Friction Index: Nowcasting and Validation

Jianmin Shao & Fiona Mellor
Jianmin.shao@vaisala.com

24 May 2012

VAISALA

Contents

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

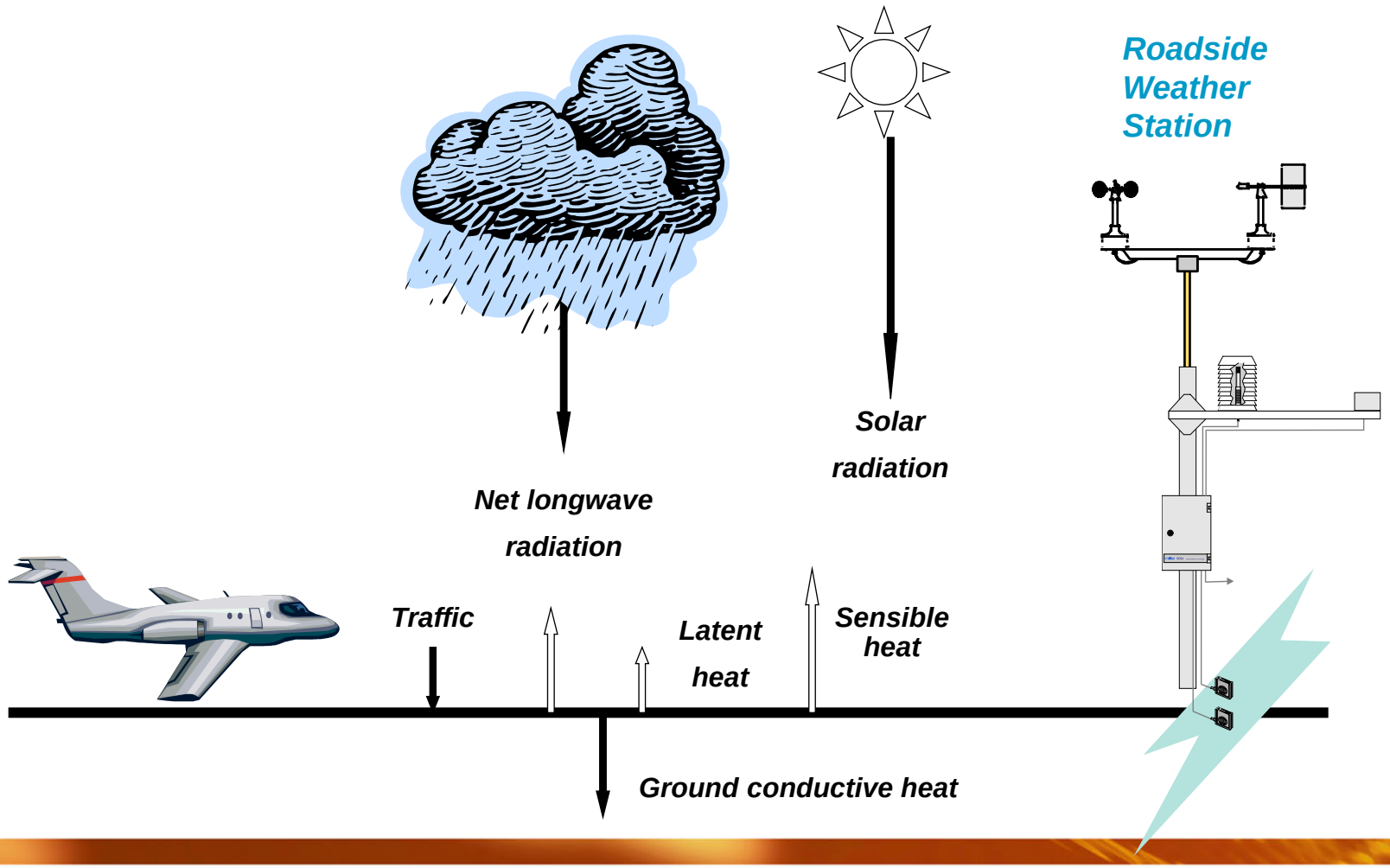
Vaisala Friction Index (FI)

- 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



How IceBreak Model Works?

Measurements:

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

+

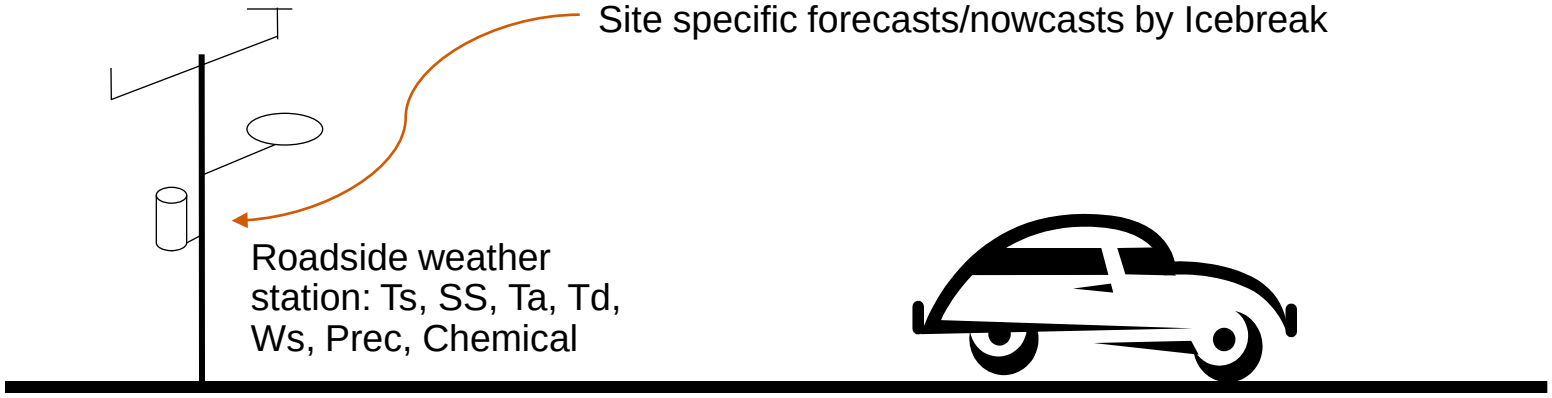
Optional:

External inputs as boundary conditions

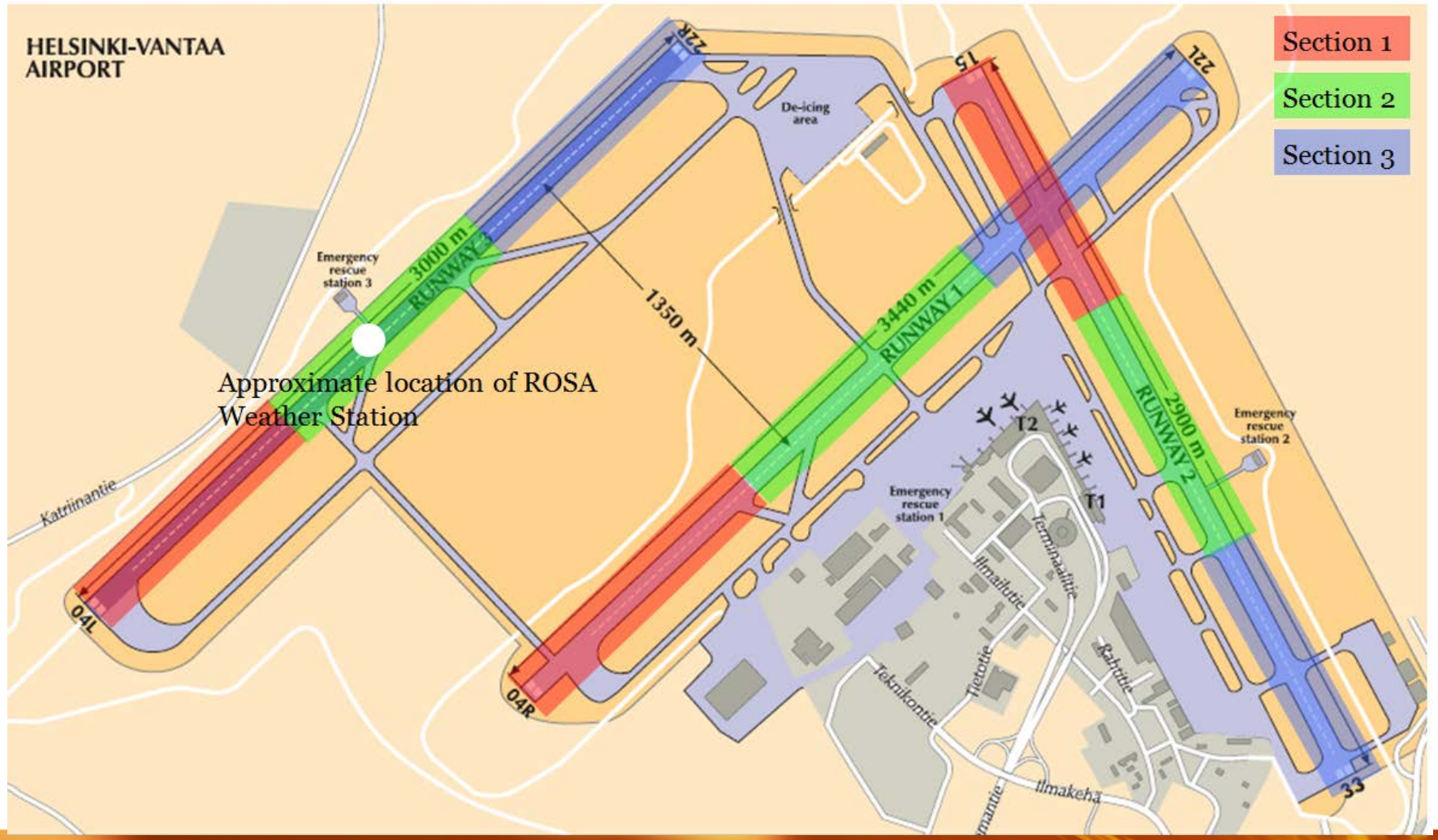
→

Output:

Ts, SS, FI, Ta, Td, Ws, cloud, etc



Test site: Helsinki Int. Airport, Vantaa



VAISALA

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)

	1 hour				2 hour				3 hour			
	Abs. error	Bias	SD	RMS error	Abs error	Bias	SD	RMS error	Abs. error	Bias	SD	RMS error
Surface Temp (°C)	1.04	-0.33	1.70	1.73	1.37	-0.43	2.19	2.23	1.64	-0.50	2.58	2.63
Air temp (°C)	0.32	-0.02	0.49	0.49	0.50	-0.03	0.76	0.76	0.69	-0.03	1.05	1.05
Dew point (°C)	0.36	-0.03	0.61	0.61	0.57	-0.05	0.94	0.94	0.77	-0.08	1.25	1.26
Water thick. (mm)	0.07	0.04	0.08	0.09	0.08	0.04	0.08	0.09	0.07	0.04	0.08	0.09

Comparison between Forecast and Observed Friction for Section 2 on Runway Three

Overall:

	Number of Samples	Absolute Error	Bias	Standard Deviation	RMS
1 Hour	1978	0.15	-0.03	0.19	0.19
2 Hour	3623	0.13	-0.03	0.19	0.20
3 Hour	5293	0.15	-0.03	0.19	0.20

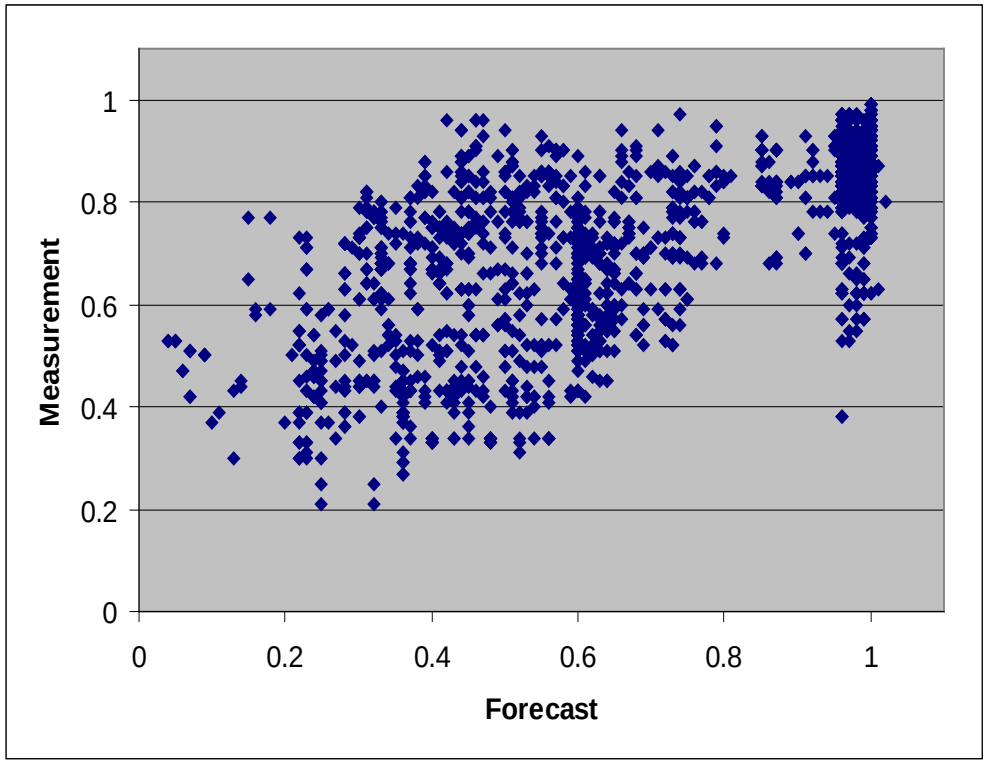
Threshold FI < 0.3 (when surface is highly risky)

	Number of Samples	Absolute Error	Bias	Standard Deviation	RMS
1 Hour	13	0.08	0.01	0.08	0.08
2 Hour	29	0.13	0.07	0.12	0.14
3 Hour	47	0.15	0.11	0.12	0.16

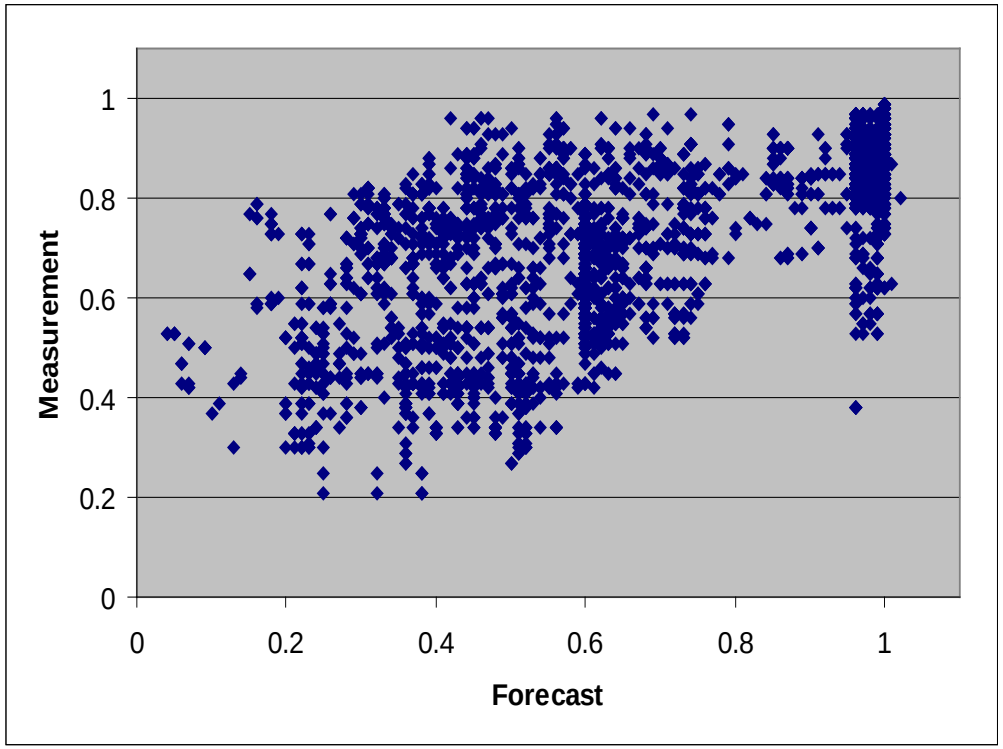
Threshold FI >= 0.3

	Number of Samples	Absolute Error	Bias	Standard Deviation	RMS
1 Hour	1965	0.15	-0.03	0.19	0.19
2 Hour	3594	0.15	-0.03	0.19	0.20
3 Hour	5246	0.15	-0.03	0.19	0.20

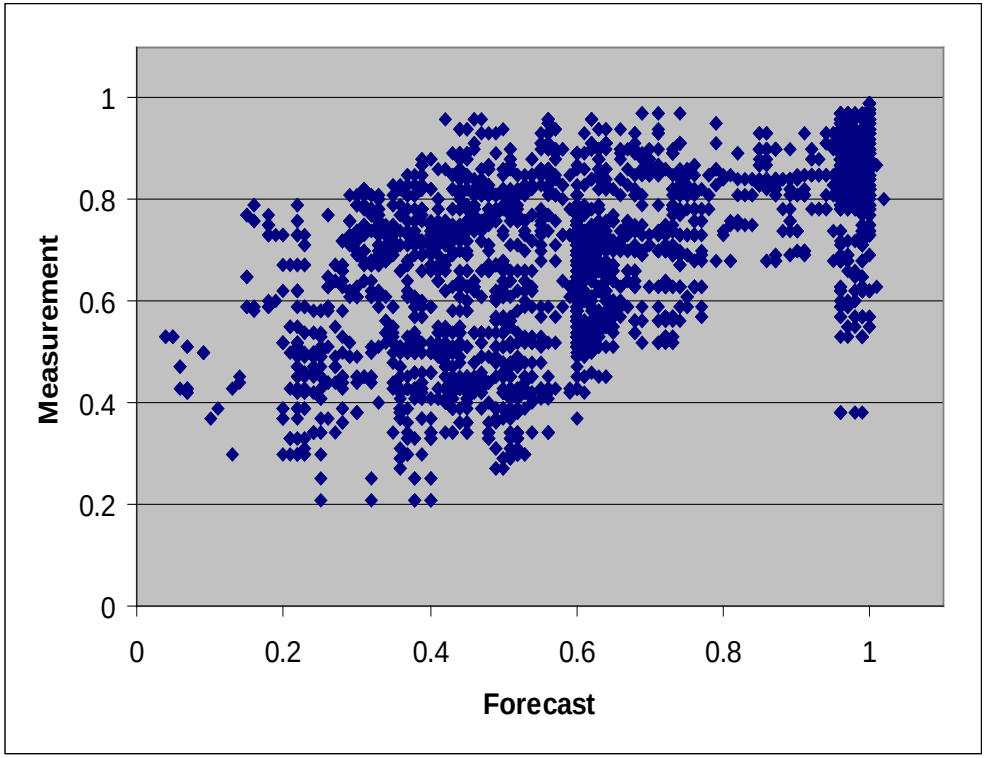
Forecast FI again Measurement (1-h ahead, Section 2, Runway Three)



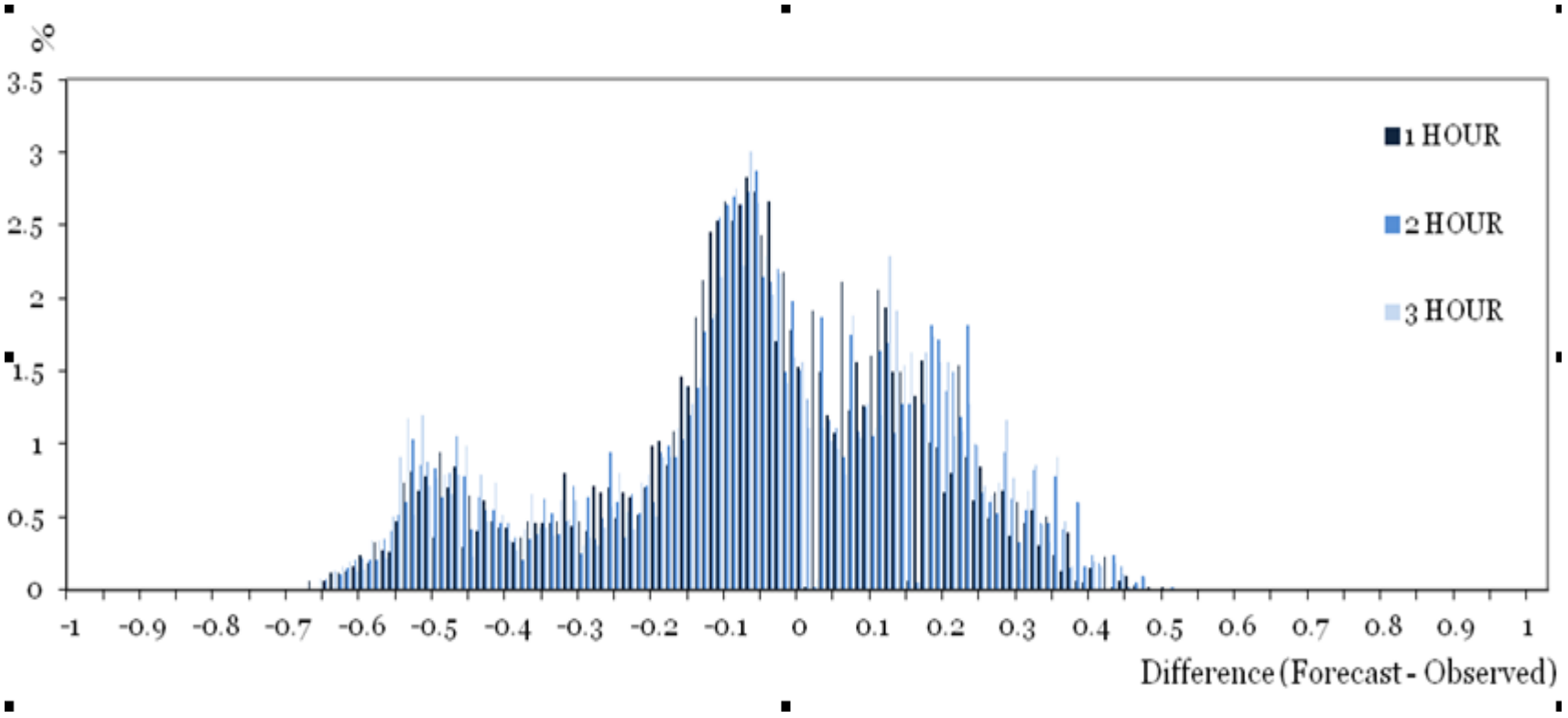
Forecast FI again Measurement (2-h ahead, Section 2, Runway Three)



Forecast FI again Measurement (3-h ahead, Section 2, Runway Three)



Error Distribution for 1,2 and 3 hour FI Forecasts



VAISALA

Thank you!

Questions?

VAISALA