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The potential of GRACE gravimetry to detect heavy rainfall-induced impoundment of a small reservoir in the upper Yellow River

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Contents of this file

Figure S1

Figure S2

Figure S3

Table S1

Table S2

Introduction

This file introduces and discusses the datasets used in this study.

All the data sources are summarized in Table S1, and the sources of reports are listed in Table S2. Detailed acquisition dates regarding the 141 Landsat scenes used herein are referenced in Fig. S1.

Joint water level changes in the LR

Once we obtain the relationship between changes in the area and water level, we can derive the missing height observations from the area observations (Fig. S2). These two results agree well with each other, but they have different data densities, and there are gaps that can be filled by other observations. Observed height changes before 2005 are so sparse that the annual variation is difficult to identify; therefore, here, we adopt derivations from area changes to supplement the height records before 2005. The result is shown in Fig. S2b. The trough and peak months in 2003 and 2004 are also found to exist in May and November, respectively. Three phases of massive water impoundment can be recognized from the joint water level series during 2003–2011 (Fig. S2b), occurring in 2003, 2005 and 2009. The amount of water level rise is close to 40 meters in 2003 and 2005 and is approximately 30 meters in 2009, but the precision of GRACE observations is relatively poor in 2003 (which represents the first years of the GRACE mission) [Yi *et al.*, 2016c].

Seasonal changes in the water level and precipitation of the LR

We separate water level records for each year into rising and declining years in Fig. S3. The years of 1988, 1997, 2004 and 2007 are not used owing to their moderate changes. The water levels decline by an amount of approximately 15 m in the first half of the year in both categories. However, in the second half, the water levels rise by an amount of 20–40 m during the rising years, and rise less than 10 m during the declining years. The average monthly precipitation in the same years that are illustrated in the lower panels of Fig. S3 clearly explain the differences: the rising years experience abundant precipitation from May to August, while the declining years experience rather scarce precipitation in July.

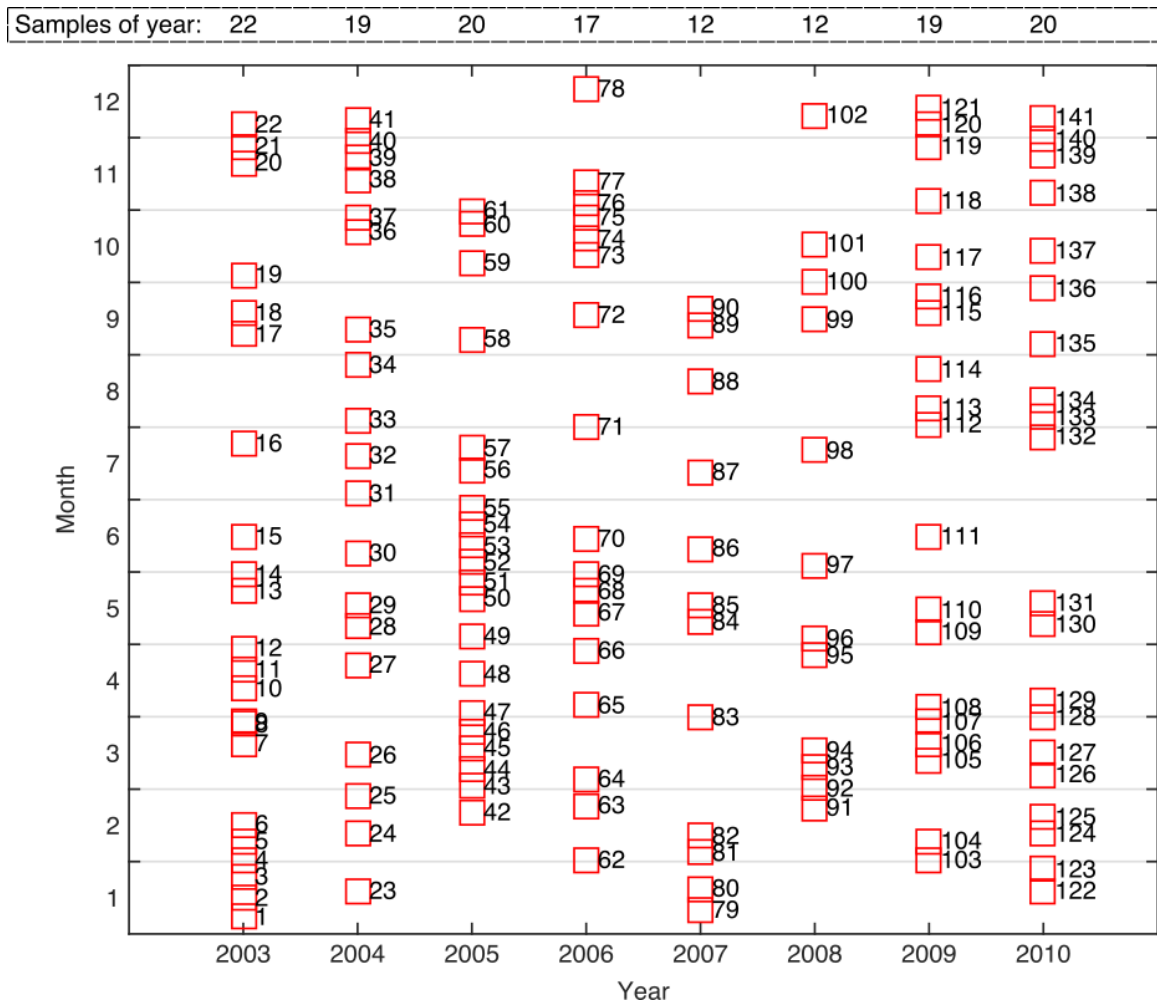


Figure S1. Time sampling information of the remote sensing images used. There are 141 images in total, and the number of samples for each year is listed within the top dashed box.

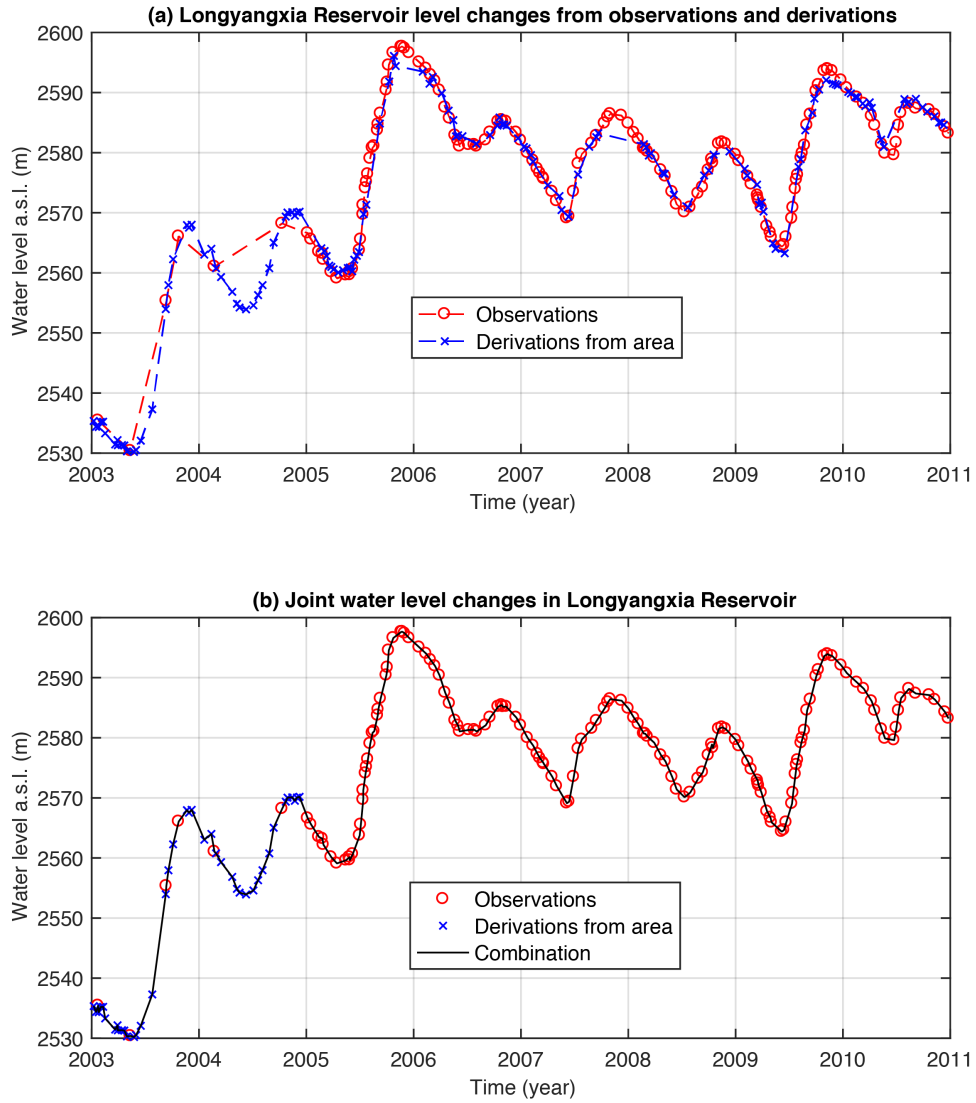


Figure S2. Water level changes within the Longyangxia Reservoir. (a) Longyangxia Reservoir level changes determined from observations and area derivations. (b) Joint water level changes in the Longyangxia Reservoir.

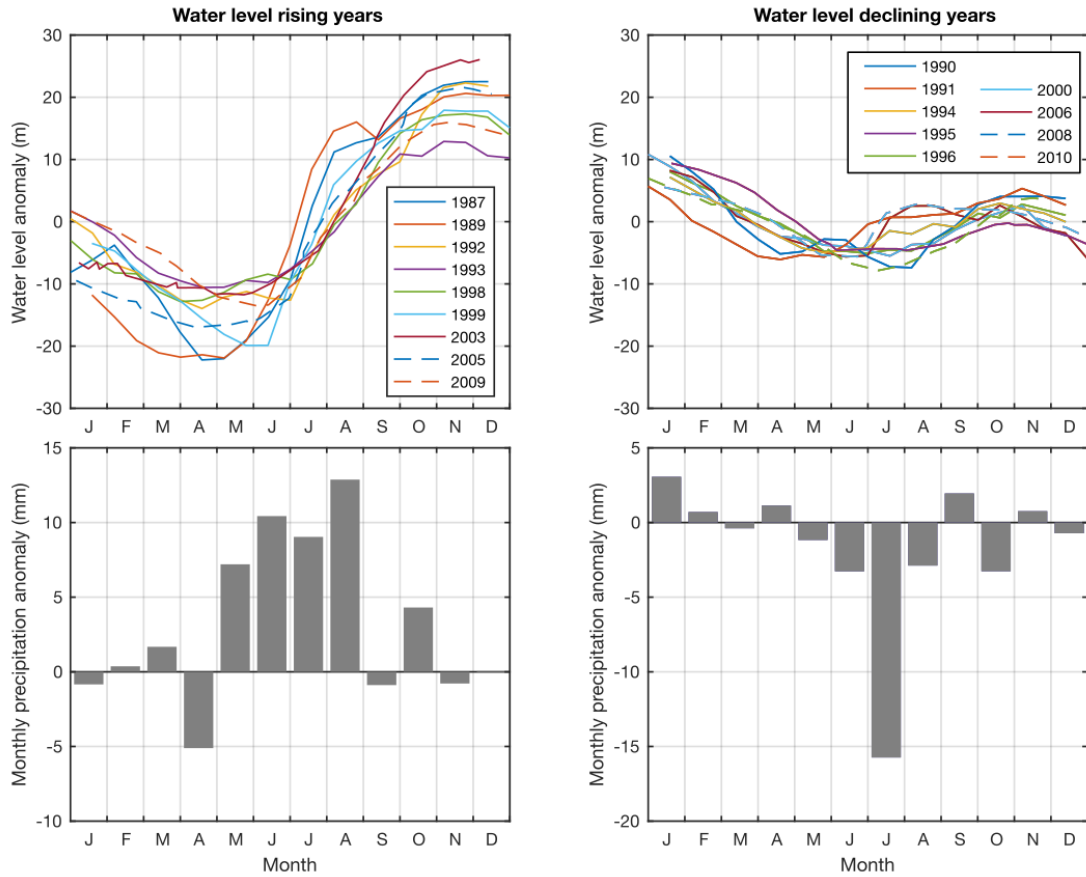


Figure S3. Annual variations of water level in the Longyangxia Reservoir in rising years (left) and in declining years (right). The water level in each year is presented separately in the upper panels, while the average monthly precipitation is shown in the lower panels, whose time period is derived from the years listed above.

Data		Source	Link
GRACE		ICGEM	http://icgem.gfz-potsdam.de/ICGEM/
Water level	ICESat	NASA	http://icesat.gsfc.nasa.gov/icesat/
	In situ, 2003-2010	[Lu, 2013]	http://www.cqvip.com/read/read.aspx?id=667640794
	In situ, 1986-2000	[Cao, 2004]	http://d.wanfangdata.com.cn/Thesis/Y850339
	altimetry	Hydroweb	http://www.legos.obs-mip.fr/en/soa/hydrologie/hydroweb/Page_2.html
	news	Table S2.	
Landsat		USGS	http://glovis.usgs.gov
GPCP precipitation		NOAA	http://www.esrl.noaa.gov/psd/data/gridded/tables/precipitation.html
SRTM		NASA	http://dds.cr.usgs.gov/srtm/version2_1/SWBD/

Table S1. Sources of data used in this study.

Date (year/month/day)	Height (m)	web link
1999/11/15	2581.08	http://www.yellowriver.gov.cn/other/hhgb/2005.htm
2003/1/22	2535.44	http://www.cctv.com/financial/jingji/sanji/toutiao_new/20030224/86.html
2003/3/20	2533.5	http://www.cnr.cn/2004news/internal/200303200175.html
2003/5/12	2530.38	http://www.yellowriver.gov.cn/other/hhgb/2005.htm
2003/9/11	2555.34	http://news.sina.com.cn/c/2003-09-11/1859734565s.shtml
2005/8/19	2581.09	http://news.sina.com.cn/s/2005-09-01/19026839050s.shtml
2005/8/31	2583.72	http://news.sina.com.cn/s/2005-09-01/19026839050s.shtml
2005/10/23	2595.98	http://news.xinhuanet.com/fortune/2005-10/26/content_3686946.htm
2005/11/19	2597.62	http://news.sohu.com/20080828/n259251752.shtml
2007/2/25	2577.34	http://news.xinhuanet.com/politics/2007-03/06/content_5808450.htm
2008/8/25	2573.32	http://news.sohu.com/20080828/n259251752.shtml
2009/11/9	2593.93	http://news.bjx.com.cn/html/20091116/233834.shtml
2010/7/29	2588.26	http://news.cnwest.com/content/2010-07/29/content_3302156.htm
2012/7/27	2589.44	http://www.cma.gov.cn/2011xwzx/2011xqxxw/2011xzytq/201207/t20120730_180095.html

Table S2. News reports about water level changes in the Longyangxia Reservoir.