# Rossby Centre Newsletter

No 1 - 2008 June 2008

The Rossby Centre is the regional climate modelling research unit of the Swedish Meteorological and Hydrological Institute, SMHI. This Newsletter aims to provide information to stakeholders on climate change research and results of the Rossby Centre. The newsletter is published 2-4 times a year. The following topics are covered in this Newsletter:



## 1. Rossby Centre Day 2008

The 2008 Rossby Centre Day will be on:

**Nordic-Arctic Climate Change: Towards an Earth System Modelling Approach.**

There is increasing recognition of the need to include a wider range of environmental processes within future climate models. This is both to better represent the myriad of potential feedbacks in the climate system and to directly simulate key environmental processes that are impacted by climate change. To this end, Global Climate Models are presently being developed that include a more complete representation of key biogeochemical cycles (such as carbon, sulphur, nitrogen cycles), with fully interactive coupling between the various components of the climate system (e.g. the terrestrial biosphere, marine biogeochemical cycles, atmospheric chemistry and the physical climate system).

The Rossby Centre, along with other departments at SMHI and collaborating universities, has begun developing a Regional version of such an Earth System Model, with an emphasis on Nordic-Arctic processes.

The aim of the Rossby Centre Day is:

(i) To give an overview of the scientific, modelling and observational challenges and techniques in Earth System Modelling.

(ii) To report on ongoing and planned Regional Environmental Modelling work at the Rossby Centre and SMHI.

(iii) To discuss future plans with potential partners, thereby phrasing Rossby Centre research and development within a wider context.

(iv) To introduce to climate impact researchers, stakeholders and decision makers, the range of information available from a Nordic-Arctic Regional System Model and to define future priorities for the provision of such information to Swedish society, governments and fellow researchers.

During the Rossby Centre Day presentations will discuss Global and Regional Earth System Modelling, from an international and Nordic-Arctic perspective. Presentations from users and stakeholders will help define key areas where future Earth System information will be important for designing and supporting adaptation and mitigation strategies.

Due to the large interest and scope of this subject we plan to modify the format of the Rossby Centre Day to be one and a half days. This is to allow time to fully discuss both scientific and user related issues pertaining to Nordic-Arctic Earth System Modelling.

This year's Rossby Day is scheduled for October 13th-14th 2008, at SMHI in Norrköping. If you are interested attending please email your name and institute, along with contact details to Rossby.Data@smhi.se, with the subject of the mail as: **Rossby Centre Day 2008**. Further information regarding the content of the day will be posted on the Rossby Centre website and circulated in poster format in late August. We look forward to meeting you in Norrköping.

## 2. An ensemble of Regional Climate Change scenarios for Europe and the Nordic Region.

Currently, a major effort is being undertaken at the Rossby Centre to create an ensemble of regional climate change scenarios for Europe and the Nordic region. The regional climate model, RCA3, is being used to downscale results from several different Global Climate Models (GCMs) for the 21st century. A number of these GCMs have, in turn, been; forced by different greenhouse gas emission scenarios, started from different initial conditions, or have been integrated using different parameterization schemes, resulting in a different model sensitivity to a given increase in greenhouse gases. Taken together the RCA3 ensemble will be suitable for exploring uncertainties in simulated regional climate change associated with; (i) using different GCM forcing data on the boundaries of RCA3; (ii) employing different emission scenarios applied to the same forcing GCM; (iii) changes to the model formulation within a given forcing GCM and emission scenario and (iv) natural variability as simulated by a single GCM/emission scenario. Table 1 details the range of GCMs, emission scenarios and climate sensitivities employed so far in forcing RCA3.

| **Forcing GCM** | **Emission scenarios** | **Note** |
|---|---|---|
| ECHAM5/MPI-OM *(MPI-Germany)* | B1, 3xA1B, A2 | The 3 A1B scenarios differ only in initial conditions in 1860 in the ECHAM5 simulation |
| ECHAM4/OPYC3 *(MPI-Germany)* | B2, A2 | |
| HadCM3 *(Hadley Centre-UK)* | 3xA1B | The 3 members are from the perturbed physics ensemble from the Hadley Centre with different degree of climate sensitivities (High, Medium and Low sensitivity). |
| CCSM3 *(NCAR, USA)* | B2, A1B, A2 | |
| BCM *(Bjerknes Centre, Norway)* | A1B | |
| CNRM *(Meteo France, France)* | A1B | |
| IPSL *(Paris, France)* | A1B | |

*Table 1. Listing of forcing GCMs and accompanying greenhouse gas emission scenarios used to force RCA3 over the ENSEMBLES domain.*

All 16 simulations in Table 1 were performed with 50km horizontal resolution, employing the common RCM grid used in the European FP6 ENSEMBLES project. The simulated time period is mostly 1961-2100. Some simulations are already finished; others are planned to be completed during 2008. Figure 1 gives an example of the range of scenario results occurring from sampling such a model matrix. The figure shows the climate change signal (2071-2100 mean minus 1961-1990 mean) for summer season average surface temperatures, as simulated by RCA3 using four different GCM for boundary conditions, each using the A1B emission scenario. Also shown is the ensemble mean temperature change. While the overall climate change signal is similar across the simulations, there are a number of notable differences. For example, over Spain mean summer temperatures increases are 3-4℃ larger in the ECHAM5 forced simulation than when CCSM3 is employed on the RCA3 boundaries. Significant differences can also be seen in the projected temperature changes over the Baltic Sea. This aspect will be investigated further in 2009, by repeating selected integrations from Table 1, using the Rossby Centre coupled Regional Climate Model, RCAO.

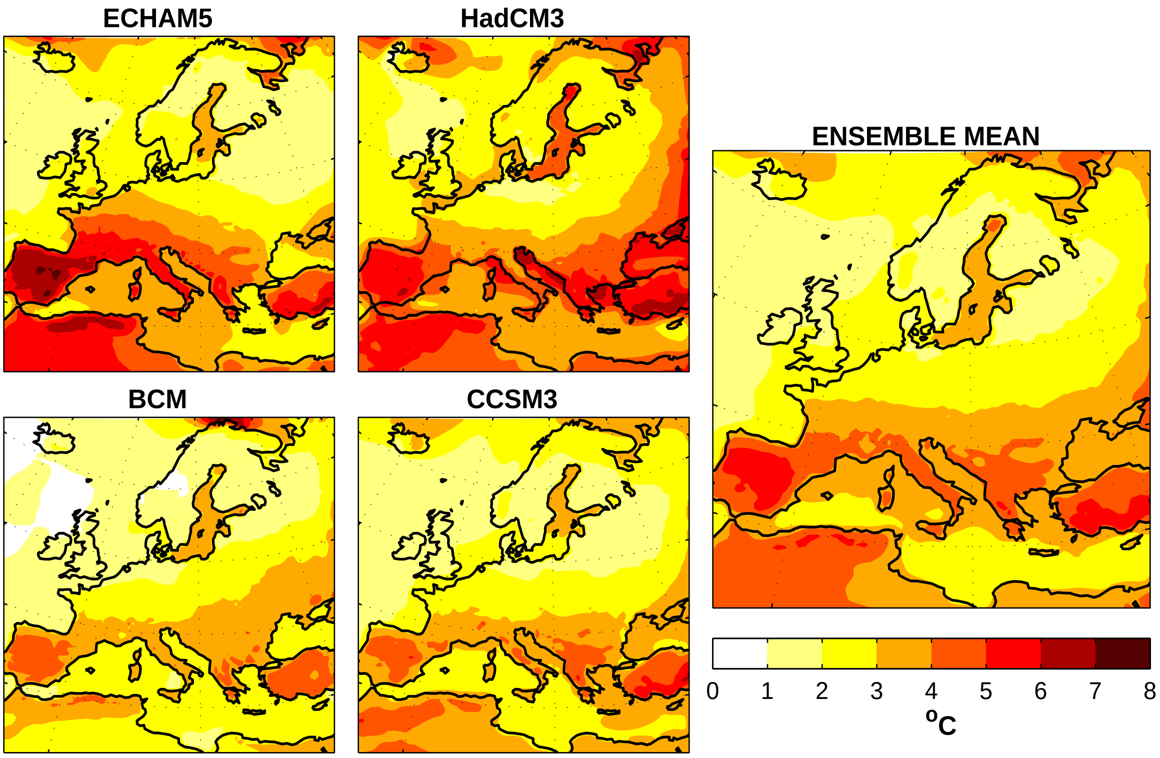


*Figure 1. Change in summer season, mean surface temperatures in four of the simulations listed in Table 1 and as an ensemble mean by the end of the 21st century (2071-2100) compared to (1961-1990).*

## 3. Temperature extremes in a future climate: the role of daily variability

Future climate scenarios show not only a pronounced warming but also changes in temperature variability on yearly and daily time scales. Together with the mean warming, such changes in temperature variability can modify the frequency and intensity of weather extremes, such as extended hot or cold spells. In general an increase in daily temperature variability leads to a higher probability of extremely cold and/or hot days within a given season, while a decrease in variability has the opposite effect. An ensemble of regional climate model (RCA3) integrations driven by four different global models (see Table 1) is used to estimate possible changes in daily temperature variability over Europe between recent (1961-1990) and future (2071-2100) climate conditions, under the A1B emission scenario (a moderate increase in greenhouse gas forcing). Employing a multi-model ensemble approach (i.e. ensemble average) reduces uncertainties related to individual ensemble members, thereby increasing the statistical robustness of the results.

The results show that in the future climate scenario, in addition to a mean warming effect, changes in daily temperature variability will result in a reduced occurrence of extremely cold days over northern Europe and the Alps in winter (reduced daily variability) and higher occurrence of extremely hot days over continental Europe in summer (increased daily variability). When expressed as a percentage change in daily variability, relative to the absolute daily variability for the control period simulation, these changes are of similar size; ~20-25% decrease/increase in daily variability in the future relative to the control period. Several underlying physical mechanisms, involving land-atmosphere interactions, which contribute to these changes are presently under investigation.

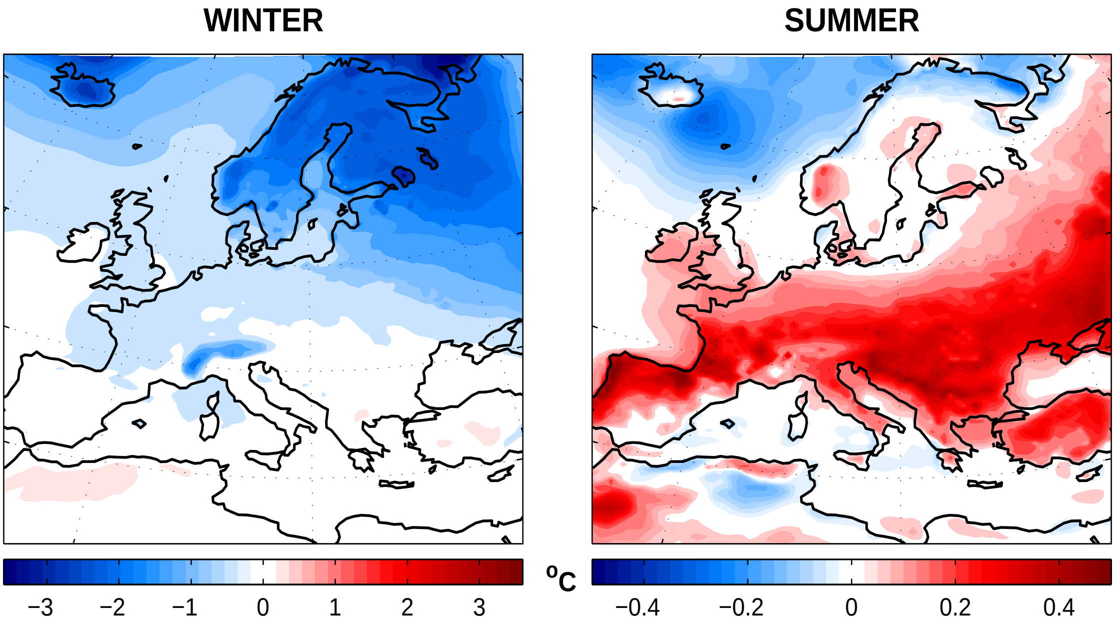


*Figure 2. Ensemble mean change in daily temperature variability (standard deviation,) for winter (DJF) and summer (JJA) seasons; (2071-2100) minus (1961-1990), as simulated by a 4 member ensemble of RCA3 integrations for the AIB emission scenario.*

## 4. Predictability studies and Regional Climate Change Scenarios for the Arctic.

Climate predictability studies, in a regional context, facilitate an estimation of the relative importance of local Arctic processes versus large-scale planetary forcing in determining Arctic climate variability. Large scale atmospheric forcing constitutes a major source of Arctic inter-annual variability. Internally generated processes, within the Arctic atmosphere, sea-ice and ocean result in additional year-to-year variability, which is generally a factor of 1-2 smaller for many climate variables, such as sea-ice thickness, than the externally forced variability. In specific areas (e.g. in coastal areas, north and east of Greenland) internally generated year-to-year variability can outweigh the influence of external forcing. Thus internally generated variability, due to non-linear interactions, needs to be taken into account for long-term climate studies, and especially for decadal prediction efforts. Figure 3 shows the Arctic sea ice extent anomaly for 4 different runs (an “ensemble”) made with the Rossby Centres coupled atmosphere-ocean-ice model RCAO. The 4 runs used exactly the same model configuration, lateral and surface boundary conditions, but differed only in tiny details related to the initial sea ice conditions applied in the year 1959. Differences in the figure therefore illustrate solely the effects of simulated internal Arctic variability on Arctic sea-ice extent. For three out of four ensemble members, the simulated sea ice extent linear trends follow the observed trend than within the range of observational uncertainty.

As a coming activity, the Rossby Centre will soon carry out regional Arctic climate scenario experiments, under the umbrella of the EU-funded project DAMOCLES. These scenarios will be based on the RCAO model forced by the Bergen Coupled Global Climate Model (BCM).

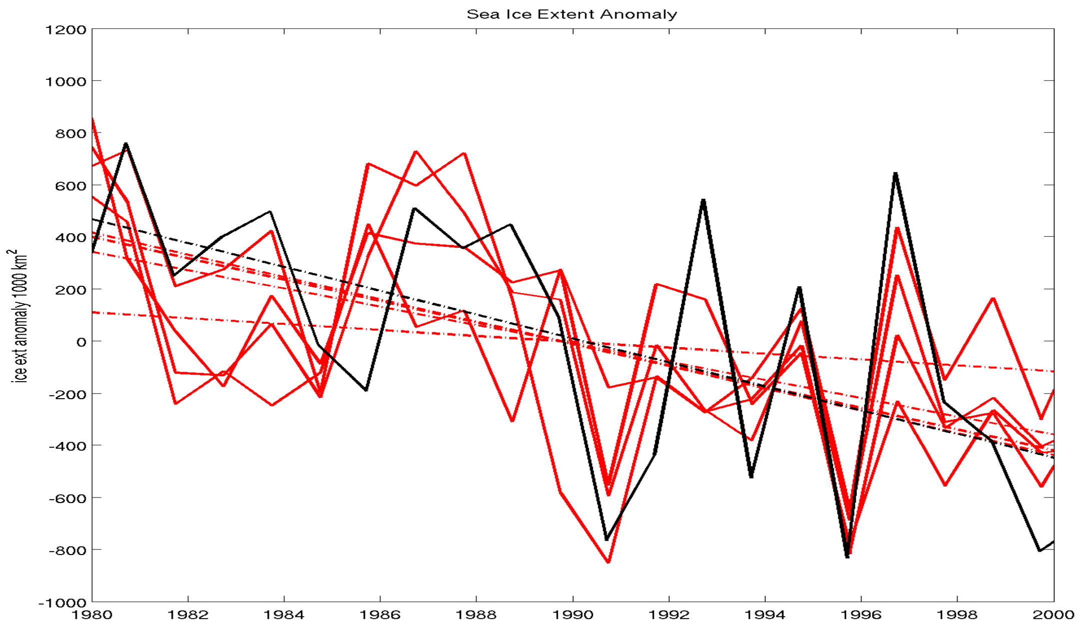


*Figure 3. Arctic sea ice extent anomalies, relative to simulated/observed mean values for the period 1979-2000, for an ensemble of model runs (red) and observations (black).The straight lines denote the respective linear trends for each RCAO integration and observations.*

## 5. Climate conditions in Sweden on a 100,000 year time perspective.

The Rossby Centre leads a project that aims to identify the extremes over which the climate in Scandinavia may vary over a 100,000 year time scale (RC Newsletter 3 2006). The project is commissioned by the Swedish Nuclear Fuel and Waste Management Company and is undertaken in collaboration with Stockholm and Lund Universities and The Royal Institute of Technology (KTH). Three cases has been studied: one warm case where the ice on Greenland has melted and sea levels are high; one cold case where Scandinavia is covered with ice; and one permafrost case with a cold, dry and almost ice free Scandinavia. Results from a fully coupled global climate model (CCSM3) are downscaled over Europe by a high resolution regional climate model (RCA3). Vegetation was adjusted to the simulated climate conditions for each period by employing a vegetation model (LPJ-GUESS) within RCA3. Model results are, when possible, compared with climate reconstructions from palaeo data. The combination of coupled global climate simulations, high resolution modelling at the regional scale, with at least 50 years of simulation per case, adjusted vegetation and palaeo reconstructions gives a broad view of the extreme climate conditions over a glacial cycle. First results were presented at the EGU spring meeting in Vienna earlier this year The project will finish in the fall, results are currently being documented in both a final report and scientific articles.

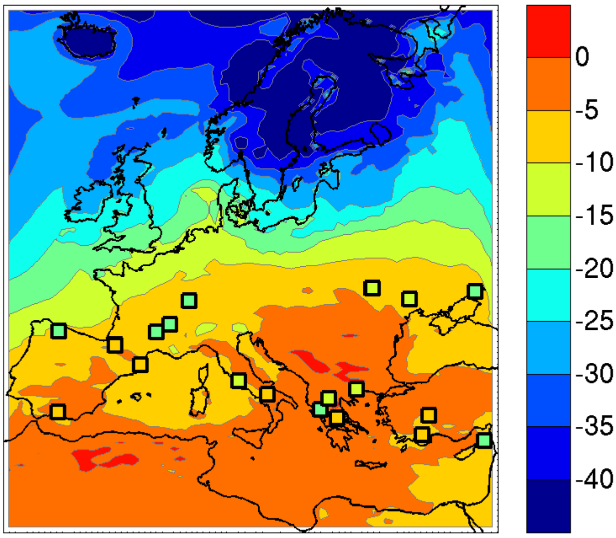


*Figure 4. Difference in temperature (˚C) of the coldest month between the last glacial maximum (when Scandinavia was ice covered) and present day climate. Squares represent temperature reconstructions from palaeo data.*

## 6. First results from the SWAN wave model coupled to RCA over the Baltic Sea

In this project we make a first attempt to simulate wave heights over the Baltic Sea, using the SWAN (Simulated WAves Near shore) wave model forced by 10m vector winds derived from RCA3. This is initially done for the recent past climate in order to evaluate the quality of the simulated results Subsequently, changes in Baltic Sea wave heights, in response to changes in the regional climate as simulated by RCA3, are made. SWAN is a phase averaged spectral model that can account for changing bathymetric depth in calculating surface wave heights. In this respect the model can be applied both over deep water and shallow, coastal regions.

For the period 1980-2004 the SWAN model is forced both by winds derived from the MESAN, mesoscale surface analysis system, and by 10m-winds derived from the ECMWF ERA40 data set. Along with these integrations, we also use 10m-winds derived from an RCA3 integration forced by ERA40 lateral and surface boundary conditions, covering the same time period. The RCA3 run used a model resolution of 25km (This is now the new standard resolution at which most new RCA3 developments are aimed at). All the forcing winds were interpolated to a common 11km grid before being used to force the SWAN model. For the present climate runs, observed ice conditions have been used to delineate ice-covered regions during the calculation of ocean wave heights. When sea-ice fraction is greater than 50% in a grid box, no wave heights are calculated

The simulated wind field output from RCA3 is a grid box average over a 25kmx25km area. Such winds often fail to resolve small scale features, such as gusts, that are important for generating large wave heights. To account for this problem a gust parameterization was included in RCA3 which resulted in increased wind velocities under conditions where the gust parameterization was triggered. Figure 5 shows the simulated wave heights from SWAN, when forced either by analysed winds from MESAN or with winds derived from the RCA3 ERA40 forced runs. The plot shows wave heights for the 50$^{th}$ percentile (median wave heights) and for the larger waves (90$^{th}$ and 99$^{th}$ percentiles). The overall distribution of the wave heights from SWAN, when forced by RCA3 winds shows a quite reasonable agreement with those derived from the MESAN forced runs

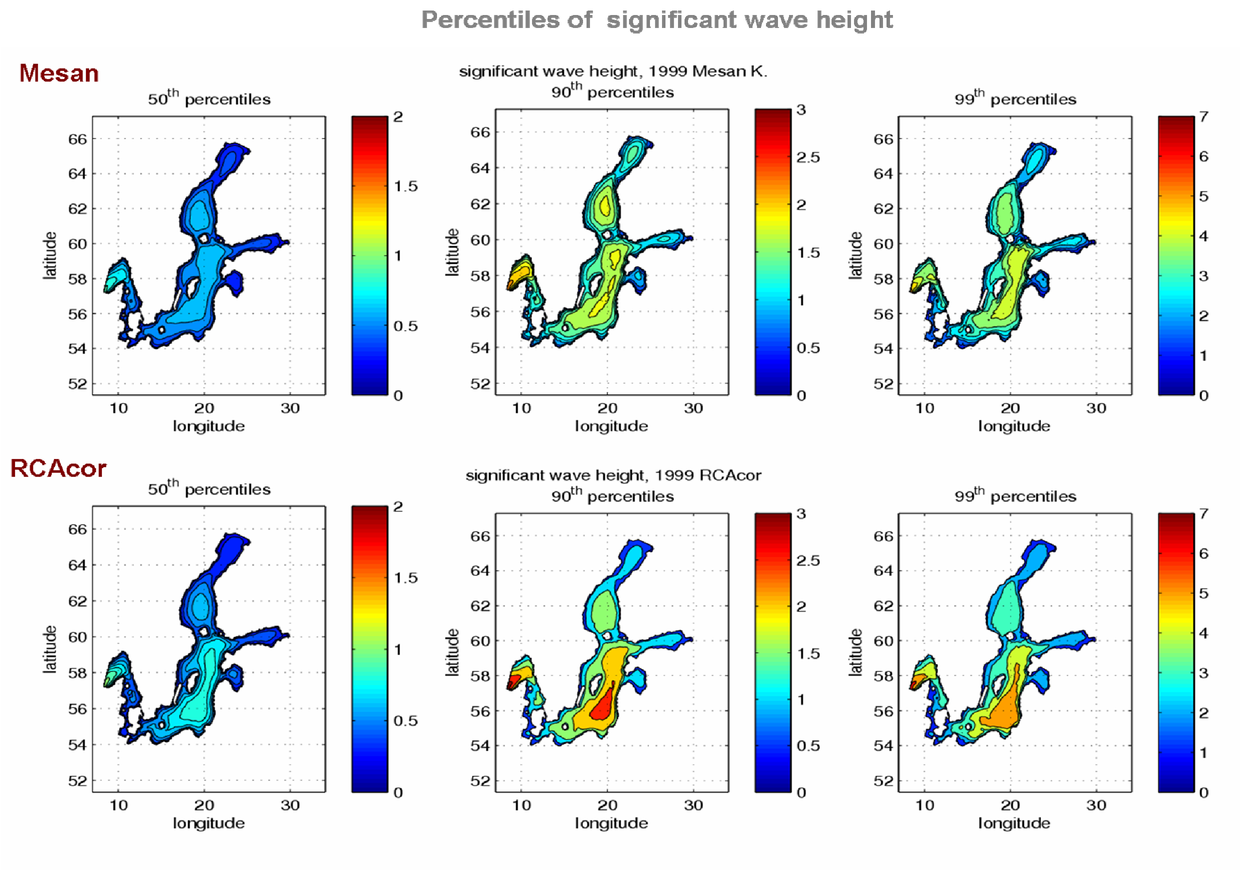


*Figure 4. Significant wave heights(metres) for various percentiles, simulated by SWAN when forced by MESAN analyzed winds or RCA3 derived winds, for the period 1980-2004.*

Subsequent to this evaluation, 10m winds were derived from an RCA3 transient integration, run under an A2 emission scenario. This run covered the period 1960 to 2100. Winds were extracted for the periods 1961-1990 and 2011-2040. By differencing the SWAN simulated wave heights for these two periods an estimate of the impact of regional climate change on Baltic Sea wave heights can be made. Figure 6 shows the wave height differences, in metres, simulated by RCA3-SWAN and the percent change of wave heights in the future. In these initial scenarios, ice conditions were based on observed conditions both for present and future periods. Future work will use winds and ice concentrations derived from a transient integration of the coupled RCAO model. This will enable an assessment of changing wave conditions in regions of significant ice melt in the future.

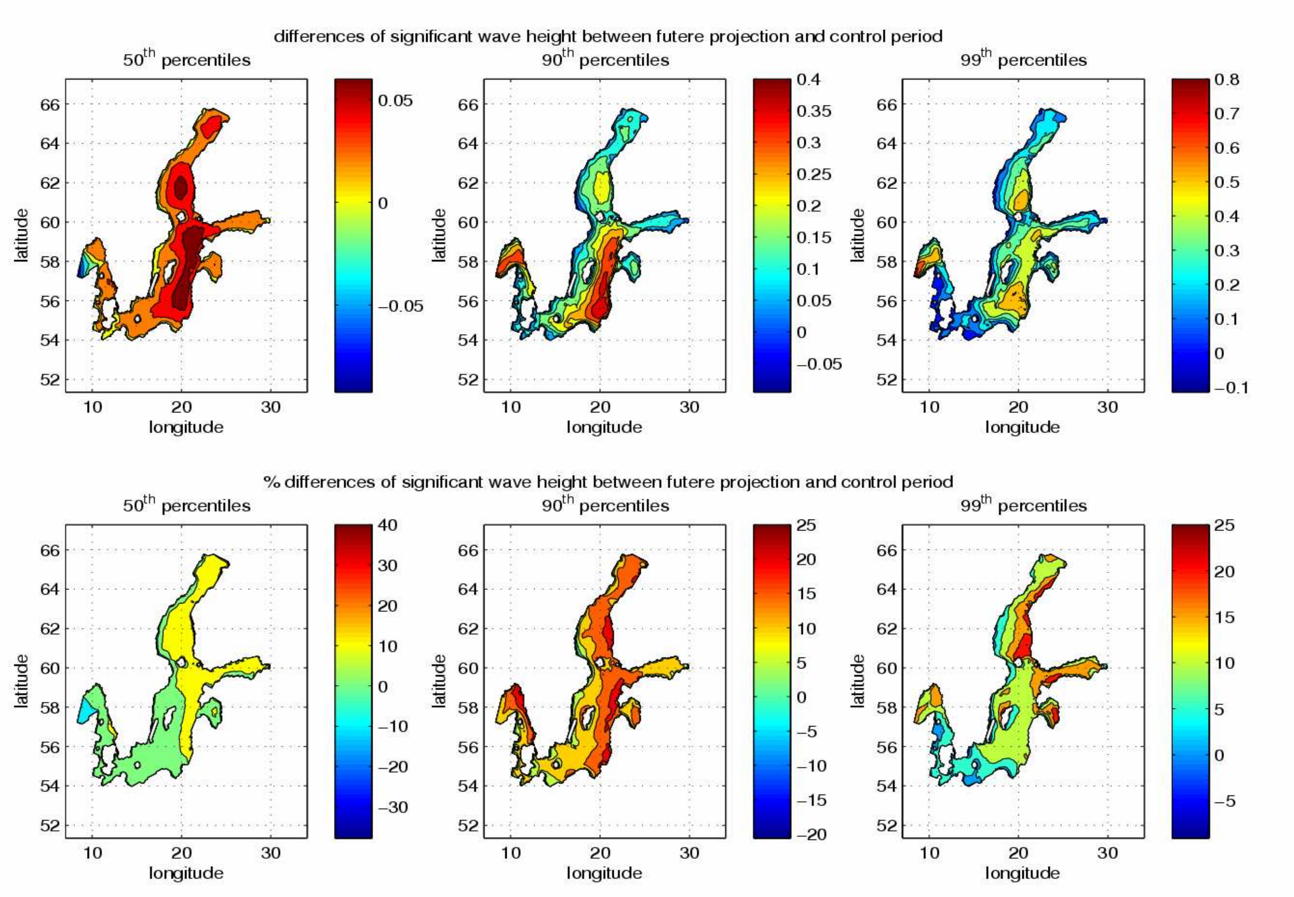


*Figure 5. Significant wave height differences in percentiles between control period (1961-1990) and future projection (2011-2040) using RCA3 forced by ECHAM5 GCM under an A2 emission scenario.*

## 7. Rossby Centre staff news

***Colin Jones*** has been appointed Head of the Rossby Centre. Colin was formerly Professor at the University of Quebec at Montreal, Department of Earth and Atmospheric Sciences and Principal Investigator for the Canadian Regional Climate Modelling and Diagnostics (CRCMD) Network. As a former Rossby Centre colleague, Colin is familiar with SMHI. He began full time as Head of the Rossby centre July 1st 2008.

The previous Head of the Rossby Centre, ***Markku Rummukainen***, has taken a position as coordinator of Climate and Air Quality at SMHI Core Services. Markku also leads the new Swedish research programme ***Mistra SWECIA*** that deals with climate, economy, impacts and adaptation (http://www.mistra-swecia.se/)

***Grigory Nikulin*** has accepted a permanent position at the Rossby Centre. Grigory has worked for the past year developing a diagnostic package to analyze various spatiotemporal modes of variability in RCA and RCAO integrations. He previously held a postdoctoral position at LMD in Paris and completed his PhD at the Swedish Institute for Space Physics in Kiruna (Umeå University).

***Torben Königk*** joined the Rossby Centre in February 2008 to work on coupled ocean-atmospere-sea ice modelling. Torben held a postdoctoral position at the

Max Planck Institute for Meteorology in Hamburg from 2006 to 2008, working on coupled climate modelling and Arctic variability. He received his PhD in 2006 from the University of Hamburg, Germany.

## 8. Recent Publications

**Graham, L., P.,** Chen, D., Christensen, O.B., **Kjellström, E**., Krysanova, V., Meier, H.E.M., Radziejewski, M., Rockel, B., Ruosteenoja, K. and Räisänen, J., 2008. Projections of future climate change. In Assessment of Climate Change for the Baltic Sea Basin. The BACC Author Team. 2008, XXI, 473 p., ISBN: 978-3-540-72785-9.

**Graham, L.P**., Andréasson, J. and Carlsson, B., 2007. Assessing climate change impacts on hydrology from an ensemble of regional climate models, model scales and linking methods - a case study on the Luleå River Basin. Climatic Change 81, Supplement 1, 293-307.

**Graham, L.P.**, Hagemann, S., Jaun, S. and Beniston, M., 2007. On interpreting hydrological change from regional climate models. Climatic Change 81, Supplement 1, 97-122.

**Graham, L.P**., Olsson, J., **Kjellström, E**., Rosberg, J., Hellström, S.-S. and Berndtsson, R., 2008. Simulating river flow to the Baltic Sea from climate simulations over the past millennium. Boreal Environment Research, (in press)

Karlsson, K.-G., U. **Willén, C. Jones, and K. Wyser** 2008, Evaluation of regional cloud climate simulations over Scandinavia using a 10-year NOAA Advanced Very High Resolution Radiometer cloud climatology, *J. Geophys. Res.*, *113*, D01203, doi:10.1029/2007JD008658.

**Kjellström, E.**, and Ruosteenoja, K., 2007. Present-day and future precipitation in the Baltic Sea region as simulated in a suite of regional climate models. Climatic Change, 81, Supplement 1, 281-291.

**Kjellström, E., Bärring, L.**, Jacob, D., Jones, R., Lenderink, G. and Schär, C., 2007. Modelling daily temperature extremes: Recent climate and future changes over Europe. Climatic Change. 81, Supplement 1, 249-265

Markovic, M., **Jones C. G**., Vaillancourt P., Paquin D., Paquin-Ricard D. 2008. An evaluation of the surface radiation budget over North America for a suite of regional climate models against surface station observations. Climate Dynamics. (Published online : 27 february 2008, DOI : 10.1007/s00382-008-0378-6)

Markovic, M., **C. G. Jones**, P. A. Vaillancourt, D. Paquin, K. Winger,2008 ; The Surface Radiation Budget over North America: An assessment of Gridded Data Sets for Model Evaluation and the Evaluation of a Suite of Regional Climate Models. (Accepted in the International Journal of Climatology)

**Wyser, K., C. G. Jones**, P. Du, E. Girard, **U. Willén**, J. Cassano, J. H. Christensen, J. A. Curry, K. Dethloff, J.-E. Haugen, D. Jacob, M. Køltzow, R. Laprise, A. Lynch, S. Pfeifer, A. Rinke, M. Serreze, M. J. Shaw, M. Tjernström and M. Zagar, 2008: An evaluation of Arctic cloud and radiation processes during the SHEBA year: Simulation results from 8 Arctic Regional Climate Models. *Clim. Dyn.* **30**(2-3), 203-223, 10.1007/s00382-007-0286-1.

## 9. General information

The Rossby Centre works on regional and global climate model development and evaluation, as well as model applications for process studies, climate system studies, climate change research and impact assessment. The Rossby Centre is also involved in a number of EU-funded and other projects on climate modelling and aspects of climate analysis and climate change research.

The Rossby Centre newsletter is sent as an email blind copy to those who wish so. Comments and suggestions as to the scope, content and form of the newsletter are welcome. Feedback can be provided via rossby.data@smhi.se.