Management and Impacts of Climate Change Programme
GICC
CRP 2000

2/00 - Studying the potential impacts of climate change on the Rhône catchment for management purposes – Second phase

Summary of Final Report

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Extended abstract

The global climate change likely to take place under the 2 x CO_2 scenario was estimated using outputs from four general atmospheric circulation models, two of which involved integrations at two different resolutions. This resulted in six different visions of the future of the planet's atmosphere. The global meteorological indications produced were disaggregated using the perturbation method to the more detailed scales needed for hydrological modelling (the jump in scale corresponding approximately to the transition from a synoptic resolution grid to a mesoscale grid).

The GICC-Rhône project used data collected for the Gewex-Rhône project, which collected a reference atmospheric forcing over the period 1981-1998 with tri-hourly and 8 km resolutions, developed using the Safran system (CNRM/CEN). This forcing includes the following fields: air temperature, snowfall and rainfall, atmospheric and solar incident radiations, wind speed, specific humidity of the air, as well as potential evapotranspiration deduced from the other terms.

Climate change is based on the scenario assuming a 1% yearly carbon dioxide (CO_2) increase, with this gas bearing the responsibitity for all the climate changes; the target date is 2050 (the hypothesized CO_2-doubling date).

On the basis of a common climate simulation providing a reference sea surface temperature (Hadley Centre), a number of atmospheric integrations of this scenario were collected, four of them at a low resolution derived from an earlier project (LSPCR, Polcher – typical resolution 2.5° x 3.5 °), and two project-specific ones at a high resolution (for LMD dx = 100 km; for CNRM dx = 50 km) .

Monthly large-scale anomalies were disaggregated using the perturbation method:

- computation of monthly anomalies deduced from a General Circulation Model (GCM) = GCM value modified climate – GCM present-time climate, interpolated on the Rhône grid;
- perturbation of the forcing: modified climate forcing = present-time forcing + interpolated anomaly.

Six scenarios were developed by combining observed climate variables with the simulated anomalies concerning temperature and precipitation.

These climate forcing scenarios were fed into five different hydrological models, most of which covered the whole of the French part of the Rhône watershed, while a few only were limited to tributaries of particular interest (in particular the Saône river).

The hydrological outputs of the models were compared, and then compared to the current hydrological regime. Methods for the comparison of regimes and for the analysis of hydrology sensitivity to certain forcing variables were designed or adjusted to meet our needs.

It was then a matter of extracting from the hydrological modelling outputs the indications that could reasonably be deduced regarding the effects of climate change on the major physical variables of the studied hydrosystems and, when possible, of interpreting these changes in terms of impacts. The physical, biological and socio-economic aspects examined were:

- The general hydrology of rivers (high water, snow cover, median discharge, low water);
- The interactions with groundwater;
- The quantitiative and qualitative trends of the natural vegetation;
- The altered relationships between the water resource and irrigated crop systems;
- The response of fish communities to an altered water regime.

Throughout this project, we took care to express and when possible quantify the uncertainties that hamper current knowledge on the subject. This also lead us to:

- Examine the contribution of satellite analysis of the state variables of the watershed;
- Study uncertainties;
- Take into account the expected anomalies of the atmospheric variables other than precipitation and temperature in order to give consistency to the future climate;
- Study the dynamics of the interactive vegetation.

The results obtained are:

- A set of atmospheric scenarios;
- A set of time series of river discharges under various climate change scenarios;
- A set of sectoral reports on the consequences of climate change;
- A number of published or presented papers (see section 6);
- A general report;
- The present summary.

The most prominent result of this investigation is that the first factor of uncertainty regarding future hydrology is the choice of atmospheric scenario. Dispersion between the different models' outputs, although significant, remains less determinant.

Chronology of research

The GICC-Rhône project started in December 1999.

The year 2000 saw the preparation of the meteorological forcing fields (activities supervised by Météo-France, with a contribution by LMD). That same year, the hydrological modelling under perturbed climate began at Météo-France and CIG, taking advantage of the distributed models of the Rhône catchment already available at these laboratories (capital from the earlier project Gewex-Rhône, sponsored by PNEDC and PNRH). EDF/DER and BRGM started setting up and calibrating their own models to the current climatic conditions. The various tasks regarding uncertainties and, within the impact studies in general, those on the analysis of time series started with exchanges on methodology between the teams involved.

By 2001, the hydrological modellings under pertubed climate designed by Météo-France and CIG were completed. Over a total of 131 stations reflecting the diversity of the hydroclimatic conditions found in the watershed, they produced time series, both reconstituted and simulated (under given scenarios), which were collected and made available to the participants of the 'impacts' tasks. 2001 also saw several papers presented on the subject at various seminars. Thesepresentations were important for public awareness of the project, and indirectly for public awareness of the GICC programme. They were also useful in that they allowed other researchers to take into account what had been already accomplished and to devise improvements.

Early in 2002,EDF/DR and BRGM completed their discharge simulations.

Throughout 2000 to 2002, two other lines of research progressed alongside the 'main' research axis described above. The first was the continued validation of the distributed modellings used by Météo-France and CIG on variables other than discharge, through the analysis of archived satellite pictures to estimate surface variables and compare them with the models' state variables. This was carried out by CETP, in close cooperation with Météo-France among others. The second centred on the characterization of uncertainties. An initial approach to this involved systematically visualizing the dispersion of the results (over the different meteorological forcing variants and the different hydrological models), using a graphic control whose construction had been suggested by Météo-France. In order to proceed further, LTHE proposed a methodology that it was expected to implement as part of a pilot study with Météo-France.

In 2003, the attention focused on uncertainties. CEMAGREF undertook the calibration of the distributed model Ecomag on the upstream part of the Saône catchment. Introducing a fifth distributed model into the project was certainly not an objective in itself, but this was a model well understood by a post-doctorate team-member who had been specially recruited by CEMAGREF to boost its contribution to the study of uncertaintiesalong the lines suggested by LTHE and following up the latter's research in this field. Meanwhile, BRGM and ENSMP cooperated to clarify the role of groundwater in the distortion of hydrological regimes. CEN of Météo-France resumed its investigations on the impact of climate change in predominantly snow-affected areas to fine-tune its diagnosis. CETP worked on the validation of the distributed models under present-time conditions, permitting the comparison of satellite pictures, field observations and hydrological modelling regarding snow cover (with Météo-France/CEN and EDF/DTG) and the comparison of satellite-determined surface temperatures and surface temperatures obtained with the ISBA distributed model (with Météo-France/CEN and EDF/DTG). CETP also recorded land-use changes in the Saône watershed during the recent period, and the data were handed over to Météo-France for it to estimate the order of magnitude of their hydrological impact on the ISBA modelling (which proved minimal). Finally, CEMAGREF and CNRS (UMR5600 Crenam) analysed the stability of the potential vegetation of the Rhône watershed in relation to the climate changes described in the scenarios.

The end of 2003 was devoted to the preparation of an long report (of almost 200 pages), which was amended in 2004 to take into account reviewers' comments. The present document is a summary of the revised report.