



## **Agile project management for software development in Earth sciences**

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Scientific software in the form of developed program code is of great importance for geosciences. In climate sciences for example, it constitutes the basis of numerical models used to perform climate experiments. A traditional linear approach to software development, is the waterfall model, based on discrete phases of analysis, design, coding and testing. The phases build on each other and are carried out in a predetermined sequence. While this approach has a high level of planning security, it also entails little flexibility and changes in the requirements can be taken into account only with great difficulty. However, software requirements in scientific projects are often unclear at the start of the software development project and subject to changes at later stages of development making the application of the waterfall model not suitable. Additionally, the iterative procedure that characterises scientific research in general makes an agile procedure more appropriate.

Many agile methods and practices have evolved from the foundations of the Manifesto for Agile Software Development (<http://agilemanifesto.org/>) and are characterised by a continuous comparison of the expectations to the actual state of the software under development, thus offering a much higher flexibility. When managing a research project according to agility principles it is critical that the project manager understands and implements the concept and philosophy of the agile method valuing individuals, interactions and collaboration, and embracing change throughout the entire project.

Starting from these considerations and the detailed analysis explained in Wieters and Fritzsich (2018), here we present the specific case of the development of ESM-TOOLS following agile principles. ESM-TOOLS (<https://www.esm-tools.net/>) is a software developed to unify model infrastructure, giving a common framework for downloading, compiling, running and organising coupled or standalone models. ESM-TOOLS is developed within the Advanced Earth System Modelling Capacity project (ESM), a Helmholtz Association-funded project that aims to improve the representation of the components of the Earth system and their coupling, and perform a series of selected numerical experiments (Frontier Simulations).