Global Influence of Lowland Depressions on Fluvial Morphology and Sediment Storage*

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Abstract

Based on a global survey of 29 floodplains, the surface morphology of Holocene floodplains is examined, wherein areas with a propensity for river flooding and sediment trapping were identified. Fifty-five percent of these floodplains contain lowland depressions. Such depressions have many origins: foreland basins (peripheral, retroarc) including foredeep and backbulge; graben, half-graben and other fault complexes; mantle-induced warping; other isostatic and flexural depressions; and those related to salt or mudtectonics. Lowland depressions are characterized as including some of the following identifiers: statistically flatter down-valley slopes; greatly expanded widths compared to the container valley widths; multiple secondary or overflow river channels similar in nature to deltaic distributary channels; regional zones of swamps and lakes connected to the main river channel. None of these features alone are diagnostic. Almost all of the lowland depressions flood annually. Satellite surveys show that many of these lakes are tied to the main river through tie-channels, allowing the seasonal flood wave to push sediment laden water into the lakes. Because these river-connected lakes exist over millennia this suggests that the rate of subsidence (thermal or tectonic) is greater than the rate of aggradation. Some examples include: (1) The Mompox depression located upstream of the Magdalena Delta an area that has experienced an area-averaged aggradation rate of 3-4 mm/y, (2) The Poyang Inland Delta feeding Lake Poyang where sediment from the Gan and Xiu rivers is filtered before discharging into the main stem the Yangtze River, and (3) the Dong Ting depression located at the intersection of the Yangtze and Xiangjiang Rivers, that during the 20th century has sequestered 128 Mt/y, largely through overflow channels. These tectonically controlled lakes and swamps greatly affect the flux of sediment within the source to sink continuum. This continental sink of sediment is not generally recognized as a petroleum target.

References

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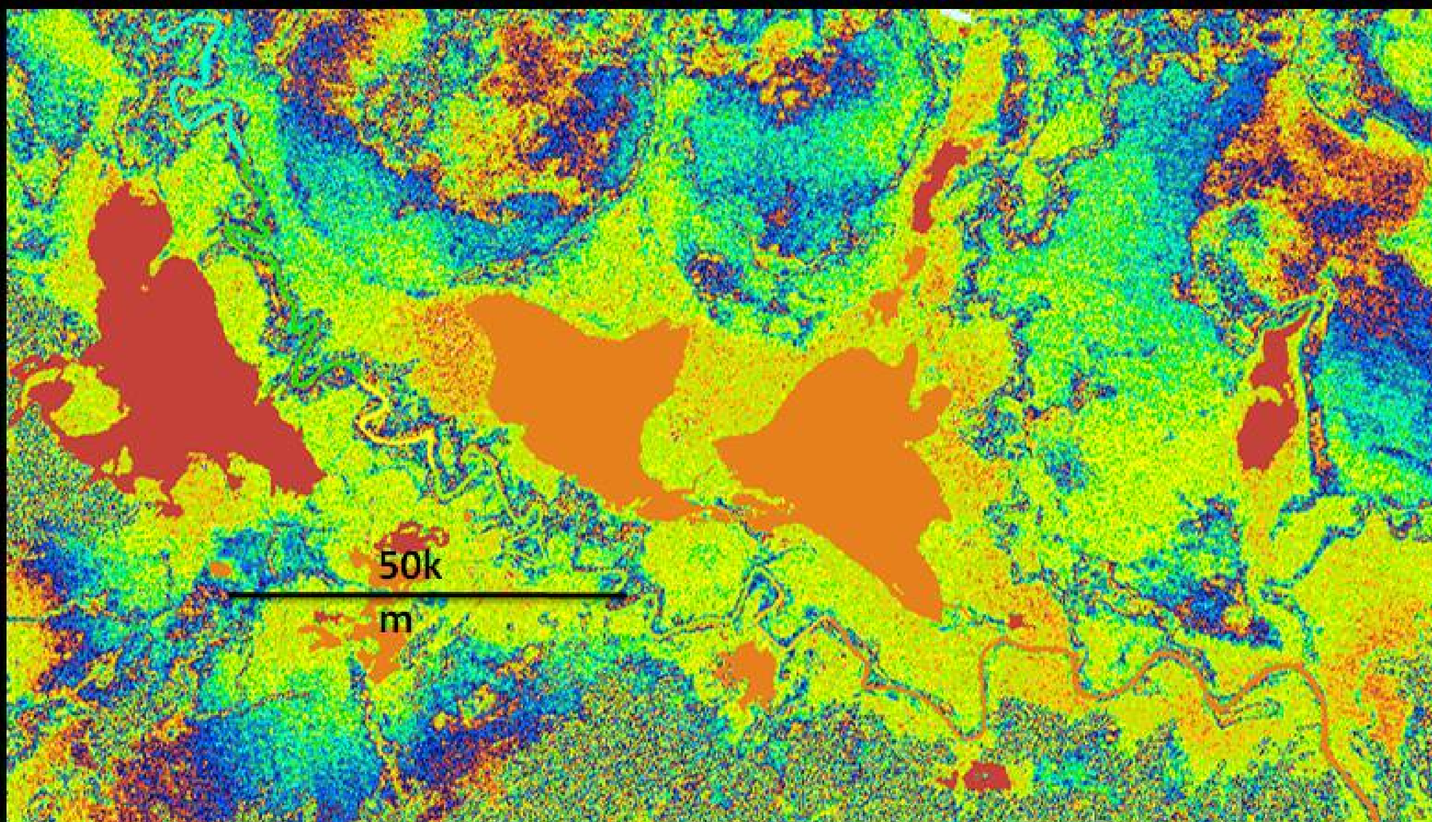
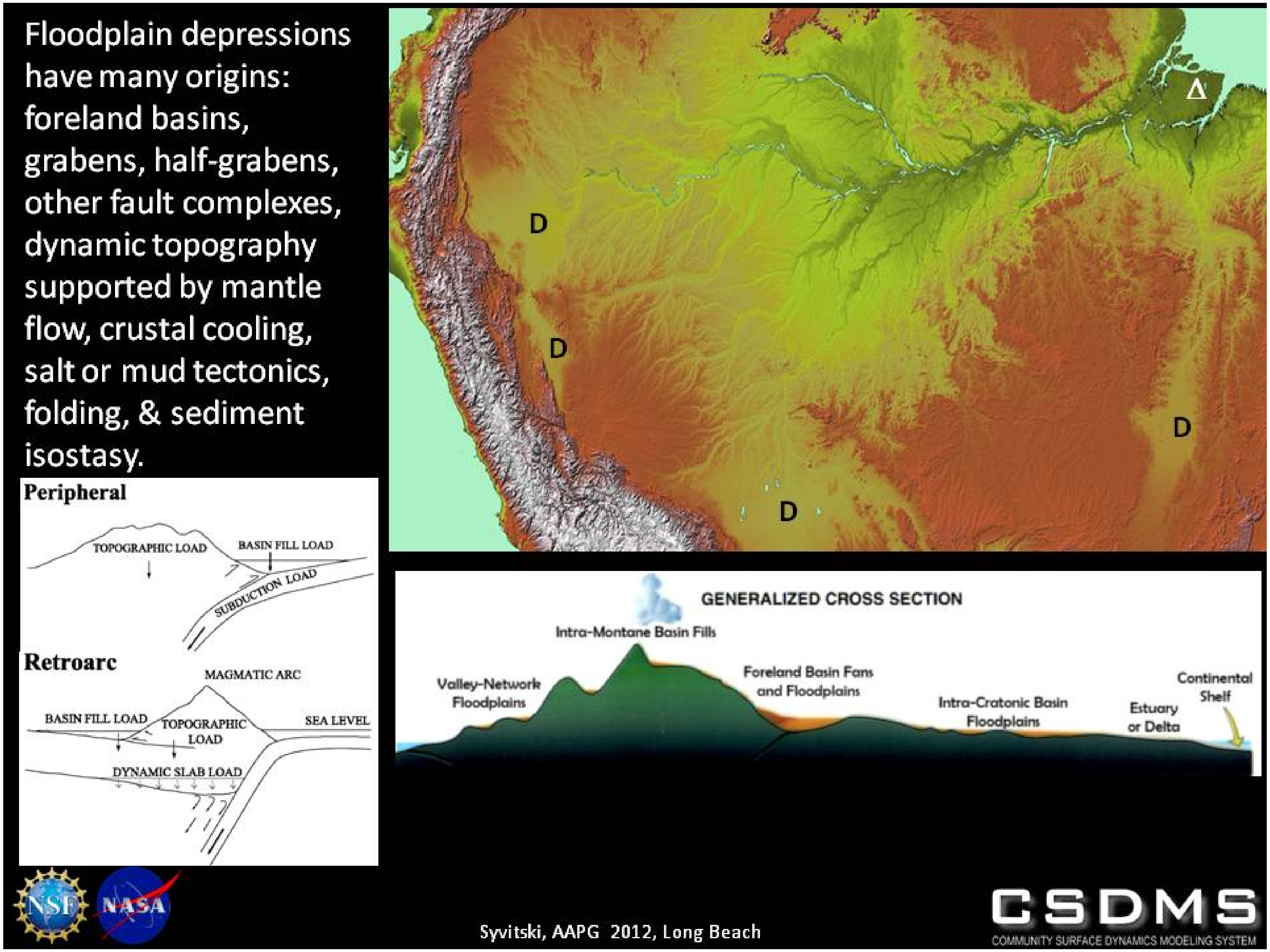


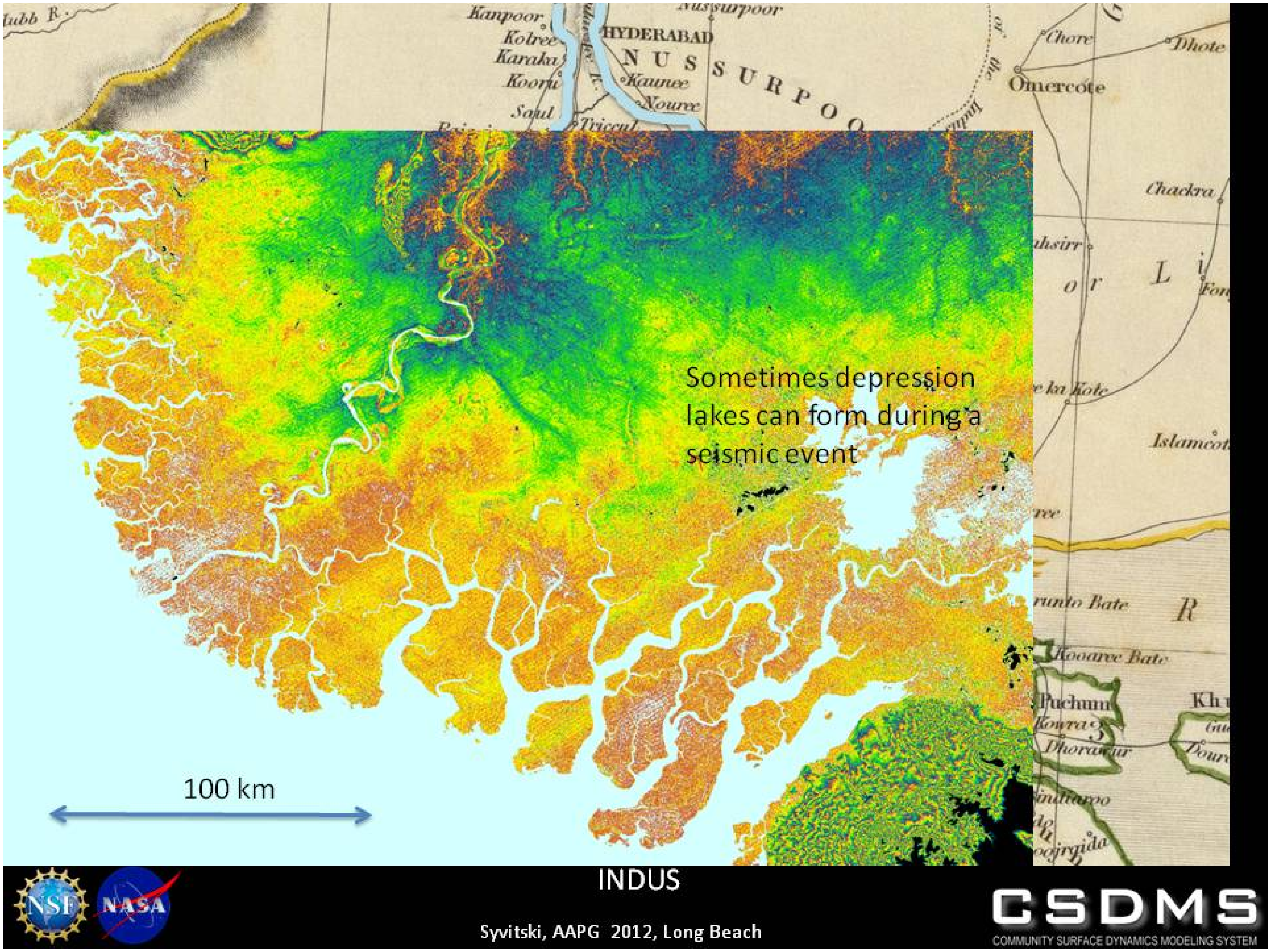
Mahakam
Intermontane
Depression
Indonesia

CSDMS
COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

Presenter's Notes: Images taken at border between Argentina and Paraguay, SE of Pilar. High discharge, Oct. 22, 2009. Low discharge, Sept 25, 2005.



Presenter's Notes: Many rivers support higher elevation floodplains. Floodplains may enclose higher standing islands or terraces of limited size. Floodplain boundaries based SRTM, LANDSAT, SPOT, and Digital Globe imagery. 41% contain tectonic depressions that contain lakes or flood annually. A) Mahakam B) Yangtze C) Orinoco D) Nile E) Amazon F) Amur G) Magdalena H) Limpopo I) Congo — its major floodplain lies above the 100 m J) Danube K) Fly L) Yellow M) Indus N) Tone both active & inactive deltas, O) Mahanadi and Brahmani, P) Sao Francisco Q) Irrawaddy R) Krishna and Godhavari S) Vistula T) Volga only drawn to 10 m asl, showing both Holocene and Pleistocene U) Po V) Chao Phraya W) Ganges Brahmaputra X) Parana Y) Mississippi Z) Mekong A1) Tigris & Euphrates B2) Pearl and C3) Niger



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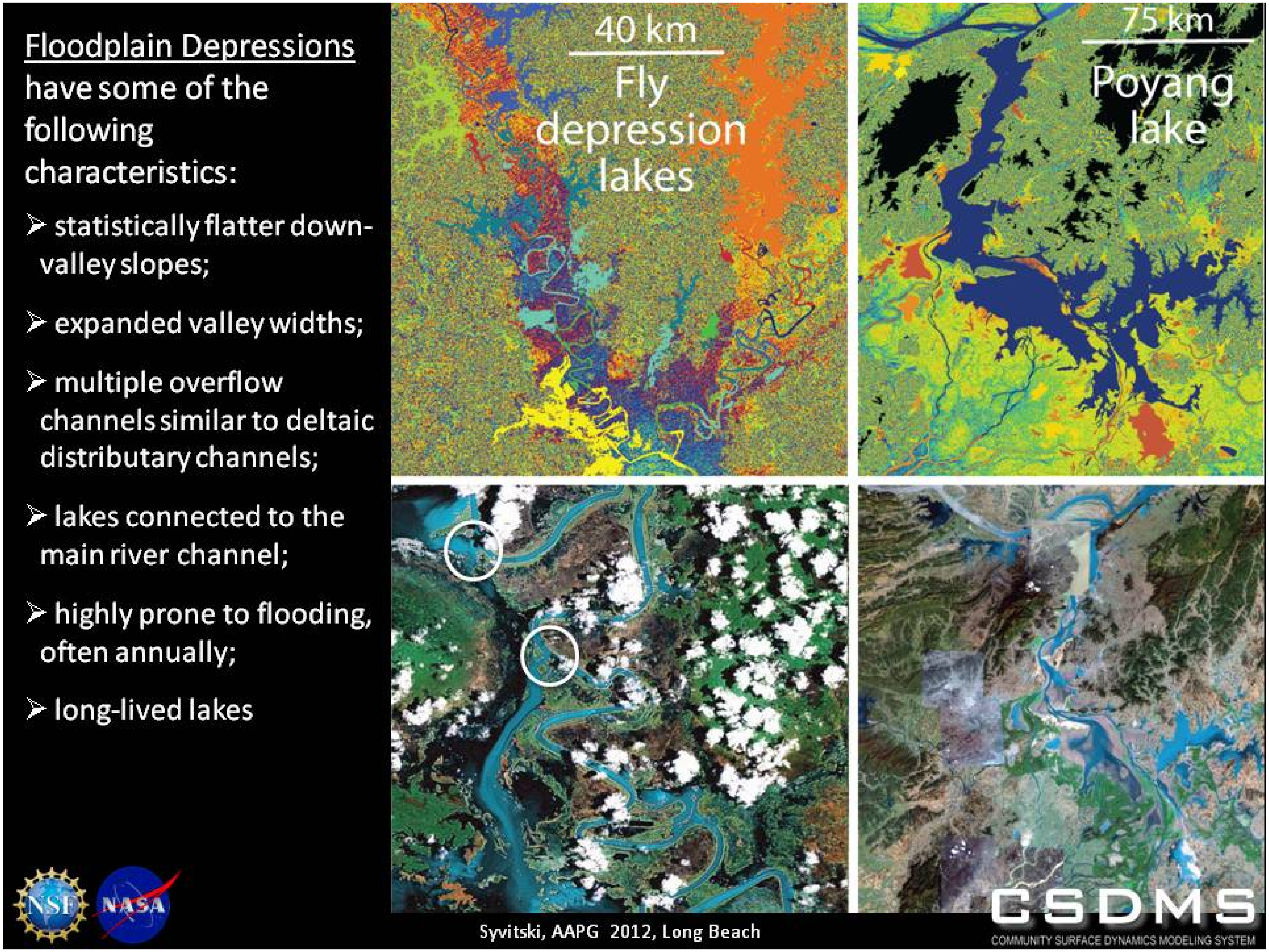
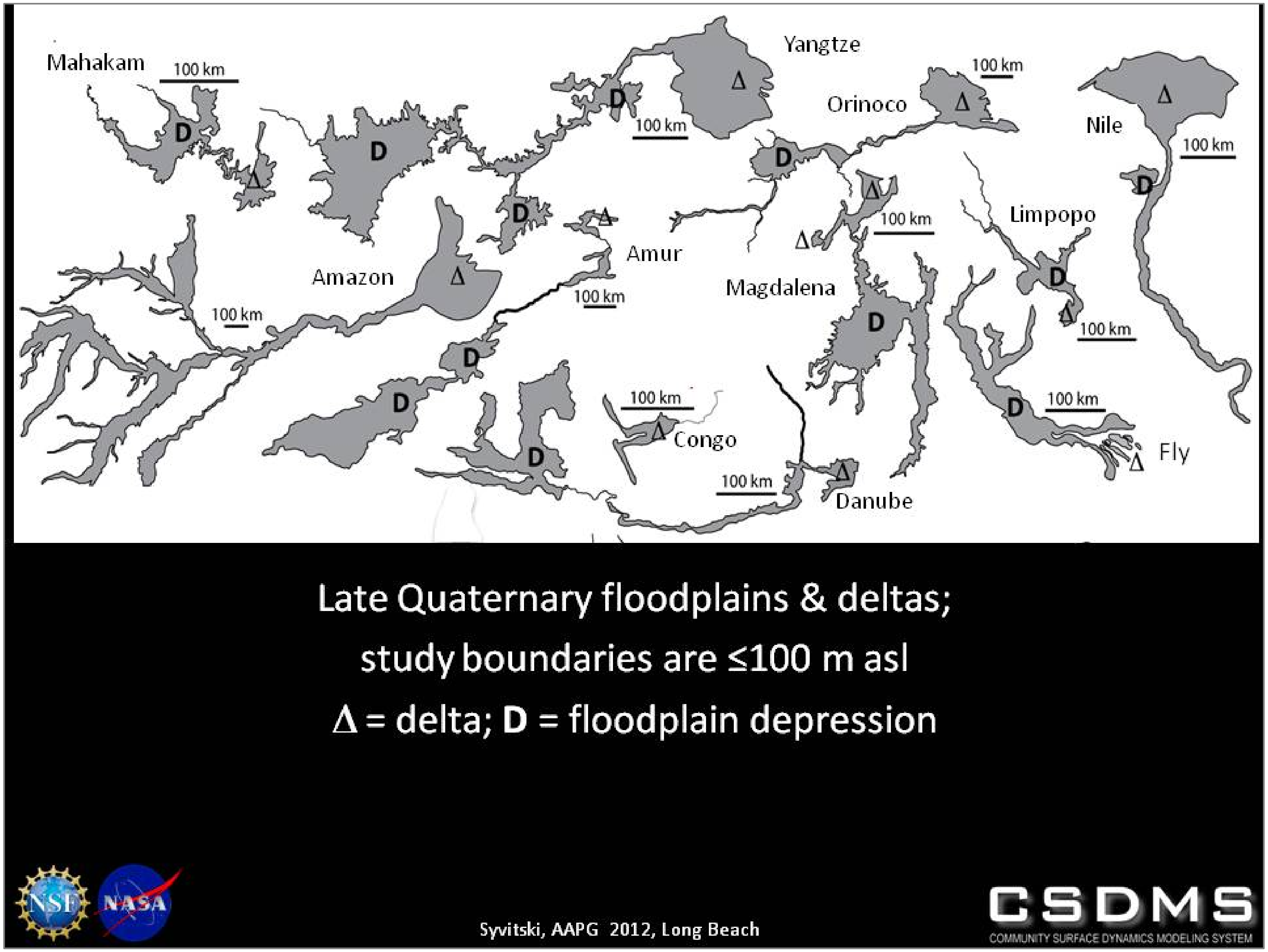


Presenter's Notes: Floodplain lakes. Poyang (depression) Lake fed by Gan / Xiu inland river delta with drainage to Yangtze.) Ria lakes of the Fly tectonic depression located at the junction of the Strickland and Fly Rivers. many of these lakes are tied to the main river through tie-channels, allowing the seasonal flood wave to push sediment laden water into the lakes



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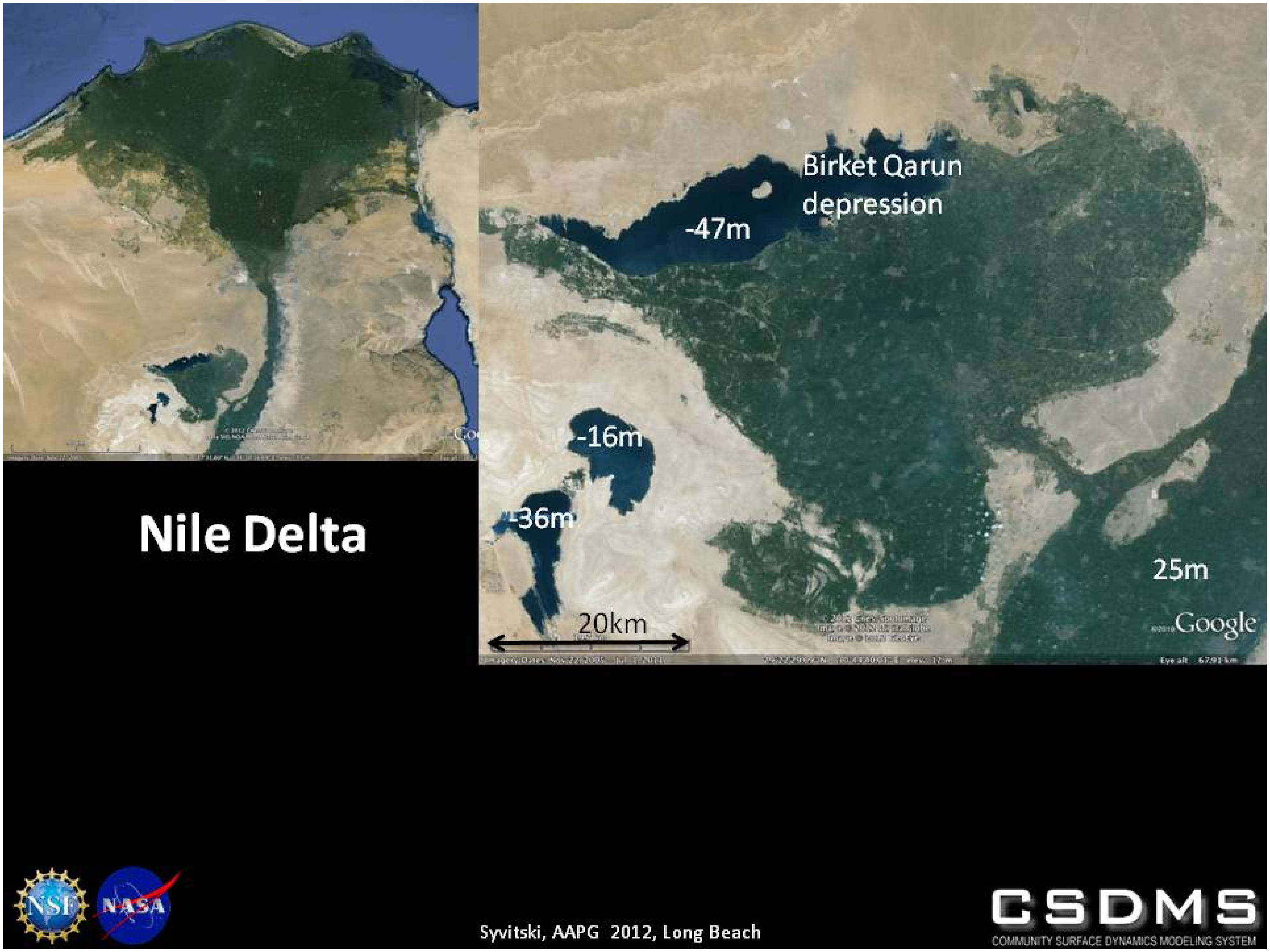

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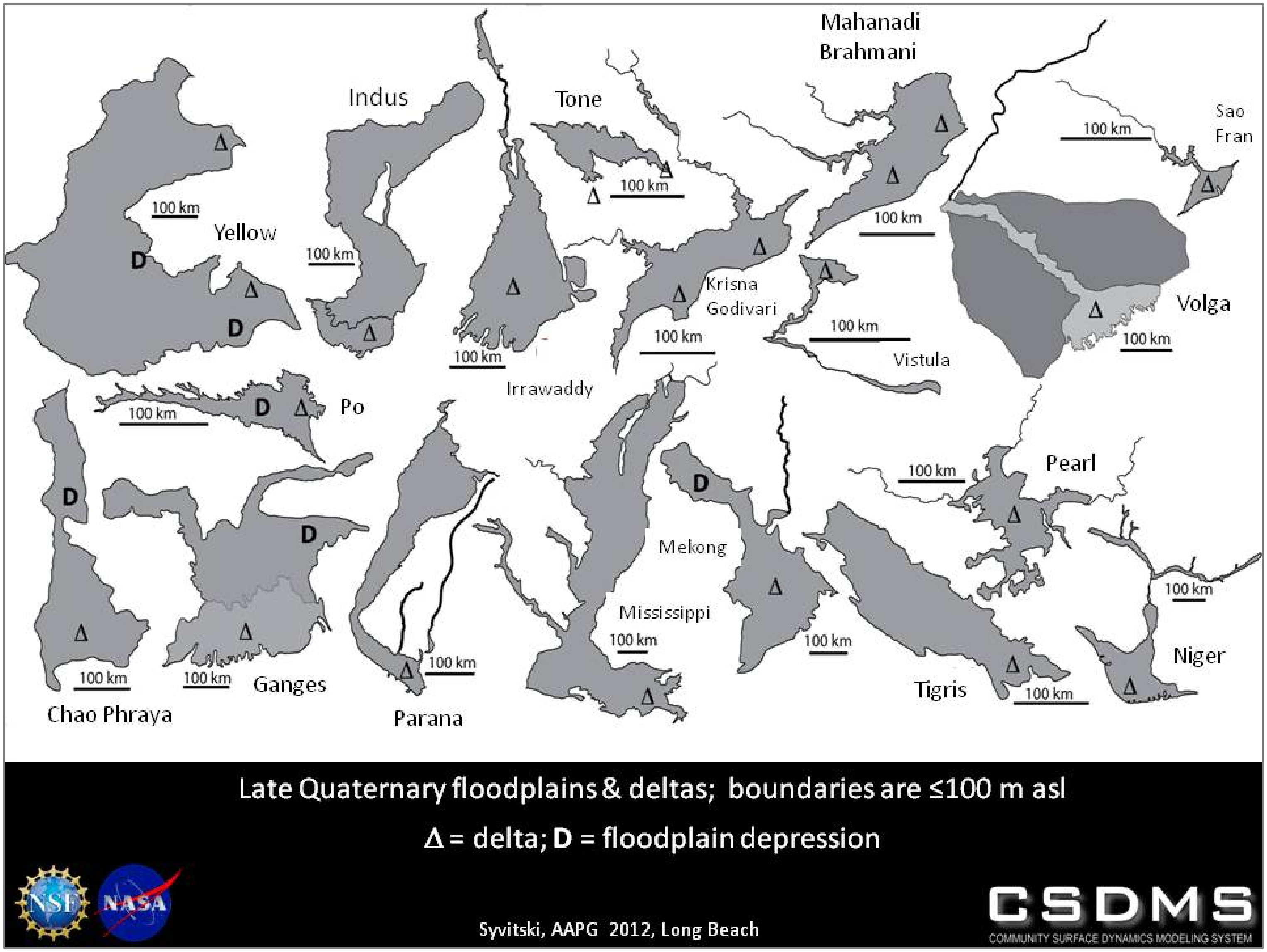

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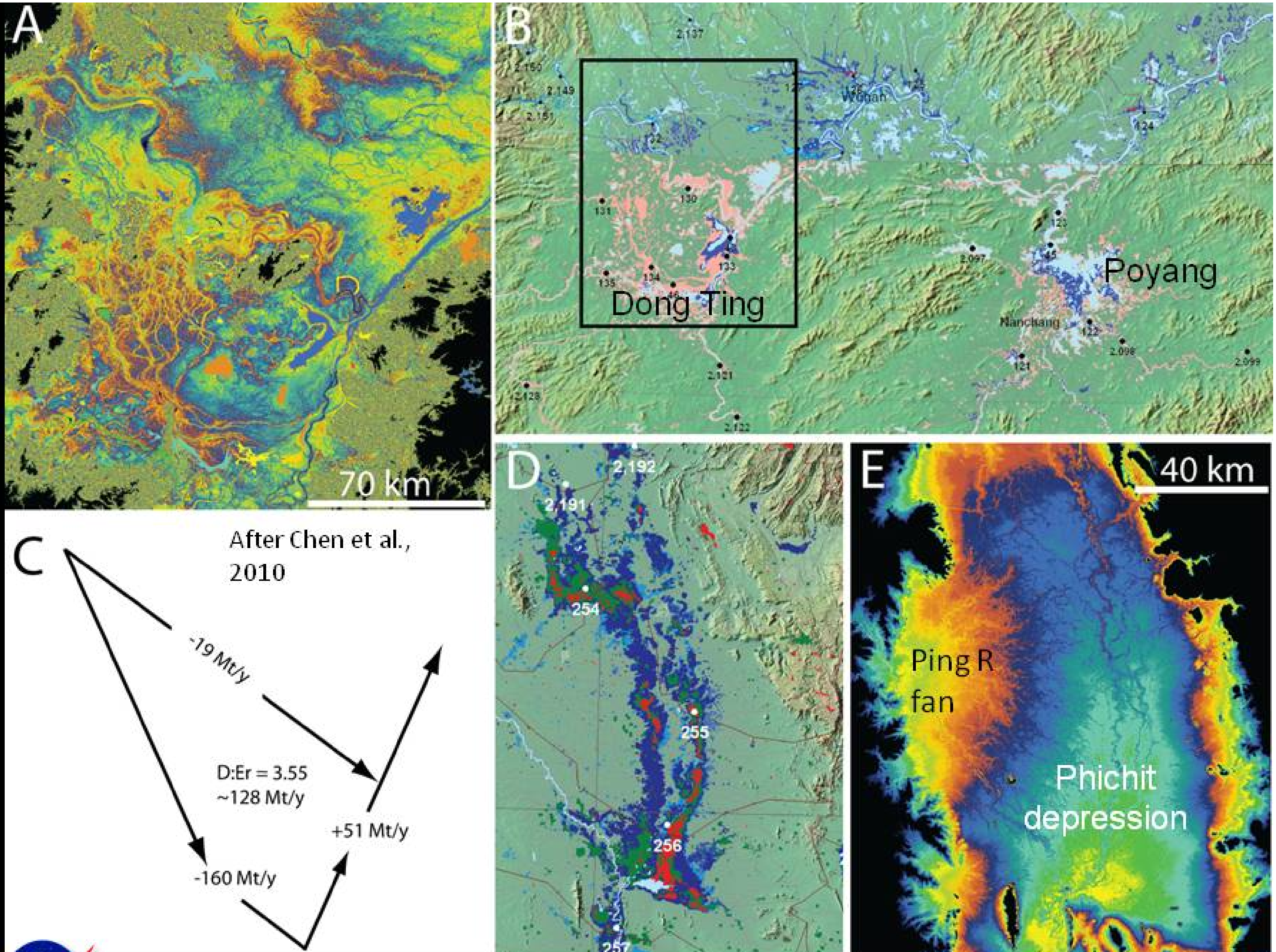
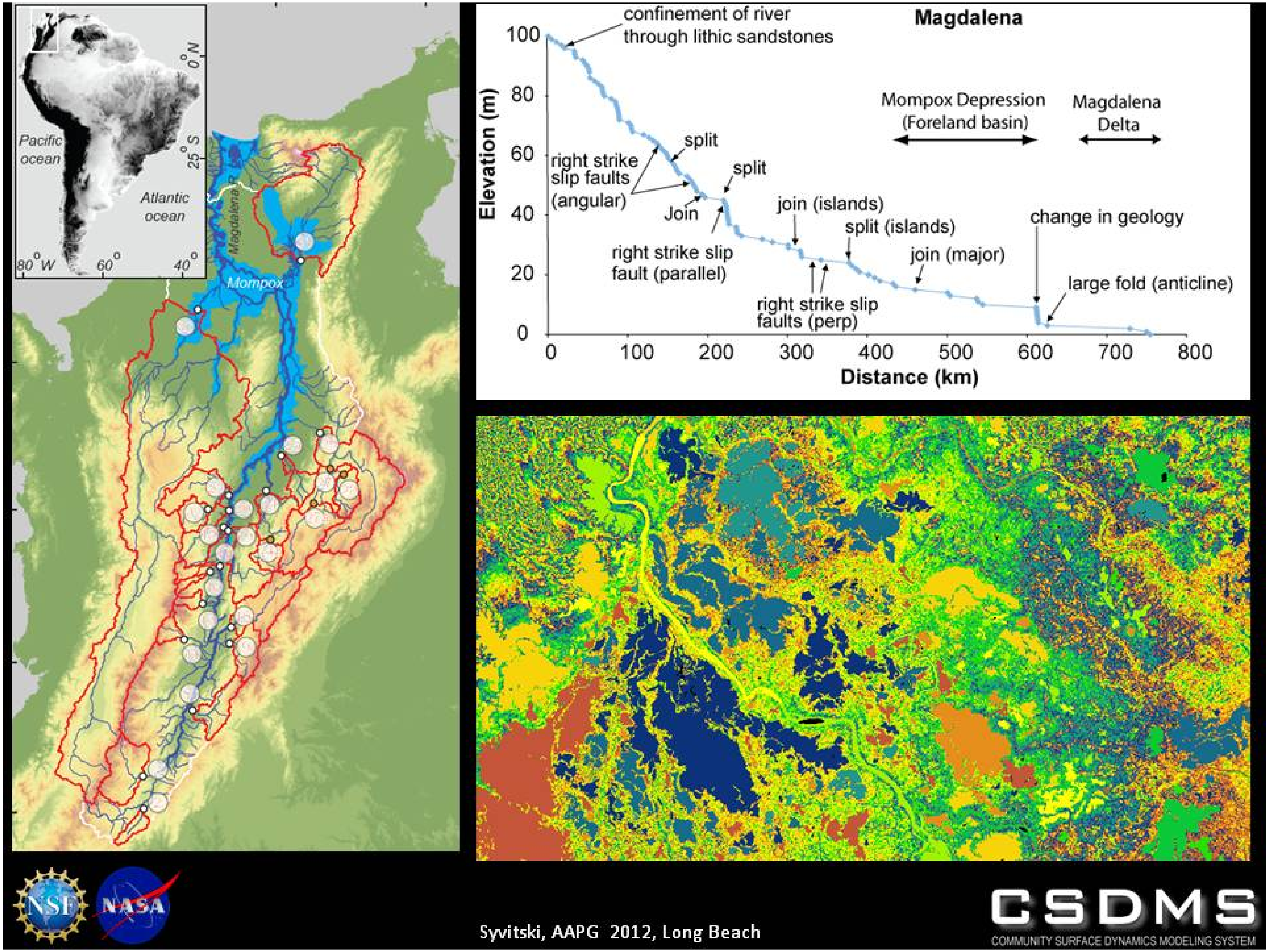
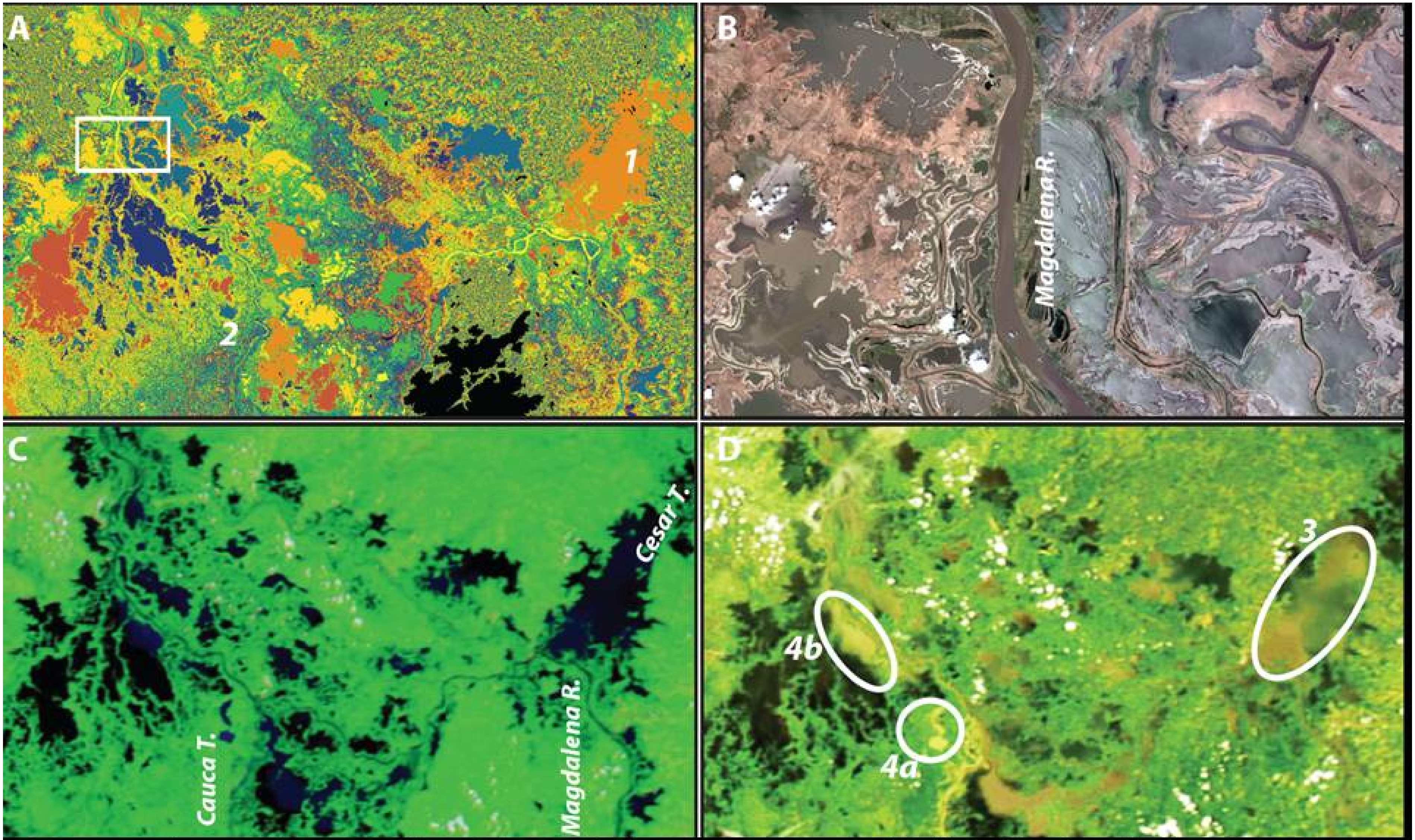

A
70 km
B
Dong Ting
Poyang
Wuhan
Nanchang
C
After Chen et al., 2010
-19 Mt/y
D:Er = 3.55
~128 Mt/y
+51 Mt/y
-160 Mt/y
D
2,192
2,191
254
255
256
257
E
40 km
Ping R fan
Phichit depression



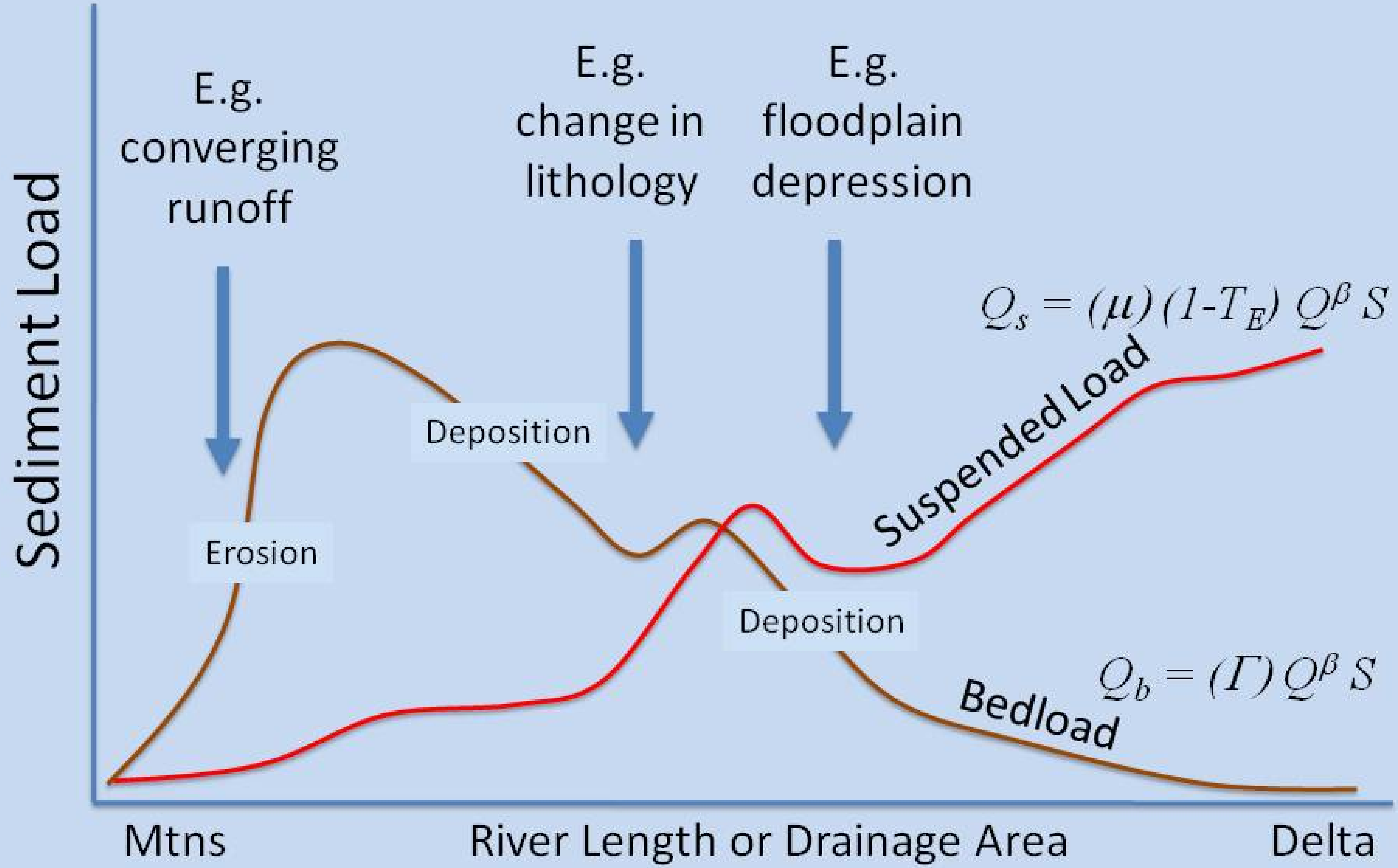
Presenter's Notes: Mompox depression through which flows the Magdalena River



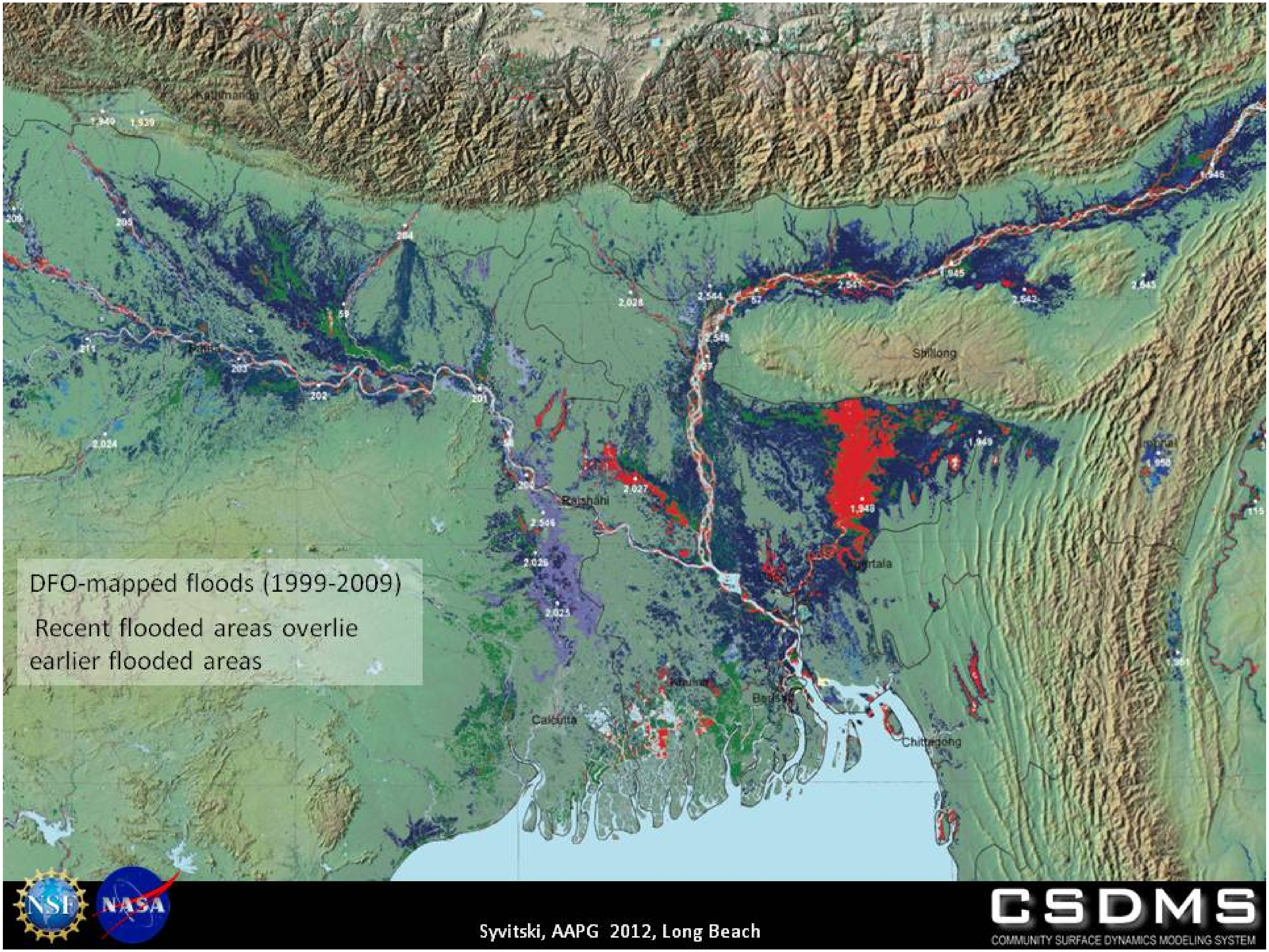
Mompox depression: overflow & levee failures cause extensive flooding (April – Nov)

Over last 7500 y, aggradation rate is 3–4 mm/y with deposits 10m to 130m thick

With 27 yr of observation, 14% of Magdalena sediment load is trapped *Kettner et al., 2010*



Sediment Load
E.g. converging runoff
E.g. change in lithology
E.g. floodplain depression
$Q_s = (\mu)\,(1\text{-}T_E)\;Q^{\beta}\,S$
Suspended Load
Deposition
Erosion
Deposition
$Q_b = (\Gamma)\;Q^{\beta}\,S$
Bedload
Mtns
River Length or Drainage Area
Delta



Presenter's Notes: DFO-produced spatial flood coverage (1999-2009) of the Ganges-Brahmaputra Rivers and joint delta. Colors represent different years with more recent years overlying earlier flooded areas. Often flooded areas reoccur from year to year.

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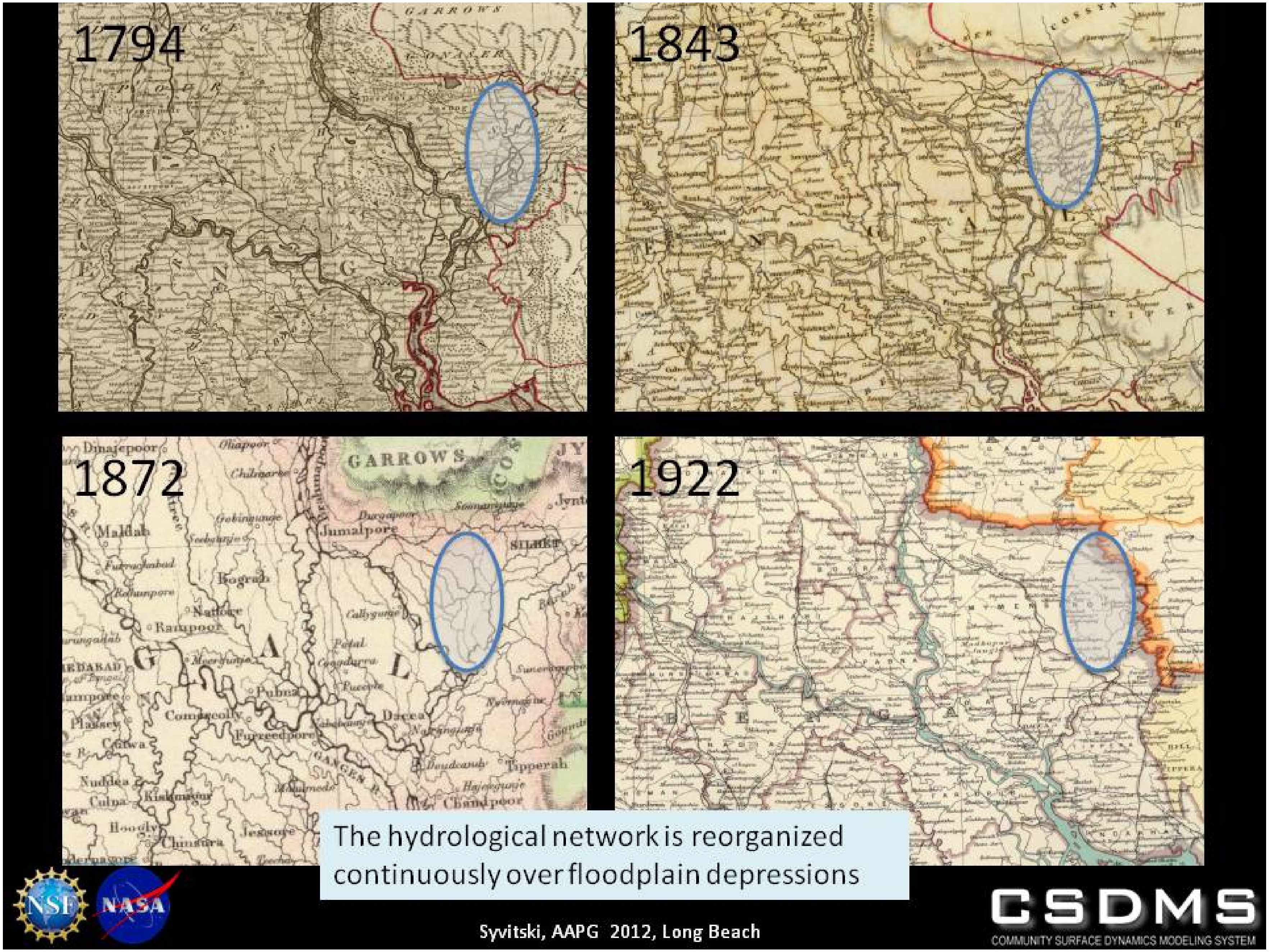

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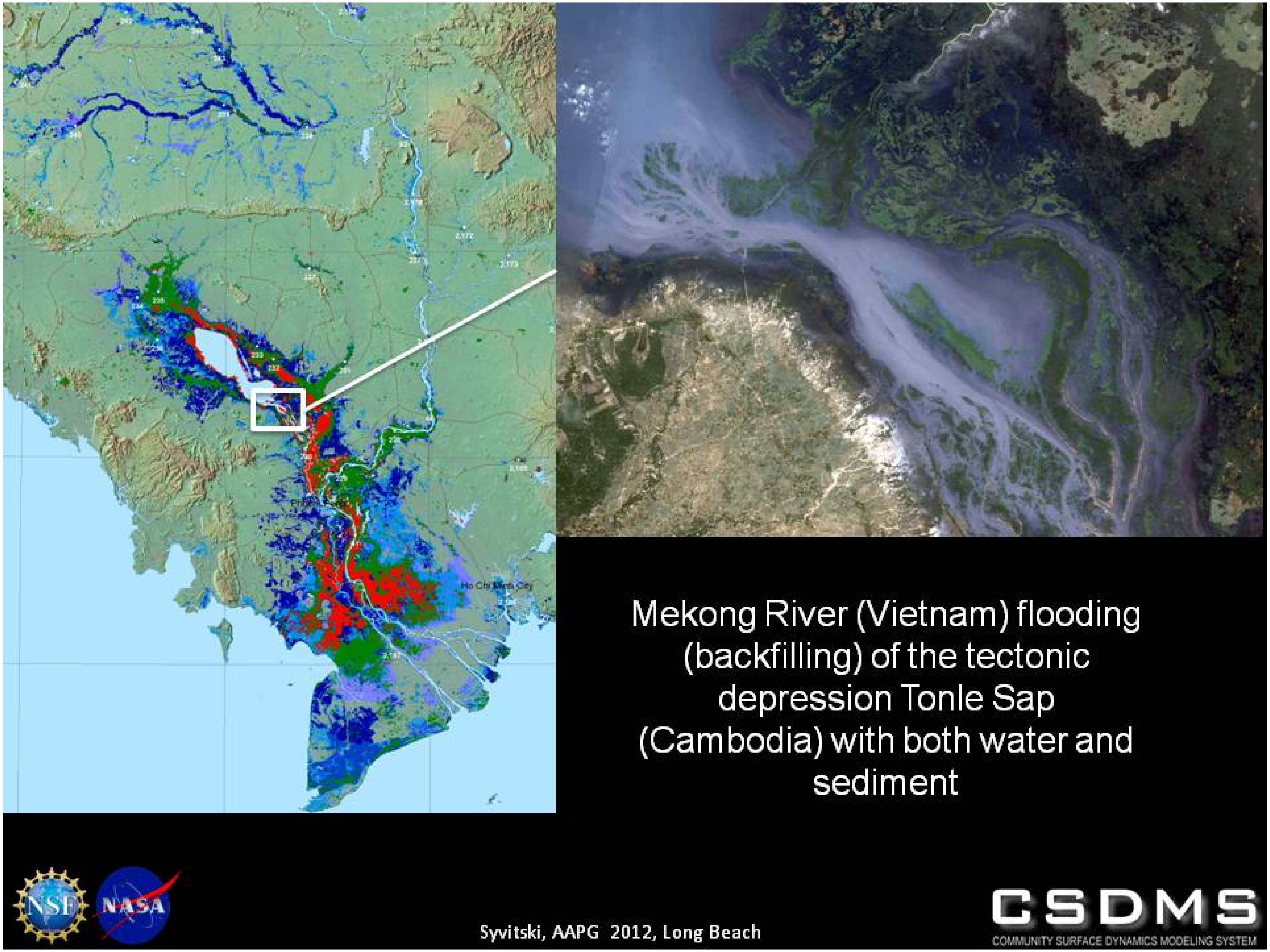

Presenter's Notes: Location map of the Mekong Delta — colors indicate size of annual floods.

Summary

- Floodplain depressions are located on 55% of 33 floodplains surveyed within the ≤100 m asl elevation study limits.
- Depressions zones are areas of subsidence, low relief, increased floodplain width, overflow channels, long lived lakes and they commonly flood annually.
- Sediment sequestration mechanisms are highly varied in floodplain depressions, trapping both fine grained suspended sediment, and coarser channel sands.
- Many shale gas plays of today are likely preserved paleo floodplain depressions.