Perspectives d'applications des modes SAR et SARin pour le suivi du niveau des fleuves et leur localisation

CNES– Journée Altimétrie et Hydrologie 2014

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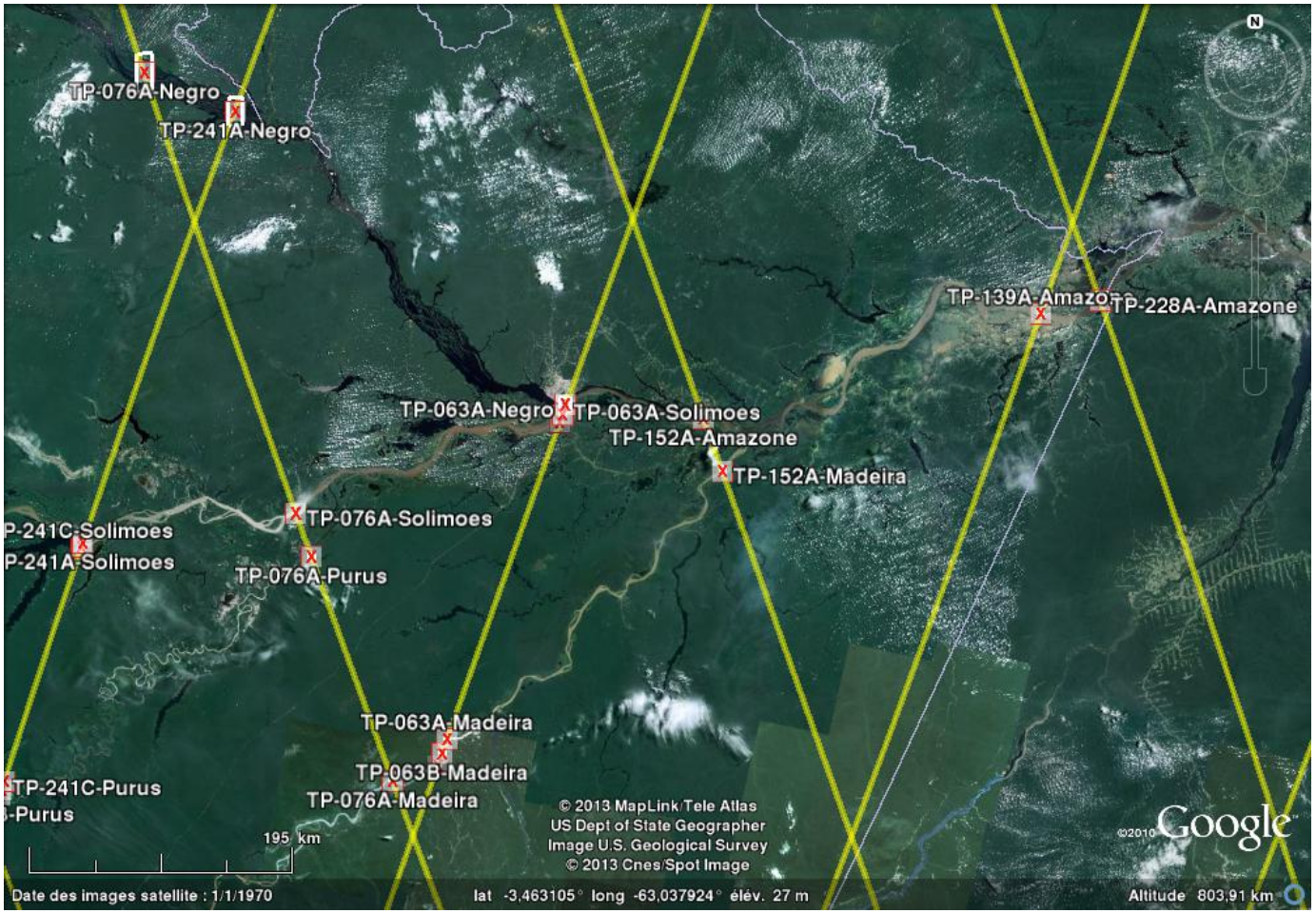
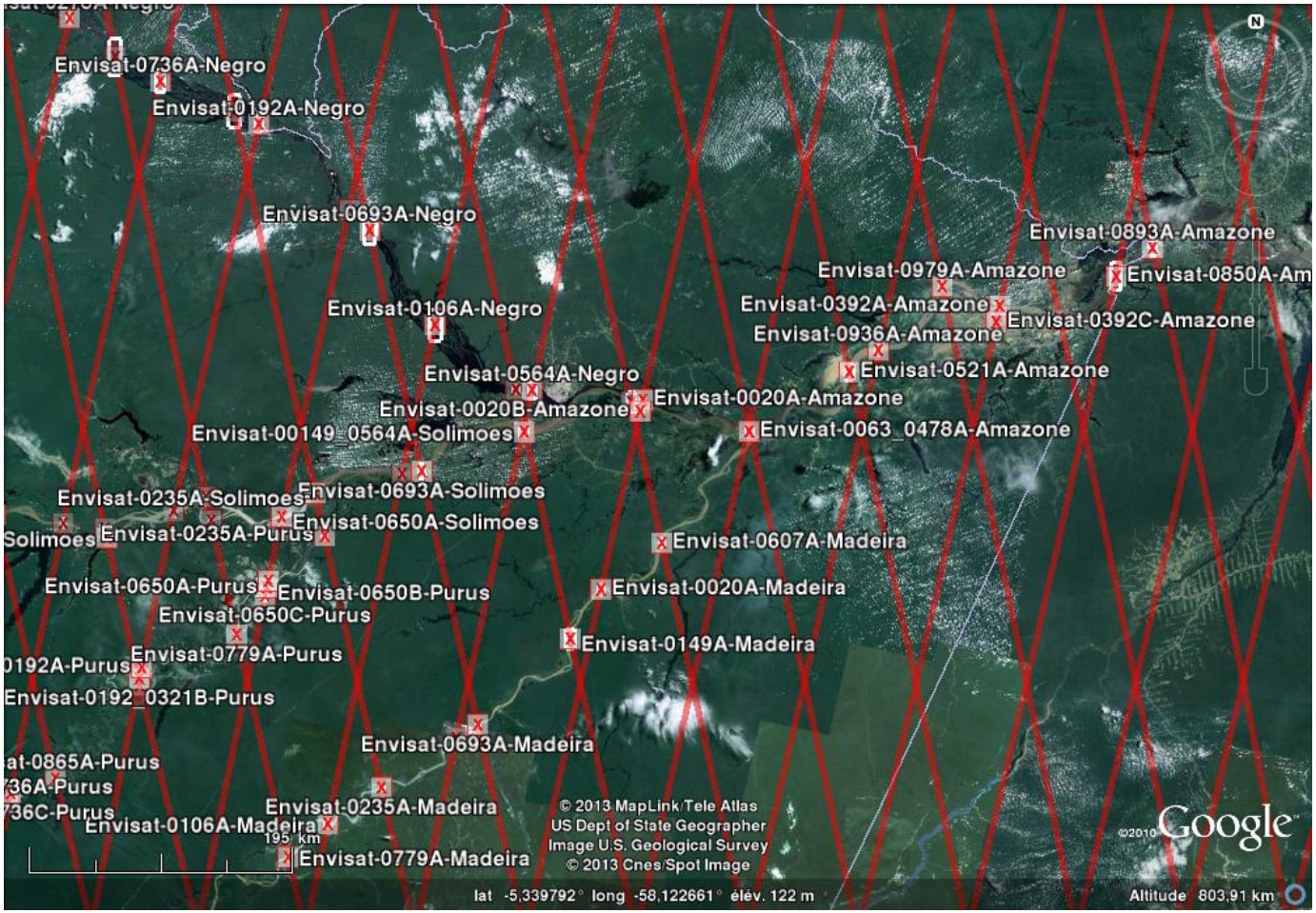
CryoSat-2 flies on a geodesic orbit !

Topex/Poseidon & Jason-2 "virtual stations"



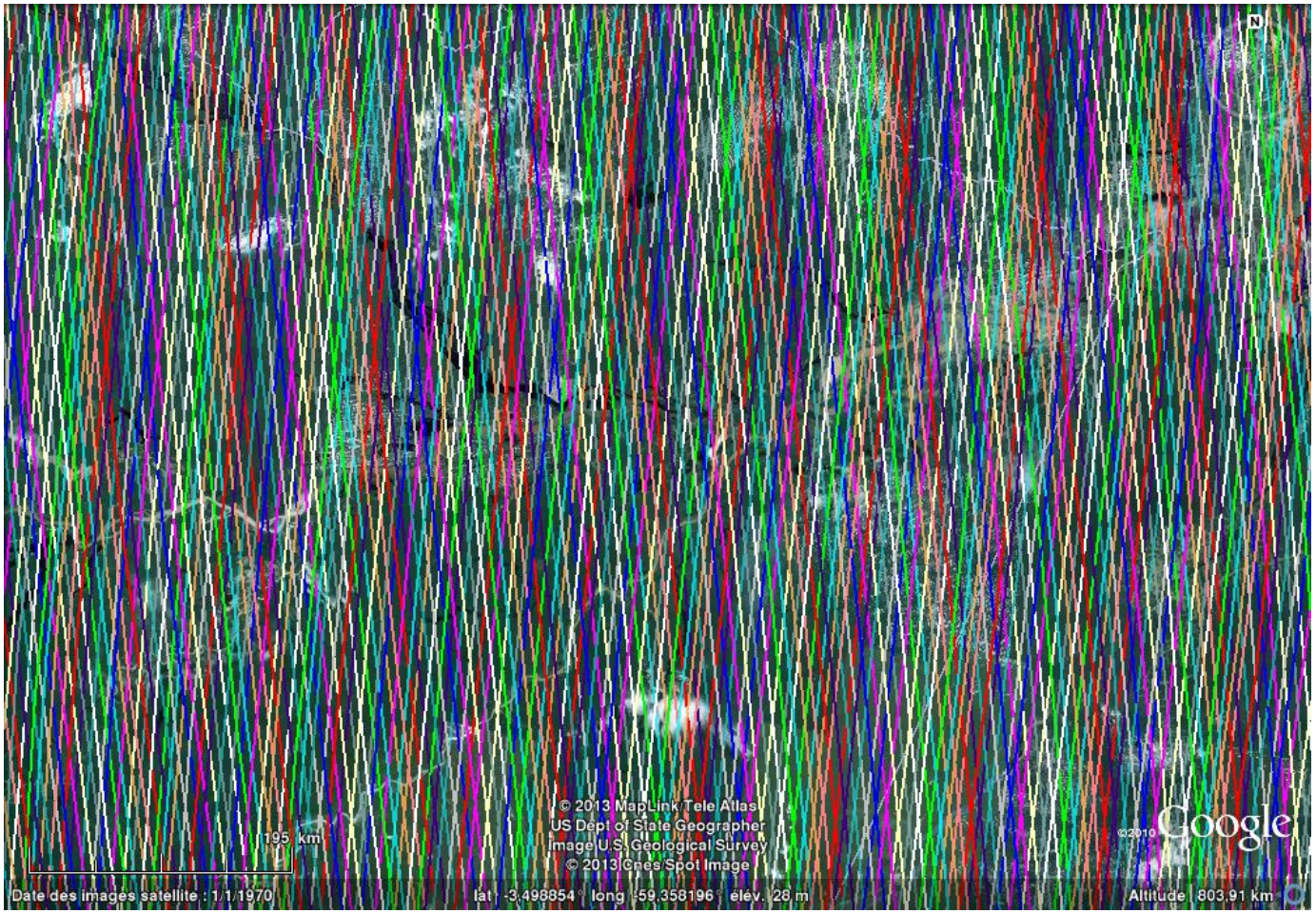
CryoSat-2 flies on a geodesic orbit !

Envisat "virtual stations"



CryoSat-2 flies on a geodesic orbit !

CryoSat-2 tracks. . . ! (369 days, 7 km //)



CryoSat-2 altimeter : SIRAL

SIRAL basics

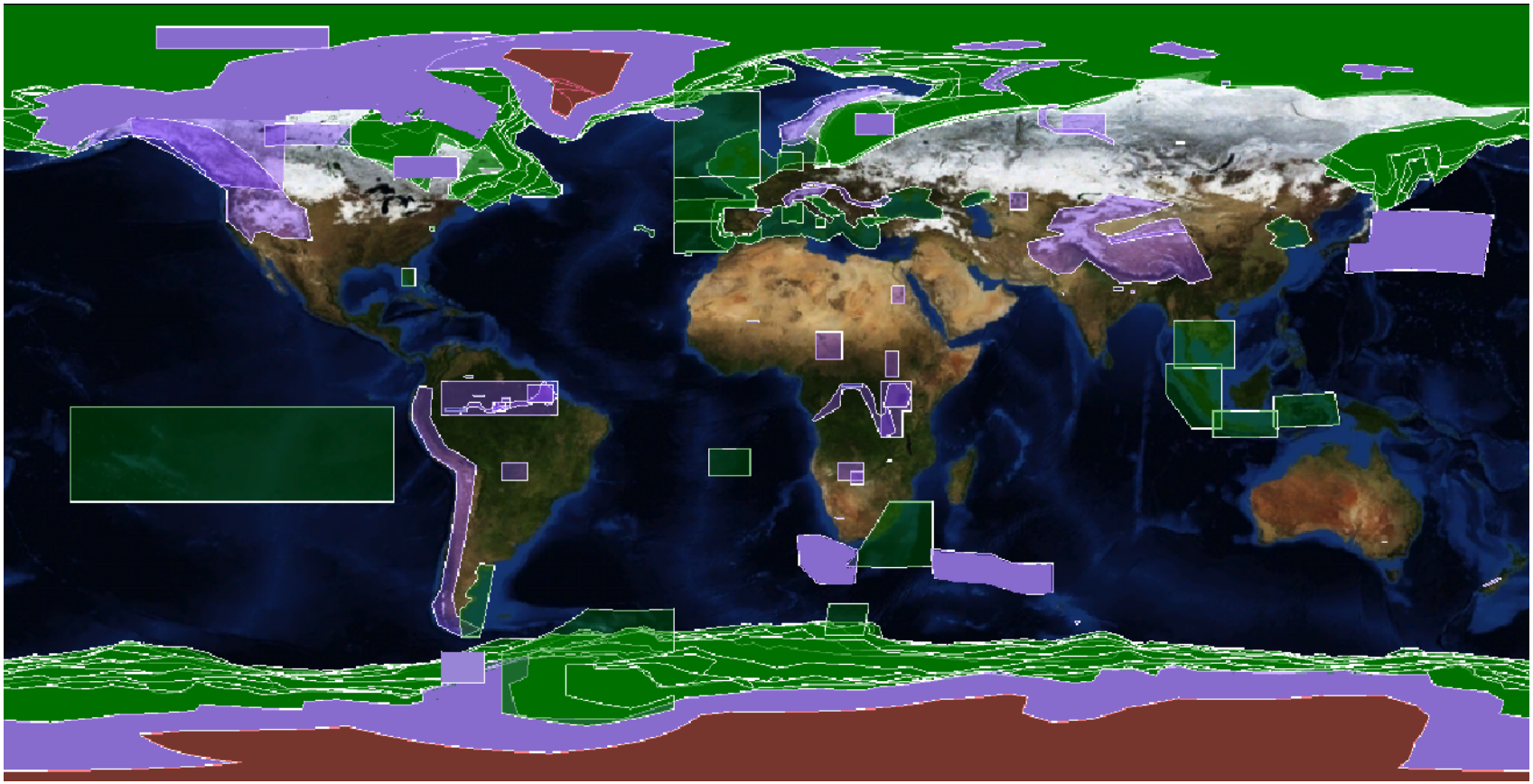
- The most advanced nadir altimeter !
- Ku band
- 20 Hz tracking cycle $\rightarrow$ 20 Hz L2 products

SIRAL : 3 exclusive measurement modes

- **LRM** : Wf : 128 bins, Res. : 200 km^2, L2 : 20 Hz
- **SAR** : Wf : 128 bins, Res. : 3 km^2, L2 : 20 Hz
- **SARin** : Wf : 2$\times$512 bins (dual channel), Res. : 3 km^2, L2 : 20 Hz + retracked echo (lat,lon)

CryoSat-2 modes mask

LRM : ≈ 66% – SAR : ≈ 17% – SARin ≈ 17%



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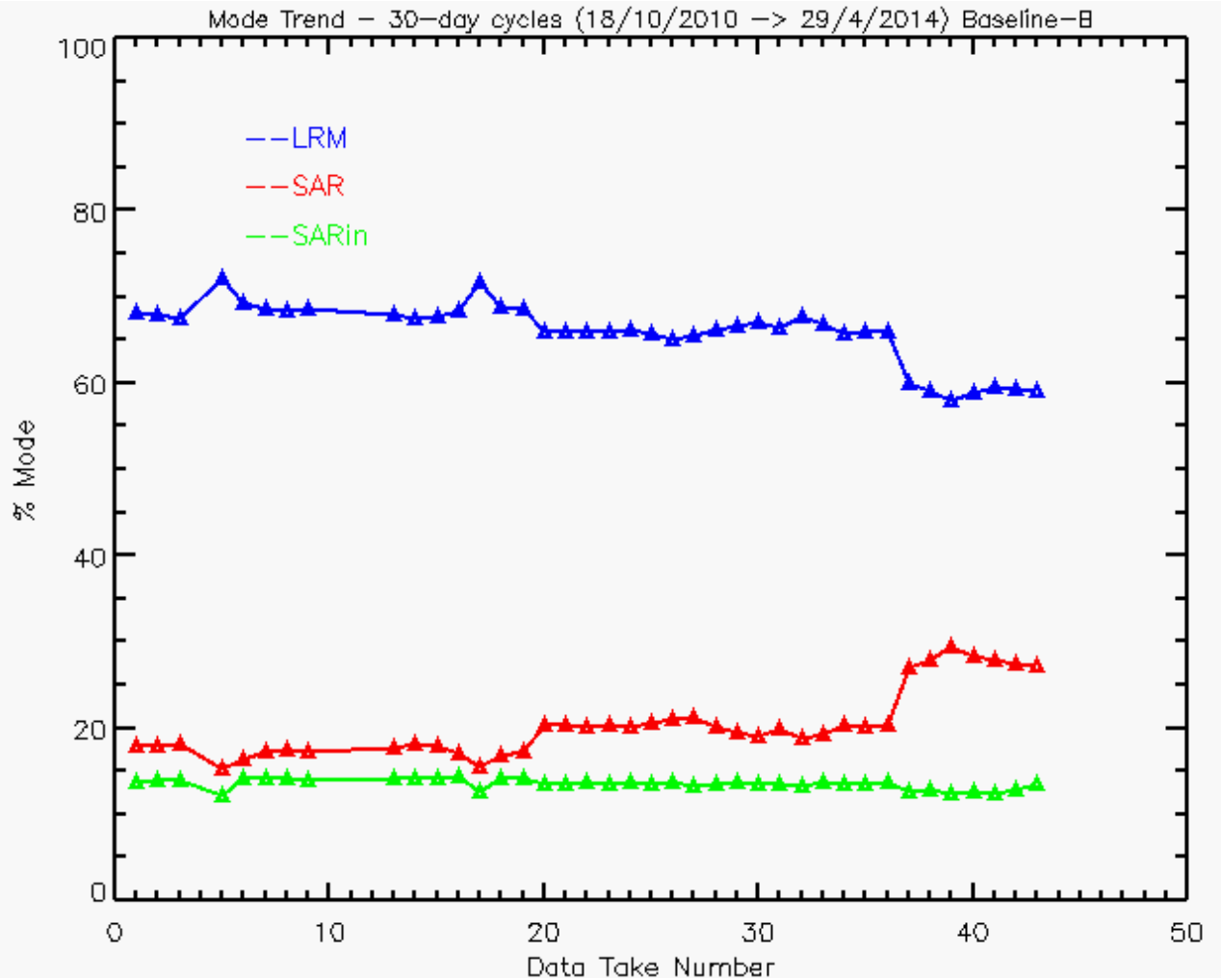


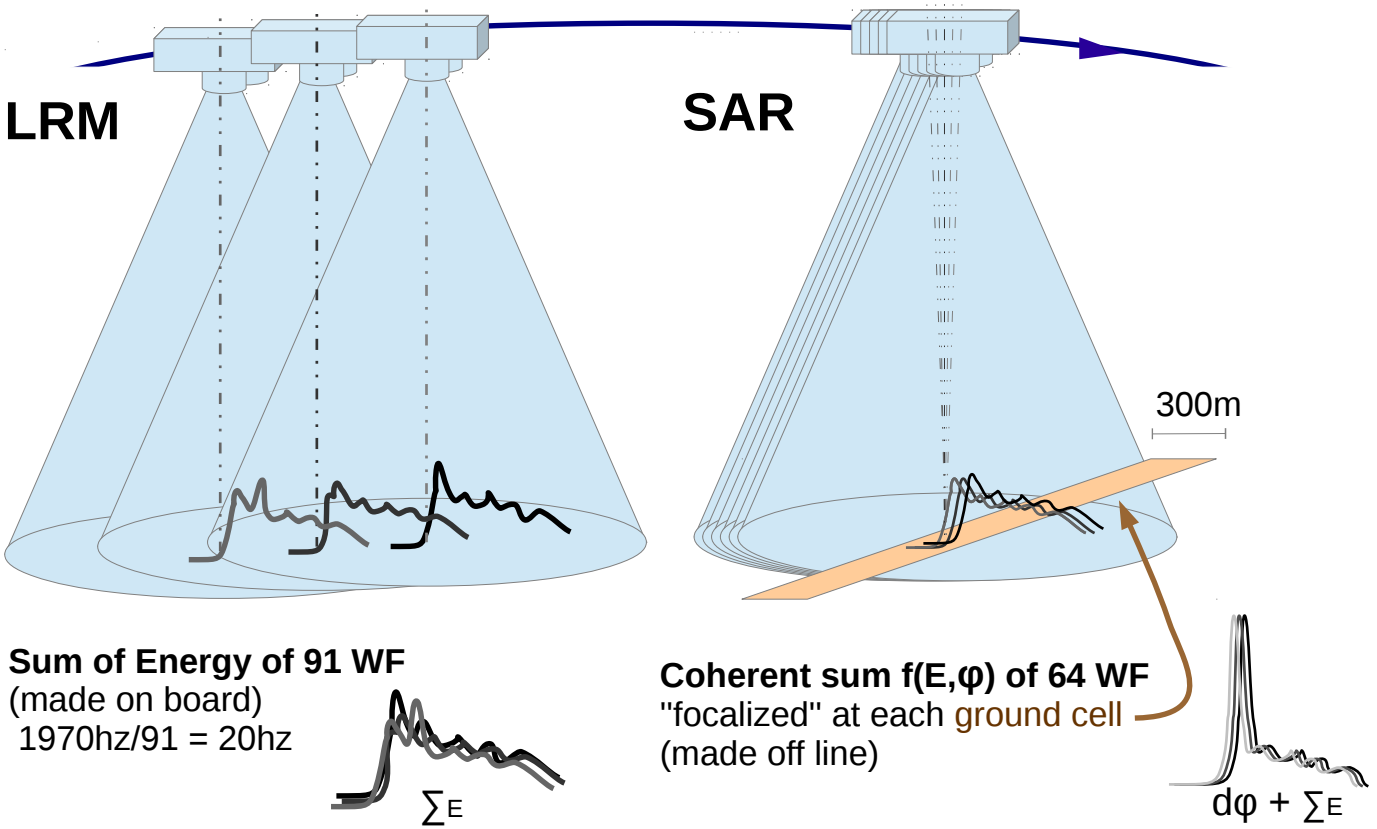
CryoSat-2 data products (and their use in hydrology)

- **ESA Official L2 products (Baseline B, since Feb. 2012)**
  - Product files for **LRM, SAR & SARin modes**
  - Use : spatio-temporal time series, longitudinal & transversal river profiles, validation : (SAR :) along-track resolution, (SARin :) cross-track angle
- **CNES CPP (CryoSat Processing Prototype)**
  - 11 months of **GDR-D-like products** for LRM, SAR & **RDSAR** modes
  - Use : SAR / Reduced-SAR comparison and assessment
- **ESA/ESRIN Sentinel-3 prototype**
  - Data samples : **stack matrices**, L1B 20 Hz & **80 Hz** (waveforms), L2 (Samosa retracker outputs)
  - Use : exploring stack applications (surface roughness & classification), along-track resampling (spotlight), etc.

LRM vs. SAR : waveforms

Doppler beam

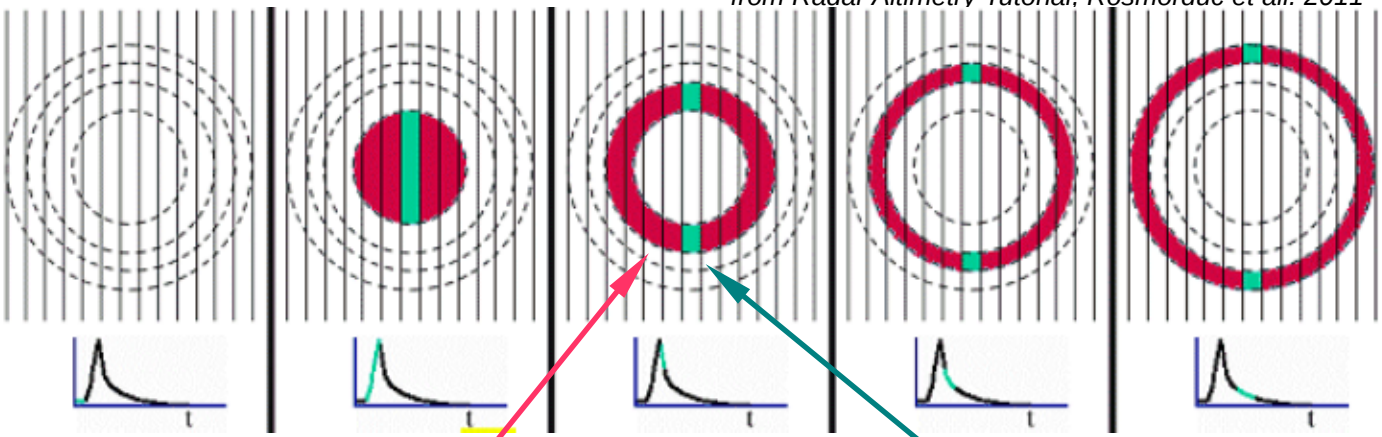
1 doppler WF = a coherent sum of 64 Brown's WF



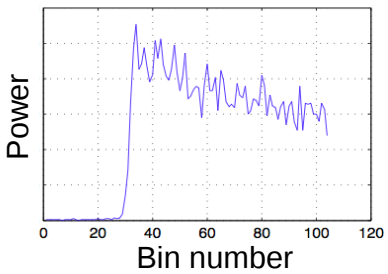
LRM vs. SAR : waveforms

Doppler beam footprint

from Radar Altimetry Tutorial, Rosmorduc et all. 2011

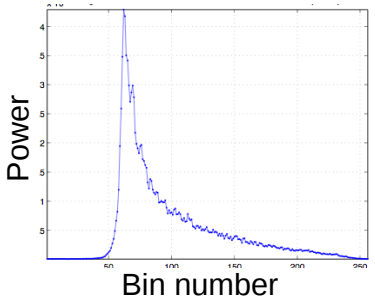


Brown wave-form

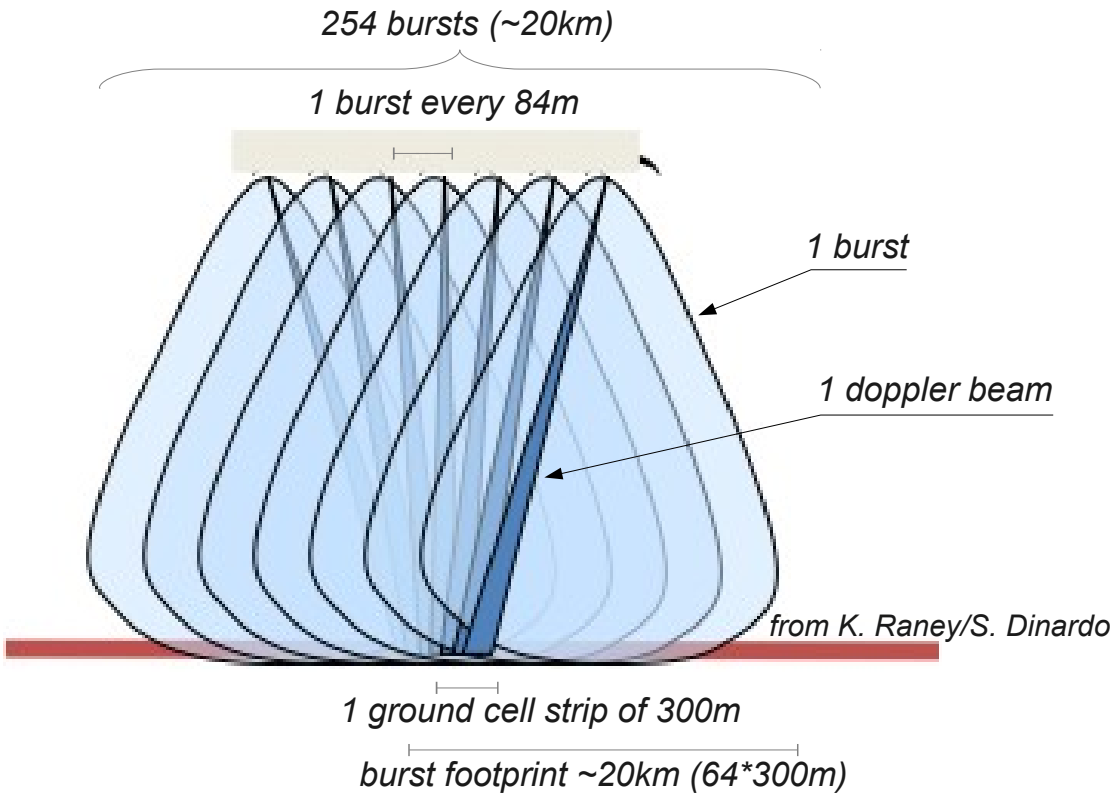


SAR wave-form much more « peaky » than Brown's wave-form (because of surface reduction from internal to external rings)

Doppler wave-form

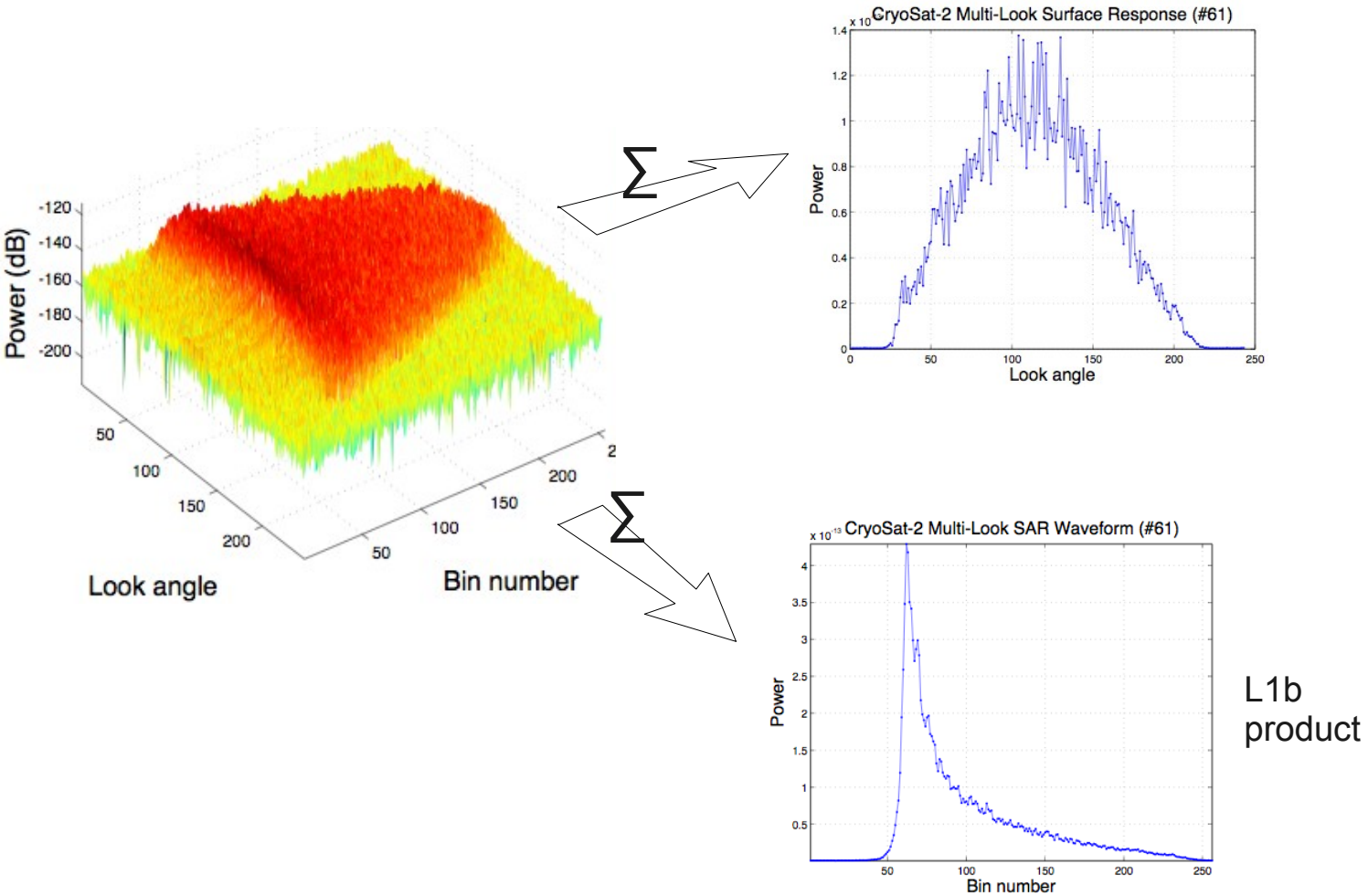


The multi-look over one ground cell

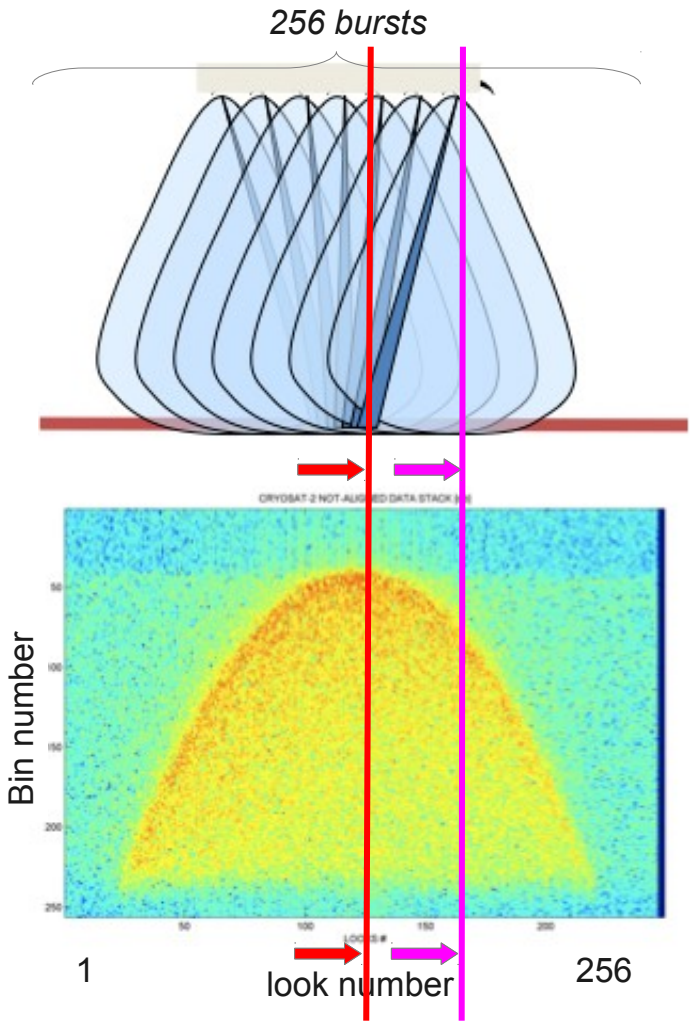


Each ground cell can be seen per theoriticaly 256 bursts
(~223 in practice over ocean)

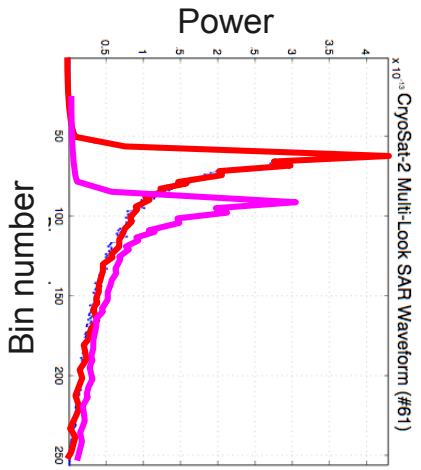
The multi-look: stack



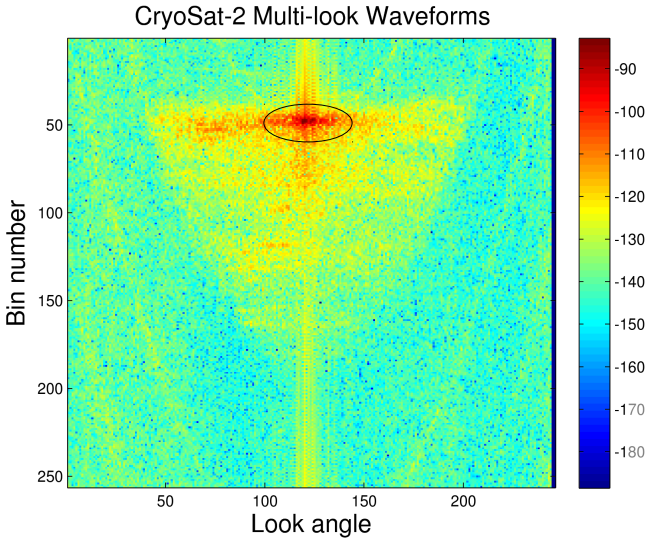
The multi-look : the stack

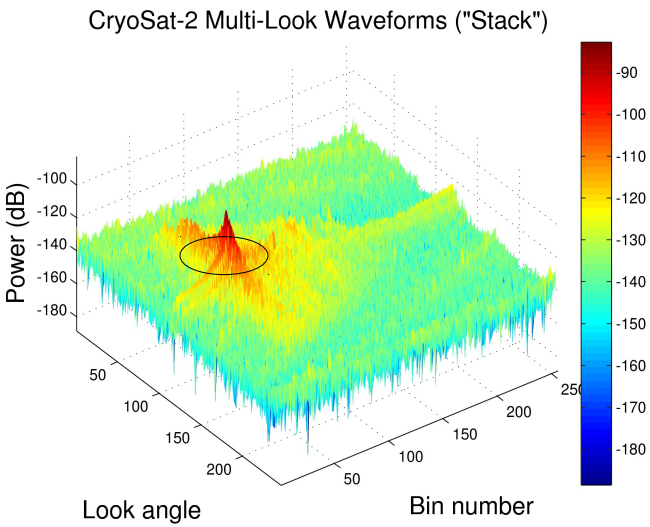


2 Doppler waveforms « looking » the same ground cell

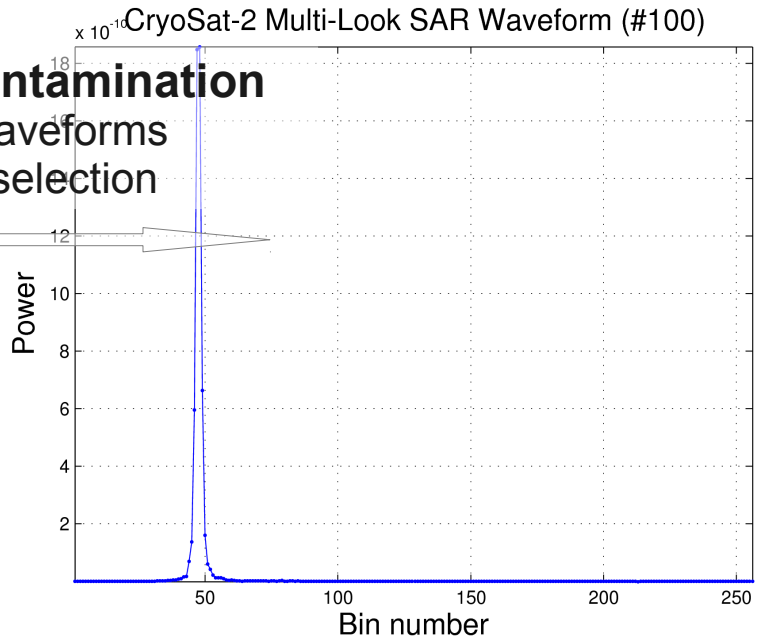


Stack: mean waveform

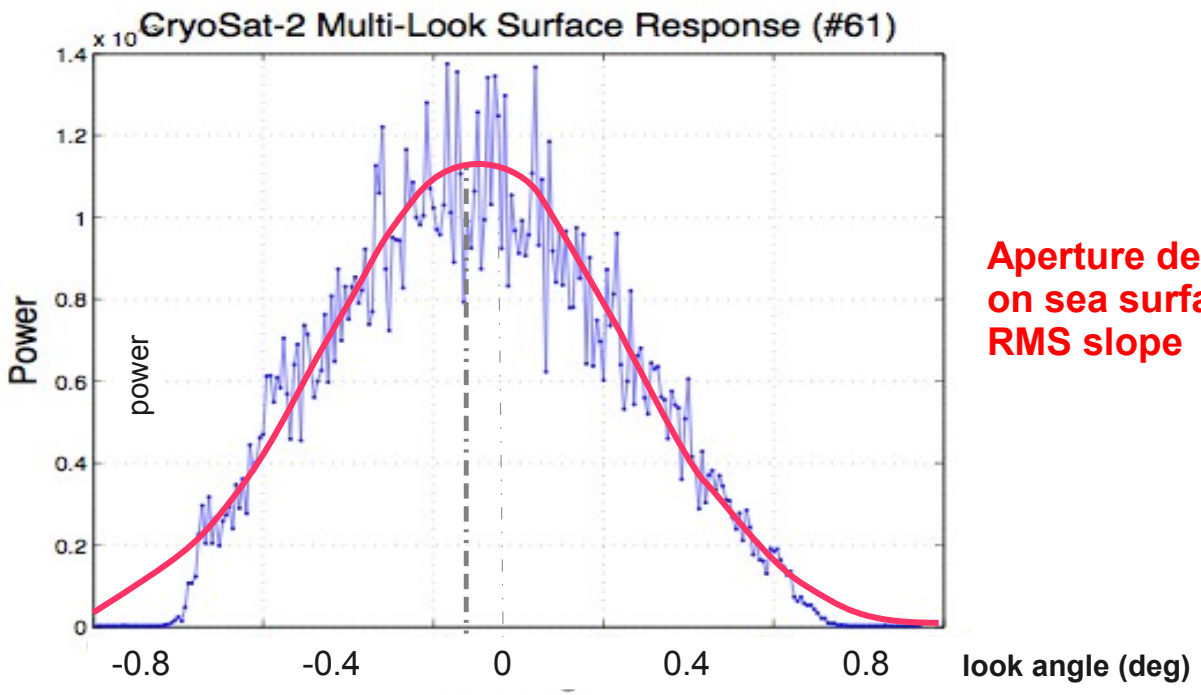




Land decontamination
SAR waveforms
Index selection



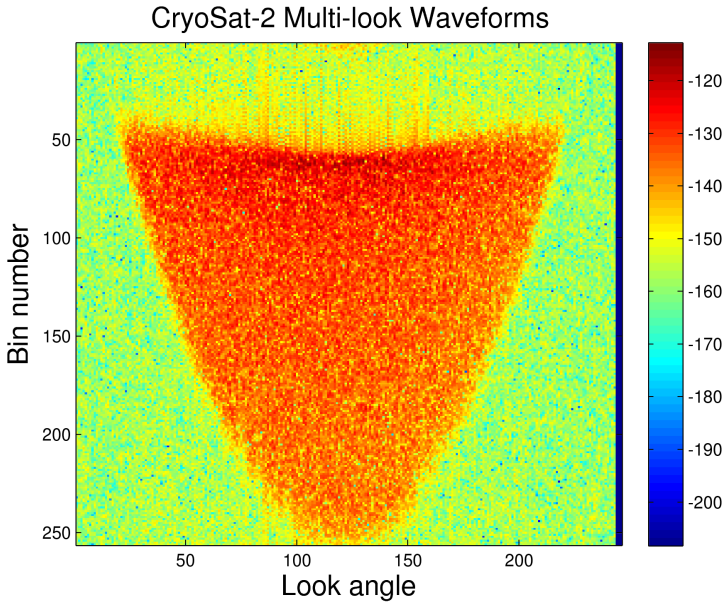
The multi-look: stack look-angles

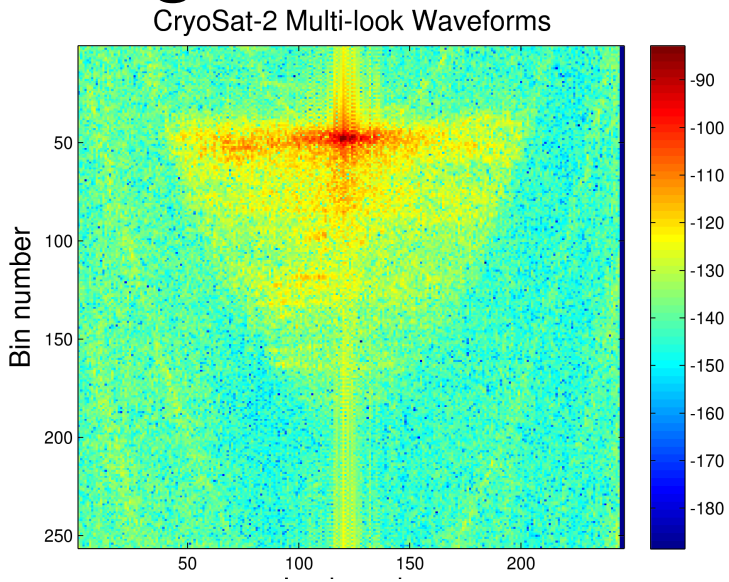


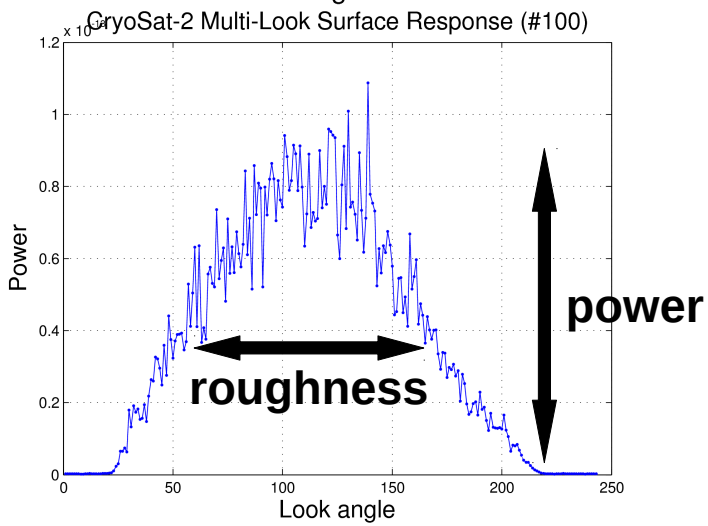
Aperture depending on sea surface RMS slope

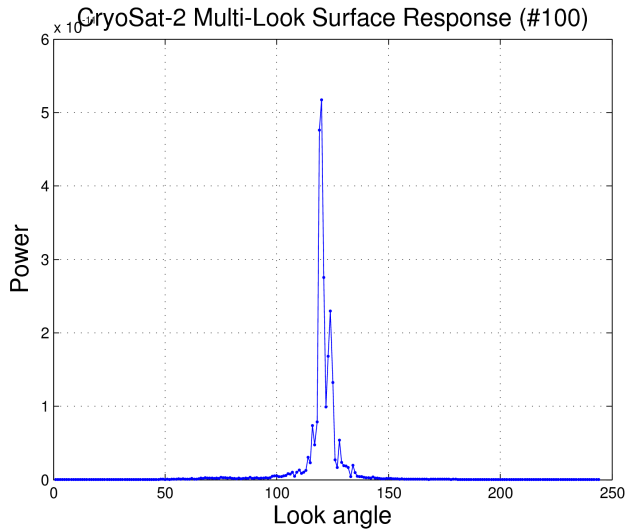
Offset depending on pitch mispointing

Stack: surface roughness









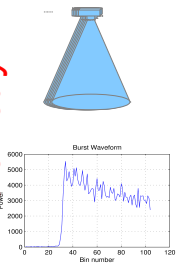
Product Levels

1Hz-20hz products

L0 / FBR | **L1b** | **L2 / L2I**

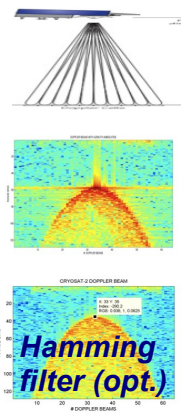
SAR mode

Telemetry



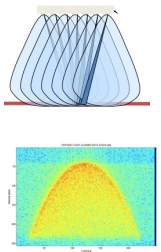
Bursts
64 echoes
Brown WF(I,φ)

SAR coherent sum



Doppler Beams
SAR WF(I)

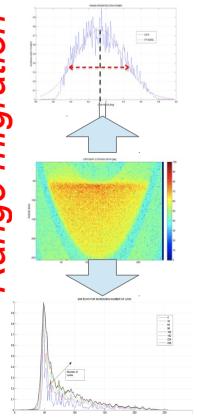
Merge SAR echoes



Multi-look

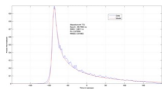
Stack (1/2)
256 ground
cell views

Range migration



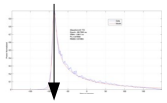
Stack (2/2)
256 ground
cell views

Mean waveform



Waveforms
128 samples

SAR Retracking

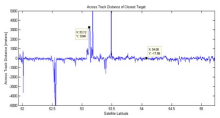


r

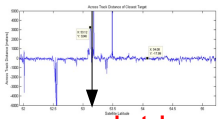
Range

SARin mode

...the "same" for 2 channels...
two reception antennas,
64 look angles instead of 256



Waveforms &
Phase diff.
2×512 samples
each



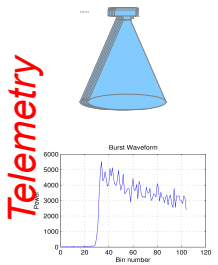
α,lat,lon

Cross-track
Angle / Coords
(retracked bin,
L2I only)

Product Levels

SAR mode

L0 / FBR



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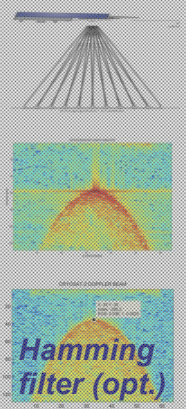
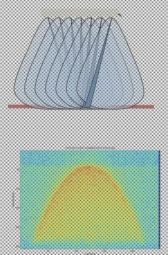


Doppler Beams
SAR WF(I)

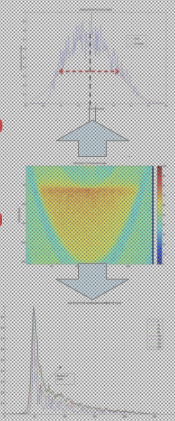
Merge SAR echoes



Multi-look

Stack (1/2)
256 ground cell views

Range migration

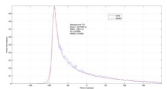


Stack (2/2)
256 ground cell views

1Hz-20hz products

L1b

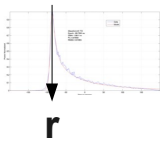
Mean waveform



Waveforms
128 samples

L2 / L2I

SAR Retracking



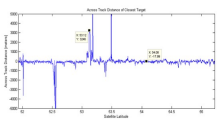
Range

SARin mode

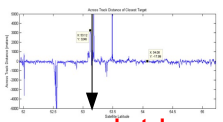
...the same for 2 channels...
(two reception antennas)

Intermediate stack
2×64 ground cell views

Stacks of
2×64 ground cell views



Waveforms & Phase diff.
2×512 samples each



Cross-track Angle / Coords
(retracked bin, L2I only)

Geo-localization of waterbodies

External data

- Geo-masks : SWBD, MODIS/MOD44W, etc.
- For : river width, inundation, river bed that moves a little throught time (e.g., SWBD already is wrong for some places)
- Can be hard to get synced in space & time with altimetry
- What about altimetry itself ?

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- What about altimetry itself ?
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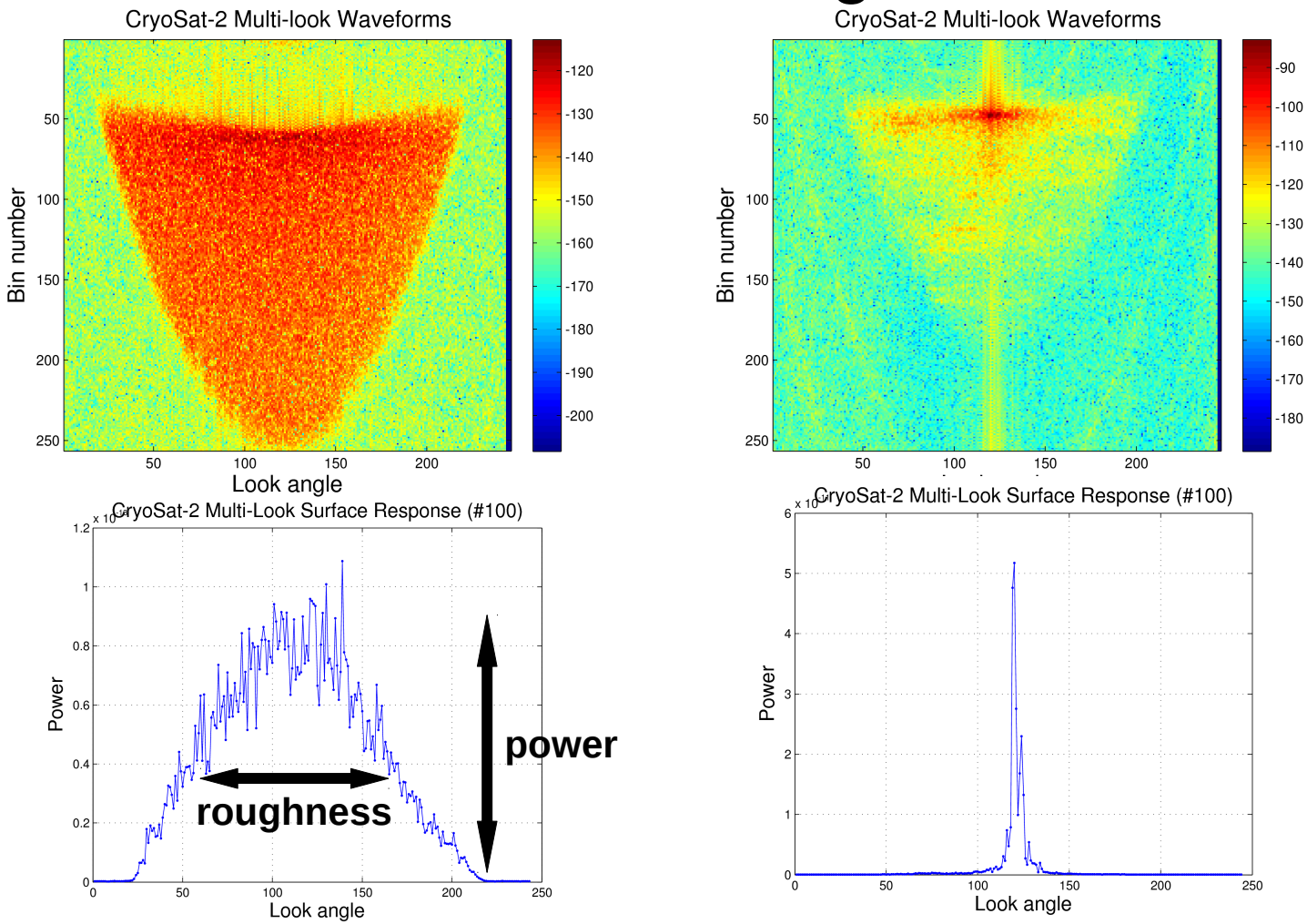
  - SARin crosstrack angle...

Remark about Sea Ice : “leads” are just like “moving rivers” and requires synced geo-masks ($\Delta t < 1$ day).

Geo-localization of waterbodies : can SAR help ?

Stack: surface roughness



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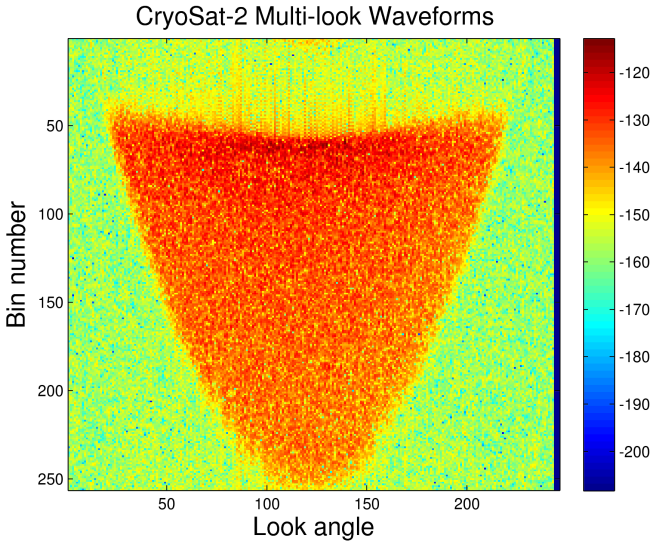
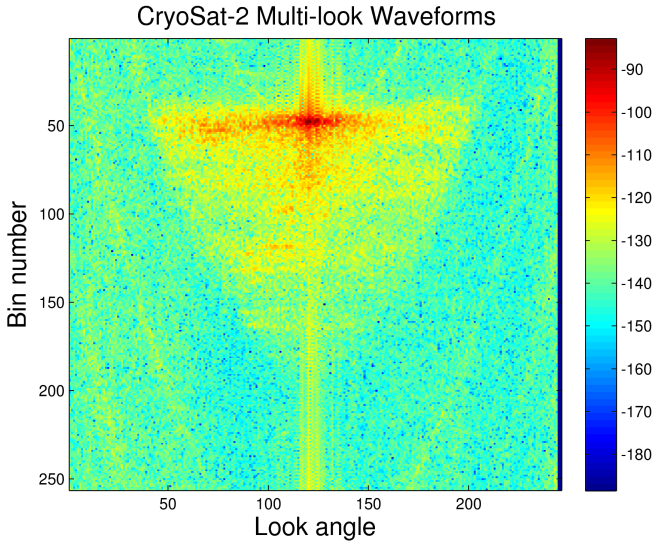
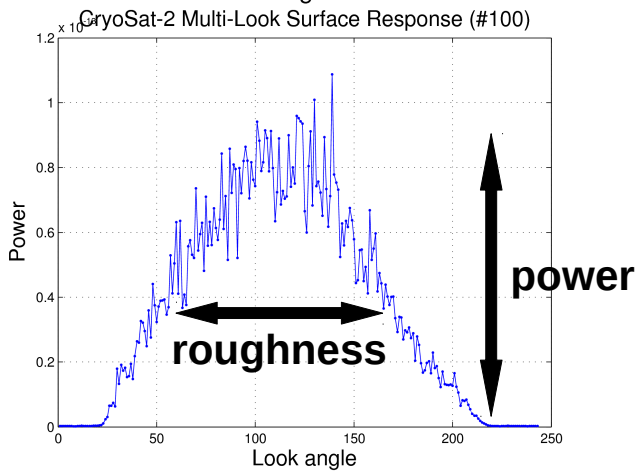


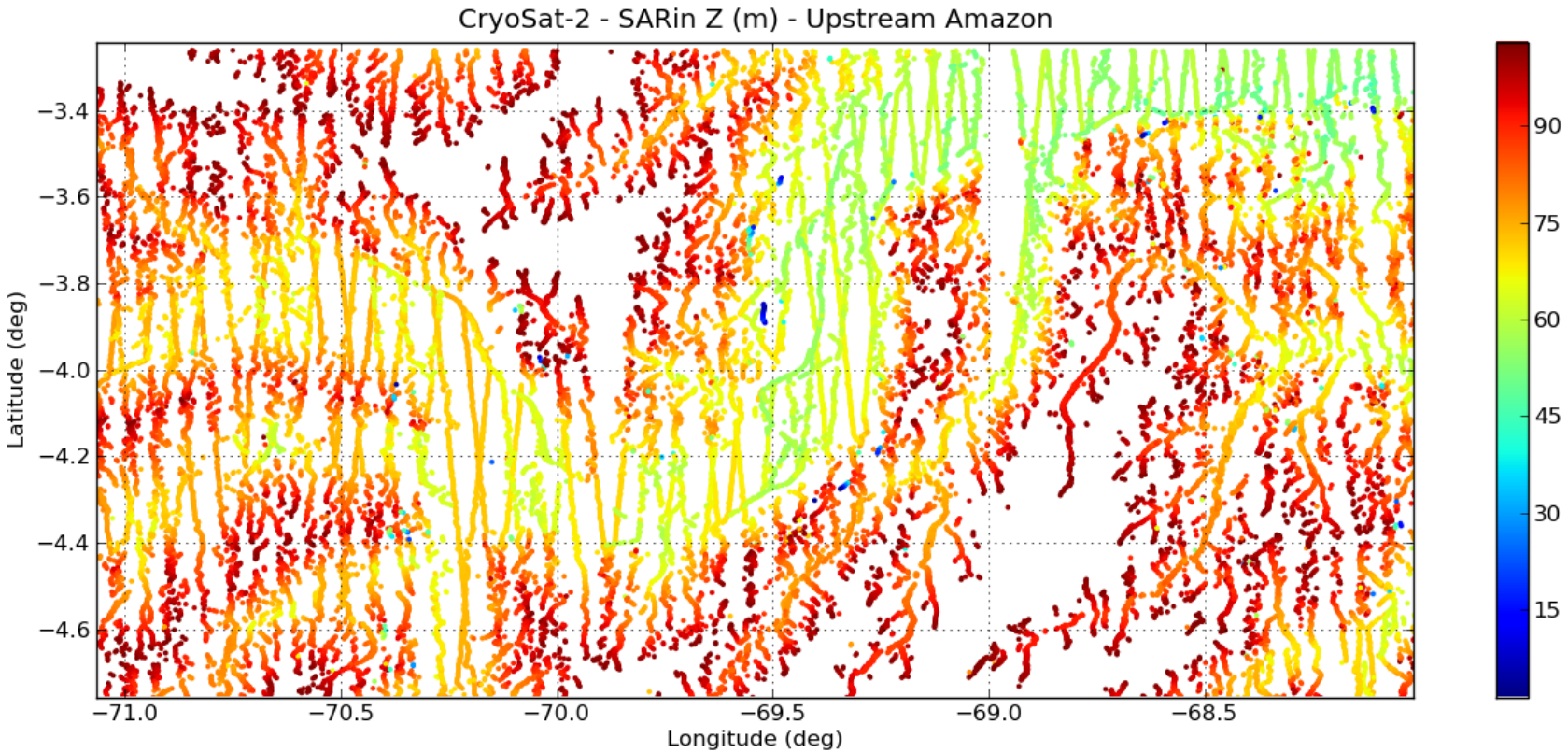




- **Surface response classification ?**
- **River extent detection ?**

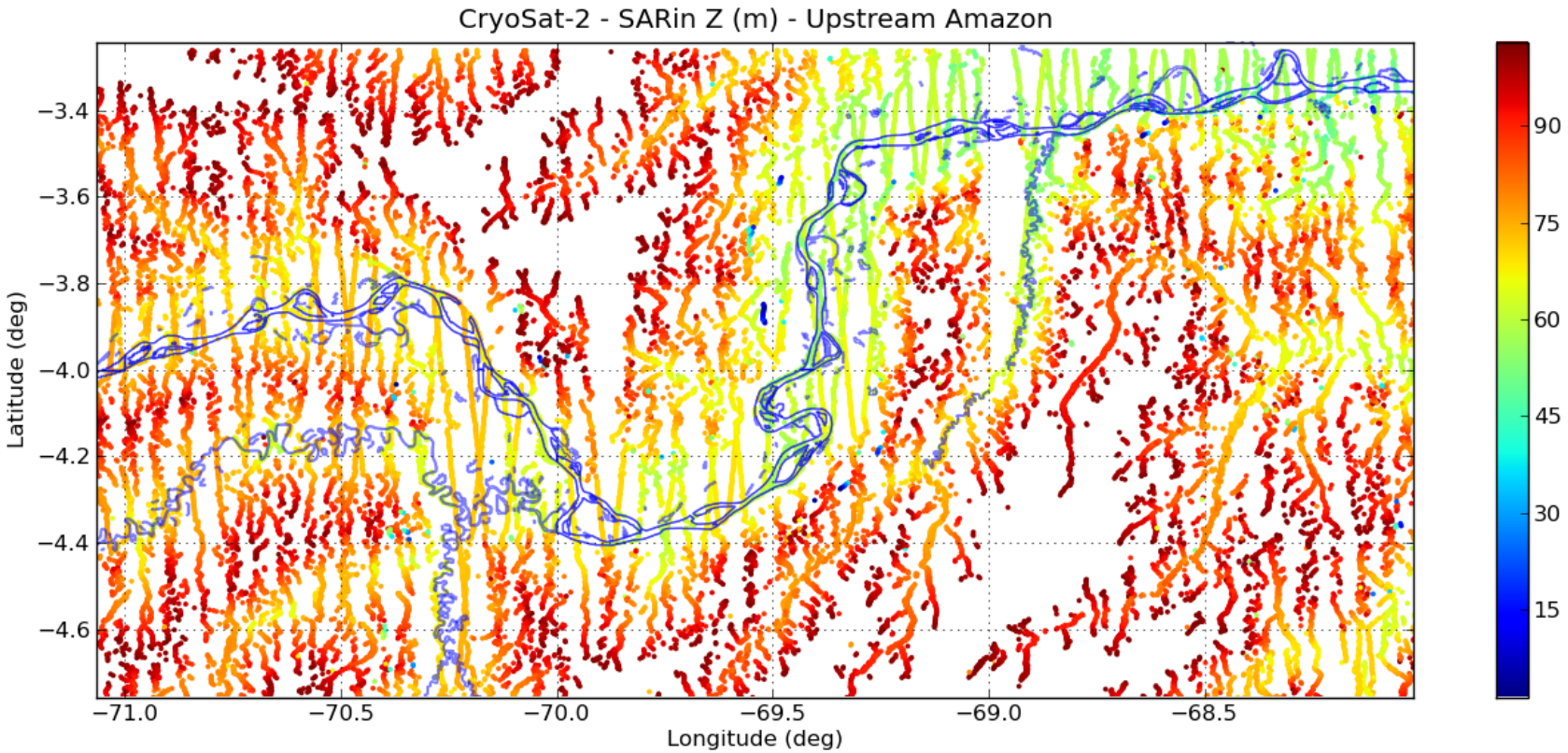
Geo-localization of waterbodies : SARin may help

SARin data extraction : tracks are zigzagging...



Geo-localization of waterbodies : SARin may help

SIRAL tracks a significant part the hydrographic network !



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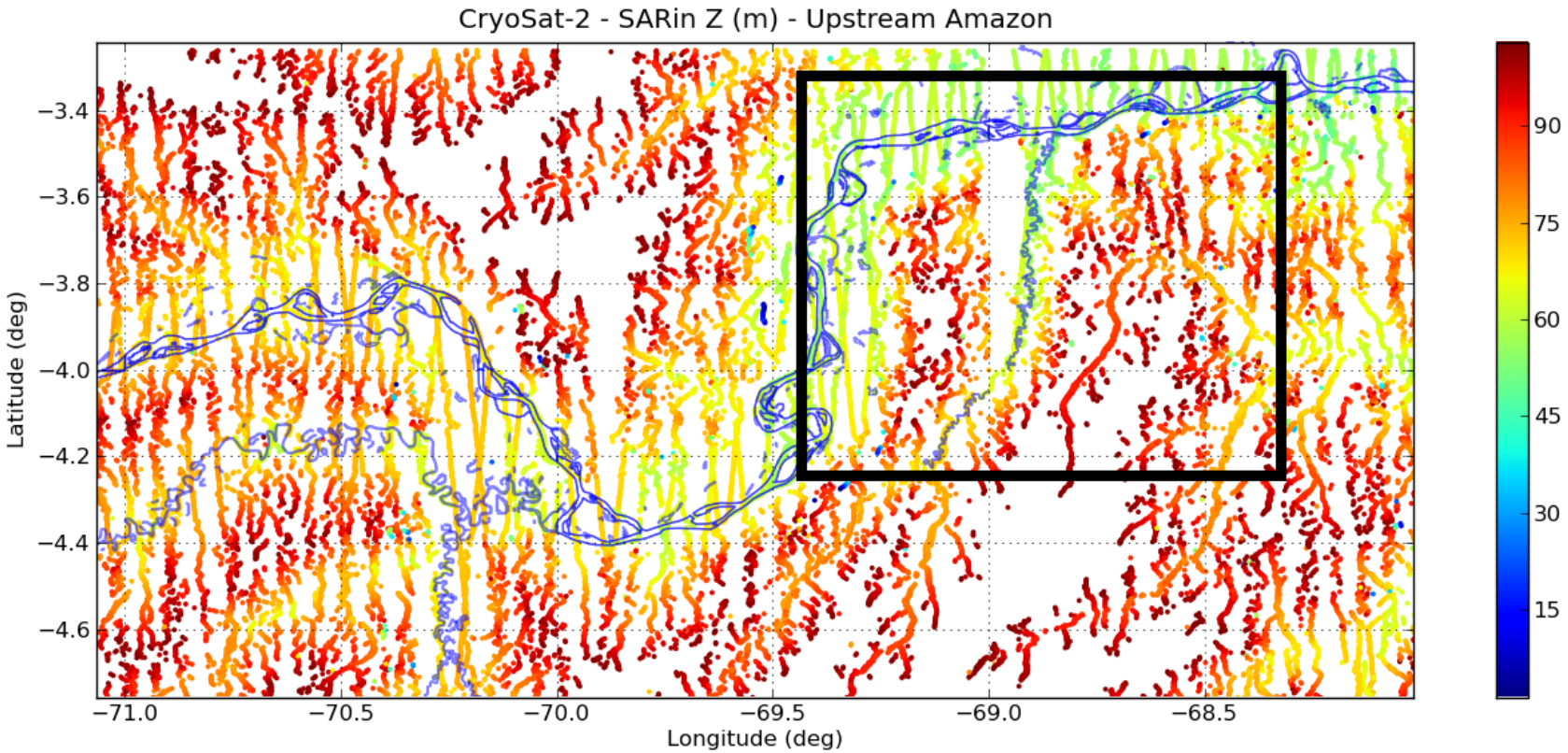


Geo-localization of waterbodies : SARin may help

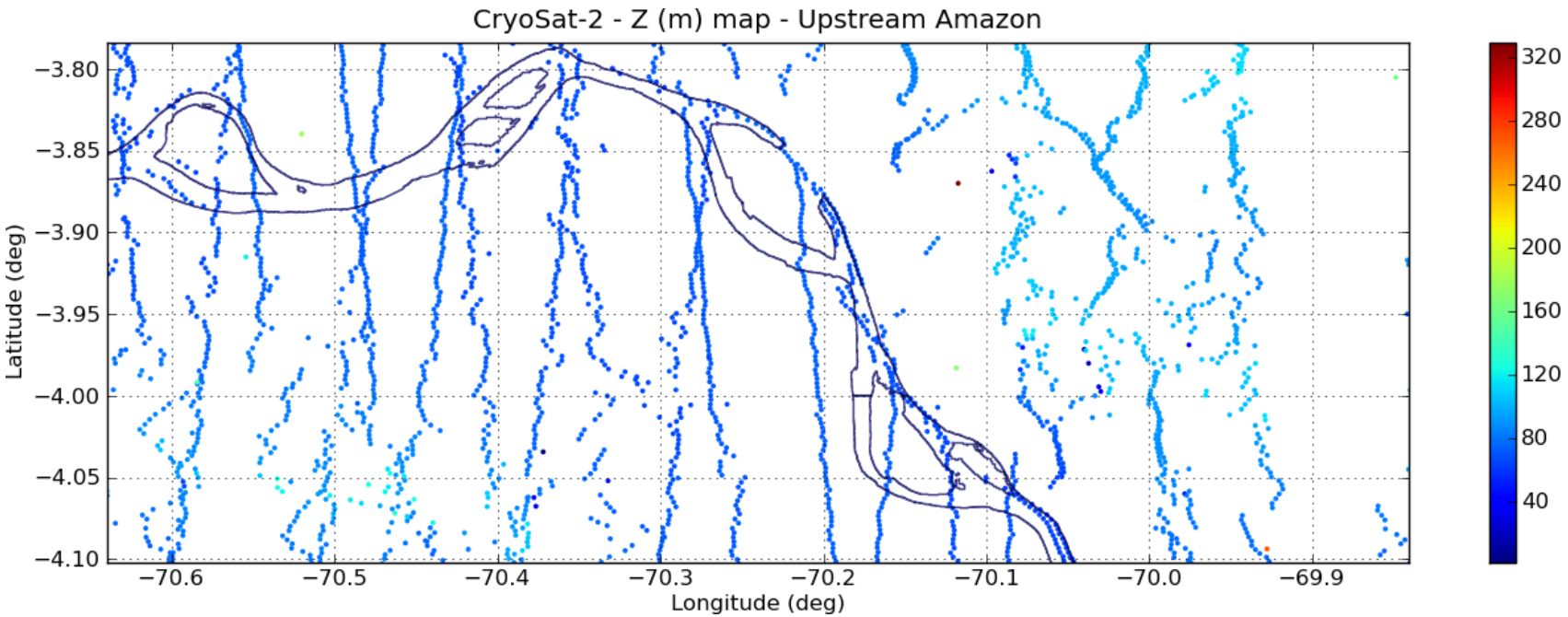
SIRAL tracks a significant part the hydrographic network !

Geo-localization of waterbodies : SARin may help

30 m wide rivers we can actually hardely see. . .

Geo-localization of waterbodies : SARin may help

Zoom-in examples. . .



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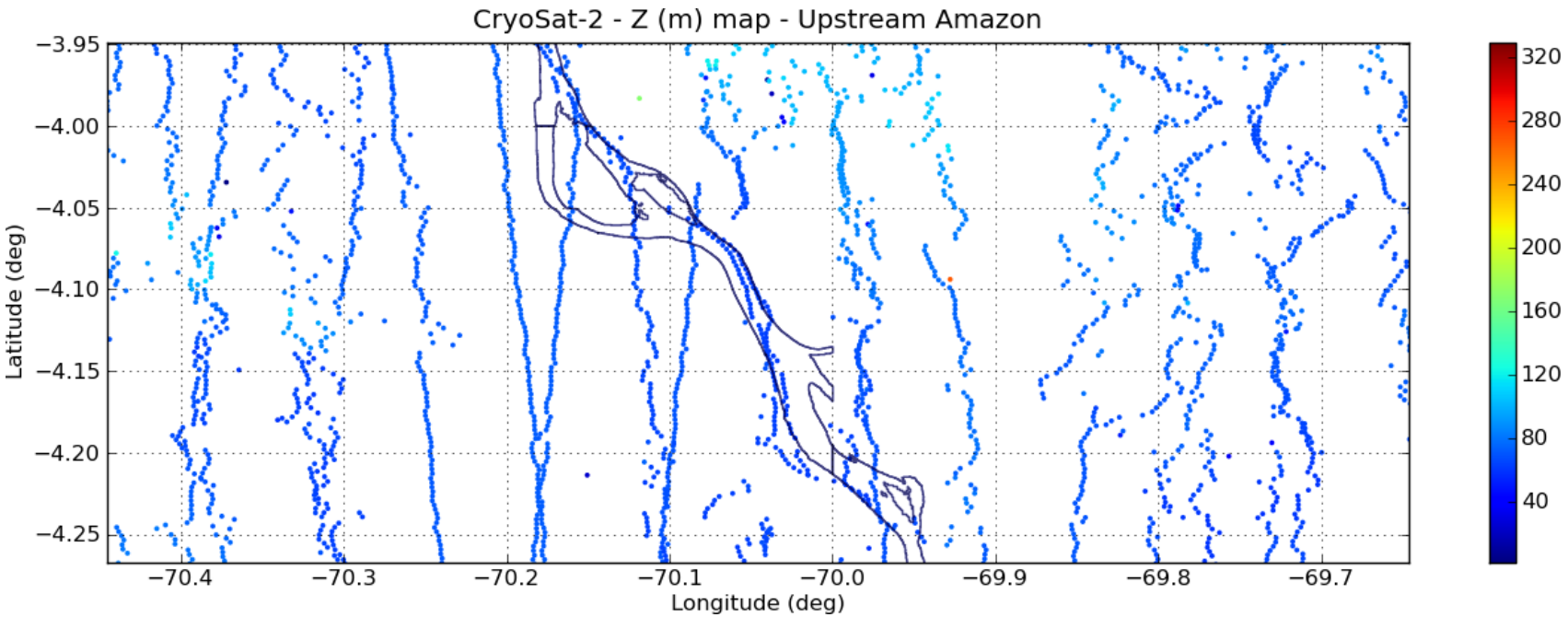

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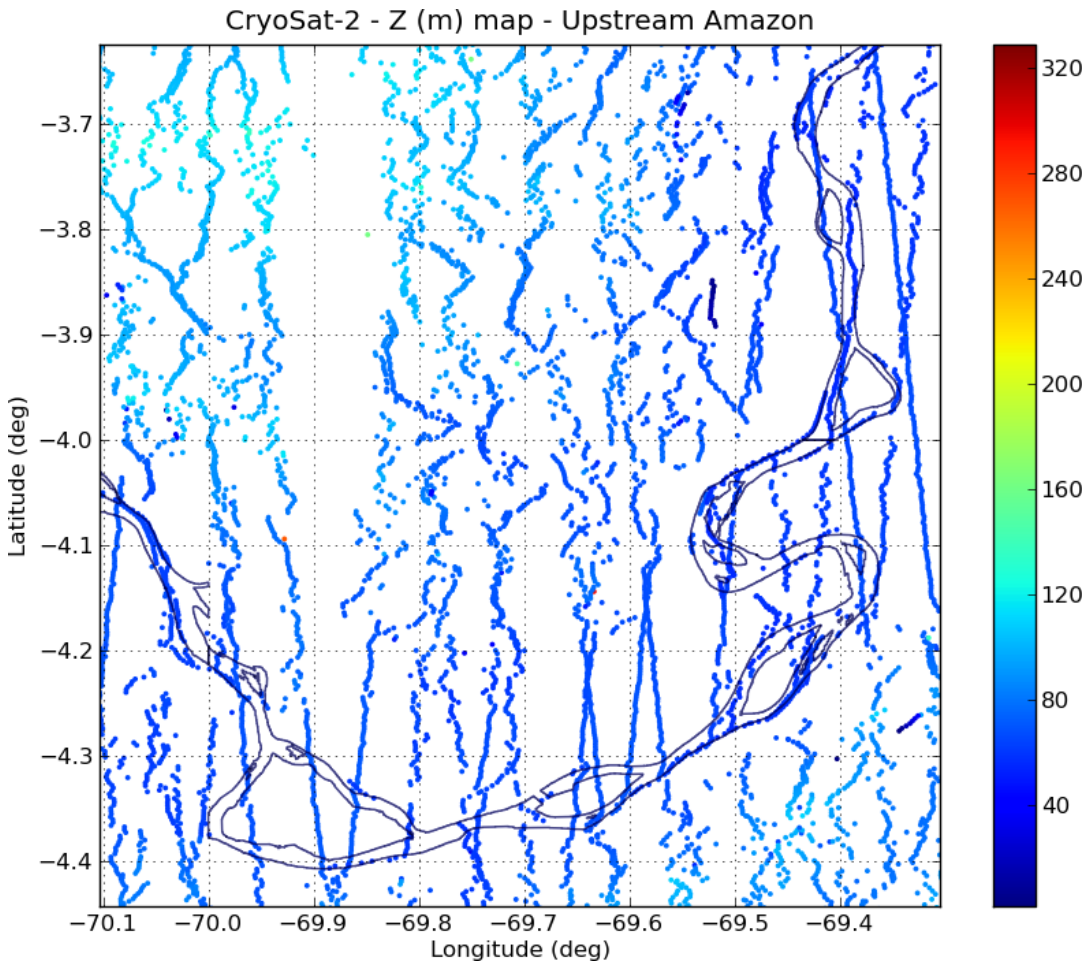
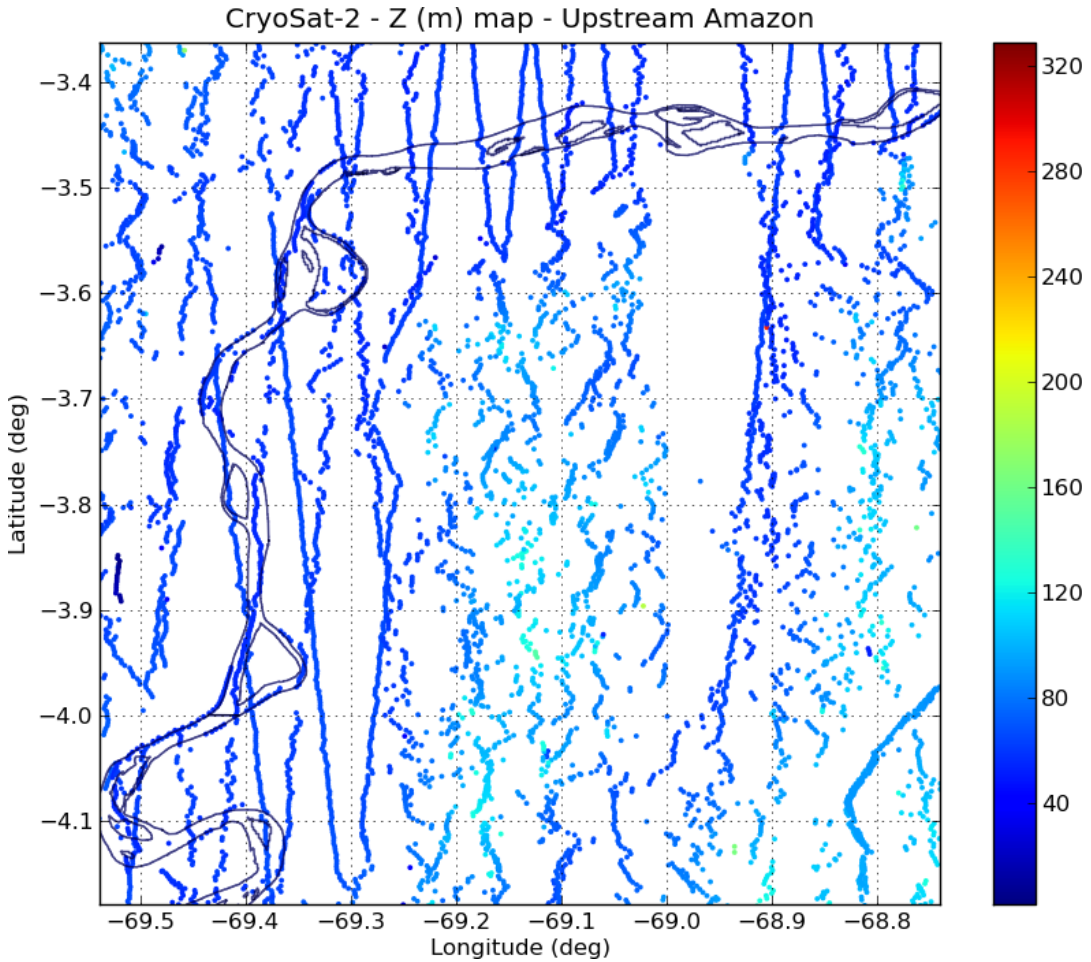


Geo-localization of waterbodies : SARin may help

Zoom-in examples. . .



Conclusion

Benefits of the mission for hydrology

- Cryosat-2 : geodesic orbit with dense spatial coverage
- SIRAL : rich instrument with SAR & SARin modes
- SAR : 64$\times$ higher resolution than LRM, peaky echoes
- SARin : retracked echo coordinates (lat,lon)

Products

- L1b, L2 : no stack matrix ! But interesting params in L1b
- Many products : ESA, CNES/CPP, NOAA/RADS, ESRIN (proto)
- Dealing with data spatio-temporal availability is confusing at times !

Perspectives regarding SAR & SARin

A new look at the rivers

- Peaky echoes, resolution...
- What about hooking ? What parabolas in range chronograms ?
- Bias between SAR and current LRM missions ?
- Explore swath processing / 3D rugosity maps from SARin/L1b, a step toward Swot...

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Validation

- How much is the benefice of SAR over LRM ?
- Is SARin crosstrack angle accurate enough ? (slopes)
- Validation : is a complex task for geodesic orbits !

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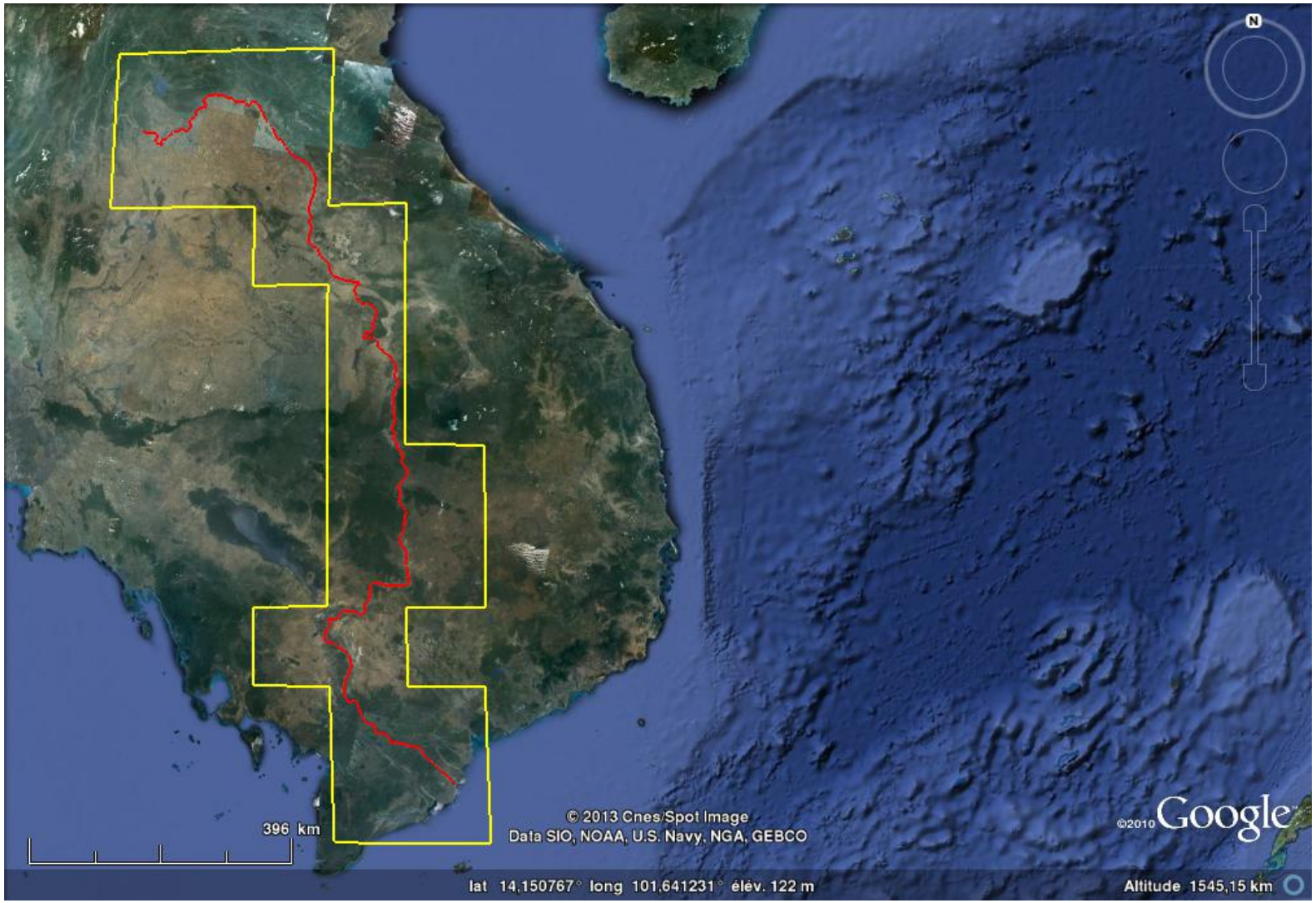
- Validation : is a complex task for geodesic orbits !

And SARin mode won't last : there's no SIRAL-2 planned !

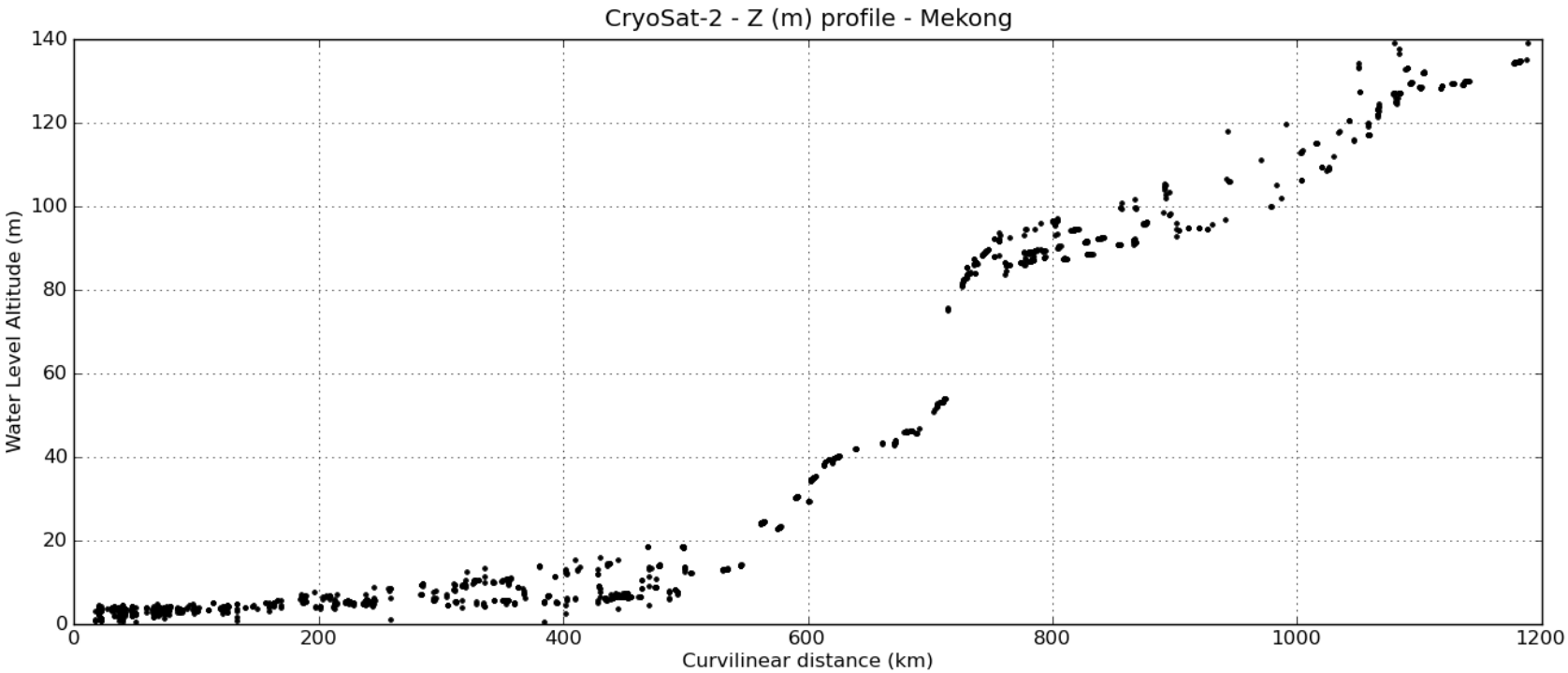
– Thank you ! –

Mekong river (SAR)

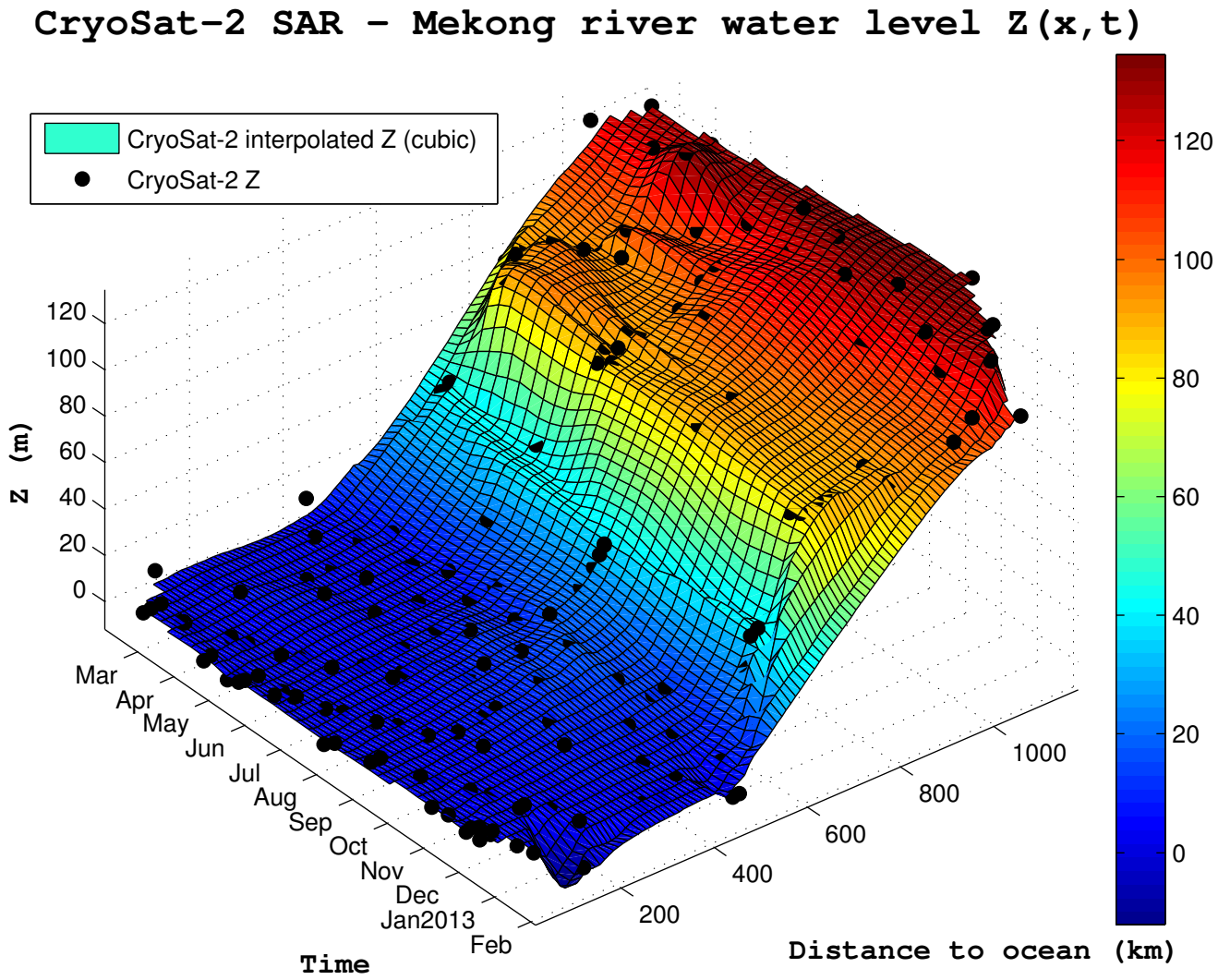


Mekong river (SAR)

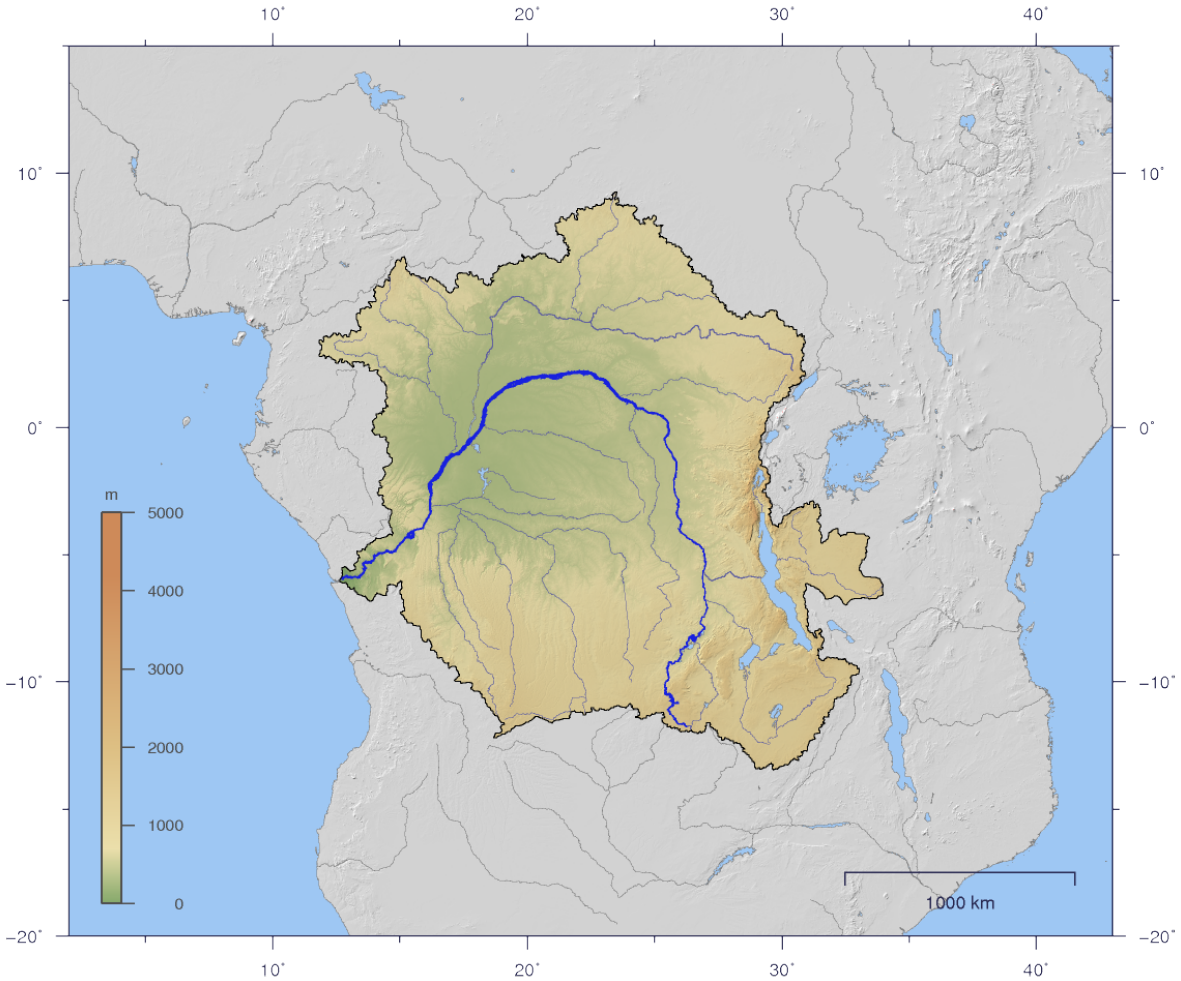
River Water level profile



Mekong river (SAR)

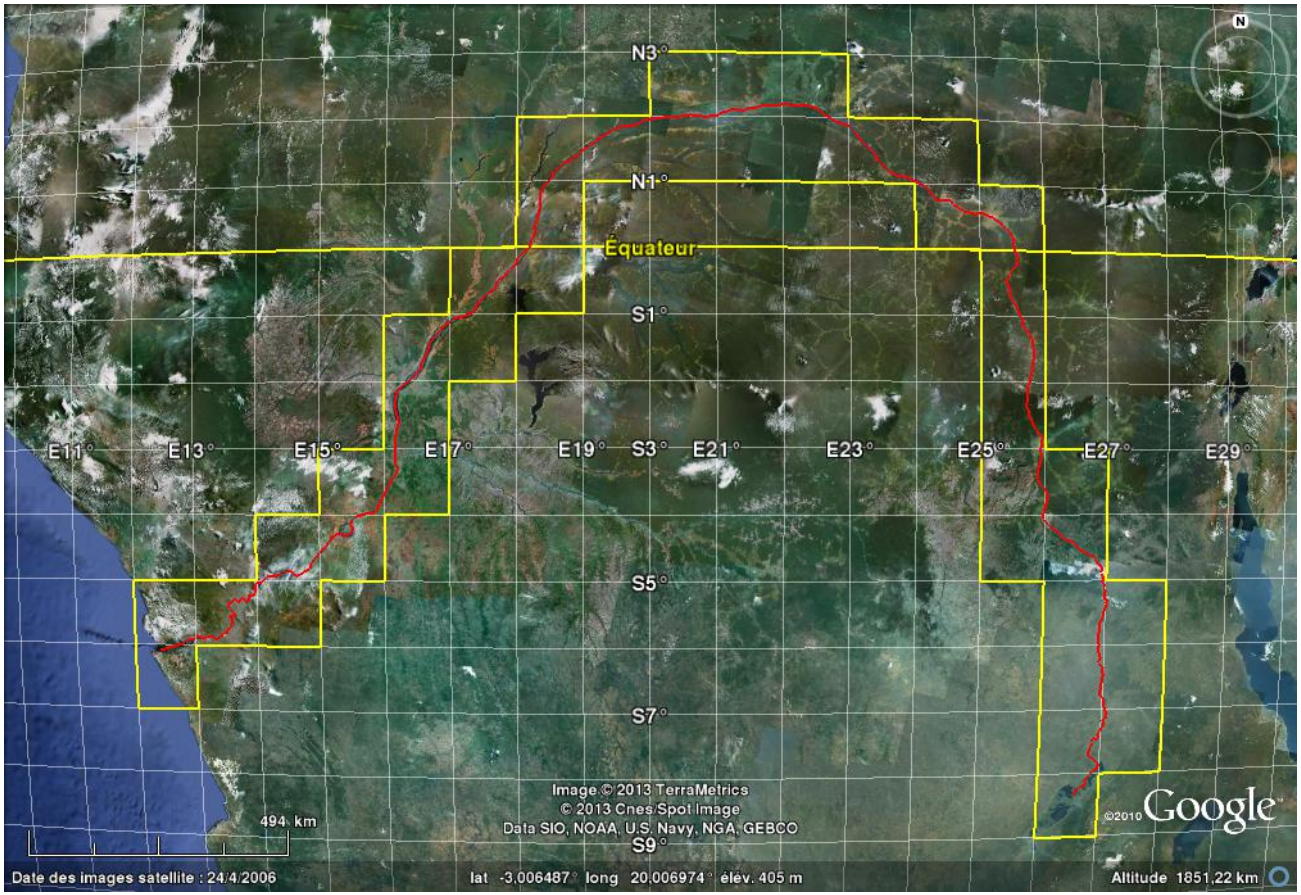


Congo river (SARin)



Source Wikipedia.org

Congo river (SARin)



Congo river (SARin)

River Water level profile