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Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the diurnal, weekly, seasonal cycles and annual trends in atmospheric CO_2 at Mount Zugspitze, Germany during 1981–2016" *by* Ye Yuan et al.

Anonymous Referee #1

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Review of the manuscript: "On the diurnal, weekly, seasonal cycles and annual trends in atmospheric CO2 at Mount Zugspitze, Germany during 1981–2016" by Y.Yuan et al. (Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-850)

The paper is describing the long term CO2 monitoring program at Zugpitze, Germany. Actually the time series is a composite from three periods during which the sampling location, the method and instrument were different: ZPT (1981-1997), ZUG (1995-2001), and ZSF (2001-ongoing). Consequently a major issue to be addressed in this study is the consistency of the three datasets, in order to determine if they can be grouped in a single series and with what limitations. I think this part is not detailed

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enough. The three datasets are merged for analysis of different time scale variabilities, although several indicators show that they differ significantly. A scientist using the Zugspitze long term time series without consideration of the change in the sampling location could misinterpret the signal. For this reason I would recommend the authors to clarify the uncertainties associated to such a merging of the different dataset.

2.1. Measurement sites: I would suggest not using the term 'sites' to distinguish between the three sampling locations (ZPT, SUG, ZSF) at Zugspitze. It is a source of confusion here and there in the manuscript.

Schneefernerhaus (ZPT, 47°25âĂš N, 10°59âĂš E, slightly below the summit): please give the elevation asl

'Information for the first and second time periods were mainly collected based on personal communication with corresponding staff and logbooks': at least it would be good to get information on the general setup of the system (dryer, calibration, and data selection . . .).

Do you use the data already selected (according to time of the day or other criteria) from previous site managers ?

2.3. Offset adjustment: The offset between the two sites (ZPT and ZUG) is huge with a large dispersion (5 to 6 ppm). A more detailed analysis of this offset, looking at its variation in time (and instrumental change), as a function of the atmospheric pressure, or CO2 concentration must be provided.

I support the hypothesis that the carrier gas effect can explain most of the differences between ZPT and ZUG, since it is well known that the CO2 concentration in air when using N2 mixtures as references, is under-estimated by few ppm. However, a discussion on this issue must be provided by the authors, with references to previous studies based on similar NDIR instruments (e.g. Pearman et al., Tellus, 1975; Griffith et al., Tellus, 1982). Is the observed differences compatible with what we can expect consid-

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ering the literature, and the atmospheric pressure at this altitude site ?

I understand that you have not applied the offset correction (-0.11ppm) between ZUG and ZSF. Please make it clear.

2.4. ADVS data selection: "The percentages of ADVS-selected data are . . . 13.5% for Zugspitze": have you merged all three Zugspitze stations together in this analysis ? Does it mean there is none significant differences between them ?

Could you provide some statistics of the hours which are selected at Zugspitze as representative of the background according to ADVS method ?

2.5. STL decomposition Missing monthly values were substituted by spline interpolation: do you allow an interpolation of large data gaps like several consecutive months ?

". . .especially for measurement sites at lower elevations": I am confused about which sites you are referring to. Low altitude sampling locations at Zugspitze, or other sites like Schauinsland ? Can you be more specific about the data gaps at stations, since it would make much more sense to use background data (after ADVS selection) for the seasonal and trend analysis, especially when comparing at other large scale time series.

3.1. Trend and seasonality "Only the mean annual growth rate between 1995 and 2001 at the ZUG site is much lower than the other sites due to missing values in 1998": Not clear for me why the 6 months data gap in summer 1998 decreases so much the total trend over the period 1995 to 2001. Please clarify.

"Amplitudes of 15.44 and 14.89 ppm": For most signals I would suggest rounding the values to one decimal place.

The comparison of the seasonal cycles would be much more meaningful with background selected data. By the way do you use also all data (without selection) at SSL, WNK and MLO sites, or do you use the data selected by the station's managers at

those sites ? Please clarify. It could be interesting to see if the ZSF site remains more influenced by the air from the valleys, compared to ZPT and ZUG, once you have selected the nighttime values at all sites.

"there are slight differences in seasonal amplitudes (ZPT: 10.86 ppm; ZUG: 11.14 ppm; ZSF: 13.09 ppm) among the three sites": I would not call a 2 ppm signal a slight difference ! A major signal to look at for such long term time series in North Hemisphere would be a possible trend in the amplitude of the seasonal cycle which could indicate a trend in the way the biosphere is interacting with atmospheric CO2. Graven et al., 2013 described for example increasing trends of the seasonal CO2 amplitude of 0.32 % per year at Mauna Loa and 0.60 % per year at Point Barrow. Considering a mean amplitude of about 12 ppm you could expect a trend of 1.4 to 2.5 ppm over the 36 years period of measurement at Zugspitze (assuming the MLO and BRW trends).

Figure 3: the significant differences you show on figure 3b with the 3 sampling locations should prevent you from mixing those three dataset together as you do in figure 3a.

3.2. Inter-annual variations Abnormal high percentage at Zugspitze in 2000: I do not understand the sentence on line 5/6 suggesting that a careful and intensive selection was performed in 2000. Is the selection process different from the other years ?

Again, due to the differences between the three sampling locations (especially ZSF which is more influenced by air uplifted from the valleys) I think you should differentiate them in figure 4.

3.3. Weekly periodicity I would suggest to discuss short-term variabilities (weeks and daily) before trend and inter-annual variations.

I do not see the interest of comparing the weekly variations at Zugspitze to the one observed at Mauna Loa.

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