SDB DEVELOPMENTS

seen from an R & D perspective

Foreword

ARGANS Ltd. is a British SME, specialised in Earth Observation (EO). Its main client is the European Space Agency (ESA) for whom it has developed among other tasks a number of applications for **sensors calibration & intercalibration** and **data validation algorithms**.

ARGANS has been tasked by its parent company, the French Group ACRI, to focus on SDB Research & Development in co-operation with a British scientist, Dr John Hedley, who is a world specialist in Marine habitats and the transmission of light from the Top of the Atmosphere (TOA) to the Bottom of Atmosphere (BOA) and shallow waters.

By associating Physicists and Hydrographers, the SDB team aims at completing the physics-based model with a conclusive application to nautical charting. Its goal is to achieve compliance with the S-44.

www.argans.co.uk

1. An IHO Priority:

'Our seas and waterways are yet to be fully charted'

e.g. Madagascar…

Survey Information / Information sur les levés

[Home] [Nautical Charts] [Nautical Charts Notes] [Surveys] [Maritime Safety Information] [GMDSS]

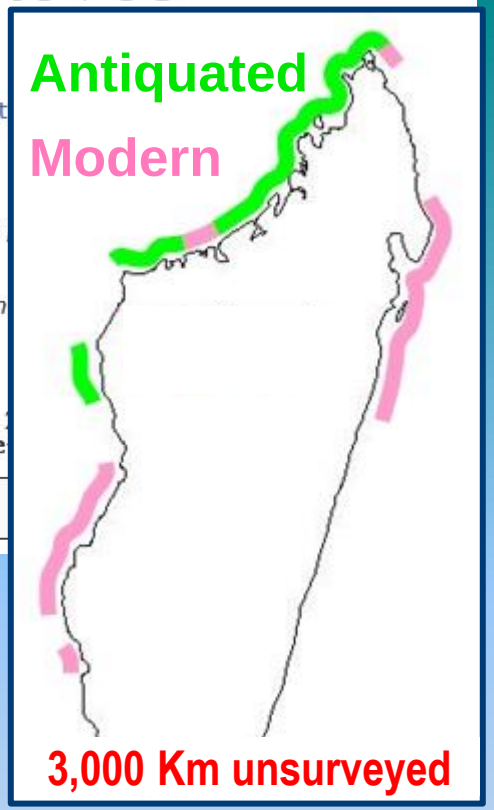
[Accueil] [Cartographie marine] [Notes sur la cartographie marine] [Levés hydrographiques] [Renseignement

Survey percentages (%) for the following depth ranges in metres (m);

- **0-200 Adequate** = *adequately surveyed between 0 to 200 m.*
- **0-200 Re-survey** = *requires re-survey at larger scales or to modern standards in depths of 0 to 200*
- **0-200 No-survey** and **200+ No-survey** = *never been systematically surveyed.*
- **200+ Adequate** = *adequately surveyed in depths greater than 200 m.*
- **200+ Re-survey** = *requires re-survey at larger scales or to modern standards in depths greater than*

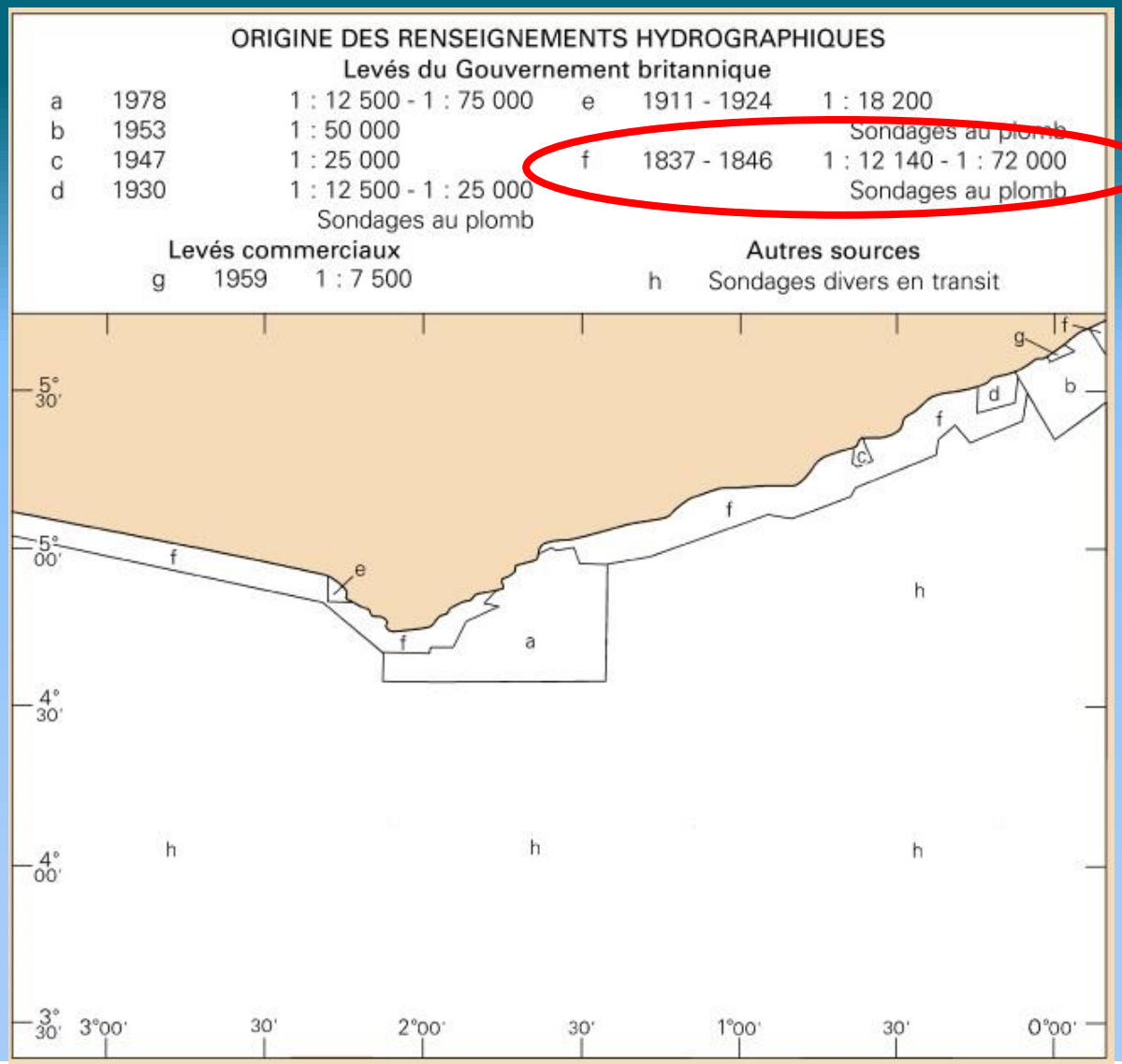
Show 100 entries

Country	INT Region	0-200 Adequate	0-200 Re-survey	0-200 No-survey	200+ Adequate	200+ Re
Madagascar	H	1	0	99	12	0



…or Western Africa

(this is a diagram of sources of a 2016 INT chart)



2. What is Satellite Derived Bathymetry (SDB)?

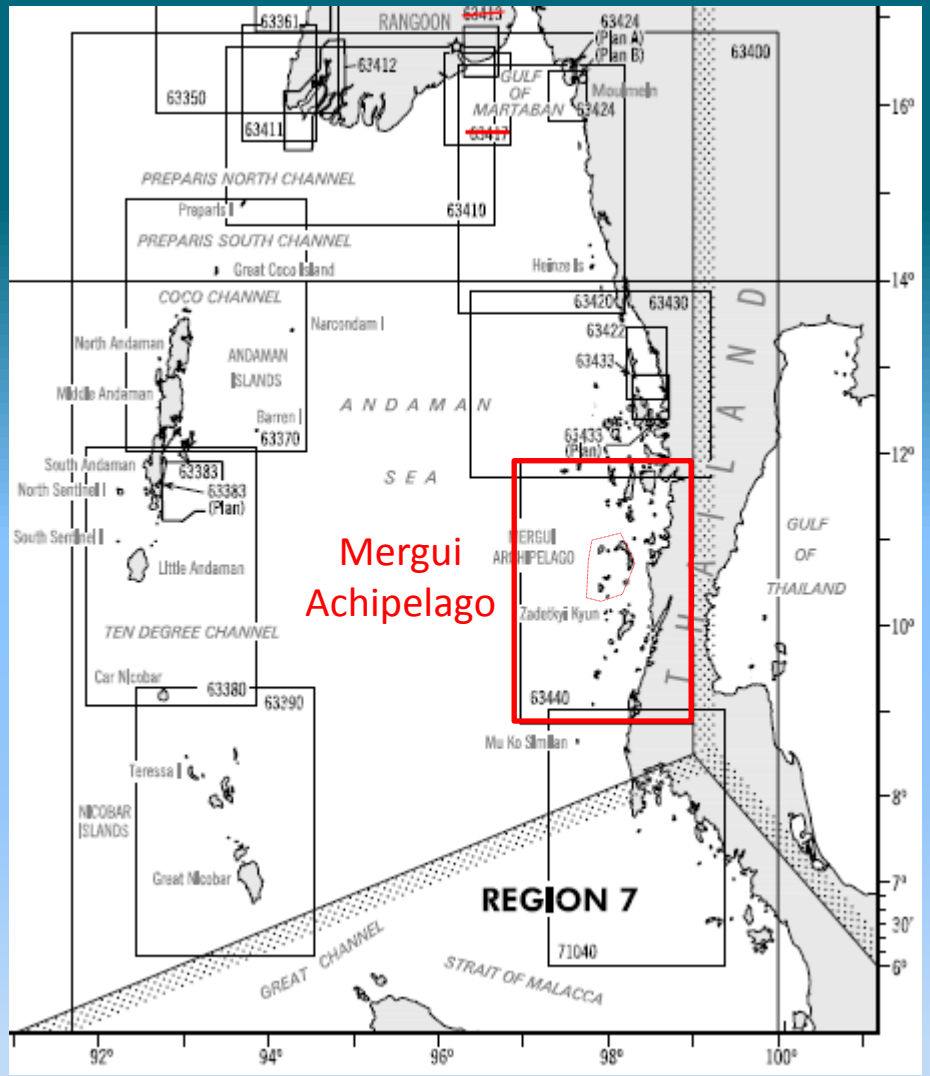
The basic equation of radiance linking the "brightness" or Luminance L, i.e. the quantity of energy received by the satellite sensor, and the depth is a function with a **logarithmic declining shape**, involving the absorption a, the scattering b, and the bottom reflectivity ϱ :

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

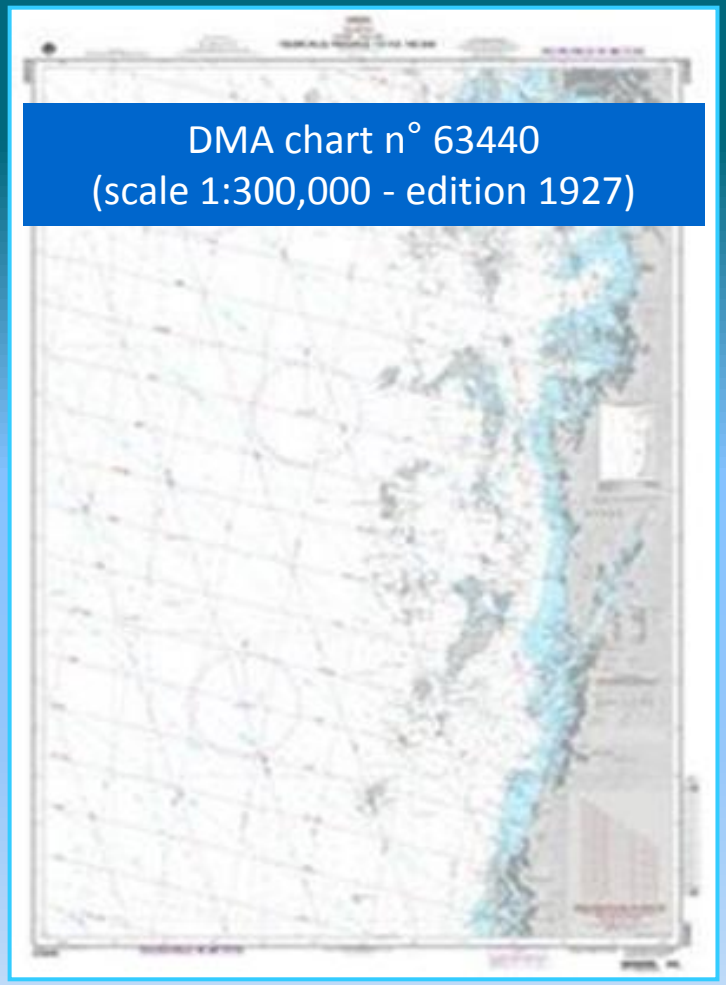
(For more details and equations, refer to the SHOM presentation.)

In short, there are 2 methods, the **Empiric** (Lyzenga) and the **Physics-based** (Lee & al.). From then on, developing the best model amounts to a recipe. Dr Hedley uses LUTs (faster & yield error-bars) but in the frame of the ESA Sen2Coral project ARGANS is now about to test in Myanmar the "Bomber" model, originally developed in lakes and based on the CSIRO (Oz) "Sambuca". Final outputs are expected to be similar.

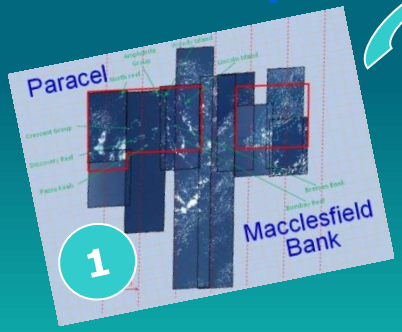
SDB to replace vintage chart of the Mergui Archipelago

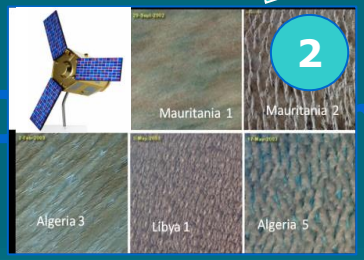


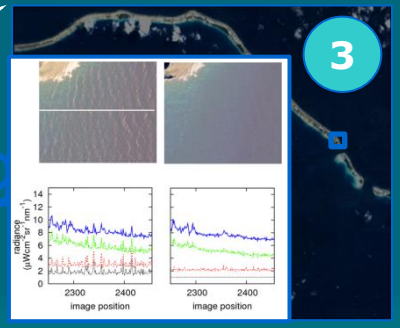
DMA chart n° 63440
(scale 1:300,000 - edition 1927)

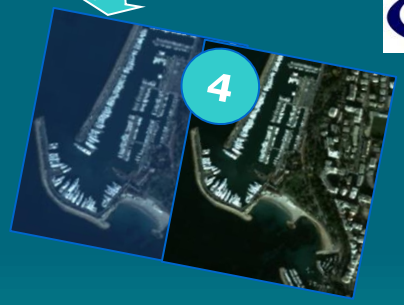


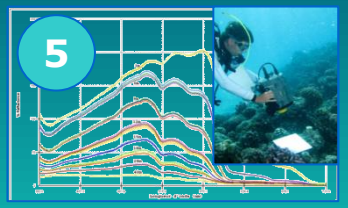
The 12 steps of SDB processing



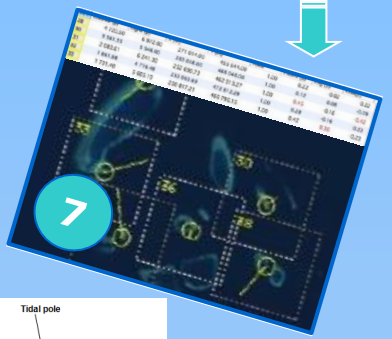


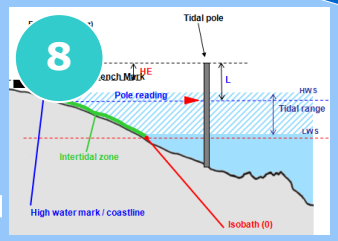


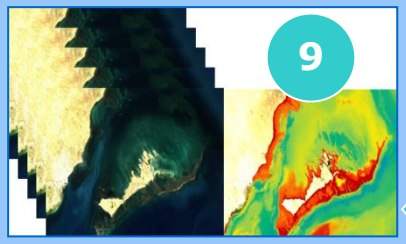


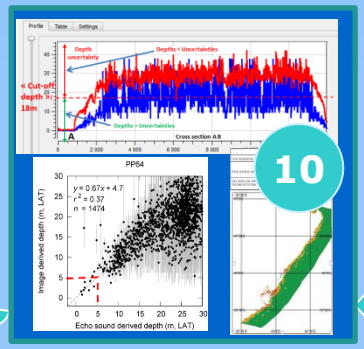


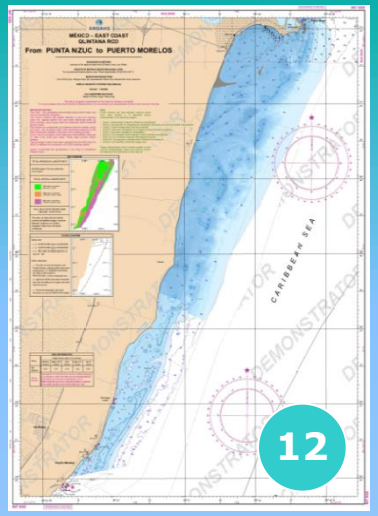
1 Selection of scenes
2 Radiometric calibrations
3 Deglinting
4 Atmospheric corrections
5 Spectrometric calibrations & LUTs
6 Inversion (ALUTs & bathymetric modelling)
7 Orthorectification
8 LAT reduction
9 Mosaicing & co-registration
10 Validation & diagram of uncertainties
11 NDVI coastline, masks & topography
12 Production of chart



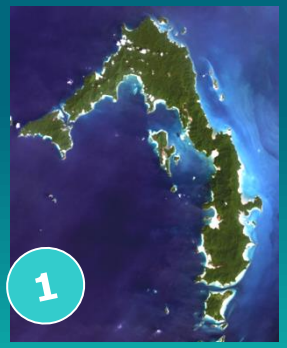


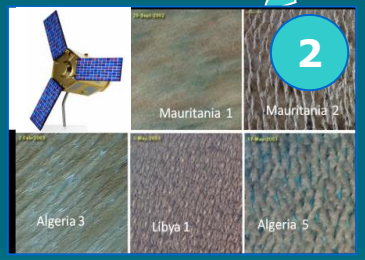


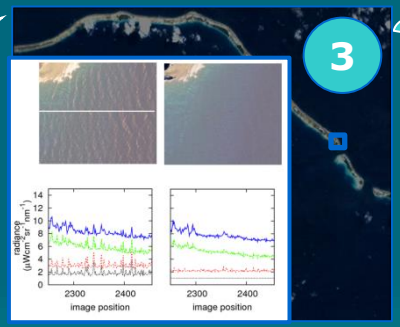


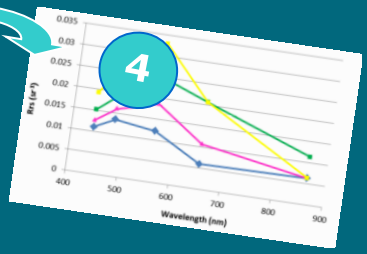


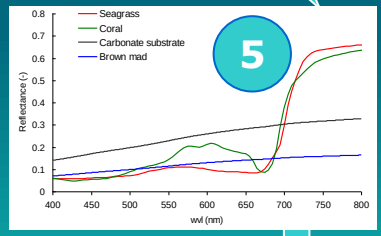
The 12 steps of "Bomber"



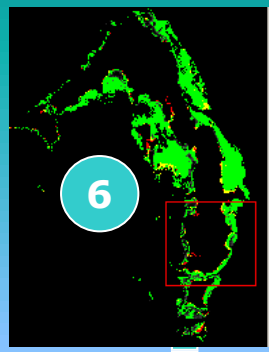


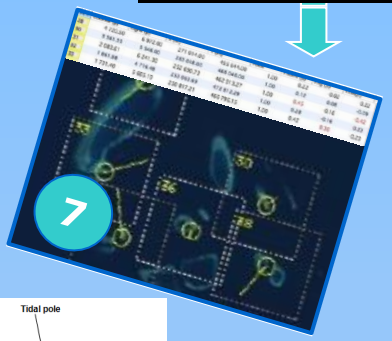


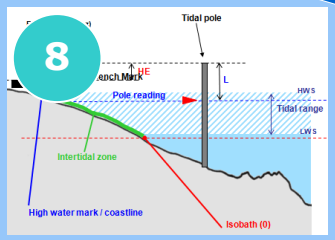


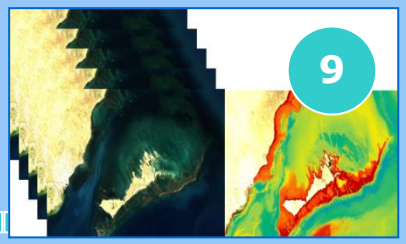


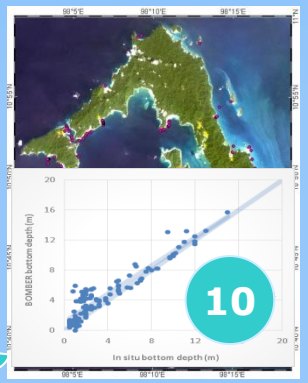
1 Selection of scenes
2 Radiometric calibrations (TOA adjustment)
3 Masking and Deglinting (not necessary in Myanmar)
4 Atmospheric corrections and validation
5 Bio-optical parameterisation (Benthic reflectance)
6 Inversion of Bio-optical model & generation of products
7 Orthorectification (Geocoding)
8 LAT reduction
9 Mosaicing & co-registration
10 Validation & diagram of uncertainties
11 NDVI coastline, masks & topography
12 Production of chart

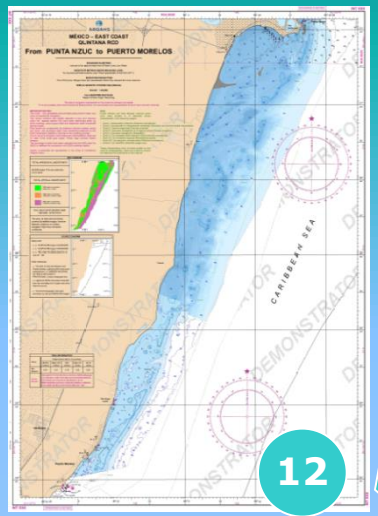








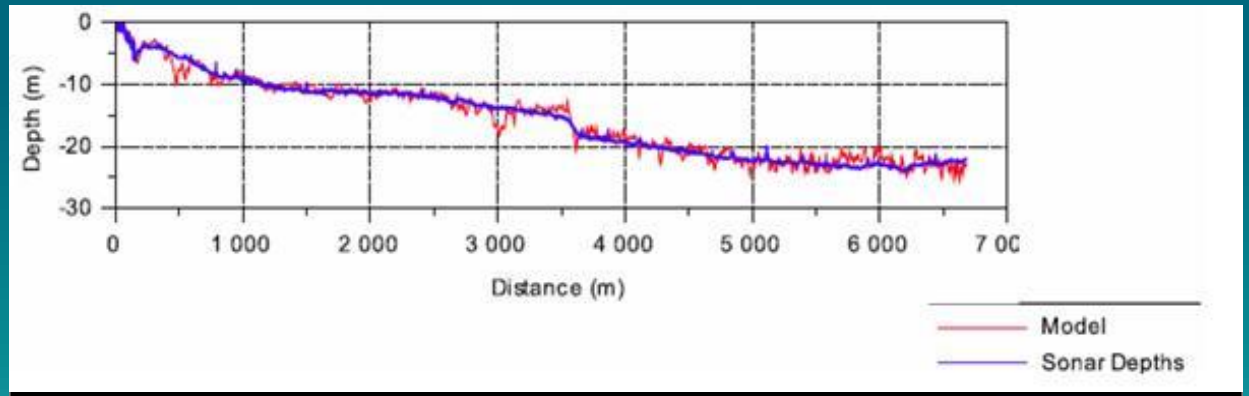


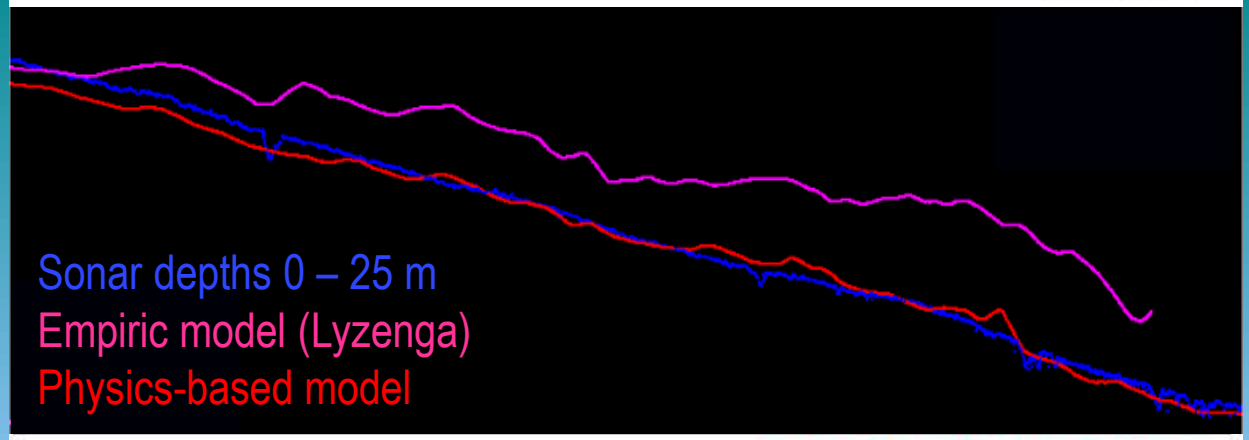


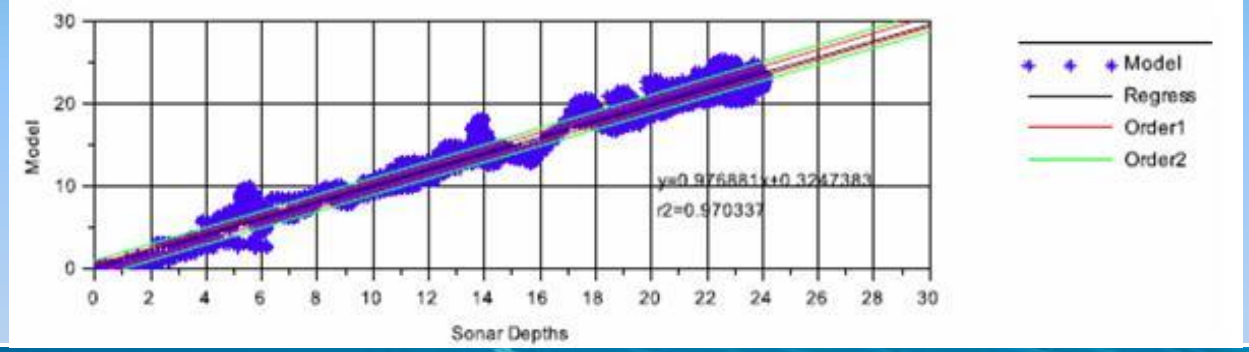
ARGANS

3. ARGANS test sites

4. Performances

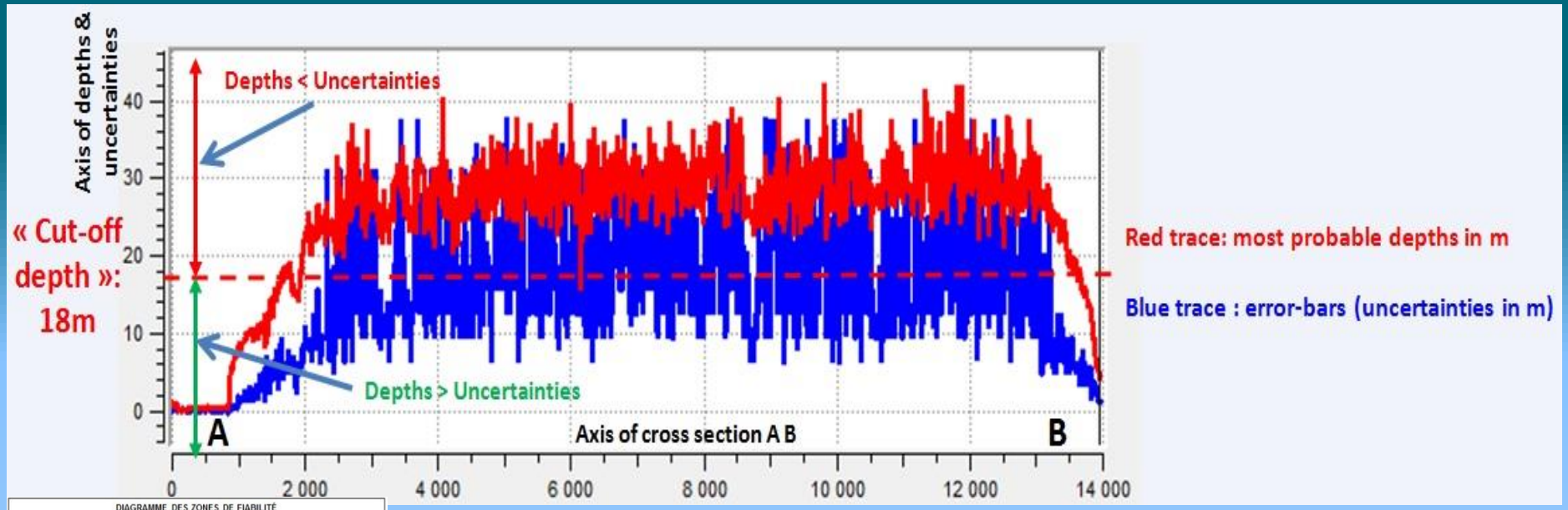


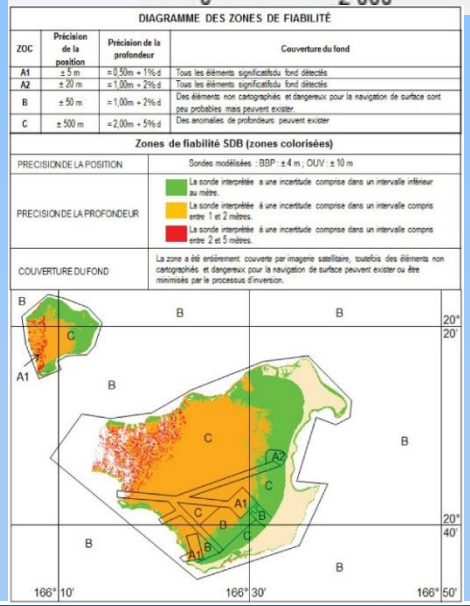




- Optimal model performances require suitable environment.
- The effect of giving preference to HR images is still to be fully investigated.
- Free, short revisit time satellites such a Sentinel 2 might offer better value-for- money solutions.

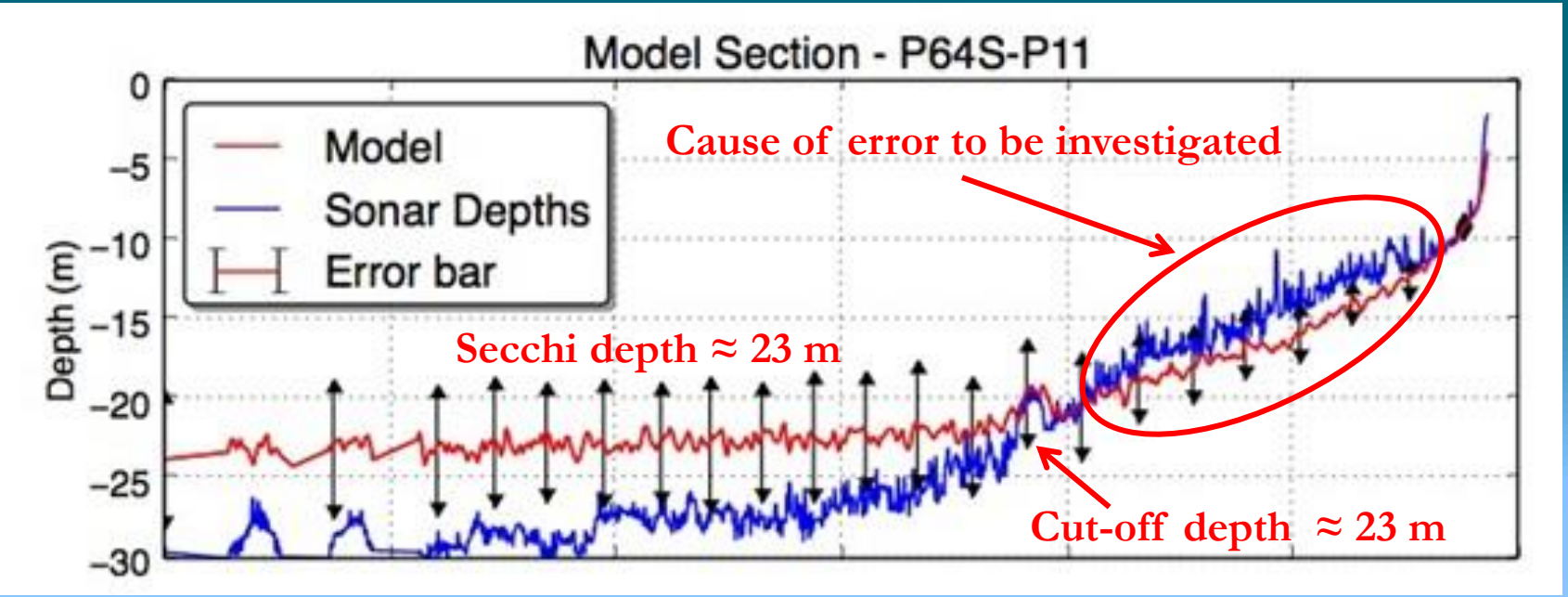
5. Uncertainties and validation





- Each pixel is associated with an uncertainty.
- Water optical properties help determine "cut-off" depths above which data can be validated.
- When the data have been validated, uncertainties can be plotted on the chart's uncertainty diagram.

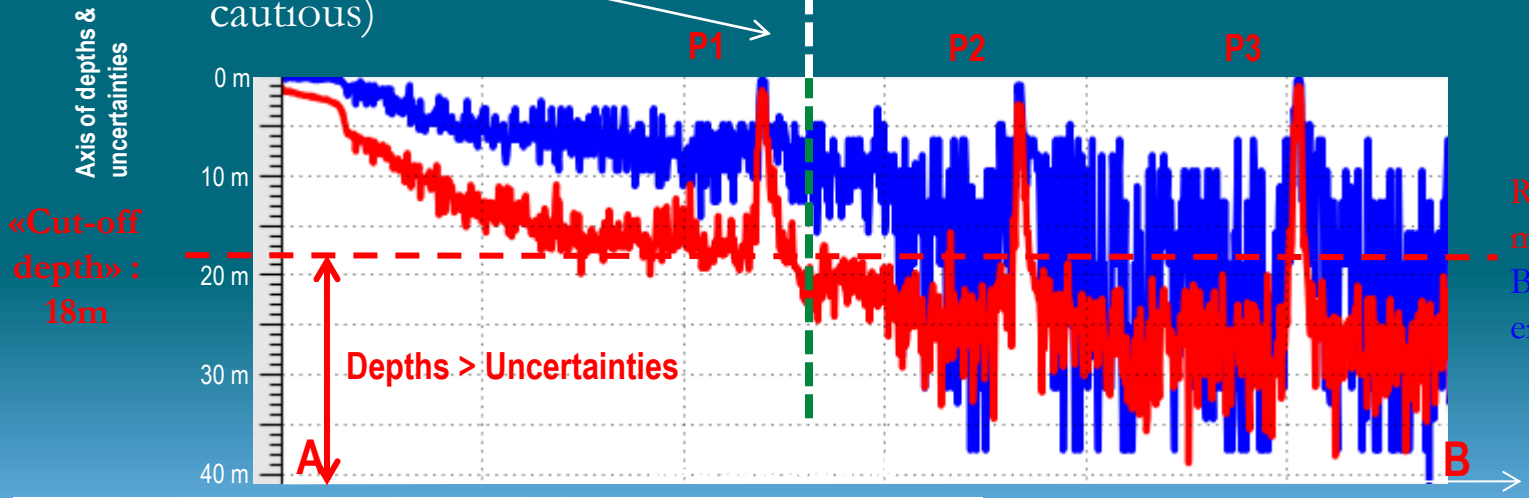
Challenge by Hydrographers can lead to improvements, e.g. SHOM: "*error bars and sonar depths split at 12 m*"

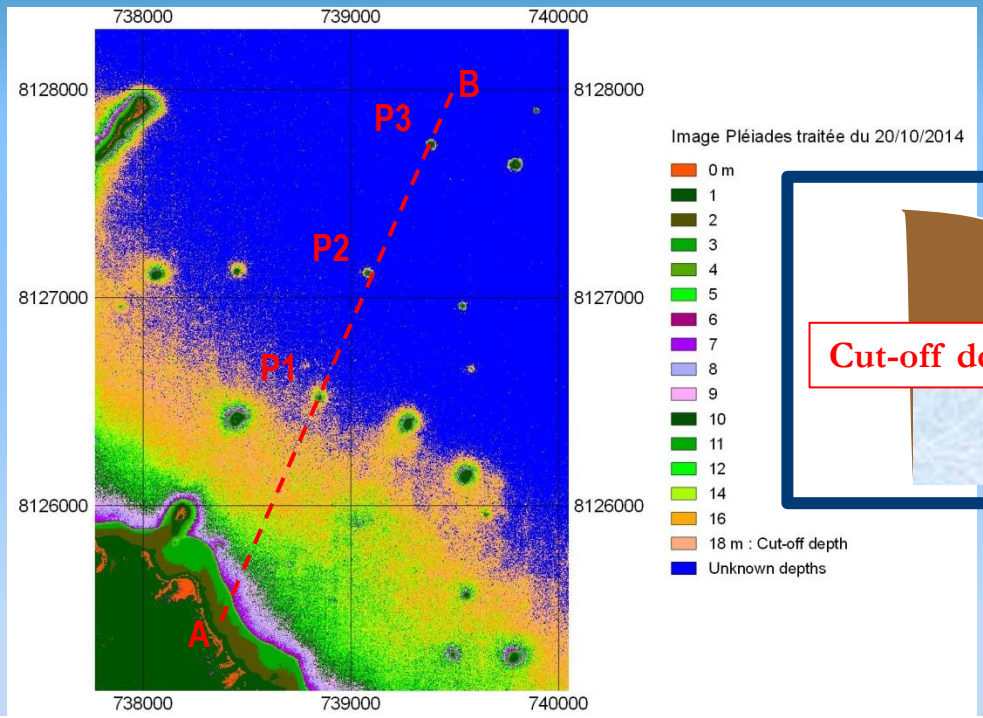


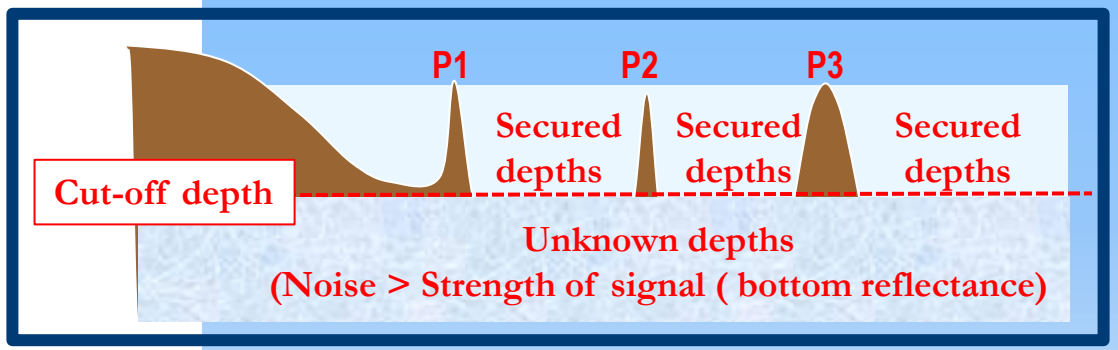
- To ARGANS, the error bars only reflect uncertainties, not systematic errors due to various causes, e.g. bad atmospheric correction, offsets, etc.
- The name "error-bars" should be changed to "bars of uncertainty".
- The systematic error causing the split between 12 m and 23 m must be investigated and corrected. However, do not miss the "cut-off depth".

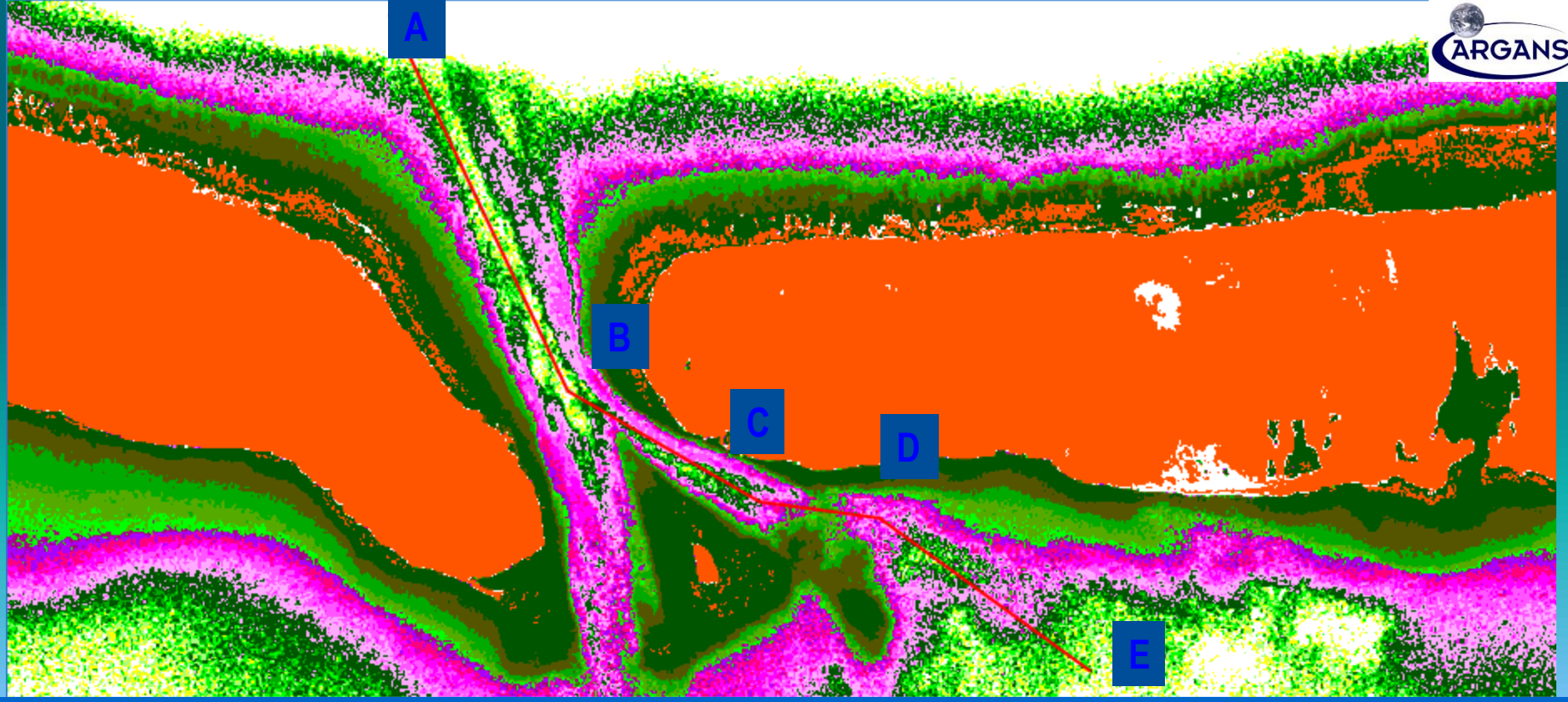
6. An Optical Wire Sweep ?

18 m cut-off (extra-cautious)

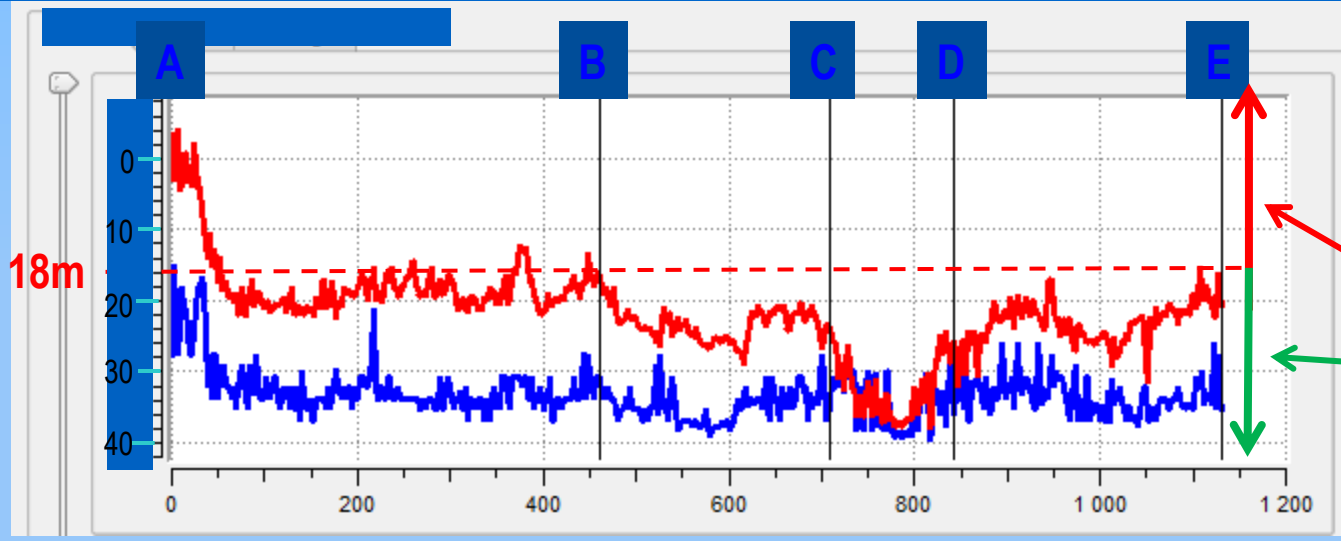








The « Optical Wire Sweep » can be adjusted instantly to match the level of noise. Here in places, it can be lowered to 30 m



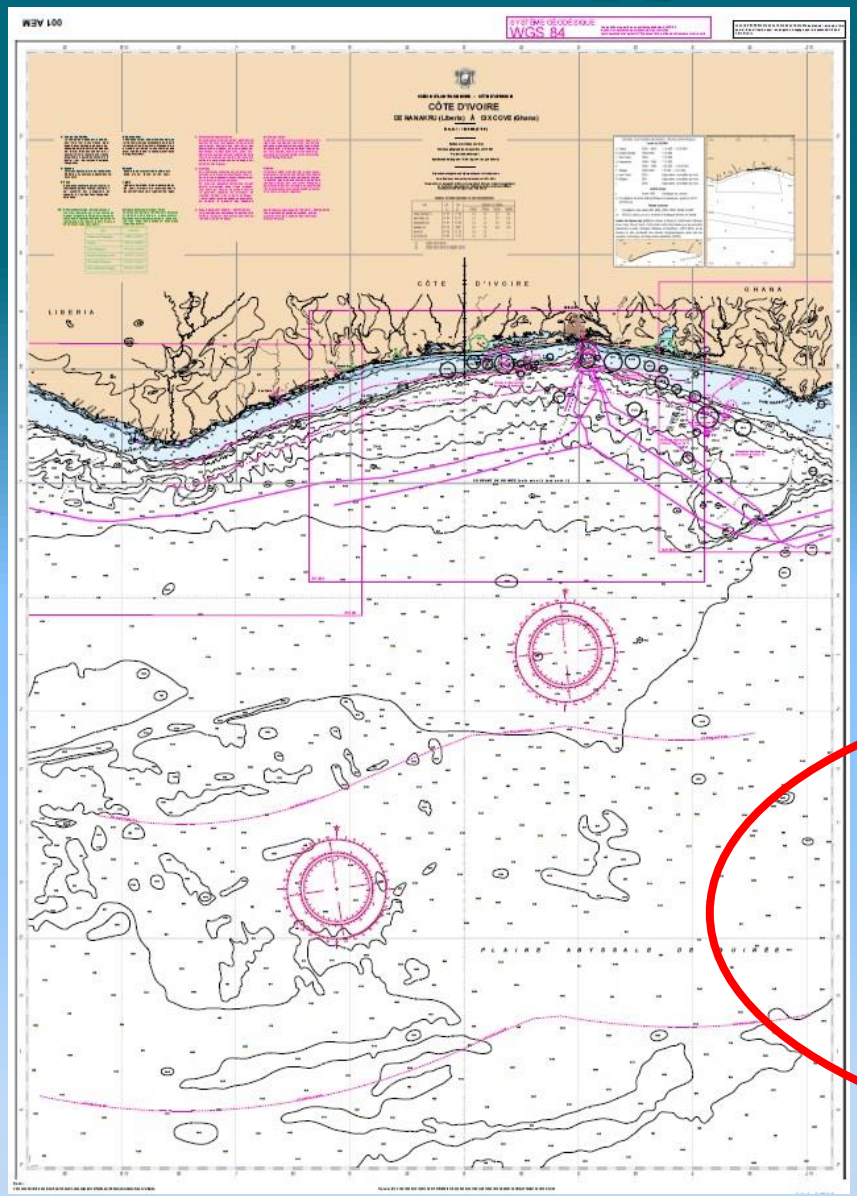
Red trace : Probable depths

Blue trace : uncertainties

Noise < depth

Noise > depth

7. An SDB app. : determination of baselines



ORIGINE DES RENSEIGNEMENTS HYDROGRAPHIQUES

Levés du SHOM

a	Tabou	1950 - 1962	1:10 000 – 1:20 000
b	Grand Béréby	1948-1963	1:10 000
c	San Pedro	1963	1:10 000
d	Sassandra	1948 – 1956	1:10 000
e		1962 – 1965	1:25 000 – 1:100 000
f	Abidjan	1950-1962	1:5 000 – 1:10 000
g	San Pedro	2010	Exploration complète du fond
h	Abidjan	2011	Exploration complète du fond
i		2005	Exploration complète du fond

Autres levés

j	Avant 1905	Sondages au plomb

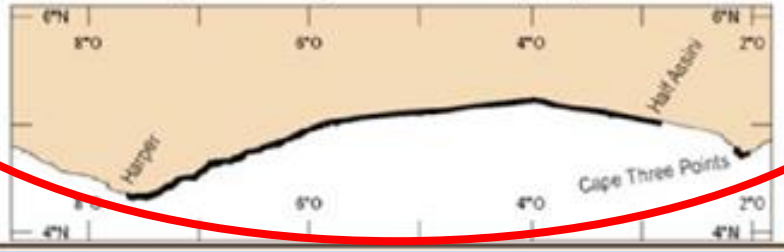
k Compilation de levés bathymétriques et sismiques jusqu'en 2014 (PETROCI)

Autres sources

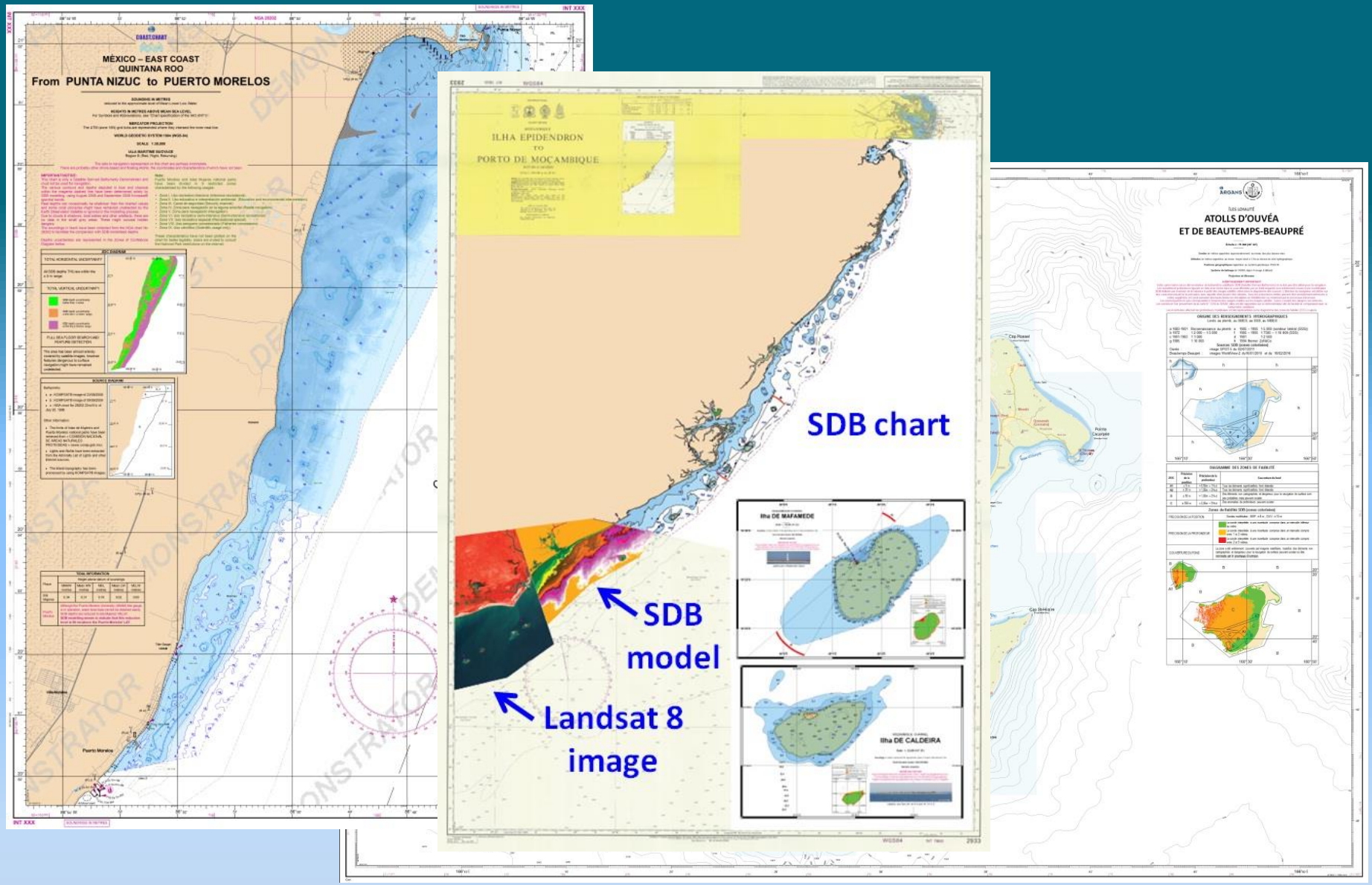
l Compilation des cartes INT 2084, 2085, 2086 et 2087

m GEBCO (GEBCO_08 Grid V. 20100927) et sondages divers en transit

Laisse de basse mer (LAT) de Harper (Liberia) à Half-Assini (Ghana) et au Cape Three Points. Cette limite a été déterminée par les autorités ivoiriennes à partir d'images Pléiades et RapidEye (2013-2014) et de travaux *in situ* combinant des relevés topographiques ainsi que les dernières techniques de bathymétrie satellitaire (SDB)



8. Demonstrators and products



9. Cost of SDB processing

- Cost of satellite images: anything between free (Sentinel 2, Landsat 8), € 0.02 and € 50 per sq. km, depending on quality *(approx. figures):*

SATELLITE	Spatial Resolution (m)	Cost per sq. km (€)
Quickbird	0.6 to 2.4	22
Pleiades	0.5 to 2	5
TerraSar-X	1 to 3	2.64
WorldView2	0.5 to 2	14 to 60
RapidEye	5	0.95
Sentinel 2	10	Free
DMC	22 to 32	0.02 to 0.12

- Target price, including satellite processing & cartography:

  £ 50 K to £ 80 K per IHO-compliant chart.

SDB DEVELOPMENTS

seen from an R & D perspective

Any questions?