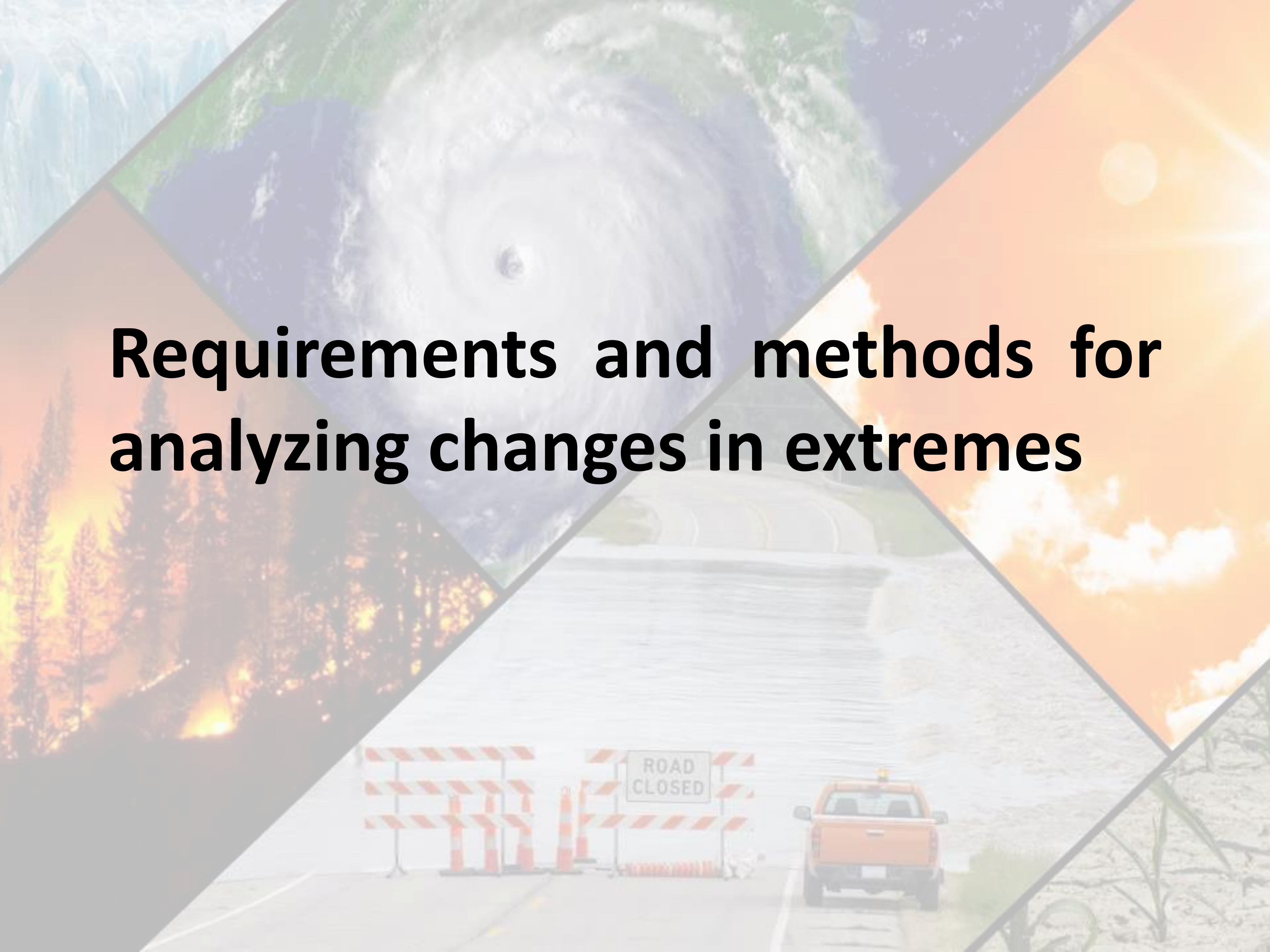
Requirements and methods for analyzing changes in extremes



Requirements and Methods for Analyzing Changes in Extremes

In this section issues are discussed related to the data and observations used to examine observed changes in extremes.

- Indeed, the more rare the event, the more difficult it is to identify long-term changes, simply because there are fewer cases to evaluate Identification of changes in extremes is also dependent on the analysis technique employed
- Another important criterion constraining data availability for the analysis of extremes is the respective time scale on which they, since this determines the required temporal resolution for their assessment (e.g., heavy hourly or daily precipitation versus multi-year drought)

normally requires the use of high-temporal resolution data, such as daily or sub-daily observations, which are generally either not available, or available only since the middle of the 20th century and in many regions only from as recently as 1970. Even where sufficient data are available, **several problems can still limit their analysis**:

First, although the situation is changing (especially for the situation with respect to ‘extreme indices), many countries still do not freely distribute their higher temporal resolution data.

Second, there can be issues with the quality of measurements.

A **third** important issue is climate data homogeneity

Is the Climate Becoming More Extreme?

Three types of metrics have been considered to avoid these problems, and thereby allow an answer to this question.

One approach is to count the number of record-breaking events in a variable and to examine such a count for any trend. However, one would still face the problem of what to do if, for instance, hot extremes are setting new records, while cold extremes are not occurring as frequently as in the past.

Another approach is to combine indicators of a selection of important extremes into a single index, such as the Climate Extremes Index (CEI), which measures the fraction of the area of a region or country experiencing extremes in monthly mean surface temperature, daily precipitation, and drought.

A third approach to solving this dilemma arises from the fact that extremes often have deleterious economic consequences. It may therefore be possible to measure the integrated economic effects of the occurrence of different types of extremes into a common instrument such as insurance payout to determine if there has been an increase or decrease in that instrument.

CONCLUSION

Thus we are restricted to questions about whether specific extremes are becoming more or less common, and our confidence in the answers to such questions, including the direction and magnitude of changes in specific extremes, depends on the type of extreme, as well as on the region and season, linked with the level of understanding of the underlying processes and the reliability of their simulation in models.

The Causes behind the Changes

This section discusses the main requirements, approaches, and considerations for the attribution of causes for observed changes in extremes.

Human-Induced Changes in the Mean Climate that Affect Extremes

- Most of the observed increase in global average temperatures is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.

- In study, an anthropogenic signal was detected in 20th-century summer temperatures in Northern Hemisphere subcontinental regions except central North America,
- Also the inclusion of additional forcing factors, such as land use change and aerosols that can be more important at regional scales,
- emerging evidence of human influence on global atmospheric moisture content and precipitation.

Has Climate Change Affected Individual Extreme Events?

challenging to associate a single extreme event with a specific cause such as increasing greenhouse gases because a wide range of extreme events could occur even in an unchanging climate, and because extreme events are usually caused by a combination of factors.

Projected Long-Term Changes and Uncertainties

In this section we discuss the requirements and methods used for preparing climate change projections, with a focus on projections of extremes and the associated uncertainties.

1- Information Sources for Climate Change Projections

Work on the construction, assessment, and communication of climate change projections, including regional projections and of extremes, draws on information from four sources:

(1) GCMs;

(2) downscaling of GCM simulations;

(3) physical understanding of the processes governing regional responses;

(4) recent historical climate change

2- Uncertainty Sources in Climate Change Projections

Uncertainty in climate change projections arises at each of the steps involved in their preparation: determination of greenhouse gas and aerosol precursor emissions (driven by socioeconomic development and represented through the use of multiple emissions scenarios), concentrations of radiatively active species, radiative forcing, and climate response including downscaling. Also, uncertainty in the estimation of the true ‘signal’ of climate change is introduced by both errors in the model representation of Earth system processes and by internal climate variability.

3- Ways of Exploring and Quantifying Uncertainties

Uncertainties can be explored, and quantified to some extent, through the combined use of observations and reanalyses, process understanding, a hierarchy of climate models, and ensemble simulations. Ensembles of model simulations represent a fundamental resource for studying the range of plausible climate responses to a given forcing . Such ensembles can be generated either by (i) collecting results from a range of models from different modelling centers (multi-model ensembles), to include the impact of structural model differences; (ii) by generating simulations with different initial conditions (intra-model ensembles) to characterize the uncertainties due to internal climate variability; or (iii) varying multiple internal model parameters within plausible ranges (perturbed and stochastic physics ensembles), with both (ii) and (iii) aiming to produce a more systematic estimate of single model uncertainty .