



SDM **09**
 Agenda Item: 4.1.2
 Person Responsible: L De Santis
 et al.

**XXXV SCAR Delegates Meeting
 Davos, Switzerland, 25-26 June 2018**

Past Antarctic Ice Sheet Dynamics (PAIS)

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Summary of activities from 2016-18 and other important matters

- PAIS aims to constrain Antarctica’s contribution to sea level, resulting from past changes in ice sheet mass loss and its impacts on environment, atmospheric and oceanic circulation. Based on paleo analysis, PAIS work can bound the estimates of future ice loss, and therefore provide a comprehensive view of our planet’s near-term future. PAIS research has been influential in the Intergovernmental Panel on Climate Change IPCC’s AR5 report and is a priority in the current sixth cycle of the IPCC.
- Extensive PAIS-facilitated field work on land and at sea has been carried out within the framework of national and multi-national projects, including International Ocean Discovery Program (IODP) <http://iodp.tamu.edu/index.html> expedition 374 in the Ross Sea in early 2018. International and multidisciplinary campaigns yielded new findings into modern and past (last 30-40 million of years) interactions between atmospheric and oceanic circulation and ice sheet-ice shelf dynamics. Intervals studied span a range of timescales from decades to millions of years, from the pre-glacial greenhouse to icehouse climate and into the future.
- An international conference held in 2017 in Trieste (Italy), with more than 200 participants from 17 countries, focused on high priority questions relevant to the IPCC <http://ipcc.ch/> and the SCAR Horizon Scan for the next 20 years of Antarctic Research <https://www.scar.org/about-us/view-from-south/>. A white paper that will be further discussed and finalised during the Polar 2018 conference, summarizes the PAIS conference outcomes and outlines research priorities over the next 4 years of the PAIS program and beyond. Over 30% of the PAIS conference participants were early career scientists, who will carry forward the PAIS legacy into new SRPs and continued engagement with Antarctic National programs and with the IODP.

Recommendations: None

Summary Budget 2017 to 2020

	2017	2018	2019	2020
	Spent	Allocated	Request	Request
(US\$)	39165	21000	21000	21000



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Progress and Plans

Major Outcomes

- 1) Recently published papers by the PAIS community provide new insights into past Antarctic ice sheet behavior and sensitivity to high atmospheric CO₂ and temperature. These studies, based on data and modelling, will significantly contribute to the sixth cycle of the IPCC, currently underway. In particular, DeConto & Pollard (2016) put PAIS findings at the centre of the debate about future sea-level change. If their model results are correct, then sea-level rise this century and beyond could substantially exceed IPCC AR5 projections, with major societal and economic implications. However, calibration of these models depends on observations that constrain what really happened to Antarctica during past climates warmer than today. As such, PAIS has focused on Pleistocene 'super' inter-glacials, and the Pliocene and Miocene, when atmospheric CO₂ was similar to that predicted for the next 200-500 years (e.g. Levy et al., 2016; Sangiorgi et al., 2018). Recent papers by the PAIS community provide new geophysical evidence from West Antarctica (e.g. Kuhn et al., 2017; Wise et al., 2017; Smith et al., 2017; Hillenbrand et al., 2017) of episodic rapid ice-sheet retreat, possibly resulting from ice-cliff collapse and warm Circumpolar Deep Water inflow into the continental shelf during the Holocene, increasing confidence in the rapid future retreat scenarios modelled by DeConto & Pollard (2016).
- 2) The long-term sediment drilling strategy (ice proximal to abyss) of PAIS proposals to the IODP has been highly ranked by the IODP that will implement five expeditions in three years (2018-2020). The first expedition (IODP Exp. 374 in the Ross Sea) was completed in early 2018. It recovered the highest percentage of sediment ever obtained from a non-riser continental shelf drilling project. Strata recovered by 374 provides a high-resolution, ice distal record of the Mid-Miocene climatic Optimum and Pliocene, that can be correlated with coastal, ice proximal records. This follows the PAIS transect concept, by providing the distal end member of a Ross Sea portfolio that including DSDP leg 28 (1973) and the ice proximal records recovered by ANDRILL (2008-2010). Data from 374 are just beginning to emerge, but the results are expected to provide a significant step forward in constraining Antarctica's sensitivity to past (and future) global warming.

The first Antarctic drilling expedition to use a multi-barrel seabed rig was successfully conducted in Feb-March 2017. Recovered sediments show that the inner continental shelf area in the Amundsen Sea was at sea level and covered in vegetation in the latest Cretaceous. Just as importantly, the MeBo70 drilling device used on the RV Polarstern, proved that this system can be used for future shallow drilling expeditions in areas difficult to be accessed by other drilling infrastructures. The MeBo70 core sites are complementary to the upcoming IODP Expedition 379 drill sites (also facilitated by PAIS) on the middle to outer shelf and on the continental rise scheduled to be drilled with JOIDES Resolution in early 2019.



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- 3) An international PAIS conference was held in Italy in September 2017. A major outcome was a comprehensive evaluation of the current state of Antarctic ice sheet and sea-level science. This evaluation is being used to guide future research priorities in the last 4 years of PAIS and beyond; both within the framework of SCAR and international data acquisition programs like beyond Beyond EPICA-Oldest Ice (BE-OI) and IODP. A white paper summarizing the conference outcomes and scientific questions to be targeted by a future SRPs, has been circulated and will be further discussed at Polar 2018 in Davos. Outreach side events at the PAIS conference (workshops and films) involved schools (about 500 students and their teachers) local public, and the media.

Notable Papers

- 1) DeConto, R. M., & Pollard, D. 2016. Contribution of Antarctica to past and future sea-level rise. *Nature*, 531(7596), 591-597.
This work uses past ice sheet retreat scenarios during the Last Interglacial and Pliocene to calibrate the physics in a numerical ice-sheet model, that considers the effects of 1) ice shelf loss by ocean melt and hydrofracturing caused by atmospheric warming, 2) marine ice sheet instability on reverse sloped bedrock, and 3) calving at thick marine-terminating ice margins (ice cliff instability). When applied to worse case future warming scenarios, the paleo-calibrated model predicts the complete collapse of WAIS and major ice retreat into deep East Antarctic basins, causing more than 10 m of sea level rise within the next five hundred years.
- 2) Levy, R., Harwood, D., Florindo, F., Sangiorgi, F., Tripathi, R., von Eynatten, H., Gasson, E., Kuhn, G., Tripathi, A., DeConto, R., Fielding, C., Field, B., Golledge, N., McKay, R., Naish, T., Olney, M., Pollard, D., Schouten, S., Talarico, F., Warny, S., Willmott, V., Acton, G., Panter, K., Paulsen, T., Taviani, M. & SMS Science Team 2016. Antarctic ice sheet sensitivity to atmospheric CO₂ variations in the early to mid-Miocene. *Proceedings of the National Academy of Sciences* **113**(13), 3453-3458. www.pnas.org/cgi/doi/10.1073/pnas.1516030113.
This work provides new insights into the recognition of the sensitivity of marine-based sectors of the East Antarctic Ice Sheet (EAIS) from models and data and the identification of ~400-500ppm CO₂ as a potential threshold for marine-based ice sheet stability
- 3) McKay, R., Golledge, N.R., Maas, S., Naish, T., Levy, R., Dunbar, G., Kuhn, G. 2016. Antarctic marine ice-sheet retreat in the Ross Sea during the early Holocene. *Geology* **44**(1), 7-10.
- 4) Simkins L., Anderson J. B., Greenwood S. K., Gonnermann H.M., Prothro L.O., Halberstadt A.R., Stearns L.A., Pollard D., DeConto R.M. 2017. Anatomy of a meltwater drainage system beneath the ancestral East Antarctic ice sheet. *NATURE GEOSCIENCE* DOI: 10.1038/NGEO3012.
These two papers provide new clues into the contested deglaciation history of the Ross Sea at the end of the Last Glacial Maximum. These papers highlight the role of bathymetry in the details of the retreat. They also demonstrate the utility of a multidisciplinary approach (using sedimentology, geomorphology, oceanography, and modelling) to better understand rates of ice sheet retreat and



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the role of ocean circulation changes. This approach, fostered by PAIS, is crucially needed for robust paleo-modelling, which ultimately informs future ice sheet projections.

- 5) Mezgec K., Stenni B., Crosta X., Masson-Delmotte V., Baroni C., Braida M., Ciardini V., Colizza E., Melis R., Salvatore M. C., Severi M., Scarchilli C., Traversi R., Udisti R. & Frezzotti M. 2017. Holocene sea ice variability driven by wind and polynya efficiency in the Ross Sea. *Nature Communications* volume 8, Article number: 1334 doi:10.1038/s41467-017-01455-x
This work combines information from marine diatom records and sea salt sodium and water isotope ice core records, to document contrasting patterns in sea ice variations between coastal and open sea areas in the Western Ross Sea over the current interglacial period. The results point to possible future impacts on sea ice, in light of recent and future changes in the Southern Ocean winds.
- 6) Graham, A.G.C., Kuhn, G., Meisel, O., Hillenbrand, C.-D., Hodgson, D.A., Ehrmann, W., Wacker, L., Wintersteller, P., dos Santos Ferreira, C., Römer, M., White, D., Bohrmann, G. 2017. Major advance of South Georgia glaciers during the Antarctic Cold Reversal following extensive sub-Antarctic glaciation. *Nature Communications* 8, doi: 10.1038/ncomms14798.
This work provides data from the more distal part of Antarctica's influence on the Southern Ocean, during the last deglaciation. This work provides an important and previously missing end-member within the PAIS concept of ice proximal-to-distal transects.
- 7) Gulick, S.P.S., Shevenell, A.E., Montelli, A., Fernandez, R., Smith, C., Warny, S., Bohaty, S.M., Sjunneskog, C., Leventer, A., Frederick, B., Blankenship, D.D. 2017. Initiation and long-term instability of the East Antarctic Ice Sheet. *Nature* 552, 225-229.
This work provides the first evidence of marine-terminating and grounded ice near the Sabrina Coast of East Antarctica, by the early to middle Eocene epoch. The geological and geophysical record shows that expanded polar EAIS existed in the Miocene and that the Aurora subglacial basin catchment was not particularly sensitive to Pliocene warmth.
- 8) Wise, M.G., Dowdeswell, J.A., Jakobsson, M. & Larter, R.D. 2017. Evidence of marine ice-cliff instability in Pine Island Bay from iceberg-keel plough marks. *Nature* 550, 506–510. doi:10.1038/nature24458.
This paper presents the first observational evidence of an episode of rapid ice-sheet retreat resulting from ice-cliff collapse, increasing confidence in the rapid past and future retreat scenarios modelled by DeConto & Pollard (2016).
- 9) Hillenbrand CD, Smith JA, Hodell DA, Greaves M, Poole CR, Kender S, Williams M, Andersen TJ, Jernas PE, Elderfield H, Klages JP, Roberts SJ, Gohl K, Larter RD, Kuhn G (2017) West Antarctic Ice Sheet retreat driven by Holocene warm water incursions. *Nature* 547(7661), 43-48. doi:10.1038/nature22995.
This work, for the first time, demonstrates warm Circumpolar Deep Water inflow variability onto the Amundsen Sea Shelf and related deglaciation forcing during the Holocene epoch. These results could increase confidence in the predictive capability of current ice-sheet models and will encourage similar analysis on core samples from past warm times.



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- 10) Huang, X., Stärz, M., Gohl, K., Knorr, G., Lohmann, G. (2017). Impact of Weddell Sea shelf progradation on Antarctic bottom water formation during the Miocene. *Paleoceanography*, 32, 304-317, doi:10.1002/2016PA002987. This study shows the effect of Miocene paleobathymetry in the Weddell Sea embayment on ocean circulation and bottom-water formation. It demonstrates that accurate paleobathymetric and paleotopographic reconstructions (like those facilitate by PAIS) are essential for meaningful paleoclimate simulations.

Main Activities

- 1) PAIS research (e.g. ice sheet, sensitivity, irreversibility, processes, ice sheet model predictions for future global sea-level rise) has been influential in the IPCC's AR5 report and is a priority in the current sixth cycle of the IPCC, including special reports on the world at +1.5°C, the state of the oceans and cryosphere, and the full AR6 assessments. PAIS representatives (Tim Naish and Rob DeConto) were involved in scoping the IPCC special report on the world at +1.5°C. Rob DeConto and Andrew Macintosh are lead authors of the IPCC special report on the Oceans and Cryosphere in a Changing Climate (in progress). PAIS member Nick Golledge has been selected as a lead author of the IPCC AR6. The APECS member of the PAIS steering committee (Mathieu Casado) is organising (with other members or participants of PAIS and APECS) a group review of the next IPCC special report on Ocean and Cryosphere. There are 75. participants from 22 countries, among which a large part of the countries are from the SCAR community

Why important, why now?

PAIS publications and activities aim to constrain Antarctica's contribution to sea level, resulting from past changes in ice sheet mass loss and its impacts on environment, atmospheric and oceanic circulation. Based on paleo analysis, PAIS work can bound the estimates of future ice loss. Thus, it is important to deliver to IPCC the results of PAIS scientific production in order to provide a comprehensive view of our planet's near-term future.

- 2) An international conference was held on September 10th - 15th 2017 in Trieste (Italy), focusing on high priority questions relevant to the Intergovernmental Panel on Climate Change (IPCC) (<http://ipcc.ch/>) and the recent Scientific Committee for Antarctic Research (SCAR) (<https://www.scar.org/>) Horizon Scan for the next 20 years of Antarctic Research (<https://www.scar.org/about-us/view-from-south/>). The meeting was attended by over 200 participants from 17 countries (62 oral presentations and 130 posters (<http://www.scar-pais.org/index.php/conference>)). One important outcome of the PAIS conference was the engagement of students and early career scientists.

Why important, why now?

The PAIS community can significantly contribute the key issues and questions addressed by the next IPCC special report on Ocean and Cryosphere. These include the future sea level rise, ecosystem change due to sea ice, ocean circulation and acidification, among others. A major outcome from the PAIS 2017 conference was a white paper summarizing the current state of past, present and future Antarctic ice sheet and sea-level science that outlines research priorities



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over the next 4 years of the PAIS program beyond. The current science plan of the IODP will end in 2023, after completing four PAIS-facilitated Antarctic expeditions across the WAIS and EAIS margins (in 2018-2020). Several pre-proposals that still require site surveys to be approved and scheduled for drilling, could be achieved in the future IODP phase, beyond 2023, under the coordination of a new SCAR SRP. One of the important aims of the PAIS conference has been to engage the future generation that will carry forward the PAIS legacy into new SRPs and continued engagement with Antarctic National program and with the IODP.

- 3) Extensive PAIS-facilitated field work on land and at sea has been carried out within the framework of national and multi-national projects. Landwork on Seymour Island, James Ross Archipelago, Pötter Cove, King George Island and Lützw-Holm Bay was aimed at paleontological, stratigraphic and geomorphologic studies. Marine surveys were carried out in the Ross Sea, Bellingshausen Sea, Amundsen Sea, the Scotia Sea, Sabrina Coast and South Eastern Pacific regions. Those studies were focused on water masses, and sea floor and subsea floor sampling and mapping, whose preliminary analysis were used to define drilling sites location of future IODP expeditions. Geophysical and geological site surveys for continental drilling have been carried out at Siple Coast (NZ) and at Ekström Ice Sheet (GER, > 600 km vibroseismic profiles). The Rosetta project (US) used airborne geophysics to explore the geology and bathymetry under the modern Ross Ice Shelf, at unprecedented resolution. Those data will be critically important for paleo-ice sheet modelling of the Ross Sea region and past changes in WAIS.

Why important, why now?

International and multidisciplinary campaigns yield new findings into modern and past (last 30-40 million of years) interactions between atmospheric and oceanic circulation and ice sheet-ice shelf dynamics. Intervals studied span a range of timescales from decades to millions of years, from the pre-glacial greenhouse climate of the Eocene and into the future. PAIS field work aims to investigate the paleobiogeographic evolution of the extant Antarctic fauna, related to past changes in the ice sheet and surrounding climate and ocean. The data will be fundamental for a developing comprehensive reconstructions Antarctica that consider both the physical and environmental setting.

Finalization Activities

- Field work:
 - 1) Four IODP-JR and one IODP-MPS Expeditions
 - 2) Other marine cruises (Bransfield Strait, Powell Basin, Scotia Sea, Lützw-Holm Bay, Indian sector of the Southern Ocean, Ross and Amundsen Sea)
 - 3) Land work including the East Antarctic International Ice Sheet Traverse to study low accumulation areas between Dome C and South Pole
- Numerical modeling and facilitation of model-data integration:
 - 1) Sponsorship of model-data integration workshops
 - 2) Ongoing development of paleo-bathymetric boundary conditions data sets (PAIS subcommittee led by S. Jamieson) for paleoclimate and ice sheet modeling.



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- 3) Sponsorship of Antarctic focused modelers to attend international symposia and summer schools, such the Urbino Summer School for Paleoclimatology.
- 4) PAIS-specific sessions focusing on model-data integration at upcoming AGU and EGU conferences.
- Publication of the results from new and legacy data and data-model integration and publication of a summary paper of PAIS findings relevant to the IPCC AR6.
- EU Marie Skłodowska-Curie projects SONAR-CO₂ (Southern Ocean Nanoplankton response to CO₂) and WAMSISE (West Antarctic Margin Signatures of Ice Sheet Evolution)
- Development of an international integrated geoscientific Antarctic drilling Project portfolio including: Ekström Ice Shelf and Siple Cost-Ross Sea ice shelf
- Ongoing update of the Antarctic Seismic Data Library System for Cooperative Research (SDLS) <http://sdls.ogs.trieste.it/>
- Complete the white paper after the PAIS conference that will be the basis for a new SCAR SRP beyond PAIS
- Submit a new white paper to the IODP INVEST meeting of 2019
- PAIS-IODP 2018 (and 2020) school at Texas AM Univ-IODP (USA)
- Polar 2018 (Davos) PAIS activities:
 - 1) Session GG-2 “Arctic and Antarctic past ice sheet dynamics and paleoclimate evolution”
 - 2) PAIS workshop to discuss and finalize the white paper with future directions for the next SCAR SRP after PAIS (June 20th)
 - 3) PAIS subcommittee on Paleoclimate Records from the Antarctic Margin and Southern Ocean (PRAMSO), side meeting (June 15th)
 - 4) PAIS paleotopography and paleobathymetry subcommittee side meeting (June 19th)
 - 5) Seismic Data Library System SDLS side meeting (June 22nd)
 - 6) Workshop on Ice-sheet ocean interactions: observations and models (June 18th)
 - 7) Plenary presentation of a video celebrating 50 years of IODP Antarctic expeditions under SCAR coordination

Expected Final Outcomes

A number of PAIS publications are expected to come from the results obtained by recent land and marine surveys and from IODP Exp. 374, 379 and 382 before the end of PAIS, as well as new work conducted in legacy sediment cores. They will provide new constraints for ice sheet and paleocirculation models during past warm climates, including those with atmospheric CO₂ content higher than today.

Paleotopographic and paleobathymetric maps of the Antarctic margin for Oligocene (?), and possibly regional maps for the mid Miocene, early/mid Pliocene will also be produced and used as a basis for ice sheet simulations. These integrated data sets will enable robust testing of a new generation of coupled Glacial Isostatic Adjustment-Ice Sheet-Atmosphere-Ocean models that include new reconstructions of past and present ice bed topography and bathymetry.

New papers on correlating ice cores and sediment cores will follow the publication (expected in 2018) of the Adelie Drift, Holocene, high-resolution stratigraphy. Discussions with the ice core community during the PAIS meeting in Trieste was mainly about understanding the mechanism of the deglaciation after the LGM and the last 2000 years. In addition, the new ice core “Beyond EPICA-Oldest Ice (BE-OI)”



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drilling will open unprecedented cross linkage opportunities between the glaciological and geological communities. The goal will be integration of continental climate data and ice sheet behaviour on orbital time scales climate over the last million of years.

The expected final outcomes of PAIS are improved projections of future sea-level rise, better understanding of drivers of ice-sheet change, and better understanding of the sensitivity of East, West, and Antarctic Peninsula ice sheets to a broad range of climatic and oceanic conditions.

Deviations from the Implementation Plan

No deviations are expected from the implementation plan

Budget

Planned use of funds for 2018 to 2020

Year	Purpose/Activity	Amount (in USD)	Contact Name	Contact Email
2020	SCAR Sidney participation/workshop organization	6000	Steering comm. Members to be decided upon request	tbd
2020	ECORD Paleoclimatology summer school Urbino, IT participation	1000	To be decided upon request	tbd
2020	PAIS-IODP school participation/ organization	20000	Trevor Williams	williams@iodp.tamu.edu
2019	AGU-EGU-ISAES-IODP conferences participation/workshop organization	8000	To be decided upon request	tbd
2019	ECORD Petrophysics Summer School, Leicester, UK participation	2000	To be decided upon request	tbd
2019	ECORD Paleoclimatology summer school Urbino, IT participation	2000	To be decided upon request	tbd
2018	PAIS-IODP school participation/ organization	20000	Trevor Williams	williams@iodp.tamu.edu
2018	SCAR Davos early career scientists participation and workshop organization	4000	Casado Parker Halberstadt	mathieu.casado@lsce.ipsl.fr rebeccaparkernz@gmail.com ahalberstadt@umass.edu
2018	SCAR Davos (IODP 50 th and SCAR 60 th anniversary) video	1000	Kim Kimberley	kimberlyannekenny@gmail.com
2018	ECORD Paleoclimatology summer school Urbino, IT participation	1000	Frida Hoem	f.s.hoem@uu.nl



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2018	Advanced course in organic-walled dinoflagellate cysts participation	1000	Peter Bijl	P.K.Bijl@uu.nl
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Briefly describe funds usage and the desired results

- **We ask permission to use in 2018 also part of the funds allocated to PAIS in 2019, since we plan more activities in 2018 than in 2019.**
- **SCAR Sidney participation/workshop organization** - The 2020 funds will be used for supporting students, early career scientists and invited speakers to attend the SCAR–OSC (Hobart) and for organizing PAIS subcommittee workshops and other workshops and meetings related to PAIS, upon request, during the SCAR–OSC (Hobart). These meetings will be mainly aimed at summarizing the final PAIS outcomes and to plan future targets to be achieved in the new SRP.
- **ECORD summer schools and other courses participation**
- PAIS funds will also be allocated for students attending the ECORD Summer schools in Paleoclimatology in Urbino (Italy) and in Petrophysics in Leicester (UK) and also in the Advanced course in organic-walled dinoflagellate cysts, organized by Peter K. Bijl, Univ. of Utrecht, Director *Laboratory of Paleobothany and Palynology LPP* Foundation.
- **PAIS-IODP school participation/ organization** - A PAIS Summer school will be held at Texas AM University – IODP repository (College Station, TX, USA) in the Summer-Fall of 2018 and of 2020, organized by Trevor Williams and Denise Kulahek et al. The school will last 4-5 days, during which students will look at the IODP sediment cores collected from Antarctic margins and will attend classes about scientific questions addressed by PAIS, methodologies employed (geophysical surveys and deep and shallow drilling/coring) and scientific gaps to be targeted in future projects. Possibly other sources for student and for the experts attendance would come from IODP, ECORD and other IODP funding agencies.
- **AGU-EGU-ISAES.IODP conferences participation/workshop organization** - The 2018-20 funds will be used for organizing PAIS subcommittee workshops and other workshops and meetings (e.g. the IODP post 2023 scientific plan conference) related to PAIS, upon request. PAIS funds will also be used for supporting students, early career scientists and invited speakers to attend the AGU, EGU, ISAES conferences and any other conference related to PAIS.
- **SCAR Davos early career scientists participation and workshop organization** - The remaining 2017 and part of the 2018 funds will be used for organizing PAIS subcommittee workshops and other workshops and meetings related to PAIS, during the SCAR–OSC 2018 (Davos). PAIS funds will also be used for supporting 3 students, early career scientists to attend the SCAR–OSC.
- **SCAR Davos (IODP 50th and SCAR 60th anniversary) video**
 A video about the DSDP-ODP-IODP main outcomes from 45 years of Antarctic drilling will be presented in Davos to celebrate 50 years of deep drilling and 60 years of SCAR. PAIS partly covers the travel expenses and film editing for the filmmaker



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Percentage of the budget to be used for support of early career researchers

2018: 30
2019: 30
2020: 30

Percentage of the budget to be used for support of scientists from countries with developing Antarctic programmes

2018: 30
2019: 30
2020: 30

Linkages

Direct support from outside organisations received for your activities

The International Ocean Discovery Program IODP <http://www.iodp.org/> is the main outside organization providing enormous support for the PAIS drilling expeditions in Antarctica, both in terms of offshore (ca. 50 million US\$ in 2018-2019 expeditions) and shore-based science and communication-outreach programs and for pre-cruise work and meetings.

Major collaborations

Within SCAR - PAIS is very much linked to some activities carried out by SERCE, AntClim21 and AntEco. Several scientists belonging to these programs were invited as key-note speakers and attended the PAIS conference 2017 and are going to be involved in the PAIS workshops in Davos. PAIS-AntClim21 link was represented during the PAIS conference also by the workshop on Holocene climate variability off Wilkes Land, East Antarctica. Organizers J. Etourneau, C. Escutia and R. McKay. 17 September 2017, Trieste (Italy)

Outside SCAR - PAIS is strongly linked to International Ocean Discovery Program (IODP), Southern Ocean Observatory System (SOOS) and ISMASS, searching for evidence and data to understand implications of the COP21 (Paris Climate Agreement) +2°C temperature targets for both Greenland and Antarctica. These programs aim to investigate processes and tipping points contributing to changes in the cryosphere, global sea level, and ocean circulation, possibly leading to irreversible environmental changes.

- PAIS representatives (Tim Naish and Rob DeConto) were involved in scoping the IPCC (Intergovernmental Panel on Climate Change) special report on the world at +1.5°C. Rob DeConto and Andrew Macintosh are lead authors of the IPCC special report on the Oceans and Cryosphere in a Changing Climate (in progress). PAIS member Nick Golledge has been selected as a lead author of the IPCC AR6. The APECS member of the PAIS steering committee (Mathieu Casado) is organising (with other members or participants of PAIS and APECS) a group review of the next IPCC special report on Ocean and Cryosphere



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- APECS representative are member of the PAIS steering committee, help with the PAIS web site management, with workshop organizing during the PAIS conference, highlighting scientific results of the new papers
- IPICS (International Partnership in Ice Core Sciences) steering committee and representative of the 2ka project (B. Stenni) is member of the PAIS steering committee
- PAIS steering committee members are External Expert Advisory Board (EEAB) of international panels and projects (e.g. EU-PolarNet).

Outreach and Capacity Building

- PAIS new web page <http://www.scar-pais.org/> in addition to the SCAR web page <http://www.scar.org/srp/pais> with the help of new APECS representatives in the PAIS steering committee Mathieu Casado (France) and Pamela Santibañez (Chile). In the new web page, we are posting scientific news with small descriptions of PAIS related articles. We also post videos and images of expeditions related to PAIS.
- PAIS presence on Facebook: Four hundred people clicked PAIS links from Facebook to the PAIS website during the last year, and we have 62 persons following the page.
- A PAIS mailing list was established within SCAR
- PAIS is supporting the planning of new data-acquisition missions using emerging technologies by making funds available for workshops and meetings (e.g. the subcommittee PRAMSO meeting during the SCAR-OSC 2016, 2018 and the IODP-ECORD-USSSP workshop on May 2016).
- PAIS is encouraging data sharing and integration of spatially targeted transect data with modelling studies by promoting the free use and exchange of data from the Antarctic Data Library System (ADLS) that stores all existing multichannel seismic data collected by all Nations from the Antarctic margins.
- PAIS is initiating/expanding cross linkages among Antarctic research communities by engaging IODP and other projects like the FP7-EU/EUROFLEETS (ANTSS project with OGS Explora 2017 seismic and sediment coring site survey for IODP Exp. 374) and IPICS projects.
- Extensive Outreach and Capacity building at the 2017 PAIS conference included workshops, movie screenings, and special programs of school children and teachers, among others.
- PIISA Project for junior & senior high-school students “Back to the future: How the paleoclimatic and ice sheet dynamics record in deep sea sediments can inform future changes” 2016. <http://piiisa.es/programacion-de-congreso-piisa-2016-2017/>
- PAIS sponsorship of Urbino Summer School for Paleoclimatology fosters the education of promising Antarctic young researchers.
- Activities in Science Museums and National Science Weeks and Education Programme (e.g.,



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<http://www.parqueciencias.com/parqueciencias/actividades/cienciaenlavidacotidiana.html>)

- Blogs of field work, in different languages like for example <http://joidesresolution.org/expedition/374/> or <https://igme404682622.wordpress.com/2018/02/15/los-estudios-han-corroborado-lo-que-ya-se-sospechaba/>

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Requests to the Secretariat

- Help with completing and updating the PAIS official SCAR web page <http://www.scar.org/srp/pais>
- Help to create inside the official SCAR web page <http://www.scar.org/srp/pais>. The direct link to the other more complete and continuously updated PAIS web page <http://www.scar-pais.org/>.

APPENDIX - Other recent papers related to PAIS

- Kuhn G, Hillenbrand C-D, Kasten S, Smith JA, Nitsche FO, Frederichs T, Wiers S, Ehrmann W, Klages JP, Mogollón JM (2017) Evidence for a palaeo-subglacial lake on the Antarctic continental shelf. *Nature Communications* **8**, doi: 10.1038/ncomms15591.
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