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Forecast for big sea level rise

By Richard Black
Environment correspondent, BBC News website, Vienna

Sea levels could rise by up to one-and-a-half metres by the end of this century, according to a new scientific analysis.

This is substantially more than the Intergovernmental Panel on Climate Change (IPCC) forecast in last year's landmark assessment of climate science.

Sea level rise of this magnitude would have major impacts on low-lying countries such as Bangladesh.

The findings were presented at a major science conference in Vienna.

The research group is not the first to suggest that the IPCC's forecast of an average rise in global sea levels of 28-43cm by 2100 is too conservative.

The IPCC was unable to include the contribution from "accelerated" melting of polar ice sheets as water temperatures warm because the

processes involved were not yet understood.

Melt water

The new analysis comes from a UK/Finnish team which has built a computer model linking temperatures to sea levels for the last two millennia.

Glaciers 'flowing faster'

"For the past 2,000 years, the [global average] sea level was very stable, it only varied by about 20cm," said Svetlana Jevrejeva from the Proudman Oceanographic Laboratory (POL), near Liverpool, UK.

"But by the end of the century, we predict it will rise by between 0.8m and 1.5m.

"The rapid rise in the coming years is associated with the rapid melting of ice sheets."

The model, she told reporters here at the European Geosciences Union (EGU) annual meeting, is able to mimic accurately sea levels reliably observed by tide gauges over the last 300 years.

There is little concrete evidence on sea levels for the thousands of years before that, explained POL's Simon Holgate, who was not involved in the new study.

"There is some limited archaeological evidence [based on] the sill heights of fish enclosures that the Romans used, that's probably the

strongest evidence that there hasn't been any significant change in sea level over the last 2,000 years."

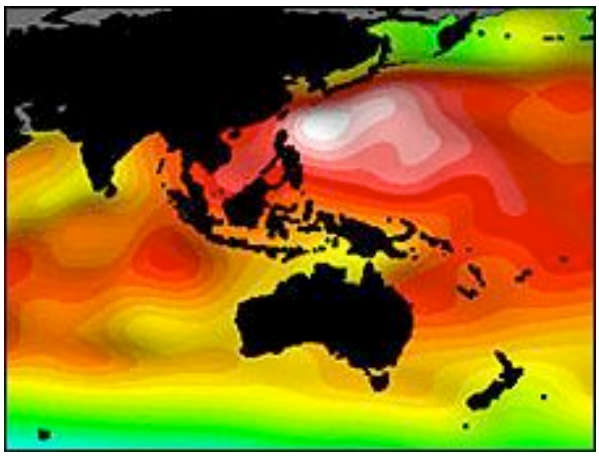
Against that, he said, the currently observed rise of about three mm per year is significant, and many scientists working in the field expect to see an acceleration.

Last year, German researcher Stefan Rahmstorf used different methodology but reached a similar conclusion to Dr Jevrejeva's group, projecting a sea level rise of between 0.5m and 1.4m by 2100.

Space-eye view

The latest satellite data indicates that the Greenland and West Antarctic ice sheets are losing mass, though the much bigger East Antarctic sheet may be gaining mass.

Ebb and flow of sea level rise



A full melting of Greenland and West Antarctica would raise sea levels by many metres; but the process, if it happened, would take centuries.

"We know what's happening today from satellite data, but trying to predict what that means in the future is very difficult science," noted Steve Nerem from the University of Colorado, whose own research concerns global sea levels.

"There's a lot of evidence out there that we're going to see at least a metre of sea level rise by 2100," he said.

"We're seeing big changes in Greenland, we're seeing big changes in West Antarctica, so we're expecting this to show up in the sea level data as an increase in the rate we've been observing."

However, a rise of even a metre could have major implications for low-lying countries - especially, noted Dr Holgate, those whose economies are not geared up to build sophisticated sea defence systems.

"Eighty to 90% of Bangladesh is within a metre or so of sea level," he said, "so if you live in the Ganges delta you're in a lot of trouble; and that's an awful lot of people."

Dr Jevrejeva's projections have been submitted for publication in the scientific journal Proceedings of the National Academy of Sciences.

Richard.Black-INTERNET@bbc.co.uk

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The ebb and flow of sea level rise

By Mark Kinver
Science and nature reporter, BBC News

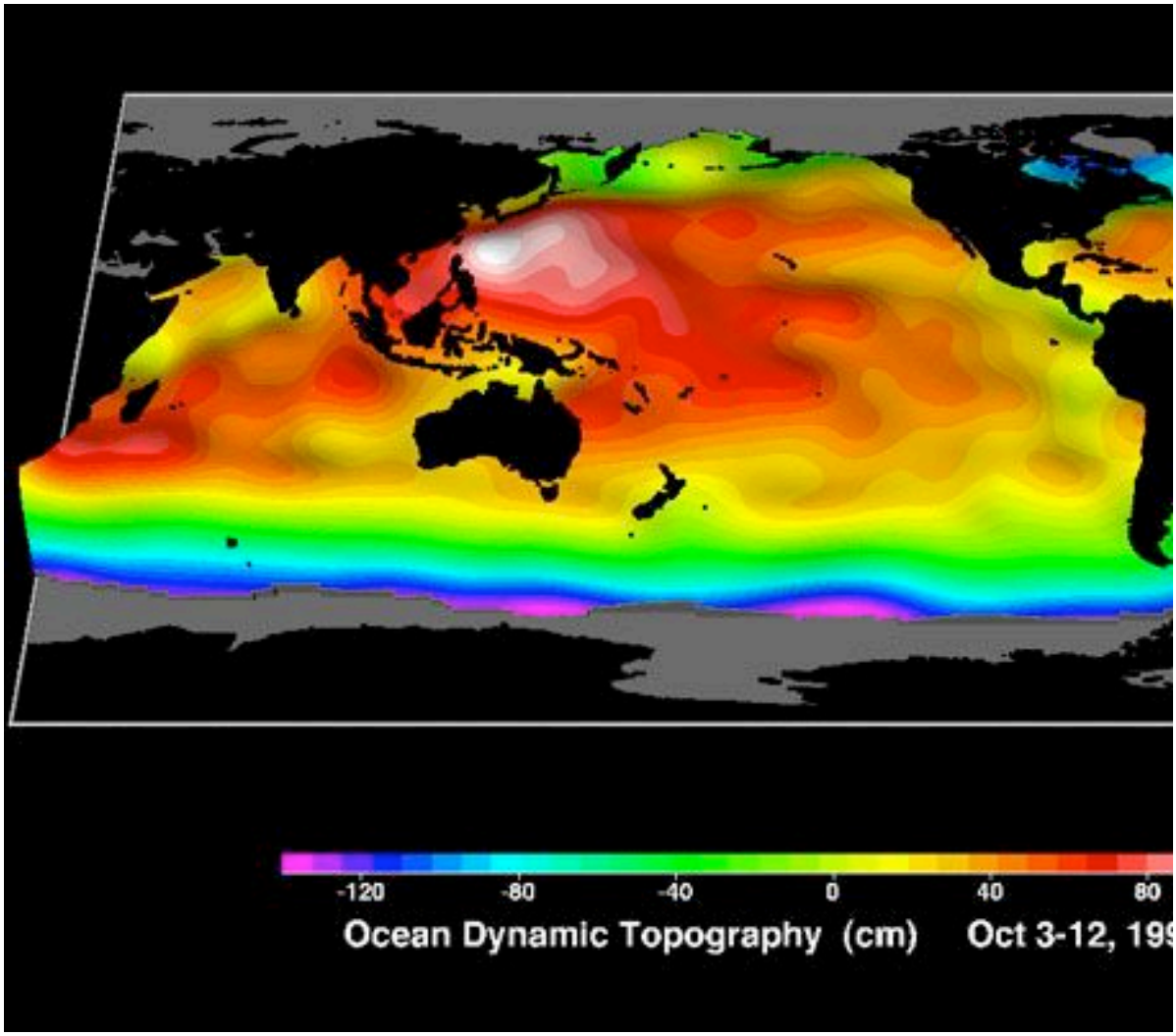
More than half of the world's population have made their home in a coastal region, whether they are subsistence fishermen in Bangladesh or high-flying City bankers in New York.

For many low-lying areas, scientists warn that the coming century is likely to see sea level rise that will change the shape of coastlines

around the globe.

While cities such as London, New York and Singapore are likely to spend billions on protecting inhabitants from flooding, many small island nations are at risk of disappearing beneath the waves.

So how much will waters rise, and what are the factors driving them up?



FACTORS AFFECTING SEA LEVEL RISE

Understanding, and more importantly, measuring the factors that influence the dynamics of the world's oceans is a relatively new area of research.

It was not until the early 1990s and the emergence of satellite technology capable of highly accurate measurement was it possible to record sea level changes and variations on a global scale.

Even today, there is still a debate among scientists about how much waters will go up by the end of the 21st Century.

But there is agreement that the mean sea surface is rising, and that there is a complex array of factors driving the increase, including:

- **Thermal expansion** - as greenhouse gases become more concentrated, more heat energy is trapped in the atmosphere. This energy is also transferred to the ocean, causing it to warm and expand
- **Ice melt** - rising air temperatures cause mountain glaciers and ice sheets to melt, sending the resulting melt water into the sea
- **Ocean current variations** - pan-ocean currents, for example the Gulf Stream, are the main way that heat energy is transported from equatorial waters to cooler higher latitudes. However, these are subject to natural variations; probably the most well-known system is El Nino, which moves vast quantities of water from one side of the southern Pacific to the other every three to four years
- **Topography** - the combination of ocean currents and atmospheric pressure systems means that the oceans are not flat. Data gathered by satellites show height variations that exceed two metres

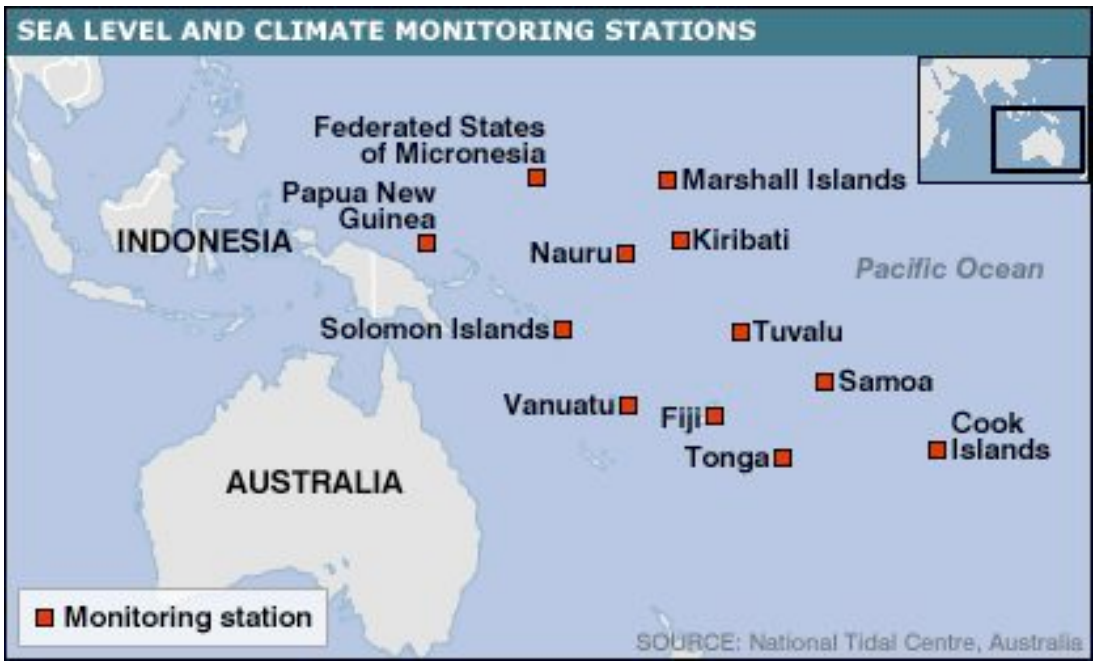
MEASURING SEA LEVEL RISE

Tidal gauges

These have been used to measure local tidal ranges since the 19th Century, with the first automated instrument being installed in the UK back in 1852.

However, it has only been in the last couple of decades that technological advances have allowed the level of precision needed to separate long-term sea level rise from natural variations.

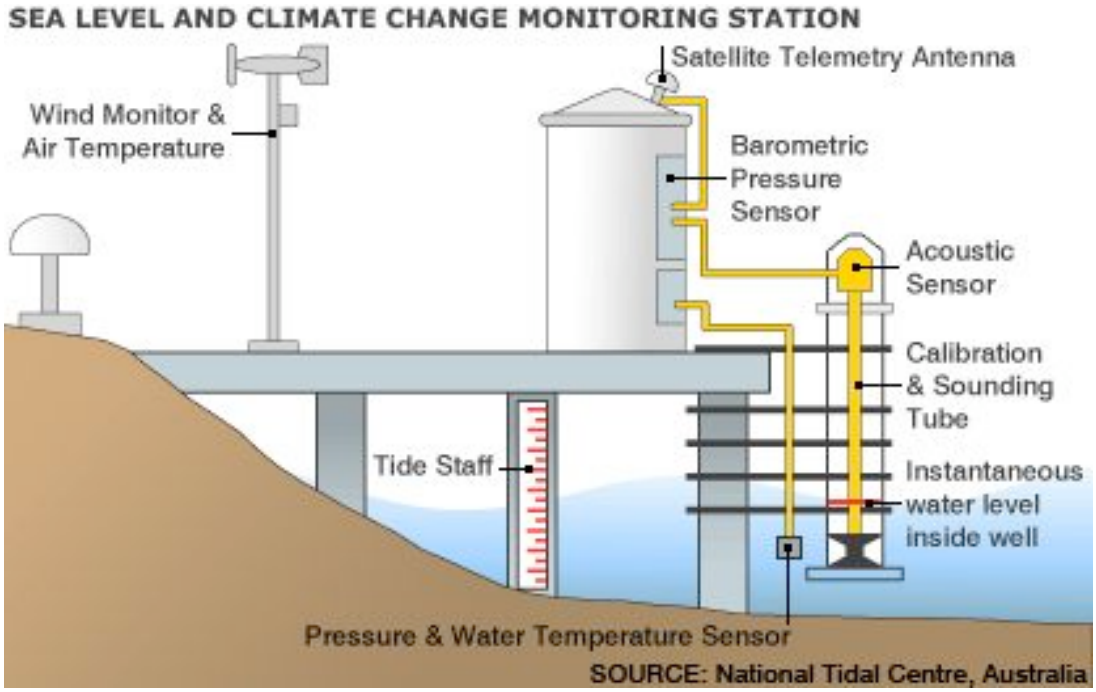
For example, the Australian government in 1991 developed the South Pacific Sea Level and Climate Monitoring Project (SPSLCMP) in response to concerns voiced by a number of neighbouring nations - many of which were low-lying island states - about the potential impact from human-induced climate change and sea level rise.



The network consists of 12 Sea Level Fine Resolution Acoustic Measuring Equipment (Seaframe) monitoring stations on small island nations located in the South Pacific.

Each station regularly measures sea levels and meteorological conditions, which are relayed via satellite to Australia's National Tidal Centre where the data is processed, analysed and made available to the international community.

Every monitoring station is also fitted with Continuous Global Positioning System (CGPS) technology, which is so sensitive that it can measure whether the elevation of the equipment is moving, either sinking or rising up out of the water.



With the exception of the station on the Federated States of Micronesia, the network has been operational since 1994.

Over that period, the project gathered data that has enabled researchers to identify sea level rise from natural variations (such as El Nino events) and any vertical movement of the tidal gauges.

Figures for June 2006 show that Tuvalu, an island state that is expected to be one of the first nations to disappear beneath the waves, is experiencing a net sea level rise of 5.7mm each year.

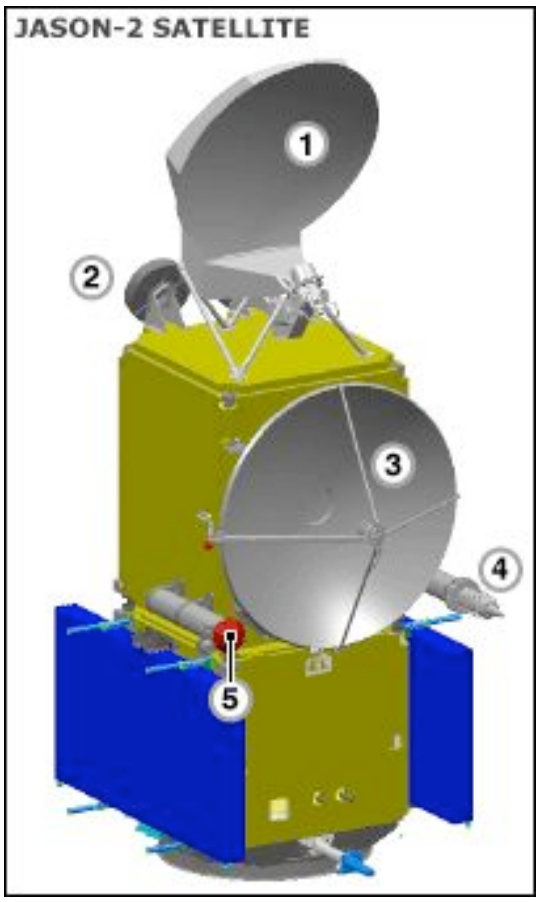
Satellite measurements
To help scientists understand the forces behind climate change and how that is going to affect ocean dynamics, they need a real-time global view of the world's waters.

- **1. Advance Microwave Radiometer (AMR)** - measures signal delay caused by water vapour
- **2. GPS antennas** - ensures precise orbit path
- **3. Poseidon-3 altimeter**- measures sea level
- **4. Doris antenna** - tracking and positioning control
- **5. Laser Retroreflector Array (LRA)** - tracks and calibrates measurements
- **Mass:** 525kg (1,155lb)

- **Power generation:** 511 watts
- **Height:** 3m (9ft 8in)
- **Orbit:** 1,338km (831 miles)

(Source: Eumetsat, Cnes, Nasa)

Space-age measurements



Since 1992, researchers have been able to measure the height of the sea surface and detect variations in ocean levels to millimetric detail via radar altimeters on satellites.

Set for launch in June 2008 is Jason-2, a low-orbit satellite fitted with the latest generation of altimeter, called Poseidon-3.

It will be able to map about 95% of the ice-free oceans' topography every 10 days and help scientists monitor ocean circulation, climate change and sea level rise.

"There is more to the dynamics of sea level rise than just a single, global rise," explained Mikael Rattenborg, director of operations for the European Organisation for the Exploitation of Meteorological Satellites (Eumetsat).

"Although we have seen, overall, global sea level rise, there are areas that have decreased for long periods, followed by an increase.

"We can only analyse the significance of regional variability of sea level rise if we have altimetry data available to us," he added. "Jason-2 will help us model and explain this evolution."

MAKING SENSE OF THE PROJECTIONS

In its latest assessment report published in 2007, the Intergovernmental Panel on Climate Change (IPCC) said that by the end of the century sea level rise was most likely to be between 28 and 43cm.

However, a number of scientists have published papers criticising the projection, calling it too conservative and warning that future climate change could cause ice currently locked into the polar ice sheets to flow into the oceans.

Glaciers 'flowing faster'

"Tidal gauges showed that there was an average annual increase of 1.8mm during the 20th Century," explained Dr Simon Holgate, a sea level scientist at the UK's Proudman Oceanographic Laboratory.

"And for the period of satellite-based observations, we have got about an average rise of 3.4mm each year.

"We are confident that sea level is rising, we're pretty confident that for the last decade or so it has been rising by an average of 3mm each year but what we are not confident about is whether that is a result of ocean warming or ice melt."

Anders Levermann, a professor of dynamics of the climate system at Potsdam University, Germany, suggested that half was a result of thermal expansion, and half was from melt water from glaciers.

While supportive of the IPCC's overall findings, he criticised the panel for using the same model to predict future sea level rise as was used to inaccurately calculate past increases.

"The models in the IPCC report underestimated the sea level rise that we have already observed by 40%," he said.

"*You start getting into difficult problems when you start trying to extrapolate limited data to the bigger picture"*

Dr Simon Holgate,
Proudman Oceanographic Lab

"The only thing used in the report were these models, which were then used to project into the future."

Professor Levermann said that more work needed to be carried out on the factors affecting the flow dynamics on the two massive ice sheets of Greenland and Antarctica.

He added that studies showed that melt water had been penetrating the glaciers and was acting as a lubricant between the ice and the base rock.

As a result, the ice was flowing faster towards the sea.

"We believe that we can make more statements on sea level rise and that you cannot trust models that are underestimating it," he said.

But Dr Holgate said that it was difficult to make such observations based on limited data.

"The question is how do you attribute observed sea level rise to thermal expansion and what is the result of freshwater entering the oceans from ice melt?" he explained.

"The main problem with trying to understand thermal expansion is that we have relatively few measurements; certainly very few measurements longer than 50 years ago.

"And very, very few from the Southern Hemisphere, where most of the planet's water is located.

"You start getting into difficult problems when you start trying to extrapolate limited data to the bigger picture."