Background Information for Teachers

Over the last several years, significant media attention has centered on the historic floods in both the United States and throughout the world. The damage caused by these flooding events is astounding and many are left to wonder: How did this unprecedented flood occur? Climate change research indicates that these events are so-called perfect storms—situations where weather patterns that led to unprecedented moisture levels in the affected areas.

One such weather event occurred in Boulder, Colorado in the summer of 2013. Meteorological data indicates that the Boulder area received more than half a year's worth of rain in three short days and that 24-hour rainfall totals for those three days exceeded 20-25 cm (Freedman 2013). Why did Boulder receive such significant amounts of rain in such a short amount of time? Meteorologists point to strange weather patterns, all related to climate change.

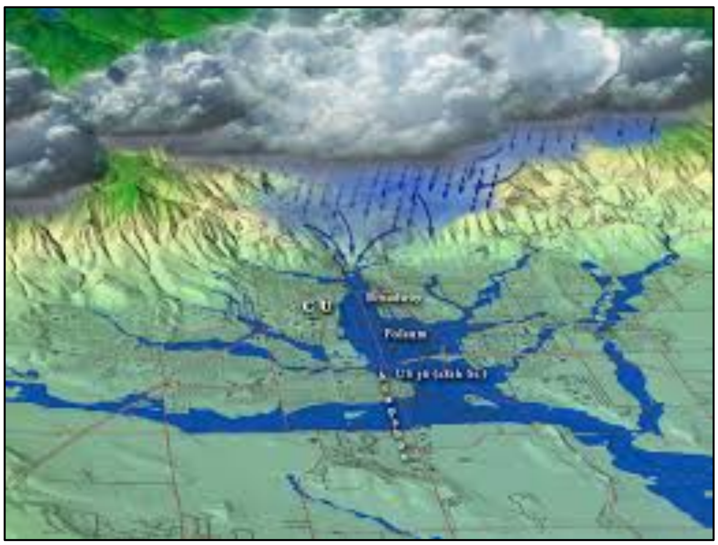

Figure 1: Boulder, Colorado Flood Plain (from floodsafety.com)

These bizarre changes in weather patterns are not confined to Colorado or the United States. Hirabayashi and associates have modeled the effects of warmer climates on flood risk (2013). Their models indicate that worldwide, the frequency of floods will increase 42% by the year 2100 and five times as many people will be affected by floods as the number of inundation zones increases (Hirabayashi et al. 2013). Their models and the interpretations of the data show there is dire need for humans to develop more robust adaptations to prevent future flood damage as well as a need to reduce global temperature by lessening greenhouse gas emissions (Hirabayashi 2013).

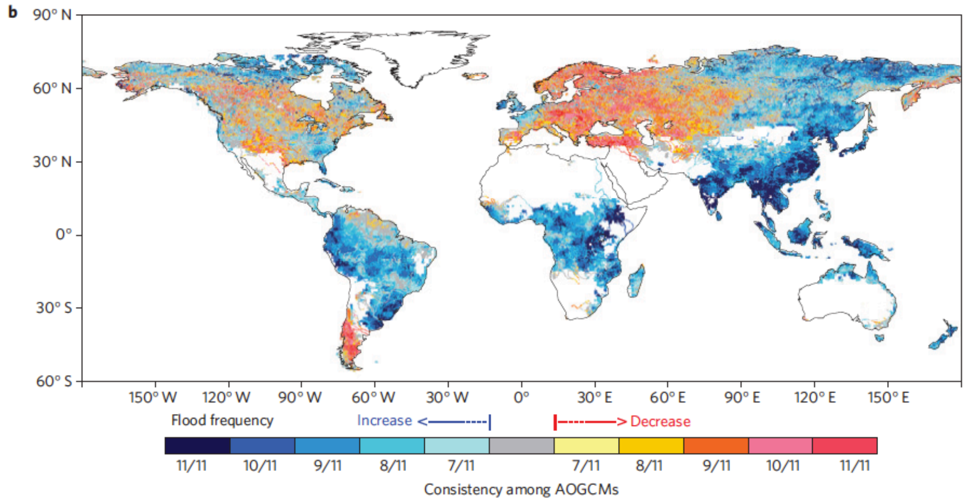

Figure 1 | Projected change in flood frequency. a, Multi-model median return period (years) in 21C for discharge corresponding to the 20C 100-year flood. **b**, Model consistency. Grid cells with mean annual discharge of a retrospective simulation[13] for 1979–2010 of <0.01 mm d^{-1} are screened out. The case for the RCP8.5 scenario is shown.

Figure 2: Projected changes in global flood frequency (Hirabayahsi 2013)

Models of Human Responses to Environmental Change

Archaeologists and other scientists have relied on models that show how human behaviors have changed as a result of environmental changes through time. These models rely on several assumptions that students will gain some insight into during this lesson. First, there is an assumption that a balance between people and the resources available in the environment is rarely achieved (Dean et al. 1985). Second, changes in the environment cannot be simply characterized as "good" or "bad;" instead these changes must be considered across time and space (Dean et al. 1985).

During this lesson, students will be looking at a snapshot of time, but should also think about long-term changes between humans and their environments. Specifically, they must understand that there is no ideal human and environment balance—their efforts to create a functional landscape favoring one human need will have affect the environment, often in unintended ways.

Human Changes to Environment and the Broad Effects

Flooding related to dam construction will change the structure of an environment, and catastrophic flood impacts may last anywhere from hours to years. Reservoirs completely change the function of ecosystems, which are immediately changed from land to water. This leads to altered species composition in plants, fishes, and wildlife.

Rivers and streams often support forested ecosystems that provide ecosystem services to humans in the form of oxygen release and water filtration. Agricultural practices have been established in flood plains and streambeds have been channelized with concrete or contained by levees. Flood plains are very fertile areas, but catastrophic flooding that tops protective levees can destroy crop harvests, leaving farmers without income and affecting the food supply at local to much larger scales. Channelized streambeds increase water speed and can lead to flooding further down the river.

Modifications of the environment may cause problems in downstream ecosystems. Dams provide electricity and water to communities while changing downstream river abiotic and biotic factors such as water temperature, sand bars, and both terrestrial and aquatic species compositions. Levees and channelized rivers increase stream flow, usually to move water out of a certain area. As a result, locations downstream must make changes due to increased water flow and changes in available nutrients. They may also be subject to more flooding than before alterations (Franklin et al. 2009).

Natural river systems provide unique habitats where species have evolved over time to native conditions. Cooler temperatures from dam water releases drive out fishes that prefer warmer waters (Valdez and Muth 2005). Sandbars and riverside habitat may disappear or be completely altered.

While humans require natural resources to support growing populations, it is important that we can pre-assess potential damage to native and human ecosystems due to catastrophic flooding events and river flow changes. This model and simulation will demonstrate to students the consequences – good and bad – of trying to control water. It will also show them what planners, managers, and landowners must consider prior to developing the landscape.

References Cited:

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