

FIG Working Week 2011
 & 6th National Congress of ONIGT
 – Bridging the Gap Between Cultures

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TS07C - Geoid and GNSS Heighting, 5231

*Comparing Global Geoids over Morocco area
 for GNSS altimetry determination*

EL Hassan EL BRIRCHI and Driss EL AZZAB, Morocco







– Bridging the Gap Between Cultures




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INTRODUCTION



Rather than classical instruments and methods for collecting spatial data, GNSS facilitate and enhance collecting time and range.

GNSS 2D positioning accuracy is well defined.

According to the receiver model, the software, the positioning Mode, the available corrections used, the 2D positioning accuracy vary from few meters to mm.

However the altimetry positioning with GNSS is less accurate than 2D one.

Without an accurate Geoid reference earth surface, the levelling survey by GNSS couldn't be done with sufficient accuracy needed for several fields of survey like construction or water management projects.

As a step in the way of computing a precise geoid surface over Morocco, the aim of this paper is to compare global geoid models especially regarding the improvement shown in the spatial determination of the gravity field during the last few years.

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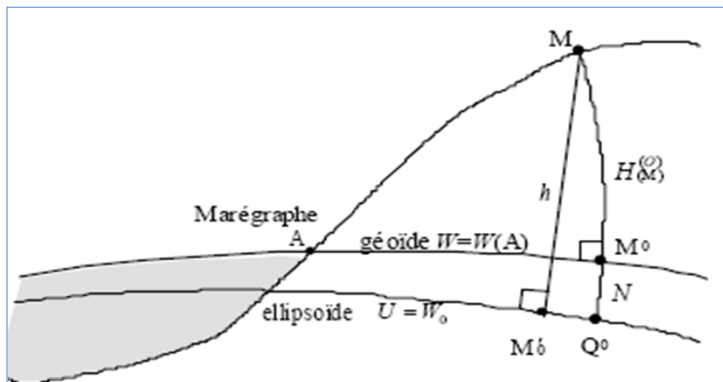
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INTRODUCTION



Source : (Dufour J.P 2001)

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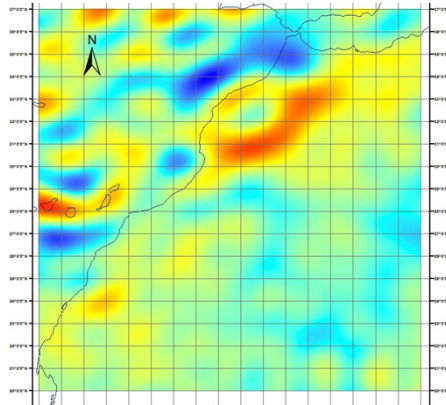
INTRODUCTION



The Study area include the Moroccan territory :

longitudes [17°W - 0°]

latitudes [17°N - 37°N].



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GEOID DETERMINATION



- Global models of spherical harmonics coefficients.

$$W(\theta, \lambda, r) = \frac{GM}{r} \sum_{l=0}^{N_{max}} \left(\frac{a}{r}\right)^l \sum_{m=0}^l (C_{l,m} \cos(m\lambda) + S_{l,m} \sin(m\lambda)) P_{l,m}(\cos(\theta)) + \frac{\omega^2 * r^2 * \sin^2(\theta)}{2}$$

$$N = \frac{T}{\gamma}$$

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GEOID DETERMINATION



- Gravimetric models based on Stokes formula

$$N = \frac{R}{4\pi\gamma} \iint_{\text{Sphere}} S(\psi) \Delta g d\sigma = \frac{R}{2\gamma} \int_{\psi=0}^{\pi} \left[\frac{1}{2\pi} \int_{\alpha=0}^{2\pi} \Delta g(\alpha, \psi) d\alpha \right] S(\psi) \sin \psi d\psi$$

$$S(\psi) = \frac{1}{\sin \frac{\psi}{2}} - 6 \sin \frac{\psi}{2} + 1 - \cos \psi \left[5 + 3 \ln \left(\sin \frac{\psi}{2} + \sin^2 \frac{\psi}{2} \right) \right]$$



GEOID DETERMINATION



- Comparing ellipsoidal height measured by GNSS and physical height measured by classical levelling allow the determination of geoid height.

$$\text{GPS / Leveling: } h_{\text{GPS}} = H^{\text{ortho}} + N$$





GEOID DETERMINATION OVER MOROCCO



Two gravimetric geoids are computed over the north of Morocco

MGG97 (Benaim et al 1997) : It is based on OSU91A (**Rapp et al 1991**) and a set of land measured free air anomaly points.

MORGE005 (Corchette et al 2007). Improvement is due to the use of EIGEN CG01C (**Reigber et al 2006**) and SRTM 90.

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SPATIAL GRAVITY MISSIONS



During the last decade three spatial gravity missions are launched in order to improve the knowledge of the gravity field. These three missions are:

CHALLENGING Minisatellite Payload (CHAMP) (Reigber et al. 1996)

Gravity Recovery And Climate Experiment (GRACE) (GRACE 1998)

Gravity field and steady-state Ocean Circulation Explorer (GOCE) (ESA 1999)

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EARTH GEOPOTENTIAL MODEL



Several Earth Geopotential Models have been computed according to the spherical harmonic development of the gravity potential.

Due to the limitation of the spatial methods some EGM included information from land measured gravity data in addition to the spatial data.

A list of these models could be found in the International Centre for Global Earth Models (**ICGEM**).

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USED DATA



In this work we compare some EGMs to Geoid heights computed from GPS/levelling data.

20 GPS/Levelling points over the study area.

GOCE geopotential models provided by the European Space Agency.

EGM96 (**Lemoine et al 1998**) developed until 360 maximum of degree and order

EGM2008 (**Pavlis et al 2008**) developed until 2160 maximum of degree and order

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USED DATA



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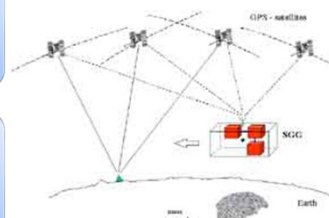
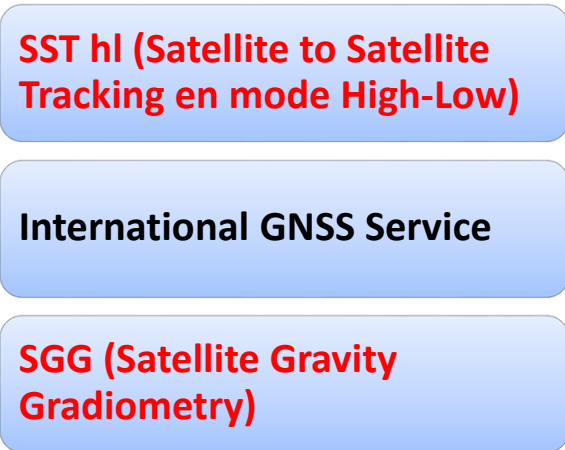
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USED DATA



Source : ESA



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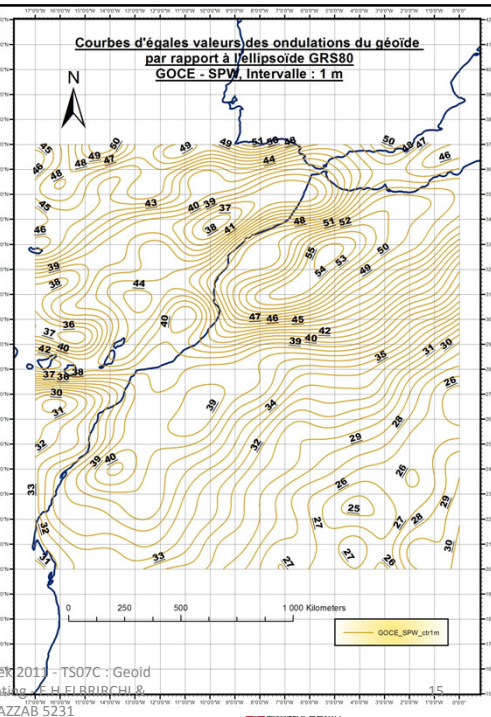


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RESULTS

- Contour Map for geoid height above GRS80 computed from GOCE Geopotential Model (Interval 1 m) (Source: EL BRIRCHI & EL AZZAB 2011)



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RESULTS



| | | GOCE (degree and order 201) | EGM2008 | EGM96 |
|--------------------|------------------------|--------------------------------|---------|-------|
| Mean | Total of the 20 points | 0,25 | 0,30 | 0,22 |
| Minimum | | -0,58 | -0,35 | -0,48 |
| Maximum | | 0,80 | 0,72 | 0,52 |
| Variance | | 0,08 | 0,06 | 0,07 |
| Standard Deviation | | 0,29 | 0,24 | 0,27 |

Statistics of results of comparing Geoid heights from EGMs and GPS/levelling

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RESULTS

| | | GOCE (degree and order 201) | EGM2008 | EGM96 |
|-----------------------|---|-----------------------------------|---------|-------|
| Mean | 10 points for the region of Casablanca | 0,228 | 0,295 | 0,329 |
| Minimum | | 0,148 | 0,269 | 0,175 |
| Maximum | | 0,335 | 0,350 | 0,478 |
| Variance | | 0,005 | 0,001 | 0,011 |
| Standard Deviation | | 0,070 | 0,024 | 0,104 |

Statistics of results of comparing Geoid heights from EGMs and GPS/levelling

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CONCLUSION

The choice of better global geoid for all the area of Morocco couldn't be done unless we use GPS/levelling points over all the study area.

Results obtained for the region of Casablanca show that EGM2008 could be used for levelling by GPS.

It is also possible because of smooth topography in this region.

New EGMs enhance considerably the determination of long and medium wavelength over Morocco.

More tests are necessary to confirm the choice of EGM2008 especially in mountainous regions in Morocco where terrain effects should be taken into account.

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