Uncertain future of Mekong's hydrology and sediments

Matti Kummu & al
Aalto University, Finland
www.wdrg.fi

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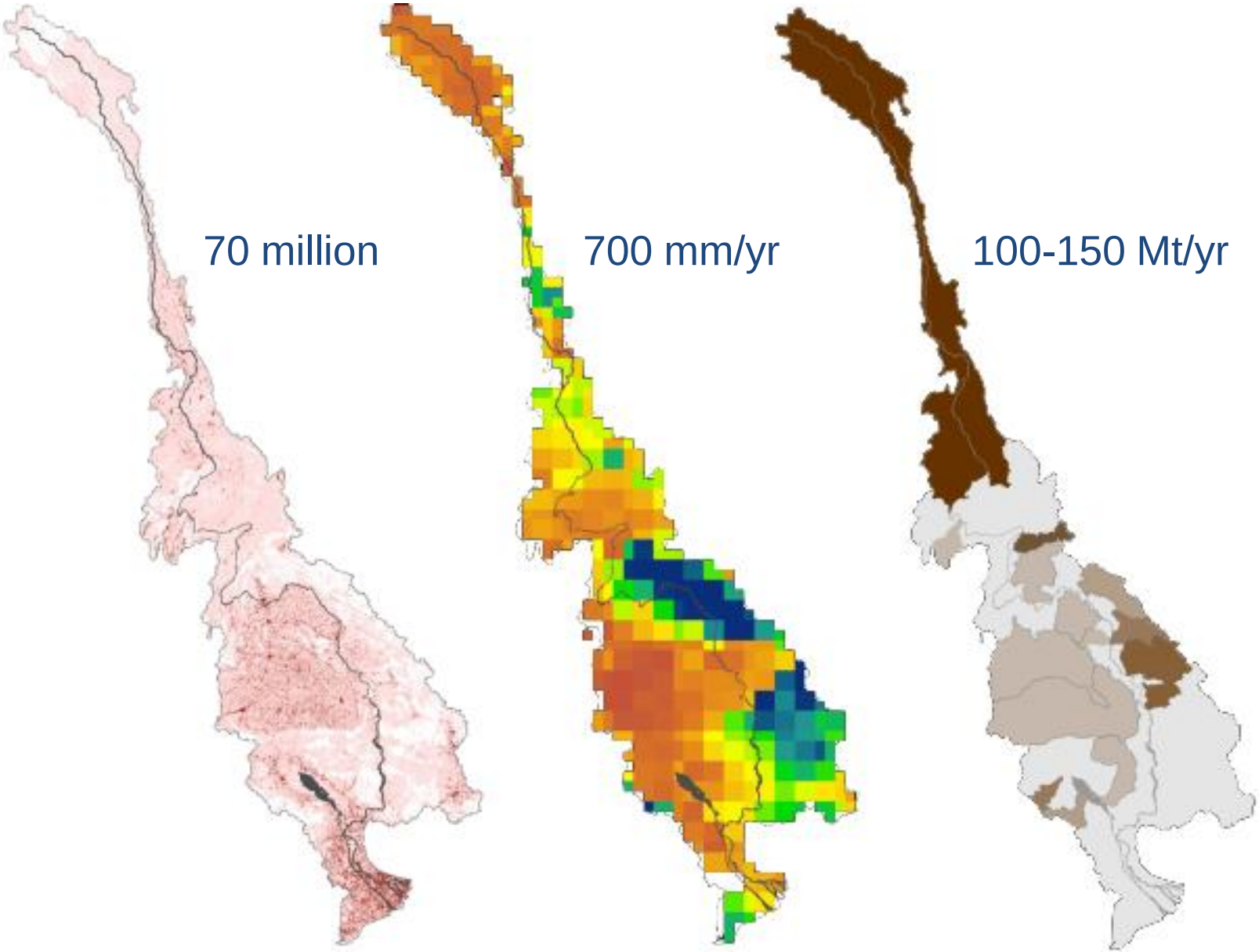
Background

- 2002 – started to work in the Mekong under WUP-Fin and Greater Angkor projects
- 2002-2006 – lived in the region
- 2008 – finished my PhD on '*Spatiotemporal scales in hydrological impact assessment in the Mekong*'
- 2009 – started as a postdoc at Aalto University
- 06/2013 – Assistant professor at Aalto University

- Work with multiple scales, from local to global. Trying to understand the interconnections between human population and water resources.

population water resources sediment



LandScan (2007) *Fekete & al (2000)* *Kummu & al (2010)*

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HYDROLOGY

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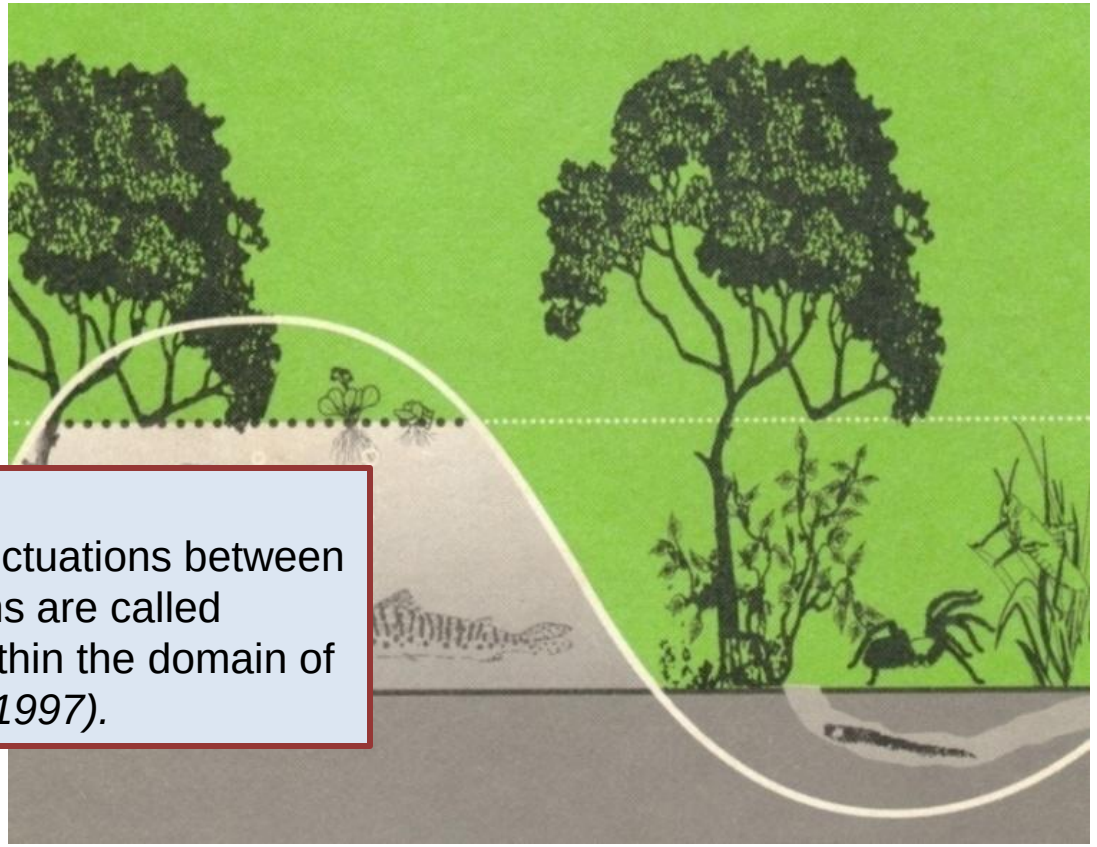
Monsoon driven hydrology: flood pulse

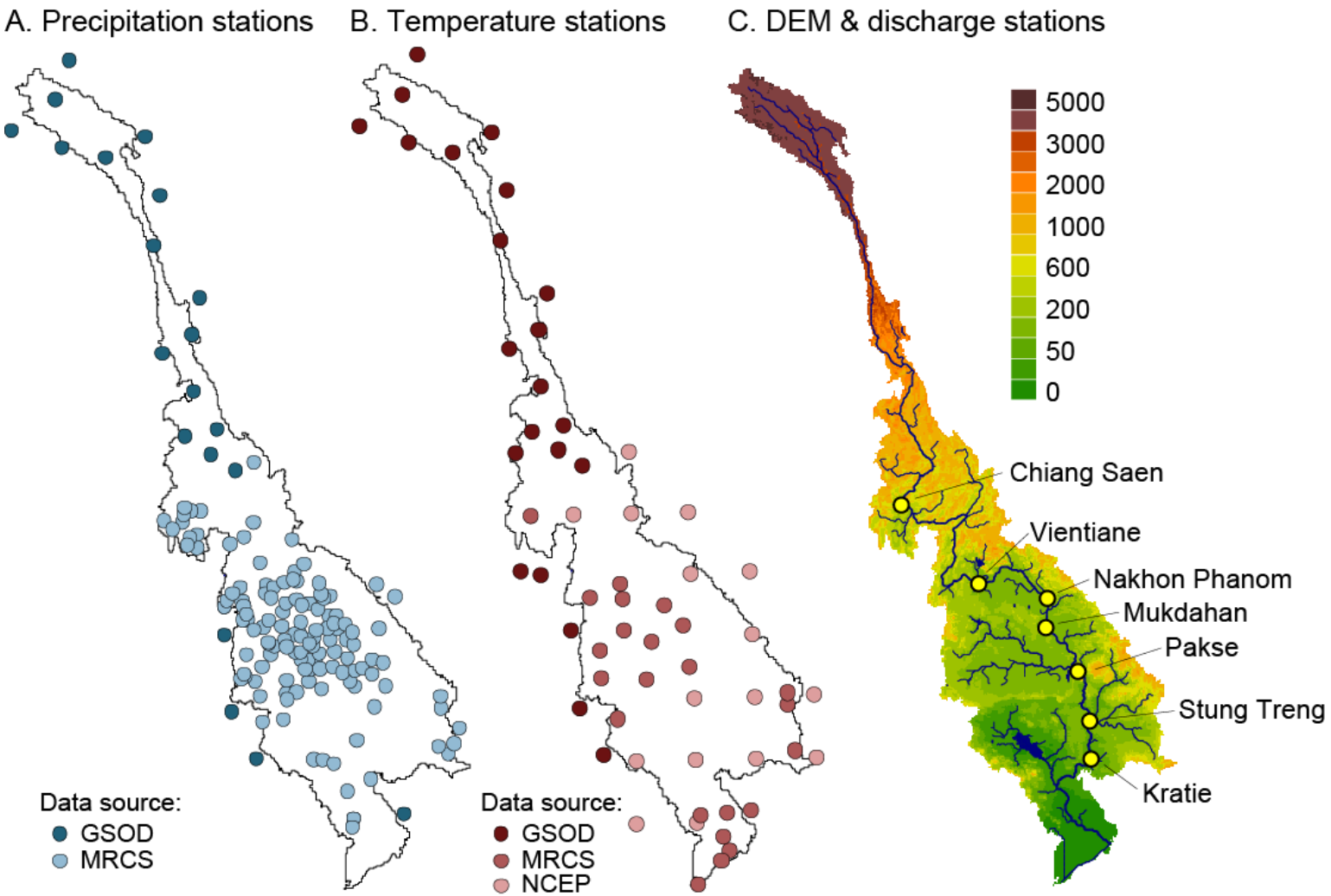
- Mekong hydrology is dominated by monomodal flood pulse with water level variation over 10 m
- Wetland ecosystems are extremely productive



'Flood pulse'
Ecosystems that experience fluctuations between terrestrial and aquatic conditions are called pulsing ecosystems, and fall within the domain of the flood pulse concept *(Junk, 1997).*

Junk (1997)

Observed data coverage



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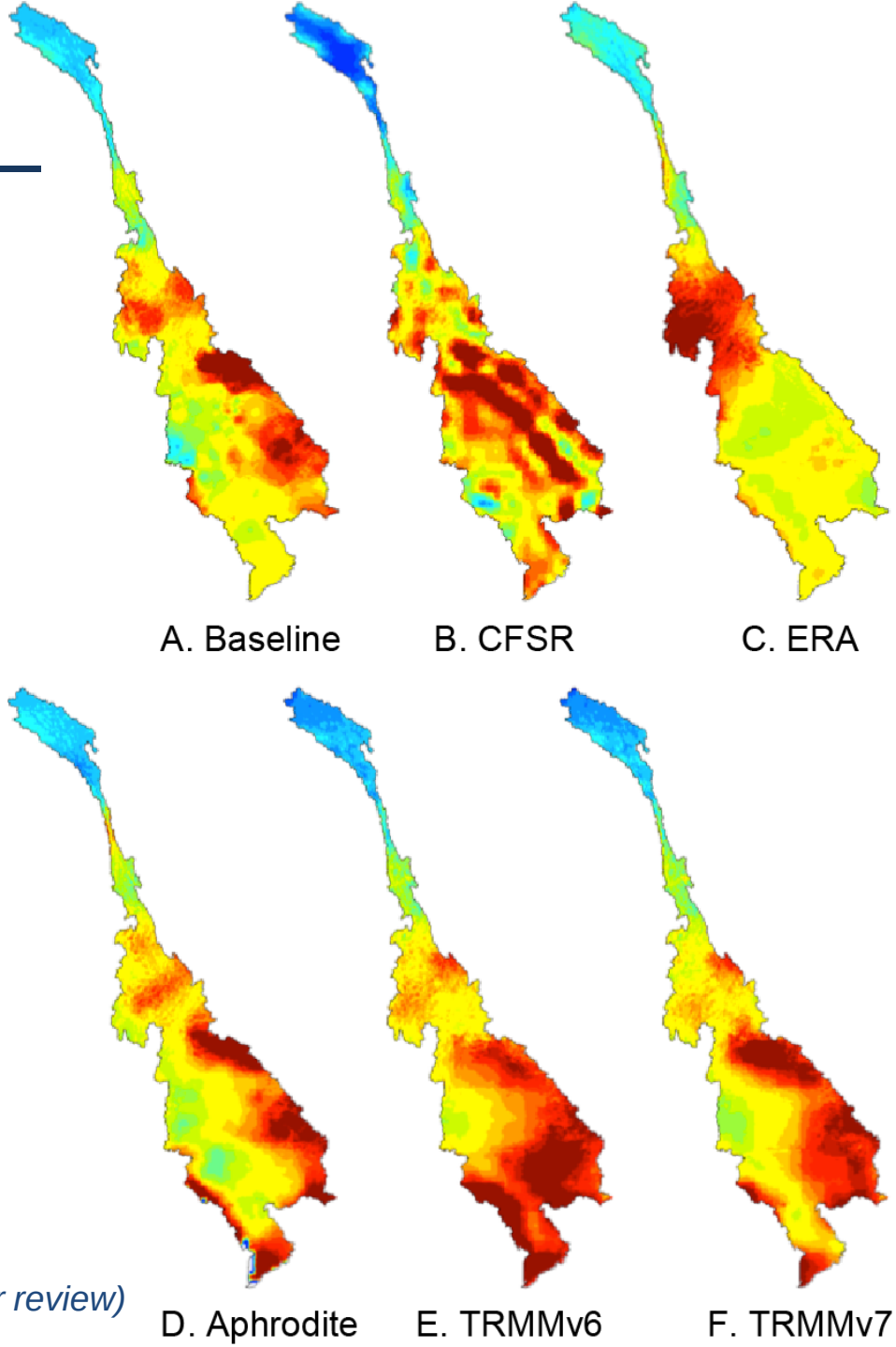
Lauri et al (2012)

Precipitation – gridded datasets



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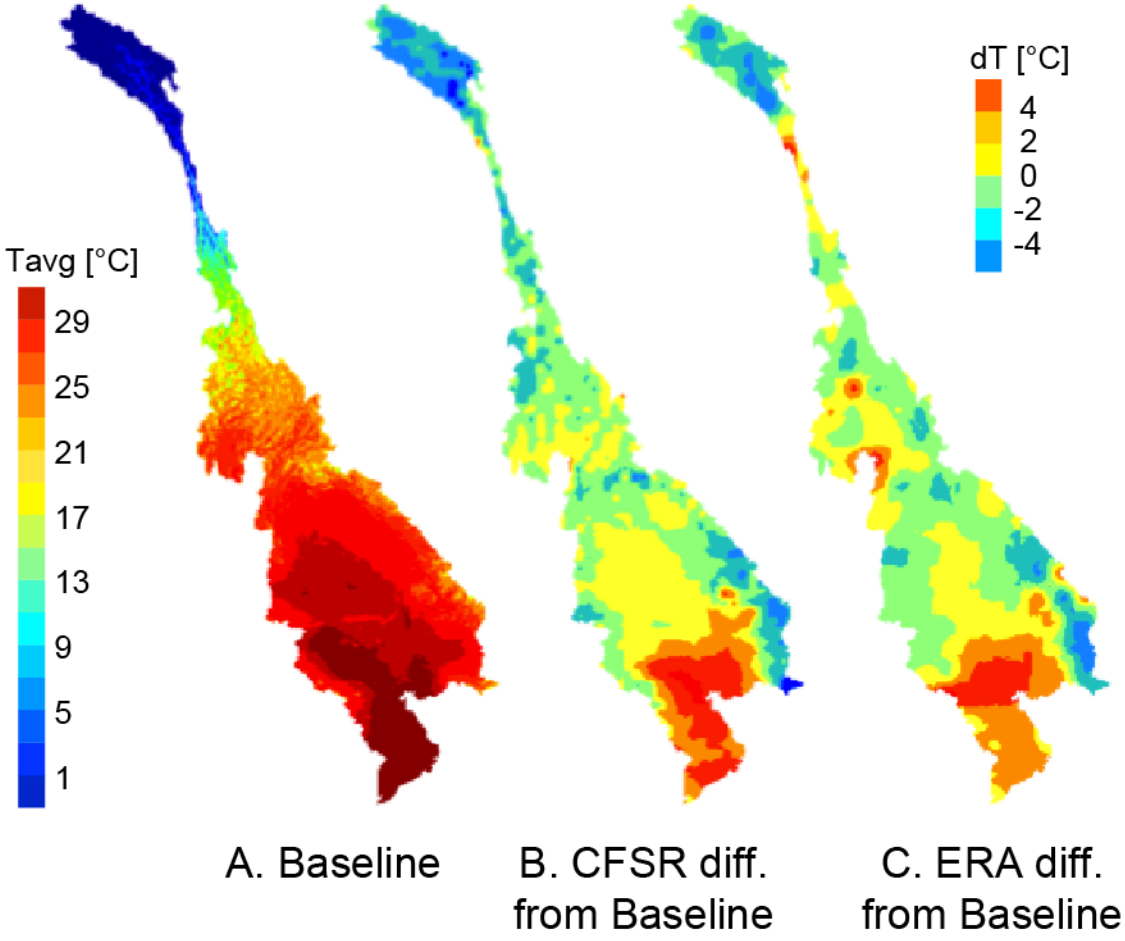
Lauri et al (under review)

Temperature – gridded datasets



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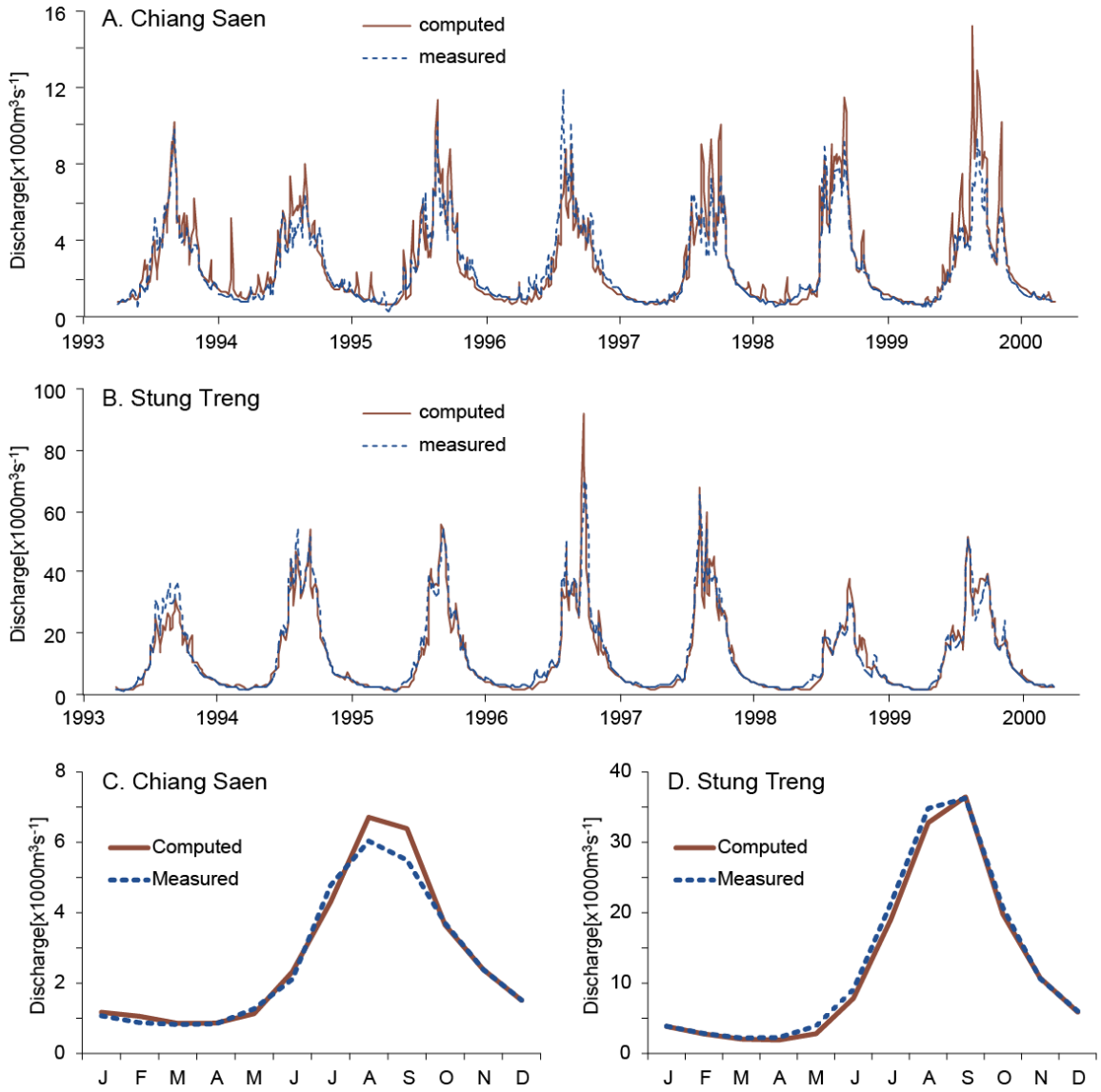
Hydrological regime – baseline



Lauri et al (2012)

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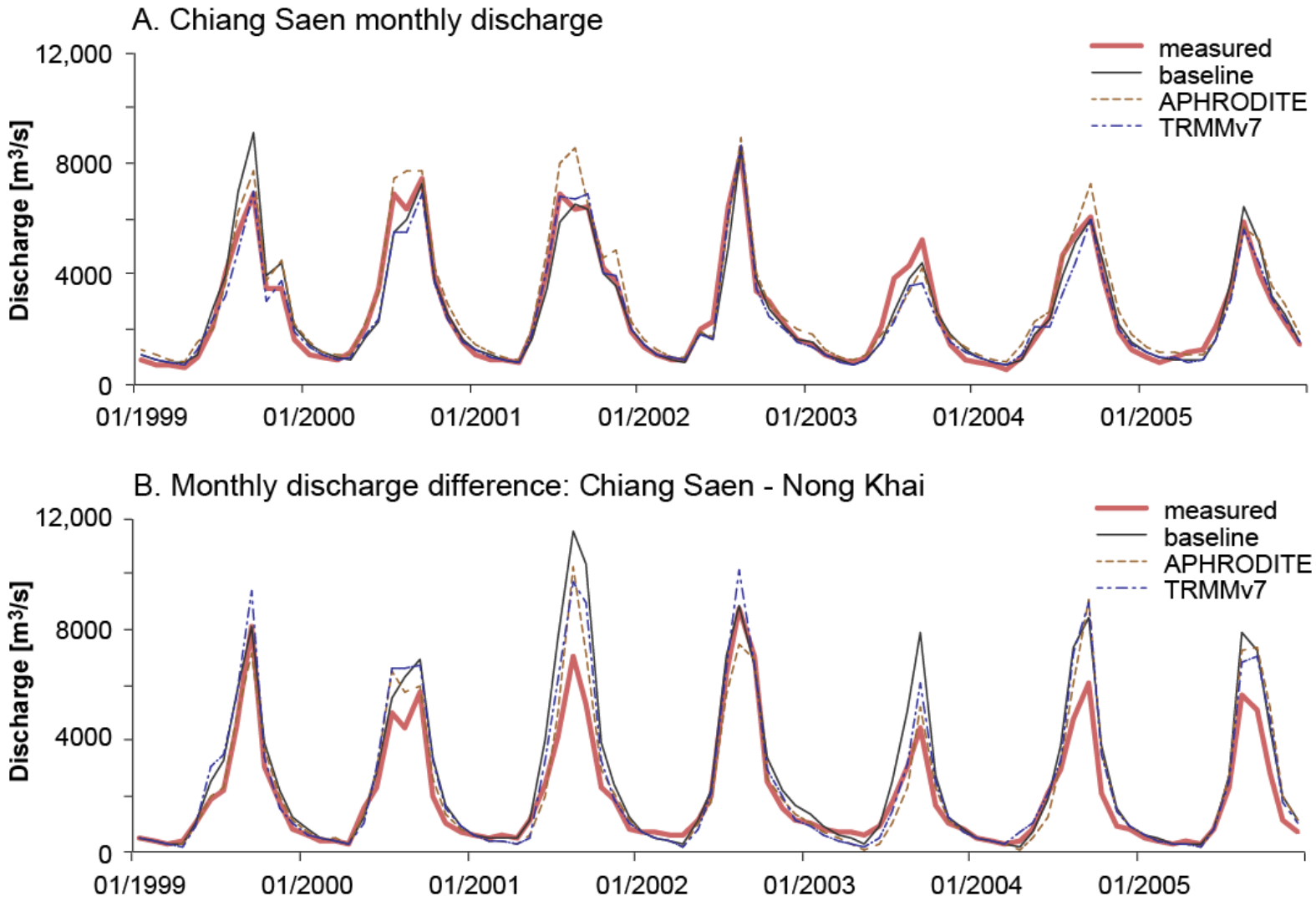
With open data rather good results



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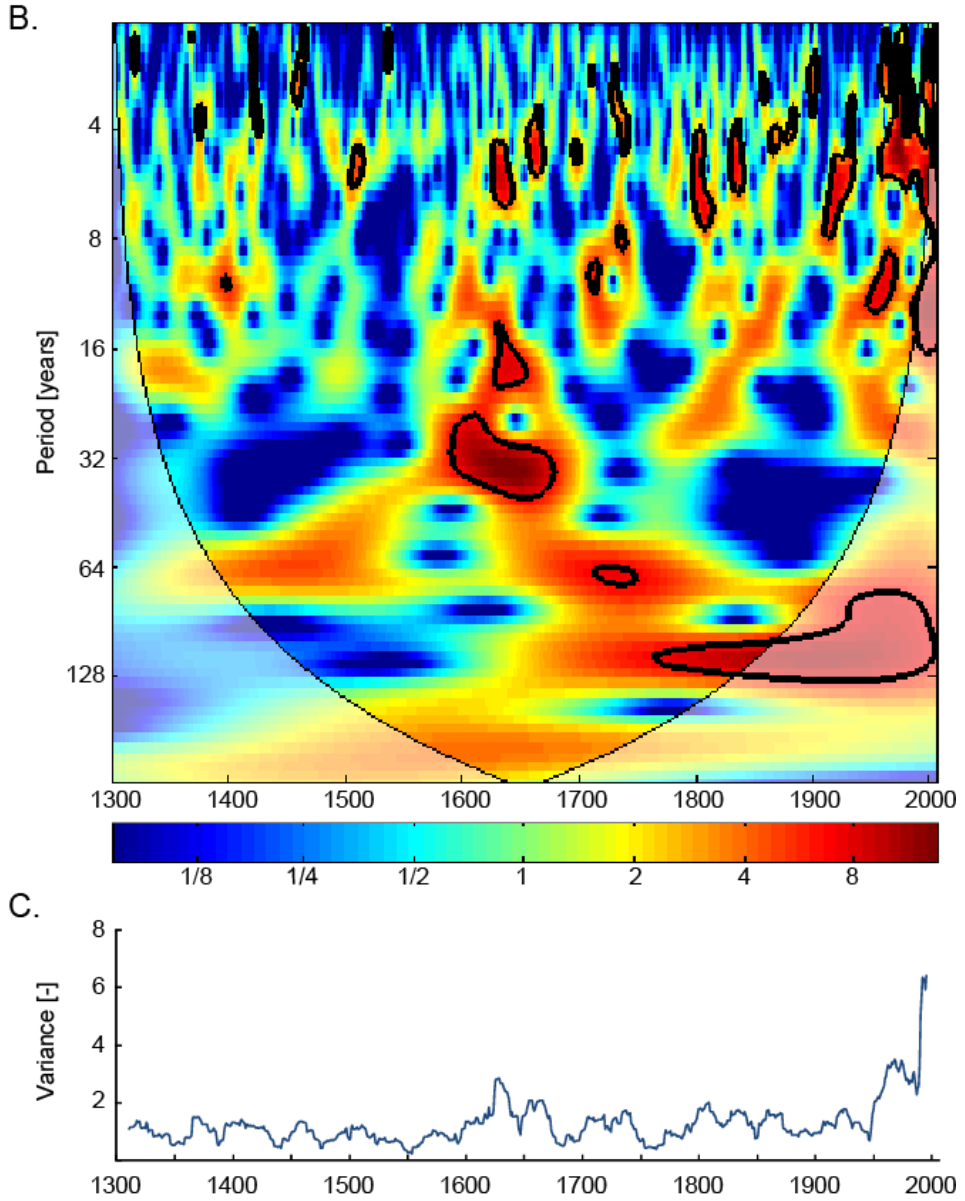
Lauri et al (under review)

View to the past 700 years

Variability in hydrometeorology is in its highest since 1300

Particularly occurrence of dry years have increased significantly

Supports findings by e.g. Delgado et al

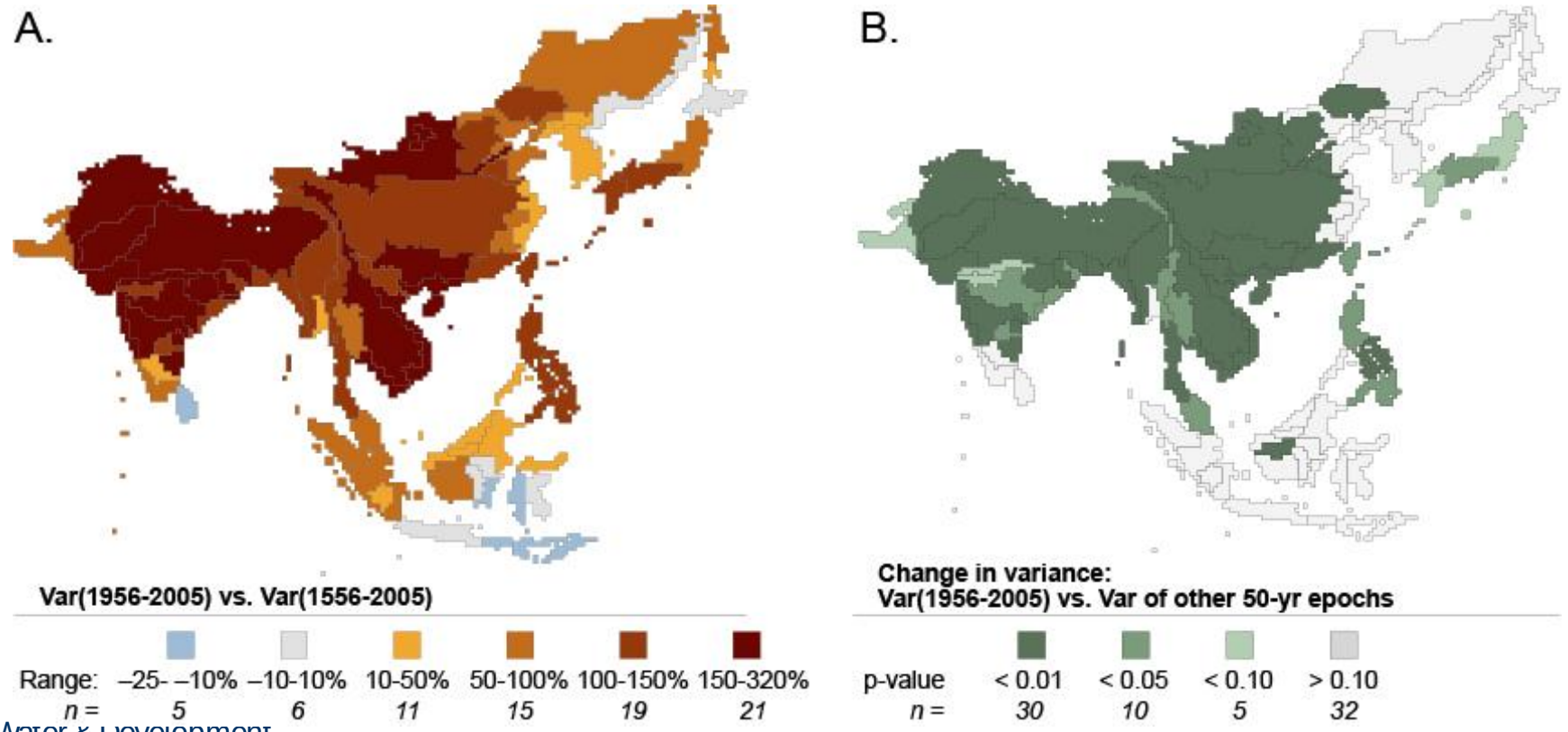


Räsänen & al (2013)

Mekong is not alone with high VAR

The variance in the last 50 years (1956-2005) is higher than the variance of the whole study period (1556-2005) in 58/77 of the basins

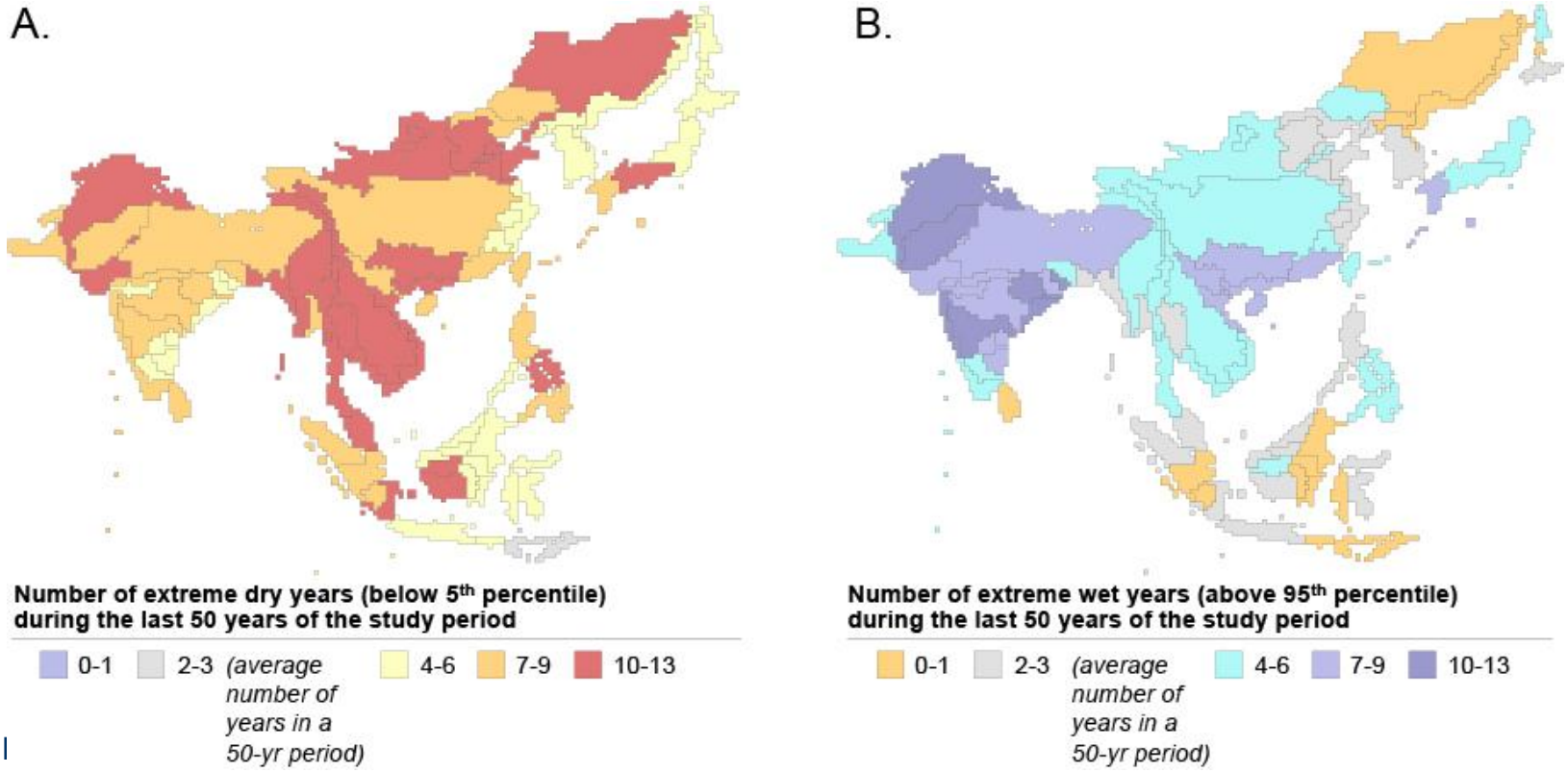
Levene's test results that the variance in the last 50 years is higher ($p<0.05$) than in any other 50 year period in 40/77 of the basins



Kummu & al (under review)

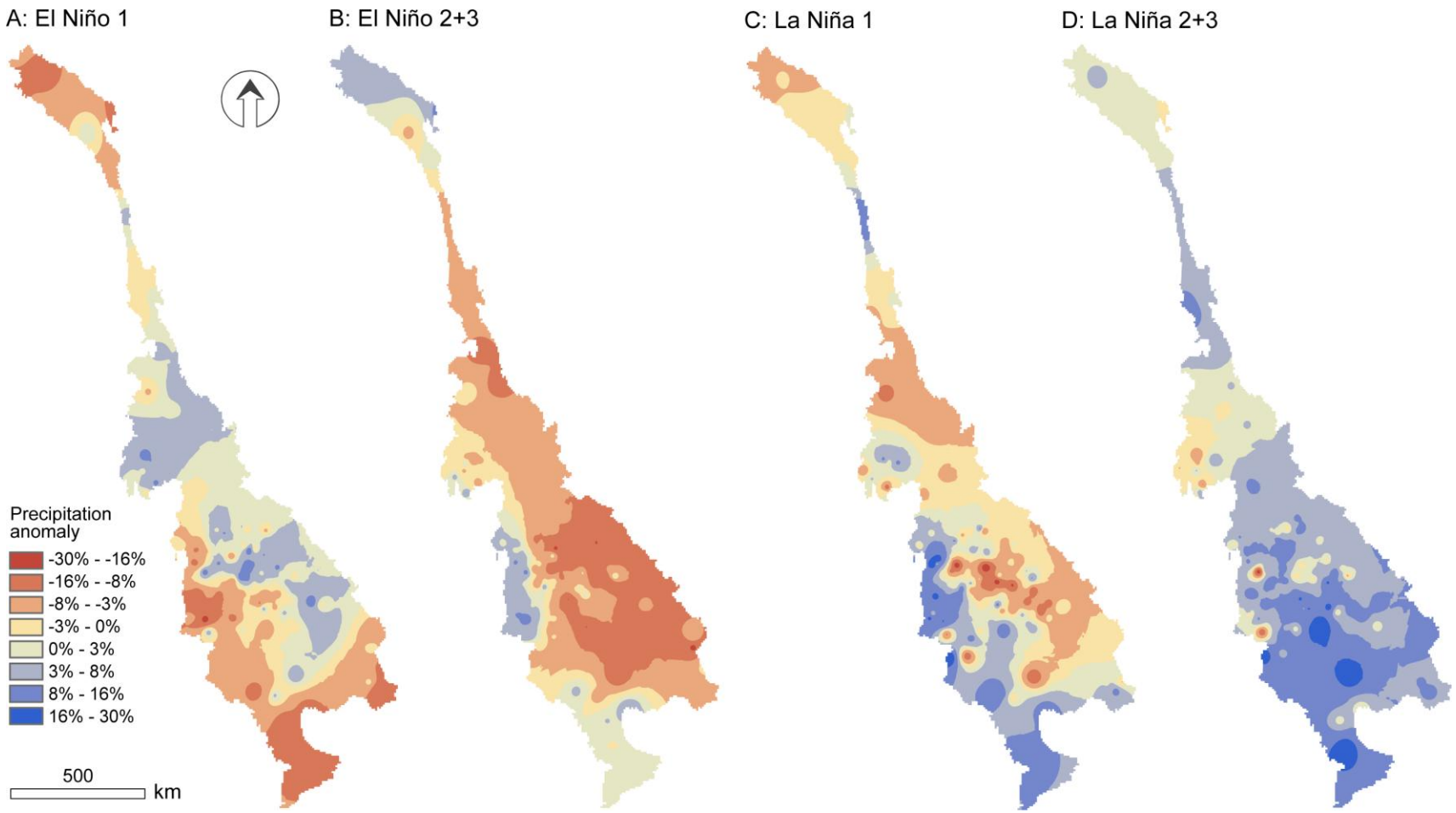
Occurrence of extreme events increased

- Extreme dry (wet) year = lower (upper) 5th percentile of $PDSI_{MADA}$
- The occurrence of extreme
  - dry year occurence double to average in majority of the basins (61/77) within the last 50 years
  - wet year occurence double to average in almost half of the basins (28/77) within the last 50 years



Kummu & al (under review)

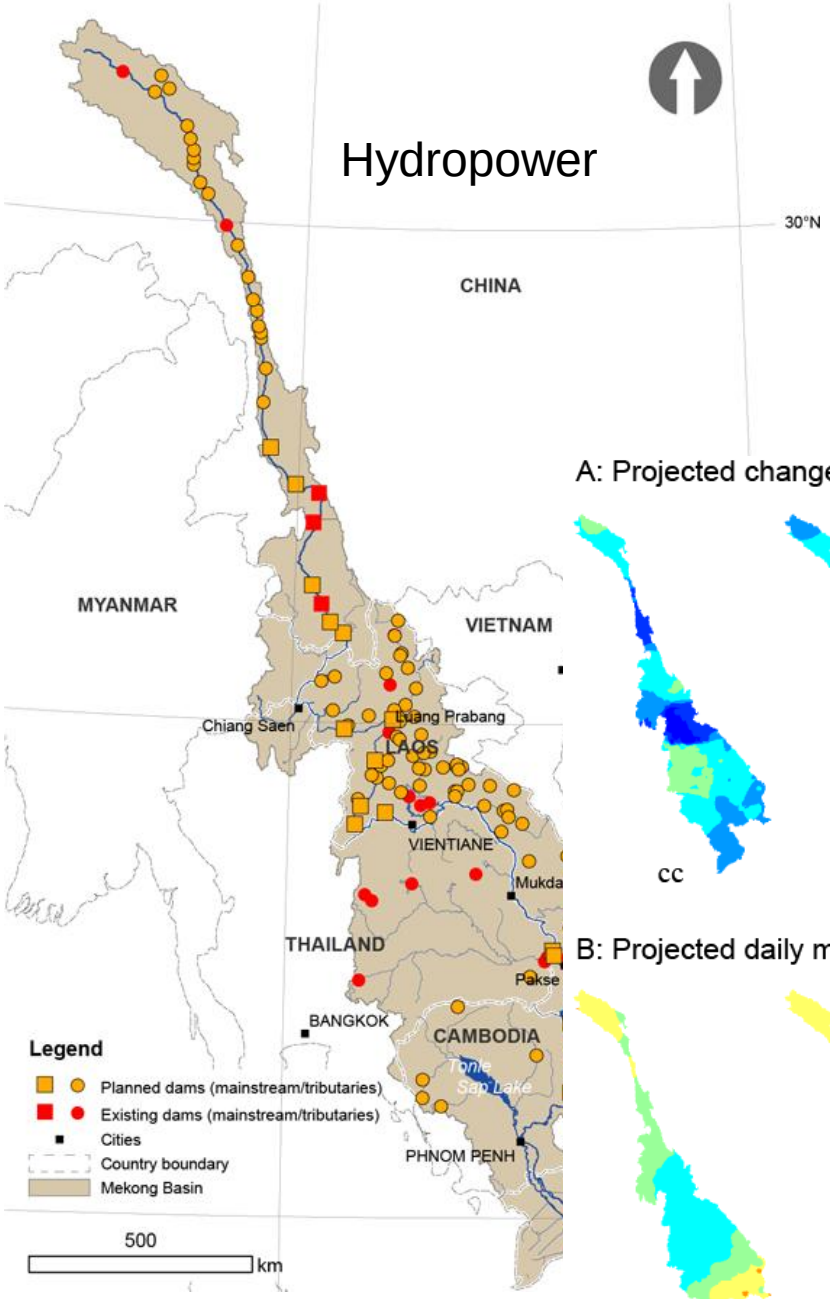
ENSO – one driver for climate variability



Räsänen & Kummu (2013)

What about future?

Hydropower



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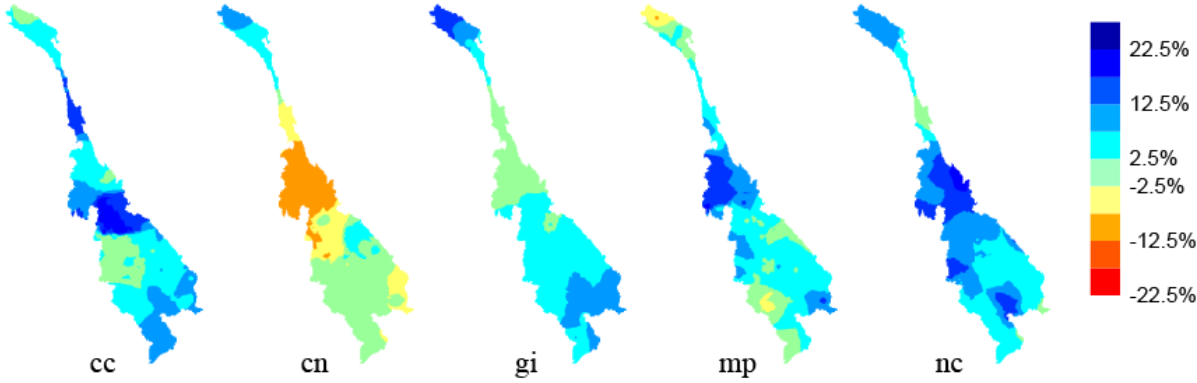
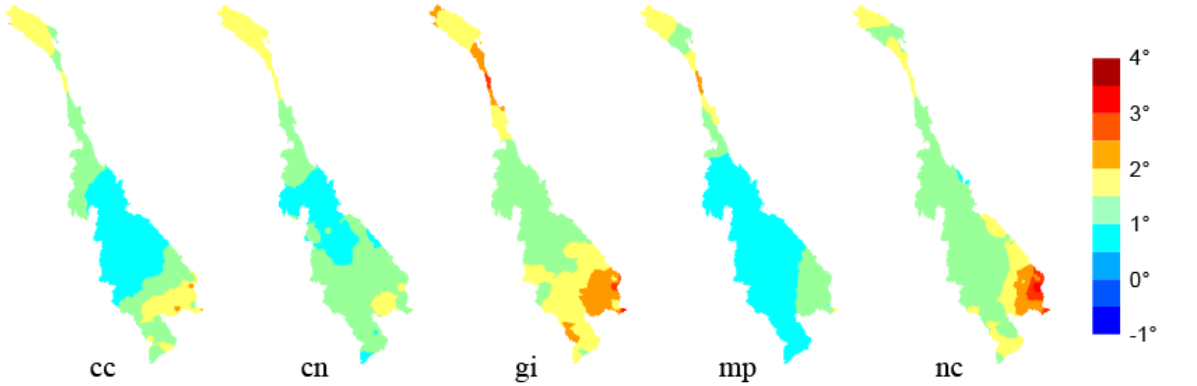
Johnston & K Kummu & al (2010)

Climate change

A: Projected changes in annual precipitation [%] under A1b scenario

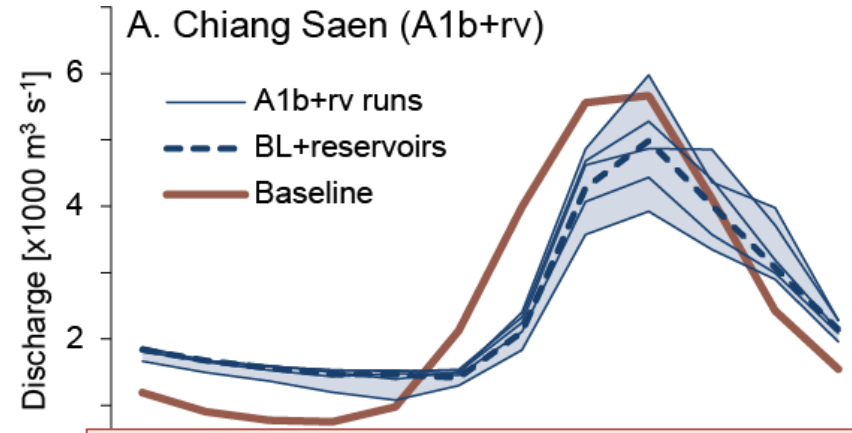


B: Projected daily maximum temperature changes [C°] under A1b scenario



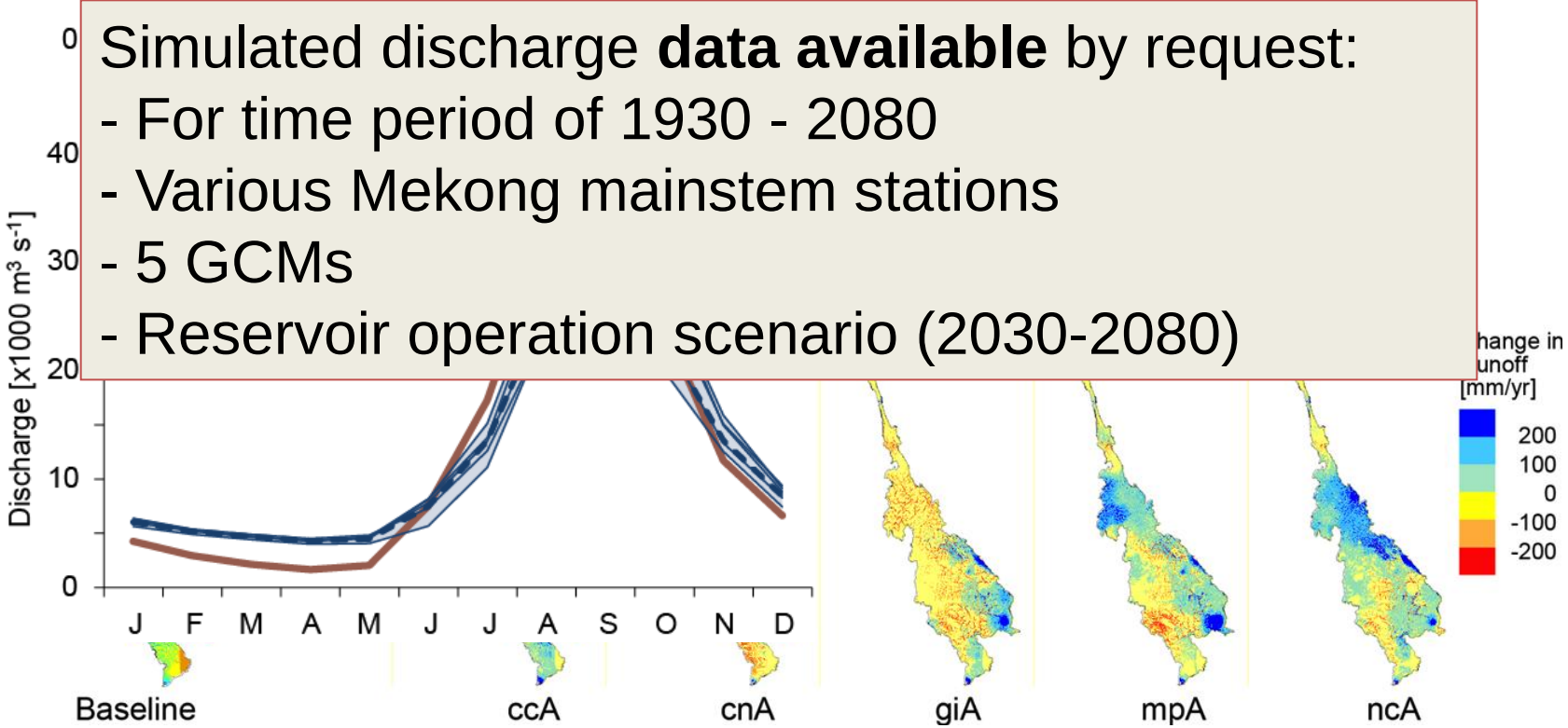
Lauri et al (2012)

ımulative impacts



Simulated discharge **data available** by request:

- For time period of 1930 - 2080
- Various Mekong mainstem stations
- 5 GCMs
- Reservoir operation scenario (2030-2080)



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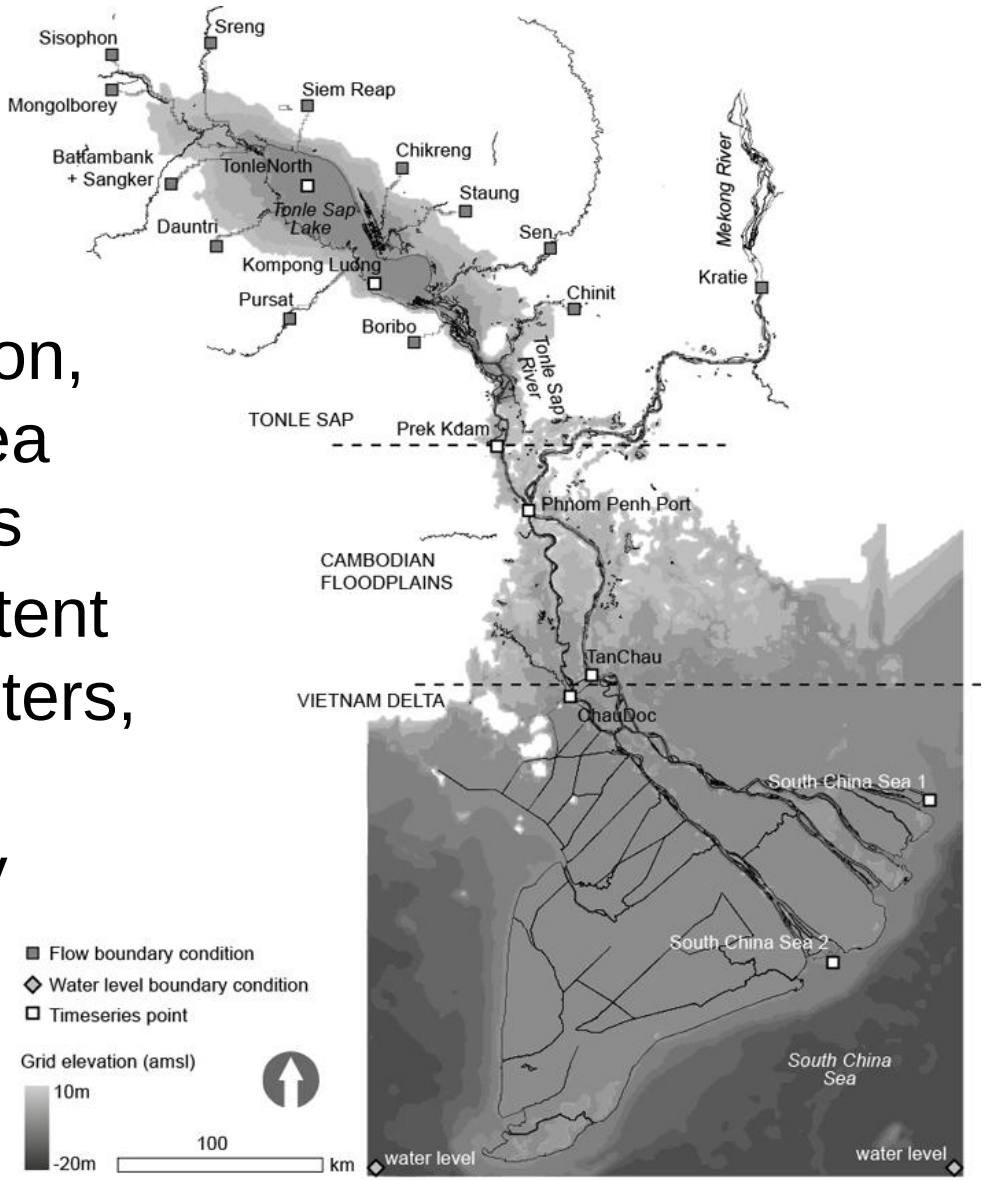
Lauri et al (2012)

Floodplain model – EIA 3D

- Full 3D model
- Applied in Mekong floodplains and elsewhere
- Input: DEM, vegetation, inflow boundaries, sea level, WQ boundaries
- Output: WL, flood extent + other flood parameters, sediment, other WQ
- Includes: productivity module



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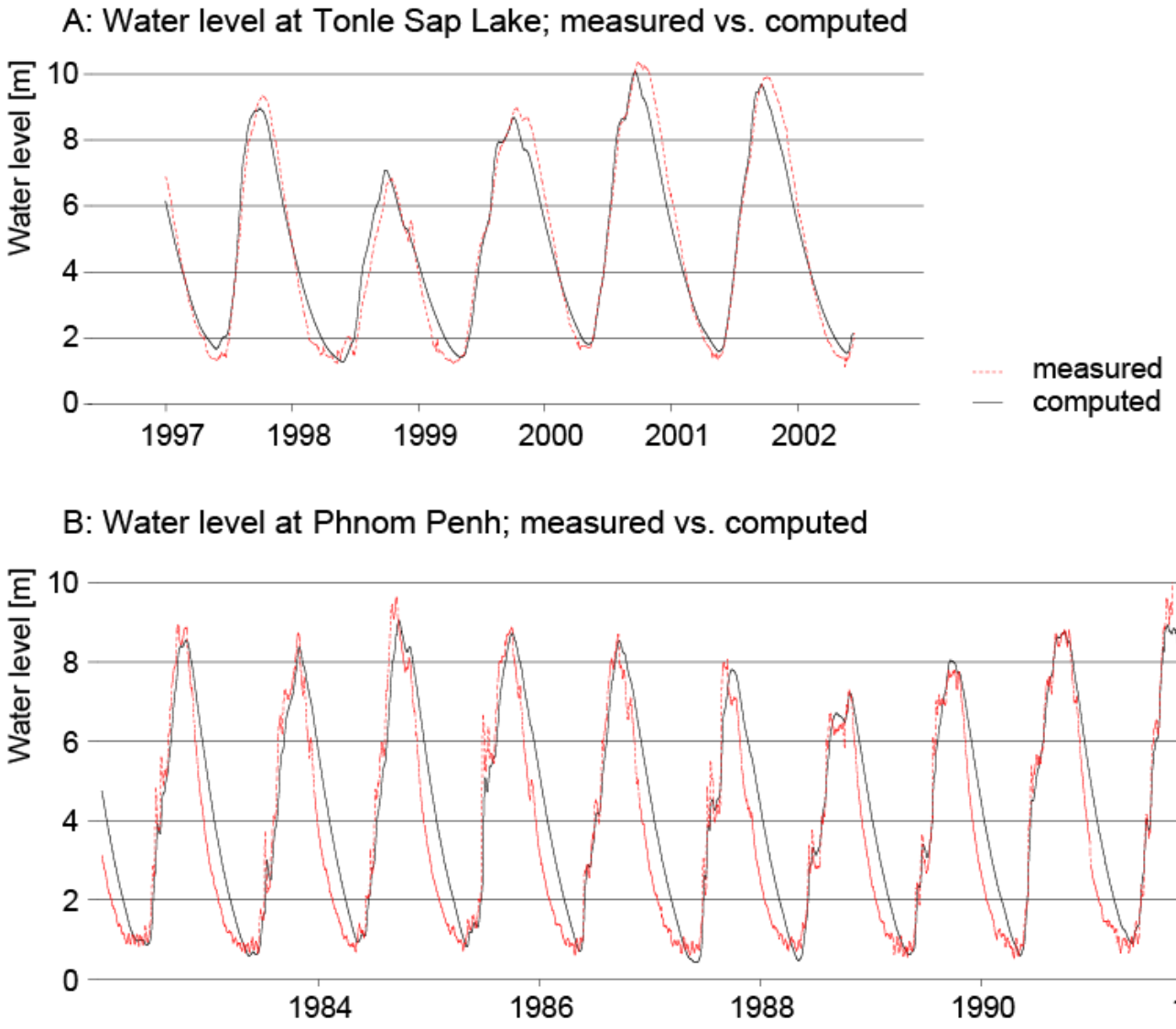
Västilä et al (2012)

EIA 3D VALIDATION



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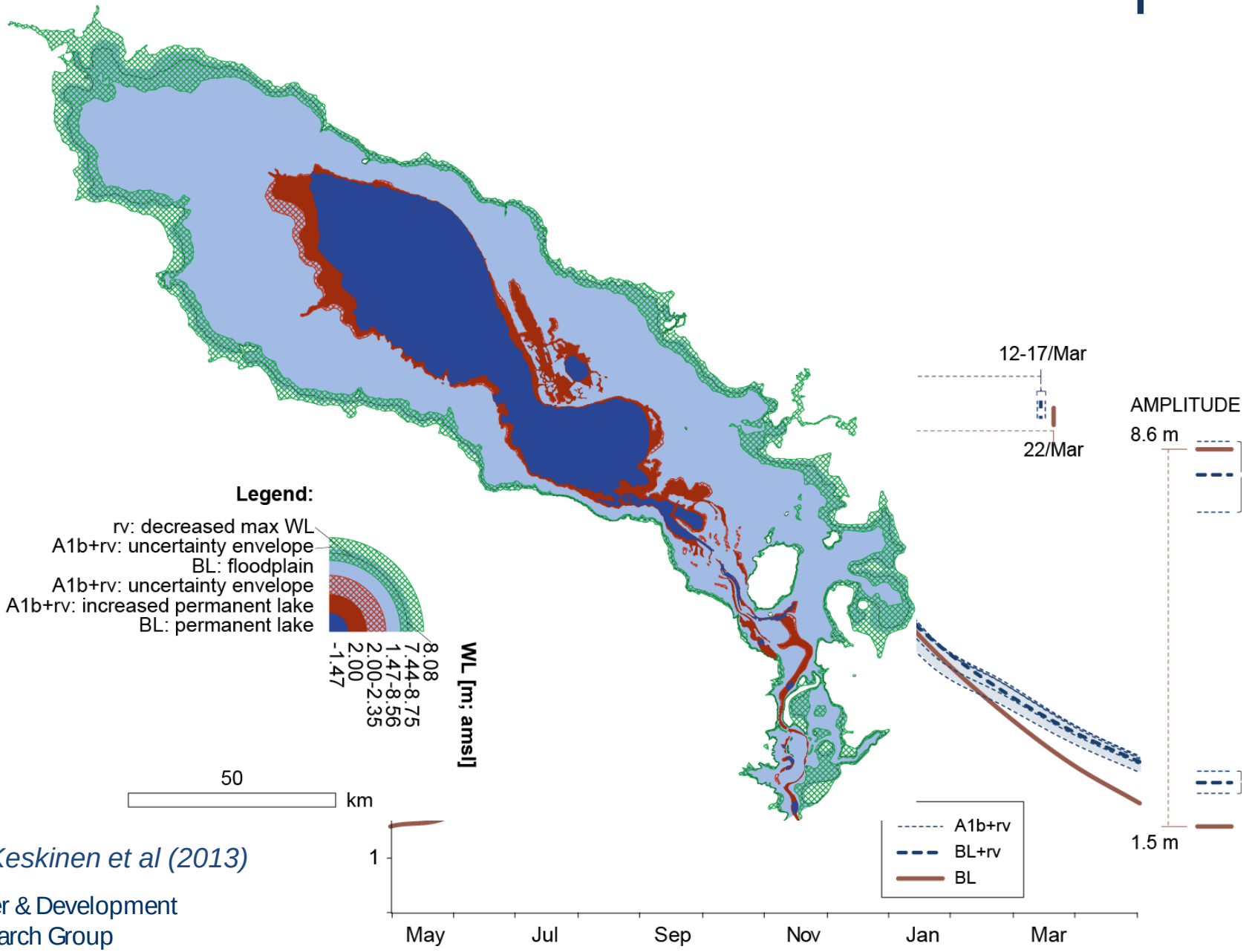
Keskinen et al (2013)

ɔnle Sap

B: Climate change (A1b) and reservoir operation (rv)



Keskinen et al (2013)

Uncertainties in future hydrology

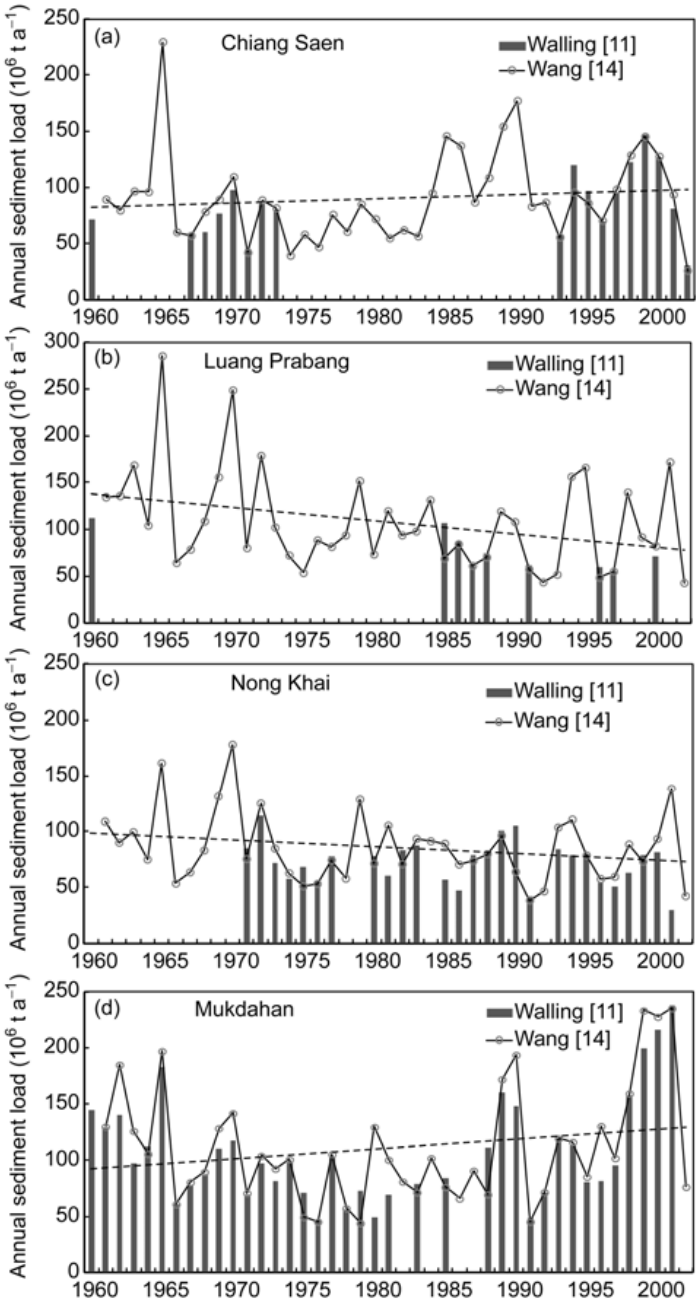
- Would interannual variability continue to increase?
- How possible future extreme weather events will impact on floodpulse?
- Direction and magnitude of climate change impacts on monsoon still unclear
- How many reservoirs will be built? And how those are managed?
- Large irrigation schemes planned in Laos and Cambodia, water transfers btw Laos and Thailand, increased domestic water use

SEDIMENTS

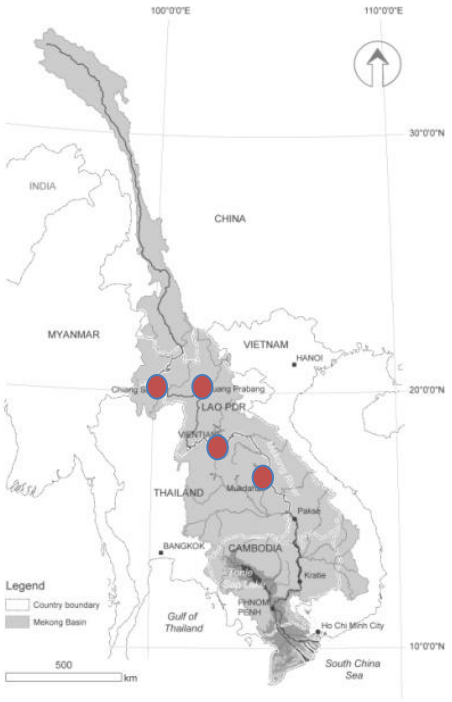
importance of sediment

- sustain the geomorphology of the floodplains, particularly Tonle Sap estuary and river, and Mekong Delta
- nutrient input
  → ecosystem productivity (Lamberts 2008)
- sustain the conditions for larvae and fish
  → e.g. buoyancy of fish larvae depends on the SSC (Agostinho & al 2007)

Sediment data

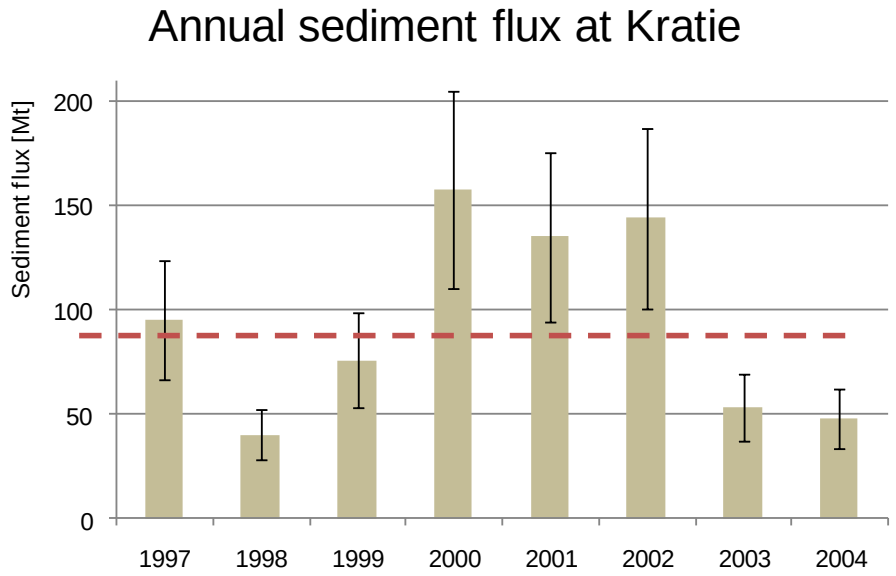


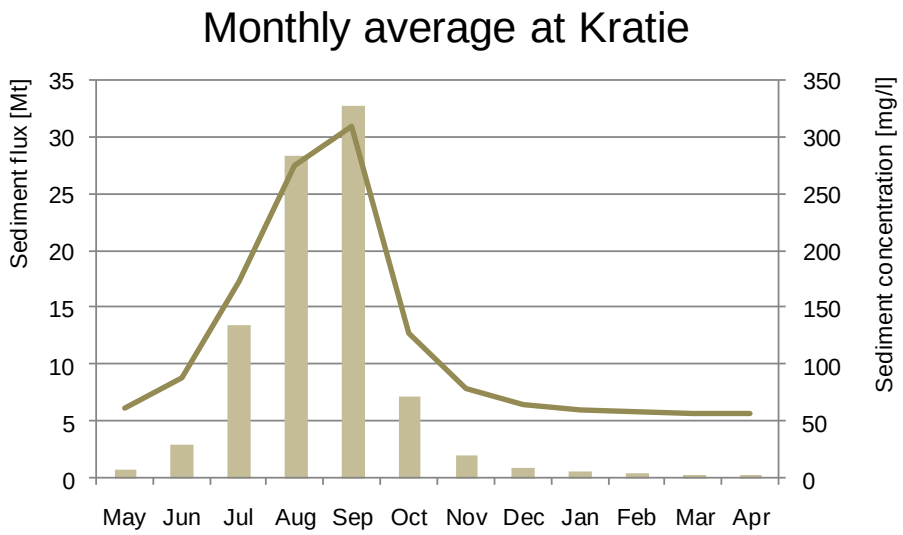
- Rather good understanding down to Mukdahan
- No reliable data between Mukdahan and Mekong Delta; although Tonle Sap Lake dynamics rather well understood



Liu & al (2013)

Sediment at Kratie





- short data series
- rather poor surface TSS data quality

→ high error: ± 30%

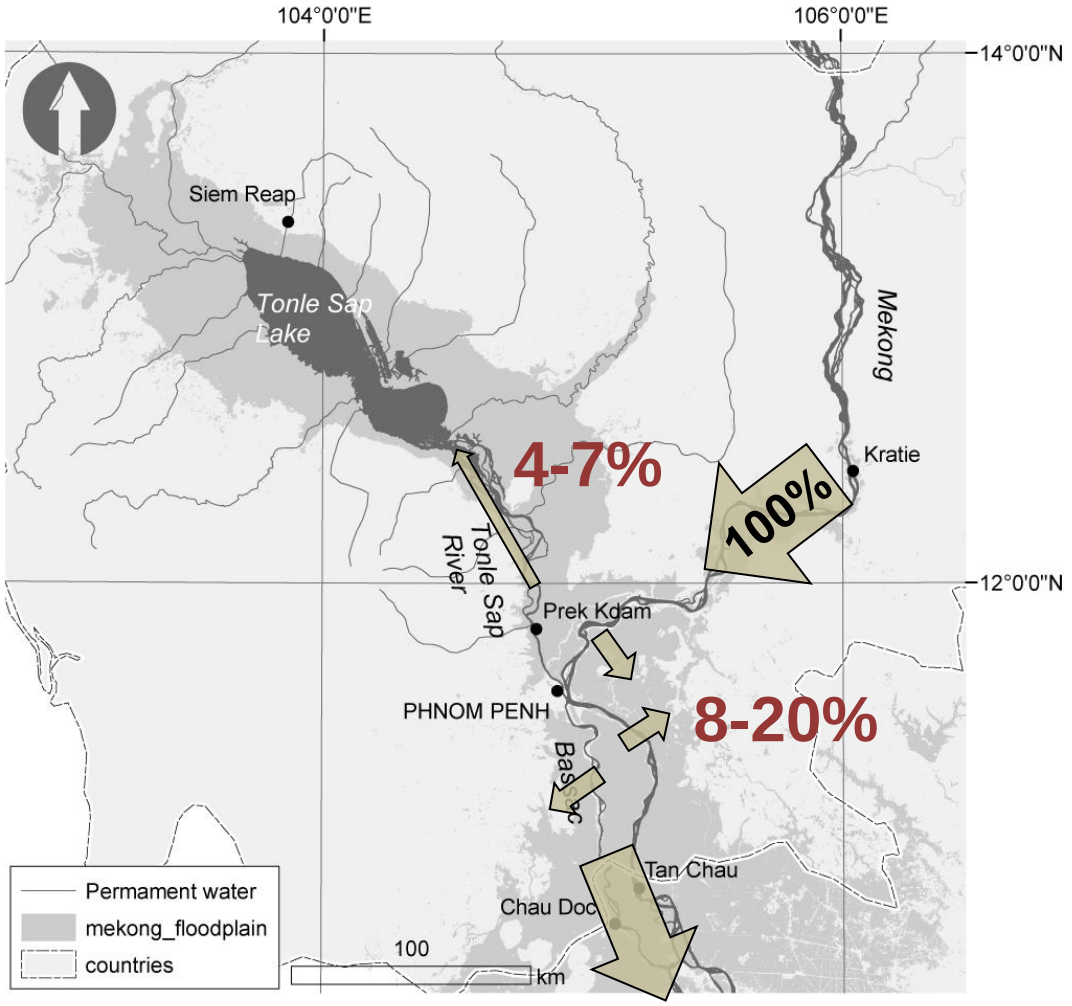
(Walling 2008)

- estimated flux in Kratie (97-04): 66-122 Mt
- over 50-70% of sediment originates from China

Kummu (unpublished)

floodplain sediment dynamics

Kummu (unpublished)



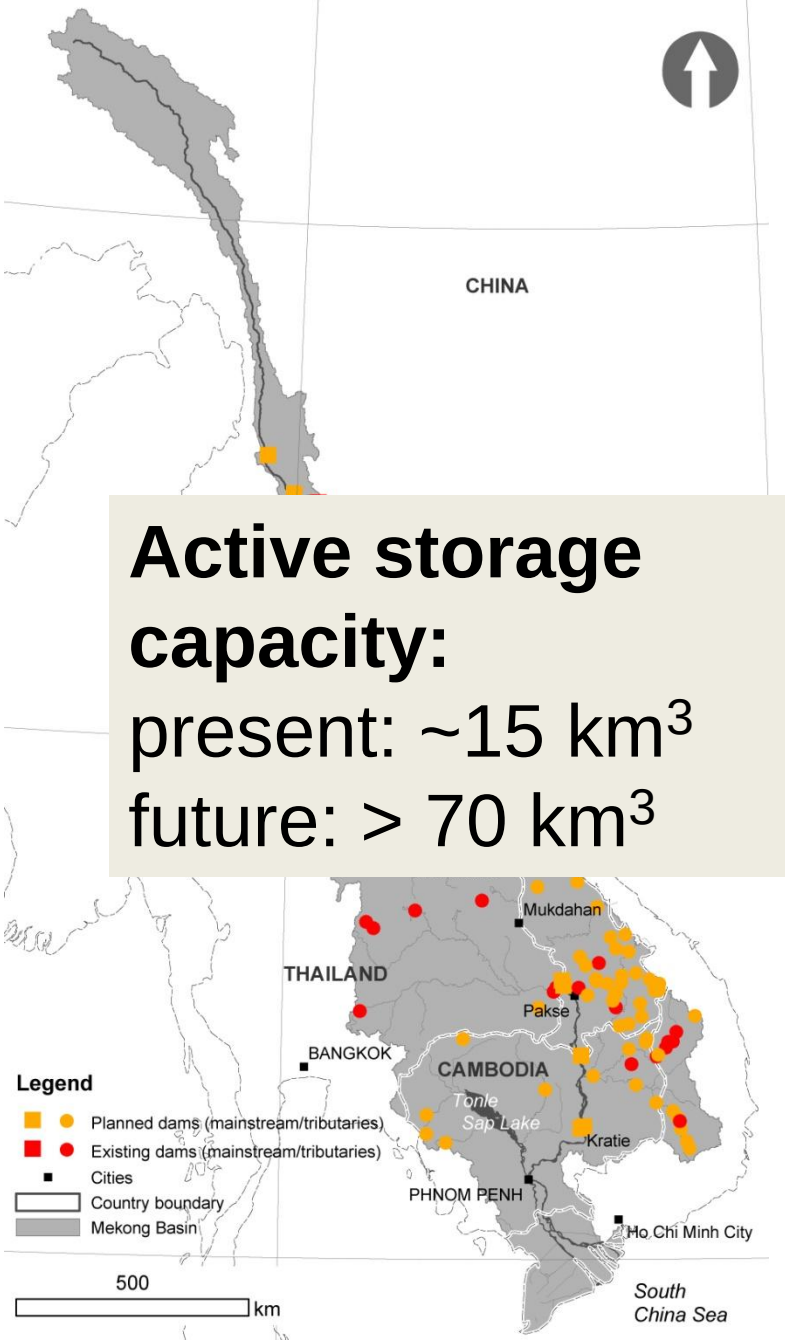
- ~ 15-25% of the sediments settle down into the floodplain
- varies depending on the flood level
- preliminary estimation

→ detail modelling would be needed

75-85% to Vietnam Delta

→ how much of that to South China Sea?

Development – threat on sediment?



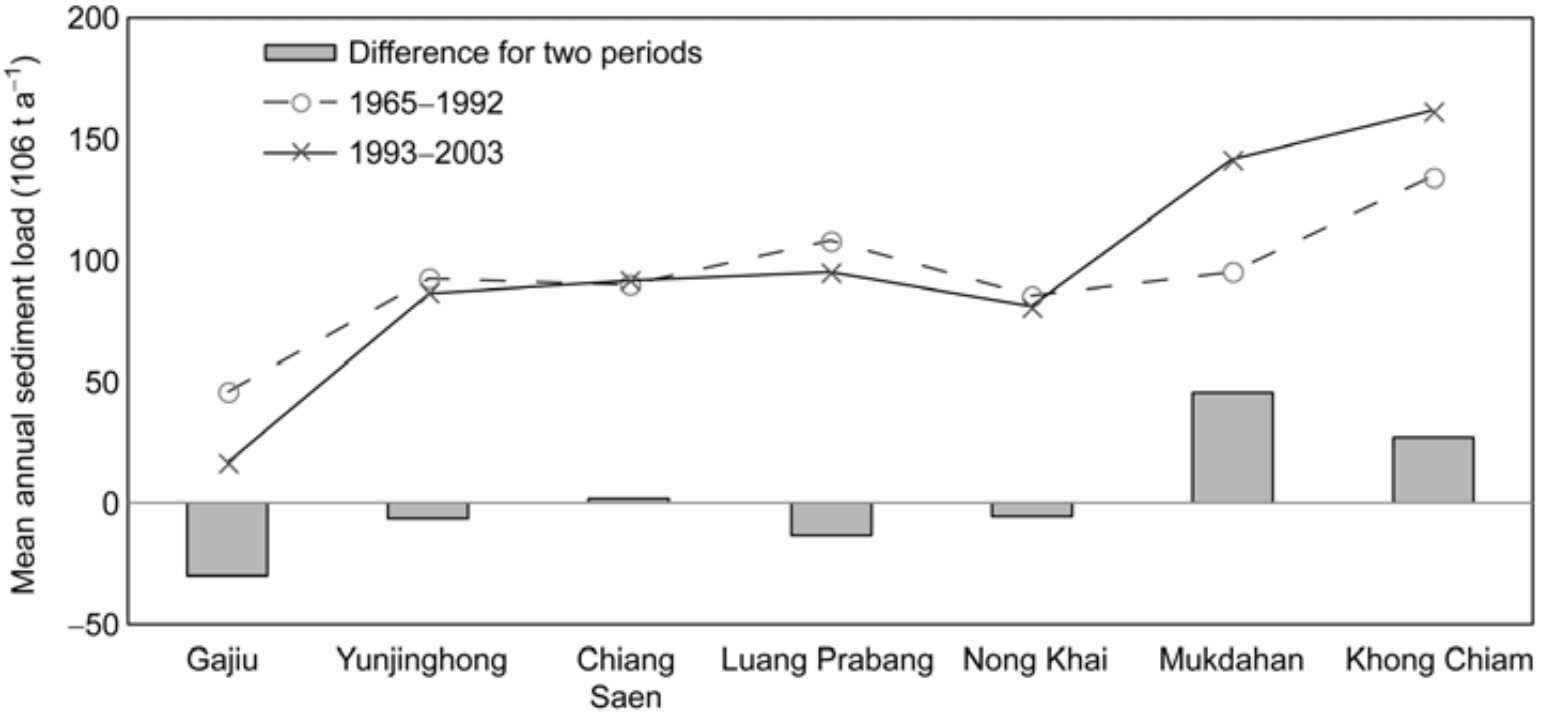
Active storage capacity:
present: ~15 km³
future: > 70 km³

Kummu & al (2010)

- Ongoing and planned developments, particularly hydropower
  → flow alteration in the Mekong
  → change the flood pulse of the floodplain ecosystem
- impact on floodplains is often referred to as a major constraint to development of the water resources of the Mekong River

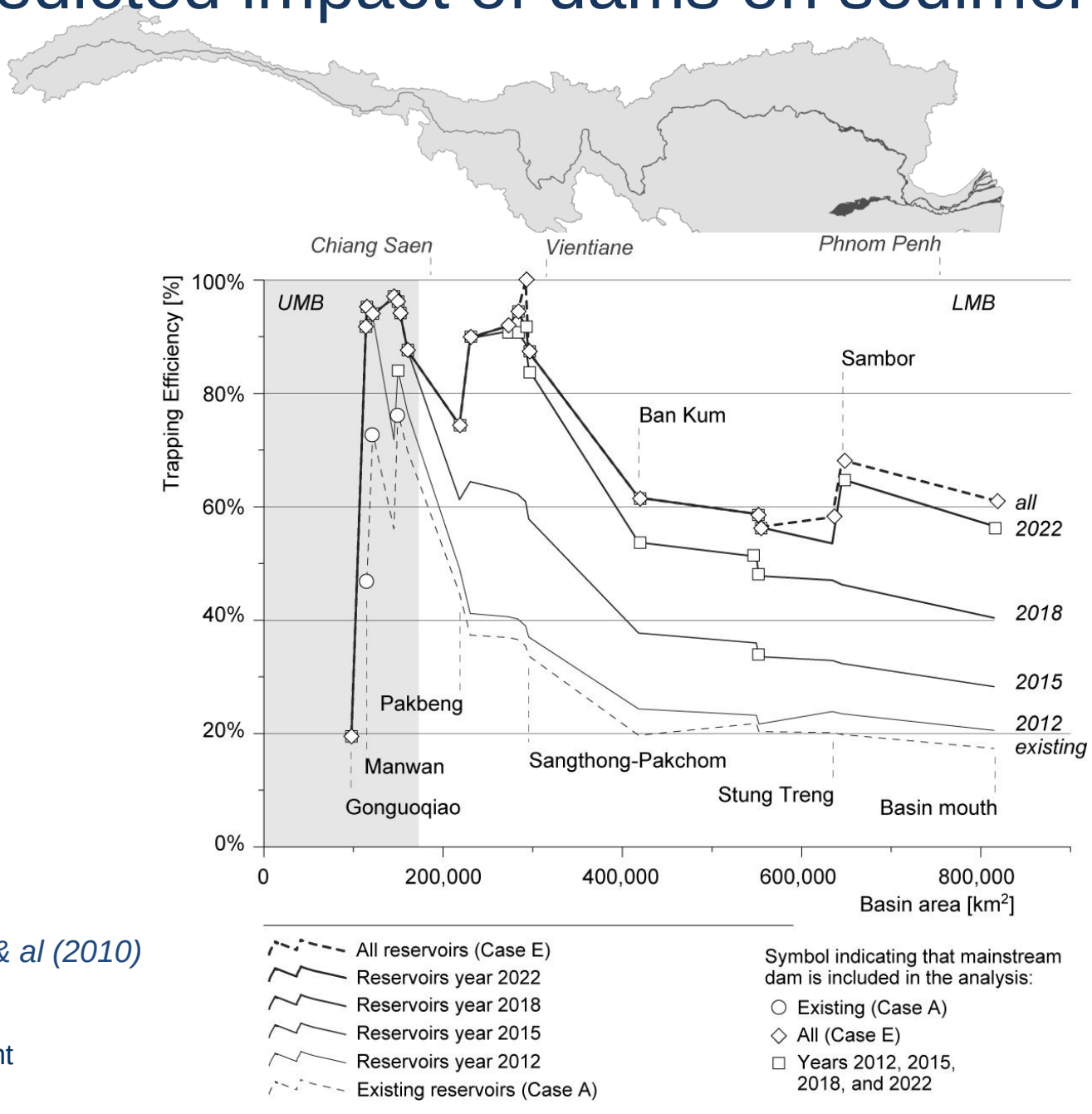
Observed impact

- Large reduction in sediment in Gaiju (downstream from Manwan dam), elsewhere no significant changes



Liu & al (2013)

Predicted impact of dams on sediment



Kummu & al (2010)

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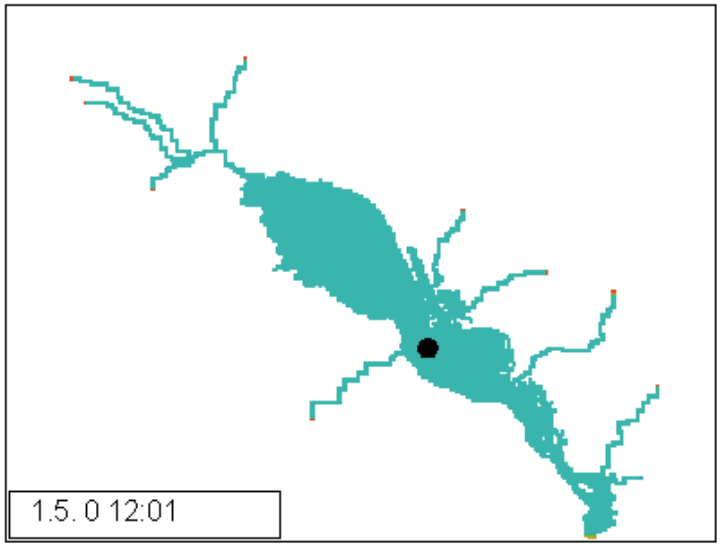
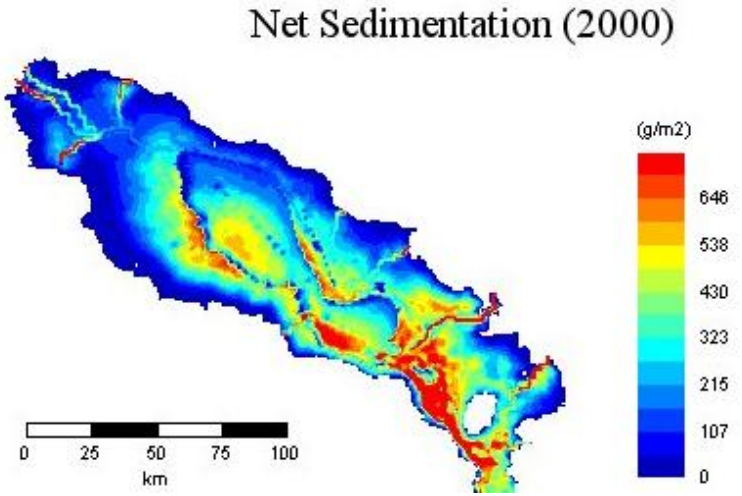
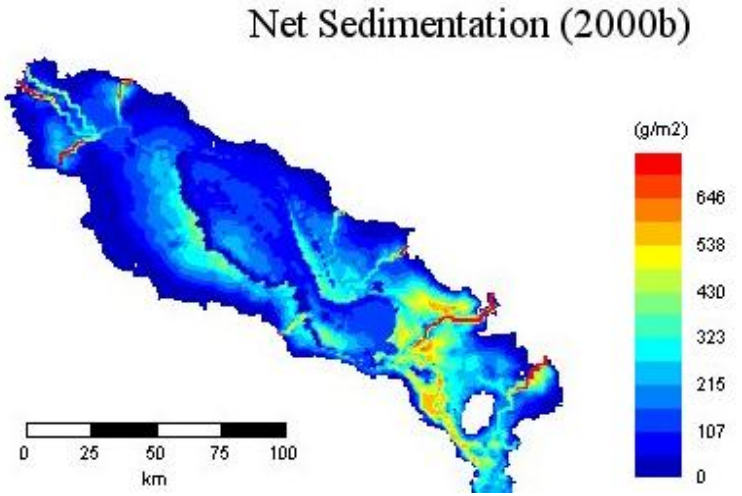
Tonle Sap – future productivity?



- One of the key driving forces for the ecosystem productivity
- not filling up with the sediment, sedimentation rate: 0.1 mm/year in lake proper



UPSTREAM TRAPPING SEDIMENTS



Kummu & al (2008); MRCS/WUP-Fin (2006)

Uncertainties in future sediments

- Floodplain dynamics still rather poorly understood
- How extreme weather events will impact on sediments in the future?
- How many reservoirs will be built? And how those are managed?
- Land cover change impacts on sediments still unclear
- Bank erosion in future flow regime and lower SSC?
- Extensive sand mining in Mekong mainstream in Cambodia and Vietnam

More information?

matti.kummu@aalto.fi

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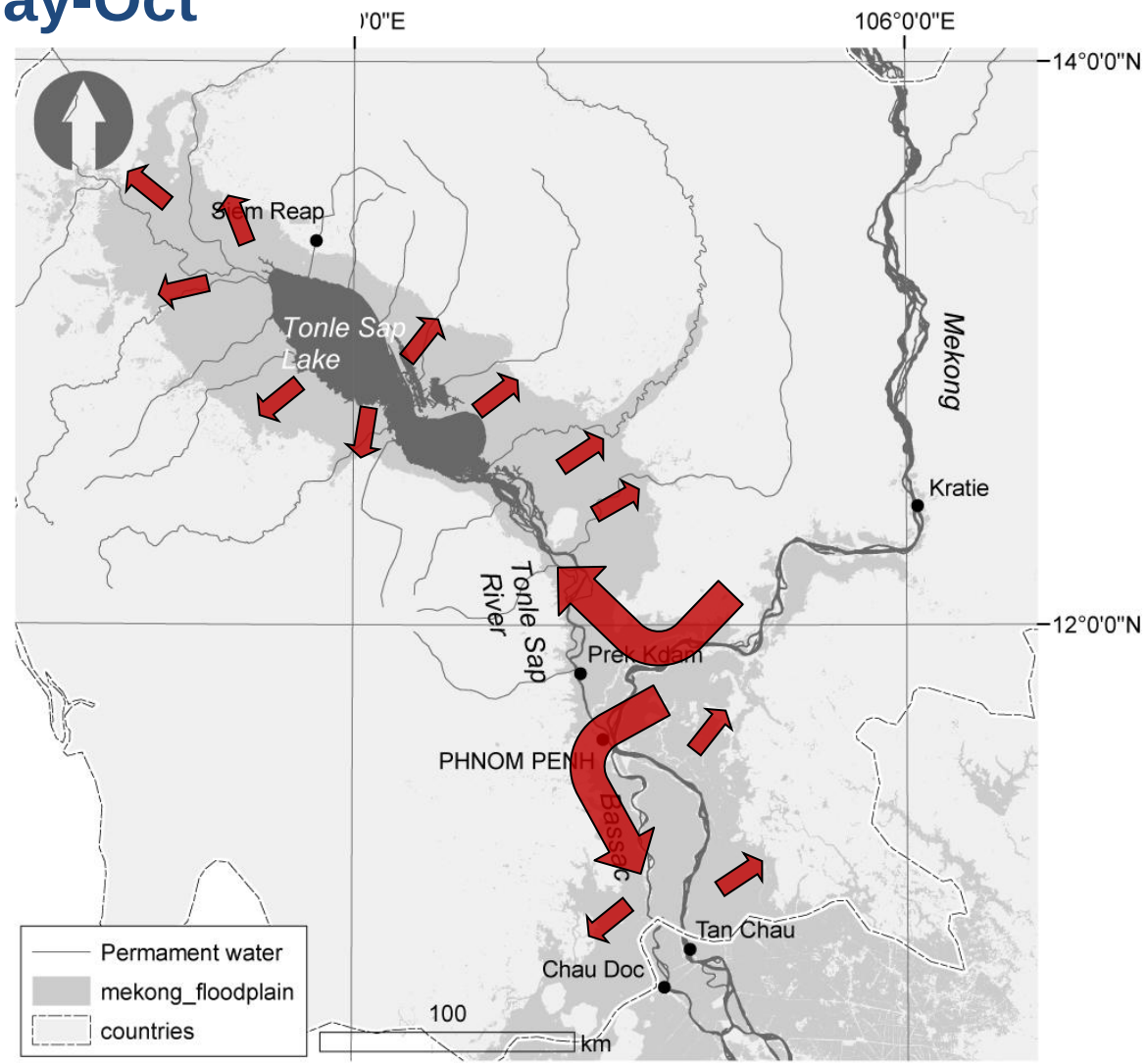
floodplain hydrology

Wet season: May-Oct



Water from the Mekong into floodplains

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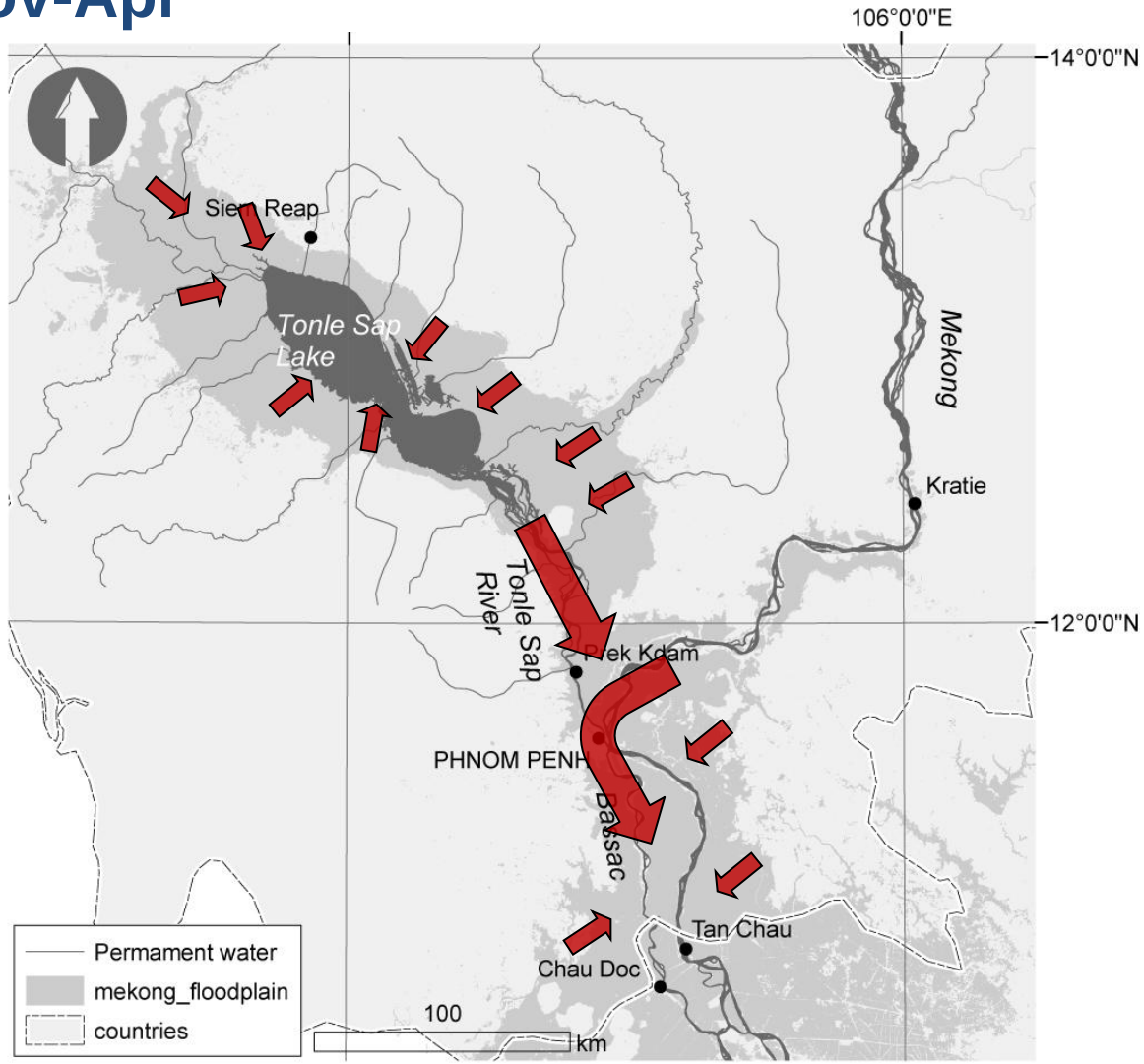
floodplain hydrology

Dry season: Nov-Apr



Water from floodplains into the Mekong

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