REPORT OF THE CROSS-SSG ACTION GROUP ON PREDICTION OF CHANGES IN THE PHYSICAL AND BIOLOGICAL ENVIRONMENTS OF THE ANTARCTIC

TO DELEGATES AT XXXI SCAR MEETING, 2010

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The cross-SSG Action Group on Prediction of Changes in the Physical and Biological Environments of the Antarctic was established at the SCAR Delegates‘ meeting in Moscow during July 2008. Its brief is to improve our ability to predict how the Antarctic environment will evolve over the next century. The full terms of reference are attached as the Appendix. It is a cross-disciplinary group that brings together meteorologists, oceanographers and marine and terrestrial biologists. It has an initial 4-year lifetime.

<u>The membership of the group consists of</u>

Prof. John Turner, British Antarctic Survey, UK (jtu@bas.ac.uk) co-chair
Dr. Julian Gutt, Alfred Wegener Institute, Germany (Julian.Gutt@awi.de) co-chair
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The group has met twice. The initial kick-off meeting was held at the headquarters of the British Antarctic Survey in Cambridge, UK over 5-6 November 2008. A second meeting was held at the Alfred Wegener Institute, Bremerhaven, Germany over 30 September – 2 October 2009. In addition, an *ad hoc* meeting took place during the SCAR biology symposium in Sapporo, Japan on 29 July 2009.

Achievements

ACCE - Members of the group have been heavily involved in the preparation of the SCAR Antarctic Climate Change and the Environment (ACCE) report. Both co-chairs and two members of the group are editors of the volume and were present at its press launch in London on 30 November 2009. After its launch several members of the Steering Committee contributed to scientific and PR-events to communicate this interdisciplinary report. Pete Convey led the production of a summary paper on ACCE for Antarctic Science, which was published in 2009. An update to the ACCE report was prepared for the ATCM in Uruguay.

High horizontal resolution climate modelling - The current generation of global climate models have a relatively coarse horizontal resolution of around 200 km, which is insufficient to resolve the complex orography, and consequently, also the ecology, of the Antarctic Peninsula and many coastal areas of the continent. We have run a series of experiments with a regional climate model that uses horizontal resolutions in the range 12 to 1 km, which covers the patch size of benthic, pelagic, and terrestrial assemblages much better than a coarser resolution. This also allows us to determine the resolution required to simulate the wind field around the continent, which is important in air-sea-ice interactions. We will publish this work during the coming year.

Natural climate variability - The climate of the Antarctic has a large natural variability as a result of interactions between the atmosphere, ocean and ice, which can result in feedbacks that amplify small perturbations. This makes it difficult to separate natural climate variability from anthropogenic factors, and complicates the prediction of how the climate will evolve and what the response of the biosphere will be. We are therefore investigating natural variability of the Antarctic climate system through examining long (1000 year) runs of climate models with all forcings held constant.

Constraining predictions with observations - Different climate models give different predictions of future climate due to differences in the way they simulate processes such as cloud formation. Observations can be used to help determine which climate models are most reliable. We are currently working on using available temperature data to constrain predictions of future Antarctic-wide temperature change in a range of different climate models.

Using atmospheric data to understand species dispersal - Antarctic terrestrial habitats are typically 'island like', isolated on various geographical scales. However, for instance along the Antarctic Peninsula and Scotia arc, some terrestrial biota are widely distributed. Passive dispersal with air movement (wind) provides one of the most frequently postulated mechanisms for explaining this wide distribution. Currently we are using atmospheric model data to assess the frequency of rapid wind-driven dispersal. The goal is to provide a species-specific assessment by combining the atmospheric data with physiological data for species groups such as springtails. A presentation is being given at the OSC, and a paper being developed.

Results on the response of the Antarctic ecosystem to recent changes in the physical and chemical environment - our knowledge is now sufficient that these responses can -with care- be ranked:

1. All ecosystem components related to the sea-ice are already significantly affected by its decrease. Krill stocks in the SW Atlantic sector are significantly reduced; negative consequences for other tropic levels ranging from microorganisms to whales are expected. Primary productivity can both increase and decrease in areas with shorter periods of sea-ice cover along the WAP. In the theoretical scenario of a Southern Ocean without sea-ice primary productivity is expected to increase by 25%. Also in the open water areas increased primary production is expected in case of further atmospheric warming. Vegetation on the Antarctic Peninsula, along with associated fauna, will extend their distributions. Some penguins will suffer from changes of the terrestrial climate conditions. Emperor and King penguin colonies could become extinct and Adelies are expected to shift their distribution range further south.
2. Disintegration of ice-shelves causes drastic changes in marine environmental conditions. Locally new habitats for invaders will be provided but organisms adapted to the under-ice conditions will probably become extinct. These new areas of open water could also act in the future as CO_2 sinks. Increase of freshwater run-off will „pollute" coastal areas.

3. There is not yet clear evidence for direct effects of increased SST, but e.g. the occurrence of invaders cannot be excluded, as already observed for terrestrial habitats on sub-Antarctic islands. Turnovers in species composition are expected to become most obvious at the margin of the Antarctic water mass due to a shift of the ACC to the south.
4. Acidification might become the most serious problem in the future because almost the entire marine environment might become affected and organisms cannot survive in refuges.

So far whaling and bottom fishing must be considered the most serious anthropogenic changes in the Southern Ocean ecosystem. For the future the impact of climate change can be regarded the most serious actual threat of life in the Antarctic.

Improved predictions - during the Cambridge meeting the first projections were presented of the temperature evolution at different water depths, which is of high relevance for the marine ecosystem since most species inhabit the sea-floor. Also the latest results on future changes in hydrodynamic circulation patterns and strengths, as well as sea-ice and the response of the marine and terrestrial ecosystem were presented and discussed. Most of these biological and physical scenarios have been used in the ACCE report. Agreed actions focused on the scientific output of the group, on recommendations to emphasize long term observations and to study physiological limits and ecological demands of ecological key species.

The scales of change – at the Bremerhaven meeting several presentations dealt with the spatial and temporal resolution of physical measurements and predictions, since many biological processes have a short-term (e.g. seasonal) and small scale (e.g. krill swarm) component. The relevance of a 25% sea-ice reduction and, as a consequence, a 10% increase in algal production for the entire marine ecosystem, especially trophic key species such as the Antarctic siverfish, was stressed.

Future plans

The Fifth IPCC Assessment Report (AR5) – The climate model output that will form the basis of the report will be released in late 2010 from the Coupled Model Intercomparison Project (CMIP). This CMIP5 data base will be a powerful tool with which to generate improved predictions of the physical environment of the Antarctic. We will assess how the models simulate the observed changes during the late Twentieth Century and weight the predictions for the coming century accordingly to produce improved predictions.

Meeting on Antarctic prediction - the group are considering a possible workshop on changes in the physical environment and the response of benthic and pelagic assemblages based on the bioregionalisation approach.

Outreach

The group maintains a web site at http://www.antarctica.ac.uk/met/SCAR_ssg_ps/Prediction/. This provides details of our activities, formal minutes of our meetings

Finance

The Bremerhaven meeting was funded by the SCAR LSSG with $ 2700,-.

Appendix – Terms of reference of the group

(1) Assess our current ability to predict how the physical and biological environments of the Antarctic will evolve over the next century;

(2) Identify the extent to which the physical and biological approaches to prediction can be integrated;

(3) Determine the parameters needed from climate models to predict changes in the biosphere;

(4) Consider the issues involved in downscaling from the resolution of climate models to those required for prediction of biological systems;

(5) Investigate the means of improving prediction of selected physical parameters and their impacts on aspects of marine and terrestrial biota;

(6) Identify areas where future research is needed.