Recent GNSS Results of the CMONOC Network and Application in Natural Hazards Monitoring

Junping Chen, Yize Zhang, Jungang Wang, Weijie Tan, Sainan Yang, Bin Wu

Shanghai Astronomical Observatory (SHAO)
junping@shao.ac.cn
http://www.shao.ac.cn/shao_gnss_ac

Content

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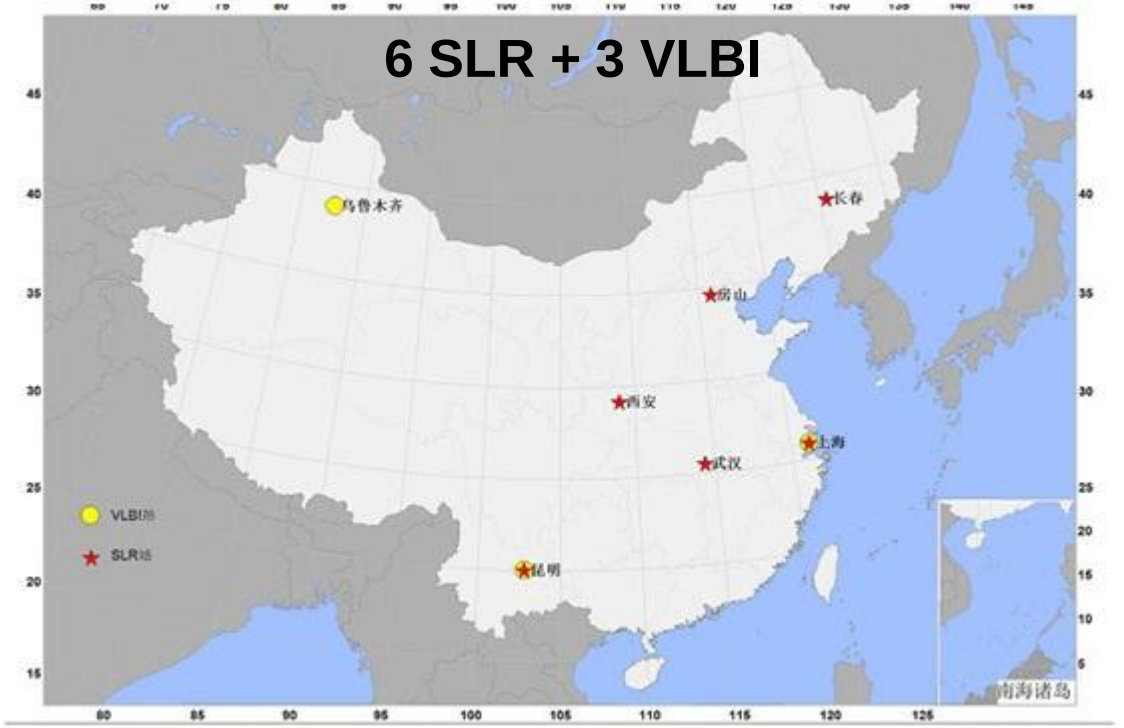
- **GNSS Velocity field**
- **GNSS coseismic monitoring**
- **Further results and analysis**
- **Summary**

Background

- **CMONOC** (Crustal Movement Observation Network of China)



http://neiscn.org/

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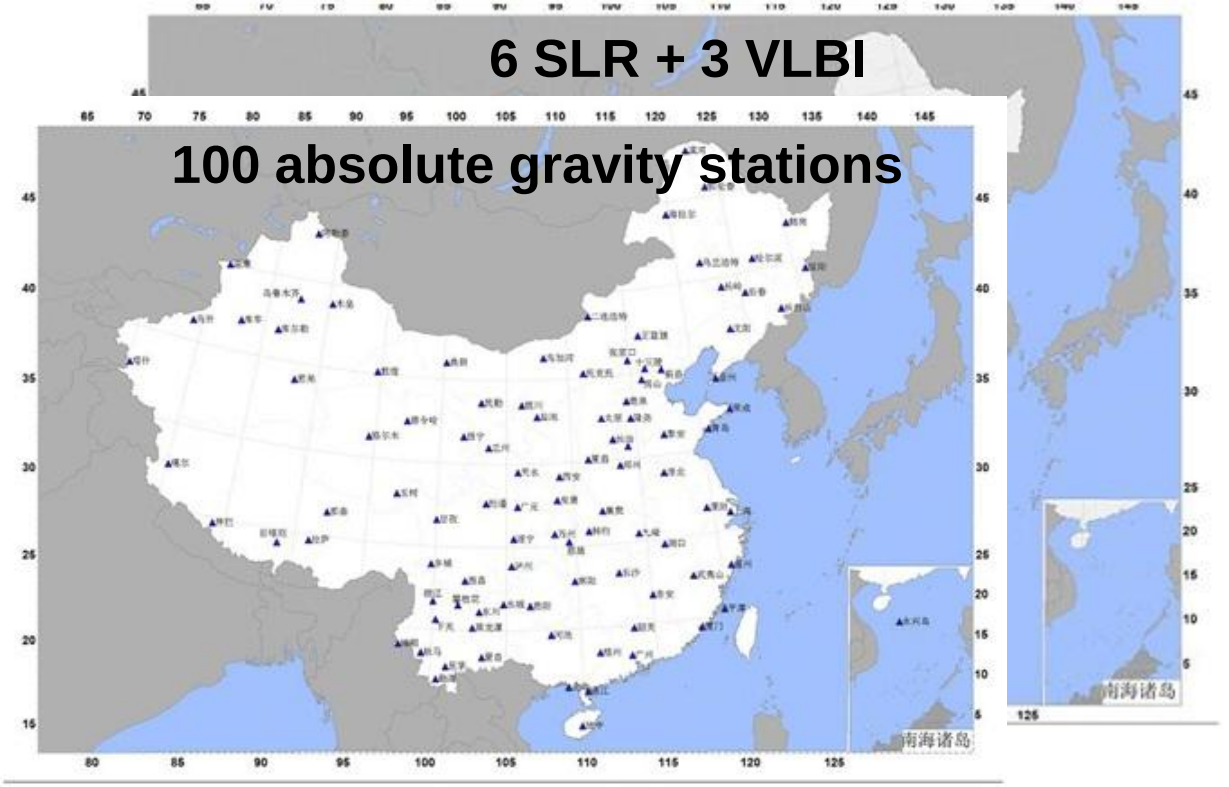

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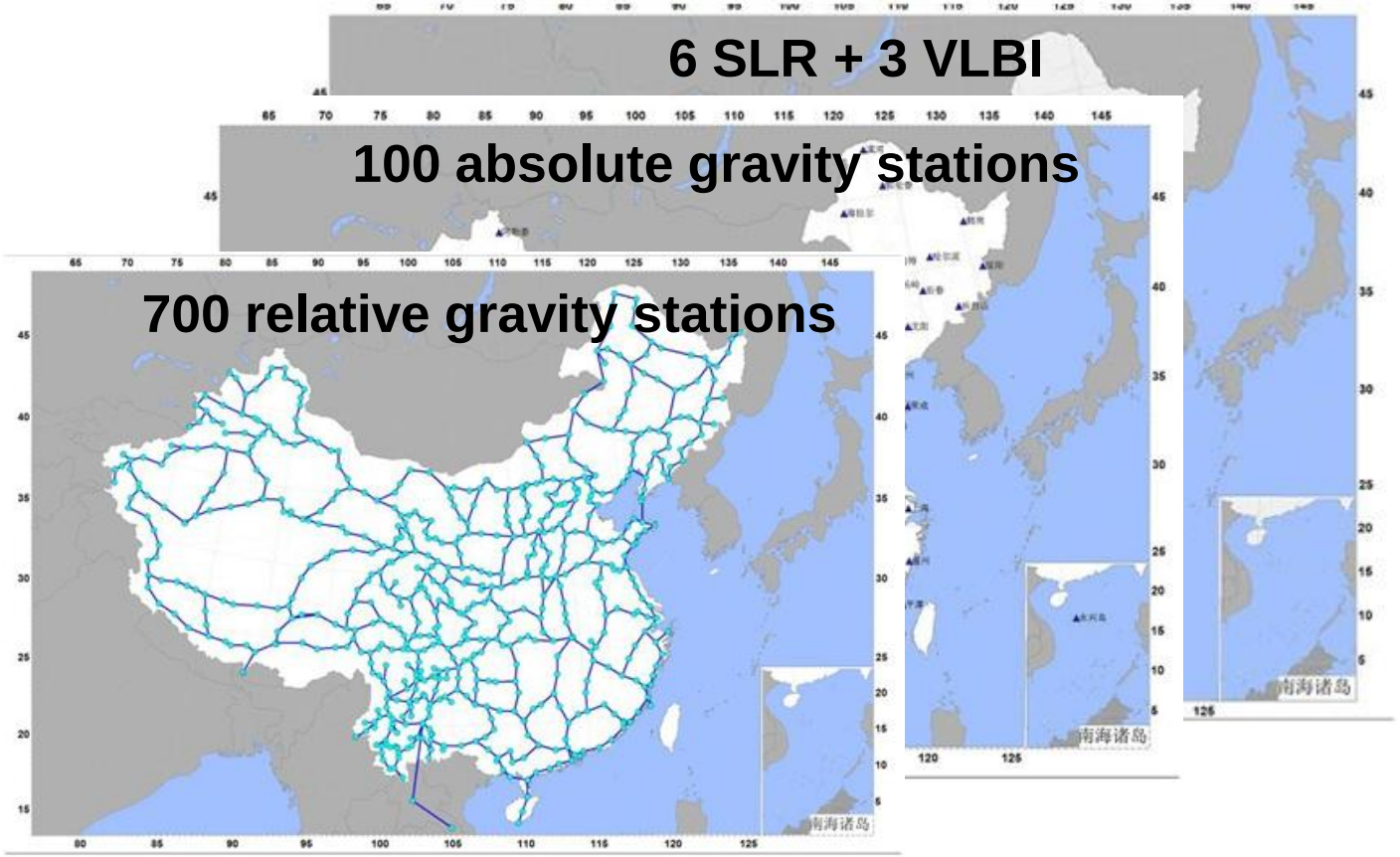

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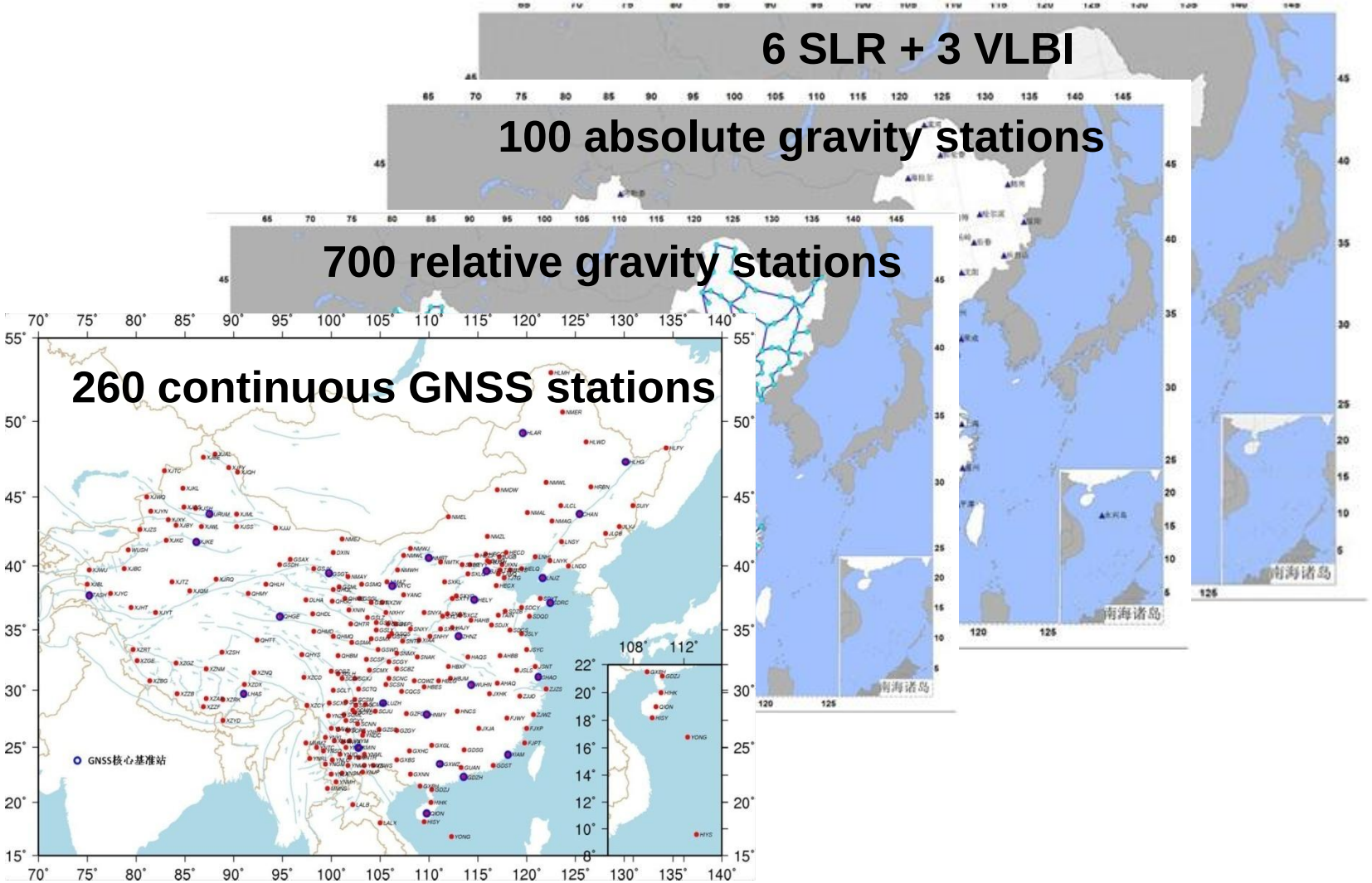

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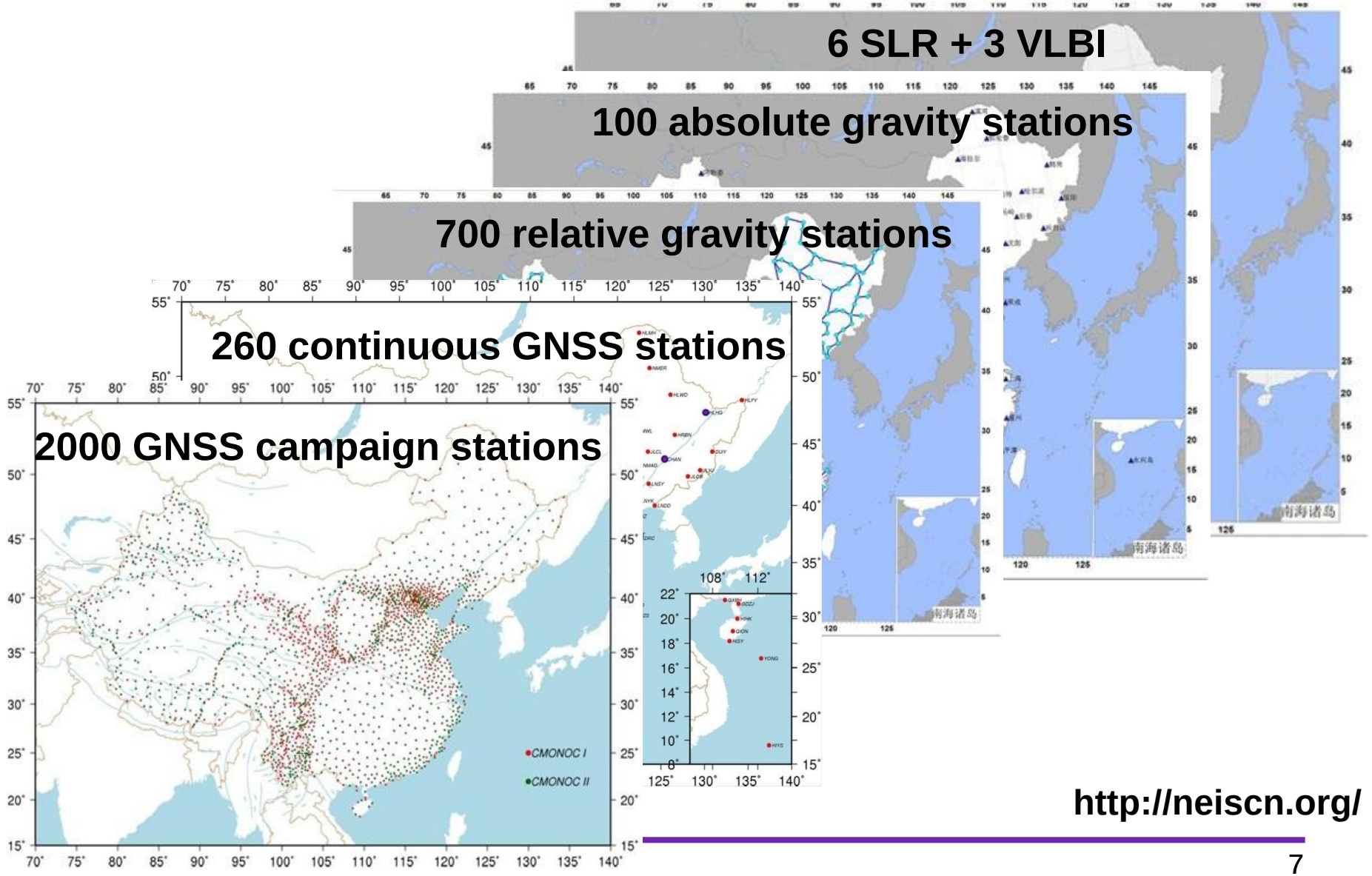

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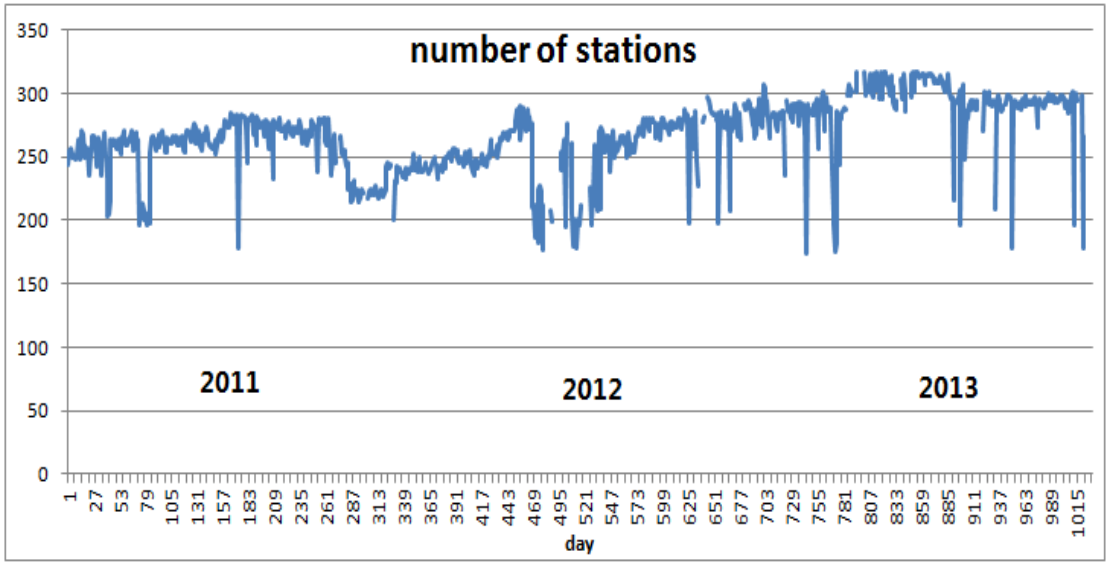
Background

➢Routine GNSS data analysis at SHAO

SHA strategy in huge network solution (Chen et al. CSNC2013)



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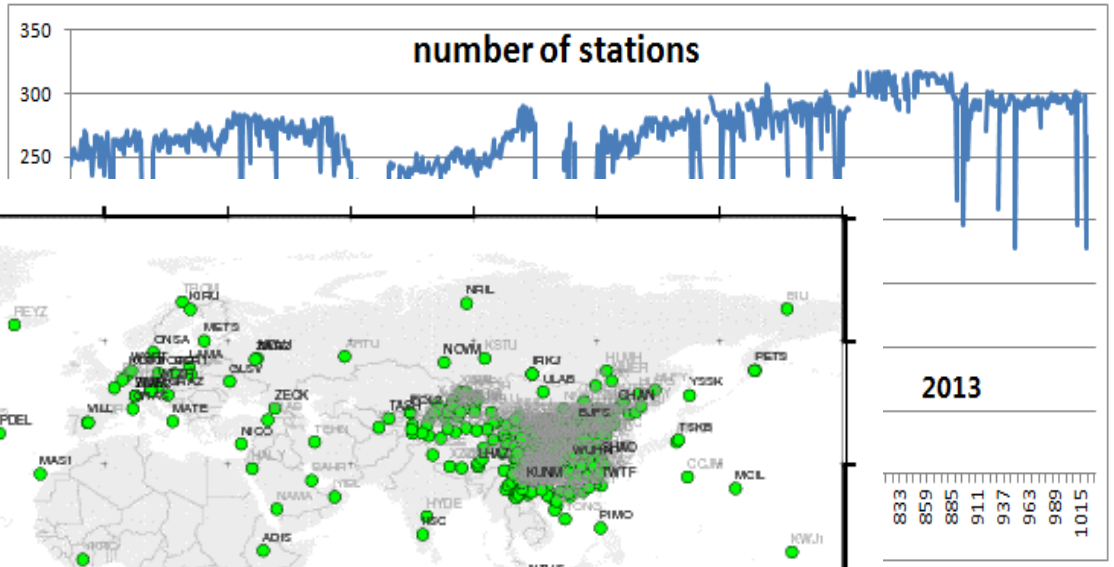
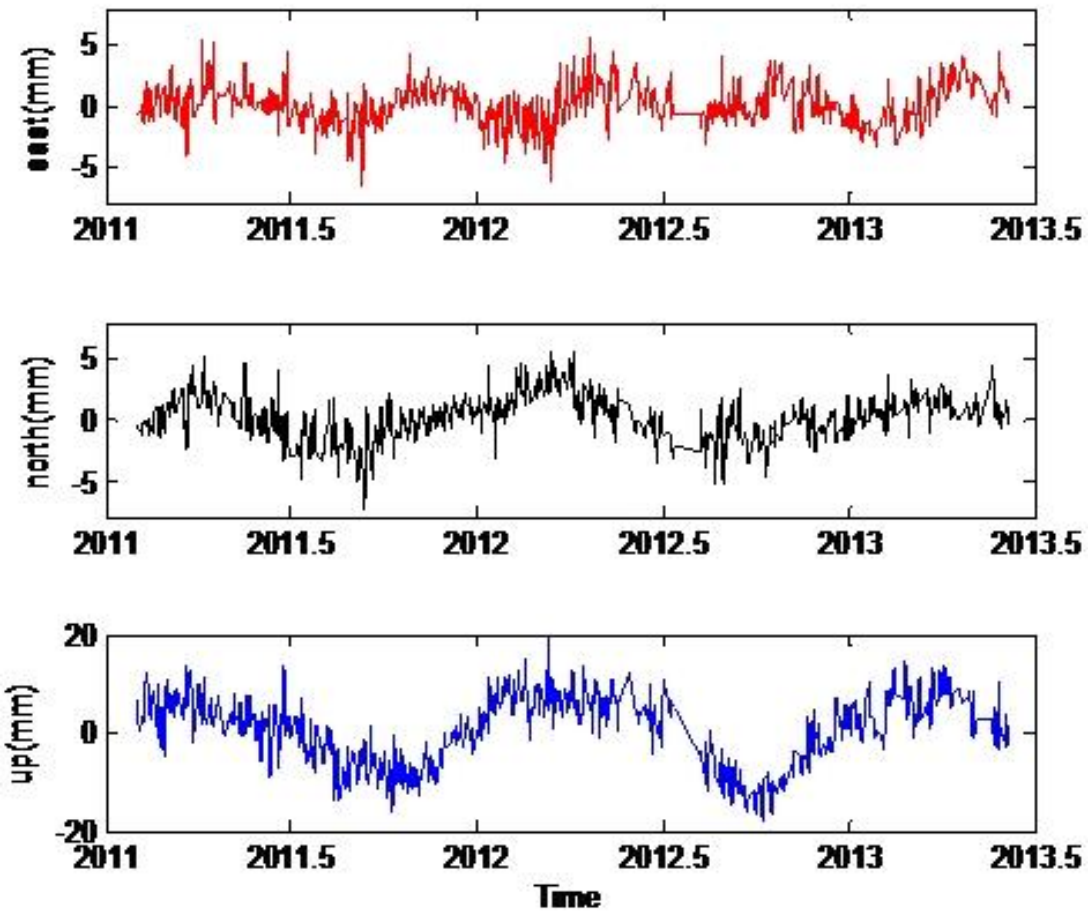


GNSS data analysis at SHAO

➢GNSS routine results

Coord. Time series

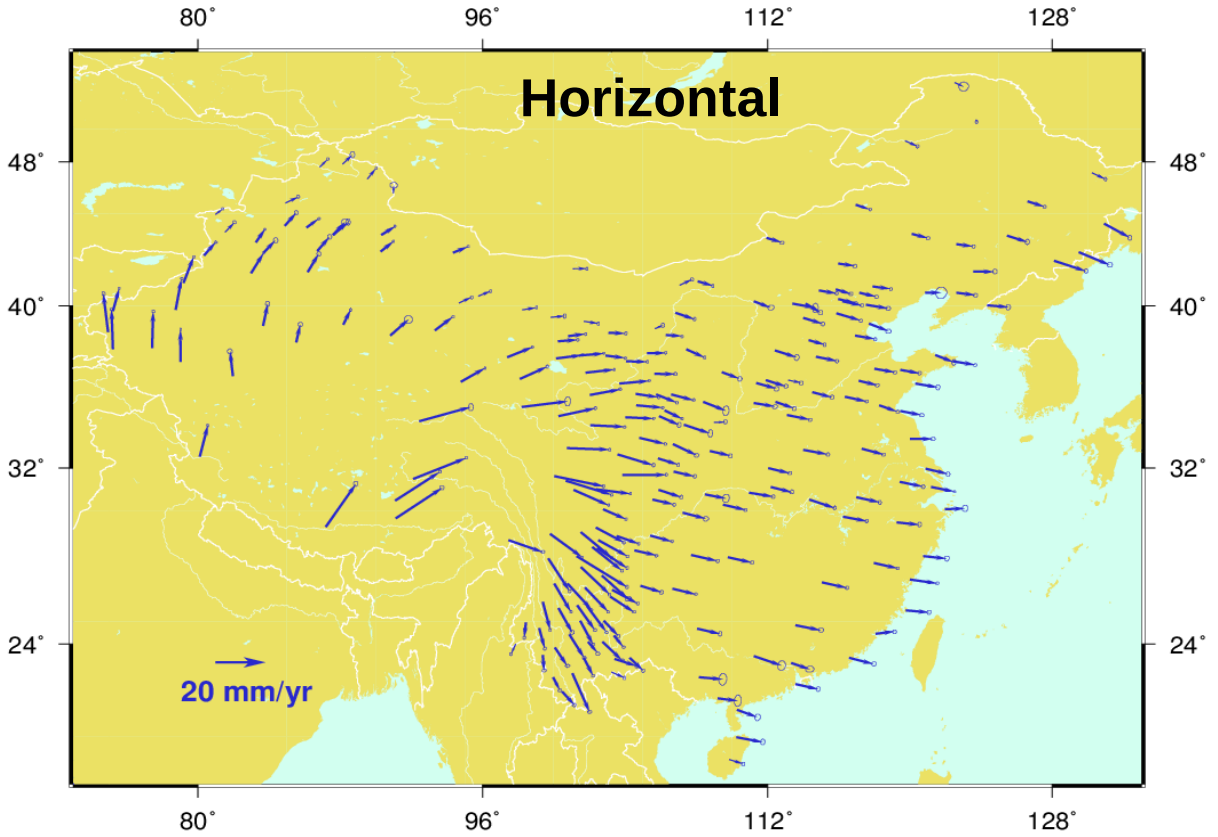


CMONOC GNSS Velocity field

➢Daily solutions combined using QOCA

247 stations with time span > 1 year

ITRF 2008 => EURA plate



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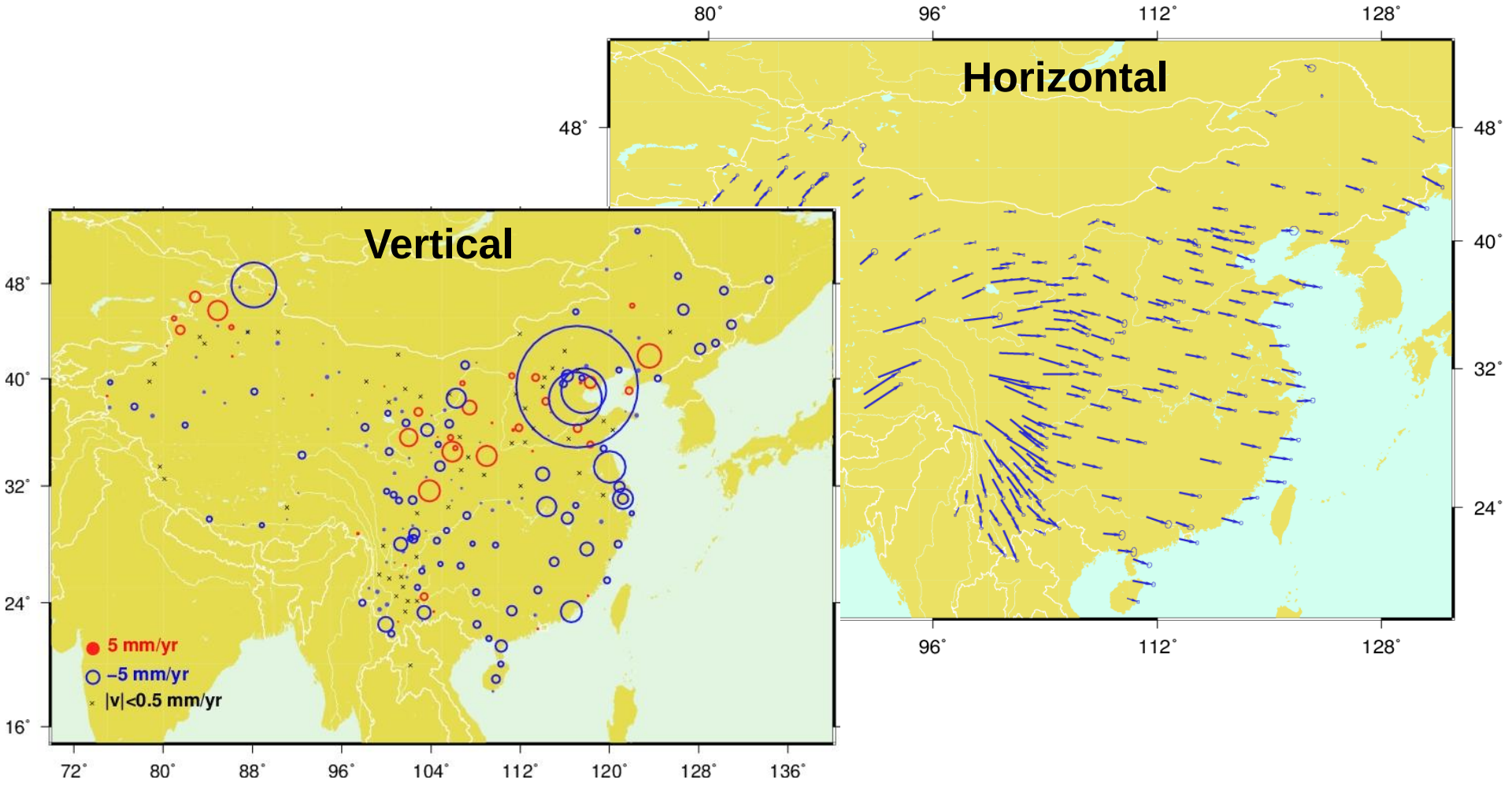


GNSS coseismic monitoring

- **instantaneous site velocity solution**

$$\lambda_1 \dot{\varphi}_m^j(t) = \frac{\boldsymbol{r}^j(t-\tau_m^j) - \boldsymbol{r}_m(t)}{\rho_m^j(t)} \cdot \dot{\boldsymbol{r}}_m^j + c \cdot \delta\dot{t}_m - c \cdot \delta\dot{t}^j(t-\tau_m^j) + \dot{\varepsilon}_m^j,$$

$$\dot{\boldsymbol{r}}_m^j = \dot{\boldsymbol{r}}^j(t-\tau_m^j) - \dot{\boldsymbol{r}}_m(t),$$

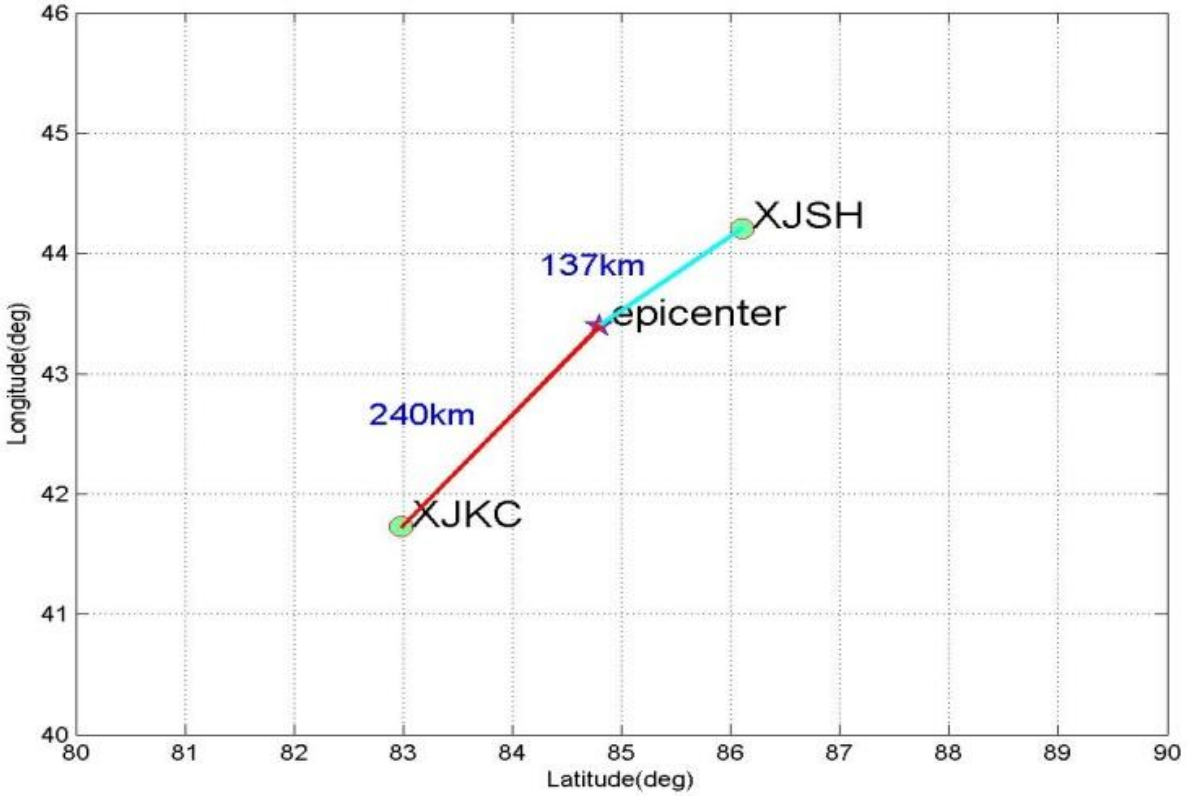
Zhang and Guo 2013

$$\dot{\varphi}_T = \frac{\varphi_{T+\Delta t} - \varphi_{T-\Delta t}}{2\Delta t}$$

GNSS coseismic monitoring

➢instantaneous site velocity solution

Xinjiang Ms6.6 earthquake on June 30,2012



$$\dot{\rho}_m^j(t) \cdot \dot{\boldsymbol{r}}_m^j + c \cdot \delta\dot{t}_m$$

$$\tau_m^j) + \dot{\varepsilon}_m^j ,$$

$$(t) ,$$

Zhang and Guo 2013

$$\frac{-\Delta t}{}$$

GNSS coseismic monitoring

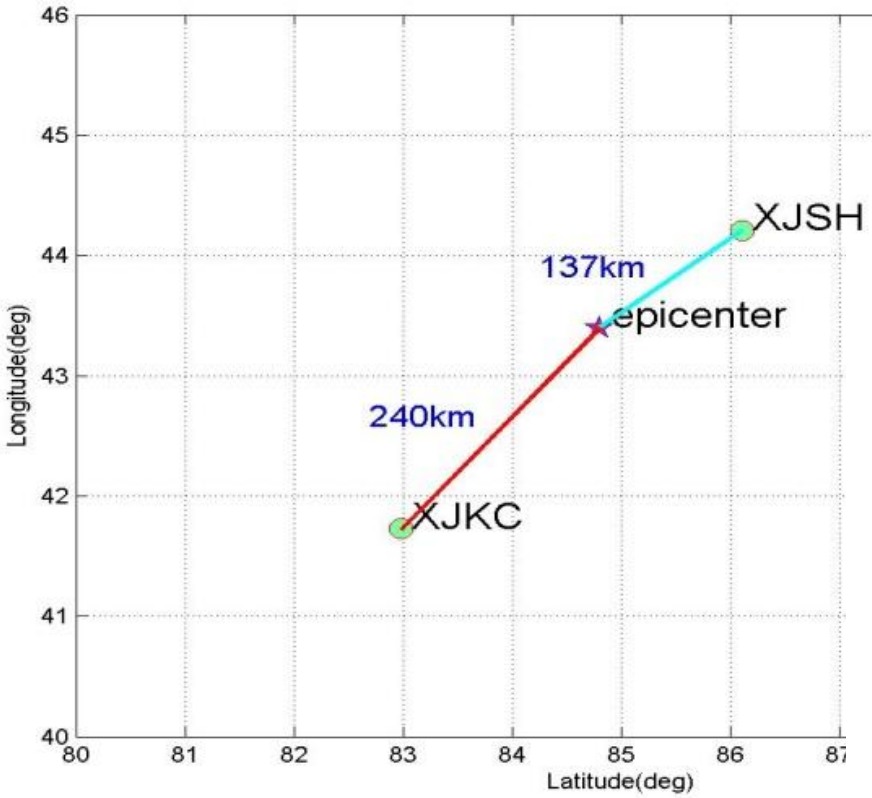
➢instantaneous site velocity solution

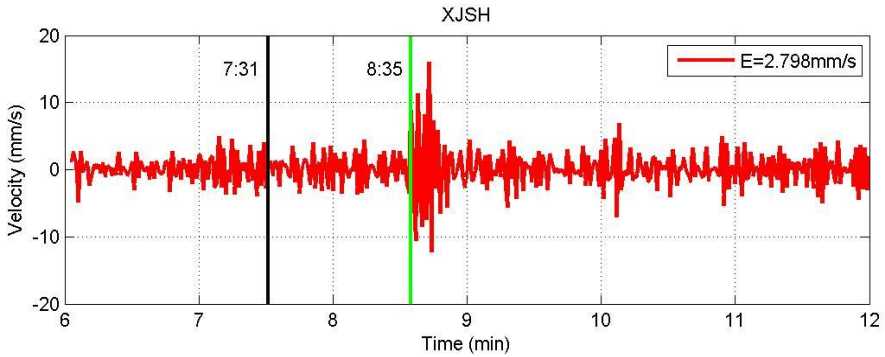
Xinjiang Ms6.6 earthquake on June 30,2012

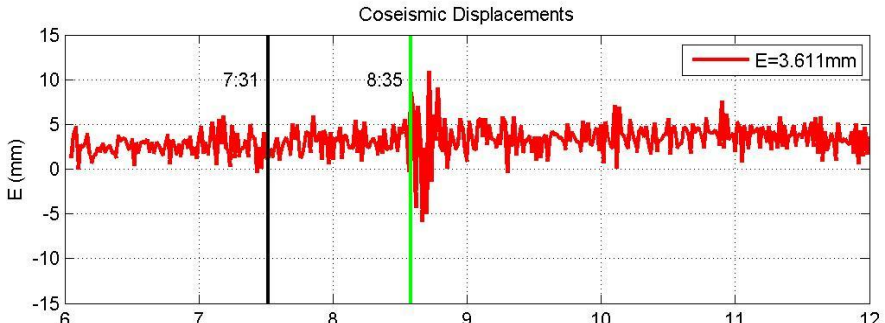
$$\frac{\dot{\rho}_m(t)}{\rho_m^j(t)} \cdot \dot{\boldsymbol{r}}_m^j + c \cdot \delta\dot{t}_m$$

$$\tau_m^j) + \dot{\varepsilon}_m^j ,$$

$$(t) ,$$



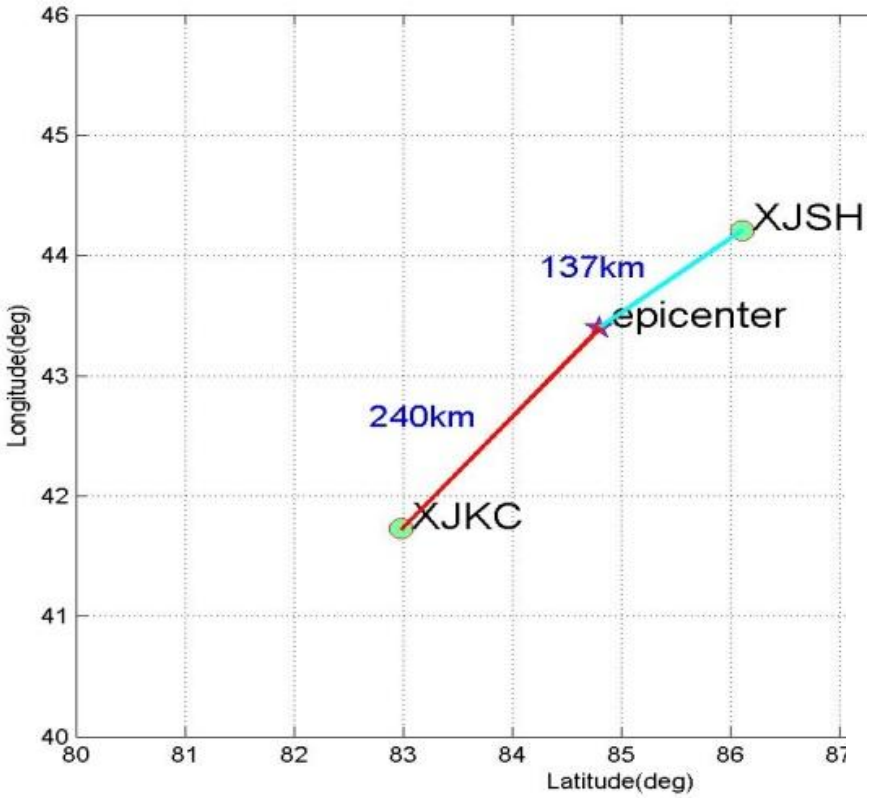


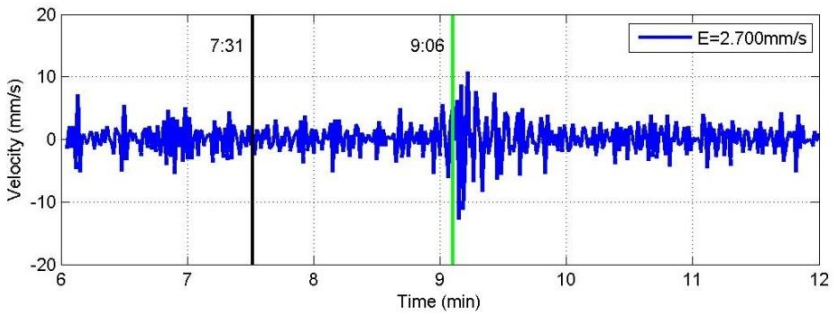


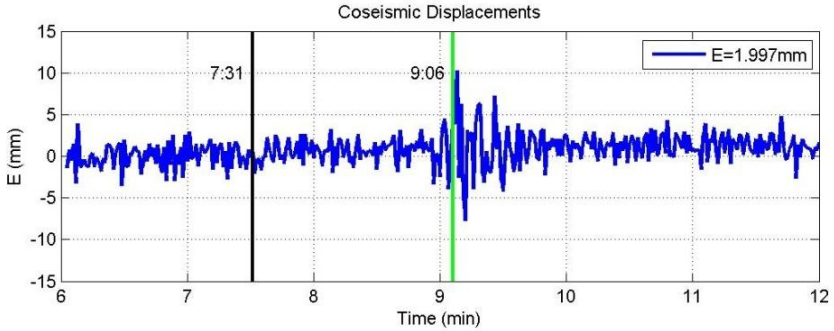
GNSS coseis

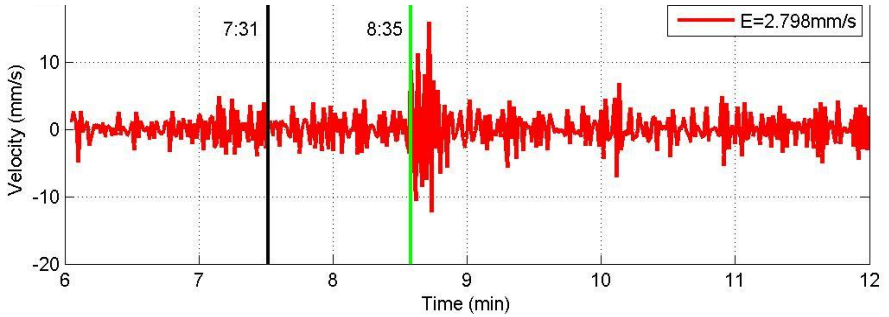
- instantaneous site vel

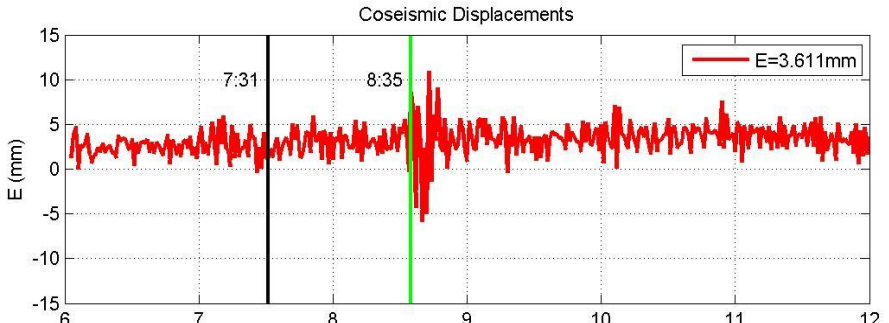
Xinjiang Ms6.6 earthquake on J











GNSS coseismic monitoring

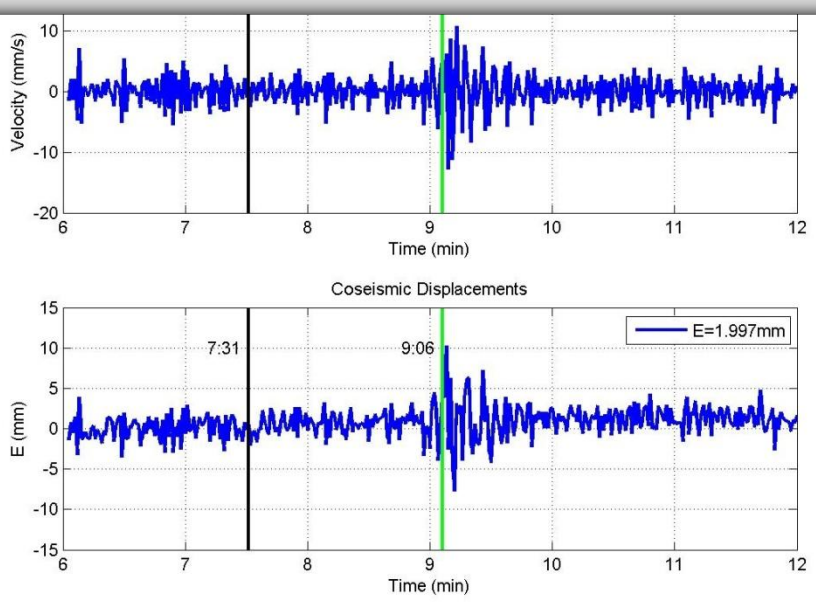
➢Real-time GNSS coseismic monitoring system

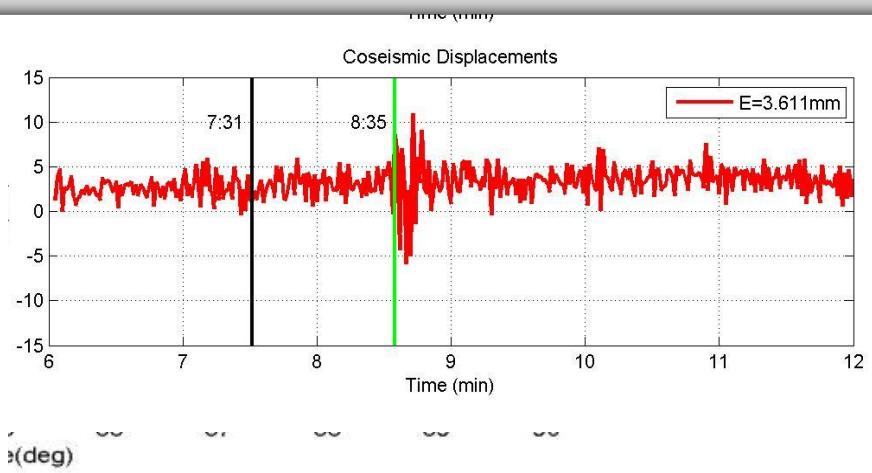
① retrieval of real-time high rate streams;

② calculation of the Doppler observations;

③ estimation of station instantaneous velocity;

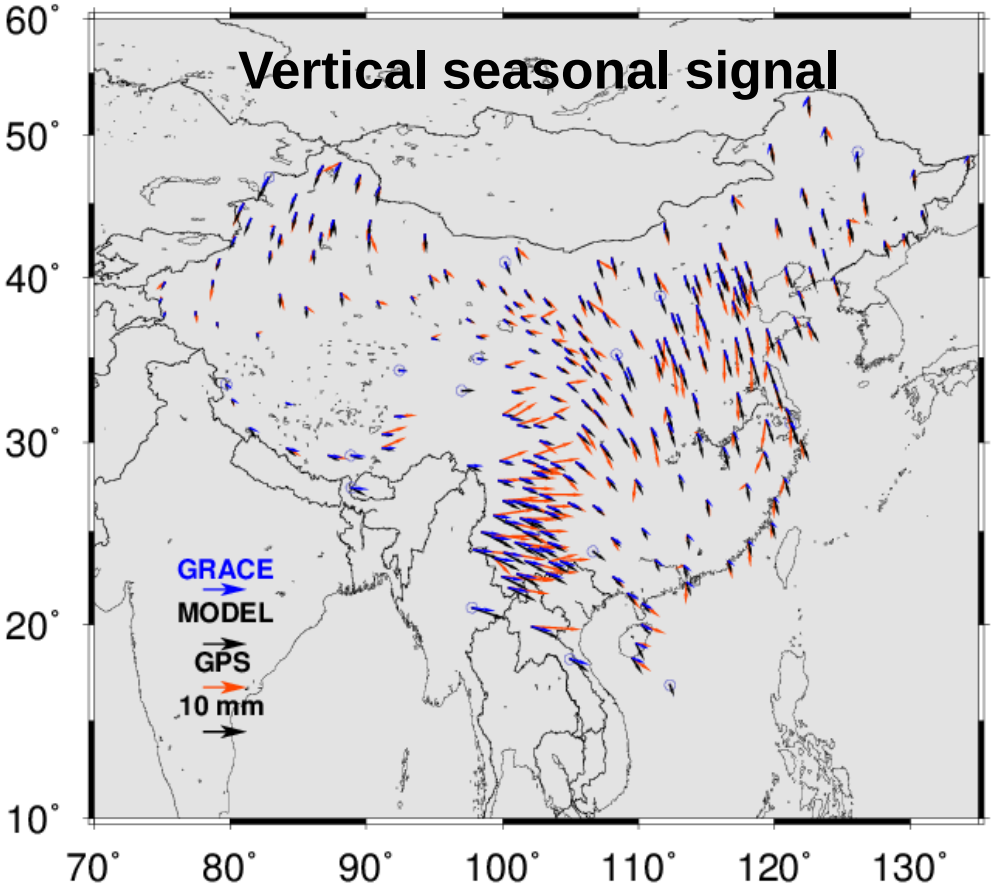
④ check for coseismic deformation.





Further results and analysis

➢Site deformation analysis



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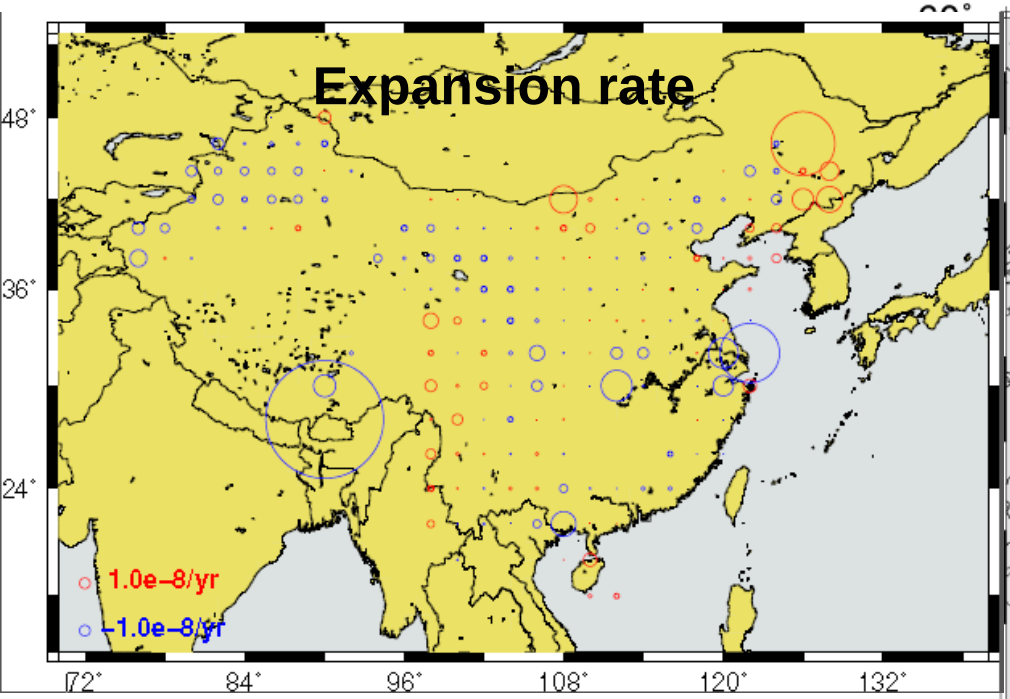

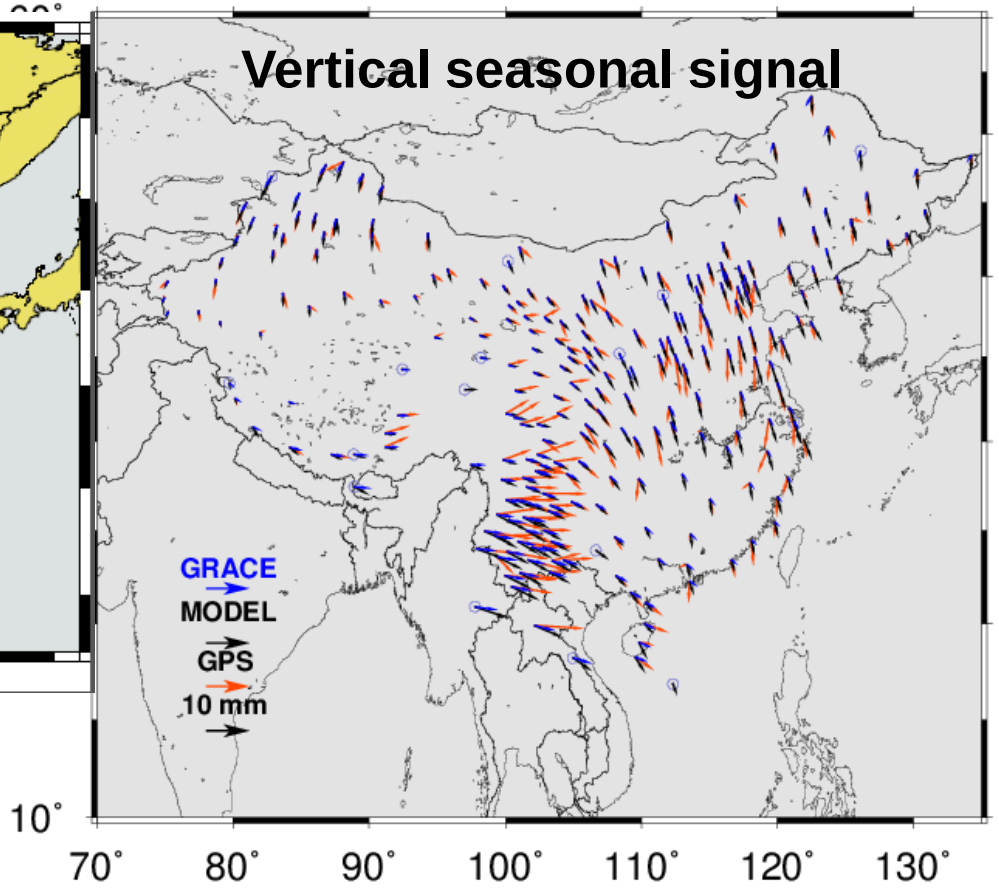

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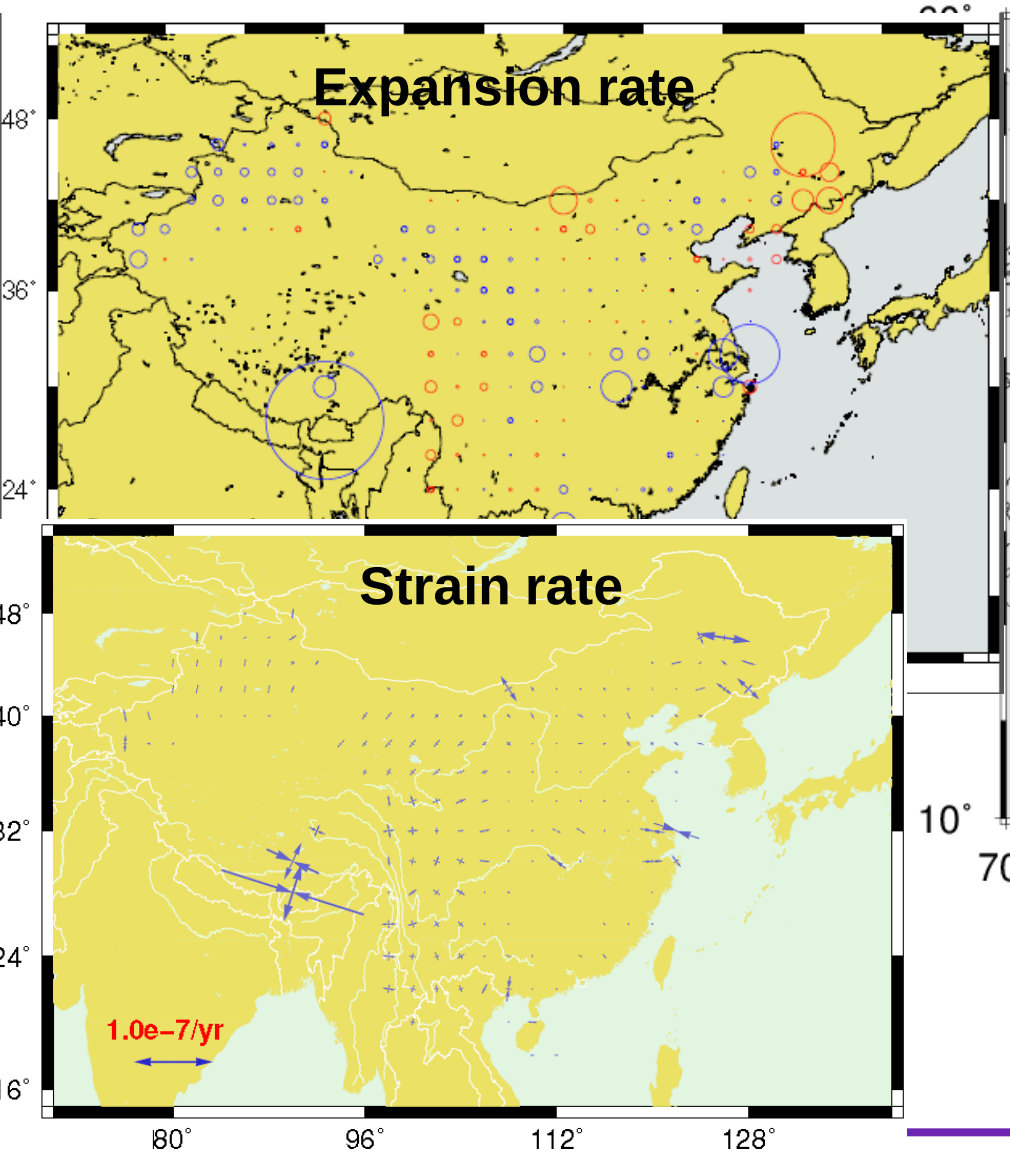
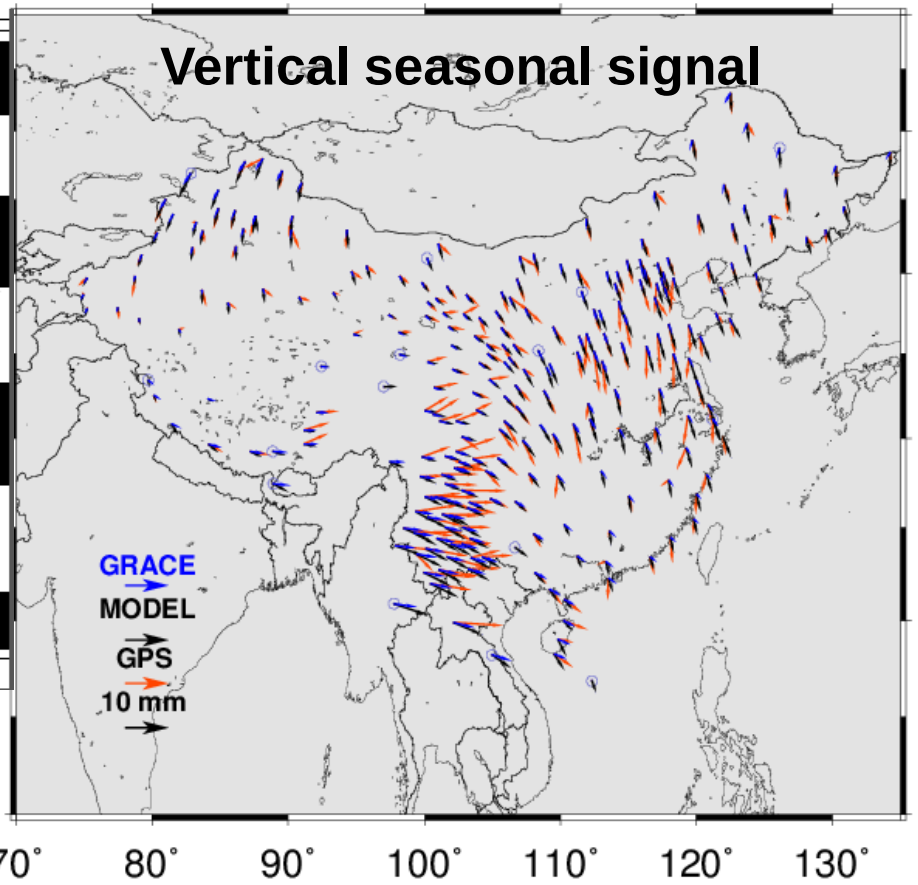
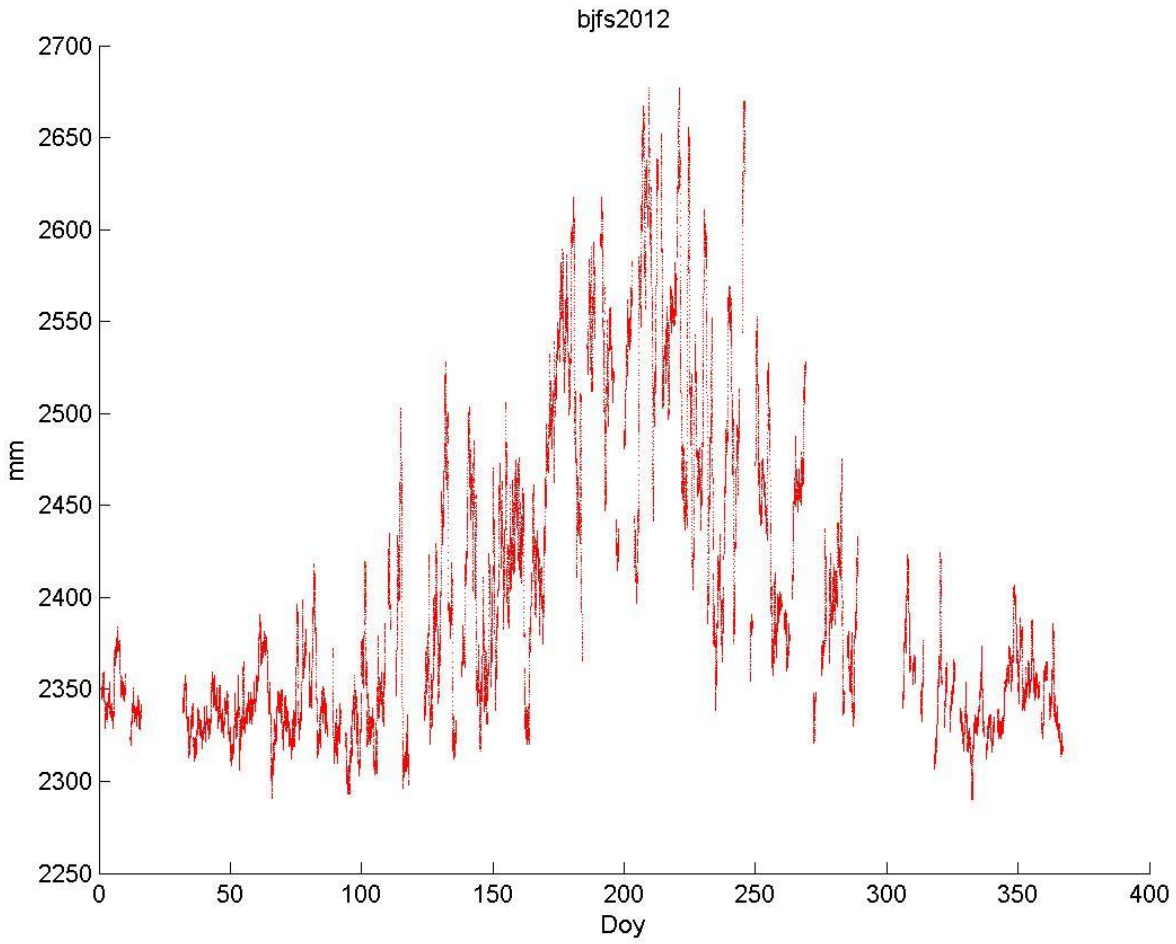




GNSS data analysis at SHAO

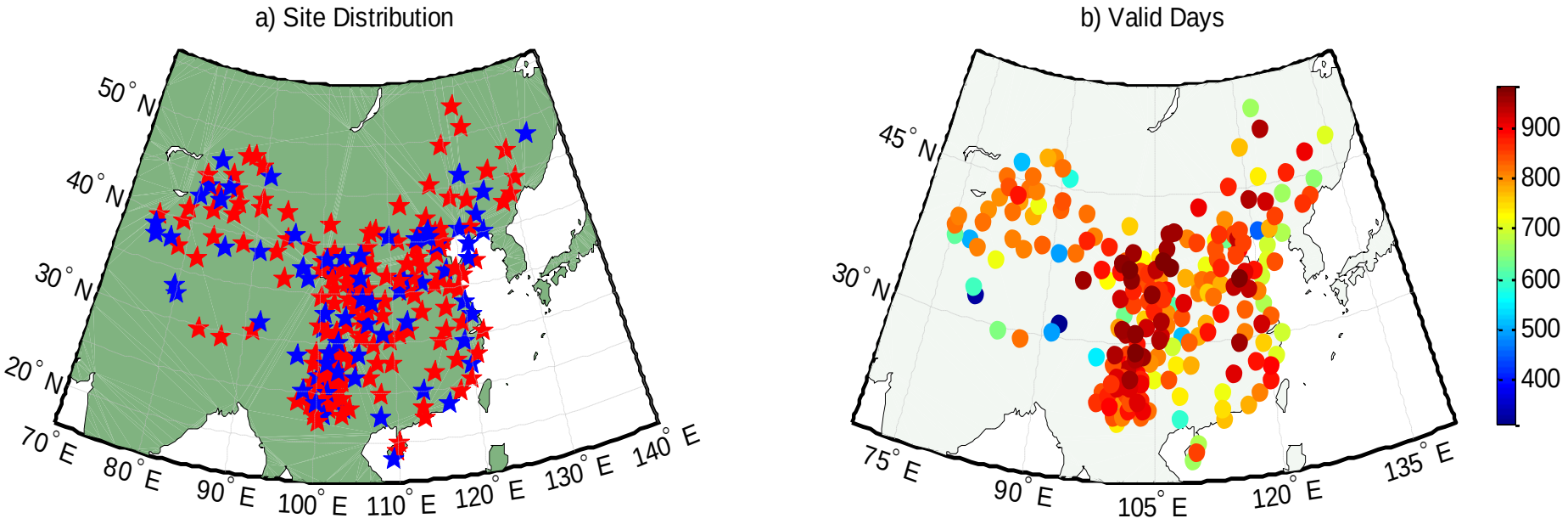
- **GNSS routine results**

Troposphere Time series



SHAtrop: *data*

- 4 years' GNSS ZTD estimates (of 223 continuous GNSS sites) at Shanghai Astronomical Observatory;
- Model determination: 152; model validation: 152+71;
- Spanning: 2012-2014



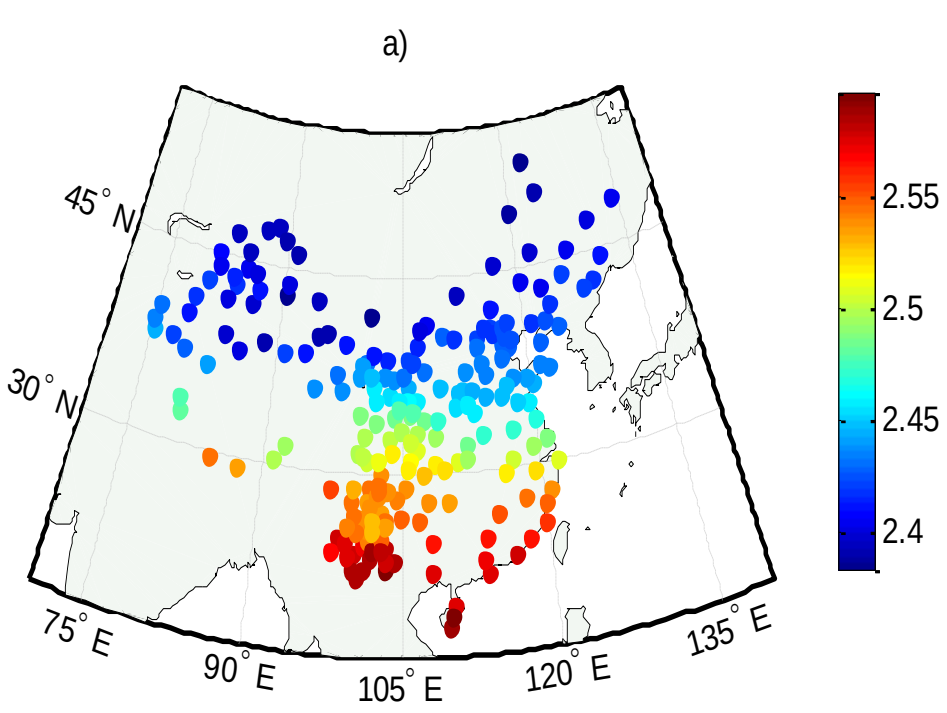
SHAtrop: ZTD model over China continent

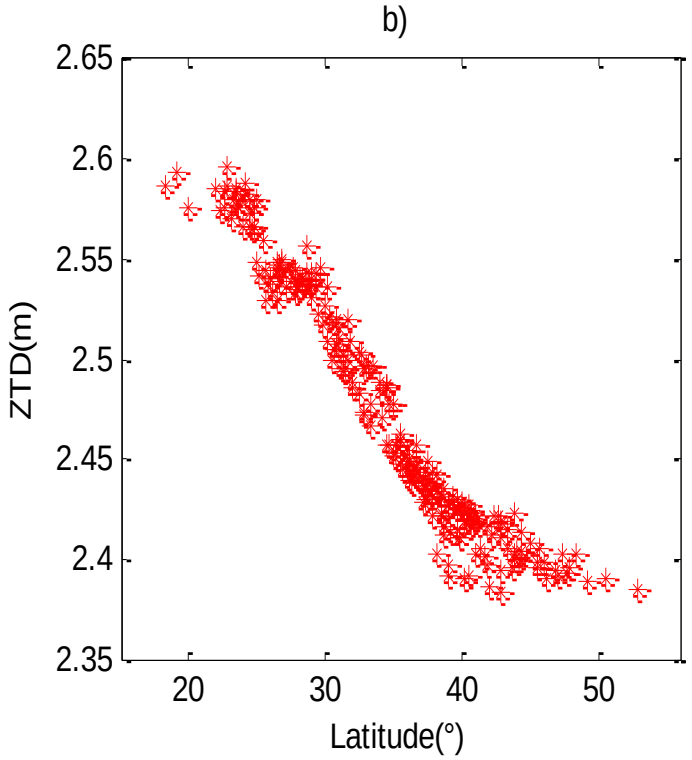
- ZTD modeled with function of station height over Geoid (constant term) and periodical terms

$$ZTD(doy) = ZTD_m + A_1 \cos\left(\frac{2\pi}{365.25}(doy - d_1)\right) + A_2 \cos\left(\frac{4\pi}{365.25}(doy - d_2)\right)$$

SHAtrop: ZTD constant term

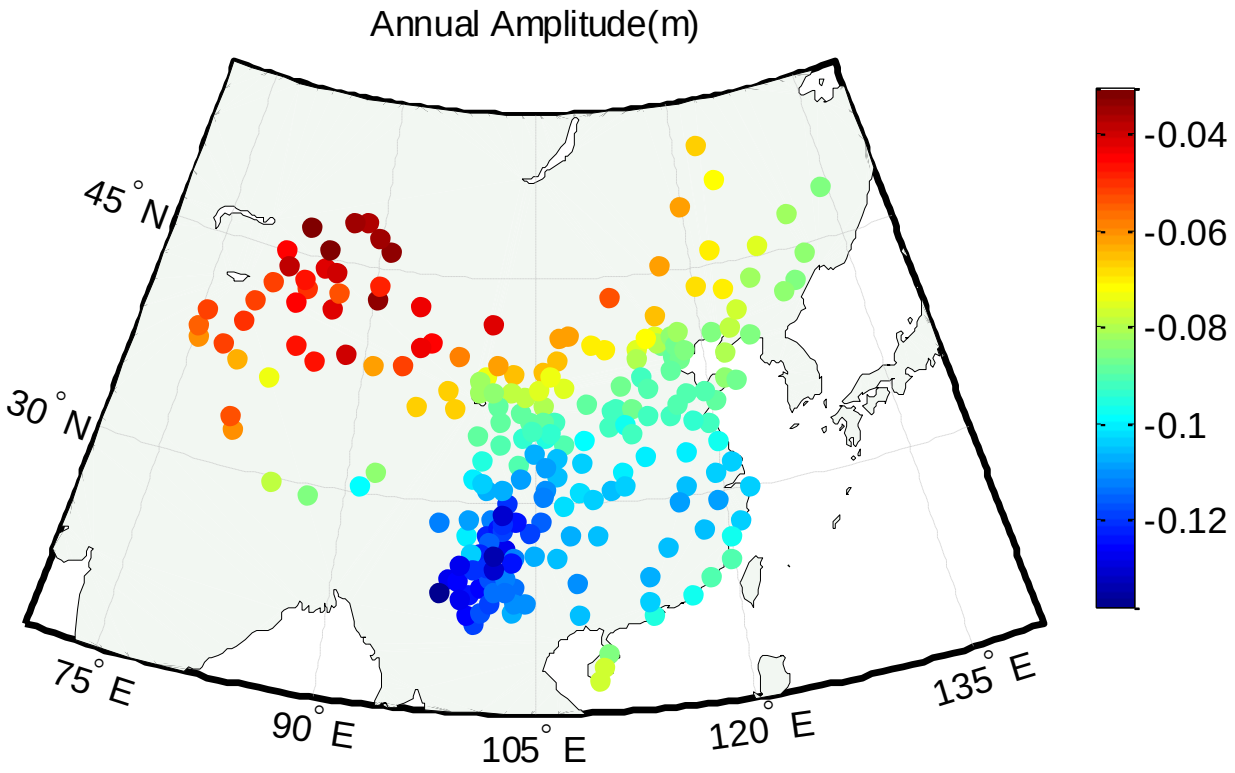
- Constant term of all sites
- Constant term v.s. site latitude





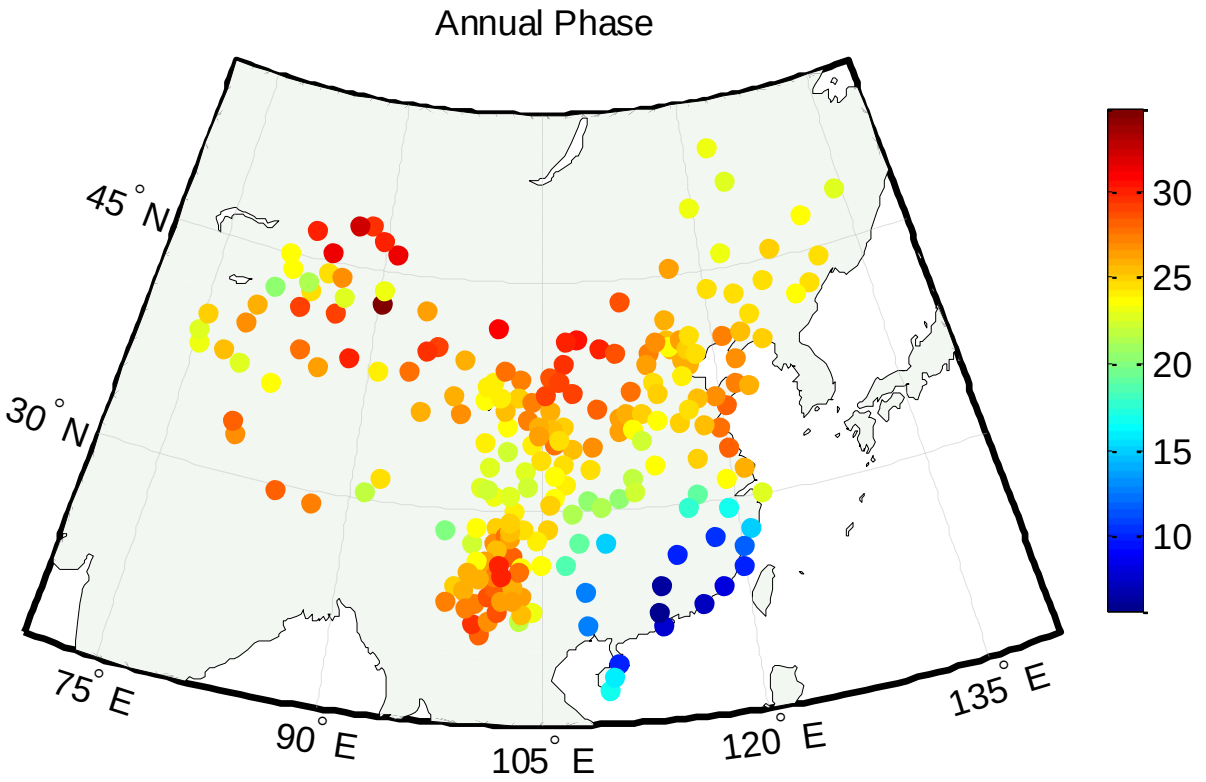
SHAtrop: ZTD annual term

- Annual amplitude



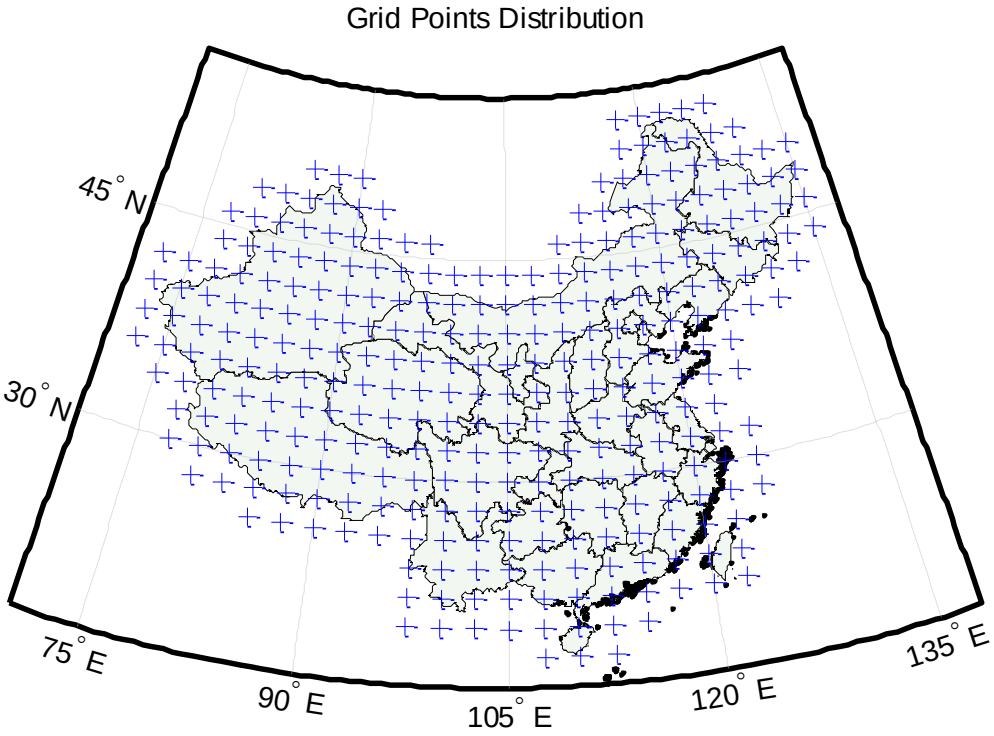
SHAtrop: ZTD annual term

- Annual phase



SHAtrop: ZTD Grid model over China continent

- Parameters of 152 sites
- Latitude-Longitude: 2°× 2.5°grid
- [70°E~135°E, 18°N~54°N]



SHAtrop: ZTD calculation for user

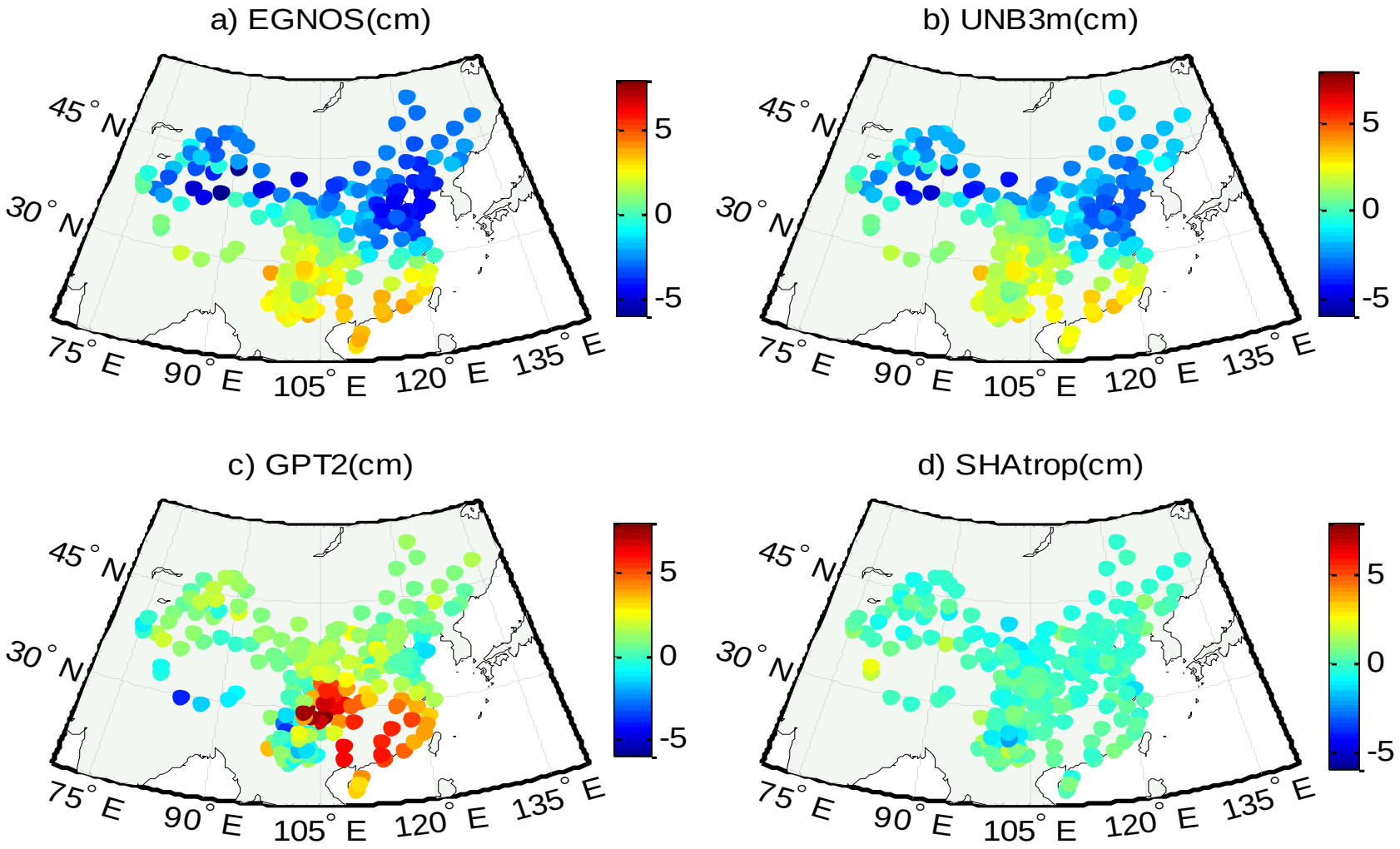
- Select four grid points around the site
- Bilinear interpolation (ZTD_m, A_1, d_1, A_2, d_2)
- Reduction to the site height

ZTD at each grid point is modeled by:

$$ZTD(doy,h) = \left(ZTD_m + A_1 \cos\left(\frac{2\pi}{365.25}(doy - d_1) \right) + A_2 \cos\left(\frac{4\pi}{365.25}(doy - d_2) \right) \right) \times e^{\beta h}$$

SHAtrop: model validation - bias

- Compare to precise ZTD estimates of SHAO



SHAtrop: model validation

- Compare to precise ZTD estimates of SHAO

Internal accuracy using sites included in model determination

	EGNOS	UNB3m	GPT2	SHAtrop
RMS(cm)	5.64(1.77, 8.22)	5.20(1.68,7.81)	4.70(1.55,9.35)	3.45(1.34,6.56)
BIAS(cm)	- 0.58(- 5.87,3.84)	- 0.32(- 5.07,3.23)	1.67(- 3.89,7.53)	- 0.02(- 2.27,1.70)

- Improved by 39%,34%,26% over EGNOS,UNB3,GPT2

SHAtrop: model validation

- Compare to precise ZTD estimates of SHAO

External accuracy using sites not included in model determination

	EGNOS	UNB3m	GPT2	SHAtrop
RMS(cm)	5.45(1.75,7.89)	5.03(1.75,7.89)	4.53(1.41,10.11)	3.48(1.30,6.41)
BIAS(cm)	- 0.32(- 4.18,4.78)	- 0.08(- 3.90,3.59)	1.51(- 3.68,8.33)	0.19(- 1.31,2.51)

- Improved by 36%,31%,23% over EGNOS,UNB3,GPT2

Summary

- Routine GNSS CMONOC analysis at SHAO

- Troposphere modeling, Velocity field & earthquake monitoring results

- site deformation analysis on going

NEXT:

- CMONOC data contributing to BDS data analysis
- Regional RF combining with SLR & VLBI

Acknowledgment: 863 projects
(No. 2013AA122402,2014AA123102)
NSFC project (No. 11273046)
CMONOC Project

http://www.shao.ac.cn/shao_gnss_ac

Thank you!