Towards an Ensemble Model for GRACE time-variable gravity fields

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Motivation

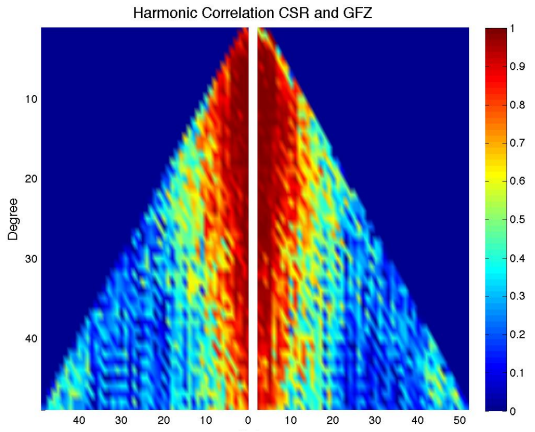
- Several centers produce estimates of time-variable gravity fields from GRACE data
- Characterize variations between center solutions
- Reduce noise in the solutions through ensemble modeling

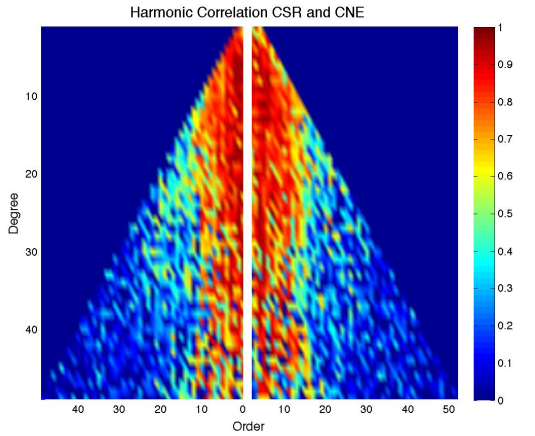
Data Selection and Analysis

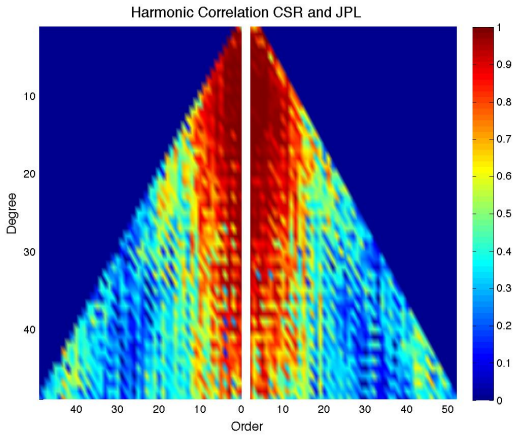
Model	Max Degree	Duration	Date Range Used	Release
CSR	60	30 days	2003-2013	5
GFZ	90	30 days	2003-2013	5
JPL	90	30 days	2003-2013	5
CNES/GRGS	50	10 days	2003-2012	2

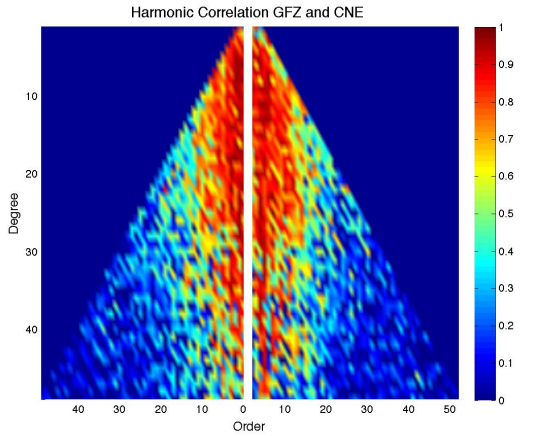
- The mean of the entire time series was removed from each coefficient to obtain the time-varying portion of the gravitational field
- Variations are due to mass transport, primarily of water
- The time-varying coefficients were converted into one degree global grids of equivalent water height (EWH)
- Filtered with the DDK-2 Filter (*Kusche, 2007*)

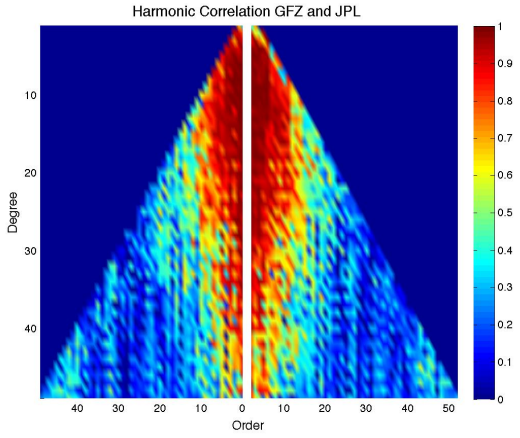
Correlation of the Solutions

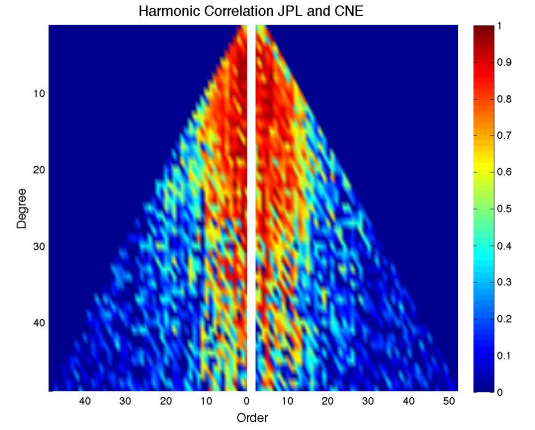




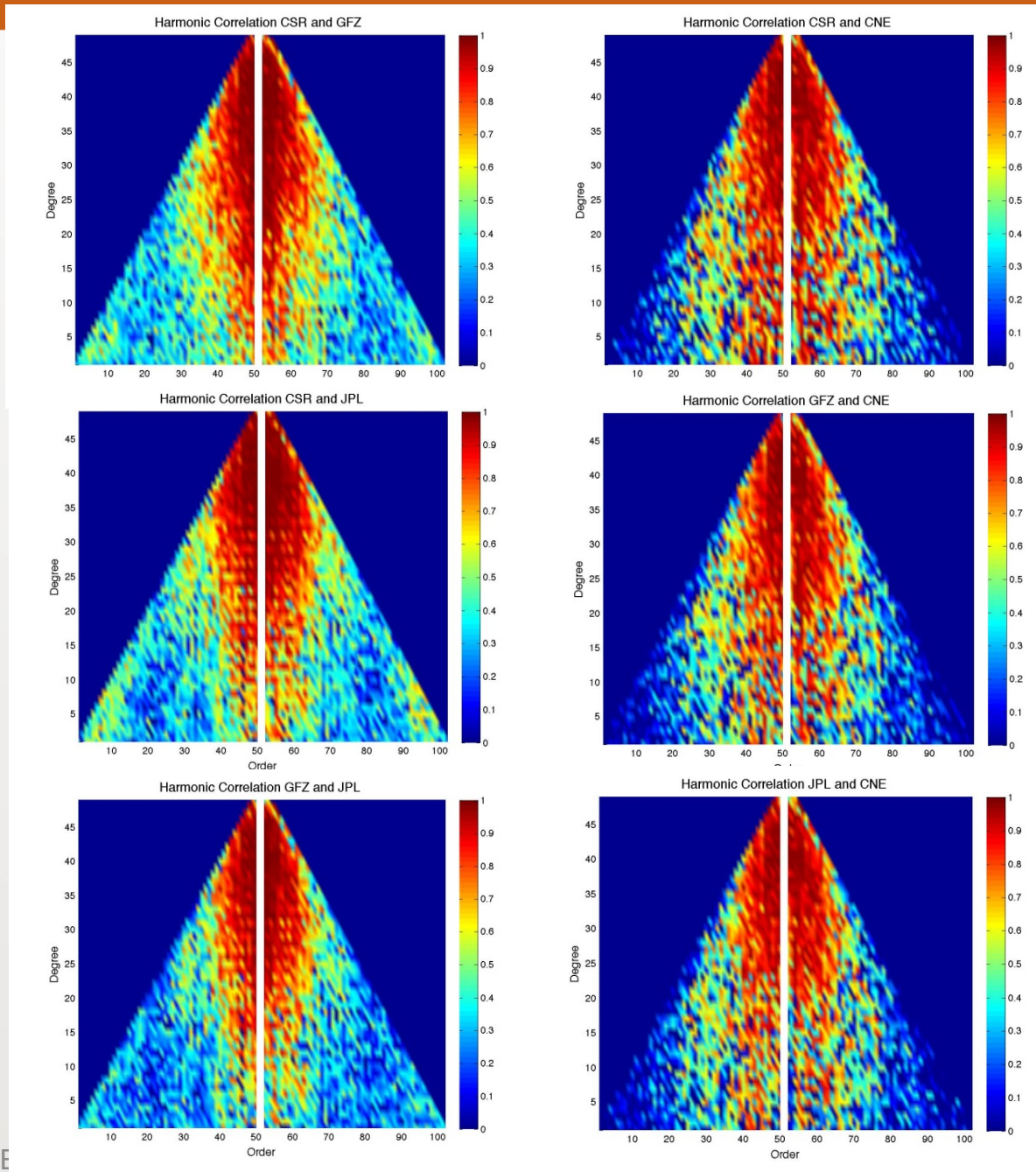








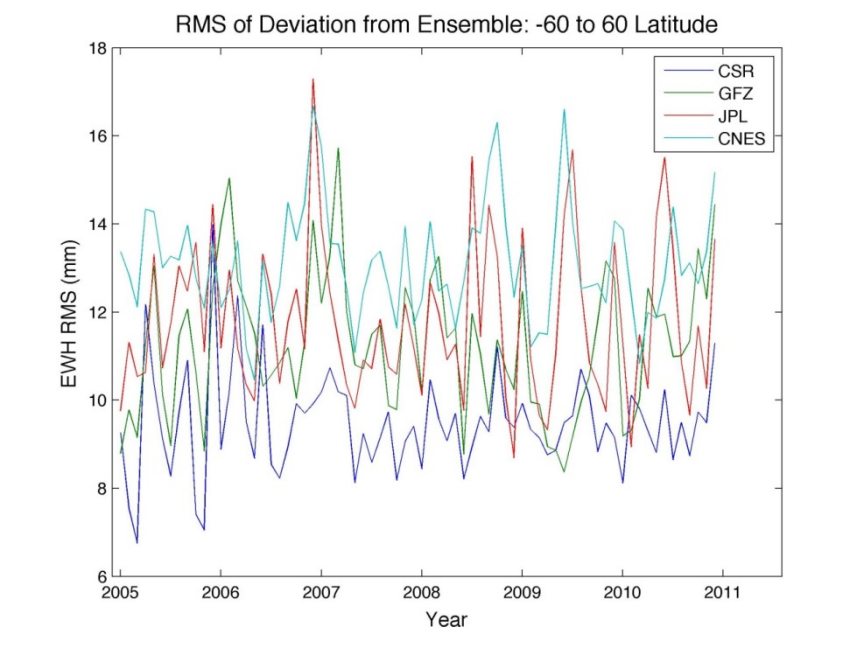
Correlation Post-Filtering

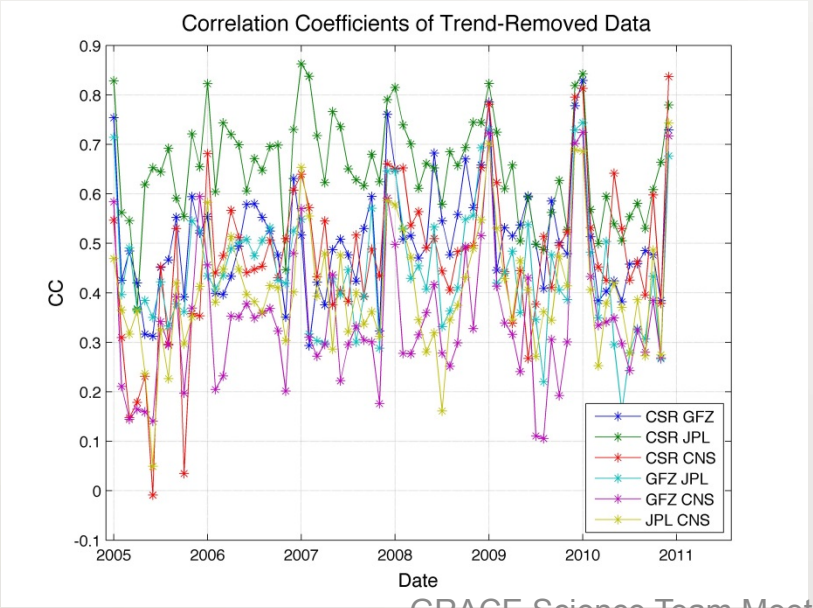


Ensemble Model Development

Variation from the mean

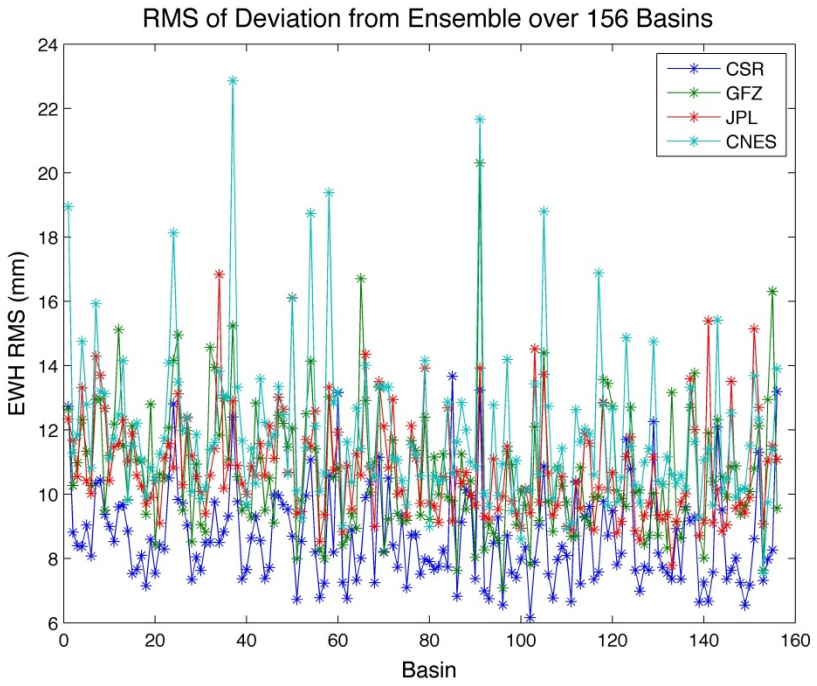
Model	RMS Deviation
CSR	8.68
GFZ	10.724
JPL	10.832
CNES/GRGS	11.892



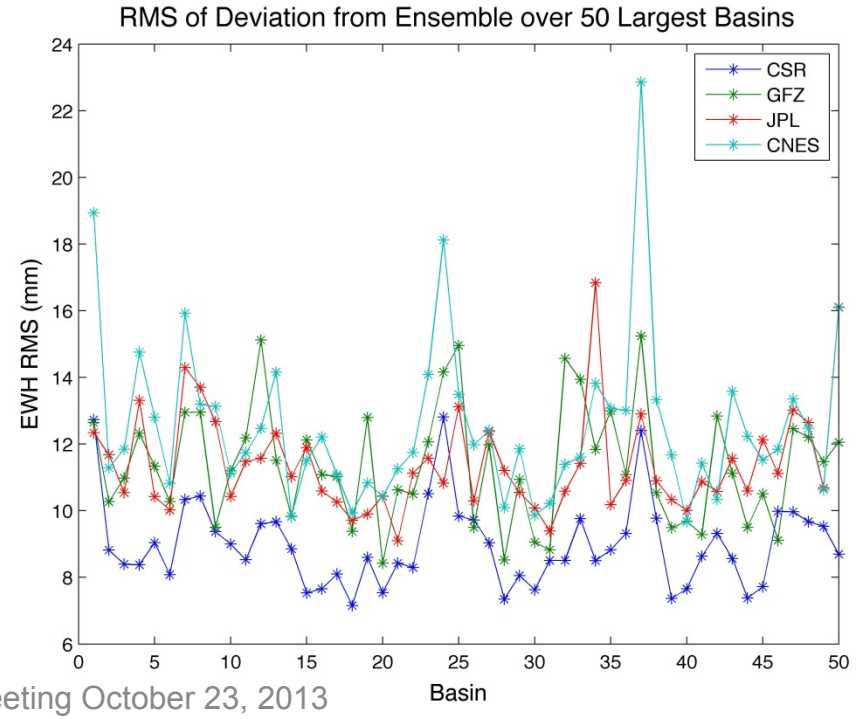


- Establish independence of solutions

Basin Scale Comparison



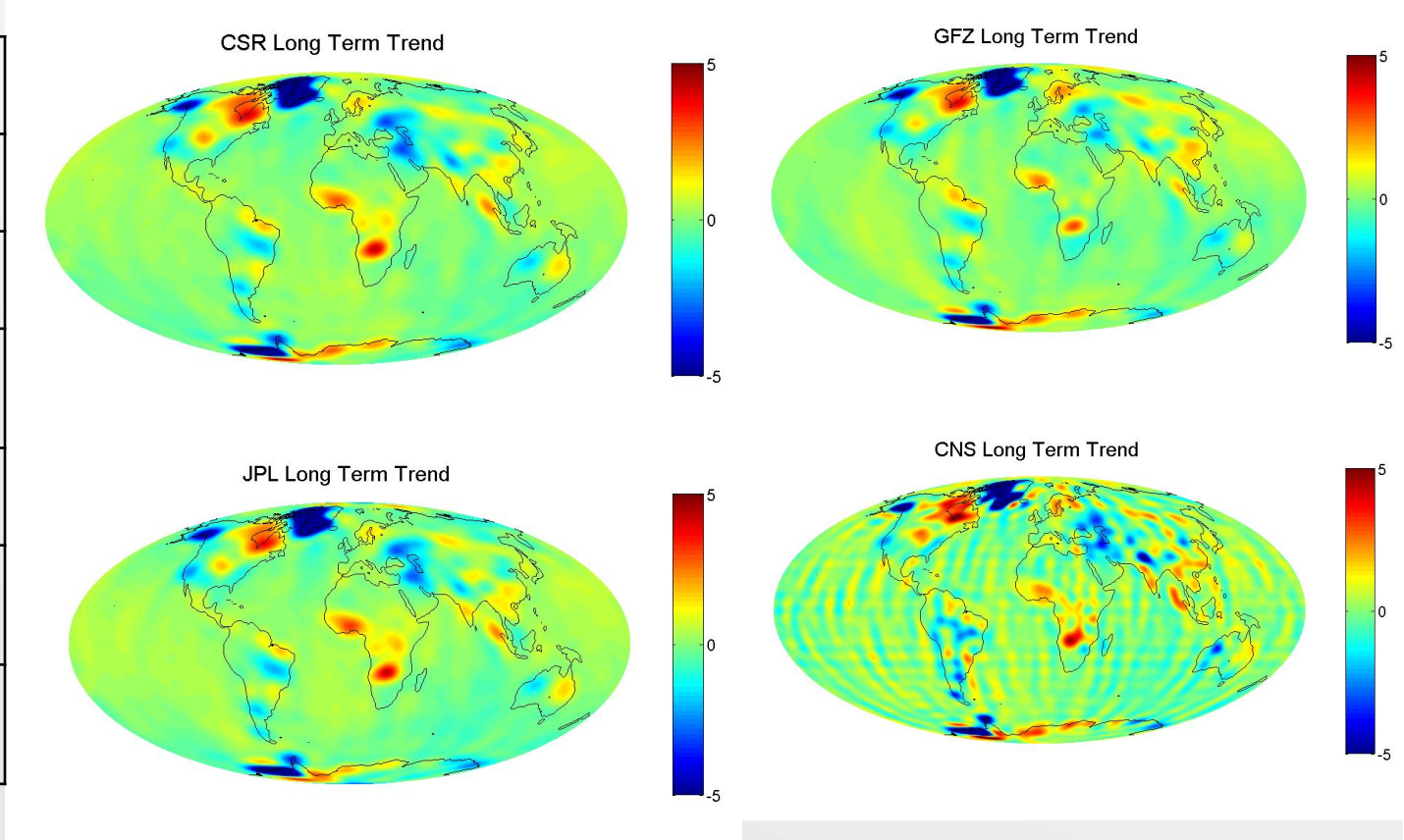
- Model solutions lie within the same analysis scatter regardless of basin size, relative amplitude



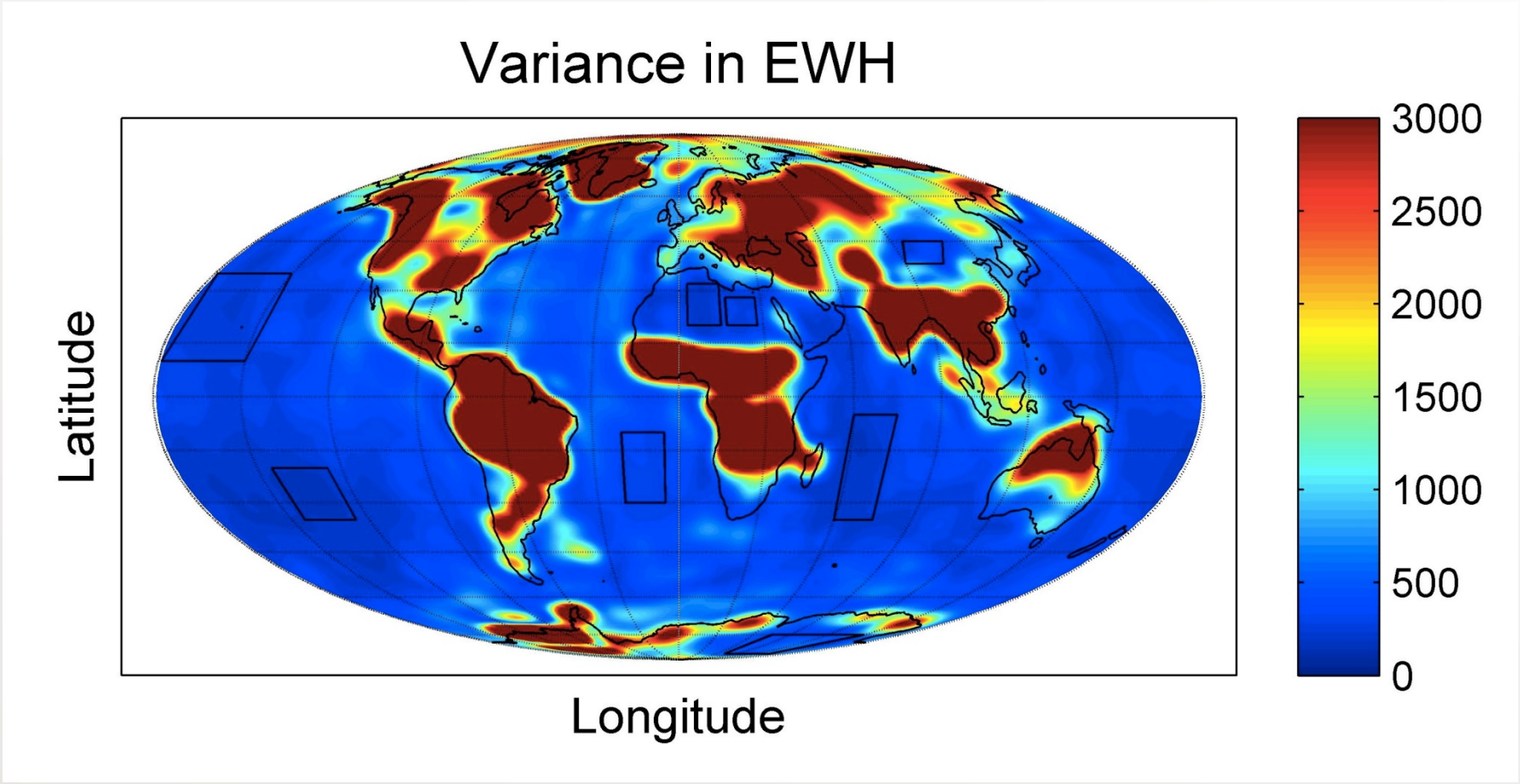
- Basin variations within the same variability range as global

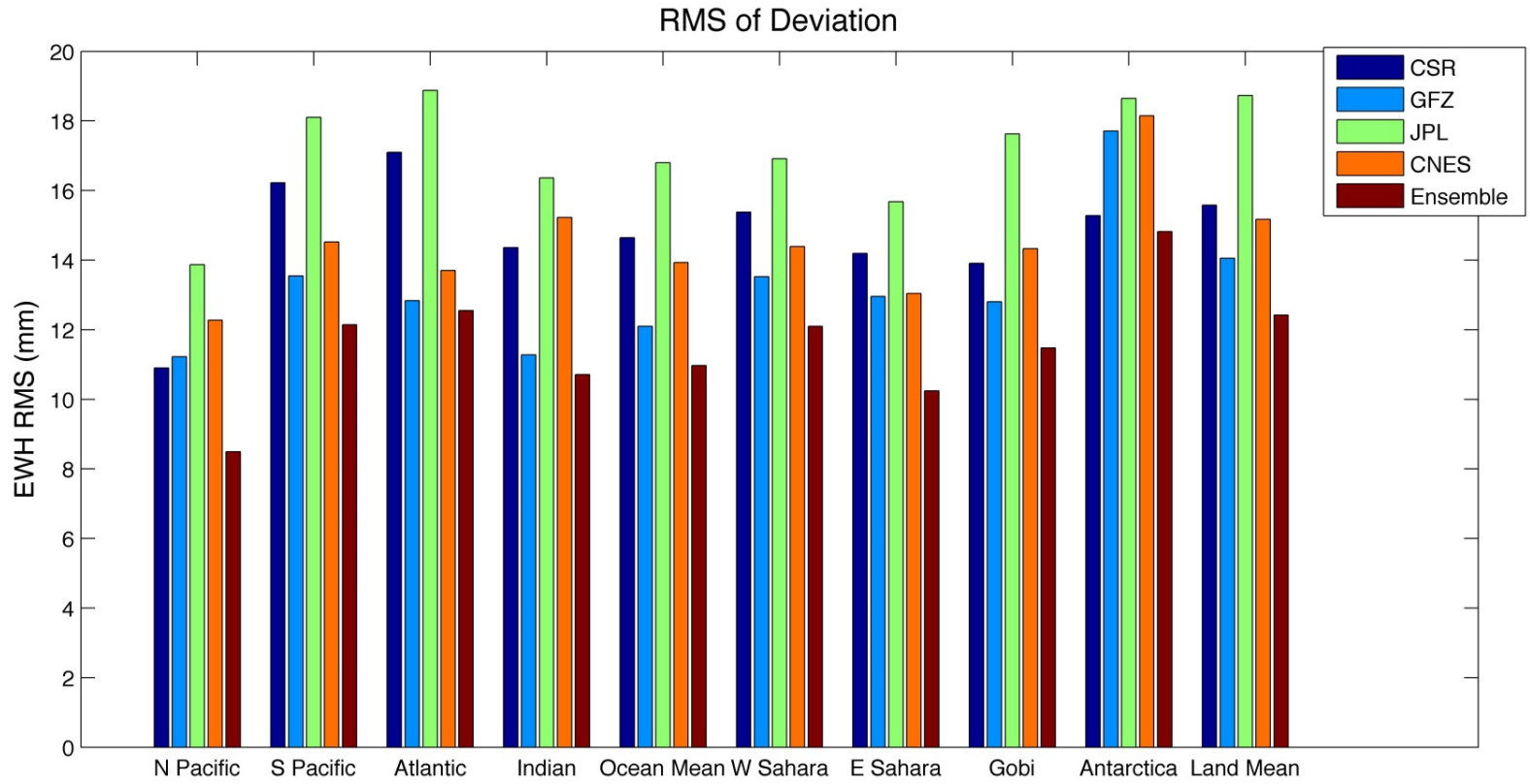
Secular Variations in Surface Mass

Correlation of Trends		
CSR	GFZ	0.957
CSR	JPL	0.937
CSR	CNES/ GRGS	0.889
GFZ	JPL	0.916
GFZ	CNES/ GRGS	0.875
JPL	CNES/ GRGS	0.8079



Scatter Analysis

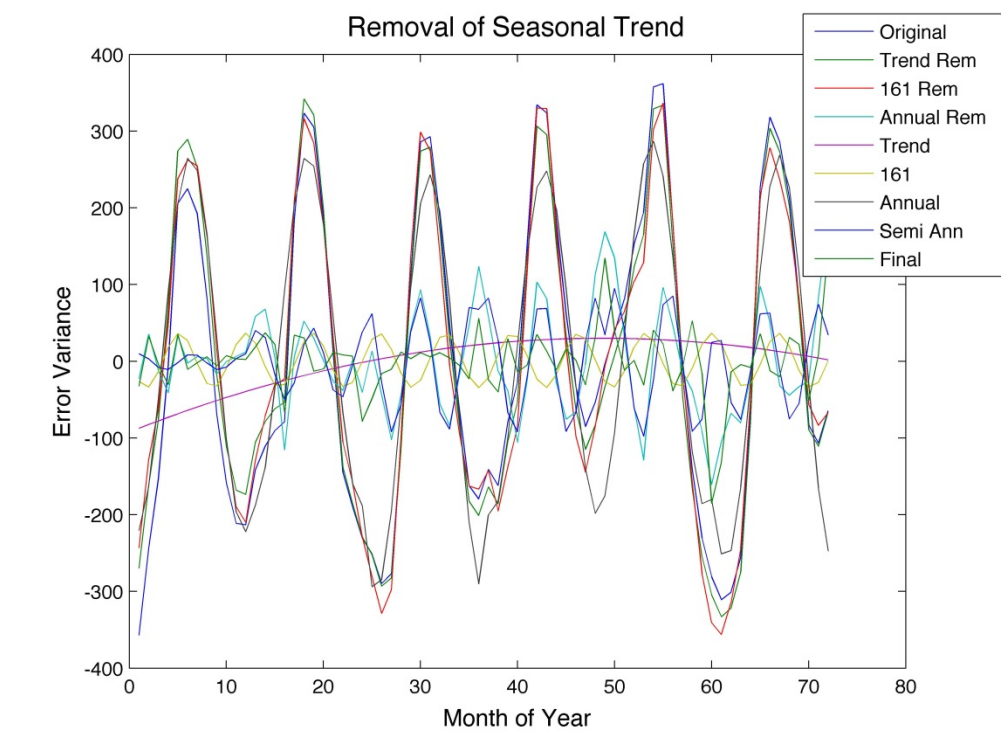


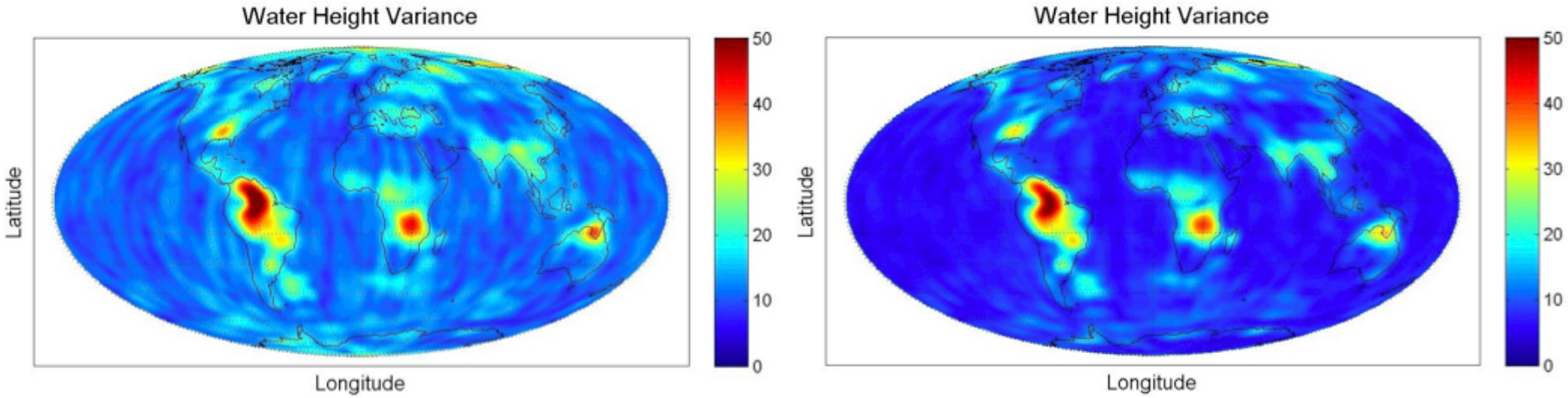


Model	Ocean Mean (mm)	Land Mean (mm)
CSR	14.64	15.58
GFZ	12.10	14.05
JPL	16.80	18.73
CNES	13.93	15.17
Ensemble	10.97	12.42

Noise Assessment

- Remove main periodic and secular signals
- Long term trend and 161 day periodic variation removed from full data span
- For each year, annual and semiannual signal removed
- Remaining variation in due to noise and residual signal





(a) JPL (b) Ensemble

Center	Global RMS	Global RMS Masked
CSR	12.32	10.62
GFZ	11.33	10.17
JPL	14.41	11.27
CNES	12.97	11.32
Ensemble	9.78	8.83

Summary

- Analysis scatter of the individual solutions is in the 10-15 mm range globally, over river basins
- Show high levels of correlation spectrally and spatially
- Within the analysis scatter realm, the Ensemble consistently outperforms individual center solutions
  - Especially effective at noise removal