Report of simulation campaign:

First research demonstration of prototype of probabilistic winter precipitation forecast

D6.1 – REPORT OF SIMULATION CAMPAIGN

PNOWWA

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PNOWWA

PROBABILISTIC NOWCASTING OF WINTER WEATHER FOR AIRPORTS

This document of user needs for PNOWWA demonstration is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 699221 under European Union's Horizon 2020 research and innovation programme.

Abstract

PNOWWAs probabilistic forecast of winter weather for airports have been successfully demonstrated. Data were provided via webpage as "live" data. Airports in Finland and Austria have been selected and we got feedback from operational staff at the airport in Finland. In Austria, due to the warm weather conditions during the test phase, the system wasn't used. Based on results from this demonstration period (winter 2017), we plan next preparation steps for winter 2017/2018 demonstration to improve the product, validate and promote the probabilistic nowcast.

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Abbreviations

ACC	Area control centre
ANS	air navigation service
APCH	approach
ATC	Air Traffic Control
ATCO	Air Traffic Controllers
AUA	Austrian Airlines
CB	Cumulonimbus cloud
DIW	De-Icing Weather Index
DLR	German Aerospace centre
EFHK	Helsinki airport
EFRO	Rovaniemi airport
FZ	Freezing
FZRA	freezing rain
FINNAIR	Finnish Airlines
+FZRA	heavy freezing rain
HIRLAM	High Resolution Limited Area Model
ICAO	International Civil Aviation Organization
LOWI	Innsbruck airport
LOWS	Salzburg airport
LOWW	Vienna Airport
LVP	Low Visibility Procedures
PROB	Probability forecast group in Terminal Aerodrome Forecast TAF
RA+	heavy rain
RWY	Runway
STEPS	Short Term Ensemble Prediction System
TAF	Terminal Aerodrome Forecast
TWR	tower
WHITE	Winter Hazards In Terminal Environment
WP	work package

Executive Summary

PNOWWA - Probabilistic Nowcasting of Winter Weather for Airports – is a research project developing methods to support the Air Traffic Management (ATM) challenged by winter weather. PNOWWA will demonstrate very short-term (0-3 hour nowcast) probabilistic winter weather forecasts in 15 minutes time resolution based on extrapolation of the movement of weather radar echoes. This deliverable documents the simulation campaign performed during the second half of winter 2017 including the first research demonstration of prototype of probabilistic winter precipitation forecast. Fulfilling the project objects, the second demonstration phase is planned for the winter period 2017/2018, which will utilize the experiences learned from the first demonstration campaign.

1 Introduction

1.1 Overview

This document describes the first demonstration phase during second half of winter 2017 of the PNOWWA probabilistic nowcasting product of winter weather for airports, derived from weather radar extrapolation. The topic of WP6 in PNOWWA includes a) test of the concepts which are developed in the other work packages and b) to collect feedback from test users and forecasters. Here, we focus on a) – the report of demonstration phase 1.

In SEASAR1 WP11.2 determinstic nowcast (short range forecast) was created for runway maintenance, visibility in snowfall and de-icing weather index. IN PNOWWA we demonstrate probabilistic nowcasting for airport users.

It was agreed in the PNOWWA webmeeting on 27th October 2016 (PNOWWA Minutes Webmeeting 20161027) , to provide the online demonstrator to deliver realistic environment, test operational applicability and collect feedback direct from users such as ATCOs (APCH, TWR), de-icing, runway/airside maintenance, airliners and airport itself.

After preparation, the stakeholder survey, personal interviews and workshops we collected relevant lead time, parameter and possible impact thresholds (see PNOWWA deliverables D4.1 “survey of user needs” and D4.2 “user needs for demonstration”). Additional 4 airports were selected as test sides. Two Finnish and two Austrian have been selected: EFHK, EFRO and LOWW, LOWI.

The PNOWWA product is still under development, but in schedule of the project plan. Short preparation time after project start leads to a first version which used simple 850hPa wind for deriving motion vectors for the weather radar extrapolation. Next version includes motion vectors gathered from stochastic ensemble. Additional, the impact of mesoscale effects (mountains and sea) to snow fall intensity will be closer investigated in the second part of the project.

With slightly delay (due to the ambitious schedule), the PNOWWA demonstrator of probabilistic winter weather forecast was provided in February and March 2017 via own webpage.

Adverse winter weather occurred in Austria in January only. During our test phase (Feb/Mar 2017) the weather in Austria was rather warm and no snow fell. In contrast, in north of Finland the winter lasted to the end of demonstration period as usual.

Feedback from airport operations and ATM is still under collection. Individual discussions and demonstration of high impact “offline” case studies will help to improve the probabilistic application for next year demonstration campaign.

Finally, second demonstration phase is planned for the winter period 2017/2018.

2 Demonstrator - first phase

2.1 Selected airports

The four selected airports reflect winter conditions in middle and northern latitudes, large and small airports as well as big and small hubs. The two northern Finnish airports are Helsinki (EFHK) and Rovaniemi (EFRO). EFHK is the main hub in Finland where winter weather can be modified from the sea (lake effect). EFRO far north ensures winter conditions for the validation of our PNOWWA prototype even during warm conditions in Central Europe. In Austria the main hub Vienna (LOWW) was selected. The airport is situated along the eastern edge of the Alps. The second airport in Austria is Innsbruck (LOWI) where winter weather is affected by topographic effects and significant charter traffic during winter weekends is predominant.

Different thresholds for different stakeholders such as ATM or airport operations are listed in PNOWWA deliverable D4.2 “user needs for demonstration”.

In

Table 1 the different user groups for selected airports during demonstration campaign 1 are listed, mainly runway maintenance for all four airports and ATM-tower and de-icing for three airports.

Table 1: User groups for different airports during first simulation campaign.

		Stakeholder				
		ATM TWR	ATM APCH	RWY maintenance	De-Icing	Airline
Airport	EFHK	x		x	X	Finnair
	EFRO			x		
	LOWW	x	X	x	X	AUA
	LOWI	x		x	X	

2.2 Login information

Web address: http://ilmanet.fi

Austria:

Username/Käyttäjätunnus: AustroControl

Passwort/ Salasana: PNOWWA17

Finland:

Username / Käyttäjätunnus: finavia_pnowwa

Passwort / Salasana: PNOWWA17

Login data were provided to ATM, runway maintenance, de-icing and airliner, as well as meteorological forecaster at the airport.

Austro Contol / FMI were responsible for coordination of Austrians airports (LOWW, LOWI) / Finish airports (EFHK, EFRO) .

2.3 Used data and availability

Demonstration phase started on 2nd February and ended on 31st March 2017. Product dissemination started on 8th February.

The product is available and updated every 15 minutes for 4 airports (LOWW, LOWI, EFHK, EFRO) – using 2 different logins for Austria and Finland.

Used radar data was the OPERA composite. The planned data, local weather radar sites Rauchenwarth/Vienna for LOWW, Patscherkofel/Innsbruck for LOWI and Finnish composite for EFHK and EFRO, were tested but not used during the demonstration because of unsolved quality difference issues.

For details the reader is revered to the PNOWWA document D5.2 “Software components and documentation”.

2.4 Method

2.4.1 Motion and uncertainty of precipitation areas

For this demonstration product 850 hPa numerical model wind is used for motion vector, extrapolating weather radar images. A 60 degree movement uncertainty sector is used to derive probabilities of snow fall intensities.

For details the reader is revered to the PNOWWA document D5.2 “Software components and documentation”.

2.4.2 Probabilities of FZRA and DIW

Excerpts from D5.2 “Software components and documentation” defining probabilities of freezing rain (FZRA) and De-Icing Weather (DIW).

Probabilities of freezing rain are defined by the rules:

- T<=0 and T is combination of METAR and HIRLAM model output. T of METAR is used during first timestep as it is and that value is changed by the change of temperature in HIRLAM model during forecasting time. If that first condition is true, then next rules will be taken into account:
- Highest Probability will be taken into account
- If it is observed FZRA in actual METAR, then PROB of FZRA = 100 at time interval 0…+15 min. During next steps the PROB_FZ (step)=Prob_FZ (previous step)*70%
- If Model (Hirlam) forecasts Precipitation Freezing rain, then Prob_FZRA=40% through all time steps model forecasts that.
- If Model (Hirlam) forecasts Freezing Potential Precipitation Form Prob_FZ=30% through all time steps model forecasts that.

Probability of frost in De-icing weather type (DIW) forecast (DIW = 1 class) is dependent on the Temperature and humidity of air. The values of METAR observations and HIRLAM model output are used same as described above. Probability distribution connected to temperature (T) and dew point temperature (Td) values are described at the ***Table 2***.

Table 2: Probability distribution connected to temperature (T) and dew point temperature (Td) values

		Td							
		-6	-5	-4	-3	-2	-1	0	1
T	-3	60	80	100	100				
	-2	30	60	80	100	100			
	-1		30	60	80	100	100		
	0			30	60	80	100	100	
	1				30	60	80	100	100

- Principle of DIW probability definitions are:
  - DIW_3=max(Freezing rain (DIW Class 3), snow (DIW Class 3) + snow (DIW Class 2))
  - DIW_2=min(Freezing rain (DIW Class 2), 100% - DIW_3)
  - DIW_1=min(Frost (DIW Class 1), 100% - (DIW_3 + DIW_2))

- ○ DIW_0=100% - (DIW_3 + DIW_2 + DIW_1)

Probability of freezing of runway is based on the rules:

- ○ Observed Liquid precipitation (Wet_Runway=100%) and then Frost (like DIW class 1 table)
- ○ Wet_Runway=Wet_Runway*70% every 15 mins
- ○ Wet_Runway>=10% (min limit)

2.5 Layout – web page

The webpage is separated in 3 parts:

- PNOWWA winter weather forecast product for demonstration
- Product definitions
- Feedback form

The selection menue from the left upper corner in the demonstrator start web page is presented in **Figure 1Error! Reference source not found.**.

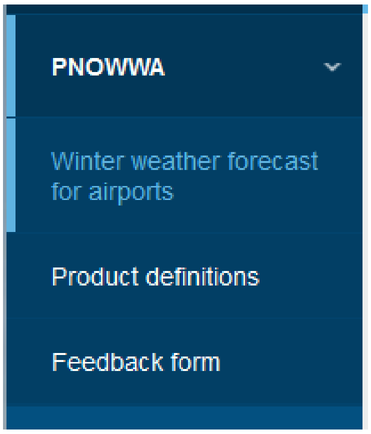

***Figure 1*: PNOWWA demonstration selection menu**

An overview of the winter weather forecast product from PNOWWAs first demonstrator web page is given in **Figure 2**. In following subchapters more detailed information is given.

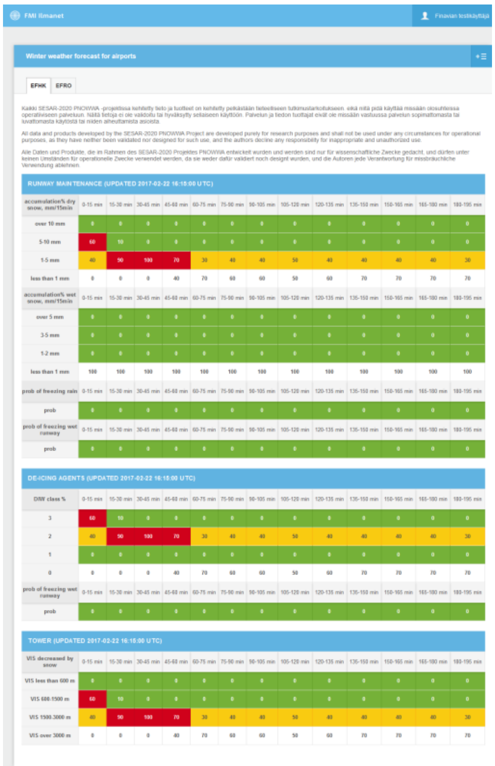

Figure 2: Layout of the first PNOWWA demonstration campaign web page for Helsinki airport on 22nd February 2017 after selecting favouring airport.

2.5.1 Preamble

A preamble in Finnish, English and German for the use as test product was included:

Kaikki SESAR-2020 PNOWWA -projektissa kehitetty tieto ja tuotteet on kehitetty pelkästään tieteelliseen tutkimustarkoitukseen eikä niitä pidä käyttää missään olosuhteissa operatiiviseen palveluun. Näitä tietoja ei ole validoitu tai hyväksytty sellaiseen käyttöön. Palvelun ja tiedon tuottajat eivät ole missään vastuussa palvelun sopimattomasta tai luvattomasta käytöstä tai niiden aiheuttamista asioista.

All data and products developed by the SESAR-2020 PNOWWA Project are developed purely for research purposes and shall not be used under any circumstances for operational purposes, as they have neither been validated nor designed for such use, and the authors decline any responsibility for inappropriate and unauthorized use.

Alle Daten und Produkte, die im Rahmen des SESAR-2020 Projektes PNOWWA entwickelt wurden und werden sind nur für wissenschaftliche Zwecke gedacht, und dürfen unter keinen Umständen für operationelle Zwecke verwendet werden, da sie weder dafür validiert noch designt wurden, und die Autoren jede Verantwortung für missbräuchliche Verwendung ablehnen.

2.5.2 Winter weather probability forecast for airports – runway maintenance:

An example of PNOWWA demonstrator layout for EFHK on 22nd February 2017 is given in ***Figure 3***. Listed table starts with probabilistic forecasts for runway maintenance. Numbers and colors indicate and highlight the probability of each individual class. (0-20% in green, 30-50% in yellow and 60-100% in red). Forecast classes in 15-minute intervals capture accumulation of dry and wet snow for different predicted snow heights, probability of freezing rain and probability of freezing wet runway. E.g the first time step (forecast up to 15 minutes) shows 60 % probability for dry snow accumulation of 5 to 10 mm and 40 % probability of dry snow accumulation between 1 and 5 mm. Second time step (forecast 15-30 min) shows 10% probability for dry snow accumulation between 5 and 10 mm, but high 90 % of snow aggregation between 1-5 mm. For the last time step (forecast time 3 hours = 180-195 min) the probability of snow accumulation above 1 mm is still 30 %. Other classes of dry snow aggregation, freezing rain or freezing of the wet surfaces show probabilities of 0 % over the entire forecast period of 3 hours.

RUNWAY MAINTENANCE (UPDATED 2017-02-22 16:15:00 UTC)													
accumulation% dry snow, mm/15min	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
over 10 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
5-10 mm	60	10	0	0	0	0	0	0	0	0	0	0	0
1-5 mm	40	90	100	70	30	40	40	50	40	40	40	40	30
less than 1 mm	0	0	0	40	70	60	60	50	60	70	70	70	70
accumulation% wet snow, mm/15min	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
over 5 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
3-5 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
1-2 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
less than 1 mm	100	100	100	100	100	100	100	100	100	100	100	100	100
prob of freezing rain	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
prob	0	0	0	0	0	0	0	0	0	0	0	0	0
prob of freezing wet runway	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
prob	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3. : Layout of demonstrator product for runway maintenance. Probabilities (dry/wet snow aggregation, freezing rain and risk of freezing wet runway) for Helsinki International Airport, 22nd February 2017 16:15 – 18:30 UTC.

2.5.3 De-icing:

The second part of the PNOWWA demonstrators web page reflects de-icing weather product as described in chapter 2.4.2. De-icing time of individual airplane is directly dependent on the weather during stay of it on ground. High values of DIW indicate long de-icing time for airport operators and airliners. DIW value of 3 reflects ice or lot of snow on the aircraft. DIW value of 2 indicates some

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amount of snow on the aircraft while DIW of 1 stands for frost on the aircraft. In case of DIW = 0, no de-icing is needed.

In the presented example in ***Figure 4***, the probability for DIW class 3 (severe icing conditions) is 60 % (red) in the first 15 minutes forecast period followed by 10 % (green) up to a lead time of 30 minutes. Higher probabilities (70-100 % in red) are shown for the DIW class 2 for lead time 15 to 60 minutes followed by lower probabilities (30-40 % in yellow). In contrast, the DIW class 0 increased up to 70 % of probability for lead times larger than 60 minutes.

DE-ICING AGENTS (UPDATED 2017-02-22 16:15:00 UTC)

DIW class %	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
3	60	10	0	0	0	0	0	0	0	0	0	0	0
2	40	90	100	70	30	40	40	50	40	40	40	40	30
1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	40	70	60	60	50	60	70	70	70	70
prob of freezing wet runway	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
prob	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4: Layout of demo product winter 2017 for de-icing agents. Probabilities for different DIW classes and probability of freezing wet runway are shown for EFHK on 22nd February 2017, forecast interval from 16:15 till 19:30 UTC.

2.5.4 ATM (APCH, TWR):

The third part of PNOWWA demo web page lists ATM relevant visibility reduction due to snow fall (***Figure 5***). ATM relevant ceiling information as requested in work-package 4 (see PNOWWA deliverables D4.1 “survey of user needs” and D4.2 “user needs for demonstration”) are not included due to the used methods and sensors in this project.

In this example, higher likelihood (60 %) for decreasing visibility below 1500 m is shown for lead time up to 15 minutes followed by very high probability (70-100 %) of visibility class between 1500 and 3000 m for lead time 16:30 to 17:15 UTC.

TOWER (UPDATED 2017-02-22 16:15:00 UTC)

VIS decreased by snow	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
VIS less than 600 m	0	0	0	0	0	0	0	0	0	0	0	0	0
VIS 600-1500 m	60	10	0	0	0	0	0	0	0	0	0	0	0
VIS 1500-3000 m	40	90	100	70	30	40	40	50	40	40	40	40	30
VIS over 3000 m	0	0	0	40	70	60	60	50	60	70	70	70	70

Figure 5: PNOWWA demonstrator for probabilities of ATM relevant visibility reduction due to snow fall.

2.6 Explanation of PNOWWA demonstrator product

Definitions and explanations were included within the PNOWWA demonstration webpage:

PNOWWA

PROBABILISTIC NOWCASTING OF WINTER WEATHER FOR AIRPORTS

PNOWWA SCIENTIFIC DEMONSTRATION DEFINITIONS:

The dependency between weather and DIW is seen in the table below

Effect on aircraft	**DIW=3, severe**	**DIW=2, medium**	**DIW=1, light**	**DIW=0,** no need for de-icing
Ice on plane	Freezing rain/drizzle			
Snow on plane	Heavy snow or sleet, visibility cased from precipitation below 2 km, deduced from weather radar information	Light/moderate snow or sleet, visibility cased from precipitation above 2 km, deduced from weather radar information		
Frost on plane			Risk for frost formation on the plane surface. Temperature between -3….+1 and humidity over 75%	
No remarkable contamination on plane				All other cases

Class Wet snow (M0<T<=3 and Td<=0); T and Td defined from combination of METAR and HIRLAM model output.

snow accumulation (mm) / 15 min	water equivalent mm/h	Visibility class (m)	De-icing weather type	dBZ
>5	>=4	<=600	3	>29.0
2-5	1.6-4	600-1500	3	23.5-29.0
1-2	0.8-1.6	1500-3000	2	19.5-23.5
<1	<0.8	>3000	0	<19.5

Class Dry snow (T<=M0 and Td<=-1); T and Td defined from combination of METAR and HIRLAM model output.

snow accumulation (mm) / 15 min	water equivalent mm/h	Visibility class (m)	De-icing weather type	dBZ
>10	>=4	<=600	3	>29.0
5-10	2-4	600-1500	3	24.5-29.0
1-5	0.4-2	1500-3000	2	15.5-24.5
<1	<0.4	>3000	0	<15.5

In the scientific demonstration the colors highlighting the probabilities follows the rules:

- 0-20%: green
- 30-50%: yellow
- 60-100%: red

2.7 Remarks for prototype operation

Several improvements of the PNOWWA demonstration webpage have been made after start on 2nd February:

- reference time included (important for assign the feedback)
- auto update of the webpage
- feedback form
- product description

3 Feedback

3.1 Feedback form:

A feedback form (***Figure 6***) is included on the web page for immediate response. But unfortunately this feedback form was not used by airport operators.

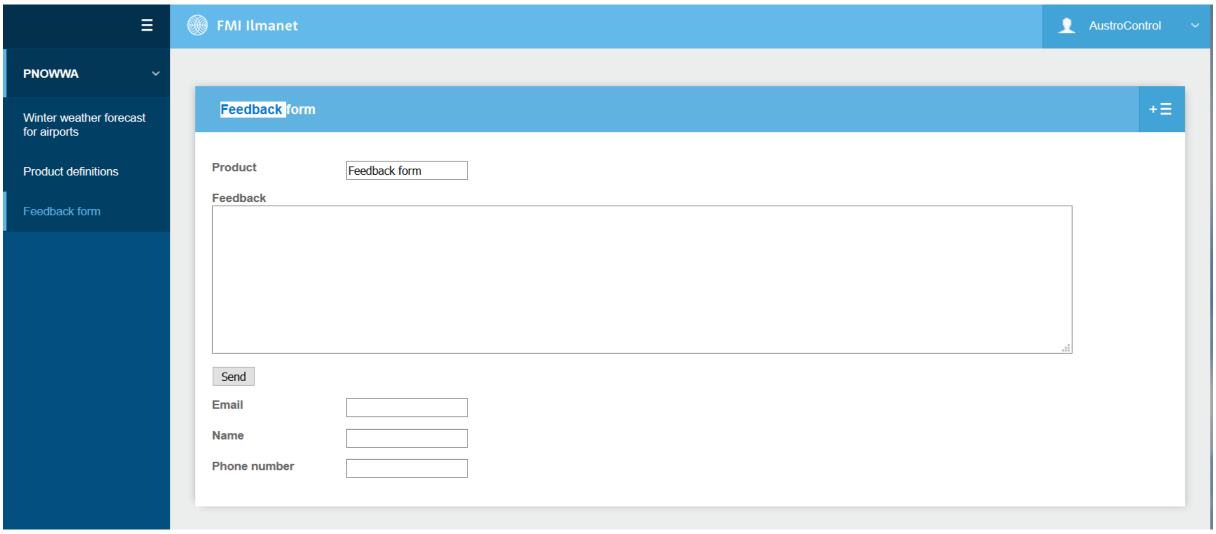


Figure 6: End user Feedback form.

3.2 User Feedback of 1st scientific demo of PNOWWA 2017

The product disseminated to users started on 8th of February. After that it took some time users were informed properly. After that there were only limited amount of real winter weather cases in Austria and Southern Finland. In Northern Finland weather was more favourable.

3.2.1 Helsinki and Rovaniemi

For lack of time in user side it was not possible to organize real kick off meetings of demo with users. As it can be seen in the feedback later in that document, that kind of hands on familiarization to the product would have been beneficial, it possibly would have got more feedback if that would have been organized. This will be changed for second demonstrator phase, when adequate information is given to users shortly before winter starts.

Helsinki

Finnair De-icing:

- Airline prefers to have forecasted weather further than 3 hour, their de-icing planning will benefit that more often than 3 hour nowcast. 3 hour nowcast is relevant in the weather situations when weather suddenly changes to totally different than has forecasted before. Yet there were any that kind of events during demonstration period.
- Airline would be interested to test product more during next winter.

Finnair OCC (Operation Control Center)

- Product was used occasionally 2-3 times/week. Starting of demo was too late, winter was nearly over, it would be more useful during December-January.
- Finnair will benefit from that kind of service indirectly by improved de-icing management and runway maintenance.
- Quality was good, but forecasting time could be longer
- Service doesn't tell when the runway will be open after cleaning, that kind of product would be useful for airline.
- That kind of service should be available to more than 2 airports, as it was now.

Swissport, de-icing operator:

- 8 hour forecast would be more useful than 3 hour.

Finavia, de-icing coordinator:

- The demo product has not been used. Lack of information that it would have been available

Rovaniemi

Runway maintenance:

- Prototype have been available, but it hasn't really been used. It has been more convenient to use same products as before.

Example: Helsinki – forecaster feedback:

<u>22nd Feb 2017:</u>

1) When the snowfall was approaching, the forecast did not work. Snowfall started 14:30 UTC, in 14:50 METAR visibility is 100 m. In 14:15 probability was almost zero
2) Typically, the first time step was OK but after that, the weather was forecasted to be too good.
3) In general, typical visibility was 600-1500 m but forecasted probability mainly in the 1500-300 m
4) Classification dry snow/wet snow went all right. 22 Feb was dry, 23 Feb morning it was wet.

Analyses/Actions prepared from FMI (WP2):

1+2) Wrong motion vectors (from numerical weather predication model). Action: comparison with SPoflow with RAVAKE motion vectors (see D5.2: Software components and documentation (demonstration campaign))

3) Drifting snow. Action: consider exceedance probability

Figure 7 shows a webcam in EFHK where the reduction of visibility due to drifting snow is evident. Drifting snow (snow is moving below 2 m above ground) can't be detected by weather radars. Hence, this visibility reduction is not included in PNOWWA probabilistic nowcasting demonstration product.

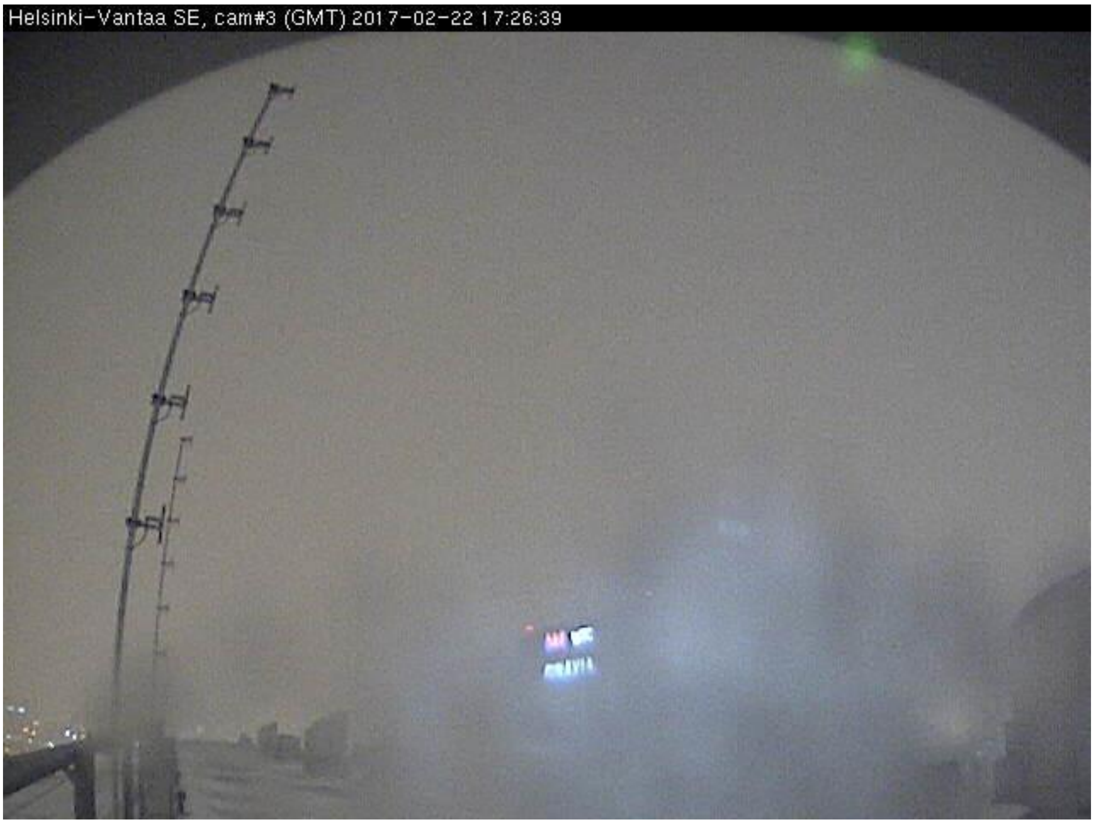


Figure 7: Webcam from Helsinki-Vantaa_ on 22nd February 2017 19:26:39UTC shows visibility reduction due to drifting snow.

3.2.2 Vienna and Innsbruck

ATM and airport operators didn't use the online provided PNOWWA product in Austria due to warm weather conditions during 1st scientific demonstration period. Nevertheless, forecaster feedback was given for LOWI during fog conditions and during weak snow fall event end of April.

Vienna:

- LOWW runway maintenance was waiting for demonstrator after the workshop in October – demonstrator should available from December
- Favour winter events occurred before 1st demonstration started
- For the two adverse winter events in January, traffic regulations for LOWW were not directly attributed to snow fall events directly (time shift of few hours).

Example: Innsbruck – forecaster feedback: 22nd Feb 2017 Fog case – reduced visibility:

METAR observations at LOWI showed fog and visibility of 600m for 07:20 and 06:50 UTC :

- SALOWI 220720Z 26004KT **0600** R08/0900D R26/1200D BCFG SCT002 BKN004 05/05 Q1016 BECMG 5000 FEW005=
- SALOWI 220650Z 23003KT 200V280 3000 **0600E** R08/P1500U R26/0800N BCFG SCT002 BKN004 BKN120 05/05 Q1016 BECMG 5000 FEW005=

The demonstration forecast doesn't take into account the fog (**Figure 8**). The boundary layer conditions aren't detected by weather radars and aren't considered in PNOWWA. A note ("VIS decreased by snow") is included in the web page, but it seems not clear for users. Final forecast product should capture entire vis reduction!

TOWER (UPDATED 2017-02-22 07:30:00 UTC)

VIS decreased by snow	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
VIS less than 600 m	0	0	0	0	0	0	0	0	0	0	0	0	0
VIS 600-1500 m	0	0	0	0	0	0	0	0	0	0	0	0	0
VIS 1500-3000 m	0	0	0	0	0	0	0	0	0	0	0	0	0
VIS over 3000 m	100	100	100	100	100	100	100	100	100	100	100	100	100

Figure 8: ATM visibility classes from PNOWWAs first demonstrator for LOWI during fog conditions, 22nd February 2017 07:30 UTC. PNOWWA demonstrator considers decreased visibility by snow.

28. April 2017 – snow fall without snow accumulation on the runway:

After the demonstration campaign temporary stronger snow showers in April 2017 caused visibility reduction at LOWI. Surface temperatures above the freezing level prevent snow aggregation on the runway.

Figure 9: View from tower in LOWI at 09:31 UTC on 28th April 2017. Snow showers caused decreased visibility but no snow aggregation on the runway.

The corresponding PNOWWA demonstrator is presented in **Figure 10**. The snow shower at 09:31 UTC is captured well and shows probability of 100% for the first time interval for the snow accumulation class 1-5 mm/15 minutes accompanied by de-icing weather class 2 and visibility class 1500-3000 m.

RUNWAY MAINTENANCE (UPDATED 2017-04-28 09:15:00 UTC)													
accumulation% dry snow, mm/15min	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
over 10 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
5-10 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
1-5 mm	100	0	0	0	0	0	0	0	0	0	0	0	0
less than 1 mm	0	100	100	100	100	100	100	100	100	100	100	100	100
accumulation% wet snow, mm/15min	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
over 5 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
3-5 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
1-2 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
less than 1 mm	100	100	100	100	100	100	100	100	100	100	100	100	100
prob of freezing rain	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
prob	0	0	0	0	0	0	0	0	0	0	0	0	0
prob of freezing wet runway	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
prob	0	0	0	0	0	0	0	0	0	0	0	0	0

DE-ICING AGENTS (UPDATED 2017-04-28 09:15:00 UTC)													
DIW class %	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
3	0	0	0	0	0	0	0	0	0	0	0	0	0
2	100	0	0	0	0	0	0	0	0	0	0	0	0
1	0	100	100	0	0	0	0	100	100	100	100	100	100
0	0	0	0	100	100	100	100	0	0	0	0	0	0
prob of freezing wet runway	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
prob	0	0	0	0	0	0	0	0	0	0	0	0	0

TOWER (UPDATED 2017-04-28 09:15:00 UTC)													
VIS decreased by snow	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
VIS less than 600 m	0	0	0	0	0	0	0	0	0	0	0	0	0
VIS 600-1500 m	0	0	0	0	0	0	0	0	0	0	0	0	0
VIS 1500-3000 m	100	0	0	0	0	0	0	0	0	0	0	0	0
VIS over 3000 m	0	100	100	100	100	100	100	100	100	100	100	100	100

Figure 10: LOWI PNOWWA probability forecast for 18th April 2017, starting from 09:15 UTC.

Discussion:

a) Snow aggregates on roofs and grassland beside runway, but not on the runway. Measured air temperature were 1 °C (dewpoint 0°C). For LOWI no runway-concrete temperature is available.
b) Short lead times of 15 minutes for the snow showers. This might be related to the weather radar coverage in the mountainous area (valley within Alps)

3.2.3 Additional feedback

PNOWWA team is eager to collect feedback as much as possible to validate the applicability of the probabilistic winter weather nowcasting product for end users at the airport. During summer 2017 we will collect and write: "D4.4 Survey of user opinions of demonstrated product." and for the demonstration phase we try to extend the user group. For e.g. a new potential end user might be SureWX (http://surewx.com) which offers weather services for airports or other airports.

4 Weather conditions during demonstration campaign

This chapter describes the winter weather conditions for selected airports during the first demonstration campaign to give an overview and to focus on cases where winter weather affected airports adversely. This cases will be prepared for further analyses and individual discussions for offline demonstration.

4.1 Austria

4.1.1 Vienna

Winter in LOWW started with temporary colder temperatures (**Figure 11**) in December accompanied by snow in the second week of January (**Figure 12**). In the end of January, second frontal event caused snowfall and even freezing rain (FZRA) in the surroundings of Vienna. With the start of the demonstration phase in February, temperatures increased above 0°C and subsequent no snow fall was observed till to the end of March.

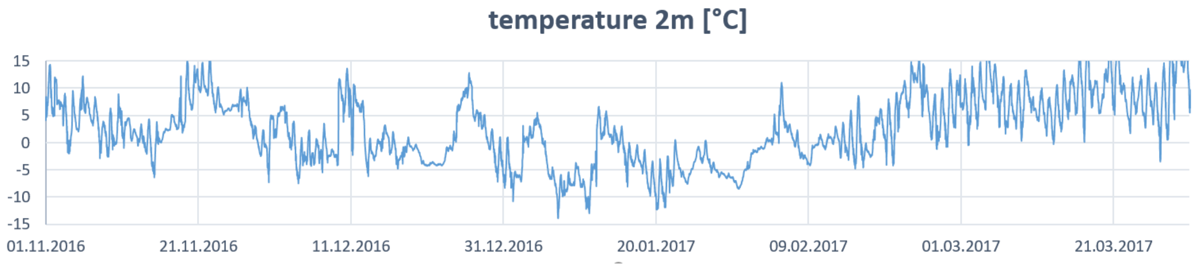


Figure 11 shows temperatures at 2m above ground in °C at LOWW (10 second interval) during entire winter period beginning with 1st of November 2016 till end of March 2017. Negative temperatures from beginning of December 2016 until start of February 2017. Afterwards temperature reached unusual maximum values above 15 degrees Celsius.

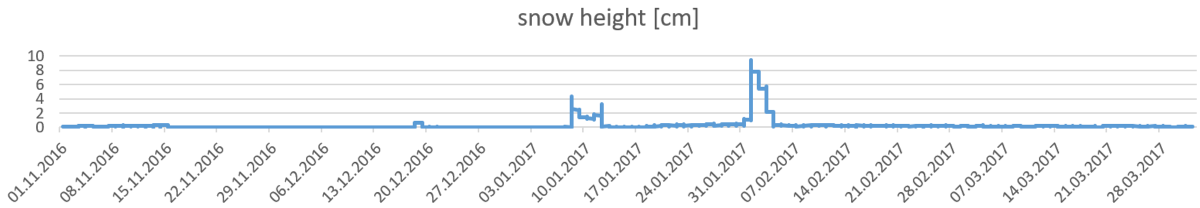


Figure 12: Ultrasonic snow height observation (10 minute interval for snow accumulation in cm) at LOWW shows 2 main snow events around 10th Jan and around 31st Jan – 2nd February. Second snow period was accompanied by moderate FZRA in the morning of 31st Jan and heavy +FZRA west of LOWW.

4.1.2 Innsbruck

Innsbruck was also affected by warm temperatures during the demonstration campaign in February and March 2017. This can be seen in the right half of **Figure 13** . Negative temperatures observed at LOWI in December 2016 and January 2017 when significant snow fall events occurred in the beginning and middle of January 2017 (seen in **Figure 14** as positive jump in snow height on y axis). The snow cover lasted till beginning of February when temperatures increased.

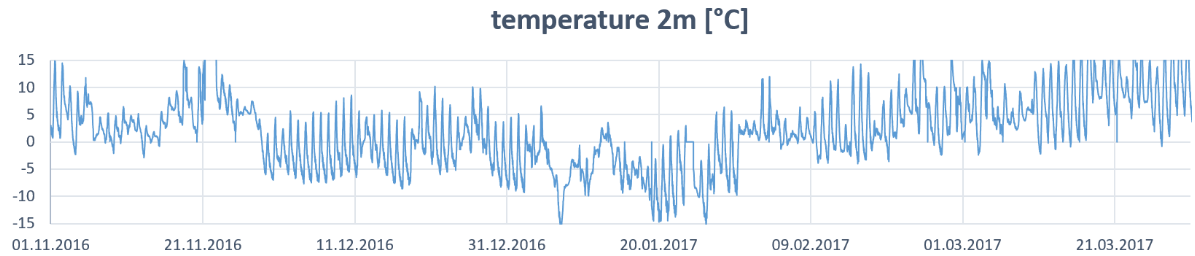


Figure 13 shows the temperatures at 2m (10 second interval) above ground in °C at LOWI during entire winter period beginning with 1st of November 2016 till end of March 2017. The cold period in December and especially in January is evident. .

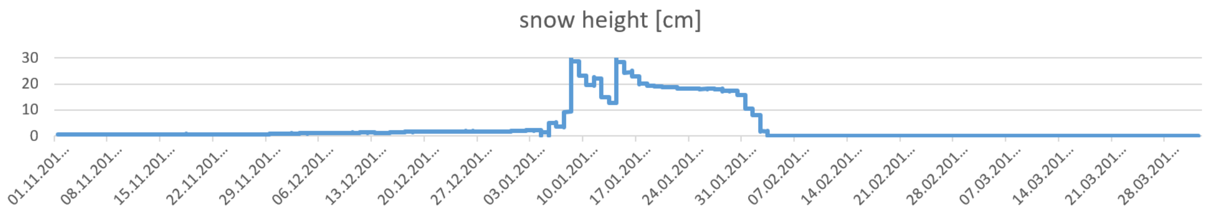


Figure 14: Ultrasonic snow height measurements at LOWI for entire winter 2016/2017. Note the different y-axis. Significant snow fall events occurred in January 2017.

Corresponding visibility during entire winter period is given in **Figure 15** for LOWI. High frequency of low visibilities below 1000 m is attributed to stronger snow fall.

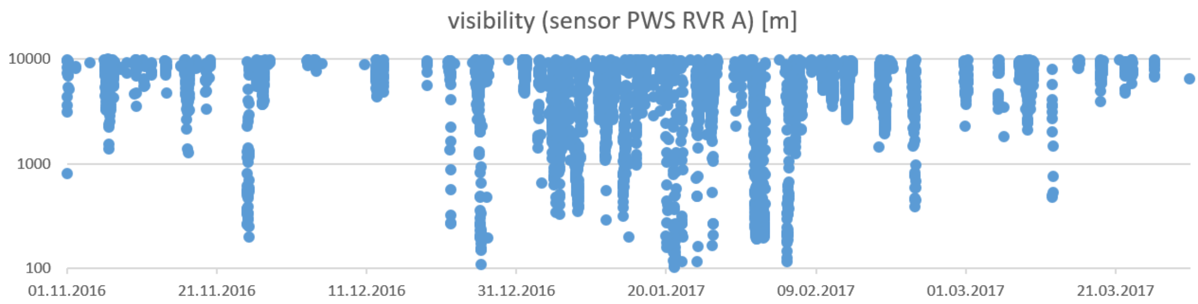


Figure 15: Visibility in m (10 second interval) from present weather sensor at LOWI. Note the logarithmic vertical axis: Large amount of decreased visibility even below 1000 m is obvious during snow events in January 2017.

4.2 Finland (EFHK and EFRO)

Winter in EFHK lasted 1 November to 10 March, in EFRO it continued to mid-April. Several good cases were observed for offline case studies. As examples, weather statistics from February at both airports are shown.

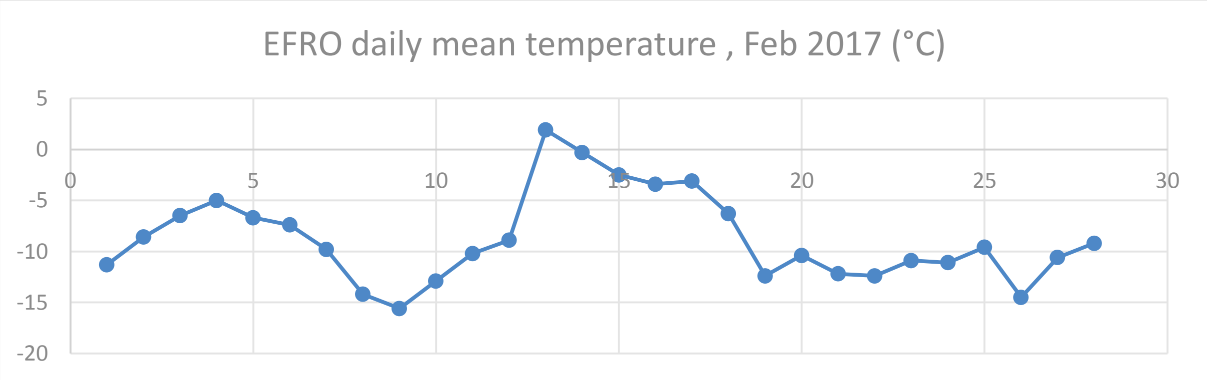


Figure 16: Daily mean temperature in °C for Rovaniemi in February 2017 shows nearly continuous negative temperatures.

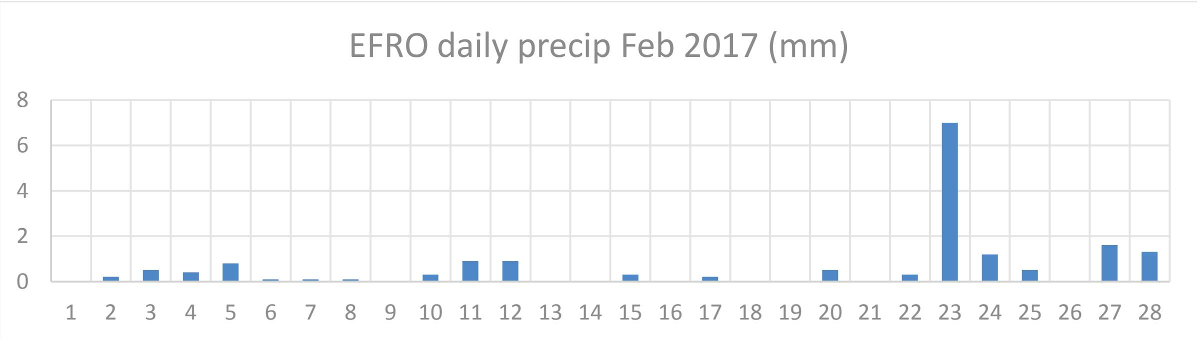


Figure 17: Daily winter precipitation amount in mm for Rovaniemi in February 2017.

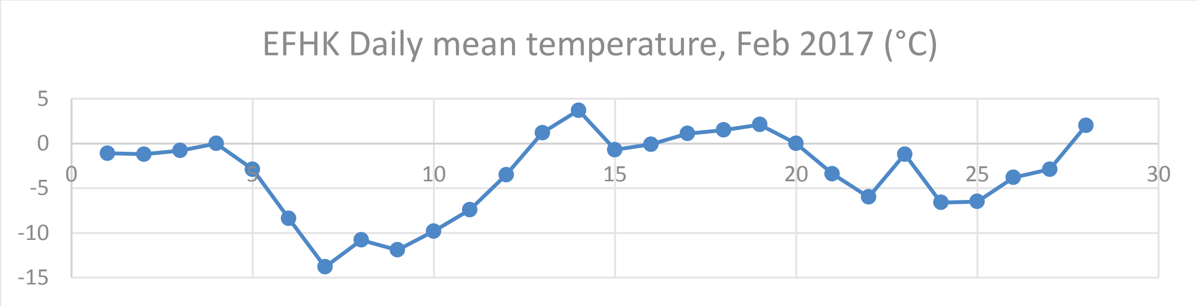
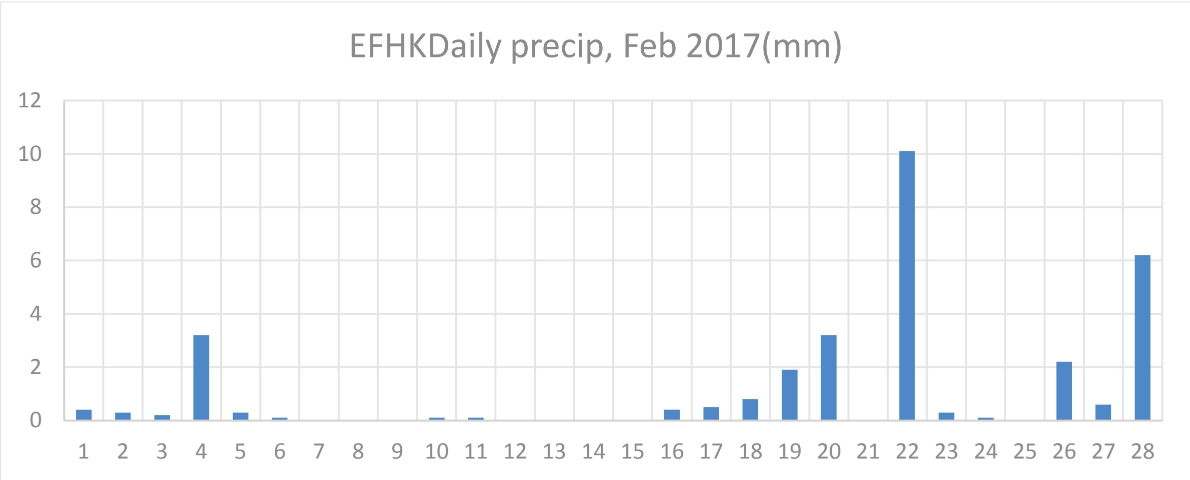


Figure 18: Daily mean temperature in °C for Helsinki in February 2017. Two colder and one warmer period (around 14th Feb.) can be seen.



Shows the daily precipitation amount in mm for Helsinki. Larger amounts correlate with lower temperatures favouring winter precipitation.

5 First selection of case studies

From collected feedback and from observations we selected case studies for further analyses and in preparation for further user consultation/demonstration:

1. Finland EFHK: 22nd Feb 2017
2. Finland EFRO: 1st Mar and 3rd Mar 2017
3. Austria LOWW: 31st Jan – 2nd Feb. 2017
4. Austria LOWI: 5th Jan – 8th Jan and 14th Jan 2017

6 Lessons learned and preparation for the second research demonstration campaign of prototype of probabilistic winter precipitation forecast:

The PNOWWA project started in April 2016 which offers the opportunity for second "online" demonstration phase during winter 2017/2018. As time for collecting the user opinions is needed, the second campaign will start on 1st December 2017 and ends earlier as the project ends by end of February 2018. Results of the second phase will be presented in the final report.

Providing online prototype to end users offers active validation of the product and validation of the concept of probability nowcast. By the other hand, collecting relevant case studies helps to analyse and discuss feedback and present PNOWWA product to a broader audience. PNOWWA team will still focus on both concepts.

We have to prepare adequate relevant case studies, to illustrate and discuss with stakeholders in kick off meetings, short prior to the second demonstrator campaign. This helps to demonstrate the nowcasting quality and the use of probabilistic forecast in short-term forecasting. Also to discuss further key performance indicators and possible calibration of likelihood using traffic load dependency, delays and regulations or the amount of used chemicals). Improvements of the PNOWWA product are expected for next winter such as dealing with different kind of motion vectors, stated in EFHK feedback from 1st demonstration campaign. Additional winter weather forcing such as mountains or lake effects will be implemented. This makes the nowcast more robust and reliable. For mountainous area such as LOWI (feedback from 28th April) with poor weather radar data coverage a special focus is given to the applicability and sensitivity of the product in the next phase.

From twelve resulting feedbacks right now, ten statements have constructive inputs which partly already results in adaption for next prototype and highlight the success of the project even with warm winter in Central Europe. The other two feedbacks stated, that they were not informed or that using the new demo product was inconvenient. For the success of the project we collect as much as possible feedback from different stakeholders and the informal process will be more direct for next campaign as following steps describe.

Additional, preparation for next phase is to collect further user feedback. We will collect survey by individual interviews which leads to better and more detailed results as an anonymous survey. A questionary templete (Appendix 1: Questionaries for user feedback/opinion:) will be used for comparable feedback from Austria and Finland.

For the next 2nd online demonstration phase we are able to start with beginning of the winter period (was not the case for 1st demo) and shortly after kick off meetings or individual introduction and discussions (instead of workshop) for demo users in the second half of autumn. Keeps the PNOWWA information for airport users fresh and ready to use for first adverse winter weather events. That kind of hands on familiarization to the product should be beneficial for the use of the product and resulting feedback as well as stakeholder satisfactory.

Individual contact to end users should be increased during the 2nd campaign. We will try to personal support/assistance in airport operation centre during relevant snow cases for better applicability of probabilistic winter weather forecast.

Additional, we will try to collect additional feedback from other airports (e.g. EDDM, ENGM or LOWS) and other weather services or companies such as ShurWX, Vaisala or Boschung.

7 Conclusions

The demonstration of the product of probabilistic short term forecast for winter weather at airports was successfully tested. The concept showed the applicability for airport stakeholders. User and forecaster feedback was collected to adapt the product and procedure for the second demonstration campaign. Feedback already results in improvement of the nowcast quality by using different motion vectors and toporgraphic forcing will further investigated till next winter.

Selection of airports form Central Europe to Norh Europe helps to collect relevant winter weather cases even during warm winter over Europe.

Lessons learned from recent 1st demonstration of the PNOWWA product was, that providing the PNOWWA prototype as online information show applicability and potential for airport operation during adverse winter weather. Users should be informed properly, short before next winter, presenting them well prepared case studies for demonstration. During 2nd demonstration campaign we will individual contact end users during adverse winter weather at the airport, to support and assist stakeholdes by using probabilistic nowcasts.

Appendix 1: Questionaries for user feedback/opinion:

Feedback of 1st scientific demo of PNOWWA 2017

(Version 0.0 2017-April-11)

Did you use the product? How often?

What was your general opinion for service?

Your specific opinions about

1. Layout of product?
2. Relevance of thresholds used?
3. Accuracy of snow accumulation?
4. Correctness of snow type dry/wet?
5. Correctness of the timing of snow periods
6. How easy/difficult it was understand what the probability means in forecast?
7. How easy/difficult it was understand how you can use the probability information in decisions making of your own work?

What kind of proposals you have for further develop the product so, that it will gives more value for you?

Are you interested in PNOWWA probability forecast product for historic events (high impact winter weather at your airport – recent winter or past)?

Are you interested in participating next year's winter demonstration for your airport?

Appendix 2: Remarks for Austrian prototype

PNOWWA-Demonstrator (Feb-März 2017) – TESTPRODUKT!

(PNOWWA…. Probabilistic Nowcasting of Winter Weather for Airports)

Zusammenfassung:

Winterwetter Kurzfristvorhersage aus Wetterradardaten mit Angabe der Eintrittswahrscheinlichkeit für den prinzipiellen TEST und Validierung an Flughäfen und Ableitung weiterer Anwendungspotentiale.
FEEDBACK an rudolf.kaltenboeck@austrocontrol.at gewünscht !

Weitere Informationen zum SESAR-2020-Projekt PNOWWA und den Projektpartnern Austrocontrol, Finnischer Wetterdienst und Deutsches Zentrum für Luft- und Raumfahrt unter: http://pnowwa.fmi.fi

Zugriff auf den Demonstrator via Browser:

http://ilmanet.fi
Username / Käyttäjätunnus: AustroControl
Passwort/ Salasana: PNOWWA17

Keine automatische Browser-Aktualisierung der im Intervall von 15 Minuten erstellten Prognosen! (Aktualisierung z.B. mit F5 Taste)

Beispiel:

Winter weather forecast for airports

LOWI | LOWW

Select Airport

Kaikki SESAR-2020 PNOWWA -projektissa kehitetty tieto ja tuotteet on kehitetty pelkästään tieteelliseen tutkimustarkoitukseen. eikä niitä pidä käyttää missään olosuhteissa operatiiviseen palveluun. Näitä tietoja ei ole validoitu tai hyväksytty sellaiseen käyttöön. Palvelun ja tiedon tuottajat eivät ole missään vastuussa palvelun sopimattomasta tai luvattomasta käytöstä tai niiden aiheuttamista asioista.

All data and products developed by the SESAR-2020 PNOWWA Project are developed purely for research purposes and shall not be used under any circumstances for operational purposes, as they have neither been validated nor designed for such use, and the authors decline any responsibility for inappropriate and unauthorized use.

Alle Daten und Produkte, die im Rahmen des SESAR-2020 Projektes PNOWWA entwickelt wurden und werden sind nur für wissenschaftliche Zwecke gedacht, und dürfen unter keinen Umständen für operationelle Zwecke verwendet werden, da sie weder dafür validiert noch designt wurden, und die Autoren jede Verantwortung für missbräuchliche Verwendung ablehnen.

RUNWAY MAINTENANCE (UPDATED 2017-02-14 08:45:00 UTC)

accumulation% dry snow, mm/15min	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
over 10 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
5-10 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
1-5 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
less than 1 mm	100	100	100	100	100	100	100	100	100	100	100	100	100
accumulation% wet snow, mm/15min	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
over 5 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
3-5 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
1-2 mm	0	0	0	0	0	0	0	0	0	0	0	0	0
less than 1 mm	100	100	100	100	100	100	100	100	100	100	100	100	100
prob of freezing rain	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
prob	0	0	0	0	0	0	0	0	0	0	0	0	0
prob of freezing wet runway	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
prob	0	0	0	0	0	0	0	0	0	0	0	0	0

DE-ICING AGENTS (UPDATED 2017-02-14 08:45:00 UTC)

DIW class %	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
3	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
1	60	60	30	0	0	0	0	0	0	0	0	0	0
0	40	40	70	100	100	100	100	100	100	100	100	100	100
prob of freezing wet runway	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
prob	0	0	0	0	0	0	0	0	0	0	0	0	0

TOWER (UPDATED 2017-02-14 08:45:00 UTC)

VIS decreased by snow	0-15 min	15-30 min	30-45 min	45-60 min	60-75 min	75-90 min	90-105 min	105-120 min	120-135 min	135-150 min	150-165 min	165-180 min	180-195 min
VIS less than 600 m	0	0	0	0	0	0	0	0	0	0	0	0	0
VIS 600-1500 m	0	0	0	0	0	0	0	0	0	0	0	0	0
VIS 1500-3000 m	0	0	0	0	0	0	0	0	0	0	0	0	0
VIS over 3000 m	100	100	100	100	100	100	100	100	100	100	100	100	100

Einfärbung der Wahrscheinlichkeitsintervalle für signifikantes Auftreten von Winterwetter:

- grün: 0-20%
- gelb: 30-50%
- rot: 60-100%

RWY-Operation: Unterscheidung trockner/nasser Schnee

- Dry snow, when T<=M0 and Td<=-1
- Wet snow, when M0<T<=3 and Td<=0

DIW (De-Icing Weather) Klasse aus Skandinavien:

- DIW=3 (severe = Long de-icing time per plane)
    - Always when FZRA or FZDZ
    - Heavy snow or sleet (visibility less than 2 km from WXR)
- DIW=2 (moderate = Medium de-icing time per plane)
    - SN or Sleet, VIS >2 km
- DIW=1 (light = short de-icing time per plane, only wash, no anti-ice fluid needed; only frost on plane)
    - T between –3°C…+1°C and relative humidity over 75%
- DIW=0, no de-icing need
    - All other weather cases

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2. PNOWWA Prototype Website (Ilmanet Website) http://ilmanet.fi
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4. PNOWWA deliverable, 2017: D4.1 - Survey of user needs.
5. PNOWWA deliverable, 2017: D4.2 - User needs for demonstration.
6. PNOWWA deliverable, 2017: D5.2 - Software components and documentation.