Chapter 1

Introduction to PRISM

1.1 Earth system modelling: the challenges ahead

The continued development and refinement of computational models that simulate the evolution of the Earth system is critical for climate research and prediction. Those models are invaluable tools for the scientific understanding of climate and some of them are also routinely used for numerical forecast purposes. They are critical for environmental impact assessment and provision of adequate information to decision makers. Significant progress has been made in the development of Earth system models (ESMs) over the last decade. The European scene of distributed research centres has been very successful in using high-end modelling as a tool for discovery-driven research. This resulted in diverse and creative approaches and contributed to Europe's leadership in the field. In the meantime however, the software environment of climate modelling has become exceedingly intricate because of the complexity of both the natural systems they describe and the computational platforms they use. If the diversity of approaches has ensured continued improvements in basic understanding of the natural processes, it has proven not to be equally beneficial for efficient software systems development. Modellers and climate scientists around the world realise today that greater software standardisation and isolation from scientific cores would facilitate their research. Likewise, standard data formats, a web-accessible data network and Grid adapted access software would accelerate progress by facilitating broader exchange, dissemination and shared analysis of model results. Staying at the forefront of scientific research in Earth system sciences requires to address these new challenges.

1.2 The PRISM concept

Today, Earth System modellers share very little beyond what is provided by computer manufacturers: compilers, message passing libraries, etc. However, for efficiency, they should share a lot more (Fig. **??**). The PRISM concept, initiated by a EURO-CLIVAR recommendation, is to share the development, maintenance and support of a comprehensive Earth System Modelling software environment. This is key to facilitate assembling, running, archiving and post-processing of ESM based on state-of-the-art component models developed in the different climate research centres in Europe and elsewhere. The PRISM software environment includes a number of technical standards for existing and future ESM internal composition and external control. It supports model diversity and promotes scientific progress of the community by

lowering technical development efforts of ESM teams.

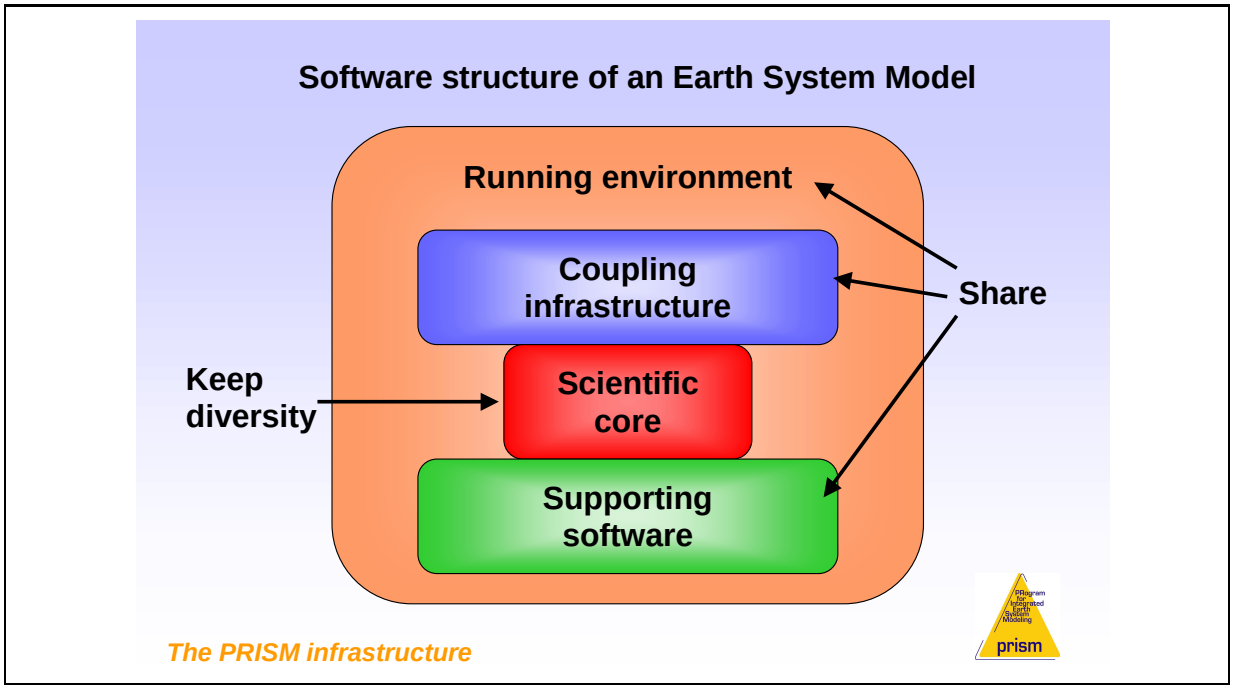

Figure 1.1: Structure of an Earth System Model. The non-Earth System science components can be share at the community level in the same way the FORTRAN compiler is shared today. This will help keep the key scientific diversity needed to ensure multi-model ensemble approaches required to address climate/seasonal weather prediction/forecast uncertainties.

A first version of the ”PRISM software” has been developed under European Framework Programme V funding and is now emerging as a core strategic infrastructure for building the European Research Area in Earth System sciences. PRISM represents the first major collective effort, at the European level, to develop ESM supporting software in a shared and coherent way, as is recognised by the Joint Scientific Committee (JSC) of the World Climate Research Programme (WCRP) that recently endorsed its value as a ”key European infrastructure project”.

The PRISM concept and project constitute the European coordinated response of a community wide undertaking. Strong collaborations are being established with related project in the US (Earth System Modeling Framework, ESMF) and elsewhere (FLUME project of the UK Met Office,...).

The long term benefits of shared software infrastructure for ESM include:

- high performance ESM software, developed by dedicated IT experts, available to institutes and teams at low cost: helps ES scientist focus on ES science and helps key scientific diversity.
- easier to assemble ESMs based on community models
- as demonstrated in other fields, a shared infrastructure is a powerful incentive for increased scientific collaboration
- computer manufacturers are willing to contribute to the infrastructure: this will help efficiency (porting, optimization) on a variety of platforms, the optimization of next generation of platforms for ESM needs, easier procurements and benchmarking, reduce computing costs.

1.3 The PRISM project

Recognising the need for shared software infrastructure, the European Network for Earth System Modelling (ENES) organised the PRISM project, which has been funded for 3 years (Dec 2001 – Nov 2004) by the European Union under the 5th Framework Programme. The PRISM project gathered 22 partners, including the main European climate modelling institutions and four computer manufacturers. It had an overall budget of 4.8 MEur, corresponding to a total effort close to 80 py.

One main objective of PRISM is to provide a portable, user-friendly, flexible, and standard based infrastructure for assembling, compiling, running, monitoring and post-processing Earth System Models built on state-of-the-art component models developed in the different European modelling groups. Structured data archiving and dissemination, NWP and data assimilation issues were not part of this pilot project.

PRISM achievements

Today, PRISM provides as standard software:

1. a standard coupler and I/O software, OASIS4
2. a standard compiling environment (SCE) at the scripting level
3. a standard running environment (SRE) at the scripting level
4. Graphical User Interfaces (GUIs) to configure the SCE and SRE
5. a GUI for an end-to-end monitoring of climate experiments
6. standard diagnostic and visualisation tools

PRISM also supports a number of standards developed in the community (like netCDF-CF for file and meta-data format, a list of universal parameters, CDAT analysis software,..) and contributes to their development and community-wide use as part of its “good practice” dissemination.

Currently, the PRISM SCE and SRE are configured for 9 European sites, and their respective GUIs are implemented on two test sites, at the Max Planck Institute (MPI) in Hamburg and at the European Centre for Medium-range Weather Forecast (ECMWF) in Reading. At the end of the project and as a major delivery, a new coupler and I/O software has been made available (OASIS4); thanks to the expertise gathered in PRISM, it benefited from the new opportunities offered by modern software design.

The PRISM project partners will provide an open source access to all PRISM software, and cost-free access to the monitoring GUI for research purposes in Europe.

Most state-of-the-art European component models have been adapted, or are being adapted, at different levels, to the PRISM standards:

- atmosphere-land models: ECHAM5 (MPI, Germany), ARPEGE4 (Mto-France, France), LMDz (Institut Pierre Simon Laplace - IPSL, France), and HadAM3 (Hadley Centre, UK)
- ocean and sea-ice models: MPI-OM (MPI, Germany), and ORCA-LIM (IPSL, France, and Universit Catholique de Louvain - UCL, Belgium)
- marine biogeochemistry models: HamOCC (MPI, Germany), and PISCES (IPSL, France)
- atmospheric chemistry models: MOZART (MPI, Germany), MOCAGE (Mto-France, France) and TM (Royal Netherlands Meteorological Institute - KNMI, The Netherlands)
- regional atmosphere models: HIRLAM (Danmarks Meteorologiske Institut - DMI, Denmark) and RCA (Swedish Meteorological and Hydrological Institute - SMHI, Sweden)

A number of combinations of these component models are assembled for the PRISM demonstrations [11] on the main community platforms (NEC-SX, SGI-Origin, Fujitsu-VPP, IBM-Power4, CRAY X1): ECHAM5 + MPI-OM; ECHAM5 + ORCA-LIM; ARPEGE4 + ORCA-LIM; ; LMDz-ORCHIDEE + ORCA-LIM; HadAM3 + ORCA-LIM; ORCA-LIM+ PISCES; MPI-OM + PISCES; MPI-OM + HamOCC; ECHAM5 + HIRLAM; ECHAM5 + RCA; ECHAM5 + MOZART; ECHAM5 + MOCAGE; Full ESM ECHAM5 + MOZART + MPI-OM + HamOCC; Full ESM ECHAM5 + MOZART + MPI-OM + PISCES,...

1.4 PRISM: the success and the next steps

Although PRISM was designed as a demonstration project, its technical value is already recognised by many European research groups. First user experiences show that using the PRISM system eases the assembly, compilation and running of complex component models via the use of PRISM standards. Some of the ESM configurations described above are starting to be used both for local scientific projects and wider community undertakings (IPCC runs, ENSEMBLES, GEMS, MERSEA FP6 projects, German COSMOS project,...). Adopting this new infrastructure will require decidated effort by most teams and parallel efforts with existing infrastructures for some time. Nevertheless, there is a clear community-wide agreement that the only long-term strategy is to adopt such a common framework.

Besides those technical achievements, one important success of PRISM is that it has brought the different partners of the European Earth system research community to interact and work closely together. This led to invaluable trust-building, naturally opening up into scientific co-operation and co-ordination. Today, thanks to the commitment of a number of institutions and IT partners, this closely co-ordinated network of experts (IT specialists, climate scientists, computer manufacturers,...) is being organised in a sustained way to 1) routinely maintain state-of-the-art software infrastructure for the Earth System Modelling community and 2) ensure coordinated development of next major phases: data management, data assimilation, link with NWP.