Presented at EGU 2020

Development of a global geoid model 2020 (GGM2020)

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1 Methodology

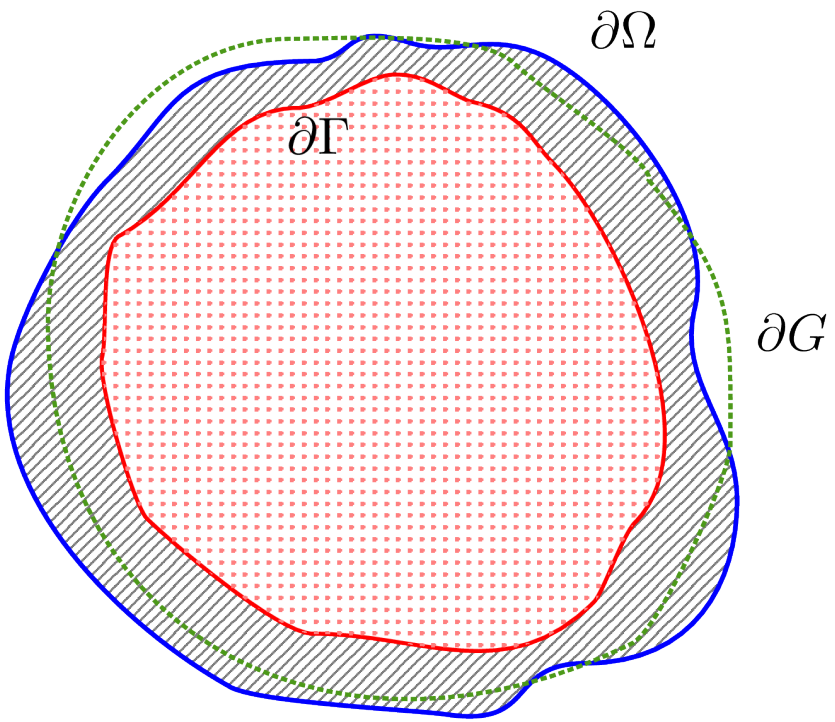


Fig 1 Definition of the shallow layer

Method (Shen 2006)

$$W(P)=V(P)+Q(P)$$

- Earth surface $\partial\Omega$
- Geoid ∂G
- Inner surface $\partial\Gamma$

Shallow-layer: the layer bounded by $\partial\Gamma$ and $\partial\Omega$

1 Methodology

Gravitational potential $V(P)$: defined outside the Earth's surface $\partial\Omega$

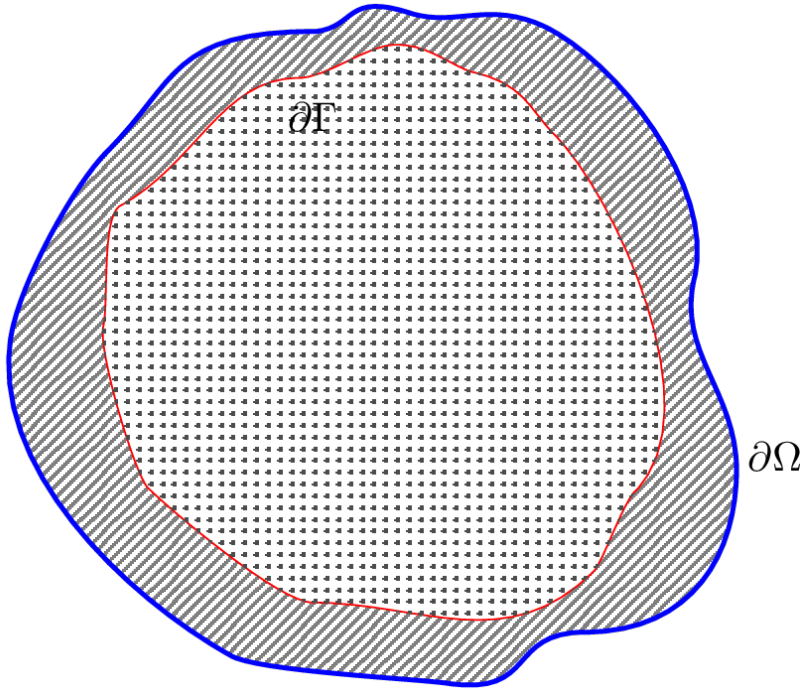


Fig 2 Two parts separated from the earth

$$M \rightarrow V(P)$$

$$M_0 \rightarrow V_0(P)$$

$$M_1 \rightarrow V_1(P)$$

$$V(P) = V_0(P) + V_1(P)$$

1 Methodology

Calculation process

i. Gravitational potential of shallow layer

$$V_1(P) = G\int_{\bar{\Gamma}-\bar{\Omega}} \frac{\rho_1}{l}\, d\tau, \qquad P \in \bar{\Gamma}$$

ii. Gravitational potential of the mass bounded by surface $\partial\Gamma$

$$V_0(P) = V(P) - V_1(P), \qquad P \in \bar{\Omega}$$

iii. Gravity field recovery, $V_0^*(P)$

Fictitious compress recovery approach (Shen, 2004)

Spherical harmonic analysis (SHA)

1 Methodology

iv. Gravitational potential produced by Earth in the region outside the surface $\partial\Gamma$

$$V^*(P)= V_0^*(P)+V_1(P)$$

v. Gravity potential of the Earth

$$W^*(P)=V^*(P)+Q(P)$$

vi. Solve geoid equation to determine point P, which defines the geoid (W_0 is the geopotential on the geoid)

$$W^*(P)=V^*(P)+Q(P)=W_0$$

2 Data & modeling

Construct 3D shallow-layer model

(1) upper surface

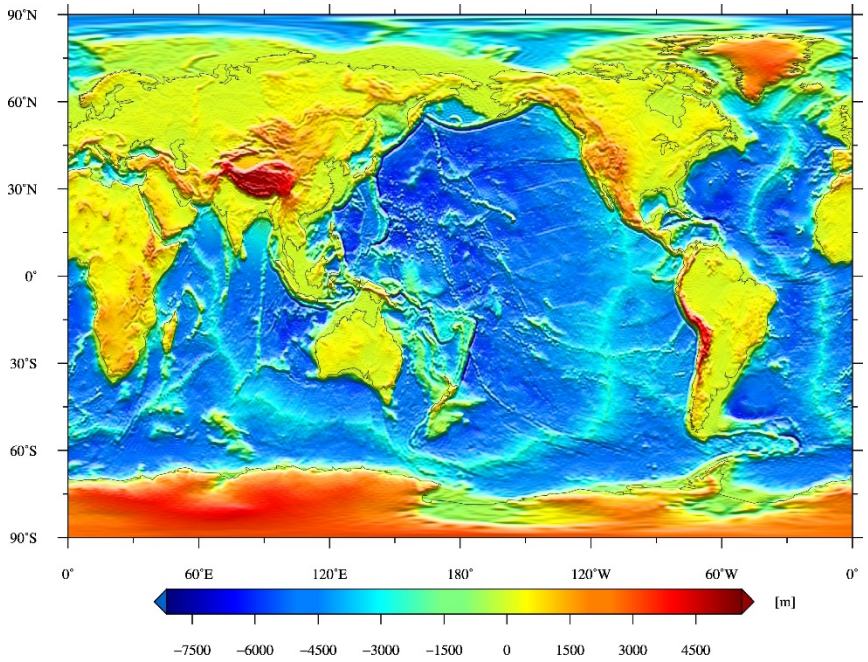


Fig 3 . land: DTM2006.0

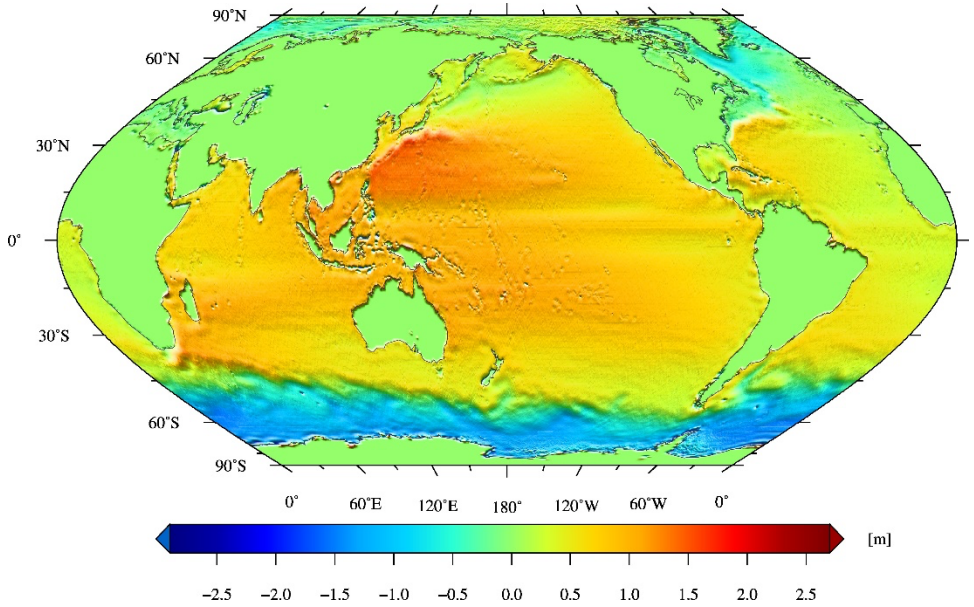


Fig 4 . Ocean: DNSC08

(2) Lower surface: extending from the EGM2008 geoid downward to a depth of 15 m

2 Data & modeling

3D shallow-layer body density: (3) CRUST2.0/1.0 model

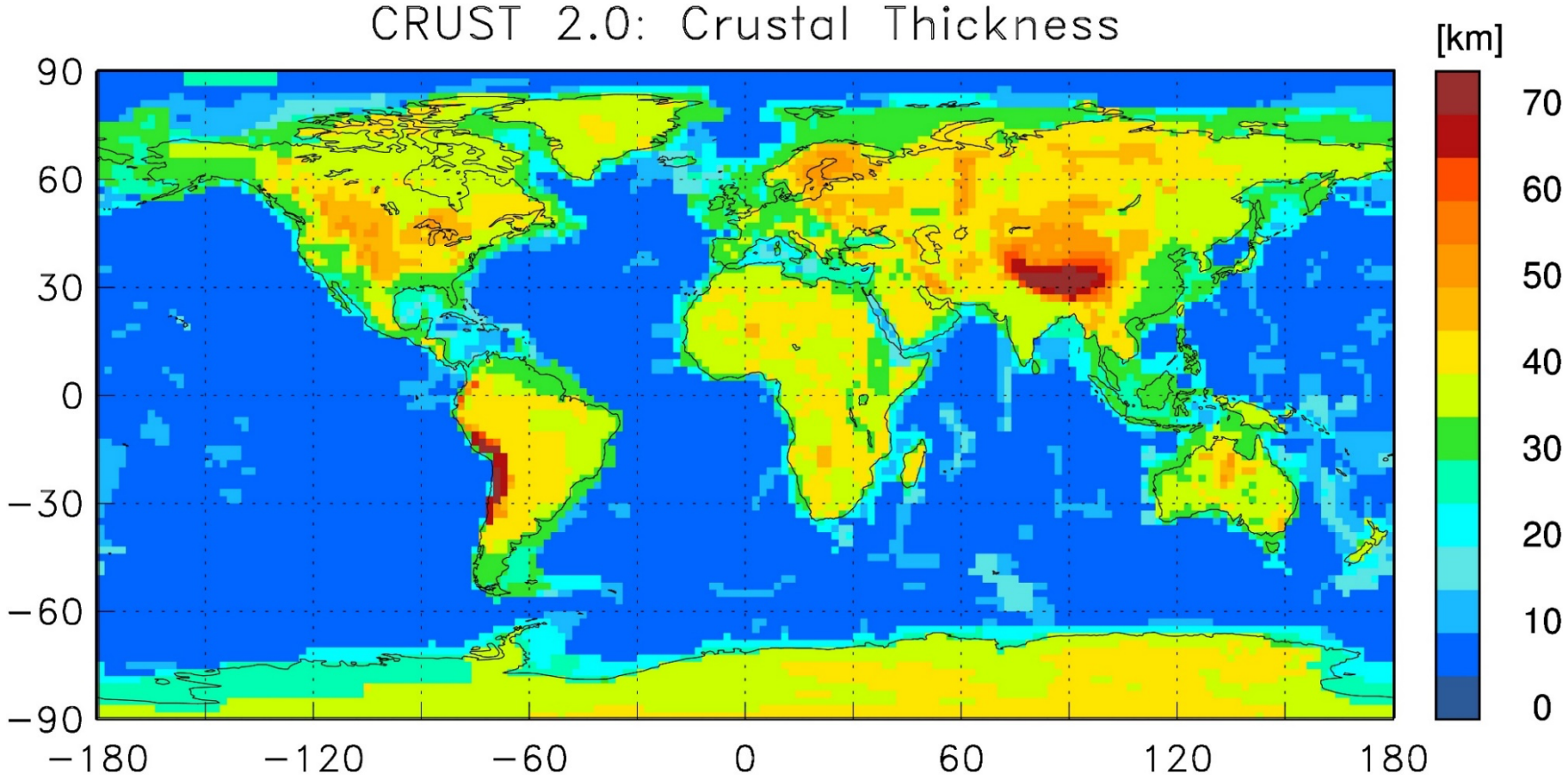


Fig 5 . Global crustal thickness from CRUST2.0

2 Results & validations

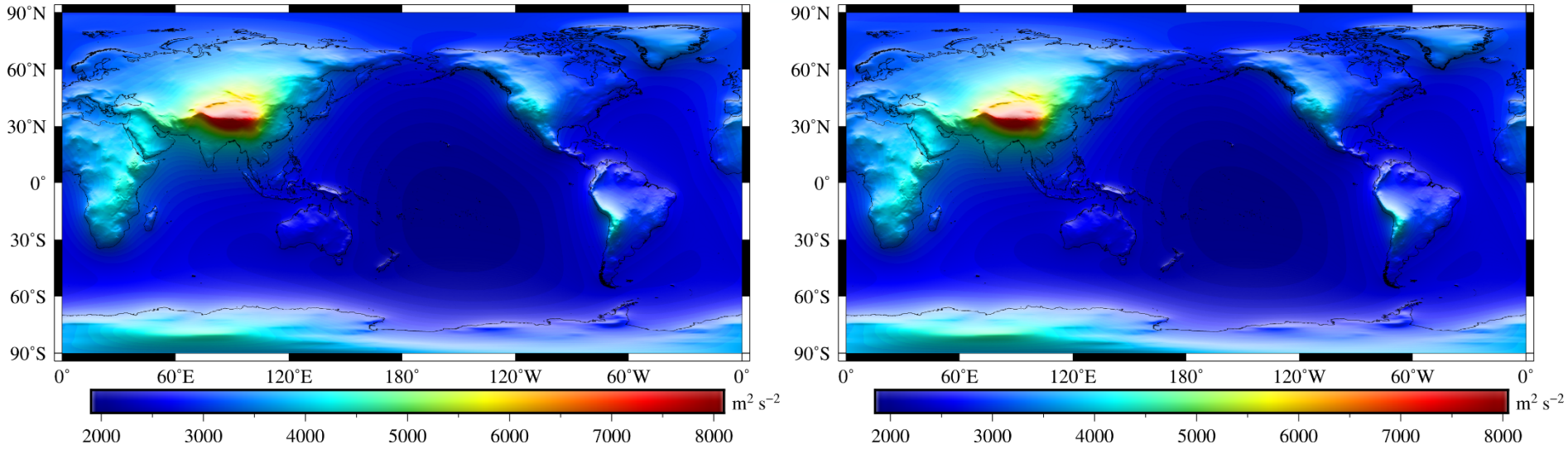
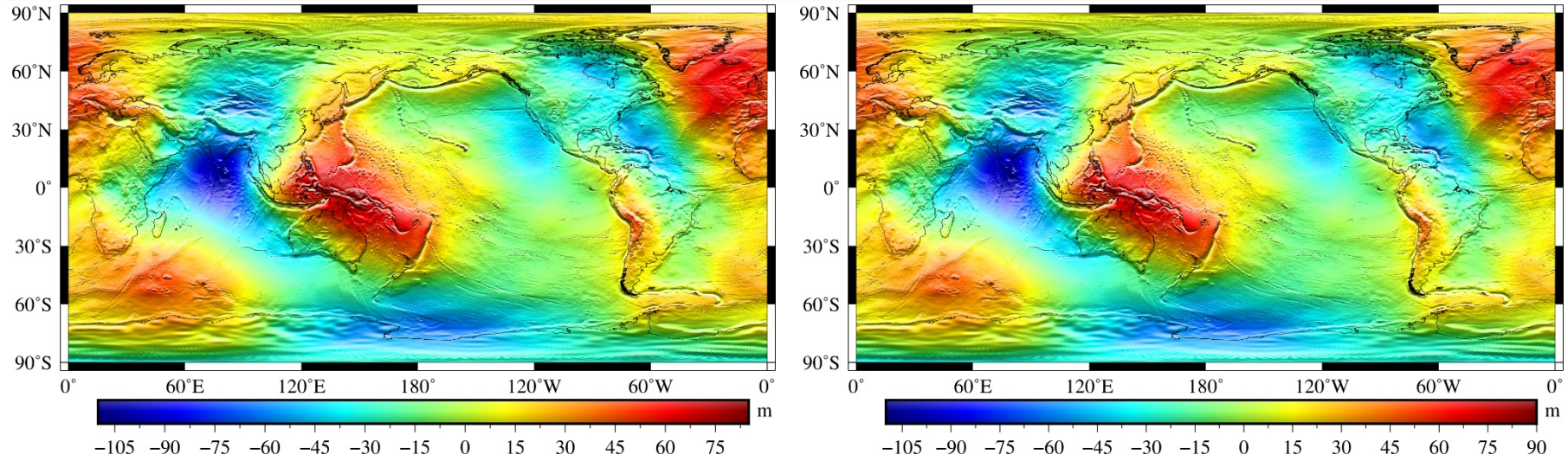


Fig 6 Gravitational potential of shallow-layer *V1(P)* (R=6386 km), *V1(P)* is based on (a) Crust 1.0 , or (b) Crust 2.0 , unit: meters

	Max	Min	Mean	STD
$V_1(P)$(crust1.0)	8027.96	1908.8	2870.5	740.79
$V_1(P)$ (crust2.0)	7851.07	1866.29	2820.28	729.34

2 Results & validations



(a) (b)

Fig 7 The calculated 5′×5′ global geoid (GGM2020), based on **(a) Crust 1.0 , or (b) Crust 2.0 ,** unit: meters

	Max	Min	Mean	STD
GGM2020(crust1.0)	86.082	-106.93	-1.311	29.131
GGM2020 (crust2.0)	86.186	-106.93	-1.310	29.130

2 Results & validations

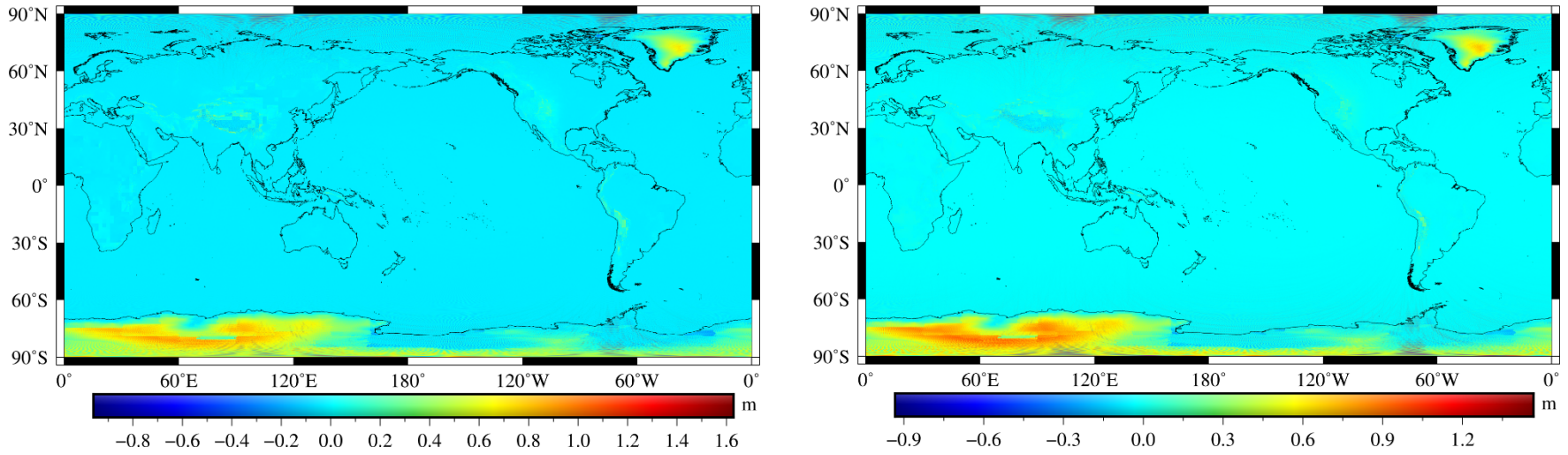


Fig 8 Differences between GGM2020 and EGM2008 geoid. GGM2020 is based on (a) **Crust 1.0 , or** (b) **Crust 2.0, unit: meters**

	Max	Min	Mean	STD	RMS
GGM2020 (crust1.0)-EGM2008	1.467	-0.935	0.0058	0.1531	0.1532
GGM2020 (crust2.0)-EGM2008	1.630	-0.960	0.0063	0.150	0.1510

2 Results & validations

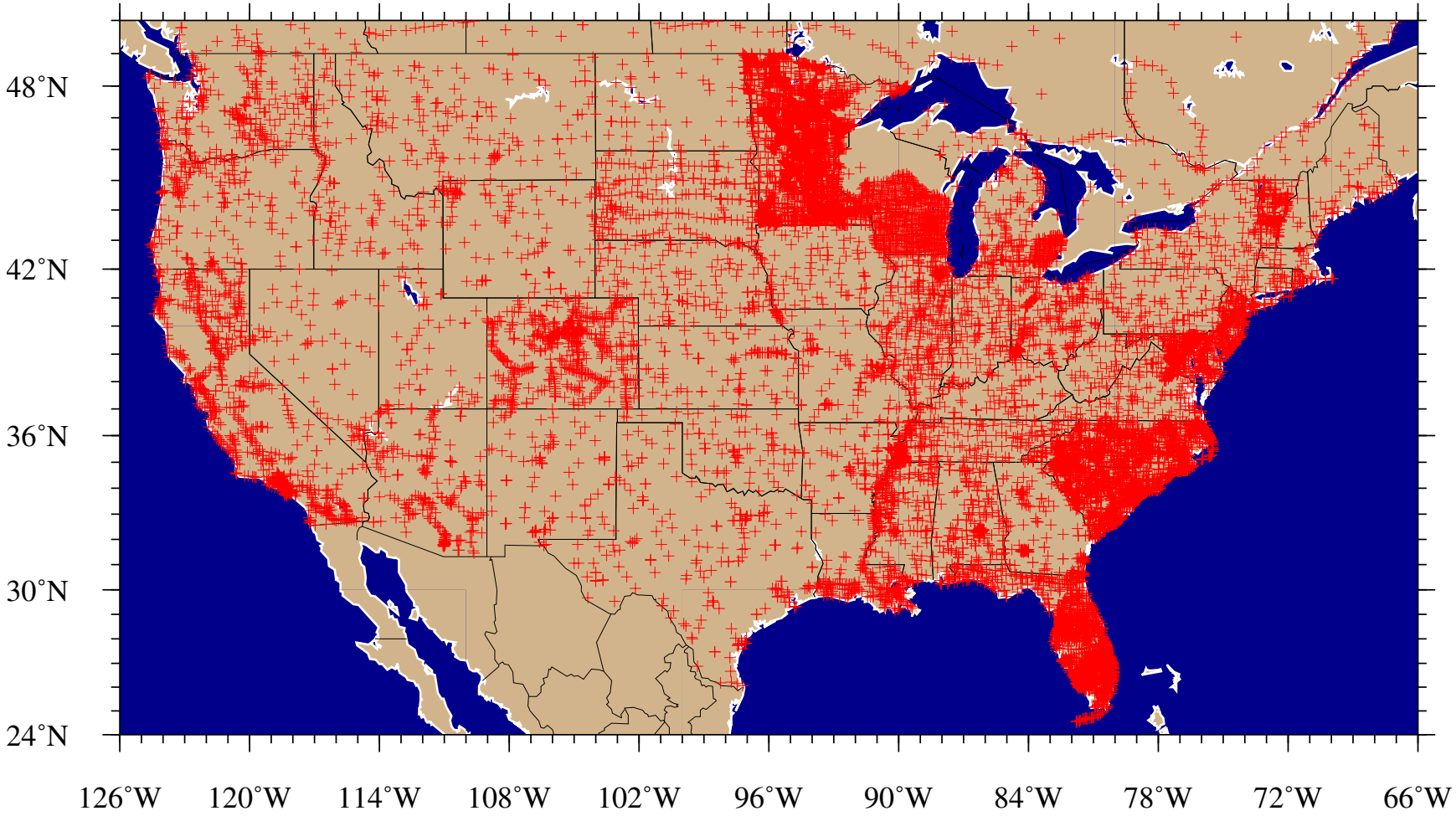


Fig 9 GPS leveling benchmarks in the USA (18972 points)

2 Results & validations

Statistics of differences between selected geoid models and GPSBMs (GBM) in the US for all points, All units are in meters

USA (all)	Max	Min	Mean	STD	RMS
GPS leveling – E08GG	0.184	-1.321	-0.5144	0.3072	0.599
GPS leveling – GGM2020 （CRUST 1.0）	0.216	-1.307	-0.482	0.3071	0.571
GPS leveling – GGM2020 （CRUST 2.0）	0.216	-1.311	-0.485	0.3092	0.575

2 Results & validations

USA(low-lying, <300 m)	Max	Min	Mean	STD	RMS
GPS leveling – E08GG	0.183	-1.299	-0.359	0.272	0.451
GPS leveling – GGM2020（CRUST 1.0）	0.216	-1.290	-0.326	0.271	0.424
GPS leveling – GGM2020（CRUST 2.0）	0.216	-1.284	-0.326	0.271	0.425

USA(mountainous, 300-3700 m)	Max	Min	Mean	STD	RMS
GPS leveling – E08GG	-0.144	-1.299	-0.709	0.239	0.748
GPS leveling – GGM2019（CRUST 1.0）	-0.104	-1.307	-0.686	0.238	0.726
GPS leveling – GGM2019（CRUST 2.0）	-0.116	-1.312	-0.706	0.235	0.744

3 Conclusions

- A 5′×5′ global geoid, GGM2020, has been established based on the shallow-layer method (Shen 2006)
- Validations show that GGM2020 fits the GPSBMs better than the EGM2008 geoid in the US

Thanks