Chapter 4

Impact-Oriented Climate Information Selection

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Abstract To support climate adaptation decision-making, a picture of current and upcoming climate and socio-economic conditions is required, including an overview of intervention scenarios and their impact. In order to be actionable, this picture needs to rely on credible, relevant, and legitimate information, which implies the use of tested models and concepts, tailored to the decision context, and with transparent and understandable assumptions on boundary conditions and process representation. These criteria are challenged when the complexity of the problem is large and stakes are high. For many conditions, unforeseeable features and events with potentially large implications affect the problem at hand and contribute to the uncertainty that is not easily quantified, let alone eliminated. We explore storyline development approaches that help in selecting relevant and credible pathways and events that enrich the understanding of the risks and options at stake. We explore two categories of storylines (climate scenario storylines and climate risk storylines) by discussing use cases in which these were developed.

Keywords Climate information • Storylines • Climate adaptation • Decision support • Risk information

Introduction

The world is a complex place, and the predictability of its dynamics is further challenged by climate change and its myriad of impacts. To support adaptation to these potentially high-impact future conditions, a description of current and future conditions and options needs to be provided, that is built on credible, relevant, and legitimate information (Vincent et al. 2018). For this, a proper system definition needs to be described that allows quantitative evaluation of (adverse) impacts of hazards and determination of the probability of event cascades. For this, a wide range of

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models is used to map potential pathways and situations, and the effects of adaptation interventions on these (Van den Hurk et al. 2018). However, credible predictions of future conditions are severely constrained by unknown drivers (greenhouse gas emissions, land use change, societal exposure, and vulnerability to hazards) and imperfect foresight capabilities (biased models, internal variability). In addition, complex compounding occurrences of drivers or impacts may lead to unforeseeable events or pathways that leave a large impact on the assessment of the current and future risk profile (Zscheischler et al. 2018). The higher the complexity of the situation, and the higher the stakes, the larger the challenge to meet the criteria of credibility, salience, and legitimacy.

To explore future conditions that are highly unpredictable but may unfold society-relevant impacts, a vast tradition of scenario construction has been developed over the past decades. In the field of climate change well-known benchmarking products are the emission and societal transition scenarios (RCPs, SSPs, Riahi et al. 2017), the modeled climate response and potential impacts (CMIP, CORDEX, ISIMIP, e.g. Eyring et al. 2016), and the expanding collection of national climate scenario and climate impact assessments embedded in regional, national, or European climate adaptation policy frameworks.

Storylines are a necessary element in these scenario frameworks. They provide a compelling and consistent narrative that is deemed plausible and relevant, and form the backbone logic of the scenarios that are derived from these. Storylines essentially consist of plausible assumptions on conditions and processes, and require the involvement of experts on these developments (Shepherd et al. 2018), both from practitioners and a scientific point of view. Many scenario frameworks provide multiple storylines, either to contrast potential but inconsistent storylines, or a form of uncertainty range to the collection of scenarios, in order to give an indication of the operation or tolerance range for which adaptation policies need to be designed.

Guided by a number of ongoing climate research programs we explore and contrast two types of climate storylines: climate scenario and climate risk storylines, both designed to condense the wide range of potential climate change projections into a compelling range that is relevant for impact assessment retaining as much as possible a link to the real world's experience with societal climate change impacts. The *climate scenario storylines* are used to aggregate a large volume of global climate change projections into a discrete set of stakeholder-oriented national scenarios. *Climate risk storylines* are mapping climate-related shocks in the complex and highly connected globalized world of trade, food security, and financial linkages.

Climate Scenario Storylines: The Dutch Climate Change Scenarios

National climate change programs are designed to provide an impact-oriented set of future climate conditions embedded in benchmark global climate scenario programs endorsed and reviewed by IPCC (RCPs, SSPs, CMIPs). Even for a given emission scenario or global warming level, an increasing uncertainty in global and regional climate change features remains present as the scenario horizon moves further into the future, and some form of selection or aggregation is needed. The Dutch climate change scenarios (KNMI' 14, www.climatescenarios.nl) have carried out this aggregation at the national scale by condensing the available ~ 250 global and regional climate change projections into four discrete narratives, mutually discerned by choosing two elementary drivers of national climate and discerning contrasting values in the climate-enforced changes of these drivers: the global warming level and the regional response of atmospheric circulation have a large impact on hydroclimatic features in the region (Van den Hurk et al. 2014).

For each combination of elementary drivers, global and regional climate model simulations are collected and aggregated, to yield a comprehensive set of meteorological characteristics that have been adjusted to the needs of a wide range of sectoral stakeholders. Not only seasonally mean temperature and precipitation but also extreme values of daily and multi-day precipitation and snowmelt (to service flood risk practitioners), extreme winds (coastal surge), precipitation deficit aggregated to the growing season (agriculture), and extreme max and min daily temperatures (urban health).

Figure 4.1 gives a summary of the climate scenarios. It displays the essential decomposition of a large number of potential futures into four discrete scenarios and gives a brief narrative of the essential consequences of each of these scenarios for climate characteristics that are highly relevant for a wide range of stakeholders. The underlying storyline for each of the scenarios has a physical origin but is well understood by practitioners as a highly relevant source of uncertainty in climate response that adequately allowed formulating alternative policy scenarios for the low-lying Dutch Delta.

Skelton et al. (2017) evaluated the societal relevance and uptake capacity of different national climate scenario products, including the KNMI' 14 scenarios. In their review, a strong interaction with users while scoping and constructing the climate scenarios is recommended. It is shown to contribute clearly to the credibility and legitimacy of the climate information, but challenges remain in making the scenarios relevant and useable for a different range of societal practitioners. For this, additional tailoring and user guidance are indispensable for efficient societal uptake of climate information (Berkhout et al. 2014).

Fig. 4.1 Summary of the overview of the KNMI’14 scenarios. Four scenario storylines are constructed varying in their level of global warming (W denoting high warming levels, G implying moderate warming) and the response of the regional atmospheric circulation (subscript L denoting a small change, H implying a large change). The driving conditions have large implications for regional climate characteristics that affect local societal impacts and their adaptation options, including many applications in water management, agriculture, and public safety (from www.climatescenarios.nl)

Climate Risk Storylines

COVID-19 convincingly demonstrates the difficulty to understand and foresee the complex cascades of shocks in our highly connected world. Although the parallels between COVID-19 and climate change impacts are only partially applicable, they clearly share the complexity of mapping consequences of remote disturbances on the European socio-economic risk profile. This complexity puts strong constraints on our ability to quantify this risk from a formalized probabilistic risk approach, by a combination of probabilities of (remote) hazards, exposure by means of socio-economic teleconnections (e.g. trade pathways), and vulnerability (European impact).

For a few years statements on the climate implications on isolated weather events are released by the application of so-called “attribution” studies, where the impact of climate change on the probability of the extreme event is quantified (Stott et al. 2016). The statements are strictly applicable to the characteristics of the event: any

change in its appearance (time, location, drivers, impacts, etc.) will require a new “attribution” statement.

In the recent socio-economic history, a number of major climatic extreme events outside Europe have led to a noticeable impact on the European economy: US hurricanes affecting European (re)insurance and investment companies, strong and simultaneous adverse growing conditions in the world’s “bread basket” regions, a flooding disrupting the supply of electronics, etc.

In an ongoing European H2020 research project RECEIPT (www.climatestorylines.eu), a number of event storylines, or climate risk storylines, are developed to map potential socio-economic consequences of extreme climate events outside Europe. The narratives are heavily inspired by experience from practitioners and stakeholders (Wilby and Dessai 2010), and new simulation and analysis techniques are developed to create analogs of these events for future climate conditions. These analyses do not aim to provide a comprehensive quantitative risk picture of any climate extreme in any region of the world but provide a strongly enriched picture of potential causal chains that may lead to (unexpected) impacts in downstream domains.

Conclusions and Recommendations

Underlying narratives are indispensable for the creation of credible, relevant, and legitimate climate information. Societal practitioners, the users of climate information, play a major role in defining the assumptions and contexts that need to be explored. Probabilistic approaches underlying many risk assessment methodologies are challenged when the context becomes very complex and stakes are high. To overcome some of these challenges, storyline approaches are maturing that enrich the picture of drivers, implications, and adaptation options of future climatic challenges. The definition of these storylines not only needs to comply with scientific standards to be credible and legitimate but also requires a thorough contextualization. This implies that a full understanding of all sources of uncertainty is not always achieved, but the inspiration provided by the climate storylines may make this uncertainty better conceivable and manageable.

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