

*Algerian Space Agency*  
Centre of Space Techniques



الوكالة الفضائية الجزائرية  
المركز للتقنيات الفضائية

# SPACE GEODESY APPLICATIONS IN ALGERIA

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*UN / UAE / USA Workshop on the applications of GNSS – Dubai, 16-20 January 2011*

# OUTLINE

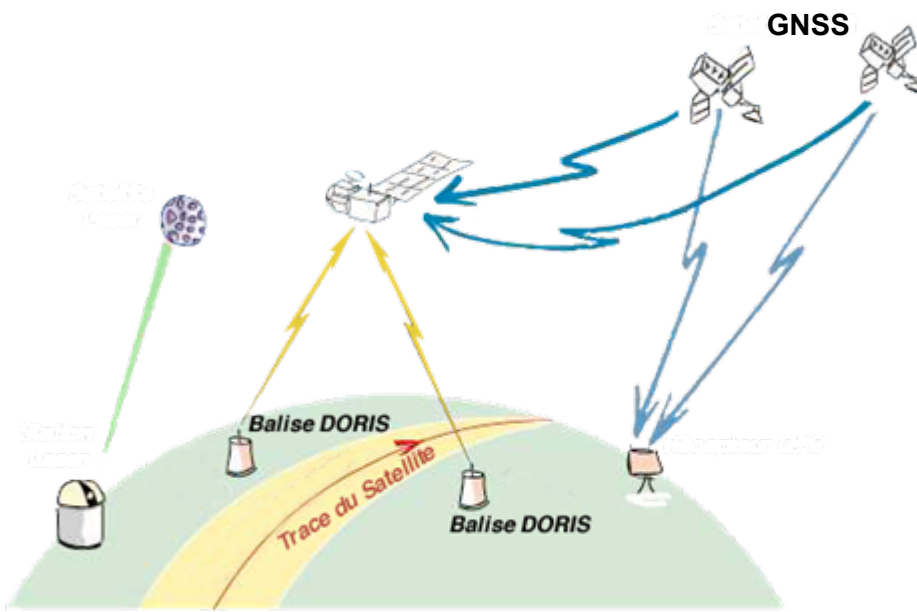
## Introduction

- **Space geodesy positioning**
- **GNSS Applications (GPS):**
  - *Real time positioning (DGPS) : maritime signalling*
  - *GPS precise positioning (mm LNG Tank auscultation)*
  - *Standard localisation (cm) : urban network*
  - *GPS precise long baseline positioning (geodynamics)*

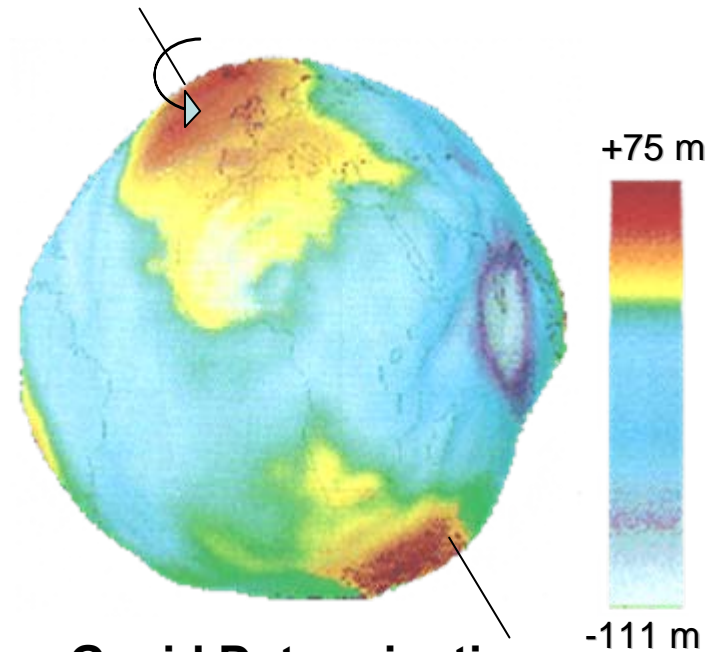
## Conclusion

# G E O D E S Y : Objectives

Geometric description of the earth including its gravity field for scientific (*geodynamics, oceanography, ionospheric modelisation,...*) and useful applications (*topography, cadastre, GIS and data bases, cartography and levelling, mineral and petrology prospection, damp and bridge auscultation, navigation,...*). *In general, for all applications using localised data.*



Satellite Positioning



Geoid Determination

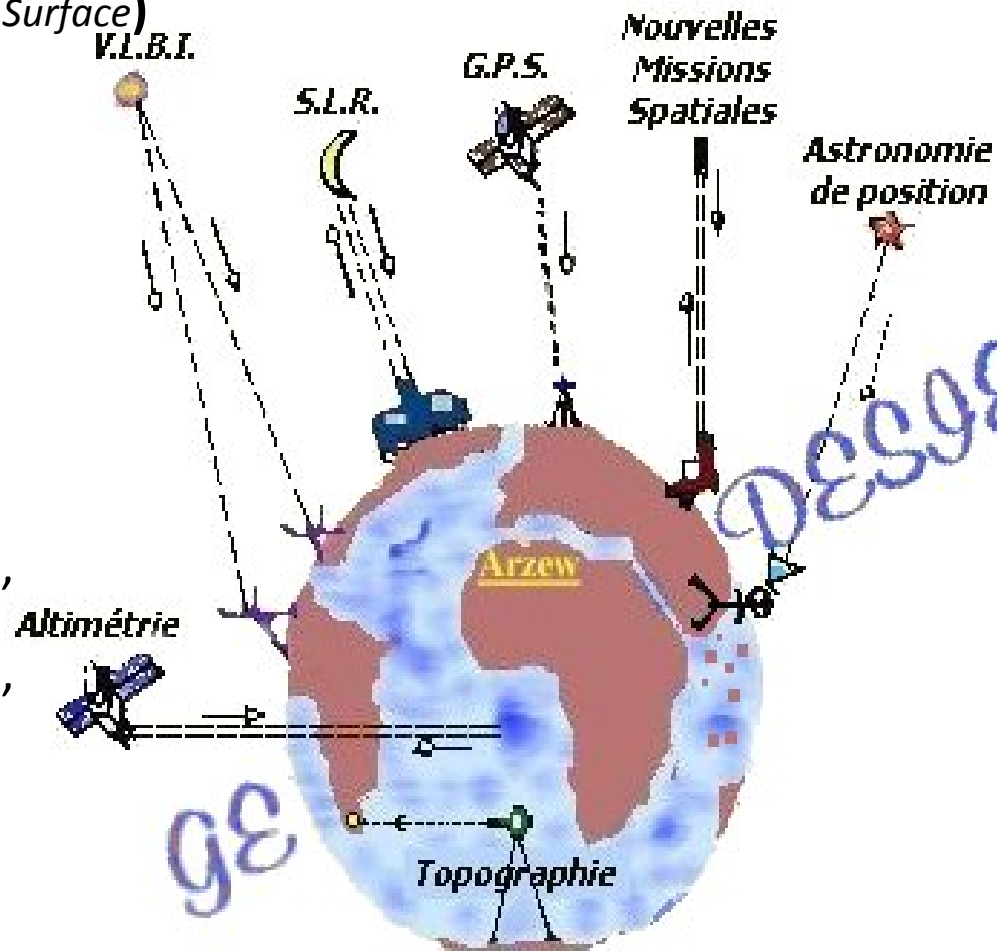
# Techniques of Space Geodesy

**Applications : (Form of the Earth and its time variation) for :**

- Precise positioning
- Gravity Field and Orbitography
- Geoid determination ( $\cong$  Mean Sea Level Surface)
- Orientation / Earth rotation pole
- Crustal deformations
- Industrial risk,
- Urban management,
- Cartography and GIS,...

**Non Global techniques :** SBAS (EGNOS, WSAS, MSAS, SDCM, GAGAN,..), Doris, Space Altimetry (Jason,..), SLR (Lageos,..), Gradiometry (CHAMP, GRACE, GOCE,..),...

**Global Systems :** GNSS (GPS, Glonass, Galileo, Compass)



# GNSS : Global Navigation Satellite System



- NAVSTAR GPS : US System (since 1973)



- GLONASS : Russian system (since 1970)



- GALILEO : European system (2014 ?)

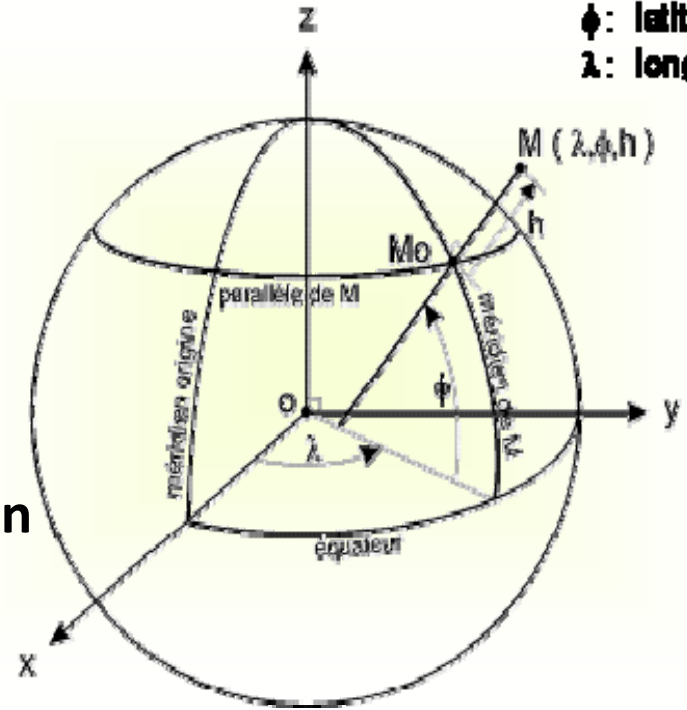
- SBAS : Satellite Based Augmentation System (**WAAS, MSAS, EGNOS, GAGAN, SDCM,...**)
- COMPASS : Chinese Navigation Satellite System: (Beidou-2 : 2020 ?)
- IRNSS : *Indian Regional Navigation Satellite System (2012 ?)*
- QZSS : *Quazi-Zenith Satellite System (Japan 2012 ?)*

# REFERENCE SYSTEM

$\phi$ : latitude  
 $\lambda$ : longitude

## Geodetic Tridimensional Reference system :

- The **centre O** is near the earth mass centre,
- **OZ axis** nearest the earth rotation axis,
- **OXZ Plan** nearest the meridian origin (Greenwich) plan.



## Reference ellipsoid :

- Its **centre** is merged with the origin **O** of the geodetic referential,
- **Short axis** is merged with **OZ** axis and,
- Its **flattening** and the **size of the two axis** are near the dimension of the earth

# MAIN ALGERIAN INSTITUTIONS USING SPACE POSITIONING

**CTS / ASAL : Centre des Technique Spatiales** (*Educational and research Centre on Geodesy, Geomatics and GIS, using GNSS and other positioning space techniques as altimetry, laser ranging and gradiometry ...*).

**INCT : Institut National de Cartographie et Télédétection** (*Algerian Geodetic reference system in planimetry and altimetry, remote sensing, photogram.*).

**CRAAG : Centre de Recherche en Astronomie Astrophysique et Géophysique** (*Monitoring geodynamical and seismological movements on active zones on principally the north of Algeria*).

**ANC : Agence Nationale du Cadastre** (*Cadastral Triangulation by GPS, GPS rural and urban surveying*).

**ONSM : Office National de Signalisation Maritime** (*Maritime signalling by Differential GPS using 3 emitting stations along the coast*).

**SONATRACH : EGZIA, GL4Z, GP1Z** (*GPS precise networks on industrial zones, GPS Auscultation of the underground Tank of LNG and aerial LNG tanks,..*).

**OGEF : Ordre des Géomètres Experts Fonciers** (*Topography, Surveying, GIS,..*)

**> 2000 bifrequency receivers**

# Main GNSS Applications

**1- Maritime Signalling by Differential GPS (DGPS)**

**2- GPS Monitoring of the underground LNG Tank**

**3- Urban GPS network on Oran city**

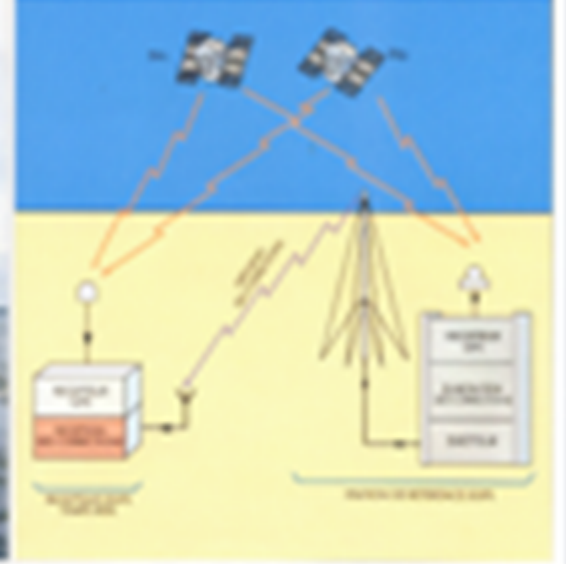
**4- Geodynamics in the North of Algeria by GPS :**

- *TYRGEONET and ALGEONET Projects*
- *TEC Modelisation*
- *GPS permanent network*





# 1-Maritime Localisation and Signalisation by DGPS



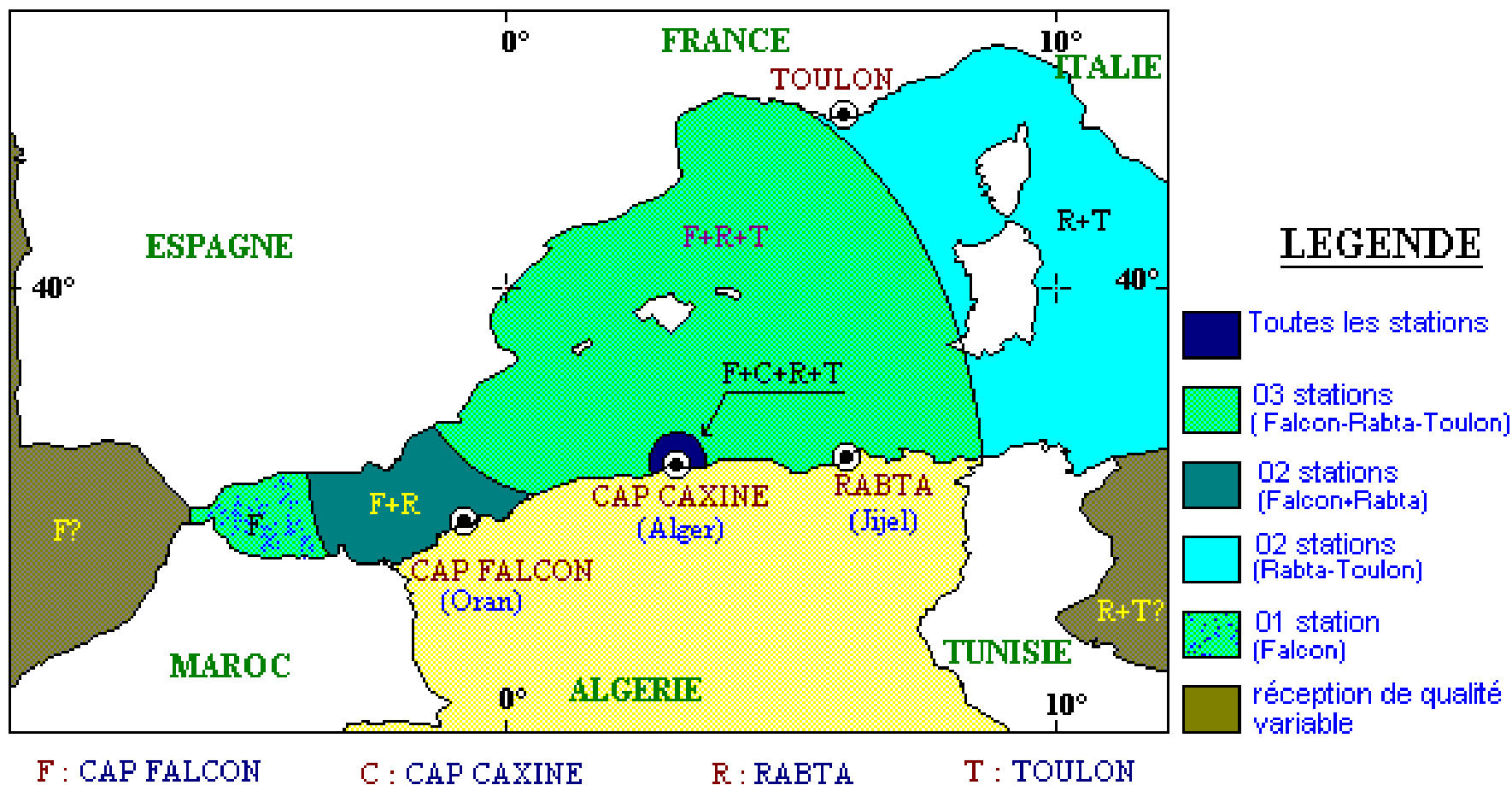
## Principle :

- ▶ Reference station well-known in WGS84
- ▶ Elaboration of the corrections on each satellite
- ▶ Diffusion of the correction with **H.F** to the marine users
- ▶ Real Time localisation with **2 to 5 m** accuracy, for a mobile (boat) far to **800 km** from the emitting DGPS stations.

# Signal reception zone in the West Mediterranean sea (Algerian stations + Toulon)

## NAVIGATION MARITIME PAR DGPS

### Zones de réception des signaux DGPS



# Real time accuracy of the DGPS

The comparison (by coordinates deviation) between the DGPS position and the precise static method, confirm the accuracy of the DGPS positioning less than (**< 5m**).

Reception site	Emitting site	Deviation	Baseline
ARZEW	TOULON	<b>2.7 m</b>	<b>&gt; 500 Km</b>
ARZEW	FALCON	1.7 m	52 Km
JIJEL	RABTA	1.7 m	25 Km

**ARZEW, FALCON, RABTA stations are linked to TYRGEONET network (2 to 5cm)**

# Potential applications of the DGPS

## Oceanographic applications :

- ✓ Maritime signalling
- ✓ Marine navigation
- ✓ Bathymetric surveys
- ✓ Insulated localisation (high-bottoms or peaks,...).

## Other applications:

- ✓ Terrestrial (coastal) navigation
- ✓ Road surveys
- ✓ etc...

# Main GNSS Applications

Maritime Signalling by Differential GPS (DGPS)

**GPS Monitoring of the underground LNG Tank**

Urban GPS network on Oran city

Geodynamics in the North of Algeria by GPS :

- *TYRGEONET and ALGEONET Projects*
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## 2- GPS Monitoring of the Underground LNG Tank



# Underground Tank from the sky



# Encountered Problems



## Presentation

- 03 aerial reservoirs (**11.000 m<sup>3</sup> each**);
- 01 underground tank with frost ground at (-161°C) (**38.000 m<sup>3</sup>**)

In exploitation from **1965**, it represent **50%** of the storage capacity of the complex;

## Encountered Problems

### Natural causes :

- Uplift of the Tank (**50 cm**)
- Deformations, blowing up and ground crack,..

### Exploitation problems:

LNG leak caused by a ground crack and probable landslide (uplift).

### Structural problems:

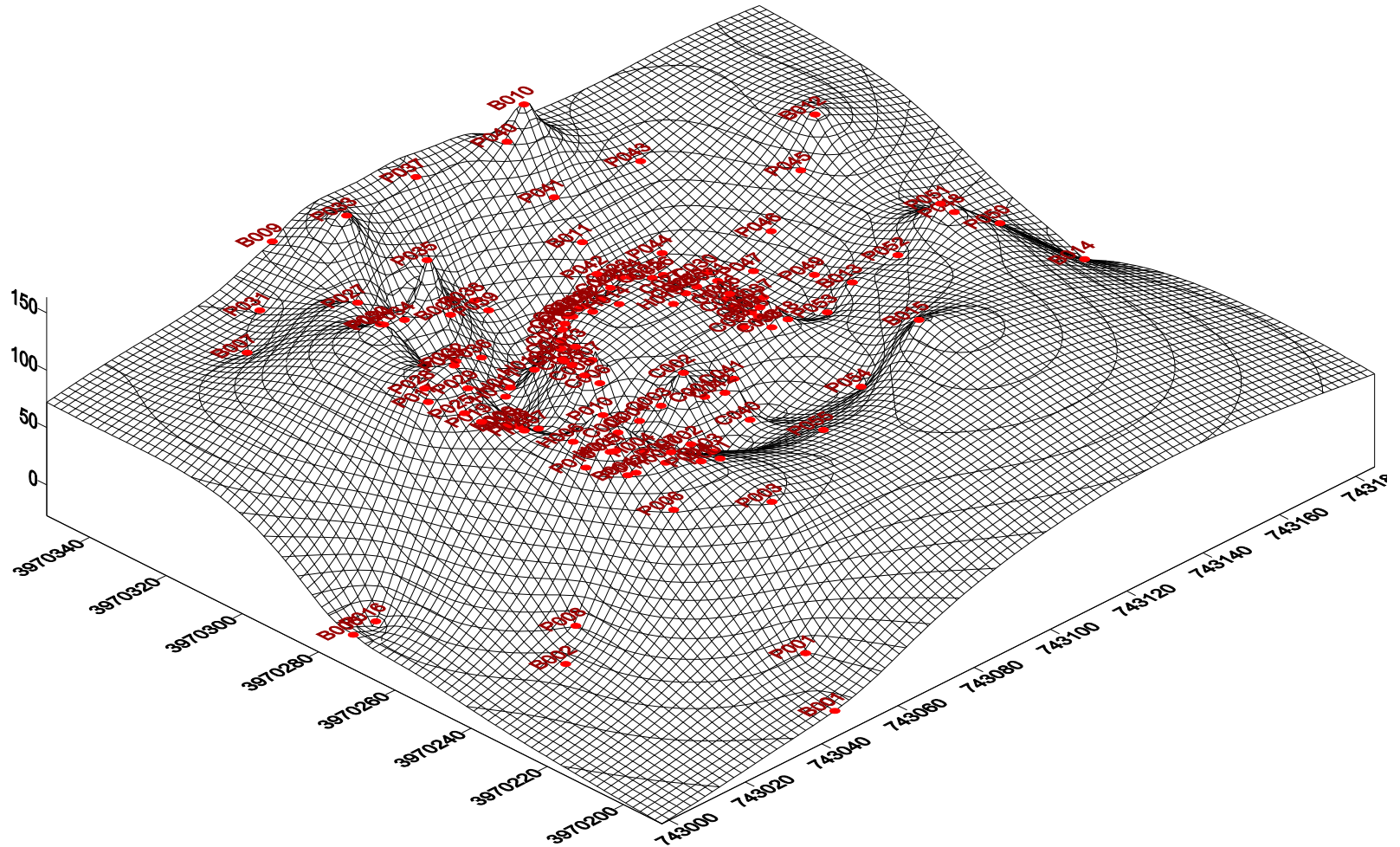
Disorders at the level of the roof structure



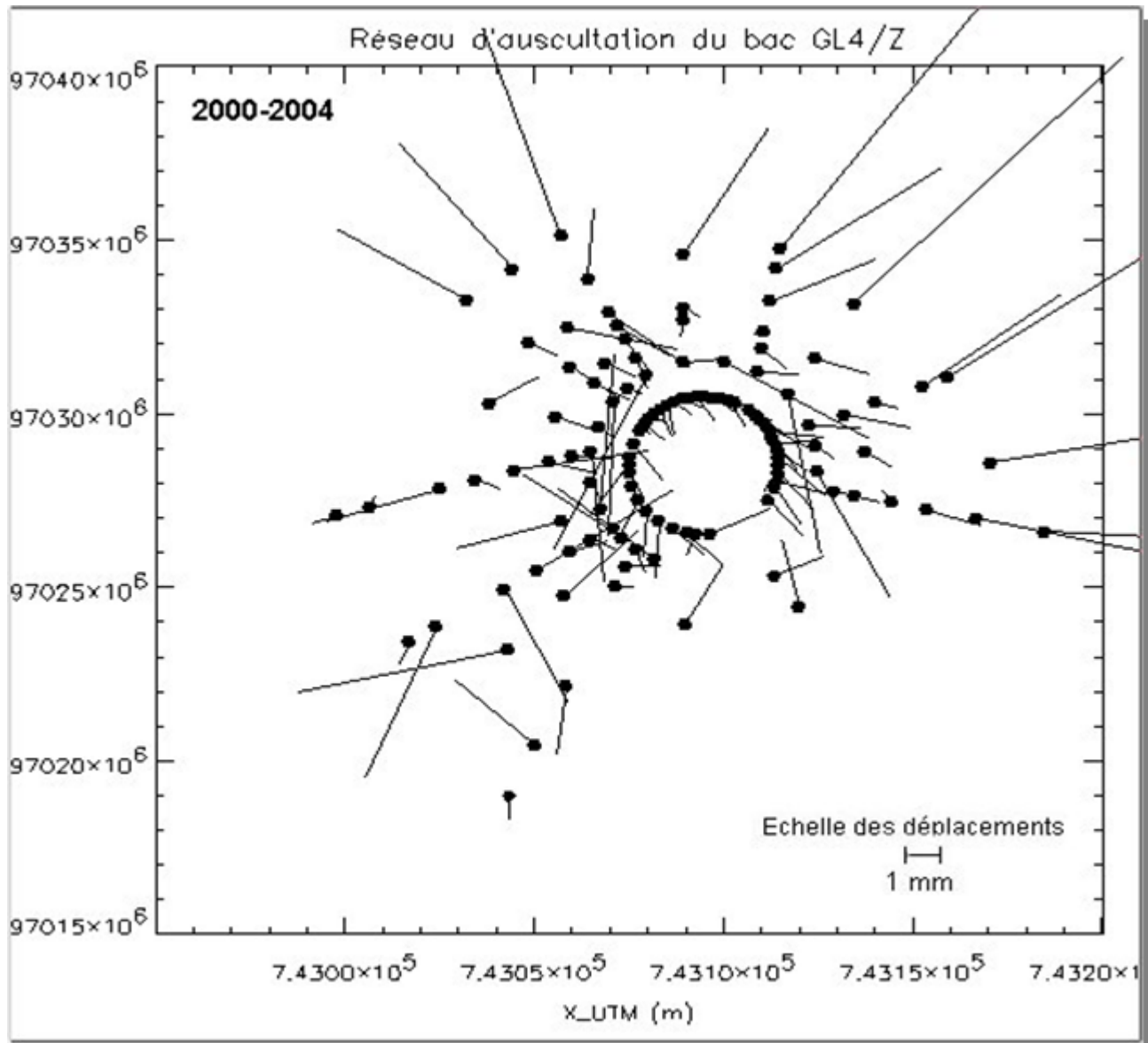
# Methodology

- **Implantation of the reference network (basic).**
- **Optimal configuration of the targets.**
- **Monitoring of the evolution and/or the stability of the Tank (GPS and levelling) .**
  - **First GPS campaign : February 2000**
  - **Second GPS campaign : July 2002**
  - **Third GPS campaign : July 2004**
- **Determination of the displacements**
- **Geometric interpretation of the results**

# Results



Altimetric displacements : 2000 - 2004



**Planimetric displacements : 2000 - 2004**

# Maximal altimetric displacement

163 mm (2000-2004)



90 mm (2000-2004)

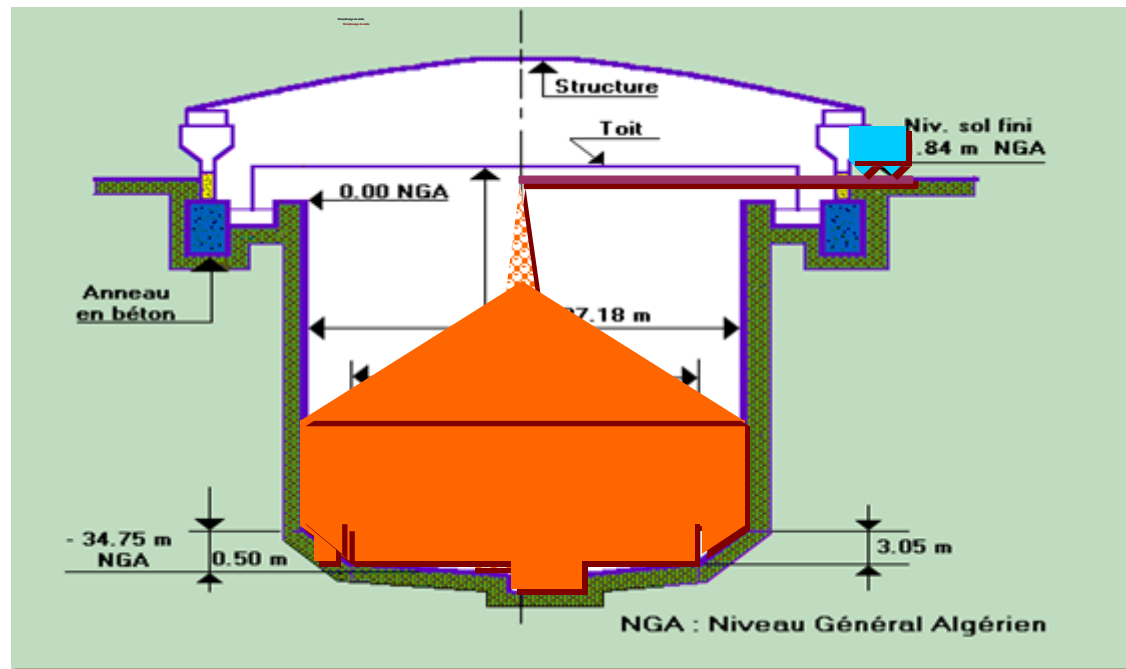
Direction of the  
Planimetric  
displacement

# Maximal planimetric displacement

# Conclusion

The results shows that the ground has a blowing up more important near the land that near the sea; and all the points of the monitoring network have an **horizontal displacement** in the north east direction.

**The last LNG underground tank in the world was disaffected in July 2007 and its exploitation stopped by the petroleum company**



**In August 2009**, an agreement was approved to monitor the site (in frost ground) of the Tank during the 5 next years.

# Main GNSS Applications

Maritime Signalling by Differential GPS (DGPS)

GPS Monitoring of the underground LNG Tank

**Urban GPS network on Oran city**

Geodynamics in the North of Algeria by GPS :

- *TYRGEONET and ALGEONET Projects*
- *TEC Modelisation*
- *GPS permanent network*



# 3 - GPS Establishment of the Geodetic network Of Oran City

**(04) Main execution steps :**

- 1. Recognition and monumentation,**
- 2. GPS Observations,**
- 3. Processing and data analysis, WGS84-Nord Sahara transform, geoid determination and levelling,**
- 4. Elaboration of the Geodetic Data Base.**

# NETWORK CONFIGURATION

- 1 – Final configuration: 65 pts** classified in (03) categories :
  - **48 stations and 09 targets** (accessible on terrace or dominant position with an eccentric point )
  - **08 inaccessible pts** (dominant **positions**: terrestrial positioning).
- 2 – Average distance between the points : 01 - 06 km**, with the visibility condition on at least **03 points**.
- 3- Accuracy of the network : 2-3 cm**, both in planimetry and altimetry



## 09 MIRETTES :



- DTP : DTP 001
- Santa Cruz (Kouba Sidi AEK) : DTP 013
- Tour USTO : DTP 036
- Lycée Tech. (face CASORAN) : DTP 024
- Batiment DAAR EL HAYET : DTP 022
- Echangeur El Bahia : DTP 029
- A proximité de "Jumbo" : DTP 031
- Pont Petit Lac chem. fer (périph 3) : DTP 025
- Ancien château d'eau (Hassi Bounif) : DTP 065

## 08 REPERES INACCESSIBLES :



- Gare (minaret : horloge) : DTP 023
- Mosquée Haï El Badr (2 minarets) : DTP 015
- Résidence El Bahia (coupole) : DTP 032
- Mosquée Bel Gueïd 2 (minaret) : DTP 044
- Santa Cruz (Vierge) : DTP 014
- Mosquée (minarets) à proximité des Arènes : DTP 016
- Château d'eau d'Es Senia : DTP 026
- CCLS (Mât) : DTP 028

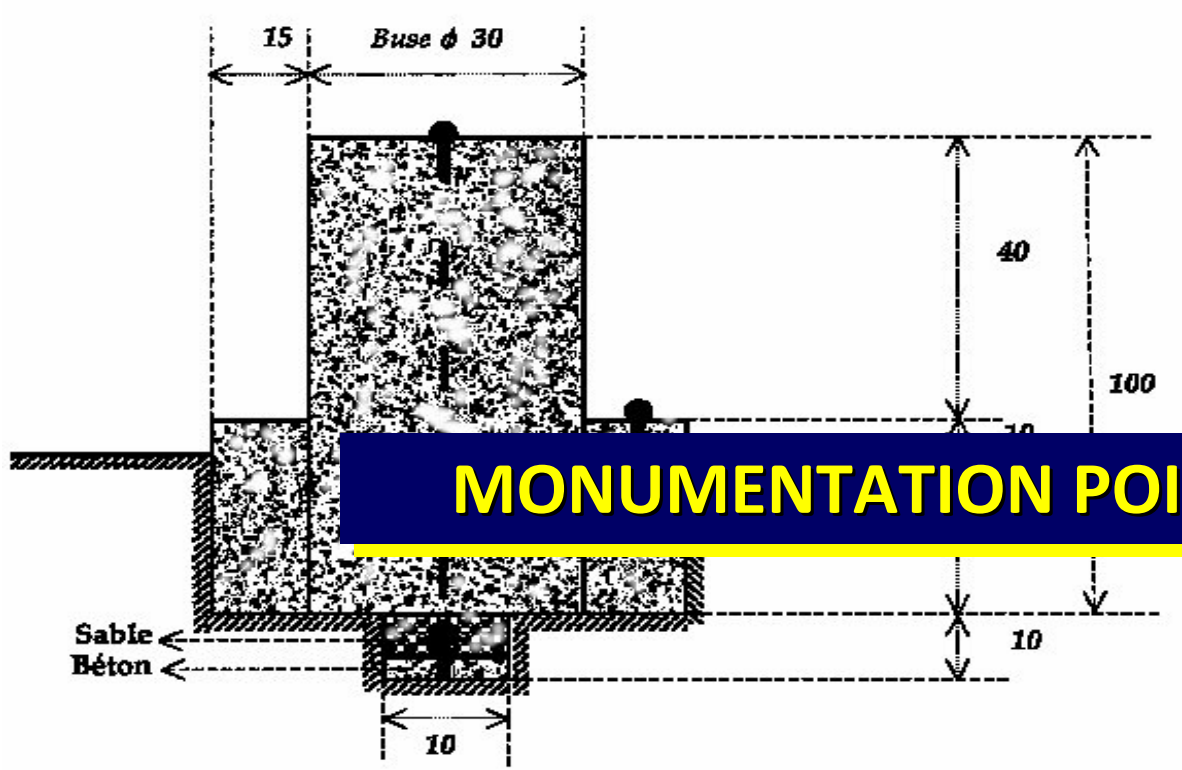
## 48 BORNES :



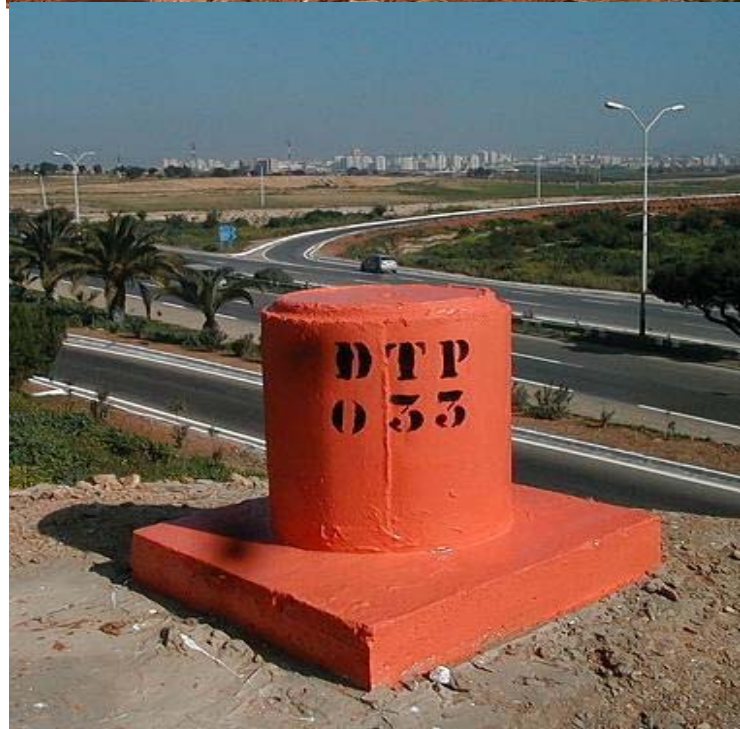
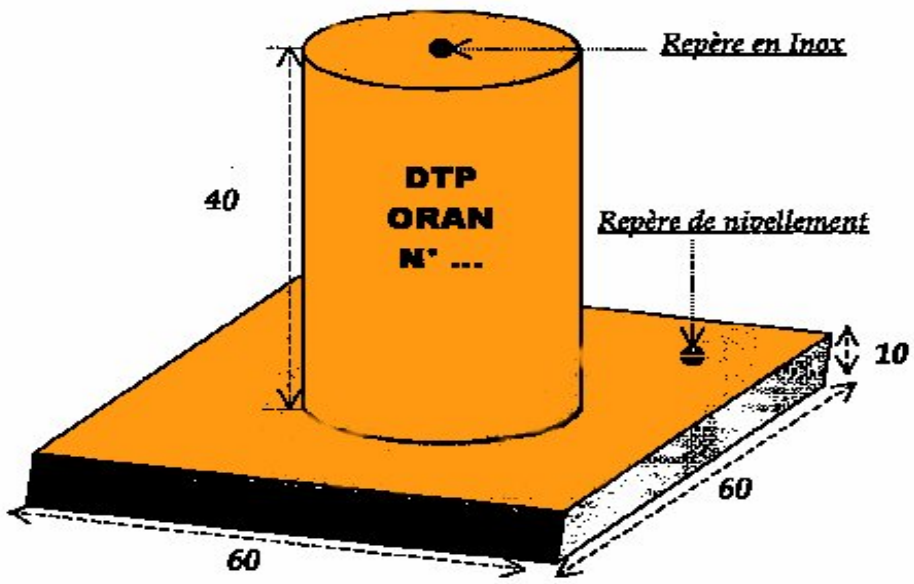
# CONFIGURATION FINALE DU RESEAU DTP (65 points)

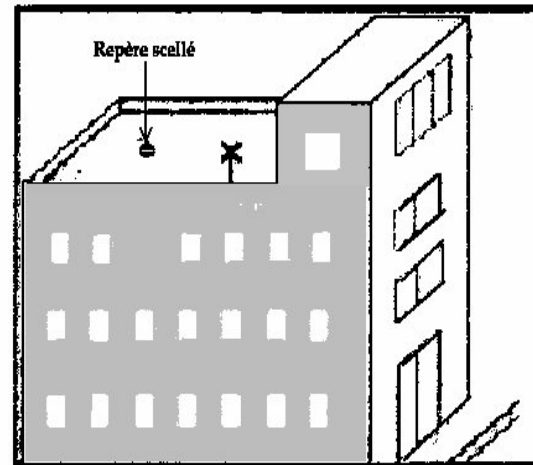
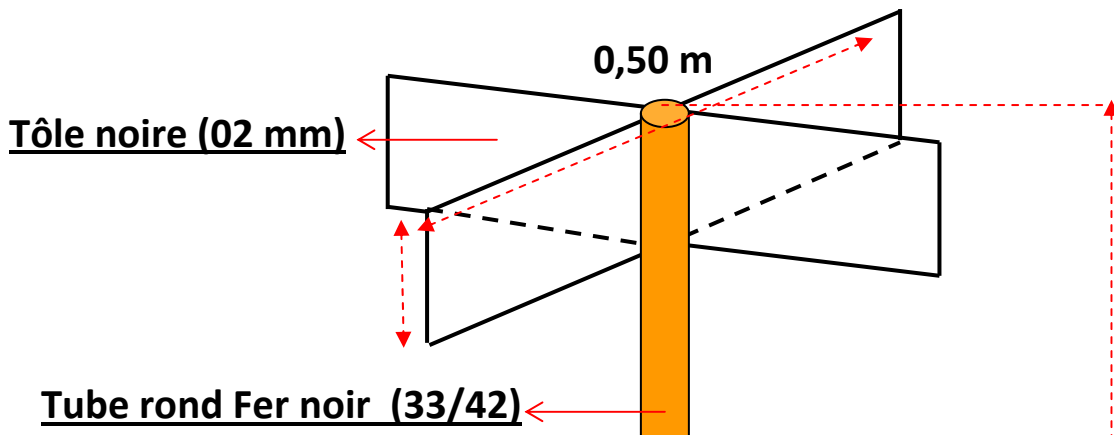
48 bornes, 09 mirettes, 08 repères inaccessibles



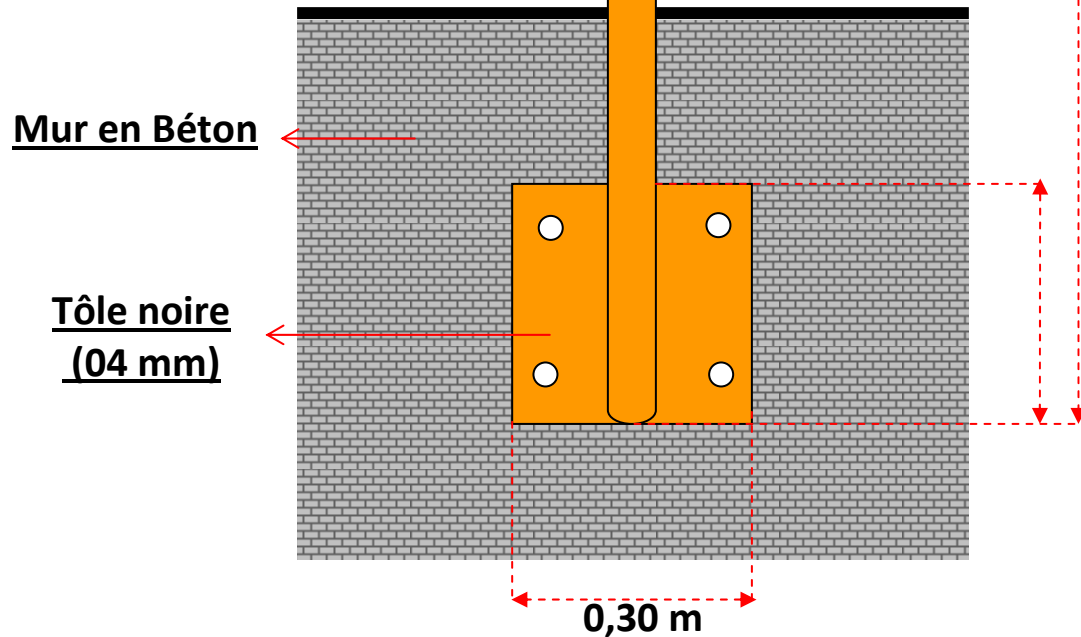


# MONUMENTATION POINTS





**ACCESSIBLE TARGETS ON TERRACE , WALLS,..**



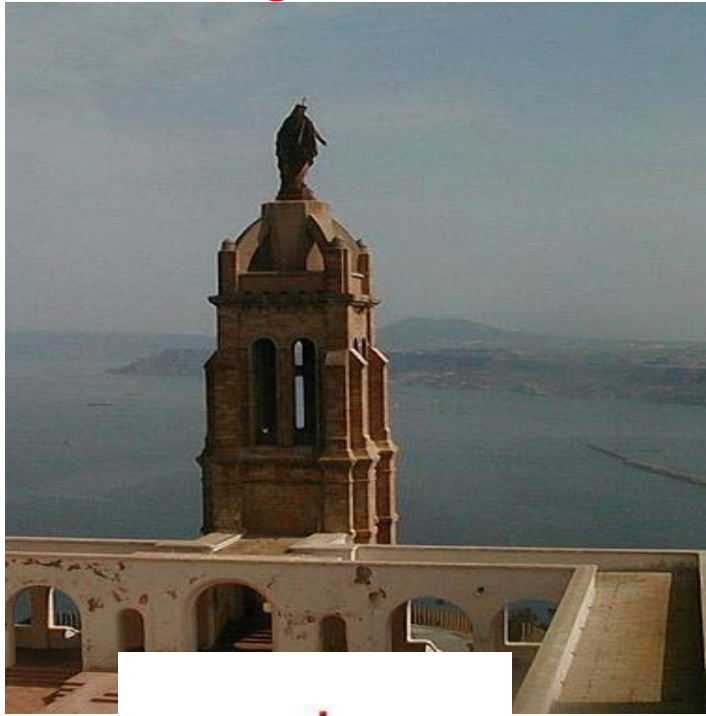
# Mosquée / HAI EL BADR (02 minarets)



**INACCESSIBLE POINTS**

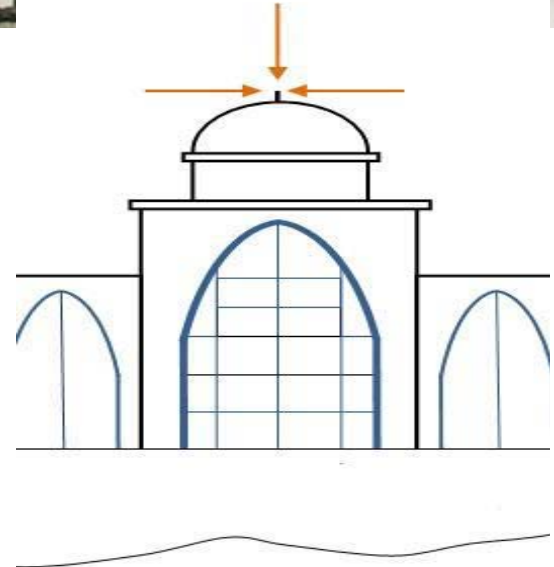


# Sainte Vierge SANTA-CRUZ

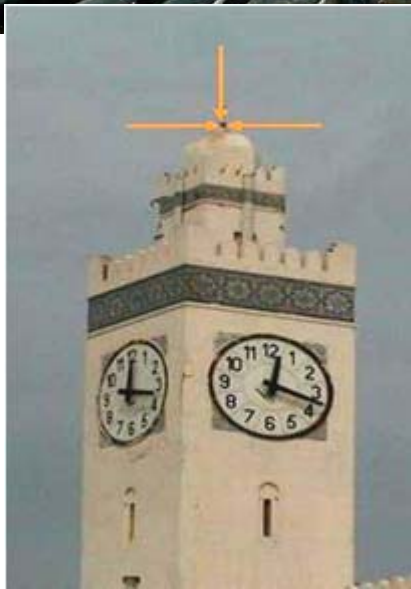


Sommet Statut  
Sainte-vierge

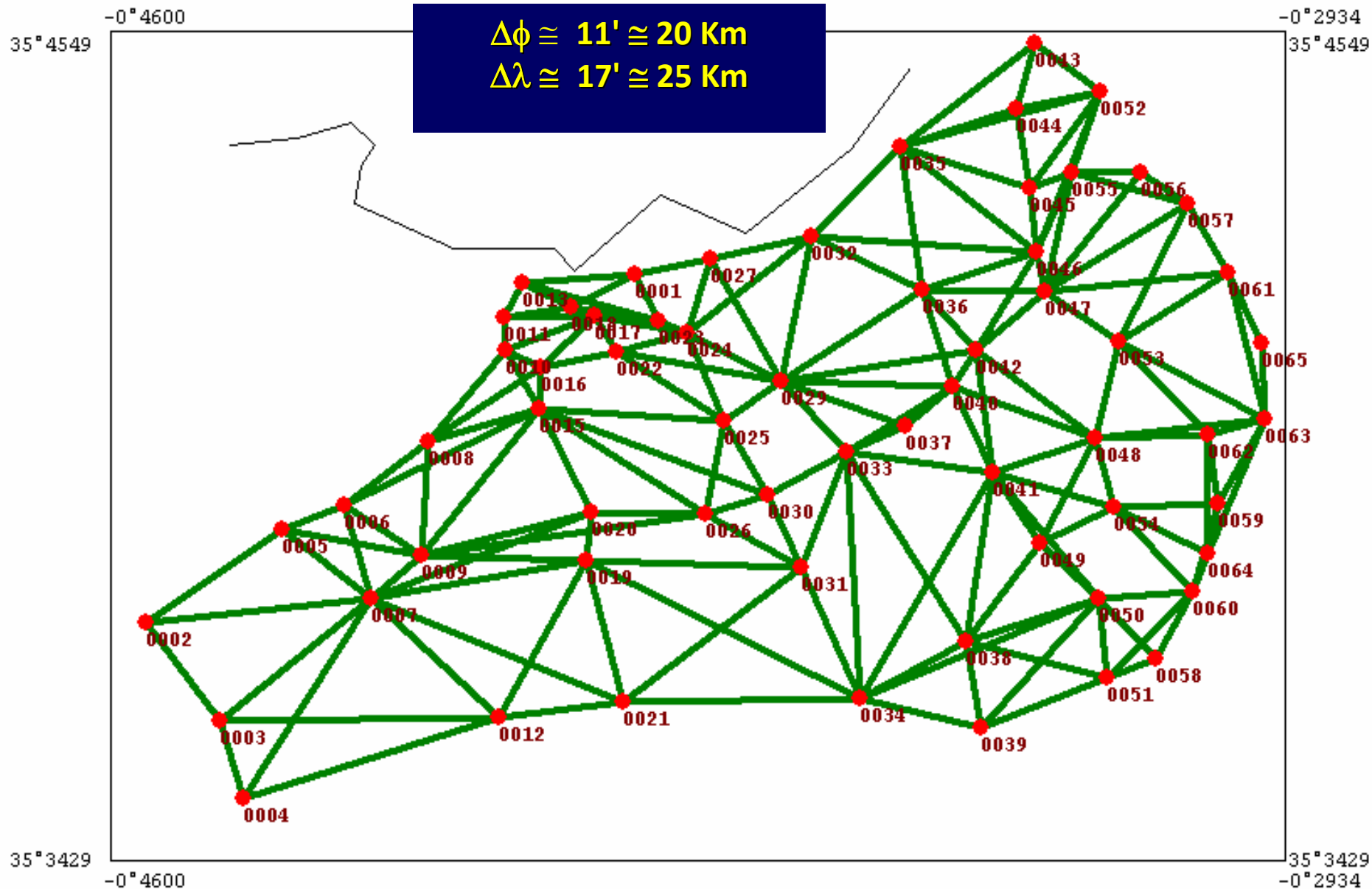
# El Bahia Résidence (Mât)



# ORAN RAILWAY STATION



# Geographical situation of the geodetic network of the city



# RESEAU DE POINTS GEODESIQUES DE LA VILLE D'ORAN

Echelle 1:30 000

## LEGENDE

### NATURE DES POINTS GEODESIQUES

- ▲ Borne
- ▲ Miette
- ▲ Inaccessible (Mose, Minaret, Chât. d'eau)

### TOPOGRAPHIE

- Route nationale
- Route secondaire
- Route étroite
- Chemin de fer
- - - Limite de commune
- Rond point
- Echangeur

Système géodésique Nord - Sahara 1959  
Projection : UTM, Fuseau : 30  
Quadrillage kilométrique

Sources : Image Spot 5 du 24-12-2004

Les données topographiques ainsi que les limites de commune ne sont portées  
qu'à titre indicatif pour faciliter la localisation des points géodésiques

Établi et édité par le Centre des Techniques Spatiales, 1 Avenue de la Palestine - Oran - Juillet 2009





# Main GNSS Applications

Maritime Signalling by Differential GPS (DGPS)

GPS Monitoring of the underground LNG Tank

Urban GPS network on Oran city

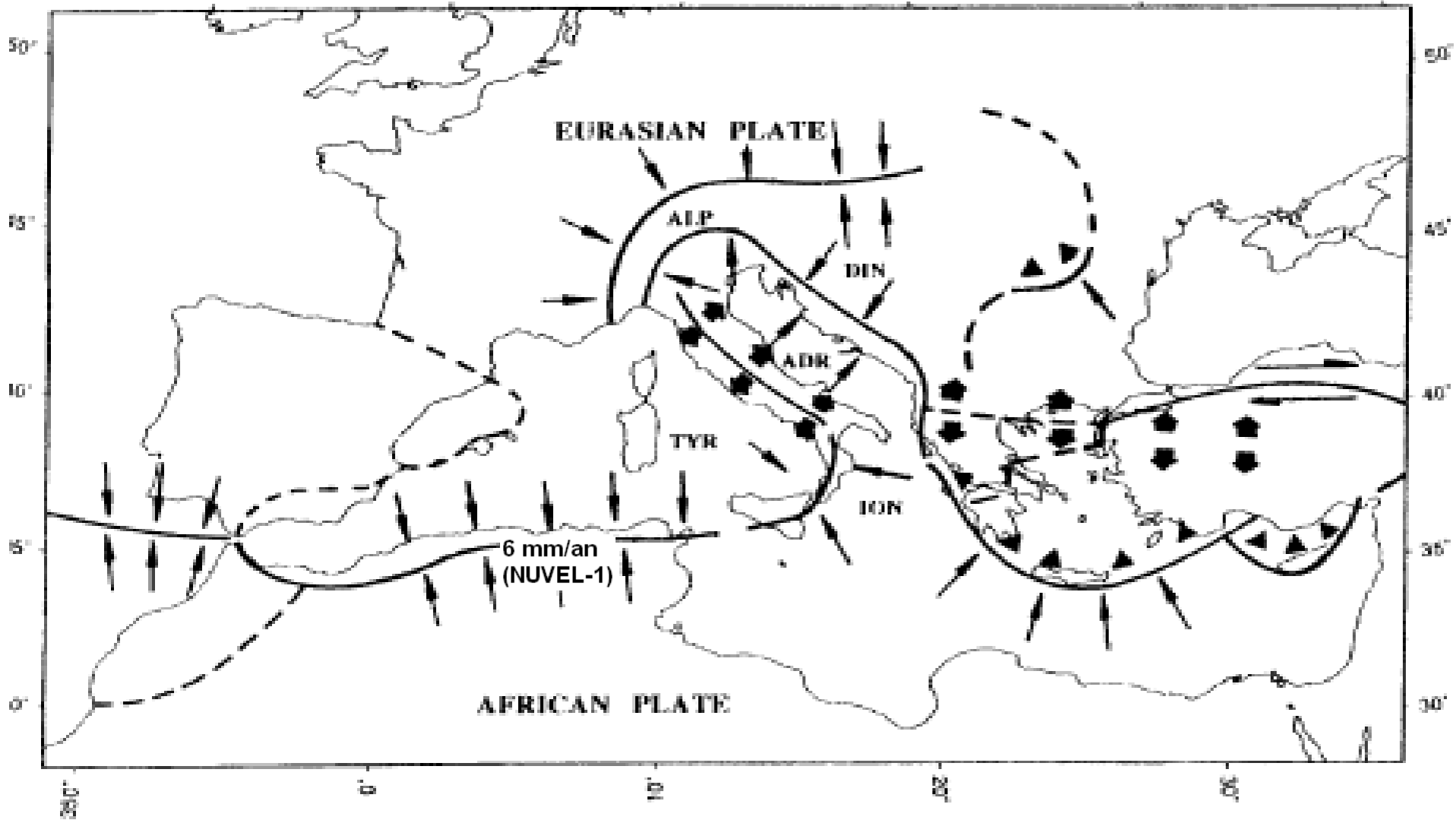
**Geodynamics in the North of Algeria by GPS :**

- *TYRGEONET and ALGEONET Projects*
- *TEC Modelisation*
- *GPS permanent network*

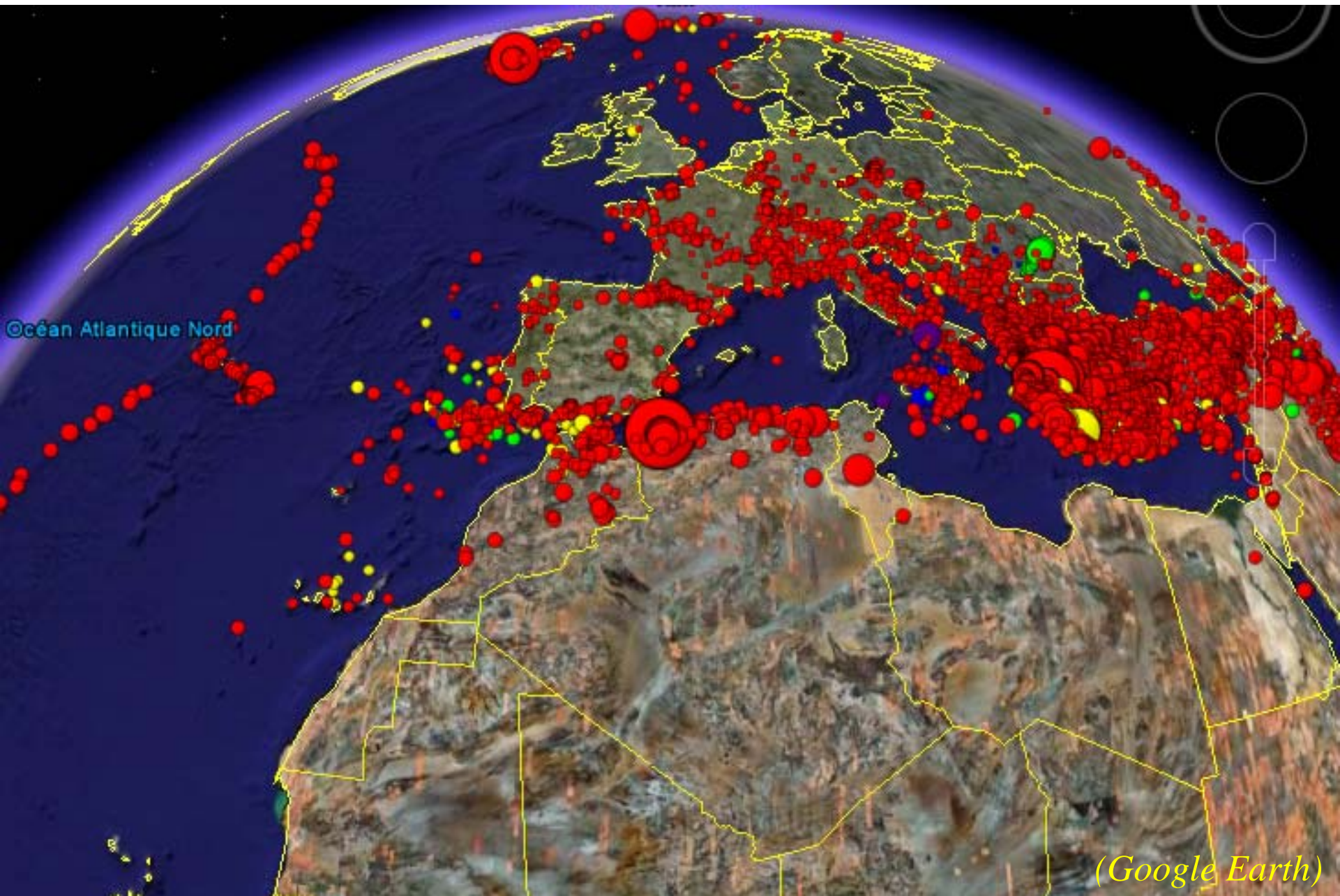


# 4 - GEODYNAMICS OF THE NORTH OF ALGERIA BY GPS : ALGEONET ET TYRGEONET PROJECTS

## AFRICAN AND EURASIAN PLATE BOUNDARIES

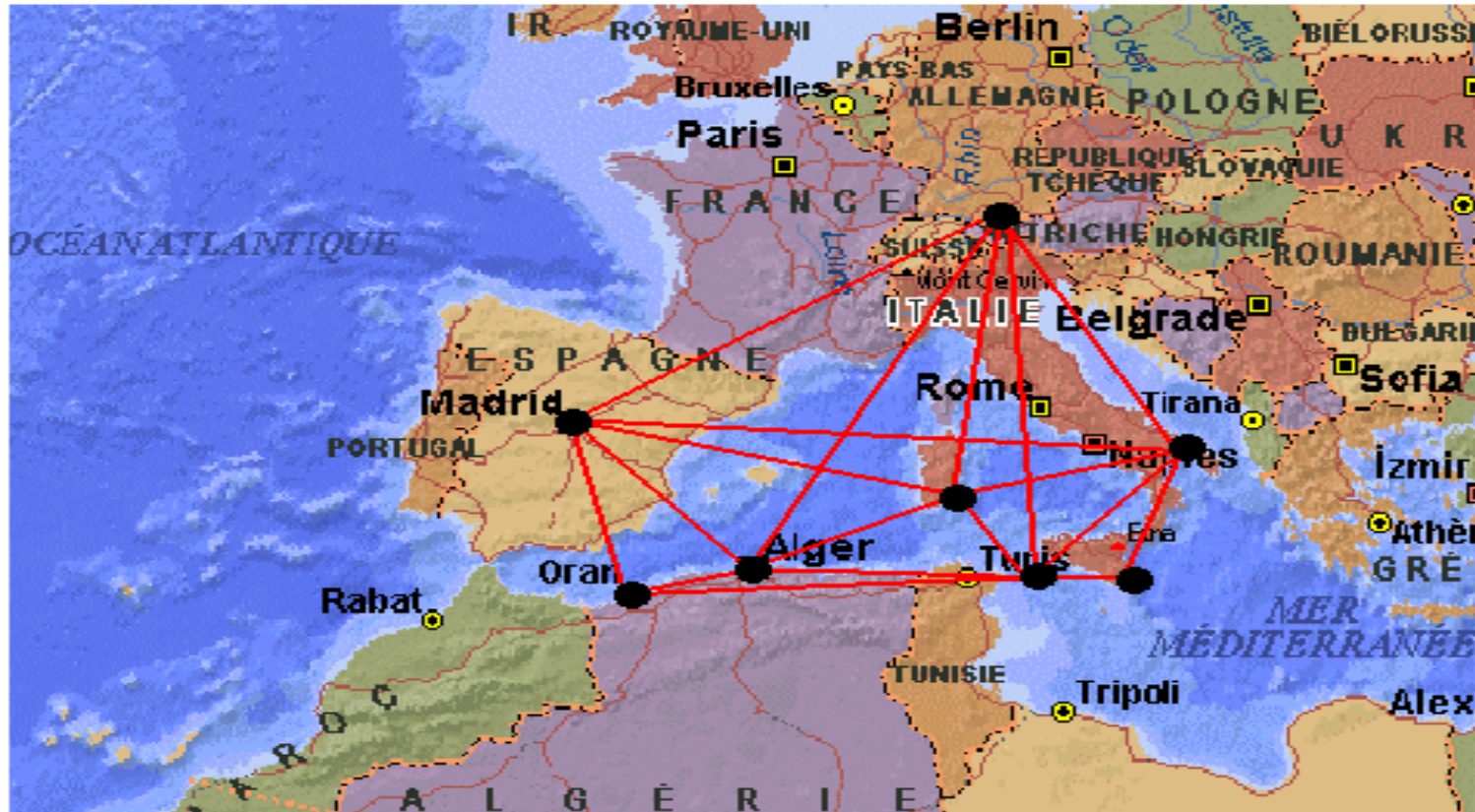


# SISMICITY OF THE MEDITERRANEAN BASIN



# TYRGEONET PROJECT

(TYRhenian GEOdetic NETwork) : Conducted by the INGV & UNIBO (Italy) with the collaboration of several Mediterranean institutions (CTS, INCT)



- **Objectives** : Oceanography and geodynamics monitoring of the Italian peninsula
- **Extension** : Algeria, Tunisia, France,.. (+ than 50 stations )

# CRUSTAL DEFORMATIONS IN THE MEDITERRANEAN REGION: 10 YEARS OF GPS OBSERVATIONS (1995- 2004)

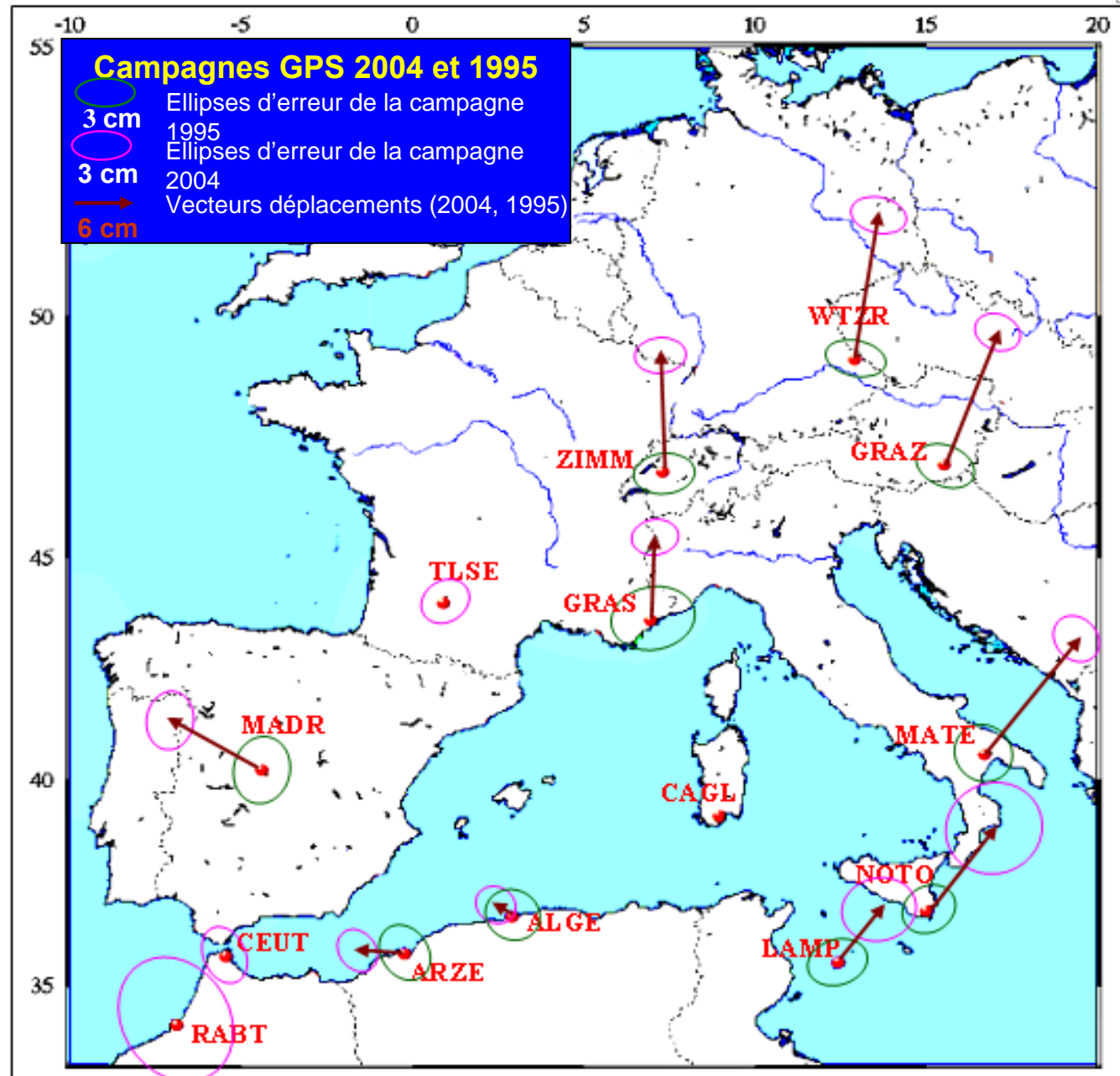
## Stations used:

- |                  |            |              |          |
|------------------|------------|--------------|----------|
| ▲ <b>Algiers</b> | ▲ Madrid   | ▲ Zimmerwald | ▲ Noto   |
| ▲ <b>Arzew</b>   | ▲ Rabat    | ▲ Ceuta      | ▲ Matera |
| ▲ Toulouse       | ▲ Wettzell | ▲ Lampedusa  |          |
| ▲ Grasse         | ▲ Graz     | ▲ Cagliari   |          |

## Objectives :

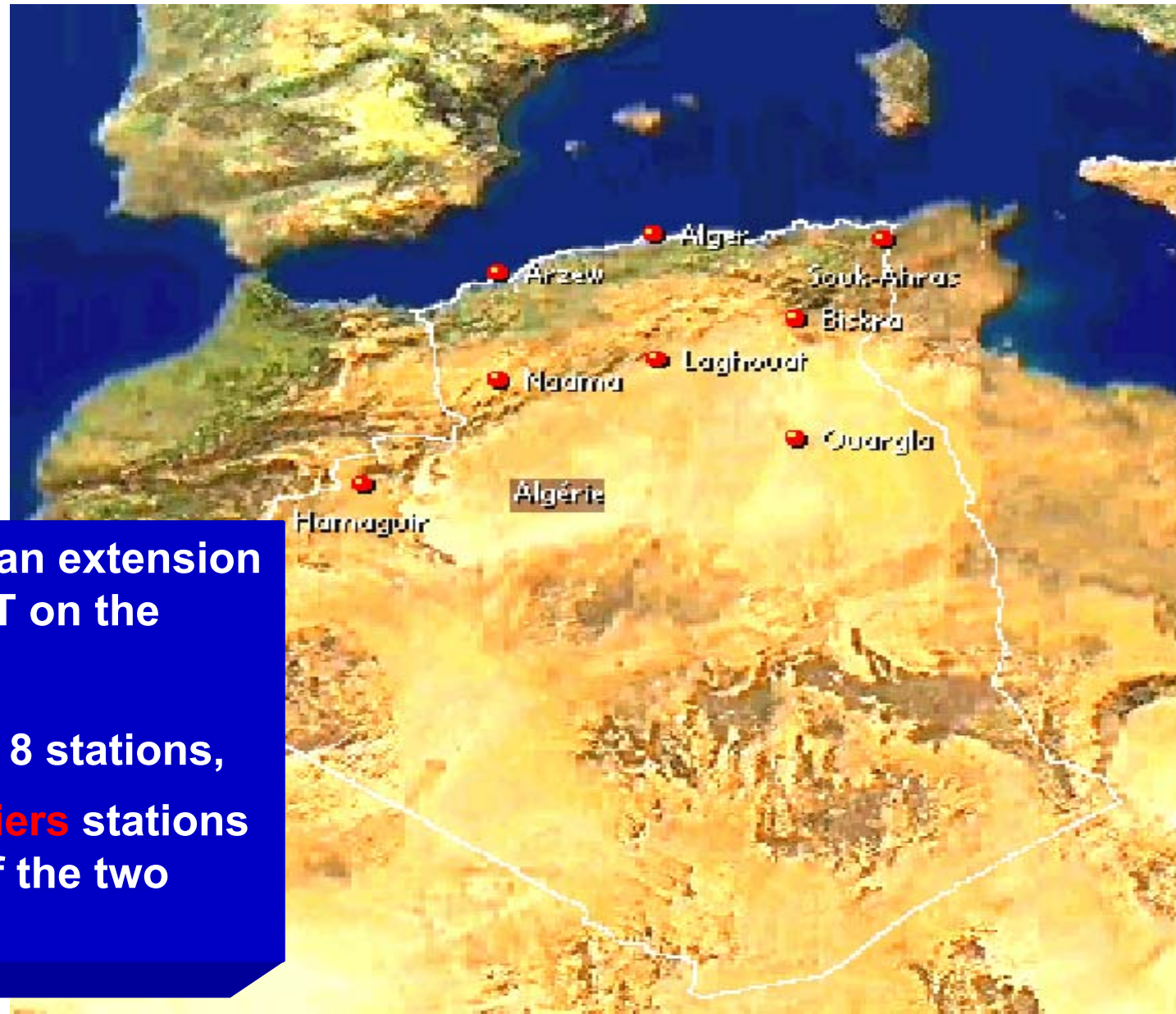
Crustal deformations in the region from periodic GPS measurements.

# GPS Data Processing



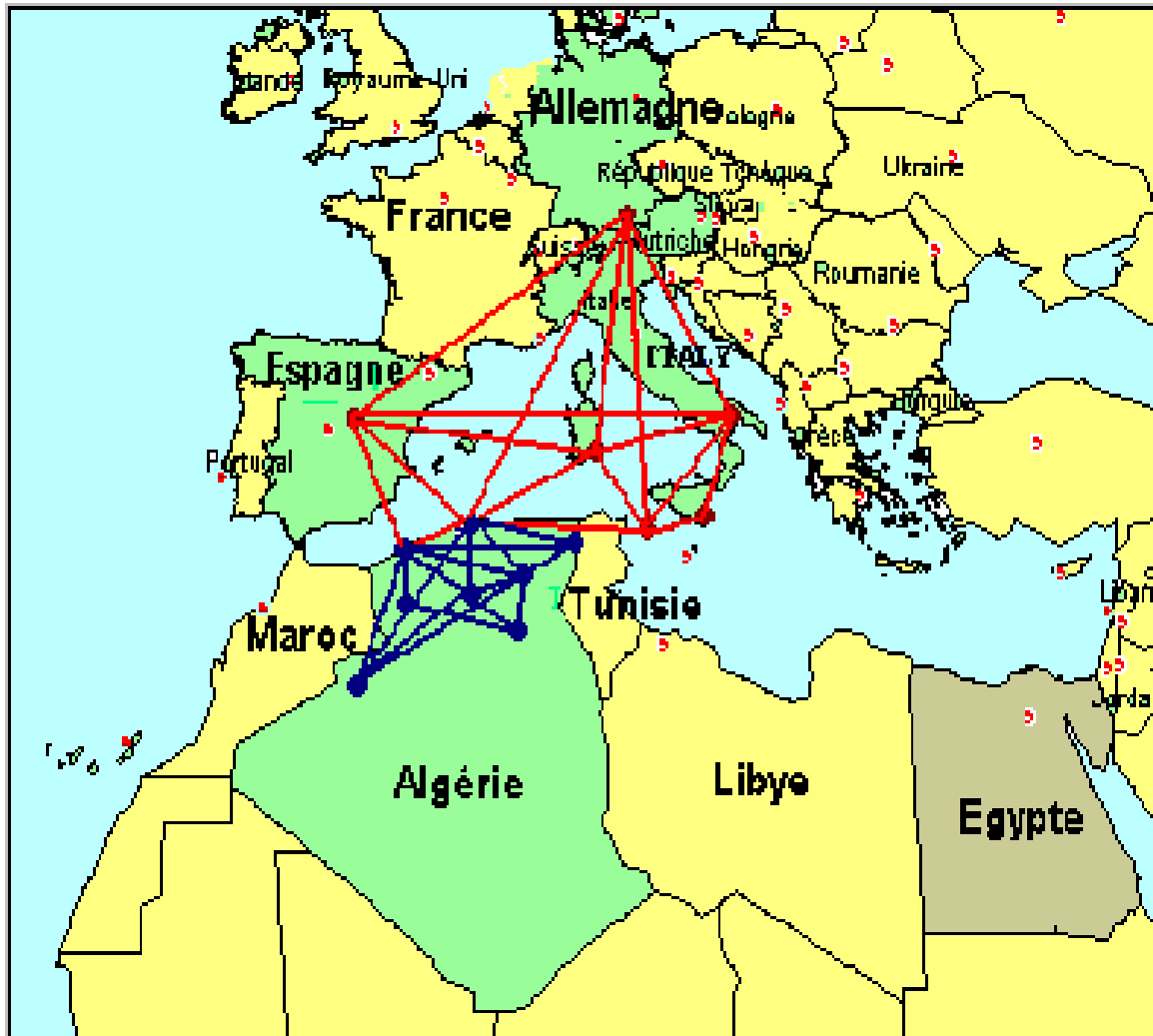
# ALGEONET PROJECT

(ALgerian GEOdynamical NETwork) : (CTS, INCT, CRAAG, INGV)



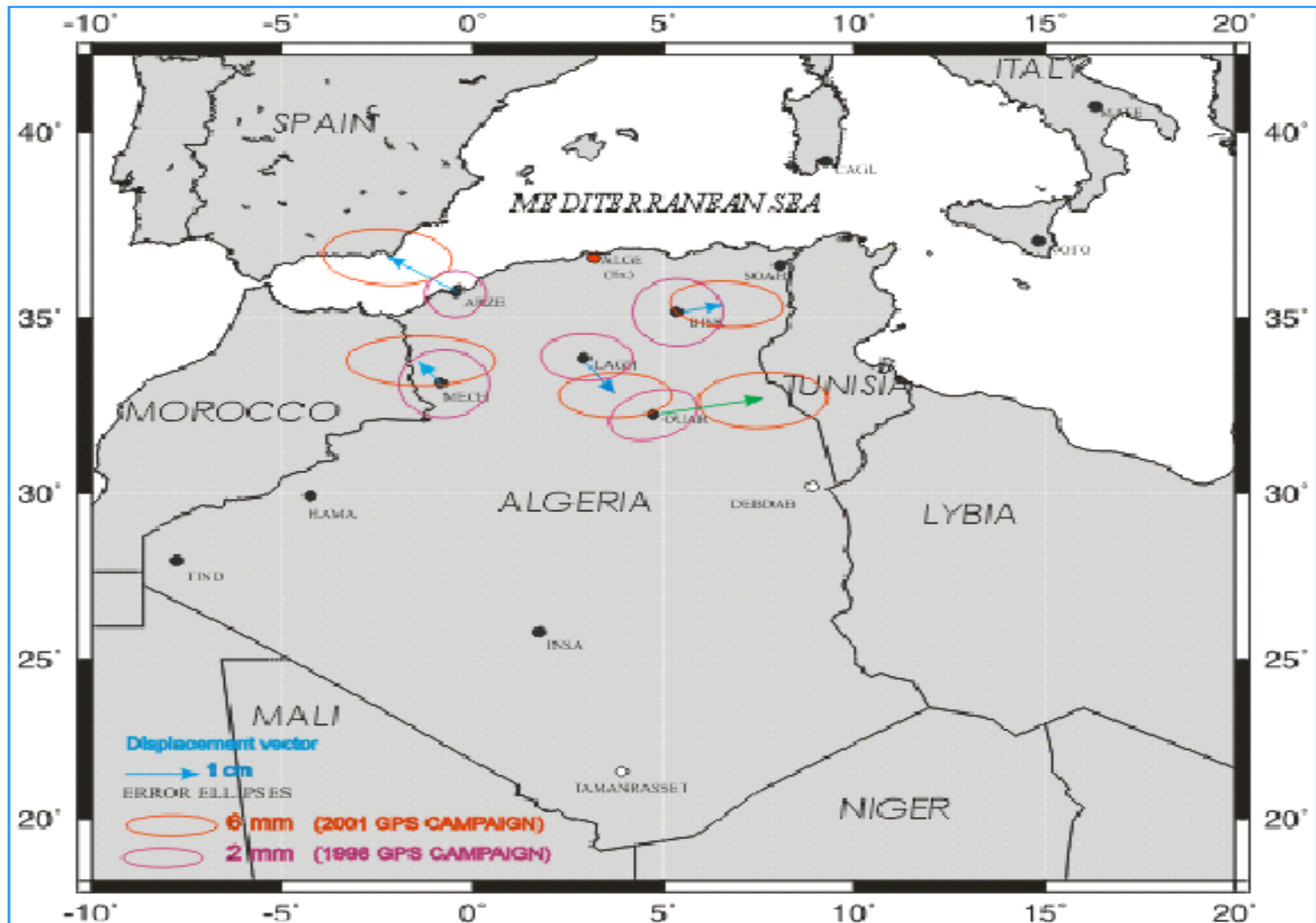
- ALGEONET is an extension of TYRGEONET on the north Algeria,
- Constituted by 8 stations,
- **Arzew** and **Algiers** stations are common of the two networks

# NETWORKS INTEGRATION : *TYRGEONET & ALGEONET*



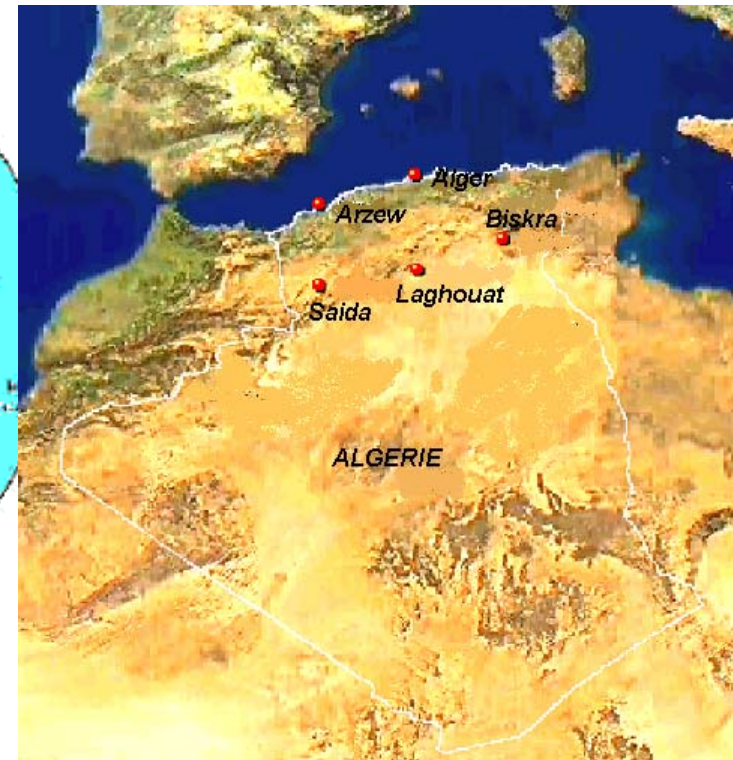
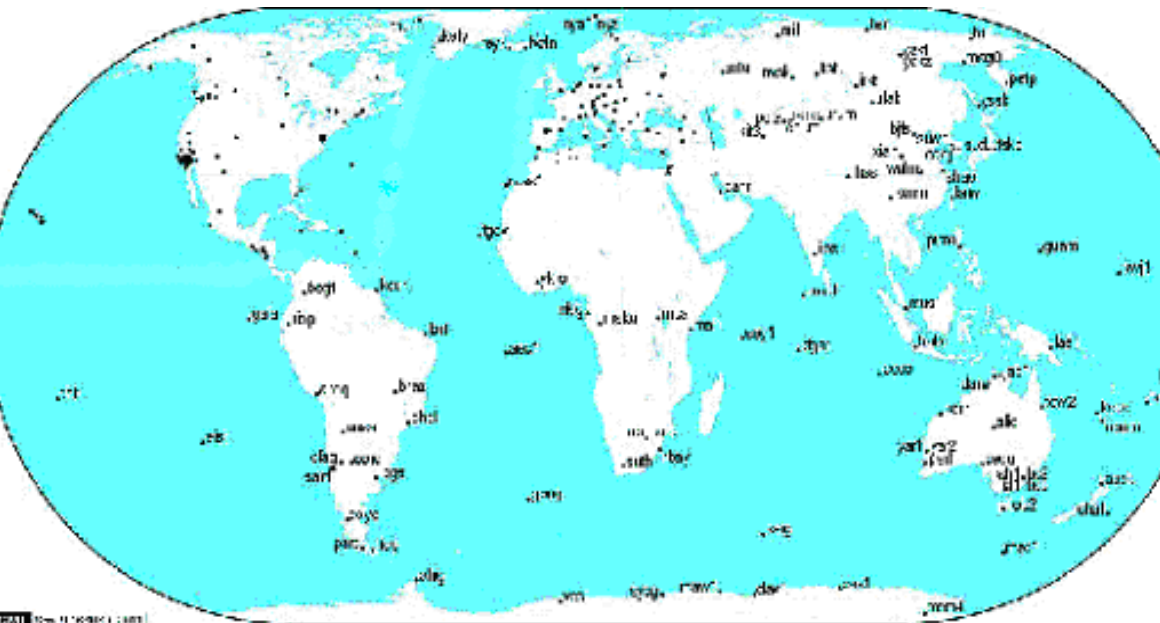


# PROCESSING GPS DATA

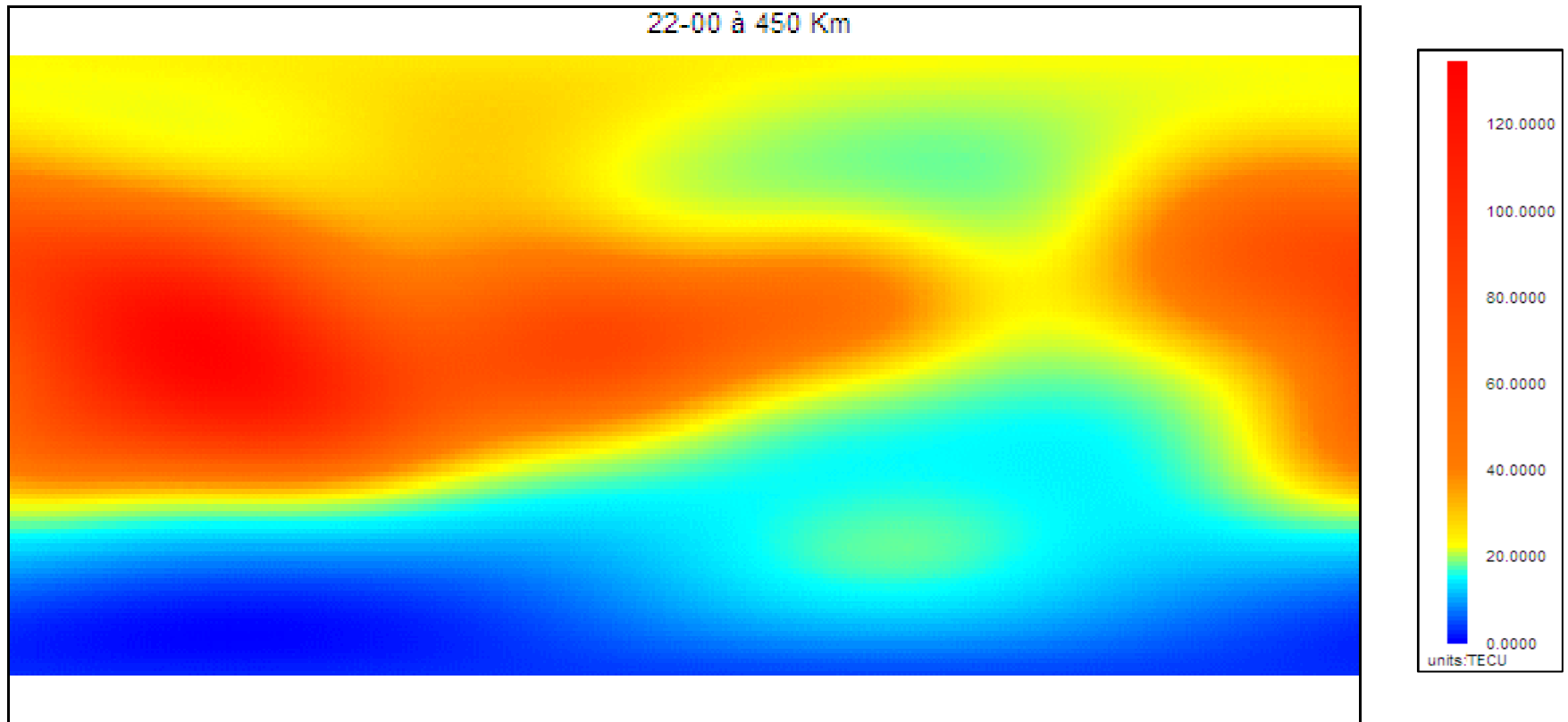


# PROCESSING THE TEC FROM GPS DATA

108 IGS stations IGS + 06 stations ALGEONET  
24 hours observation

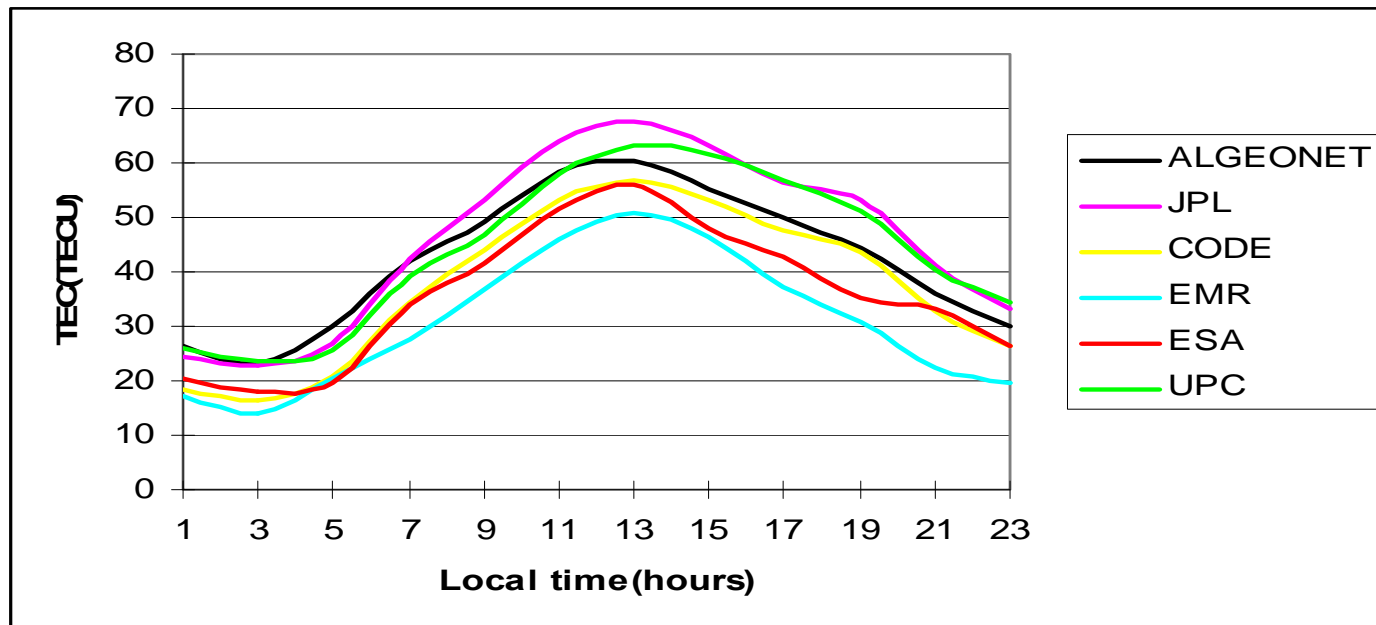


# Ionospheric Map in 2D



Daily variation of the TEC at 450 Km height

# VALIDATION RESULTS



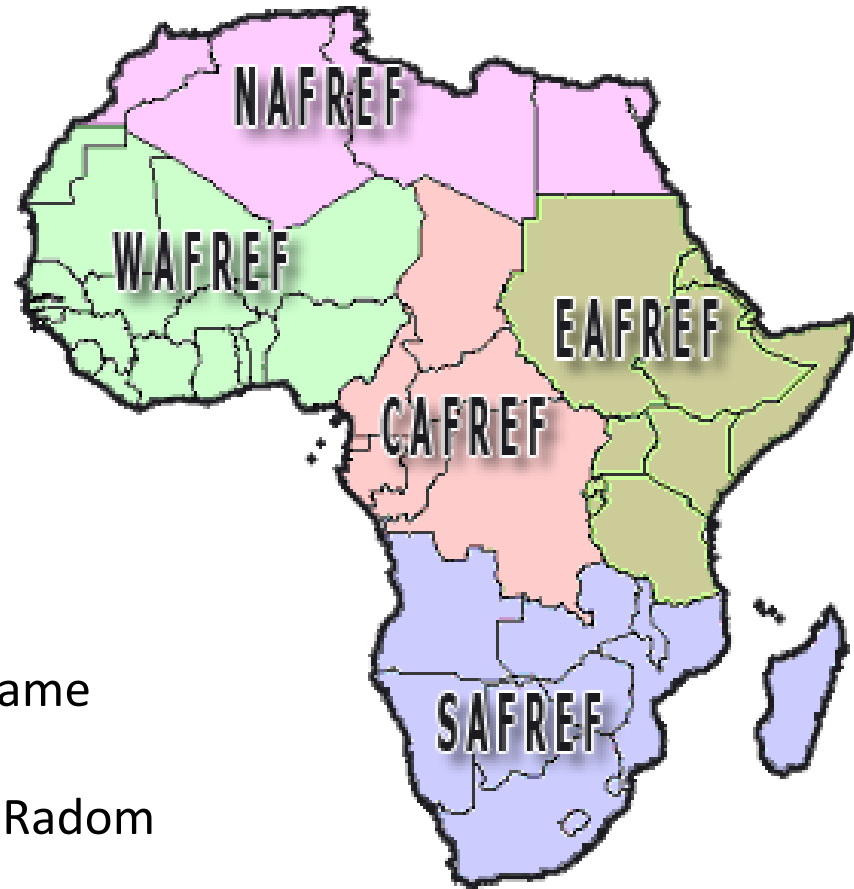
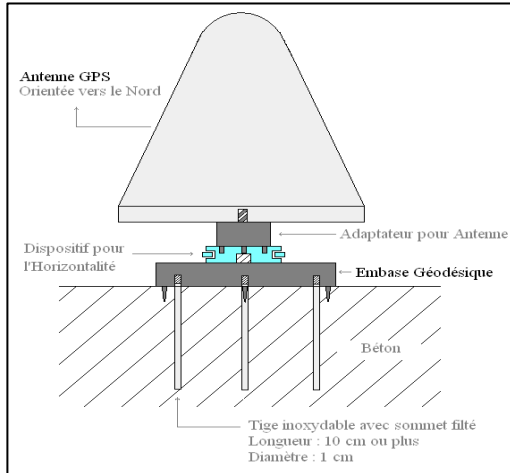
The value of the local TEC processed at Algiers (with **6** Algerian and **108** IGS stations) is compared with the international solution of the **5 IGS** associated centres : **CODE** (Center for Orbit Determination in Europe, University of Berne, Switzerland), **ESOC** (European Space Operations Center of ESA, Darmstadt, Germany), **JPL** (Jet Propulsion Laboratory, U.S.A), **NRCAn/EMR** (Natural Resources Canada, Ottawa, Canada) et **UPC** (Technical University of Catalonia, Spain).

- To improve the temporal and spatial resolution, it's necessary to use the planned GPS permanent networks.

# ALGERIAN GPS PERMANENT NETWORKS :

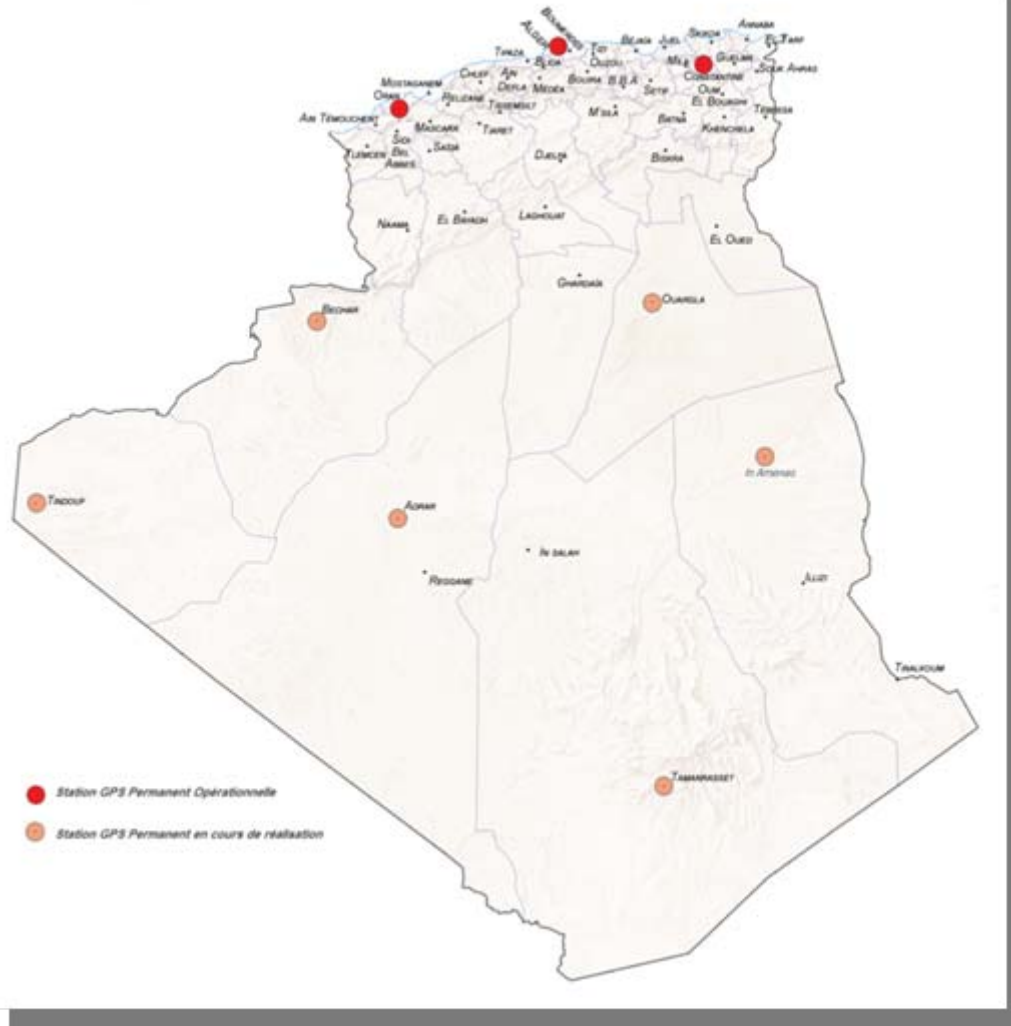
1. Geodetic GPS Permanent Algerian Network
2. REGAT Project
3. 100 GPS permanent stations (ongoing ASAL Project)

# Geodetic GPS Permanent Algerian Network



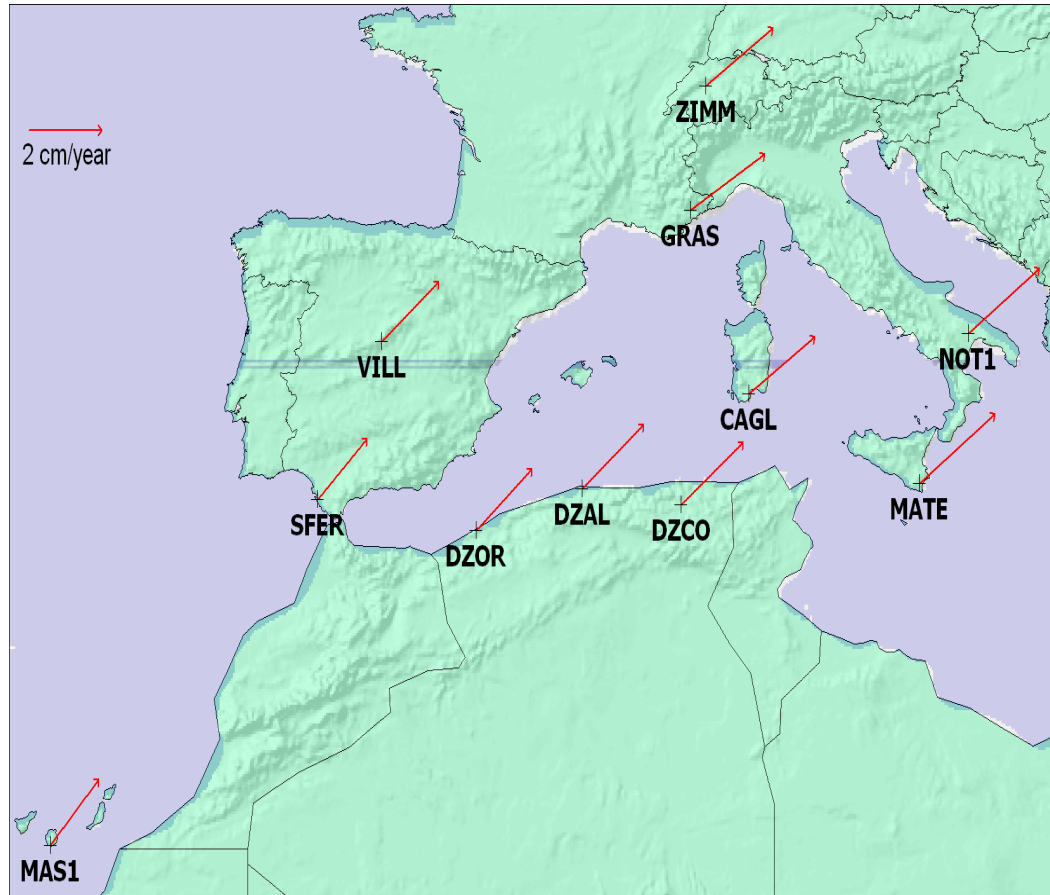
*AFREF Regional frames*

- Conducted by INCT in the NAFREF/AFREF Frame
- Receivers: ASHTECH UZ-12, choke ring with Radom NGS antenna, and ASHTECH Micro Manager
- Daily sessions in Rinex format
- Recording cadence : 30 s.



*Configuration of the geodetic permanent GPS network (3 operational stations)*

# Preliminary results



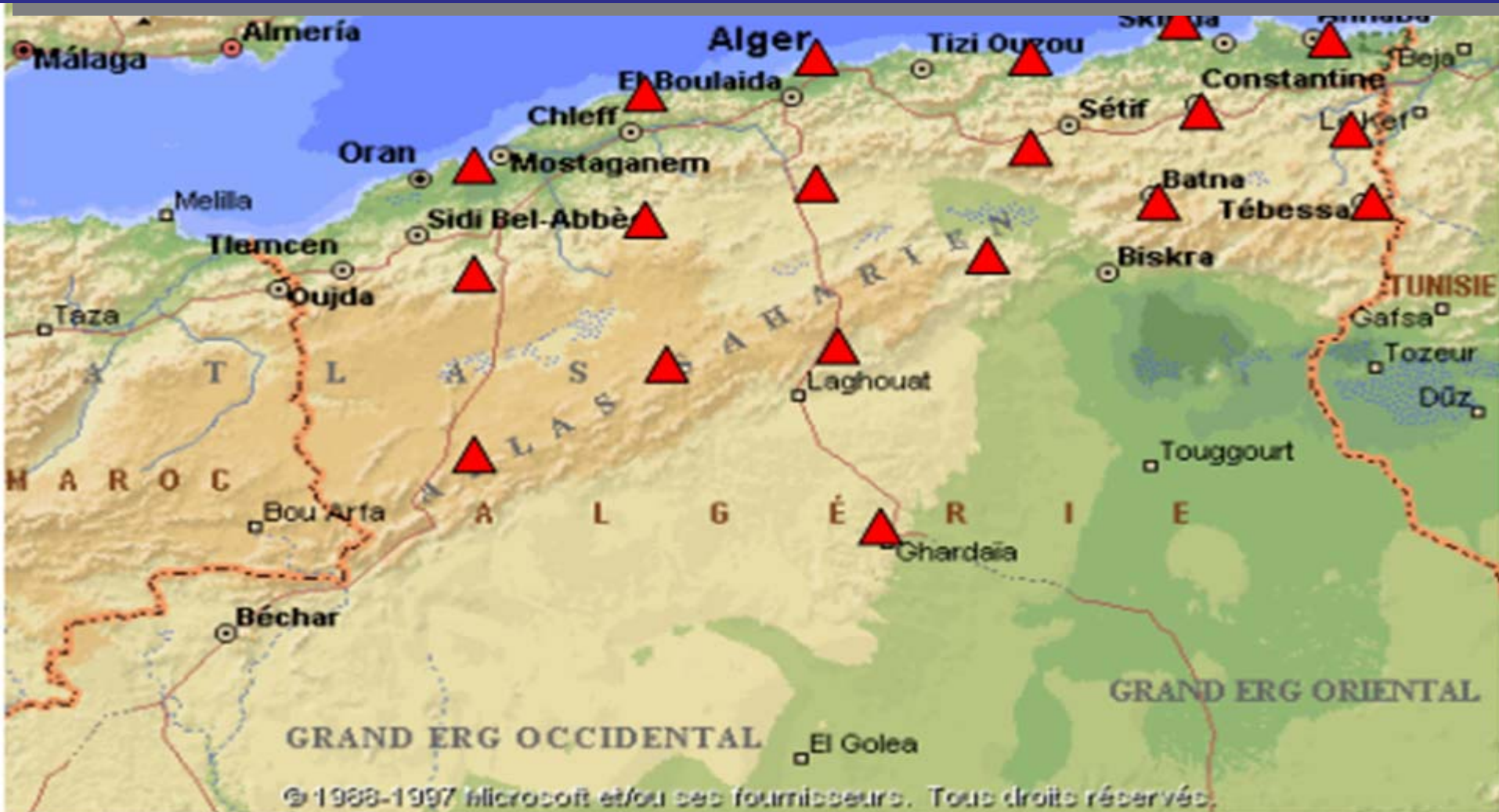
DZAL : 2.6 cm /an Nord/Est  
DZOR : 2.4 cm/an Nord/Est  
DZCO: 2.6 cm /an Nord/Est

*Displacement vectors*

*Référence: M. Haddad (Octobre 2008). Algerian Permanent GPS Network : First results. Bulletin des Sciences Géographiques, n° 22, ISSN : 1112-3745, pp. 02-06.*



# REGAT PROJECT



REGAT (REseau Gps permanent de l'ATlas) project: will be set up by the CRAAG for geodynamical aims with initially 20 GPS permanent stations at the boundary of the European/African plates and in Saharian Area (*Tamanrasset for stability*): **20** stations were installed at end of 2010, extension to **40** stations up to 2012.

# ASAL GPS PERMANENT NETWORK : 100 GPS permanent stations (Ongoing Project)



# CONCLUSION

## GNSS (GPS) applications :

- **High level accuracy** : Auscultation (mm), Geodynamics (cm)
- **Standard applications of localisation** : urban networks (2-3 cm), Real Time Positioning (DGPS: metric accuracy), RTK (2 – 5cm)

## Perspectives :

- **Dense GPS permanent network for geodynamics (more than 100 stations)**
- **EGNOS RIMS station at Tamanrasset (south Algeria)**
- **MEOSAR station**
- ***DORIS Station at Tamanrasset***

# The Future Centre of Space Techniques Oran (June 2011)

**CNTS** CENTRE NATIONAL DES TECHNIQUES SPATIALES ARZEW - ALGERIE JANVIER 2005



Division de Géodésie Spatiale

