

Introduction

Compound hot-dry events are becoming more frequent and severe in various regions of the world. It is therefore crucial to understand and project their future characteristics to develop effective strategies to adapt to and mitigate their impacts. However, future projections are subject to uncertainty and require thorough analysis to interpret the implications of climate change and make informed policy decisions to mitigate associated risks.

Objective

This study employs a CMIP6 multi-model ensemble to investigate the uncertainty in projected changes in compound hot-dry events. It further cascades the uncertainty into uncertainties associated with the definitions of these events, GCMs, and SSPs using the variance decomposition-same sample size (VD-SSS) method, which corrects overestimations from sources with larger sample sizes.

Data and methods

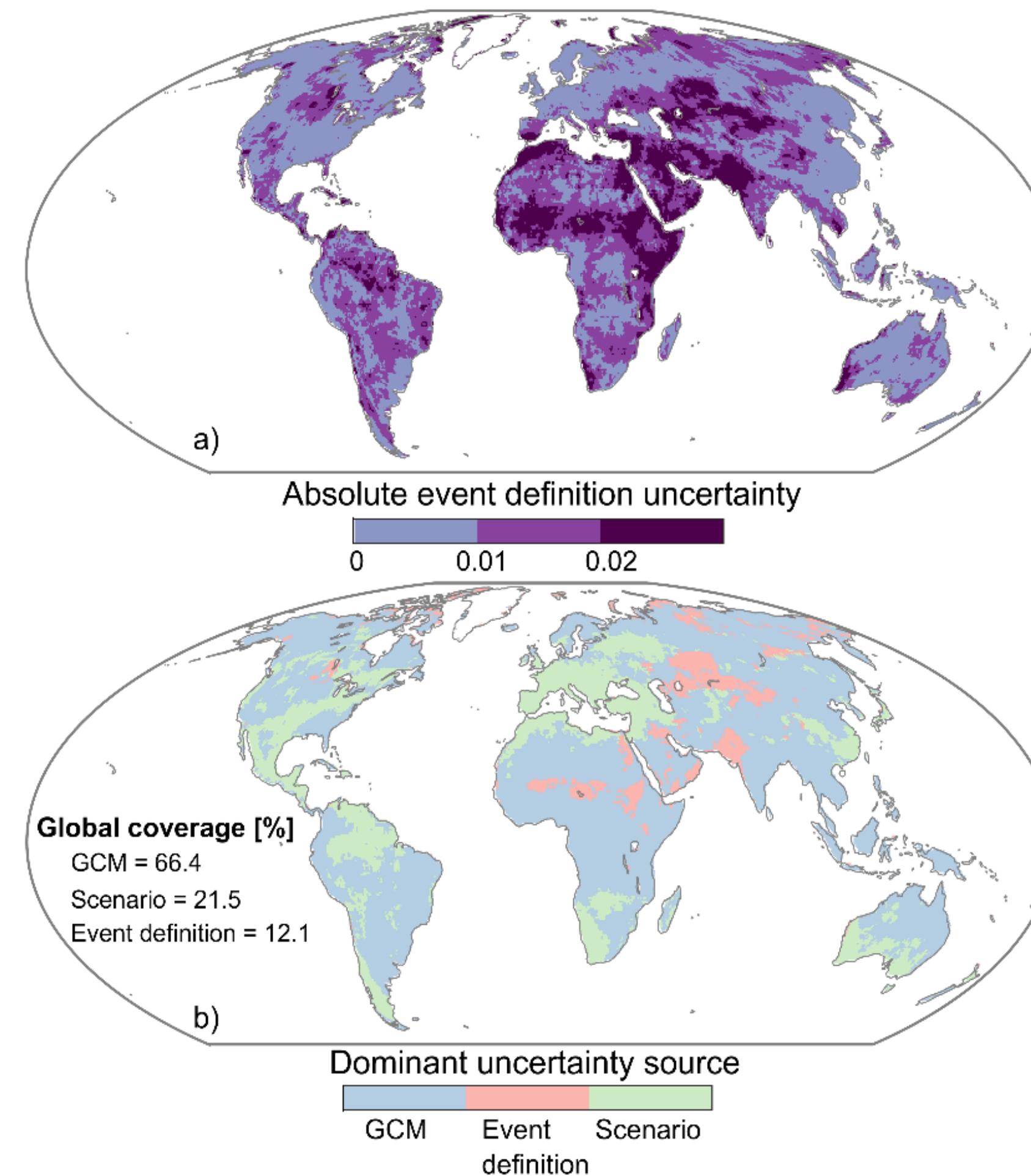
- Precipitation flux
- Total runoff
- Total soil moisture content
- Air temperature
- 22 CMIP6 GCMs

Four Shared Socioeconomic Pathways (SSPs)

- SSP1-2.6
- SSP2-4.5
- SSP3-7.0
- SSP5- 8.5

Standardized compound hot-dry event index

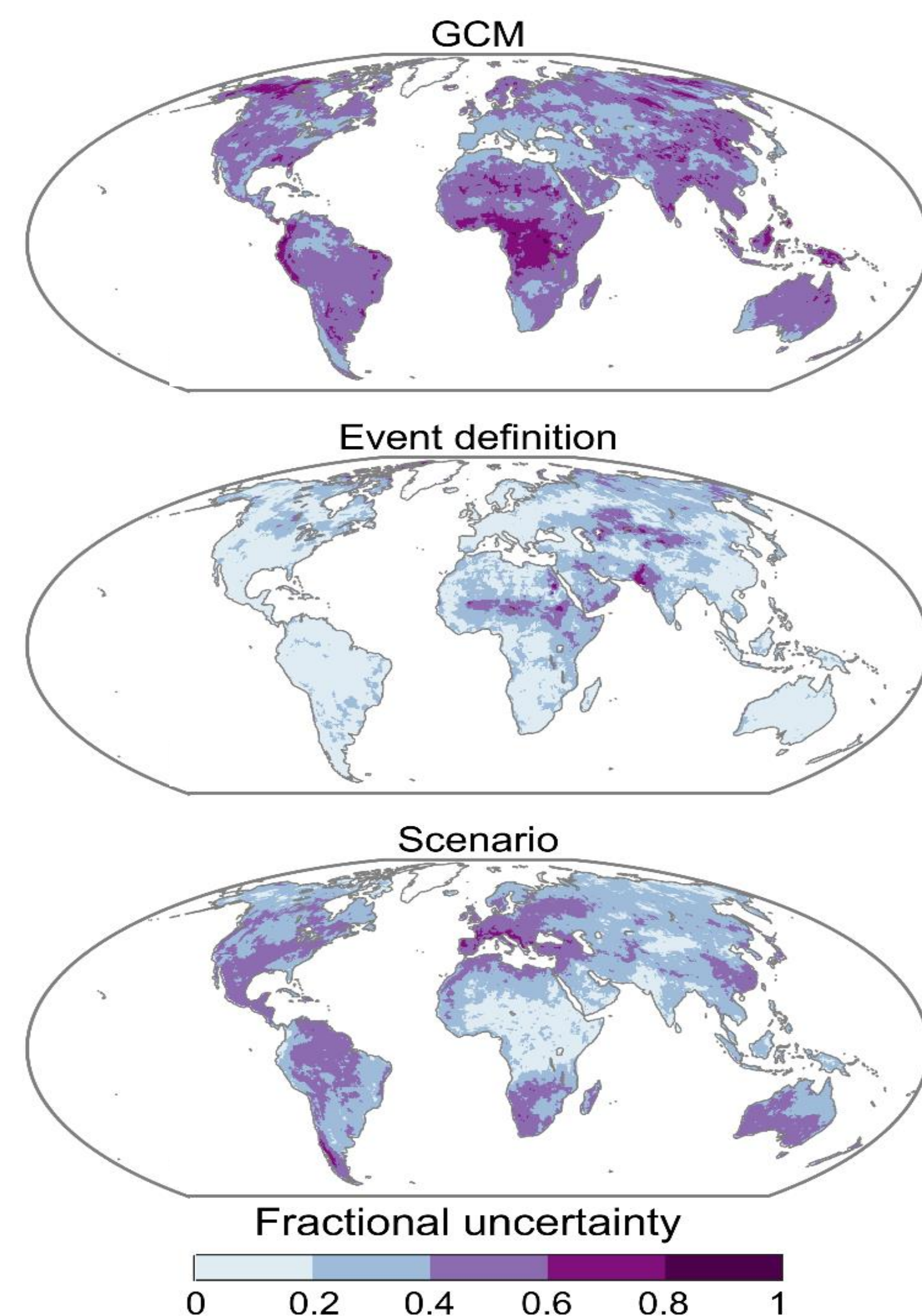
- HDI(P): For precipitation
- HDI(R): For runoff
- HDI(S): For soil moisture
- HDI(MSDI): For precipitation, runoff, and soil moisture based on a multivariate standardized drought index (MSDI)



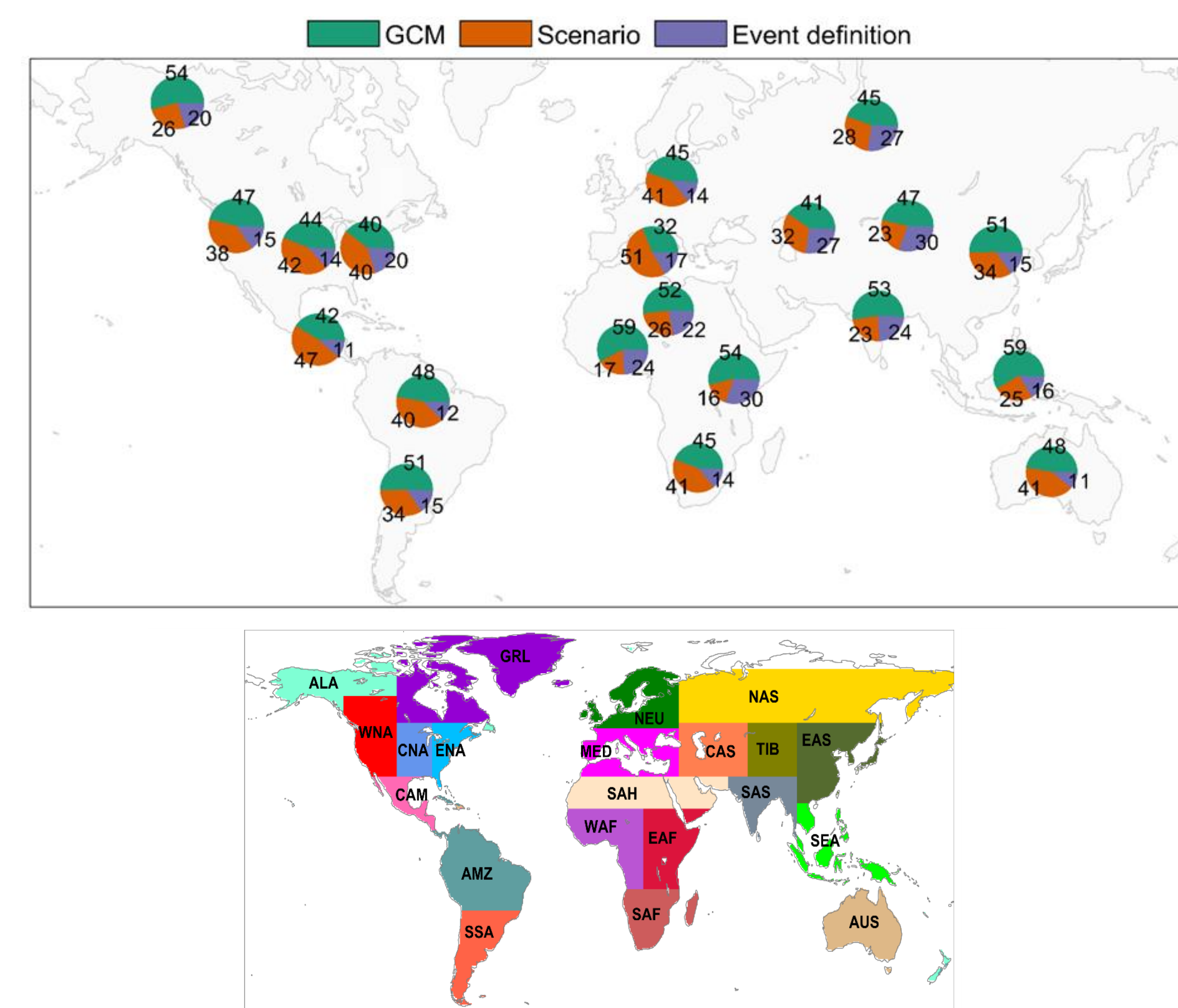
(a) Spatial distribution of absolute uncertainty in the definition of dry events for compound hot-dry events, and (b) its importance in relation to the uncertainties in GCMs and scenarios

Conclusions

- GCM uncertainty emerges as the dominant source of uncertainty in 17 out of 20 regions, accounting for an average of 48% across the regions. GCM uncertainty dominates the total uncertainty of compound hot-dry event projections, being the dominant source in 66% of the global land area.
- Scenario uncertainty takes precedence in Central America and the Mediterranean, while holding a slight margin in eastern North America: 40.3% for scenario uncertainty compared to 39.8% for GCM uncertainty.
- On average across the regions, the uncertainty associated with scenarios is 33%, while the uncertainty related to the dry event definition for compound events averages at 19%. Notably, the uncertainty related to the event definition surpasses the scenario uncertainty in four regions: east and west Africa, South Asia, and Tibet. Additionally, a noticeable uncertainty related to the dry event definition (i.e., 27%) is seen in central and north Asia regions.
- The dry event definition for compound hot-dry events is largest in the Middle East and parts of central Asia and central Africa, accounting for 12% of the global land area. Scenario uncertainty of > 40% in compound hot-dry event projections is observed in 27% of the global land area, while the dry event definition uncertainty of > 40% is seen in 11% of the global land area.
- The uncertainty associated with the event definition was substantial, reaching up to 30% in certain regions and even surpassing the uncertainty attributed to scenarios



Spatial distribution of fractional uncertainties associated with GCMs, dry event definitions for compound hot-dry events, and scenarios, calculated using the VD-SSS method.



Fractional contribution of individual sources to total uncertainty in projected changes in the probability of compound hot-dry events in the continental and subcontinental regions by 2061–2100 relative to 1971–2010. Event definition uncertainty represents the uncertainties associated with the choice of the index among HDI(P), HDI(R), HDI(S), and HDI(MSDI)

