CSQ-10 Summary

Question	Knowledge Advancement Objectives	Geophysical Observables	Measurement Requirements	Tools & Models	Policies / Benefits
How can we improve the characterization and preparedness for risks related to compound climate extremes?	• Characterize and quantify risks related to heat waves and linked compound effects including droughts and fires.	• Temperature, soil moisture, humidity, clouds, winds, FRP, vegetation, land use,	In general specifications are commensurate with local climate models	ESMs, RCMs, statistical downscaling, event attribution	Improved climate adaptation (UNFCCC Loss and damage, IPCC WG), disaster response (Sendai), general sustainability and SDGs.
	• Characterize and quantify risks related to flooding and heavy precipitation in specifically vulnerable areas like coastal areas.	• Precipitation, humidity, sea level, river discharge, wind,	Sufficient repeat measurements at requisite scales to adequately capture short duration pluvial extremes	ESMs, RCMs, statistical downscaling, event attribution	
	• Characterize processes, environmental conditions related to extreme air quality events, like haze formation and serious air pollution events during heat waves.	• Aerosols (AOD, size distribution, type), air quality, UV-radiation, • Meteorological conditions	Synoptic and mesoscale measurements to understand pollution event scale, duration and evolution	Development of aerosol proxies or improved observations for aerosol size distribution. ESMs, RCMs	
	• Quantify environmental, social and economic hazards and impacts linked to climate extremes in local and regional scales.			Utilize also AI techniques, especially in socio-economic responses of systems to extreme events	

CSQ-10 Narrative

Simultaneous (in space and / or time) or sequential extreme events, which may or may not be extreme individually, can in combination lead to a compound extreme event that can cause severe environmental, economic, and societal impacts. Examples include coincident heatwave and drought, or pluvial river flooding combined with storm surge in the estuarine zone (amongst many others). Risk assessment of these *compound* hazards is particularly challenging and often underestimated (IPCC-21). An improved understanding of environmental vulnerability and risks related to compound events is therefore needed. Furthermore, quantification of the economic and societal hazards and impacts are also needed to understand climate adaptation needs arising from compound extreme events.

Climate change is affecting flooding by altering the intensity, frequency, and timing (e.g., earlier snowmelt) of floods. Rising sea levels also affect human activities and infrastructures in coastal areas in multiple ways, whilst simultaneously making coastal areas more vulnerable to damages due to storms, cyclones, and flooding.

Drought (low soil moisture and low humidity) and heatwaves are associated with increased wildfire risks. Dramatically large wildfires have recently taken place e.g. in Australia, Europe, Siberia, California, and very recently in Canada. In Australia, observations already show a long-term trend of weather conditions that may support bushfires (IPCC 2021). Whilst in 2012 – 2018 a catastrophic sequence of extreme weather events took place in southern California (Figure 1) resulting in 23 deaths. This was caused by extreme precipitation induced mudslides and debris flows on areas that had just been seriously burnt after a dry and hot season.

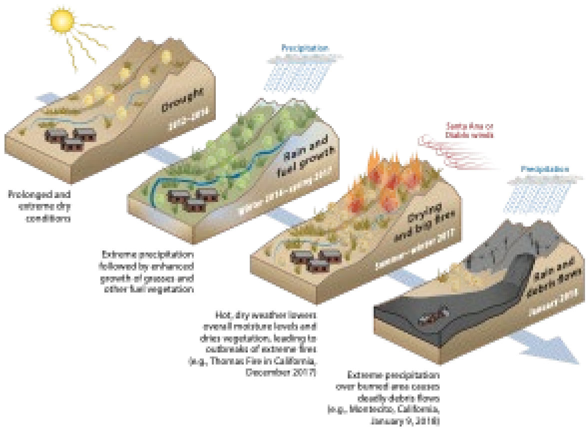

Figure 1: Example of Southern Californian compound extreme event which consisted of four events that occurred In a sequence. Figure from AghaKoucha et al., 2020.

Serious air pollution episodes are also climate related extreme events. They are often linked to suitable meteorological conditions, e.g. heat waves, but uncertainties in the details of these processes remain. For example, our understanding of haze (and new aerosol particle) formation is still limited. Furthermore, several studies indicate that the mortality risks related to air-pollution (PM2.5, PM10, ozone, NO_2) increase during heat waves. Fires and urbanisation also further amplify the compound risk of heat and air pollution.

Finally, vulnerability is a key concept in risk assessment of extreme events. In addition to environmental factors, it is known to depend on various socioeconomic, demographic, biophysical, cultural, and institutional factors. Quantifying environmental, social and economic hazards and impacts linked to climate extremes at local and regional scales can help identify the communities and regions that are most vulnerable to extreme events, and thus direct funding and planning to the areas and populations most at risk from this aspect of climate change.

References

AR6, IPCC 2021 (WG-I: Climate Change 2021, The Physical Science Basis)

AghaKouchak, A. et al., Climate Extremes and Compound Hazards in a Warming World, *Annu. Rev. Earth Planet. Sci.* 2020. 48:519–48, doi: 10.1146/annurev-earth-071719-055228