Global Warming Matters? 15th July 1998

Impact and Options for London's Tidal Defences

Some initial thoughts in response to a consultation evening

from Jonathan Cowie

(science policy analyst and author of *Climate and Human Change*)

Question: What are the sea level flood risks over the next 75 to 100 years due to global sea level rise?

The official 'most-likely' scientific view

Roughly half a metre rise over 75 years

To consider what options are available to London one first must identify the *likely* risks from sea level rise. These have been forecast by the UN (WMO and UNEP) InterGovernmental Panel on Climate Change (or IPCC).

The IPCC 1990 assessment anticipates the following sea level rise:

Year	***2070***	***2100***
High estimate	71cm	110cm
Best estimate	44	66
Low	21	31

Importantly, the IPCC notes that sea level rise will rise roughly twice as fast in the second half of the next century than in the first. This is of import when considering the investment and construction frame of any coastal defence plan.

The subsequent IPCC 1995 assessment modified this Business-as-Usual estimate best estimate to roughly 49cm by 2100.

Of course locally (SE England) these estimates need to be increased to allow for the isostacy effect of the land geologically sinking as the north of the UK rises now that the weight of the last glacial ice cap has been removed.

Question: How likely are the IPCC best-estimate scenarios?

Though the IPCC scenarios are likely it also warns of surprises!

The IPCC does not encourage complacency! It positively warns of "the possibility of unexpected surprises" and devotes a section of its 1995 report to these.

Question: So what are the most <u>likely</u> forecasts of the remaining <u>unlikely</u> scenarios?

A long-term 6m rise?

We know that during the last interglacial some 120,000 years ago (and we are currently coming towards the end (or are in last third at least) of the current interglacial) that the sea level was some 6m higher than today. It is therefore likely (virtually certain) that we will see a 6m rise this interglacial.

The above can be found in the climate change review text Climate and Human Change *(1998 from Parthenon Publishing ISBN 1-85070-971-8). What follows is an assessment which includes that based on research published subsequently (*i.e. *in the past 6 months).*

Question? How likely is a 6m rise in the medium term future?

Though of a minority probability the likelihood is certainly a distinct one (and the few advance symptoms one would expect are already becoming manifest)

If one were to ignore human-induced (anthropogenic) global warming (from the burning of fossil fuels and deforestation) then it would be likely (far more likely than not) that the sea level would rise by 6m sooner or later in the *long-term* over the next 2,000 years or so. Indeed it would be surprising if this did not happen since there is nothing to suggest that this interglacial is radically different from previous interglacials. The reason why the sea level continues to rise so late in the interglacial (or to be more accurate why there is a second, comparatively mini spate of rising (the first being the flooding of the continental shelves over a 4,000 year period starting some 12,000 years ago)) is because whereas the initial post-glacial flooding (12,000 years ago) was largely due to the melting of the northern European and north American glacial ice sheets, this second spate will be largely due to the melting of grounded Antarctic ice sheets and particulalry the West Antarctic Ice Sheet (WAIS).

If one includes the effects of anthropogenic global warming (which begun albeit modestly over a century ago) then this 'sooner or later' anticipated 6m sea level rise will happen sooner rather than later.

Finally, assuming that this second 6m spate of anticipated interglacial sea level rise were to take place one would expect glaciers Worldwide to be in retreat (*they are*), for Antarctica's floating ice shelves -- the melting of which do not contribute to sea level rise -- to increasingly calve (*they do*), and finally for the smaller floating Antarctic shelves to disintegrate (*which is currently happening*), before the grounded ice shelves fracture and then disintegrate so largely contributing to the 6m sea level rise.

Question: How soon is 'sooner?

A less likely but a realistic-worse-case scenario would be 500 years leading to over 2 metres rise over the next century

It all depends on how fast the **West Antarctic Ice Sheet** (WAIS) collapses (the East Antarctic sheet is more stable and is not thought to have collapsed during previous inter-glacials). A review paper published in May (Oppenheimer, M., (1998) Global warming and the stability of the WAIS, *Nature* vol 393, pp325-332) notes that estimates for how long it would take for complete collapse range from 1,600 - 2,400 years (equivalent to a sea level rise of 25cm *per* century) to 1,200 (or a sea level rise of between 30 - 50 cm *per* century). However *if* all WAIS glaciers were equivalent to the current movements of the faster WAIS glaciers (Thwaites and Pine Island glaciers) then a collapse time of 500 years would be obtained, resulting in a sea level rise of 80 - 120cm *per* century. This is unlikely but not impossible due to the uncertainties involved.

NB. The above WAIS collapse contributions need to be *added* to the IPCC sea level rise forecasts for the 21st century -- as the IPCC assumes the WAIS will not collapse -- this might give us a total of a little over 2 metres rise over the next century should the collapse start soon. (Remember we are making this calculation on the basis of 'the most likely of the *least* likely scenarios' *i.e*. a less likely but realistic worst case scenario.)

Question: What are the comparative probabilities for the medium to long-term forecast for West Antarctic Ice Sheet contributions to sea level rise?

Most likely (of the least likely scenarios) is about a metre rise over the next century due to WAIS sheet collapse combined the other IPCC warming sea level factors

There are three broad categories of WAIS collapse scenario:-

1) Gradual dynamic ice shelf response to global warming.
Leading to seas rising by initially up to 19cm a century due to WAIS (West Antarctic Ice Sheet) collapse alone (*i.e.* ignoring other IPCC considerations such as thermal expansion and non-Antarctic glacier melt which added to the afore would give us just under a metre rise by the end of the century). The collapse would take up to 700 years, towards the end of which the sea level would be rising by over a metre a century.

2) No dynamic response to global warming.
In effect there is no net contribution to sea level rise (Antarctic snow fall (from evaporated sea water *i.e.* trapping the sea water as ice on land) is at broadly equal to WAIS disintegration (as has been up to now)). This leaves us with the IPCC best estimate forecast for sea level rise.

3) Very rapid dynamic response to global warming.
The WAIS collapses over 250 - 400 years. This together with the other (non-Antarctic) IPCC sea level rise factors could give us a sea level rise of a little over two metres over the next century.

Michael Oppenheimer (1998 referenced above) considers scenario (3) to be the least likely, but does "not eliminate it entirely". Of the three individual options he consider (1) to be most likely but "with low confidence". Over all he feels that a combination between (1) and (2) to of greatest relative likelihood.

Wild cards and how to deal with them
On page 64 of *Climatic and Human Change* I have noted that there appears to be volcano activity under part of the WAIS. Such geology could lead to considerable WAIS instability. More recently (July 1998) Anandarkrishnan et al (*Nature* vol 394 pp62-65) argues that even basic geological variabilities result in different likelihoods of stability. Sub-glacial geology research, particularly under the WAIS, must be a research priority. A heavy investment in this research in the short term (next decade) would be better value than the far greater major investment required for a theoretical worse case sea defence scenario. (For instance an annual investment of just £9m for a few years would represent a 33% increase in the total UK polar science budget.)

Question: Is there a global warming risk of flooding due to increased rainfall?

Yes -- Consider Easter 1998 something to recur.

In an over all warmer World (which may be cooler in a few parts) one expects there to be over all greater evaporation from the ocean. An old environmental scientist adage is 'what goes up must come down', so one would expect greater rainfall. Personally I consider (in a most unscientific way) the 1996 floods in Western mainland Europe to be illustrative of this increased rainfall, as I do the 1997 May floods in central Europe and the 1998 Easter flooding in western Europe including the UK midlands. So paradoxically while we in the UK should prepare for the periodic hot dry summer, we should also prepare for very wet Springs (possibly Autumns too).

[Though not directly related to global warming *per se*, work published March 1998 by Stockdale *et al* (*Nature*, vol 392 pp370-373 and pp334) has demonstrated that coupled ocean-atmosphere general circulation models (not dissimilar to those used in climate change research) can successfully make useful rainfall forecasts up to 6 months in advance which predicted the heavy 1998 Spring Western European rainfall.]

Policy-making action for the Thames Estuary

- currently plan for a metre rise in global sea level (plus whatever is required to allow for local land falling) over the next century.
- ensure that built into tidal/sea defence plans are the possibilities of further enhancing defences over the next century (perhaps to over two metres). Again think of the long term. One hopes that London will still be economically active in 5 centuries time so always build into sea defence plans options for further enhancement.
- after appropriate debate and internal discussion (perhaps broadening these to some external but semi-formal fora (such as the Parliamentary and Scientific Committee) the Environment Agency (as is its statutory prerogative) should call upon the Chief Scientific Advisor with his cross departmental remit to review the available global warming literature with a view to calling for new money funding into sub-glacial geology and in particular to sub West Antarctic Ice Sheet geology. A major new money investment in this research would be far cheaper than an investment in 2 metre defences (???defences costing maybe some 20 billion for *all* of the SE (a 1998 cost equivalent guestimate using a 1989 Inst of Terrestrial Ecology estimate as a base)???). (It would be in the City's financial institutions interests to provide this funding.)
- both in terms of public good and public expense, the Environment Agency should immediately advise Councils and local planning authorities in the SE not to authorise any green field development on land below 2 metres (arguably below 6 metres since it likely that green field sites once brown will remain so for centuries). Indeed the EA may wish to disown its responsibilities to protect such subsequently new green field communities. This may at first seem a little alarmist. However when one considers that one would expect such communities to exist for centuries (indeed many Londoners already live in communities centuries old (indeed many homes are themselves over a century old (including my own)), then one should plan for the long-term. Incidentally this would take care of any short term 'surprises' of which the IPCC warn. To this scientist concerned with climate change issues, the developments currently being prepared for on Crayford Marshes are due to either highly ill-informed or are the ultimate in planning cynicism.

Note: the above concerns solely the sea level rise risks due to global warming and SE UK rain fall flood risks. It quantitatively ignores risks to local geological altitude change. Nor does it take into account tidal and storm surge risks.

The views expressed above are the personal interpretation of *current* (July 1998) scientific research by Jonathan Cowie, and not of any body associated him. Furthermore, as advised above, independent appraisal of the global warming literature is firmly recommended.

Making Sense of Information

a ten minute introduction by Jonathan Cowie

Perceiving risk

Humans tend not to assess information and data scientifically

We live in a society not used to assessing probabilities. There are two reasons for this.

- people tend not understand statistics (the science of probability): which is apparent from the common misnomer 'lies, damn lies, and statistics', as well as the popularity of the national lottery (there are better ways to gamble (ex: premium bonds) and better ways to give to charity (ex: deed of covenant)).
- people tend not to perceive and assess things as they are (which is perfectly natural as we have imperfect biological sensory and processing equipment). For instance what number of people do we need in a room for two people to share the same birthday?

Interestingly a study in the US shows that Americans (from an odd culture in itself) over-estimate risks from external natural phenomena such as botulism, tornadoes and floods, while under-estimate personal health risks largely affected by life style (ex: stroke, heart attacks, cancer, and diabetes) -- *Journ Exp Psych: Hum Learn & Mem* (1978) **4**, 551 reported in *Living With Risk* (1987) BMA/Pan: London.

In 1997 POST (the Parliamentary Office of Science & Technology) published a report on risk assessment and the environment (*Safety in Numbers*). It notes two things of interest to this evening. First that in terms of certainty and controllability, that the risk from floods seems to be similar to the way the report views the risks of nuclear power. Secondly, that in 1996/7 the Environment Agency's ***own*** flood defence spend equalled 38% of the EA's £550m budget. The total proportion of the EA's annual budget spent on flood defense, including a MAFF flood defence grant, is 45% or £245m (nearly a quarter of a billion a year).

Politicians tend not to assess information and data scientifically

Politicians make sense of information and assess risk in a most peculiar way, at least as far as life scientists are concerned. But perhaps this is not surprising. Politicians are used to reconciliation hence compromise. Unfortunately biology does not work this way.

Example where economics is involved: fisheries

For instance biologists will through ecological sampling, estimate the size of a fishery and its maximum sustainable yield (MSY). Now the thing about MSY is that if you exceed the maximum it is no longer sustainable. However what has happened consistently to date is that biologists estimate the MSY for various species in North Sea fisheries. Politicians from various countries get lobbied by their respective fishing communities, and so the politicians come to a compromise figure. Unfortunately this has invariably been higher than the MSY and so the fisheries have become stressed... (with no surprise to biologists).

Example where economics is involved: BSE

Another example is with infection. It may not come as a surprise to you but an animal is either infected or it is not. It cannot be slightly infected any more than a woman can be slightly pregnant -- there are some hard biological principles. This example relates to the history of AIDS and BSE policy. With BSE, back at the end of the last decade biologists said that they did not think it likely that BSE was transmissible to humans but called on politicians to invoke the precautionary principle to be safe and ensure that humans were not at risk. The clear advice was given for *all* infected cattle to be taken out of the human food chain. Did this happen? In fact the Government decided to pay farmers just 50% compensation for infected cattle (saving several million pounds) and they allowed cattle brains to continue to go into feed for non-cattle farm species with no warnings on the packs. These two errors, both clearly contrary to the scientific advice given has, a decade on, cost the tax payer a couple of a billion pounds, the nation several billion, and considerable economic hardship to many families and rural communities.

There are other examples

One could also point out that biology has no political boundaries (*cf*: the national basis for UK woodland policy). That infirm and elderly people biologically react to warmth differently (*cf*: VAT on energy).

Getting a handle on risk?

On a personal basis I have found it important to do two things when analysing risk for science policy:

- distance myself personally (psychologically) from the problem
- rely heavily on scientific and statistical basics

The first point is, I hope, obvious, but important nonetheless.

By the second I mean recognise exactly what it is the experts are telling you. When you are given a forecast remember:

- usually (if not invariably) assumptions are made. What are these assumptions?
- there is usually a data set, therefore in turn note:
  - what is the size of that data set?
  - that there is usually a spread of data on which this forecast is based. What is that spread?
  - what are the controls for that data set?
- have type I and type II errors been allowed for?
  (This is the chance of being right when you should be wrong, and the chance of being wrong when you should be right. We all, and society, allow for type I and II errors and bias decisions accordingly. For example in our legal system we have to decide whether to balance the innocent getting wrongly convicted against the guilty going free.)
  With regards to greenhouse policy both type I and II approaches give us a win-win scenario (see table). Unfortunately this is not so with regards to dealing with all of the symptoms of global warming such as sea level rise.
- What are the key unknowns required to be known to improve the quality of the forecast?

However, and finally, with regard to global sea level rise due to climate change using the above I would like to make a few preliminary observations:

- computer models are very useful but they are only models and contain many assumptions (for instance they have not been particularly good at reflecting high latitude climatic change and are only now (late 1990s) beginning to couple vegetation interactions with the ocean and atmosphere climatic system (see *Phil Trans B* (1998) vol 353, pp1-171). In short they are rough pointers only (but *are* improving).
- the present data set is just 1 -- as there is only one Earth. However temporally there are numerous Earths under different climatic regimens stretching back in time. These palaeo analogues can help both verify computer models and provide pointers in their own right.
- to begin to take type I and II errors into account we need to:
  - identify then next likely scenario should the preferred scenario (from which our least, worst and best estimates are currently calculated)
  - recognise that both sea level and sea defence costs both rise incrementally (*i.e.* we need to identify the extras added risk or probability of the sea level rising an extra cm, and also the costs for raising sea defences each extra cm. For each of these there will need to be type I and II error allowances.
- finally we need to reconcile uncertainties. This also means that it should not be taken for granted that the national and international research needed to underpin local decisions regarding sea level rise is taking place, and even if it is that policy-makers are affording it the appropriate priority. It is therefore important that those with responsibility for the local problem of sea defences make their research needs known to those responsible for national policy across the disciplines. There are fora for semi-formal discussion (ex: the Parliamentary and Scientific Committee), there are more formal discussion fora such as through the Technology Foresight programme (I note that a consultation is currently under way and that one proposed cross-panel theme is the future of cities, while another is sustainability); then there is the OST's Science & Technology Committee (in effect a re-vamped ACOST); finally there are the Science and Technology select committees of both the House of Commons and House of Lords. All provide precursors (of varying formality) to any full-blown Green Paper on the topic.

  With regard to scientific uncertainties and the latest science, I note that there have been papers pointing to the importance of the stability of the West Antarctic Ice Sheet to medium to long-term sea level rise (*i.e.* sea level rise beyond the middle of next century for the next few hundred years). Out of interest I attach a couple of sheets with further thoughts. Here uncertainties abound because we do not know the sub-glacial geology, but it has been suspected for a while that at one key point it is likely that there is volcanic activity! (Blakenship *et al* (1993) *Nature* v361 p526-9).