



Satellite Altimetry over rivers : from the data processing to thematic applications, with focus on the Amazon River

Stéphane CALMANT
LEGOS / IRD

Why is river altimetry so different from ocean altimetry ?

Why is it so difficult to validate the series globally ?

What is the width limit ?

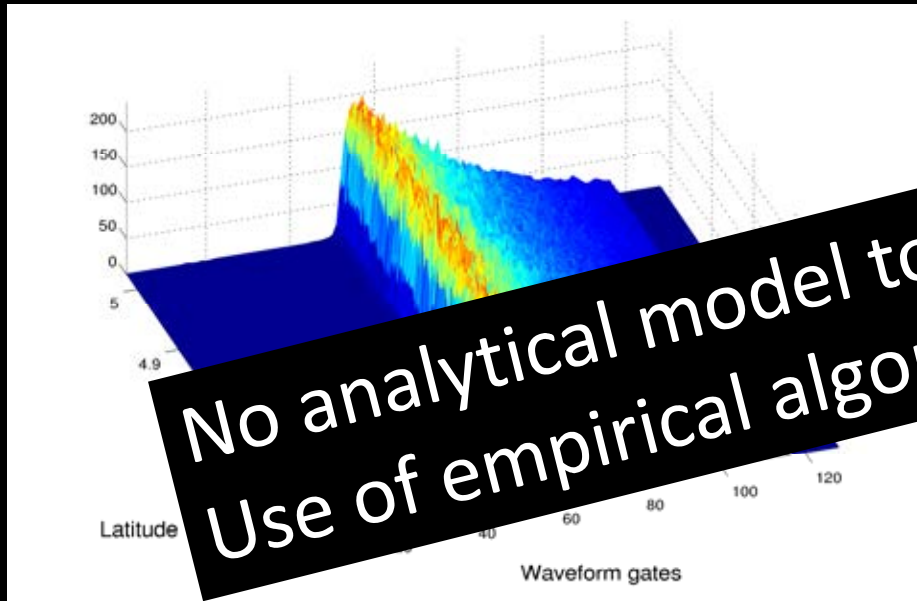
Even so.... Yes we can

Some examples of series and applications

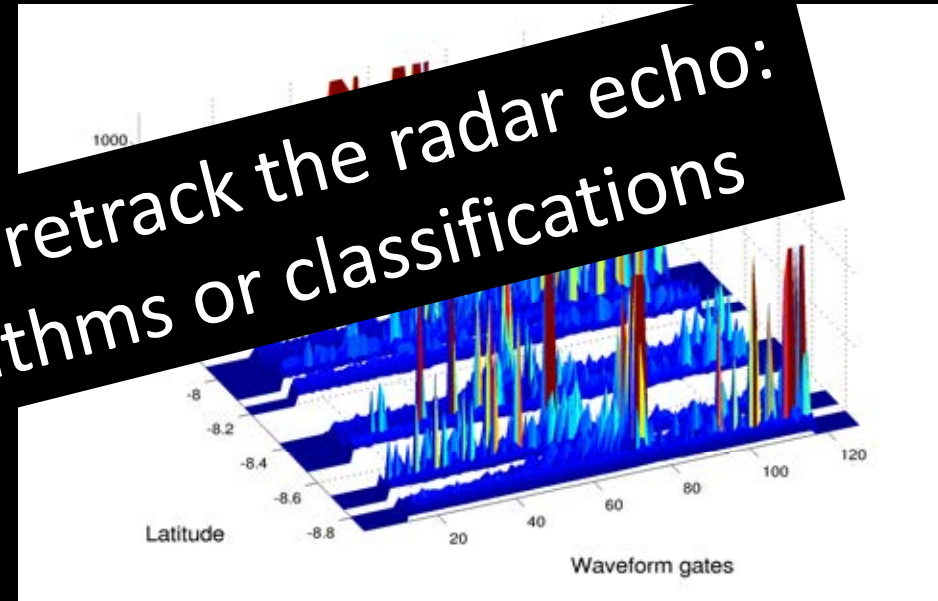
Past and Future

1- The waveforms are not homogenous

AltiKa waveforms

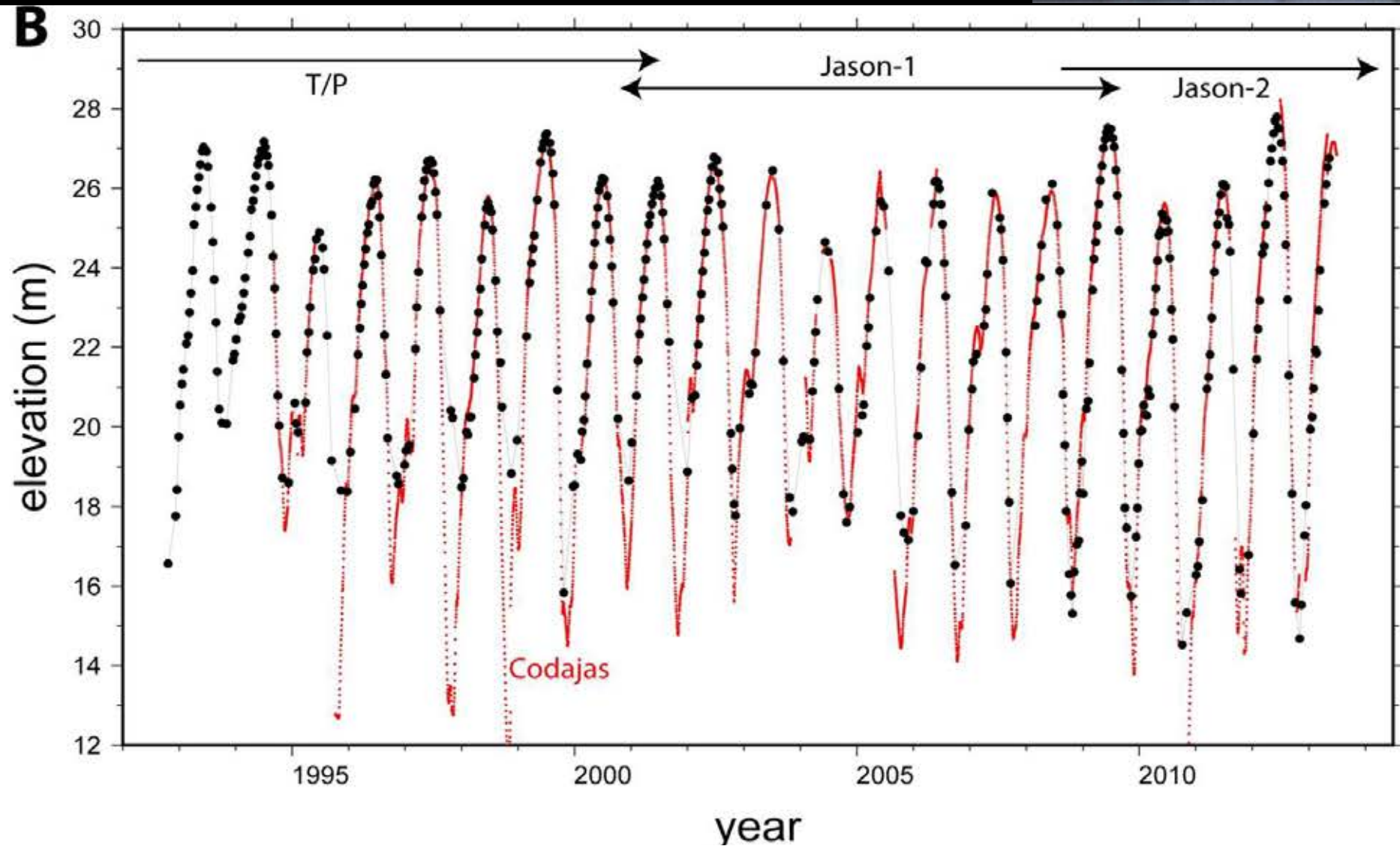


OCEAN



CONTINENT

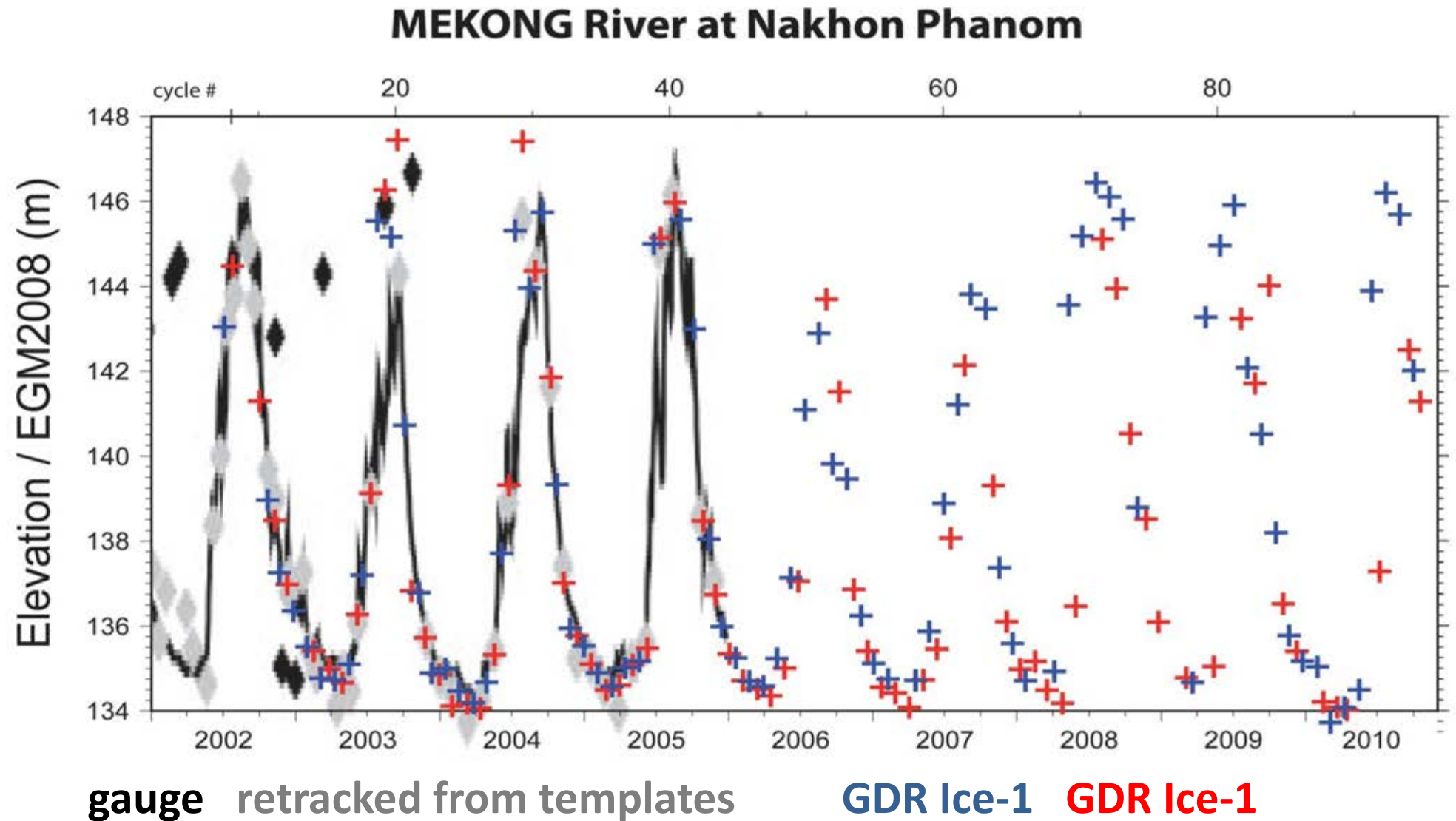
2- not a unique way to process the echoes



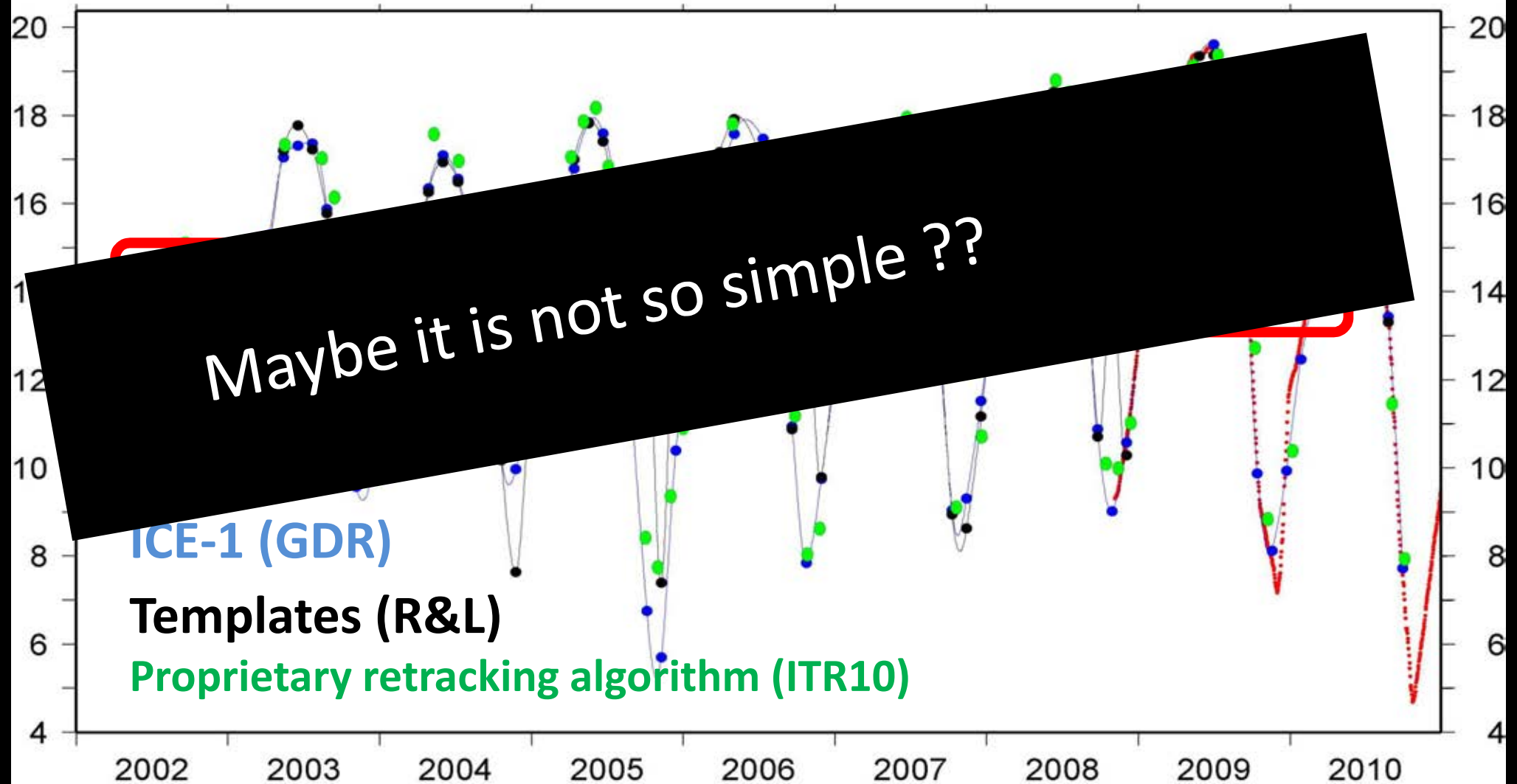
Proprietary retracking ITR10

gauge

2- not a unique way to process the echoes

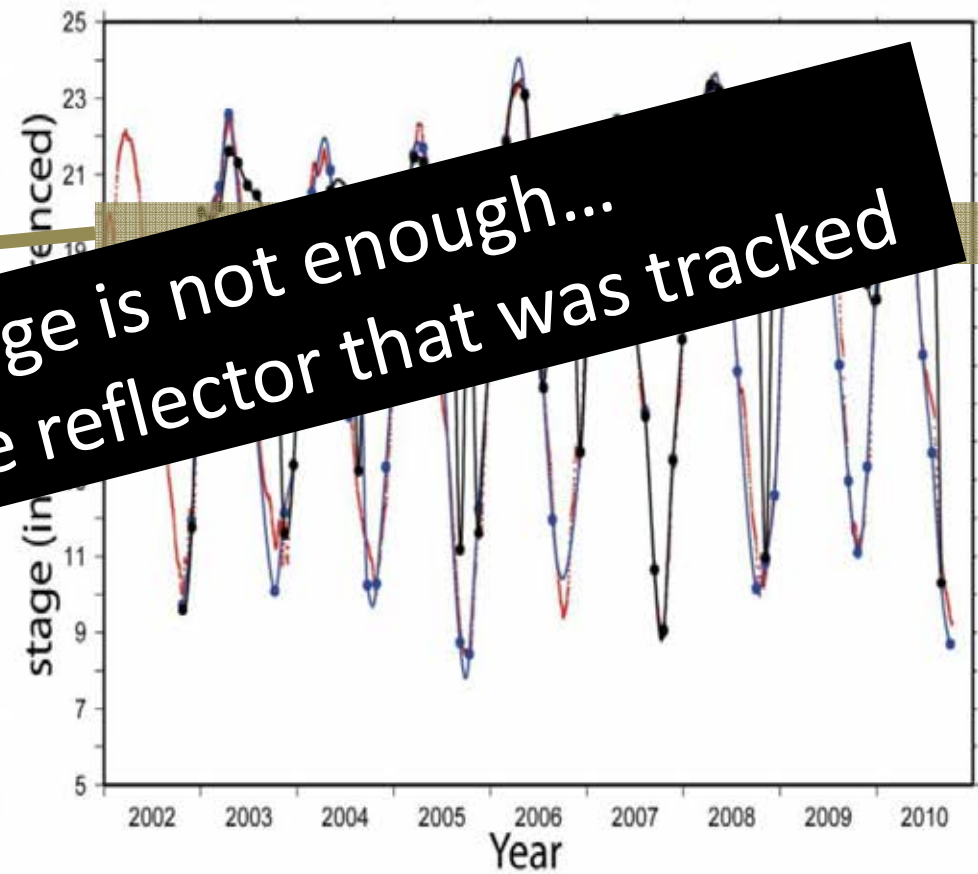


2- not a unique way to process the echoes



3- Identification of river echoes is not straightforward

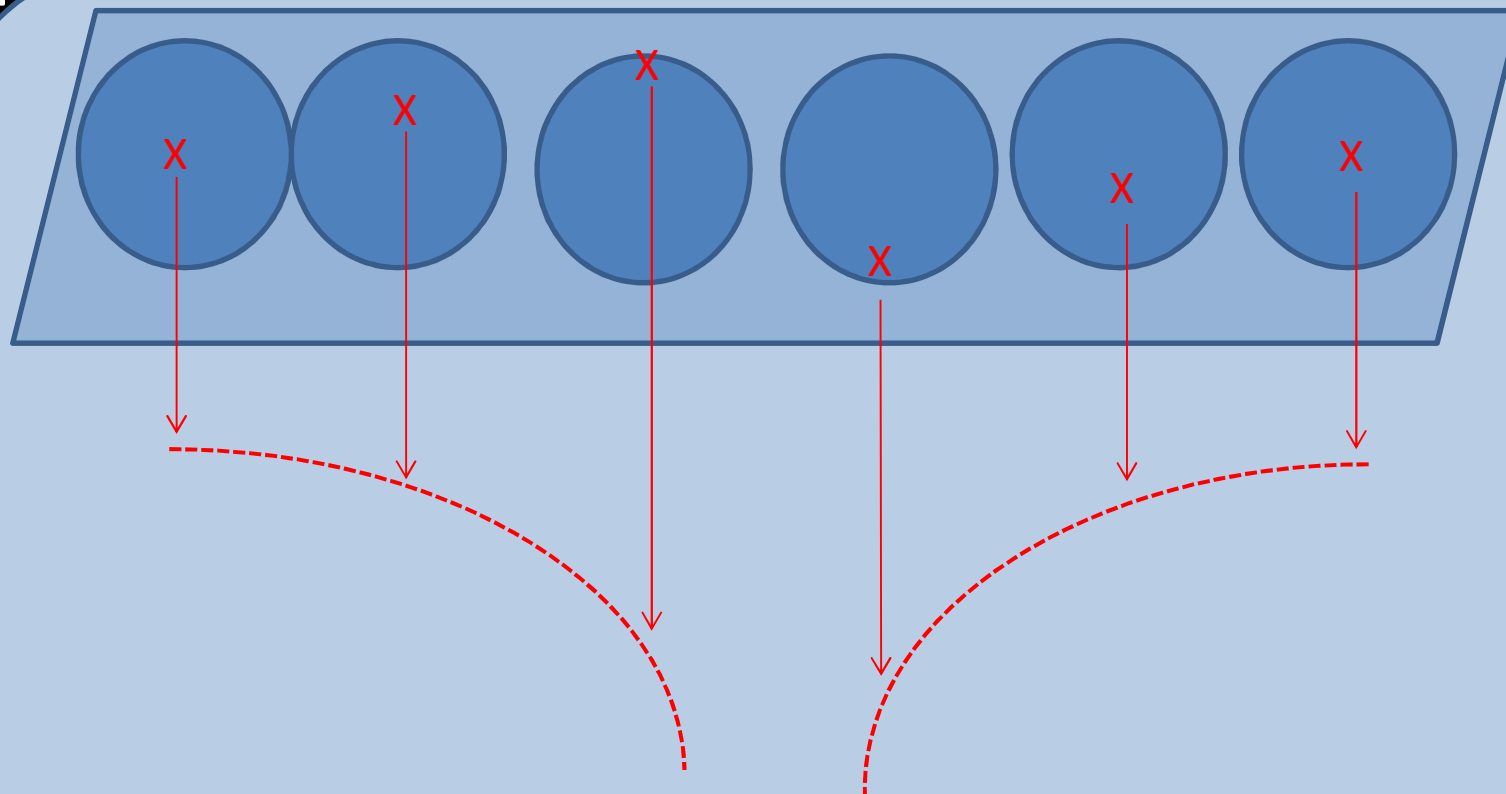
Envisat



A good estimate of the range is not enough...
One must also identify the reflector that was tracked

4- Are

Cro
rev

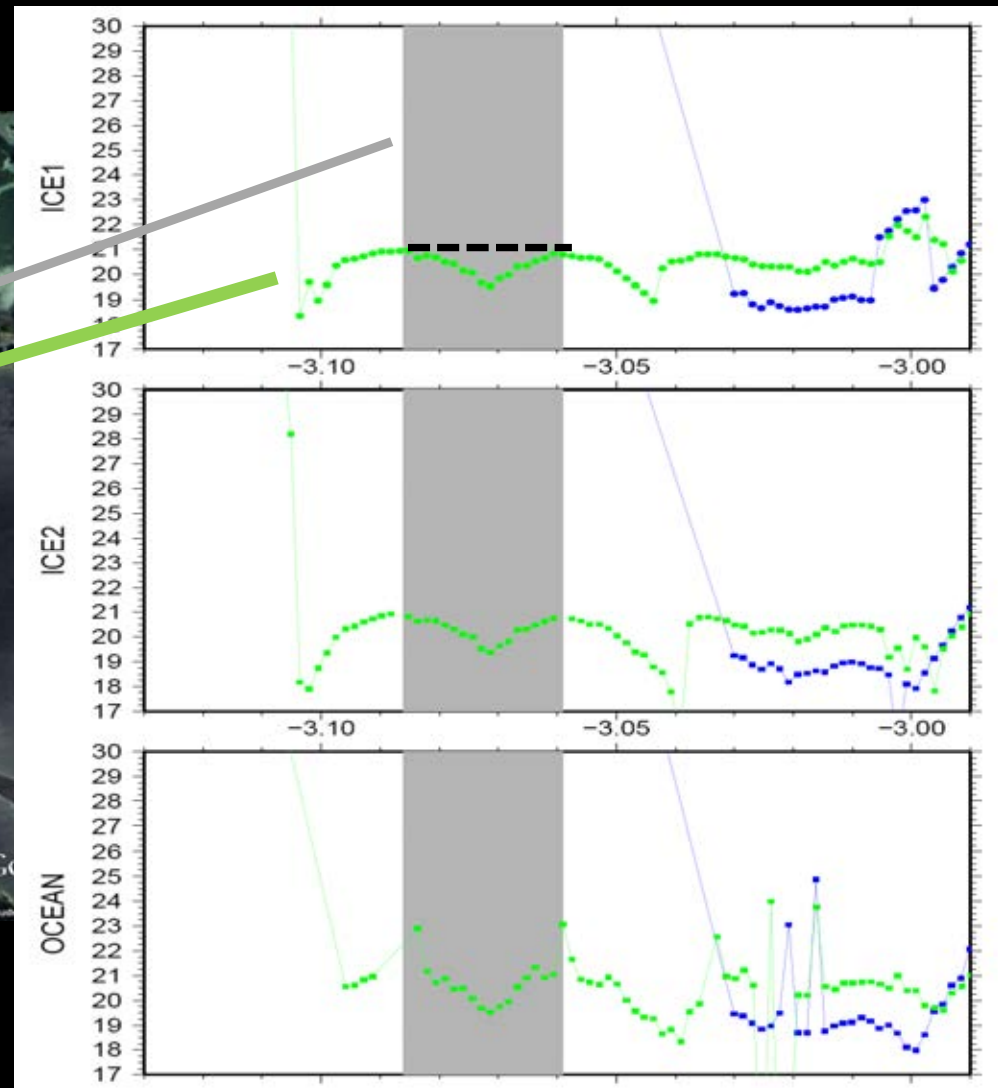
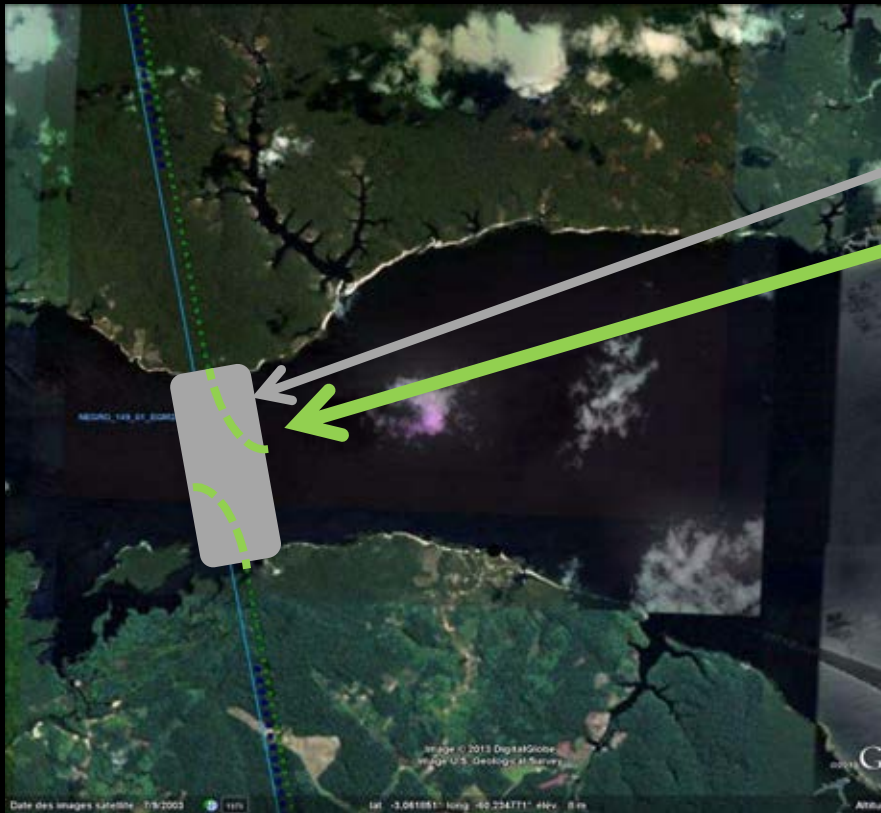


Cross-track deviations -> Pair of parabolas in the ranges

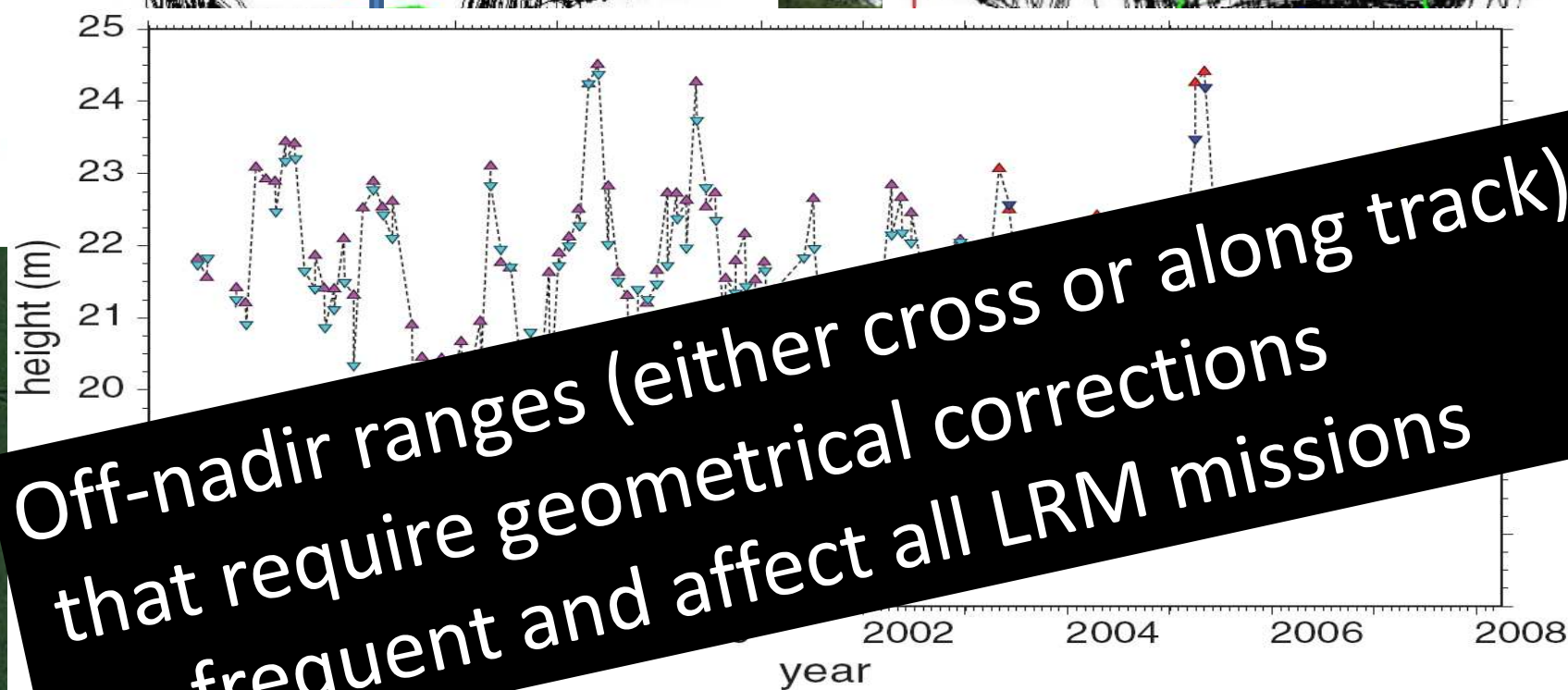
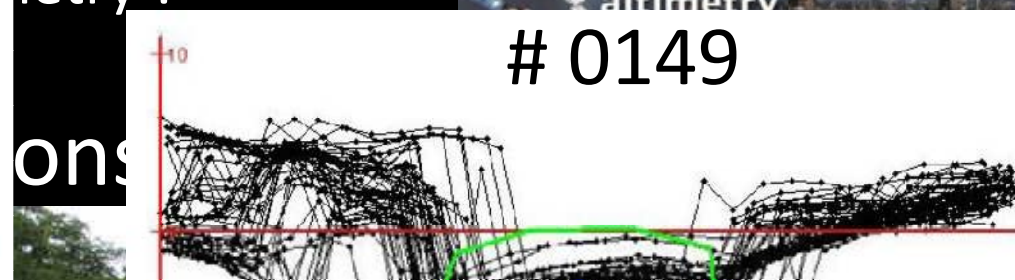
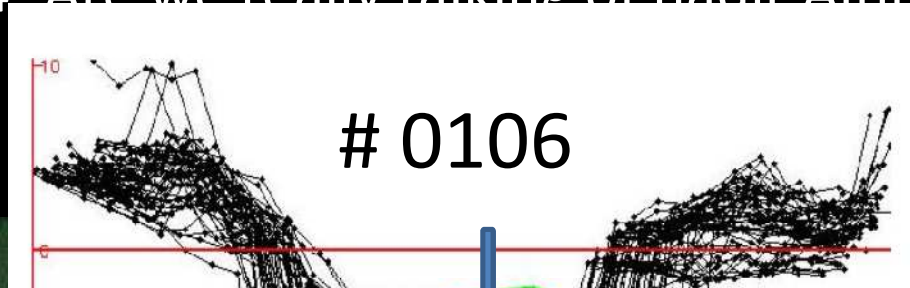


4- Are we really talking of nadir Altimetry ?

Cross-track deviations in the AltiKa measurements ?



4- Are we really talking of nadir Altimetry ?



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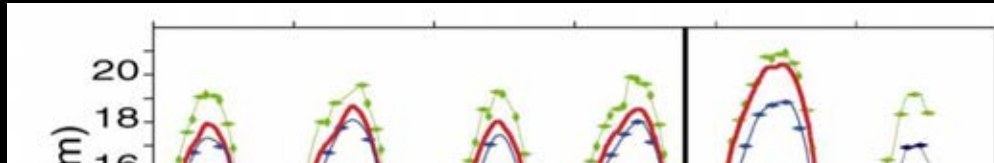
Past and Future

1- are there gauges available ??

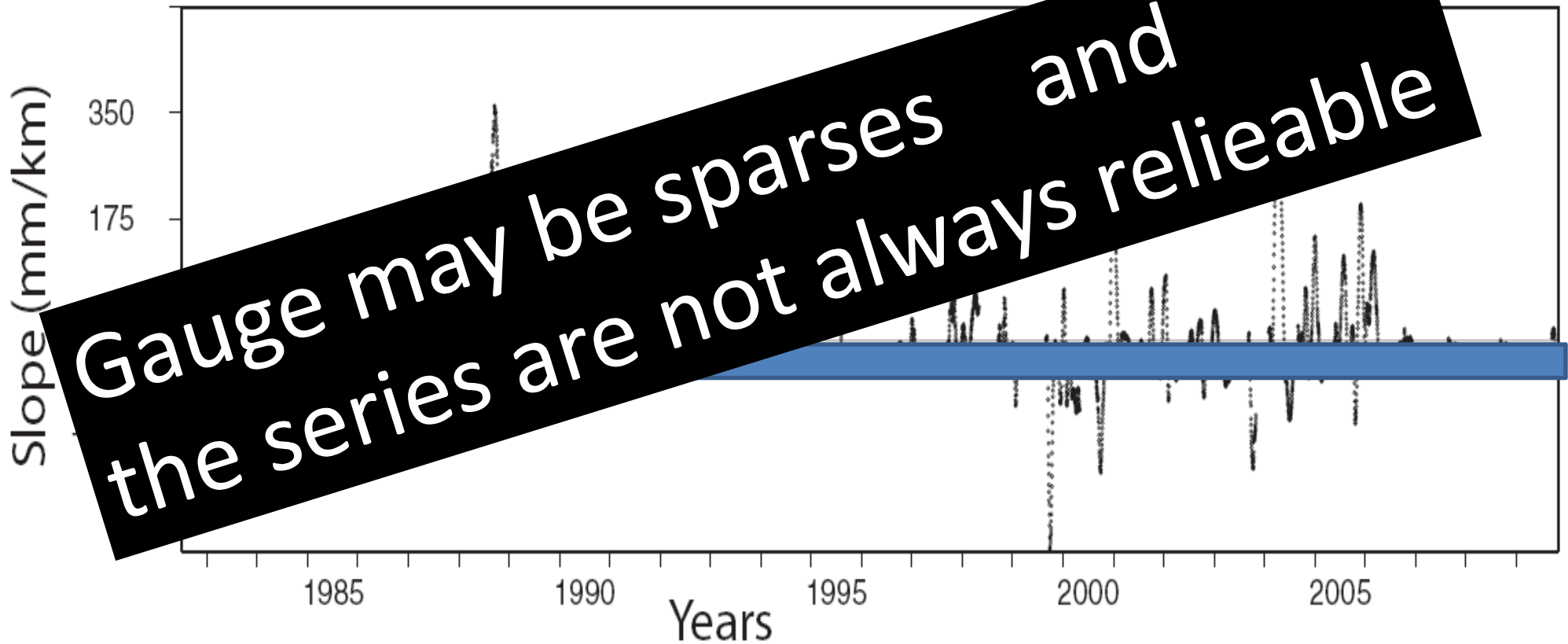
AFTER 2000



2- Are the gauges reliable enough ??



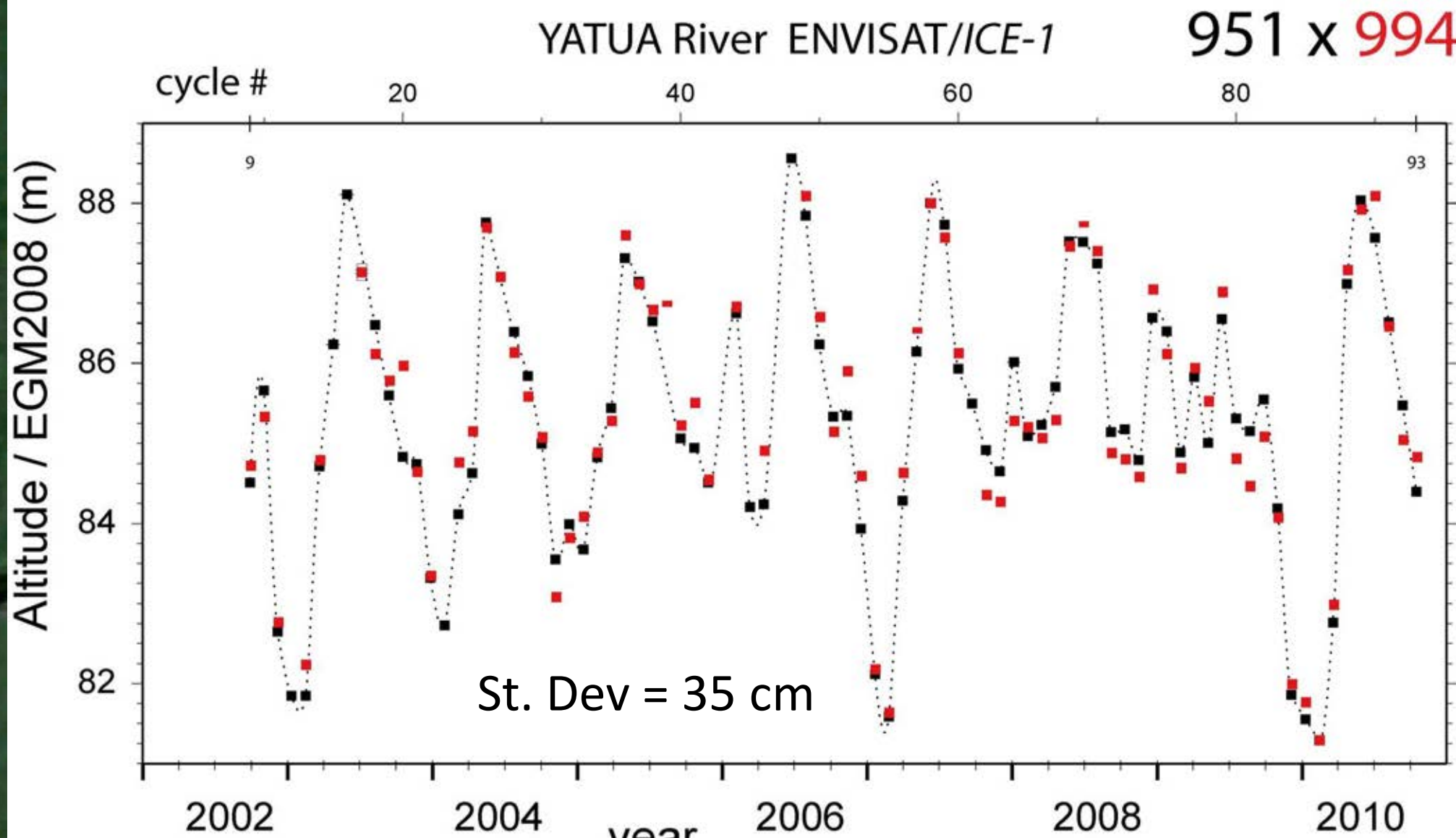
Before



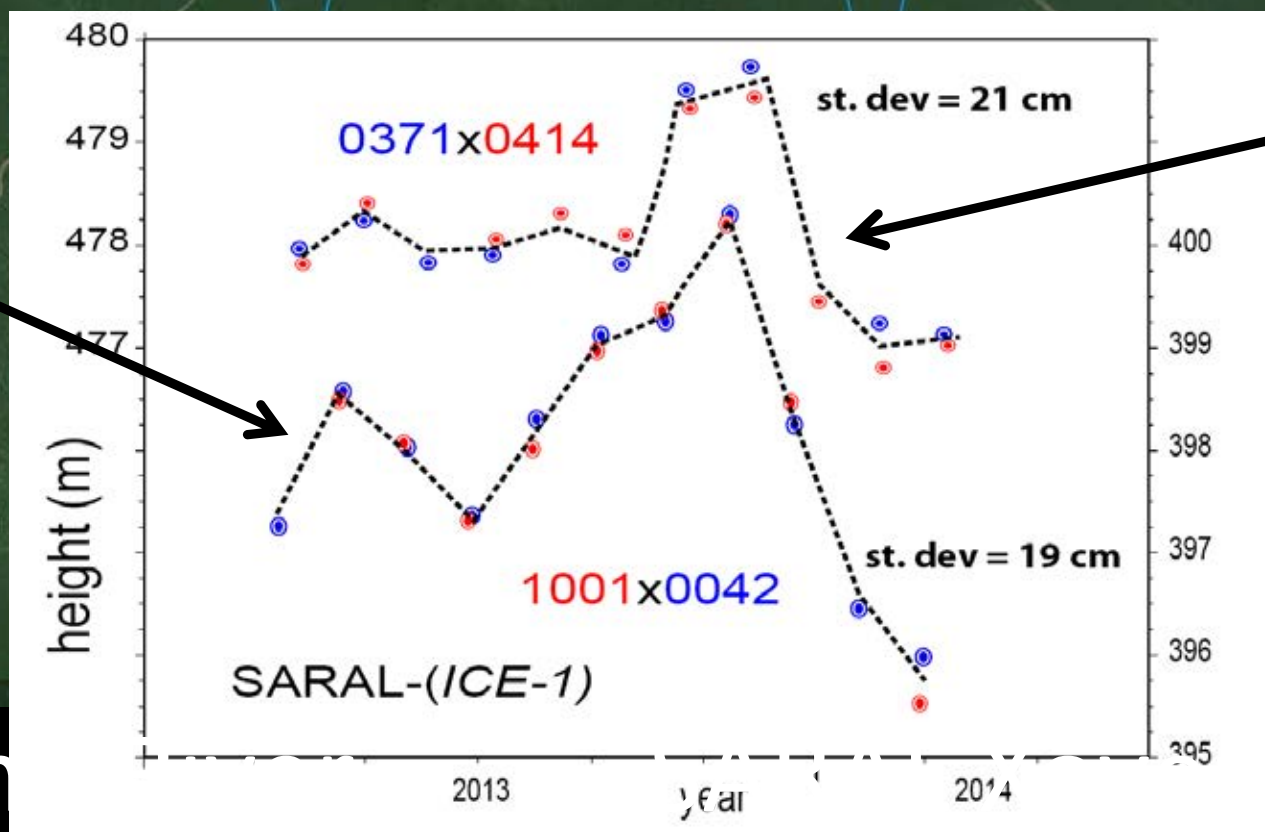
2005 2006 2007 2008 2009 2010
Year



2nd option : Internal calibration at cross-overs



2nd option : Internal calibration at cross-overs



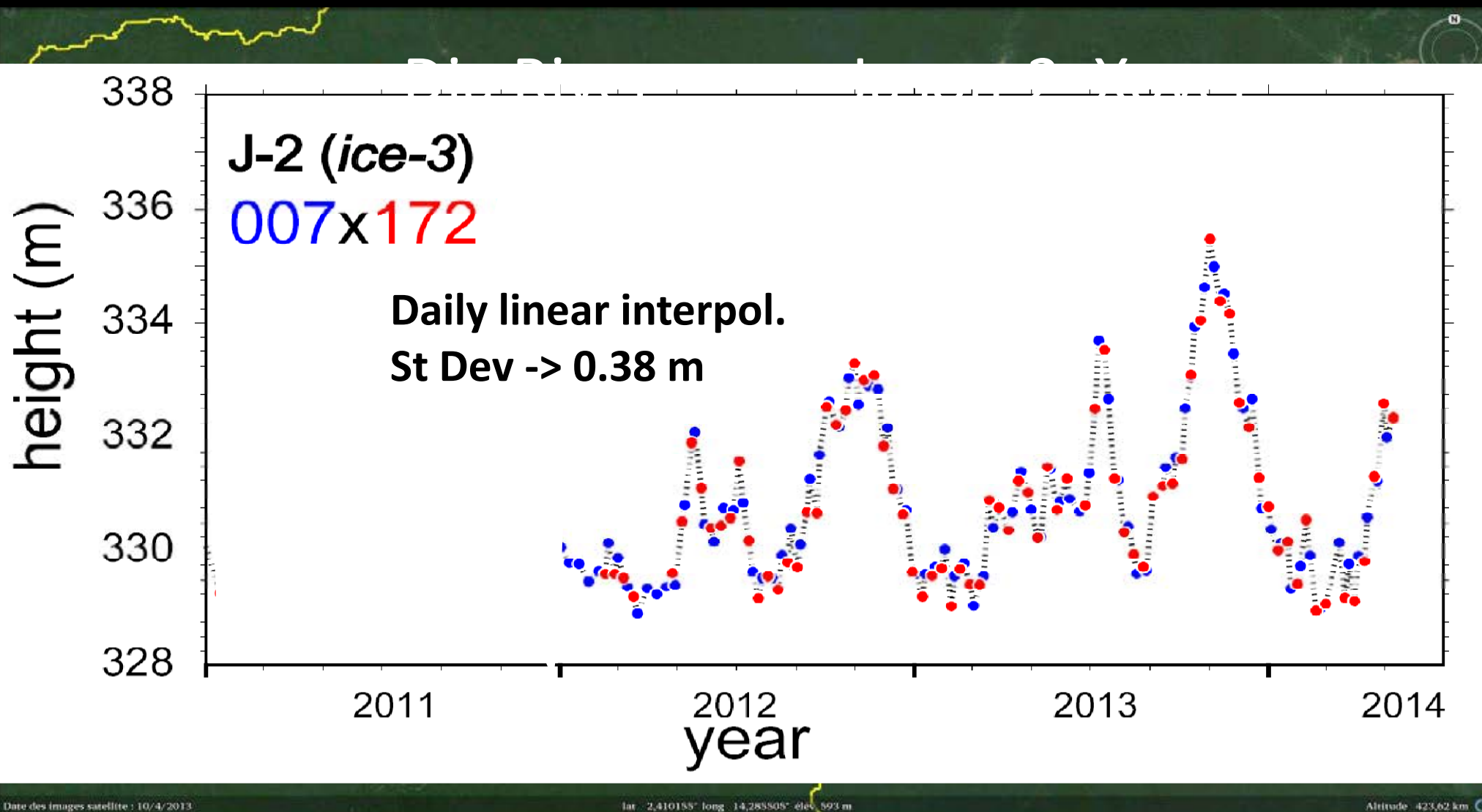
Date des images satellite : 10/4/2013

Aruwin

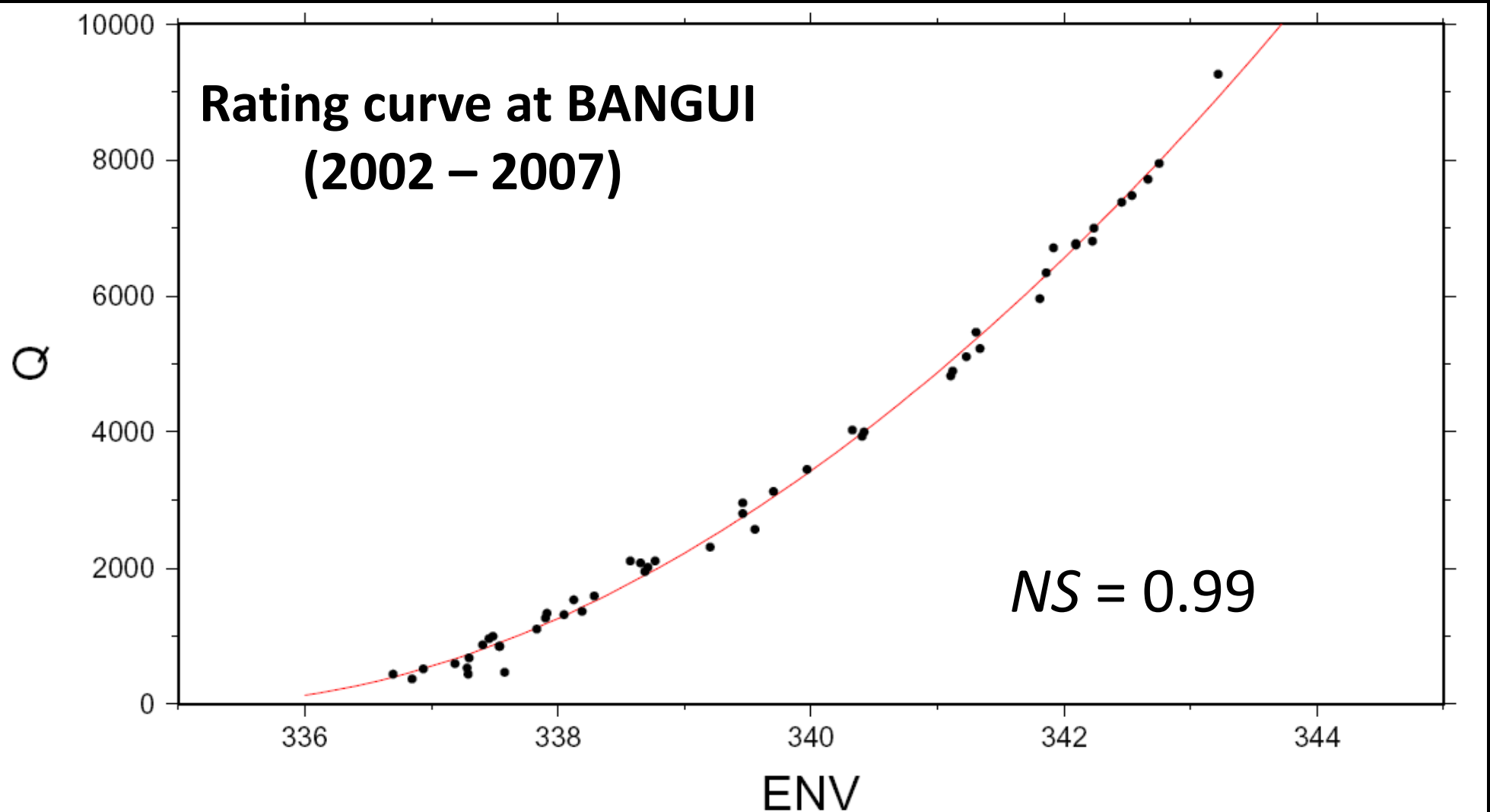
©2010 Google

Altitude 251,10 km

2nd option : Internal calibration at cross-overs



3rd option : compare to Independant data



Why is river altimetry so different from ocean altimetry ?

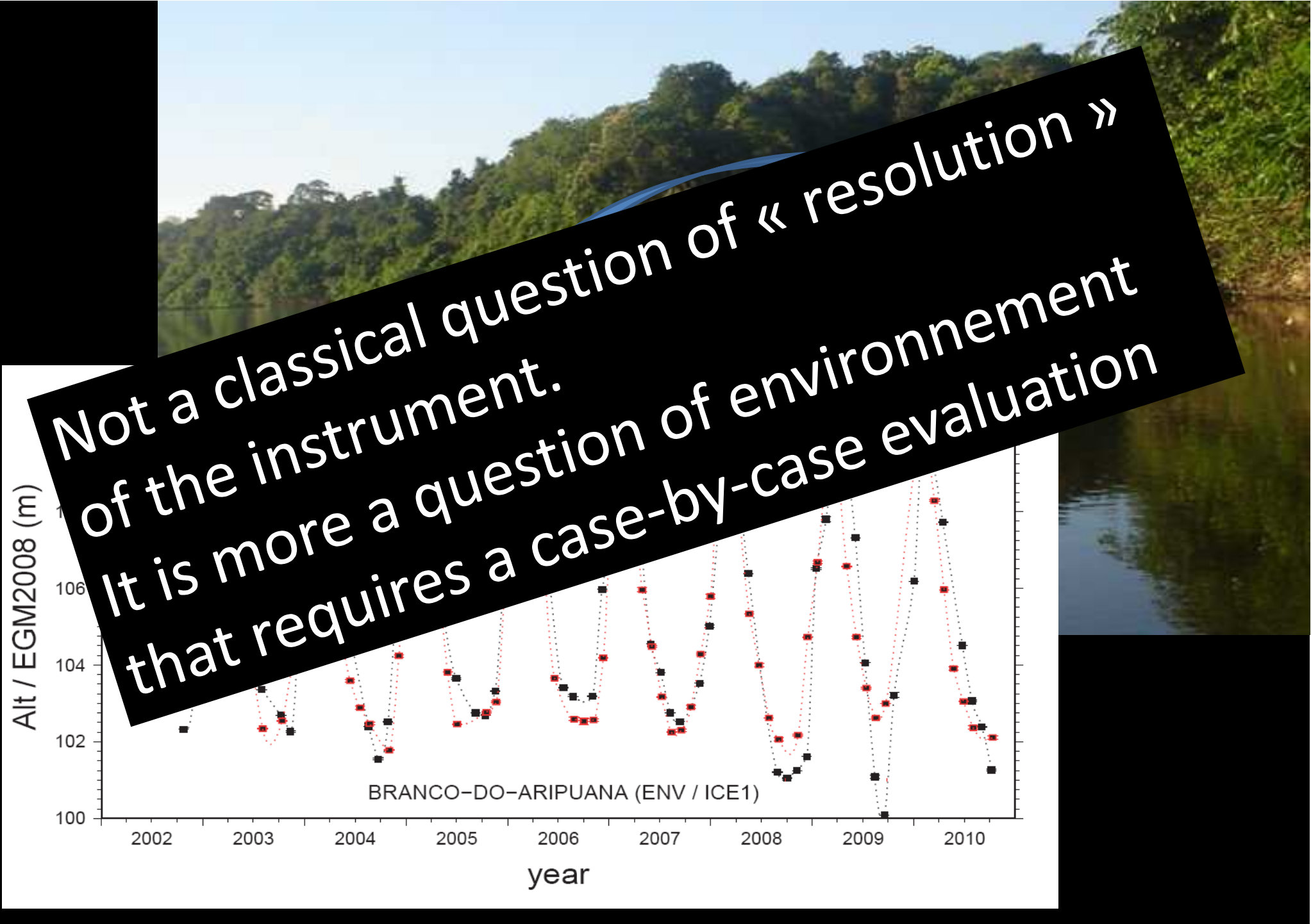
Why is it so difficult to validate the series globally ?

What is the width limit ?

Even so.... Yes we can

Some examples of series and applications

Past and Future



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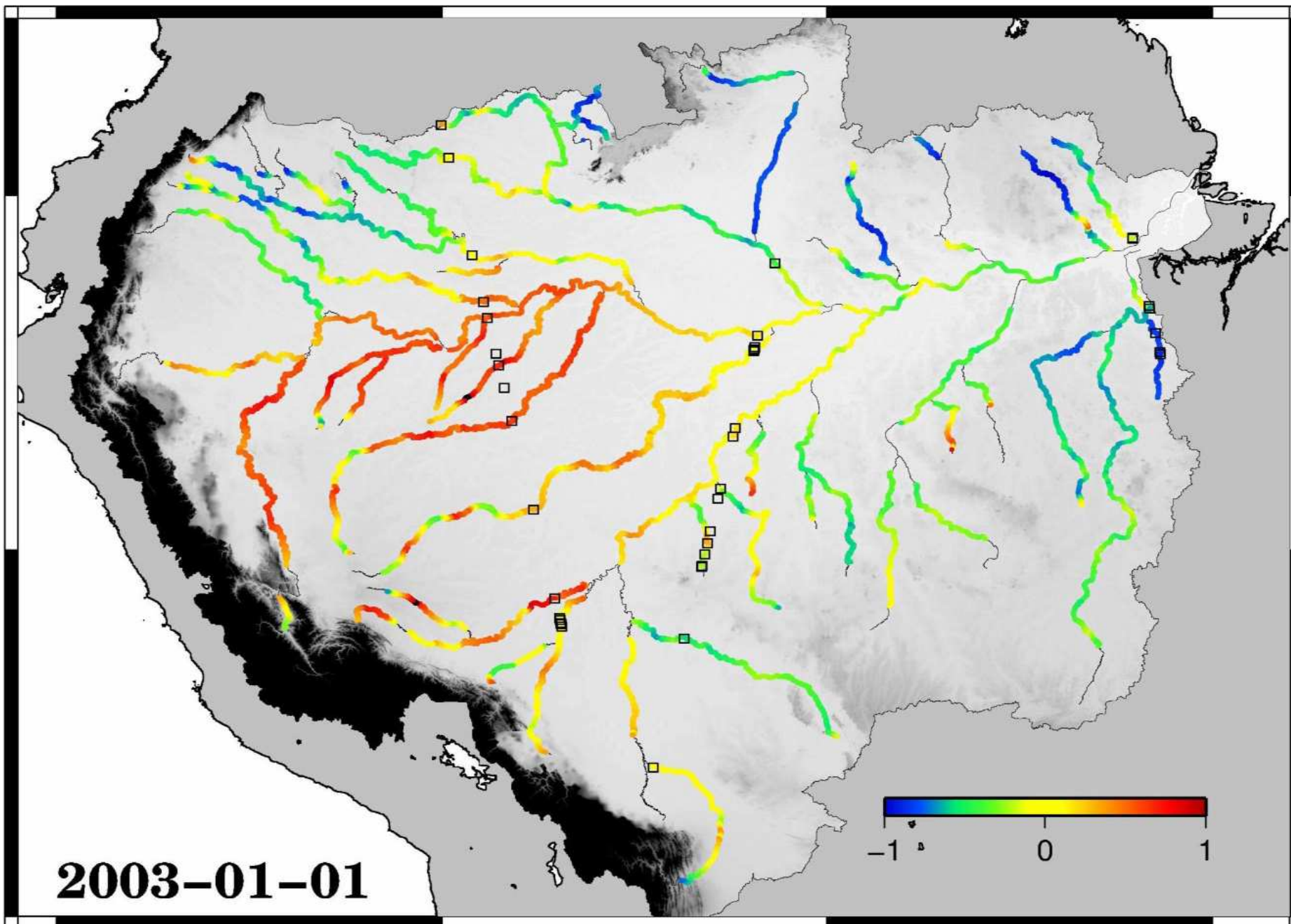
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Even so.... *Yes we can*

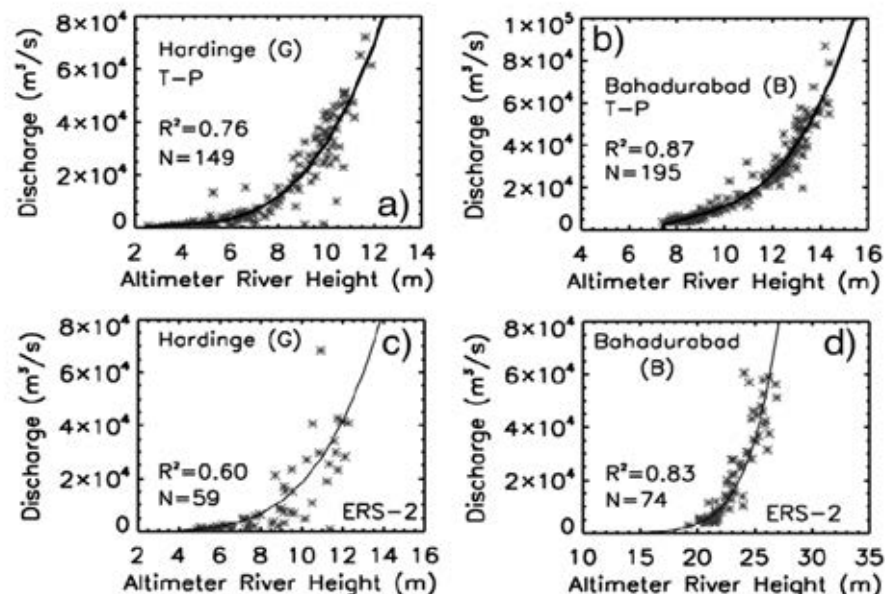
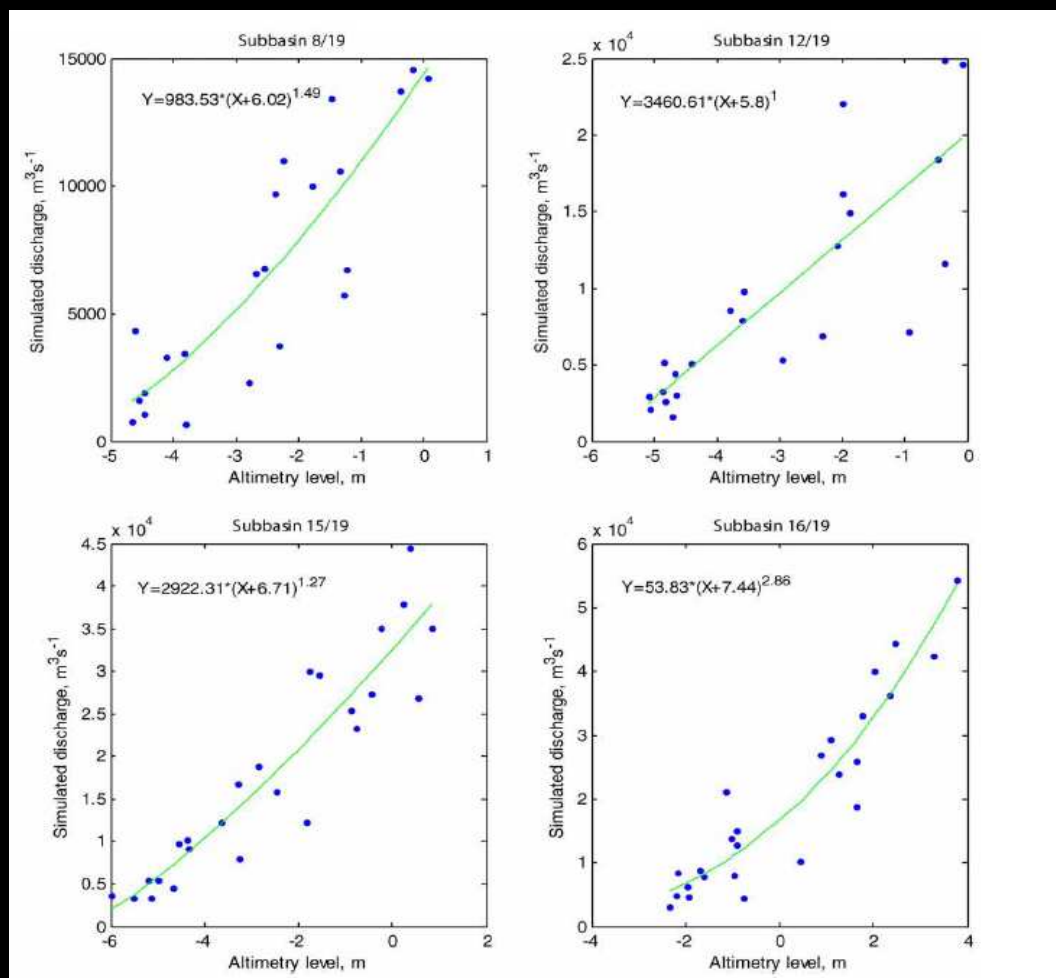
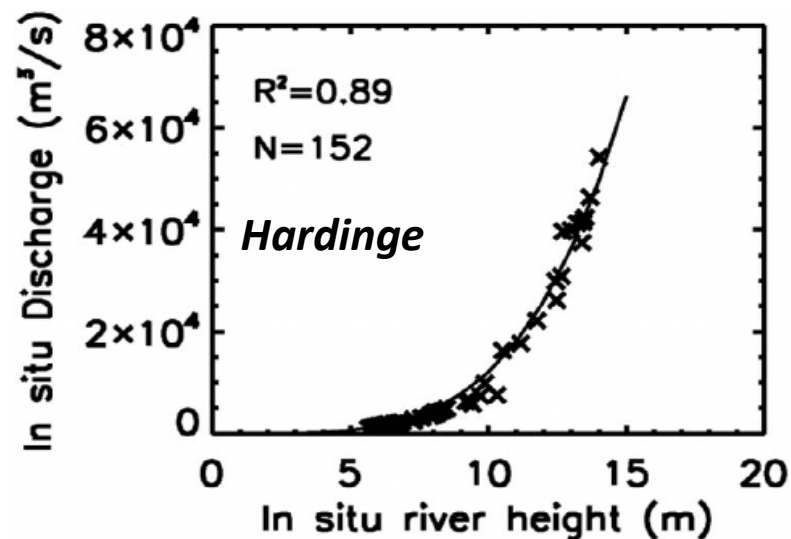
Some examples of series and applications

Past and Future

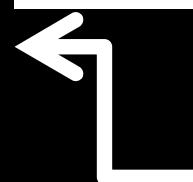


From stage to discharge

Finsen *et al.* 2013



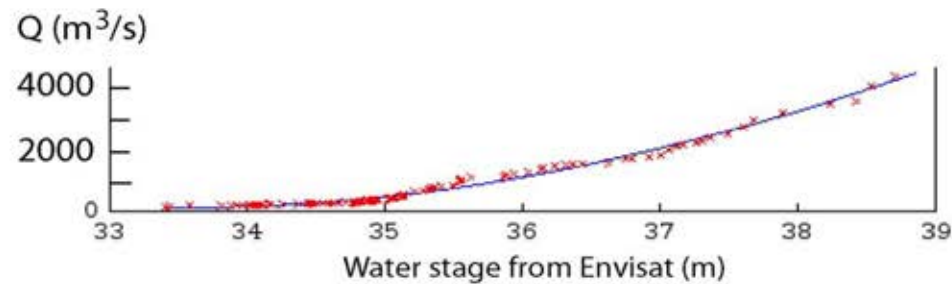
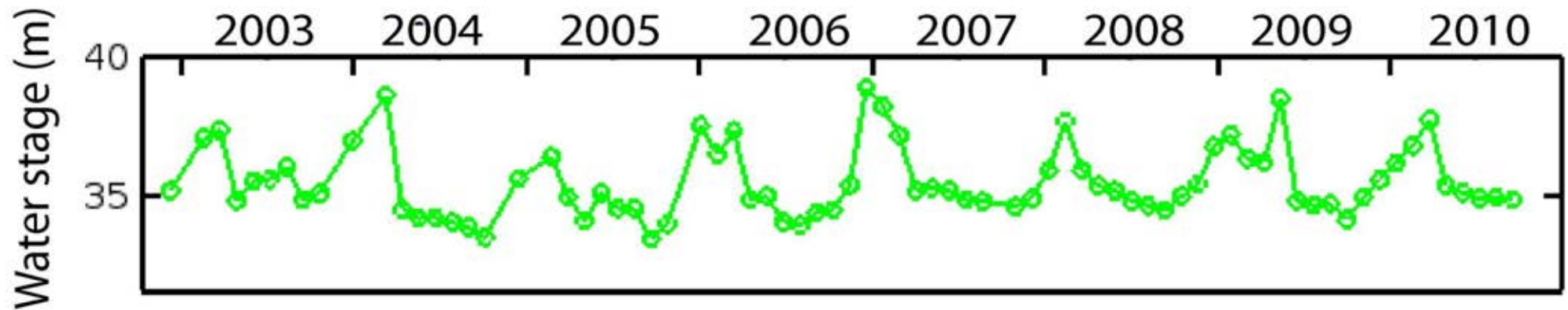
Papa *et al.* (2010)



Gange

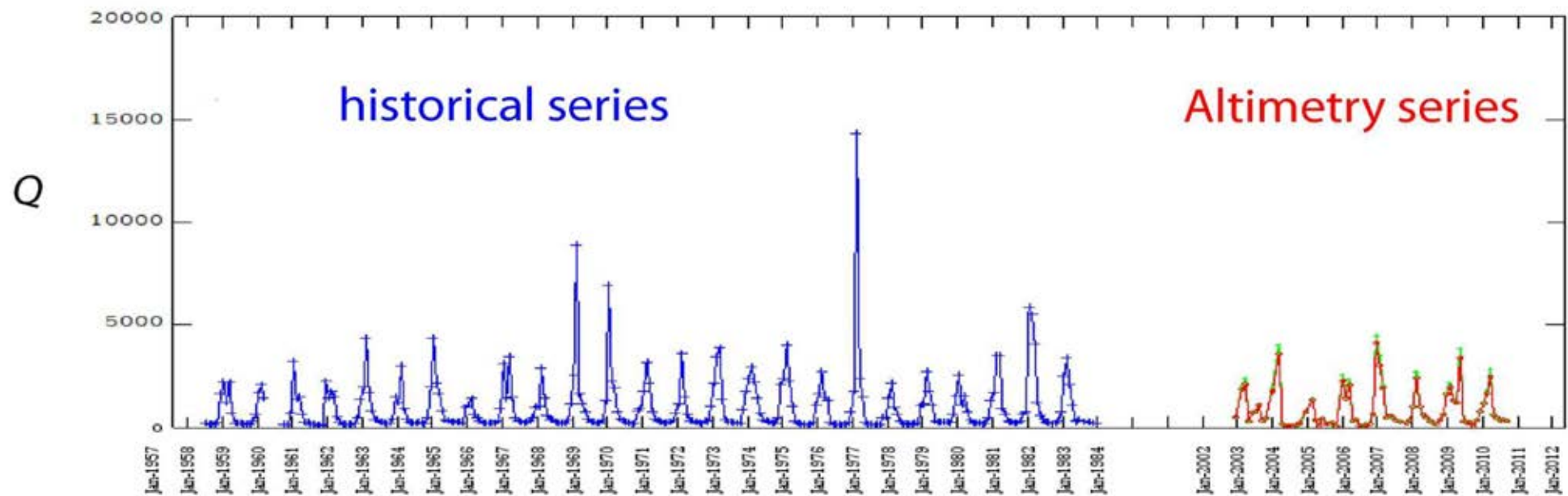


Brahmapoutra

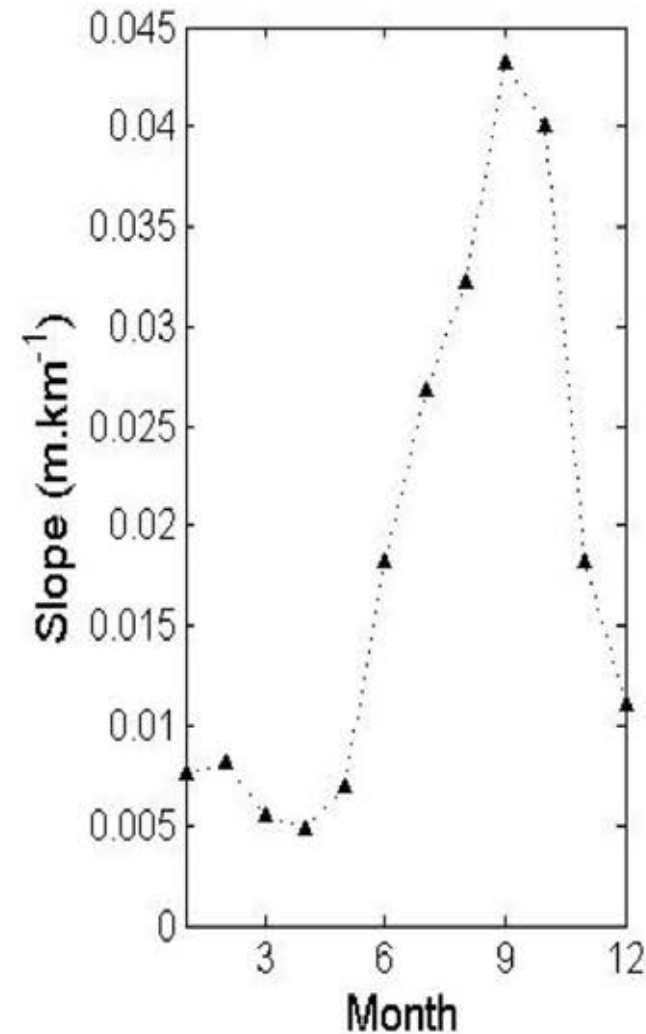
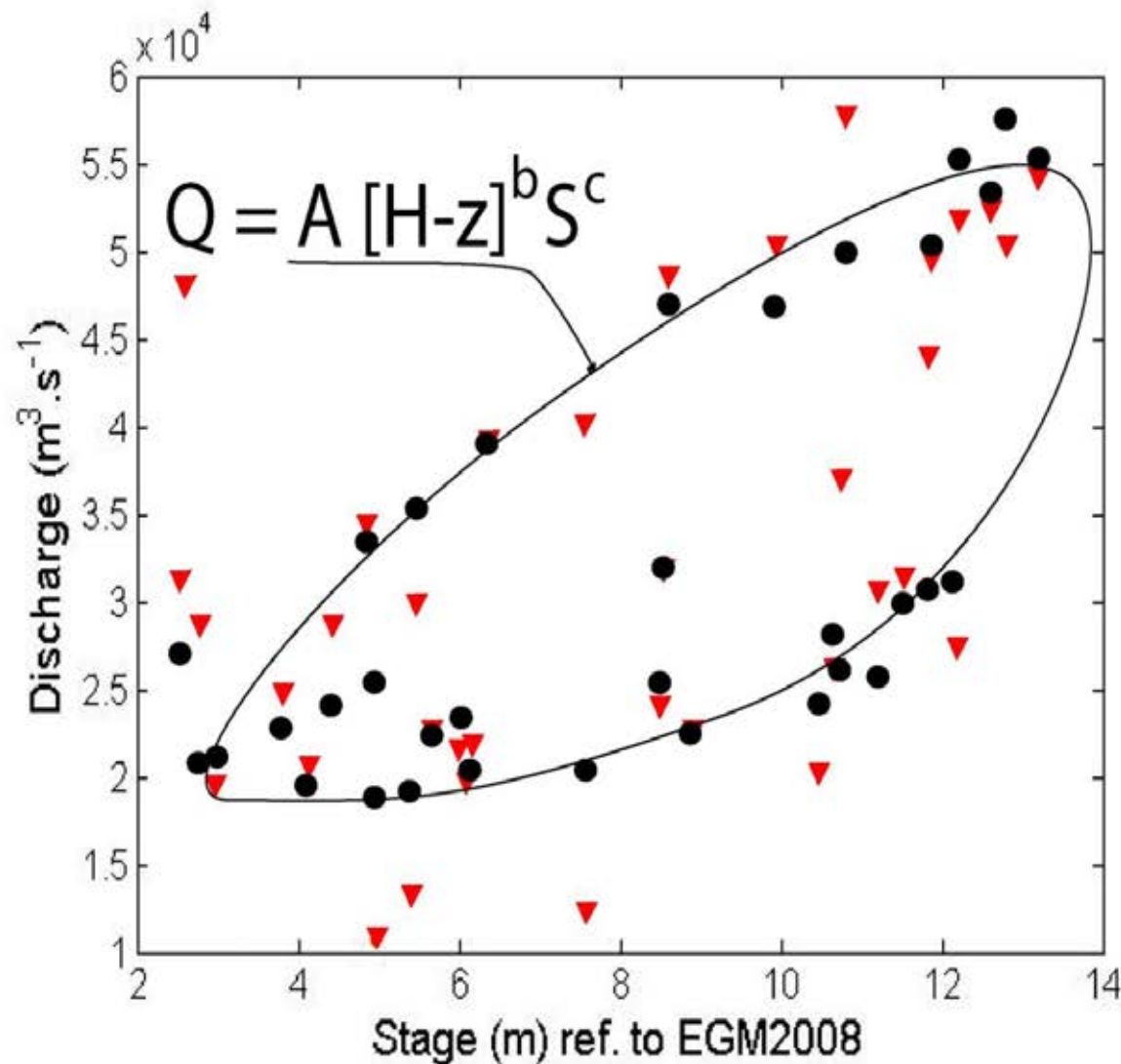


Quantile method by Tourian *et al.* (2013)

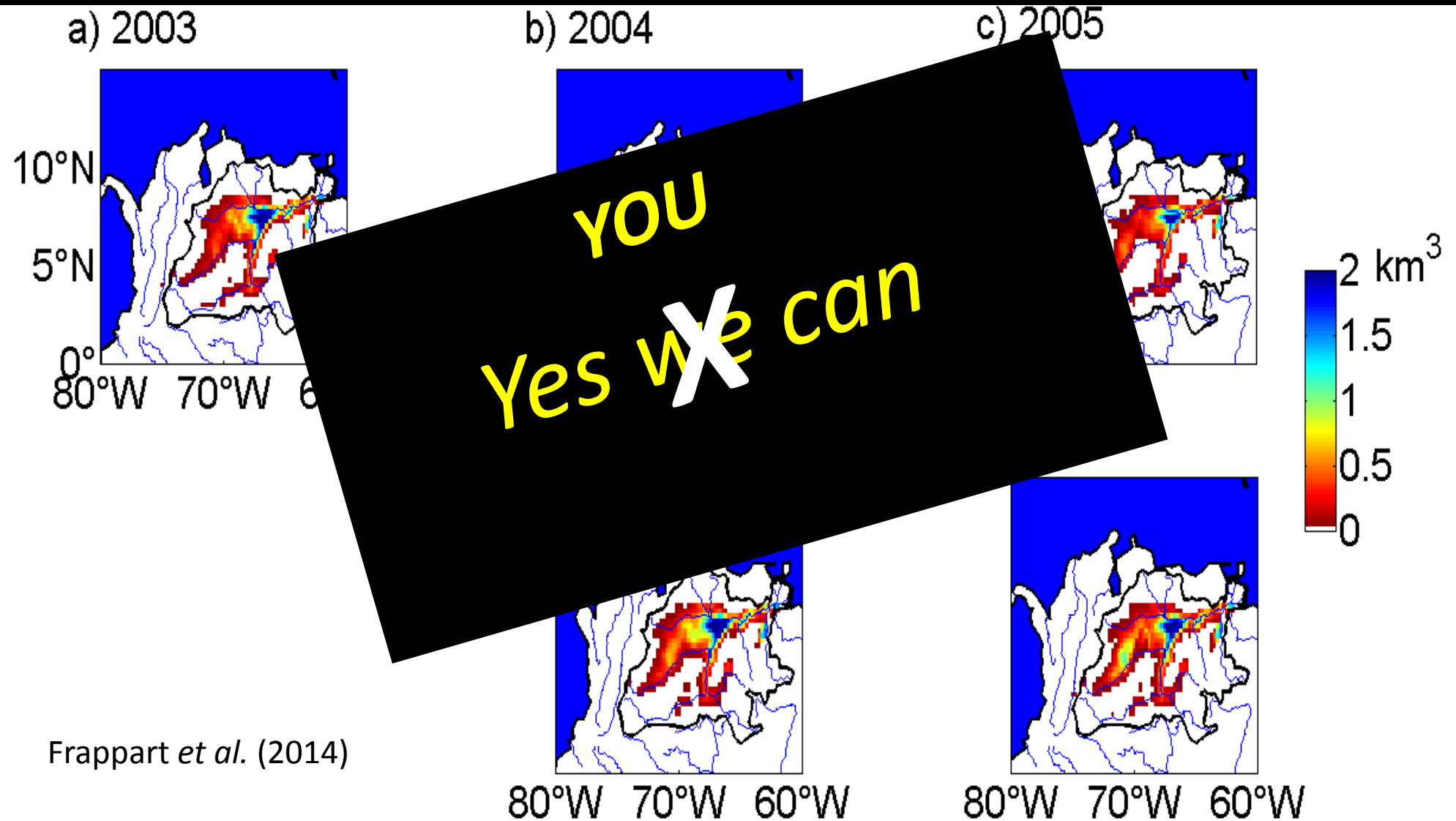
(by J. Andriambeloson)



Altimetry for backwater effects



Storage change by combination with surface estimates



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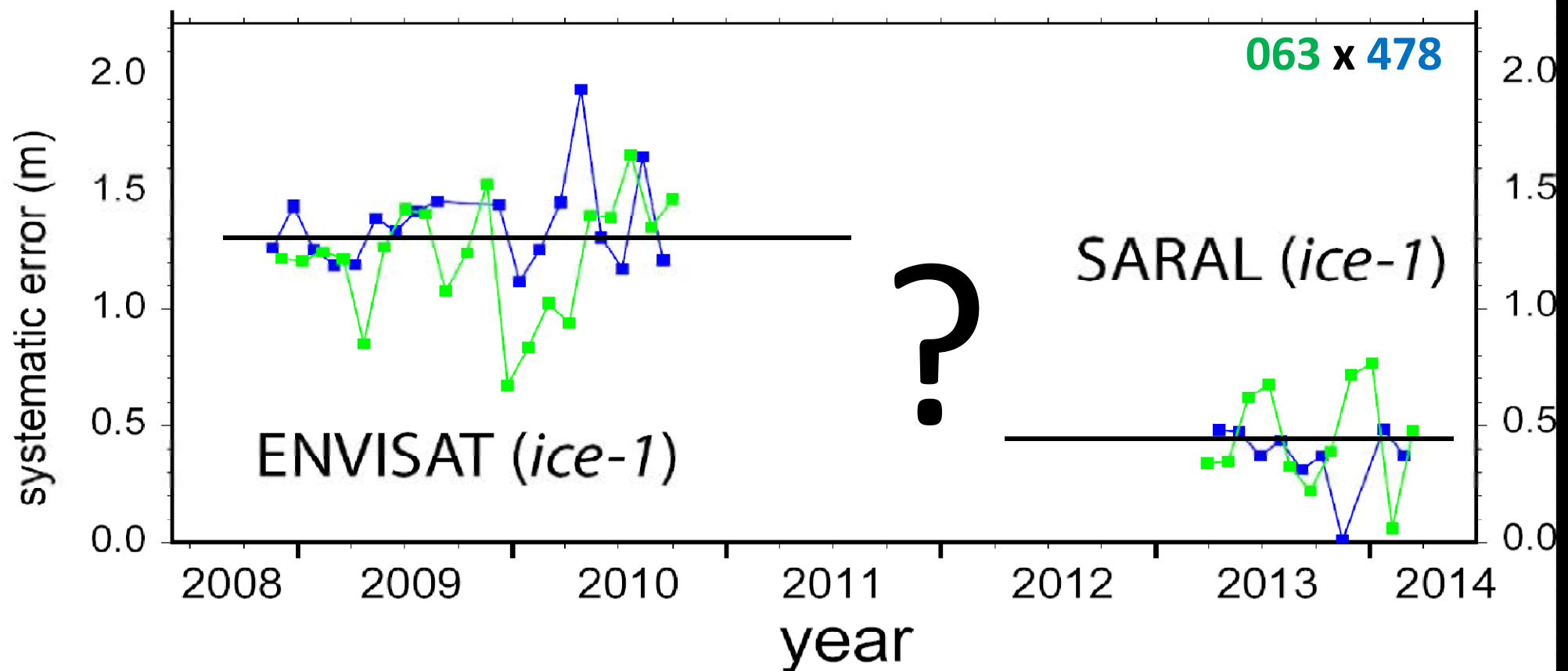
Continuity from past to future :

The key question of bias (systematic error)



ENVISAT series at IRACEMA (validation station)

DAHITI



The future



2014: Jason-2 (LRM Ku /10 days) GAP wrt T/P

AltiKa (LRM Ka /35 days) GAP wrt ENVISAT

Cryosat - 2 (LRM/SAR/SARIn K

Global coverage by SWOT ->
put all the ongoing missions
(and predecessors ?) in a
common reference frame

2015

2015

2017 : J

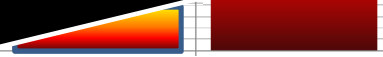
2020 : J

SW

/22 j + LRM Ku)

(²)

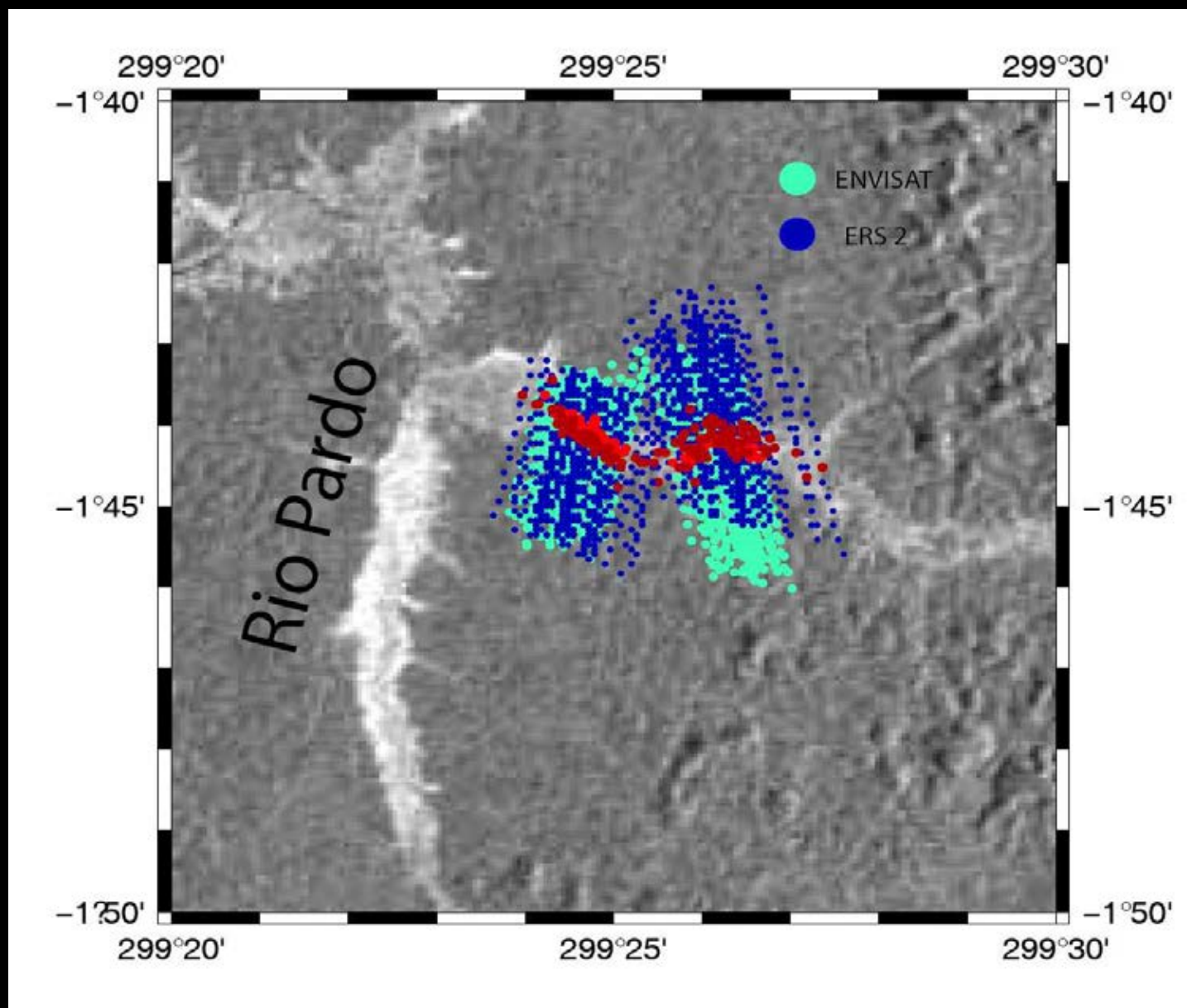
V-2



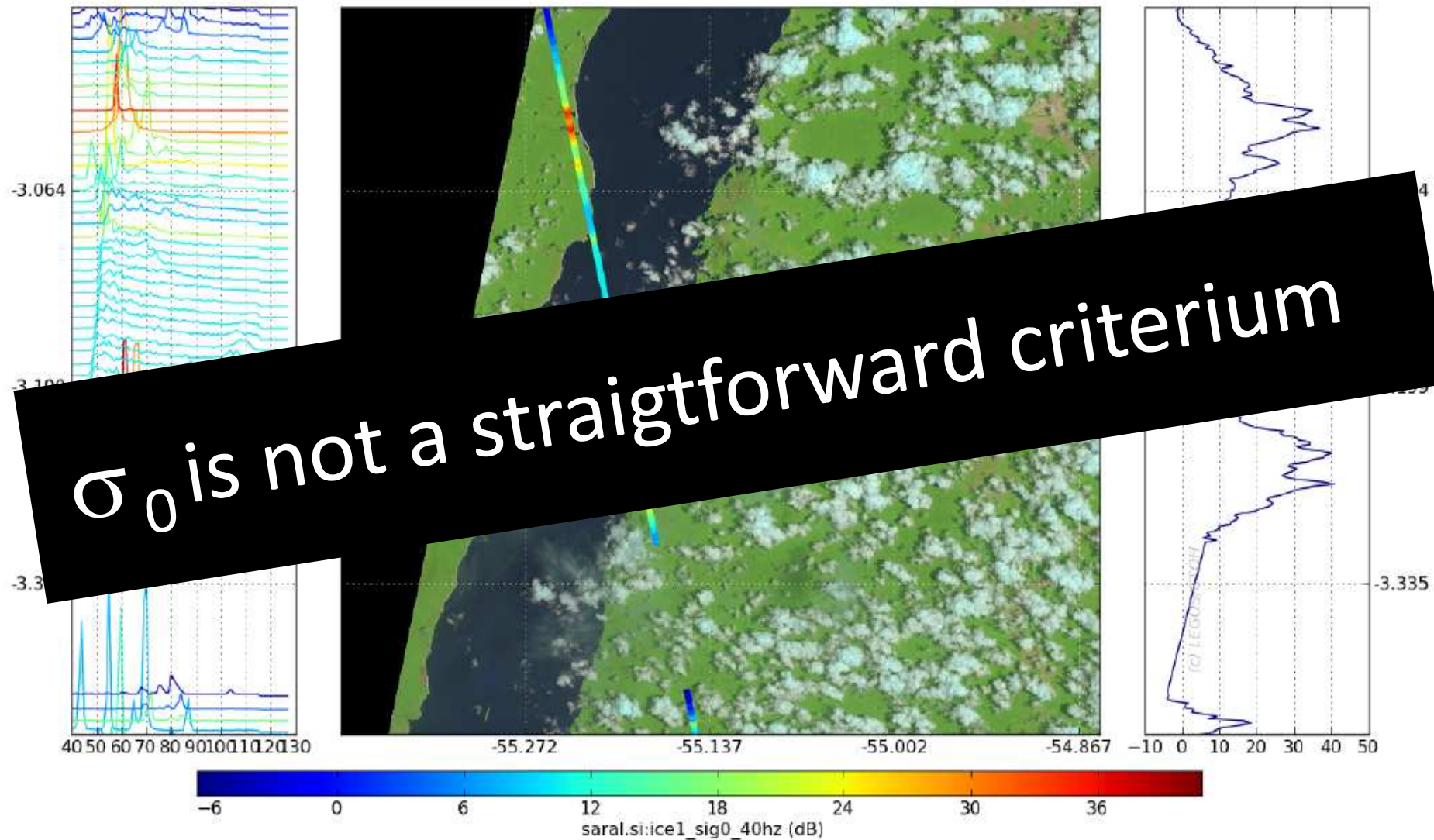


Thank you for coming

SPARES



Automatisation ?



The past



Present without past has no future

ENVISAT
SARAL

Brazzaville



Kinshasa

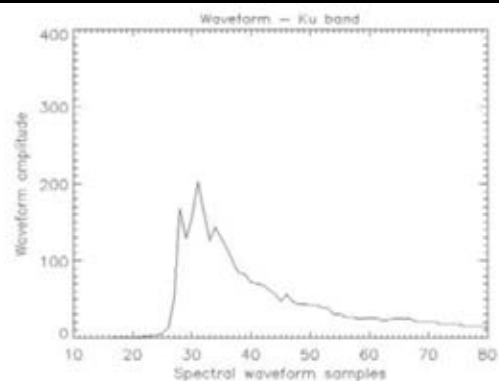


Kimbanza
Image © 2014 Digital Globe
© 2014 Google

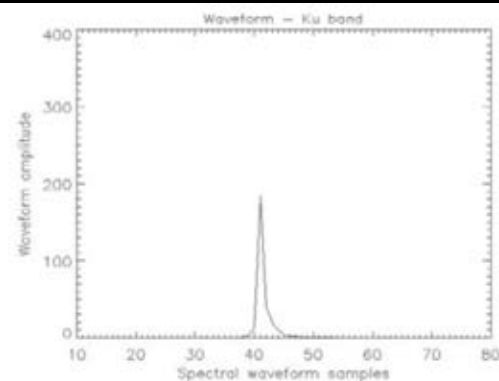
Image © 2014 CNES / Astrium

Date des images satellite : 17/6/2014

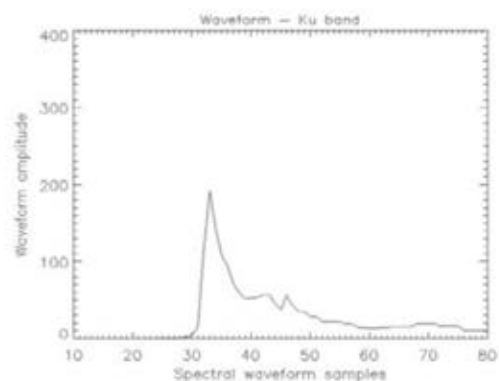
lat -4,257685° long 15,460187° elev. 270 m



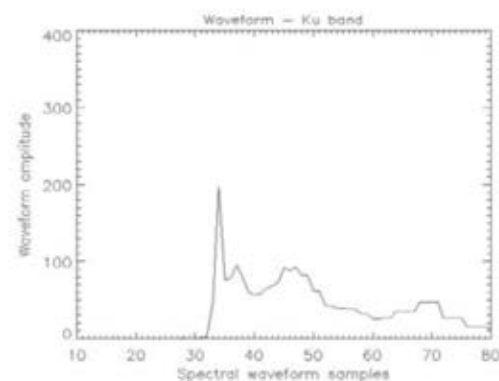
(a) Forme d'onde océanique



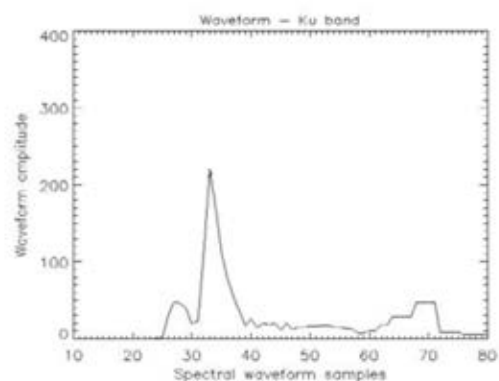
(b) Forme d'onde quasi-spéculaire



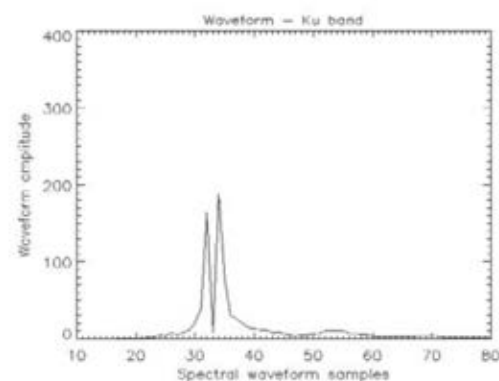
(c) Forme d'onde large pic de type a



(d) Forme d'onde large pic de type b

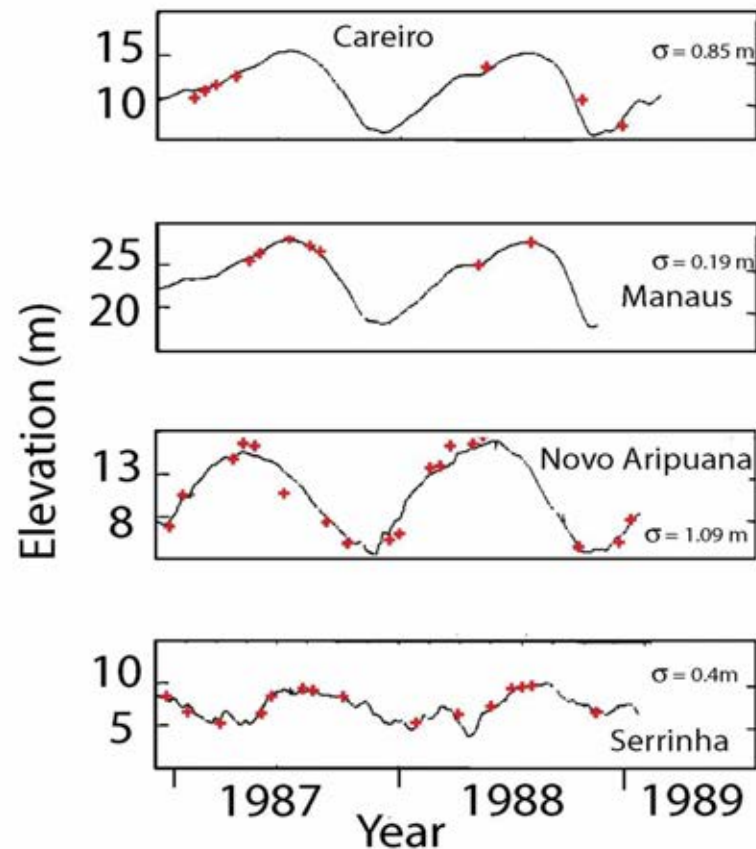


(e) Forme d'onde large pic de type c



(f) Forme d'onde multi-pics

Tribute to the pionniers

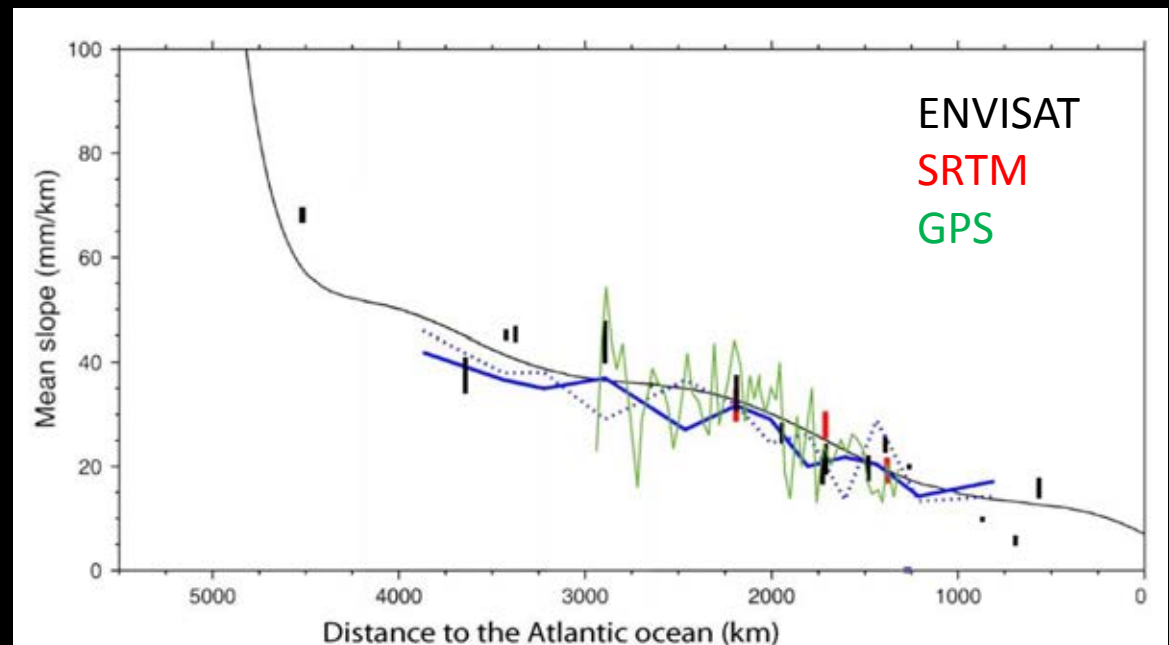


+ = GEOSAT

Koblinsky *et al.* (1993)

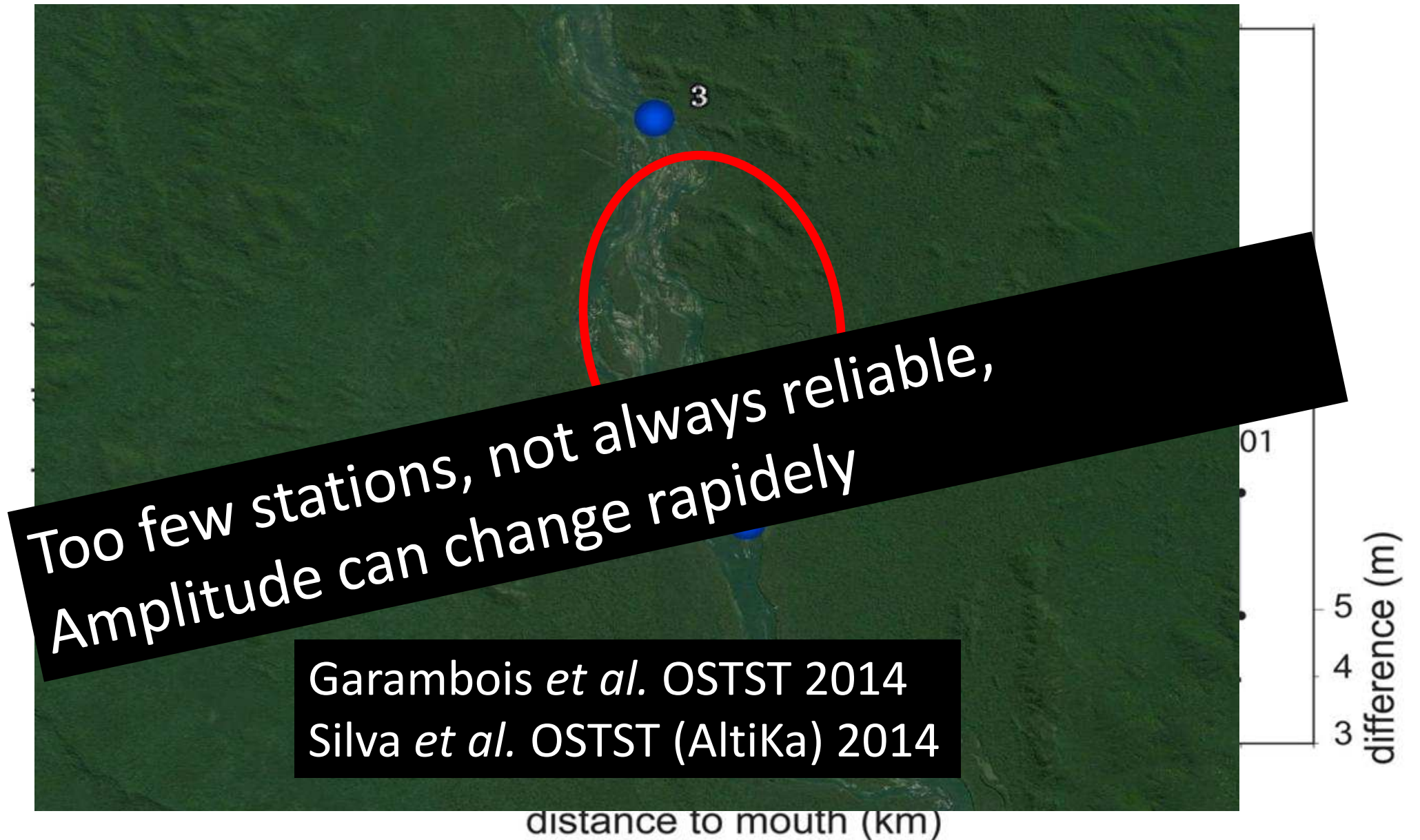
STAGES

SLOPES

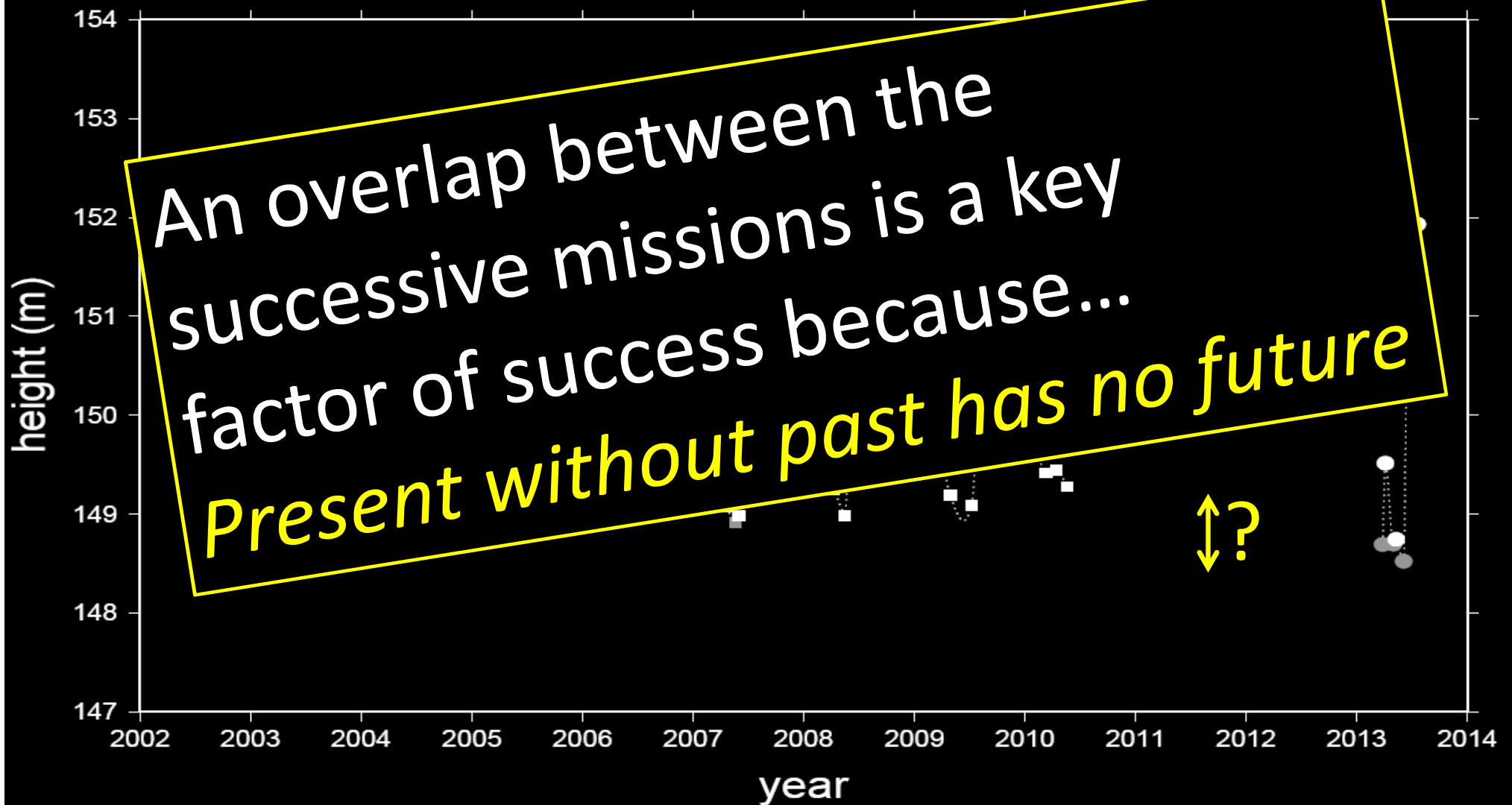


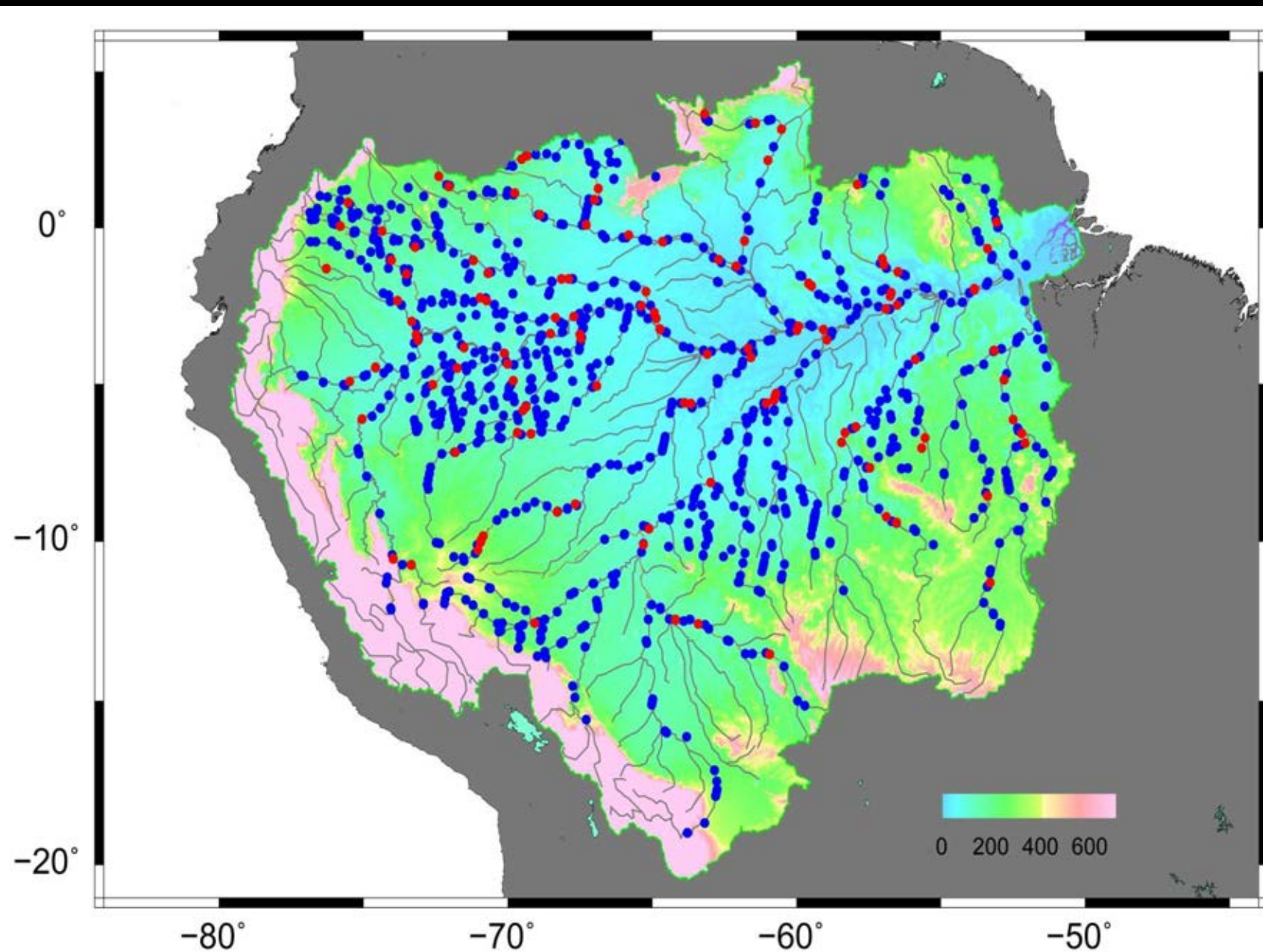
 Birkett *et al.* (2002)

Envisat Altimetry over the Xingu river



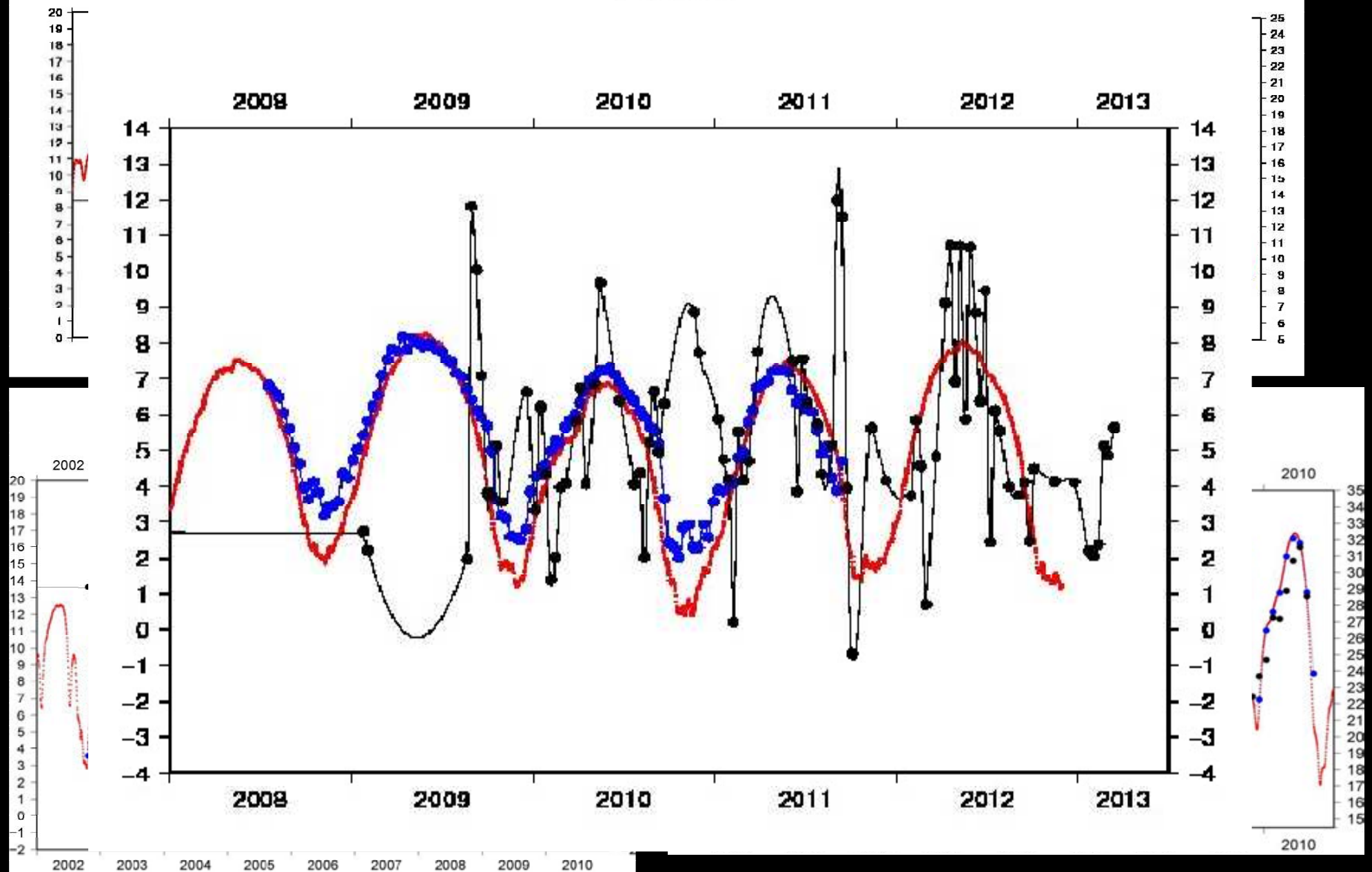
SARAL

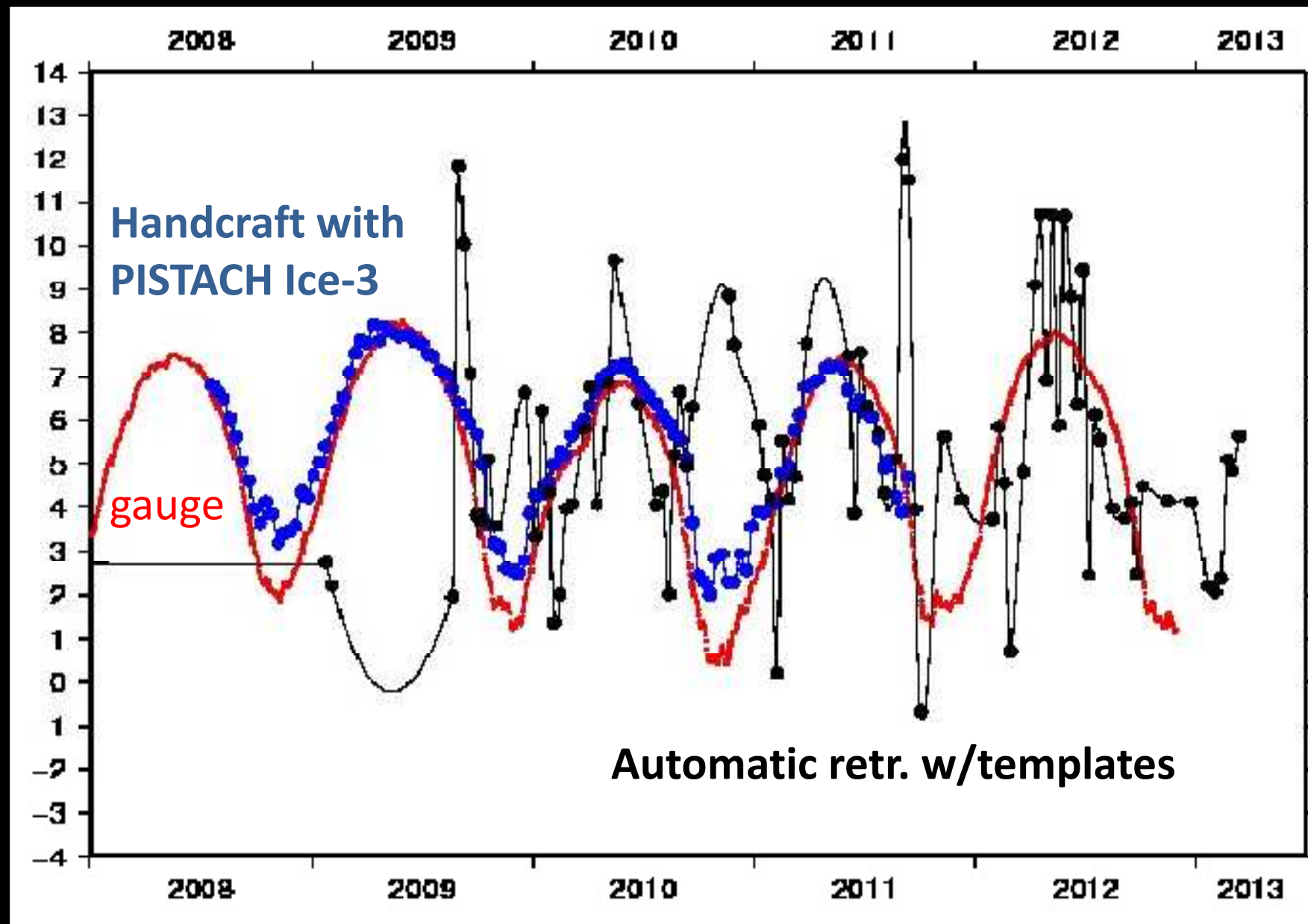




mama

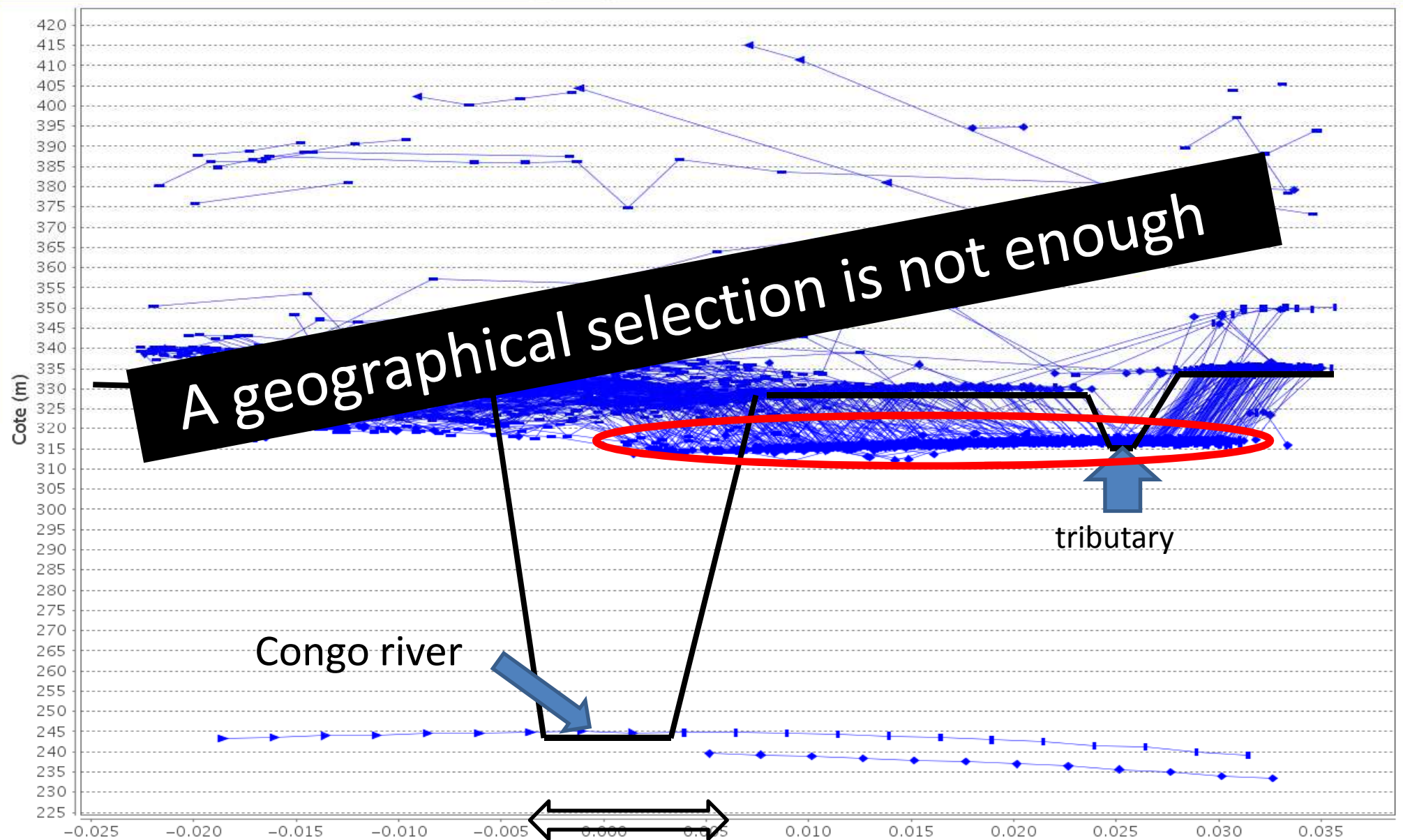
santarem

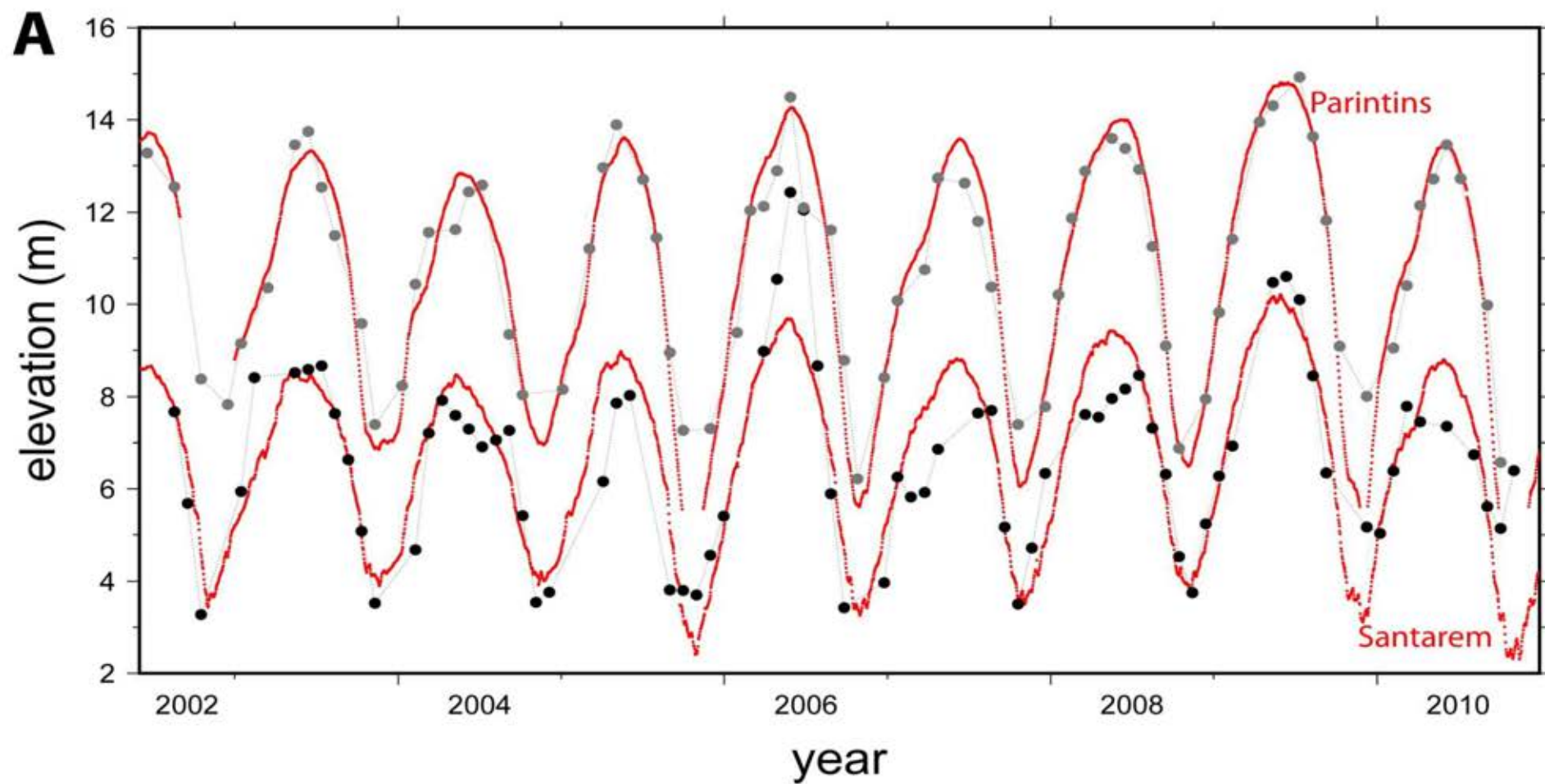




Jason-2 altimetry over the Congo

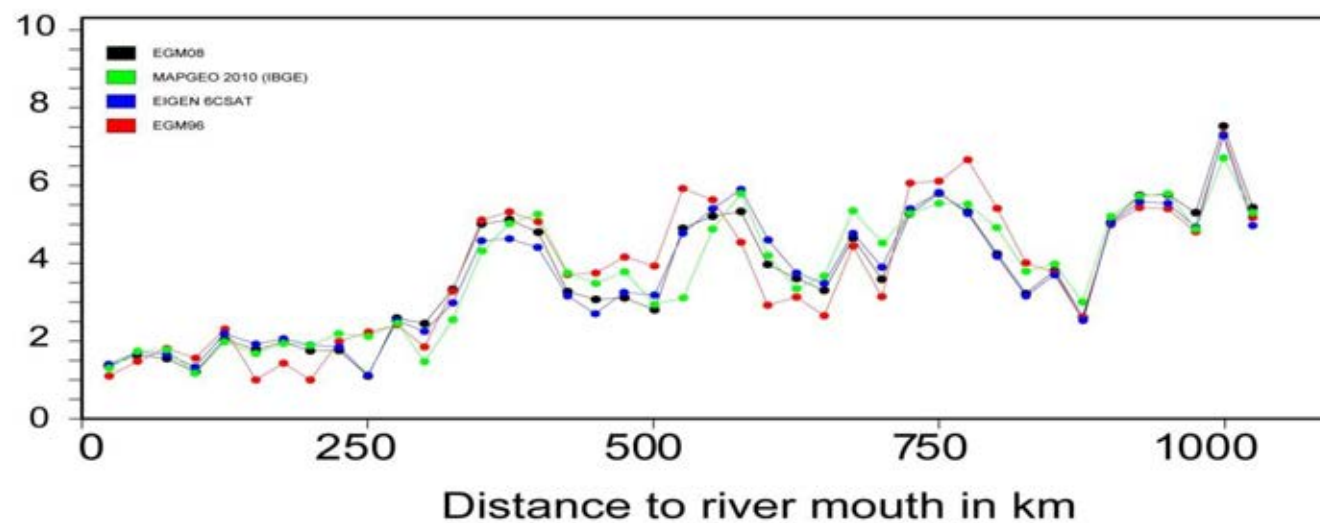
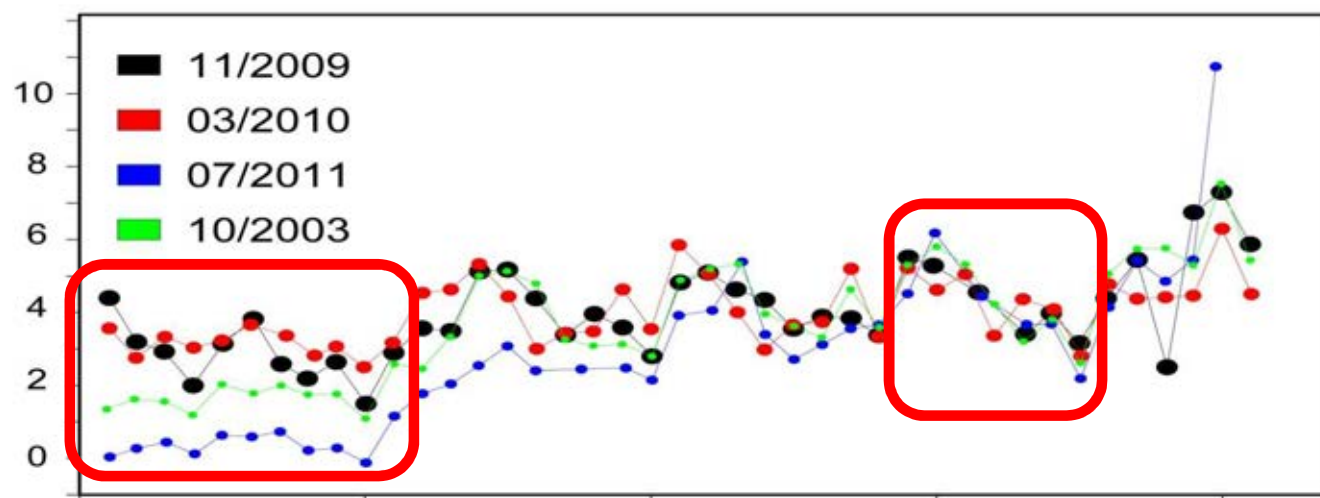


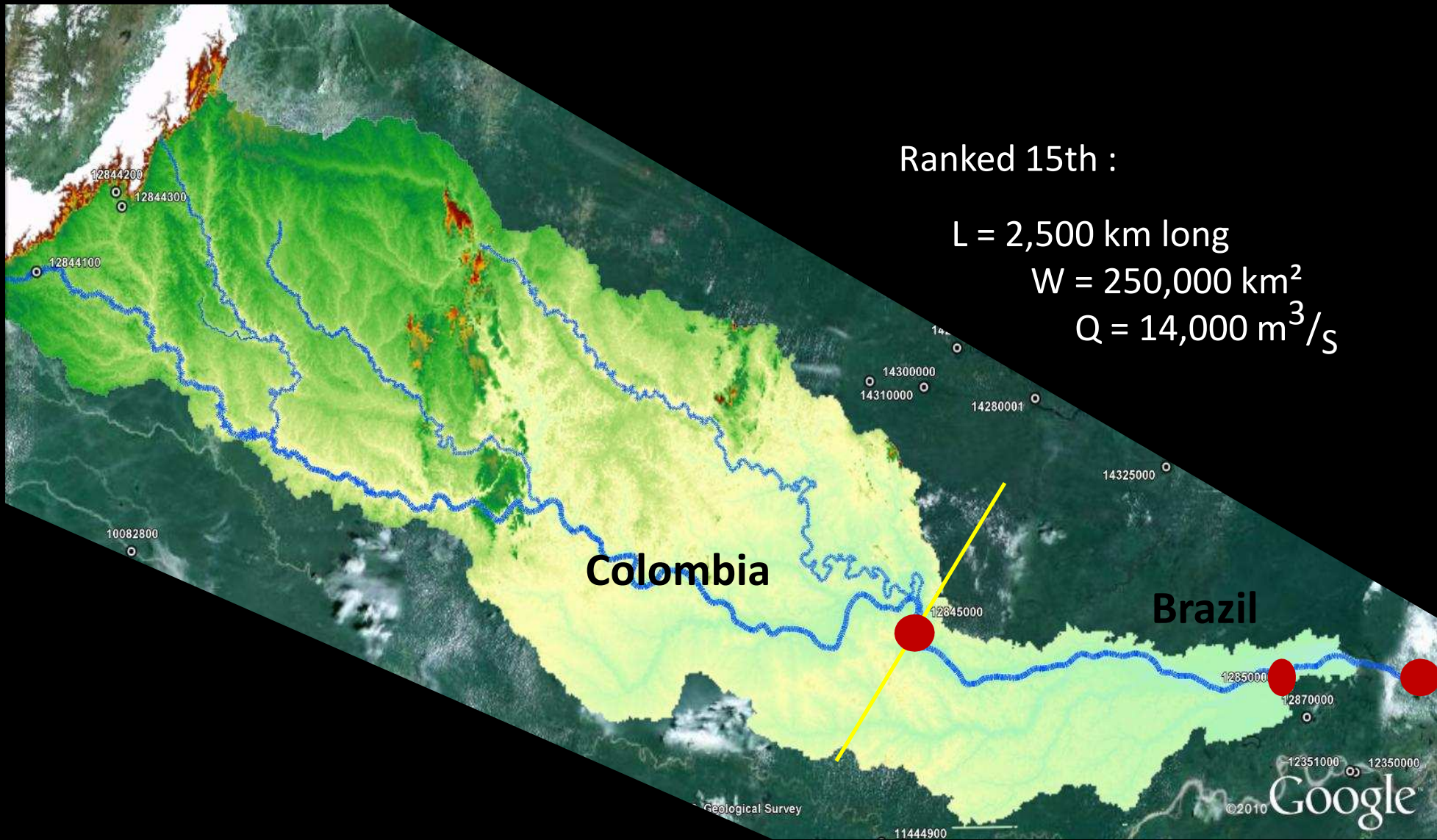




GPS profiles on the Madeira river

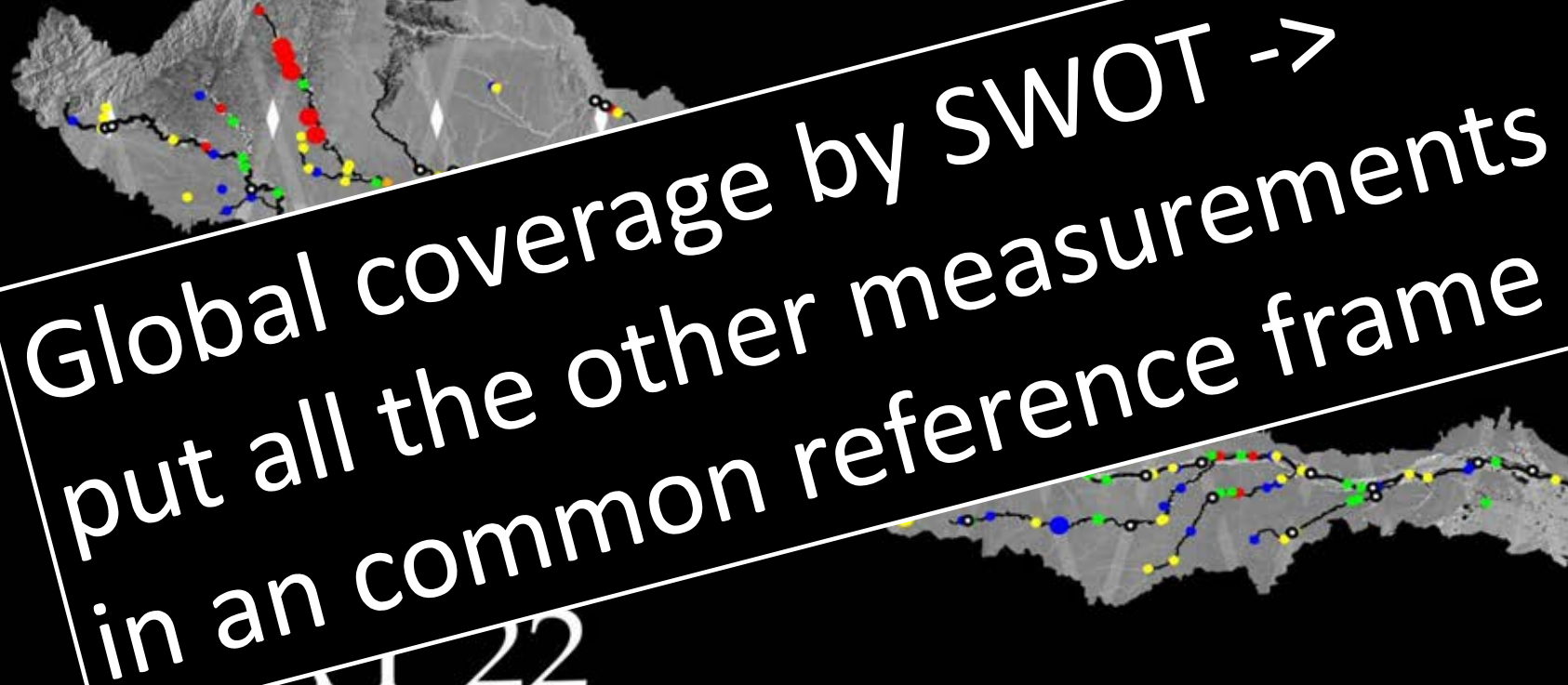
Slope (cm/km)





Ranked 15th :

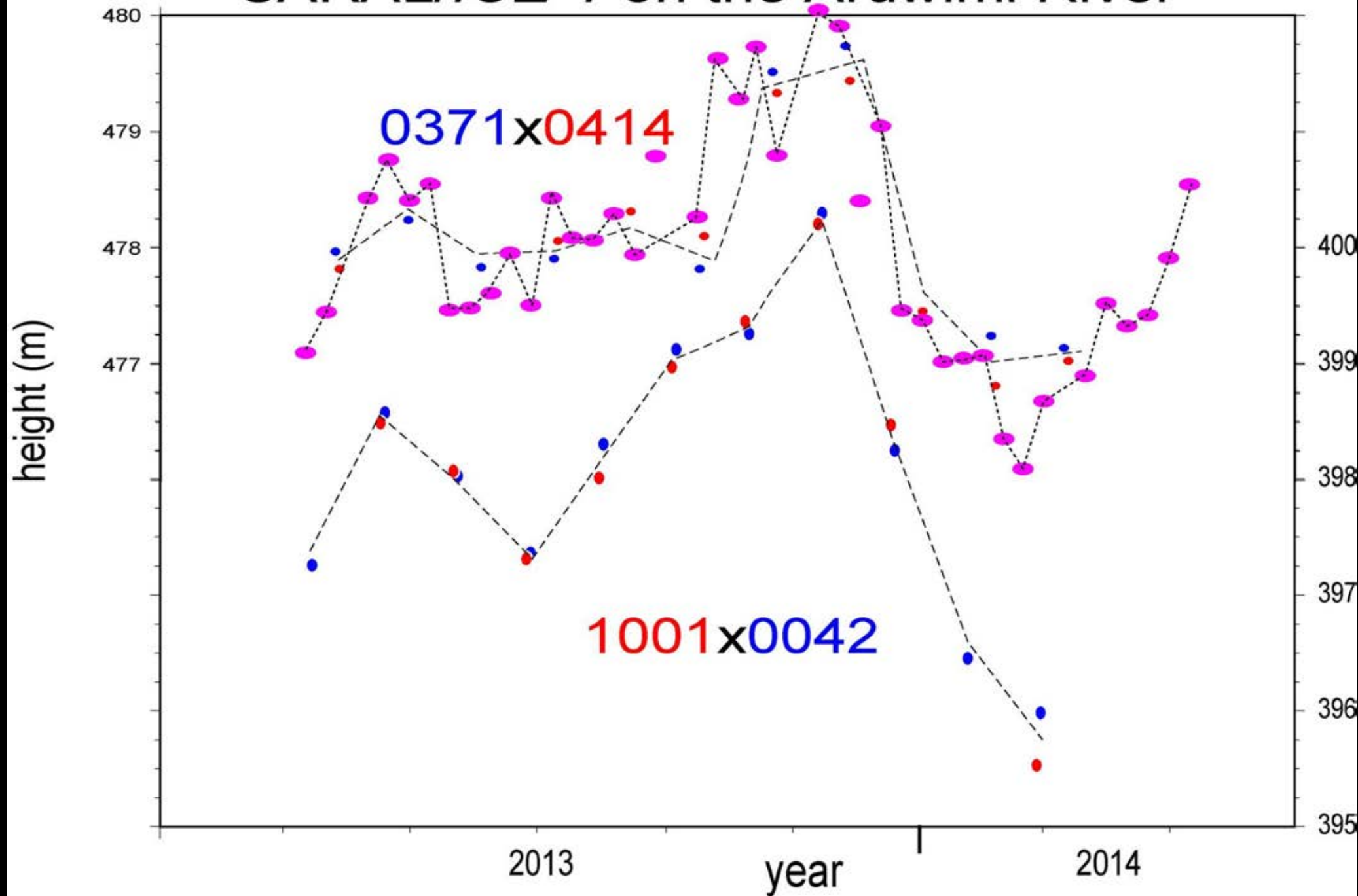
$L = 2,500 \text{ km long}$
 $W = 250,000 \text{ km}^2$
 $Q = 14,000 \text{ m}^3/\text{s}$



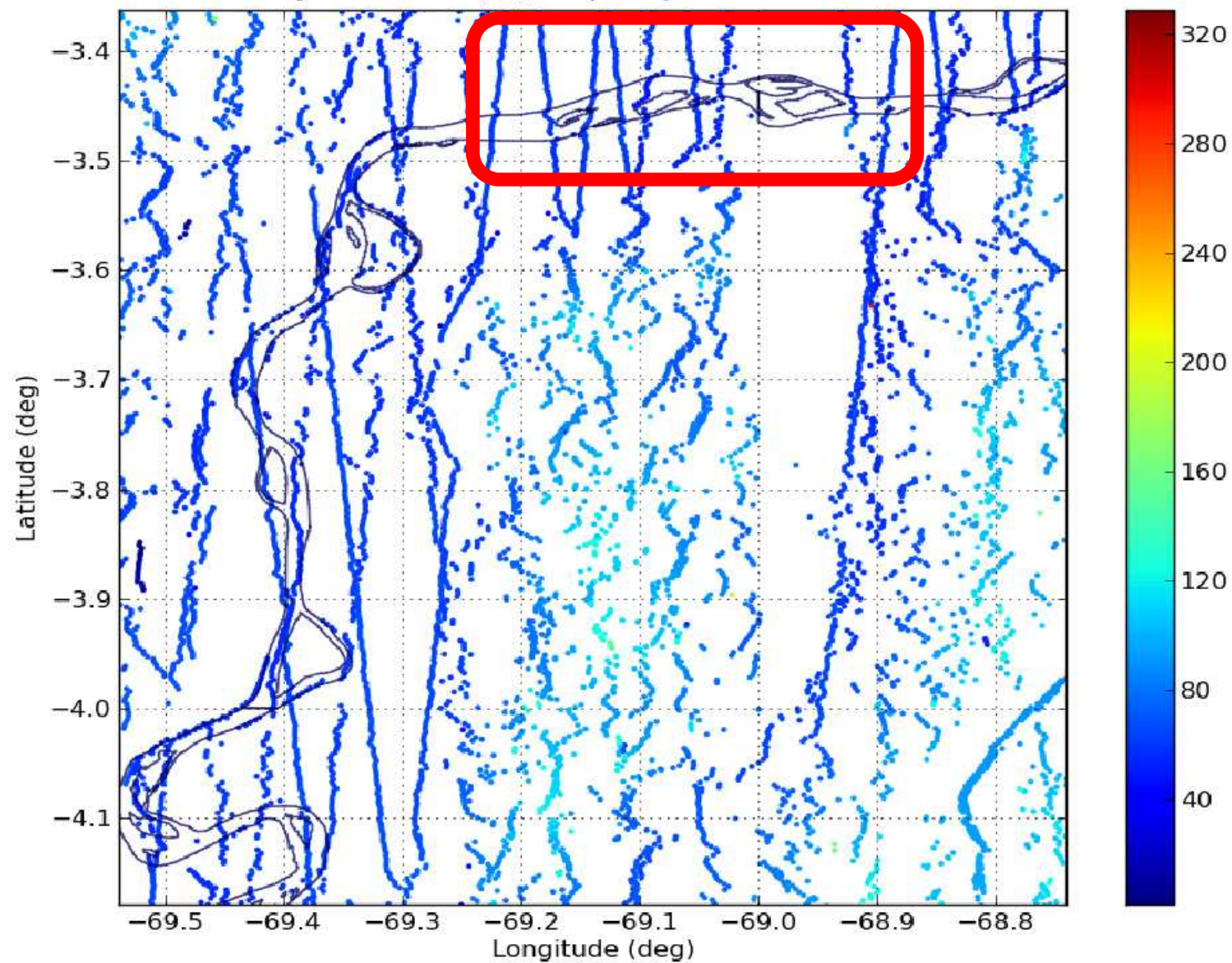
Global coverage by SWOT ->
put all the other measurements
in an common reference frame

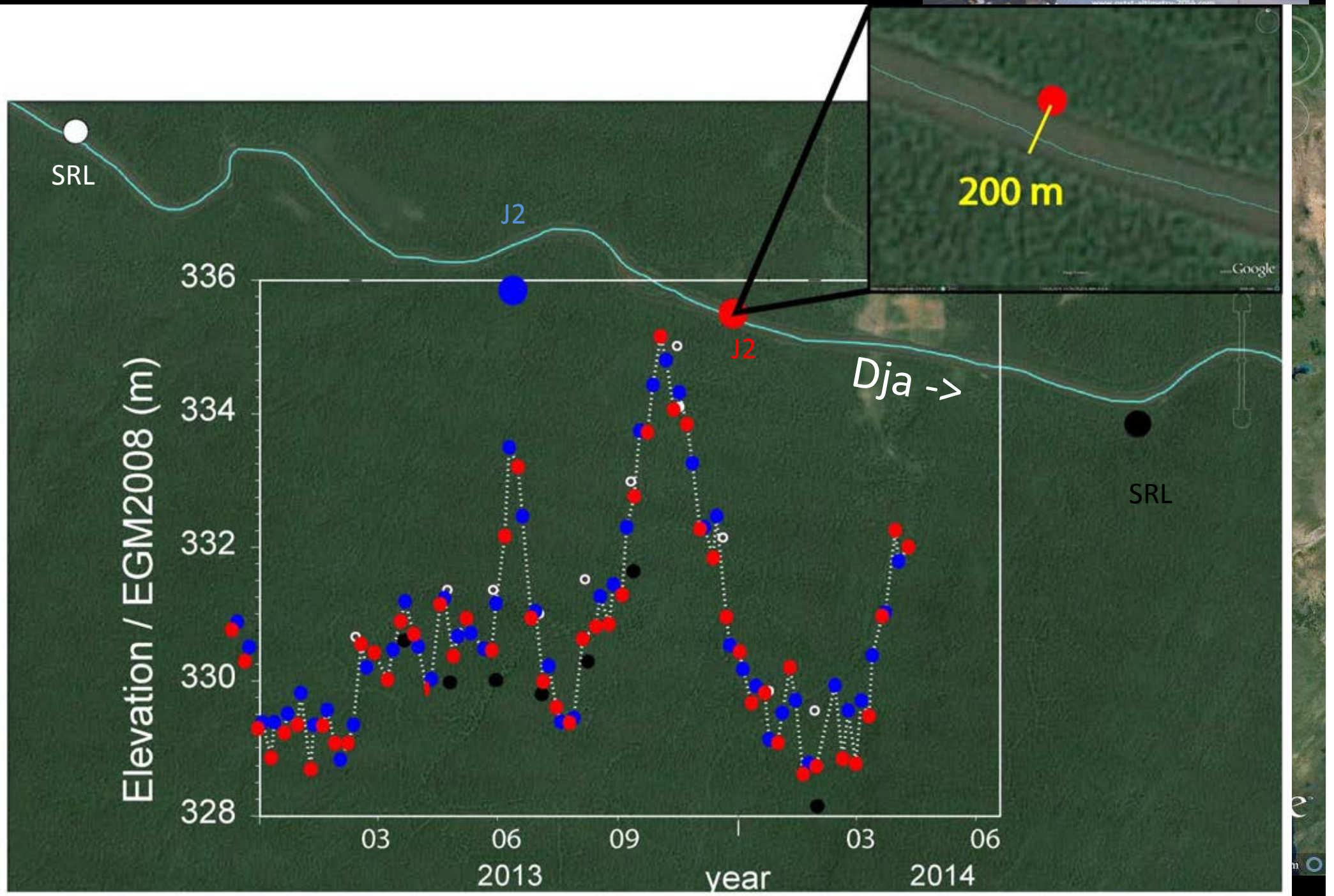
11 22

SARAL/ICE-1 on the Aruwimi River

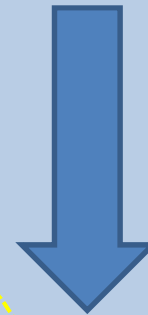


CryoSat-2 - Z (m) map - Upstream Amazon

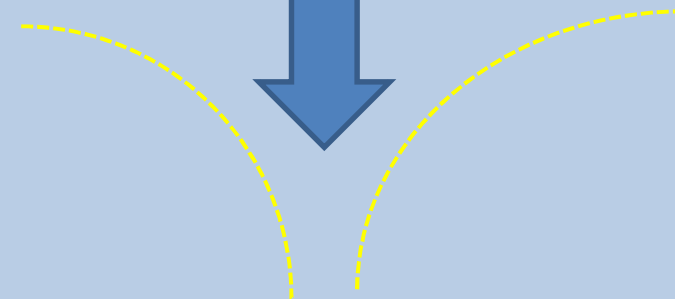




Water surface



Cross-track deviation



Pair of parabolas in the ranges

