BanD-AID: Mitigating Bangladesh Delta Coastal Vulnerability Due to Sea-level Rise, & Integrated Natural & Social Framework

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Belmont Forum Mid-Term Project Meeting

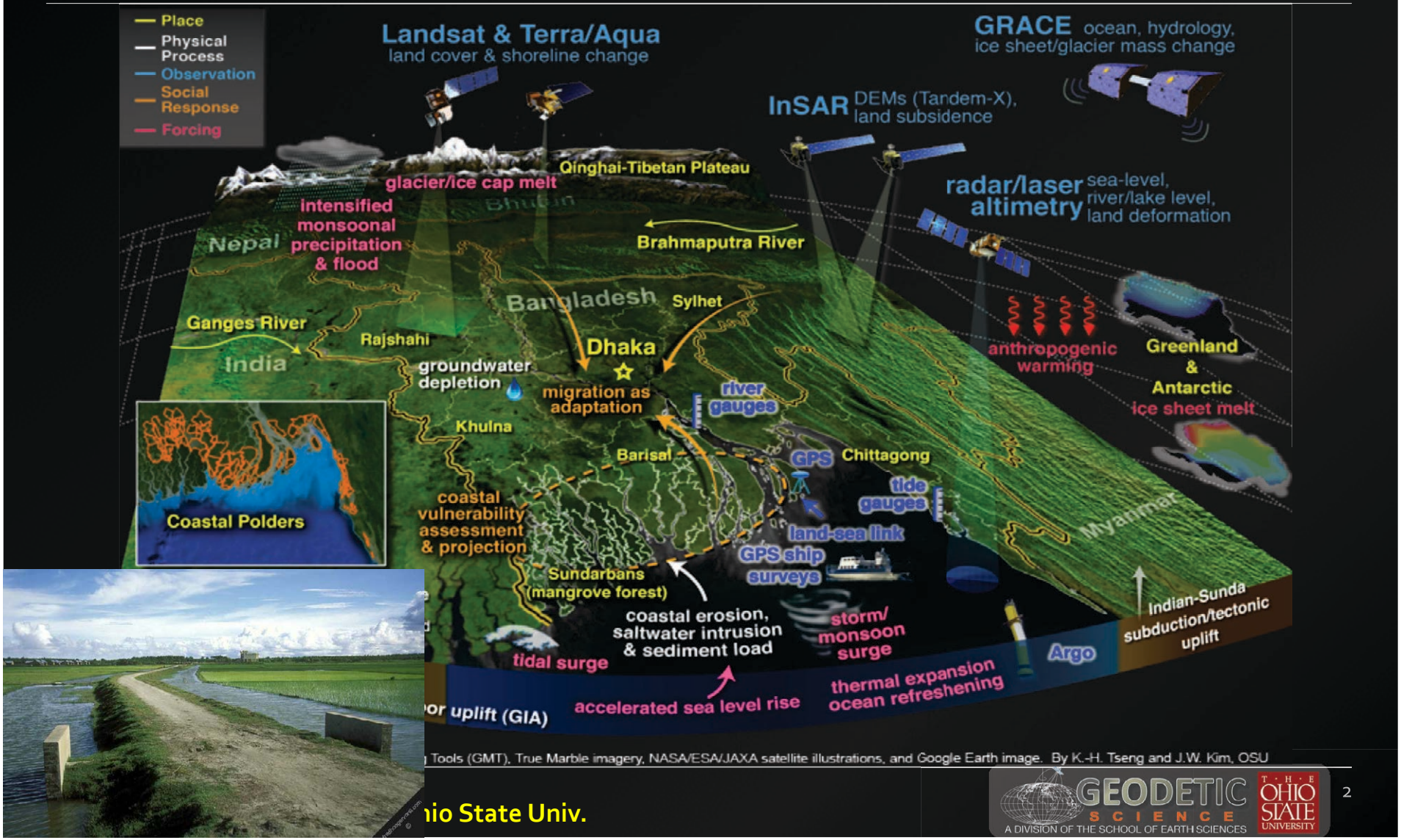
Beurs-World Trade Center, Rotterdam, The Netherlands

23 September 2014

http://Belmont-BanDAID.org

Belmont Forum Project: BanD-AID, 2013–2016

The Ohio State U., U. Washington.; Universität Bonn, Univ. Cologne; Institut de Recherche pour le Developpement (IRD); Univ. La Rochelle; IGN; LEOGS/GRGS; Curtin U.; Institute of Water Modeling (IWM), Univ. Rajshahi, http://Belmont-BanDAID.org



BanD-AID: Mitigating Bangladesh Delta Coastal Vulnerability Due to Sea-level Rise, & Integrated Natural & Social Framework

Project Objectives

- To build the *Belmont Challenge* identified *Earth System Analysis & Prediction System* (ESAPS) based on contemporary space geodetic sensors towards alleviating Bangladesh coastal vulnerability from climate change-induced hazards from accelerated sea-level rise

- Joint characterization of the natural processes and the human interactions that govern coastal vulnerability and resilience in Bangladesh: (1) sea-level and land subsidence monitoring & projection; (2) understand migration & land-use change as adaptation, and assess village resilience to climate risk; and (3) integrated scenario analyses

Mid-Term Project Progress: (1) GPS@tide gauge geodetic instrument installations, geodetic and social science surveys; (2) initial results to estimate & quantify causes of sea-level rise and land subsidence; (3) socioeconomic analysis of land use change, & village resilience to flooding

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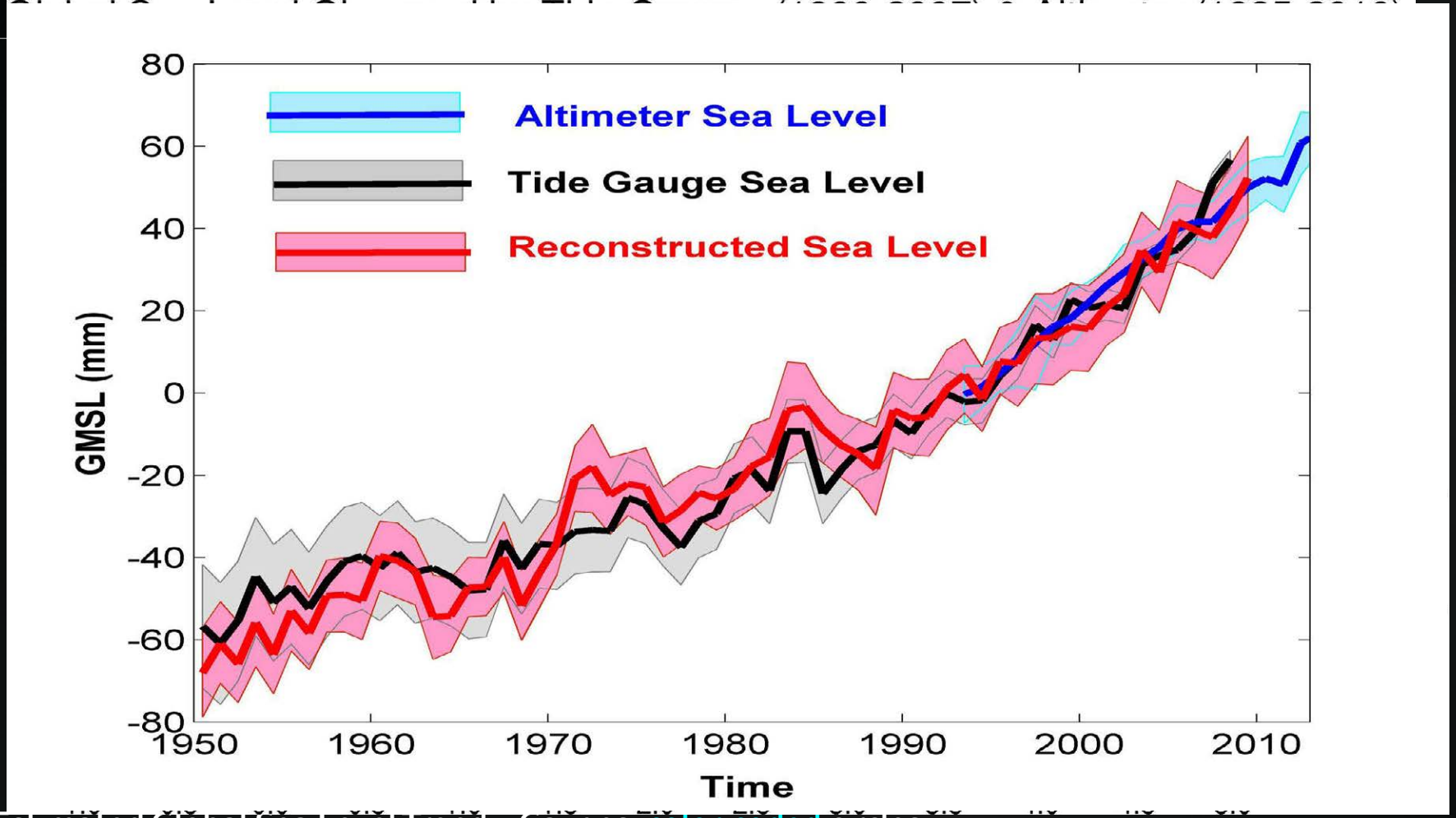
Sea-Level Rise Observed by Multi-mission Altimetry, Tide Gauges, & Reconstruction

Trends: Tide gauges (1900–2010), altimetry (1985–2010), reconstruction (1950–2009)



Estimated Global Sea Level Trend: Gauges: color-coded circles

Tide gauges (1900–2010, 575 selected sites) = 1.64±0.407mm/yr

Multiple altimetry (1992–2010) = 2.90±0.4 mm/yr (GIA/IB correct. applied)

Reconstruction (1950–2010) = 1.77±0.06 mm/yr [*Meyssignac et al.*, 2012]

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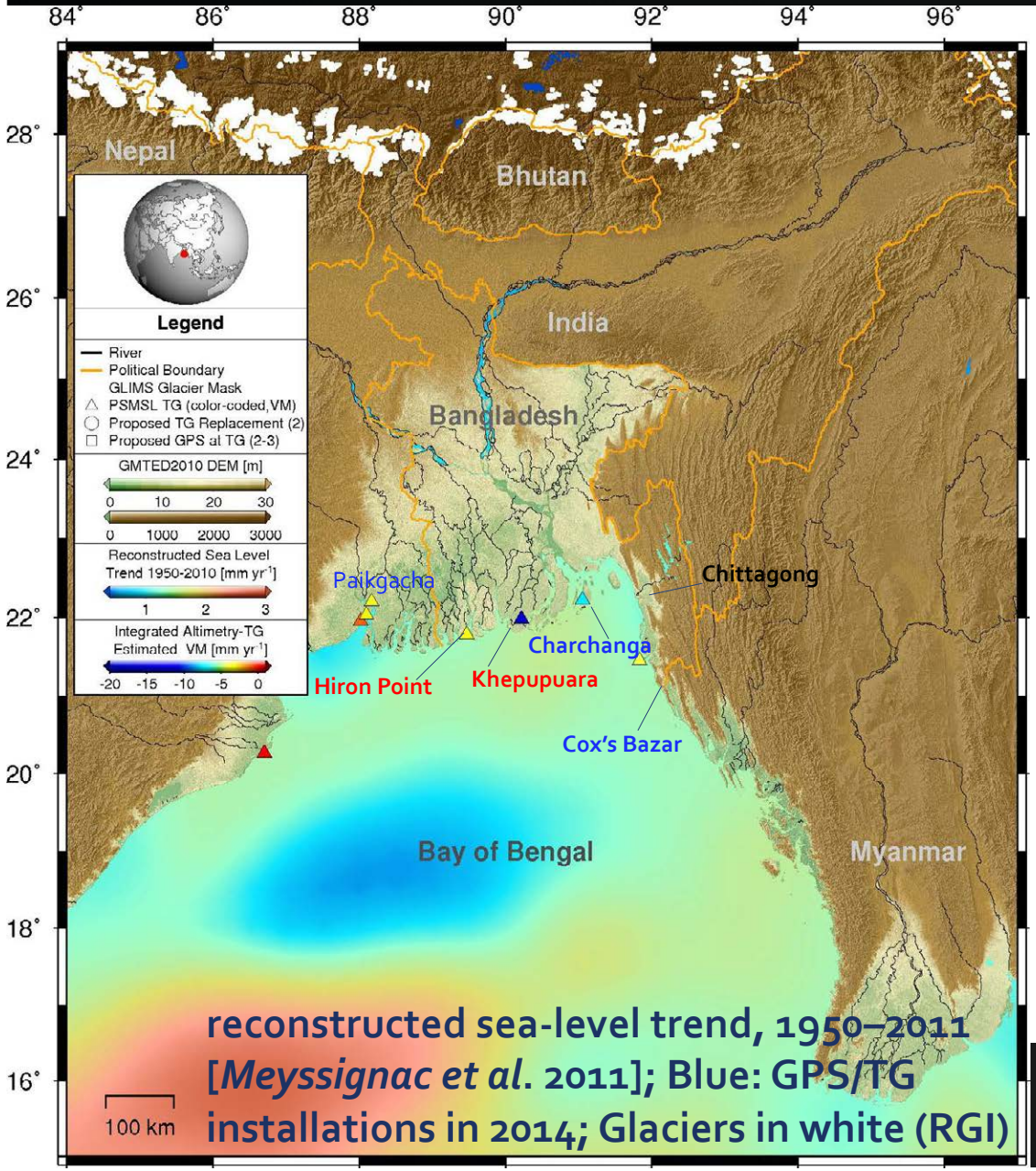
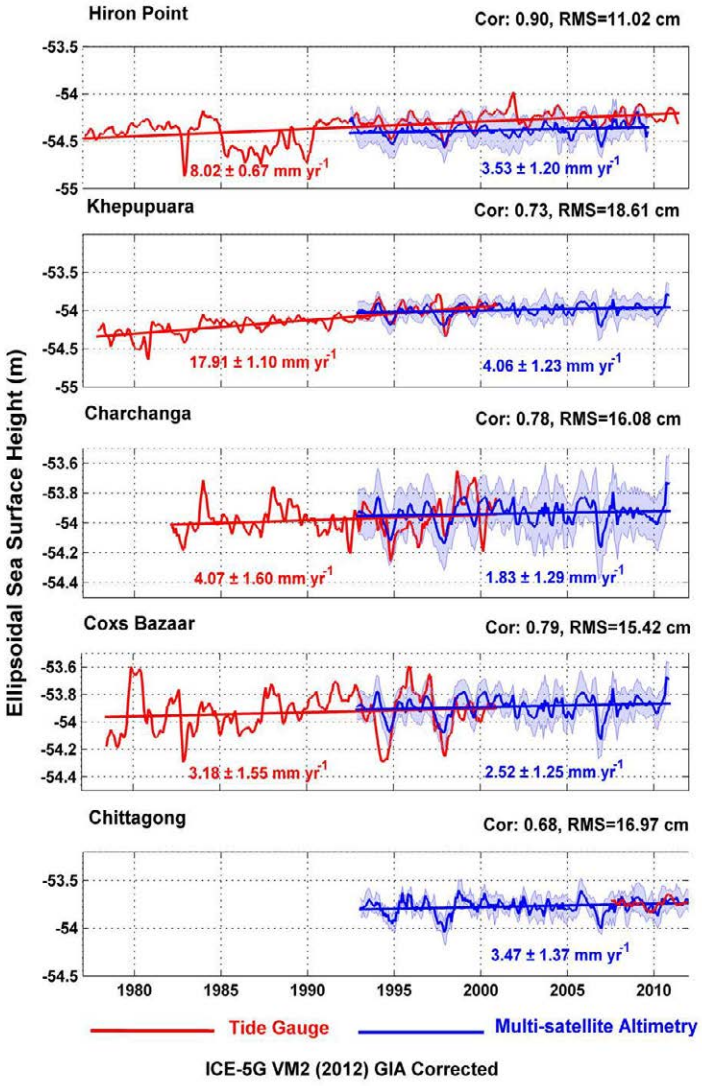
Bay of Bengal: Estimates of Crustal Uplift at Tide Gauge Benchmarks Combining Altimetry & Tide Gauge Sea-Level Record



reconstructed sea-level trend, 1950–2011 [*Meyssignac et al.* 2011]; Blue: GPS/TG installations in 2014; Glaciers in white (RGI)



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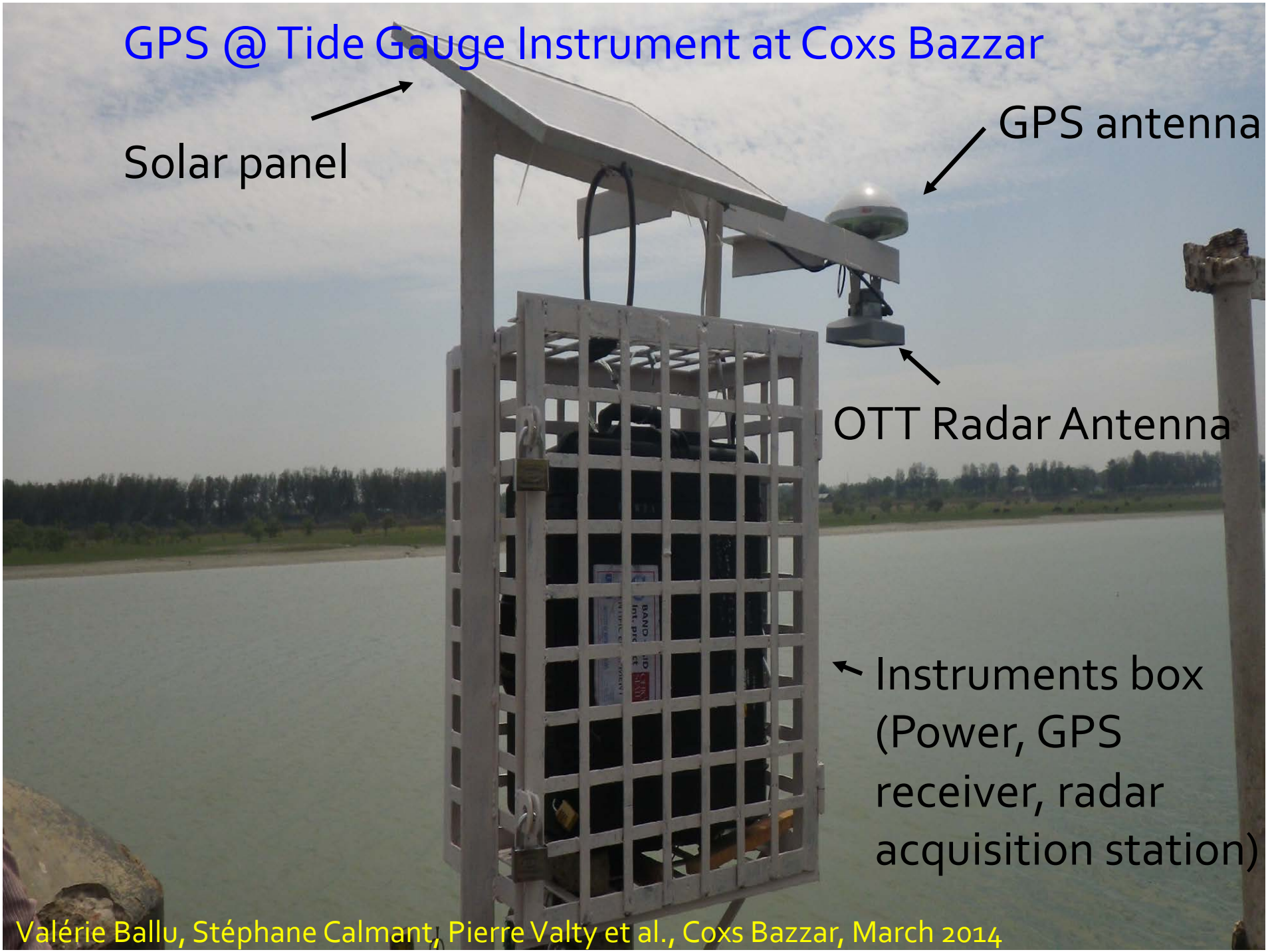
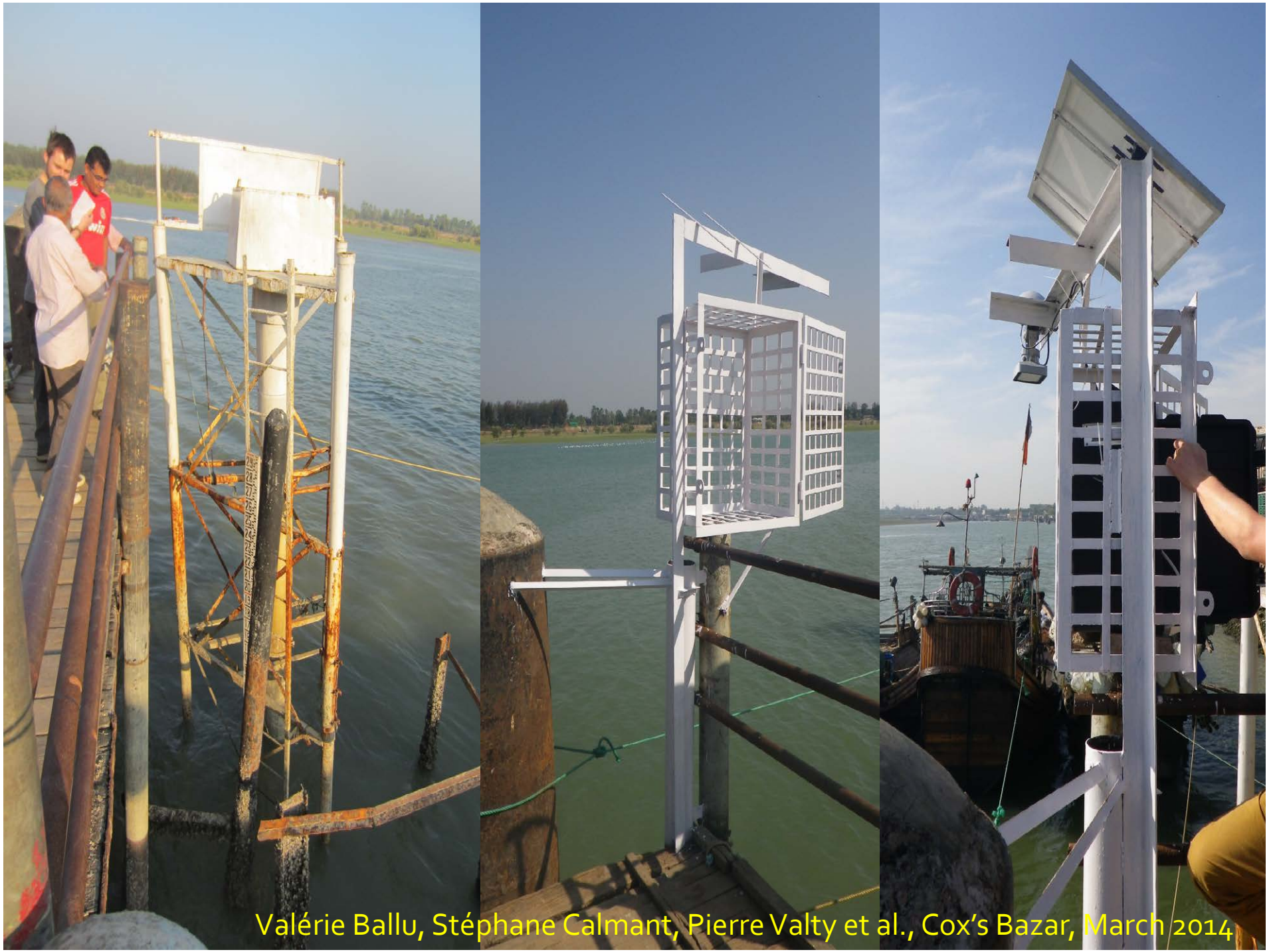
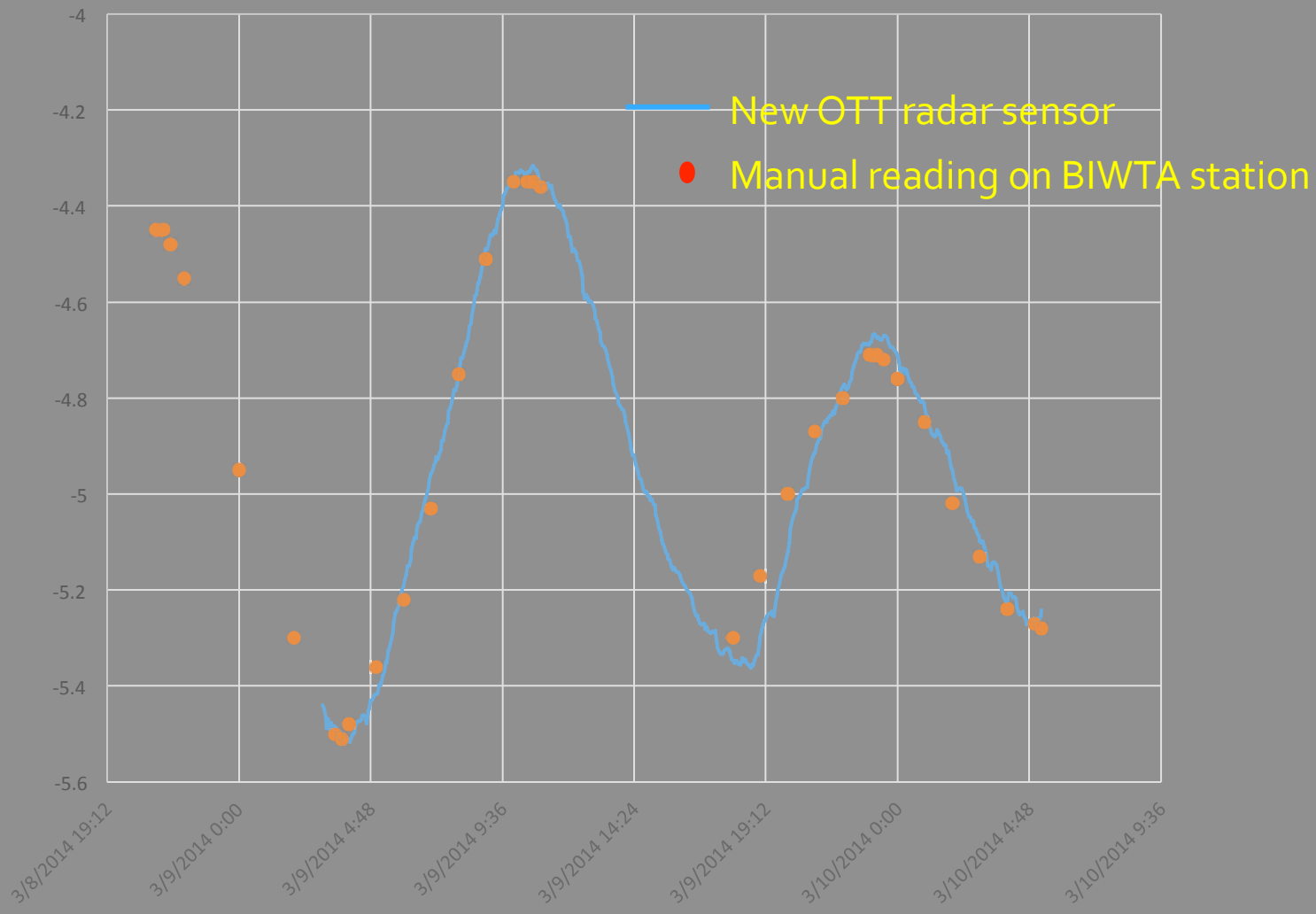

GPS @ Tide Gauge Instrument at Coxs Bazzar
Solar panel
GPS antenna
OTT Radar Antenna
Instruments box (Power, GPS receiver, radar acquisition station)
Valérie Ballu, Stéphane Calmant, Pierre Valty et al., Coxs Bazzar, March 2014

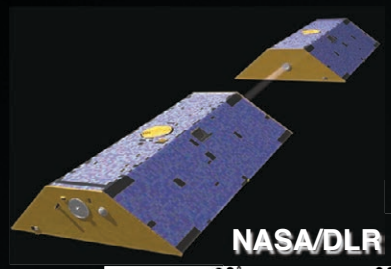


Valérie Ballu, Stéphane Calmant, Pierre Valty et al., Cox's Bazar, March 2014

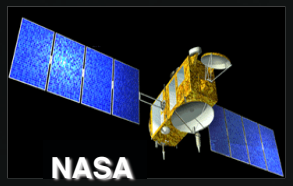
March 2014: First data from the new tide gauge at Cox's Bazar, Bangladesh, Comparison with manual readings

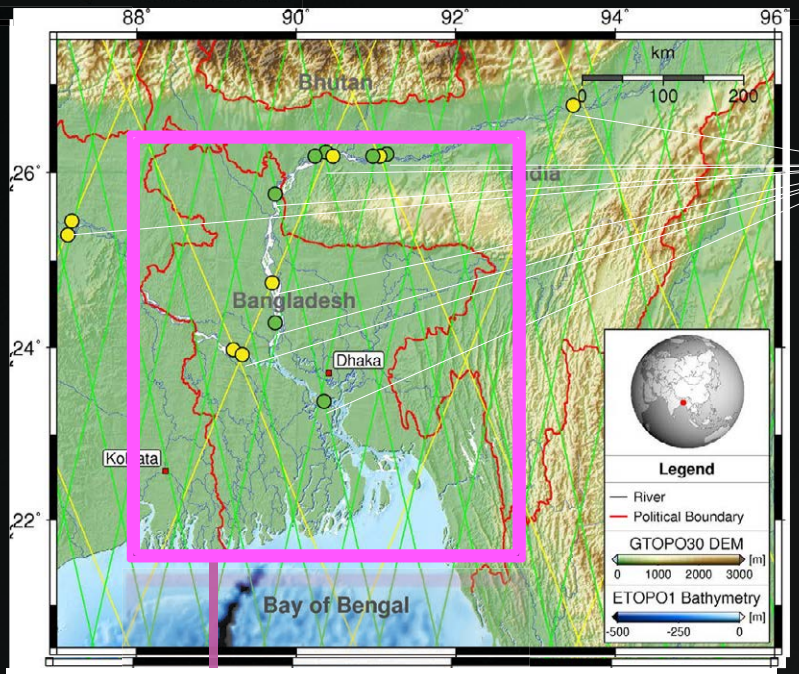


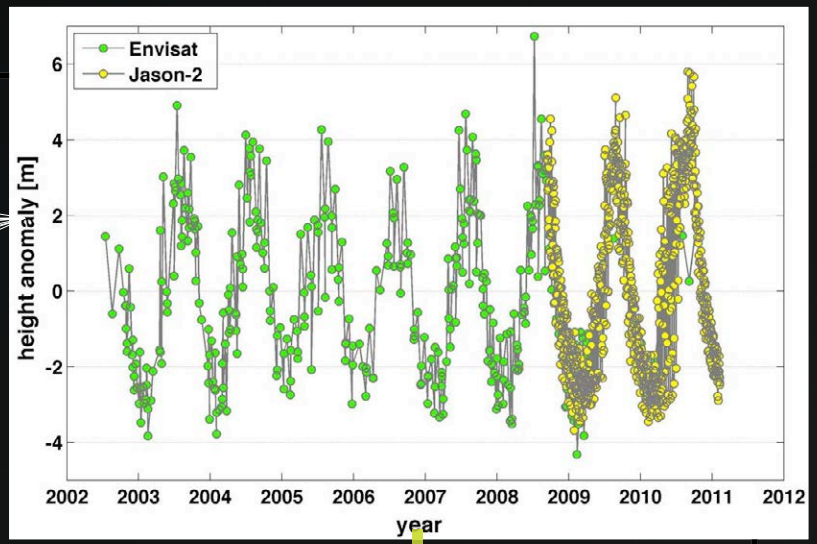
Valérie Ballu, Stéphane Calmant, Pierre Valty et al., 2014

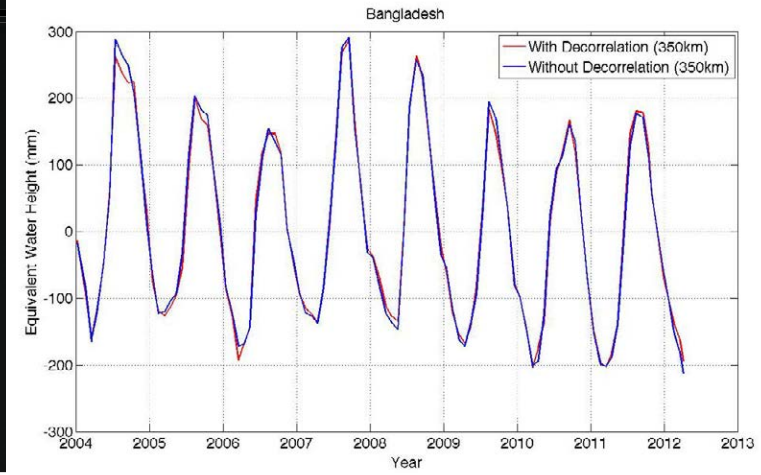


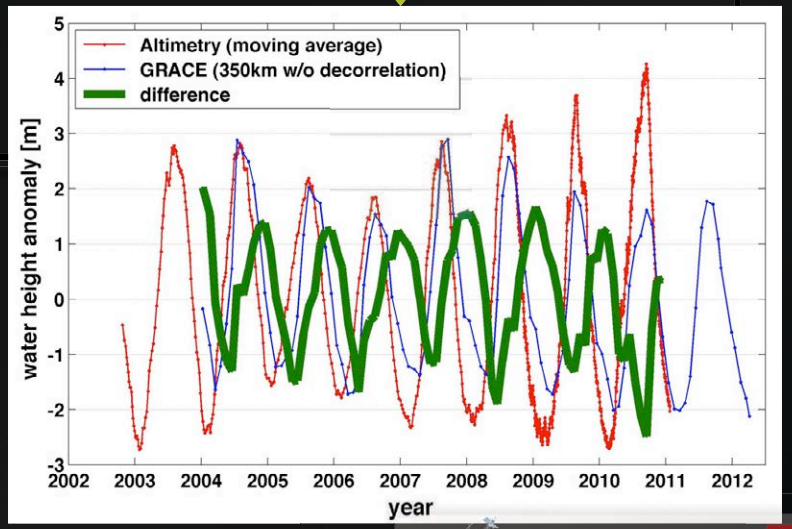
Jason/Envisat
Altimetry water level











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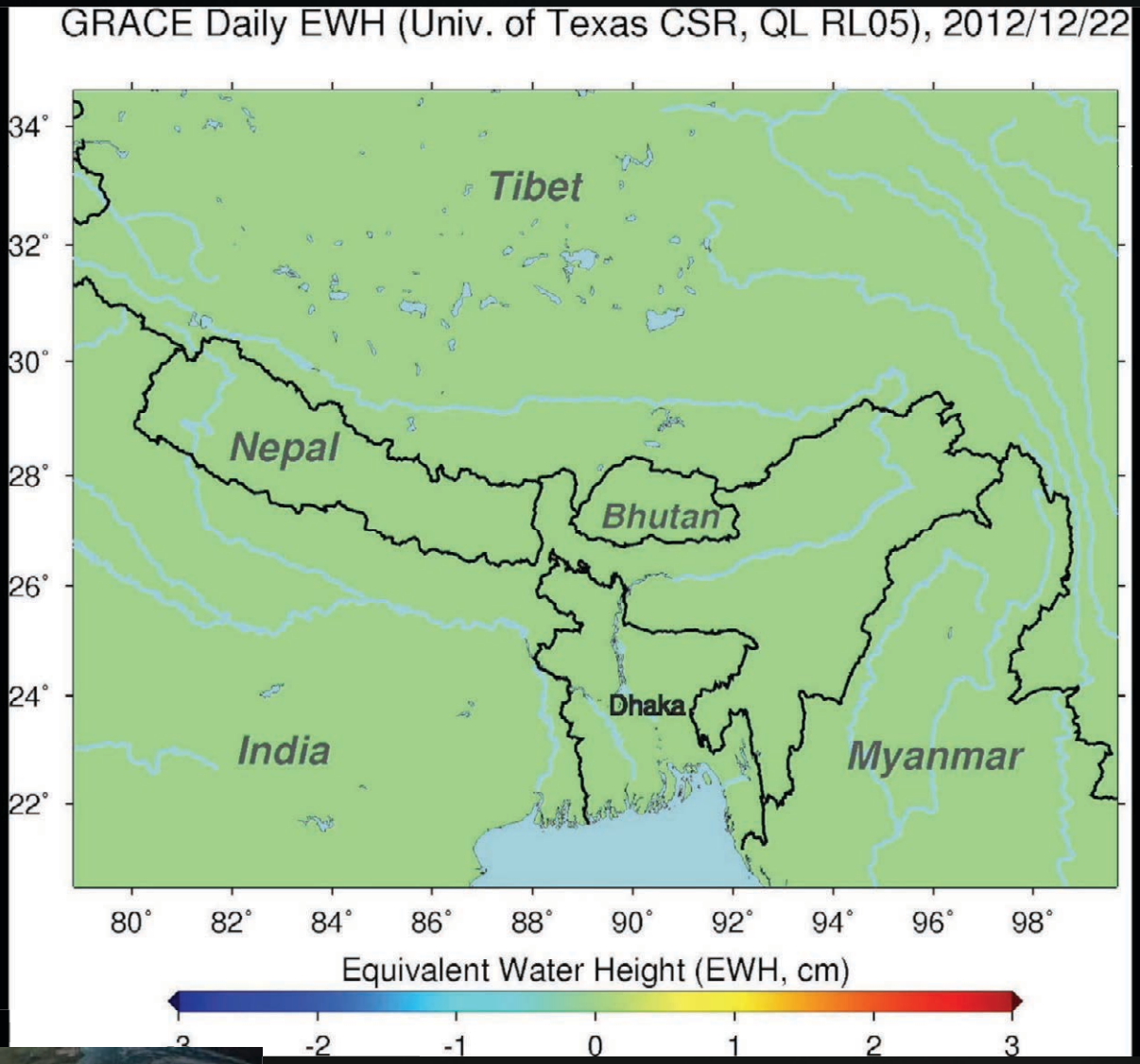
Bangladesh Delta Observed by GRACE Quick-Look (Daily) Solution*



12/2012–10/2013

GRACE near-real time data (CSR QuickLook, QL): 15-30 day solutions with 1-day steps. Latency: ~2 days after data acquisition


NASA/DLR

*Data courtesy: S. Bettadpur & B. Tapley, U. Texas CSR

De-correlation, no smoothing [*Duan et al.*, 2009; *Guo et al.*, 2010], Paulson GIA model corrected

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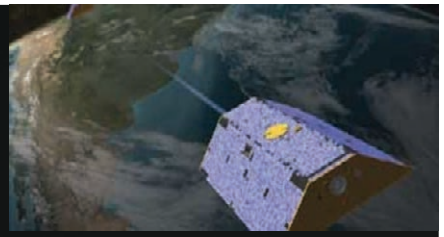
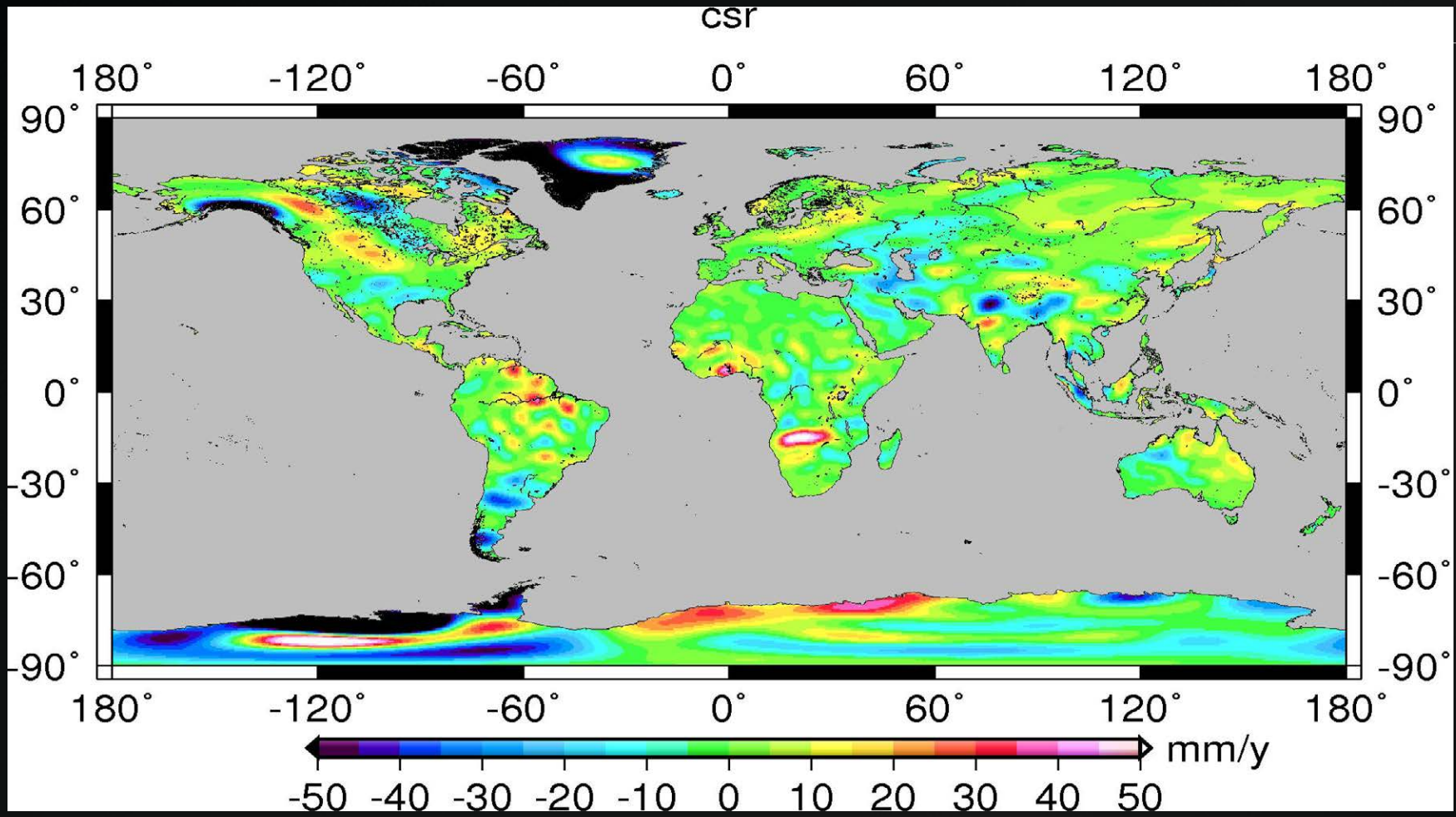
GRACE-Observed Mass Change, 2002–2014 Used to Generate Ice & Hydrology "Fingerprints"





SLR geocenter solution added to GRACE data. Decorrelated, smoothed (250 km), land signal leakage repaired [*Duan et al.*, 2009, *Guo et al.*, 2010]. CSR RL05 data product. GIA removed using Paulson-Zhang-Wahr model.

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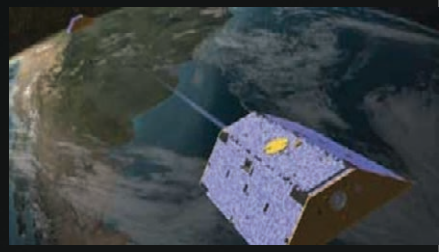
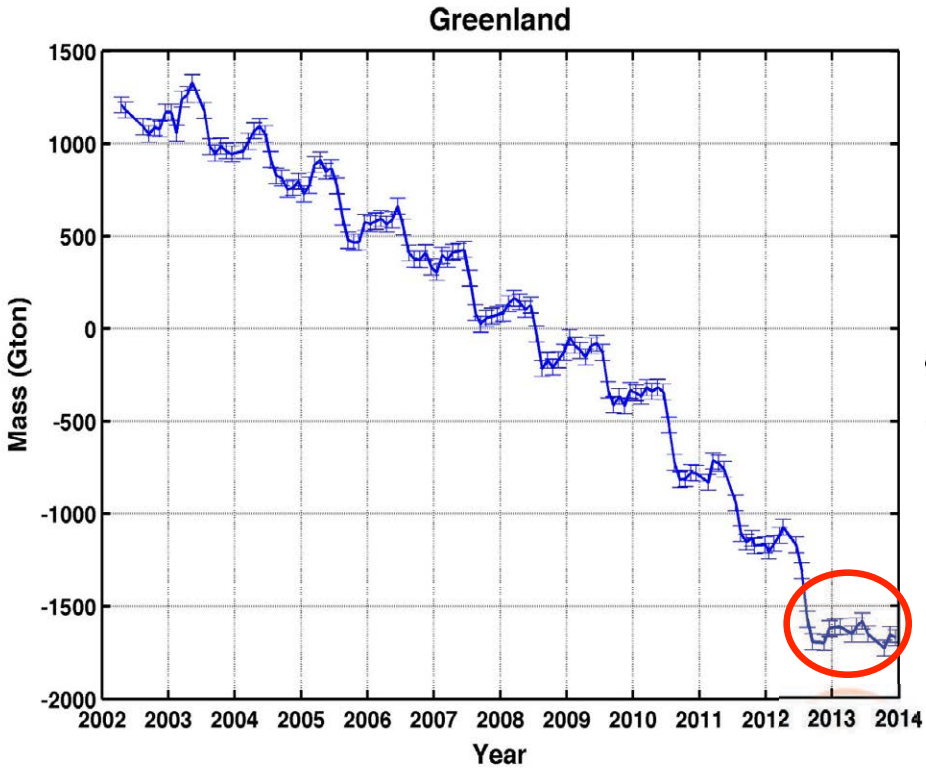
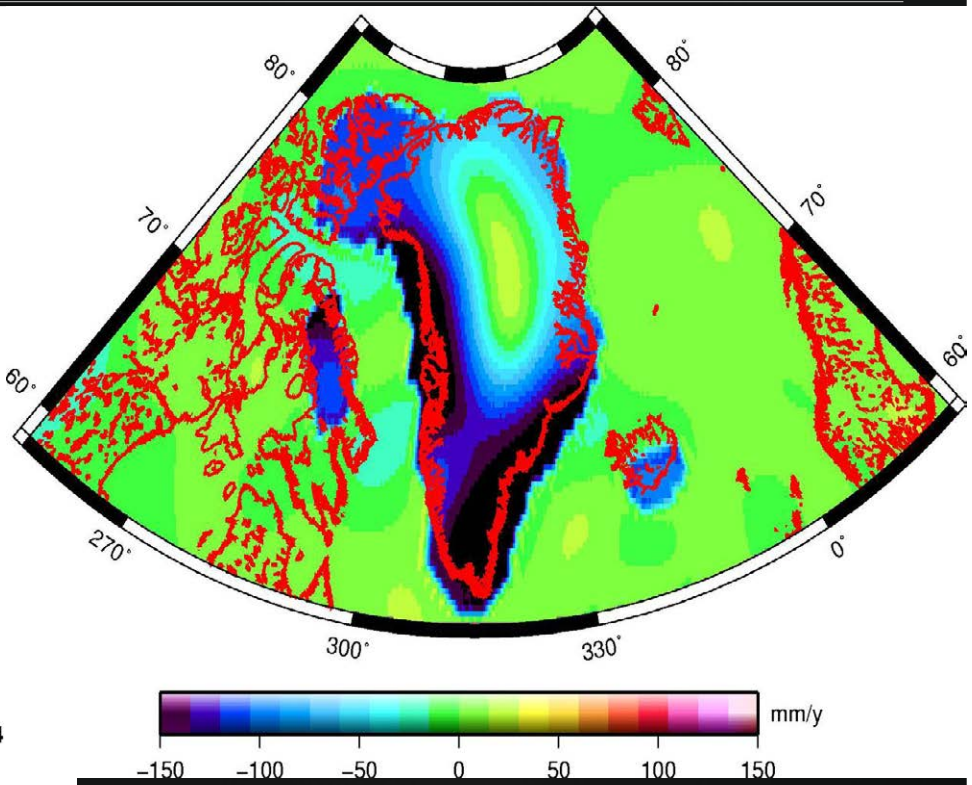
GRACE Observed Ice-Sheet Mass Balance Trend Over Greenland, 1/2000–12/2013





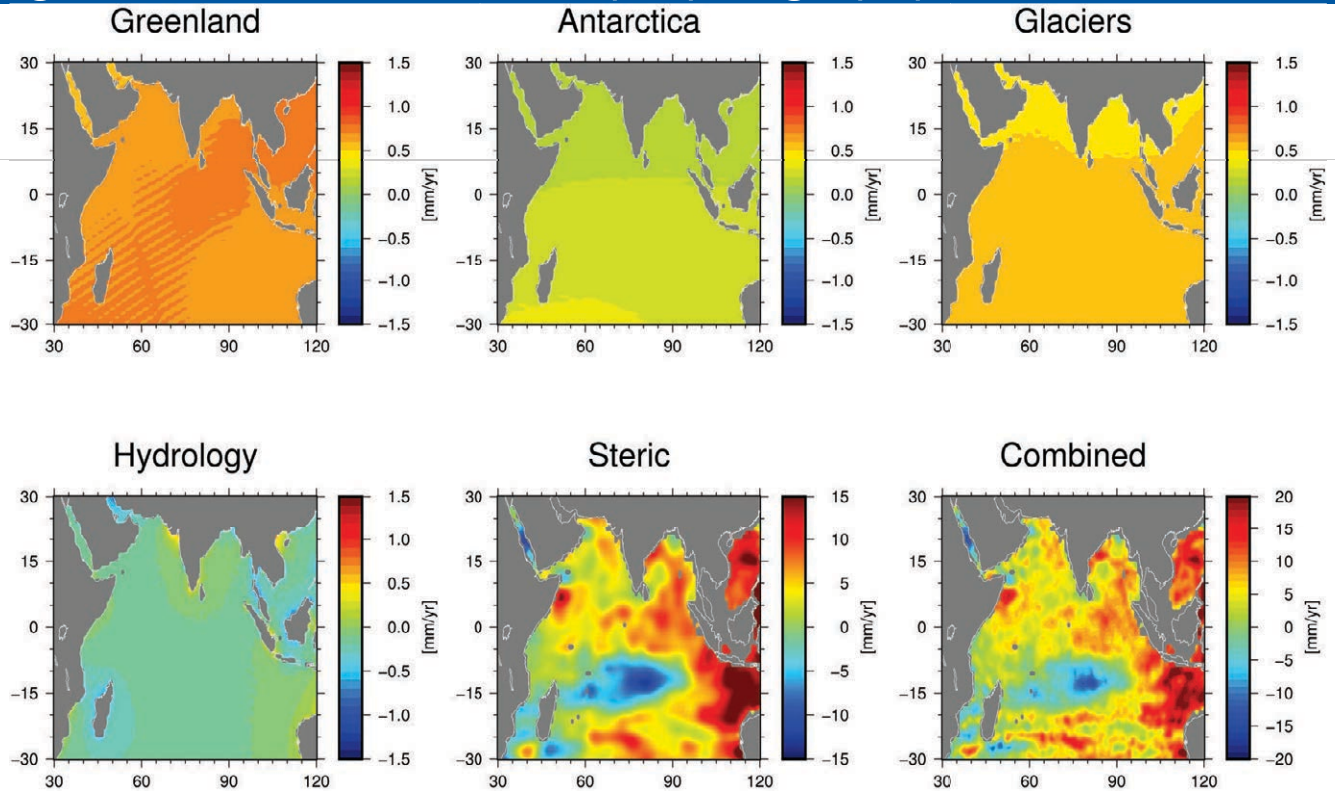


After leakage correction

−253±25 Gton yr^{-1}

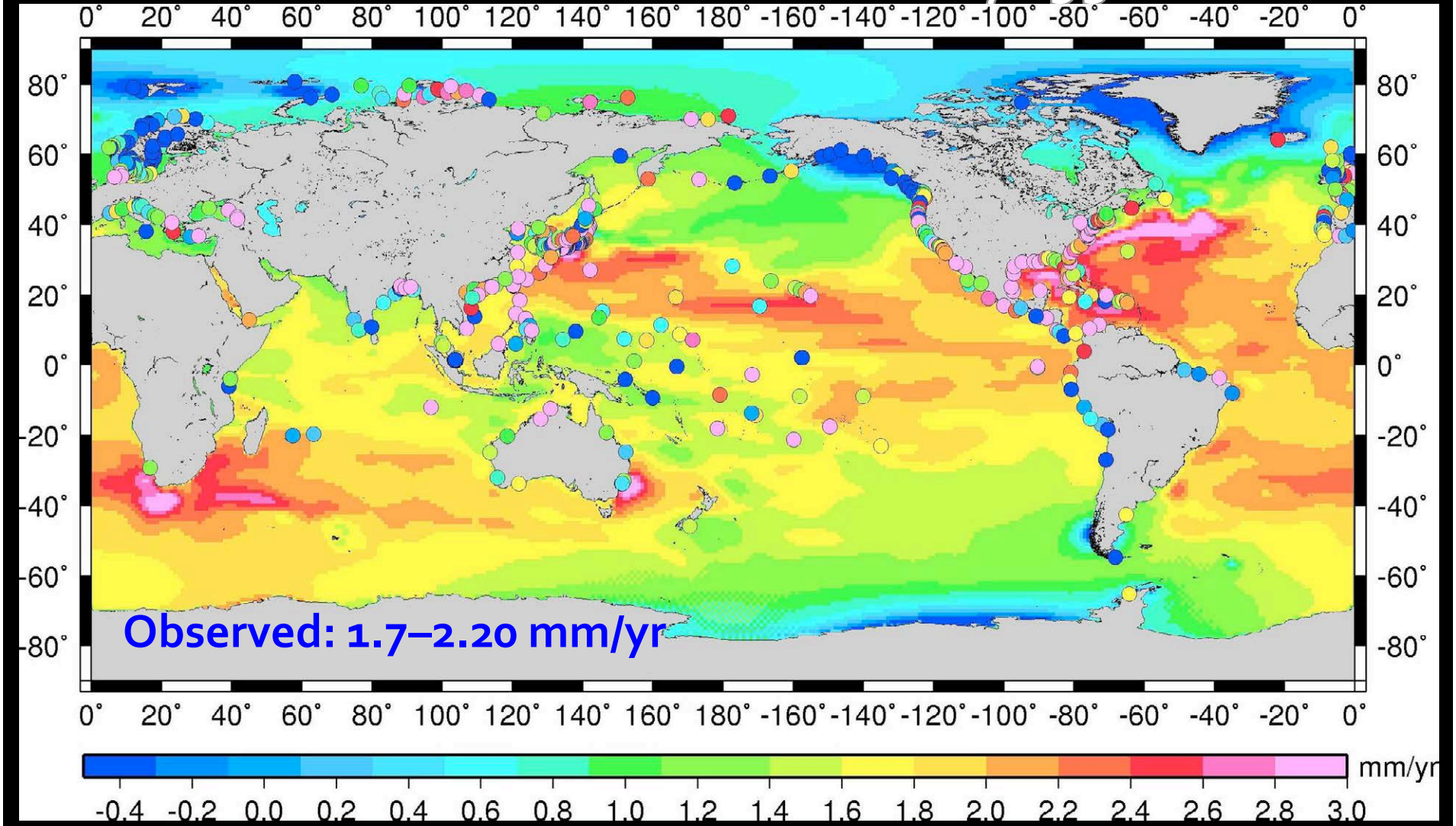
CSR RL05 Data Product, 300 km filtering, leakage repaired [*Guo et al.*, 2010], Paulson GIA correction applied, SLR C20 used

Quantifying contributors of sea-level rise via fingerprint inversion using GRACE, satellite altimetry, hydrography data, 2003–2014



- **Largest contribution in the Bay of Bengal region is from steric sea-level change**
- **Contribution of Greenland is larger than that of Antarctica**
- **The spatial variability from the total sea-level change is dominated by steric sea-level variations**

Sea-Level Fingerprint Adjustment Using Geodetic and Long-term Tide Gauge Data, 1950–2010



Estimated Sea Level Rise = 1.92±0.23 mm yr^{-1}

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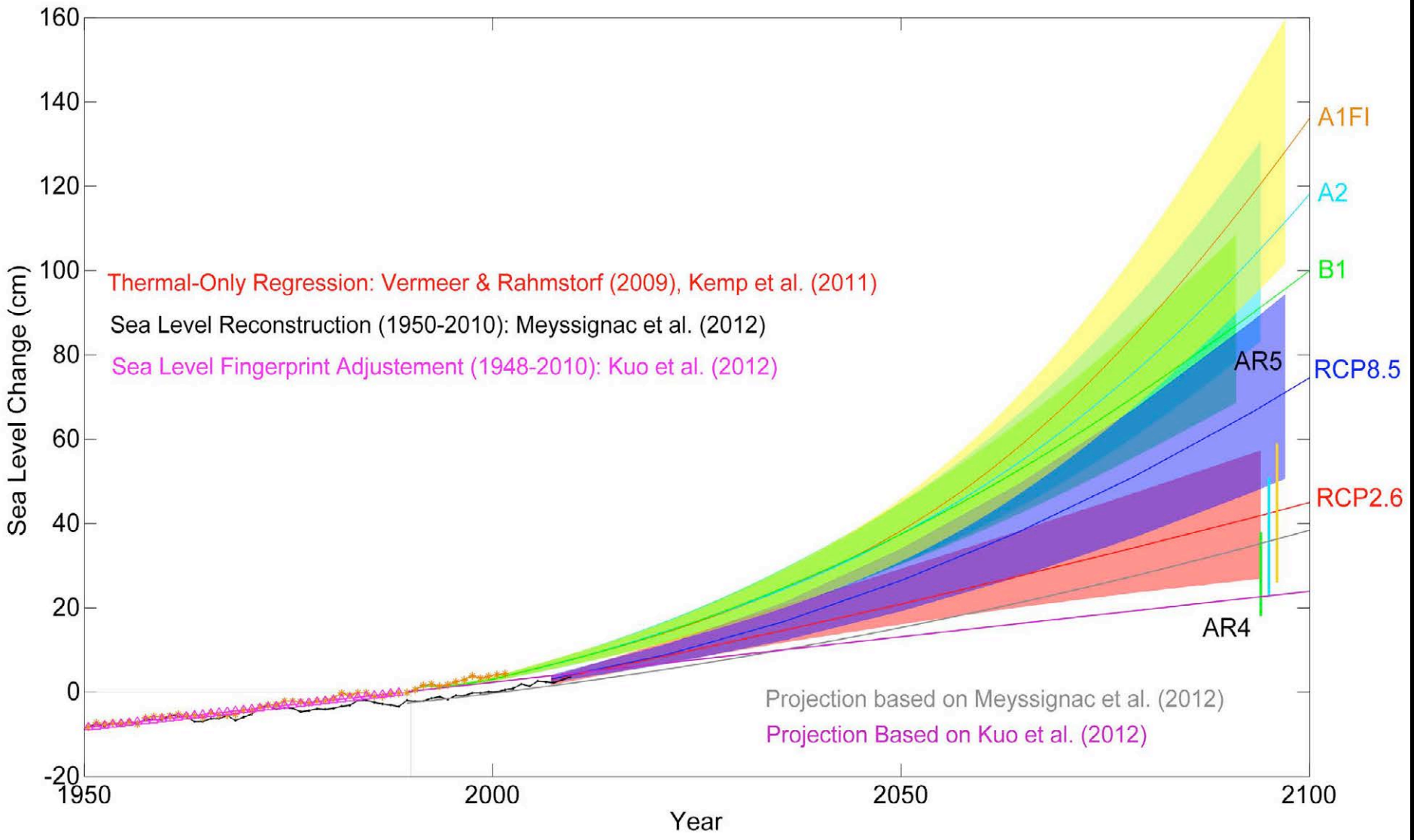
Projection of Global Sea-Level Rise (100 BC–2100 AD): Preliminary



IPCC AR5 [*Church et al.*, 2013, 1993–2010]: *obs.*: **2.3→3.4 mm yr^{-1}** vs ***explain:*** **2.8→3.6 mm yr^{-1}** ***Unexplained:*** **–0.4→1.2 mm yr^{-1}**

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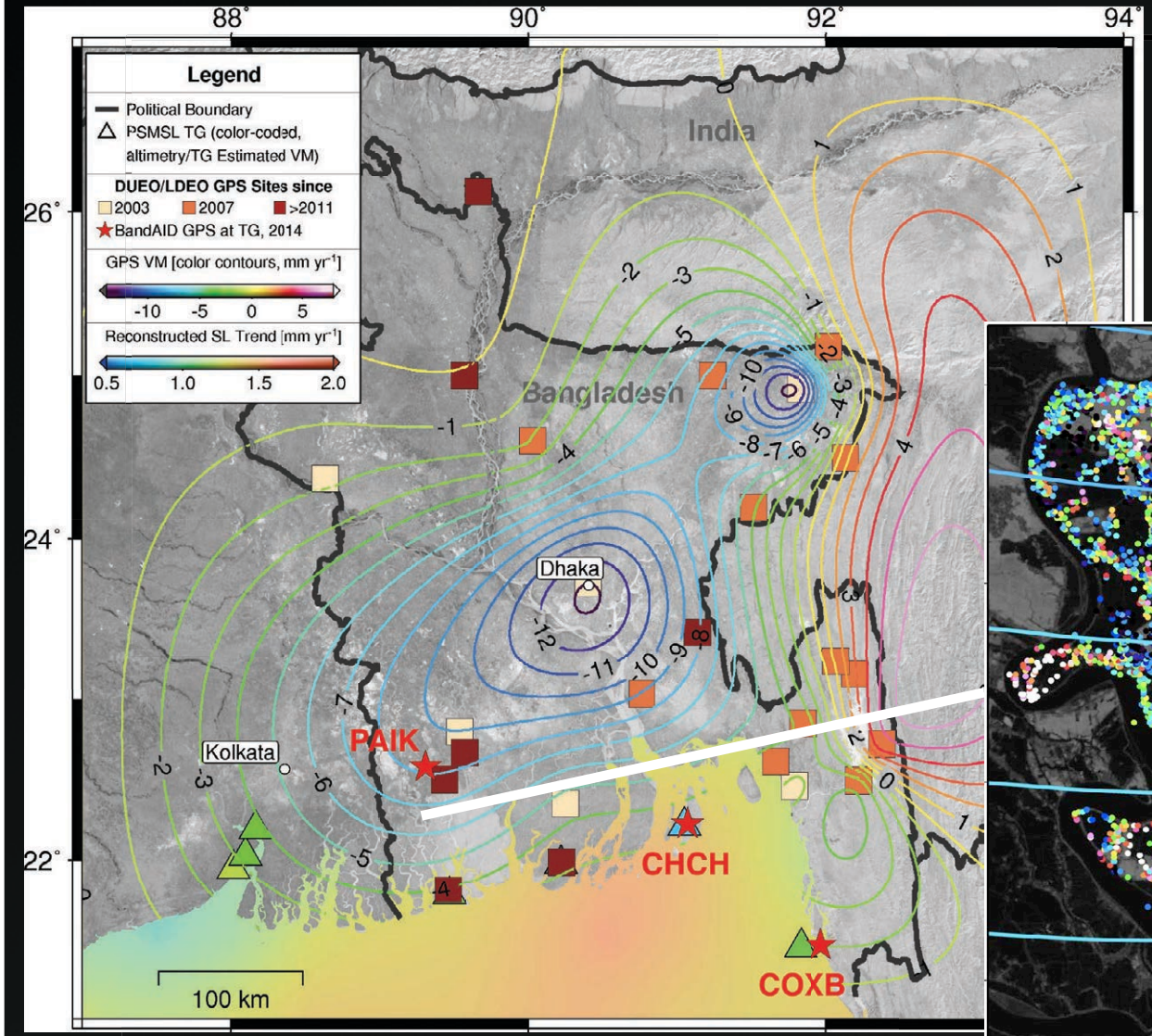
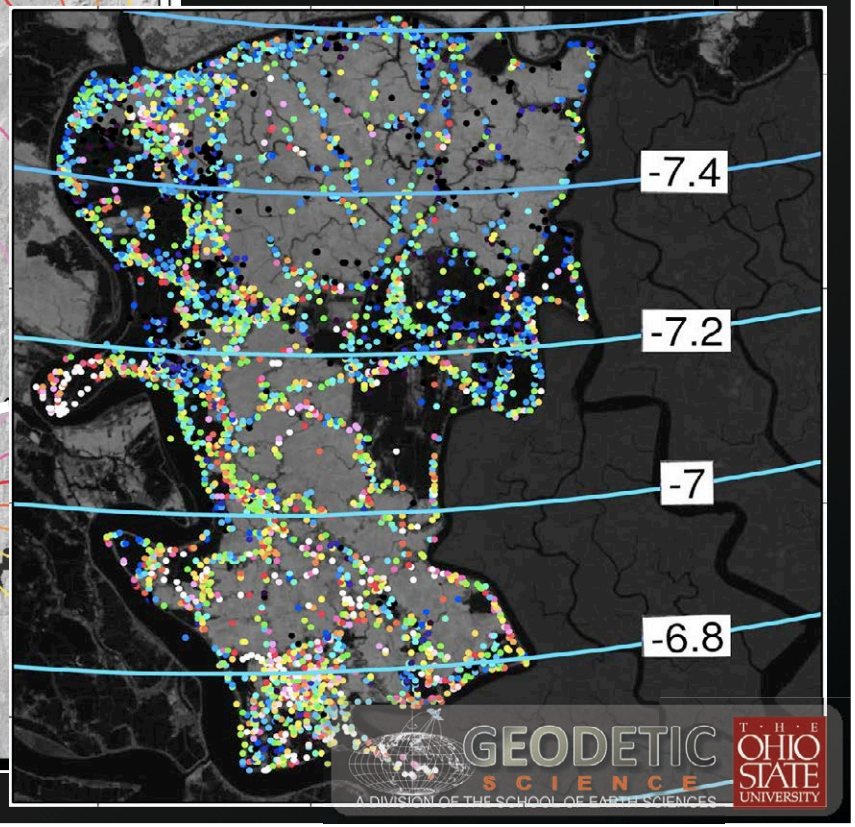
BANGLADESH LAND SUBSIDENCE: SEDIMENT LOAD & GROUNDWATER PUMPING

Vertical motion combining tide gauges (>60 years) and altimetry (20 years), method based on *Kuo et al*. [2004] . GPS velocities [courtesy, *Steckler et al.*, 2012]. Vertical motion solutions combining tide gauges (>60 years) and altimetry (20 years), method based on [*Kuo et al*. 2004].



Inset: Color dots denote land vertical motion (VM) on Polder No. 13-14 using ALOS PALSAR, 2008-2011, and PSInSAR technique. Color contours are VM interpolated from GPS velocities



Village Adaptation to Flood Risk

Craig Jenkins & Joyce Chen, Ohio State U., USA

Key Questions:

1. Does flooding reduce village resilience?
2. How do villages adapt to flooding risk?
3. Is Migration (permanent, short-term) a form of adaptation to climate risks?

Method:

1. Study of flooding impact on village population change using satellite data (MODIS, Polarimetric SAR)
2. Focused interviews with selected high and low risk villages
3. Examination of migration decision-making through longitudinal survey (1981–82; 2000–03; 2007–08); includes data on type of migration, household structure, age & gender, village characteristics (including climate risk)

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An Integrated Natural & Social Science Study: Flood Risk Analysis, 2002–2010

- Use MODIS data to estimate water coverage of Bangladesh *union parishads* (2002 – 2010); sum count of observations greater or equal to 0.1 MNDWI
- Use multiple regression to assess relationship of flooding to population change (2001–2011)
- Key preliminary finding: significant negative effect of flooding on village population change

Next Steps

1. Refine regression analysis (data cleanup, additional predictors, etc.)
2. Village interviews with mayors/villagers about adaptation; 2 w/ high pop. loss & 2 w/ pop.
3. Integrate with scenario analysis

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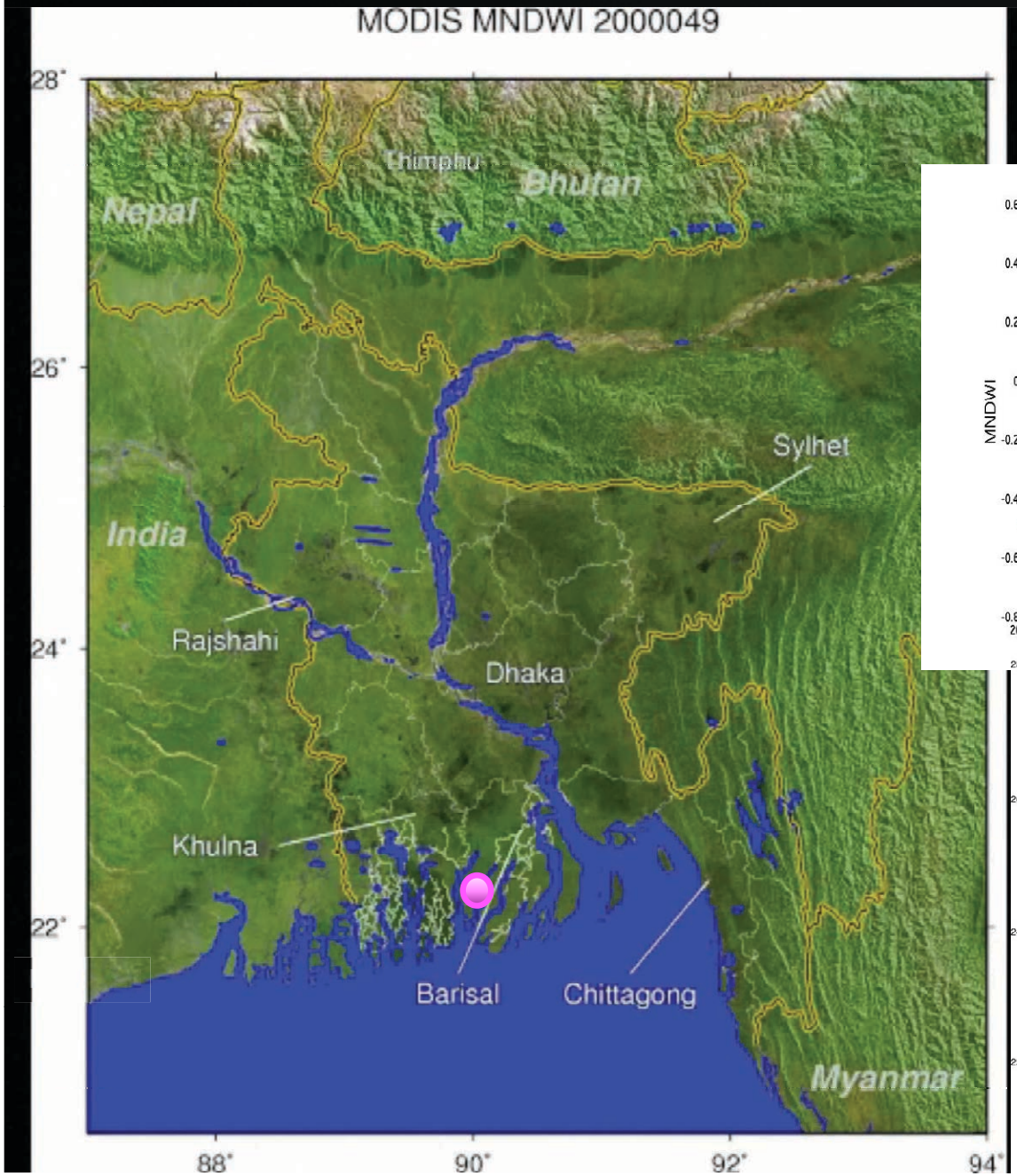
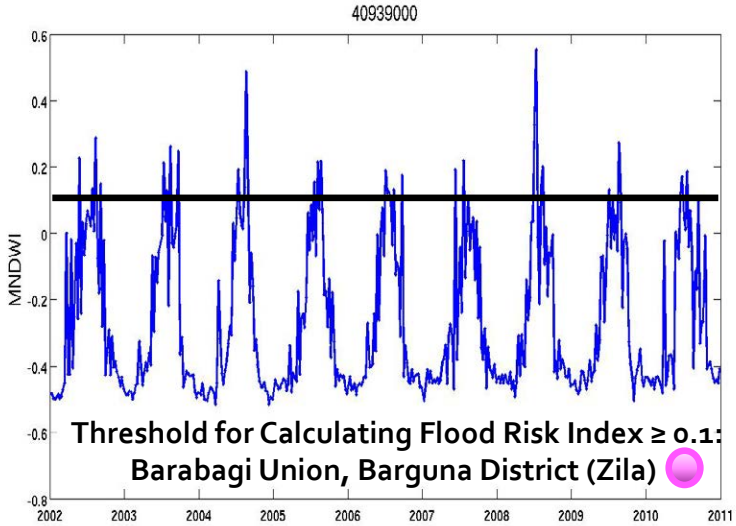
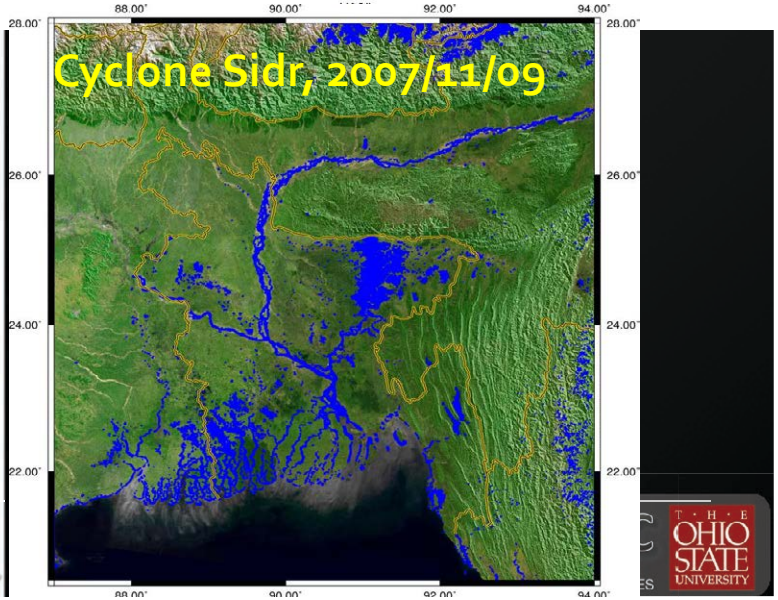
Bangladesh Delta Observed by Terra/Aqua MODIS Water Extents



2/2001–1/2010
8-day, MNDWI





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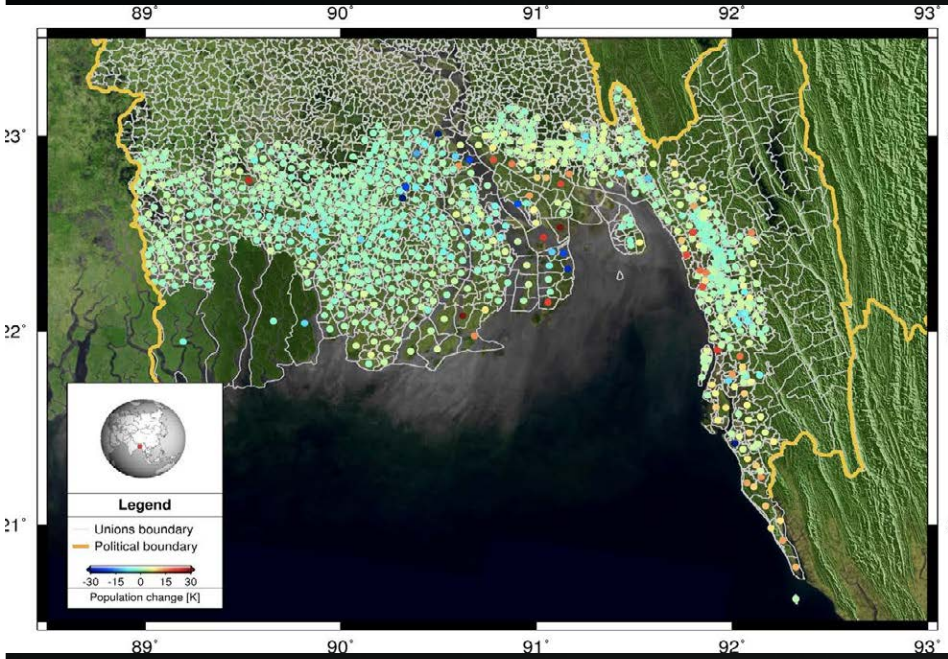
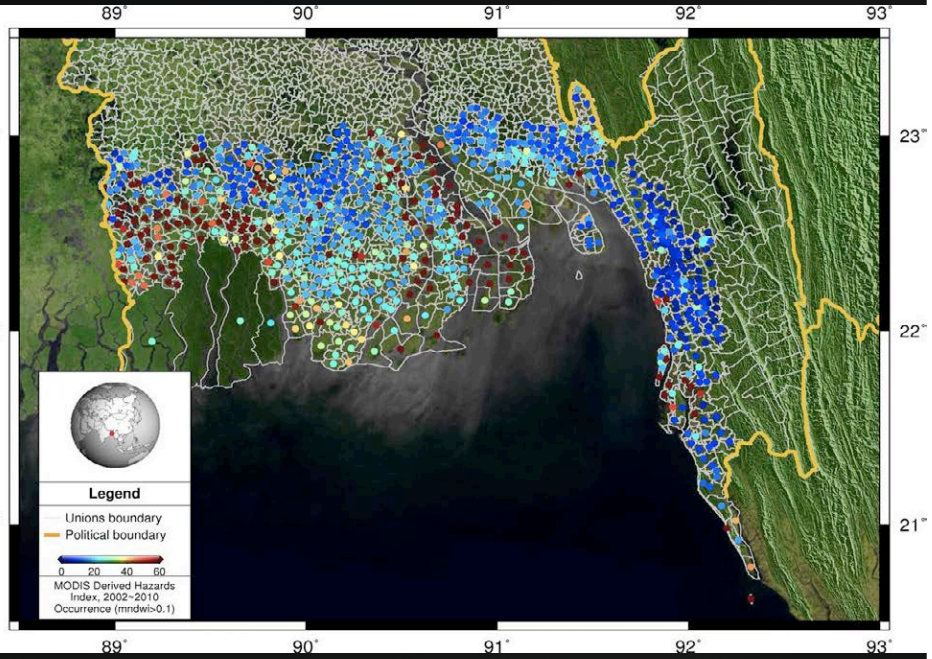
Bangladesh Flood Risk & Migration Analysis, 2002–2010

Change in Union Population, 2001- 2011



Counts of MODIS Index ≥ 0.1, 2001- 2011



Multiple Regression Analysis of Union Population, 2001–2011

Independent Variable:	Coefficient	T stat.	beta
Population 2001	1.03	43.23***	.84
Population Density 2001	–226.98	–2.62**	.05
Flood Vulnerability Index	–9.64	–3.06**	.06

** p < .01; *** p < .001

Key preliminary finding:
significant negative effect of flooding on village population change

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Land Use Change & Micro Adaptation

Boris Braun, & Amelie Bernzen, Univ. of Cologne, Germany;
Raquib Ahmed, Univ. of Rajshahi, Bangladesh

Key Questions:

1. How is land use change (esp. shift from rice to shrimp production) related to livelihood strategies, migration, natural disasters?
2. Are these changes adaptive?

Method:

1. Randomized survey of 1000+ households in selected rural & semi-urban environments (in progress)
2. 40–50 semi-structured interviews with businesses in 3 major coastal industries (shrimp farming, logging and paper manufacturing), in progress

Social Science Preliminary Findings

- Severe flooding is a source of village population loss
- Out-migration is adaptive: Temporary emigration response to wage/remittance gains. Permanent emigration response to household changes & flooding risk
- Future work needs to integrate climate risk into analysis of migration & assess particular village adaptations

Bangladesh & International Partners, NGO Collaborators:

• IWM, BWBD, BIWTA, SDOB, Env. BD, BD IDS, U. Mymensingh

• World Bank, UNDP, IFPRI, US-AID, ONR, NSF PEER (funded IWM BanD-AID), Columbia-LDEO, Potsdam IFCIR, WARPO, CDMP, BD-CAS, BARCIK, Uttaran, Ch. 1 TV, U. Dhaka, BU E&T, BRAC, CC-PA

Research Questions + **Field Work in Bangladash**

Amelie Bernzn, Boris Braun