Table 2. Solid precipitation tests in Sodankylä: summation of daily precipitation.

	Number of events (Days)	FMI reference gauge (manual gauge with Tretyakov shield)	Vaisala gauge
TOTAL	15	51.5 mm 100 %	49.6 mm 96 %
RDay < 1 mm	4	2.0 mm 100 %	1.2 mm 60 %
RDay 1– 4.4 mm	7	14.1 mm 100 %	14.1 mm 100 %
RDay > 4.4 mm	4	35.4 mm 100 %	34.3 mm 97 %

3.2 Solid precipitation

After the liquid precipitation test period the gauge was equipped with rim heating and fitted with a Tretyakov type wind shield, in order to continue the tests with solid precipitation.

Another, identical gauge was installed in the FMI Sodankylä Observatory in Northern Finland. Snowfalls are more abundant in Sodankylä and extend further into spring than they do in Jokioinen. The reference used in Sodankylä was a standard FMI precipitation station equipped with a manual gauge and a Tretyakov type wind shield.

After the installations and preliminary testing, the actual solid precipitation test period commenced in late February 2005. No antifreeze solution was used in the Vaisala gauge containers because it was anticipated their capacity was sufficient for the remaining snowfalls of the winter. The results reported here extend to mid-April 2005.

In Jokioinen snowfalls during the test period were scarce and light. The Vaisala gauge and the reference collected only 3.0 and 3.9 mm, respectively. The accumulation was insuffcinent to enable proper analysis of the gauge performance.

However, in Sodankylä the conditions were, more favourable: the test field received more than 50 mm solid precipitation. Table 2 shows the summation of the daily results. The Vaisala and the reference gauges were in good agreement. The difference in the total values being only 1.9 mm or 4 %.

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4. CONCLUSIONS

The Vaisala all weather gauge represents a new generation of weighing precipitation gauges. Simple and robust mechanics, large collecting area, the latest high-accuracy load cell technology and advanced measurement and heating control algorithms ensure high performance, both in liquid and solid precipitation and in all weather conditions.

Preliminary test results from liquid precipitation show that undercatchment by the Vaisala gauge is very low - in fact it measured a few percent more precipitation than the FMI reference gauge at the Jokioinen Observatory.

Results from tests in the Sodankylä Observatory also demonstrate good performance of the Vaisala gauge in solid precipitation. During the test period the observed difference between the Vaisala and the FMI reference gauges was only 4 %.

Fig. 7. The gauge on the Vaisala test field with wind shield.

Next Generation All Weather Precipitation Gauge

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ABSTRACT

The new Vaisala weighing precipitation gauge features technical innovations that provide high quality measurements in all weather conditions with low life-cycle costs. Highlights of the gauge design and operation are presented, as well as first results obtained from field tests at the Finnish Meteorological Institute's test field sites in Jokioinen and Sodankylä.

1. INTRODUCTION

Accurate measurement of precipitation has been a challenge, especially in climatic conditions where both liquid and solid precipitation (snow, sleet) occur. In principle weighing gauges are the most suitable point precipitation gauges for these conditions due to the fact that the melting of snow is not a prerequisite for measurement.

Fig. 1. Vaisala all weather precipitation gauge with wind shield.

However, the accuracy of conventional weighing precipitation gauges can be impaired by a multitude of other errors. These include error sources common to all point precipitation gauges - wind, evaporation and wetting errors - all of which tend to cause systematic underestimation. In winter conditions, instrument errors related to accumulation of snow and ice on rim and funnel parts of the gauge, as well as complete filling of the gauge with snow may result in gross underestimation. These problems are only partially solved by using antifreeze solution in the container and with rim heating.

The new Vaisala all weather precipitation gauge features technical innovations that provide higher quality of measurement combined with lower life-cycle costs in all weather conditions. The new gauge is based on Vaisala's long experience of measuring precipitation and designing sensors for meteorological applications.

This poster highlights the gauge operation and the lower life-cycle cost features. It also presents preliminary results obtained at the Finnish Meteorological Institute's test field sites in Jokioinen and Sodankylä.

2 TECHNICAL HIGHLIGHTS

2.1 Weighing method

The gauge utilizes the latest high-accuracy, temperature-compensated load cell technology. The single point - type load cell is designed for direct mounting of the weighing platform. Eliminating levers and flexures, this allows simple, robust and low cost mechanics.

The load cell is insensitive to eccentric loading. Therefore, unlike some other types of weighing gauges, unsymmetrical distribution of snow in the collecting bucket (typical for winter conditions) does not introduce measurement errors.

Another error source, which is eliminated by enhanced mechanics is the underestimation caused by water and snow sticking on the inner surfaces of the gauge inlet funnel. In conventional designs this mass is not measured and eventually evaporates. In Vaisala's design the funnel element rests on the collector container. All water and snow on it's surface is therefore included in the measured mass.

2.2 Gauge heating

Optional rim heating is recommended whenever solid precipitation measurement is needed. Heating prevents accumulation of snow and ice on the rim and collecting funnel. To prevent extraneous evaporation error caused by heating, as well as to minimize power consumption, the heating is controlled by the gauge's software. The control algorithm is based on ambient temperature and precipitation conditions.

2.3 Ease of maintenance

In the design special emphasis has been put on easy maintenance and extended service intervals. The hinged upper part (rim and collecting funnel) and detachable enclosure door allow smooth access for maintenance or adding antifreeze agents, as well as easy removal of the collector container (see fig. 2)

Fig. 2. The gauge with enclosure opened.

Fig. 3. Electronics unit and load cell are situated under the weighing platform.

The electronics unit, including the load cell is field-removable (fig. 3). Replacement of the electronics is straightforward and quick. Data loss is kept to a minimum, as there is no need to transport the whole gauge to the laboratory for calibration. If needed, field calibration can be done using calibration weights.

A selection of optional features enhance performance and extends service intervals.

3. TEST RESULTS

3.1 Liquid precipitation

The gauge was tested at the Finnish Meteorological Institute's (FMI) field test facility in Jokioinen in Southwestern Finland. The test site is a grass-covered field about 60m x 100m in size (fig.4). The test unit was installed in the middle of the field with it's orifice height at 1.5 m. A wind shield was not used in the first tests.
The Vaisala gauge was compared with the FMI's double fence intercomparison reference (DFIR): a high accuracy weighing gauge with it orifice height set at 3 m and surrounded by an octagonal vertical double fence. The reference is located in the north-west corner of the field, the distance between the gauges being approximately 50 meters.

Fig. 4. Jokioinen test field

The comparison started on 20.8.2004 and it will be continued until summer 2005. Data on rainfall, temperature, humidity, wind speed and direction at the height of the orifices of the gauges are being collected at 1-min intervals. Using the 1-min dataset, daily totals of precipitation have been calculated. The first preliminary results from liquid precipitation, obtained in autumn 2004, are presented here.

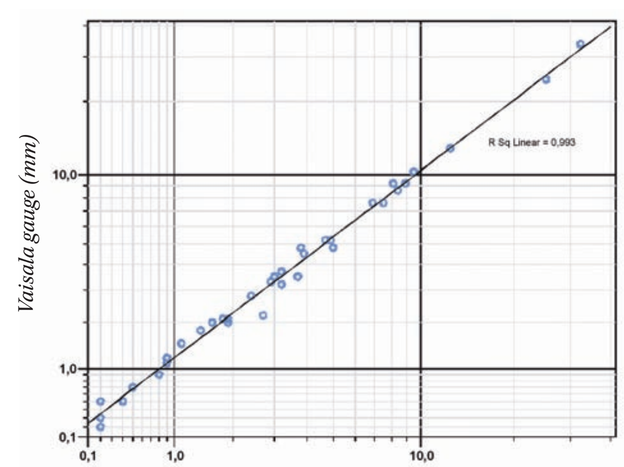

Fig. 4. Jokioinen test field

Table 1 shows daily total values divided into three categories (light rain, rain and heavy rain). Additionally it shows that the Vaisala gauge's catch ratio was highest in light rain and decreased with increasing rainfall rate. Since the end of August to the end of November 2004 the total precipitation measured was 176.9 mm. Daily total values varied from 0.2 mm to 32.3 mm.

Overall, the Vaisala gauge caught 6 % more precipitation compared to the FMI (DFIR) gauge. The catch ratio ranged from 80% to 150 % for single rainfall episodes. The highest ratio being for light rain events.

The observed differences between values obtained with the Vaisala gauge and the FMI reference gauge (DFIR) are possibly due to the different construction features of the gauges. The Vaisala gauge has a larger catchment area (400 cm^2 versus 200cm^2). Additionally, the inlet funnel of the the Vaisala gauge is a part of the instrument weighing system, whereas this is not the case for the reference gauge. Therefore water droplets caught on the surface of the inlet of the DFIR gauge cause an underestimation of rain totals.

Fig. 6. The Vaisala gauge installed on the FMI Sodankylä test field.

Table 1. Liquid precipitation tests in Jokioinen: summation of daily precipitation

	Number of events (Days)	FMI reference gauge (DFIR)	Vaisala gauge
TOTAL	37	176.9 mm 100 %	188.1 mm 106 %
RDay < 1 mm	10	4.5 mm 100 %	6.2 mm 137 %
RDay 1– 4.4 mm	15	38.5 mm 100 %	43.0 mm 112 %
RDay > 4.4 mm	12	133.9 mm 100 %	138.9 mm 104 %