A review of CryoSat-2/SIRAL applications for the monitoring of river water levels

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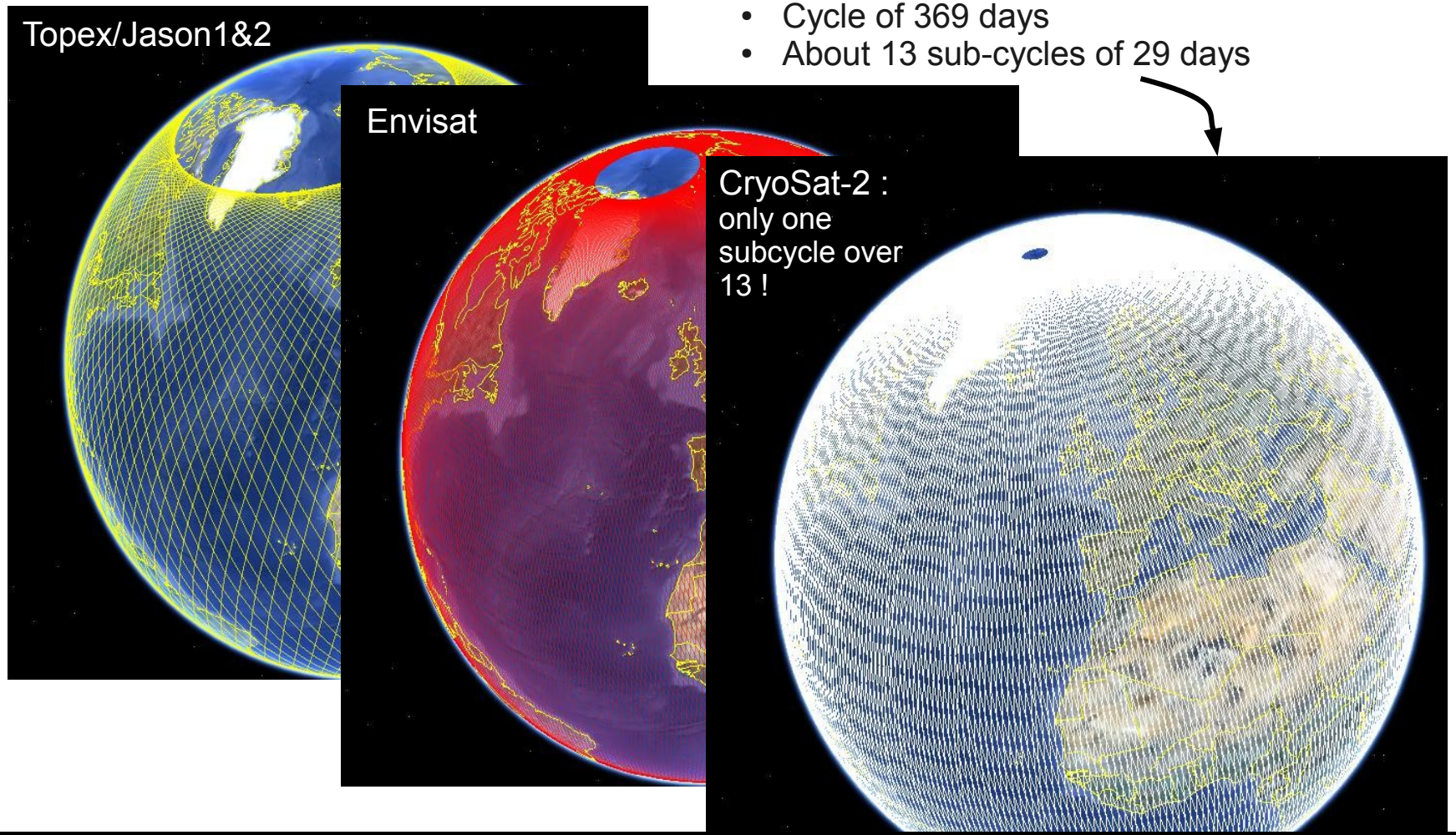
Thursday 12th September 2013

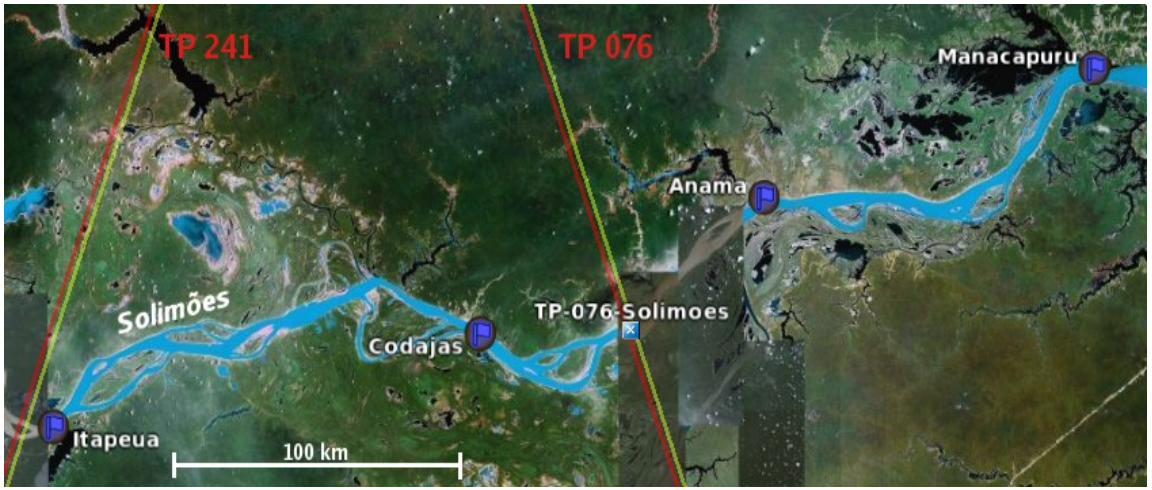
CryoSat-2 orbit

- Near polar (92°)
- Cycle of 369 days
- About 13 sub-cycles of 29 days



Repetitive orbits : time series

(Topex/Poseidon example)



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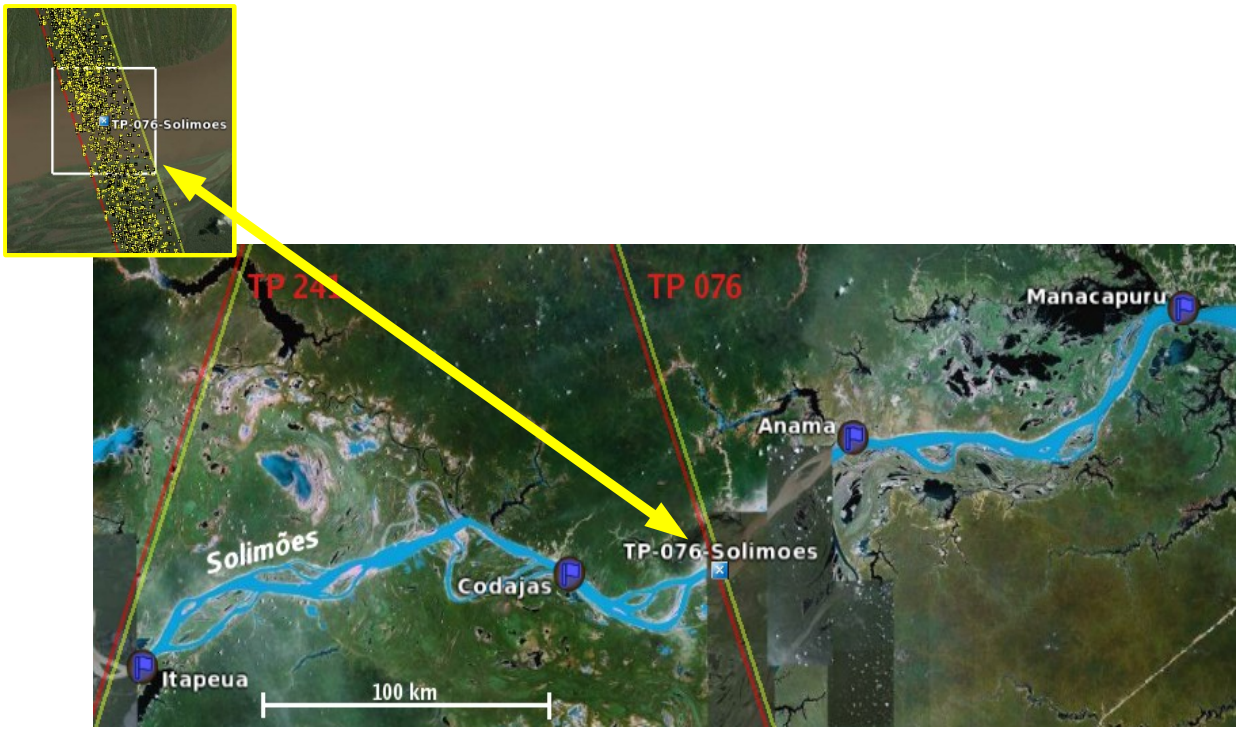

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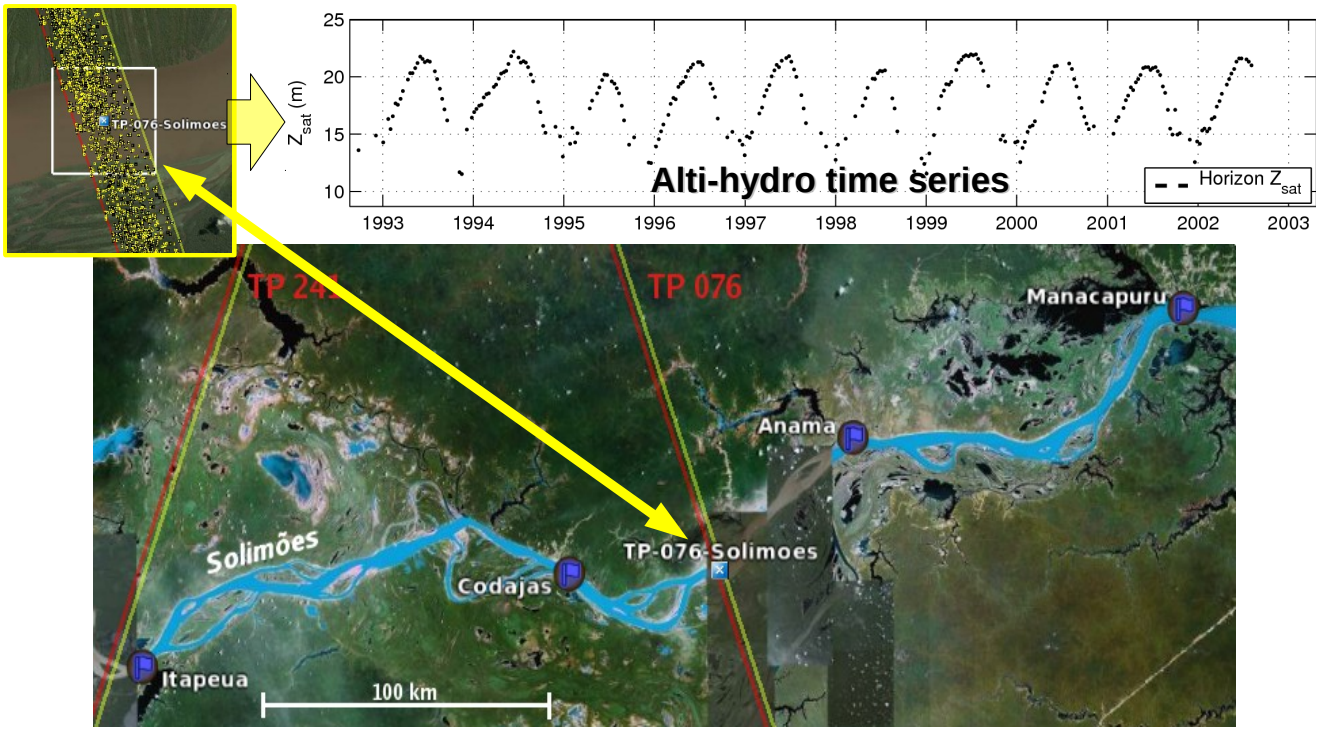

Repetitive orbits : time series

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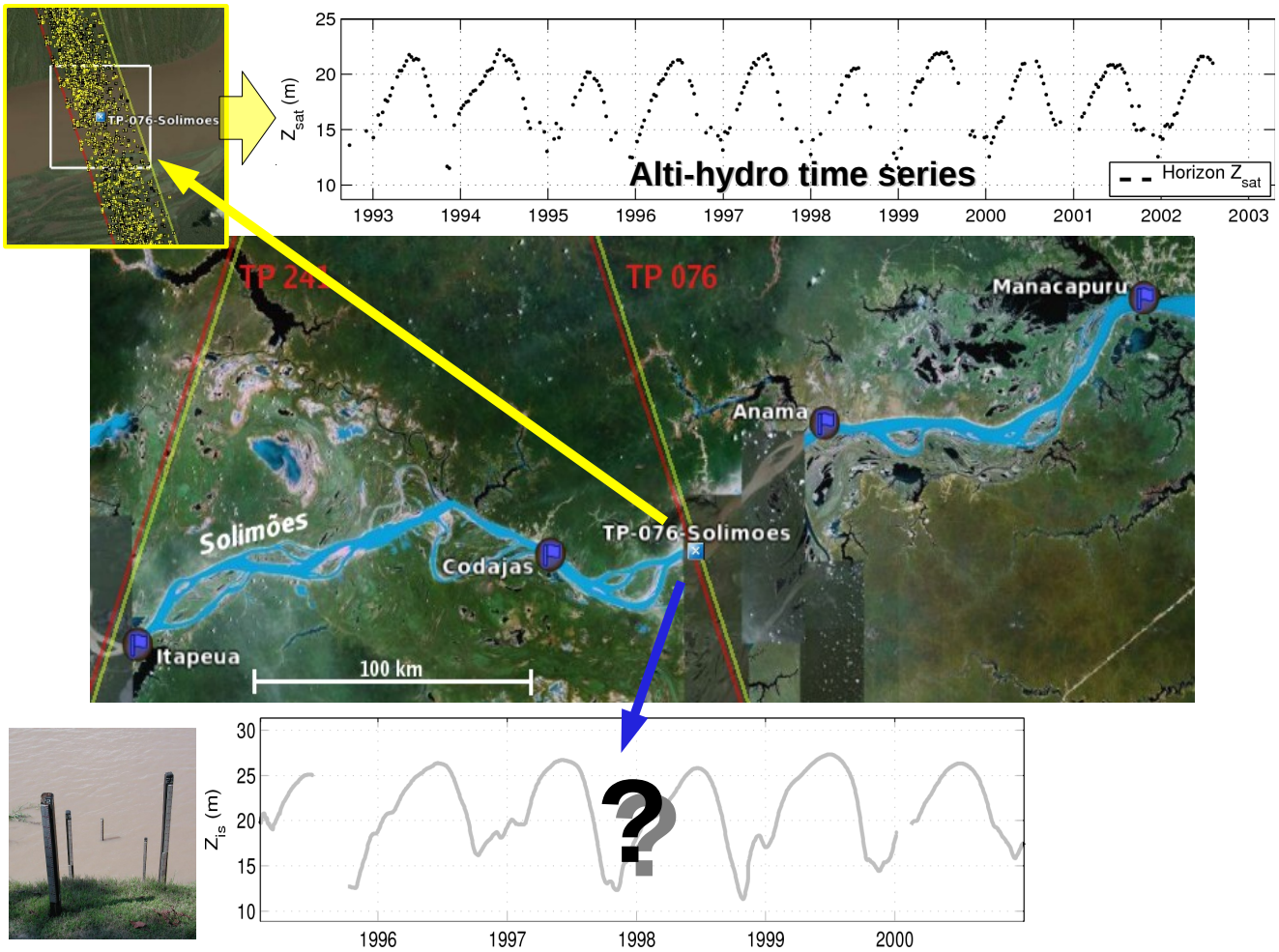

Repetitive orbits : time series

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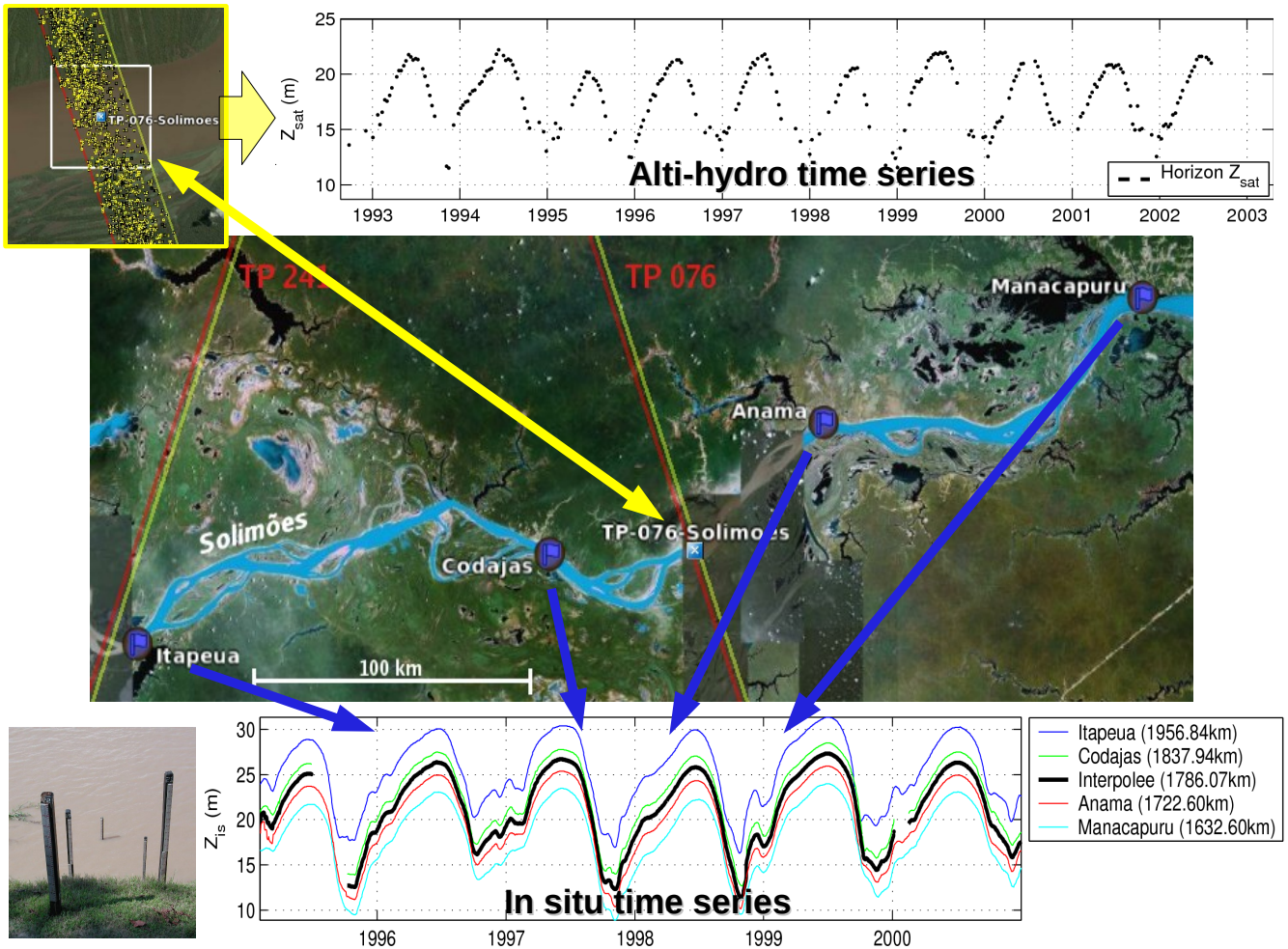
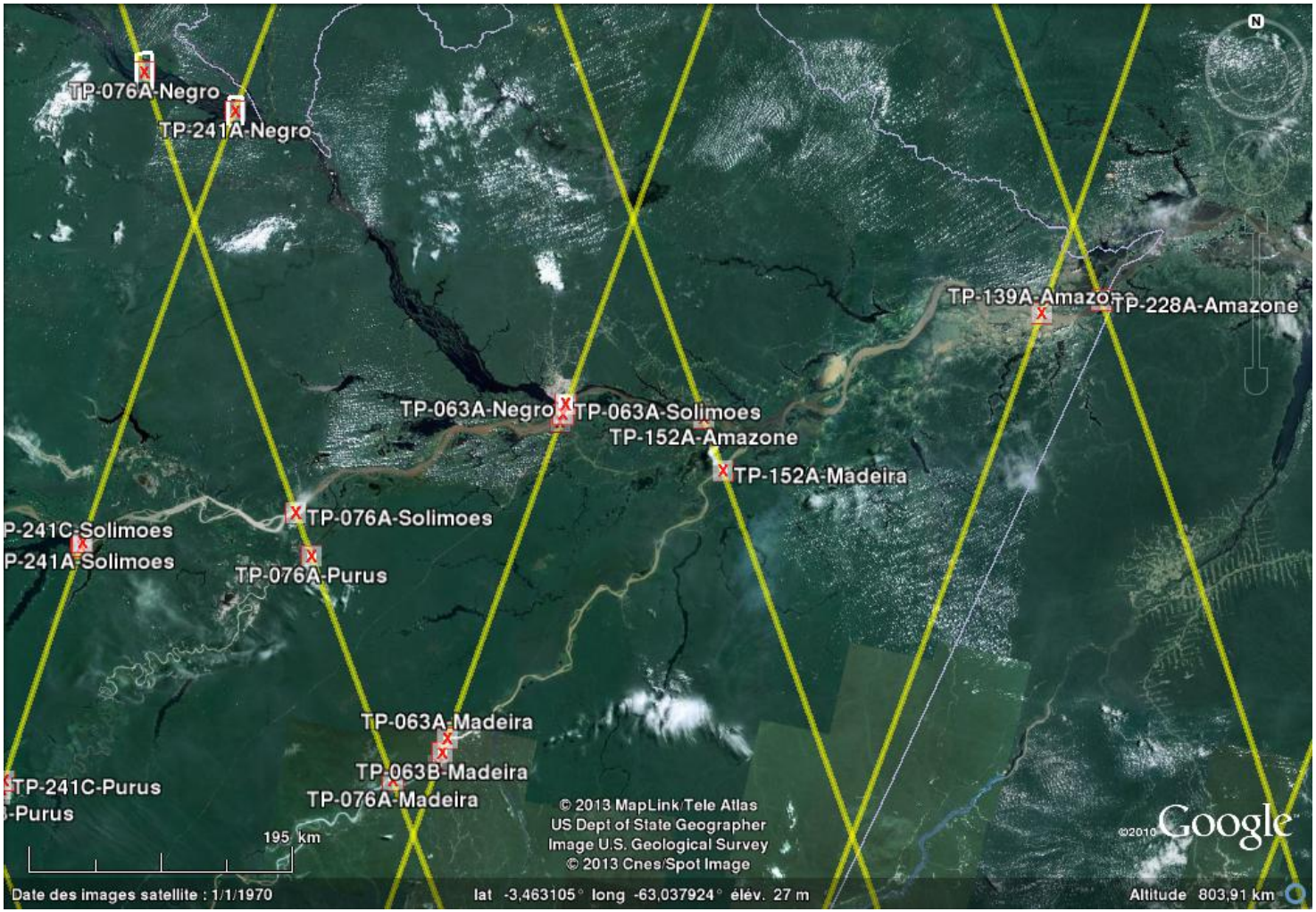


Repetitive orbits : time series

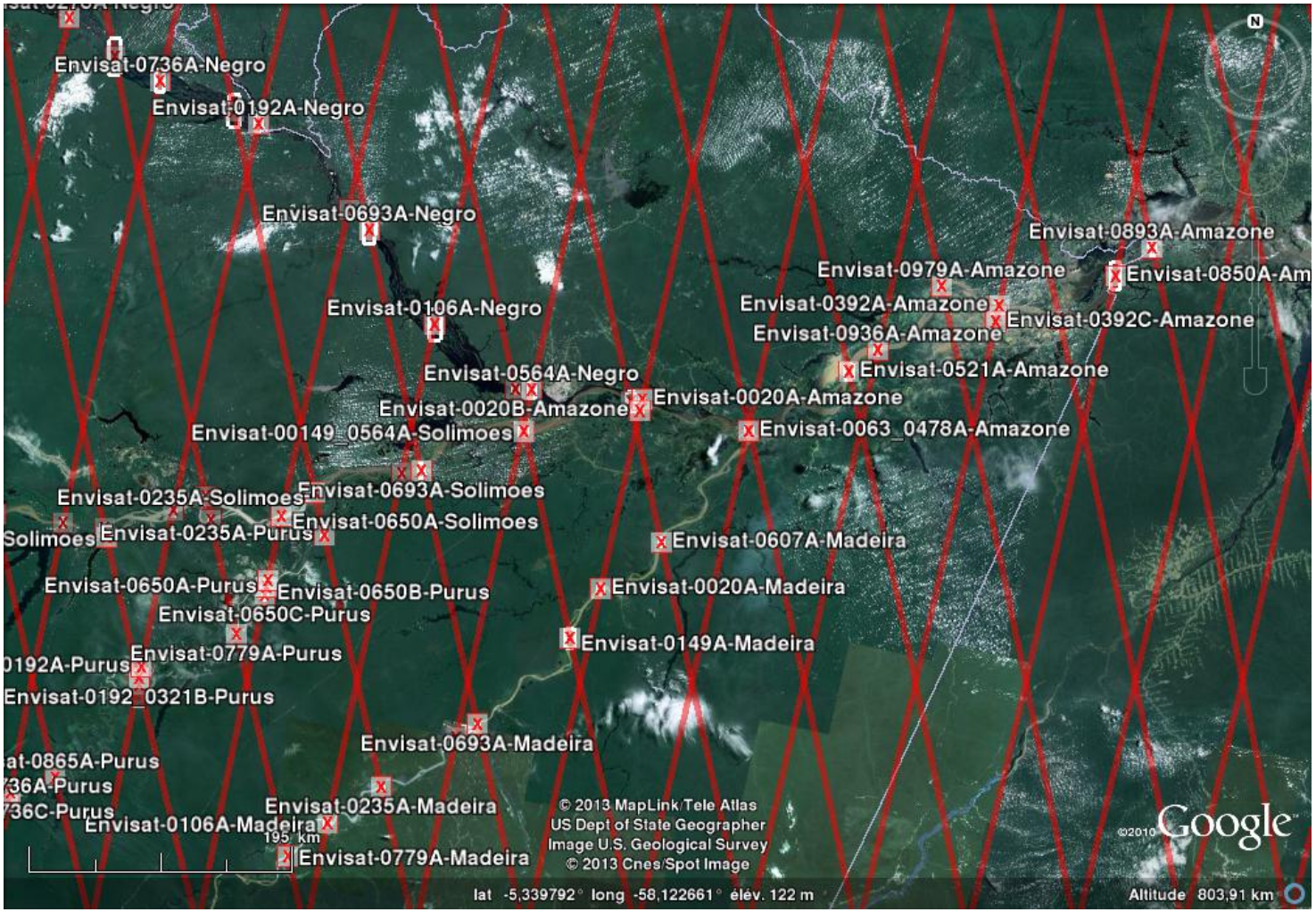
Typical processing

- Rivers / Tracks crossings localisation
- Data geo-extraction
- Building time series of river water levels
- Custom editing, filtering, etc.
- Time series quality validation against in situ gauging data
- Time series distribution through HydroWeb portal
  `http://www.legos.obs-mip.fr/en/soa/hydrologie/hydroweb/`

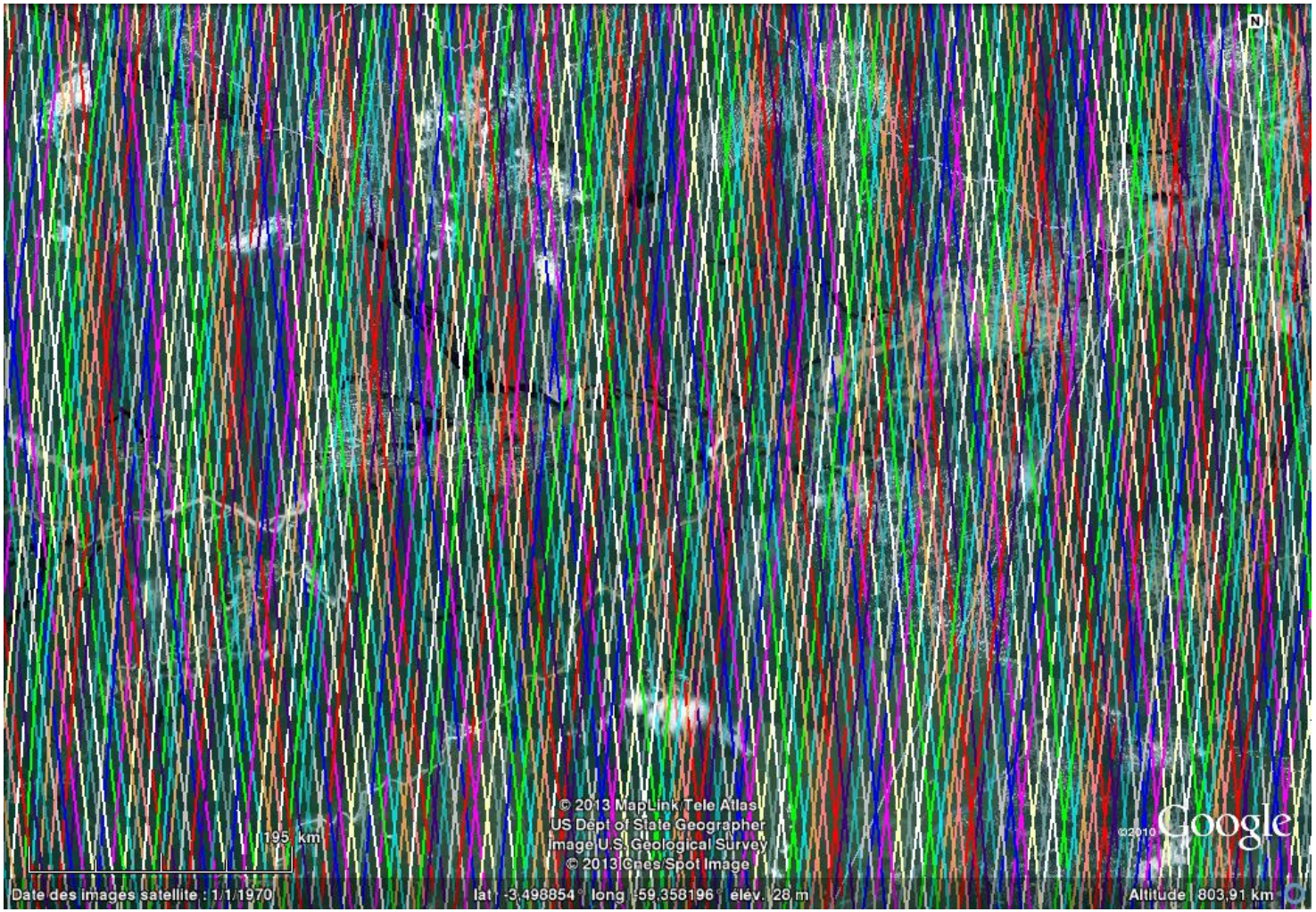
Topex/Poseidon & Jason-2 "virtual stations"



Envisat "virtual stations"

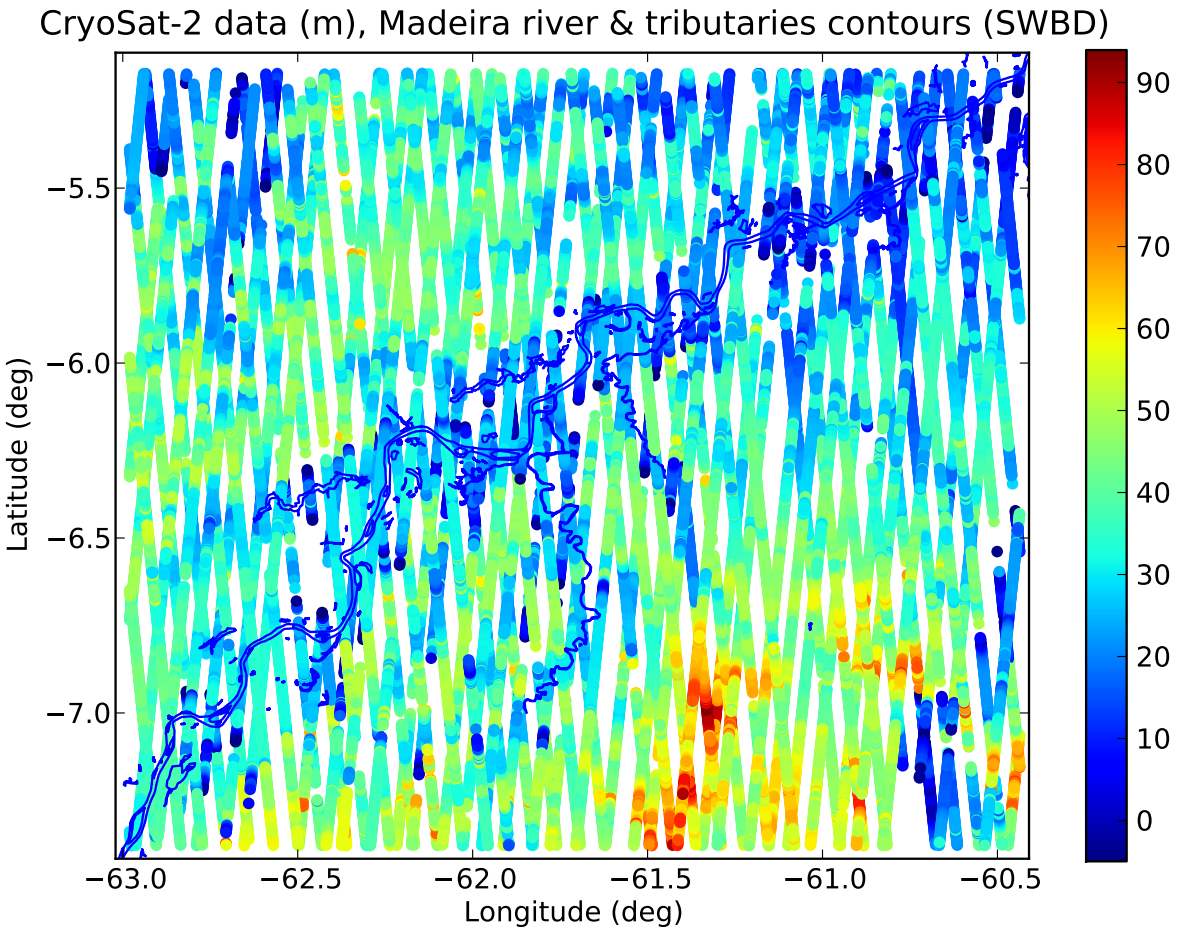


CryoSat-2 tracks. . . ! (KML file available on ESA website)



Processing spatio-temporal time series (LRM ex.)

Spatio-Temporel sampling of the river water level $Z(x, t)$



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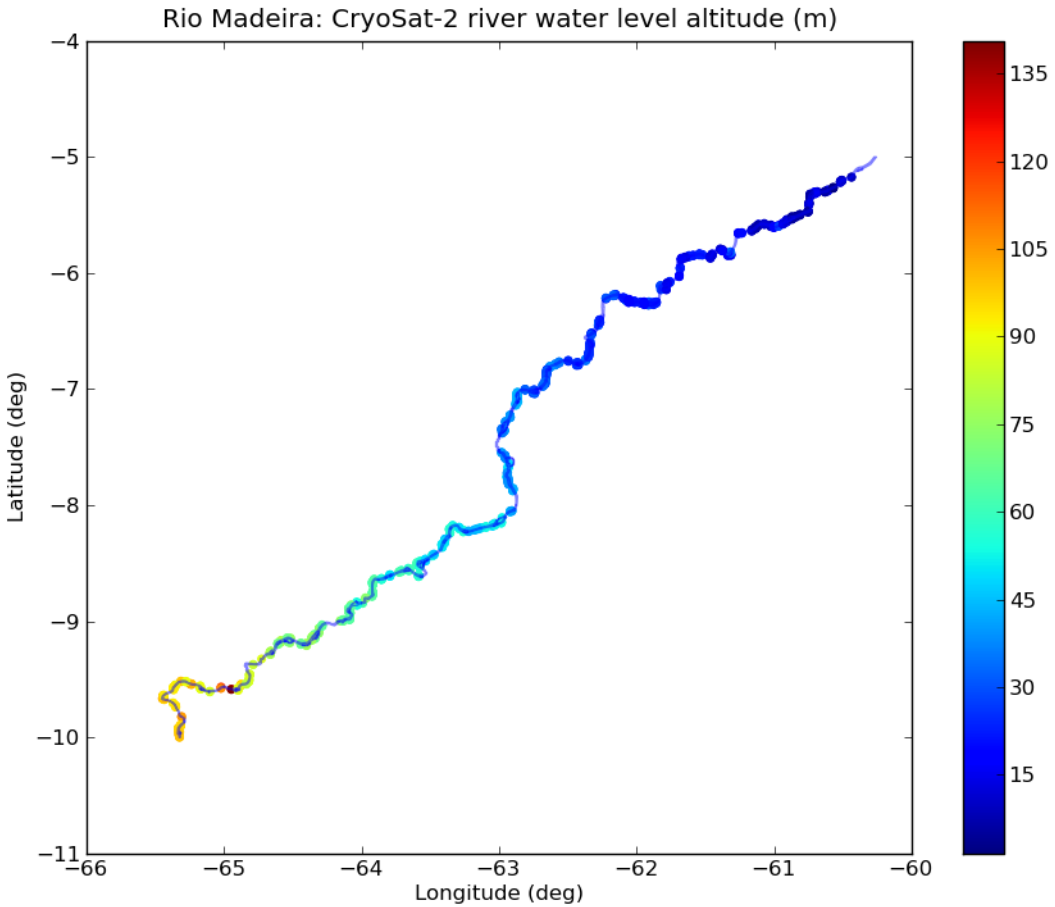

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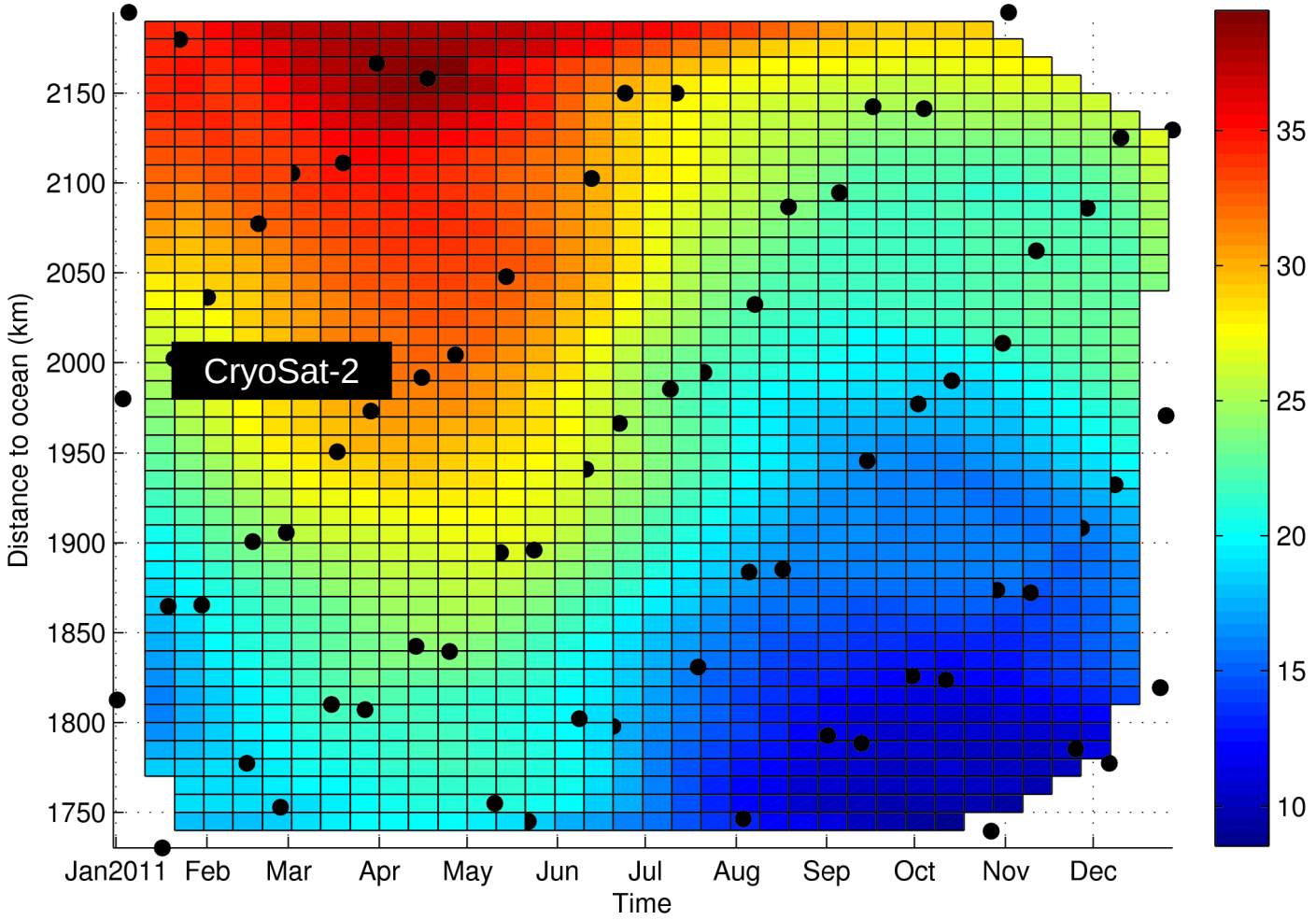

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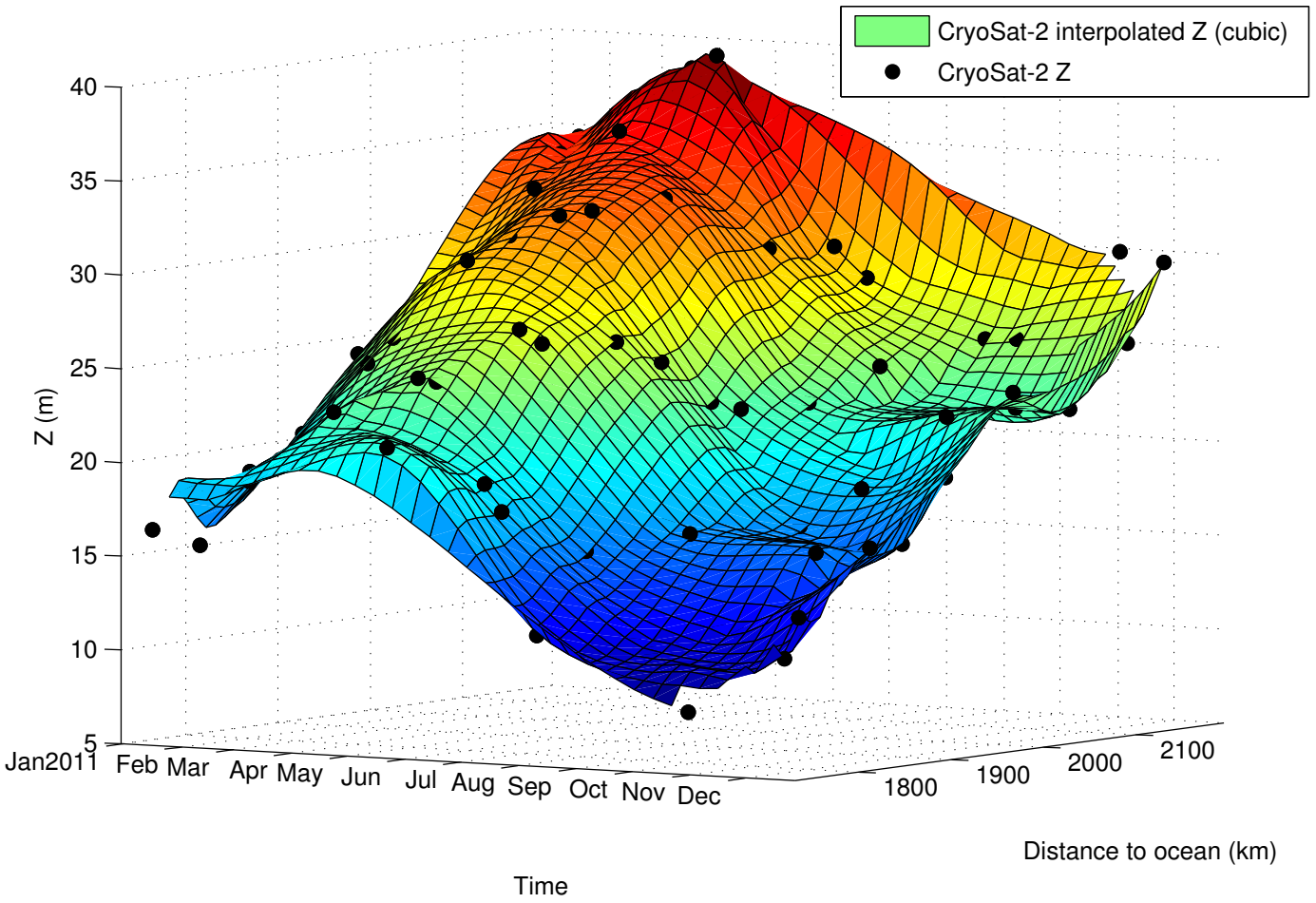
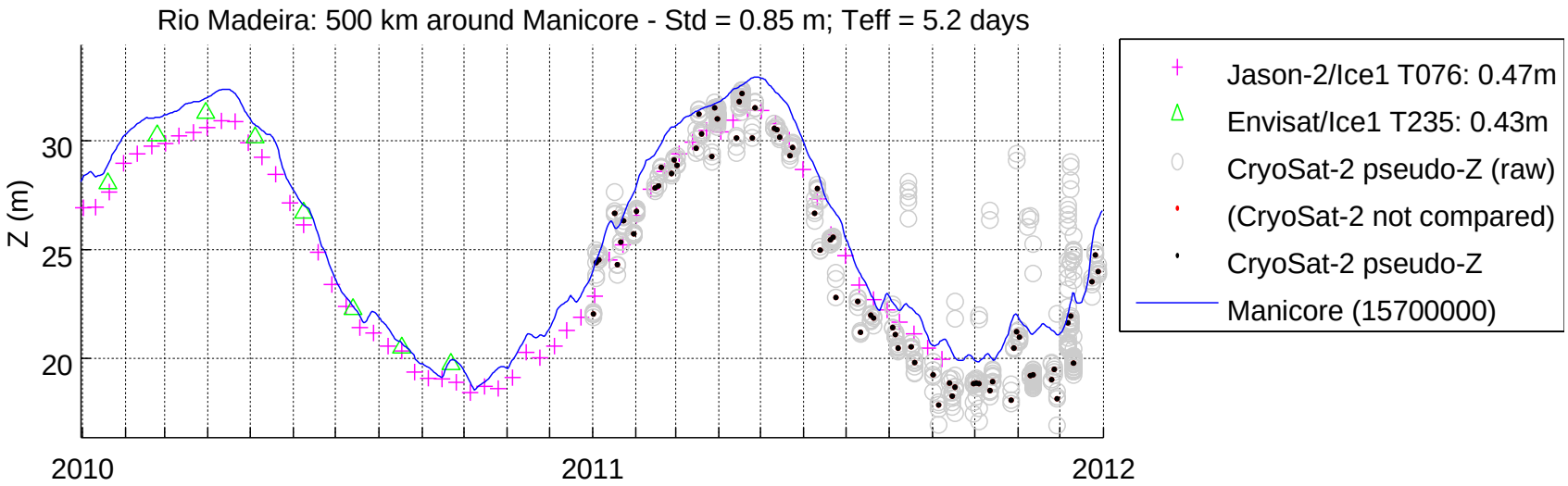


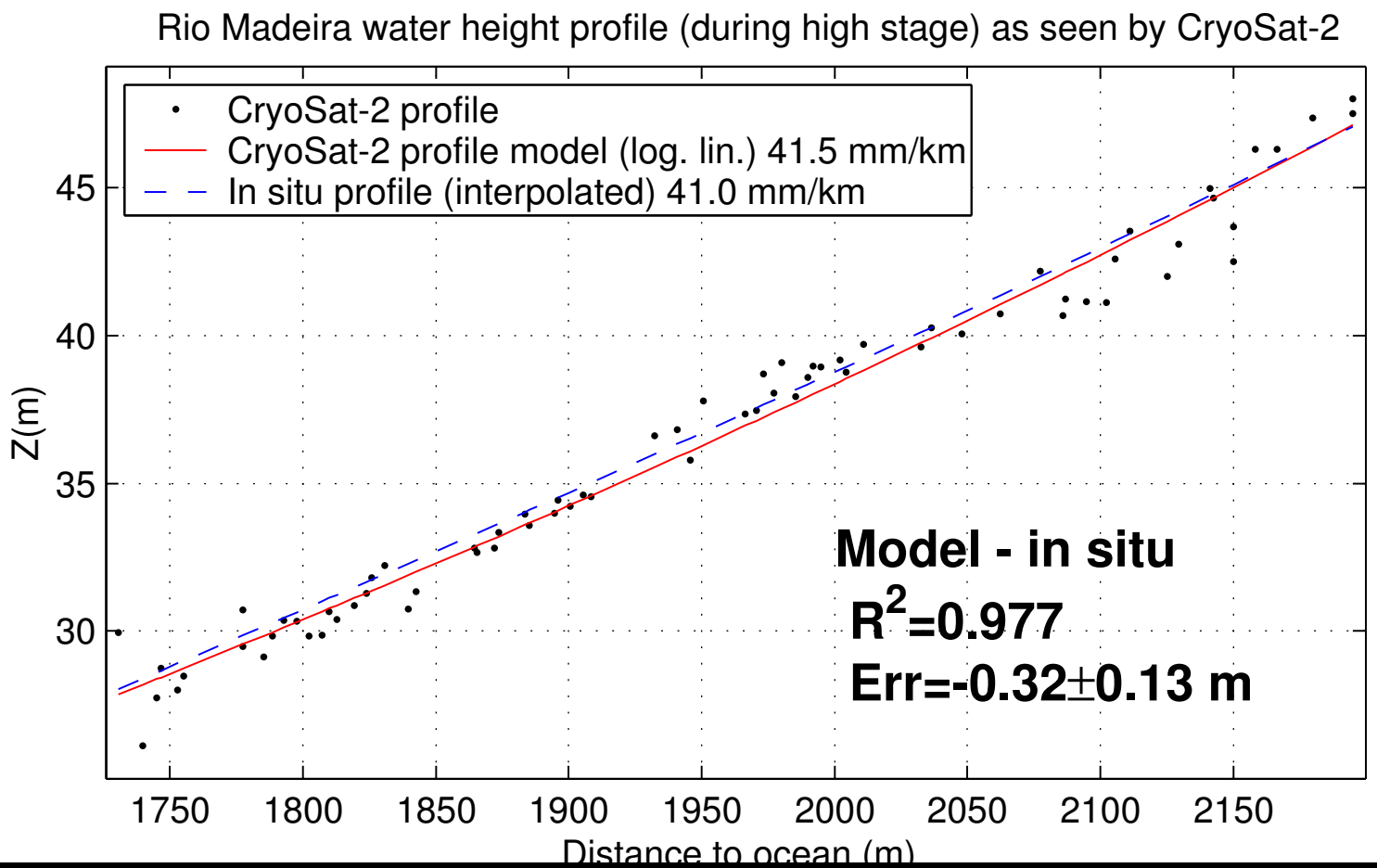
Processing spatio-temporal time series (LRM ex.)

Remove spatial variations (Jason-2, high water stage) = river water level pseudo-time series $Z(t)$



Processing spatio-temporal time series (LRM ex.)

Remove temporal variations
= river water level pseudo-profile $Z(x)$



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

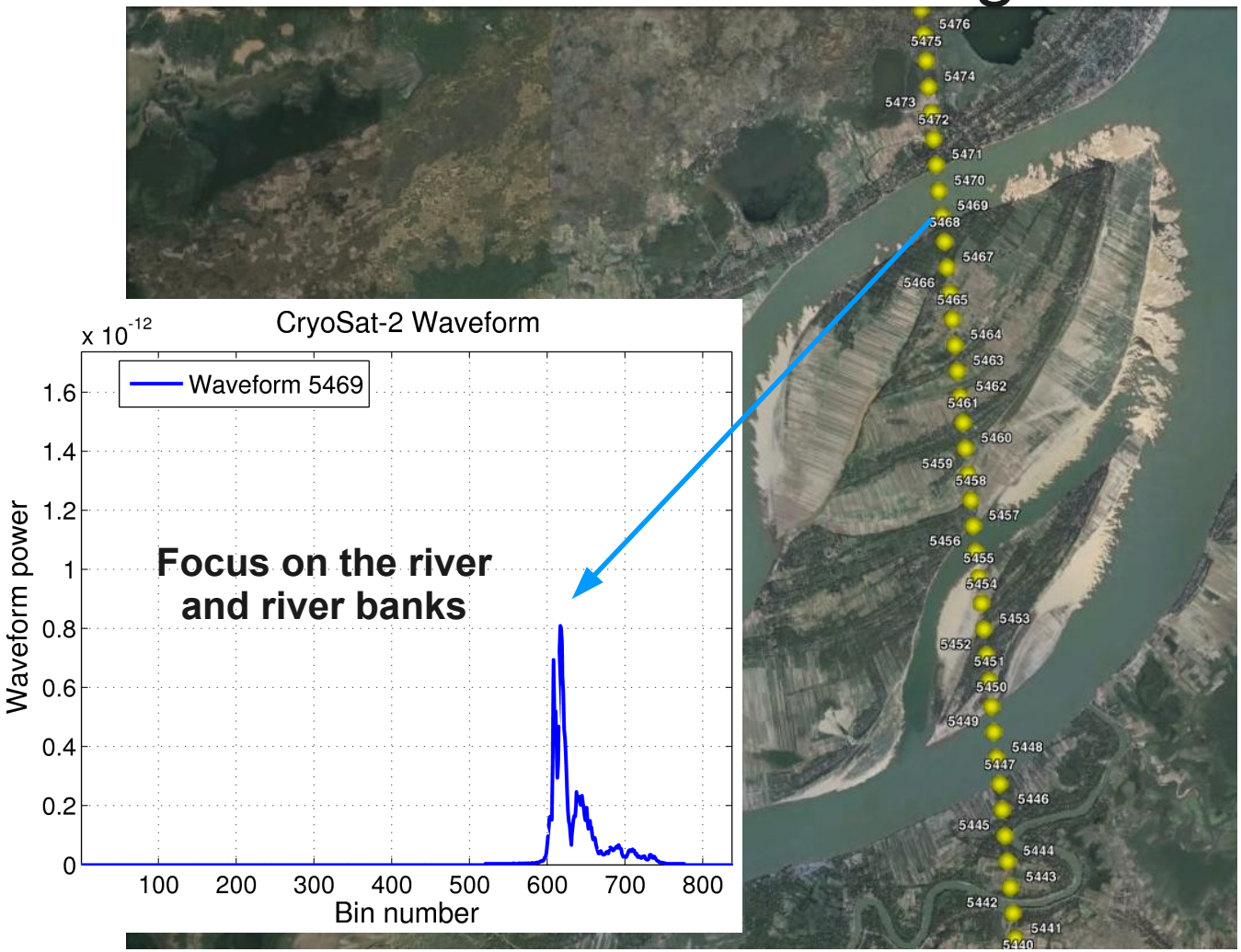
- **ESA Official L2 products (Baseline B, since Feb. 2012)**
  - Product files for **LRM, SAR & SARin modes**
  - Use : spatio-temporal time series, validation, longitudinal & transversal river profiles, (SAR :) along-track resolution, (SARin :) cross-track angle
- **ESA/ESRIN Sentinel-3 prototype**
  - 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.
- **CNES CPP (CryoSat Processing Prototype)**
  - 11 months of **GDR-D-like products** for LRM, SAR & **RDSAR** modes
  - Use : SAR / Reduced-SAR comparison and assessment

Along-track resolution

SAR mode over Mekong river

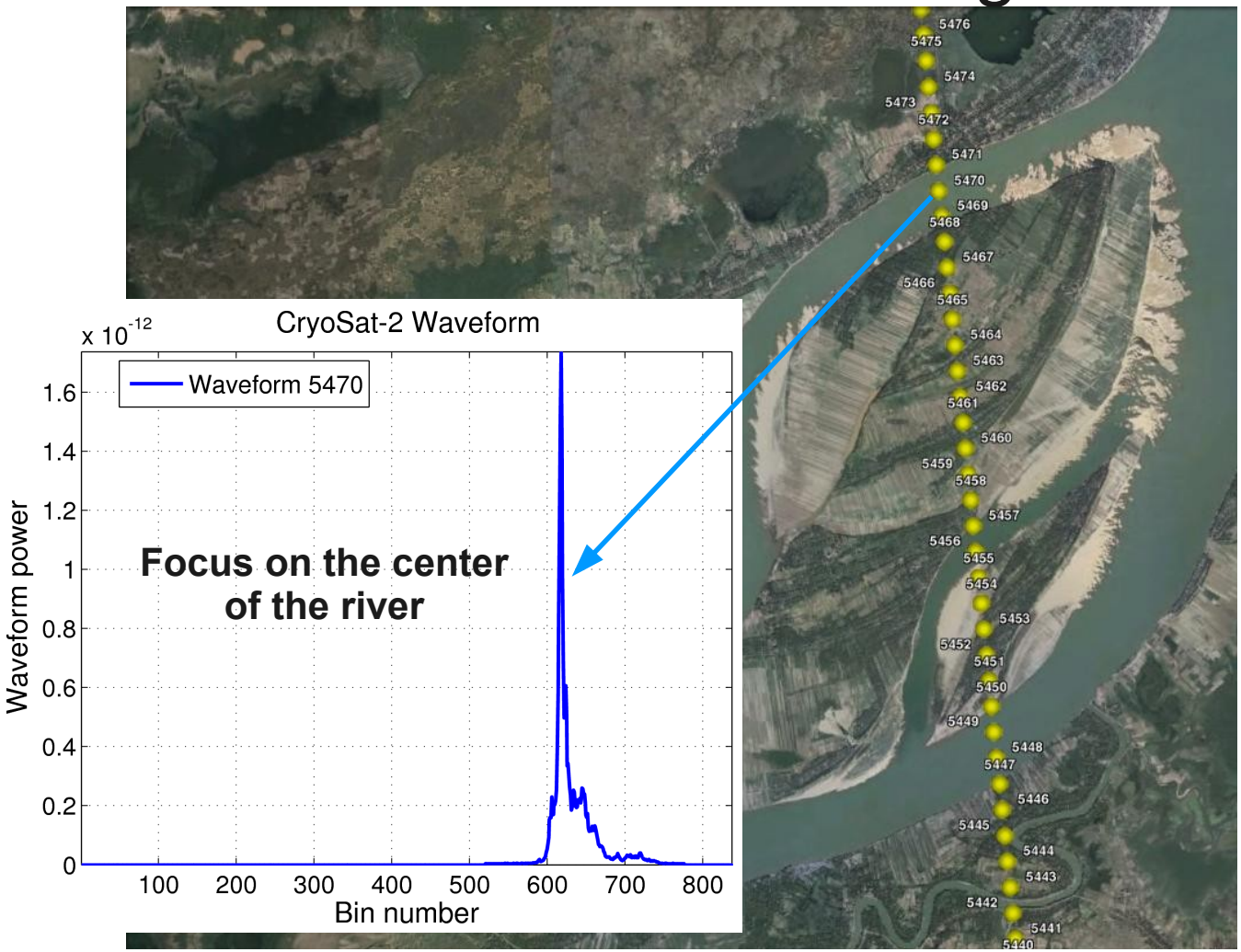
Along-track resolution

SAR mode over Mekong river



Along-track resolution

SAR mode over Mekong river



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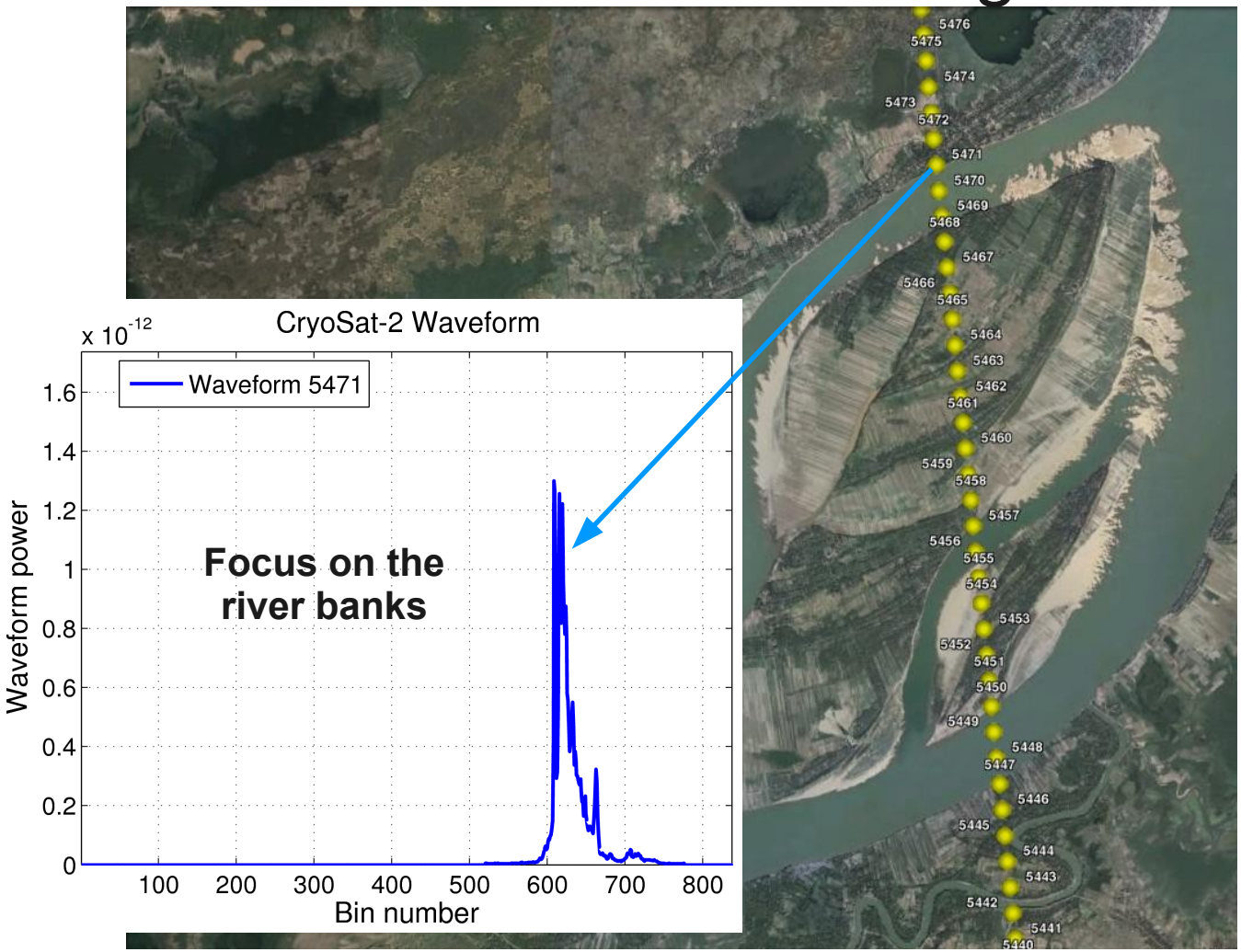
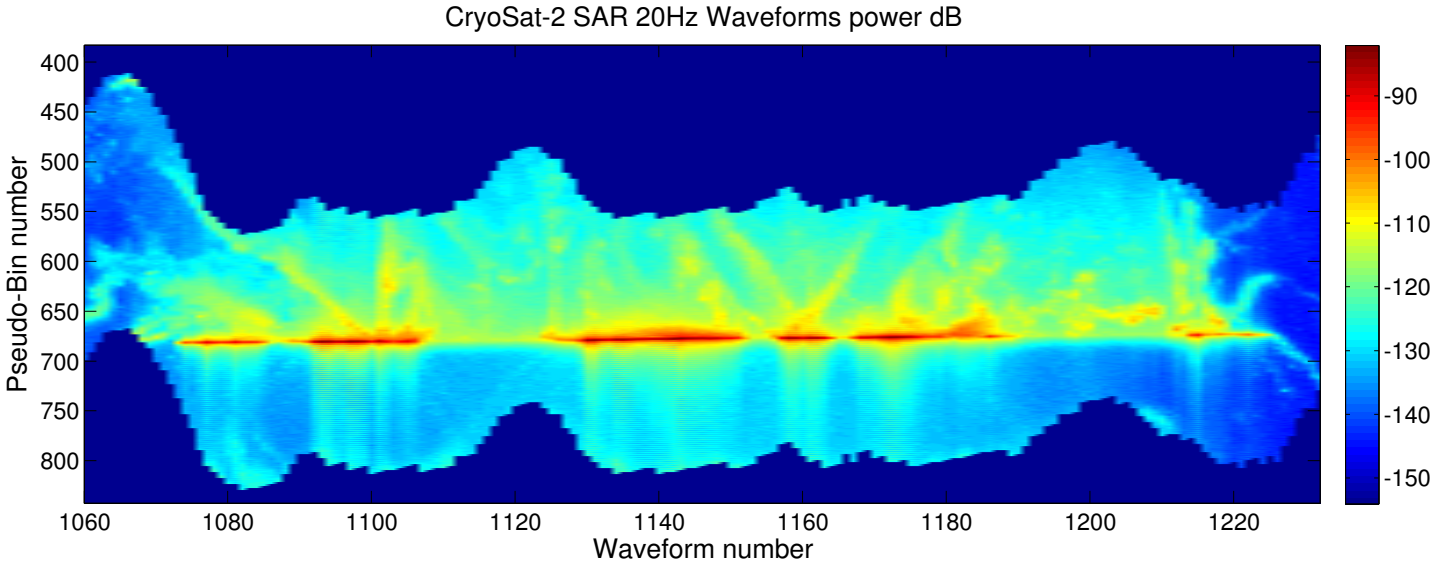


80 Hz SAR : a way to refine small rivers monitoring ?

Data from S. Dinardo, ESRIN



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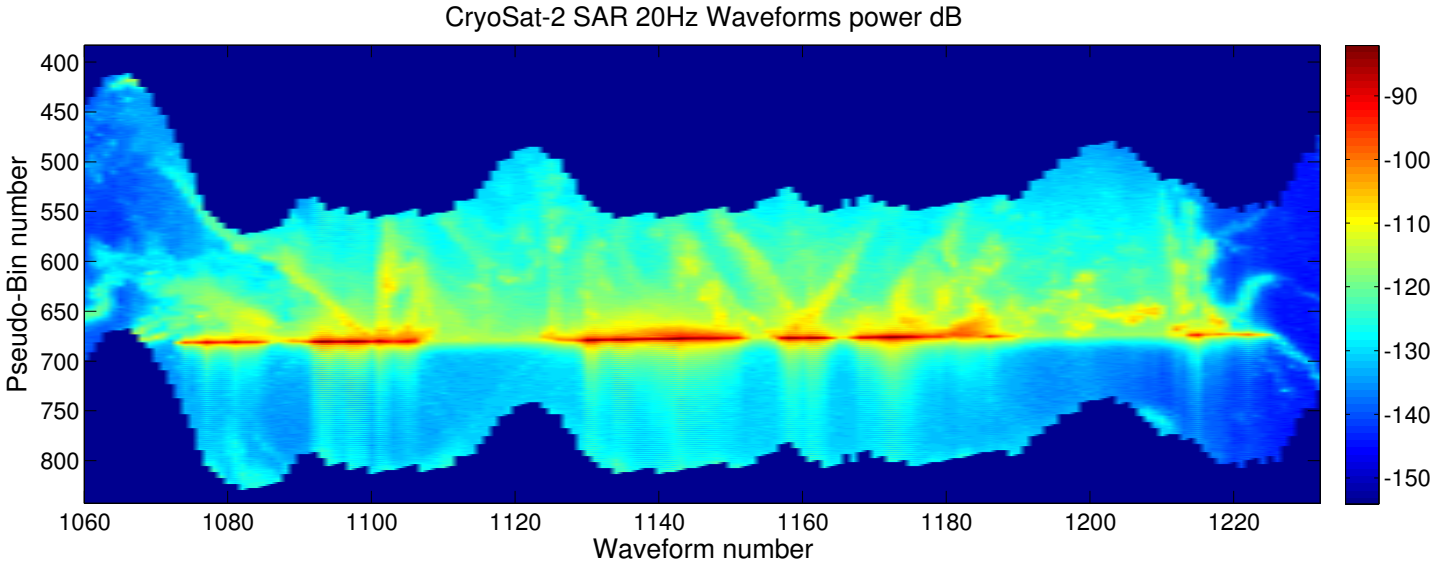

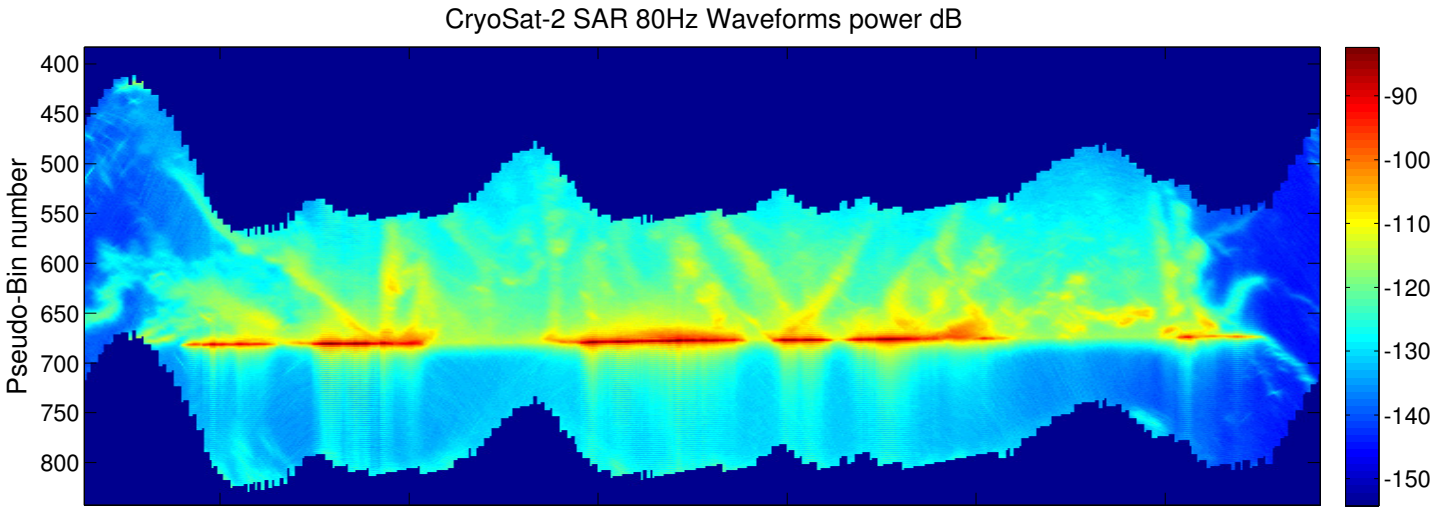

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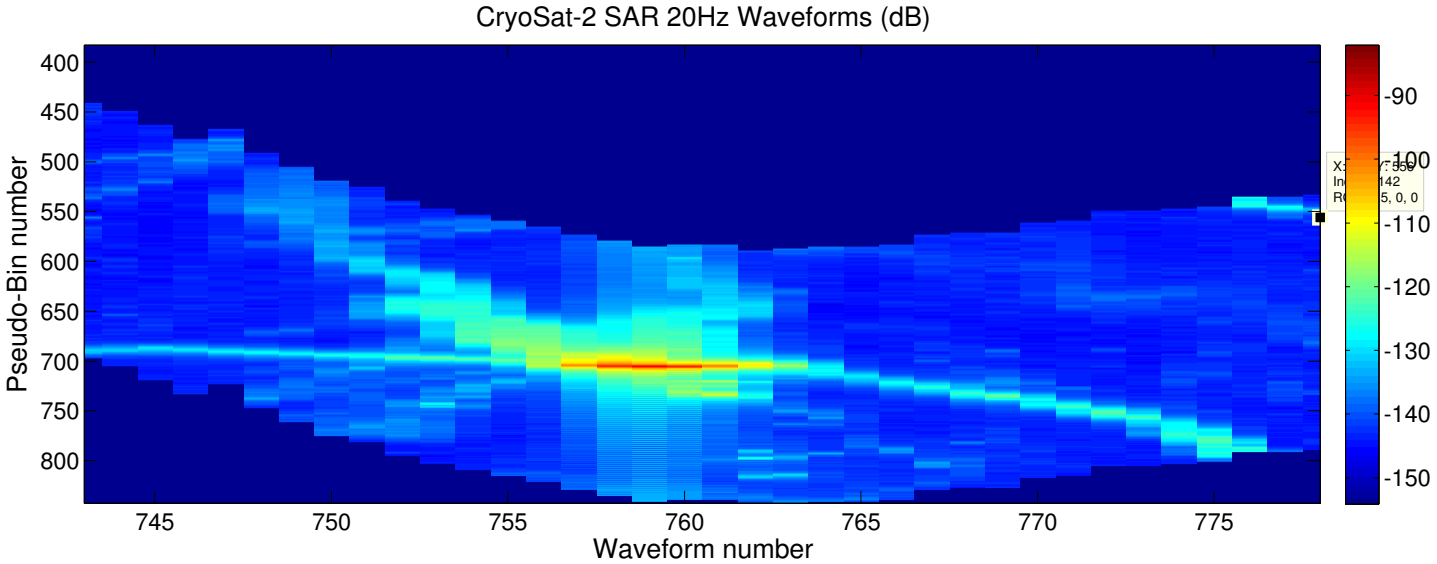

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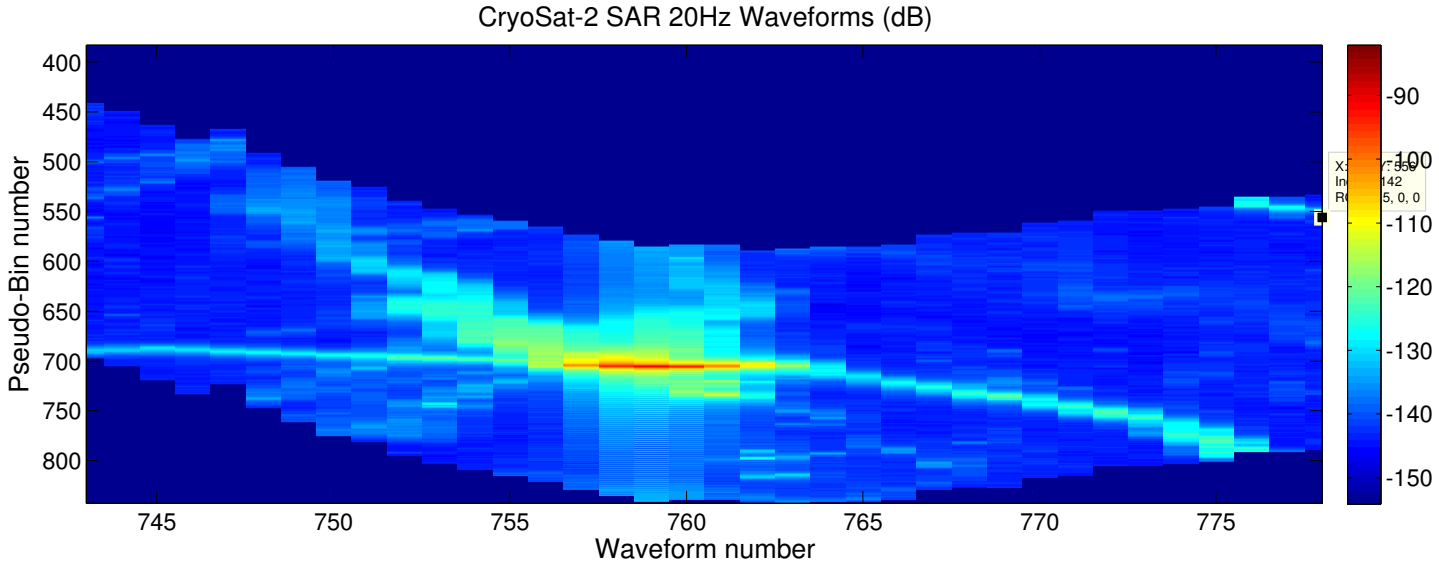
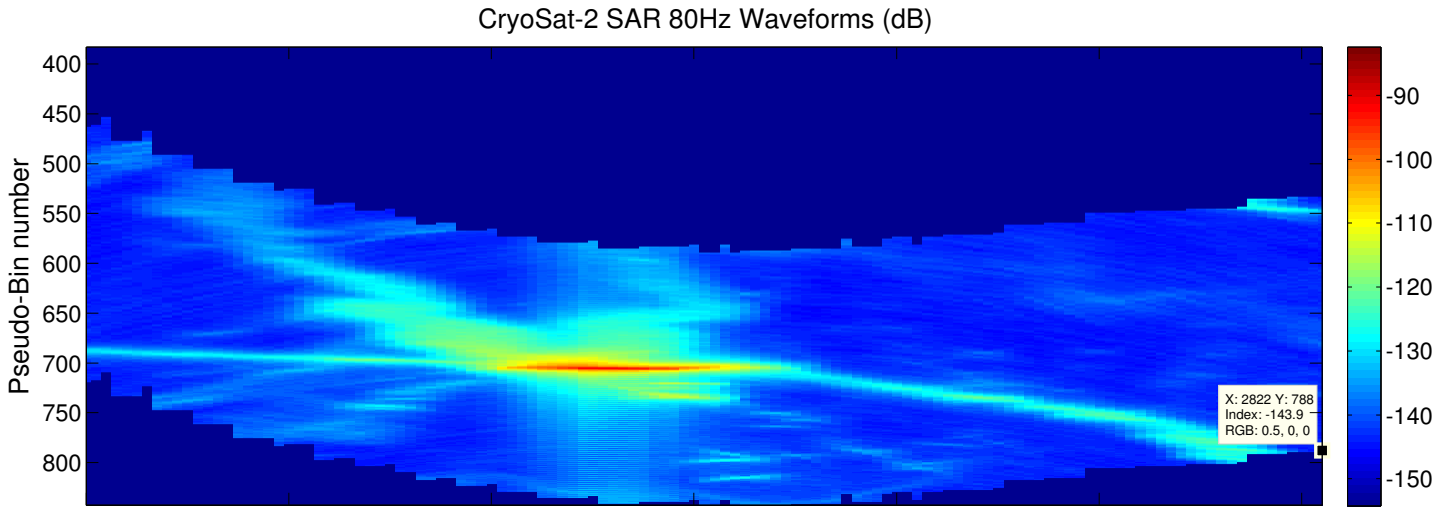
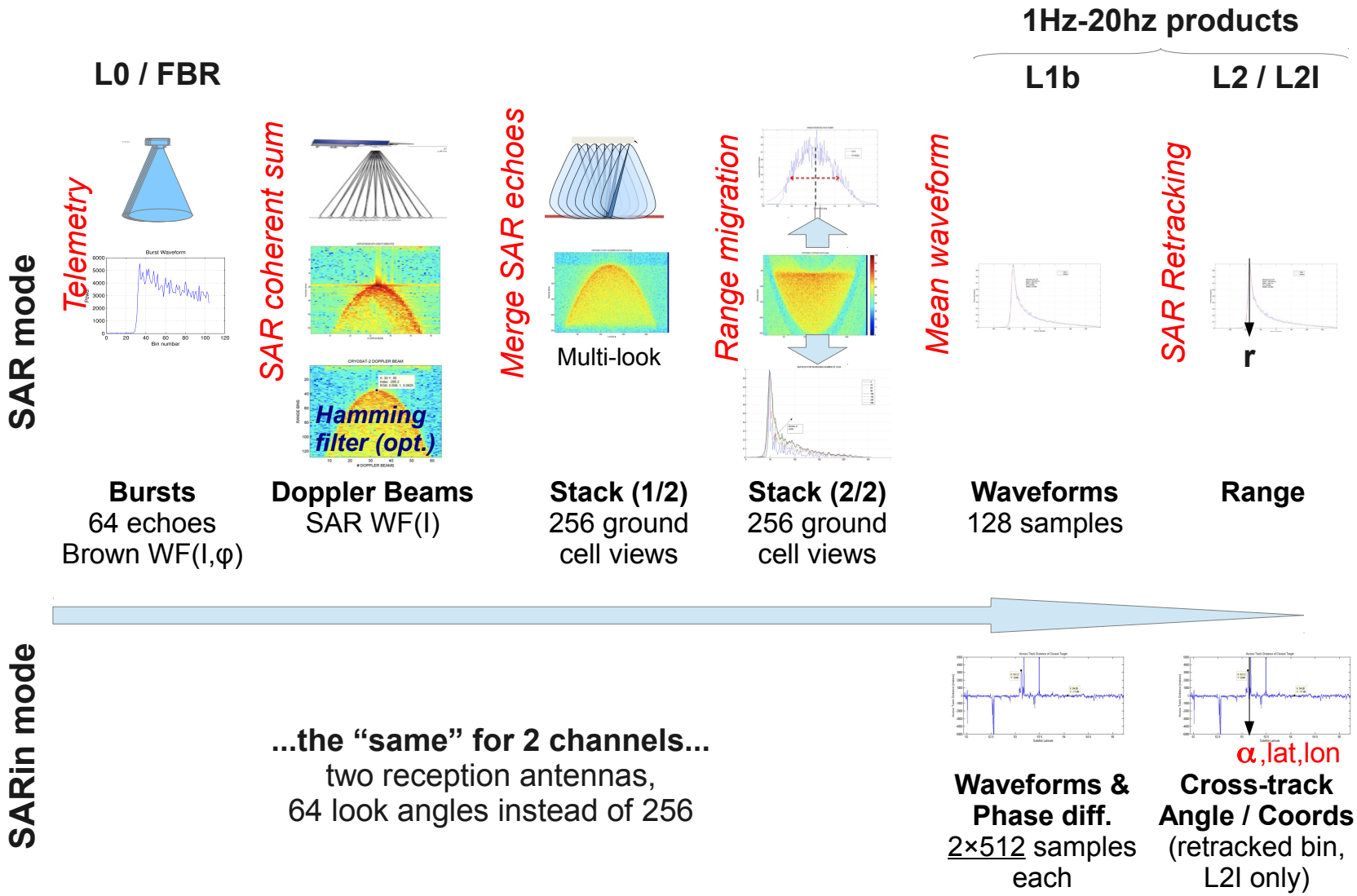




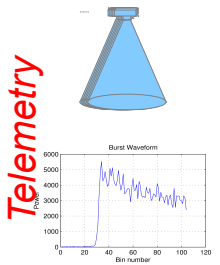
Product Levels



Product Levels

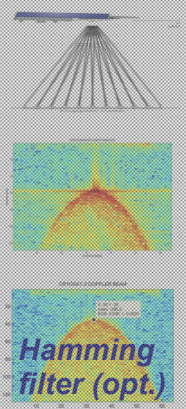
SAR mode

L0 / FBR



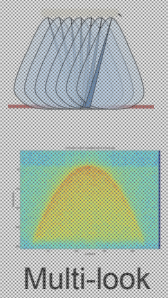
Bursts
64 echoes
Brown WF(I,φ)

SAR coherent sum



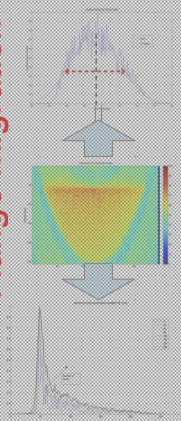
Doppler Beams
SAR WF(I)

Merge SAR echoes



Stack (1/2)
256 ground cell views

Range migration

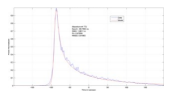


Stack (2/2)
256 ground cell views

1Hz-20hz products

L1b

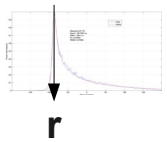
Mean waveform



Waveforms
128 samples

L2 / L2I

SAR Retracking



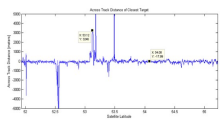
Range

SARin mode

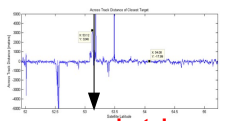
...the same for 2 channels...
(two reception antennas)

Intermediate stack
2×64 ground cell views

Stacks of
2×64 ground cell views

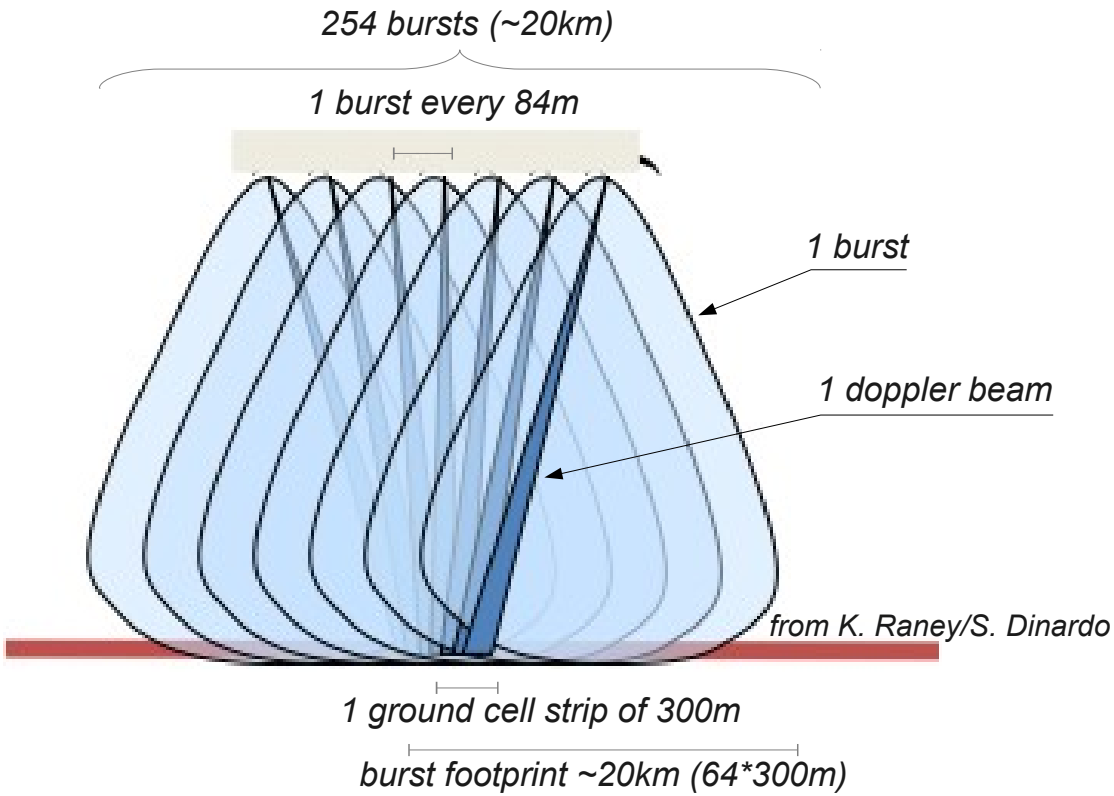


Waveforms & Phase diff.
2×512 samples each



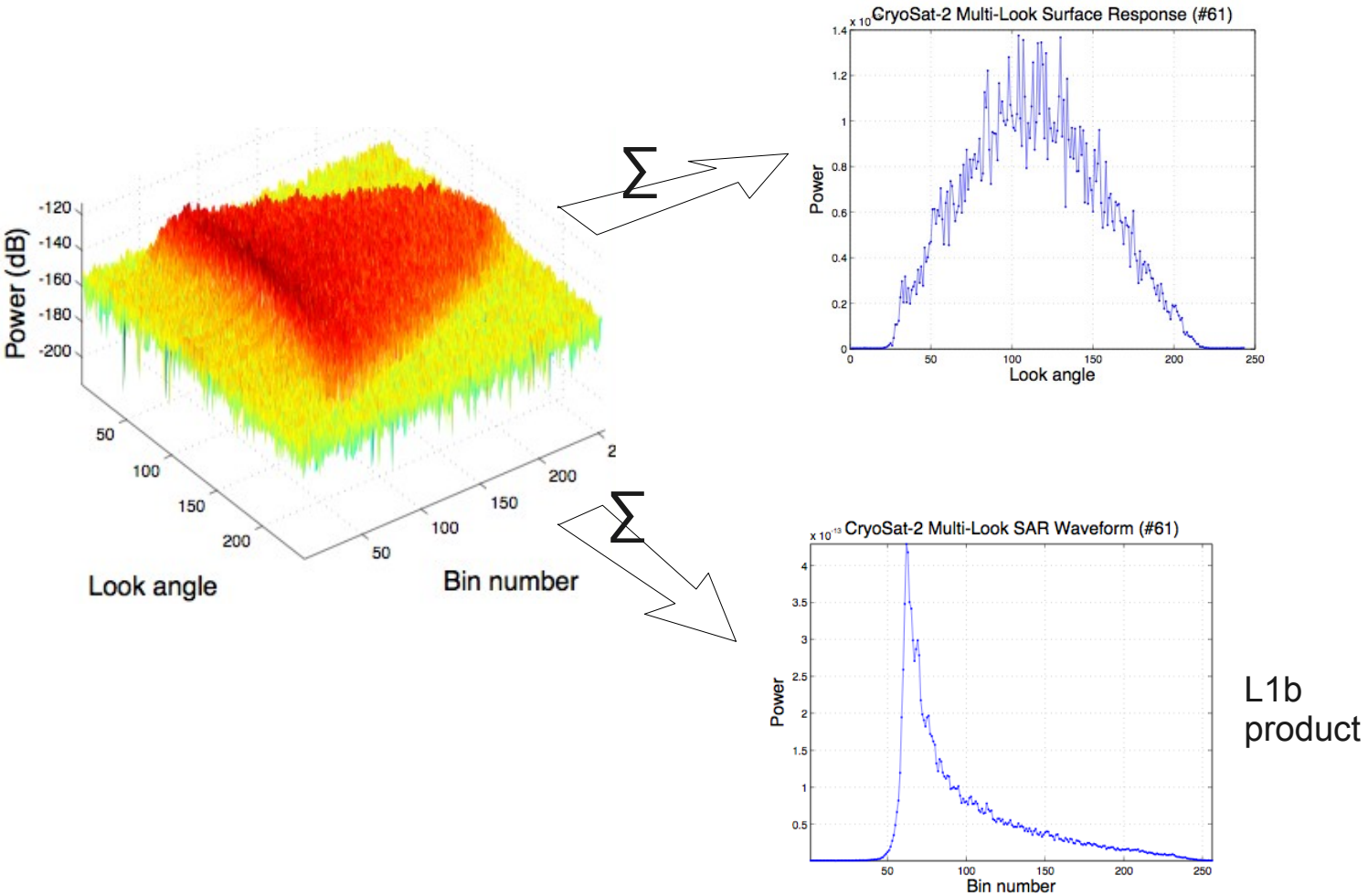
Cross-track Angle / Coords
(retracked bin, L2I only)

The multi-look over one ground cell



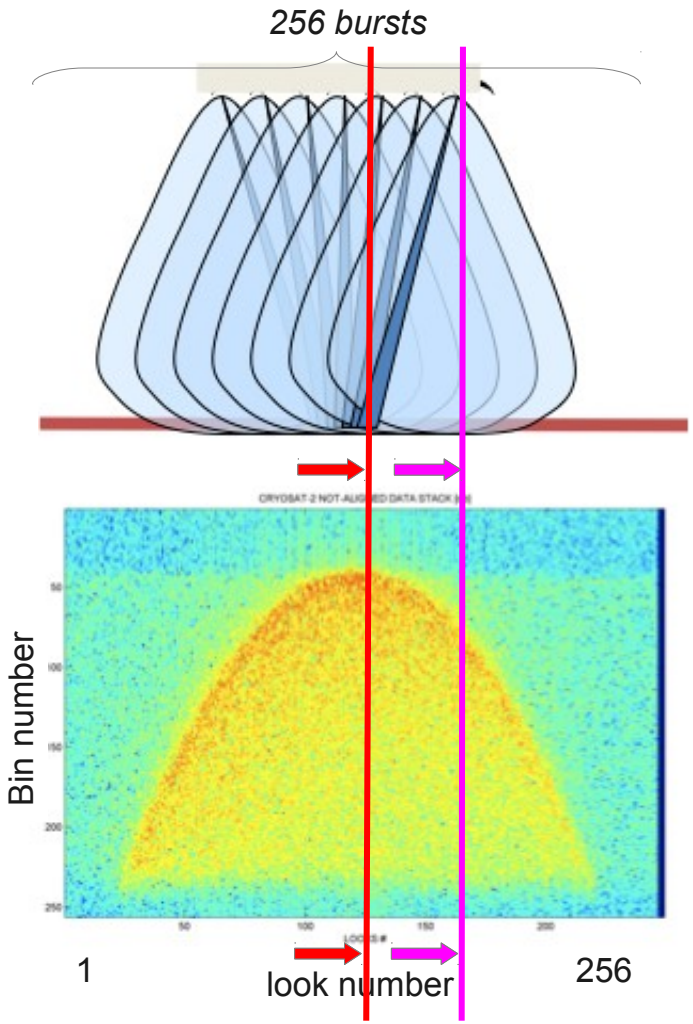
Each ground cell can be seen per theoriticaly 256 bursts
(~223 in practice over ocean)

The multi-look: stack

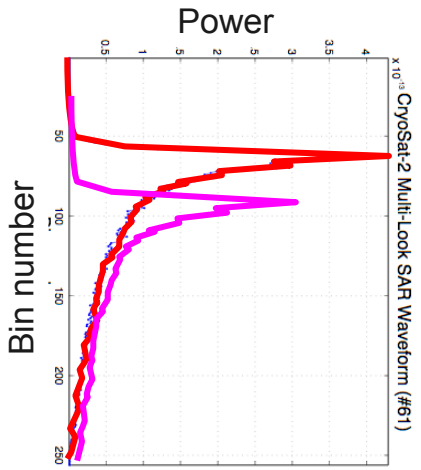


L1b product

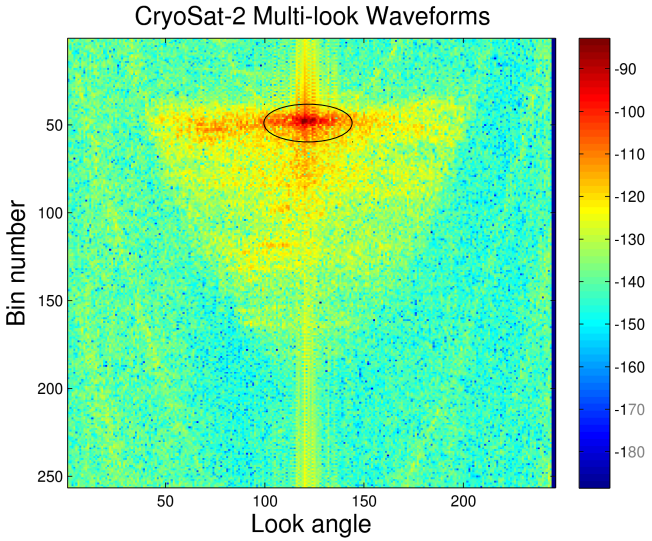
The multi-look : the stack

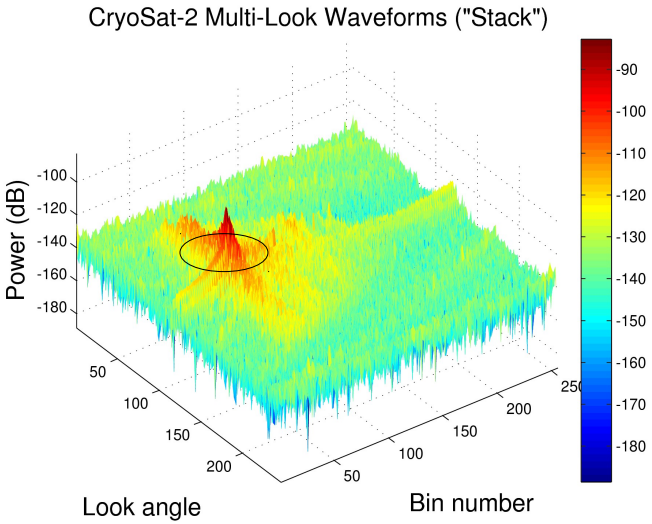


2 Doppler waveforms « looking » the same ground cell

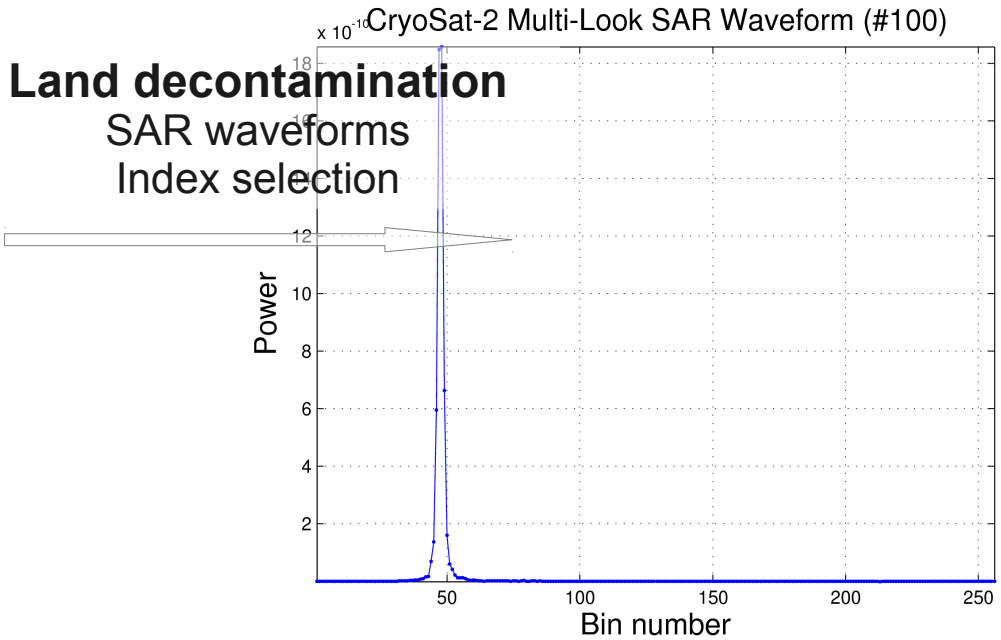


Stack: mean waveform

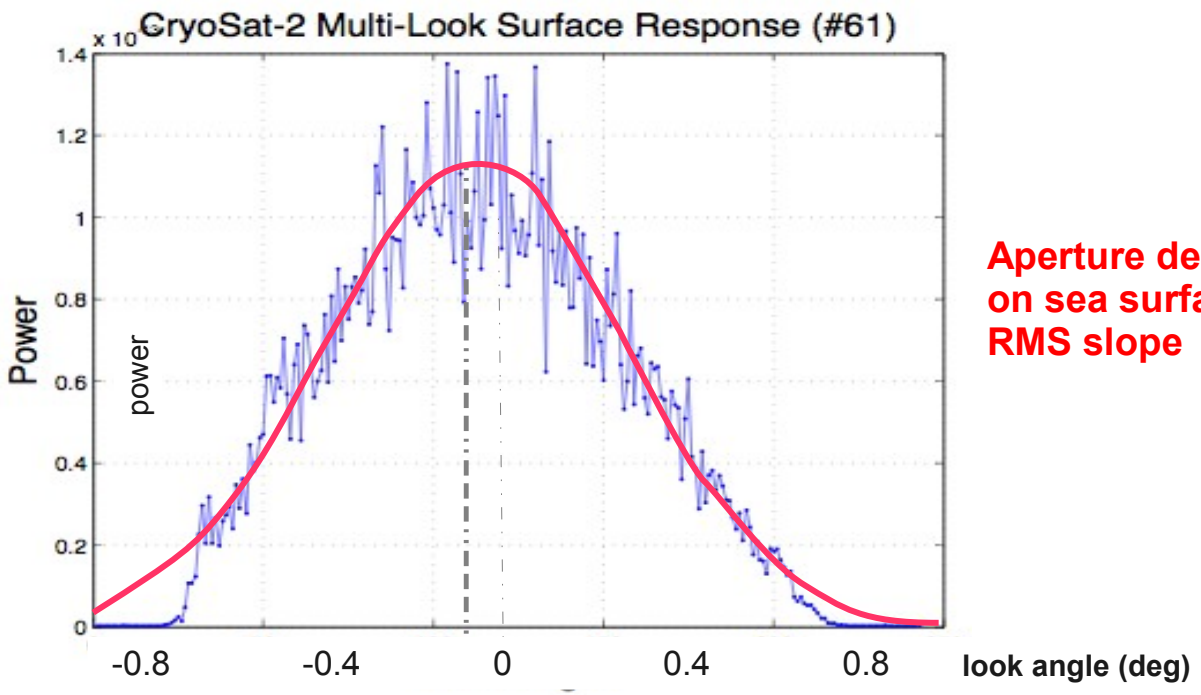




Land decontamination
SAR waveforms
Index selection



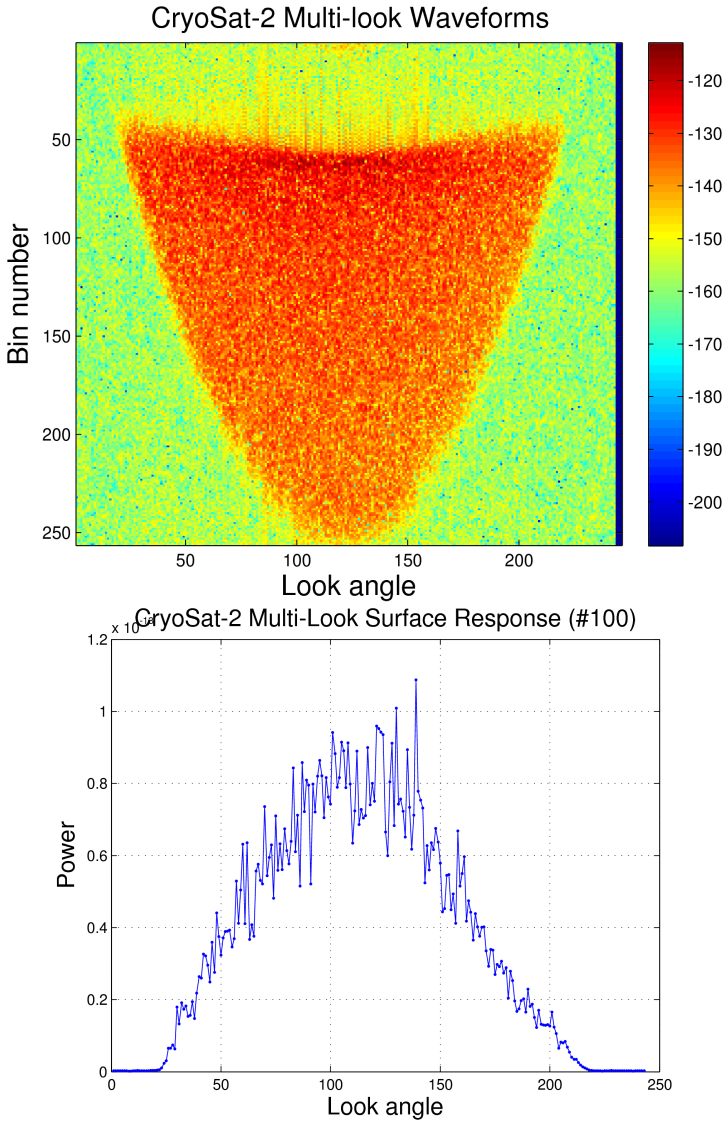
The multi-look: stack look-angles

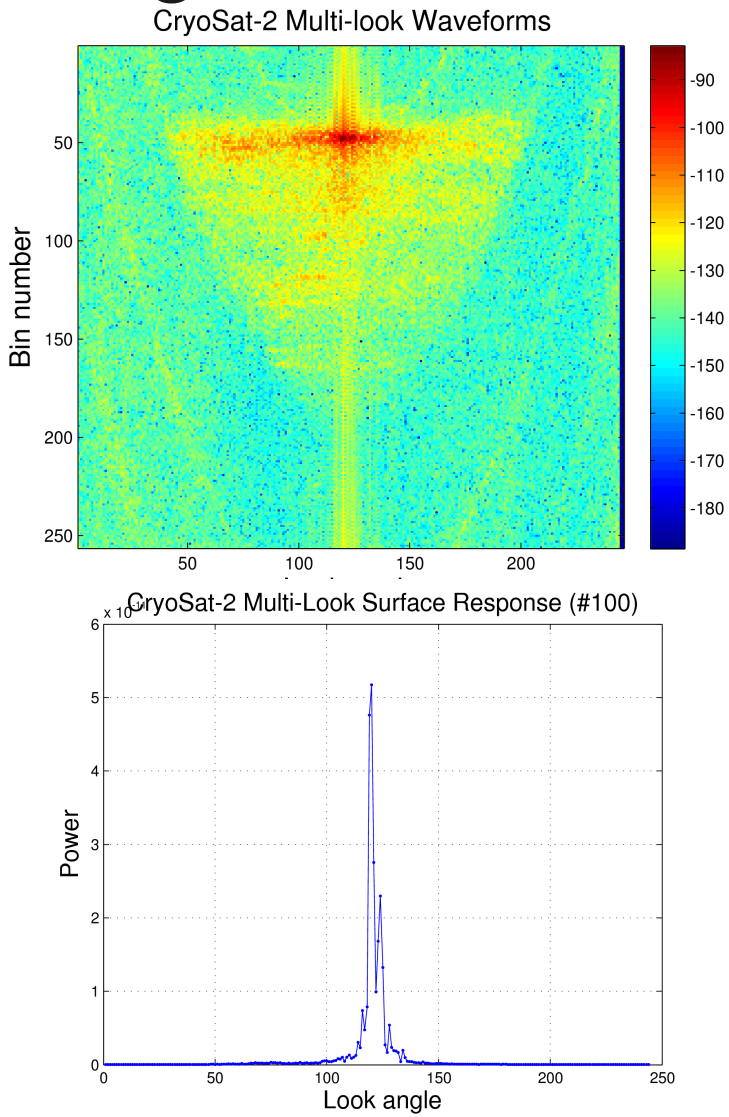


Aperture depending on sea surface RMS slope

Offset depending on pitch mispointing

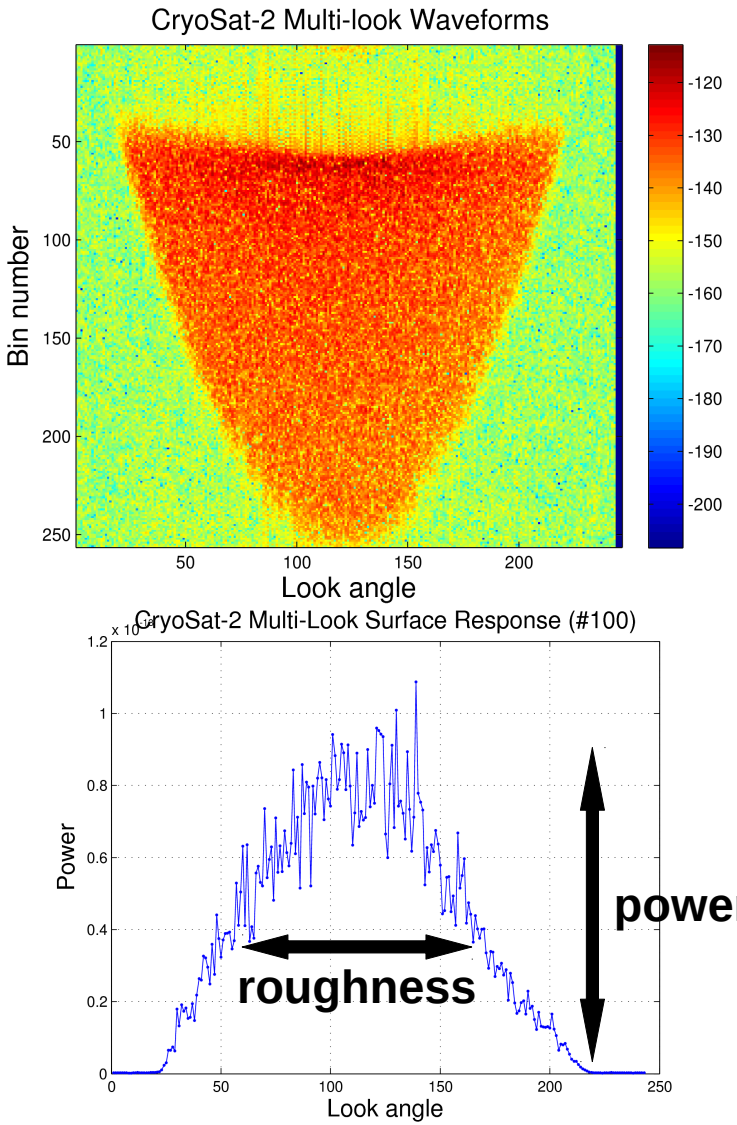
Stack: surface roughness

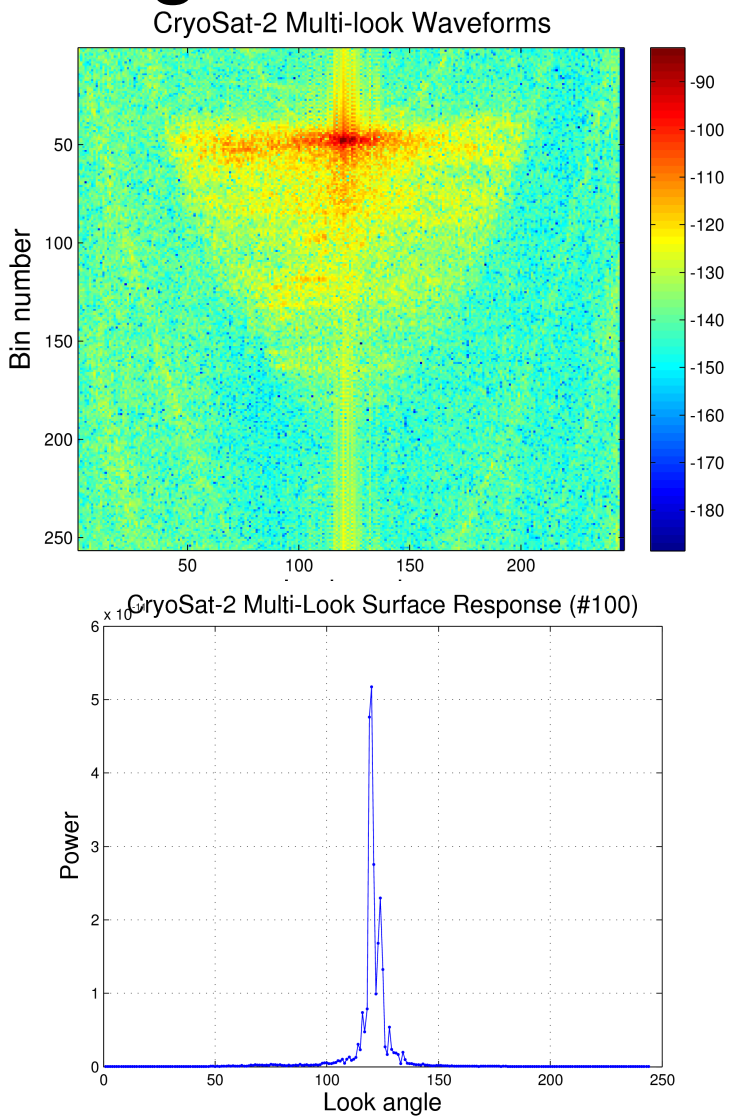




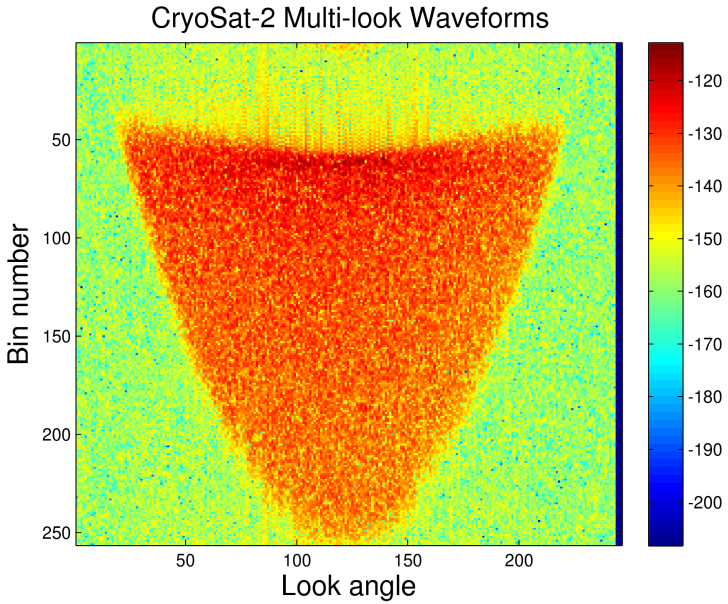
VIDEO

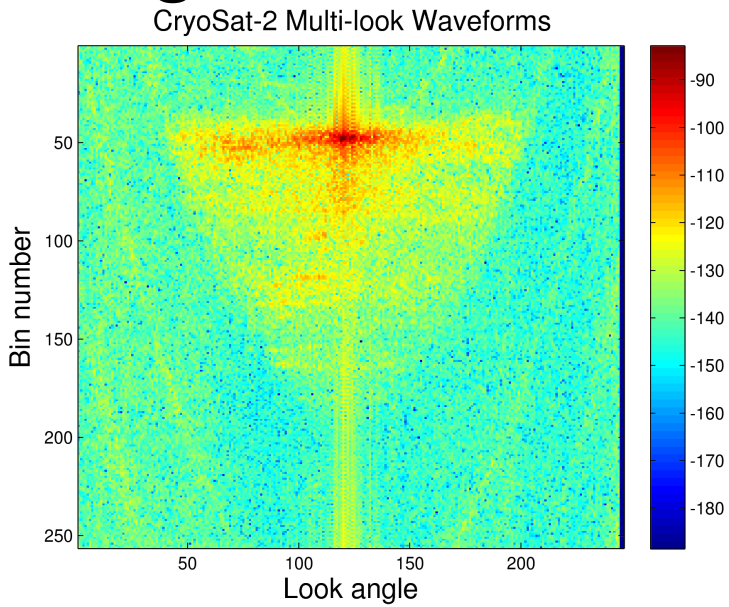
Stack: surface roughness

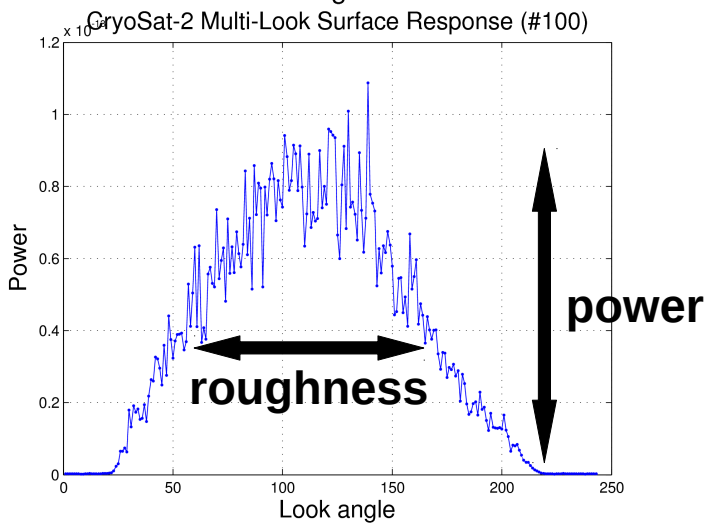




Stack: surface roughness



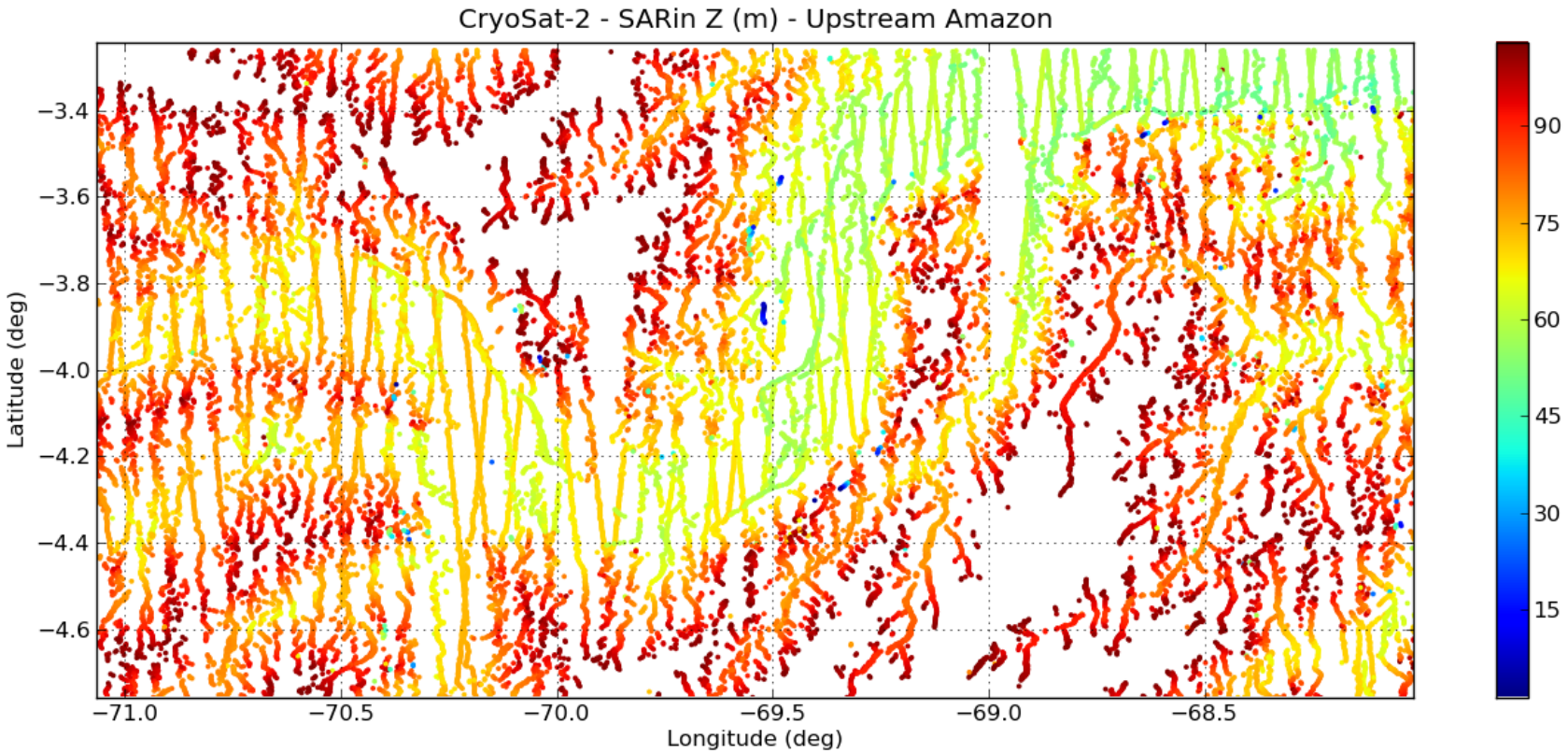




- **Surface response classification ?**
- **River extent detection ?**

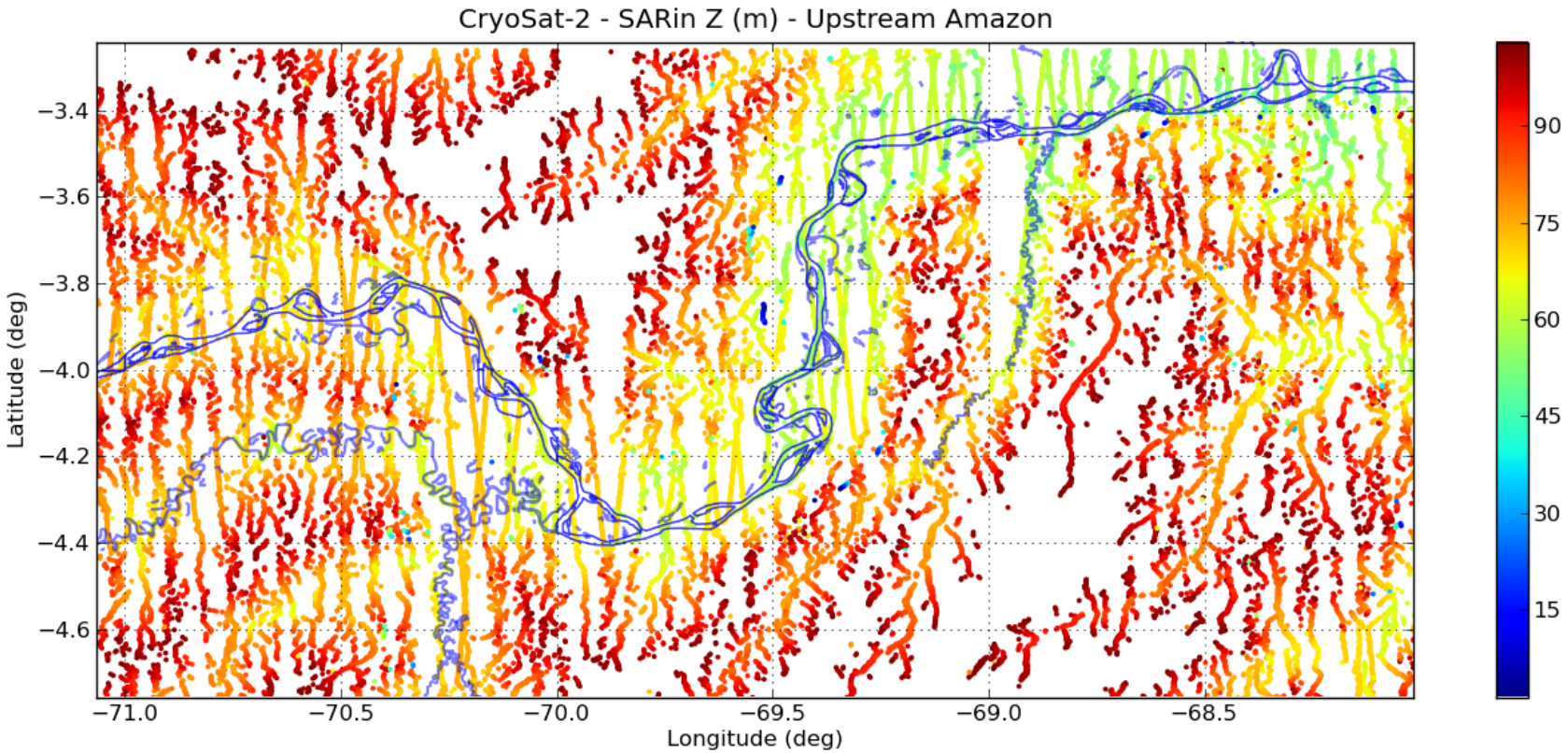
SARin & "the magic of two antennas"

SARin data extraction : tracks are zigzagging...



SARin & "the magic of two antennas"

SIRAL tracks a part the hydrographic network !



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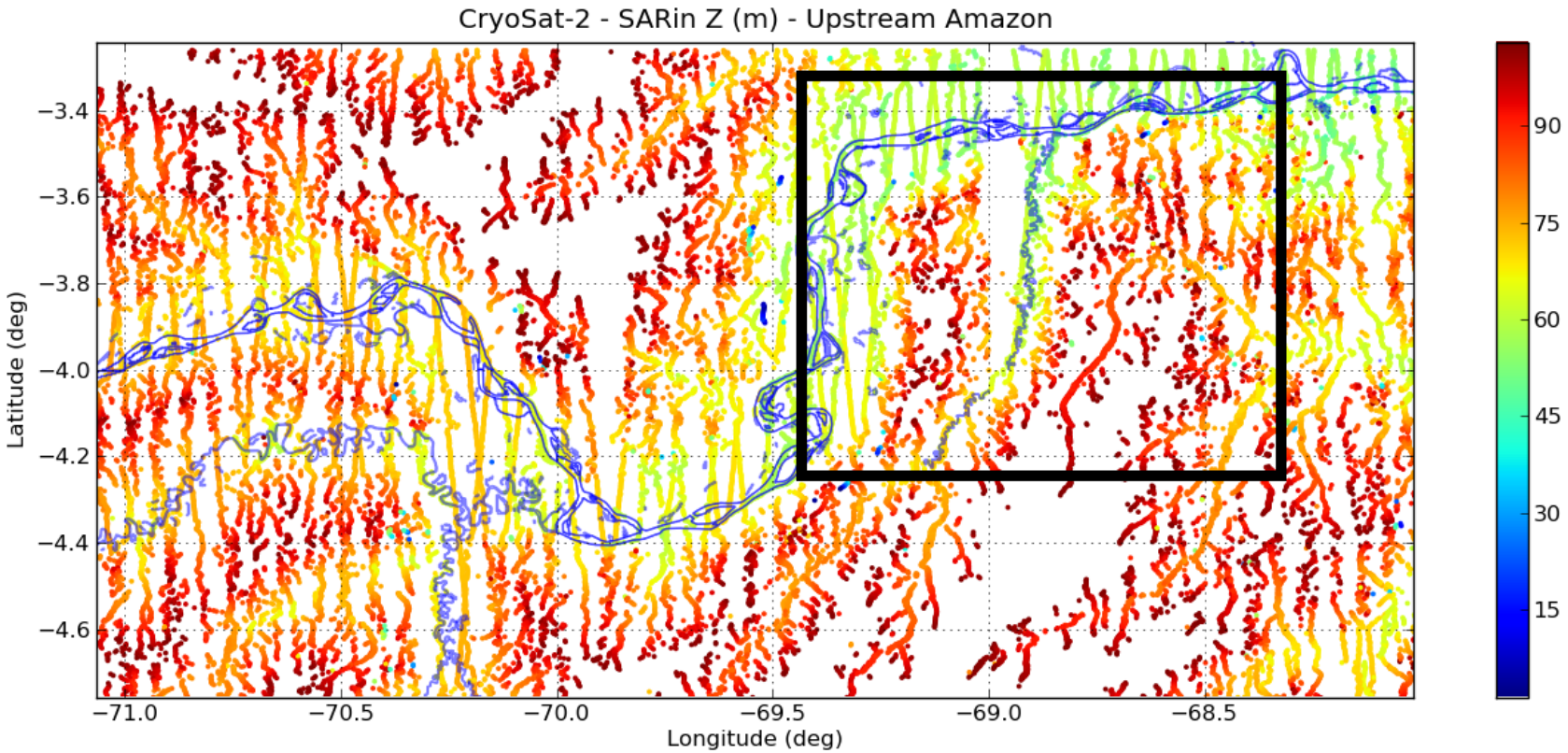

SARin & "the magic of two antennas"

SIRAL tracks a part the hydrographic network !

SARin & "the magic of two antennas"

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

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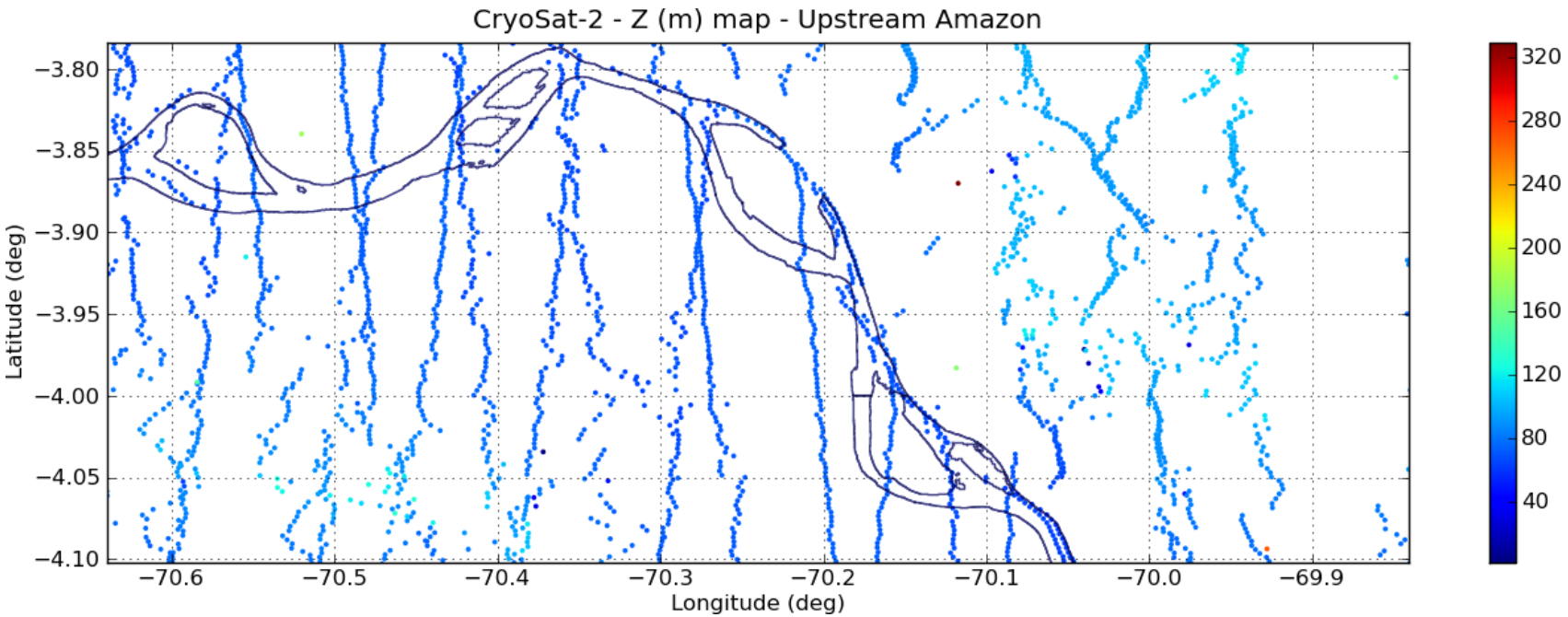
Zoom-in examples...



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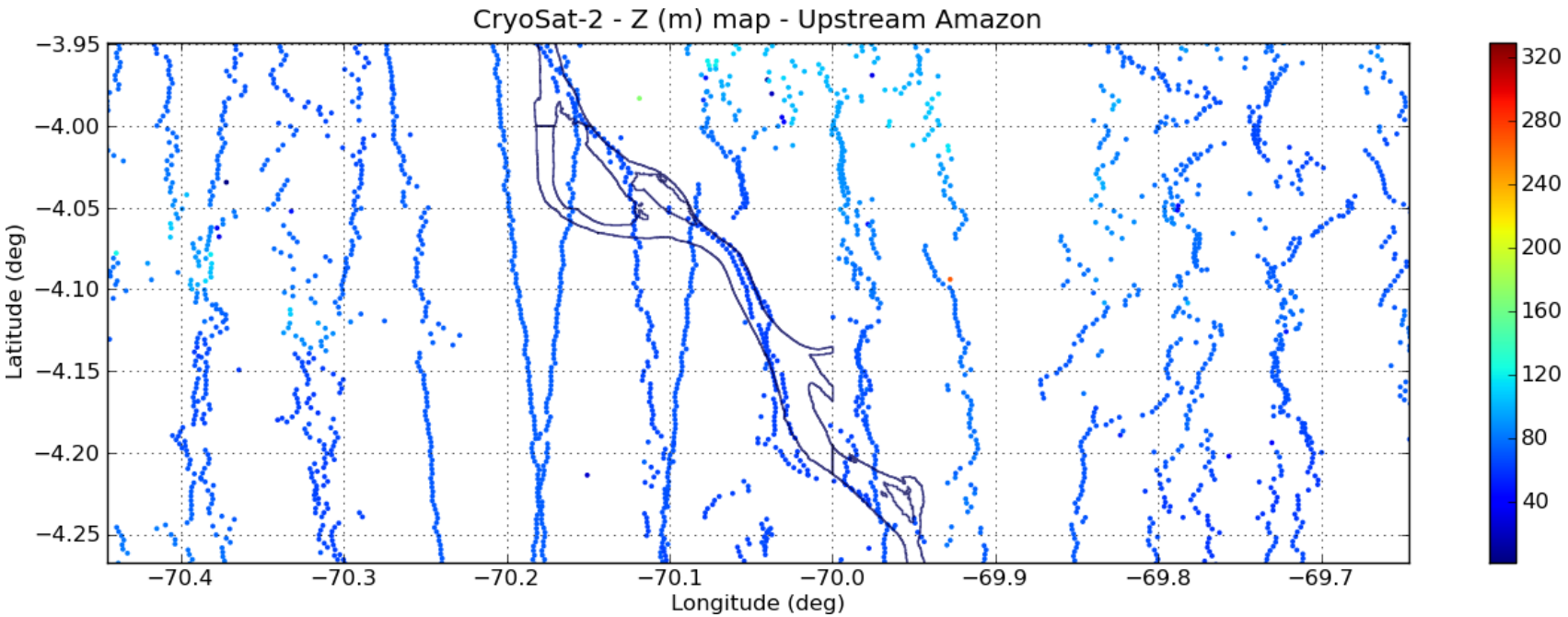

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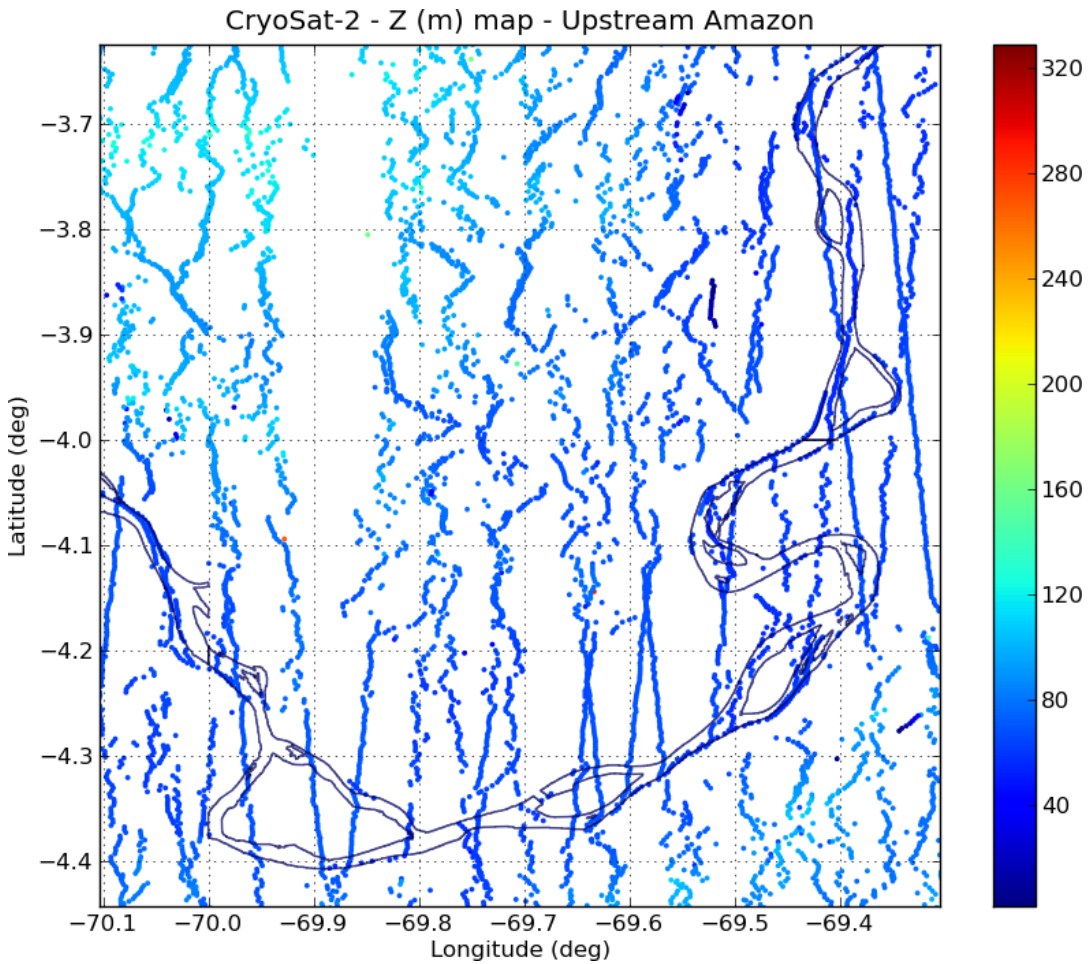

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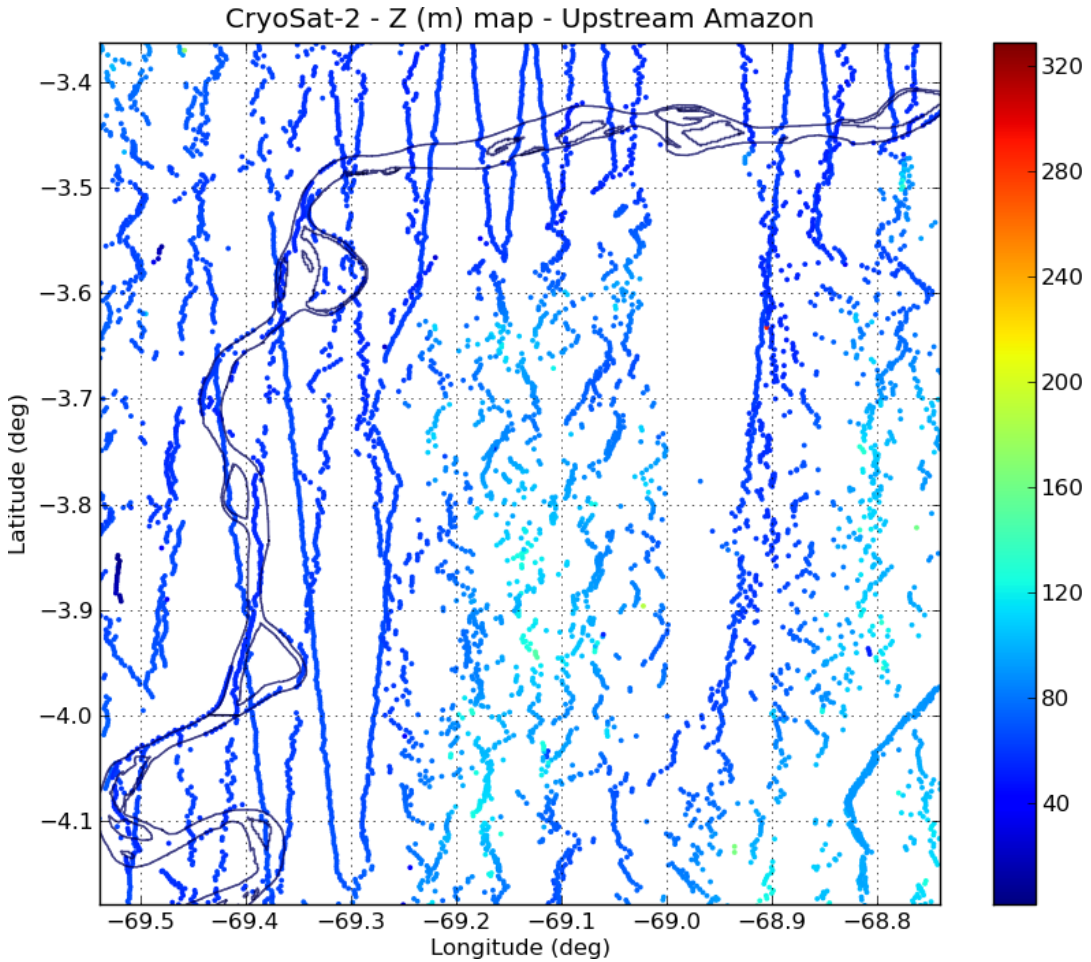

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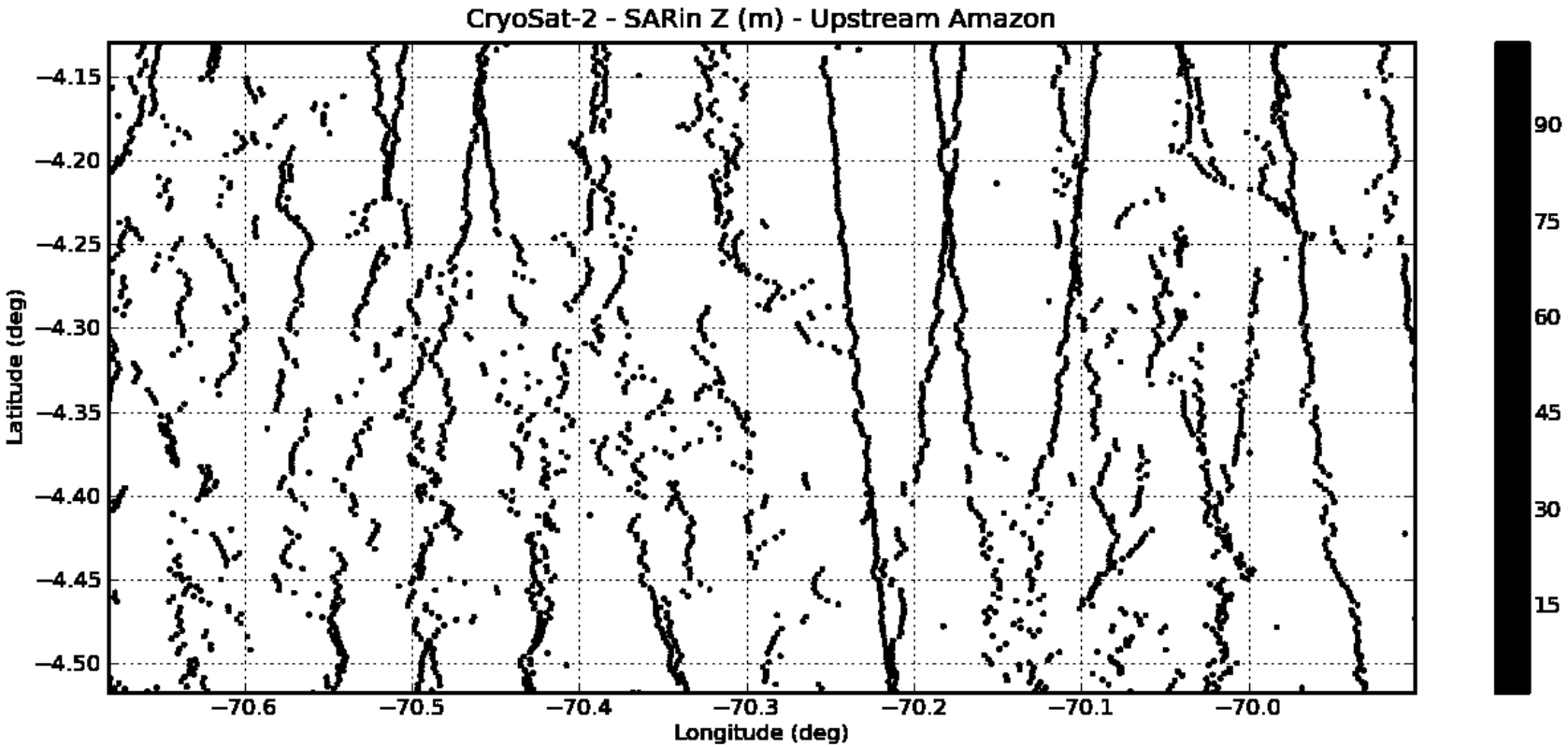

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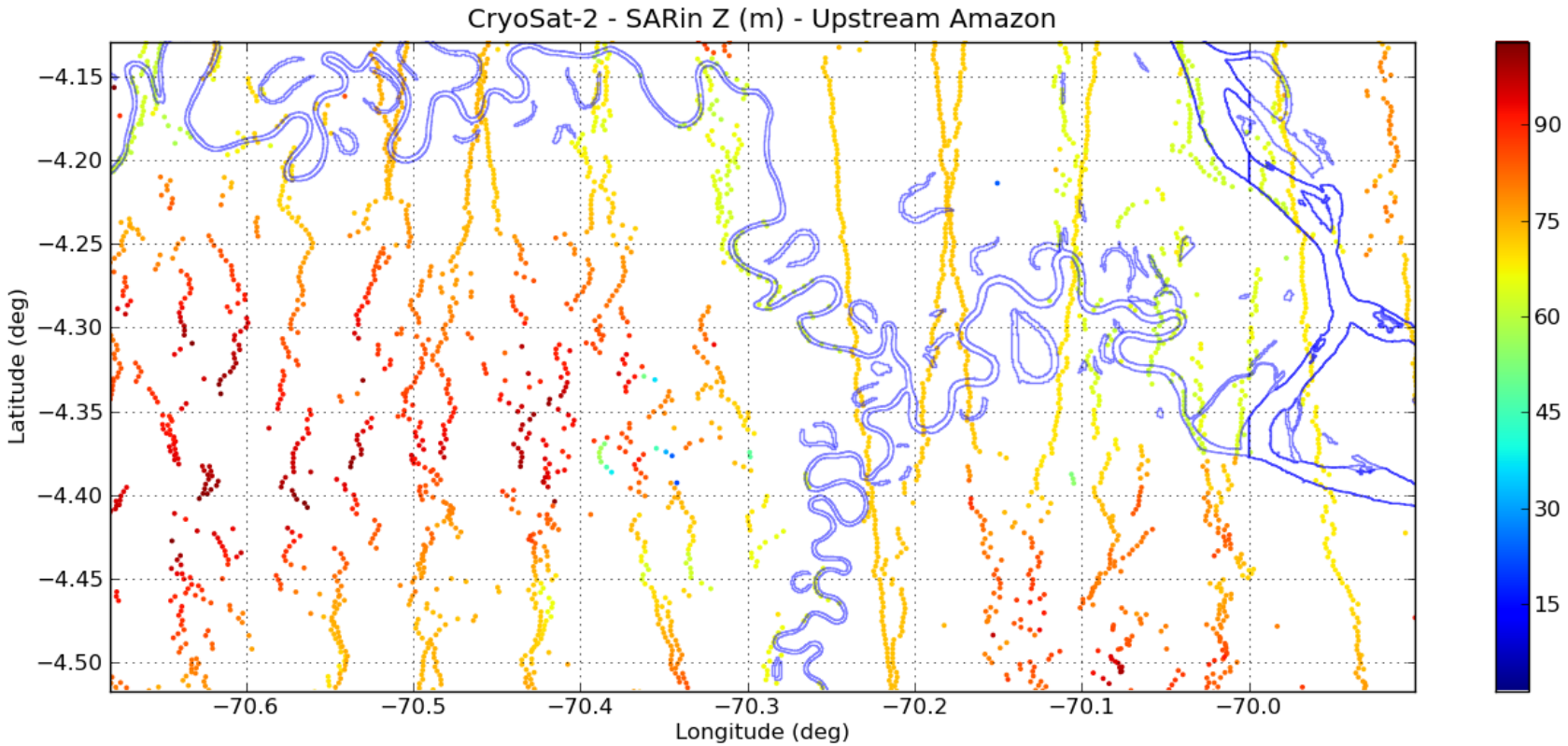

Conclusion

Background : complex products line

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- Greatly improved with Baseline B products (Feb. 2012)
- Teams developped alternative products
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- SIRAL : rich instrument with 2 new modes

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- SAR : higher along-track resolution
- SARin cross-track angle :
  - potential for small rivers detection and mapping of hydrographic networks
  - measurement of instaneous river's reach slope ?
  - track rivers on rough terrain ? (were conventional LRM missions usually fail)

Perspectives

Extensive products assessment

- Validation against in situ data (not yet available !)
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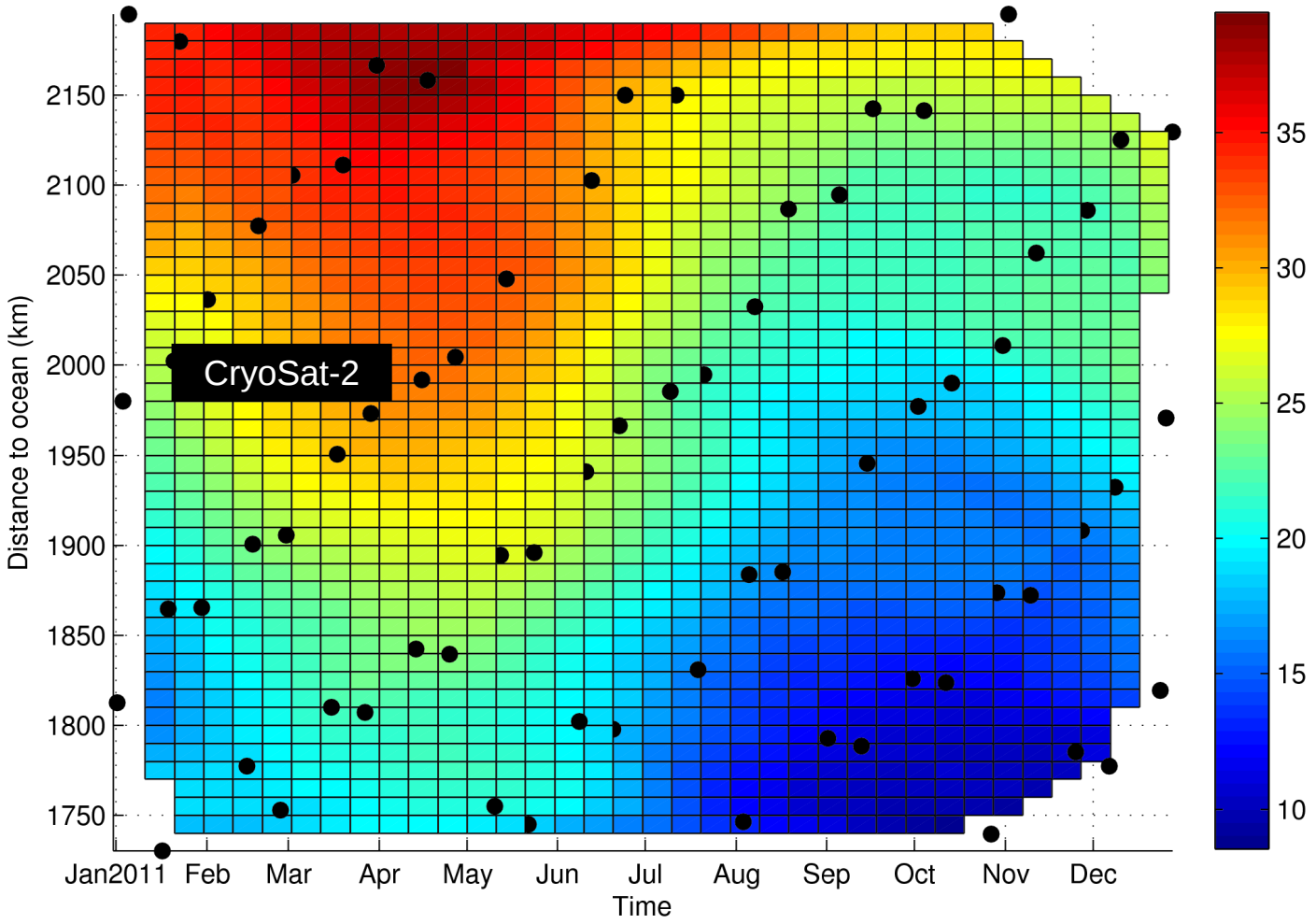
ESRIN proto : more explorations using the stacks

- Slicing stacks for better land decontamination
- Stacks power & roughness information to detect rivers ?

Perspectives : Mapping rivers topography from multi-mission data



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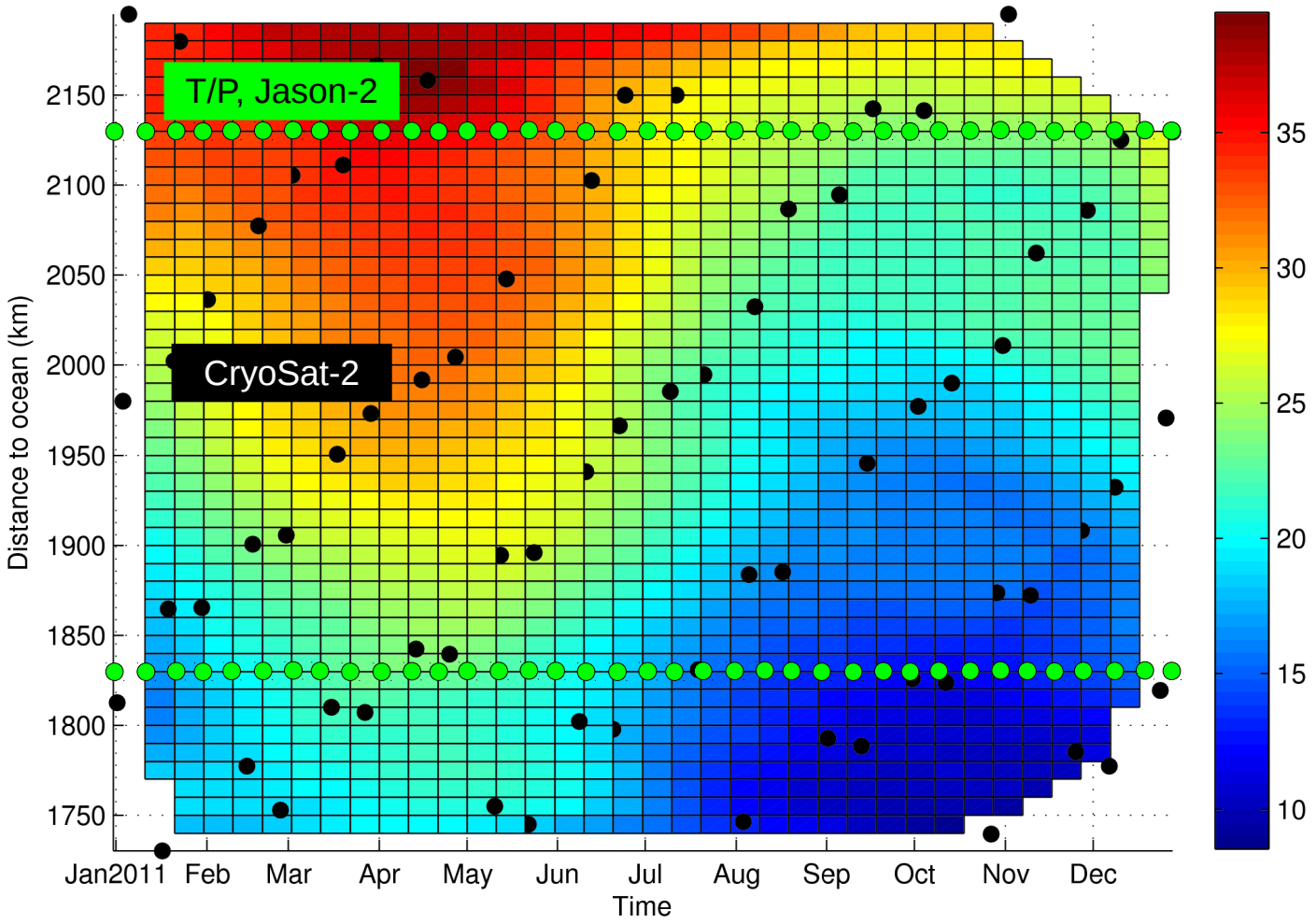

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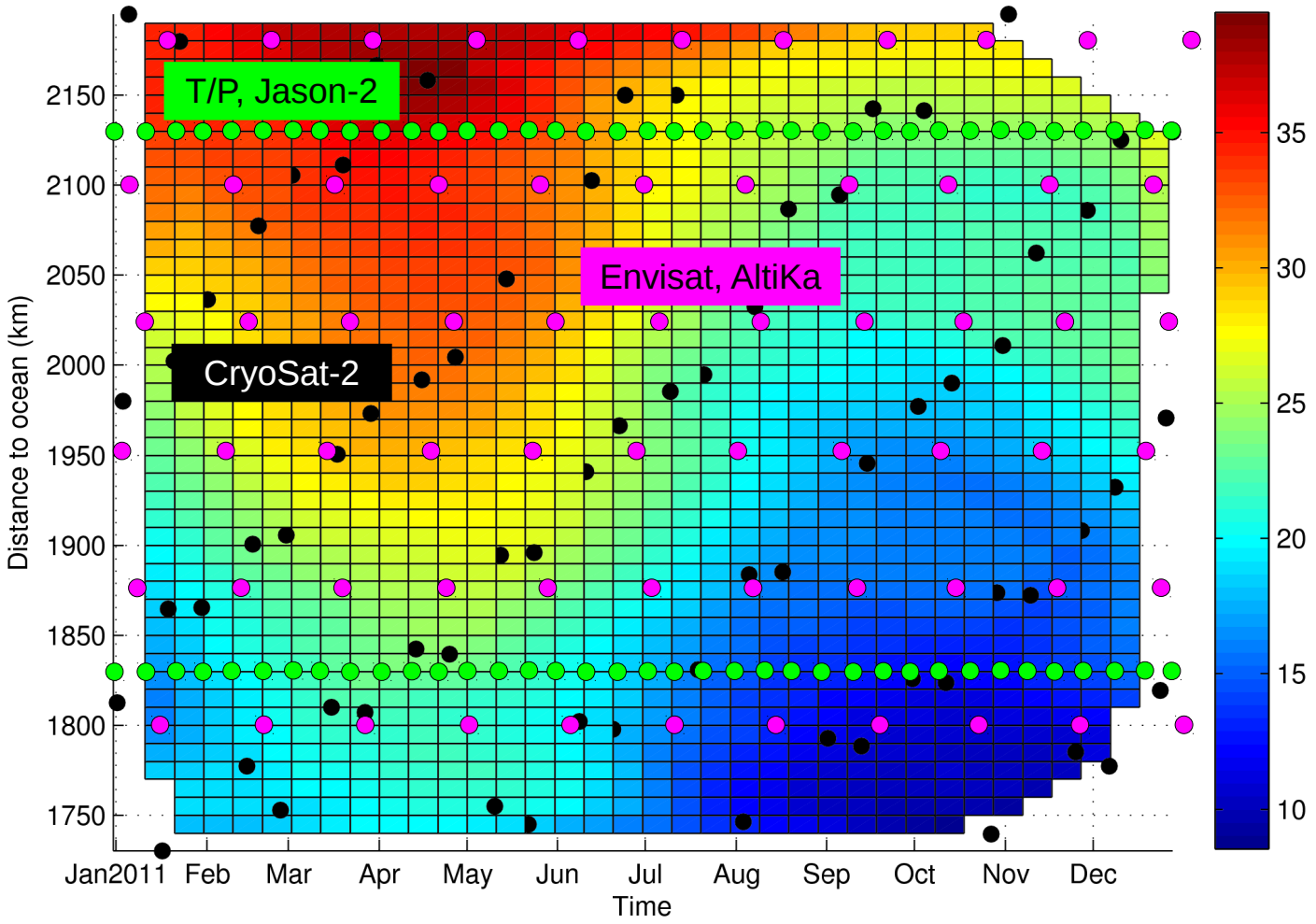

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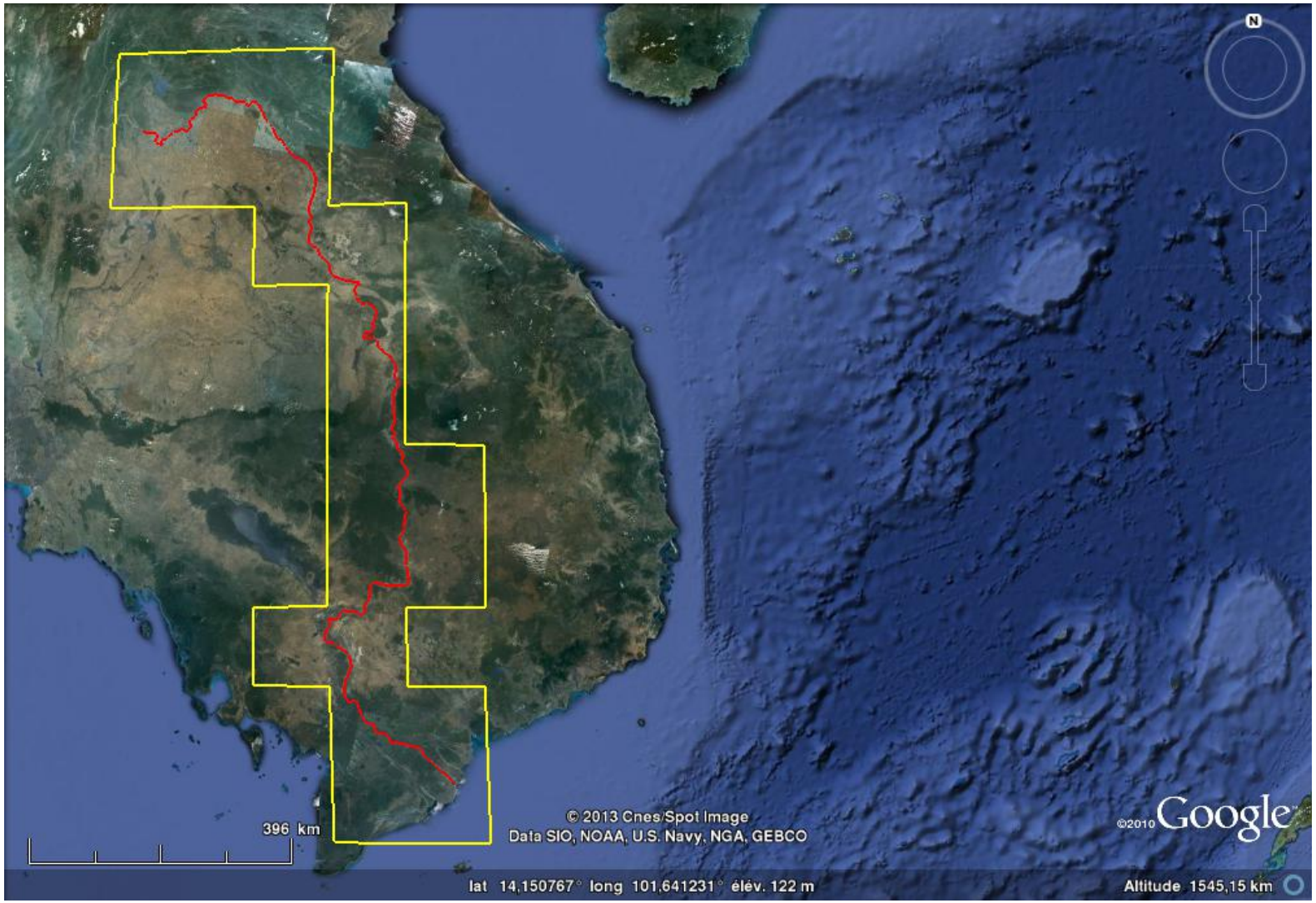
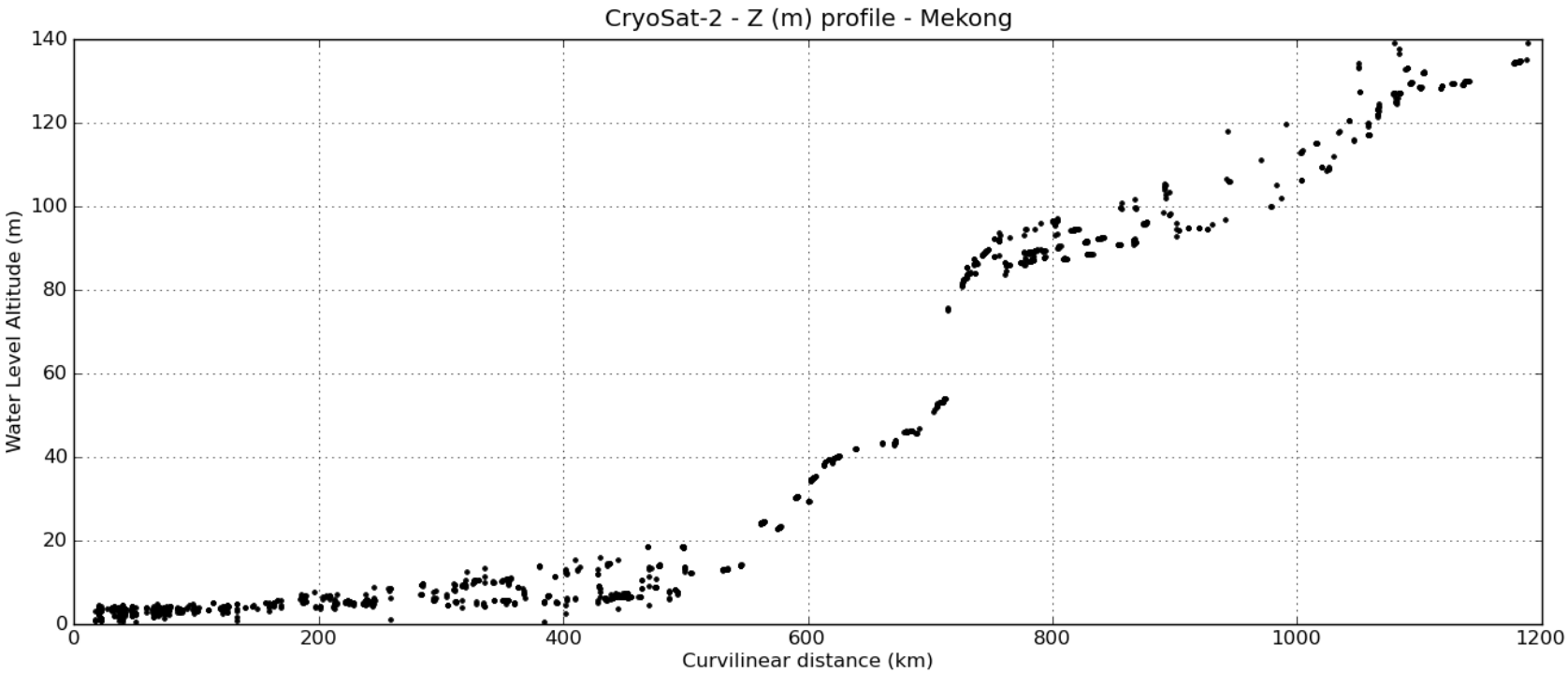
- Need to develop physical interpolation methods using hydraulic constraints/models

Mekong river (SAR)



Mekong river (SAR)

River Water level profile



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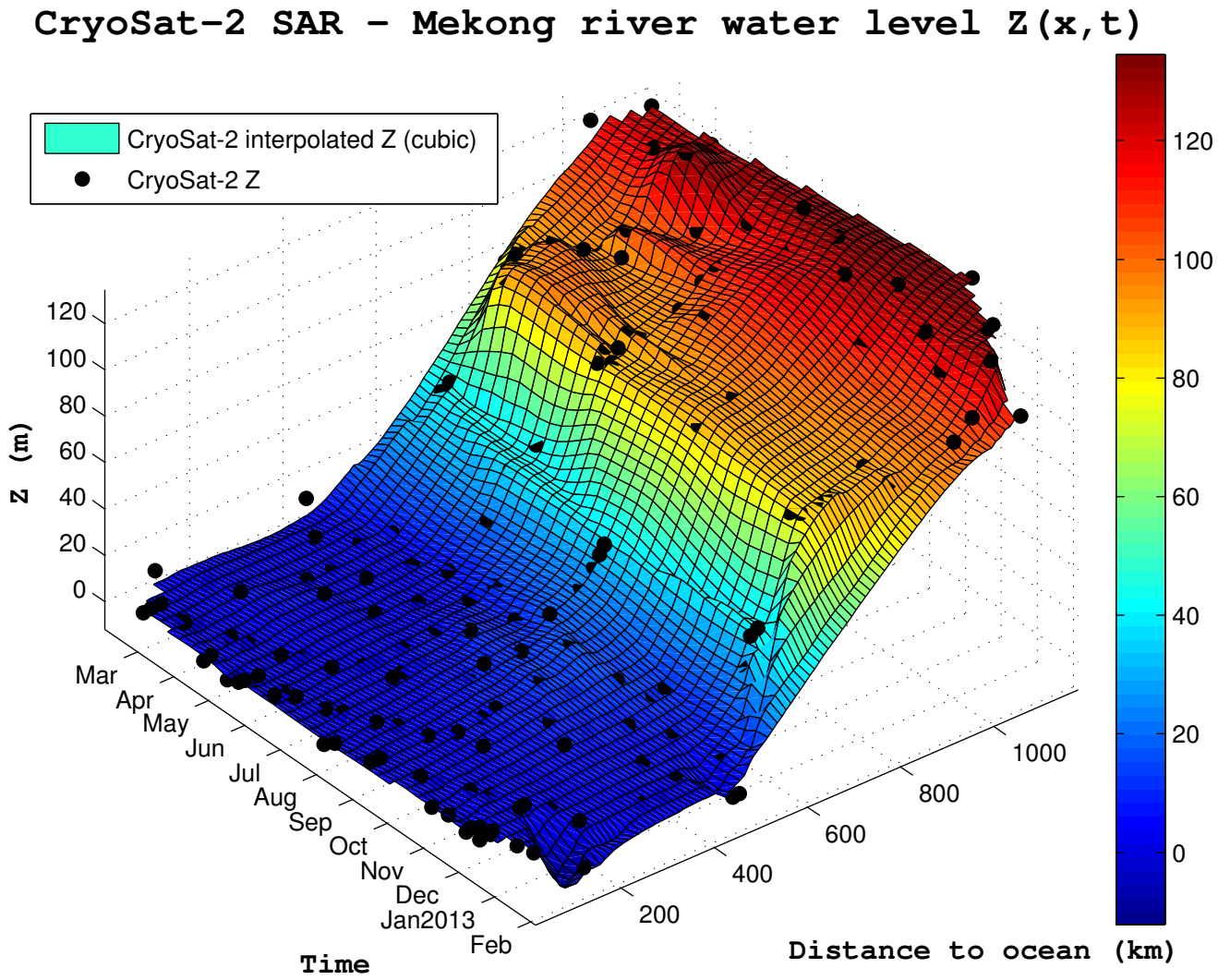
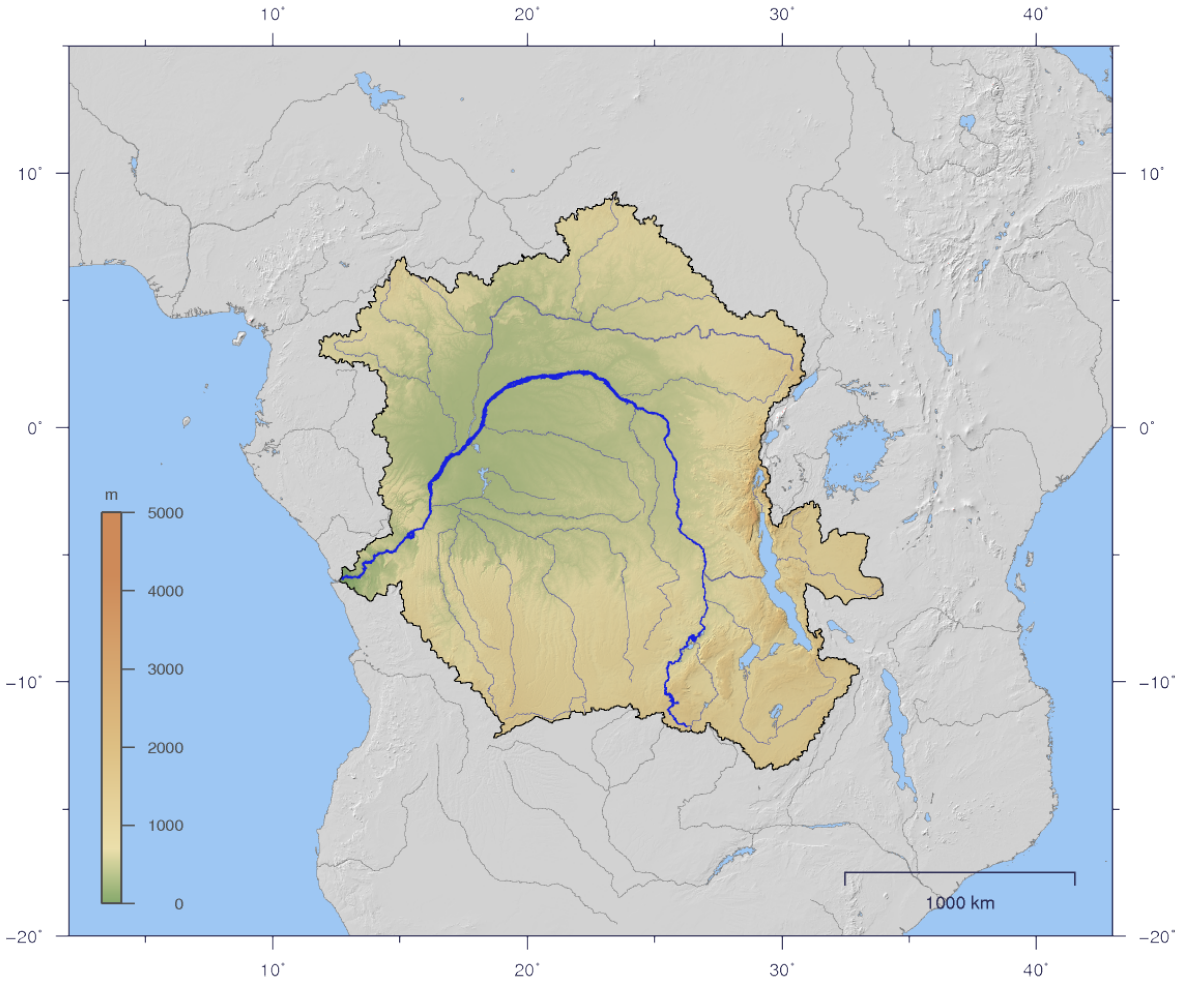
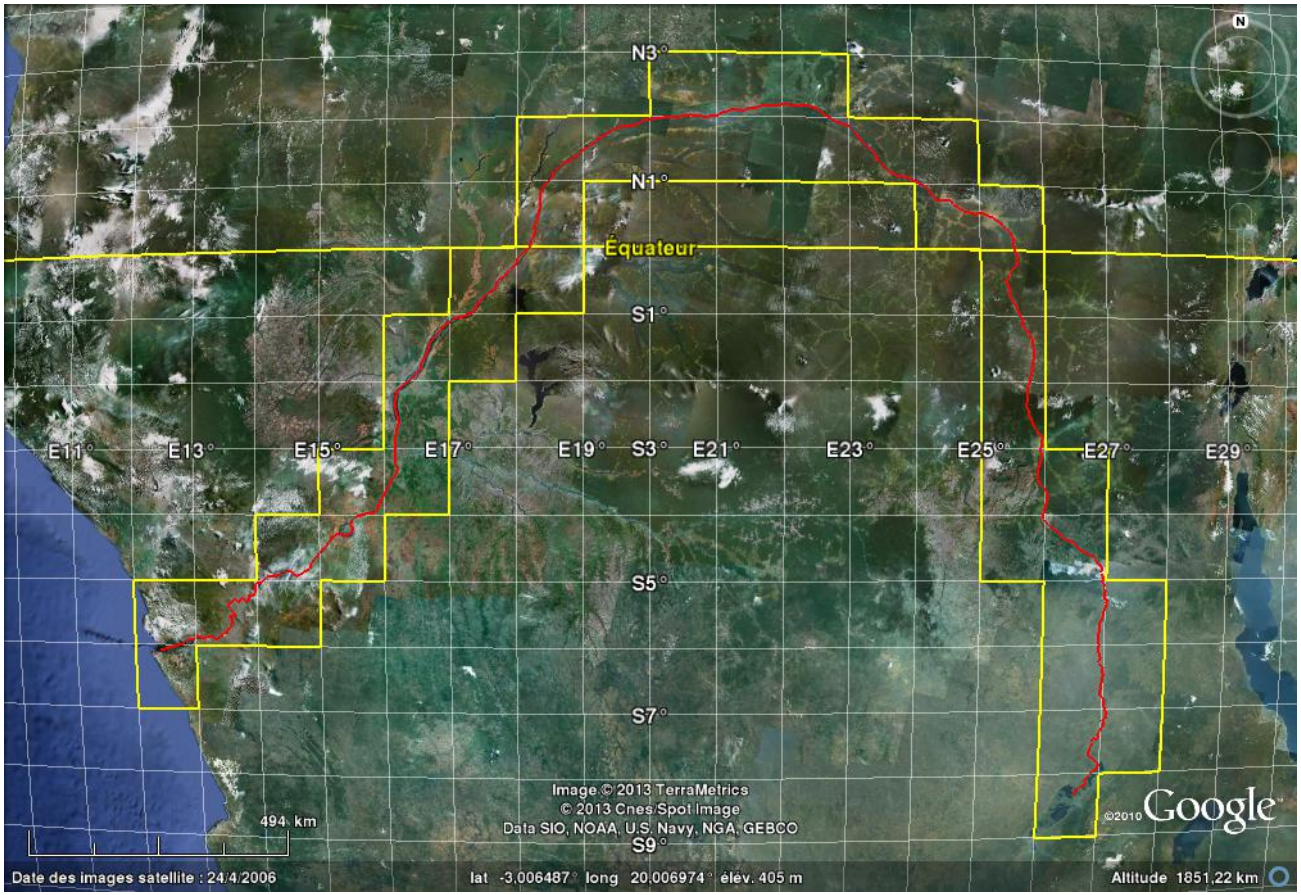


Congo river (SARin)



Source Wikipedia.org

Congo river (SARin)



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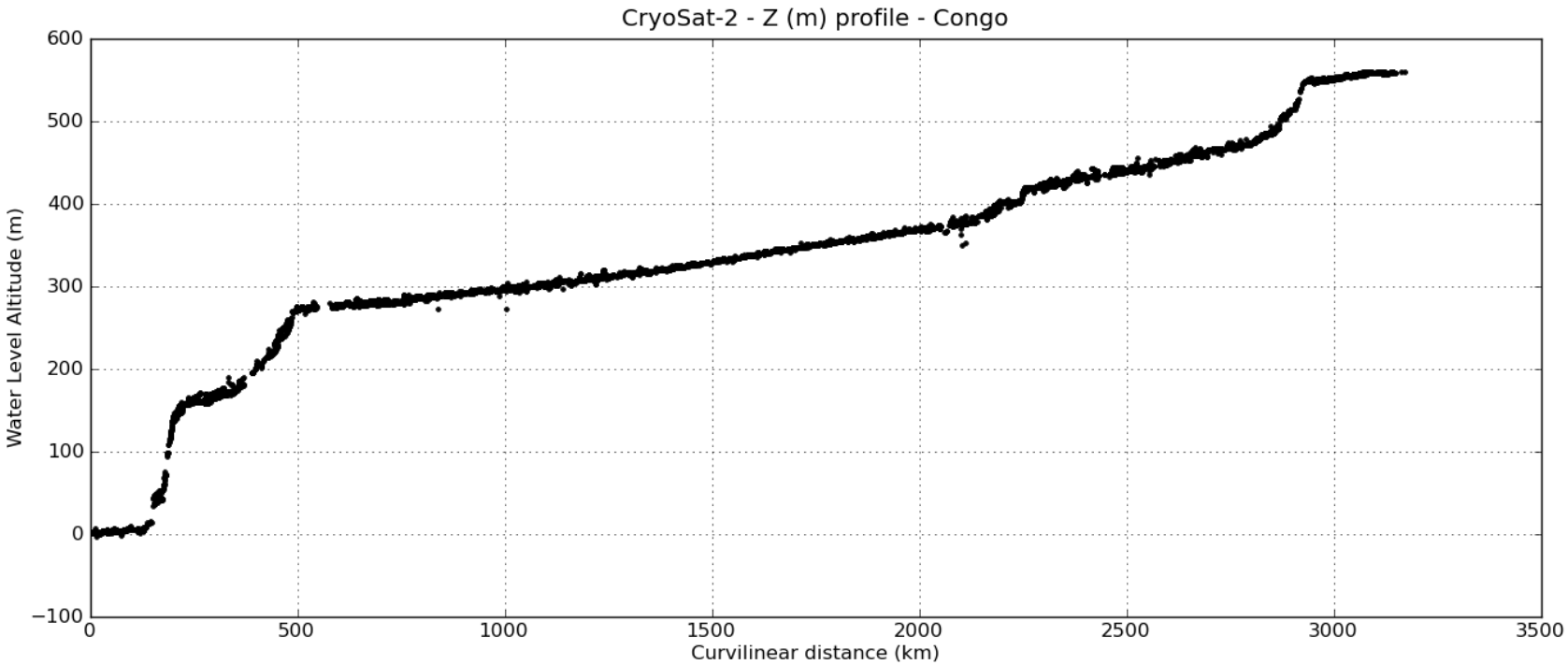

– Thank you ! –