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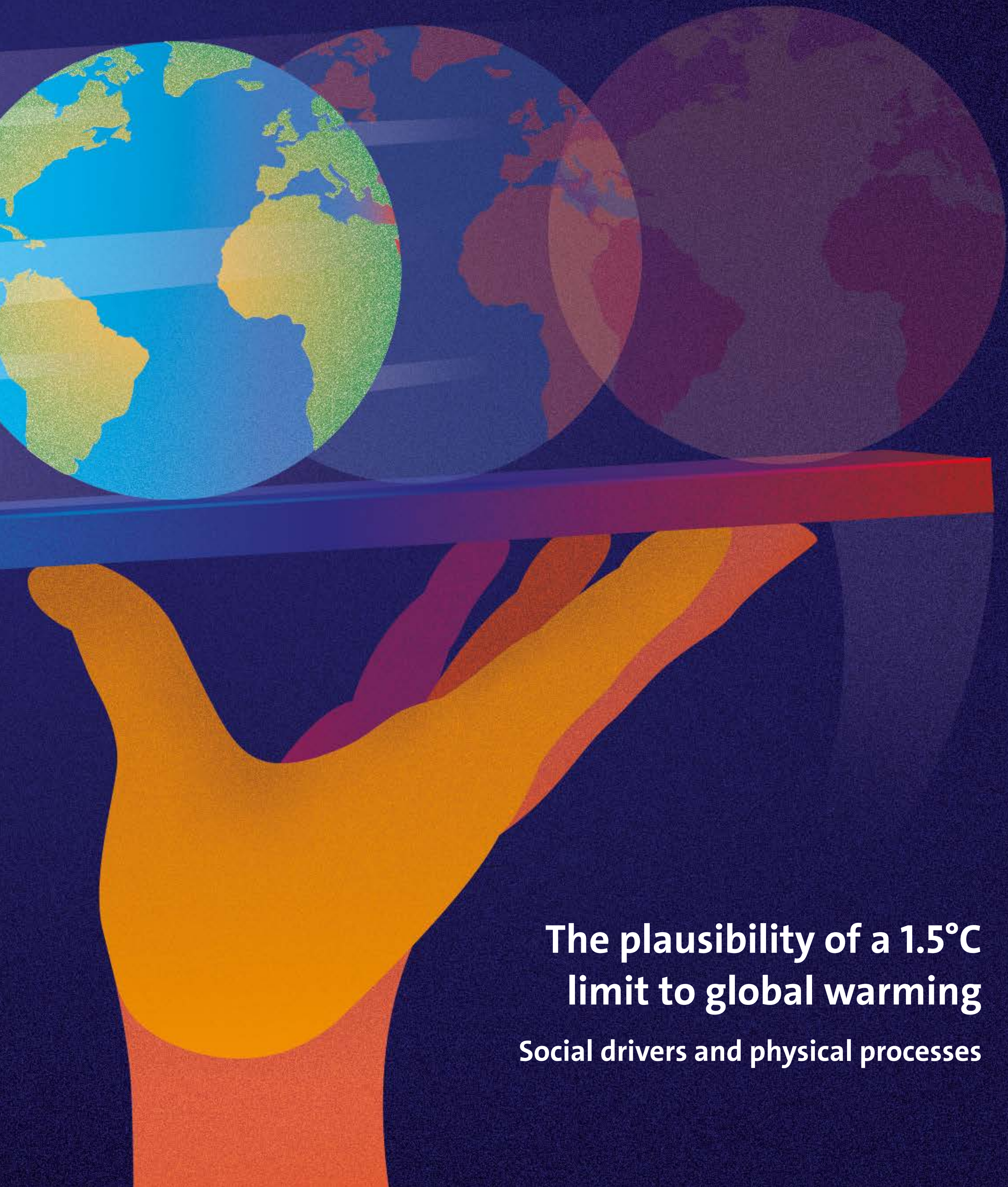
HAMBURG CLIMATE FUTURES OUTLOOK



The plausibility of a 1.5°C limit to global warming

Social drivers and physical processes

BOX II The Planck response and the stabilization of the global surface temperature

This box addresses concerns in the public discourse that global warming might develop into a runaway climate instability, perhaps similar to what is thought to have happened on Venus during the early Solar System (e.g., Ingersoll, 1969). The concern is voiced particularly frequently in connection with permafrost thaw, which is expected to cause additional emission of the greenhouse gases CO_2 and methane (CH_4) into the atmosphere (Section 6.2.1). Discussing the scientific foundations of these concerns requires a general discussion of feedback processes in the climate system.

A climate feedback can amplify climate change and thus have a destabilizing effect, or it dampens climate change and thus has a stabilizing effect. In technical usage, an amplifying feedback is called “positive feedback” and a dampening feedback “negative feedback”, in stark contrast to the everyday use of the terms. There, “positive feedback” is usually interpreted as “encouraging comment” and carries positive connotations. In technical usage, by contrast, a positive feedback is that which tends to create instability, usually carrying negative connotations.

Physical climate science invests large efforts in quantifying the magnitudes of feedback processes, especially those affecting the evolution of the global surface temperature (e.g., Forster et al., 2021, WGI AR6 Chapter 7). A positive feedback affecting global surface temperature increases the amount of surface warming following a certain magnitude of anthropogenic CO_2 emissions and thus constrains the attainment of the Paris Agreement temperature goals, whereas a negative feedback decreases the amount of surface warming and thus enables attainment of the temperature goals.

For example, permafrost thaw leads to a positive feedback between surface warming, increased atmospheric concentration of greenhouse gases CO_2 and CH_4 previously stored in the permafrost, and hence further surface warming (e.g., Canadell et al., 2021, WGI AR6 Chapter 5; Section 6.2.1). This feedback thus constrains the attainment of the Paris Agreement temperature goals. Moreover, this feedback often gives rise to concern since permafrost thaw is viewed as a potential tipping element (e.g., Lee et al., 2021, WGI AR6 Chapter 4) and is often feared to cause a runaway climate instability (e.g., Canadell et al., 2021, FAQ 5.2). However, the public discourse and even part of the scientific discourse frequently overlook the following. The climate system contains a dominating negative feedback, in that rising global surface temperature leads to increased energy loss to space, an increase that tends to cool the climate. This feedback, sometimes called the Planck temperature response (e.g., Forster et al., 2021 , WGI AR6 Chapter 7), can be viewed as the fundamental physical enabling condition for any climate goal since it keeps the global surface temperature stable, albeit at a higher level following anthropogenic CO_2 emission. The positive feedback arising from permafrost thaw counteracts the Planck response but is much weaker than the Planck response in the current climate (compare Canadell et al., Figure 5.29c to Forster et al., 2021, Table 7.10).

In summary, permafrost thaw amplifies global warming and constrains the attainment of the Paris Agreement temperature goals but cannot cause a runaway climate instability (e.g., Canadell et al., 2021, FAQ 5.2). A runaway is prevented by the stabilizing Planck temperature response.

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