Update on POD-related tasks at DGFI-TUM

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Recent developments

Next steps mentioned at IDS workshop 2024 in Montpellier:

- Finishing the implementation of VMF3
  - ➢ Still pending
- Reprocessing of orbits with new implementations
  - ➢ Some results shown on the next slides
- Correlation analysis of POD parameters
  - ➢ Still ongoing
- Refine the parameter setup of DORIS-only and SLR-DORIS combined orbits
  - ➢ Not yet started
- Comparison between Jason-2 IDS2.2- and RINEX-derived orbits
  - ➢ Still ongoing
- Continue working on Sentinel satellite platforms
  - ➢ Some results shown on the next slides
- Additional: Alternative values than 0.4 mm/s for the system error
  - ➢ No significant differences

Recent developments

Complete reprocessing of missions TOPEX/Poseidon and Jason-1/-2/-3 with most recent DOGS-OC version including:

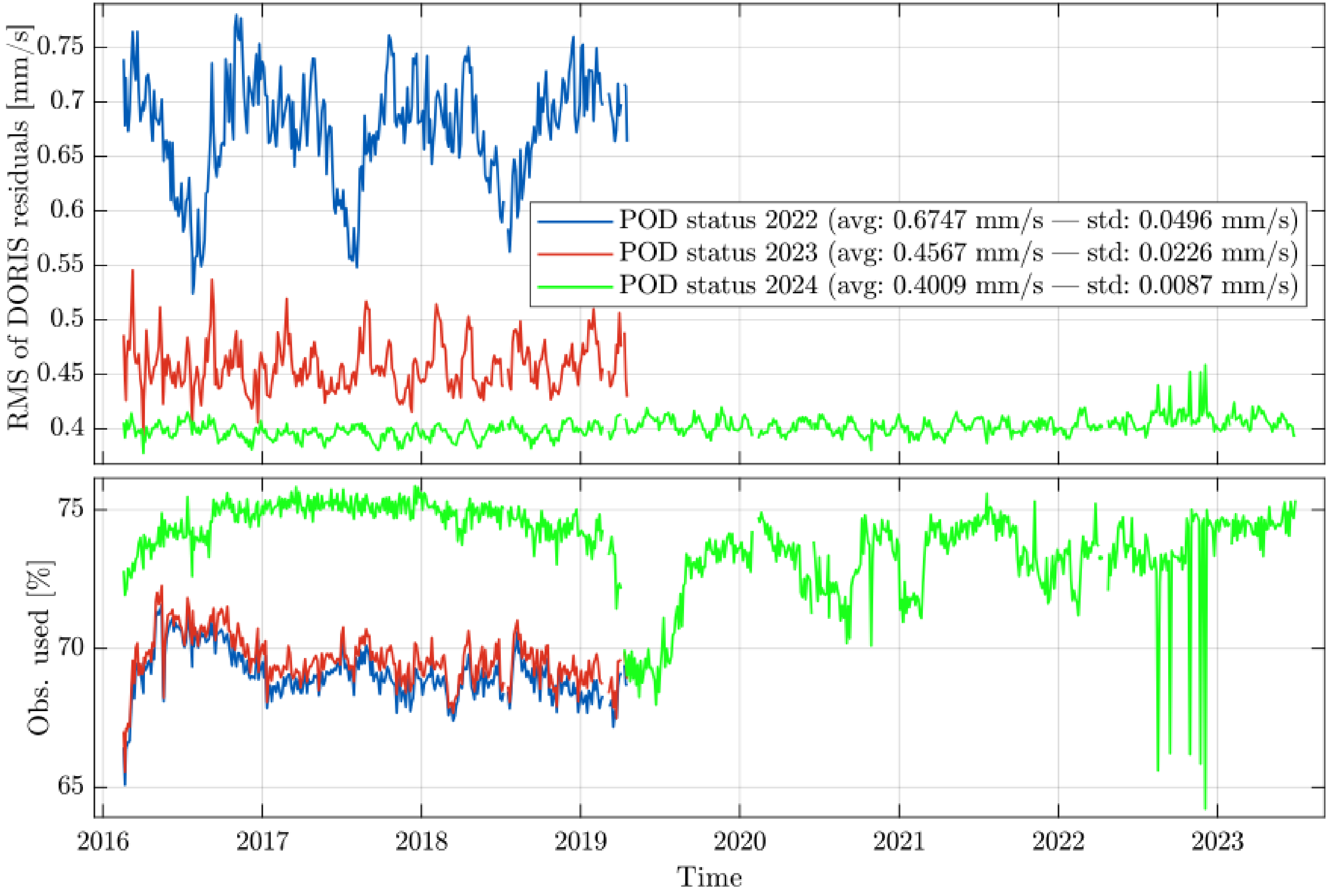
- Refined processing of RINEX observations
- Consideration of beacons with shifted frequency
- Consideration of ionosphere-free phase centre (at beacon and on-board)
- Application of the DORIS phase wind-up effect
- Weighting of DORIS observations (suggestion by CNES)

Reprocessing of Jason-3 orbit

Results of POD status 2022 and 2023 are with constrained orbit parameters, POD status 2024 is based on loosely constrained a priori information (reduced-dynamic orbit).

- Current minimum average RMS: 0.40 mm/s

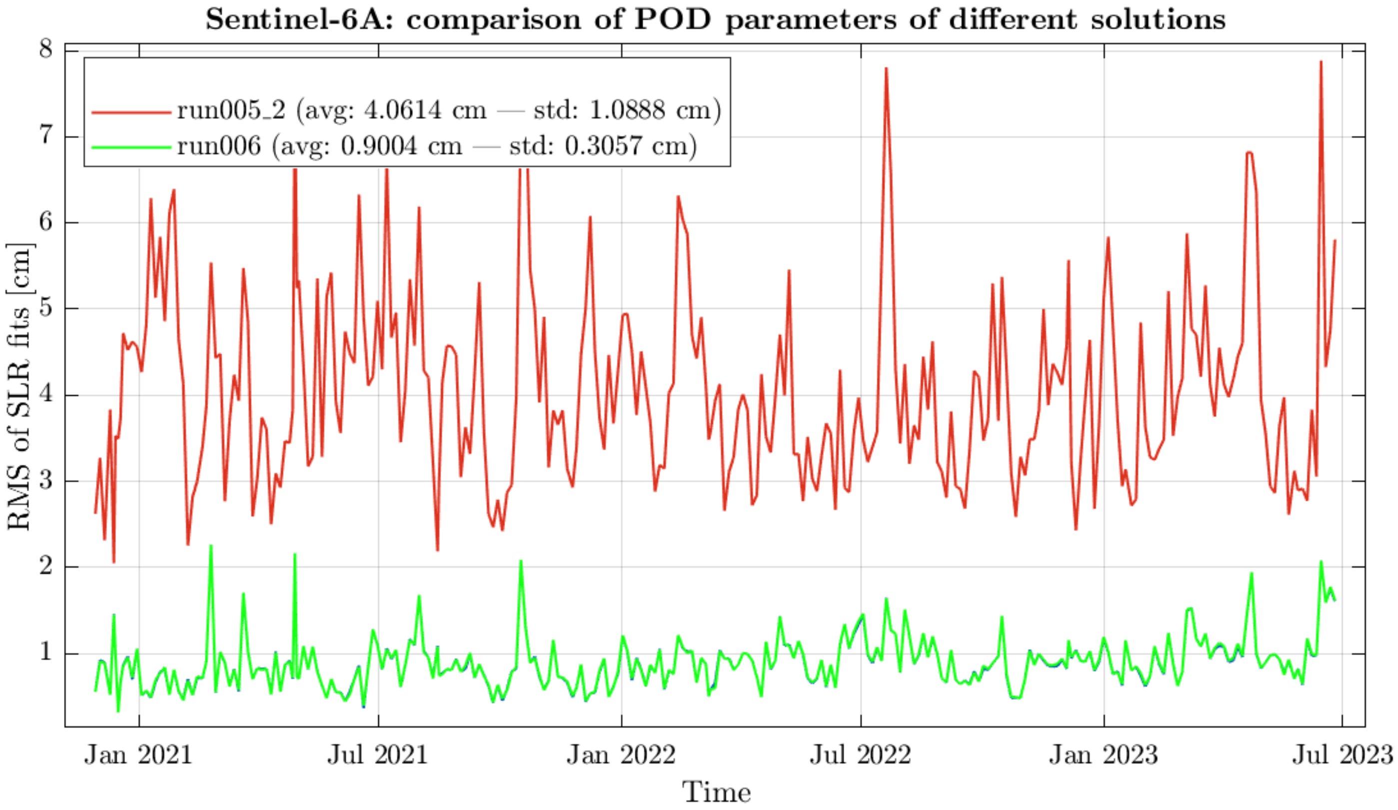
- Gain of additional observations (bottom plot) mainly due to including observations of frequency shifted beacons (e.g., Wettzell WEUC).



Implementation status of Sentinel-6A

RMS values of SLR observation residuals:

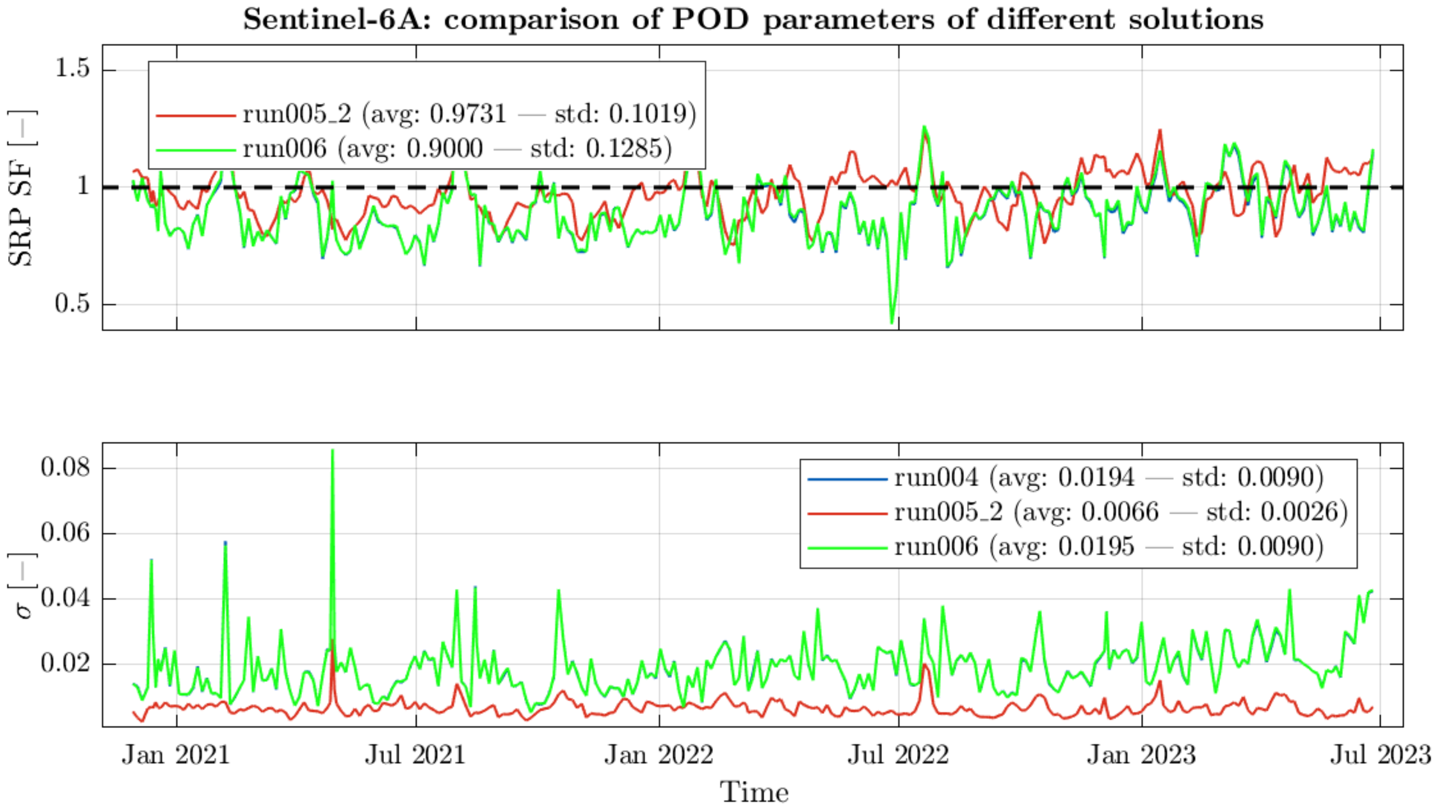
- Red time series (also in the next slides): constrained parameter setup
- Green time series (also in the next slides): loosely constrained parameter and estimation of SLR range biases



Implementation status of Sentinel-6A

Solar radiation pressure scale factor:

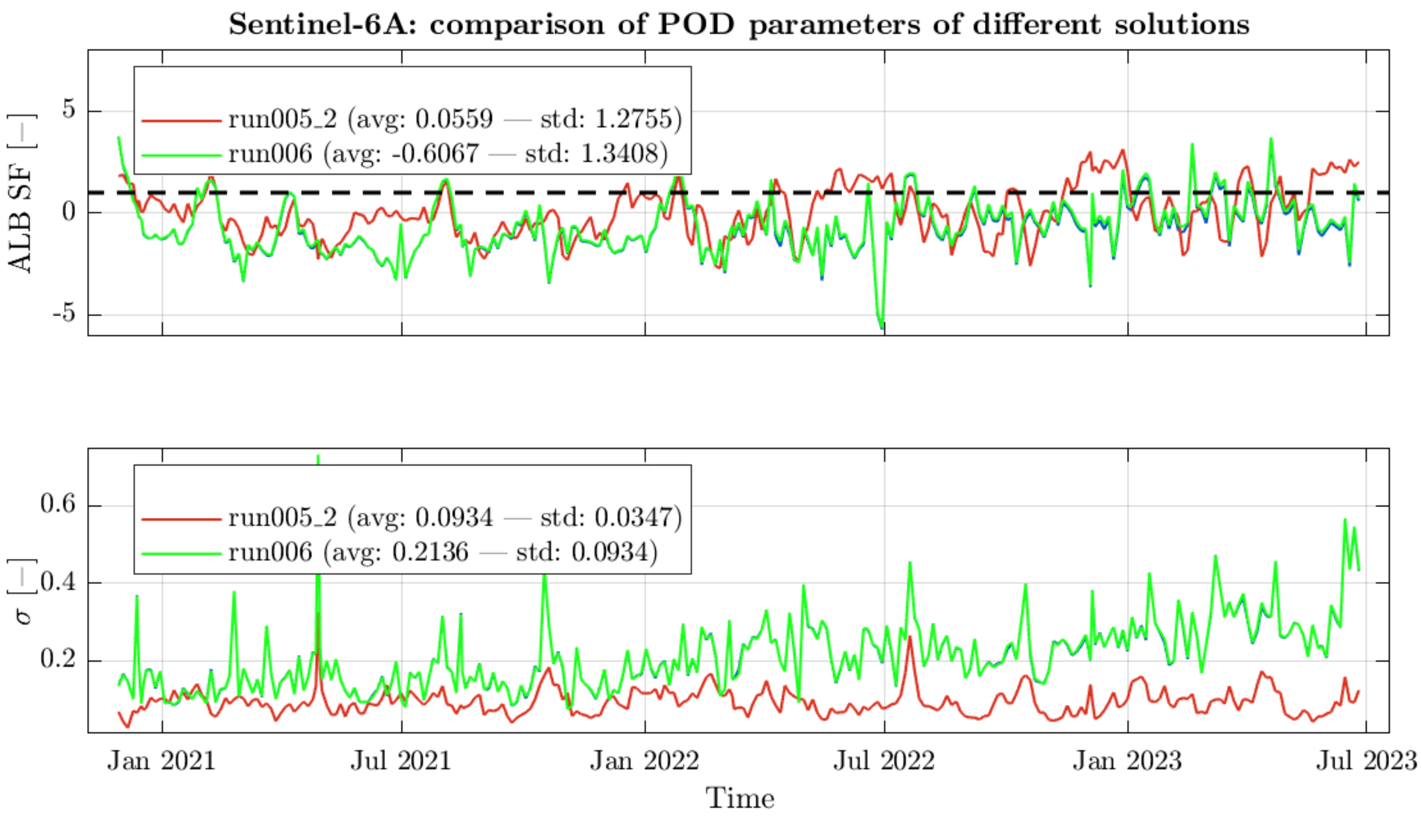
- Larger scattering of estimated parameters in both solutions compared to Jason's
- Less reliably estimated parameters in case of loose parameter setup



Implementation status of Sentinel-6A

Earth albedo and infrared radiation pressure scale factor:

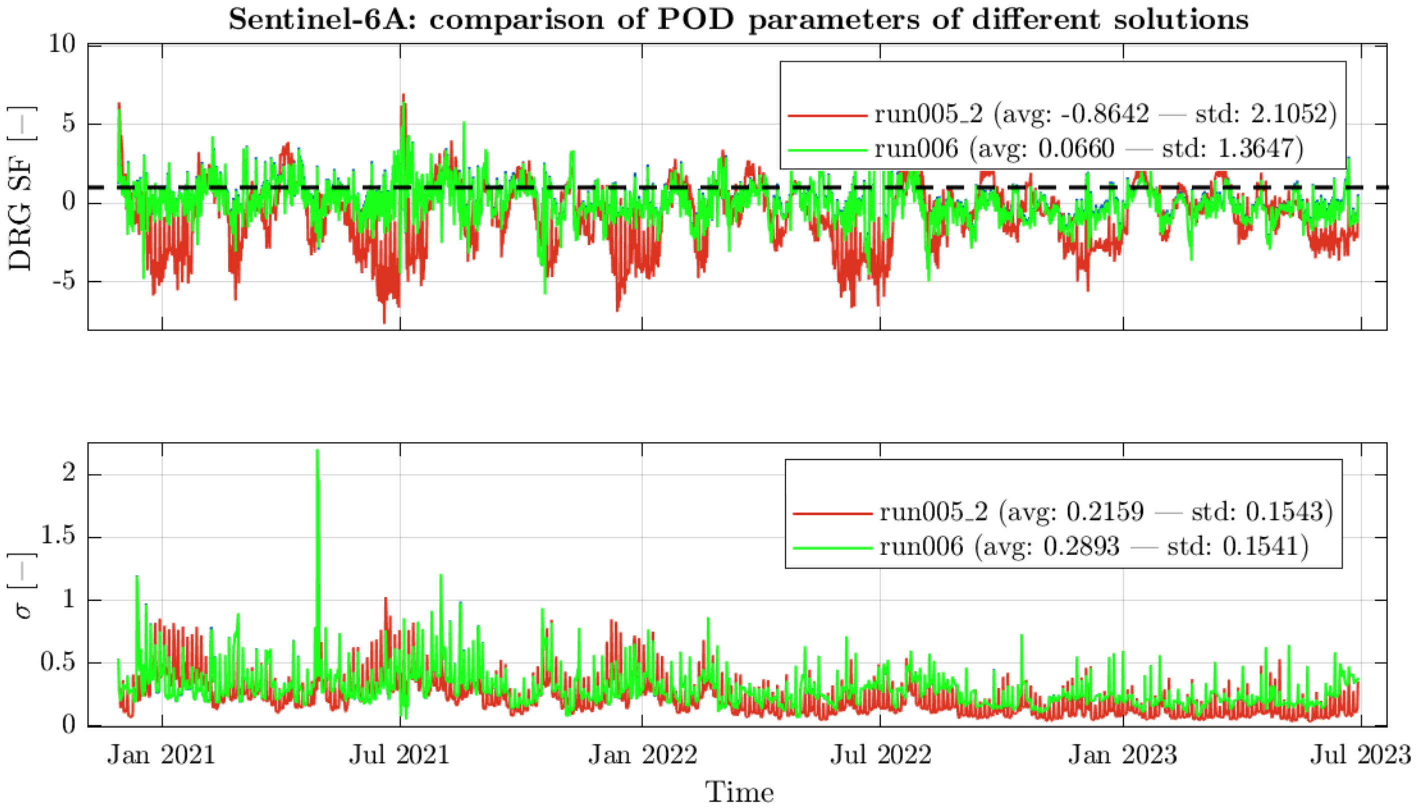
- Some problems assumed in radial component since this parameter is highly correlated with errors in the range direction



Implementation status of Sentinel-6A

Atmospheric drag scale factor:

- Large values and scattering of both factors and standard deviations
- Despite simple attitude (actually only flying forward) some errors assumed in the box-wing model since Sentinel-6A has more complex shape than the Jason's => currently debugging of aerodynamic force modelling of non-spherical satellites



Aerodynamic force modelling

Aerodynamic acceleration (drag and lift+side):

$$\boldsymbol{a}_{\text{aero}} = \boldsymbol{a}_{\text{D}} + \boldsymbol{a}_{\text{LS}} = -\frac{1}{2}\frac{\rho v_{\text{rel}}^2}{m}\sum_i A_i \cos\theta_i \, C_{\text{D},i} \hat{\boldsymbol{u}}_{\text{D}} + \boldsymbol{a}_{\text{LS}}$$

Drag coefficient according to Doornbos (2012):

$$C_{\text{D},i,j} = \left[\frac{P_{i,j}}{\sqrt{\pi}} + \gamma_i Q_j Z_{i,j} + \frac{\gamma_i}{2}\frac{v_{\text{re}}}{v_{\text{inc}}}\left(\gamma_i \sqrt{\pi} Z_{i,j} + P_{i,j}\right)\right]\frac{A_i}{A_{\text{ref}}}$$

$$\frac{v_{\text{re}}}{v_{\text{inc}}} = \sqrt{\frac{1}{2}\left[1 + \alpha\left(\frac{4RT_{\text{w}}}{v_{\text{inc}}^2} - 1\right)\right]}$$

$$\alpha = k_s \frac{m_i m_j}{\left(m_i + m_j\right)^2}$$

i	Satellite surface	m	Relative atomic mass
j	Atmospheric constituent	α	Energy accommodation coefficient
k_s	Scale factor (3.6 according to Mehta et al., 2013)		

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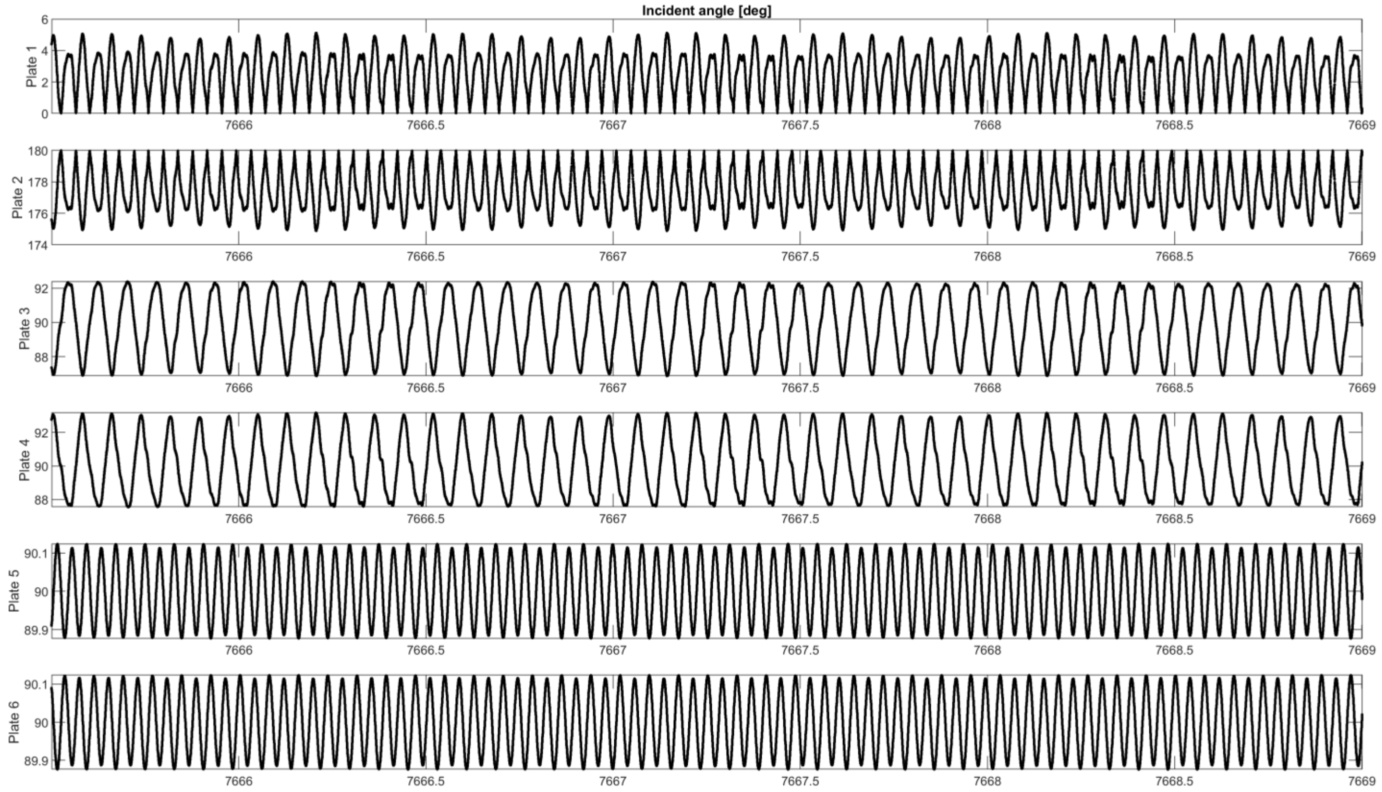
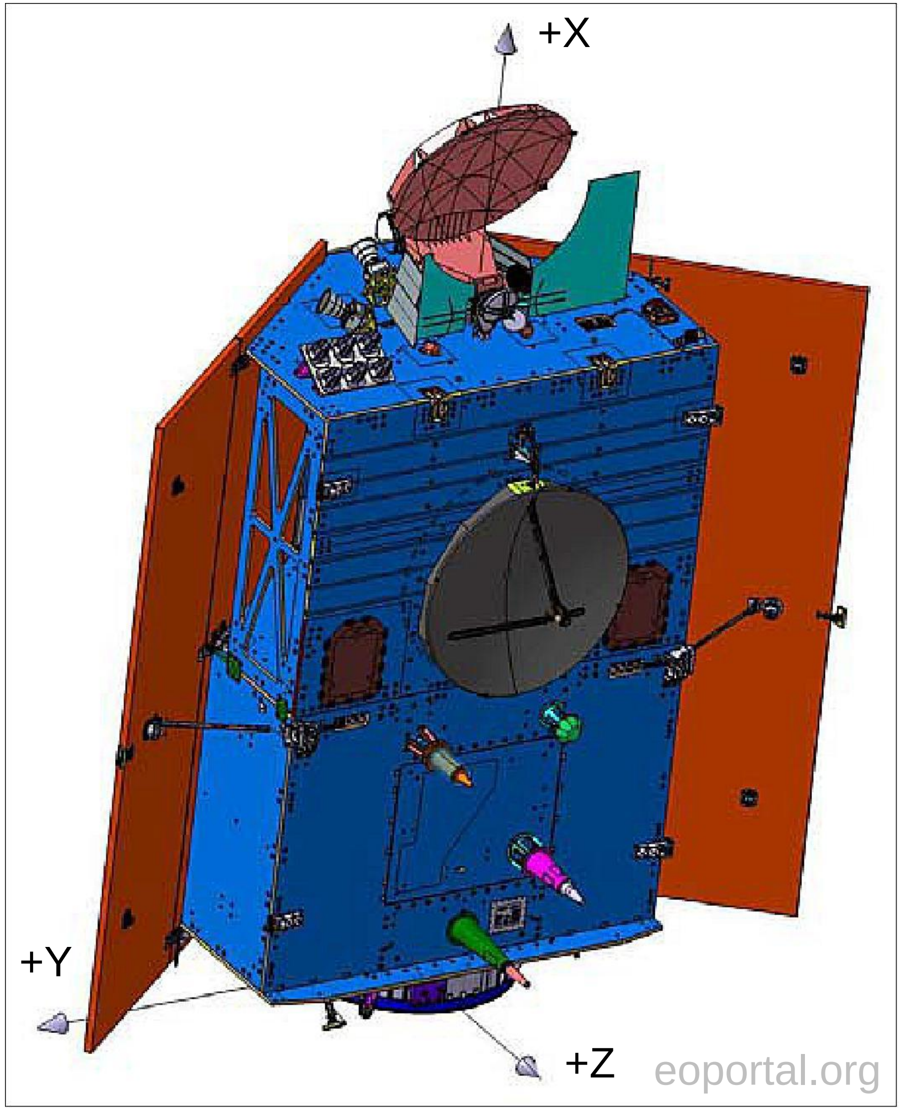
Is there a source for relative atomic mass of satellite surfaces at IDS? What values do other centres use?

i	Satellite surface	m	Relative atomic mass
j	Atmospheric constituent	α	Energy accommodation coefficient
k_s	Scale factor (3.6 according to Mehta et al., 2013)		

Aerodynamic force modelling

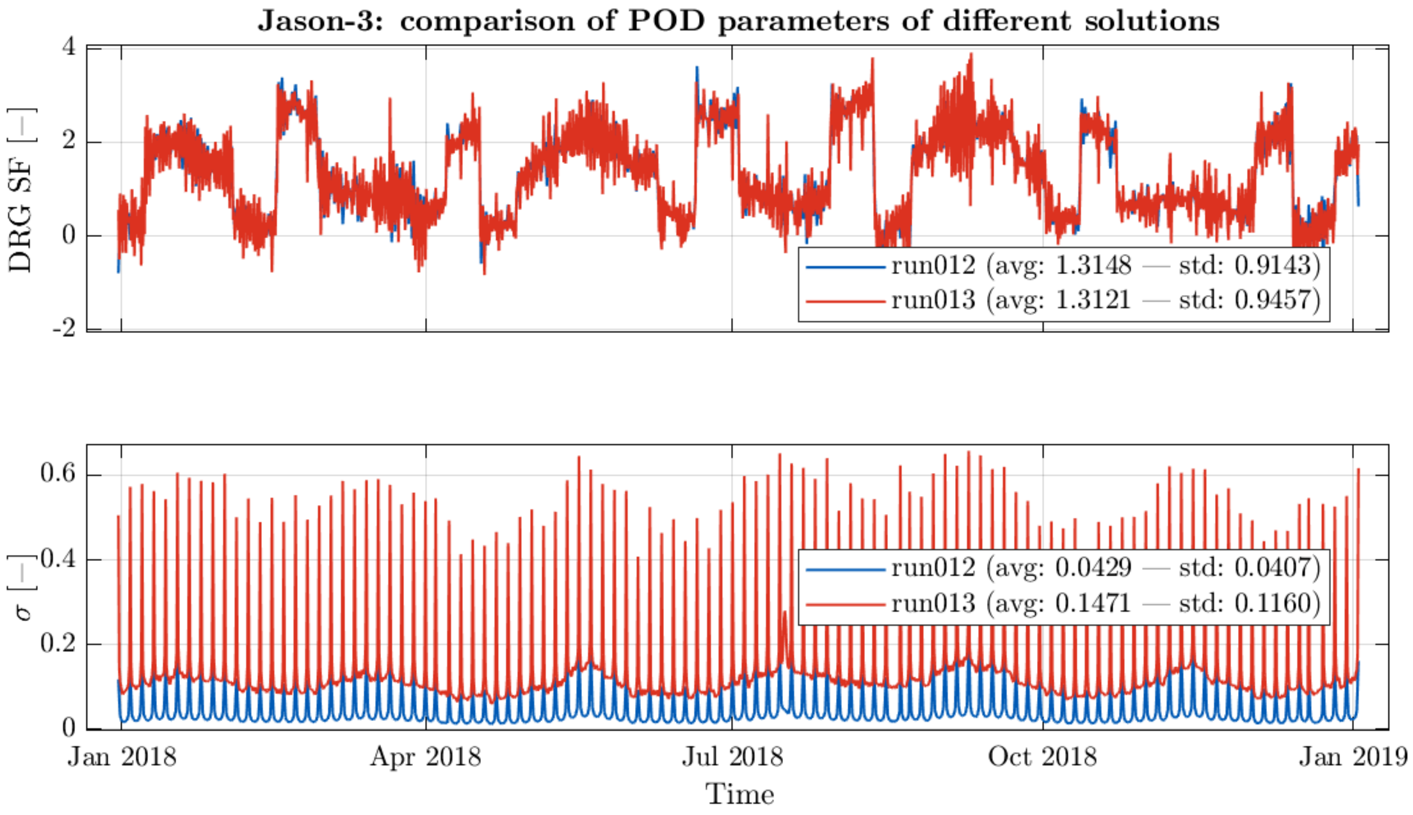
- Cross-sectional areas affected by drag for Sentinel-6A flying forward:
- IDS macro-model (panels 1-6: +X, -X, +Y, -Y, +Z, -Z)





Aerodynamic force modelling

- Clear attitude-dependent estimated parameters (but mainly in the atmospheric drag parameters)
- Red time series: temporal resolution 6h, blue time series: 12h



Conclusions and outlook

- Further improvement in modelling of non-spherical satellite POD
- Atmospheric drag scale factors have clear attitude dependence

Next steps:

- Finishing the implementation of VMF3
- Correlation analysis of POD parameters
- Refine the parameter setup of DORIS-only and SLR-DORIS combined orbits
- Comparison between Jason-2 IDS2.2- and RINEX-derived orbits
- Continue working on Sentinel satellite platforms
- Comparison of orbit parameters (drag, solar and Earth radiation pressure, empirical accelerations) among ACs?

Thank you very much for your attention!

References

- Doornbos E. (2012) Thermospheric Density and Wind Determination from Satellite Dynamics. https://doi.org/10.1007/978-3-642-25129-0. Springer Theses, Springer Berlin, Heidelberg
- Mehta PM, McLaughlin CA, Sutton EK (2013) Drag coefficient modelling for grace using Direct Simulation Monte Carlo. https://doi.org/10.1016/j.asr.2013.08.033. Advances in Space Research, 52(12), 2035–2051.