Algerian Space Agency

Center of Space Techniques

Investigation of deformations in North of Algeria with GPS data and kinematic model

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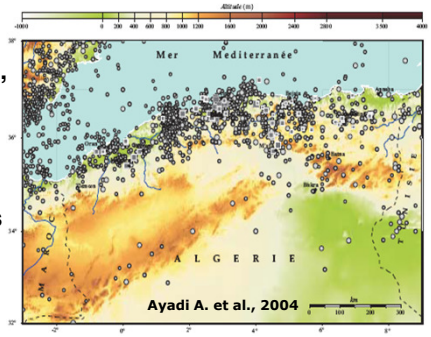
Outline

- Geodynamical Context of the North of Algeria
- GPS data processing
- Modeling by the Kalman Filter
- Results analysis
- Conclusion

Geodynamical Context of the North of Algeria

The North of Algeria, situated at the tectonic plate boundary, Particularly a complex limit of plates; it is an area with an :

- ✓ Intense seismic activity : El Asnam (54-80), M=7.3; Tipaza, M=6.0; Aïn Témouchent, M=5.8; Boumerdès (2003), M=6.8);....
- ✓ Geodynamical history of several phases
- ✓ Fast variation of the geological structures



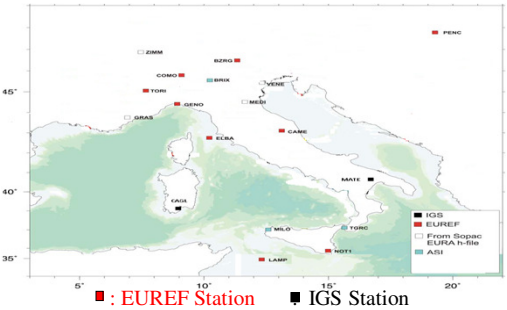
Deformation

1. A convergence motion between the African and Eurasian plates,
2. Response of the higher crust to the tractions by the influence of the forces.

In Earth science, GPS is today a very powerful tool to quantify the tectonic movements.

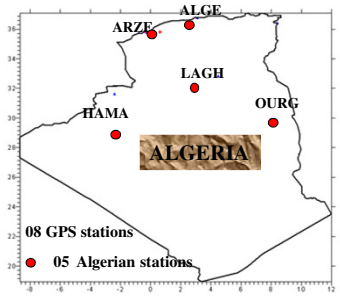
Used data for deformations analysis

Network test on Italy



■ : EUREF Station ■ IGS Station

Algerian Network (ALGEONET)



ITALY

4 Campaigns of GPS measurements : 2000, 2002, 2004, 2006

ALGERIA (ALGEONET)

2 Available campaigns : 1998 and 2001

- ➔ Occupations: 5 days
- ➔ Time window : 24 h, Sampling Rate : 30 s, Cut off angle : 15 ,
- ➔ Bifrequency Receivers.

The « Bernese » processing strategies and Kinematic deformation model with Kalman Filter

Tools and parameters of GPS data processing

- Software used : BERNESE v. 5.0 and Kalman Filter ,
- Use of IGS precise ephemeris, satellite clock corrections ,
- The ionospheric dispersion taken into account estimating a model by the L_3 (Ionsphere free) linear combination of the L_1 and L_2 observables ,
- Troposphere : Saastamoinen standard model was used ,
- Eccentricity of the phase centres reduced (orientation) ,
- Other effects (Tides,...) : Averaged over a period of 5 days of observations

Kalman Filter : it is essentially a set of mathematical equations that implement a predictor-corrector type optimal estimator that it minimizes the estimated error covariance.

KF operates by each itération two phases

⇨ Prédiction of the new state and its uncertainty

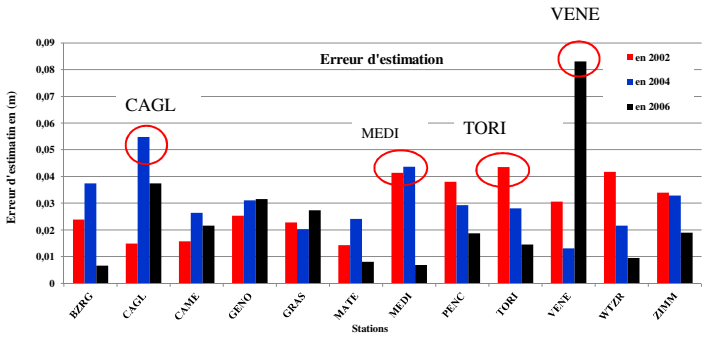
⇨ Correction with the new measurement

Analysis results with Kalman filter

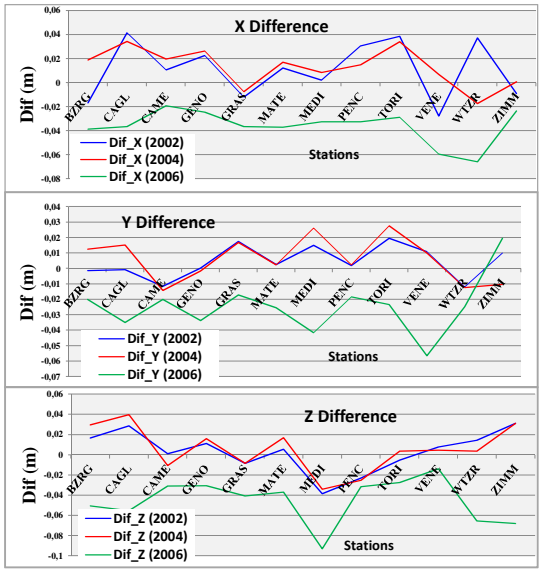
Error estimation of the state vector :

The Euclidean distance between the point determined by GPS and its correspondent by Kalman filter estimate

$$Err = \sqrt{(X_K - X_B)^2 + (Y_K - Y_B)^2 + (Z_K - Z_B)^2}$$



Validation by comparison with the reference solution (Bernese)

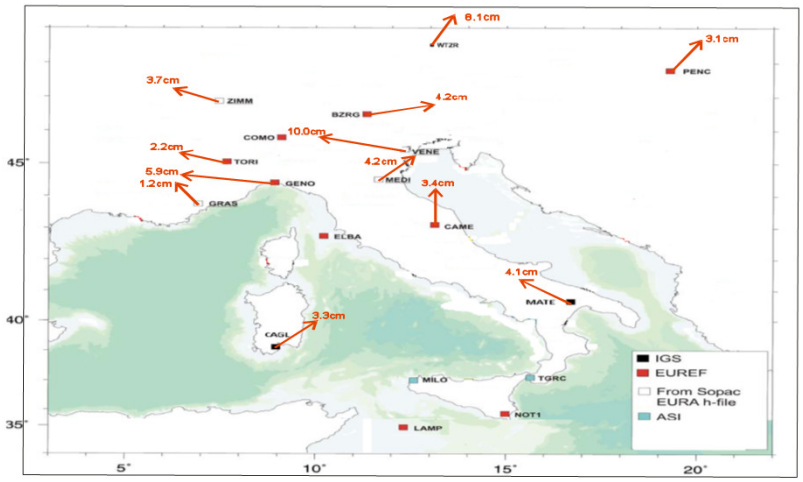


⇨ **A small difference between the coordinates obtained in 2002 and 2004;**

⇨ **Its value in X, Y and Z is a few centimeters for the total of network stations;**

⇨ **In 2006, the estimated coordinates show a significant difference essentially on selected network stations.**

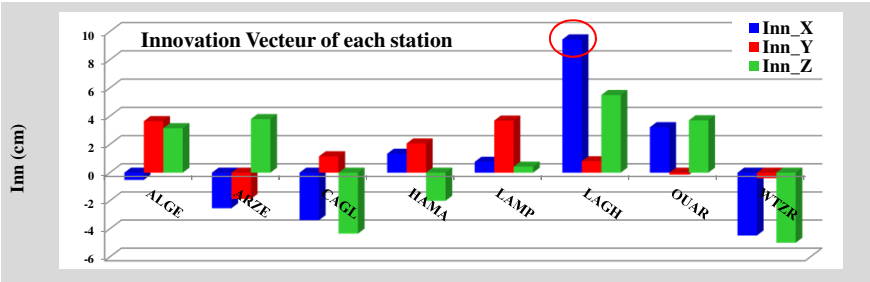
Horizontal displacement by the kinematic model between 2000-2006



➔ **Spacing of the extreme boundary of the Eurasian plate towards the North-West**

The Kalman Filter on the North of Algeria

Innovation of the 2001 period



Results :

- **Amplitudes of the innovation vector are in centimeter order, significant innovation on the station LAGH;**
- **In addition, we remark that the similarity to the CAGL and ARZE stations, and a certain confidence between the measurements performed in 2001 and predicting the state vector in the same period.**

Conclusions

- **Realization of kinematic models predictive for deformation analysis in the Northern Algeria;**
- **Define and implement a methodology for studying the deformation field on a permanent GPS network;**
- **Validate an adjustment step based on the Kalman filter technique on a relatively small number of GPS stations and data;**
- **Correlation between the displacements obtained, would provide interesting indications into the approach taken and the feasibility of applying the Kalman filter for monitoring geodynamical deformations;**