Perspectives on IPCC Special Report "Global Warming of 1.5℃"

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1. Origin of the Special Report 1.5℃

On October 8, 2018, IPCC (The Intergovernmental Panel on Climate Change) released its Special Report "Global Warming of 1.5℃" (SR1.5) as a response to the invitation for IPCC "... to provide a Special Report in 2018 on the impacts of global warming of 1.5℃ above pre-industrial levels and related global greenhouse gas emission pathways" contained in the Decision of the 21st Conference of Parties of the United Nations Framework Convention on Climate Change (COP) held in Paris in 2015. The IPCC accepted this invitation in April the next year, and its first lead authors' meeting was held in March 2017. SR1.5 was completed within 2 years. First of all, the author of this short paper truly appreciates all coordinating lead authors, lead authors, reviewers and all the persons involved in writing process for their devoted efforts in completing the report in such a short period.

2. Summary of SR1.5

2.1. Structure of SR1.5

SR1.5 consists of a Summary for Policymakers (SPM) and 5 chapters. Here the author focuses on the SPM, while touching upon 5 chapters as necessary. The titles of 5 chapters are as follows;

Chapter 1 Framing and Context
Chapter 2 Mitigation pathways compatible with 1.5℃ in the context of sustainable development
Chapter 3 Impacts of 1.5℃ global warming on natural and human systems
Chapter 4 Strengthening and implementing the global response
Chapter 5 Sustainable Development, Poverty Eradication and Reducing Inequalities

2.2. Outline of SPM

The SPM consists of 4 sections. Sections A, B, C and D each corresponding to a summary of chapters 1, 3, 2, and 4-5.

Section A. Understanding Global Warming of 1.5℃

This section mainly deals with climate science. The main messages are that the temperature has increased by around 1.0℃ since 1850-1900 period and that without further mitigation measures, temperature will likely to increase by 1.5℃ between 2030 and 2052.

So far the base year of temperature increase was set at the pre-industrialization era without any clear definition of what year it is. In SR1.5, the base year is defined as 1850-1900 period. Also, GMST (Global Mean Surface Temperature) is defined as the estimated global average of near-surface air temperature over land and the surface temperature over ice-free ocean regions. When estimating changes in GMST, however, near-surface air temperature over both land and oceans (Surface Air Temperature, SAT) are also used.

Section B. Projected Climate Change, Potential Impacts and Associated Risks

This section addresses "the impacts of global warming of 1.5℃ above the pre-industrial levels" as requested by the COP decision. The conclusion is quite simple, i.e. impacts and risks are smaller in a 1.5℃ increase case than in a 2℃ increase case. For example, the rise in sea level the year 2100 (since 1986-2005) in a 1.5℃ case will be 26-77 cm, and 10

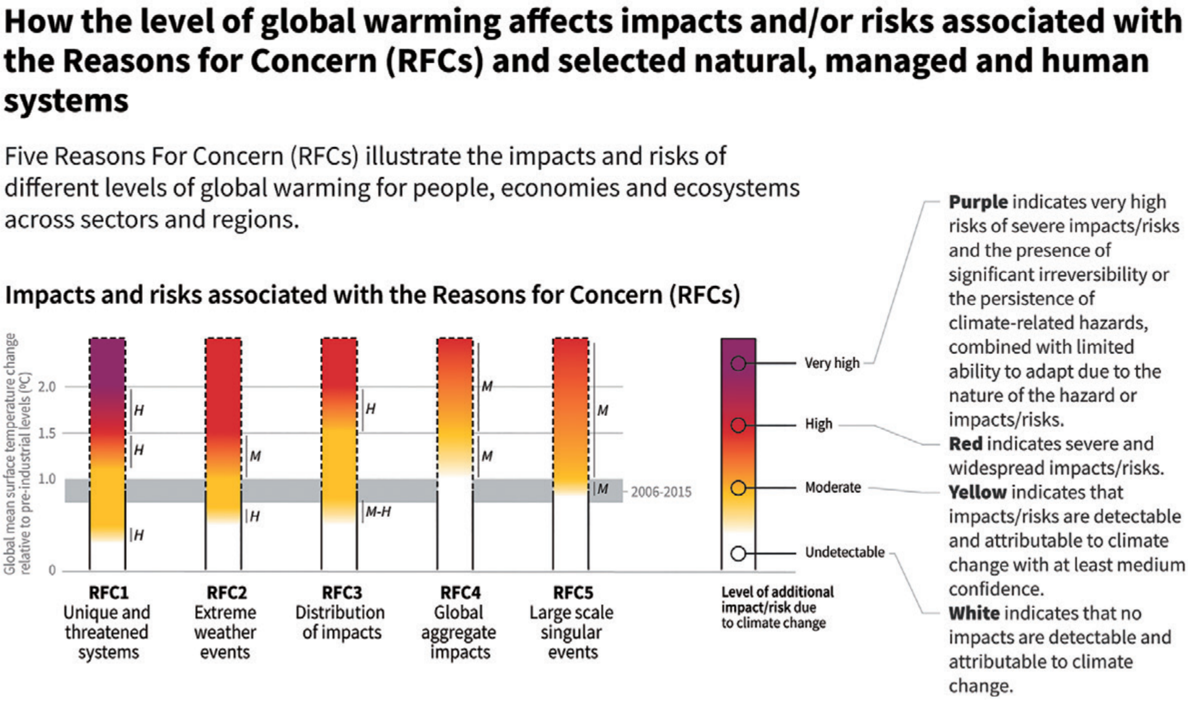

Figure 1 : Five Reasons For Concern (RFC)
Source: IPCC SR1.5 Figure SPM.2
Due to space limitations, only RFC Figure in SR1.5 has been shown here.

cm lower than in a 2℃ case, ice-free ocean in the Arctic sea during summer will occur once in every 100 years in a 1.5℃ case whereas it will occur once every 10 years in a 2℃ warmer world, and 70-90% of the coral reefs will disappear in a 1.5℃ case but more than 99% in a 2℃ case.

Besides, there is another important point that should not be ignored. In SR1.5, Reasons for Concerns (RFCs), that was shown in 5th Assessment Report (AR5), is also presented (Refer to Figure 1 above).

When we compare the above figure with that in AR5 (not shown due to space constraint), there is an important difference especially in RFC5, namely large-scale singular events. In chapter 3 of SR1.5, there is a description that "moderate risk is now located at 1℃ of global warming and high risk is located at 2.5℃ of global warming, as opposed to at 1.6℃ (moderate risk) and around 4℃ (high risk) in AR5, because of new observations and models of the West Antarctic ice sheet". As RCF5 is considered as imposing large scale and irreversible global impact, and as an increase in the global sea level by 6-9 m is expected if either the Greenland or West Antarctic ice sheet collapses, such information should be included in the SPM.

Section C. Emission Pathways and System Transitions Consistent with 1.5℃ Global Warming

This section includes responses to the request by the COP to provide global greenhouse gas emission pathways consistent with a 1.5℃ warmer world. There are 2 key observations that are discussed. Figure 2 represents the emission pathways modeled to maintain the temperature increase at 1.5℃ or less by the year 2100. Please focus on the global total net CO_2 emissions (the main panel). Two scenarios are shown: one pathway has no or limited overshoot (less than 0.1℃), while the other pathway has a higher overshoot. At the bottom of the figure, timing of net zero CO_2 line is illustrated. It implies that to achieve 1.5℃ goal, the net CO_2 emissions should be reduced by about 45% from 2010 levels by year 2030 and become zero around 2045-2060 and thereafter emissions should be negative. Just think of current pledges towards 2030 (NDCs) under which the global 2030 emissions are expected to increase (not decrease) from 2010, it is rather clear that 1.5℃ will be extremely hard to achieve.

Figure 3 (below) shows 4 different socio-economic development models (P1-P4) and emission pathways toward achieving the 1.5℃ goal. P1 illustrates a low emission demand society (LED), P2; a sustainable development society, P3; middle of the road, P4; fossil-fueled development society. Business as usual, emissions become larger from P1 to P4. The green lines for P1-P4 illustrate the net CO_2 emission pathways to achieve the 1.5℃ goal in the respective socio-economic society. The grey area represents the CO_2 emissions from fossil fuel use and industrial processes. The brown area represents CO_2 absorption by AFOLU (Agriculture, Forestry and Other Land Use) while the yellow area represents BECCS (bio-energy with carbon capture and storage). BECCS is considered to be a negative emission technology, whereas AFOLU could be negative or positive. As illustrated in Figure 3, if we follow the P4 model, we have to rely upon massive negative emissions by BECCS to achieve the 1.5℃ goal. On the other hand, if we follow the P1 model, it may be possible to achieve the goal with small nega-

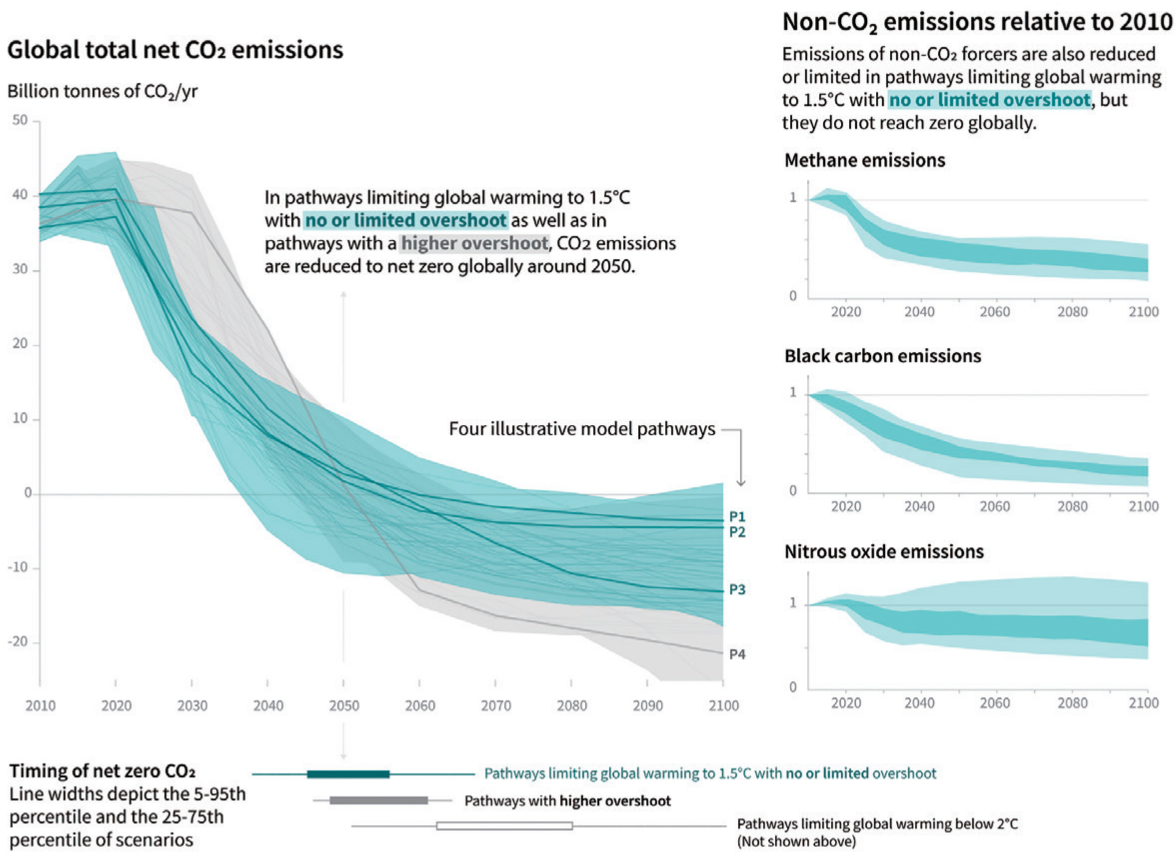

Figure 2 : Global emissions pathways consistent with 1.5℃ warmer world
Source: IPCC SR1.5 Figure SPM.3a

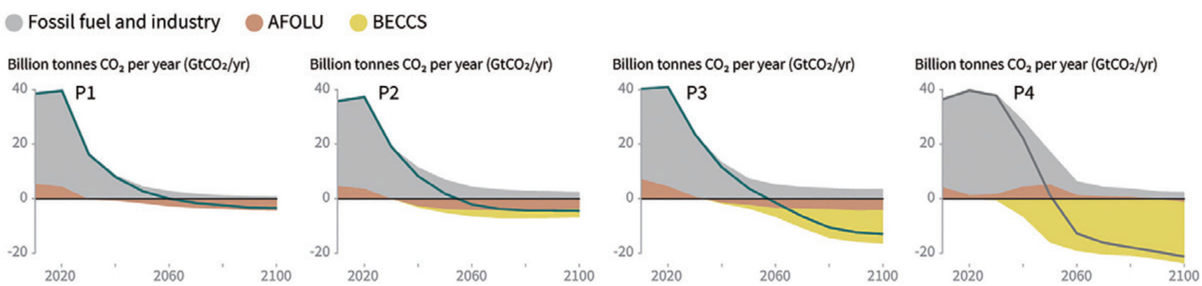

Figure 3 : Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways
Source: IPCC SR1.5 Figure SPM.3b

tive emissions by AFOLU. Thus, what kind of socio-economic society we should aim at is the key in our choice of a development model.

Section D. Strengthening the Global Response in the Context of Sustainable Development and Efforts to Eradicate Poverty

The most important message here is that current pledges, even if fully implemented, are never enough to keep temperature increase below 1.5℃. In other words, it is almost impossible to achieve the 1.5℃ goal unless each party drastically strengthen their pledges toward 2030.

This section summarizes chapters 4 and 5, which contain several statements with major implications for the implementation of climate policies, such as "whatever its potential long-term benefits, a transition to a 1.5℃ world may suffer from a lack of broad political and public support, if it exacerbates existing short-term economic and social tensions, including unemployment, … competitiveness issues …". Regrettably, this sentence does not appear in the SPM.

SR1.5 is the first IPCC report that has directly addressed the relationships between climate change and other Sustainable Development Goals (SDGs). Since literatures are quite limited and the scope is broad, the report was short of success at this point. Though SDGs have no priority among 17 goals, it is impossible for policymakers to pursue all those goals to the same extent. Policymakers may be indecisive to what extent they should put limited resources to climate change mitigation.

3. Evaluation of SR1.5

The efforts of the authors in completing the assessment report through extensive literature review within a short period in response to the COP invitation are commendable. SR1.5 surely would be referred to in future as one of the most reliable reports on climate change policy-makings. However, there are a few issues that lack in the report (such as mitigation cost) or that should be stressed a little bit more (such as uncertainty). The following are the author's personal comments on these issues.

3.1. Lack of information of economic cost

The SR1.5 report analyzed and showed in detail on how negative impacts and losses could be minimized if we were to succeed in limiting temperature increase at 1.5℃ instead of 2℃. From the report, it is evident that we should aim at 1.5℃, assuming all other factors are the same. For policymakers, it is impossible to make decision, however, without knowing economic cost (GDP loss or consumption loss). The report is silent on this critical point. If differences of mitigation costs were included, the report would be more *policy relevant*.

Remember that cost information was not included in COP's request to IPCC. Negotiators at COP in Paris may not have thought of the critical importance of cost information. Even in that case, however, SR1.5 should have included the cost information. SR1.5 cites the reason as "the literature on total mitigation cost of 1.5℃ mitigation pathways is limited and was not assessed". Even if the literature was limited, the cost information (more concretely, how many models calculated mitigation cost per GDP and the range of them) could have been included in the SPM. This may benefit the policymakers. In chapter 2 of SR1.5, there are 90 pathways for 1.5℃ (Table 2.1 of SR1.5). Readers may wonder how many among them have mitigation costs figures. In fact, several governments insisted in vain on the importance of including total mitigation costs in the report at the last-minute Governments Review meeting.

In this regard, the author would like to draw readers' attention to the fact that total mitigation costs are clearly mentioned in both the IPCC AR5 Synthesis and SPM of Working Group 3 reports. For example, the mitigation cost (reduction in consumption relative to baseline) in 2100 for 2℃ is estimated to be 4.8% (2.9-11.4%) of consumption, and reduction in the annual consumption growth rate is estimated to be 0.06%. This is based on the assumption that all parties adopt mitigation measures immediately and a global uniform carbon tax would be introduced, i.e. an idealistic assumption. In the AR5, additional costs in a non-idealistic assumption are also shown. One example is the case of lack of technologies. If CCS technology is not commercially available, then the mitigation cost will increase by 2.4 times as compared to a situation when this technology becomes available. All these descriptions indicate that the IPCC lead authors have considered the economic cost as one of the critical pieces of information for the IPCC report to be policy relevant.

SR1.5 SPM illustrates without showing numerical figures that marginal abatement cost (MAC) for 1.5℃ will be 3-4 times higher than that for 2℃. For policymakers, this information is meaningless. The MAC is the cost of abating an additional ton of CO_2 to reach the goals and is completely different from the concept of the total economic cost. The MAC for 1.5℃ is equivalent to the global carbon tax to achieve the 1.5℃ goal. In this sense, the MAC is a useful information for policymakers for their decision. Chapter 2 describes the MAC for 1.5℃. The MAC ranges for achieving the goal without overshoot are $135-6050 in 2030 and $690-30100 in 2100 (before discounting). While the ranges seem wide, including such information in the SPM may be useful for policymakers as opposed to having no numerical basis at all.

3.2. Efficient allocation of scarce resources and cost benefit analysis

SR1.5 SPM simply explains that cost-benefit analysis (CBA) for the 1.5℃ goal has not been conducted due to knowledge gaps. From chapters 1 and 2, however, it is evident that the lead authors are rather negative to apply CBA to climate change issues. The main reasons are as follows. First, it is difficult to estimate the non-market loss such as a monetary value of human life. Second, even if the total benefits exceed the total cost, these would not necessarily be the same in all the regions or countries. Third, we tend to rely on value judgement when applying the discount rates to calculate the current value of avoided damages (benefits). All of these are reasonable criticisms against CBA. William Nordhaus, the 2018 Nobel laureate in economics, while fully acknowledging those challenges, argues that rather than abandoning CBA, "natural and social scientists need to develop the research base for climate science and economics substantially to refine our estimates of the SCC"[1]. Here SCC (social cost of carbon) is similar to the monetary value of avoided climate damages. The author of this short article shares the same view.

CBA is not only a useful tool to decide the extent of introducing the mitigation measures, but also useful to allocate scarce resources efficiently among important global issues such as SDGs. Numerous urgent global and domestic issues exist in the world but resources to cope with them are scarce and limited. In some countries people suffer from poverty, inequality, and in other countries, budget deficit and unemployment will be the major concern in addition to climate change. For policymakers of all countries, CBA could be the most useful tool for the efficient allocation of global and domestic resources. CBA has many shortcomings as described above but receives too little attention. In view of the fact that climate change is not the sole issue in the world, we should pay a little bit more attention to the CBA and try to overcome the shortcomings of this tool.

3.3. Uncertainty (carbon budget etc.) and Risk Management

Given the near linear relationship between cumulative CO_2 emissions and temperature increase, the concept of carbon budget was introduced. Carbon budget is defined as the cumulative CO_2 emissions to limit the temperature at a certain level. In the AR5, the remaining carbon budget since 2011 to limit the temperature increase at 1.5℃ (66% probability) was estimated at 400 $GtCO_2$ (Table 2.2 in the synthesis report). Since emissions during the 2011-2017 period was estimated at 290 $GtCO_2$, the remaining budget should have been 110 $GtCO_2$. According to the SPM of the SR1.5, the remaining carbon budget is estimated at 420 $GtCO_2$ (SAT) and 570 $GtCO_2$ (GMST), respectively. Carbon budget in the AR5 was estimated using the SAT method in climate modeling. This implies an increase in the SR1.5 carbon budget (SAT) by 310 (difference between 420 and 110) Gt, and an increase in the remaining 150 (difference between 570 and 420) $GtCO_2$ is due to the difference in methodology (SAT vs. GMST).

The fact that the carbon budget has rapidly increased in a short period between AR5 (2013) and SR1.5 (2018) signals another change likely in IPCC AR6 report to be published in 2021. Also, the carbon budget in SR1.5 does not include the effect of possible feedback from the earth system, such as the CO_2 and CH_4 release from permafrost thawing. These events could contribute to reductions in the budget.

In addition to the carbon budget, there are other uncertainties in climate science. Equilibrium climate sensitivity (temperature increase following a doubling of the atmospheric CO_2) has remained unchanged since AR5 and has been assessed to be in the 1.5℃ to 4.5℃ range, with a three-times spread. It is impossible, therefore, to predict the extent of temperature increase for the same CO_2 concentration. Furthermore, CO_2 emissions and mitigation pathways are expected to differ substantially depending on the type of socio-economic developments occurring in future as described earlier. Technology development and availability is also one of critical uncertainties. In view of these uncertainties, the author believes that coping with climate change is a risk management issue under uncertainties and that we should be flexible to respond to new scientific findings. Fixing our goal and making a headlong rush to attain certain temperature target will not be effective in a long run.

4. Concluding remarks

Based on the current situation, one point is quite clear. Continuous emission of CO_2 certainly contributes to the increase in the surface temperature of the earth due to long life time of CO_2, and temperature continues to increase and never stabilizes. It is vital that we avoid such a situation. We must aim for zero CO_2 emissions in the long run, a paradigm shift from temperature target. All efforts should be focused on this purpose, including zero emission technology developments in all sectors of our economy.

1 Nordhaus, W.D., 2017: Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences*, **114(7)**, 1518-1523, doi:10.1073/pnas.1609244114.