Aviation operational nowcasting systems

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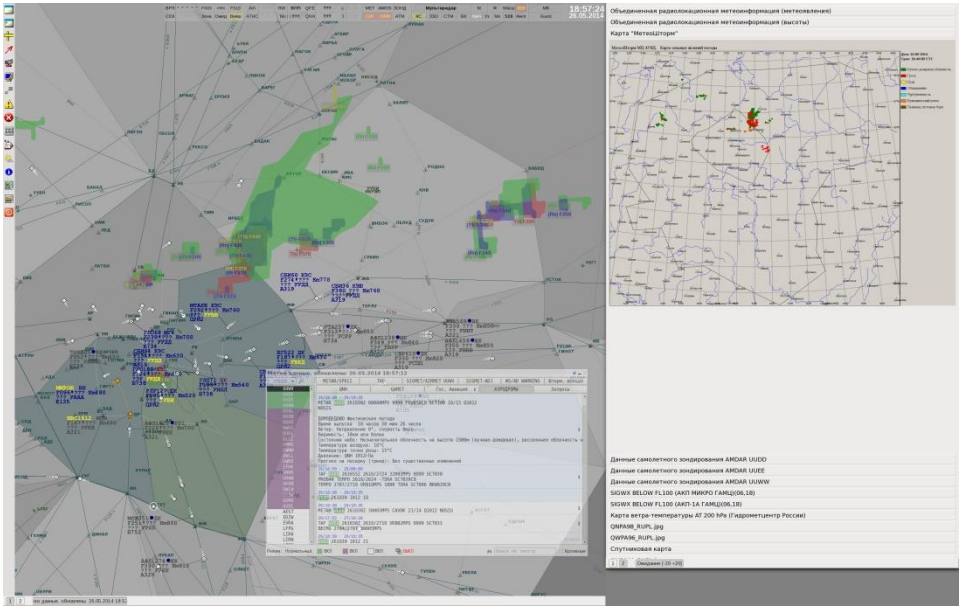
ENC2019, Madrid

Background

- The main **objective** of aviation nowcasting is to increase the **accuracy of high impact weather forecast** that facilitate **decision-making** aimed at improving **aerodrome capacity**, **efficiency** and **safety**.
- **ICAO** Global Aviation Navigation Plan (**GANP)** 2016-2030: Aviation System Block Upgrade (**ASBU**); Key concepts emphasize the importance of **nowcasting**:
  - **TBO -** Trajectory-Based Operations: *4D trajectories, seamless, gate-to-gate, the most accurate trajectory, **nowcasting** in initial and final phases*
  - **MSTA** - Met Services to ATM for **airport terminal area** – The area mostly needs **nowcasting.** *The closer to the area, the fine weather information is required (spatial res ~ 100 m, temporal res ~ minutes, update frequency ~ minutes)*
- Nowcasting is applicable at airports with **heavy traffic** (> 1000 take-off & landing operations) and/or many **high impact weather** events.

AvRDP (WMO Aviation Research and Development Project) aims

- To demonstrate the capability of nowcasting in support of the development of the next generation aviation initiative, the ASBU under the ICAO GANP
- To translate the MET information into ATM impact products so as to demonstrate the benefits of the nowcasting to the aviation community



Participants:

11 international airports incl. Saint-Petersburg (Pulkovo).

Nowcasting systems of IRAM

- Nowcasting systems **MeteoTrassa** and **MeteoExpert** have been developed and implemented with the aim to give information support to **aviation forecasters**, **aerodrome maintenance service** and **decision-makers**.
- Particular emphasis is placed on the forecasts of adverse weather conditions, relevant for **landing and takeoff,** inclusive ascent and descent, and useful for **optimization of AMAN/DMAN** procedures.
- A methodology is based on **local observations**, an adaptive **assimilation** scheme, and **numerical ABL model**.
- **Available data sources** are used incl. aviation weather observation station (**AWOS**), high frequency observing **additional automatic weather station** (**AWS**), Doppler **weather radar, AMDAR**, runway weather station (**RWS**).
- A radar–based algorithm has been developed to **nowcast precipitation** at res of 1 km in space and 10 min in time. A combination of a cross - correlation tracking method, averaged Doppler velocity, and prognostic wind (at 700 hPa) is employed.

Model

- The 1D ABL model represents the evolution of vertical profiles in the lower atmosphere.
- The momentum, water conservation and thermodynamic equations in terms of wind components, specific humidity, and potential temperature are written in the standard form.
- The k-ε turbulence closure scheme is used which is based on the prognostic equations for TKE and EDR.
- The surface temperature is modeled with a force-restore equation, where the soil flux at the surface is given by the surface energy balance.
- The upper BC is set in accordance with GRIB-coded data from NWP model.
- Initialization: measurement data + Monin-Obukhov similarity theory, AMDAR data.
- **The model provides fast and stable calculations which are required for operational use**.

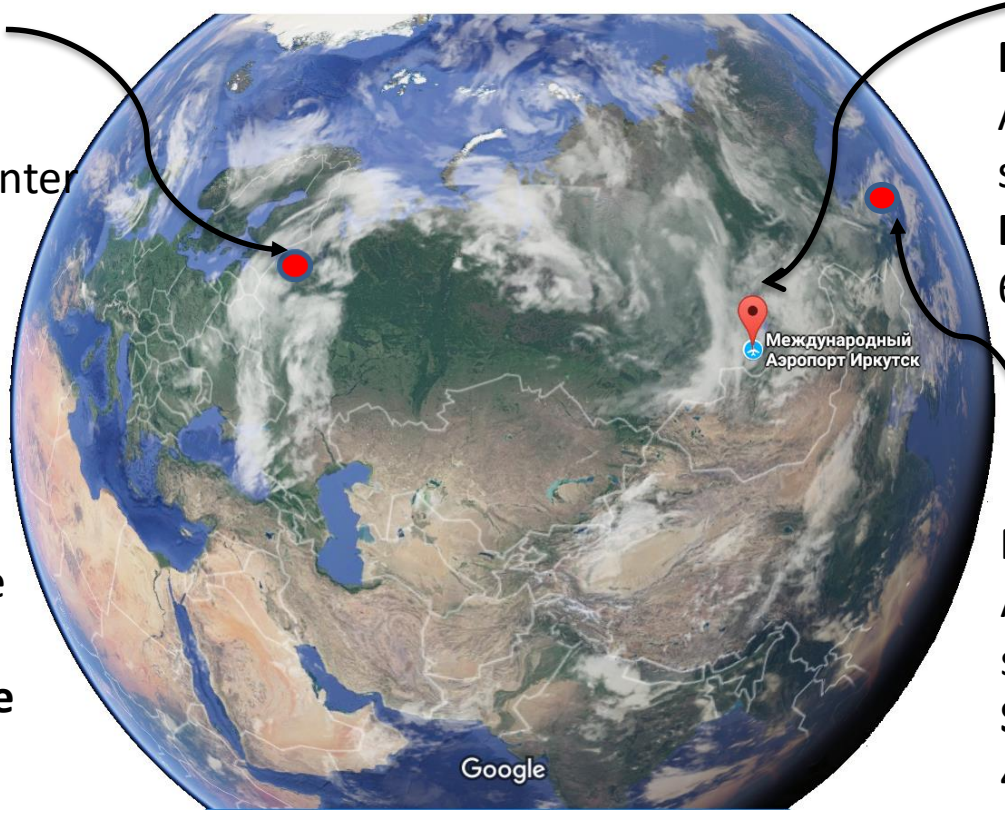
Nowcasting systems of IRAM

operate 24/7 and provide location-specific forecasts of the **most critical weather parameters** for the airport operation with lead time of 4 - 6 h and update cycle of 10 min.

SPb (Pulkovo)

MeteoExpert
Aviation Meteo Center
since 2018
Visibility
Cloud ceiling
4 hours

MeteoTrassa
Aerodrome service
since 2014
Surface T and state
4 hours



Irkutsk

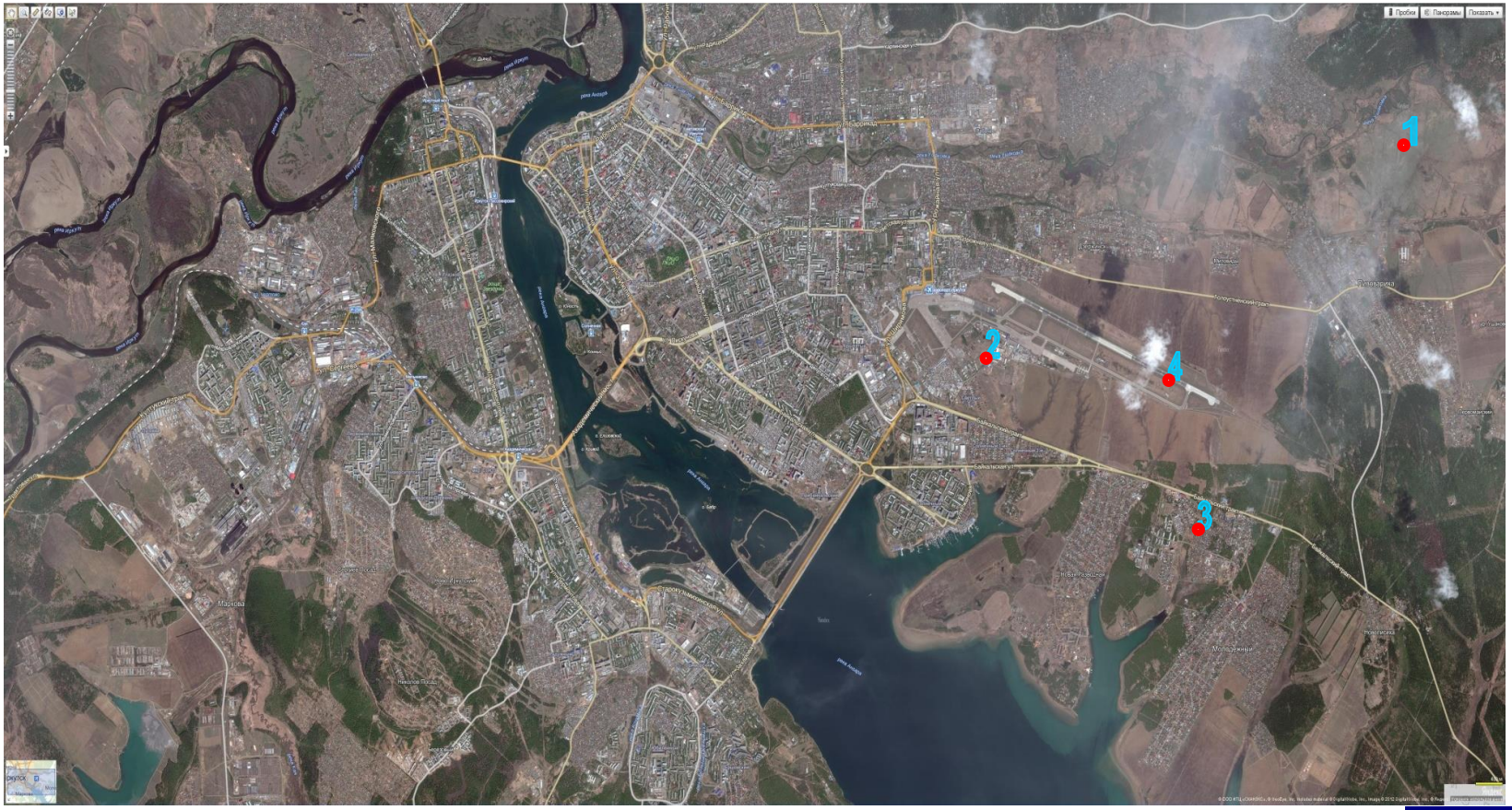
MeteoExpert
Aviation Meteo Center
since 2014
Fog, visibility
6 hours

Yuzhno-Sakhalinsk

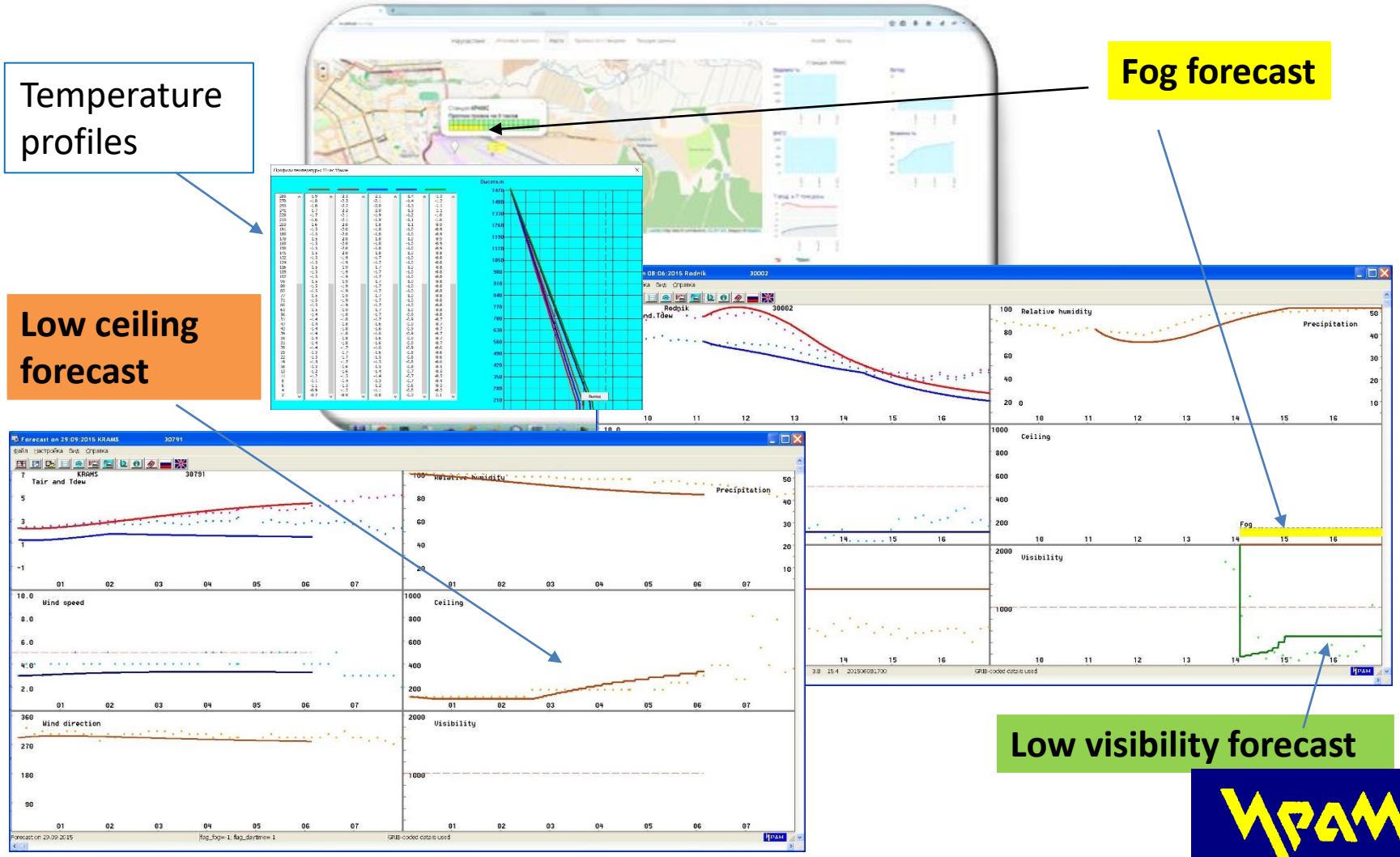
MeteoTrassa
Aerodrome service
since 2018
Surface T and state
4 hours

Operations at the **Irkutsk airport** are significantly impacted by **low visibility** caused by **fog** **=>** MeteoExpert has been implemented to provide forecasts of fog and visibility

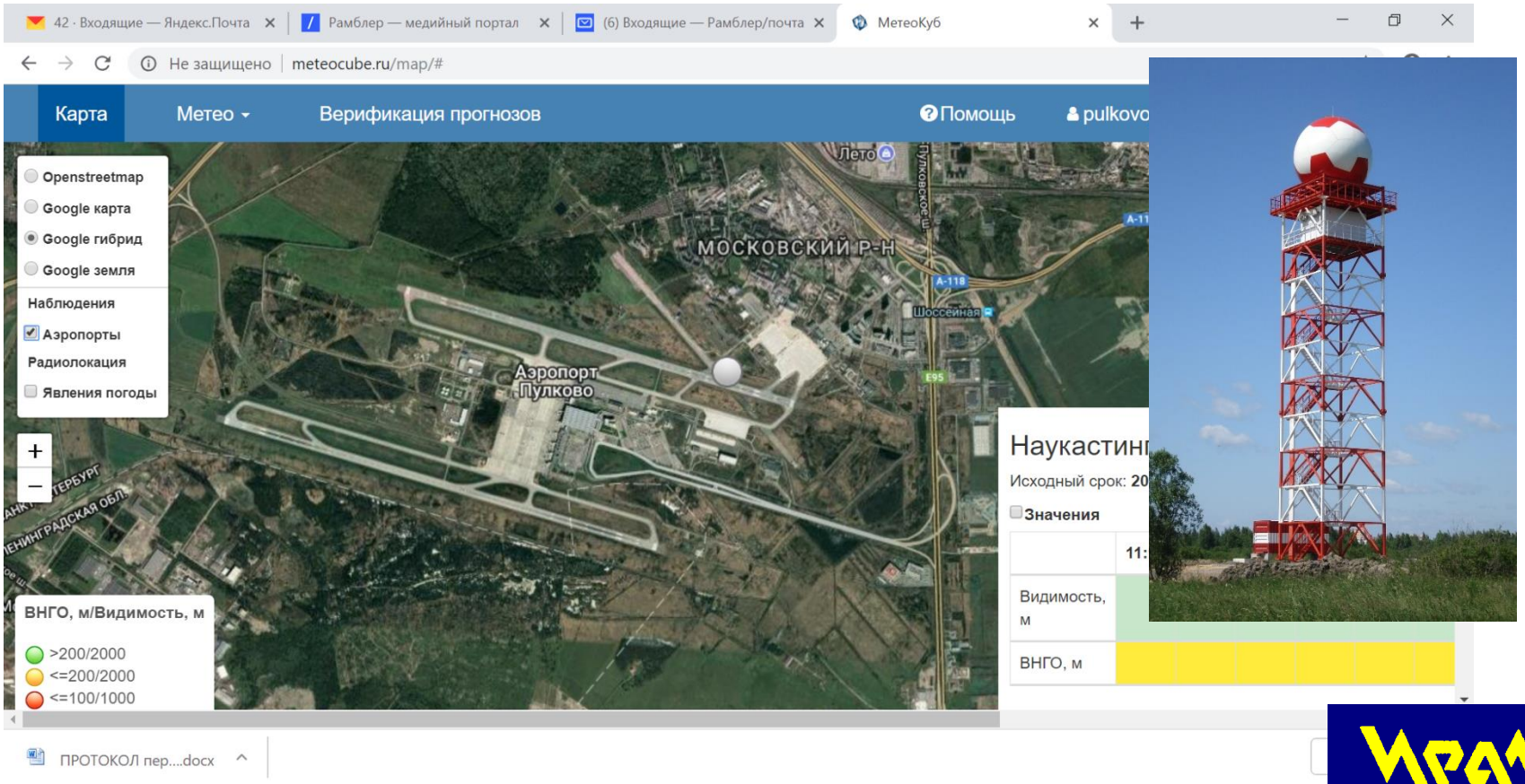
Data input: **AWOS** (1 min) and 3 **additional AWSs** (10 min) **at fogging sites** in the vicinity of the aerodrome (radius of ~5 km) for anticipating advection fog



Tabular, graph and map data displays on workstation and the website

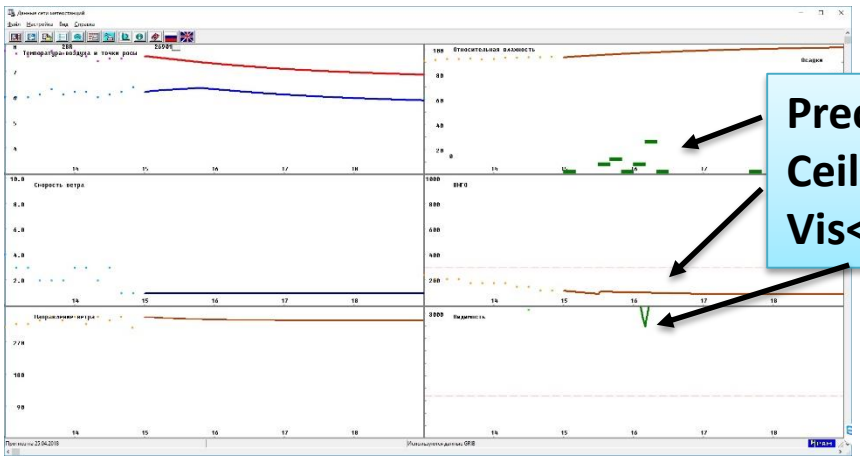


Operations at **Saint-Petersburg (Pulkovo)** airport are significantly impacted by **low visibility and ceiling => MeteoExpert** provides **Visibility and Ceiling** nowcasts.
To ensure the effective **maintenance in winter** (to keep runways, taxiways, stands free of **snow and ice**), **MeteoTrassa** provides the **aerodrome service** with measurements and forecasts, with emphasis on icing at the surface and precipitation.
Data input: **AWOS** KRAMS-4, **AWS** Saima, Doppler **weather radar**, **AMDAR**, **RWS**.

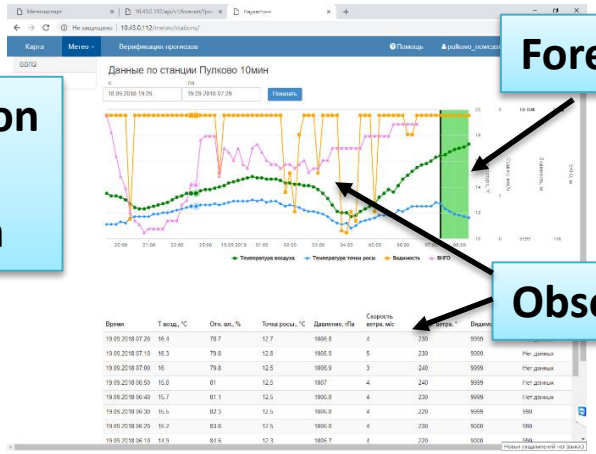


Observations and forecasts are visualized on screens of workstations and the MeteoCube website

The **4-D MeteoCube** was designed at IRAM in accordance with the **ASBU concept** of the 4-D database of MET information as the best choice to ensure that accurate and timely weather data would be integrated into operational decision making



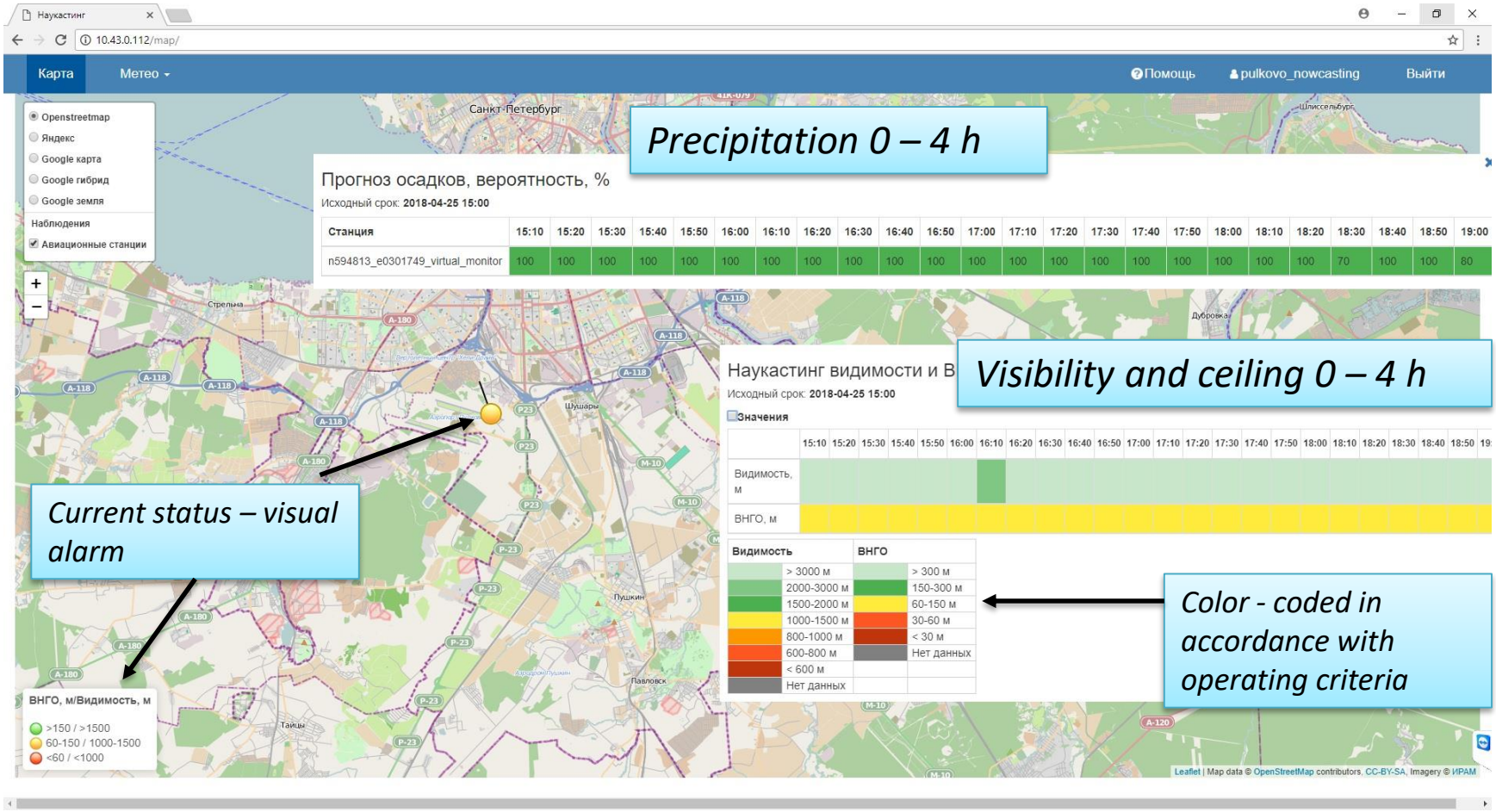
Precipitation
Ceiling
Vis<3000m



Forecasts

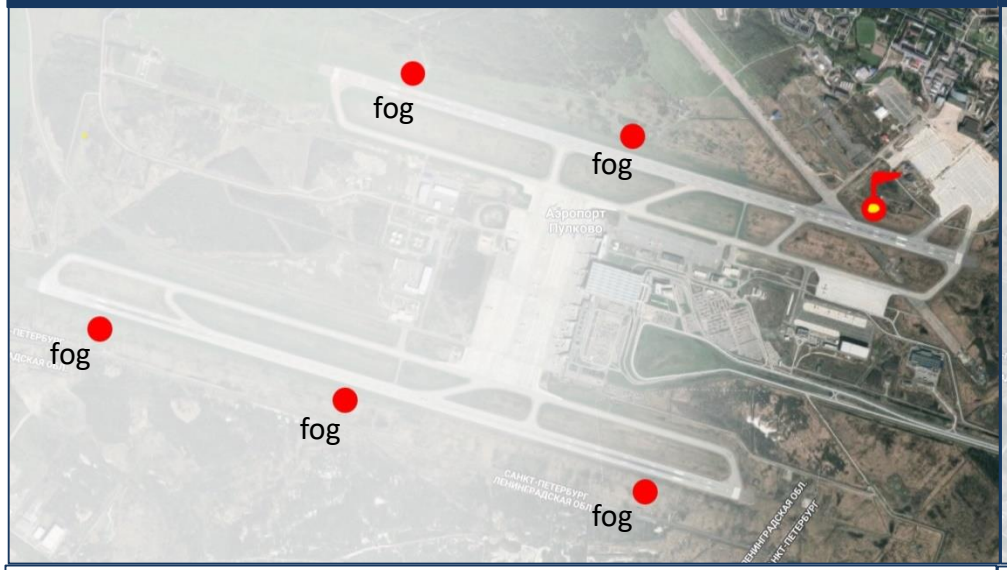
Observations

Precipitation, low ceiling and visibility



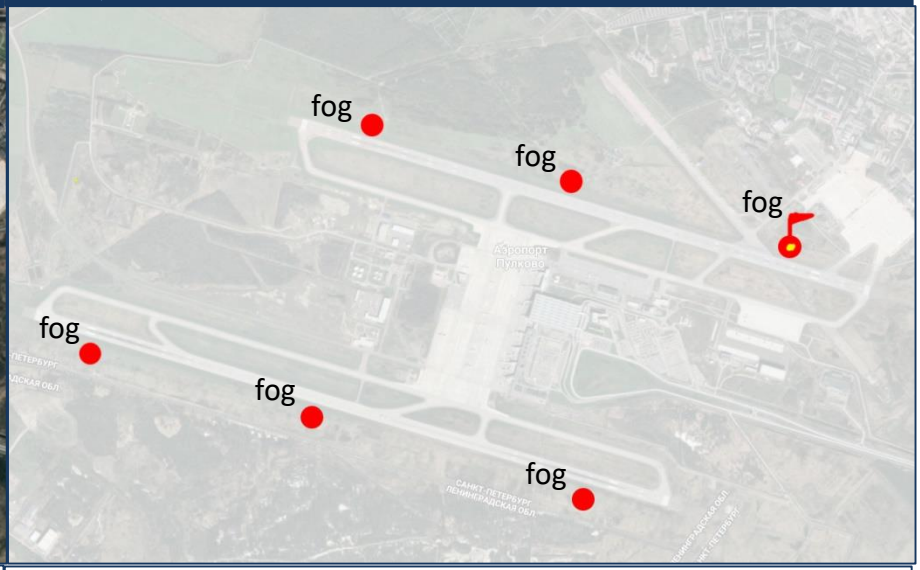
Case study (fog, 05.09.2018, Pulkovo) demonstrates an importance to have correct visibility forecasts for different aerodrome points, especially in inhomogeneous visibility conditions

19:03 – 23:40 UTC



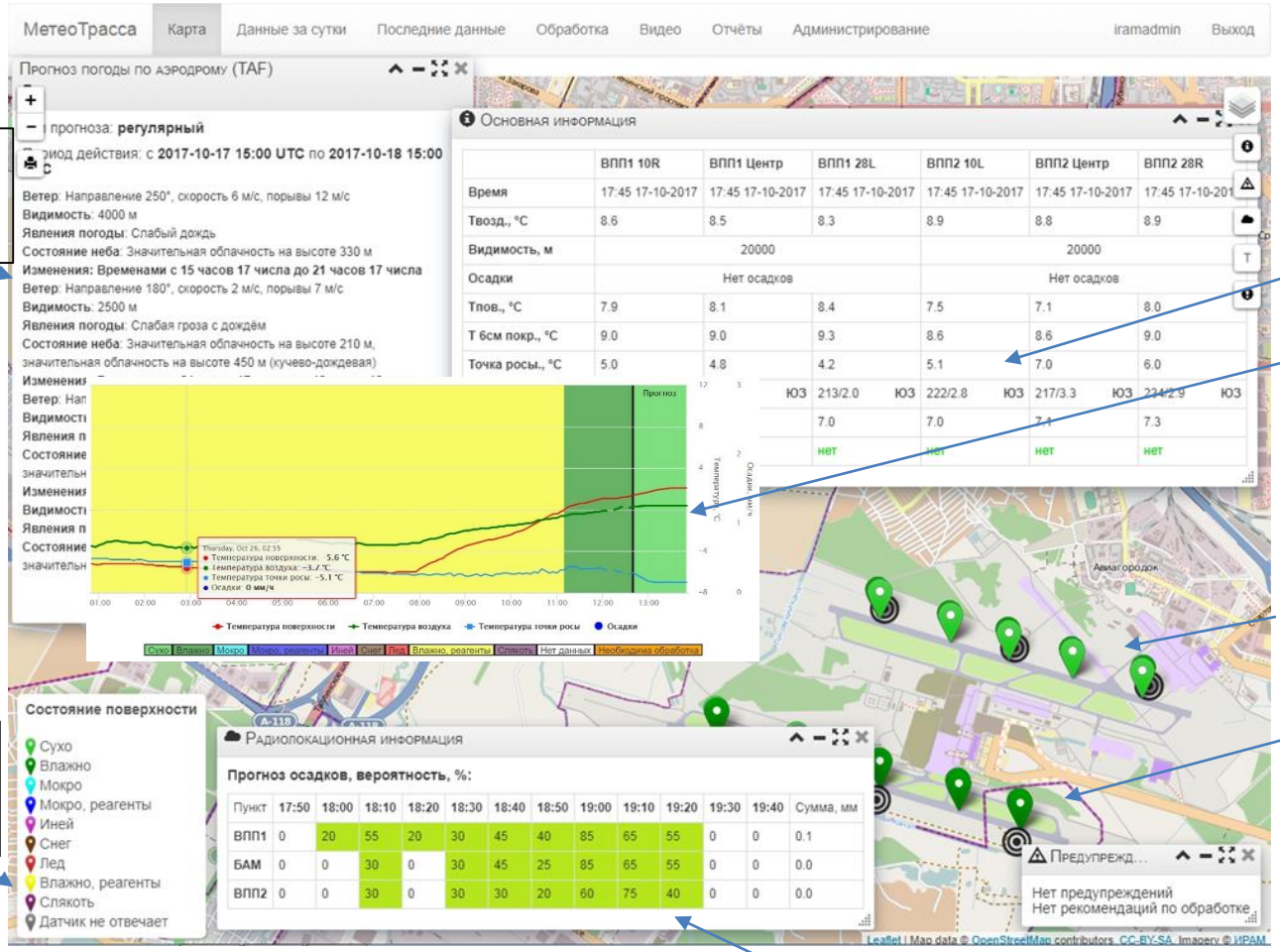
19:03-23:40 – forecast: no fog at the flagged point (МКп 28R), observation: no fog (VIS > 3000 m) at the point and fog at 5 other points => forecast is correct.

23:50 UTC



Later, fog is forecasted and observed at the flagged point => forecast is correct

Displays of recent, current and forecast weather for aerodrome service SPb



Regular forecast

Recent, current weather& forecasts for runways

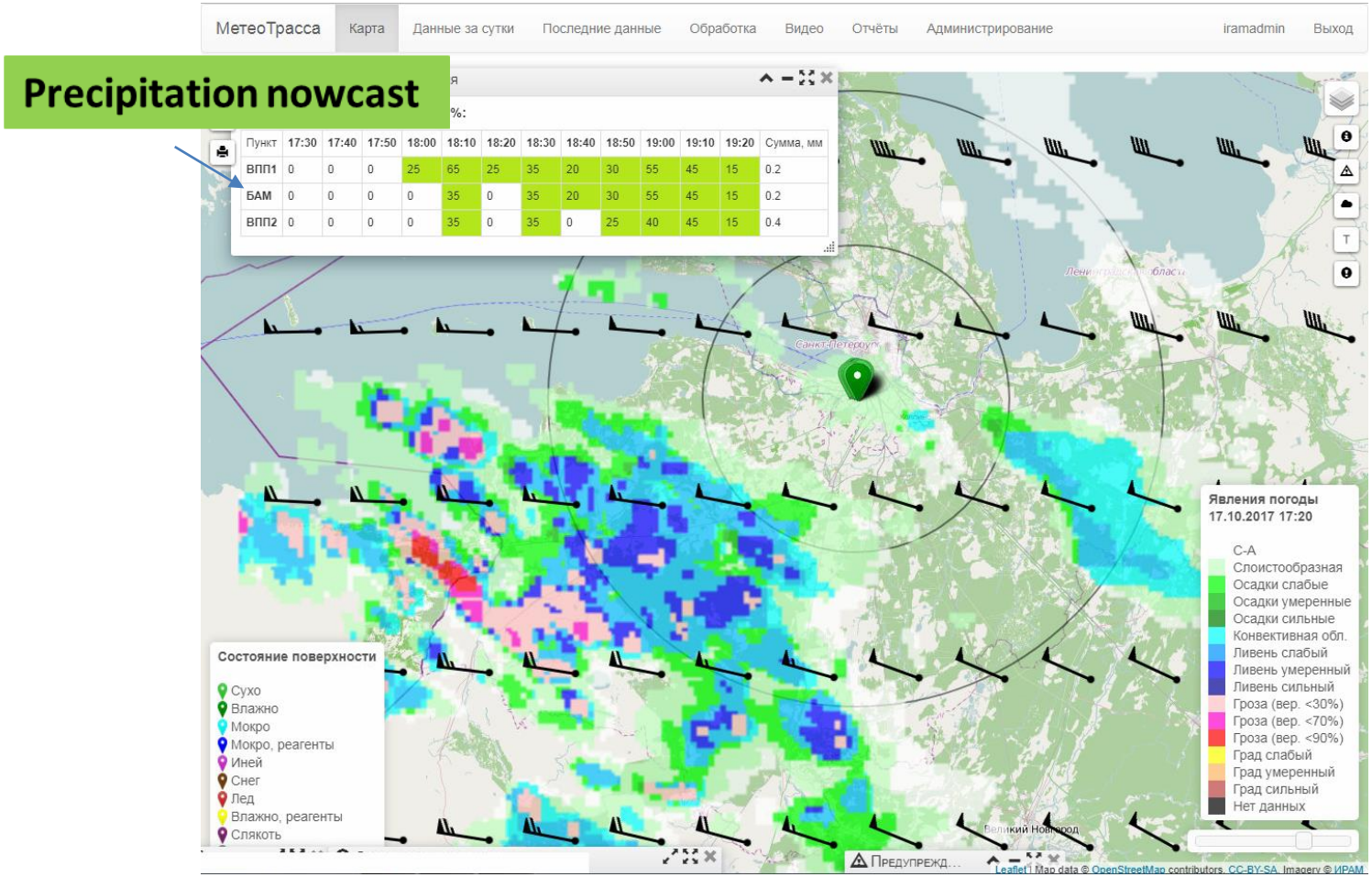
Runway sensors

Surface conditions

Precipitation nowcast

Accurate weather data and forecasts help aerodrome service **to react to hazardous weather in time** and to initiate **preventive** works.

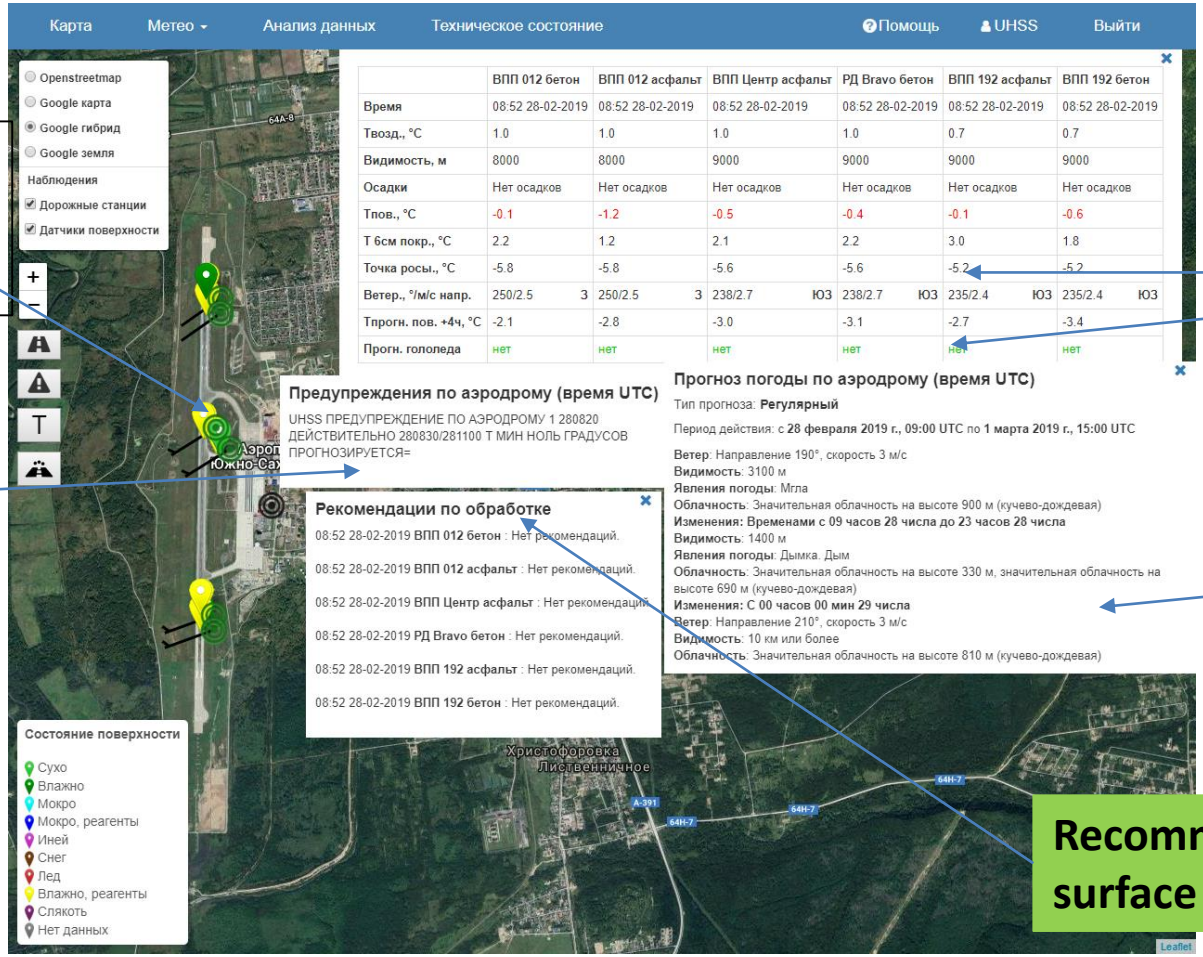
Weather radar mosaic & wind vectors help visualize forthcoming weather



MeteoTrassa for aerodrome service Yuzhno-Sakhalinsk

Surface condition, wind

Warnings



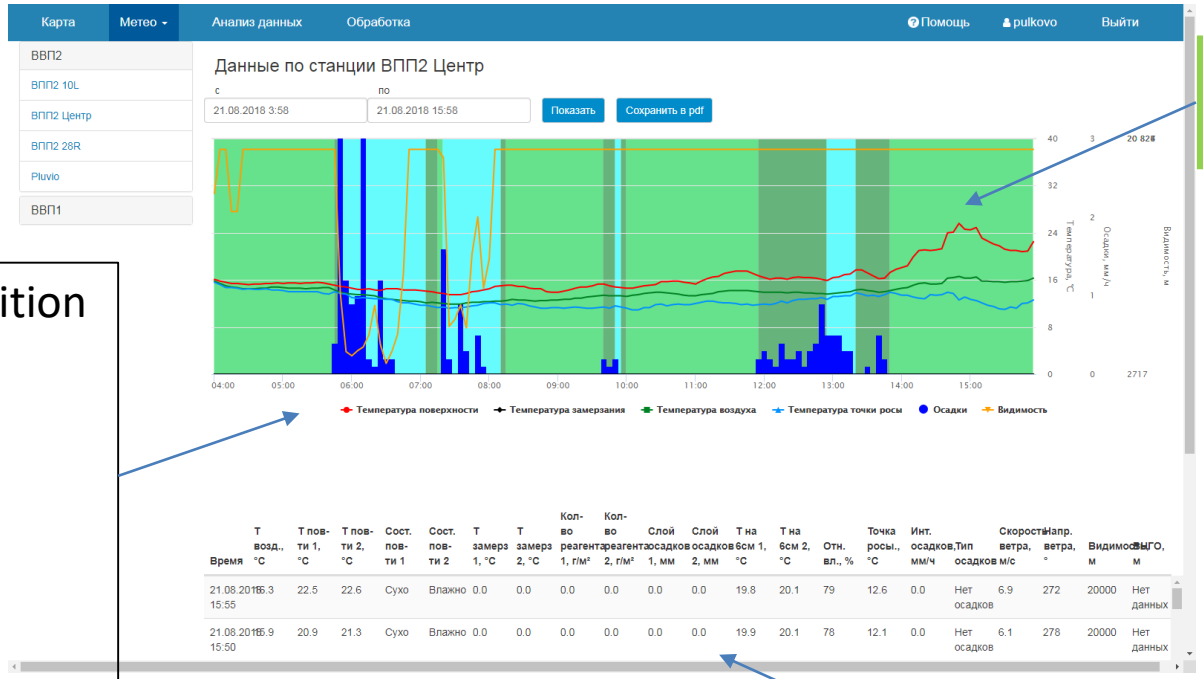
	ВПП 012 бетон	ВПП 012 асфальт	ВПП Центр асфальт	РД Bravo бетон	ВПП 192 асфальт	ВПП 192 бетон
Время	08:52 28-02-2019	08:52 28-02-2019	08:52 28-02-2019	08:52 28-02-2019	08:52 28-02-2019	08:52 28-02-2019
Твозд., °C	1.0	1.0	1.0	1.0	0.7	0.7
Видимость, м	8000	8000	9000	9000	9000	9000
Осадки	Нет осадков	Нет осадков	Нет осадков	Нет осадков	Нет осадков	Нет осадков
Тпов., °C	-0.1	-1.2	-0.5	-0.4	-0.1	-0.6
Т 6см покр., °C	2.2	1.2	2.1	2.2	3.0	1.8
Точка росы., °C	-5.8	-5.8	-5.6	-5.6	-5.2	-5.2
Ветер., °/м/с напр.	250/2.5 З	250/2.5 З	238/2.7 ЮЗ	238/2.7 ЮЗ	235/2.4 ЮЗ	235/2.4 ЮЗ
Тпрогн. пов. +4ч, °C	-2.1	-2.8	-3.0	-3.1	-2.7	-3.4
Прогн. гололеда	нет	нет	нет	нет	нет	нет

Current weather, forecasts

TAF

Recommendations on surface treatment

MeteoTrassa for aerodrome service Yuzhno-Sakhalinsk

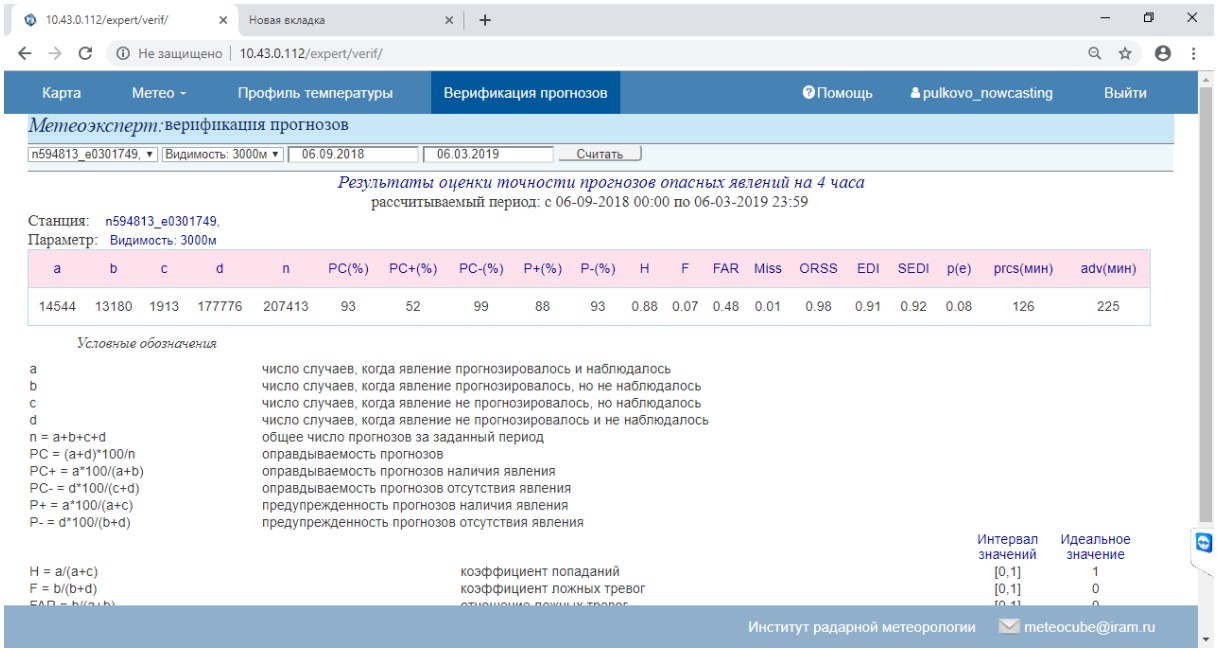


Measurements and forecasts

Surface condition
T surface
T freezing
T air
T dew point
Precipitation
Visibility

All measurements

Verification is available on the website



- **Forecasts** have been verified **against actual observations at 10-min** intervals. Criteria of **accuracy** correspond to Annex 3 **ICAO**.
- **15 verification measures** are applied, incl.

PC - Proportion Correct, **F** - False alarm rate, **H** - Hit rate, **Miss** - Miss frequency …

ORSS- Odds Ratio Skill Score

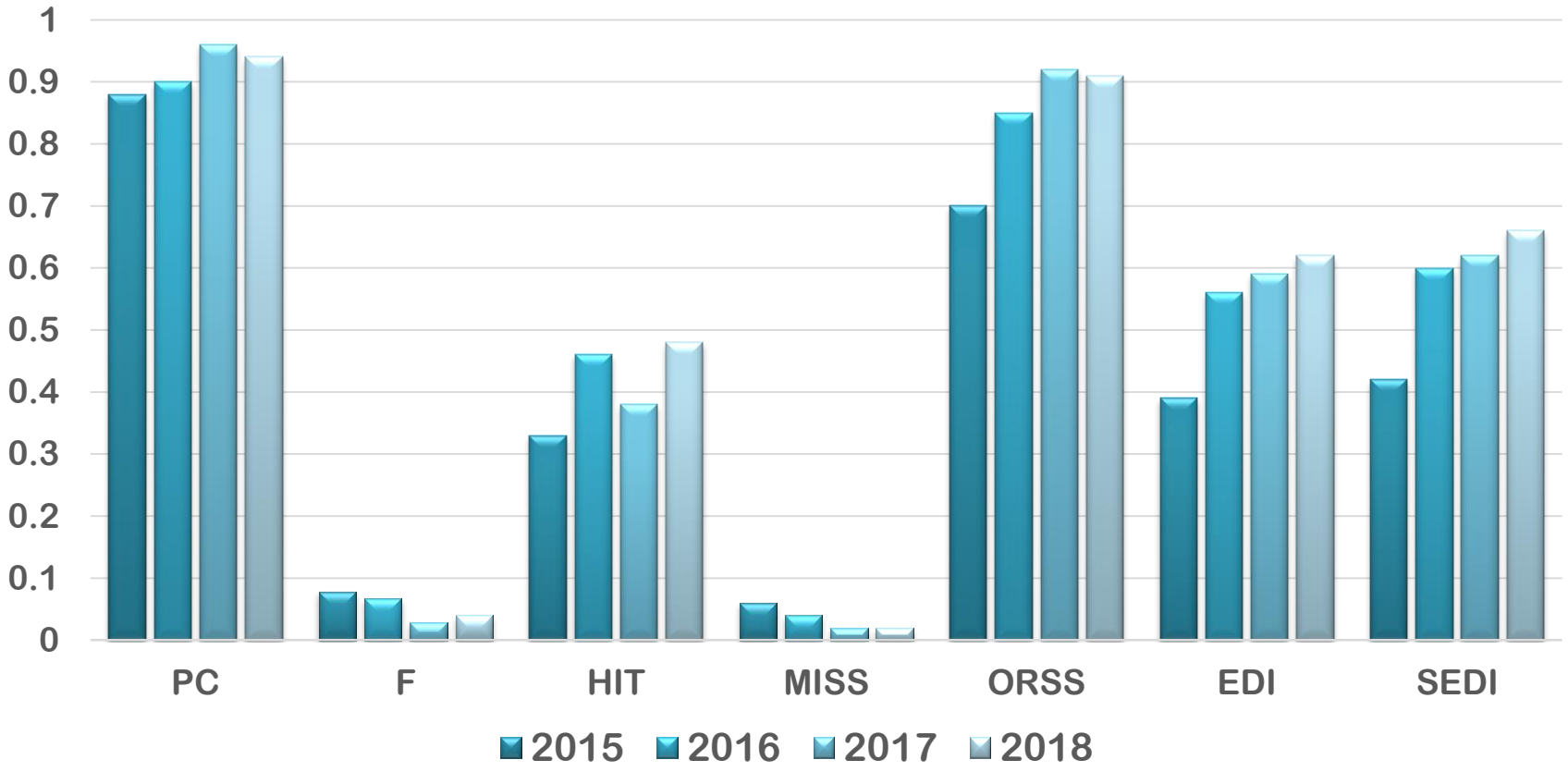
EDI - Extremal Dependency Index

SEDI - Symmetrical Extremal Dependency Index

the most informative for forecast verification of rare events

Fog forecast verification

for the operation period over **2015-2018 in Irkutsk**

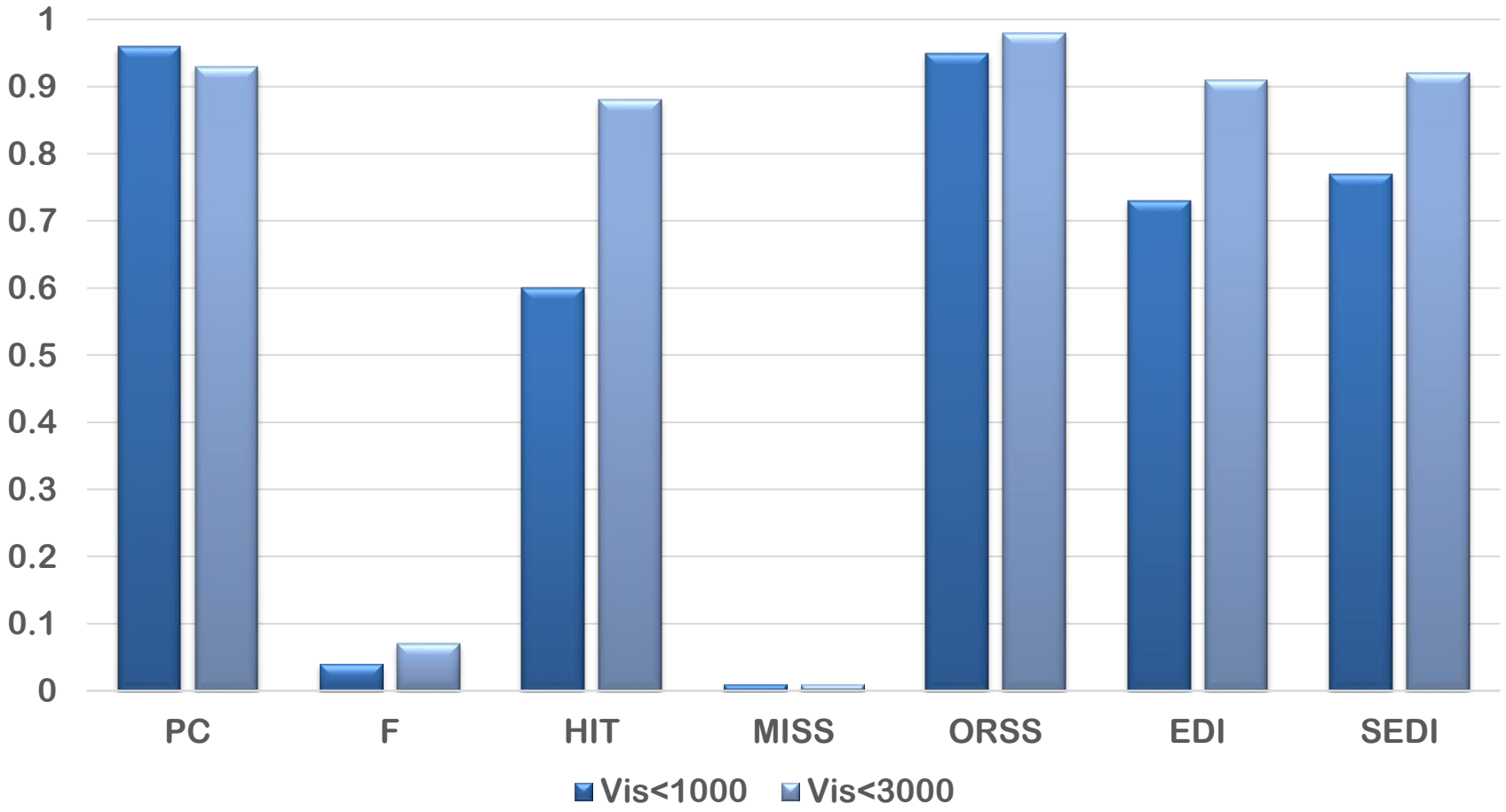


Range: [0,1] [0,1] [0,1] [0,1] [0,1] [-1,1]

Underlined symbols correspond to ideal values

Visibility forecast verification

for the operation period over **2018.09 – 2019.03 in SPb**



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Visibility forecasts were verified under two thresholds (1000 and 3000m)

Conclusion

- The nowcasting system is **specifically tailored to the airport needs**. Impact weather parameters are to be taken into account which are most critical for the airport.
- Verification shows the **reasonable accuracy** of forecasts and the **gradual increase of accuracy** for the operation period.
- Based on the **verification** it can be concluded that the nowcasting systems **MeteoExpert** and **MeteoTrassa** can give real **support** to aviation forecasters, aerodrome maintenance service and decision-makers at the airports.
- Development of the system is the process of making **algorithms gradually better**, and **technical component more diverse and advanced**.
- New MET information about high impact weather can be translated into the **ATM** systems for decision-making by means of the MeteoServer (the IRAM's system to provide ATM with MET data, > 40 systems in 6 countries)

Thank you