Modeling treatment cycles & road surface conditions

Figure 10: *Development of road conditions for two precipitation events during one day without treatment and with typical, heavy and light treatment strategies*



- Very helpful for comparison of treatment strategies for typical situations
- For implementation of findings see *NEUHOLD et. al. (2014) „Innovative winter maintenance guidelines in Austria“*

9. Conclusions and outlook

- Holistic winter maintenance model developed
- Findings and practical guidelines available for the public
- Implementation and training of staff implemented
- Test procedures for deicing agents established
- Reliability of main input variables for live calibration determined
- Simulation and optimization of typical treatment cycles conducted
- Full live implementation with some adjustments feasible

Thank you for your attention