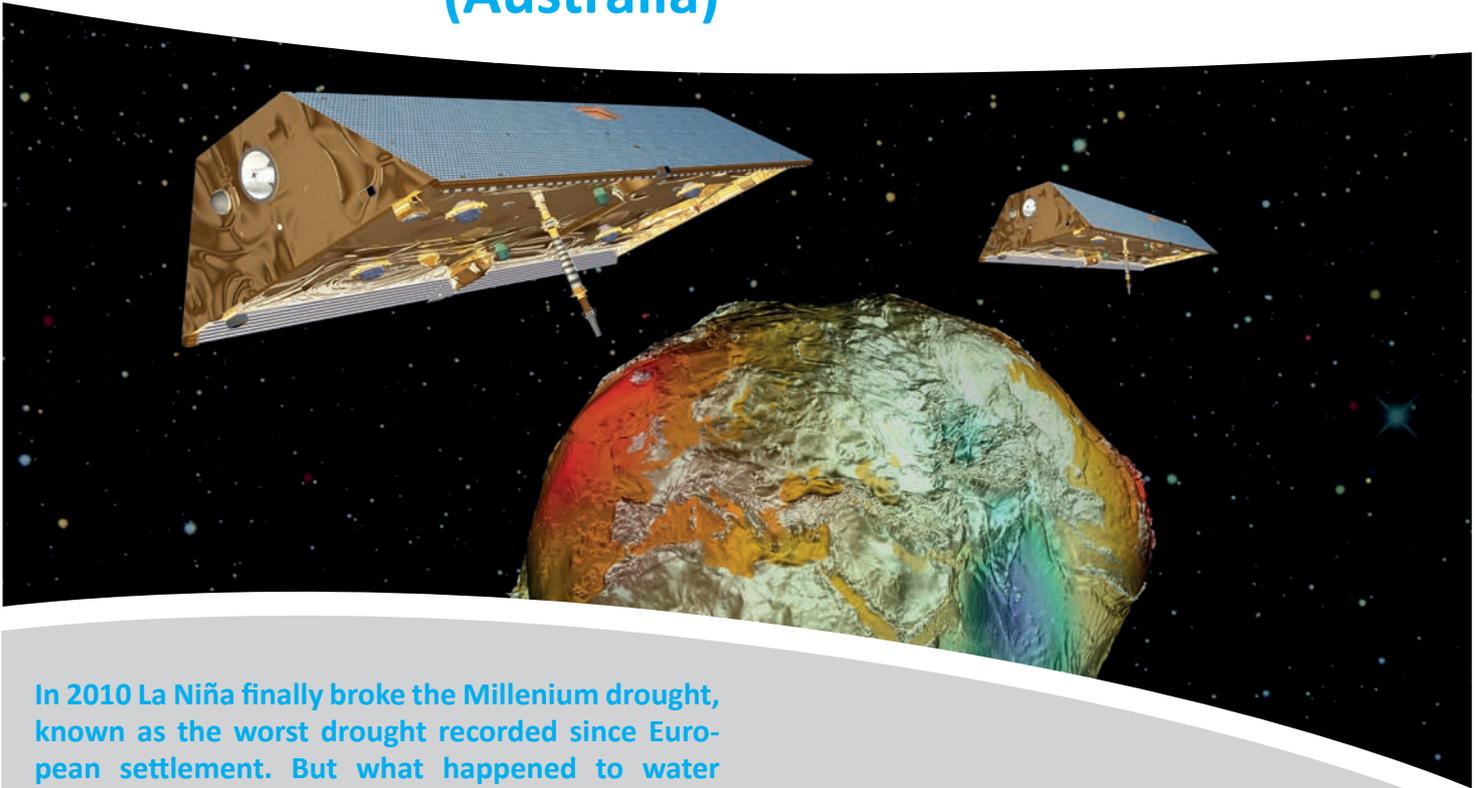


GRACE over the Great Artesian Basin (Australia)

Quantifying ground and surface water loss from 2011 to 2015 over the area of the Great Artesian Basin using gravity data from GRACE satellite mission



In 2010 La Niña finally broke the Millenium drought, known as the worst drought recorded since European settlement. But what happened to water storage over the GAB area after that?

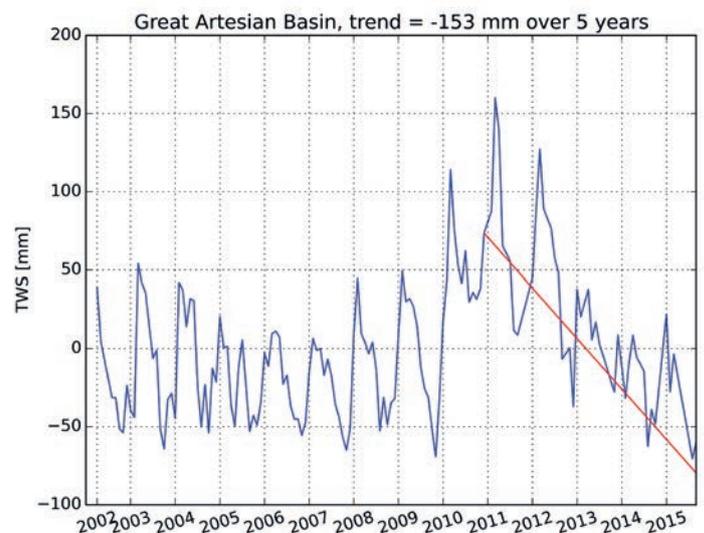
We used spaceborne gravity data in order to approximate the rate at which water storage diminished over the period of 5 years and estimated the total quantity of water lost over the area defined by the Great Artesian Basin in Australia.

The gravity data was measured by the Gravity Recovery and Climate Experiment (GRACE) mission (2002-2017). The GRACE mission is a joint project between the National Aeronautic and Space Administration (NASA), the German Aerospace Center (DLR) and the German Research Centre for Geosciences (GFZ) in Potsdam.

The above image is an illustration of the twin GRACE satellites orbiting Earth at an altitude of approximately 490 km. The distance between the two satellites is 220 km and they orbit the Earth in about 95 minutes.

The potato shaped image of the Earth known as the "Potsdam gravity potato" shows the difference in the strength of the gravity field across the planet, where higher (red) areas represent stronger gravity and lower (blue) areas weaker gravity.

The strength of the gravity signal in a particular region changes with the available mass concentrated in it. One of the most common reasons for change of mass in a region not covered by ice is the depletion or accumulation of large quantities of ground and surface water, i.e. due to dry or rainy seasons as well



Monthly Terrestrial Water Storage (TWS) of the 1,700,000 km² over the area of the Great Artesian Basin, Australia. Graph shows the calculated change (+/- mm) in water level above a modelled surface; TWS throughout the years 2011-2015 has decreased 153 mm, corresponding to 301.6 Gt of water in the depicted area.

as intensive groundwater usage. As the signal is not weather dependent, we get continuous global coverage from the satellites. The total amount of accumulated ground and surface water, soil moisture, snow, and ice is called Terrestrial Water Storage (TWS). The magnitude of the change of the strength of the gravity signal between seasons can be described as changes (+/- mm) in the height of a water layer above the particular region.

The graphic above demonstrates that the total loss of water in the 1,700,000 km² GAB region in Australia amounts to 301.6 Gt. This amount is comparable to a water column of 153 mm high covering the entire area. The reduction of this enormous volume of water occurred between 2011 and 2015 and probably beyond. In contrast, we observe an increase in TWS of 80 mm over the same area between 2009 and 2011. This increase was most likely driven by the extension of the La Niña effect on the SW Pacific, which periodically results in above average rainfall. The increase however does not compensate for the massive loss in TWS observed during the ensuing drought.

An update on the GRACE analysis for the GAB area since 2015 and ongoing data is available through our service. The GRACE Follow On (GRACE-FO) mission launched successfully on 22nd May 2018 from Vandenberg Air Force Base in California and enables continuing observation of the TWS in Australia and will quantify the fluctuation of water levels in the coming years. First data from GRACE-FO will be available by the end of 2018.

Service offered:

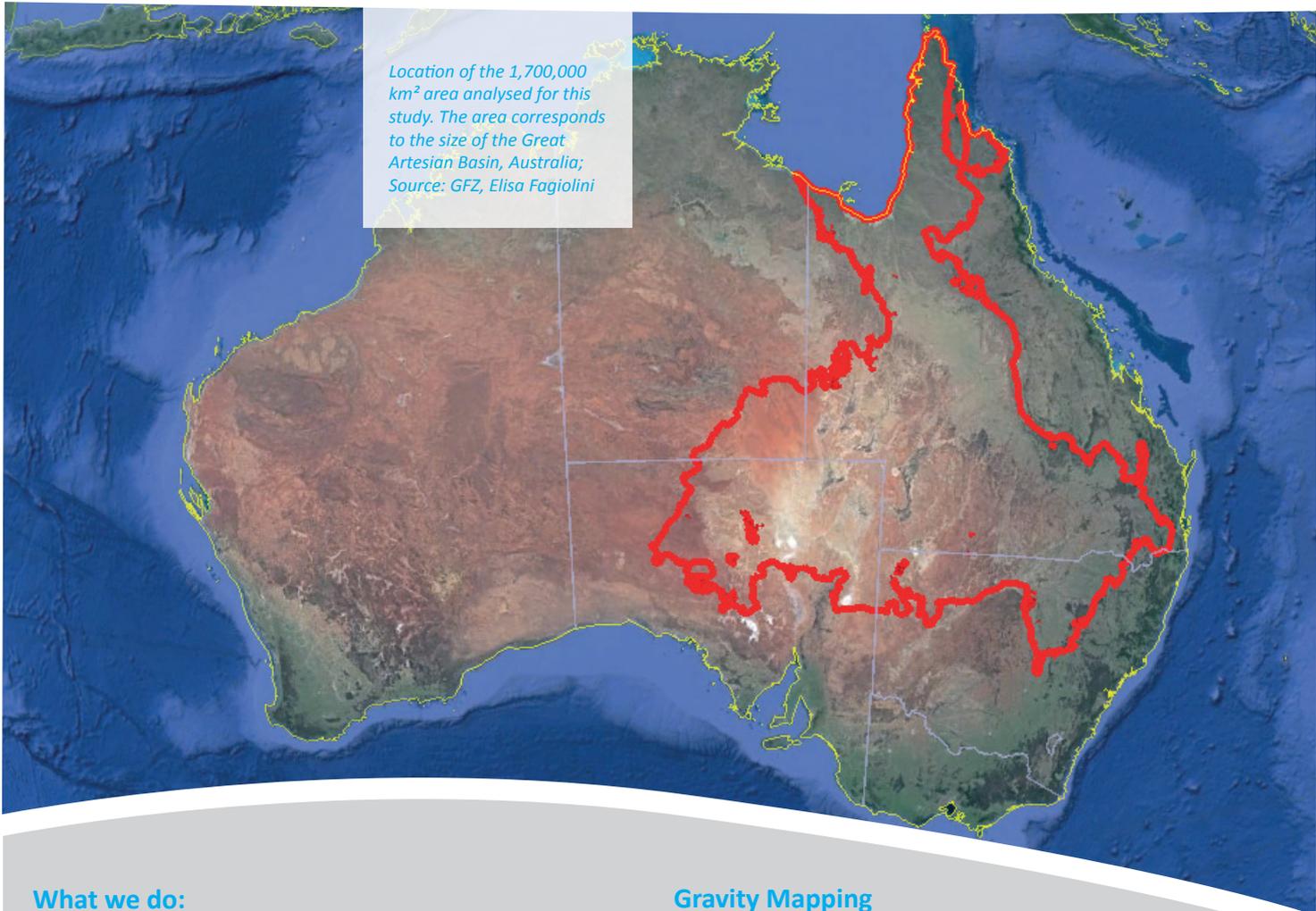
We offer Water Sustainability Assessment using GRACE gravity data in combination with additional remote sensing and in-situ measurements to help improve planning processes for public administrators, water utility companies or agribusinesses. We can provide large-scale water storage analysis and monitoring, including identification of trends indicating water

shortage or potential flood risk in regions with little or no available hydrological data.

Our services enable:

1. Better regional water management insights from historical analysis of groundwater and surface water availability using spaceborne gravity data.
2. Improved early warning system with monthly water sustainability assessment to plan and mitigate water storage trends and flood risks.
3. Quantification of water loss or gain on a regional scale based on GRACE data
4. Enhancements of existing hydrological models; using GRACE data to improve spatial and time series data derived from in-situ data at local and regional scales.

Local area and regional catchment (< 100,000 km ²)	At local scale, GRACE data can be applied in association with in-situ measurements, hydrological models, other satellite and meteorological data.
Larger area (> 100,000 km ²)	At these scales, GRACE data can provide information to monitor areas where little or no in-situ hydrological data is available. When integrated with local hydrological models, GRACE spaceborne gravity data from regional and larger catchment areas can provide a prediction of risks such as water shortages or floods at the local scale.



Location of the 1,700,000 km² area analysed for this study. The area corresponds to the size of the Great Artesian Basin, Australia; Source: GFZ, Elisa Fagiolini

What we do:

1. Collection and pre-processing of GRACE data for the region of interest.
2. Post-processing and interpretation of GRACE data for available time series.
3. Integration of additional hydrological data provided by the customer or through open sources.
4. Surveillance of regional trends and identification of changes in water availability

Gravity Mapping

The mass within the Earth and on its surface is not evenly distributed. Molten rock flows in the Earth core, water masses move in the oceans and on the continents, and atmospheric masses are also in continuous movement. Since the gravity force of a body depends on its mass, the irregular mass distribution on our planet causes an inhomogeneous gravity field. Regions of slightly stronger gravity will affect the leading GRACE satellite first, pulling it slightly away from the trailing satellite. This is reflected by a small change

Contact

If you wish to learn more about how to use GRACE data to assess water sustainability and improve water management and drought mitigation efforts in your region, please get in touch with ReSens+Space initiative at Helmholtz Center Potsdam, German Centre for Geosciences (GFZ) of our regional representatives.

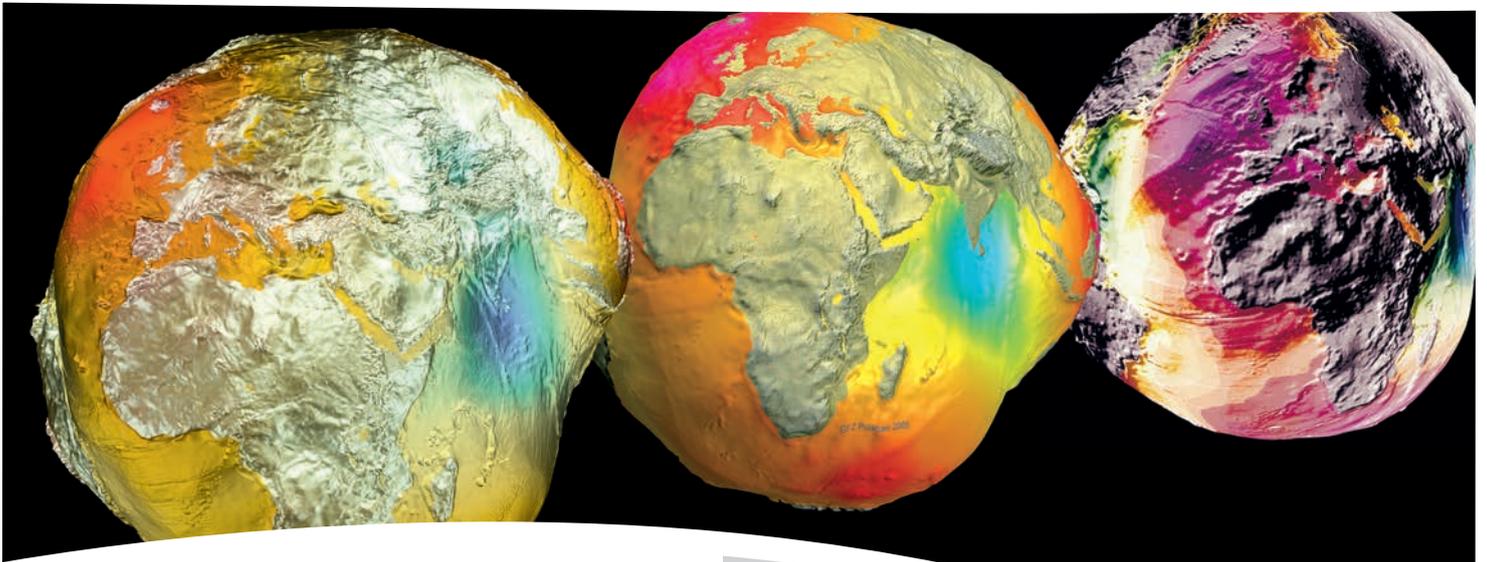
Contact Elisa for a free consultation on (+49) 8153-90832-23 or fagiolini@gfz-potsdam.de (Timezone: CEST) c/o DLR Oberpfaffenhofen, D-82234 Wessling, Germany

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Increased spatial resolution of the geoid models calculated at the GFZ in recent years. Source: http://media.gfz-potsdam.de/gfz/wv/doc/infothek/leaflets/12_07Kartoffel.pdf

in the distance between the satellites. Consequently, high-precision tracking of the constantly changing distance enable tiny mass variations of the Earth to be measured. To conduct this measurement, GRACE uses a uniquely precise microwave ranging system measuring the distance between both satellites with an accuracy of some microns – about one-tenth the width of a human hair – over a distance of 220 km!

The immense accuracy of the distance measurements enables the Earth gravity field to be mapped approximately once a month continuously over years. With the GRACE mission, for the first time, systematic and

thorough monitoring and mapping of water and mass transfer processes between land, ocean and atmosphere is performed, allowing us to quantify water loss or gain on a regional scale.

As the NASA mission partner, GFZ takes the lead in the collection and analysis of data from both GRACE and GRACE-FO missions. We continuously improve the mathematical modelling behind the results presented and use the most advanced processing techniques to fully exploit GRACE's ability to map water and mass redistribution within the Earth system.

References

Selected studies carried out at GFZ about GRACE mission and its application are:

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