# SAMOSA retracker for SAR Altimeter observations over water

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- **SAMOSA** (**ESA**): "Development of SAR Altimetry Studies and Applications over Ocean, Coastal zones and Inland waters"

- This presentation concentrates on → progress towards the development of a **theoretical model for the mean return waveform from a SAR altimeter over water surfaces**

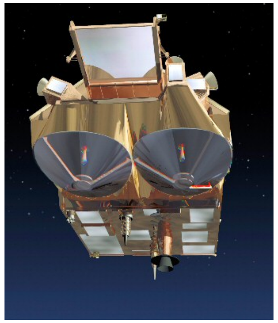
- **Development of a re-tracking methodology** (based on MLE)

Theoretically tested
Cramer-RAO Bound

Experimentally tested

National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

- The application of SAR techniques to classical radar altimetry offers a potential solution to significantly enhance Earth surface mapping
- CryoSat (2009) will be the first satellite to provide such data
- This data is of great interest to the Hydrosphere and Oceanographic communities, since it would allow quantitative assessment of expected enhanced altimetric capabilities in **coastal monitoring**, ocean floor topography, gravity field and inland water monitoring.
- **SAMOSA FOCUS:** analyze the potentialities of advanced SAR Altimetry over water surfaces.



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CryoSat was designed for Cryosphere applications

**Requirements** for the application of SAR mode observations for **oceanography**:

1. Retracker adapted to the specific nature of SAR altimeter echoes
2. Theoretical Model for the Mean Return Echo Over Water Surfaces in the same spirit set by conventional altimeters [Brown, 1977] [Hayne, 1980]

- **SAR Altimeter** (a.k.a Delay/Doppler altimeter) introduced by Dr. Keith Raney (1998)
- Key innovation is the introduction of along track processing:
  - Increased Resolution
  - Multi-look processing
- Technique requires echo delay compensation analogous to Range Cell Migration correction (conventional SAR)

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- Spatial resolution is increased in the along-track dimension.
- Accumulation of more statistically independent looks for each scattering area

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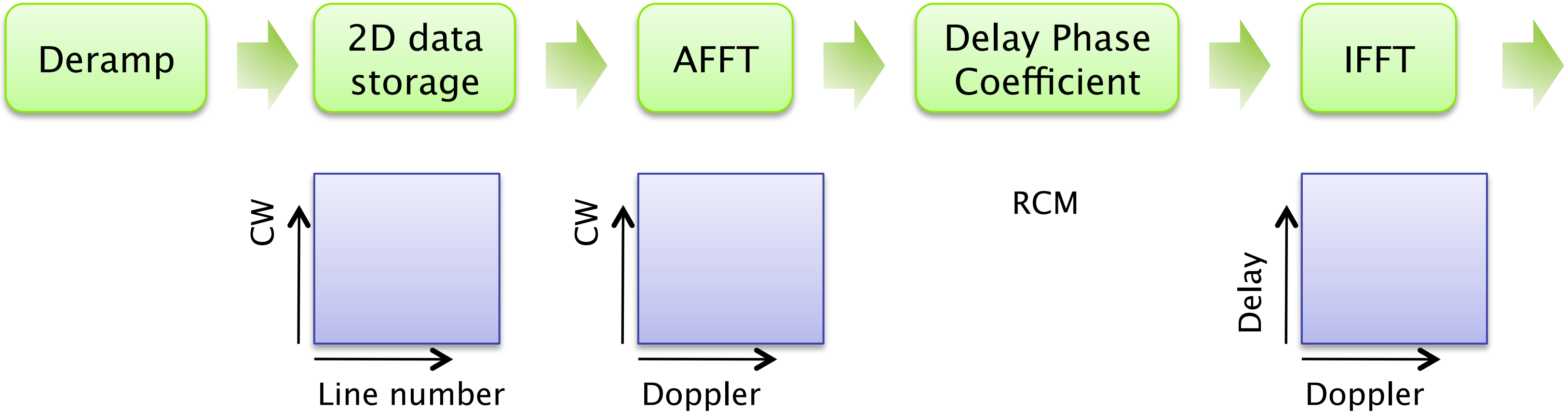
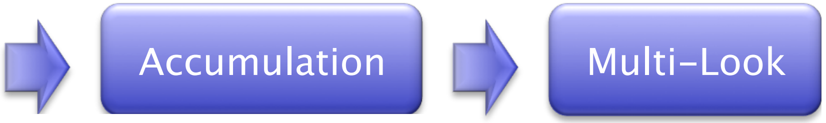
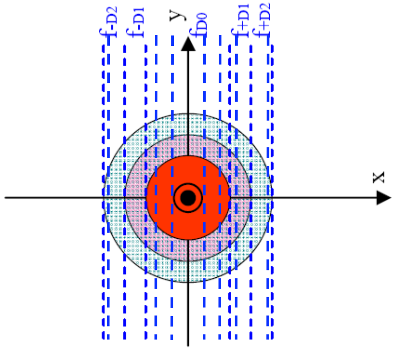
- Better speckle reduction → finer precision of altimetric measurements.

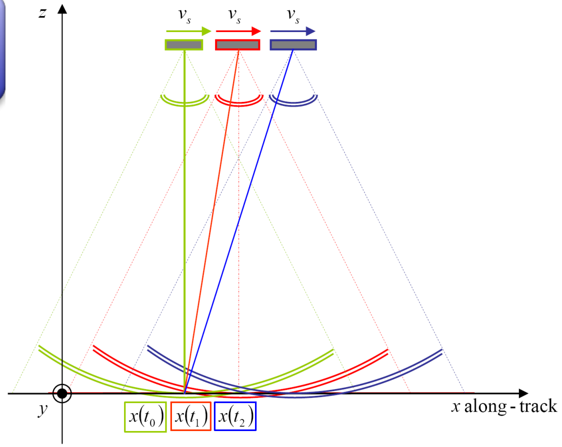


Deramp → 2D data storage → AFFT → Delay Phase Coefficient → IFFT →



→ Accumulation → Multi-Look

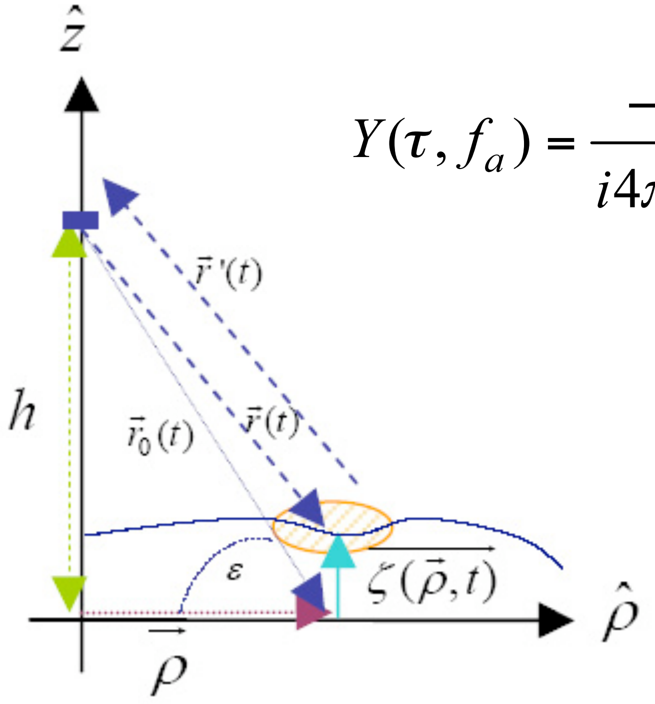




After the accumulation block the received intensity shall be written as:

$$I_R = Y(\tau, f_a) Y^*(\tau, f_a)$$

$$Y(\tau, f_a) = \frac{-\Re \lambda_0}{i 4\pi \sqrt{4\pi}} \int_{Area} \frac{1}{r^2} G(\overrightarrow{\rho}) \chi(\tau, f_a) \frac{q^2}{q_z} d^2 \rho$$



If Brown approach is applied

Calculate the mean of the incoherent addition of an infinite number of echoes

$$E[I_R]_{\zeta(\vec{\rho},t)} = E[Y(\tau,f_a)\,Y^*(\tau,f_a)]_{\zeta(\vec{\rho},t)}$$

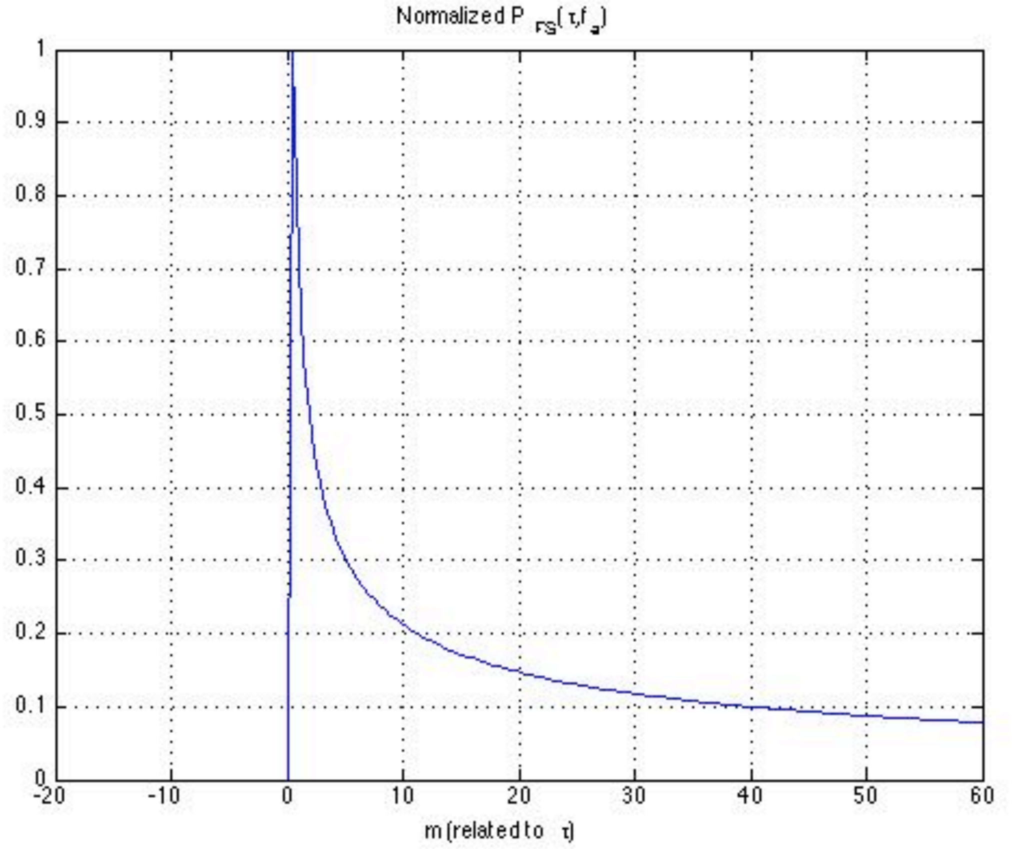
$$E[I_R] = P_{FS}(\tau,f_a) \; ** \; S_R(\tau,f_a) \; * \; \left(\frac{c}{2}\right) P_z\left(\frac{cT}{2}\right)$$

Flat Surface Impulse Response

System point target response

Surface elevation p.d.f

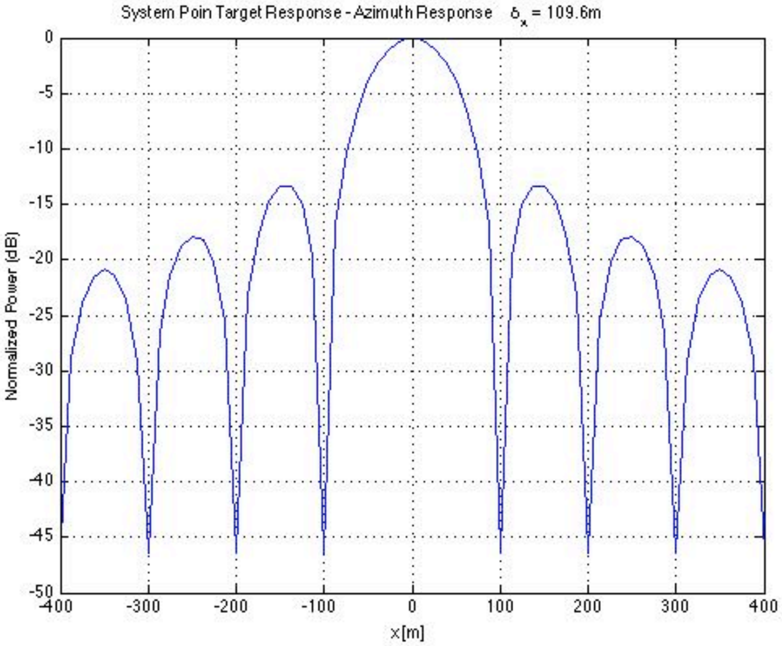
$$P_{FS}(\tau, f_a) = \frac{\lambda_0^2}{(4\pi)^2} \int G^2(\vec{\rho})\, \frac{1}{r^4}\, \sigma_0(\vec{\rho})\, \delta^2(s\tau - \tau_s(\vec{\rho}), f_a - f_s(\vec{\rho}))\, d^2\rho$$

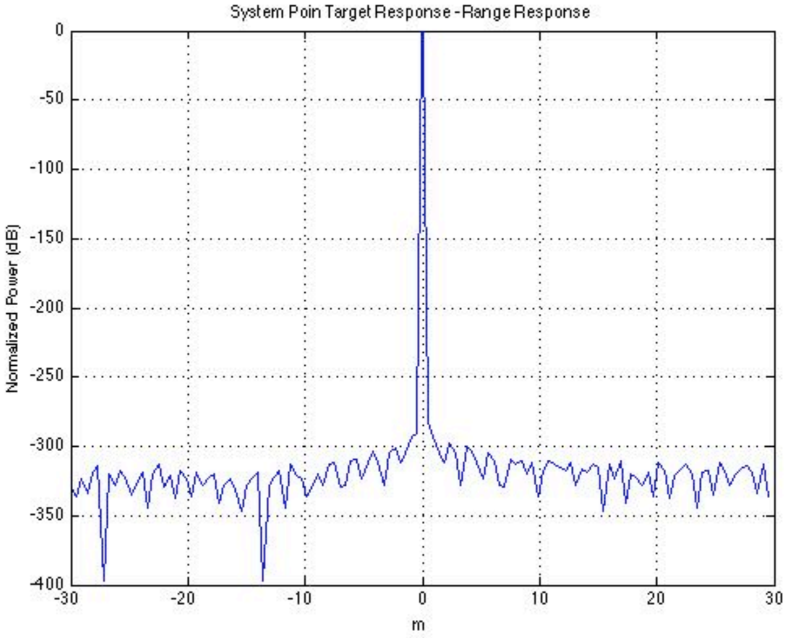


$$\tau_s = \frac{s}{hc}(y^2 + (h-z)^2 - h^2)$$

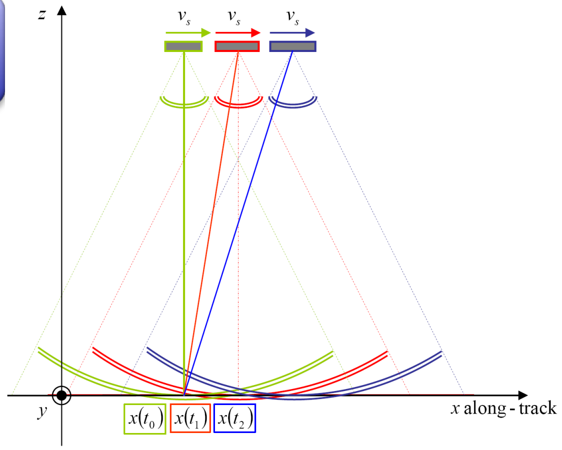
$$f_s = \alpha f_D$$

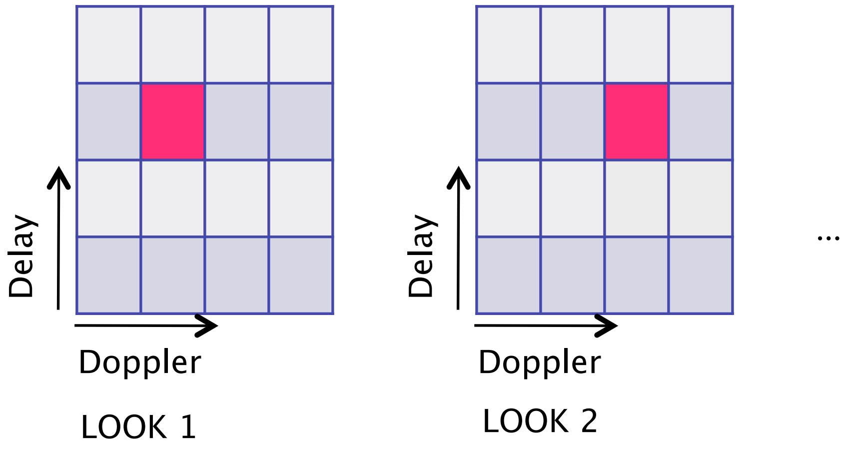
$$S_R(\tau, f_a) = T^2 \tau_u^2 \operatorname{sinc}^2(T f_a) \operatorname{sinc}^2(\tau_u s \tau)$$





## Multi-Look





$$I_{ML} = \sum_{m=-M/2}^{M/2-1} Y(\tau, f_a - m\Delta f)Y^*(\tau, f_a - m\Delta f)$$

$$E[I_{ML}]_{\zeta(\vec{\rho},t)=z} = \sum_{m=-M/2}^{M/2-1} E[Y(\tau, f_a - m\Delta f)Y^*(\tau, f_a - m\Delta f)]_{\zeta(\vec{\rho},t)}$$

- The SAR Altimeter waveform satisfies Hayne's model with different: Flat surface impulse response and System point target Response adapted to the SAR geometry
- The Flat surface impulse response is along track and across track dependent
- The System point target response of the SAR altimeter results in finer resolution which will be of great interest to the scientific coastal altimetry community

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