Be vary of false certainty from uncertainty

COST Action CA19139 PROCLIAS, Working Group: 3, Task Group: 3.7

Summary report, March 2023

The Task Group (TG) concluded its work upon achieving its main objective.

1. Details

Topic: Cross-sectoral risk assessment

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2. The objective

The main objective of the TG was to organise a workshop in the first semester of 2022 to contribute towards better understanding of how uncertainty and risk are addressed in sectoral climate impact assessments, comparing also experiences in uncertainty and risk analysis and focusing on methods, findings and lessons learnt.

3. Implementation

The two-day online workshop took place on 21 and 22 April 2022, with the following contributions:

Contributor	Title of the contribution
James Rising University of Delaware, US	***Full-uncertainty down-scale-driven estimation approach for climate damage estimations in UK***
Stephen Jewson CEO, Lambda Climate Research Ltd, UK	***Closing the gap between research and applications: helping the insurance industry use information about tropical cyclones and climate change***
Chahan Kropf Weather and Climate Risks, ETH Zurich, Switzerland	***Uncertainty and sensitivity analysis for probabilistic weather and climate risk modelling: an implementation in CLIMADA v.3.1***

Jun'ya Takakura National Institute for Environmental Studies, Japan	***Uncertainty in climate impacts simulations and emulations***
Jan Semenza	***Cascading risks from climate change for diseases in Europe***

4. Main insights and conclusions from the workshop:

4.1. Uncertainty in cross-sectoral risk assessment

Types of "uncertainties" in risk models:

- Epistemic (imperfect understanding of the system)
  - measurements errors
  - model approximations
- Random (uncertain due to system properties)
  - weather patterns are inherently probabilistic
- Predictive (different model specifications might seems equally plausible and it is unclear how to best represent the target system for specific purposes)
  - Different climate models runs
- Normative (uncertainty about value itself, and uncertainties and how to decide and how to act)
  - choice of discount rate
  - choice of impact metrics (average, cumulative, etc)

The uncertainty associated with total estimate of climate risk can be considered along the main steps of the modelling chain. The steps of the modelling chain usually begin with a global climate scenario converted into warming levels or time horizon, then translated into local hazards, which in turn are interfaced with an impact model that provides biophysical impacts as output. The biophysical impacts are further used in an economic model to account for socioeconomic resilience and general equilibrium effects, informing about welfare implications. One of the benefits of representing uncertainty throughout this process is that the final result, the total risk estimate, can be interpreted in terms of the risk averse certainty equivalent of the total damages.

Accounting for uncertainty related to the different risk assessments relates, among other, to different spatial attributes (coverage, scale, resolution), different methodologies (emulated, process-based, statistics, econometrics, review), different climate representations (SCMs, GCMs, RCPs, time, tipping points), and on how the response to adaptation is represented.

Tails of climate risk distribution are challenging in representation but important to account for. Some climate models (FAIR, MAGICC) can produce full range of climate uncertainty, but individual global climate models are designed for stability and are designed to represent the middle of the uncertainty distribution. Some methods attempt an account for the tails representation by broadening the ensemble of climate models by ‘surrogate’ models representing the tails of the climate probability distribution (CIL approach).

Important for the uncertainty account is the inclusion of the tipping points (permafrost melting, ocean methane hydrates, arctic sea ice/surface albedo, Amazon die-back, AMOC slowdown).

4.2 Examples of accounting for uncertainty in climate risk models

Some frameworks allow the measurement of uncertainty associated with the results. That can be combined with sensitivity analysis to understand which part of the uncertainty is driven by which component of the model, such as parameter or input data. The sensitivity analysis can also be structured along the risk framework so the drivers of the uncertainty are the components of the risk analysis: hazard, exposure and vulnerability. Uncertainty here is defined as distribution of output metrics due to a distribution of input variables/parameters, while the sensitivity analysis is the attribution of the output metric variation to the input variable/parameters.

4.3 Cascading risks from climate impacts

A positive feedback loop can occur in certain combinations within the nexus of hazard, exposure and vulnerability. An example of infectious diseases illustrates how a hazard can lead to vulnerabilities for individuals and, in turn, can lead to a new hazard. A climate event (flood or drought) can lead to cascading exposure such as drinking water exposure (to a virus). Then the virus can lead to other events (standing water leads to mosquito breeding grounds) which, if combined with a vulnerability (lack of window screens) can lead to infectious disease outbreaks.

Cascading risks pathways can include (not exhaustive but illustrative enumeration):

- Cascading risk pathways from heavy rain and flooding
  - Storm runoff yields water turbidity, which compromises water treatment efficiency
  - Storm runoff mobilizes and transports pathogens
  - Overwhelmed or damaged infrastructure compromises water treatment efficiency
  - Floods overwhelm containment systems and discharge untreated waste water
  - Floods damage critical water supply and sanitation infrastructure

    - Floods displace populations towards inadequate sanitation infrastructure
- Cascading risk pathways from drought
    - Low water availability augments travel distance to alternative (contaminated) sources
    - Intensified demand and sharing (e.g., with livestock) of limited water resources decreases water availability and quality
    - Intermittent drinking water supply results in cross-connections with sewer lines and water contamination
    - Uncovered household water containers are a source of vector breeding
    - A decrease in the volume of source water and an increase in the concentration of pathogens results in poor hygiene
    - Accumulated human excrement and animal manure results in human exposure to pathogens
- Cascading risk pathways from increasing temperature
    - Extended transmission season for opportunistic pathogens
    - Permissive temperature for the replication of marine bacteria
    - Enhanced pathogen load in animal reservoirs (e.g., chicken)
    - Pathogen survival and proliferation outside of host
    - Degradation of water quality from wildfires during heat waves
    - Exposure to contaminated water due to higher water consumption
    - Behavior change (e.g., barbecue) and food spoilage
- Cascading risk pathways from sea-level rise
    - Population displacement due to powerful storm surges
    - Disruption of drinking water supply and sanitation infrastructure due to inundation
    - Decline in soil and water quality due to saline intrusion into coastal aquifers
    - Seawater infiltration into drinking water distribution and sewage lines

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