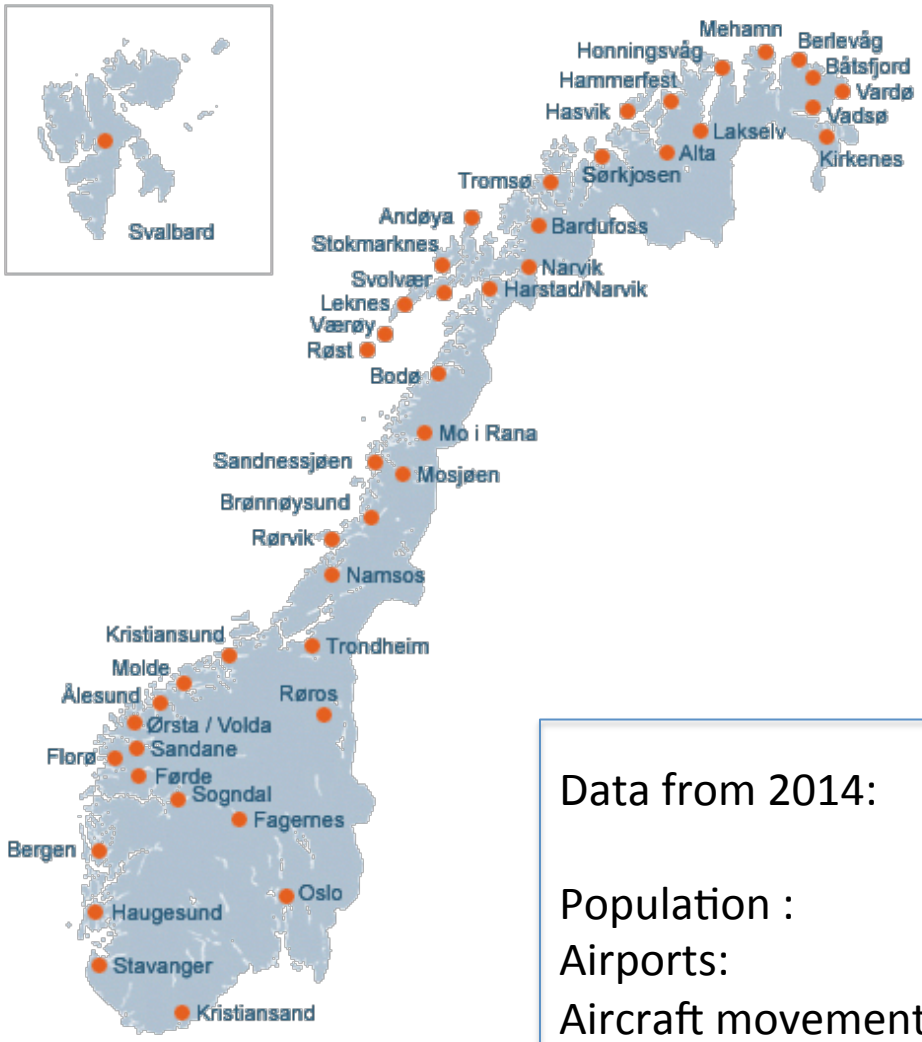
The IRIS runway model
A decision support model for assessing runway conditions

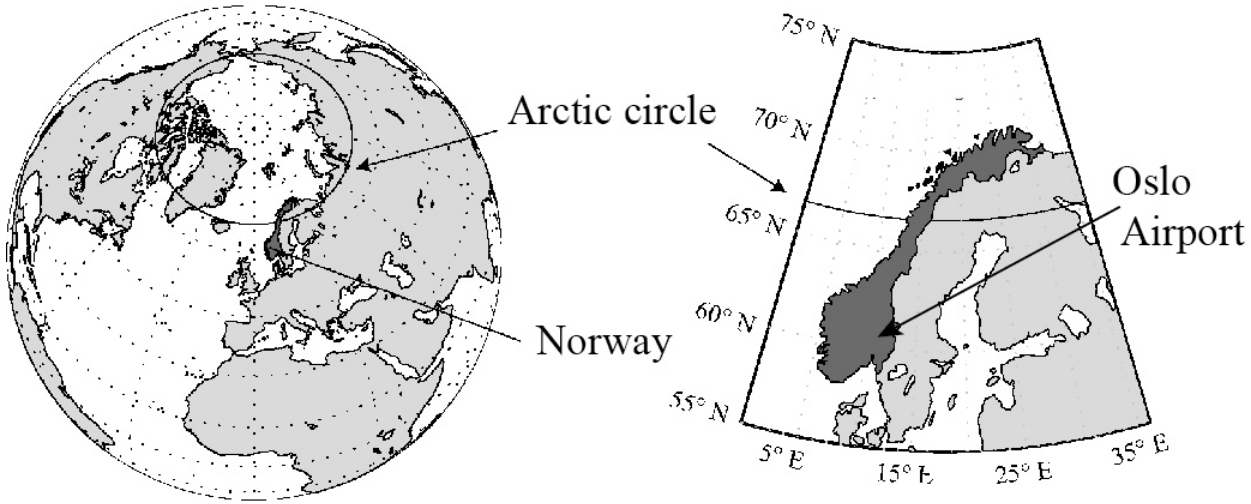
Alex Klein-Paste
Associate professor
NTNU, dept of Civil and Transport Engineering

Norwegians love to fly…

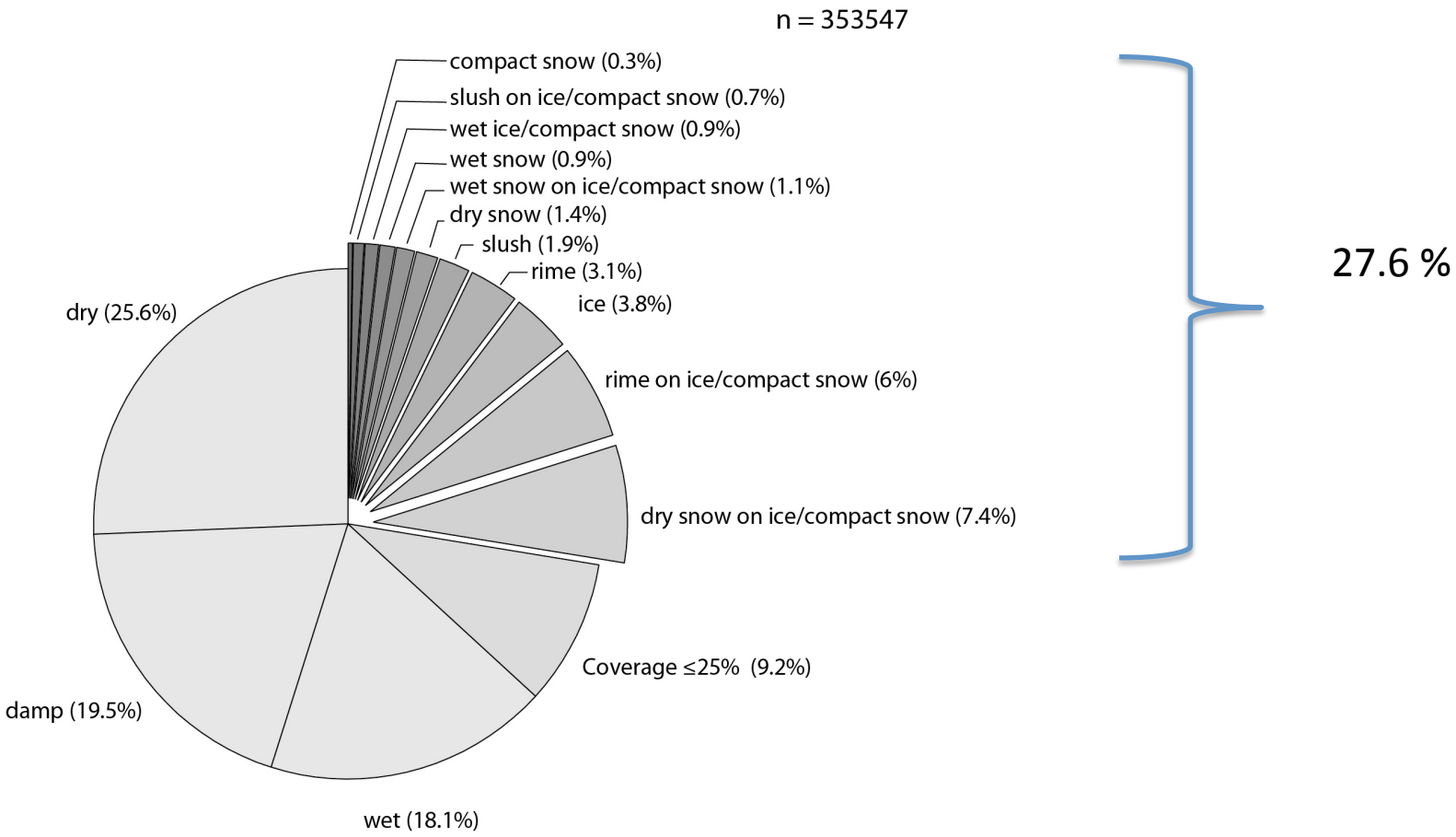


Data from 2014:

Population :	5.1 Million
Airports:	52
Aircraft movements:	0.93 Million


Arctic circle
Norway
Oslo
Airport
75° N
70° N
65° N
60° N
55° N
5° E
15° E
25° E
35° E

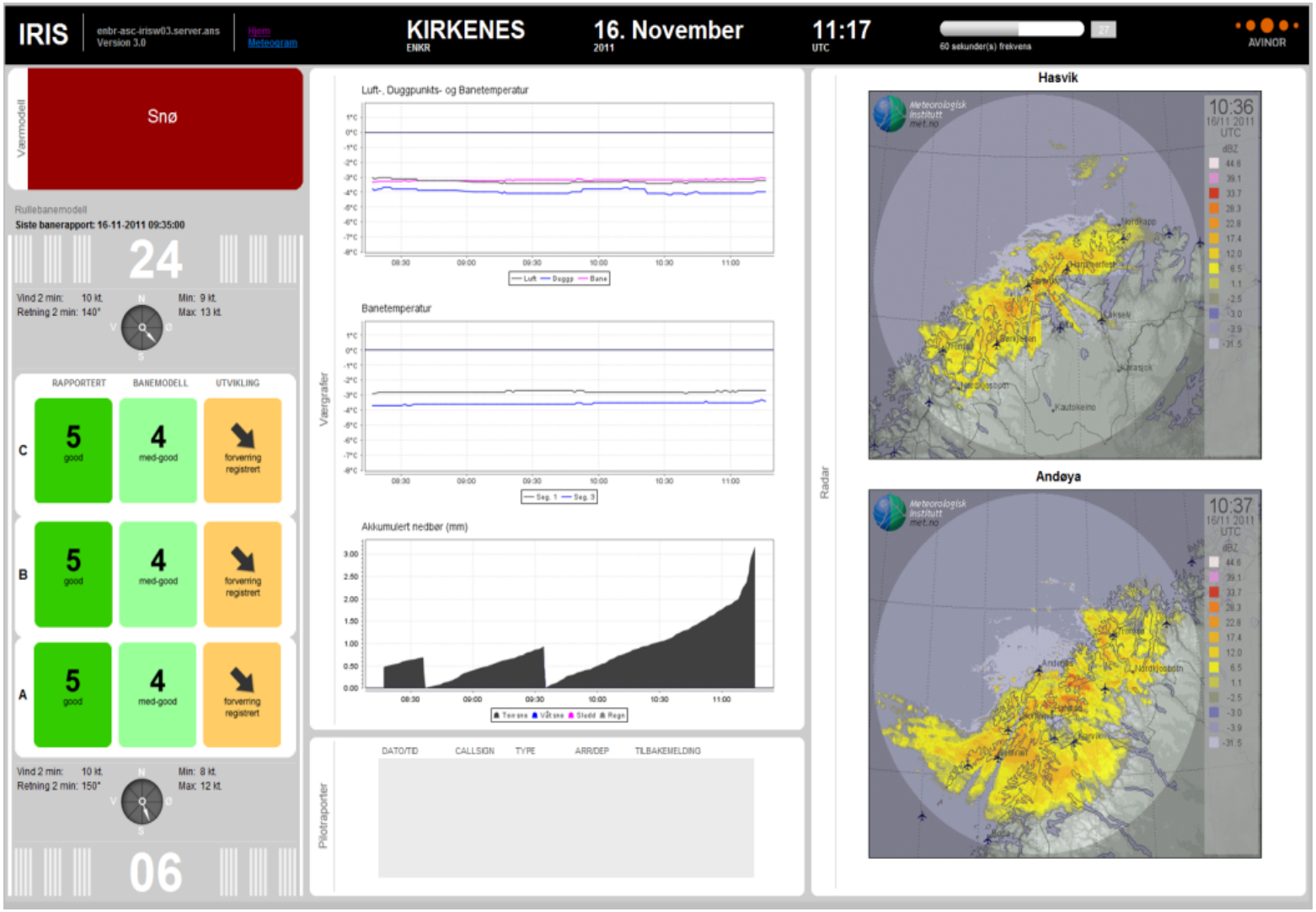
Landings on contaminated runways



IRIS project

- Integrated Runway Information System
- 2008 – 2013
- Large scale data collection

IRIS project

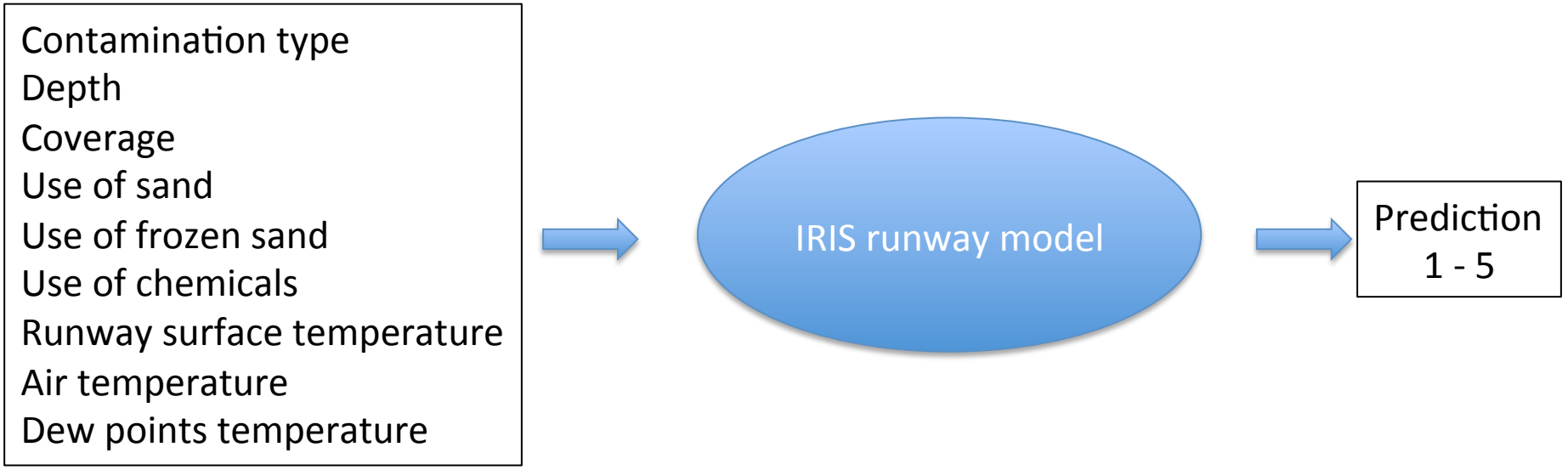


Can descriptive data be used to support assessment of runway surface conditions?

Talpa-ARC


Contamination type
Depth
Temperature
Coverage
TALPA matrix
Prediction
0 - 6

IRIS runway model



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A decision support model to assess the braking performance on snow and ice contaminated runways

Alex Klein-Paste [a,*], Hans-Jørgen Bugge [b,1], Arne Bang Huseby [c,2]

[a] Norwegian University of Science and Technology, Dept. of Civil and Transport Engineering, Høgskoleringen 7A, 7491 Trondheim, Norway
[b] Aklima, Postboks 410, 1327 Lysaker, Norway
[c] University of Oslo, Dept. of Mathematics, Postbox 1053 Blindern, Oslo 0163, Norway

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ABSTRACT

Pilots need accurate predictions on the quality of runway surface conditions when operating on snow/ice contaminated runways. These predictions are typically made by friction measurements, or by expert judgments of runway inspectors. This study presents a decision support model (the IRIS runway model) for runway inspectors that interprets descriptive data from SNOWTAM reports and predicts the braking action on the common scale from 1 to 5, ranging from "poor" to "good". The model is tested on two airports in Norway during the winter seasons 2008/2009 to 2010/2011. Two other predictors of the braking action (assessments by runway inspectors and friction measurements) were also included. Analyses of 1261 friction-limited landings of commercial airplanes were used to compare predicted and measured braking actions.
The IRIS runway model was found to be more conservative than the assessments of Norwegian runway inspectors, and even more conservative than friction measurements. In 86% of the landings, the IRIS runway model predicted the conditions within ± 1 category in 61% of the landings. The model is now implemented in 15 airports in Norway.

1. Introduction

Before pilots can land on snow/ice contaminated runways, they need accurate information on the prevailing surface conditions. Hence, reporting the surface conditions is an important task for winter maintenance personnel at airports. During winter operation, a ground vehicle regularly drives over the runway and the runway inspector collects visual information like the type and depth of the snow/ice contamination, percentage of coverage of the contaminant and the presence of sand and chemicals. In addition it is common to perform friction measurements during these inspections, using a ground friction measurement device (GFMD). All this information is transmitted to the pilots in a so-called SNOWTAM report (ICAO, 2013).
Pilots refer to slipperiness of the runway as the braking action, or braking performance. They typically use a scale of five categories ranging from "poor" to "good". Sometimes a sixth category "NIL" is used, meaning it is very slippery and is considered unsafe to land. GFMDs have been used since the 1950s to predict the braking action (Norheim, 2004). Throughout the world, many different models and makes are operative at airports and their readings are often directly reported to the pilots. Unfortunately, different GFMDs do not always give consistent readings on the same surface (Sinha, 2004) and large efforts have been devoted to correlate devices with each other and to airplane braking performance (Andrisoy, 1999; Boccanfuso, 2004; Croll, 2004). Despite these efforts, there still seems to be no consensus on how to interpret these readings and the quality of their predictions.
The use of friction measurement devices has been debated (Norheim, 2004; Norheim et al., 2001) and several aircraft accidents have occurred where the conditions were significantly worse than measured by the GFMDs (AIBN, 2011). One of the reasons why it is so difficult to get a valid prediction with GFMDs is that the test tires form scaled tribosystems, compared to the aircraft tire. Parameters like the travel speed, tire characteristics, normal load, braking mode and contact time differ significantly between the GFMDs and the aircraft tires. During braking the rotational speed of the tire is less, compared to a free-rolling tire, inducing slip. As the tire rolls and slides friction is created by hysteresis within the rubber (Bowden and Tabor, 1954; Moore, 1975), by deformations within the snow/ice (Klein-Paste and Sinha, 2010b; Tuisma, 1977) and by the creation and destruction of interfaces at the contact points (Maklonnen, 2012). The high sliding speeds can induce frictional melting

* Corresponding author. Tel.: +47 73 59 46 13; fax: +47 73 59 70 21.
E-mail addresses: klein.paste@ntnu.no (A. Klein-Paste), hans.jorgen.bugge@hermetar.no (H.-J. Bugge), arne@math.uio.no (A.B. Huseby).
[1] Tel.: +47 97 66 50 66.
[2] Tel.: +47 22 85 58 60.

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Structure

$$P = x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7$$

Base Prediction

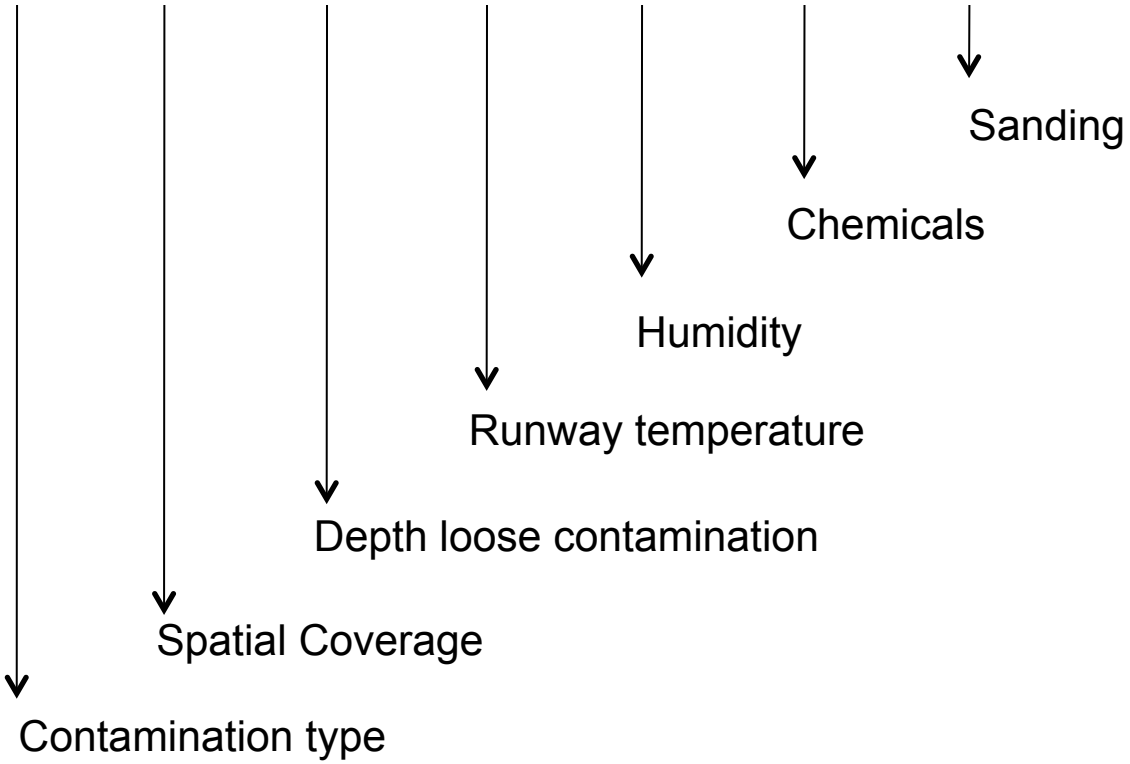
Additional factors

1	Poor
2	Poor-medium
3	Medium
4	Medium-Good
5	Good

+2
+1
0
-1
-2

Structure

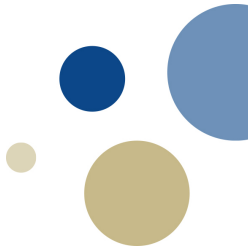
$$P = x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7$$



Base prediction

$x_1 = 1$	$x_1 = 2$	$x_1 = 3$
Wet ice (27) Wet compact snow(28)	Wet snow (5) Wet snow on ice (57) Wet snow on compact snow (58) Slush on ice (67) Slush on compact snow (68)	Slush (6) Ice (7) Compact Snow (8) Rime on Ice (37) Rime on compact snow (38) Dry snow on ice (47) Dry snow on compact snow (48)
$x_1 = 4$	$x_1 = 5$	
Rime (3) Dry snow (4) Frozen ruts (9)	Dry (NIL) Damp (1) Wet (2)	

Example: x_2 Coverage



$$
\begin{array}{l|l}
x_2 = 0 & S > 50 \\
x_2 = +1 & 10 < S \leq 50 \\
P = 5 & S \leq 10
\end{array}
$$

Example: x_4 RWY temperature

RWY temp			profile 1	profile 2	profile 3
	$T_{RWY} >$	-0,5	0	-2	-2
-0,5	$\geq T_{RWY} >$	-2	0	-1	-1
-2	$\geq T_{RWY} >$	-8	0	0	0
-8	$\geq T_{RWY}$		0	1	0

Validation

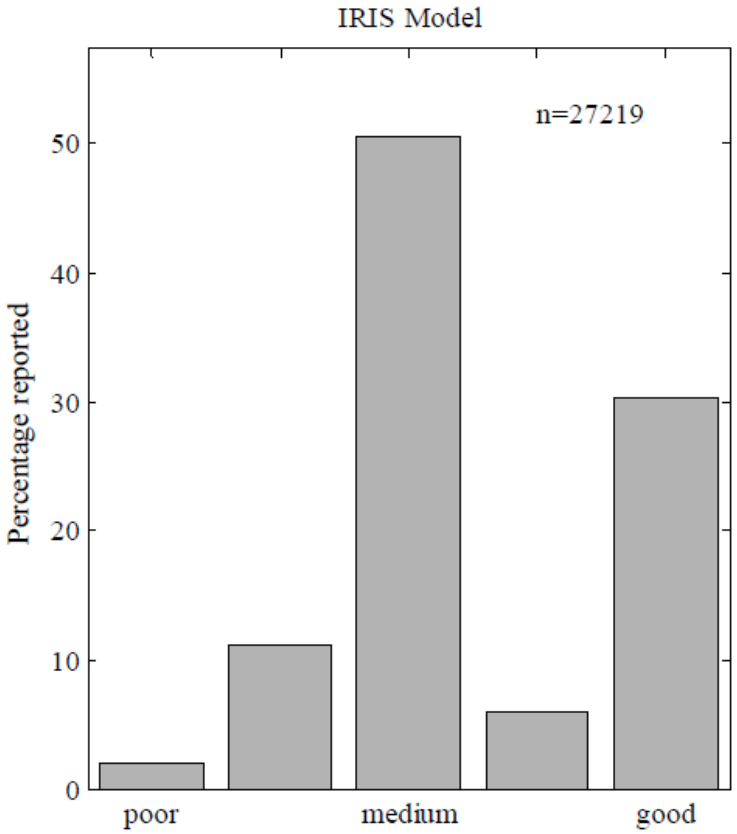
- 3 winter seasons on two airport in Norway
- 9073 SNOWTAM reports
  - 27219 runway sections
- 46153 landings of Boeing 737-600,700,800
  - 1261 Friction limited landings

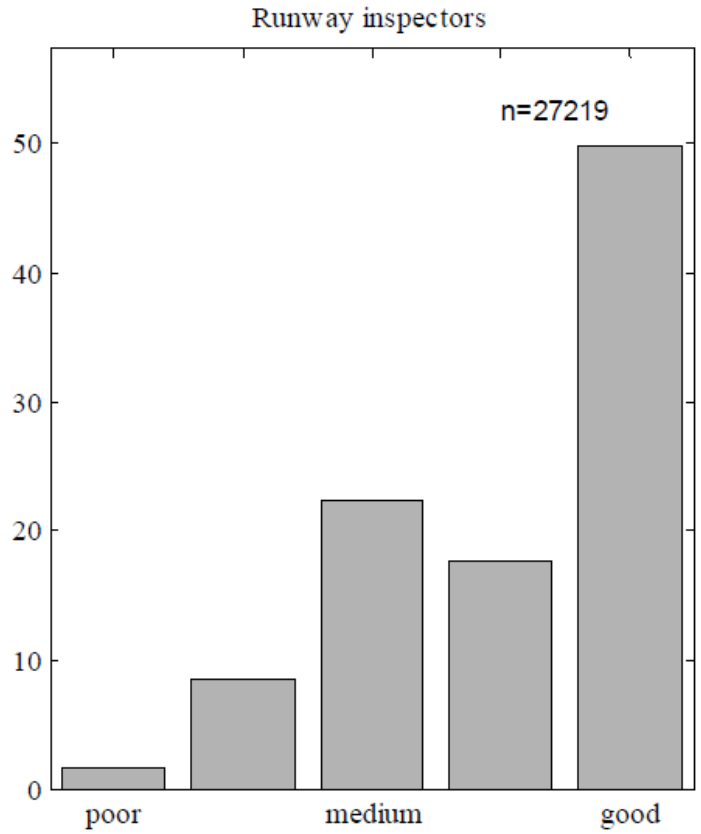
Validation

- Inspectors did not see the results of the model while doing their judgment

- No data when the runway is closed

Validation


IRIS Model
n=27219
Percentage reported
0
10
20
30
40
50
poor
medium
good


Runway inspectors
n=27219
0
10
20
30
40
50
poor
medium
good

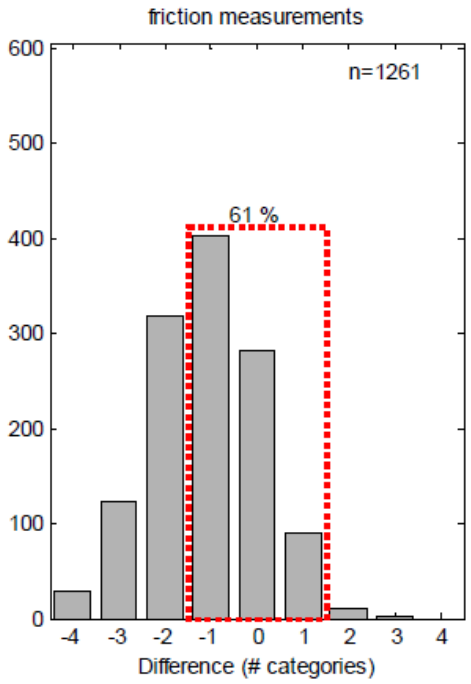
Validation

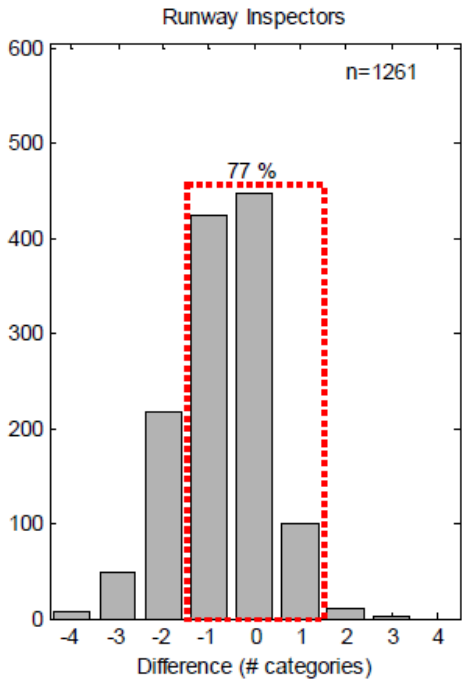
IRIS
Runway model

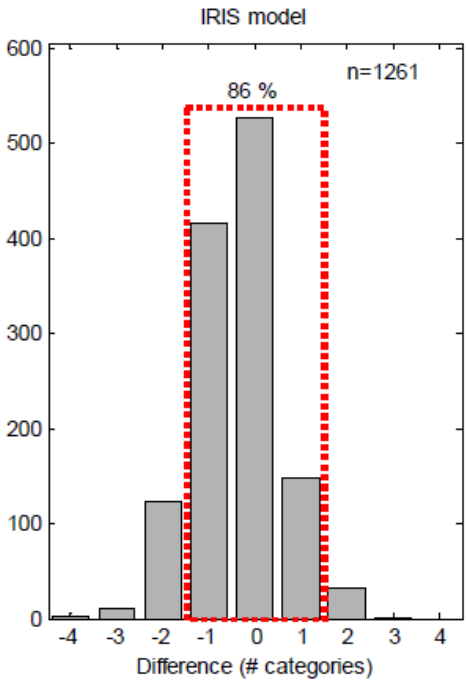
1 – poor
2 – poor/medium
3 – medium
4 – medium / good
5 – good

2 – 3 = -1

Validation


friction measurements
n=1261
61 %
600
500
400
300
200
100
0
-4 -3 -2 -1 0 1 2 3 4
Difference (# categories)


Runway Inspectors
n=1261
77 %
600
500
400
300
200
100
0
-4 -3 -2 -1 0 1 2 3 4
Difference (# categories)

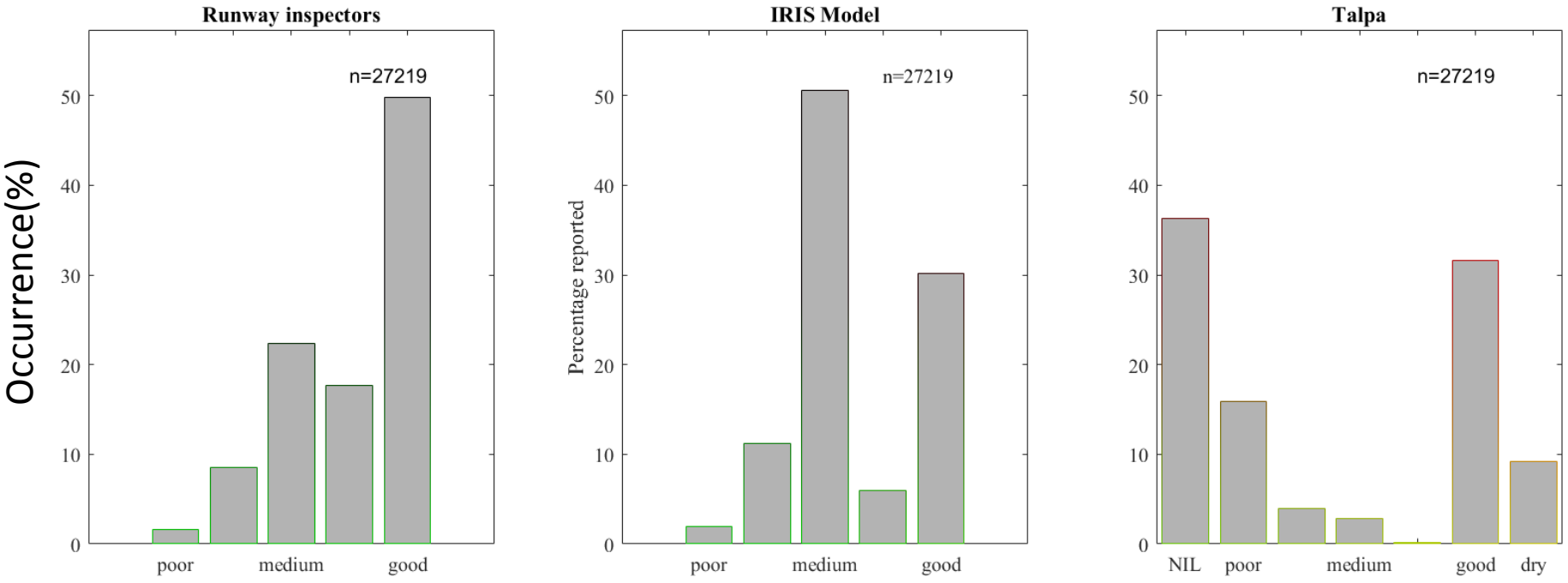

IRIS model
n=1261
86 %
600
500
400
300
200
100
0
-4 -3 -2 -1 0 1 2 3 4
Difference (# categories)

Implementation

IRIS vs TALPA

27 219 SNOWTAM rapports

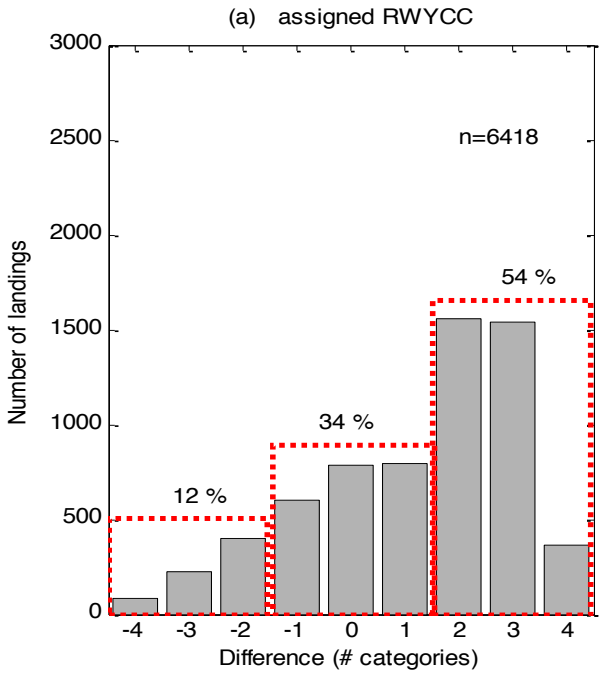
IRIS vs TALPA

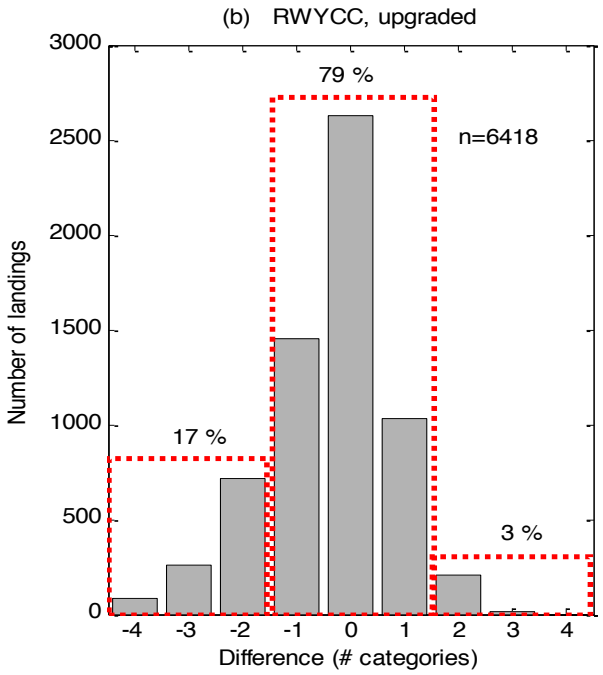


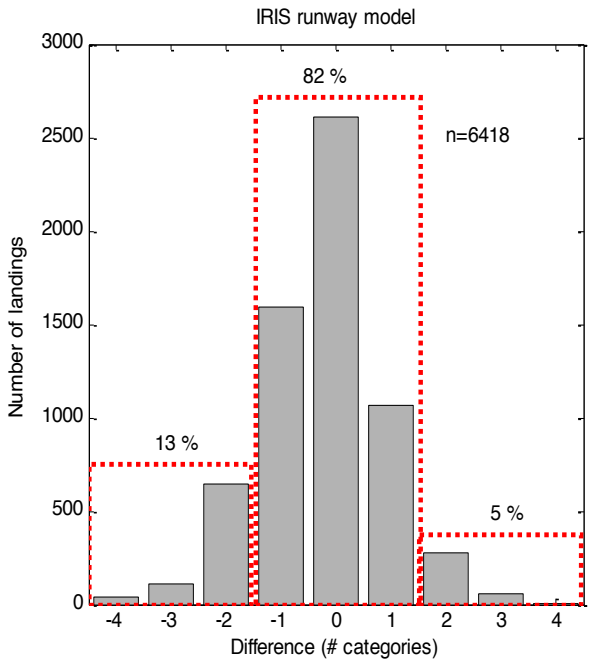
IRIS vs TALPA

6418 Friction-limited landings

IRIS vs TALPA



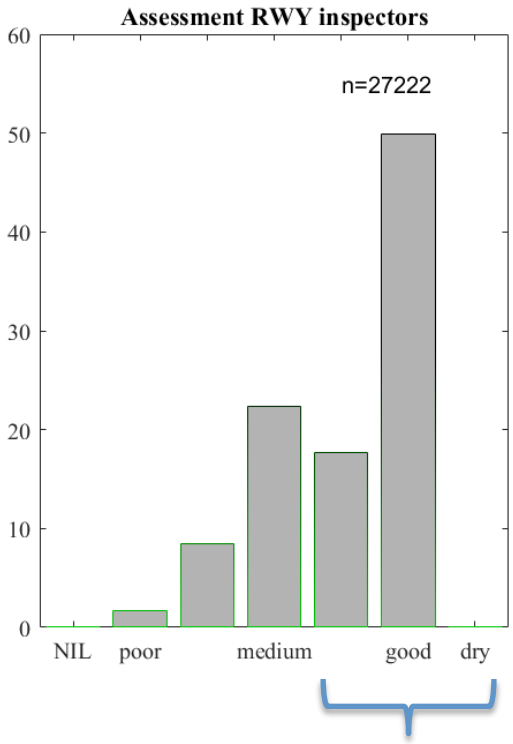




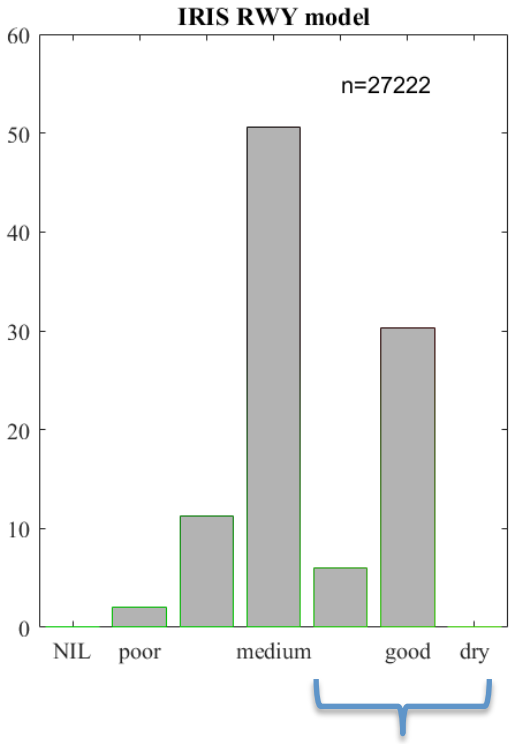
Pireps

- We got very few pireps….

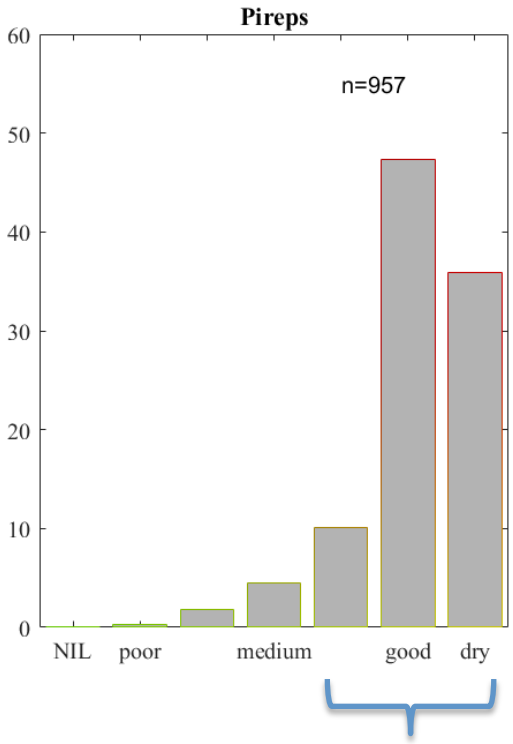
Pireps



68 %



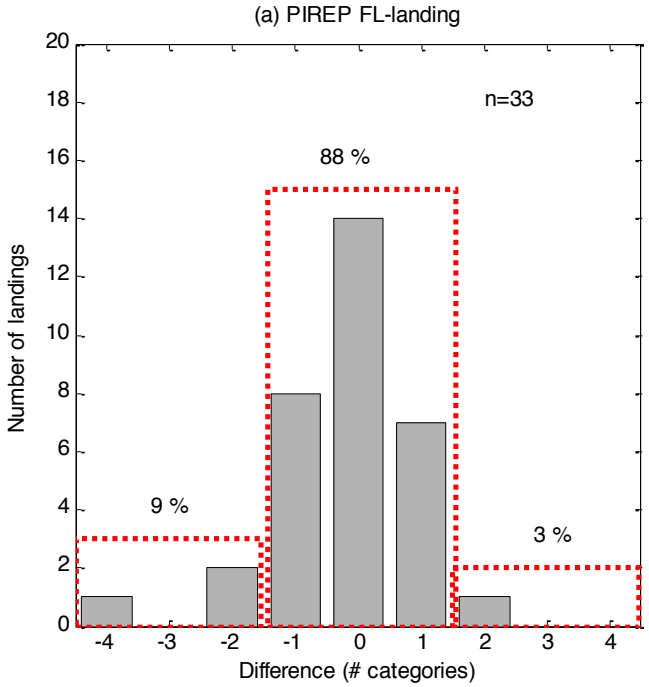
37%

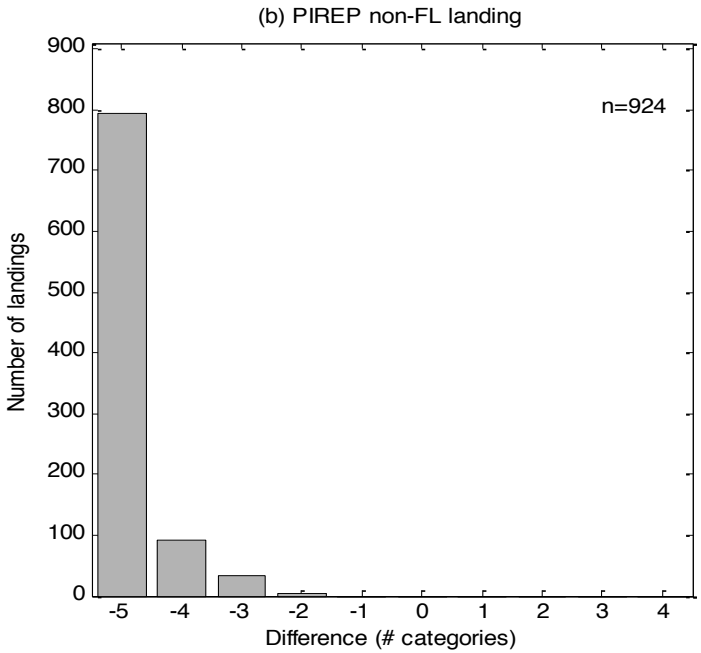


93 %

The pireps were the least conservative !!

Pireps


(a) PIREP FL-landing
n=33
88 %
9 %
3 %
Number of landings
Difference (# categories)
0
2
4
6
8
10
12
14
16
18
20
-4
-3
-2
-1
0
1
2
3
4


(b) PIREP non-FL landing
n=924
Number of landings
Difference (# categories)
0
100
200
300
400
500
600
700
800
900
-5
-4
-3
-2
-1
0
1
2
3
4

Discussion

- Assessments based on descriptive information

- Can we improve further?
  - Data quality
  - Detecting significant changes
  - Human interpretation

Conclusions

- The IRIS runway model outperformed the Talpa / ICAO methodology

- Pireps were found to be the least conservative