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Distributing the Global Carbon Budget with climate justice criteria

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Abstract In this paper, a model for the distribution of the Global Carbon Budget between the countries of the world is presented. The model is based on the criteria of equity while also taking into account the different historical responsibilities. The Global Carbon Budget corresponds to the quantity of carbon dioxide emissions that can still be released into the atmosphere while maintaining the increase in the average earth surface temperature below 2 °C, and it is therefore compatible with the long-term objective defined in the Paris Agreement. The results of applying the model are shown both for the 15 emitters that currently top the ranking for world emissions as well as for the other countries, which are grouped together in three main groups: Other African, Other Latin American and Caribbean, and the Rest of the World. Mitigation curves compatible with the carbon budget allocated to the different countries are presented. When comparing each emitter's historical emissions for the period 1971–2010 with the proposed distribution for the period 2011–2050 obtained using the model, it can be seen that developed countries must face the future with a greatly reduced carbon budget, whereas developing countries can make use of a carbon budget that is higher than their cumulative historical emissions. Finally, there is a discussion about how a model with these characteristics could be useful when implementing the Paris Agreement.

1 Introduction

The Paris Agreement, that came from the COP21, and that entered into force in November 2016, is the new legal international framework in the fight against climate change (United Nations 2015). Referring to the issue of mitigation, the agreement establishes a long-term goal

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(article 2.a): "… keeping the increase in the global average temperature to well below 2 °C above pre-industrial levels," a methodology based on the "Nationally Determined Contributions" (NDCs) and a periodic assessment of the level of accomplishment of this goal, named "global balance" or "global stocktake."

On the way towards COP21, countries were asked to send their mitigation intentions: "Intended Nationally Determined Contributions" (INDCs), to the UNFCCC (UNFCCC 2013; UNFCCC 2014). This permitted an analysis of these INDCs to assess if humankind is on the path to achieving the previously mention 2 °C objective, or not. All the studies (UNFCCC 2015b; UNFCCC 2016; UNEP 2015; UNEP 2016) agree that these INDCs are far away from the goal and that a considerable increase in the level of ambition of the countries' contributions is needed. In fact, the package of decisions that accompany the Paris Agreement (UNFCCC 2015a) highlights the concern about this gap. This gap can be explained if we consider that currently every country elaborates its contribution to the global reduction of emissions in its own way, partly because there is no consensus about the criteria and the model that can be used in order to distribute between countries the burden of emission reductions.

In this paper, a new model, based on climate justice criteria, is presented. This model can be used to help countries to elaborate an effective contribution to reach the global objective and also as a reference to assess the level of ambition of each countries' contributions. In the literature, other models that try to apply equity, as a central pillar of climate justice, can be found. In order to contextualize our proposal, a short review about equity and climate change is provided in the next section.

The model presented takes as a starting point two of the global references which are being used to evaluate the degree of approximation to the objective of 2 °C: the Global Carbon Budget (GCB) and the RCP2.6 scenario. As we explain below, they are separate concepts but interrelated with each other.

The GCB can be defined as the total amount of CO_2 emissions that lead to a specific increase in the global mean temperature. The specialized literature (Matthews et al. 2009; Zickfeld et al. 2012; Frölicher et al. 2013; Herrington and Zickfeld 2014) and especially the last IPCC report (IPCC 2014), establish very clearly that cumulative CO_2 emissions are the main agent responsible for global warming and show the proportional relationship between cumulative CO_2 emissions and the long-term increase in temperature. This means that the increase in temperature does not depend on the level of emissions in one specific target year but on the cumulative emissions released up until this year. This is the idea that underlies the concept of the GCB.

Of all the Representative Concentration Pathways (RCP) published in the AR5, the RCP2.6 scenario is the only one which is compatible with the goal of not exceeding the 2 °C temperature rise expressed in the Paris Agreement (article 2.a) (van Vuuren et al. 2011). The cumulative CO_2 emissions of the RCP2.6, calculated from 1870 to 2100, amount to 2900 $GtCO_2$. Of these emissions, 1900 $GtCO_2$ were already released before 2011, leaving approximately 1000 $GtCO_2$ to emit from 2011 onwards (IPCC 2014). This means that if humankind wants to achieve the 2 °C goal, the amount of CO_2 emissions that can still be released into the atmosphere must be restricted to 1000 $GtCO_2$. We refer to this amount as the GCB, which is equal to the integral area of the CO_2 emission mitigation scenario RCP2.6, between 2011 and 2100.

The aim of this paper is to present a methodology, based on climate justice criteria, to distribute this GCB (approximately 1000 $GtCO_2$ to emit from 2011 onwards) fairly between all

the countries. In other words, we present a method to calculate the cumulative emissions, or carbon budget (CB), that each country can release into the atmosphere from now on, in order to achieve the global objective that the rise in temperature will not exceed 2 °C. We also show possible emission mitigation pathways that are compatible with the allocated CB.

It is worth noting that since COP21, the international community has been working to implement the Paris Agreement. Specifically, the "Ad Hoc Working Group on the Paris Agreement" (APA) has a mandate to elaborate the necessary guidelines, procedures, and modalities which, among other things, will define the format and contents of the new NDCs that countries must present by 2020. Now, could be a good time to actively start considering frameworks and models that, in the end, can help to achieve an implementation of the Paris Agreement in the light of equity and climate justice.

In accordance with this general objective, the layout of this paper is as follows: Section 2 is devoted to equity and climate justice; in Section 3, we present the methodology: the Model of Climate Justice (MCJ) per capita, the set of data used, and the group of countries studied in this paper. In Section 4, we present the results of the distribution of the GCB obtained using the MCJ, and we discuss the role it could play within the framework of the Paris Agreement. In Section 5, we present the main conclusions.

2 Equity and climate change

Equity, as a pillar of climate justice, is a concept deeply rooted in the UNFCCC. The article 3.1 of its founding treaty starts by saying:

> The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof. (United Nations 1992).

Mattoo and Subramanian 2012, in an in-depth review about equity and climate change highlight among others, four principles for applying equity to the share of future emission allowances. These principles are equal emissions per capita (based on the idea that all the inhabitants of the planet are equal), historical responsibility (based on the idea that it is necessary to compensate for the harm caused to others), ability to pay (based on distributive justice notions), and preservation of the right to development (also based on distributive justice).

With reference to historical responsibility, the year from which historical responsibility begins to be taken into account has been a widely discussed issue (Müller et al. 2009; Füssel 2010; Caney 2009; Jacoby et al. 2009). Considering that at the beginning of the industrial revolution, there was little awareness that GHG emissions could alter the climatic system (one exception was Arrhenius' paper (Arrhenius 1896)); the discussion focuses on whether or not liability can be demanded for any harm caused at a time when it was unknown that that action was causing harm. In this sense, some authors state that the progress of developed countries has been closely related to the increase of their emissions; and because of that, when establishing systems that compare them with developing countries, the historical emissions must be counted from the beginning of the industrial revolution (Cao 2008; Kanitkar et al. 2013). On the other hand, there are authors who maintain that the historical responsibility can

only be demanded from the moment when the international community became aware of the problem of GHG emissions.

Considering this point further, it is necessary to establish from what moment it can be considered that the international community became aware of the problem of climate change. With regard to possible dates, most authors usually choose the beginnings of the 1990s when the negotiations that led to the founding treaty of the UNFCCC began (Ott et al. 2004; Parikh and Parikh 2009; Baer et al. 2008; Gignac and Matthews 2015; German Advisory Council on Global Change (Wbgu) 2009). But some authors also place it at the beginning of the 1970s when the United Nations Conference on the Human Environment was celebrated and the United Nations Environment Program was created (Kanitkar et al. 2010). Both arguments are reasonable, but in our view, the first can definitely not be questioned. More specifically, we chose 1992, the year in what the founding text of the UNFCCC was approved, as the year from which we started taking into account the historical responsibility.

When specifying the principles of equity in models that give quantitative results, two groups of models can be clearly identified. On the one hand, those that distribute the burden of emission reduction and on the other those that assign future emission quotas. It is important to keep in mind, that it is not the same to distribute the necessary emission reduction to achieve a certain objective of stabilization of the temperature than to distribute quotas or levels of emissions between the different countries.

Within the first group of models, we can find The Greenhouse Development Rights framework (Baer et al. 2008; Cao 2008; Holz et al. 2017) that distributes the burdens of emission reductions and adaptation to climate change according to an assessment of capacity (assessed as income not demanded by the necessities of daily life, which can be an indicator of the ability to pay) and responsibility (historical contribution to the climate problem).

Within the second group, we can find models that distribute the GCB like those proposed by the Raupach et al. 2014; Kanitkar et al. 2013; Giménez-Gómez et al. 2016; Gignac and Matthews 2015; and German Advisory Council on Global Change (Wbgu) 2009. All of them in their different ways take into account the concept of equity. The Raupach model, allows for a balance between equal emissions per capita and "inertia" which takes into account the current distribution of emissions between countries. The Kanitkar and Gignac models are based on equity and also include an evaluation of the historical responsibility when distributing the GCB. The former calculates the historical responsibility in a very strict way, starting from the very beginning of the industrial revolution whereas the later calculates it from 1990.

The model we present incorporates, in a different way, two principles in order to operationalize equity: equal emissions per capita and the historical responsibility.

3 Methodology and data

3.1 The Model of Climate Justice per capita

The Model of Climate Justice per capita (MCJ) that we are presenting has been developed with the aim of distributing the GCB between all the countries. The MCJ allows us to calculate the CB available to each country, according to climate justice criteria. These criteria can be summarized as follows: the model treats all inhabitants of the planet equally (i.e., equal

number of emissions per capita) but takes into account the different historical responsibilities of each country, insofar as emissions are concerned.

Firstly, with regard to the issue of historical responsibility, we have calculated the figures from 1992 onwards. As of 1992, when the text of the UNFCCC was approved, no country could argue that it was unaware of the serious problems that humankind was facing. Thus, we have taken 1992 as the year in which the historical responsibilities that we wish to compensate for should start to be considered. Since 2012 is the last year for which we currently have data, the mathematical application of the model begins after this date: in 2013. We base our historical responsibility calculations for 2013 on the data from the 21-year compensation period 1992–2012. For every year after 2013, we use the data from the 21 years that immediately precede it.

In order to illustrate how the year from which we start considering the historical responsibility can greatly affect the resulting distribution of the CB obtained with the MCJ, in Annex 2 of the complementary on-line material, we present the results obtained taking 1970 as the year from which we assess the historical responsibility.

The calculation of the emission distribution for year (*yr*) is explained in detail in the Annex 1 included in the electronic supplementary material. Throughout this paper, following the standard term used in the UNFCCC, we use the term Party to refer both individual countries and a group of countries (e.g., the EU 28). We can summarize the methodology in the following four steps:

1. We calculated the historical emissions per capita for each of the Parties (*pt*) prior to the year being calculated (*yr*). This is done by calculating the quotient between the total emissions over the historical period of time and the sum of the population during the same period.

For each year of calculation, beginning in 2013, we considered the data from the previous 21 years as the historical period of time. In Table 1 we show, as an example, the historical emissions per capita to be applied in the first year of calculation, 2013.

2. Then, the historical responsibility per capita, ($\Delta_{pt,\ yr}$) is calculated for each country using the difference between the historical emissions per person for each Party and the global historical emissions per capita during the same time period. The historical responsibility in the first year of calculation is presented, as an example, in Table 1. The way we calculate the historical responsibility is slightly different from that used by Gignac and Matthews 2015 and proposed by Neumayer 2000b, but the final results are very similar.
3. Next, we started to calculate the emissions that can be allocated in the future. Firstly, we extracted the total global emissions for the year (*yr*) being calculated from the mitigation curve of scenario RCP2.6 (available on the Potsdam Institute for Climate Impact Research database). This value, together with data that projects the world population increase, is used to calculate the permitted world emission per capita at this year.
4. Secondly, the possible emissions that would correspond to each country for the year of calculation are determined. To each inhabitant of each country, we assign the world emissions per capita calculated in the third step corrected for their historical responsibility per capita. Then, we calculate the future emissions of each Party at the year (*yr*), by

Table 1 Historical emissions per capita and historical responsibility per capita at year 2013 for each of the 15 countries in the "TOP-15" and for the three groups of Others: (OA) Other African countries, (OLAC) Other Latin American and Caribbean countries, and (RW) the Rest of the World

	Historical emissions per capita (tCO2)	Historical responsibility per capita (tCO2)
World	4.3	0.0
China	4.0	− 0.3
USA	19.1	14.8
EU 28	8.1	3.8
India	1.1	− 3.2
Russia	11.0	6.8
Japan	9.5	5.2
Iran	6.0	1.8
Korea, Rep.	10.0	5.7
Canada	16.6	12.3
Saudi Arabia	12.9	8.7
South Africa	6.9	2.7
Mexico	3.6	− 0.6
Indonesia	1.5	− 2.8
Brazil	1.8	− 2.4
Australia	17.5	13.2
TOP-15	5.3	1.0
OA	0.7	− 3.6
OLAC	2.5	− 1.7
RW	3.5	− 0.8
Others	2.3	− 2.0

multiplying its corresponding emissions per capita by its population according to the projection of population data for this Party.

Finally, we calculate the total emissions allowed for each Party from 2013 to 2100, i.e., the CB that the model allocates to each country, by adding up the yearly emissions that correspond to each country over this period.

It is important to mention that while the simulation calculates year-to-year emissions for each of the countries studied, these annual emissions themselves do not constitute possible mitigation paths for these countries. This is because, by strictly applying the criterion of climate justice per capita explained above from the first year of calculation, some mathematical discontinuities emerge within the first year of calculation, which in practice are meaningless and impossible to apply on a practical level. This is not a problem because the objective of this model is to calculate the CB of each Party by applying the criteria of climate justice per capita and not to calculate mitigation pathways. Later, once the CB has been determined, we can design the mitigation pathway for each country (see Section 4).

3.2 Input data, countries, and groups of countries studied

The model that we present has been built upon two sets of data: emissions and population data.

The CO_2 emissions data from 1970 to 2012 have been obtained from the CAIT Climate Data Explorer (World Resources Institute 2015). In this study, we have not included emissions from land-use, land-use change, and forestry (LULUCF).

The projected population data is taken from the UN World Population Prospects: The 2015 Revision Population Database (UNDESA Population Division 2015), on its medium variant population growth scenario. The model runs on a moving population basis where population varies yearly, based on the projections provided by the abovementioned database for each country until 2100.

An initial analysis of the emission data allows us to see that the 15 Parties that head the ranking of CO_2 emissions (the "TOP-15") contribute 79% of total global CO_2 emissions. Although we have calculated the allocation of carbon budget for every country, in this first paper where we present the Model of Climate Justice per capita, we adopt the criterion of showing the results only for these 15 state-parties: China, USA, EU 28, India, Russia, Japan, Iran, Rep. Korea, Canada, Saudi Arabia, South Africa, Mexico, Indonesia, Brazil, and Australia. This criterion allows us to show a country from every continent.

The rest of the countries, responsible for 21% of global emissions, have been grouped into three subsets according to a geographical criterion: "Other African countries" (OA), "Other Latin American and Caribbean countries" (OLAC), and the "Rest of the World" (RW). We understand OA as all the countries of the African continent with the exception of South Africa, which is already part of the "TOP-15" group. Similarly, the OLAC is made up of all the countries of Latin America and the Caribbean excluding Mexico and Brazil. Having separated these two areas from the "Others" group, we are left with a very heterogeneous group of countries in Europe, Asia, and Oceania, which we have called "Rest of the World" (RW).

It is necessary to point out that the results of the "Others" groups are calculated by adding up the emissions that our model allocates to the different countries within these groups, and which are calculated individually for every country (with their own population). We are aware that the groups of "Others" include countries that are very different from each other. These groups are only included for the sake of completeness, and they are presented as three different groups only to give a picture of the geographical differences between them. A detailed study of the countries that make up the "Others" groups is one of the goals that we have set for the immediate future.

4 Results and discussion

By applying the MCJ model, we can determine the CB for each of the Parties (each of the "TOP-15" and the three aggregated groups of "Others"), when we apply the criterion of climate justice per capita that we previously explained. These results, the cumulative emissions or "possible or available CB", in $GtCO_2$, are shown in the first column of Table 2.

The final column of Table 2 shows the distribution of the GCB (in percentages) obtained using only the criteria of equal emissions per capita, without taking into account the historical responsibility. This enables us to see how the method we have used to incorporate the historical responsibility serves to finely-tune the distribution based only on equal emissions per capita. It can be seen that the country which most benefits from taking the historical responsibility into account is India, whereas the worst off is the USA. The group of Other African countries also benefits greatly.

As we commented previously, the results we are presenting have been obtained using the medium variant UN-DESA scenario for the projection of population evolution. We also used the high and low variant scenarios (UNDESA Population Division 2017) and found that the changes in the distribution of the GCB do not reach 1%. This is because in these scenarios, the

Table 2 In the first column, carbon budgets, in $GtCO_2$, for each of the 15 countries in the "TOP-15" and for the three groups of Others, obtained by applying the MCJ. In the second column, the CB expressed as a percentage of the World GCB. In the last column, the share of the same GCB obtained without considering the historical responsibility

	MCJ		Equal emissions per capita
	CB 2011–2100 (GtCO2)	CB 2011–2100 (%)	CB 2011–2100 (%)
World	1057	100	100
China	183	17.30	17.63
USA	29	2.73	4.93
EU 28	58	5.50	6.43
India	202	19.09	17.21
Russia	15	1.39	1.90
Japan	13	1.26	1.60
Iran	11	1.01	1.10
Korea, Rep.	6	0.54	0.70
Canada	4	0.34	0.55
Saudi Arabia	4	0.40	0.52
South Africa	7	0.67	0.74
Mexico	19	1.76	1.72
Indonesia	39	3.67	3.34
Brazil	30	2.86	2.63
Australia	3	0.24	0.39
TOP-15	621	58.75	61.39
OA	202	19.08	17.17
OLAC	44	4.13	3.90
RW	191	18.04	17.55
Others	436	41.25	38.61

relative distribution of the population between countries does not change significantly. The results of the MCJ depend on the relative population of each country (compared to the world population) and not on the absolute figures for any given population. If we do not use any population projection and we assume that the population will remain constant from now on, the MCJ allocates a lower CB to those countries where higher population growth is expected, and vice versa (see annex 2 of the complementary on-line material).

It is also interesting to compare the distribution of historical emissions with the distribution obtained using the MCJ with the two components: equal emissions per capita and historical responsibility. By looking at the two pie charts of Fig. 1, we can compare the distribution of the accumulated historical emissions during the 40-year period 1971–2010, with the distribution that the MCJ model offers for the 40-year period 2011–2050. We choose these two periods of 40 years because the figures for the total world emissions are practically the same (around 850 $GtCO_2$), and this enables us to directly compare the percentages.

We can quickly see that the Parties with large populations and low levels of historical emissions—such as India, Indonesia, Brazil, and the Other African (OA) and Other Latin American and Caribbean (OLAC) countries—, come out clearly benefiting with respect to their historical emissions. On the other hand, those Parties with historical emission levels that are well above the world average—such as the USA, EU 28, and Canada, would face a future with a considerably reduced CB. It should be further stressed that these Parties are also the ones that already have the technological knowledge and a high level of development in order to cope immediately with this situation. They also have, according the UNFCCC and the Paris Agreement, the responsibility to take a leading role in the fight against climate change.

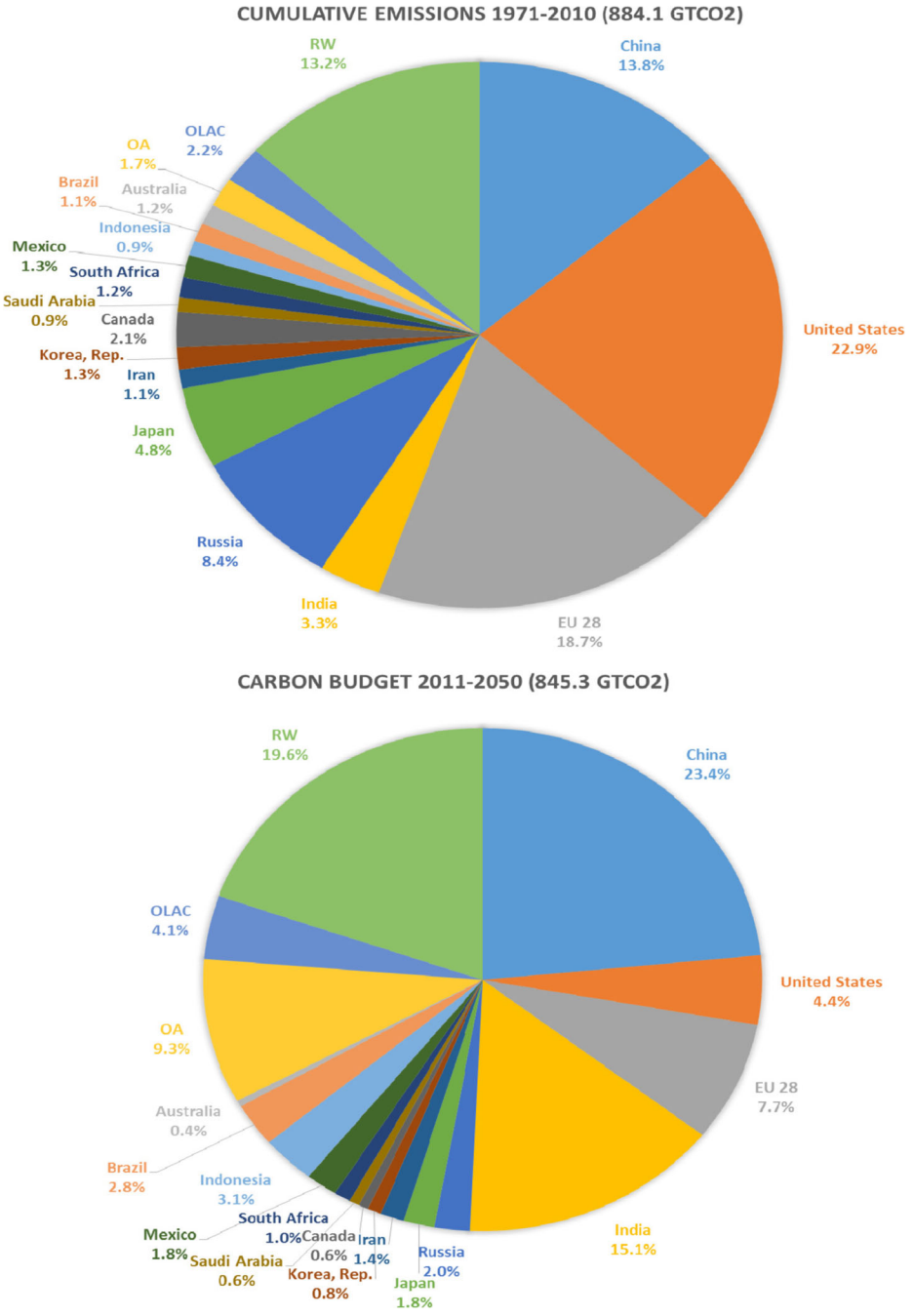

Fig. 1 The upper diagram, distribution of cumulative historical emissions for the 1971–2010 period. The lower diagram displays the proposed distribution that the MCJ model offers for the 2011–2050 period

Now we will present some of the possible mitigation pathways that strictly comply with the CB allocated to each country. These pathways which we call "Pathways According to

the Carbon Budget" (PACBs) allow the reader to have an idea about the percentage of emission reductions that some countries have to achieve in order to reach the 2 °C objective at a global level. Of course, in every case, the integral area defined by the PACB corresponds to the CB.

Gignac and Matthews 2015 have drawn lineal mitigation pathways for all the countries using the contraction and convergence framework proposed by Meyer 2000. All their mitigation pathways converge to the same number of emissions per capita between the countries. The difference between their model and ours is that the mitigation pathways that we present are designed with the objective of achieving the CB assigned to each one of the countries according to our Model of Climate Justice per capita, whereas Gignac and Matthews 2015 have calculated the CB the other way round by starting with the mitigation pathways that they have designed. Because of that, although both models are based on a very similar estimation of the historical responsibility, there is an important difference between how the CB is shared out.

We will start by presenting the mitigation pathways of three Parties. The first is the EU 28, whose historical responsibility is far above the world average. The second is China which, although it is now the number one CO_2 emitter, has a relatively reduced historical responsibility compared with other top emitters. The third is India, whose historical responsibility is below the world average. These pathways have been calculated using the same curves as Raupach et al. 2014:

$$f(t) = f_0(1 + (r + m)t)\exp(-mt)$$

Figure 2a shows the EU 28 has to make a drastic reduction in emissions in order to achieve zero emissions by approximately 2060. According to our model, in 2030, the EU-28 emissions must be 69% lower than in 1990. If we look at the first EU 28 contribution to the Paris Agreement (NDC) and use the MCJ as reference, we can see that the EU 28 contribution to reduce emissions in 2030 to 40% lower than the emissions in 1990 is far removed from the necessary level of ambition. As well as this, when socio-economic development tendencies, the increase in energy consumption and the development of renewable energy in the EU 28, are analyzed, it can be seen that although the EU 28 is on the correct path to achieve its 2020 objectives, it must increase its efforts in order to reduce its energy consumption and increase the contribution made by renewable energies, if it is to achieve the commitments made in the EU-28 NDC for 2030 (Liobikienė and Butkus 2017).

Referring to China, Fig. 2b shows one of the possible mitigation pathways compatible with its CB. This country, which is currently the number one emitter, should soon reach its emission peak and then start a drastic reduction in its emissions. Elzen et al. 2016 have studied the evolution of China's emissions by using its NDC as a base and taking into account its energy policy. This study situates China far away from the mitigation pathway of Fig. 2b.

Figure 2c shows one of the possible mitigation pathways using India's CB. When compared to the other figures, it shows that India can delay its emissions peak and then start its decarbonization process at a slower rhythm. As we previously mention, the MCJ allocates a large CB to India because it is a country with a very high population and a historical responsibility well below the world average. India, a country with 240 million inhabitants who still do not have an electricity supply (International Energy Agency 2015; Srivastava and Rehman 2006) and with 40% of children under the age of 5 suffering from under nutrition

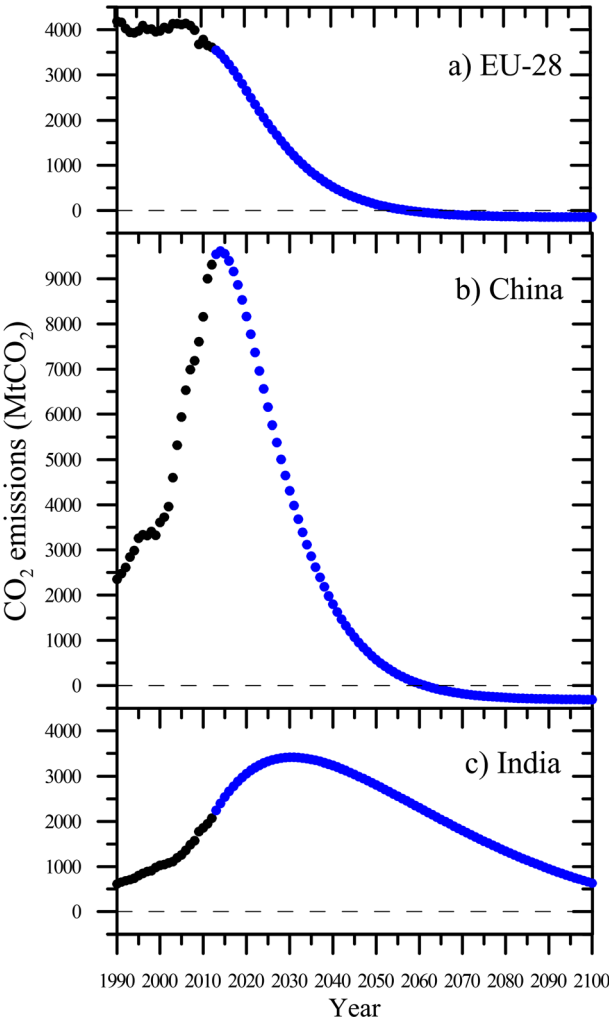

Fig. 2 Historical data (black dots) and mitigation pathway designed according the allocated CB (blue dots). **a** European Union. **b** China. **c** India

(Shankar et al. 2017), could justify an increase in its emissions in the medium term, in order to achieve sustainable development objectives such as providing its population with basic infrastructures and covering their nutritional needs.

Finally, Fig. 3 shows the mitigation pathways until 2050 for the TOP-15 and the three "Other" groups. Countries such as the USA, EU-28, Russia, Japan, South Korea, Canada, and Australia have to immediately start a drastic reduction in their emission levels; whereas others such as China, India, Iran, Saudi Arabia, South Africa, Mexico, Indonesia, and Brazil can still increase their emissions and delay their peak. This figure makes it evident that, although the mitigation efforts that the most developed countries have to apply are huge and a great challenge in themselves, these efforts are clearly necessary in order to progress towards a global scenario compatible with the 2 °C goal and to keep the carbon space for developing countries in order to respect their social and economic development opportunities.

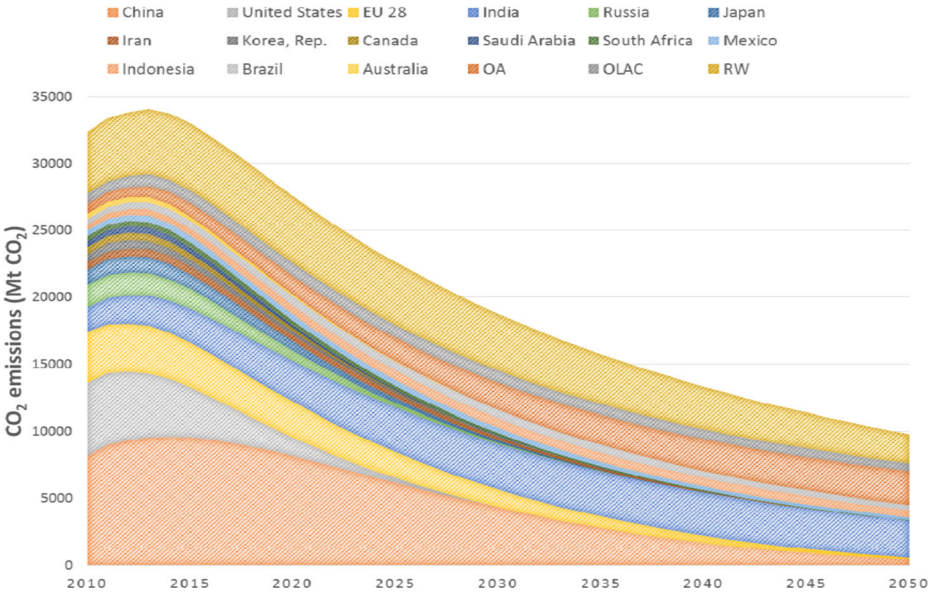

Fig. 3 Aggregated mitigation pathways for the TOP-15 countries studied in this paper and the other three groups of countries: Other African (OA), Other Latin American and Caribbean (OLAC), and the Rest of the World (RW)

The results of the GCB distribution that we present could seem very difficult to implement. But we would like to point out that including a GCB distribution model such as this could be used as a reference when implementing different aspects of the Paris Agreement.

– According to the Paris Agreement itself, equity and the differentiation of responsibilities between countries are principals that must be implemented within in the agreement:

  This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

– In article 4.1, the Paris Agreement also states that equity must be taken into account when countries elaborate their NDCs. A GCB distribution such as the one we present could be used as a reference. Countries could declare what part of their CB they intend to use in each one of their NDCs.
– According to article 14, the "Global Stocktake" must be elaborated following the principal of equity. With this in mind, the use of a reference point such as the one we present could help to evaluate the level of ambition of each one of the NDCs and give the countries an objective framework in order to improve climatic action at a global level.
– In article 6, the Paris Agreement contemplates the creation of systems of voluntary cooperation between the different Parties, which would help them to achieve the mitigation objectives and contribute towards sustainable development. Some authors (Stua 2017; Keohane et al. 2015) see article 6 and the establishment of alliances between Parties as a way that will allow ambitious mitigation objectives to be achieved. The basic idea is that a country would be able to use its CB as asset for the country. Developing

countries could take a part of their CB and exchange it with other countries for investment in sustainable technologies.

– Any implementation should be done taking into account the articles 4.4. and 4.1; respectively:

(4.4) Developed country Parties should continue taking the lead by undertaking economy-wide absolute emission reduction targets. Developing country Parties should continue enhancing their mitigation efforts, and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances.

(4.1) In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties.

5 Conclusions

The Model for Climate Justice, which is presented in this article, is based on the principle of equal number of emissions per capita and takes into account the historical responsibility of each of the countries, starting from 1992, the year in which the text of UNFCCC was approved. The model allows us to calculate the CB related to the combustion of fossil fuels that would correspond to each country when these said criteria are taken into consideration.

The model has been designed so that the GCB that is obtained from adding up the CBs allocated to each country coincides in value with the GCB compatible with the 2 °C objective: 1000 $GtCO_2$ for the period 2011–2100 (IPCC 2013). In this paper, we present the model's results for the 15 countries that top the ranking for world emissions and for each of the three "Other" combinations of countries: Other African, Other Latin American and Caribbean, and the Rest of the World.

On comparing the historical distribution of emissions with the distribution obtained using the MCJ, it can be seen that countries such as the USA, the European Union, Russia, Japan, Canada, or Australia, must face the future with a greatly reduced carbon budget. On the other hand, countries such as India, Mexico, Indonesia, Brazil, or the OA and OLAC groups can make use of a carbon budget that is higher than their historical emissions. This is coherent with the previously cited articles of the Paris Agreement, but provides a quantifiable reference for their implementation.

We have also presented mitigation pathways that comply with the CB allocated to some countries. It is demonstrated that developed countries, using the EU 28 as an example, must face a drastic reduction in their emissions, whereas developing countries, represented by the example of India, could delay their peak emissions and then later initiate a gradual reduction of emissions.

Finally, we discuss how the MCJ could help to implement the principals of equity and differentiated responsibilities within the Paris Agreement framework and be used when countries elaborate their NDCs, when the Global Stocktake is elaborated or in order to build systems of collaboration between groups of countries.

The use of a GCB distribution such as the one we present, even if it is only used as a reference point, could help the developing countries to justify an increase in their emissions in

order to establish the basic infrastructures necessary for their development. The agendas of development and climate control must be implemented together. The model also serves to demonstrate how developed countries can neither ignore their responsibility nor further delay the implementation of truly ambitious mitigation policies. Only a clear and radical commitment by the developed countries in the mitigation process could achieve complete worldwide decarbonization.

The MCJ could be a way to attend to the demands expressed by the prime minister of India during the Paris summit: Justice demands that carbon curbs should not limit poorer nations' ability to grow (Modi 2015).

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