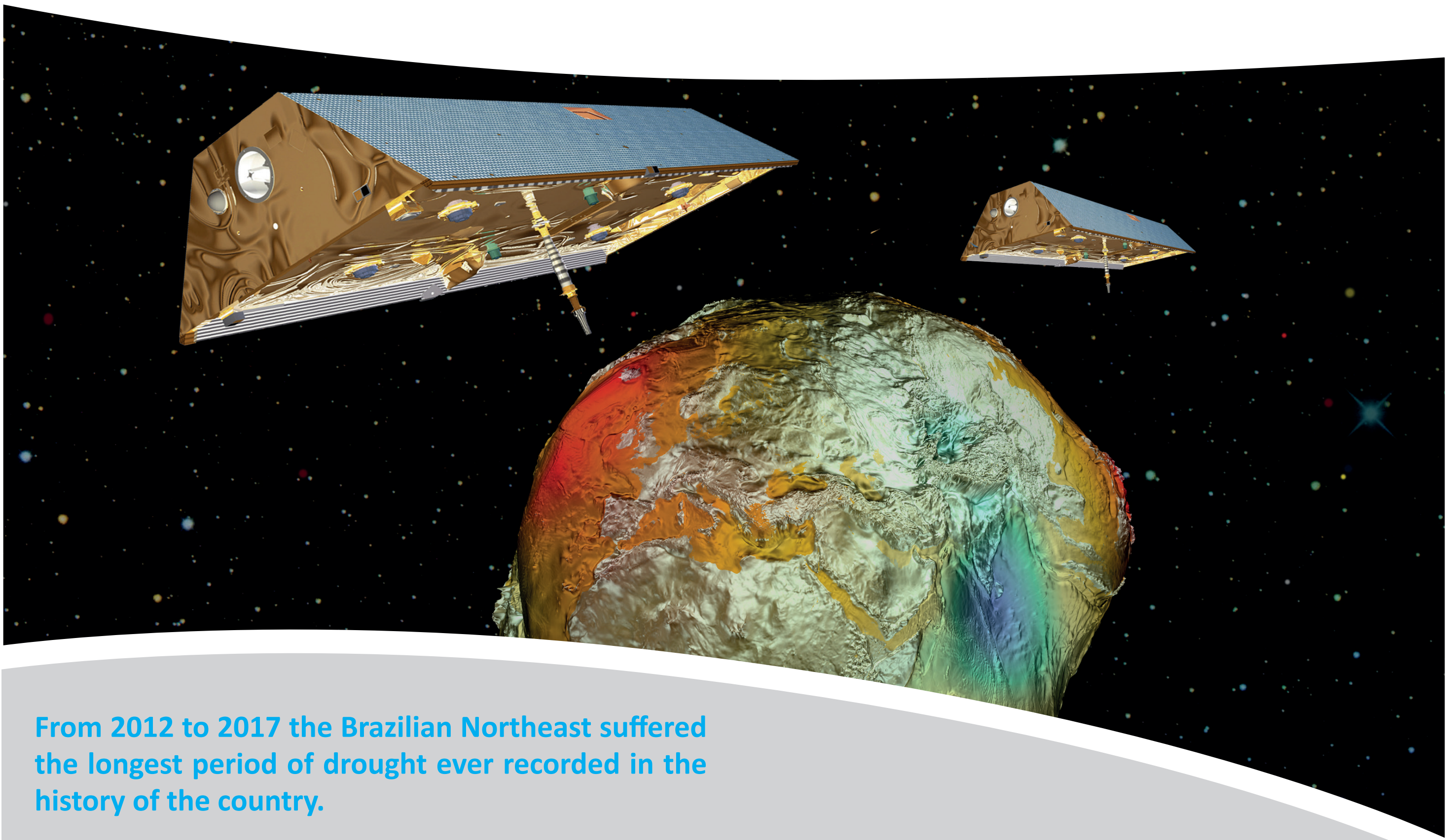
GRACE for the Northeast of Brazil

Quantifying ground- and surface water loss during the 2012-2017 drought in northeast Brazil using gravity data from GRACE satellite mission



From 2012 to 2017 the Brazilian Northeast suffered the longest period of drought ever recorded in the history of the country.

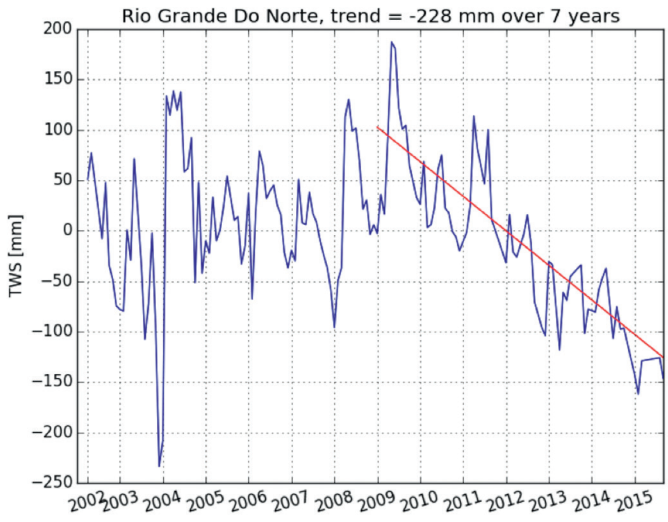
We used spaceborne gravity data in order to approximate the rate at which water storage diminished over the period of 6 years and estimated the total quantity of water lost in a selected area in the State of Rio Grande do Norte.

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 Aeronautics 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 the Earth at an altitude of approximately 490km. The distance between the two satellites is 220km 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 sea-



Monthly Terrestrial Water Storage (TWS) of a 48,400 sqkm region in Rio Grande do Norte, Northeast Brazil. Graph shows the calculated change (+/- mm) in water level above a modeled surface; TWS throughout the years 2002-2009 has risen 38 mm; From 2009 to 2016 the loss of water level above the modeled surface was 228 mm, corresponding to 11.1 Gt of water in the depicted area. The onset of the drought is marked by the first below average TWS in the year 2012. Source: GFZ, Elisa Fagiolini

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sons as well as intensive irrigation with groundwater. 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.
In the graphic below the loss of water in a 48,400 sqkm region in Rio Grande do Norte is strongly reflected by the reduction of 228 mm over 7 years. This reduction corresponds to a volume of 11.1 Gt of water that has been lost between 2009 and 2016, leading to the long lasting drought in the region. In contrast, the increase in TWS from 2008 until mid 2009 is most likely driven by the El Niño effect, known for it's large-scale impact on global weather and climate.

The GRACE Follow On (GRACE-FO) mission launched successfully on 22nd May 2018 from Vandenberg Air Force Base in California will allow us to continue our observation of the TWS in Northeast Brazil and eventually quantify the hopeful restoration of water levels due to heavier and more regular rain fall 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 measurments 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:

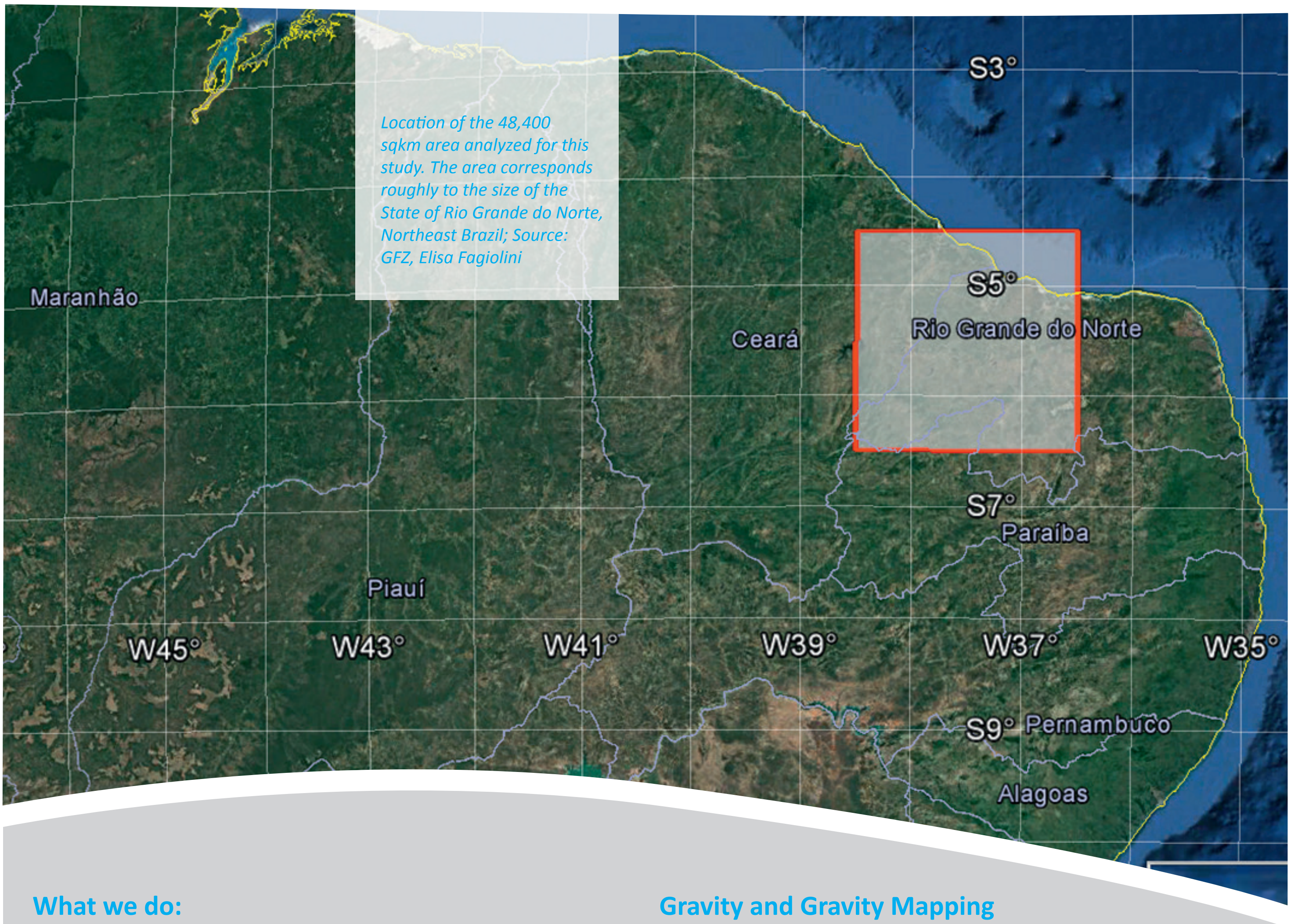
1. Better regional water management insights from historical analysis of groundwater and surface water availability using spaceborne gravity data;

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 provides 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 48,400 sqkm area analyzed for this study. The area corresponds roughly to the size of the State of Rio Grande do Norte, Northeast Brazil; Source: GFZ, Elisa Fagiolini

What we do:

1. Collection and pre-processing of GRACE data for the region of interest;

2. Post-processing and intepretation of GRACE data for available times 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 and 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.

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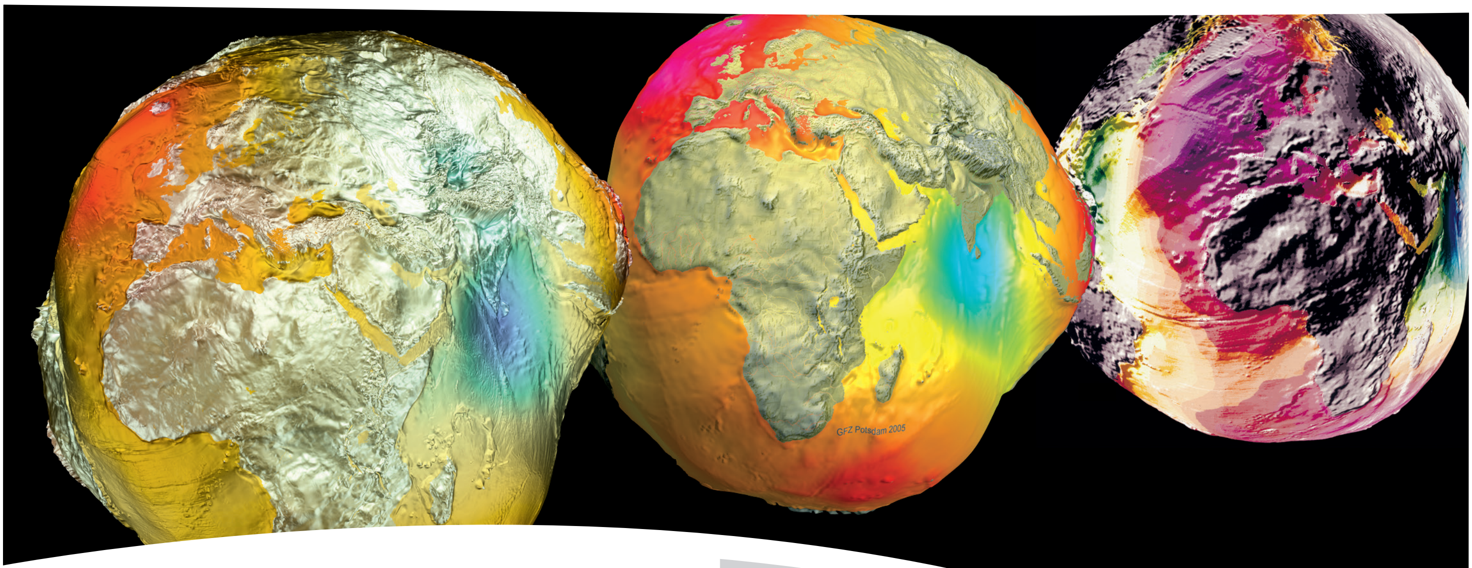

Increased spatial resolution of the geoid models calculated at the GFZ in recent years. Source: http://media.gfz-potsdam.de/gfz/wv/doc/infothek/leaflets/12_07Kartoffel.pdf

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. For 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:

Dahle, Christoph et al., 2012. GFZ GRACE Level-2 Processing Standards Document for Level-2 Product Release 0005, Scientific Technical Report

Flechtner, F., 2014. LOTSE-CHAMP/GRACE: An Interdisciplinary Research Project for Earth Observation from Space. Observation of the System Earth from Space - CHAMP, GRACE, GOCE and future missions

Flechtner, et al., 2016. What Can be Expected from the GRACE-FO Laser Ranging Interferometer for Earth Science Applications?. Surveys in Geophysics

Güntner, A., 2008. Improvement of Global Hydrological Models Using GRACE Data. Surveys in Geophysics

Güntner, A., 2010. Continental Water Storage Variations from GRACE Time-Variable Gravity Data. System Earth via Geodetic-Geophysical Space Techniques

Zhang, L., et al., 2016. Globally gridded terrestrial water storage variations from GRACE satellite gravimetry for hydrometeorological applications. Geophysical Journal International