The EGSIEM project brought together scientists from around Europe and a number of specialist fields to address fundamental problems in the monitoring of earth's water resources by using existing and future Earth Observation (EO) satellite data. The project sought to show how the redistribution of environmental mass can deliver fundamental insights into the global water cycle, using observations, derived from the Gravity Recovery and Climate Experiment (GRACE) and the subsequent GRACE Follow On mission.

Changes in continental water storage control the regional water budget and can, in extreme cases, result in floods and droughts that often claim a high toll on infrastructure, economy and human lives. EGSIEM has demonstrated that mass redistribution products open the door for innovative approaches to flood and drought monitoring and forecast. The timeliness and reliability of information is the primary concern for any early-warning system and EGSIEM has improved the temporal resolution from one month, to just one day, and to provide gravity field information within less than 5 days (near real-time). Early warning indications derived from these products are expected to improve the awareness of potentially evolving Hydrological extremes and have started to help in the scheduling of high-resolution follow-up satellite
observations. EGSIEM has provided improved data and indicators for integration into the work of the Center for Satellite Based Crisis Information (ZKI, operated by the German Aerospace Center) and its use within international initiatives, such as the Copernicus Emergency Management Service and the International Charter "Space and Major Disasters".

To ensure robust performance of EGSIEM products they have been assessed with complementary data and post-processed mass products derived from the combined knowledge of the entire European GRACE community unified within our consortium.

The overall objectives for EGSIEM can be summarised as:

1) a scientific combination service
2) a near real-time service
3) and a hydrological/early warning service

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

During the first years of the project most of the wide-ranging work undertaken by the EGSIEM consortium was concerned with the improvement of existing gravity products, to this end there was significant work undertaken on creating a combined solution from the various GRACE Analysis Centres which are represented within EGSIEM. Based on the EGSIEM processing standards, the scientific service delivers the best combined Earth's gravity field solutions and user-friendly L3 products covering a demonstration period of two years of GRACE data from 2006 to 2007, these have been made available via the project website. For the calculation of the combined solutions, a common denominator needed to be defined to allow for a controlled exchange and combination of the Analysis Centres (AC) solutions. For the first time in the gravity field community, the already existing Solution INdependent EXchange (SINEX) format has been used to exchange the normal equations of the various ACs in the EGSIEM consortium. Single AC solutions as well as the combined solution have been provided to the ICGEM (the International Center for Global Gravity Field Models) where they are archived and are in the process of being assigned with a digital object identifier. The Scientific Combination Service shall be continued as part of IAG’s International Gravity Field Service (IGFS). It is intended that the International COmbination Service for Time-variable Gravity fields (COST-G) will be formally established as a service center under the umbrella of the IGFS. In terms of non expert access to GRACE data the consortium is pleased to report development undertaken on the EGSIEM Plotter which allows for a number of different visualisations of gravity Data and which has been updated continuously since the start of the project, users can now save and share their work created within the plotter, a unique feature developed to encourage cross-disciplinary research at all levels.

Hydrological applications using GRACE data proved that it is possible to derive gravitational based wetness indicators that allow users to quantify catchment anomalies. However, reducing the latency from 60 to less than five days and increasing the temporal resolution to daily for a low degree Earth’s gravity field solution has been a prerequisite to establish a prototype monitoring service. The EGSIEM consortium realized this within the near-real time (NRT) objective. In terms of operational processing, the Analysis Centers at GFZ and TUG are now able to deliver daily global and regional gravity field solutions
within less than the projected five days latency in a fully automated manner including computation, internal evaluation and distribution. For the operational test period the consortium successfully ran the service in real-time. In the run up to the NRT service operational test run, the whole GRACE time series from 2002 until 2017 was successfully processed. The resulting post-processing solutions of both GFZ and TUG are publicly available as gridded water storage products at the respective ftp servers, the service is currently on-hold due to the decommissioning of GRACE. The gravitational wetness index derived by the EGSIEM consortium enables users to monitor (sub-) surface hydrological mass variations in near-real time. The primary effort of this service was therefore the reliable and robust derivation of the wetness index from the products provided by the NRT.

**Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)**

The EGSIEM consortium was dedicated to combining a various of Earth Observation data into three main products for use by the scientific community, but for the benefit of everyone. By incorporating GRACE derived daily wetness indicators into existing flood and drought monitoring applications (such as the Interactive DLR Web-Client utilizing Terrasar-X/Sentinel-1 data) the monitoring of and reaction time for potentially disastrous events has been improved. GRACE L2 data is now available in a much more standardized format (thereby simplifying access to this rich source of gravity field information), which will encourage users from all scientific backgrounds to use the data (which is freely available from various providers, all of which can be found on our project website). Lastly the time resolution for data on the global water cycle has been improved by a factor of 30, this means better, quicker decision making is possible and the potential impact could save lives by highlighting unusual water movement patterns, and providing significantly better data to hydrologists and emergency services.