Latest numbers show at least 5 metres sea-level rise locked in

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It's too late to stop the seas rising at least 5 metres and only fast, drastic action will avert a 20-metre rise, ***New Scientist*** *calculates based on recent studies*

Still dreaming of that seaside villa? *(Image: Francesco Zizola/Eyevine)*

WHATEVER we do now, the seas will rise at least 5 metres. Most of Florida and many other low-lying areas and cities around the world are doomed to go under. If that weren't bad enough, without drastic cuts in global greenhouse gas emissions – more drastic than any being discussed ahead of the critical climate meeting in Paris later this year – a rise of over 20 metres will soon be unavoidable.

After speaking to the researchers behind a series of recent studies, *New Scientist* has made the first calculations of what their findings mean for how much sea level rise is already unavoidable, or soon will be.

Much uncertainty still surrounds the pace of future rises, with estimates for a 5-metre rise ranging from a couple of centuries – possibly even less – to a couple of millennia. But there is hardly any doubt that this rise is inevitable.

We already know that we are heading for a rise of at least 1 metre by 2100. The sea will then continue to climb for many centuries as the planet warms. The question is, just how high will it get?

No return

According to the latest report by the Intergovernmental Panel on Climate Change (IPCC), over the next 2000 years we can expect a rise of about 2.3 metres for each sustained 1 °C increase in the global temperature. This means a 5-metre rise could happen only if the world remains at least 2 °C warmer than in pre-industrial times up to the year 4100. That doesn't sound so bad: it suggests that if we found some way of cooling the planet, we could avoid that calamity.

Unfortunately, the report, published in 2013, is not the whole story. Last year, two teams reported that two massive glaciers in West Antarctica have already passed the point of no return.

Ian Joughin of the University of Washington, Seattle, modelled the fate of one of the glaciers. "No matter what, the glacier continued to lose mass," he says.

The loss of those two glaciers alone will raise sea level 1.2 metres. If they go, Joughin says, it's hard to see the rest of the West Antarctic surviving.

Others agree. "I think these are very convincing studies," says Anders Levermann of the Potsdam Institute for Climate Impact Research in Germany, one of the authors of the sea level chapter in the last IPCC report. "The West Antarctic ice sheet is gone."

The reason is that the West Antarctic ice sheet sits in a massive basin, its base as much as 2 kilometres below sea level. At the moment, only a little ice on the edges is exposed to the warming waters around Antarctica. As the ice retreats, however, ever-deeper parts of the basin will be exposed to warming waters, leading to ever more of it being lost. The process is irreversible because once it starts, it will continue as long as warm conditions persist. This means a 3.3-metre rise is now unavoidable.

And that's not all (see chart). Even in the unlikely event we manage to limit warming to 2 °C, we're in for a 0.8-metre rise as the oceans warm and expand. Mountain glaciers around the world will contribute 0.4 metres. Adding those figures to the 3.3 metres, we get 4.5 metres in total, or 5 metres rounded up. That's conservative, given that it doesn't count any melting from East Antarctica or Greenland.

Most of the ice in East Antarctica is more stable than that in West Antarctica as it rests on land above sea level. There are two large basins, the Aurora and the Wilkes, whose floors are below sea level, but these are shallower than the West Antarctic one. We had thought only massive warming would destabilise the ice here.

Trough threat

However, Totten, the main glacier that drains the Aurora basin, is thinning, says Jamin Greenbaum of the University of Texas at Austin. His team reported in March that radar sounding has revealed a trough under the ice that could let warm water enter the basin and trigger enough melting to eventually raise sea level by 5.1 metres (*Nature Geoscience*, doi.org/27w). "The mind-blowing thing is that there is as much ice in one glacier in East Antarctica as in all of West Antarctica," says Greenbaum.

The situation is similar in the Wilkes basin. It's not losing ice yet, but once a small amount on the margins is lost it will continue disintegrating until enough ice has melted to raise sea level 3.5 metres, Levermann's team reported last year (*Nature Climate Change*, doi.org/snz).

What will it take to kick-start the loss of all this ice? Not much. During the Pliocene period around 4 million years ago, for instance, when the planet was 2 or 3 °C warmer at times, sea level was over 20 metres higher than now. Researchers suspect that much of this came from the Aurora and Wilkes basins.

Support for this idea comes from an improved ice sheet model that, for the first time, includes dynamic processes such as cliff collapse resulting from ice sheets being undercut by warming waters. In January, a team including Richard Alley of Pennsylvania State University reported that Pliocene conditions will lead, so the model indicates, to ice loss not only in Aurora and Wilkes but also in several smaller East Antarctic basins. Together, they hold enough ice to add at least 15 metres to global sea level (*Earth and Planetary Science Letters*, doi.org/42m).

We are currently on course for a world even warmer than the Pliocene, which means we could soon trigger the loss of the Wilkes and Aurora ice – if we haven't already.

This break-up will be traumatic *(Image: NASA)*

Then there's Greenland. The ice here mostly rests on land above sea level, so should take thousands of years to melt. You might think, then, that there is plenty of time left to save it. Not so, says Alexander Robinson of the Complutense University of Madrid, Spain.

He says his team's studies show that we are already nearing the point of no return for Greenland (*Nature Climate Change*, doi.org/kkw). "Within the next 50 years, we could be committing ourselves to continuous sea level rise from Greenland over the next thousands of years," he says. "That's a very profound thing to think about."

The reason is that as warming continues, various positive feedbacks will kick in. As the surface of the ice sheet lowers, for instance, it experiences higher temperatures. In theory, the melting could still be stopped if temperatures fall, but because carbon dioxide persists in the atmosphere for many centuries, says Robinson, it is hard to see how that could happen (see "Can geoengineering save coastal cities?").

The loss of Greenland's ice would add at least 6 metres to global sea level. And in this business-as-usual scenario, ocean warming would contribute 1.6 metres or more. Adding all this up leads to the frightening conclusion that we don't have much time left before we're on a one-way street to a world with seas 20 metres higher. "It's kind of scary," says Robinson.

It will take thousands of years for the seas to rise to this extent, but much of the rise could happen early on – within the first few centuries – although no one can say for sure. Joughin thinks the IPCC estimate of up to 1.2 metres by 2100 could still be in the right ball park. "It's likely to be on the high end [of the IPCC estimate] but not far outside."

Yet in the improved ice model that Alley's team ran, Antarctica alone added 5 metres to sea level in the first two centuries. That model was run with warm Pliocene-like conditions from the start, not where we are at now.

It might not take too long to reach a similar point, though. We're in danger of soaring past Pliocene levels of warmth as early as the middle of the century if we don't slash emissions soon. In the study, the West Antarctic ice sheet collapsed in mere decades in response to this kind of warmth.

What's more, the model might still leave out some melting processes, Alley says. "It is possible that this rather short timescale is not the worst possible case."

This article appeared in print under the headline "Five metres and counting"

Can geoengineering save coastal cities?

It's already too late to prevent massive sea level rise (see main story). Or is it? Can geoengineering stop low-lying cities sinking beneath the waves?

It certainly won't be easy. "Once you kick in the melting feedbacks, it's very hard to shut them off," says Alexander Robinson of the Complutense University of Madrid. To have any chance, we have to get the planet's temperature back down to pre-industrial levels in the not too distant future. "I personally see that as quite unlikely," Robinson says.

One key problem is that most geoengineering methods, such as pumping sulphates into the atmosphere, rely on reflecting sunlight and would cool the tropics more than the poles (*Geophysical Research Letters*, doi.org/453). Cooling the poles enough to halt ice loss would devastate the rest of the world, slashing rainfall, for instance.

The best solution would be to suck all the excess carbon dioxide from the atmosphere, but the immense scale of the task and the speed required make this seem nigh on impossible. Other suggestions, such as building huge barriers between warming waters and glaciers, don't look feasible either.

Another major problem is that until cities start drowning, it is hard to see politicians spending trillions on megaprojects. And once they begin to drown, it will already be too late to prevent major sea level rise.