Objectives

- Optimal composition of a mitigation portfolio given the uncertainty surrounding key variables
- Natural sinks modelled stochastically and as a function of atmospheric Greenhouse Gas (GHG) concentration accounting for possible climate feedbacks
- Analyze different emissions targets and identify best hedging strategies in the technosphere given the uncertainty in the biosphere with explicit focus on their interrelation
- Examine the role of bioenergy with carbon capture and storage (BECCS) when accounting for natural sinks and the potential climate feedbacks

Model

- A global decision maker plans abatement and negative emission technology (NET) deployment bound by a cumulative emission target over the 21st century
- Three periods: 1) Short-term (2010-2030), 2) Medium-term (2030-2050), and 3) Long-term (2050-2100)
- Select most cost-effective policy plan with two available options: (1) abatement and (2) deployment of NETs consisting of BECCS and direct air capture (DAC). The technologies differ in their cost structure and mitigation levels.
- CO₂ sink modelled similar to Friedlingstein et al. (2006): feedback between atmospheric CO₂ concentration and the sink, with additional stochastic shocks representing extreme events like forest fires, pests, etc. (Probability of shock occurrence modelled as being positively dependent on the cumulative emissions)

Sink Sensitivity to Atmospheric CO₂

- Deployment of BECCS (and DAC) very dependent on sink’s sensitivity to atmospheric CO₂ (β)
- For high CO₂ fertilization effect: NETs are a relatively stable share in the mitigation portfolio, which is equal to the maximum BECCS potential
- For a lower effect: amount of CO₂ abated with NETs increases, i.e. deployment of DAC starts and increases.
- Result as expected because “free” mitigation through uptake by natural sinks decreases and NETs have to make up for the difference

BECCS potential

- Even though BECCS is used only in the third period, its potential has direct impact on the optimal abatement already in the first and second periods.
- Increase of 50% in potential of BECCS is reflected in an over 40% (20%) decrease in the first (second) period abatement.
- If BECCS potentials are higher than in our baseline the present value (PV) of the portfolio costs decrease relatively little, as we deploy more BECCS.
- If BECCS potential is lower than in the baseline, however, the PV of the costs almost doubles because of the increased deployment of DAC

Cumulative Emission Target

- Least stringent cumulative emissions target (2,960 GtCO₂): NETs are not part of the optimal portfolio anymore.
- Most stringent target (88 GtCO₂): in last period maximum amount of BECCS (1,605 GtCO₂) plus 1,035 GtCO₂ of DAC, as so much abatement in the last period needed that DAC becomes cheaper than marginal unit of abatement.
- Abatement need in first period similar with different targets (140 GtCO₂ for the 88 and 880 GtCO₂ targets to only 80 GtCO₂ for the 1,500 and 2,900 GtCO₂ targets)
- The present value (PV) of the portfolio cost increases exponentially with the stricter cumulative emissions targets

Shocks to the Carbon Sink

- With increasing shock size, more mitigation needs to be carried out to meet the target in the last period in total.
- The larger part of this increase is achieved through NETs deployment. As the potential of BECCS is already fully exploited in the baseline case, the increase can here only happen via a deployment in DAC.
- With a higher probability of a shock to the sink, this increase gets steeper with the shock size