

## Rising sea levels: Predictions and plans

Global warming as a result of the "greenhouse" effect will cause the water in the world's oceans to expand, raising the average sea level by 4 to 8 centimeters in the next 40 years, according to British researchers working with computer models of the ocean.

These estimates of the "thermal" expansion of the ocean, reported in the Nov. 12 NATURE, "are the most sophisticated calculations published yet," says Tom M.L. Wigley, who worked with Sarah C.B. Raper at the University of East Anglia's Climatic Research Unit in Norwich.

Over the past decade, scientists have started to explore the implications of a warmer climate as they continue to observe carbon dioxide and methane accumulating in the atmosphere. Like the glass of a greenhouse, these and other gases are thought to trap heat radiated by the earth, thereby warming the planet. Indeed, some findings indicate that global temperatures are already rising.

Wigley and Raper worked with an ocean model that represents the transfer of heat between a warming atmosphere and the ocean. As input for the model, they adopted a standard estimation that temperatures would rise 0.6 to 1°C by the year 2025.

Such a rise not only would cause the thermal expansion of the oceans, but also would hasten the melting of glaciers and possibly even the icecaps that cover Greenland and the Antarctic. Though meltwater from ice would swell the oceans more than thermal expansion, it is more difficult to forecast how a temperature rise would affect melting, says Wigley. A 1983 report by the National Research Council (NRC), considering all factors, estimated that sea levels will rise 70 centimeters by the year 2075.

A new NRC report released in September explores the engineering implications of such a rise. While large increases in sea level would obviously flood low-lying areas, even small increases would cause significant damage, says Robert G. Dean of the University of Florida at Gainesville, who headed the committee drafting the report.

For every 1-centimeter rise in sea level, 1 meter of sandy beach on the outer coast would erode under the incessant pounding of waves, according to the report. For a 10-centimeter rise in the ocean level, the boundary between saltwater and freshwater at the mouths of rivers would advance 1 kilometer into the river, and saltwater would similarly advance into underground deposits of freshwater. Such a saline intrusion causes concern for drinking-water supplies and for the animal habitats in estuaries.

While the average sea level is now rising by a fraction of a centimeter per year, scientists expect the rate to increase

in the future. Says Dean, "There's really no cause for immediate alarm, but it's also not a time for complacency. The next three or four decades should be used to plan for the rise."

The NRC report recommends that decision-making models be used to help coastal planners determine whether to abandon or to fortify facilities and areas threatened by the encroaching ocean. Many power plants built in low areas are designed with a limited lifetime, and so could be abandoned. But airports built on landfills could require dikes and pumping stations.

## Ring around a gravitational lens

Early this year, two astronomers announced the discovery of what appeared to be huge arcs of luminous matter associated with two small clusters of distant galaxies (SN: 1/17/87, p.36). If real, these sausage-shaped arcs, which are hundreds of thousands of light-years long, might have been an entirely new kind of astronomical object or evidence of fantastically energetic processes going on at the cluster.

Now, however, the two astronomers announce that spectroscopic study of one of the arcs convinces them that it is a kind of optical illusion, an image formed by a gravitational lens.

A strong gravitational field, like that of this galaxy cluster called Abell 370, will bend rays of light coming from a more distant object. It can act like a lens distorting the image of the more distant object.

The spectrum of an object like the arc characteristically shows a continuous rainbow background with bright or dark lines representing resonant emissions or absorptions by different chemical substances superimposed. As the expansion of the universe is carrying distant galaxies away from us, these resonance lines will appear shifted to the red by some amount from the wavelengths at which they appear at rest in the laboratory. The trick is to identify the lines properly and determine the amount of redshift.

In the spectrum of this arc is one prominent emission line, note Vahe Petrosian of Stanford University and C. Roger Lynds of Kitt Peak National Observatory in Tucson, Ariz. If the arc is real matter and associated with the cluster, that line can be identified as an emission of ionized helium. However, as Lynds puts it, "Since September we've been processing the data with greater and greater care to try to reveal and confirm any spectroscopic features other than the one strong emission line." This study showed that the spectrum lacks the pattern of fainter lines usually associated with the

helium line.

According to the report, scientists studying the rise will need more monitoring stations that record not only the sea level rise but also the rate of beach erosion and other secondary effects. This is especially true in the relatively unmonitored Southern Hemisphere.

Though sea levels on the average will rise due to global warming, other, unrelated processes will also affect these levels and may even offset the rise in certain areas. For example, the earth's crust under Scandinavia is still reacting to the retreat of the Ice Age glaciers. Without the weight of that ice, the crust is rebounding and rising, thereby lowering the sea level along that coast.

— R. Monastersky

The alternative is to identify the bright line as an emission of oxygen, for which an accompanying pattern of faint lines does appear in the arc's spectrum. That means, however, that the light in the arc is actually coming from something twice as far away as the cluster Abell 370.

The theory of gravitational lenses says that if the lensed object, the lens and the observer are perfectly in line, the lens should make an image in the form of a circular ring. This appears to be almost such a case, with part of the ring present. The rest may be suppressed by the presence of a second lens, Petrosian suggests. Abell 370 actually has two closely spaced concentrations of mass, he points out.

— D. E. Thomsen

### Quakes hit Pacific coast

Only five hours apart, two significant but unrelated earthquakes shook the Pacific coast of North and Central America on Nov. 16. The larger one, measuring between 6.8 and 6.9 on the Richter scale, struck in the Gulf of Alaska, shaking Anchorage, which lies 240 miles to the northwest.

The earlier quake, measuring 6.1 on the Richter scale, was centered off Nicaragua's west coast, causing slight building damage and several injuries in Managua, 50 miles away.

Because of the magnitude of the Alaskan quake, officials at the Tsunami Warning Center in Palmer, Alaska, issued a tsunami warning 11 minutes after the 11:46 p.m. earthquake. They canceled the warning 1½ hours later, after tide gauges in coastal cities measured an earthquake-generated wave of only a few inches, says George Carte of the Warning Center. By that time, several cities and towns closest to the center of the quake had already moved residents to higher ground. □