# Agenda

# Polar CORDEX meeting

Place: Conference room no 213, Institute of Geophysics Polish Academy of Sciences, Ksiecia Janusza 64, Warsaw, POLAND
Date: 17-19 October, 2018
Attendees:

1. Mirseid Akperov* (A.M. Obukhov Institute of Atmospheric Physics, RAS, Moscow, Russia)
2. Deniz Bozkurt* (Universidad de Chile, Santiago-Chile)
3. John Cassano (University of Colorado)
4. Yang Diyi (Chinese Academy of Meteorological Sciences)
5. Narayan Prasad Gautam (Tribhuvan University, Nepal)
6. Diana Gergel* (University of Washington, USA)
7. Signe Gevik (DMI/Technical University of Denmark)
8. Alexandra Gossart* (KU Leuven, Leuven, Belgium)
9. Nicolaj Hansen* (DMI/Technical University of Denmark)
10. Günther Heinemann* (University of Trier, Germany)
11. Agnieszka Herman (Institute of Oceanography, University of Gdansk, Poland)
12. Flavio Justino* (Universidade Federal de Viçosa, Brasil)
13. Magdalena Kossakowska* (Institute of Geophysics Polish Academy of Sciences)
14. Svitlana Krakovska* (Ukrainian Hydrometeorological Institute)
15. Gerhard Krinner* (IGE/CNRS, France)
16. Hiroyasu Kubokawa (The University of Tokyo, Japan)
17. Oskar Landgren (Norwegian Meteorological Institute)
18. Wieslaw Maslowski* (Naval Postgraduate School, Monterey, California, USA)
19. Heidrun Matthes* (Alfred Wegener Institut Helmholtz Center for Polar and Marine Research, Germany)
20. Bart Nijssen (University of Washington, USA)
21. Hanna Ojrzyńska (University of Wrocław, Poland)
22. Andrew Orr* (British Antarctic Survey, UK)
23. Robert Osinski (Institute of Oceanology Polish Academy of Sciences, Poland)
24. Marzena Osuch (Institute of Geophysics Polish Academy of Sciences, Poland)
25. Natalia Pilguj (University of Wrocław, Poland)
26. James Pope* (British Antarctic Survey, UK)
27. Kabir Rasouli* (University of Calgary, Canada)
28. Annette Rinke (Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Germany)
29. Joseph Sedlar* (University of Colorado Boulder; Stockholm University)
30. Igor Shkolnik ( Voeikov Main Geophysical Observatory, Russia)
31. Amy Solomon* (University of Colorado/NOAA, USA)
32. Michael Tjernström (Stockholm University, Sweden)
33. Tomasz Wawrzyniak (Institute of Geophysics Polish Academy of Sciences)
34. Marta Wenta* (University of Gdańsk, Poland)

*Indicated will give a presentation.

## Day 1, Wednesday

8:30 – 8:45 **COFFEE**

8:45 – 9:00 **Welcome (Cassano and Rinke)**

9:00 - 12:00 **Session 1: Process based studies and coupled modelling**

- Observations and modelling of gap flow induced low-level jets in the Nares Strait, Greenland, **Günther Heinemann** and Svenja Kohnemann
- Foehn event triggered by an atmospheric river underlies record-setting temperature along continental Antarctica **Deniz Bozkurt**, Roberto Rondanelli, Julio C. Marín and René Garreaud
- High Heat Flux events and the role of sea ice in the Iceland Greenland Seas **James Pope**, Thomas Bracegirdle, Ian Renfrew, Andy Elvidge

10:15-10:30 Coffee break

- The influence of sea ice floes size and distribution on the averaged turbulent fluxes. **Marta Wenta**, Agnieszka Herman
- Quantification of sea ice production in the southern Weddell Sea using a synergy of atmospheric and sea-ice/ocean modelling and remote sensing data **Günther Heinemann**, Rolf Zentek, Lukrecia Stulic, Ralph Timmermann, Andreas Preußer
- Summer drivers of atmospheric variability affecting ice shelf thinning in the Amundsen Sea Embyament, West Antarctica. **Andrew Orr,** Pranab Deb, Dave Bromwich, Julien Nicholas, John Turner and Scott Hosking
- On Oceanic Contribution to the Arctic Energy Imbalance. **Wieslaw Maslowski,** Younjoo Lee, Robert Osinski, Jaclyn Clement Kinney, John Cassano, Bart Nijssen

12:00 – 13:00 **LUNCH**

13:00 – 16:00 **Session 2: Model evaluation**

- Initial model evaluation of the surface energy budget and atmospheric thermodynamics during ACSE. **Joseph Sedlar**
- Long-term high-resolution simulations over Antarctica with COSMO-CLM, N. Souverijns **, A. Gossart** , S. Vanden Broucke, S. Helsen, S. Sotiriadis, M. Demuzere, J.T.M. Lenaerts, B. Medley, I.V. Gorodetskaya, and N.P.M. van Lipzig
- Present and projected regional Antarctic climate simulations with the ARPEGE AGCM, **Gerhard Krinner**

14:30-14:45 Coffee break

- PDO and NAM during the Marine Isotope Stage 31 (1.08 Ma ago), **Flavio Justino**
- Model result intercomparison of Antarctic CORDEX simulations **Nicolaj Hansen**, Fredrik Boberg, Ruth Mottram, Sebastian Simonsen
- Simulations of Arctic Cyclones observed during ACSE with a fully-coupled regional Arctic system model: Preliminary observational analyses and model diagnostics. **Amy Solomon**

## Day 2, Thursday

8:45 – 9:00 **COFFEE**

9:00 - 12:00 **Session 3: Impact and projection studies**

- The influence of the aviation emission on the changes in the propagation of the jet stream over the Arctic. **Magdalena Kossakowska**; Jacek W. Kaminski
- Projections of cyclone activity in the Arctic for the 21st century from regional climate models (Arctic-CORDEX) **Mirseid Akperov**, Annette Rinke, et al.

10:15-10:30 Coffee break

- An overview on the European Space Agency Climate Change Intitiative (ESA CCI+ Program) Project on Permafrost, **Heidrun Matthes**
- Nordic Seas polar low projections from 18 downscaled members of the CESM Large Ensemble. **Oskar Landgren**

12:00 – 13:00 **LUNCH**

13:00 – 15:30 **Session 4: Impact and projection studies**

- Impacts of Climate and Vegetation Changes on Hydrological Processes in an Arctic Research Basin **Kabir Rasouli**
- Representing the land surface in the Regional Arctic System Model (RASM) **Diana R. Gergel,** Joseph J. Hamman, Bart Nijssen

14:00-14:20 Coffee break

- Observed and projected surface air warming at the Faraday-Vernadsky station in the Antarctic Peninsula region, **Svitlana Krakovska,** Denys Pishniak, Larysa Pysarenko

## Day 3, Friday

8:45 – 9:00 **COFFEE**

9:00 - 12:00 **Session 5: Future activities and plans**

12:00 – 13:00 **LUNCH**

**END OF MEETING**

Title and abstracts (in alphabetical order, based on the presenting author's name)

# Projections of cyclone activity in the Arctic for the 21st century from regional climate models (Arctic-CORDEX)

**Mirseid Akperov[1], Annette Rinke[2], et al.**

[1]*A.M. Obukhov Institute of Atmospheric Physics, RAS, Moscow, Russia*

[2]*Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, AWI, Potsdam, Germany*

# Foehn event triggered by an atmospheric river underlies record-setting temperature along continental Antarctica

**Deniz Bozkurt[1], Roberto Rondanelli[1,2], Julio C. Marín[3] and René Garreaud[1,2]**

1 *Center for Climate and Resilience Research, University of Chile, Santiago, Chile, Email: dbozkurt@dgf.uchile.cl*

2 *Department of Geophysics, University of Chile, Santiago, Chile*

3 *Department of Meteorology, University of Valparaiso, Valparaiso, Chile*

A record-setting temperature of 17.5oC occurred on 24 March 2015 at the Esperanza station located near the northern tip of the Antarctic Peninsula (AP). We studied the event using surface station data, satellite imagery, reanalysis data, and numerical simulations. The MODIS Antarctic Ice Shelf Image Archive provides clear evidence for disintegration and advection of sea ice, as well as the formation of melt ponds on the ice sheet surface at the base of the AP mountain range. A deep low-pressure center over the Amundsen-Bellingshausen Sea and a blocking ridge over the southeast Pacific provided favorable conditions for the development of an atmospheric river with a northwest-southeast orientation, directing warm and moist air towards the AP, and triggering a widespread foehn episode. A control simulation using a regional climate model shows the existence of local topographically-induced warming along the northern tip of the AP (~60% of the full temperature signal) and the central part of the eastern AP (>90% of the full temperature signal) with respect to a simulation without topography. These modeling results suggest that more than half of the warming experienced at Esperanza can be attributed to the foehn effect (a local process), rather than to the large-scale advection of warm air from the midlatitudes. Nevertheless, the local foehn effect also has a large-scale advection component, since the AR provides water vapor for orographic precipitation enhancement and latent heat release, which makes it difficult to completely disentangle the role of local versus large-scale processes in explaining the extreme event. We highlight that an anomalous source of water vapor enhancing the moisture transport towards the AP through ARs may play a crucial role in the occurrence of foehn events, as well as in determining the extremity of these events. Furthermore, moisture transport is also critical in understanding temperature effects on the surface cryosphere, given the large warming amplification that occurs with this particular event. The occurrence of these extreme temperature events in the AP opens questions concerning the cause of frequency of such events, as well the role of extreme episodes versus weaker, long-term temperature trends in the fate of ice sheet surfaces and ice shelves in the eastern side of the AP.

# Representing the land surface in the Regional Arctic System Model (RASM)

**Diana R. Gergel, Joseph J. Hamman, Bart Nijssen**

*University of Washington, USA*

Permafrost and seasonally frozen soils are a key characteristic of the terrestrial Arctic, and the fate of near-surface permafrost, as well as the partitioning of runoff and evaporation, are highly sensitive to changes in seasonal and annual mean precipitation and temperature. The soil active layer is the layer of soil that freezes and thaws annually, and shifts in active layer depth (ALD) are projected to occur due to large-scale changes in permafrost extent and snow cover as a result of warming temperatures. Faithful representation of permafrost in land models that are part of global and regional climate models is a product of both internal soil dynamics as well as the coupling of air and soil temperatures and their interplay with snow cover. Soil temperatures often show systematic biases, which in turn lead to biases in air temperature due to poorly represented air-soil temperature feedbacks. To investigate these large-scale modeling issues across the Arctic, we use the Regional Arctic System Model (RASM), a fully-coupled regional earth system model that uses the Variable Infiltration Capacity (VIC-5) as its land model. RASM is a fully-coupled regional earth system model (ESM) that is run at a 50-km land-atmosphere resolution and a 9-km ice-ocean resolution over a pan-Arctic domain. Using RASM, we show how VIC-simulated permafrost extent compares to observed permafrost extent and active layer depth across our circumpolar Arctic domain.

As part of the ESM shift toward higher-resolution regional climate modeling, we have developed a new, high-resolution set of soil and vegetation parameters for the VIC-5 model using high-resolution global soil datasets (1-km) and a new set of vegetation classes drawing from the plant functional types (PFTs) used in the Community Land Model, the land model in the Community Earth System Model (CESM). We use these parameters to run VIC-5 (and eventually RASM) at a 25-km resolution, but our parameter derivation process is resolution-agnostic. We are in the process of using these parameters to conduct a series of sensitivity runs to understand the sensitivity of runoff, evaporation and active layer depth to changes in precipitation and temperature, and we discuss our methods and process for developing these new parameter sets.

Our sensitivity experiments described herein will inform future fully-coupled RASM simulations that will explore land-atmosphere feedbacks in the Arctic and how changes in runoff/evaporation partitioning, permafrost extent and ALD depth, and surface albedo may impact both local and non-local changes in near-surface air temperatures and general circulation patterns.

# Model result intercomparison of Antarctic CORDEX simulations

**Nicolaj Hansen, Fredrik Boberg, Ruth Mottram, Sebastian Simonsen**
*DMI/Technical University of Denmark*

Three different Antarctic CORDEX model runs currently exist in the CORDEX database: DMI-HIRHAM5, KNMI-RACMO2.3, and MOHC-HadRM3.

Here, we compare the three models to examine their internal discrepancies. As surface mass balance (SMB) is most often used as forcing fields for ice sheet models, we also evaluate the three components of SMB; precipitation, run-off and evaporation/sublimation. Climate simulations with DMI-HIRHAM5 are forced by three EC-Earth runs (Historical, RCP 4.5 and RCP 8.5) and are also inspected to determine the implications of future climate change for Antarctica (The future simulations are done for DMI-HIRHAM5 and KNMI-RACMO2.3 50 km, and DMI-HIRHAM5 12.5 km).

The current state-of-the-art of Antarctic Regional Climate Modelling is highlighted by evaluation against in-situ observations of temperature and wind speed. In addition to the CORDEX models, we also compare additional simulations performed by DMI- HIRHAM5 at high resolution (12.5 km); furthermore UU-RACMO2.3p2 at higher resolution (~25km) with upper atmosphere nudging is also examined to determine if resolution and nudging assist in representing climate over Antarctica.

It is clear that results from the three CORDEX model simulations differ considerably from each other and with substantial biases compared to observed temperatures and wind speeds. While the nudged simulation (RACMO2.3p2) may be closer to observed weather on a daily basis, on climatological timescales (monthly to annual) the implemented top of atmosphere nudging from the driving model shows little effect on temperature and wind speeds. The estimated magnitude of the surface mass balance differs by up to 1000 GT/year in the evaluation data sets, driven by ERA-Interim. This indicates substantial work is needed to improve regional climate models in Antarctica. Currently RCMs simulate SMB for both Antarctic and Greenland ice sheets. The biases in the CORDEX and other models suggest that we can be less confident in our results for Antarctic than Greenland. This conclusion is in line with the IMBIE (Shepherd et al., 2018) Antarctica mass balance inter-comparison; where different methods show a wide variation in estimates of total Antarctic mass budget. Previously this wide spread has been attributed largely to ocean forcing but this study suggests that uncertainties in atmospheric circulation models also contributes to uncertainties in SMB and therefore total mass budget. The improved performance of the higher resolution DMI-HIRHAM5 and UU-RACMO model simulations suggest one route to improving estimates of Antarctic SMB. But more work is needed and accompanied by the need for additional in-situ observations to fully assess the performance of regional climate models in Antarctica.

# Observations and modelling of gap flow induced low-level jets in the Nares Strait, Greenland

**Günther Heinemann and Svenja Kohnemann**

*Environmental Meteorology, University of Trier, Germany*

Gap flows and the stable boundary layer were studied in northwest Greenland during the aircraft-based experiment IKAPOS (Investigation of Katabatic winds and Polynyas during Summer) in June 2010. The measurements were performed using the research aircraft POLAR 5 of Alfred Wegener Institute (AWI, Bremerhaven). In the area of Smith Sound at the southern end of the Nares Strait a stable, but fully turbulent boundary layer with strong low-level jets (LLJs) with winds of up to 22 m s-1 was found during conditions of synoptically induced northerly winds through the Nares Strait. Strong surface inversions were present in the lowest 100 m to 200 m. The wind maximum is located at 20-50 km distance from the exit of Smith Sound. The observations of the channeling process are consistent with gap flow theory.

Simulations of the LLJs in the Nares Strait region were performed using the regional atmospheric model COSMO for the IKAPOS experiment and with its climate version COSMO-CLM (CCLM) for the winters 1987-2017. COSMO was run with 15, 5 and 1km resolution for June 2010, while the regional climate model CCLM was run with a resolution of 15km, which is necessary to resolve the Nares Strait. The COSMO simulations can reproduce most features of the ABL structure found in the observations and confirm that the interaction of the 2D channeling of the stably-stratified flow in the gap of Smith Sound and the gravity wave system associated with the flow over the mountains result in a 3D channeling.

With the aid of the 30 years CCLM data, the climatology of the gap flows was studied. Results are compared with the Arctic System Reanalysis data. The LLJ caused by the Smith sound is a climatological feature. The height of the LLJ is between 100 to 200m with maximum monthly mean winds of around 16m/s. Wind events stronger than 20 m/s occur in average almost once a week during winter, but with a high interannual variability. The orographically channeled flow through Smith Sound plays a key role for the formation of the North Water polynya being the largest ice producing polynya in the Arctic.

# Quantification of sea ice production in the southern Weddell Sea using a synergy of atmospheric and sea-ice/ocean modelling and remote sensing data

**Günther Heinemann*, Rolf Zentek*, Lukrecia Stulic**, Ralph Timmermann**, Andreas Preußer***

**Environmental Meteorology, University of Trier, Germany*

***Alfred-Wegener Institute, Bremerhaven, Germany*

A multi-method approach is used to quantify sea ice production polynyas in the southern Weddell Sea (Antarctic) for the period 2002-2014. We use 1) a regional climate model (CCLM) with 5km and 15 km resolution (C05/15), 2) retrievals from MODIS data at a high resolution of 1-2km and 3) simulations of a sea ice-ocean Model (FESOM) with a resolution down to 3 km. Methods 2) and 3) need atmospheric forcing, which is taken from different reanalyses (ERA-I, CSFR, JRA55, NCEP2) as well as from CCLM data. Estimates of sea ice production and comparisons of the different methods are presented for polynya areas of the Weddell Sea. The effects of different atmospheric forcings and the presence of fast ice on the dense water formation are investigated. In all methods, the largest ice production (IP) is found for the polynyas of the Ronne Ice Shelf and the Brunt Ice Shelf. Significant differences between different methods and forcing data sets are found for polynya area (POLA) and IP. In particular, relatively low temperatures in JRA and C05 lead to higher IP compared to ERA in the MODIS retrievals. Estimations based on CCLM simulations agree generally well with MODIS/ERA-I. In contrast, FESOM yields generally a larger ice production and shows also a pronounced sensitivity to the atmospheric forcing and fast ice, but the effect depends on the region. These effects have also an impact on the basal melting rates of the Filchner Ice Shelf.

# PDO and NAM during the Marine Isotope Stage 31 (1.08 Ma ago)

**Flavio Justino**
*Universidade Federal de Viçosa, Brasil*

It has long recognized that the amplitude of the seasonal cycle can substantially modify climate features in distinct timescales. This study evaluates the impact of enhanced seasonality characteristic of the Marine Isotope Stage 31 (MIS31) on the Pacific Decadal Oscillation (PDO) and the Northern Annular Mode (NAM). Based upon coupled climate simulations driven by present day (CTR) and MIS31 boundary conditions, we demonstrated that the CTR simulation shows sharper peak in the 3-7 year band. Signicant concentration of power is also noted on the multidecadal time scale between 15-30 years. However, the MIS31 simulation shows drastically modified temporal variability, but absence of the decadal periodicity. The PDO and NAM absence of decadal variability is tightly connected to a weakening of the air-sea exchange and a shallow thermocline in agreement with a simple stochastic climate model assumption. A deeper thermocline supports fluctuations on the order of decades, whereas in the shallow case (e.g., MIS31 climate), fluctuations occur and are locked on a few years. The warmer Northern Hemisphere in the MIS31 climate also modified the transient eddies and changes in storm-track positions are associated with higher extratropical boreal precipitation but lower snowfall during MIS31. Moreover, seaice is extremely reduced in Northern Hemisphere due to strong astronomical forcing.

# The influence of the aviation emission on the changes in the propagation of the jet stream over the Arctic.

**Magdalena Kossakowska*; Jacek W. Kaminski**

*Department of Atmospheric Physics, Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland*

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Keywords: Aviation, Climate, jet stream, Arctic, UTLS

The upper troposphere and lower stratosphere (UTLS) region is a layer around the tropopause. Perturbation of the chemical composition in the UTLS region can impact physical and dynamical processes that can lead to changes in cloudiness, precipitation, radiative forcing, stratosphere-troposphere exchange and zonal flow. The aviation emission is almost the only anthropogenic emission that inject $NO_x$, $CO_2$, $H_2O$, CO, HC, sulphate and soot particles directly into the UTLS region.

The objective of this study is to investigate the potential impacts of aviation emissions on the perturbation in dynamic processes in the upper troposphere and lower stratosphere over the Arctic. In order to assess the impact of the aviation emissions we will focus on changes in the wind field in the high latitudes in the UTLS region. Our study will be based on simulations using a high resolution climate model with troposphere – stratosphere chemistry module for two emission scenarios of current (2006) and future (2050) climate: with and without aircraft emissions.

The tool that we use is the GEM-AC (Global Environmental Multiscale with Atmospheric Chemistry) climate model where air quality, free tropospheric and stratospheric chemistry processes are on-line and interactive in an operational weather forecast model of Environment Canada. In vertical, the model domain is defined on 70 hybrid levels with model top at ~60km. The gas-phase chemistry includes detailed reactions of Ox, NO*x*, HO*x*, CO, CH4, ClOx and BrO. Also, the model can address aerosol microphysics and gas-aerosol partitioning. Aircraft emissions for 2006 and projection for 2050 will be from the AEDT database developed by the Federal Aviation Administration (USA).

Results from model simulations on a global variable grid with ~100 km uniform resolution over the Arctic and ~500 m vertical resolution in the UTLS region will be presented.

# Observed and projected surface air warming at the Faraday-Vernadsky station in the Antarctic Peninsula region


**Svitlana Krakovska[1,2], Denys Pishniak[2], Larysa Pysarenko[1]**

*1 Ukrainian Hydrometeorological Institute, State Emergency Service of Ukraine and the National Academy of Sciences of Ukraine, Kyiv ,*

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According to modern research, surface air temperature increase is the most rapid in polar regions, particularly in the Antarctic Peninsula. It has been one of the most intensive warming on the Earth for the last 70 years with rate over 0.5°C/10 years calculated from the measurement data since 1947 at the Ukrainian Antarctic station Akademik Vernadsky (British Faraday station before 1996). For the future temperature tendencies, as a climate change indicator in the Antarctic Peninsula region, 10 Atmosphere-Ocean Global Circulation Models (AOGCMs) were taken from phase 3 of the Coupled Model Intercomparison Project, the IPCC Fourth Assessment Report (AR4). These models and their ensembles were compared and verified with observed annual mean temperature data at Akademik Vernadsky station for 1947-2016 and then applied till the end of the 21st century for 3 main SRES IPCC socio-economic scenarios usually referenced as “pessimistic” A2, “balanced” A1B and “optimistic” B1. Overall 93 model runs of 10 AOGCMs were analyzed. Comparative analysis between scenarios of air temperature change from IPCC AR4 and AR5 demonstrated, as a result, an absence of strong contradiction between the respective scenarios for annual surface air temperature projections particularly in the Antarctic region. Also, strong correlations between 10 AOGCMs and observational datasets from Akademik Vernadsky station were received. As a result, these models are found applicable for calculations of future climate projections. At the same time, average bias of all AOGCMs, computed as a difference between modelled surface air temperature data and observational data by using running average method, was negative with value 1.5 °C till the end of the 20th century, means that majority of models were unable to represent the whole scale of recent warming in the Antarctic Peninsula region. Calculated for the 21st century climate projections of 10 AOGCMs and their ensembles demonstrated the continuation of air temperature increase for all 3 scenarios of anthropogenic greenhouse gases emissions. The most rapid warming in the studied region has been expected for “pessimistic” A2 scenario with average temperature rise 0.29°C/10 years; “balanced” A1B scenario has projected 0.26°C/10 years and “optimistic” B1 – 0.15°C/10 years.

# Present and projected regional Antarctic climate simulations with the ARPEGE AGCM

**Gerhard Krinner**
*IGE/CNRS, France*

We present simulations of the Antarctic climate with the ARPEGE stretched-grid global atmospheric model at 35 km resolution over the continent. The model is run with a bias-adjustment method developped by Guldberg et al. (2005) which allows to reproduce present-day atmospheric circulation patterns with unprecedented fidelity in global circulation models. We compare our simulations with outputs from regional climate models (RACMO and MAR), focusing in particular on the simulated surface mass balance. We discuss evidence that this method can be extended to climate projections and present RCP8.5 projections of the end of the 21st century with the same setup.

# Nordic Seas polar low projections from 18 downscaled members of the CESM Large Ensemble

**Oskar Landgren**

*Norwegian Meteorological Institute*

18 members of the Community Earth System Model Large Ensemble (CESM-LE) were dynamically downscaled to 12 km horizontal resolution using the quasi-hydrostatic ALARO model within the HARMONIE script system running in climate mode (HCLIM-ALARO). The domain covers the Nordic (GIN), Barents and Kara Seas. One historical and two future time-periods (RCP8.5) were studied: 1990-2005, 2026-2035 and 2071-2080. For comparison, the ERA-Interim reanalysis (1981-2010) was also downscaled using the same model setup. A cyclone tracking algorithm was used to identify and track individual cyclones based on local vorticity maxima and thresholds on surface wind speed and SST–T500. The climatology of cyclone strike maps, frequencies, and life times were compared between the different periods and model runs.
The frequency of occurrence of polar lows shows a significant future decrease in Oct-Jan in the Nordic Seas. At the same time an increase is found in March, leading to a delay in the peak. Changes were found to correspond with large-scale lower atmospheric stability increase, with a larger change in the autumn and early winter. In the Barents Sea the changes are not significant, with contributions from static stability increase partly being offset by the increase in ice-free area. Polar low lifetimes also decrease significantly in the early winter in the Nordic Seas.

# On Oceanic Contribution to the Arctic Energy Imbalance

**Wieslaw Maslowski[1], Younjoo Lee[1], Robert Osinski[2], Jaclyn Clement Kinney[1], John Cassano[3], Bart Nijssen[4]**

*[1]Naval Postgraduate School, [2]Institute of Oceanology, Polish Academy of Sciences, [3]University of Colorado in Boulder, [4]University of Washington*

We use the Regional Arctic System Model (RASM) to investigate some of the key uncertainties of the Arctic surface energy budget, including the oceanic forcing of the Arctic sea ice and the potential role of its ongoing decline in the regional and global energy imbalance. RASM is a fully coupled limited-domain ice-ocean-atmosphere-land model developed to better understand the linkages and coupling channels within the Arctic System at a process scale and to improve prediction of its change at a spectrum of timescales. Its domain is pan-Arctic, with the atmosphere and land components configured on a 50-km grid. The ocean and sea ice components are configured on rotated sphere meshes with four configuration options: 1/12o (~9.3km) or 1/48o (~2.4km) in the horizontal space and with 45 or 60 vertical layers.

Our main objective is to use RASM to quantify the oceanic heat convergence into the Arctic Ocean in order to understand its sensitivity to model configurations and varying parameter space as well as their impacts on the sea ice cover and regional surface energy budget. Our results imply significant variability of the total oceanic heat convergence into the Arctic Ocean, subject to different model configurations. We find that the range of uncertainty in the net oceanic heat transport is comparable to the amount of extra energy required to melt almost all the Arctic sea ice in summer. We argue that changes in the Arctic sea ice cover contribute substantially to the regional energy imbalance, via the dramatic reduction of surface albedo and accumulation of heat in the upper ocean due to insolation. Finally, we'll propose a coordinated Arctic CORDEX effort to intercompare regional surface energy budgets in a hierarchy of regional models, i.e. atmospheric models with prescribed surface boundary conditions, ice-ocean models forced with atmospheric reanalyses and fully coupled models.

# An overview on the European Space Agency Climate Change Initiative (ESA CCI+ Program) Project on Permafrost

**Heidrun Matthes**

*Alfred Wegener Institut Helmholtz Center for Polar and Marine Research*

# Summer drivers of atmospheric variability affecting ice shelf thinning in the Amundsen Sea Embyament, West Antarctica

**Andrew Orr, Pranab Deb, Dave Bromwich, Julien Nicholas, John Turner and Scott Hosking**

*British Antarctic Survey*

A 35-year hindcast of the Amundsen Sea Embayment summer climate using the Weather Research and Forecasting model are used to understand how regional and large-scale atmospheric variability affects thinning of ice shelves in this sector of West Antarctica by melting from above and below (linked to intrusions of warm water caused by anomalous westerlies over the continental shelf edge). El Niño episodes are associated with an increase in surface melt (a finding that is corroborated by analysis of satellite data) but do not have a statistically significant impact on westerly winds over the continental shelf edge. The location of the Amundsen Sea Low and the polarity of the Southern Annular Mode (SAM) have negligible impact on surface melting, although a positive SAM and eastward shift of the Amundsen Sea Low cause anomalous westerlies over the continental shelf edge. The projected future increase in El Niño episodes and positive SAM could therefore increase the risk of disintegration of West Antarctic ice shelves.

# High Heat Flux events and the role of sea ice in the Iceland Greenland Seas

**James Pope, Thomas Bracegirdle, Ian Renfrew, Andy Elvidge**
*British Antarctic Survey*

The Iceland Greenland seas Project (IGP) represents a coordinated meteorological and oceanographic study of the Iceland and southern Greenland Seas. The aim being to characterise the atmospheric forcing and the ocean response of coupled atmosphere-ocean processes; in particular cold-air outbreaks in the vicinity of the marginal-ice-zone and their triggering of oceanic heat loss and the generation of dense water masses. Within the project a climatological assessment using regional climate modelling tools of changes in the distribution late winter/early spring (January-February-March-April) sea ice concentration will be undertaken. The modelling will focus on how changes in the location of the sea ice front over the duration of the satellite record have impacted on location, magnitude and frequency of cold air outbreaks and high heat flux events. Here we present the initial analysis of these modelling studies, using three fixed sea ice conditions representative of the maximum (1986), minimum (2016) and median (2004) sea ice concentrations. Our results will focus on the changes in the distribution and frequency of high heat flux events and an initial assessment of how these will change into the future.

# Impacts of Climate and Vegetation Changes on Hydrological Processes in an Arctic Research Basin

**Kabir Rasouli**[1, 2]

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Investigation of climate change impacts on snow and frozen ground processes in Arctic and subarctic regions is of great interest to water resources stakeholders and the climate change research community. Wolf Creek Research Basin (WCRB) in northern Canada, which has an archive of high elevation weather, snowpack, soils, and streamflow data, was selected to analyze the sensitivity and response of cold regions hydrology to climate and transient vegetation changes. A physically based semi-distributed hydrological model was developed from the Cold Regions Hydrological Modelling (CRHM) platform. The model was then perturbed on an annual or a monthly basis. Instead of direct application of regional climate model outputs with large biases when compared against local observations, monthly perturbed climate was reconstructed based on the historical observations and changes in monthly climatology. A sensitivity analysis shows that the impact of warming on peak snowpack and annual runoff can be offset by an increase in precipitation. The increased precipitation needs to be greater than 5% in WCRB to offset the impact of 1°C warming on simulated peak snowpack and greater than 8% to offset the impact of warming by 5°C on annual total runoff. The impact of the same warming and precipitation change at different latitudes will not necessarily be similar and even though northern latitudes will warm up more, they will also have more precipitation and hence will be resilient to changes relative to mid-latitudes. A large decrease in snow accumulation, annual total runoff, and peak streamflow and lengthening of the snow-free period are expected under warming and decreased precipitation. Under monthly perturbed climate, sublimation from blowing snow, snow surface, and snow intercepted on the canopy drops in the study area. Not only climate changes but also vegetation and associated soil changes affect cold regions hydrological mechanisms. Vegetation changes act similarly to climate changes and decrease peak SWE at middle elevations, the spatial variability of peak SWE, and sublimation amounts. However, the impact of climate change is partially offset by the impact of vegetation change on peak SWE at high elevations, peak SWE timing, peak streamflow, ET, annual total runoff, soil moisture, and permafrost degradation. The models used here can be applied to investigate impacts of the combined climate and vegetation changes and to detect snow and streamflow regime shifts due to transient vegetation and soil changes.

# Initial model evaluation of the surface energy budget and atmospheric thermodynamics during ACSE

**Joseph Sedlar**
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An initial regional climate model evaluation of the terms influencing the surface energy budget (SEB) and the thermodynamic structure of the atmosphere during the Arctic Clouds during Summer Experiment (ACSE) is discussed. This 3-month moving-platform field campaign operated within open water, 100% sea ice cover, and a mixture of both open water, sea ice and melt ponds. In this talk, model processes contributing to the representation of the SEB will be examined, including how well the models capture the observed sharp transition from melt season to freeze up. The timing and location of the ACSE platform during early August coincided with direct observations of a significant, large-scale atmospheric advection event. Lower atmospheric temperatures and moisture spiked to anomalously large values, impacting the atmospheric stability, cloud formation and ultimately enhanced sea ice melt. The models will be evaluated on their capacity in representing this important synoptic event.

# Simulations of Arctic Cyclones observed during ACSE with a fully-coupled regional Arctic system model: Preliminary observational analyses and model diagnostics

**Amy Solomon**
*CIRES/University of Colorado, USA*

Three significant Arctic cyclones were observed during the ACSE campaign. I will present an observational analysis of these cyclones and present preliminary model results of cyclone formation and evolution, and cyclone-surface interactions.

# Long-term high-resolution simulations over Antarctica with COSMO-CLM

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Given the large potential contribution of the Antarctic ice sheet to future sea level rise, understanding the climate system in the region is of high importance. To tackle this challenge, the regional climate modeling approach, which is not very commonly applied to the region, is the adequate tool, given the scarcity and low spatial coverage of observations over Antarctica.

In this study, we use COSMO-CLM 5.0 coupled to the Community Land Model (CLM4.5) and adapt it to Antarctic conditions. Lackings in the model representation of basic climatic variables such as temperature and wind speed were tackled by adapting the turbulence scheme, implementing a two-moment cloud microphysics parametrization, as well as several modifications to the Community Land Model (e.g. snow metamorphosis, wind dependent compaction,...). In this study, we present an evaluation of a 30-year COSMO-CLM² simulation adapted for Antarctica. Results are compared to observations from satellites, automatic weather stations, field campaigns and radiosondes, over both the continent and the surrounding oceans.

Further, in the aim of the newly funded PARAMOUR project (http://www.climate.be/php/users/klein/PARAMOUR/project.html), a new set of simulations (historical and near-future) are planned in order to study key processes that control the variability of the ice-ocean-atmosphere system at decadal time scales. Attention will be paid to the interactions between these components at both the regional (with a focus on the Totten glacier) and the Antarctic-wide scale.

# The influence of sea ice floes size and distribution on the area averaged turbulent fluxes.

**Marta Wenta, Agnieszka Herman**
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The response of oceanic and atmospheric boundary layer (ABL) to subgrid-scale variations of sea ice properties and fracturing has only recently attracted attention and mostly focused on the mixing occurring in the upper ocean. Therefore, processes taking place at the level of individual ice floes are not fully understood and not taken into account in mesoscale Numerical Weather Prediction (NWP) models parameterizations. As the multiyear ice decreases from year to year the sea ice cover becomes more vulnerable to breaking, the need for models improvement is growing. In the presented research a series of high-resolution simulations with Weather Research and Forecasting (WRF) model is performed for different spatial sea ice distributions, ice concentrations and ambient wind speed profiles. The model parameters are set to represent Arctic winter conditions. The results show that the changes in spatial distribution of sea ice floes significantly alter the ABL circulation and structure. Even though the sea ice concentration remains the same in the simulations, considerable variability of domain-averaged quantities like the surface turbulent heat flux (THF) for different arrangements of ice floes is found. Furthermore, the convective circulation within the ABL is also sensitive to the subgrid-scale spatial distribution of sea ice. Moreover, the organized structure of the air circulation leads to spatial covariance of variables characterizing the ABL (wind speed, air temperature and humidity). Based on the example of THF, it is demonstrated that this covariance may lead to substantial errors when THF values are estimated from area-averaged quantities, as it is done in mesoscale NWP models. To study the problem further, the comparison of the values of THF estimated from area-averaged quantities ($\overline{THF_1}$ ) with the ones calculated for very grid cell of 100x100 m ($\overline{THF_2}$ ) is made. On the basis of those results, the ratio of $\frac{\overline{THF_1}}{\overline{THF_2}}$ is computed for every simulation with different floe size distribution and ambient wind speed. The regression analysis is performed to find the relationship between the size and distribution of the floes and the values of $\frac{\overline{THF_1}}{\overline{THF_2}}$. The results suggest a possibility of formulating parametrizations of the influence of sea ice floes spatial arrangement and size on the values of THF. The enhancement of NWP models with such parametrizations of the analyzed processes would likely improve their performance over regions covered with fractured sea ice.