

IERS Workshop on site co-location

Session 3: Analysis and SINEX

Latest Results from Hartebeeshtoeck

Valérie MICHEL

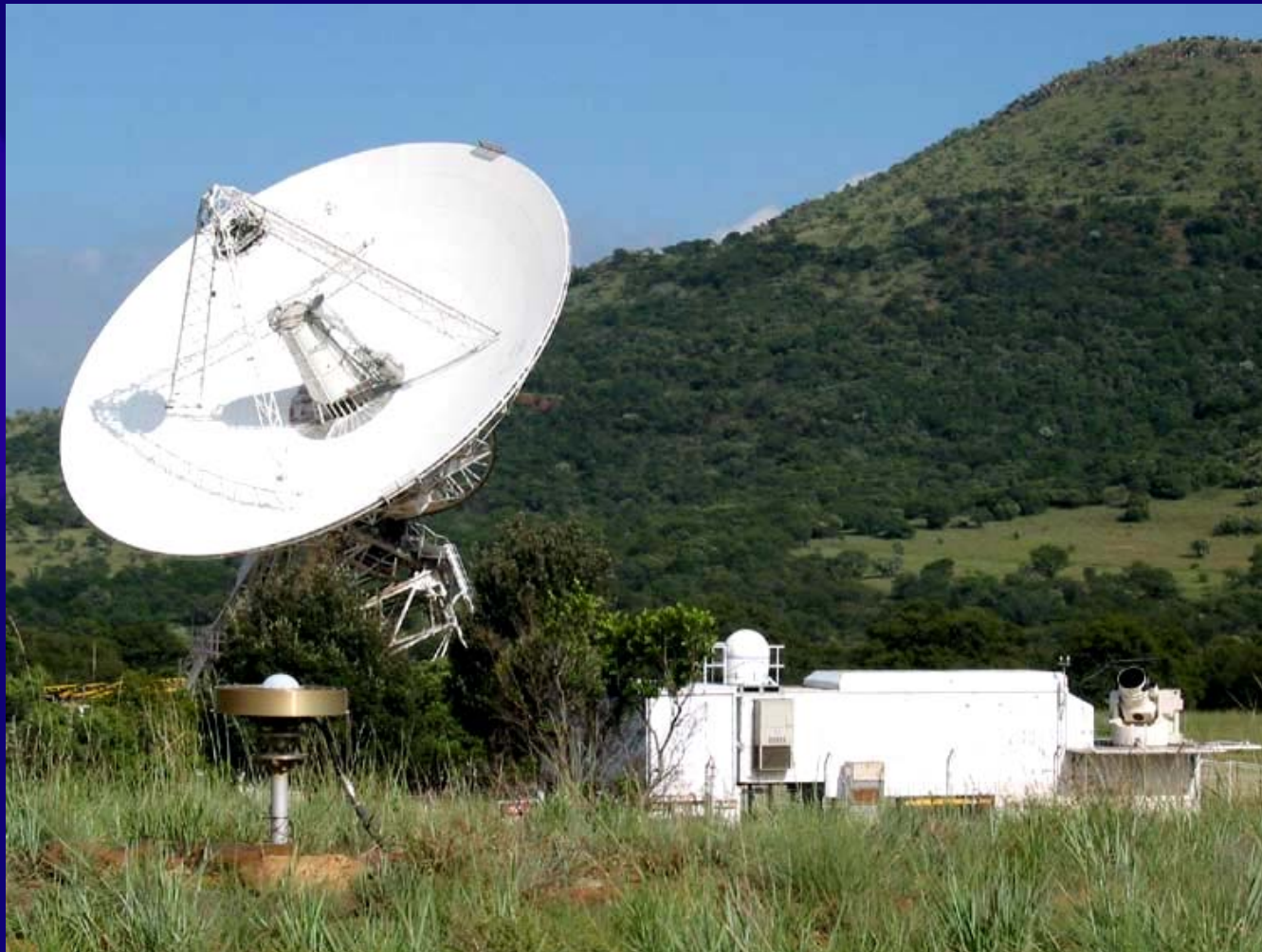
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ON SITE COMPUTATIONS

ON SITE COMPUTATIONS

Polygons
Levelling
GPS

VLBI REFERENCE POINT
GLOBAL COMPENSATION
SINEX



On-site Polygons Validation

For each polygon independantly

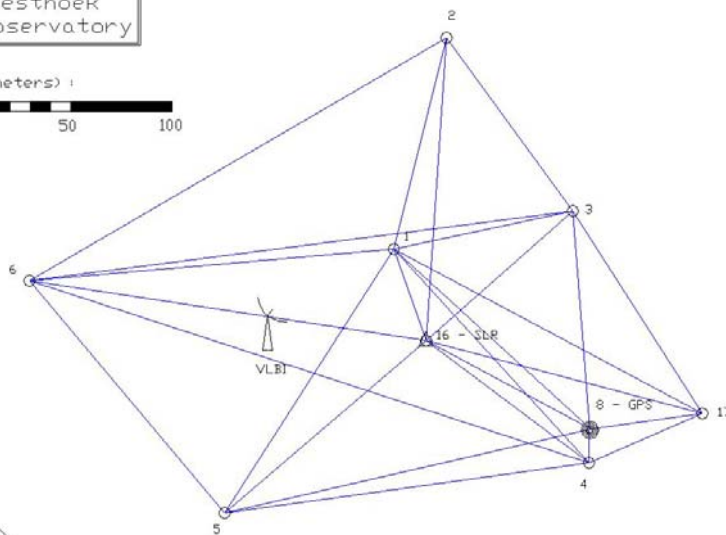
- Checking of the observations:
 - in a local coordinate system,
 - by Least Squares adjustment,
 - with COMP3D.
- Detection of blunders
- Precision estimation

On-site Polygons Validation

Hartebeesthoek
Radio Observatory

Scale (meters) :
0 50 100

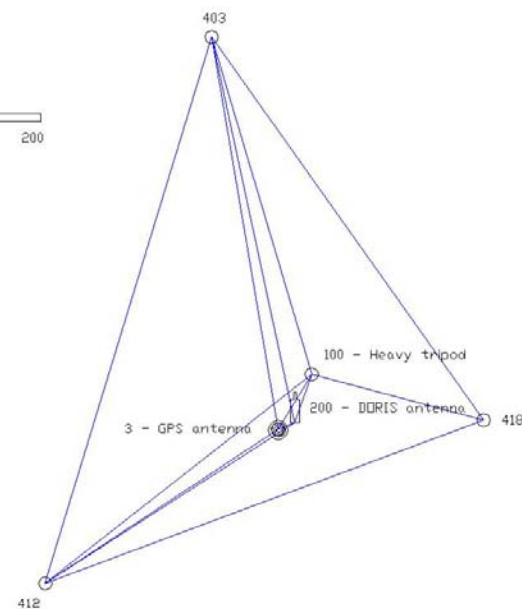
North



CSIR

Scale (meters) :
0 100 200

North



On-site Levelling Validation

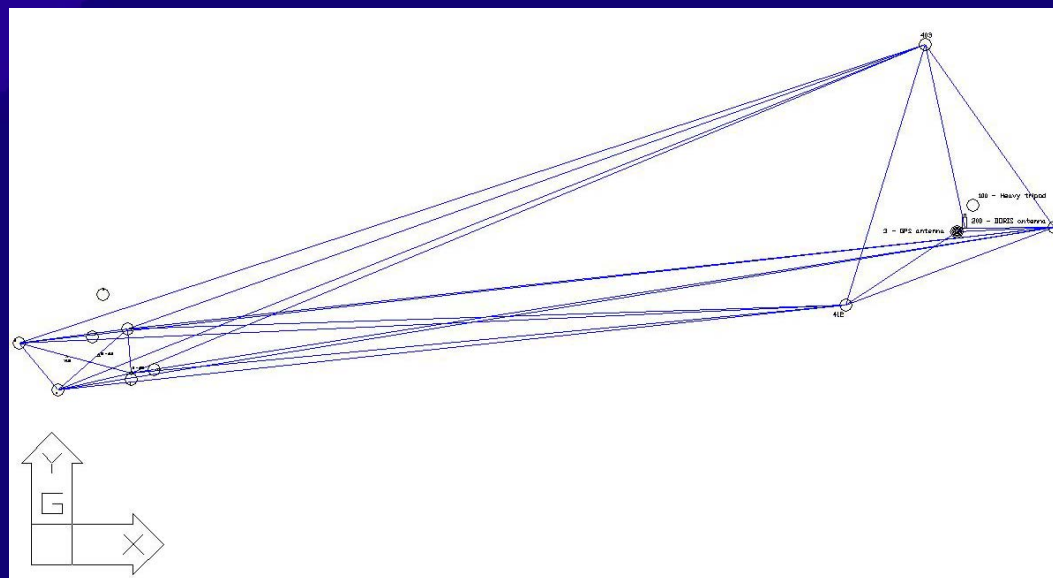
- Compensation between two successive benchmarks
- Trigonometric levelling computation
- Compensation of the 3 networks :
 - HartRAO Site
 - SAC Site
 - Link between the two sites (3km)
- Global levelling compensation

On-site GPS validation

- GPS Baseline processing with manufacturer software (Leica Ski Pro)

On each site:

- One GPS permanent station HRAO and HARB
- 2 pillars are equipped with Choke ring antennas and Leica SR500 GPS receivers



VLBI REFERENCE POINTS

ON SITE COMPUTATIONS

VLBI REFERENCE POINT

Definition

Observations

Planes and Circles

Determination

Fictive observations

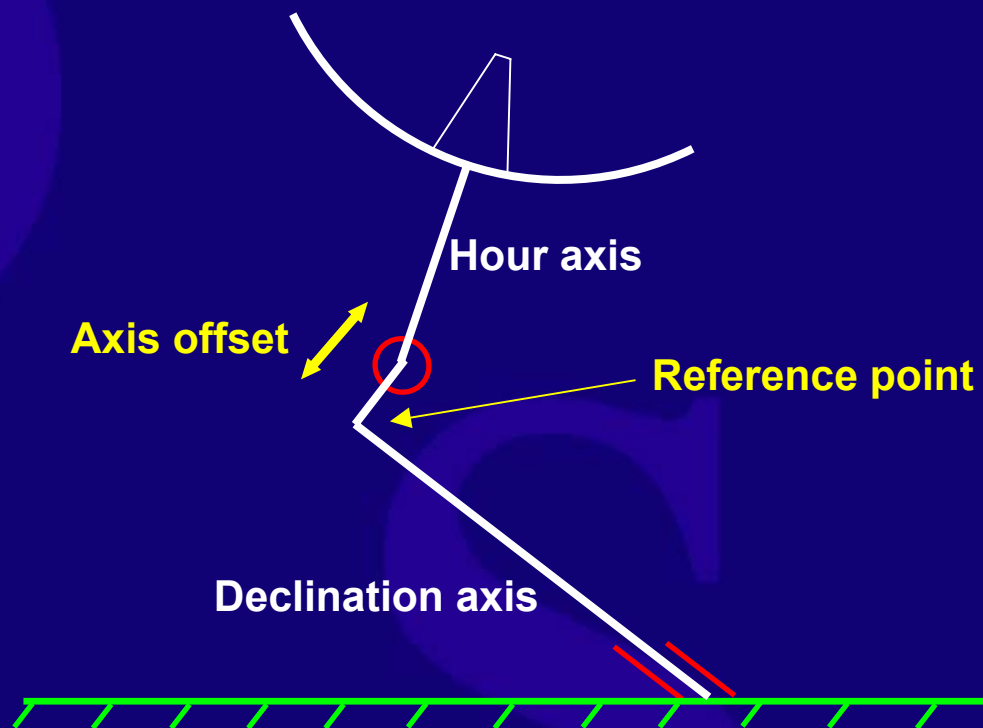
GLOBAL COMPENSATION

SINEX



Reference Point

- Definition: intersection of the fixed axis with the plane containing the moving axis orthogonal to the fixed axis



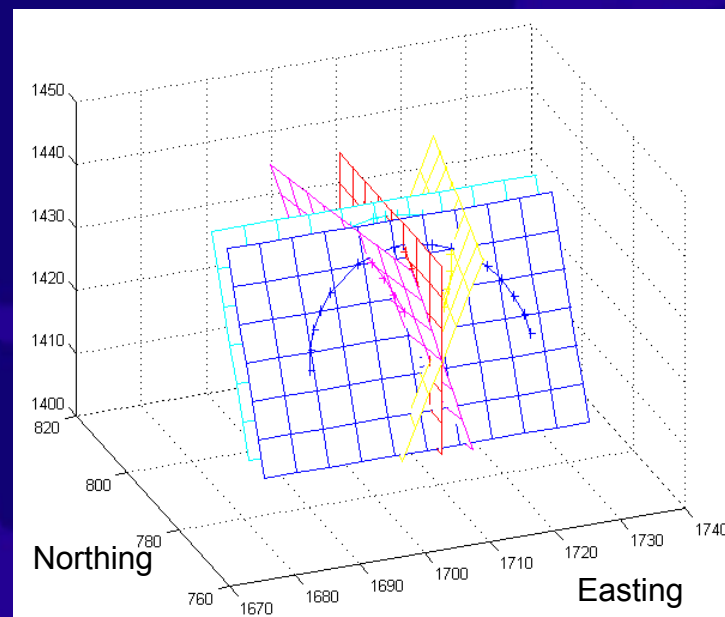
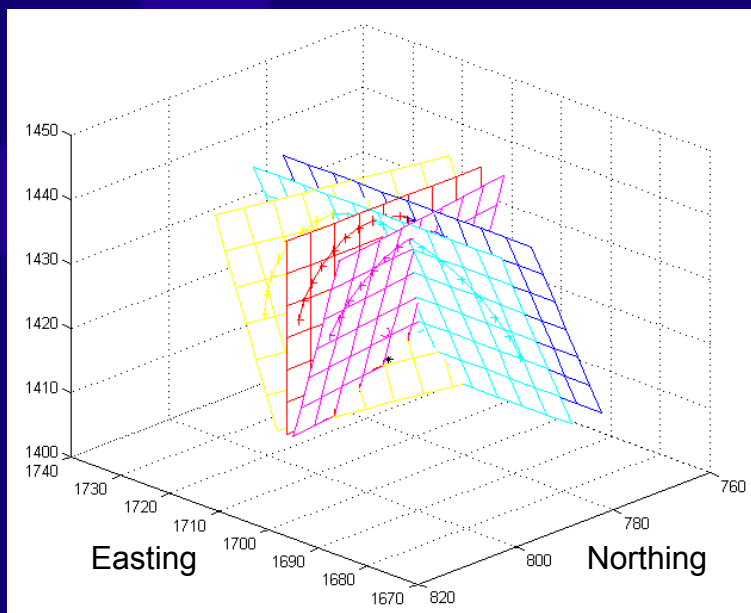
Observations

- Equatorial radiotelescope
- Target at the apex of the feed horn intersected by 3 theodolites
- stations set up on the different pillars determined by the polygon (and using them as orientation)
- Rotations about 10° by 10°
 - around declination axis (for 3 different H A positions)
 - around hour axis (for 2 different DEC A positions)

		HOUR ANGLE	DECLINATION ANGLE	NUMBER OF POINTS
DECLINATION AXIS	Position 1	-25°	45° - 275°	14
	Position 2	0°	45° - 275°	14
	Position 3	19°	45° - 275°	14
HOUR AXIS	Position 1	85° - 275°	309°	17
	Position 2	85° - 275°	334.112°	19

Planes and Circles Fits

- Computations in a local network
- Least Squares Adjustments processed with Matlab 6.1:
 - fitting plane for each one of the 5 rotations
 - fitting circle for each one of the 5 rotations



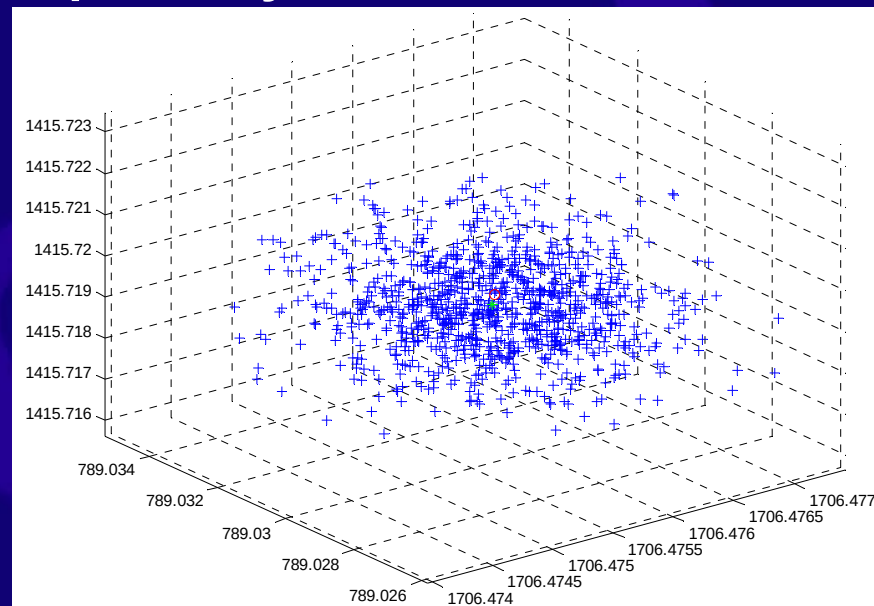
Reference Point

- **Coordinates determination in the local system by taking into account:**
 - precision of each pillar coordinates (given by the polygon adjustment)
 - precision of each VLBI points
- **Axis offset :** $6.6954 \text{ m} \pm 0.0025\text{m}$
- **Standard deviation computed by Monte Carlo Method**

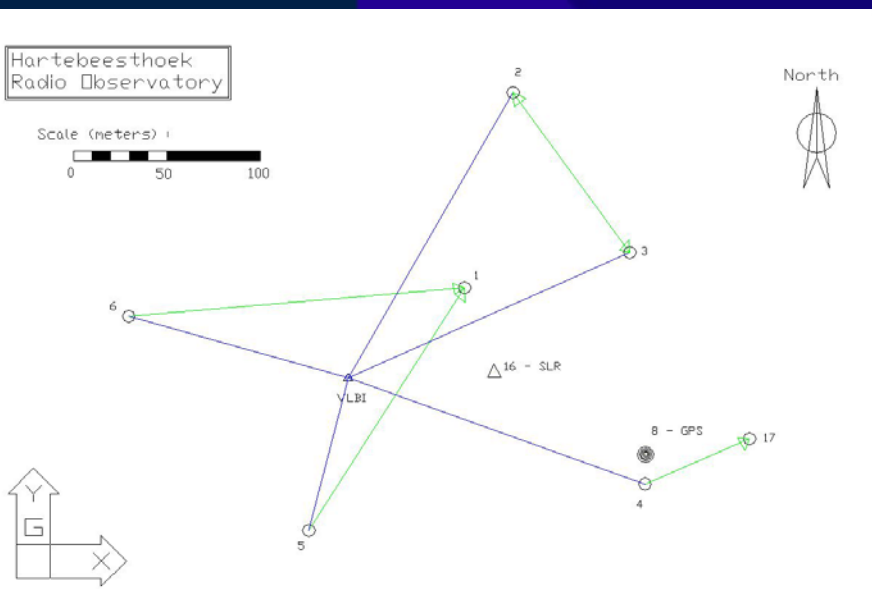
$$\sigma_e = 5.2\text{e-}004 \text{ m}$$

$$\sigma_n = 1.6\text{e-}003 \text{ m}$$

$$\sigma_h = 1.1\text{e-}003 \text{ m}$$



Fictive observations



- As if VLBI reference point was intersected from five pillars (those were used to point out the VLBI target)
- Precision of each horizontal and vertical angles were determined from the design matrix and Monte Carlo results.
- Fictive observations are introduced in the global compensation with their respective standard deviation.

GLOBAL COMPENSATION

ON SITE COMPUTATIONS
VLBI REFERENCE POINT

GLOBAL COMPENSATION

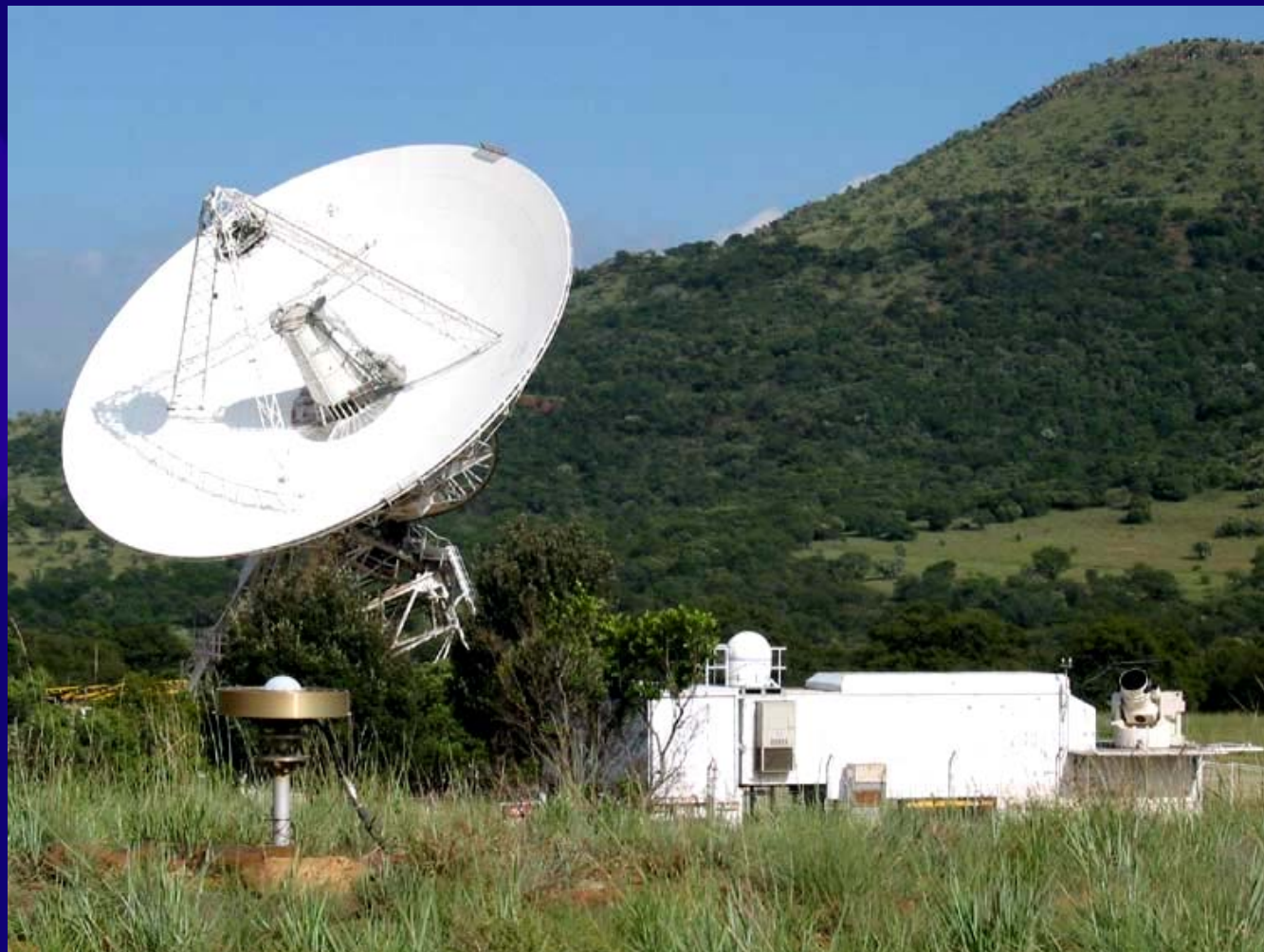
GPS Data

Input Data

Adjusted Coordinates

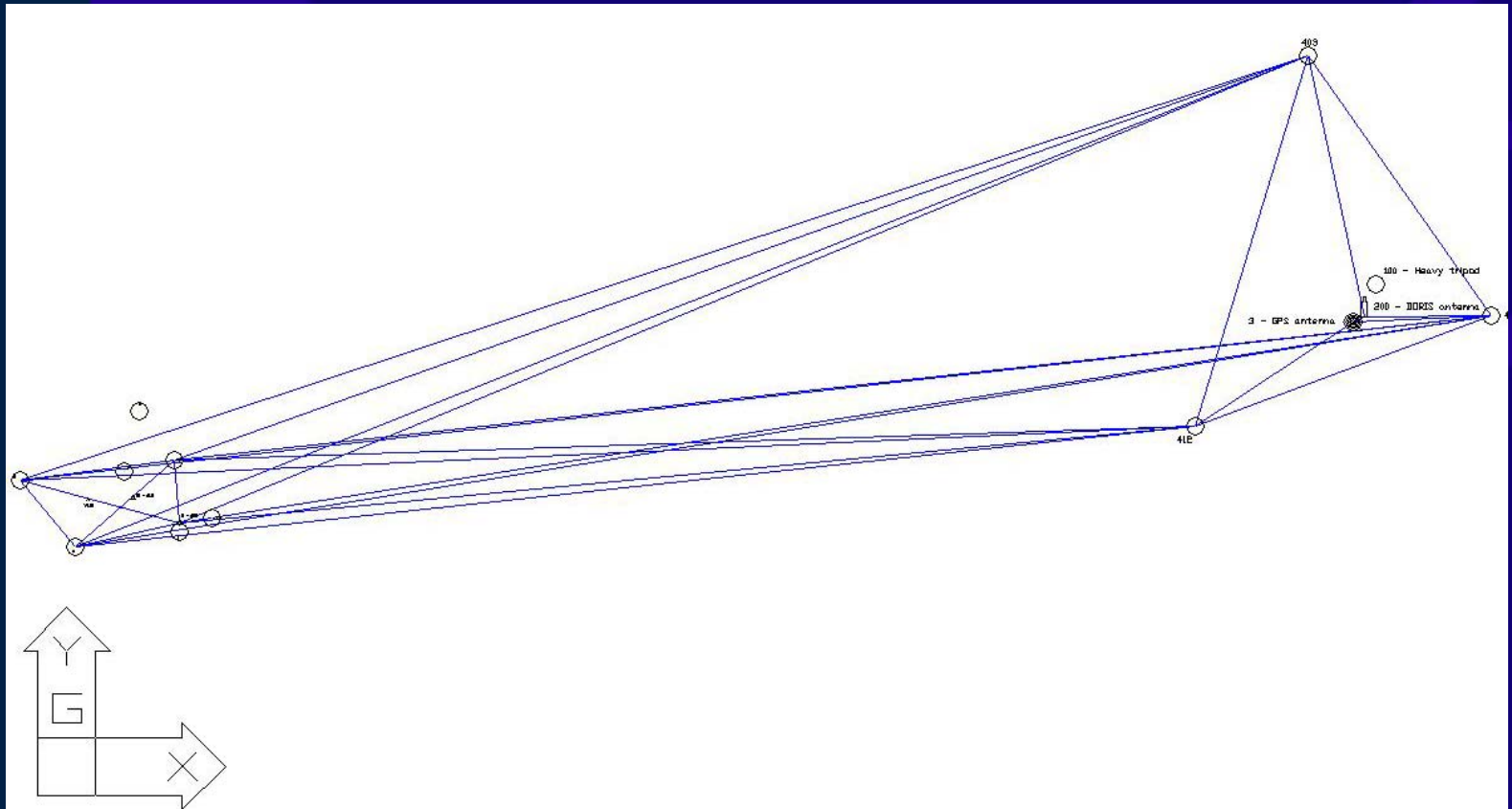
Confidence Region

SINEX



GPS Network

- **BERNESE 4.2**
- **Baselines**
- **Covariance Matrix**



Input Data

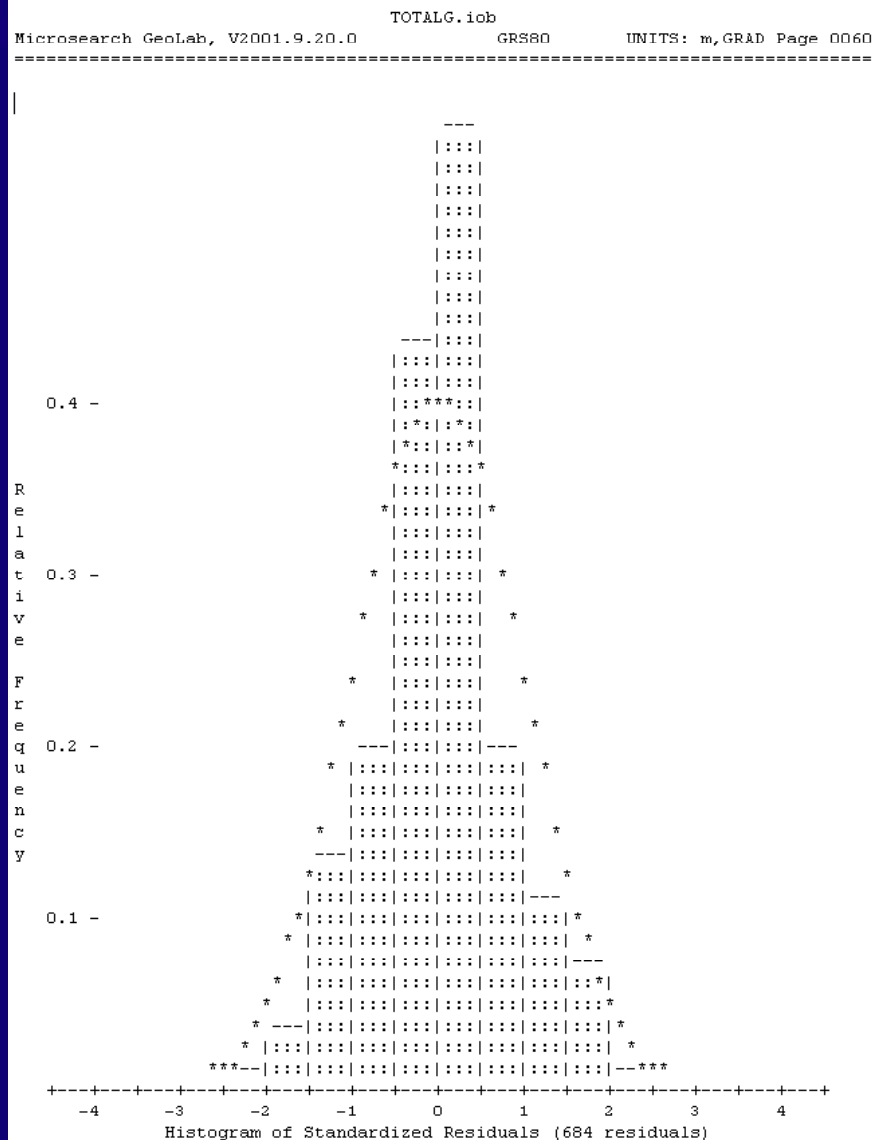
- Software: Geolab Microsearch (**rapportgg**)
- Observations :
 - HartRAO polygon
 - SAC polygon
 - HartRAO levelling network
 - SAC levelling network
 - Levelling link between the 2 sites
 - GPS network
- Geoid Model extracted from EGM 96
- Fixed point: HRAO, IGS station
- Geodetic System: ITRF 2000 epoch

Input Data

PARAMETERS		OBSERVATIONS	
Description	Number	Description	Number
No. of Stations	90	Directions	169
Coord Parameters	221	Distances	106
Free Latitudes	67	Azimuths	0
Free Longitudes	67	Vertical Angles	0
Free Heights	87	Zenithal Angles	148
Fixed Coordinates	49	Angles	0
Astro. Latitudes	0	Heights	0
Astro. Longitudes	0	Height Differences	123
Geoid Records	0	Auxiliary Params.	0
All Aux. Pars.	52	2-D Coords.	0
Direction Pars.	52	2-D Coord. Diffs.	114
Scale Parameters	0	3-D Coords.	0
Constant Pars.	0	3-D Coord. Diffs.	24
Rotation Pars.	0		
Translation Pars.	0		
	-----		-----
Total Parameters	273	Total Observations	684
Degrees of Freedom =		411	

Compensation Results

Standardized Residuals Distribution



ITRF 2000 Coordinates

TOTALG.iob									
Microsearch GeoLab, V2001.9.20.0				GRS80		UNITS: m,GRAD Page 001			
Adjusted PLH Coordinates:									
CODE	FFF	STATION	LATITUDE		LONGITUDE		ELIP-HEIGHT		
			STD DEV		STD DEV		STD DEV		
PLH	000	17_P	S 25 53 24.118549	E 27 41 15.137430			1415.8598	m	
			0.0005	0.0004			0.0002		
PLH	000	1_P	S 25 53 21.480913	E 27 41 9.655502			1409.8244	m	
			0.0006	0.0006			0.0003		
PLH	000	2_P	S 25 53 18.080066	E 27 41 10.584505			1411.1440	m	
			0.0006	0.0011			0.0004		
PLH	000	3GPS	S 25 53 13.067750	E 27 42 26.079460			1558.1007	m	
			0.0000	0.0000			0.0018		
PLH	000	3_P	S 25 53 20.864523	E 27 41 12.832466			1413.6734	m	
			0.0005	0.0007			0.0004		
PLH	000	403_P	S 25 52 58.117945	E 27 42 23.271013			1553.0896	m	
			0.0008	0.0018			0.0027		
PLH	000	412_P	S 25 53 18.925288	E 27 42 16.283517			1574.9623	m	
			0.0011	0.0009			0.0021		
PLH	000	418_P	S 25 53 12.714916	E 27 42 34.702694			1564.8536	m	
			0.0010	0.0008			0.0020		
PLH	000	4_P	S 25 53 24.904188	E 27 41 13.124509			1413.1990	m	
			0.0004	0.0002			0.0002		
PLH	000	5_P	S 25 53 25.716199	E 27 41 6.650730			1408.0664	m	
			0.0010	0.0004			0.0004		
PLH	000	6_P	S 25 53 21.982323	E 27 41 3.183197			1401.8097	m	
			0.0014	0.0005			0.0003		
PLH	000	7232	S 25 53 23.102890	E 27 41 7.417482			1415.7195	m	
			0.0014	0.0008			0.0008		
PLH	000	7501	S 25 53 22.949400	E 27 41 10.230961			1406.7991	m	
			0.0006	0.0005			0.0003		
PLH	000	8GPS	S 25 53 24.378770	E 27 41 13.128500			1414.1705	m	
			0.0001	0.0001			0.0010		
PLH	000	DORIS	S 25 53 12.673672	E 27 42 26.858068			1559.4374	m	
			0.0008	0.0009			0.0023		

TOTALG.iob						
Microsearch GeoLab, V2001.9.20.0			GRS80		UNITS: m,GRAD Page 0020	
Adjusted XYZ Coordinates:						
CODE FFF	STATION	X-COORDINATE STD DEV	Y-COORDINATE STD DEV	Z-COORDINATE STD DEV		
XYZ	17_P	5085330.9349 0.0003	2668447.6604 0.0004	-2768725.1038 0.0005	m	
XYZ	1_P	5085428.4362 0.0003	2668326.4543 0.0006	-2768649.4283 0.0006	m	
XYZ	2_P	5085457.9427 0.0006	2668371.1468 0.0011	-2768555.8291 0.0006	m	
XYZ	3GPS	5084657.6399 0.0015	2670325.0876 0.0008	-2768481.1889 0.0008	m	
XYZ	3_P	5085397.7390 0.0005	2668410.2396 0.0006	-2768634.0400 0.0005	m	
XYZ	403_P	5084867.8688 0.0022	2670347.1654 0.0020	-2768064.9921 0.0013	m	
XYZ	412_P	5084728.1863 0.0018	2670054.0571 0.0012	-2768650.7616 0.0013	m	
XYZ	418_P	5084555.5746 0.0017	2670542.6874 0.0012	-2768474.3662 0.0013	m	
XYZ	4_P	5085345.5060 0.0002	2668392.0145 0.0002	-2768745.6975 0.0004	m	
XYZ	5_P	5085415.4999 0.0006	2668225.1897 0.0004	-2768765.9421 0.0009	m	
XYZ	6_P	5085499.8098 0.0005	2668160.3984 0.0007	-2768659.8137 0.0013	m	
XYZ	7232	5085442.7804 0.0008	2668263.6117 0.0010	-2768696.9175 0.0013	m	
XYZ	7501	5085401.1049 0.0004	2668330.2074 0.0005	-2768688.7721 0.0006	m	
XYZ	8GPS	5085352.4815 0.0008	2668395.8002 0.0004	-2768731.5721 0.0004	m	
XYZ	DORIS	5084653.3133 0.0019	2670347.3027 0.0013	-2768470.8594 0.0012	m	

Confidence Regions

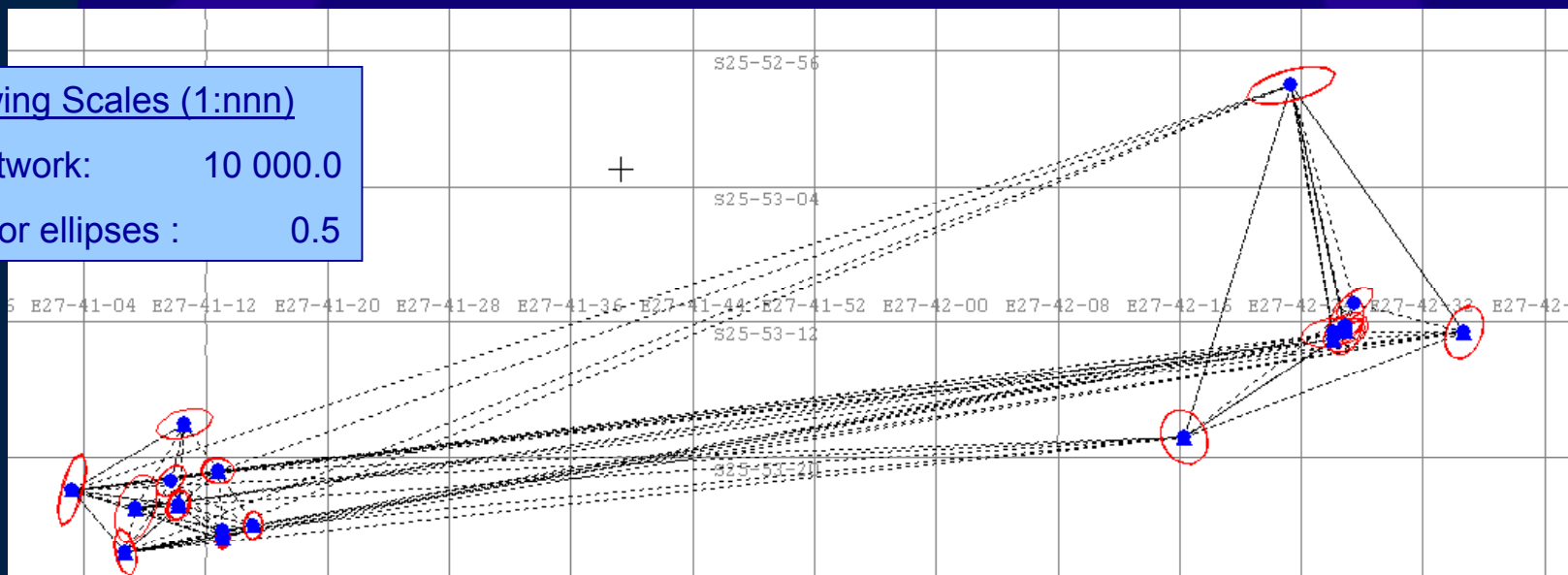
TOTALG.iob				
Microsearch GeoLab, V2001.9.20.0		GRS80	UNITS: m,GRAD Page 0062	
2-D and 1-D Station Confidence Regions (95.000 and 95.000 percent):				
STATION	MAJOR SEMI-AXIS	AZ	MINOR SEMI-AXIS	VERTICAL
17_P	0.0013	1	0.0009	0.0003
1_P	0.0018	42	0.0010	0.0006
2_P	0.0028	75	0.0013	0.0008
3GPS	0.0001	0	0.0001	0.0036
3_P	0.0017	96	0.0012	0.0007
403_P	0.0045	75	0.0015	0.0052
412_P	0.0028	156	0.0022	0.0041
418_P	0.0027	22	0.0018	0.0039
4_P	0.0010	4	0.0005	0.0003
5_P	0.0024	168	0.0009	0.0007
6_P	0.0036	15	0.0009	0.0006
7232	0.0035	19	0.0018	0.0016
7501	0.0016	24	0.0012	0.0007
8GPS	0.0002	1	0.0002	0.0020
DORIS	0.0025	54	0.0016	0.0046

TOTALG.iob			
Microsearch GeoLab, V2001.9.20.0		GRS80	UNITS: m,GRAD Page 0064
3D Station Confidence Regions (95.000 percent):			
STATION	MAJ-SEMI (AZ,VANG)	MED-SEMI (AZ,VANG)	MIN-SEMI (AZ,VANG)
17_P	0.0015 (181, 0)	0.0010 (91, 0)	0.0005 (309, 90)
1_P	0.0021 (42, 0)	0.0011 (132, 0)	0.0008 (260, 90)
2_P	0.0032 (75, 0)	0.0015 (345, 0)	0.0011 (225, 90)
3GPS	0.0051 (28, 90)	0.0001 (210, 0)	0.0001 (120, 0)
3_P	0.0019 (96, 0)	0.0013 (6, 0)	0.0010 (241, 90)
403_P	0.0075 (58, 89)	0.0051 (255, 1)	0.0017 (165, 0)
412_P	0.0058 (76, 89)	0.0032 (336, 0)	0.0025 (246, 1)
418_P	0.0056 (48, 88)	0.0031 (202, 2)	0.0020 (292, 1)
4_P	0.0011 (184, 0)	0.0006 (274, 0)	0.0005 (92, 90)
5_P	0.0028 (348, 0)	0.0010 (78, 3)	0.0010 (257, 87)
6_P	0.0041 (15, 0)	0.0011 (105, 0)	0.0009 (274, 90)
7232	0.0040 (19, 0)	0.0023 (151, 90)	0.0021 (289, 0)
7501	0.0018 (24, 0)	0.0013 (114, 0)	0.0009 (240, 90)
8GPS	0.0028 (38, 90)	0.0002 (211, 0)	0.0002 (301, 0)
DORIS	0.0065 (56, 89)	0.0029 (234, 1)	0.0018 (324, 0)

Drawing Scales (1:nnn)

Network: 10 000.0

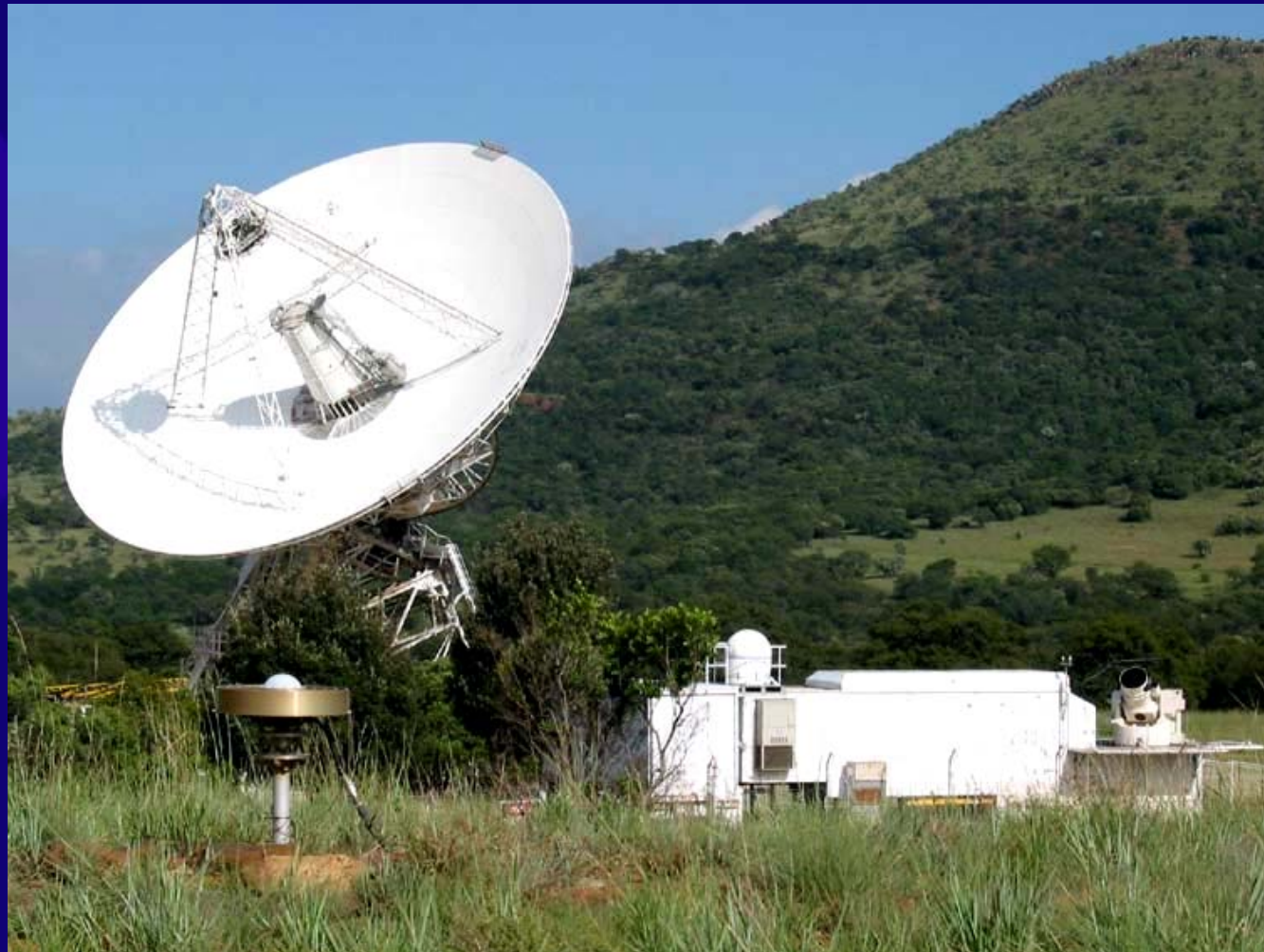
Error ellipses : 0.5



SINEX FILES

ON SITE COMPUTATIONS
VLBI REFERENCE POINT
GLOBAL COMPENSATION

SINEX



Input Data

- **Extraction of the points of interest**
 - HRAO GPS permanent station reference point
 - HARB GPS permanent station reference point
 - SLR mark
 - DORIS reference point
 - VLBI reference point
- **Extraction of the covariance matrix**