cnes

Analysis Working Group

International DORIS Service

POLAR MOTION USING DORIS MEASUREMENTS

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London,
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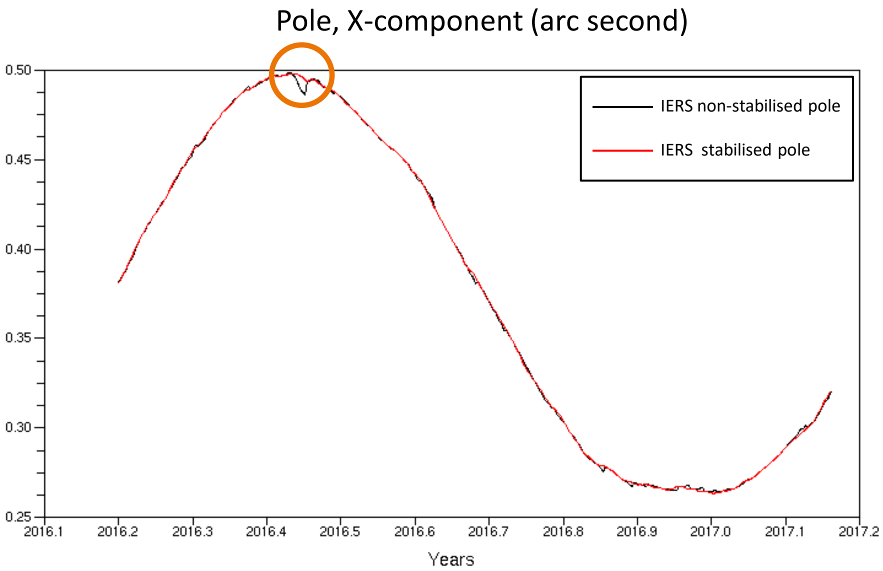
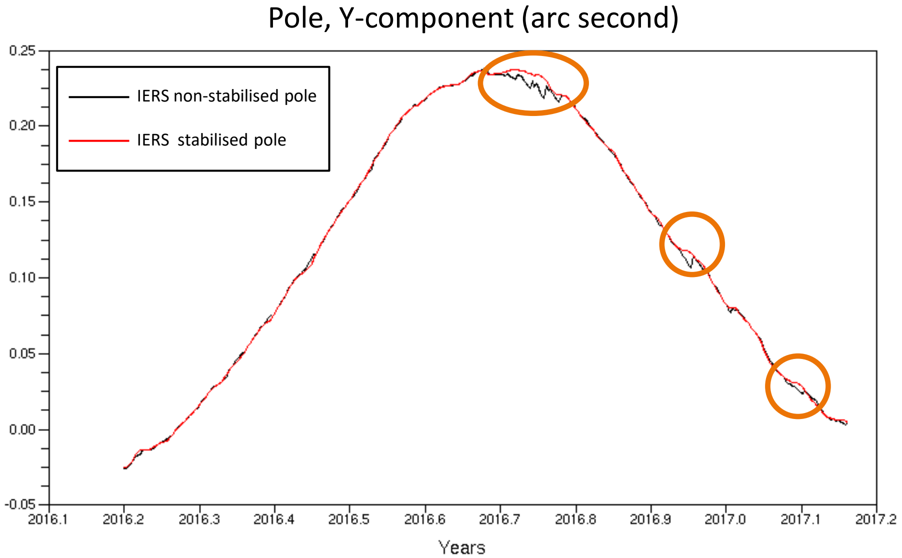
INTRODUCTION

- Two types of operational orbits : POE and MOE
  - MOE : non-stabilised IERS pole values (prediction)
  - POE : stabilised IERS pole values

- Predictions can be really off





- Can we estimate a better pole for MOE computation using DORIS measurements ?

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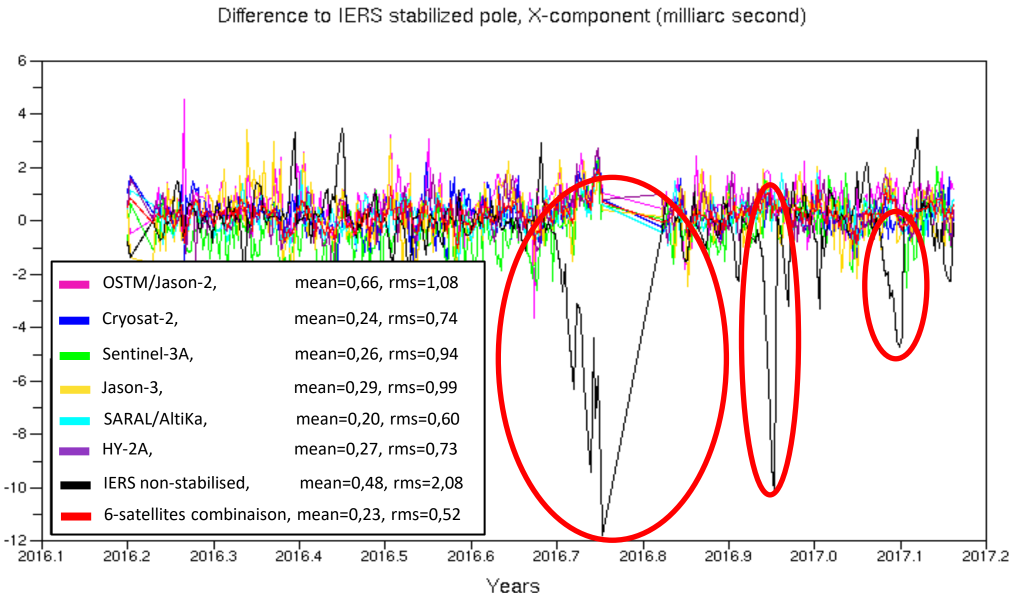
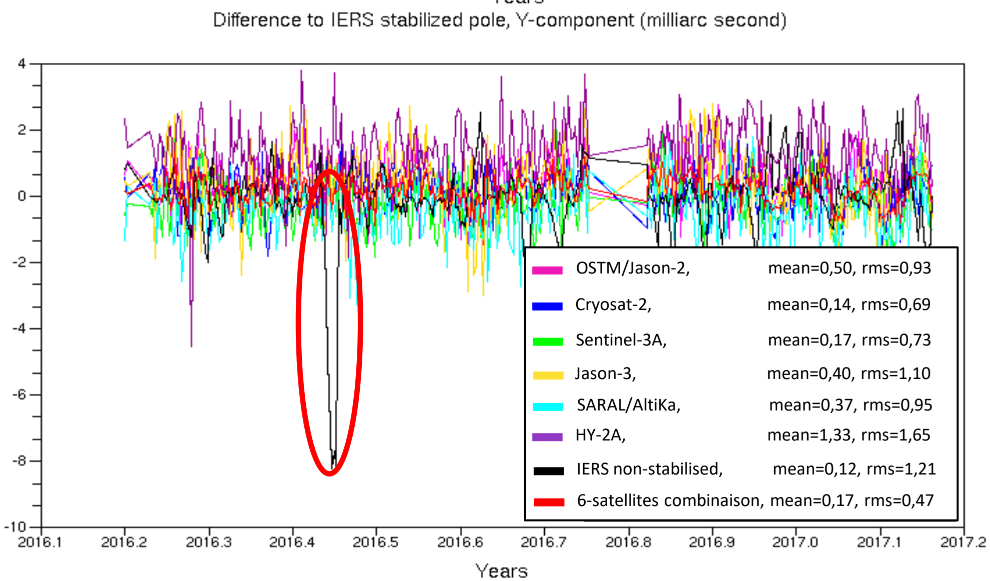
- INTRODUCTION
- POLE ESTIMATION
- ORBIT COMPARISON
- SLR RESIDUALS
- CONCLUSION
- A FEW WORDS ABOUT THE IERS CONVENTIONAL MEAN POLE

POLE ESTIMATION : METHOD

- It is possible to **estimate X and Y components of the pole** in our software.
- (X,Y) is computed on **1-day arc** for each active altimetry satellite (Cryosat-2, OSTM/Jason-2, Jason3, Sentinel-3A, SARAL/AltiKa, HY-2A).
- Orbits used in this study are **DORIS-only dynamic orbits**.
- This study covers **~1 year** (15/03/2016 – 28/02/2017)
- Then, a combined pole is estimated by **stacking normal equations**

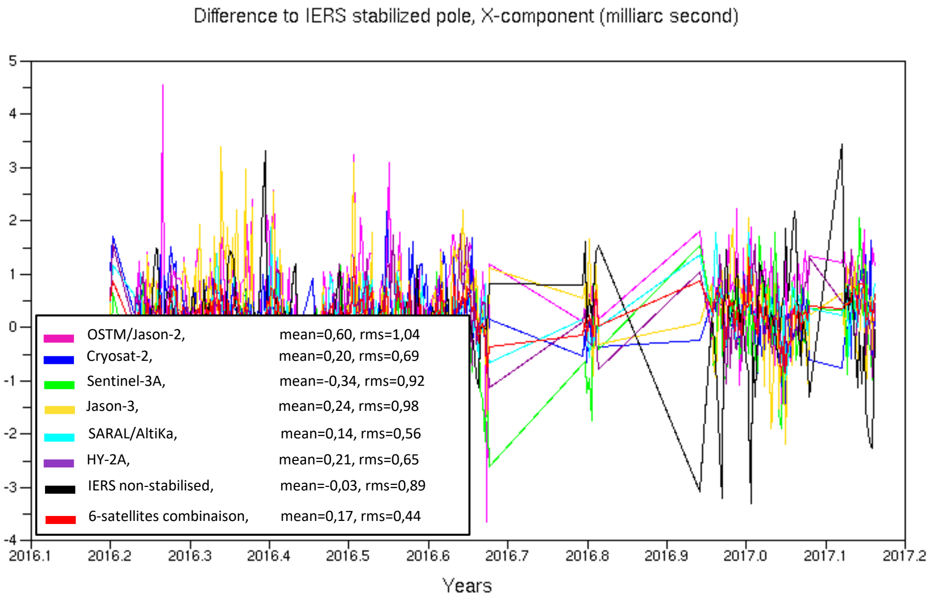
POLE ESTIMATION : RESULTS

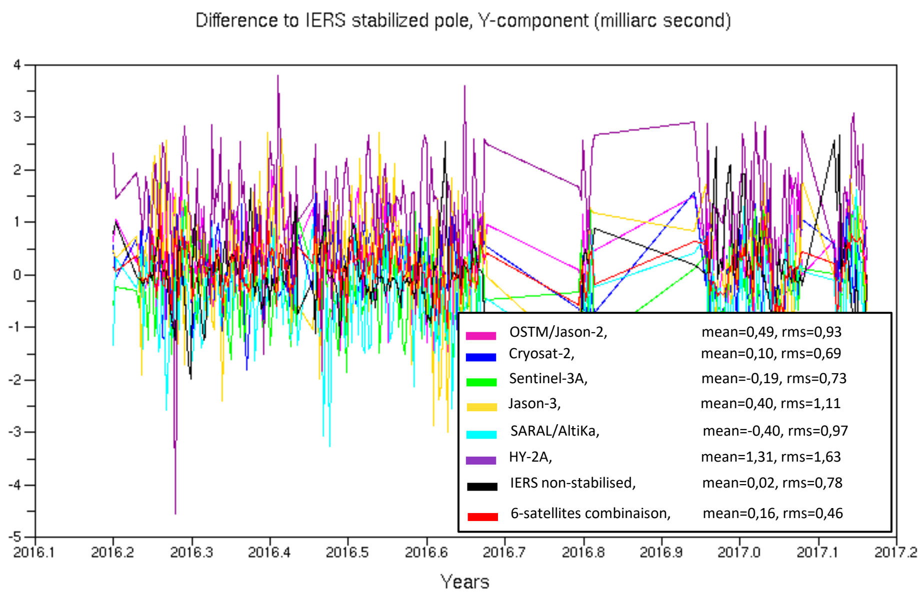




- The estimated poles stay closer to the IERS stabilized pole
- Combinaison pole has the smallest RMS (~0,5 milliarc second)

POLE ESTIMATION : RESULTS

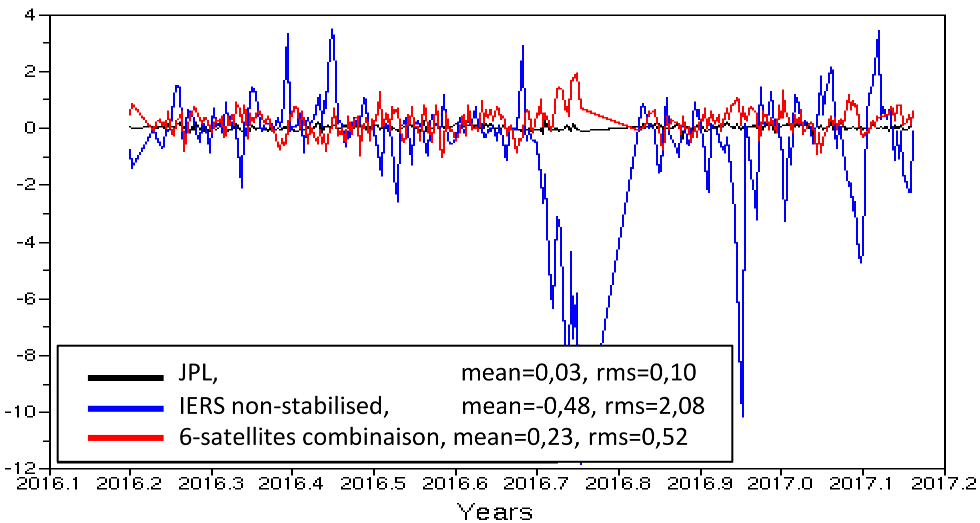




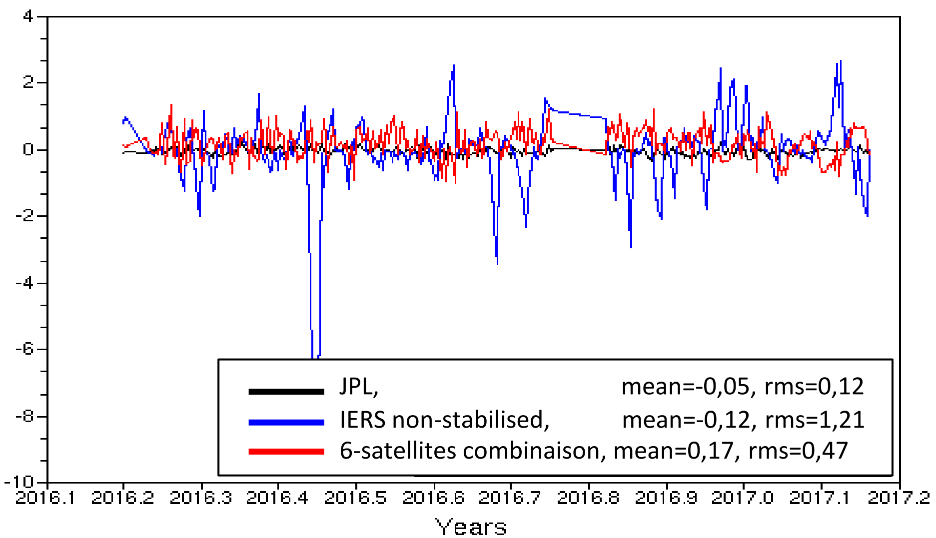
- The quality of the estimated poles depends on the satellite.
- When comparing to the IERS stabilised pole, the **combined pole** has the **lowest noise** and the **smallest mean**.

POLE ESTIMATION : COMPARAISON TO JPL

Difference to IERS stabilized pole, X-component (milliarc second)



Difference to IERS stabilized pole, Y-component (milliarc second)



- JPL has the lowest noise and is the closest to the IERS stabilized pole. (GPS)
- The combined pole has a larger noise, but still shows a good behaviour. (DORIS)
- 0,5 milliarcsecond corresponds to 1,5 cm on the surface of the Earth.

POLE ESTIMATION : CONCLUSION

- Estimating a DORIS pole enables to **correct the poor predictions** of the IERS non-stabilised pole.
- The DORIS **combination pole** is quite close to the IERS stabilised pole, with **0,5 milliarc second RMS**.
- **JPL** pole is the closest pole to the IERS stabilised pole, with **0,1 milliarc second RMS**.

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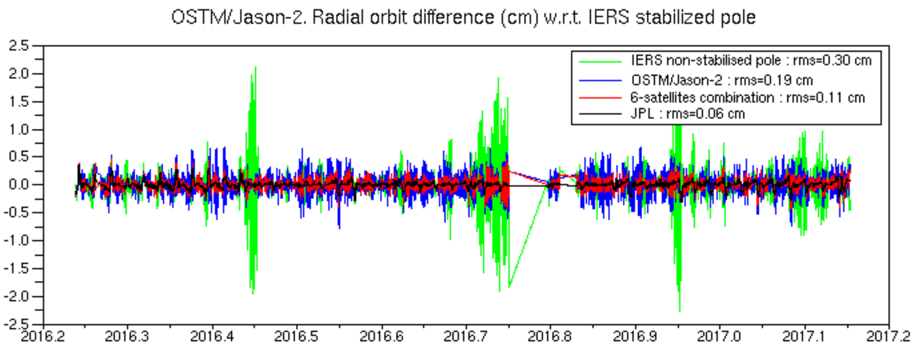
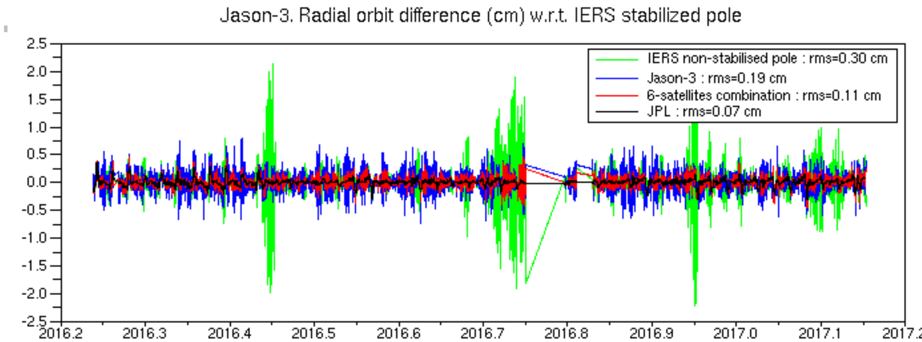
ORBIT COMPARISON : METHOD

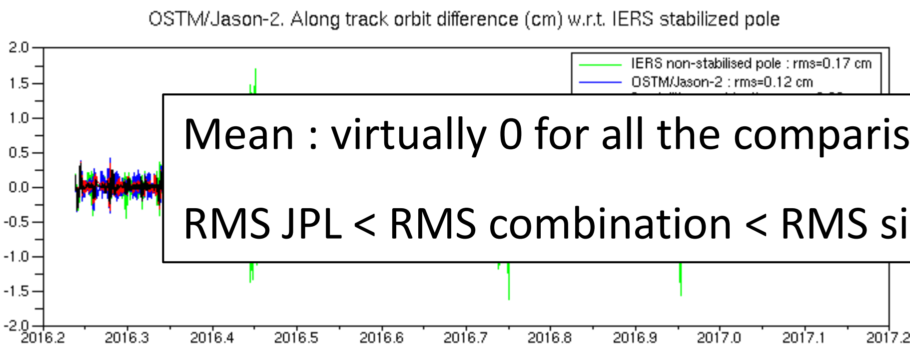
- DORIS-only dynamic orbits
- Comparison between orbits with CNES and JPL pole to orbits using IERS stabilised pole
- The different orbits to be compared are in different inertial reference frames, because they don't use the same pole.
- These orbits cannot be compared directly

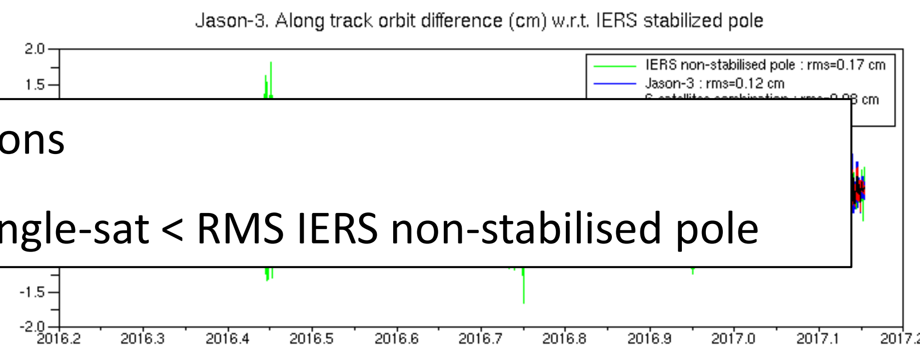
Orbit in the inertial frame tied to a pole P (JPL, CNES, …) → Orbit in the terrestrial reference frame → Orbit in the inertial frame tied to IERS stabilised pole

ORBIT COMPARISON : JASONS



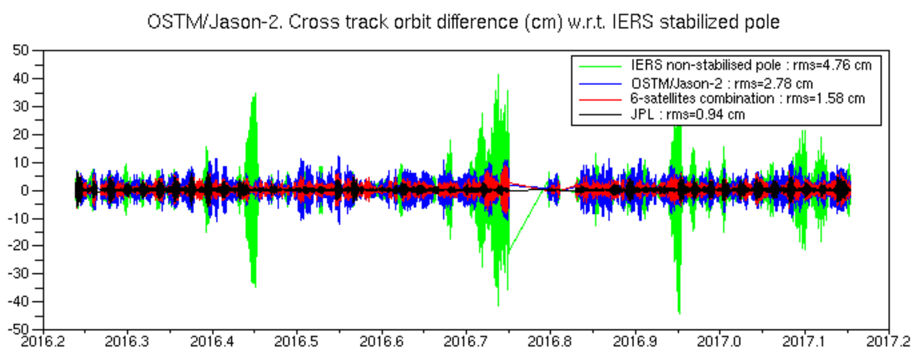


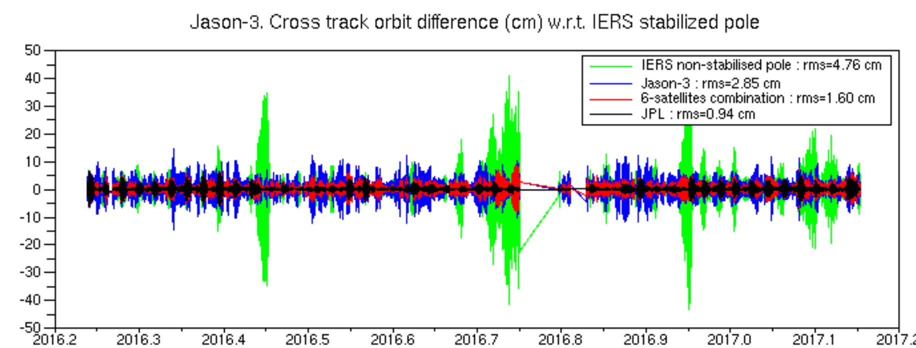




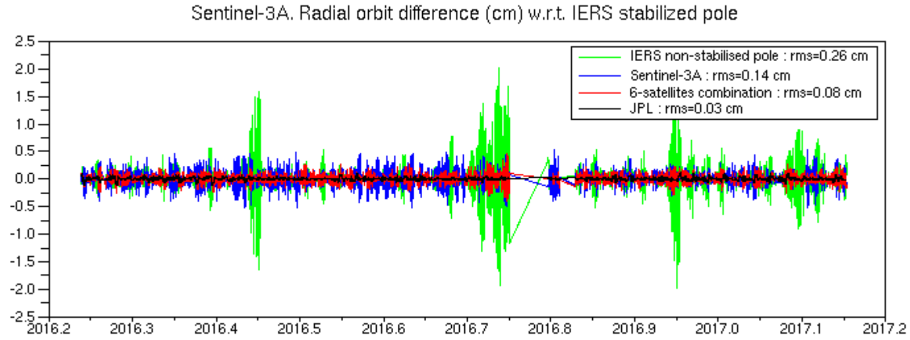
Mean : virtually 0 for all the comparisons

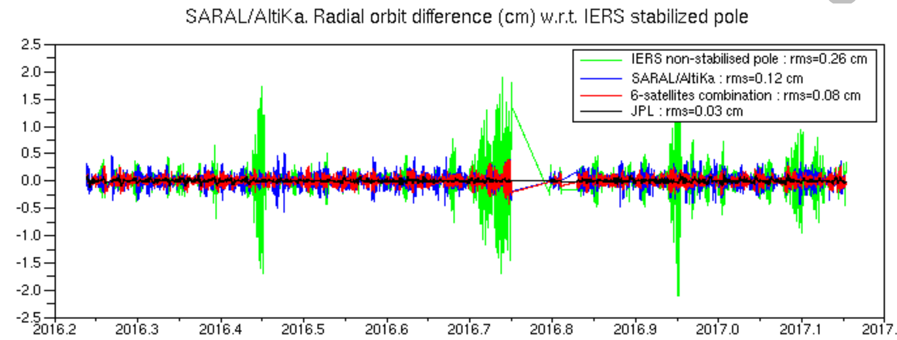
RMS JPL < RMS combination < RMS single-sat < RMS IERS non-stabilised pole

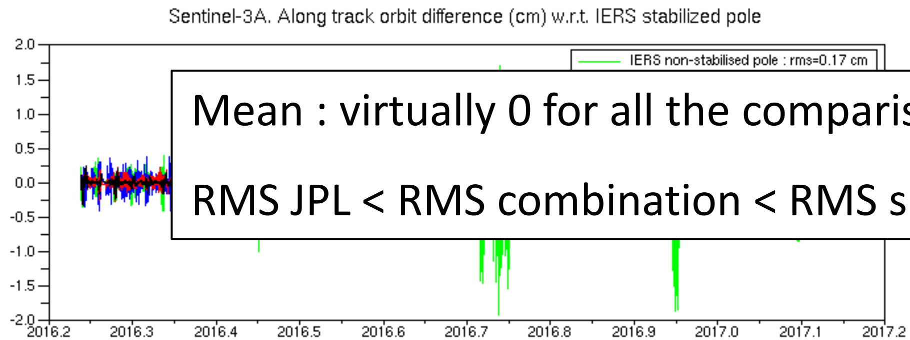


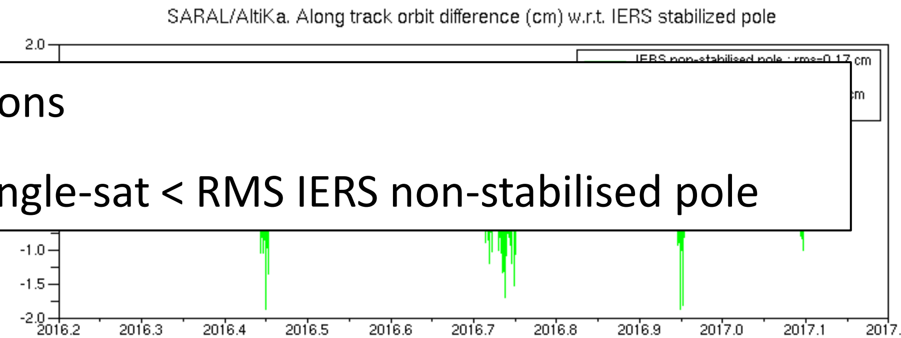


ORBIT COMPARISON : SENT3A AND SARAL



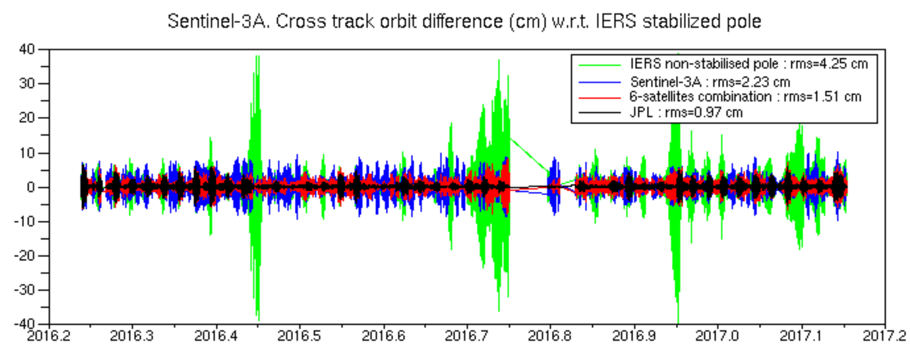


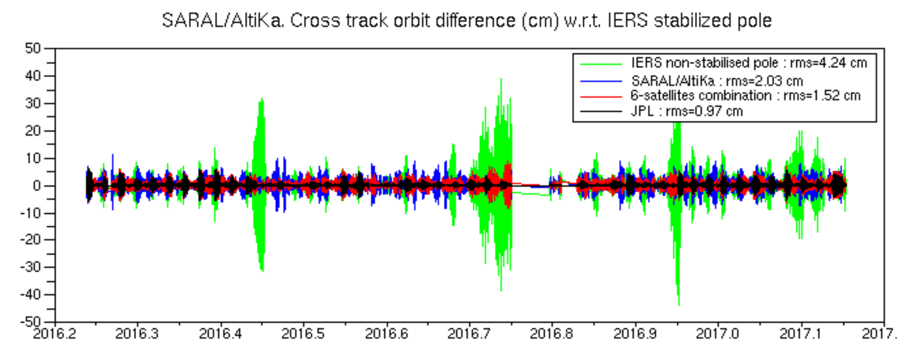




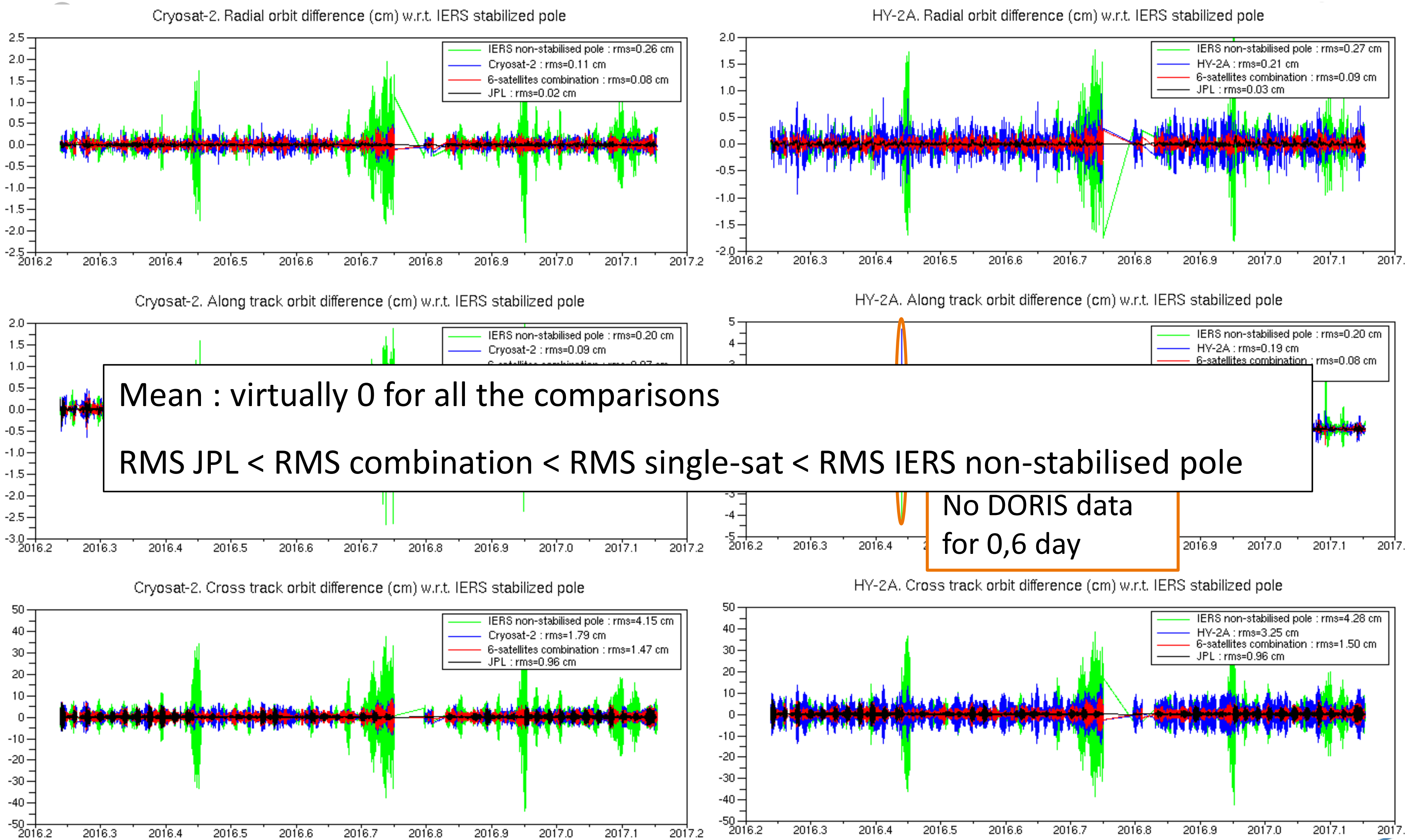
Mean : virtually 0 for all the comparisons

RMS JPL < RMS combination < RMS single-sat < RMS IERS non-stabilised pole





ORBIT COMPARISON : CRYOS2 AND HY2A



Mean : virtually 0 for all the comparisons

RMS JPL < RMS combination < RMS single-sat < RMS IERS non-stabilised pole

No DORIS data
for 0,6 day

ORBIT COMPARISON : CONCLUSION

- Using an estimated pole (mono-satellite or 6-satellites combination) gives a **better orbit than using MOE** (IERS non –stabilised pole).

- Combination of normal equations gives a **pole closer to the IERS** stabilised pole.

- **Radial orbit differences** between orbits using the combination pole and the IERS stabilised pole is **around 1 mm RMS**.

- Radial orbit differences between orbits using the IERS stabilised and non-stabilised pole is around 3 mm RMS

  → **combination pole** shows a **2 mm RMS improvement** in the radial direction compared to the IERS non-stabilised pole

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SLR RESIDUAL

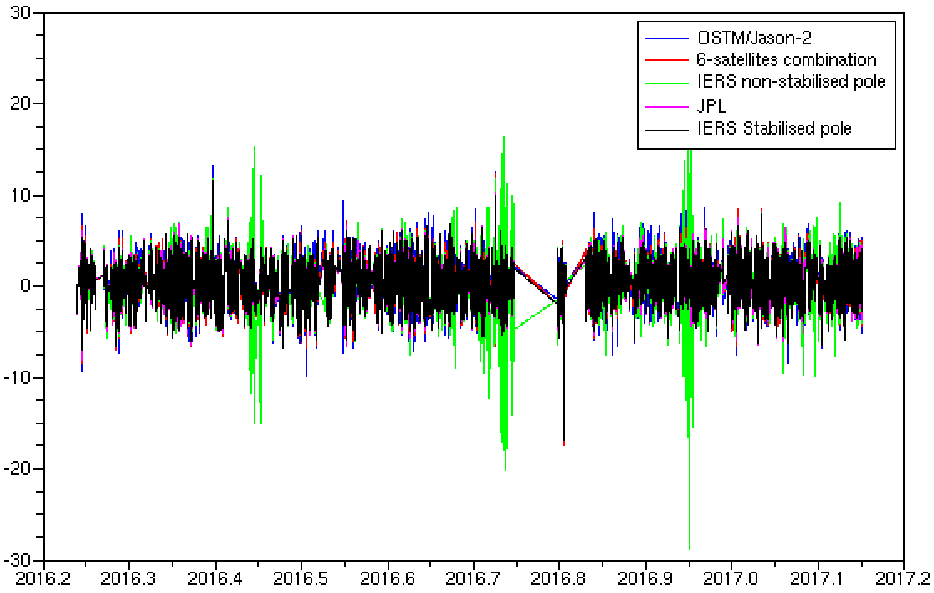
- SLR residuals are computed on the orbits converted in the **inertial frame** using **IERS stabilised pole**

- SLR residuals are computed **using IERS stabilised pole** :
  - No study of the impact of the other poles on station positioning
  - Study of the quality of the orbits using other poles

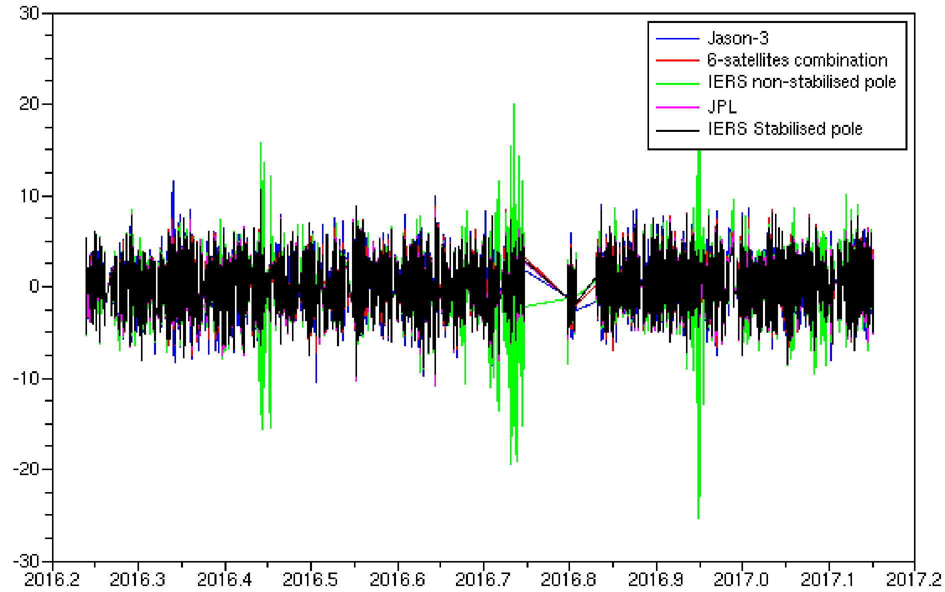
- Results from **core network** stations : L7090 (Yarragadee), L7105 (Washington), L7810 (Zimmerwald), L7839 (Graz-Lustbuehel), L7840 (Herstmonceux), L7941 (Matera), L8834 (Wettzell), L7821 (Shanghai), L7841 (Potsdam), L7501 (Hartebeesthoek) and L7119 (Maui).

SLR RESIDUAL : JASONS, WHOLE PERIOD

OSTM/Jason-2. SLR residuals, core network (cm)

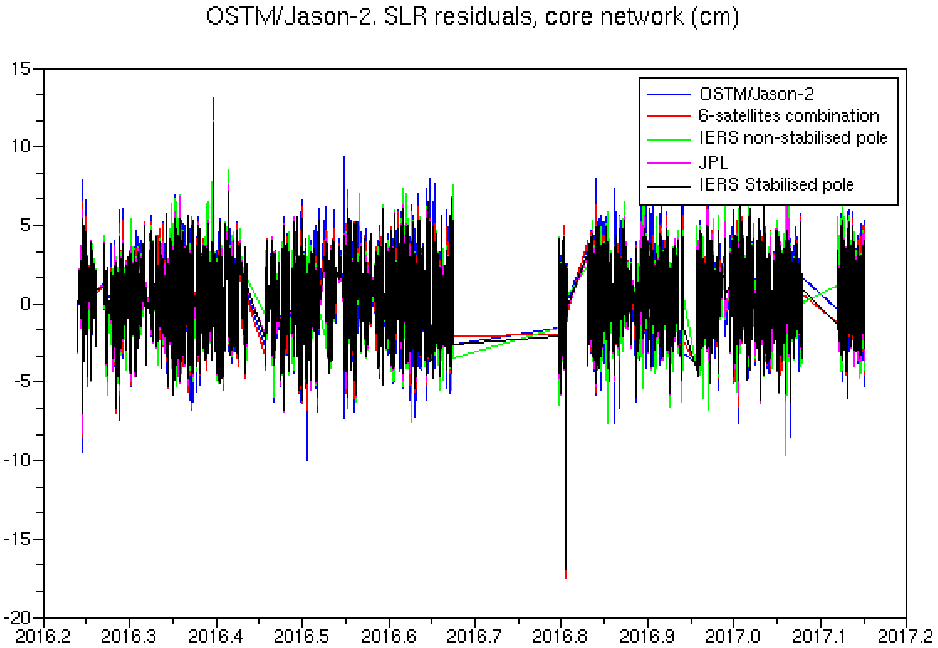


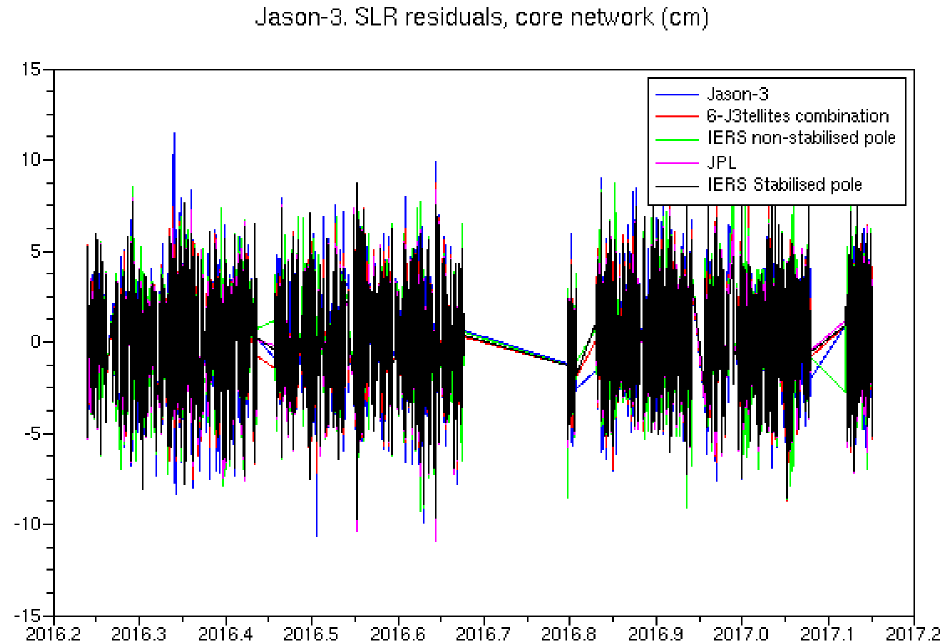
Jason-3. SLR residuals, core network (cm)



SLR RMS (cm)	OSTM/Jason-2	Jason-3
Single-satellite pole	2,37	2,53
6-satellites combination	2,13	2,37
IERS non-stabilised pole	3,04	3,18
JPL	2,04	2,34
IERS stabilised pole	1,99	2,31

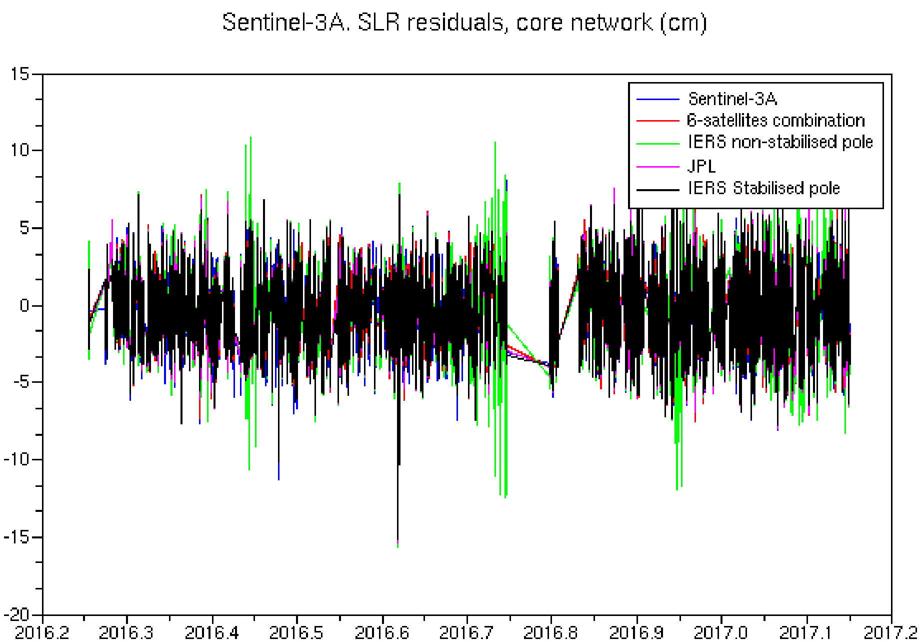
SLR RESIDUAL : JASONS, WITHOUT POOR IERS PREDICTIONS

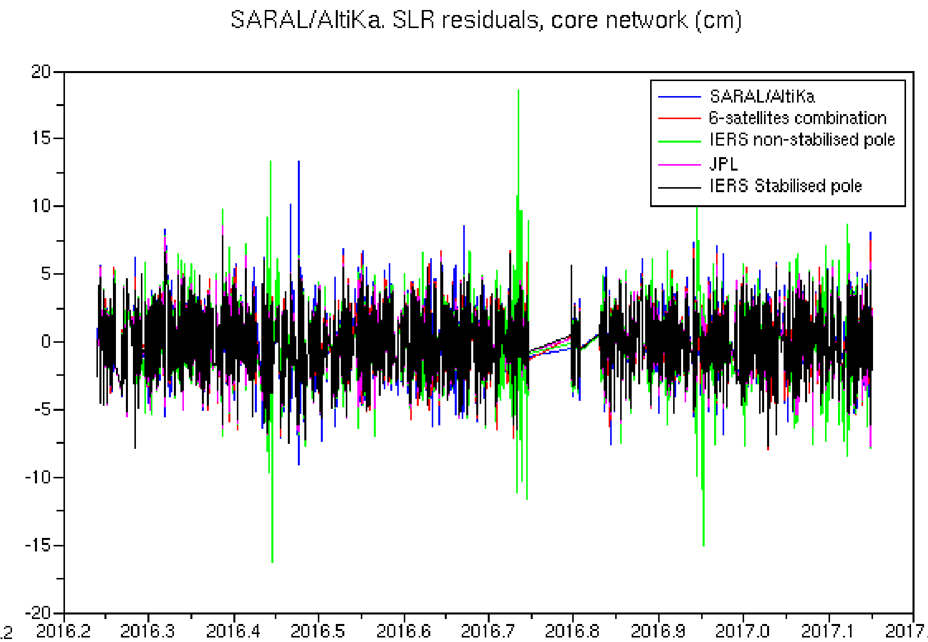




SLR RMS (cm)	OSTM/Jason-2	Jason-3
Single-satellite pole	2,36	2,57
6-satellites combination	2,12	2,41
IERS non-stabilised pole	2,21	2,46
JPL	2,04	2,36
IERS stabilised pole	2,00	2,34

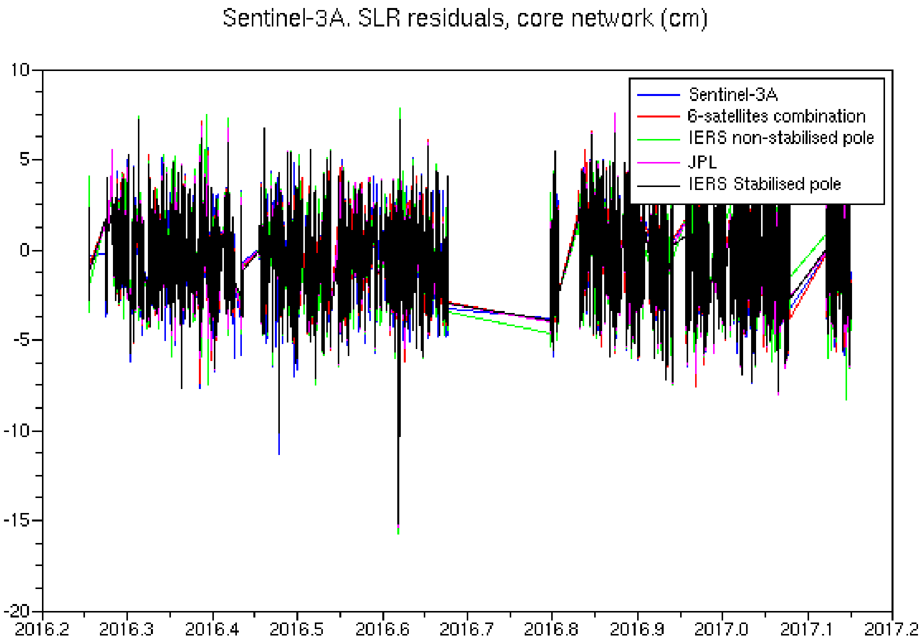
SLR RESIDUAL : SENTINEL-3A AND SARAL, WHOLE PERIOD

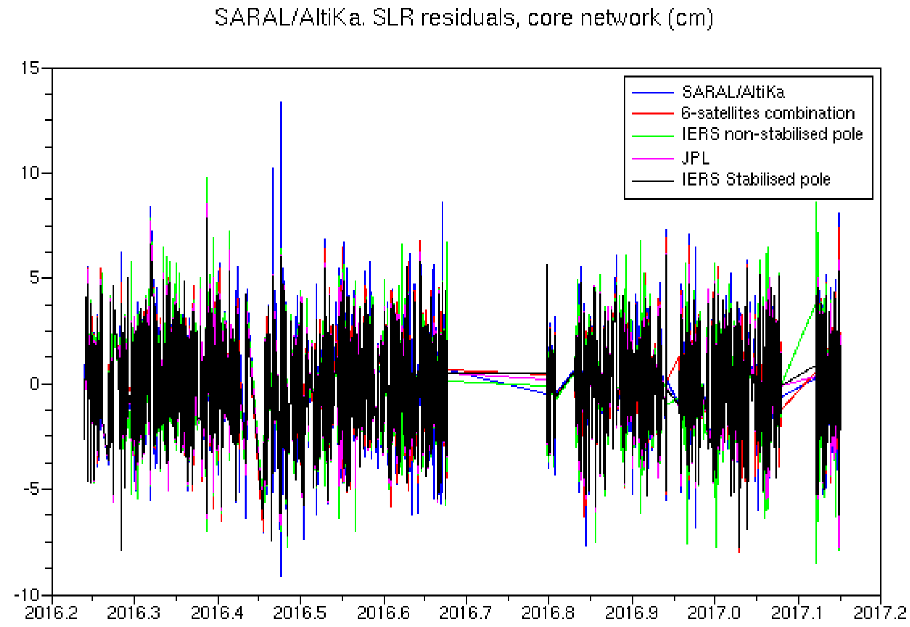




SLR RMS (cm)	Sentinel-3A	SARAL/AltiKa
Single-satellite pole	2,42	2,24
6-satellites combination	2,38	2,04
IERS non-stabilised pole	2,73	2,46
JPL	2,31	1,97
IERS stabilised pole	2,27	1,92

SLR RESIDUAL : SENTINEL-3A AND SARAL, WITHOUT POOR IERS PREDICTIONS

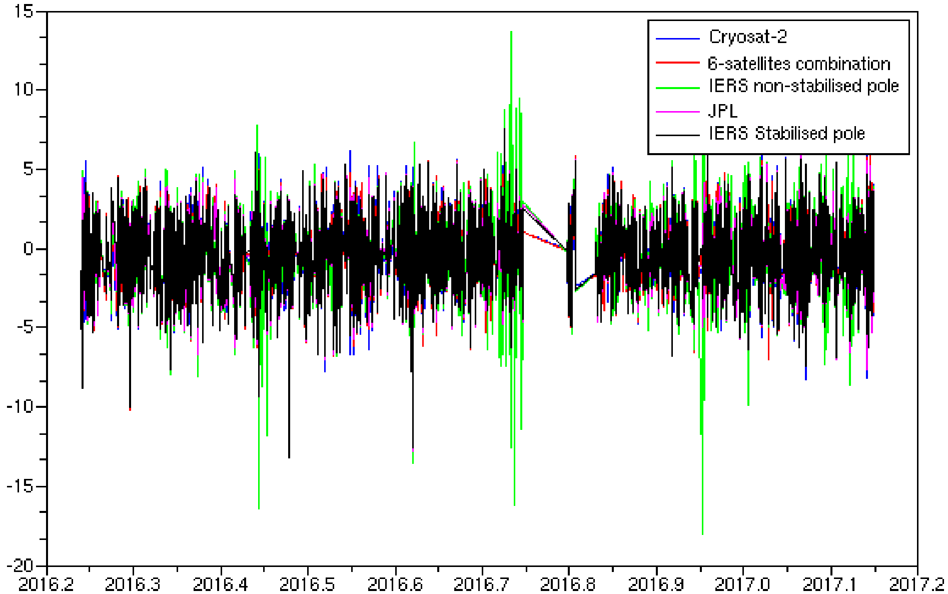




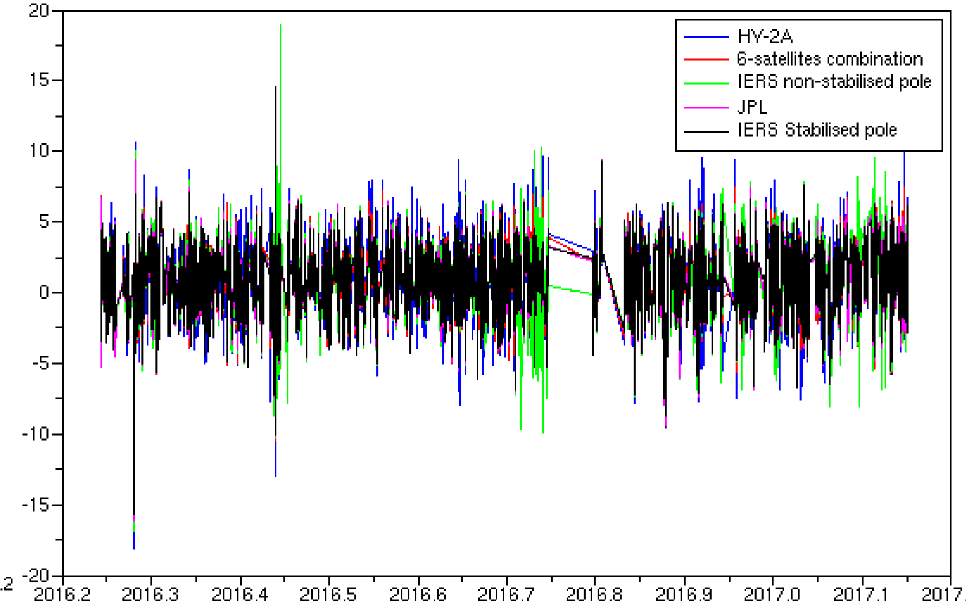
SLR RMS (cm)	Sentinel-3A	SARAL/AltiKa
Single-satellite pole	2,41	2,30
6-satellites combination	2,37	2,07
IERS non-stabilised pole	2,44	2,18
JPL	2,32	2,01
IERS stabilised pole	2,28	1,95

SLR RESIDUAL : CRYOSAT-2 AND HY-2A, WHOLE PERIOD

Cryosat-2. SLR residuals, core network (cm)

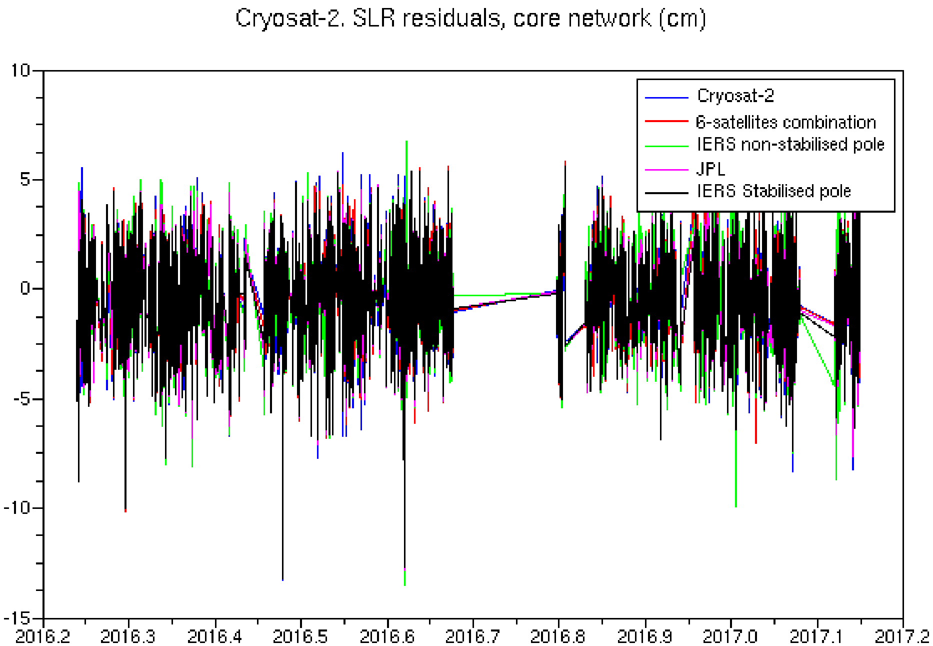


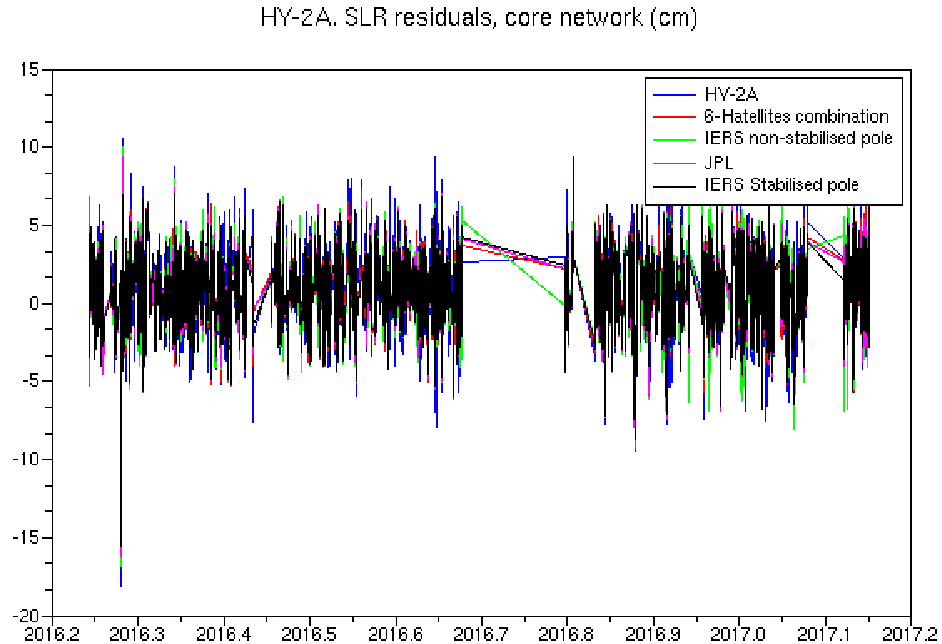
HY-2A. SLR residuals, core network (cm)



SLR RMS (cm)	Cryosat-2	HY-2A
Single-satellite pole	2,07	2,82
6-satellites combination	2,03	2,44
IERS non-stabilised pole	2,42	2,68
JPL	1,94	2,36
IERS stabilised pole	1,89	2,31

SLR RESIDUAL : CRYOSAT-2 AND HY-2A, WITHOUT POOR IERS PREDICTIONS





SLR RMS (cm)	Cryosat-2	HY-2A
Single-satellite pole	2,08	2,79
6-satellites combination	2,04	2,41
IERS non-stabilised pole	2,11	2,48
JPL	1,96	2,35
IERS stabilised pole	1,91	2,3

SLR RESIDUAL : CONCLUSION

- Using an estimated pole (mono-satellite or 6-satellites combination) gives a **better orbit than using IERS non-stabilised pole** on the poor IERS prediction periods.

- For Cryos2 and Sent3a, the mono-satellite estimated pole already gives better results than IERS non-stabilised pole

- The **combination pole** always gives **better results than the MOE** pole

- The JPL pole gives marginally lower RMS values (from 0,05 to 0,1 cm lower)

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CONCLUSION

- It is possible to estimate the pole using only DORIS measurements.
- When combining data from several satellite, the **precision of the pole estimation** is around **0,5 milliarcsecond** (1,5 cm).
- The estimated pole can **compensate for the poor IERS predictions**
- Outside of these poor prediction periods : the impact of estimating a DORIS pole shows a **small but consistent improvement** on SLR residuals and on orbit comparison.

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- **A FEW WORDS ABOUT THE IERS CONVENTIONAL MEAN POLE**

MEAN POLE IERS

CONTEXT

Introduction of the new version 2015 of the IERS conventional Mean Pole

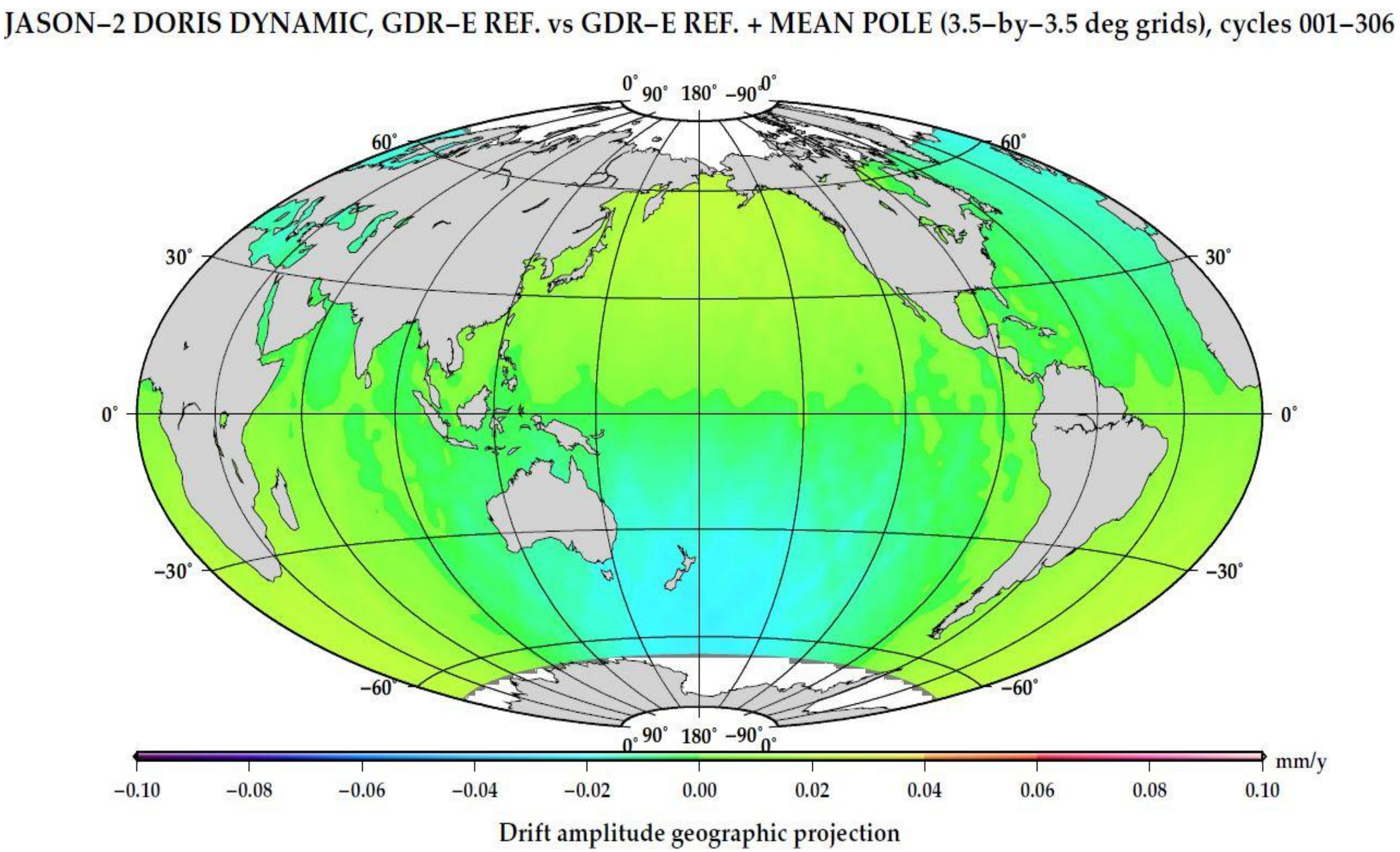
- *IERS_CMP_2015 Fortran subroutine including first version of table of {X,Y} coordinates*
- *Update version of mean pole coordinates {X,Y} table, june 2016*
- *All elements available for download on web site hpiers.obspm.fr/eoppc/eop/eopc01/*

Integration of new mean pole version in GDR-E standard

- *GDR-E standard uses IERS MEAN POLE Convention 2010*
- *Reference orbits to improve new convention : JASON-2 DORIS dynamic*
- *Evaluate orbits impact in regards of 2 following criterions*
  - *Geographically correlated radial difference drift*
  - *Orbits comparisons , RMS radial*

MEAN POLE IERS

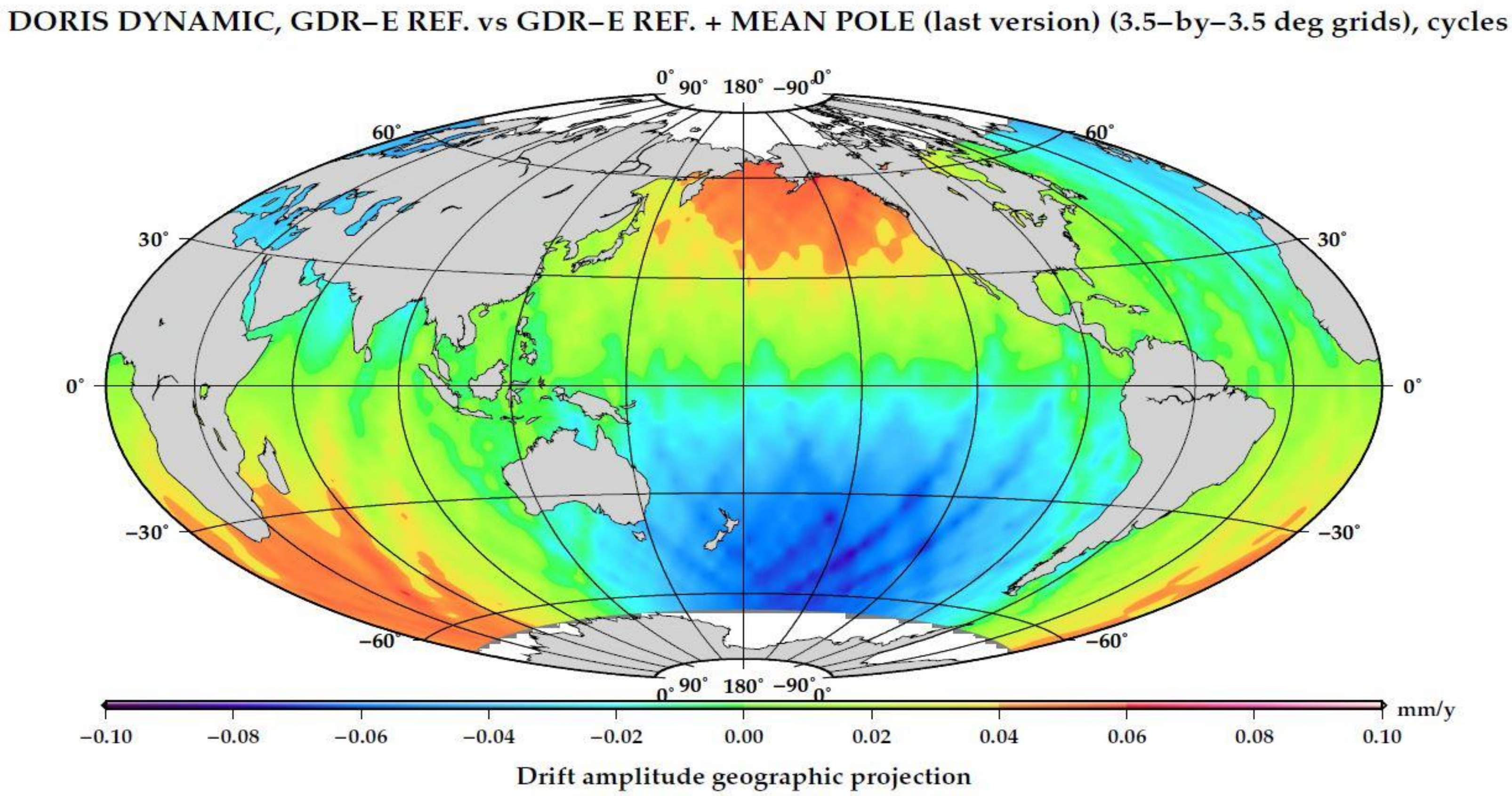
GEOGRAPHICALLY CORRELATED RADIAL DRIFT



Mean pole IERS 2015 first version, few impact < 0.05mm/year

MEAN POLE IERS

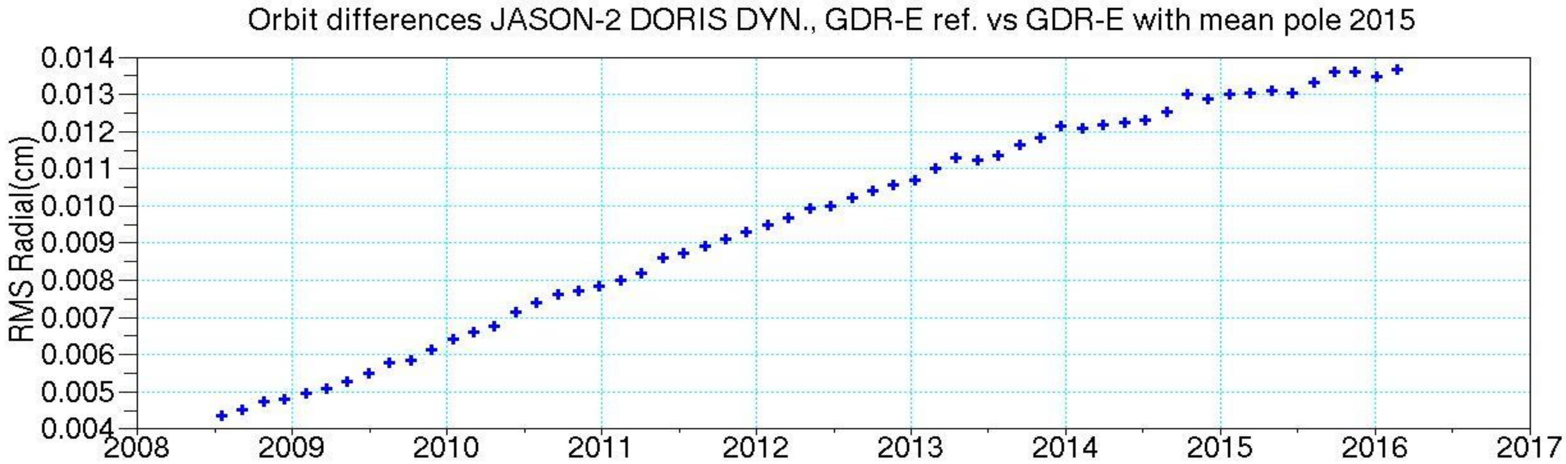
GEOGRAPHICALLY CORRELATED RADIAL DRIFT

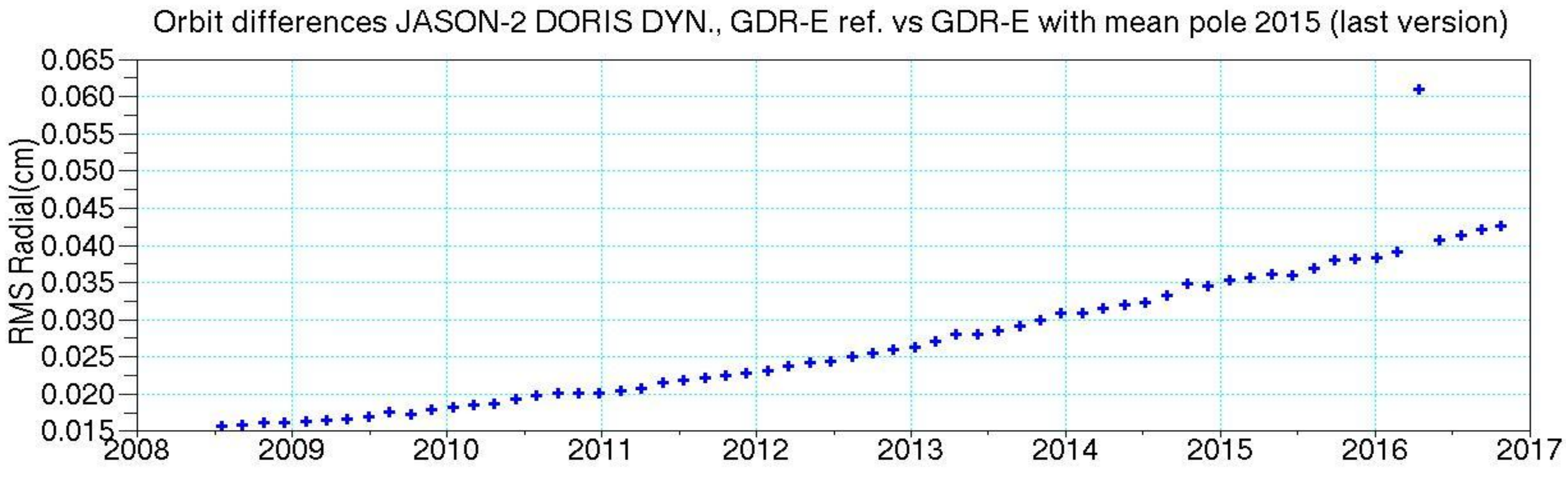


Mean pole IERS 2015 second version, few impact < 0.07mm/year

MEAN POLE IERS

ORBITS DIFFERENCE, RMS RADIAL





Submillimetric impact on orbits, radial component