Notes on submitted material to the UNFCCC assessment

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For the attribution calculation we first used our SCM to calculate the global dT (and dSL) from global emissions of all major climate gases (see Phase I submission for model documentation). Emission data from the period 1750 and 1990 was taken from the CDIAC (for CO2) and EDGAR (for other gases) databases and emissions from 1990 to 2100 was taken from the SRES A2 scenario. This was used as a reference run (dTw in the formula below). In order to estimate the contributions for the different regions we chose a subtractive approach. Each regional emission of CO2, CH4 and N2O from the datasets mentioned above was regarded as negative perturbations to the global "background" emission and the model was used to calculate the dT given the perturbed emissions (dTr below). The results were the global temperatures one should expect *without* the emissions from region *r* (see Figure 1). The absolute contribution from a given region could then be calculated as the deviation between dTw and dTr and each region's relative contribution was given as:

$$\alpha_r = \frac{\Delta T_w - \Delta T_r}{\sum_{i=1}^{n} (\Delta T_w - \Delta T_i)}$$

where *n* is the number of regions.

Conceptually this way of calculating the contributions seems reasonable since it models what dT would have been in absence any given GHG emitter. Furthermore, by superimposing the changes in emissions (i.e. the contributions from each region) on a background that is closer to reality, the calculations are less influenced by non-linear effects as compared to an approach where dT is calculated from the emissions from each region alone.

From Figure 2 we can see that the absolute contributions calculated for each region don't sum up to the total temperature change. This is mainly because the background, when perturbing only the most important *warming* climate gases, consists of a majority of *cooling* gases (especially during the 20^{th} century) and that the removal of total CO2, CH4 and N2O emissions would result in negative dT during that period. In fact the contributions for all regions would not have summed up to the total dT even if all climate gases (cooling and warming) were included in the perturbations due to non-linear effects. The absolute contribution from each region does therefore make little sense in itself and must be looked upon as a relative share of the sum of contributions.
When using the perturbation approach we found it natural to let emissions return to the background (world) level after the perturbation period (the period between emission start and end dates in the exercise guide) was ended. As a test we tried using zero emissions after the emission end date and found that the each region's relative contribution did not change notably compared to our approach.

Attribution was calculated using temperature and sea level change (see Figure 3 and Figure 4). We did also look into possibilities for using rate of change of dT for attribution calculation, but found that with the method we had used this parameter only yielded meaningful results when attribution was calculated during the emission (or perturbation) period. This is because the rate of change was calculated on the absolute dT attribution (the

deviation between dTw and dTr). After the end of the perturbation period dTw and dTr will start converging and the rate changes from positive to negative (see Figure 5).
Attribution calculation was done for 6 different cases. In four of the cases the perturbations were made on CO2 (including LUC), CH4 and N2O only, but start and end points for the perturbations were varied. In the two last cases we tested how each region's contribution changed when only perturbing CO2 emissions (1b) and when perturbing all gases included in the Kyoto Protocol (1c).

Case	Emission start	Emission end	Gases
1a	1890	2000	CO2, CH4, N2O
2	1890	2100	CO2, CH4, N2O
3	1950	2000	CO2, CH4, N2O
4	1950	2100	CO2, CH4, N2O
1b	1890	2000	CO2
1c	1890	2000	CO2, CH4, N2O, HFCs, PFCs and SF6

Figures

All figures are made with data from case 1 (default parameters).

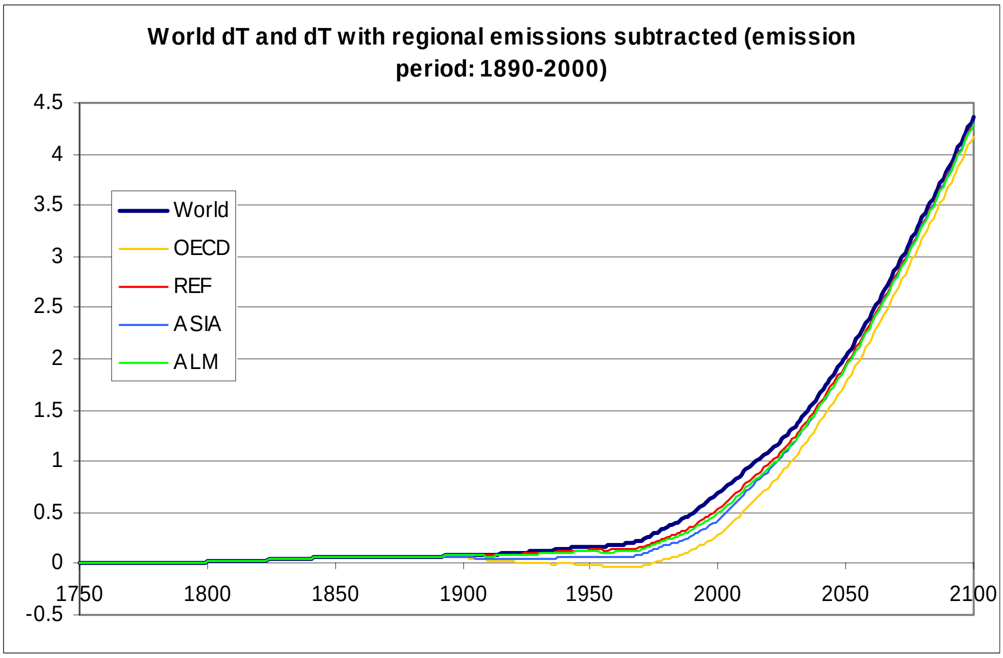

Figure 1

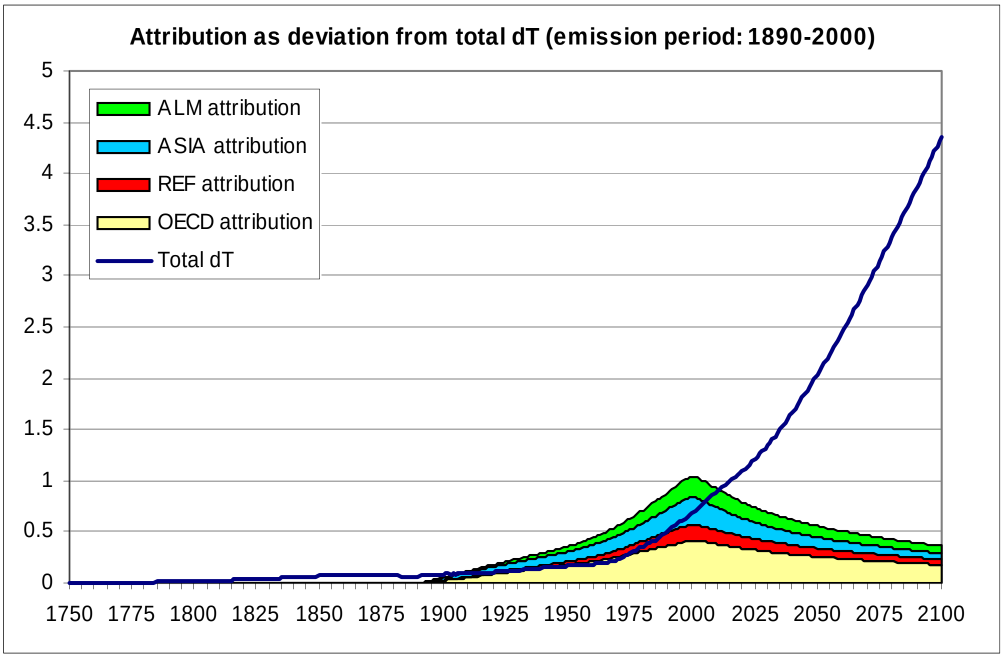

Figure 2

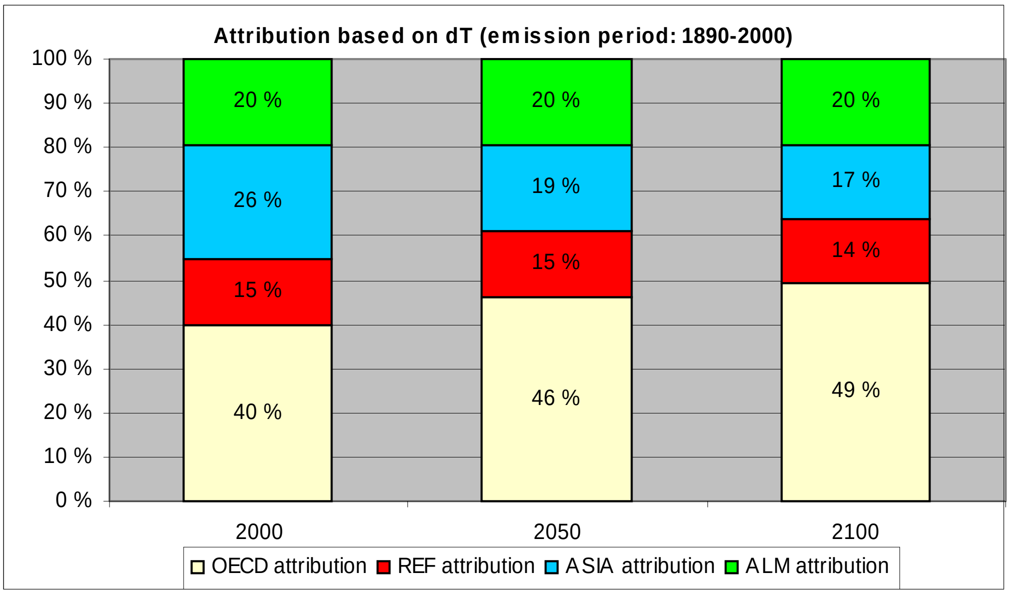

Figure 3

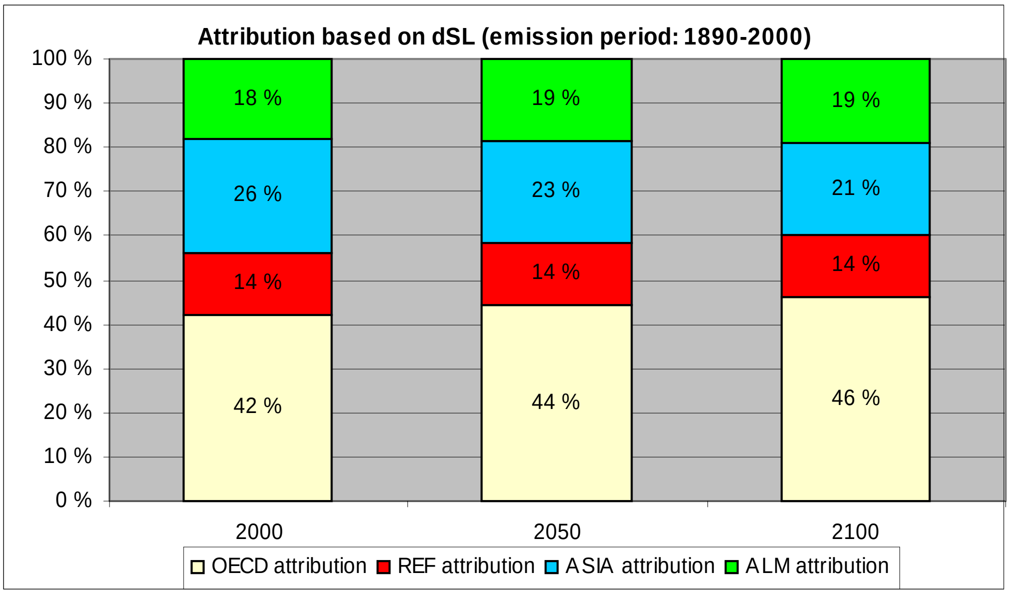

Figure 4

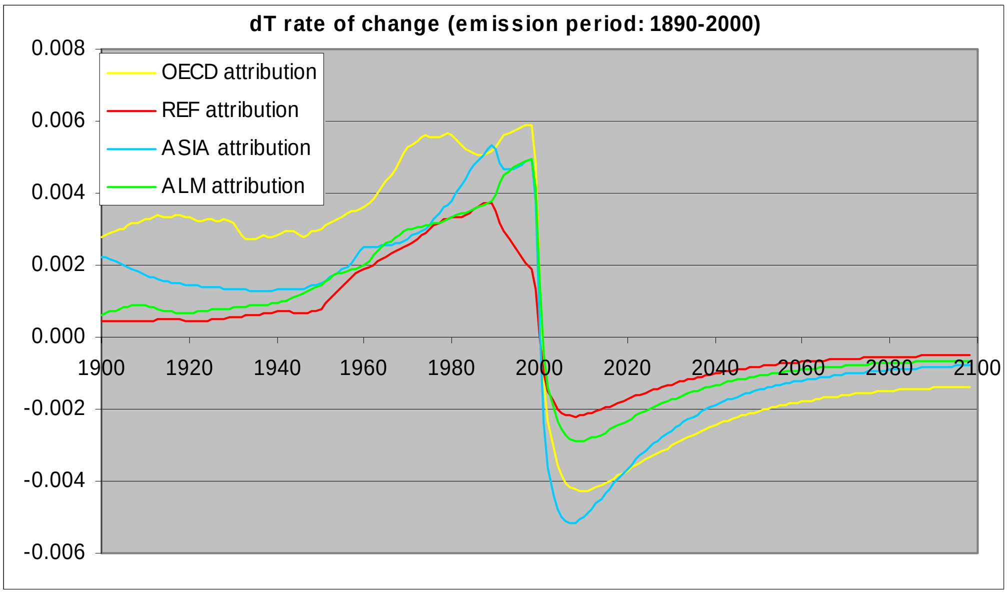

Figure 5