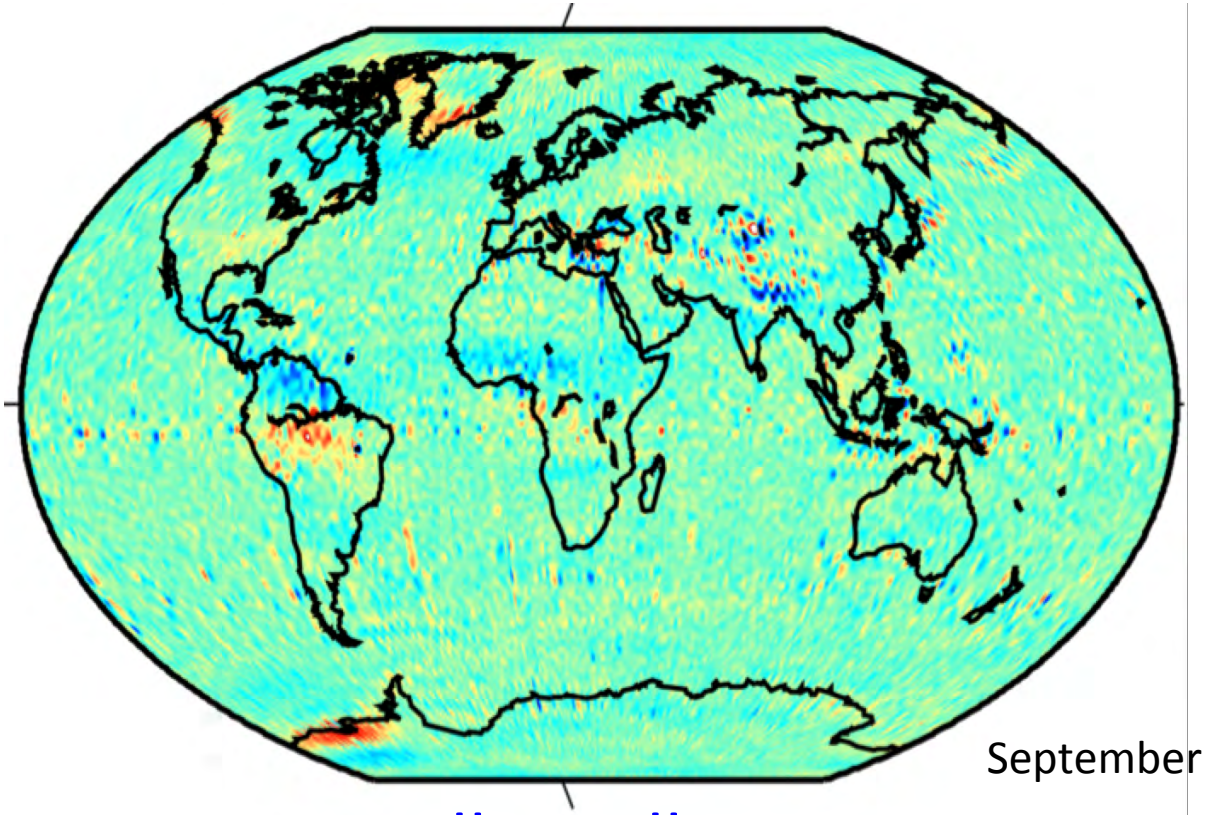
Why do we use range rate and not range acceleration observations ?



September 2010

P. Tregoning, A. Purcell, S. Allgeyer, H. McQueen, S. McClusky, E-K Potter, T.A. Herring, J-P Montillet

Research School of Earth Sciences

The Australian National University

GSTM Austin, Texas, 10-12 October 2017

KBR Level-1B "observations"

- 10Hz Inter-satellite phase measurements are made
- KBR1B range, range-rate and range-acceleration observables are *derived*
- Most analysts use the range rate as the "observation"
- Is there any advantage in using any particular observation: range, range rate or range acceleration ?

KBR Level-1B "observations"

- CRN filter (Thomas, 1999) is applied to the phase measurements to decimate and create observables

range $$R_i = \sum_{n=-N_h}^{N_h} F_n \, R'_{i-n}$$

Range rate $$\dot{R}_i = \sum_{n=-N_h}^{N_h} \dot{F}_n \, R'_{i-n}$$

Range acceleration $$\ddot{R}_i = \sum_{n=-N_h}^{N_h} \ddot{F}_n \, R'_{i-n}$$

Thomas (1999)

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Inter-satellite phase measurements

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Digital filter

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range $$R_i = \sum_{n=-N_h}^{N_h} F_n \, R'_{i-n}$$ CRN filter F_n

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Time derivative of F_n

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Double time Derivative of F_n

Digital filter

Thomas (1999)

Alternate derivations

- Instead of differentiating the digital filter, one can differentiate the observable

$$\dot{R} = \frac{\partial R}{\partial t}$$

Time derivative of range

Alternate derivations

- Instead of differentiating the digital filter, one can differentiate the observable

$$\dot{R} = \frac{\partial R}{\partial t}$$

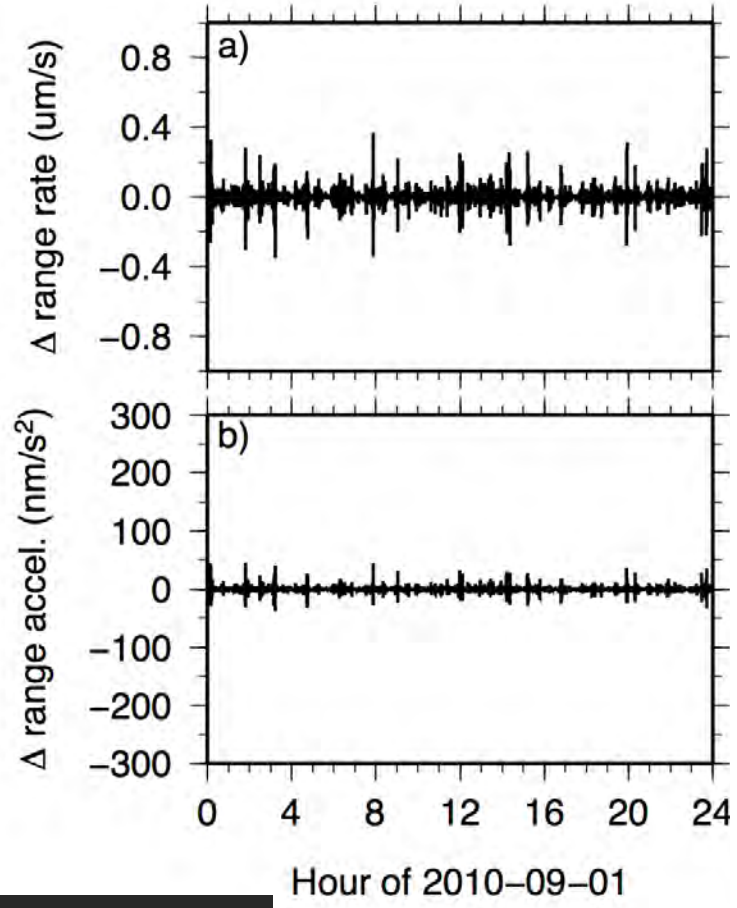
Time derivative of range

$$\ddot{R} = \frac{\partial \dot{R}}{\partial t}$$

Time derivative of range rate

Alternate derivations

- Compare derived values with analytical values for range rate, range acceleration



Difference between derived and analytical range rate computations

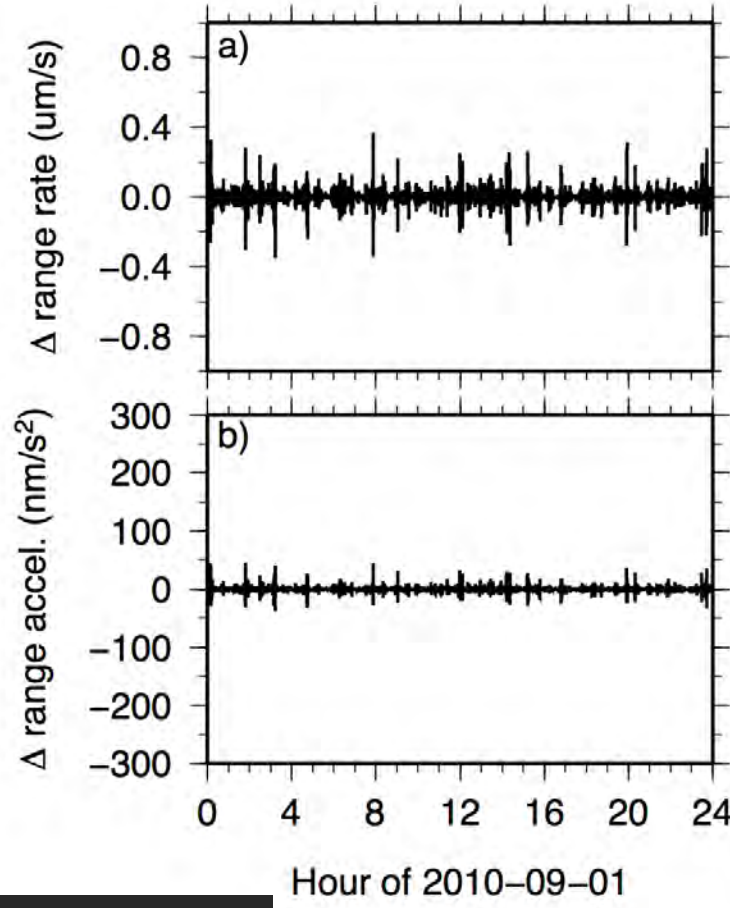
RMS = 0.04 *um*/s

Difference between derived and analytical range acceleration computations

RMS = 4 nm/s^2

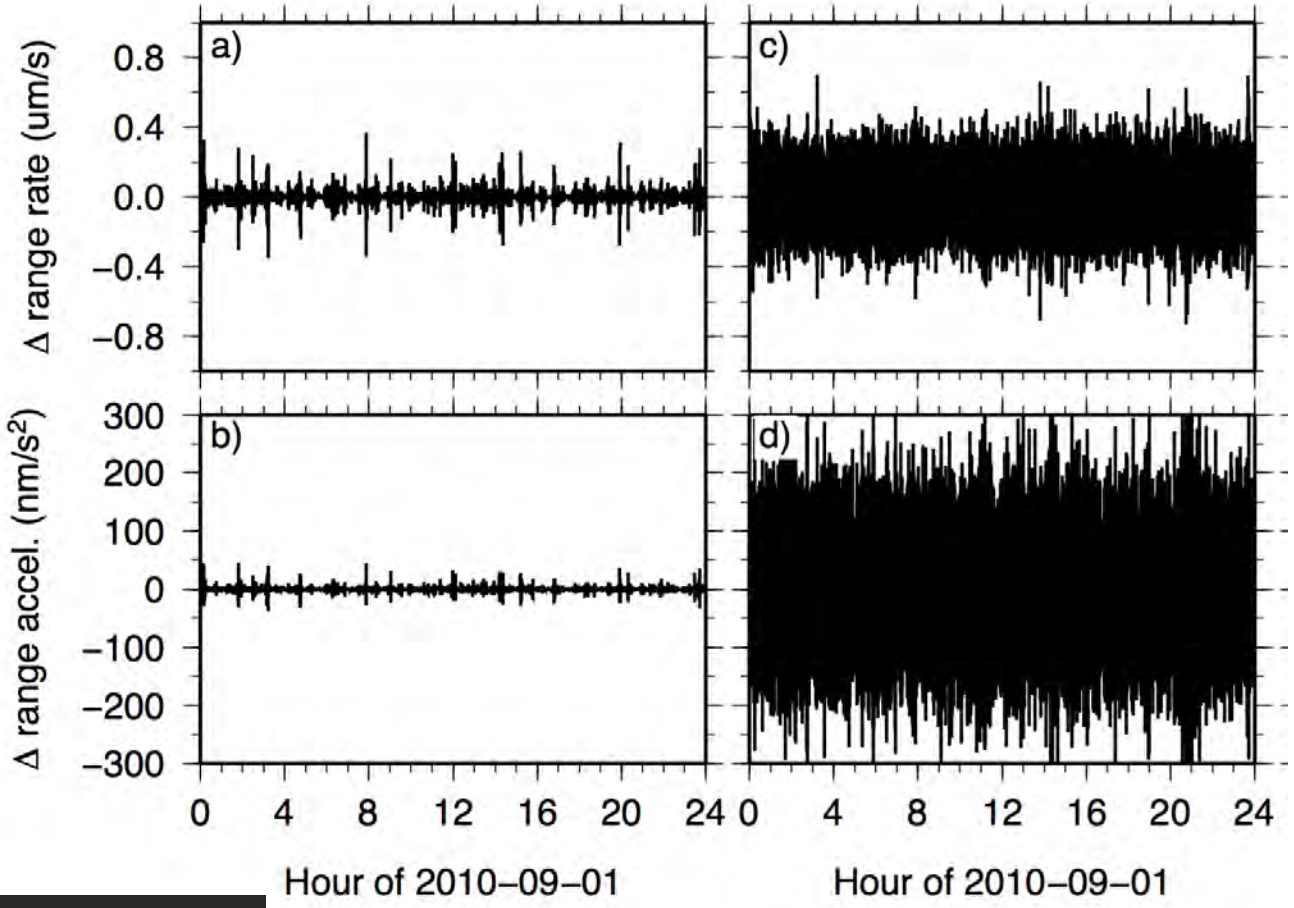
Alternate derivations

- Compare derived values with Level-1B values for range rate, range acceleration



Alternate derivations

- Compare derived values with Level-1B values for range rate, range acceleration



Derived versus L1B range rate

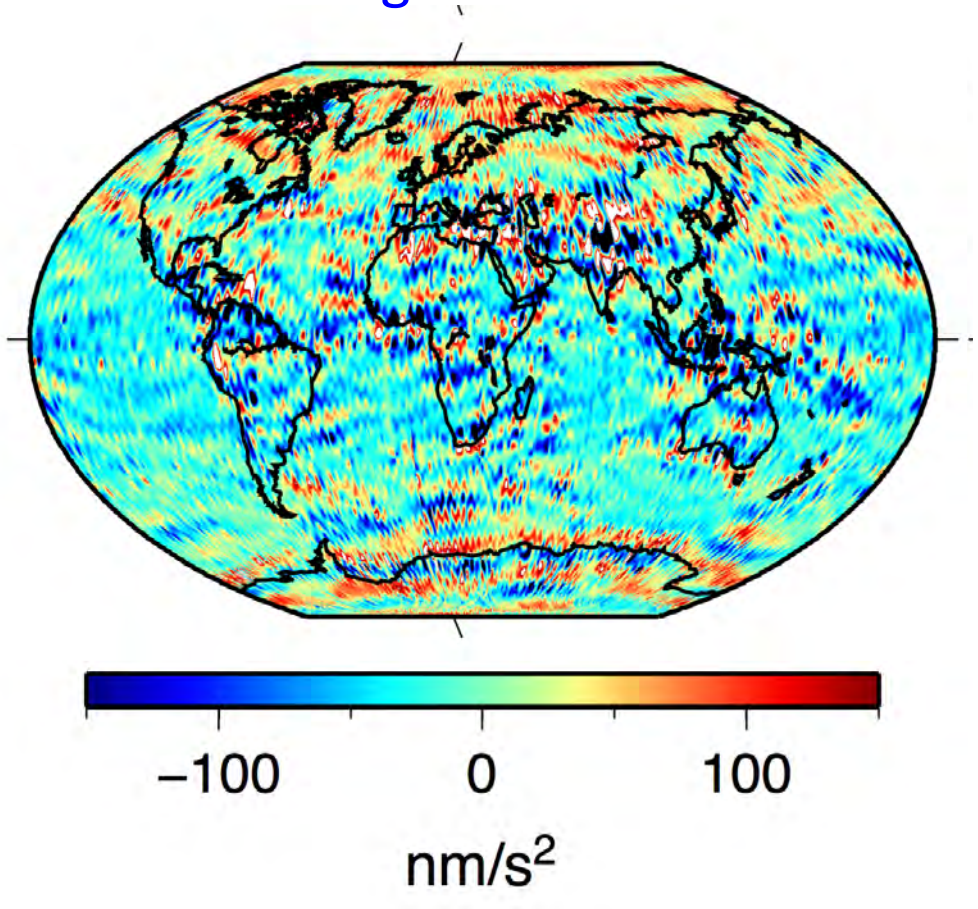
Derived versus L1B range acceleration

ANU Mascon Solutions

- 24-hour orbits
  - Pos, vel, 1 x bias/scale per axis per satellite per orbit
  - 12 parameters per satellite per orbit
- (roughly) 100 x 100 km mascons
  - Mascons follow coastlines (improves leakage)
- Light regularisation
  - 0.5 m continental mascons
  - 0.1 m ocean mascons
- Iterate solutions,
  - update bias/scale (three times) then all 12 parameters per satellite
- Finally, estimate simultaneously satellite and mascon parameters

KBR1B Prefit Residuals

L1B range acceleration



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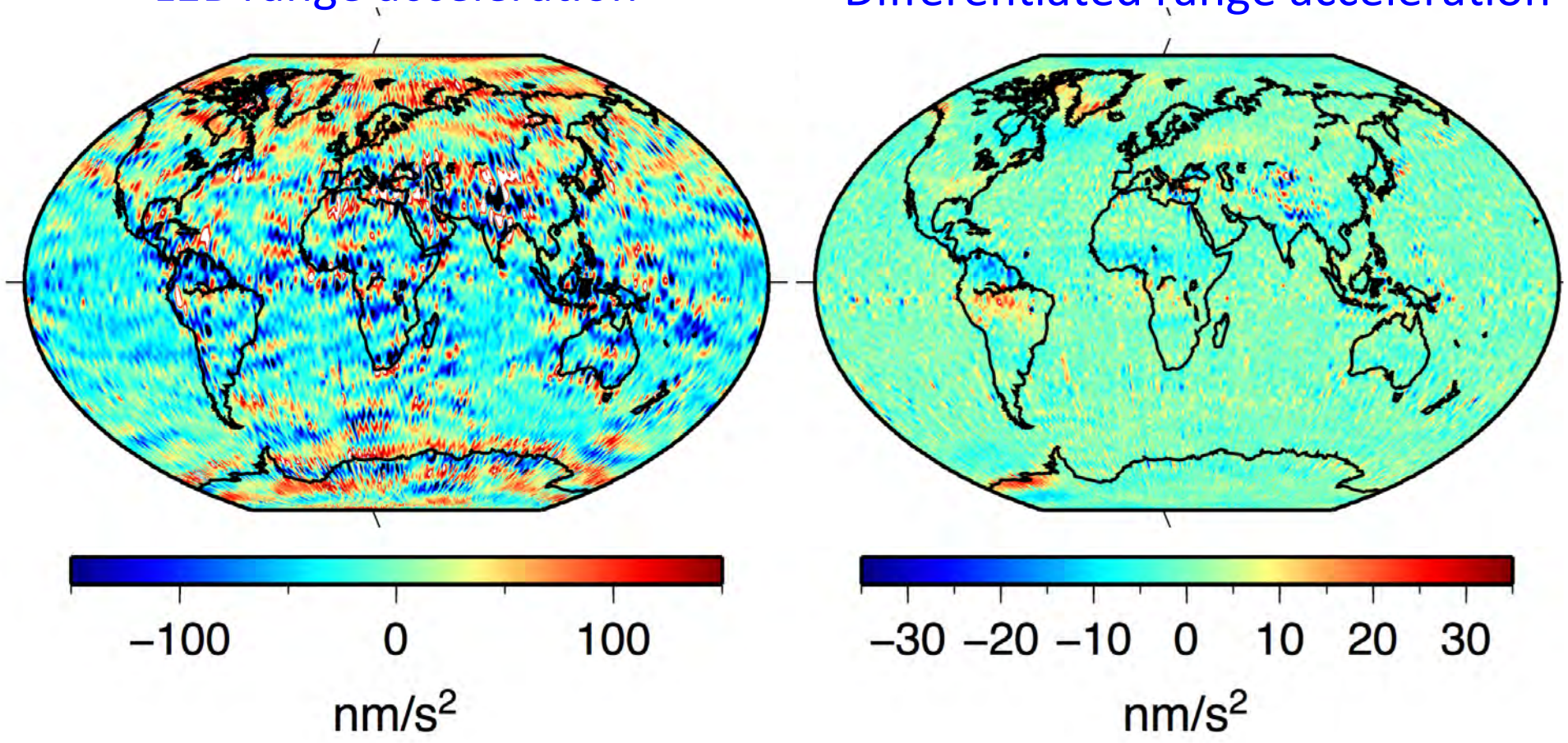
KBR1B Prefit Residuals

L1B range acceleration

Differentiated range acceleration



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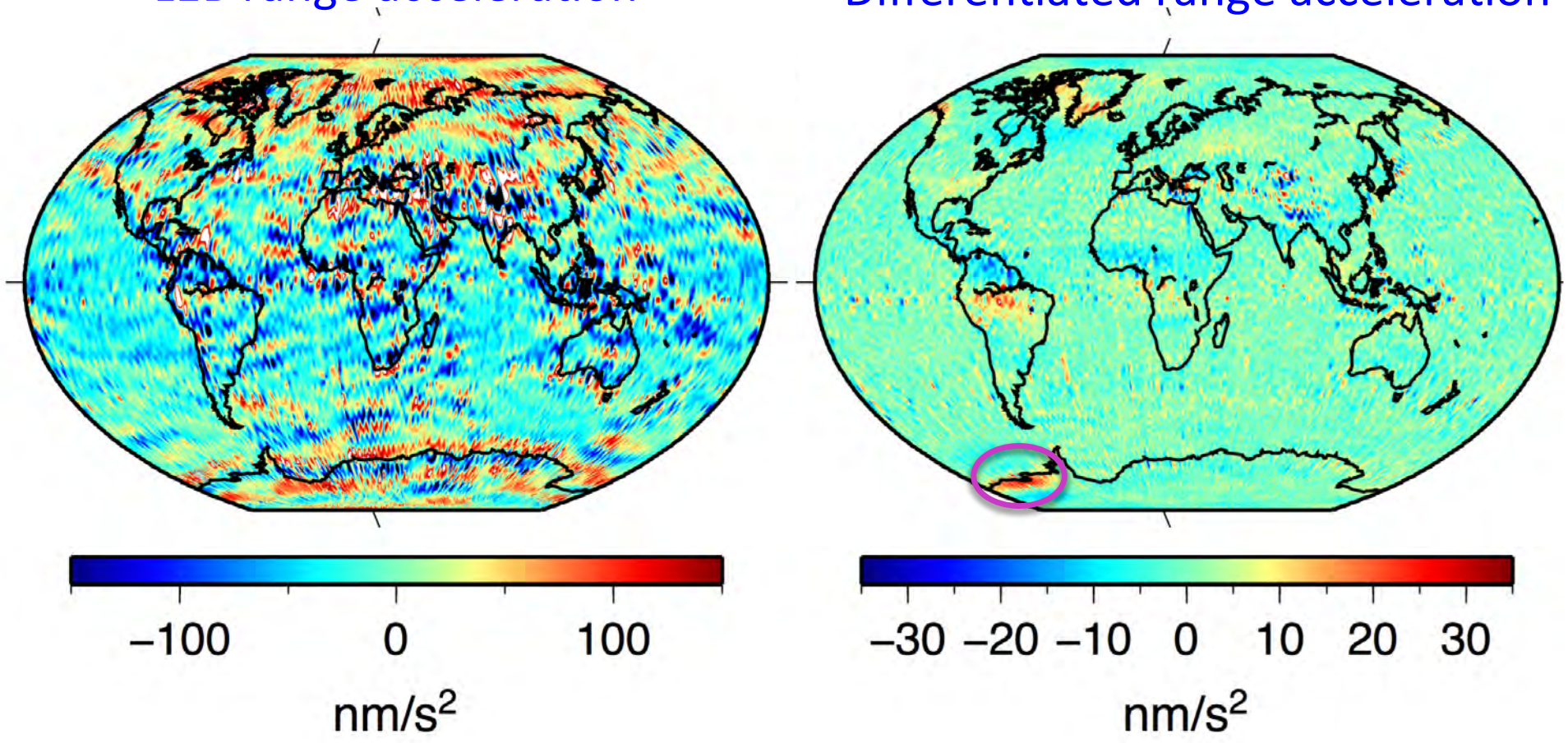

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KBR1B Prefit Residuals

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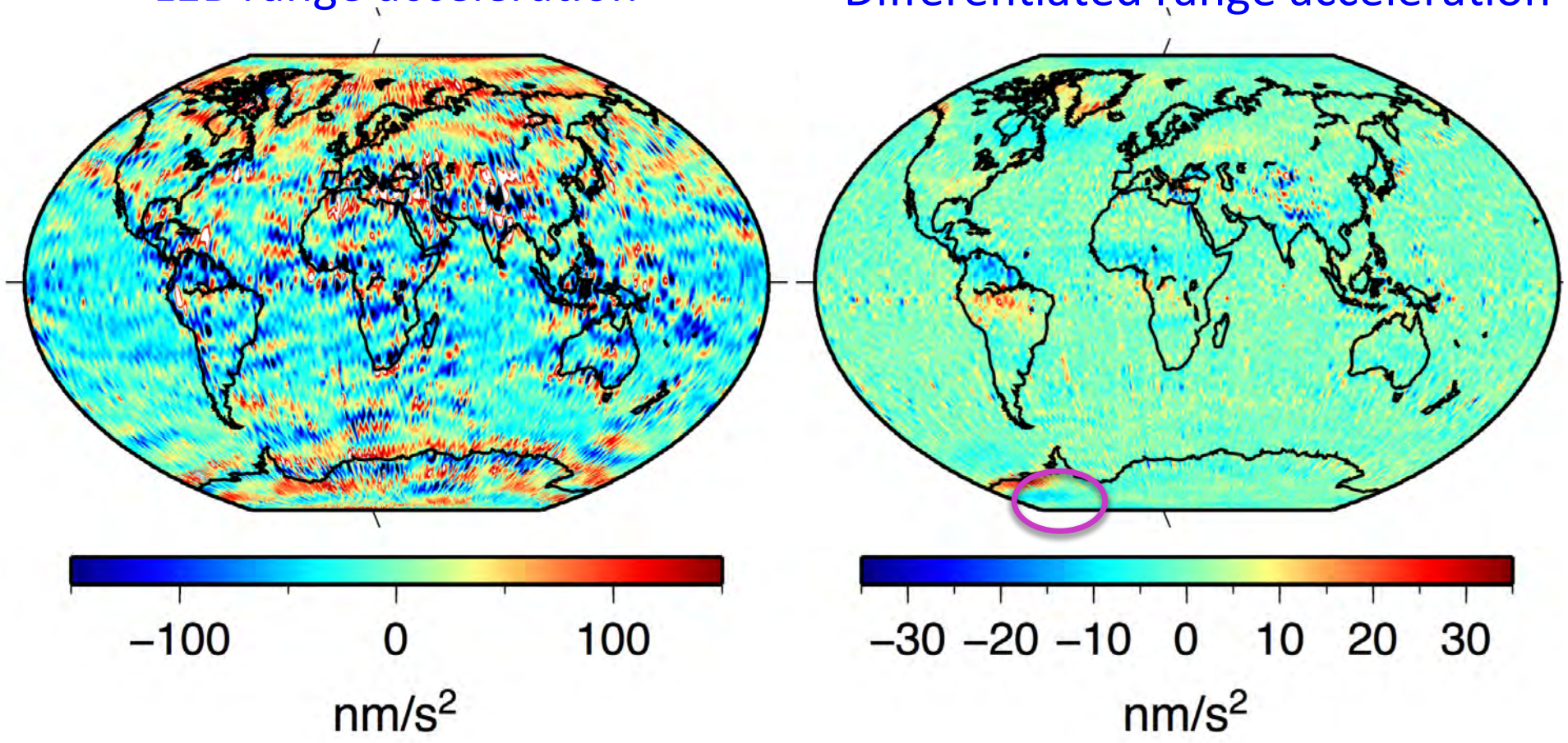

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KBR1B Prefit Residuals

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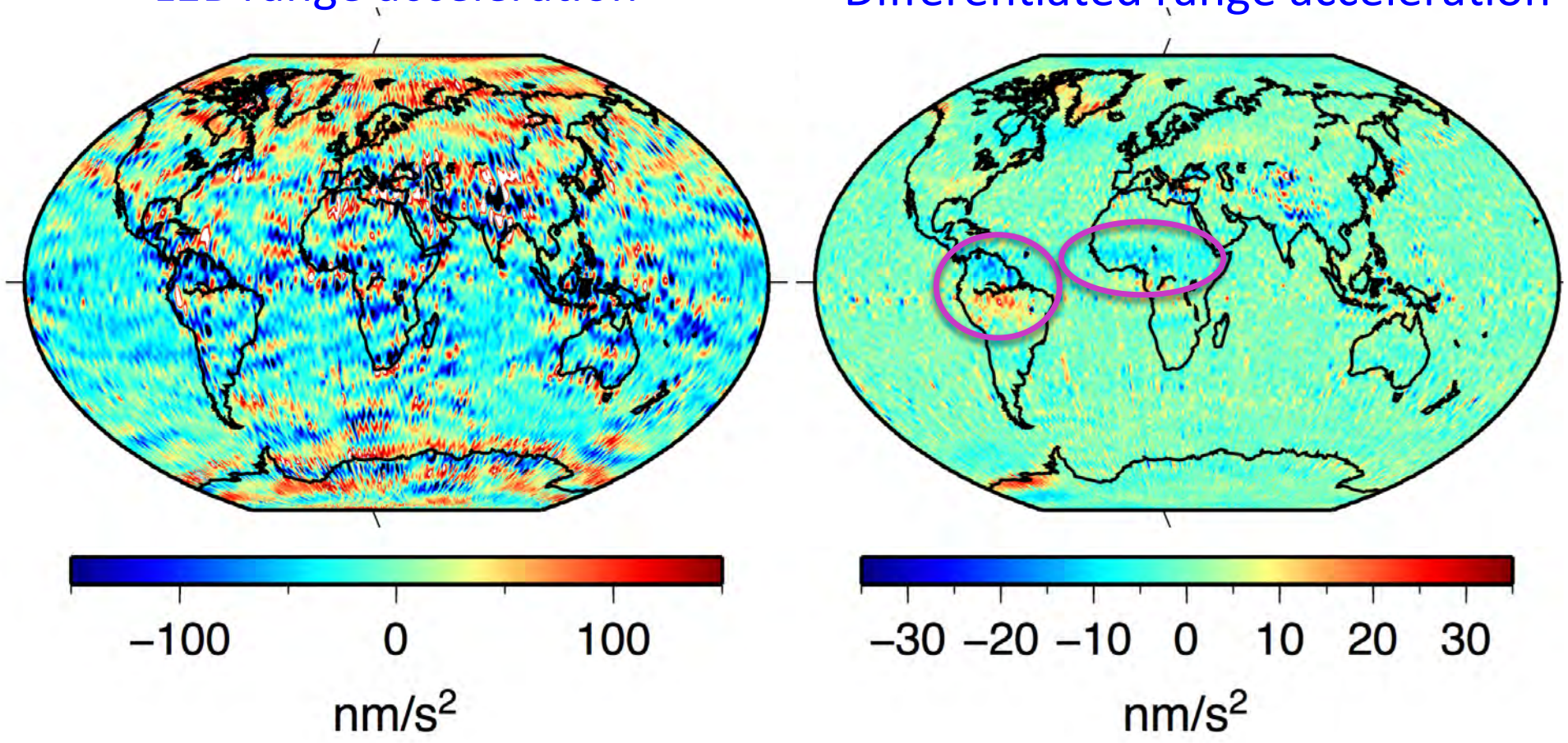

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KBR1B Prefit Residuals

L1B range acceleration

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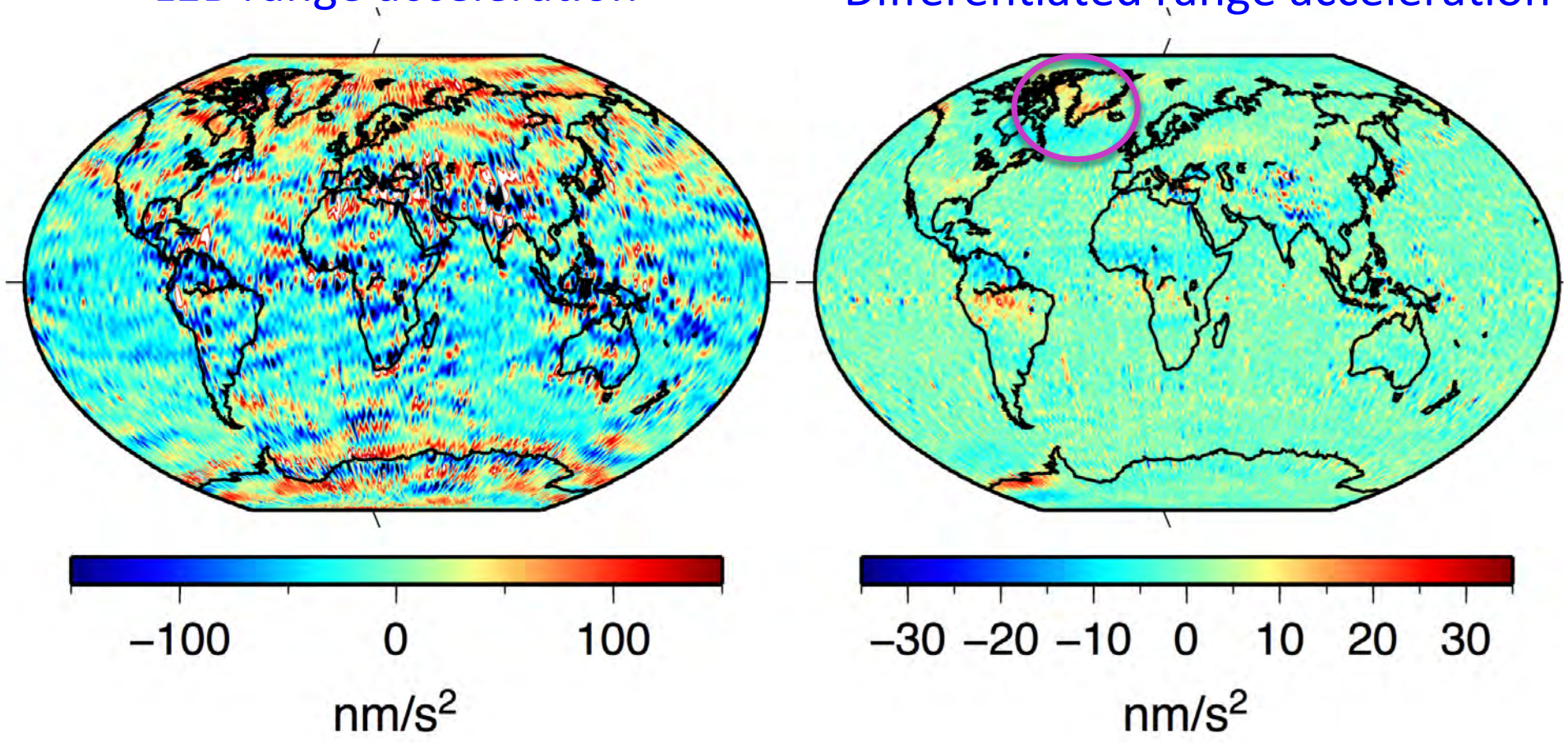

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KBR1B Prefit Residuals

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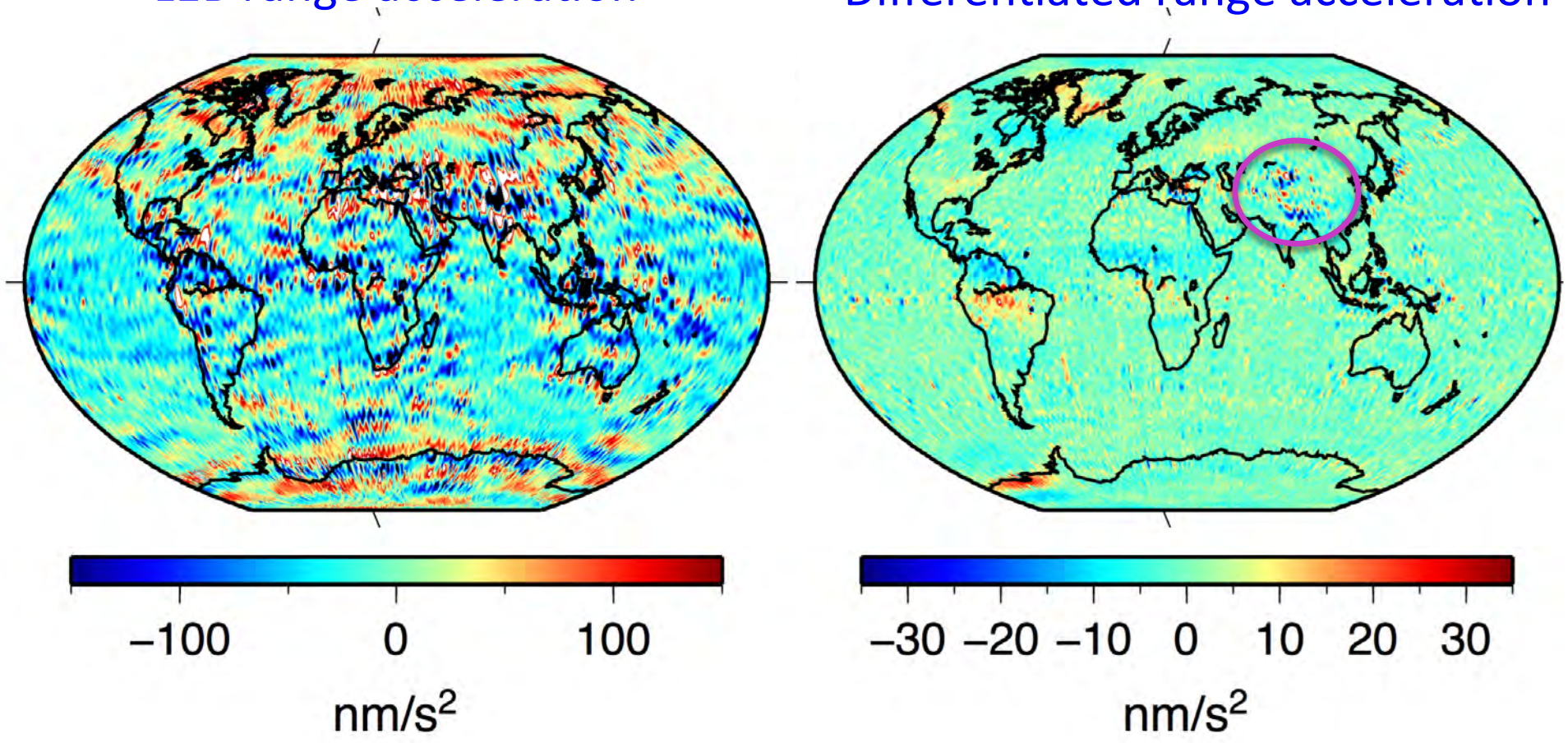

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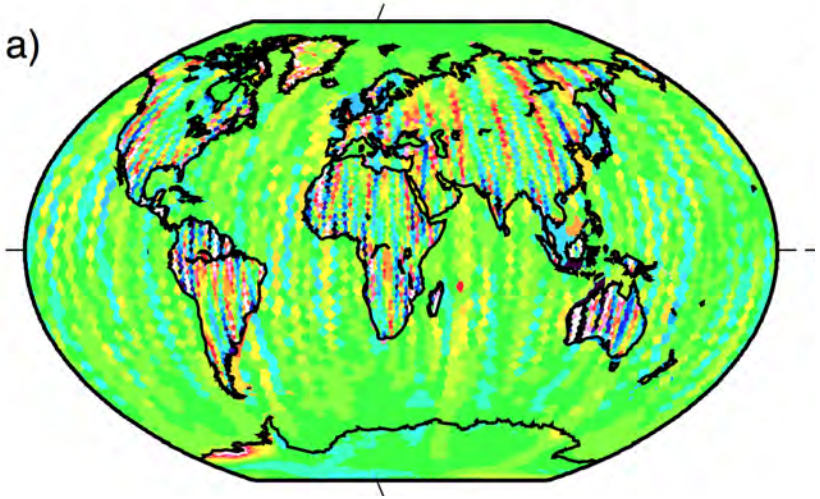
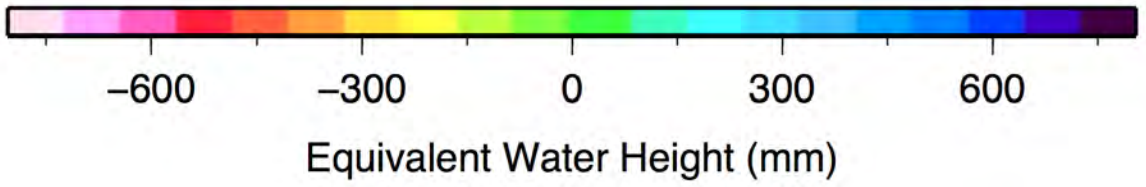
Temporal Gravity Field Estimates

Level-1B

range rate





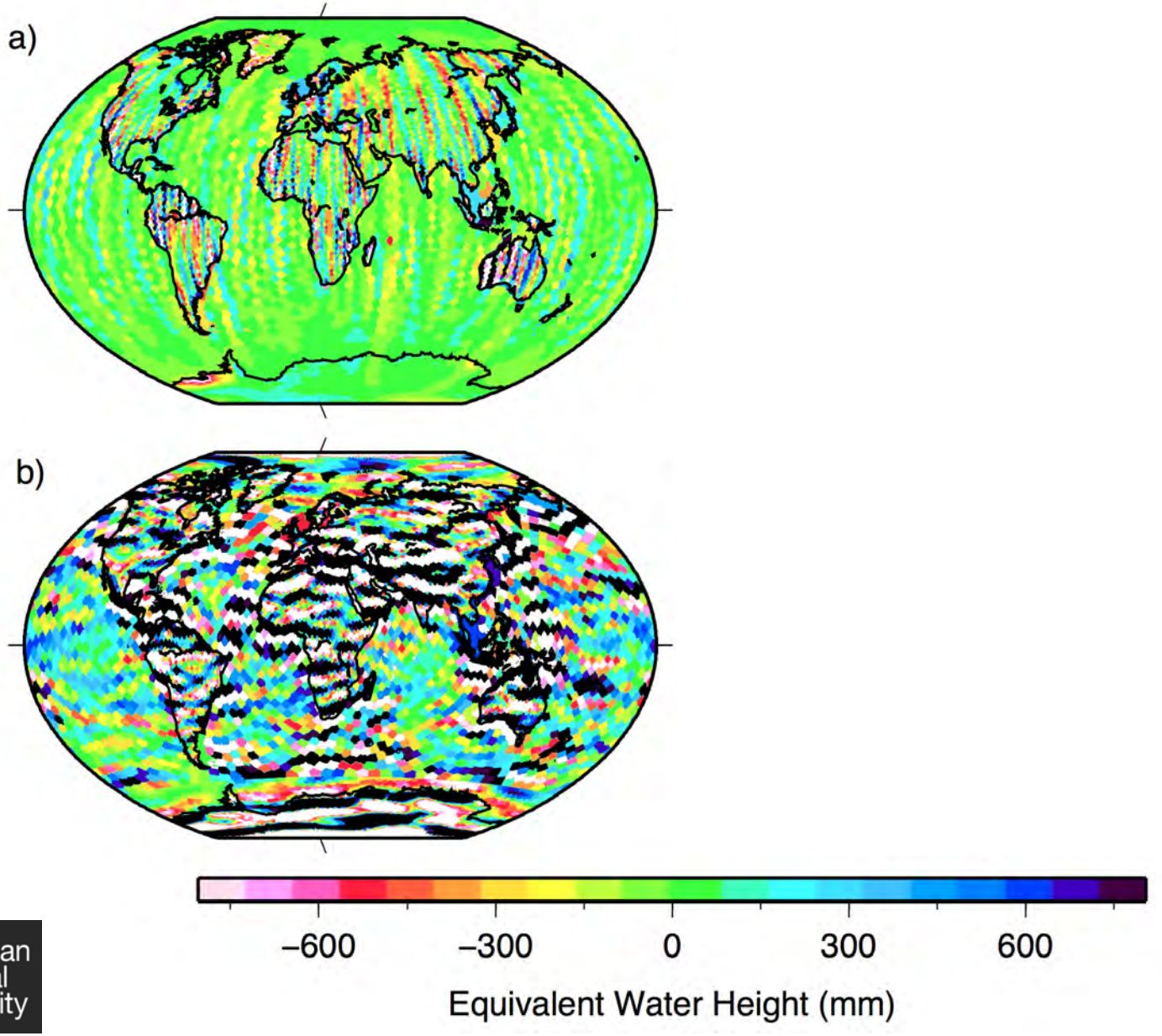
Australian National University

Temporal Gravity Field Estimates

Level-1B

range rate

range accel.



Australian National University

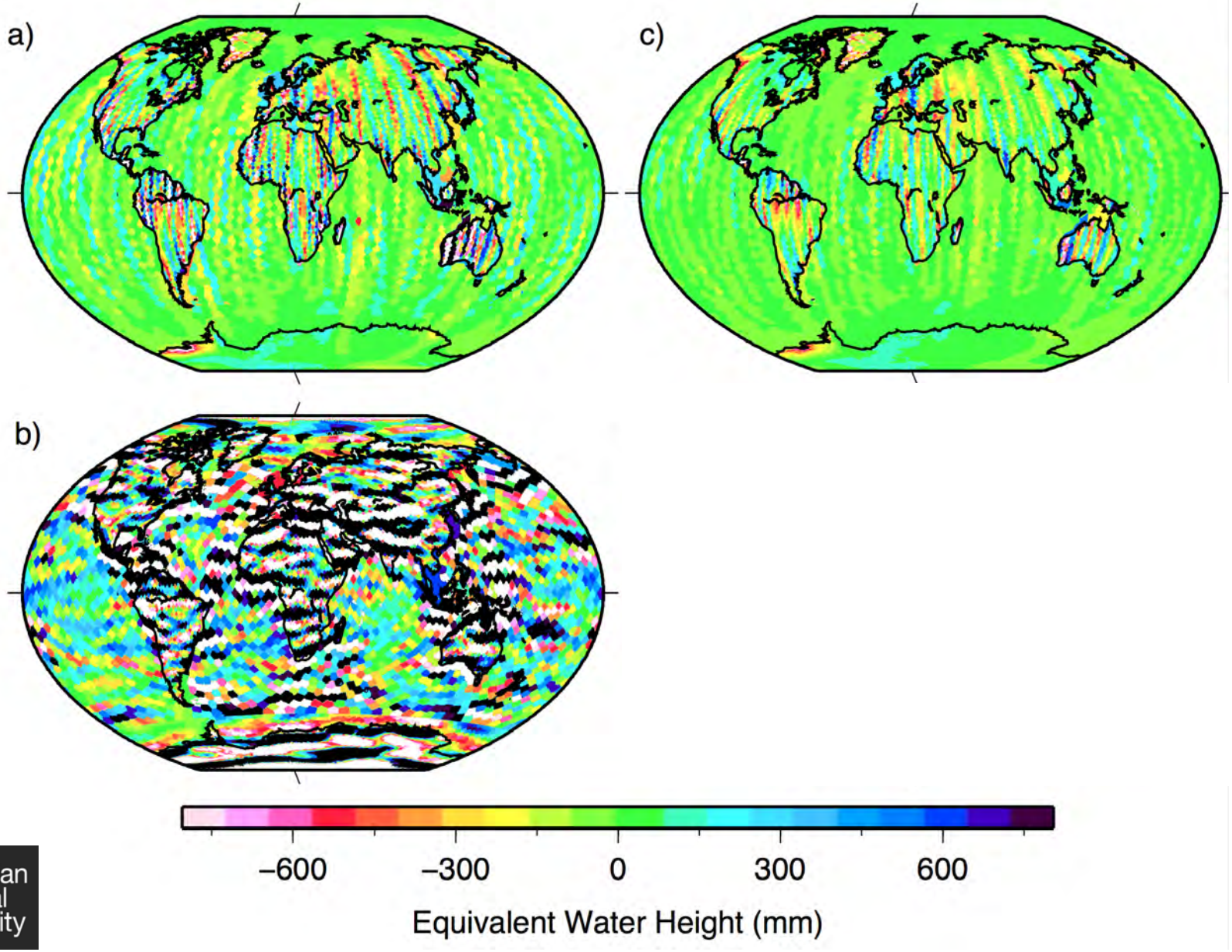
Temporal Gravity Field Estimates

Level-1B

Time derivatives

range rate

range accel.



Australian National University

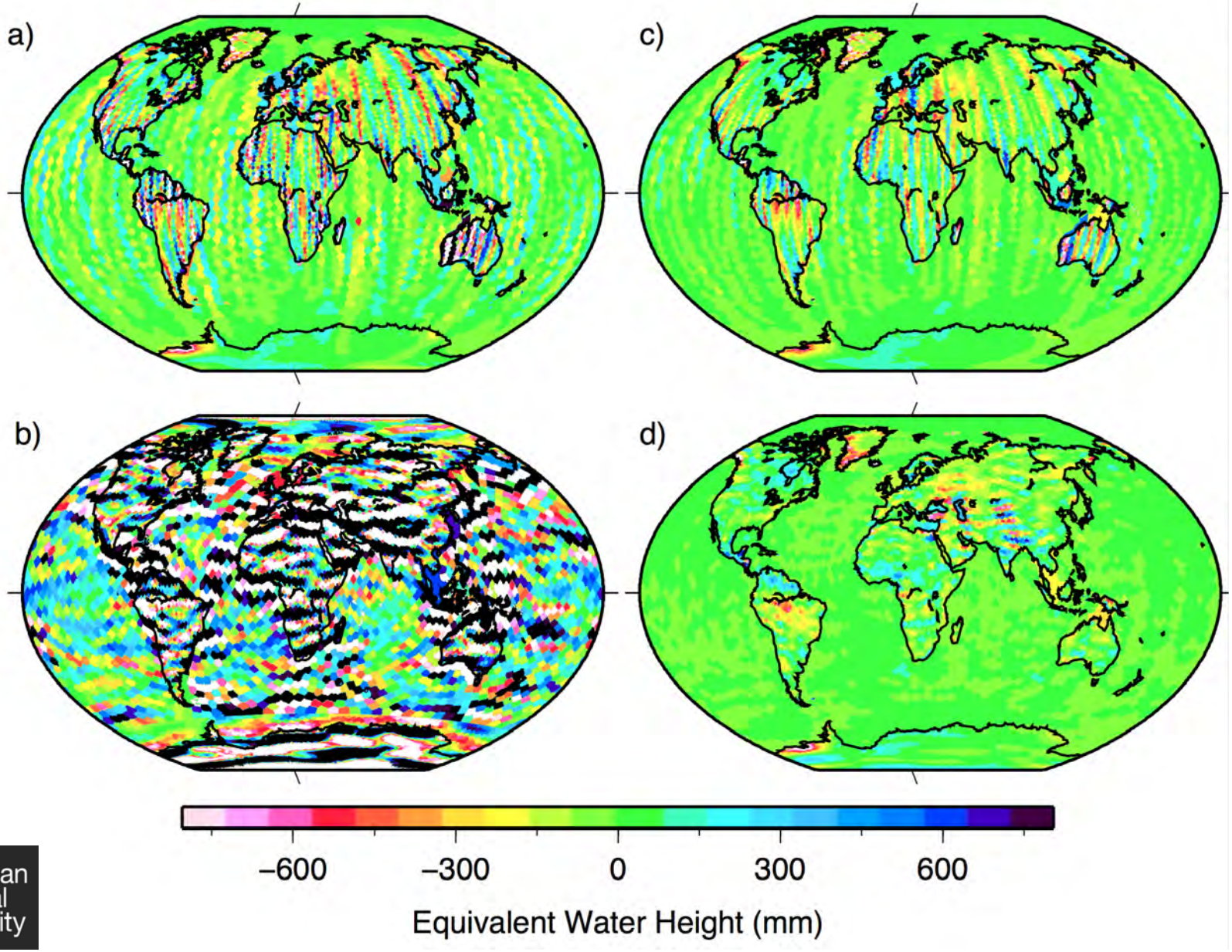
Temporal Gravity Field Estimates

Level-1B

Time derivatives

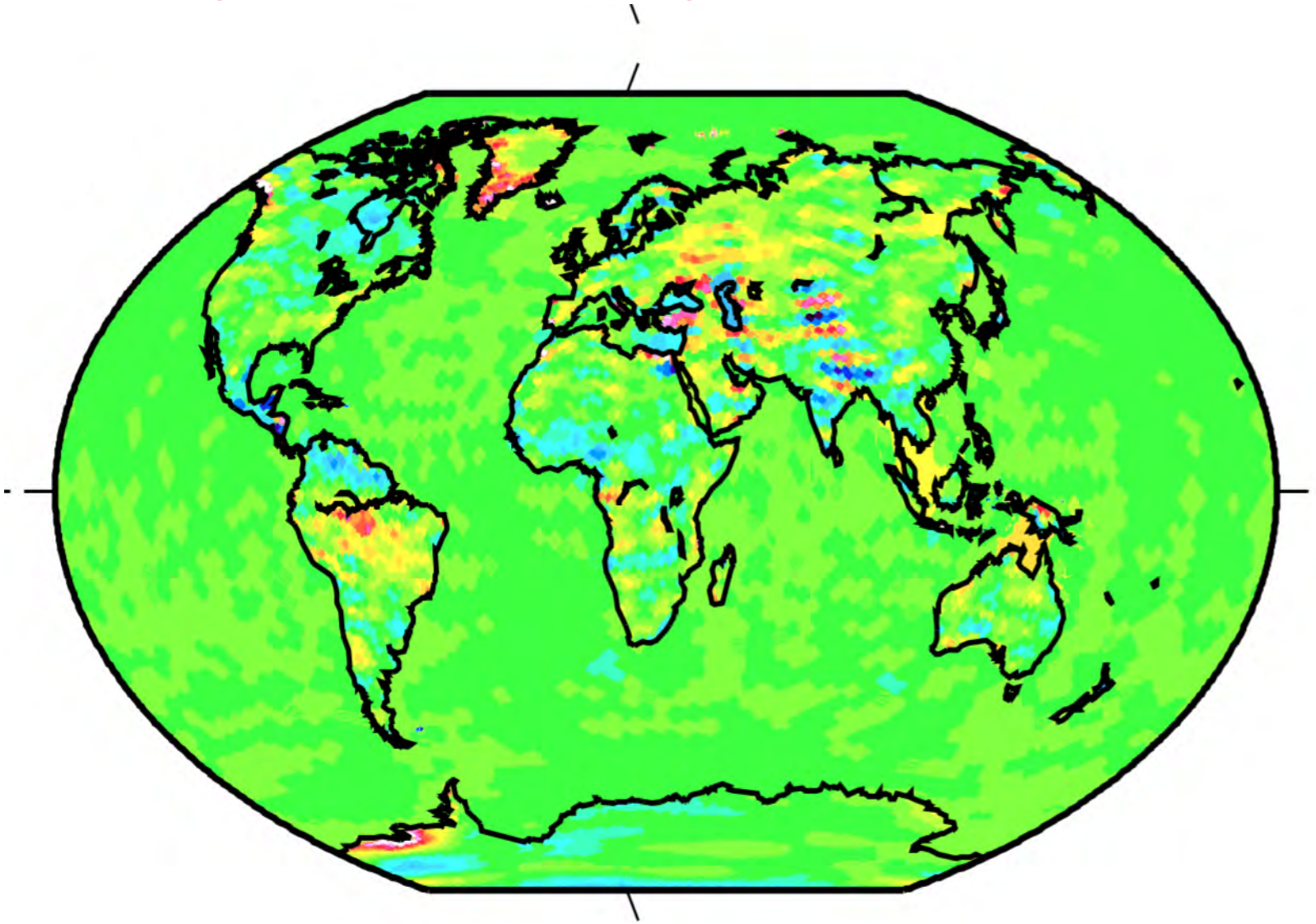
range rate

range accel.



Australian National University

Temporal Gravity Field Estimates



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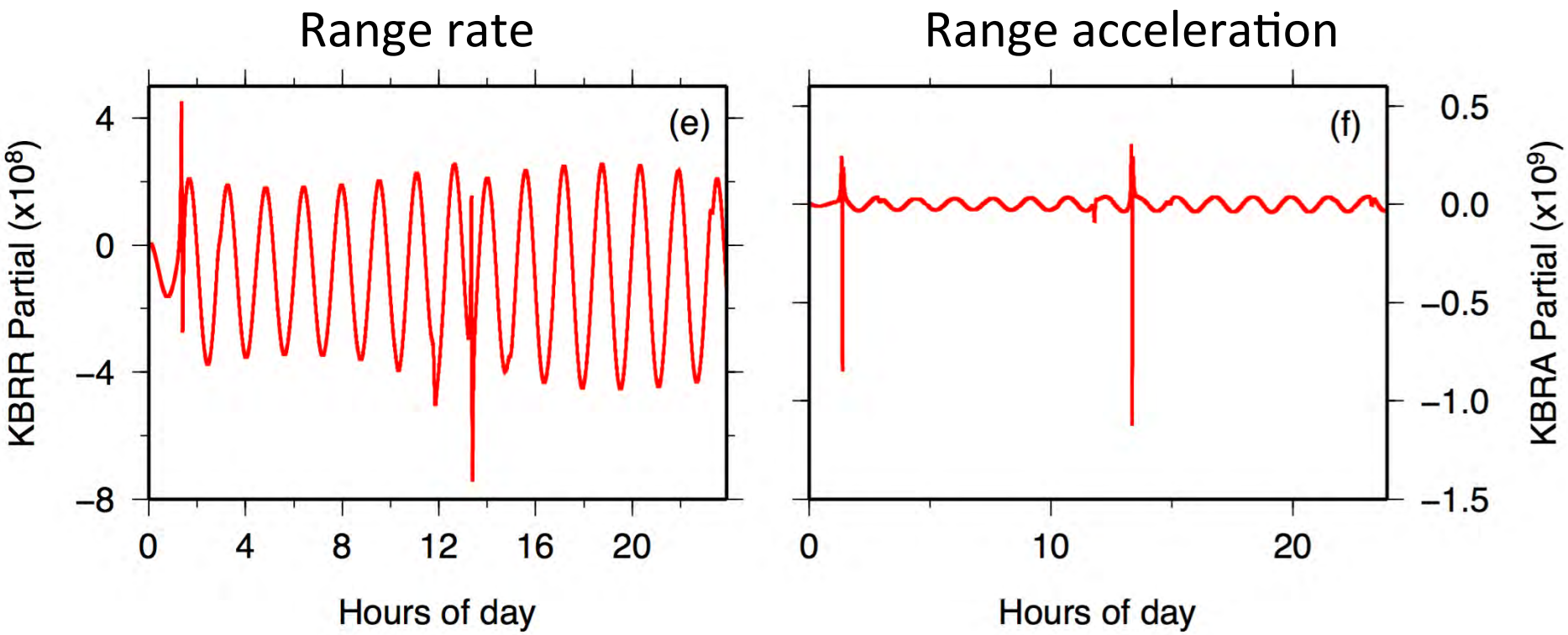
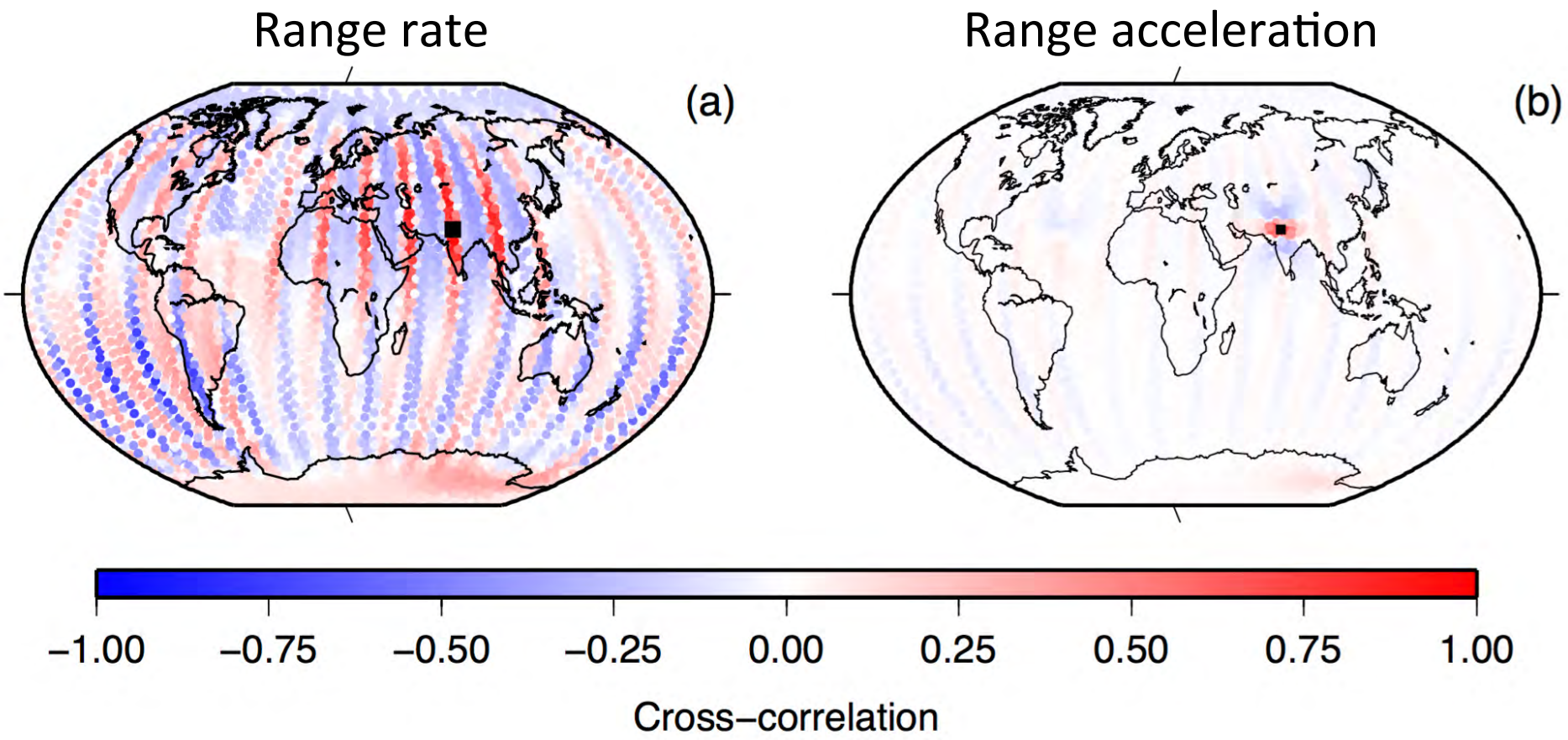
Why is range acceleration better?

Partial derivatives wrt a single mascon



Why is range acceleration better?

Cross-correlation of partial derivatives

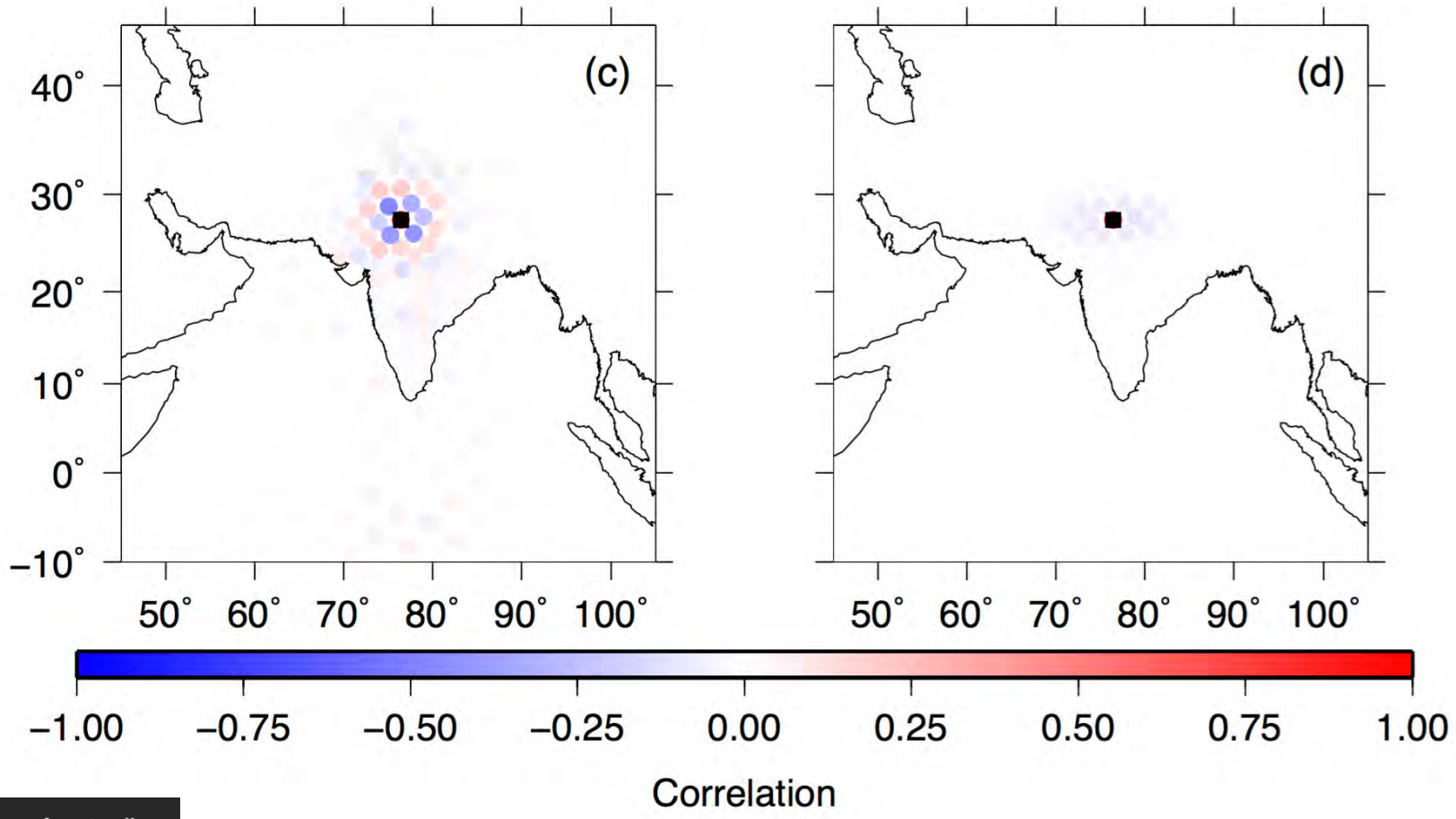


Why is range acceleration better?

Postfit correlations between mascon parameters

Range rate

Range acceleration



Conclusions

- Derive range acceleration through time differentiation of the KBR1B range
  - Less noise
  - Reduced correlations between observations and parameters
- Solutions are improved
  - Reduced striping in gravity field estimates
  - Reduced correlations between mascon parameters
- 10-day solutions show comparable spatial resolution to monthly solutions (better?)