The Importance of Increasing Actual INDCs' Ambitions to Meet The Paris Agreement Temperature Targets

An Innovative Fuzzy Logic Approach to Temperature Control and Climate Assessment using FACTS

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Abstract: This work presents an alternative assessment of climate projections using FACTS (Bastien and Gay, 2016), based on possible future emissions pathways related to the Intended National Determined Contributions presented in 2015 as part of the Paris Agreement on climate change. Moreover it proposes emission reductions in order to stabilize the climate to the desired levels proposed by the international community. Ultimately, it shows the importance of the emissions pathways that the world could take in the crucial period of time 2020-2030. FACTS uses a fuzzy logic approach to solve this physical problem, aware of it dependence on the complexity of climate diplomacy.

1 INTRODUCTION

Climate models have widely projected different scenarios under assumptions of a warmer world (Rahmstorf and Coumou, 2011; Silliman et al., 2013), however due to the great uncertainty and the natural continuity of change in climatic variables, it would be unrealistic to propose a warming limit that prevent human and ecosystem collapse. On the other hand, in order to promote international mobilization toward reducing greenhouse gases emissions, in 2009 was convenient to set the goal of not exceeding $2°C$ the average global temperature above pre-industrial levels (UNFCCC, 2010).

Under the imminent decision of the 2 degrees goal, research groups were dedicated to identify stabilization routes consistent with the limit (Baer et al., 2009; Bossetti et al., 2010; den Elzen et al., 2010; Edenhofer et al., 2010; van Vuuren et al., 2011), while other groups estimated future projected emissions from international agreements and existing energy structures (Riahi et al., 2007; Rogelj et al., 2013; Clarke et al., 2009; Davis et al., 2010), with this, the United Nations Environment Programme made the first emissions gap report (UNEP, 2010), which shows how well the actual policy fits the temperature stabilization goals and elaborates on the efforts that need to be made in future negotiations.

Since that time, it have been developed methodologies to find emissions pathways that stabilize global average temperature. Currently, the state of the art is to find the most efficient mitigation strategies in economic, energetic and social terms, differentiating between global and regional scales (Belenky, 2015; Rogelj et al., 2013; Garg et al., 2014). Nevertheless, in this moment is clearly set a whole new international structure based on domestic pledges that demand understandable methodologies for their analysis in order to spread the urgency of proposing more ambitious goals. In that context, our work presents an alternative approach and methodology for facing this challenge.

This study uses 'FACTS: Fuzzy Assessment and Control for Temperature Stabilization' (Bastien and Gay, 2016) which is a fuzzy controller and evaluator that uses the output variables of a simple climate model in an specific time i (temperature, CO_2 emissions, CO_2 concentration, temperature change), and give as an output the change in emissions that would need to be made in the subsequent year $i+1$ in order to stabilize the climate. We use the FACTS-assessment to present the fuzzy evaluation of possible climate states under different emissions pathways between 2016-2030. Moreover, the FACTS-control was triggered in 2030 in order to stabilize the average tem-

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perature according to the Paris Agreement (UNFCC, 2015).

Finally it was made a comparison between the FACTS' stabilization pathways and the inertial emissions routes, which remarks the importance of more ambitious pre-2030 mitigation efforts.

2 DATA ANALYSIS AND CLIMATE STATES

The core instrument of the Paris Agreement for climate change mitigation are the Intended National Determined Contributions (INDC), a set of nationally projected greenhouse gases emission trajectories from 2020 to 2030. Since every country has different type and quality of information, the INDCs are expressed in heterogeneous ways: relative to a baseline, relative to historical data, or as reduction goals.

There have been several works that integrates and analyse the INDCs in order to create global greenhouse gases emissions pathways and project the possible future climate (AGCEC, 2015; CI, 2015; DEA, 2015; Kitous and Keramidas, 2015; IEA, 2015; Boyd et al., 2015; Spencer and Pierfederici, 2015)

In this study, we used the analysis made by Climate Interactive [CI], which states possible pathways that cover different scenarios of global commitment, where the current INDCs pledges are the worst case (INDC Strict), and the best case is a success in the climate change mitigation that stabilizes the temperature in 1.5°C (Ratchet Success), plus four more scenarios that lie between the mentioned above in terms of emissions intensity (Ratchet 1, Ratchet 2, Ratchet 3, 2 degrees pathway). The INDC Strict scenario is described as the integration of the INDCs pledges as of December 13th 2015, where CO_2 changes apply to CO_2e except for China, supposing no commitment after 2030 and using RCP8.5 emissions; while Ratchet Success is the scenario on track through 2020 to fulfill INDC pledges, thereafter, all developed countries reduce to 45% below 2005 levels by 2030 and 80% below 2005 levels by 2050, continuing the rates of decline through 2100. China peaks in 2025, all other developing countries peak in 2027, decline 2% annually through 2040 and then 4% annually through 2100.

Taking these emissions scenarios, we used MAGICC 6 (Meinshausen et al., 2011) to project the climate and make an assessment with FACTS (Bastien and Gay, 2016), an easy-to-use tool that classifies the climate variables into fuzzy sets that altogether create fuzzy climate states. In Figure 1, are shown the climate states projection in 2100 under the different proposed by CI.

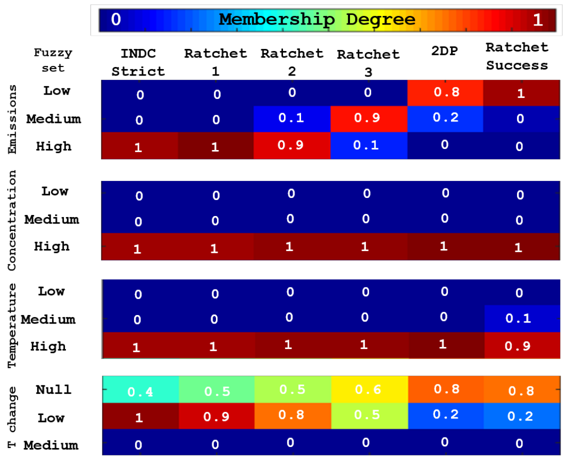

Figure 1: FACTS assessment of the climate states in 2100 that result from INDCs and more ambitious emissions pathways. Every column represent a single scenario which is evaluated in terms of its fossil fuel emissions, atmospheric CO_2 concentration, temperature and temperature change; each variable belongs to three linguistically-defined fuzzy sets in different degree, which is shown in a color scale and numerically (rounded to decimals): zero is not membership at all, 1 is full membership. As we can observe, in 2100 the emissions remain high in the worst scenarios (INDC Strict, Ratchet 1, Ratchet 2) and decay continuously to low in the best scenarios (Ratchet 3, 2DP, Ratchet Success). As expected, the CO_2 concentration and temperature are high in all the scenarios, since those measures are in terms of a 2 degrees stabilization in 2100. Finally, the last rows tell us that the temperature keep increasing in the worst scenarios and remains stable in the best ones. As an example of interpretation of the climate state, we could read the 'INDC Strict' scenario (column on the far left) as follows: Emissions, Concentration and Temperature are high and the Temperature keeps increasing, this means no stabilization in 2100 and future temperatures above 2 degrees.

As we can observe in the FACTS climate analysis, the higher-emissions routes (INDC Strict, Ratchet 1 and Ratchet 2) lead to climate states in 2100 of high emissions, high concentrations, high temperature and low temperature increment. While the lower-emissions routes (Ratchet 3, 2-Degrees Pathway and Ratchet Success) lead to medium-low emissions, high concentration, high temperature and to the crucial null temperature change. We will further discuss the importance of having a different instrument for the Earth climate state visualization, rather than the unrealistic precise number that describes the increment of the average global temperature above pre-industrial levels.

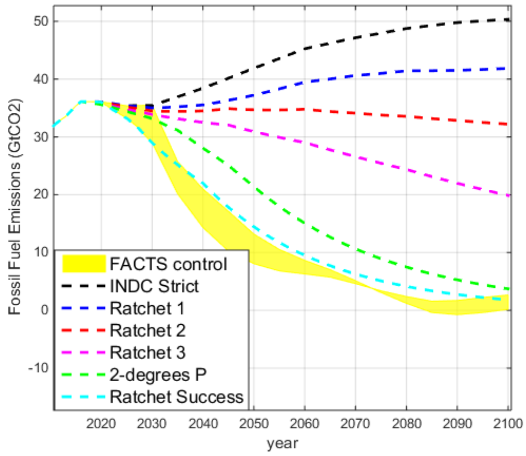

Figure 2: The dashed lines are the emissions scenarios proposed by Climate Interactive after United Nations pledges analysis. The shaded yellow area is the envelope of the six controlled emissions pathways created using FACTS in order to stabilize global average temperature.

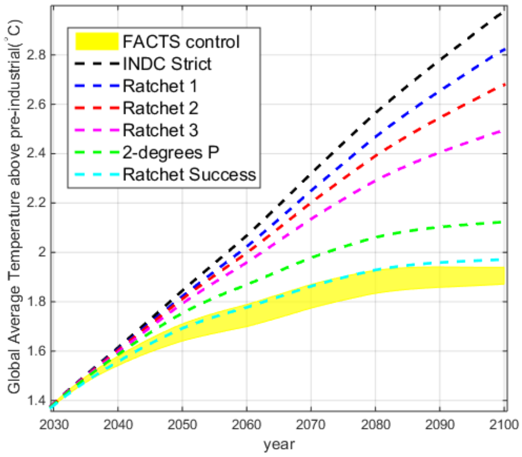

Figure 3: The dashed lines are the emissions scenarios proposed by Climate Interactive after United Nations pledges analysis. The shaded yellow area is the envelope of the six controlled emissions pathways created using FACTS in order to stabilize global average temperature.

3 STABILIZATION ROUTES AND FINAL CLIMATE STATES

FACTS control reduces the emissions of a certain baseline in order to stabilize the global average temperature and reach an stable climate state. In this experiment, FACTS control was applied every 5 years starting in 2030, simulating the the new and more ambitious communications that need to be made periodically by all the Parts as stated in the Paris Agreement. We stabilize the six possible scenarios that range from the current INDCs to an ideal pathway that lead to the $1.5°C$ stabilization. In Figure 2 is shown the reduction that results from FACTS as a yellow shaded area, which is the envelope of the six stabilization routes applied to the baseline scenarios.

FACTS needs to be embedded in a climate model that projects climate parameters as a function of the control results in order to give a climatic output that are recycled and serve as an input for FACTS control. We used MAGICC6 (Meinshausen et al., 2011) as the core climate model, the results of implementing FACTS can be seen in Figure 3, which shows the temperature through 2100.

A more complete overview of the climate in 2100 is made by the FACTS-assessment tool (Figure 4), which shows that not only the temperature, but also other climate parameters are stable in 2100 after implementing FACTS-control during 70 years every 5 years.

One of the most important characteristics of Figure 4 is the noticeable color-value homogeneity of the rows, which provides an easy visual proof that all scenarios were successfully stabilized in *very low* emissions and concentrations, *almost high* temperatures and *almost null* temperature change. The *italics* labels are intuitive adjectives that come from a simple inspection and encompass the uncertain nature of climate projections, but is still valid.

4 DISCUSSION

A measure of how important is to choose a low emissions pathway before 2030 is the gap that exists in 2040 between the baseline emissions and the controlled ones.

This gap represents the emissions that would need to be cut to the six baseline emissions in order to stabilize the climate. For INDC Strict pathway, the gap is $17.46 GtCO_2$; for the Ratchet 1, the gap is $14.98 GtCO_2$; for Ratchet 2, the gap is $14.46 GtCO_2$; for Ratchet 3, the gap is $13.01 GtCO_2$; for 2-degrees Pathway, the gap is $9.30 GtCO_2$; and finally, for Ratchet Success, the gap is $7.67 GtCO_2$. Even though the Ratchet Success should be almost equal to the stabilization route proposed by FACTS-control, this does not happens due to the different climate models used by the data source and this experiment, nevertheless, the importance resides in the difference between the gaps.

On the other hand, we recognize the influence of the historical emissions in the efforts of decreasing certain quantity of emissions per year. In order to show that influence we present in Figure 5 the rate of

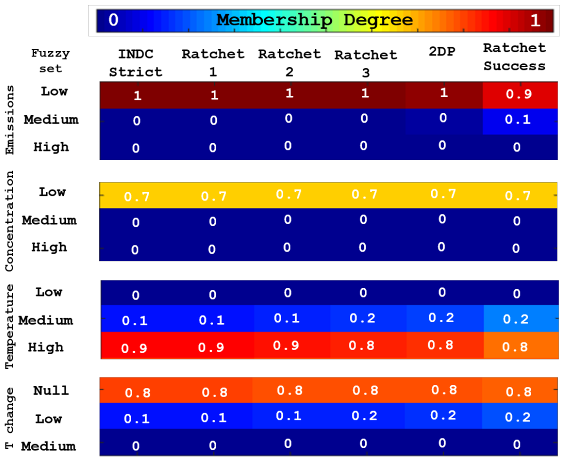

Figure 4: FACTS assessment of the climate states in 2100 that result from implementing FACTS-control INDCs and more ambitious emissions pathways. Every column represent a single scenario which is evaluated in terms of its fossil fuel emissions, atmospheric CO_2 concentration, temperature and temperature change; each variable belongs to three linguistically-defined fuzzy sets in different degree, which is shown in a color scale and numerically (rounded to decimals): zero is not membership at all, 1 is full membership. As we can observe, in 2100 the emissions and concentrations are low in every scenario. The temperatures are somewhat high, relative to the 2 degree limit (which means that is very close to the 2 degrees, this result is expected in 2100). Finally, the most important result. This whole assessment represents a climate stabilization, which means that the FACTS-control worked well.

emissions change of the different scenarios in 2040, the slope differences between the rates of change represent the effort that would need to be made in order to reduce a unit of emission due to the energetic and economical structure that the world has developed until 2030 which is represented in the pre-2030 emissions. The lines that lie in the right side of the figure, are scenarios that represent a world that keeps developing energetic structures based in fossil fuels and would be very hard to put on the stabilization track, on the contrary, the left side lines are those scenarios which represent a world that is in the track of clean energies, and further reductions would be feasible.

5 CONCLUSIONS

This work shows that the INDCs pledges as of December 2015, will not be sufficient to stabilize the climate in 2100, nevertheless, it proves that is physically possible to meet the international climate targets. And a crucial step on the pursue of this goal is to immediately revise the proposed INDCs and make more ambitious reductions before 2030.

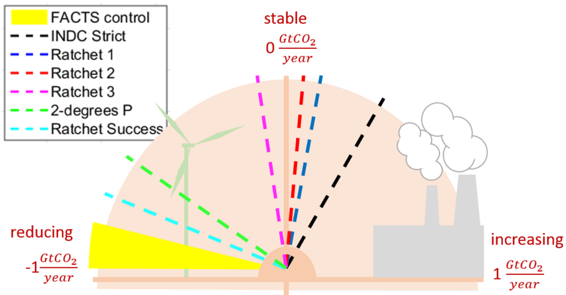

Figure 5: Difference between the rate of change in emissions in 2040.

The difference among accomplishing or not the climate goals, resides in the construction of a common ground where negotiators and researchers could interact and understand each other. As presented here, FACTS play an important role in this prevailing problem. On one hand FACTS-assessment presents the climate states which the negotiators need to be looking for, on the other hand, FACTS-control presents the pathways that the world need to follow in order to accomplish those climate states.

Much more work need to be done in the development of this new and more easy ways to present and model the climate change, however, as presented in this study, the alternative methodologies are up to the classical methods currently used by the most of international community, and moreover,they are crucial in creating an efficient communication bridge that closes the gap between different actors in the climate change mitigation challenge.

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