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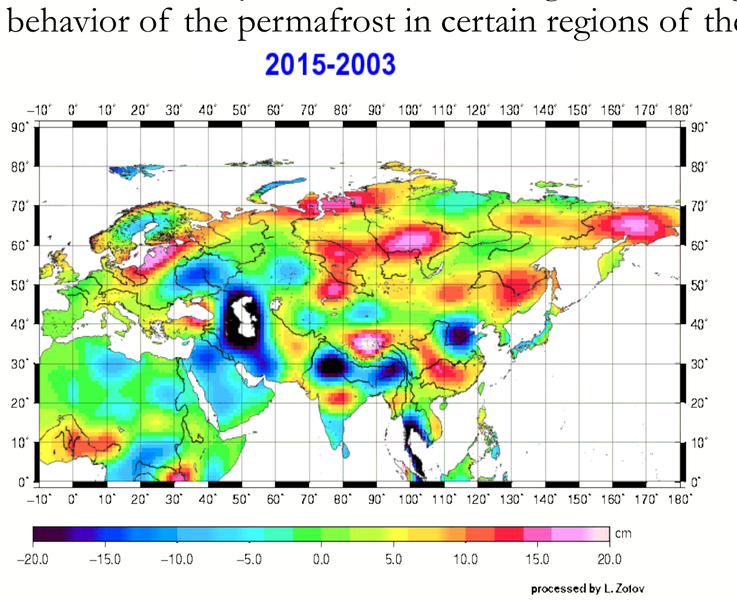
Hydrological balance in the large Russian river basins from GRACE satellites

Introduction

Gravity Recovery and Climate Experiment (GRACE) twin satellites have been observing the large-scale Earth's mass transports since 2002. These transports are related to natural hazards, hydrological and lithosphere processes, such as sea level rise, ground water evolution, snow and ice ablation and accumulation, etc. Climate change is increasing the frequency of extreme weather events, floods and droughts [OECD, 2012]. For example, about 90% of disasters in Asia are nowadays related to water [*Saritas et al.*, 2014]. This makes the global scientific community scrutinizing the climate change effects, and GRACE data is involved as an important source of geophysical and hydrological information, which helps to predict drafts and floods, can have agricultural and water management applications.

Aims of the research

The research applied data from GRACE satellites for quantifying the hydrologic and climate-induced mass variations for the 15 largest Russian river basins over the last 13 years (2003-2015). The application of space gravimetry allows studying the impact of climate change in form of long-term and seasonal changes in water balance of river basins. It may also increase the forecast accuracy of flood and drought events, agriculture productivity, and behavior of the permafrost in certain regions of the country by tens of %.



↑ Fig 1. Trend in mass changes since 2003 till 2015 from GRACE over Eurasia.

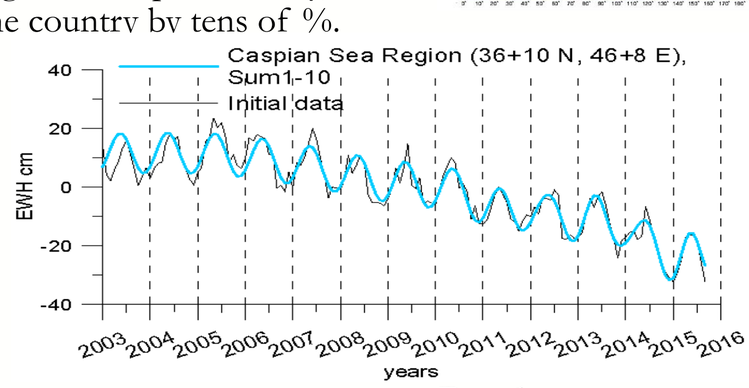
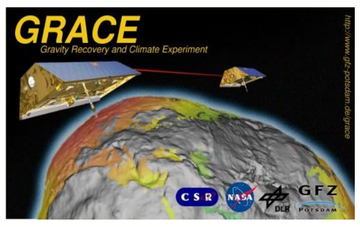


Fig 2. ↑ Average mass changes in the Caspian Sea region.



Methodology

The research introduced a new approach to process the data from GRACE – Multi-channel Singular Spectrum Analysis (MSSA), eliminating the meridional noises (or stripes), and separating the principal signal components. Despite the mathematical complexity, MSSA is more flexible compared to other methods of removing stripes. The data from GRACE Level 2 RL05 JPL data was filtered by MSSA, only variations in the gravitation field associated with climate and hydrological processes remained. The data was studied in the region, constrained by the 15 major river basins of Russia, such as Ob, Yenisei, Lena, Amur, Volga, Kolyma, Dnepr, Don, Khatanga, Indigirka, the Northern Dvina, Pechora, Anadyr, Jan, Olenyok.

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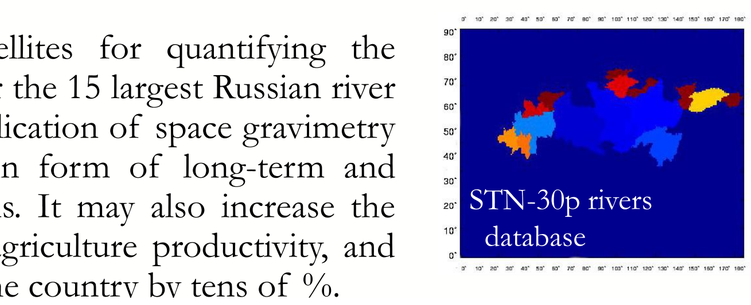
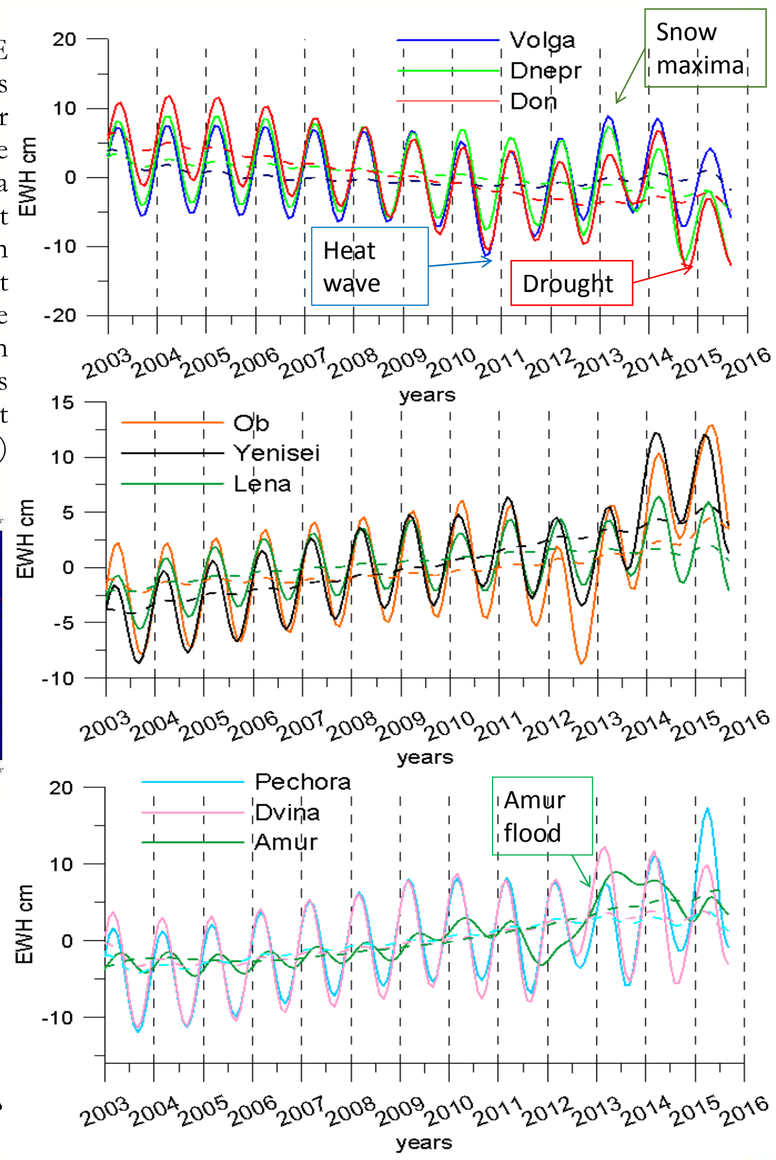
→ Fig 3. The GRACE data for mass anomalies averaged in particular river basins of: the European part of Russia (top), Siberian part (middle), the Russian North and the Far East (bottom). The solid line is MSSA filtered sum signal, the dotted line is the trend. Equivalent water height (EWH) levels in cm.





Results

Firstly, the maps for **climate-driven trends**, reflecting the changes of the gravitational field over 13 years over territory of Russia were obtained and analyzed (Fig 1) . In Eastern Siberia, in the sources of the Yenisei and the Lena, a positive anomaly associated with the permafrost degradation [*Landerer et al.*, 2010] was detected. The large negative trend at the Caspian Sea (Fig 2) can be attributed to its level decrease.

Secondly, smoothed variations, annual components and **trends of water redistribution** were averaged in the largest Russian river basins. Major rivers from the European part of Russia show decreasing trends, while the Siberian rivers show positive trends (mass increase) (fig.3). The letter define the general increasing trend throughout Russia, and have important influence on the Arctic region.

Such events as the heat wave in Volga basin in summer 2010, the Amur flood in 2013 can be clearly observed in GRACE data. GRACE results match hydrological models such as GLDAS or INMOM.

GRACE data is very useful for hydrological and climatological studies, especially over large territory. We propose **to create a GRACE data processing center** in Russia using a novel technique such as MSSA.

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