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SCAR Annual Report 2013/14

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SCAR Annual Report 2013/14

1. Background

The Scientific Committee on Antarctic Research (SCAR) is a non-governmental, Interdisciplinary Scientific Body of the International Council for Science (ICSU), and Observer to the Antarctic Treaty and the UNFCCC.

SCAR's mission is (i) to be the leading, independent, non-governmental facilitator, coordinator, and advocate of excellence in Antarctic and Southern Ocean science and research and (ii) to provide independent, sound, scientifically-based advice to the Antarctic Treaty System and other policy makers including the use of science to identify emerging trends and bring these issues to the attention of policy makers.

2. Introduction

SCAR's scientific research adds value to national efforts by enabling national researchers to collaborate on large-scale scientific programmes to accomplish objectives not easily obtainable by any single country. SCAR's members currently include 37 nations and 9 ICSU scientific unions.

SCAR's success depends on the quality and timeliness of its scientific outputs. Descriptions of SCAR's research programmes and scientific outputs are available at: www.scar.org. This paper summarises SCAR highlights since the last annual report, including selected science highlights for the past year, which are listed in Appendix 1.

SCAR produces an electronic quarterly Newsletter highlighting relevant science and other SCAR related issues (www.scar.org/newsletter). Please email: info@scar.org if you wish to be added to the mailing list. As well as the web (www.scar.org), SCAR is also available on Facebook, LinkedIn, Google+ and Twitter.

3. SCAR Highlights (2013/14)

In this paper, we highlight examples of SCAR activities that we believe to be of particular interest to Treaty Parties and others. For further details see www.scar.org.

State of the Antarctic Ecosystem (AntEco) www.scar.org/srp/anteco

The Scientific Research Programme (SRP) AntEco focuses on patterns of biodiversity across terrestrial, limnological, glacial and marine environments within the Antarctic, sub-Antarctic and Southern Ocean regions, and will provide scientific knowledge on biodiversity that can be also used for conservation and management. A primary product of this programme will be recommendations concerning Antarctica's management and conservation.

Antarctic Thresholds - Ecosystem Resilience and Adaptation (AnT-ERA)
www.scar.org/srp/ant-era

The AnT-ERA SRP examines the current biological processes in Antarctic ecosystems, to define their thresholds and thereby determine resistance and resilience to change. Polar ecosystem processes are key to informing wider ecological debate about the nature of stability and change in ecosystems. The programme will attempt to determine the likelihood of cataclysmic shifts or "tipping points" in Antarctic ecosystems.

Antarctic Climate Change in the 21st Century (AntClim^{21})
www.scar.org/srp/antclim21

The goals of the SRP AntClim^{21} are to deliver improved regional predictions of key elements of the Antarctic atmosphere, ocean and cryosphere for the next 20 to 200 years and to understand the responses of the physical and biological systems to natural and anthropogenic forcing factors. Palaeo-reconstructions of selected time periods, recognised as past analogues for future climate predictions, will be used to validate model performances for the Antarctic region.

Southern Ocean Acidification
www.scar.org/ssg/physical-sciences/acidification

SCAR will synthesise the scientific understanding of Southern Ocean acidification. The Action Group tasked with this consists of an international cross-disciplinary team of ocean acidification experts representing the fields of marine carbonate chemistry, global and regional modelling, marine ecology, ecotoxicology/physiology and paleoceanography. The final report will be published in August 2014.

Geoheritage Values ***www.scar.org/ssg/geosciences/geoheritage***

A new Action Group on Geoheritage Values, conservation and management has been formed by SCAR. In this context, geological “values” will examine aspects such as unique mineral or fossil localities and landforms or outcrops of special significance. The outcomes of discussions held at the Treaty will be considered when the Terms of Reference and future work plan of this group are discussed during the SCAR Business meetings in August 2014.

Antarctic Biodiversity Informatics ***www.scar.org/ssg/life-sciences/abi***

Biodiversity Informatics is the application of informatics techniques to biodiversity information for improved management, presentation, discovery, exploration and analysis. This Expert Group will coordinate biodiversity informatics activities across SCAR for research, management, conservation and monitoring purposes and promote free and open access.

Environmental Contamination in Antarctica (ECA)
www.scar.org/ssg/life-sciences/eca

The main aims of the Environmental Contamination in Antarctica Action Group are the analysis and comparison of national research projects, the coordination of studies on environmental contamination in Polar regions and to identify new research on the subject.

Ice Sheet Mass Balance and Sea Level (ISMASS)
www.scar.org/ssg/physical-sciences/ismass

The SCAR/IASC/CliC Expert Group on Ice Sheet Mass Balance and Sea Level (ISMASS) aims to improve estimation of the mass balance of ice sheets and their contribution to sea level, to facilitate coordination of the different international efforts focused on this field of research, to propose directions for future research in this area, to integrate the observations and modelling efforts, as well as the distribution and archiving of the corresponding data, and to attract a new generation of scientists into this field of research.

Operational Meteorology in the Antarctic (OpMet)
www.scar.org/ssg/physical-sciences/opmet

The OpMet Expert Group focuses on establishing links between groups working in the same area of operational meteorology in Antarctica, in particular the WMO EC-PORS (Panel of Experts on Polar Observations, Research and Services) group.

Remote Sensing ***www.scar.org/ssg/life-sciences/remotesensing***

The SCAR Action Group on Remote Sensing has been established with the full name "Development of a satellite-based, Antarctic-wide, remote sensing approach to monitor bird and animal populations", with the aim of addressing the topic of "animal monitoring via remote sensing".

The Southern Ocean Observing System (SOOS) ***www.soos.aq***

The SCAR/SCOR Southern Ocean Observing System (SOOS) has the mission *to establish a multidisciplinary observing system to deliver the sustained observations of the Southern Ocean*. A SOOS International Project Office, established in Australia and supported by the Institute for Marine and Antarctic Studies at the University of Tasmania in Hobart and Antarctica New Zealand, supports implementation of the SOOS.

Antarctic Climate Change and the Environment (ACCE)
www.scar.org/othergroups/acce

The climatic, physical and biological properties of Antarctica and the Southern Ocean are closely coupled to other parts of the global environment by the oceans and the atmosphere. In 2009, SCAR published the landmark *Antarctic Climate Change and the Environment Report* and since then has provided annual updates to the Antarctic

Treaty Consultative Meeting. For more information, see the Treaty information paper IP060 at www.scar.org/treatypapers/atcm37.

The SCAR Science Horizon Scan www.scar.org/horizonscanning/

Following the crowdsourcing of over 850 unique scientific questions and the nomination of almost 500 leading scientist by the SCAR community, the 1st SCAR Antarctic and Southern Ocean Science Horizon Scan assembled more than 70 of the world's leading Antarctic scientists, policy makers and visionaries (including many early career scientists) in Queenstown, New Zealand, in April this year. Their remit was to identify the most important scientific questions that will or should be addressed by research in and from the southern Polar regions over the next two decades. The Scan outcomes will assist in aligning international programmes, projects and resources to effectively facilitate Antarctic and Southern Ocean science in the coming years. A full report will be submitted to the 2015 Treaty Meeting. Details of the main Scan results can be found on the Horizon Scan website (www.scar.org/horizonscanning).

Antarctic Conservation in the 21st Century www.scar.org/antarctic-treaty-system/scats

SCAR, COMNAP, New Zealand and the IUCN, in collaboration with several partners, are developing a strategy entitled '*Antarctic Conservation for the 21st Century*'. The activity will encourage participation from all stakeholders in the region. The approach will be structured to align with both the Protocol on Environmental Protection to the Antarctic Treaty and the Five Year Work Plan of the Committee for Environmental Protection. The Antarctic Conservation Strategy links closely with the Antarctic Environments Portal. See also the COMNAP-SCAR joint Treaty information paper, IP010 entitled '*Antarctic Conservation Strategy: Scoping Workshop on Practical Solutions*' (www.scar.org/treatypapers/atcm37). Note that a conservation 'flipped symposium' will be held during the SCAR Open Science Conference in August 2014 as part of this process.

Antarctic Data Management www.scar.org/data-products

SCAR promotes free and unrestricted access to Antarctic data and information by promoting open and accessible archiving practices, through its Standing Committees on Antarctic Data Management (SCADM) and Antarctic Geographic Information (SCAGI). SCAR also has several products of use to the Antarctic community.

4. SCAR Fellowships and Prizes

In order to expand capacity in all its members, SCAR runs several fellowship and prize schemes (www.scar.awards):

- ***SCAR/COMNAP Fellowships*** are focussed on early career scientists and engineers in Antarctic scientific research, to build new connections and further strengthen international capacity and cooperation in Antarctic research. The

fellowships are being launched in tandem with the CCAMLR Scholarships. See www.scar.org/awards/fellowships for more information.

- ***Martha T Muse Prize for Science and Policy in Antarctica,*** sponsored by the Tinker Foundation, is a US$ 100,000 unrestricted award presented to an individual in the fields of Antarctic science or policy. See: www.museprize.org.
- ***SCAR Visiting Professor Scheme*** provides the opportunity for mid- to late-career scientists to undertake short-term visits to a facility in or operated by another SCAR member country, to provide training and mentoring. See www.scar.org/awards/visitingprofs for more information.

5. SCAR wins 2013 Prix Biodiversité of the Prince Albert II of Monaco Foundation

SCAR was awarded the Prince Albert II of Monaco Foundation's 2013 Prix Biodiversité in recognition of its contribution to science and its work to improve our understanding of the environment.

6. Future SCAR Meetings

There are several major SCAR Meetings coming up (www.scar.org/events), including:

- ***XXXIII SCAR Meetings and Open Science Conference.*** 22 August-3 September 2014, Auckland, New Zealand. The SCAR Open Science Conference will be held on 25-29 August. See: http://www.scar2014.com.
- ***XII International Symposium on Antarctic Earth Sciences (ISAES) 2015.*** 13-17 July 2015, Goa, India. http://www.ncaor.gov.in/files/ISAES-2015Flyer1.pdf

Appendix 1

Selected Antarctic and Southern Ocean Science Highlights for 2013/14

Here we highlight some recent key papers published over the past year. Although not highlighted below, the latest ACCE update (Treaty Information Paper IP060 at www.scar.org/treatypapers/atcm37) should also be consulted as it contains many pertinent references to climate change in the Antarctic region. It should also be noted that this is by no means a complete list (there have been many highly significant papers published over the last year) but represents a sample of key science papers highlighted by SCAR groups.

Ice Sheet Mass Balance and Sea Level:

- The recent review by Hanna et al. (2013) synthesizes the latest advances in monitoring and modelling of ice-sheet mass balance. The current ice-sheet models are no longer constrained to use overly simplified physics, allowing them to simulate more accurately the important coupling between ice sheets, ice streams and ice shelves. This major advance has been accompanied by improved model representation of the complex interactions of the ice sheet with its bed, the atmosphere and the ocean. Despite recent advances, improved observations and predictions of ice-sheet response to climate change are still urgently needed to feed into mitigation and adaptation models of ensuing sea level rise.

  Hanna, E., Navarro, F.J., Pattyn, F., Domingues, C.M., Fettweis, X., Ivins, E.R., Nicholls, R.J., Ritz, C., Smith, B., Tulaczyk, S., Whitehouse, P.L., and Zwally, H.J. 2013. Ice sheet mass balance and climate change. Nature, 498, 51-59, DOI:10.1038/nature12238

- This research suggests that the largest single contributor to global sea level rise, a glacier of the West Antarctic Ice Sheet, may continue thinning for decades to come. Geologists from the UK, USA and Germany found that Pine Island Glacier (PIG), which is rapidly accelerating, thinning and retreating, has thinned rapidly before. The team say their findings demonstrate the potential for current ice loss to continue for several decades yet. Their findings reveal that 8000 years ago the glacier thinned as fast as it has in recent decades, providing an important model for its future behaviour. The glacier is currently experiencing significant acceleration, thinning and retreat that is thought to be caused by 'ocean-driven' melting; an increase in warm ocean water finding its way under the ice shelf.

  Johnson, J.S., Bentley, M.J., Smith, J.A., Finkel, R.C., Rood, D.H., Gohl, K., Balco, G., Larter, R.D., and Schaefer, J.M. 2014. Rapid thinning of Pine Island glacier in the early Holocene, Science, 343, 999-1001, DOI: 10.1126/science.1247385

Past Climate:

- Bijl et al. (2013) present marine microfossil and organic geochemical records spanning the early-to-middle Eocene transition from the Wilkes Land Margin, East Antarctica. Dinoflagellate biogeography and sea surface paleothermometry

reveal that the earliest throughflow of a westbound Antarctic Counter Current began 49–50 Ma through a southern opening of the Tasmanian Gateway. This early opening occurs in conjunction with the simultaneous onset of regional surface water and continental cooling (2–4 °C), evidenced by biomarker- and pollen-based paleothermometry. The paper shows that the westbound flowing current across the Tasmanian Gateway resulted in cooling of Antarctic surface waters and coasts, which was conveyed to global intermediate waters through invigorated deep convection in southern high latitudes. Although atmospheric CO_2 forcing alone would provide a more uniform middle Eocene cooling, the opening of the Tasmanian Gateway better explains Southern Ocean surface water and global deep ocean cooling in the apparent absence of (sub-) equatorial cooling.

Bijl, P.K., Bendle, J.A., Bohaty, S.M., Pross, J., Schouten, S., Tauxe, L., Stickley, C.E., Röhl, U., Sluijs, A., Olney, M., Brinkhuis, H., Escutia, C., and Expedition 318 Scientists. 2013. Onset of Eocene Antarctic cooling linked to early opening of the Tasmanian Gateway. Proceedings of the National Academy of Sciences of the U.S.A, 110, 9645-9650. DOI:10.1073/pnas.1220872110

- The stepwise expansion of ice on Antarctica during the Eocene-Oligocene Transition (EOT, 34 million years ago), induced crustal deformation and gravitational perturbations around the continent. The paper by Stocchi et al. (2013) identifies the crustal response to ice-sheet growth by forcing a glacial-hydro isostatic adjustment model with an Antarctic ice-sheet model. The result is that close to the ice sheet, sea level rose despite an overall reduction in the mass of the ocean caused by the transfer of water to the ice sheet. Consequently, the coasts experienced a progressive relative sea-level rise. Sediment cores from the vicinity of the Antarctic ice sheet are in agreement with the spatial patterns of relative sea-level change indicated by models. These results are consistent with the suggestion that near-field processes such as local sea-level change influence the equilibrium state obtained by an ice-sheet grounding line.

  Stocchi, P., Escutia, C., Houben, A.J.P., Bijl, P.K., Brinkhuis, H., DeConto, R., Galeotti S., Vermeersen, B.L.A., and Expedition 318 Scientists. 2013. Relative sea level rise around East Antarctica during Oligocene glaciation. Nature Geoscience, 6, 380-384. DOI:10.1038/ngeo1783

- The paper by Houben et al. (2013) shows, on the basis of fossil marine dinoflagellate cyst records, that a major restructuring of the Southern Ocean plankton ecosystem occurred abruptly and concomitant with the first major Antarctic glaciation in the earliest Oligocene (approximately 33.6 million years ago). This turnover marks a regime shift in zooplankton-phytoplankton interactions and community structure, which indicates the appearance of eutrophic and seasonally productive environments on the Antarctic margin. The authors conclude that earliest Oligocene cooling, ice-sheet expansion, and subsequent sea-ice formation were important drivers of biotic evolution in the Southern Ocean.

  Houben, A.J.P., Bjil, P.K., Pross, J., Bohaty, S.M., Stckley, C.E., Passchier, S., Roel, U., Sugisaki, S., Tauxe, L., van de Flierdt, T., Olney, M., Sangiorgi, F., Sluijs, A., Escutia, C., Brinkhuis, H., and the Expedition 318 Scientists. 2013. Modern Southern Ocean plankton ecosystems arose at the onset of Antarctic glaciation. Science, 340, 341-344. DOI:10.1126/science.1223646

Permafrost:

- The paper by Bockheim et al. (2013) provides an overview of permafrost conditions on the Antarctic Peninsula, showing that the dramatic warming of the climate over the last decades has influenced the properties and distribution of permafrost. Permafrost is continuous in the South Orkney Islands (60–61°S) and along the eastern Antarctic Peninsula (63–65°S), it is discontinuous in the South Shetland Islands (62–63°S), and occurs only sporadically in the Palmer Archipelago and Biscoe Islands along the western Antarctic Peninsula (64–66°S). Permafrost then becomes continuous on Alexander Island (71–74°S) along the western Antarctic Peninsula as the maritime climate shifts to a more continental climate. Recent measurements suggest that permafrost is absent or close to 0°C in the upper 14 metres of the highest ice-free areas (67 m a.s.l.) near Palmer Station. Permafrost temperatures elsewhere along the western Antarctic Peninsula region range from −0.4 to −1.8°C in the South Shetland Islands (62–63°S) to −3.1°C at Adelaide Island (67°34′ S).

  Bockheim, J., Vieira, G., Ramos, M., López-Martínez, J., Serrano, E., Guglielmin, M., Wilhelm, K., and Nieuwendam, A. 2013. Climate warming and permafrost dynamics in the Antarctic Peninsula region. Global and Planetary Change, 100, 215-223. DOI: 10.1016/j.gloplacha.2012.10.018

The Southern Ocean:

- Physical dynamics of Southern Ocean water masses are rapidly changing due to atmospheric variations. Changes in the wind forcing driven by the loss of stratospheric ozone and the increase of greenhouse gas concentrations lead to changes in Southern Ocean circulation processes. A key question is how do the oceanic carbon pumps respond to these variations? Hauck et al. identify several processes that are of relevance for current and future CO_2 exchange between the atmosphere and the Southern Ocean. Biological primary production and export production is stimulated by upwelling of iron, a limiting nutrient in large parts of the Southern Ocean. In the annual mean, the upper ocean region south of the Polar Front loses more carbon by additional export production than by the release of CO_2 into the atmosphere, highlighting the role of the biological carbon pump in response to a positive SAM event.

  Hauck, J., Völker, C., Wang, T., Hoppema, M., Losch, M., and Wolf Gladrow, D.A. 2013. Seasonally different carbon flux changes in the Southern Ocean in response to the Southern Annular Mode. Global Biogeochemical Cycles, 27, 1236-1245. DOI: 10.1002/2013GB004600

- In 1974, newly available satellite observations unveiled the presence of a giant ice-free area, or polynya, within the Antarctic ice pack of the Weddell Sea, which persisted during the two following winters. Subsequent research showed that deep convective overturning had opened a conduit between the surface and the abyssal ocean, and had maintained the polynya through the massive release of heat from the deep sea. Although the polynya has aroused continued interest, the presence of a fresh surface layer has prevented the recurrence of deep convection there since 1976, and it is now largely viewed as a naturally rare event. The paper by de Lavergne et al. (2014) presents a new analysis of historical observations and model simulations that suggest deep convection in the Weddell Sea was more active in the past, and has been weakened by anthropogenic forcing. The

observations show that surface freshening of the southern polar ocean since the 1950s has considerably enhanced the salinity stratification. Meanwhile, among the present generation of global climate models, deep convection is common in the Southern Ocean under pre-industrial conditions, but weakens and ceases under a climate change scenario owing to surface freshening. A decline of open-ocean convection would reduce the production rate of Antarctic Bottom Waters, with important implications for ocean heat and carbon storage, and may have played a role in recent Antarctic climate change.

de Lavergne, C., Palter, J.B., Galbraith, E.D., Bernardello, R., and Marinov, I. 2014. Cessation of deep convection in the open Southern Ocean under anthropogenic climate change, Nature Climate Change, DOI:10.1038/nclimate2132.

Marine Ecosystems:

- Silica-shelled diatoms dominate marine phytoplankton blooms and play a key role in ocean ecology and the global carbon cycle. This study shows how differences in ecological traits of dominant Southern Ocean diatom species can influence ocean carbon and silicon cycles. The authors argue that the ecology of thick-shelled diatom species, selected for by heavy copepod grazing, sequesters silicon relative to other nutrients in the deep Southern Ocean and underlying sediments to the detriment of diatom growth elsewhere. This evolutionary arms race provides a framework to link ecology with biogeochemistry of the ocean.

  Assmy, P., Smetacek, V., Montresor, M., Klaas, C., Henjes, J., Strass, V.H., Arrieta, J.M., Bathmann, U., Berg, G.M., Breitbarth, E., Cisewski, B., Friedrichs, L., Fuchs, N., Herndl, G.J., Jansen, S., Krägefsky, S., Latasa, M., Peeken, I., Röttgers, R., Scharek, R., Schüller, S.E., Steigenberger, S., Webb A., and Wolf-Gladrow, D. 2013. Thick-shelled, grazer-protected diatoms decouple ocean carbon and silicon cycles in the iron-limited Antarctic Circumpolar Current. Proceedings of the National Academy of Sciences of the U.S.A., 110, 20633-20638; DOI:10.1073/pnas.1309345110.

- In the Southern Ocean, that is areas south of the Polar Front, long-term oceanographic cooling, geographic separation, development of isolating current and wind systems, tectonic drift and fluctuation of ice sheets amongst others have resulted in a highly endemic benthic fauna, which is generally adapted to the long-lasting, relatively stable environmental conditions. The Southern Ocean benthic ecosystem has been subject to minimal direct anthropogenic impact (compared to elsewhere) and thus presents unique opportunities to study biodiversity and its responses to environmental change. Since the beginning of the century, research under the Census of Marine Life and International Polar Year initiatives, as well as SCAR biology programmes, have considerably advanced our understanding of the Southern Ocean benthos. In this paper, recent progress in Southern Ocean benthic research is described and priorities for future research identified. In a time of potentially pivotal environmental change, one of the greatest challenges is to balance conservation with increasing demands on the Southern Ocean's natural resources and services. In this context, the characterization of Southern Ocean biodiversity is an urgent priority requiring timely and accurate species identifications, application of standardized sampling and reporting procedures, as well as cooperation between disciplines and nations.

Kaiser, S., Brandao, S.N., Brix, S., Barnes, D.K.A., and Bowden, D.A. 2013. Patterns, processes and vulnerability of Southern Ocean benthos: a decadal leap in knowledge and understanding. Marine Biology, 160, 2295-2317. DOI: 10.1007/s00227-013-2232-6

- According to Smith Jr. et al. (2014), the Ross Sea, a major, biologically productive Antarctic ecosystem, "clearly will be extensively modified by future climate change" in the coming decades as rising temperatures and changing wind patterns create longer periods of ice-free open water, affecting the life cycles of both predators and prey. The researchers note that over the last 50 years, the distribution and extent of Antarctic sea ice, or ice that floats on the ocean surface, have drastically changed. Among these changes are a documented decrease of sea ice in the Bellingshausen-Amundsen sector, but an increase of sea ice in the Ross Sea sector of Antarctica. Observations show, they write, that "the duration of ice-free days on the Ross Sea continental shelf has decreased by over two months over the past three decades," which may have had effects on the current balance of biological productivity and the roles of various creatures and microscopic plants in the ocean ecosystem. But, they also note, "future projections of regional air temperature change, however, suggest that substantial warming will occur in the next century in the Ross Sea sector" while wind speeds are predicted to increase in some areas while decreasing in others. "These changes are expected to reverse the sea-ice trends in the future; however the projected changes in heat content on the continental shelf and ecosystems dynamics that will occur as a result of such changes remain far from certain." The model, however, indicates that summer sea ice in the Ross Sea could decrease by more than half, or 56%, by 2050 and by more than three-quarters, or 78%, by 2100. At the same time, the summer mixing of shallow and deep waters in the region as a result of other changes is expected to decrease. "Regardless of the exact nature of the alterations," the researchers write, "substantial portions of the food web that depend on ice in their life cycles will be negatively impacted, leading to severe ecological disruptions."

  Smith Jr., W.O., Dinniman, M.S., Hofmann, E.E., and Klinck, J.M. 2014. The effects of changing winds and temperatures on the oceanography of the Ross Sea in the 21st century. Geophysical Research letters, DOI: 10.1002/2014GL059311.

- Global climate change is the main threat facing the Southern Ocean ecosystem. This study uses the current generation of climate model projections to assess the potential effects of warming on the productivity of Antarctic krill, an important Southern Ocean species and fishery resource. It suggests that warming could reduce productive krill habitat by 20% by the end of the century and that the impacts are likely to be most severe in the Antarctic Circumpolar Current, which is where high concentrations of air-breathing predators feed during the summer breeding season. The authors suggest that more rapid progress is needed in developing management strategies to deal with the risks to the Southern Ocean ecosystem that climate change implies.

  Hill, S.L., Phillips, T., and Atkinson, A. 2013 Potential Climate Change Effects on the Habitat of Antarctic Krill in the Weddell Quadrant of the Southern Ocean. PLoS ONE, 8, e72246. DOI:10.1371/journal.pone.0072246.

- Louzao et al. reconstructed the foraging patterns of the wandering albatross, *Diomedea exulans*, in the highly dynamic Southern Ocean over the last half-century. Their findings: (1) provide a historical baseline (1958 – 1968) of

recurrent, occasional and unfavourable foraging habitats; (2) reveal a progressive habitat shift in the following decades driven by a propagation of sea surface height from SE South Africa towards Antarctica from 1958 to 2001; and (3) measure habitat change rates of wandering albatross over the last half century. This study provides a quantitative long-term assessment of the spatial response of a marine top predator to changing pelagic habitats of the Southern Ocean and highlights the oceanographic mechanisms involved, offering new insights about future effects of climate change on the pelagic realm.

Louzao, M., Aumont, O., Hothorn, T., Wiegand, T., and Weimerskirch, A. 2013. Foraging in a changing environment: habitat shifts of an oceanic predator over the last half century, Ecography 36, 57–67. DOI:10.1111/j.1600-0587.2012.07587.x

Terrestrial Ecosystems:

- Despite considerable research on biological invasions, key areas remain poorly-explored, especially ways to reduce unintentional propagule transfer. The Antarctic represents a microcosm of the situation, with the numbers of established non-native species growing. Information to help reduce potential impacts is therefore critical. Huiskes et al. measured the propagule load of seeds, and fragments of bryophytes and lichens (the number of other plant or animal fragments was too low to draw any conclusions) carried in the clothing and gear of visitors to the Antarctic, during the 2007/08 austral summer. Samples were collected from different categories of visitors associated with national research programmes and tourism and different categories of clothing and gear, new as well as used. They also collected information about the timing of travel and the regions visitors had travelled to prior to Antarctic travel. Seeds were found in 20% and 45% of tourist and science visitor samples, respectively. For bryophyte and lichen fragments the proportions were 11% and 20%, respectively. Footwear, trousers and bags belonging to field scientists were the highest risk items, especially of those personnel who had previously visited protected areas, parklands/botanic gardens or alpine areas. Tourists who visited rural/agricultural areas prior to travel, and/or travel with national programmes or on smaller tourist vessels had the highest probability of transferring plant propagules. Travel either during the boreal or austral autumn months increased the probability of propagule presence. Their assessment is applicable to other areas, given evidence of propagule transfer patterns in those areas that are broadly similar to those documented here. The current work provides a sound evidence base for both self-regulation (e.g. taking care of personal equipment) and organization-based regulation (e.g. issuing guidelines and holding regular inspections) to reduce propagule transfer of plants to the Antarctic.

  Huiskes, A.H.L., Gremmen, N.J.M., Bergstrom, D.M., Frenot, Y., Hughes, K.A., Imura, S., Kiefer, K., Lebouvier, M., Lee, J.E., Tsujimoto, M., Ware, C., Van de Vijver, B., and Chown, S.L. 2014. Aliens in Antarctica: Assessing transfer of plant propagules by human visitors to reduce invasion risk. Biological Conservation, 171, 278–284, DOI:10.1016/j.biocon.2014.01.038.

- Mosses, dominant elements in the vegetation of polar and alpine regions, have well-developed stress tolerance features that allows them to lower their metabolic activity to extremely low levels (cryptobiosis). However, direct regeneration after

longer periods of cryptobiosis has been demonstrated only from herbarium and frozen material preserved for 20 years at most. In this paper, Roads et al. (2014) show unprecedented millennial-scale survival and viability deep within a moss bank preserved in permafrost on Signy Island, maritime Antarctic. Gametophyte material adjacent to regrowth at 110 cm depth was radio-carbon dated to 1533–1697 cal. years BP. The radiocarbon date obtained here therefore considerably extends the potential timescale for viability demonstrated for entire bryophytes. Further, the potential clearly exists for much longer survival – although viability between successive interglacials would require a period of at least tens of thousands of years – for instance, where a moss bank profile already preserved through permafrost formation is subsequently over-run by an advancing cold-based glacier (i.e. in the absence of glacial scouring). The findings in mosses have special relevance for Antarctic ecosystems and climate, because mosses are primary producers on land in both northern and southern Polar regions. If mosses can survive in this way for such long periods of time, then regrowth once the ice retreats wouldn't require long-distance, transoceanic colonization events. The potential clearly exists for much longer survival, and such a possibility provides an entirely new survival mechanism and a refugium for a major element of the polar terrestrial biota.

Roads, E., Longton, R.E., and Convey, P. 2014. Millennium timescale regeneration in a moss from Antarctica. Current Biology, 24, R222-R223, DOI: 10.106/j.cub.2014.01.053

- Climate change has played a critical role in the evolution and structure of Earth's biodiversity. Geothermal activity, which can maintain ice-free terrain in glaciated regions, provides a tantalizing solution to the question of how diverse life can survive glaciations. No comprehensive assessment of this 'geothermal glacial refugia' hypothesis has yet been undertaken, but Antarctica provides a unique setting for doing so. The continent has experienced repeated glaciations that most models indicate blanketed the continent in ice, yet many Antarctic species appear to have evolved in almost total isolation for millions of years and hence must have persisted in situ throughout. How could terrestrial species have survived extreme glaciation events on the continent? Under a hypothesis of geothermal glacial refugia and subsequent recolonization of non-geothermal regions, we would expect to find greater contemporary diversity close to geothermal sites than in non-geothermal regions, and significant nestedness by distance of this diversity. Fraser et al. used spatial modelling approaches and the most comprehensive, validated terrestrial biodiversity dataset yet created for Antarctica to assess spatial patterns of diversity on the continent. Models support their hypothesis, indicating that geothermally-active regions have played a key role in structuring biodiversity patterns in Antarctica. These results provide critical insights into the evolutionary importance of geothermal refugia and the history of Antarctic species.

  Fraser, C.I., Terauds, A., Smellie, J., Convey, P., and Chown, S.L. 2014. Geothermal activity helps life survive glacial cycles. Proceedings of the National Academy of Sciences of the U.S.A., DOI: 10.1073/pnas.1321437111

Social Sciences and History:

- This book reviews the existing security construct in Antarctica, critically assesses its status in the early part of the 21st century and considers how Antarctic security

may be viewed in both the immediate and distant future. The book assesses emerging new security threats, including the impact of climate change and the issues arising from increased human traffic to Antarctica by scientists, tourists, and mariners. The authors call into question whether the existing Antarctic security construct framed around the Antarctic Treaty remains viable, or whether new Antarctic paradigms are necessary for the future governance of the region. The contributions to this volume engage with a security discourse which has expanded beyond the traditional military domain to include notions of security from the perspective of economics, the environment and bio-security. This book provides a contemporary and innovative approach to Antarctic issues which will be of interest to scholars of international law, international relations, security studies and political science as well as policy makers, lawyers and government officials with an interest in the region.

Hemmings, A.D., Rothwell, D.R., and Scott, K.N. (eds). 2013 Antarctic Security in the Twenty-First Century: Legal and Policy Perspectives. Routledge,

Astronomy and Astrophysics:

- The IceCube Collaboration announced the observation of 28 very high-energy particle events, which constitute the first solid evidence for astrophysical neutrinos from cosmic accelerators. These results were published in *Science* and put IceCube in the headlines of hundreds of journals, news websites, and radio broadcasts around the world. By the end of 2013, *Physics World, Scientific American, Nature* and the editors of the *Physical Review* journals from the American Physical Society had also acknowledged that these results were opening a new era in astronomy. The IceCube collaboration now includes 41 institutions in 12 countries.

  IceCube Collaboration (Aartsen et al.). 2013. Evidence for high-energy extraterrestrial neutrinos at the IceCube detector. Science, 342 no. 6161, 901-2012. DOI: 10.1126/science.1242856.

Appendix 2

List of Acronyms

ABI	Antarctic Biodiversity Informatics
ACCE	Antarctic Climate Change and the Environment
AntClim[21]	Antarctic Climate Change in the 21st Century
AntEco	State of the Antarctic Ecosystem
AnT-ERA	Antarctic Thresholds - Ecosystem Resilience and Adaptation
a.s.l.	above sea level
ATCM	Antarctic Treaty Consultative Meeting
ATS	Antarctic Treaty System
cal. years BP	calibrated years before the present
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CEP	Committee for Environmental Protection (Antarctic Treaty)
CliC	Climate and Cryosphere Project (a project of the WCRP)
CO_2	carbon dioxide
COMNAP	Council of Managers of National Antarctic Programs
ECA	Environmental Contamination in Antarctica
EC-PORS	Panel of Experts on Polar Observations, Research & Services (a WMO group)
e.g.	for example (from Latin: exempli gratia)
EOT	Eocene-Oligocene Transition, 34 million years ago
IASC	International Arctic Science Committee
IceCube	the South Pole Neutrino Observatory
ICSU	International Council for Science
i.e.	that is (from Latin: id est)
ISAES	International Symposium on Antarctic Earth Sciences
ISMASS	Ice Sheet Mass Balance and Sea Level
IUCN	International Union for Conservation of Nature
Ma	million years (Geological age)
m a.s.l.	metres above sea level
OpMet	Operational Meteorology in the Antarctic
PIG	Pine Island Glacier
SAM	Southern Annular Mode
SCADM	Standing Committee on Antarctic Data Management
SCAGI	Standing Committee on Antarctic Geographic Information
SCAR	Scientific Committee on Antarctic Research
SCOR	Scientific Committee on Oceanic Research
SOOS	Southern Ocean Observing System
SRP	Scientific Research Programme
UK	United Kingdom
UNFCCC	United National Framework Convention on Climate Change
USA	United States of America
WMO	World Meteorological Organisation