

The MJO and a Tale of Two Winters

By Zack Guido

Call it a tale of two winters.

For the past two years, a series of December storms dumped rain and snow across the southwestern U.S. before clear skies and record-setting warm temperatures rang in the new year.

A La Niña event prevailed during both of these winters, and while total winter precipitation during such an event is dependably below average in the Southwest, soggy interludes can punctuate the dry spells.

This familiar story, the wet-dry seesaw, is driven not by El Niño or La Niña, but by the Madden Julian Oscillation, a pulse of storms in the tropical Pacific Ocean that periodically migrate eastward. The MJO, as climatologists call it, substantially influences weather in the Southwest, making it clear there is more to winter weather in the region than El Niño or La Niña.

The Basics of MJOs

While El Niño-Southern Oscillation (ENSO) events dictate weather over many months, the leading cause of shorter-term winter variability is the MJO.

“Of all the climate fluctuations that influence the weather, ENSO is the granddaddy”, said Mike Crimmins, climate extension specialist at the University of Arizona. “But intra-seasonal variability is controlled by the MJO.”

The MJO is an atmospheric oscillation, in which intense convective activity begins over the warm waters of the Indian Ocean, travels eastward, and dissipates over the colder waters of the eastern Pacific Ocean. Every 30 to 60 days, on average, a new burst of convection forms, and the eastward march begins anew. MJOs occur regardless of the season or year, and scientists have yet to identify what sparks them.

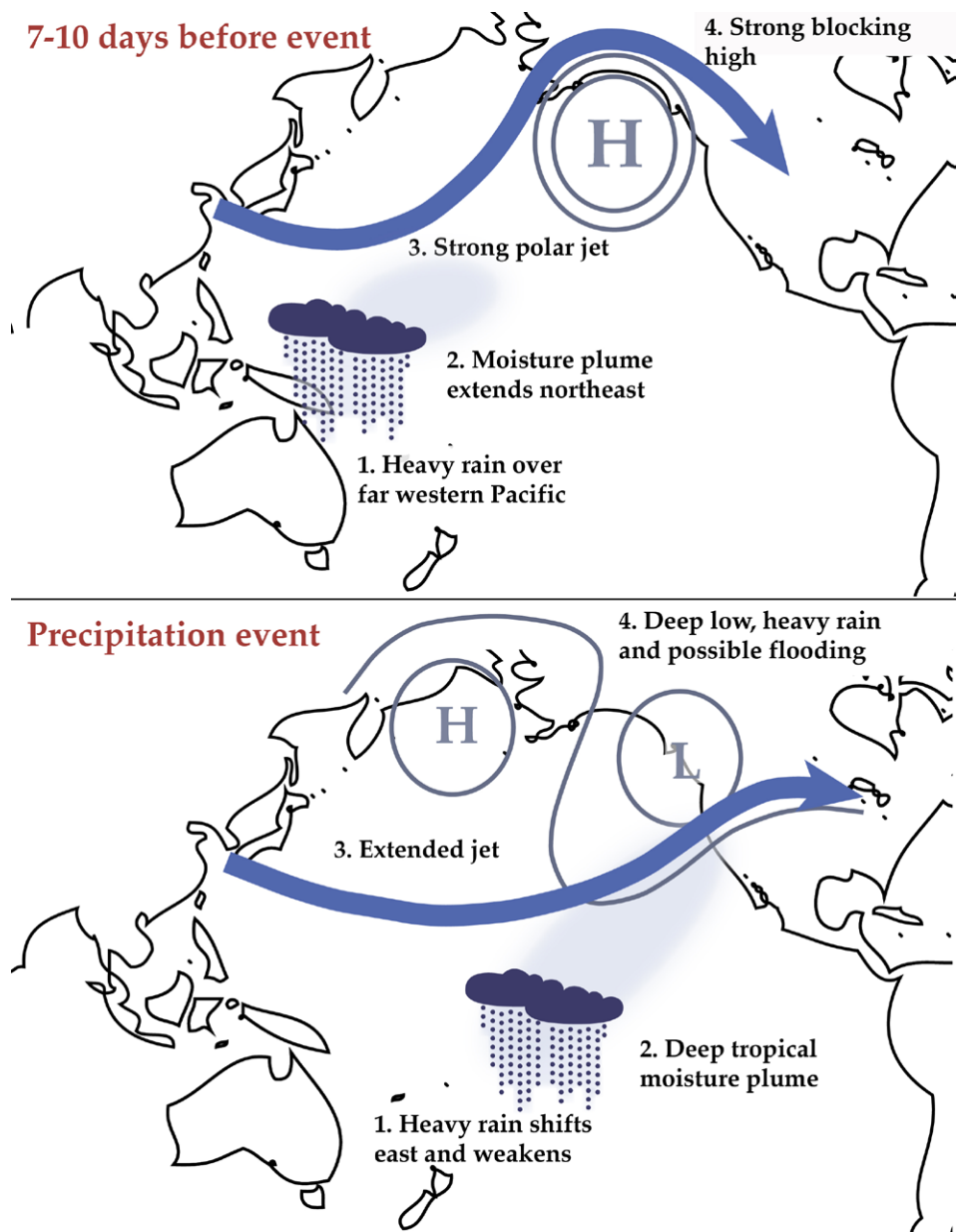


Figure 1. Generally, Madden-Julian Oscillations migrate east into the middle of the tropical Pacific Ocean where their moisture often is entrained in the jet stream and hurled into the West. *Source: modified from the NOAA-Climate Prediction Center*

“There are lots of theories about why they begin,” said Wayne Higgins, director of NOAA’s Climate Prediction Center (CPC). “There are about 100 peer review articles published about it, but I’d say it’s still an open research question.”

Researchers do understand how they evolve, however. Warm, moist air rises in

the Indian Ocean, cools, and is squeezed like a sponge, eventually flowing east and west high in the atmosphere. That air ultimately descends, colliding with the Earth’s surface and spreading horizontally. Some air is forced headstrong into the trade winds streaming from the east, causing moist air from both directions to converge and igniting another

continued on page 4

MJO, continued

round of vigorous convection. In this way the process repeats itself, and MJOs are propelled against the prevailing winds at about 11 miles per hour, or 5 meters per second. Most events pass through Indonesia and the western Pacific before waning in the central tropical Pacific Ocean. Usually only one fully developed MJO event exists at a given time. Occasionally, however, two weak events briefly coexist, with one forming while the other decays.

The effects of an MJO are far reaching, touching nearly every continent. They tune the intensity and frequency of precipitation across the Pacific islands, the Asian monsoon regions, western North America, and many other regions, and influence cyclone activity in the Pacific and Atlantic. In the U.S., Higgins said, impacts are most noticeable in the West, closer to the source.

MJO and ENSO

The frequency of MJOs appears to be related to the background climate condition unfurled by ENSO, which alters atmospheric patterns in reliable ways. During La Niña events, for example, stronger-than-average easterly winds plow warm water westward in the tropical Pacific Ocean.

The zone of rain, tethered to that warm water, also moves west. This, in turn, helps a bulge of high pressure develop off the coast of the northwestern U.S. that deflects northward the swift-moving winds in the jet stream.

This pattern partially explains why more winter storms drench the Pacific Northwest than the Southwest during La Niña events, but does not preclude wet winter spells in Arizona and New Mexico.

“When there are bursts of precipitation in the Southwest in the winter, more often than not they are related to MJO,” Higgins said.

MJO events yank the atmospheric winds much like ENSO events do. As MJOs enter the central Pacific Ocean,

they tug the high pressure bulge east and a low forms in its place. The low acts as a vortex, sucking air from the tropics. It also causes the jet stream to dive south, where it scoops moist air before slamming into the west coast (Figure 1).

MJOs tend to form more frequently during La Niña and neutral events than El Niño events and are therefore critical for providing some wet respites during otherwise dry conditions.

“In the historical record, extreme precipitation in the West occurs more often during La Niña or ENSO-neutral events,” Higgins said.

But the strength of ENSO matters.

“If you have an El Niño in full effect, the easterly winds weaken a lot and there is no wind for the MJO to propagate into,” Crimmins said. But if you have a strong La Niña, the easterly winds can be too strong, which also can cause an MJO to die out prematurely.

Weaker La Niña and neutral events present ripe conditions for more frequent MJOs. This helps explain why strong La Niñas, like the one last winter, cause drier conditions than weaker ones do.

The Near and Far

In recent years, global climate models (GCMs) have improved substantially, enabling better MJO forecasting.

The Coupled Forecast System Model, or CFS, used by the CPC, is successful at predicting MJO events and their impacts in the Southwest, said Higgins.

Based on models and current observations, the CPC provides weekly updates of MJO conditions. The most recent update, issued Feb. 13, states an MJO is on the march in the western Pacific, suggesting increased chances for precipitation for some areas across the southern tier of the U.S. through the end of February. This would bring much needed rain and snow to the Southwest,

which has generally received less than 50 percent of average in Arizona and southwestern New Mexico in the past 60 days.

Models have shown skill in accurately reproducing active hurricane periods during MJO events nine months into the future, so there is reason to believe that with continued research, outlooks that factor in MJO events will improve seasonal predictions.

Advanced information like this can help emergency managers prepare for potential floods, or reservoir managers take heed of possible swelling water storage. But the science is not quite advanced enough to forecast the effects of human-caused climate change on MJOs.

Accurately simulating MJOs in a warmer future is more challenging. It is harder to model phenomena that occur in relatively short periods, like 30 to 60 days, than it is for events that occur over longer periods. Scientists still need to be able to confidently forecast ENSO events years in advance to be able to predict how they will influence an MJO. Climate science is not yet there. Nevertheless, knowledge of MJO dynamics, the influence they wield, and how they in turn are altered add critical insights to the climate puzzle.

“We know a lot,” Higgins said. “But I’d be misleading you if I said we know all the answers.”