



SATELLITE DERIVED BATHYMETRY (SDB)

***Precautions to be taken when using SDB
in support of Maritime Delimitations***

SUMMARY

1. SDB current status
2. SDB models: Sambuca, ALUTs, Bomber, etc.
3. Applying SDB in Africa surf zones
4. Calibration and atmospheric corrections
5. Controls and field surveys
6. Tidal observations
7. Precision and final results
8. ARGANS / EOMAP challenge
9. Precision and final results
10. ITLOS views and arbitration

1. SDB CURRENT STATUS

- Since 1999, SDB is based on depth-log attenuation and Lee et al. physics based equations (1999) involving the absorption a , the scattering b , and the bottom reflectivity ρ

$$\boxed{L = f(Z_{a, b, \rho})} \quad \text{or} \quad \boxed{Z = f^{-1}(L_{a, b, \rho})}$$

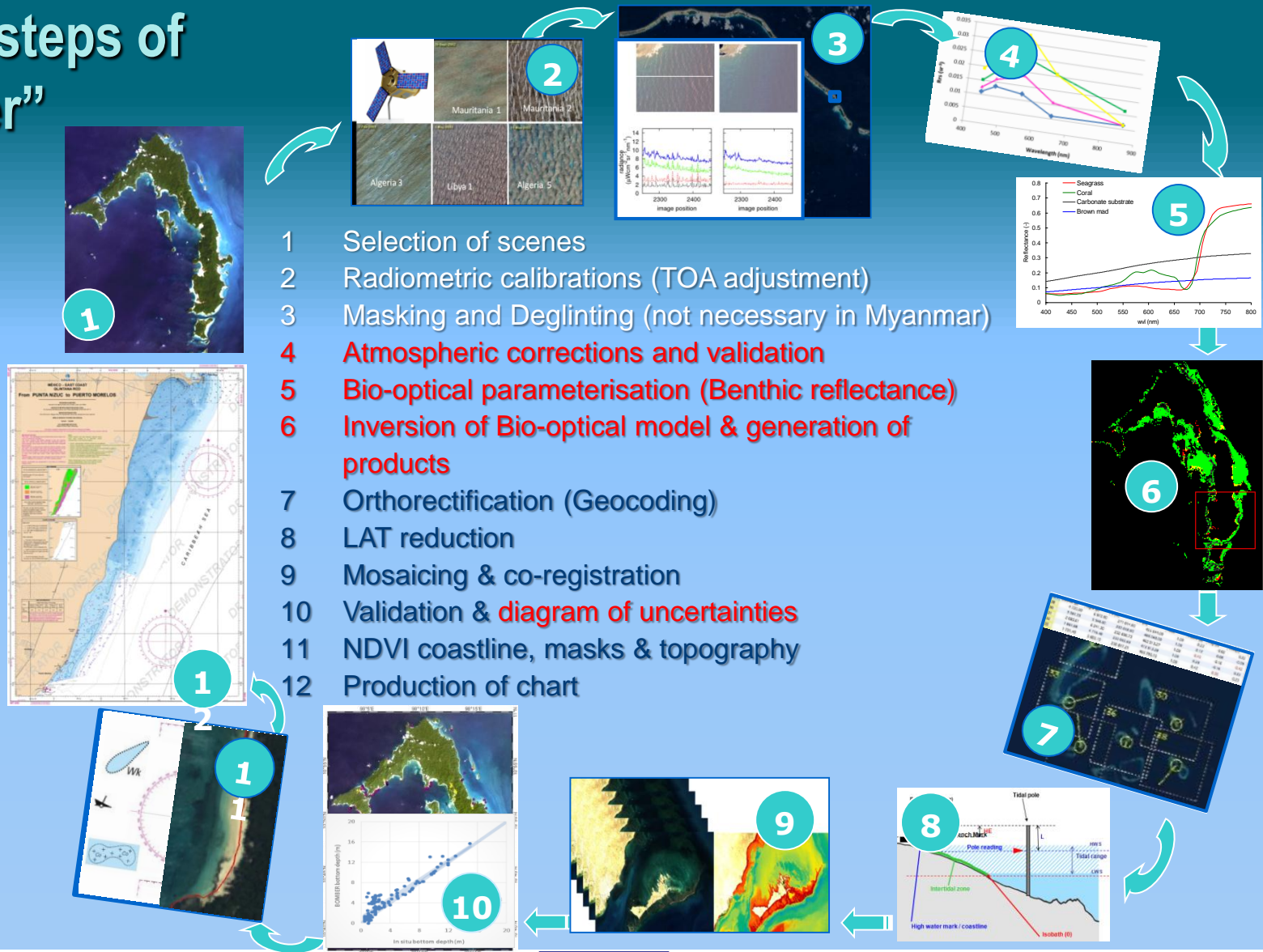
Lyzenga Forward model Lee et al radiance inversion model

- Several models have been developed since; some are better performing than others, but all yield similar results.
- HOs are reluctant to implement SDB, which they find unreliable and insufficiently proven and invest little in R&D.
- Laboratories are confident but are not specially interested in reaching the cartographic world and meeting the IHO standards.
- Access to satellite images has improved significantly (Cal/Val, Big Data, HPC, frequent revisit, cost).

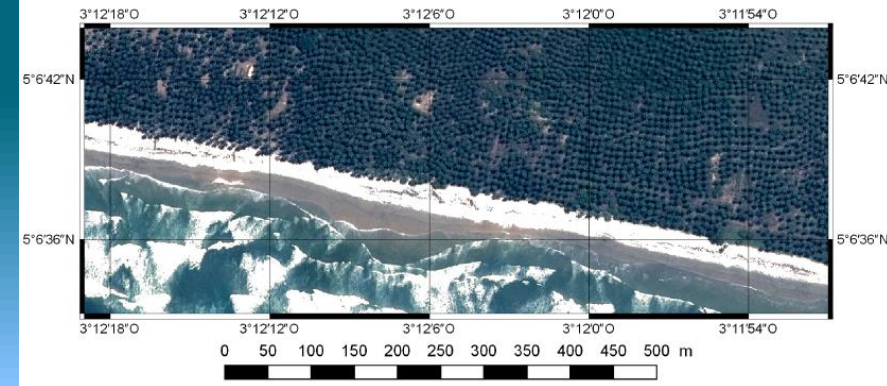
2. SDB MODELS: SAMBUCA, ALUTs, BOMBER, etc.

The 12 steps of “Bomber”

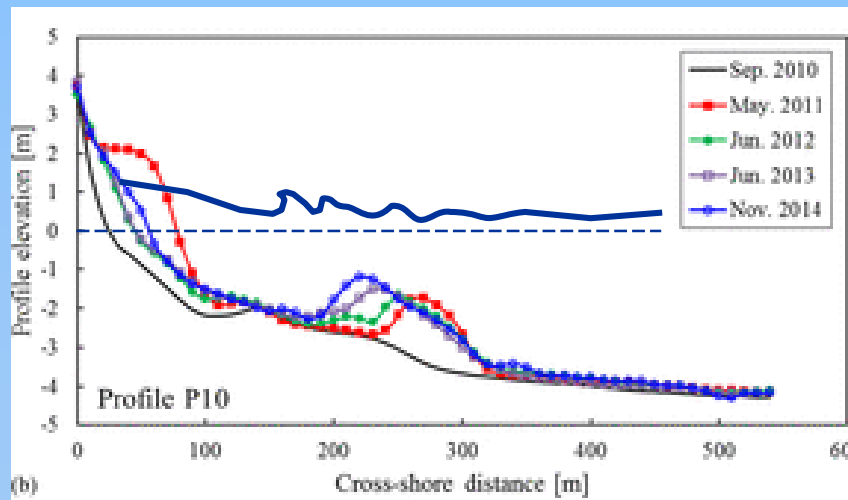
Most models are inspired by the CSIRO original



3. APPLYING SDB IN AFRICA SURF ZONES



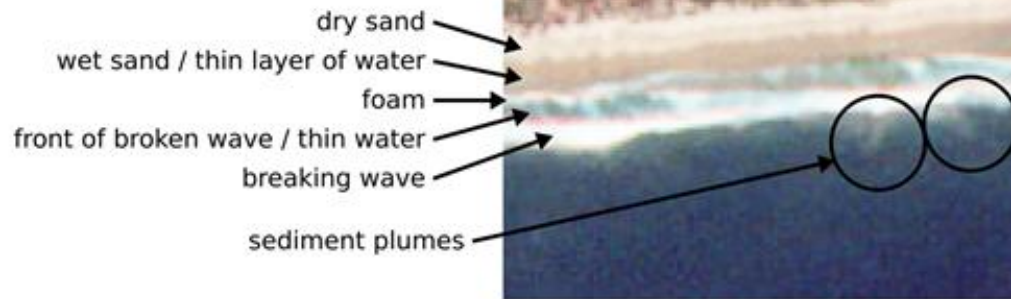
Ivoirian surf zones



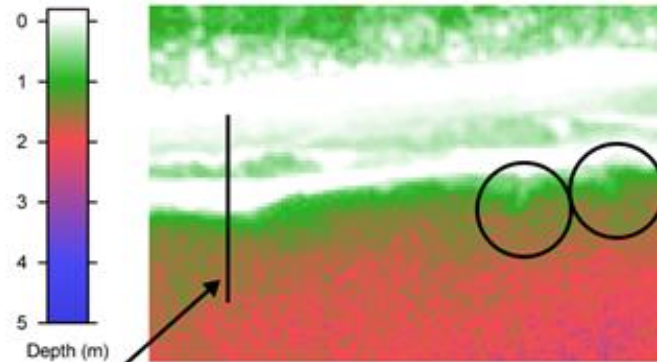
Cross-shore profiles

- Full physics based SDB processing is used to determine profiles, not depth layers
- Between highly reflective foam bands, valid bathymetry can be retrieved
- Sediment plumes are detected by visual inspection
- Beach slope starts at the first point at which $Z > 0$
- Most reliable depths are found behind the breakers
- No glint removal, no spatial filtering, independent pixel processing \Rightarrow pixel to pixel analysis can be noisy
- Ground truth is essential to post-calibrate the model

(a) Composition of beach profile



(b) Bathymetry estimation

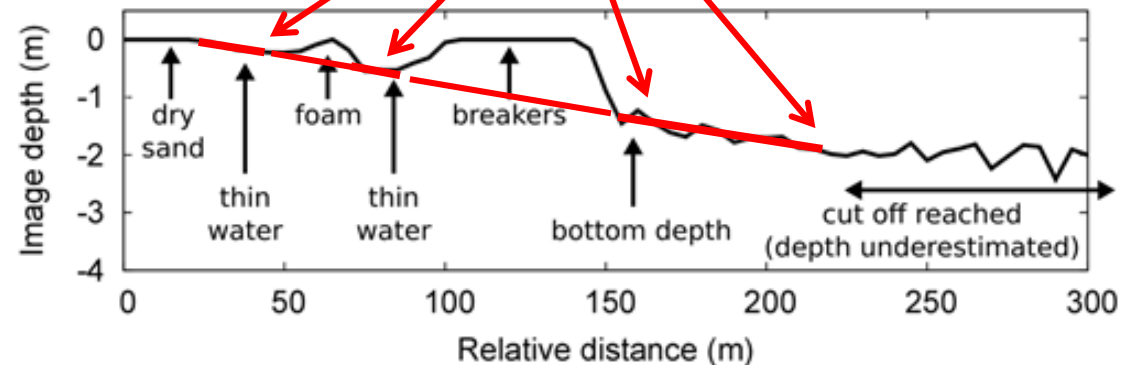


(c) Typical profile from beach to offshore avoiding sediment plumes

Avoiding sediment plumes and foam

valid depths

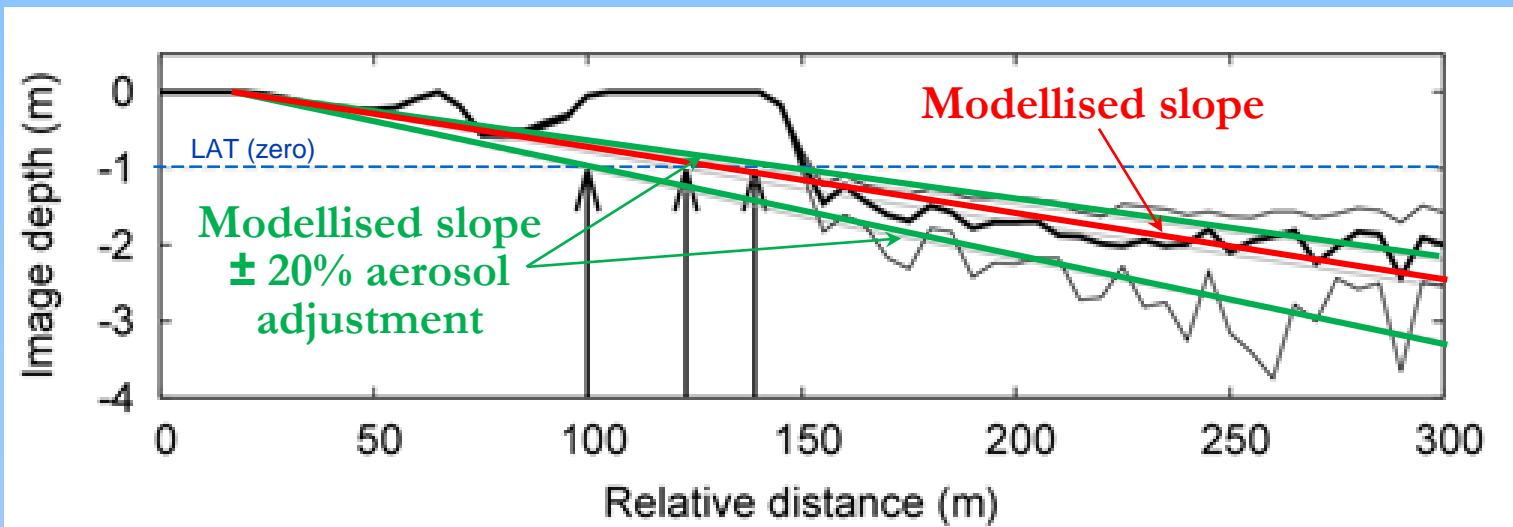
Estimation of slope



4. CALIBRATION AND ATMOSPHERIC CORRECTIONS



Aerosols generated by breakers



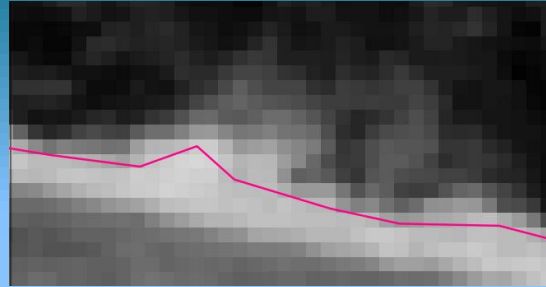
Influence of aerosol optical thickness

5. CONTROLS AND FIELD SURVEYS

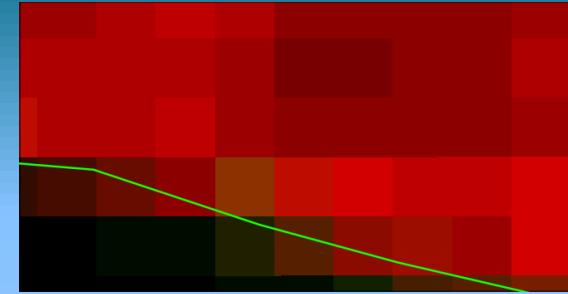
➤ Optimisation of satellite images



Pleiades (Pixel 0.5 m)

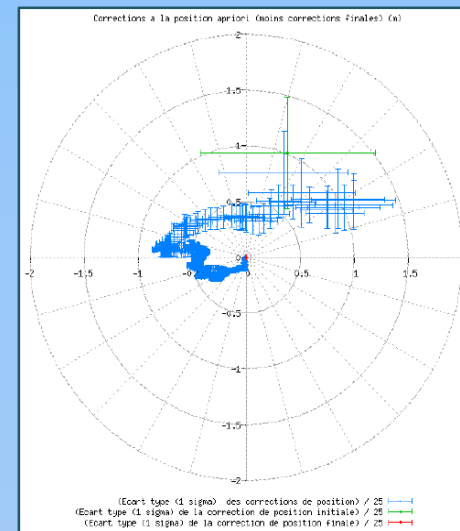


Spot 1 (Pixel 20 m)

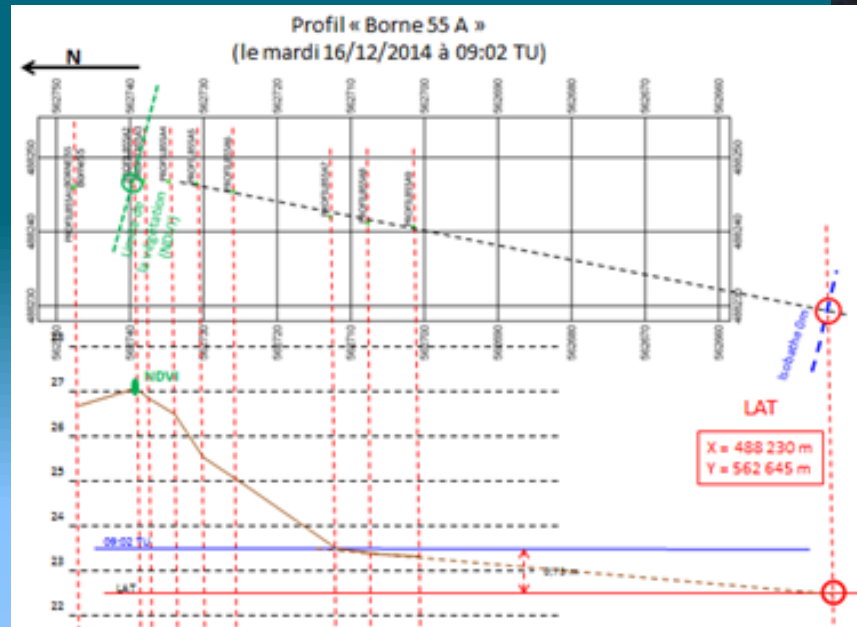


Spot 5 (Pixel 5 m)

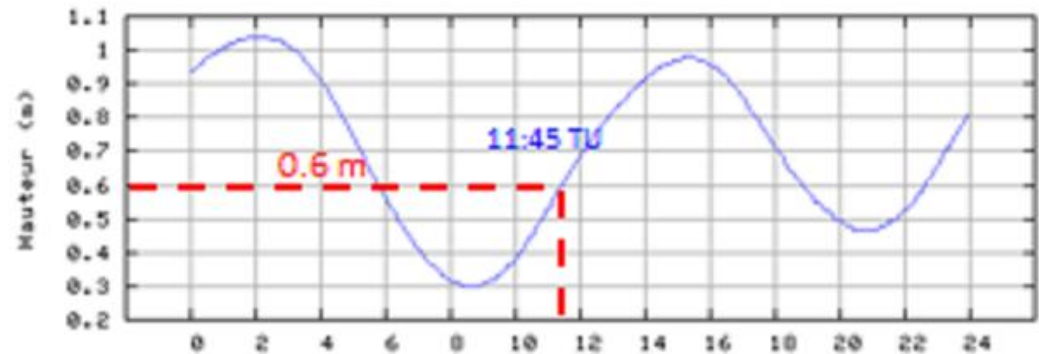
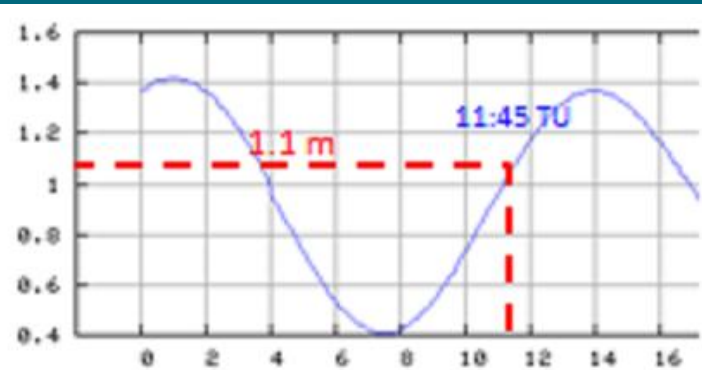
➤ Professional geodetic determinations



Determination of beach profiles and image setting by traditional topographic surveys



6. TIDAL OBSERVATIONS



Sassandra and Abidjan predicted tides (SHOM tide tables, although Admiralty tide tables could do)

- Field observations must be reduced to the LAT
- Predicted tides should be sufficient
- However an even better precision can be obtained by observing water level at local tide stations

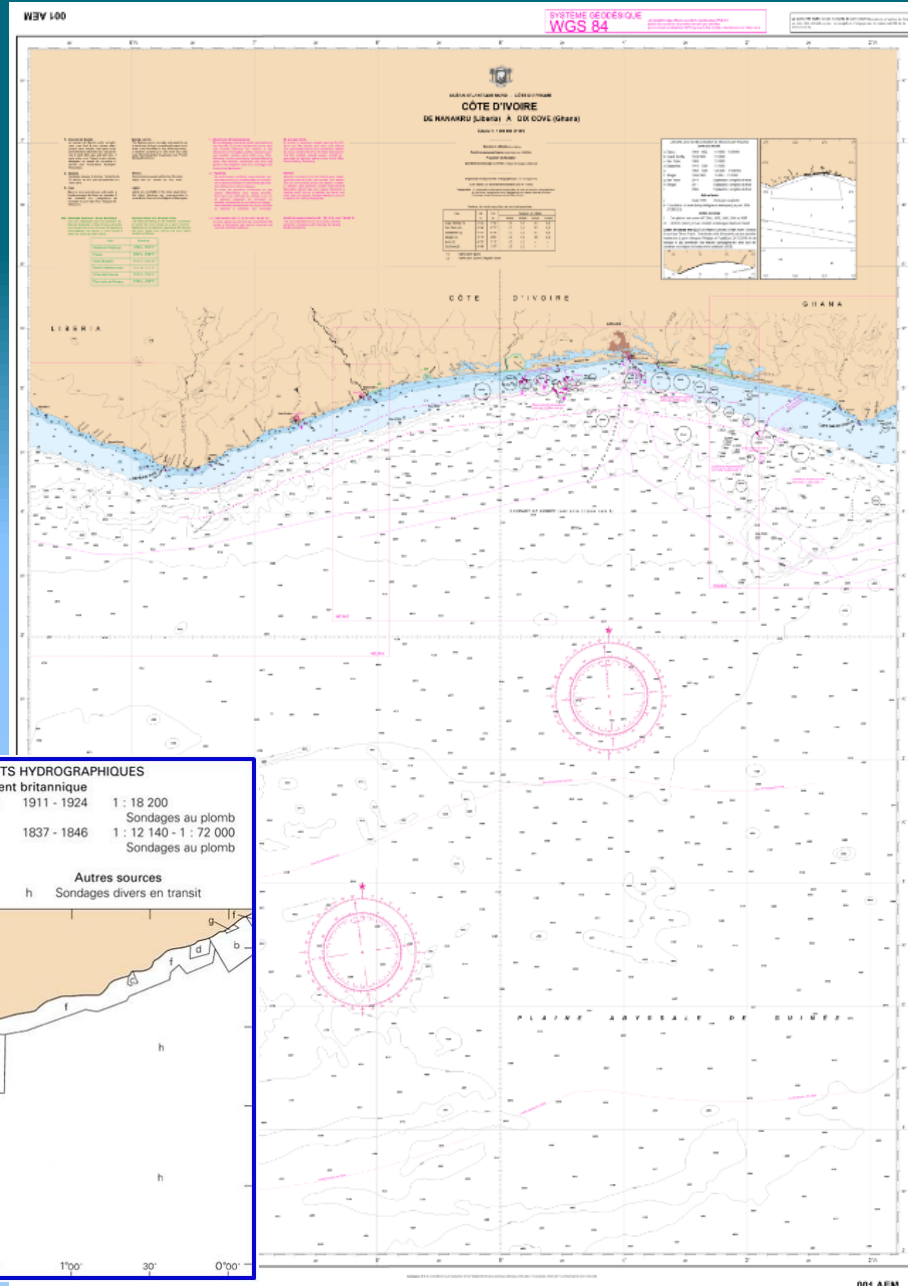
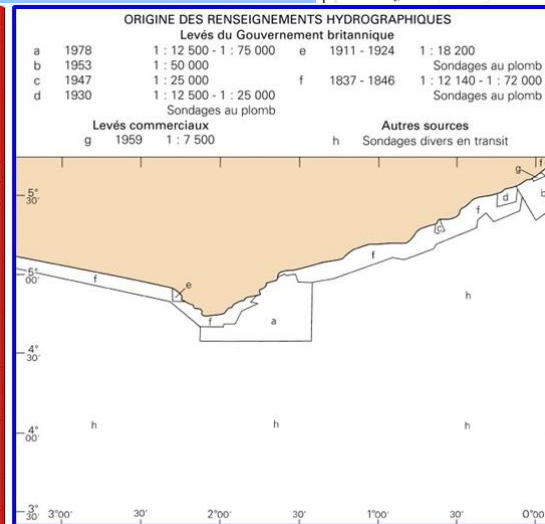
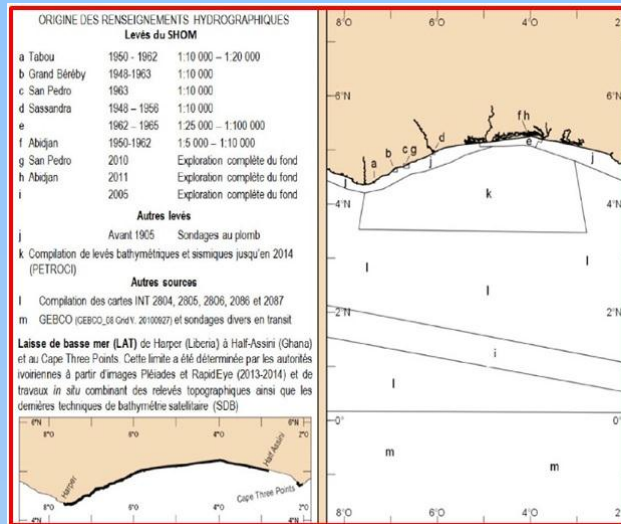
7. PRECISION AND FINAL RESULTS

Precision of baseline:

± 5 m with Pleiades image (Cote d'Ivoire)

± 10 m with RapidEye images

± 15 m with RapidEye images, without ground control (Ghana)



8. ARGANS / EOMAP CHALLENGE

According to EOMAP:

- SDB is not applicable due to the turbidity
- ARGANS did not provide the full data as required
- All ARGANS results challenged (charts, beach profiles, baselines, tides, etc.)

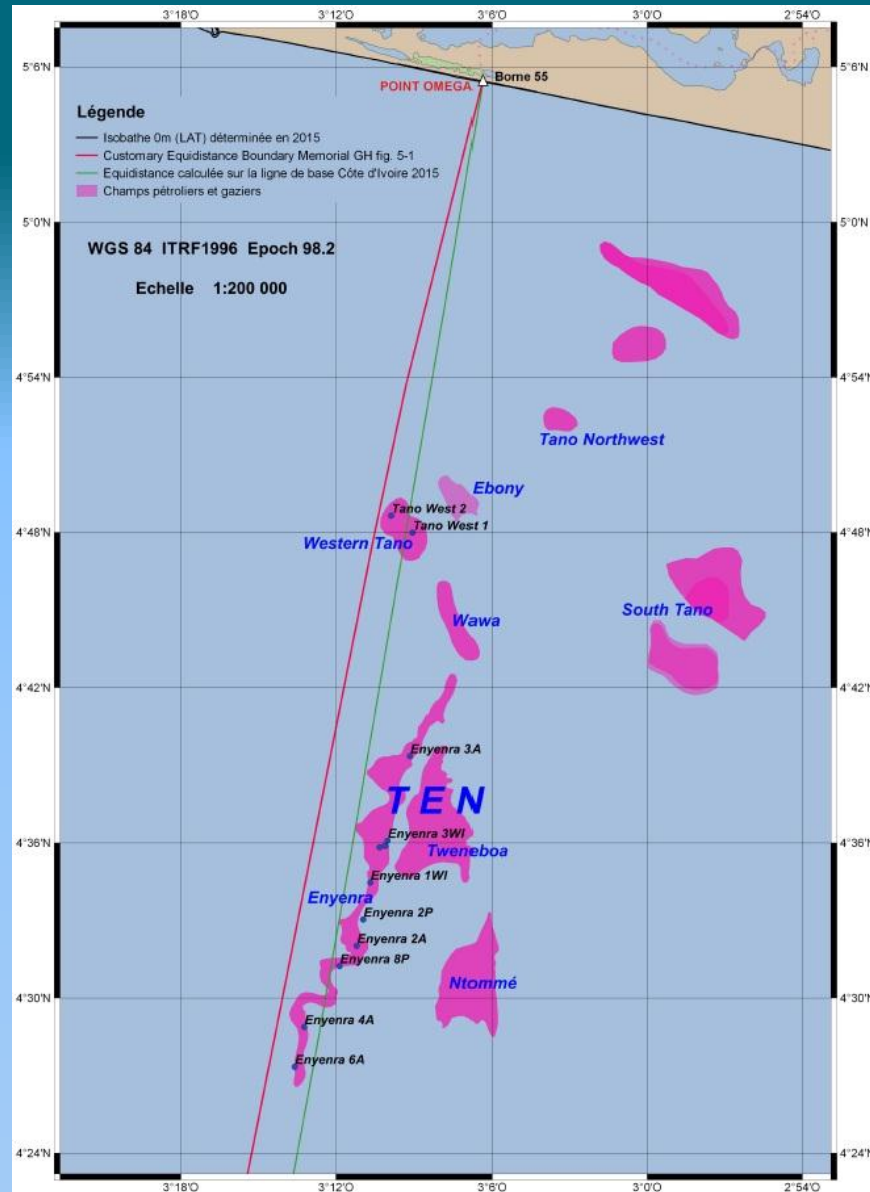
According to ARGANS:

- The operators were all experienced Cat A FIG/IHO
- SDB has been validated and field-proven
- Because of lack of ground controls, EOMAP's images and conclusions are irrelevant

9. ITLOS VIEWS AND ARBITRATION

- Although more recent and precise, the Cote d'Ivoire chart is discarded as it would create two equidistances.
- Using an 1837 coastline was not discussed as the INT chart series BA 1383 / SHOM 7786 were used by both Parties until 2014.
- ITLOS calculated a simplified equidistance based on INT chart.
- The Court neither objected, nor approved the validity of SDB.
- The Court did not address the EOMAP/ARGANS challenge.
- All other Cote d'Ivoire relevant circumstances (concavity, Jomoro dog's leg, coastal instability, consequences on Togo/Benin delimitations, location of hydrocarbons) have been rejected.
- Apart legal issues (Estoppel...) of no practical consequences, Cote d'Ivoire loses all chances to gain access to the oil fields.

OBJECT OF THE EXERCISE



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KLH

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Any Questions?