Response to Referee #1:

We would like to thank the referee for the review of this manuscript and their constructive comments. Our response to each comment is below with the referee's comments highlighted in italic typeface.

P251, L12: I suggest the authors to add the equation for Cf here, because all the evaluations in this study are based on this variable. Moreover, it would be helpful for readers to understand the fact that Cf does not depend on surface fluxes nor observations.

Response: We agree with the referee and we will add the equation for Cf in the revised manuscript as suggested. On page 252, L20-21 we have already stated that Cf only depends on the transport model, the prior flux uncertainties and the observational uncertainties, however the equation for Cf should make this even clearer.

P252, L25: Is the contribution of the initial condition also negligible?

Response: Yes. The initial conditions are very well constrained by the observations and their contribution to the flux uncertainty is therefore thought to be small. We will add this statement to the revised manuscript.

Section 2.2.1: I would like the authors to elaborate the description of CO2 prior flux uncertainties more, even though it is the same as Ziehn et al. (2014). At least, the data sources of the terrestrial biosphere and fossil fuel fluxes should be described.

Response: We agree with the referee and we will extend section 2.2.1 accordingly in a revised version.

P254, L8: "assuming three different flux levels (high, moderate and low)" Please elaborate "high, moderate and low" by using numbers and how to determine the level for each grid.

Response: The spatial pattern of fluxes for each sector is based on information from the literature as described in the manuscript. For example, for ruminant animals we consider the distribution and density of cattle (beef and dairy) and sheep. According to the density we assign a "high" flux, which is twice as high as the "moderate" flux and the "moderate" flux is twice as high as the "low" flux. Actual flux values at these three levels are then assigned to match the sectors total. The sector total for ruminant animals is 2.1 TgC/yr (or 2.02e10 gC/week divided into day and night), which translates into a "high" flux of about 0.016 gC/m2/week, a "medium" flux of about 0.008 gC/m2/week and a "low" flux of about 0.004 gC/m2/week.

We will include this explanation in a revised version of the manuscript.

P254, L11: "(50 % of their value)" This is important information of the flux uncertainty. It should be described more clearly, not being in parentheses.

Response: We agree with the referee and we will correct this in a revised version of the manuscript.

P256, L20: Does "n" include not only the number of model grids but also the 4 months

(seasons)? Because the authors do not discuss differences of the cost function (reduction) among the 4 months, it is conceivable that the cost function is defined over the 4 months. However, it is not clearly described in the text.

Response: This is correct. The cost function includes all 4 seasons (4 example months). We will clarify this in a revised version of the manuscript.

P257, L5: "which is also know" ==> "which is also known"

Response: This will be corrected in a revised version of the manuscript.

P258, L11: "Similar" => "Similarly"

Response: This will be corrected in a revised version of the manuscript.

P258, L7-13: Probably, the reason why the aobs for Cape grim is halved is that the measurement accuracy is also high for this station. But I cannot understand the difference of aobs between Cape Grim and Gunn Point. Please elaborate the reason more.

Response: Cape Grim is our primary ground based observing station in Australia with the longest data record (since 1976). We therefore decided that it should have the lowest observational uncertainty assigned. Gunn Point is one of our key stations, but only operational since 2011. To distinguish between the data quality we expect from Cape Grim and Gunn Point we decided to use slightly different observational uncertainties for the two stations. Additionally, the sampling height for both stations is different: Cape Grim is located at a cliff with a sampling height of 70m, whereas Gunn Point has a sampling height of only 40m. We therefore might expect noisier records for Gunn Point.

P259, L8-12: Please clearly say that the GWP weights are not used in this case.

Response: We will clarify this in a revised version of the manuscript and highlight that we use an alternative set of weights (and not the GWP weights).

P260, L14: In Eq. (6), probably summation for d is missing.

Response: The cost function value is calculated for a certain configuration of the network. We use incremental optimisation, adding only one station at a time. Therefore, the additional term in the cost function (Eq. (6)) is the normalised distance (multiplied by the weight) for only one station.

P262, L15: "show in Fig. 5a" => "shown in Fig. 5A"

Response: This will be corrected in a revised version of the manuscript.

P262, L19-22: I cannot understand these sentences clearly. It seems that CO2 has the smallest impact on the cost function reduction according to the GWP weights. The largest uncertainty of CO2 in the prior flux significantly contributed even with the smallest GWP weight. Is this understanding correct? If so, could you show with some numbers how large the flux uncertainty of CO2 is compared to the other uncertainties?

Response: This is correct. CO2 has the smallest GWP weight (w_co2 = 1), but by far the

largest prior flux uncertainties. The spatial distribution of the prior flux uncertainties for CO2, CH4 and N2O are presented in Figs. 1, 2 and 3, respectively. For example, CO2 flux uncertainties are by a factor of 10e3 larger than CH4 flux uncertainties. We will clarify this in a revised version of the manuscript.

P264, L3 and elsewhere: "performance" is a little bit ambiguous word and should be replaced with "uncertainty reduction", for instance.

Response: The performance of the network is assessed based on the uncertainty reduction that can be achieved. We will clarify this in a revised version of the manuscript.

P265, L12: "the flux uncertainty" => "the flux uncertainty reduction"?

Response: We will replace "the flux uncertainty" with "the reduction in flux uncertainty".

P265, L28: "3 GHG" => "3 GHGs"

Response: This will be corrected in a revised version.

Figure 5, 7: Color legends would be helpful.

Response: Colours are explained in the caption of Fig. 5, but we will add a colour legend to the figure in a revised version.

Figure 5: The unit of "Uncertainty reduction" is missing.

Response: This will be corrected in a revised version.

Figure 5: The x-axis labels should be integer and the smaller scales (by 0.2) are not necessary because the x-axis shows only the 5 ranks.

Response: We agree with the referee. This will be corrected in a revised version.