# A Look at the REPRO3 Orbits

SVOD WG Meeting 2022

Tim Springer

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# Introduction

- Investigated the systematic effects between the AC orbits
  - Try to reduce the draconic terms in our products
    - Must be coming from orbit modelling errors
  - Defined “minimal requirements” for the orbit model for repro3
    - And routine solutions
- Evaluate REPRO 3 results
  - For 2010 (II, IIA), 2015(IIR, IIF) , and 2020 (IIF, IIIA)
  - ACs: COD, ESA, GFZ, GRG, JPL, MIT, NGS, TUG, WHU
    - 6 ACs including GALILEO
  - Combined IGS orbits also included
  - Also a first look into Galileo results

# Findings from previous investigations

- IGS Routine Orbits from 2018
  - Differences for IIR larger then for IIF
  - COD, ESA and JPL use “enhanced” models
    - For IIR these are in agreement, for IIF not
- IGS REPRO-2 Orbits from 2014
  - Similar results for IIR and IIF as observed in 2018
  - Also significant differences for II/IIA but smaller then for IIR
- Presentation and Position paper from 2019 AC Workshop available
  - on the google drive of this session

**Due to highly systematic nature of these differences they hardly show up in the RMS differences of orbit comparisons**

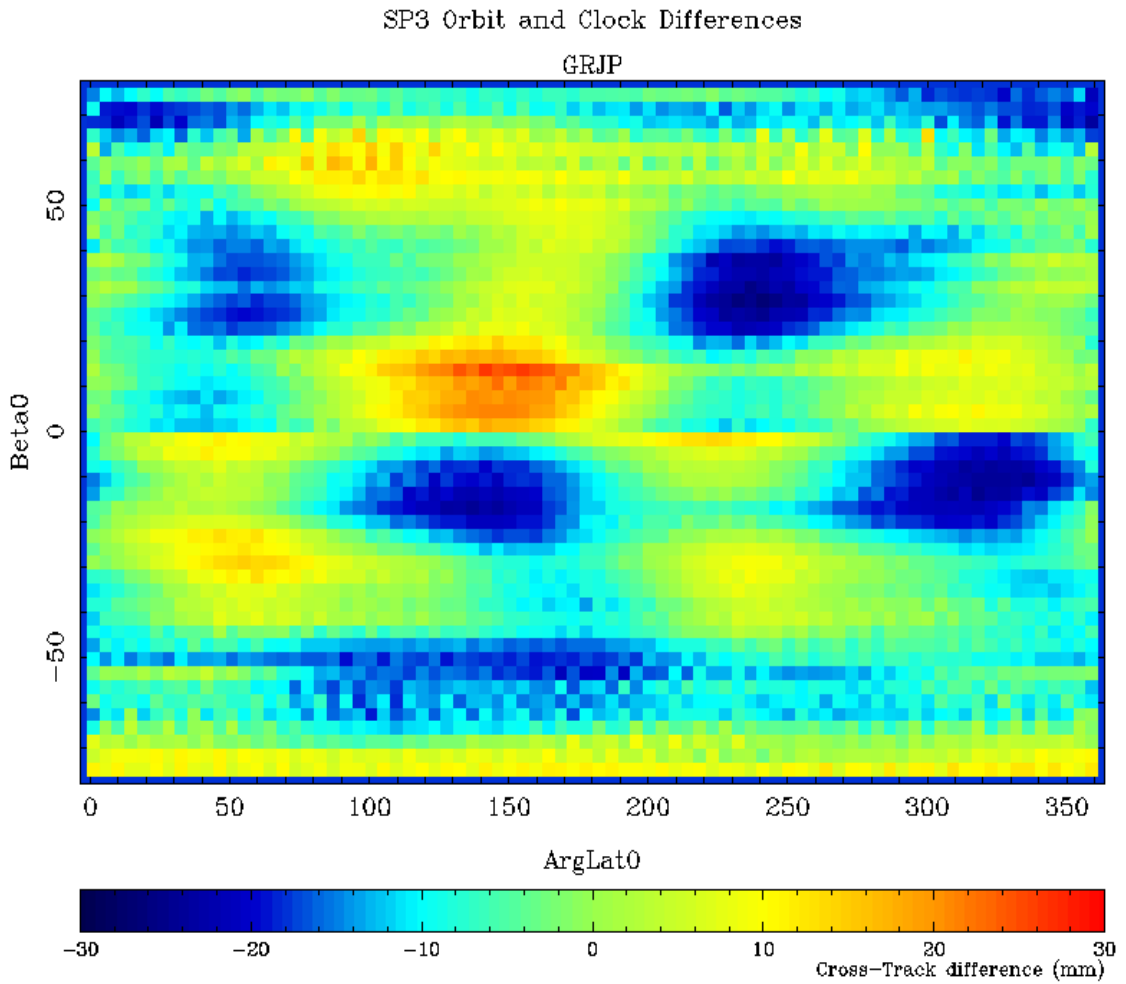
# Recommendations for Repro3

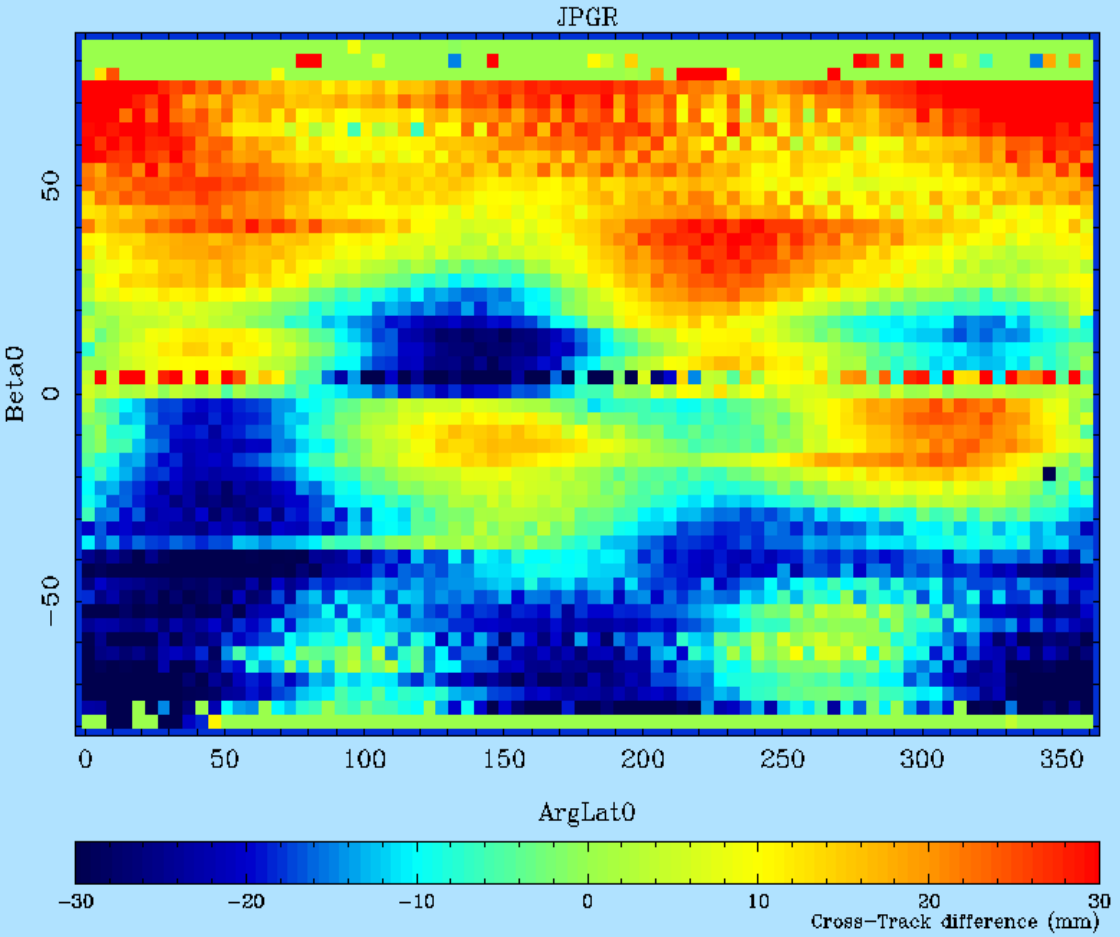
- The JPL GSPM model may be used for all GPS satellites
  - Not available for GLONASS nor GALILEO
- ECOM2 is certainly to be preferred over the ECOM approach
  - Some issues for the IIF
  - Not optimal for GLONASS
- IGS/ESA box-wing approach also better then ECOM
  - For those who used it for Earth Albedo (and IR?) it should be easy to do

- All three models will still result in draconic periods in the IGS products
  - But we should see a clear improvement

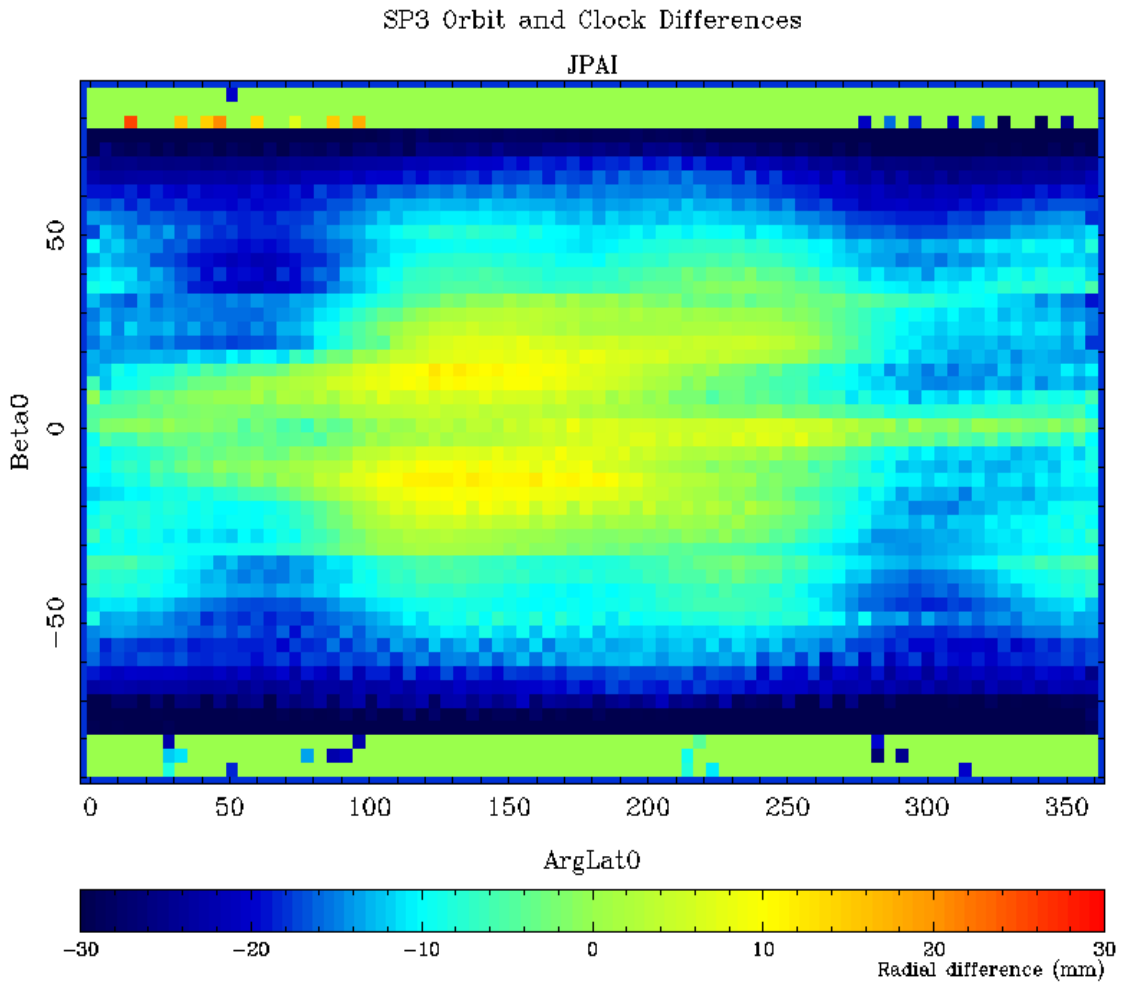
# REPRO-3

# REPRO-2



# REPRO-3

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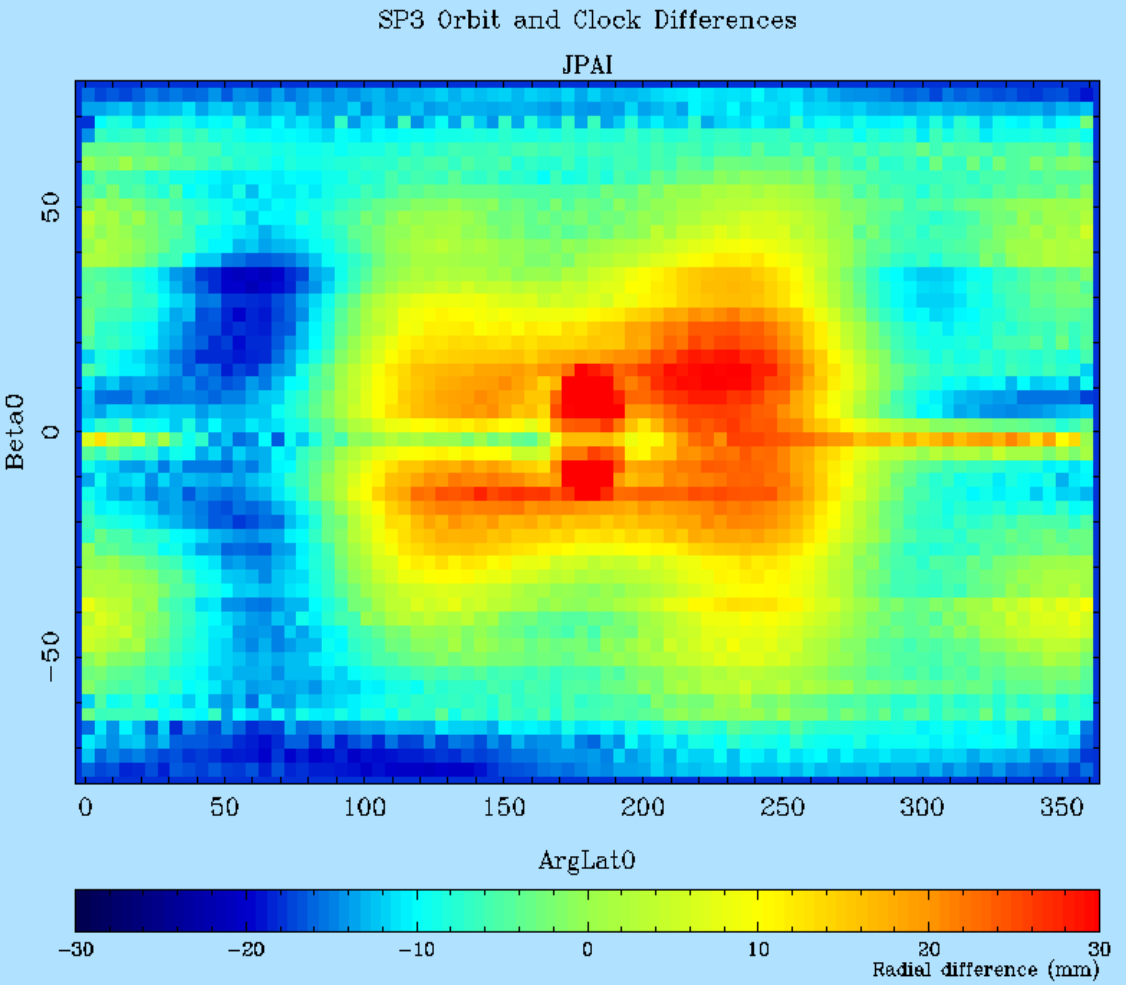
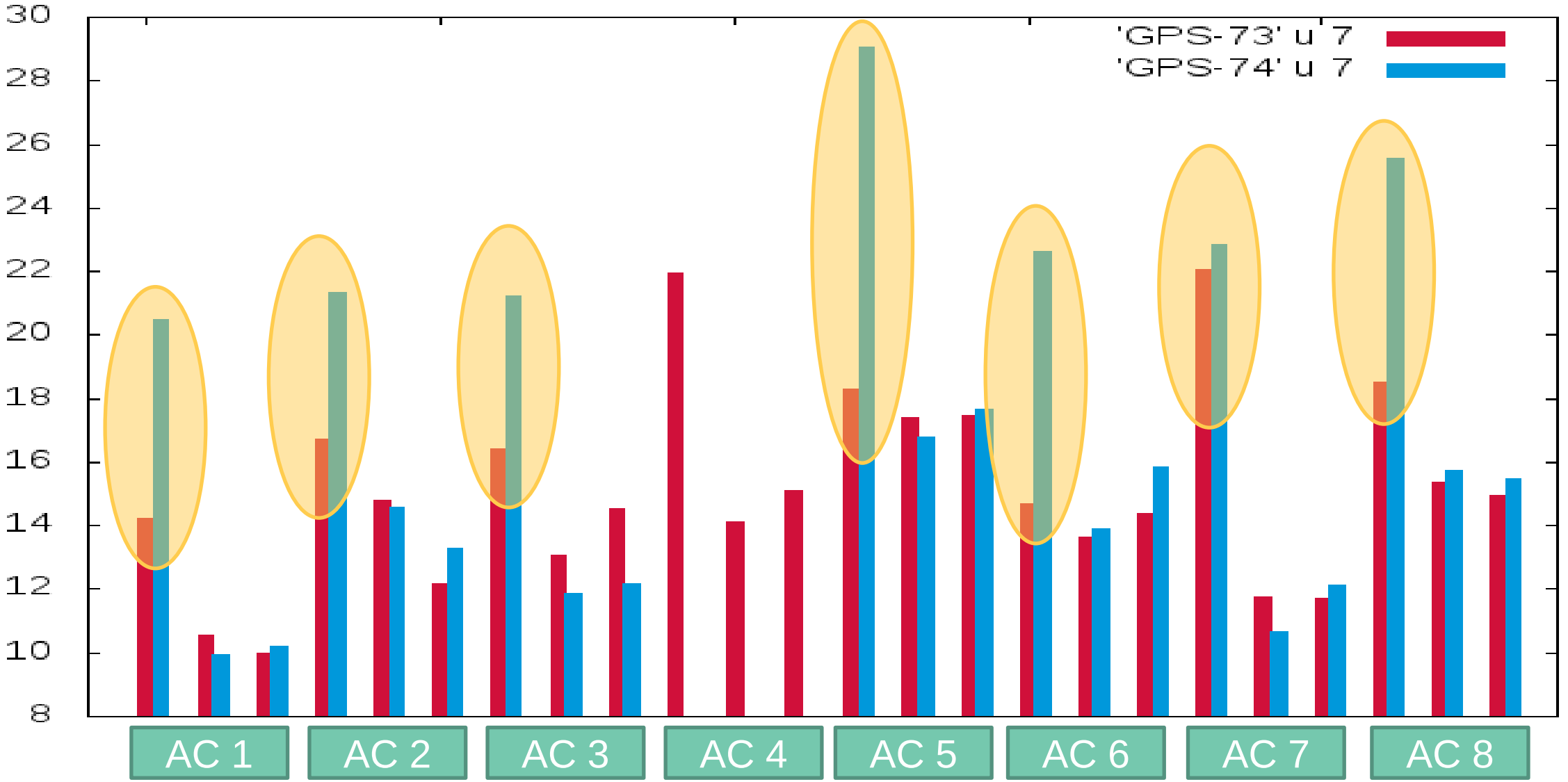
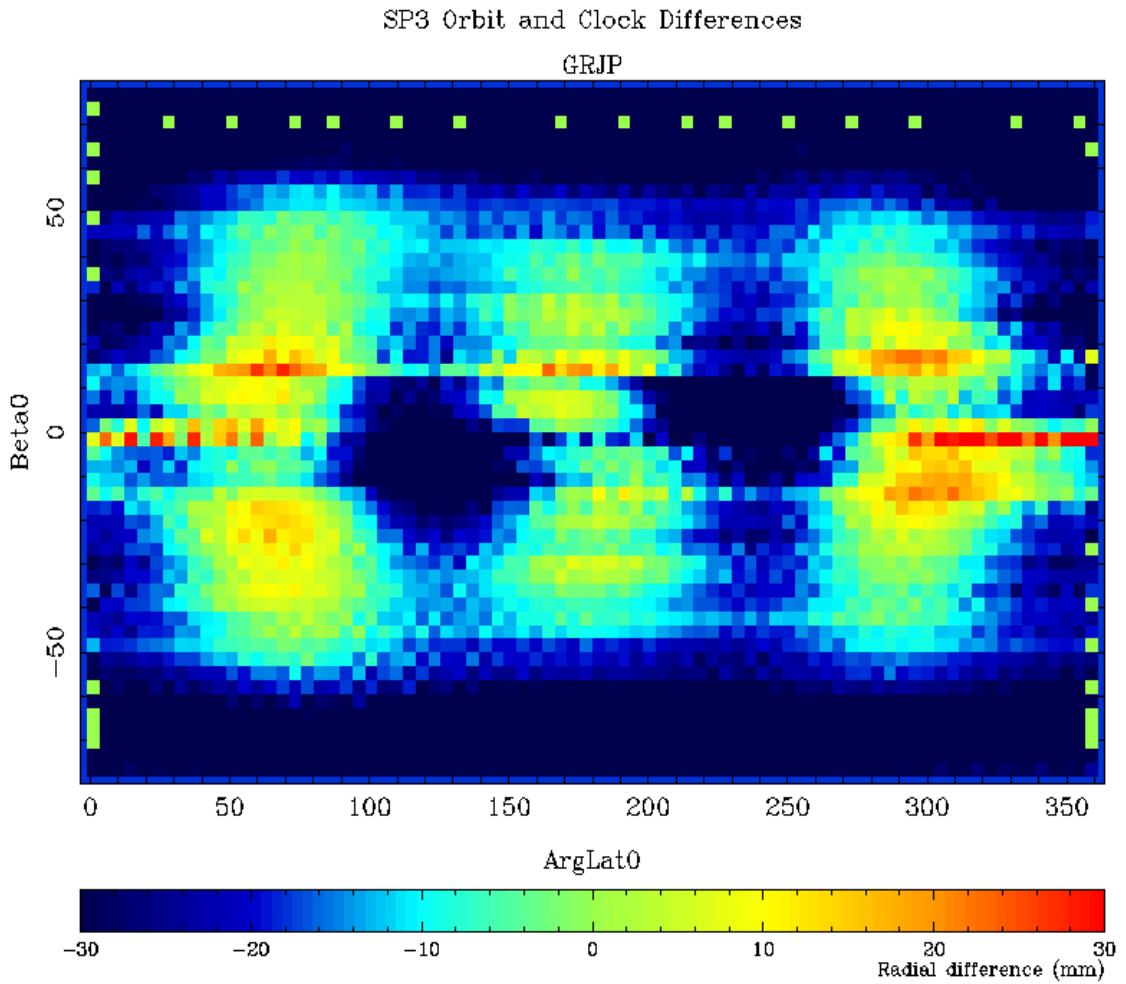
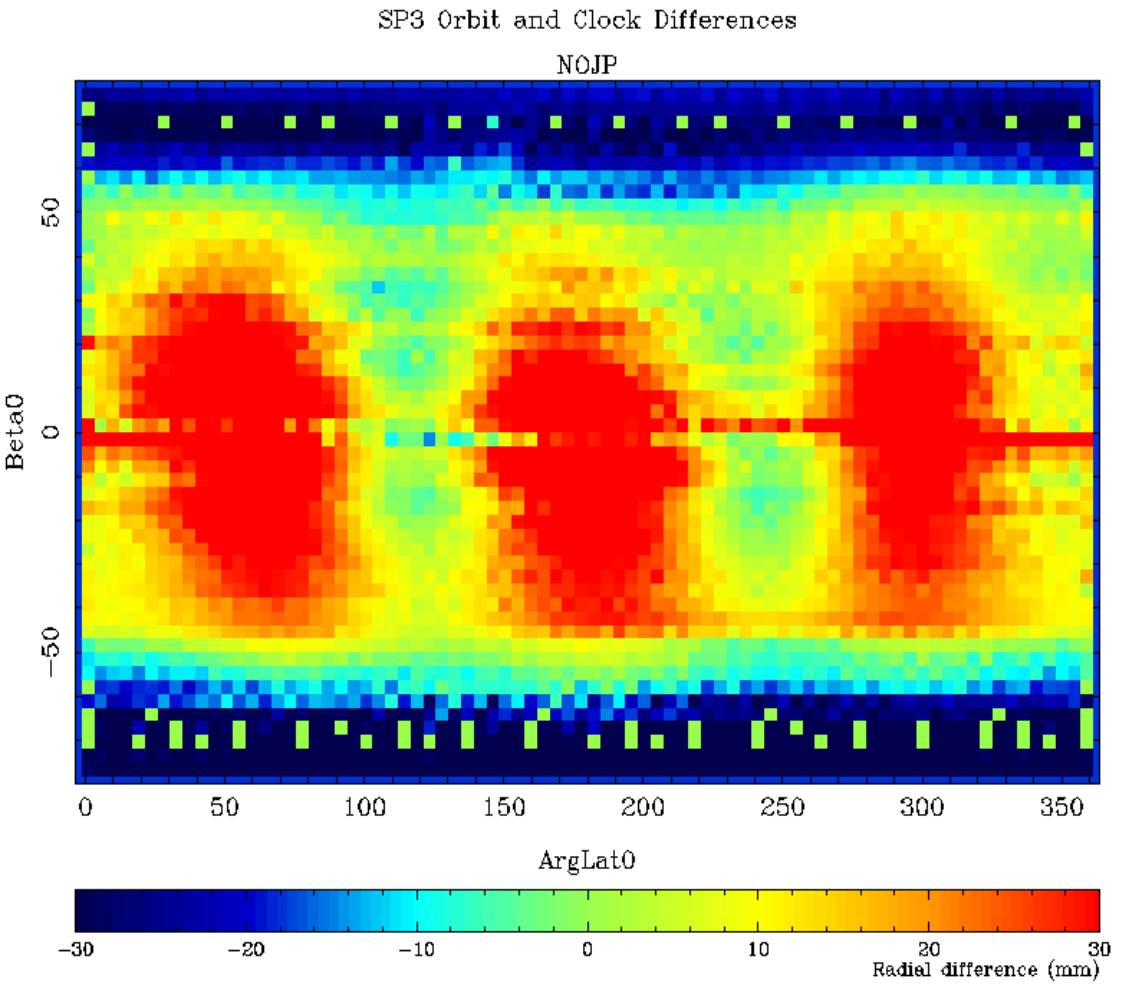


# REPRO-3 GPS Block IIIA satellites (GPS-74)
# Orbit difference RMS (mm): radial, along-, and cross-track

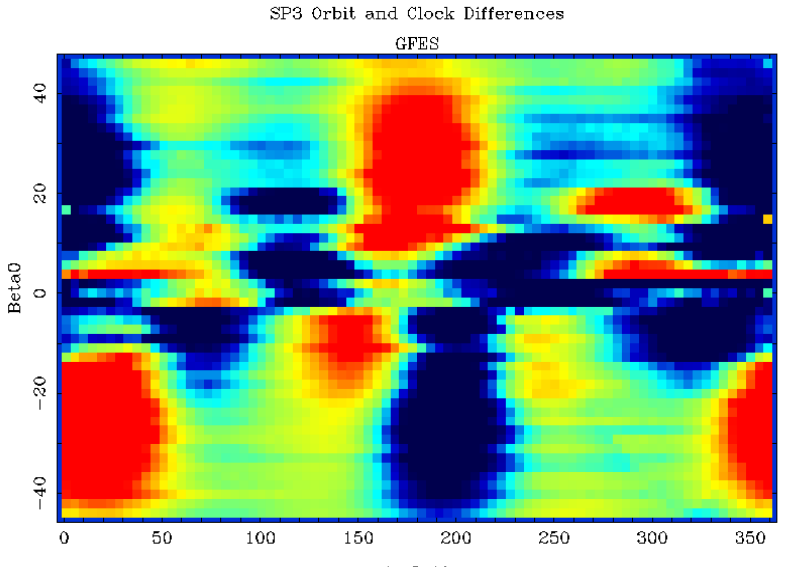


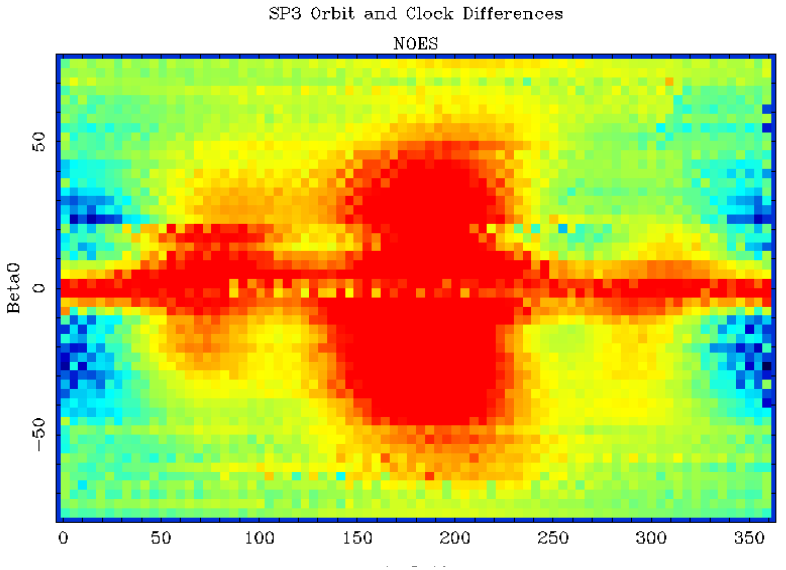
# GPS Block IIIA Radial Differences (AC vs JPL)

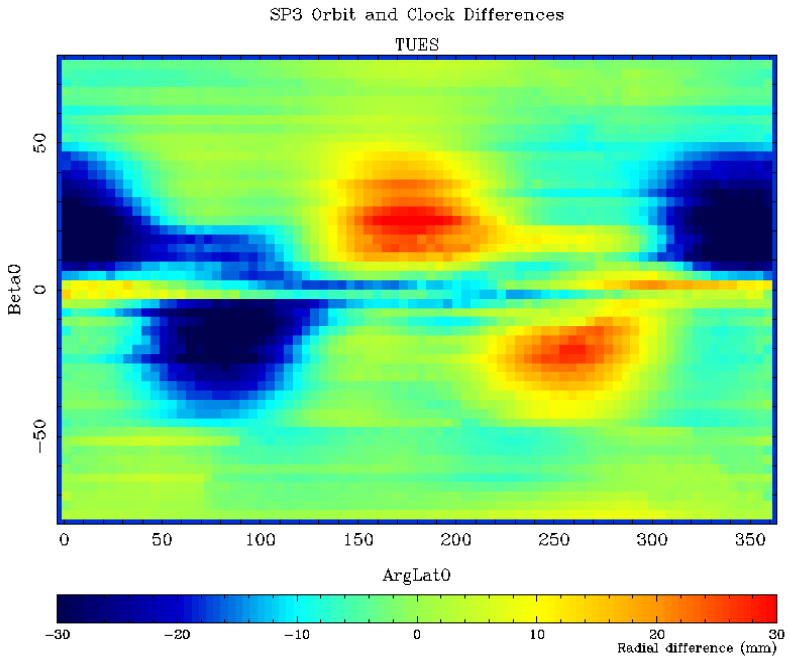


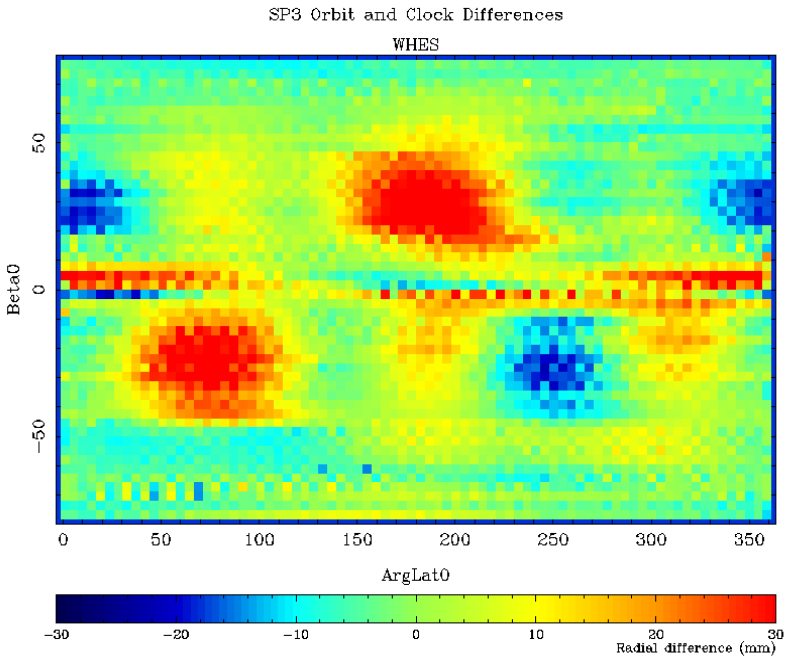



# GPS Block IIIA Radial Differences (AC vs ESA)



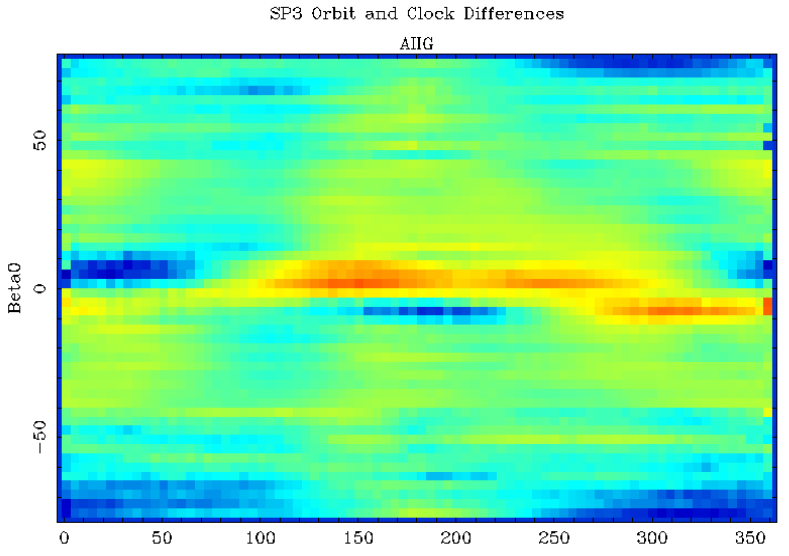

Highly significant differences for Block IIIA radial component

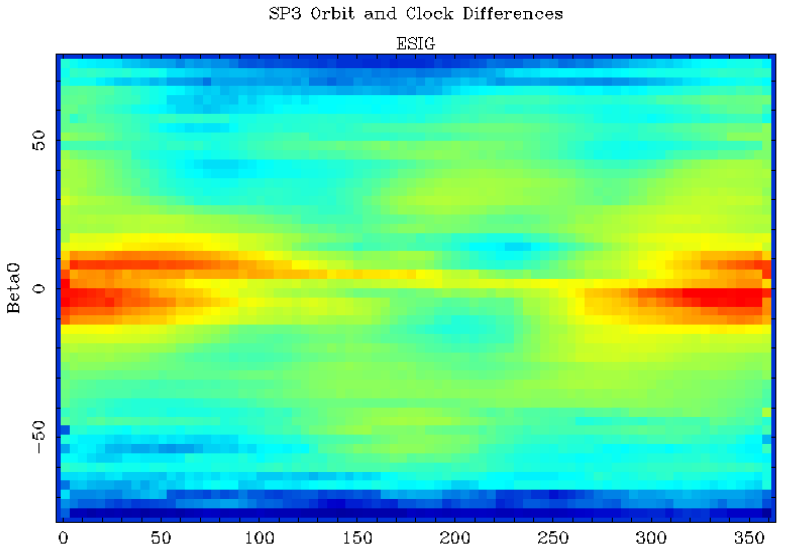
Improvements necessary!

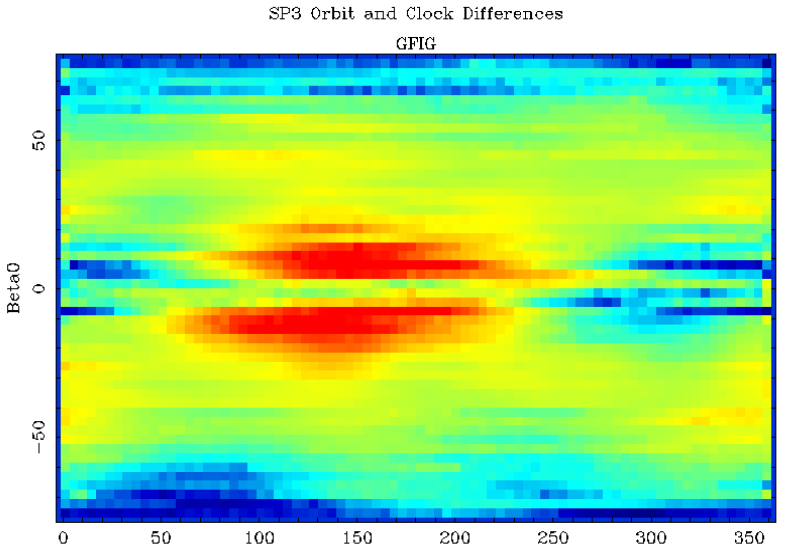
(only GPS-74 and -75)

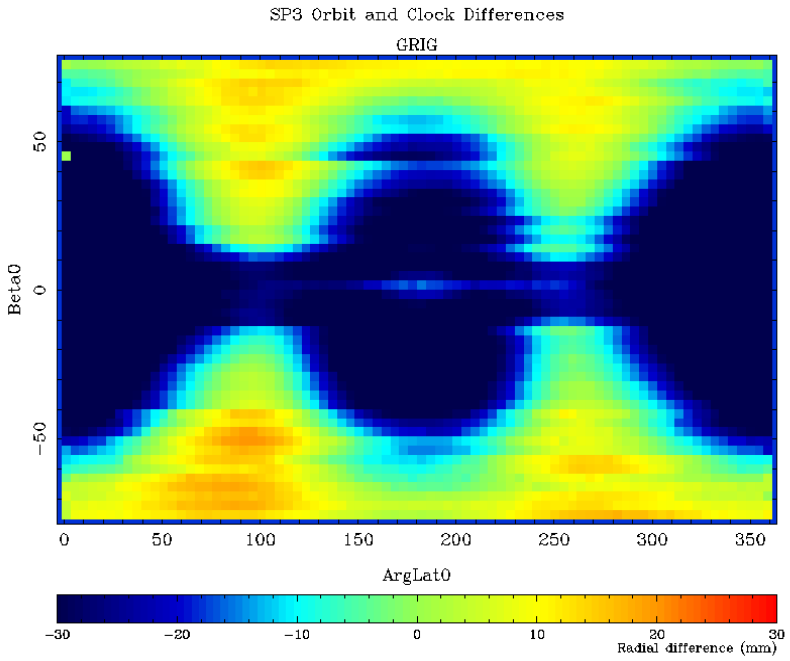
# A close look at the GALILEO REPRO3 Orbits

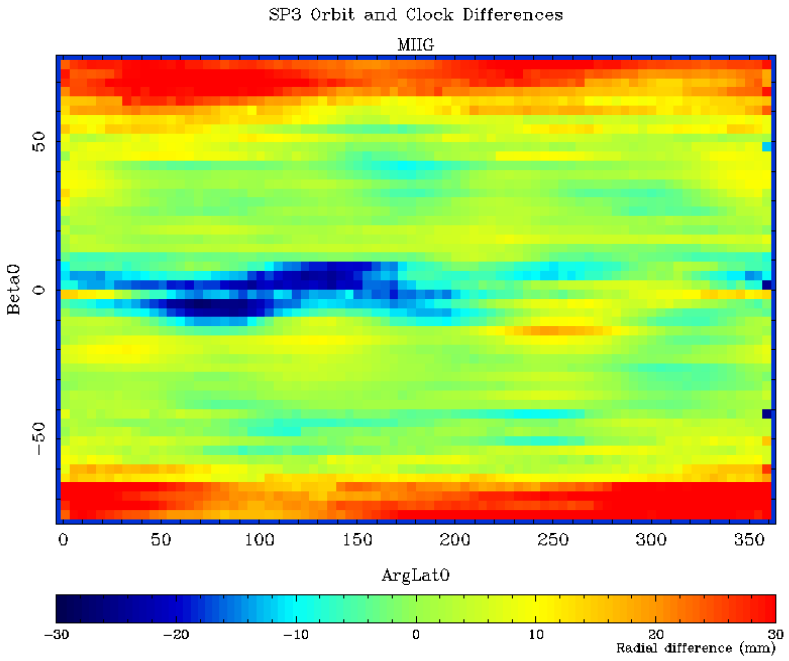
# GALILEO IOV Radial Differences (AC vs IGS)

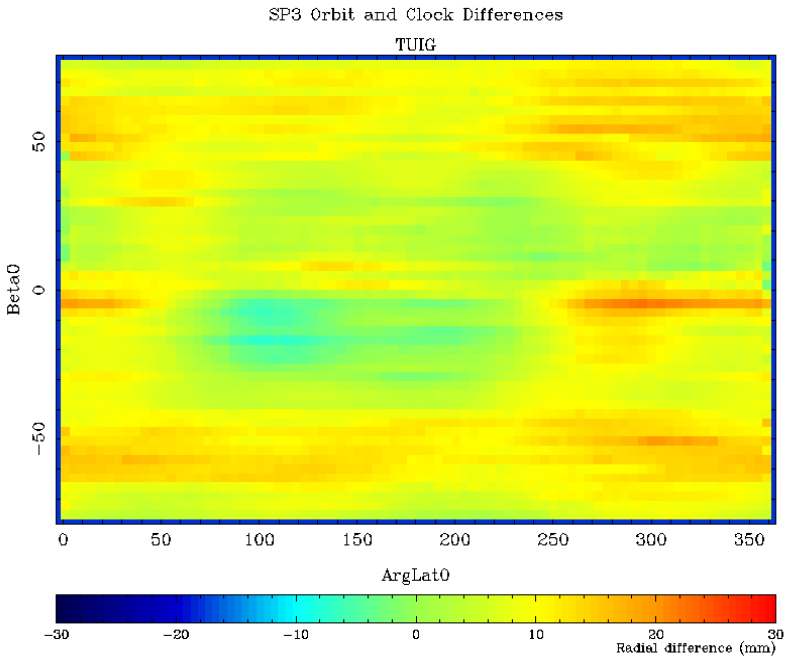


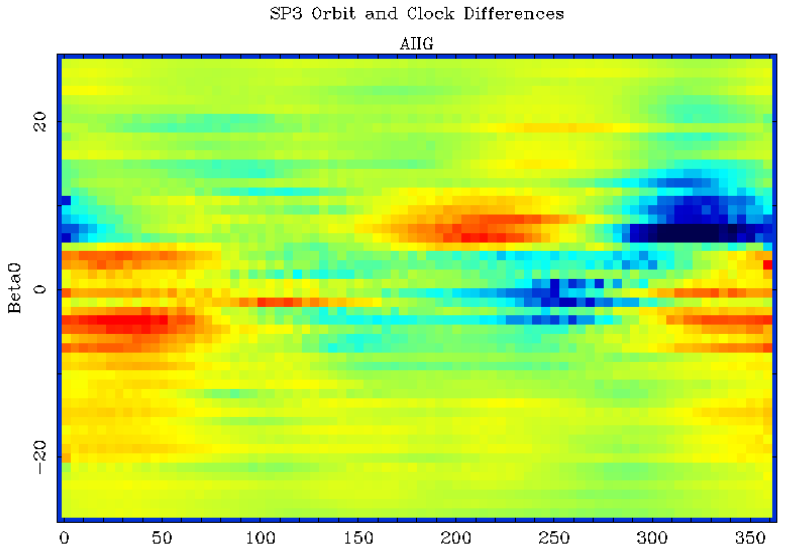



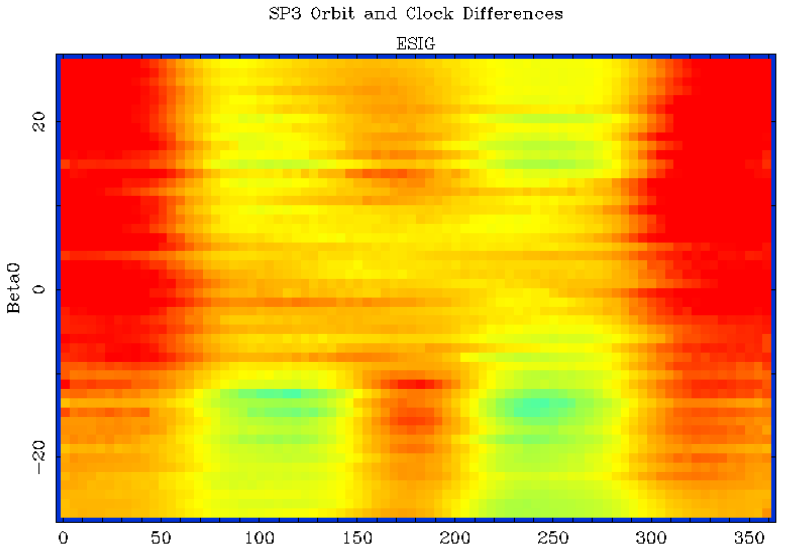



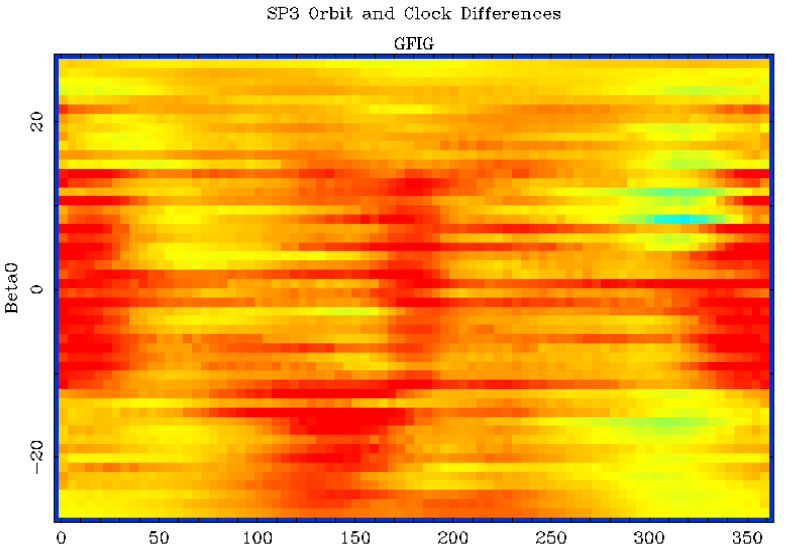



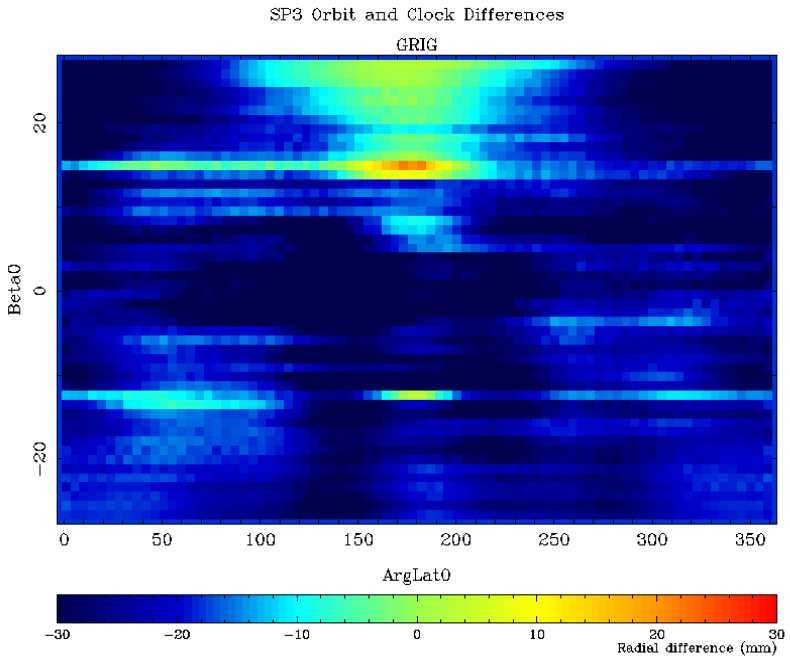



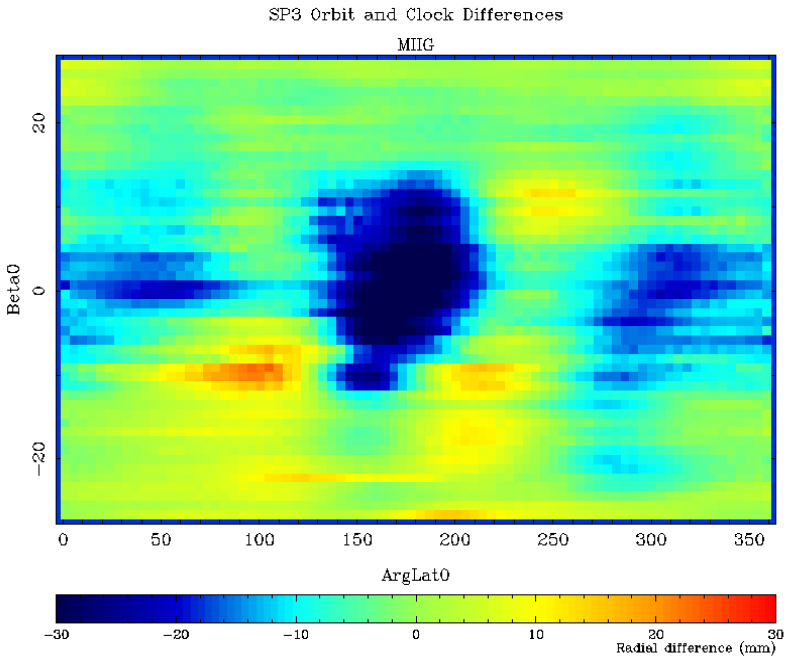
# Eccentric GALILEO Radial Differences (AC vs IGS)

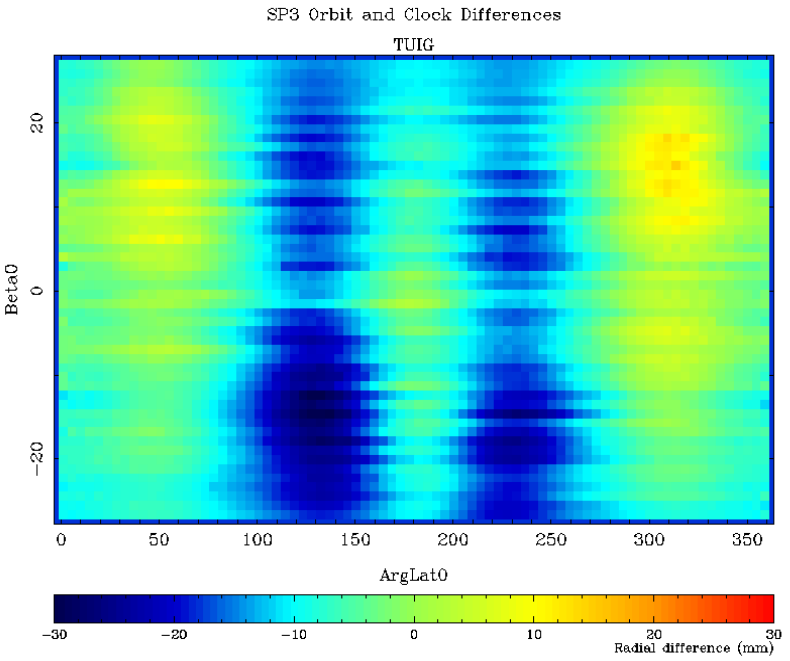


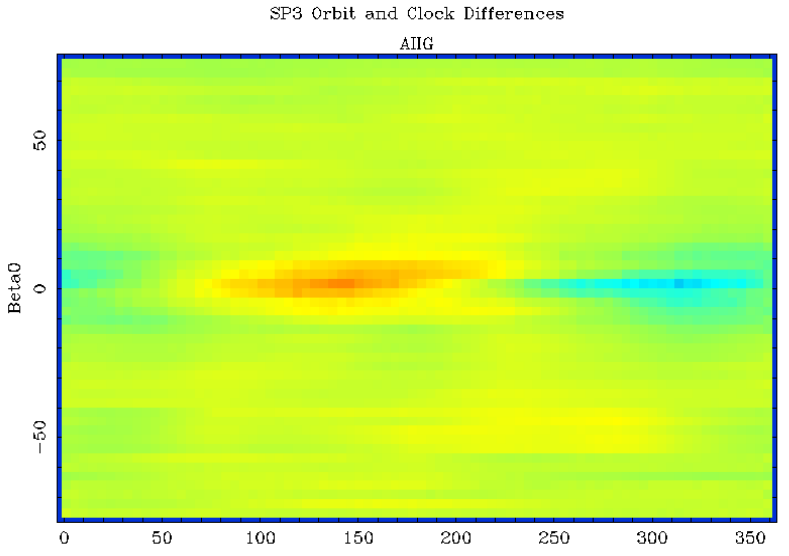



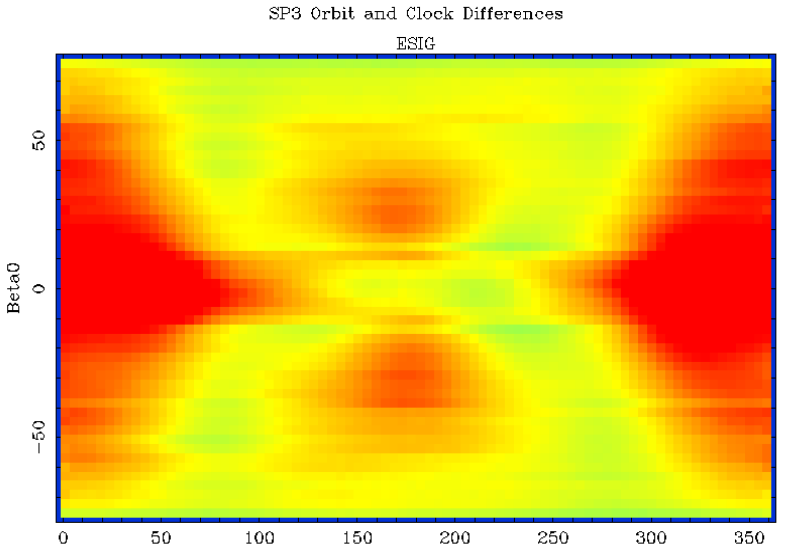



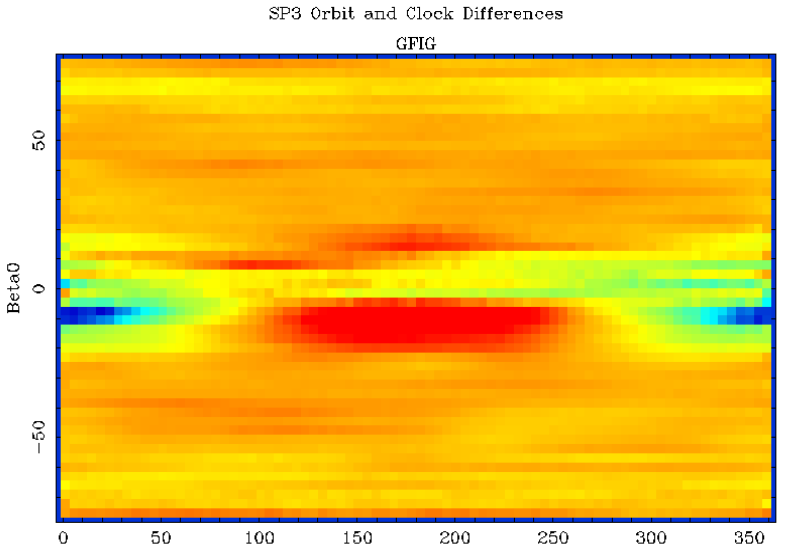



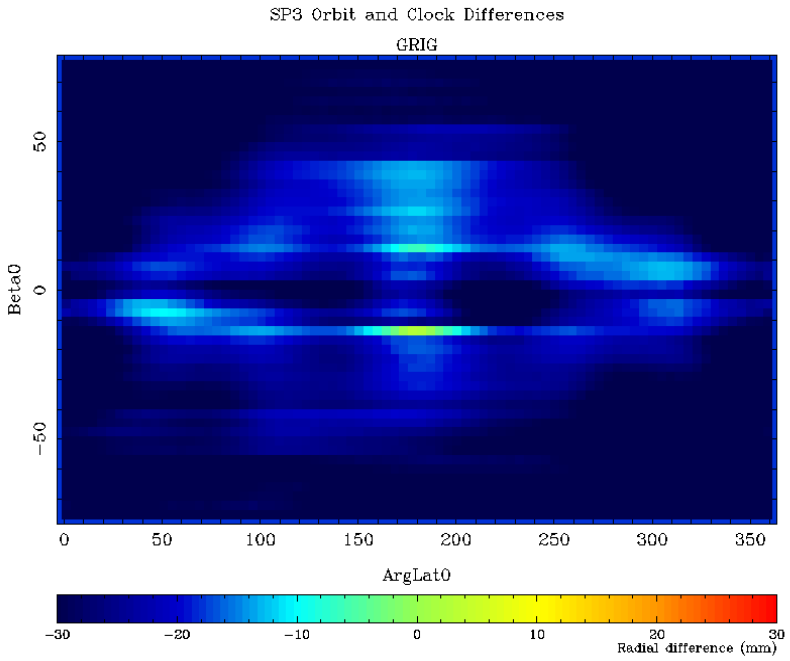



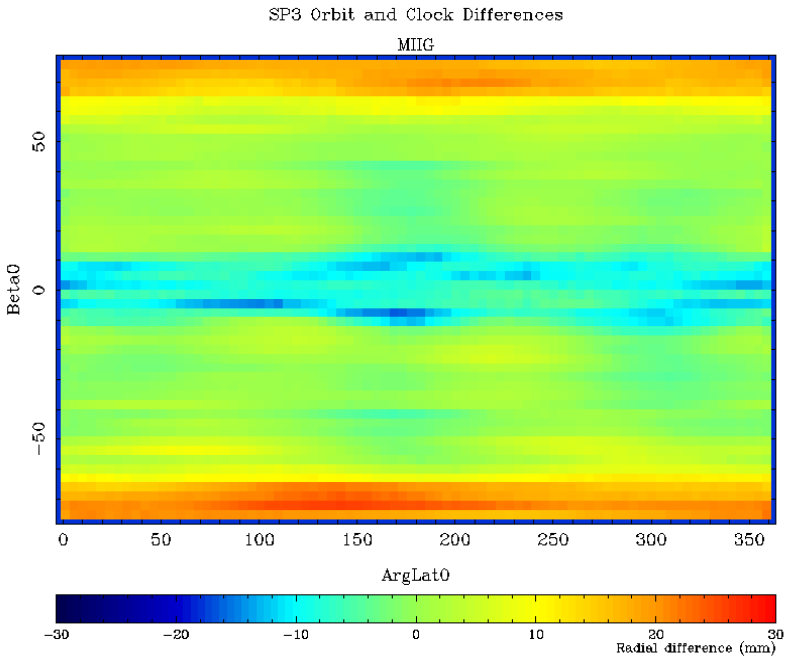
# GALILEO FOC Radial Differences (AC vs IGS)

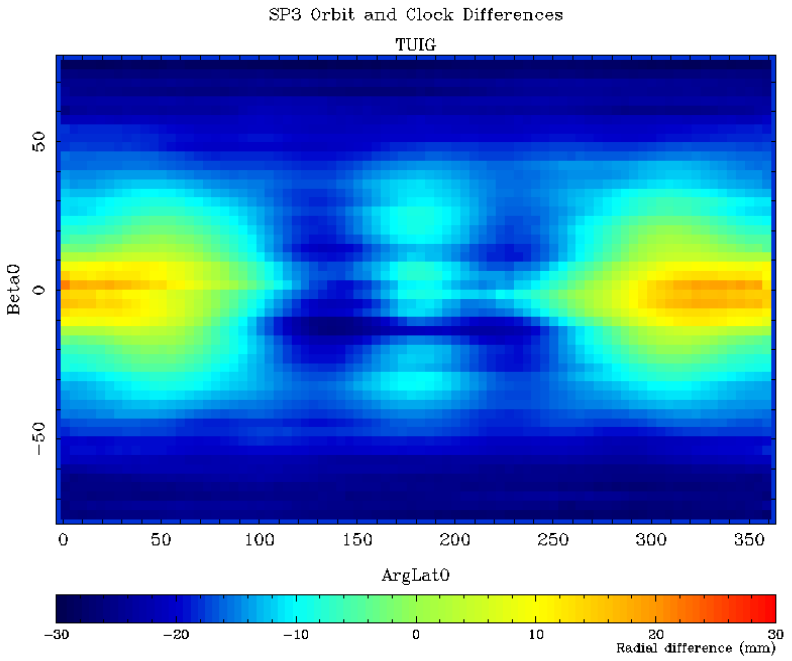


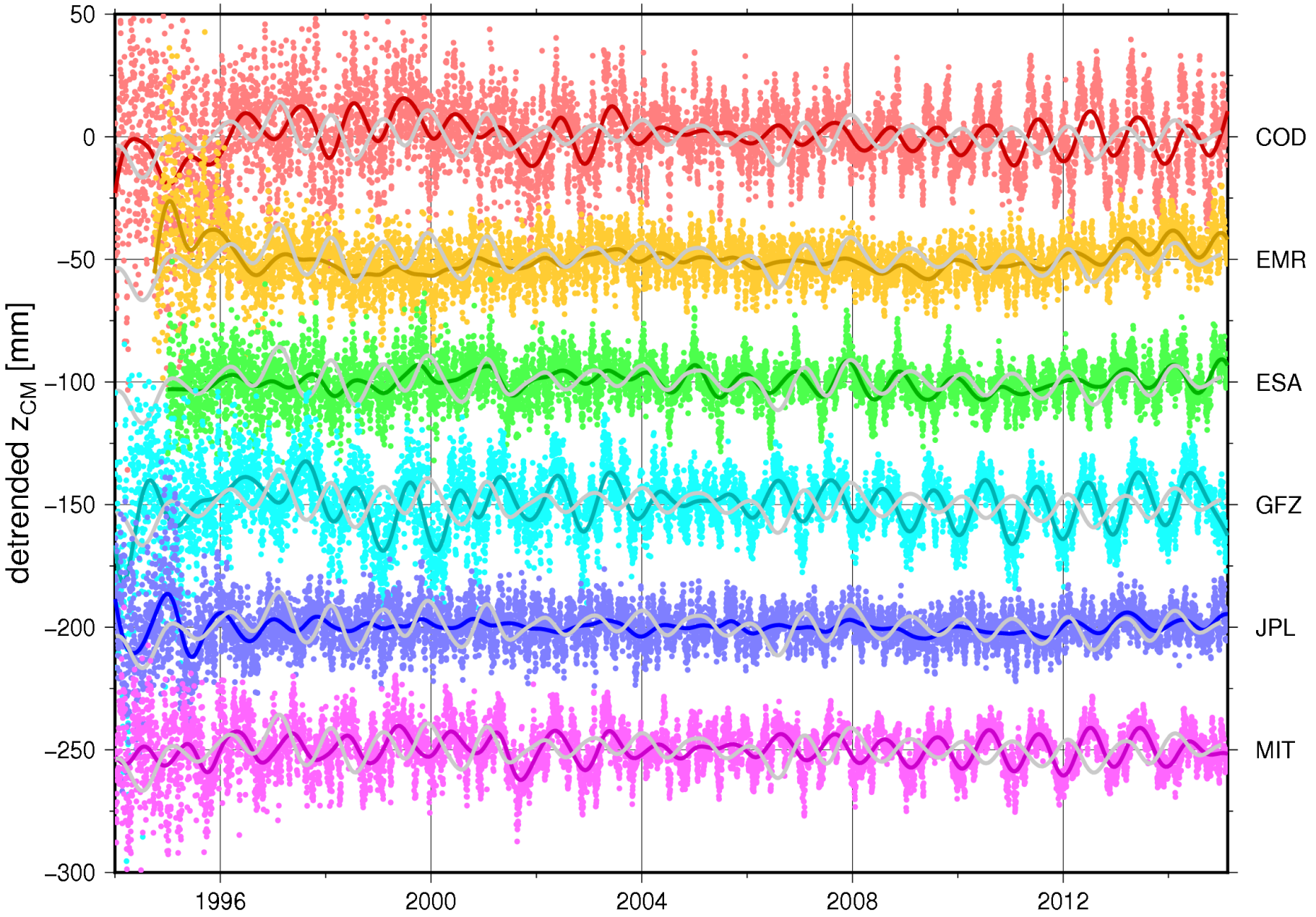



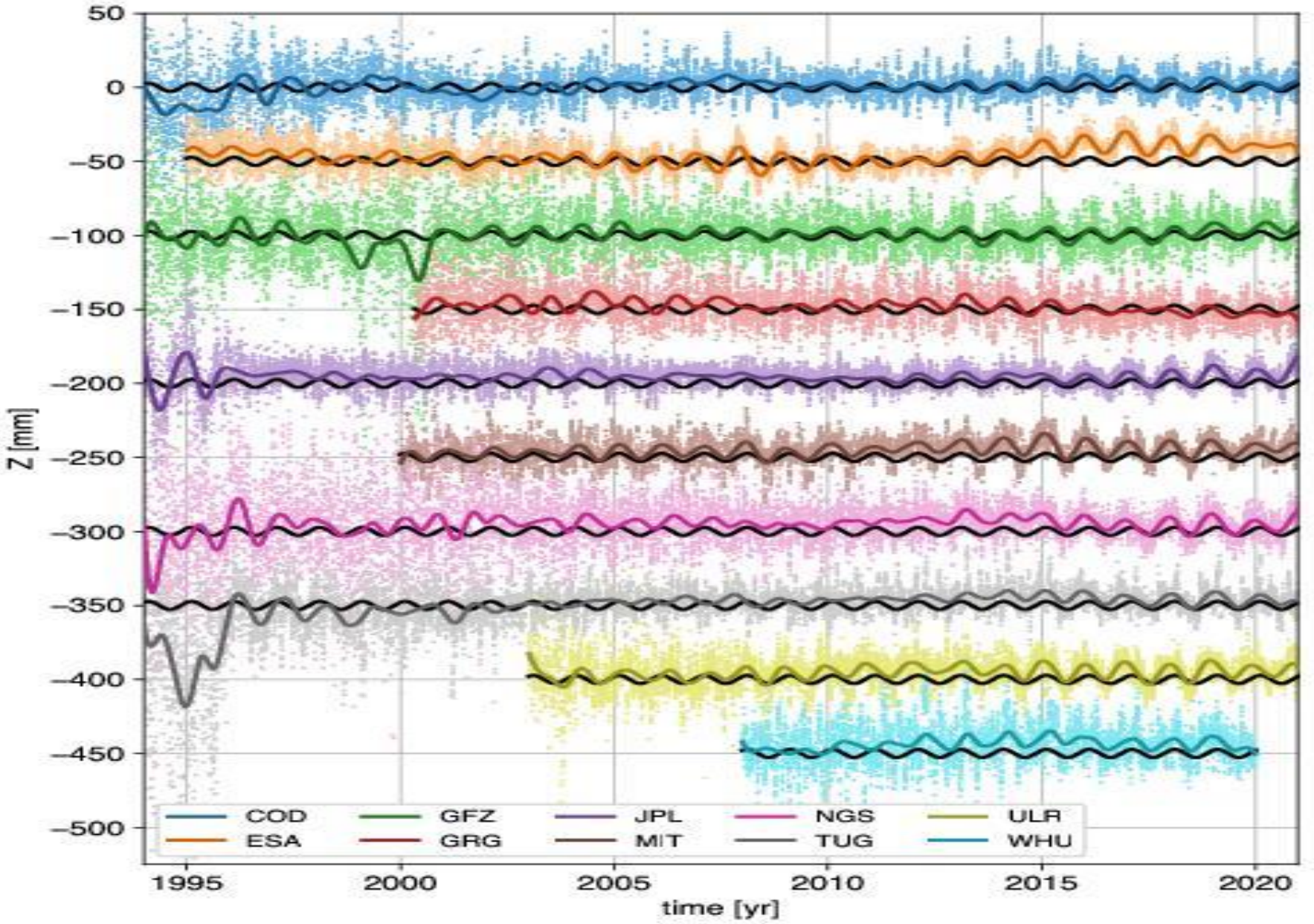
# GALILEO Differences

- Very good agreement for the GALILEO IOV satellites
  - Those are easier to model!
- Significant differences for the “eccentric” GALILEO satellites
  - Expected as one per revolution ECOM terms do not work very well
  - ECOM2 not adequate for these two satellites
- Very significant differences for the GALILEO FOC satellites
  - Not really expected
  - But they are harder to model than the IOV satellites
    - Most likely due to heat radiators on the –Z side
    - And GNSS transmit antenna working like “heat sink” giving a significant periodic force in the Z-direction.
- Significant work needed to get the results more similar!

# Z-Geocenter
# REPRO2



# Z-Geocenter REPRO3



# Conclusions

- Significant improvements for the different GPS satellite block types!
  - Thanks to all the ACs who put effort into this!
- GPS Block IIIA shows significant differences
  - In particular radial component improvements needed!
- Significant differences for GALILEO observed
  - Expected for the eccentric satellites
  - Less expected for the FOC satellites -> work needed!
- Clearly the REPRO-3 orbits still have significant systematic orbit differences
  - Consequently, the IGS products will and do still show signals with frequencies related to the orbit periods
- We have done a good step forward but more needs to be done

**Much more effort needs to be put into improving the RPR modeling of the GNSS satellites to reduce the spurious draconic terms in the IGS products!**

# The End