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Assessment of marine weather forecasts over the Indian sector of Southern Ocean

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The Southern Ocean (SO) is one of the important regions where significant processes and feedbacks of the Earth's climate take place. Expeditions to the SO provide useful data for improving global weather/climate simulations and understanding many processes. Some of the uncertainties in these weather/climate models arise during the first few days of simulation/forecast and do not grow much further. NCMRWF issued real-time five day weather forecasts of mean sea level pressure, surface winds, winds at 500 hPa & 850 hPa and rainfall, daily to NCAOR to provide guidance for their expedition to Indian sector of SO during the austral summer of 2014–2015. Evaluation of the skill of these forecasts indicates possible error growth in the atmospheric model at shorter time scales. The error growth is assessed using the model analysis/reanalysis, satellite data and observations made during the expedition. The observed variability of sub-seasonal rainfall associated with mid-latitude systems is seen to exhibit eastward propagations and are well reproduced in the model forecasts. All cyclonic disturbances including the sub-polar lows and tropical cyclones that occurred during this period were well captured in the model forecasts. Overall, this model performs reasonably well over the Indian sector of the SO in medium range time scale.

Dimethylsulfide model calibration and parametric sensitivity analysis for the Greenland Sea

Bo Qu, Albert J. Gabric, Meifang Zeng, Jiaojiao Xi, Limei Jiang, Li Zhao

Sea-to-air fluxes of marine biogenic aerosols have the potential to modify cloud microphysics and regional radiative budgets, and thus moderate Earth's warming. Polar regions play a critical role in the evolution of global climate. In this work, we use a well-established biogeochemical model to simulate the DMS flux from the Greenland Sea (20°W–10°E and 70°N–80°N) for the period 2003–2004. Parameter sensitivity analysis is employed to identify the most sensitive parameters in the model. A genetic algorithm (GA) technique is used for DMS model parameter calibration. Data from phase 5 of the Coupled Model Intercomparison Project (CMIP5) are used to drive the DMS model under 4 × CO_2 conditions. DMS flux under quadrupled CO_2 levels increases more than 300% compared with late 20th century levels (1 × CO_2). Reasons for the increase in DMS flux include changes in the ocean state—namely an increase in sea surface temperature (SST) and loss of sea ice—and an increase in DMS transfer velocity, especially in spring and summer. Such a large increase in DMS flux could slow the rate of warming in the Arctic via radiative budget changes associated with DMS-derived aerosols.

Geostatistical analysis and isoscape of ice core derived water stable isotope records in an Antarctic macro region

István Gábor Hatvani, Markus Leuenberger, Balázs Kohán, Zoltán Kern

Water stable isotopes preserved in ice cores provide essential information about polar precipitation. In the present study, multivariate regression and variogram analyses were conducted on 22 δ^2H and 53 $\delta^{18}O$ records from 60 ice cores covering the second half of the 20th century. Taking the

multicollinearity of the explanatory variables into account, as also the model's adjusted R^2 and its mean absolute error, longitude, elevation and distance from the coast were found to be the main independent geographical driving factors governing the spatial $\delta^{18}O$ variability of firn/ice in the chosen Antarctic macro region. After diminishing the effects of these factors, using variography, the weights for interpolation with kriging were obtained and the spatial autocorrelation structure of the dataset was revealed. This indicates an average area of influence with a radius of 350 km. This allows the determination of the areas which are as yet not covered by the spatial variability of the existing network of ice cores. Finally, the regional isoscape was obtained for the study area, and this may be considered the first step towards a geostatistically improved isoscape for Antarctica.

Regional distribution and variability of model-simulated Arctic snow on sea ice
Karel Castro-Morales, Robert Ricker, Rüdiger Gerdes

Numerical models face the challenge of representing the present-day spatiotemporal distribution of snow on sea ice realistically. We present modeled Arctic-wide snow depths on sea ice (h_{s_mod}) obtained with the MITgcm configured with a single snow layer that accumulates proportionally to the thickness of sea ice. When compared to snow depths derived from radar measurements (NASA Operation IceBridge, 2009–2013), the model snow depths are overestimated on first-year ice (2.5 ± 8.1 cm) and multiyear ice (0.8 ± 8.3 cm). The large variance between model and observations lies mainly in the limitations of the model snow scheme and the large uncertainties in the radar measurements. In a temporal analysis, during the peak of snowfall accumulation (April), h_{s_mod} show a decline between 2000 and 2013 associated to long-term reduction of summer sea ice extent, surface melting and sublimation. With the aim of gaining knowledge on how to improve h_{s_mod}, we investigate the contribution of the explicitly modeled snow processes to the resulting h_{s_mod}. Our analysis reveals that this simple snow scheme offers a practical solution to general circulation models due to its ability to replicate robustly the distribution of the large-scale Arctic snow depths. However, benefit can be gained from the integration of explicit wind redistribution processes to potentially improve the model performance and to better understand the interaction between sources and sinks of contemporary Arctic snow.

Assessing the efficiency of carbide drill bits and factors influencing their application to debris-rich subglacial ice
Cheng Yang, Jianliang Jiang, Pinlu Cao, Jinsong Wang, Xiaopeng Fan, Yuequan Shang, Pavel Talalay

When drilling into subglacial bedrock, drill operators commonly encounter basal ice containing high concentrations of rock debris and melt water. As such conditions can easily damage conventional ice drills, researchers have experimented with carbide, diamond, and polycrystalline diamond compact drill bits, with varying degrees of success. In this study, we analyzed the relationship between drilling speed and power consumption for a carbide drill bit penetrating debris-rich ice. We also assessed drill load, rotation speed, and various performance parameters for the cutting element, as well as the physical and mechanical properties of rock and ice, to construct mathematical models. We show that our modeled results are in close agreement with the experimental data, and that both penetration speed and power consumption are positively correlated with drill speed and load. When used in ice with 30% rock content, the maximum penetration speed of the carbide bit is 3.4 mm/s with a power consumption of ≤0.5 kW, making the bit suitable for use with existing electromechanical drills. Our study also provides a guide for further research into cutting heat and equipment design.

Hydrographic observations by instrumented marine mammals in the Sea of Okhotsk
Takuya Nakanowatari, Kay I. Ohshima, Vigan Mensah, Yoko Mitani, Kaoru Hattori, Mari Kobayashi, Fabien Roquet, Yasunori Sakurai, Humio Mitsudera, Masaaki Wakatsuchi

The Sea of Okhotsk is a challenging environment for obtaining in situ data and satellite observation in winter due to sea ice cover. In this study, we evaluated the validity of hydrographic observations by marine mammals (e.g., seals and sea lions) equipped with oceanographic conductivity-temperature-depth (CTD) sensors. During 4-yr operations from 2011 to 2014, we obtained total of 997 temperature-salinity profiles in and around the Soya Strait, Iony Island, and Urup Strait. The hydrographic data were mainly obtained from May to August and the maximum profile depth in shelf regions almost reaches to the seafloor, while valuable hydrographic data under sea ice cover were also obtained. In strong thermoclines, the seal-derived data sometimes showed positive biases in salinity with spike-like signal. For these salinity biases, we applied a new thermal mass inertia correction scheme, effectively reducing spurious salinity biases in the seasonal thermocline. In the Soya Strait and the adjacent region, the detailed structure of the Soya Warm Current including the cold-water belt was well identified. Dense water up to $27.0_{\sigma\theta}$, which can be a potential source of Okhotsk Sea Intermediate Water, has flowed from the Soya Strait into the Sea of Okhotsk in mid-winter (February). In summer, around the Iony Island and Urup Strait, remarkable cold and saline waters are localized in the surface layers. These regions are also characterized by weak stratification, suggesting the occurrence of tidally induced vertical mixing. Thus, CTD-tag observations have a great potential in monitoring data-sparse regions in the Sea of Okhotsk.

Crustal formation and evolution processes in the Natal Valley and Mozambique Ridge, off South Africa

Tomoko Hanyu, Yoshifumi Nogi, Masakazu Fujii

The evolution of seafloor spreading of Africa, South America, and Antarctica is key to understanding the initial break-up of Gondwana. Vector geomagnetic surveys were conducted in the Natal Valley and Mozambique Ridge, off South Africa. We summarize the nature of the crust using the results of dense vector geomagnetic anomaly data, as well as satellite gravity data. Based on both inversion and forward analytical results, we identified areas of stretched continental crust, with basaltic magma intrusion in parts, as the northern Natal Valley, north part of the Mozambique Ridge, and north part of the southern Natal Valley. Oceanic crust was identified in the south part of the southern Natal Valley and south part of the Mozambique Ridge. Magnetic isochrons M0–M10 were identified in the south part of the southern Natal Valley. Clear magnetic lineations were observed in the south part of the Mozambique Ridge, where some areas were distorted by hotspot volcanism. The location of the continental ocean boundary in the Natal Valley, along with a four-stage model of tectonic evolution of the study area since about 183 Ma, are newly proposed.

Diversity of proteolytic microbes isolated from Antarctic freshwater lakes and characteristics of their cold-active proteases

Mihoko Matsui, Akinori Kawamata, Makiko Kosugi, Satoshi Imura, Norio Kurosawa

Despite being an extreme environment, the water temperature of freshwater lakes in Antarctica reaches 10 °C in summer, accelerating biological activity. In these environments, proteolytic microbial decomposers may play a large role in protein hydrolysis. We isolated 71 microbial strains showing proteolytic activity at 4 °C from three Antarctic freshwater lakes. They were classified as bacteria (63 isolates) and eukaryotes (8 isolates). The bacterial isolates were classified into the genera *Flavobacterium* (28 isolates), *Pseudomonas* (14 isolates), *Arthrobacter* (10 isolates), *Psychrobacter* (7 isolates), *Cryobacterium* (2 isolates), *Hymenobacter* (1 isolate), and *Polaromonas* (1 isolate). Five isolates of *Flavobacterium* and one of *Hymenobacter* seemed to belong to novel species. All eukaryotic isolates belonged to *Glaciozyma antarctica*, a psychrophilic yeast species originally isolated from the Weddell Sea near the Joinville Island, Antarctica. A half of representative strains were psychrophilic and did not grow at temperatures above 25 °C. The protease secreted by *Pseudomonas prosekii* strain ANS4-1 showed the highest activity among all proteases from representative isolates. The results of inhibitor tests indicated that nearly all the isolates secreted metalloproteases. Proteases from four representative isolates retained more than

30% maximal activity at 0 °C. These results expand our knowledge about microbial protein degradation in Antarctic freshwater lakes.

Navigable windows of the Northwest Passage

Xing-he Liu, Long Ma, Jia-yue Wang, Ye Wang, Li-na Wang

Artic sea ice loss trends support a greater potential for Arctic shipping. The information of sea ice conditions is important for utilizing Arctic passages. Based on the shipping routes given by “Arctic Marine Shipping Assessment 2009 Report”, the navigable windows of these routes and the constituent legs were calculated by using sea ice concentration product data from 2006 to 2015, by which a comprehensive knowledge of the sea ice condition of the Northwest Passage was achieved. The results showed that Route 4 (Lancaster Sound – Barrow Strait – Prince Regent Inlet and Bellot Strait – Franklin Strait – Larsen Sound – Victoria Strait – Queen Maud Gulf – Dease Strait – Coronation Gulf – Dolphin and Union Strait – Amundsen Gulf) had the best navigable expectation, Route 2 (Parry Channel - M'Clure Strait) had the worst, and the critical legs affecting the navigation of Northwest Passage were Viscount Melville Sound, Franklin Strait, Victoria Strait, Bellot Strait, M'Clure Strait and Prince of Wales Strait. The shortest navigable period of the routes of Northwest Passage was up to 69 days. The methods used and the results of the study can help the selection and evaluation of Arctic commercial routes.

Life on thin ice: Insights from Uummannaq, Greenland for connecting climate science with Arctic communities

Juan Baztan, Mateo Cordier, Jean-Michel Huctin, Zhiwei Zhu, Jean-Paul Vanderlinden

What are the links between mainstream climate science and local community knowledge? This study takes the example of Greenland, considered one of the regions most impacted by climate change, and Inuit people, characterized as being highly adaptive to environmental change, to explore this question. The study is based on 10 years of anthropological participatory research in Uummannaq, Northwest Greenland, along with two fieldwork periods in October 2014 and April 2015, and a quantitative bibliometric analysis of the international literature on sea ice – a central subject of concern identified by Uummannaq community members during the fieldwork periods. Community members' perceptions of currently available scientific climate knowledge were also collected during the fieldwork. This was done to determine if community members consider available scientific knowledge salient and if it covers issues they consider relevant. The bibliometric analysis of the sea ice literature provided additional insight into the degree to which scientific knowledge about climate change provides information relevant for the community. Our results contribute to the ongoing debate on the missing connections between community worldviews, cultural values, livelihood needs, interests and climate science. Our results show that more scientific research efforts should consider local-level needs in order to produce local-scale knowledge that is more salient, credible and legitimate for communities experiencing climate change. In Uummannaq, as in many Inuit communities with similar conditions, more research should be done on sea ice thickness in winter and in areas through which local populations travel. This paper supports the growing evidence that whenever possible, climate change research should focus on environmental features that matter to communities, at temporal and spatial scales relevant to them, in order to foster community adaptations to change. We recommend such research be connected to and co-constructed with local communities to ensure their needs and values are integrated into the research process and outputs.