Gravimetric excitation function of polar motion from the GRACE RL05 solution

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Outline

- Introduction
- Data
- Comparison of gravimetric excitation functions.
- Comparison of gravimetric excitation functions with geodetic residuals computed by removing atmospheric and oceanic signals from geodetic excitation functions of polar motion.

Introduction

Satellite mission Gravity Recovery and Climate Experiment (GRACE) is a source of data on temporal changes in Earth's gravity field. These data are available, in the form of changes in the coefficients ΔC_{mn} ΔS_{mn} - the so-called Level 2 gravity field product.

χ_1, χ_2 - Gravimetric excitation functions are determined from ΔC_{21}, ΔS_{21} coefficients from the following formulas (Gross, 2013):

$$\chi_1 = -\sqrt{\frac{5}{3}}\frac{1.098 a_E^2 M}{(C-A)}\Delta\widehat{C}_{21} \qquad \chi_2 = -\sqrt{\frac{5}{3}}\frac{1.098 a_E^2 M}{(C-A)}\Delta\widehat{S}_{21}$$

M-mass of the Earth
a_E-average equatorial radius of the Earth
C,A principal moments of inertia

Data used

GSM product - coefficients ΔC_{21} ,ΔS_{21} from RL05 GRACE solutions developed by three centers, the Center for Space Research (CSR), the Jet Propulsion Laboratory (JPL) and GeoForschungsZentrum (GFZ). These coefficients reflect mainly the impact of the land mass of the hydrosphere on the gravitational field changes. To a lesser extent, they reflect changes in ice mass, and changes from seismic events. However they do not include information about the influence of the atmosphere and ocean.

GAC **dealiasing product** -coefficients ΔC_{21}, ΔS_{21} of gravitational field from atmospheric pressure (ECMWF) and from pressure of the ocean (OMCT), prepared by CSR, JPL, GFZ.

GEOD - Geodetic polar motion excitation function estimated by the International Earth Rotation and Reference Systems Service (IERS) based on the C04 series of x,y coordinates of the pole. *From this function motion term is removed.*

Data determined

Gravimetric ~ hydrological (HAM) excitation function of polar motion – computed from the GSM coefficients ΔC_{21} and ΔS_{21} . This function represents primarily change of the excitation function due to changes in land mass of the hydrosphere.

AAM+OAM **–** merge atmospheric and oceanic excitation function of polar motion – computed from the GAC coefficients ΔC_{21} ΔS_{21}. This function represents primarily excitation due to atmospheric and oceanic mass changes.

GEOD – (AAM+OAM) - **Geodetic residuals** computed by removing atmospheric and oceanic signals AAM+OAM (computed from the GAC) from the geodetic excitation function.

Comparison of gravimetric – hydrological excitation functions

χ_1 and χ_2

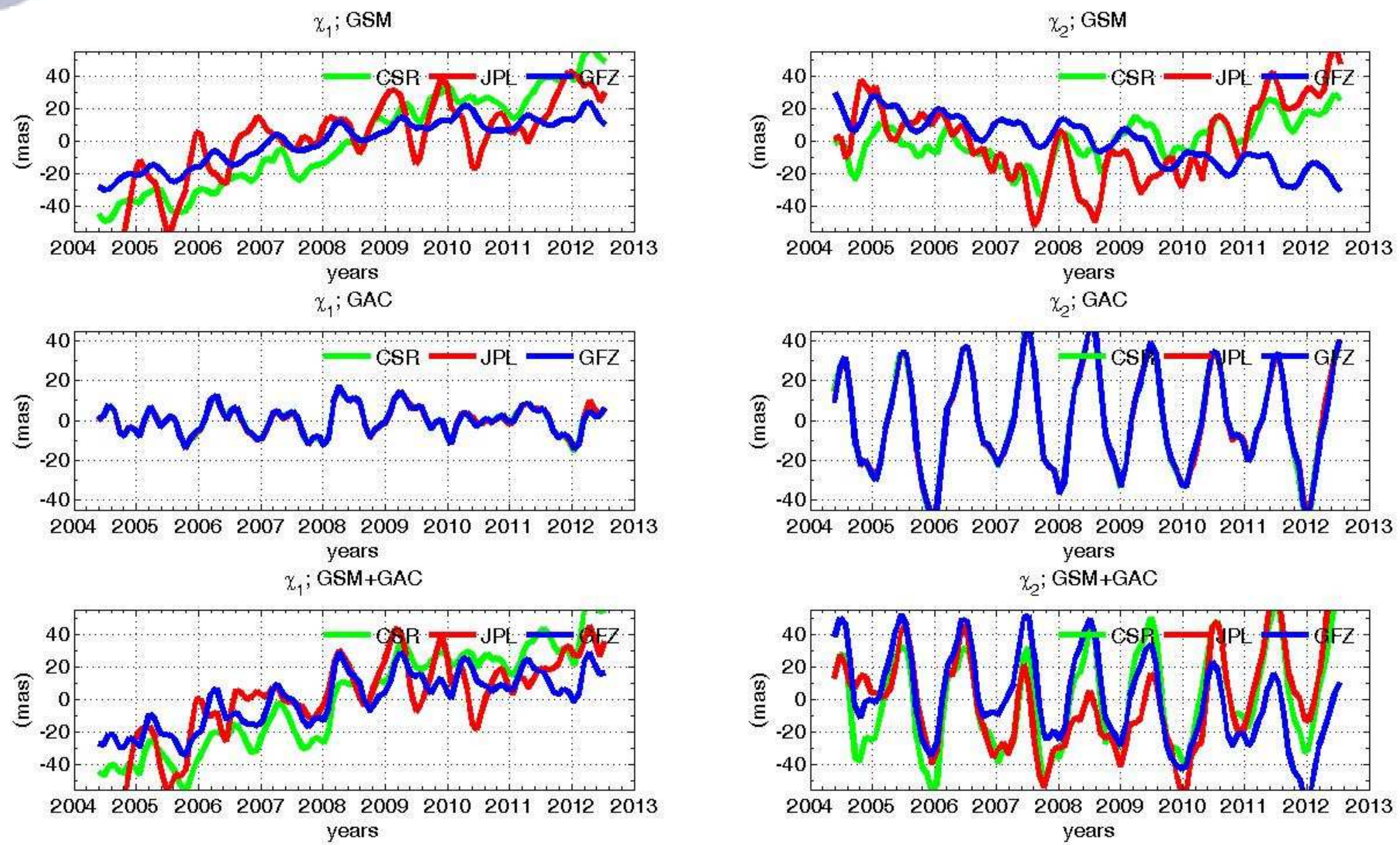

Fig.1 Gravimetric excitation function (HAM) computed from GSM coefficients from CSR,JPL,GFZ (top panel), joint atmospheric and oceanic excitation function computed from GAC coefficient from CSR,JPL,GFZ (middle panel), joint atmospheric oceanic and gravimetric excitation function AAM+OAM+HAM (bottom) panel.

χ_1 i χ_2 – non seasonal changes

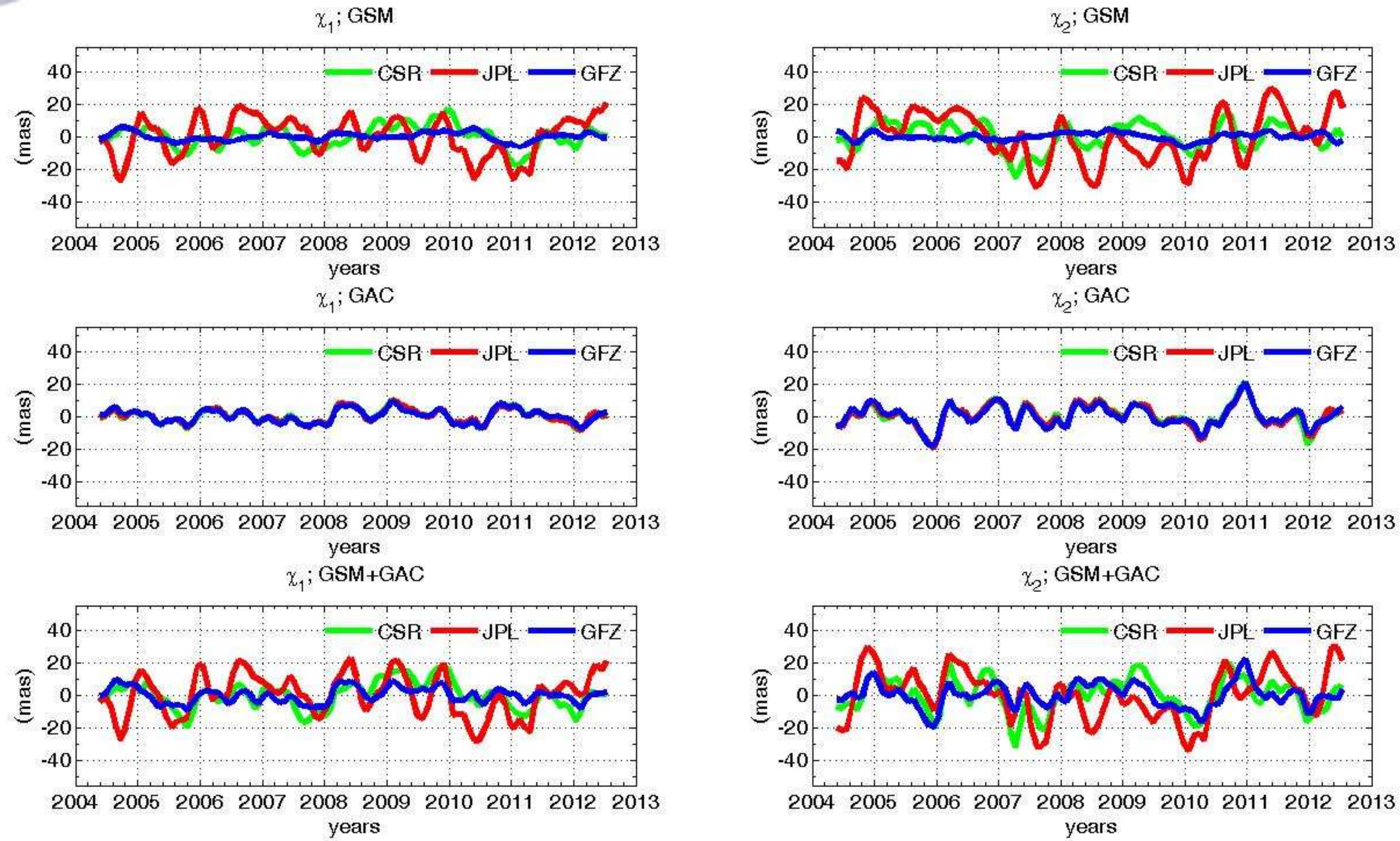

Fig.3 Gravimetric excitation function (HAM) computed from GSM coefficients from CSR,JPL,GFZ (top panel), joint atmospheric and oceanic excitation function computed from GAC coefficient from CSR,JPL,GFZ (middle panel), joint atmospheric oceanic and gravimetric excitation function AAM+OAM+HAM (bottom) panel. Seasonal oscillations are removed.

Comparison of gravimetric (HAM) excitation functions with geodetic residuals (GEOD-GAC)

Geodetic residuals (GEOD-GAC) vs HAM

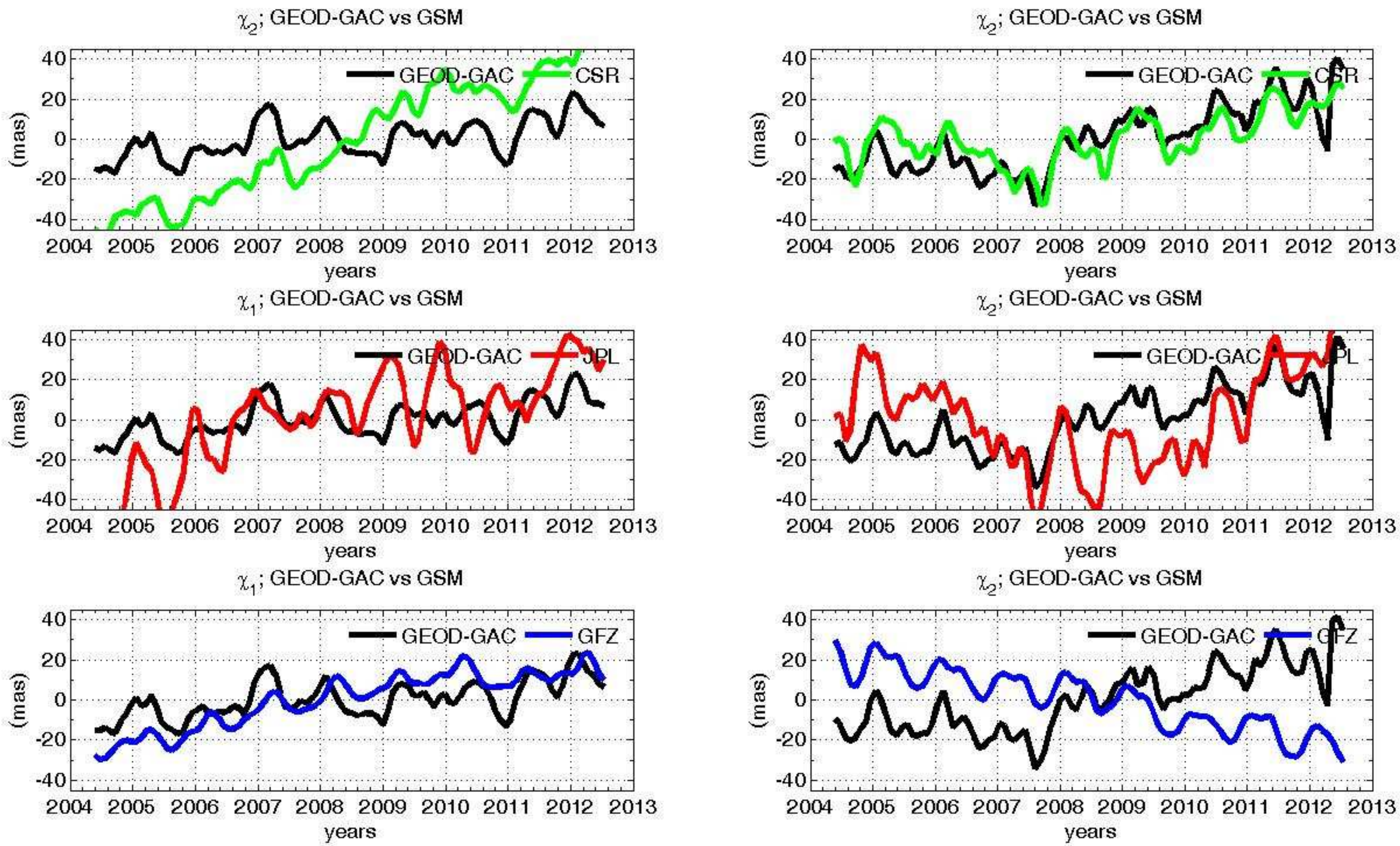

Fig.4 Comparison of gravimetric excitation function HAM computed from GSM coefficients (CSR, JPL,GFZ), with geodetic residuals GEOD-GAC.

Geodetic residuals (GEOD-GAC) vs HAM

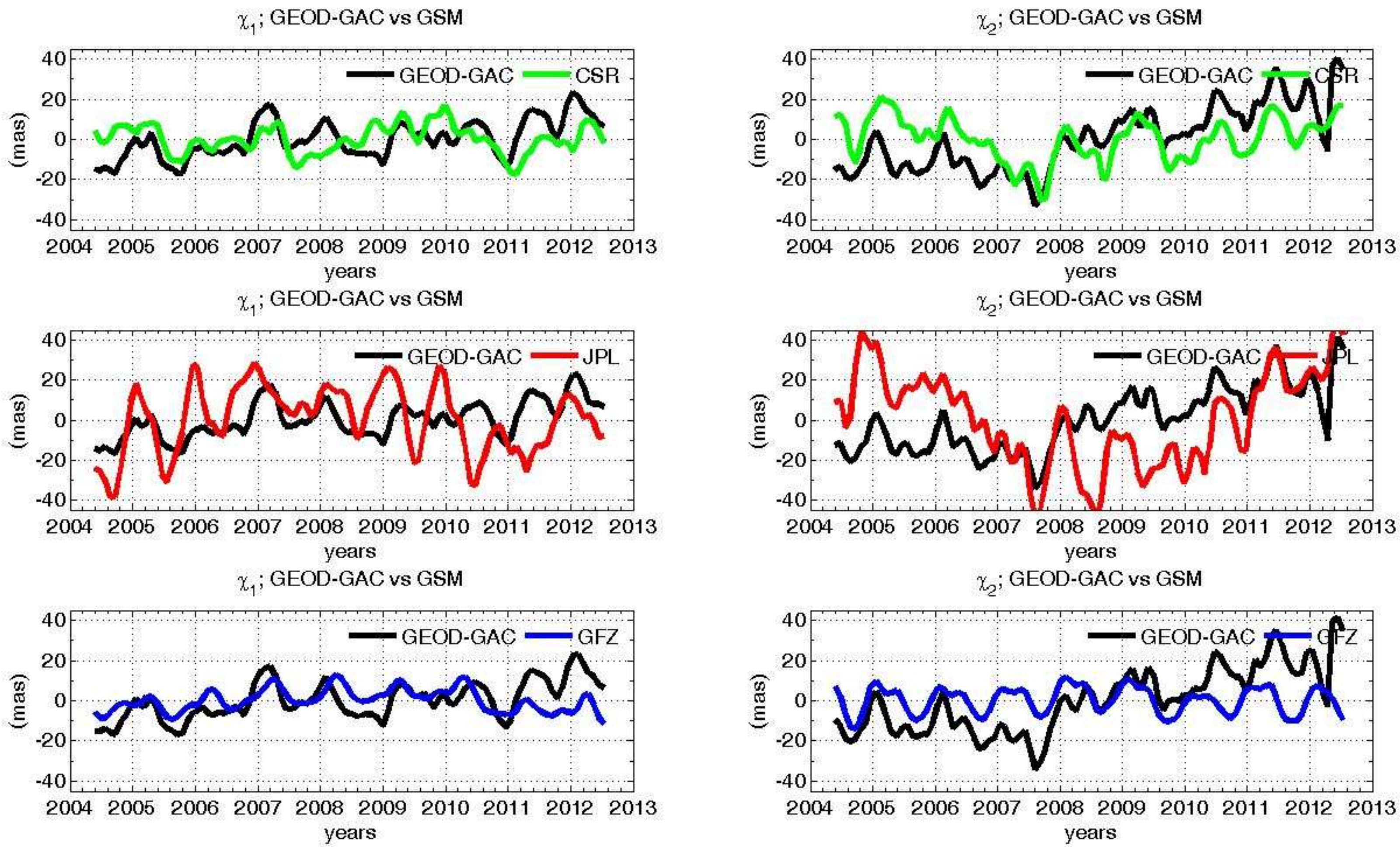

Fig.4 Comparison of gravimetric excitation function HAM computed from GSM coefficients (CSR, JPL,GFZ), with geodetic residuals GEOD-GAC.

Geodetic residuals (GEOD-GAC) vs HAM

non seasonal oscillations

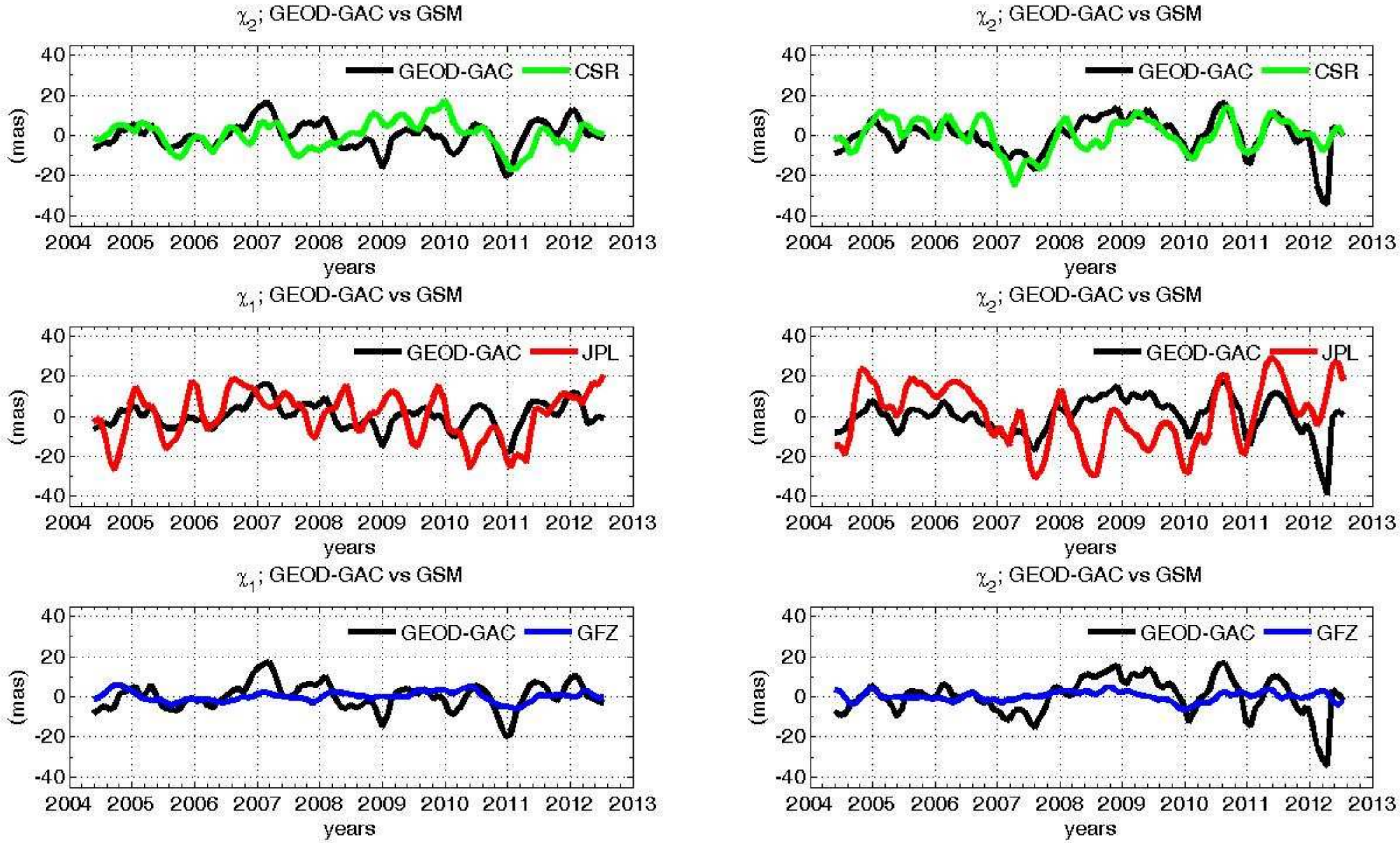

Fig.6 Comparison of gravimetric excitation function HAM computed from GSM coefficients (CSR, JPL,GFZ), with geodetic residuals GEOD-GAC. Seasonal oscillations are removed.

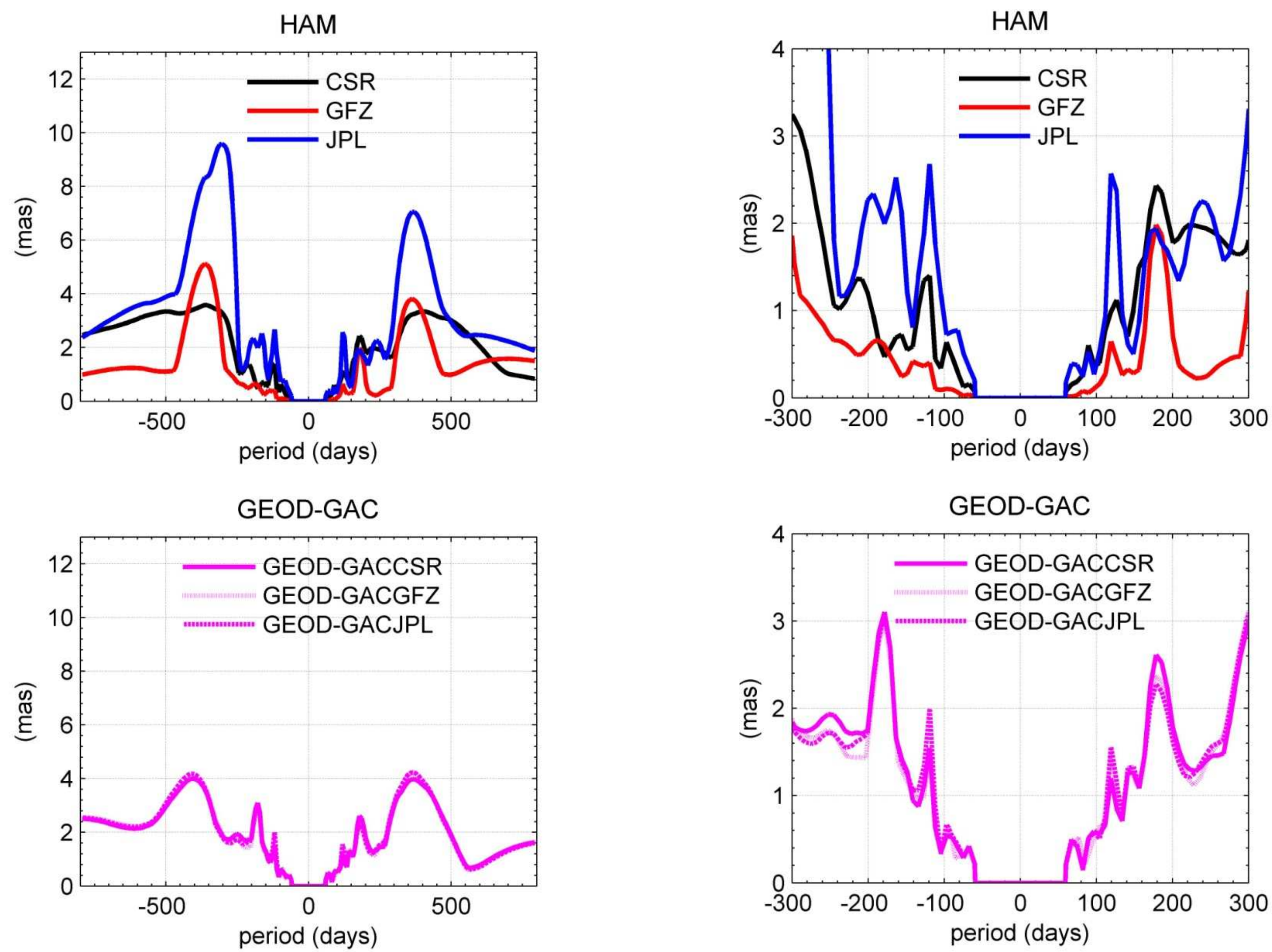

Fig.7 Comparison of spectra of gravimetric excitation function HAM computed from GSM coefficients (CSR, JPL,GFZ), with geodetic residuals GAM-GAC spectra. (FTBPF, lambda=0.02).

Annual oscillations – phase diagrams
GRACE vs Geod -GAC

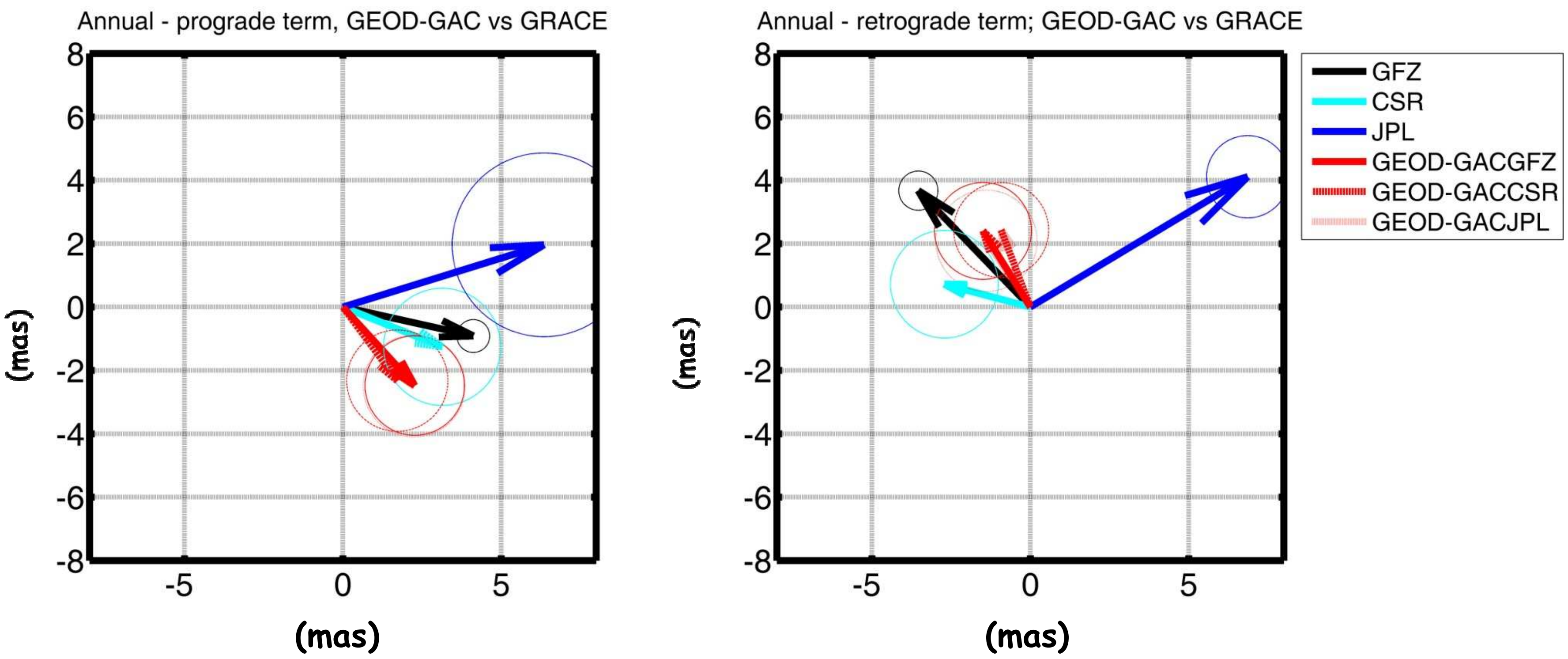

Fig.8 Phase diagrams of annual oscillations of gravimetric excitation functions HAM computed from EWT (GFZ,JPL,CSR) with phase diagrams of annual oscillations of geodetic residuals computed by removing atmospheric and oceanic signals using GAC coefficients from geodetic excitation function.

HAM vs HAM

Table 1a Correlation coefficients HAM		
Series	χ_1	χ_2
CSR/GFZ	0.62	0.24
CSR/JPL	0.30	0.54
JPL/GFZ	0.08	0.01

Table 1b Variance of differences HAM (mas^2)		
Series	χ_1	χ_2
CSR/GFZ	31.7	61.2
CSR/JPL	137.6	165.2
JPL/GFZ	148.8	232.4

HAM vs GEOD-GAC

Table 2a Correlation coefficients HAM vs. Geodetic residuals		
Series	χ_1	χ_2
JPL	0.32	0.23
GFZ	0.30	0.20
CSR	0.18	0.58

Table 2b Variance of differences HAM – GEOD Res (mas^2)		
Series	χ_1	χ_2
JPL	62.7	256.7
GFZ	134.2	84.6
CSR	40.0	62.7

Conclusions

- Gravimetric-hydrological excitation functions obtained from the GSM coefficients from RL05 solution from three data centers JPL, GFZ, CSR differ significantly.
- GFZ solution exhibits a greater degree of smoothness than JPL and CSR.
- The best agreement between gravimetric-hydrological excitation functions and geodetic residuals was obtained from the CSR data series.

Differences EWT-AAM+OAM (GAC)

JPL-GFZ JPL-CSR CSR-GFZ

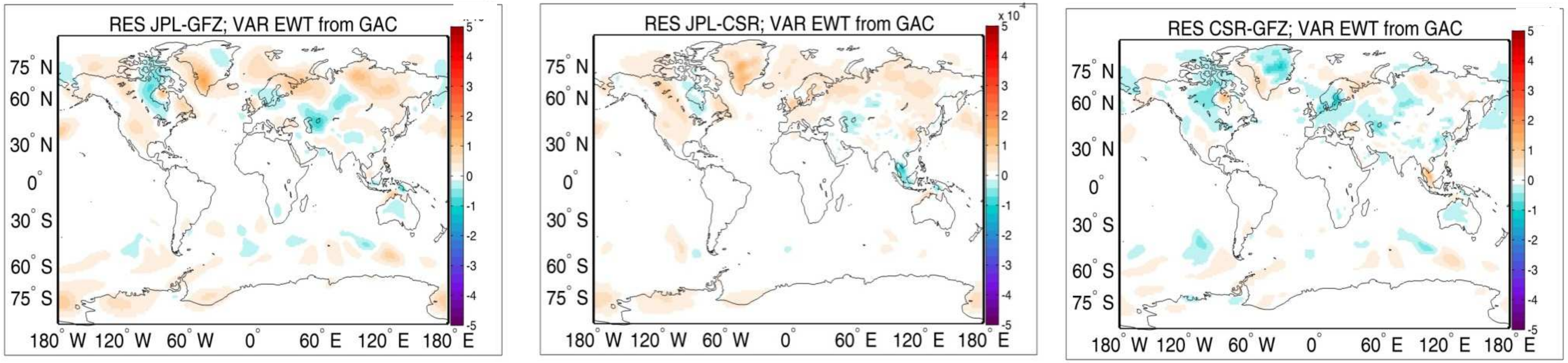

Fig. 2.a Differences among the EWT maps computed from GAC coefficients in Figure 5a (units meters^2/grid).

Differences EWT-HAM (GSM)

JPL-GFZ JPL-CSR CSR-GFZ

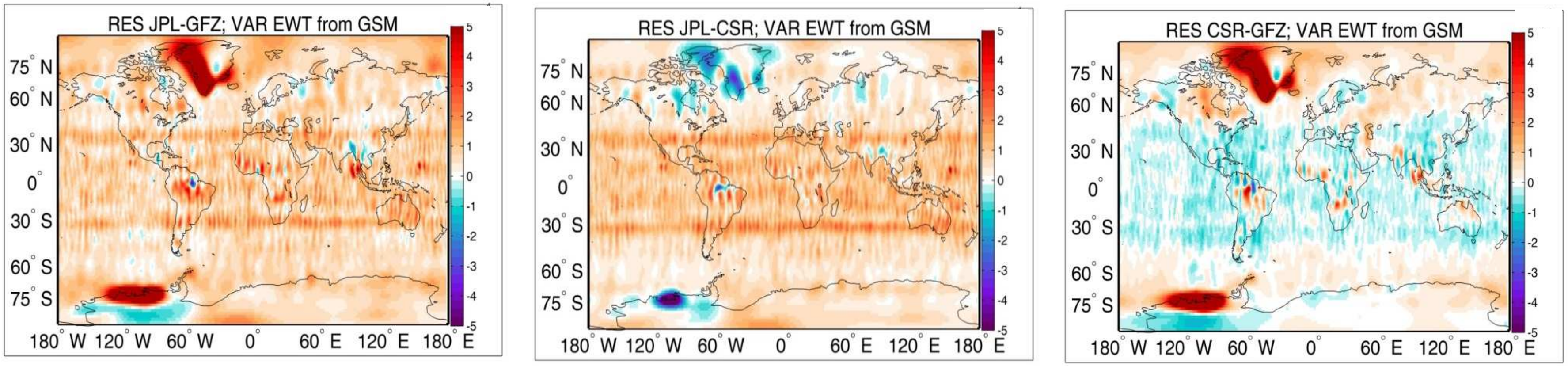

Fig. 2b. Differences among the EWT maps computed from GSM coefficients in Figure 5b (units meters^2/grid).

χ_1 and χ_2 – seasonal changes

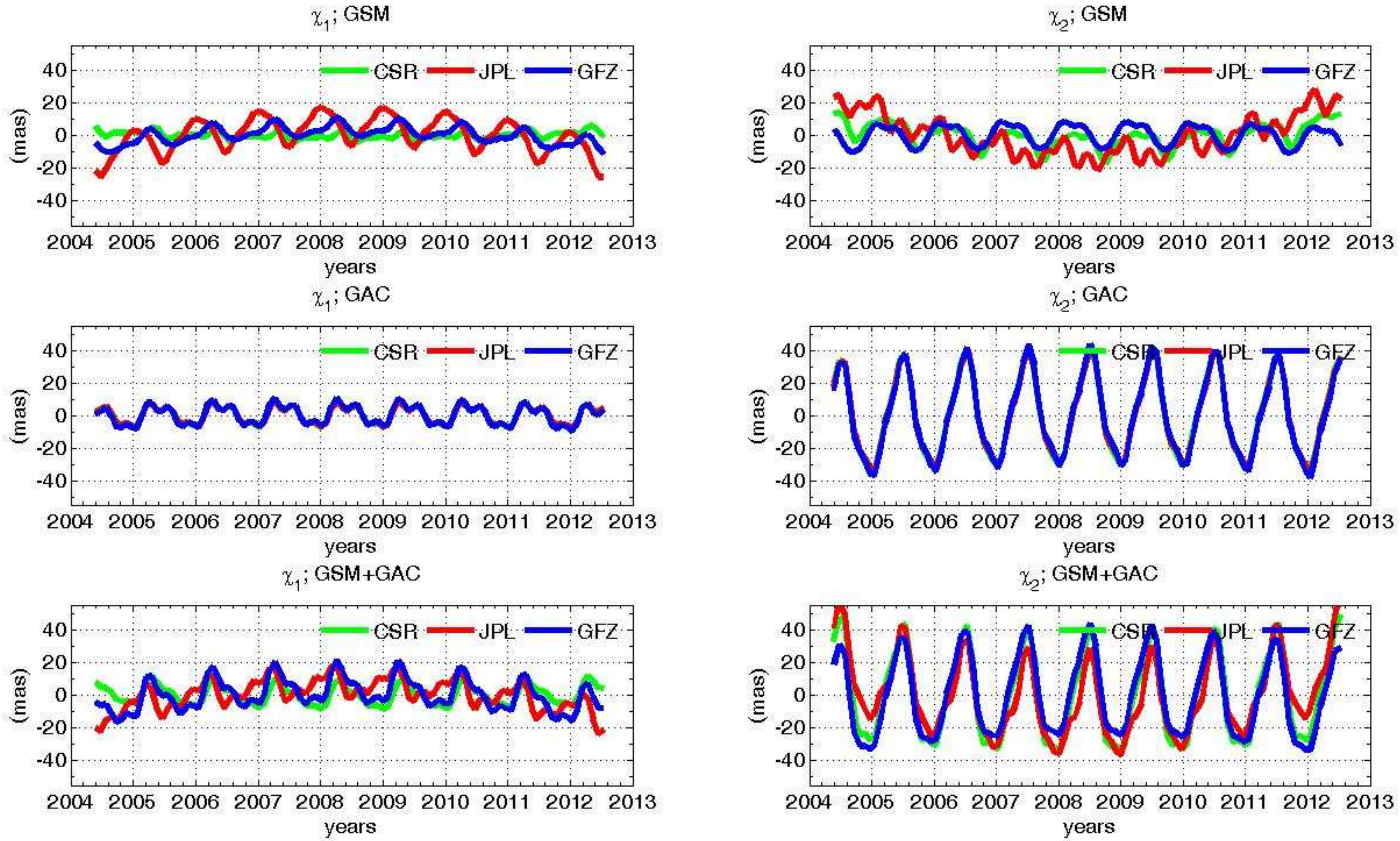

Fig.2 Gravimetric excitation function (HAM) computed from GSM coefficients from CSR,JPL,GFZ (top panel), joint atmospheric and oceanic excitation function computed from GAC coefficient from CSR,JPL,GFZ (middle panel), joint atmospheric oceanic and gravimetric excitation function AAM+OAM+HAM (bottom) panel. Combination of annual, semiannual and 120-day oscillations.

Geodetic residuals (GEOD-GAC) vs HAM

Seasonal oscillations

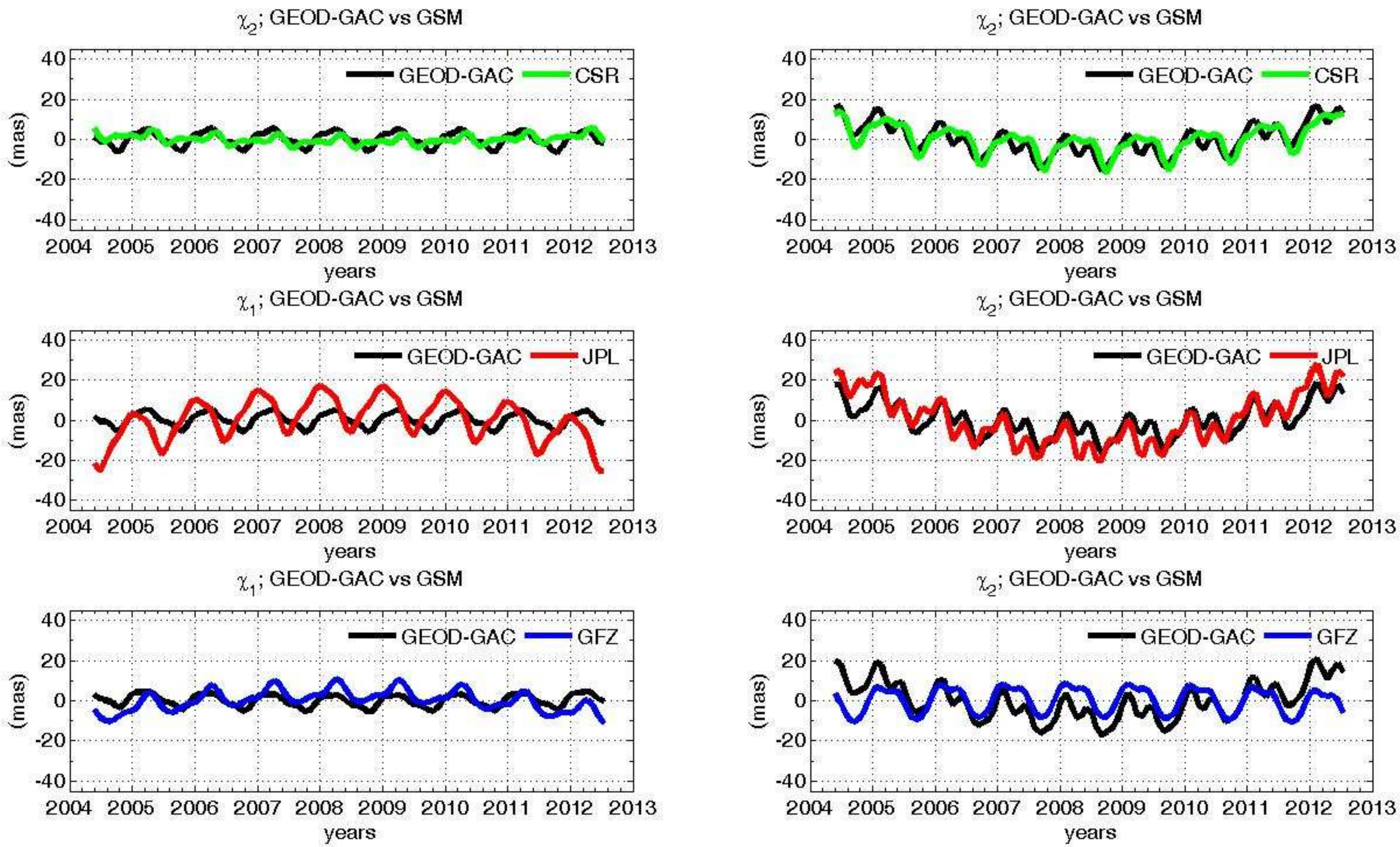

Fig.5 Comparison of gravimetric excitation function HAM computed from GSM coefficients (CSR, JPL,GFZ), with geodetic residuals GEOD-GAC. Combination of annual, semiaanual and 120 day oscillations.

Semiannual oscillations – phase diagrams

GRACE vs Geod -GAC

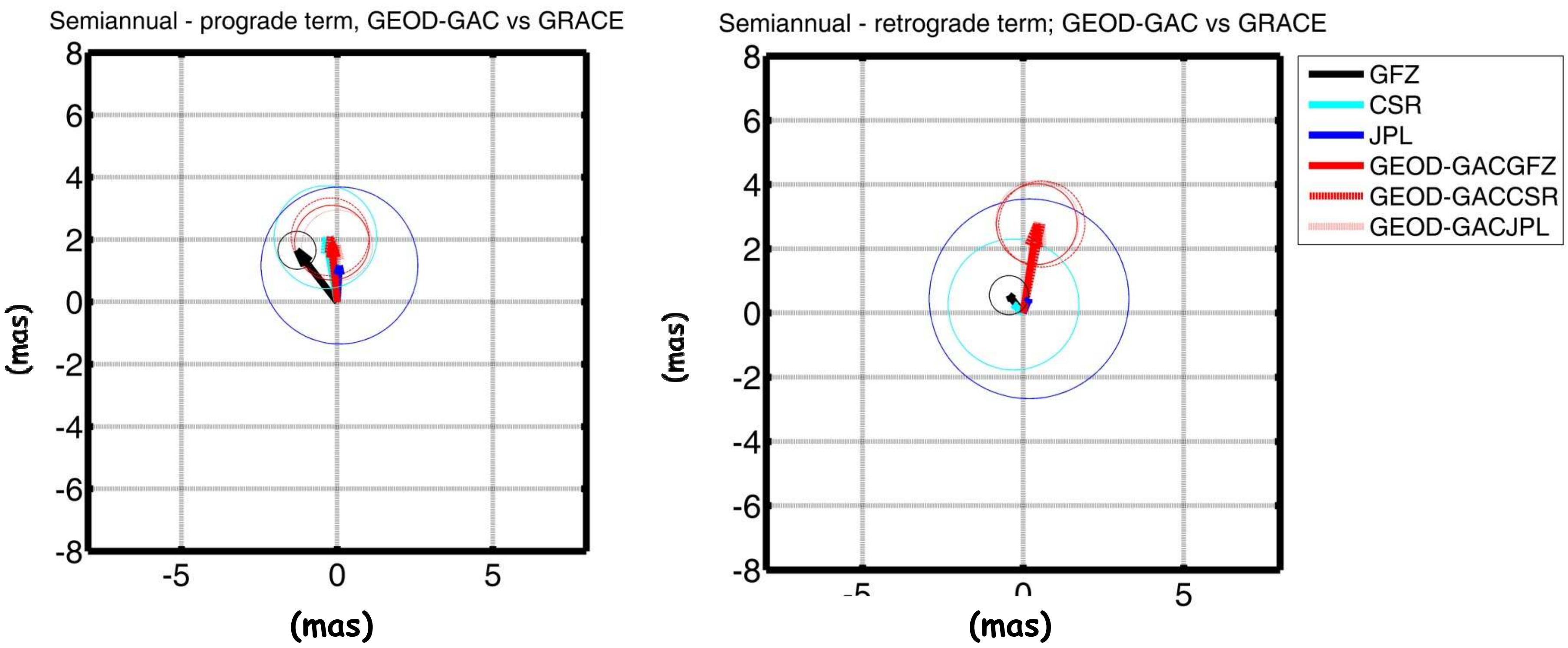

Fig.9a Phase diagrams of semiannual oscillations of gravimetric excitation functions HAM computed from EWT (GFZ,JPL,CSR) with phase diagrams of annual oscillations of geodetic residuals computed by removing atmospheric and oceanic signals using GAC coefficients from geodetic excitation function.

Semiannual oscillations – phase diagrams

GRACE vs Geod -GAC

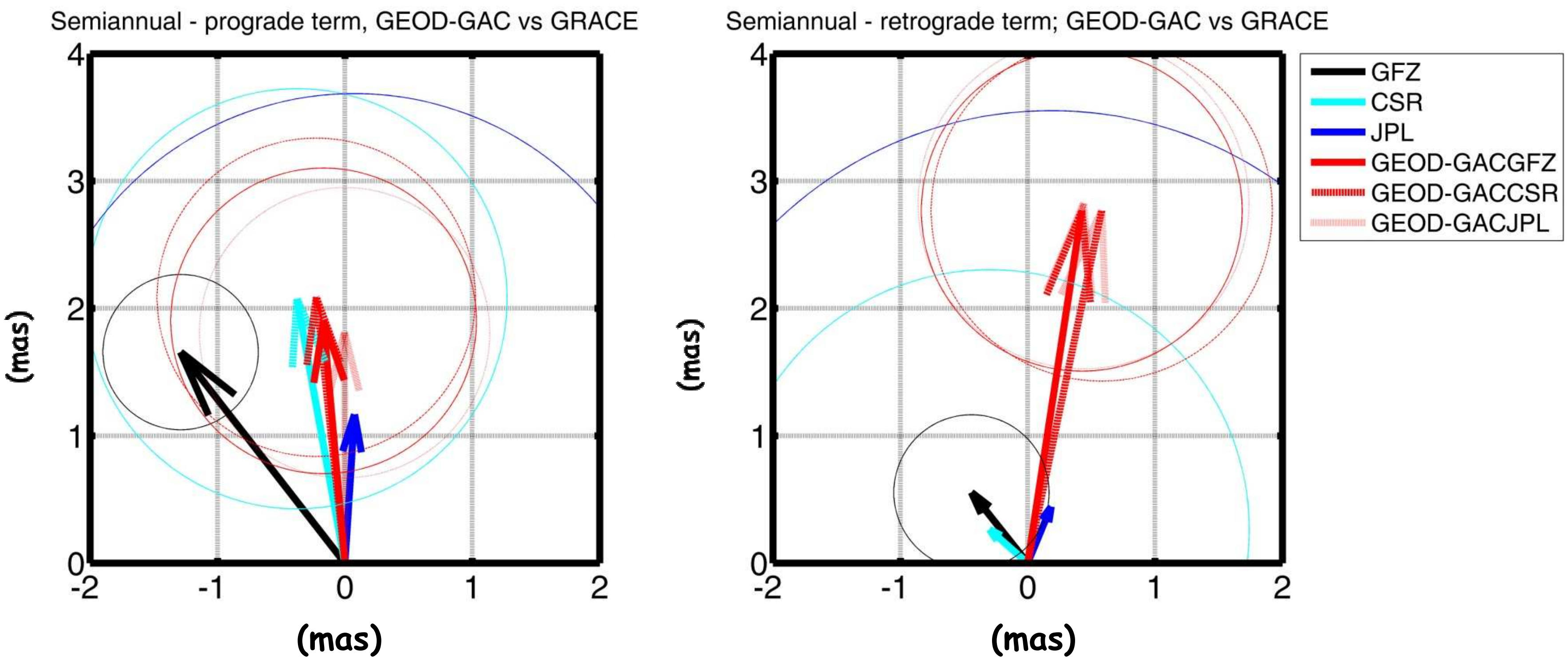

Fig.9b Phase diagrams of semiannual oscillations of gravimetric excitation functions HAM computed from EWT (GFZ,JPL,CSR) with phase diagrams of annual oscillations of geodetic residuals computed by removing atmospheric and oceanic signals using GAC coefficients from geodetic excitation function.