University of Bremen

CENTER OF
APPLIED SPACE TECHNOLOGY
AND MICROGRAVITY

EVALUATION OF GRACE FOLLOW-ON ACCELEROMETER TRANSPLANT BASED ON HIGH-PRECISION ENVIRONMENT MODELLING

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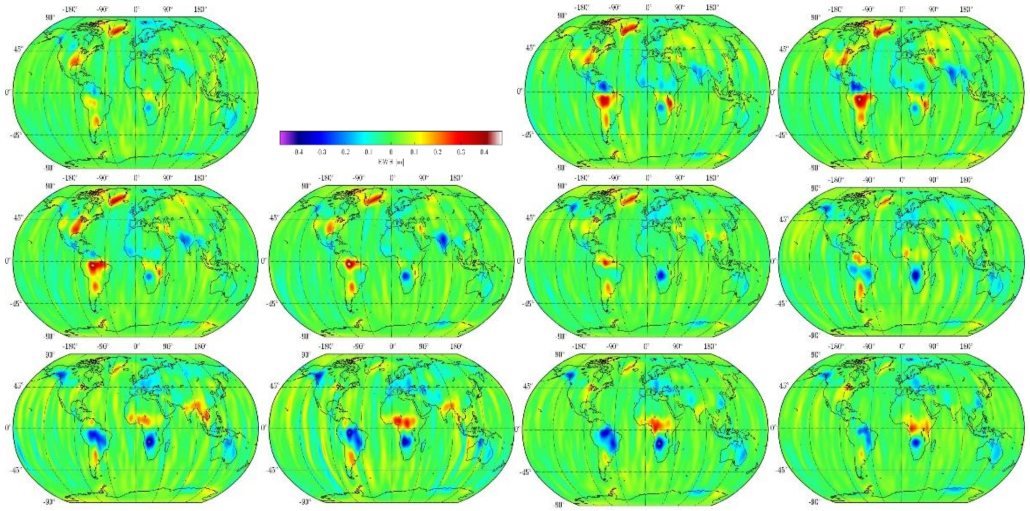
Motivation



- Accelerometer data recovery through high-precision environment modelling
- Drag model limiting factor
- Solution with ZARM data and JPL ACT are comparable
- Using simulated data for both satellites leads to better gravity field solutions

Calibration for Transplant

- Calibration of JPL ACT for GRACE-C
- External calibration parameters from POD
  - Const. scale vector **s**
  - Three hourly const. bias vector **b**
  - No fitting of modelling errors
- Additional calibration of cross-track and radial direction
  - improves limitations of POD parameters

$$ACT_{cal} = \mathbf{s} \cdot ACT1B + \mathbf{b}, \quad \mathbf{b} = \begin{pmatrix} pod \\ sim \\ sim \end{pmatrix} \vee \begin{pmatrix} pod \\ pod, sim \\ pod, sim \end{pmatrix}$$

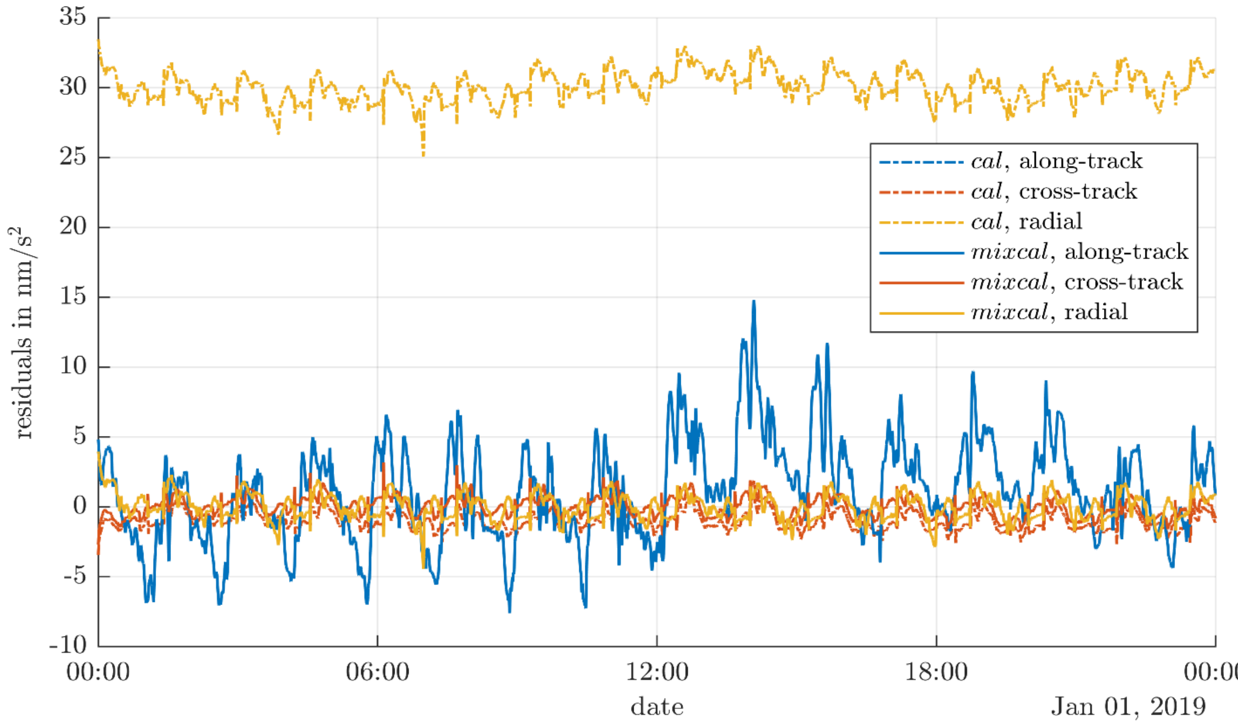


Figure 1: Residuals of ACT to simulated data after POD calibration and additional simulation calibration for January 01 2019

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Transplant

- Transplant procedure to decrease differences between simulated and real data

- Minimalistic approach

- Estimation of density at positions of GRACE-C and time-correction to GRACE-D positions

$$\rho = \frac{ACT_{cal} - \Sigma \vec{a}_{rad}}{k_d}, \qquad k_d = -\frac{A_{proj} C_D \|\vec{v}_{inc}\|^2}{2\, m_{sat}}$$

- Only effect on along-track axis, measurement direction

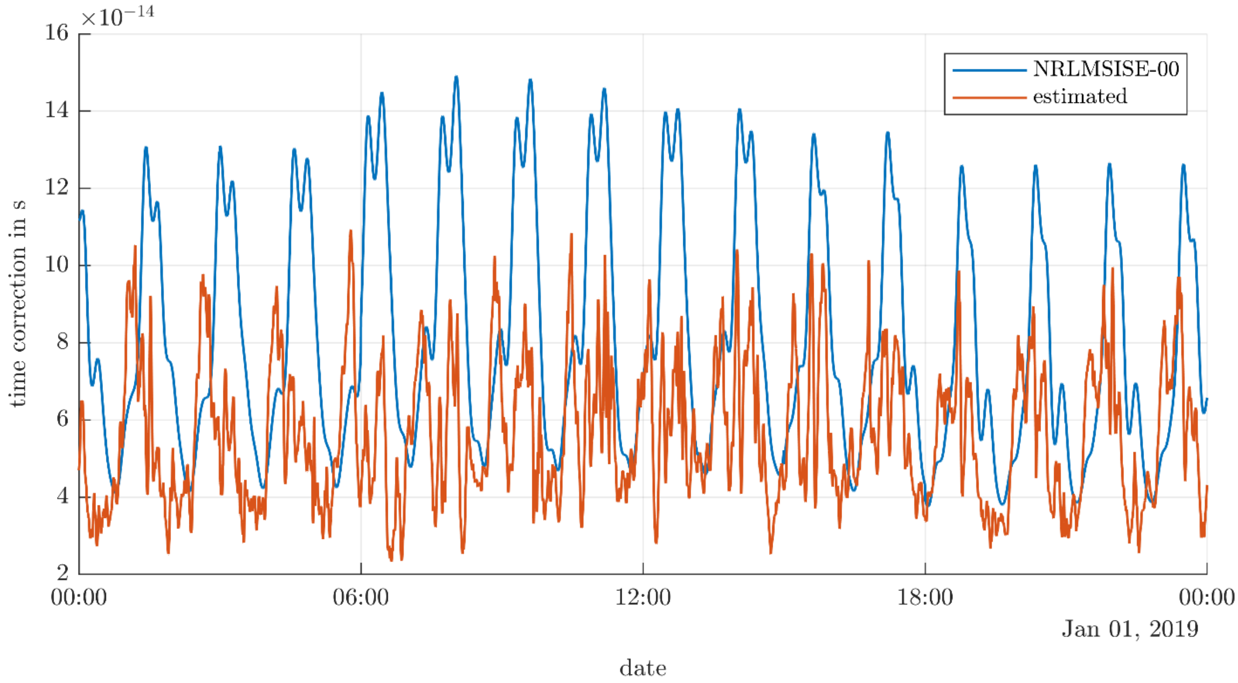

Figure 2: Modelled and estimated density values for January 01 2019

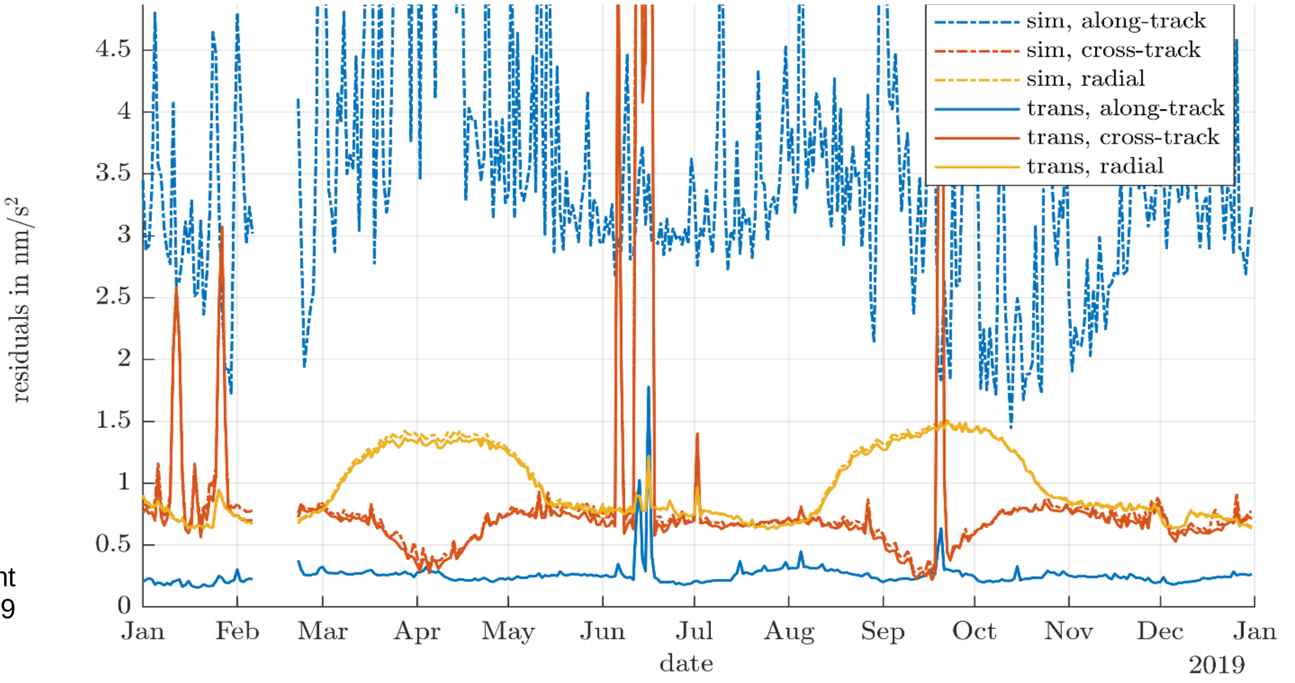

Figure 3: Residuals of ZARM simulation and transplant data to ACH for GRACE-D for 2019

Performance in GFR

- Multiple combinations
  - Calibration
  - Input models
  - Estimation parameter
- Ocean rms
  - Omits signal over continents and tidal signals near coasts
  - Only errors over ocean

Table 1: Ocean rms of equivalent water height with respect to mean 2019 GOCO201906s
Unit is cm

estimation	input	*calcal*	mixcal
ρ	*NRLM, var.* C_D	5,18	5,24
	JB08, const. C_D	4.57	4.22
$C_D\rho$	*JB08, const.* C_D		
	NRLM, var. C_D	4.44	4.58

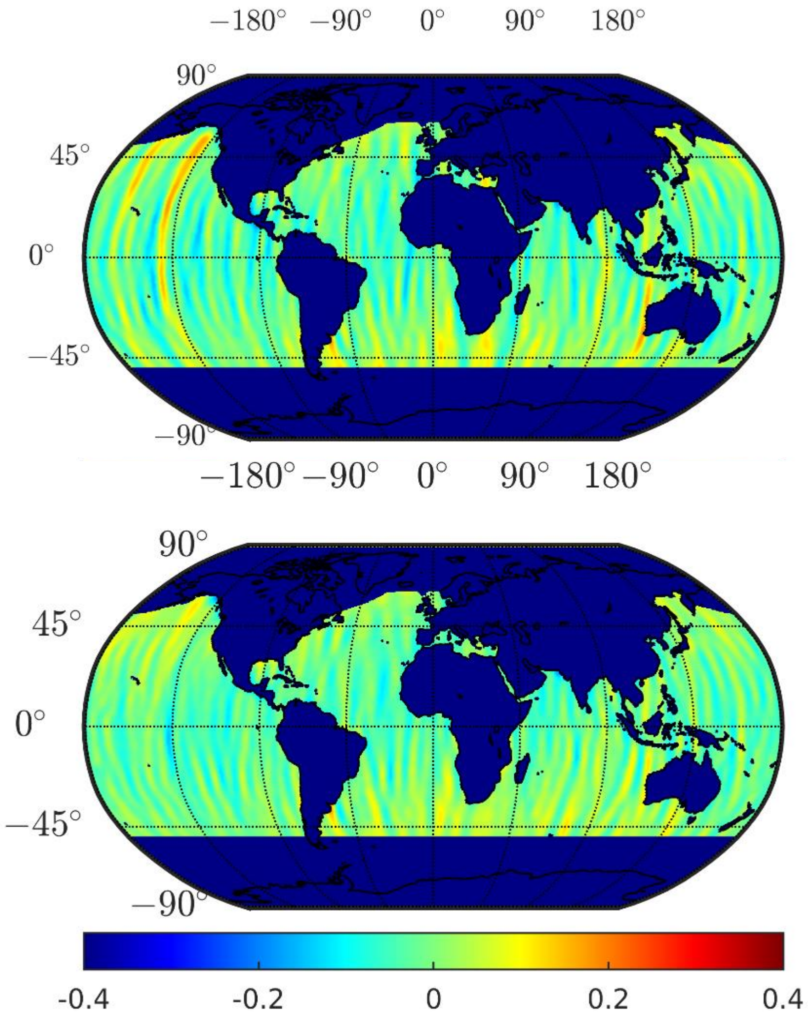

Figure 4: Equivalent water height of ZARM 2019 mean solutions to GOCO06s
Top: worst, bottom: best

Validation of Transplant

- Comparison to ITSG
- Only systematic errors
  - J2
  - Higher degrees
- Validation of our transplant procedure

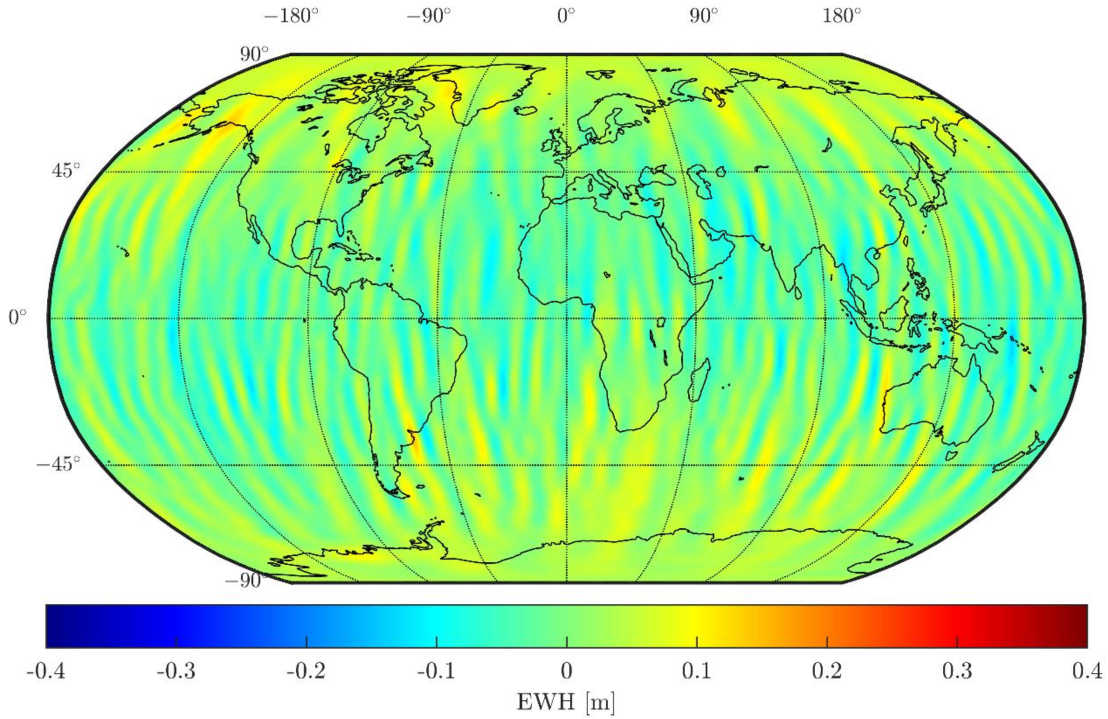

Figure 5: 2019 mean degree difference of transplant to mean 2019 ITSG-operational

Comparison to other Transplants

- Solutions with in-house GFR tool
  - ZARM Transplant
  - JPL Transplant (ACH)
  - TUG Transplant
- Official solution
  - ITSG

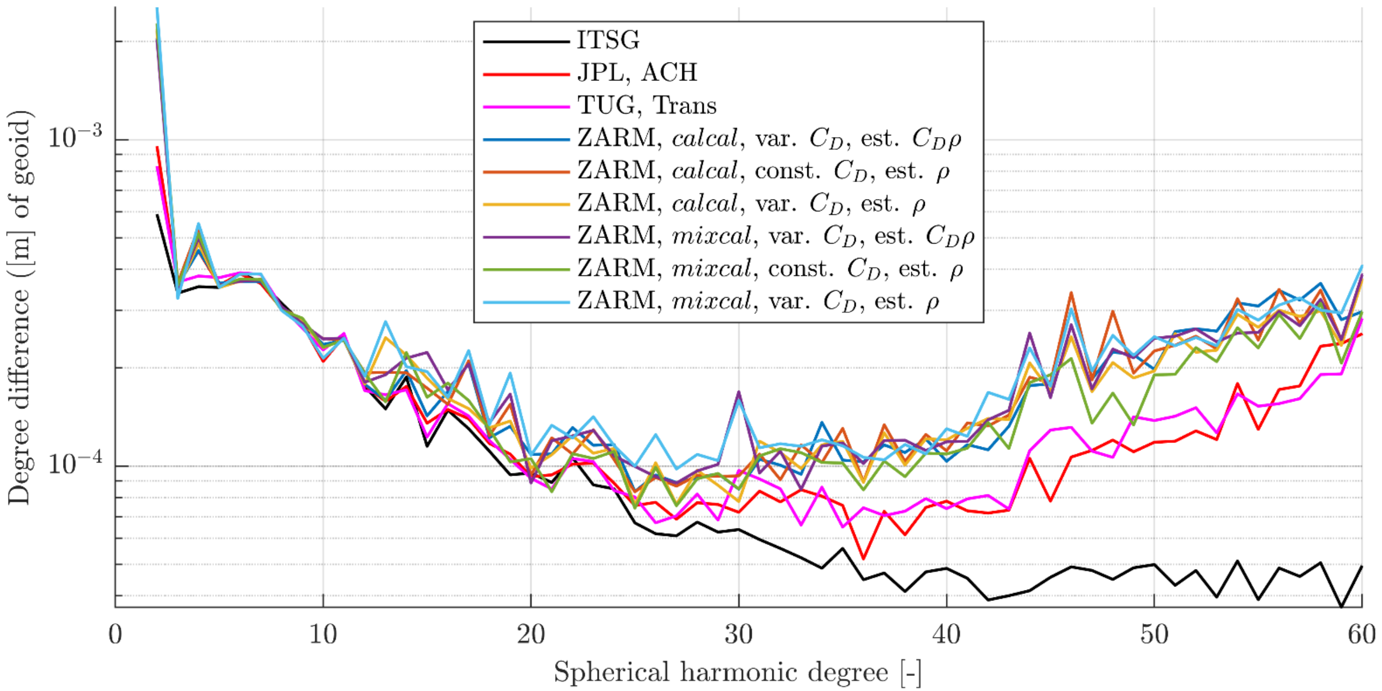

Figure 6: 2019 mean degree difference of transplants to mean 2019 GOCO201906s

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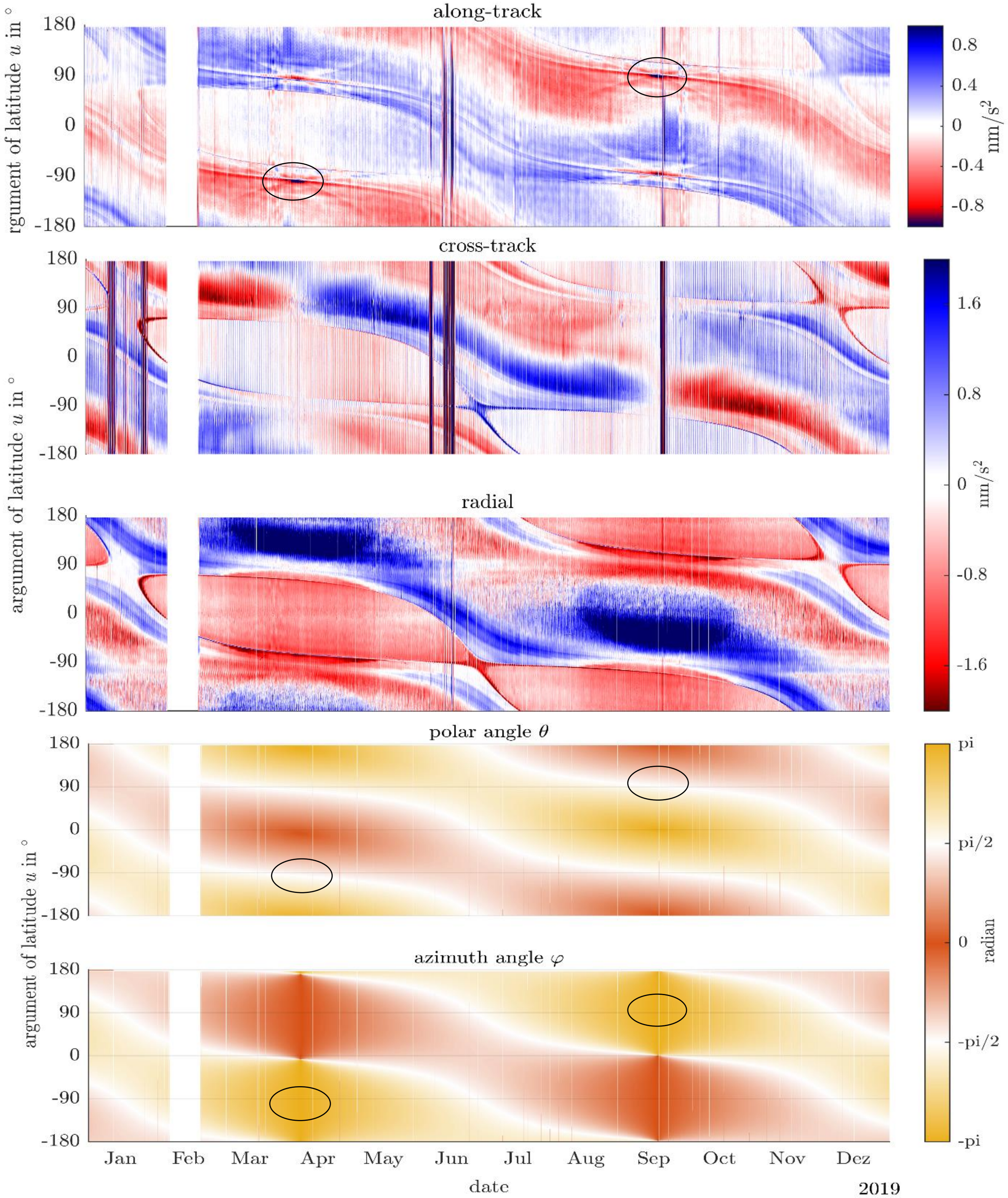
Figure 7
Top three: residuals of ZARM Transplant to ACH for 2019
Bottom two: polar and azimuth angle of Sun direction in satellite body frame for 2019



Outlook

- after transplant systematic errors dominating
  - Radiation based
  - Eclipse transition
  - Incident direction of radiation

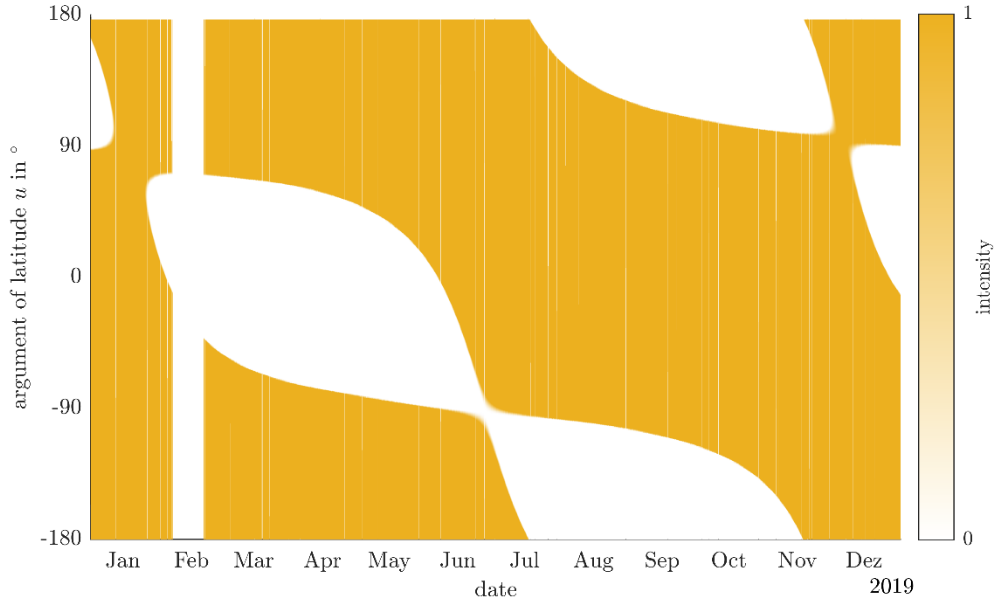


Figure 8: Eclipse conditions for 2019 in terms of the normalized Sun intensity

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ZARM

Thank you!

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References

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