
LLR Reduction Model | GINS

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Thésard - 1er année

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Introduction

- Comparison of LLR Reduction Models
- 4 teams : IMCCE - Paris, IfE - Hannover, **GeoAzur - OCA**, CFA Harvard
- **Simulated** Normal Points
- **Residuals** comparison (~10 years)
- Work in progress..

Methodology

- Modeling in GINS - range of possibilities
- Remove all effects - **basic light time model**
- Step by step **addition** of parameters - IERS Convention 2010
- Comparison at **each stage**
- **Identify/fix** source of error
- Maintain **semi-distance discrepancy** within **1mm**.

Initial changes introduced

- Before comparison:
 - ❖ Lunar ephemeris replaced by calceph
 - ❖ Lunar libration angles computed with calceph

Initial Configuration (1/2)

- Simple light time model :

1. No deformation of **terrestrial crust**:

- ❖ no tectonic plate motion, no solid tides, no loading, ...

2. No deformation of **Moon's surface**:

- ❖ no solid tides, no displacement due to the spin, ...

3. No **Earth Orientation Parameters**

- ❖ no UT1-UTC, no polar motion, no correction to CIP coordinates, ...

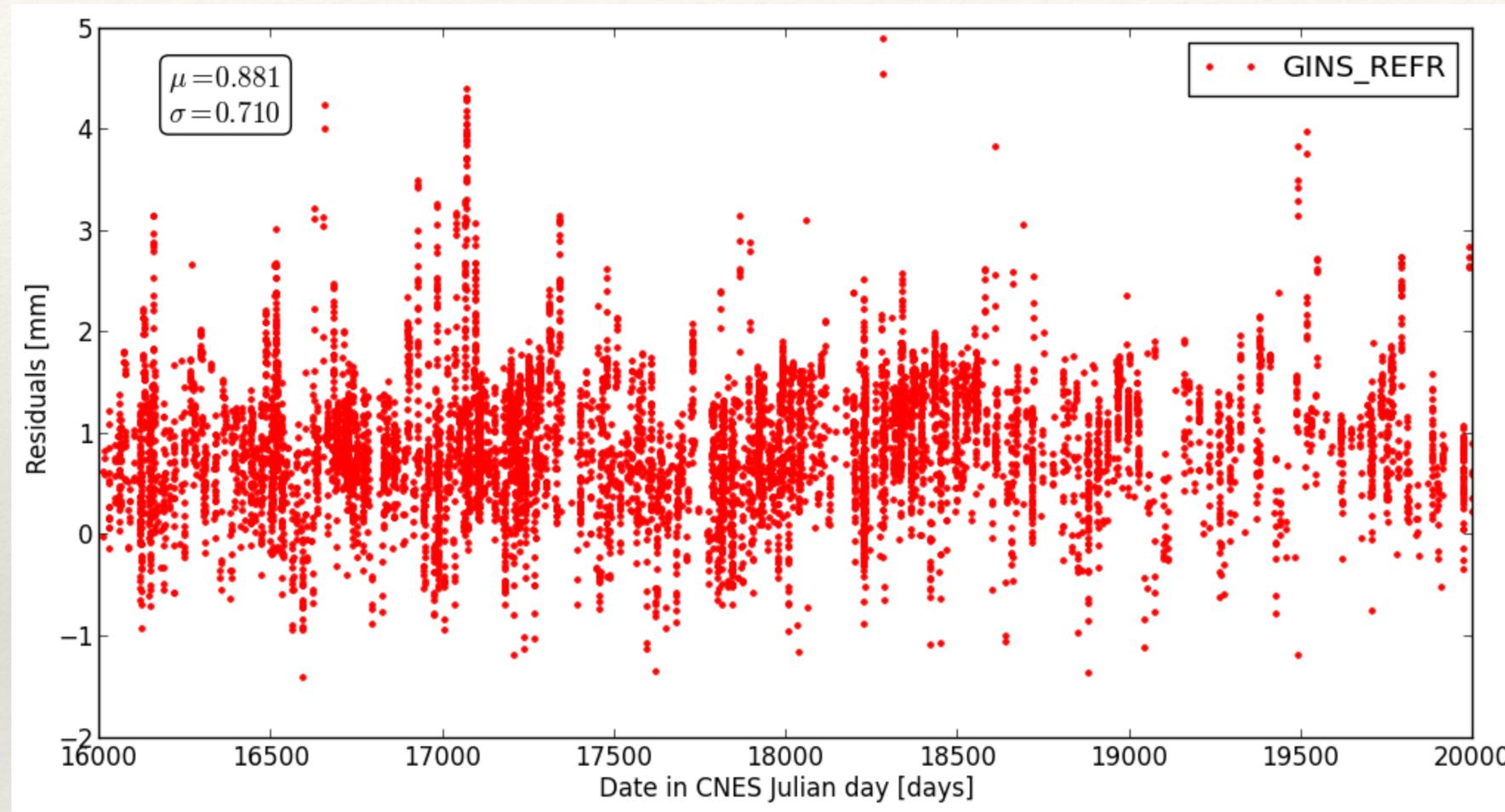
4. No **TT-TDB** differences

Initial Configuration (2/2)

5. **CIP** coordinates using:
 - ❖ precession **IAU2006** and nutation **MHB2000A** model
6. No delay due to **relativistic** deviation of light
7. No **atmospheric** delay
8. No **relativistic** correction due to the **transformation** between :
 - ❖ GCRF and BCRF
 - ❖ LCRF and BCRF
9. No **empirical** correction to the light time

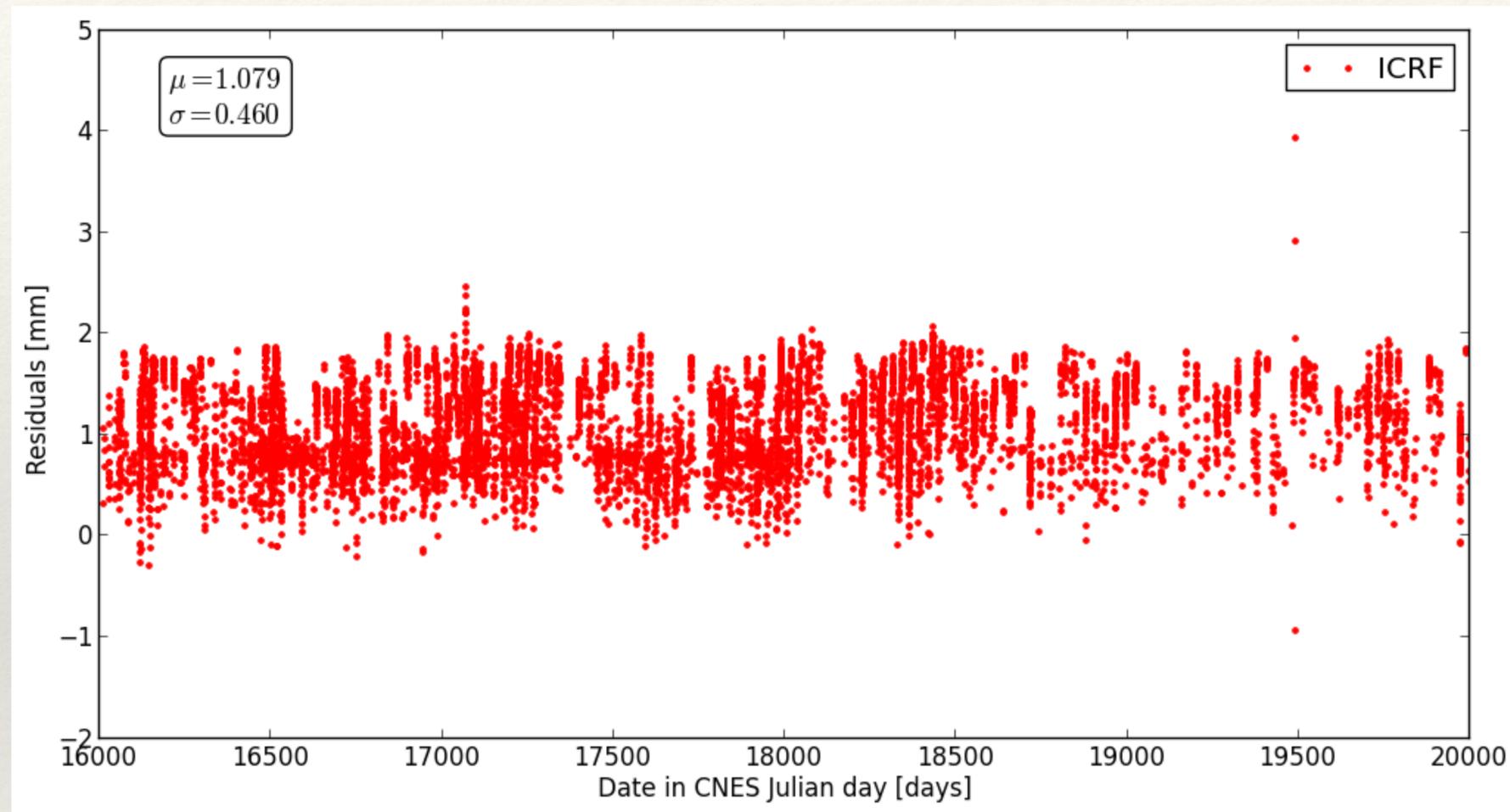
Variation of Residuals

- Original reference frame



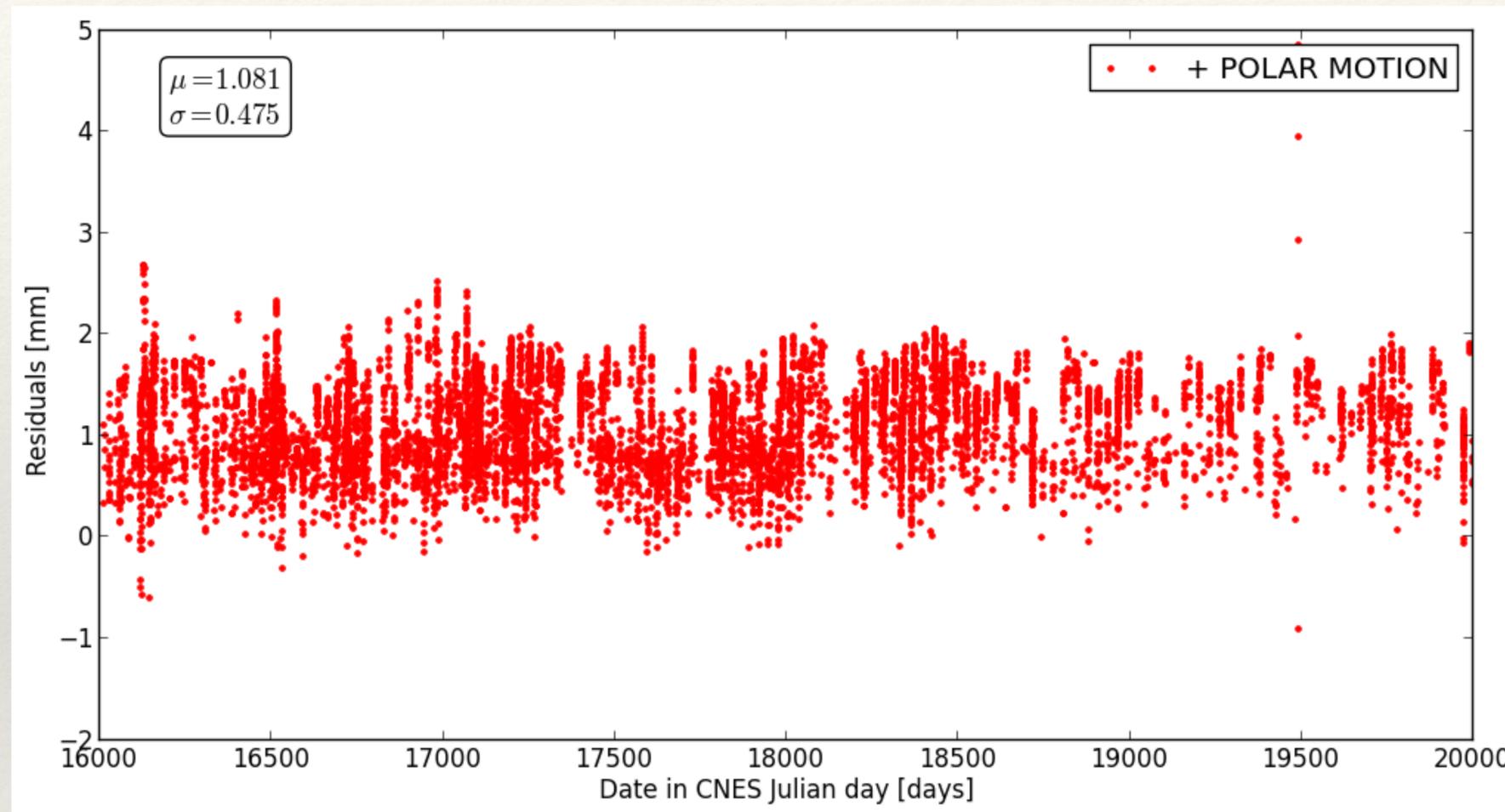
Variation of Residuals

- Original reference frame
- **Change into ICRF**



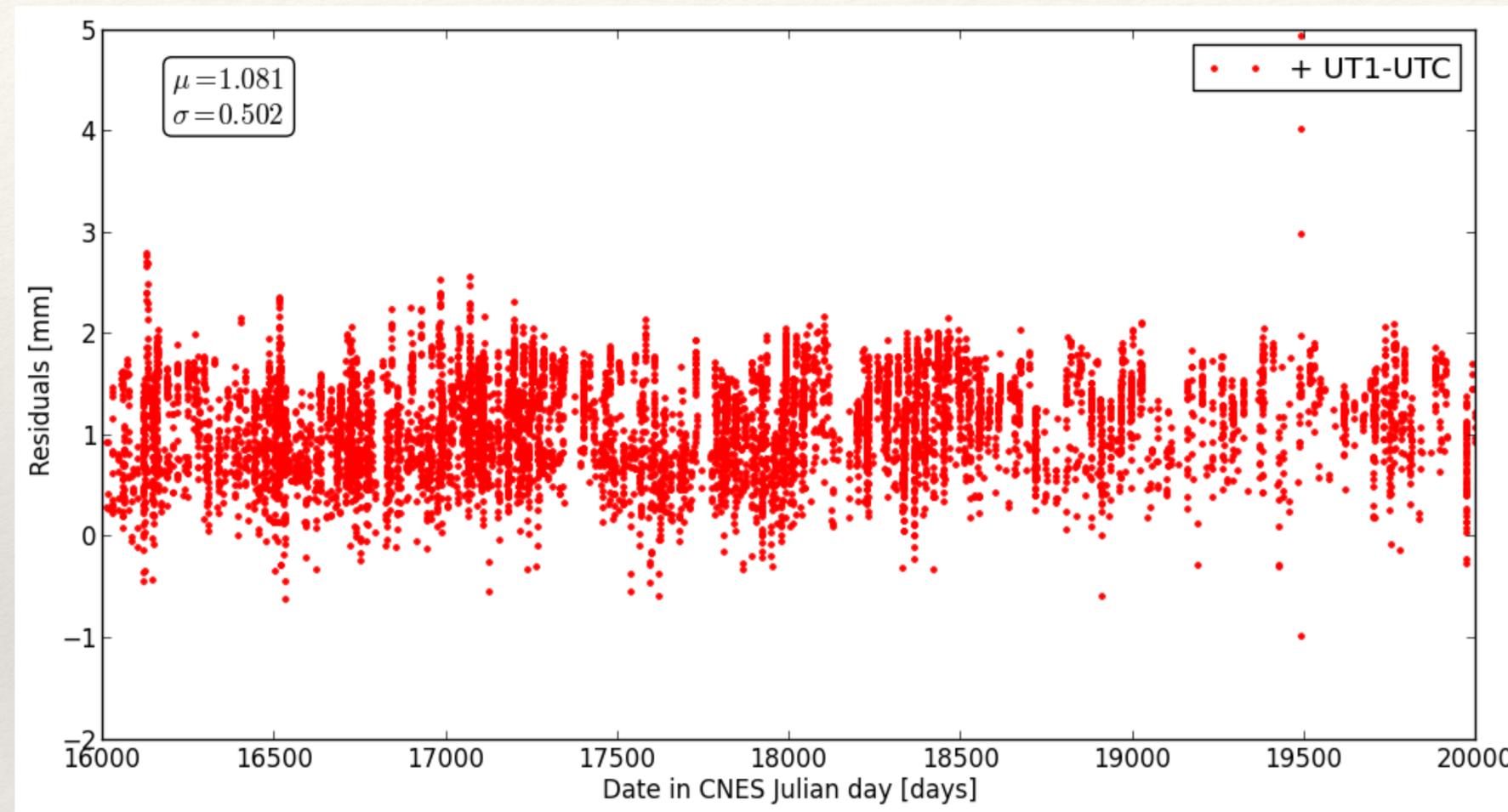
Variation of Residuals

- Original reference frame
- Change into ICRF
- **Polar motion - [EOP C04]**



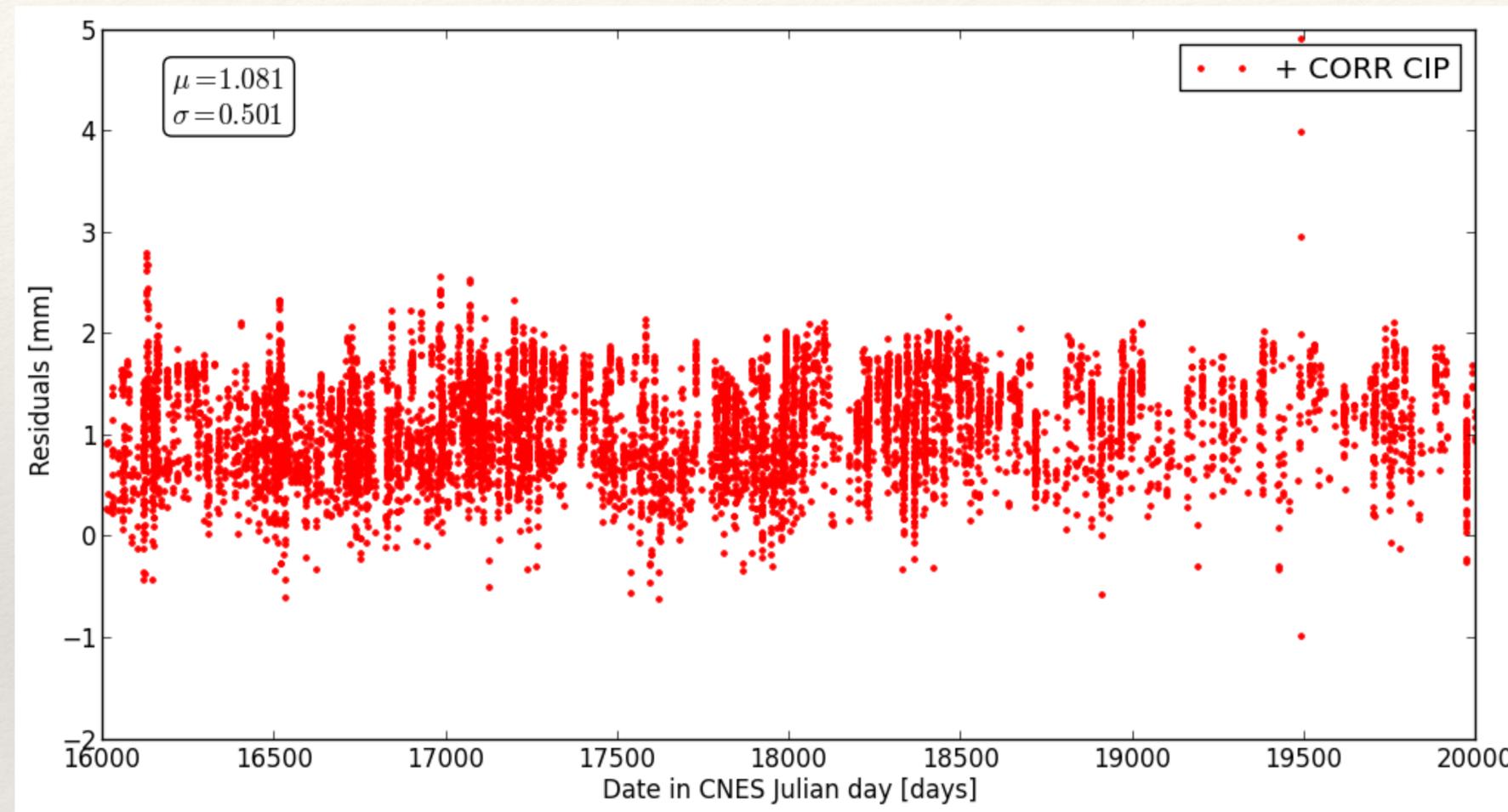
Variation of Residuals

- Original reference frame
- Change into ICRF
- Polar motion - [EOP C04]
- **UT1 - UTC [EOP C04]**



Variation of Residuals

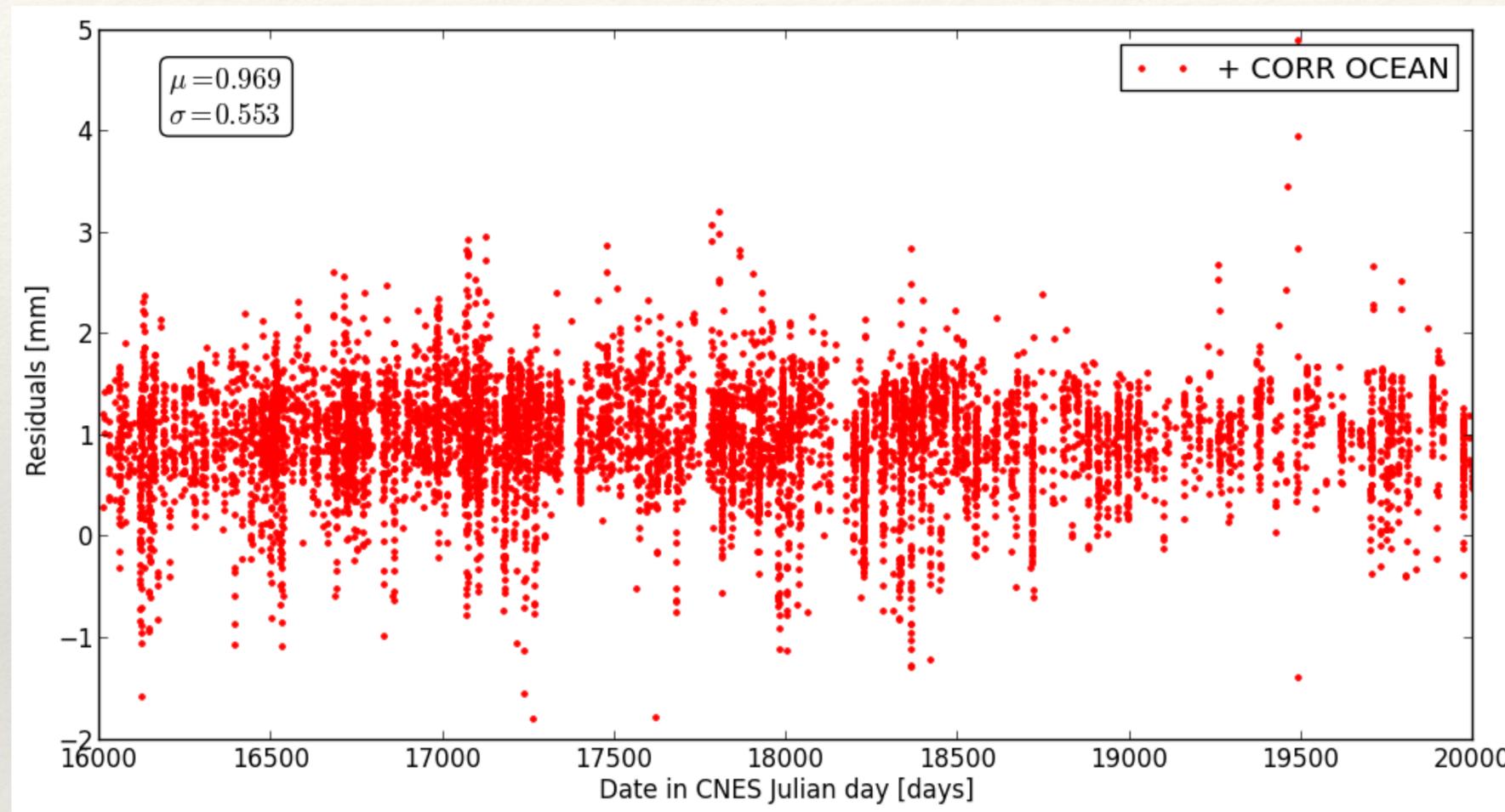
- Original reference frame
- Change into ICRF
- Polar motion - [EOP C04]
- UT1 - UTC [EOP C04]



- Correction CIP - [EOP C04]

Variation of Residuals

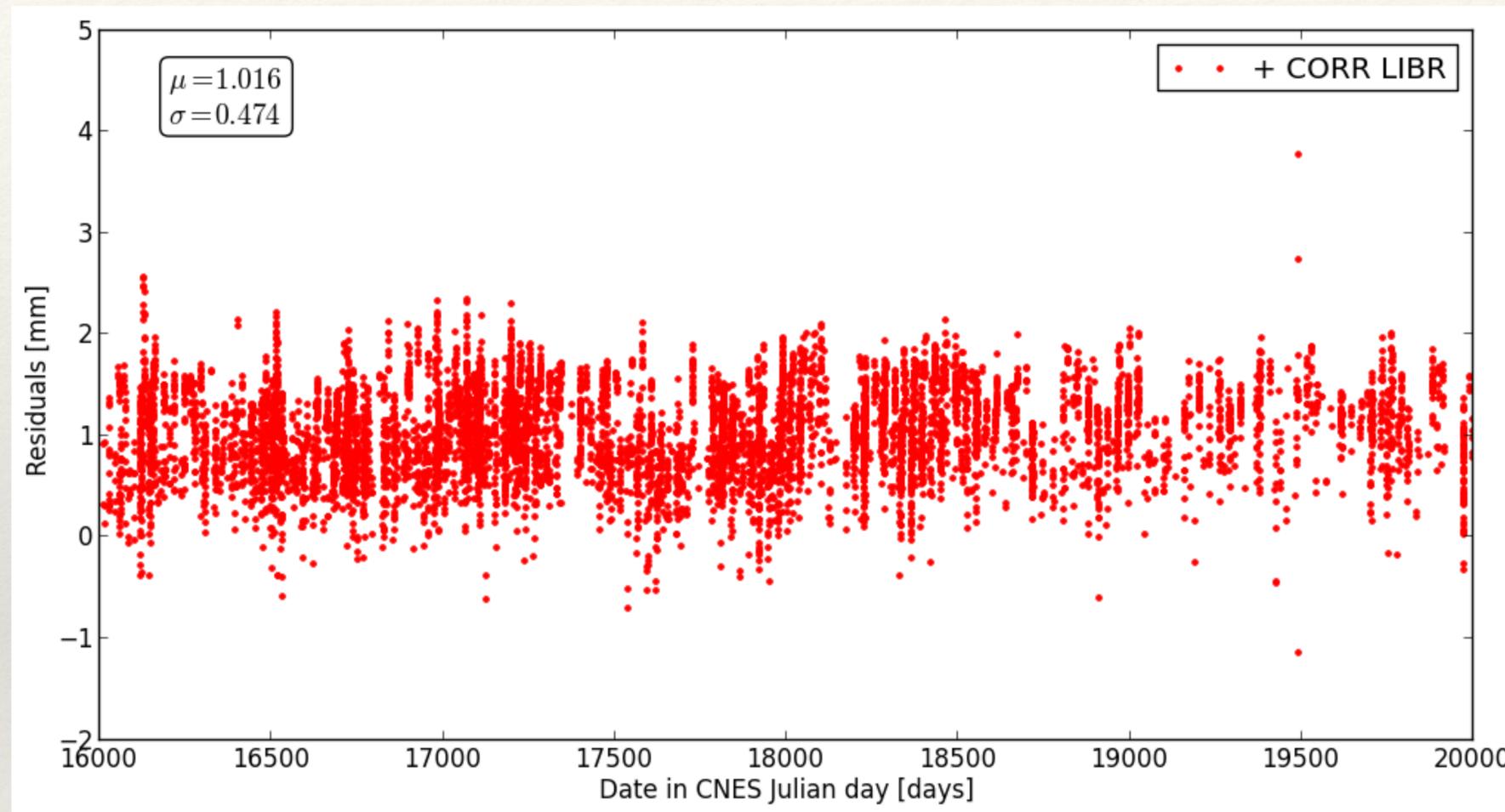
- Original reference frame
- Change into ICRF
- Polar motion - [EOP C04]
- UT1 - UTC [EOP C04]



- Correction CIP - [EOP C04]
- Ocean tides - [IERS 2010]

Variation of Residuals

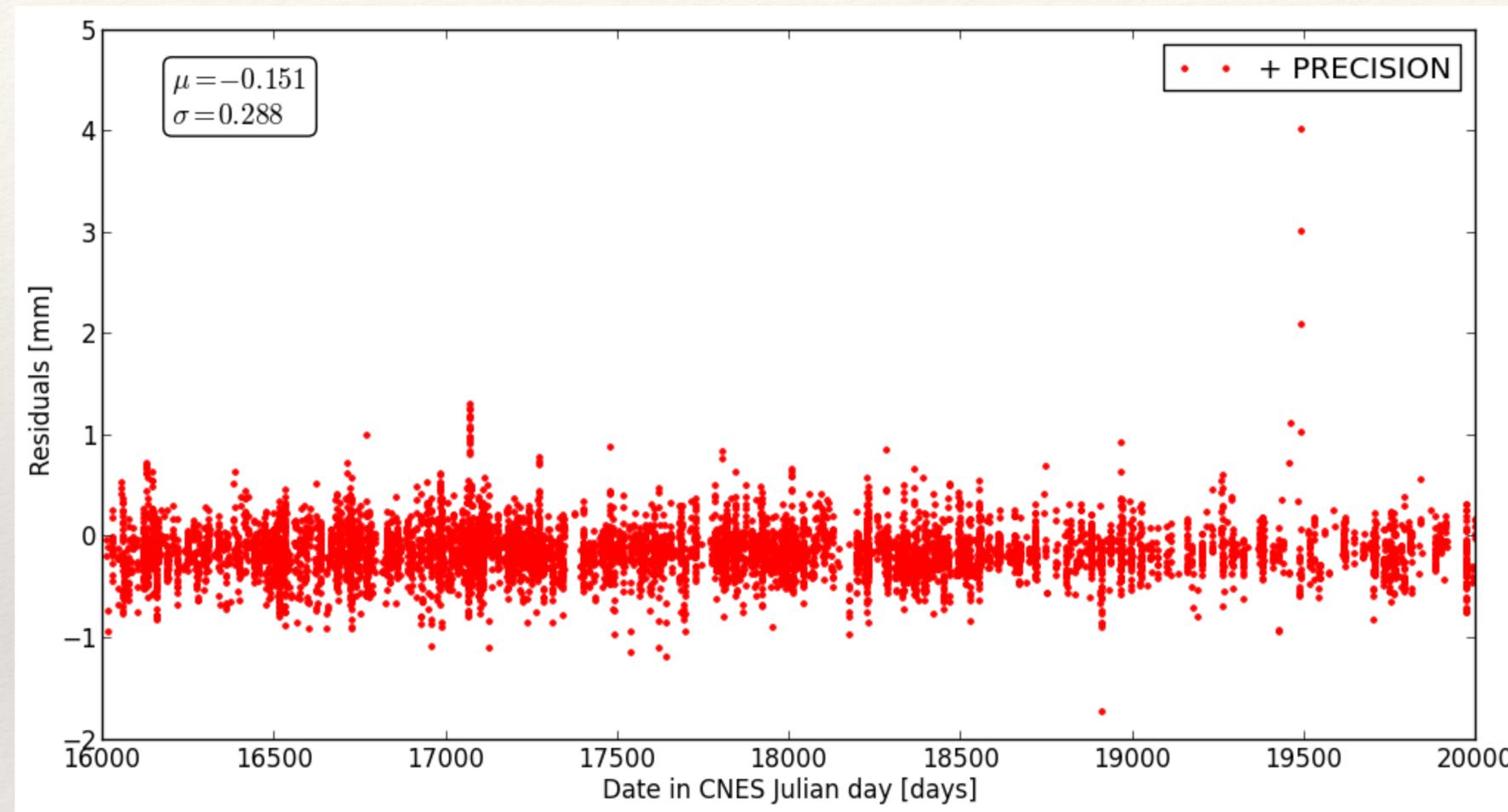
- Original reference frame
- Change into ICRF
- Polar motion - [EOP C04]
- UT1 - UTC [EOP C04]



- Correction CIP - [EOP C04]
- Ocean tides - [IERS 2010]
- **Libration - [IERS 2010]**

Variation of Residuals

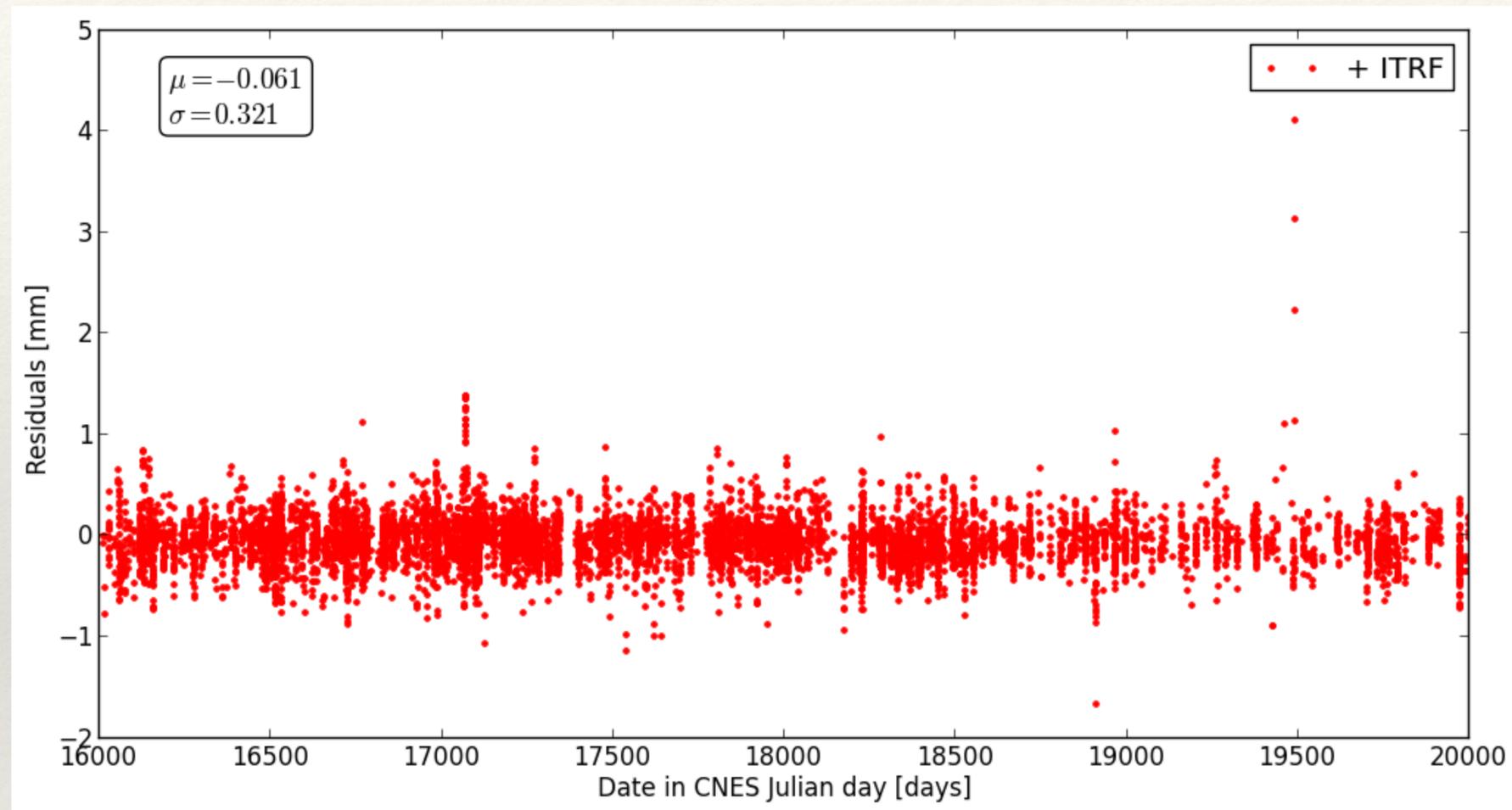
- Original reference frame
- Change into ICRF
- Polar motion - [EOP C04]
- UT1 - UTC [EOP C04]



- Correction CIP - [EOP C04]
- Ocean tides - [IERS 2010]
- Libration - [IERS 2010]
- **Station - [~ 0.1 mm]**

Variation of Residuals

- Original reference frame
- Change into ICRF
- Polar motion - [EOP C04]
- UT1 - UTC [EOP C04]
- ITRF positions - [ITRF97]

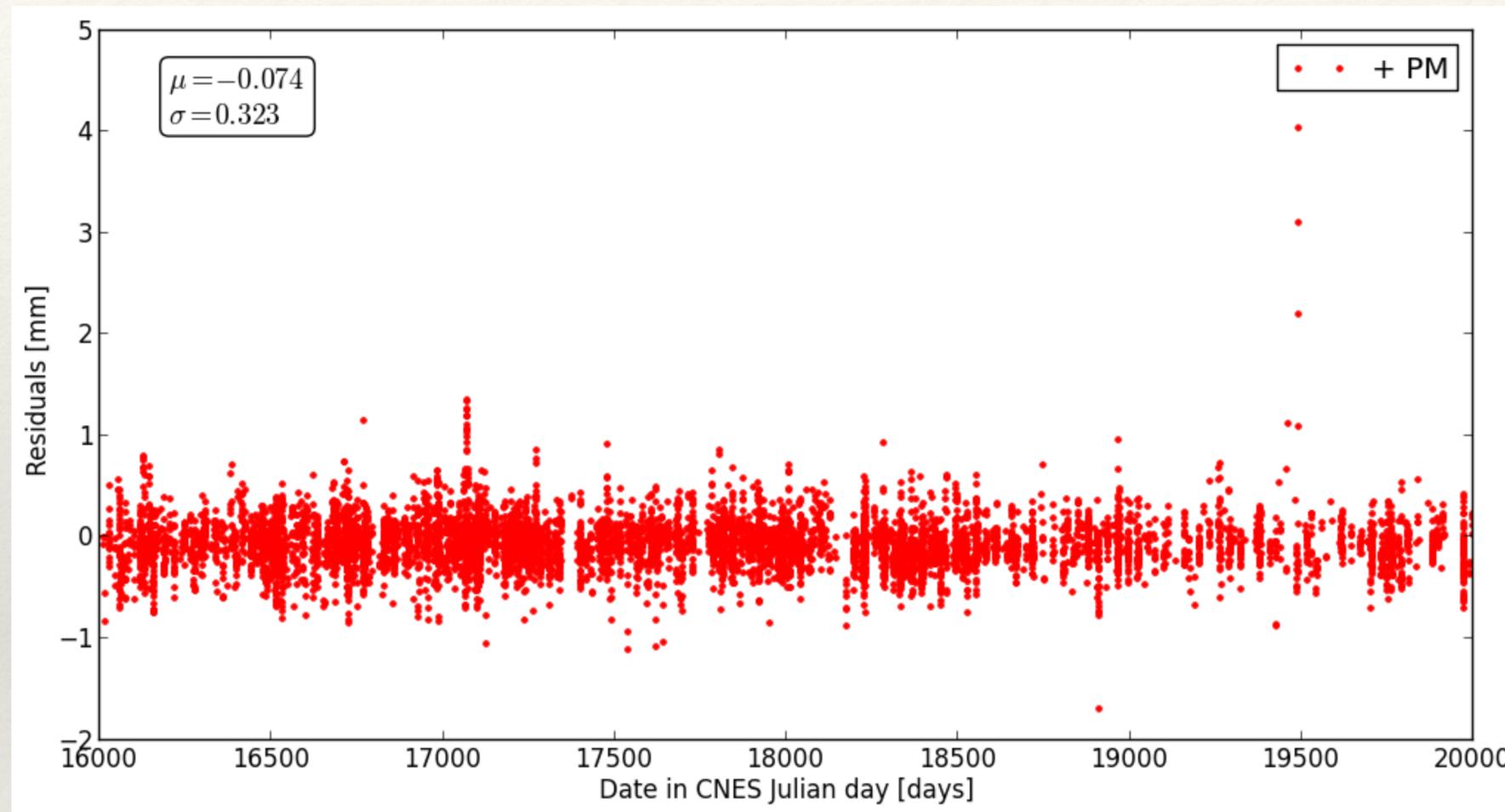


- Correction CIP - [EOP C04]
- Ocean tides - [IERS 2010]
- Libration - [IERS 2010]
- Station - [~ 0.1 mm]

Variation of Residuals

- Original reference frame
- Change into ICRF
- Polar motion - [EOP C04]
- UT1 - UTC [EOP C04]

- ITRF positions - [ITRF97]



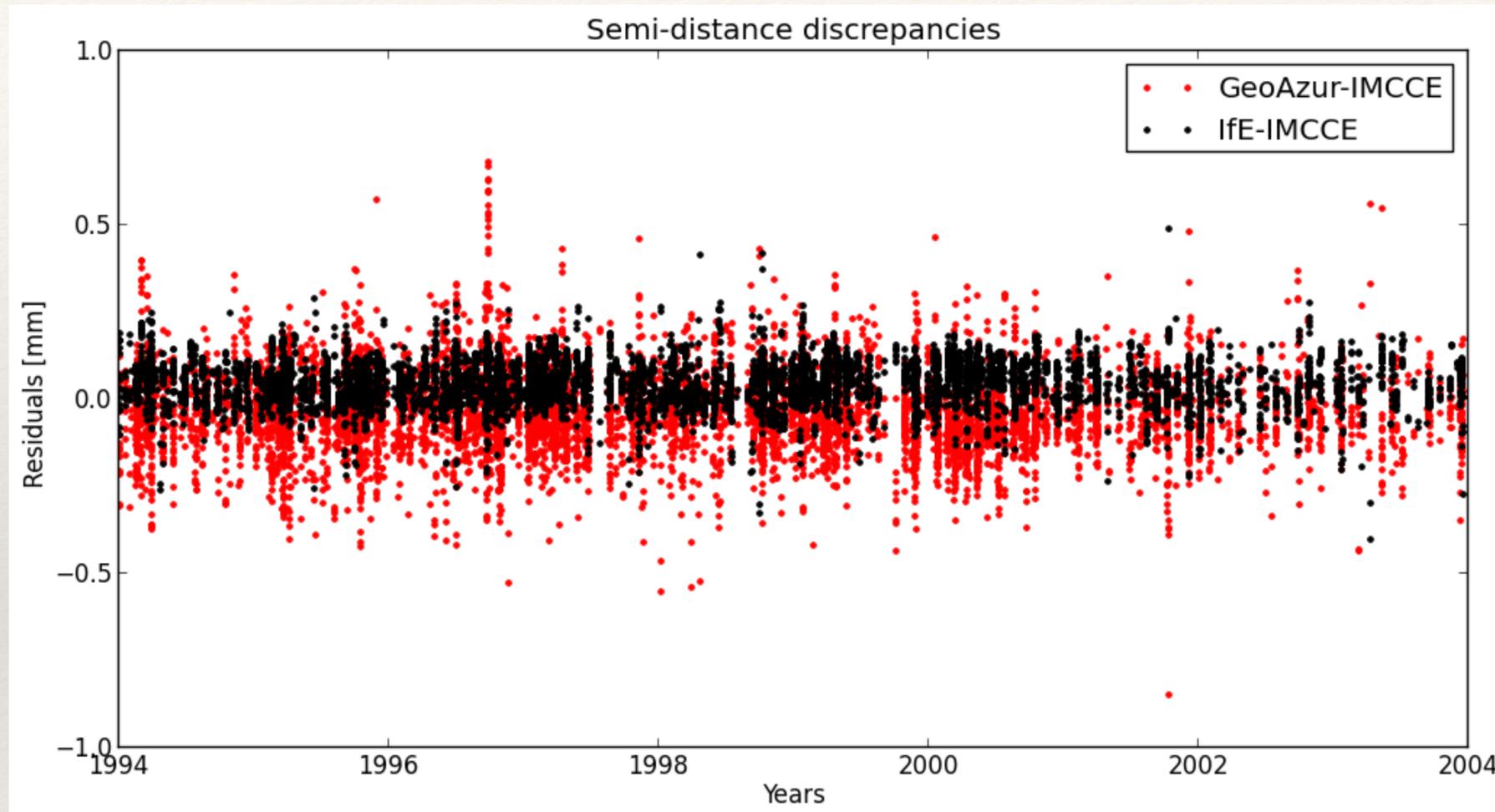
- Correction CIP - [EOP C04]
- Ocean tides - [IERS 2010]
- Libration - [IERS 2010]
- Station - [~0.1 mm]

- **Tectonic plate motion**

Residual comparison with Teams

- Original reference frame
- Change into ICRF
- Polar motion - [EOP C04]
- UT1 - UTC [EOP C04]

- ITRF positions - [ITRF97]



- Correction CIP - [EOP C04]
- Ocean tides - [IERS 2010]
- Libration - [IERS 2010]
- Station - [~ 0.1 mm]

- Tectonic plate motion

Discrepancies within **1mm** with other teams

Tests in progress

- Other **deformations** of terrestrial crust:
 - ❖ Ocean loading, atmospheric loading, etc
- **Atmospheric** delay
- **Relativistic** effects and correction:
 - ❖ deviation of light, transformation from GCRF to BCRF, LCRF to BCRF
- TT-TDB

Other usages of GINS for planets

- **MESSENGER** : 2011-2014 for INPOP construction and GR tests
- In the future: Juno (2016), Bepi-Colombo (2017), JUICE (3GM)

“Merci”

Journée GINS 2015 - Toulouse