Fast delivery of Geoinformation for disaster recovery after the tsunami in South East Asia

By

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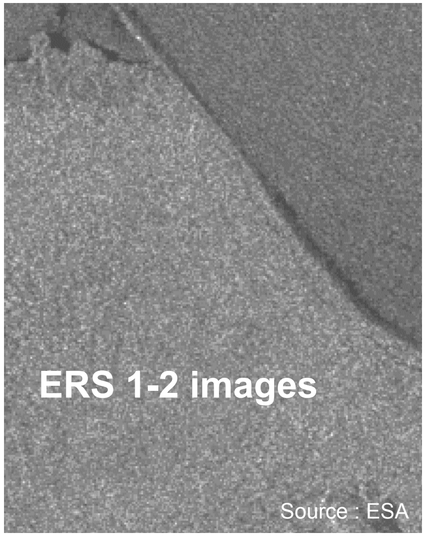
Background : our experience

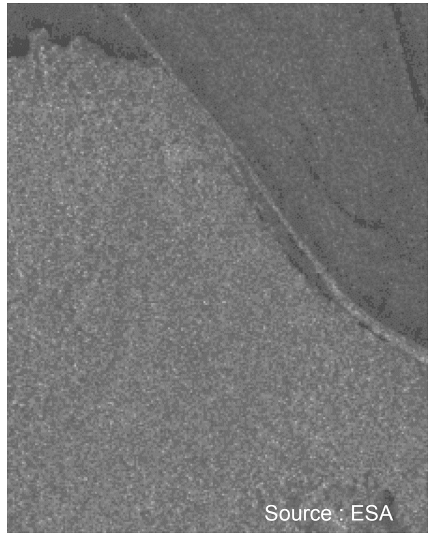
- 15 years of analysis of all types of natural disasters from geophysical point of view, earth observation, field survey, protection design, vulnerability analysis in co-operation with geophysical institutes

- Several mega-disasters already studied on the field such as Hurricane Mitch, Lothar and Martin, Izmit and Bhuj earthquakes, + many volcanic eruptions, tens of floods,

- A usual co-operation with field relief actors such as NGO's which have assessment needs within a few days

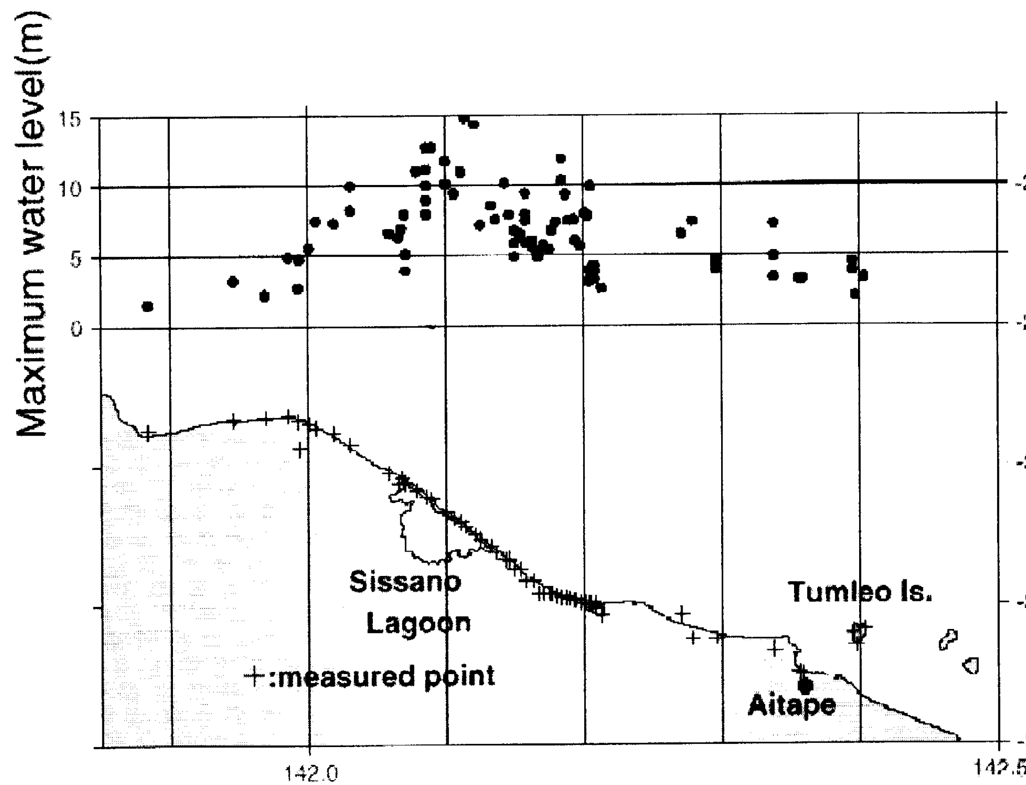
- A usual practice of disaster impact assessment from earth observation since 1990 (the 1998 Papua New Guinea tsunami impact mapped with ERS images)





Tsunami in Papua New Guinea 1998

Detection of damages and impacts on villages based on ERS images



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Triggering the work on 27th Dec.

- The disaster took place on a Sunday and during christmas vacations (we had enough experience to know that this is not a favourable factor for a quick assessment and relief)
- The disaster appeared to have surely the major extent recorded of the last decades, inducing a likely delay in the real assessment of impacted areas, fatalities and casualties (i.e Mitch, Bhuj where real impact assessment took between 3 to 5 days)
- The usual exponential growth of death toll during the aftermath was promising an extreme number of victims and a delay for relief arrival to all affected places
- The location and extension would probably make complete coverage by space imagery too long for emergency phase.

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Objectives and targets

- Provide global view of magnitude and potential extent of event to local actors and to NGO's
- Cover the widest area in a time as short as possible, assuming but describing uncertainty on documents
- Deliver data very fast to many users in a portable and universal format accessible event with slow internet connections

Initial conditions and time table of the action from 27 to 28th Dec.

Known :

- Approximate location and focal mechanism of earthquake (USGS, ECMS)
- Rough differenciation by countries of waves heights and run-up from fist media-reports
- Local informations on level of damages

Unknown :

- Real propagation and direction of propagation of major waves
- Local wave height and run-up
- Real extent of affected coasts

Construction of product

- Hourly evolving report on damages and intensity
- Likely fast growing death toll within days
- Likely large mobilisation for relief
- Very little space imagery available during the first week
- Usual predictable period of 3 days minimum without assistance for victims
- Wave height and run-up were postulated or estimated according to preliminary reports in each country (media, internet)

Input

SRTM DEM, VMAP0, LANDSAT COVERAGE + data collection on the internet and medias + considerable field experience and observations

Distribution to users

- A choice of simple, compressed and universal formats geotiff (for integration in GIS) and pdf (for those not using GIS) for all potential users
- Very small size of data
- Distributed attached to email or dropped on a FTP server
- Send to international organizations (European, UN), NGO's, relayed to local users
- Example of users : Action Against Hunger, MSF, University Of Peradenyia (Sri lanka)

First product delivery : Sri Lanka

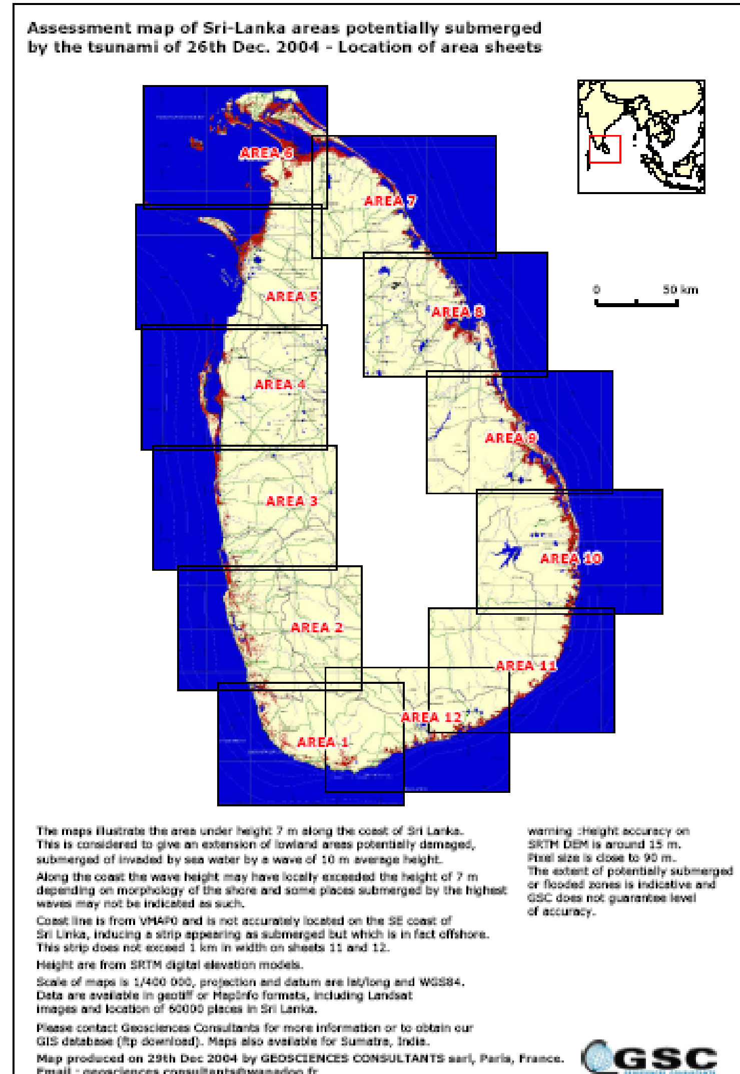
Chosen elevation for run-up and inundation: 7,5 m

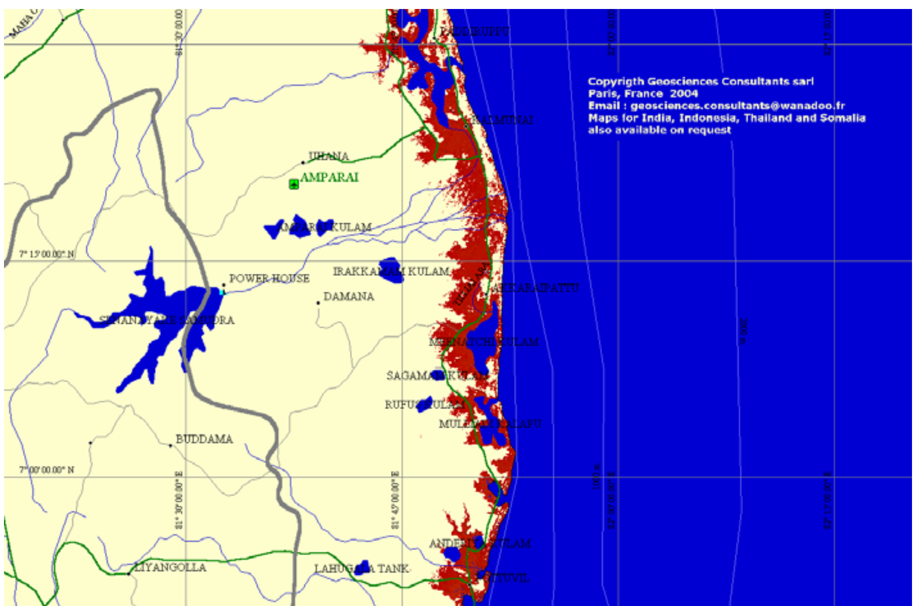
Lowest coast and damages are detected but also a lot of low and wet lands

2/3 of west coast are false alarm

The use of a baseline background image allows to limit such errors

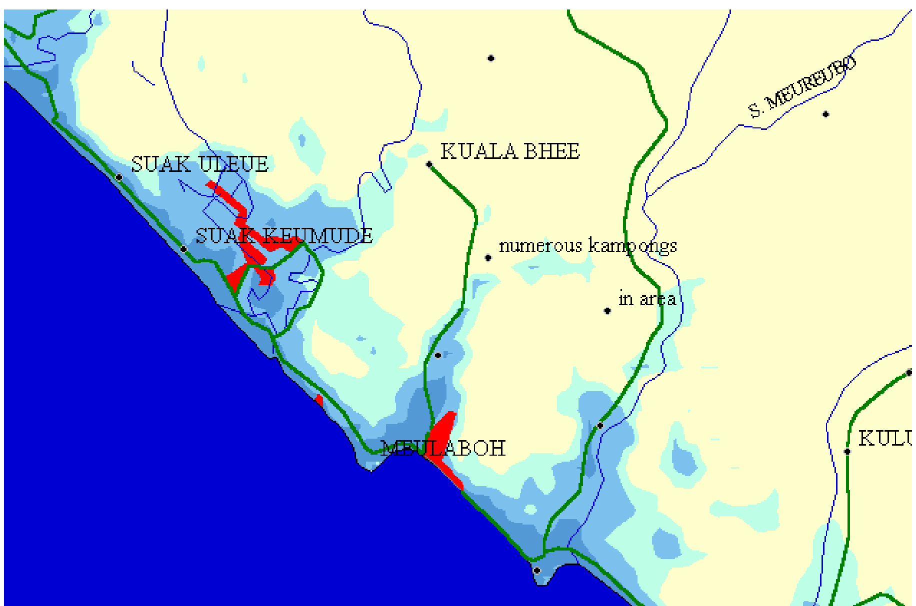
1 day for testing,1 day for production, then distributed with mailing list

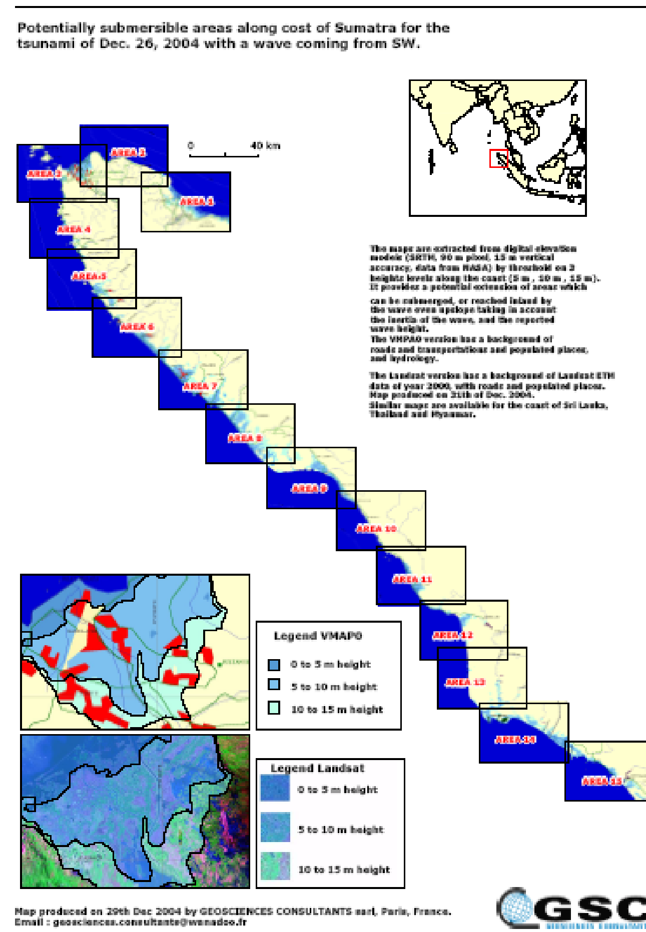




Second product delivery : Sumatra

Chosen heights thresholds : 5, 10, 15 m)





Third product delivery within the week after the tsunami

- Thailand
- Andaman Island
- Myanmar

Product Interest and limits

Limits :

- Defaults and limits known a priori
- An advise on limits of products comes along with the maps
- Usual observed vertical accuracy of SRTM varies from 5 to 15 m depending on region (likely to work only for major tsunamis waves or run-up)

Advantages :

- No post-event satellite images used, all data in-house, very fast and delivery on the field to local potential users, compatibility with almost everybody

Validation process

- Comparison to flooded area and run-up extent maps extracted from earth observation (HR to VHR imagery) in several context (Thailand, Sumatra, Sri lanka)
- Comparison of results with run-up heights and inland penetration from field surveys
- Criticizing the approach : advantages, limits, dangers
- User feedback (on-going)

Validation in Sumatra

- Comparison to High resolution optical imagery and field surveys

Banda Aceh area :

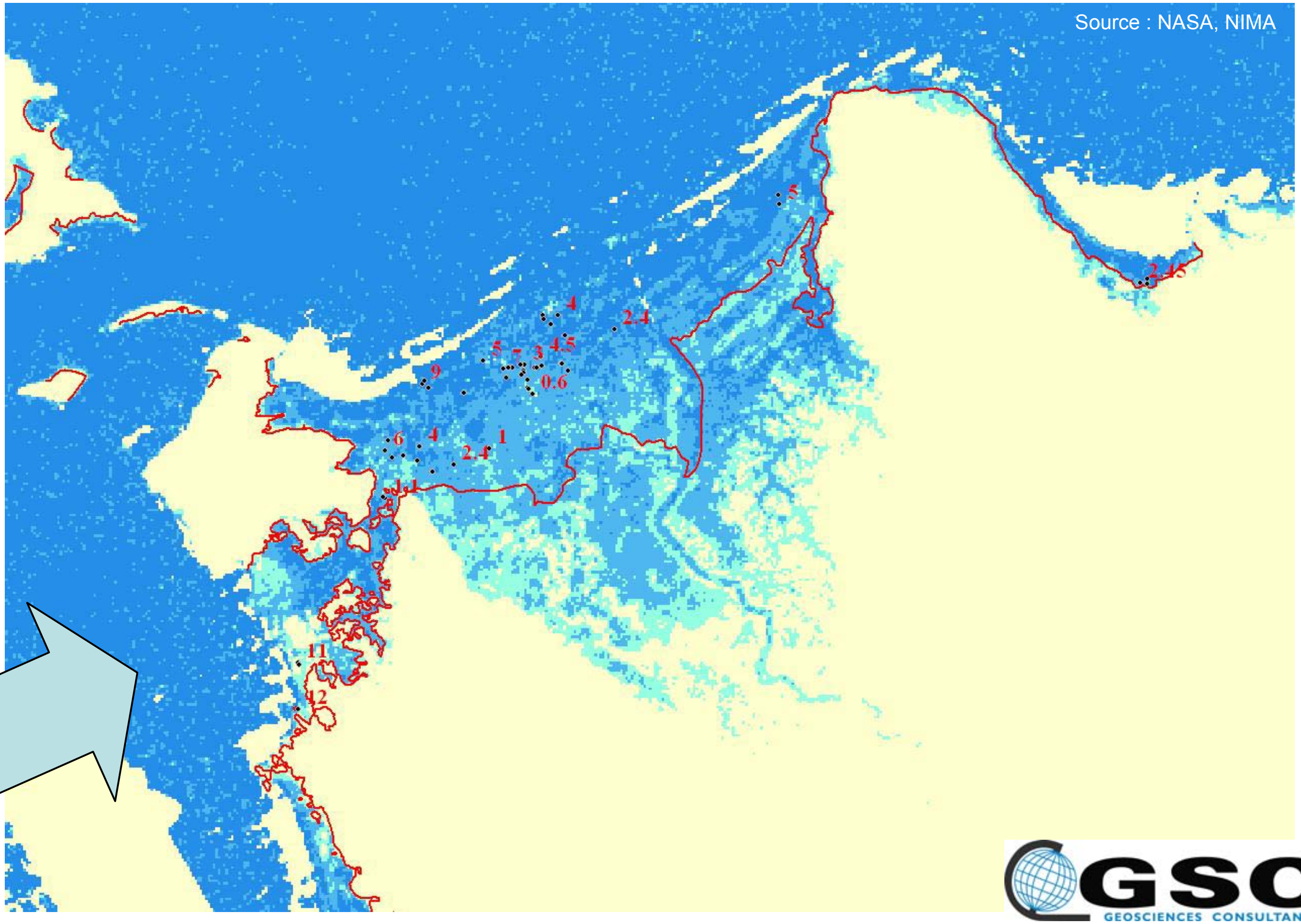
15 m height level fits well on coast exposed SW directly exposed to initial wave (maximum power before refraction around cape

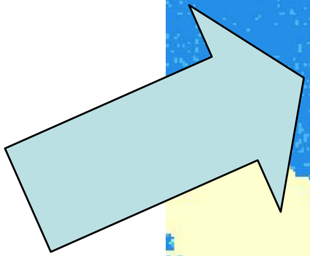
Inundation limit (red line) between 5 and 10 m in Banda Aceh, after refraction around cape or Islands

Run-up closer

To 5 m in coast

Exposed NE





Wave direction

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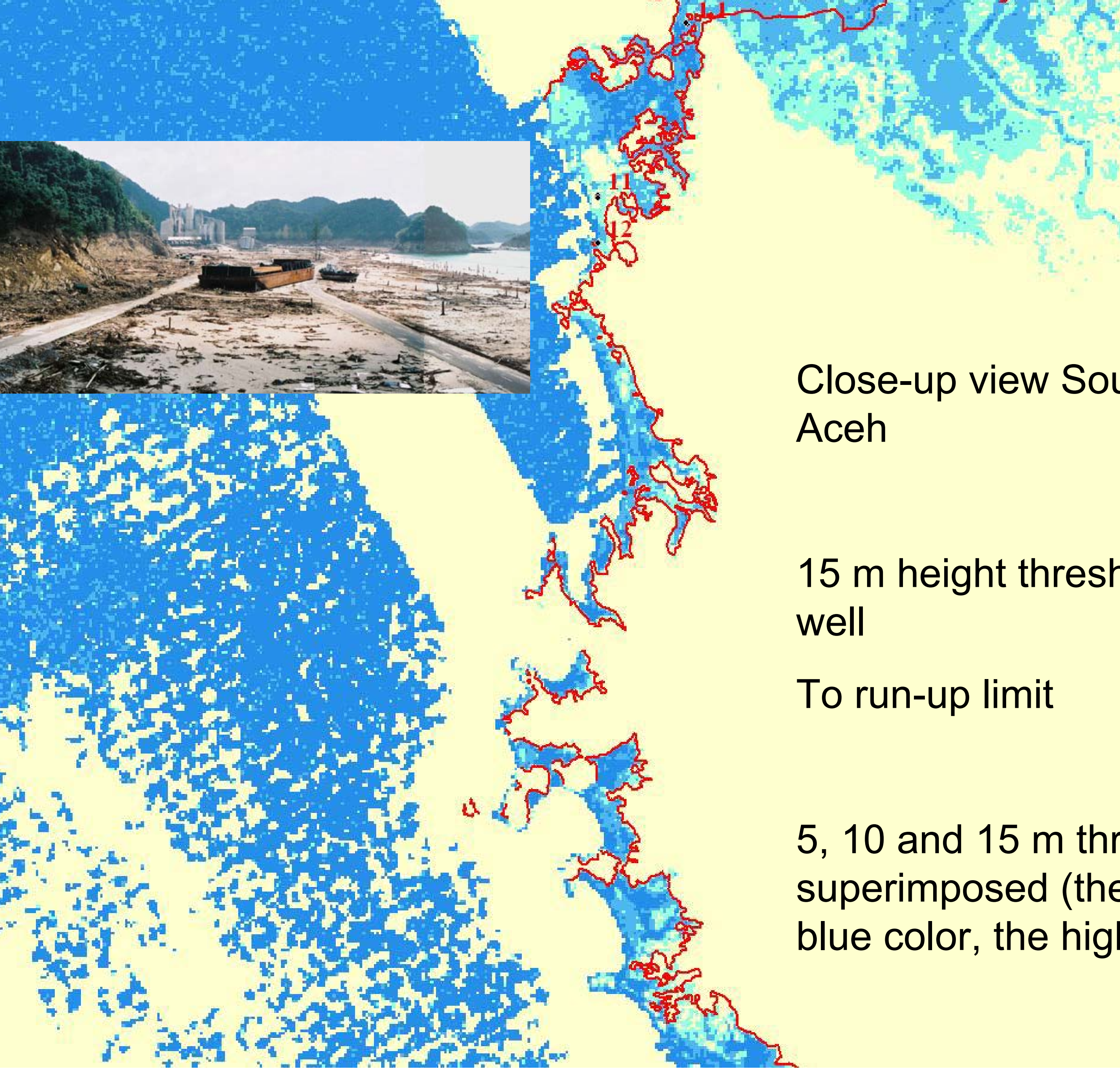

Close-up view South of Banda Aceh

15 m height threshold fits very well

To run-up limit

5, 10 and 15 m threshold layers superimposed (the lighter the blue color, the higher in elevation)

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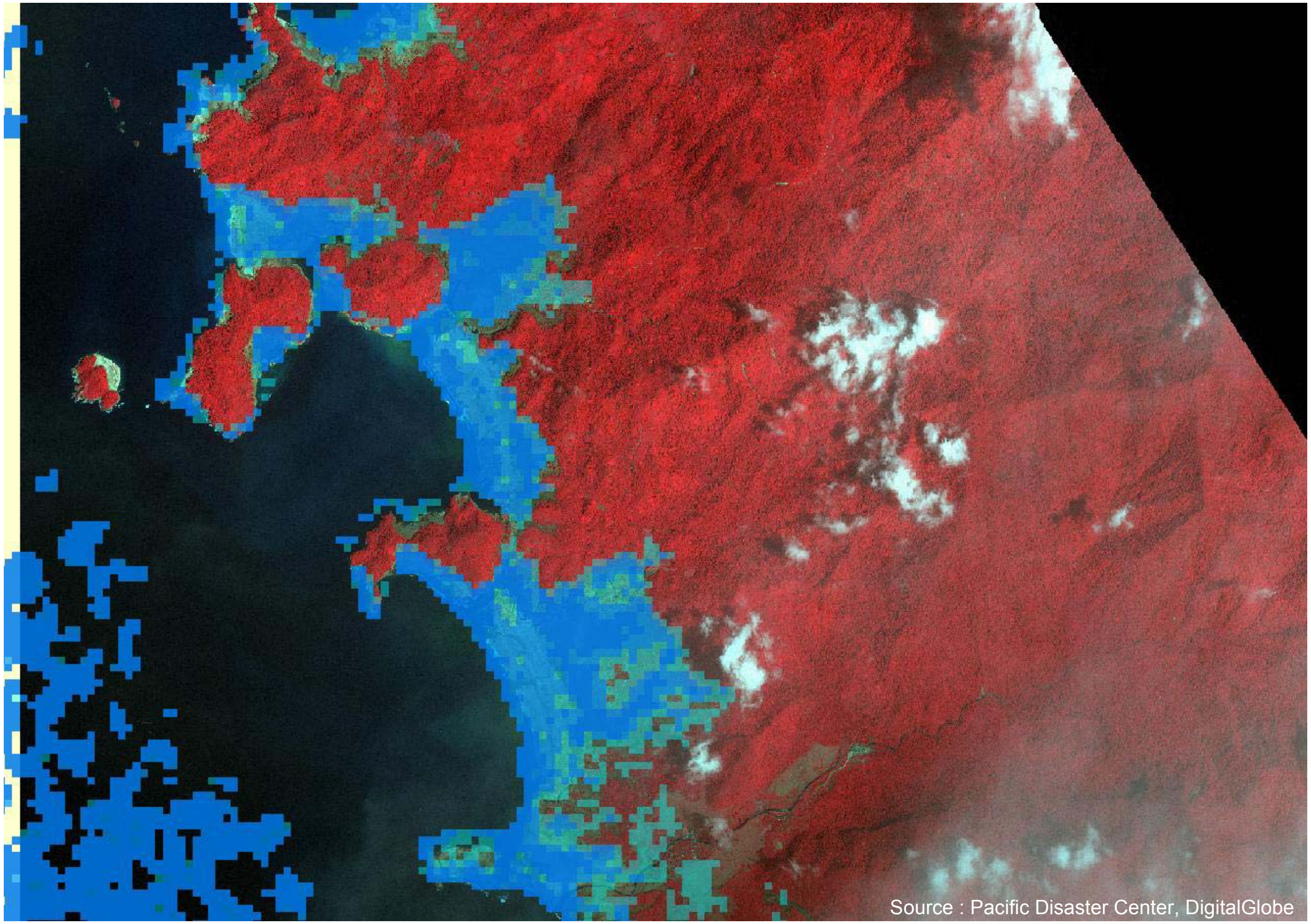
Dampening of wave and run-up height toward the SE



15 m elevation

Fits well

50 km south of Banda Aceh

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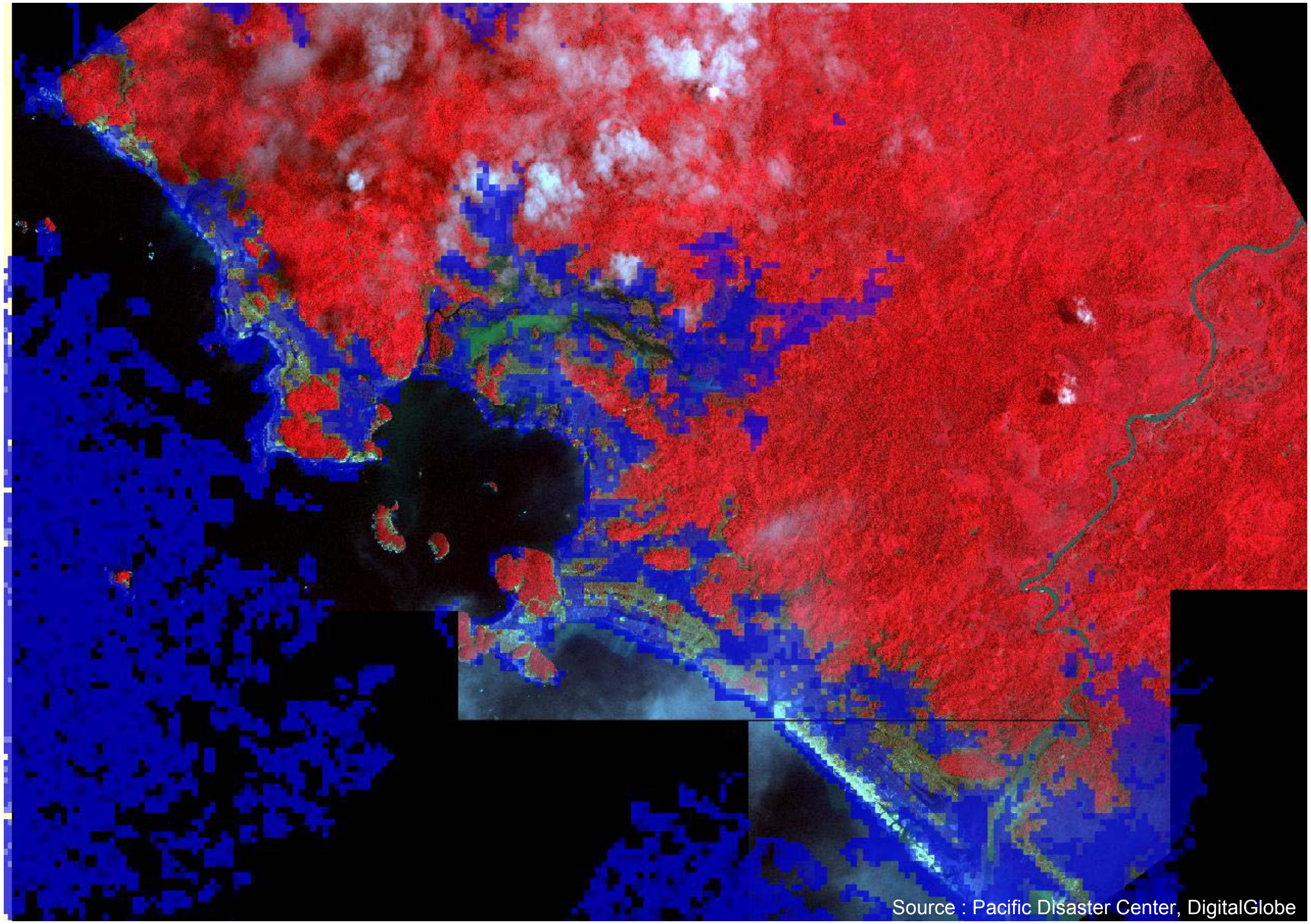
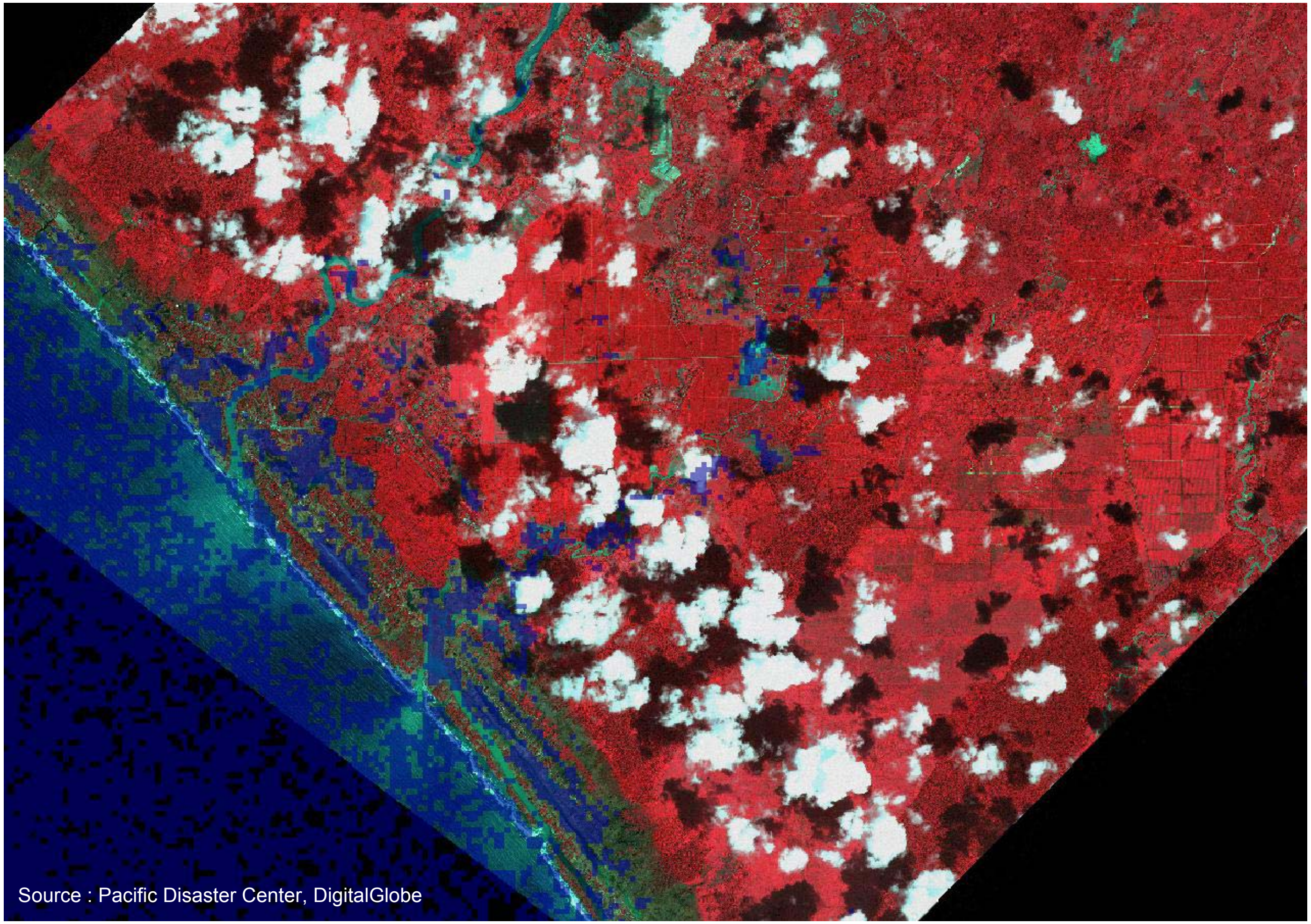


10 m elevation

Fits well

Farther south



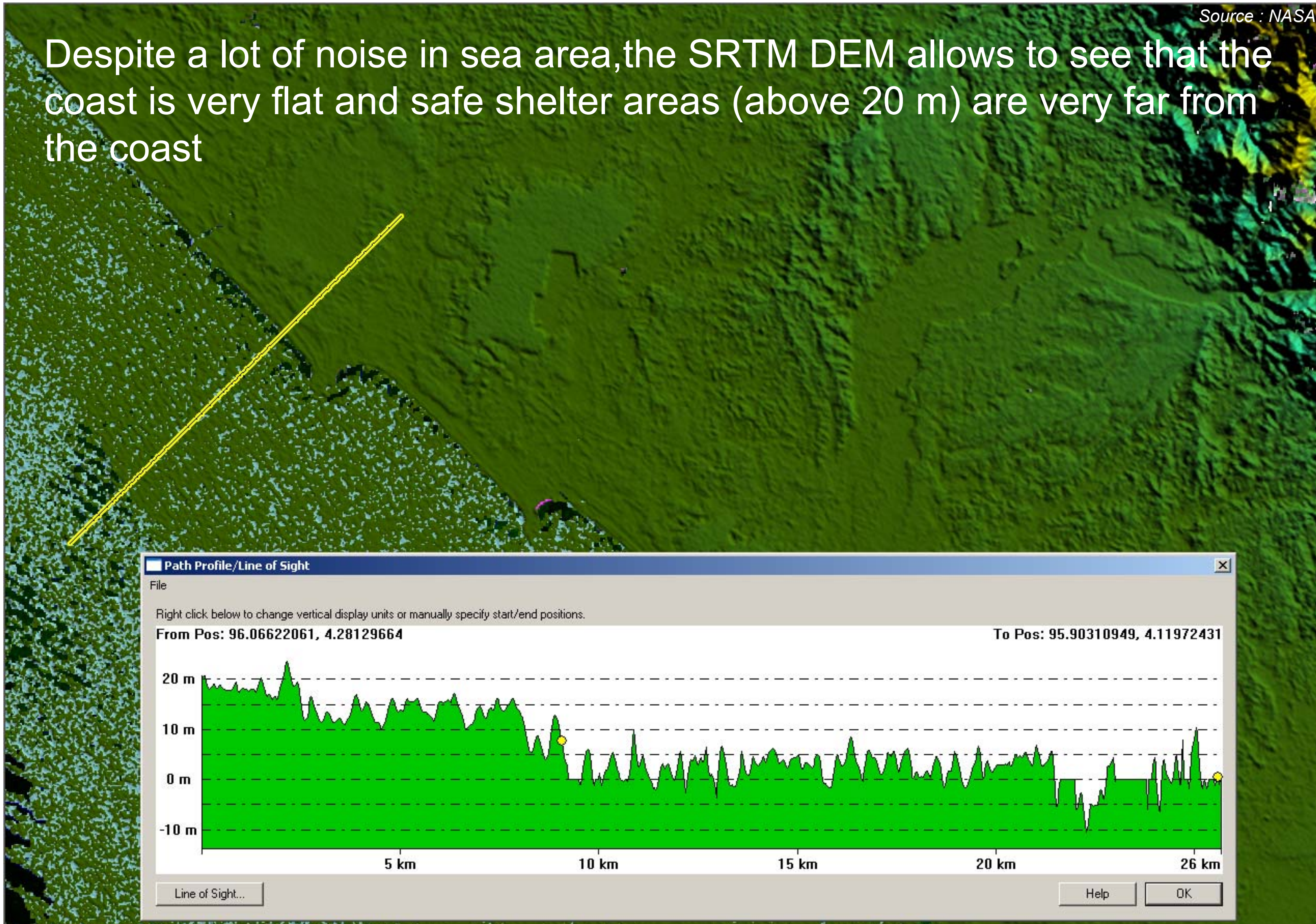
10 m elevation

Too much and

5 m not enough south of Meulaboh

Local value closer to 7 m

Despite a lot of noise in sea area,the SRTM DEM allows to see that the coast is very flat and safe shelter areas (above 20 m) are very far from the coast



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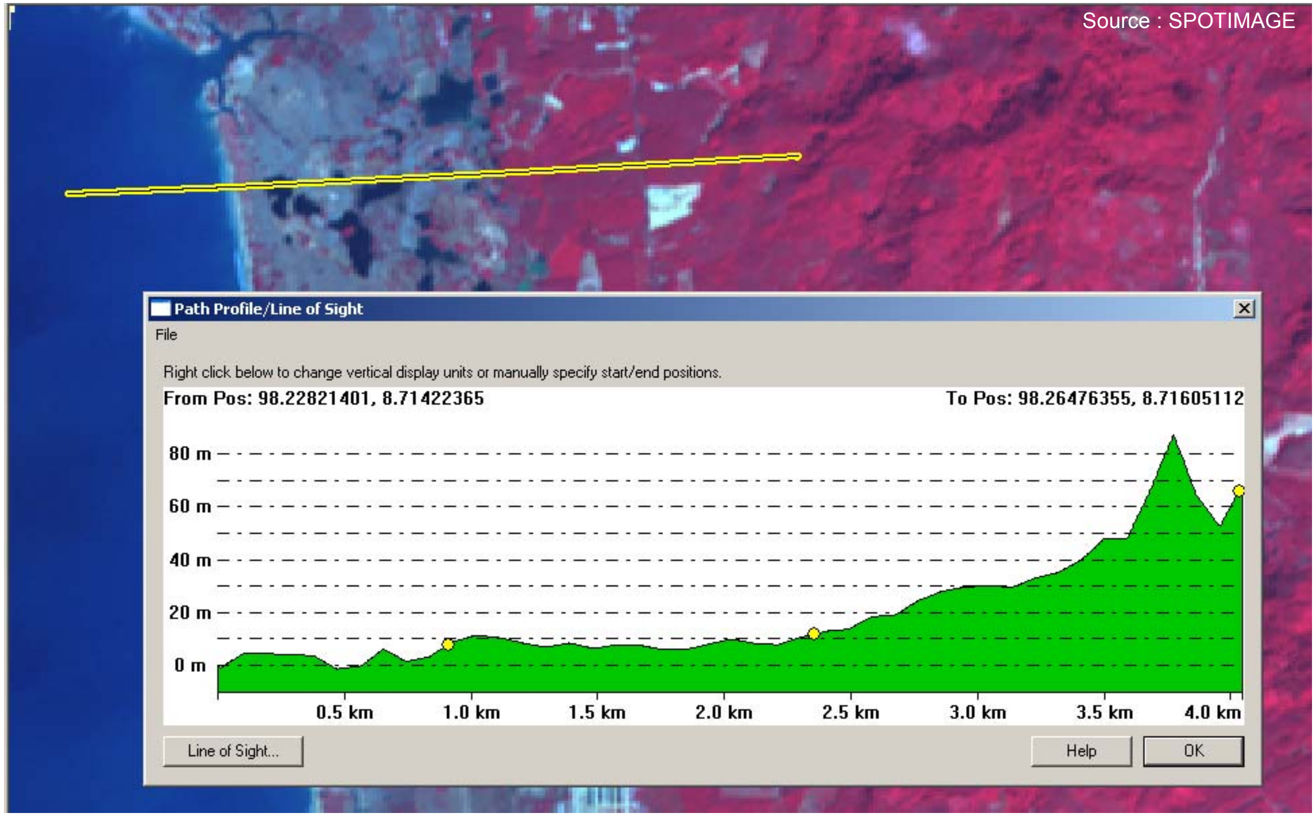
Conclusion for Sumatra

- Pretty good fit on the first 200 km south of Banda Aceh
- Dampening of tsunami toward SE not considered (Half of the coast analysed did not see significant destruction, waves of run-up
- Even with 90 m pixel size and 15 m vertical accuracy SRTM DEM offered a good way to assess potential extent of damaged zones

Validation in Thailand

Topo profile extracted from SRTM DEM

Run-up reached 10 m elevation



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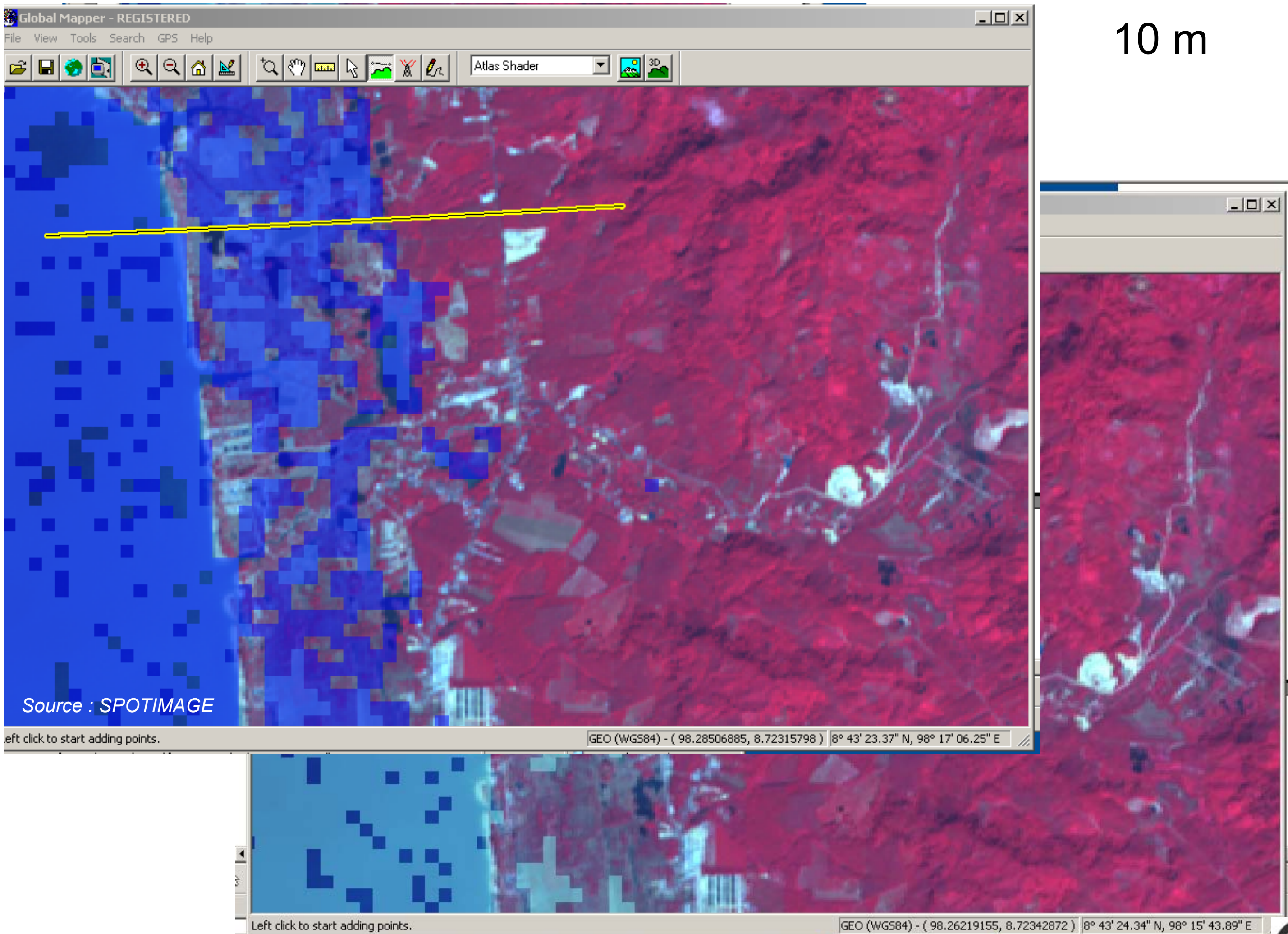
Best fit with 10 m Threshold superimposed but some gaps



10 m

7 m

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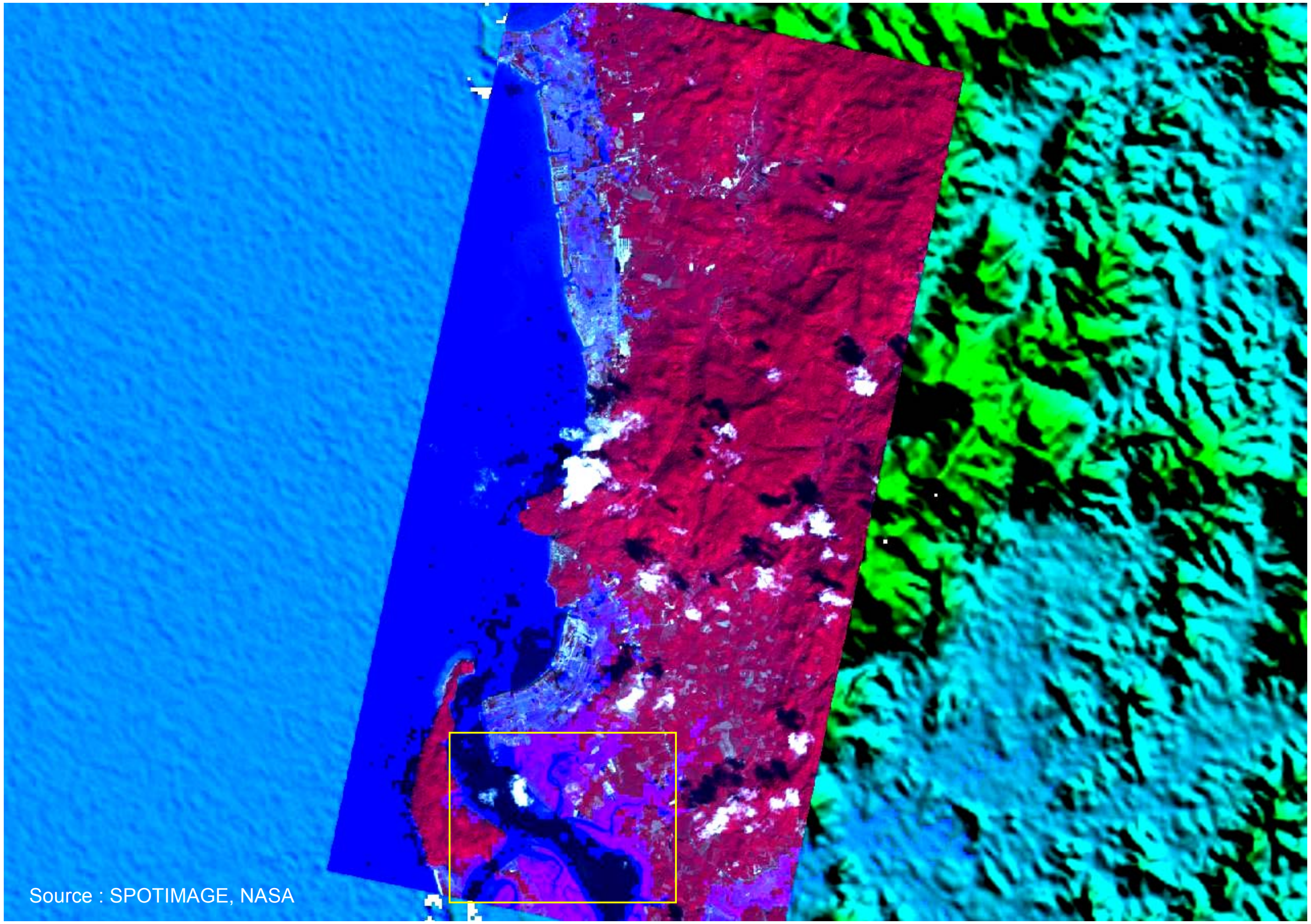
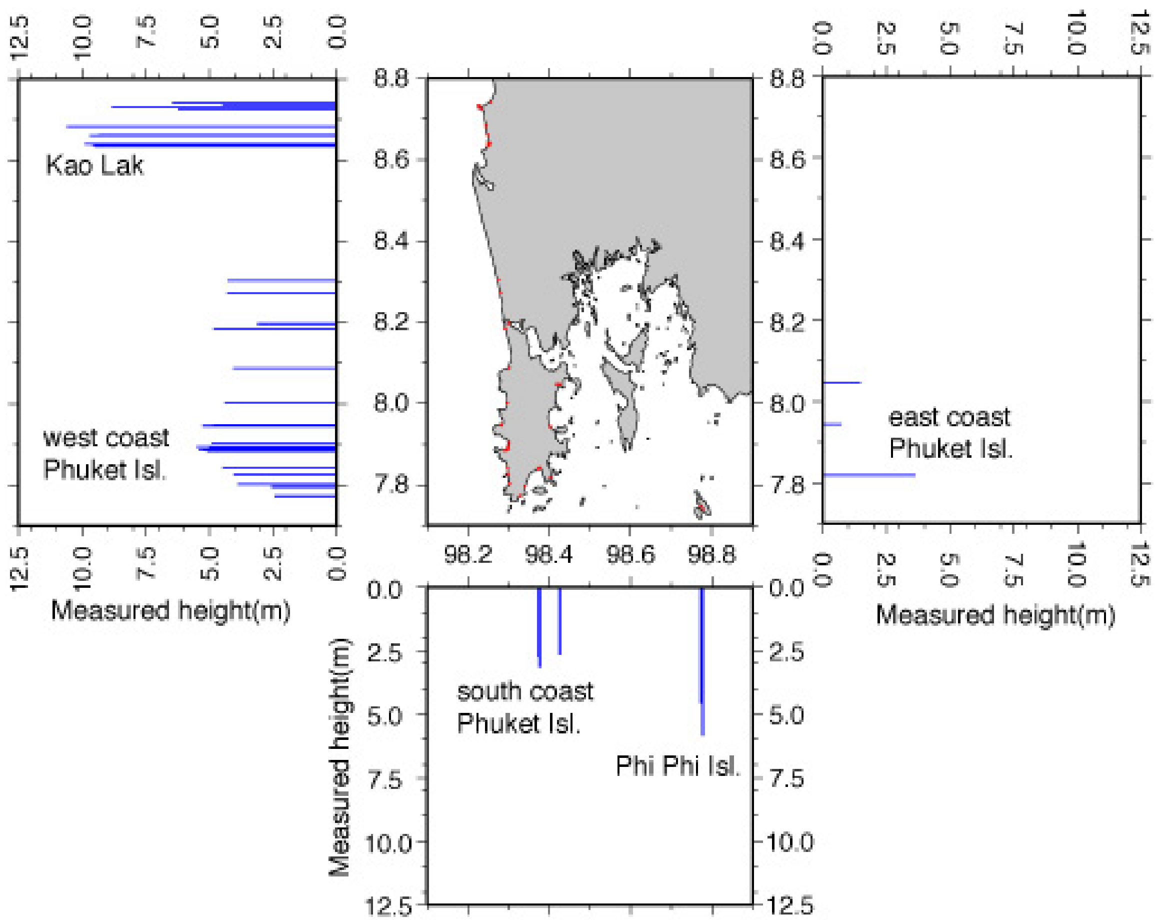
Exageration of submersion in estuaries or shores protected behind island



Depending of the location, fixing height thresholds between 5 and 10 m was a good choice for the coast directly exposed to tsunami wave

For coast protected by islands, capes or not exposed to west, wave heights and run-up reduced of a half



Conclusion for Thailand

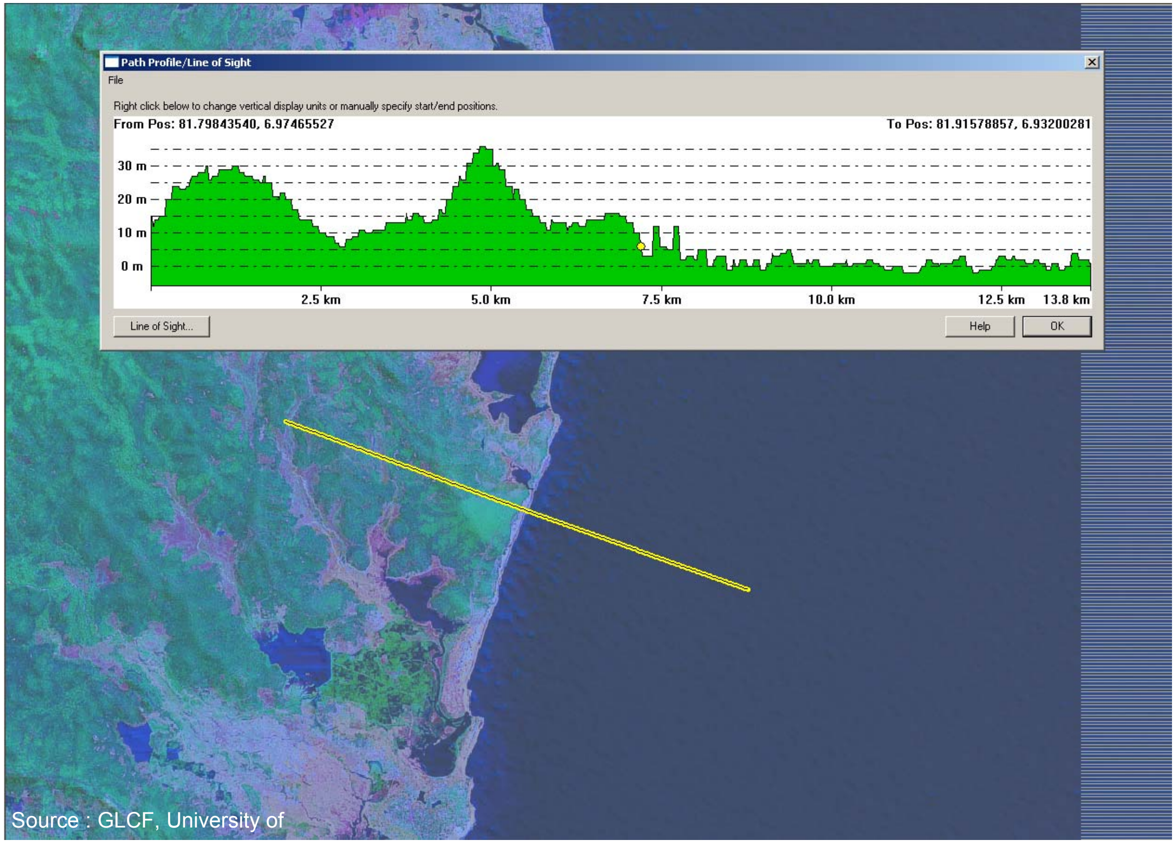
- Good hypothesis for coast directly hit by first wave before refaction around capes or behind islands

- Method was applied also to Myanmar but no apparent damages visibles on satellite images due to numerous islands which absorbed the main shock

Validation in Sri Lanka

Pretty good morphological quality and height accuracy

On East coast of Sri Lanka



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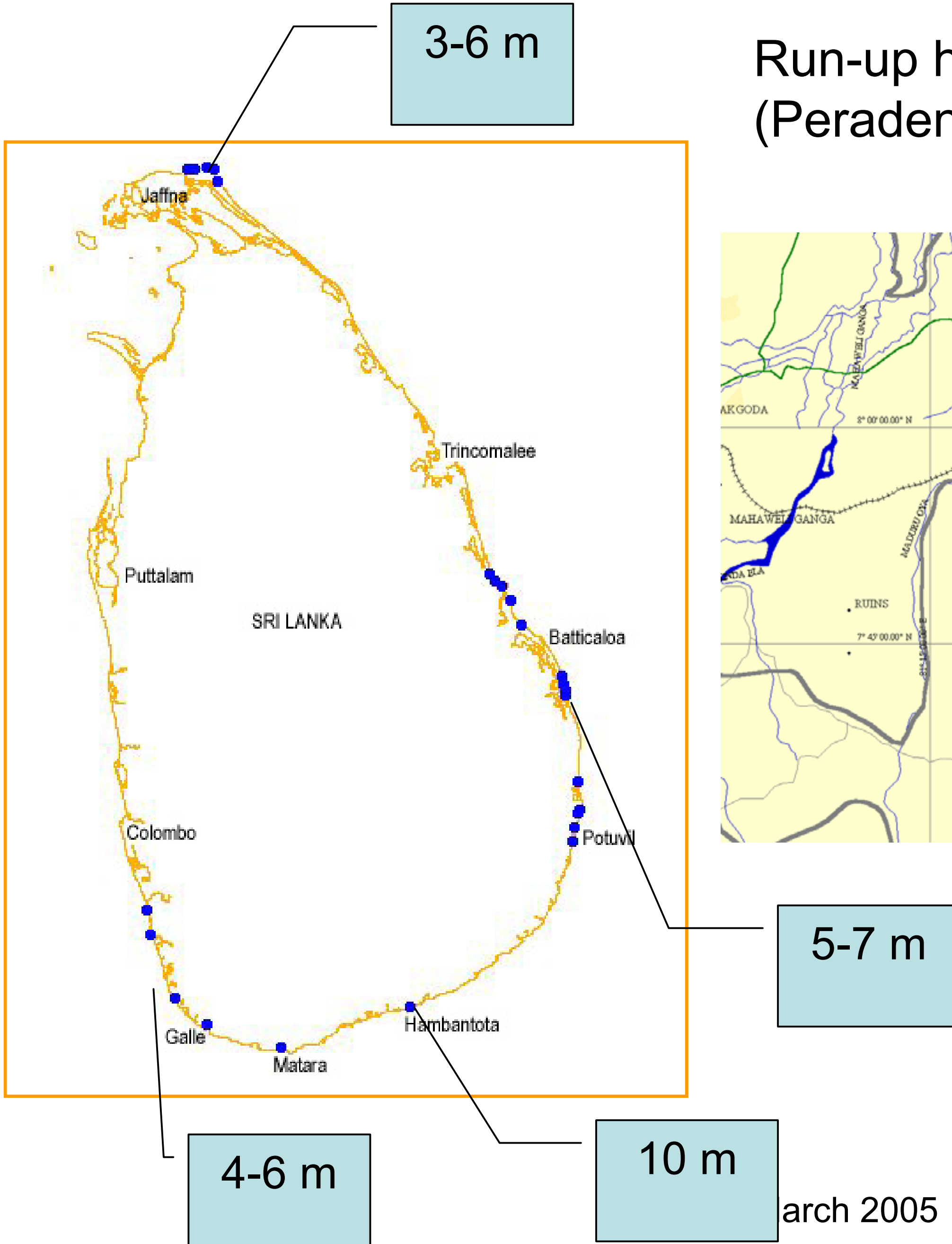
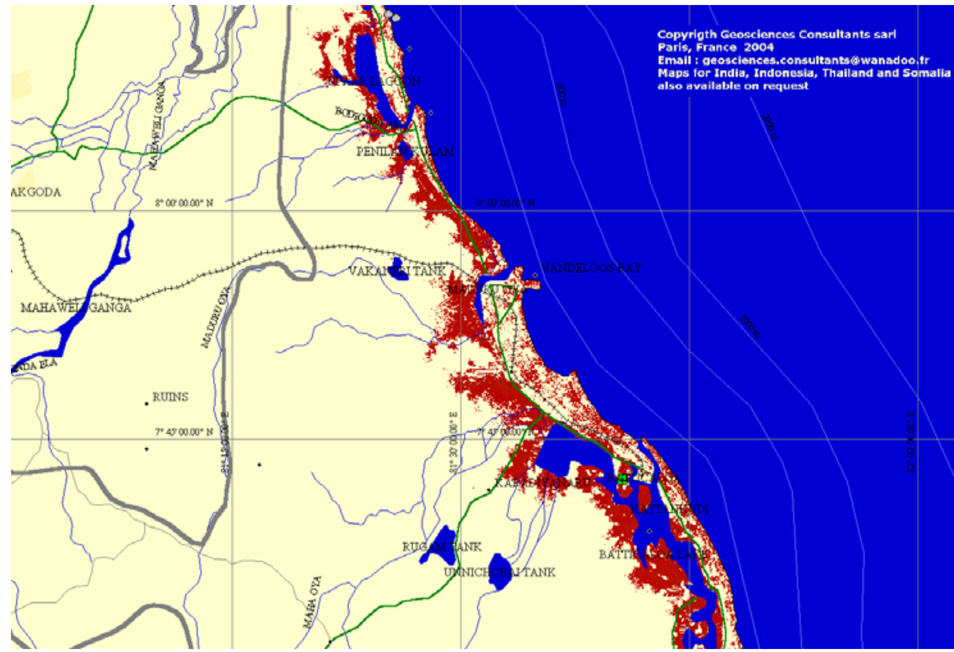
Run-up heights from field survey (Peradeniya university, Sri lanka)





Lowest coastal zones or shores well revealed but lowlands behind coastal dune strip also included (false alarm)

arch 2005

Chettipalayam – Potuvil, East coast

West coast
Kalutara

Quickbird image

EXCEPT ON SOME PARTS OF EAST COAST SUBMERSION WAS NOT ALWAYS DESTRUCTIVE AND DID NOT MODIFY COASTAL MORPHOLOGY IN A STRONG WAY, BUT FLOW WAS STRONG AND FAST ENOUGH TO KILL THOUSANDS OF PEOPLE.

Conclusion on Sri lanka

- Wave heights and run-up (3 to 7 m) are smaller than the range of value of SRTM DEM vertical error (5 to 10 m in Sri Lanka)
- Significant modifications of landcover and morphologies or destruction only on limited portions of east coast
- Inland penetration exagerated as east coast of Sri Lanka is mostly lowlands, wetlands with a dune strip along shore
- Most vulnerable and damaged areas are however detected along the shore
- False alarm for wetlands can be detected using baseline imagery
- Limited of method reached for wave heights of 5 to 7 m

Potential and limits of the method

- Worked quite well for assessment of damage extent in near field in areas with run-up higher than 5 m

- Exageration on Sri lanka but vulnerable areas detected and the help of auxiliary data allows to separate significant results from obvious errors

- A well suited method for global assessment of shores most exposed to deep penetration inland of inundation and run-up at large scale
- Better accuracy required for DEM and bathymetry for far field tsunamis or moderate wave heights (below 5 m) and local vulnerability assessment
- In a near future such new product should be distributed on dedicated platforms such as ORCHESTRA, respecting new standards (INSPIRE) if it does not induce too much complexity

Second part :

Impact assessment and characterization with a tsunami impact intensity scale

Based on a scales system developped by GSC in co-with Meteo France and Cemagref in 2003.

Context

✓ Project funded by French Ministry in charge of Ecology (MEDD)

✓ Aims : developing, in a general consistent way, intensity scales for natural phenomena: earthquakes, floods, forest fires, volcanic eruptions, landslides, mudflows and lahars, avalanches, tsunamis, atmospheric phenomena (storms, tornadoes, cyclones, black ice, snow, thunderstorms, hail)

✓ Project group under the lead of Geosciences Consultants in partnership with Météo-France and CEMAGREF

✓Only post-event description but potential use for pre-event hazard level assessment or crisis management.

✓Generic scale template inspired by HAZUS scale and other pre-existing scales with both physical values of the phenomenon and corresponding damage levels

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PRE-EXISTING TSUNAMI SCALES

Inamura & Lida

Murty

Sieberg

Soloviev

tsunami scale inspired from HAZUS, EMS98 and Modified Sieberg Sea-wave Intensity Scale

1	Very light. Wave so weak as to be perceptible only on tide-gauge records.
2	Light. Wave noticed by those living along the shore and familiar with the sea. On very flat shores generally noticed
3	Rather strong. Generally noticed. Flooding of gently sloping coasts. Light sailing vessels carried away on shore. Slight damage to light structures situated near the coasts. In estuaries reversal of the river flow some distance upstream.
4	Strong. Flooding of the shore to some depth. Lightscouring on man-made ground. Embankments and dikes damaged. Light structures near the coasts damaged. Solid structures on the coast injured. Bid sailing vessels and small ships drifted inland or carried out to sea. Coasts littered with floating debris.
5	Very strong. General flooding of the shore to some depth. Quay-walls and solid structures near the sea damaged. Light structures destroyed. Severe scouring of cultivated land and littering of the coast with floating items and sea animals. With the exception of big ships all other type of vessels carried inland or out to sea. Big bores in estuary rivers. Harbor works damaged. People drowned. Wave accompanied by strong roar.
6	Disastrous. Partial or complete destruction of manmade structures for some distance from the shore. Flooding of coasts to great depths. Big ships severely damaged. Trees uprooted or broken. Many casualties.

The Modified Sieberg Sea-wave Intensity Scale

Inamura & Lida scale

Imamura (1949) and Iida (1970

$$m = \log_2 H_m$$

$$H_m = 2^m$$

Hm is the maximum height of a Tsunami relating to the coast for an epicentre located between 10 and 300 km further. These magnitudes are defined as follows:

-1: Hm less than 0.5m; minor Tsunami.

0: Hm=1m; no damages.

1: Hm=2m; damages (ships broken and dragged to the coast).

2: Hm=4 à 6m; habitations destroyed; human deaths.

3: Hm=10 to 20m; damages observed in a 400 km radius area.

4: Hm=more than 30m; damages observed in a 500 km radius area.

Iida has also defined an equation linking m wih the earthquake magnitude which triggered the Tsunami:

$$m = 2.61M - 18.44$$

Murty scale

(derived from Inamura & Lida scale)

L'échelle de Murty, basée sur des observations attribuées à Imamura et lida, propose une classification des tsunamis en 5 niveaux, en combinant des propriétés physiques comme la hauteur de la vague avec une intensité de dommages possibles.

Degré	**Description**
-1	Tsunami mineur avec une hauteur maximum de vague inférieure à 0.5m
0	Hauteur maximal (h) de la vague de l'ordre de 1 m; sans dégâts
1	h est de l'ordre de 2m; maisons endommagées au long de la côte; bateaux projetés sur la plage
2	h est de l'ordre de 4-6m; certains maisons complètement endommagées, pertes de vies humaines
3	h est de l'ordre de 10-20m; Dégâts importants sur 400 km de côte
4	h supérieur à 50m; Dégâts importants sur plus de 500 km de côte

Tableau 1 : Echelle de Murty

Soloviev scale

$I = \log_2(\sqrt{2}H)$

H is wave height

Intensité	Hauteur maximum de la vague (m)	Description du tsunami
I	0.5	*Très léger.* Vagues saisies que par instruments de mésure
II	1	*Léger.* Vagues observées par les gens à proximité de la mer. Observations que sur des rives très plats.
III	2	*Assez grand.* Généralement observé. Inondations des rives à petite pente. Bateaux légers de pêche ou de loisir projetés sur la plage. Endommagements légers aux petites structures situées à proximité de la mer.
IV	4	*Grand*. Inondations sur les côtes à une certaine profondeur. Digues endommagées. Structures légères situées à proximité de côte endommagées. Structurels solides légèrement endommagées. .. Bateaux moyens projetés sur les côtes. Débris sur les plages. .
V	8	*Très grand*. Inondations générale de la côte. Quais et autres structures importants à proximité de mer endommagées. Structures légères détruites. Endommagement de champ et des plantations à proximité de la côte. A l'exception de très gros bateaux, la plupart se font projetés sur la côte. Ports endommagés. Larges mascarets dans les estuaires.
? VI	16	*Destructeur*. Endommagement partiel ou complet des structures jusqu'une certaine distance de la côte. Inondations des côtes à des profondeurs importants. Bateaux importants endommagés. Arbres arrachés. Victimes humaines.

The new scale

5 levels of impact

Correspondance between run-up/wave height and damages to different types of exposed elements at risk

Existing scale (Soloviev)	Classe	Physical parameters	Graphical scale	Potential damages to elements at risk				other observations
		Wave height		humans	Buildings	Infrastructures	Natural and rural environments	
I , II	1 weak	maximum run up or waves height lower than 1 m.	10% gray	Small or no injuries for people on beaches Evacuation possible	No or few damages to buildings immediately on low beaches	No damages	No damage, but loss of production	Very little vortex inside harbours Minor or no damages to boast anchored
III	2 moderate	Maximum run up or wave height of 2 m.	25%	High risk of drowning Fatalities and injuries due to shock with object projected and pulled by the wave	Minor damages to buildings and houses located along low beaches.	Wooden structure may be damaged and light structures along the shore or in harbours Debris deposited in city streets Limited damages to lifelines. Little or no interruption.	Gentle slopes shores are invaded Wetlands are invaded by see water Estuaries partially invaded	Small beaches invaded, small sea water ponds created behind shore line Small boats brought to beaches
IV	3 moderate to strong	Maximum run up or wave height up to 4 m.	50%	Likely fatalities Numerous injured by shock with objects brought by flood People brought by tidal wave several hundreds of meters inland	Low damages or perturbations to major concrete or masonry buildings. Light or mobile structures partially or totally destroyed.	Damages to light dykes or wharfs damages to lifelines causing temporary service interruption Cars are brought away by front waves or flood	Debris on beaches and low coast Small flooded areas Sand and mud deposit generalized in low lands	Medium size boats projected on beaches or wharf in harbours Pockets of sea water and sediment deposited inland.
V	4 strong	Maximum run up or wave height below 15 m.	75%	Numerous fatalities Numerous injured people Few find refuge in trees or upper floors of buildings Dead people found several kilometres of shore	Weak or temporary construction all destroyed. Concrete and masonry buildings partially destroyed or damaged, mostly along shore by percussion with boats or cars Damages observed far inland	Important damages to harbour infrastructures : wharfs, docks, etc Destruction of portions of roads or railroads along shoreline Most of lifelines are destroyed	General flooding on low coast sometime several hundreds of meters inland. Tidal waves invading estuaries Numerous trees destroyed Crops and agriculture destroyed due to invasion by sea water and debris or deposits. Run-up reaching several meters above wave height	Except major boat anchored far from shore, most boats are projected inland or on wharf, and destroyed Large surfaces invaded by sea water
VI	5 catastroph ic	Maximum run up or wave height over 15 m.	100%	No survivors in area affected by run up of flood	Massive destructions very far inland, Except major concrete buildings, all others are totally destroyed. If close to earthquake epicentre, even strongest buildings devastated.	Major damages to harbour infrastructures Bridges, wharf, docs, destroyed when close to shore Huge amount of debris accumulated in streets Roads and railroads destroyed No lifelines remaining	All vegetation destroyed Thick blanket of debris and deposits inland Penetration of run up and flood several kilometres inland Major contamination of soils and wells remaining improper for agriculture for years. Modification of low coast line and beaches morphology Run-up along steep slopes reaching tens of meters above sea level.	Very big ships severely damaged in harbours Many ships sunk or projected on wharf or inland, sometimes on several kilometres Extended sea water surfaces remaining inland

Similar scale system exist and tested for :

- Volcanic eruptions
- Earthquakes
- Landslides
- Hurricanes
- Storms
- Hail
- Thunderstorms
- Black ice
- Snowfalls
- 3 types of Floods (slow, fast, water table uplift)
- Mudflows
- Forest fires
- avalanches

Required characteristics of scales

- 5 levels of intensities
- For *a posteriori* characterization
- Common presentation for different phenomena
- Adaptation if well-known scale exists.
- Available for local characterization (district scale ≈10km2) and event-characterization.
- Qualitative and quantitative criteria derived from on-field observations or classical physical measurements
- Independent of local vulnerability
- Workable and understandable by non-specialists
- Test and Validation (by producers and end-users)

Key points of work

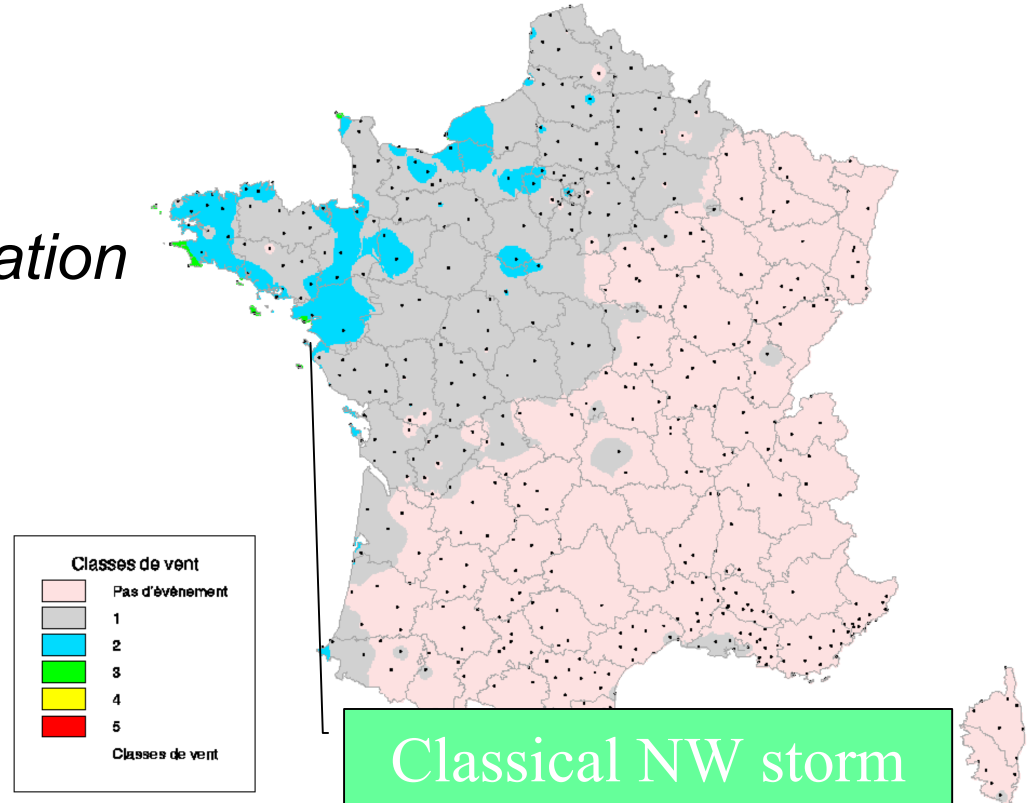
- Main challenge for the intensity criteria : to reach a **compromise** between accessibility and representativity.
- Main difficulty for damaging criteria : to establish a set of **standard stakes**, independent of local specific vulnerabilities : Hazus classification (FEMA USGS)
- Designed to be applied for hazards with very limited extension as well as extremely extended impact areas.
- Applicable anywhere with qualification criteria always available if no physical measures or monitoring network of natural event exists
- Elementary cell for characterization of intensity in France : the municipality (average surface 15 km²)

Purpose of scales :

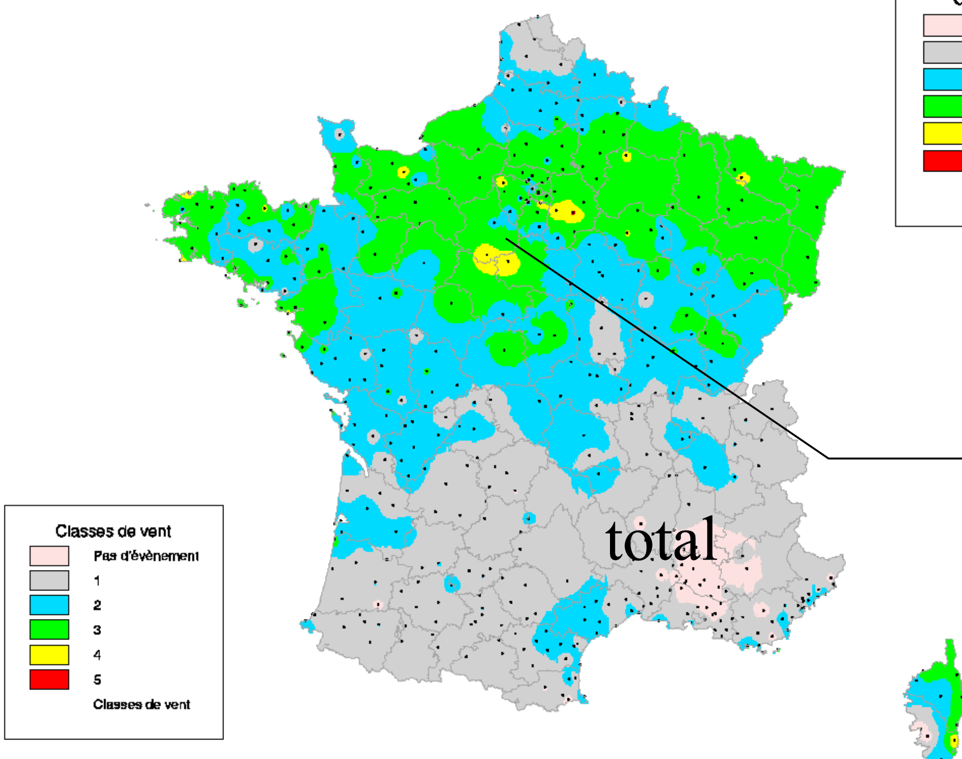
- Memory of events
- Comparison of events (successive on same territory or in different areas
- Implementation of prevention, mitigation policies

Characterization of limited or large event

definition of a Cumulative Intensity Index compatible with GIS representation



Classical NW storm
From 0 to 3
Σ= 3864



Dec99 storm#1
From 0 to 5
Σ= 15146

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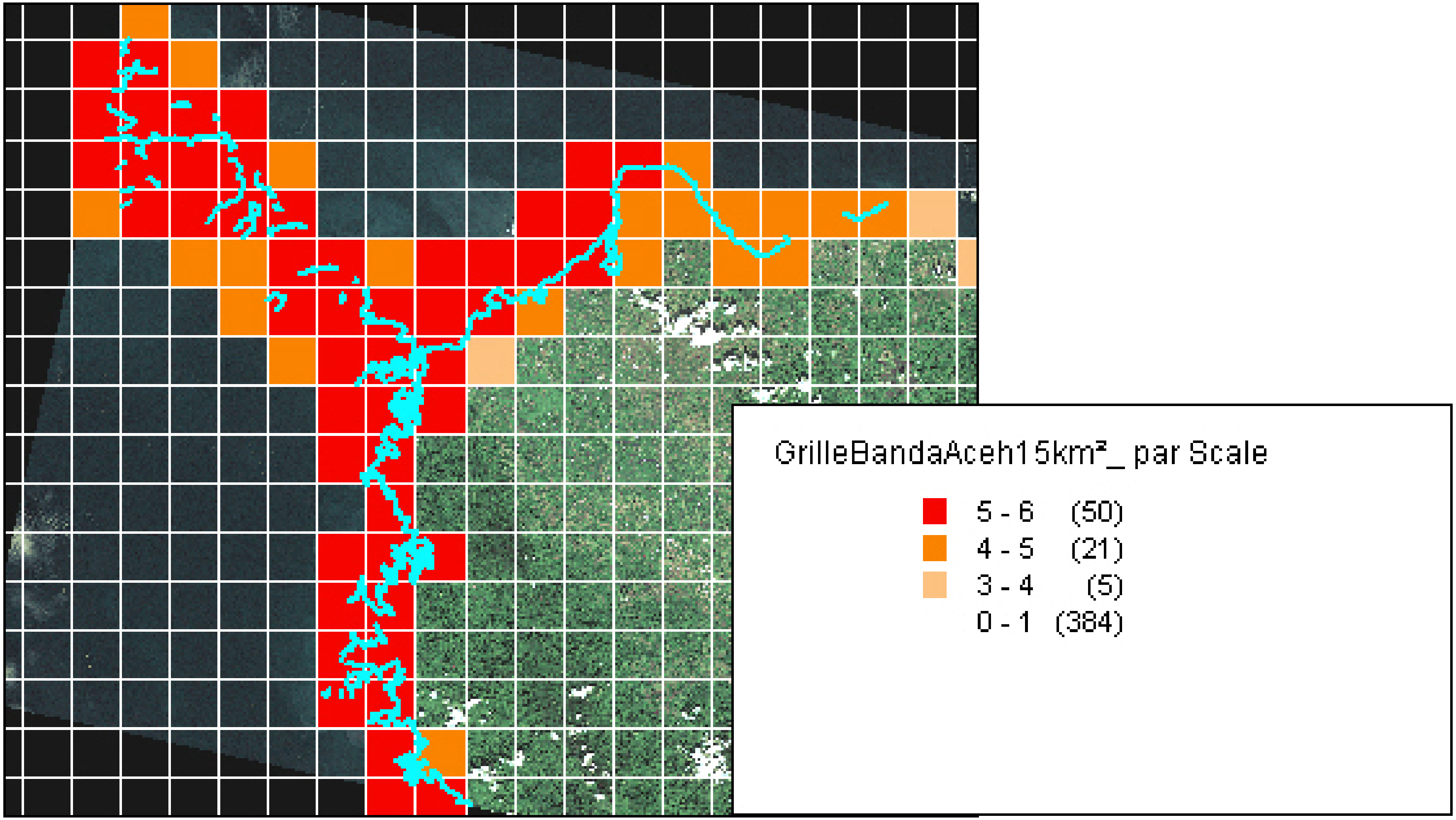
Application of tsunami scale on 26th Dec. event

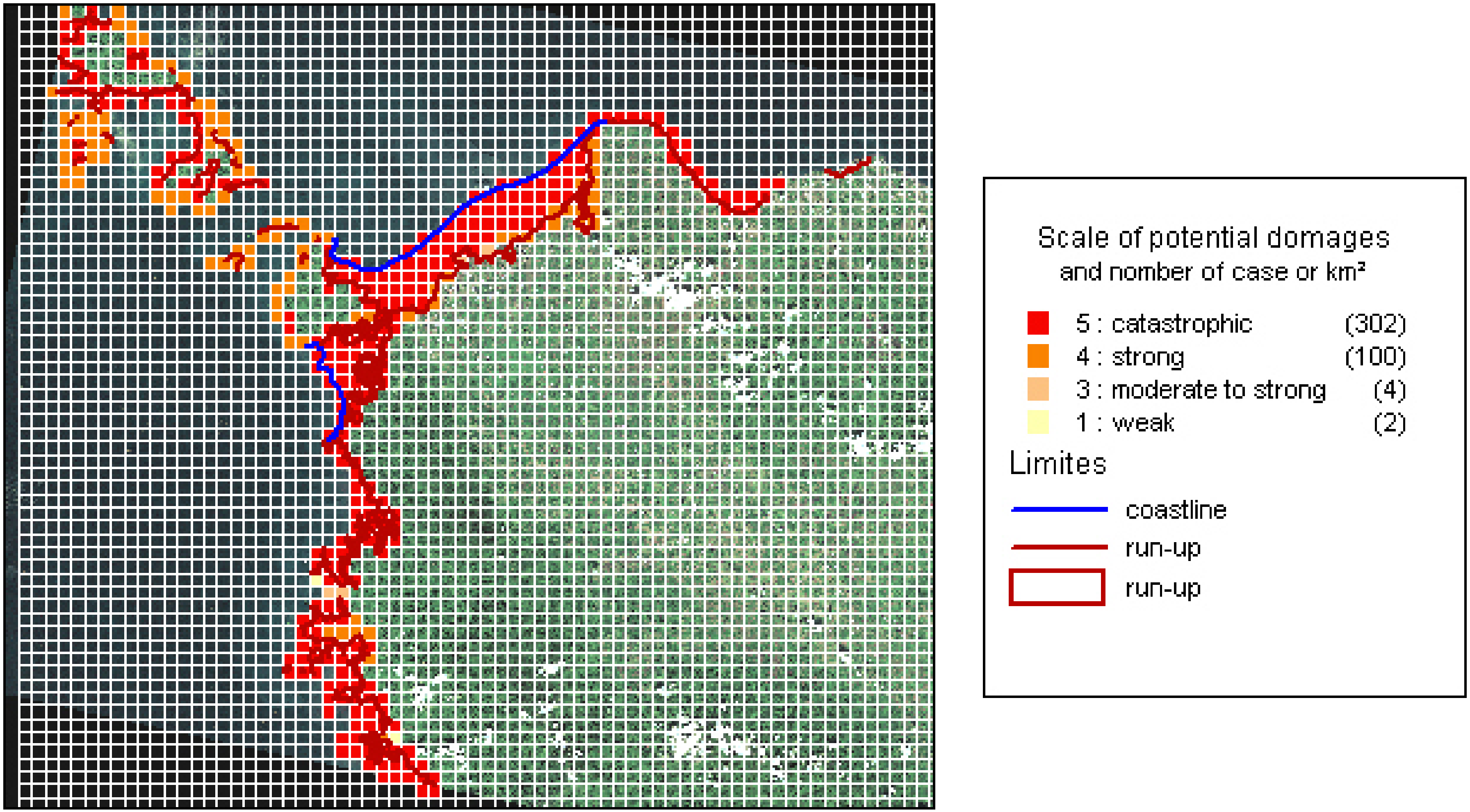
- No field survey yet, but appears difficult due to the extent and difficult access to affected areas : we chose to try mapping from satellite imagery
- A good preliminary base for detection of areas with high vulnerability
- Approach by regular grid or by homogeneous zone

5 x 5 km grid (too coarse)



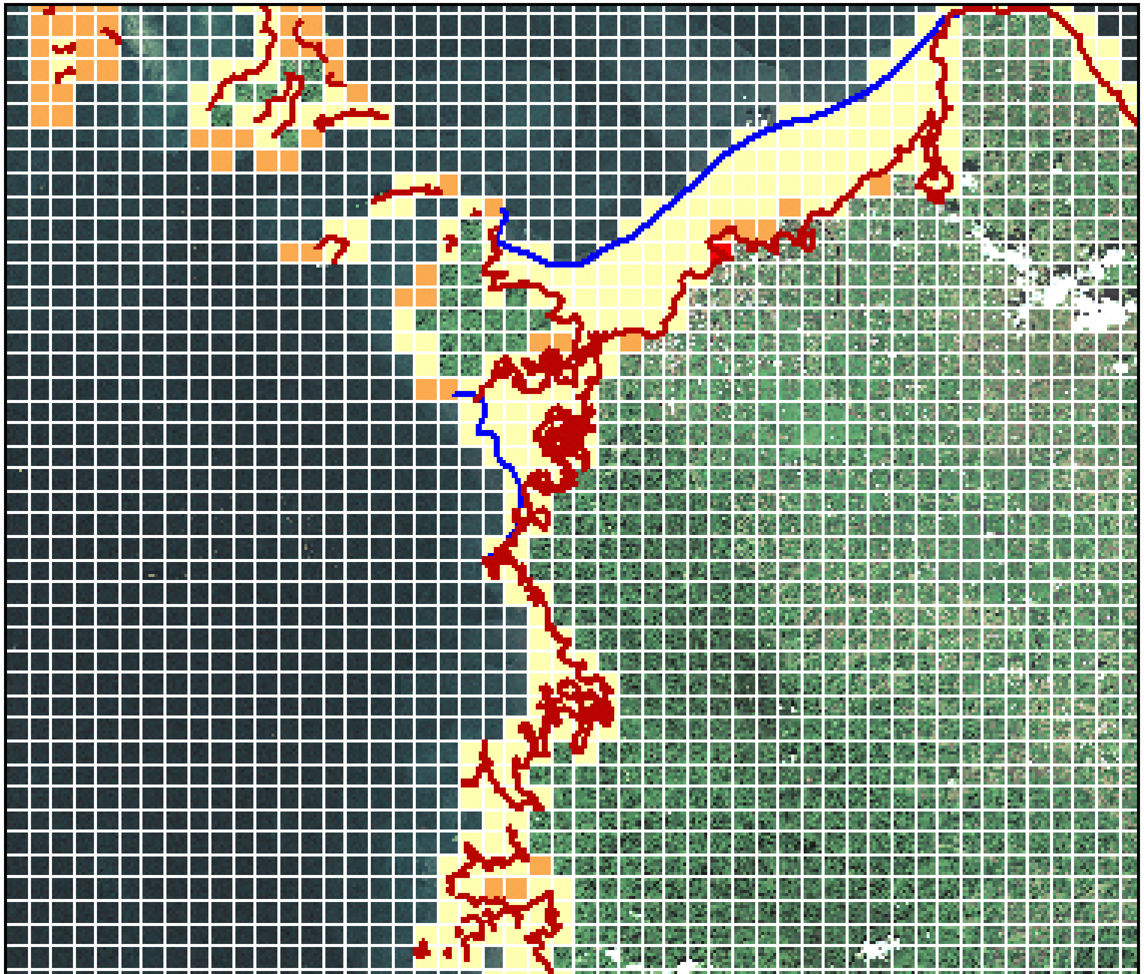
Source : SPOTIMAGE

1 x 1 km grid (adapted)



Source : SPOTIMAGE

Quality and validation grid (required if use in emergency and relied phase)



Source : SPOTIMAGE

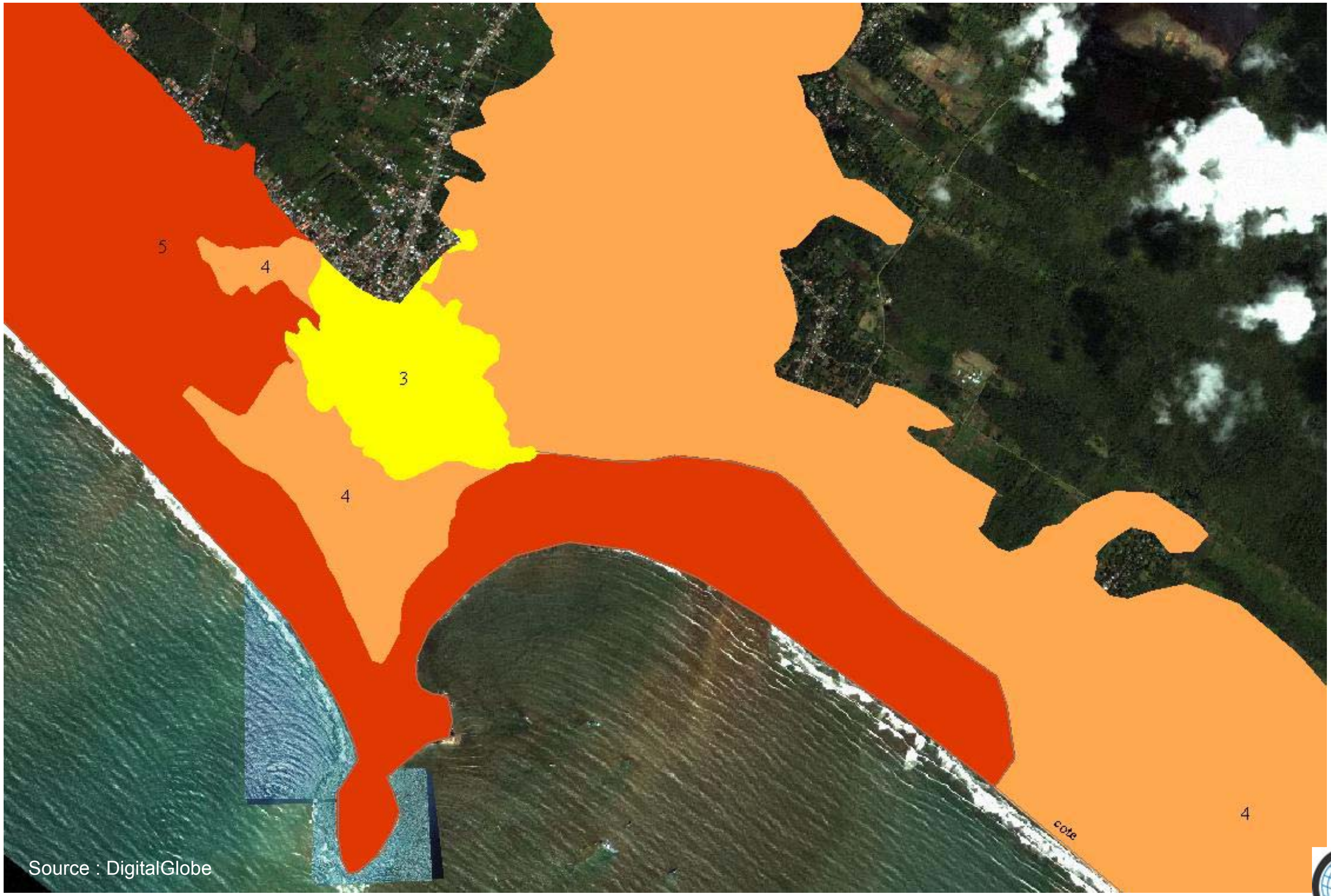
Reliability's level
and le nomber of case

3 : doubtful (1)
2 : means (69)
1 : sure (338)

Limites

Coastline
Run-up
Run-up

Homogeneous zones interpreted from very high resolution imagery or/and field surveys



Preliminary results

- Tentative application of scale using space imagery
- Regular grid not necessarily the best solution
- 1 x 1 cell size is good for Sumatra but not for Sri Lanka where cell size must be smaller

THIRD PART

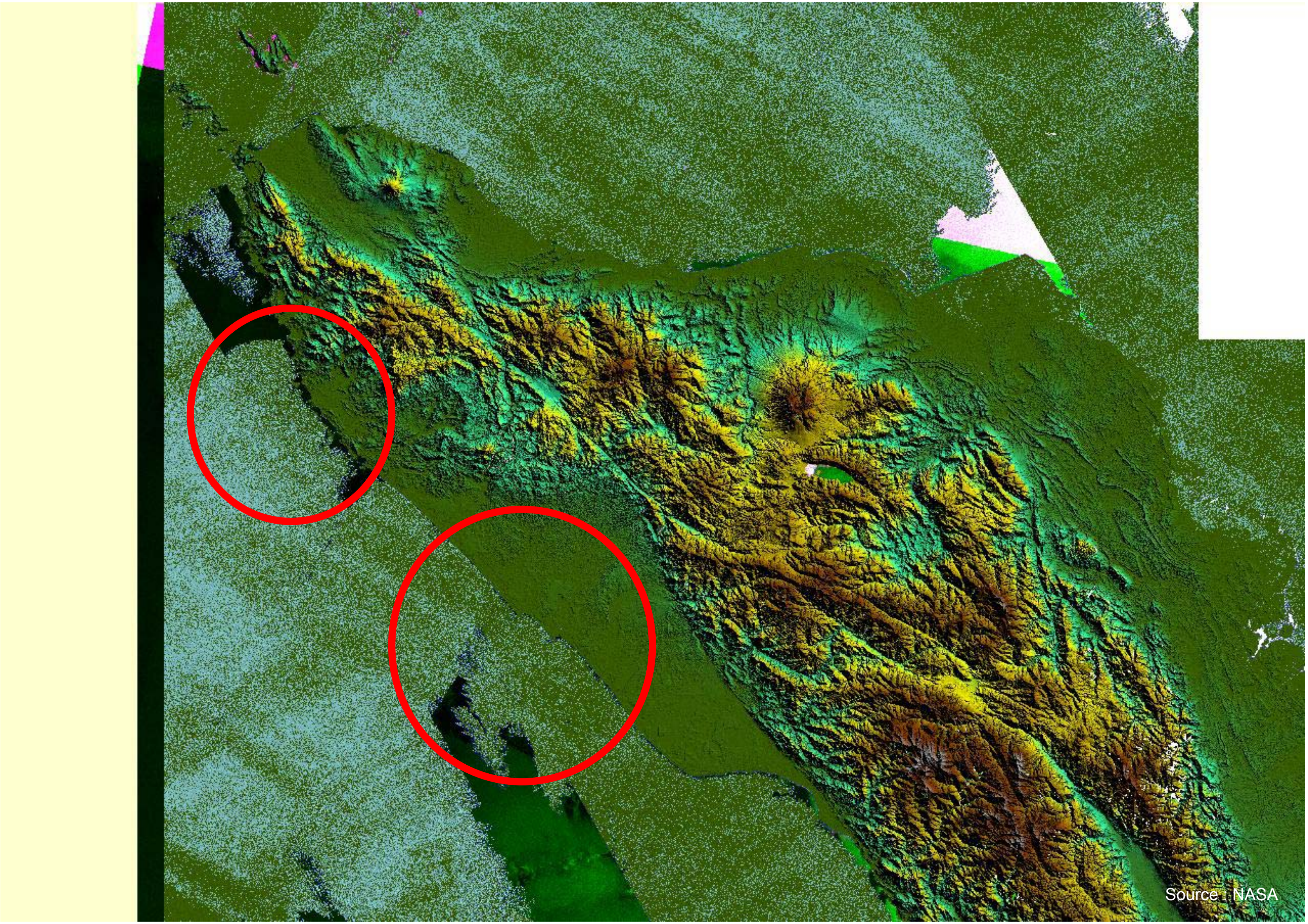
Fast mapping of tsunami damages extent based on ENVISAT ASAR wide swath images

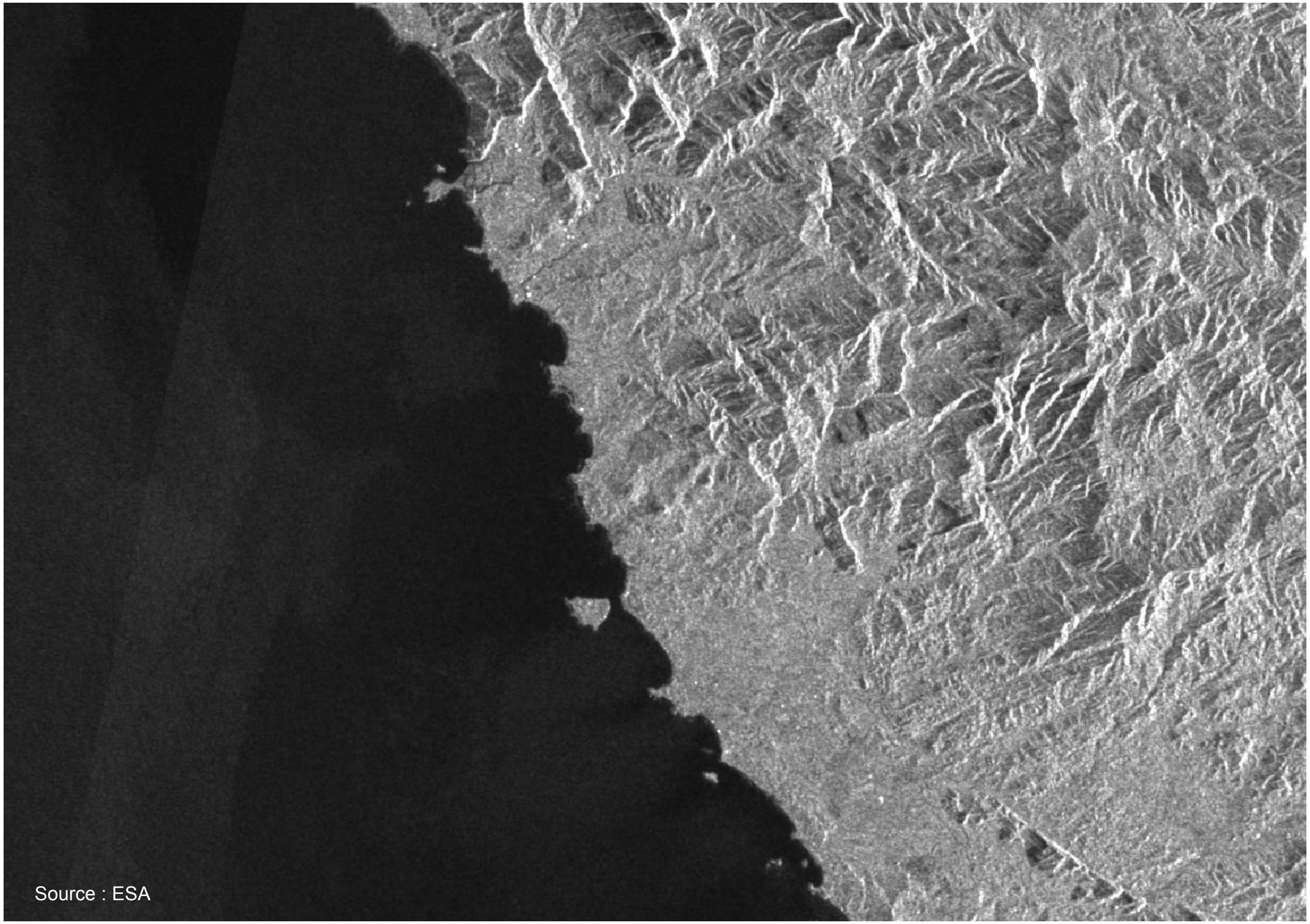
Data provided by ESA under Mass-ser-o2 contract

We know this would work with ASAR NS (25 m pixel) but decided to use ASAR WS (75 m pixel) for its wide swath (400 km) and long extent (1000 km) considering the extension of the disaster.

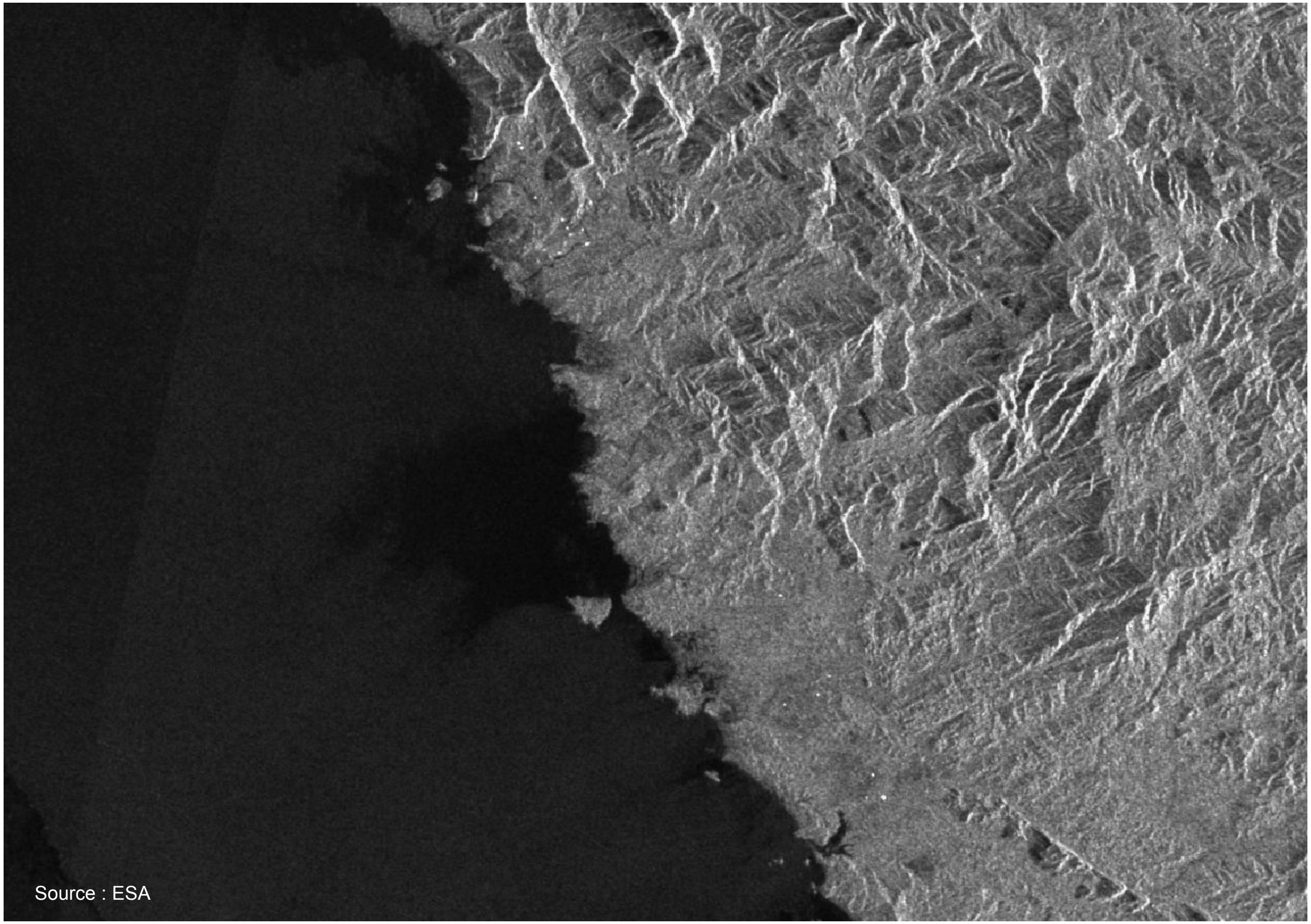
Whole extent in Samatra, Thailand and Sri Lanka covered by 3 scenes

Test area on ASAR WS data of Sumatra



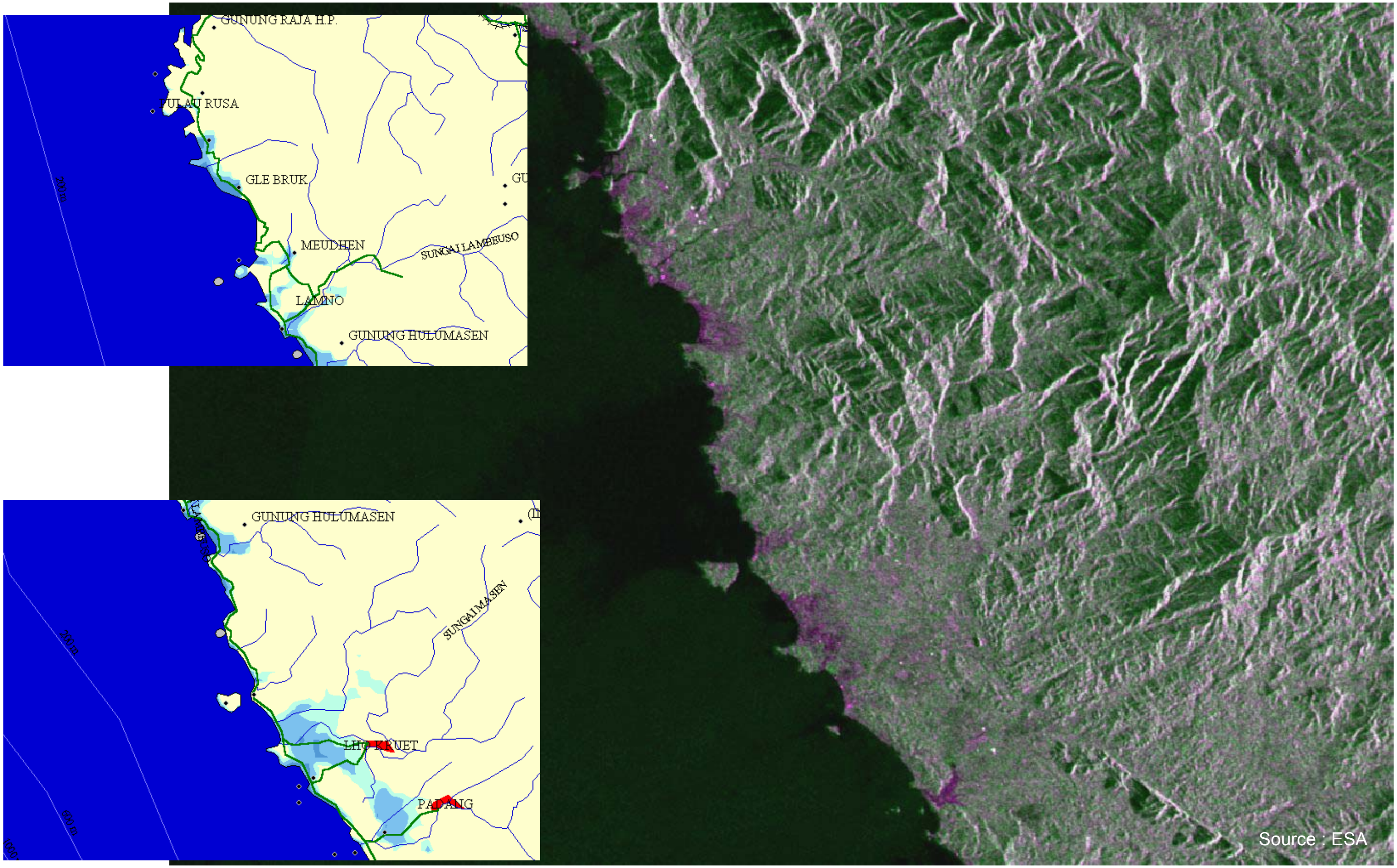


ASAR WS 17 Feb 04

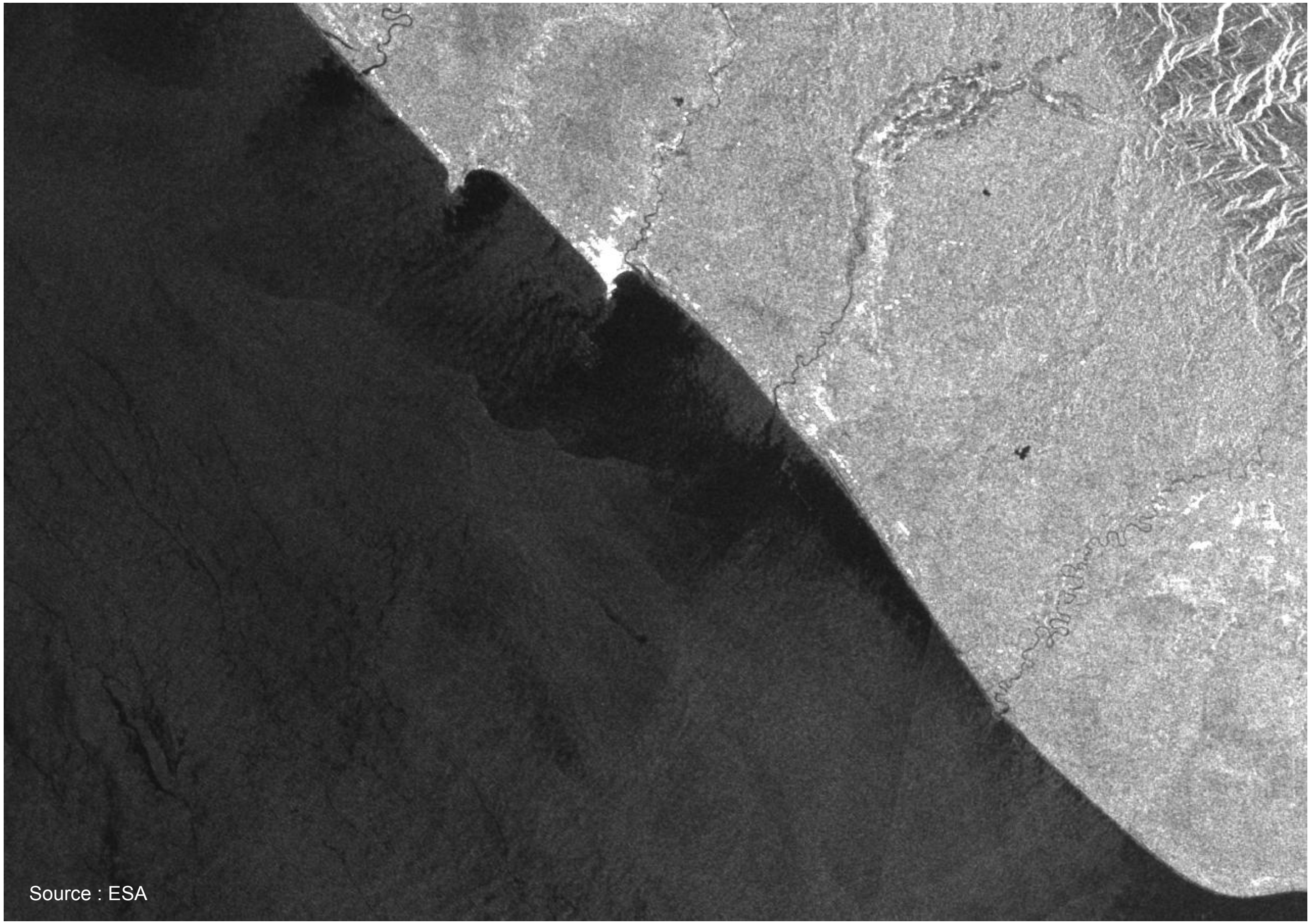


ASAR WS 31 Dec 04

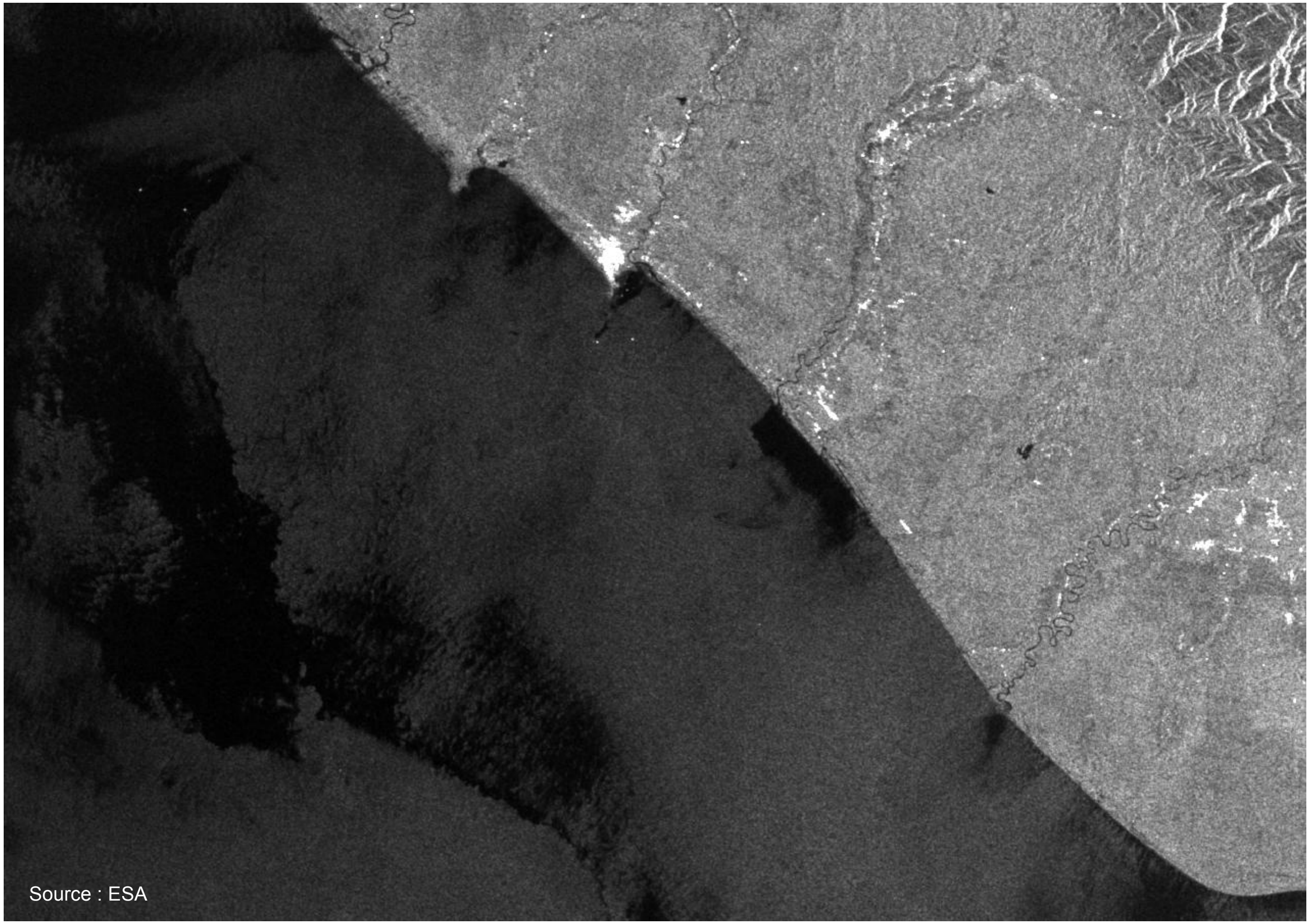
Major changes to coastal line becoming fuzzy and withdrawn of several tens of pixel in some places + missing major reflectors along shore after tsunami



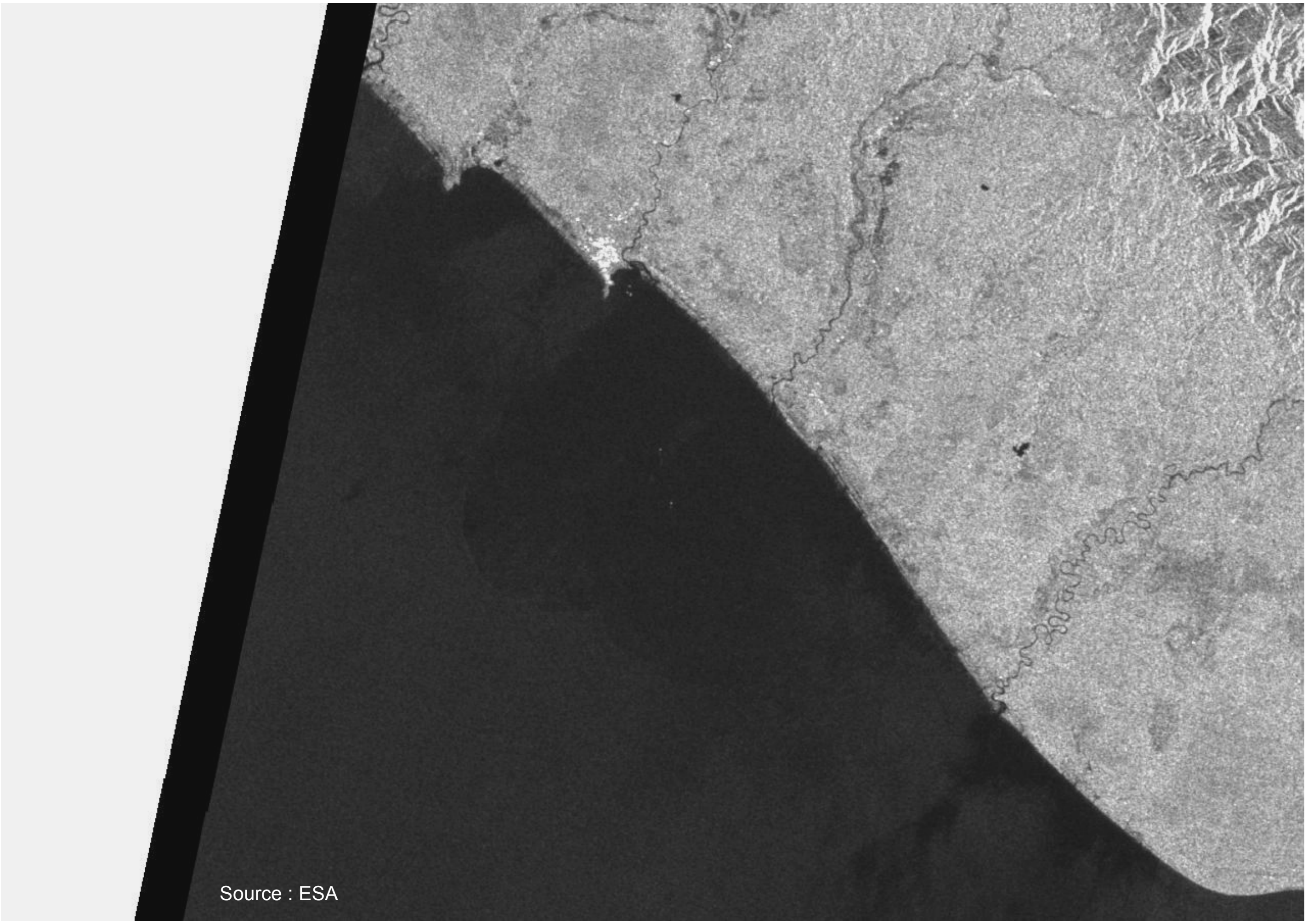
Color comp ASAR WS R : after G : before : B: after



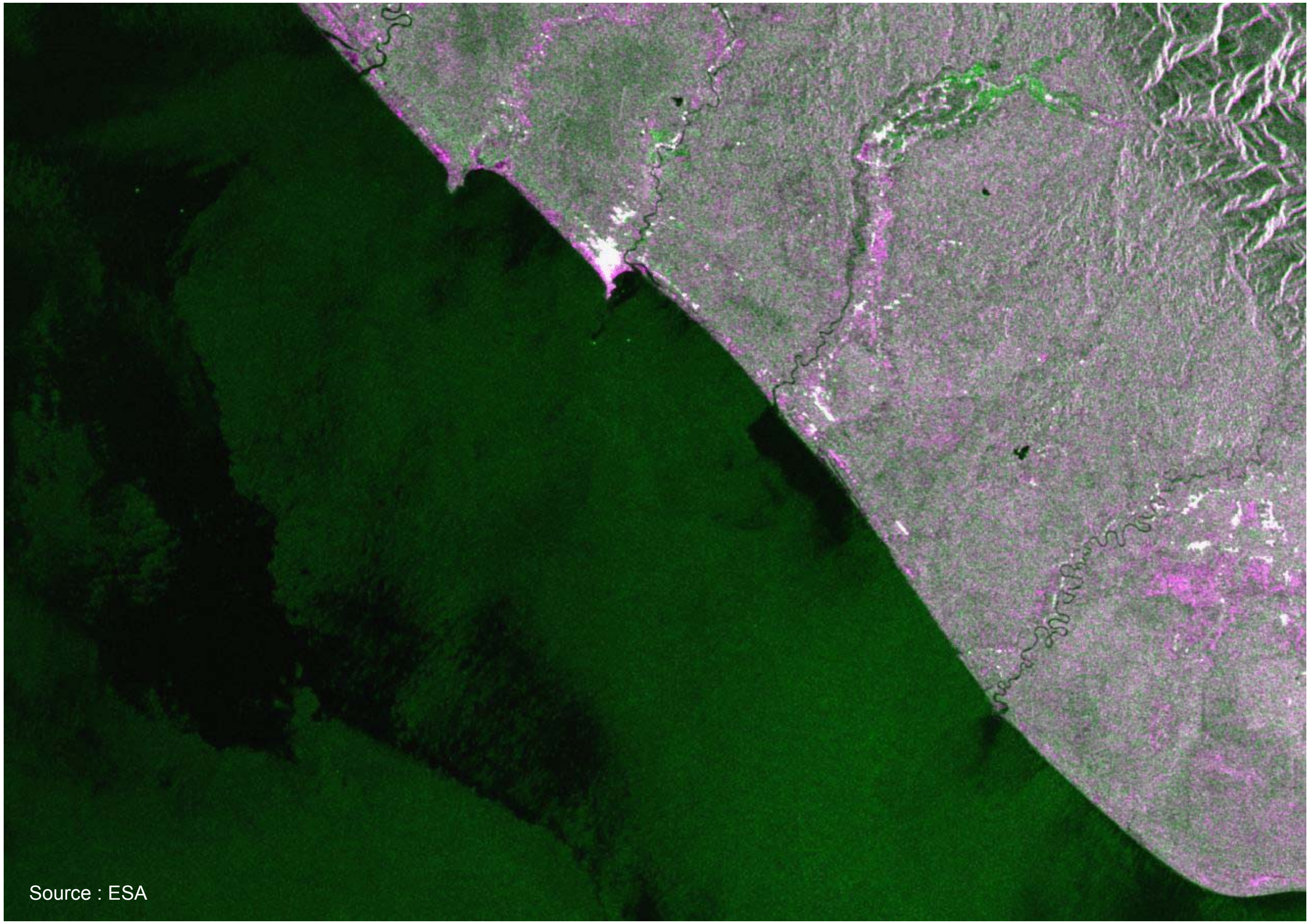
ASAR WS 17 Feb 04



ASAR WS 22 Jan 05



ASAR WS 31 Dec 04

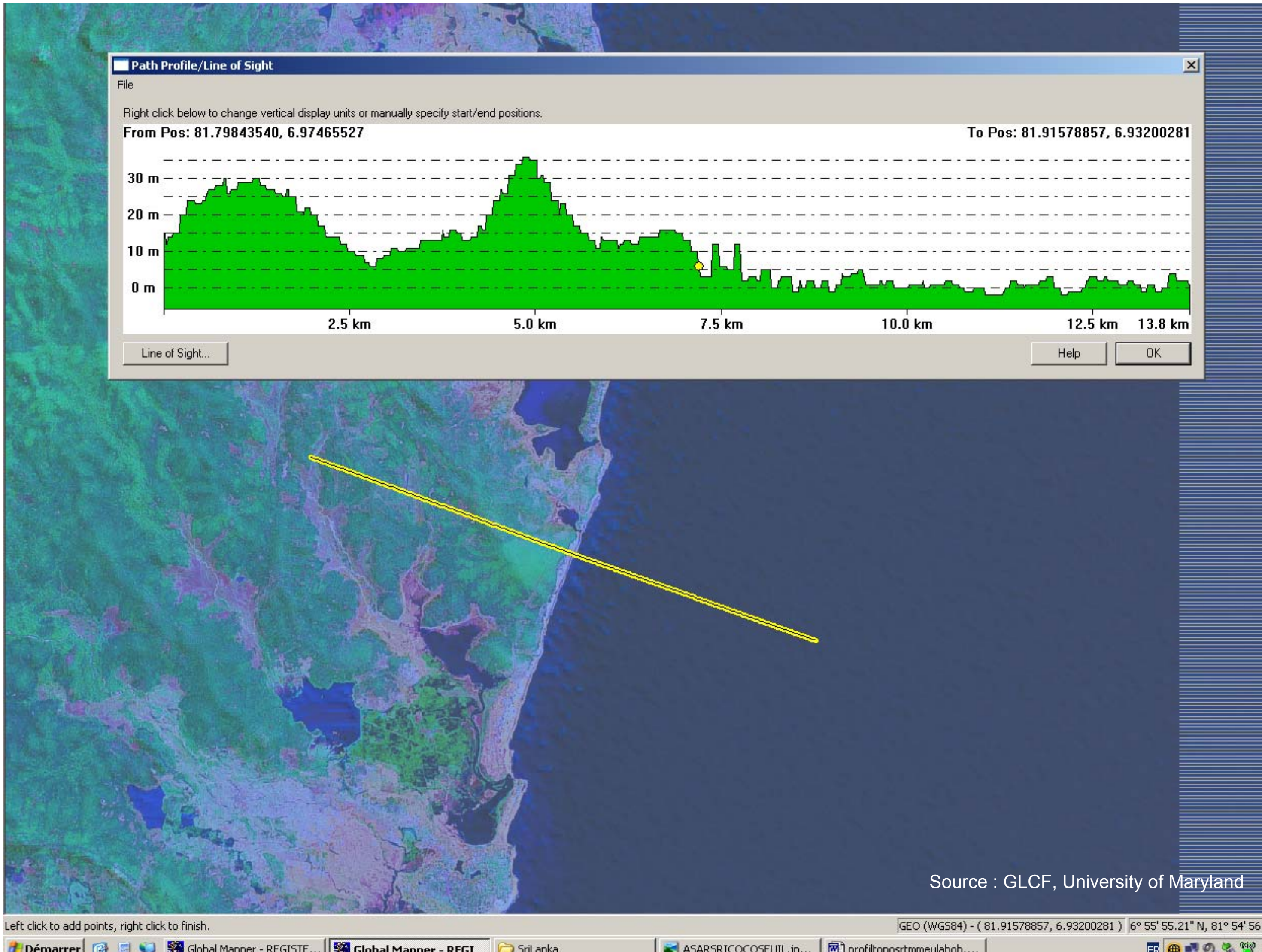


Color comp ASAR WS R : after G : before : B: after

Very detectable changes on shores disappearing on southern part. Attenuation of impact confirmed also by VHR optical images

Similar analysis on Sri lanka

- Highest run-up known of 12 m, no waves higher than 10 m reported
- Much less changes on land surface than in Sumatra except on some areas on Eastern coast
- Many areas of severe destruction on buildings but with little changes in vegetation cover
- Many areas with high death toll of people drowned with no major damages to infrastructures, vegetation, etc.. Not detectable on ASAR NS or WS



Source : GLCF, University of Maryland

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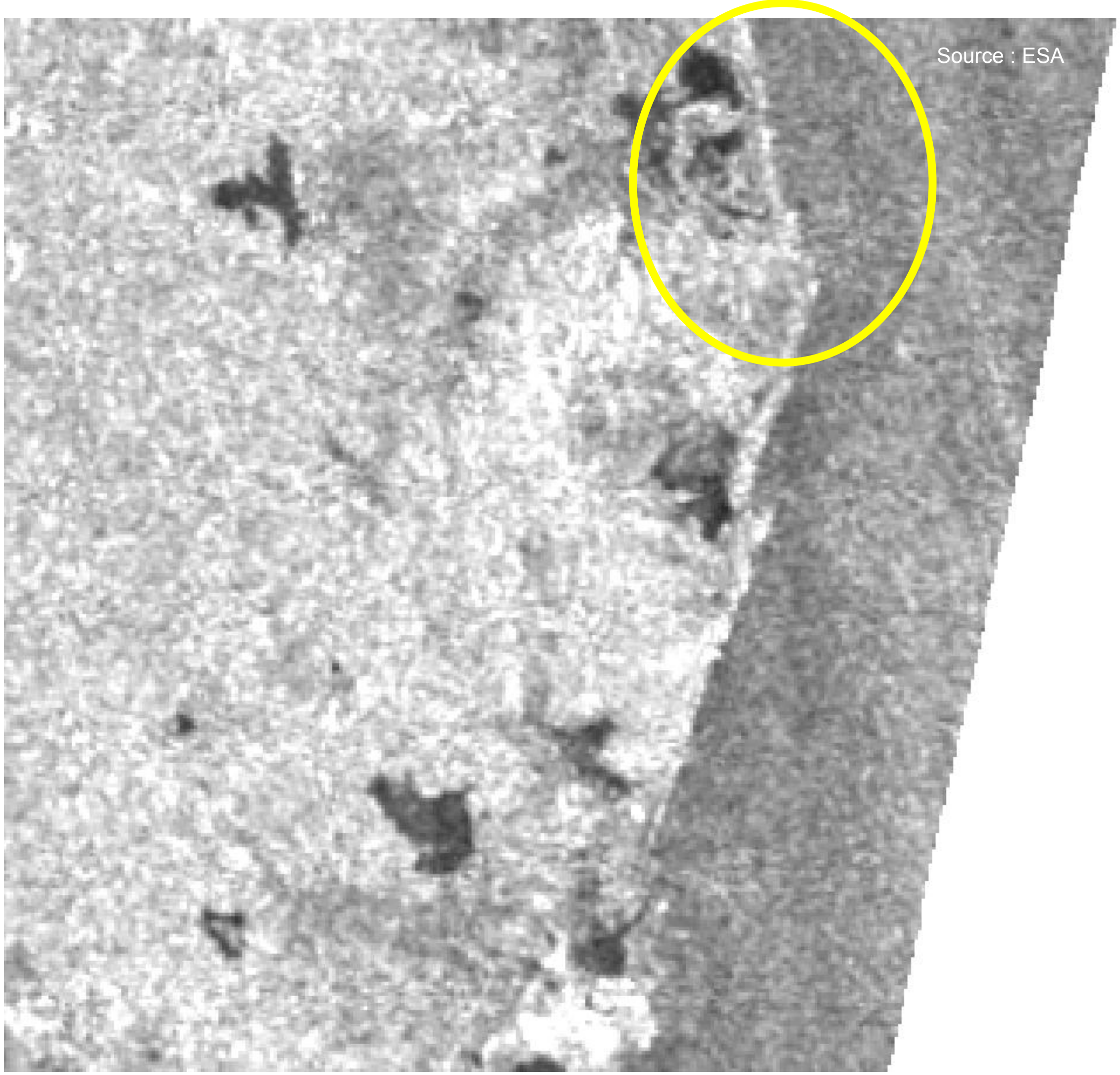
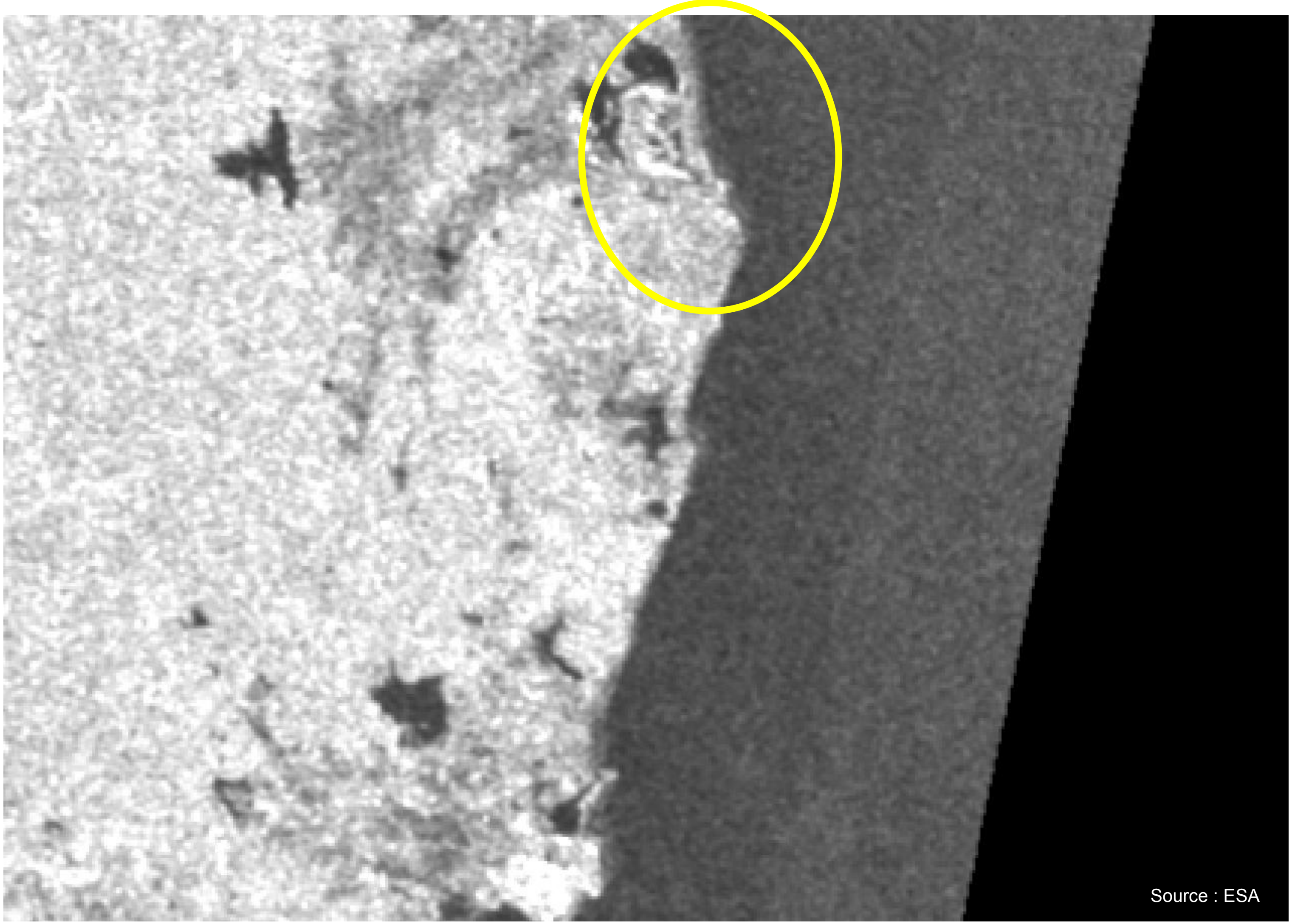
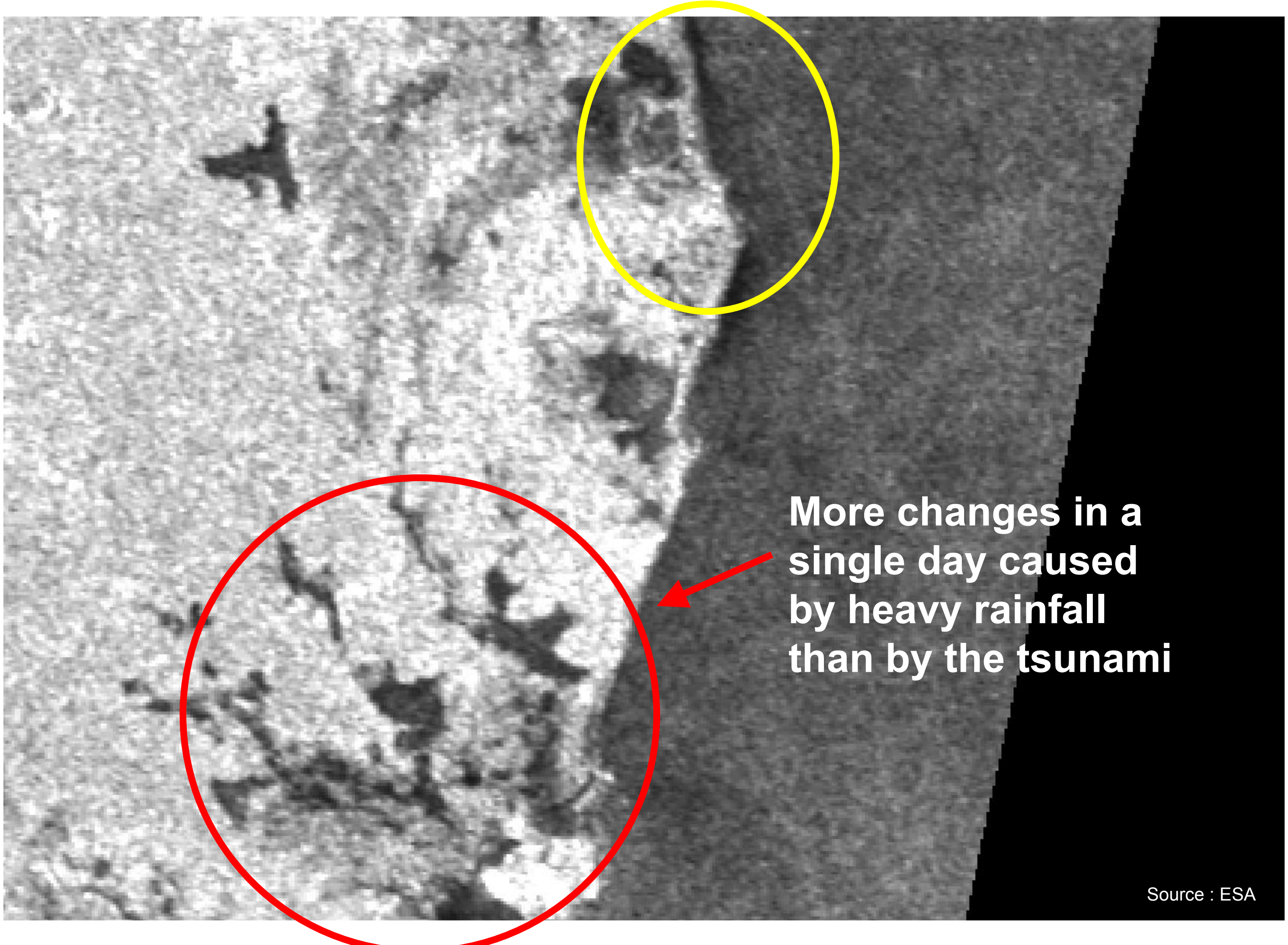


ASAR WS 17 Feb 04



ASAR WS 31 Dec 04



ASAR WS 1 Jan 05

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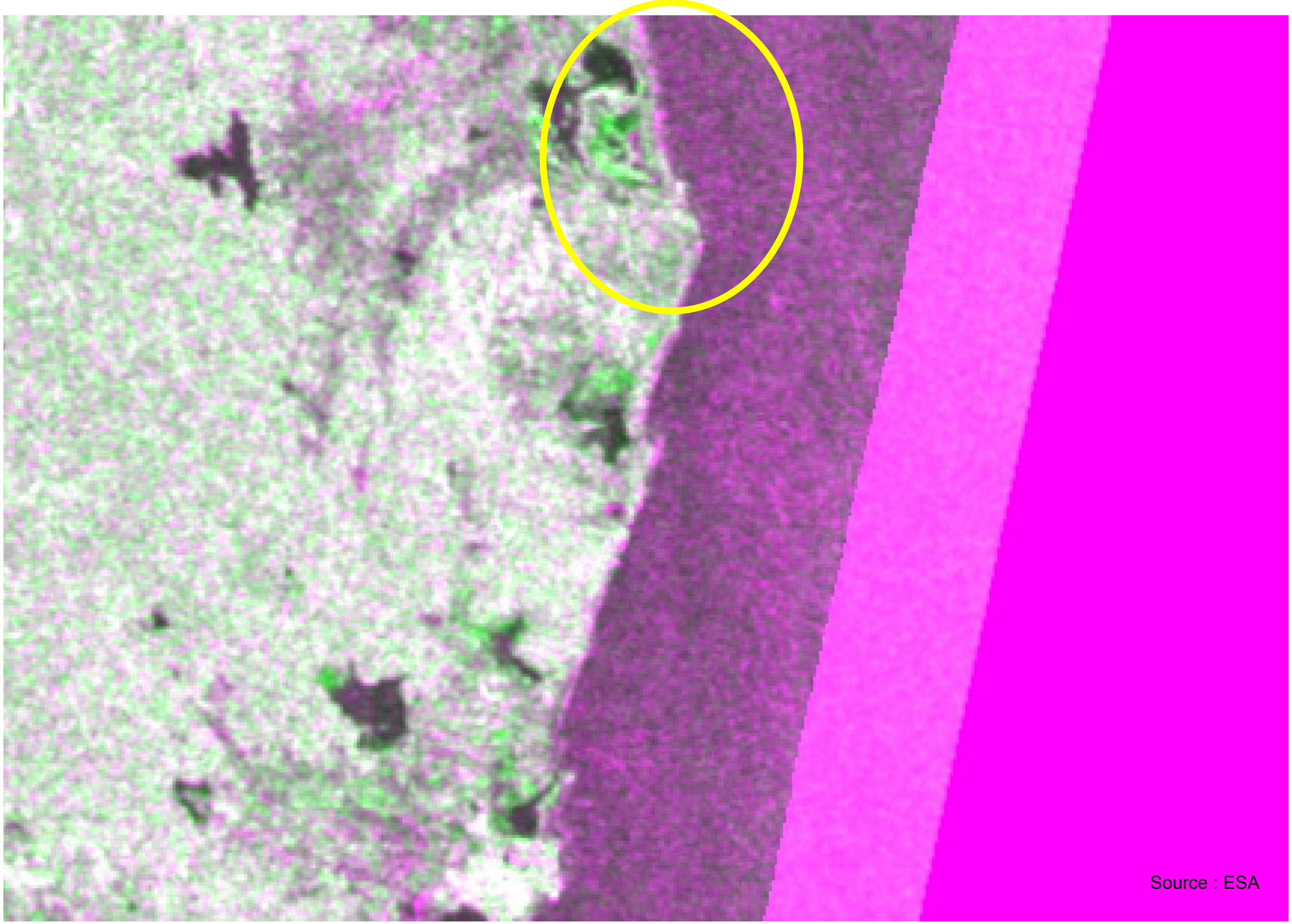
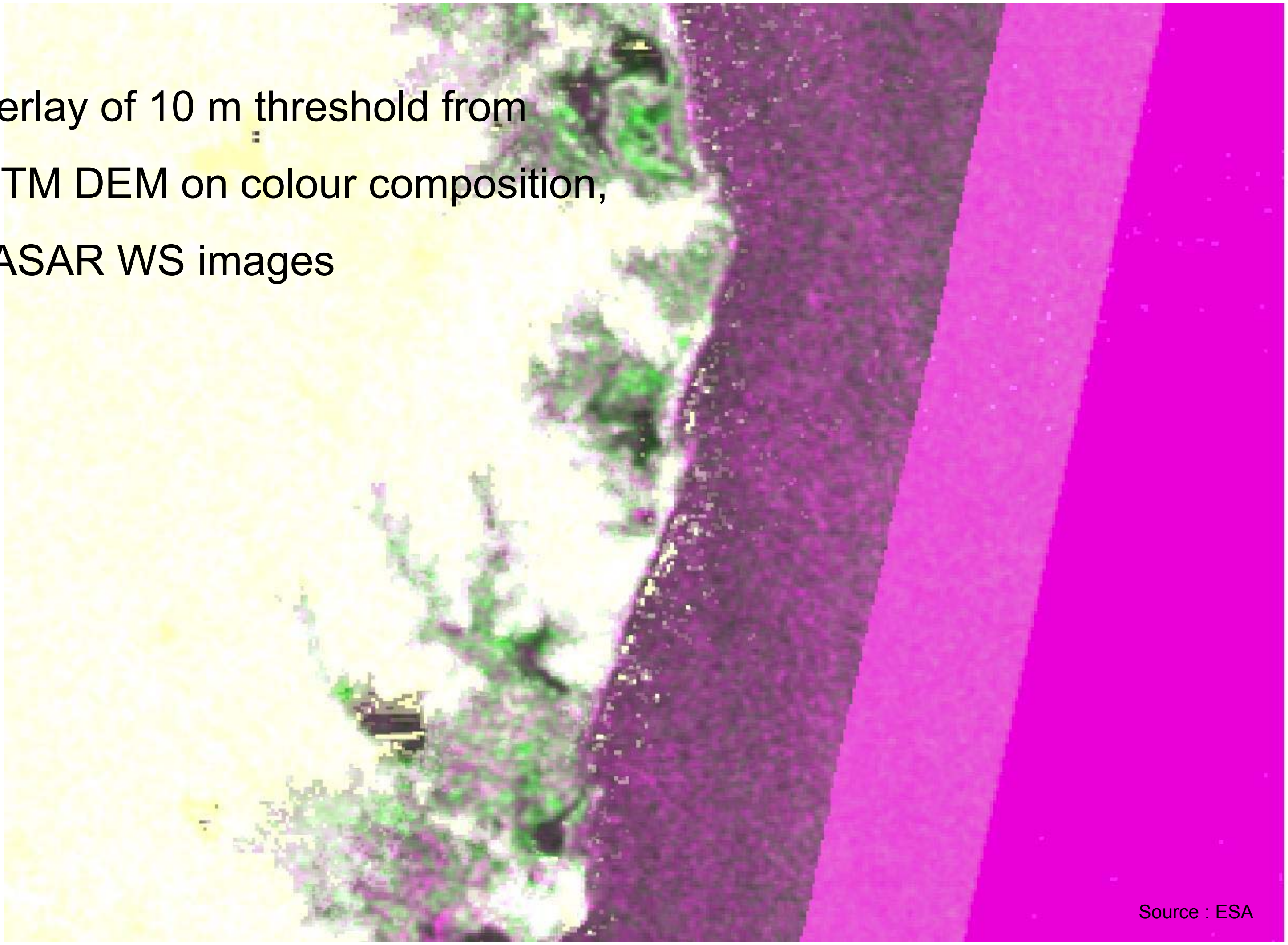


It Is possible to point out places where total destruction are sure along the shore

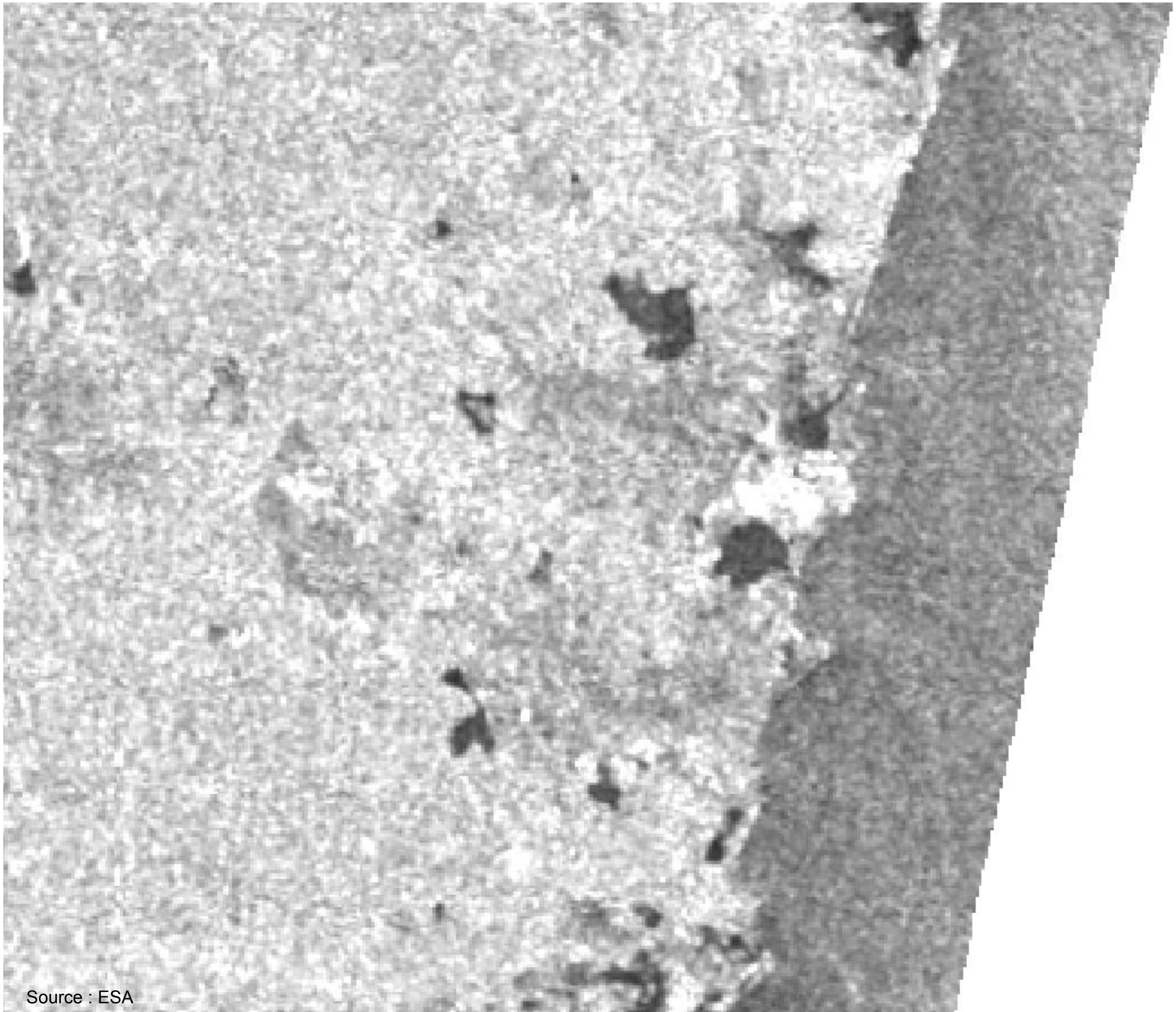
Overlay of 10 m threshold from

SRTM DEM on colour composition,

of ASAR WS images



Source : ESA



ASAR WS 17 Feb 04

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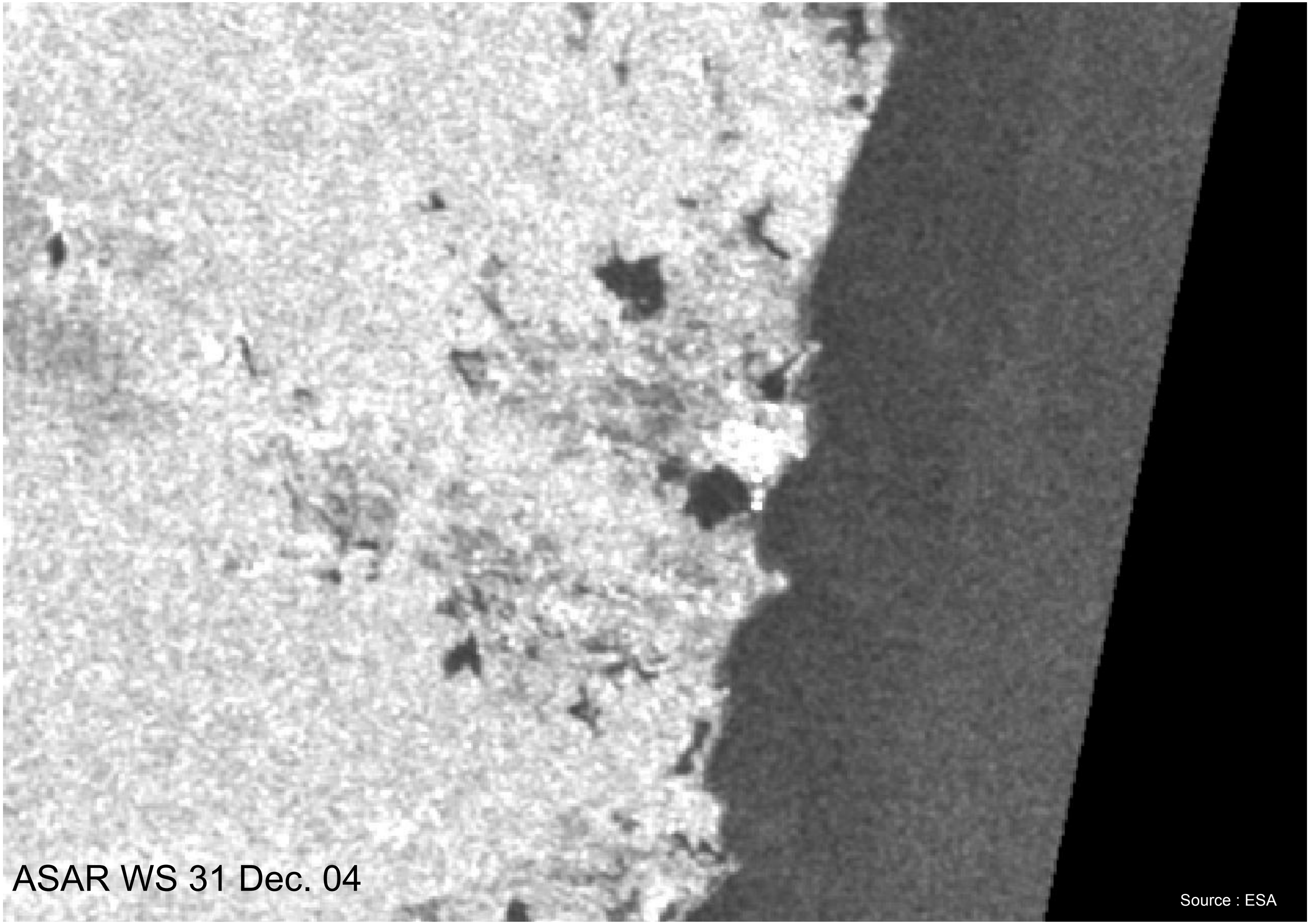
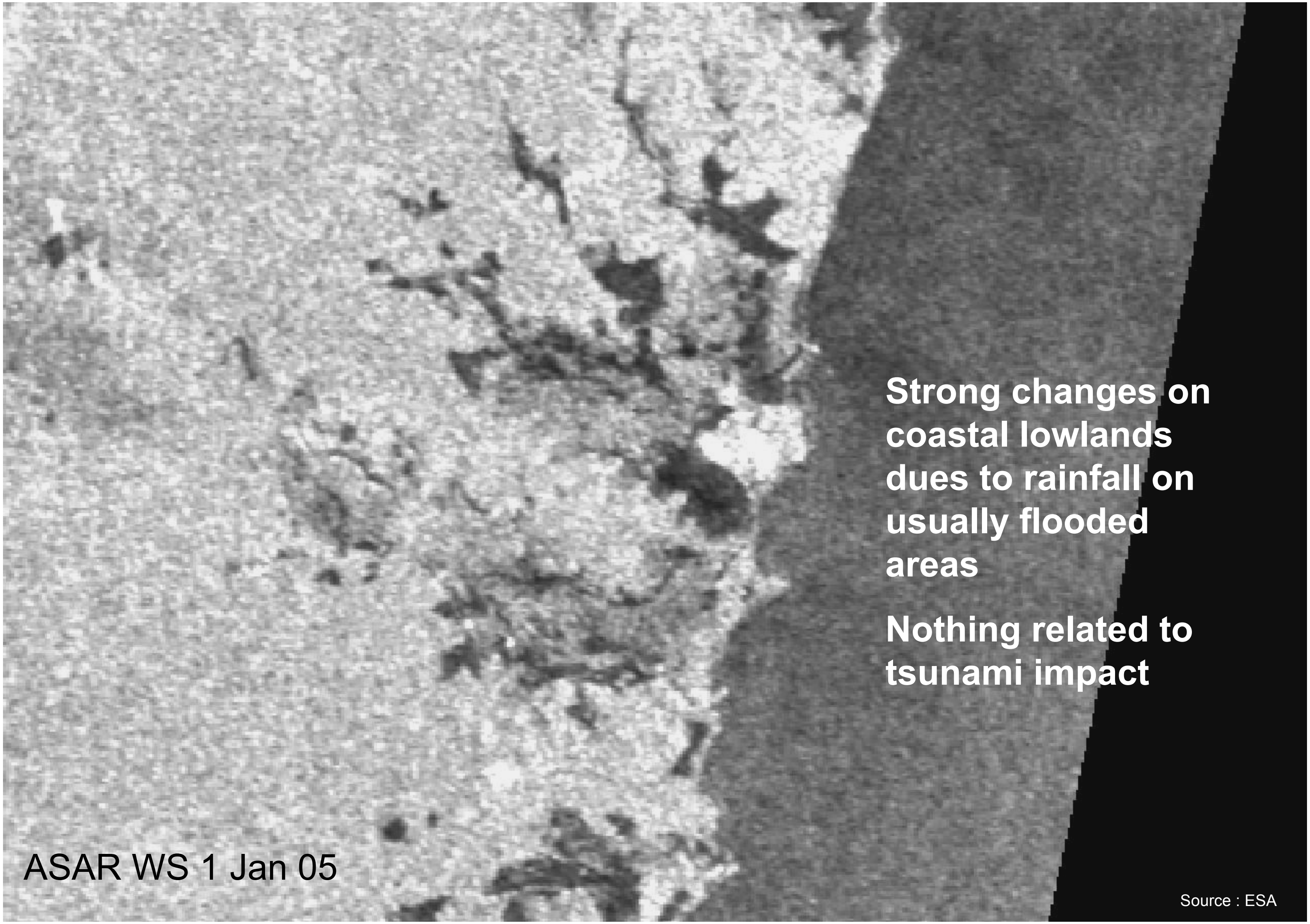
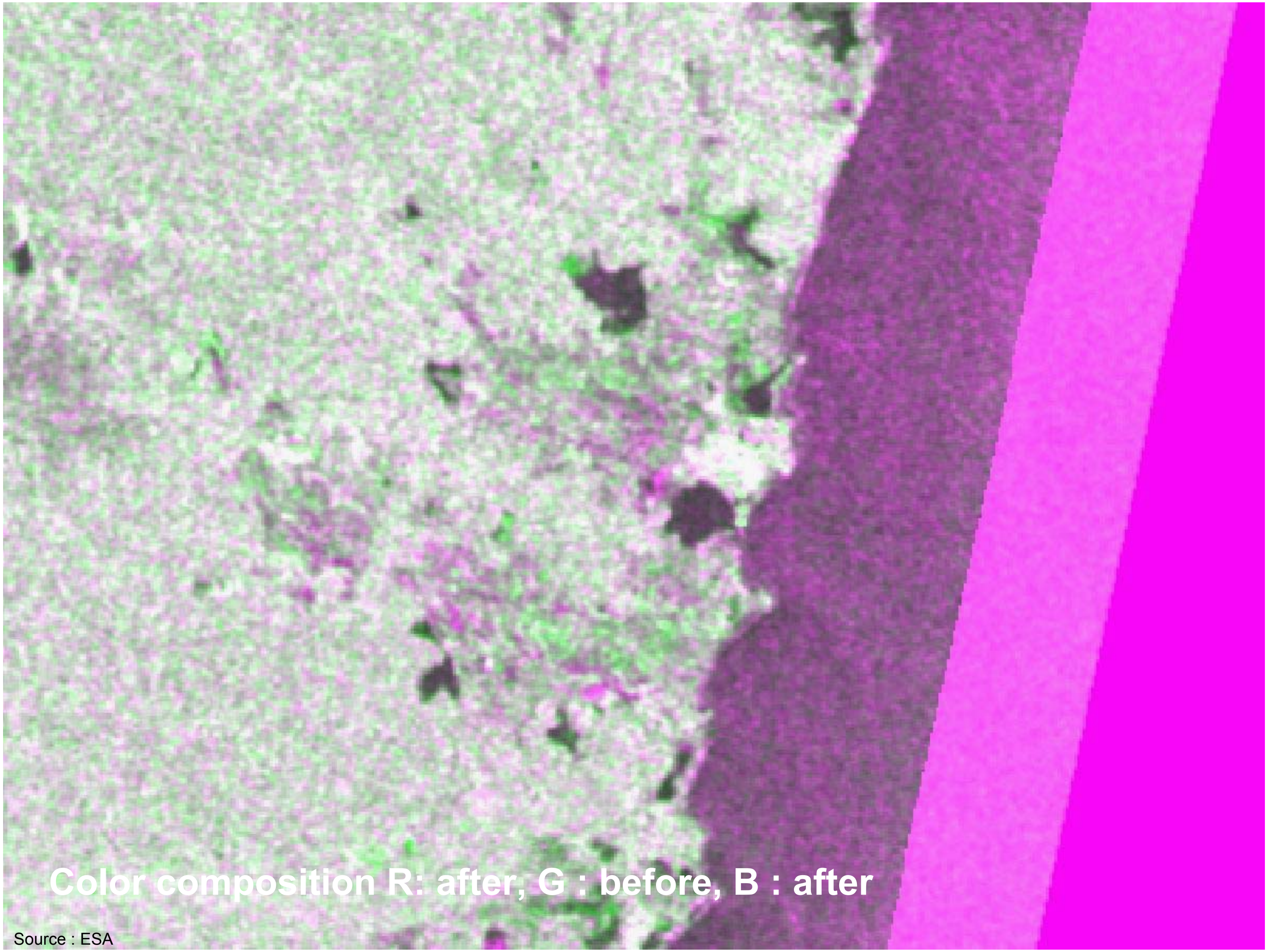

ASAR WS 31 Dec. 04
Source : ESA


Strong changes on coastal lowlands dues to rainfall on usually flooded areas
Nothing related to tsunami impact
ASAR WS 1 Jan 05
Source : ESA


Color composition R: after, G : before, B : after
Source : ESA

Extension of method to Mediterranean basin

- A good preliminary base for detection of areas with high vulnerability to tsunami but also storm surges
- All Mediterranean countries already covered and mapped by similar approach with thresholds on SRTM DEM
- Carribean Island done

Future trends for Tsunami vulnerability and hazard mapping and assessment :

- Detailed human and infrastructures vulnerability assessment method to develop

- Detailed bathymetry mapping of shores for run-up modelling or assessment

- Detailed LIDAR DEM of coastal areas exposed

Future trends for Tsunami vulnerability and hazard mapping and assessment :

- Nearly 80% of tsunami alerts in the Pacific region are false alarms
- The wave destruction power highly depending on nature of earthquake rupture but also shelf and coast bathymetry and morphology
- Tsunami generated down to 6,5 magnitude
- For close earthquake sources (near field source), propagation time is a few minutes and will remain too short to analyse generation of tsunami or not by gauges or sea bottom sensors. The processing and transfer chain is too long. Feeled earthquake or visible precursors (receding sea if any) will remain the only local indicator
- Most of the prevention will rely on Interpretation of precursors and immediate proper reaction of exposed population to flee from evaluated risk area

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The real question of assessing exposure to tsunami hazard

- For many historical tsunami, the exact source location and mechanism is unknown
- What about assessment of other sources (landslides submarine or not, volcanic collapses, etc...)
- Minor, local tsunamis ex : Papua new Guinea, 1998, up to 15 m of run-up but real damaged coast only on 200 km. The task was « easy » for Pacific region and far field tsunamis
- What to do when the typical scenario of submersion does not let any chance to reah a shelter to population installed on shores ?
- Freezing or prohibiting (re)construction on a strip behind the beaches is probably only a fast an easy « political » solution to public anxiety but there are more problems generated than solved

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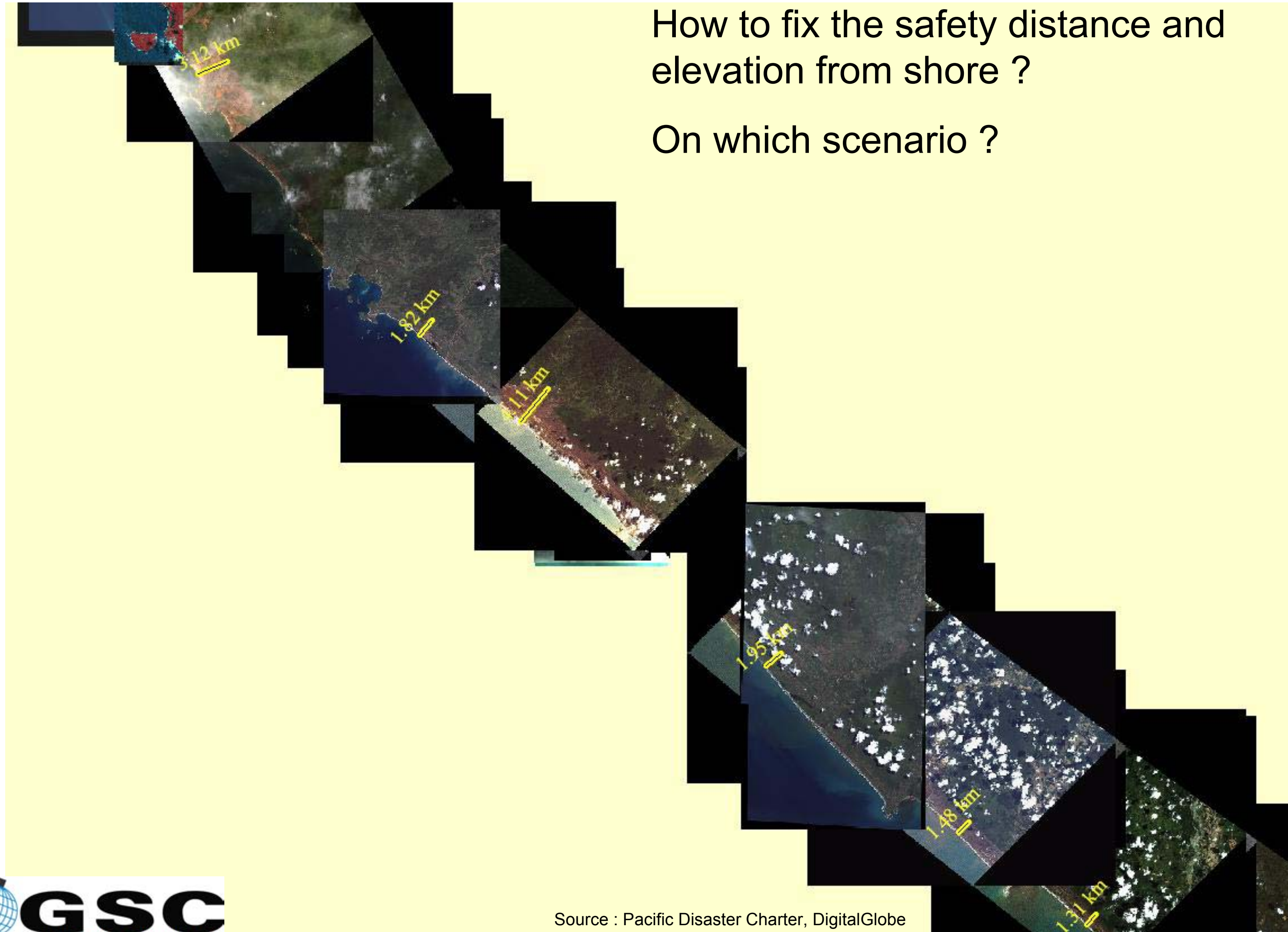
The probel of producing hazard or vulnerability maps : what is the likely potential event to consider ?

How to fix the safety distance and elevation from shore ?

On which scenario ?

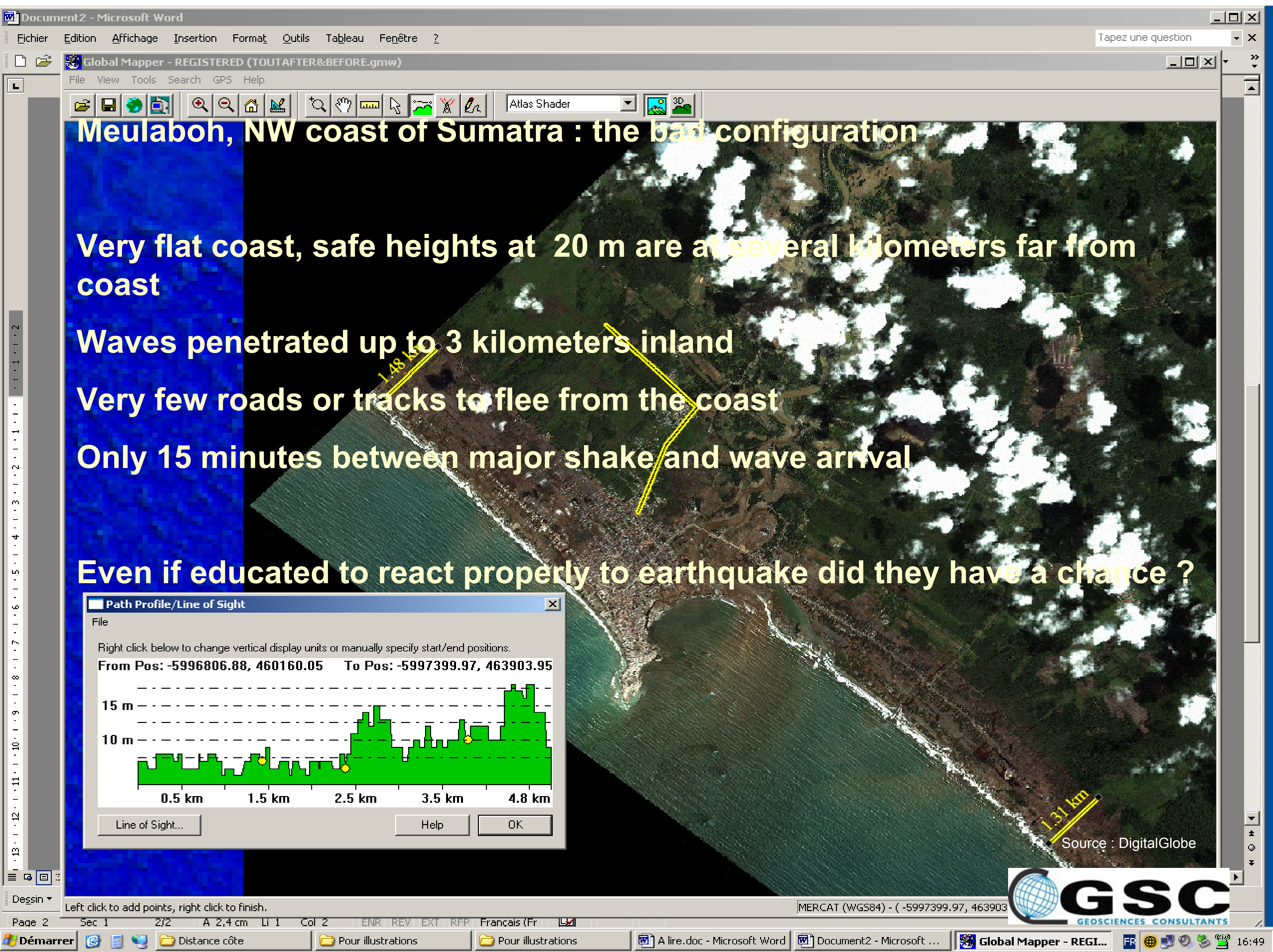


Source : Pacific Disaster Charter, DigitalGlobe

Lokh Nga , Sumatra, South of Banda Aceh:

In a few kilometers, run-up elevation vary from 15 to 50 m.

Heights were easily accessible. Escaping seemed to have been possible with a prior alert or with good behaviour of population


Global Mapper - REGISTERED (TOUTAFTER&BEFORE.gmw)
Meulaboh, NW coast of Sumatra : the bad configuration
Very flat coast, safe heights at 20 m are at several kilometers far from coast
Waves penetrated up to 3 kilometers inland
Very few roads or tracks to flee from the coast
Only 15 minutes between major shake and wave arrival
Even if educated to react properly to earthquake did they have a chance ?
1.48 km
1.31 km
Path Profile/Line of Sight
Right click below to change vertical display units or manually specify start/end positions.
From Pos: -5996806.88, 460160.05 To Pos: -5997399.97, 463903.95
15 m
10 m
0.5 km
1.5 km
2.5 km
3.5 km
4.8 km
Line of Sight...
Help
OK
Source : DigitalGlobe
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Left click to add points, right click to finish.

CONCLUSING REMARKS :

There is still a long way both for understanding tsunami generation and destruction mechanism. The way is even longer for assessing vulnerability to tsunami

Developping international alert system will not be enough :

•Many tsunamis occur in near field with only a few minutes between generation and impact on coast

•80% of the tsunami alerts in the Pacific are false alarms. Who can imagine a population tolerant enough to evacuate for 100% of alerts

•We are unable to predict when and how strong could be a future tsunami (same limitation than for earthquakes)

•We are able only to predict and modelize major transoceanic tsunami but not local tsunami generated by moderate earthquakes or other sources

•What could be the worst scenario to envisage for know (or unknown) exposed coasts. Since the 26th Dec. tsunami it is suspected that many major historic tsunamis remain undiscovered

Thank you and let start working....

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Tel : 0033146646060, fax : 0033146646161

Field surveys data :

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Thailand : Disaster Reduction Systems, Disaster Prevention Research Institute, Kyoto University, JAPAN

Sumatra : CNRS, Kyoto university

Satellite Images credits :

IKONOS and QUICKBIRD : courtesy of Pacific Disaster Center

SPOT : SPOT IMAGE

ENVISAT ASAR : European Space Agency