

Satellite Based Monitoring of Total Water Storage and Groundwater Variations over Indus Basin

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Introduction:

Gravity Recovery and Climate Experiment (GRACE) Satellite is a twin satellite gravity mission was launched in 2002 as a joint satellite mission of NASA (National Aeronautics and Space Administration), USA and DLR (German Aerospace Centre) (Rodell, et al, 2009). GRACE is a polar orbit at an altitude of 456 km and provides ten daily to monthly temporal solutions. These twin satellites are revolving around earth maintaining about 220 km distance from each another with spatial resolution of 100 ~ 350 km with objective to monitor the variations in the hydrological cycle at global to regional scales.

GRACE is especially designed to measure temporal variations in the gravity field caused by mass changes in different bodies over earth surface. These measurements can be processed to estimate changes in terrestrial water storage (TWS) and groundwater variations. The uniqueness of GRACE is its specialty to sense complete vertical profile of water cycle including Snow, Glacier, Surface water, Soil Moisture, Biomass and groundwater. With its interesting capability to measure water at all levels, GRACE establishes its superiority on others like altimeters which are only restricted to monitor one or two parameters.

The GRACE based ten daily to monthly scales water storage anomalies which are the estimates of the changes in TWS over a specific region. Using this, the phenomenon like floods (Reager and Famiglietti, 2009) and droughts (Long et al., 2013) could be studied easily. Similarly, GRACE has verified its potential to clearly identify areas with more groundwater recharge and the areas where groundwater mining is taking place as a result of huge groundwater withdrawals or pumping over India (Rodell, et al., 2009). The satellite datasets are very cost-effective (some are even free), reliable, frequent data availability (no data sharing issues as compared to traditional datasets), high to coarse range of spatial resolution (providing ease to understand different hydrological phenomenon from local to regional scales) and their repetitive coverage from days to months (long term data continuity).

Pakistan Council of Research in Water Resources (PCRWR) in collaboration with University of Washington-USA under NASA-SERVIER and NASA Water program has started a program of organizational capacity building of PCRWR in early 2015. As a result of this collaborative capacity building program, PCRWR has acquired training at University of Washington, USA on GRACE data processing as a part of Remote Sensing training. Now, PCRWR has become one of the premier leading organizations to independently process GRACE data and to get maximum benefit from NASA's free available satellite datasets for the monitoring of basin scale hydrology in the region.

Satellite Based Groundwater Storage Monitoring:

For the extraction of GRACE based TWS, the Centre for Space Research at University of Texas (CSR) Release 05 Level-2 data product called "CSR RL05 L2" is used in this study. GRACE monthly gravity field datasets are provided by the NASA PODAAC (<ftp://podaac.jpl.nasa.gov/allData/grace/L2/CSR/RL05/>). CSR is one of the three key GRACE data processing centres as a part of Science Data System (SDS). The data smoothing, de-correlation and signal restoration techniques have been applied for the extraction of TWS. The de-correlation filters are required to apply for the removal of correlated data errors whereas the smoothing help to minimize the de-striping or noise reduction. The average of six model's output is used as scaling factor for actual signal restoration after filtering as proposed by Long et al., 2015a.

The map (Fig. 1) shows the monthly TWS variations over Indus Basin during the month of April, 2015. The average TWS variation over Indus basin is 6.83 mm for the month of September, 2015 whereas, the average variation of TWS over Upper Indus Plain (UIP) is 22.11 mm.

The Fig. 2 shows GRACE satellite based monthly groundwater storage variations during the month of September, 2015 over Upper Indus Plain where groundwater is majorly exploited for agricultural requirements. The average GWS depletion is 8.90 mm per month for the month September, 2015.

Acknowledgement:

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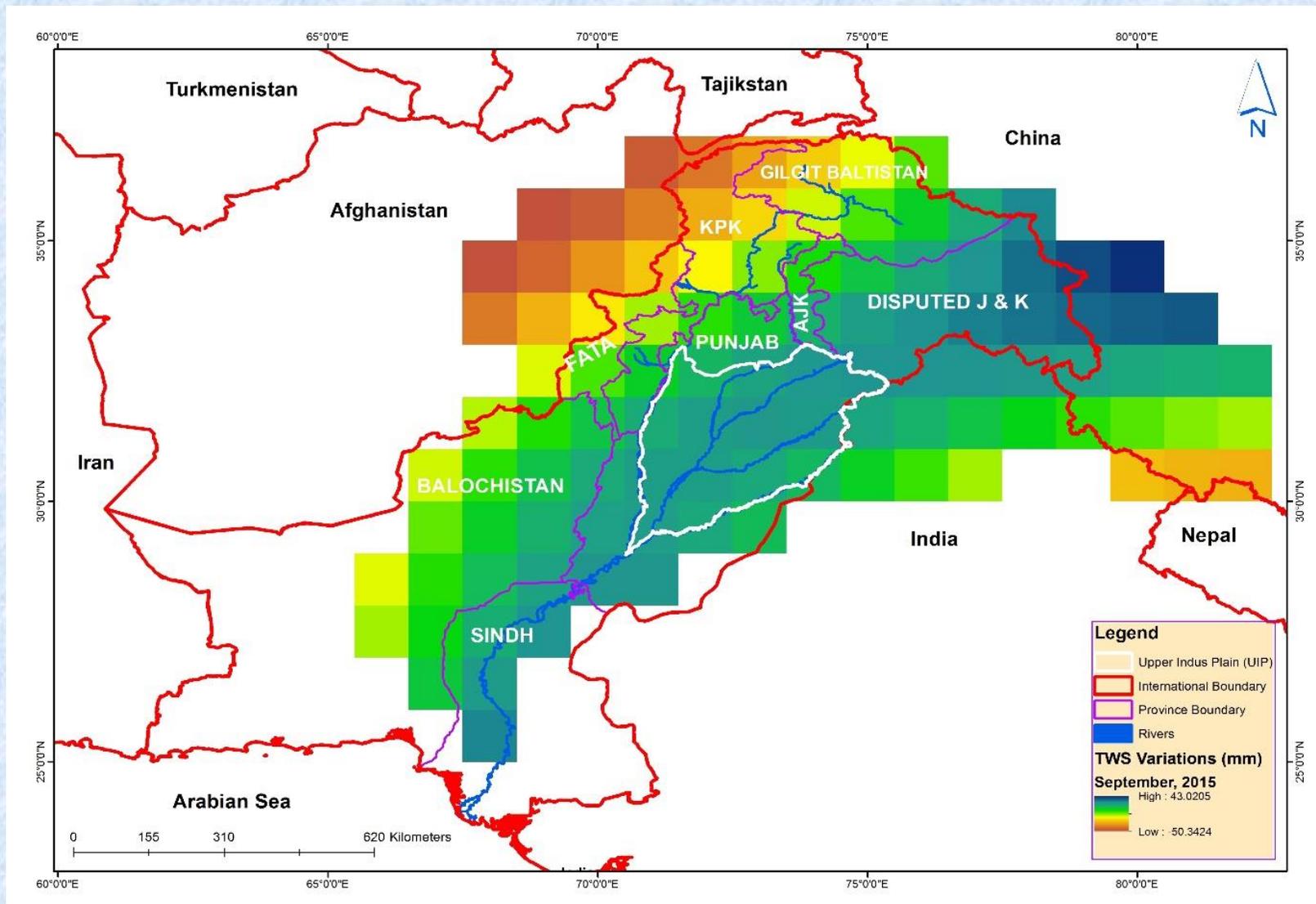


Fig. 1: TWS Variations over Indus Basin during the month of September, 2015

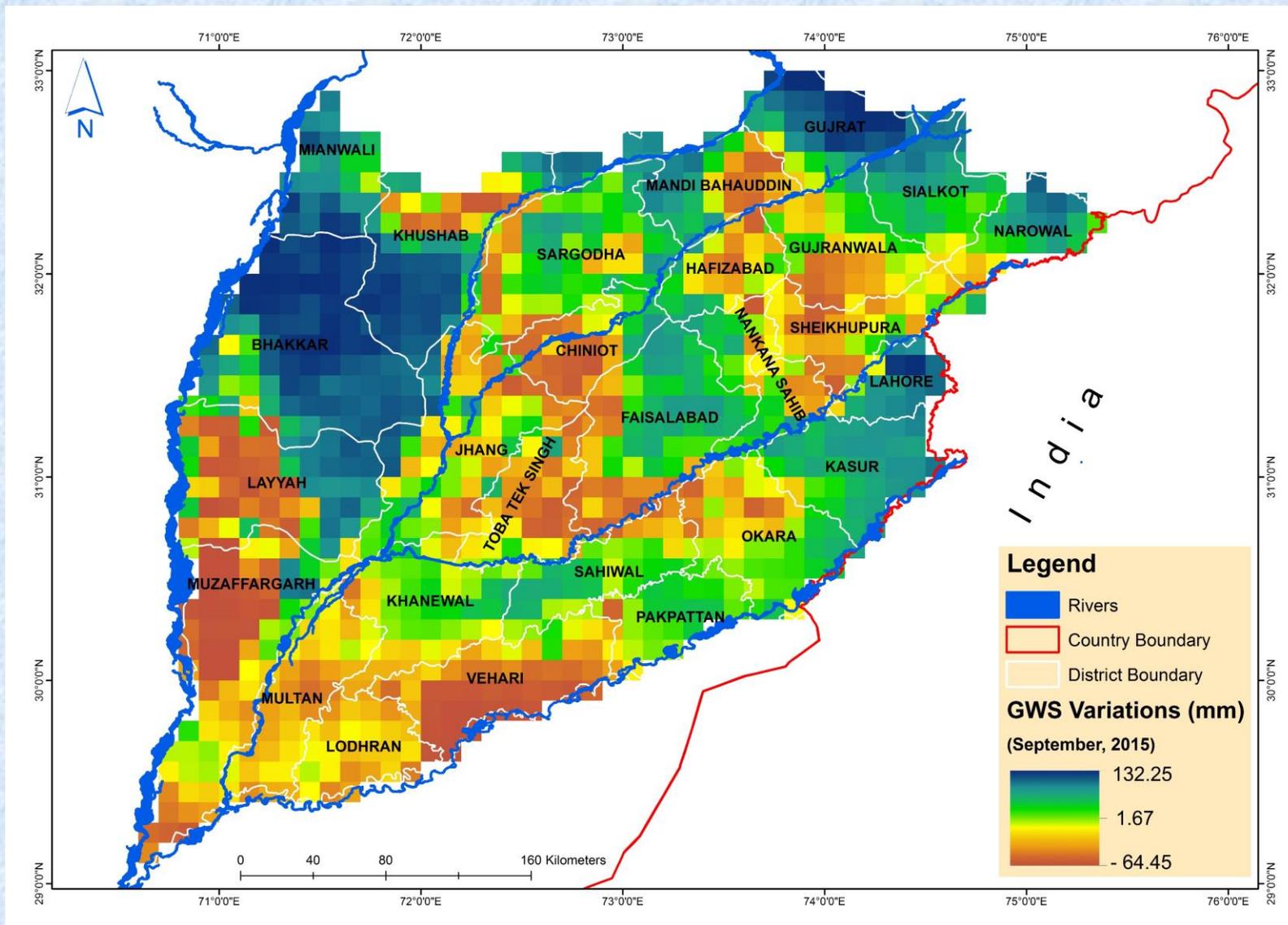


Fig. 2: Monthly GWS variations over Upper Indus Plain during September, 2015