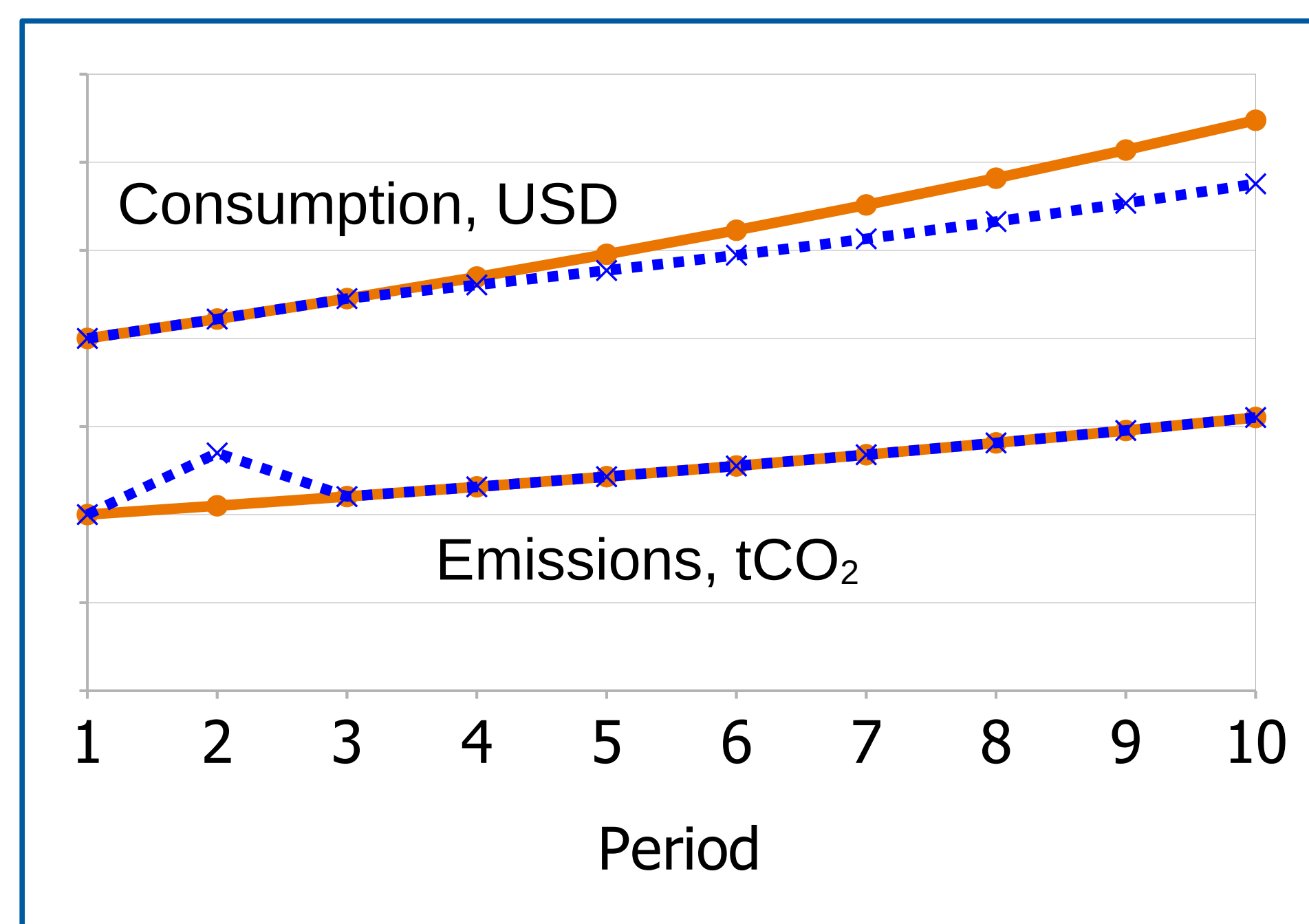


Social Cost of Carbon: Systems Analysis Perspective & Relevance to Policy Targets

Nikolay Khabarov¹, Johannes Bednar¹, Alexey Smirnov^{2,3}, Michael Obersteiner^{1,4}

Concept



Uncertainty

Year	DR = 5%	DR = 2.5%
2020	12	62
2025	14	68
2030	16	73
2035	18	78
2040	21	84
2045	23	89
2050	26	95

Calculation method

$$E(t) = f(t, \dots) + X \quad (\text{tCO}_2)$$

$$C(t) = g(t, \dots) + Y \quad (\text{USD})$$

X and Y are such that total welfare remains constant then

$$SCC(t) = Y / X \quad (\text{USD/tCO}_2)$$

Social Cost of Carbon (SCC) values emissions

Carbon dioxide emissions, when increased in just one time period, can lead to a higher climate damage and consequently lower consumption over longer time (blue dotted line). The SCC aims at valuation of such damage as USD/tCO₂. It can be obtained from e.g. DICE model DOI:10.1086/676035.

SCC estimation range for two values of the discount rate (DR)

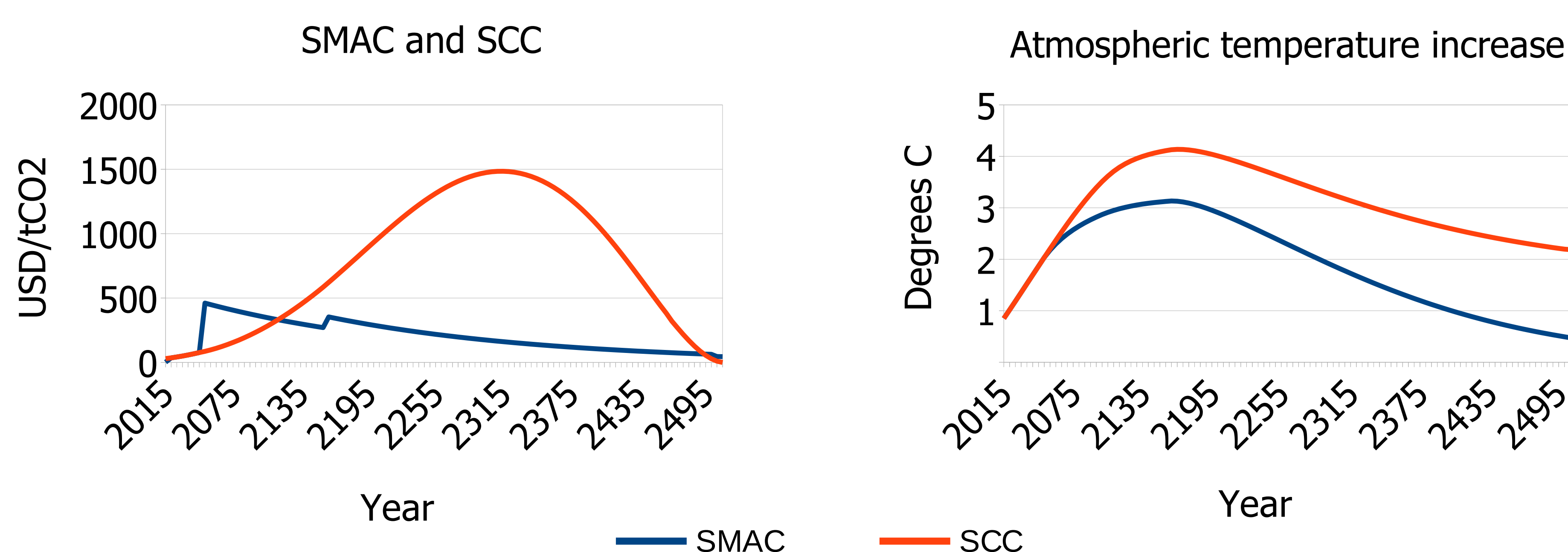
Discount rate is not the only source of uncertainty: other model parameters such as e.g. climate sensitivity and damage functions increase the span in SCC estimates. Table adapted from https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf.

SCC is based on hypothetical exogenously added quantities

SCC in DICE is calculated by breaking the model dynamics – its equations for emissions “E” and consumption “C” in a particular time period “t”. SCC values “X”, which is external to the system i.e. emissions beyond policy control. More details are available in DOI:10.3389/fenvs.2022.923631.

SCC as CO₂ Tax & Net-zero Emissions Target

Standard DICE 2016R model with added net-zero 2050 target produces different socially optimal marginal abatement cost (SMAC) and SCC (left figure). Using SCC instead of SMAC as a tax in DICE, leads to a failure in reaching net-zero target, lower than optimal abatement, and higher warming (right figure).



Key notes

From the systems analysis perspective, SCC calculation method in DICE is disintegrating the modeled closed system by introducing exogenous emissions.

Similar consideration is valid for other SCC calculation methods, where full system linkages cannot be taken into account.

Inside DICE, the concept of SCC is implemented by SMAC and there is no practical need to use SCC, which can lead to a policy failure e.g. when used as a tax.

Contact authors:
khabarov@iiasa.ac.at
bednar@iiasa.ac.at

¹ Exploratory Modeling of Human-Natural Systems Research Group (EM), Advancing Systems Analysis Program (ASA), International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria; ² Integrated Biosphere Futures Research Group, Biodiversity and Natural Resources Program, IIASA, Laxenburg, Austria; ³ Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia; ⁴ Environmental Change Institute, Oxford University Centre for the Environment, Oxford, UK.
Funding: Medium Complexity Earth System Risk Management (ERM) Project, Austrian Science Fund (FWF): P31796-N29.