Scientific Computing at MPI-M

Climate and Earth system models run on high-performance computers with hundreds of processors, even thousands in the future. They generate large amounts of data. The objective of programming is not only to design a scientifically optimal program but also to be able to run the programs as quickly as possible to receive results soon. Constant adjustments of the programs to the high-performance computer architectures ensure high processing speed. How and by whom can these models be created in an effective and fast way? How do scientists handle the vast amounts of data in the order of tera- and petabytes?

Climate researchers at the Max Planck Institute for Meteorology (MPI-M) utilize the high-performance computing and data storage systems by the German Climate Computing Center (DKRZ). They develop special software for analyzing model data and need numerics and software specialists to address the tasks of model development and model use together.

CIMD - Computational Infrastructure and Model Development

In order to create synergies between all parties, MPI-M established the new scientific group CIMD (Computational Infrastructure and Model Development) and integrated it into a superordinate structure, a “laboratory” for scientific computing (SCLab – Scientific Computing Laboratory). The aim is to help scientists finding solutions for their scientific questions with the help of models more efficiently.

The CIMD group supports the technical development of Earth system models.
CIMD provides software libraries and tools for the model infrastructure, in close cooperation with the scientific departments and CIS (Central IT-Service). In addition, it is one of CIMD´s responsibilities to supervise the strategic medium and long-term modelling developments. For this purpose, CIMD is involved in the advancement of new projects and strategic decisions regarding model development. Specific tasks include model optimization for high-performance computing, pre- and post-processing, workflow and computer environment as well as the adaptation of new technologies.

CDOs - Climate Data Operators

A successful development and application of the Earth system models by MPI-M (MPI-ESM) requires a substantial, highly specialized software environment. This includes programs that facilitate the further processing of the generated, extensive data. Huge amounts of data in the order of petabytes have to be administrated and evaluated. How can those amounts of data be handled? For this purpose, Climate Data Operators (CDOs) have been designed under the lead of Uwe Schulzweida at MPI-M. This development is a true success story by now.

The CDOs are a collection of more than 400 operators to process and analyze data generated by climate and forecast models. They enable the scientists to create uniform formats, to interpolate between different computational grid types and resolutions and to convert the data into other formats.

With the help of the CDOs, large data sets can be partitioned and smaller data sets can be merged. CDOs allow equations and the arithmetic processing of data and also the computation of geophysical parameters and statistics. Thus, they are one of the most important tools for climate researchers when analyzing large model data sets. An extensive documentation and development platform helps the scientists with the application.

Further groups within SCLab

SCLab consists of CIMD and two other groups: Central IT Service (CIS) and Applied Mathematics and Computational Physics (AMCP). Furthermore, an IT strategist maintains the MPI-M IT partnerships. SCLab is headed by one of the three MPI-M directors, currently by Managing Director Prof. Bjorn Stevens.

CIS, being the Central IT Service at MPI-M, supports and develops the IT environment for the climate researchers, including the access to DKRZ. The tasks include the hardware provision and operation, constructing and maintaining servers and software and the technical website support. Specific requirements of the MPI-M are managed in projects. The central focal point for every MPI-M employee is the help desk of CIS.

AMCP is responsible for the development of the dynamic operators underlying the Earth system models. Those are applied mathematics algorithms for the flow dynamic cores of the MPI-M atmosphere and ocean models, formulated as partial differential equations. Furthermore, AMCP´s field of activity covers the interface between the cores and the physical parameterizations. AMCP currently leads the development of the ocean component in the new ICON model. Their development work requires a close cooperation with the group CIMD and its expertise in computer architecture and infrastructure.

MPI-M actively cooperates with numerous other institutes in IT infrastructure projects.
Those cooperative projects often have a strategic character, positively affecting the scientific progress. The IT manager for strategic MPI-M IT partnerships initiates and maintains those partnerships and represents MPI-M in this respect. He works closely with the director responsible for SCLab and the SCLab groups.

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