A Celestial Reference Frame based on parameterized source positions

Maria Karbon (maria.karbon@ua.es), S. Belda, J.M. Ferrándiz, A. Escapa

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Introduction

For geodesy, the radio sources are the most stable remote targets.

*The **ICRF3** (International Celestial Reference Frame) is the most precise and stable frame available.*

BUT…

$$\tau_{geom} = t_B - t_A = -\frac{1}{c}\boldsymbol{b}\cdot\boldsymbol{k}$$

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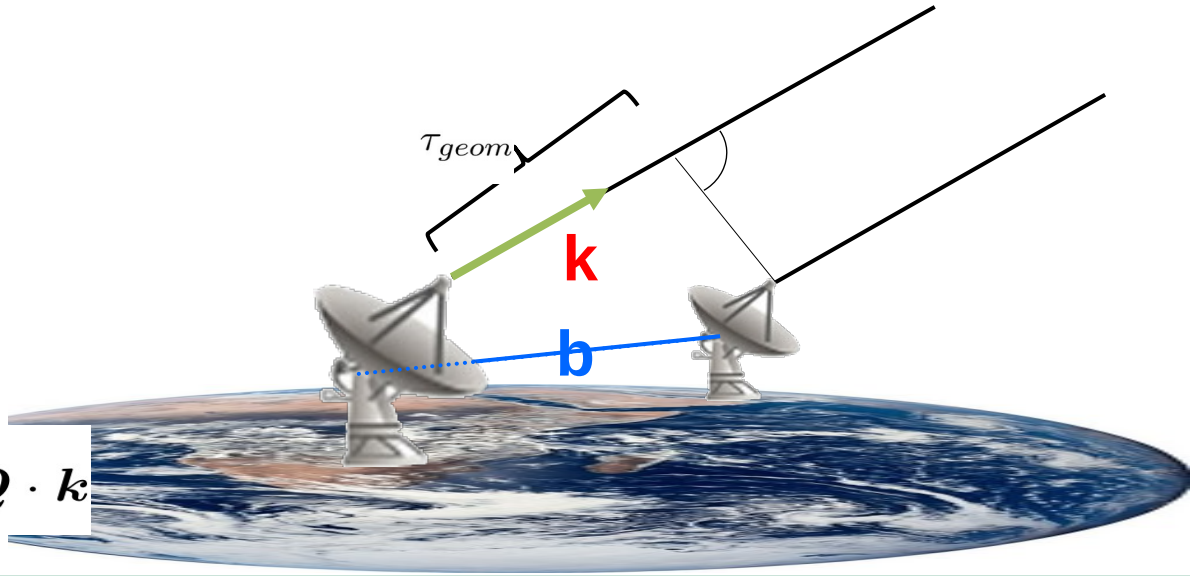

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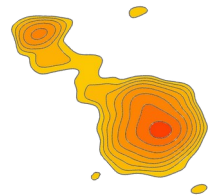

BUT…

geodetic VLBI considers radio source positions as **time-invariant**,i.e. they have **no apparent proper motion**.

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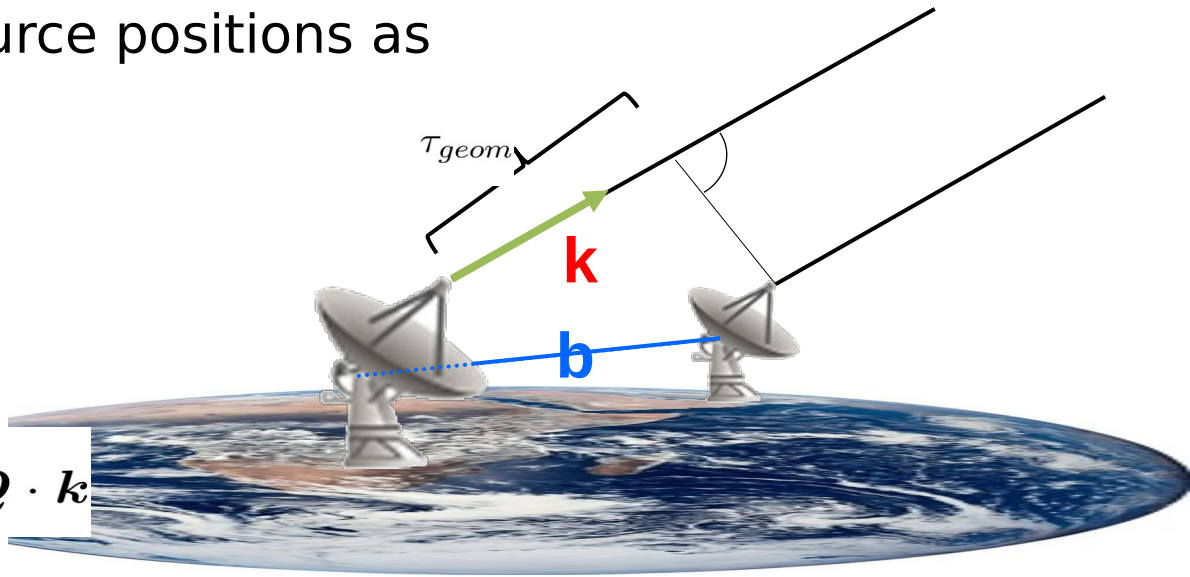


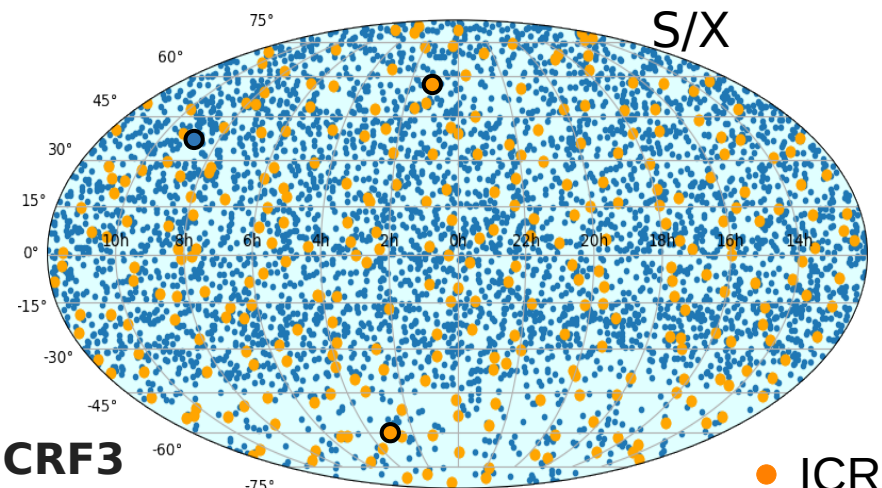
Introduction

Defining sources:

- Highest class of accuracy
- Define the datum of
  - each observing session
  - each new CRF

Defining sources: requirements

1) Stable in time
2) Good spatial coverage
3) Well observed
   - at least 3 in each session



ICRF3
Charlot et al. *(2021)*

- ICRF3 has **303** defining sources

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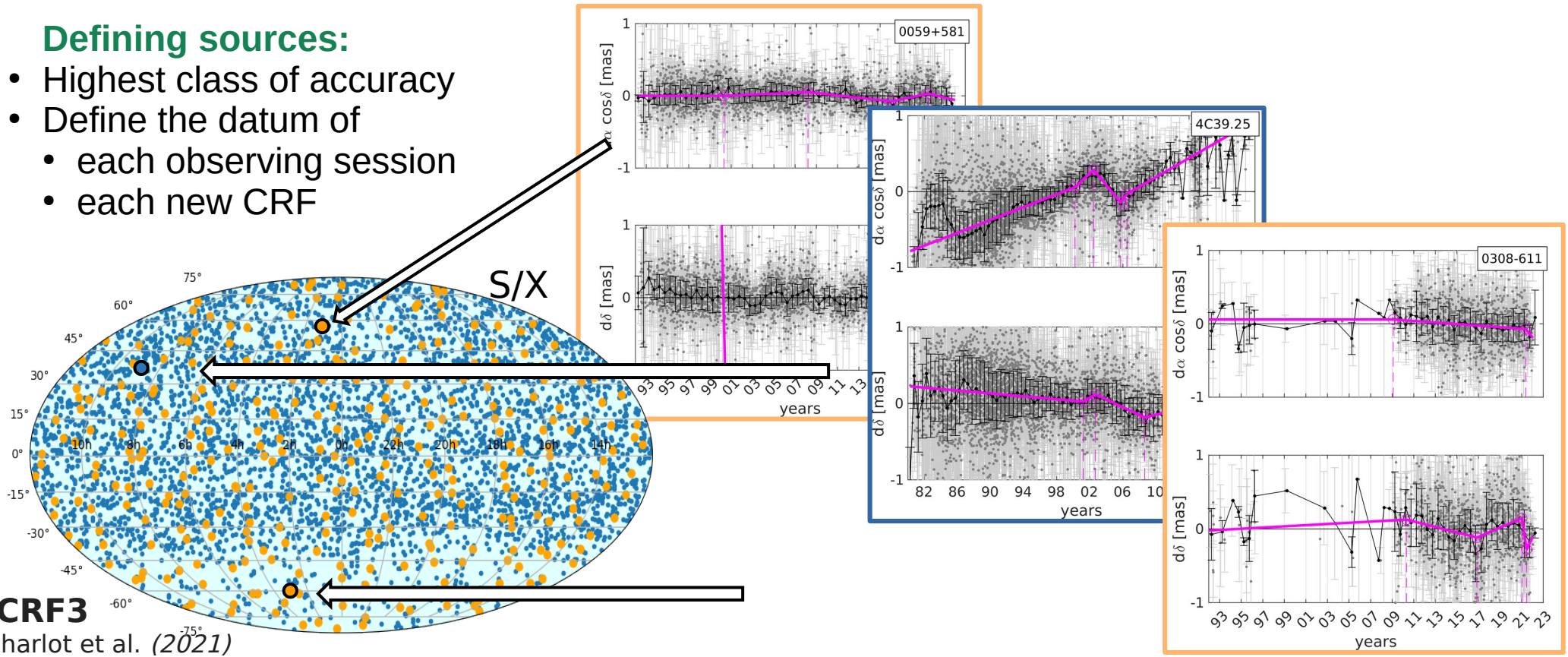

ICRF3
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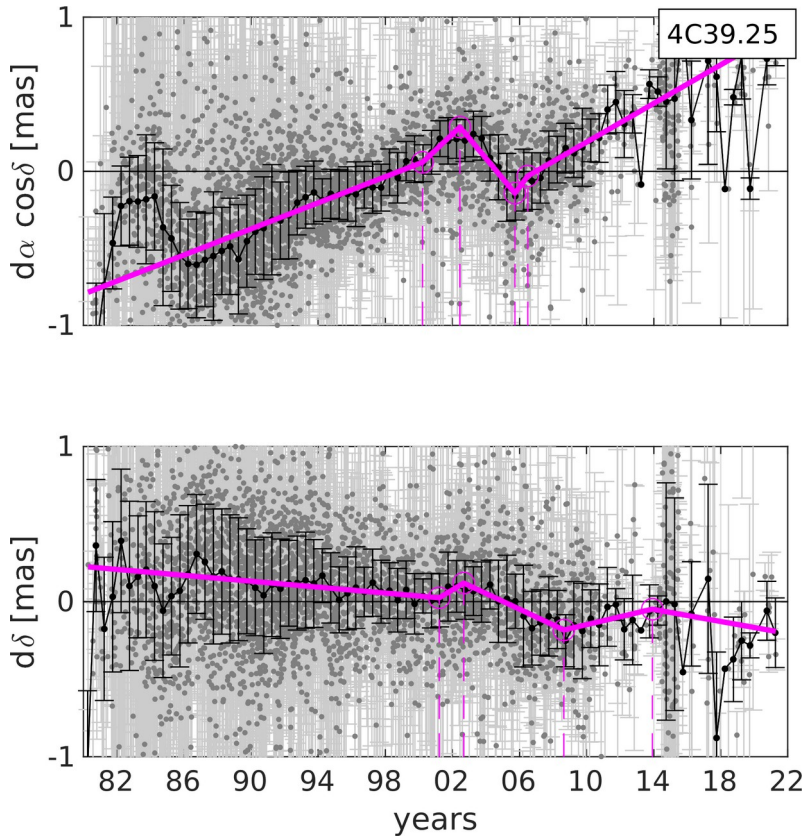
Introduction

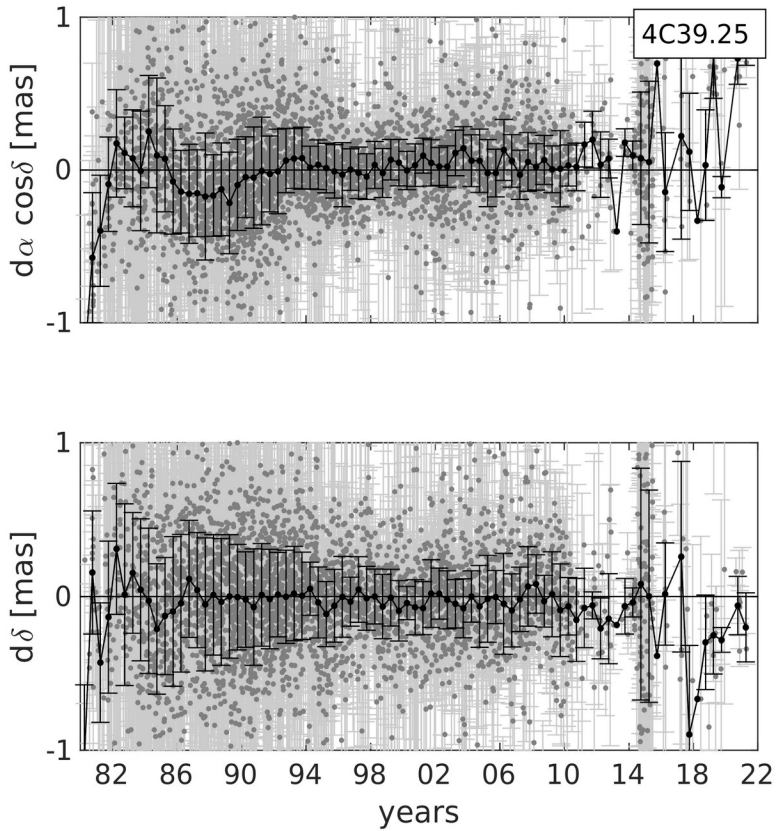
- **How to solve this problem?**
  - Parameterization of source positions using the Multi-adaptive regression splines algorithm (MARS, in Karbon et al. 2017)



Introduction

- **How to solve this problem?**
  - Parameterization of source positions using the Multi-adaptive regression splines algorithm (MARS, in Karbon et al. 2017)

  - Mitigates source position variations and thus allows the inclusion of ‘unstable’ sources into the datum definition.
    - **All sources become potential defining sources.**



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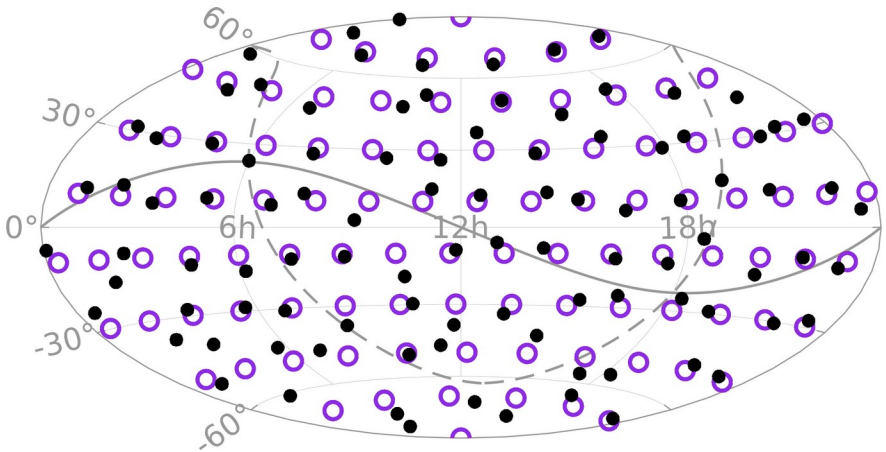
  - Datum sources can be chosen freely based on their spacial distribution and observational history.



#sou =100

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  - Parameterization of source positions using the Multi-adaptive regression splines algorithm (MARS, in Karbon et al. 2017)
  - Mitigates source position variations and thus allows the inclusion of ‘unstable’ sources into the datum definition.
  - Datum sources can be chosen freely based on their spacial distribution and observational history.
  - **Leads to a more stable and deformation free CRF?**

Data & Datum

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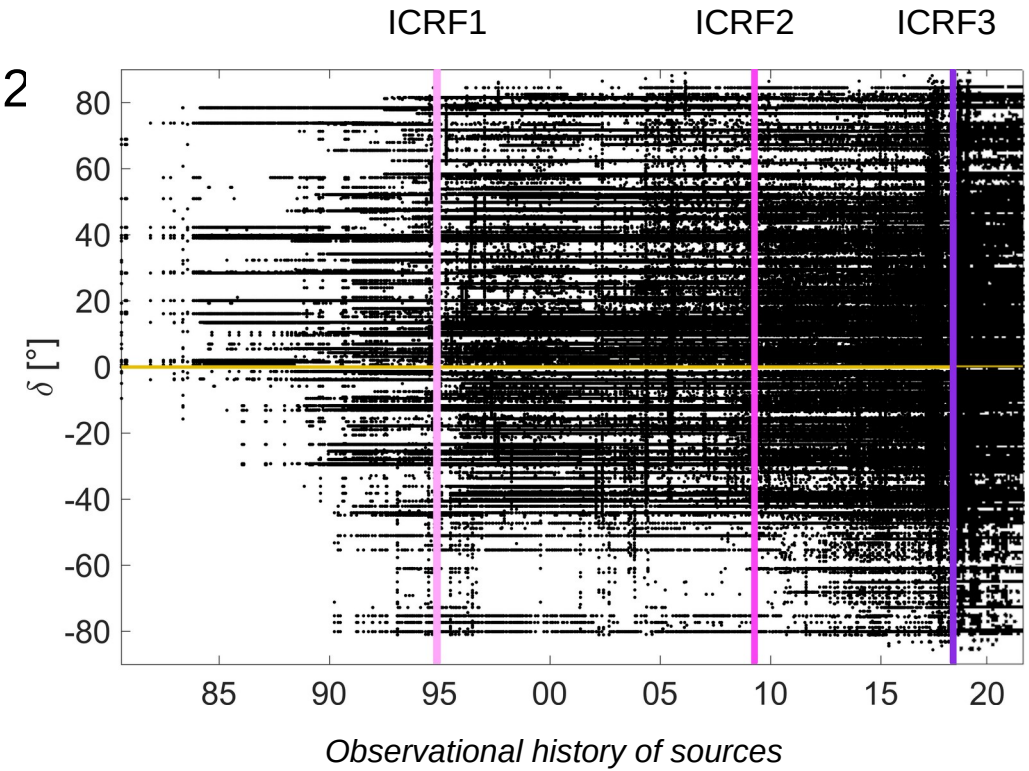
1) Stability

- ~4000 ‘global’ IVS sessions 1980-202
- Standard VLBI-analysis



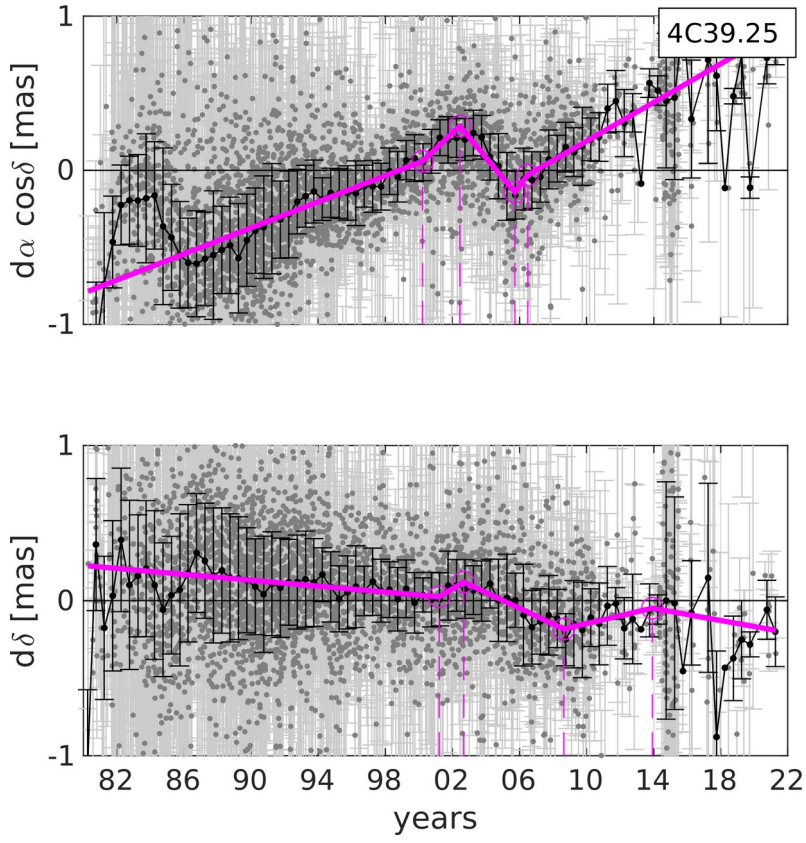
Observational history of sources

Data & Datum

1) Stability

- ~4000 ‘global’ IVS sessions 1980-2022
- Standard VLBI-analysis
- MARS-splines for each source

➡ corrections for ICRF3 a-priori source coordinates



Data & Datum

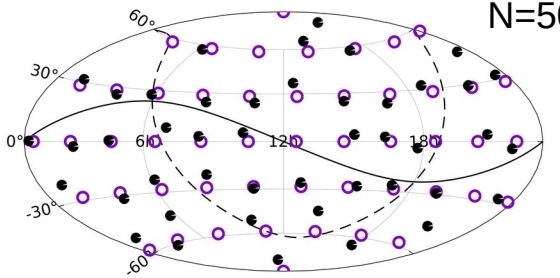
2) Distribution

- Splitting celestial sphere in N=50-800 equal areas

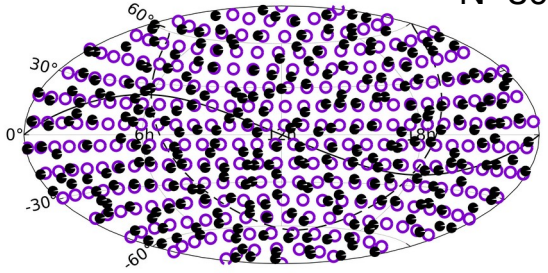
3) Observational history

- Select closest source to center point with #obs>100 over 3+ years, otherwise source with most observations.

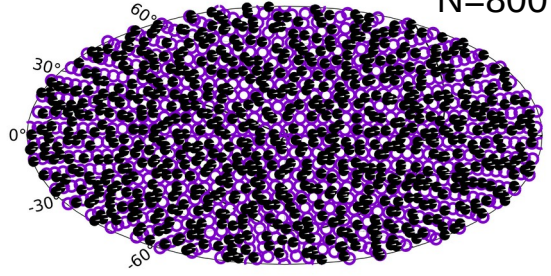
N=50



N=300



N=800

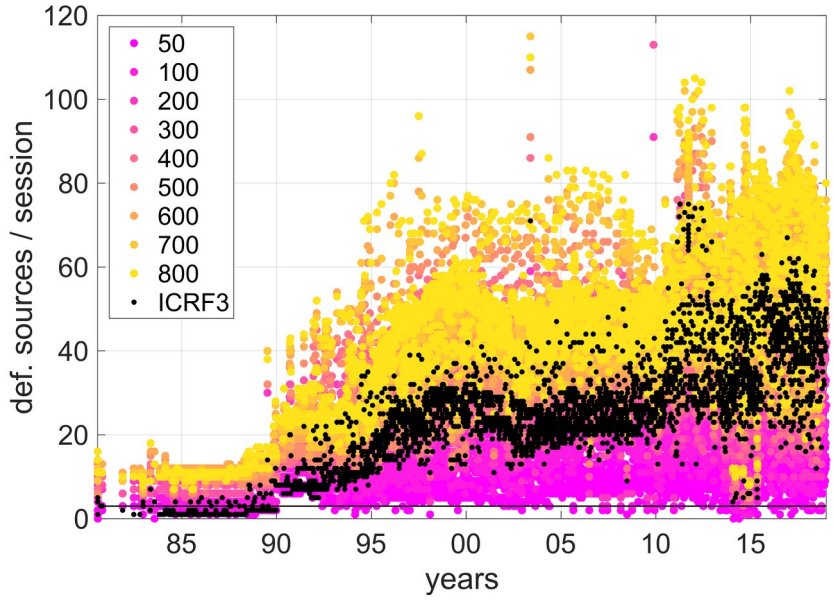


Data & Datum

1) **Stability**
2) **Distribution**
3) **Observational history**

✓

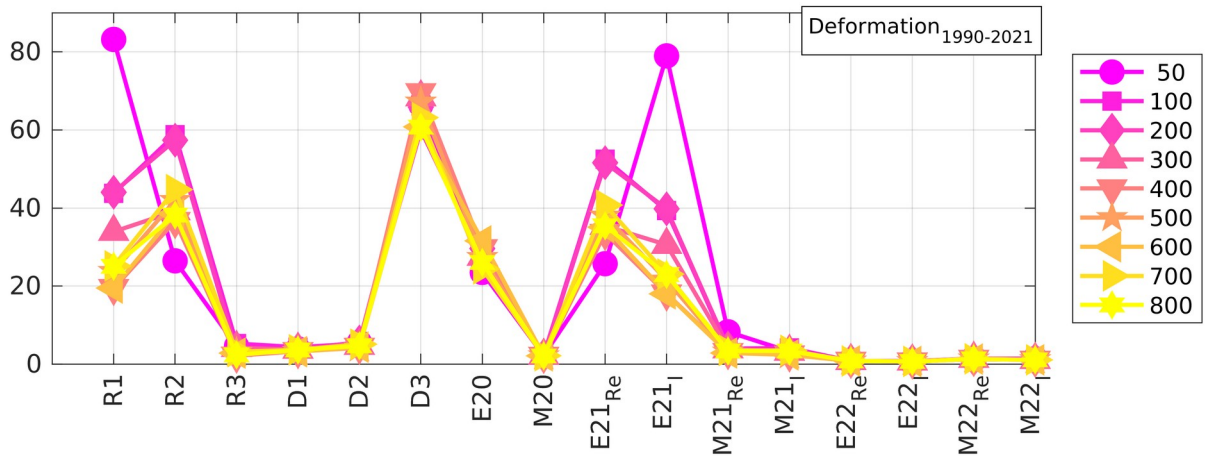
4) **Number of defining sources**
   - min. 3 per session
   - max=? → over-constraining



Number of defining sources contained in each session.

Data & Datum

1) **Stability**
2) **Distribution**
3) **Observational history**



Mean deformation parameters of yearly CRFs w.r.t. ICRF3 for different numbers of defining sources

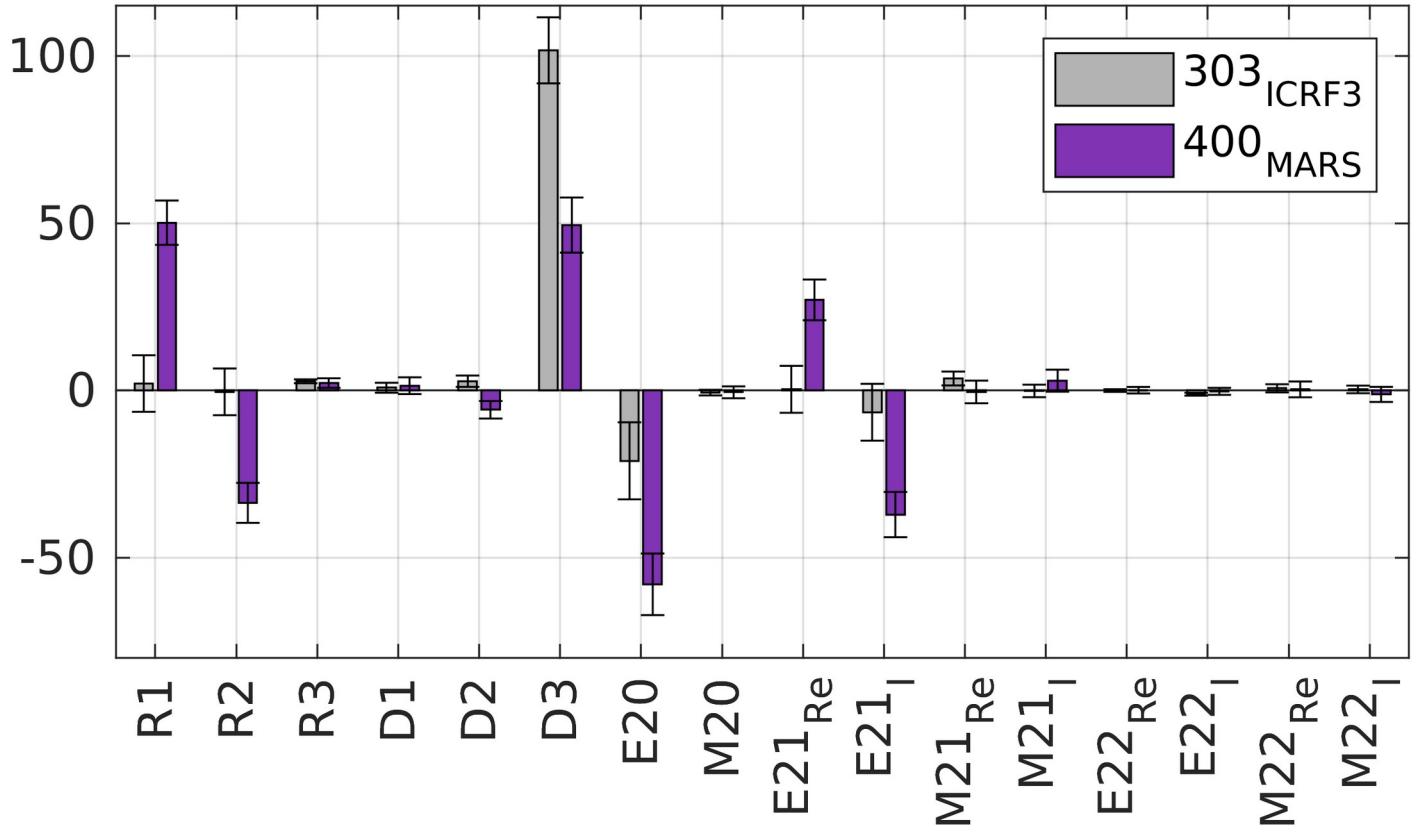
4) **Number of defining sources**
   - min. 3 per session
   - max=? → over-constraining

   - Yearly CRFs with each set
   - Mean deformation parameters w.r.t. ICRF3

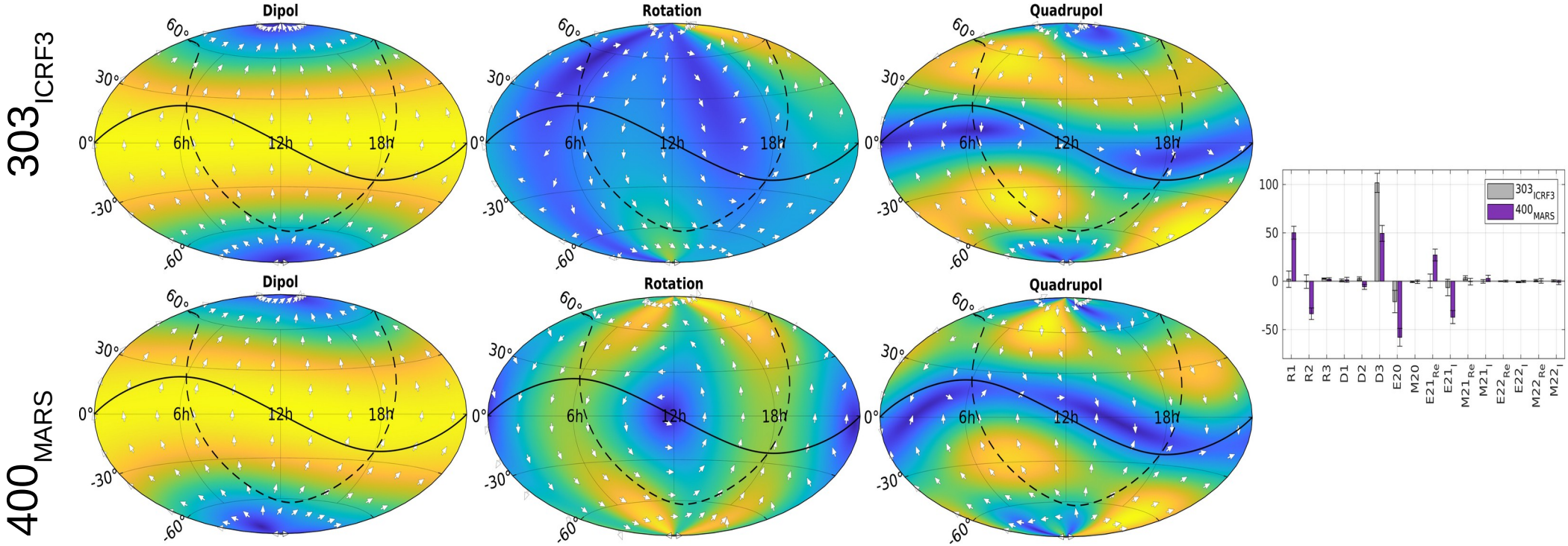
➡ **400 defining sources**

Results

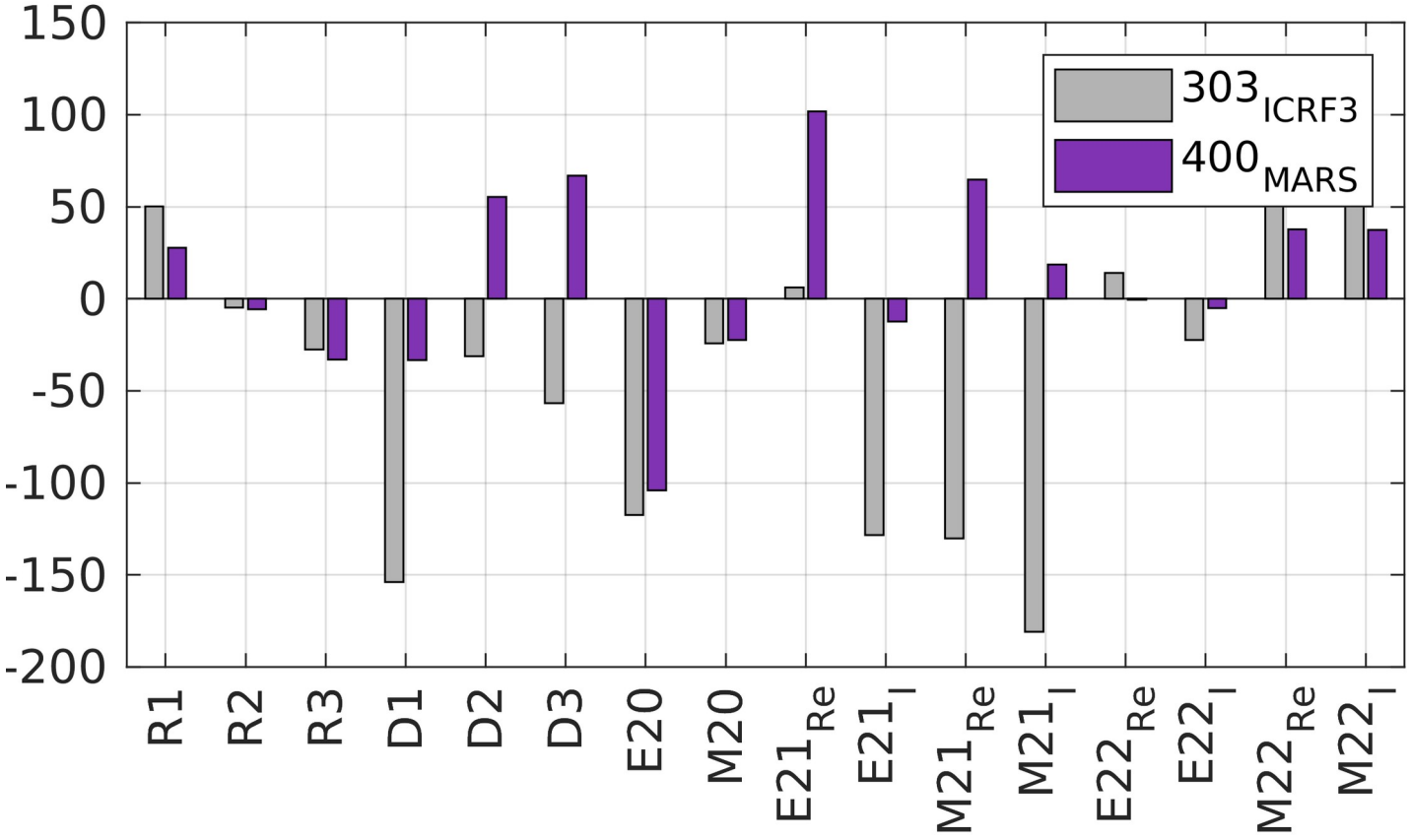
Results w.r.t. ICRF3



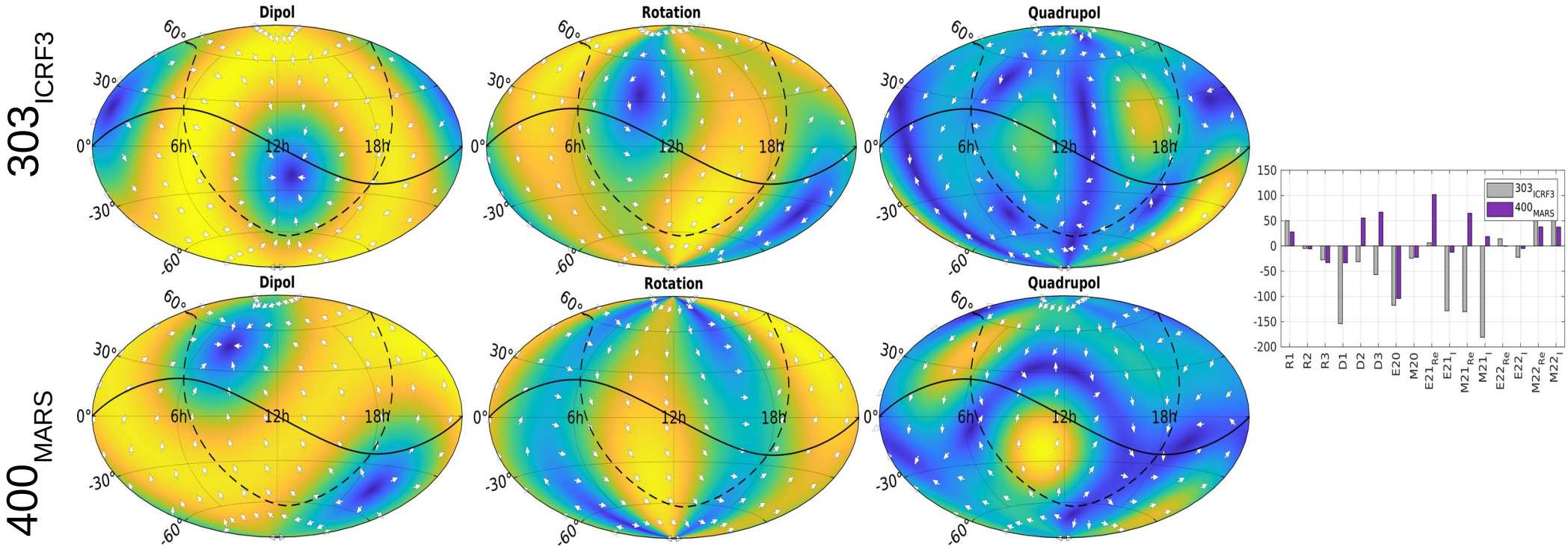
Deformation parameters vs. ICRF3



Restults w.r.t GAIA



Deformation parameters vs. GAIA



Preliminary conclusions

- **vs ICRF3**
  - 400_{MARS} rotations are bigger w.r.t. ICRF3, as well as higher order deformations
  - Declination shift using 303_{ICRF3} is significantly bigger
  - 400_{MARS} Signals seem to have a more physical origin

- **vs GAIA**
  - Overall 400_{MARS}-deformations are smaller
  - 303_{ICRF3} shows significant dipole, not as closely attributable to SA (GC) as for 400_{MARS}.
  - Significant higher order deformation, more dominant for 303_{ICRF3}.

Preliminary conclusions

- **To do:**
  - Include most recent data
  - Comparison of proper motion estimates
  - Impact on EOP (next talk)
  - Impact on TRF estimations

Thank you very much for your attention!

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