IPCC Fourth Assessment Report: Climate Change 2007

Climate Change 2007: Working Group I: The Physical Science Basis

5.5 Changes in Sea Level

5.5.1 Introductory Remarks

Present-day sea level change is of considerable interest because of its potential impact on human populations living in coastal regions and on islands. This section focuses on global and regional sea level variations, over time spans ranging from the last decade to the past century; a brief discussion of sea level change in previous centuries is given in Section 5.5.2.4. Changes over previous millennia are discussed in Section 6.4.3.

Processes in several nonlinearly coupled components of the Earth system contribute to sea level change, and understanding these processes is therefore a highly interdisciplinary endeavour. On decadal and longer time scales, global mean sea level change results from two major processes, mostly related to recent climate change, that alter the volume of water in the global ocean: i) thermal expansion (Section 5.5.3), and ii) the exchange of water between oceans and other reservoirs (glaciers and ice caps, ice sheets, other land water reservoirs - including through anthropogenic change in land hydrology, and the atmosphere; Section 5.5.5). All these processes cause geographically non-uniform sea level change (Section 5.5.4) as well as changes in the global mean; some oceanographic factors (e.g., changes in ocean circulation or atmospheric pressure) also affect sea level at the regional scale, while contributing negligibly to changes in the global mean. Vertical land movements such as resulting from glacial isostatic adjustment (GIA), tectonics, subsidence and sedimentation influence local sea level measurements but do not alter ocean water volume; nonetheless, they affect global mean sea level through their alteration of the shape and hence the volume of the ocean basins containing the water.

Measurements of present-day sea level change rely on two different techniques: tide gauges and satellite altimetry (Section 5.5.2). Tide gauges provide sea level variations with respect to the land on which they lie. To extract the signal of sea level change due to ocean water volume and other oceanographic change, land motions need to be removed from the tide gauge measurement. Land motions related to GIA can be simulated in global geodynamic models. The estimation of other land motions is not generally possible unless there are adequate nearby geodetic or geological data, which is usually not the case. However, careful selection of tide gauge sites such that records reflecting major tectonic activity are rejected, and averaging over all selected gauges, results in a small uncertainty for global sea level estimates (Appendix 5.A.4). Sea level change based on satellite altimetry is measured with respect to the Earth's centre of mass, and thus is not distorted by land motions, except for a small component due to large-scale deformation of ocean basins from GIA.

The TAR chapter on sea level change provided estimates of climate and other anthropogenic contributions to 20th-century sea level rise, based mostly on models (Church et al., 2001). The sum of these contributions ranged from –0.8 to 2.2 mm yr^{-1}, with a mean value of 0.7 mm yr^{-1}, and a large part of this uncertainty was due to the lack of information on anthropogenic land water change. For observed 20th-century sea level rise, based on tide gauge records, Church et al. (2001) adopted as a best estimate a value in the range of 1 to 2 mm yr^{-1}, which was more than twice as large as the TAR's estimate of climate-related contributions. It thus appeared that either the processes causing sea level rise had been underestimated or the rate of sea level rise observed with tide gauges was biased towards higher values.

Since the TAR, a number of new results have been published. The global coverage of satellite altimetry since the early 1990s (TOPography EXperiment (TOPEX)/Poseidon and Jason) has improved the estimate of global sea level rise and has revealed the complex geographical patterns of sea level change in open oceans. Near-global ocean temperature data for the last 50 years have been recently made available, allowing the first observationally based estimate of the thermal expansion contribution to sea level rise in past decades. For recent years, better estimates of the land ice contribution to sea level are available from various observations of glaciers, ice caps and ice sheets.

In this section, we summarise the current knowledge of present-day sea level rise. The observational results are assessed, followed by our current interpretation of these observations in terms of climate change and other processes, and ending with a discussion of the sea level budget (Section 5.5.6).