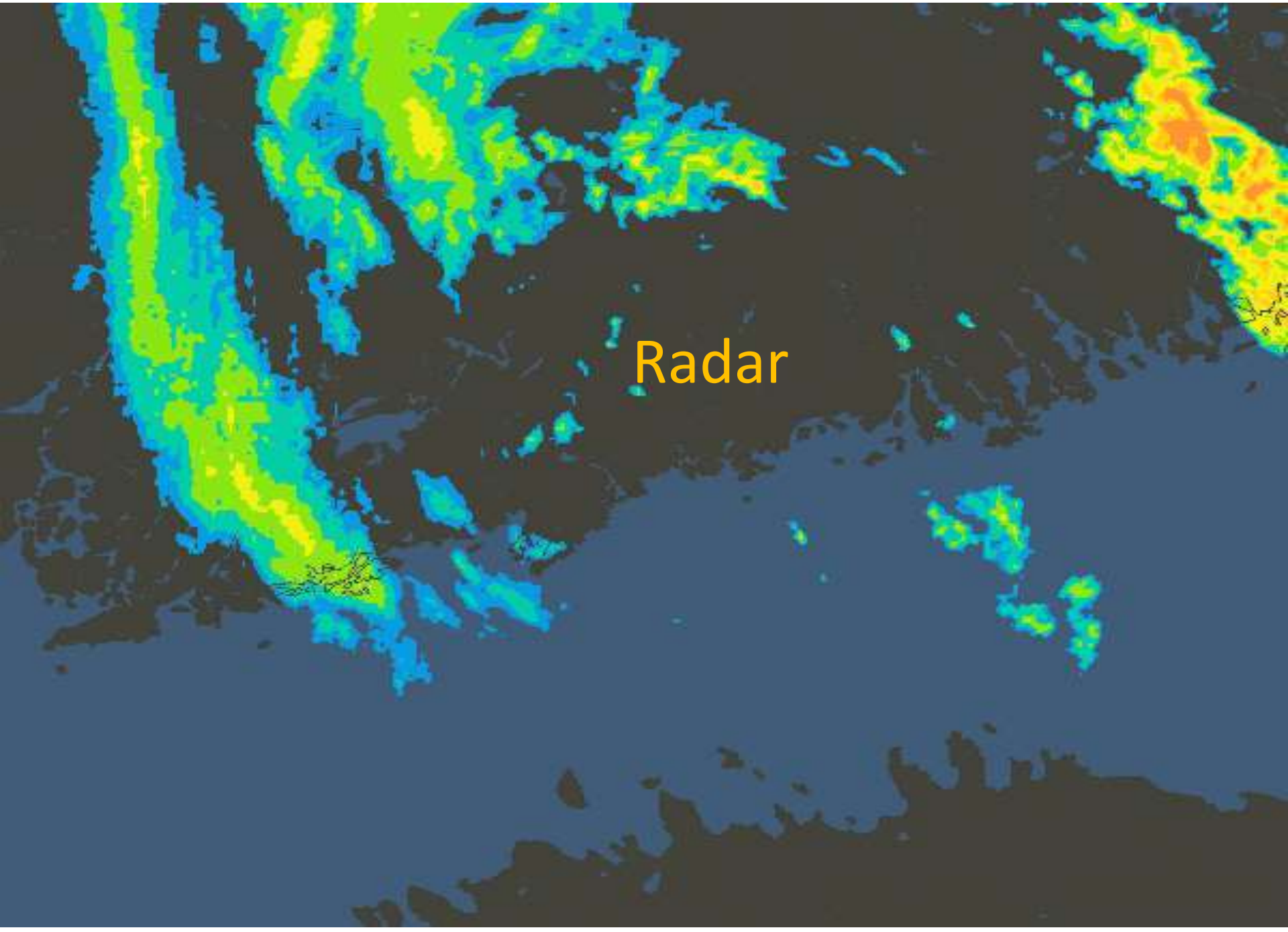
Improving snow nowcasts for airports

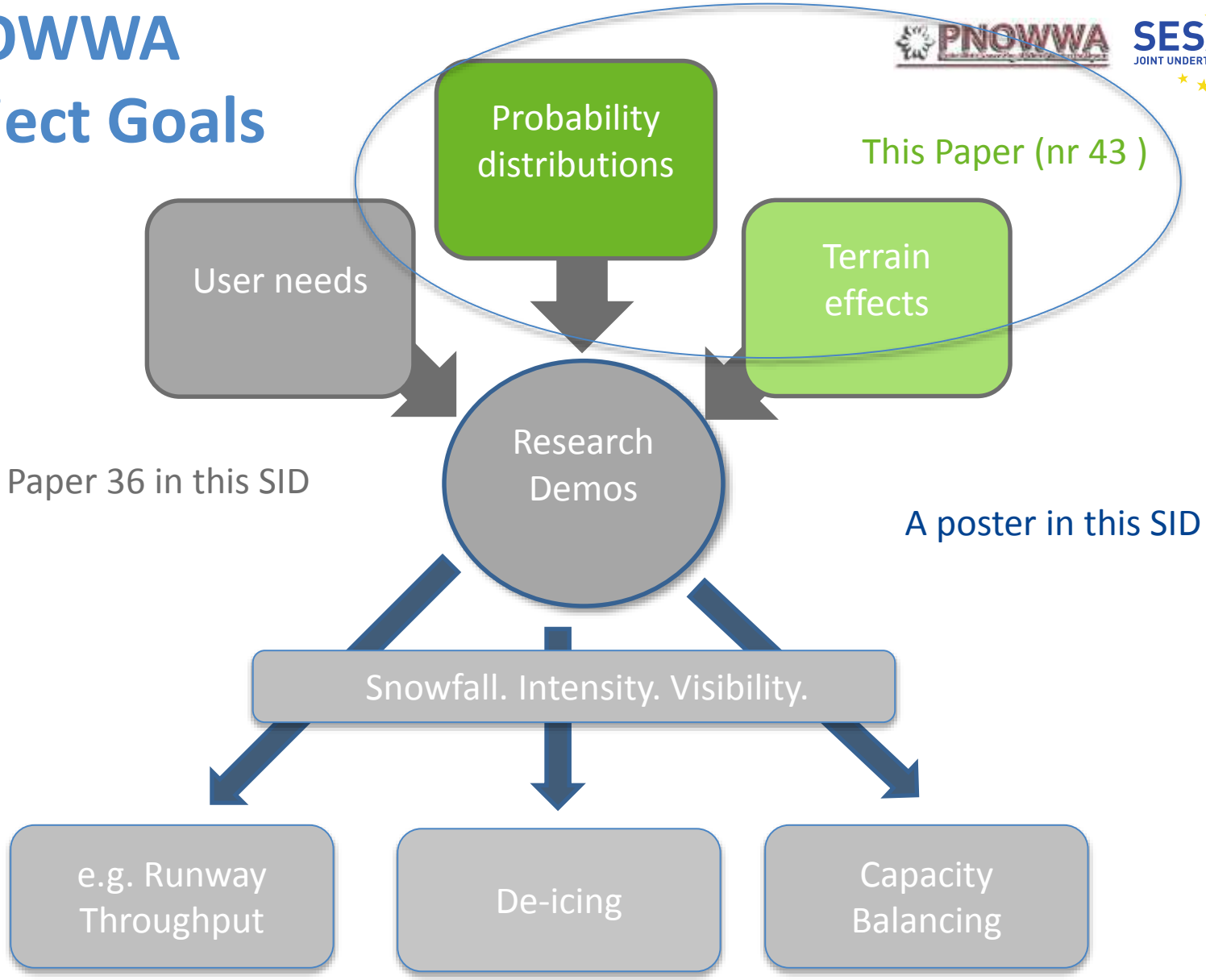
Elena Saltikoff, Finnish Meteorological Institute (FMI)
Seppo Pulkkinen, FMI
Annakaisa von Lerber, FMI
Martin Hagen, German Aerospace Center (DLR)

PNOWWA (Probabilistic Nowcasting of Winter Weather for Airports)

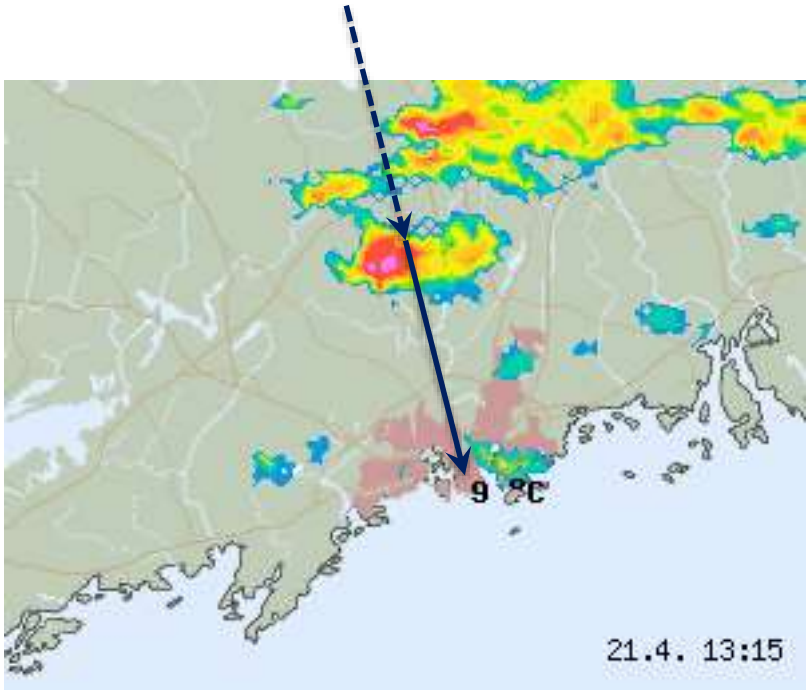

Radar

Winter weather

PNOWWA
Project Goals



Nowcasting with extrapolation of radar images in PNOWWA



Common principle:

Time= distance/speed

Example:

storm 75 km away,

moving 50 km/h

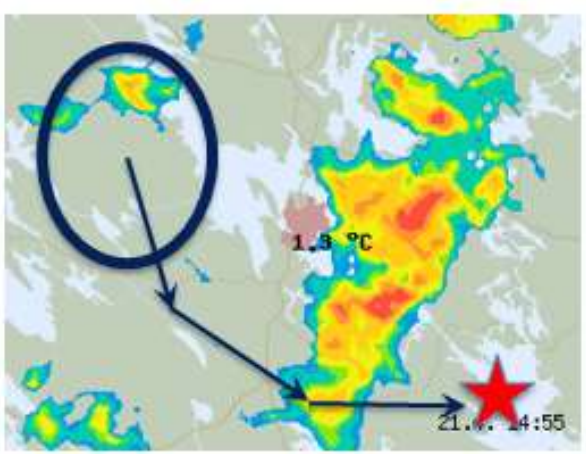
arrives in 90 minutes

15	30	45	60	75	90	105	120	135	150	165

.....dry..... snow...maybe

Task split in two

1. Calculate the motion vectors and their uncertainty
2. Move the radar image with the vectors, assess uncertainty



In PNOWWA we have tried three methods for both.

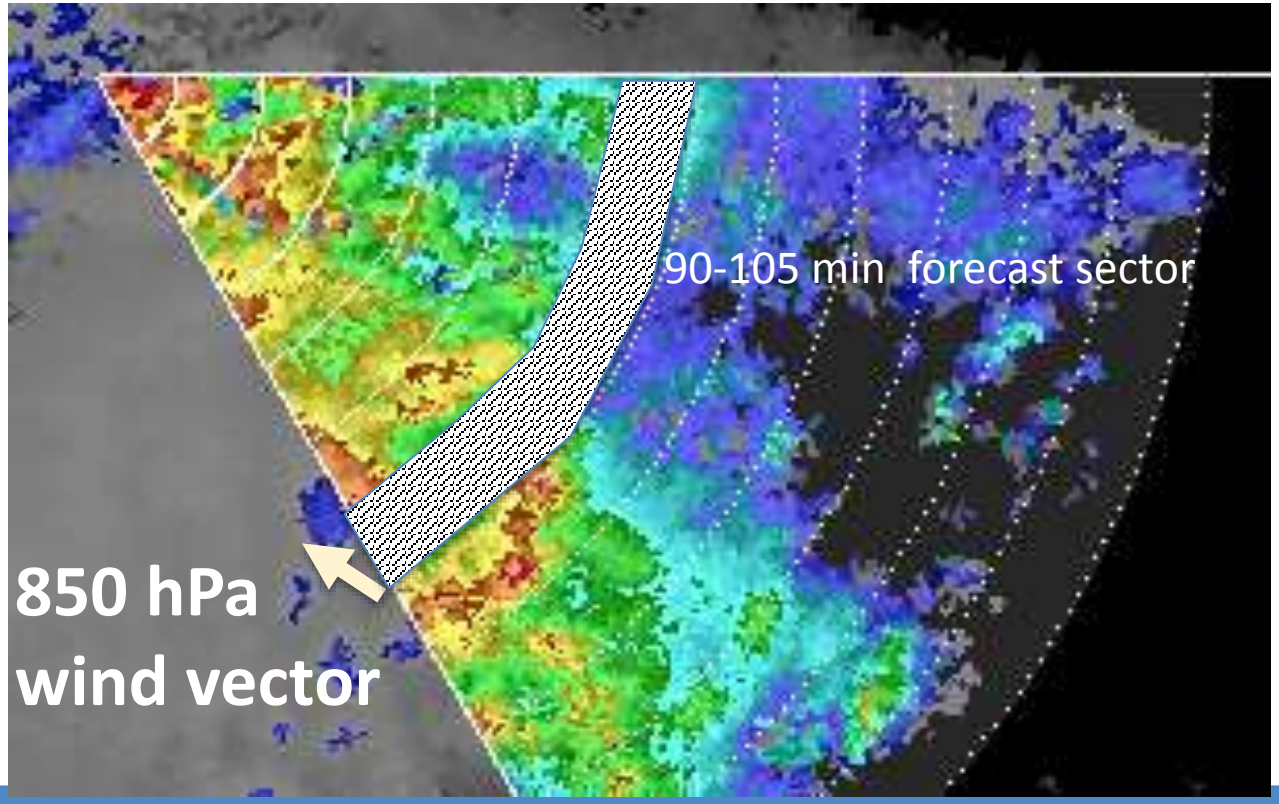
- Simple one from 1990s (Andersson & Ivarsson 1991)
- Operational one from Finnish Met Institute (Hohti et al 2000)
- New ones in research (Proesmans et al, Pulkkinen et al.)

- (This picture related to the FMI Operational one: ellipse is related to the uncertainty of motion vectors.)

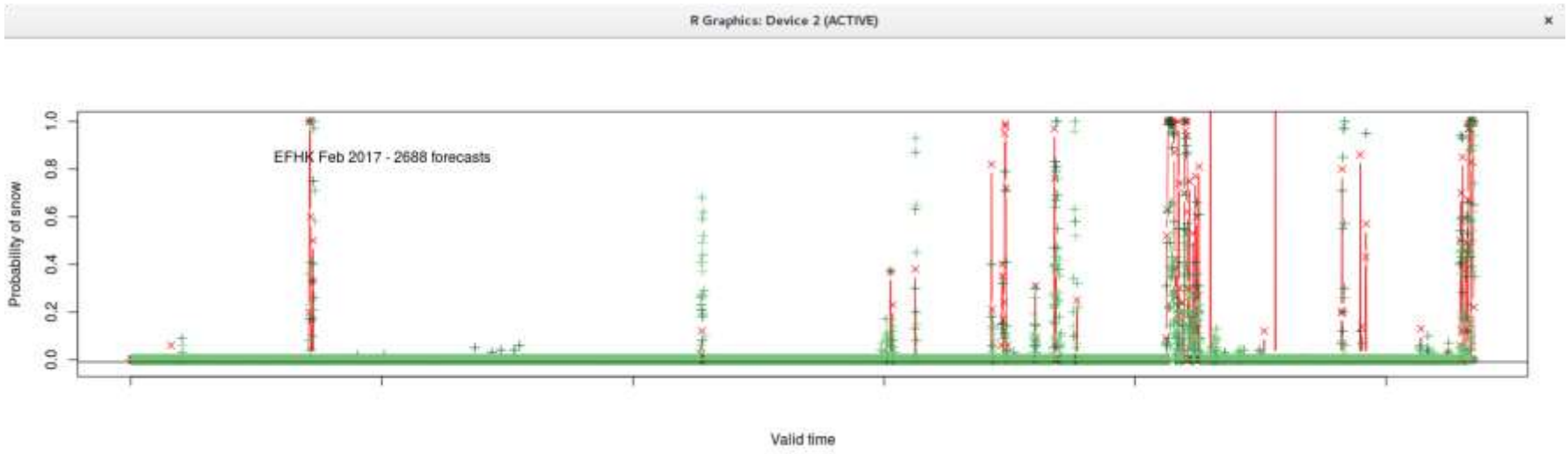
The Simple Method: Andersson & Ivarsson 1991

Frequency distribution in source area
as probability distrubution by time of arrival

Uncertainty of movement direction estimated as constant +/-30 degrees

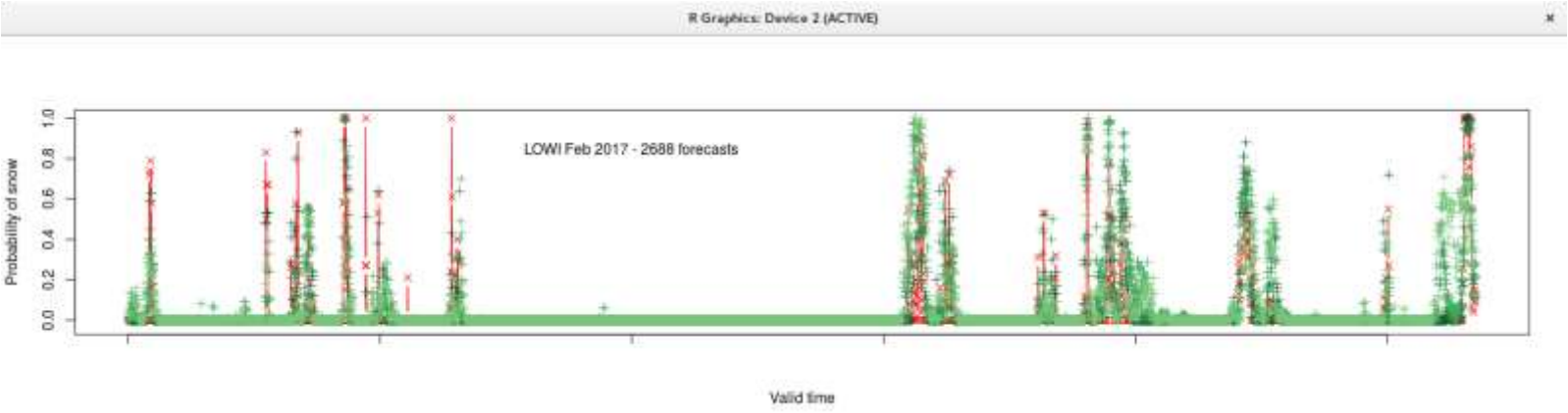


The simple one was used in first demos, and it performed quite well !



EFHK
Red: Observations (15 minutes)
Green shades: 30-120 min forecasts

Even in Innsbruck, which is a challenging place for radars

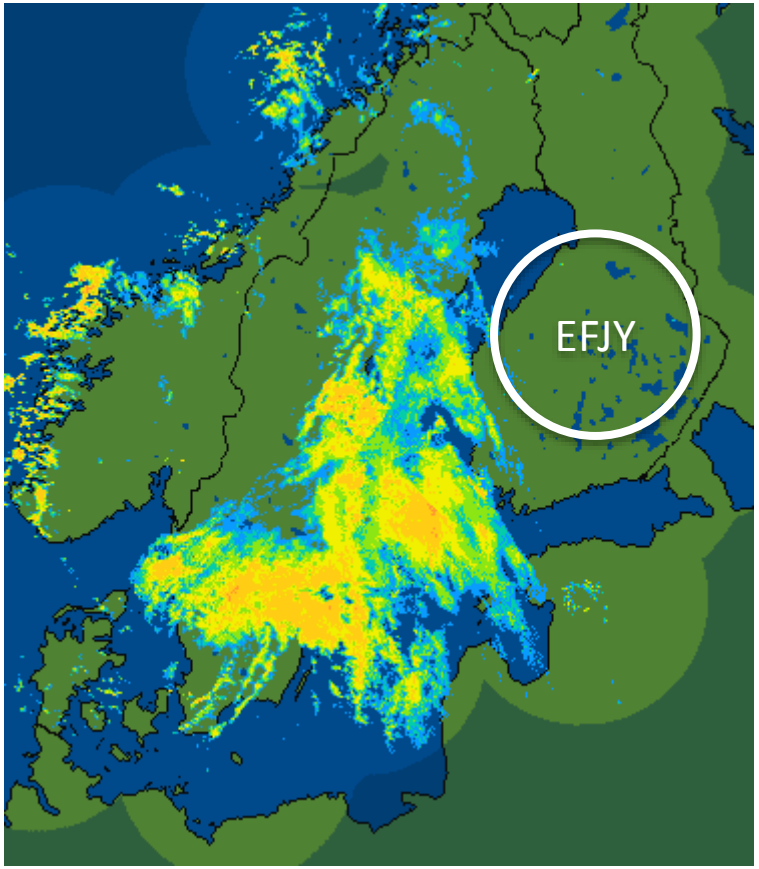


”Radar is an excellent tool to say it is not raining”

Based on this image we can say that the precipitation does not start in EFJY in 2 hours.

It is obvious for a meteorologist*.

But it is valuable information for the snowplough driver.



*In Finland, in wintertime

Why snow ? Why Airport ?

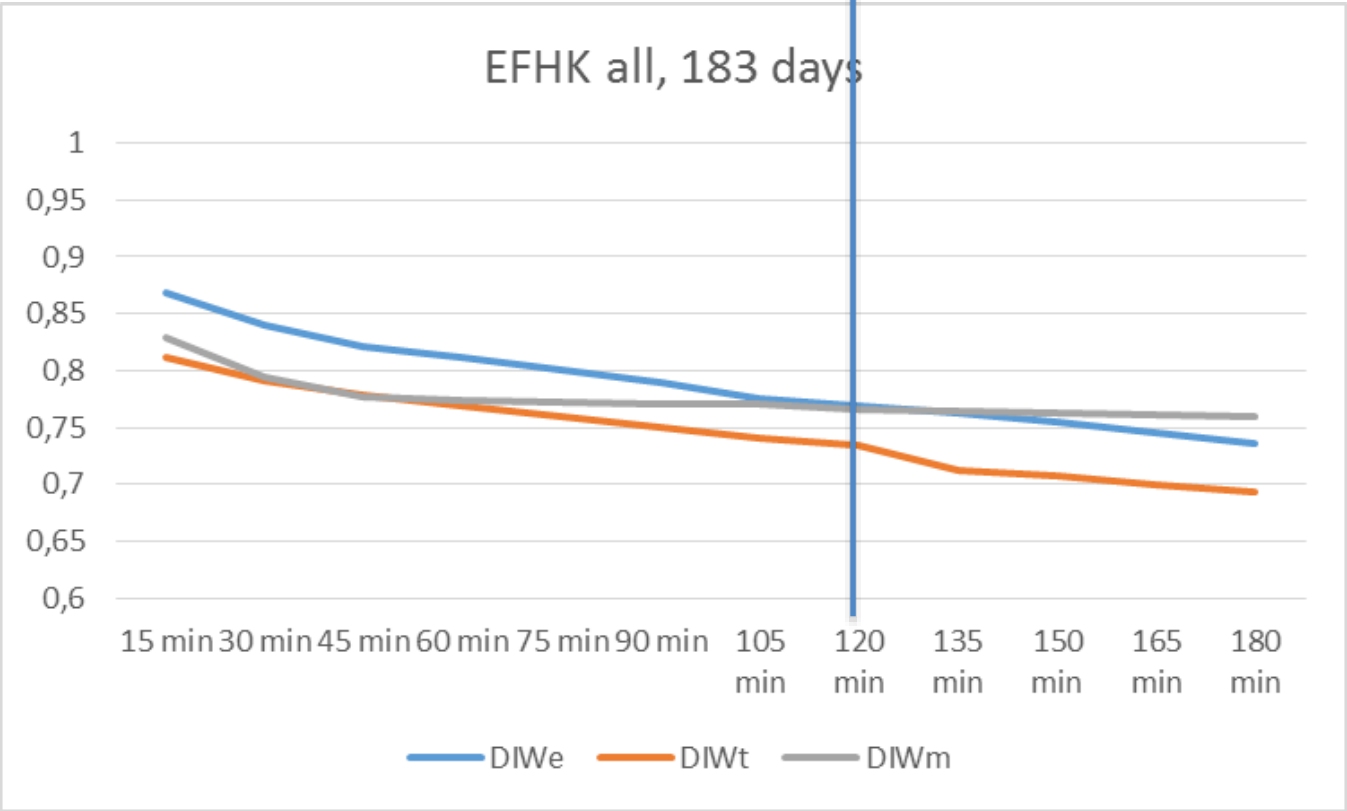
Extrapolation works only for already **existing precipitation**: you can not forecast summertime afternoon showers in the morning with these methods.

Airport is a known point with limited number of professional users

Radar better than NWP model up to 2h

Helsinki-Vantaa, 15 minutes steps:

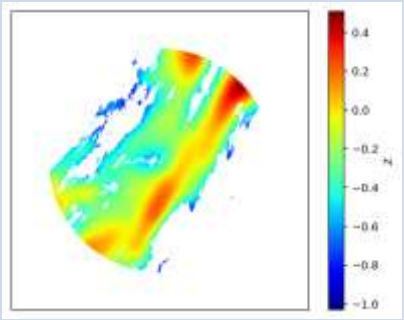
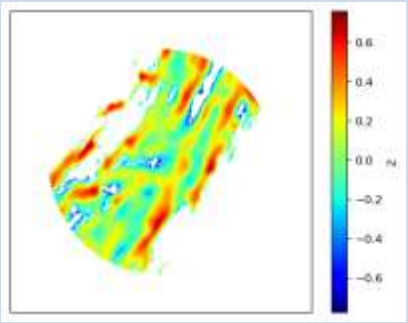
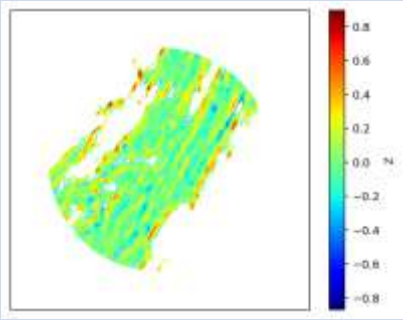
Hitrate, winters 2015-2016. Colours: Radar-based extrapolation TAF NWP Model



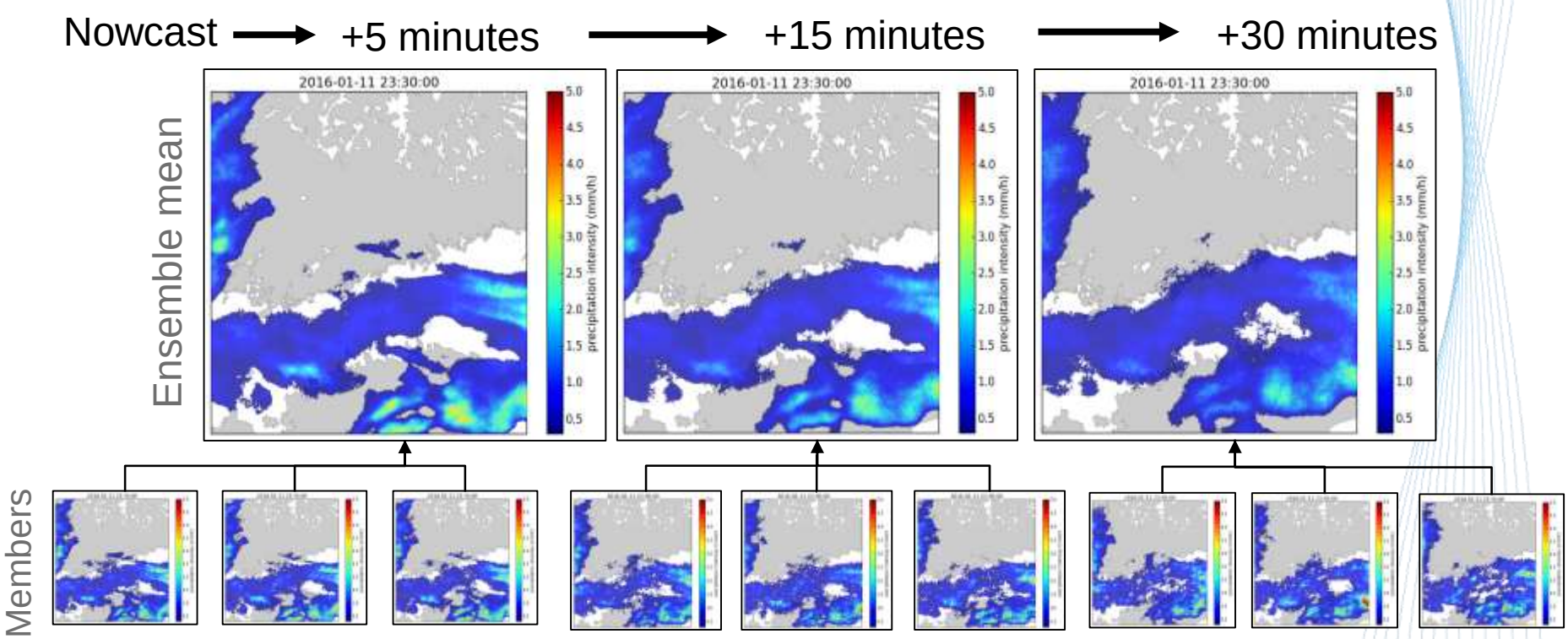
New nowcasting method based on Stochastic Ensembles: STEPS

- Motion field from consecutive radar images
- Uncertainty of motion
  assessed from a set of trajectories
- Uncertainty due to **growth and decay**
  modeled by a stochastic random field

A radar image is decomposed to different scales

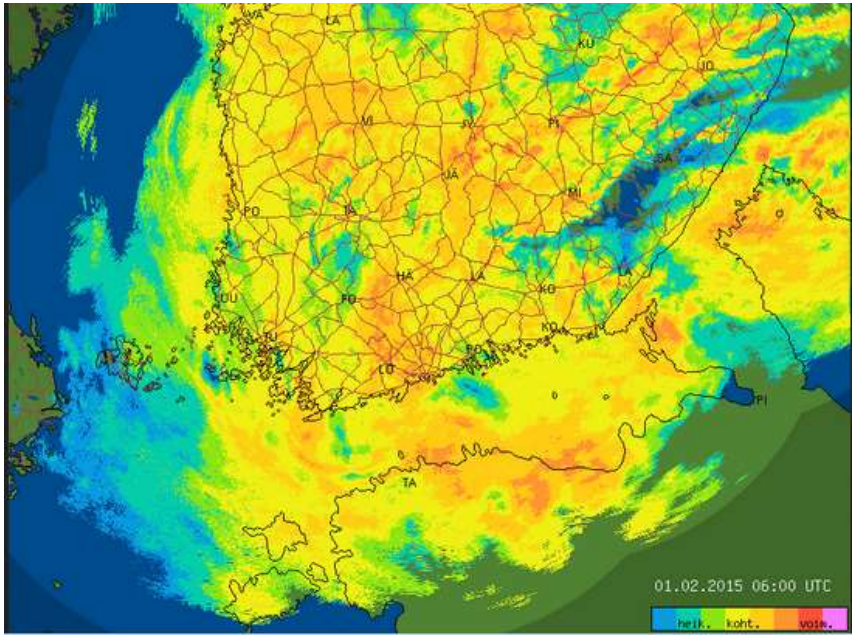
Large	Medium	Smallest
		
Long-living features which move as they are	Inbetween	To be quickly replaced with random noise , smoothed out in output

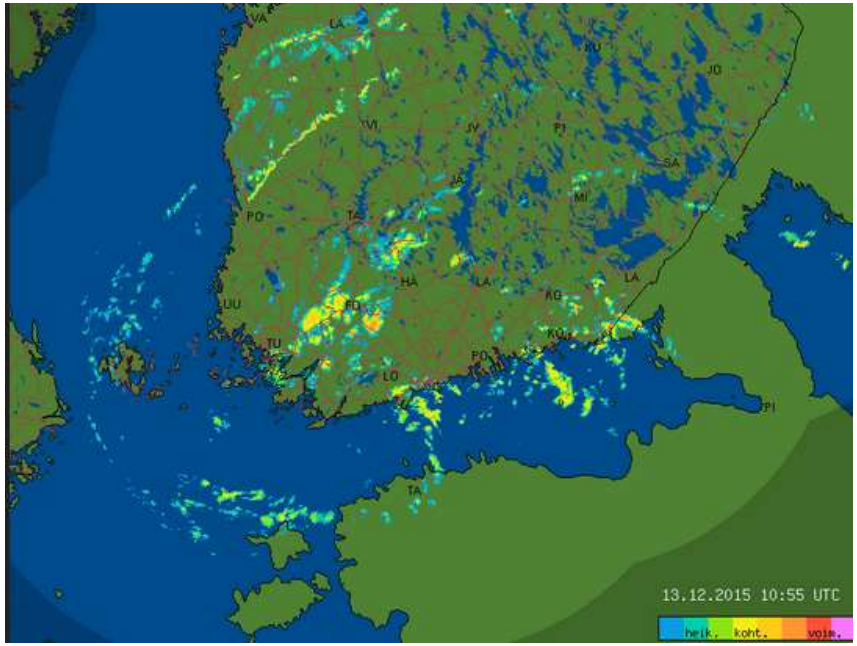
STEPS: Forecast Ensembles and Probabilities



- 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.

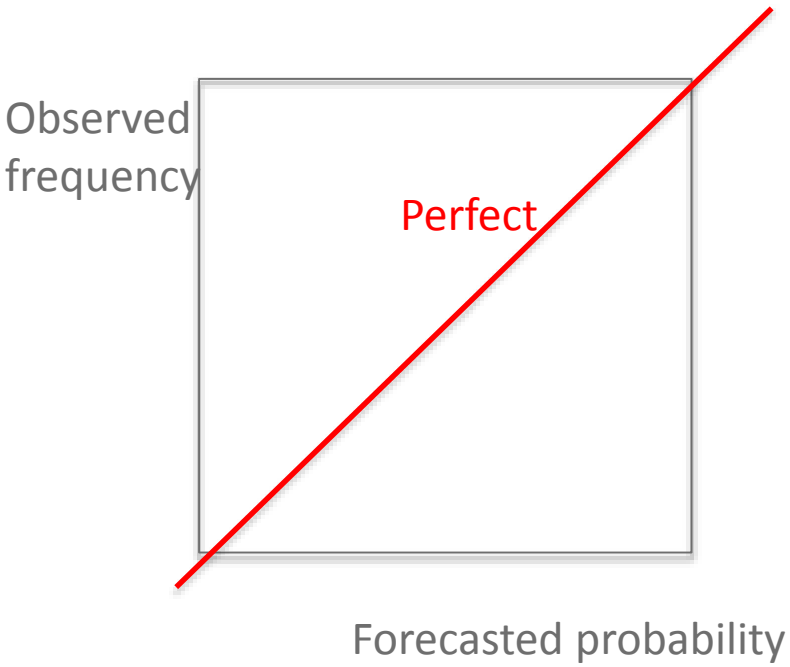
Comparing two cases in STEPS (the advanced method). Time step 5 minutes, 60 min range.



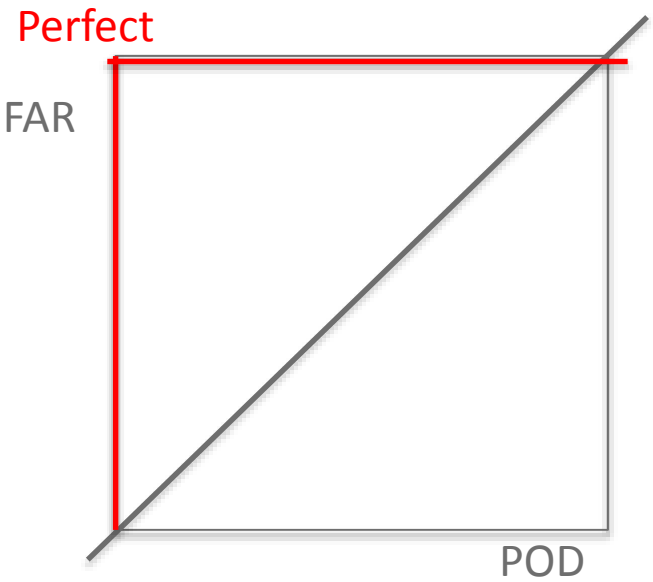


Two diagram types

Reliability diagrams



ROC – Relative Operating Characteristics



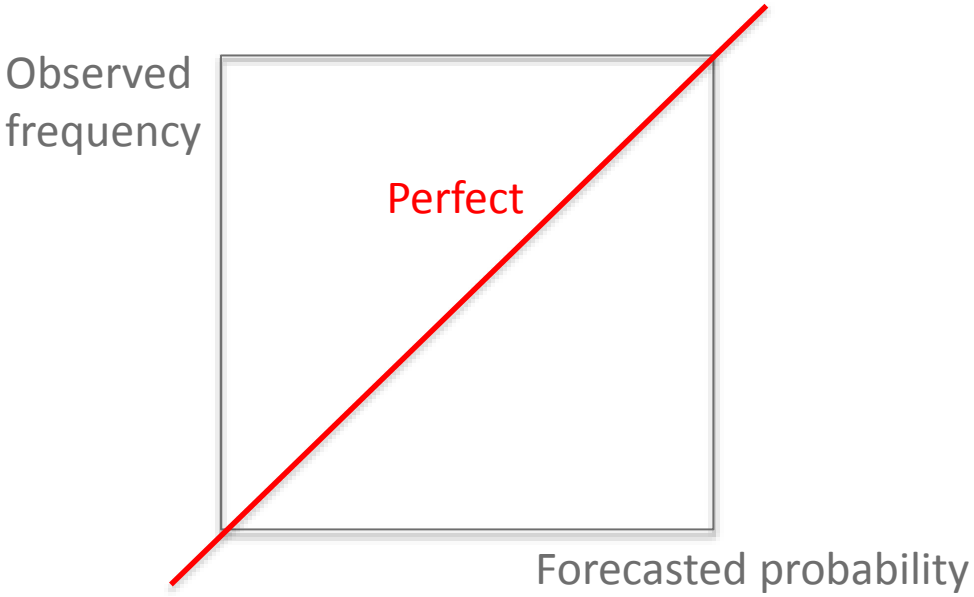
Reliability diagrams

Plots **observed frequency** against the **forecast probability,**

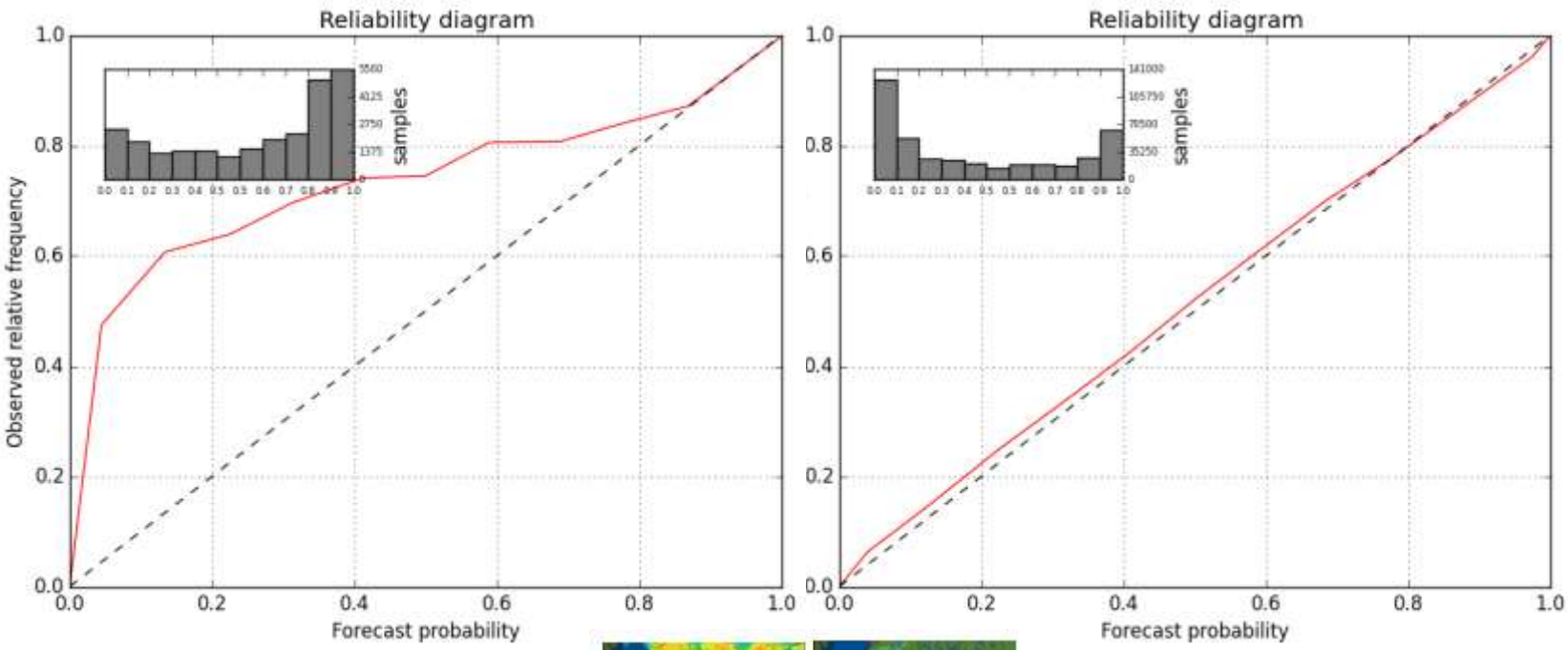
where the range of forecast probabilities is divided into bins (0-5%, 5-15%, 15-25%, etc.).

The sample size in each bin is included as a histogram or values.

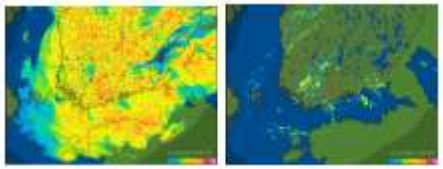
Reliability is indicated by the proximity of the plotted curve to the diagonal.



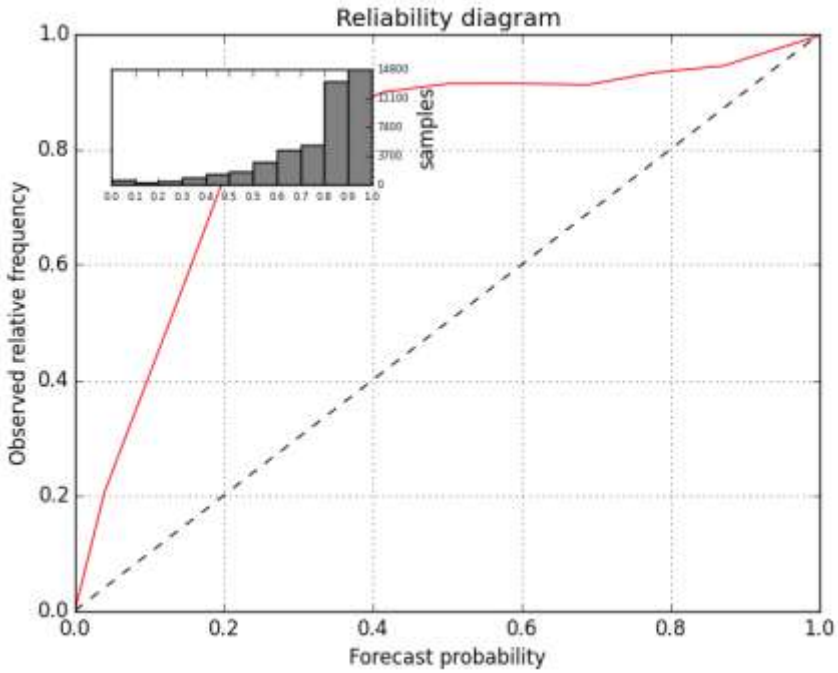
Reliability diagram 15 min

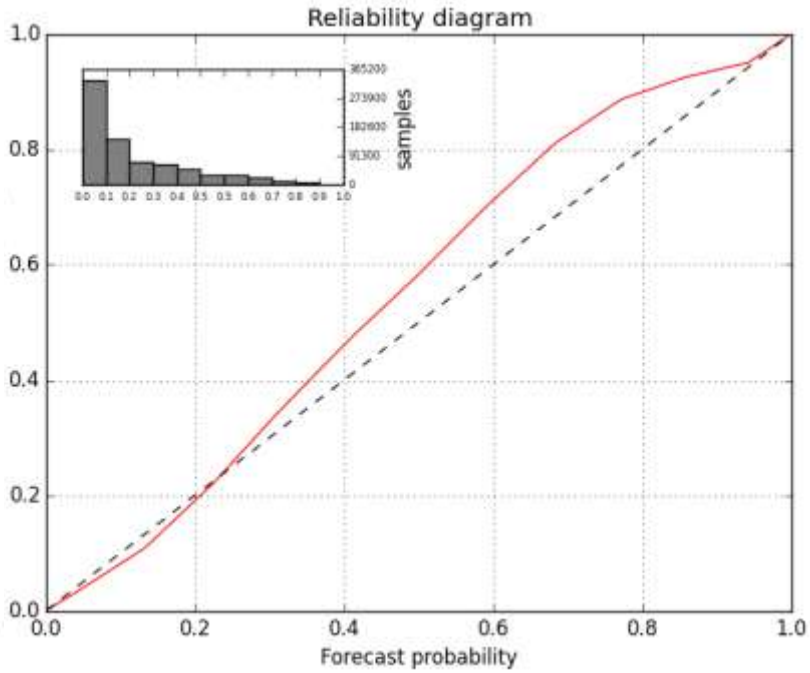


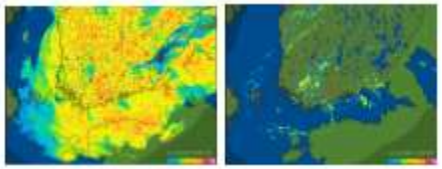
La



Reliability diagram 30 min

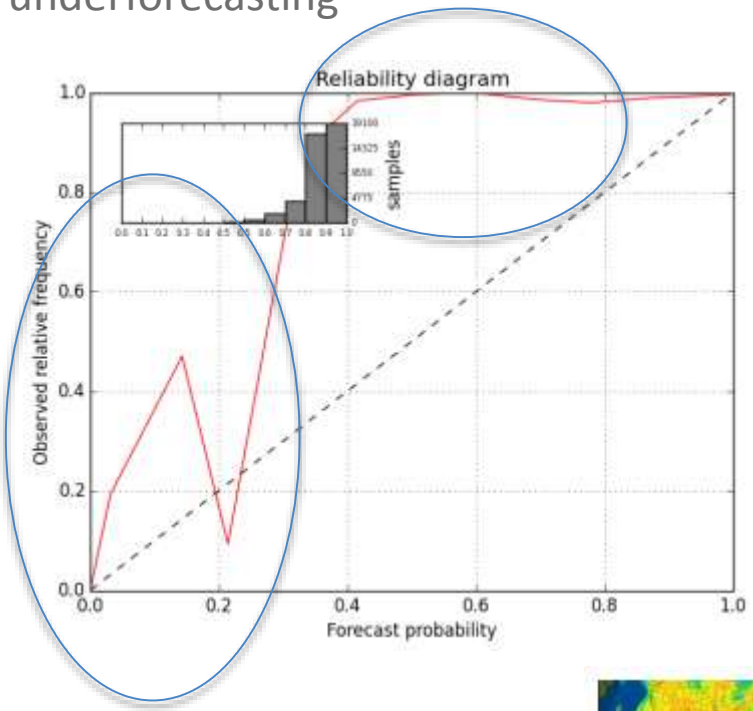




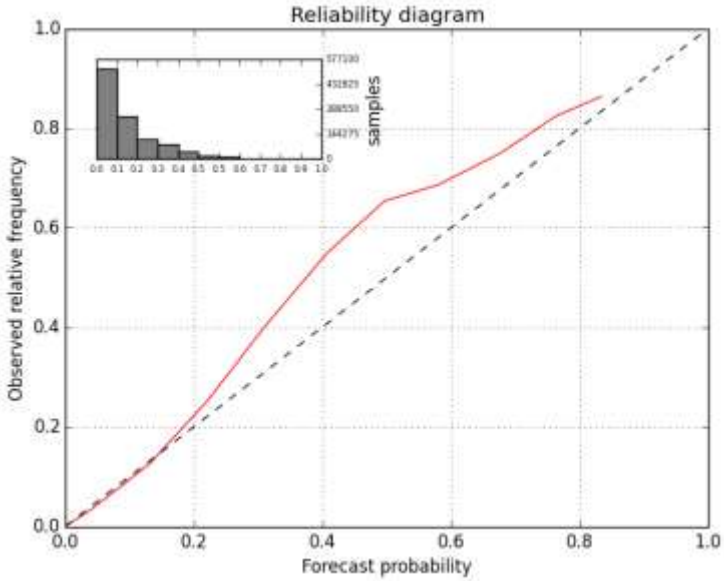


Reliability diagram 60 min

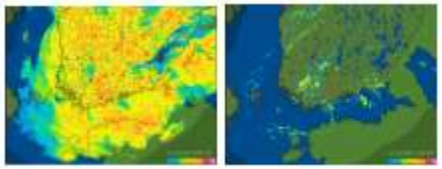
In widepread case, when 40-80% was forecasted, almost 100% happened: underforecasting



In the isolated showers case, even 60 min forecast almost perfect !



Small probabilities forecasted so seldomly, that this measure is not reliable

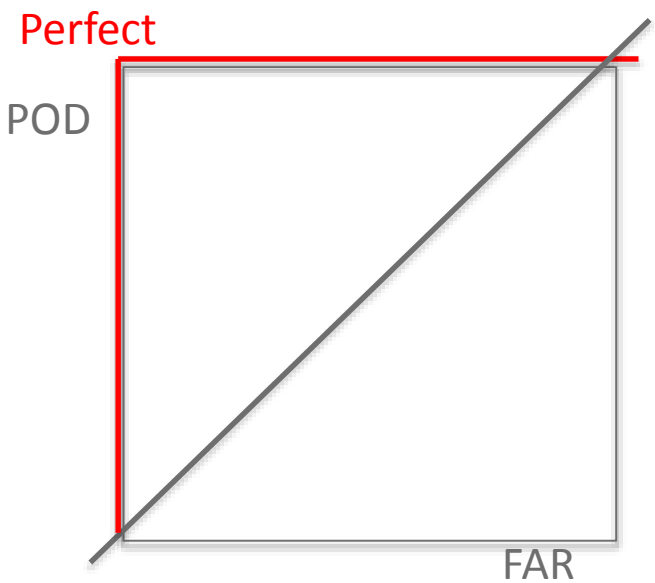


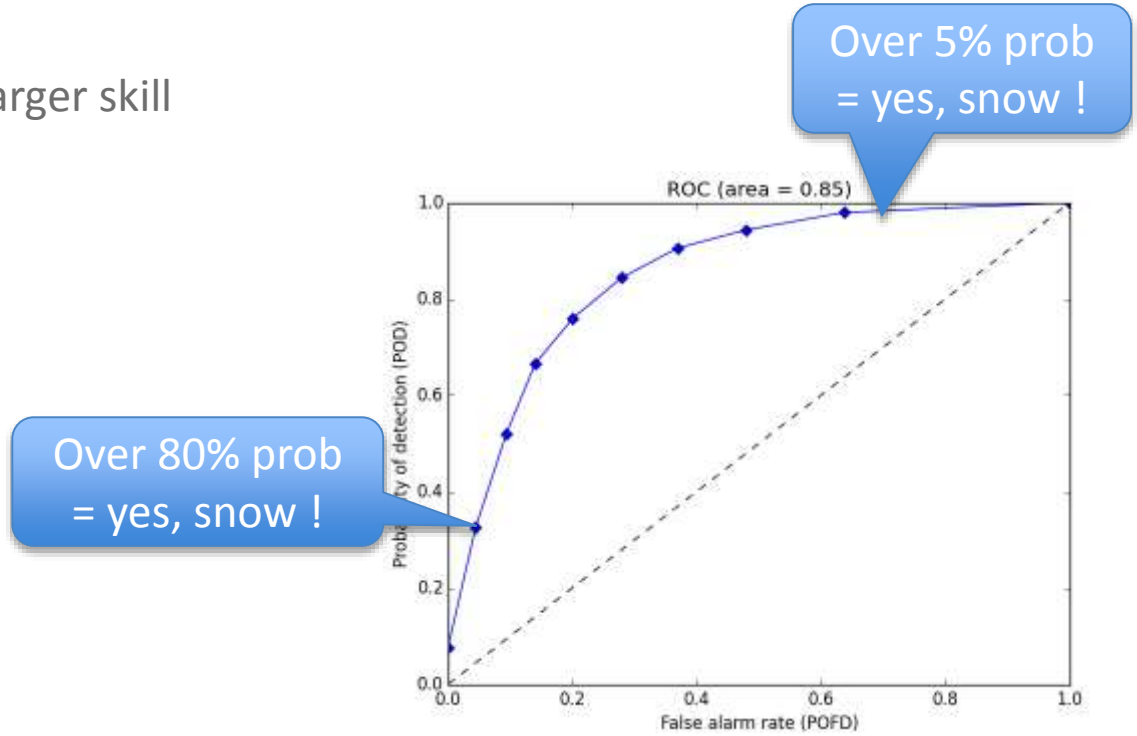
ROC – Relative Operating Characteristics

Plot hit rate or **probability of detection** against **false alarms** using set of increasing probabilities to make a yes-no decisions.

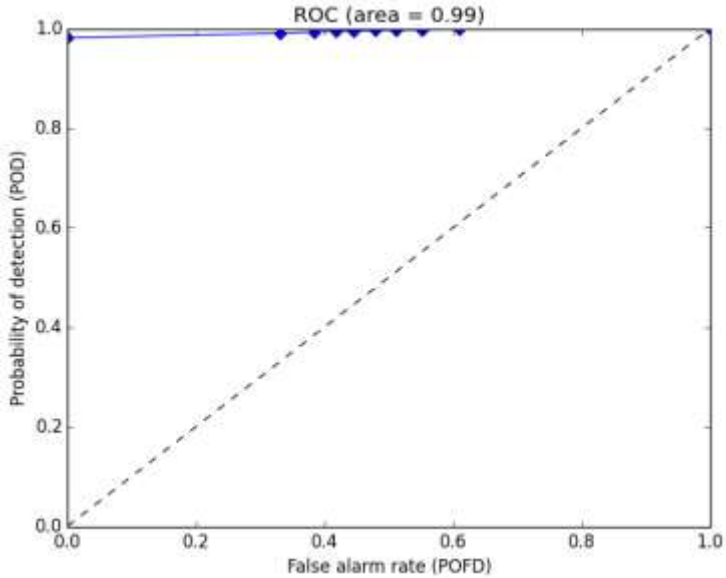
Diagonal: no skill .

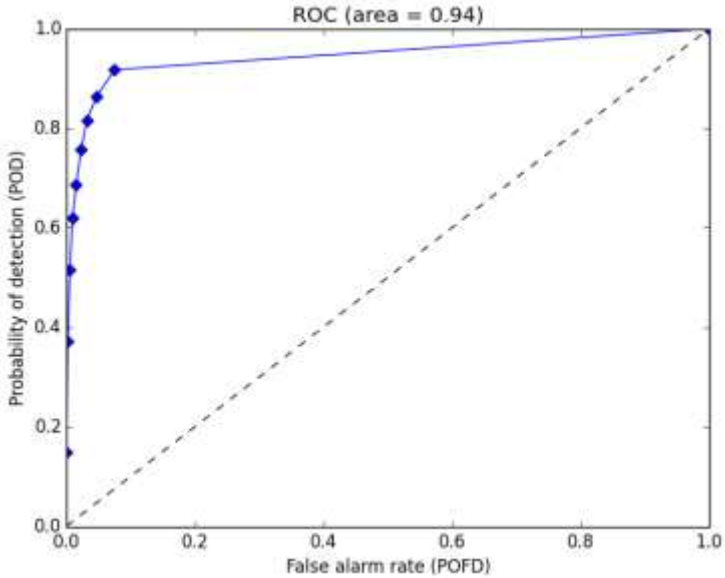
Larger area above diagonal: Larger skill

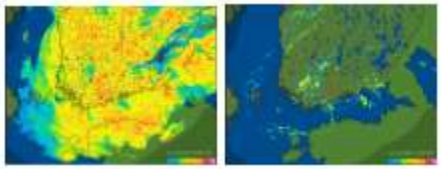




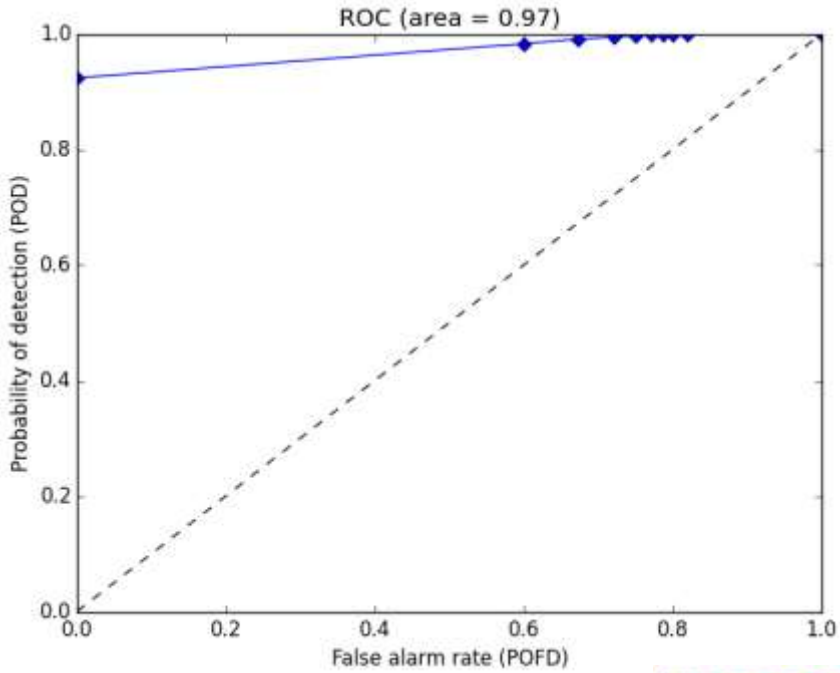
ROC 15 min

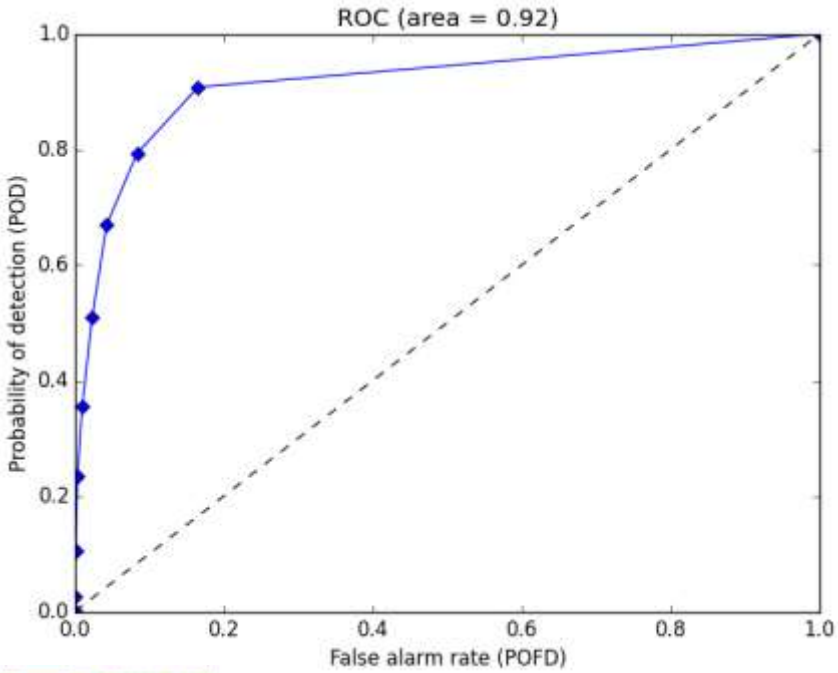

ROC (area = 0.99)
Probability of detection (POD)
False alarm rate (POFD)
0.0
0.2
0.4
0.6
0.8
1.0

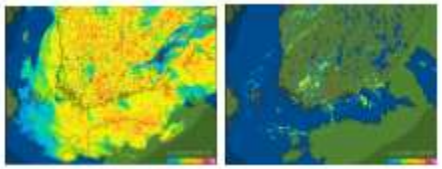

ROC (area = 0.94)
Probability of detection (POD)
False alarm rate (POFD)
0.0
0.2
0.4
0.6
0.8
1.0



ROC 30 min


ROC (area = 0.97)
Probability of detection (POD)
False alarm rate (POFD)
0.0
0.2
0.4
0.6
0.8
1.0

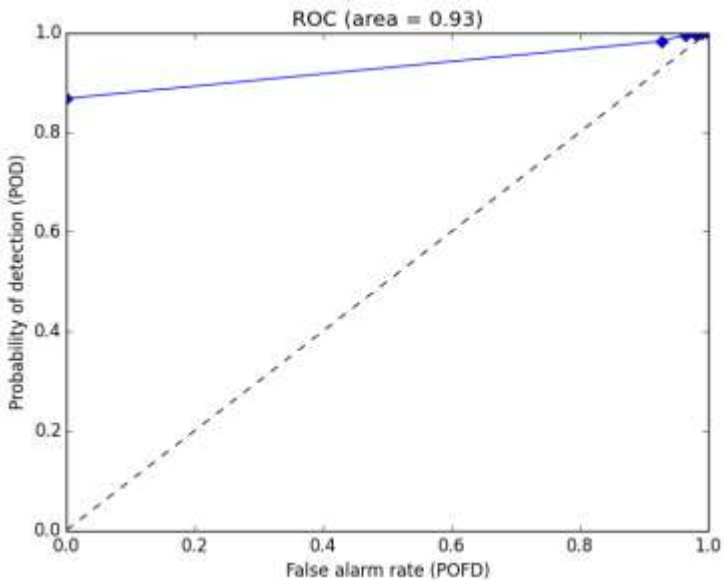

ROC (area = 0.92)
Probability of detection (POD)
False alarm rate (POFD)
0.0
0.2
0.4
0.6
0.8
1.0

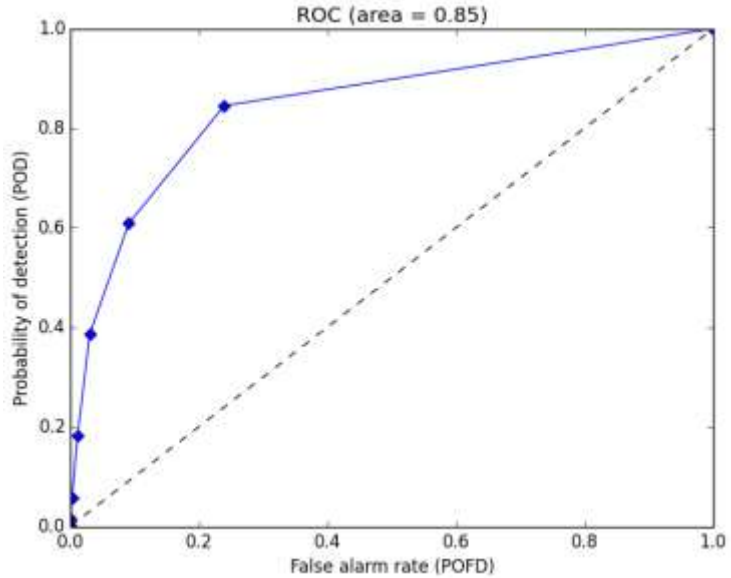


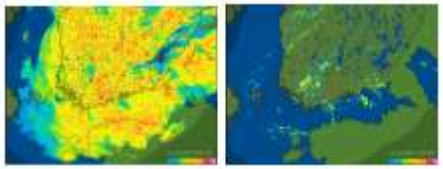
ROC 60 min

Still very high Probability of Detection

Still very low false alarm rate







This was all radar-to-radar

Radar reflectivity is a measure of sum of diameters of particles in power of six.

So, it is related to

- Number of snowflakes in volume
- Size of snowflakes in volume
- Other microphysical properties (dielectricity) of the snowflakes

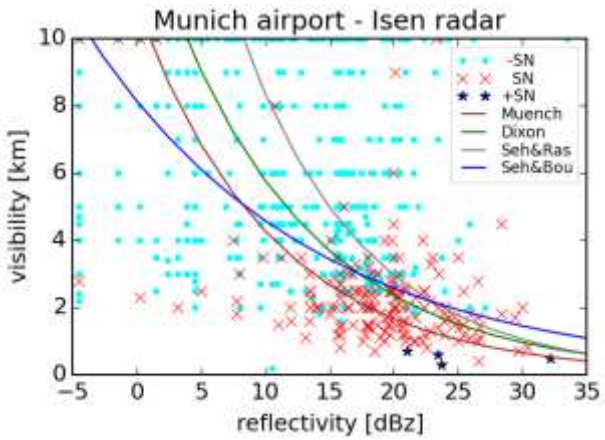
Visibility and snow depth are also related to these parameters.

But the relationship is not straightforward.

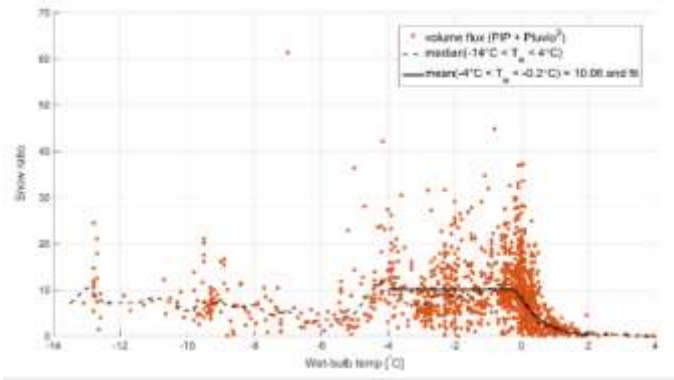
For dBZ, one 2 mm snowflake contributes as much as 64 snow flakes of 1 mm – for visibility not.

A lot of variability

From dBZ to visibility



Snow ratio: from mm to cm



Scandinavian ”mountains”

Mountains

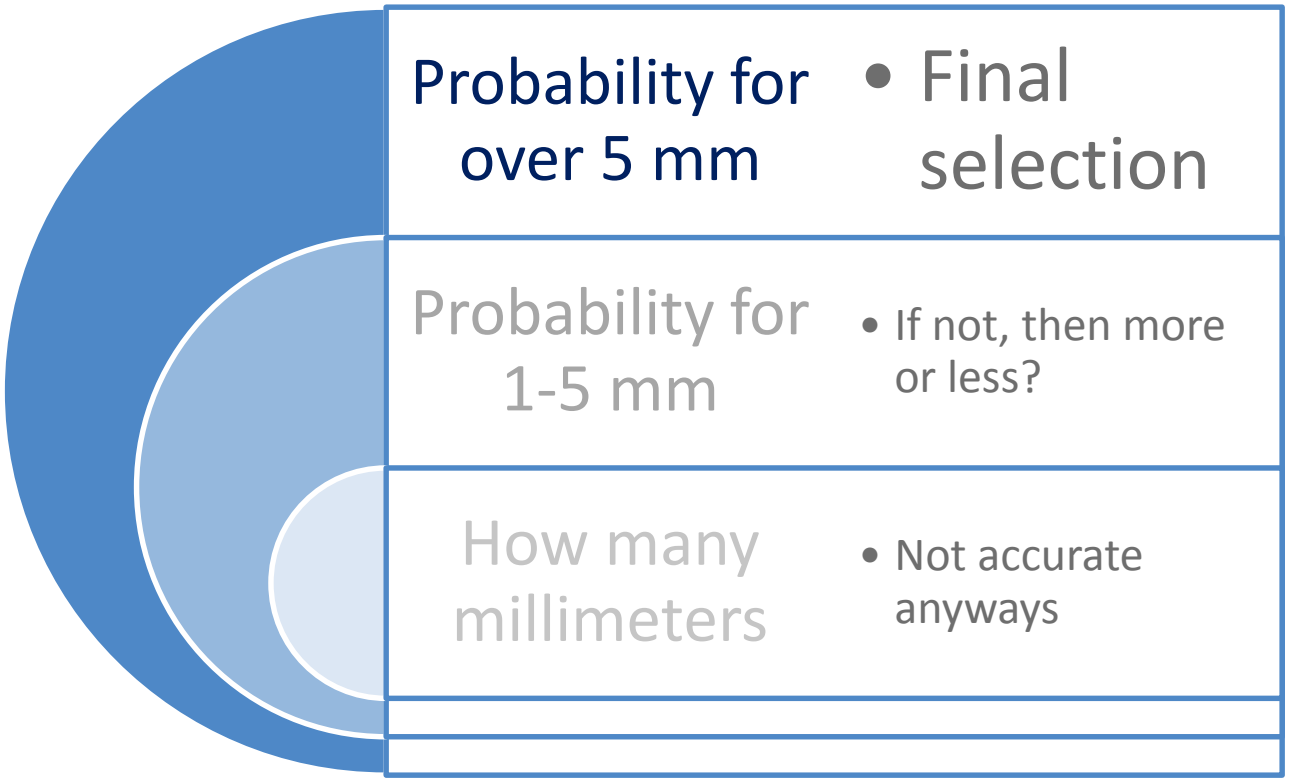
It's complicated.

Results from hills in Scandinavia do not apply to real mountains of the Alps.

Motion vectors from radar data or the upper level wind do not explain why fronts sometimes stop.

Future: analysis of motion vector uncertainty to assess cyclogenesis

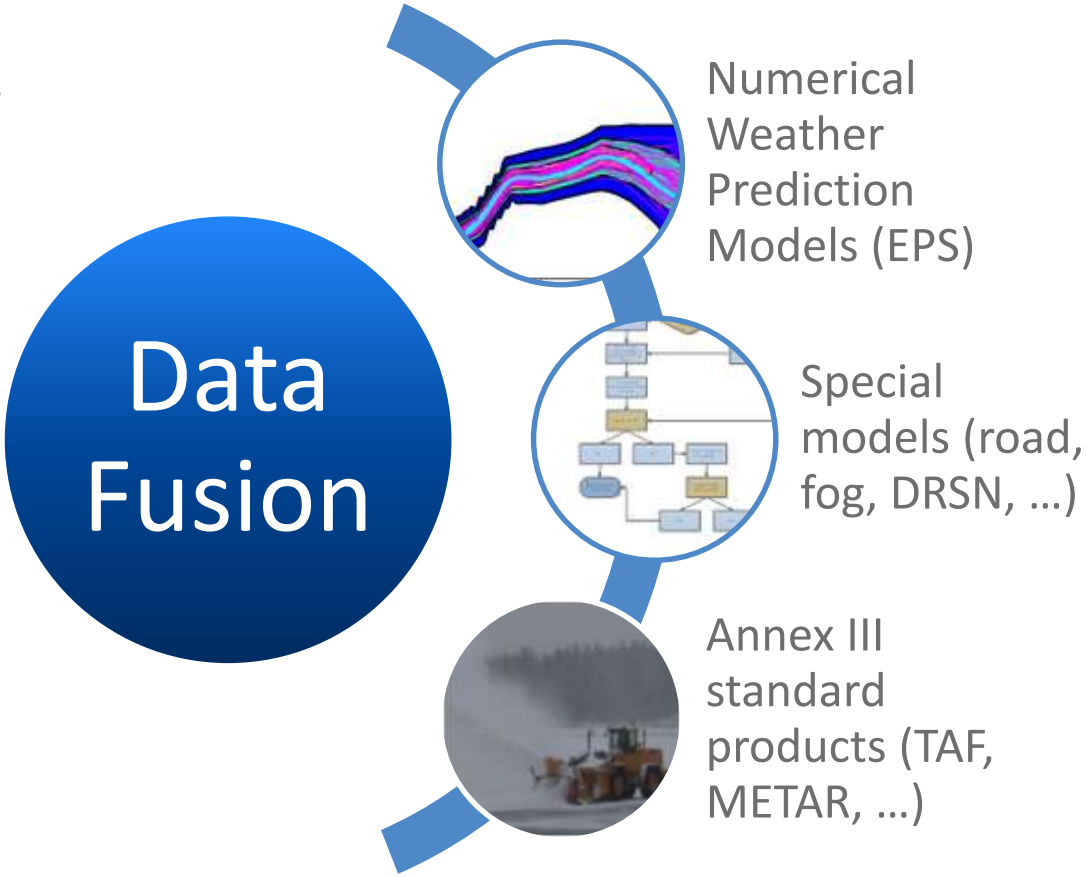
Forecasting with thresholds



Potential for follow-up projects

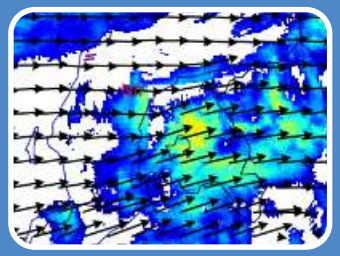
as identified in PNOWWA Surveys

PNOWWA is S2020 Fundamental Explonatory Research. To reach higher maturity levels, more work is needed



Snow at airport

Aviation users are not afraid of probabilities



Radar is a useful tool for nowcasting

- Timing in steps of 15 minutes
- Lead times up to 2-3 hours

It is also important to forecast that it will not snow

PNOWWA Probabilistic Nowcasting of Winter Weather for Airports

Thank you very much for your attention!

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 699221

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL