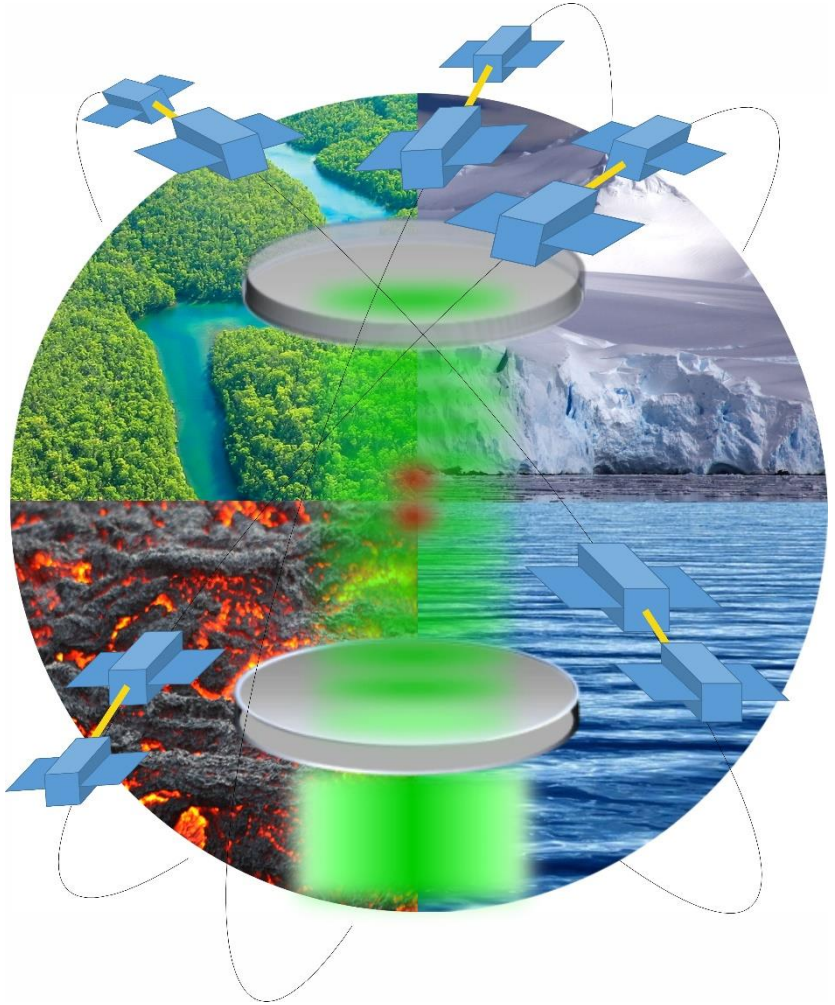
ESA RFP/3-17687/22/NL/SD

Future satellite gravity field missions

Impact of quantum sensors and extended satellite constellations



EGU General Assembly 2023

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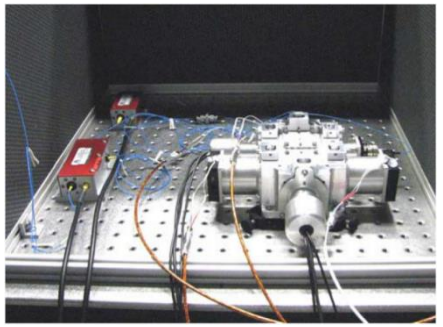
1.1 Future mission concepts: *potential for improvements*

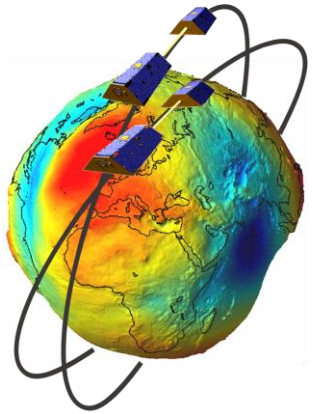
1. New/improved measurement technologies

- Improved inter-satellite ranging: KBR vs. LRI
- Improved technologies of accelerometry/gradiometry
- High-precision optical clocks
- Improved thruster technologies; AOCS



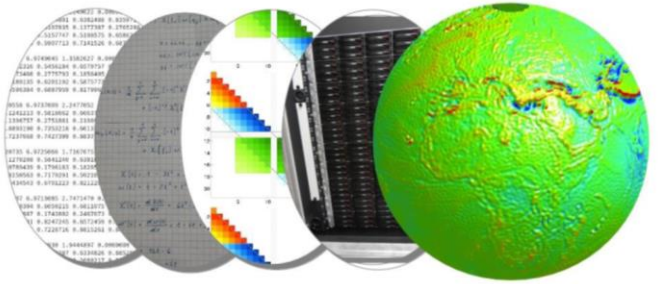
2. Satellite formations

- Improved spatial and temporal resolution due to formation flights in extended constellations
- Reduction of temporal aliasing effects (“self de-aliasing”)



3. Processing & combination with complementary geophysical models

- De-aliasing by means of improved spatial-temporal parameterization
- Improved separation of signals due to complementary information
- Integrate models of the complex system Earth



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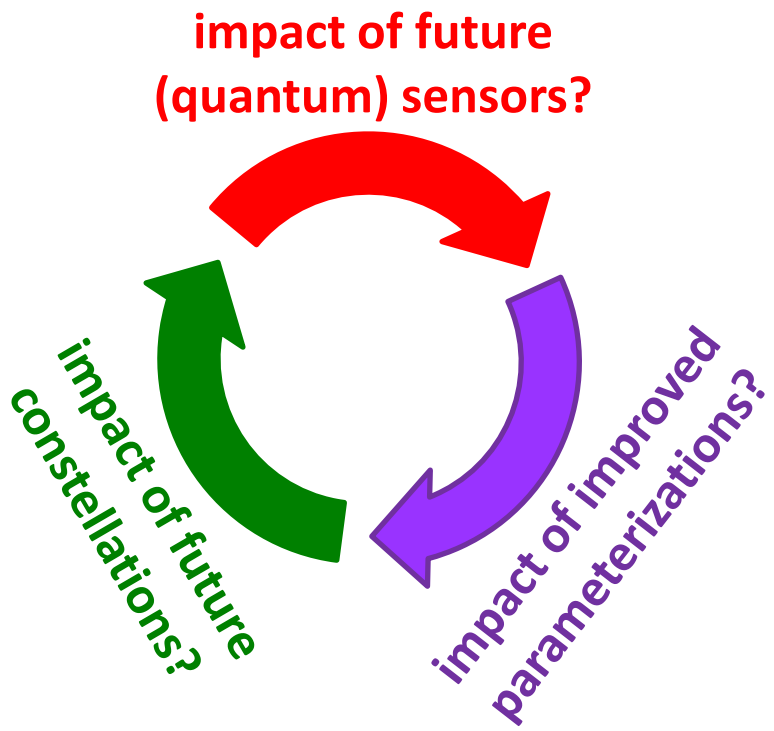
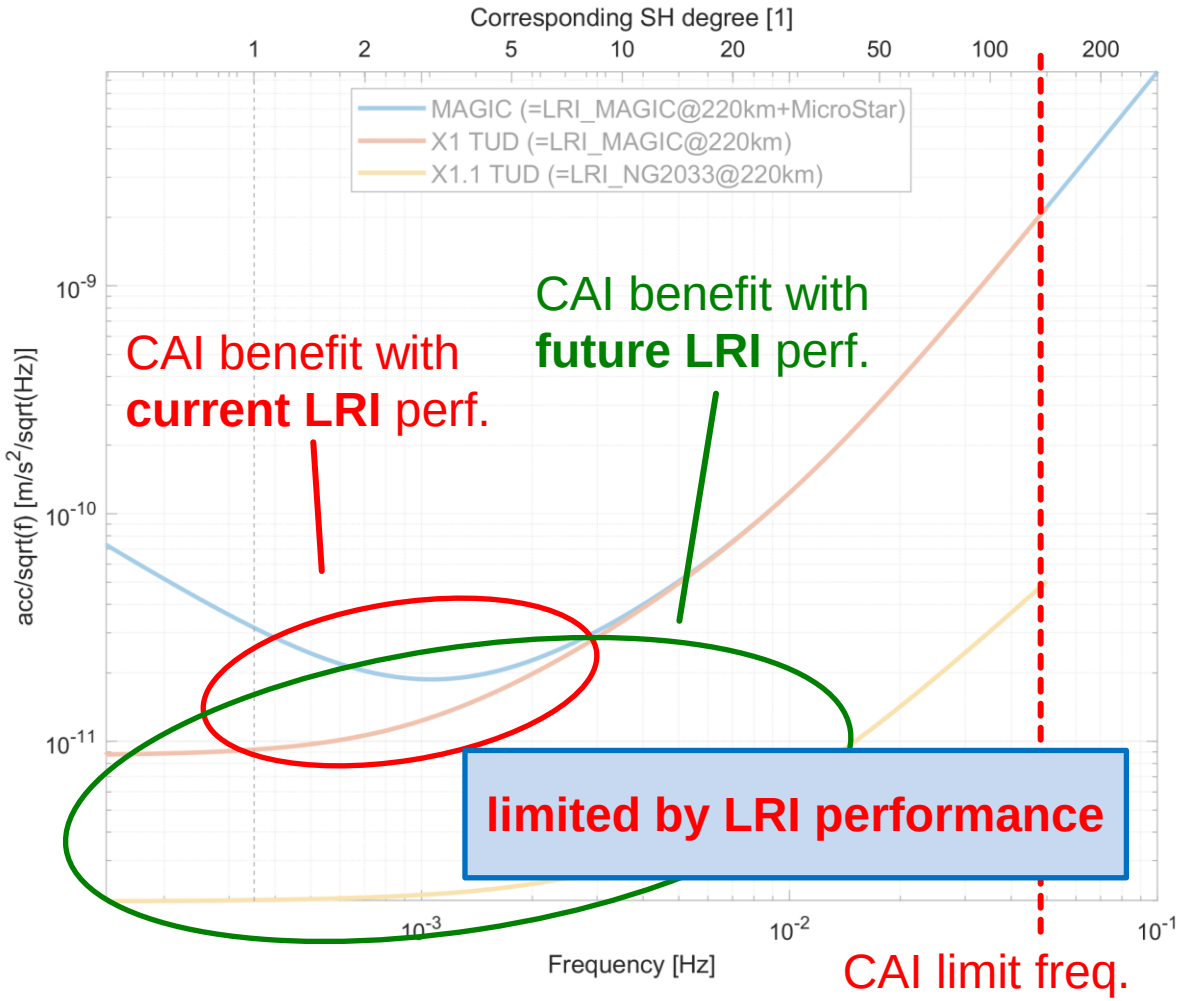


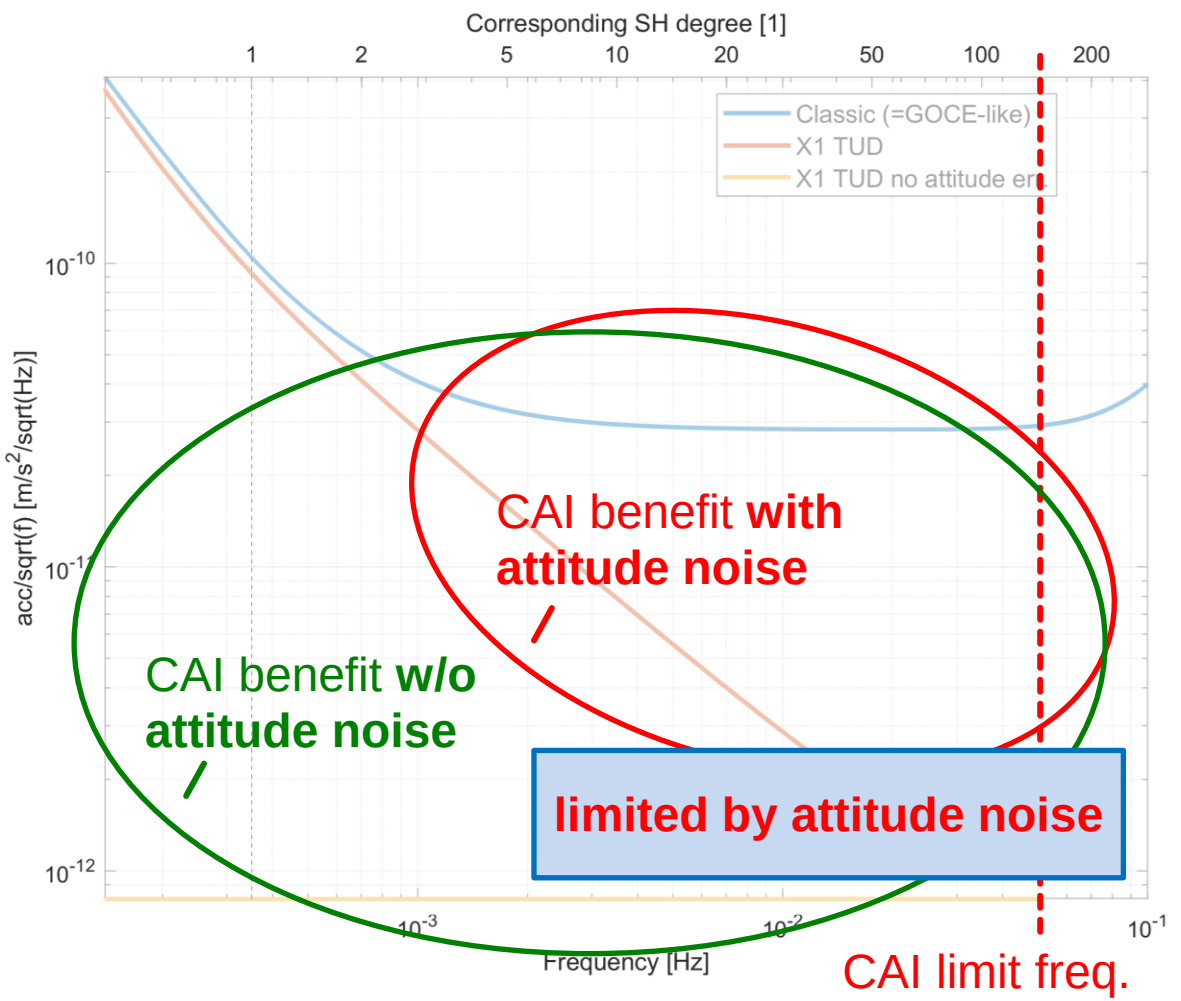
2.1 Impact of future sensors: *instrument ASDs*

ASDs of CAI instruments (product noise):

For **LL-SST (GRACE-like)** missions:



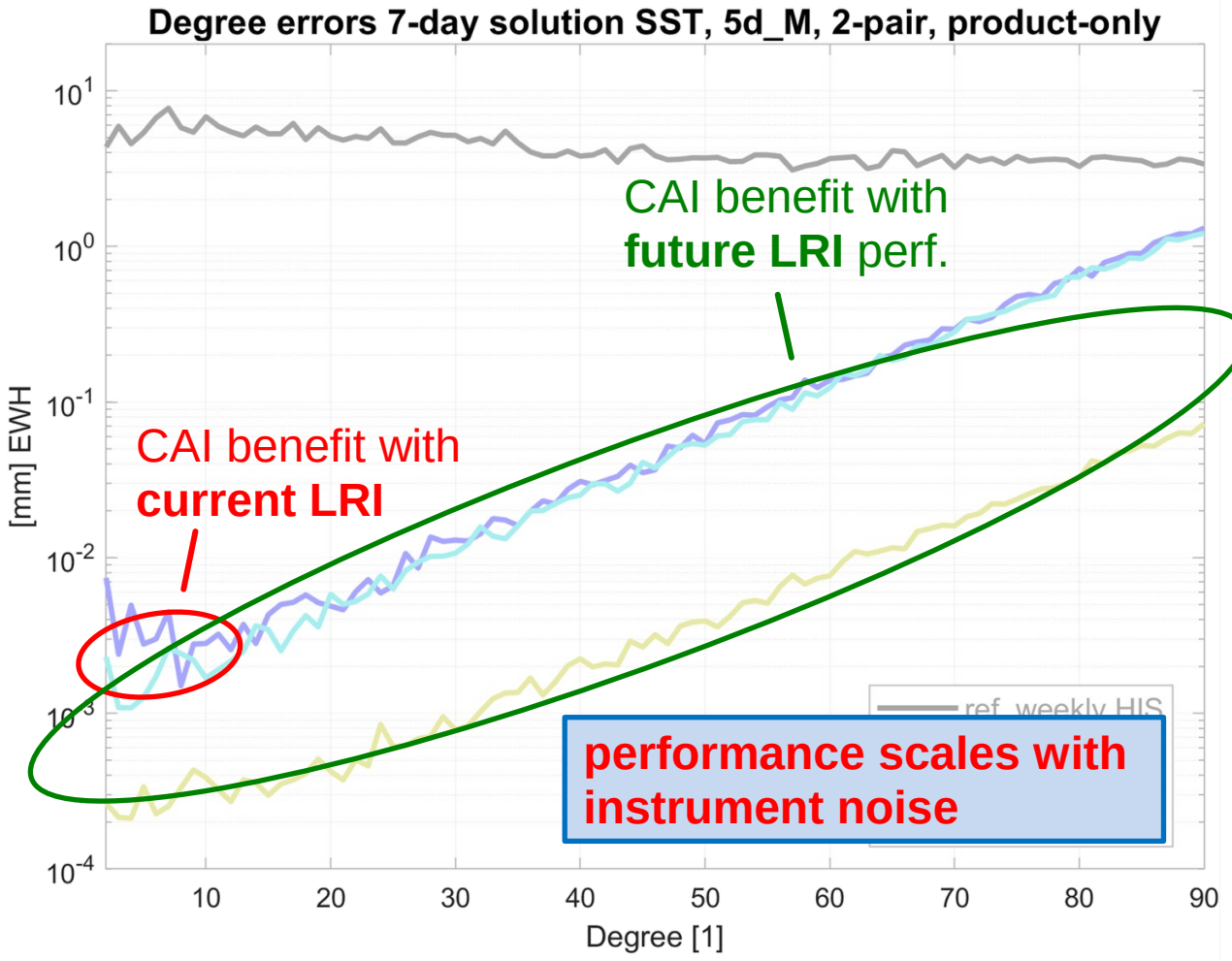
For **SGG (GOCE-like)** missions:



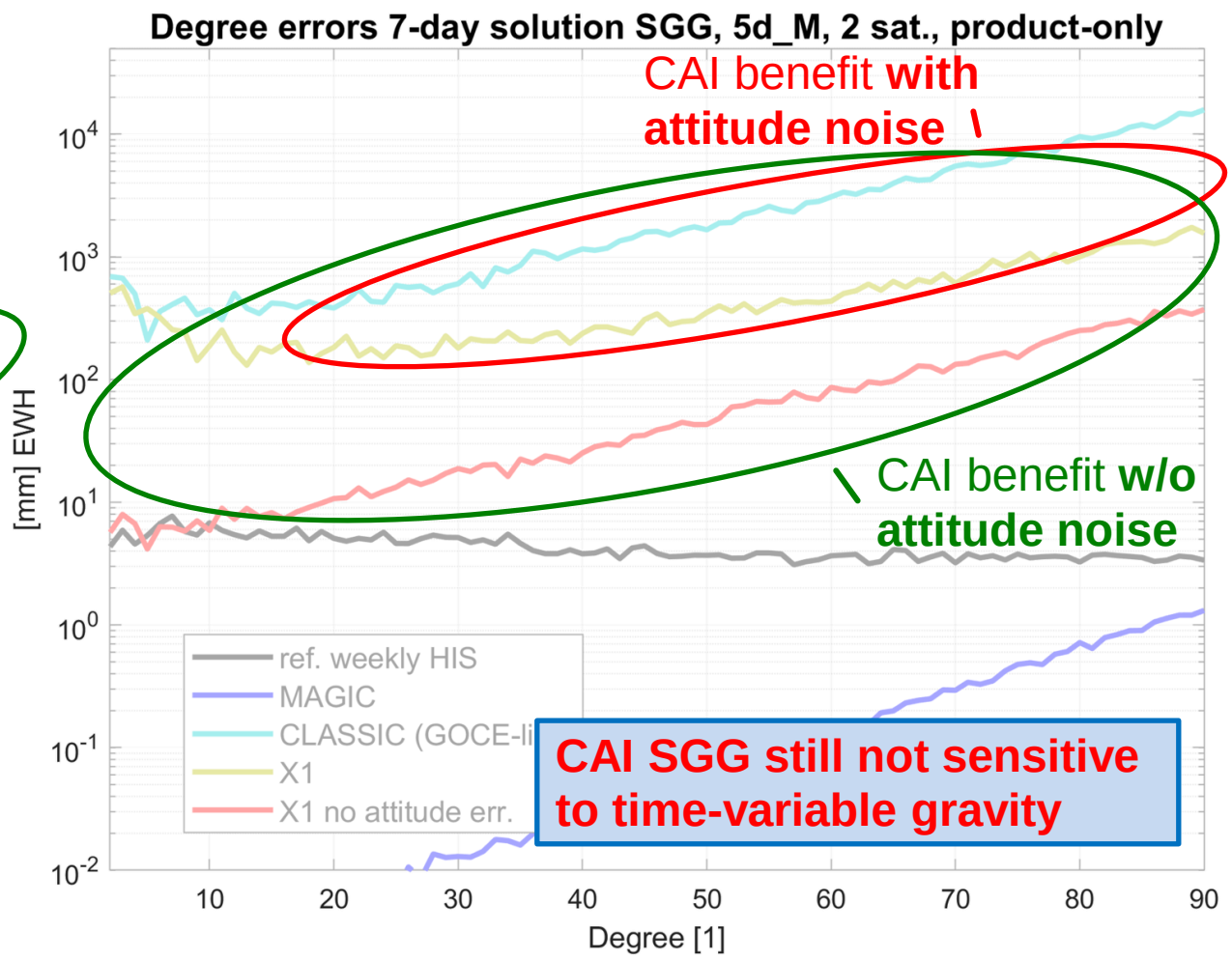
2.2 Impact of future sensors: *static gravity field retrieval performance*

Retrieval performance of CAI instruments (static gravity only):

For **LL-SST (GRACE-like)** missions:



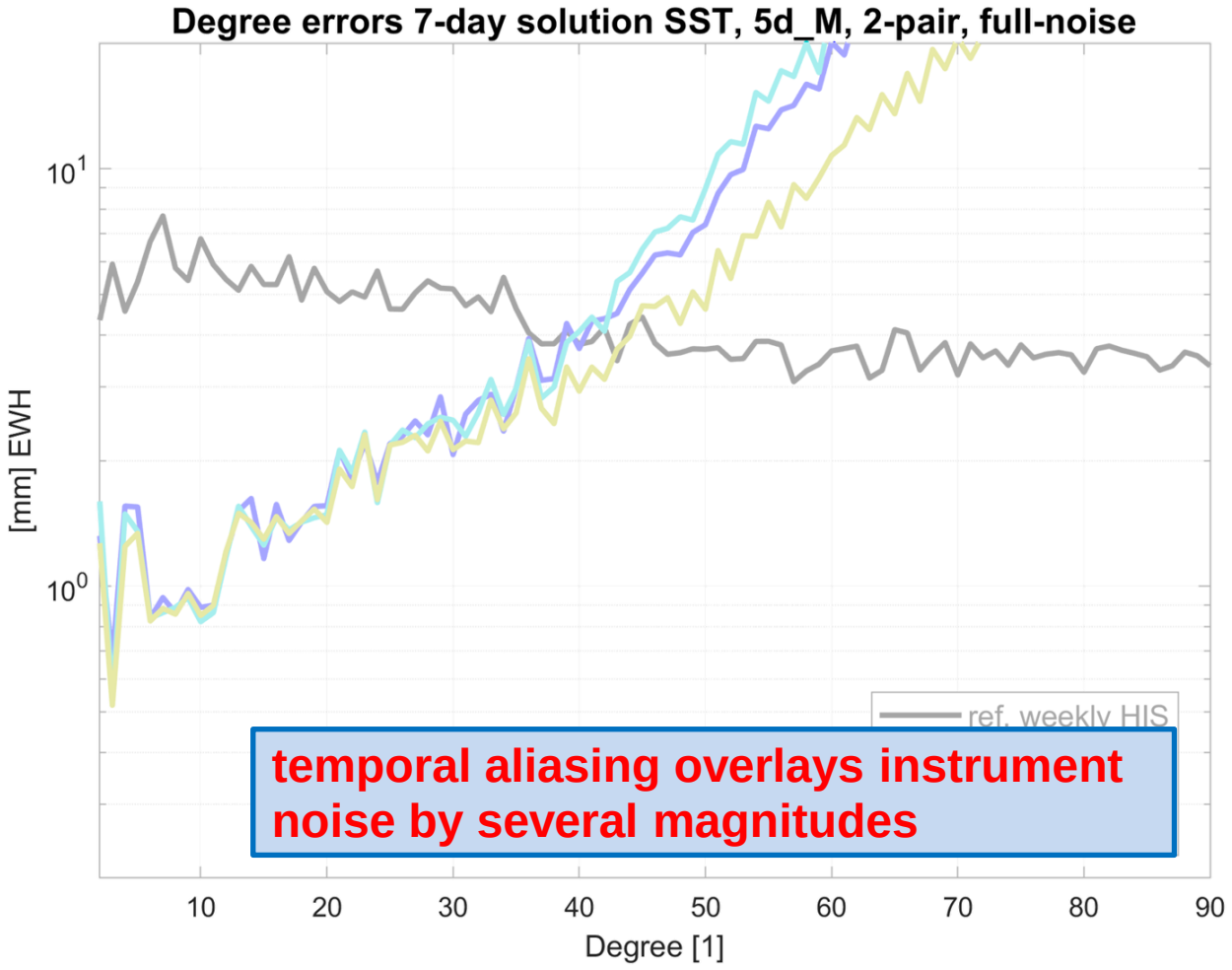
For **SGG (GOCE-like)** missions:



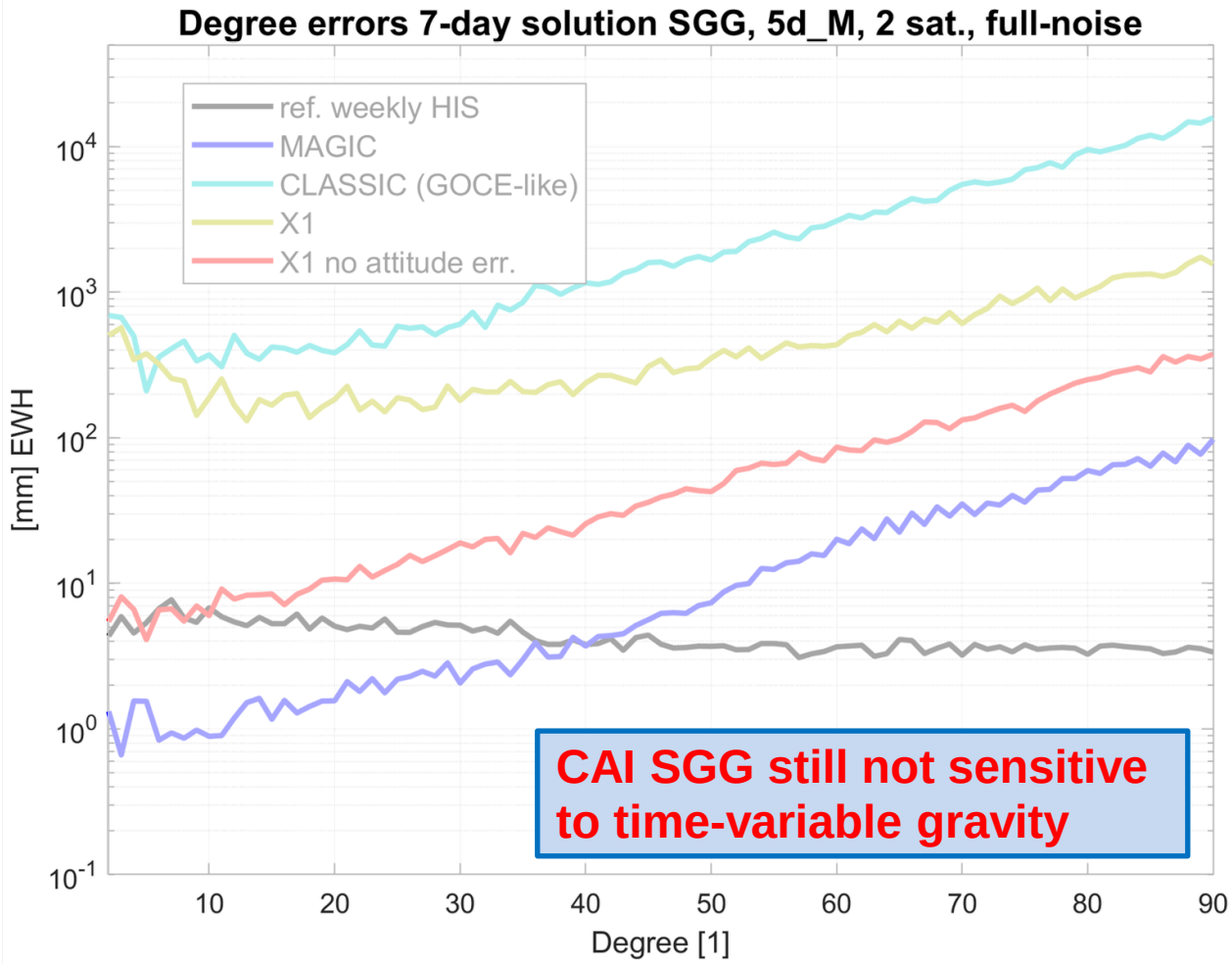
2.3 Impact of future sensors: *time-variable gravity field retrieval performance*

Retrieval performance of CAI instruments (time-variable gravity field):

For **LL-SST (GRACE-like)** missions:



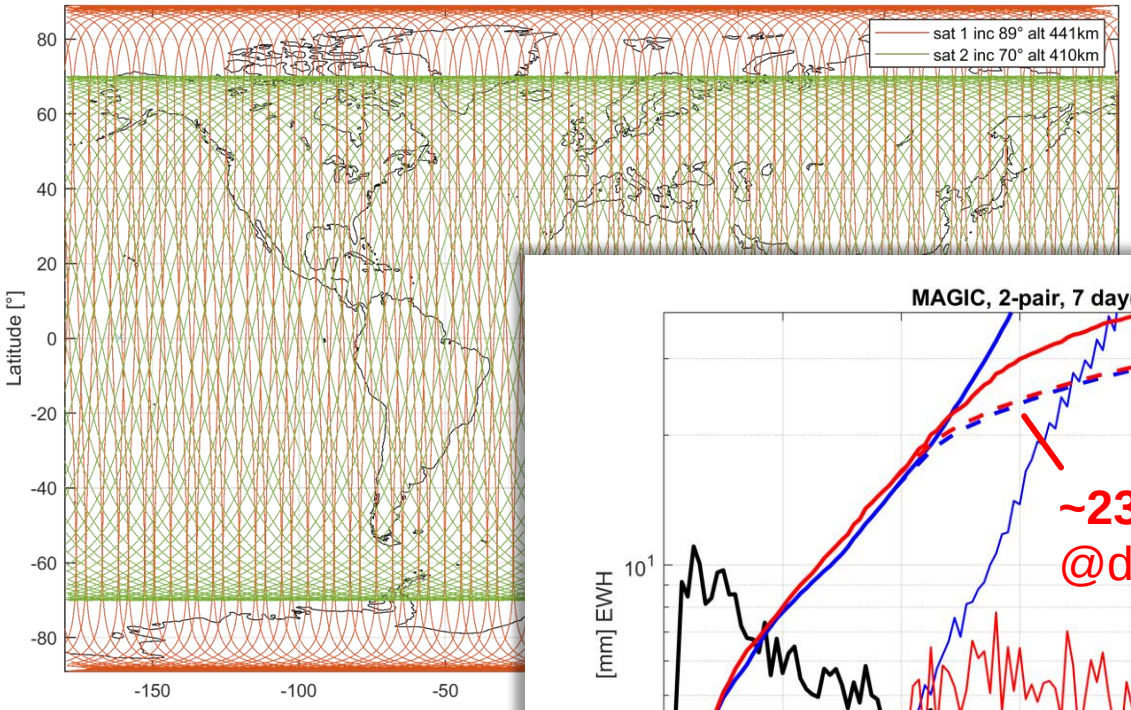
For **SGG (GOCE-like)** missions:

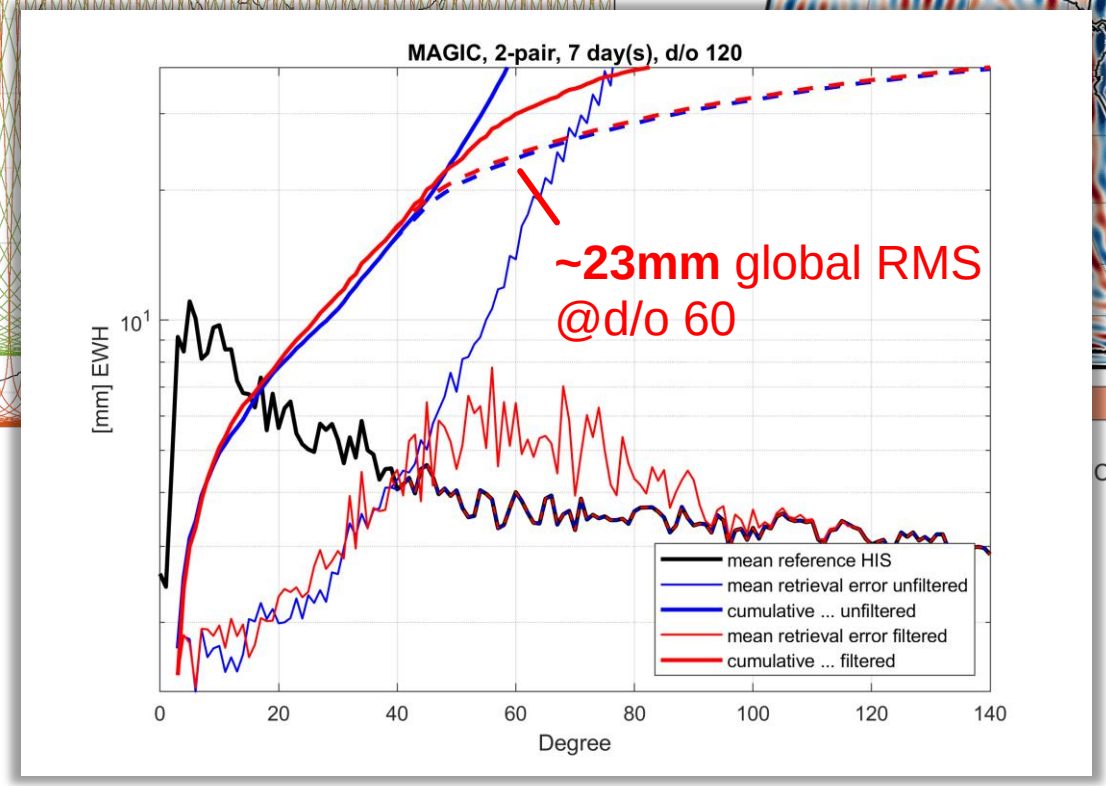


3.1 Impact of future constellations: *2-pair inclined constellation*

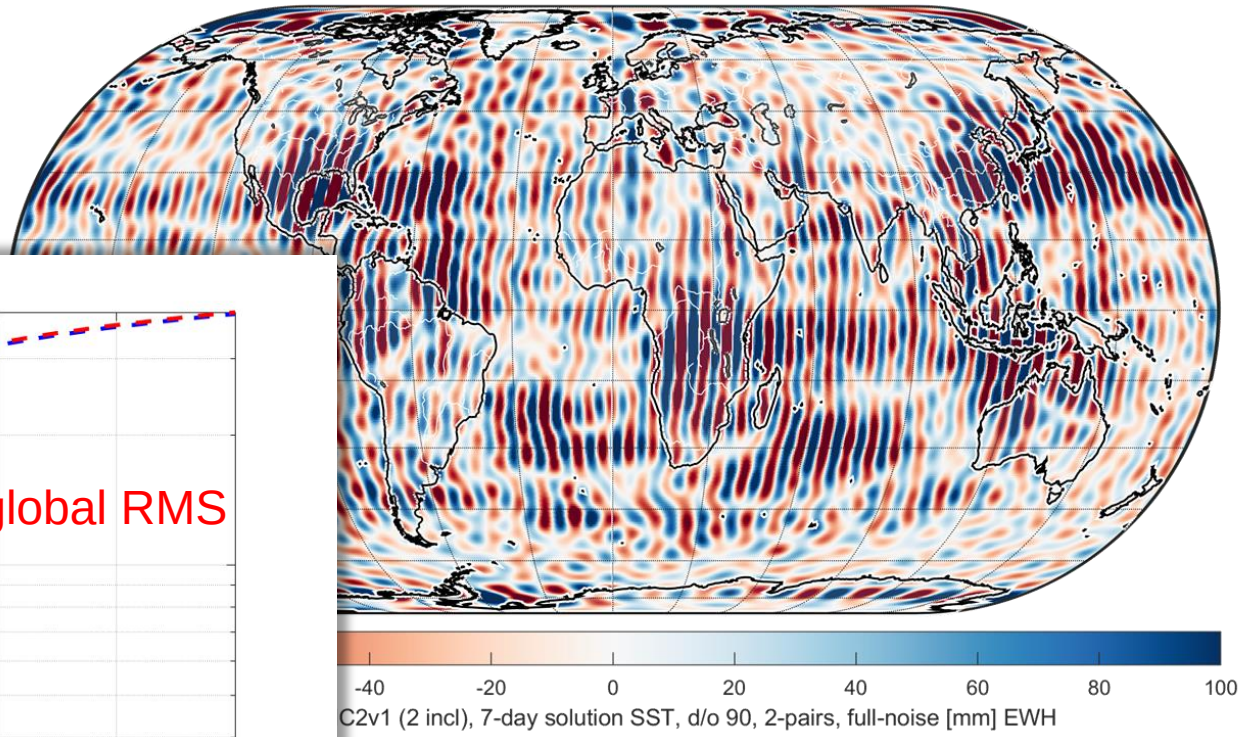
Retrieval performance of 2-pair inclined constellation (after 7 days)

Ground-track pattern





Retrieval error (up to d/o 60)

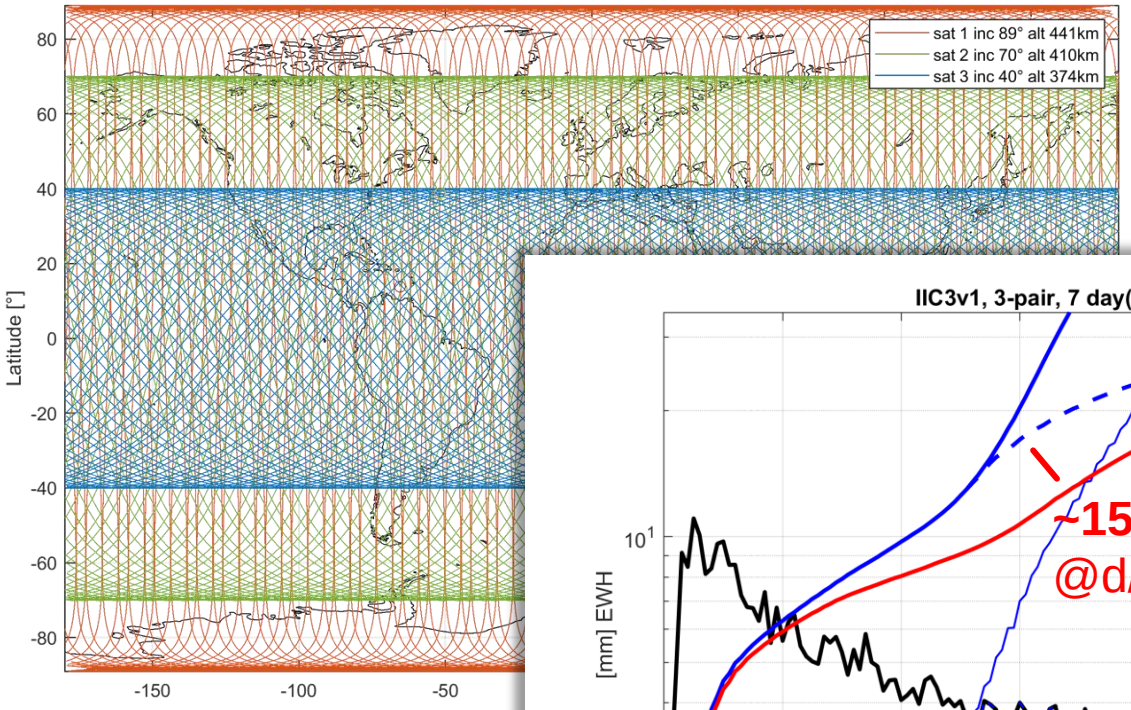


Cumulative degree amplitudes

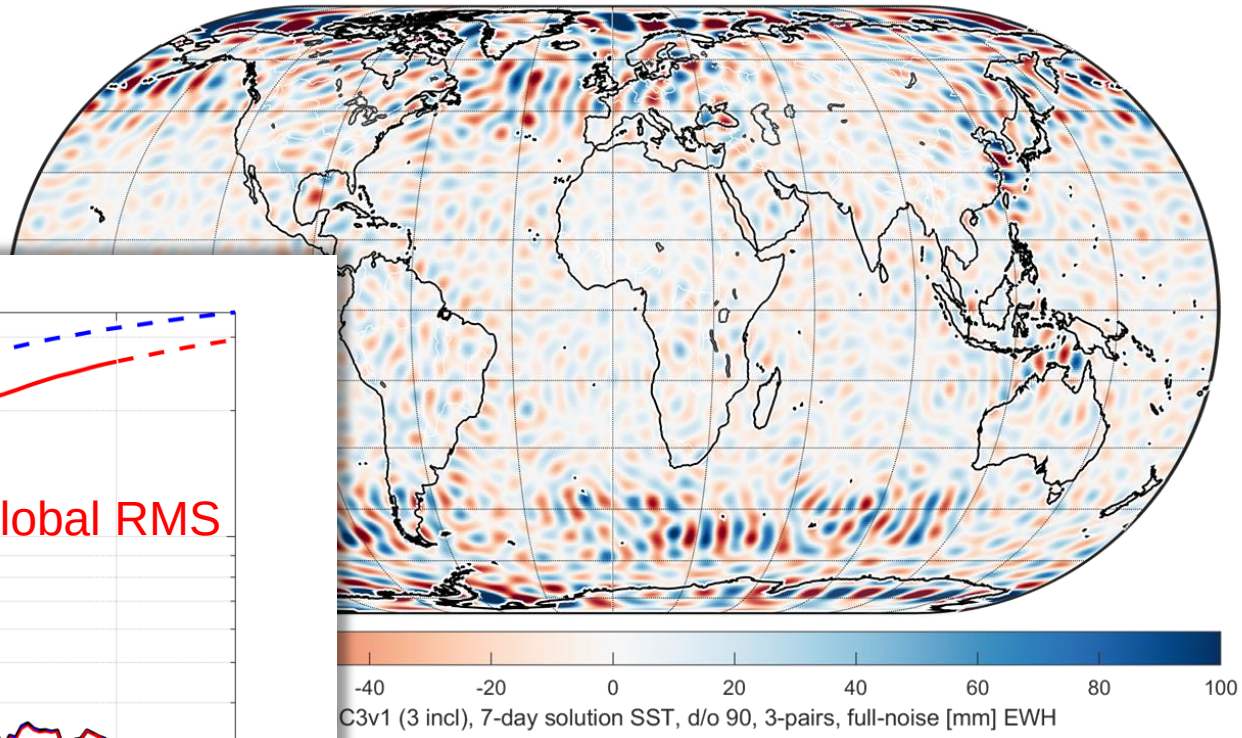
3.2 Impact of future constellations: *3-pair inclined constellation*

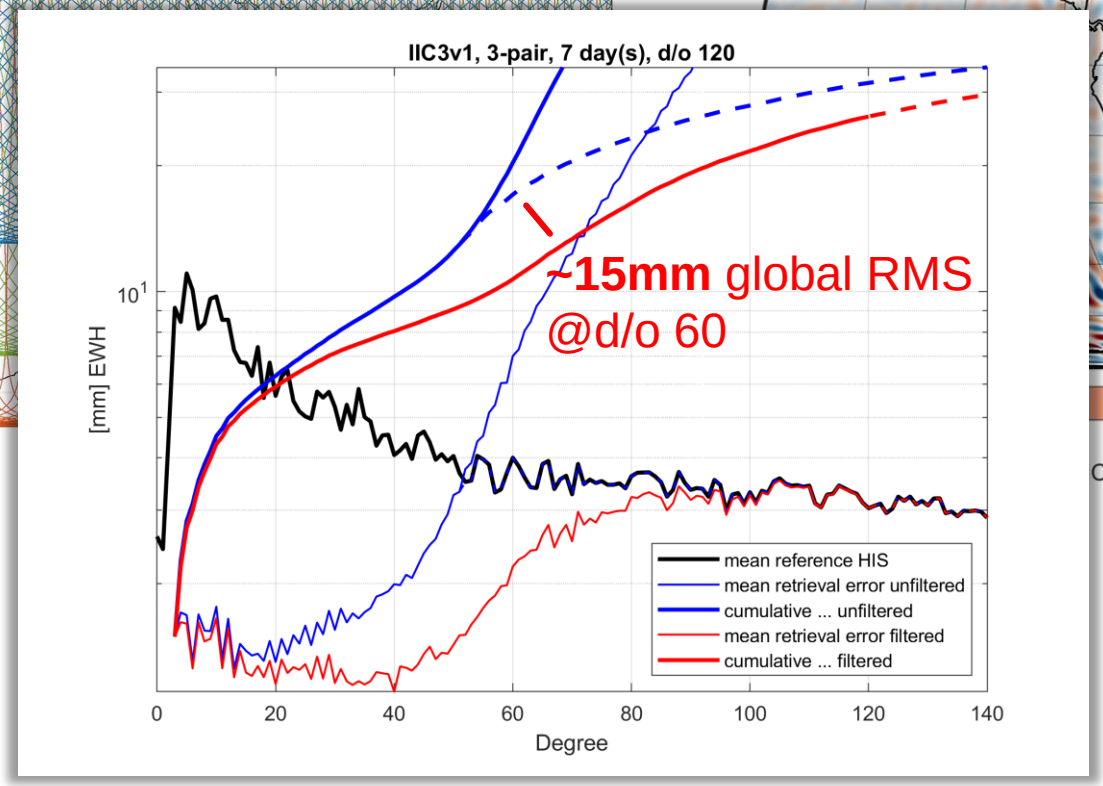
Retrieval performance of 3-pair inclined constellation (after 7 days)

Ground-track pattern



Retrieval error (up to d/o 60)



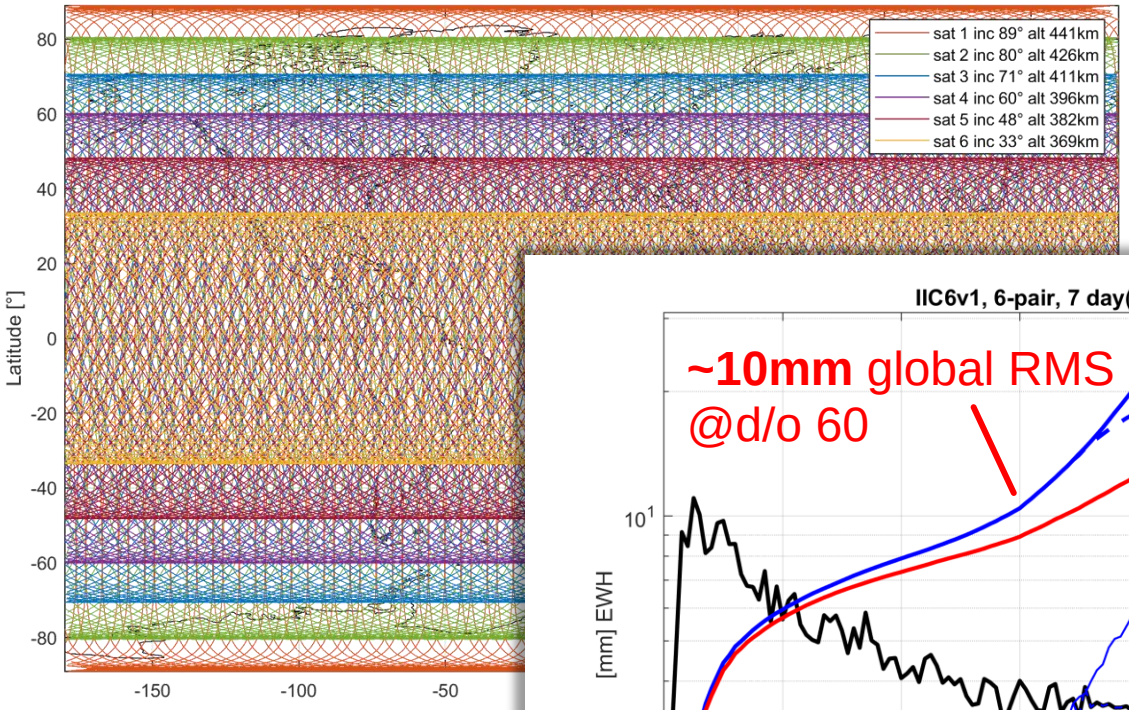


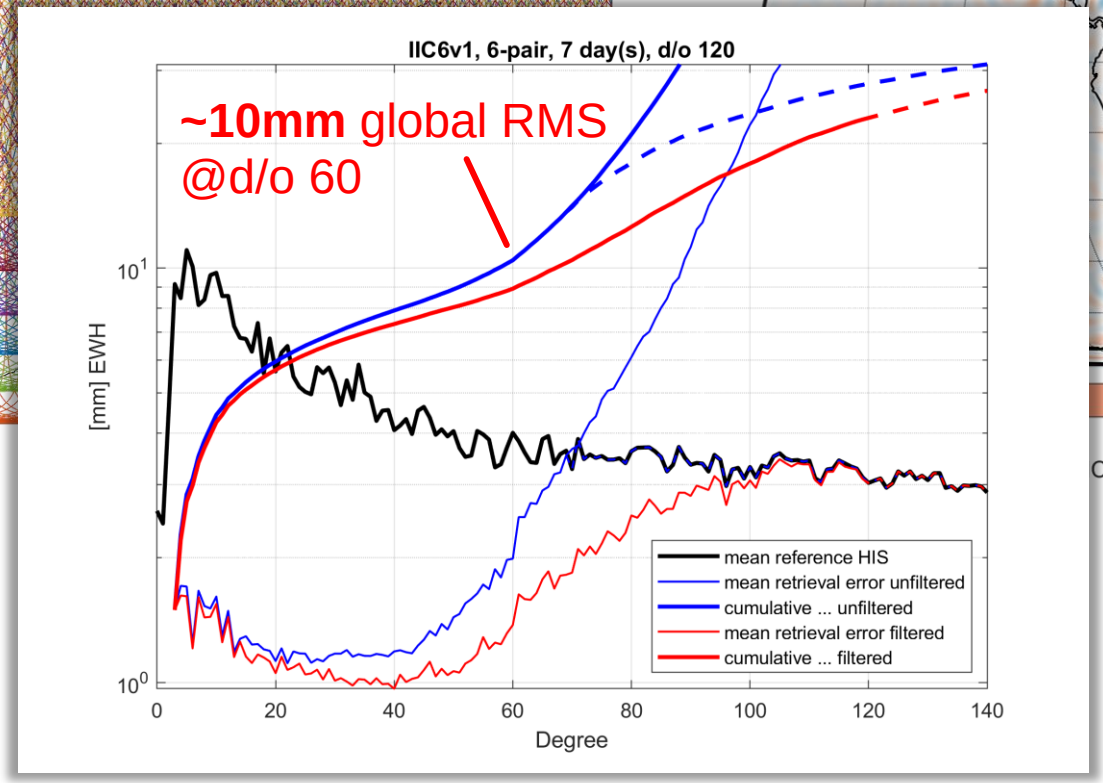
Cumulative degree amplitudes

3.3 Impact of future constellations: *6-pair inclined constellation*

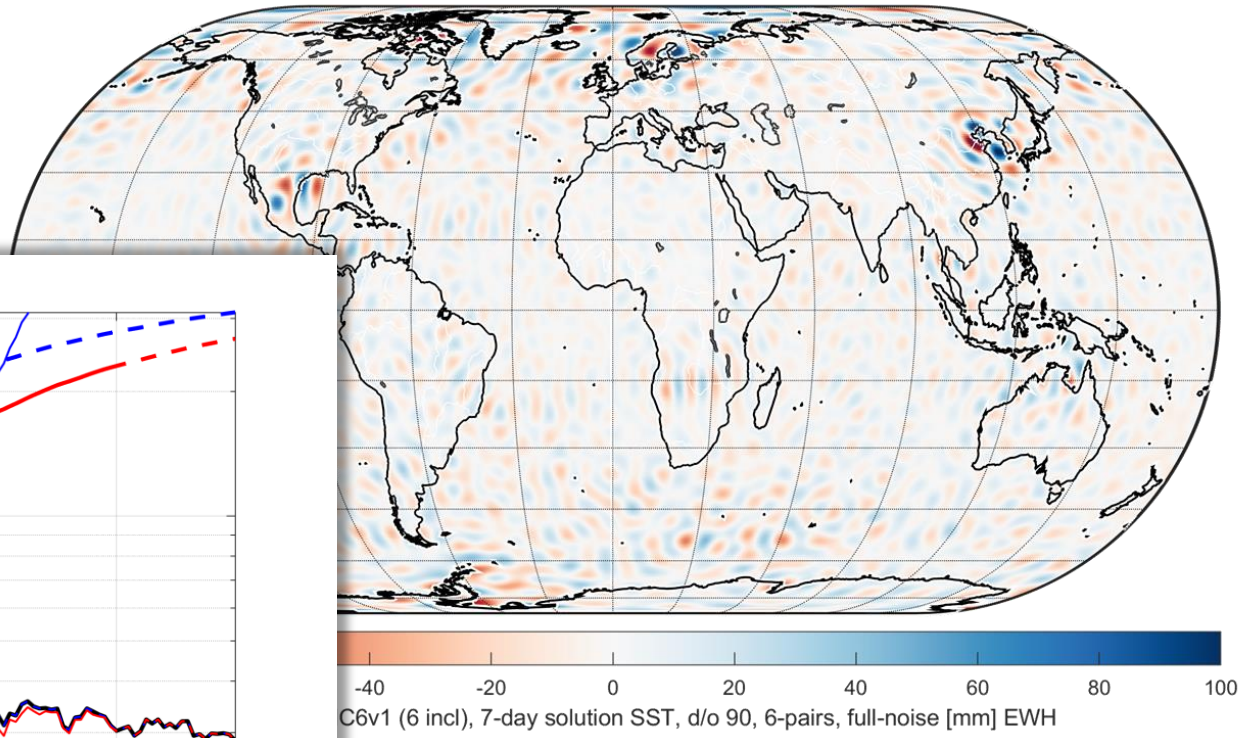
Retrieval performance of 6-pair inclined constellation (after 7 days)

Ground-track pattern





Retrieval error (up to d/o 60)

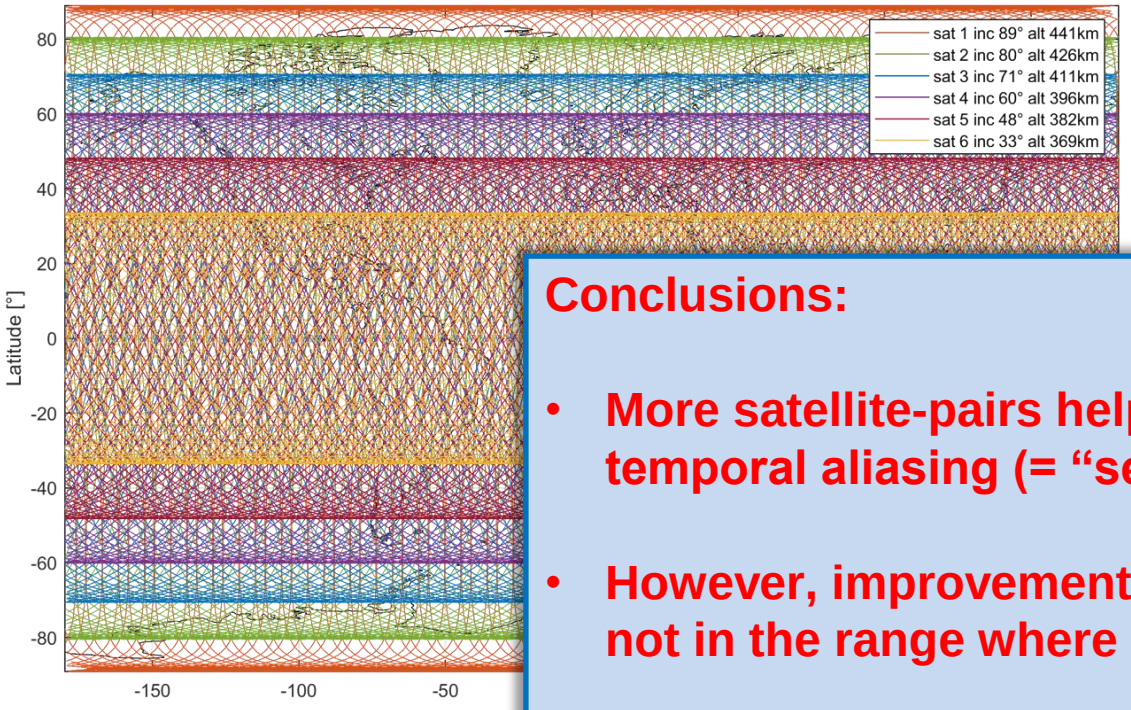


Cumulative degree amplitudes

3.3 Impact of future constellations: *6-pair inclined constellation*

Retrieval performance of 6-pair inclined constellation (after 7 days)

Ground-track pattern



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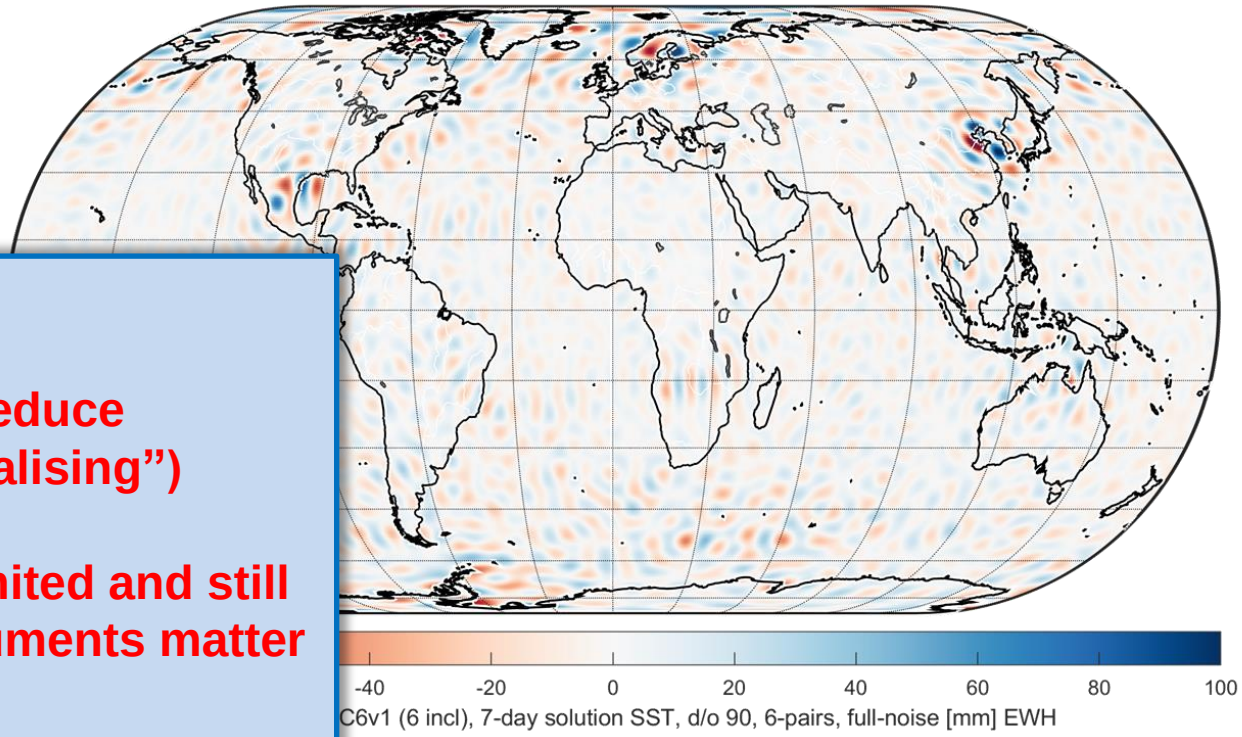


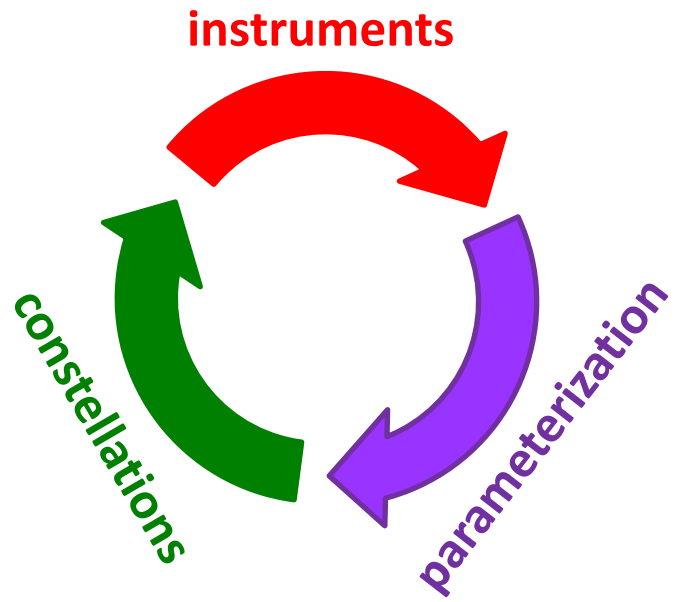
Conclusions:

- More satellite-pairs help to reduce temporal aliasing (= “self-dealising”)
- However, improvement is limited and still not in the range where instruments matter
- Better parameterization strategy needed in addition
  - ➔ *Investigations ongoing, idea of direct parameterization (e.g., through splines) or indirect parameterization (“Kalman”)*

Q: are quantum (CAI-)accelerometers useful for satellite gravity field missions?

A: **YES**, but…

- ➔ **better ranging instruments needed** in case of LL-SST (GRACE-like)
- ➔ **better attitude determination needed** in case of SGG (GOCE-like)
- ➔ **larger constellations needed** to increase spatio-temporal resolution
- ➔ **improved parameterization needed** to benefit from larger constellations



Any questions?