Accuracy assessment of the two WVRs, Astrid and Konrad, at the Onsala Space Observatory

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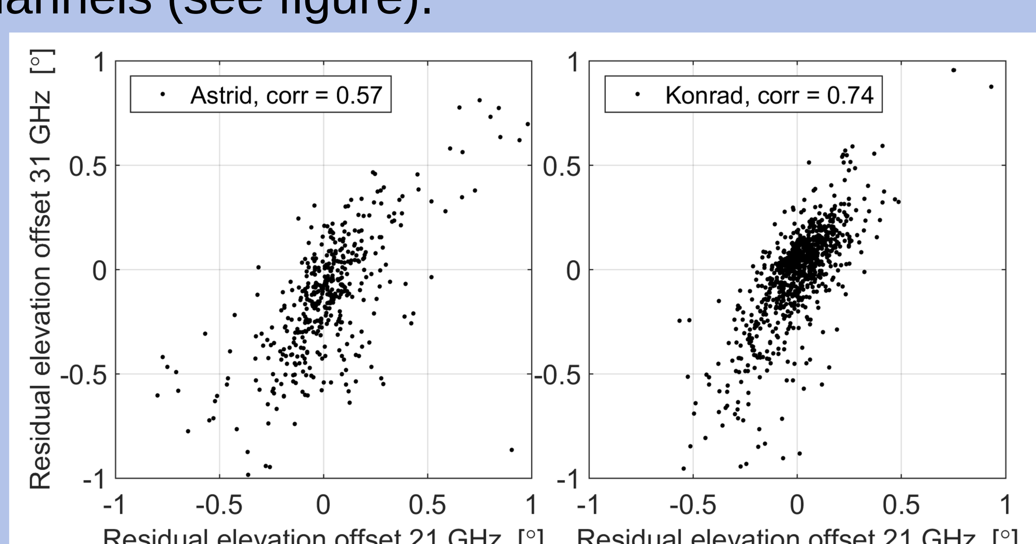
Introduction

Two Water Vapour Radiometers (WVRs), Astrid and Konrad, have been operating at the Onsala Space Observatory. We are now considering a new WVR and we see a need for a careful comparison of the accuracy, reproducibility, and repeatability. A first step is a comparison of the results from of the existing WVRs using data from recent years. Here we give an overview of comparison results obtained during the time period 2013–2016. Unfortunately, there are several data gaps due to different types of instrument failures — both WVRs are becoming old. Therefore we also use estimates of the equivalent zenith wet delay (ZWD) from the two GNSS reference stations: ONSA and ONS1. They are more reliable and offer almost continuous time series during the four years. There is one common GNSS data gap in the winter 2014–2015 due to a failure of the primary pressure sensor. This will be corrected in the future. Additionally ONSA has a data gap in the summer of 2015 due to a failing amplifier.

Data analysis and diagnostic tools

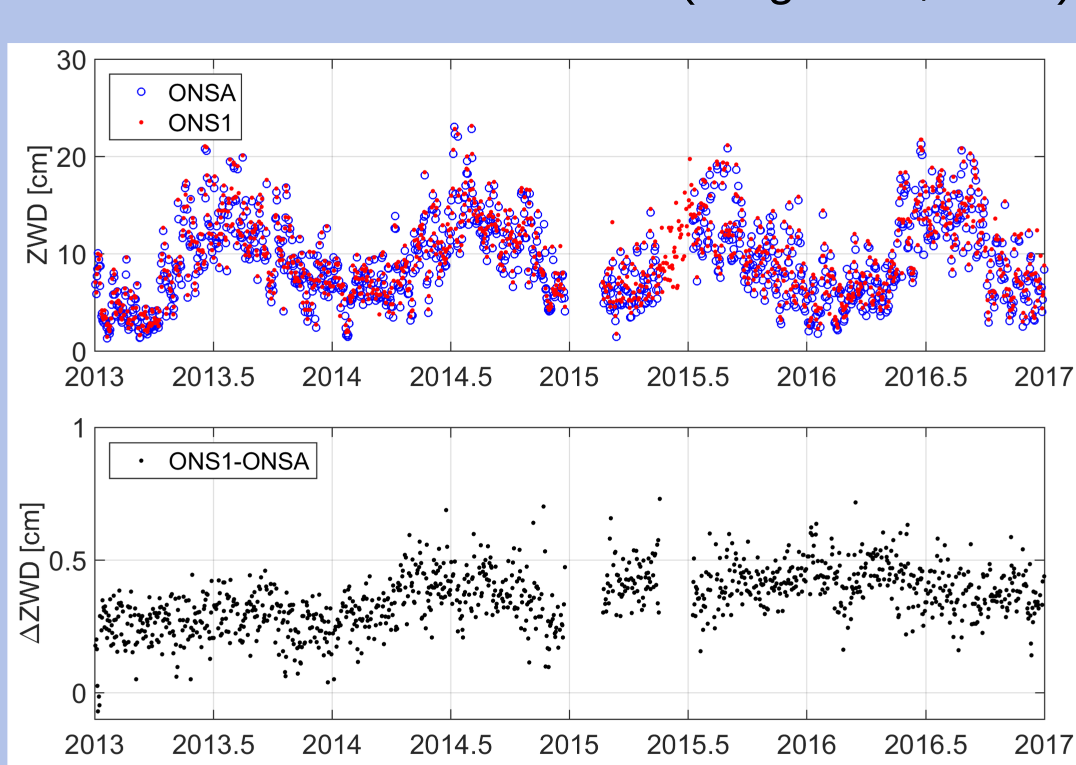
A common method for calibration of the WVR is the tip curve method where observations spread over a range of elevation angles are used in order to get an extrapolated sky brightness temperature at zero air mass (*Elgered and Jarlemark,* 1998). Additionally an elevation pointing offset can be estimated. Here we estimate both hot load corrections, low pass filtered with a time constant of ≈ 5 h, and daily elevation offsets. Because of atmospheric inhomogeneities we expect a correlation between the residual offsets of the two channels (see figure).



The sky brightness temperatures are finally used to calculate the ZWD (*Elgered,* 1993).

Results

The first comparison is between the two GNSS reference stations. The data have been analysed using the method described by *Ning et al.* (2013). We note that the observed bias between ONS1 and ONSA of 0.36 cm is consistent with earlier results showing the influence of the suppression of multipath using a microwave absorber at ONSA, which is not the case for ONS1 (*Ning et al.,* 2011).

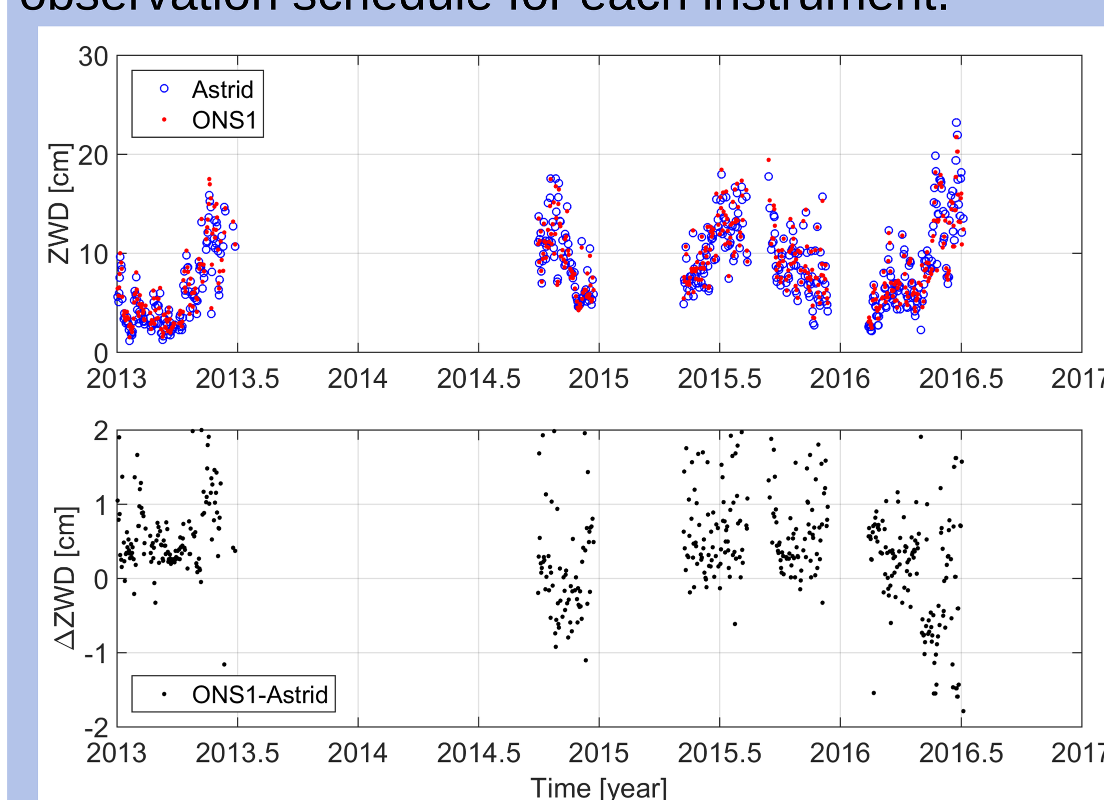


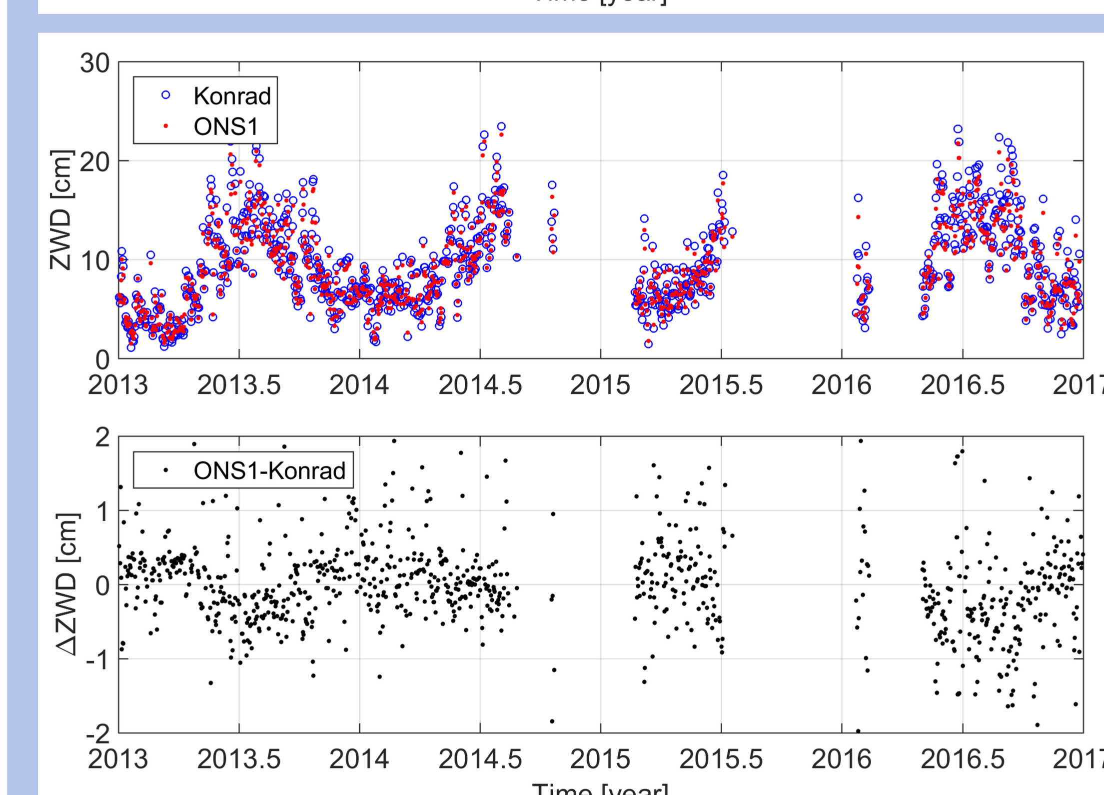
We chose to use ONS1 for the WVR comparison because of the slightly better data coverage over the four years.

Instrumentation used in the comparison

Results (continued)

In the plots below we calculate daily averages of the ZWD based on hourly averages where the data coverage is at least 75 % of the default observation schedule for each instrument.





The following table summarize the results (depicted in the plots above) in terms of bias, standard deviation (SD) and root-mean square (RMS) of the differences, ΔZWD.

Instruments compared	Bias (cm)	SD (cm)	RMS (cm)
ONS1–ONSA	0.36	0.14	0.38
ONS1–Astrid	0.44	0.81	0.92
ONS1–Konrad	0.07	0.75	0.75

Conclusion

We find that in spite of their old age the two WVRs give biases comparable to historical results. The standard deviations are slightly worse. *Ning et al.* (2012) report typical SDs around 0.7 cm between ONSA and Astrid for ZWD averages over 1.5 h. The main problem with the WVRs is the frequent failures causing significant data loss.

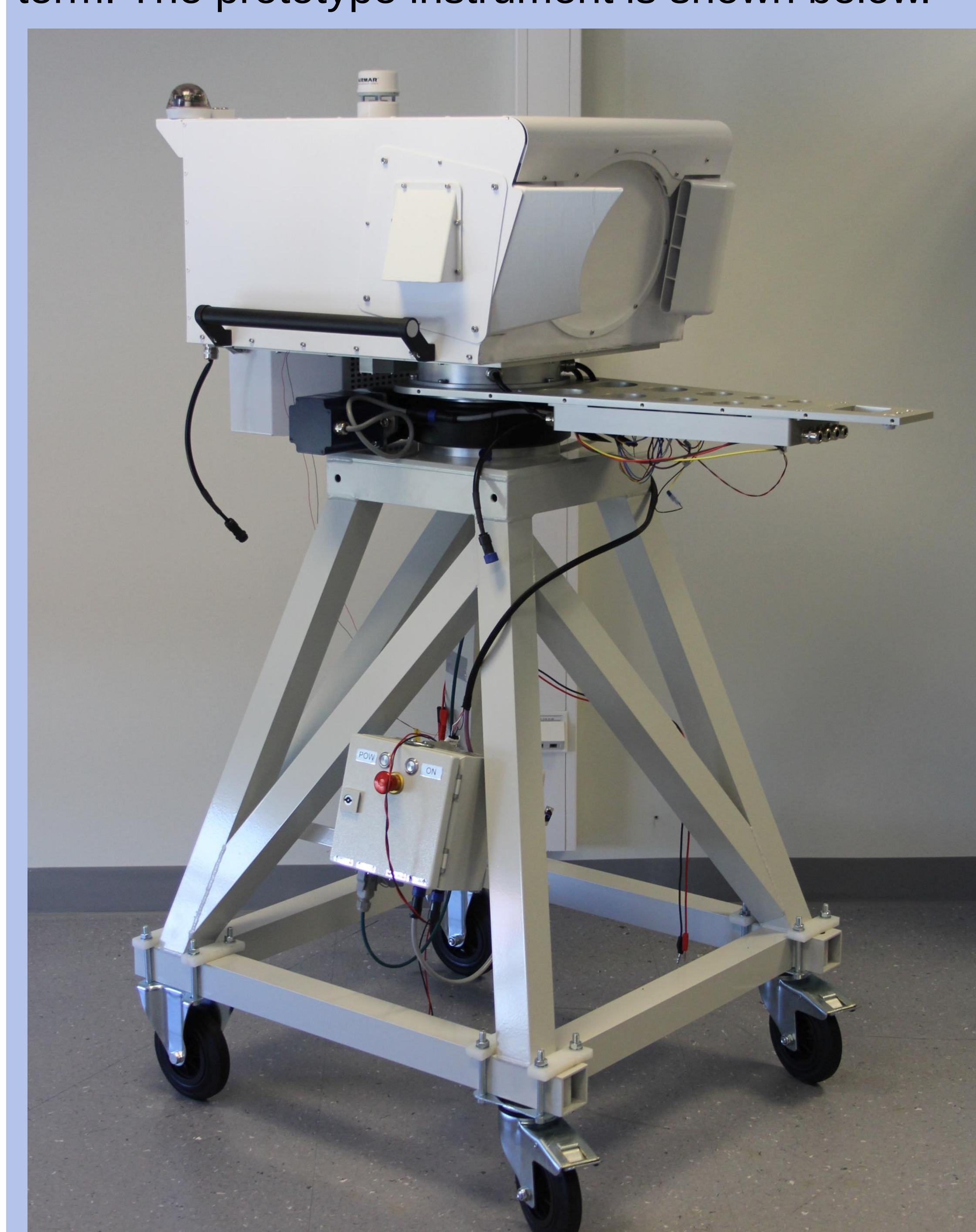
The vision

The two WVRs at the Onsala site have been in operation for a long time.

Astrid did the first comparison measurements with radiosondes at the Gothenburg-Landvetter Airport in May 1980.

Konrad's first field campaign was in Kiruna, at the Esrange Space Center, in August 2000.

We plan for a new installation of a WVR. Presently Omnisys Instruments in Gothenburg is developing a prototype WVR for the European Space Agency. When this instrument is completed a field campaign will be carried out at Onsala. Thereafter a copy will operate at the site for a long term. The prototype instrument is shown below.



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The 23rd Working Meeting of the European VLBI Group for Geodesy and Astrometry (EVGA), Gothenburg, May 15–19, 2017