GEODESEA : first French experiment of absolute seafloor positioning in the perspective of long-term experimentation in the West Indies

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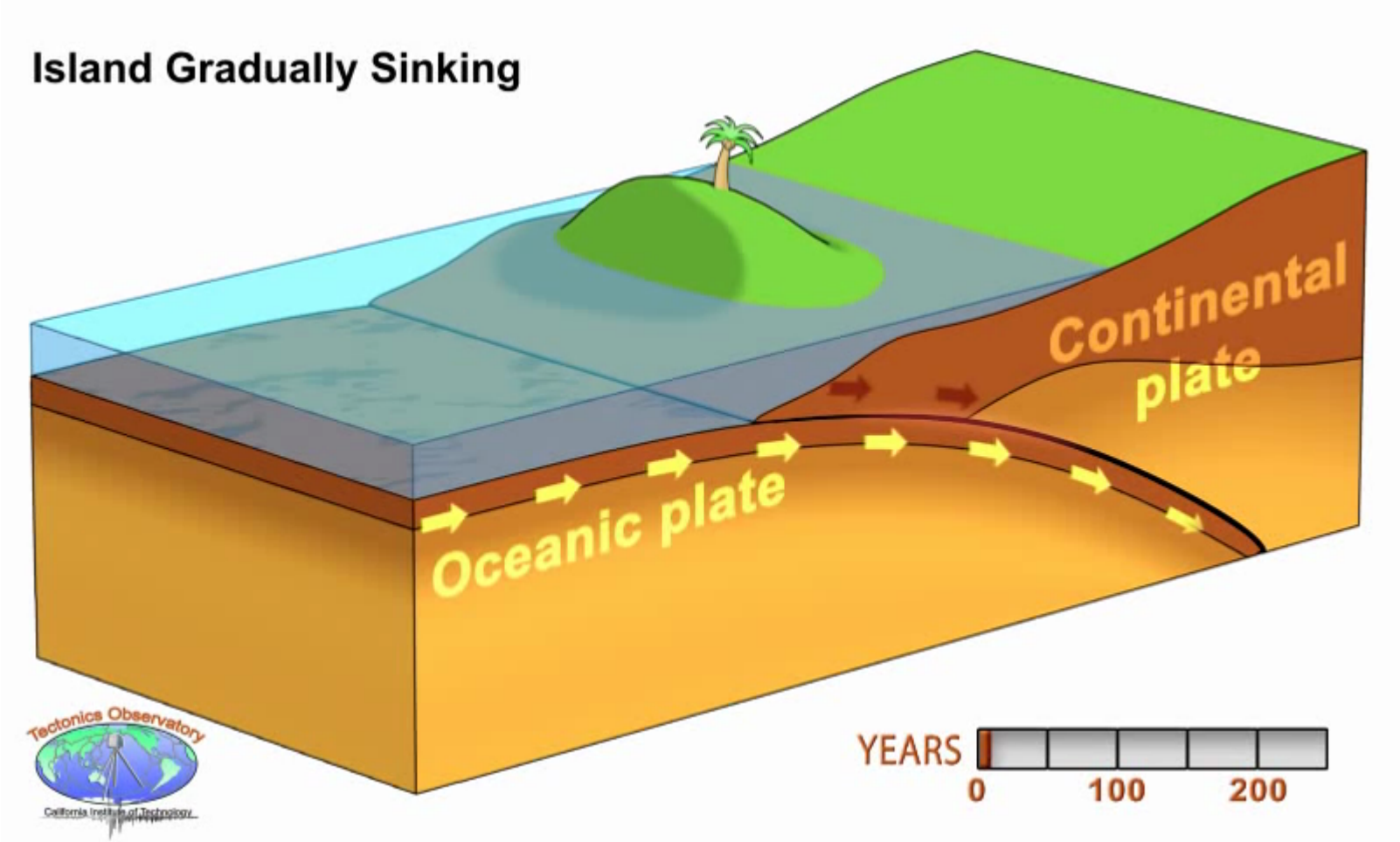
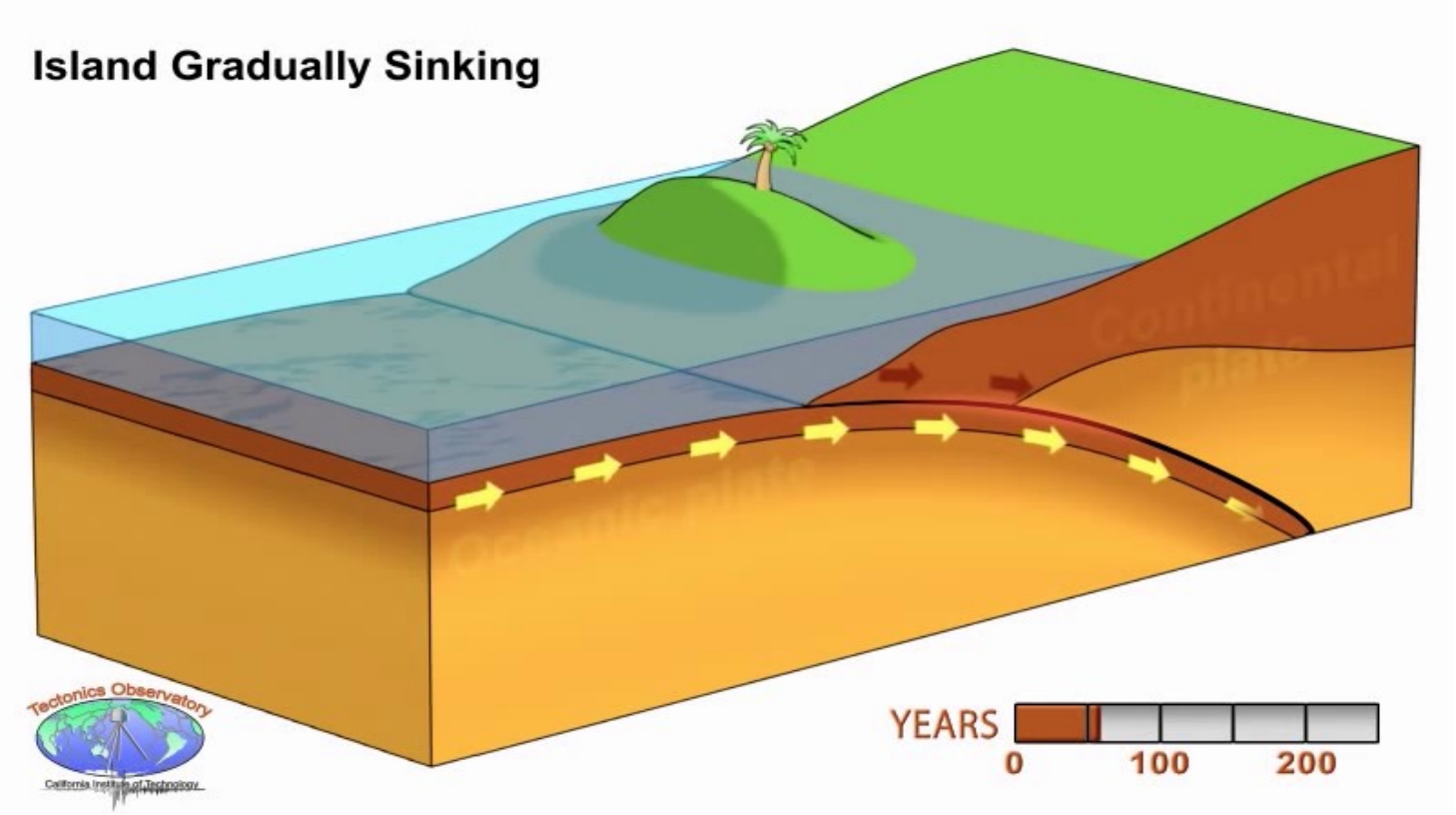
2 : CNRS / Laboratoire Domaines Océaniques - CNRS UMR 6538 - Institut Universitaire Européen de la Mer

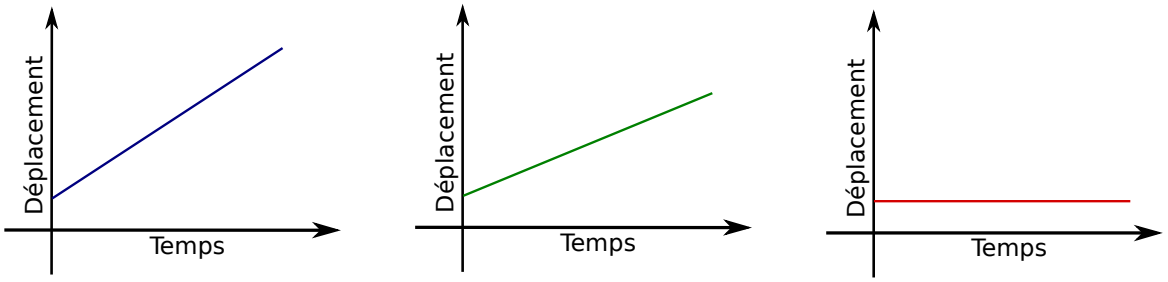
Problematics

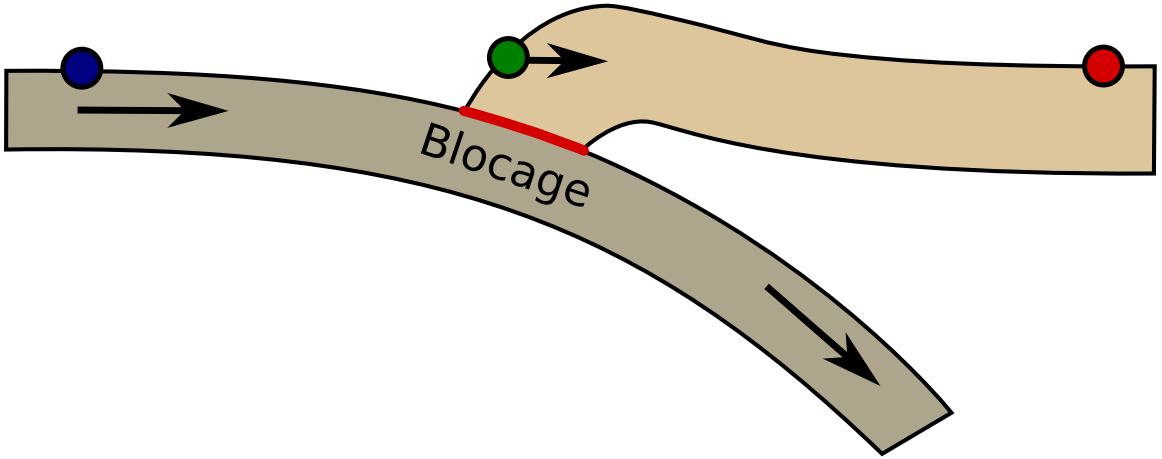


Problematics



Monitoring tectonic deformation

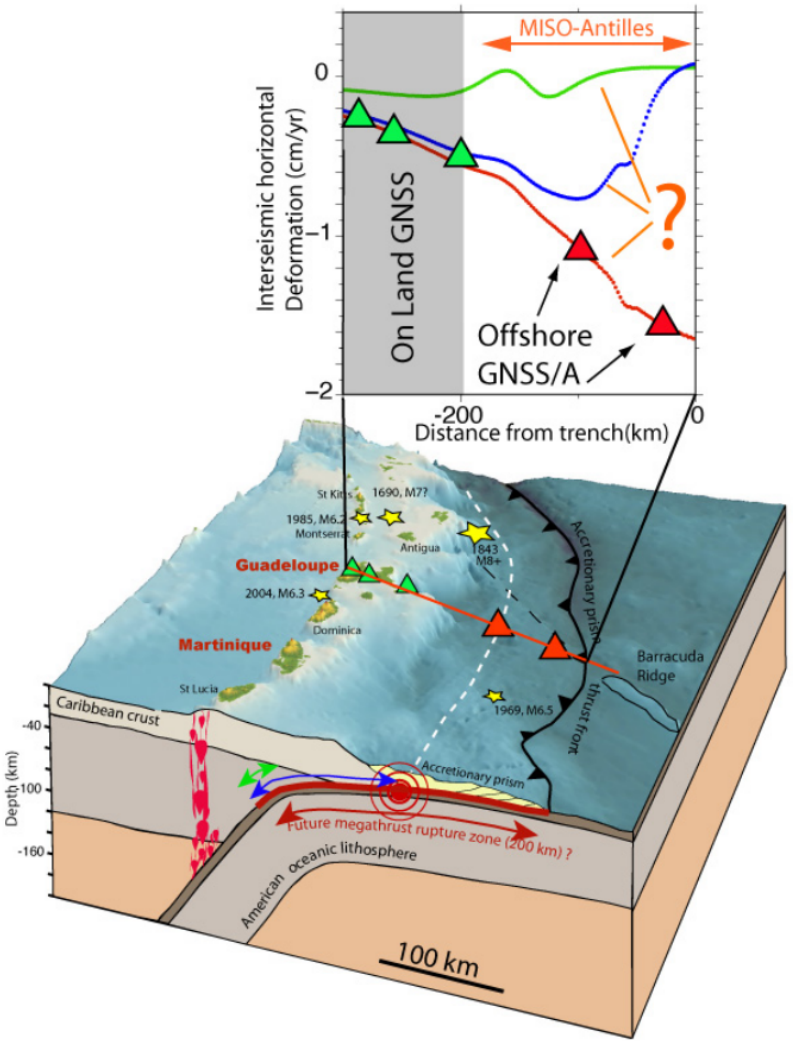




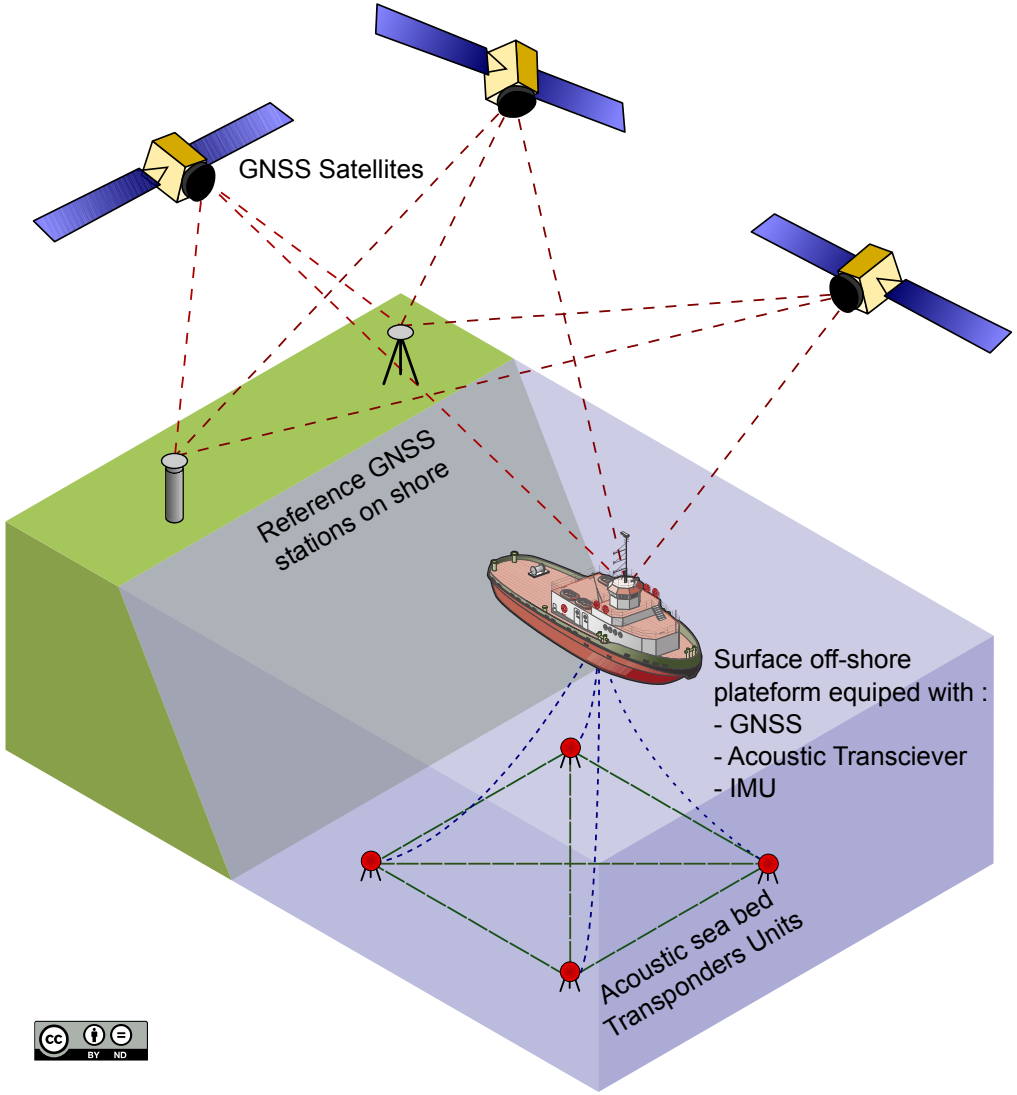
Lesser Antilles Case

- Can a tsunamigenic earthquake occur ?
  - No tsunami during 1843 eve nt (IX Intensity)

- No significant signal with on shore GNSS
  - Trench is 300km far from the islands
  - ~ 5000m water depth



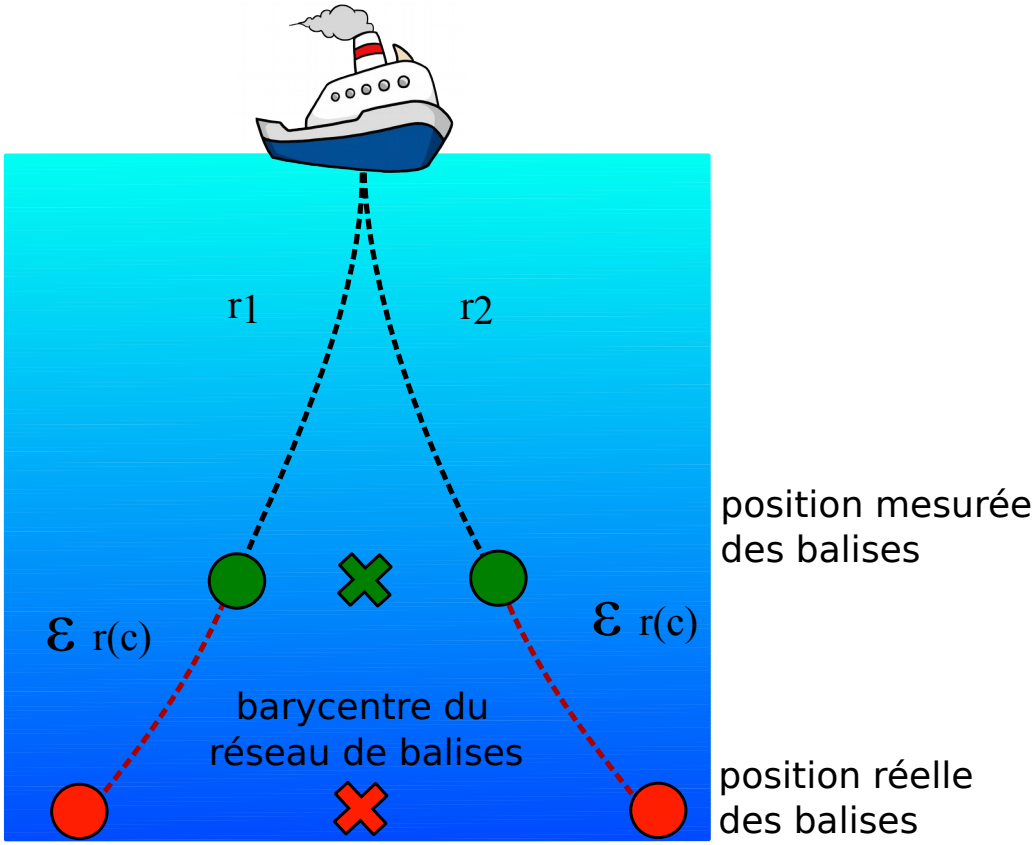
GPS/Acoustics



Oceanographic parameters observations
⇒ **sound speed monitoring**

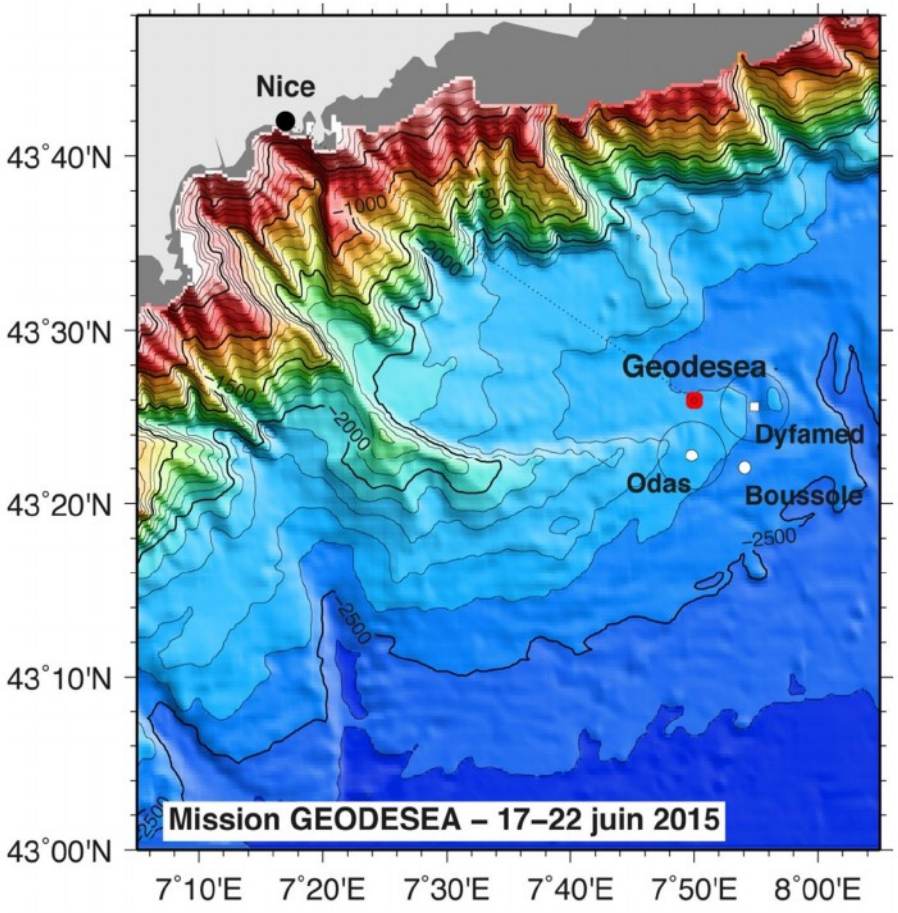
Dealing with the Sound Velocity Variations

[Spiess et al. 1998] : positioning in an absolute frame the **barycenter** of an **array of seafloor beacons**



1 Array = 1 Position

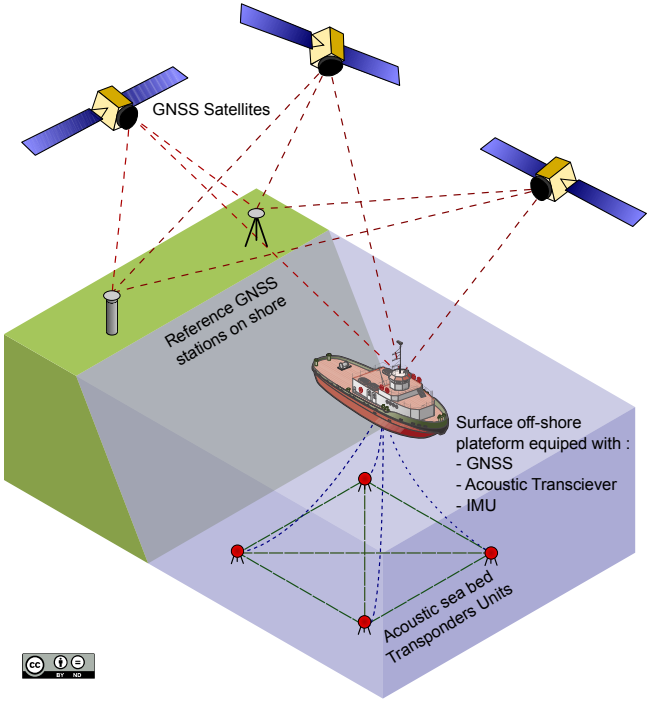
GEODESEA Campaign



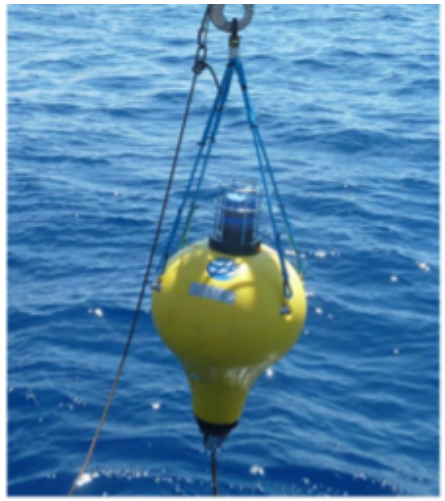
- 17-22 June 2015
- N/O Téthys II
- IUEM/LDO, LIENSs & Sonardyne collaboration
- 37 h 20 of acquisitions (~12900 pings)

Practical approach

- *Underwater Segment*
- *Surface Segment*
  - Topometric Ties
  - Kinematic positionning
- Processing

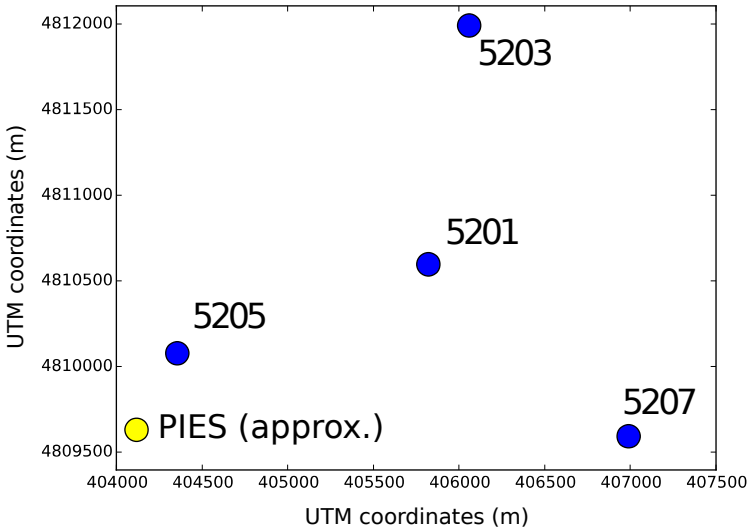


Underwater Segment



↑ 4 Sonardyne *Compatt* **Transponders**

← **PIES** (Sound speed monitoring)



~2300m deep

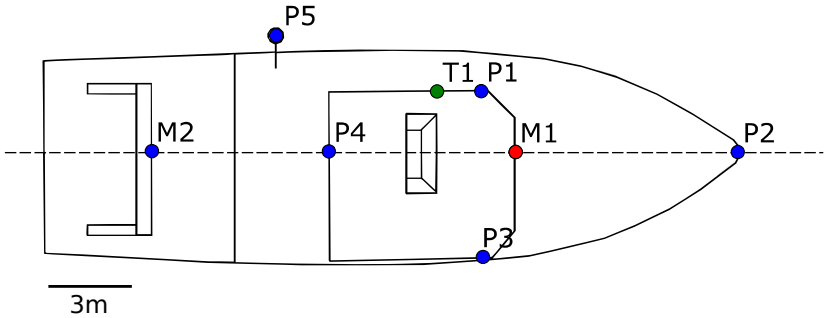
Underwater Segment

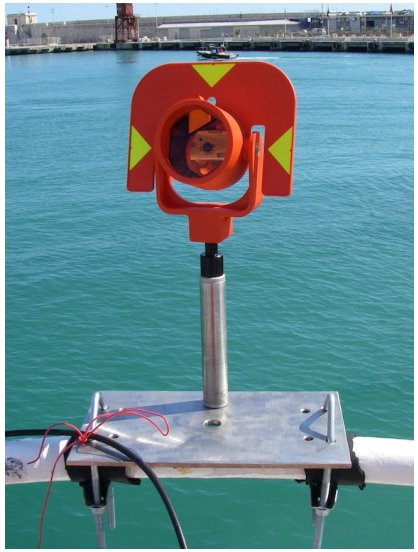
Acoustic Head + IMU
GyroUSBL 7000
Lodestar Sonardyne

CTD Probe SBE9+
Conductivity (Salinity),
Temperature, **D**epth (Pressure)

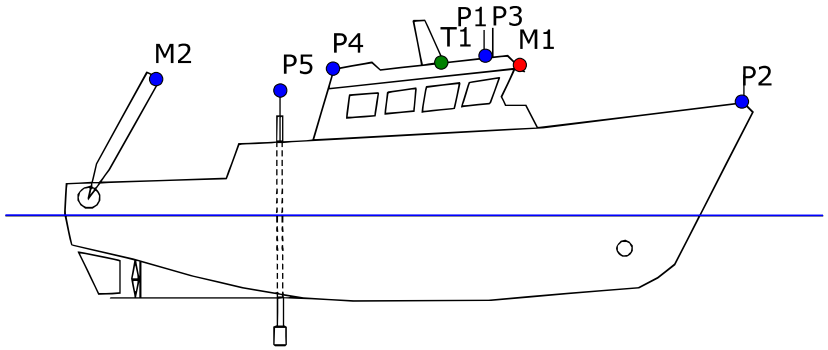
1/2 time a day

Surface Segment





Tethys II - Marseille



Topometric Ties

Measuring procedure

- 2 surveys sessions
- Each point is shooted 10 times and the observations are averaged (minimizing engine vibrations noise)
- Difficulty to set the tacheometer vertical

Cible	X (m)	Y (m)	Z (m)
M1	+0.0000	+0.0000	+0.0000
M2	-12.9944	+0.0335	-0.7793
P1	-1.1614	+2.1755	+1.0777
P2	+8.5398	-0.0000	-1.6292
P3	-1.2571	-3.4563	+1.1017
P4	-5.6112	+0.0248	+0.2645
P5	-8.5374	+3.9268	-1.6505
T1	-3.0253	+2.0811	+0.1789

1st session results

Cible	X (m)	Y (m)	Z (m)
M1	+0.0000	+0.0000	+0.0000
M2	-12.9988	+0.0327	-0.7779
P1	-1.1822	+2.1765	+1.0723
P2	+8.5393	+0.0000	-1.6315
P3	-1.2592	-3.4548	+1.1004
P4	-5.5926	+0.0380	+0.2638
T1	-3.0263	+2.0815	+0.1782

2nd session results

Milimetric Repetability

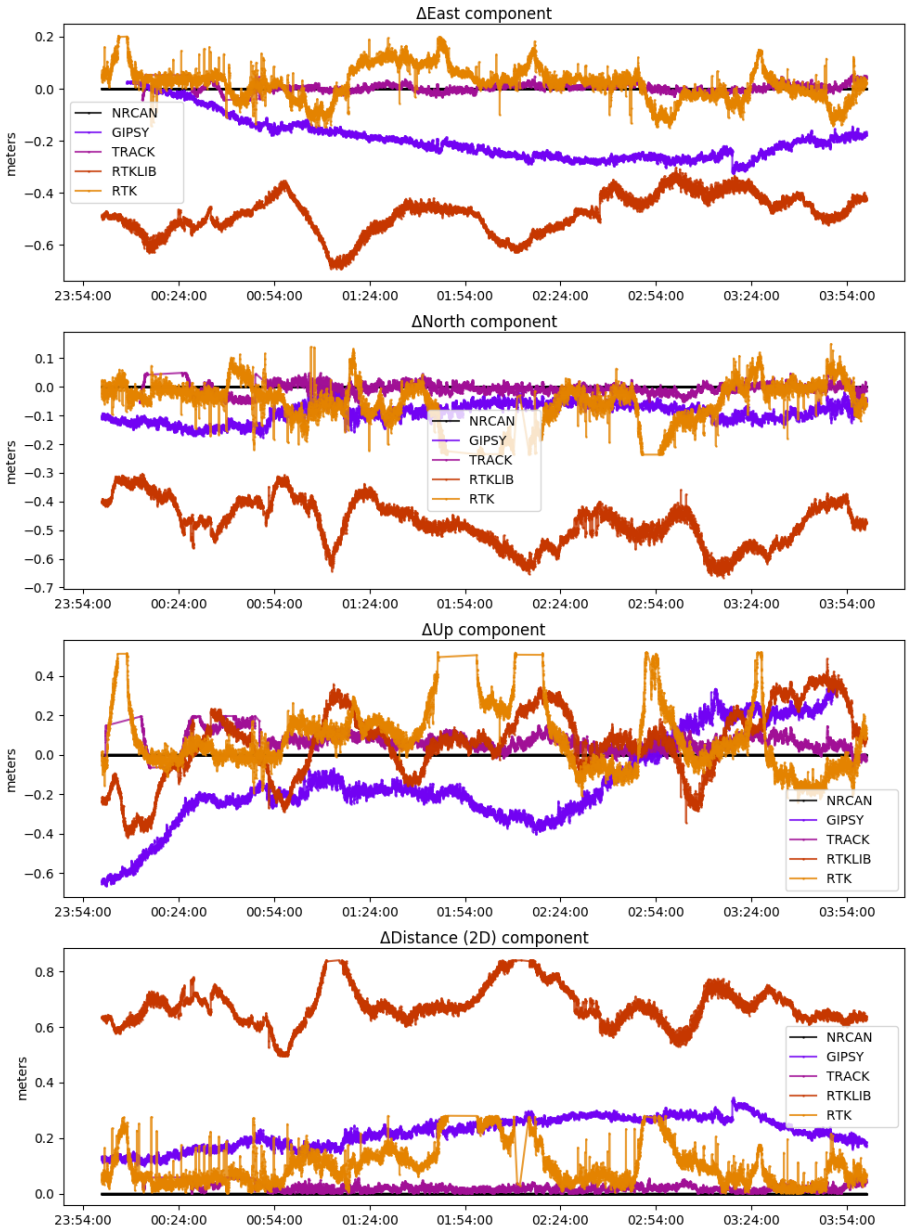
Kinematic GNSS benchmark

PPP method

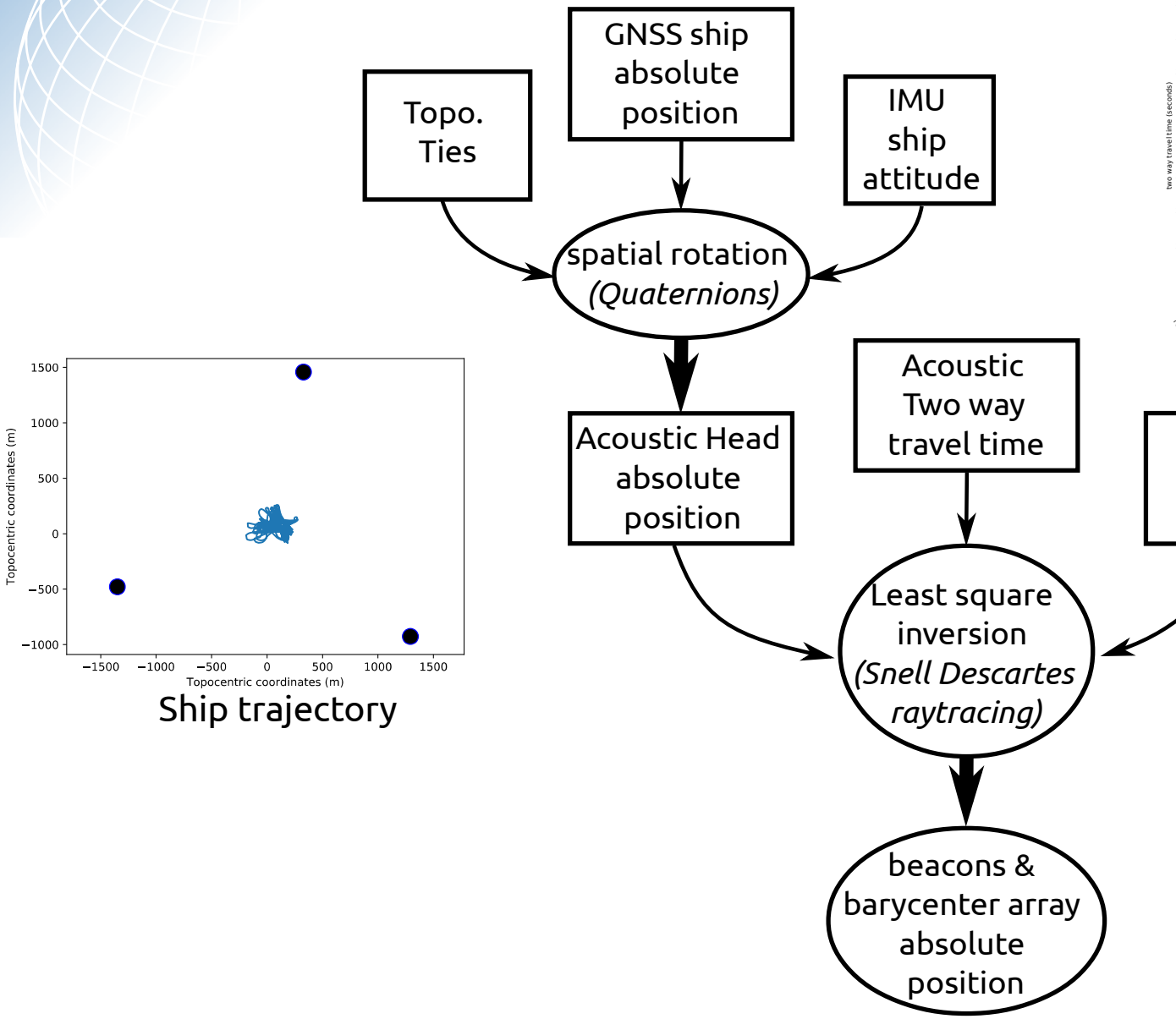
- GIPSY APPS
- NRCAN

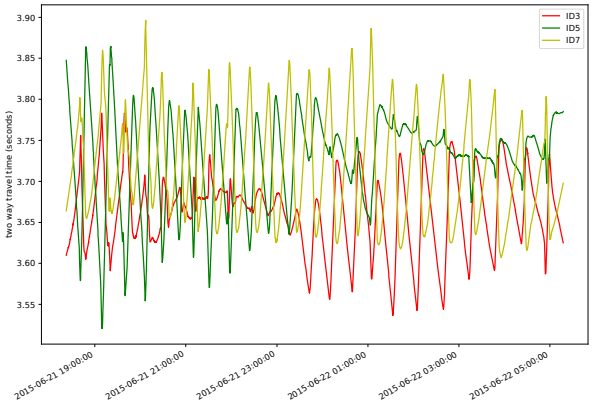
Differential method,
using RGP NICA station (~40km)

- TRACK
- RTKLIB
- Real time RTK



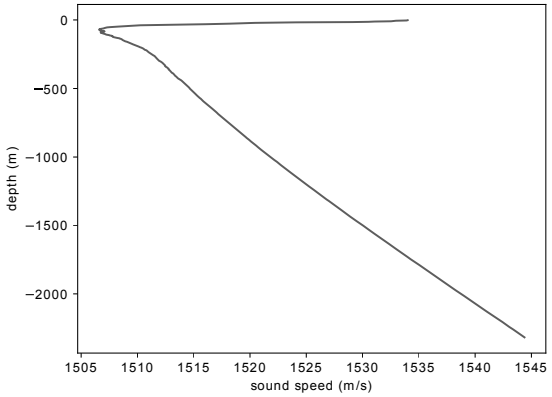
Acoustic processing





Acoustic travel time

Ship trajectory



Sound Speed Profile

Results

Used session : 21th June, 10h of acquisition, 13500 pings

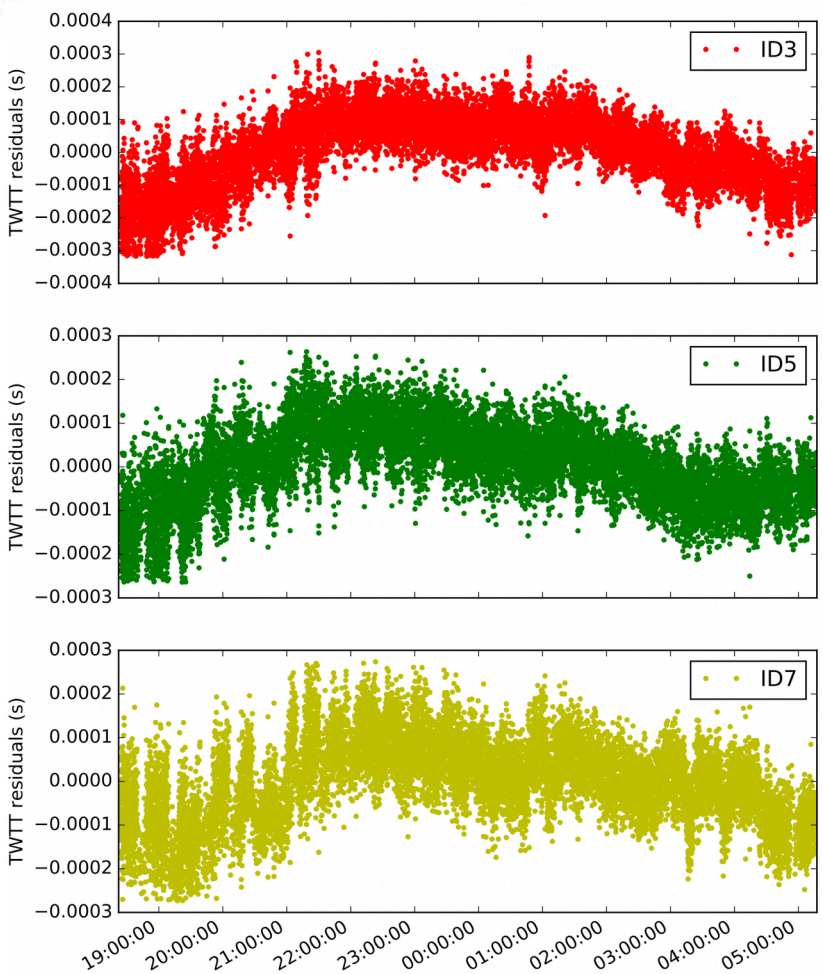
Point	*5203*	*5305*	*5307*	Barycentre
Local N (m)	1459.5193	-478.5392	-926.6242	18.1187
Local E (m)	329.0651	-1348.9036	1293.2587	91.1401
Local D (m)	2407.1061	2383.5635	2375.9380	2388.8692
σ_N (m)	0.0256	0.0264	0.0273	
σ_E (m)	0.0221	0.0219	0.0243	
σ_D (m)	0.0159	0.0162	0.0146	
ITRF X (m)	4592277.2989	4593843.1724	4593793.7191	4593304.7301
ITRF Y (m)	632238.9572	630760.6447	633420.8986	632140.1668
ITRF Z (m)	4362678.0733	4361287.0891	4360966.9901	4361644.0509
Latitude (deg)	43.45493980	43.43748810	43.43345360	43.44196128
Longitude (deg)	7.83888250	7.81814770	7.85079410	7.83594147
Hauteur (m)	-2400.3357	-2376.8086	-2369.1451	-2382.2740

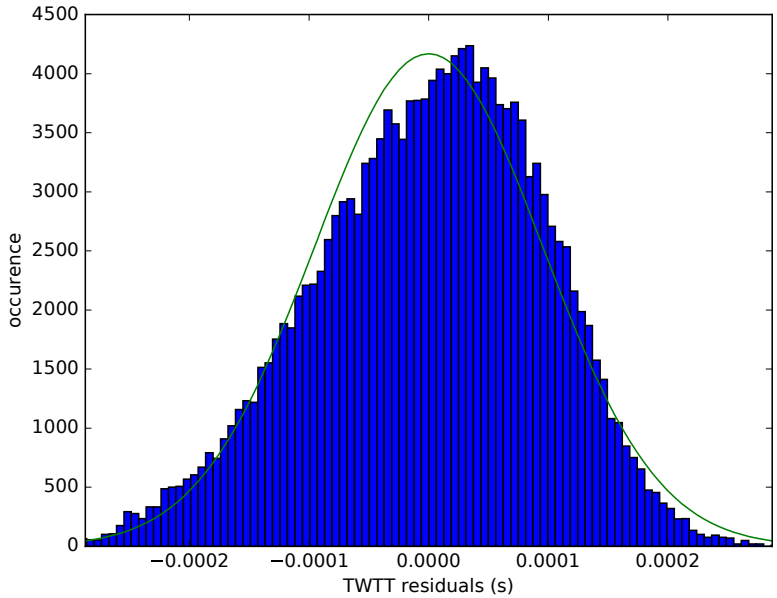
Coordiates of the 3 beacons and the barycenter in local and global frames, and formal standard deviations

Local N (m)	Local E (m)	Local D (m)
18.1221	91.1382	2388.8681
σ_N (m)	σ_E (m)	σ_D (m)
0.01855	0.02170	0.0089

boot-strap test on
250 samples

Residual Analysis





- manage the Sound Speed Variation in the Inversion
- Monitor on a whole cycle

Key points

- GNSS/A combine underwater acoustics, kinematic positionning and attitude of an off-shore platform to monitor seafloor deformation
- Centimetric formal sigmas for 10h observation. Processing can be improved by taking into account sound speed variations
- Plateform simplification (AUV) can improve the suface positionning quality