



**EXCOM/COs Meeting 2011**

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Agenda Item: 2.4.1

Person Responsible: Carlota Escutia;  
Robert DeConto

# **Antarctic Climate Evolution (ACE) Report**

# Executive Summary

**Title:** Antarctic Climate Evolution (ACE)

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**Relevant URLs or references to other reports:** <http://www.scar-ace.org/>

**Introduction/ Background:** The SCAR Antarctic Climate Evolution (ACE) Programme represents the interests of a large land and marine geoscience research community focusing in deciphering the record of the onset and the response of the Antarctic ice sheets to past climate changes across a range of timescales. ACE coordinates the integration between geophysical and geological records of past ice sheet behavior and coupled climate, ocean, and ice sheet models.

**Important Issues or Factors:** The present Antarctic ice sheet has existed for approximately 34 million years. Understanding the response of the Antarctic ice sheet to climatic forcing is essential because changes in the ice sheet can have major impacts on global sea level and can impact the entire climate system through a wide range of physical and chemical feedbacks. ACE continues to be very active in its primary coordination role, catalyzing interactions amongst geologists, geophysicists, modelers and other polar scientists from the climate, ocean and ice coring communities. During the 1<sup>st</sup> ACE Symposium (Granada, 2009) new subcommittees with a processes-oriented focus were developed to address gaps in our knowledge about the role of Antarctic ice sheets in the global climate system. ACE subcommittees synthesize the state of the art of our knowledge and define the future questions and challenges that are critical for providing science-based advice to major scientific programs (i.e., IODP, ERICON-AB) and policy makers (i.e., IPCC). To address some of these outstanding questions ACE is coordinating the submission of a series of drilling proposals (ANDRILL and IODP) in key areas around Antarctica and the Southern Ocean. In this last 2 years of the programme, ACE is playing an active and central role in the development of a proposal to SCAR for a new SRP to succeed ACE. In addition, and as it has been done in the past, ACE will continue to be active in proposing dedicated sessions and workshops in all international meetings, including 2011 ISAES and the 2012 SCAR OSC, and in the publishing of its results in high impact journals.

**Recommendations/Actions and Justification:** Support for ACE plans for the remaining life of the Programme and input from EXCOM on ACE plans based on the new SCAR Strategic Plan.

**Expected Benefits/Outcomes:** Significant publication output (both in content and numbers). Publications and science relevant to “Big- science” programmes and policy makers, enhancement of SCAR profile.

**Partners:** IPICS; PAGES of the IGBP; IASC on APEX; ANDRILL, SHALDRIL, IODP and ERICON-AB.

**Budget Implications:** Request for confirmation of SCAR science programme funding at current level for planned remainder of the Programme’s operation to 2013.

# Antarctic Climate Evolution (ACE) Report

## 1. *Rationale*

ACE is one of the approved Scientific Research Program (SRP) of the Scientific Committee on Antarctic Research (SCAR). The mission of ACE is to facilitate the study of Antarctic climate and glacial history through integration of numerical modeling with geophysical and geological data. ACE is designed to determine both climate conditions and climatic changes and their impact on ice sheet and sea ice behavior during the recent past (i.e., the Holocene prior to anthropogenic impacts, as well as at the last glacial maximum and other Quaternary glaciations, when temperatures were cooler than at present) and the more distant past (i.e. the pre-Quaternary, when global temperatures were several degrees warmer than today).

Antarctica has been glaciated for approximately 34 million years, but its ice sheets have fluctuated considerably and are one of the major driving forces for changes in global sea level and climate throughout the Cenozoic Era. The spatial scale and temporal pattern of these fluctuations is subject to considerable debate. Understanding the response of large ice masses to climatic forcing is of vital importance because ice-volume variations impact global sea level and also alter the capacity of ice sheets and sea ice to act as major heat sinks/insulators. It is particularly important to assess the stability of the cryosphere in the face of rising CO<sub>2</sub> levels, as modeling of the climate shift from a warm, vegetated Antarctica to a cold, ice-covered state 34 Myrs ago suggests a powerful greenhouse gas influence. As Antarctica is a major driver of Earth's climate and sea level, much effort has been expended in deriving models of its behavior. Some of these models have been successfully validated against modern conditions. Modeling the past record of ice-sheet behavior in response to changes in climate (inferred from ice cores for example), paleoceanographic conditions (inferred from paleoecology and climate proxies in ocean sediments) and paleogeography (as recorded in landscape evolution) is the next step and will allow for modeling of the large and dynamic changes observed in geologic history.

The cross-disciplinary approach within ACE, involving climate and ice sheet modelers, geologists, and geophysicists leads to a substantial improvement in the knowledge of past Antarctic climate, and our understanding of the factors that have guided its evolution. This in turn allows us to build hypotheses, examinable through numerical modeling, as to how Antarctic climate is likely to respond to future global change. Equally important, the development of data-driven models for Antarctic climate will allow us to extend our results to the analysis and forecasting of global climate variability.

### *ACE is structured in subcommittees:*

- 1) LGM/Deglacial/Holocene (Active since 2004);
- 2) Pleistocene (Active since 2004);
- 3) Middle Miocene-Pliocene (Active since 2004);
- 4) Oligocene-Miocene (Active since 2004);
- 5) Eocene-Oligocene (Active since 2004);
- 6) Radio-echosounding (Active since 2005);
- 7) Circum Antarctic Stratigraphy and Paleobathymetry (CASP) (Resulting from the merge between ROSSMAP and CASP (Active since 2008);
- 8) ANTScene: Antarctic Paleotopography (Active since 2009);
- 9) Paleoclimate Records from the Antarctic Margin and Southern Ocean" (PRAMSO) (Active since 2010).

The subcommittees provide the overall leadership, direction and management for their respective topics. They contribute to the overall understanding of the Antarctic's climate evolution by encouraging and facilitating communication and collaboration among research scientists working on any aspects of Antarctic climate evolution pertinent to the respective topic. The subcommittees also ensure that activities within each committee are communicated and wherever possible integrated with those of other time-based, modelling and process-based themes of the ACE programme.

## 2. *Major Tasks and Timeframe*

### 2011:

- ISAES 2011: ACE sessions, workshops and business meetings (i.e., meetings of the ACE Steering Committee, SDLS, CASP, ANTscape, Amudsen Sea, etc);
- Publication of a Special Volume in *Palaeogeography, Palaeoclimatology, Palaeoecology* with a selection of articles presented during the 1<sup>st</sup> ACE Symposium (Florindo, Escutia, DeConto and Bentley);
- Publication of the Proceedings Volume from the Integrated Ocean Drilling Program (IODP) Expedition 318: Wilkes Land Glacial History (Escutia et al., 2011);
- Second International Innovation, Research Media Publication on ACE (2011);
- Post-cruise science meeting for IODP Expedition 318, (7-10 July 2011, Edinburgh);
- Continue to coordinate cross-linkages across programs (e.g., with the paleoceanography community and through ESF EuroPOLAR Project HOLOCLIP: integration of the Holocene paleoclimate record from very high resolution sediment cores with the ice core records);
- Continue to provide science-based advise to major scientific programs (i.e., IODP and ERICON-AB Science Plan writing) and policy makers (i.e., Tim Naish charged with contributing in paleoclimate-pre-Quaternary);
- ANDRILL Coulman High Project: work related to data obtained during the Site Surveys and technological, logistical and science planning for drilling in 2013-2014;
- Field seasons for major Projects (e.g., ICECAP, WIZZARD, LIZZARD);
- ACE sessions in major international meetings (EGU, ISAES, AGU);
- Coordinate and guide the submission of new SRP proposal to succeed ACE;
- ACE funding of early career scientists to attend the ISEAS in Edinburgh.

### 2012:

- SCAR Open Science Conference in Portland: ACE sessions, workshops and business meetings;
- Guiding the writing and submission of a coordinated set of proposals and pre-proposals to IODP (deadline 1<sup>st</sup> October) and ANDRILL;
- ACE Meeting-s to wrap up ACE results and guiding new SRP proposal;
- Continue to coordinate cross-linkages across programs, including the publication of results from some of the cross-linkages projects (i.e., ESF EuroPOLAR Project HOLOCLIP: integration of the Holocene paleoclimate record from very high resolution sediment cores with the ice core records);
- Continue to provide science-based advise to major scientific programs (i.e., IODP, ICDP, ERICON-AB) and policy makers (i.e., Tim Naish charged with contributing in paleoclimate-pre-Quaternary);
- Preparations for the drilling of the ANDRILL Coulman High Project;
- Field seasons for major Porjects (e.g., ICECAP, WIZZARD, LIZZARD);
- ACE sessions in major international meetings (EGU, SCAR OSC and AGU);
- ACE participation in the Urbino Paleoclimate School.

## 3. *Deliverables*

- High impact publications and books;
- First ACE Symposium conference proceedings in *Paleo3 Special Publications* 2011;

- ACE Programme reports;
- Continue coordination and integration, through subcommittees, of field work results;
- Continue development of process-based multidisciplinary subcommittees to formulate future research directions;
- Provide science-based advise to major scientific programmes (i.e., IODP) and policy makers (i.e., IPCC), Synergies with other SCAR programmes;
- Guide the submission of a set of ocean drilling proposals;
- Guide proposals to SCAR for future SRPs;
- Train PhD graduates and post-doctoral research fellows;
- Outreach via National/International Programmes;
- Participation and support for Urbino graduate summer school in paleoclimatology;
- Continue efforts to develop an European ANDRILL consortium (EuroANDRILL);
- Apply for a Chapman or Gordon conference on bi-polar paleoclimate records after Oslo IPY 2010;
- ACE Website;
- Input to databases.

#### 4. *ACE Committee*

\* co-chair since 2008

<b>Name</b>	<b>Role</b>	<b>Gender</b>	<b>Country</b>	<b>Term From</b>
Dr Carlota Escutia	<i>Co-Chair</i>	Female	Spain	2004*
Dr Robert DeConto	<i>Co-Chair</i>	Male	United States	2004*
Bob Arko	<i>JCADM liaison</i>	Male	United States	2008
Dr Mike Bentley	<i>Member</i> LGM Subcommittee leader	Male	United Kingdom	2008
Sun Bo	<i>Member</i>	Male	China	2005
Dr Fabio Florindo	<i>Member</i>	Male	Italy	2004
Dr Andrzej Gazdzicki	<i>Member</i>	Male	Poland	2005
Dr Alan Haywood	<i>Member</i> Miocene-Pliocene Subcommittee leader	Male	United Kingdom	2008
Dr Robert Larter	<i>Member</i>	Male	United Kingdom	2004
Dr Andrew Mackintosh	<i>Member</i>	Male	New Zealand	2008
Dr Sandra Passchier	<i>Member</i>	Female	United States	2005
Dr Ross Powell	<i>Member</i>	Male	United States	2004
Dr Gary Wilson	<i>Member</i>	Male	New Zealand	2005
Dr Eric Wolf	<i>Member</i>	Male	United Kingdom	2005
Dr Detlef Damaske	<i>Member</i> Radio-echo sounding Subcommittee leader	Male	Germany	2005
Dr Martin Siegert	Ex-Officio	Male	United Kingdom	2004

Dr Robert Dunbar	Ex-Officio	Male	United States	2004
Dr Tim Naish	Pleistocene Subcommittee leader Member (2004-2008)	Male	New Zealand	2004
Dr Jane Francis	Eocene.Oligocene Subcommittee leader Member (2005-2008)	Female	United Kingdom	2005
Dr Karsten Gohl Dr Stuart Henrys	CASP Subcommittee	Male Male	Germany New Zealand	2007
Dr Peter Barrett	ANTScape	Male	New Zealand	2009
Dr Alan Cooper	Seismic Data Library System	Male	United states	2004

## 5. *Outputs*

ACE has made substantial progress in 2010 in programmes that cover some of the original objectives for ACE, for example:

- The IODP Expedition 318 drilled the Wilkes Land margin (4 January-9 March). The recovered cores represent ~53 m.y. of Antarctic history from an ice-free “greenhouse Antarctica,” to the first cooling, to the onset and erosional consequences of the first glaciation and the subsequent dynamics of the waxing and waning ice sheets, all the way to thick, unprecedented “tree-ring style” records with seasonal resolution of the last deglaciation that began ~10,000 y ago. The Proceedings Volume will be published in July 2011.
- The Antarctic Geological Drilling programme (ANDRILL) continues to develop results from its SMS and MIS Projects. A science meeting was held in Erice, Italy (April 2010) focusing on results from the SMS Project. The 2010-2011 field season saw a major step forward for the Coulman High Project. Oceanographic equipment and a ROV were deployed through 270 m-thick ice and short sediment cores and new seismic data were obtained. These achievements help establish the case for deep drilling.
- The US-UK-AUS ICECAP programme completed its third season of airborne geophysics of the Aurora and Wilkes basins in East Antarctica. The new data shed new insights into former ice sheet dynamics and size. In addition, the UK completed the first airborne survey of the Institute and Moller ice streams in West Antarctica that help us understand modern flow processes and how these have changed in the past.
- The UK-led programme to undertake the direct measurement and sampling of Lake Ellsworth in West Antarctica remains on track for exploration in December 2012. A comprehensive environmental evaluation of the programme has recently been submitted to the Antarctic Treaty Committee on Environmental Protection.

### a. **Key ACE achievements**

#### *I. Contributions to IPY other science Programmes and policy makers*

Besides being a SCAR programme, ACE is also an IPY Project (Project ID No: 54). In addition, several other IPY projects contribute to ACE (e.g. PLATES&GATES; BIPOMAC, ANDRILL).

ACE continues to be very active in Antarctic geological drilling. For this, ACE was involved in the planning meetings (EGU 2009 in Vienna and INVEST in Bremen) for the IODP Beyond 2013 planning. The workshop on "Developing an Integrated Strategy to Recover Paleoclimate Records from the Antarctic Margin and Southern Ocean" (12-13 September, 1<sup>st</sup> ACE Symposium, Granada, Spain) addressed knowledge gaps in the role of Antarctic Ice Sheets in climate change and outlined a sediment drilling strategy. This strategy was submitted to the IODP New Ventures in Exploring Scientific Targets (INVEST) meeting as a reference document for the planning of IODP beyond 2013. In addition, members of the ACE community acted as Theme chairs during the INVEST meeting and have been part of the writing of the Science Plan for IODP

beyond 2013. The ACE community has also been very active in the development of the Science Plan for the ERICON-Aurora Borealis Project.

ACE has been also active in making the case for a more developed paleoclimate section for the next IPCC report. P. Barrett (member of the ACE community) was the SCAR-IUCN Observer 31<sup>st</sup> IPCC Plenary Meeting, Bali, 26-29 October 2009. T. Naish, also part of the ACE community has been invite to contribute to the IPCC report in the section of pre-Quaternary paleoclimate.

## **II. Publications in peer reviewed literature**

ACE as it stands has produced key peer reviewed publications, which include:

- 2004 Special issue of *Palaeogeography, Palaeoclimatology, Palaeoecology: Antarctic Cenozoic Palaeoenvironments: Geologic Record and Models*, F. Florindo, A.K. Cooper and P. E. O'Brien (Editors). *Palaeogeography, Palaeoclimatology, Palaeoecology*, Volume 198, issues 1-2,
- 2005 Special Issue of *Global and Planetary Change: Long-term changes in Southern high-latitude ice sheets and climate: the Cenozoic history*. Florindo, F., Harwood, D.M., Wilson, G.S. (Editors), *Global and Planetary Change* 45, 1-264.
- 2008 Special Issue of *Palaeogeography, Palaeoclimatology, Palaeoecology: Antarctic cryosphere and Southern Ocean climate evolution (Cenozoic–Holocene)*, F. Florindo, A. Nelson and A. Haywood (Editors). *Palaeogeography, Palaeoclimatology, Palaeoecology*, Volume 260.
- 2009 ACE Book: *Developments in Earth and Environmental Sciences: Antarctic Climate Evolution*. F. Florindo and M. Siebert (Editors). *Developments in Earth and Environmental Sciences Volume 8*, 2009. The Netherlands: Elsevier, 2009, DOI 10.1016/S1571-9197(08)00005-0.
- 2011 Special Issue in *Palaeogeography, Palaeoclimatology, Palaeoecology: Cenozoic Evolution of Antarctic Climates, Oceans and Ice Sheets*, F. Florindo, C. Escutia, R. DeConto, M. Bentley (Editors), in press.

Additional publications related to ACE as it stands include:

- Integration of climate modelling gathers pace. International Innovation. Research Media Ltd. Escutia, C. 2010.
- 1<sup>st</sup> ACE Symposium publications: *Understanding Antarctic Climate and Glacial History First Antarctic Climate Evolution Symposium*; Granada, Spain, 7–11 September 2009. DeConto C, and Escutia, E., *Eos*, Vol. 91, No. 4: p 34, 26 January 2010.
- 1<sup>st</sup> ACE Symposium publications: *Improving Constraints on Paleo Ice Sheets in the Amundsen Sea Embayment Amundsen Sea Embayment: Tectonic and Climatic Evolution - Granada, Spain*, 9 September 2009. Larter et al., *Eos*, Vol. 91, No. 4: p 33, 26 January 2010
- Back to the future. International Innovation. Research Media Ltd. 2011. Escutia and DeConto, 2011.

ACE has contributed through collaborative efforts with other communities (i.e., PAGES, AGCS, and EBA) to the following publications:

- Antarctic Climate Change and the Environment', edited by Turner et al (2009) available at: <http://www.scar.org/publications/occasionals/acce.html>
- Brigham-Grette, J., Powell R.D. Newman, L. and Keiffer, T. (editors). 2009. *Changing Poles: A Paleoscience Perspective*. PAGES News, 17: 48pp.
- Brigham-Grette, J. and Powell R.D. 2009. Editorial: *Changing Poles: A Paleoscience Perspective*, in Brigham-Grette, J., Powell R.D. Newman, L. and Keiffer, T. (editors), *Changing Poles: A Paleoscience Perspective*. PAGES News, 17: 2.
- Powell, R., Naish, T., Levy, R. and the MIS Science Team. 2009. *New Records of the Role of Antarctic Ice Sheets in Late Cenozoic Climate*, in Brigham-Grette, J., Powell R.D. Newman, L. and Keiffer, T. (editors), *Changing Poles: A Paleoscience Perspective*. PAGES News, 17: 32-34.

Publications from individual groups in many national and international projects and programmes that contribute to ACE are numerous. Listed below are some of the highlights for 2009-2011.

- Naish, T., Powell, R., Levy, R., Krissek, L., Niessen, F., Pompilio, M., Scherer, R., Talarico, F., Wilson, G., Wilson, T., Barrett, P., Browne, G., Carter, L., Cody, R., Cowan E., Crampton, J., DeConto, R., Dunbar, G., Dunbar, N., Florindo, F., Gebhardt, C., Graham, I., Hannah, M., Harwood, D., Hansaraj, D., Henrys, S., Helling, D., Kuhn, G., Kyle, P., Läufer, A., Maffioli, P., Magens, D., Mandernack, K., McIntosh, W., McKay, R., Millan, C., Morin, R., Ohneiser, C., Paulsen, T., Persico, D., Pollard, D., Reed, J., Ross, J., Raine, I., Schmitt, D., Sagnotti, L., Sjunneskog, C., Strong, P., Taviani, M., Vogel, S., Wilch, T., Williams, T. and Winter, D. 2009. Obliquity-paced Pliocene West Antarctic Ice Sheet Oscillations. *Nature* 458, 322-328, doi:10.1038/nature07867.
- Pollard D. and DeConto R.M., 2009. Modelling West Antarctic Ice Sheet growth and collapse through the past five million years. *Nature* 458, 329-33, doi:10.1038/nature07809.
- Sun Bo, Siegert, M.J., Mudd, S.M., Sugden, D.E., Fujita, S., Xiangbin, C., Yunyun, J., Xueyuan, T. & Yuansheng, L. The Gamburtsev Mountains and the origin and early evolution of the Antarctic Ice Sheet. *Nature*, 459,690-693 (2009).
- Wilson, D.S. and Luyendyk, B.P., 2009. West Antarctic paleotopography et the Eocene-Oligocene climate transition. *Geophysical Research Letters*, 36, L16302, doi:10.1029/2009GL039297.
- Williams et al. 2010. Sea ice extent and seasonality for the Early Pliocene northern Weddell Sea. *Palaeogeography, Palaeoclimatology, Palaeoecology* 292, 306-318. doi:10.1016/j.palaeo.2010.04.003.
- Dowsett et al. 2010. The PRISM3D paleoenvironmental reconstruction. *Stratigraphy* 7, 123-139.
- Haywood et al. 2010. Pliocene Model Intercomparison Project (PlioMIP): experimental design and boundary conditions (Experiment 1). *Geosci. Model Dev.*, 3, 227-242.
- Mackintosh, et al., 2011. Retreat of the East Antarctic ice sheet during the last glacial termination. *Nature Geoscience*. DOI 10.1038/NGEO1061.
- Scopelliti et al., 2011. Petrography and carbonate isotope stratigraphy from MIS AND-1B core, Antarctica: Evidence of the early Pliocene warming event. *Global and Planetary Change* 76 (2011) 22–32.

### **III. Meetings and workshops**

In 2009, ACE held its First Antarctic Climate Evolution in Granada, Spain (7-11 September) (<http://www.acegranada2009.com/>). Nearly 200 international scientists from the fields of climate, ocean, and ice modeling joined geologists, geophysicists and geochemists for five days of intense interaction. A summary of the symposium and its outcomes, is published in EOS (DeConto and Escutia, 2010 as listed previously).

In addition to providing co-funding for the First ACE Symposium, ACE coordinated and financially supported the following workshops:

- First and Second Reconstruction of Antarctic Paleotopography (ANTscape) workshops, 15-17 April, Leeds (UK), and 10-11 September, Granada (Spain).
- Circum-Antarctic Stratigraphy and Palaeobathymetry (CASP) Project. 7-8 September, Granada, Spain.
- Antarctic Ice-Volume Proxies: High and Low Latitude Sequence and Seismic Stratigraphy and Deep-Sea Records. 9 September, Granada, Spain.
- Seismic Data Library System (SDLS) workshop, 9 September, Granada, Spain.
- Amundsen Sea Embayment: Tectonic and Climatic Evolution workshop, 9 September, Granada, Spain. Information and outcomes from this workshop are published in EOS (Larter, Gohl and Bentley, 2010).
- Developing an Integrated Strategy to Recover Paleoclimate Records from the Antarctic Margin and Southern Ocean, 12-13 September, Granada, Spain.



- ACE has been also active in organizing special sessions, business meetings and Town Meetings in all major scientific meetings such as the European Geophysical Union, Vienna; and AGU Fall Meeting, San Francisco, SCAR OSC 2010, and ISAES 2011.

#### **IV. Links to other SCAR SRPs or SCAR Action or Expert Groups and to other Programmes**

ACE has links to the ice core community via the International Partnership in Ice Core Sciences (IPICS) and through the ESF EuroPOLAR Project HOLOCLIP; to the palaeoclimate community via the past climate change (PAGES) programme of the International Geosphere Biosphere Programme (IGBP); to the IASC programme on Arctic Palaeoclimate and its Extremes (APEX); and to drilling programs such as are the Antarctic Geological Drilling programme (ANDRILL), the Shallow Drilling Program (SHALDRIL), the Integrated Ocean Drilling Program (IODP) and ESF ERICON-AB.

#### **V. Education and training**

ACE provided funding for travel expenses, student housing and low registration fees for students to attend the First ACE Symposium. ACE also co-funded an Association of Polar Early Career Scientists (APECS) workshop, 7 September, Granada, Spain.

ACE also provided co-financing for early career scientists and students to attend the SCAR-OSC in Buenos Aires (2010) and the ISAES in Edinburgh (2011)

Members of ACE participate as teachers and, when possible, ACE provides funding for 1-2 students to attend the Urbino Summer School in Paleoclimate: <http://www.uniurb.it/ussp/>

ACE has been very active in education and outreach programmes within the ANDRILL and the IODP Programmes (e.g., <http://www.andrill.org/education>; <http://www.youtube.com/user/OceanLeadership>; <http://www.iodp.org> and <http://www.iodp-usio.org/>).

#### **VI. Project Databases**

ACE database is the SCAR-ACE Seismic Data Library System (SDLS) (<http://scar-sdls.org/>).

In addition, for the research conducted within ACE, other databases supported by other programmes are used such as:

- ANDRILL: PANGAEA <http://www.pangaea.de/>
- IODP:  
Riserless Core data and log data: <http://iodp.tamu.edu/database>  
Riserless Downhole log data: <http://iodp.ldeo.columbia.edu/DATA/index.html>
- Antarctic and Southern Ocean Data existing coring expedition can be checked at the Google earth link: <http://campanian.iodp-mi-sapporo.org/google/data/iodp.kml>