Video: MJO in-depth & TC interactions

Nick: (00:06)
The Madden Julian Oscillation (MJO) is the main cause of week to week and month to month variability in the weather, in the tropics. It is classed as an intra-seasonal oscillation, which means that it tends to recur once every 30 to 60 days or so on average. But the MJO is quite episodic and quite variable. So there can be periods where we have several MJO events, back-to-back-to-back, each spaced apart by maybe 30 or 40 days. And then we can have a period of a month or two with no MJO activity at all. The MJO can be split into an active phase and a suppressed phase. So when a particular region is underneath the active phase of the MJO, we tend to see enhanced convection, more rainfall, high cloud cover, stronger winds, as well. And then the suppressed phase is classed as sort of clear skies, light winds, and low rainfall activity. The MJO tends to form, it's active phases tend to form in the equatorial Indian Ocean, and then move to the east across the Indian Ocean, across the islands of Indonesia and into the Pacific, and ahead of, and behind the MJO active phases where we tend to see those suppressed conditions.

Nick: (01:25)
So in February, 2013 an active MJO event developed here in the central equatorial Indian Ocean and moved to the east and in the wake of this event, we saw several tropical cyclones form here. You can see one in each Hemisphere, one in the South and one in the North, that spin off from the MJO as Rossby waves and then an area of convection moves to the South. Here, you can see a tropical cyclone, a developing tropical cyclone, Haruna, in the Mozambique channel, that struck the southwest of Madagascar.

Nick: (01:58)
The MJO affects tropical cyclones in two ways first because the MJO convection is a source of equatorial wave activity. And those editorial waves include Rossby waves. The Rossby waves form in the wake of the MJO to the west of the active MJO convection behind it, in a sense. And those waves can spin up into tropical cyclones because they are a source of vorticity and a source of rotation in the atmosphere. And then that rotation can develop into tropical cyclones. The MJO also affects tropical cyclogenesis by modifying the background atmospheric conditions under which tropical cyclones can form and intensify. So the MJO brings moisture, it brings energy for convection with it. And it can also modify the patterns of vertical wind shear in the tropics, which are an important ingredient for tropical cyclogenesis and tropical cyclone intensification. So there's the direct effect of the MJO is a source of wave activity, a source of vorticity. And, and then there's the indirect effect of the MJO active phase as a source of moisture and energy for convection. And that helps tropical cyclones to develop and intensify whenever the MJO active phase is around.

Nick: (03:15)
We divide the MJO into eight phases, usually by the Wheeler and Hendon realtime multi-variate MJO indices. For the Southern Indian Ocean the most important MJO phases are phases two, three, and four. In phases two and three, the MJO is developing over the Indian Ocean. The active convection is becoming quite established there. And in phase four, it's moved a little bit to the east, over the islands of Indonesia. And these are the most important MJO phases because it's in the wake of the MJO, to the west, that we tend to see tropical cyclones develop and intensifying. So for the Southern and Southwestern Indian Ocean, it's those phases where the MJO was slightly to the east over the eastern Indian Ocean and over the islands of Indonesia in those phases, two, three, and four, that we tend to see most tropical cyclones form, that go on to affect Mozambique, Madagascar

and Seychelles.

Nick: (04:07)
Cyclones can form in any phase of the MJO. But we tend to see the greatest chance of tropical cyclones forming during those active MJO phases over the eastern equatorial Indian Ocean and the Maritime Continent. The MJO is not the only reason why we have tropical cyclones in this part of the world, there are many other weather systems that can cause tropical cyclones to develop.

Nick: (04:28)
In the MJO active phase we tend to see quite large-scale organized rainfall, but the rainfall tends to be on the moderate side. It's not necessarily the most intense rainfall that you're going to experience. But it is quite large scale, often a thousand or 2000 kilometres across envelope of fairly stratiform fairly moderate rainfall. During the MJO suppressed phase, despite that being when we tend to see clear skies and light winds, it is actually when we can see some of the most intense convection. Because that really strong heating of the surface from those clear skies can give rise to quite small scale, but very intense, almost popcorn style convective features you could imagine, going off and they don't tend to cover a very large area. They're not everywhere. They're quite rare events, but if you look in the historical record, some of the most intense bursts of convection that we've seen have actually been during the MJO suppressed phase.

Rebecca: (05:39)
The key phases of the MJO for this region of the world are usually phases two, three, and four, which is when the MJO is most active over the Indian Ocean. And it's most likely to cause tropical cyclones to form in this region that might impact Mozambique, Madagascar or Seychelles.

Rebecca: (05:59)
We tend to talk about the MJO in terms of its current phase and its amplitude. And we calculate those using various different indices. But the most common one to use is the realtime multi-variate MJO index. Which is calculated based on upper and lower level winds, so 850 hPa and 200hPa in the atmosphere and also the outgoing longwave radiation (OLR), which tells us about the clouds and the convection. And from all of those different conditions, we calculate this MJO index. And from that, we can work out the phase, which tells you the location of the active and suppressed convection around the world. And it also tells you about the amplitude, which is essentially the strengths of the MJO. And you can tell this by looking at phase diagrams of the, of the current MJO conditions. And if usually the amplitude is greater than one, we would say that's an active MJO.

Rebecca: (06:52)
The MJO can occur at any time of year, but it tends to be most active during November to April. And we tend to have an amplitude greater than one of the MJO about 60% of the time.

Rebecca: (07:06)
So there are a couple of different places that you can look for to get information on the current state of the MJO. There's the Australian Bureau of Meteorology website and the US National Oceanic and Atmospheric Administration website. They both show phase diagrams, which give you an idea of how the MJO has developed over the past, usually 40 days and the current phase and amplitude of the MJO. The NOAA website will also give you forecasts from different forecasting centres of how the MJO is likely to develop in the coming weeks. And those websites are linked in the resources section of the training.

Nick: (07:49)
The MJO is forecast reasonably well in numerical weather prediction models. So forecast that run out to five days or seven days or so tend to capture the evolution of individual MJO events fairly well. On sub-seasonal scales from monthly forecasts, we can usually predict, two to three weeks ahead, how an individual MJO event is going to evolve, or how it's going to propagate. One thing that we do not forecast particularly well about the MJO is the genesis of an event. So generally models perform much better when there already is an MJO event present in the tropics, than when there is no MJO event present. So we don't tend to forecast the genesis of those events well, but once an individual MJO event gets going in the Indian Ocean, then its propagation tends to be better forecast again, maybe up to two, two to three weeks ahead.

Nick: (08:44)
The MJO is quite a large scale phenomenon, thousands of kilometres across. It's made up of individual convective cells that are all developing and interacting with each other. That convection is not particularly well forecast. Where models tend to do better at describing the MJO is describing the large scale wind signals, as they, as they propagate across the tropics, because the MJO is not just convection. It is also the overturning atmospheric circulation that's associated with that convection. And that signal is large-scale and much easier for the models to be able to forecast.

Nick: (09:20)
The MJO is modified or changed by changes in both the atmosphere and the ocean on a seasonal basis. So when we have an event like an Indian Ocean Dipole (IOD) event, we tend to see that MJO activity is focused towards the warmer sea surface temperatures. So if we have an Indian Ocean Dipole event where sea surface temperatures are warmer in the eastern part of the equatorial Indian Ocean and colder in the west, we tend to see MJO activity gravitate towards the eastern equatorial Indian Ocean, which would favour MJO phases three and four, and tend to not favour MJO phases one and two. So we'd see more phase three and four activity, less phase one and two activity. Conversely, if we have an IOD event where we have warmer sea surface temperatures in the west and colder sea surface temperatures in the east, then we would tend to see more MJO activity focused in the western equatorial Indian Ocean phases, one and two, and say fewer MJO events able to propagate east into that region of colder sea surface temperatures. And that's just because convection, which is key to the MJO really favours those warmer waters. So wherever we see those warmer sea surface temperatures is where we're going to see more MJO activity in that particular season.

Nick: (10:37)
So in El Nino and La Nina events, those interact with the MJO. So we tend to see the MJO focused towards the region of warmer surface temperatures. So in El Nino events, sea surface, temperatures are warmer in the Pacific but colder over the Maritime Continent region. So we tend to see MJO events propagate further out into the Pacific and stay away from those colder sea surface temperatures over the Maritime Continent. So we tend to see more MJO activity in Pacific phases, so phases six, seven, and eight of the MJO. And less MJO activity in phases, three, four, and five when that convection should be over the, over the Maritime Continent. Conversely during La Nina events, sea surface, temperatures are colder in the equatorial Pacific and warmer over the Indian Ocean and the Maritime Continent. And so we tend to see more MJO activity over the eastern equatorial Indian Ocean, more over the Maritime Continent and less MJO events able to propagate into those colder sea surface temperatures in the Pacific.

Nick: (11:40)
Although the MJO has been an active topic of research for 40 or 50 years, we still don't really understand how individual MJO events form or why they tend to form preferentially in the equatorial of the Indian Ocean and not in other parts of the tropics. So most MJO events form quite close to the Seychelles in the Western part of the equatorial Indian Ocean, and then propagate to the east. But the mechanisms of MJO genesis and propagation are still not perfectly well understood. We also don't really understand why some MJO events propagate quite smoothly across the tropics, why they move very steadily to the east across the Indian Ocean, across the Maritime Continent and into the Pacific while others tend to get blocked or stopped at the boundary of the Maritime Continent, and don't make it across the complicated land and sea features there, the complicated terrain of Indonesia, into the Pacific.

Nick: (12:40)
So in the last 20 to 30 years, we have generally added about one week of lead time of the MJO per five to 10 years or so. Every five to 10 years models have improved to the state where a further week ahead, we're able to give better guidance about the phase and the amplitude of the MJO. These days even in sub-seasonal forecasts that are run out to 30 days or 40 days, we tend to see a forecast, be able to predict reasonably well, the phase and the amplitude of the MJO two to three or even four weeks ahead, in some cases. And this contrasts with where we were 10 to 20 years ago, where we could only forecast the MJO one to two weeks ahead, or so. We're getting better at predicting the large scale signals of the MJO as they move across the tropics. And that's generally been the success of MJO prediction.