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Interactive comment on "Historical greenhouse gas concentrations" *by* Malte Meinshausen et al.

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Thanks to R. Pincus for these additional comments.

Comment 1: This comment raises the fairly narrow question as to whether the level of detail provided by this reconstruction of greenhouse gas concentrations is appropriate for CMIP.

Reply 1: We agree with R. Pincus that the level of detail is more than what the CMIP6 end-user will need. For this, a simple description of the datasets, the formats, the scope and some key limitations would have been sufficient. We hence provided a section 4 that is dedicated to the CMIP6 needs. However, without the details of the data derivation, the developed method would be intransparent. We hence hope that this structure of the manuscript with a dedicated section 4 is a suitable compromise to bridge the two communities, i.e. the measurement community as well as the modelling

community.

Comment 2: Without diminishing the tremendous amount of work represented by this reconstruction nor its possible value in other contexts, discussions with modeling centers over the protocol for the Radiative Forcing MIP (https://dx.doi.org/10.5194/gmd-9-3447-2016) suggests that much of the detail in these specifications will not implemented as part of the CMIP6 protocol. In particular:

Reply 2: We are aware that some models choose to only implement globally uniform concentrations and that is ok. We feel there is some imbalance in terms of how much detail is implemented in some other aspects of the CMIP6 input data, which would have similar or lesser effect on seasonal and latitudinally dependent forcings, though. If CO were implemented (see comment below), that would be an example. Time will tell, whether the broader community regards the additional detail of seasonality and latitudinal dependence as something important.

Comment 3: 1) We fear that few modeling centers will implement the latitudinal variations or vertical profiles of well-mixed greenhouse gases as described in section 4. We discussed this only with GFDL and the Met Office, so we may well be wrong, but these are two topnotch centers with strong local interest and expertise in radiation issues, and both will use time-dependent scalar values.

Reply 3: We were made aware at a late stage of our project that the default minimum recommendation will be to only use time-dependent scalar values and we fully respect that some modelling centres will only follow the minimum recommendation. However, given the importance of regional inhomogenous forcings, for example to correctly undertake historical constraining excercises and detection and attribution (e.g. Shindell, 2014, doi:10.1038/nclimate2136), it seems worthwhile to provide the choice to the modelling community. Only using time-dependent scalar values for all latitudes will insert easily avoidable biases into the models (although they are not dramatic of course). We are aware that there are some models that can choose to nudge their internally generated mixing ratio fields with a similar seasonality and latitutudinal resolution towards the scalar global average values and that is a perfectly legitimate approach, too (although it might hinder slightly the historical comparability given the differences in those internally generated fields during CMIP5, as we highlight in some of the CMIP5 figures in Appendix B).

Comment 4: 2) The three options for describing atmospheric composition (lines 369-377) offer a useful range of compromises but option 1, using a subset of gases, might be improved by greatly restricting the number of halocarbon species provided. It is not clear how many, if any, line-by-line models include the long list of species. It is certain that no climate model radiation codes include more than a few. Based on rough calculations using radiative efficiencies from IPCC AR4, including only CFC-11, CFC-12, HCFC-22, CFC-113, HFC-134a, and CCl4 reproduces the total instantaneous radiative forcing in 2014 to within 0.045 W/m2.

Reply 4: We fully agree that the subset of species can be further reduced and we provide the impact of that choice by stating the cumulative percentage radiative forcing change covered by the top 15 species. (see our Table 5, reproduced at the bottom of this reply). It is of course up to the modelling centre to only choose the top, say, 8, species and then cover 99.1% instead of 99.7% of the GHG-induced radiative forcing. The choices by modelling centres will vary. It is important though that those choices get clearly documented by the modelling centres.

Comment 5: If the protocol includes levels of details that modeling centers are unlikely to observe it may be more appropriate to reduce to level of detail to something practical.

Reply 5: We agree. And this is the reason why we provide Option 2 and 3, in which case modelling centres only have to include 5 (equivalent) gases to cover together 100% of the forcing change. Of course, the more top notch modelling centres can (and have done in the past) come up with their own aggregations.

Comment 6: On a distinct issue, we are surprised that the protocol does not include

estimates of CO. Rough estimates suggest a clear-sky instantaneous radiative forcing at 2014 of roughly 0.05 W/m2, or the same contribution from one gas as from 35 of the specified halocarbons in total.

Reply 6: CO did not fall into our scope of “long-lived” GHG concentrations, so we would like to refer to the CMIP panel for who will cover CO concentration (fields). We agree that it would be important to include. And by the same token, it can be important to include the seasonality of CO2 and latitudinal gradient of CH4 and other GHGs also, which has locally an influence of multiple times that of CO forcing. . . ïĄŁ

Thanks for taking the time for these additional comments.

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Table 5- Options for reducing the number of GHGs to be taken into account to approximate full radiative forcing of all GHGs. In Option 1, a climate model explicitly resolves actual GHG mixing ratios. With 8 and 15 species, 99.1% and 99.7% of the total radiative effect can be captured. In Option 2, only CFC-12 is modelled next to CO_2, CH_4, and N_2O; all other gases are summarized in a CFC-11-equivalence mixing ratio. In Option 3, all ODS are summarized in a CFC-12-equivalence mixing ratio, and all other fluorinated substances are summarized in HFC-134a-equivalence mixing ratios. The first column indicates the importance of gases in terms of the radiative effect change between 1750 and 2014. Note that below shares are approximations, as linear radiative forcing efficiencies are assumed here for all gases, also for CO_2, N_2O and CH_4.

			Option 1		*Option 2*		*Option 3*	
	The GHG contribution to climate change since 1750.		**Using subset of actual mixing ratios, no equivalent gases**		**Summarizing all gases of lower importance than CFC-12 into CFC-11eq.**		**Summarizing all ODS into CFC-12-eq and all other fluorinated gases into HFC134a-eq**	
Rank	**Shares of change of total warming effect since 1750: Approx. Radiative forcing contribution between 1750 and 2014 relative to that of all GHGs**		**Shares of total warming effect: Approx. Radiative effect compared to effect of all GHGs (absolute in 2014, not relative to 1850)**					
1	CO_2	64.0%	CO_2	72.9%	CO_2	72.9%	CO_2	72.9%
2	CH_4	79.5%	N_2O	86.1%	N_2O	86.1%	N_2O	86.1%
3	CFC12	86.0%	CH_4	95.0%	CH_4	95.0%	CH_4	95.0%
4	N_2O	92.2%	CFC12	97.2%	CFC12	97.2%	CFC12-eq	99.5%
5	CFC11	94.5%	CFC11	98.0%	CFC11-eq	100.0%	HFC134a-eq	100%
6	HCFC22	96.4%	HCFC22	98.6%				
7	CFC113	97.2%	CFC113	98.9%				
8	CCl_4	97.8%	CCl_4	99.1%				
9	HFC134a	98.3%	HFC134a	99.3%				
10	CFC114	98.5%	CF_4	99.4%				
11	HFC23	98.7%	CH_3Cl	99.5%				
12	SF_6	98.8%	CFC114	99.5%				
13	CF_4	99.0%	HFC23	99.6%				
14	HCFC142b	99.2%	SF_6	99.7%				
15	HCFC141b	99.3%	HCFC142b	99.7%				
…	28 more GHGs	100%	28 more GHGs	100%				

Fig. 1. Table 5