Station Positions and Earth Rotation Parameters from JASON-1, JASON-2, and ENVISAT

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Outline

- Motivation
- Missions and data
- Precise Orbit Determination
- Estimation of station positions and velocities, and Earth rotation parameters
- Summary

Motivation

- Situation
  - Highly precise orbits of altimetry missions based on DORIS and SLR data are available
- Objective here
  - How can they be employed to infer the Terrestrial Reference Frame (TRF) and the Earth Rotation Parameters (ERP)
  - Can the orbit serve as global tie between DORIS and SLR?
  - Can UT1-UTC be estimated?

The Missions

- ENVISAT
  - Altitude: 796 km
  - Inclination: 98.5°
  - Eccentricity: 0.0012
- Data analyzed
  - JAN 2008 – APR 2012

(Courtesy ESA, 2018)

The Missions

- JASON1
  - Altitude: 1325 km
  - Inclination: 66.0°
  - Eccentricity: 0.0009
- Data analyzed
  - JAN 2008 – JUL 2013

(Courtesy CNES, JPL, 2018)

The Missions

- JASON2
  - Altitude: 1335 km
  - Inclination: 66.0°
  - Eccentricity: 0.0008
- Data analyzed
  - JUL 2008 – DEC 2014

(Courtesy CNES, JPL, 2018)

Precise Orbit Determination

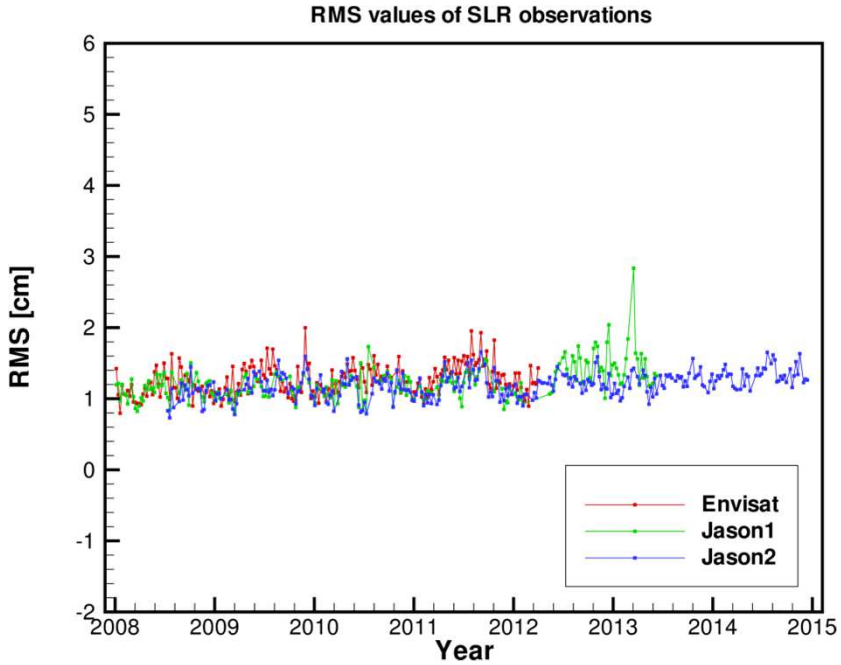
- Models and standards used:
  - Earth Gravity Field: EIGEN-6C up to degree/order 90 and time-variable coefficients up to degree/order 50
  - Non-tidal atmospheric mass variations: GRACE AOD RL05
  - Atmospheric density model: CIRA 86
  - Albedo model: Knocke, CSR
  - Ocean tides: EOT11A
  - Station coordinates: LPOD/DPOD 2008 by J. Ries, CSR
  - DORIS troposphere model: VMF1
  - SLR troposphere model: Mendes-Pavlis
- Arc length: 7 day arcs according to GPS weeks

Precise Orbit Determination

- Solved-for parameters:
  - Initial orbits elements: 1 set per arc
  - Scaling factor for solar radiation pressure: 1 per arc
  - Atmospheric drag scaling factors:
    - ENVISAT: 8 per day
    - JASON1 and JASON2: 5 per day
  - Empirical accelerations:
    - ENVISAT: 1 per day
    - JASON1 and JASON2: 2 per day
  - DORIS time biases: 1 per arc
  - DORIS frequency biases: 1 per pass per station
  - DORIS tropospheric scaling: 1 per pass per station
  - SLR range biases: 1 per station per arc

Precise Orbit Determination

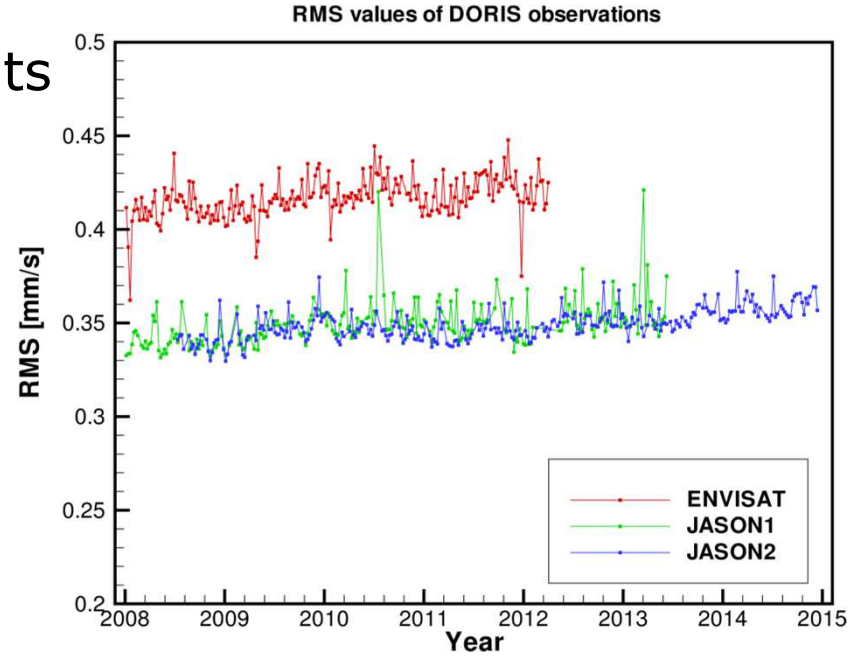
- SLR orbital fits



Mission	RMS (cm)	No. Obs.
ENVISAT	1.259	321,626
JASON1	1.222	624,297
JASON2	1.197	999,355

Precise Orbit Determination

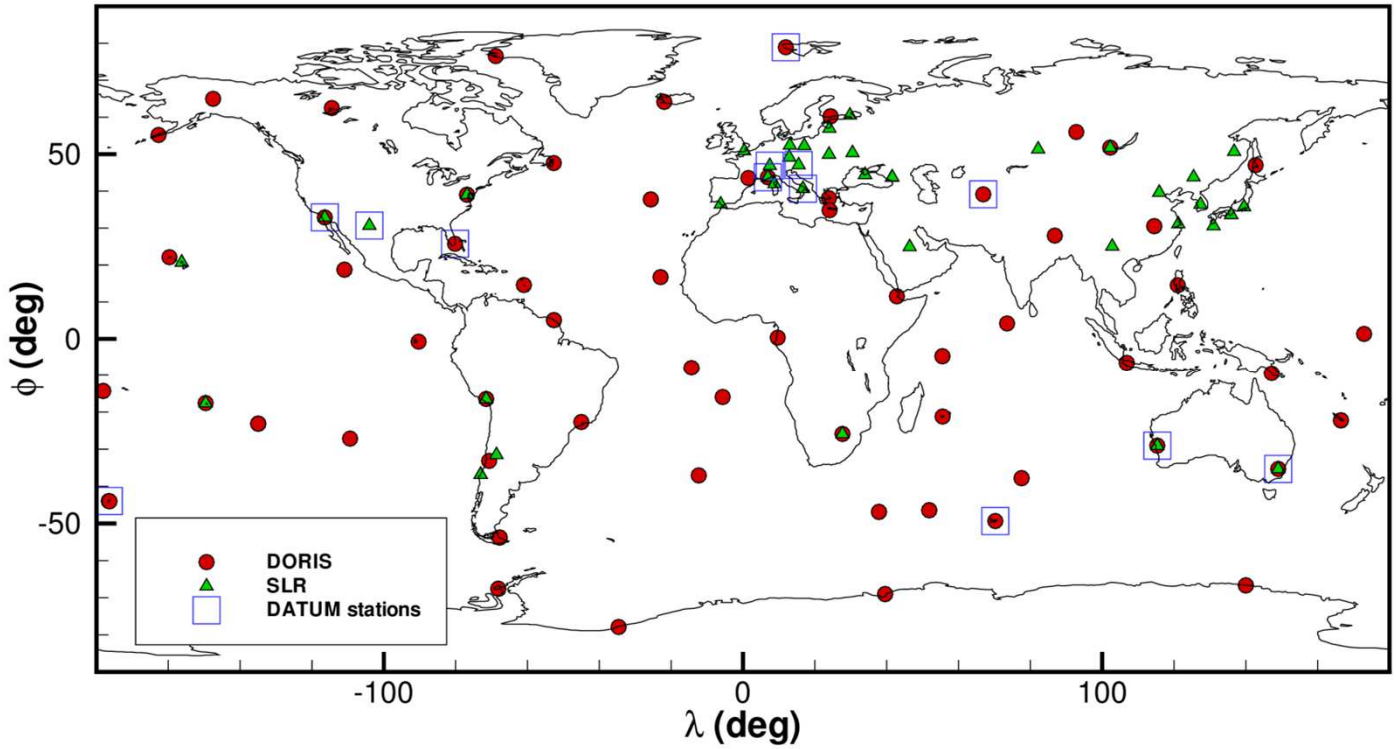
- DORIS orbital fits



Mission	RMS (cm/s)	No. Obs.
ENVISAT	0.04166	12,535,150
JASON1	0.03491	18,013,116
JASON2	0.03490	33,659,167

Ground stations network

- DORIS: 69
- SLR: 51
- Datum stations: 8 SLR, 9 DORIS

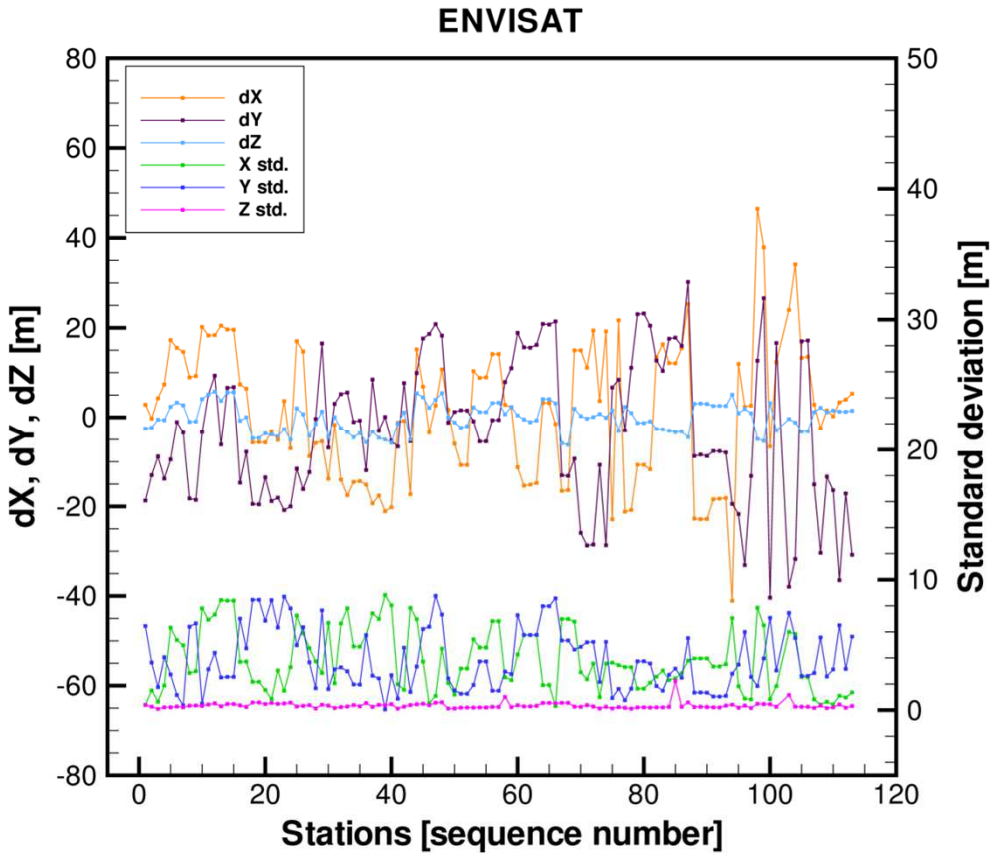


Estimation of Station Coordinates, Velocities and ERPs

- Solution strategy:
  - Converge orbits
  - Set station coordinates, velocities, and ERPs free and compute normal equation matrices (NEQ) per arc per satellite
  - Accumulate NEQs per satellite
  - Solve accumulated NEQS for station coordinates, velocities, and ERPs
- Eventually add No-Net Rotation (NNR) constraints

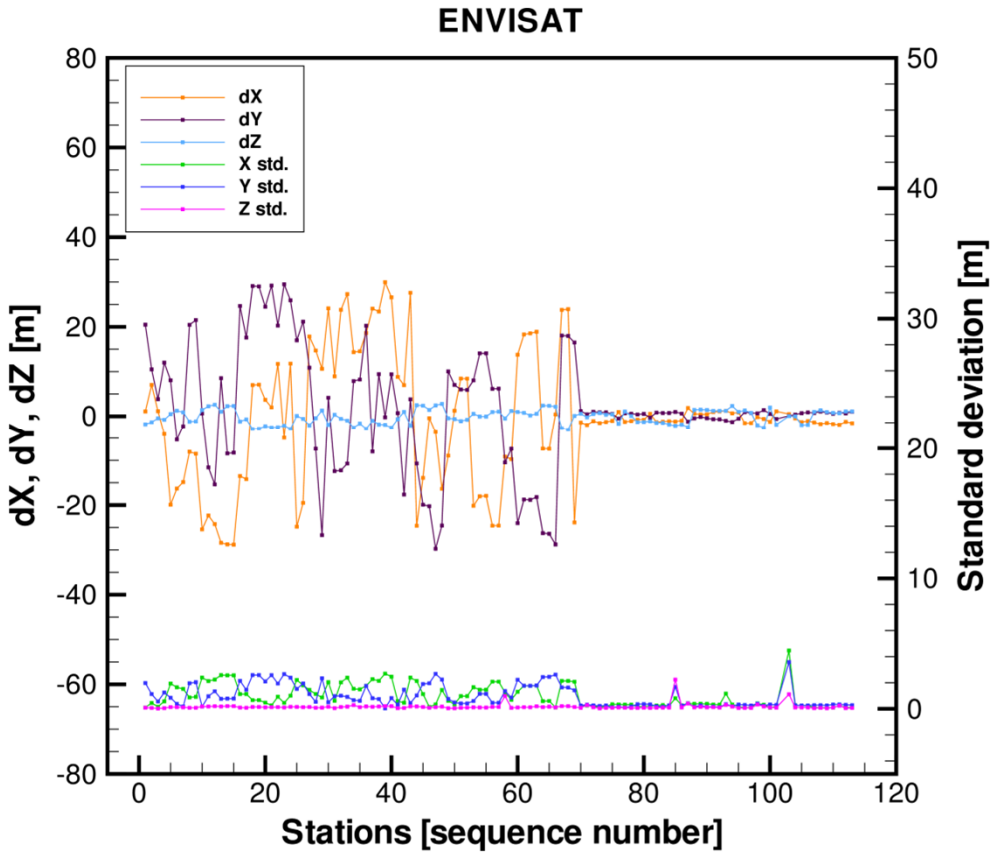
Coordinate Solutions

- Solution with no datum constraints



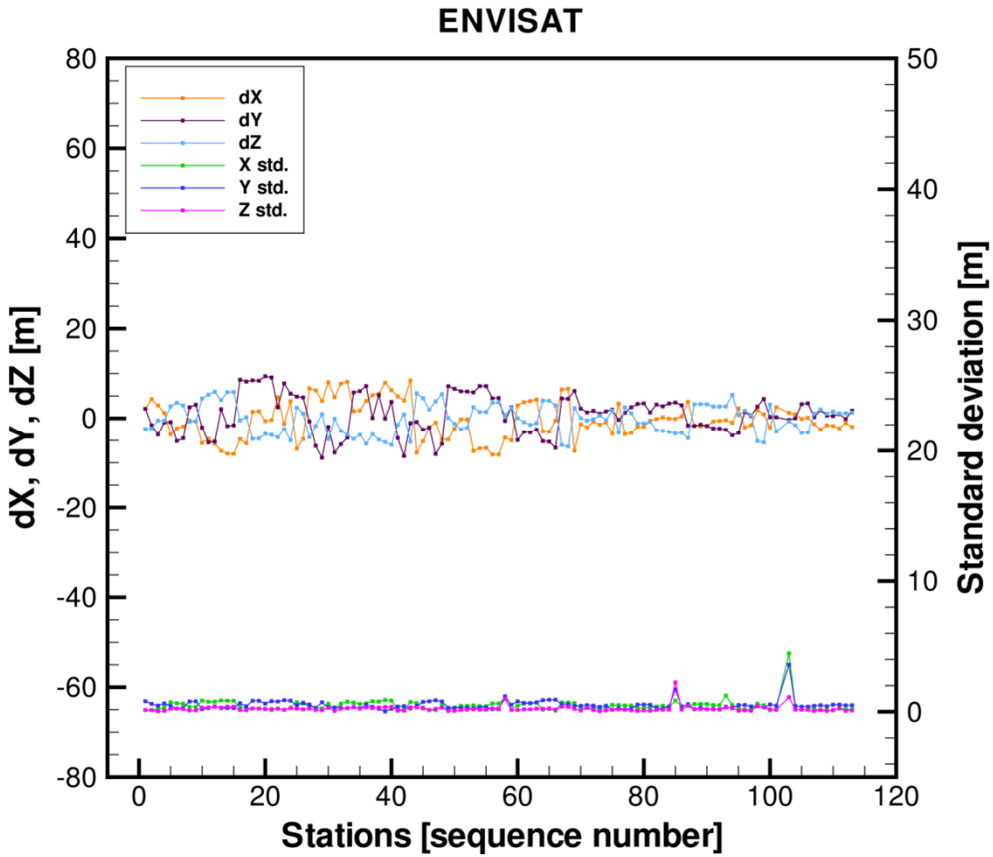
Coordinate Solutions

- NNR constraints on the SLR datum stations



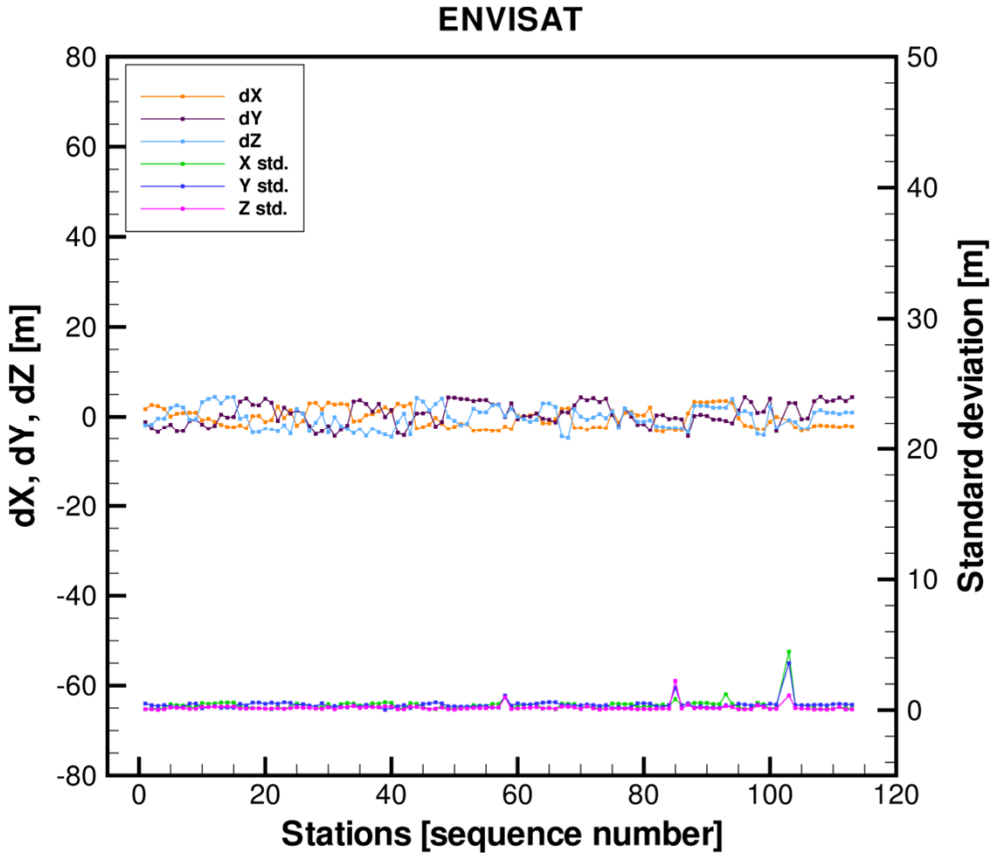
Coordinate Solutions

- NNR constraints on the SLR and DORIS datum stations



Coordinate Solutions

- NNR constraints on the SLR and DORIS datum stations, UT1-UTC fixed



Coordinate Solutions

- Standard deviation of the estimated coordinate corrections for **DORIS**
  - NNR constraints on datum stations

Mission	X (m)	Y (m)	Z (m)
ENVISAT	5.10	5.27	3.58
JASON1	10.34	9.94	0.46
JASON2	6.14	5.91	0.47

  - NNR constraints on datum stations, UT1-UTC fixed

Mission	X (m)	Y (m)	Z (m)
ENVISAT	1.98	2.54	2.71
JASON1	3.82	3.68	0.70
JASON2	1.89	1.81	0.57

Coordinate Solutions

- Standard deviation of the estimated coordinate corrections for **SLR**
  - NNR constraints on datum stations

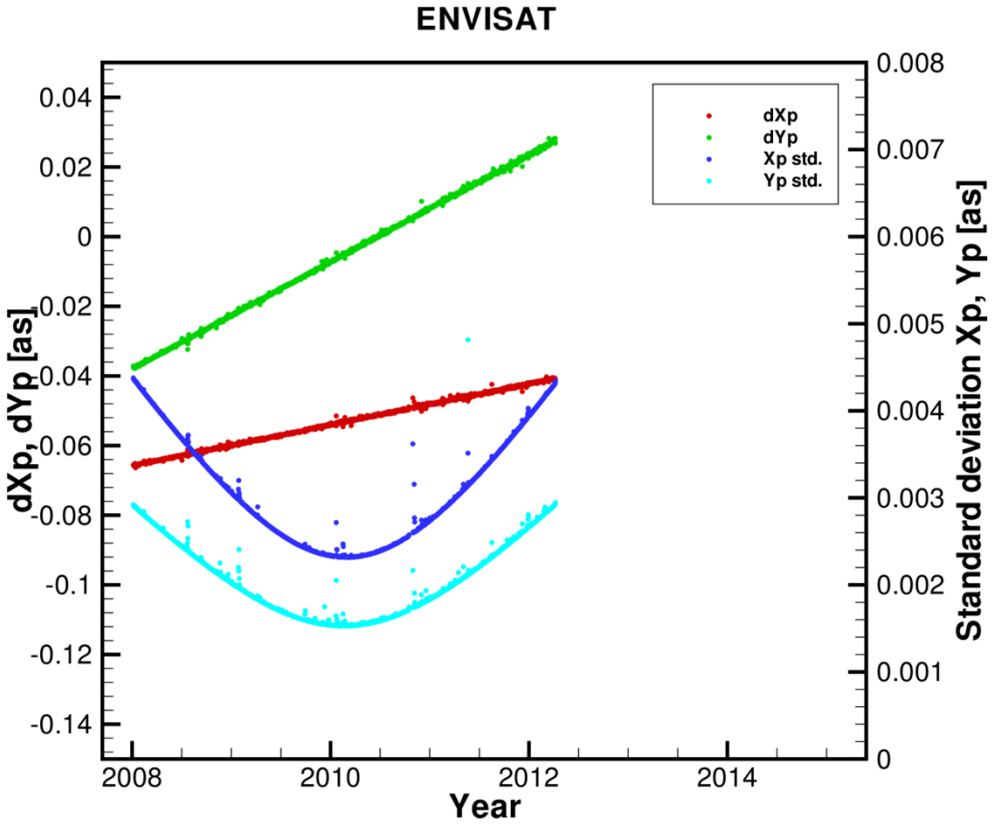
Mission	X (m)	Y (m)	Z (m)
ENVISAT	1.69	2.05	2.61
JASON1	0.71	0.70	0.55
JASON2	0.98	0.96	0.56

  - NNR constraints on datum stations, UT1-UTC fixed

Mission	X (m)	Y (m)	Z (m)
ENVISAT	2.31	2.47	2.04
JASON1	3.82	3.72	0.60
JASON2	1.83	1.90	0.55

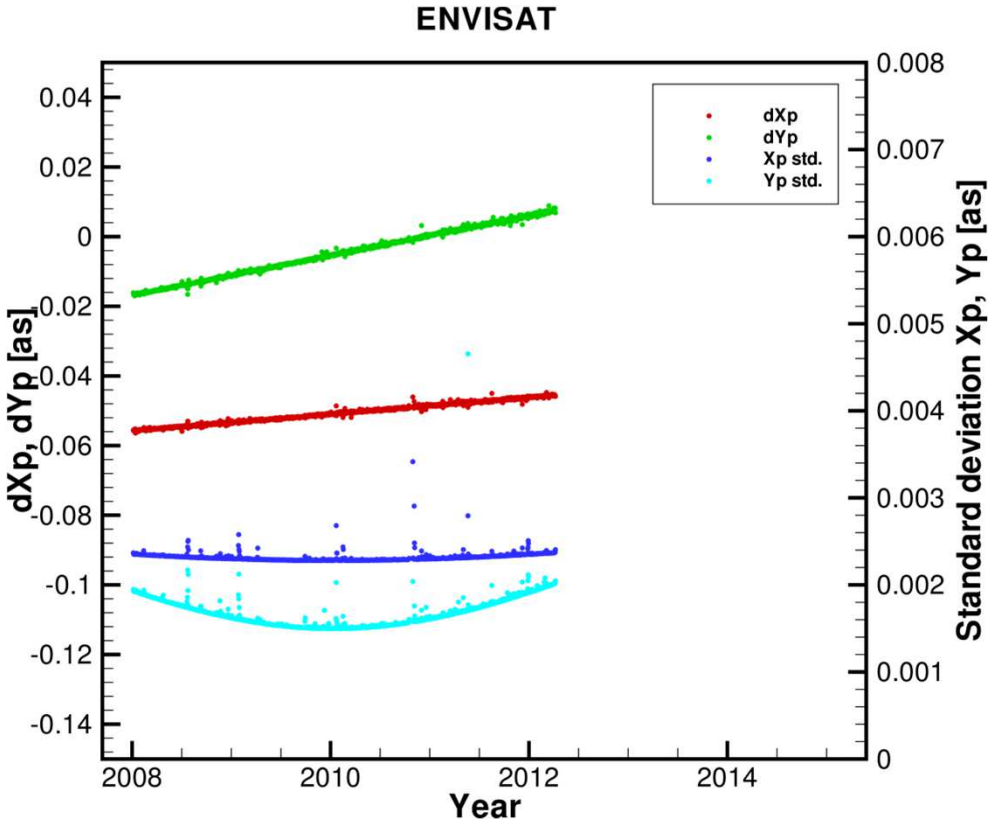
ERP Solutions

- Solution with no constraints



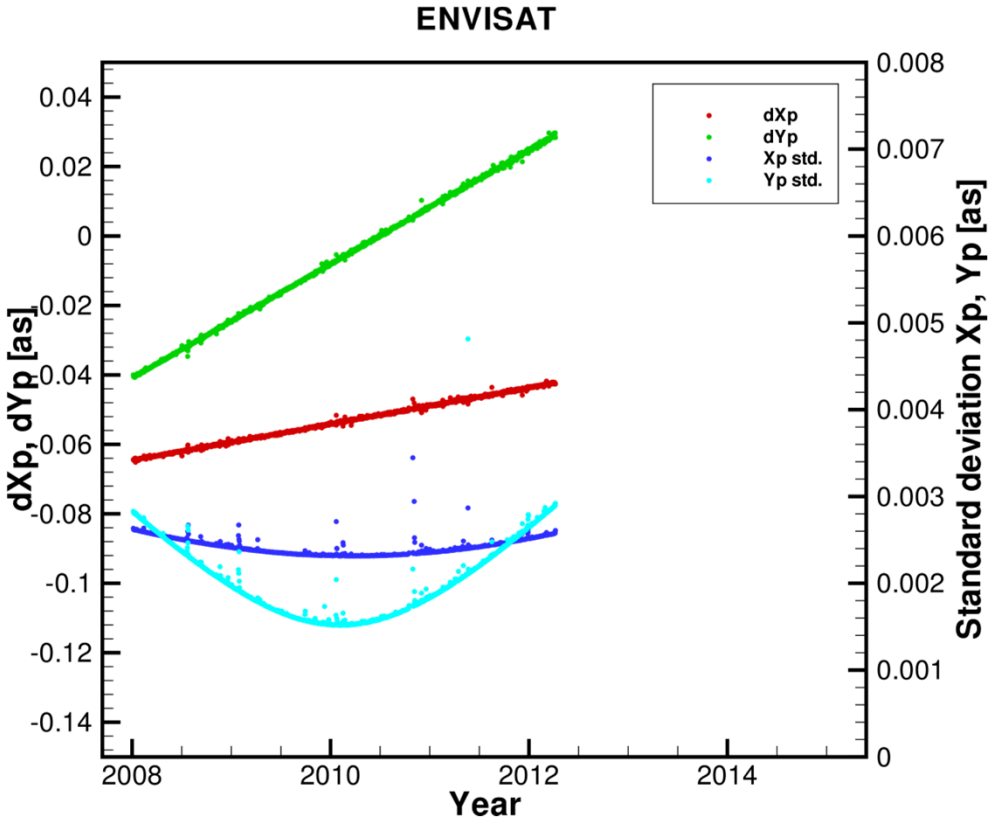
ERP Solutions

- NNR constraints on SLR datum stations



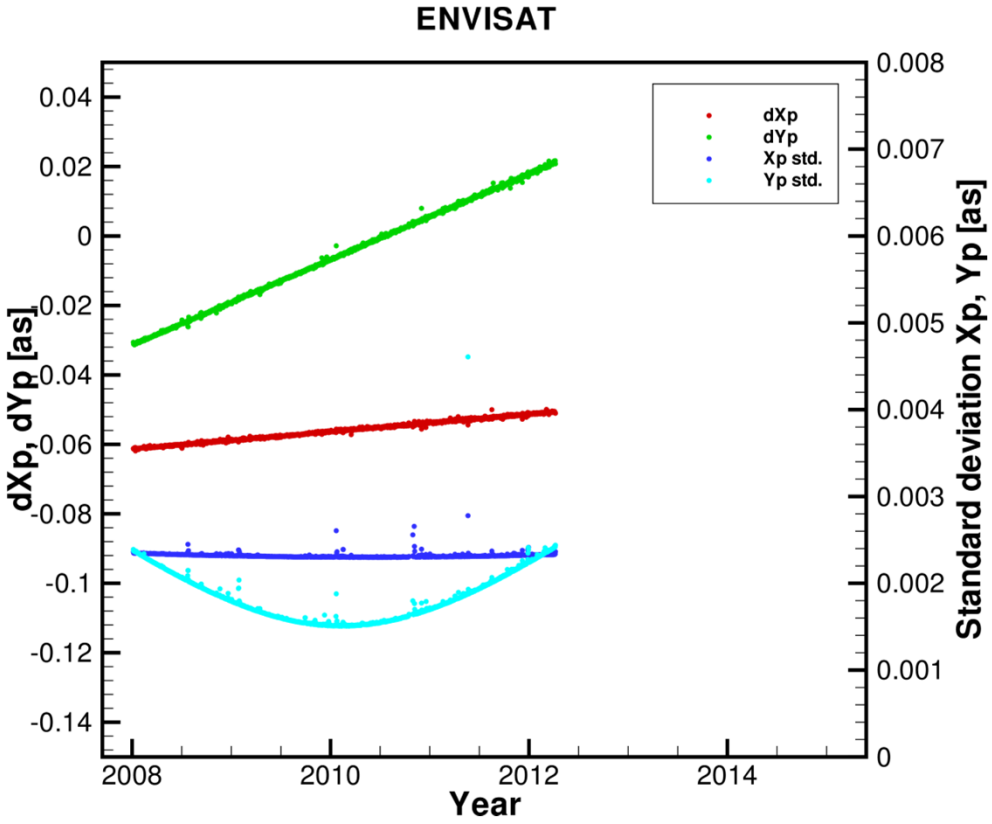
ERP Solutions

- NNR constraints on SLR and DORIS datum stations



ERP Solutions

- NNR constraints on SLR and DORIS datum stations, UT1-UTC fixed



ERP Solutions

- External accuracy of polar motion parameters from regression
  - NNR constraints on SLR and DORIS datum stations

Mission	X_pole (as)	Y_pole (as)
ENVISAT	0.00027	0.00031
JASON1	0.00301	0.00421
JASON2	0.00172	0.00204

  - NNR constraints on SLR and DORIS datum stations, UT1-UTC fixed

Mission	X_pole (as)	Y_pole (as)
ENVISAT	0.00022	0.00028
JASON1	0.00244	0.00417
JASON2	0.00114	0.00223

Summary

- Gaps in the orbits prevent the solution of UT1-UTC and deteriorate the coordinate solution
- The orbit does not serve as global tie for DORIS and SLR
- The polar motion parameters serve as global ties
- The polar motion parameters have the potential to be solved with an accuracy of about 0.3 mas by ENVISAT and about 3 mas by each of the JASONs

Next Steps

- Take care of the X_pole and Y_pole datum
- Combine the satellite NEQs
- Take care of UT1-UTC gaps and datum

Acknowledgements

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