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# **A GNSS PROCESSING APPROACH TO ESTABLISH A LARGE GEODETIC NETWORK (RGSH2020) FOR PETROLEUM APPLICATIONS**

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- 2. Data and method**
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- 4. Conclusions**

# Problematic & Objectives

## Introduction

- Geodetic networks used by the Algerian petroleum company “SONATRACH” are heterogeneous (Astronomical, WGS84 or fictitious origins) => Only used on a very small scale.

## Data and method

- The overlap between two very expensive seismic studies based on two different networks, often poses problems of localization.

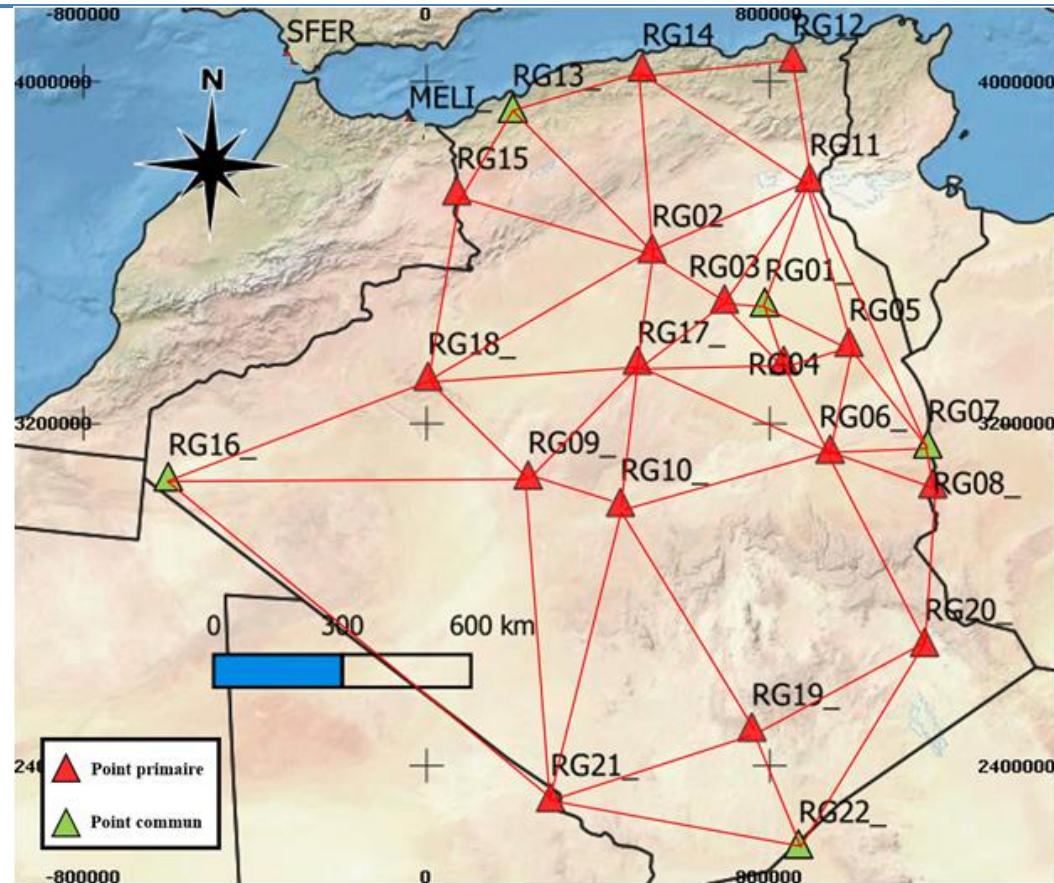
## Results and discussion

- A unique, homogeneous and precise geodetic reference on which will be based all positioning work undertaken by SONATRACH

## Conclusions & Perspectives

- Set up a new SONATRACH geodetic reference network “RGSH2020” : Precise and consistent with ITRF14.
- RGSH2020 : a solution to the problems and difficulties of standardization of the geodetic systems used at the whole Algerian oil fields.

## Used data



- 22 benchmarks covering the Algerian territory (2.4 M km<sup>2</sup>) are observed in static mode by using 13 Trimble NetR9 GNSS receivers.
- Two (02) continuous measurement sessions (3 and 4 days): in February to and March 2020.
- Five (05) points among the 22 points are common to both sessions → Guarantee better network consistency.

# Used data

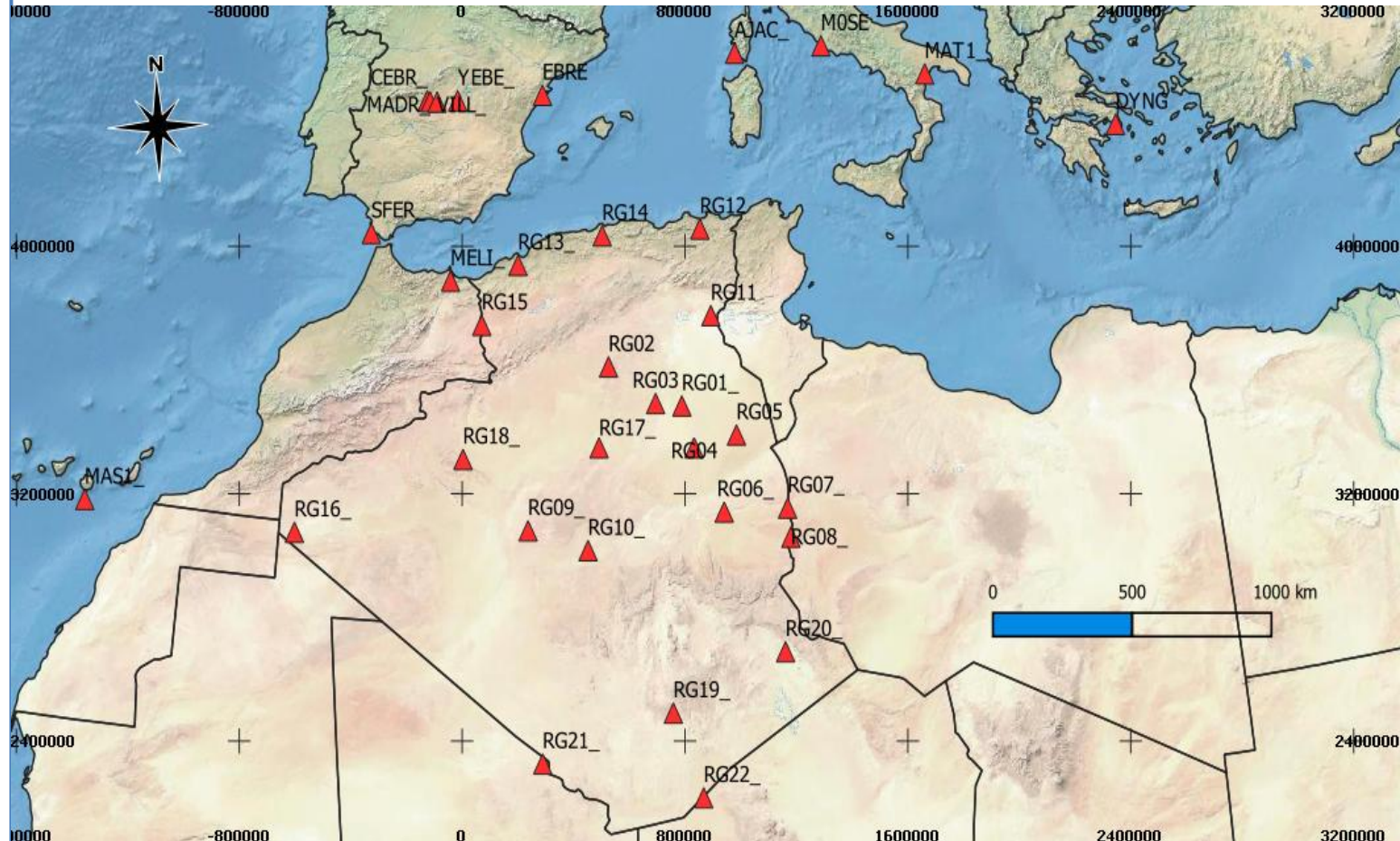
- 16 IGS stations.
- 22 RGSH2020 Benchmarks
- Baselines : from 300 km to 1450 km

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**RGSH2020 and used IGS stations**

# Methodology

## Introduction

→ GPS data are processed in 24 hour sessions => average errors (effect of the day / night alternation on the troposphere and the ionosphere, satellite geometry).

## Data and method

→ Use of final combined IGS orbits (2.5 cm).

→ Use of Earth Orientation Parameters (EOP of IERS : International Earth Rotation and Reference Systems Service).

## Results and discussion

→ Modeling of receiver and satellite antenna PCO and PCV.

→ Modeling of polar solid tides, and the ocean tides effects (FES2004 model).

## Conclusions & Perspectives

→ Tropospheric effect : Saastamoinen model (hydrostatic part). Estimation of a zenith delay parameter (ZTD) for each site every hour and tropospheric gradients (wet part).

→ Ionospheric effect : Ionosphere-Free combination is used.



# Methodology

## → ***Estimated parameters (using Bernese Software) :***

- 03 component positions (X,Y,Z) of each station.
- 24 zenithal tropospheric delays and (02) gradient parameters per station and per day.

Estimation is performed using a least squares fit where integer ambiguities are resolved.

## → ***Adopted strategy :***

- Coordinates are relatively loose except during the step of fixing the ambiguities.
- Once the ambiguities have been resolved, the constraints are relatively relaxed in order to obtain the “free” daily solution.
- “free” solutions are transformed in IGS14 (no-net-translation condition : the barycenter of the estimated and true IGS positions coincide) => daily series of positions.
- Daily solutions => repeatabilities => verify the quality of individual solutions.
- Daily solutions and variance-covariance are combined and adjusted => final solution.

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## Quality Indicators of the obtained results

Using IGS standards, the indicators are :

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1. RMS (Root Mean Square) values of individual solutions,
2. Percentage of resolved ambiguities,
3. Difference between fixed and float solutions,
4. Repeatability values,
5. Verification of fiducial stations.



# RMS (Confidence level of 95%)

Station ID	Precision on latitude	Precision on longitude	Precision on height
RGSH01	0.0002	0.0002	0.0010
RGSH02	0.0004	0.0004	0.0018
RGSH03	0.0004	0.0004	0.0016
RGSH04	0.0004	0.0004	0.0016
RGSH05	0.0004	0.0004	0.0020
RGSH06	0.0004	0.0004	0.0018
RGSH07	0.0004	0.0004	0.0012
RGSH08	0.0004	0.0004	0.0020
RGSH09	0.0004	0.0004	0.0018
RGSH10	0.0004	0.0004	0.0020
RGSH11	0.0004	0.0004	0.0016
RGSH12	0.0004	0.0004	0.0014
RGSH13	0.0004	0.0002	0.0012
RGSH14	0.0004	0.0004	0.0020
RGSH15	0.0004	0.0004	0.0016
RGSH16	0.0004	0.0004	0.0012
RGSH17	0.0004	0.0004	0.0016
RGSH18	0.0004	0.0004	0.0018
RGSH19	0.0004	0.0004	0.0016
RGSH20	0.0004	0.0004	0.0018
RGSH21	0.0004	0.0004	0.0018
RGSH22	0.0004	0.0004	0.0014

RMS of horizontal coordinates :  
Submillimeter

RMS heights  $\leq$  2 mm

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# Percentage (%) of fixed ambiguities

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Session day	Percentage of resolved ambiguities
10/02/2020	81.7%
11/02/2020	81.2%
12/02/2020	79.9%
06/03/2020	76.9%
07/03/2020	79.1%
08/03/2020	80.9%
09/03/2020	78.7%

# Difference between fixed and float solutions

Day 041 Year 2020 (coordinate system IGS14)			
STATION ID	Differences in positions (M)		
	$\Delta X$	$\Delta Y$	$\Delta Z$
RGSH01	0,000	0,002	0,001
RGSH06	0,003	0,001	0,002
RGSH07	0,002	0,001	0,003
RGSH08	-0,002	0,001	0,001
RGSH09	0,003	-0,001	0,004
RGSH10	-0,005	0,001	0,001
RGSH13	0,002	0,004	0,003
RGSH16	0,001	0,007	0,005
RGSH17	0,000	0,002	0,002
RGSH18	-0,006	0,000	0,000
RGSH19	0,004	-0,002	0,002
RGSH20	0,000	0,000	0,003
RGSH21	0,017	0,003	0,006
RGSH22	-0,002	-0,005	0,002

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# Day to day repeatabilities

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				1st session February 2020			2nd session March 2020			
Station	Repetition	Component	RMS	10/02	11/02	12/02	06/03	07/03	08/03	09/03
				1 (24 h)	2 (24 h)	3 (24 h)	4 (24 h)	5 (24 h)	6 (24 h)	7 (24 h)
RGSH01	6	N mm	1.34	1.27	1.01	0.98	-0.34	-2.11	-0.91	/
		E mm	1.89	1.41	1.99	1.44	-0.74	-2.08	-2.23	/
		U mm	2.49	-0.73	2.44	2.41	-0.61	-2.50	-3.47	/
RGSH02	3	N mm	0.46	/	/	/	0.55	-0.16	-0.30	/
		E mm	0.69	/	/	/	0.97	-0.07	-0.09	/
		U mm	1.61	/	/	/	-1.18	1.90	-0.41	/
RGSH03	3	N mm	0.54	/	/	/	0.34	-0.51	0.46	/
		E mm	0.90	/	/	/	1.14	-0.56	-0.14	/
		U mm	1.02	/	/	/	-0.45	0.26	-1.34	/
RGSH04	3	N mm	0.43	/	/	/	0.41	-0.18	0.41	/
		E mm	0.76	/	/	/	1.01	-0.37	0.07	/
		U mm	2.29	/	/	/	-2.88	1.46	0.32	/
RGSH05	3	N mm	0.54	/	/	/	0.73	-0.02	0.21	/
		E mm	1.28	/	/	/	1.63	-0.67	-0.40	/
		U mm	1.87	/	/	/	0.81	-2.33	0.95	/
RGSH06	3	N mm	0.93	-0.14	-0.12	-1.30	/	/	/	/
		E mm	0.84	0.26	-0.06	-1.16	/	/	/	/
		U mm	2.69	-2.72	0.02	2.65	/	/	/	/
RGSH07	6	N mm	1.14	-0.53	-0.54	-1.50	1.66	0.18	0.91	/
		E mm	0.97	0.57	0.08	-0.69	1.64	-1.02	-0.47	/
		U mm	7.31	-7.74	-7.93	-4.85	1.55	8.53	6.77	/
RGSH08	3	N mm	0.96	-0.57	-1.02	-0.70	/	/	/	/
		E mm	0.88	0.43	-0.21	-1.15	/	/	/	/
		U mm	1.13	0.62	-1.28	0.75	/	/	/	/
RGSH09	3	N mm	0.46	0.45	-0.41	-0.23	/	/	/	/
		E mm	0.94	-0.81	-0.57	-0.90	/	/	/	/
		U mm	1.29	-0.57	1.51	0.86	/	/	/	/
RGSH10	3	N mm	1.31	1.22	-0.85	-1.10	/	/	/	/
		E mm	0.84	-0.65	-0.88	-0.46	/	/	/	/
		U mm	3.89	-1.76	-1.72	4.92	/	/	/	/
RGSH11	3	N mm	0.72	/	/	/	0.93	0.12	-0.40	/
		E mm	0.59	/	/	/	0.62	-0.56	0.09	/
		U mm	2.12	/	/	/	2.01	-0.35	-2.21	/

# Day to day repeatabilities

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				1st session February 2020			2nd session March 2020			
Station	Repetition	Component	RMS	10/02	11/02	12/02	06/03	07/03	08/03	09/03
				1 (24 h)	2 (24 h)	3 (24 h)	4 (24 h)	5 (24 h)	6 (24 h)	7 (24 h)
RGSH12	4	N mm	1.76	/	/	/	0.94	0.10	0.58	-2.84
		E mm	1.59	/	/	/	1.70	-1.52	-0.66	1.38
		U mm	2.99	/	/	/	-1.21	-3.68	2.71	2.13
RGSH13	7	N mm	1.27	0.35	-1.08	-1.71	1.94	0.87	-0.45	0.86
		E mm	1.71	-2.11	-1.95	-1.18	2.66	0.21	0.77	0.39
		U mm	7.07	6.46	7.30	6.51	2.69	-9.52	-6.21	-5.07
RGSH14	3	N mm	0.47	/	/	/	/	-0.36	-0.06	0.56
		E mm	0.29	/	/	/	/	0.31	-0.05	-0.25
		U mm	3.07	/	/	/	/	3.94	-0.59	-1.71
RGSH15	3	N mm	1.55	/	/	/	1.33	-0.29	-1.71	/
		E mm	0.58	/	/	/	0.68	0.40	-0.24	/
		U mm	0.73	/	/	/	-0.95	0.39	-0.14	/
RGSH16	7	N mm	1.22	1.07	1.41	1.20	-1.20	-1.12	-0.83	0.99
		E mm	2.79	2.60	3.02	5.02	-0.96	1.97	0.44	-0.69
		U mm	12.10	-14.45	-12.20	-10.63	12.73	5.98	6.63	12.85
RGSH17	3	N mm	0.44	0.26	-0.03	-0.56	/	/	/	/
		E mm	1.15	0.17	-0.04	-1.61	/	/	/	/
		U mm	1.95	-0.96	-0.09	2.59	/	/	/	/
RGSH18	3	N mm	0.50	0.68	-0.12	-0.16	/	/	/	/
		E mm	1.05	-1.06	-0.94	-0.46	/	/	/	/
		U mm	3.06	-2.44	3.57	0.04	/	/	/	/
RGSH19	3	N mm	0.98	-0.30	-0.56	-1.23	/	/	/	/
		E mm	1.21	-1.31	0.00	-1.09	/	/	/	/
		U mm	1.82	-1.65	1.83	0.73	/	/	/	/
RGSH20	3	N mm	1.34	-0.01	-1.21	-1.46	/	/	/	/
		E mm	0.67	0.11	-0.53	-0.78	/	/	/	/
		U mm	1.03	-0.68	0.31	-1.24	/	/	/	/
RGSH21	3	N mm	1.28	0.90	-1.21	-0.99	/	/	/	/
		E mm	1.57	-0.42	-2.03	-0.79	/	/	/	/
		U mm	4.09	5.02	0.23	-2.88	/	/	/	/
RGSH22	7	N mm	0.98	0.28	-0.41	-1.57	-1.55	-0.44	0.41	0.57
		E mm	3.95	2.23	1.51	1.09	-7.21	-3.88	-3.46	-2.47
		U mm	2.92	1.65	0.96	-1.73	-3.90	-0.37	1.70	-5.14

# Verification of fiducial stations

## PART 7: VERIFICATION OF DATUM DEFINITION

### Verification of fiducial stations

LOCAL GEODETIC DATUM: IGS14  
RESIDUALS IN LOCAL SYSTEM (NORTH, EAST, UP)

NUM	NAME	FLG	RESIDUALS IN MILLIMETERS		
8	AJAC 10077M005	I W	-7.5	4.6	13.1
89	EBRE 13410M001	I W	1.1	-2.5	-11.5
112	GRAS 10002M006	I W	-2.1	-8.4	1.6
178	MAS1 31303M002	I W	9.4	5.8	-2.0
361	YEBE 13420M001	I W	-0.9	0.5	-1.2
RMS / COMPONENT			6.2	5.7	8.8

### Verification of fiducial stations

16-SEP-20 08:46

Number of accepted stations : 5  
Number of rejected stations : 2

### List of rejected stations

Station	Residuals (millimeters)		
	N	E	U
MAT1 12734M009	-1.9	-16.0	15.4
SFER 13402M004	10.5	7.7	-40.5
RMS of accepted stations	6.1	5.7	8.9

## Conclusions

### Introduction

- The RGS2020 is determined with millimeter accuracy ( $\sigma < 1$  cm).

### Data and method

- Accuracy is sufficient for all the petroleum work carried out by SONATRACH (geodesy, topography, cartography, GIS, etc.).

### Results and discussion

- The RGS2020 is linked to the IGS14 ( $\approx$ ITRF14) reference system (consistent with the IGS14 at the time of observation : on February 24, 2020).

### Conclusions & Perspectives



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- RGS2020 coordinates are static.
- RGS2020 re-observation → Velocities estimation → Maintain its consistency with the ITRF and allow the exploitation of new techniques (such as PPP: Precise Point Positioning).
- The estimation of the velocity field requires the use of data from permanent stations or, data from periodic campaigns.

***Thank you for your attention***