Response to Referee #2:

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, L9-10: "assuming a Gaussian error distribution for the surface fluxes and concentrations. . ." Is this supported by the literature or by any previous error analysis done by the authors?

Response: Gaussian distributions are commonly used in inverse modelling and for random variables whose distributions are not known. Unless we have more detailed information on the error distribution of surface fluxes and observations (which we do not), the Gaussian distribution is a valid choice. It also simplifies the calculation of the posterior covariance matrix Cf. We will add the equation for the calculation of Cf in a revised version of the manuscript.

P251,L12: A equation for the covariance matrix Cf could be helpful for the reader.

Response: The equation for the calculation of Cf will be added in a revised version.

P252,L25-L26, P253,L1-2: In Zienh et al. (2014), was established " . . . the uncertainty contribution of the boundary concentrations to the uncertainty observations can be consider negligible. . ." This conclusion was obtained for CO2 and Darwin, Aspendale, Arcturus and Geraldton stations that are close to the Australian coasts. The authors suggest the same behavior expected for CH4 and N20 boundary concentrations. Some experiments has been done in that sense? What happen with initial condition uncertainty?

Response: The inflow from the boundary can affect the concentrations measured at a certain point. These boundary effects have been investigated in Ziehn et al. (2014) and it was concluded that the uncertainty contribution of the boundary concentrations can be considered negligible for stations close to the Australian coast. Although this study was focusing on CO2 only, the assessment of the boundary effects presented in this study was more general and is therefore valid for other gases as well.

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.

P255, L9-10: "The spatial distribution of the wetland CH4 fluxes . . . is based on Australian mean rainfall" but in P255, L4 "Emissions depend mainly on temperature and ground water (Bloom et al.,2010)" . Although ground water has a strong correlation with the men rainfall the temperature distribution has not been taken into account to compute the CH4 fluxes. Could the authors justify the use of the mean precipitation as single estimator of the wetland fluxes?

Response: Wetland emissions are only one of seven CH4 sources that we consider in this study. We assign large (50%) uncertainties to the derived prior fluxes to acknowledge the limited amount of information used to generate the spatial distribution of wetland CH4 emissions. We also perform a sensitivity experiment (SE3, P259-260), to test the impact of variations in our assigned spatial flux distribution on the network design which was found to be only minor (P264, L10-21). Although the spatial distribution of CH4 is based on annual mean rainfall, we do take temperature into account as part of the seasonality that we assume. For example, peak emissions in South Australia occur during spring time (October-November) as stated on P255, L7-10 and therefore our flux estimates for CH_4 will have the highest values for this season and the lowest values for late autumn and winter.

P257, L12-14. The global-warming potential for 100 years time has been derived for Myhre et al.(2013) to obtain the GHGs weights. This is one of the multiple plausible future escenarios for the GWP. A discussion about the GWP estimates could be interesting for the reader.

Response: The global-warming potential (GWP) has been used as weights to combine the CO_2, CH_4 and N_2O contributions (multi-objectives) in a single objective scalar function. The GWP values have simply been used as an example. It is up to the user to decide what values should be assigned to the weights (dependent on what the aim is for the network design). A discussion about GWP estimates is probably not within the scope of this paper.

P261, L16-18: Although the motivation for selecting only 2 stations has been described on P257, L23 and P258 L1-6,. and this 2 stations are able to reduce the uncertainties in the 3 GHGs fluxes between 12 and 17 %, such small number of station on base network could produce a bias on the final locations selection. Could the authors justify, among P257-258 reasons, the influence of the number and location of the stations of the base network in the final network proposed?.

Response: The impact of using a base network on the results of the network design has been investigated in Ziehn et al. (2014). They assumed a base network consisting of 6 stations which was able to reduce the uncertainties on CO_2 fluxes by about 30%. Another 6 (new) stations were required to obtain an uncertainty reduction of 50%, which means a total of 12 stations were included in this network. However, Ziehn et al. (2014) also performed the network design from an empty network and in order to achieve a 50% reduction in uncertainties only 9 (new) stations were required.

In the current study we only include 2 stations, Cape Grim and Gunn Point, in our base network (instead of 6 as used in Ziehn et al. (2014)) in order to limit the impact of the base network on the final optimal network. The two stations are key stations that provide highly accurate in situ measurements of all 3 major GHGs and from an economic point of view it makes sense to include them in any network that we consider for the Australian continent. However, we also stated in the manuscript (P261, L16-18) that the network extension for the base network consisting of 2 stations is similar to the network extension for the base network consisting of 6 stations. This highlights the small impact of choosing different base networks on the performance of the final network.

P266. L8-9: The authors suggest constraint to network design due to preselected locations Are the size and location of the base network could be consider an other constraint? Have other posible base networks been considered?

Response: By pre-selecting our potential stations we add a constraint to the network design and as shown in Fig. 7b we can only achieve an uncertainty reduction of about 70% for CO_2. The maximum reduction in uncertainty is independent of the base network, because this assessment includes all stations (existing stations and potential stations).

Figure 4a: Some of the station numbers are over the coast line, would be better to put *in a more readable place. I understand that in Figure 4b it is not possible due to the large number of the stations.*

Response: We will improve the readability of the station numbers in Fig.4 in a revised version.

Figure 5 and 7: Color legends could be added for clarity.

Response: Colours are explained in the caption of both figures, but we will add a colour legend for both figures in a revised version.