Challenges for low stabilization of climate change: The complementarity of non-CO_2 greenhouse gas and aerosol abatement to CO_2 emission reductions

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In the Copenhagen Accord it was recognized that global mean temperature should not exceed 2° C above preindustrial levels. Reaching this target will require deep cuts in CO_2 emissions. However, reducing CO_2 emissions alone will not be enough. To reach stringent climate targets, other substances have to be taken into account as well. In this thesis, I analyze potential bottlenecks for reaching low stabilization targets. My focus is on the complementarity of non-CO_2 greenhouse gas and aerosol abatement to CO_2 emission reductions.

Greenhouse gas emissions rise particularly fast in developing countries. These countries want to sustain their economic growth and reach self-sufficient energy levels, which has historically lead to higher emissions. Without climate policies, currently used integrated assessment models continue this historic pattern. In case of stringent climate policies however, models break with this historical pattern and assume sustained economic growth with very low energy levels. These model results seem to be either not realistic or driven by strong implicit assumptions. In order to determine residual CO_2 emissions we need to either understand or correct these results.

Long-lived non-CO_2 greenhouse gases account for almost one quarter of anthropogenic greenhouse gas emissions. To achieve ambitious climate targets, these gases have to be reduced as well. The Kyoto protocol determined emissions reductions for CO_2, as well as the well-mixed greenhouse gases CH_4, N_2O, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and SF_6. In the Kyoto protocol, emission budgets were determined not for each separate gas, but in one single budget, leaving nations full flexibility as to which greenhouse gas to reduce. This single budget required a metric to make the different gases comparable. In the Kyoto protocol a simple constant metric called the global warming potential was chosen. This metric has been challenged on various grounds and a number of alternatives have been proposed. We analyze different constant and time-dependent metrics with regard to their implications on global economic costs, transient emission pathways, and regional and sectoral impacts. We find that although impacts on global costs are negligible, there are considerable effects on medium term emissions and regional wealth transfers.

In recent model intercomparisons, the possibility to generate negative CO_2 emissions using a combination of bioenergy with carbon capture and storage has proven to be a crucial mitigation option. Low stabilization scenarios become much more costly when bioenergy is limited or when carbon capture and storage (CCS) is not available. Moreover, bioenergy provides one of the rare alternatives to produce low-carbon liquids fuels. In our study, we analyze bioenergy deployment depending on the stringency of the climate target, the availability of CCS, and bioenergy supply.

Another important group of emissions determining today's radiative forcing are aerosols.

They are not controlled under any climate treaty so far, and it seems far more likely that they will rather be subject to air pollution policies than to climate policies. Yet since aerosols contribute substantially to anthropogenic forcing, the question arises how they interact with climate and climate policy. In the literature we find different lines of arguments. Some argue that since overall aerosol forcing is negative, a fast reduction of aerosol emissions could lead to accelerated global warming. Others focus on black carbon, which is an important contributor to warming, and suggest that it should be reduced first as this would lead to synergies between air pollution policies and climate policies. With the model we are using we are able to consider interactions not only between air pollution policies and climate policies, but also between the various aerosol
species which are often times co-emitted. We find that air pollution policies are hardly able to influence long-term climate targets. On the other hand, climate policies efficiently reduce air pollutants. Our results suggest that there are synergies rather than trade-offs between air pollution policies and climate policies.