# JPL Level 2 Gravity Processing: Status and Prospects

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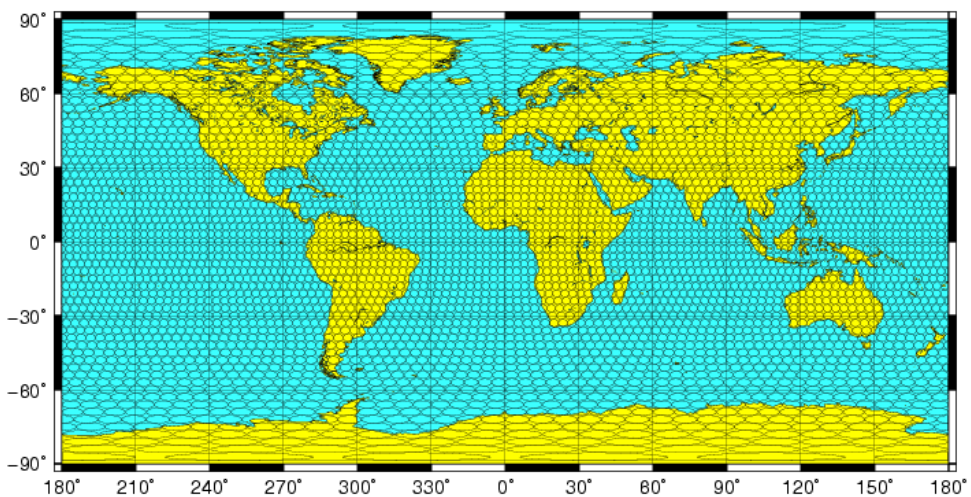
October 5, 2016
GRACE Science Team Meeting
Potsdam, Germany

# Outline

- Status Update
  - Transition to Version 2 mascon solution
  - Data release strategy
- Error and Uncertainty in the mascon solution
- Future plans
  - Preparing for RL06
  - Initial $1^{o}$ mascon results

# Status

- Spherical harmonic solutions
  - Current through June 2016
- Mascon solutions
  - Current through June 2016
- Changes since last year
  - In March 2016, parameterization of the estimation process changed
    - Estimate 3-hourly accelerometer bias and rate in the crosstrack direction to account for drifts that are initiated by heater events
  - In May 2016, Version 2 of the mascon solution was released

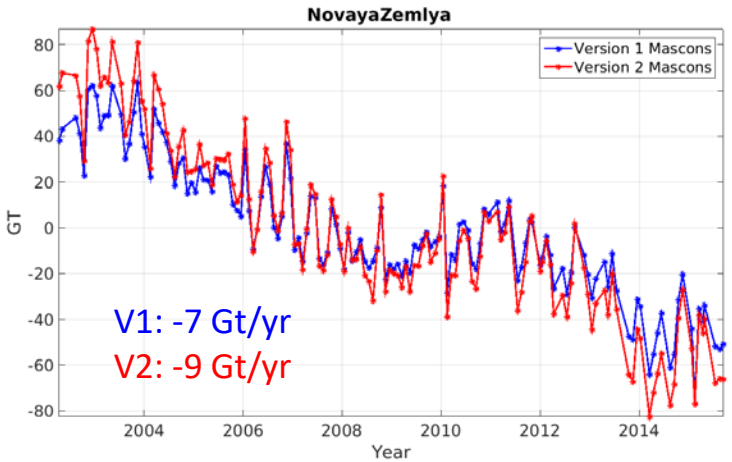


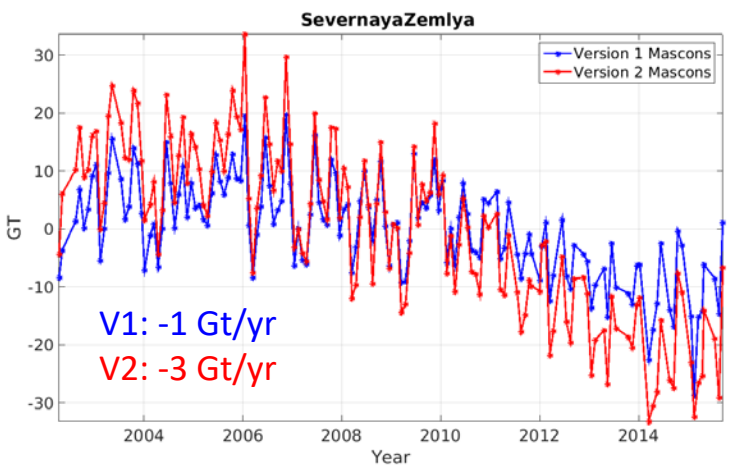

Solve for 4,551 equal-area 3° spherical cap mascons each month

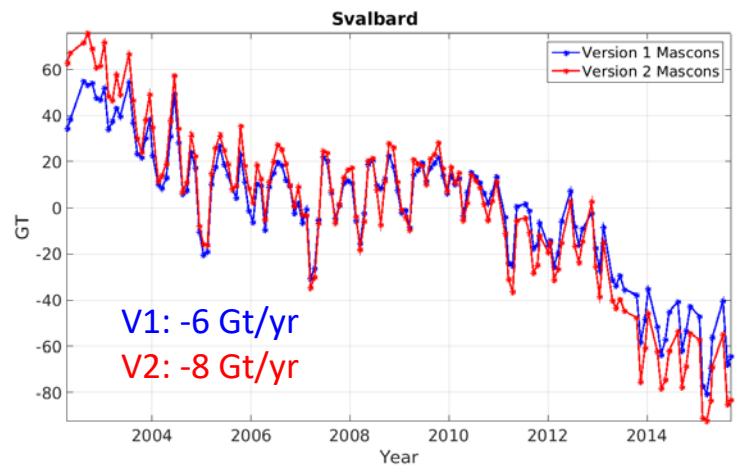
Implement regularization using spatial and temporal constraints to remove correlated errors

# Version 2: JPL mascons

- Changes relative to version 1
  - Slight relaxation of constraints in Svalbard and the Russian Arctic



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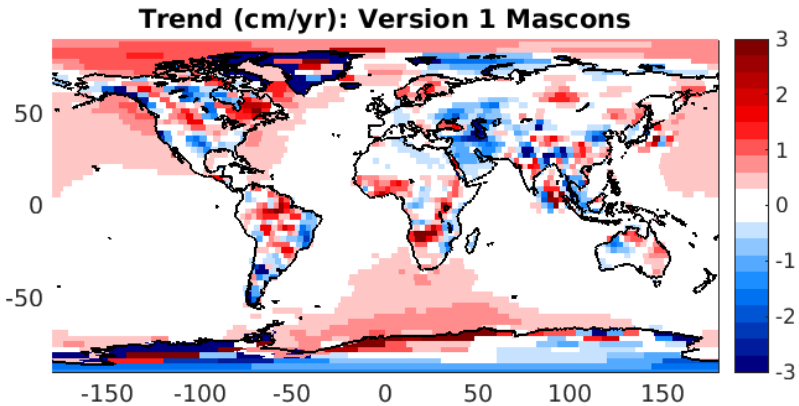
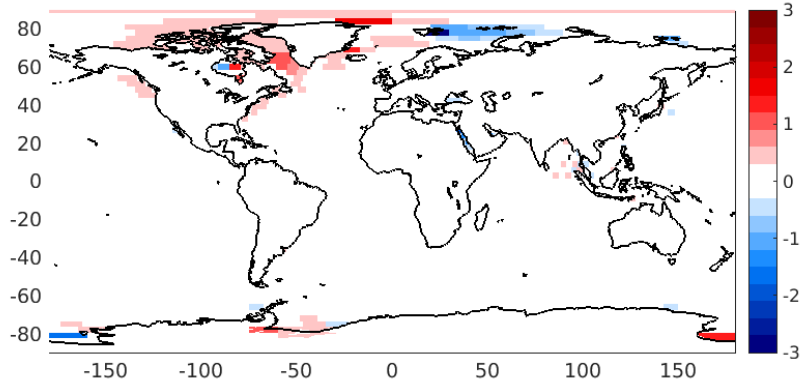
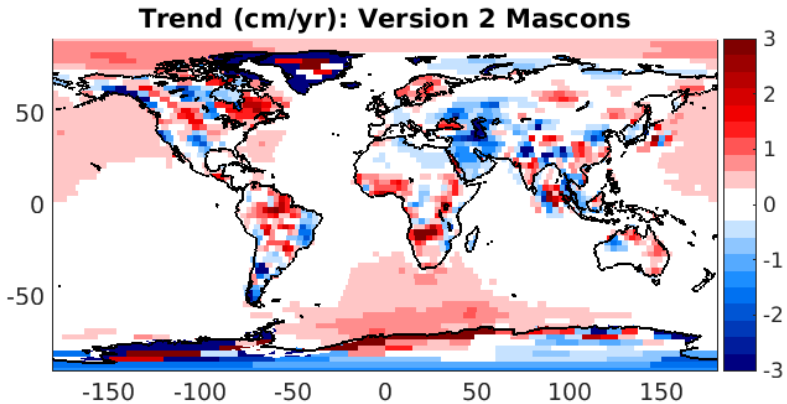
  - Forward model GIA in ocean

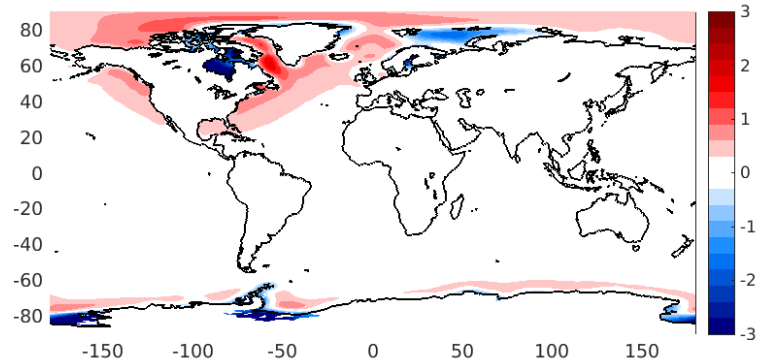



Trend difference over ocean (V1 – V2) (cm/yr)




A. et al (2013) inverse GIA trend over ocean (cm/yr)

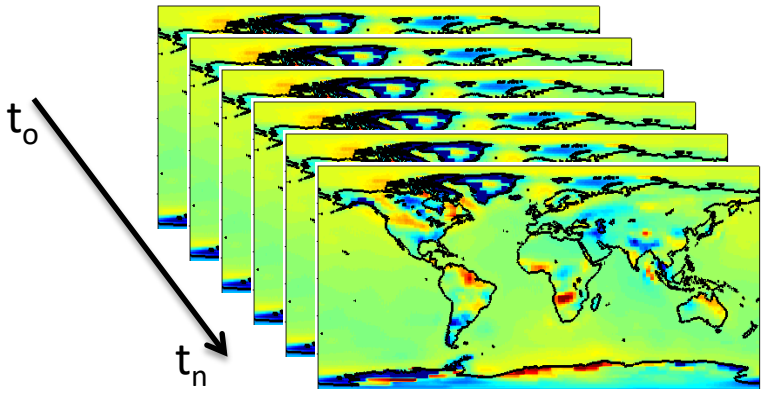


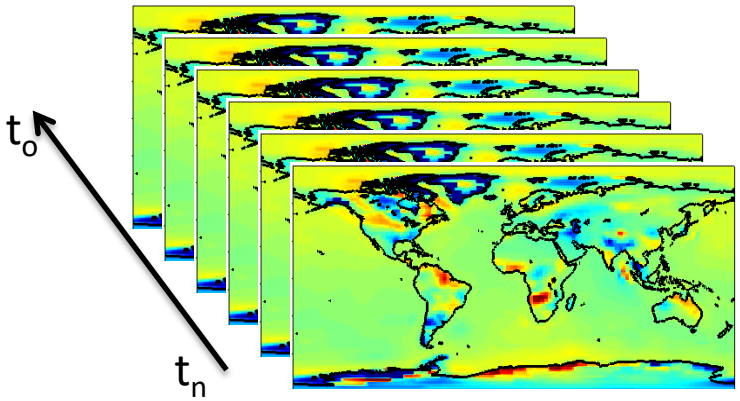
# Version 2: JPL mascons

- Changes relative to version 1
  - Slight relaxation of constraints in Svalbard/Russian Arctic
  - Forward model GIA in ocean
  - Relative weight of the data and apriori covariance
    - Now based on the formal covariance of the JPL spherical harmonic solution
    - Improved estimates for months with poor groundtrack coverage (Feb 2015)
  - Geocenter computation is now done “in-house” using Swenson method
    - Compares well with Tellus values; small differences
    - Provides a testbed for GRACE-FO; allows for more control on data latency
  - CRI filter (separates land/ocean mass in coastal mascons)
    - Turned “on” for all mascons (previously was “off” for select mascons)
    - In mascons with highly skewed ratios of land/ocean area (particularly for ice), the filter does a poor job
- Change in release strategy

# Release Strategy

- Time correlation causes all months to change with the addition of a new month
- Previous strategy employed a 4-month lag to let solution stabilize
- New strategy is to stay current and overwrite all previous months with the addition of each new month
- Changes in the gravity field are encompassed by calibrated formal errors that accompany the solution



# Release Strategy

## Example

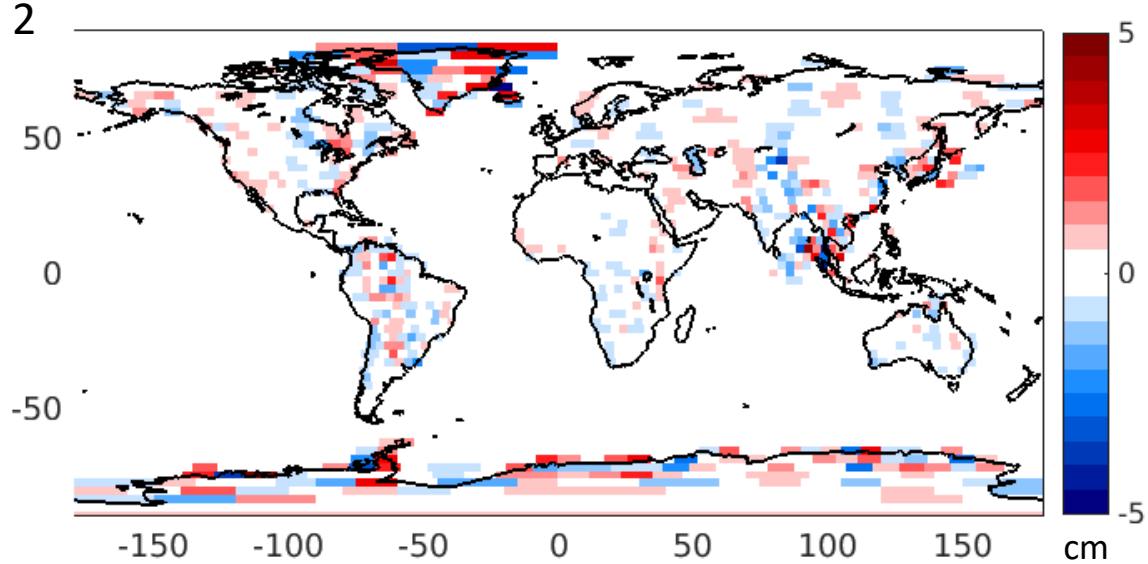
Solution 1: Apr 02 – Mar 16

Solution 2: Apr 02 – July 16

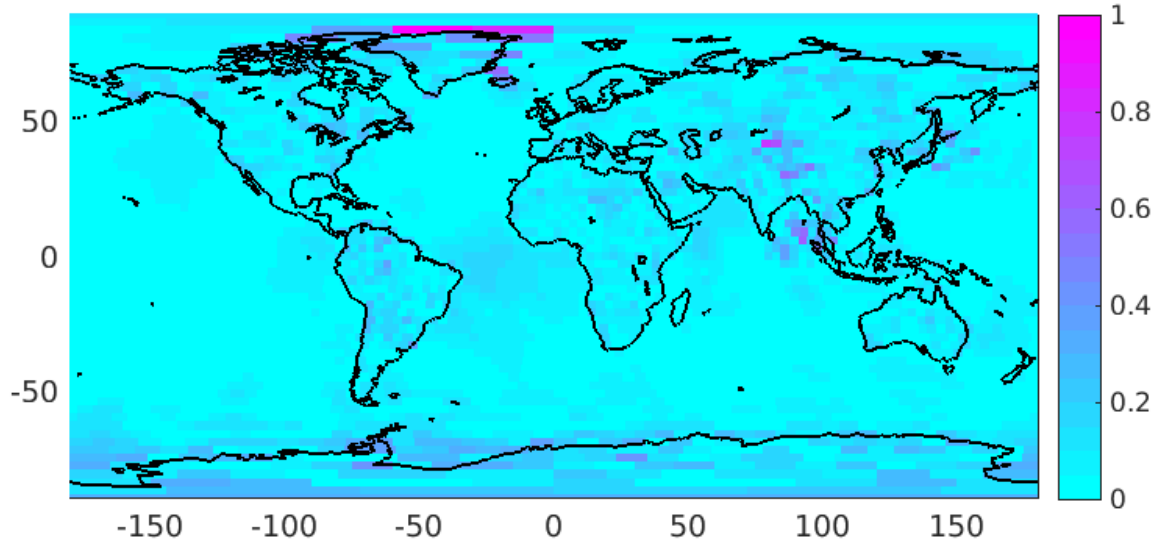
(3 new months added)

*How much does March 2016 change as a result of adding new data?*

Change in March 2016 between Solution 1 and Solution 2




Ratio of change/sigma for March 2016



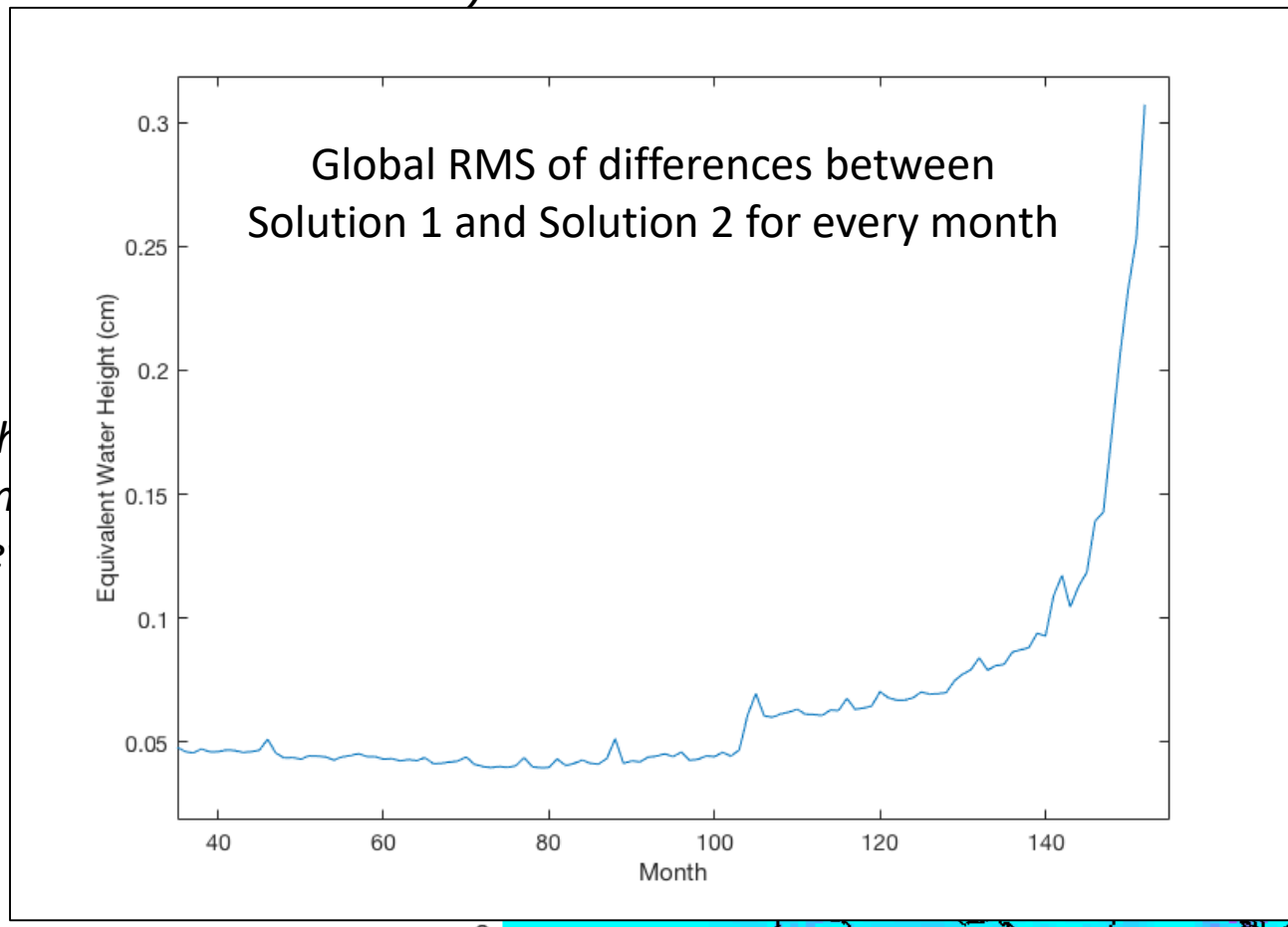
# Release Strategy

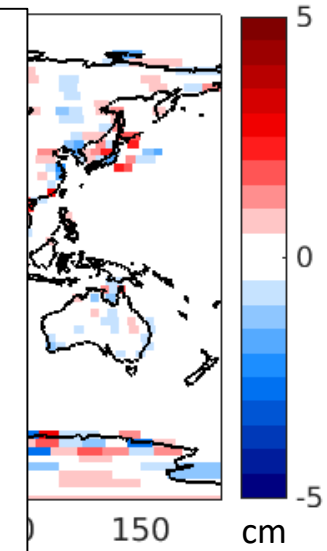
Change in March 2016 between Solution 1 and Solution 2

Solution 1:

Solution 2:

*How much*
*2016 chan*
*adding ne*

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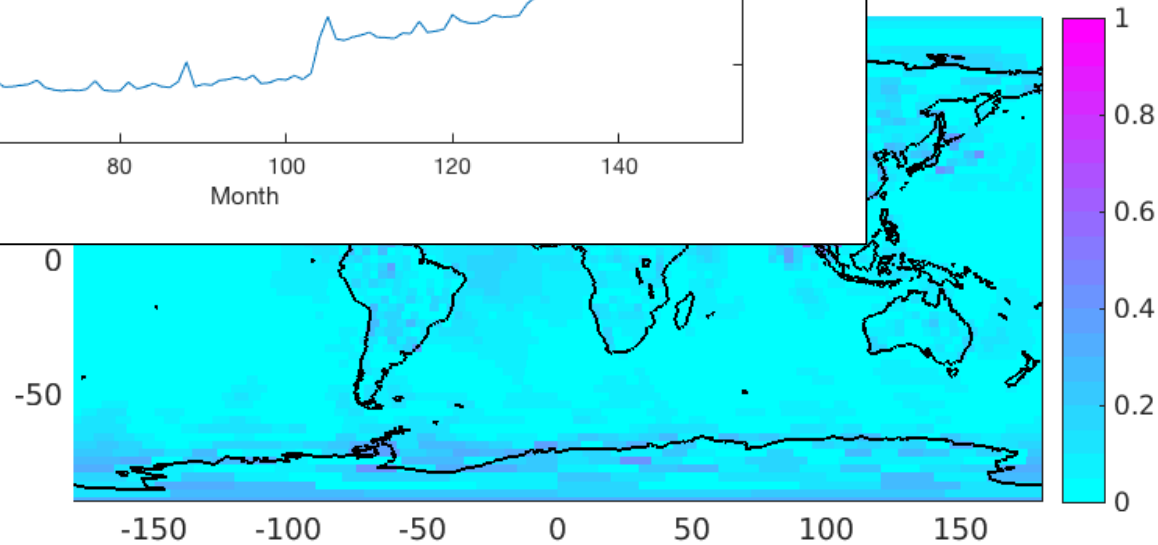

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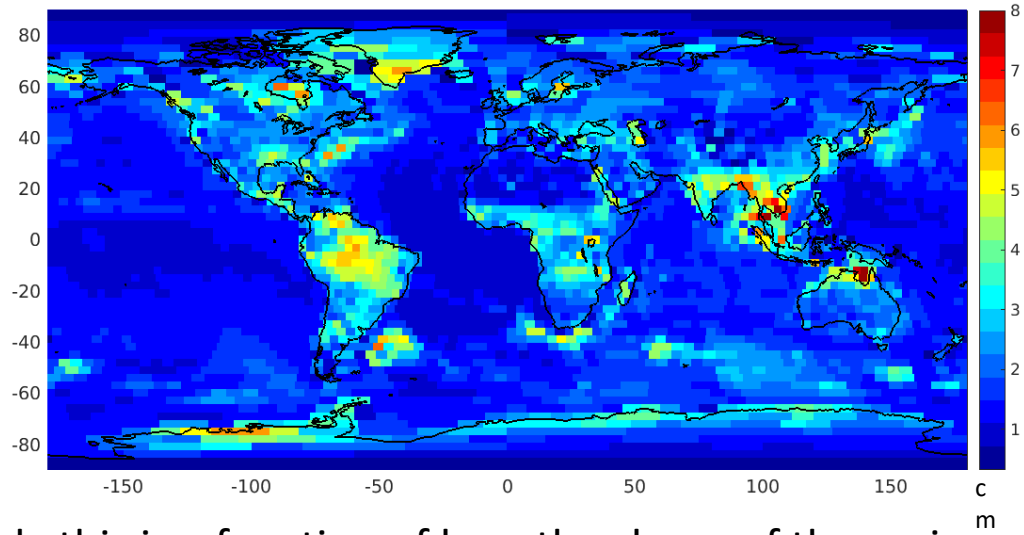
# Error and Uncertainty

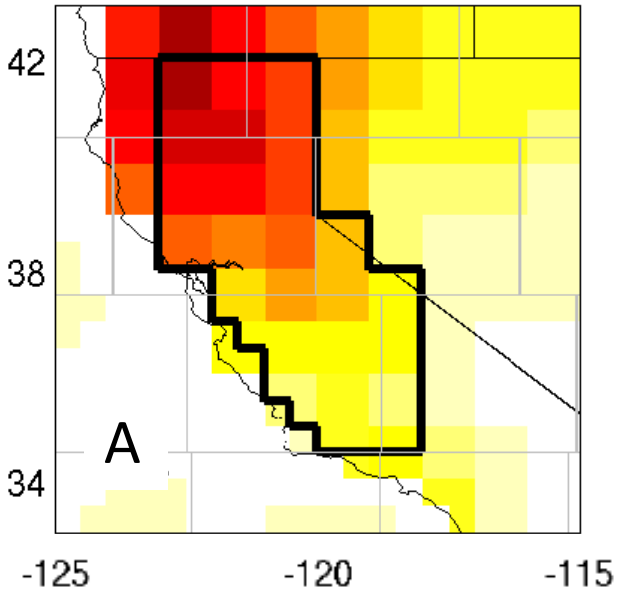
- Measurement error
  - We report 1-sigma formal error for each monthly mascon estimate
  - Derived by scaling the formal posteriori covariance matrix
    - Ocean scale factor: 4
    - Land scale factor: 2
    - Ice scale factor: 1

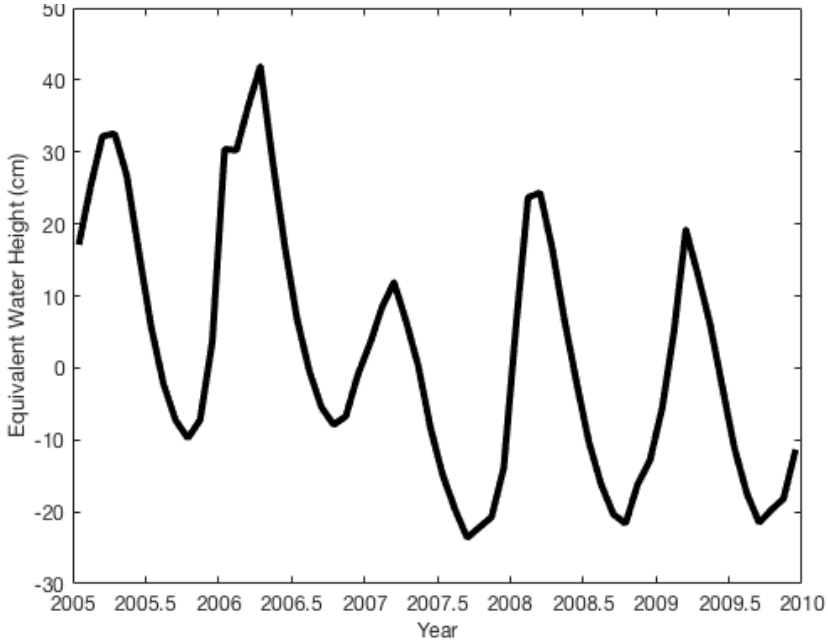
Reported measurement error for Feb. 2007



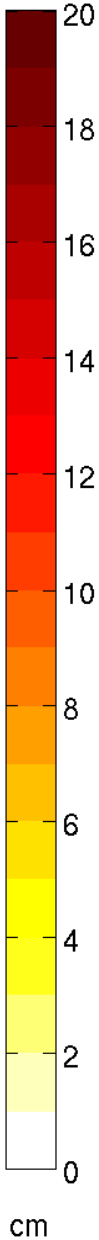

- Leakage error
  - Application specific: largely this is a function of how the shape of the region of interest conforms to the placement of the mascons, convolved with the spatial distribution of mass within individual mascon elements (at sub-mascon resolution).

Mass variations from CLM hydrology model
at 1° x 1° resolution for one month



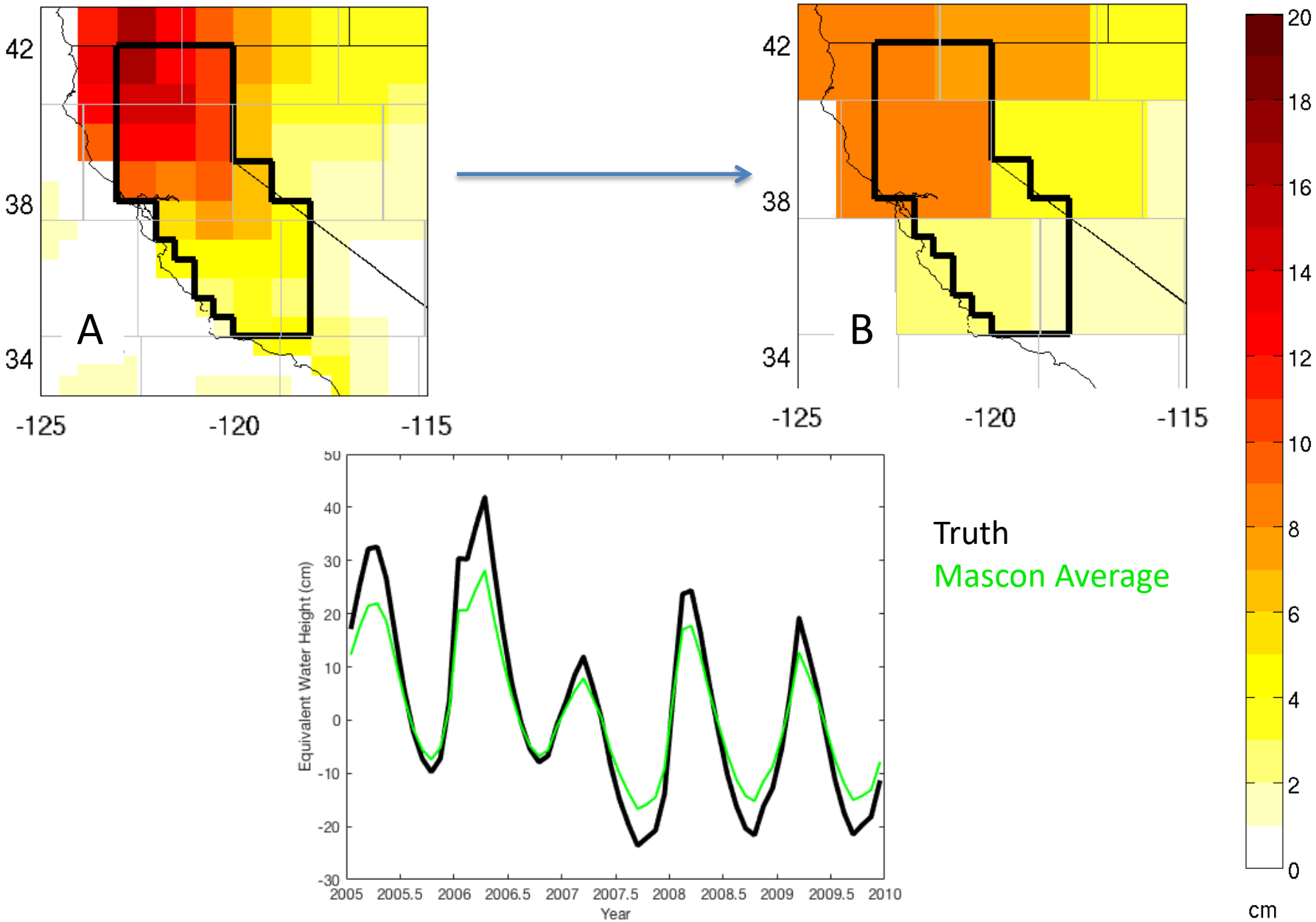




Truth



Mass variations from CLM hydrology model at 1° x 1° resolution for one month

"mascon-average" of (A) (how we sample the gravity field)



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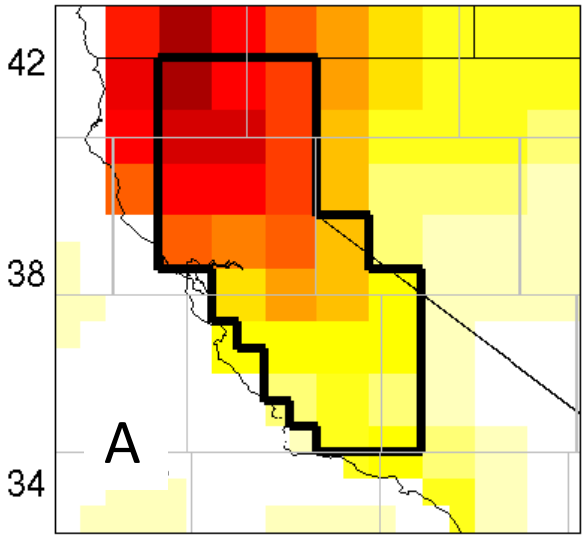


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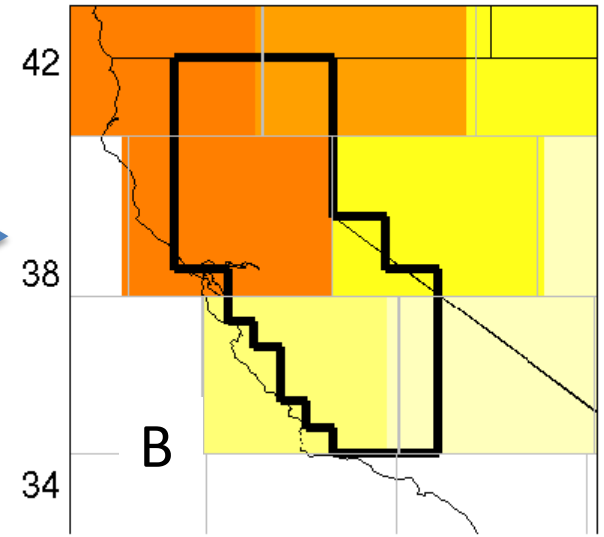
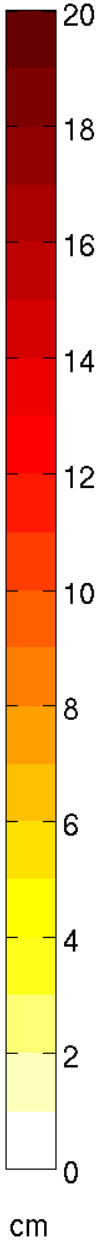
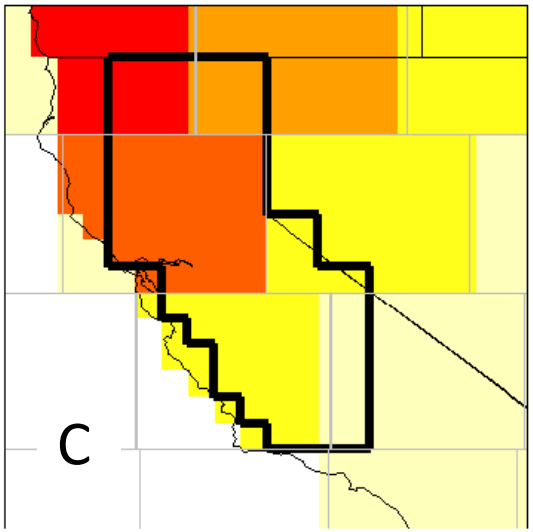


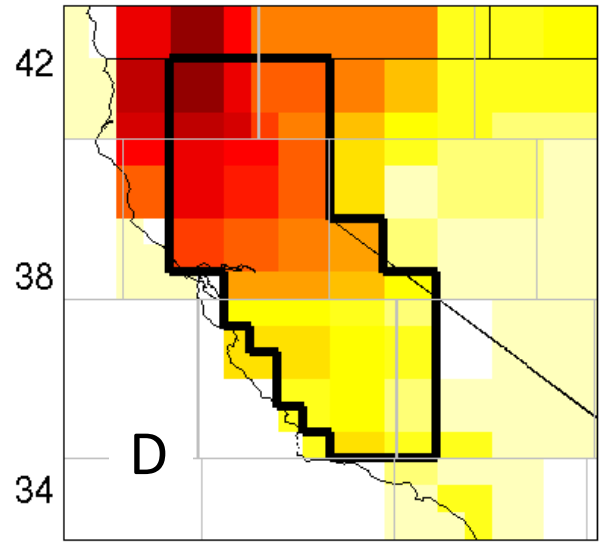




Two ways to correct this leakage error:

1) Implement CRI filter




2) Apply scale factors



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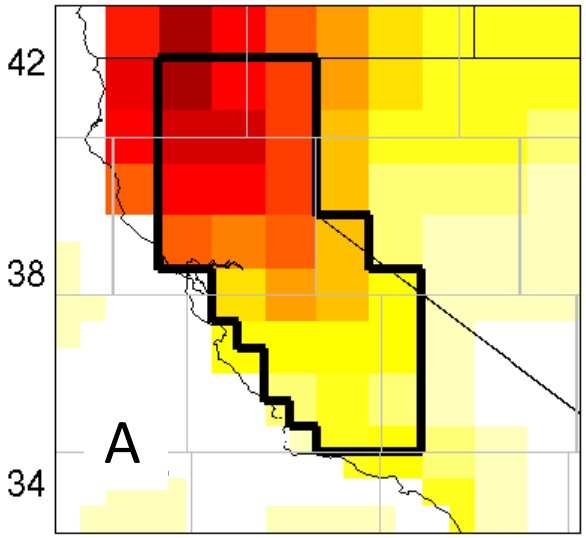


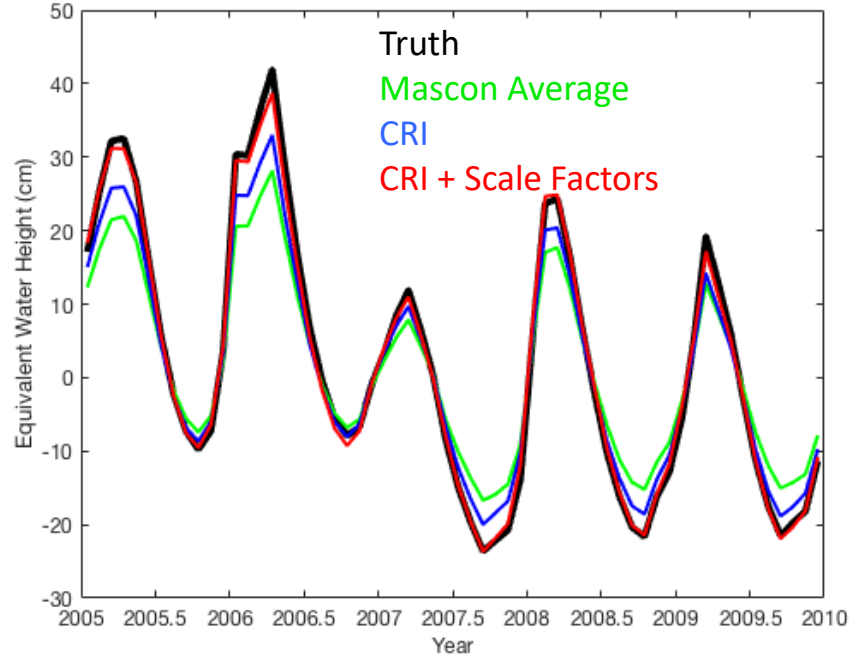


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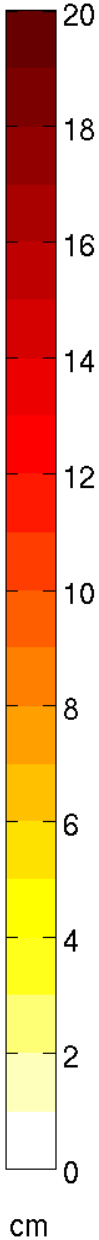


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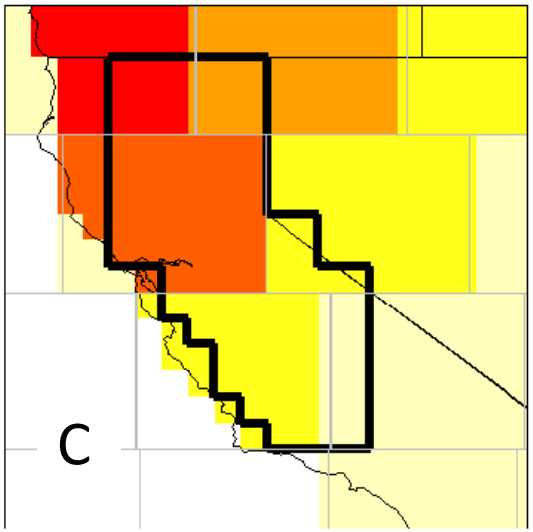


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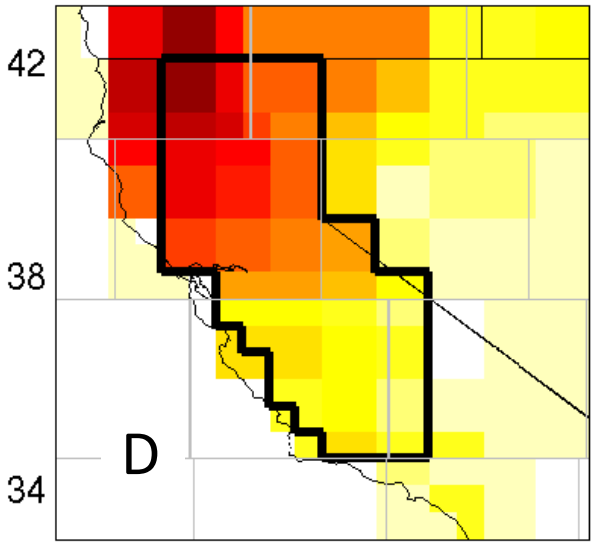
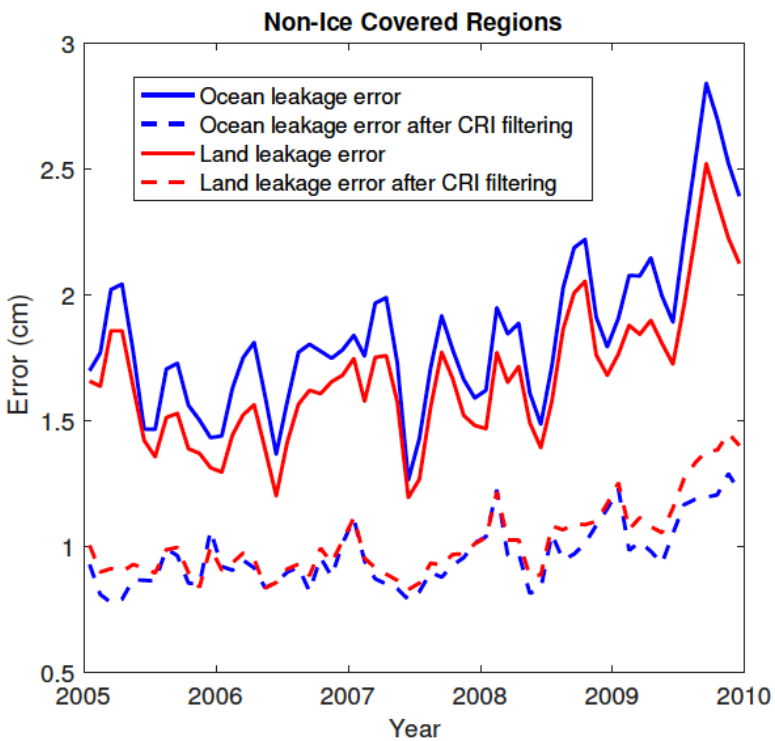
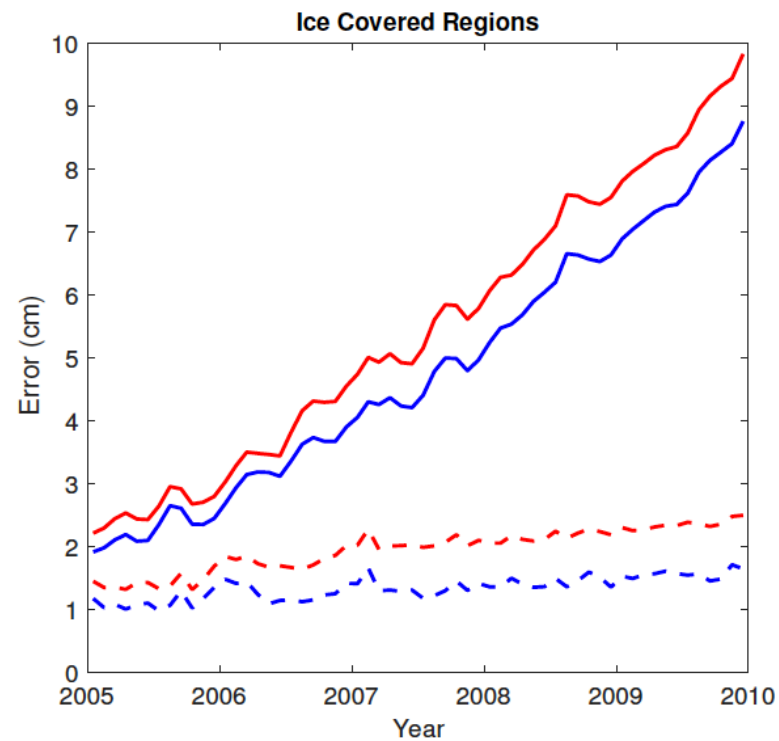


# How effectively can we reduce leakage error?

- Synthetic simulation:
  - Construct composite model: CLM (hydrology) + OMCT (oceans) + ESA Earth system model (ice) for five years
    - 1) "mascon-average" the composite model
      - Difference between this and the truth is the leakage error
    - 2) Apply CRI filter
    - 3) Apply scale factors
      - Derived from two different models: GLDAS and CLM

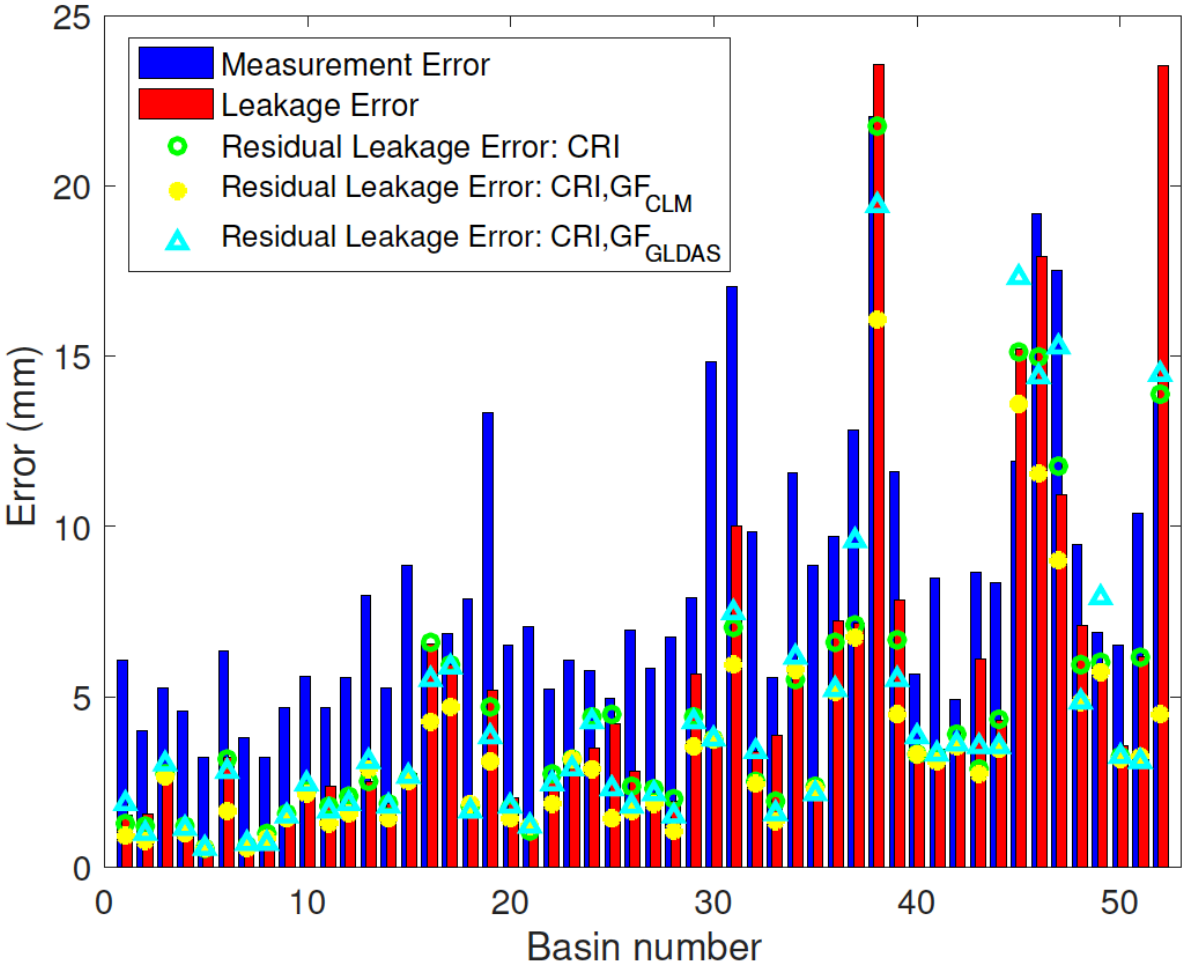
Global RMS of leakage error for all land/ocean mascons



# How effectively can we reduce leakage error?

Summary of results for 52 of the world's largest river basins




Larger Basins ⟷ Smaller Basins

**Takeaways:**

1) Leakage error on par with measurement error for smaller basins
2) Model dependence of gain factor is small: differences > 2 mm RMS in only 7 basins
3) Overall, leakage errors are reduced modestly: ~10% - 30% (0.5 mm to 1.5 mm) averaged over all basins
4) Accounting for leakage errors, especially in smaller river basins, is important for uncertainty quantification

WATER RESOURCES RESEARCH, VOL. ???, XXXX, DOI:10.1002/,

# Quantifying and Reducing Leakage Errors in the JPL RL05M GRACE Mascon Solution

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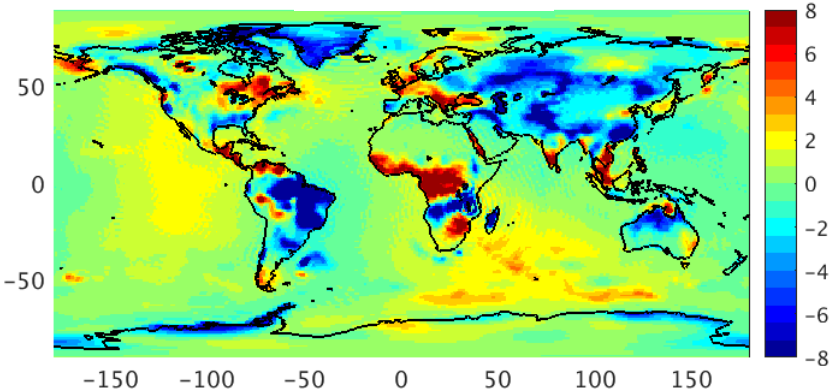
# Future plans

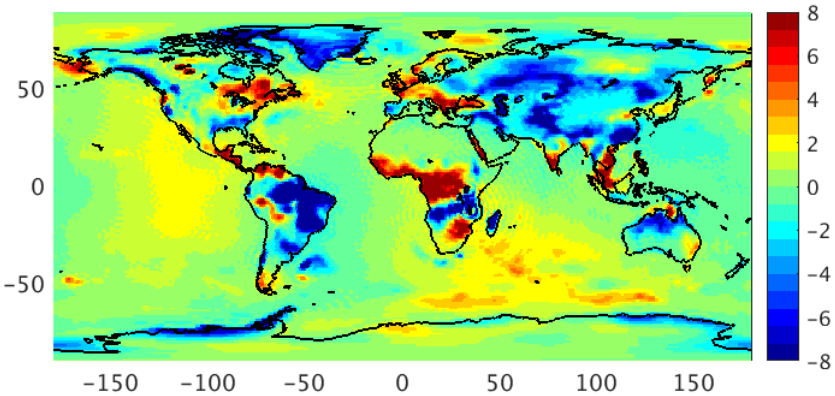
- RL06 processing
  - Use Version 3 Level 1 data
  - Use AOD RL06
  - Estimate 3-hourly accelerometer bias + rate in crosstrack direction for entire mission (rather than starting in March 2016)
  - New data editing strategy
  - Other options still being explored
- Mascon solutions
  - Experimenting with parameterizing the gravity field using $1^{o}$ mascons
    - Spherical Caps
    - Disks
    - Point mass

## Disk

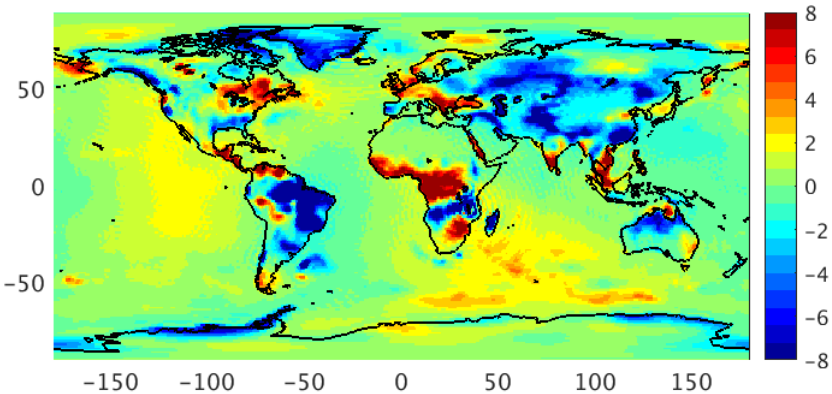
Units: cm water height




## Spherical Caps



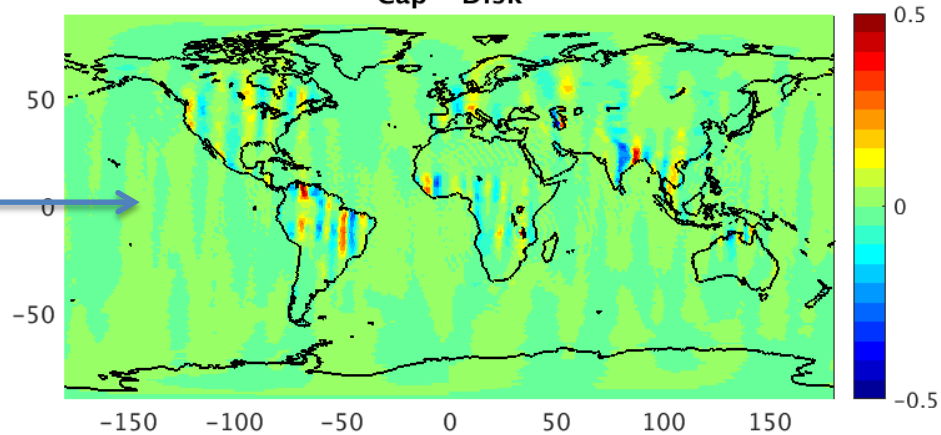

## Point mass



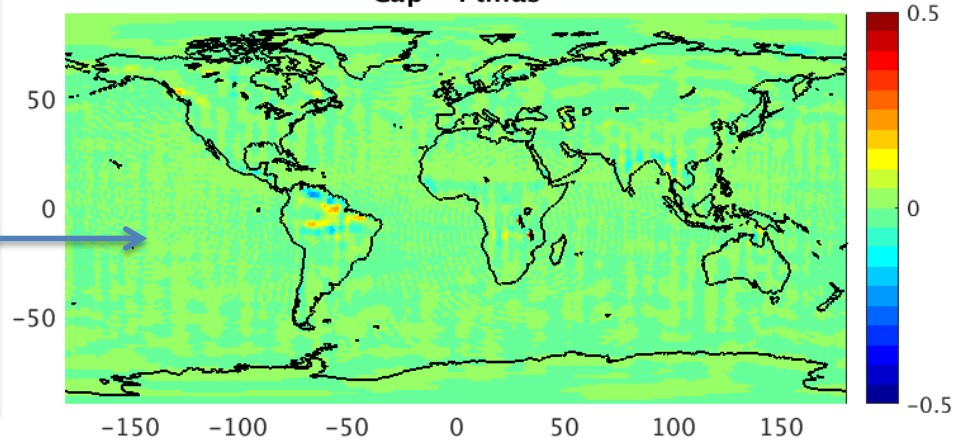

## Computation time: Normal equations for 1 day

| | |
|---|---|
| Spherical caps | ~ 8 hours |
| Disks | ~ 1 hour |
| Point Mass | ~ 1 hour |

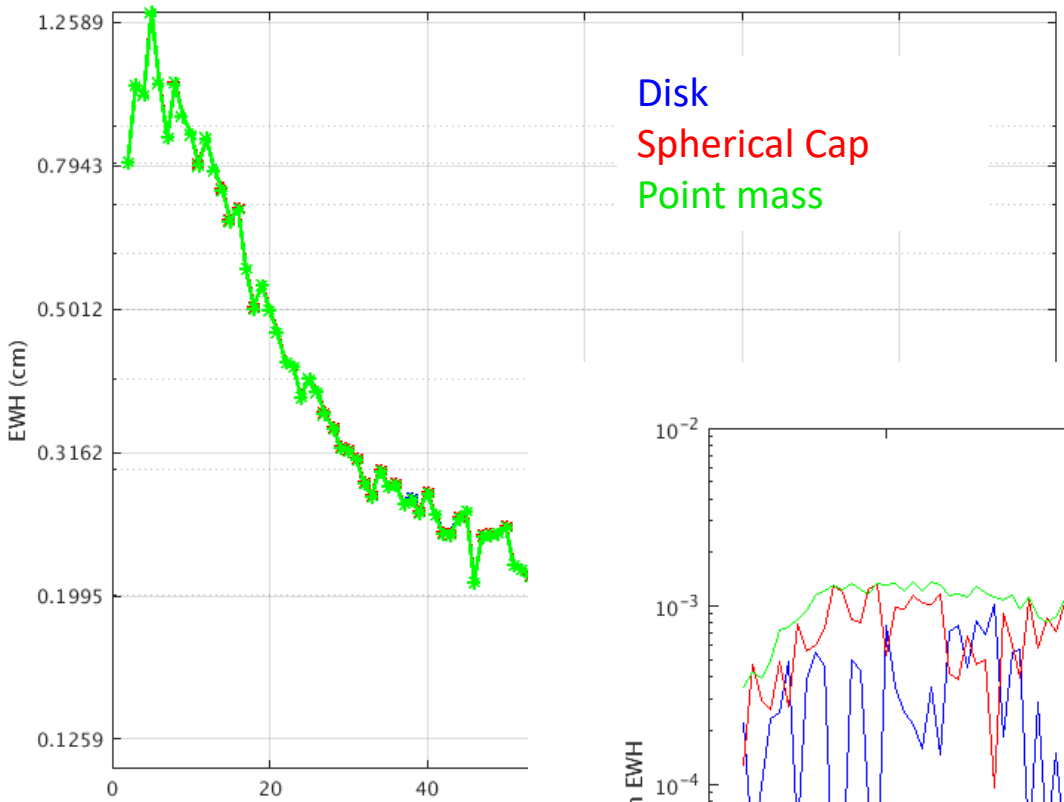
**Cap – Disk**



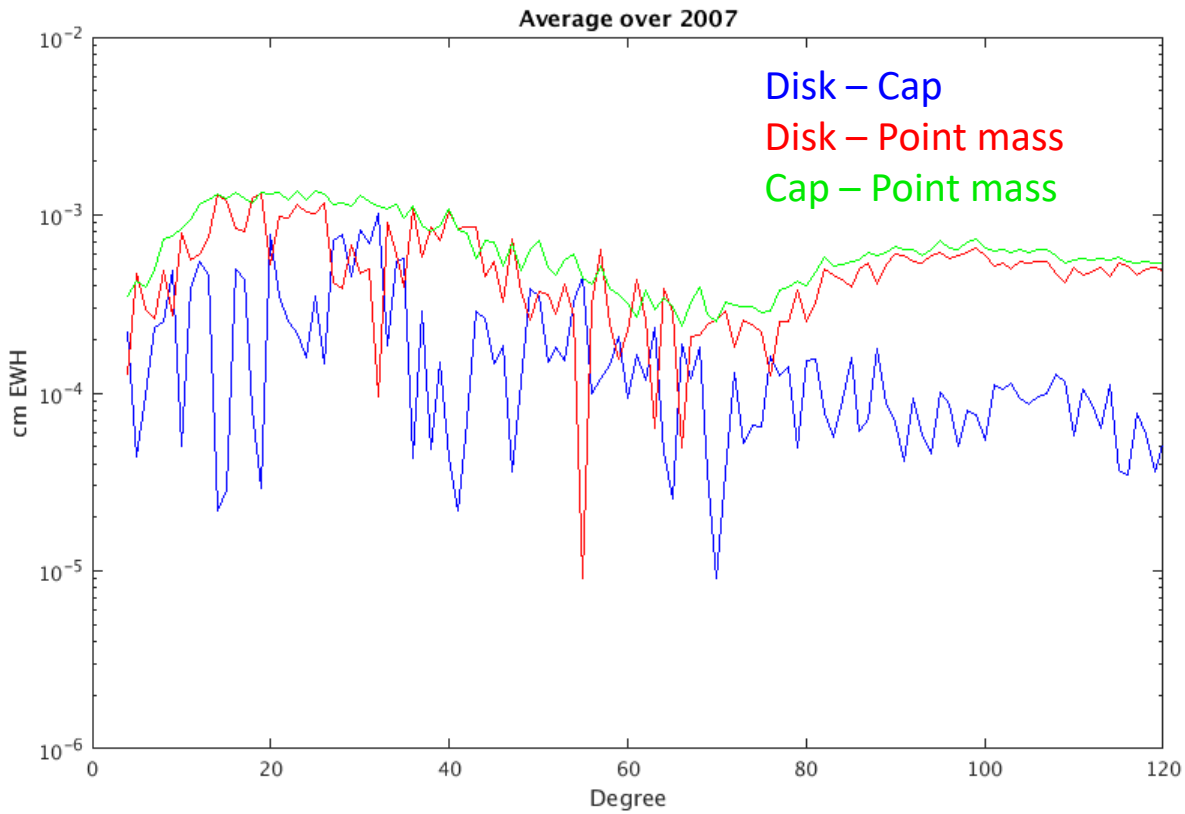

**Cap – Ptmas**



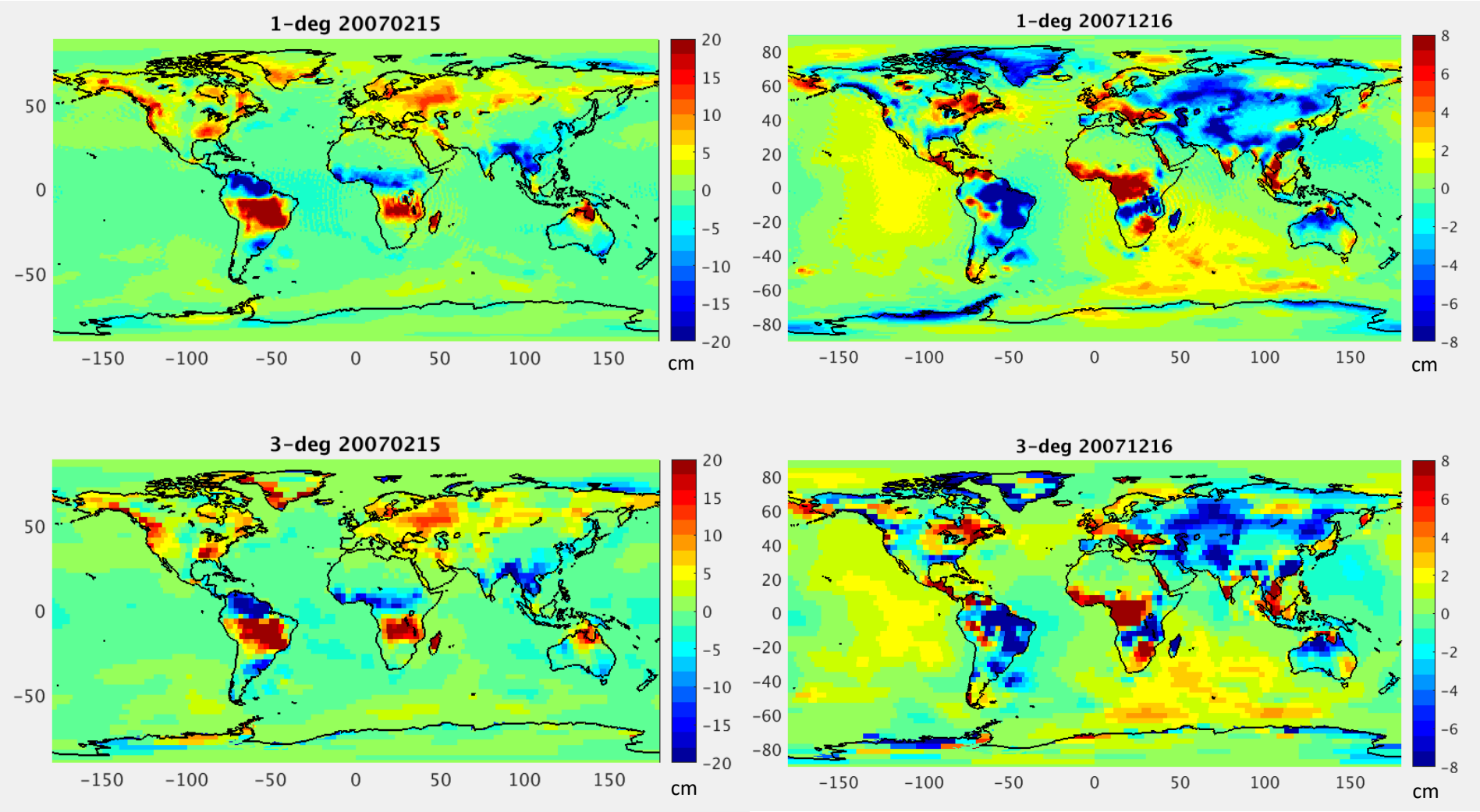
# Comparison of mascon basis functions




General agreement overall:
Best agreement for disks and caps



# Comparison 1º and 3º maps



# Conclusions

- Version 2 JPL mascons are available
- Users should consider leakage errors in addition to measurement errors when doing uncertainty analysis; particularly for small river basins
- Ready for RL06 processing
- Continue experimentation of 1° mascon solutions