Animation: NWP Improvements – UK Met Office & ECMWF

Voiceover: (00:05)
In 2019 two intense tropical cyclones, Idai in March and then Kenneth and April, made landfall in Mozambique causing devastating flooding and affecting over 3 million people. Providing advanced warning of these devastating impacts was the focus of the research project PICSEA (Predicting the Impacts of Cyclones in South-East Africa). The work quantified the operational forecasts of tropical cyclones in the Southwest Indian Ocean by Numerical Weather Prediction (NWP), the computer simulations used by weather forecasters. The work looked at the outputs of the UK Met Office and the European Centre for Medium-Range Weather Forecasts, ECMWF.

Voiceover: (00:40)
NWP continually improves at modelling tropical cyclones. Those improvements come from increases in spatial and temporal resolution and better simulations of the physical processes. NWP is generally good at capturing the large-scale circulations and how tropical cyclones are steered by those features. So NWP is quite good at predicting where a tropical cyclone is likely to go. But there are processes at the centre, near the eye and areas of maximum wind speed, which are occurring on length scales, smaller than an individual NWP grid box. So models are often biased and consistently underestimate central pressure and maximum winds, particularly for the strongest storms.

Voiceover: (01:22)
When forecasting for a tropical cyclone, using models of different forecasting centres, and ensembles, can demonstrate the uncertainties in track and intensity. The model products of operational weather services, such as the UK Met Office and ECMWF are available around the world. One of the advantages of considering forecasts from different NWP is to find out how consistent the forecasts are. If models from different centres provide similar outcomes, you may have higher confidence in that scenario playing out. Conversely, if different NWP sources have different forecasts, you may have less confidence in the forecast. It shows that there's a higher uncertainty in the circulation and forecast evolution.

Voiceover: (02:06)
And several operational weather services run their main high resolution deterministic model, but also have a suite of lower resolution ensembles. The ensemble consists of multiple forecast solutions, all valid at the same time, which are our best estimate to quantify the amount of uncertainty by showing the spread of possible outcomes. And it can even provide information on the probability distribution of predicted variables. Individual ensemble members can also draw attention to possible alternative developments. But sometimes, the real outcome is not always within the ensemble solutions. While high resolution deterministic forecast models are better at forecasting the intensity of a tropical cyclone, ensemble forecast models add important information because rather than just giving you one possible outcome, they take into account the uncertainty of the initial conditions of the forecast and provide a range of possible outcomes, including location of landfall, which can help people and organizations prepare for the impacts of tropical cyclones.

Voiceover: (03:04)
Forecasting systems are regularly updated and these improvements can reduce errors in predictions

of the track and intensity of tropical cyclones. For example, improvements in the UK Met Office NWP track forecast over the last decade is equivalent to an extra two days of lead time, with similar improvements in intensity.

Voiceover: (03:25)
What would that average improvement in forecasting, a tropical cyclone's central position look like for predicting the track of Idai just before landfall. For the forecast system in operation from 2006 to 2010, the average errors for the Met Office deterministicmodel would put the one day ahead position in the darker shaded area, and at three days ahead it could be anywhere in the larger area, which not only includes Mozambique, but also potential landfall in Madagascar. The expectation is that the tropical cyclone centre would be anywhere within that circle at that lead time.

Voiceover: (03:59)
And if we do the same analysis for the NWP used for mid 2017 to 2020, the average one and three day errors would be this. So what was the one day error is now the three-day error. So an improvement of two days on average, of forecast location of the central pressure.

Voiceover: (04:18)
Do keep in mind that this is just the average error in positioning over many tropical cyclone tracks. But this analysis provides useful guidance by quantifying the NWP improvements over time. But in an operational sense, the error is not known and will vary from storm to storm and even day-to-day in a storm's evolution.

Voiceover: (04:38)
And this improvement can be seen over different timescales for both the UK Met Office and ECMWF. This plot shows the average error of all cyclone tracks from the UK Met Office and ECMWF from 2010 to May 2020. For one day and less ahead the Met Office model has smaller errors, and at about one day ahead, both ECMWF and the Met Office deterministic high resolution models have an average error radius of about a hundred kilometres in positioning the tropical cyclone central pressure. And for longer lead times, ECMWF has smaller errors. For example, at three days ahead, the ECMWF average error is approximately 200 kilometres and the UK Met Office is 250 kilometres. And here's how the average position error changes for both models forecasting up to seven days ahead.

Voiceover: (05:30)
Let's look at how the average position error would look for forecastingIdai and Kenneth in real time for the UK Met Office predictions.

Voiceover: (05:42)
At seven days ahead, this is where the Met Office model predicted the centre ofIdai to be, some way west of where the actual centre was at the same time. And the actual centre is outside the average errors. At five days ahead, the centre would be too faroff shore, but the centre is within the average error. And at three days ahead, the prediction improves. And at one day ahead.So for cyclone Idai, the actual location on the 14th of March is within the average error radius for forecast produced one, three and five days ahead, indicating that the forecast were better than average. You can see that seven days ahead, the storm was predicted to move too fast and be further inland by the 14th of March. And it five days ahead, it was predicted to slow. And at one in three days ahead,the forecast were accurate.

Voiceover: (06:38)
And for Kenneth at five days ahead, this is where the Met Office model predicted the centre to be. That prediction is too far east and is even outside the average error radius. The same for three days ahead, the forecast is better, but the actual location of the centre is just outside the average error expected for a forecast three days ahead. And by one day ahead, the location is within those errors. For cyclone Kenneth, the actual location on the 25th of April is within the average error radius one day ahead, but at five and three days ahead of landfall, the forecast of Kenneth's location were worse than average. The direction was correct, but the movement of the tropical cyclone was much too slow.

Voiceover: (07:23)
For intensity, the predictions of ECMWF's high resolution deterministic forecasts are typically slightly more accurate than the UK Met Office. For the UK Met Office and ECMWF deterministichigh resolution models, the central pressure of tropical cyclones is forecast between 2 and 8hPa too high a day ahead. For the maximum wind speeds models are often biased and consistently underestimate winds, with the high -resolution deterministic models, underestimating by between 20 to 30 kilometres an hour up to seven days ahead. But these higher resolution models still capture the maximum wind speeds with greater accuracy than the lower resolution ensemble members.

Voiceover: (08:06)
And the key thing to keep in mind is that NWP is in a process of continuous research and development improving year on year.