# Preliminary comparison of the TOPEX and POSEIDON-2 Radar Altimeters

O.Z. Zanifé, J.P. Dumont, P. Thibaut – CLS, France
P. Vincent, G. Carayon, N. Steunou – CNES, France

**Abstract :**

Taking advantage of the flying formation JASON-1, TOPEX/POSEIDON satellites (both on the same ground track and separated by 60 seconds), a preliminary performance comparison of their operational radar altimeters, respectively POSEIDON-2 and TOPEX, has been carried out.

After recalling the features of each altimeter, the comparative procedure is presented. It is mainly focused on the fact that the TOPEX data has been re-processed using the same ground retracking as the one used for the POSEIDON-1 data. Such procedure has been already used in the past with success (validation of the ENVISAT radar altimeter ground processing). The major ouputs of this processing are the precise range, the significant wave height and the backscatter coefficient at the rate of the input waveforms (10 or 20 Hz). From these outputs one can then derive the 1 Hz parameters and the associated standard deviations.

The results we present are issued from the analysis of a few passes of data. They range from point by point comparison, to statistical analysis and noise characterization of the instruments. It is shown that both altimeters are in agreement and measure the same signal. It is also shown that they have about the same level of accuracy. These conclusions will be fully assessed in the future by performed this analysis over a larger set of data.

In parallel we are conducting an identical comparison using the POSEIDON-2 retracker. All the process is currently under validation. Finally, with the inclusion of the POSEIDON-1 data and the focus on JASON-1 cycles 17, 18, 19 and TOPEX/POSEIDON cycles 360,361,362, we will be able to have a full comparison of the three radar altimeters.

# 1 TOPEX and POSEIDON-2 Major Features (Ku band)

## TOPEX

| | |
|---|---|
| Frequency : | 13.60 GHz |
| Pulse duration : | 102.4 μs |
| Bandwidth : | 320 MHz |
| PRF : | 4200 |
| Waveform Samples : | 128 |
| Sample resolution : | 3.125 ns or 46.84 cm |
| Pulses number : | 228 |
| Antenna Beamwidth : | 1.1° |
| Waveform Telemetry : | 64 samples at 10 Hz |
| On board tracker : | Adaptative windows |
| range - | α,β filter (0.25 and 1/64) |
| AGC - | α filter (0.3) |
| SWH : | on board, by ratio of power difference |
| On board retracking : | No |
| Ground retracking : No | |

## POSEIDON-2

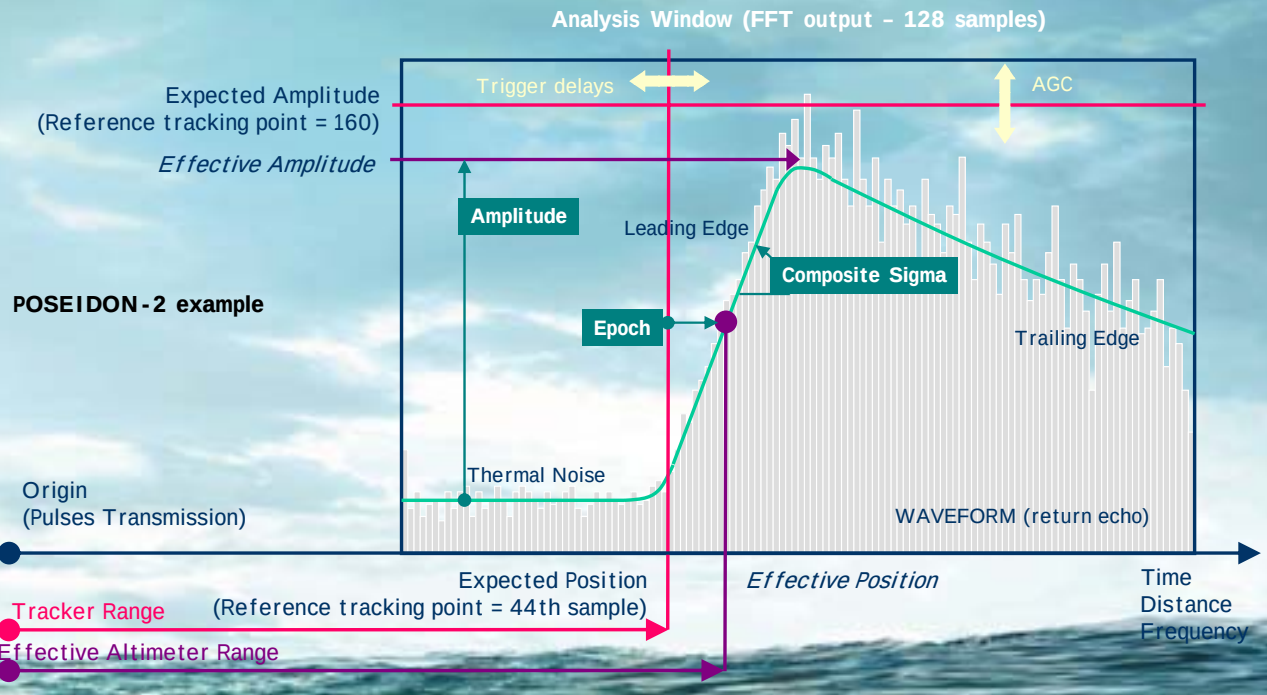
| | |
|---|---|
| Frequency : | 13.575 GHz |
| Pulse duration : | 105.6 μs |
| Bandwidth : | 320 MHz |
| PRF : | 1800 |
| Waveform Samples : | 128 |
| Sample resolution : | 3.125 ns or 46.84 cm |
| Pulses number : | 90 |
| Antenna Beamwidth : | 1.34° |
| Waveform Telemetry : | 64 samples at 20 Hz |
| On board tracker : | Fixed windows |
| range - | α,β filter (0.25 and 1/64) |
| AGC - | α filter (0.5) |
| On board retracking : | Yes (gain = 1) |
| Ground retracking : Yes (gain = 1) | |

(Both retracking are based on a weighted Least Square Estimators derived from Maximum Likelihood Estimators using Hayne model for modelling the ocean return)

# 2 Tracker and Retracking (1/2)

**Tracker :**
The function of the tracker is to maintain the echo in the window analysis (range and power). When sophisticated as for TOPEX, the trackers plays also the role of the altimetric parameters estimator.

**Retracker :**
The function of the retracker is to extract the precise altimetric parameters (range, SWH, power)



# 2 Tracker and Retracking (1/2)

**Tracker Equations :**

range $\begin{cases} h_n = h_{n-1} + r_{n-1} + \alpha * \varepsilon_{n-2} \\ r_n = r_{n-1} + \beta * \varepsilon_{n-2} \end{cases}$

$h_n$ is the estimate value of the range to be applied on cycle n
$r_n$ is the estimate value of the range increment to be applied on cycle n
$\varepsilon_n$ is the range error. It is determined by balancing the return power in fixed or adaptative windows, accounting for an **ocean echo model (Brown or Hayne)**
$\alpha$ and $\beta$ are the first and second order loop coefficient

AGC : first order loop (very closed to the top one equation)

**Retracking equations (iterative solution):**

$$\begin{cases} \theta_{k,n} = \theta_{k,n-1} + g * \left(BB^T\right)^{-1} BD \\ B_{k,i} = \dfrac{1}{P_u} \dfrac{\partial \overline{V}_i}{\partial \theta_k}, D_i = \dfrac{\overline{V}_i - V_i}{P_u} \end{cases}$$

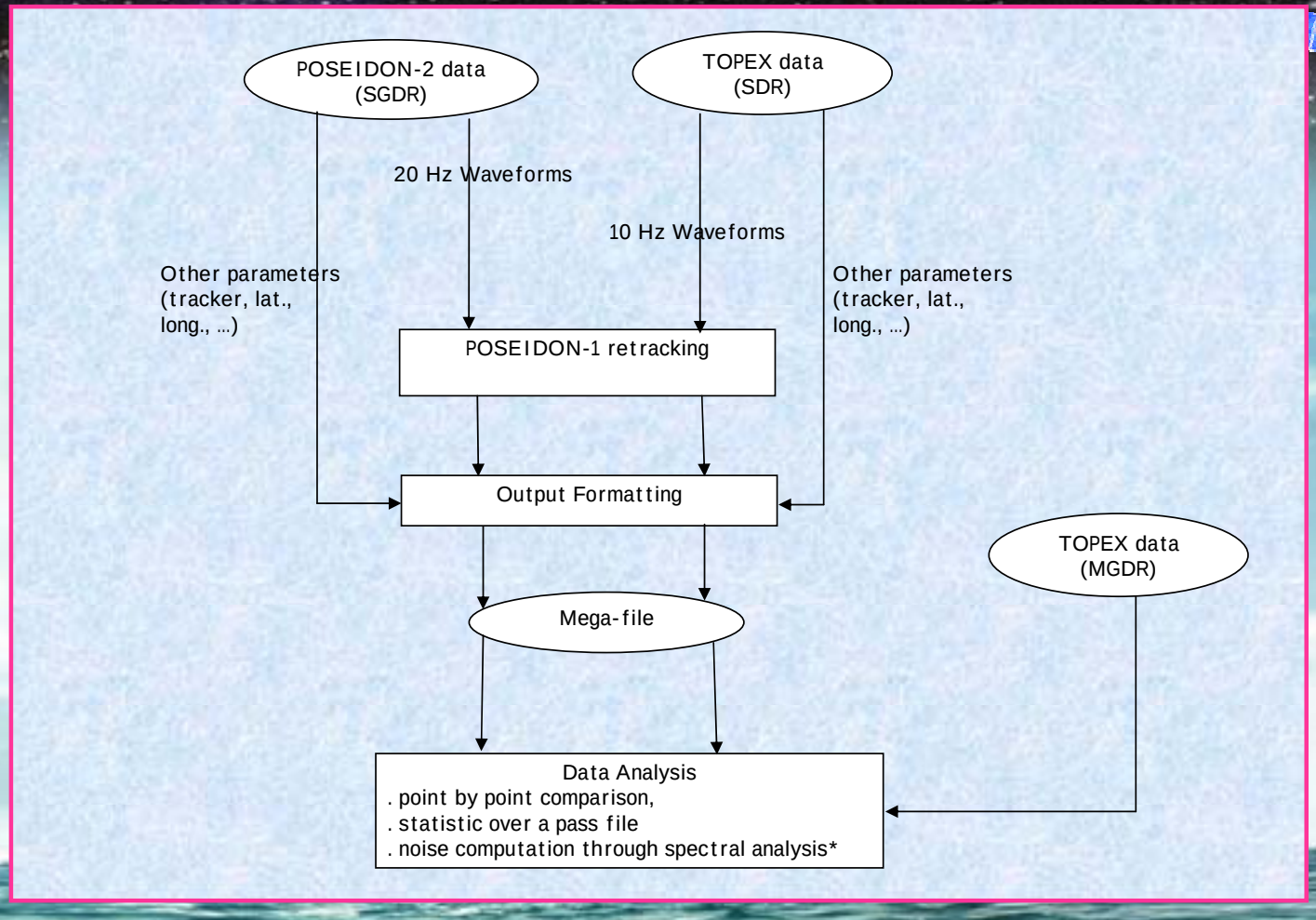
$\theta_{k,n}$ is the estimate value of the altimetirc parameter (range, SWH, power) at iteration n
g is the gain
$P_u$ is the estimate of the power
$\overline{V}_i$ is the theoretical sample based on an **ocean echo model (Brown or Hayne)**
$V_i$ are the samples from the measured echo radar

The retracking of POSEIDON-2 and POSEIDON-1 differs by : - estimation of SWH for POSEIDON-1 instead of SigmaC for POSEIDON-2
- criteria convergence

**Altimetric parameters equations**
The **accurate** altimetric estimates are given by :

| | |
|---|---|
| Altimeter Range | = Tracker Range + Epoch (0 without retracking) |
| Backscatter Coefficient | = «Radar equation» + AGC + Amplitude (about 160 without retracking, reference power) |
| Significant WaveHeight | = 2c.Sqrt (SigmaC**2-SigmaP**2), SigmaP = PTR width<br>or directly from the retracking (POSEIDON-1 retracking),<br>or by the ratio of the difference of energy (TOPEX) |

# 3 Comparative Procedure




* For details on the spectral analysis see poster 'POSEIDON-1 and POSEIDON-2 Noise Analysis'

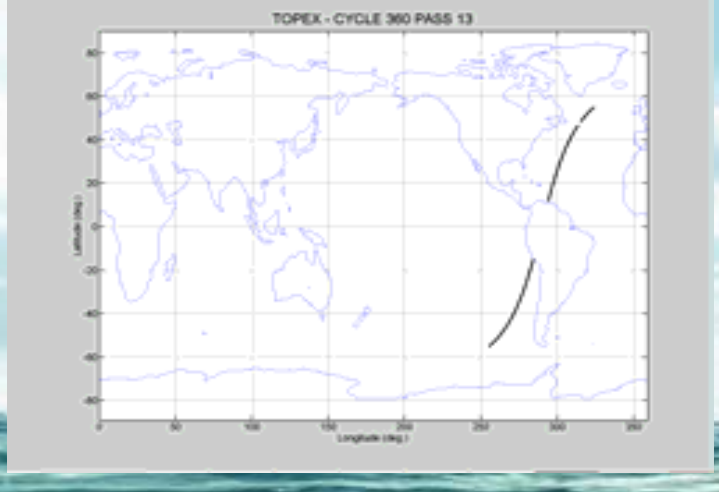
# 4 Data used and Editing criteria

## TOPEX

pass 13 and 19 of cycle 360
10 Hz waveforms retracked :
- all of them
- 54 samples (the ones used on-board)
- skewness of 0.1

Noise computation :
- 20 seconds per segment
- residuals obtained by fitting a 2nd order polynome

Editing : - number of valid data = 10
- SWH_Ku between 0 and 8 m
- Sigma0_Ku not available in SDR

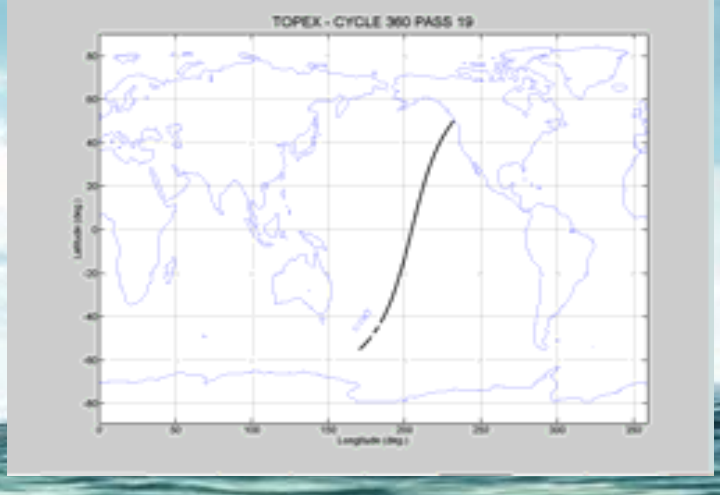



## POSEIDON-2

pass 13 and 19 of cycle 17 (received on October 18 2002)
20 Hz waveforms retracked :
- all of them
- 104 samples(the ones used in the operationnel retracking)
- skewness of 0.1

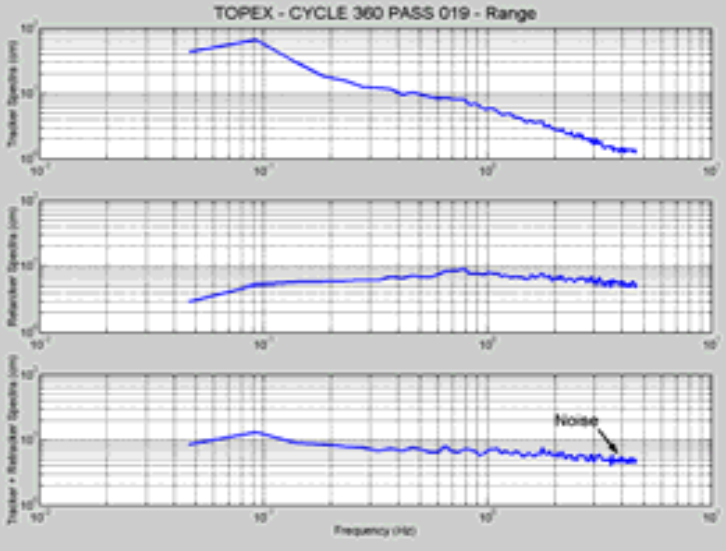
Noise computation :
- 10 seconds per segment
- residuals obtained by fitting a 2nd order polynome

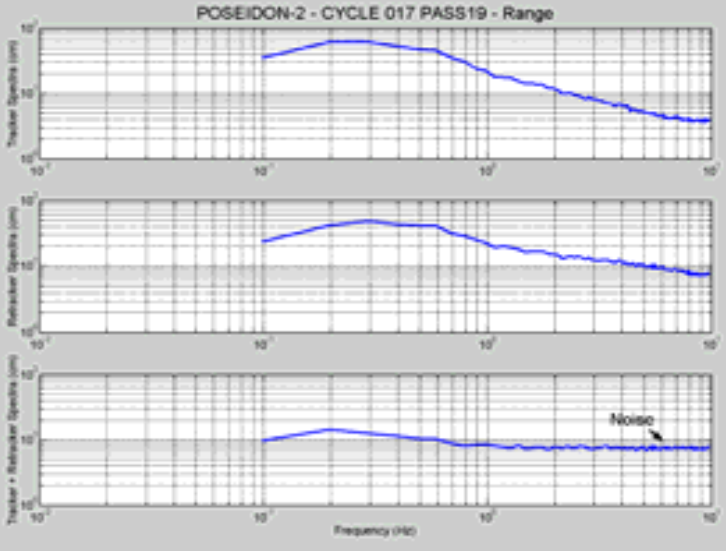
Editing : - number of valid data = 20
- SWH_Ku between 0 and 8 m
- Sigma0_Ku between 7 and 15 dB



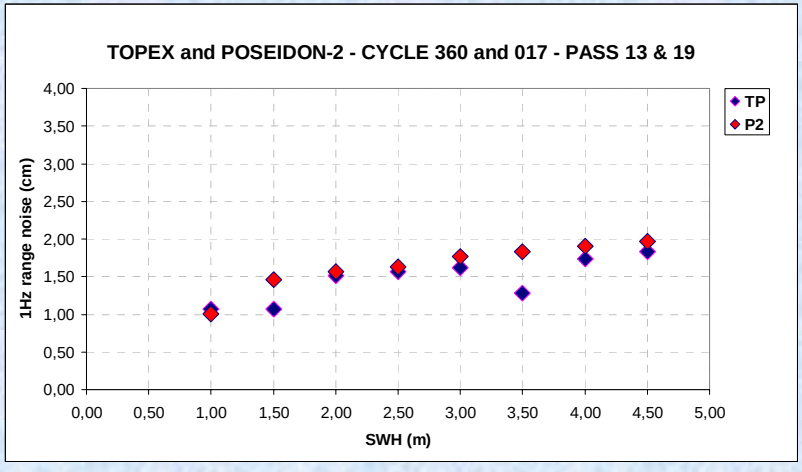
# 5 Noise from Spectral Analysis (1/2)

**Average spectra over the pass**
- **TOPEX has 10Hz data**
- **POSEIDON-2 has 20 Hz data**



# 5 Noise from Spectral Analysis (2/2)




The noises are computed at 1Hz using the decorrelation assumption (division of the 10 or 20 Hz noise by square root 10 or 20) .
For SWH = 2 m the values are :

- TOPEX : 1.52 cm
- POSEIDON-2 : 1.56 cm

For SWH, the values at 2m SWH are :

- TOPEX : 9.83 cm
- POSEIDON-2 : 12.88 cm

These values can be considered as identicaldue to the low number of passes

## Conclusions

TOPEX and POSEIDON-2 waveforms have been retracked using the same retracking (POSEIDON-1) as well as quasi-identical conditions of retracking. A couple of passes have been analysed and the preliminary noise figures indicate that both altimeter give the same answer, which is for a SWH of 2 m :

**1.5-1.6 cm** for the 1Hz range noise
**10-12 cm** for the 1Hz SWH noise.

These results are preliminary and need to be confirmed, nevertheless one can start guessing that the radar altimeters will be very close one to each other. In the future, POSEIDON-1 will be included in this comparison.