AR FAQ's

General Information about Atmospheric Rivers

What is an atmospheric river?

An atmospheric river is a narrow corridor or filament of concentrated water vapor transport in the atmosphere. Atmospheric rivers occur in the lower portions of the atmosphere and, when they are forced to ascend by mountains or local atmospheric dynamics, they can produce heavy precipitation. Pineapple Express storms are a subset of atmospheric river that originate near Hawaii and impact the U.S. West Coast. Atmospheric rivers have been defined by the American Meteorological Society here.

Where do atmospheric rivers occur?

Atmospheric rivers occur all over the world outside the tropics (north of 30˚N and south of 30˚S) and are most common in the midlatitudes, between 30˚and 60˚. Using satellite data, the Space Science and Engineering Center at University of Wisconsin has developed a map of the current water vapor in the atmosphere (precipitable water) which shows where current atmospheric rivers throughout the world are located. The images can be seen here.

How much water does an atmosphere river transport?

Based on a recent study, Ralph et al., 2017, atmospheric rivers over the Northeast Pacific Ocean on average transport as much water as about 27 times the amount of water flowing through the Mississippi River.

How are atmospheric rivers measured?

Atmospheric rivers are measured multiple ways including observations from satellites radiosndes (weather balloons) and dropsondes, as well as in models. The two primary units of measurement for ARs are integrated water vapor (IWV) and integrated water vapor transport. IWV is s detected by satellites, ground-based GPS measurements, or in models and is calculated by vertically integrating the moisture in the atmosphere The units are typically cm of liquid water (the amount of water that would form if all the vapor in the atmosphere overhead was condensed and gathered on the surface). IVT is measured in climate and weather models or from dropsonde or radiosonde observations. IVT is calculated by vertically integrating the wind speed and moisture in the atmosphere, and the units are kg m^{-1} s^{-1} (the total mass of water vapor passing overreach meter of AR cross section each second). IVT is the measurement that is most often used to describe the intensity of an atmospheric river.

What are the difficulties in forecasting ARs?

During the course of their lifetimes, atmospheric rivers are born, strengthen, progress 1000s of kms more or less west to east, and then eventually dissipate altogether. During this progress, they can temporarily stall in place, change their landfall locations, intensify or weaken, interact with other ARs or remnants of previous ARs, and warm or cool. Any of those outcomes can affect AR impacts and can change with short notice. Current research is looking into better representations and forecasts of each of these factors that

can determine the impacts of ARs. ARs are also difficult to forecast as they travel and develop over the ocean because of the limited observations as compared to the number of observations over land.

What happens when an atmospheric river moves inland, beyond the coast or the Sierra?
Depending on the strength and orientation, an atmospheric river can reach far inland, spreading heavy rain and warmth to areas hundreds of miles from the coast. Research has identified certain pathways that ARs often follow inland, often through gaps in the mountains. For more information, please see Rutz et al., 2015.

What months should we expect ARs? What months have the strongest ARs? What months have the least or no ARs?
Generally impactful ARs along the U.S. West Coast occur from September through March, with the northern latitudes receiving more ARs earlier in fall and southern latitudes receiving more ARs during winter. In California, the most frequent and significant ARs occur in December, January and February. The dry summer months yield few if any AR storms.

Do ARs occur in other areas of the U.S., besides the West Coast?
Yes, ARs occur throughout the US. One example is a strong atmospheric river occurred during the spring of 2010 in the southeastern U.S., moving in from the Gulf of Mexico. That AR produced record flooding in the Tennessee Valley (Moore et al. 2012) .

Since an AR is narrow, what happens north and south of the AR core?
Generally when the AR makes landfall, the heaviest rainfall is in the narrow AR core. North of the AR core respectable rainfall occurs, but usually with lower snow levels and cooler temperatures. South of the AR core, there will be modest rainfall with mild temperatures and higher snow levels. Once the AR makes landfall, it often will drift southward along the West Coast and deposits a broad swath of precipitation. ARs often weaken as they progress southward and so it is common that an AR will deposit maximum precipitation near its initial landfall, with later landfalling precipitation from that AR weakening, until eventually the AR dissipates.

AR Scale Questions

More information about the AR Scale can be found in Ralph et al., 2019.

What is the purpose of the atmospheric river scale?
Atmospheric rivers are the source of 85% of the U.S. West Coast's heaviest rains and floods with multi-day ARs producing the most damage, but ARs also contribute 30-60% of the region's water supplies. The purpose of the scale is to better communicate the potential risks and benefits that a given AR is likely to bring by characterizing the strength, duration, and potential impacts of an atmospheric river at a specific location.

The scale helps to inform officials, the media and the public, whether an incoming atmospheric river storm is more likely to be beneficial or hazardous.

How does CW3E determine the scale of an AR?
The scale is determined for every location separately, and is based on maximum storm intensity (specifically IVT) and duration above that location. A given AR can produce different scale numbers at different locations. The forecast of an AR scale can change if the duration and/or the intensity of the AR forecast changes at a specific location. More infor

What's the difference between lower and higher numbers on the atmospheric river scale?
The lower numbers (1 or 2) on the scale indicate weaker, more-likely-to-be-beneficial, ARs that provide needed rain and snow in less hazardous forms and amounts. These can also be hazardous given certain conditions, such as when falling on already saturated soils. The higher numbers (4 or 5) indicate stronger, more-likely-to-be-hazardous ARs that have historically often produced floods, landslides, and other hazards.