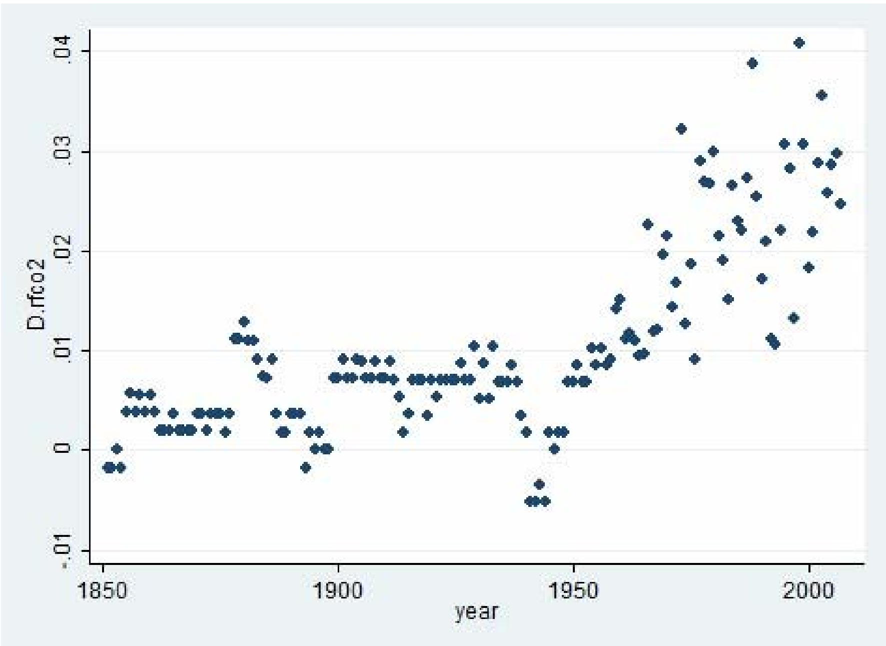
Response

Referee #1 points out that the results in Table 2 “are merely assertions”. In reference to the battery of tests applied to CO_2 forcing reported in Table 1, we wrote on page 14, “We have applied these test procedures to the variables in Table 2”. In this response we provide detailed test results for all the variables in Table 2. These results establish our claim convincingly that whereas temperature and solar irradiance are I(1) variables, anthropogenic forcings are I(2) variables.

Informal inspection of Figure 1 (in the ESDD version) suggests that the time series properties of greenhouse gas forcings (panels a and b) are visibly different to those for temperature and solar irradiance (panel c). In panels a and b there is evidence of acceleration, whereas in panel c the two time series appear more stable. In the figure below we plot $rfCO_2$ in first differences, which confirms by eye that $rfCO_2$ is not I(1). Similar figures are available for other greenhouse gas forcings. Whereas the first differences of temperature and solar irradiance are trend free, the first differences of the greenhouse gas forcings are not. This is consistent with our claim that that anthropogenic forcings are I(2), whereas temperature and solar irradiance are I(1).

The First Differences of $rfCO_2$



What we see informally is born out by the formal statistical tests for the variables in Table 2, which are presented in the table below. As mentioned in the ESDD paper, although the KPSS and DF-type statistics (ADF, PP and DF-GLS) test different null hypotheses, we successively increase d until they concur. If they concur when d = 1 we classify the variable as I(1), or difference stationary. For the anthropogenic variables concurrence occurs when d = 2. Since the DF-type tests and the KPSS tests reject that these variables are I(1) but do not reject that they are I(2), there is no dilemma here. Matters might have been different if according to the DF-type tests these anthropogenic variables are I(1) but according to KPSS they are I(2).

The required number of augmentations for ADF is moot. The frequently used Schwert criterion uses a standard formula based solely on the number of observations, which is inefficient because it may waste degrees of freedom. We prefer instead to augment the ADF test until its residuals become serially independent according to a lagrange multiplier (LM) test. In most case 4 augmentations are needed, however, in the cases of $rfCO_2$, rfN_2O and stratospheric H_2O 8 augmentations are needed. In any case, the classification is robust with respect to augmentations in the range of 2 – 10. Therefore, we do not think that the number of augmentations affects our classifications.

The KPSS and Phillips-Perron statistics use the standard nonparametric Newey-West criteria for calculating robust standard errors. In practice we find that these statistics use about 4 autocorrelations, which is similar to our LM procedure for determining the number of augmentations for ADF.

We have added the DF-GLS statistic due to Elliot, Rothenberg and Stock (1996) which instead of augmentations estimates the DF statistic using generalized least squares. In some case this statistic conflicts with ADF and Phillips-Perron.

For each variable we begin in step 1 by testing whether it is stationary (d = 0, no deterministic trend). This is easily rejected for all the variables in the table below except for staratospheric aerosols. Next, in step 2 we test whether the variable is trend stationary (d = 0 with a deterministic time trend). According to the KPSS statistic none of the variables is trend stationary. However, in some cases (temperature, solar irradiance) the Phillips – Perron statistic suggests trend stationary as does the ADF statistic for ocean heat.

In step 3 we test for difference stationary (d = 1, no deterministic trend). The concurrence criterion is achieved for both measures of temperature (GISS and BEST), solar irradiance and ocean heat content. Therefore, we classify these variables as I(1). Notice that none of these variables is anthropogenic.

In step 4 we test whether these anthropogenic variables are I(2). The test statistics unanimously concur that d = 2 for $rfCO_2$, rfN_2O, reflective tropospheric aerosols, black carbon and stratospheric H_2O. The same applies to $rfCH_4$ except for DF-GLS. Notice that this classification is implied by DF – type tests as well as KPSS. For example, the ADF test statistics reject the hypothesis that d = 1 but do not reject that d =2.

Just as Table 1 in the ESDD version established that $rfCO_2$ is I(2), so does the table below establish that the classifications in Table 2 are correct and robust. We suggest that the table below, appropriately edited, be included in the ESD version of the paper.

	Period (Obs)	d	Trend	ADF	DF-GLS	Phillips-Perron (PP)	KPSS
rfCO2	1850-2007	0	NO	2.147	1.249	10.589	3.60
		0	YES	0.716	-1.438	4.41	0.809
		1	NO	-0.459	0.676	-3.253	2.66
		2	NO	-5.583	-8.548	-20.856	0.0349
rfCH4	1850-2007	0	NO	-1.990	0.689	3.341	3.84
		0	YES	-3.523	-3.064	-1.962	0.963
		1	NO	-1.324	-0.971	-2.005	1.91
		2	NO	-4.932	-1.701	-15.517	0.107
rfN2O	1850-2007	0	NO	1.210	0.285	14.461	3.56
		0	YES	-0.298	-2.338	5.013	0.897
		1	NO	0.394	-1.334	-6.398	3.17
		2	NO	-6.745	-9.230	-40.369	0.0508
Temperature (NASA-GISS)	1880-2007	0	NO	0.135	0.371	-1.821	2.46
		0	YES	-2.138	-1.481	-5.514	0.321
		1	NO	-8.228	-11.285	-17.921	0.139
Temperature (BEST)	1850-2007	0	NO	0.227	0.540	-2.999	3.01
		0	YES	-2.393	-4.238	-7.077	0.397
		1	NO	-8.377	-0.713	-23.996	0.0624
Solar irradiance	1880-2003	0	NO	-1.258	1.094	-2.034	2.68
		0	YES	-4.129	-1.016	-4.162	0.185
		1	NO	-9.489	-0.895	-6.613	0.0153
Reflective tropospheric aerosols	1880-2003	0	NO	-0.796	-0.714	1.941	3.03
		0	YES	-2.450	-2.121	-1.458	0.757
		1	NO	-1.691	-1.486	-1.718	0.991
		2	NO	-4.724	-7.290	-10.932	0.168
Black carbon	1880-2003	0	NO	0.056	0.462	1.323	2.94
		0	YES	-1.945	-2.030	-0.892	0.692
		1	NO	-2.795	-2.440	-2.731	0.527
		2	NO	-4.696	-7.272	-11.053	0.059
Staratosphetic aerosols	1880-2003	0	NO	-4.743	-4.183	-5.330	0.212
StratospherH$_2$O	1880-2003	0	NO	-2.862	-2.703	3.272	3.04
		0	YES	-3.896	-4.908	-1.843	0.762
		1	NO	-3.021	-8.446	-1.954	1.61
		2	NO	-4.129	-8.872	-16.445	0.287
Ocean heat content	1952-1996	0	NO	-1.200	-1.307	-0.824	1.3
		0	YES	-4.232	-2.746	-2.462	0.107
		1	NO	-5.621	-2.471	-4.834	0.13