



CENTRE NATIONAL D'ÉTUDES SPATIALES

# **KaRIn/SWOT Performance analysis tool**

## **Application to near nadir swath extension**

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OSTST Meeting / Lisbon / October 2010

- ▶ **NASA and CNES** have recently agreed on the sharing of responsibilities for the SWOT mission.

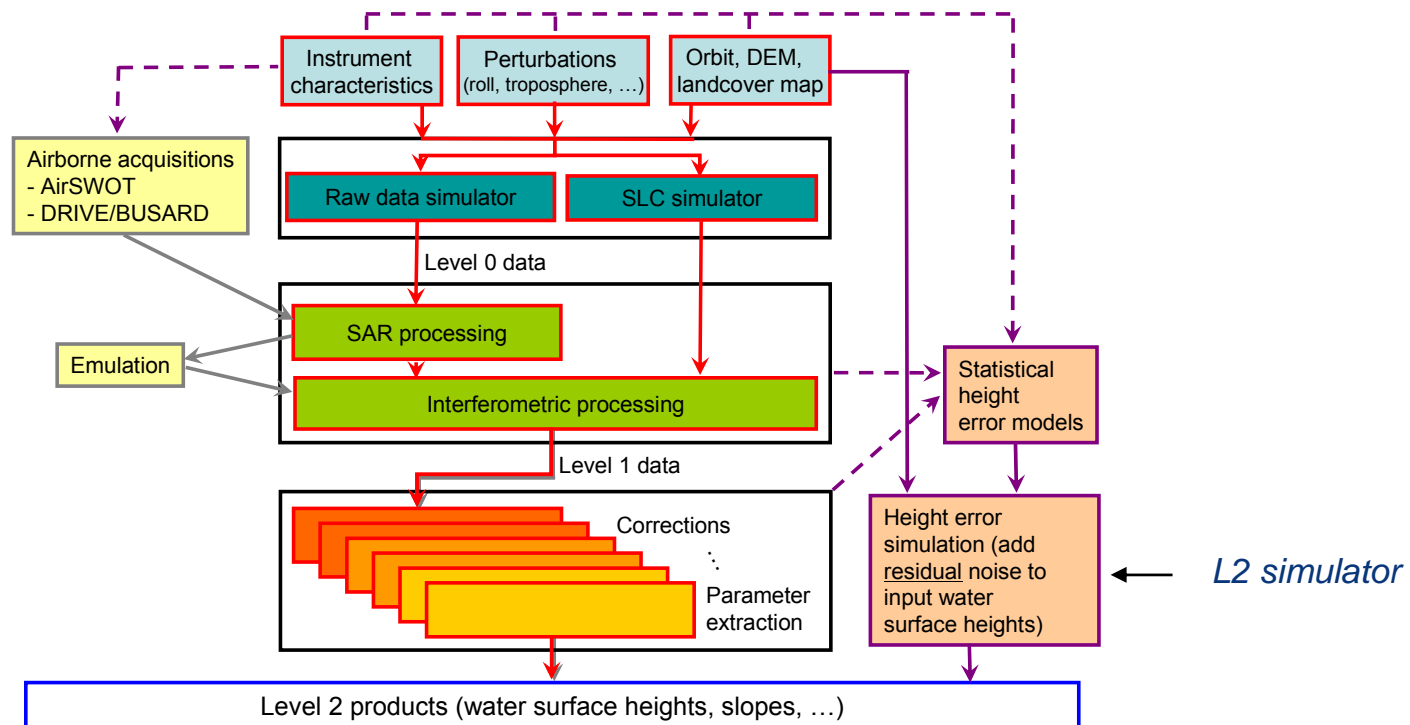


- ▶ Closer technical discussions between JPL and CNES will take place in the framework of a joint team.
- ▶ The following study is based on a set of KaRIn input parameters that are likely to evolve in the next future

- ▶ KaRIn/SWOT Performance analysis tool
  - Introduction
  - Presentation
  
- ▶ Application to near nadir swath extension
  - Introduction
  - Chronogram
  - Geometry
  - Signal to Noise Ratio
  - Interferometric / Height Sensitivity

### ► Goals :

- Evaluate height error performances at instrument level in order to consolidate the operating point, to evaluate the sensitivity of different parameters, ...
- To couple this statistical height error model with a L2 simulator [*PhD thesis of S. Biancamaria*]



- **Developed** by B. Mametsa at CNES from a tool delivered by Thales Alenia Space [*in the continuity of PhD thesis of V. Enjolras*]

**Paramètres configuration**

Choisissez un fichier associé :

Nadir\_dedicated\_instrumentl

Ok

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**Paramètres d'entrées**

LABEL	SYSTEME ANTENNAIRE	SIGNAL RECU	HR PROCESSING
Label de la configuration Nadir_Interfer_dedicated_instl	Base interférométrique (m) 10	Température système (K) 605	Mode d'opération NPP(bistatique)
ORbite	Longueur antenne(m) 4	F_échantillonnage (MHz) 200	Bid doppler traitée HR(%) 100
Altitude (m) 970000	Gain TX (dB)	Pertes Rx (dB) 2.7	facteur présomation 2
SIGNAL EMS	Angle vue range TX (*)	ERREURS SYSTEMES	LR PROCESSING
Fréquence porteuse (GHz) 35.75	Angle range 3dB TX (*)	Erre	
Bande passante (MHz) 200	Angle vue azimut TX (*) 0	Erre	
Puissance crête HPA (W) 1500	Angle azimut 3dB TX (*)	Erre	
Rendement électrique 0.32	Gain RX (dB)	Angle	
Durée de l'impulsion (us) 7.5	Angle vue range RX (*) 0	Angle	
Fréquence répétition (Hz)	Angle vue azimut RX (*) 0	Angle	
Pertes TX (dB)	Angle 3dB RX (*)	Angle	

**Input parameters for a given stored configuration:**

- geometry (orbit, ..)
- instrument parameters (antenna gain, pulse characteristics, ...)
- product processing (HR, LR, ..)

**Paramètres configuration**

Appuyez sur ctrl+m pour créer ou modifier un fichier texte

Choisissez un fichier associé :

Nadir\_dedicated\_instrumentl

Fauchée minimale (km) : 1

Fauchée maximale (km) : 10

Vitesse du vent (m/s) : 7.2

SWH (m) : 0

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**Contributions de bruit**

Sélectionner les contributions souhaitées :

- Thermique
- Quantification/compression
- Décorrélration géométrique
- migration distance non corrigée

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**Erreurs de hauteur**

Sélectionner les erreurs de hauteur souhaitées :

- erreur d'altitude
- erreur de range
- erreur de baseline
- erreur de roulis
- erreur de phase

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**Courbes**

Appuyez sur la courbe souhaitez

- Hauteur ambiguë
- Résolution et Pixel range
- Sigma0
- Gain des antennes
- Gain antenne aller-retour
- Nb de points moyennés
- SNR HR
- Cohérences HR
- Cohérence totale HR
- Erreur phase moyennée HR
- Erreur phase pixel HR
- Erreur hauteur moyennée HR
- Erreur hauteur pixel HR
- SNR LR
- Cohérences LR
- Cohérence totale LR
- Erreur de phase LR
- Erreur de hauteur LR

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**Options**

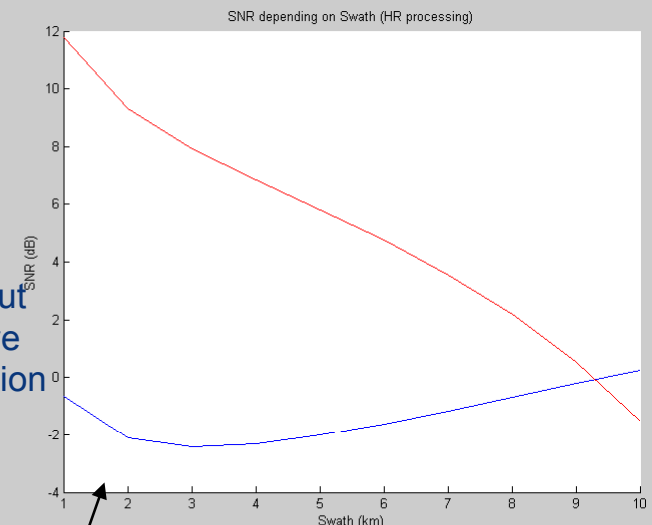
Ajouter une courbe

Supprimer dernière courbe

Relancer programme

Impression courbe

output curve selection



**Informations Label**

Label: KaRIn extended swath      Nadir Interfer dedicated instrument

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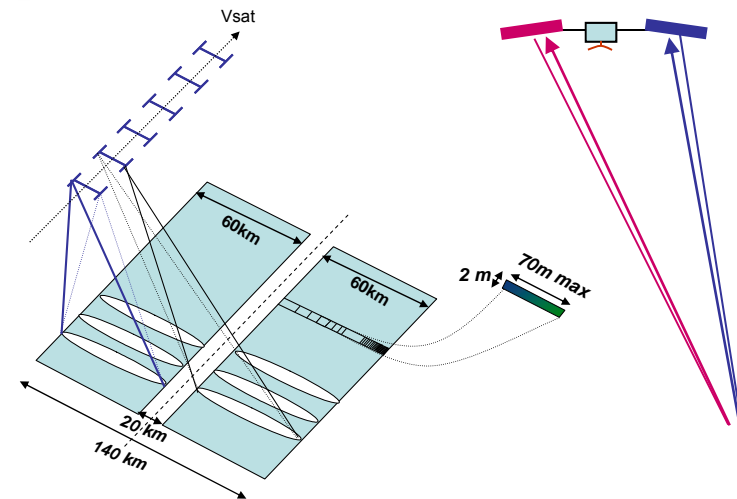
**Nadir Interfer dedicated instrument**

Puissance moyenne consommée HR (W) : 155.3906	Puissance moyenne consommée LR (W) : 155.3906
Débit de données HR (Mbits/s) : 41.9546	Débit de données LR (Mbits/s) : 0.074685
Débit relatif HR (Mbits/s) : 14.6841	Débit relatif LR (Mbits/s) : 0.048545

### Simulation parameters:

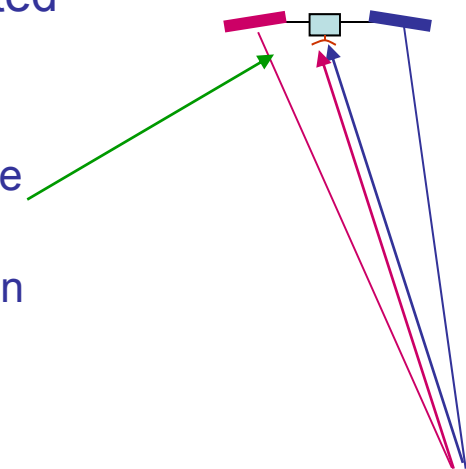
- swath
- wind speed
- noise contribution (thermal [SNR], geometric dec., ...)
- additive height error contribution (roll, baseline, ...)

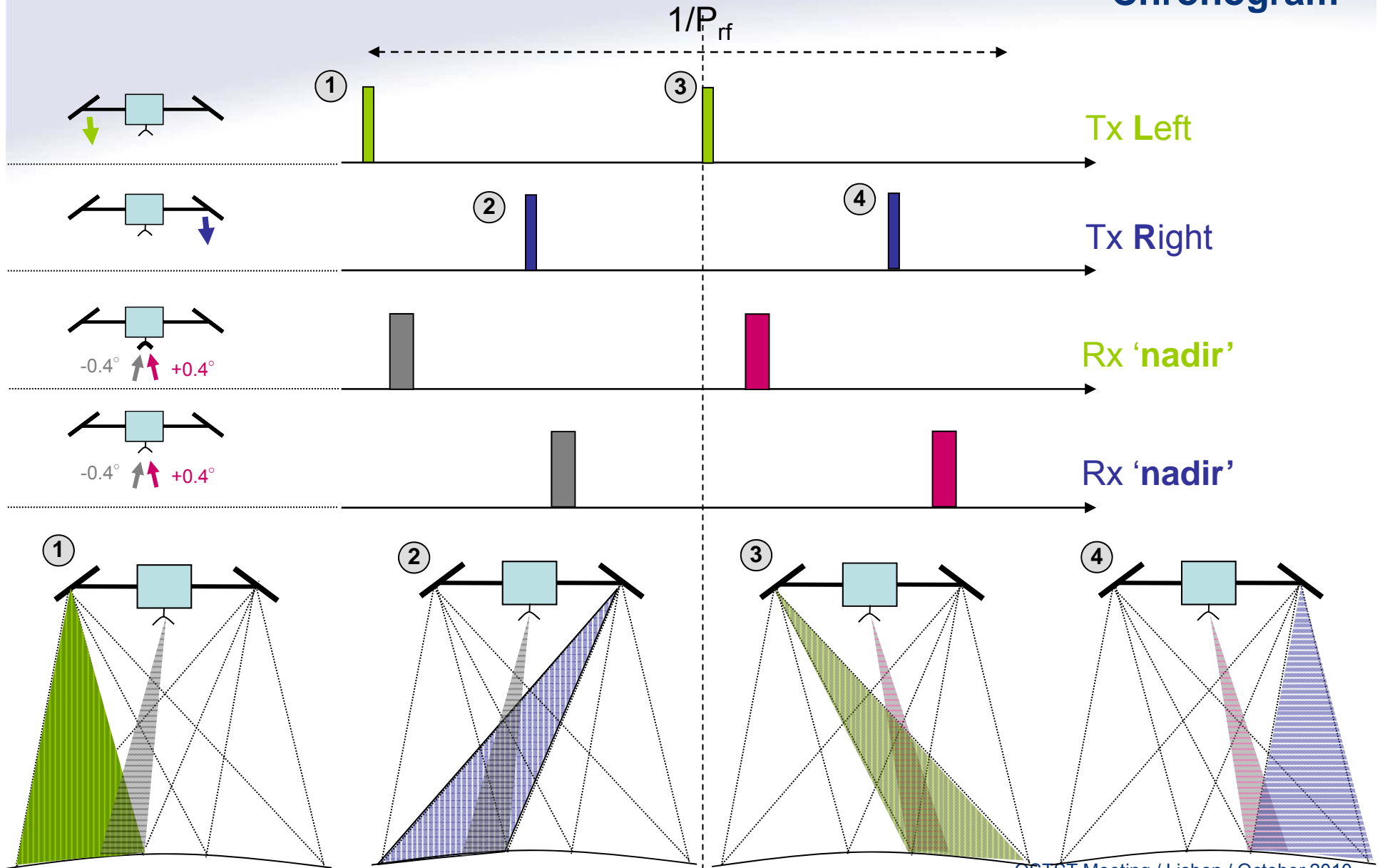
- ▶ KaRIn is basically a **side looking radar** that is by nature incompatible with nadir observation. Thus, the nominal KaRIn swath is **10km to 60km** from nadir, leading to a **20km** nadir gap.

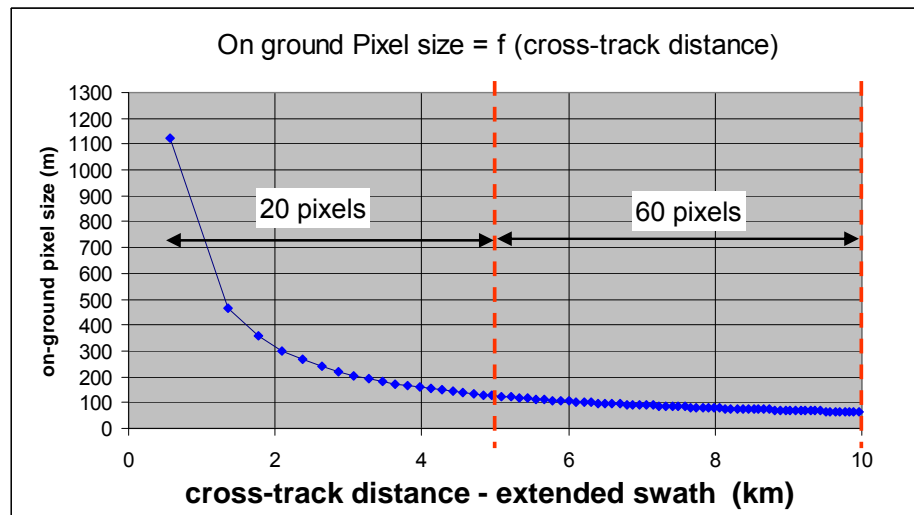
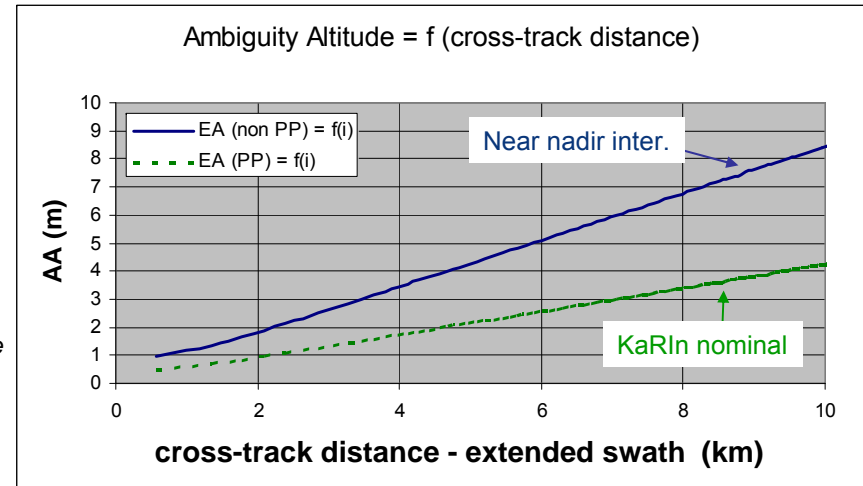
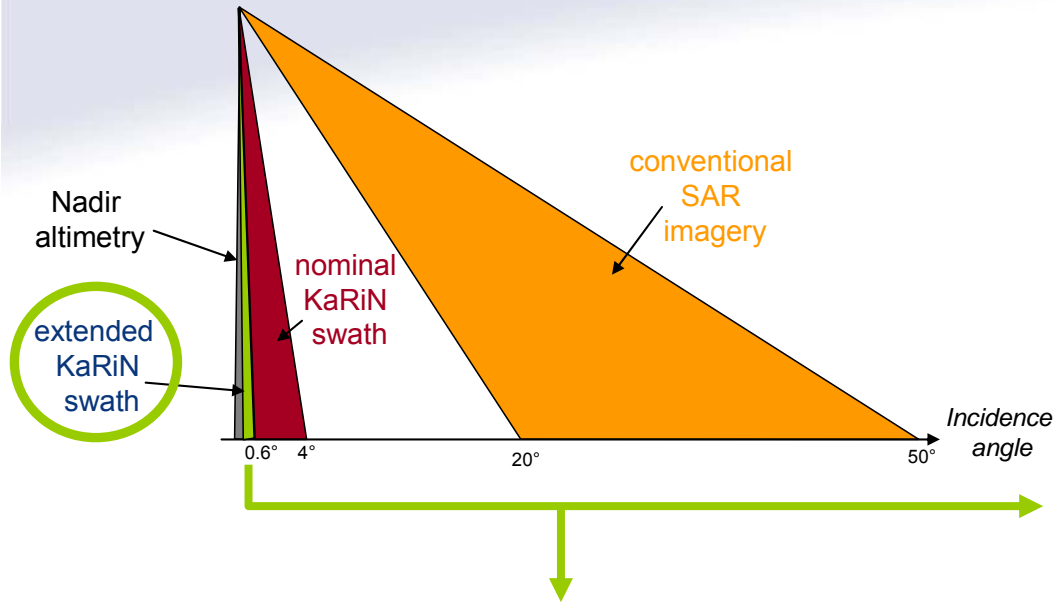


- ▶ In that context, E. Rodriguez has proposed a partially dedicated instrument, the “**Nadir interferometer option**”, to extend the observation closer to nadir

- Two additional feeds looking at  $\sim \pm 0.4^\circ$  accommodated on the AMR antenna (switched into a single receive channel)
- The near nadir interferometry is based on the signals received on the near nadir feeds from the KaRIn nominal transmission
- The equivalent baseline is halved







► Swath extension

- Negligible impact on TM data rate
- Only considered for **oceanography** due to large range pixel size (compared to 10m-70m for the nominal swath)
- More limited range multilooking (1 km<sup>2</sup>)

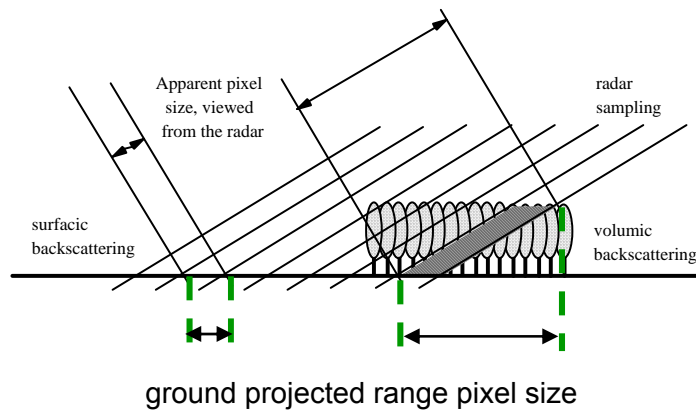
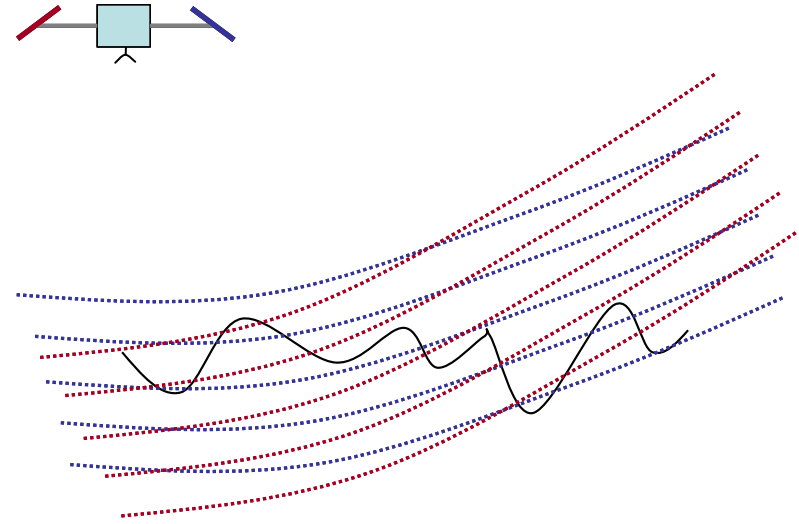
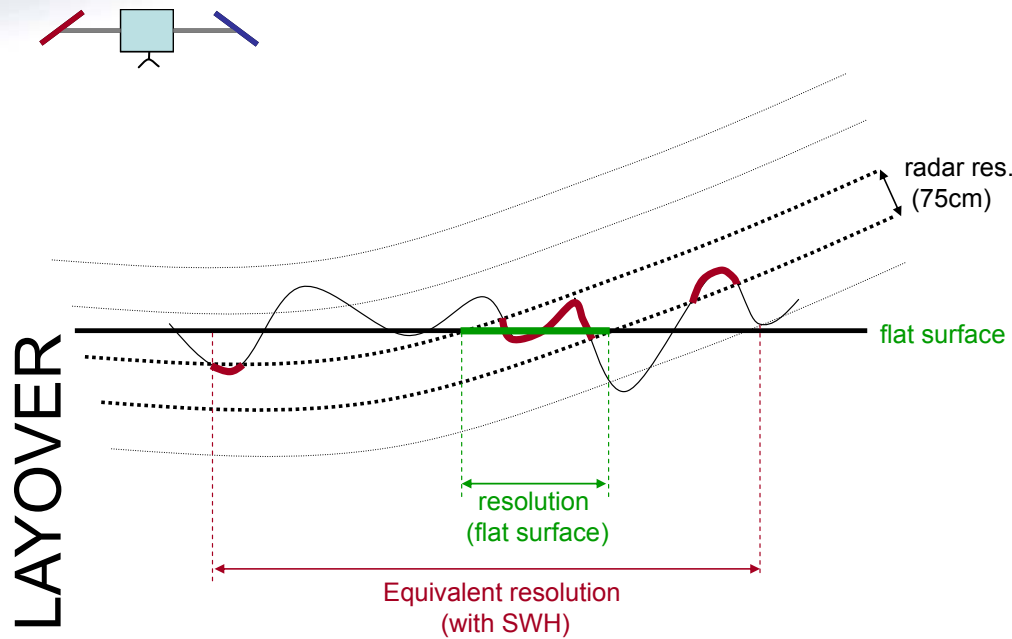
► Near nadir interferometer vs. nominal KaRiN

- Altitude of ambiguity doubled

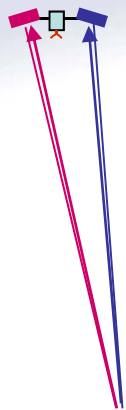


➤ Degradation of projected resolution

➤ Geometric decorrelation



### KaRIn nominal mode / extended swath



$$\gamma_{SNR} = \frac{1}{1 + \frac{1}{SNR}}$$

$$\gamma_{BAQ} = \frac{1}{1 + \frac{1}{SQNR}}$$

$$\gamma_{GEOM} = 1 - \frac{\Delta_f}{B_f}$$

$$\Delta_f \approx \frac{f_o \cdot B}{2 \cdot r \cdot \tan(\theta)}$$

Total coherence

$$\gamma = \gamma_{SNR} \cdot \gamma_{BAQ} \cdot \gamma_{GEOM}$$

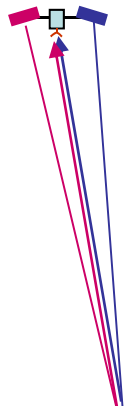
$$\tau_\Phi = \frac{1}{\sqrt{2 \cdot N_{look}}} \cdot \frac{\sqrt{1 - \gamma^2}}{\gamma}$$

Random phase error

$$\tau_z \approx \frac{\lambda \cdot R \cdot \tan(\theta)}{2 \cdot \pi \cdot (2 \cdot B)} \cdot \tau_\Phi$$

Random height error

### Near nadir interferometry option



Higher gain near nadir (AMR nadir pointing)

$$\gamma_{SNR} = \frac{1}{1 + \frac{1}{SNR}}$$

$$\gamma_{BAQ} = \frac{1}{1 + \frac{1}{SQNR}}$$

$$\gamma_{GEOM} = 1 - \frac{\Delta_f}{B_f}$$

$$\Delta_f \approx \frac{f_o \cdot (B/2)}{2 \cdot r \cdot \tan(\theta)}$$

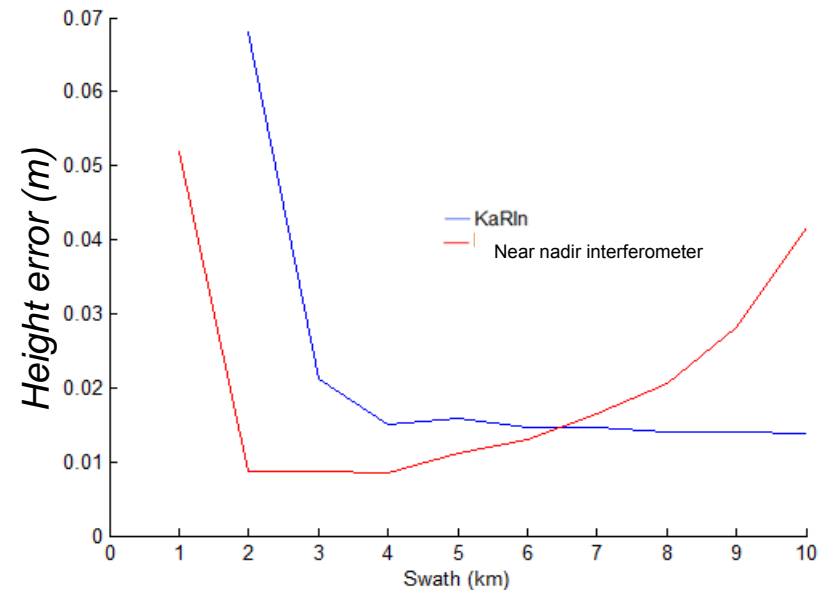
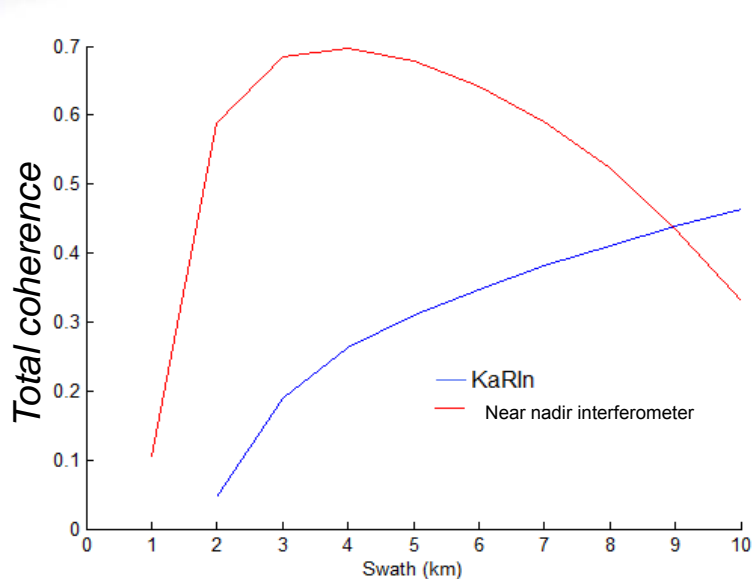
$$\gamma = \gamma_{SNR} \cdot \gamma_{BAQ} \cdot \gamma_{GEOM}$$

$$\tau_\Phi = \frac{1}{\sqrt{2 \cdot N_{look}}} \cdot \frac{\sqrt{1 - \gamma^2}}{\gamma}$$

$$\tau_z \approx \frac{\lambda \cdot R \cdot \tan(\theta)}{2 \cdot \pi \cdot (1 \cdot B)} \cdot \tau_\Phi$$

Equivalent baseline (B/2)  
OSTST Meeting / Lisbon / October 2010

- Comparison of Near nadir interferometer and nominal KaRIn with extended swath



Limitations (phenomena not yet taken into account):

- Impact of azimuth ambiguities
- **Geometric decorrelation** must be carefully studied, mainly at very low look angles on ocean (with waves)
- Ground projected resolution also affected by SWH

- ❑ *Update results after JPL/CNES technical discussion*
  
- ❑ *Continue the analysis of the geometric decorrelation (near nadir) with a precise sea high resolution model [PhD thesis of P. Dubois]*
  
- ❑ *Couple the KaRIn/SWOT performance analysis tool with level 2 thematic simulator (PhD thesis of C. Lion in the continuity of PhD thesis of S. Biancamaria)*
  
- ❑ *Apply this methodology to evaluate the performances of airborne validation campaigns (DRIVE on BUSARD on French side soon [2010-2011])*