Supporting Information for

Spatio-temporal evaluation of water storage trends from hydrological models over Australia using GRACE mascon solutions

Xinchun Yang [1,2], Siyuan Tian [3], Wei Feng [4], Jiangjun Ran [5], Wei You [1,*], Zhongshan Jiang [1] and Xiaoying Gong [1]

[1] Faculty of Geosciences and Environmental Engineering, Southwest Jiaotong University, Chengdu 611756; China; xcyang@my.swjtu.edu.cn (X.C.Y.); youwei@swjtu.edu.cn (Y.W.); jzshhh@my.swjtu.edu.cn (Z.S.J.); xygong@swjtu.edu.cn (X.Y.G.)

[2] School of Environment and Resource, Southwest University of Science and Technology, Mianyang 621010, China

[3] Fenner School of Environment & Society, Australian National University, Canberra 2601, Australia; siyuan.tian@anu.edu.au (S.Y.T)

[4] State Key Laboratory of Geodesy and Earth's Dynamics, Institute of Geodesy and Geophysics, Innovation Academy for Precision Measurement Science and Technology, Chinese Academy of Sciences, Wuhan 430077, China; fengwei@whigg.ac.cn (W.F.)

[5] Department of Earth and Space Sciences, Southern University of Science and Technology, Shenzhen, 518055, China; ranjj@sustech.edu.cn (J.J.R)

* Correspondence: youwei@swjtu.edu.cn (W.Y.)

Table S1. Statistical summary of TWSA trends (mm/year) derived from three different GRACE mascon solutions in regions (Carpentaria Coast (CC), North East Coast (NEC), Murray-Darling Basin (MDB), and North Western Plateau (NWP)), and the whole continent of Australia.

Region	CSR-M	JPL-M	GSFC-M
CC	7.71 ± 0.84	8.32 ± 0.95	6.96 ± 0.66
NEC	10.98 ± 0.75	13.15 ± 0.73	11.09 ± 0.62
MDB	7.41 ± 0.85	8.73 ± 0.96	6.86 ± 0.69
NWP	−6.84 ± 0.69	−6.79 ± 0.79	−6.47 ± 0.62
Australia	3.69 ± 0.57	3.38 ± 0.62	2.38 ± 0.50

Table S2. Statistical summary of different water storage trends (mm/year) derived from hydrological models and reference values in CC from 2003 to 2014. The statistically non-significant values (M–K test) at the 95% confidence limit are demonstrated in bold

Models	TWSA Trends	SMSA Trends	GWSA Trends
Noah-3.6	**–0.16 ± 0.49**	**–0.16 ± 0.49**	-
CLSM-F2.5	**–1.03 ± 0.94**	**–0.25 ± 0.18**	**–0.78 ± 0.76**
VIC-4.1.2	**0.43 ± 0.25**	**0.43 ± 0.25**	-
WaterGAP-2.2d	**0.14 ± 0.34**	**0.16 ± 0.13**	**–0.02 ± 0.22**
PCR-GLOBWB-2	**1.36 ± 0.85**	**–0.75 ± 0.46**	2.11 ± 0.51
CLM-4.5	4.99 ± 1.20	**0.44 ± 0.59**	4.55 ± 0.67
AWRA-L v6	2.18 ± 0.82	1.60 ± 0.65	0.58 ± 0.18
Reference	7.66 ± 0.81	**0.57 ± 0.48**	7.09 ± 0.51

Table S3. Statistical summary of different water storage trends (mm/year) derived from hydrological models and reference values in NEC from 2003 to 2014. The statistically non-significant values (M–K test) at the 95% confidence limit are demonstrated in bold

Models	TWSA Trends	SMSA Trends	GWSA Trends
Noah-3.6	2.77 ± 0.67	2.77 ± 0.67	-
CLSM-F2.5	3.33 ± 0.95	0.69 ± 0.20	2.64 ± 0.75
VIC-4.1.2	2.10 ± 0.52	2.10 ± 0.52	-
WaterGAP-2.2d	1.90 ± 0.40	1.12 ± 0.21	0.78 ± 0.20
PCR-GLOBWB-2	10.41 ± 0.94	1.45 ± 0.52	8.96 ± 0.57
CLM-4.5	28.62 ± 1.28	9.34 ± 0.68	19.28 ± 0.83
AWRA-L v6	9.16 ± 0.92	6.96 ± 0.80	2.20 ± 0.14
Reference	11.74 ± 0.69	5.29 ± 0.65	6.45 ± 0.31

Table S4. Statistical summary of different water storage trends (mm/year) derived from hydrological models and reference values in MDB from 2003 to 2014. The statistically non-significant values (M–K test) at the 95% confidence limit are demonstrated in bold

Models	TWSA Trends	SMSA Trends	GWSA Trends
Noah-3.6	5.37 ± 0.79	5.37 ± 0.79	-
CLSM-F2.5	4.30 ± 0.70	0.85 ± 0.15	3.45 ± 0.54
VIC-4.1.2	4.04 ± 0.68	4.04 ± 0.68	-
WaterGAP-2.2d	1.50 ± 0.19	0.58 ± 0.11	0.92 ± 0.10
PCR-GLOBWB-2	**0.30 ± 0.38**	**0.33 ± 0.34**	**–0.03 ± 0.06**
CLM-4.5	3.94 ± 1.00	4.61 ± 0.69	**–0.67 ± 0.46**
AWRA-L v6	3.57 ± 0.55	2.42 ± 0.50	1.15 ± 0.09
Reference	7.67 ± 0.83	4.11 ± 0.64	3.56 ± 0.41

Table S5. Statistical summary of different water storage trends (mm/year) derived from hydrological models and reference values in NWP from 2003 to 2014. The statistically non-significant values (M–K test) at the 95% confidence limit are demonstrated in bold

Models	TWSA Trends	SMSA Trends	GWSA Trends
Noah-3.6	**–0.13 ± 0.51**	**–0.13 ± 0.51**	-
CLSM-F2.5	**–0.18 ± 0.58**	**–0.04 ± 0.13**	**–0.14±0.45**
VIC-4.1.2	1.22 ± 0.50	1.22 ± 0.50	-
WaterGAP-2.2d	**0.06 ± 0.07**	0.05 ± 0.02	**0.01 ± 0.06**
PCR-GLOBWB-2	–0.82 ± 0.13	–0.47 ± 0.12	–0.35 ± 0.02
CLM-4.5	–2.99 ± 0.46	–5.12 ± 0.43	2.13 ± 0.25
AWRA-L v6	–1.06 ± 0.47	**–0.59 ± 0.35**	–0.47 ± 0.12
Reference	–6.70 ± 0.70	–1.15 ± 0.44	–5.55 ± 0.31

Table S6. Statistical summary of temporal agreement metrics between GRACE mason solutions in CC. The bold and underlined numbers are the best and the worst values for the metrics, respectively.

Mascon solutions	r	RMSE (cm)	NSE
CSR–JPL	**0.96**	3.11	**0.91**
CSR–GSFC	0.95	<u>3.69</u>	<u>0.87</u>
JPL–GSFC	<u>0.95</u>	**2.94**	0.89

Table S7. Statistical summary of temporal agreement metrics between GRACE mason solutions in NEC. The bold and underlined numbers are the best and the worst values for the metrics, respectively.

Mascon solutions	r	RMSE (cm)	NSE
CSR–JPL	<u>0.93</u>	<u>2.28</u>	<u>0.86</u>
CSR–GSFC	**0.94**	**2.15**	**0.87**
JPL–GSFC	0.93	2.21	0.86

Table S8. Statistical summary of temporal agreement metrics between GRACE mason solutions in MDB. The bold and underlined numbers are the best and the worst values for the metrics, respectively.

Mascon solutions	r	RMSE (cm)	NSE
CSR–JPL	**0.99**	1.94	**0.94**
CSR–GSFC	<u>0.96</u>	**1.60**	0.89
JPL–GSFC	0.96	<u>2.19</u>	<u>0.85</u>

Table S9. Statistical summary of temporal agreement metrics between GRACE mason solutions in NWP. The bold and underlined numbers are the best and the worst values for the metrics, respectively.

Mascon solutions	r	RMSE (cm)	NSE
CSR–JPL	<u>0.96</u>	<u>1.53</u>	<u>0.90</u>
CSR–GSFC	<u>0.96</u>	**1.31**	**0.93**
JPL–GSFC	**0.97**	1.48	0.92

Table S10. Statistical summary of agreement metrics between reference values and hydrological models in CC. The bold and underlined numbers are the best and the worst values for the metrics respectively.

Models	TWSA			SMSA			GWSA		
	r	RMSE (cm)	NSE	r	RMSE (cm)	NSE	r	RMSE (cm)	NSE
Noah-3.6	0.88	4.79	0.71	**0.99**	**0.94**	**0.98**	-	-	-
CLSM-F2.5	0.87	5.29	0.64	0.97	<u>4.32</u>	<u>0.55</u>	0.48	<u>6.47</u>	<u>–1.43</u>
VIC-4.1.2	<u>0.83</u>	<u>5.68</u>	<u>0.58</u>	0.96	2.08	0.89	-	-	-
WaterGAP-2.2d	0.88	5.67	0.59	<u>0.90</u>	4.06	0.60	<u>0.47</u>	4.15	0.00
PCR-GLOBWB-2	0.91	3.93	0.80	0.96	1.92	0.91	**0.66**	**3.27**	**0.38**
CLM-4.5	0.91	3.98	0.80	0.98	1.35	0.95	0.65	3.39	0.33
AWRA-L v6	**0.92**	**3.86**	**0.81**	0.98	1.40	0.95	0.49	4.08	0.03

Table S11. Statistical summary of agreement metrics between reference values and hydrological models in NEC. The bold and underlined number are the best and the worst values for the metrics respectively.

Models	TWSA			SMSA			GWSA		
	r	RMSE (cm)	NSE	r	RMSE (cm)	NSE	r	RMSE (cm)	NSE
Noah-3.6	0.71	5.11	0.21	0.97	1.61	0.91	-	-	-
CLSM-F2.5	0.71	5.33	0.14	0.93	<u>4.25</u>	<u>0.36</u>	–0.17	6.39	–2.98
VIC-4.1.2	0.69	5.09	0.22	0.96	1.89	0.87	-	-	-
WaterGAP-2.2d	<u>0.67</u>	5.19	0.18	<u>0.88</u>	3.47	0.58	–0.21	4.24	–0.76
PCR-GLOBWB-2	0.93	2.61	0.79	0.93	2.38	0.80	0.66	3.26	–0.04
CLM-4.5	**0.94**	<u>9.16</u>	<u>–1.54</u>	0.96	2.37	0.80	**0.75**	<u>6.98</u>	<u>–3.76</u>
AWRA-L v6	0.93	**2.49**	**0.81**	0.98	**1.28**	**0.94**	0.65	**2.93**	**0.16**

Table S12. Statistical summary of agreement metrics between reference values and hydrological models in MDB. The bold and underlined number are the best and the worst values for the metrics respectively.

Models	TWSA			SMSA			GWSA		
	r	RMSE (cm)	NSE	*r*	RMSE (cm)	NSE	*r*	RMSE (cm)	NSE
Noah-3.6	0.86	**2.80**	0.67	**0.98**	**1.16**	0.91	-	-	-
CLSM-F2.5	0.84	3.05	0.60	0.92	3.21	0.23	0.26	<u>3.34</u>	–1.00
VIC-4.1.2	0.78	3.50	0.48	0.97	0.99	**0.93**	-	-	-
WaterGAP-2.2d	0.75	4.70	0.06	<u>0.63</u>	<u>3.45</u>	<u>0.12</u>	0.62	2.33	0.03
PCR-GLOBWB-2	<u>0.60</u>	<u>4.87</u>	<u>–0.01</u>	0.79	2.78	0.43	<u>0.24</u>	2.69	<u>–0.30</u>
CLM-4.5	0.88	2.38	**0.76**	0.94	1.52	0.83	0.62	**2.09**	**0.21**
AWRA-L v6	**0.90**	2.90	0.64	0.97	1.28	0.88	**0.84**	2.20	0.13

Table S13. Statistical summary of agreement metrics between reference values and hydrological models in NWP. The bold and underlined number are the best and the worst values for the metrics respectively.

Models	TWSA			SMSA			GWSA		
	r	RMSE (cm)	NSE	*r*	RMSE (cm)	NSE	*r*	RMSE (cm)	NSE
Noah-3.6	0.80	3.10	0.60	**0.98**	**0.77**	**0.95**	-	-	-
CLSM-F2.5	0.82	2.96	0.64	0.91	2.64	0.44	0.33	3.46	–0.56
VIC-4.1.2	0.69	4.01	0.34	0.96	1.74	0.76	-	-	-
WaterGAP-2.2d	0.66	<u>4.56</u>	<u>0.15</u>	<u>0.45</u>	<u>3.41</u>	<u>0.07</u>	0.21	2.80	–0.02
PCR-GLOBWB-2	<u>0.64</u>	4.25	0.26	0.79	2.69	0.42	**0.80**	2.73	0.03
CLM-4.5	**0.86**	**2.69**	**0.70**	0.86	2.03	0.67	<u>–0.29</u>	<u>3.50</u>	<u>–0.60</u>
AWRA-L v6	0.85	2.80	0.68	**0.98**	0.88	0.94	0.63	**2.41**	**0.24**