Reply to the referee comments of Anonymous Referee #2

General comments:

A topic which has received much attention during recent years both in scientific literature and in general discussion papers has been further studied in the article by Popa et al. The new results for atmospheric H2 mixing ratio, deposition velocity and H2/CO ratio have been obtained at an interesting site in Western Europe well suited for monitoring the long term developments in H2. A specific new feature is the use of four monitoring levels in a tall tower ranging from 20 to 200 m altitude. The authors take advantage of the versatility of the observations.

As referee #1 suggested, the article would benefit from applying the gradient method to determine the H2 fluxes. Generally the paper is very thorough and well written and can be recommended for publication in ACP.

A. We agree that it would be interesting to use a different approach for estimating the H_2 soil uptake fluxes, and to compare with the results of the radon tracer method. Applying the flux gradient method at Cabauw tall tower would however be a work in itself and it is beyond the purpose of this paper. One complication of this approach is that we only observe significant H_2 gradients due to soil uptake in very stable conditions, and in this situation one or both of the two lowest sampling heights at Cabauw (20 and 60 m) are above the atmospheric surface layer (constant flux layer). A possibility for a future study would be to perform H_2 measurements in air sampled via additional inlet lines closer to the ground, below the 20 m level. For comparison with the radon tracer method results we recently started a one-year campaign of flux measurements with a soil chamber.

Specific comments:

1. p.5598 l.21: Add more information on radon monitor. How did you calibrate your 222Rn measurement?

A. We extended the text on the radon monitor as follows:

“ ^{222}Rn is measured in air sampled via dedicated inlet lines at two heights of the tower, 20 and 200 m, by two independent dual flow loop, two-filter radon instruments, designed and constructed at the Australian Nuclear Science and Technology Organisation (ANSTO) (Whittlestone & Zahorowski, 1998). The inlet flow rate is 80 L/min and each detector has a delay volume of 1500L. From each height there is one data point every half hour, with the exception of few hours per month when the calibration is performed. The lower limit of detection, defined as the radon concentration corresponding to a relative counting error of 30% for a one hour count, is equal to or less than 30 mBq/(m^3). Calibrations of the radon detectors are performed monthly by injecting known amounts of radon into the inlet air stream from a calibrated radon source (Model 2000A, Pylon Electronics Inc., Canada). Calibration accuracy of the source is +- 4% at a 1-sigma confidence level. For concentrations higher than 700 mBq/(m^3) the overall uncertainly is predominantly attributed to the accuracy of the source.”

2. p.5601 l. 20: Does the time series include all data or has it been selected somehow?

A. A careful quality check has been performed, and only the data considered "good" are shown and used here.

3. p.5604 l. 1: To me the April-May secondary maximum in fig. 4 is not very clear for H2. Rather is seems that H2 is gradually decreasing after the winter maximum and then there is a steady period before the minimum in October.

A. The text has been changed as follows: "They sharply decrease to an inflexion point in March, and after that is a steady period in April – May."

4. p.5606 l. 22: In fig. 5a the rush hour seems to be best visible in the evening of 18th March and morning of 19th March, where all levels rise for few hours (all levels should rise also according to fig. 7). During 20-21 March only lowest level rises (and stays up throughout the night). Is there something misunderstood here?

A. The rush hour signal is primarily seen at the lower sampling levels, and depending on the atmospheric vertical mixing situation, sometimes at the higher sampling levels. In very stable conditions, it can only be seen at the lowest sampling levels.

In some nights the boundary layer is even lower than 20 m, and then no increase in the mole fraction can be seen in our measurement.

In conditions of low and relatively constant vertical mixing, the accumulation continues through the night, leading to a monotonous increase in mole fractions.

Fig. 5 is quite hard to read as part of article pdf printout, because the panels are so small.

A. The figure will be much easier to see if published in ACP, on a A4 portrait page.

p.5614 l. 11: It would be nice if you could give a short qualitative description of the seasonal variation of soil moisture in Cabauw. Can the high soil water content prevent H2 deposition in winter? In addition to the dominating anthropogenic emissions and high atmospheric instability, can high soil moisture be the reason for the rare or nonexistent winter deposition events?

A. We think that high soil water content can indeed prevent H_2 deposition during winter, and the same can be the cause (at least partly) for the low deposition velocities during summer (as also mentioned in Sect. 4.5). Moreover, in the Cabauw region the water table is managed, the winter water table level is higher than the summer one. Thus is indeed possible that the soil moisture leads to very low deposition velocities during winter.

However, even if the soil moisture were the same during summer and winter, the higher atmospheric instability during winter would not allow detecting many deposition events.