

Evaluation of regional groundwater storage variations in China using GRACE data

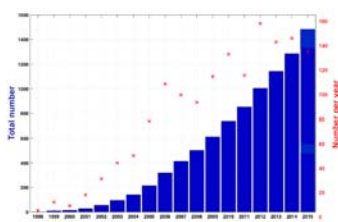
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1. Introduction

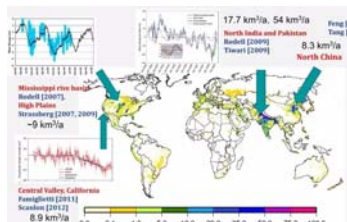
Launched: **March 17, 2002**
Initial Altitude: 500 km
Inclination: 89 deg
Eccentricity: ~0.001
Separation Distance: ~220 km
Nominal Mission : **5 years**
Over 14 years in space now!!!

GRACE Follow-On

Scheduled to launch: 2017/2018



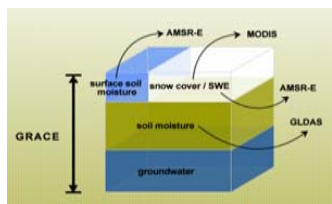
GRACE Publication Statistics From Jianli Chen



Areas about groundwater depletion
Groundwater crisis in China!

2. Method

$$\Delta GWS = \Delta TWS - (\Delta SWS + \Delta SWE + \Delta SM)$$



TWS: Release-05 of GRACE (GRACE-RL05)

SWE, SM: Noah Land surface model (GLDAS);

Δ SWS=0

Two official datasets

WR datasets:

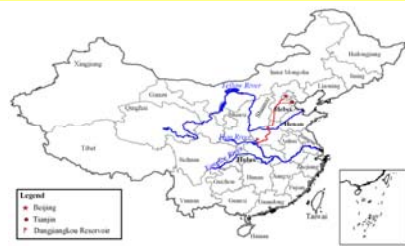
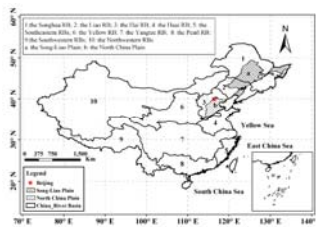
the quantity of groundwater resources of ten river basins is published in *Water Resources Bulletin of China*, which is issued annually by the MWR (<http://www.mwr.gov.cn/zwzc/hygb/szygb/>)

GWS datasets:

GWS variations in the Song-Liao Plain and the North China Plain can be collected from the reports from monthly groundwater observations issued by the MWR (<http://www.mwr.gov.cn/zwzc/hygb/dxsdytb/>)

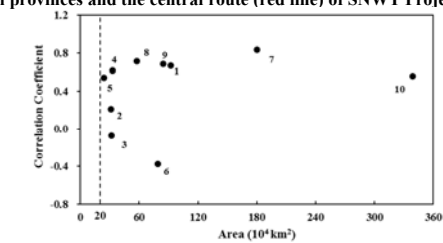
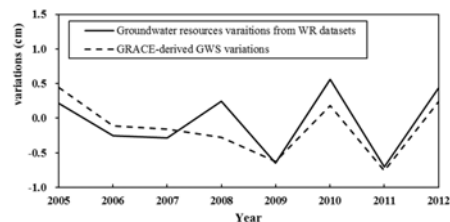
3. Results

10 River basins in China



Main provinces and the central route (red line) of SNWT Project.

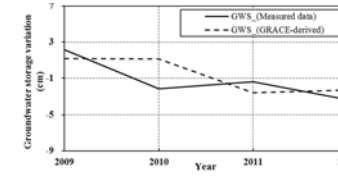
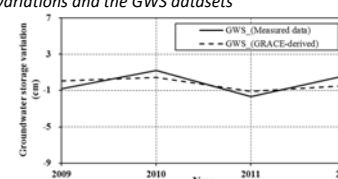
(1) Comparison of GWS variations and the WR datasets



Area of the river basins and correlation coefficient between groundwater resource variations from the official reports and GRACE-derived GWS variations for different river basins.

Over the period of 2005 to 2012, the groundwater resource variation from official bulletins is well correlated with the GRACE-derived GWS variation with a linear correlation coefficient of 0.84.

(2) Comparison of GWS variations and the GWS datasets

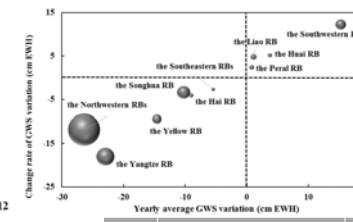
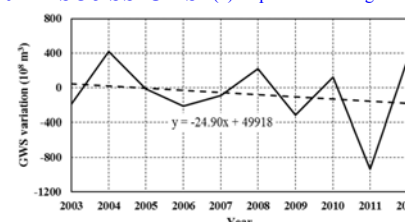


Comparison of the measured and derived GWS variations in (left) the Song-Liao Plain; (right) the North China Plain.

Period	Study area (km²)	groundwater depletion rate (cm yr⁻¹)	Authors
2003-2010	~370,000	-2.5~-1.9	Feng et al. (2013) [37]
2003-2011	~300,000	-1.4~-0.84	Tang et al. (2013) [38]
2005-2010	~140,000	-4.15~-2.25	Huang et al. (2015) [18]

4. Discussions

(1) Depletion rate of groundwater in the whole China

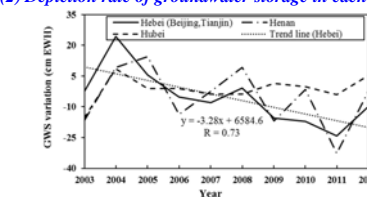


Big bubble size suggests that GWS variations vary a lot from 2003 to 2012.

(3) Measurement error analysis

Groundwater storage decreases at a rate of about 2.5 billion m³ yr⁻¹

(2) Depletion rate of groundwater storage in each province



5. Summaries

GRACE data is used to evaluate the change of GWS in China. Two official observed datasets from MWR are used to verify the accuracy of GRACE-derived GWS.

The change of GWS in ten river basins and 27 provinces based on GRACE data demonstrates that the yearly average depletion rate of groundwater is about 25 cm EWH in China from 2003 to 2012. Six river basins, including the Songhua RB, the Hai RB, the Southeastern RBs, the Yellow RB, the Yangtze RB and the Northwestern RBs, show decreasing groundwater storage from 2003 to 2012.

The variation of surface water storage and biomass is assumed to be negligible in this study, which will bring about certain error during estimating GWS variation. For example, according to studies in the Amazon River basin, the variations of surface water storage take account of about 5% of the TWS. Three Gorges Reservoir (TGR) water storage in the Hubei Provinces an increasing trend during the past decade. In addition, GLDAS does not account for anthropogenic effect of groundwater, which need to be further studied.

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