

## ***Interactive comment on “Continuous measurements of greenhouse gases and atmospheric oxygen at the Namib Desert Atmospheric Observatory” by E. J. Morgan et al.***

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We thank the reviewer for his or her helpful and thorough comments. Responses to individual comments are given below.

COMMENT: Abstract, line 16-17: what is a working tank? RESPONSE: Text now reads: “a reference cylinder”. Additionally we also altered the text with the first mention of working tank, to define the term, on line 177-180. Text now reads: “In practice this is quite challenging, so to minimize artefacts measurements of reference gases or sample air are always made differentially against a dedicated reference cylinder that

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flows continuously while the instrument is operational. Since it is not necessary to know the exact  $\delta(\text{O}_2/\text{N}_2)$  content of this reference gas, it is not measured; in this work such a cylinder is called a “working tank”.

COMMENT: 1 Introduction, fourth paragraph (on atmospheric O<sub>2</sub>): move the paragraph to the end of Chapter 1 to keep the same order (GHGs, O<sub>2</sub>) throughout the document. RESPONSE: Done.

COMMENT: 1.1 Site description: add coordinates (lat, lon); RESPONSE: Coordinates added.

COMMENT: please provide a short description of the meteorological measurements as they are not mentioned here but data are presented later in Fig.11; RESPONSE: A new methods subsection was added after Subsection 2.5. Text now reads: “A small meteorological array is located at the inlet height on the mast. Wind direction and wind speed are measured with a Thies Clima 2-D sonic anemometer (model 4.3810.30.310), temperature and relative humidity with a combined Galltec-Mela instrument (model C 2.4), barometric pressure with a Young pressure sensor (model 61202V), and solar irradiance with a Kipp and Zonen ISO 9060 first class pyranometer (model CMP11). Data is passed to the LabVIEW system via a controller area network (CAN bus).”

COMMENT: It is uncommon to have a chapter 1.1 but no chapter 1.2. Please revise the numbering. RESPONSE: A new subsection heading was added to the first part of the introduction to keep the numbering convention consistent.

COMMENT: 2.1 Overview of the measurement system: please clarify in the beginning of the chapter that separate inlet lines are installed for each individual analyser. It is not clear until you refer in the third paragraph to Fig. 1. I supposed first that “the intakes of the sample lines” refer to several inlet heights; RESPONSE: Text now reads: “The top of an aluminum 21 m mast serves as the basis for all atmospheric observations at the observatory. Each of the three main instruments and the flask sampler has its own dedicated sample line.”

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COMMENT: Concerning the lab view programme: does it only control the entire system or does it also serve as data acquisition? If so, what is the data logging rate? RESPONSE: Line 121, text now reads: "Data is logged at an interval of 1 second; data generated at a higher frequency than this is averaged by the software."

COMMENT: For some specific parts the manufacturer is given in the text (e.g. "four-port, two-position valve (Bürkert : : :)") while it is not the case for others (e.g. "Large volume (5 lpm) pumps run : : :)"). Please be consistent. I suggest skipping the specification of the manufacturers for the periphery items in the text as this information is given in Table 1. RESPONSE: Parenthetical manufacturer specifications have been removed from the text, except for instrumentation.

COMMENT: 2.2 CO<sub>2</sub> and CH<sub>4</sub> measurements: "Likewise, standard gases should have the same composition as the sample : : :." I suggest replacing "composition" by "buffer matrix" RESPONSE: Done.

COMMENT: 2.5 Flask sampling: How long does the sampling take? RESPONSE: I believe this is already in the text, lines 233-235.

COMMENT: Line 12: explain MPI-BGC; RESPONSE: Done

COMMENT: Line 19: please specify the pump (model, material) as this can be crucial since the sampled air passes the pump. RESPONSE: An entry was added to Table 1 for model/make, and text now reads (line 231): "The pump body and valve plates are aluminum, and the structured diaphragms are made of PTFE."

COMMENT: 2.6 Sensor stability: The 24-hour test, was it done on-site or in Jena prior to the installation? RESPONSE: On-site, text now reads (line ): "In order to characterize the stability of the main instruments, a stream of dry air with a constant composition was supplied to each device for a 24-hour period during the final stages of the laboratory installation on site."

COMMENT: Drying and water correction: The water droplet method setup applied

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here: is it one of the methods described in Rella et al., 2013? If so, please refer to it; RESPONSE: Text now reads: "A version of the 'water droplet' method was used to humidify the air stream of a target gas cylinder, using a slight variant of one of the methods in Rella et al, (2013) (Method 2, "Empa variation")."

COMMENT: Page 1524, line 20: add below: "a and b are empirically determined factors determined by the experiment described above." RESPONSE: Done.

COMMENT: 2.8 Calibrations : : :: First paragraph: Make reference to WMO/GAW report #213 where part of the numbers in Table 2 are coming from. RESPONSE: A citation was added to the table header.

COMMENT: Page 1525, line 9: why are initial cylinder pressures above 200bar unwanted? RESPONSE: This was based on a WMO/GAW recommendation, which states "The maximum acceptable initial pressure for calibration standards is unclear, but is at least 140 bar, with little experience within the community at higher pressures.". After some discussion with colleagues, it seems that there is no known artifact/problem with cylinders filled to 200 bar; the cucumber round robins have used cylinders filled to 200 bar with no problems. The aside has been removed from the text, text now reads: "The initial pressure of each cylinder is 200 bar."

COMMENT: Page 1525, lines 14-15: This statement is physically wrong. Concentrations cannot be reported as mole fractions RESPONSE: "Concentrations" has been replaced with "abundances", and elsewhere in the text where the mole fractions are referred to as concentrations.

COMMENT: Page 1526, lines 3-5: "... a linear fit of the average of the last 5 min of working secondary standards (WSS) measurements and the mole fraction determined by the MPI-BGC facilities (all WSSs are traceable to NOAA or Scripps primary standards): : : ." last part is a repetition. Why not ": : : and the mole fractions determined at MPI-BGC." RESPONSE: Done.

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COMMENT: How long were the secondary standards measured? How long does it take after valve switching to reach stable signals? RESPONSE: Text now reads: "Reference gases (WSSs or targets) were measured for a total of 12 minutes after a two minute, high flow rate (250 mL/min) purge of the sample line. During purges the reference gas flow is not directed to the instrument, but vented at the junction closest to the instrument. A stable signal is generally reached after 6 minutes of measurements for all measurands."

COMMENT: Page 1526, lines 17-19: what do you mean by "small matrix-related artifacts due to gas storage or gas handling"? RESPONSE: Poor choice of wording, by this we mean adsorption of CO<sub>2</sub> onto tubing or regulator surfaces. Text now reads, "For some species, like CO<sub>2</sub>, there can be small adsorption-related artefacts during gas storage or gas handling".

COMMENT: 2.9 Drift correction : : : Page 1527, line 6: "through" -> "thorough" RESPONSE: Through is the intended word.

COMMENT: 3.1 General performance: Page 1528, line 6: "measurement computer" -> "control and data acquisition computer"? RESPONSE: Done.

COMMENT: Page 1528, line 12: "communication computer": is it the same as the measurement computer? Is there no chance to use the raw data of the individual analyzers when the data acquisition computer fails? RESPONSE: It is possible to use the instruments' data files, but if the outage is sufficiently long, no calibrations or targets will be run and as a result the data is not usable. To clarify the communication computer reference, a sentence was added to Section 2.1, "In addition to the control and data acquisition computer running the LabVIEW software, a second computer is used for daily data transfer and communication with the outside world."

COMMENT: Page 1528, line 26: how was this leak test performed? RESPONSE: Text now reads: "The leak test was conducted by capping the top of the sample line on the mast and connecting the sample line terminus (ending just before the instrument)

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to a small hand pump. The line was then evacuated to the typical operating pressure. After accounting for temperature fluctuations, leak rates determined after this time were lower than. . ."

COMMENT: 3.2 Stability of the CRDS: Was this test repeated? By doing so, a tank artifact could be maybe distinguished from temperature effects. RESPONSE: Yes, the test has been repeated several times, and shows the same dependency on tank temperature in the insulated box, but not device or room temperature. Text now reads: "Repetitions of this test during maintenance visits have shown similar results."

COMMENT: 3.5 Water correction: Page 1530, lines 21-24: I don't agree that Table 3 shows substantial differences. It is difficult to assess the effect when choosing difference parameters just by looking at the individual numbers of the parameters. How much can a different set of parameters account for in absolute mole fractions? RESPONSE: Text changed from "substantial" to "small but significant". An example was provided, text now reads: "For instance, using the values from Rella et al (2013) to correct a NDAO CO<sub>2</sub> wet value of 390 ppm at 1.5% water vapor content data would result in a difference of 0.23 ppm."

COMMENT: Please elaborate on your exact strategy. Which correction was finally applied? A mean over all tests? Did you use different correction factors for different episodes? Did you see any systematic influence on the GHG mole fractions itself, since e.g. at least for CO the mole fraction ranged from 46 to 238ppb. RESPONSE: Text now reads "The final fit parameters applied to the time series were determined as a quadratic fit to all tests, and were consistent between tests and across a range of mole fractions."

COMMENT: 3.6 Water correction of the OA-ICOS: Page 1531, lines 21-22: " : : : by comparing it to values calculated from the meteorology." It sounds too colloquial. Please rephrase. RESPONSE: Text now reads: "We verified the accuracy of the CRDS water vapor measurements by comparing them to water vapor mole fractions derived from in

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situ NDAO relative humidity, temperature, and barometric pressure.”

COMMENT: 3.7 Calibrations: Page 1542, line 15: “greater” must read “smaller” RESPONSE: Done.

COMMENT: 3.8 Target measurements: Page 1533, line 10: how does the “more robust power-down procedure” look like? RESPONSE: Text now reads: “In the new procedure, after power loss the control computer, while running on an uninterrupted power supply (UPS) system, returns all valves to a configuration that prevents the loss of gas.”

COMMENT: Page 1534, lines 4-5: change order: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CO, O<sub>2</sub> RESPONSE: Done.

COMMENT: 3.10 External validation: Flask to in-situ comparison: Which aggregate of the continuous measurements was compared to the flask data? Also refer to the length of the flask sample filling procedure that you may add in Chapter 2.5 RESPONSE: Text now reads: “After accounting for differences in flow rates, the final 10 minutes of the 15 minute filling procedure were averaged to compare to the flasks,”

COMMENT: 3.11 Time series: Page 1535, line 20: it is the first time that the meteorological measurements are mentioned. RESPONSE: Addressed per previous comment

COMMENT: Page 1536, line 3: growth rates should be also calculated for full years as it can result in misleading results in particular for trace gases with strong seasonal cycles; RESPONSE: Growth rates have been added for NDAO for the Oct 2013–Oct 2014 period.

COMMENT: Page 1536, line 12: Dlugokencky et al : year is missing; Page 1536, line 13: “results” -> “result” RESPONSE: Done.

COMMENT: Table 2, caption: “in-situ vs. in-situ” refers to the cylinder comparison, right. If so, please clarify as in-situ vs. in-situ is misleading. RESPONSE: What was meant by in-situ vs in-situ is that both CPT and NDAO measured the cylinder on site.

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The parenthetical has been removed since the meaning is clearer without it.

COMMENT: Table 3: add one extra column that states that Winderlich data were retrieved for a Picarro EnviroSense analyzer, Chen for a G1301. The Rella coefficients are an average over a bunch of different analyzers. RESPONSE: Column added

COMMENT: Figure 2: labels are wrong, it is not “log tau” and “log sigma” that is shown. It is “tau” and “sigma” on a log scale. Add second x-axis on top that shows the time in hours? As it is down in the lower panel on Figure 3. RESPONSE: Figure labels changed, x-axis was changed to be in hours, since this is more intuitive. Grid lines were also added.

COMMENT: Figure 3: see first comment to Fig. 2 RESPONSE: See previous comment.

COMMENT: Figure 5: change order: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CO, O<sub>2</sub> RESPONSE: Done

COMMENT: Figure 10: change order RESPONSE: Done. The order for Figure 9 was also changed.

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Interactive comment on Atmos. Meas. Tech. Discuss., 8, 1511, 2015.

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