

Review of *High-resolution continuous flow analysis setup for water isotopic measurement from ice cores using laser spectroscopy* by Emanuelsson, et al.

#### GENERAL COMMENTS :

A customised experimental setup is proposed in this paper for high resolution (seasonally resolved) continuous flow measurements of water isotopes from melted ice cores using a commercial laser spectrometer and a calibration system from Los Gatos Research. Such a setup already exists in combination with a cavity ring-down spectrometer from Picarro. The setup proposed here tries to take advantage of the shorter response time of the off-axis integrated cavity output spectroscopy system of Los Gatos to further increase the (temporal) resolution of the isotope signal available from the ice core. Changes to the existing Water Vapor Isotopic Standard Source (WVISS) calibration unit include among others and most importantly a drastic reduction of the internal volume of the evaporation chamber to reduce the response time of the system, increased evaporation temperature, and the possibility to switch between several liquid water samples.

This paper is in the scope of Atmospheric Measurement Techniques and presents a valuable new analytical setup for the analysis of water isotopes in ice cores that can be useful as well for the calibration of continuous water vapour measurements. The authors make a great effort to characterise their setup in a thorough way. I have the following major comments that I think the authors should address before final publication :

#### 1) Characterisation of the response time of the full continuous flow analysis (CFA) system

As already discussed in Gkinis, et al. 2011 for a full characterisation of the CFA-IWA system a step change in the water isotope composition should be done at the melt head to fully characterise the presented system.

Such an experiment may be beyond the scope of this publication but it should be discussed why this has not been done. Would it be possible to construct an artificial ice core with several distinct layers from different standard waters, so that the step change is introduced at the very beginning of the whole setup, i.e. at the ice melting unit ?

2) Since another laser-based high-resolution CFA system already exists (Gkinis, et al. 2011) mention clearly the advantages of your system. E.g. that your system can potentially provide even higher time resolution ice core measurements due to the shorter response time of the laser instrument used.

#### 3) Structure and conciseness of writing

The paper generally reads well. However several passages, especially the introduction and the results and discussion should be written in a more concise and better structured way (see specific comments below).

#### 4) Abbreviations for different instruments and customised versions

In my opinion there are too many abbreviations for the different instruments and device versions used in this paper. LGR IWA, IWA, IWA-35EP, TIWA-45EP, WVISS system, custom 2013, 2014 custom setup, custom delta-CFA setup etc. It would help the reader a lot if a more consistent and simple naming system would be used.

#### Specific comments :

- Abstract : p. 12082 L. 6 continuously analyse water samples, add water

- Abstract : p. 12082 L. 15 The authors say « Another improvement... is that the modified setup has a reduced memory effect », is that really another improvement ? To me this is not another result and simply comes along with the response time reduction.

- Abstract : p. 12082 L. 20 « For the WVISS setup... » and L22 « For the WVISS setup... ». The

first one should be the 2014 modified setup.

- Abstract : p. 12082 L 24-26 this sentence has no verb.

- Abstract in general : to me the Allan deviations do not add any information in the abstract. The authors could mention that the stability is comparable in all the setups, shortly discuss the overall uncertainty and mention the longer response times but higher precision of the Picarro system.

- Introduction : start with the broader context and a motivation for this study. The start in the present version of the paper is a bit technical and abrupt.

- Introduction : p. 12083 L. 6 mention explicitly what i stands for

- Introduction : p. 12084 L. 4 I do not understand what « replacing high resolution discrete measurements for delivering near-instrumental resolution » exactly means. Could you reformulate and explain the term « near-instrumental resolution ».

- Introduction : p. 12084 L. 10-13 explain that this is the general aim of the project not of this publication

- Introduction : p. 12084 L. 21 this is a very incomplete list of publications please say (e.g. Johnson et al., 2011 ; Steen-Larsen et al., 2013)

- Introduction : p. 12084 L. 27 Sturm and Knohl, 2010 and not Strum

- Introduction : p. 12085 L. 2-3 in my opinion the references Rambo et al. 2011 and Tremoy et al. 2011 are not adequate here. These authors just used the commercial systems, and the mentioned values are not a result of their research. Rather cite the manufacturers directly.

- Introduction : p. 12085 L. 5 « During ice core CFA campaigns several analyses are performed simultaneously, with at times... »

- Introduction : p. 12085 L. 10 shouldn't it be « consecutive core sections » and not « consecutive cores » ?

- Introduction : p. 12085 L. 12 formulation unclear « between... and... » the and is missing

- Introduction : p. 12085 L. 13 « with the following aims : (1) increase... (2)

- Introduction : p. 12085 L. 13 to me it is not a priori clear why you need goal (2). Shortly explain why you need to be able to measure several water standards in your setup.

- Introduction : p. 12085 L. 15 « The response time mainly depends on the size of **the** evaporation chamber in of the vaporizer »

- Introduction : p. 12086 L.11 «is» innovative not «was»

- Introduction : p. 12086 L. 21 mention Gkinis, 2014 personal communication (or otherwise reference the publication in the references)

- Introduction : p. 12086 L. 22 « presented in Sect. 3.3 (remove parentheses)

- Introduction : p. 12086 L. 26 replace «was» by «is»

- Experimental (is this section title really correct? Shouldn't it be Methods or Experimental methods ?) : p. 12087 L. 20 mention that T in TIWA stands for triple

- Experimental p. 12088 L. 24 replace complete by unaltered

- Experimental p. 12090 L.2 reference a sketch of the evaporation chamber

- Results and Discussion section 3.1 : in my opinion section 3.1 is too long and prominent. What is the purpose of these tests ? Is it to characterise the new setup or the laser instruments ? It is of course necessary to shortly discuss the results of the very thorough stability tests that were performed by the authors but only with the aim of defining how frequently the measurement system should be calibrated and to show how the stability is affected by the changes made to the WVISS. To me the results of the stability tests are not the innovative results of this paper and should be placed in the background, since the response time tests are the central aspect of the paper.

Furthermore, the stability section should be merged with the calibration section since information on instrument drift is gained from the Allan deviation analysis and thus the ideal calibration frequency can be deduced.

- Results and Discussion Eq. 2 : I don't think  $\delta D$  and  $\delta^{18}O$  measurements are uncorrelated. If they are correlated you probably underestimate the error with this equation.

- Results and Discussion Section 3.5 : p. 12102 L 2 what is the « uncorrected bias in the CFA data » ? I do not understand with sentence

- Conclusions : remove the reference to the figures in the conclusions.

- Conclusions : p. 12102 L. 17 «The» should be «This».

- Conclusions : p. 12102 L. 18 « Direct measurements of water vapour of ambient atmosphere can also be performed ». This could be done before and without your customised setup, be more explicit, here. Your system could indeed be useful for the calibration of ambient air measurements, since it allows for automated switching between several liquid water standards, providing the basis for an easier and better calibration framework.

Figures : are Figs. 4-6 necessary or would a summarising table with the key figures be sufficient ?  
To me Figure 11 is not helpful and could be removed.