CENTRE NATIONAL D'ÉTUDES SPATIALES

European Space Agency

→ 25 YEARS OF PROGRESS IN RADAR ALTIMETRY SYMPOSIUM

OSTST MEETING

24–29 September 2018
Ponta Delgada, São Miguel Island
Azores Archipelago, Portugal

Fixed GPS ambiguities orbit solutions

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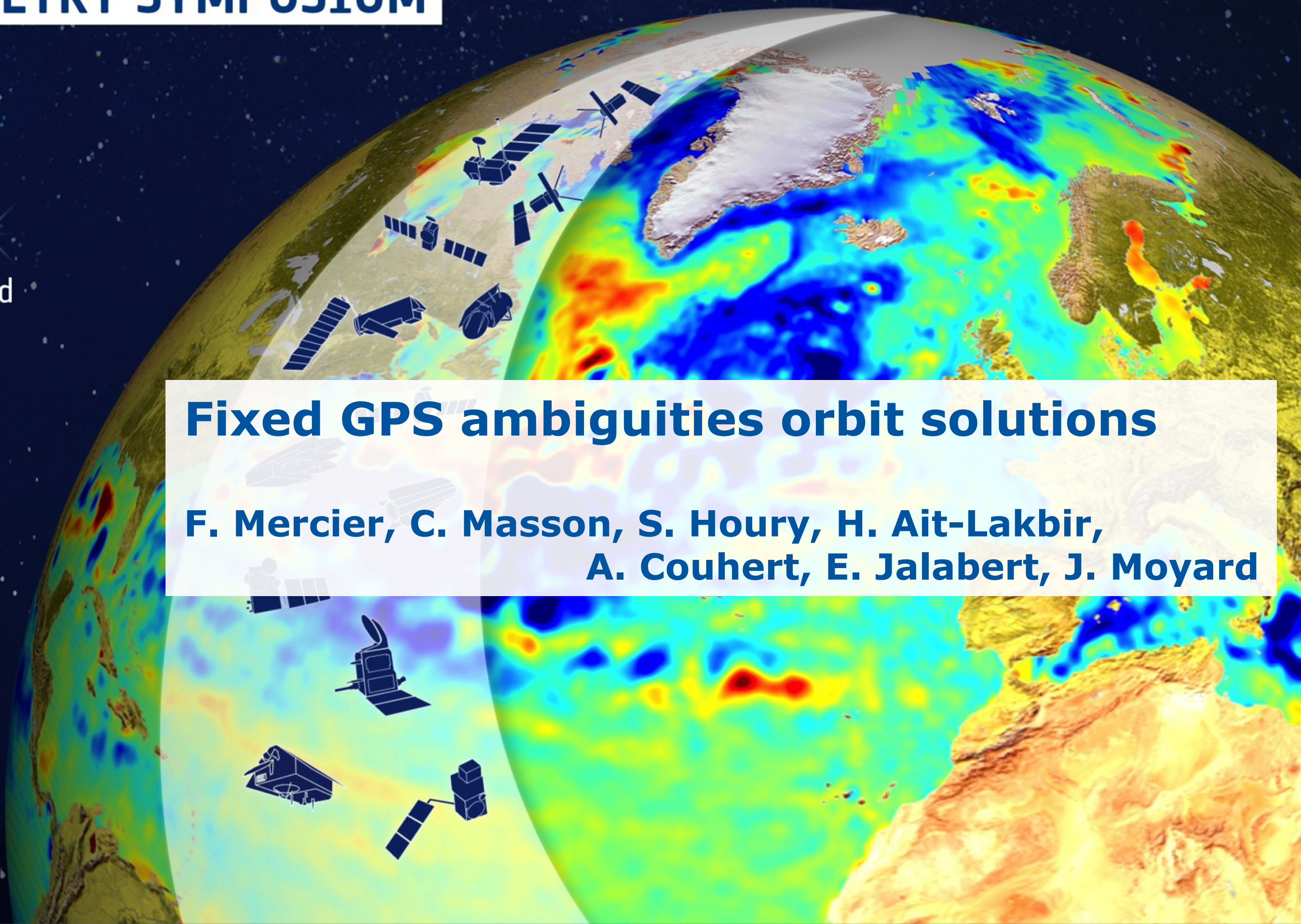
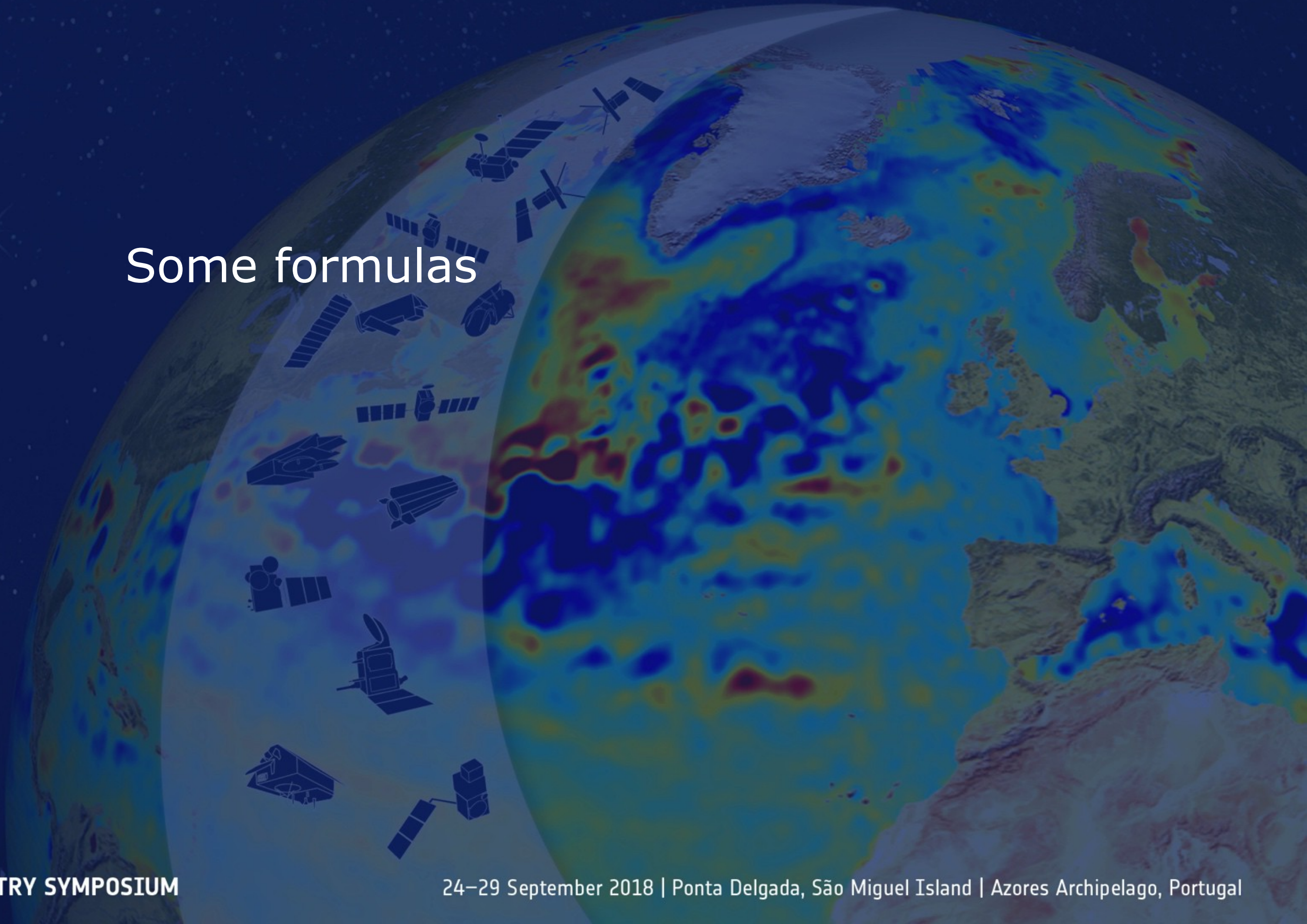




Some formulas

Ambiguity fixing formulation

Zero difference formuation, phase measurements

$$Q = \frac{\gamma\lambda_1(L_1 + N_1) - \lambda_2(L_2 + N_2)}{\gamma - 1}$$

Iono free phase, with ambiguities N1 and N2

N1 ambiguity ('narrowlane')

Nw ambiguity ('widelane')

$$Q = \frac{\gamma\lambda_1 L_1 - \lambda_2 L_2}{\gamma - 1} + \frac{\gamma\lambda_1 - \lambda_2}{\gamma - 1} N_1 - \frac{\lambda_2}{\gamma - 1} N_w$$

λ_c 10.7 cm

37.7 cm

One cycle error in Nw ~3.53 cycles in N1

Nw can be identified using measurements only (no model)

Widelane (Melbourne – Wubbena)

Iono-free and geometry-free combination,

Used for N2-N1 ambiguity determination, integer value Kw for each pass

Daily GPS satellite bias
(from GRG/IGS solution)

Integer (per pass)

$$L_2 - L_1 - f(P_1, P_2) = K_w + \tau_i - \tau_r$$

receiver bias

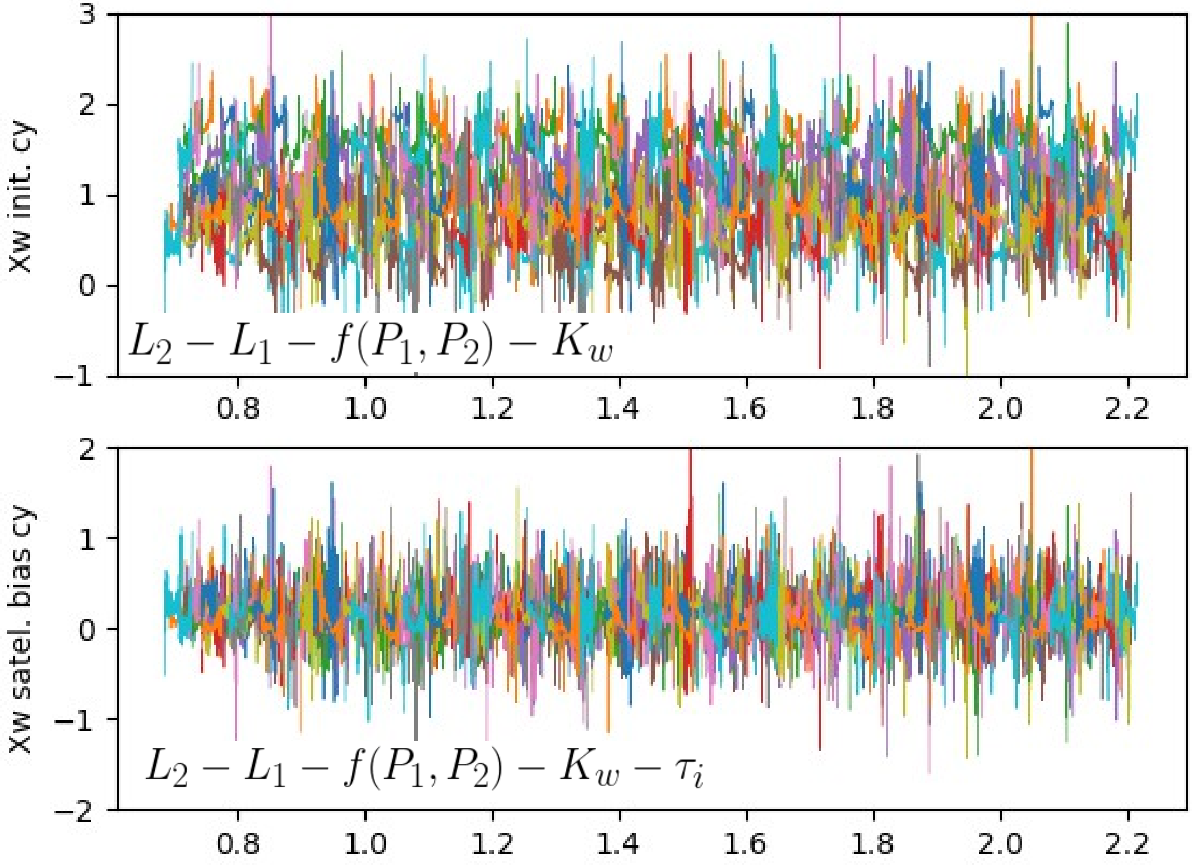
Phase and pseudo-range combination

→ The receiver bias is stable over a day (Jason 3, Sentinel 3)

Allows a robust widelane integer ambiguity estimation
each pass is fixed independently

Example : widelane

Widelane ambiguity fixing



Initial combination

Satellite biases correction

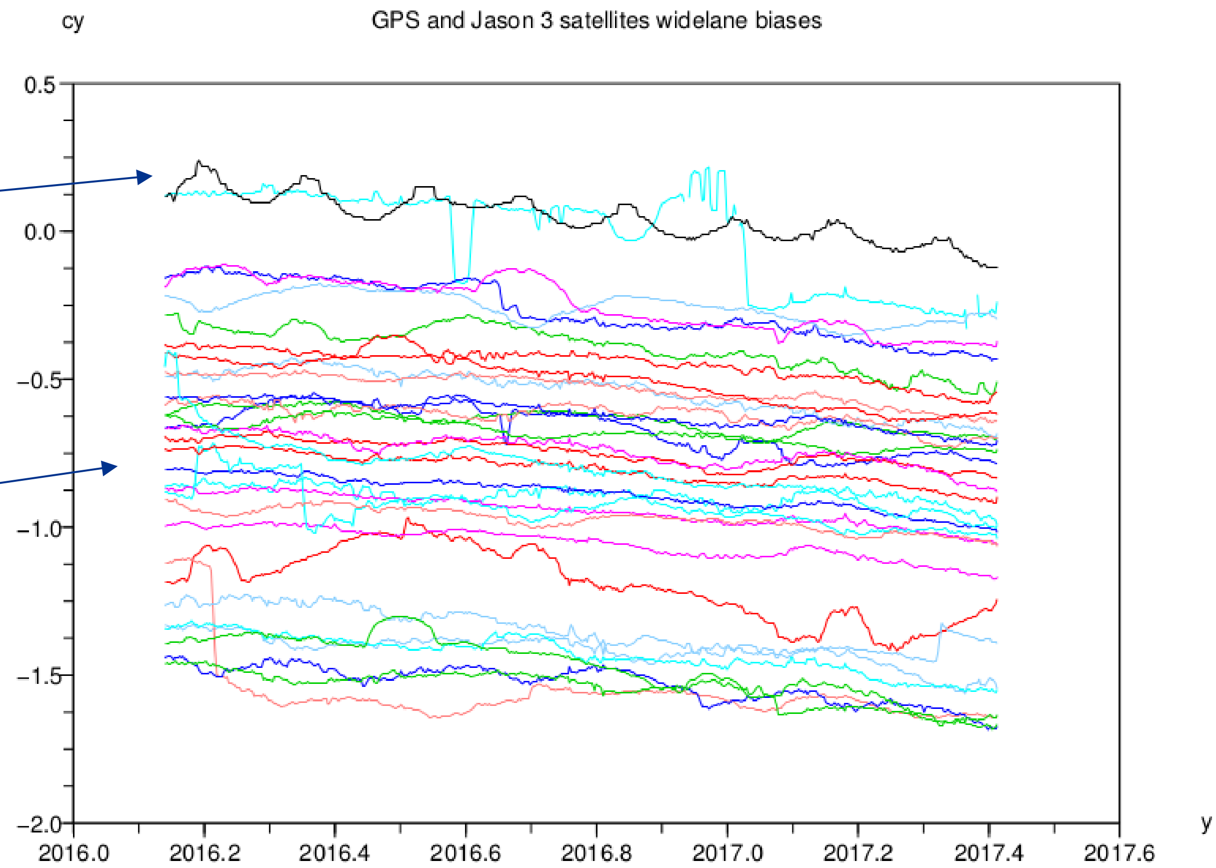
All passes are fixed

Jason 3 receiver widelane bias

Small drift observed in τ_r (daily estimation) , but due to the GRG solution

τ_r

GPS satellites biases



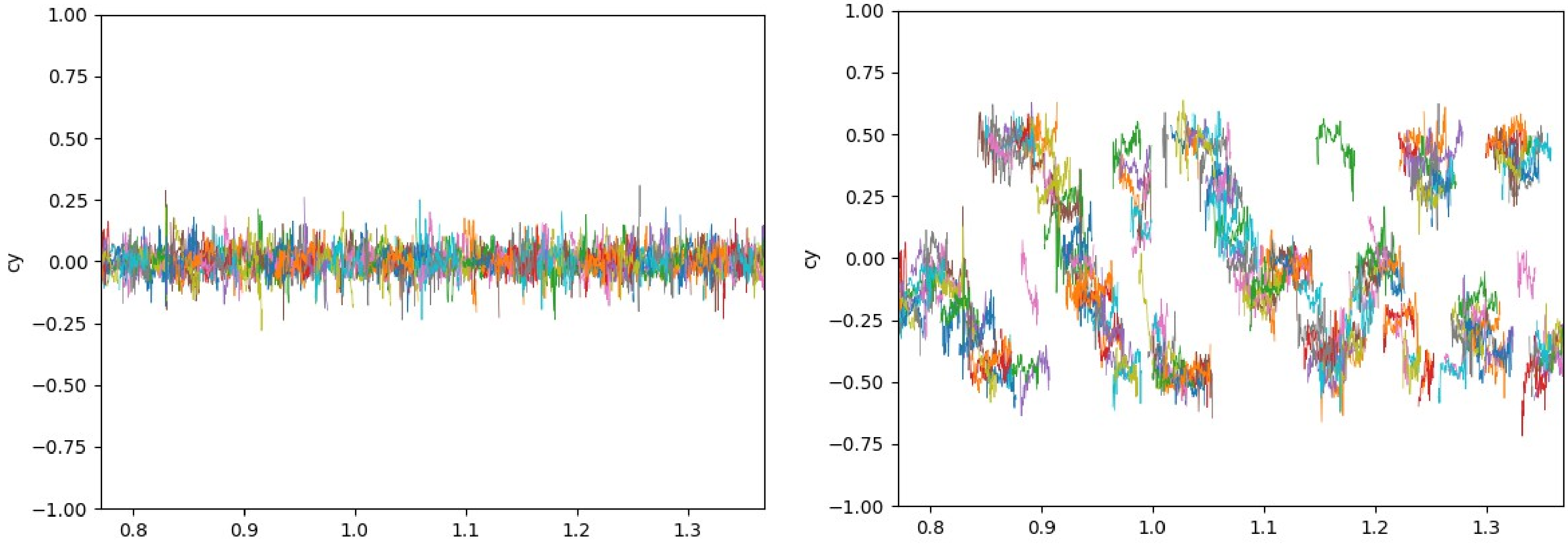
The jason 3 receiver bias is stable with time

only small variations depending on solar angle (~0.1 cycle)

Example : narrowlane

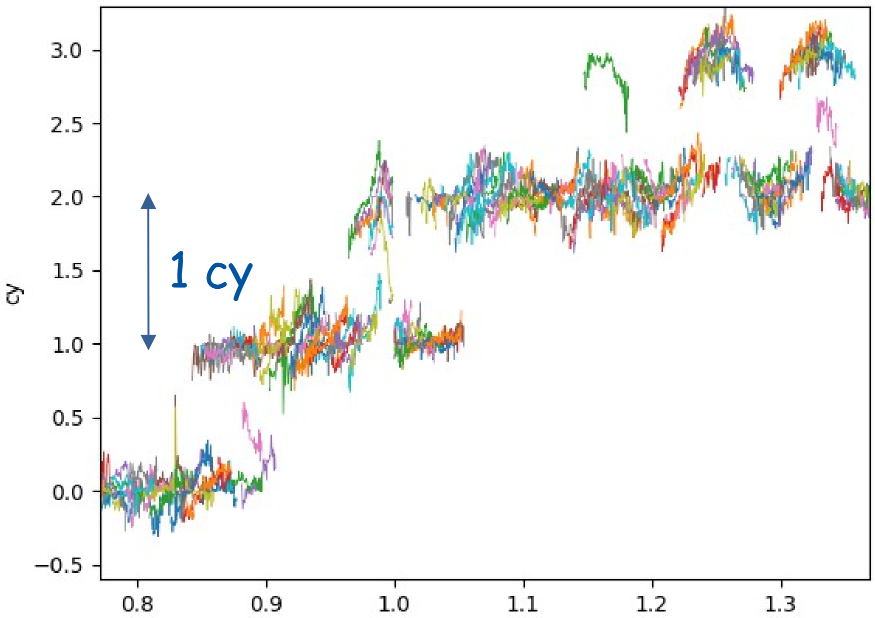
Narrowlane ambiguity fixing process

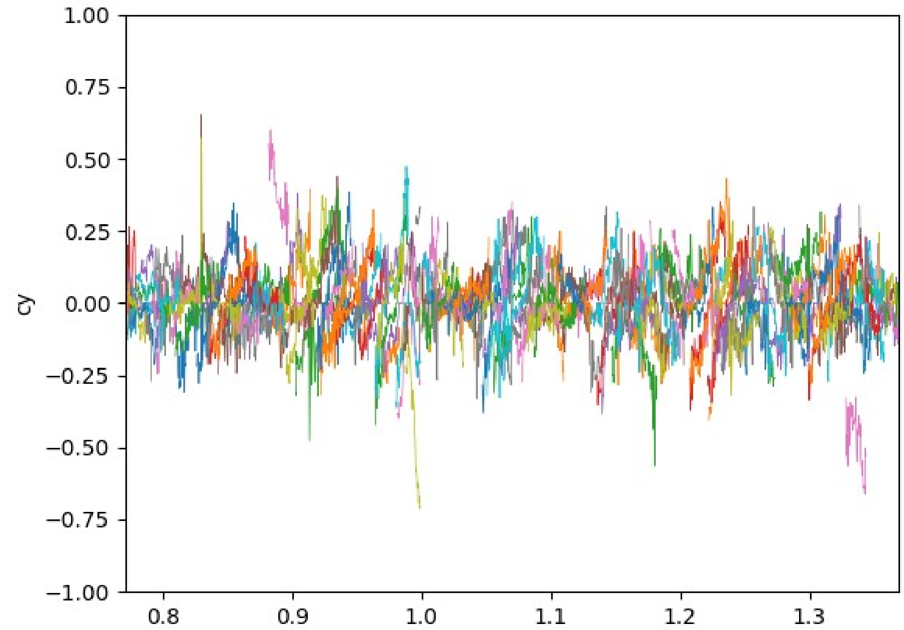
Phase residuals (orbit with floating ambiguities)



Floating ambiguities → Nearest integer

Narrowlane ambiguity fixing process

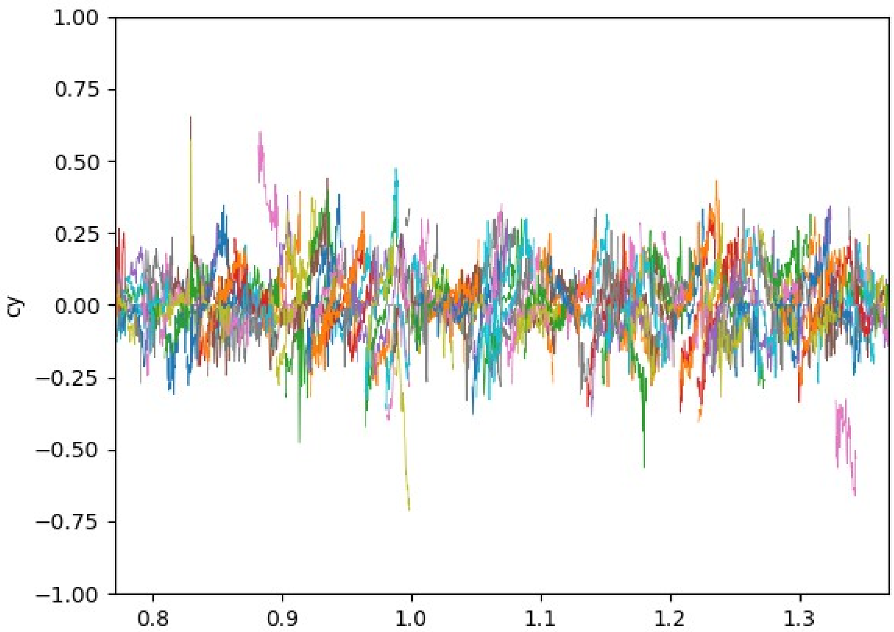


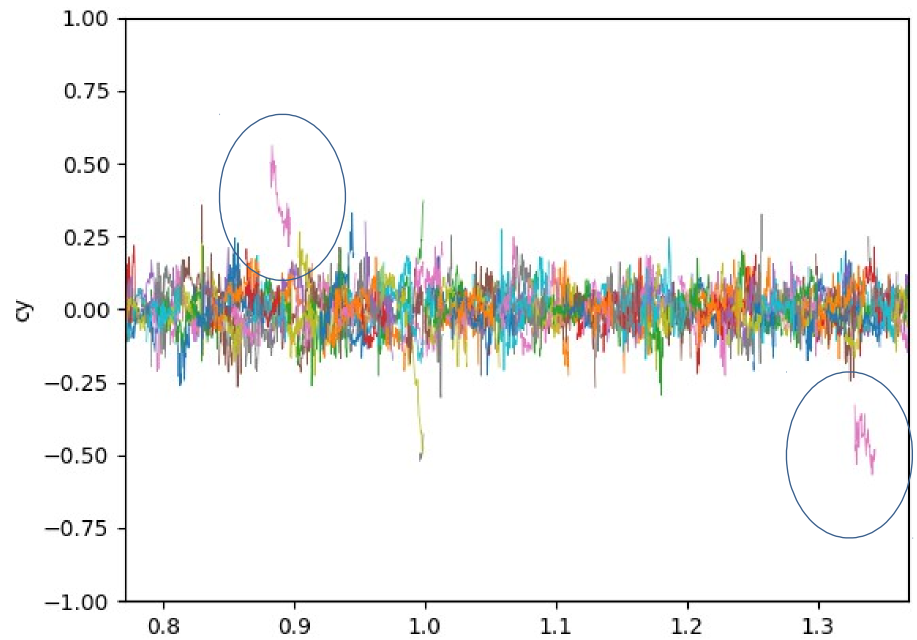


Nearest integer
+ Clock correction

Nearest integer
+ Integer correction
+ Clock correction

Narrowlane ambiguity fixing process



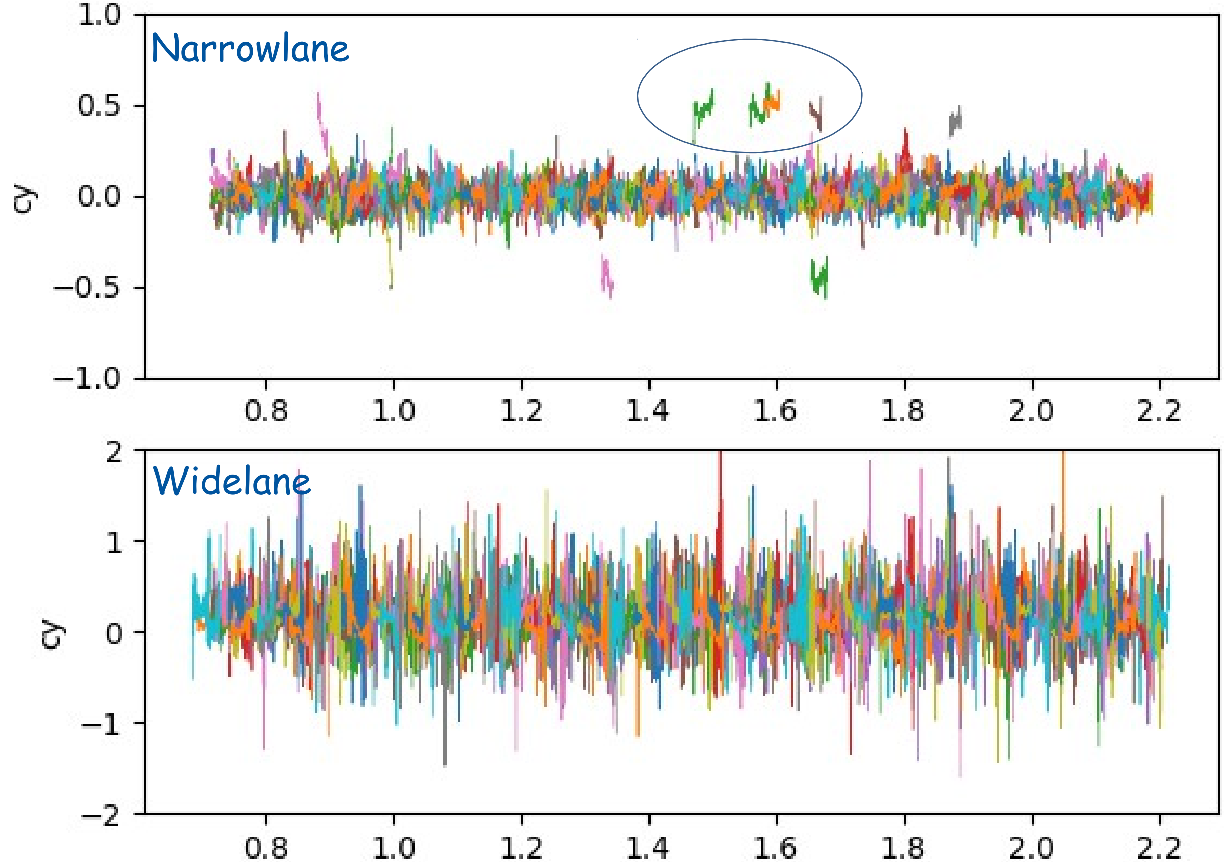


Floating ambiguities orbit → Fixed ambiguities orbit

Fixing algorithm

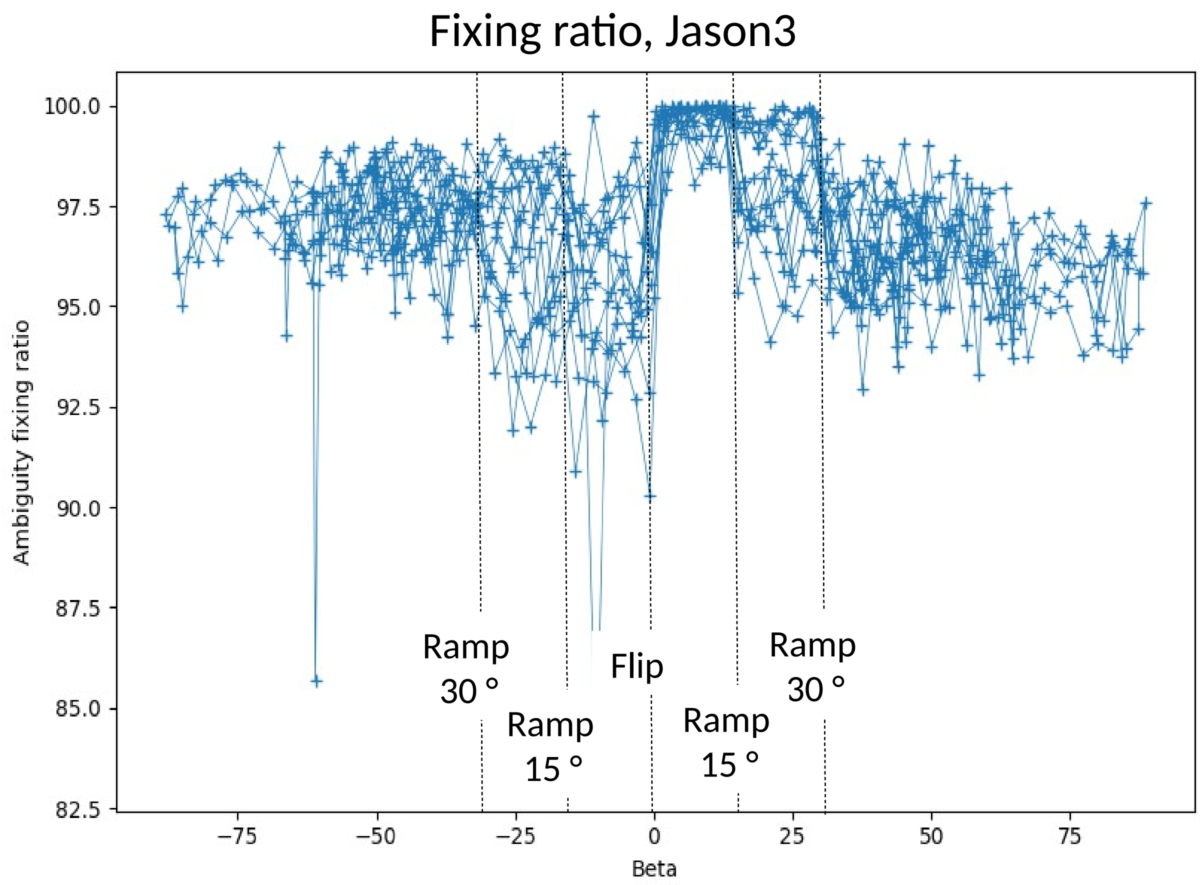
- simple to implement (works on the residuals only)
- robust to biased passes
- we need an initial good floating solution

Narrowlane ambiguity outliers



Some ~0.5 cycles narrowlane passes on Jason 3
- not due to wrong widelane ambiguity fixing
- not dependent on duration or elevation

Narrowlane ambiguity fixing



~0.5 cycles passes on Jason 3

- ~92 % fixing flying backward
- 100 % fixing flying forward
- intermediate ratios in yaw steering

Implementation

Implementation : floating ambiguities orbits

Rinex

Satellite Biases (wsb)

igs/grg orbits (sp3/clk)

Preprocessing

Daily file
- cycle slips
- passes definition

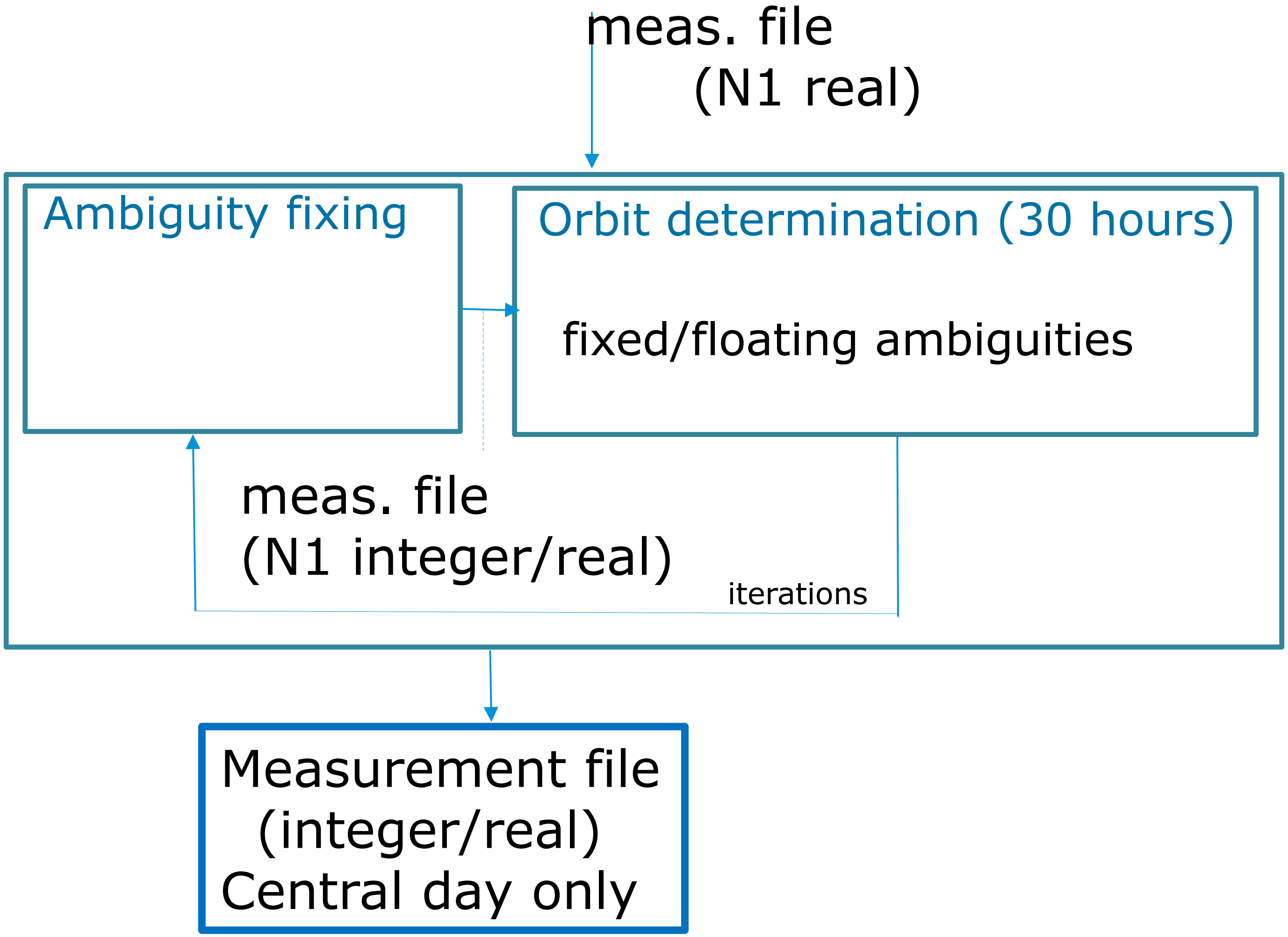
Widelane ambiguity fixing

Orbit determination (30 hours)

floating ambiguities
outliers elimination
(passes, pseudo-range biases)

meas. file
(N1 real)

Implementation : fixing process



Advantage : the daily measurement files can be directly used for other uses (phase maps, long arcs, reduced dynamic…)

Results

Phase maps

For the floating solution, the phase map improves the fixing rate
(pre-launch phase map for Jason 3, adjusted PCO for Sentinel3)

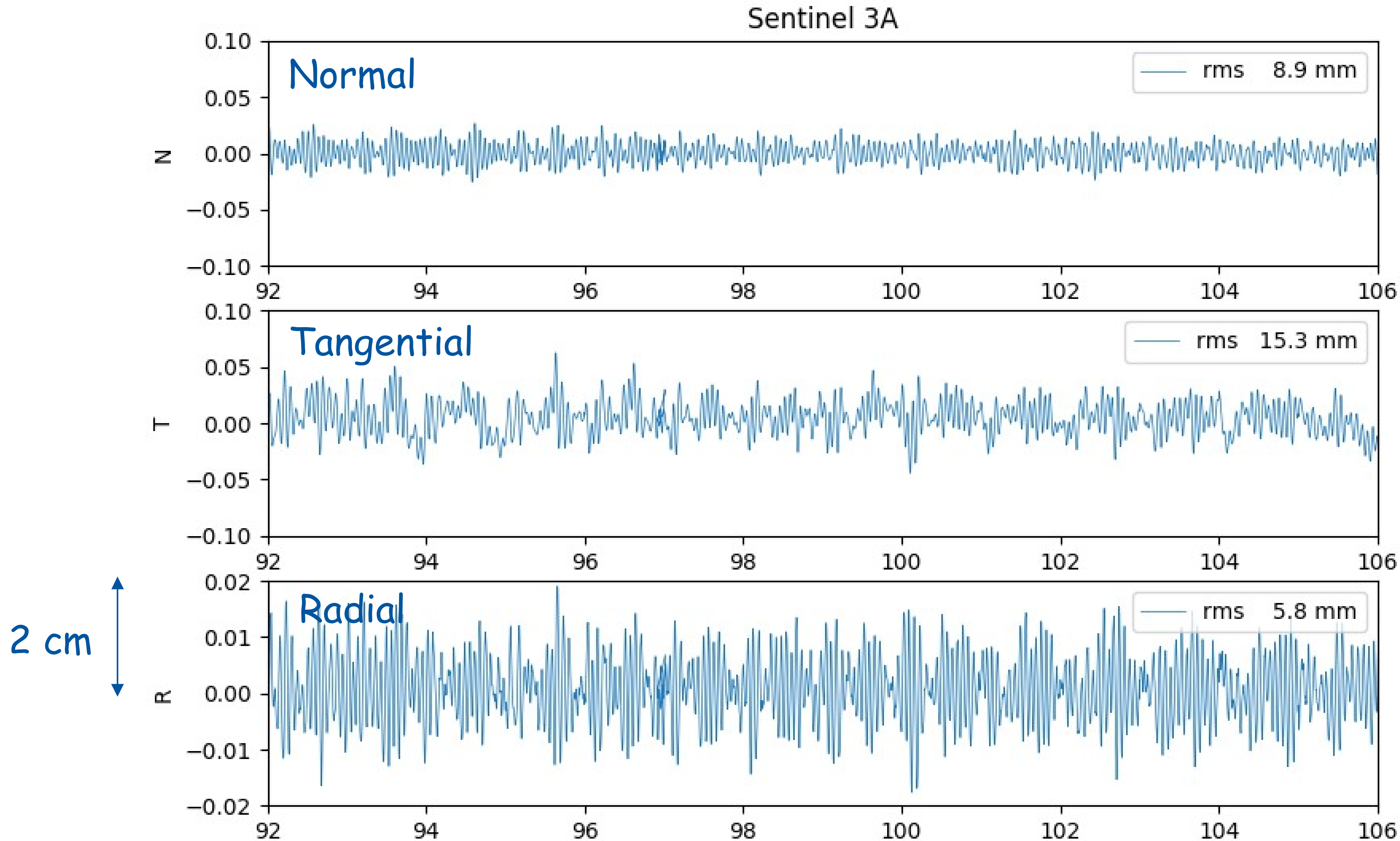
The phase map construction
- parametric model (Zernike polynomials)
- adjusted simultaneously with drag and prsd models
- fixed ambiguities

improves the transverse observation (for example x axis in fixed yaw)

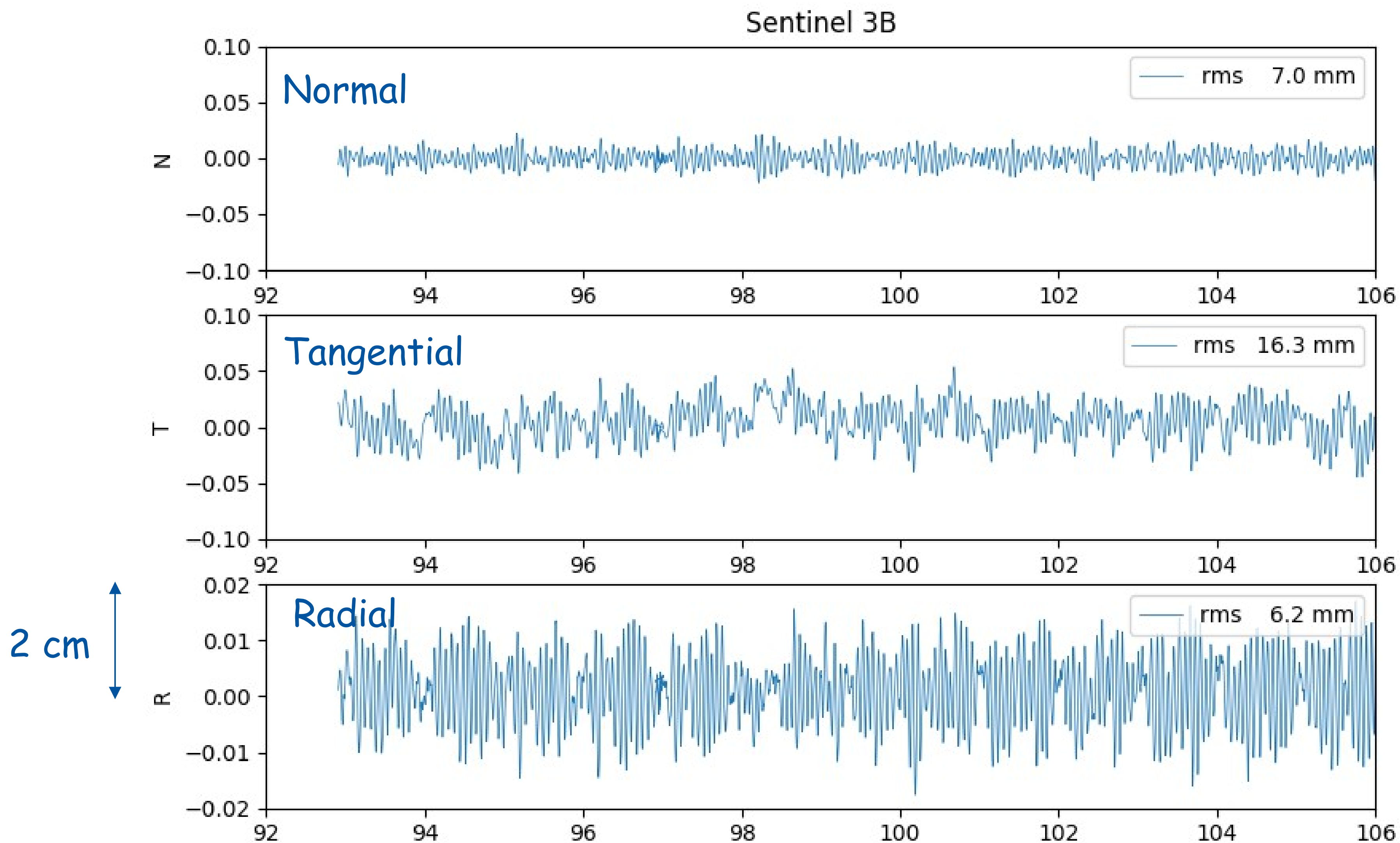
The final orbit performance (fixed ambiguities) is not very dependent on the phase map used

see poster 'Improved GNSS phase maps, in flight modelling and identification'

Orbit differences (float-fixed), Sentinel 3A

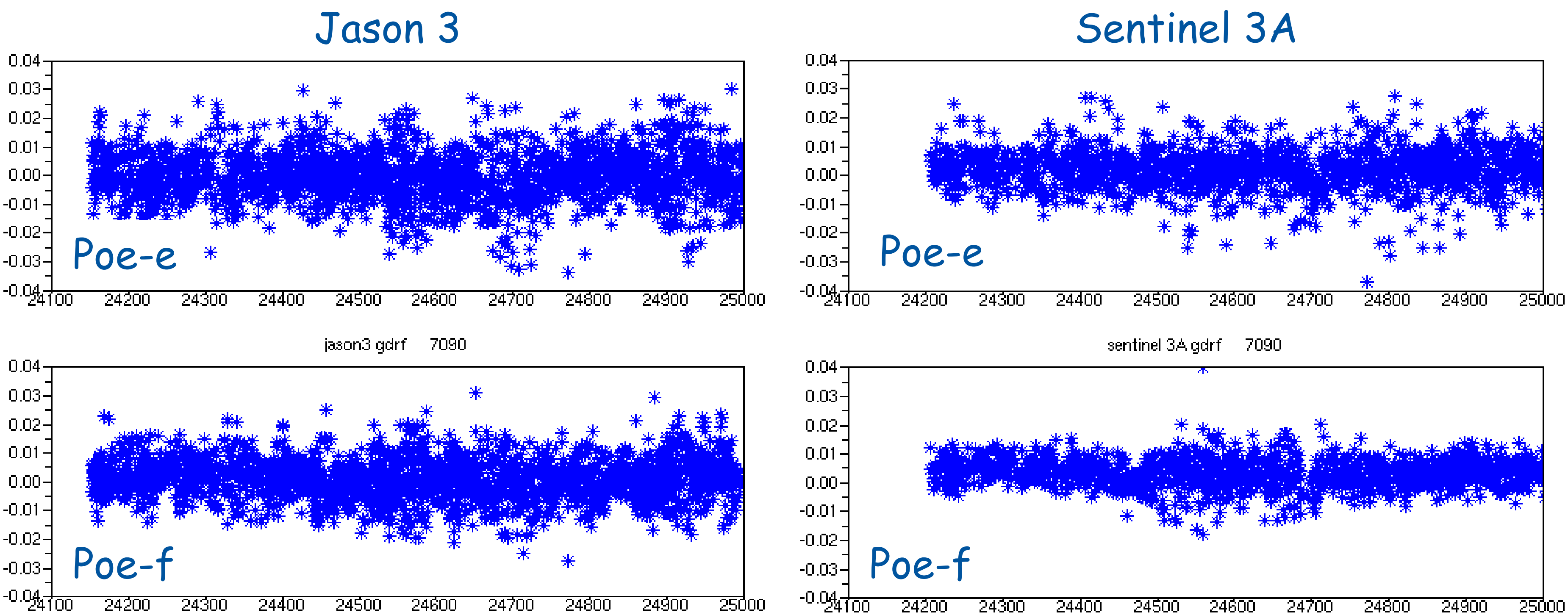


Orbit differences (float-fixed), Sentinel B



Jason 3 and Sentinel 3 SLR residuals

Yarragadee

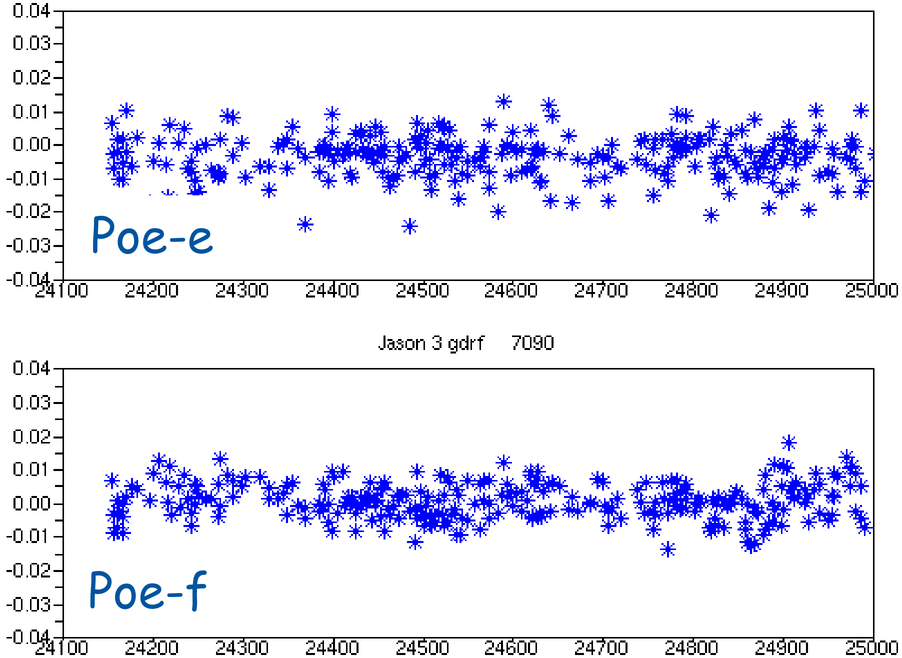


SLR residuals scattering smaller with fixed ambiguities

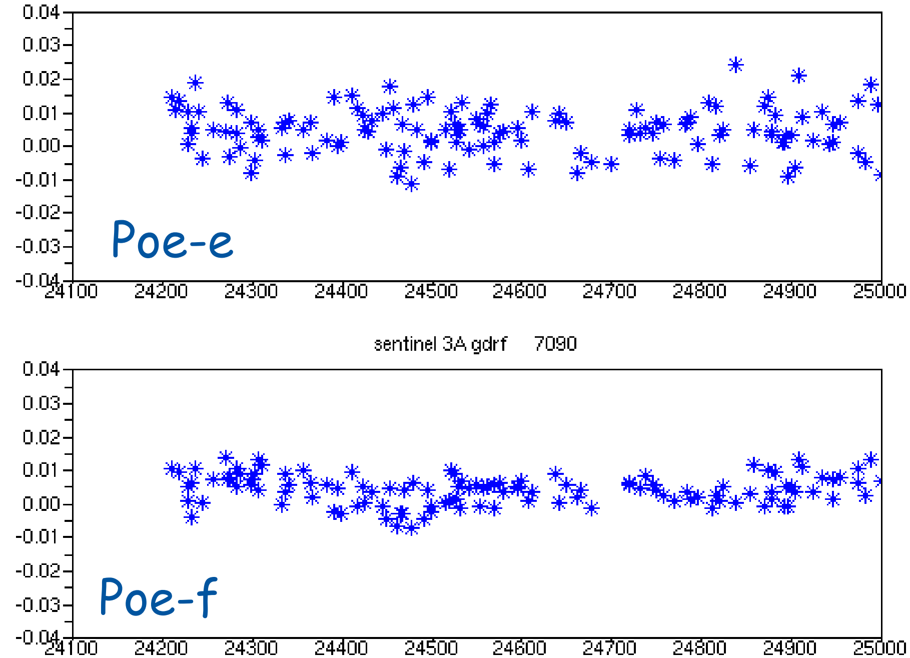
SLR high elevation residuals

Yarragadee

Jason 3



Sentinel 3A

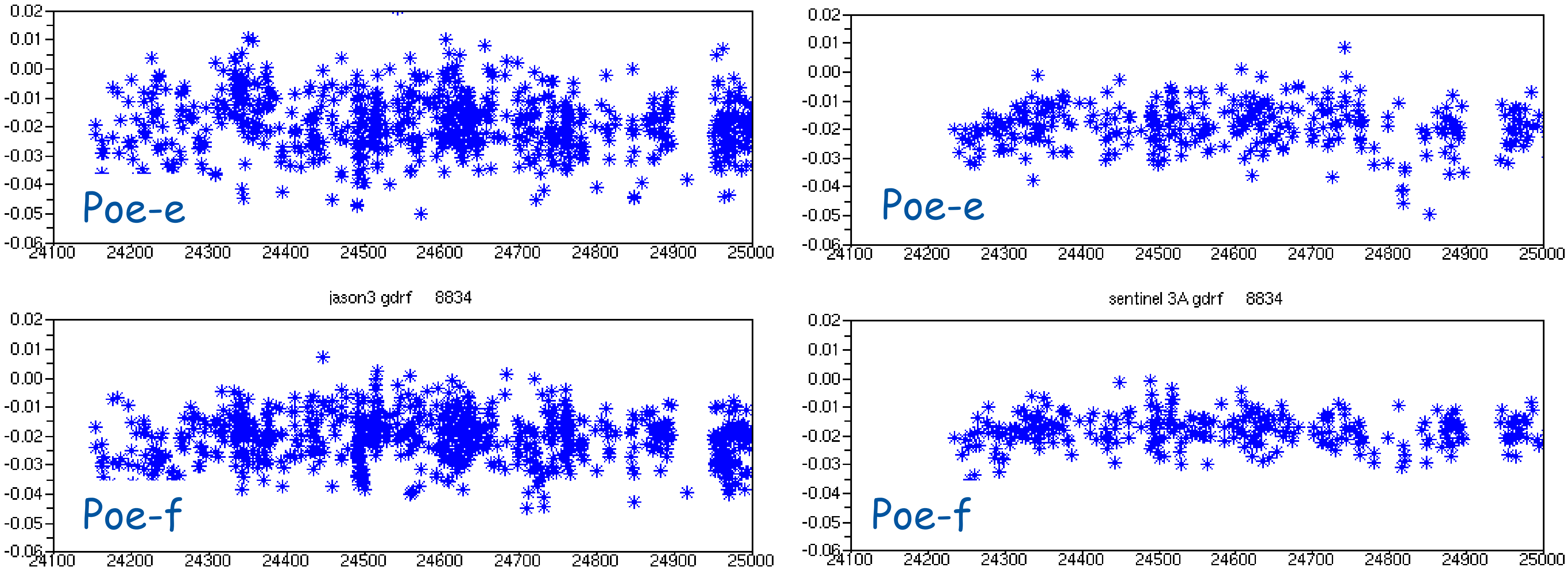


SLR high elevation residuals scattering smaller with fixed ambiguities

Jason 3 and Sentinel 3 SLR residuals

Wettzell

Jason 3 | Sentinel 3A

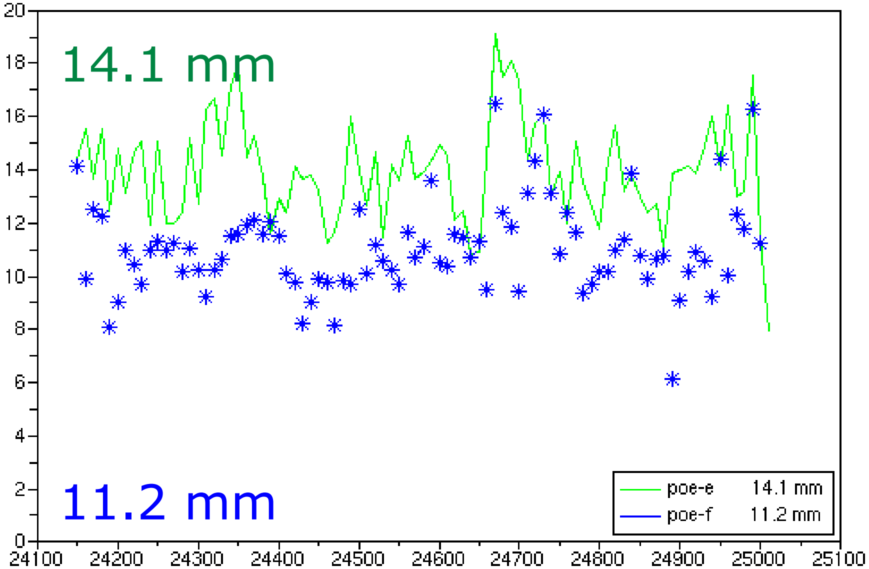


SLR residuals scattering smaller with fixed ambiguities

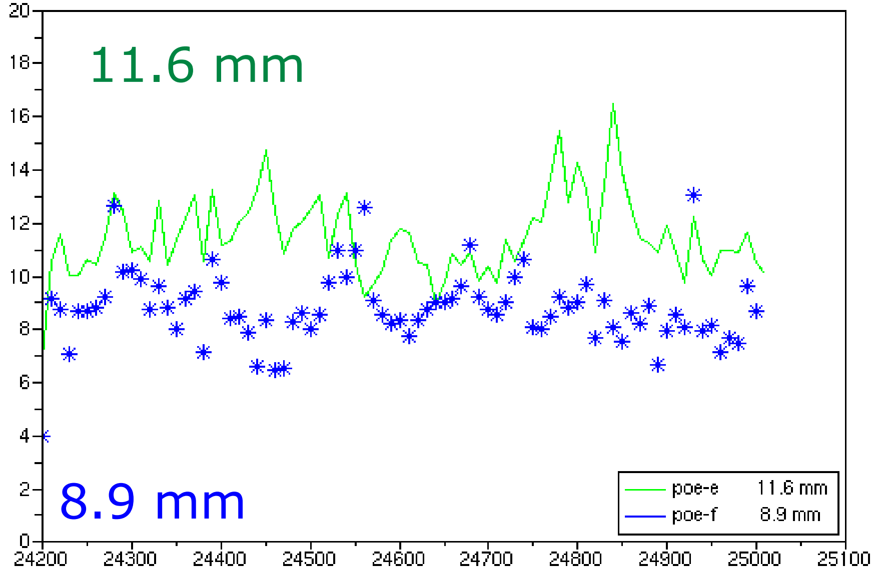
However, bias ~-2cm for both satellites, probably due to station

SLR rms, all elevations

Jason 3



Sentinel 3A



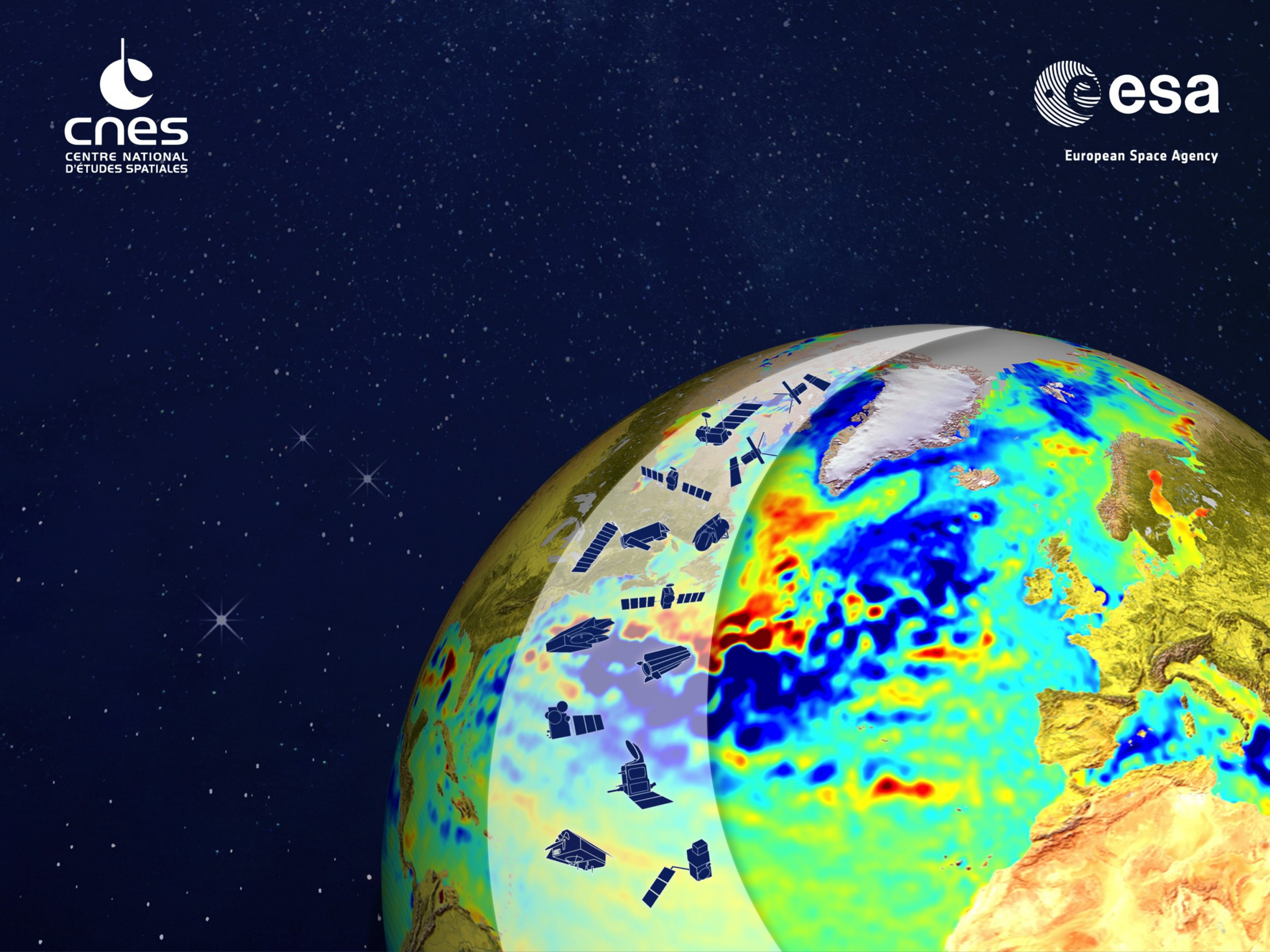
Conclusion

An efficient and robust ambiguity fixing process has been developed

Implemented for Jason 3 and Sentinel 3A for Poe-f standard

Significant improvement of the horizontal errors (SLR residuals)

Siginificant improvement of the radial error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