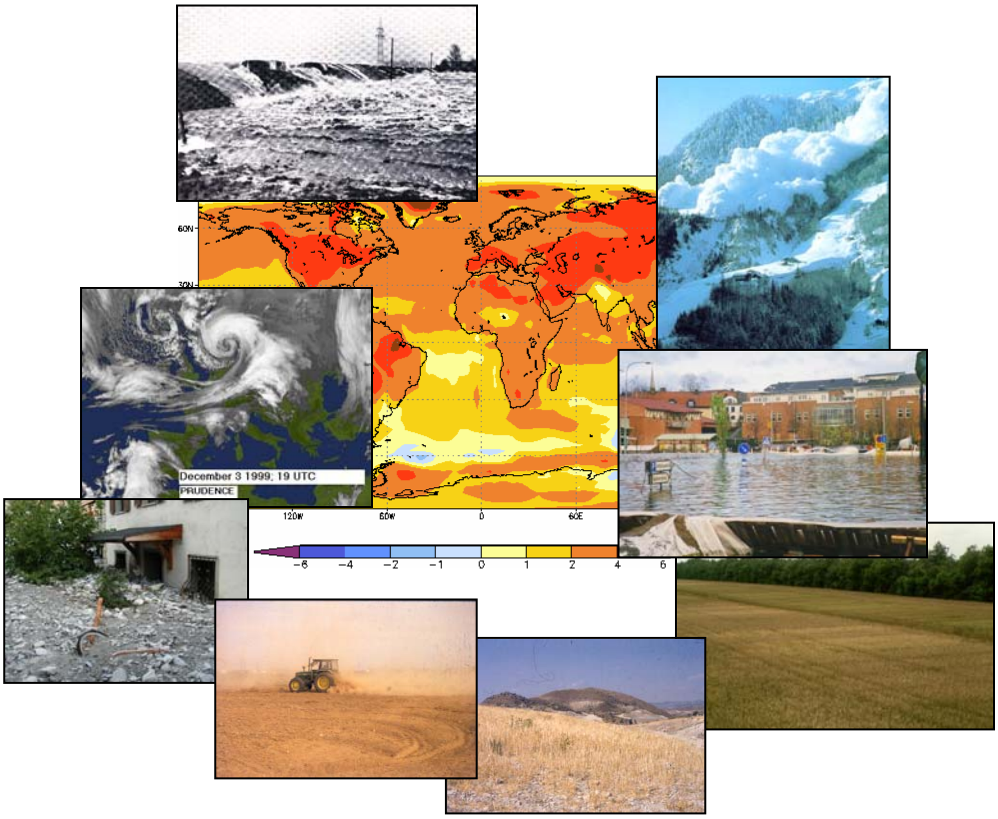

Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects

PRUDENCE

Contract No. EVK2-2001-00156

Event: 2nd PRUDENCE project meeting
The Abdus Salam ICTP
Trieste, 2 – 4 October, 2002

Date of preparation: 15 October 2002

Content list

Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects – PRUDENCE

PRUDENCE is a project funded by the European Commission under its fifth framework programme. It has 21 participating institutions from a total of 9 European countries. Within the first project year more than 5 institutions from 3 more European countries, Israel, Australia and Canada have expressed their interest in the projects and offered to carry out complimentary work. The ideas and objectives giving the basis of the project has been summarised as follows:

Problem to be solved:
European decision-makers in government, non-governmental organisations (NGOs), and industry as well as the general public need detailed information on future climate. In this way it becomes possible to evaluate the risks of climate change due to anthropogenic emissions of greenhouse gases. Projections of future climate change already exist, but are deficient both in terms of the characterisation of their uncertainties and in terms of their regional detail. To date, the assessment of potential impacts of climate change has generally relied on projections from simple climate models or coarse resolution Atmospheric-Ocean General Circulation Models (AOGCMs), neither capable of resolving spatial scales of less than ~300km. This coarse resolution precludes the simulation of realistic extreme events and the detailed spatial structure of variables like temperature and precipitation over heterogeneous surfaces e.g. the Alps, the Mediterranean or Scandinavia. Simple models include, at best, a limited physical representation of the climate system.

Scientific objectives and approach:
PRUDENCE is a European-scale investigation with the following objectives:

a) to address and reduce the above-mentioned deficiencies in projections;
b) to quantify our confidence and the uncertainties in predictions of future climate and its impacts, using an array of climate models and impact models and expert judgement on their performance;
c) to interpret these results in relation to European policies for adapting to or mitigating climate change.

Climate change is expected to affect the frequency and magnitude of extreme weather events, due to higher temperatures, an intensified hydrological cycle or more vigorous atmospheric motions. A major limitation in previous studies of extremes has been the lack of: appropriate computational resolution - obscures or precludes analysis of the events;
long-term climate model integrations - drastically reduces their statistical significance;
co-ordination between modelling groups - limits the ability to compare different studies.
These three issues are all thoroughly addressed in PRUDENCE, by using state-of-the-art high resolution climate models, by co-ordinating the project goals to address critical aspects of uncertainty, and by applying impact models and impact assessment methodologies to provide the link between the provision of climate information and its likely application to serve the needs of European society and economy.

Expected impacts:
PRUDENCE will provide a series of high-resolution climate change scenarios for 2071-2100 for Europe, characterising the variability and level of confidence in these scenarios as a function of uncertainties in model formulation, natural/internal climate variability, and alternative scenarios of future atmospheric composition. The project will provide a

quantitative assessment of the risks arising from changes in regional weather and climate in different parts of Europe, by estimating future changes in extreme events such as flooding and windstorms and by providing a robust estimation of the likelihood and magnitude of such changes. The project will also examine the uncertainties in potential impacts induced by the range of climate scenarios developed from the climate modelling results. This will provide useful information for climate modellers on the levels of accuracy in climate scenarios required by impact analysts. Furthermore, a better appreciation of the uncertainty range in calculations of future impacts from climate change may offer new insights into the scope for adaptation and mitigation responses to climate change. In order to facilitate this exchange of new information, the PRUDENCE workplan places emphasis on the wide dissemination of results and preparation of a non-technical project summary aimed at policy makers and other interested parties.

Project start:
PRUDENCE was formally accepted by the European Commission as contract No. EVK2-2001-00156, which was duly signed on 29 October 2001. The project thus accordingly officially started on 1 November 2001. A kick-off meeting took place during 3 – 5 December, 2001 in Snekkersten, Denmark. The present document presents the minutes of the second meeting attended by the entire PRUDENCE consortium and many of the afore mentioned additional groups. It took place during 2 – 4 October, 2002 in connection with *the Second ICTP Conference on DETECTION AND MODELING OF REGIONAL CLIMATE CHANGE,* 30 September - 4 October 2002, held at

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SYNOPSIS

The 2nd meeting of the PRUDENCE project was held with the aim to activate and review the interactions between the involved partners and identify issues, which will require action in order for the project to progress smoothly according to the EU contract – here the description of work (DoW) document. Having the partners giving scientific presentation, highlighting the main activities relevant for PRUDENCE at their home institution, did this in combination with a set of keynote presentations by some partners during the main ICTP conference. The scientific presentations by the partners were given in parallel sessions, where participants in related WPs were meeting separately. For more details, see the meeting agenda and the abstract compilation. By following the procedure from the kick-off meeting, the PRUDENCE project intends to keep an 'open door' policy. This is reflected by the back-to-back arrangement in connection with the ICTP conference. Also at the present meeting, a number of external participants were invited to attend the more specific PRUDENCE part of the conference. On the first PRUDENCE day, which had a complete open morning session (see the agenda), the total number of participants exceeded 100, while 60 – 80 took part in the more business related part of the meeting. A (not complete) list of participants present during the full session is provided in the back of this report.

During the meeting two breakout sessions were scheduled with the aim that any outstanding issues in the seven workpackages could be identified and strategies to amend these could be established. Three break out groups were formed dealing with WP1 & WP2, WP3 – WP5, and WP6, respectively. Issues with respect to WP7 were dealt with in a steering committee meeting held during the first evening of the meeting. Also the external advisory group met at that time. Separate minutes from the breakout groups and the combined steering committee and external advisory group meeting are provided elsewhere in this report.

After the meetings in the various break out groups, a final and short plenary session revealed that actions towards solving remaining issues had been initiated. The most pressing need for action seemed to be a better organisation of the data handling. It was decided that the project coordinator and the project manager would take a lead on this and strive towards having a workable solution ready before the end of the year. The basic idea would be to have a central data archive with software facilities available at DMI (or alternatively at another institution), which could process data to the need of the individual groups. This seemed as a great advantage compared to the present procedure, where a large number of DVD's should be produced and send around amongst partners. Details are given elsewhere.

Scientific Steering Group and External Advisory Group Meetings

The management of PRUDENCE will broadly follow the Project Management methodology of the PRINCE (Projects IN a Controlled Environment) system widely used in government and industry.

A Scientific Steering Group (SSG) consisting of senior scientists from most of the contracting organisations will fulfil the role of the Project Board. A Project Manager (Dr. Ole B. Christensen) has been assigned to the PRUDENCE project to assist the Project Co-ordinator in maintaining the control on the various phases of the project. The leaders of the seven research Work Packages will fulfil the role of the Project Assurance Team, plus other experts co-opted as required. At this stage the SSG is formed by:

Jens H. Christensen, Co-ordinator and WP7
Ole B. Christensen, Project Manager
Daniela Jacob (here replaced by Tido Simler), WP1
Richard Jones, WP2
Markku Rummukainen to be substitued by Phil Graham, WP3
Jørgen E. Olesen, WP4
David Stephenson, WP5
Jean-Charles Hourcade, WP6
Tim Carter,
Filippo Giorgi,
Jean Palutikof

2nd SSG and EAG meetings

On the evening of the 2 October, the members of the PRUDENCE SSG and EAG met for the second time time. As only three of the EAG members were able to attend the meeting, it was decided to hold only one common meeting. The EAG is presently formed by
All steering committee members &
Jean Palutikof; for MICE (EU project)
Clare Goodess; for STARDEX (EU project)
 ÷ *Gunner Hovsenius; for Elsforsk (Sweden)*
 ÷ *Jean-Yves Caneill; for Électricité de France (France)*
 ÷ *Axel Michaelowa; for Hamburg Institute of International Economics (Germany)*
Trond Iversen; for RegClim (Norway) presented by Dag Bjørge
 ÷ *Manfred Lange; for University of Münster(Germany)*
 ÷ *Gerhard Berz; for Munich Re (Germany)*
Peter Whetton; for CSIRO (Austrlia)
 ÷ *Ib Troen; for DG-XII*

(Persons indicated with a ÷ were not able to attend the meeting)

The project co-ordinator wellcomed the members of the SSG and the EAG and expressed his hopes and wishes for the role of the SSG and the EAG. The main aim for these groups should be to enable an efficient way to communicate key problems and developments within and between the individual WPs, as well as to make such information available to the co-ordinator as early as possible. Therefore, the WP task leaders should also be responsible for capturing the essentials from the break out sessions scheduled under the main meeting agenda and duly report this to the co-ordinator in a meeting summary. The agenda was relatively modest with only 2 items:

1. WP progress.
2. Identification of issues to be raised during the meeting
3. Other issues

The WP leaders briefly gave an over view of the status within the different WPs. Overall, no substantial problems had so far been identified, except that the distribution of boundary data based on the Hadley Centre AGCM simulations had been an issue of concern by most partners. The major problem seemed to have been a sense amongst the partners of inappropriate planning and some miscommunication particularly with the Hadley Centre, which had some problems in providing data at a speed, which was expected by the partners (but actually never committed by HC). Moreover, the distribution of boundary data had been confused by a somewhat fragmented distribution. The coordinator was asked to make sure that a complete tape archive would be hosted at DMI, and that this would be announced via the PRUDENCE web pages. Discussions on data issues through the rest of the evening, essentially reduced the agenda to one topic, and the agenda was not really followed, although the items were covered well in the discussions.

It was discussed how such experience of confusion could be prevented in the future. It was noted that a more rigorous set of protocols for data access would seem appropriate. E.g. partners – or anyone else interested – should register at the PRUDENCE web pages and through a specified procedure provide timely information about their specific need and in return along with the data tapes receive all relevant information about these data. Following these ideas, it was also suggested to provide on the PRUDENCE web pages information from all modellers about their expected availability of model runs for further analysis within the project. This could be linked to the retrieval boundary data.

An issue about the common analysis of the many AGCM and RCM simulations was raised. A set of variables (not formally agreed upon, but monthly or seasonal values of temperature, precipitation, wind and mean sea level pressure would seem appropriate) should be analysed by the individual partners and provided to the rest of the PRUDENCE partners as soon as possible after a run has been finished. The report by the Rossby Centre available at the PRUDENCE home page could serve as a role model for this. On the longer term an attempt should be made to homogenise the plots of systematic biases should be made. The CRU gridded data set should be used as the common verification data set. After this first quite raw analysis, each partner should along with this objective verification of the simulations provide an overall assessment of the quality of their simulation of present day climate. Moreover, a similar type of analysis of the climate change simulation should be provided as well. Once again, the Rossby Centre presentation is providing the basic information needed for this. The result of this enterprise should then allow for some expert judgement of the results coming from the impact models applied afterwards. This would make feed back from the impact analysis more relevant for the climate modellers as well.

Since most of the time was spend discussing data related issues, it was noticed that a strong emphasis on non-data issues had to be assured during the main meeting, otherwise it could easily evolve into non-constructive discussions, rather than stimulation from new ideas. It was pointed out that the data issue should be dealt with on the last day in details. In connection with this, the issues raised from WP3 – WP5 also dealt with availability of data. It was decided to address these problems in the plenary.

It was furthermore agreed that Dr. Whetton as an independent external expert should write a summary report about his impression of the activities and the procedures adopted in the PRUDENCE projects. His report follows these SSG and EAG meeting minutes.

Notes on PRUDENCE

(Peter Whetton, CSRIO)

This is an exciting project and I feel privileged to be associated with it. It has a number of very strong features. The set of coordinated high resolution climate model runs is unique. This will enable a number of key uncertainties associated with climate change projects to be assessed in a controlled manner. The results of this will be of considerable interest to climate change researchers throughout the world as well as in Europe. This emphasis on uncertainty also flows through to the set of coordinated impact studies that form a key part of the project. There will also be extensive analysis of extreme events. Overall the project breaks considerable new ground.

The following comments and suggestions are based on the presentations I was able to see during the meeting at Trieste and my reading of the project description. Note that as the workpackages were dealt with in parallel in the meeting, my knowledge of the meeting discussions is incomplete.

Although the project has a strong emphasis on representation of uncertainty, it is important to recognise that it deals only with a portion of the full 'cascade of uncertainty' (see Chapter 13 of the IPCC WG1 TAR) which stretches from emission scenarios through to impact modelling. The emphasis in this project is on uncertainty due emission scenario differences, internal variability and model to model differences in high resolution downscaling of the results. In particular, inter-model differences in driving AOGCMs is not well represented (just two models). How much of the full cascade of uncertainty is likely to be represented in the results of this project needs to be appreciated and conveyed in the project reporting so the results are seen in their proper context. Without greater sampling of uncertainty the project can't deliver an assessment of impact risk, and it is important to guard against overselling the results in this way.

It also seems as though only a subset of the model runs will be used in some of the impact assessments. In particular, there are some high resolution model runs that come very late in the project and it is not clear to me that there will be scope to use these fully in the impact studies. This will mean that the link between the uncertainty explored in the modelling study and that represented in the impact studies will need to be very carefully managed.

It might also be useful if more effort was given to coordination amongst the impact groups of the methods used to turn climate model output into impact model input (e.g., using simple deltas applied to observed data versus use of weather generators etc.). My impression was that concern regarding the most appropriate methods at this point varied amongst studies. Some variation would be appropriate, but needless variation affects the scope for combining the results of the studies into an integrated impact picture. In particular, I think it would be good if there was comparison between the results of the extremes workpackage (WP5) and the way changes in extremes were represented implicitly or explicitly in the data used in the impact studies. As an example of this, some impact studies were applying a simple delta to daily observed temperature or precipitation series. This will automatically change extremes in a particular way which may or may not be consistent with the model analysis in WP5.

Workshop Agenda

Wednesday 2 October

Scientific presentations in common with the SECOND ICTP CONFERENCE ON DETECTION AND MODELING OF REGIONAL CLIMATE CHANGE. Detailed agenda available at http://agenda.ictp.trieste.it/agenda/current/fullAgenda.php?email=0&ida=a01160

19:00 – 22:00? Board meetings

Steering committee meeting

Jens H. Christensen
Ole B. Christensen
Daniela Jacob
Richard Jones
Markku Rummukainen
Filippo Giorgi
Jørgen E. Olesen
Jean-Charles Hourcade
Tim Carter
Jean Palutikof

PRUDENCE external advisory board meeting

Steering committee members +

√ *Jean Palutikof; for MICE (EU project)*
√ *Clare Goodess; for STARDEX (EU project)*
Gunner Hovsenius; for Elsforsk (Sweden)
Jean-Yves Caneill; for Électricité de France (France)
Axel Michaelowa; for Hamburg Institute of International Economics (Germany)
√ *Dag Bjørge for Trond Iversen; for RegClim (Norway)*
Manfred Lange; for University of Münster(Germany)
Gerhard Berz; for Munich Re (Germany)
√ *Peter Whetton; for CSIRO (Austrlia)*
Ib Troen; for DG-XII

Thursday 3 October

PRUDENCE open session

9:00 Wellcome and opening of PRUDENCE meeting
Jens Hesselbjerg Christensen/Filippo Giorgi

9:10 PRUDENCE — Jens Hesselbjerg Christensen

9:35 STARDEX — Clare Goodess

10:00 MICE & Cluster of projects — Jean Palutikof

10:40 Coffee break

11:00 The Hadley Centre suite of models — Richard Jones

11:30 Experience with an RCM model at SHMI — Jouni Räisannen

12:00 Climate and physical information needed for economic and policy analysis
Jean-Charles Hourcade

12:30 Lunch

14:00 Starting 1st PRUDENCE business meetings

Defining break out task groups

WP1 + WP2	Headed by: Hadley and MPI
WP3 + WP4 + WP5	Headed by: SMHI, DIAS, UniReading
WP6	will join where appropriate

The groups will meet in separate rooms. The overall objective will be to follow up on the tasks defined at the kick-off meeting, reporting on significant problems encountered so far, identification of further gaps in information flow and data needs, and identify how these can be amended.
Reference persons for cross WP issues must be identified prior to meetings.
Reporteurs to sum up for plenary must be identified.

Project progress: Presentation by partners 10-15 minutes each, with focus of 1) aims of work, 2) results so far, 3) problems encountered, 4) integration with other parts of PRUDENCE, 5) timetable for the next phase up to the next meeting, etc.
Rapporteurs are responsible for summarising the presentations and make sure that general issues are identified and put forward in plenary.

16:00 Coffee break

Break out sessions continue

18.00 *Meeting adjourn*

20:00 PRUDENCE dinner

Friday 4 October

9:00 Break out sessions continued and initiating 2nd PRUDENCE business meetings

Discussion of further needs for developments in the task groups.
The task group dealing with data exchange formats should also meet.

Identification of possible PRUDENCE scientific papers on

Level 1: Documenting work by individual partners
Level 2: Documenting work by at least two partners with comparable field of research
Level 3: Documenting work by at least two partners with crossing of fields
Level 4: Truly inter-disciplinary documentation
Level 5: Documentation of PRUDENCE overall achievements

The coordinators of PRUDENCE, STARDEX, and MICE meet.

10:30 Coffee break

10:50 1st PRUDENCE business meetings plenary session

General aspects of Netcdf — Burkhard Rockel

The next IPCC report (AR4) — Filippo Giorgi

Presentations by WG PI's based upon break out sessions

Discussion across WG's

12:40 Lunch

14:00 Bridging the gaps; plenary session
Reports from break out sessions and general discussion

Wrapping up
From here to the annual report - practical matters, outstanding issues.
Stimulating inter-institutional and interdisciplinary work. Identifying possible scientific presentations, papers, etc.

General discussions continued

16:00 End of meeting

Status of activities in PRUDENCE WP1-WP2: Climate models and their analysis

(Michel Déqué, Meteo France)

The first part of the session was devoted to individual presentations by the global- and regional-simulation producers. The state of the integrations is not detailed here, since the 6-month management reports of the project provide an accurate view on this status. Most participants have produced the control 1960-1989 simulation, and a few have already one (or three) simulations for A2 with Hadley Centre forcing available. Additional simulations using B2 radiative forcing or other boundary conditions have also been performed. The warm and dry bias in summer south Eastern Europe is reported by the modellers. Some participants found a "summer hell" impact over south Western Europe (anomaly above 5 K in A2 scenario). Warm summer SSTs over the Baltic Sea in A2 produce intense precipitations in some simulations.

The discussion was led by R. Jones, since the sub-coordinator, D. Jacob, could not attend the meeting. Some coordinated effort was proposed with exchange of high resolution data (20 km) in the Baltic area (MPI, SMHI and DMI). An other area of interest for high resolution is the Alpine area (ETHZ and MPI). However, a common analysis as in MERCURE, implying that each participant provides data and one participant provides manpower is not proposed. Instead, each participant should be able to compare his basic diagnostic results (i.e. 2m temperature, precipitation and msl pressure) with the other participants, and then to explain his own model behaviour using extended diagnostics (radiative and hydrological cycles). It was thus proposed that 30-year averages of these 3 fields and 4 seasons should be made available for each model run of the project. The exchange format should be (global) CRU grid and NetCdF.

There will be a common meeting in Hamburg in early 2003 for WP1 and WP2.

The study of extremes should be done with the same thresholds as in STARDEX, but the first step would be to focus on the statistical distribution (first moments and quantiles) in the model data before investigating the tails of the distribution.

The exchange of boundary conditions seems OK now, after a few problems have been solved. Then, the next exchange is model output (19 daily fields) which represents at least 500 GB of data. It was previously decided to burn DVDs for data dissemination, but experience shows incompatibility problems and data overload for those wishing only a few grid points. It is proposed that data will be saved on a single site (DMI or MPI) in public access with a software (ETHZ proposes a NASA software used for the MAP project) allowing to extract the required information as a NetCdF file. According to the size of the extracted data, the most appropriate device is chosen (ftp, CDROM, tape or DVD). Anyway, the DVD initial solution is kept in mind as a backup in case of problems when installing the database solution.

The only exchange format is NetCdF with COARDS/CF conventions. Archiving latitudes and longitudes of the grid points in the same format will allow a simple conversion into (lat, lon, field) format through ncdump. A sample file is available on the PRUDENCE Web page. Among the 19 fields that were proposed in Helsingor, sea-ice thickness is to be removed since it is the same for all regional simulations. Additional fields may appear on the list (e.g. 6-hourly data). The way NetCdF files are to be written is one field per file with the whole time series (30 years). Modellers are asked again to provide their grid description (latitude, longitude, land sea mask and surface elevation).

Status of activities in PRUDENCE WP3: Impacts on Hydrology

(Phil Graham, SMHI)

WP3 focuses on the impacts of climate change scenarios on hydrology. Both northern and central European basins are being analysed. Work in the north focuses on the large-scale hydrology of the entire Baltic Sea drainage basin, as well as the specific Lule River basin in Sweden. In Central Europe, the Rhine River basin is being studied. SMHI (partner 9) is conducting hydrological modelling in the north, while ETH (partner 6) concentrates on the Rhine. Hydrological studies at MPI (partner 8) will be conducted both in the north and in the Rhine basin. Thus, at least two hydrological analyses will be available for comparison in both north and central basins. In addition, U. Fribourg (partner 15) will conduct studies on climate change impacts to snow and glaciers in the Alpine region, which are important contributors to runoff generation.

As of the Trieste meeting, all three of the hydrological modelling groups have established working hydrological models of the basins under study. Adjustments may be necessary as they are applied to the climate change scenarios delivered by WP1. Both ETH and MPI will use models that are coupled to the respective RCMs used at these institutes. SMHI will use an offline model for most analyses, but will also compare to coupled results coming directly from its own RCM. Substantial work has also been performed on the interfaces between the hydrological models and the climate models. The impacts work on snow and glaciers by U. Fribourg is scheduled to start later in the project.

Using hydrological models to analyse the hydrology in control simulations of the climate models is an important aspect of this workpackage. This will pinpoint biases and help to identify both deficiencies in the surface processes of the climate models and sources of uncertainty in the scenario simulations. Using different approaches to transfer the signal of climate change from climate models to hydrological models will provide insight into uncertainties associated with impact assessment techniques. The northern studies aim to analyse different scenarios from a number of different climate models. The Rhine studies aim to analyse in detail the effects of different model resolutions on impact studies, which limits the number of scenario simulations to be analysed. However, after initial analyses of the effects of increased resolution, a decision will be made as to whether more focus will be put on further resolution studies or on additional scenario analyses. Part of MPI's analyses will also focus on the effects of resolution.

Although the partners in WP3 are rather clear on what they intend to do to accomplish their respective deliverables, there are still modelling details that require additional discussion. These concern specifics on how best to proceed to get consistent results that can be compared between the different groups and the different approaches. It is also still unclear how much scenario impacts analysis will be performed by MPI; they have a limited budget for WP3. The details under consideration are being pursued in an ongoing dialogue between the partners.

The specifics of data transfer were not a prominent part of WP3 discussion. Most of the partners in the workpackage are associated with a climate modelling centre and all have experience with climate model studies. Most participate also in WP1 and WP2 where data transfer issues are being pursued in detail. Thus, although data handling is recognised as a time consuming activity, it is not perceived as a major issue for WP3.

Status of activities in PRUDENCE WP4: Impacts on agriculture, forestry and ecosystems

(Jørgen E. Olesen, DIAS)

The overall objectives of WP4 are to analyse the impacts of a range of detailed climate change scenarios on agriculture, forestry and ecosystems for selected regions in Southern and Northern Europe, and to evaluate adaptation options and possible effects on mitigation strategies. Most milestones of this WP occur later in the project. However, all parts of the WP are well on track, and much of the preparations for performing the impacts analyses have been performed.

Impacts on agriculture in a South European region (ISAg-UPM)

Two different crop-climate models (DSSAT and CropSyst) are being applied to study the effect of climate change on crop production in Spain. The sensitivity of the models to slope and soils have been analysed for barley. A number of simulation areas have been selected for the climate change study and the reference crops have been selected. An initial test of the HIRHAM test data have been performed for barley. The current work is concerned with the linkage between the crop models and a geographical information system (GIS).

Impacts on agriculture in a North European region (DIAS)

The DAISY soil-plant-atmosphere model has been used to simulate crop production and changes in soil C and N for range of crop rotations under changing temperature, rainfall and atmospheric CO_2 concentration. Two different parameterisations of the soil organic matter model were used to estimate uncertainty in soil carbon development and in associated effects on nitrogen dynamics.
The model was applied to three crop rotations typical for arable farming in Denmark on loamy sand soil. A scientific paper on impacts of climate change on greenhouse gas emissions has been submitted, and an additional scientific paper on effects of climate change on N cycling is being prepared.

Impacts on forestry and ecosystems (University of Lund)

The LPJ-GUESS dynamic ecosystem model has during the first year been used to simulate current forest composition, biomass NEP, NPP, soil and vegetation carbon in a number of natural and semi-natural forested regions in Europe included in the EUROFLUX project. This has included compilation of a full set of data from the EUROFLUX sites, and calibration and testing of the model against these data. A long-term climatology for 20th century (CRU) monthly 0.5° lat/lon gridded dataset has been reformatted for use by LPJ-GUESS. Changes in the input/output format of LPJ-GUESS has been implemented to allow transient runs. A problem that remains to be solved is how to fill the time gap of climate data from 1991 to 2070, as the LPJ-GUESS model must be run for 200 years from 1901 to 2100. However, discussions during the meeting made it clear that an option could be to use the full set of ensemble members from the Hadley Centre to simulate natural variability for the lacking period and then use pattern scaling to do the rest. Later the DMI model will also be able to provide natural variability generated this way.

Uncertainties in estimating resource potential under changing climage (FEI)

Uncertainties of climate estimates are being investigated by means of an array of impact models and indices. The approach has been demonstrated using the effective temperature sum

(ETS) to study the cultivable limits of grain maize in Europe. Gridded estimates of mean ETS based on observed climate have been compared for three different baseline periods, 1951, 1961-1990 and 1971-2000 and against previously published results. Inter-annual variations in ETS have also been studied, and future prediction of ETS based on two climate change scenarios (A1FI and B1, HadCM3) have been tested.

Uncertainties in modelled predictions of extremes of the Mediterranean Basin (UEA-CRU)

The analyses of uncertainty in the Mediterranean Basin will primarily concentrate on analysis of heat waves and cold spells, and of droughts and high-intensity rainfall. Daily maximum and minimum temperatures and rainfall will be extracted from a selection of grid points in the RCM, chosen to represent the geographical diversity of Mediterranean environments. Scenarios of change in mean rainfall and temperatures across the Mediterranean have previously been studied by UEA based on transfer functions.

Plans for next period

Most of the impact modellers need to develop and test routines to convert the climate data from netCDF files to the input formats used by the impact models. For models using daily data this also involves extrapolating from a 360-day year to a 365-day year.

A methodological study on the application of the GCM/RCM output data will be performed for several of the models and regions being studied:

- Use the RCM/GCM output data directly (Do we recalibrate the impact model for the control run?)
- Apply anomalies to the observed baseline dataset (observed climate variance)
- Adjust for anomalies in the RCM/GCM output dataset (simulated climate variance)
- Use the anomalies as input to a weather generator (with/without change in variance)

A meeting of the WP will be held in March or April 2003 to discuss individual work plans and plan cross-cutting work within the workpackage for the remaining project period.

Status of activities in PRUDENCE WP5: risk and extremes breakout discussions

(David Stephenson, UniReading)

Progress

The WP5 participants presented preliminary results. David Stephenson (U. of Reading) discussed point-process attributes suitable for describing extreme events (deliverable D5A1). These techniques have been applied to daily winter temperatures from the HadRM3 runs. Brigitte Koffi (U. of Fribourg) explained the progress she has made in learning about extreme value analysis and in getting suitable software set up for such analyses (IDL, Splus). U. of Fribourg next plans to investigate heat waves (and cold waves) in the PRUDENCE simulations using suitable exceedance-based techniques (deliverable D5A4). Jean Palutikof presented results produced in collaboration with M.J. Livermore on the comparison of downscaled temperatures from scenarios with observed temperatures in Southern Europe. Similar analyses will be applied to the PRUDENCE runs when available as part of deliverable D5A4. Downscaling calibration was found to be essential for correcting model biases but did not correct all the problems such as the tendency of the maximum temperatures to be bounded above by freezing point in some of the runs. Katja Woth (GKSS) presented preliminary results from the Hamburg storm surge model and explained how extremes in storm surge were the complex result of both extreme winds and sea-level pressure variations (deliverables D5B1 and D5B2). In the absence of Kirsti Jylhä (FMI), Tim Carter (SYKE) summarised the plans of FMI in WP5. FMI has identified 5 of the STARDEX indices for investigation in the PRUDENCE runs (deliverables D5A7 and D5A8): max. no. of consecutive dry days, max. 5-day precipitation total, heat wave duration index, total no. of frost days, frost/snow free season. Hans Von Storch (GKSS) presented some interesting results from the HIPOCAS project which showed how the models seemed to be underestimating maximum wind speeds over land but were performing better over sea. To summarise, the WP5 participants have all started to make progress towards the deliverables and are preparing themselves for the availability of model data from WP1 and WP2.

Issues

- Confusion in the use of the word *extreme* that is ambiguously used to mean either a *large value* of a meteorological variable, a *rare* event, or a *severe* event that causes large losses. These definitions will be clarified in future months by WP5. Furthermore, it would be useful to develop a typology of extremes to be agreed and then applied by all PRUDENCE partners. The IPCC TAR could provide a starting point for this (WG II, Table 1-1, p. 92).
- Which are the best measures for characterising changes in extremes? And how can the statistical significance of any changes be tested? Can changes be attributed to changes in the mean and variance of the parent distribution? Careful attention will have to be paid to spatial and temporal dependency in the data.
- Common diagnostics by WP1 and WP2. WP5 will supply a short list of common diagnostics to WP1 and WP2 that can be used by all the modelling groups to characterise the overall changes in the whole probability distribution of the meteorological variables. This will provide a comprehensive first look at all the models before going into more detailed extreme analysis.
- A comprehensive table of model runs (as on the AMIP site) should be established as soon as possible on the PRUDENCE web site. It should contain information on all the runs that will be available and when the data is due. It should also provide hyperlinks to the netcdf data and e-mail contact information for each data provider.

WP5 participants

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Status of activities in PRUDENCE WP6: the role of PRUDENCE on European climate policies

(Jens Hesselbjerg Christensen, DMI)

A preliminary report, providing a discussion of the climate and physical impact information needed for economic and policy analysis at the national and regional sector level was send to the coordinator prior to the meeting. This was done shortly before the meeting and therefore the document was not circulated to a wider community. A more elaborated version will be distributed before the end of the year. Also, only one of the major participants in this WP was present at the project meeting. Therefore, the coordinator and Jean-Charles Hourcarde met for brief discussions during the meeting. It was decided that a WP6 workshop would be hosted at CIRED, SMASH in spring 2003 (most probably in May) for PI's involved in the other WPs. The focus of this workshop would be to give a broader overview of the issues and possibilities that are central for economic and policy assessments. The same workshop should also ensure a focused final workshop (deliverable D6A4) in that the achievements from WPs 1-5 can be defining a procedure which will ensure the most appropriately integration of the work carried out in the assessments within WP6.

It was agreed that a stronger involvement by the natural scientists in WPs 1-5 in the activities of WP6 would be needed for further progress. Therefore, the report mentioned above is considered as instrumental for this. The participants in this break out group would like to stress that any feed back from the rest of the consortium to this report is greatly acknowledged. This WP serves two purposes, one as outlined in the DoW, the other is a pedagogical introduction of what can be expressed in brief as the socio-economic link between the natural sciences and the policy decision process within the context of climate change. This is a very challenging task and a broad support from the PRUDENCE team is very important if this WP is to become successful.

Meeting between MPS Co-ordinators

Jens and Jean present, apologies from Clare

Recommendations:

Publicity

- The MPS poster which is being prepared in CRU will be made available for download by MPS participants

- A powerpoint presentation will be prepared, to publicize the three projects. The first deadline for this is the end of November – each Co-ordinator will circulate overheads setting out the work in the project (i.e. the 5 results slides in the list below). We're looking for a total presentation of around 25-30 slides. The presentation is intended for use by any participant, and primarily aimed at meetings outside Europe. The proposed deadline for having it ready is the EGS/AGU meeting in 2003. This might break down as:

  3 introductory slides
  1 slide on PRUDENCE structure
  5 slides on PRUDENCE results
  1 slide on future PRUDENCE work
  1 slide on STARDEX structure
  5 slides on STARDEX results
  1 slide on future STARDEX work
  1 slides on MICE structure
  5 slides on MICE results
  1 slide on future MICE work
  3 slides on relationships to policy, future work, dissemination etc.

Meetings

- The Co-ordinators should meet on a regular basis, around every 6-9 months. We suggest the MICE meeting in Cologne in January for the next meeting, followed by Wengen in September 2003.

- Jean as the MICE co-ordinator should attend the STARDEX meeting following the one in Copenhagen.

- For discussions between Jens and Clare at the Copenhagen meeting, Jean will make available in advance:
  - the list of MICE indices of extremes, and
  - information on the MICE data sets available for download by ftp.

Abstracts provided by partners

Changes in severe precipitation events over Europe under Global warming.

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Projections of future climate change of extreme precipitation for Europe already exist, but are deficient in terms of their regional detail. High-resolution (50 km) climate change simulations for an area covering the entire European continent and a substantial part of the North Atlantic sector have been conducted with the regional climate model HIRHAM4. The experiments were driven by large-scale atmospheric conditions from transient climate change scenario simulations performed with the Max Planck Institute for Meteorology coupled ocean atmosphere general circulation model ECHAM4/OPYC3 with a resolution of ~300 km. The emission scenarios used were the IPCC SRES marker scenarios A2 and B2. Three 30-year time slice experiments were conducted with HIRHAM for periods representing present-day (1961-1990) and the future (2071-2100) in the two scenarios.

Resolution limitation in an OAGCM precludes the simulation of realistic extreme events and the detailed spatial structure of variables like temperature and precipitation over regions characterised by heterogeneous surfaces. Due to a much better representation of the surface topography in an RCM, the geographical distribution of seasonal mean precipitation patterns generally represents a substantial improvement compared to the driving OAGCM. Likewise, high resolution is needed to provide sufficient information on the distribution of daily rainfall events. Based on the HIRHAM simulations, we estimate that the risk for an increase in the occurrence of severe precipitation events is everywhere largest during autumn and winter, while most of Europe will experience little change or even a reduction during the rest of the year. In spite of this, in many areas and in all seasons, the relative change in the 95% fractile of daily precipitation is positive. This also holds for intermediate to weekly time scales, and in some cases even with a larger increase. With the caveat in mind that the statistics is poor, we also find that for events with a longer return period (i.e. 2 years), this is true as well, and again with an enhanced amplitude.

CLM 50km Simulations within WP1 and WP2

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Germany **(Partner 7)**

For the simulations we defined the following setup:
The data will be performed on a rotated lat-lon grid with 101 x 107 grid points (including 8 boundary grid points). The horizontal grid width is 0.5˚ x 0.5˚ (~ 56 km x 56 km). There are 20 levels in the vertical direction on a hybrid sigma-pressure grid.
The Hadley centre data has been read with routine provided by DMI (Ole Christensen). We modified this routines for our special needs, which are mainly the conversion into netCDF format, the elimination of the wind interpolation from wind to mass points, and the combination of the 6 hourly data with the SST and sea ice data in one program.
We do not use cloud water data for Theta to T conversion.

Problems encountered
A new super computer (NEC SX 6) was installed at the German Climate Research Centre. The adaptation of the model to the new computer took longer than expected due the stability of the system (both the compute and the data server and their connection).
A new multi-layer soil model was provided by the German Weather Service and implemented into the model. This model overcomes a problem with the climatological soil temperature. The old soil model has 2 layers with a climatological temperature below 0.41 m. Soil moisture and temperature layers have different depth. For the new multi-layer soil model we choose 9 model layers. The climatological temperature is now below 7.66 m, it was derived from the CRU 0.5 degree data set. Soil moisture, ice and temperature layers have the same depth in the multi-layer soil model. Due to this change the interpolation program from the driving model data onto the CLM grid had to be re-written.

Present status
Data conversion routines from Hadley Centre data to local format have been written and the whole control data set has been converted. An interpolation routine converting Hadley Centre data to the CLM grid has been written. A first climate test simulation with control data is currently running. When the control simulation has been successfully completed a control run with spectral nudging will be performed. As soon as the tape with the Hadley Centre ScA2 scenario data arrives at GKSS we will convert this for CLM input and start the ScA2 simulation with and without spectral nudging. The computing time for one 30-year run in praxis is 30 days. It is possible to run several simulations in parallel.

PRUDENCE REPORT FOR 2002 meeting in Trieste, Italy 2-4 October 2002

Katja Woth, Hans von Storch

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Germany **(Partner 7)**

Possible changes in North Sea storm surge climate will be derived by running the "Trim_geo" surge model associated with a series of 30 year atmospheric regional simulations under present-day and enhanced greenhouse gas conditions.
The model covers the North Sea shelf area from 48.55 N to 59.75 N and from 4.25 W to 13.43 E, with a grid size of 6′ in the meridional direction and of 10′ in the zonal direction. This results in a grid of 107 x 113 grid points with a gridbox size of approximately 10 km x 10 km. A time step of 10 min is used. The model bathymetry is taken from the North Sea Model of the Federal Maritime and Hydrographic Agency of Germany (BSH). The model is initialized by mean water level and is forced by wind velocity components as well as by air pressure. Water level and tidal coefficients are used as boundary conditions. As model output we get barotropic current velocity and the water level.

Some results from the Rossby Centre PRUDENCE regional climate simulations

Jouni Räisänen
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Sweden **(Partner 9)**

The Rossby Centre has this far completed four PRUDENCE-related 30-year climate simulations with its couple regional climate model RCAO. Control simulations for 1961-1990 and A2-based scenario simulations for 20721-2100 have been made by using boundary data from both HadAM3 (experiment RCAO-H) and ECHAM4/OPYC3 (experiment RCAO-E). (The RCA-O simulations are not officially part of our PRUDENCE commitment but have been done anyway). Some of the main findings obtained this far are listed below.

- The RCAO-H and RCAO-E control simulations are in many respects very similar. Both show a slight overall warm bias (about 1ºC in annual land area mean), with larger warm biases in southeastern Europe in summer and apparently also in northern Scandinavia in winter. Precipitation and cloudiness appear to be somewhat too abundant in northern Europe and too low in southern Europe. The biases in these variables are somewhat larger in RCAO-E than in RCAO-H.
- The simulated climate changes, calculated as the difference between the A2 scenario run and the control run, feature a somewhat larger warming in RCAO-E than RCAO-E. In RCAO-E in particular, the annual mean warming is largest (up to over 6ºC) in southern and central Europe, with a local maximum of 10ºC in June-July-August mean warming in France. This is at least in part related to local feedbacks between reduced precipitation and soil moisture, suppressed evaporation and decreased cloudiness, but ciculation changes may also play a role (RCAO-E already shows a marked decrease in precipitation in southern Europe in spring, apparently due to more anticyclonic conditions in the A2 run). RCAO-H also shows large warming in southern Europe in summer, but this only reaches 6-7ºC
- The changes in atmospheric circulation, as indicated by the change in the time mean sea level pressure, are quite similar in RCAO-H and RCAO-E in spring but markedly different in the other seasons and in the annual mean. The RCAO-E experiment indicates a large decrease in pressure over the northern Scandinavia and the Arctic ocean (up to 11 hPa in winter and 7 hPa in the annual mean). In RCAO-H, the annual mean pressure changes are small and the pattern in winter is even qualitatively different from RCAO-H (largest pressure decrease over the North Sea).
- Both RCAO-H and RCAO-E indicate increasing precipitation in northern Europe (especially in winter) and decreasing precipitation in southern Europe (especially in summer). However, apparently as a consequence of the different circulation changes, the contrast between northern and southern Europe is larger in RCAO-E than in RCAO-H. In addition, the regional details of the change in Scandinavia are very different. At the west coast of Norway, RCAO-E indicates and increase of 60-70% in annual precipitation (due to increasing westerly winds), whereas the annual increase in RCAO-H is only 0-10%.
- As expected from the different changes in circulation, the changes in windiness also differ between RCAO-H and RCAO-E. Very little happens to the annual mean wind speed in RCAO-H, whereas the mean wind speed in RCAO-E increases up to about 10% in parts of Scandinavia, with decreases in southern Europe and over the central Mediterranean Sea. The largest increase in windiness in northern Europe in RCAO-E occurs in winter.
- Comparison between RCAO-E and the driving ECHAM4/OPYC3 simulation reveals (not surprisingly) where similar changes in sea level pressure in the two simulations. The temperature changes are also generally similar, although RCAO-E simulates

somewhat smaller warming than the driving model in northeastern Europe in winter, and slightly larger warming in southern Europe in summer. Unlike both RCAO-H and RCAO-E, ECHAM4 indicates only a small decrease in summer precipitation in southern Europe. Otherwise, the large-scale features of precipitation change are similar, but especially in northern Europe RCAO-E shows much more detail than ECHAM4. In particular, the increase in precipitation at the west coast of Norway is smaller, smoother, and located further west in ECHAM4 than in RCAO-E.

- The changes in extremes in RCAO-H and RCAO-E have been briefly studied using the 30-year means of highest maximum temperature and lowest minimum temperature, highest one-day precipitation and highest instantaneous (36-min time step) 10 m level wind speed. The changes in wind extremes and the highest temperatures are approximately as expected from the changes in time mean climate. However, the lowest winter temperatures increase in most of Europe at least twice as much as the winter mean temperature, probably mainly because of reduced snow cover. In addition, the yearly maximum one-day precipitation generally increases even in those parts of southern and central Europe where the mean precipitation decreases. The decrease in mean precipitation in these areas results from a reduced number of precipitation days, rather than from reduced precipitation intensity.

Next, HadAM3- and ECHAM4/OPYC3-driven scenario runs based on the IPCC SRES A2 emission scenario will be made and analysed.

Projections of future climate change are complicated by several uncertainties. One is the fact that the results of different climate models differ even when the same external forcing is applied in all of them. Here the data set collected for CMIP2, the second phase of the Coupled Model Intercomparison Project (Meehl et al. 2000), is used to study this issue.
At the doubling of CO_2, which takes 70 years in the idealized CMIP2 experiments, the 19-model mean global mean warming is 1.75ºC, ranging from 1.1ºC to 3.1ºC in the individual models. The global mean precipitation increases on the average by 2.5%, with a range of –0.2 to 5.6%. The average large-scale patterns of temperature and precipitation change are familiar from earlier studies, including a maximum of warming over the Arctic Ocean but otherwise larger warming over land than sea and a large geographical variation in the sign and magnitude of precipitation changes. The differences between the different experiments increase with decreasing scale, but even at the grid box level, the 19-model mean warming is in most areas at least twice the model-to-model standard deviation. The agreement on precipitation changes is worse and the average change exceeds (in absolute value) the standard deviation only in limited parts of the world, mainly in high latitudes (where precipitation increases) and some subtropical and lower midlatitude areas (where precipitation decreases). Part of the differences in climate change reflect the noise resulting from simulated internal variability. However, for the period surrounding the doubling of CO_2 and for climate changes estimated by comparing two 20-year means, most of the differences are truly model-related, especially regarding the changes in temperature.
The good agreement on local temperature changes does not indicate that the models would agree with each other on the small-scale patterns of temperature change, such as the difference in warming between two nearby grid boxes. These small-scale patterns are inconsistent between different models, but their amplitude is small compared with the overall large-scale warming.
The issues discussed in this talk are covered in more detail by Räisänen (2001).

References

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Update of modeling activities for climate change impacts on hydrology at SMHI/Rossby Centre

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As reported at the PRUDENCE kickoff meeting in 2001, modeling the hydrological impacts from climate change scenarios in the Baltic Basin for WP3 is carried out at both the Rossby Centre and the Research and Development Unit of SMHI. Work at the Rossby Centre focuses on large-scale hydrological modeling while the research unit focuses on basin and river scale modeling. The HBV hydrological model is used on all scales for the impact simulations. During 2002, the hydrological work has focussed on improvements to the calibration of the impact models to be used and investigation of different options for the input of climate model results into these models.

To date, the “delta change” approach in various modes is the most common method of transferring the signal of climate change from climate models to hydrological impacts models. This implies that only the differences between climate model control and scenario simulations are used to transfer the signal of climate change into hydrological models. These differences in variables are used to modify a database of the existing climate, which is then used as a proxy for the future climate. This approach has been applied directly for temperature and precipitation. It has also been applied indirectly to evapotranspiration for some simulations.

Direct use of either GCM or RCM simulations in hydrological impact models is uncommon. This is mostly due to the combination of biases in seasonal precipitation from these simulations and the inherent sensitivity of hydrological systems (and models) to precipitation. Past experiments have shown that direct input of precipitation from control simulations into hydrological models leads to incorrect representation of the present-day hydrological regime. Knowing this, hydrological modelers hesitate to directly input scenario simulation results in their models, as they know even less about the validity of the future climate.

Within PRUDENCE, variations of the delta change approach will continue to be used by SMHI. However, better ways to represent changes will be introduced. Improvements in the way that the change in temperature is represented have already been made and better representation of the change in precipitation is being investigated.

Substantial progress has been made in the land parameterization schemes of climate models over recent years and representation of runoff processes is now starting to get the attention that it deserves. This means that the hydrological components of these models are starting to behave more as a hydrologist would like and less as the error correction function that they so often were in earlier climate models. Still, this does not mean that the models will provide the correct hydrological outputs; problems with precipitation remain.

Hydrological evaluation of the climate model results is an important component of WP3. Their ability to represent runoff volumes in both time and space for the present climate will be analyzed. In addition, direct use of selected scenario simulations will be carried out in the hydrological impact models and compared to those performed with the delta change approach.

PROMES RCM simulations: control run and first A2 scenario results

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Spain **(Partner 10)**

As part of the planned contribution of UCM partner to PRUDENCE, a high resolution version of PROMES RCM (50 km horizontal grid, 28 vertical levels) is being run. The RCM is nested in HadAM3H data. Control run (1960-1990) has been finished, and 3 years of A2 scenario runs have been simulated so far.

A preliminary analysis of control simulation, compared to CRU present climate data, shows a cold bias for maximum 2m temperatures in several regions and seasons, and predominantly a slight warm bias of minimum 2m temperatures. Precipitation follows reasonably good the observed values. Particularly, summer precipitation over southwestern Europe and autumn and winter precipitation around the Mediterranean Sea is well captured. The largest precipitation bias is found over eastern and north-eastern Europe in summer.

A first look on precipitation extremes reveal a reasonable distribution of intense precipitation events, with higher frequency over Mediterranean countries in autumn, and over the Alps and southwestern Scandinavia throughout the year.

With regard to A2 scenario runs, the first results (to be taken only as a general tendency indication, due to the small number of years simulated) show a general temperature increase, particularly large in summer over south-western Europe. Precipitation increases over north-western Europe, and decreases over the Mediterranean regions particularly in summer.

During the next year, the A2 scenario run will be finished, as well as the B2 scenario run. A detailed analysis of the results will be performed, together with a comparison with the results of other groups.

Impacts on agriculture in a South European Region

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In PRUDENCE, ISAg-UPM is studying the impacts of climate change on the Iberian Peninsula agriculture, water use and sustainability.

Work completed

- Sensibility analysis with the crop models in relation to changes in slope and soil type.
  - Slope only produced effects when erosion was considered in the simulations.
  - Soil: a wide range of yields was obtained depending on the soil type. The simulation with 1 to 3 soil types per RCM square was decided.
- Determination of the simulation area for PRUDENCE, excluding non-agricultural areas, and choice of prioritary areas of simulation
- Maize, wheat, barley, and a legume (faba bean or pea for crop rotations and the sustainability study) were chosen as reference crops. In zones where these crops are not usually cultivated, the simulation of these crops will be useful as a reference for the ET, and the estimation of Eto.
- Simulations with the HIRHAM test data sets were performed for reporting format and/or data problems and for checking the coherence of the climate data and crop simulation results. Simulations have been done for barley, with DSSATv3.5 and CropSyst v3.02.23.

Current and future work for deliverable D4A1 (month 16)

- The linkage between a GIS and the Cropsyst model has been done, and we are still linking the other crop model DSSAT.
- The updating of our data base is been done: genetic coefficients, and new data on sowing, anthesis and maturity dates, yield and biomass production for different regions of the Iberian Peninsula is being introduced.
- Crop Models: calibrations with ERA 15-year data for the agricultural areas (C0) will be performed.
- Crop Models: fine tunning re-calibrations are expected to be needed with the different RCM control climate data (C1s).
- Comparison between parameters of calibrations C0 and C1s will provide a description of first differences among RCMs
- Simulations with the different RCM control climate data for water use, biomass production, yield and sustainability analysis (simulations of 30-year crop rotations).

Problems with data format

- HIRHAM-RCM provides a file per variable and year, for every grid, while crop models need a file per cell grid and year with all the variables in it.
- RCM simulations of 360 days: 5 missing days x 30 years= 150 days. We have to fill these 5 missing days.
- These tasks were performed in the test with both crop models. In these conditions the construction of our climate files is a very time consuming task
- The importance of all the RCMs providing data with the same format is stressed.

Sensitivity of arable cropping systems in Denmark to climate change

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The DAISY soil-plant-atmosphere model (Hansen et al., 1991) was used to simulate crop production and changes in soil C and N for range of crop rotations under changing temperature, rainfall and atmospheric CO_2 concentration. The effects on net CO_2 emissions were estimated from simulated changes in soil C. Two different parameterisations of the soil organic matter model were used to estimate uncertainty in soil carbon development and in associated effects on nitrogen dynamics. The effects on N_2O emissions were estimated using the IPCC methodology (IPCC, 1997) from simulated N turnover, including amounts of N in crop residues and nitrate leaching.

The model was applied to three crop rotations typical for arable farming in Denmark on loamy sand soil (Table 1). The crop rotations consist of winter and spring cereals and oil seed crops. The three crop rotations varied in proportion of spring sown crops and in use of cover crops, which are considered some of the possible adaptive responses to climate change.

Table 1. Arable crop rotations used in the simulations. Undersown ryegrass is used as catch crop in rotation 3. The straw from fields 1 and 2 were incorporated, whereas the straw from fields 3 and 4 were removed. The standard nitrogen fertiliser rates (kg N ha^{-1} yr^{-1}) are shown in brackets.

Field	Rotation 1		Rotation 2		Rotation 3	
1	Winter barley	(142)	Spring barley	(115)	Spring barley/grass	(115)
2	Winter rape	(167)	Spring rape	(112)	Spring rape	(112)
3	Winter wheat	(116)	Winter wheat	(124)	Winter wheat/grass	(124)
4	Spring barley	(110)	Spring barley	(110)	Spring barley/grass	(110)

The effects changes in increased temperature and CO_2 concentration on simulated nitrogen fluxes and changes in soil C are shown in Table 2 for two different parameterisations of the soil organic matter (SOM) model. The revised model is based on the carbon content of Danish long-term field experiments (Bruun et al., 2002). This revised parameterisation takes into account higher C input to soil (rhizodeposition is taken to account), and the turnover rates of soil C are adjusted in order to reflect especially the larger medium-term turnover observed experimentally.

Table 2 shows a larger decline in soil organic carbon content over time with the revised than with the original SOM model. This large decline is in agreement with new evidence from national inventories of changes in soil carbon content on arable soils (Heidmann et al., 2001). The higher turnover of soil organic matter in the revised model also means higher nitrogen turnover rates, higher nitrogen losses (Table 2) and higher yields (Table 3). The yield level for the revised SOM model is more in line with what is found on farms with good management. The revised SOM model is therefore selected for the further analyses.

Tables 2 and 3 shows that the nitrogen and carbon turnover and losses in soils are more sensitive to changes in environmental factors that yield is. Only in a few cases were there significant effects of changes in temperature and CO_2 on the grain yield of the crops. In contract there were significant effects on changes in soil organic carbon and in nitrate leaching, which therefore for Danish conditions seem to be more influenced by climate change than the productivity of the systems.

Table 2. Simulated nitrogen fluxes and net changes in soil carbon and nitrogen storage for the original and revised SOM model parameterisations, each for the baseline climate, for a 4°C temperature increase and for a 50% increase in atmospheric CO_2 concentration. Values with different letters within each row are significantly different at the 5 % level.

Flux type	Crop rotation	Original SOM			Revised SOM		
		Base	Temp +4°C	CO_2 +50%	Base	Temp +4°C	CO_2 +50%
Harvested N (kg N ha^{-1} yr^{-1})	1	97.8 b	91.8 a	98.1 b	118.3 cd	115.3 c	119.9 d
	2	71.4 a	70.1 a	68.0 a	106.0 b	106.0 b	102.8 b
	3	77.0 a	73.8 a	74.8 a	95.8 b	94.7 b	93.3 b
N in crop residues (kg N ha^{-1} yr^{-1})	1	80.5 b	74.3 a	82.0 bc	90.6 d	85.4 c	92.4 d
	2	70.1 a	68.9 a	71.6 a	89.9 bc	88.9 b	92.4 c
	3	158.6 a	169.2 ab	162.0 ab	177.3 abc	191.9 c	181.5 b
Nitrate leaching (kg N ha^{-1} yr^{-1})	1	36.5 ab	45.3 bc	33.1 a	44.2 bc	51.9 c	38.7 ab
	2	45.6 b	49.1 b	46.9 b	34.2 a	38.9 a	33.4 a
	3	16.2 ab	20.3 bc	15.2 a	22.0 cd	25.3 d	20.7 c
Denitrification (kg N ha^{-1} yr^{-1})	1	6.34 a	6.90 a	6.40 a	8.24 ab	8.94 b	8.11 ab
	2	5.33 a	6.14 ab	5.49 a	7.50 bc	8.55 c	7.54 bc
	3	7.27 a	8.33 ab	7.30 a	8.68 ab	10.13 b	8.66 ab
Change in SOC (kg C ha^{-1} yr^{-1})	1	-55 e	-80 d	-31 f	-313 b	-365 a	-286 c
	2	-41 e	-68 d	-26 f	-263 b	-317 a	-230 c
	3	+213 d	+203 d	+244 e	+10 b	-32 a	+39 c

Table 3. Simulated dry matter grain yield (Mg ha^{-1} yr^{-1}) for individual crops in three rotations for the original and revised SOM model parameterisations, each for the baseline climate, for a 4°C temperature increase and for a 50% increase in atmospheric CO_2 concentration. Values with different letters within each row are significantly different at the 5 % level.

Crop rotation	Crop	Original SOM			Revised SOM		
		Base	Temp +4°C	CO_2 +50%	Base	Temp +4°C	CO_2 +50%
1	Winter barley	4.53 a	4.90 b	5.17 bc	4.60 a	4.98 b	5.40 c
	Winter rape	2.91 b	2.60 a	3.22 cd	3.01 bc	2.77 ab	3.35 d
	Winter wheat	6.17 b	5.60 a	5.93 ab	7.69 d	7.22 c	7.67 cd
	Spring barley	3.78 a	3.80 a	3.74 a	5.20 b	5.30 b	5.23 b
	Average	4.35 ab	4.22 a	4.51 b	5.13 c	5.07 c	5.39 d
2	Spring barley	3.85 a	3.87 a	3.70 a	5.52 b	5.58 b	5.57 b
	Spring rape	1.59 a	1.58 a	1.60 a	2.50 b	2.52 b	2.54 b
	Winter wheat	6.12 b	5.80 a	5.84 ab	7.60 c	7.30 c	7.38 c
	Spring barley	3.85 a	3.92 a	3.74 a	5.45 b	5.54 b	5.51 b
	Average	3.85 a	3.79 a	3.72 a	5.27 b	5.24 b	5.25 b
3	Spring barley/grass	3.14 ab	3.30 b	2.93 a	4.05 cd	4.30 d	3.85 c
	Spring rape	1.73 a	1.77 a	1.75 a	2.09 b	2.15 b	2.11 b
	Winter wheat/grass	7.98 b	7.27 a	8.02 b	8.87 c	8.31 b	9.22 c
	Spring barley/grass	3.67 a	3.44 a	3.58 a	4.55 b	4.46 b	4.38 b
	Average	4.13 a	3.94 a	4.07 a	4.88 b	4.80 b	4.89 b

These results are currently being prepared for a paper in *Nutrient Cycling in Agroecosystems*. Additional sensitivity analyses will investigate the effect of climate change on different soil types. This will be done for the revised SOM model only. When these sensitivity analyses are completed, the model will be applied to results from the GCM and RCM runs, probably in a grid for Denmark with defined soil types for each grid.

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Climatic change, extreme events, and their impacts

Prof. Martin Beniston
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While changes in the long-term mean state of climate will have many important consequences on numerous environmental, social, and economic sectors, the most significant impacts of climatic change are likely to come about from shifts in the intensity and frequency of extreme weather events. Indeed, insurance costs resulting from extreme weather events have been steadily increasing over the last two decades, in response to both population pressures in regions that are at risk, but also because of the frequency and severity of certain forms of extremes. Regions now safe from catastrophic wind storms, heat waves, and floods could suddenly become vulnerable. The associated damage costs would consequently be extremely high.

It seems appropriate, therefore, considering the environmental, human and economic costs exerted by extreme climatic events, to address the problem of whether there may be significant shifts in extremes of wind, precipitation or temperature in a changing global climate. In order to achieve these goals, the level of current scientific understanding and the availability of computational resources now enable numerical modeling techniques to be applied to this problem area.

Examples will be given of particular numerical simulations of extreme events, such as the recent December 1999 strong winter storm that affected Western Europe and the alpine region. Furthermore, some of the expected impacts resulting from shifts in climatic extremes in a changing global climate will also be addressed, in the sense that issues related to impacts on environmental and economic systems also need consideration in both scientific and policy terms. These simulations and impacts studies will be compared to observed events and trends during the 20th century, where adequate data is available to assess the manner in which certain forms of extreme events have changed, in part as a response to the global warming observed over the last 100 years.

Uncertainties in estimating resource potential in Europe under a changing climate: an example for crop suitability

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Uncertainties of climate estimates are being investigated by means of an array of impact models and indices. We demonstrate the approach using the effective temperature sum (ETS) to study the cultivable limits of grain maize in Europe (Zea mays). Gridded estimates of mean ETS based on observed climate are compared for three different baseline periods, 1951-1980, 1961-1990 and 1971-2000 and against previous published results. Inter-annual variations are also presented, which provide information on crop suitability. Future projections of ETS based on two climate scenarios, A1FI and B1 (HadCM3), indicate how the range of uncertainties in future climate can be depicted.
The presentation describes the status for the deliverables D4C5 and D4C6. Future work will extend the analysis for a suite of climate scenarios from AOGCMs and RCMs and for a number of other indices.

Introduction

In workpackage I of PRUDENCE, a series of model runs of Regional Climate Models (RCMs) are being carried out that require thorough testing especially in the light of their use in impact studies. One of the key questions to be addressed by PRUDENCE concerns the uncertainties of RCMs and whether their additional detail compared to Atmosphere-Ocean General Circulation Models (AOGCMs) is of any extra value for the study of the impacts of climate change.
SYKE's contribution to PRUDENCE is the application of AOGCM- and RCM-based scenarios to a suite of relatively simple impact models and indices. It will therefore allow a comparison among a large number of climate model runs which may not be feasible with more complex impact models that require more computational power and a bigger effort in analysing the results. The uncertainties demonstrated with impact indices may be indicative of the uncertainties of more complex impact models.
One example of a simple impact index is the effective temperature sum (ETS) which can be used to study the cultivable limits of crops. To make its application to new data sets comparable to earlier work, we adopt a similar methodology as in Carter et al. (1991) who used it to relate temperature to the cultivable limit of grain maize (Zea mays). Here, we demonstrate the visualisation of uncertainties in ETS deriving from sources such as the yearly variation and from using two climate scenarios for the 2080s.
This report presents preliminary results for the deliverables D4C5 (GIS environment for mapping of uncertainties) and D4C6 (Analysis, interpretation and presentation of uncertainties in impacts in GIS).

Data and methods

Climate data

The baseline climate data was derived from the newly developed CRU database described by New et al. (2002). This database has, among other variables, the monthly mean temperature on a 10' x 10' grid worldwide averaged over the 1961-1990 period. These data were used to derive monthly mean temperature for each year of the 20th century.[1]

[1] Source of baseline climate: T. Mitchell, Tyndall Centre, UK (ATEAM project).

The climate scenarios used here were developed by adding GCM temperature changes to the observed 1961-1990 baseline data. The chosen climate scenarios were HadCM3 model runs using the SRES emission scenarios A1FI and B1 for the 2080s.[2] They are used as preliminary example of the potential future range for the ETS calculation. To provide a larger range of models and scenarios, the ATEAM scenarios will be replaced by GCM scenario calculations provided by the IPCC DDC as well as the RCM experiments in PRUDENCE.
A map of monthly standard deviations (SD) of daily mean temperature around the monthly mean on a 0.5° x 1.0° latitude/longitude grid for Europe (1951-1980) developed by Carter *et al*. (1991) was used for the ETS calculation (see below). They produced sets of standard deviation for the 1951-1980-period on a 0.5° x 0.25° grid raster for Europe based on daily temperature from 226 stations.

The effective temperature sum (ETS)
The ETS is defined using daily mean temperature as follows:

$$ETS = \sum_{i=1}^{365} \delta_i (T_i - T_b) \qquad (1)$$

For $\delta_i = 0$ if $T_i < T_b$
$\delta_i = 1$ if $T_i \geq T_b$

where T_i denotes the mean temperature on day i, T_b denotes the base temperature. This formula requires the mean temperature at a daily resolution, which is not generally available for Europe on a high resolution grid. An alternative is the method suggested by Kauppi and Posch (1988), which integrates the ETS function in equation (1) over an assumed Gaussian daily temperature distribution.
This method requires the standard deviations of daily mean temperatures about the monthly mean. As the Kauppi-Posch method has shown to give best results if realistic values for the standard deviation are used, we used it in combination with the Carter *et al*. standard deviations for the ETS calculation in this study.
We used an ETS requirement of 850 degree-days with a base temperature T_b of 10°C to calculate suitability maps of grain maize. Maps have been plotted for three baseline periods, 1951-1980, 1961-1990 and 1971-2000 and for the individual years from 1951 to 2000 to investigate inter-annual variability (i.e. the climate risks for cultivating grain maize). The ETS index has then been applied to the two future scenarios, A1FI and B1, representing the 2080s (mean of the period 2070-2099). All ETS calculations have been conducted on a regular grid at the same resolution as the climate data, i.e. 10' x 10'.

Preliminary results
The baseline calculations for the suitability of grain maize cultivation are shown in Figure 1 for the three periods, 1951-1980, 1961-1990 and 1971-2000. For all three periods, the northern limit of suitable grid cells is located in the Netherlands, Northern Germany and Poland. South of this limit, only grid cells in areas of high altitude are estimated as unsuitable for crop cultivation, e.g. large areas of the Pyrenees and the Alps.
While the regional patterns of the suitability maps for the three baseline periods are very similar, they can differ by up to ca. 100 km in their suitability limits. Suitable grid cells in the 1961-1990 period reach farther north in some parts in eastern European compared to the suitability map of the period 1951-1980 whereas in western European areas the limits of the two periods are generally closer to each other. The limits of suitability show their most northerly extent in the period 1971-2000 in both western and eastern parts of Europe compared to the two earlier periods (shifts in suitability of up to 100 km).

[2] Source of HadCM3 scenarios: T. Mitchell, Tyndall Centre, UK (ATEAM project).

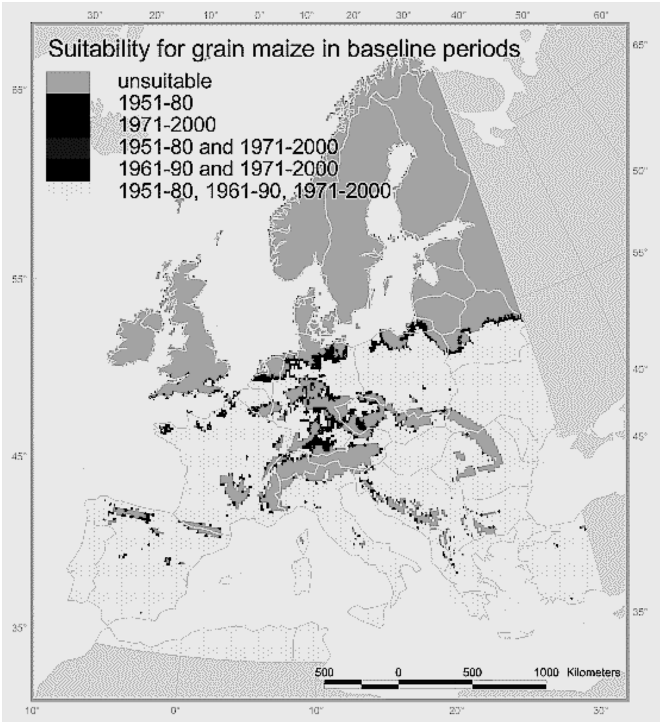


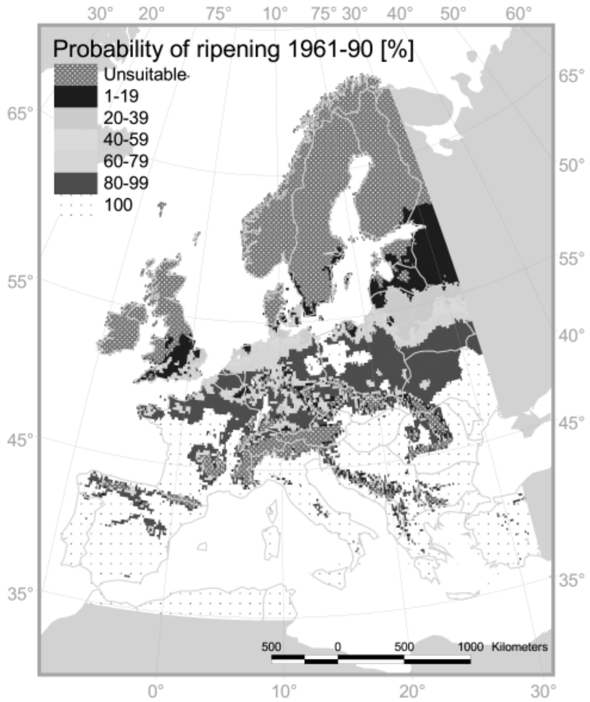
Figure 1: Grain maize suitability based on ETS for observed temperatures during 1951-1980, 1961-1990 and 1971-2000.

The inter-annual variability for the period 1961-1990 is represented in figure 2 (left) as the probability of ripening of grain maize, i.e. the percentage of years in this period which have been estimated as suitable for successful cultivation in each grid cell. The area described between the 100%-probability limit and the limit of the region predicted to be unsuitable in all years has a N-S extent of about 1000 km; the extent between the 20th and 80th percentile is still in the order of up to 500 km.
Similar distances are found between the suitability limits of the A1FI and the B1 scenario for the 2080s (figure 2, right). In both scenarios, suitability limits are shifted northwards into northern Britain, Sweden and Finland.
Maize suitability derived from the average of the ETS of the individual years of a 30-year period extended the areas suitable for crop cultivation compared to calculations using mean climate data of the corresponding period. The difference in limits was up 100 km.

Conclusions and outlook

A climate database for the baseline and scenario information has been set up within a GIS environment and can now be used for investigating uncertainties using impact indices. We demonstrated how different sources of uncertainty can be quantified and visualized with the example of a model to estimate the suitability for grain maize cultivation:

- Inter-annual variability covers a range of N-S shifts of up to 1000 km in the suitability limits.
- The N-S difference between limit for three 30-year periods as baseline, 1951-1980, 1961-1990 and 1971-2000, spans about 100 km.
- The difference between using a 30-year mean climate and the average of 30 individual years to compute ETS is described by a shift in suitability of about 100 km.
- The range of suitability shifts northwards when using different future scenarios in a range covering about 500 km in the N-S direction between the A1FI and B1 scenario. The uncertainty is therefore comparable to the uncertainties deriving from yearly variations.



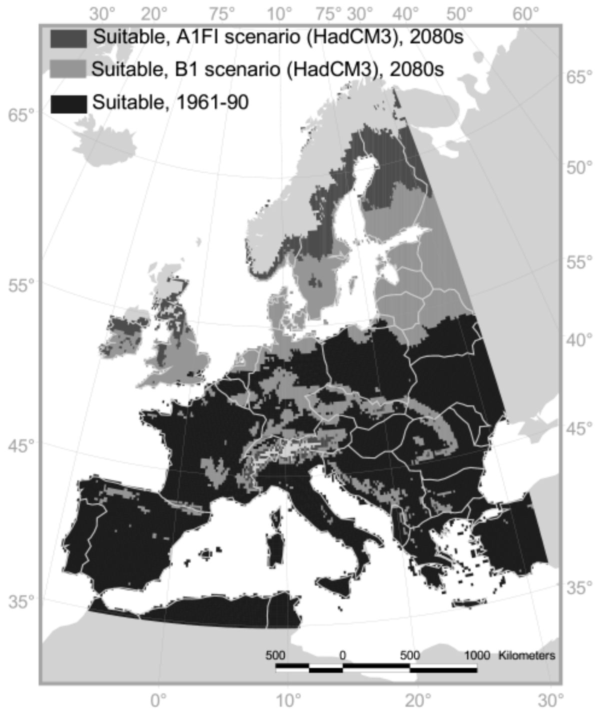


Figure 2: Probability of ripening of grain maize during 1961-1990 based on ETS (left) and the suitability for grain maize cultivation based on ETS in the 2080s (A1FI and B1 scenarios, HadCM3) and the baseline period 1961-1990 (right).

Our plans for future work includes the application of a range of impact models to the baseline in a similar manner for that shown above. The impact models are:

- ETS for different crops
- ETS as cooling and heating degree days
- Thermal growing season
- Index for potential biomass (Lieth models)
- Sea-ice index (applied to the Baltic sea)

These impact models and indices will be applied to both control runs of AOGCMs and the PRUDENCE suite of RCMs as well as their respective future simulations for the 2080s.

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PRUDENCE REPORT FOR 2002 meeting in Trieste, Italy 2-4 October 2002

Pablo Morales and Martin Sykes
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Sweden **(Partner 18)**

1st deliverable (12 months): Simulations of present day forest landscapes and ecosystem processes from selected regions under current climates

WORK:

As is described in the Prudence work plan, in our first year we are using LPJ-GUESS our dynamic ecosystem model to simulate current forest composition, biomass, NEE, NPP, soil and vegetation carbon etc. in a number of natural and semi-natural forested regions in Europe included in the EUROFLUX project. This has involved a number of different tasks:

TASK 1 (completed)

-Compilation of a full set of data from the EUROFLUX sites using what is available from different sources: FLUXNET and EUROFLUX web sites, EUROFLUX Database, Version 1.0 (CD-ROM), literature covering research carried out over the sites and personal contact with Principal Investigators at various EUROFLUX sites. From this dataset we have been selecting a number of sites that have as much of the information on for example site history as possible for our model-data comparison using LPJ-GUESS.

-Full site-specific dataset including – vegetation structure and composition, stand characteristics, climate, soils, management history, soils, N deposition - for most EUROFLUX sites has been collected.

-The next step was to calibrate and test the model against site data and for model-data inter-comparison and analysis. The aim of this exercise has been ensuring that the model "meets the benchmark", i.e. that LPJ-GUESS reproduces the observed time series of NEE and the existing vegetation on the selected EUROFLUX sites.

TASK 2 (completed)

-A long –term climatology for 20th century (CRU) monthly 0.5°lat/lon gridded time series climate dataset) is used to drive the model. A first task was reformatting such dataset as model input data for LPJ-GUESS.

-For the comparison against the EUROFLUX site data, the available monthly site data (from 1996-1998) was first regressed against the EUROFLUX site climate data, for the nearest grid cell, then historical 1901-1998 site climatologies were constructed.

- A fully reconstructed time series data (from 1901-1998) of monthly temperature, precipitation and sunshine for 15 sites included in the EUROFLUX.

Task 3 (completed)

- Other tasks performed include changes in the source code of the LPJ-GUESS model for particular use in PRUDENCE, specifically in the input/output module through which all driver data and static parameters for plant functional types (PFT) or species are provided to the model. This allows LPJ-GUESS to be run with transient reconstructed time series data (from the CRU05 climate dataset and EUROFLUX climatology) of monthly temperature, precipitation and sunshine

RESULTS

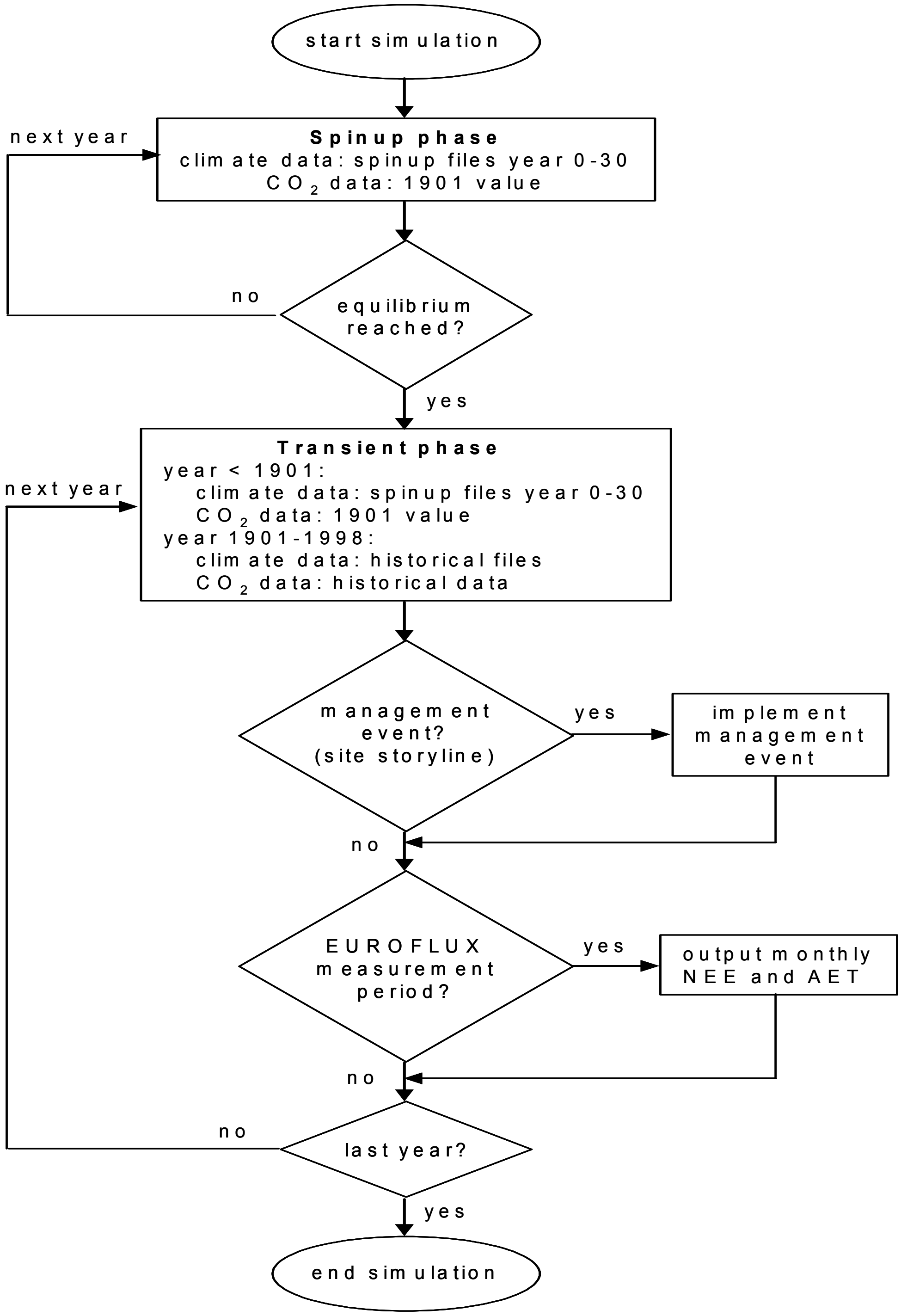
- Simulation experiments from three EUROFLUX sites (Collelongo, Tharandt, Flakaliden) have been completed and will be presented in Trieste, using reconstructed site climatology and including management history with relevant tree species, planting date and other important management events. The general procedure adopted for simulation of a particular site is illustrated in Figure 1.

- Modelled results from the selected forest stands have been compared to available forest inventory data (LAI, NEE, NPP, etc) as a means of validating modeled fluxes and vegetation composition. In this sense, the model correctly simulates the vegetation composition and structure at the selected sites.

- Seasonal cycles of net ecosystem exchange (NEE) compare well with local measurements in the selected sites.

- In summary the main purpose in the current phase has been to test LPJ-GUESS runs using site-specific data and climate. Simulations at other EUROFLUX sites will follow through the autumn and winter 2002.

Figure 1. *Summary of simulation procedure for a single EUROFLUX site*



Uncertainty in modelled predictions of extremes over the Mediterranean Basin

Jean Palutikof
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The presentation in Trieste will look at the methods we intend to employ in the Climatic Research Unit (CRU) to explore changes in the occurrence of extremes as modelled by the regional climate models (RCMs) used in the PRUDENCE project. There are three areas of analysis which we plan to carry out, all of which relate to the Mediterranean Basin.

i. Analysis of heat waves and cold spells. Daily maximum and minimum temperatures will be extracted from a selection of grid points in the RCMs, chosen to represent the geographical diversity of Mediterranean environments.
ii. Analysis of droughts and high-intensity rainfall. Daily rainfall series will be extracted for the same grid points in the RCMs.

These datasets of present-day and future model output will be used to examine changes in the in the occurrence of extremes, as modelled by indices such as degree days and number of exceedances of percentile thresholds. A problem with extremes analysis is the very few data points available. By using simulation models, we hope to artificially lengthen the data sets in order to improve sample size, which should allow more robust conclusions to be drawn about the occurrence of extremes. If the time series characteristics can be preserved, this approach should yield sufficient data to explore patterns of clustering in the occurrence of extremes.

iii. Evaluation of modelling uncertainty in soil moisture parameters. These analyses will be carried out at the monthly scale, looking at the range of predictions of temperature, rainfall and evapotranspiration in the PRUDENCE RCMs throughout the Mediterranean. The impact of these uncertainties on climate change impacts work will be evaluated.

It is important to note that the techniques described above are all currently in use in CRU. We await the climate model data in order to proceed with the analyses. All analyses will emphasise the understanding of uncertainty in the predictions of changes in extremes, by making use of the large number of model simulations to be undertaken in PRUDENCE.

Responsibility: Within work package 4

UEA participates in task D4A4.
Evaluation of modelling uncertainty in soil moisture parameters

UEA will carry out an evaluation of modelling uncertainty in soil moisture parameters. These analyses will be carried out at the monthly scale, looking at the range of predictions of temperature, rainfall and evapotranspiration in the PRUDENCE RCMs throughout the Mediterranean. The impact of these uncertainties on climate change impacts work will be evaluated. An important part of the work is to explore with end users issues surrounding the incorporation of uncertainty in scenarios of climate change.

UEA has constructed scenarios of the change in mean rainfall and temperature across the Mediterranean. These are based on the construction of a family of transfer functions which related terrain predictors (altitude, distance to sea etc.) to observed climate variables. These transfer functions can be used in a GIS to construct baseline climatologies at a resolution of 0.5 km by 0.5 km. Then, by combining these baseline climatologies with modelled difference fields, scenarios can be constructed. These scenarios make the assumption that terrain – climate relationships will remain constant under conditions of greenhouse forcing. The PRUDENCE simulations will be used to explore the validity of this assumption.

Reference:
Agnew, M.D. and Palutikof, J.P., 2000: GIS-based construction of baseline climatologies for the Mediterranean using terrain variables. *Climate Research*, **14**, 115-127.

Responsibility: Within work package 5

UEA is responsible for task D5A6.
Analysis of droughts and high-intensity rainfall. Daily rainfall series will be extracted for the same grid points in the RCMs.
UEA participates in task D5A4
Analysis of heat waves and cold spells

Statistically downscaled scenarios for the Mediterranean have been used to explore future changes in the occurrence of temperature and rainfall extremes in two Mediterranean catchments – the Guadalentin and Agri (see for example Table 1, for temperature, and Table 2, for rainfall).

A problem with these scenarios is that there is no estimate of the range of uncertainty. The PRUDENCE simulations will be used to construct scenarios of the change in the occurrence of extremes. These will be validated against present-day observations from the Guadalentin and Agri. Then, future scenarios will be constructed and compared with the existing statistically downscaled scenarios. Uncertainty due to inter-model effects will be explored. End users will be consulted to address the utility of these uncertainty estimates.

Table 1 Behaviour of temperature extremes at Alcantarilla, (10-year totals).

NoHD = number of hot days ≥35°C;
HDG = degree days above a threshold of 35°C;
NoFD = number of cold days ≤ 0°C;
FDG = degree days below a threshold of 0°C.

	Observations	GCM data		Scenarios for:	
	1970-79		1970-79	2030-39	2090-99
Hot-day measures calculated from TMAX:					
NoHD	146	7	77	134	465
HDG	272	9	131	211	1197
Cold-day measures calculated from TMIN:					
NoFD	84	0	91	34	1
FDG	94	0	111	40	2

Table 2 **Analysis of rainfall extremes at Alcantarilla, (10-year totals).**

	Observed 1970-9	Scenarios 1970-9	Scenarios 2030-9	Scenarios 2090-9
MISSANELLO				
Wet spells				
Longest run	16	7	10	8
GEV mode	6.4	5.5	6.1	5.2
GEV dispersion	2.1	0.9	1.3	1
Return period extreme (days)				
10 year	11.2	7.4	8.9	7.5
20 year	12.7	8.1	9.8	8.3
50 year	14.6	8.9	11	9.2
Dry spells				
Longest run	73	53	54	47
GEV mode	30.7	27.8	26.4	26.7
GEV dispersion	11.7	9.6	9.7	6.2
Return period extreme (days)				
10 year	57.2	49.3	48.2	40.6
20 year	65.6	56.2	55.2	45.1
50 year	76.6	65.1	64.2	50.8

A problem with extremes analysis is the very few data points available. If necessary, simulation models will be used to artificially lengthen the data sets in order to improve sample size, which should allow more robust conclusions to be drawn about the occurrence of extremes. If the time series characteristics can be preserved, this approach should yield sufficient data to explore patterns of clustering in the occurrence of extremes.

It is important to note that the techniques described above are all currently in use in CRU. We await the climate model data in order to proceed with the analyses. All analyses will emphasise the understanding of uncertainty in the predictions of changes in extremes, by making use of the large number of model simulations to be undertaken in PRUDENCE.

Reference:

Palutikof, J.P., Goodess, C.M., Watkins, S.J., and Holt, T., 2002: A methodology to generate rainfall and temperature scenarios at multiple sites. Accepted for publication in *Journal of Climate* and to appear in November 2002.

Uncertainties in the future climate changes in Europe relevant to impact studies

Kirsti Jylhä, Heikki Tuomenvirta and Kimmo Ruosteenoja
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Finland **(Partner 21)**

During the first year of the PRUDENCE project, the work conducted by the Finnish Meteorological Institute has mainly focused on assessing the uncertainties in European climate change attributable to the SRES emission scenarios and climate sensitivities (deliverable D2A3). Based on the AOGCM data available from the IPCC-DDC, we have constructed scatter plots that characterize seasonal mean temperature and precipitation changes in Europe relative to the period 1961-90. The projected changes are compared with internal variability in long, unforced control simulations, which are assumed to provide a reasonable representation of natural climate variability. By combining the projected changes in temperature and precipitation with observational climate datasets, uncertainties in future locations of climatic zones have also been assessed.

Since the AOGCM simulations are generally based on SRES A2 and B2 only, a slightly modified pattern-scaling technique has been applied to also cover the most extreme SRES marker scenarios (in radiative forcing), A1FI and B1. The scaling is done from the "closest" model simulation, i.e. from B2 to B1 and from A2 to A1FI. The scaling is based on the MAGICC model that can be tuned to represent several GCMs (IPCC TAR WG1 p. 577). In order to get pattern-scaled approximations of GCM-A1FI changes, GCM-A2 changes are multiplied by the ratio between global mean temperature changes due to MAGICC-A1FI and MAGICC-A2 runs. Likewise, the GCM-B2 changes are multiplied by the ratio between MAGICC-B1 and MAGICC-B2 global temperature changes to get scaled GCM-B1 changes.

On the basis both of direct and pattern-scaled AOGCM results, upper and lower estimates of regional temperature change across Europe will be given. The range of these estimates reflects the uncertainties in the future climate changes. By comparing the RCM outcomes to be provided by PRUDENCE with these estimates, the PRUDENCE climate change scenarios and impact assessments for 2071-2100 can be placed in the perspective of a wider range of emission scenarios and climate sensitivities.

Within the work package 5, geographical distributions of various present-day and future indicators of weather extremes, or resource risk indices, will be considered (deliverables D5A7-A8). These indicators, such as the maximum 5-day precipitation total and the heat wave duration index, are used as simple quantitative measures of the risk involved with climate change in Europe. The range of changes in these indices may give an approximation of the uncertainties likely to be met in more detailed impact modelling studies.

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