Executive Summary: GSP Study **12056**

SEA LEVEL RESEARCH OF THE BENFITS OF HIGH RESOLUTION

Changes in global sea level arising from man's activity is today a subject of wide interest and concern. However, changes in sea level arise from a range of processes at the Earth's surface and within the 'solid' Earth that act on timescales that range from 1 to 10^7 years. The pattern of sea level change that will emerge from the ongoing sequence of satellite altimeter missions will be the net contribution of all these processes. An understanding of the likely behaviour of the components of the problem is essential to gaining a comprehensive capability to predict sea level rise.

This study was concerned with a comprehensive survey of the magnitude and spatial distribution of the evolution of sea level in the 20^{th} and 21^{st} centuries. Its particular contribution is to examine not only the (now fairly well known) individual contributions to sea level change, but in addition to examine in addition the interactions that may occur between changes the ice sheets, the solid Earth, and the ocean dynamical circulation.

In the first section of the report, 'The Status of Understanding', we survey what is known concerning the various contributions to sea level. The section is split into three sections, which describe respectively the contributions of the solid Earth, the ice sheets and the oceans. The main purpose of this section is to point out the complexity that arises from changes in mass: these effect the gravity field, which in turn effects the sea level. The problem needs solving simultaneously, using sophisticated representations of the Earth's viscosity structure. In introducing the ice sheets, the status of knowledge of their current mass exchange with the ocean is described. Finally, the section on the ocean introduces the main concerns from the oceanic point of view. Here, the report emphasises what is a first order problem in predicting sea level rise due to thermal expansion: the dependence of the expansion coefficient on temperature. In addition, evidence that the circulation may change as a result of freshwater input to the ocean, particularly in the Northern Hemisphere, is also summarised.

These three aspects of the problem are then considered in detail in the following three sections of the report. In the section ‘Contribution of the Solid Earth’, the effect of the viscosity of the Earth in response to movements of ocean or ice mass at its surface is considered. The largest of these effects is the result of the Pleistocene deg1aciation, and this is considered first globally. The effects are rather greater in the gravity free-air anomaly than the geoid, and this distinction is described. The regional effects around Europe are discussed. The GOCE gravity mission is likely to have unique capability at short wavelengths, and so this part of the gravity field is considered particularly. The smaller (elastic) affects of present-day imbalance of the Earth's ice sheets are described.

In the section ‘Contribution of the Cryosphere’ we describe the best estimates that are available of the spatial distribution of changing ice sheet, ice cap and glacier mass. The spatial distribution is important in considering the response of the solid Earth to the distribution of ice and ocean load, and to the impact on the ocean thermohaline circulation that freshwater input may have. Few new observations are available to improve on existing uncertainties in the mass imbalance of ice sheets and glaciers. In this report therefore, existing estimates are reported. Considerable uncertainty remains, and the impact of the CryoSat mission on improving this situation is also described.

In the final section, the ‘Contribution of the Ocean’ the effects of thermal expansion, and of historical and present inputs of freshwater from the ice sheets are examined. A contemporary, global ocean atmosphere model is used to explore the effect on ocean dynamics, and on sea level, of these contributions. This model, including these effects, are used to generate a ‘reference sea level’ from which the influence of thermal expansion and freshwater input can be examined. The effect of large inputs of freshwater in the North and South Hemispheres are examined, in the former case, the effect is to stop the N. Atlantic thermohaline circulation. However, more reasonable amounts of freshwater (of the magnitude indicated in the Cryosphere chapter) do not have such an effect.

In summary, this study shows that the interactions between the present ice sheet mass imbalance, and the dynamical response of the solid earth on the one hand, and the ocean

circulation of the other, are rather small in comparison with those of post-glacial rebound and thermal expansion. The one substantial effect, the reduction or stopping of the N. Atlantic thermo-haline circulation, requires what appears to be unrealistic amounts of freshwater forcing. On the other hand, there may be regions where these interactions have an appreciable signal in measured sea level change.