Comparing GRACE-FO Mascon Solutions: Using Range-Rate vs Range-Acceleration Data

Himanshu Save, Srinivas V Bettadpur, Steven R Poole, Nadège Pie and Peter B Nagel

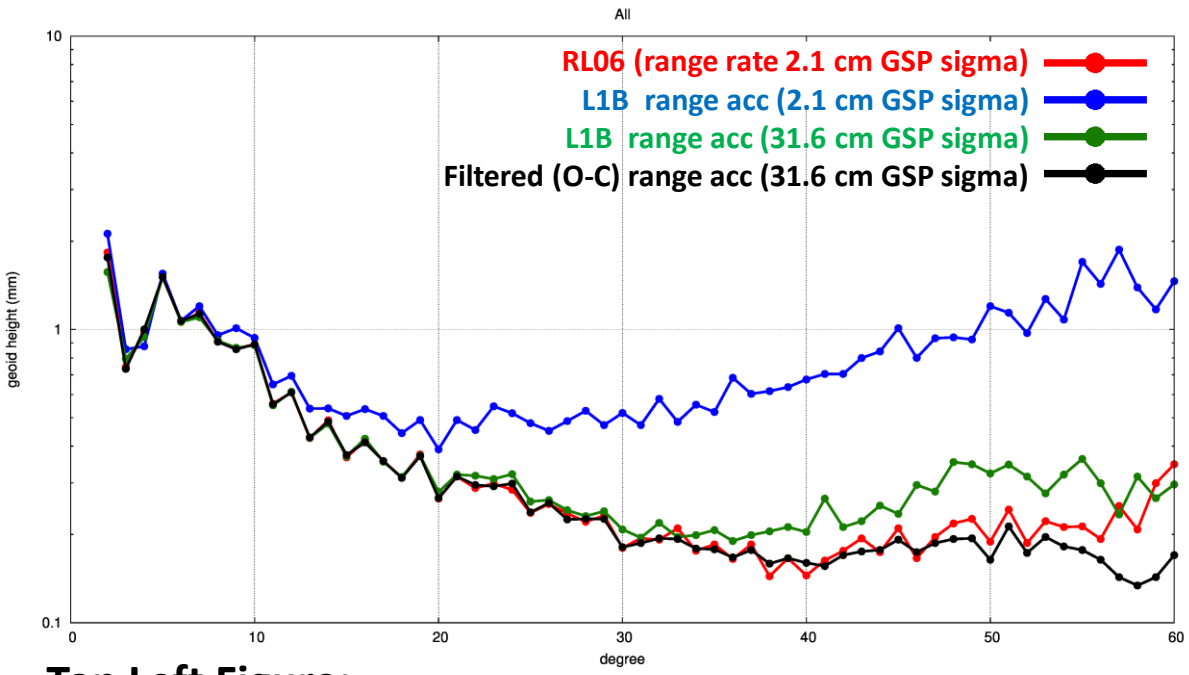
Center for Space Research,
The University of Texas at Austin

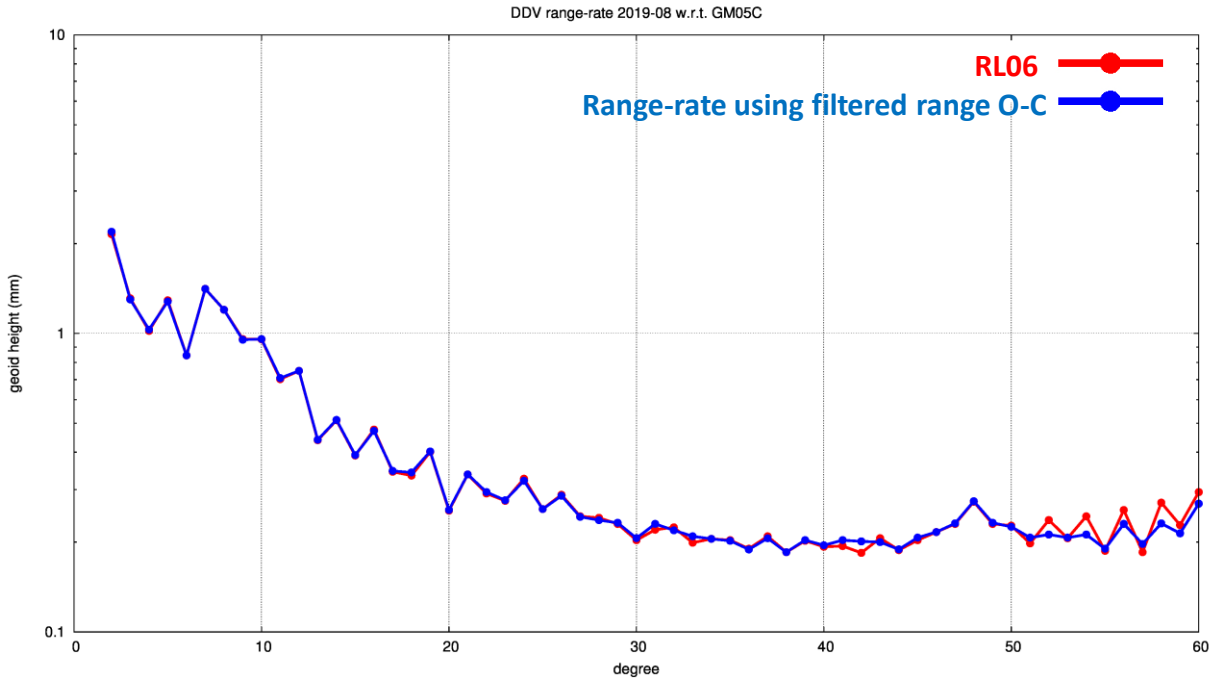
EGU General Assembly 2020 – EGU2020-11664 – May 8, 2020

Range acceleration solution

- CSR GRACE and GRACE-FO RL06 gravity fields are produced using KBR range-rate measurements
- We have been able to achieve consistent gravity fields from KBR range and range-rate data
  - Attempts early in GRACE mission showed range-acc solutions to be too noisy
- Researchers at ANU had shown successful mascon processing of range-acc data using optimized differentiating filter
- Revisited estimation of SH using range-accelerations
  - Based on work done by Matt Smith (Master's Thesis at UT)
  - Use CRN filtered range-rate "O-C" (prefit residuals) to compute range-acc "O-C" (prefit residuals)

Monthly range-acc SH solutions





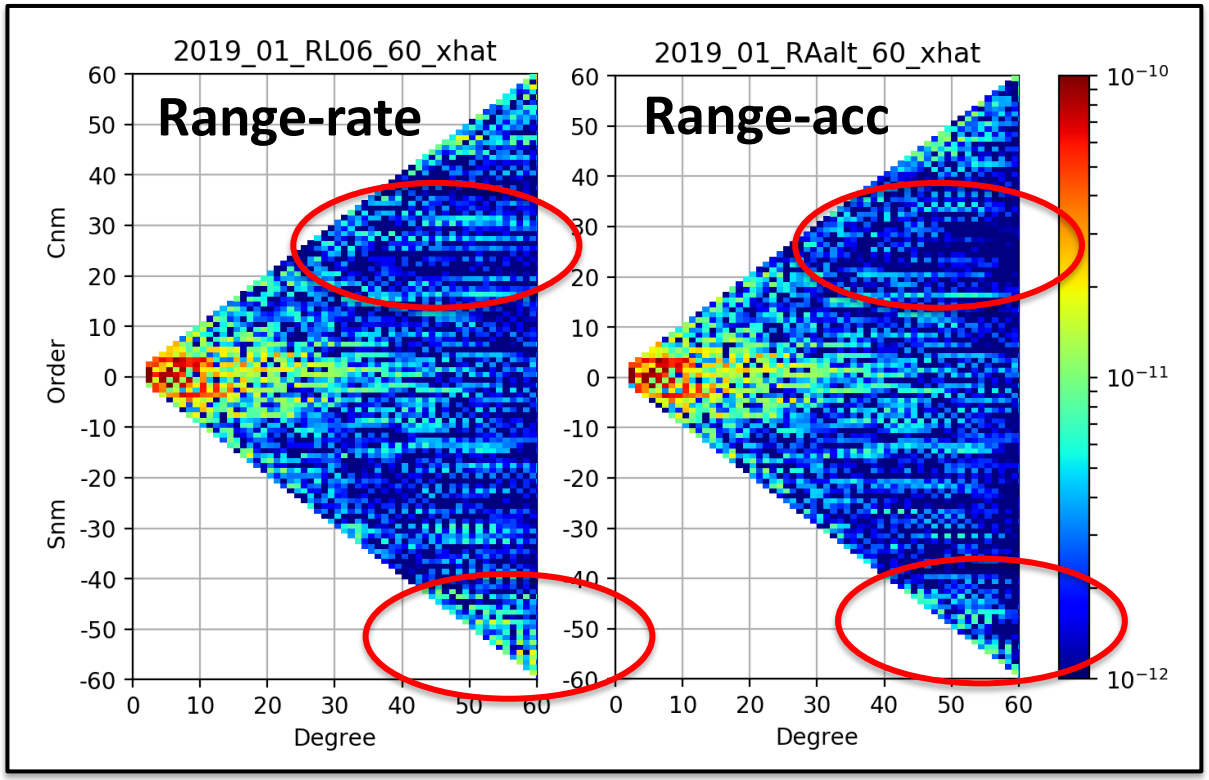
Top Left Figure:

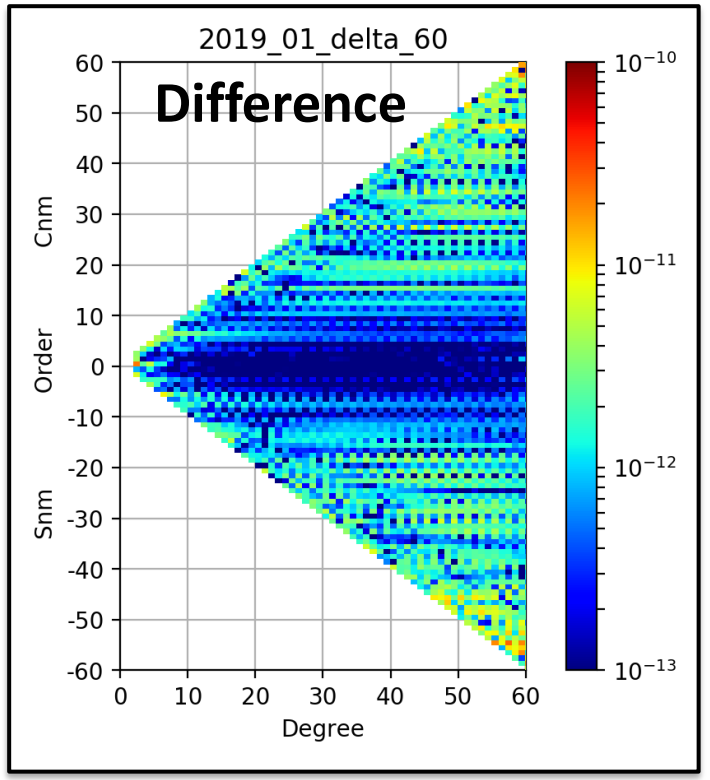
- Using the raw L1B range accelerations with 2.1 cm sigma for GPS (same as the range-rate case) results in a poor gravity field estimate
- Down-weighting GPS to sigma of 31.6 cm improves the gravity field using raw L1B range acc measurements
- Need to CRN filter the range acceleration "O-C" (prefit residuals) to improve the gravity field compared to range-rate case

Top Right Figure

- Using CRN filtered range to generate range-rate "O-C" (prefit residuals) does improve the solutions at higher degrees

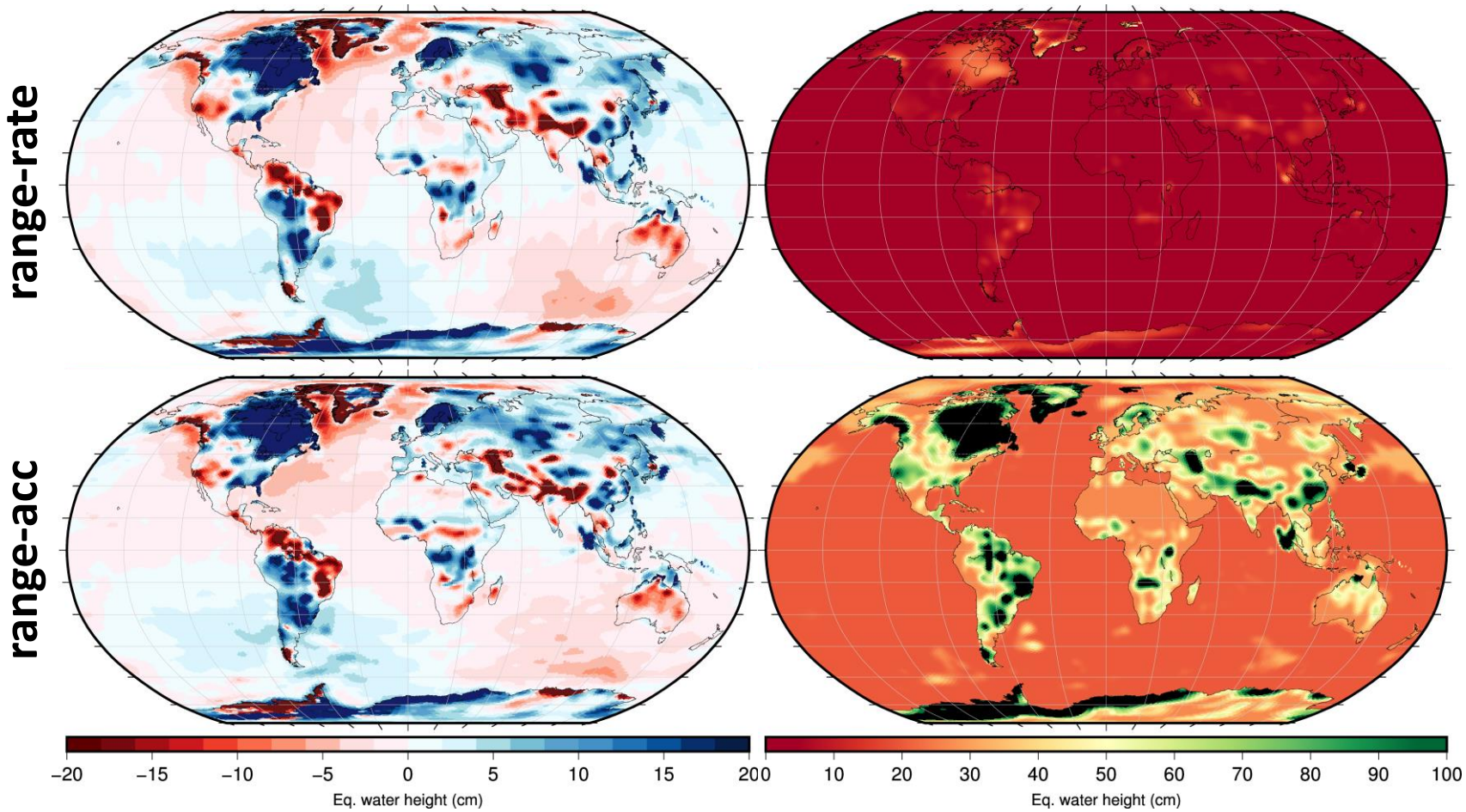
Range-acc SH solutions summary





- We believe that the improvement is due to how the O-Cs are made (same as ANU), not due to the type of filter (different from ANU)
- Search for optimal parameterization and filter settings is ongoing
- New "O-C" product for range acc residuals could be of interest to users
  - along with a compatible orbit, background models etc.

Monthly Mascon Solutions: range-rate vs range-acc



Resulting Solution

Sqrt (reg par) * Reg matrix

2019 - 01

Use the same regularization matrix for processing range-rate and range-acceleration.

The apriori sigmas have been increased by an order of magnitude (using regularization parameter) when using range acceleration compared to range-rate.

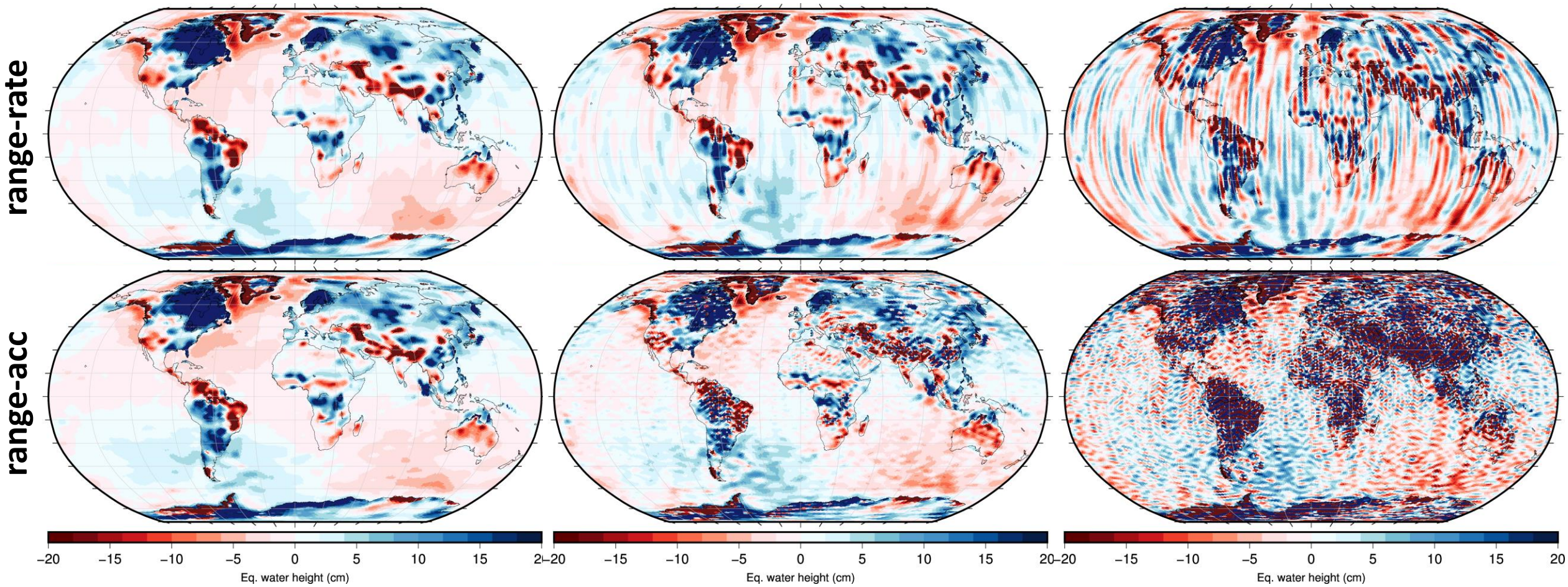
Analysis is ongoing to understand the interaction of the apriori sigmas and different data types.

Monthly Mascon Solutions: range-rate vs range-acc

(Summary for the next slide)

- Using the same regularization matrix, the a-priori sigmas in range-acceleration are an order of magnitude higher than range-rate case => less constrained
- As you decrease the regularization parameter by two orders of magnitude => less constrained
  - the range-rate mascon solutions shows north south striping as expected
  - but the range-acceleration solution shows small east-west banding while localizing majority of the signals

Monthly Mascon Solutions: range-rate vs range-acc



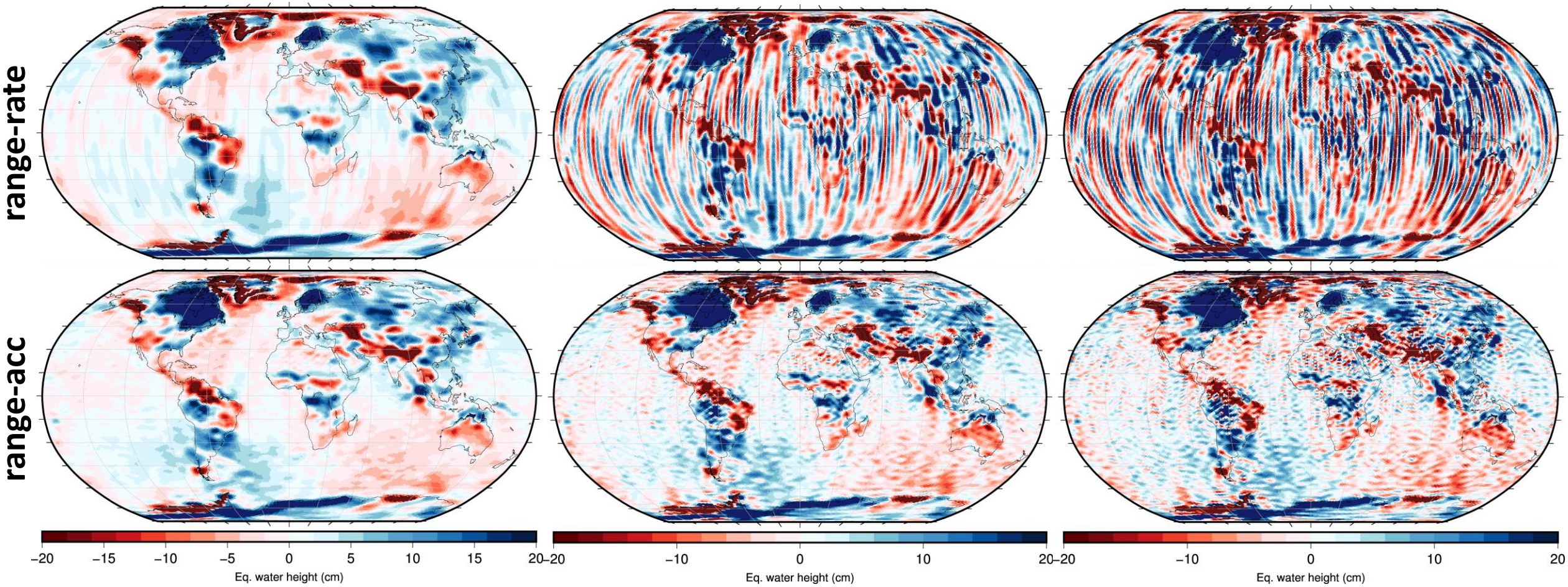
Regularization parameter **decreases** by two orders of magnitude

Using uniform (identity) regularization

(Summary for the next slide)

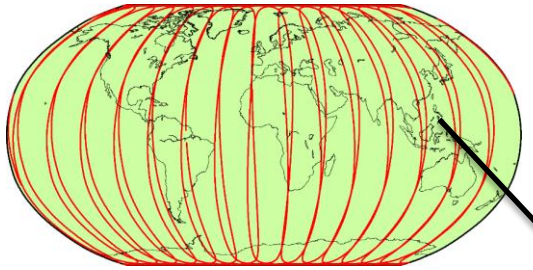
- Range acceleration mascon processing is more “forgiving” when applying regularization matrix with geophysical patterns.
- Even when applying generous and uniform sigmas across the globe, one can get a reasonable solution from range acceleration processing.
  - range-rate solutions show significant N-S striping when using Identity regularization
- This is true even when decreasing the regularization parameter by two orders of magnitude (less constrained)

Using uniform (identity) regularization

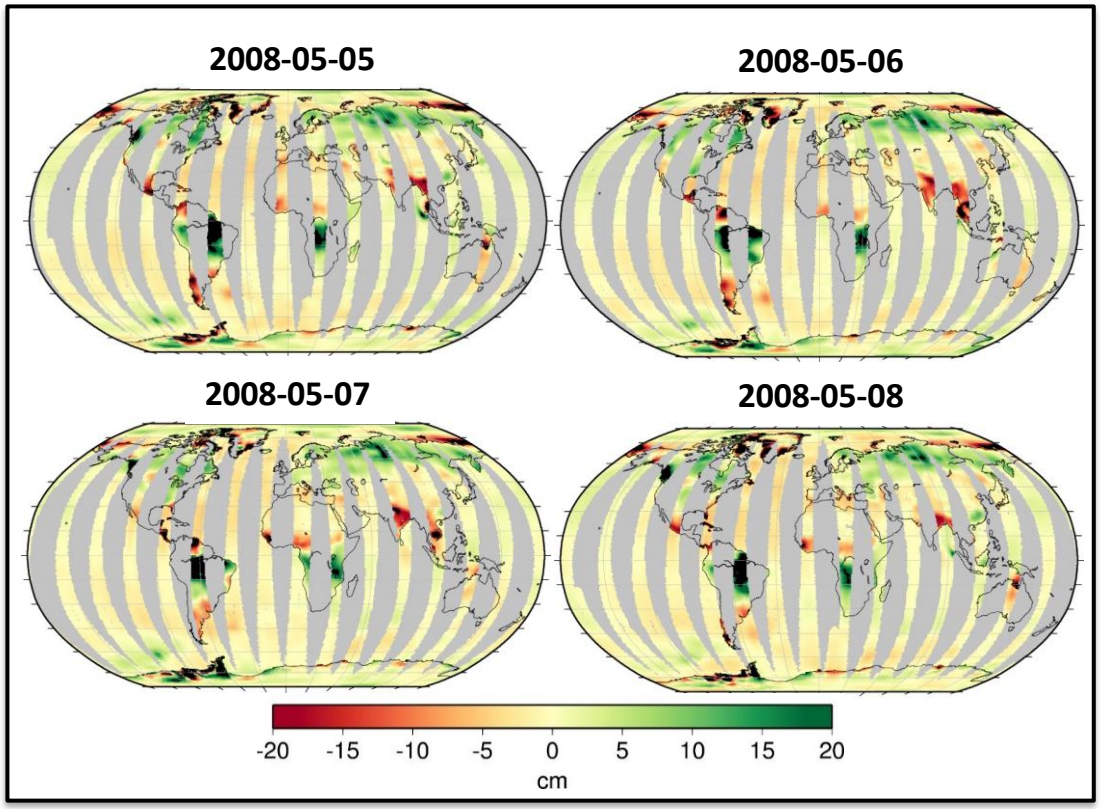


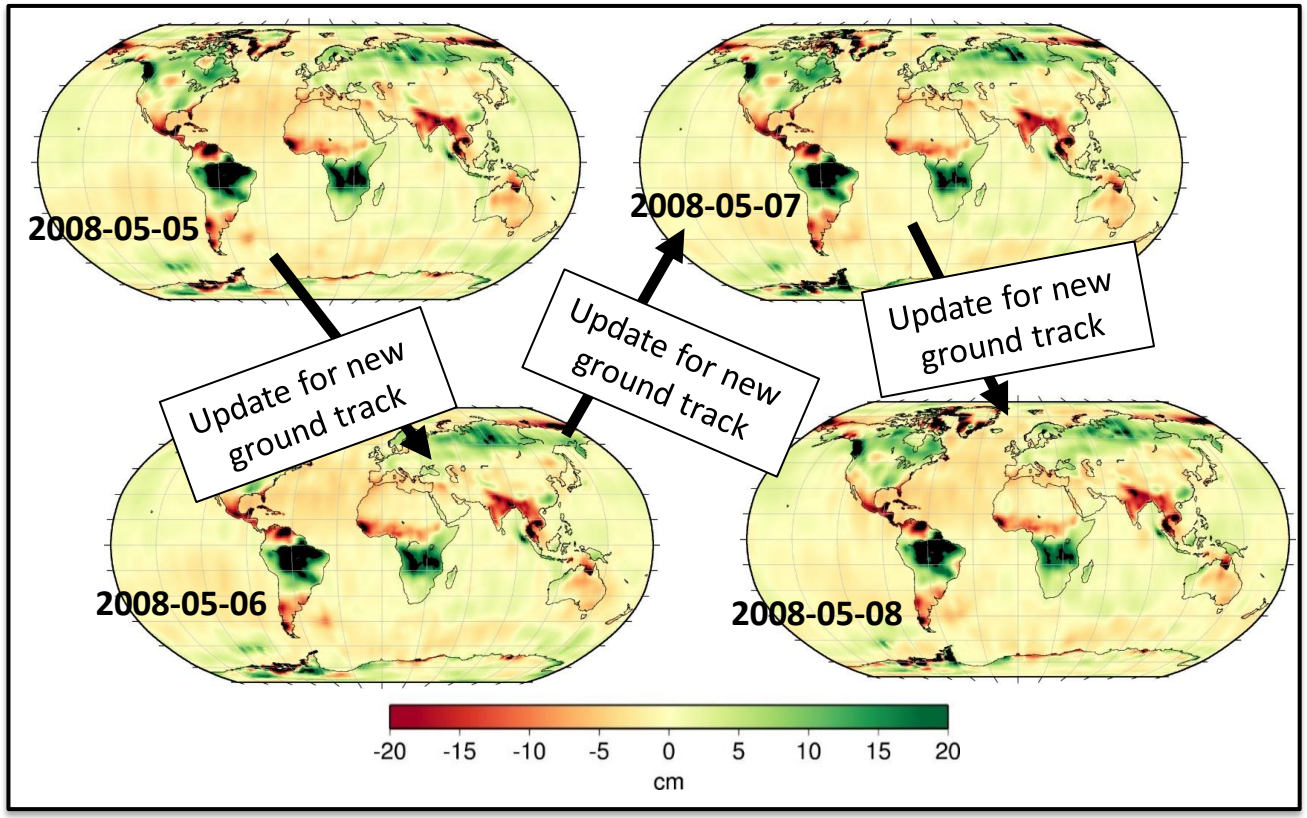
Regularization parameter **decreases** by two orders of magnitude

Daily swath solutions



Compute Mascon solutions for daily ground track (swath)



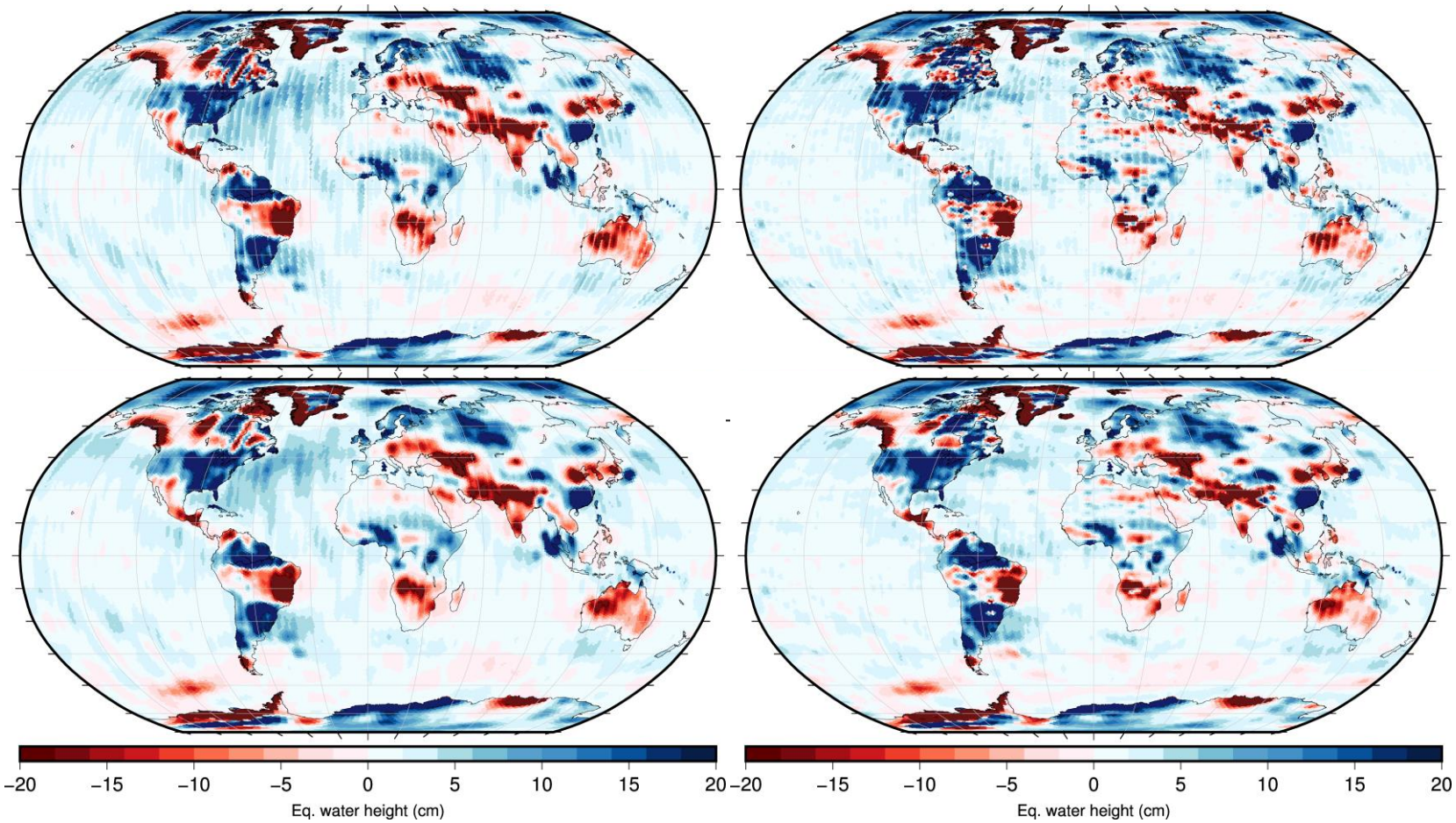


Compute daily update swath solutions

Daily Swath solutions from range-acc

Raw estimates

w/ swath edge smoothing



Range-rate **Range-acceleration**

2019-07-10

** GIA corrected*

- The range-rate swath solutions inherently have more N-S striping.
- This is mitigated in the range-acceleration solution.
- There are some signal differences in these first experimental solution set.
- Need further analysis and refinement of the regularization parameters.

Summary

- On-going work on all fronts
- Range-acc SH solutions
  - We need to CRN filter the “O-C” instead of O to make the range acceleration solutions work
  - We need to further down-weight the GPS data relative to range-acc data for range-acc solution
  - Range-acceleration solutions are consistently better than the corresponding range-rate solutions
- Range-acc Mascon solutions
  - these do not exhibit N-S striping as you free up the regularization
  - the errors in these solutions are more localized as compared to range-rate solutions
  - these solutions are less dependent on the exact patterns of constraints applied to the mascons.
- Range-acc daily swath solution
  - The daily swath solutions would benefit from the range-acc processing greatly
  - Swath solutions have inherently higher N-S striping as compared to the other time-averaged solutions and signal (and error) localization due to the use of range-accelerations help mitigate the N-S striping.
- Next step is to use the GRACE-FO LRI data to compute range-acceleration mascon solutions

Thank you

save@csr.utexas.edu

Special thanks to the Texas Advanced Computing Center (TACC) for their support with high performance computing and data storage.

This work is sponsored by JPL contract 1604489.