Floods

What is the difference between floods and flash floods:

Floods:

An overflow of water onto normally dry land. The inundation of a normally dry area caused by rising water in an existing waterway, such as a river, stream, or drainage ditch. Ponding of water at or near the point where the rain fell. Flooding is a longer term event than flash flooding: it may last days or weeks.

Types of floods:

River floods:

River floods are caused when consistent rain or snow melt forces a river to exceed capacity.
River Flooding can happen at any time of the year, but is most common in the late winter/early spring due to snowmelt and heavy spring rainfall. A second peak in river flooding appears in the late summer when the remnants of Tropical Storms and Hurricanes can bring heavy rain to Pennsylvania.

Coastal Floods:

Coastal floods are caused by storm surges associated with tropical cyclones and tsunami.

Coastal flooding is a sudden and abrupt inundation of a coastal environment caused by a short-term increase in water level due to a storm surge and extreme tides. The magnitude and extension depend on the coastal topography, storm surge conditions and broader bathymetry of the coastal area.

Flash Floods:

A flood caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours and rivers, streams, channels or roads may be overtaken.. Flash floods are usually characterized by raging torrents after heavy rains that rip through river beds, urban streets, or mountain canyons sweeping everything before them. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen, for instance after a levee or dam has failed, or after a sudden release of water by a debris or ice jam.

Causes of floods:

- Floods are often caused by heavy rainfall, rapid snowmelt or a storm surge from a tropical cyclone or tsunami in coastal areas
- Overflowing of the rivers , Collapsed dams , Deforestation , Emission of greenhouse gases and Climate change
- Develop slowly or quickly. Flash floods can come with no warning

Now let's on each cause

1- Heavy Rainfall:

- **Definition:**

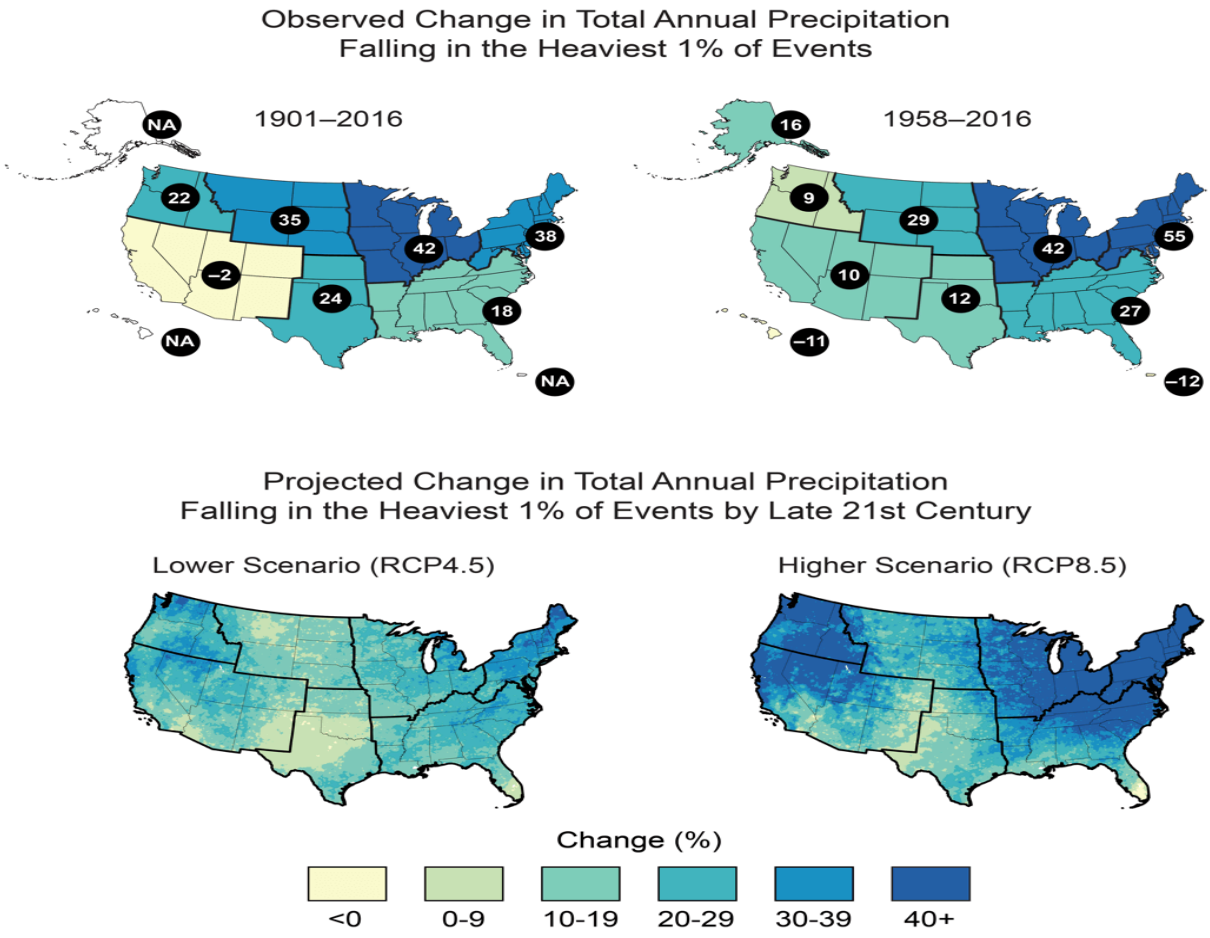
  Heavy rainfall is defined as high amounts of precipitation in a short period of time, which usually falls spatially limited and is accompanied by short warning times due to its convective origin.

- **Causes of heavy rainfall:**

  Climate change can affect the intensity and frequency of precipitation. Warmer oceans increase the amount of water that evaporates into the air. When more moisture-laden air moves over land or converges into a storm system, it can produce more intense precipitation

  Extreme precipitation events have increased in frequency and intensity in the U.S. and across many regions of the world since the 1950s

  In the contiguous United States, annual precipitation has increased at a rate of .2 inches per decade since 1901



2- Rapid SnowMelt:

What is a “snowmelt flood”? A flood is considered a snowmelt flood when melting snow is a major source of the water involved. Unlike rainfall, which reaches the soil almost immediately, snow stores the water for some time until it melts, delaying the arrival of water at the soil for days, weeks, or even months. Once it does reach the soil, the water either soaks into the ground or runs off. If more water runs off than soaks in, flooding occurs.

The causes of extreme snowmelt events identified are as follows:

1. **Pacific Northwest and Sierra Nevada:**
    - **Subtropical Jet and Atmospheric River:** Extreme snowmelt events are associated with the positioning of a subtropical jet and atmospheric river over the West Coast. This is characterized by:
        - **Pacific Northwest:** A ridge over the western United States with an enhanced IVT region oriented southwest-northeast, indicating significant moisture intrusion into the region.
        - **Sierra Nevada:** The inflection point of the ridge near the coastline, associated with strong atmospheric river conditions.
2. **Rocky Mountains:**
    - **Late Spring Timing and Ridge Amplification:** Extreme snowmelt events here are influenced by late spring conditions when temperatures and heights are higher, and ridge amplification is notable. The IVT pattern is less defined, suggesting that the timing and seasonality of snowmelt are more significant factors than moisture transport.
3. **Great Lakes and Northeast:**
    - **Ridge Position and Moisture Transport:**
        - **Great Lakes:** Snowmelt events are associated with a ridge positioned over the central United States, with enhanced moisture transport from the Gulf of Mexico and frontal passages.
        - **Northeast:** Snowmelt is influenced by a similar ridge configuration, but with a more zonal and

stronger IVT structure, leading to significant moisture advection and frontal passage.

4. **Rain-on-Snow (RoS) Events:**
    - **Fronts and Troughs:** RoS events are tied to specific synoptic patterns:
        - **Northwest and Sierra Nevada:** Presence of a trough near the coast
        - **Rockies:** A trough propagating through the central United States
        - **Great Lakes and Northeast:** Frontal passages and deep moisture transport, with varying meridional orientations.
5. **Non-RoS Events:**
    - **General Synoptic Patterns:** These events are associated with broader synoptic patterns:
        - **Northwest, Sierra Nevada, and Rockies:** Amplified ridging with deeper heights indicative of warmer temperatures
        - **Great Lakes and Northeast:** Enhanced moisture transport from the Gulf of Mexico over the eastern United States

Overall, extreme snowmelt is influenced by the positioning and intensity of atmospheric ridges, moisture transport patterns, and the timing of events relative to seasonal changes.

For the three decades from 1988 to 2017, there is a weakly increasing trend of extreme snowmelt occurrence, as well as RoS-related extreme

snowmelt occurrence, though there is no clear trend for average extreme snowmelt magnitude. Regardless, as the climate system continues to evolve with global warming, extreme snowmelt will become increasingly more relevant, with implications for water availability, ecosystem stability, and potential hazards to life and property.

This July alone, Greenland's ice sheet lost 197 billion tons of ice – the equivalent of around 80 million Olympic swimming pools – according to Mottram. She told CNN the expected average would be between 60-70 billion tons at this time of year.

Tusunami:

Definition:

Tsunami is the Japanese term meaning wave ('nami') in a harbour ('tsu'). It is a series of travelling waves of extremely long length and period, usually generated by disturbances associated with earthquakes occurring below or near the ocean floor

Causes:

1-Earthquakes

2-Landslides

3-Volcanic ereuptions

4- Meteorite impacts

5- Most frequent catalyst for tsunamis are underwater earthquakes, known as **seaquakes**

But not every earthquake under water triggers a tsunami - strictly speaking, **only 10 to 20 percent of all seaquakes result in a giant wave**. Only when the seaquake reaches a **magnitude of 7.0 on the Richter scale** and the earth's tectonic plates shift vertically are the forces sufficient to generate a destructive flood wave.

A less frequent trigger for tsunamis are **volcanic eruptions**. These can eject enormous amounts of rock and ash into the sea, creating a **pressure wave that can trigger a tsunami**. One such example is the eruption of the stratovolcano on Knight Island (Papua New Guinea) in 1888. The natural event was followed by a tsunami that devastated neighboring islands.

- **Deforestation**:

Definition:

Deforestation is the purposeful clearing of forested land. Throughout history and into modern times, forests have been razed to make space for agriculture and animal grazing, and to obtain wood for fuel, manufacturing, and construction.

Effects of Deforstation:

Destruction of Millions of Acres

While exact statistics are challenging to determine, the World Resources Institute reported a loss of over 2.9 million acres of tropical forest in 2018 alone, including an area the size of Belgium of untouched rainforest. The destruction of these forests jeopardizes global climate, displaces wildlife, and deprives communities of essential resources.

Unsustainable Agricultural Development

According to the Food and Agriculture Organization (FAO) of the United Nations, land conversion for large-scale agricultural production is the leading cause of tropical deforestation, accounting for about 80% of forest loss. Land is often cleared using slash-and-burn techniques to create fields for commercial agriculture, palm oil production, soy farming, or cattle ranching. Such methods are major contributors to wildfires in rainforests, as seen in 2019.

Immense Biodiversity Loss

Rainforests are home to 80% of the world's terrestrial biodiversity, which is fundamental to life on Earth. For instance, the FAO states that one-quarter of all modern medicines are derived from rainforest plants. The destruction of these tropical forests not only

results in the loss of critical species but also eliminates the potential for discovering many others.

Major Contributor to the Climate Crisis

NASA estimates that the trees in the Amazon contain more than a decade's worth of human-generated greenhouse gases. When these trees are cut down, they release vast amounts of gases, such as carbon, back into the atmosphere, ultimately altering the planet’s temperature and destabilizing global climate.

Floods that was caused by each reason:

Heavy Rainfall:

Total Accumulated Rainfall

Flood risk thresholds vary by region, but common warning levels are:

50 - 100 mm of rain in 24 hours: Moderate flood risk.

100 - 150 mm in 24 hours: High flood risk.

Above 150 mm in 24 hours: Extreme flood risk, especially in low-lying areas or near rivers.

Soil Saturation Level:

- **100% soil moisture saturation**: Once the soil reaches its maximum water-holding capacity, any additional rainfall leads to runoff, increasing flood risk.
    - **Measurement**: Typically measured in volumetric water content (VWC), where 100% saturation is the maximum amount of water the soil can hold.

1975 Flood(Egypt):

Heavy rains caused the Nile River to overflow, leading to widespread flooding in Cairo and surrounding areas. The floods caused significant damage to infrastructure and homes.

1993 Mississippi River Flood (USA):

This catastrophic flood affected several states, causing extensive damage and displacing thousands of people. Prolonged heavy rainfall led to record river levels.

2021 Floods (Egypt):

In October 2021, heavy rainfall in Cairo and other areas caused street flooding and disruptions in traffic, highlighting the challenges of drainage in urban areas.

Rapid SnowMelt:

Indicators:

Temperature

Above freezing temperatures: When temperatures rise above 0°C (32°F) for an extended period, snow begins to melt.

Significant snowmelt occurs when daytime temperatures are between 5°C to 15°C (41°F to 59°F), especially when nights remain above freezing.

Snow Water Equivalent (SWE)

SWE measures the amount of water contained in snow. It is the depth of water that would result if the snow melted completely.

High SWE values (e.g., above **100 mm**) indicate that a significant volume of water is stored in the snowpack, posing a greater flood risk during rapid melt periods.

Rate of Snowmelt:

Rapid snowmelt: Occurs when more than **25 mm (1 inch)** of snow-water equivalent melts in a single day. This often leads to runoff that can overwhelm rivers and drainage systems.

Very rapid snowmelt: Melting at a rate of **50 mm (2 inches) or more per day** significantly increases the chance of flooding.

Wind and Humidity:

Strong winds and **low humidity** can accelerate snowmelt by increasing evaporation rates, leading to faster snow loss.

Wind speeds of **10 to 20 km/h** or more can intensify the snowmelt process.

The Great Flood of 1937 (USA):

A combination of heavy rainfall and rapid snowmelt in the Ohio River Valley led to one of the most devastating floods in U.S. history, affecting states like Kentucky, Indiana, and Ohio.

The 1996 Spring Floods (USA):

Rapid snowmelt in the Midwest, particularly in the Upper Mississippi River Basin, caused widespread flooding, displacing thousands and damaging infrastructure.

Tusunami:

Seismic Activity (Earthquakes):

Magnitude of Earthquake: Tsunamis are often triggered by undersea earthquakes with magnitudes of 7.0 or higher. The larger the earthquake, the more likely it is to generate a tsunami.

An undersea earthquake of magnitude **8.0** or higher typically has a significant tsunami risk, especially if its epicenter is near the coast.

Depth of Earthquake: Shallow earthquakes (within **0 to 30 km** below the seafloor) are more likely to generate tsunamis.

Wave Speed: Tsunami waves travel very fast across the ocean, at speeds of up to **800 km/h (500 mph)** in deep water. However, near coastlines, the waves slow down but increase in height.

Wave Height: Tsunami wave heights can range from **0.5 meters to over 30 meters** when they reach shore. Even smaller waves (e.g., **1 to 3 meters**) can cause severe flooding and destruction.

A sudden rise of **0.5 meters or more** in the deep ocean detected by these buoys can indicate a tsunami is underway.

Time Between Earthquake and Tsunami

Proximity to Epicenter: If you're near the earthquake's epicenter, the tsunami can arrive in **minutes** (e.g., within 10 to 30 minutes). Farther away, it can take **hours** for the tsunami waves to reach.

Example: If an earthquake occurs 300 km away from the coast, a tsunami may reach the shore in about **30 to 45 minutes**.

2004 Indian Ocean Tsunami:

- **Date:** December 26, 2004
- **Magnitude of Earthquake:** 9.1–9.3 (Sumatra-Andaman earthquake)
- **Countries Affected:** Indonesia, Thailand, Sri Lanka, India, Maldives, Malaysia, Myanmar, Somalia, and other surrounding regions.
- **Flood Impact:** The tsunami caused massive flooding in coastal areas, with waves reaching heights of up to 30 meters (98 feet) in some places. Low-lying areas were inundated, destroying entire villages, cities, and infrastructure.
- **Casualties:** Over 230,000 people lost their lives, making it one of the deadliest natural disasters in recorded history.
- **Economic Damage:** Billions of dollars in damages, with large-scale destruction of homes, businesses, and tourism infrastructure.

2011 Tōhoku (Great East Japan) Tsunami

- **Date:** March 11, 2011
- **Magnitude of Earthquake:** 9.0 (off the coast of Tōhoku, Japan)
- **Countries Affected:** Primarily Japan, but also coastal areas in the Pacific, including the west coasts of North and South America.
- **Flood Impact:** The tsunami waves reached heights of up to 40.5 meters (133 feet), causing widespread flooding along Japan's northeastern coast. Entire towns were submerged under water, with waves traveling as far as 10 kilometers (6 miles) inland.

- **Casualties:** Around 18,500 people died or went missing.
- **Nuclear Disaster:** The flooding led to the Fukushima Daiichi nuclear power plant meltdown, causing long-term environmental damage.
- **Economic Damage:** Estimated damages of $235 billion, making it the costliest natural disaster in history.

1964 Alaska Tsunami:

- **Date:** March 27, 1964
- **Magnitude of Earthquake:** 9.2 (Prince William Sound, Alaska)
- **Countries Affected:** Alaska, Canada, U.S. west coast, Hawaii.
- **Flood Impact:** The tsunami caused flooding along Alaska's southern coast, with waves reaching heights of up to 67 meters (220 feet) in certain areas due to localized effects. Coastal towns like Valdez and Seward were severely flooded and destroyed.
- Casualties: 131 people were killed, including in Alaska, Oregon, and California.
- **Economic Damage:** Billions in damages to infrastructure, ports, and coastal communities.

Resources

https://www.weather.gov/mrx/flood_and_flash

https://www.ready.gov/floods

https://www.epa.gov/climate-indicators/climate-change-indicators-heavy-precipitation#:~:text=Warmer%20oceans%20increase%20the%20amount,heavier%20rain%20and%20snow%20storms.

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Flood Research has ended :)