Title: Low and overshot emission scenarios – from a high to a low carbon society (LOES)

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Tentative budget: 1 MNOK for a researcher at UiB (metric development, scenario analysis, co-funded from CRESCENDO), 4.5 MNOK (30 PM) to UNI for global ocean modelling as well as global and regional terrestrial modelling, carbon cycle feedback analysis, metric development and scenario analysis , 2 MNOK to IMR for regional ocean modelling and scenario analysis on regional scale, 0.5 MNOK for outreach activities and travel (all partners)

In kind contributions/synergies (applicants that are involved in brackets)

- existing projects: EVA (Heinze, Tjiputra, Schwinger, Ekici), CRESCENDO (Heinze, Lee, Ekici), FEEDBACK (Lee), HiddenCosts (Lee), ORGANIC (Tjiputra, Heinze), Time will tell (Bjune, Lee)
- proposed projects: INES (Schwinger, Tjiputra, Ekici, Heinze), CCneg (Schwinger, Ekici, Goris, Tjiputra, Lee), OCEAN-VITALS (Lauvset), FISHSTRESS21 (Goris, Skogen)

Short background / purpose: The COP21 Paris Agreement has opened the perspective for a transition from a high to a low carbon society. The remaining range of allowable carbon emissions for temperature targets of 2-degrees and below, however, is extremely tight. Therefore, an accurate estimation of carbon fluxes between the atmosphere and the land biosphere/the ocean for strong mitigation scenarios is critical. Temperature targets, on the other hand, are arbitrary to some degree, since research on impact differences between 3, 2, or 1.5 degree global warming scenarios is scarce, particularly on a regional scale. Moreover, it is still unclear how a temporary overshoot of the temperature target, differs in impacts from trajectories without such overshoot. Further challenges arise as some mitigation-options compete with food production or are hampered by climate impacts (e.g. re-forestation, BECCS=Bio-energy with carbon capture and storage, blue carbon). Research on the realism/feasibility of these mitigation measures is urgently needed to better inform decision makers. LOES will support the transformation to a low-carbon society by

1. better constraining the carbon cycle under low and overshoot scenarios to reduce uncertainties in allowable carbon emissions,
2. investigating key impacts on terrestrial and marine ecosystems for high, low, and overshoot emission pathways (including multiple mitigation targets and potential tipping points), and
3. assessing the feasibility and efficiency of proposed mitigation options (particularly re-forestation and BECCS).

Impacts on ecosystems and food production will be highly dependent on exceedance of climatic thresholds (e.g. frequency and duration of droughts/floods as well as of temperature, pH, and low-oxygen extremes). Food security and conservation of life below water and on land are among the sustainable development goals defined by the United Nations (goals 2, 14, and 15), and LOES will close critical knowledge gaps regarding climate change aspects of these goals. The land and ocean biospheres are both being modified by humans at accelerating rates in addition to the impacts of climate change. It is, thus, crucial to project accurately the future of terrestrial and marine ecosystems under impacts from multiple stressors.

Methodology:

We will employ the Earth system model NorESM (fully coupled or as components) and regional models of the land biosphere and the ocean. Model baselines will be the NorESM2 components as developed for CMIP6 as well as the regional NORWECOM model. We will analyse simulations performed for CMIP6 and augment these with specifically designed model experiments. Our focus is to contrast projections of high emission pathways (SSP2-4.5) with low (SSP1-1.9, SSP1-2.6), and overshoot (SSP5-3.4-OS) pathways. An impact assessment including extremes in the biogeochemical variables will be carried out. Critical thresholds for ecosystem functioning will be identified, and a multiple targets metric will be developed for evaluating the projections taking both strength and duration of stressors into account. Special emphasis will be placed on the quantification of changes in available biomass as a function of multiple stressors and consequences for (i) ecosystem functioning

and sustainability and (ii) food production and food security. Results will be regionalised for Norway and the Norwegian/Barents Sea. In order to guide the design of impact assessment, the project will strengthen existing and establish new links with specialists on agriculture, fisheries, and aquaculture. LOES will build up collaborations with the Centre for Climate and Energy Transformation (CET) and the integrated assessment modelling community.

Deliverables:

D1: Define multiple mitigation targets (e.g., avoid exceedance of pH, oxygen, and temperature thresholds, duration of droughts, extreme precipitation). Workshop with specialists on agriculture, fisheries, and aquaculture to guide definition and ensure usefulness of targets (M 1-12).

D2: Analysis of low versus high and overshoot emission scenarios with respect to

- carbon cycle feedbacks; assess the relevance of irreversible processes for overshoots (e.g., ocean acidification, permafrost thawing) (M 1-24),
- exceedance of multiple mitigation targets (D1) on global and regional scale (M 13-36),
- biomass production changes and drivers thereof, potential tipping points of ecosystem stability and food production security (M 13-36)

D3: Assessment of the (biogeochemical) feasibility of mitigation options used in the CMIP6 SSPs, particularly re-forestation (M 25-48).

D4: Synthesis and communications. Assess feasibility of multiple mitigation targets under different GHG emission pathways as guardrails for decision makers. Analyse safe operating spaces and potential threats as a function of human climatic forcing (M 36-48).

Strategic considerations

LOES brings together expertise on global and regional modelling as well as land/ocean C cycling from 3 BCCR partners (UNI, UiB, and IMR). The topic and results have important implications also in the fields of physical climate science and climate dynamics. The project addresses key questions regarding strategies for climate change mitigation and is as such of high scientific and societal relevance. The project will provide consultancy to decision makers through a systematic analysis of multiple mitigation targets under differing emission pathways. It will strengthen our expertise in studying impacts of climate change, and will establish/strengthen collaboration with experts on agriculture, fisheries, and aquaculture. The research proposed in this project is at the heart of topics dealt with in FutureEarth and WRCP. The project will clearly strengthen BCCR's competence on using climate modelling to answer societal challenges such as food production, thus should enable the research groups to attract further funding in this field from RCN as well as EU. LOES involves two leaders, both relatively junior, one male and one female. The project includes participants at different career stages from early career to professorship level.