Probabilistic Winter Weather Nowcasting supporting Total Airport Management

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1. Winter Weather impact on airport operations
2. The PNOWWA (Probabilistic Nowcasting of Winter Weather for Airports) project
3. Weather radar based nowcasting methods for precipitation forecasting
4. Preliminary findings

Photo: heikki.junntti@fmi.fi
Winter Weather is a significant cause of flight delay and cancellations
Snow events affect all airport users

- Runway Maintenance
- Pilots
- De-icing crews
- Air Traffic management
- Ground operations
- Passengers
- Landside
Snow is not only snow

- How many centimetres to be removed from runway?
- Wet or dry snow – will it wash away the de-icing liquid?
- How bad is the visibility – can we land?
- More likely at EFTU or EFTP – where to re-route?
- Luggage!
- Taxi queue!
- Bus delay!
Effects of winter weather to airport activities can be mitigated if
- Forecasts are good
- Information reaches users
Better forecasts -> better timing of airport activities -> reduces the effects of adverse weather

-> improve airport capacity
-> improve efficiency and punctuality of air traffic
Nature of weather forecast is PROBABILISTIC

Based on the area covered by the phenomenon

- Probability of snow 30%
- Probability of snow 90%
PNOWWA = Probabilistic Nowcasting of Winter Weather for Airports

Research Demos

Probability distributions

User needs

Terrain effects


Runway Maintenance

De-icing

Tower

Finnish Meteorological Institute

AustroControl

Deutsches Zentrum für Luft- und Raumfahrt (DLR)
Airport users opinions for probabilistic winter weather forecasts – potential benefits

- Helps to make objective decisions
- When cost-loss ratios are known it can be used in decision support
- Positive attitude to probabilistic forecasts
- Need for lead time 3 and 12-24 hours products

Useful lead time for warning of critical weather from all respondents (PNOWWA survey)
Airport users opinions—highest negative impact affecting on airport operations

1. Heavy snowfall
2. (low visibility)
3. Freezing rain and drizzle
4. Moderate snowfall
5. Wind speed above
6. Sleet

the type of winter weather with a negative impact on airport operations (PNOWWA survey)
## Thresholds of winter weather to runway maintenance, de-icing and tower

Based on communication with users in different airports for relevant weather conditions affecting to their processes. Impact verification during demonstration.

<table>
<thead>
<tr>
<th>user</th>
<th>weather</th>
<th>thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>dry snow</td>
<td>&gt; 10 mm/15min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-10 mm/15min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-5 mm/h/15 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 1 mm/15 min</td>
</tr>
<tr>
<td></td>
<td>wet snow</td>
<td>&gt; 5 mm/15min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-5 mm/15min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-2 mm/15min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 1 mm/15min</td>
</tr>
<tr>
<td></td>
<td>freezing RA</td>
<td>occurrence probability %</td>
</tr>
<tr>
<td></td>
<td>freezing of surfaces after air cooling to minus deg.</td>
<td>occurrence probability %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>De-icing</th>
<th>De-icing weather type (based of duration of de-icing of a plane)</th>
<th>DIW 3</th>
<th>DIW 2</th>
<th>DIW 1</th>
<th>DIV 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower</td>
<td>VIS in Snow</td>
<td>&lt; 600 m</td>
<td>600-1500 m</td>
<td>1500-3000 m</td>
<td>&gt; 3000 m</td>
</tr>
</tbody>
</table>
Nowcasting with extrapolation of radar images in PNOWWA

Combining three approaches:

- Andersson
- RAVAKE
- STEPS

Common principle:
Time = distance/speed

Example:
Storm 75 km away, moving 50 km/h arrives in 90 minutes

.....dry.............. snow...maybe
Benchmark:
Andersson & Ivarsson 1991

Motion vector from 850 hPa wind vector from numerical weather prediction model
Uncertainty = uncertainty of movement direction = area of sector
Classic approach: RAVAKE

Movement analysed with AMV (atmospheric motion vectors) comparing recent radar images

Trajectory field calculated backwards from 2d motion vector field

Uncertainty from Gaussian ellipse around source area

Pixels in ellipse = forecast for 90 min
51 ensemble members are obtained by perturbing precipitation intensities and motion field.
- The ensemble mean represents the “most probable” precipitation intensity.
- The mean field becomes smoother when the forecast time increases: badly predictable scales are filtered out.
- The ensembles also yield probability distributions of precipitation intensities.

It is more user friendly deliver one probabilistic forecast than 51 radar extrapolations.
PERJANTAIILTAPÄIVÄ 24.3.2017
Luoteesta virtaa kuivempaa ilmaa.
Lasajäätä aurinkoinen ja poutainen päivä.
Idässä ja oisella pienein runsaat ja
pakkoin synnytys yleisellä tähtäviä lentävä
lumikuuajoja. Kennyitä hyvin vähäällä.
Lämpötiloihin otettu mukaan HIR ja MOS
lämmittämään EC-ta.
Tehty 24.3. / Ida

Ennuste 24.03.2017 klo 12 UTC

Snow Showers 24 March 2017 Helsinki
Snow Showers 24 March 2017 Helsinki
Snowing over threshold intensity only in two 15-minute periods
30 min forecast

24 March 2017
EFHK observations, 1=snow, 0=dry
30 min forecast

Forecasted probabilities 20-50%
Low probabilities provide a hint 120min in advance

Forecasted probabilities 5-20%

Snow showers observed
Winter Weather challenges still remaining

MET timelines vs. SESAR ATM phases (SESAR: P11.02.01: D26 MET Detailed Operational Description (MET-DOD) – report)
Winter Weather and climate change

“Snowfall will generally decrease throughout Europe although there may be heavy snow events in new areas and an increase in more-challenging wet snow conditions. Snow in locations where it is not usually experienced has the biggest effect on airport operations due to relative lack of preparedness. Overall, more snow clearing and de-icing equipment may be required. A balance always needs to be struck between the financial costs and an adequate level of preparedness, but climate change may shift the balance.”

(Challenges of Growth 2013, Summary report, Eurocontrol)
PNOWWA research demo 2017

- Online service with automatic update
- Tailored products to:
  - Runway maintenance
  - De-icing agents
  - Tower
- Probabilities of the weather categories defined with users are used to individual users
- Forecasted parameters:
  - Accumulation of DRY snow
  - Accumulation of WET snow
  - Probability of freezing rain
  - Probability of freezing of wet runways
  - De-icing weather type (categories dependent on the time of individual plane de-icing duration
- Decrease of visibility CAUSED BY SNOW (fog or mist outscored)
PNOWWA Probabilistic Nowcasting of Winter Weather for Airports

Thank you very much for your attention!

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