Doris ground antennas Radio Frequency characterization Impact on localization

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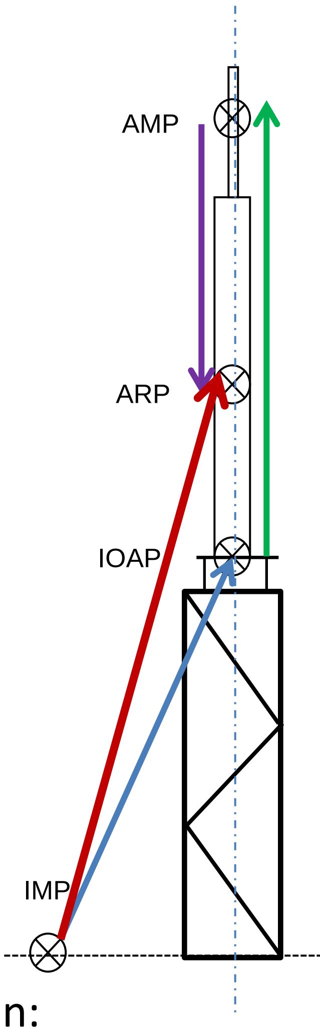
OUTLINE

- Characterization of DORIS STAREC ground antennas
  - Work performed,
  - Error budget elaboration

- Impact of the characterization on localization

Introduction



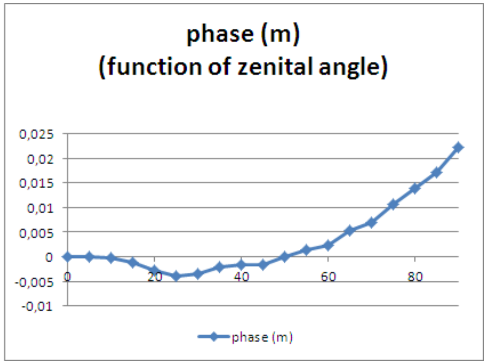
- The DORIS system measures distance between 2 points :
  - the ground station antenna phase center,
  - the on-board DORIS instrument antenna phase center,

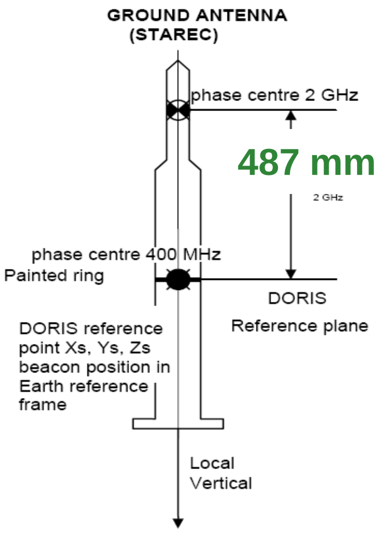
- Difficulties :
  - Determine antennas phases centers positions in their own frame :
    - No physical existence
    - Position function of signal incidence
    - Influence of environment on antenna radiation pattern
  - Tie antenna frame to ground station or satellite reference frame

- At ground level :
  - Work performed to give an enhanced Starec antenna characterization:
    - Phase center position / phase law,
    - Associated error budget (UP, North/East)

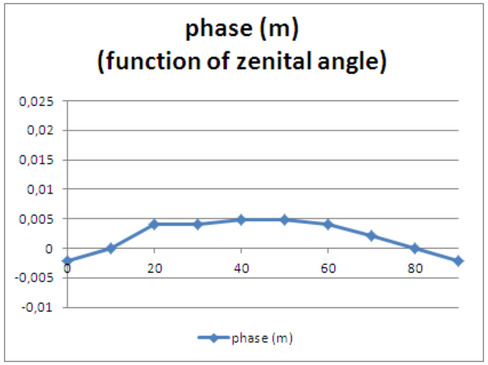
Reminder : DORIS Starec ground antenna

- Characterization provided for DORIS STAREC ground antennas
  - 2GHz :
    - Phase center : 487 mm above the reference plan
    - 2Ghz Phase law :





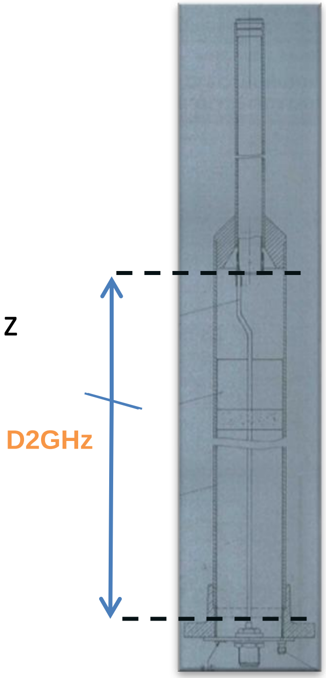
  - 400 MHz : no change
    - Phase center: 0 mm above the reference plan
    - 400Mhz Phase law



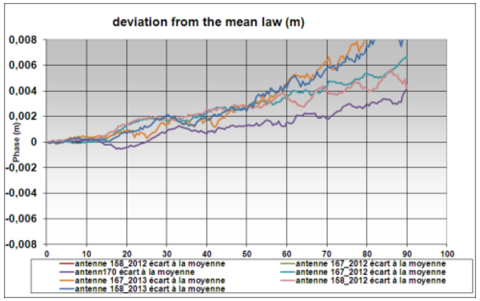
  - Characterizations provided via antex files

Antenna dispersion : Up component

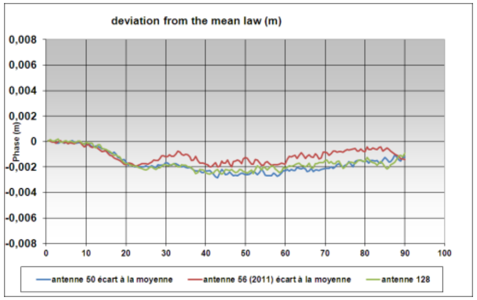
- Antennas characterized at CNES compact antenna test range (CATR)
  - Phase law provided : mean of the phase laws measured
  - Observation of discrepancies in phase laws
- In parallel, a set of antennas dismantled
  - Distance between 2GHz radiating element bottom and mounting flange : D2GHz
  - Dispersion in distance measured explaining discrepancies in phase laws:



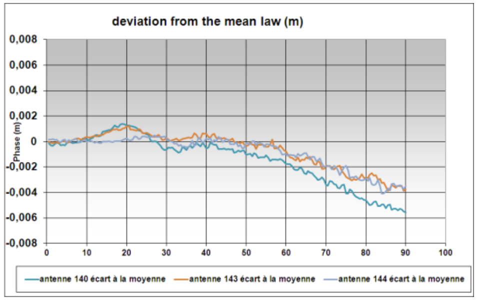
710 < D2GHz(mm) < 714



715,5 <D2GHz(mm)< 716,5



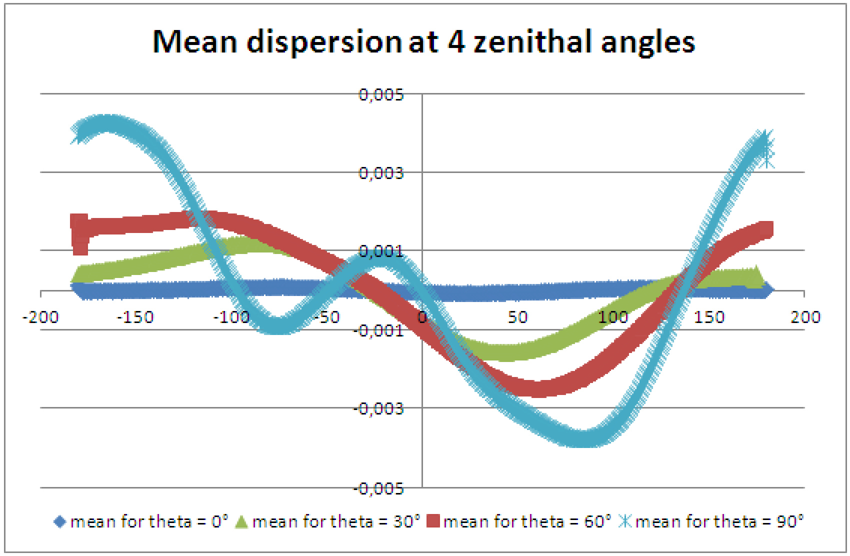
717 <D2GHz(mm)< 720



- Distance corresponding to the mean law provided via antex files : 716mm
  - Dispersion wrt this distance : **-6mm /+4mm** for old antennas (mnemo DORIS : XXXB)
- Work preformed with antenna manufacturer :
  - For future antennas : distance guaranteed at **716 ±1mm**
  - Sites equipped with those antennas : mnemo DORIS : XXXC.

Analysis of dispersion w.r.t. azimuth angle measurements

- Specific analysis performed at CATR
  - 3 antennas analyzed :
    - 4 plans (4 zenithal angle): θ = 0°, 30°, 60°, 90°; with ϕ going from -180 to 180°
- To eliminate inter-antennas variability
  - we determine the mean dispersion over all antennas
- mean azimuthal dispersion for 4 zenithal angles
- Impact of dispersion :
  - Law θ values :
    - impact on the up component
    - small dispersion => small impact on up
  - High θ values :
    - impact on the N/E component
    - greater dispersion (±3,7mm at 85°)
    - => greater impact
    - for standard passes we can estimate a max impact of **±3mm (N/E)**
- This dispersion includes:
  - True Azimuthal RF dispersion
  - Perpendicularity / Coaxiality defaults of Antenna axis w.r.t. Mounting flange
  - Centering default of radiating elements
  - CATR assembly eventual default, rotation axis perpendicularity



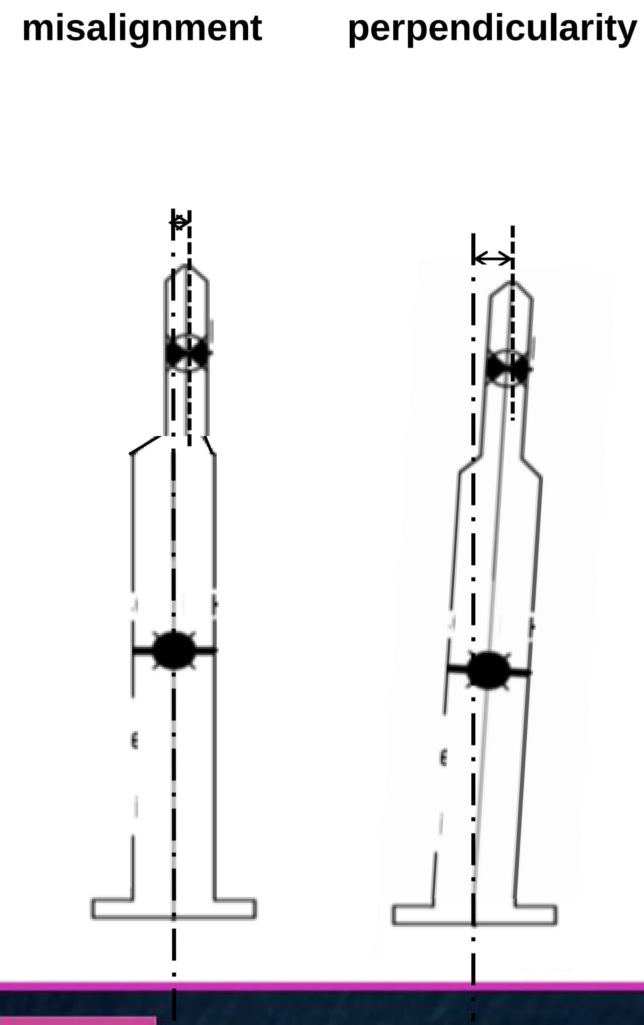
θ	Max dispersion
0°	0 mm
30°	±1,4mm
60°	±2,15mm
85° (interpolation)	±3,7mm
90°	±4 mm

Analysis of dispersion w.r.t. azimuth angle Antenna axis eventual defaults

- Misalignment / perpendicularity defaults
  - Now controlled by manufacturer on a machine tool w.r.t. mounting flange (plane&axis)
  - The error due to non perpendicularity or misalignment does not exceed : ±0,5mm at antenna extremity

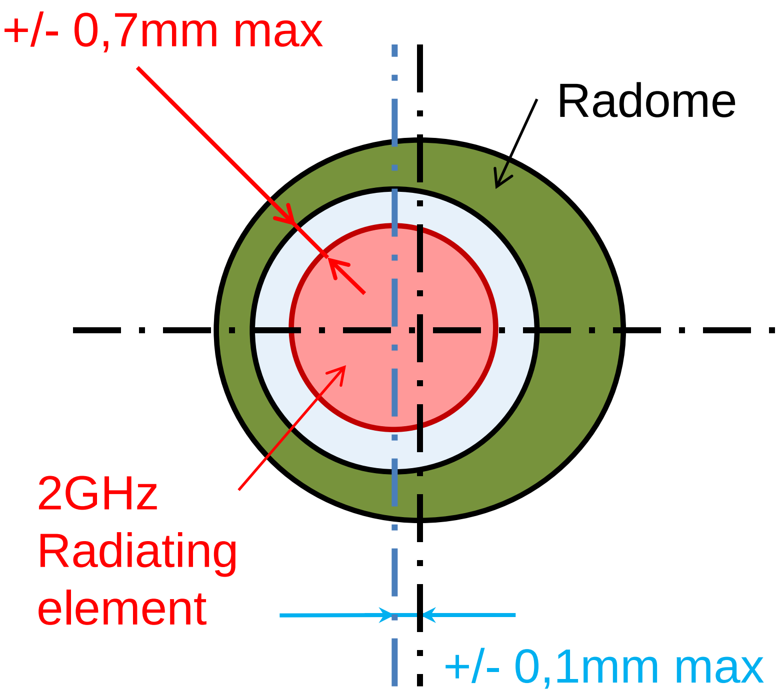
=> This implies an error in the horizontal plane

≈ ±0,5mm of 2GHz phase center position N/E



Analysis of dispersion w.r.t. azimuth angle

Centering default of 2GHz radiating elements



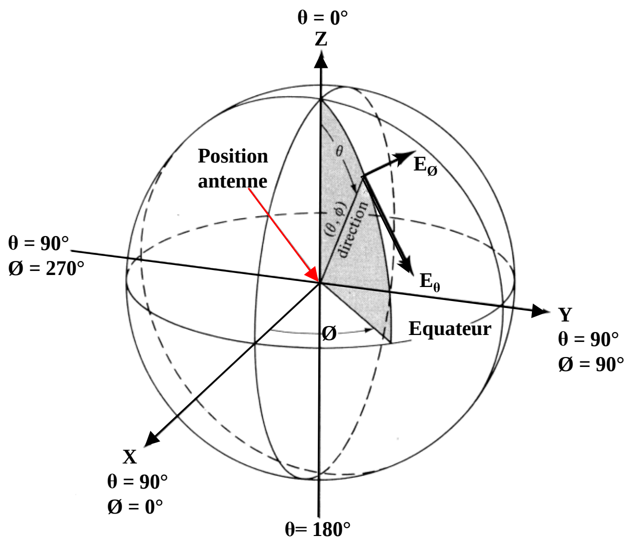
- Perpendicularity of the radome external skin axis is controlled by the manufacturer with respect to mounting flange
- Remaining internal / external discrepancies
  - Irregularity of radome thickness
  - clearance between radiating elements and radome

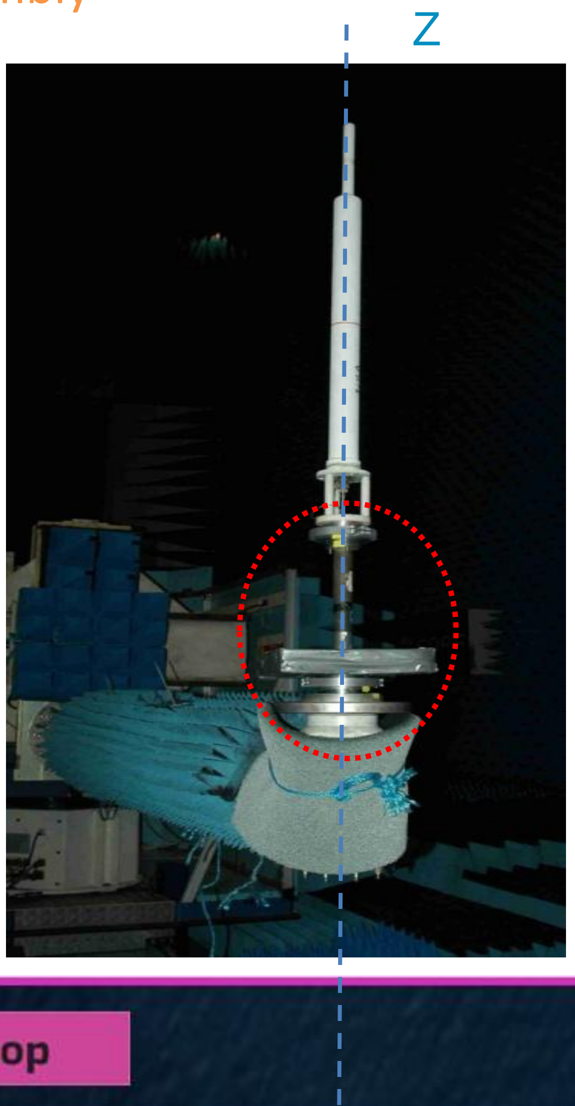
Discrepancy between internal axis and radome external surface	± 0,1mm
Gap between radiating element and internal radome surface	± 0,7mm
total	**± 0,8mm N/E**

Analysis of dispersion w.r.t. azimuth angle
Antenna perpendicularity default in CATR

Perpendicularity default due to measurement assembly

- Antenna aligned on Z axis of measurement device
- Antenna is set on measurement device thank to mechanic interface
  - Perpendicularity is not totally perfect
  - Default assumed : **± 1 mm (N/E)** at 2GHz height (887mm)





Analysis of dispersion w.r.t. azimuth angle Conclusion

- The worst impact of azimuthal dispersion would be ±3mm in horizontal plane (N/E), assuming the dispersion is totally due to antenna
  - But ±1mm is probably due to CATR measurement assembly

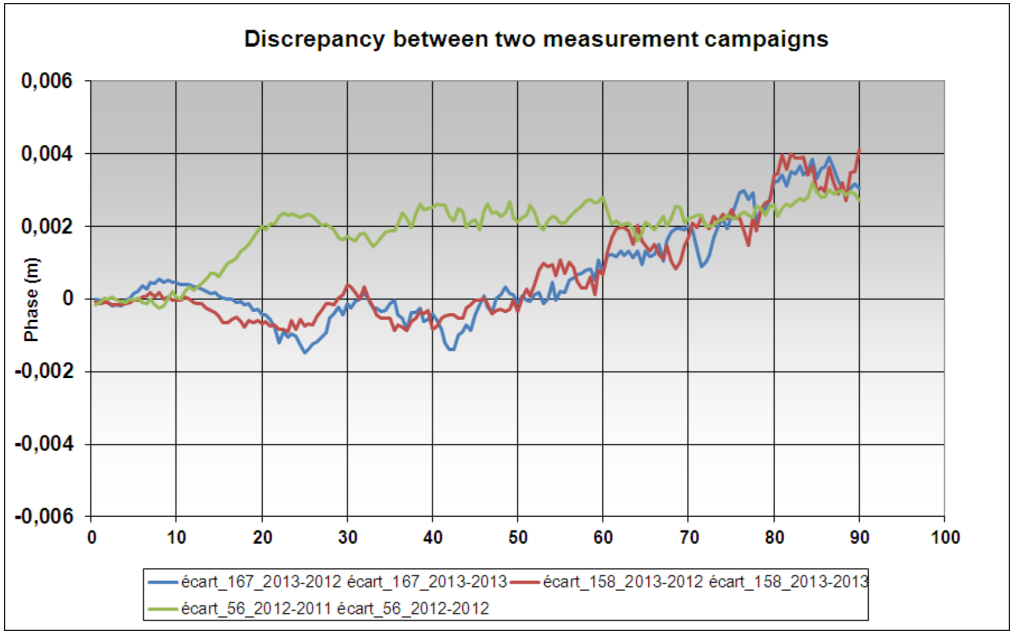
- This allows to establish the following azimuth error budget

Antenna Azimuth error budget	
Error source	**N/E impact**
Total observed	**±3 mm**
CATR assembly	**±1 mm**
=> Total antenna	**±2 mm**
Axis default	**±0,5 mm**
Centering	**±0,8 mm**
=> Azimuth phase pattern variation	**±0,7 mm**

- We assume the DORIS STAREC antenna is non azimuth dependent
  - Not really a surprise, STAREC antenna is helicoidal, it has a revolution symmetry by conception

CATR measurement error

- The CATR has its own measurement error
- This error impact directly values given for antenna characterization
  - To get an estimation of this error
    - Some antennas characterized twice at CATR at 3 different epochs
    - Measurement discrepancy observed : 4mm max



  - We assume a CATR measurement noise error of ±2mm (up)

DORIS Ground antenna (STAREC) error budget

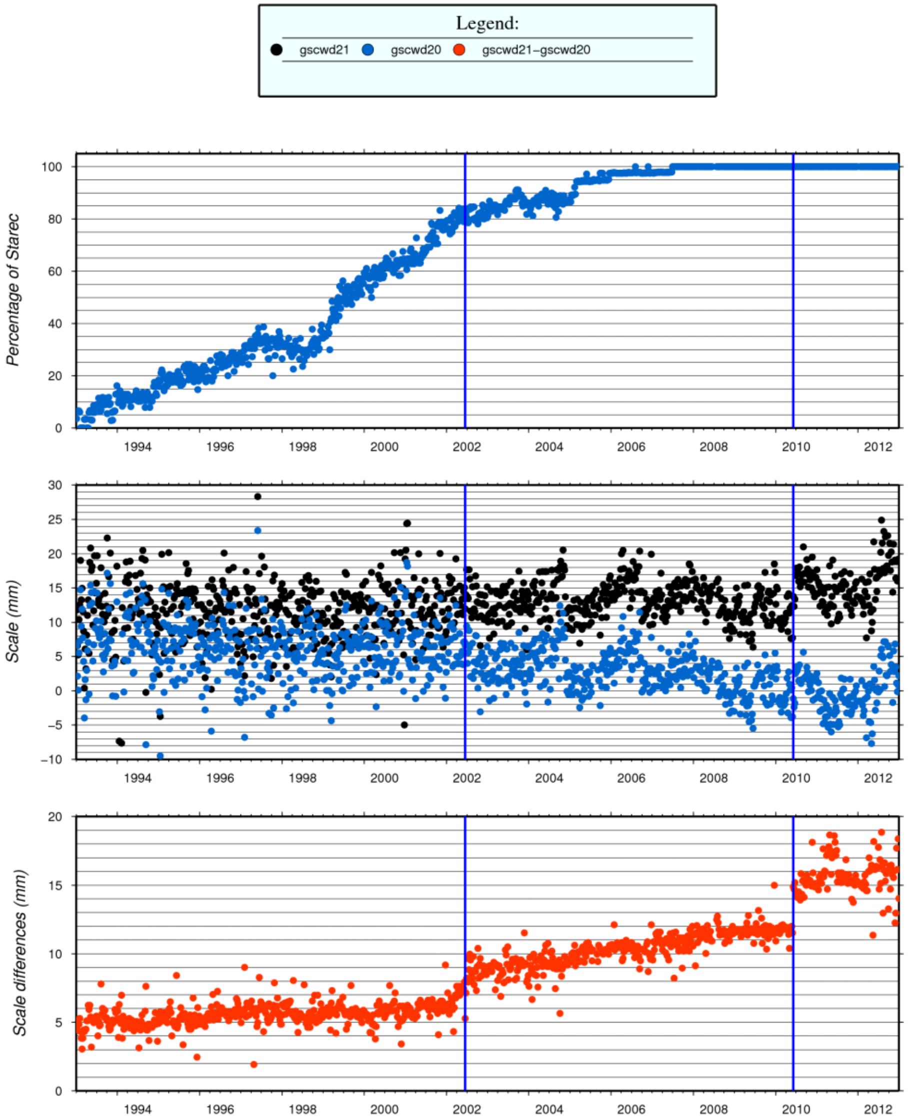
Error source	up	plan (N/E)
Antennas variability (2GHz phase center position) before consolidation with manufacturer (SN < 171)	+4/-6 mm	
Antennas variability (2GHz phase center position) after consolidation with the manufacturer (From SN 171)	±1 mm	
Antenna characterization error (CATR)	±2 mm	
Azimuthal dispersion (including RF, perpendicularity, centering)	0mm	± 2mm
Total antenna alone		
SN < 171	+6/-8 mm max 5,4 mm rms	± 2 mm max 0,7 mm rms
From SN 171	**± 3 mm max** 1 mm rms	**± 2 mm max** 0,7 mm rms
Antenna environment impact	TBD	TBD

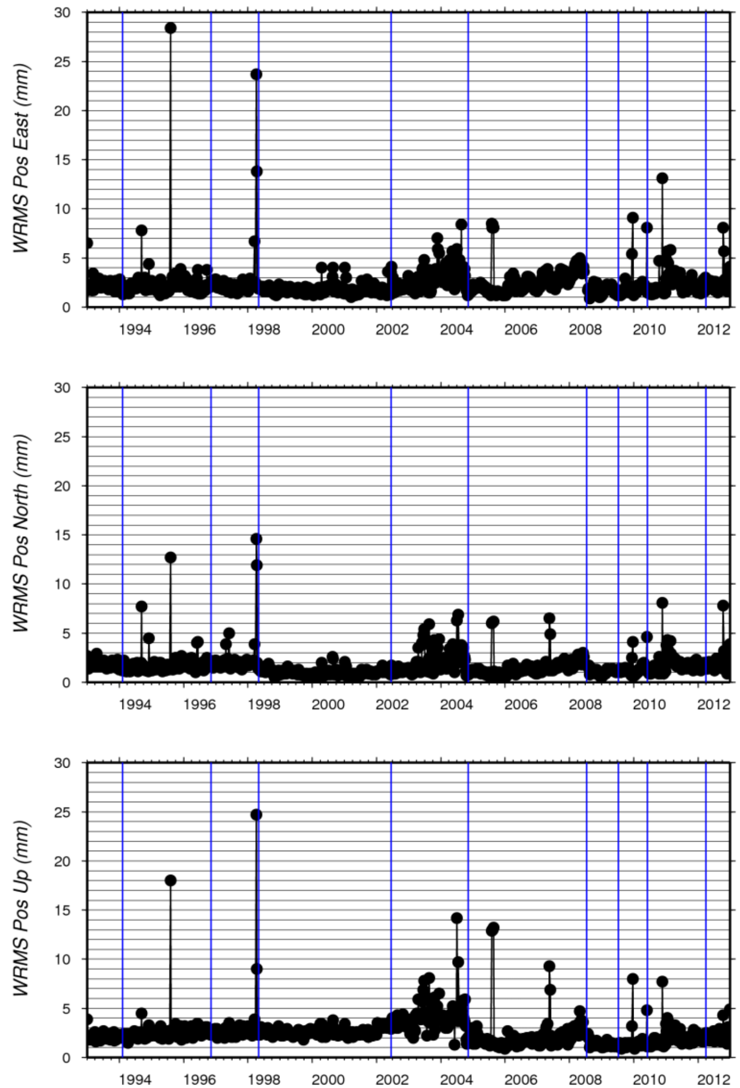
Impact of the characterization on localization

- **Objective: Impact of phase laws in terms of Helmert parameters and station positions.**
- **Input: SINEX series which differ by phase laws only.**
  - **GSC series 20 and 21 (==20+Phase Laws)**
  - **IGN series 13 and 15 (==13+Phase Laws)**
- **Methods:**
  - **Series are compared after projection in ITRF2008 by using common weekly network.**
  - **Evaluation of the later series wrt first one (as datum).**

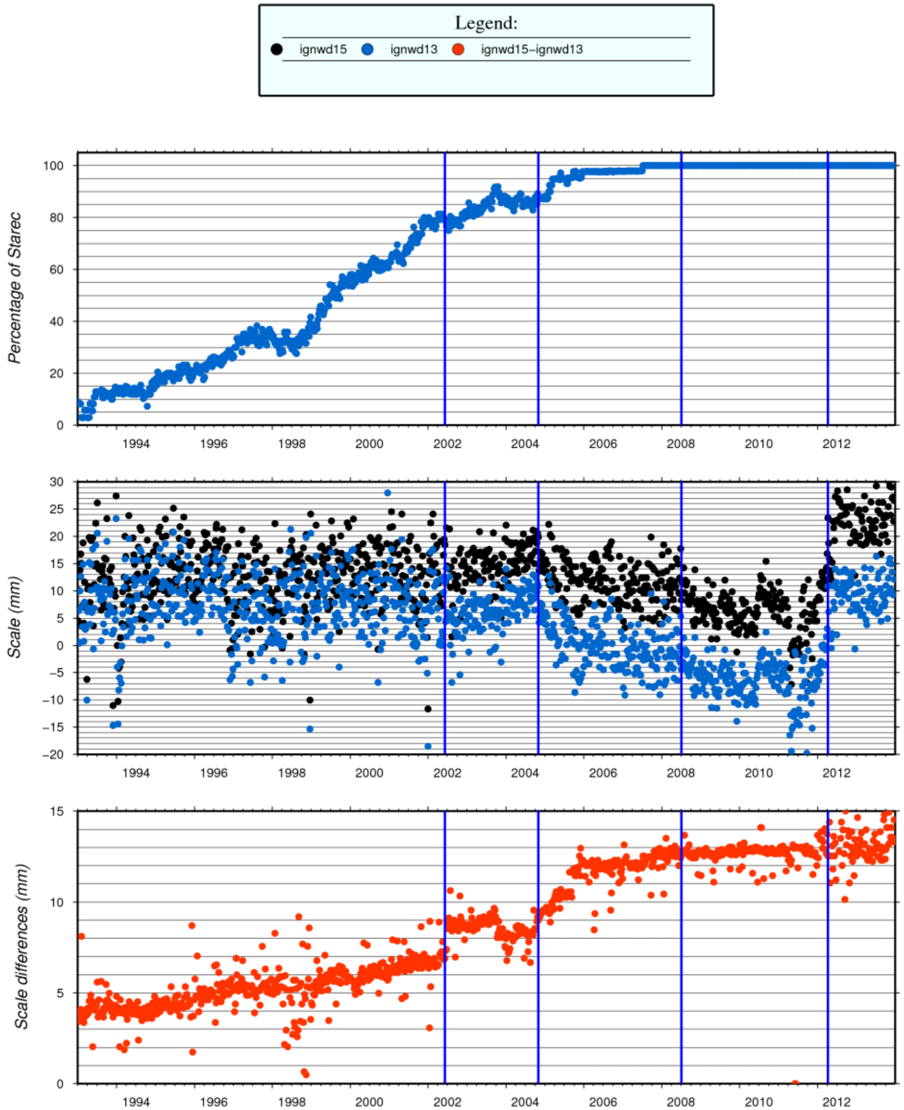
➔ **same results**

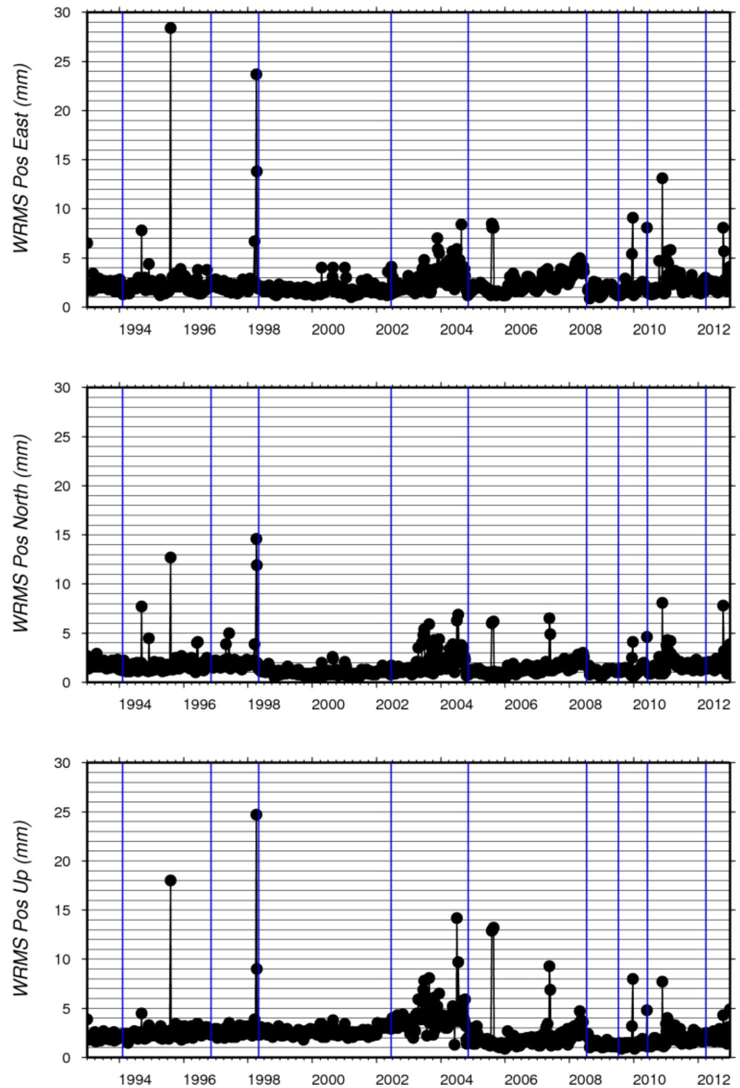
Impact of the characterization on localization





Impact of the characterization on localization





Impact of the characterization on localization

- **Conclusions:**
  - **Does only impact scale factors.**
  - **No impact on station positions as coordinate differences (around 3mm for all the 70 DORIS sites) is 5 times less than the position error.**

THANK YOU