Ocean Surface Topography Science Team Meeting
Precise Orbit Determination Splinter

JASON2 & JASON3 POD STATUS

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La Rochelle,
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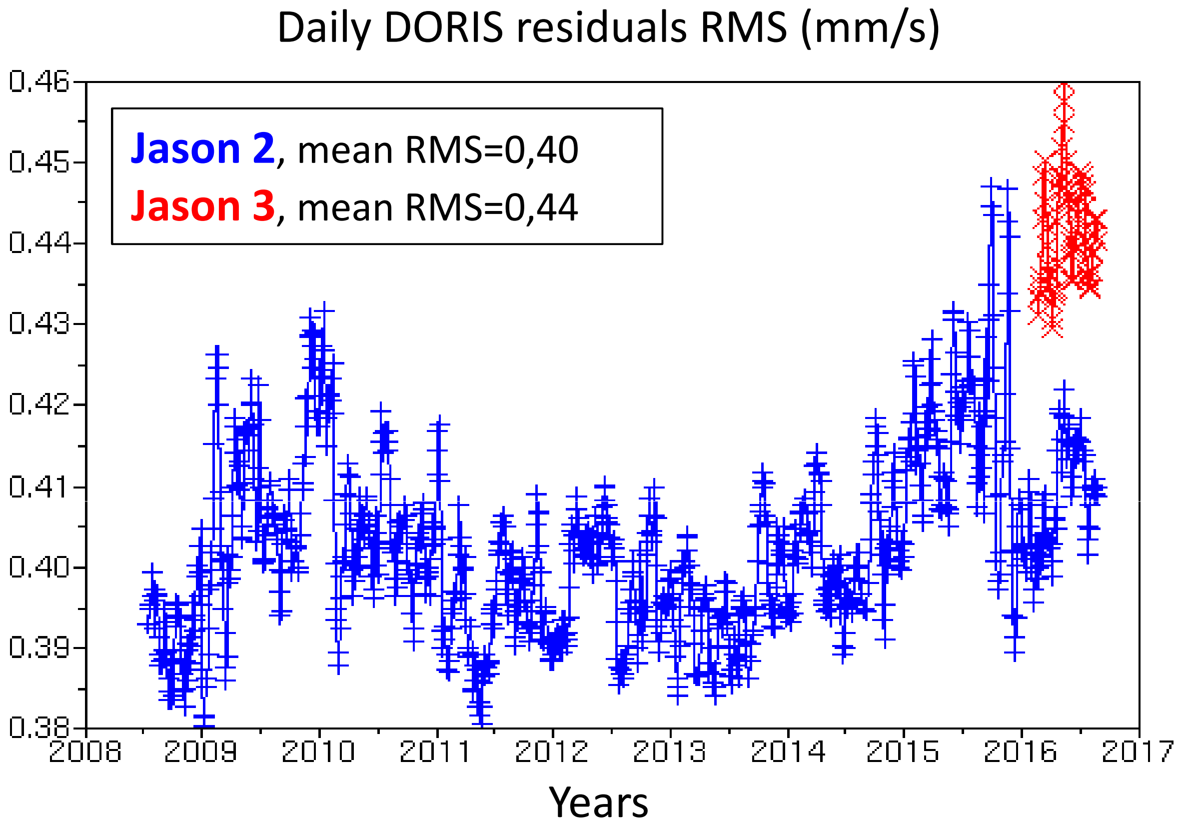
INTRODUCTION

Jason3: Launched on the 17th of January 2016

Jason2 and Jason3 flying in tandem : ~80 seconds apart for cross-calibration purpose up until the 2nd of October (first maneuver of orbit change operations).

CONTENTS

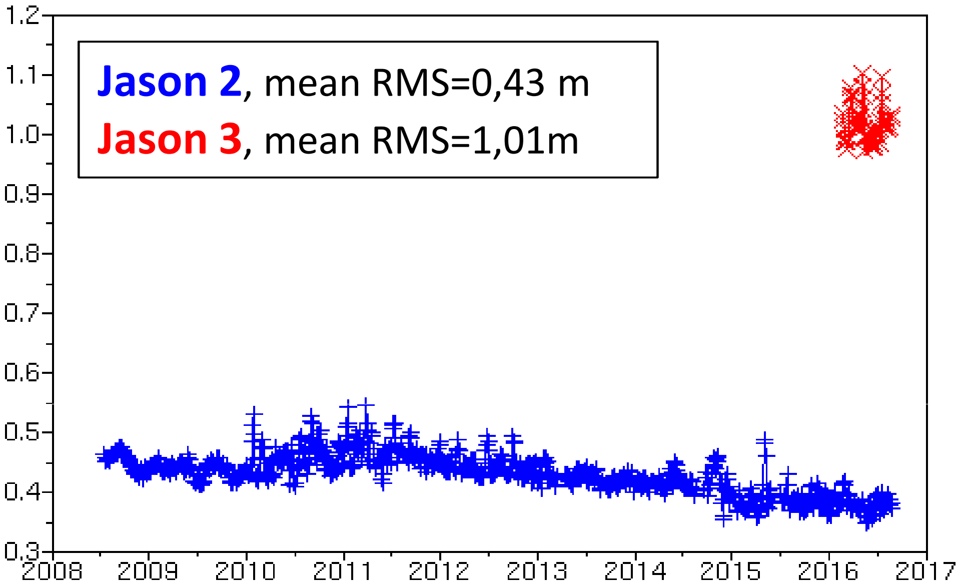
MEASUREMENTS RMS : DORIS



- Jason 2 : Stable performance
- Jason 3 : larger RMS values : SAA impact ?

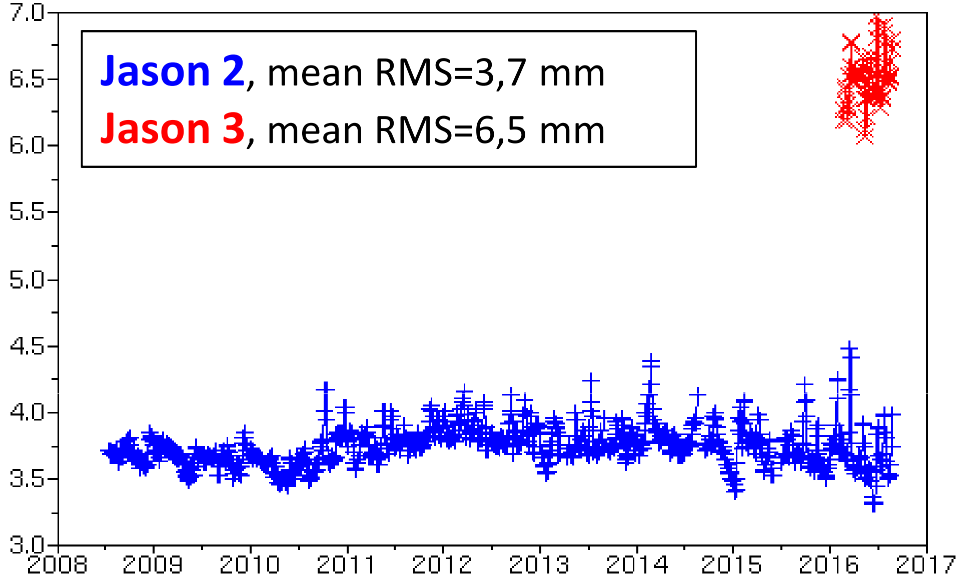
MEASUREMENTS RMS : GPS

Daily GPS pseudo-range residuals RMS (m)



Years

Daily GPS phase residuals RMS (mm)



Years

- Jason 2 : Stable performance
- Jason 3 : larger RMS values

CONTENTS

SAA IMPACT ON JASON 3

- DORIS SAA stations considered :

ARFB LAOB KRWB LICB ASEB
HEMB CADB SANB RIRB BEMB
EASB KEUC SAPC SCRB

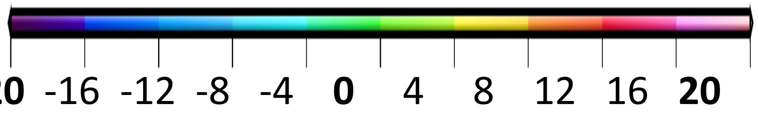
- Comparison between sets of reduced dynamics orbits computed with and without these SAA stations
  - DORIS-only reduced dynamics
  - DORIS+GPS reduced dynamics

- Study of reduced dynamics to focus on the measurements rather than the dynamic modeling

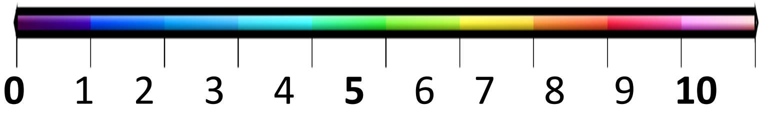
cnes

SAA IMPACT ON JASON 3 : GEOGRAPHIC PROJECTION

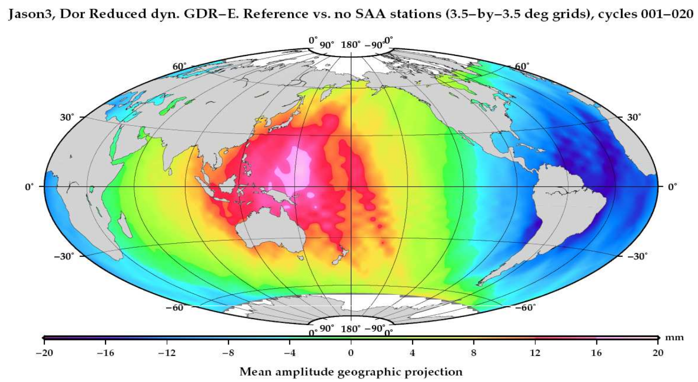
Mean amplitude (mm)

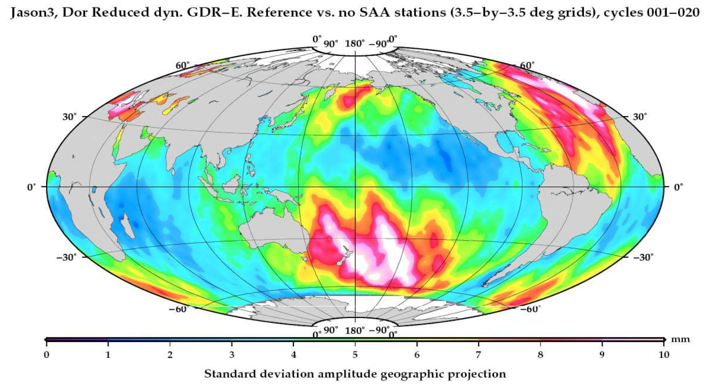


Standard deviation (mm)

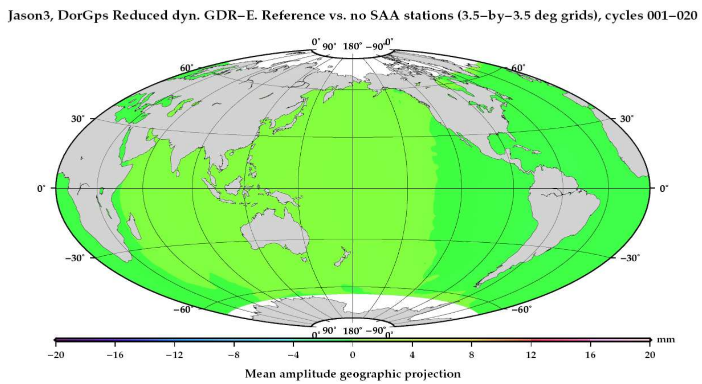


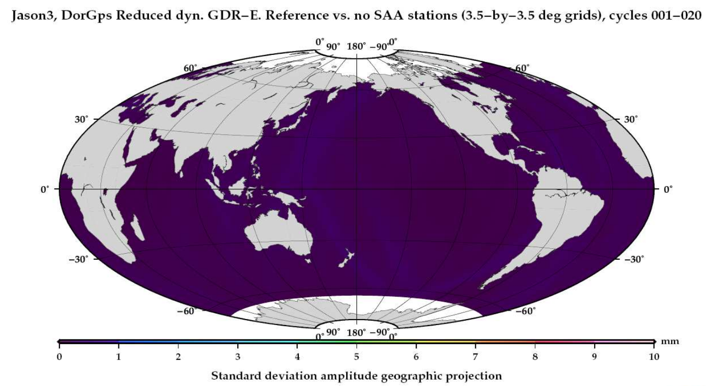
DORIS-only
reduced dynamics
orbits





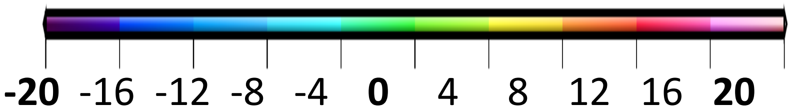
DORIS+GPS
reduced dynamics
orbits



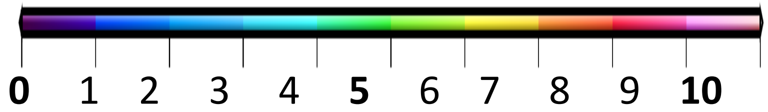


SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION

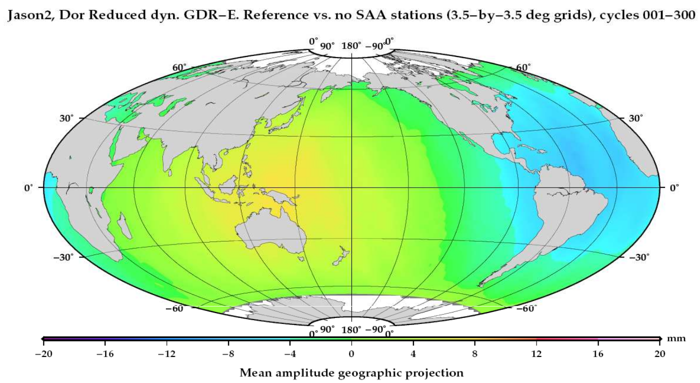
Mean amplitude (mm)

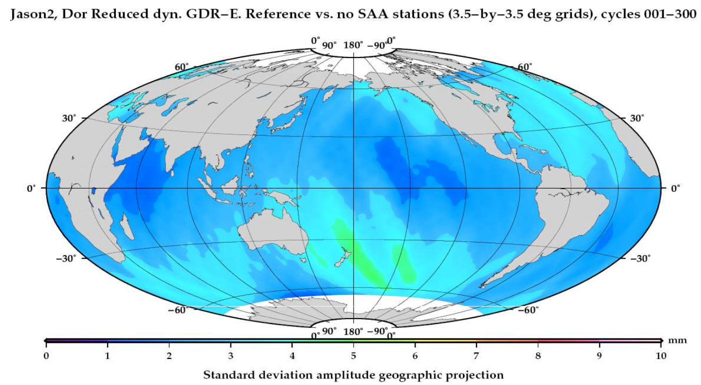


Standard deviation (mm)

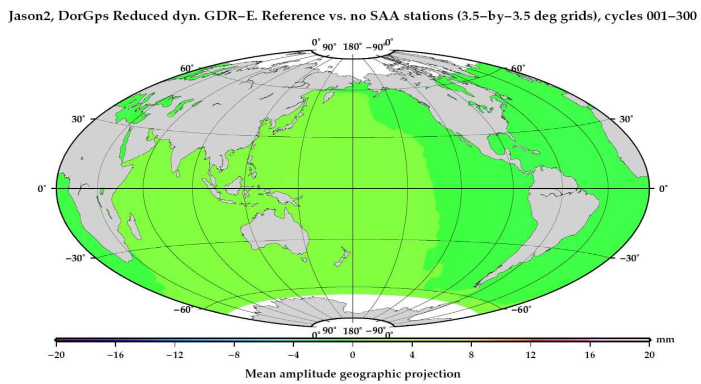


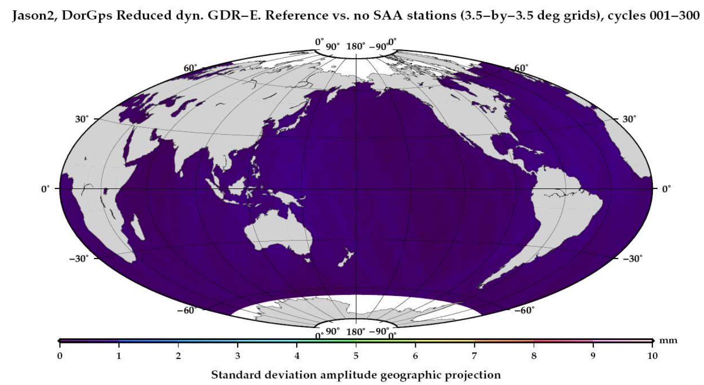
DORIS-only
reduced dynamics
orbits





DORIS+GPS
reduced dynamics
orbits





SAA IMPACT ON JASON 3 :
EFFET OF ANOTHER EQUIVALENT SUB-NETWORK

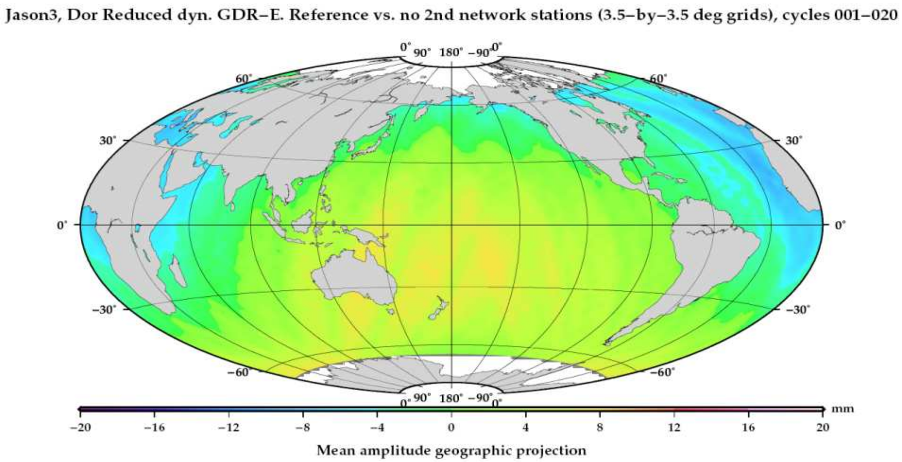
- DORIS SAA stations considered :

LICB TRJB DJIB MAIB MALB REUB HBMB
AMVB YASB MAUB KEUC CRQB HEMB SYQB

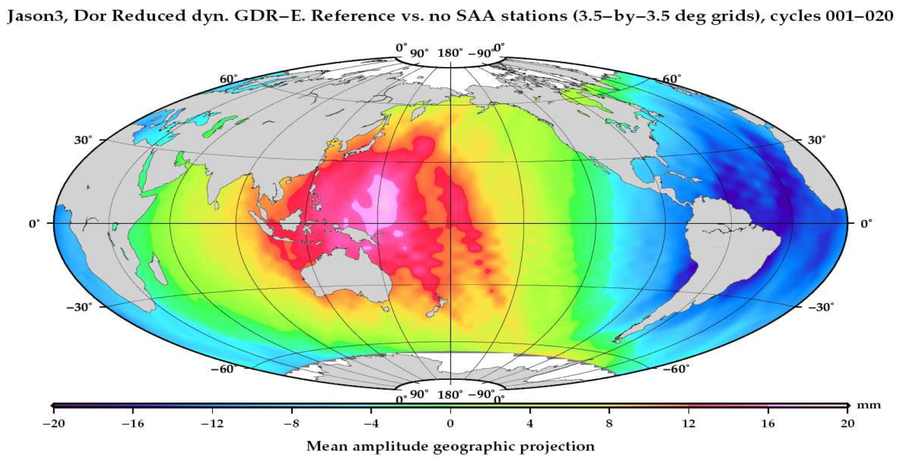
- Impact of modifying the network :
  - no SAA stations : up to 2 cm
  - no stations from another sub-network : up to 8 mm

- Therefore SAA impact up to 1,2 cm left on Jason 3

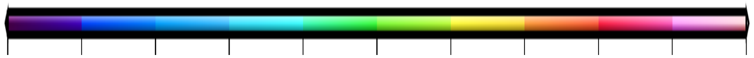
No stations from the newsub-network



No stations from SAA



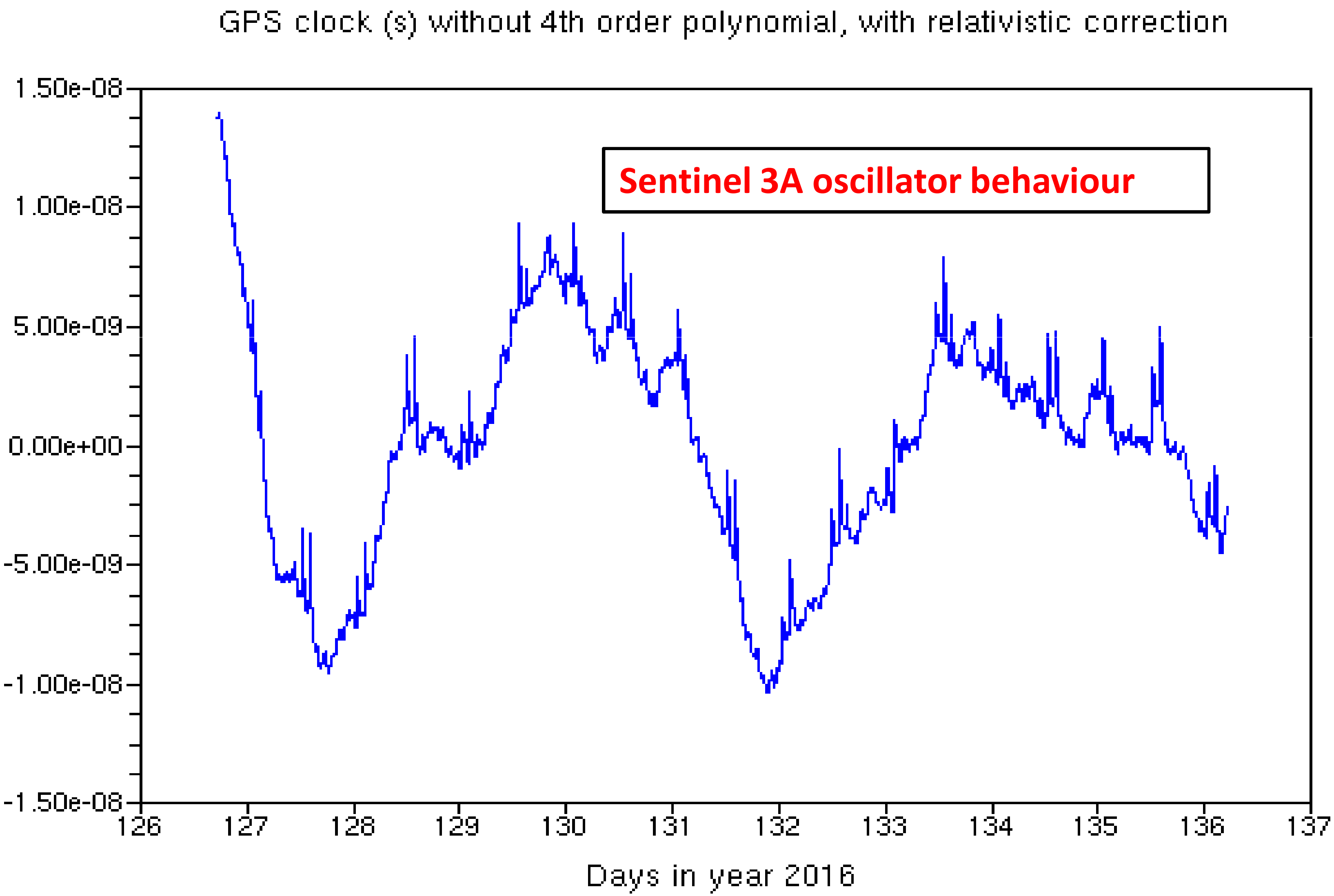
Mean amplitude (mm)



-20 -16 -12 -8 -4 **0** 4 8 12 16 **20**

SAA IMPACT ON JASON 3 : ESTIMATING THE FREQUENCY DRIFT (1)

- Is it possible to correct the SAA error ?



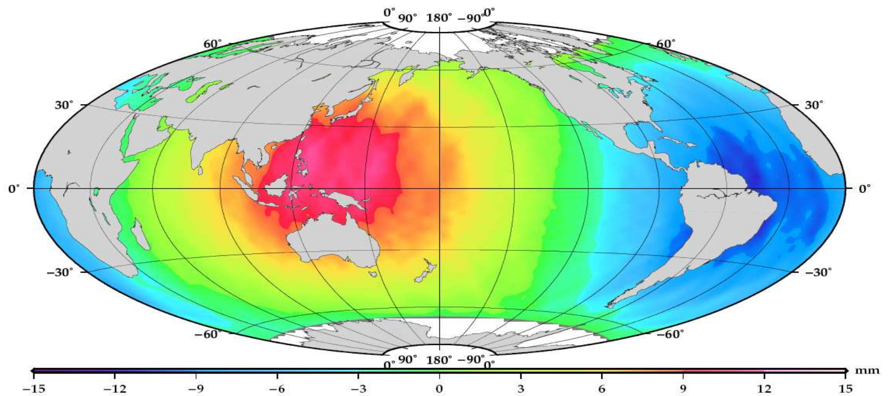
SAA IMPACT ON JASON 3 : ESTIMATING THE FREQUENCY DRIFT (2)

- Is it possible to correct the SAA error ?
- Estimation of the beacon frequency drift on SAA station to account for the on-bord frequency drift
- 2 effects : **SAA** (1,2 cm) and **network** changes (8 mm)

- Comparaison of this « frequency drift estimated » orbit to
  1. Reference orbit (with SAA stations) : no network changes. Expectations : correction of SAA effect
  2. Orbit without SAA stations : no SAA effect. Expectations : network changes effect

1.

Jason3, Dor reduced dyn. Reference vs. estim. freq. drift on SAA stations (3.5–by–3.5 deg grids), cycles 001–020

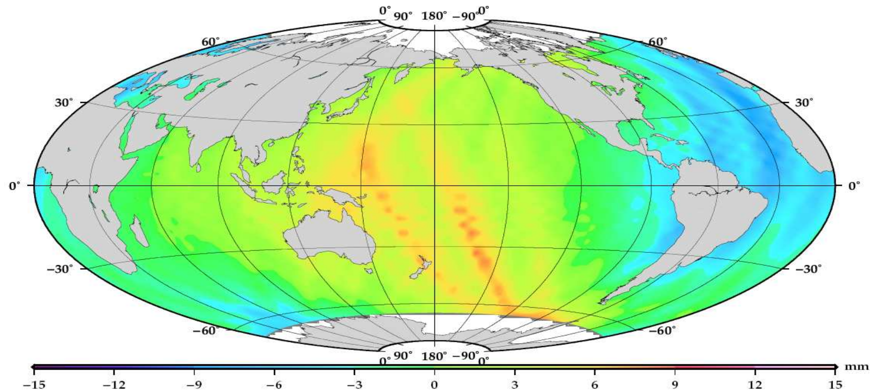


Mean amplitude geographic projection

→ 1,2 cm

2.

Jason3, Dor red. dyn. estim. freq. drift on SAA stations vs. no SAA stations (3.5–by–3.5 deg grids), cycles 001–020



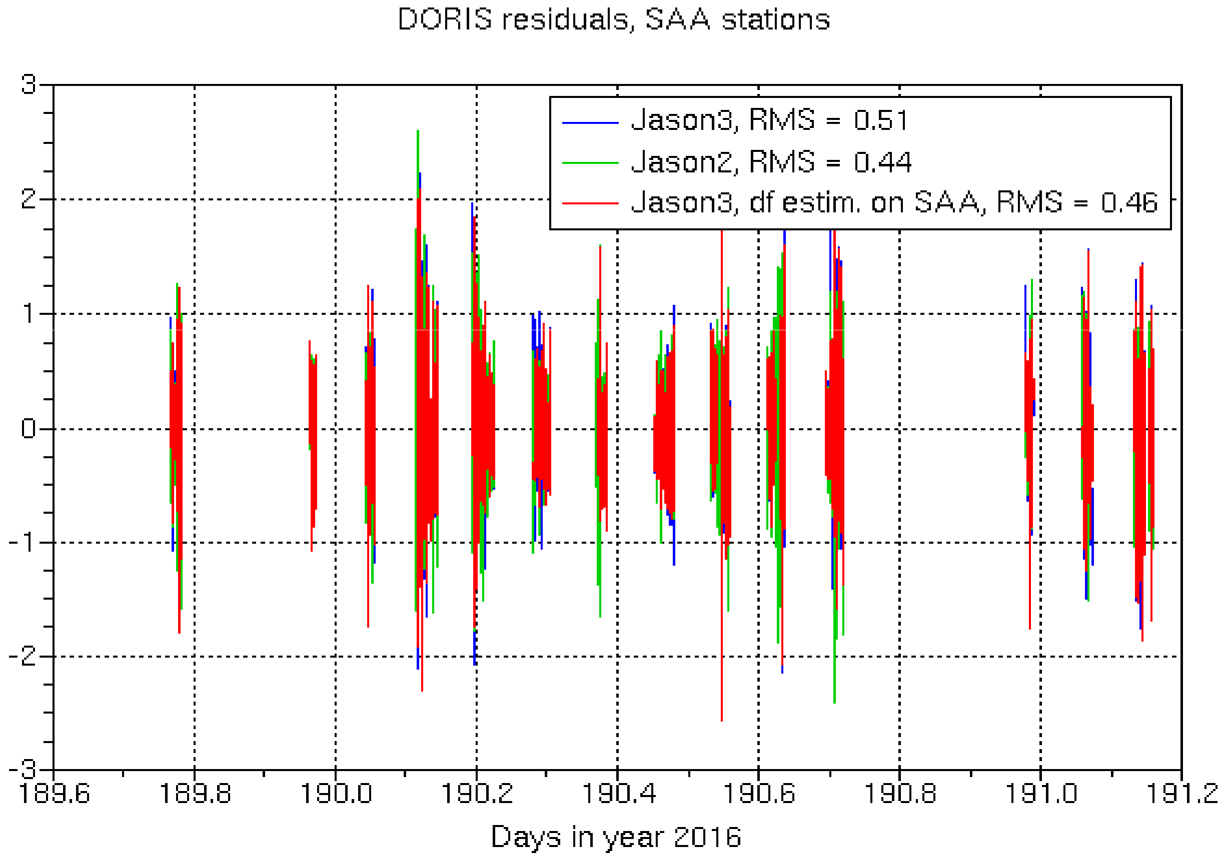
Mean amplitude geographic projection

→ 8 mm

Mean amplitude (mm)

SAA IMPACT ON JASON 3 : ESTIMATING THE FREQUENCY DRIFT (3)

- SAA impact on DORIS residuals ?
- Impact of the estimation of the beacon frequency drift on SAA station on DORIS residuals ?



SAA IMPACT ON JASON 3

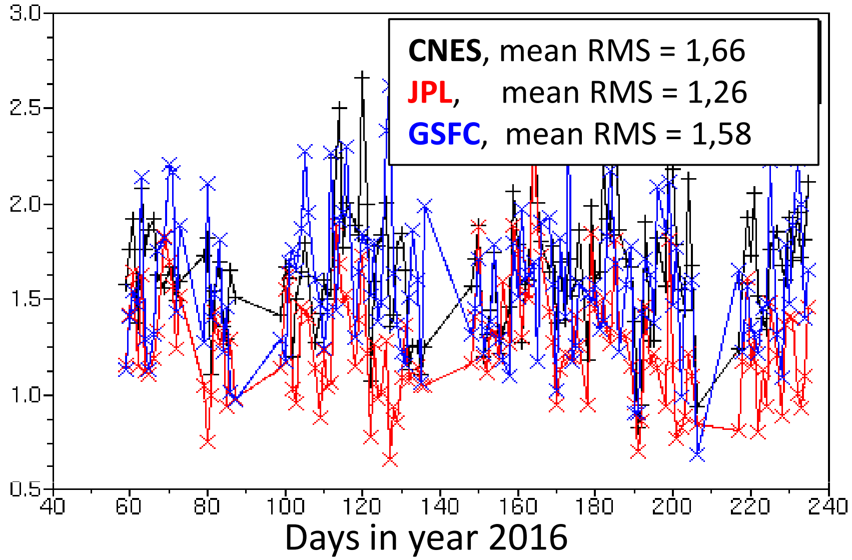
- Visible impact of SAA stations on Jason 3 DORIS-only orbit (up to 1,2 cm biais)
- SAA impact on Jason 2 DORIS-only orbit lower : up to 5mm biais
- When using GPS measurements as well :
  no more SAA-induced geographically correlated biais
- Estimating the beacon frequency drift can mitigate the SAA effect

CONTENTS

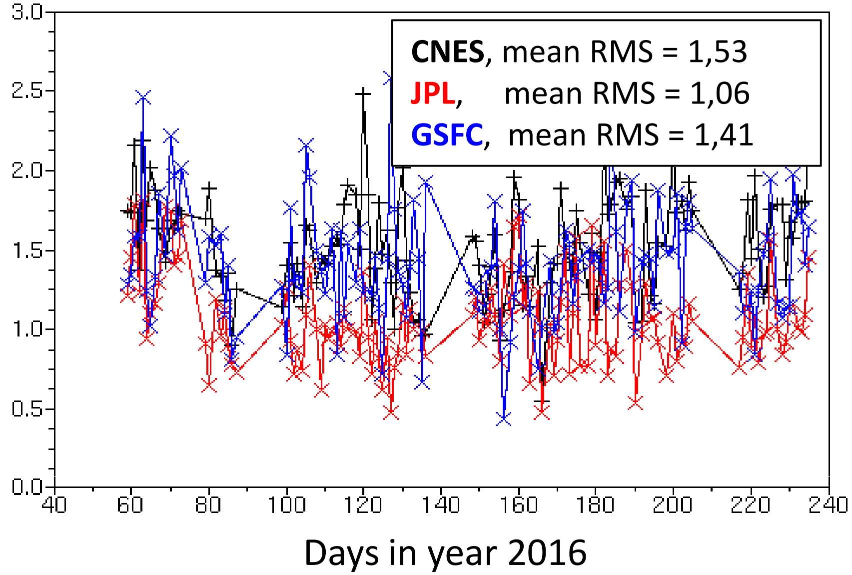
- INTRODUCTION
- POST-FIT RMS
- SAA IMPACT ON JASON 3
- COMPARISON TO JPL/GSFC ORBITS
- CONCLUSION

JASON 3 : SLR RESIDUALS

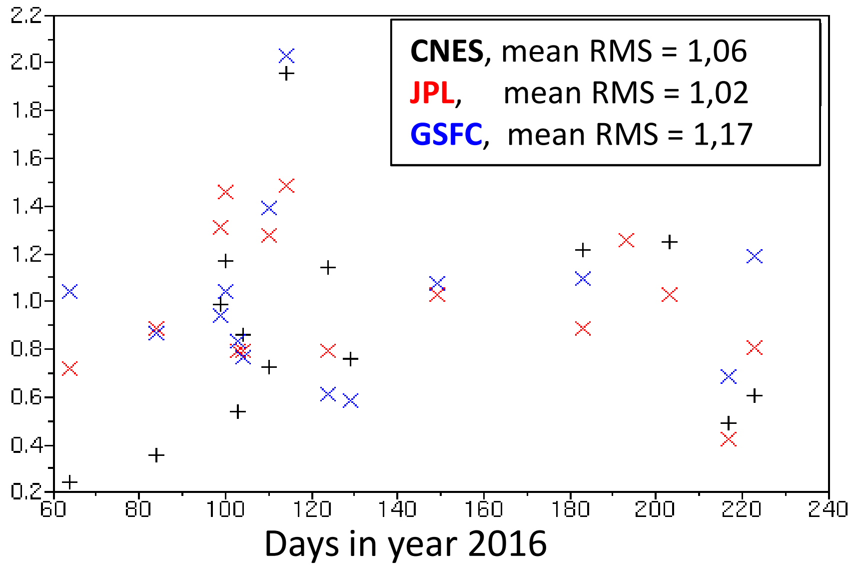
Jason 3, SLR residuals RMS (cm)



Jason 3, SLR residuals RMS, core network (cm)



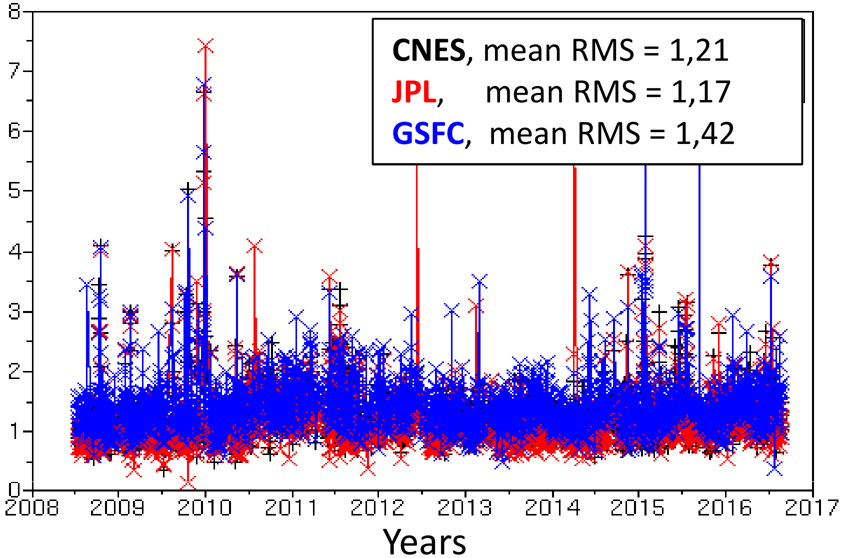
Jason 3, SLR residuals RMS, core network, high elevation (cm)



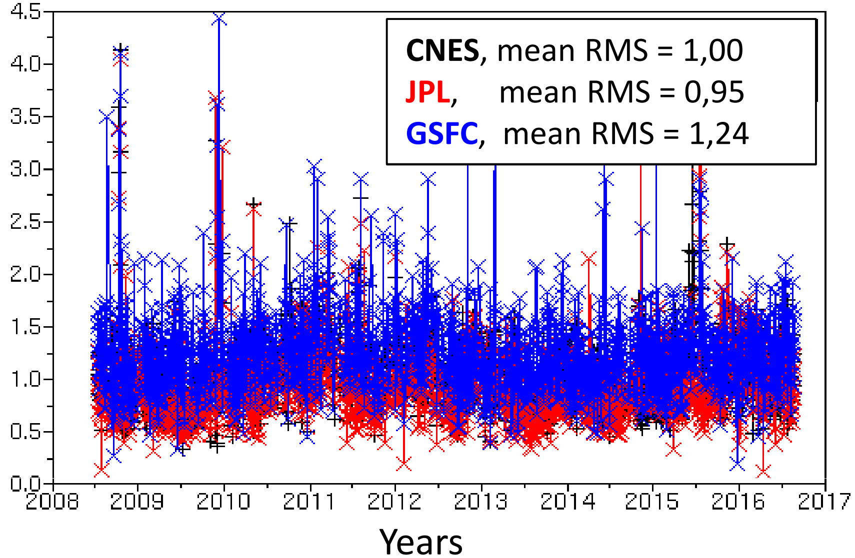
- Similar radial performances
- CNES and GSFC orbits : bias on the non-radial direction

JASON 2 : SLR RESIDUALS

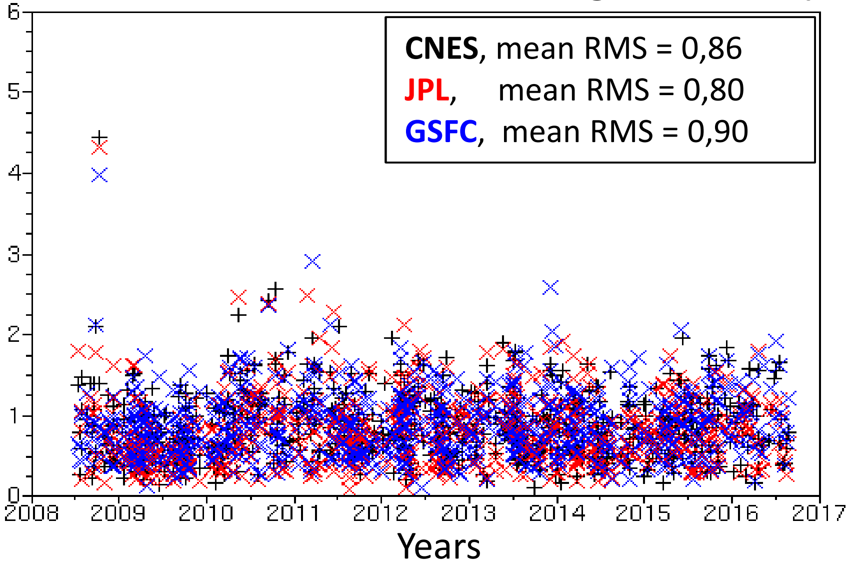
Jason 2, SLR residuals RMS (cm)



Jason 2, SLR residuals RMS, core network (cm)



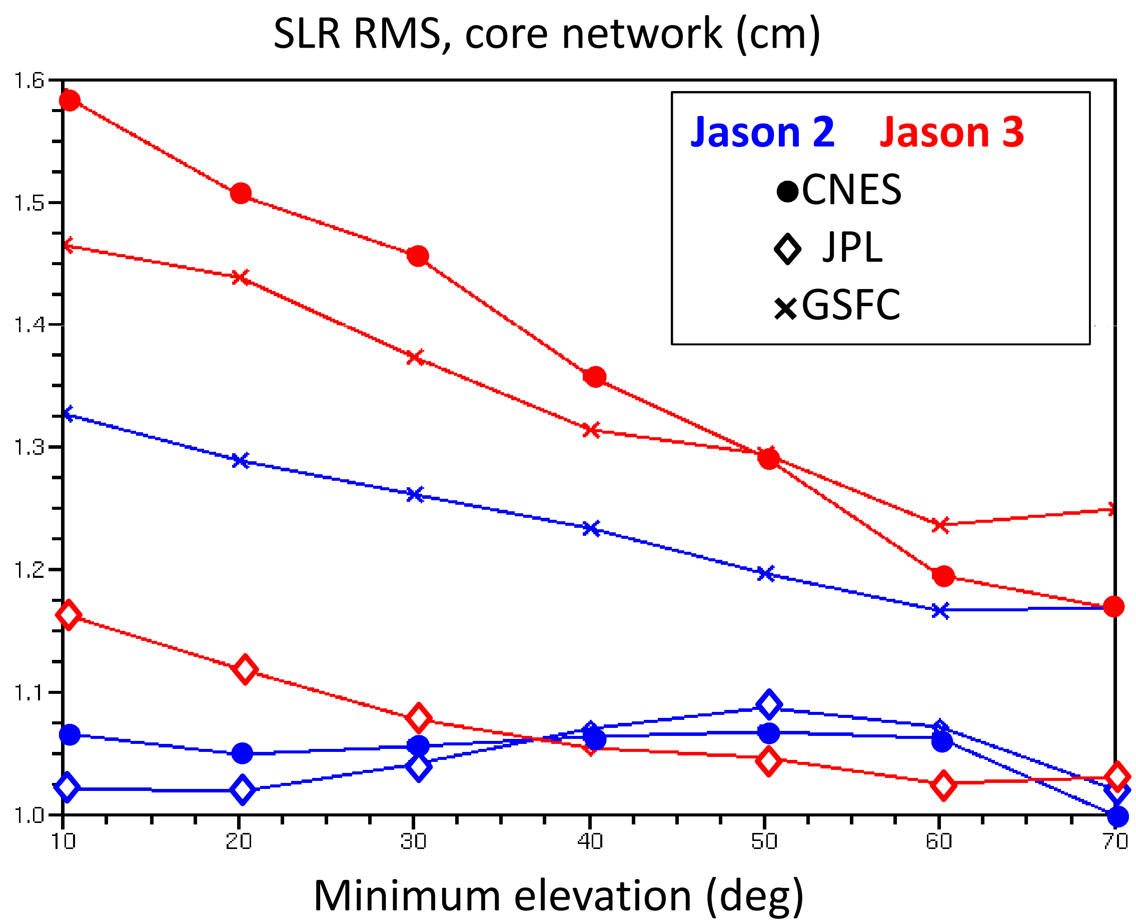
Jason 2, SLR residuals RMS, core network, high elevation (cm)



- Similar performances
- All elevations : 1cm precision

MEASUREMENTS RMS : LASER (3)

Data set : 20 first Jason 3 cycles, and corresponding Jason 2 cycles
intersection of data available in the three solutions



Jason 2

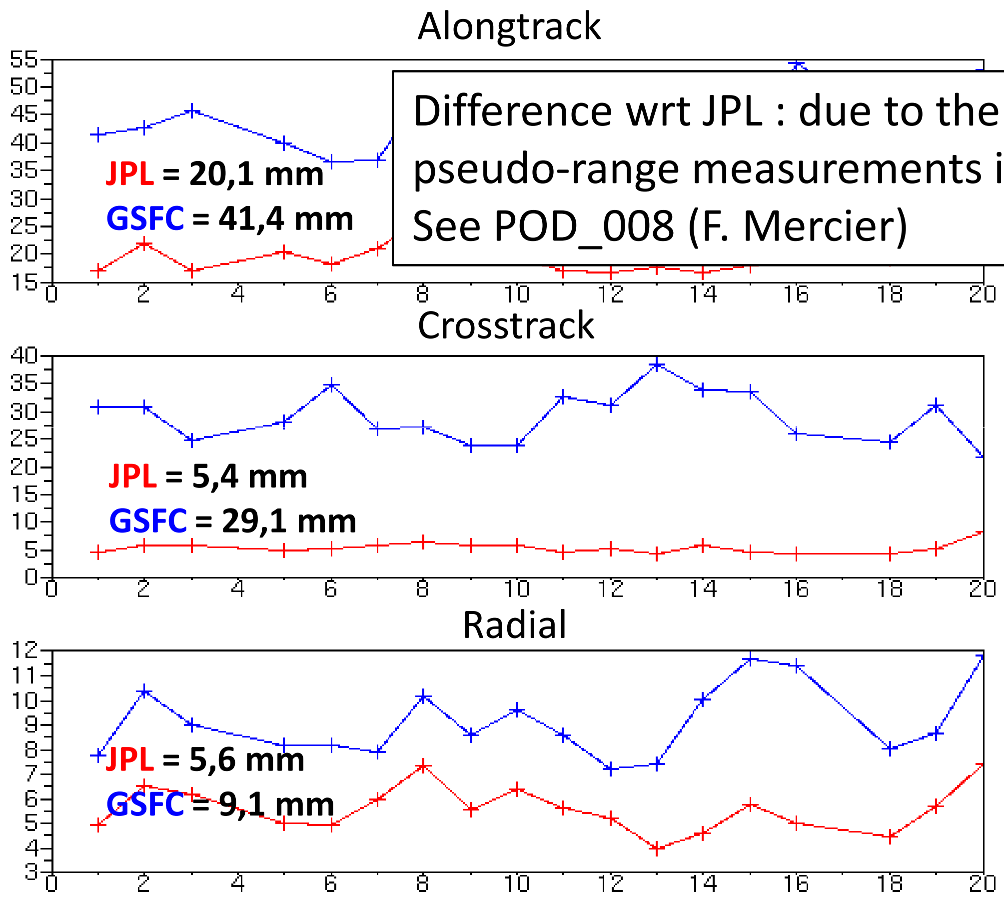
- CNES and JPL : similar performances

Jason3

- CNES and GSFC show large RMS values when low elevation used

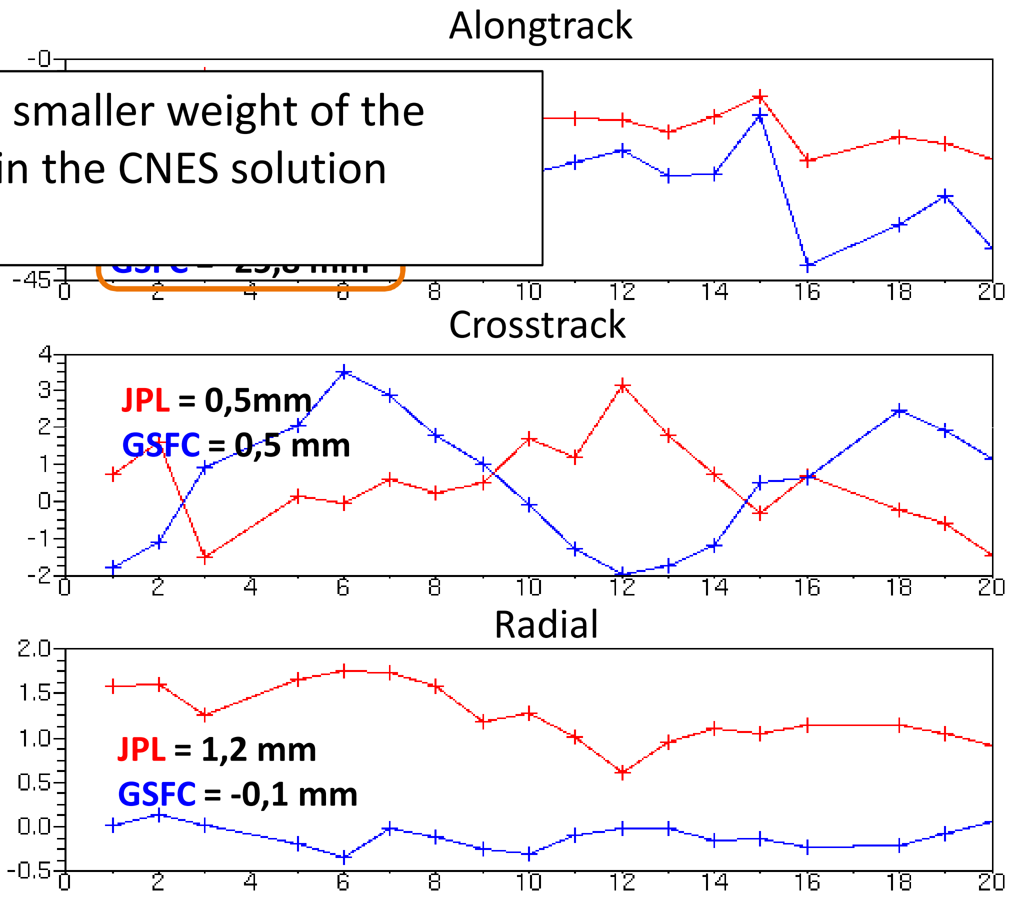
JASON 3 ORBIT DIFFERENCE
COMPARISON TO JPL (RL16A) AND GSFC (STD1504)

RMS of orbit differences (mm)



Cycles

Mean of orbit differences (mm)

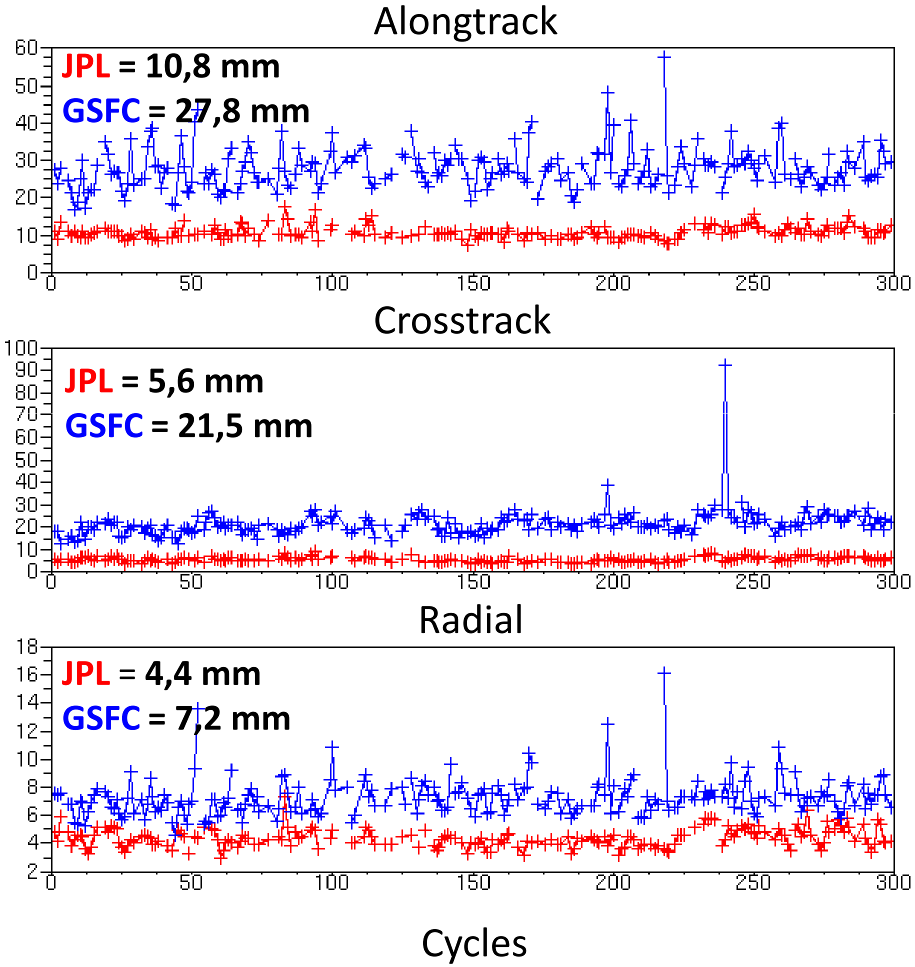


Cycles

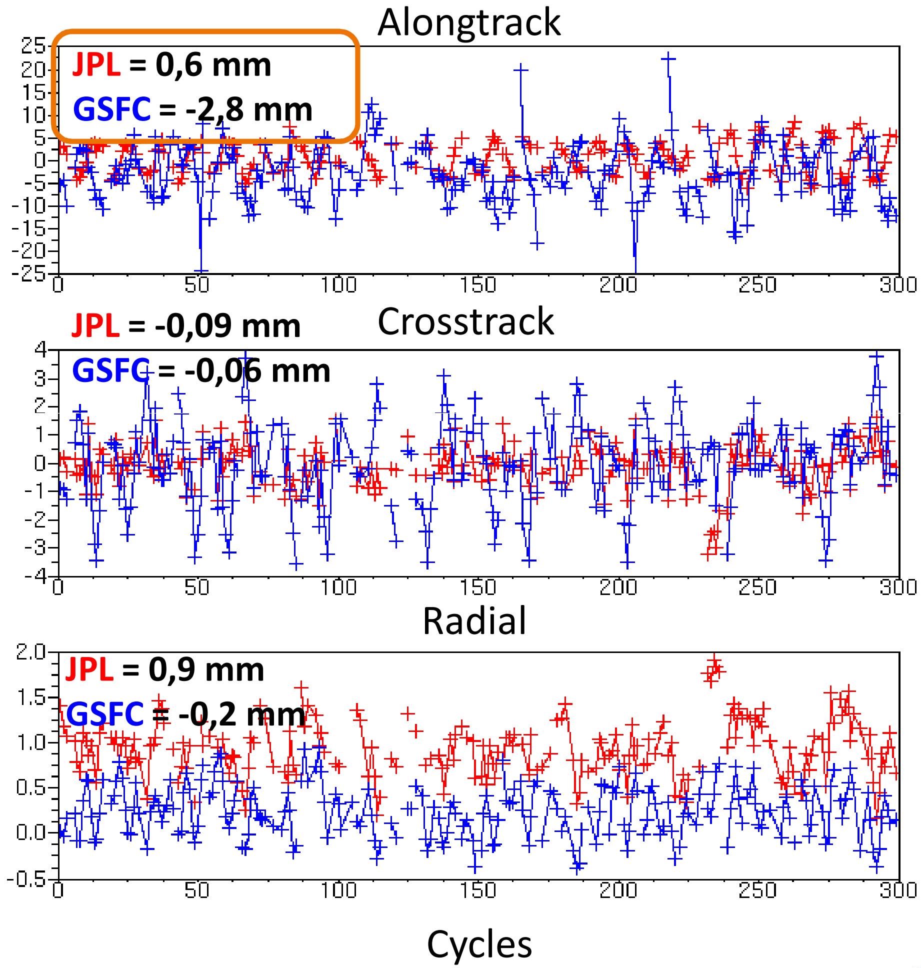
Difference wrt JPL : due to the smaller weight of the pseudo-range measurements in the CNES solution
See POD_008 (F. Mercier)

JASON 2 ORBIT DIFFERENCE
COMPARISON TO JPL (RL16A) AND GSFC (STD1504)

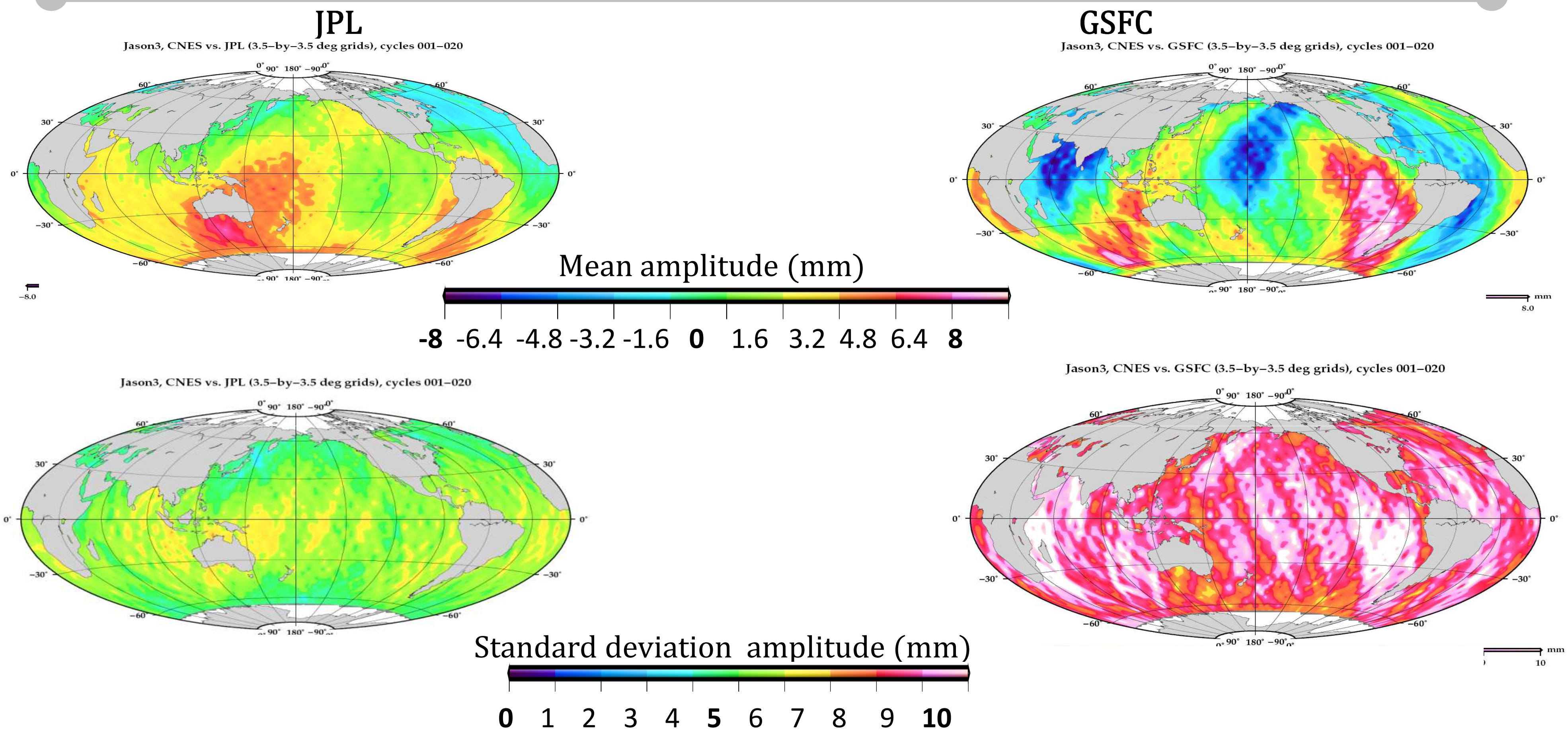
RMS of orbit differences (mm)



Mean of orbit differences (mm)



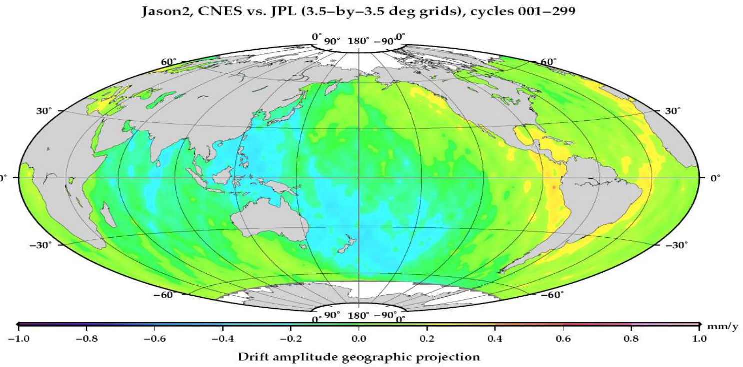
JASON 3 : GEOGRAPHICALLY CORRELATED ERRORS MEAN



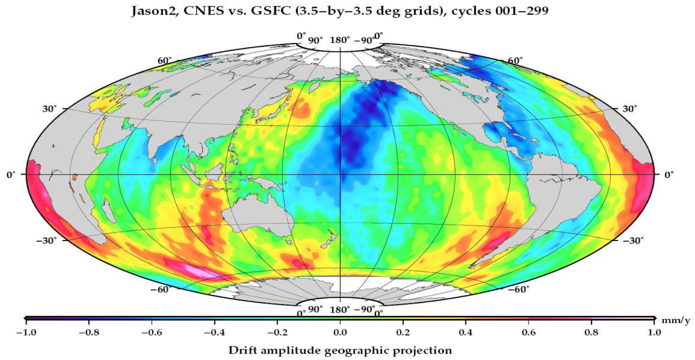
- Drift and annual signal not observable yet (only 200 days of data)
- Small mean (<1cm)
- Larger standard deviation w.r.t. GSFC

JASON 2 : GEOGRAPHICALLY CORRELATED ERRORS

JPL

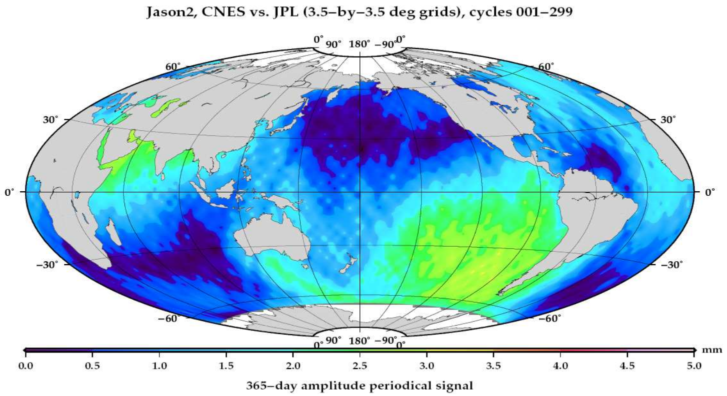


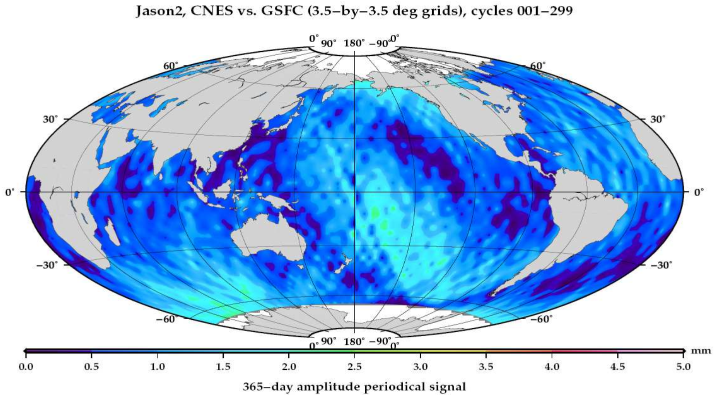
GSFC



Drift amplitude (mm/y)

-1 -0.8 -0.6 -0.4 -0.2 **0** 0.2 0.4 0.6 0.8 **1**





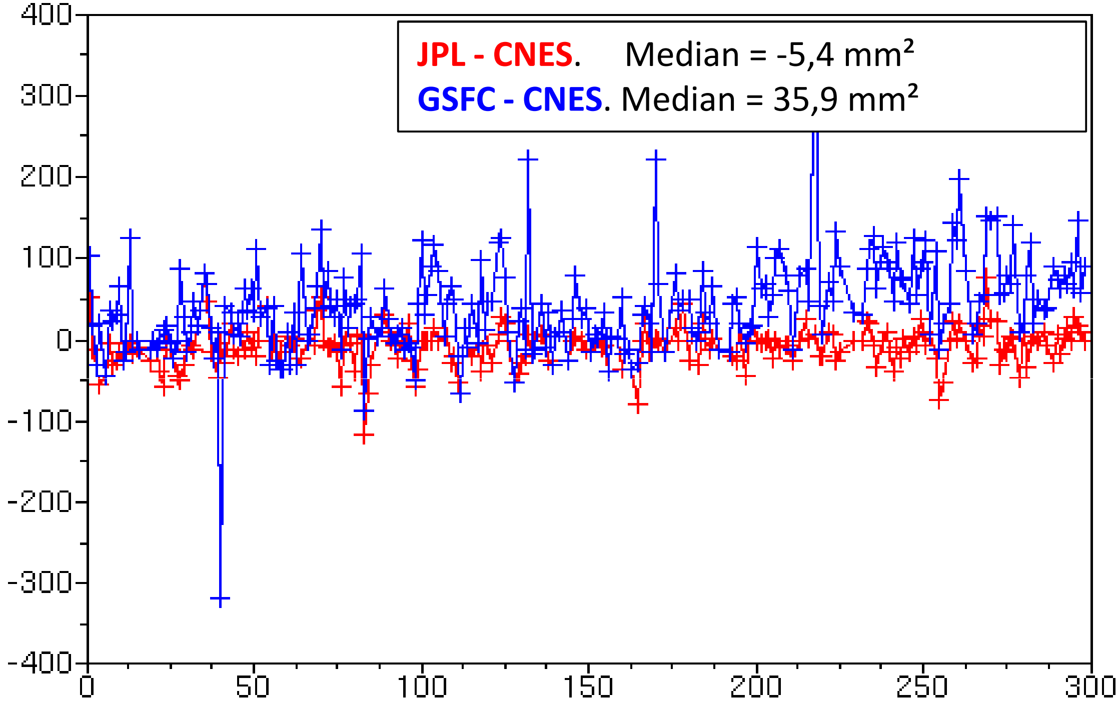
orbit centering ?

365-days amplitude periodical signal (mm)

-5 -4 -3 -2 -1 **0** 1 2 3 4 **5**

CROSSOVER

Jason2, Difference of crossover variance (mm²)



- The lower the variance, the better the solution

CONTENTS

CONCLUSION

- SAA on Jason 3 :
  - Visible impact on DORIS-only reduced dynamic orbits,
    can be lowered when estimating SAA beacons frequency drift
  - Recommandation : implement frequency drift estimation in MOE orbits computation

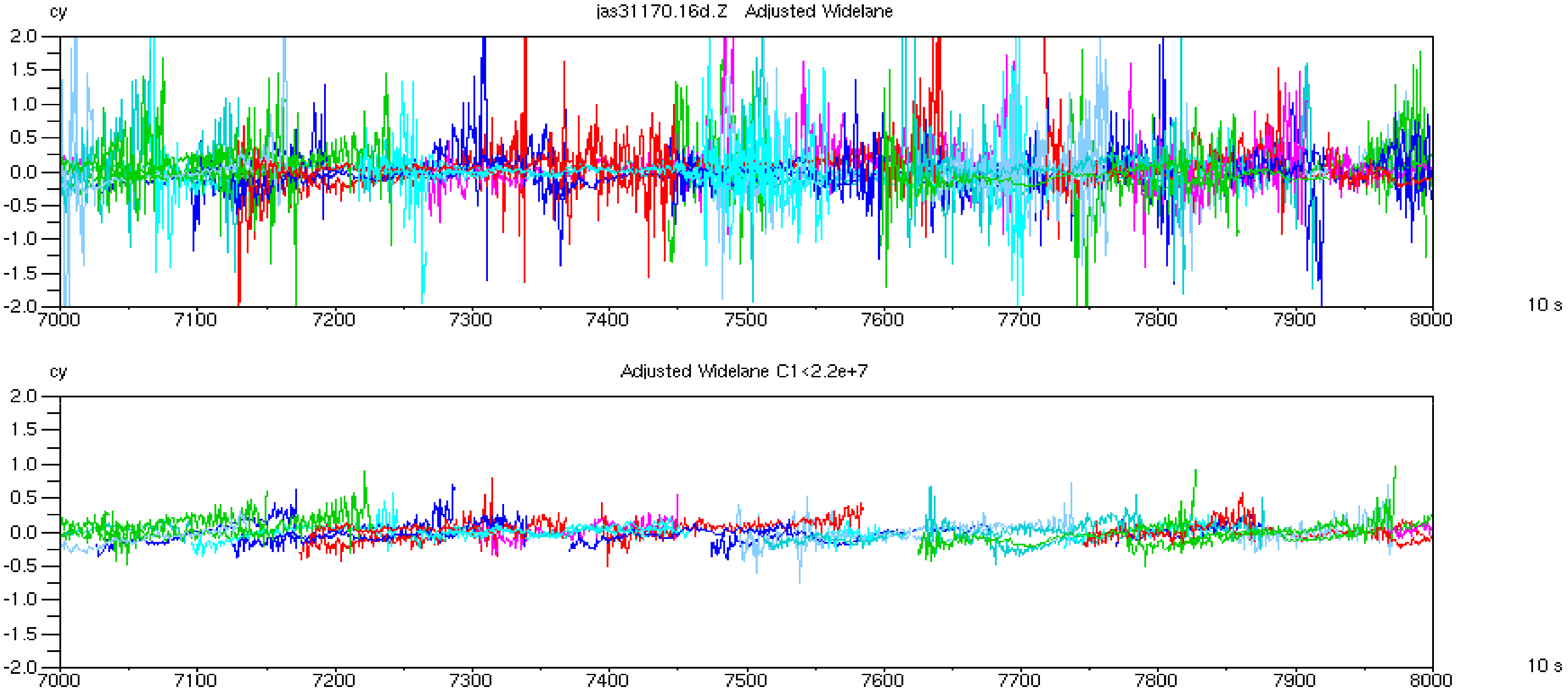
- Jason 2 : very good and stable performance
  - SLR RMS, core network : < 1 cm
  - CNES, JPL and GSFC solutions very close

- Jason 3 : getting there
  - Good radial performance (~1cm SLR RMS)
  - Differences between CNES, JPL and GSFC solutions
    - Along-track bias between CNES and JPL : GPS receiver behaviour ?
  - Improvement still possible for post-fit residuals

Thank you for your attention !

BACK UP SLIDES

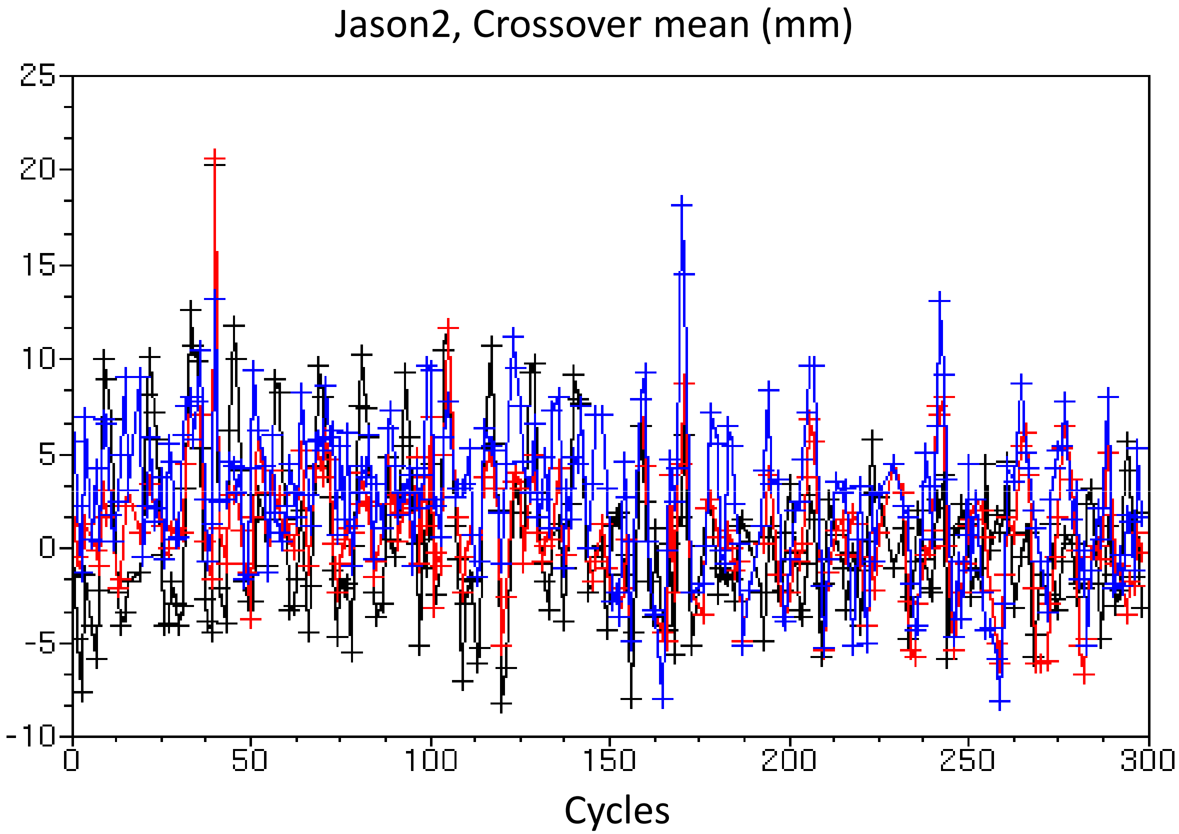
GPS BEHAVIOUR PROBLEM ?



Same run : phase measurements centered around 0
pseudo range measurements drift

Plot from F. Mercier's poster. OSTST 2016.

CROSSOVER (2/2)

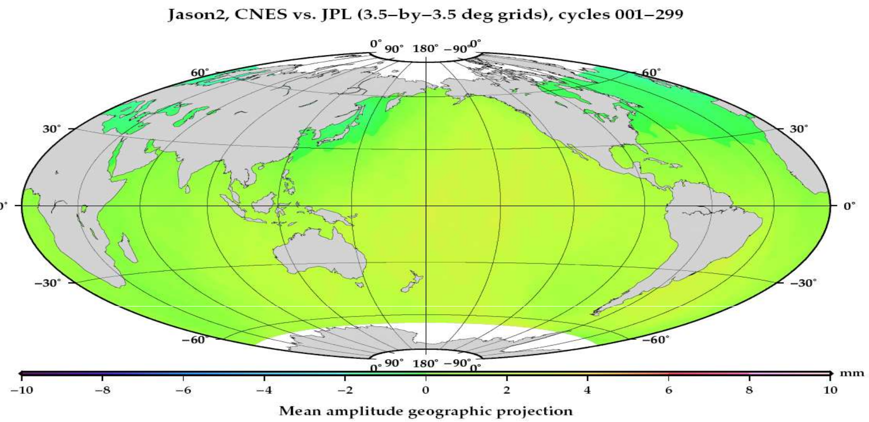


CNES	Mean = -0,39 mm	RMS = 4,5 mm
JPL	Mean = 0,62 mm	RMS = 3,55 mm
GSFC	Mean = 2,92 mm	RMS = 4,9 mm

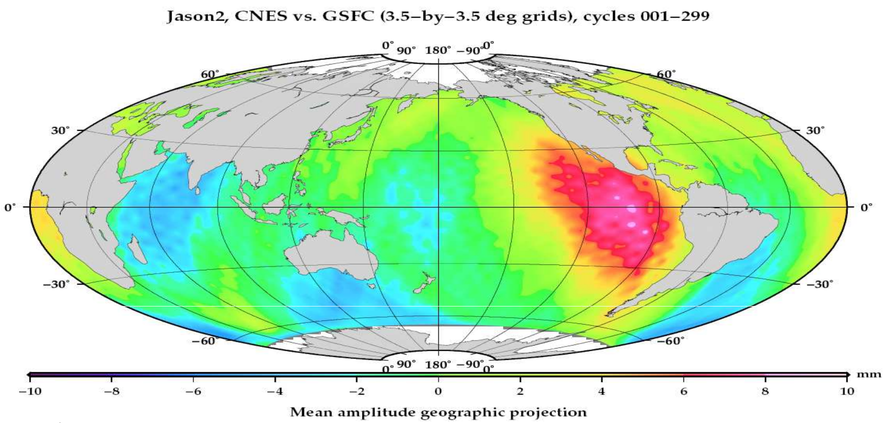
- Crossover mean enables to evaluate the (X,Y) centering of an orbit
- Centering and noise are equivalent on the different solutions

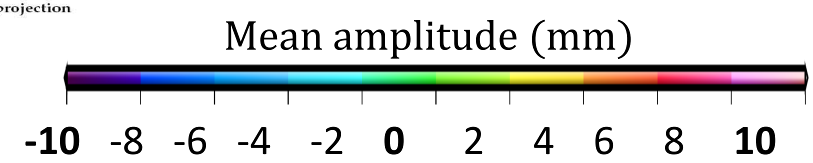
JASON 2 : GEOGRAPHICALLY CORRELATED ERRORS

JPL



GSFC





AGING OF THE GRAVITY FIELD

Gravity field used

EIGEN-GRGS.RL03-v2.MEAN-FIELD

- Non-tidal TVG, up to deg/ord 80
- one annual, one semiannual, one bias and one drift terms for each year
- Ajusted on data until July 2014

Comparisons of the GDR-E field to the Grace series

- CSR
- GRGS

Conclusion

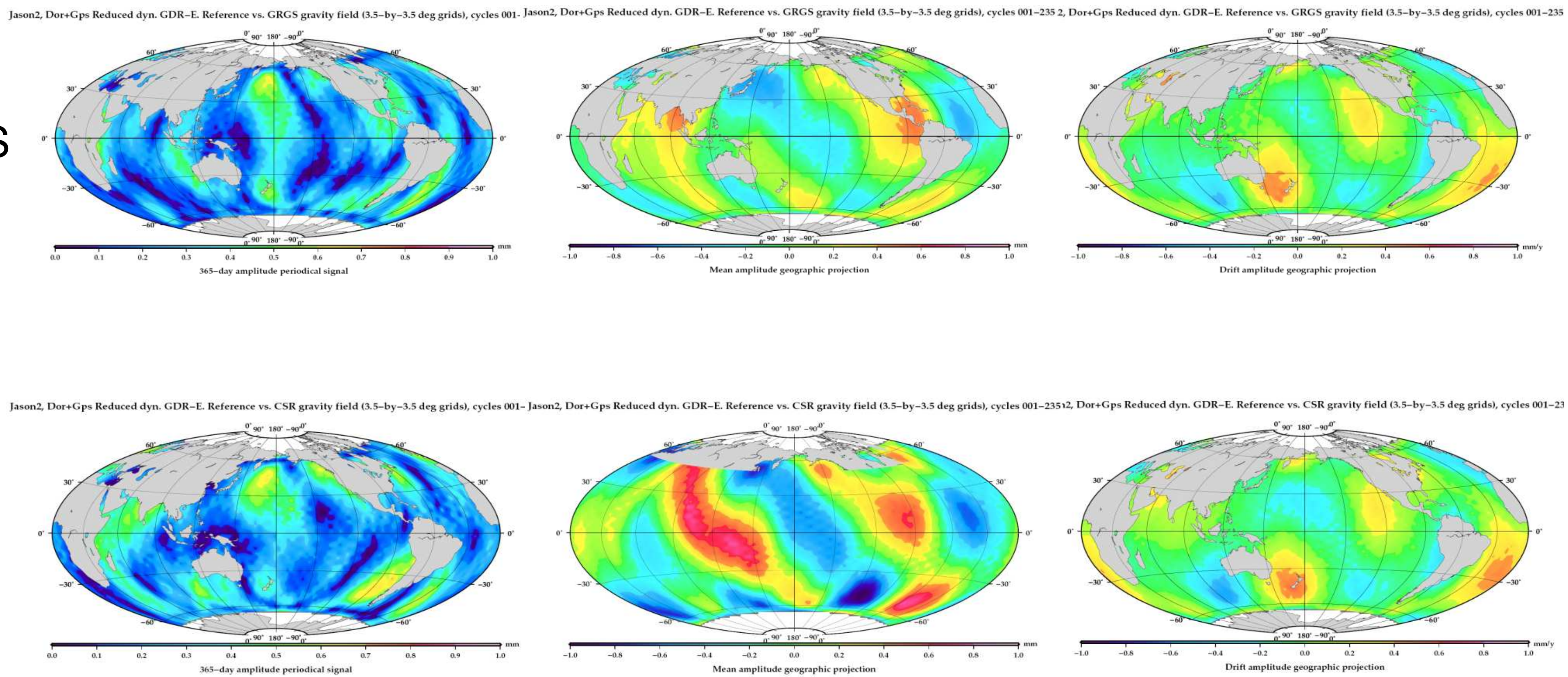
- geographically correlated radial orbit differences very small
- Drift <1 mm/y, mean <1mm and annual signal <1mm

AGING OF THE GRAVITY FIELD (2)

365-day amplitude periodical signal (mm)	Mean amplitude (mm)	Drift amplitude (mm/y)
0.0 0.1 0.2 0.3 0.4 **0.5** 0.6 0.7 0.8 0.9 **1.0**	**-1.0** -0.8 -0.6 -0.4 -0.2 **0.0** 0.2 0.4 0.6 0.8 **1.0**	**-1.0** -0.8 -0.6 -0.4 -0.2 **0.0** 0.2 0.4 0.6 0.8 **1.0**

GRGS

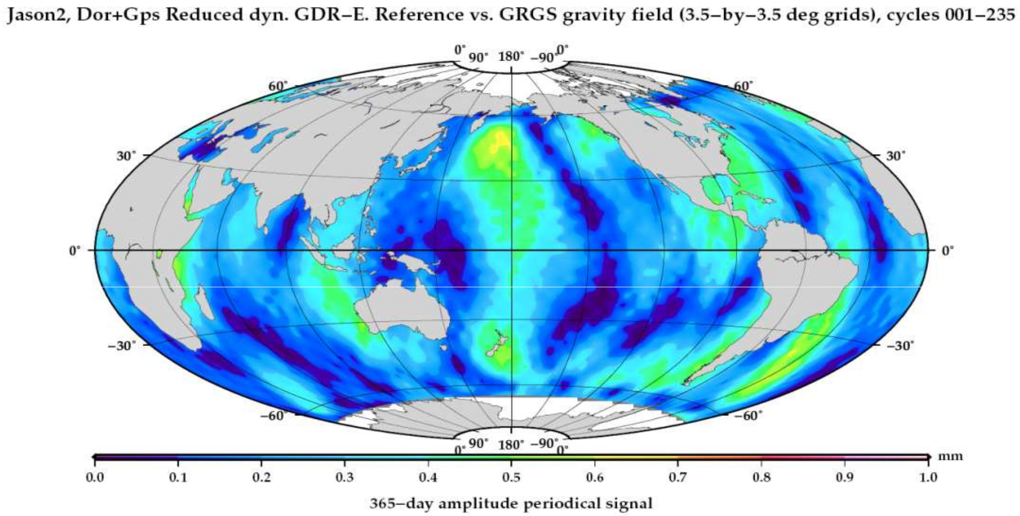
CSR

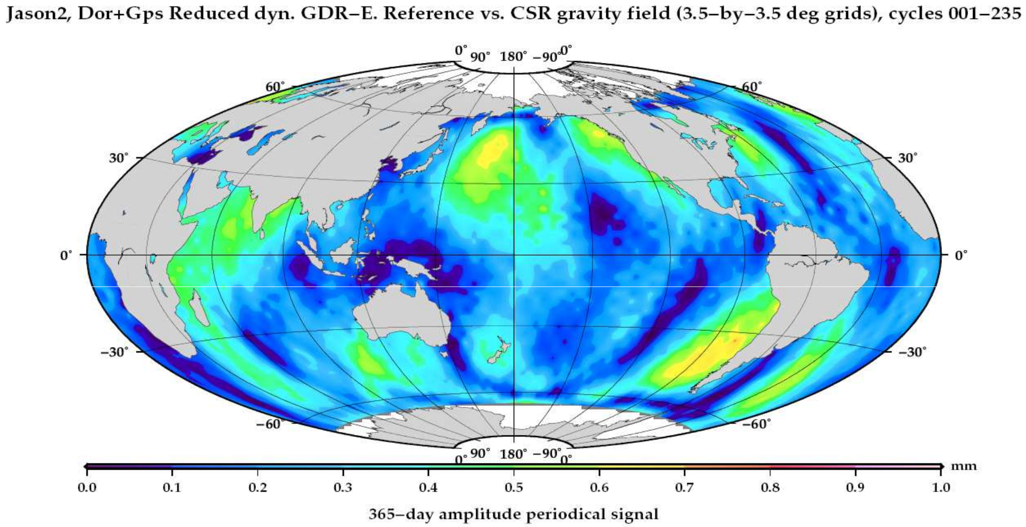


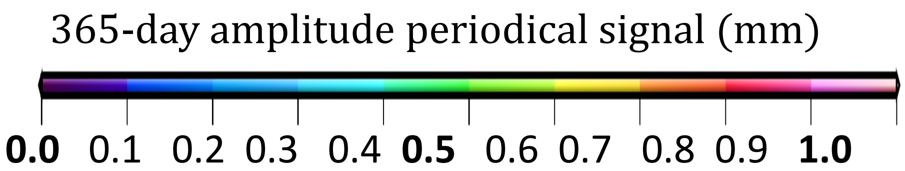
AGING OF THE GRAVITY FIELD (2)
AMPLITUDE OF THE ANNUAL SIGNAL

GRGS

CSR



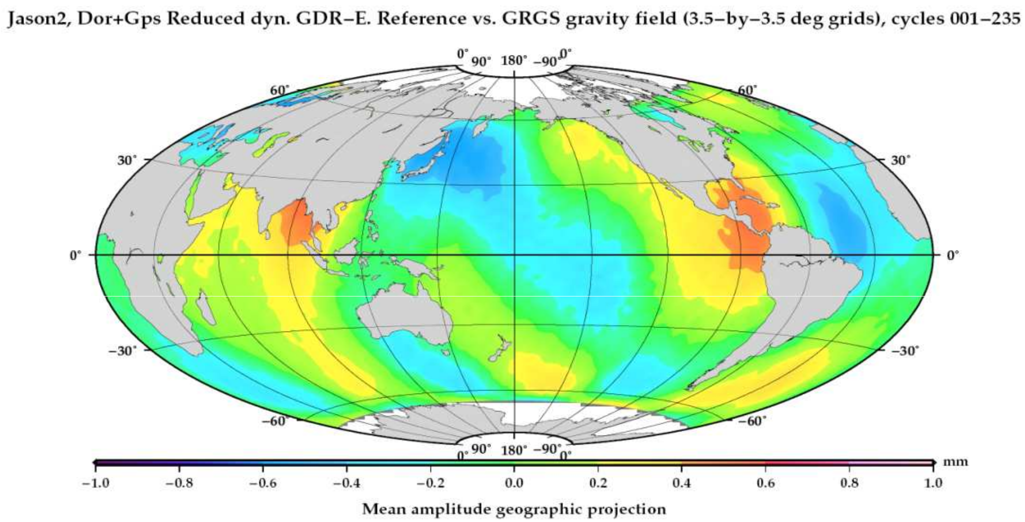


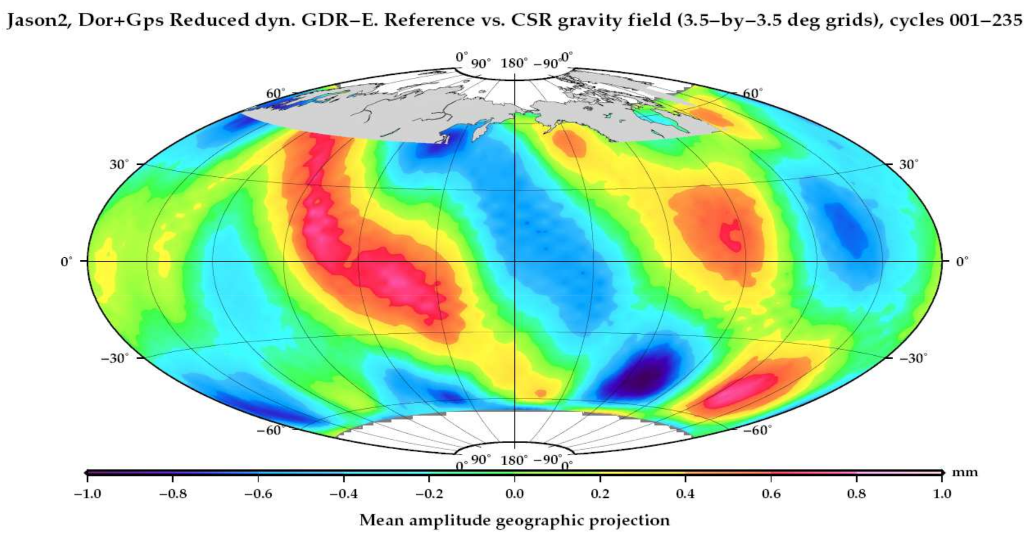


AGING OF THE GRAVITY FIELD (3)
MEAN AMPLITUDE

GRGS

CSR



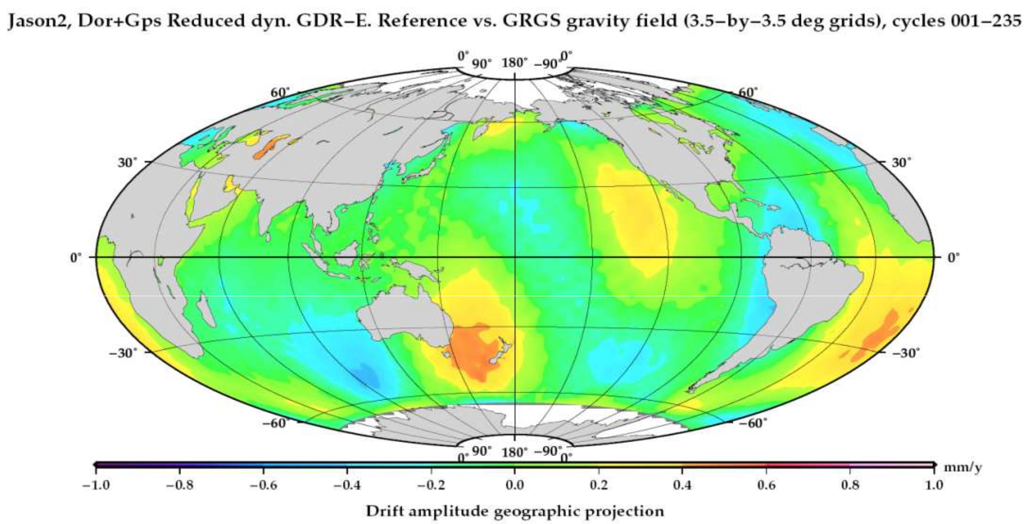


Mean amplitude (mm)

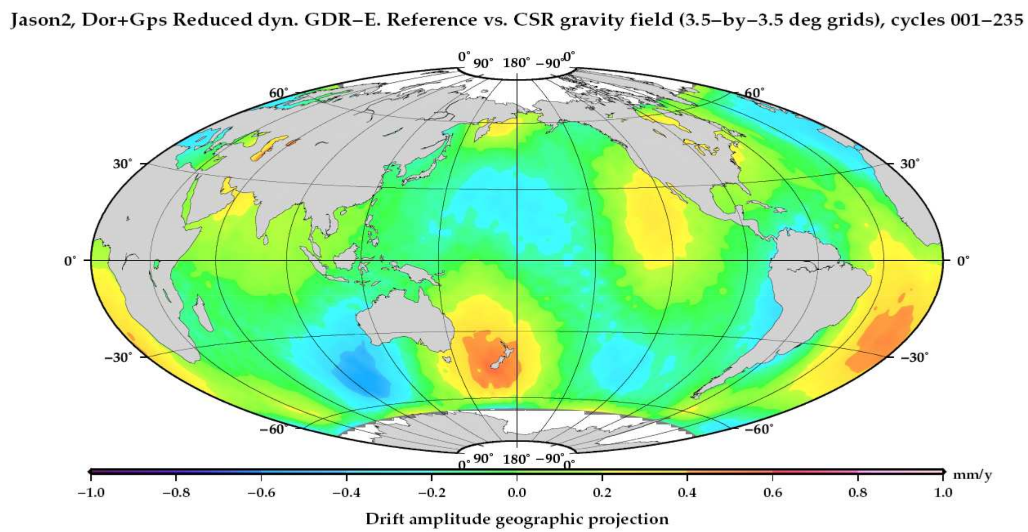
-1.0 -0.8 -0.6 -0.4 -0.2 **0.0** 0.2 0.4 0.6 0.8 **1.0**

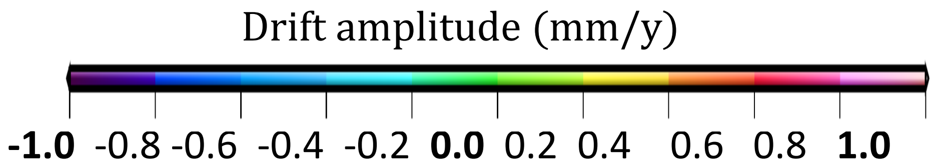
AGING OF THE GRAVITY FIELD (4)
DRIFT AMPLITUDE

GRGS



CSR





AGING OF THE GRAVITY FIELD (5)
CONCLUSION

EIGEN-GRGS.RL03-v2.MEAN-FIELD behaviour is satisfying

SAA IMPACT ON JASON 2 :
EFFET OF ANOTHER EQUIVALENT SUB-NETWORK

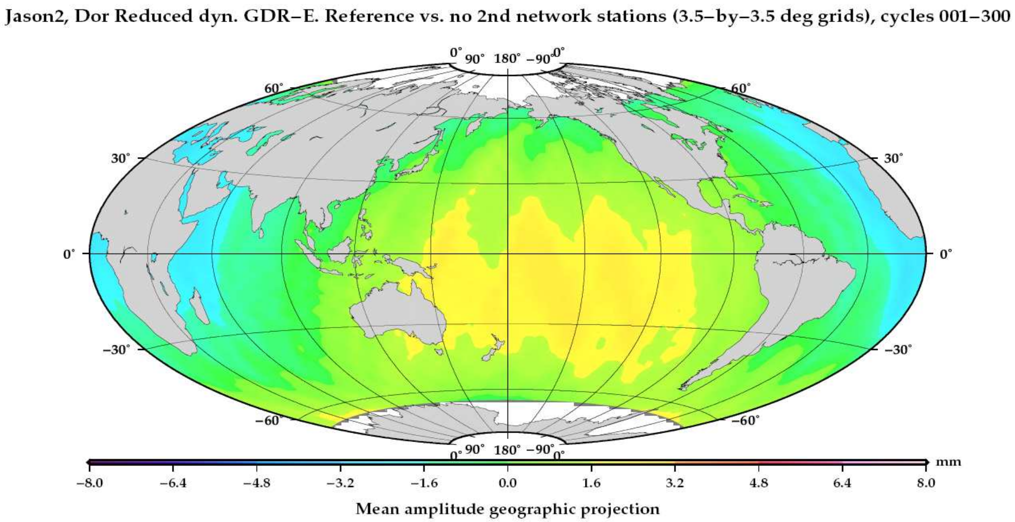
- DORIS SAA stations considered :

LICB TRJB DJIB MAIB MALB REUB HBMB
AMVB YASB MAUB KEUC CRQB HEMB SYQB

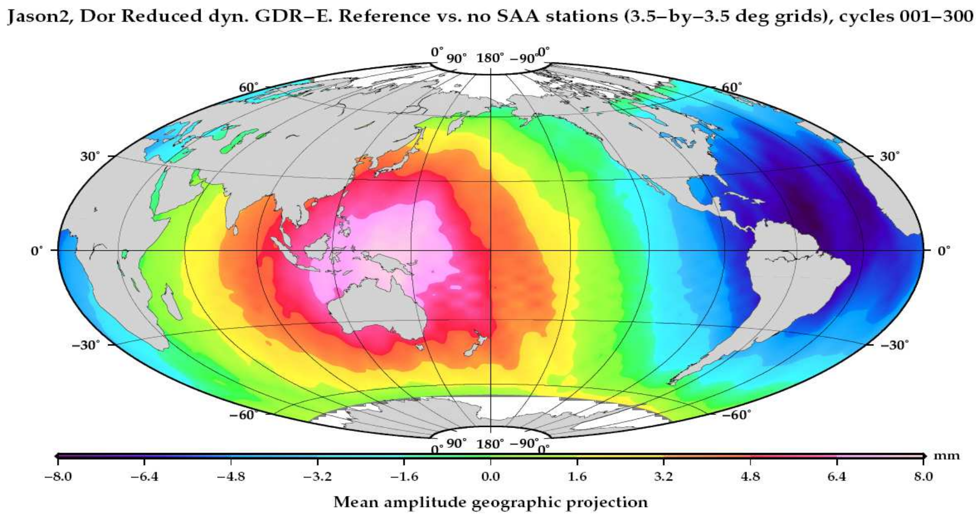
- Impact of modifying the network :
  - no SAA stations : up to 8 mm
  - no stations from another sub-network : up to 3 mm

- Therefore SAA impact up to 5 mm left on Jason 2
  → significantly lower than the effect on Jason 3 (2cm)

No stations from the newsub-network



No stations from SAA



SAA IMPACT ON JASON 3 : ESTIMATING THE FREQUENCY DRIFT

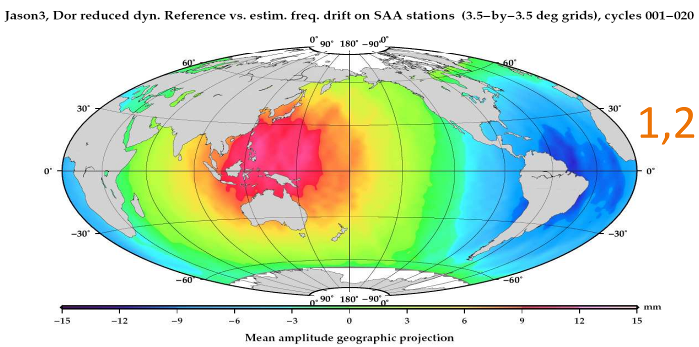
- Is it possible to correct the SAA error ?
- Estimation of the beacon frequency drift on SAA station to account for the on-bord frequency drift
- 2 effects : **SAA** (Jason3 : 1,2 cm, Jason2 : 5mm) and **network** changes (Jason3 : 8 mm, Jason2 : 3mm)

- Comparaison of this « frequency drift estimated » orbit to
  1. Reference orbit (with SAA stations) : no network changes. Expectations : correction of SAA effect
  2. Orbit without SAA stations : no SAA effect. Expectations : network changes effect

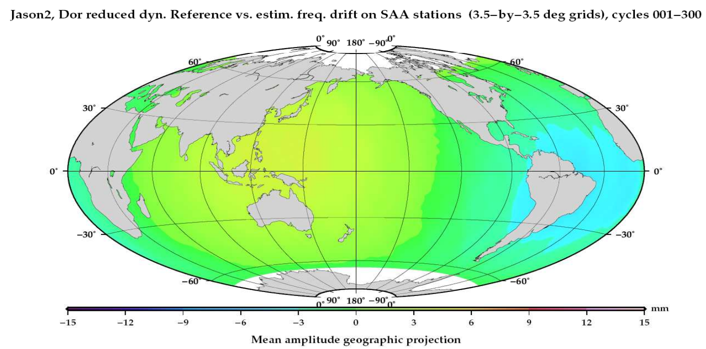
Jason 3

Jason2

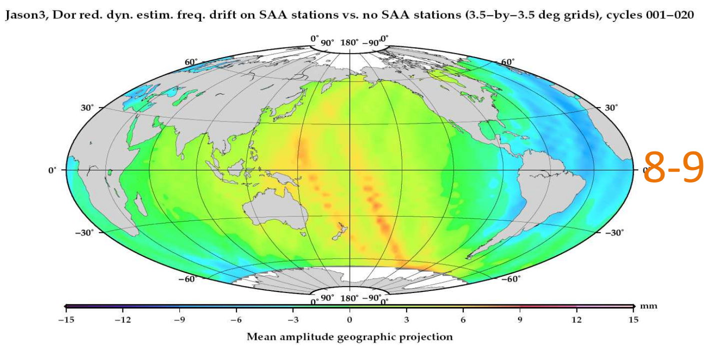
1.



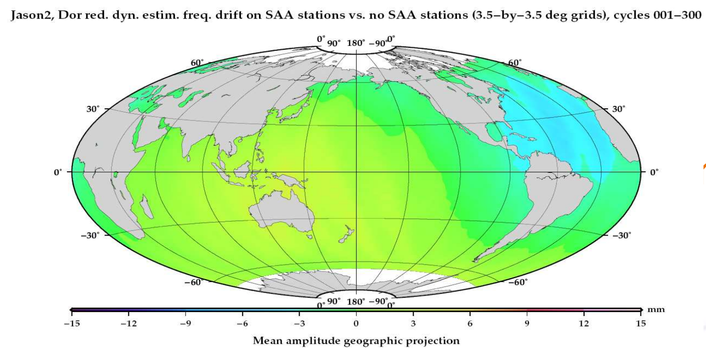
1,2 cm



2.



8-9 mm



SAA IMPACT ON JASON 3 : ESTIMATING THE FREQUENCY DRIFT

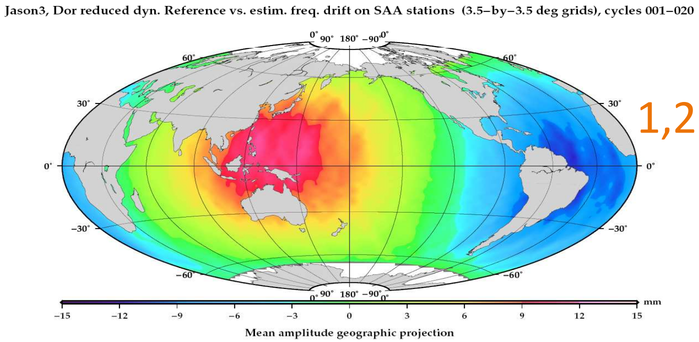
- Is it possible to correct the SAA error ?
- Estimation of the beacon frequency drift on SAA station to account for the on-bord frequency drift
- 2 effects : **SAA** (Jason3 : 1,2 cm, Jason2 : 5mm) and **network** changes (Jason3 : 8 mm, Jason2 : 3mm)

- Comparaison of this « frequency drift estimated » orbit to
  1. Reference orbit (with SAA stations) : no network changes. Expectations : correction of SAA effect
  2. Orbit without SAA stations : no SAA effect. Expectations : network changes effect

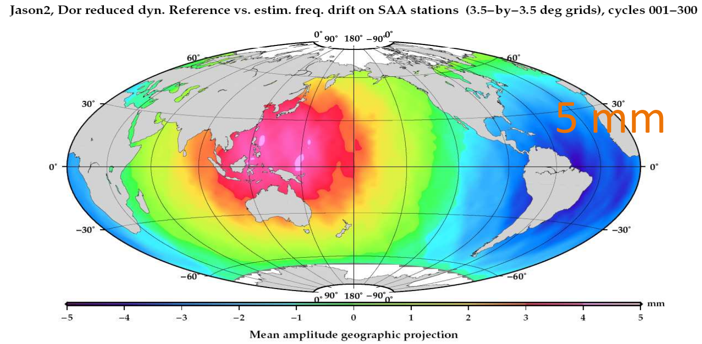
Jason 3

Jason2

1.

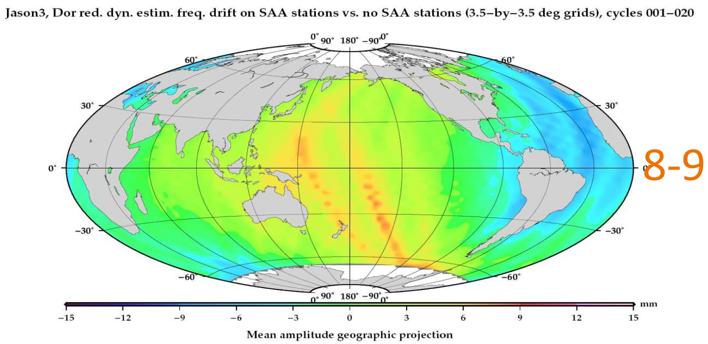


1,2 cm

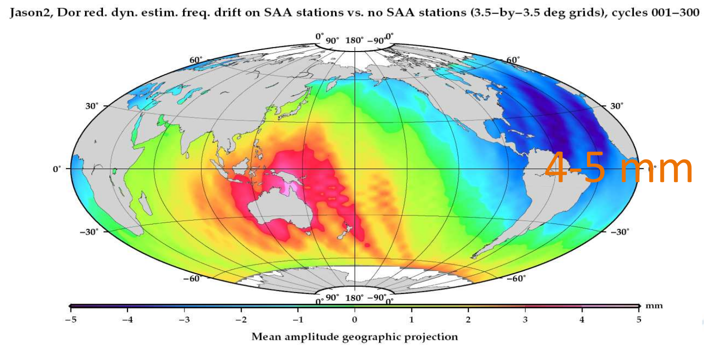


5 mm

2.

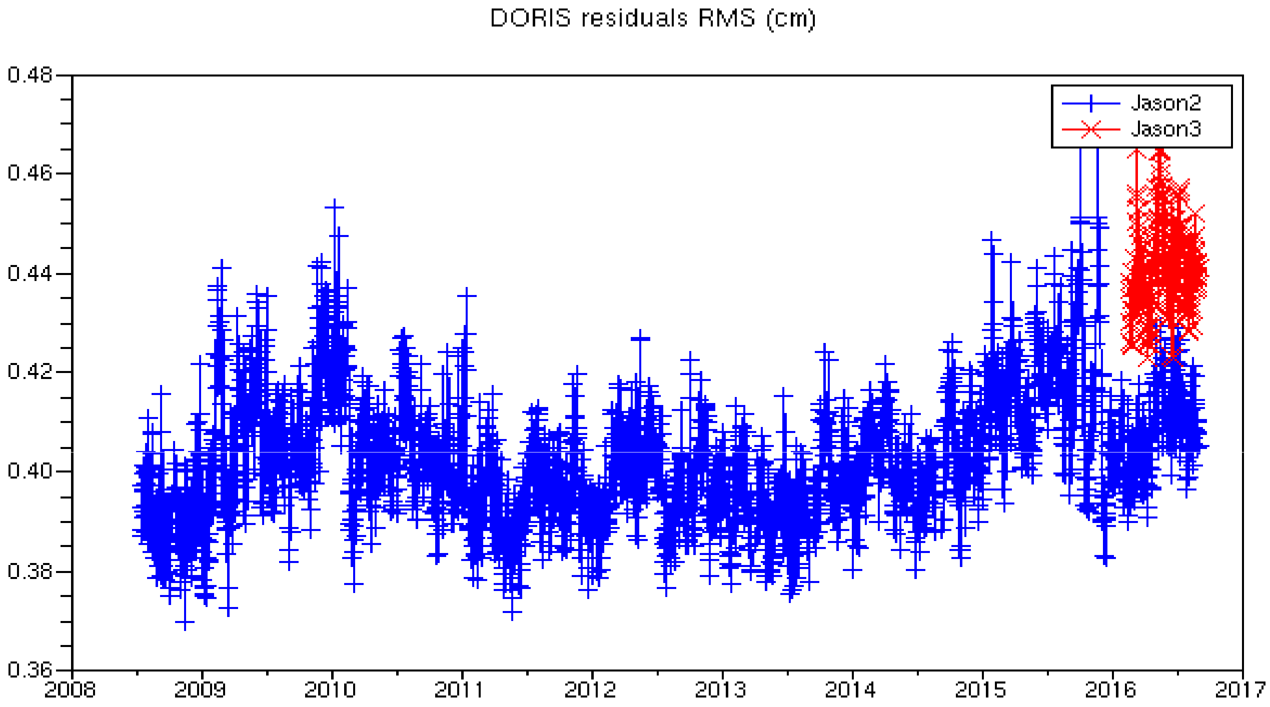


8-9 mm



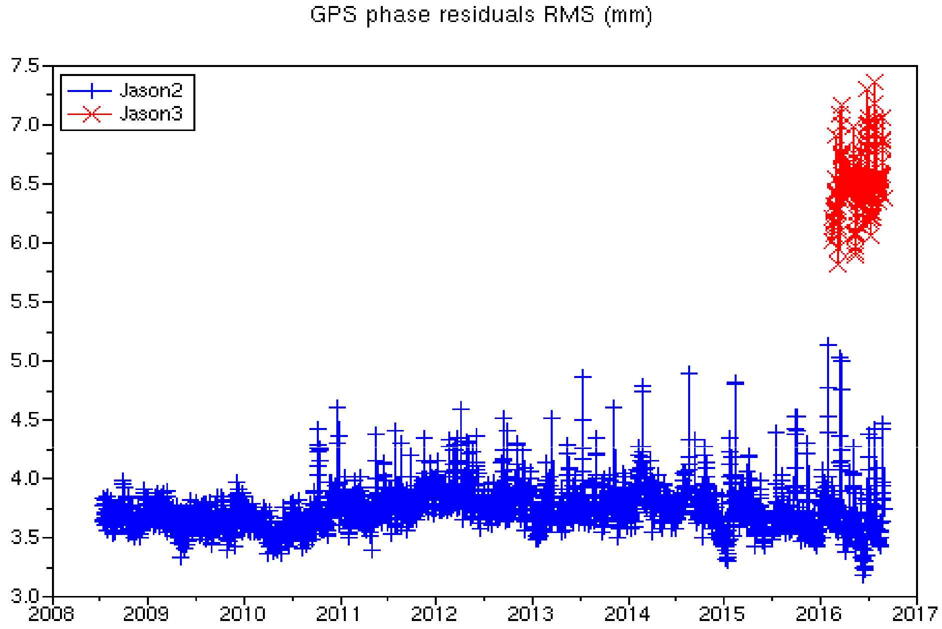
4-5 mm

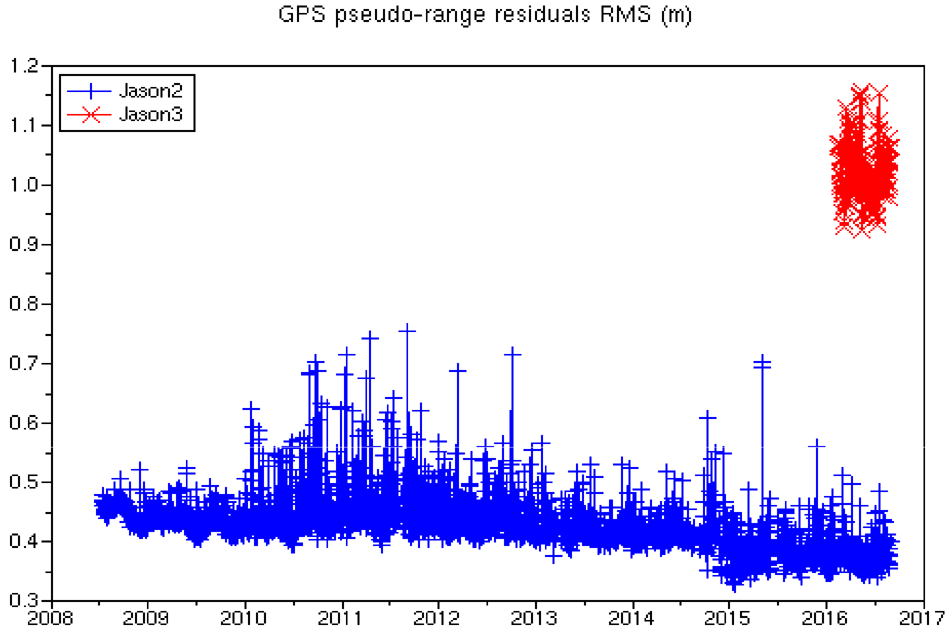
MEASUREMENTS RMS : DORIS



- Jason 2 : Stable performance
- Jason 3 : larger RMS values

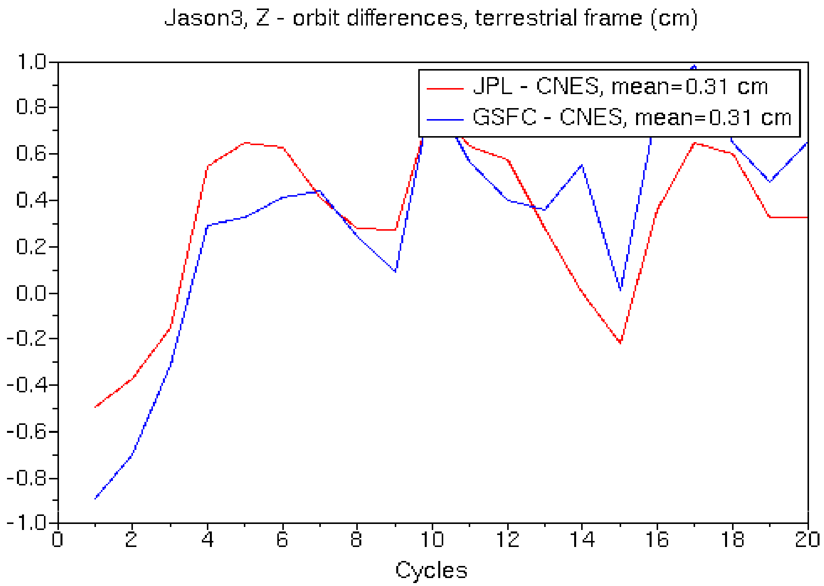
MEASUREMENTS RMS : GPS

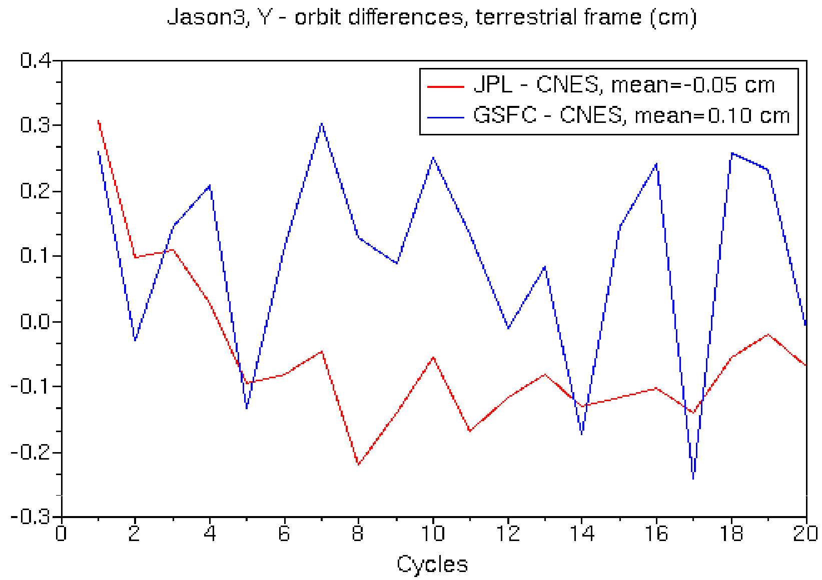


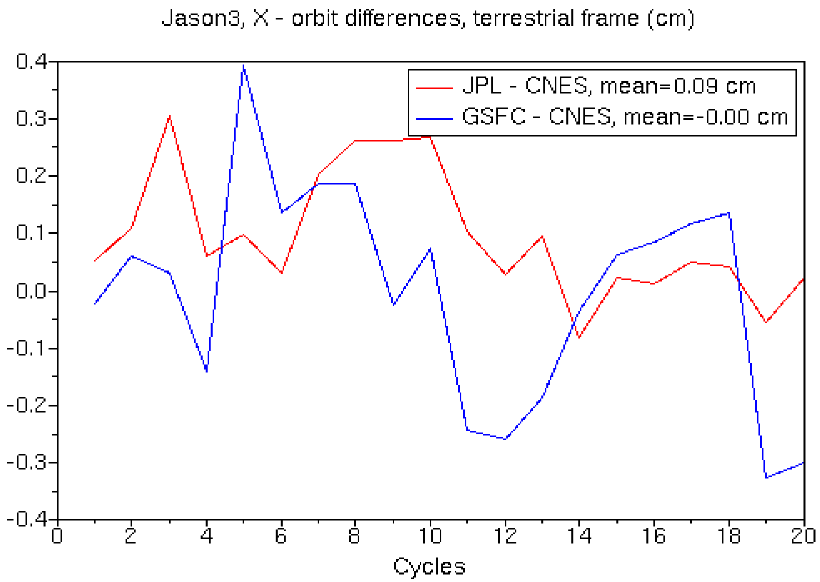


- Jason 2 : Stable performance
- Jason 3 : larger RMS values

JASON3, ORBIT DIFFERENCE, TERRESTRIAL FRAME

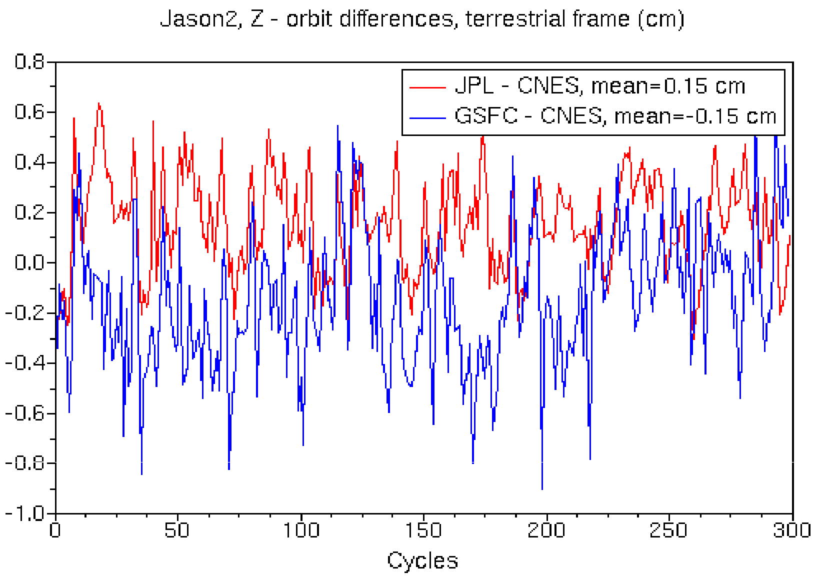


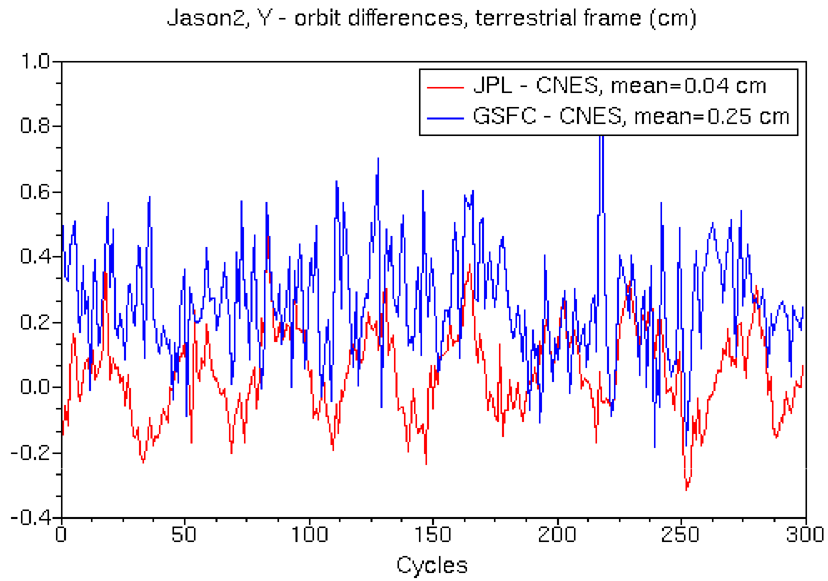


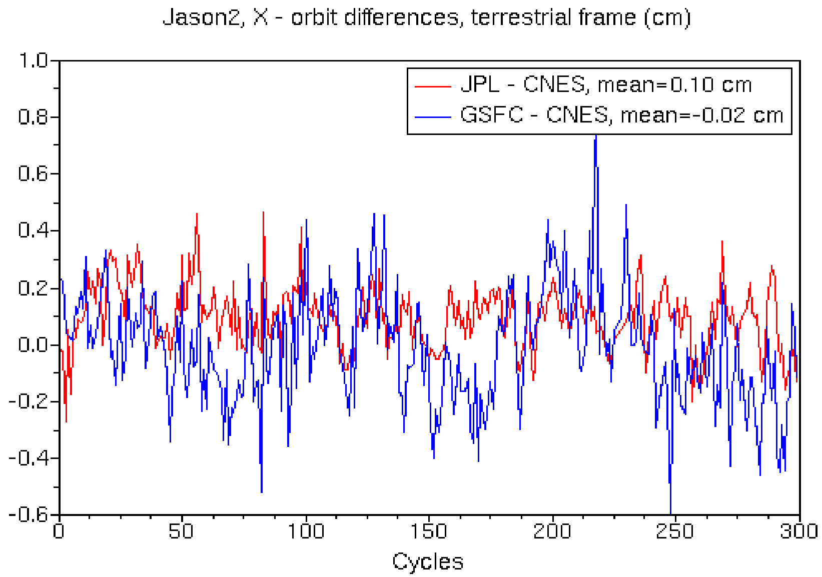


Orbit centering differences

JASON2, ORBIT DIFFERENCE, TERRESTRIAL FRAME



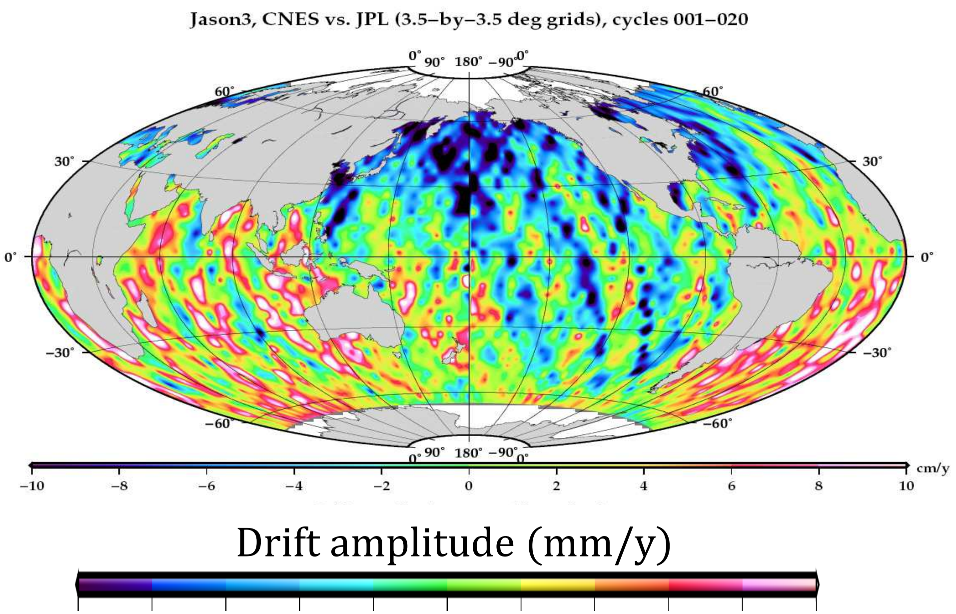




Orbit centering differences

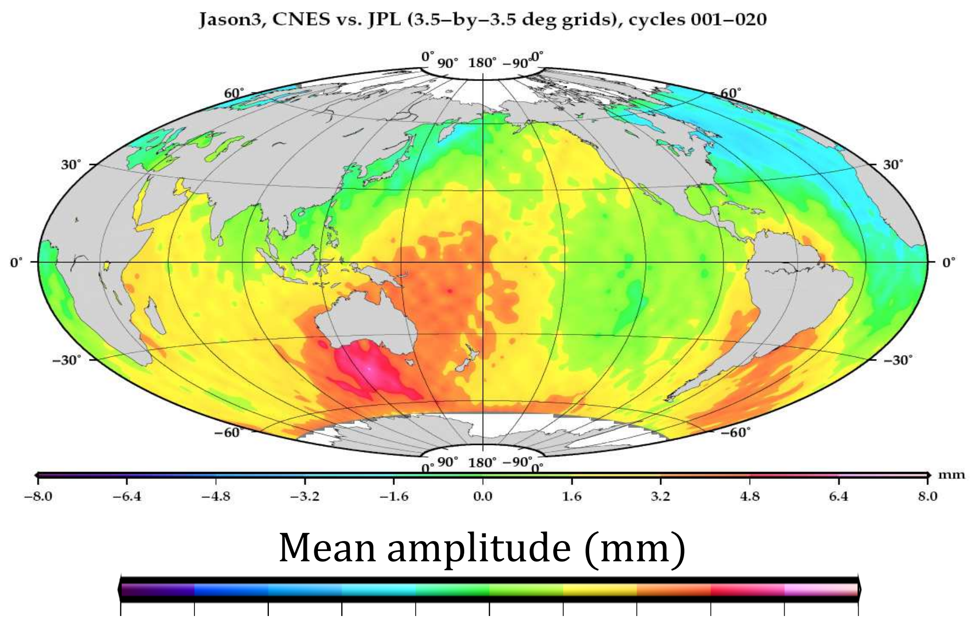
!

JASON 3 : GEOGRAPHICALLY CORRELATED ERRORS



Drift amplitude (mm/y)

-10 -8 -6 -4 -2 **0** 2 4 6 8 **10**

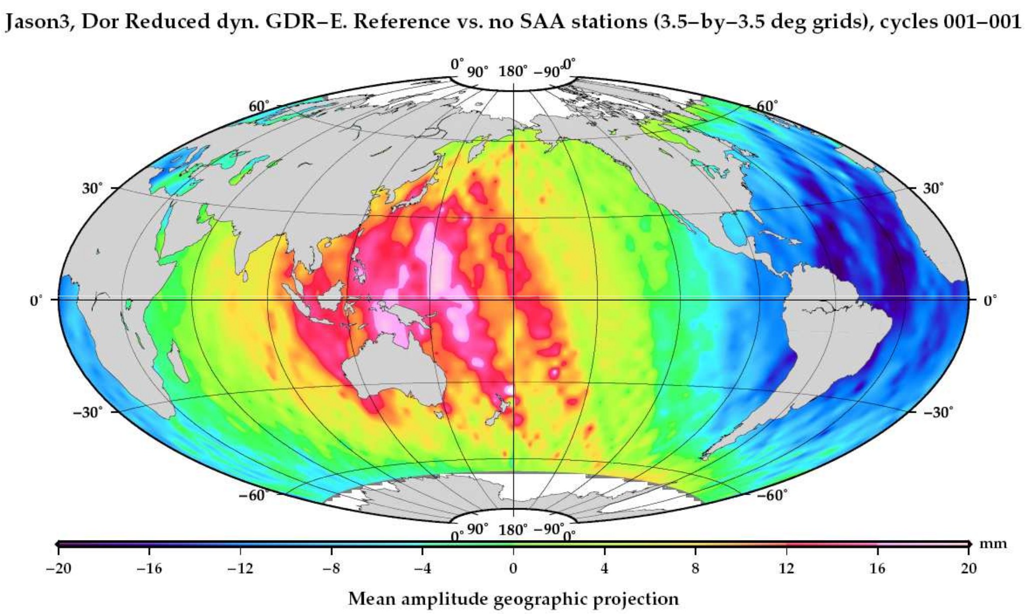


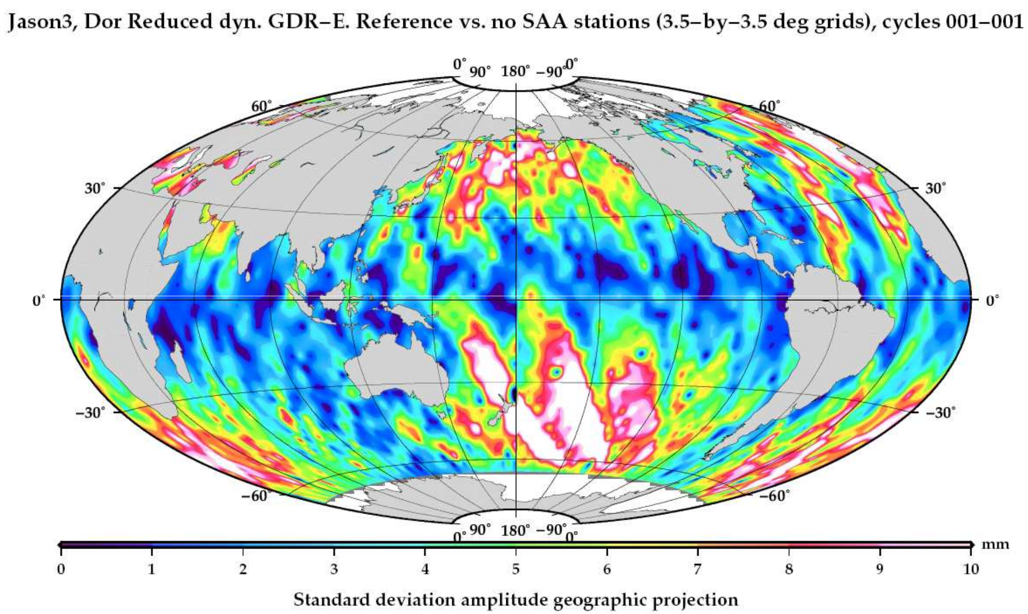
Mean amplitude (mm)

-8 -6.4 -4.8 -3.2 -1.6 **0** 1.6 3.2 4.8 6.4 **8**

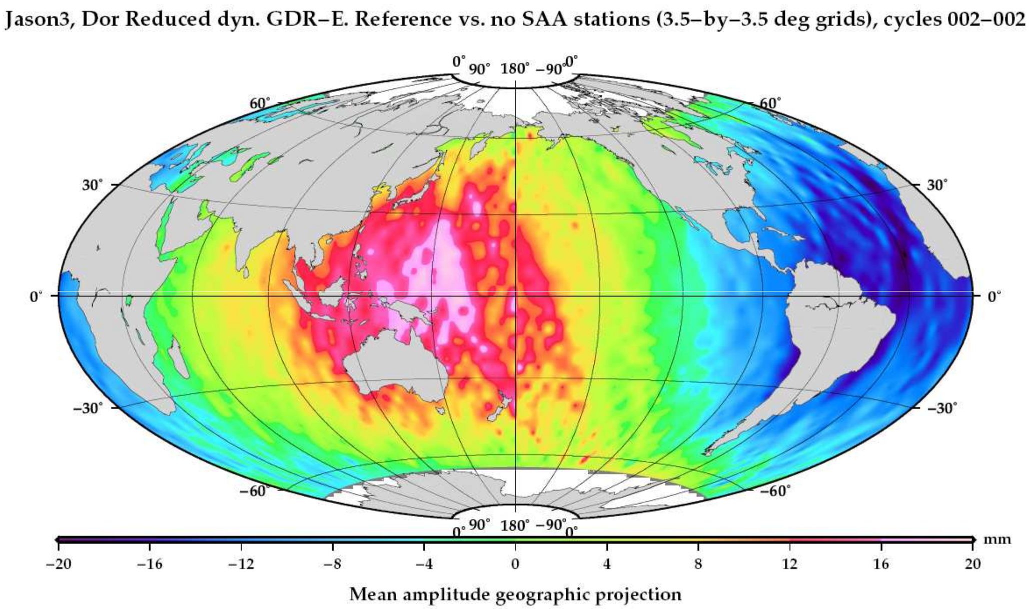
- Drift and annual signal not observable yet (only 200 days of data)
- Small mean (<1cm, locally up to 7 mm, globally up to 3 mm)

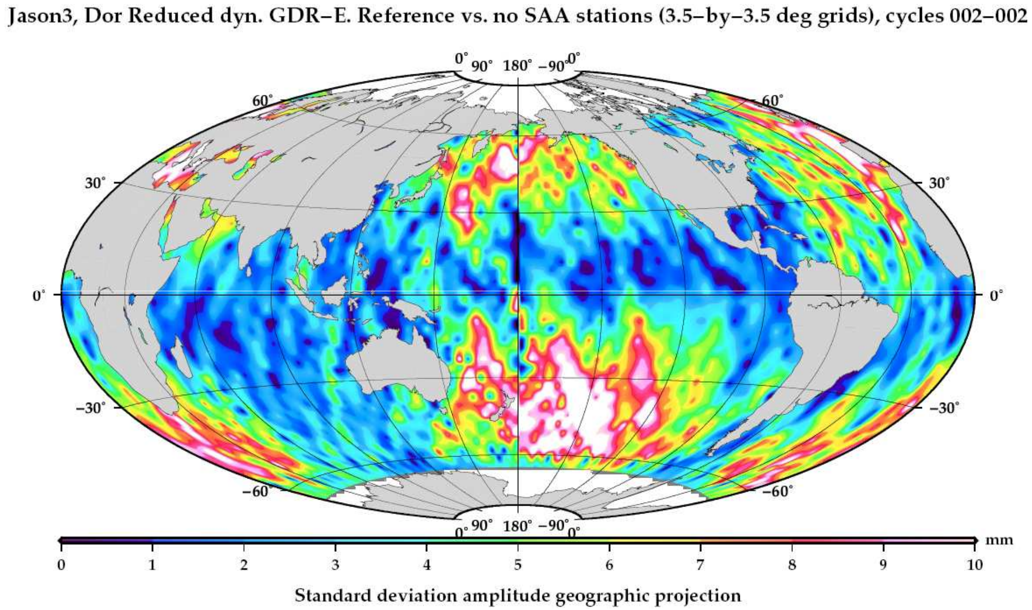
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)





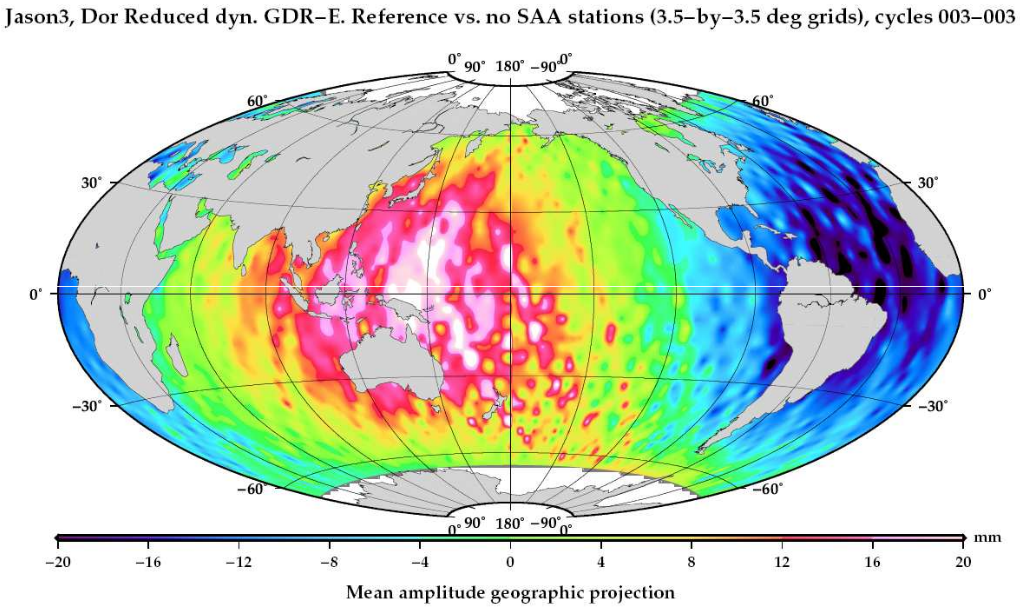
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)

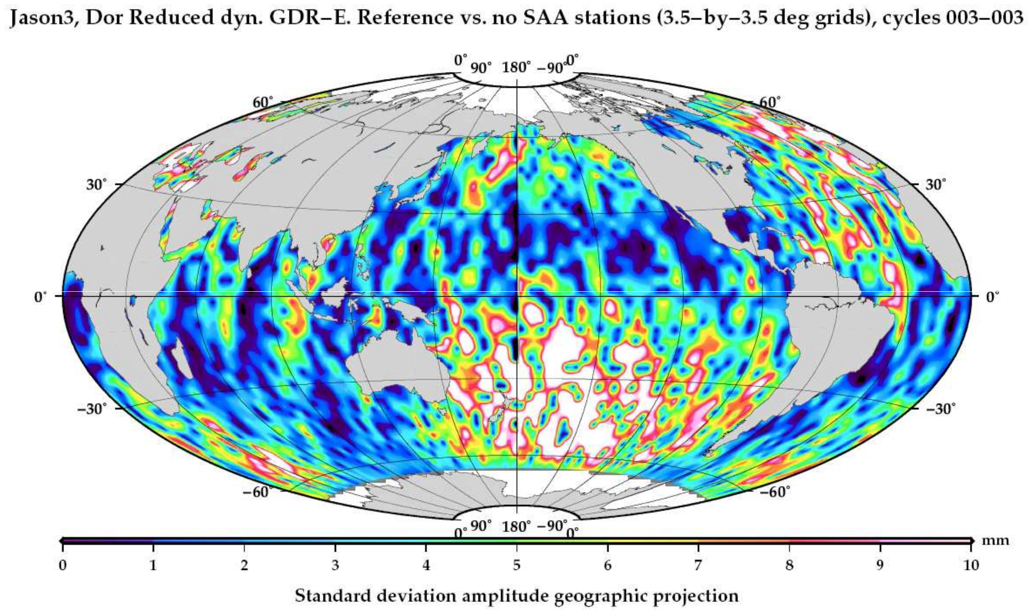




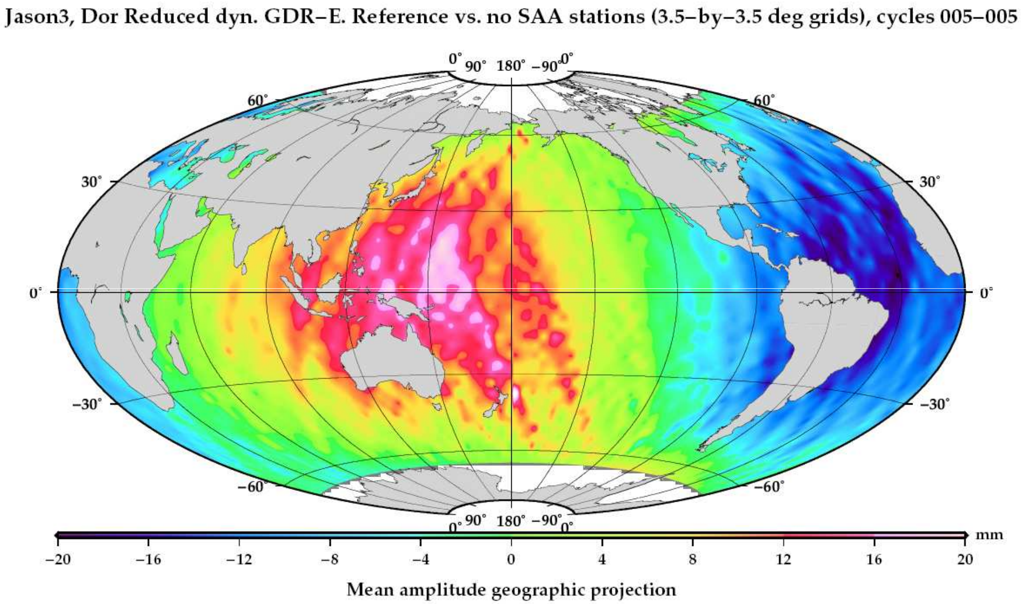
cnes

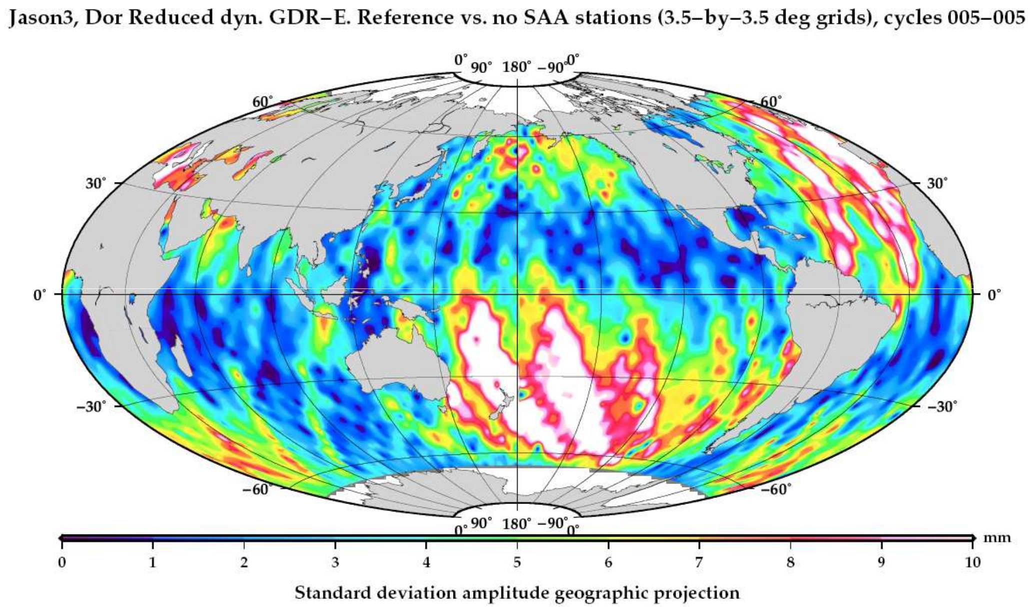
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)



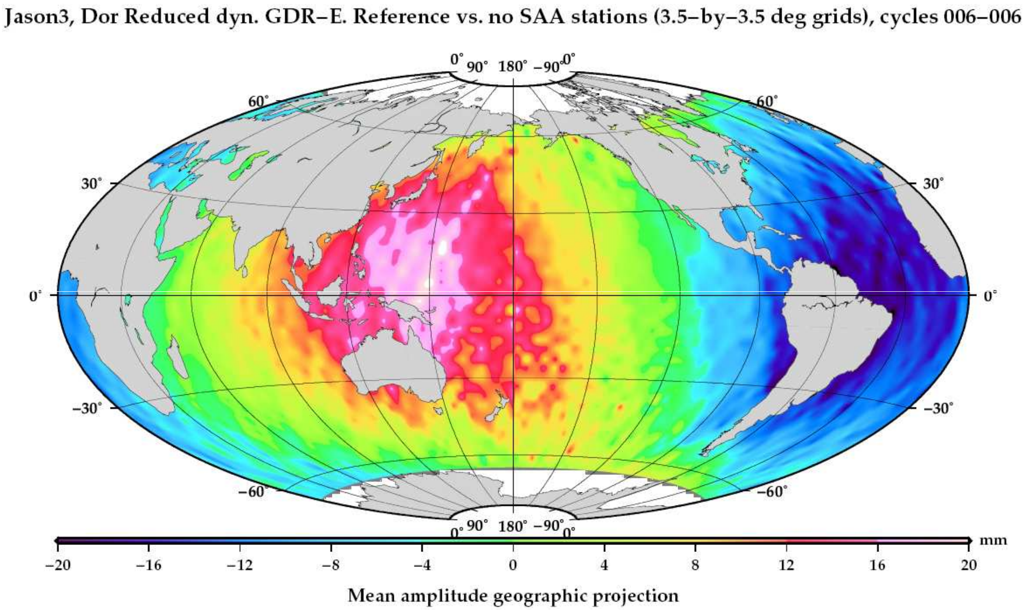


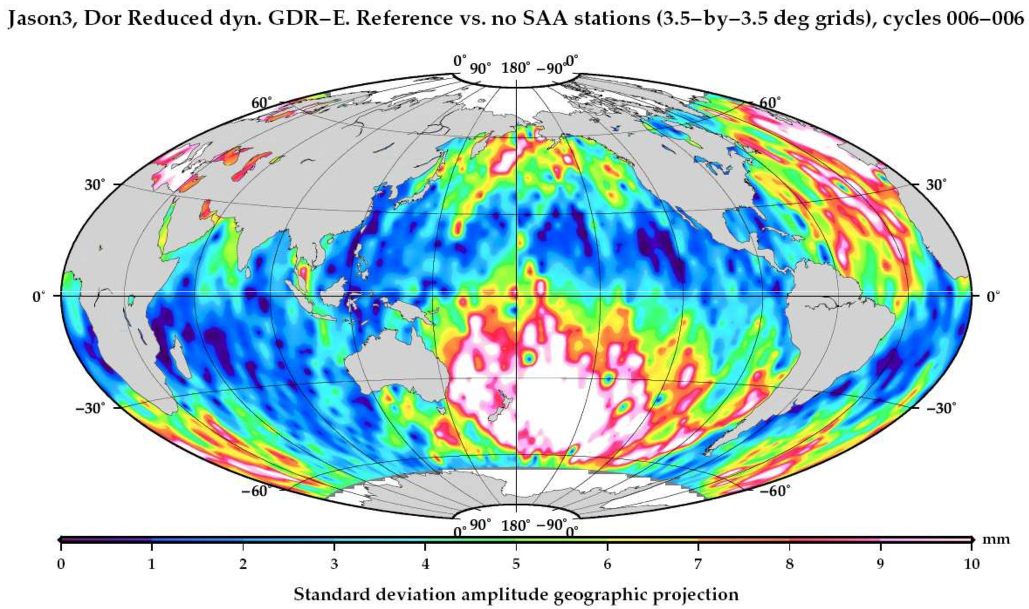
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)



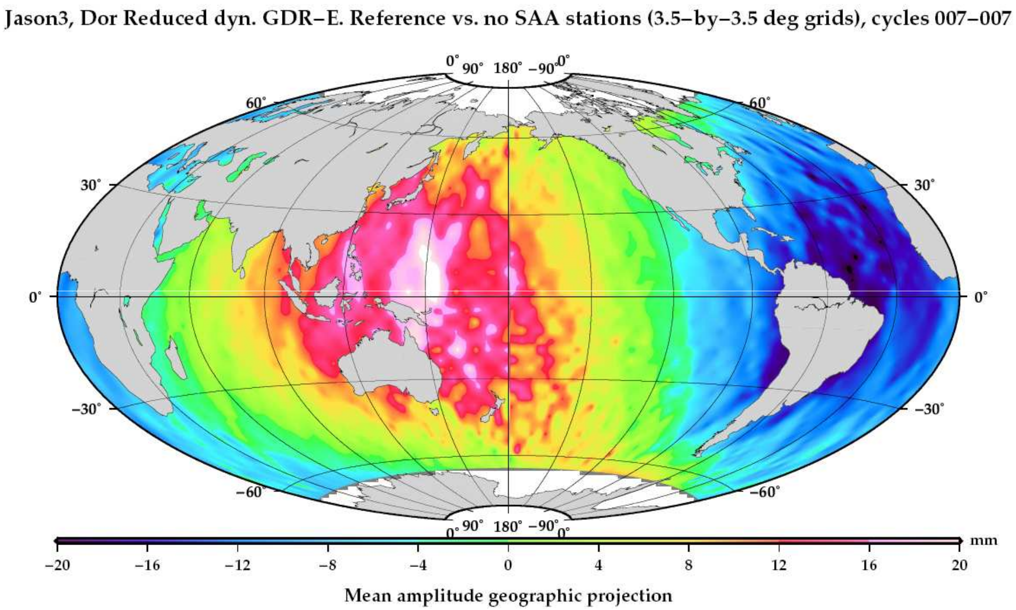


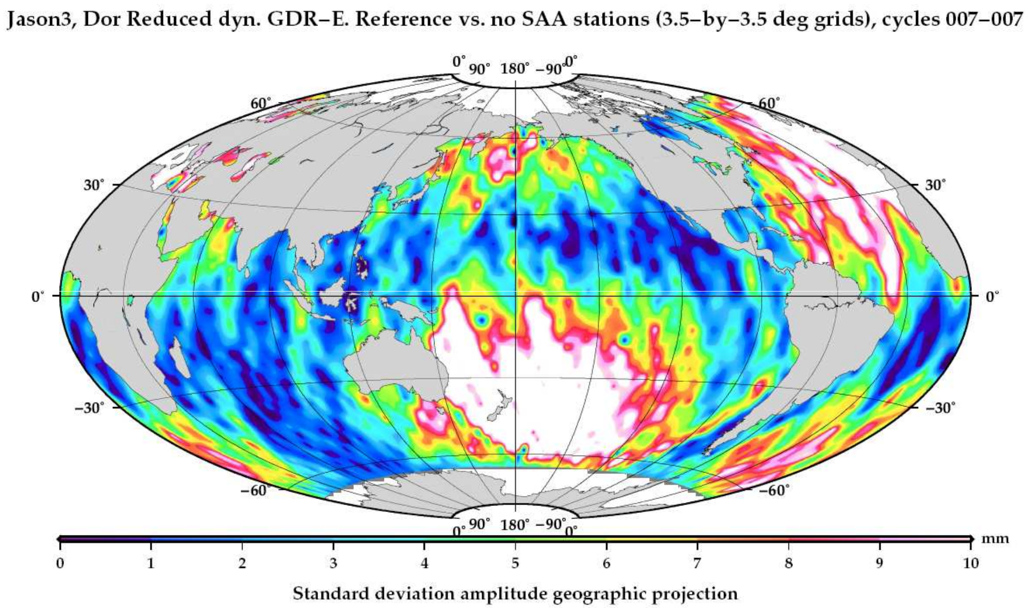
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)



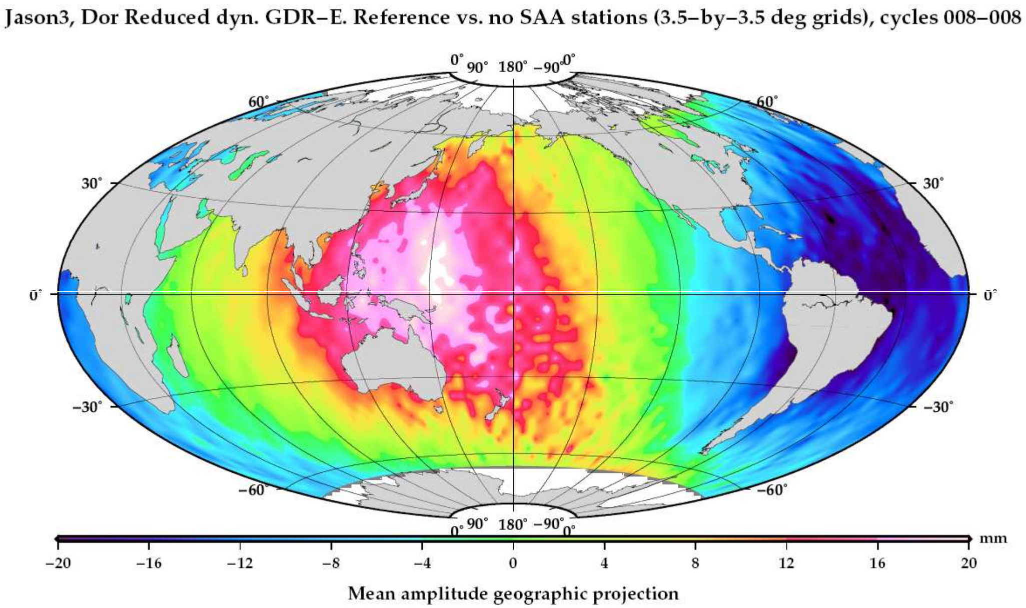


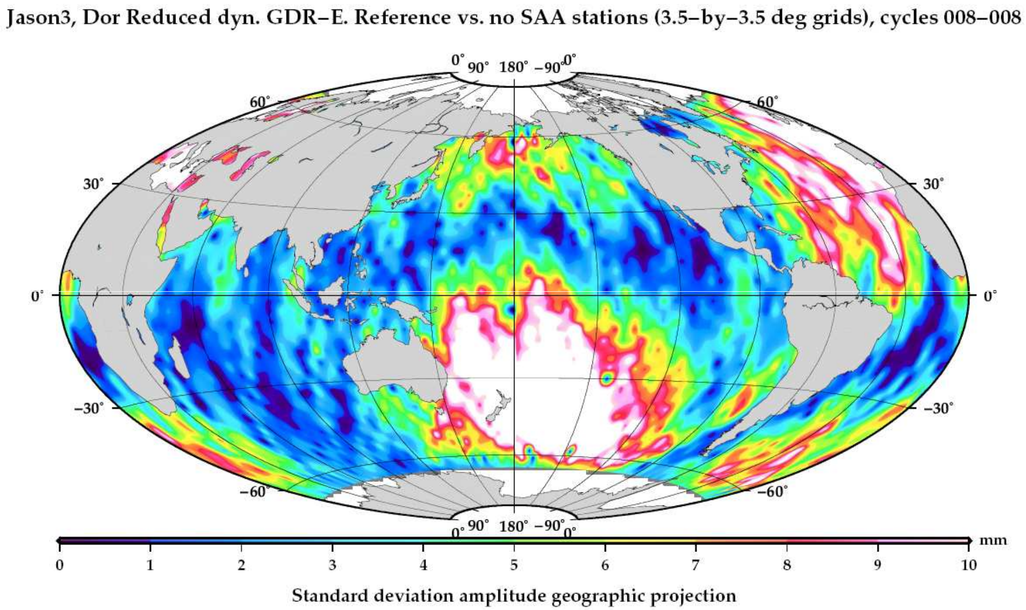
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)



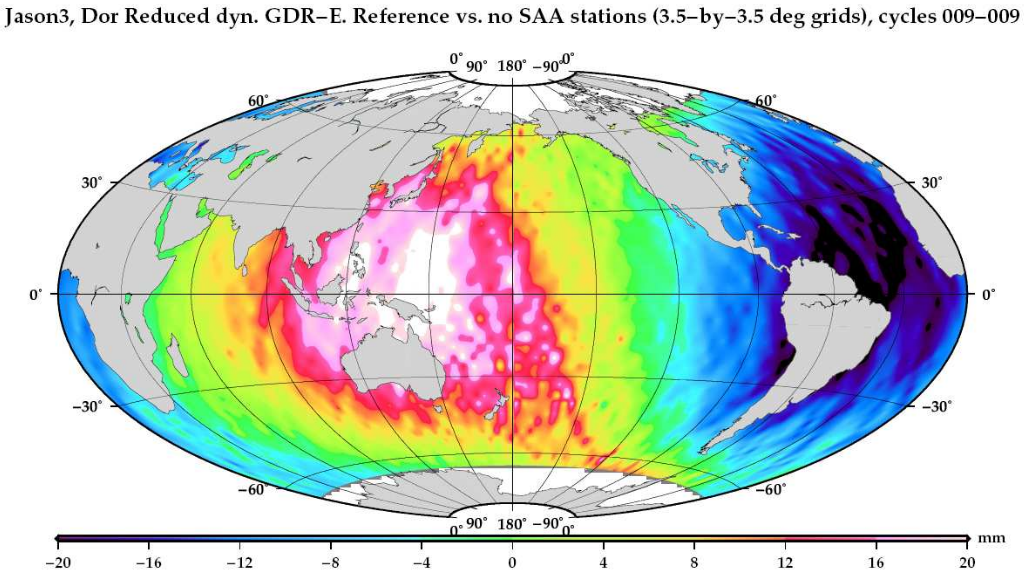


SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)

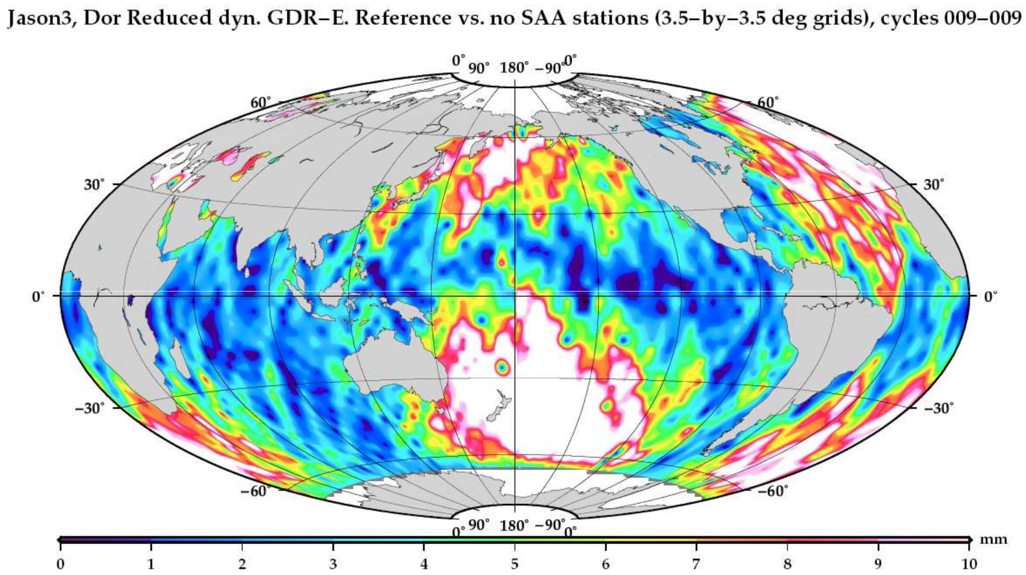




SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)

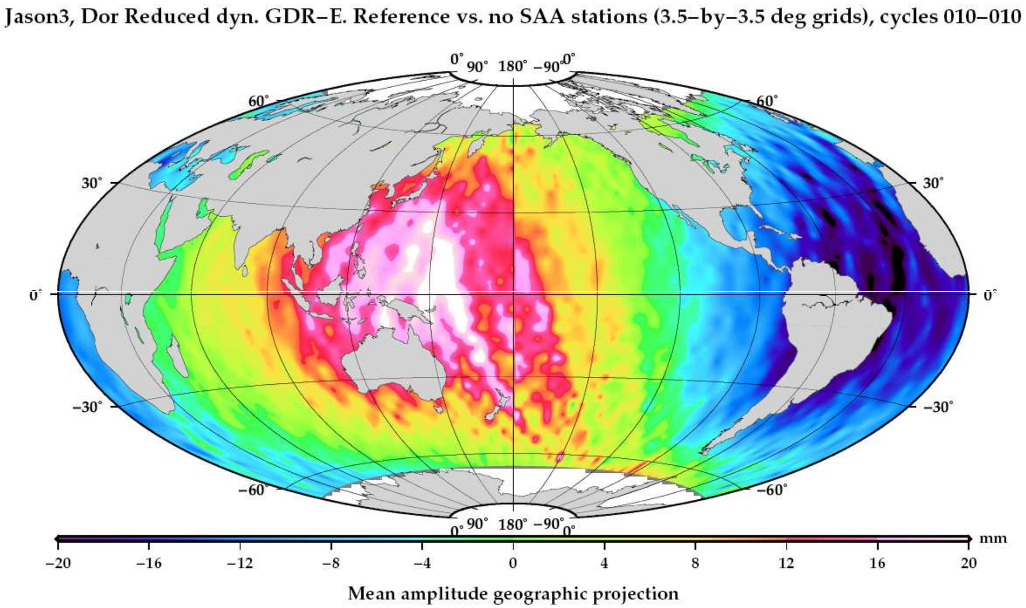


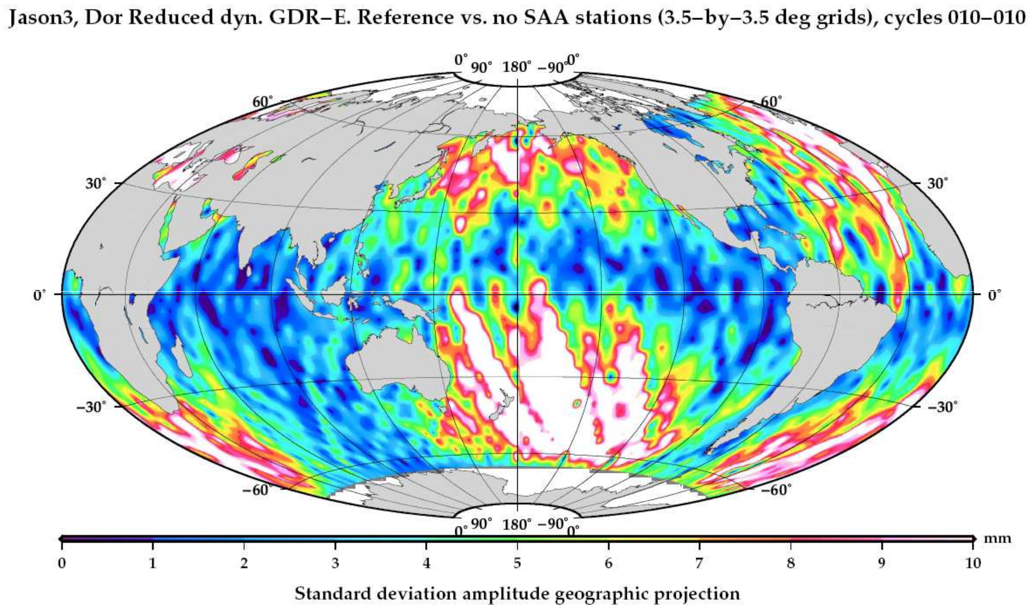
Mean amplitude geographic projection



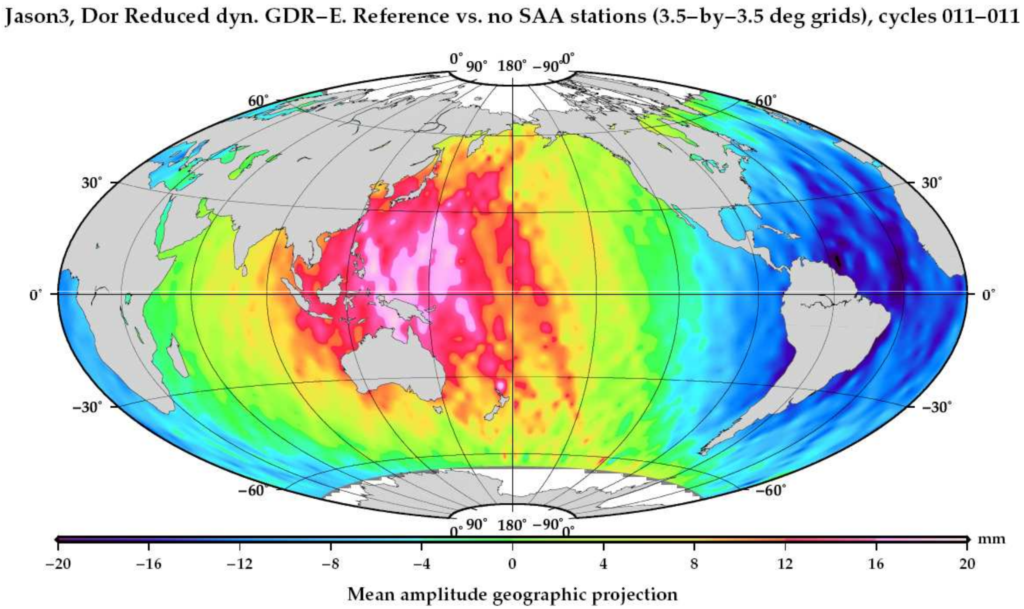
Standard deviation amplitude geographic projection

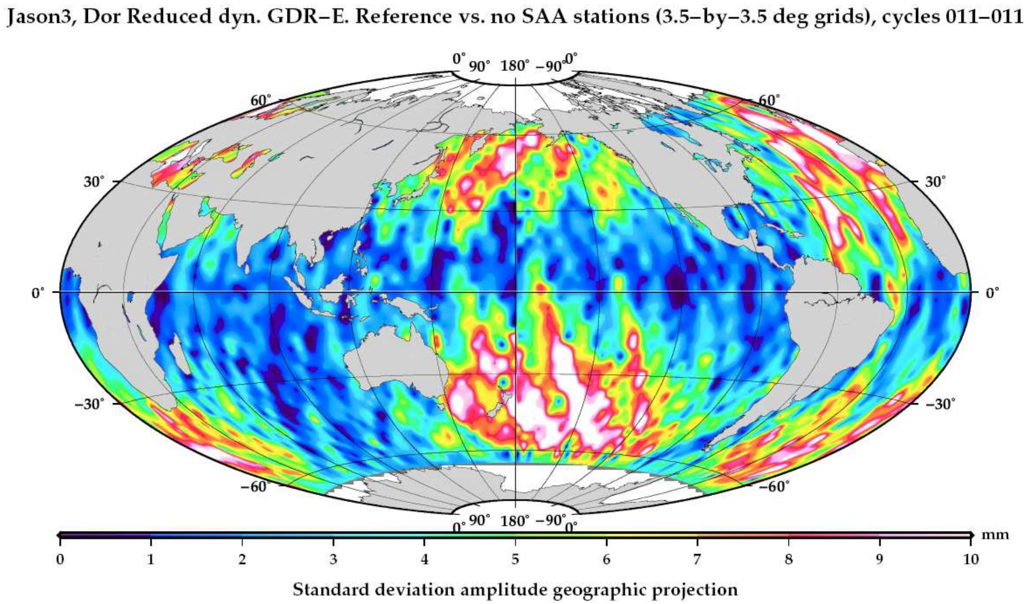
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)



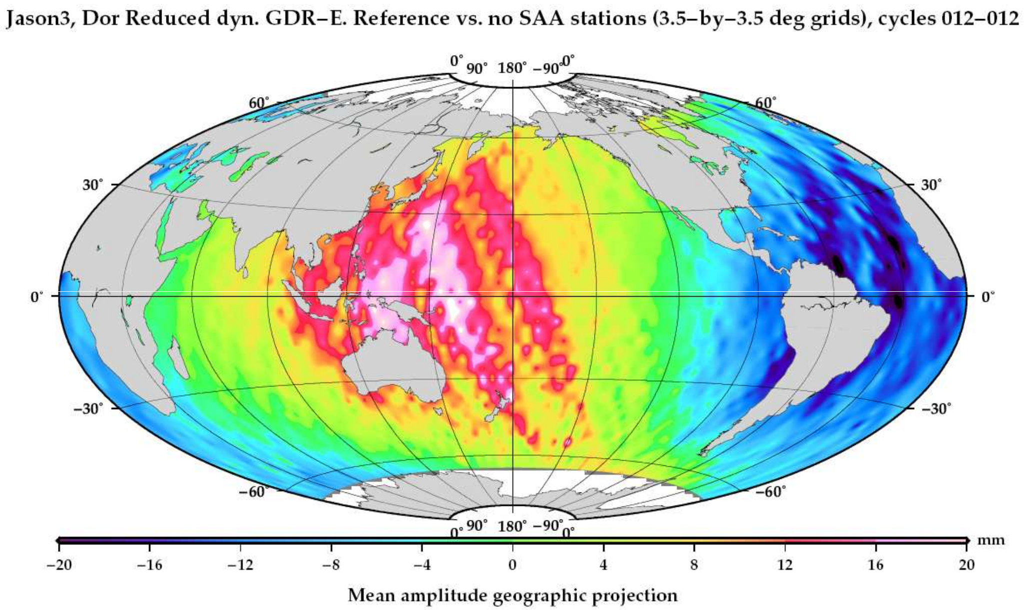


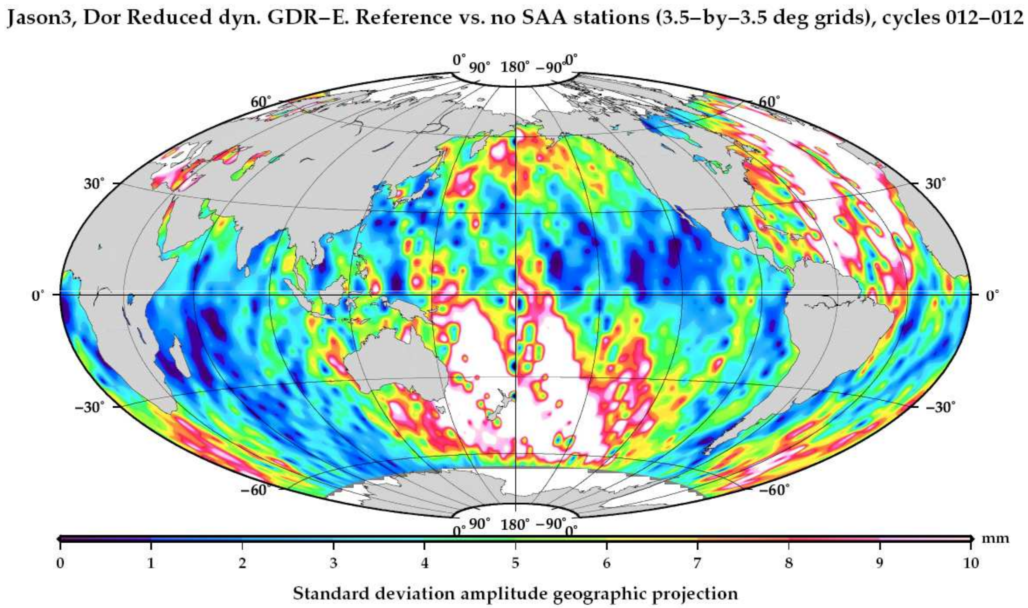
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)



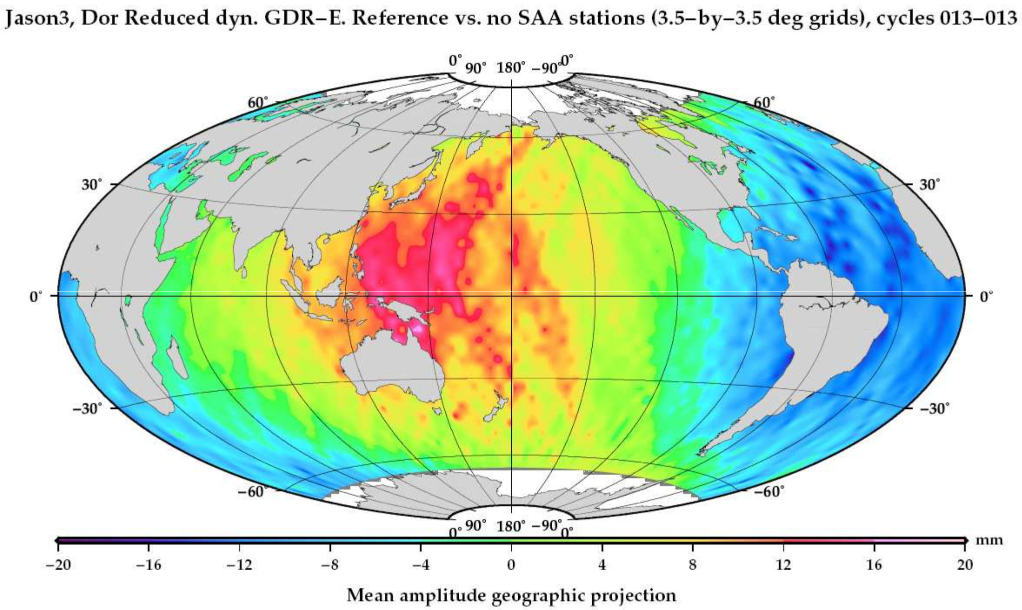


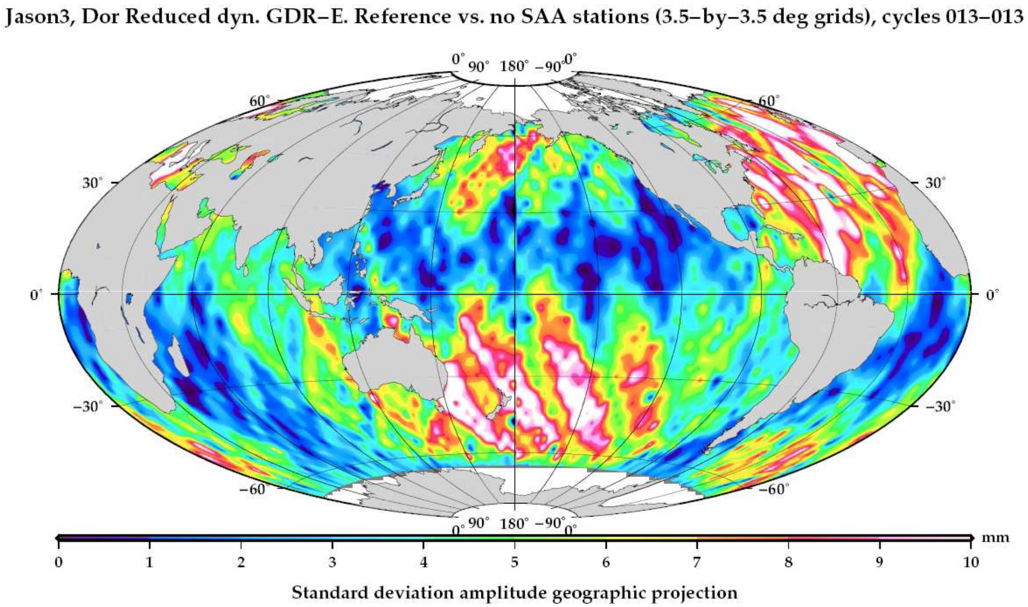
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)





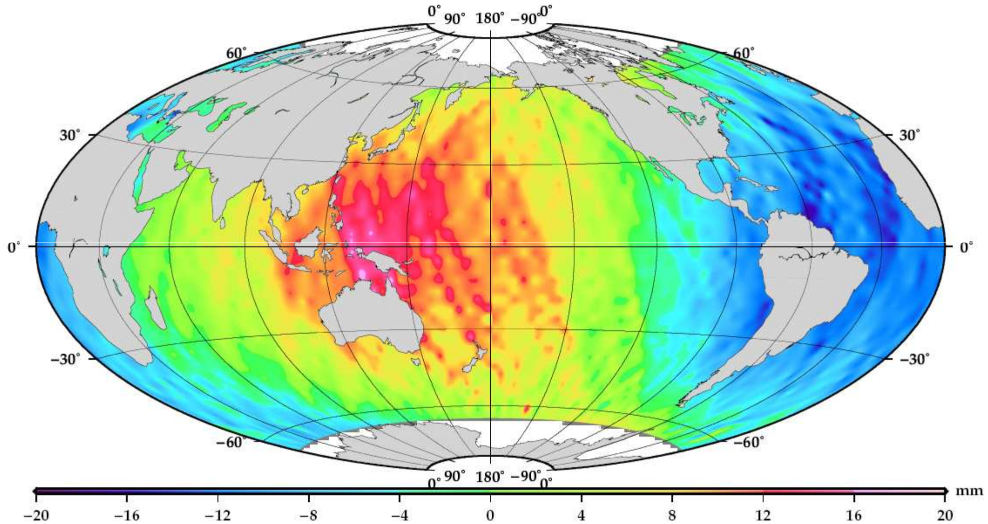
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)





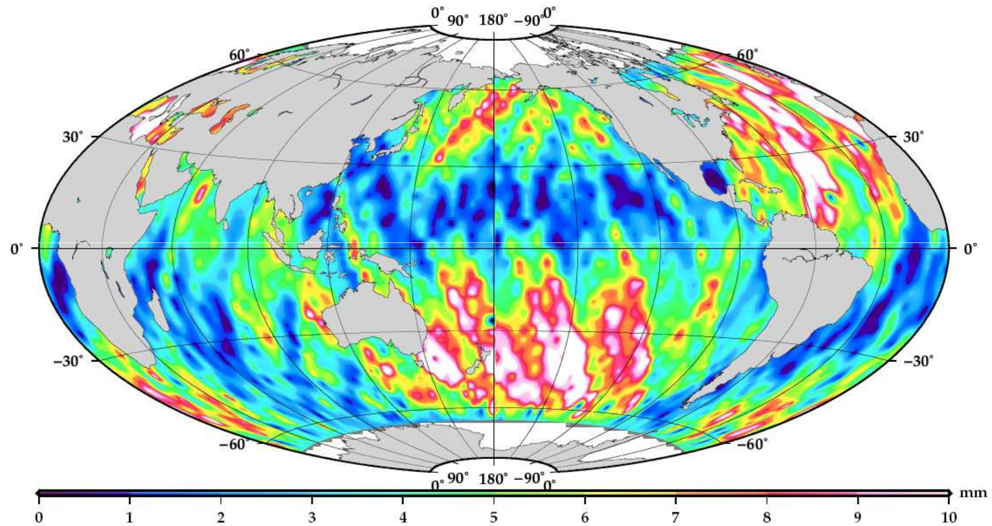
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)

Jason3, Dor Reduced dyn. GDR–E. Reference vs. no SAA stations (3.5–by–3.5 deg grids), cycles 014–014



Mean amplitude geographic projection

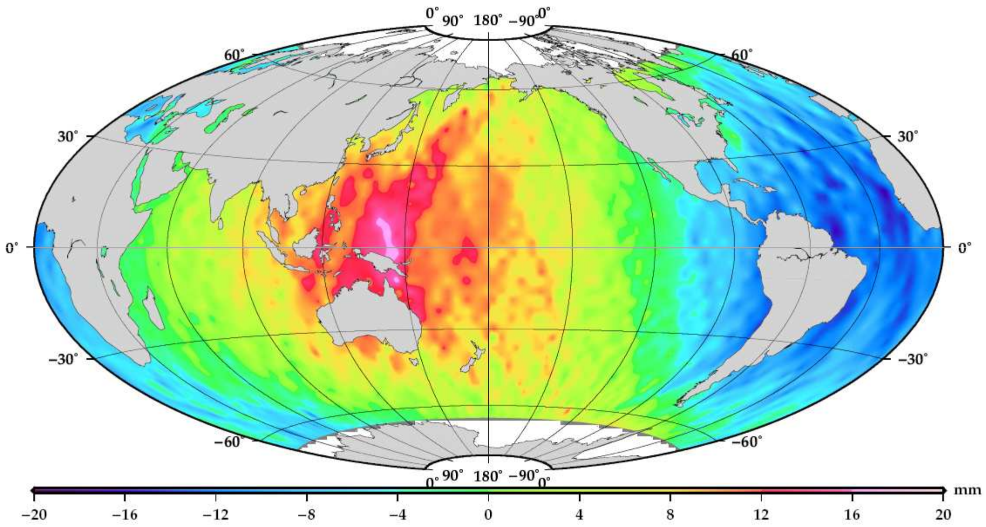
Jason3, Dor Reduced dyn. GDR–E. Reference vs. no SAA stations (3.5–by–3.5 deg grids), cycles 014–014



Standard deviation amplitude geographic projection

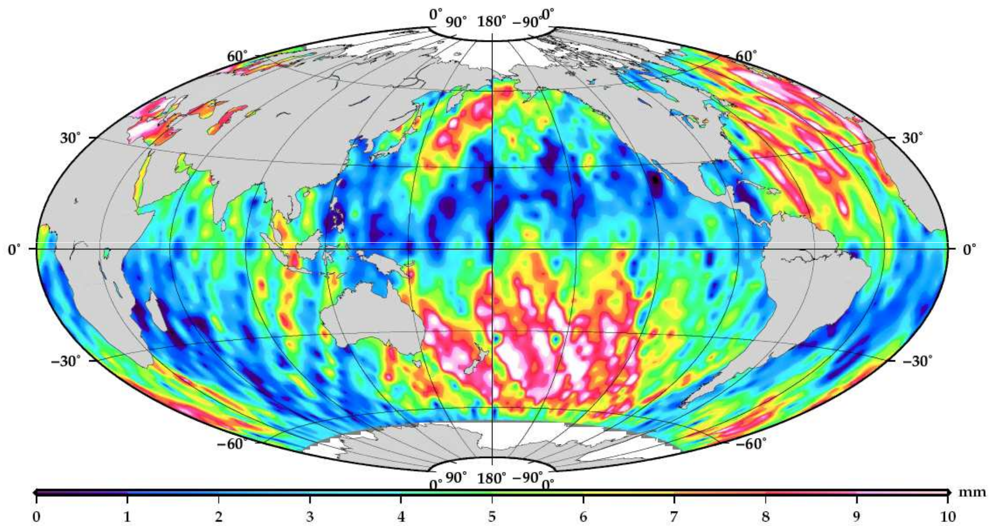
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)

Jason3, Dor Reduced dyn. GDR–E. Reference vs. no SAA stations (3.5–by–3.5 deg grids), cycles 015–015



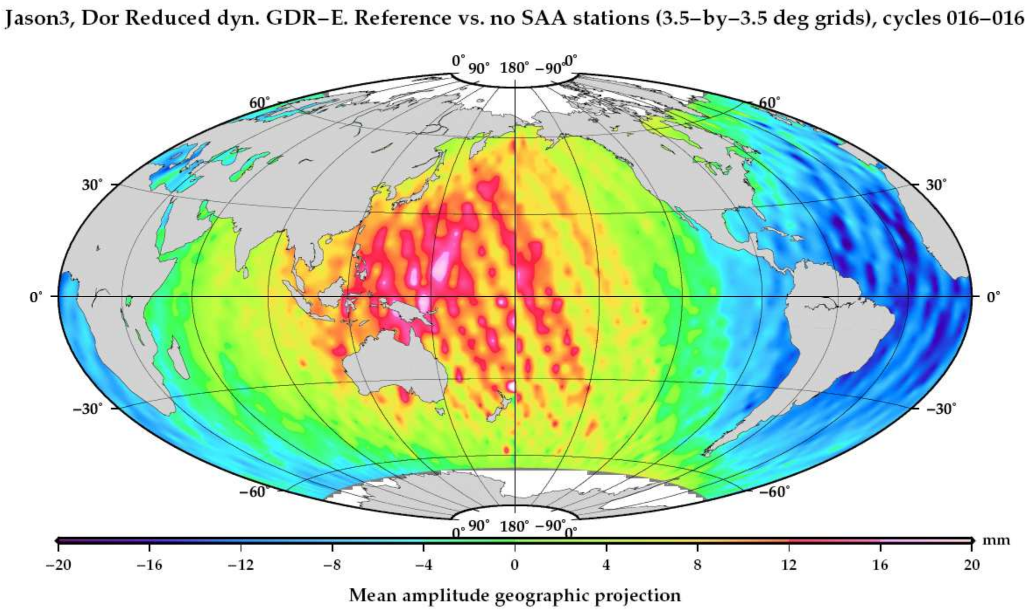
Mean amplitude geographic projection

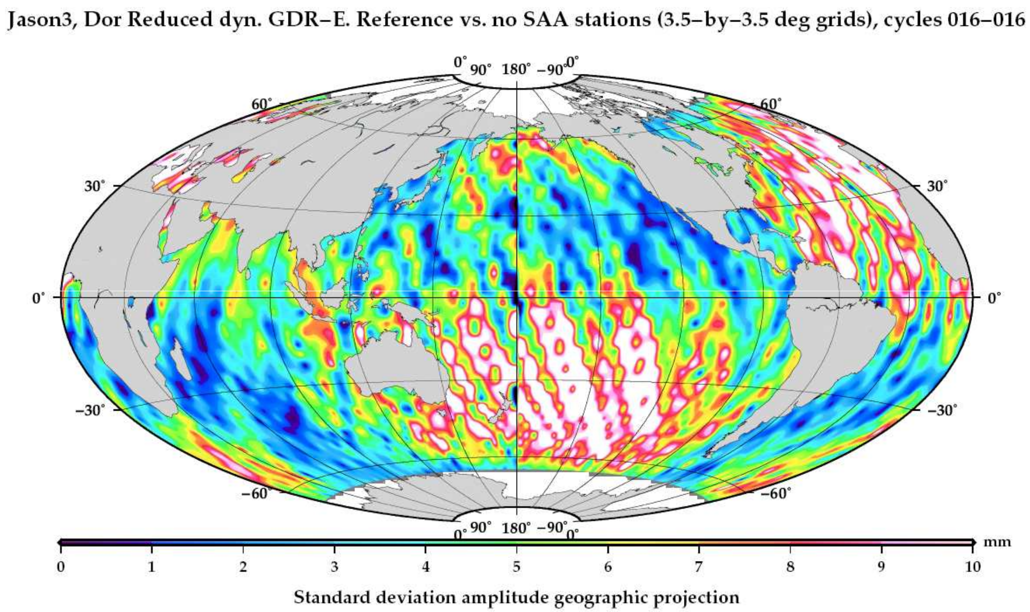
Jason3, Dor Reduced dyn. GDR–E. Reference vs. no SAA stations (3.5–by–3.5 deg grids), cycles 015–015



Standard deviation amplitude geographic projection

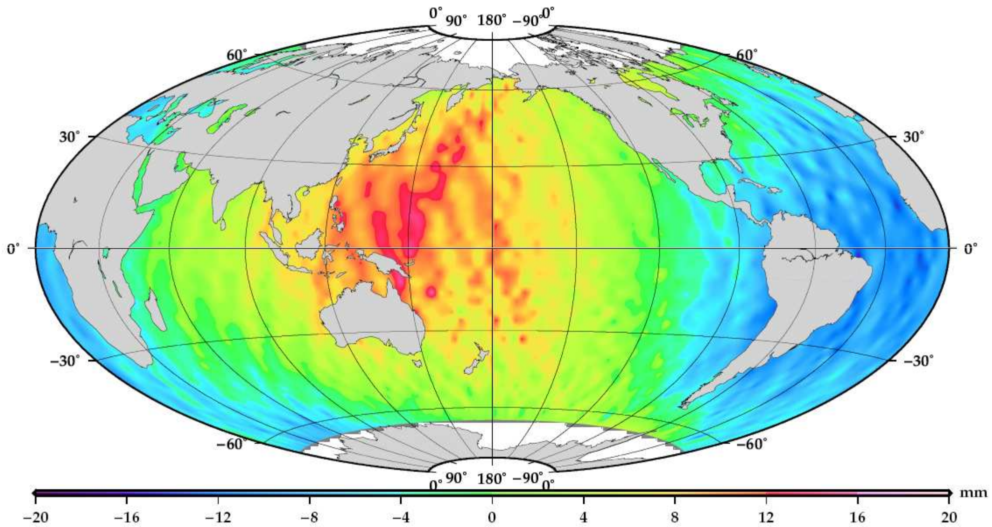
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)





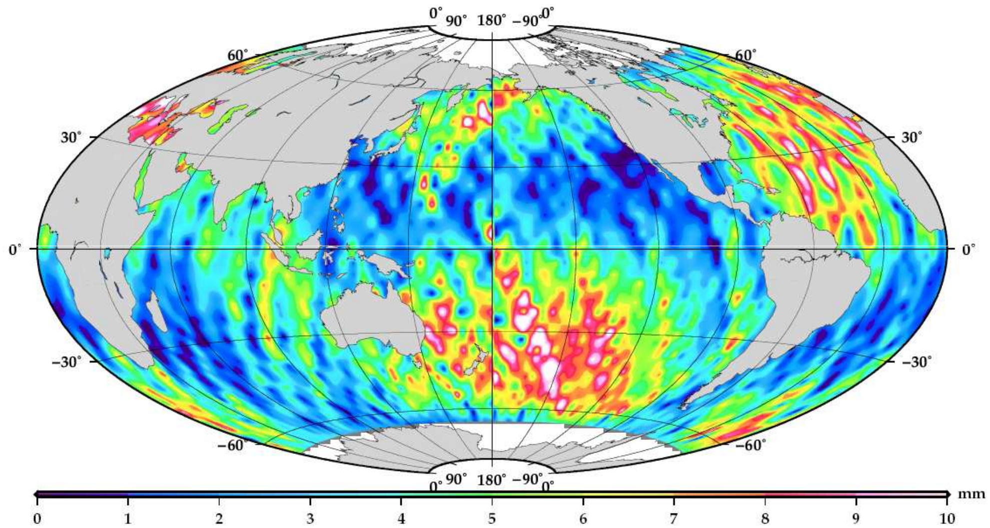
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)

Jason3, Dor Reduced dyn. GDR–E. Reference vs. no SAA stations (3.5–by–3.5 deg grids), cycles 017–017



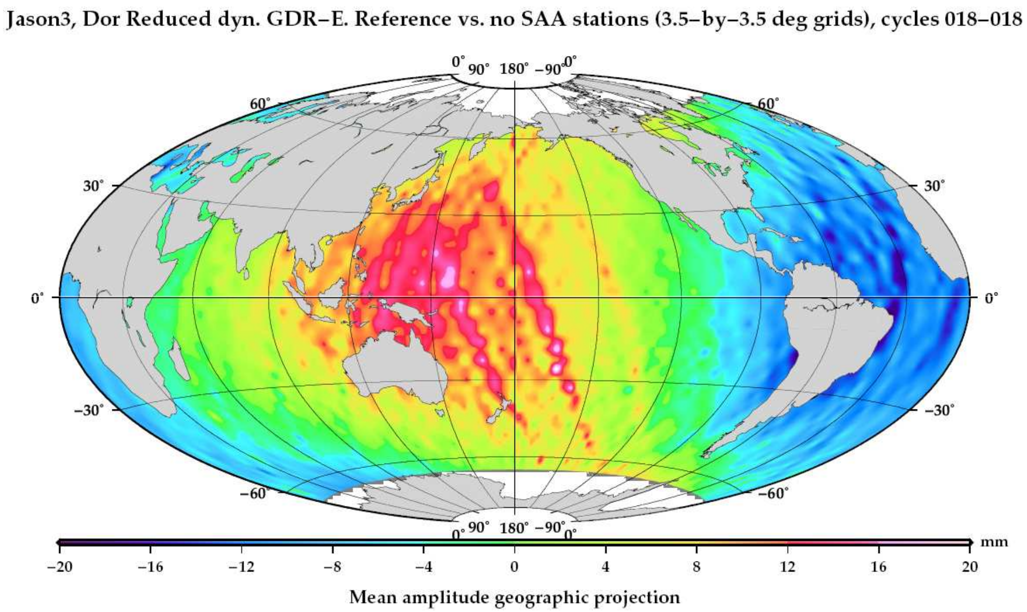
Mean amplitude geographic projection

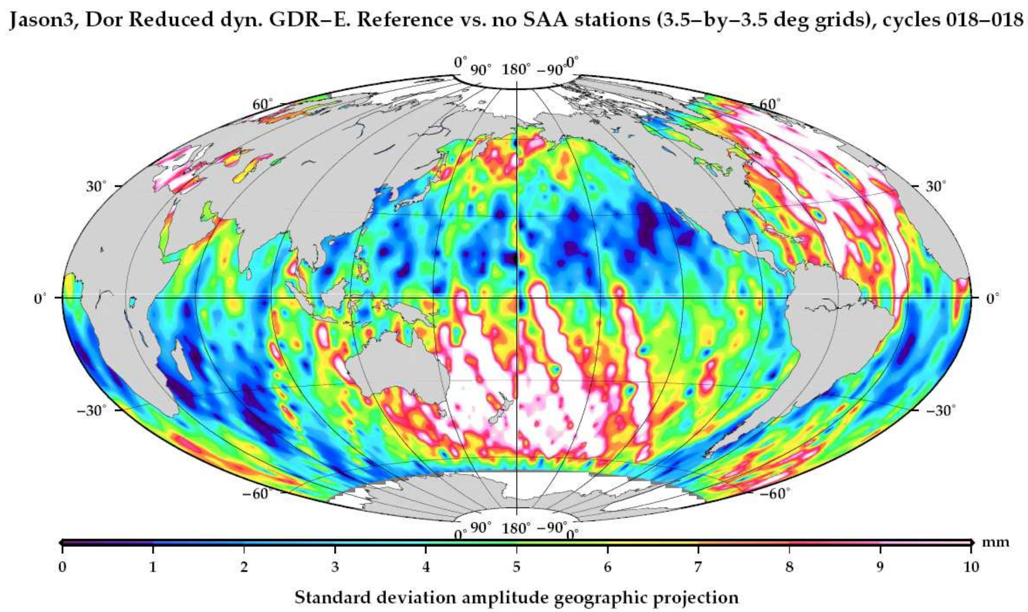
Jason3, Dor Reduced dyn. GDR–E. Reference vs. no SAA stations (3.5–by–3.5 deg grids), cycles 017–017



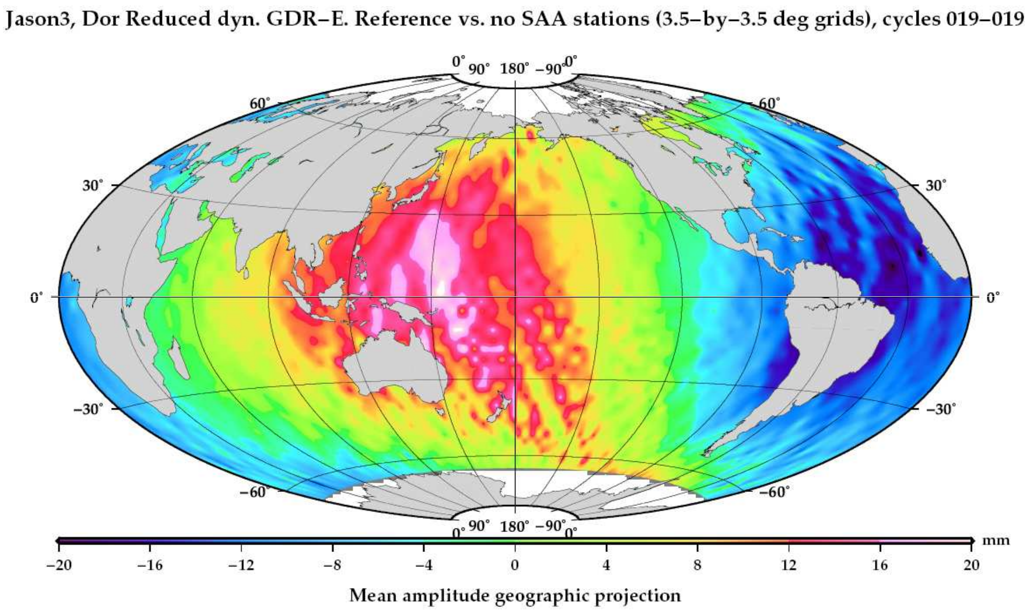
Standard deviation amplitude geographic projection

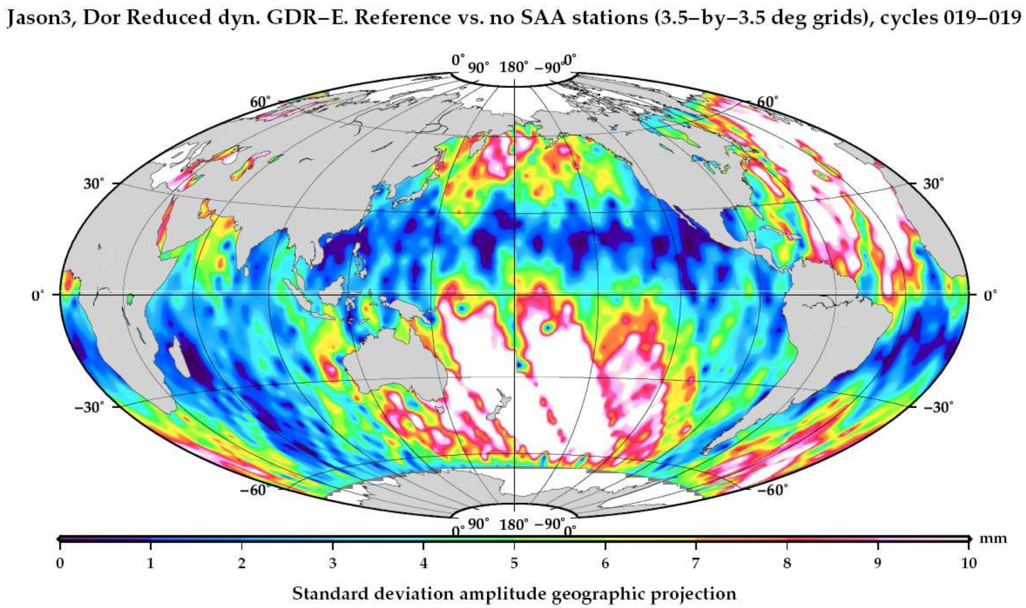
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)





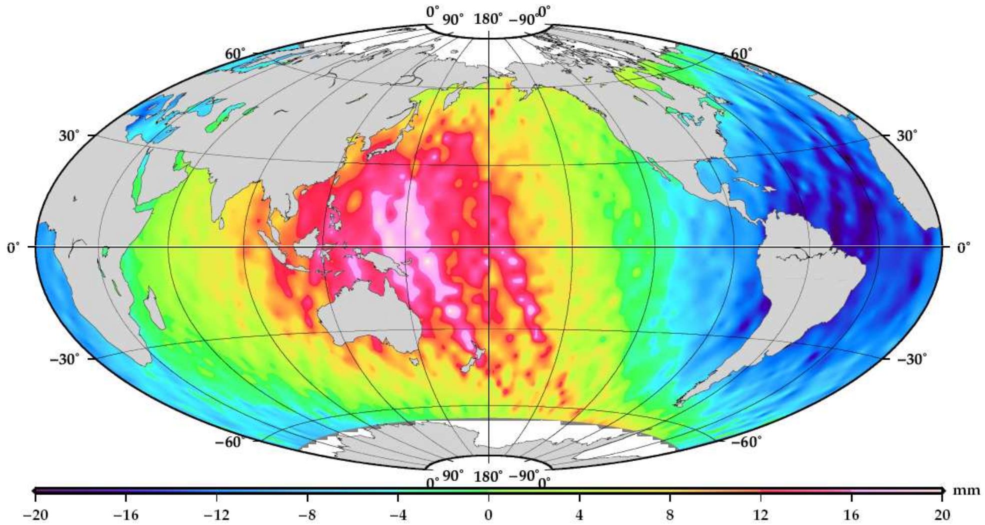
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)





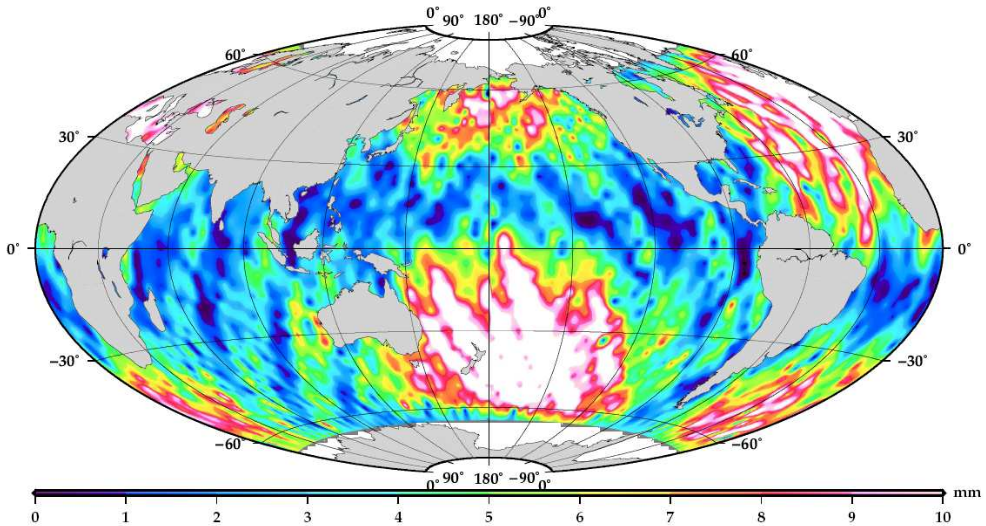
SAA IMPACT ON JASON 2 : GEOGRAPHIC PROJECTION (4)

Jason3, Dor Reduced dyn. GDR–E. Reference vs. no SAA stations (3.5–by–3.5 deg grids), cycles 020–020



Mean amplitude geographic projection

Jason3, Dor Reduced dyn. GDR–E. Reference vs. no SAA stations (3.5–by–3.5 deg grids), cycles 020–020



Standard deviation amplitude geographic projection