Kalman filtering for statistically rigorous separation of geophysical signal and stripe noise in decade-long GRACE solutions

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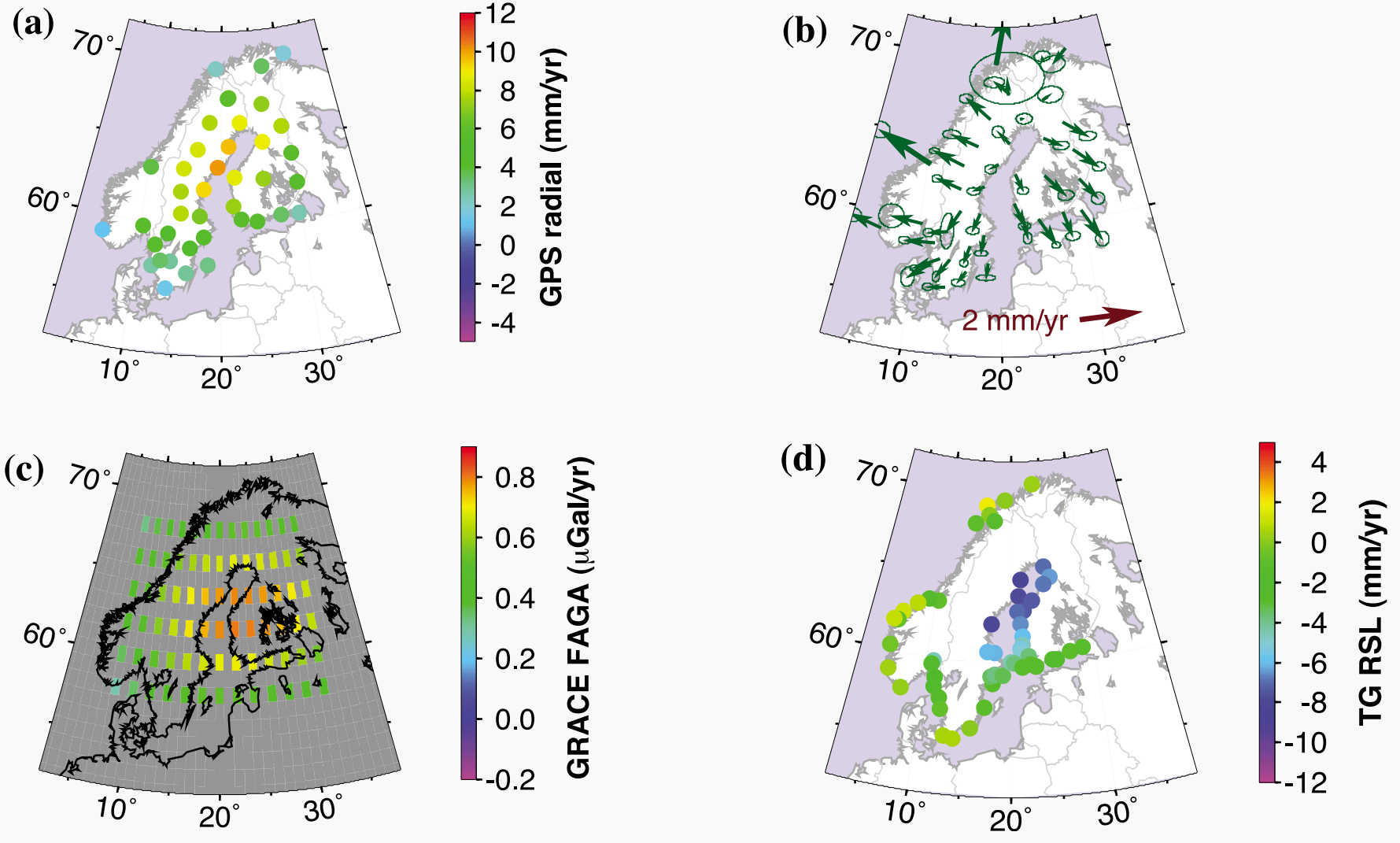

$$J[u] = (d - A \cdot u)^T W^{-1} (d - A \cdot u) + (m - u)^T \Lambda^{-1} (m - u)$$

[Hill et al., 2010]

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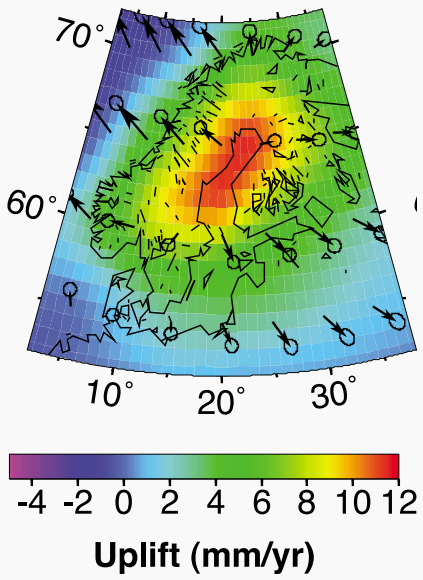
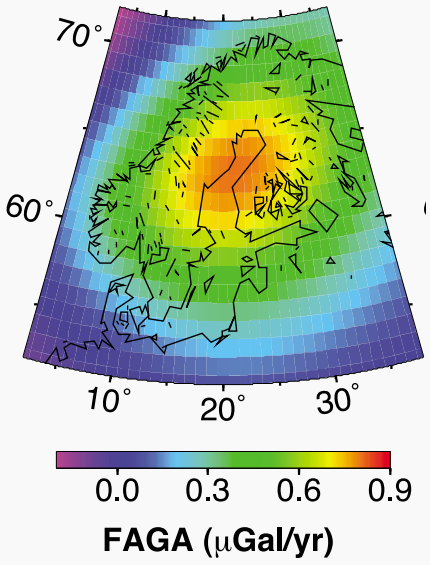
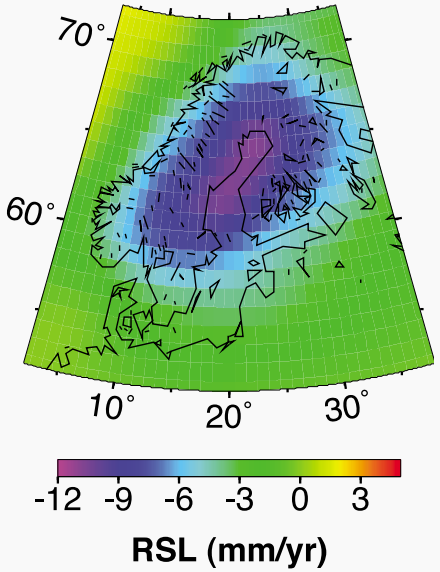
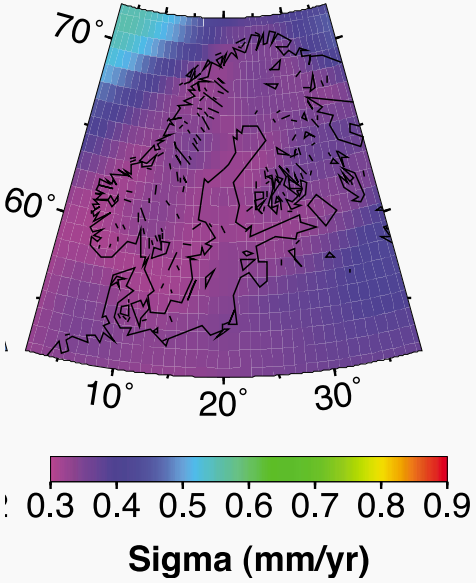
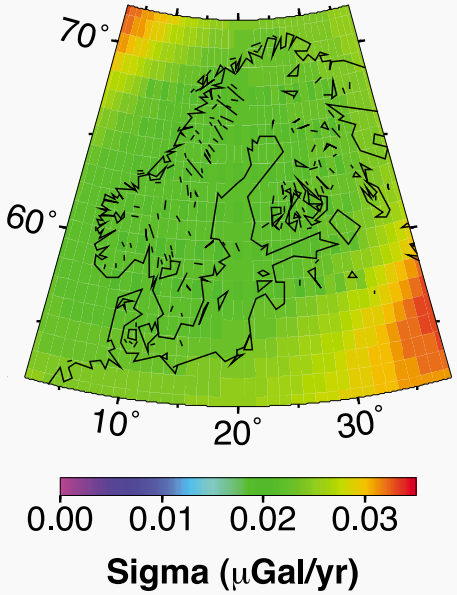
Data-driven GIA fields : Bayesian approach

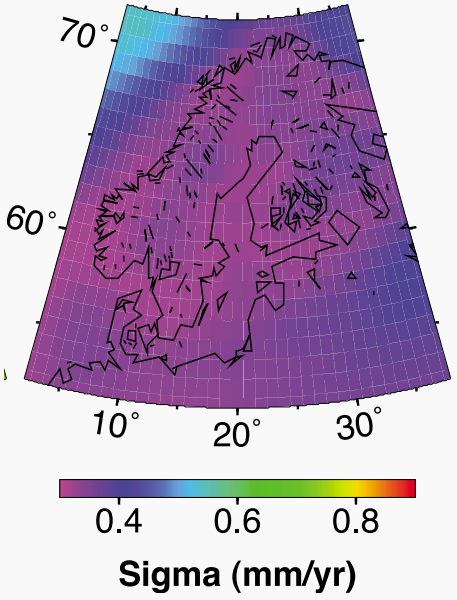












[Hill et al., 2010]

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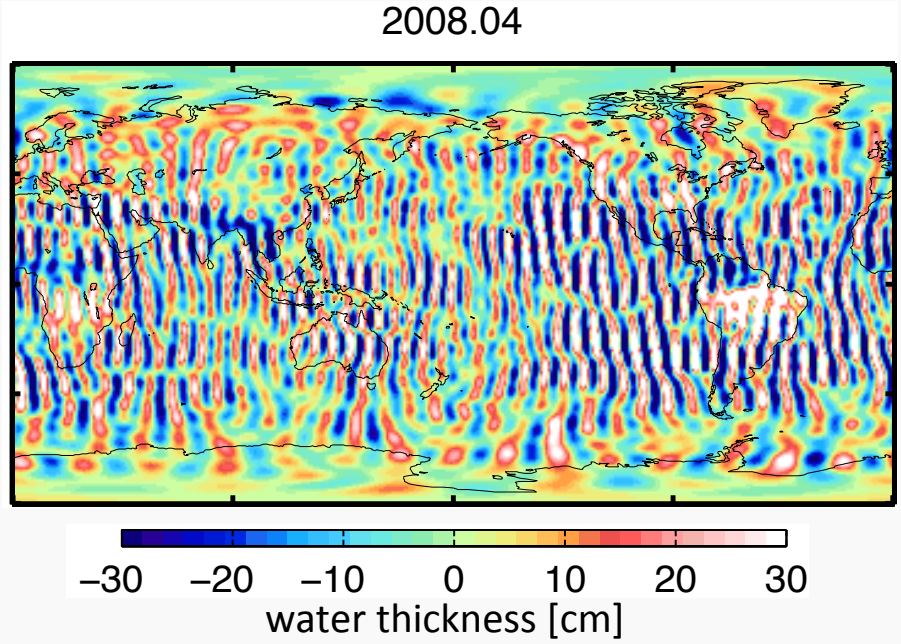
Bayesian approach for GRACE ?

- Expand Bayesian approach to global field to simultaneously estimate melting signal and GIA
- The uncertainty in the GRACE estimate is desired
- Both stripe noise and destriping procedure contribute to uncertainty
- Could we extend Bayesian approach to GRACE data and properly account for stripe noise ?



Original GRACE monthly solution of a single month, illustrating stripe noise.

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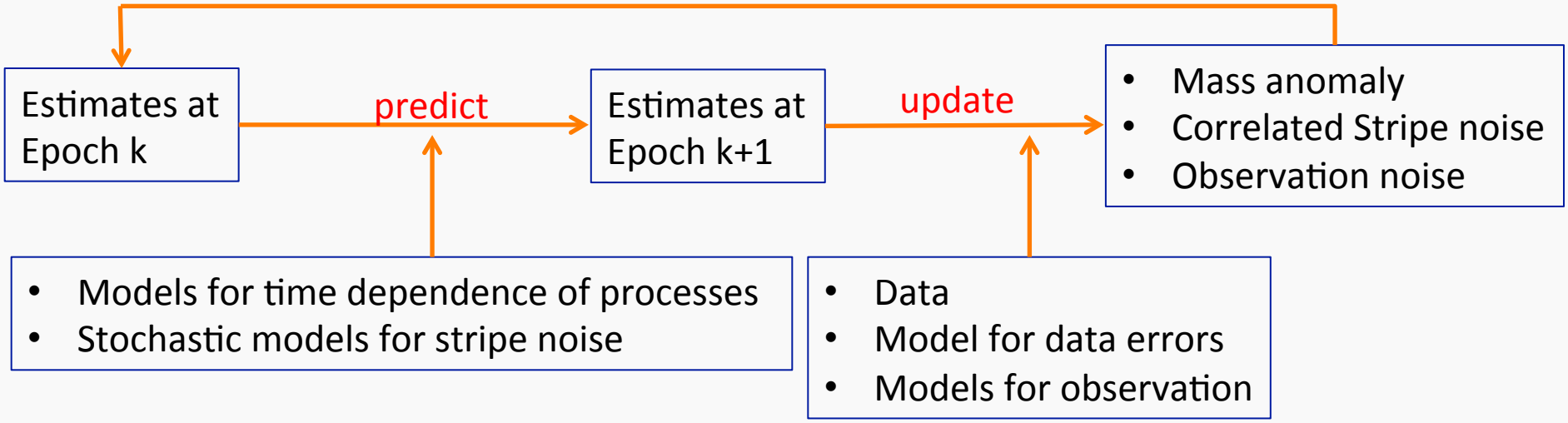
Stochastic (Kalman) Filter

Forward solution

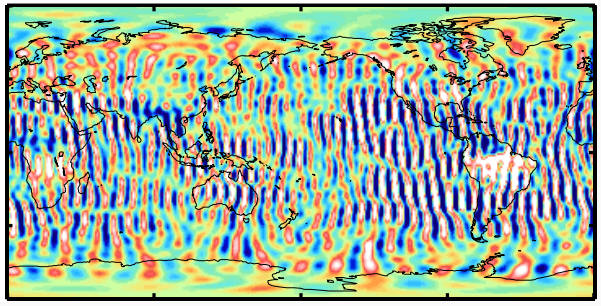


Backward solution

Backward "smoothing" ensures that estimates at a single epoch use all the available data

Original solution (GRACE CSR RL05 monthly gravity field)

2008.04



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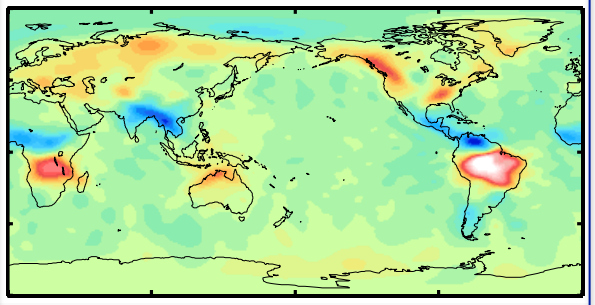
Estimated mass anomaly

2008.04



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Estimated stripe noise

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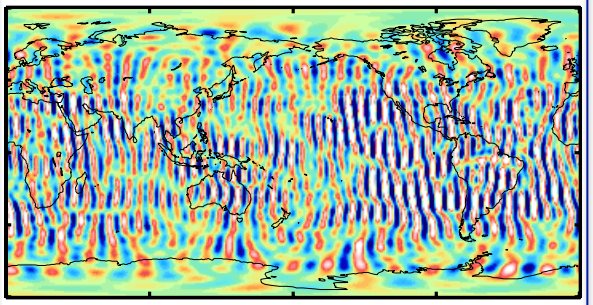

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Residual

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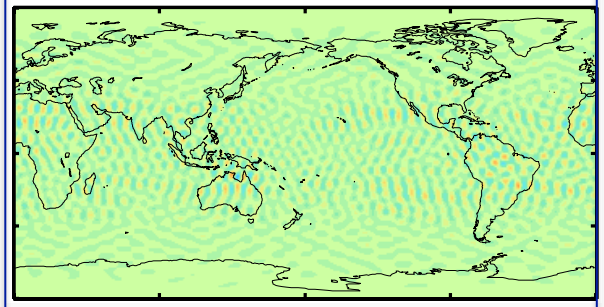
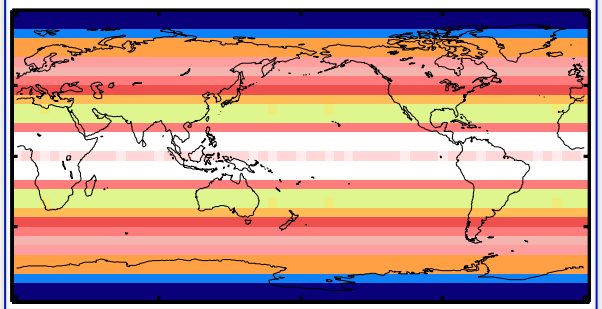


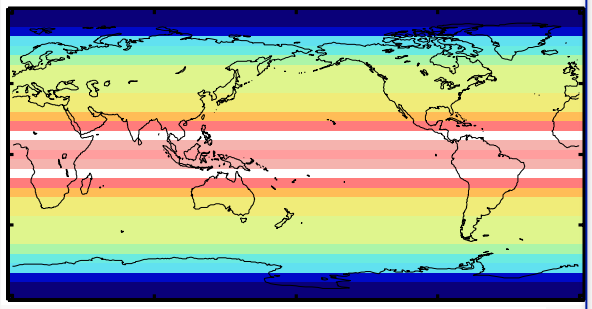
uncertainty

2008.04



uncertainty

2008.04



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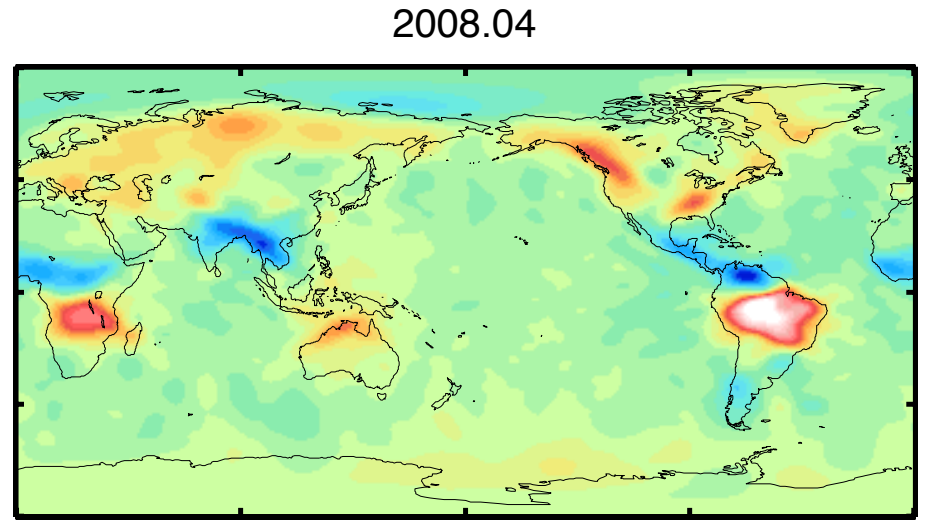
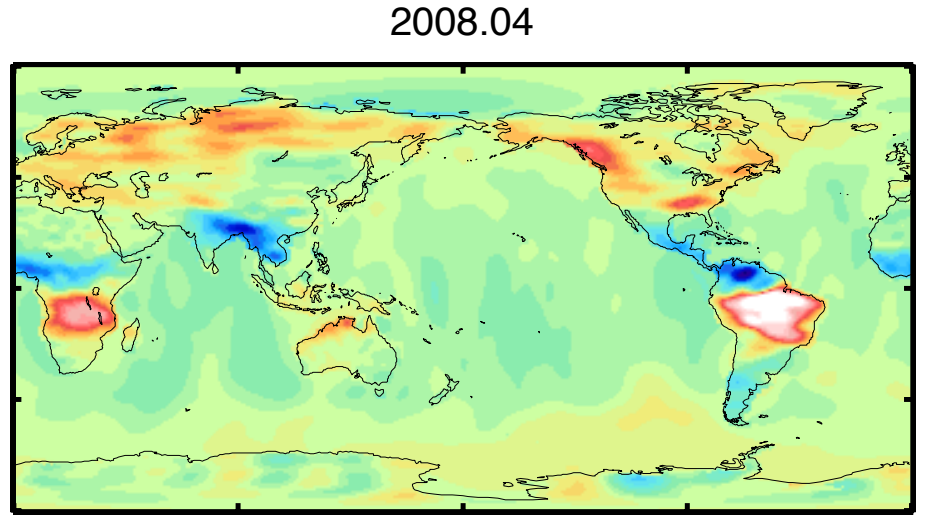
Comparison with Ad-hoc Destriping Procedure

Solution by Kalman filter



Solution by ad-hoc destriping



water thickness [cm]

Tellus solution

- Downloaded from http://grace.jpl.nasa.gov/data/
- Land : ad-hoc destriping filter + 200km gaussian filter + cutoff at SH degree 60
- Ocean : ad-hoc destriping filter + 500km gaussian filter + cutoff at SH degree 40

Kalman filter solution

- No gaussian filter is needed

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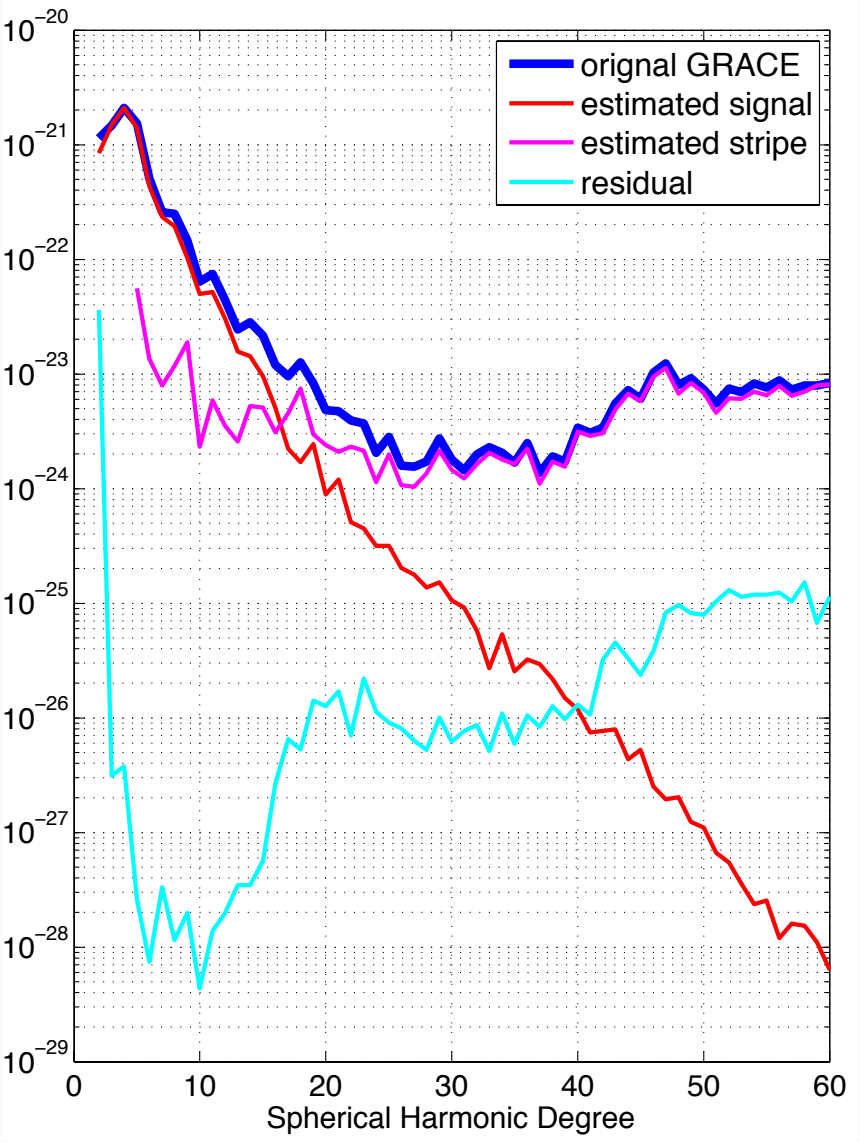
Comparison of Degree Variances



Gaussian smoothing is not required as the Bayesian approach yields a natural resolution for the geophysical signal that reflects the correlated errors.

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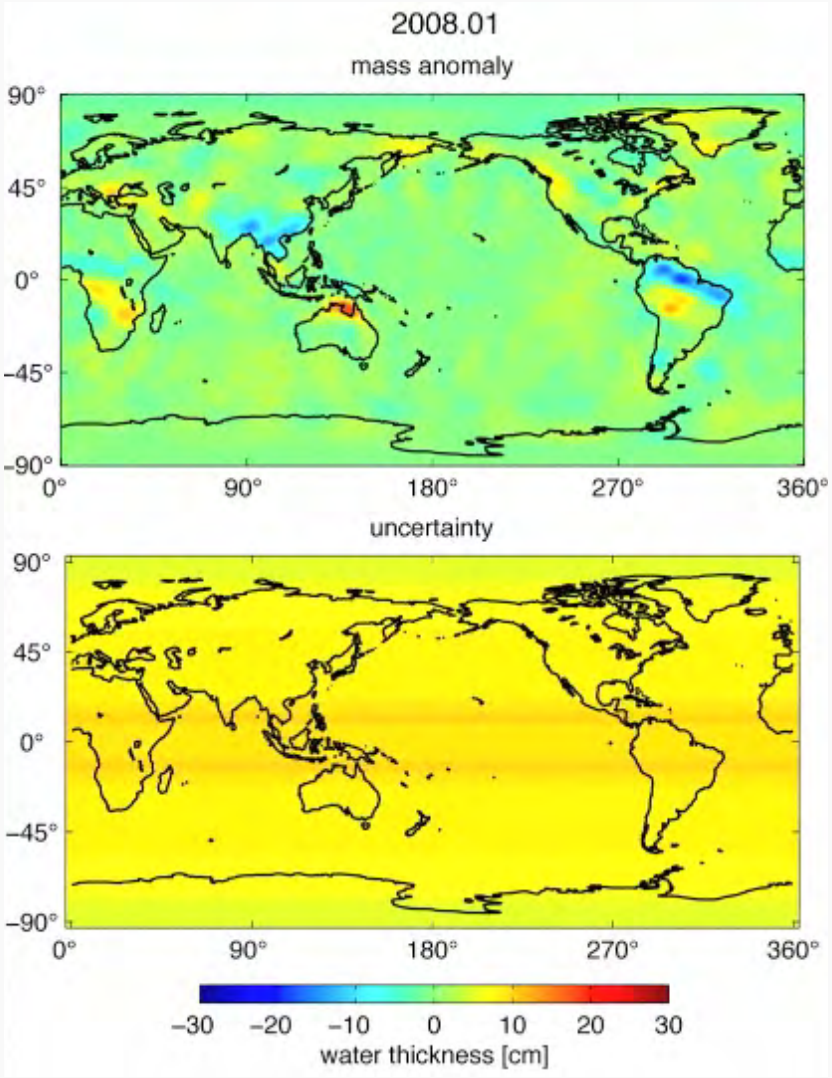
Kalman Filter Solutions



Conclusion

- Preliminary results show that the designed Kalman filter can effectively separate gravity signals from stripe noise in Bayesian framework.
- This new technique enables the evaluation of the impact of destriping, and thus provides statistically rigorous estimate of uncertainty.

Future work

- Introduce spatial constraint
- Integrate GRACE with other data types to enable simultaneous estimation of present-day melting, GIA and sea-level and associated uncertainties.