New weather forecast system makes predictions faster and more accurate

Denmark launches a world-first weather forecast system that can provide more accurate forecasts by the hour, using just a fraction of the computing power of conventional models.

Weather forecasting agencies around the world are constantly developing new systems to produce ever more accurate forecasts, capable of capturing fast moving, often chaotic and localised weather events. But this means bigger models and even bigger computing capacity.

But scientists at the Danish Meteorological Institute (DMI) may have found a work around. Their new forecasting setup should provide more precise weather forecasts, updated every hour, while using a fraction of the computing power typically required by such systems.

“No one in the world is doing this,” says DMI scientist Xiaohua Yang, who designed the new system, which is called the Continuous Mesoscale Ensemble Prediction System—or COMEPS.

The new system has been running alongside DMI’s regular forecasts for Denmark and the Faeroe Islands, since September 2016. During this time it has convincingly outperformed the existing system, producing an hourly updated forecast and predicting weather conditions at a much finer scale than previously, says Yang.

“So far it has performed consistently better than the existing systems,” he says.

DMI officially switched over to COMEPS at midnight last night, and will now use this setup for their daily operational forecasts.

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Better resolution to improve predictions of extreme events

According to Yang, the new setup offers several advantages over traditional forecasting systems. One is that more frequent updates should make their short-term forecasts more accurate.

“The weather forecast used to be refreshed every six hours, then with the previous upgrade [in June 2016] it was every three hours. With the new COMEP system we’ll be able to do it every hour,” he says.

The hourly updates use the latest observations from satellite data and data from across DMI’s observational network of weather stations and radars and should avoid sudden changes from one forecast to the next after each update.

Another improvement is that the new system can forecast conditions for every 2.5 square kilometres, which should help them to capture localised events. The previous system produced meteorological data for every 5.5 square kilometres. Yang and his colleagues at DMI are now experimenting with even smaller scales,
down to as little as 300 metres.

This, he says, in combination with more frequent updates, will provide an almost continuous local forecast that will allow DMI to improve their predictions of chaotic and often highly localised extreme weather events more precisely, such as cloud bursts—severe storms that can develop quickly with little advance warning.

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**Global interest in new system**

Other countries are watching to see how much of an improvement the new setup offers.

Inger-Lise Frogner from the Department of Research and Development at the Norwegian Meteorological Institute describes this type of approach as “state of the art and in line with what other institutes are running and developing.”

“These types of setups are the best that we can do with our current knowledge and computing power,” she says.

The national meteorological agencies in the Nordics plan to establish a joint forecasting consortium in 2022. The plan is to have one common forecasting system in operation by then.

“We don’t yet know what ensemble system we will use, but this is an interesting option,” says Frogner.

Yang says several countries outside of the Nordics have also expressed interest in the new system.

“We hope that with the operational launch we’ll make a strong case,” he says.

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**Swedish colleague: curbed enthusiasm**

Ulf Andrae is head of development for the operational meteorological model within MetCoOp, a cooperation between the Norwegian Meteorological Institute, the Swedish Meteorological and Hydrological Institute (SMHI), and the Finnish Meteorological Institute (FMI), and an expert in numerical modelling and high performance computing at SMHI. He is weary of singing the praises of DMI’s new system until he has seen the results.

“All institutes are heading in this direction, towards something called “nowcasting,”” which means that you update the forecast every hour with input from meteorological observations,” he says.

Andrae says that DMI and MetCoOp will send data to each other and compare forecasts between their two systems. In a couple of weeks they should know if there are any major differences, he says.

“What DMI is doing is interesting but we have to wait to see what the pros and cons are,” says Andrae.

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**Uses existing model with a new layer of statistics**

The new setup is comprised of two existing models, which are run multiple times to produce a so-called
ensemble forecast—essentially lots of slightly different individual weather forecasts that can all be analysed all at once.

This produces an ensemble of possible weather scenarios for a certain location at a certain time in the future, which the forecasters then use to calculate the probability of heavy rain or bright sunshine, for example.

Running more ensembles at regular intervals allows forecasters to see a greater spread of results that are updated as often as possible with up to date observations from weather stations, satellites, and radar networks.

“It’s not a new concept, but DMI is utilising the computer resources they have available in a clever way,” says Frogner.

Read More: Studying shooting stars to improve weather forecasting

“It’s magic in terms of computing power”

Increasing the amount of model runs requires an extraordinary amount of computing power, which can only be accomplished with expensive super computers.

Yang’s priority was to run a bigger model without increasing the amount of computing power beyond DMI’s current capacity. “Every time you double the resolution of your model you need around ten times more computing capability,” he says.

The secret is in the timing.

DMI’s new system splits up their simulations so that just a handful are launched every hour. This reduces the overall computing power needed at any one time and spreads the demand for energy more evenly throughout the day.

See a description of how the system works in the side story below.

“It’s magic in terms of computational power,” says Yang.

Frogner agrees.

“This approach is a way of better utilising the available computing power. Some institutes may use a similar approach, but they’re not using it in the same way, every hour,” she says.

Fact box

The new model system

DMI switched over to The Continuous Mesoscale Ensemble Prediction System (COMEPS) at midnight on
June 15th.

It is based on two existing forecast systems known as HARMONIE and HIRLAM.

It runs on a 2.5 square kilometres resolution and is updated every hour.

It produces a 24-member ensemble forecast, which means 24 possible scenarios for the weather over the next 2 days.

The meteorologists then produce a forecast based on the probability of what the weather is likely to be doing at a certain place and certain time.

This is called probabilistic forecasting.

Source: Yang et al. 2017 (PDF download)[13]

Fact box

More precise forecasts of extreme weather

One of the aims of COMEPS is to better predict more extreme weather, such as large convective storms that may erupt in summer.

By forecasting at a finer resolution (smaller spatial scale) and updating the forecast more frequently, DMI hope to be able to follow these fast moving, often small scale systems more closely.

DMI’s new set-up runs 24 individual scenarios—more than most other meteorological agencies at a similar resolution.

“The traditional way is to [launch all these ensembles at once] twice a day or four times a day. This is how it’s done in the Met Office in the UK, using a 12 member ensemble. In Norway and Sweden, they run a ten member ensemble with the same resolution as ours (2.5 kilometres) four times a day. But we’re doing it 24 times a day with 24 members,” says Yang.

There are three other crucial differences between DMI’s set-up and their sister agencies around the world.

First, DMI use two independent computer models to produce the 24-member ensemble forecast. Second, they use a new technique to “perturb” the initial set of weather conditions for each of the 24 members, which kick-starts each model run to produce 24 slightly different outcomes.

Finally they use a technique known as “time-lagging” where they run the 24-member ensemble in groups of four. In practice this means that they launch four scenarios every hour and then analyse the previous...
six hours of model runs in one go. That is 24 scenarios every hour.

“So we make a continuous forecast on moving time windows, launching new forecasts each hour that takes the latest observational data into account,” says Yang.

“For a weather service we need to make these continuous and high resolution forecasts, with the ability to capture the latest weather development. Weather in high pressure systems doesn’t change so much so it’s not as important, but in critical situations when a storm is coming you want to follow what’s happening,” he says.

The new forecast contains additional information compared to DMI’s previous system. Note: DMI have not yet changed their website display to this new system. They expect to do so after Monday June 19th. (Photos: DMI)

DMI under pressure to keep costs down

Developing ever more accurate forecasts at a reduced price is a challenge for any meteorological agency, but of late, DMI has hard hit by budget cuts.

One third of DMI’s workforce has been lost over the past four years, which you can read more about in the article: Long term funding cuts put the squeeze on DMI [5].

Budget cuts can hurt future research and development projects like the new ensemble system. Yang agrees that this type of research is inevitably affected.

“It’s very hard to get funding for weather forecasting research from non-government sources or the funding agencies,” says Yang.

“So we’re using funds from our own resources [government grants] for this development. And of course we’re affected by budget cuts. Our ability to do normal research is limited because of the funding situation,” he says.

Future developments will have to focus on multinational collaborations and working within DMI’s existing capacity, he says.

“To me this is what a national weather service is about. We collaborate with others as we’re too small on our own. So through collaborations we can think about how to use the same system in the most beneficial way,” says Yang.

Read More: Danish Meteorological Institute has lost one third of its staff in four years[21]

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Catherine Jex [22]

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