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GUIDE

Reporting on Atmospheric Rivers

by Chad Small and Rachel Ramirez

Definition/Overview

Atmospheric Rivers, or ARs, are large filaments of water vapor that move globally from the tropics to midlatitudes. When ARs make landfall, they are often associated with precipitation as that water vapor condenses into rain or snow.

While ARs *technically* take place all year long (i.e., water vapor transport takes place year-round), precipitation associated with ARs is usually experienced during the colder seasons of the year (October through March in the Northern Hemisphere and May through September in the Southern Hemisphere). This precipitation mostly takes place during colder seasons because the subtropical jet stream — a band of midlatitude winds that spans each ocean basin — is strongest during the winter. This jet stream both enhances the transport of moisture and helps with the development of coastal meteorology that leads to storms that bring rain or snow.

Example of how it's been explained/described in articles:

From Rachel Ramirez, CNN:

> *Imagine a long river of water vapor in the sky coming into the West Coast.*
>
> *The storms are called "atmospheric rivers," which are narrow bands of concentrated moisture in the atmosphere emerging from the warm waters of the Pacific Ocean, cruising more than two miles above the sea.*

Why atmospheric rivers matter

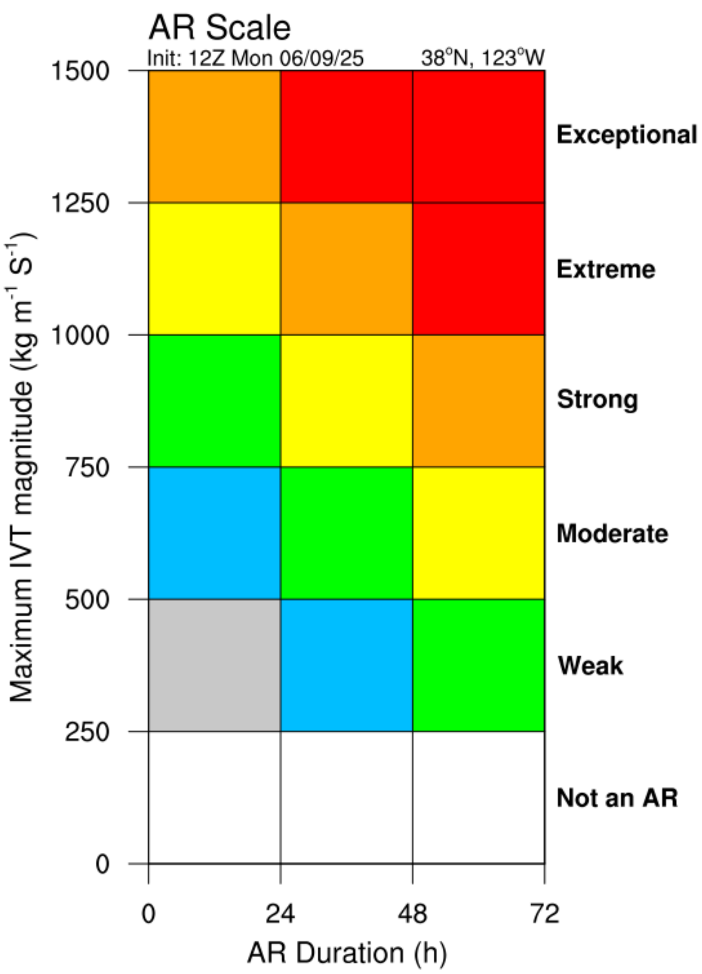
If you live on the West Coast of the U.S., you've likely noticed the uptick in weather stories about ARs recently. That's for good reason (from a science communication perspective, at least)! Eighty percent of all flood damage on the West Coast is AR-related. Additionally, ARs cause about $1 billion in damages each year. Much of this damage is because the most torrential AR-related precipitation can be difficult to prepare for in the long term. Seasonal forecasts that emergency managers, farmers, and others use to gauge the likelihood of a dry or wet season can often be disrupted by ARs.

With the longest ARs being about ten days, and seasonal forecasts trying to predict three months of time, there ends up being a forecasting mismatch. Because some ARs can generate 50 to 75 percent of a region's expected annual rainfall all at once, ARs can make long-term infrastructure development and emergency management plans difficult to develop safely. The AR forecasting problem is one that many scientists are still trying to solve.

Tracking ARs and AR Intensity

ARs are often tracked by [vertically integrated vapor transport](), or IVT. IVT effectively measures how much moisture is in the atmosphere and how quickly it is moving. The Center for Western Weather and Water Extremes (CW3E) at Scripps Institution of Oceanography has developed an [AR intensity scale]() that utilizes AR duration and IVT intensity to determine the intensity of an AR. You can think of this scale like the Saffir-Simpson Scale used for hurricanes and typhoons (Category 1-5). ARs are ranked from 1 (weak) to 5 (exceptional).

Good nugget to add in stories: *An average atmospheric river transports more than 20 times the water the Mississippi River does, as vapor.*



Climate connection

News reports are beginning to attribute severe precipitation events on the East Coast as well as in Gulf States, with ARs. Additionally, climate change will further complicate how ARs affect weather extremes. Warming temperatures will increase moisture availability for ARs — potentially making them rainier. Warming wintertime temperatures could also weaken the intensity of the subtropical jet stream which could change — or perhaps limit — the frequency at which precipitating systems occur on the West Coast.

Beyond that, ARs coupled with climate change could have counterintuitive impacts on drinking water availability in the West. Many western states rely on snowpack to provide year-long potable water supplies. Warmer ARs could precipitate as rain more often than snow. This not only limits the growth of new snowpack, but also warm rain could melt existing snowpack.

In a nutshell: As the planet warms, the atmosphere can hold more moisture — about 7% more for every 1 degree C increase in temperature. This creates a paradox:

- **More intense droughts:** A warmer atmosphere acts like a "thirstier sponge," pulling more moisture out of soils and vegetation, leading to more severe and prolonged droughts.
- **More intense downpours:** When that extra moisture in the atmosphere finally releases, it can result in much heavier and more intense rainfall events, leading to flash floods. So, you get longer, hotter dry spells, followed by deluges.

Other terms to know:

Extratropical cyclone: your typical storm that forms outside of the tropics, usually in the middle latitudes (where the US, Canada, Europe, etc., are located). These storms are powered by the clash of different air masses – warm air from the south mixing with cold air from the north. This clash creates fronts (like cold fronts and warm fronts) that you often hear about in weather forecasts. They can bring all sorts of weather, from light rain and clouds to strong winds, heavy snow, and even thunderstorms. They're a common part of our weather patterns.

Bomb cyclone: occurs when that everyday extratropical cyclone suddenly gets a huge burst of energy and intensifies incredibly quickly. The "bomb" part comes from a process called "bombogenesis" (or "explosive cyclogenesis"). This is a fancy way of saying the storm's central atmospheric pressure drops very rapidly – specifically, it drops at least 24 millibars (a unit of pressure) in just 24 hours. Think of it like a weather system "exploding" in strength — faster winds and heavier precipitation. It's like an extratropical cyclone on steroids!

Weather whiplash refers to the dramatic shift in weather, likely periods of drought and high precipitation. For example, after a historic megadrought in California, the state was pummeled by a series of heavy rains from an atmospheric river event.

Note: Climate change is supercharging the swings between weather extremes — wet and dry. The atmosphere's increased capacity to hold and then release water, combined with disruptions to major weather patterns, means we're likely to see more frequent, intense, and rapidly transitioning weather events, leading to greater challenges for agriculture, infrastructure, and human well-being.

Interesting research area to watch

- ARs can cause wintertime heat waves that melt Antarctic ice and snow (Scholz & Lora, 2024)
- ARs are also changing the Arctic, slowing down wintertime ice recovery (Zhang et al., 2023)
- ARs originating in certain parts of the Pacific are associated with more damaging rainfall (Prince et al., 2021)

Experts to contact

- Marty Ralph - Center for Western Weather and Water Extremes (mralph@ucsd.edu)
- Juan Lora - Yale University (juan.lora@yale.edu)
- Christine Shields - National Center for Atmospheric Research (shields@ucar.edu)
- Bin Guan - NASA Jet Propulsion Laboratory (bin.guan@jpl.nasa.gov)
- Duane E. Waliser - NASA Jet Propulsion Laboratory (duane.waliser@jpl.nasa.gov)
- Julie Kalansky - UC San Diego Scripps Institution of Oceanography (jkalansky@ucsd.edu)