Friction Index: Nowcasting and Validation

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Contents

- Introduction
  - Why the study
  - What is the Friction Index (FI)
  - What is the forecasting model

- The study
  - Test site
  - Data sources
  - Methodology

- The results
  - Comparison in meteorological variables
  - Comparison in FI

- Summary and discussion
Ice Prediction

- During weather events (winter seasons), maintenance personnel are under pressure to:
  - Maintain the highest level of service (LOS) possible on a 24/7 basis
    - Increase safety
    - Improve mobility and efficiency
  - Minimize the cost associated with maintenance activities
    - Material usage
    - Vehicle operations
    - Human resources
  - Minimize the impact maintenance activities (e.g., chemical applications) have on the surrounding environment

- To achieve these goals, there is a need to understand the evolution of the atmosphere and pavement, as well as have the capacity to diagnose the current environmental and pavement conditions.
The Needs for Friction Forecasting

- Friction is very important in the safety of road traffic and aircraft taking-off and landing
- Loss of friction is closely related to incidents/accidents on road and at airport, especially in winter conditions when the surfaces are covered by ice, frost, snow or water
- Friction forecasting enables authorities to take preventative safety measures
Vaisala Friction Index (FI)

- A measure of road/runway surface slipperiness
- At speed of 60km/hour on a concrete surface
- Varying between 0.0 (no friction between tyre and surface) and 1.0 (highest possible friction)
- FI<0.3 is closely related to accidents in roads and at airports
The Forecasting Model - IceBreak

- It is used worldwide for road ice prediction
- It is a numerical model with embedded statistical tools
- Inputs:
  - Observations of air temp, dew point, wind speed, precipitation, surface temp, surface state (for nowcasts)
  - Optional: forecasts of cloud amount, cloud type and the above variables (for forecasts)
- Outputs:
  - Surface temperature, surface state, water thickness on surface, surface Friction Index
- Two prediction modes: Nowcasts (<=6 hours ahead), or forecasts (>6 hours ahead with optional inputs)
Physics of the IceBreak model: Energy balance

- Solar radiation
- Sensible heat
- Latent heat
- Net longwave radiation
- Traffic
- Ground conductive heat
- Roadside Weather Station
How IceBreak Model Works?

Measurements:
Ts, SS, Ta, Td, Ws, Prec, Salt

Optional:
External inputs as boundary conditions

Output:
Ts, SS, Fl, Ta, Td, Ws, cloud, etc

Site specific forecasts/nowcasts by Icebreak

Roadside weather station: Ts, SS, Ta, Td, Ws, Prec, Chemical
Test site: Helsinki Int. Airport, Vantaa

Approximate location of ROSA Weather Station
Data sources

- **Meteorological observations**
  - ROSA weather station located in the middle of runway three
  - Data collected at 1-min interval: Ta, Td, Ws, Prec, Ts, T6cm, Ss, water thickness
  - 55 days in total: Feb – Mar 2007

- **Friction measurements**
  - SNOWTAM system at the airport
  - Each of three runways is divided into 3 sections
  - The skiddometer gave the average braking action for each section of the runways
  - Measurements of 0 to 100 from the skiddometer was multiplied by 1/100 to give FI valued at 0.0 – 1.0
Methodology

- The IceBreak model was run in a nowcasting mode (1-, 2- and 3-hours ahead), in which cloud cover was automatically generated.
- Prediction of meteorological variables from the model was compared against sensor observations.
- Prediction of FI from the model was compared to skiddometer measurements in all 3 sections on Runway 1.
- The comparison is done in absolute error, bias, standard deviation (SD) and root-mean-square (RMS) error.
## Comparison of Met Forecasts at the Test Site (on Runway Three)

<table>
<thead>
<tr>
<th></th>
<th>1 hour</th>
<th>2 hour</th>
<th>3 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abs. error</td>
<td>Bias</td>
<td>SD</td>
</tr>
<tr>
<td>Surface Temp (°C)</td>
<td>1.04</td>
<td>-0.33</td>
<td>1.70</td>
</tr>
<tr>
<td>Air temp (°C)</td>
<td>0.32</td>
<td>-0.02</td>
<td>0.49</td>
</tr>
<tr>
<td>Dew point (°C)</td>
<td>0.36</td>
<td>-0.03</td>
<td>0.61</td>
</tr>
<tr>
<td>Water thick. (mm)</td>
<td>0.07</td>
<td>0.04</td>
<td>0.08</td>
</tr>
</tbody>
</table>
### Comparison between Forecast and Observed Friction for Section 2 on Runway Three

#### Overall:

<table>
<thead>
<tr>
<th></th>
<th>Number of Samples</th>
<th>Absolute Error</th>
<th>Bias</th>
<th>Standard Deviation</th>
<th>RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hour</td>
<td>1978</td>
<td>0.15</td>
<td>-0.03</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td>2 Hour</td>
<td>3623</td>
<td>0.13</td>
<td>-0.03</td>
<td>0.19</td>
<td>0.20</td>
</tr>
<tr>
<td>3 Hour</td>
<td>5293</td>
<td>0.15</td>
<td>-0.03</td>
<td>0.19</td>
<td>0.20</td>
</tr>
</tbody>
</table>

#### Threshold FI < 0.3 (when surface is highly risky)

<table>
<thead>
<tr>
<th></th>
<th>Number of Samples</th>
<th>Absolute Error</th>
<th>Bias</th>
<th>Standard Deviation</th>
<th>RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hour</td>
<td>13</td>
<td>0.08</td>
<td>0.01</td>
<td>0.08</td>
<td>0.08</td>
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<tr>
<td>2 Hour</td>
<td>29</td>
<td>0.13</td>
<td>0.07</td>
<td>0.12</td>
<td>0.14</td>
</tr>
<tr>
<td>3 Hour</td>
<td>47</td>
<td>0.15</td>
<td>0.11</td>
<td>0.12</td>
<td>0.16</td>
</tr>
</tbody>
</table>

#### Threshold FI >= 0.3

<table>
<thead>
<tr>
<th></th>
<th>Number of Samples</th>
<th>Absolute Error</th>
<th>Bias</th>
<th>Standard Deviation</th>
<th>RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hour</td>
<td>1965</td>
<td>0.15</td>
<td>-0.03</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td>2 Hour</td>
<td>3594</td>
<td>0.15</td>
<td>-0.03</td>
<td>0.19</td>
<td>0.20</td>
</tr>
<tr>
<td>3 Hour</td>
<td>5246</td>
<td>0.15</td>
<td>-0.03</td>
<td>0.19</td>
<td>0.20</td>
</tr>
</tbody>
</table>
Forecast FL again Measurement (1-h ahead, Section 2, Runway Three)
Forecast FI again Measurement (2-h ahead, Section 2, Runway Three)
Forecast FI again Measurement (3-h ahead, Section 2, Runway Three)
Error Distribution for 1, 2 and 3 hour FI Forecasts
Thank you!

Questions?