The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2066-15

Workshop and Conference on Biogeochemical Impacts of Climate and Land-Use Changes on Marine Ecosystems

2 - 10 November 2009

The Drainage Basins of the World - from the Amazon to the Zaire

J. Richey
University of Washington
U.S.A

Part 2: The Drainage Basins of the World - from the Amazon to the Zaire

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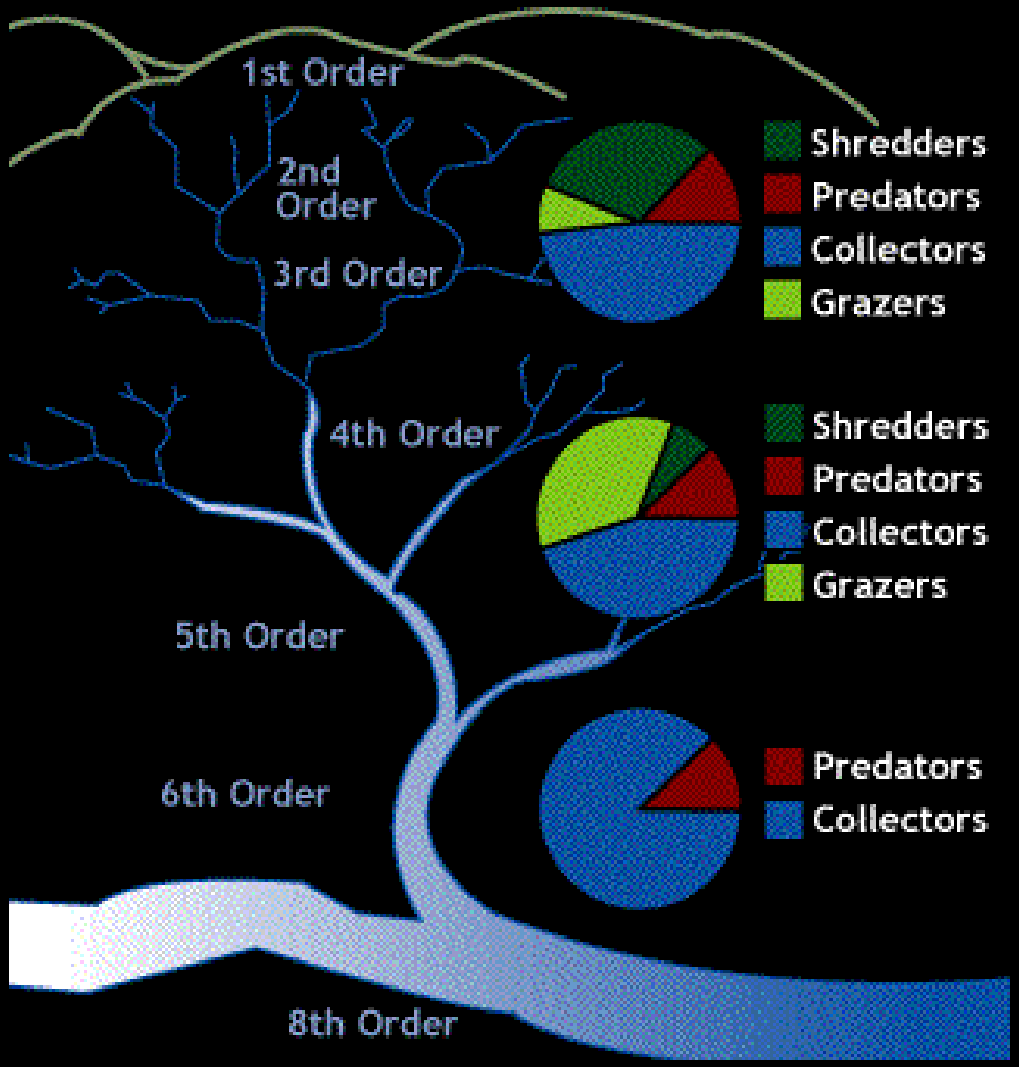
University of Washington
jrichey@u.washington.edu

THE RIVER CONTINUUM



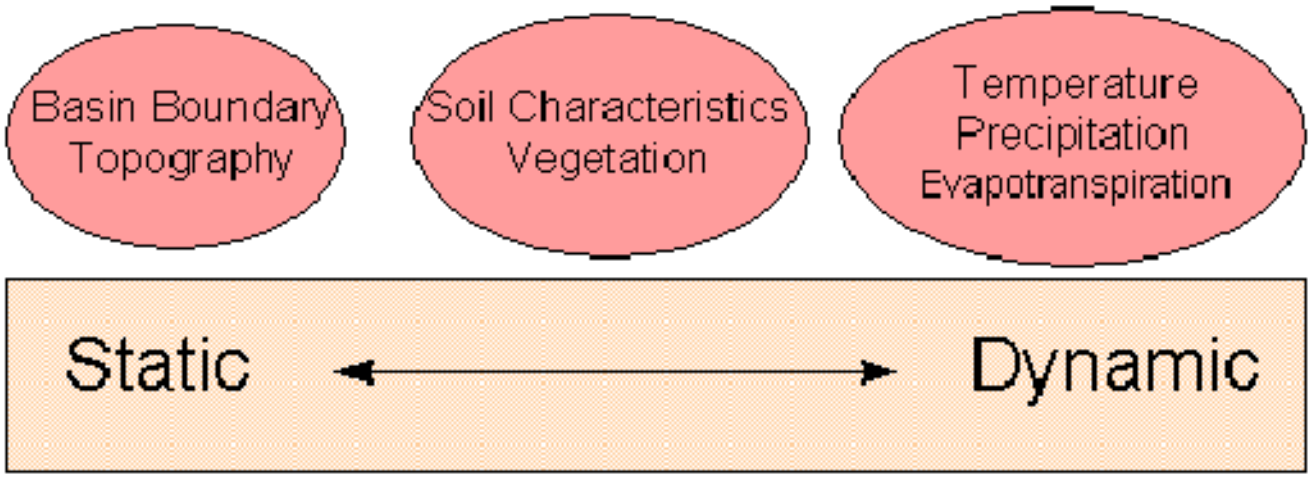
RIVERS IN THE GLOBAL CONTEXT

- What are the time sequences, quantities, and chemical attributes of the riverborne fluxes of water, C, N, and P to the ocean?
- What are the physical and chemical controls operating at continental scales on those fluxes?
- Can major tributary chemistry coupled to hydrology be used to infer aggregate ecosystem processes?

HOW DOES A LARGE RIVER SYSTEM OBTAIN AND SUBSEQUENTLY MODIFY ITS BIOGEOCHEMICAL COMPOSITION?

- How is the biogeochemical signature which persists through the river system imparted by the (aggregated) land surfaces?
- How is the land-derived signature modified through transit within the river system?
- What is the fate of riverborne materials in the coastal zone?

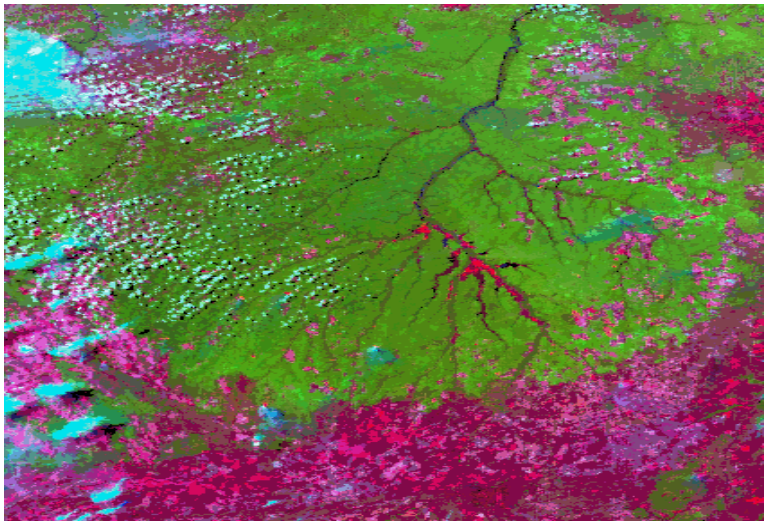
Temporal Scale



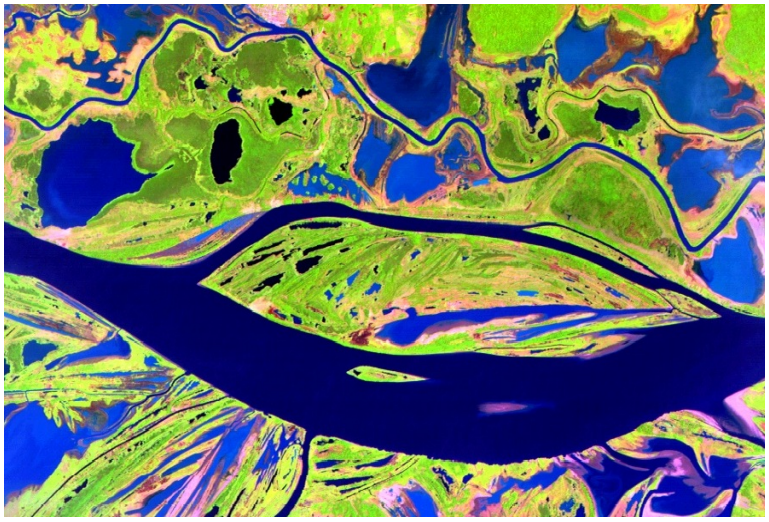
SCALING

Amazon Floodplain from Aircraft: 'eye'

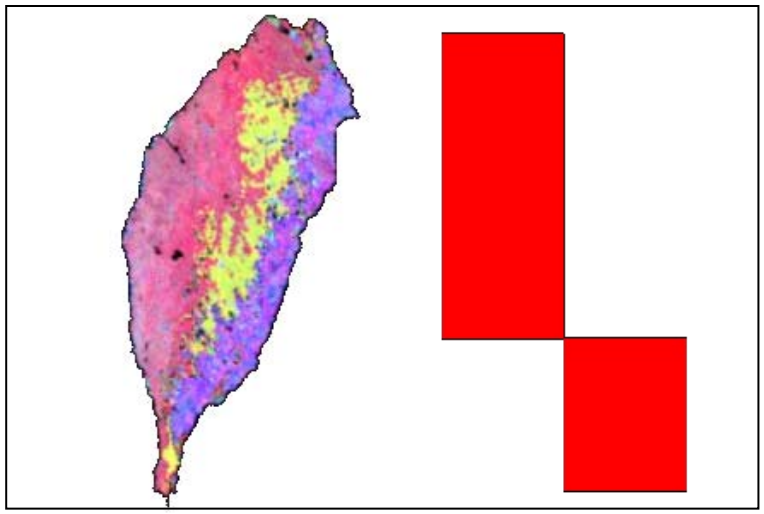
Xingu (Amazon trib) from AVHRR: 1 km



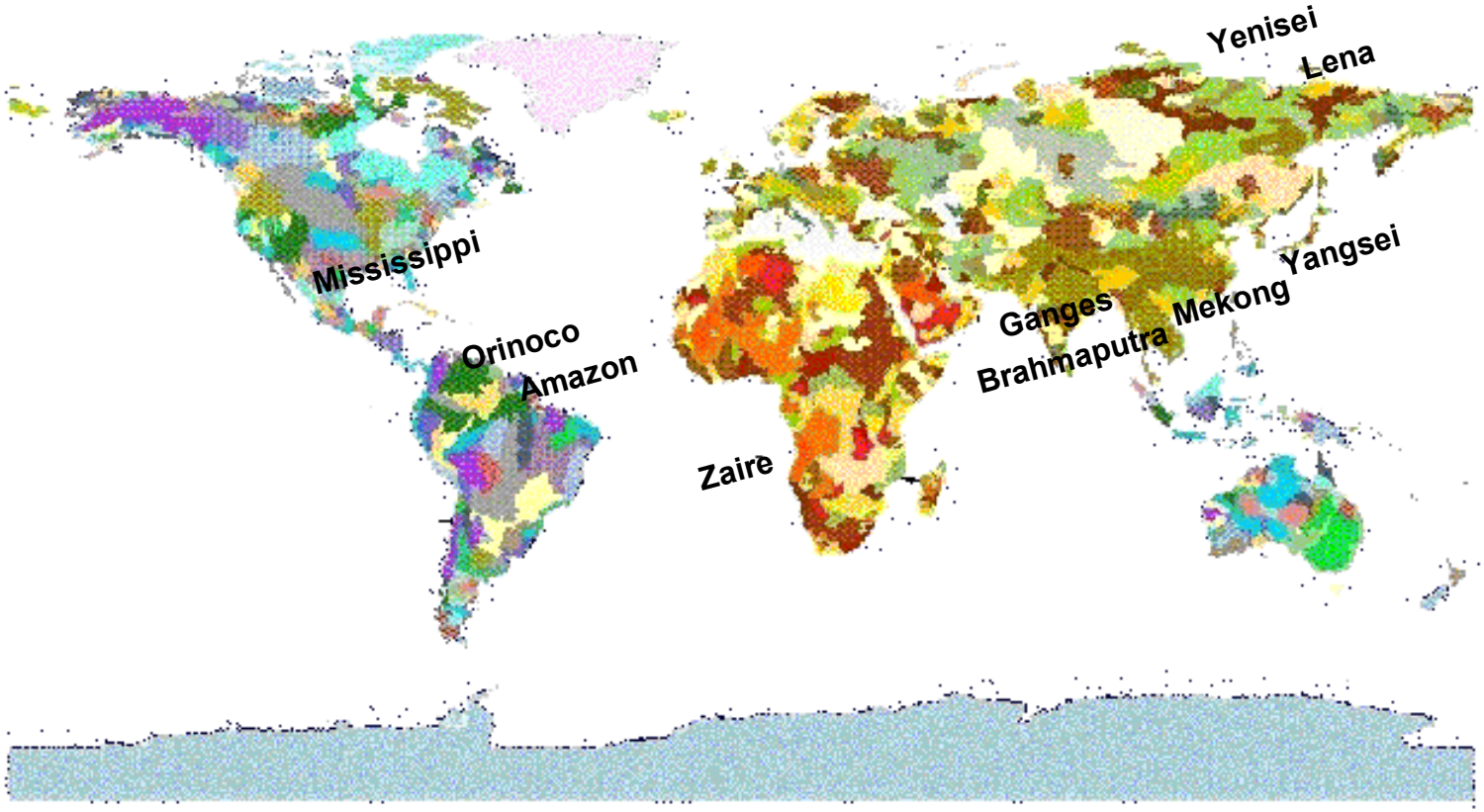
Amazon Floodplain from Landsat TM: 30 m

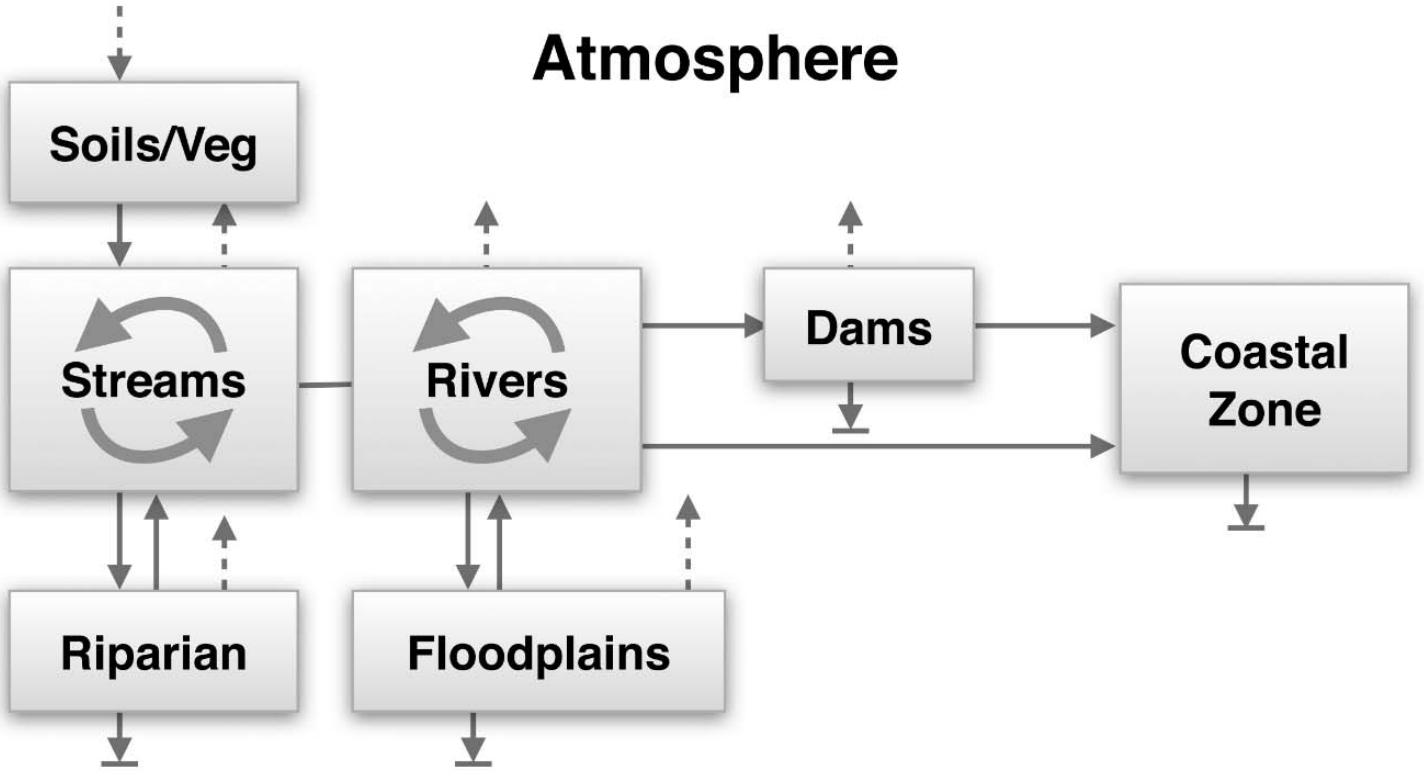


Taiwan: AVHRR to Global 1-degree (~100 km)



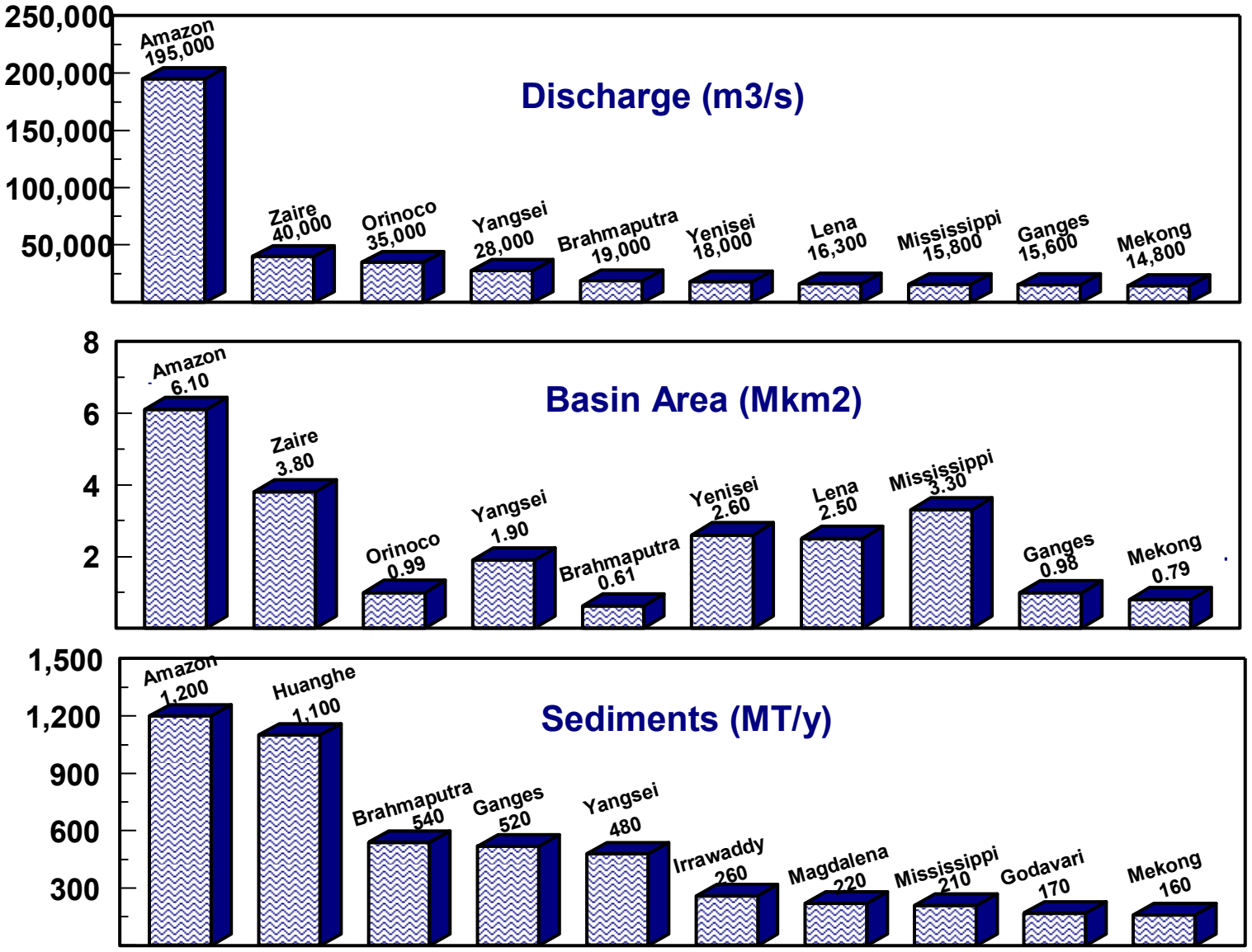
River Basins of the World



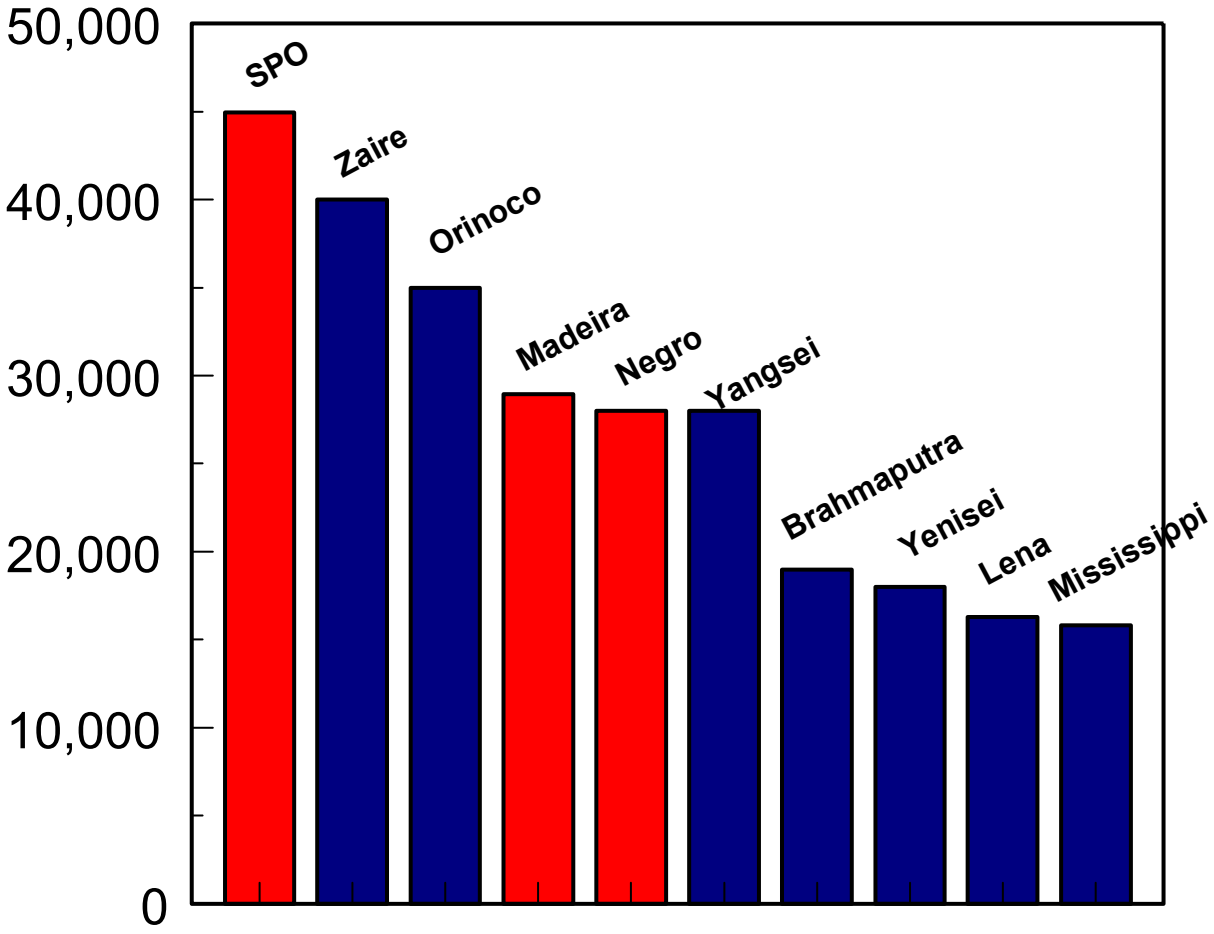


- Conventional Wisdom, as of ~ 5-10 years ago
- NEWS & friends updates
- Less conventional wisdom

Top 10 Rivers



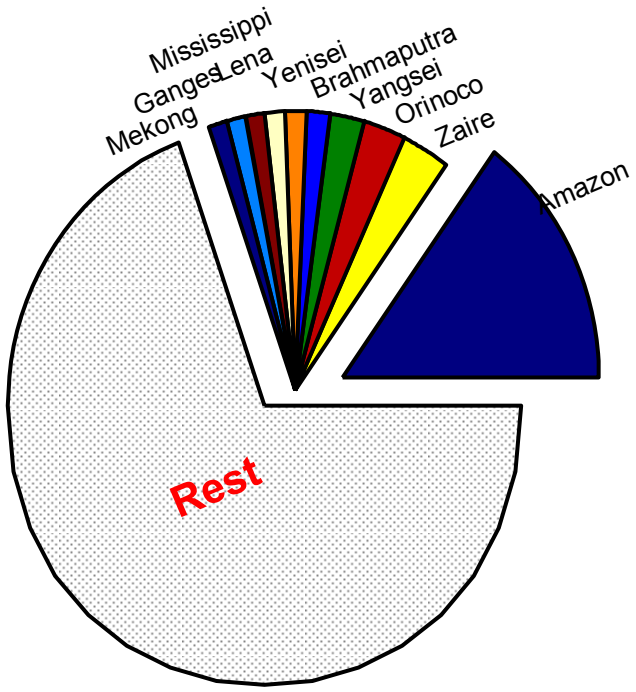
Top 10 Rivers by Discharge, with Amazon tributaries



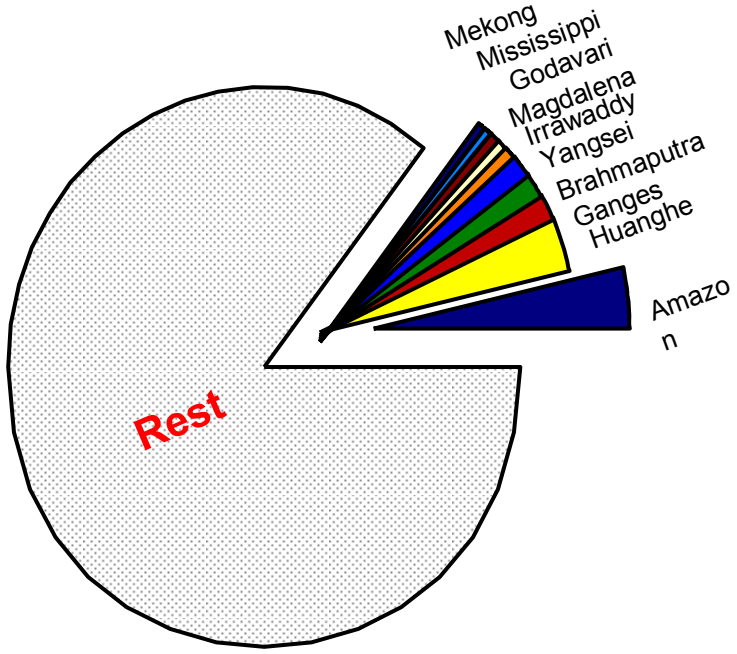
SPO= Amazon at Sao Paulo do Olivenca, exit from Peru

TOP 10 vs REST OF RIVERS

Discharge
1.3 M m3/s

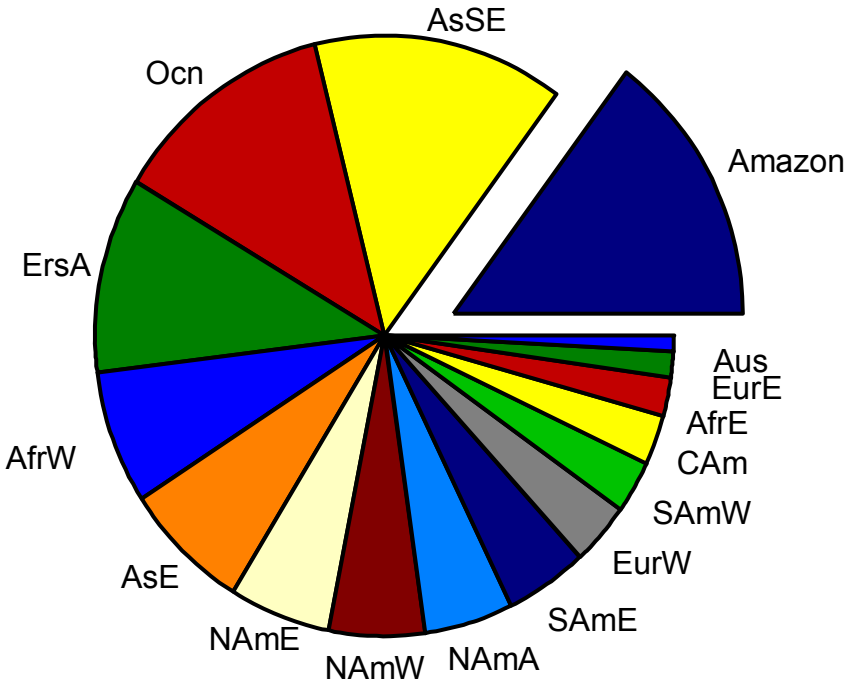


Sediment Transport
31,000 MT/y

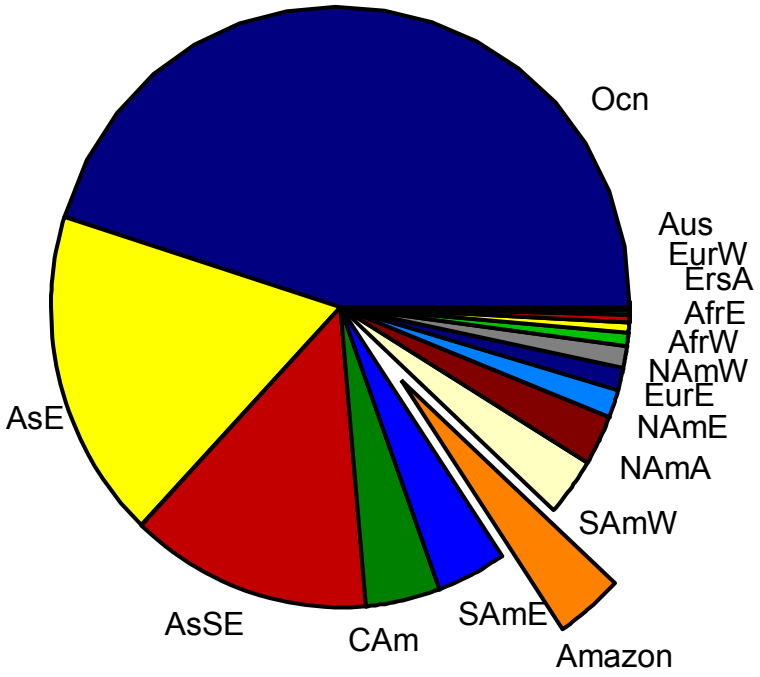


GEOGRAPHIC ZONES

Discharge
1.3 M m3/s



Sediment Transport
31,000 MT/y



Estimation of global river transport of sediments and associated particulate C, N, and P

A. Beusen, A. Dekkers, A. Bouwman, W. Ludwig, and J. Harrison
GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 19, 2005

The global river export of TSS: 19 Pg/y (95% ci 11–27 Pg/yr when accounting for sediment trapping in regulated rivers.

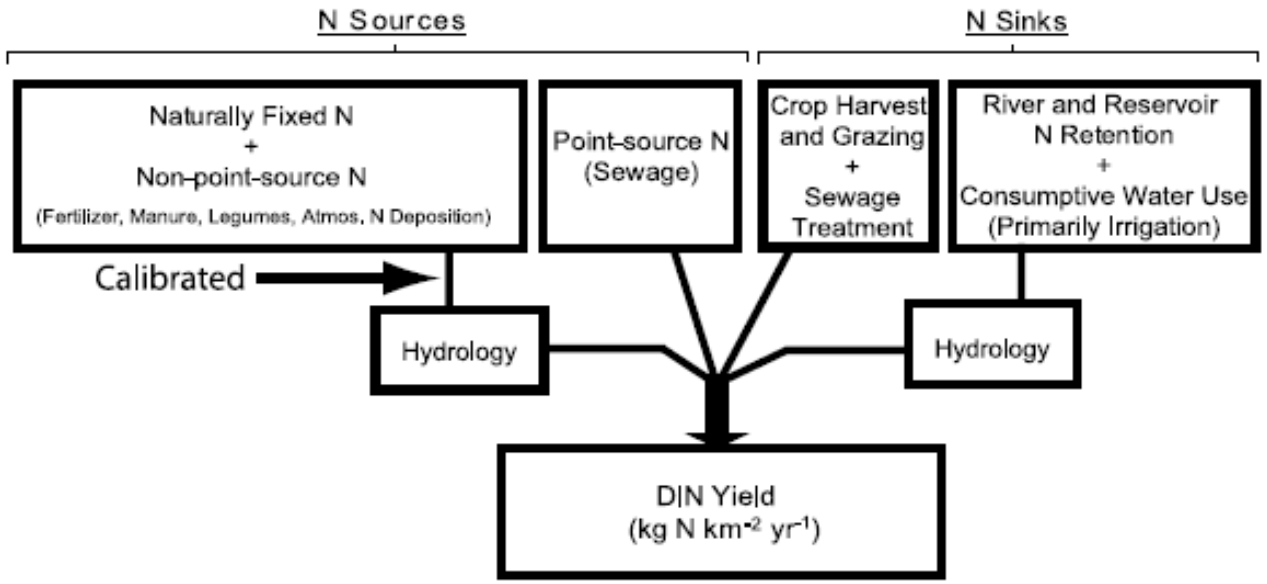
POC :197 Tg C/y (.01 wgt %), PN 30 Tg N/y (C:N 7.7:1), and PP 9 Tg P/y, respectively. The global sediment trapping included in these estimates is 13%.

Most particulate nutrients are transported by rivers to the Pacific (37% of global particulate nutrient export), Atlantic (28–29%), and Indian (20%) oceans, and the major source regions are Asia (50% of global particulate nutrient export), South America (20%), and Africa (12%).

Sources and delivery of carbon, nitrogen, and phosphorus to the coastal zone: An overview of Global Nutrient Export from Watersheds (NEWS) models and their application

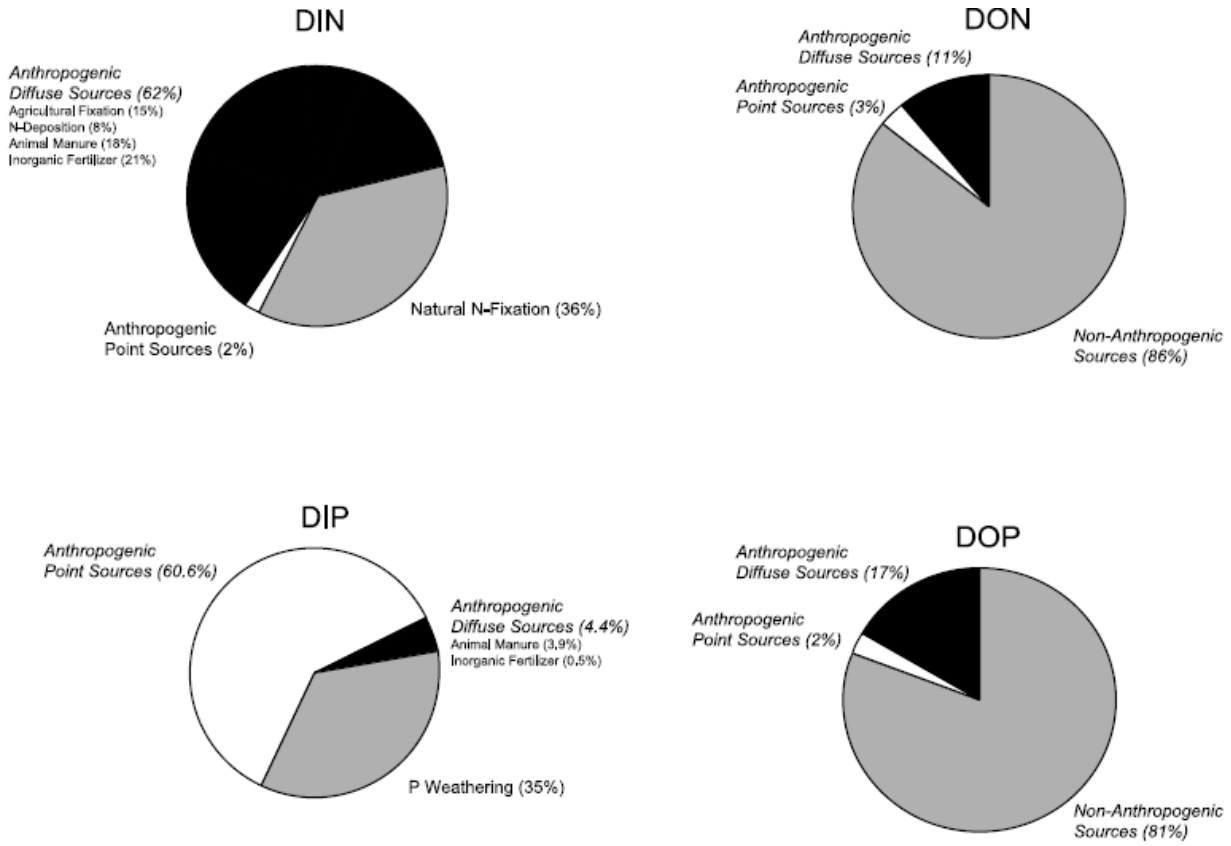
S. Seitzinger, J. Harrison, E. Dumont, A. Beusen, and A. Bouwman

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 19, 2005



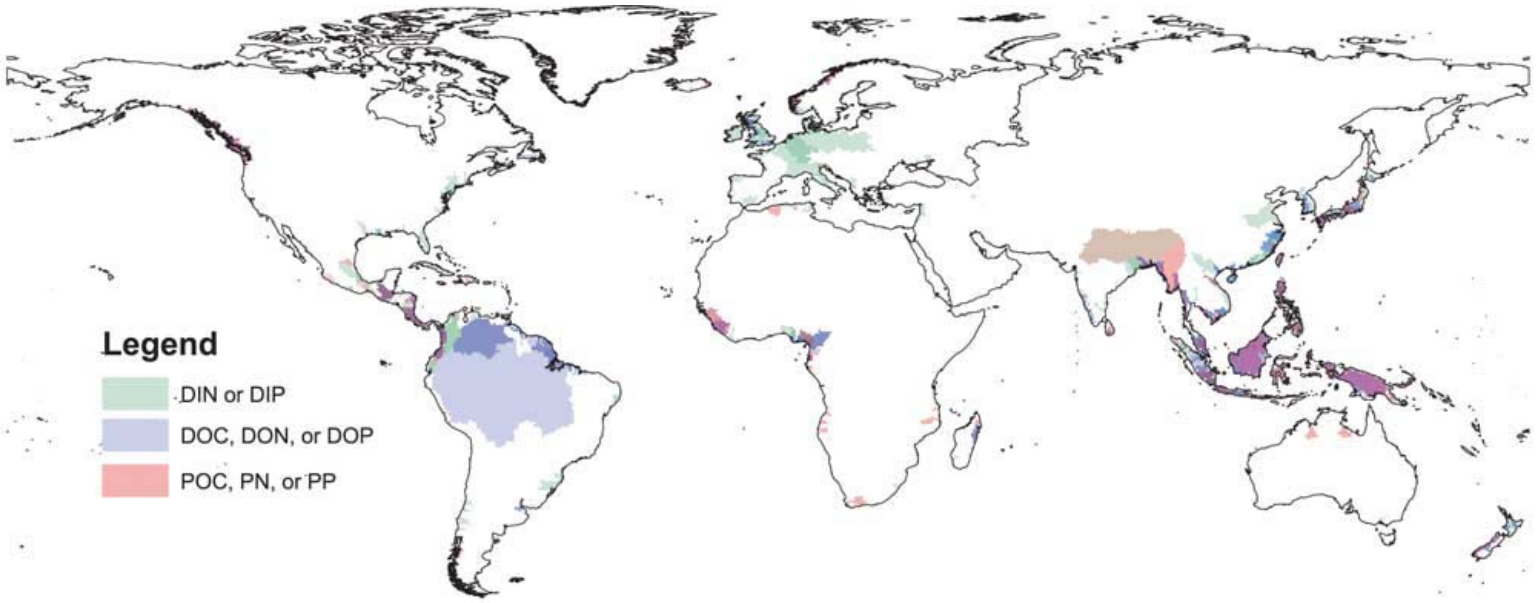
A conceptual diagram for one of the NEWS submodels (NEWS-DIN),

NEWS-model estimated global sources of DIN, DIP, DON, and DOP to the coastal zone



anthropogenic point sources, anthropogenic nonpoint sources, and natural sources represented as white, black, and gray pie slices, respectively.

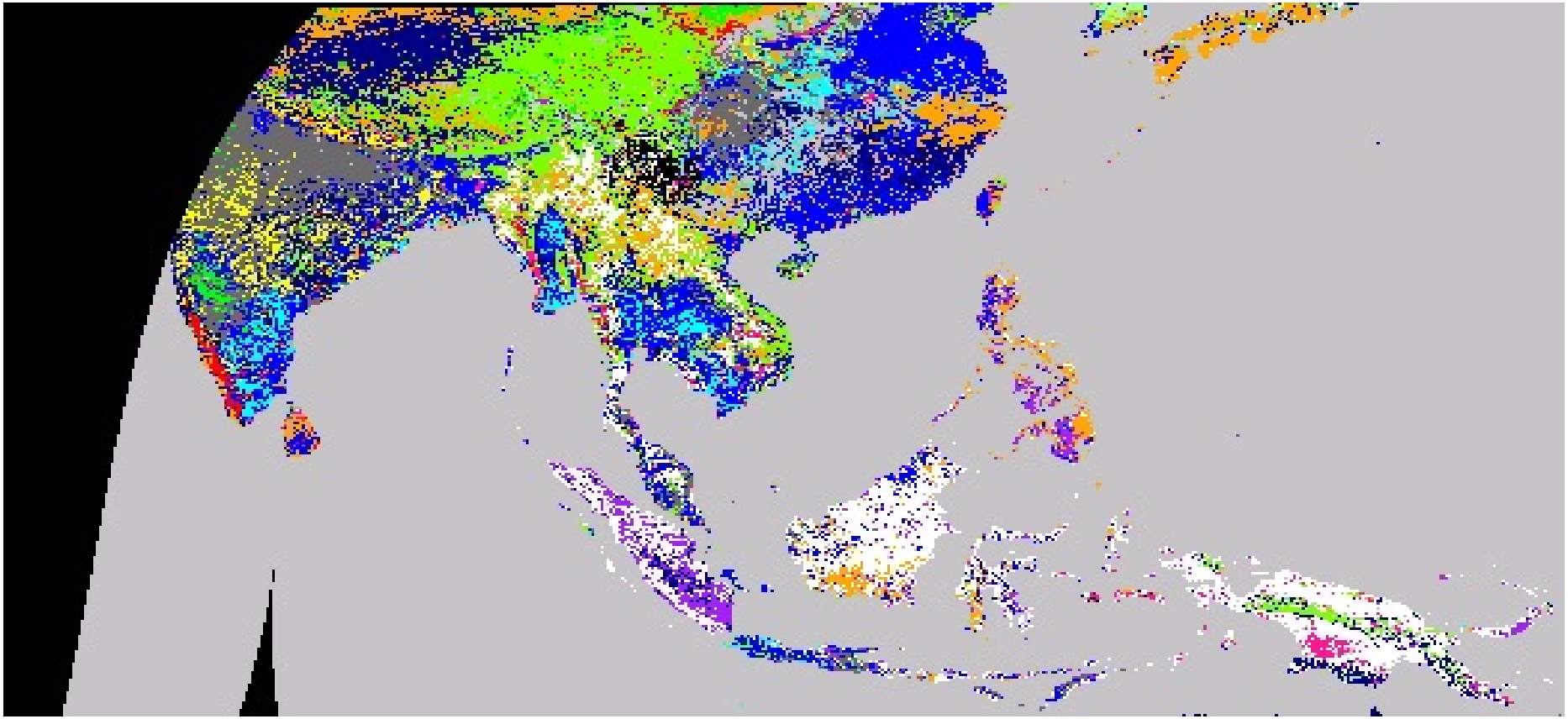
Hot spots for river nutrient yield
(kg C, N, or P km2 /y)



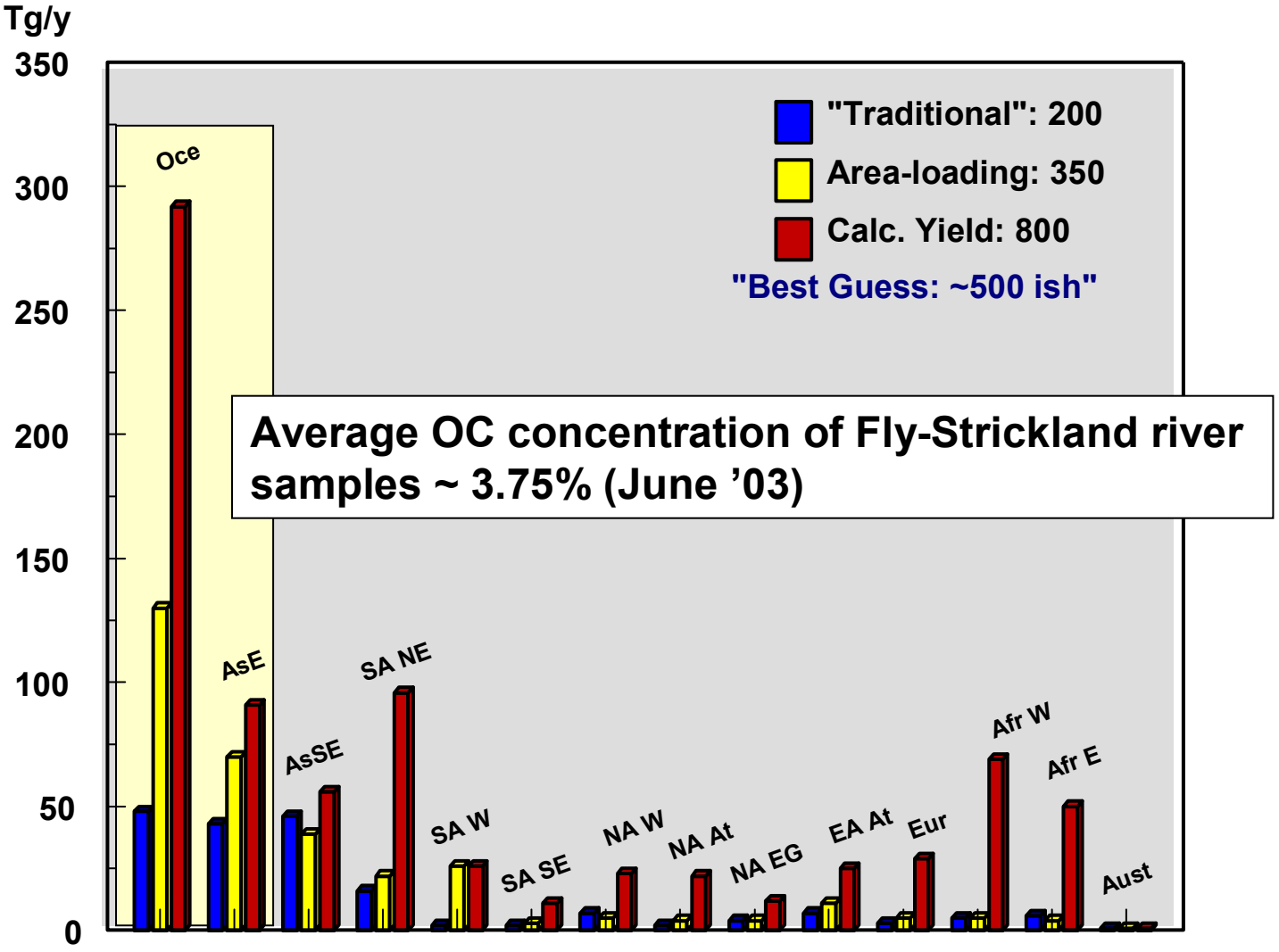
River basins with the highest predicted DIN and DIP yields (top 10% globally) are shaded green. River basins with the highest predicted DOC, DON and DOP yields (top 10% globally) are shaded blue, and river basins with the highest predicted POC, PN, and PP yields (top 10% globally) are shaded pink.


E2L AMANAÍ

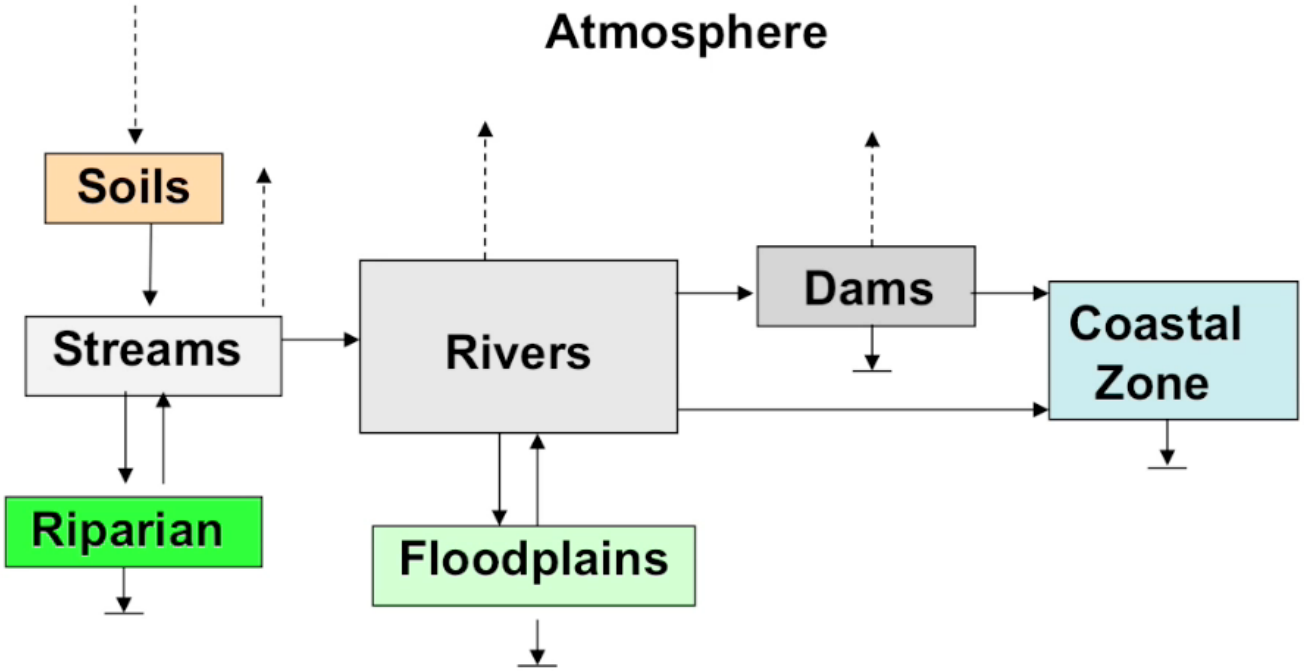
UNCERTAINTIES IN POC LOADING BY GEOGRAPHIC REGION



UNCERTAINTIES IN POC LOADING BY GEOGRAPHIC REGION



PATHWAYS OF ATMOSPHERIC CO2 THROUGH FLUVIAL SYSTEMS



Richey, J.E. (2004). Ch. 15. Field et al (eds) A SCOPE/GCP Rapid Assessment Project. Island Press.

movie

o.k. --- what's the problem here?

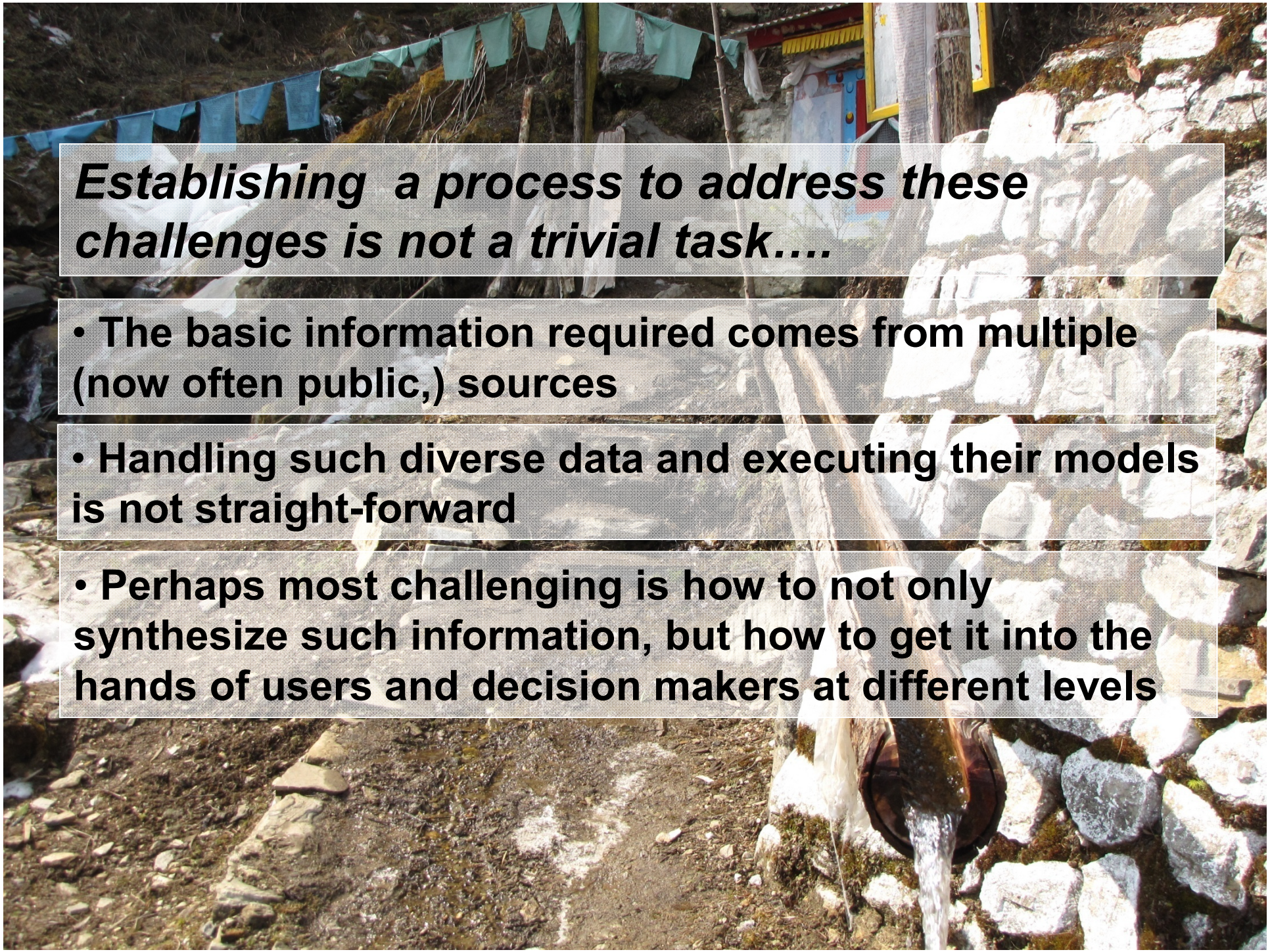
1. Sampling issues are sufficient to at least blur if not warp the "answer"

2. The Obidos Syndrome (or Phnom Penh or…) – "last" station is still a long way

3. These are ultimately "global" balances, of little utility to a specific region

Decision makers world-wide are facing a series of challenges critical to resource management

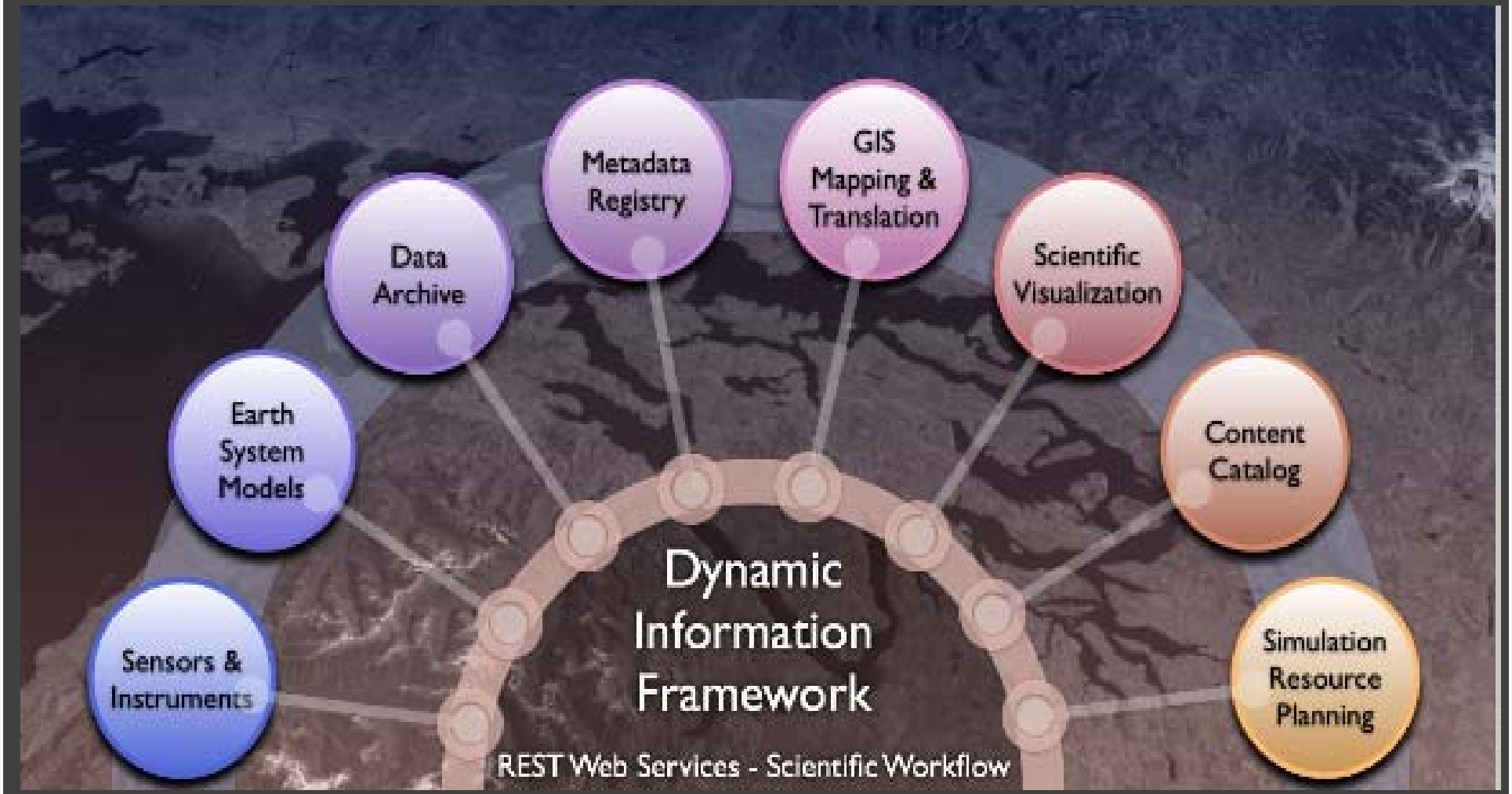
- ***How will floods and droughts impact freshwater resources, agriculture and livelihoods?***
- ***How will increasing development of hydropower (cascades) alter the water flow and sediment transport regime of rivers?***
- ***What are the implications for climate change across river basins?***
- ***What tools can be developed to optimize informed tradeoffs?***



Establishing a process to address these challenges is not a trivial task….

- **The basic information required comes from multiple (now often public,) sources**
- **Handling such diverse data and executing their models is not straight-forward**
- **Perhaps most challenging is how to not only synthesize such information, but how to get it into the hands of users and decision makers at different levels**

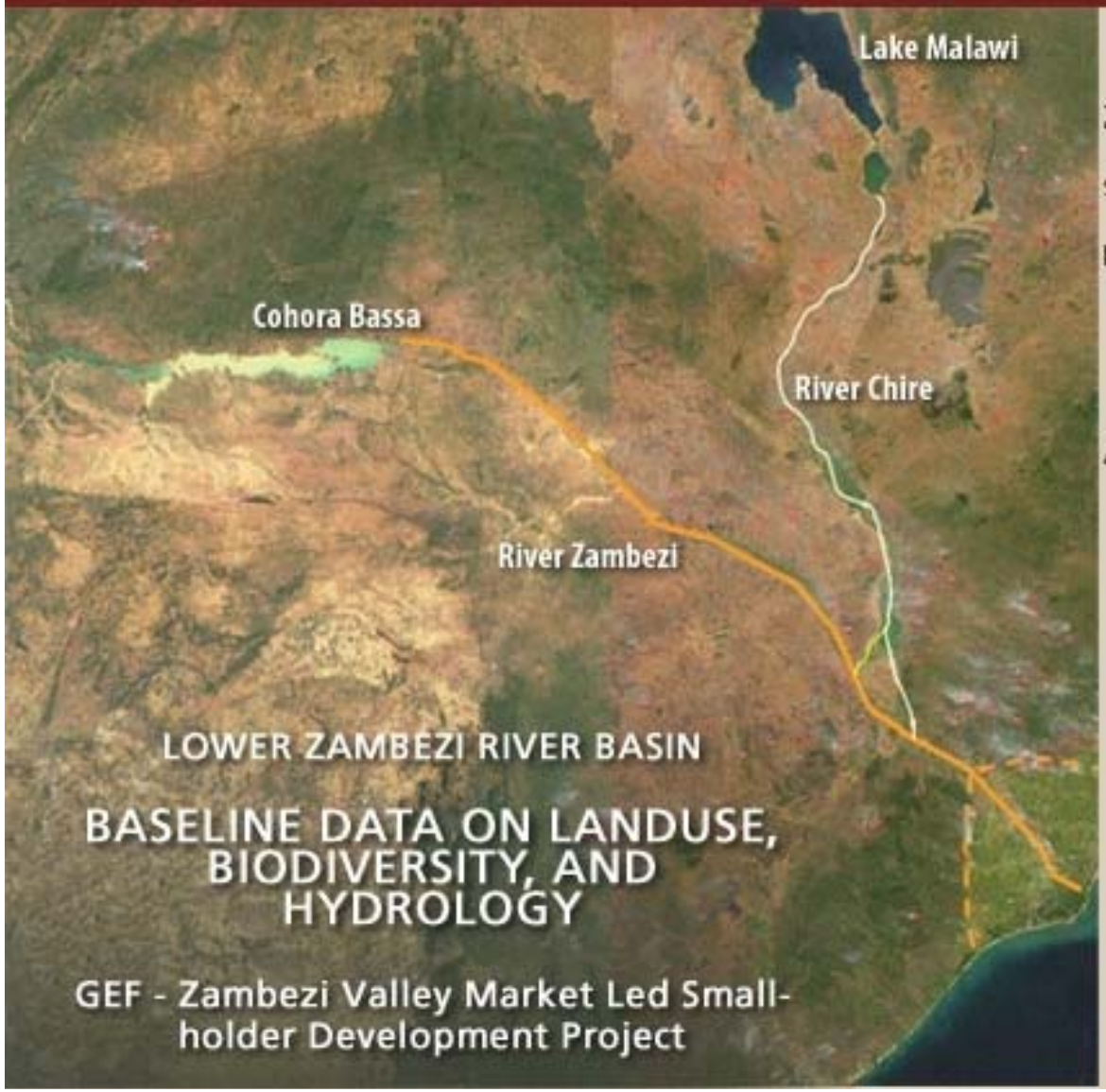
What is needed - a practical "information laboratory and forum," for organizing and synthesizing multi-source data towards <u>readily accessible</u> scenario and decision support (and doing science)



The Zambezi Dynamic Information Framework

(ZambeziDIF) Version 1

http://www.riversystems.washington.edu/zambezi_dif



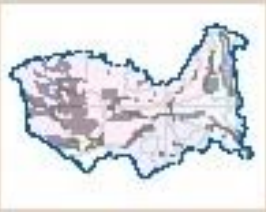
Zambezi SLM Project

SLM Project Baseline study description

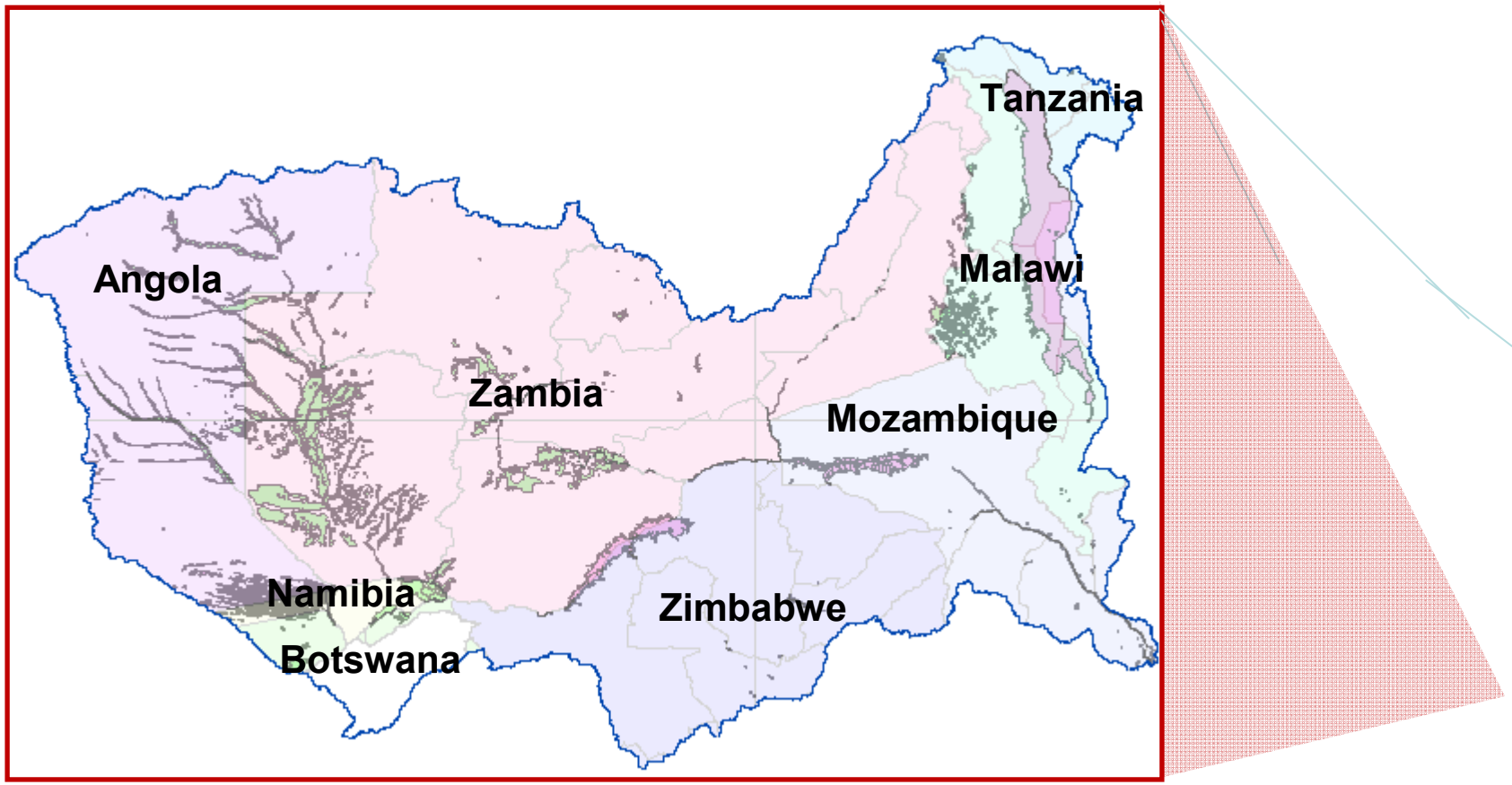
People and Places of the SLM Districts

- **Images**
- **Maps** from Biodiversity and survey transects

ArcIMS Accessible Data Layers



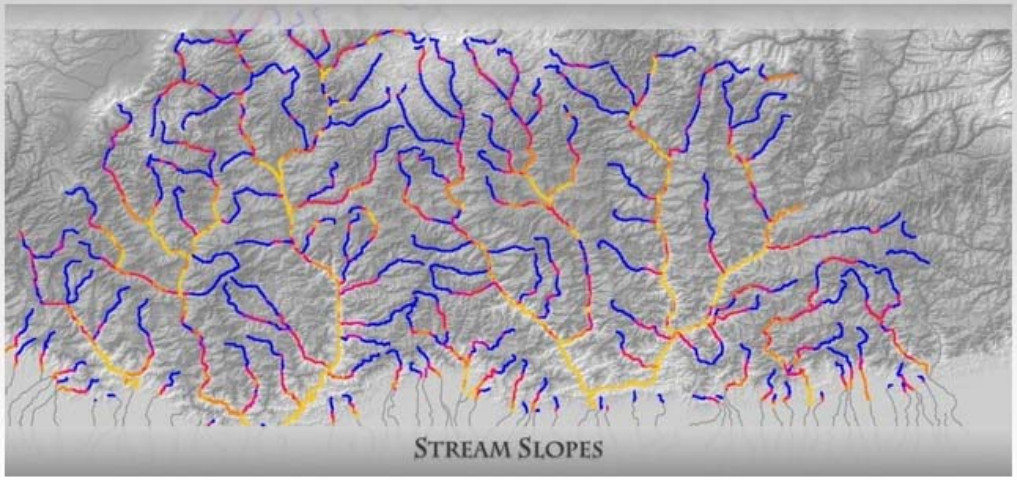
- **Zambezi Basin Boundaries**
- **Soil Properties**
- **Southern Africa Landcover**
- **Landcover and Landuse**
- **Basin %Landcover**
- **Surface Climate and Water Distributions**


Tanzania
Malawi
Angola
Zambia
Mozambique
Namibia
Zimbabwe
Botswana

UNIVERSITY of WASHINGTON

DRUK DIF

DRUK DYNAMIC INFORMATION FRAMEWORK



Provides interactive GIS Layers: Political Boundaries, Administrative, Infrastructure, Water Resources, Hydrology, Landcover, Landuse, Physical Template

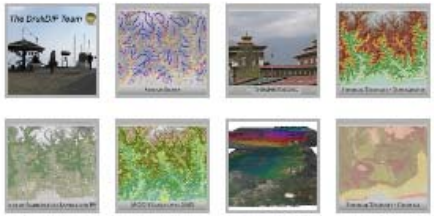
Launch >

DrukDIF

DrukDIF, is being developed to provide a robust *dynamic information framework of* data sets and state of the art models that can be utilized by staff in National Agencies to address the cross-sector resource problems facing Bhutan. Some key questions that might be asked are:

- What would be the impacts of changes in agriculture (including irrigation) and forestry practices on local and regional water balances?
- How does biodiversity respond to altitude, soil, and climate gradients? What are the linkages between biodiversity and agricultural productivity?
- How would changes in land use practices affect water supply, water quality, and biodiversity?
- If some indication of climate over a growing season was provided, could crop selection (and fire management) be improved?
- Can floods or droughts be predicted, or at least anticipated, one or two months into the future, as an early-warning system?
- What effects would changing climate have on water supply and hydropower?

FEATURED STORIES : VIEW ALL



Mainstreaming Climate Change Adaptation in Irrigated Agriculture Project in the Huang-Huai-Hai Plain

WB/GEF 黄淮海地区适应气候变化农业开发(MACC)项目 --科学基础

Uncertainties to be Addressed in the Hydrological and Overall Resources Assessment of Development Scenarios

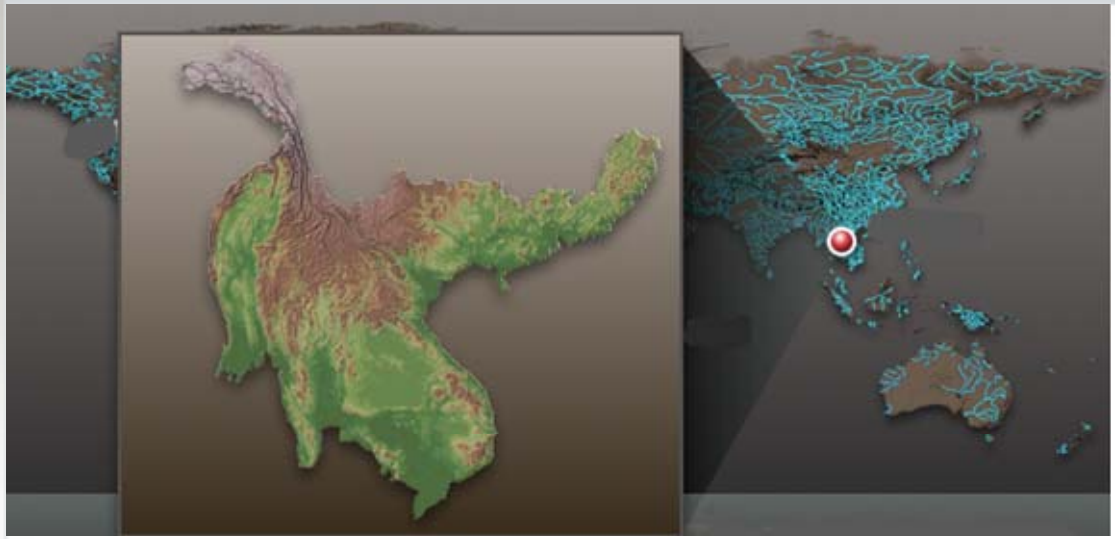
- *Scientific*
- *Social*
- *Political*

Virtual Mekong Basin

Khmer | Lao | Thai | Vietnamese |

HOME | RESEARCH | BASINS | PUBLICATIONS | RESOURCES | OUTREACH

TOP STORY

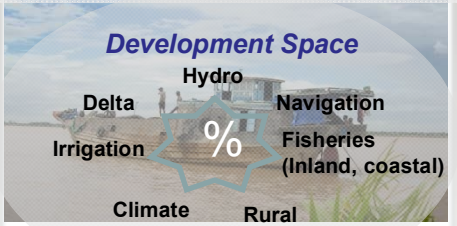


Mekong Yesterday, Today, and Tomorrow

Watershed *Country* *Region*

MISSION

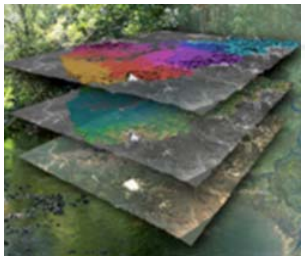
To provide an integrating, cross-sector platform -Science to Sustainability of the Mekong Basin



HIGHLIGHTS

NEWS & ANNOUNCEMENTS

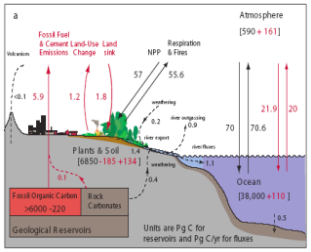
QUICK LINKS RSS Feeds



Basin Environment

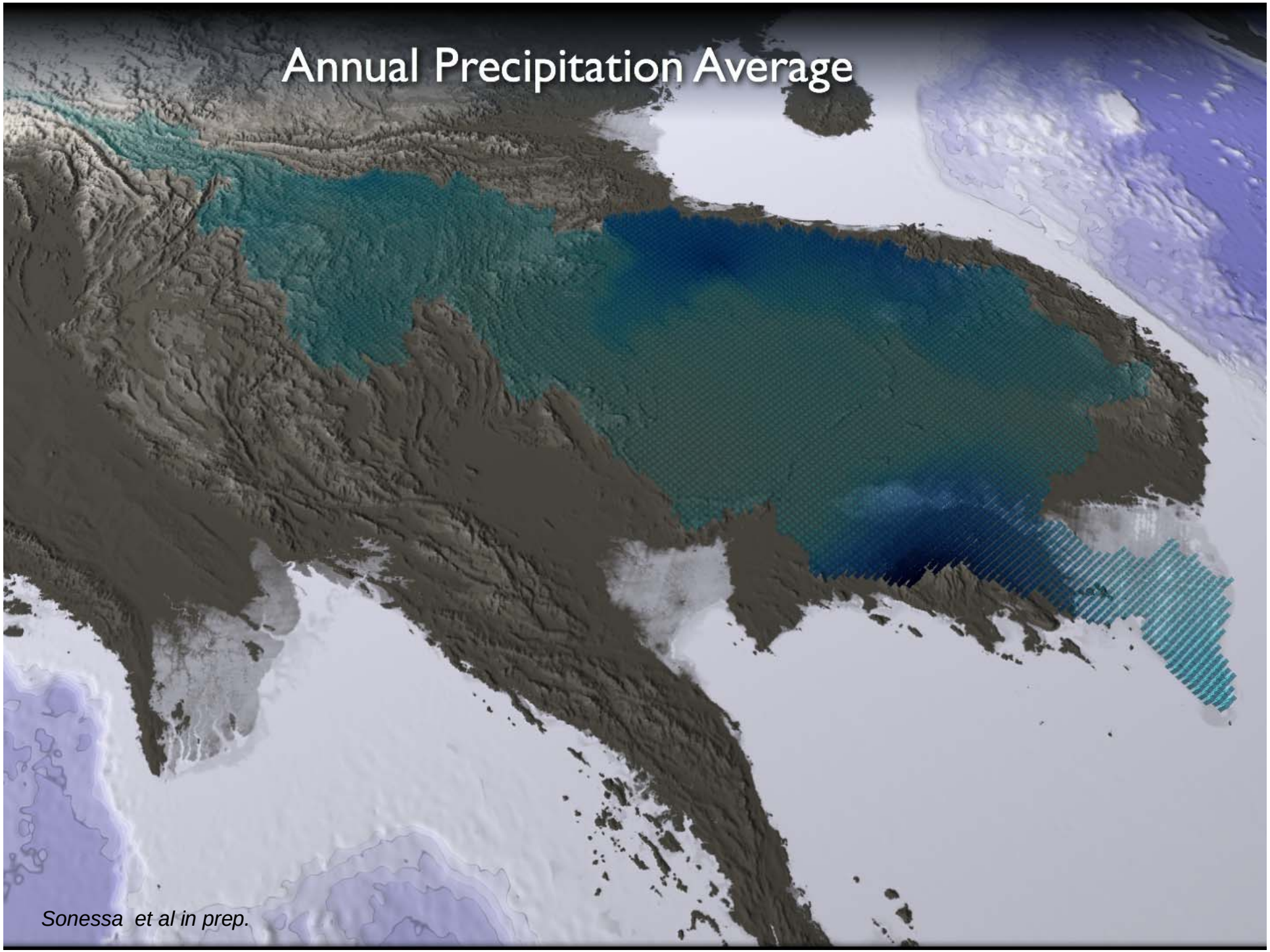
Water & Water Resources

Fisheries



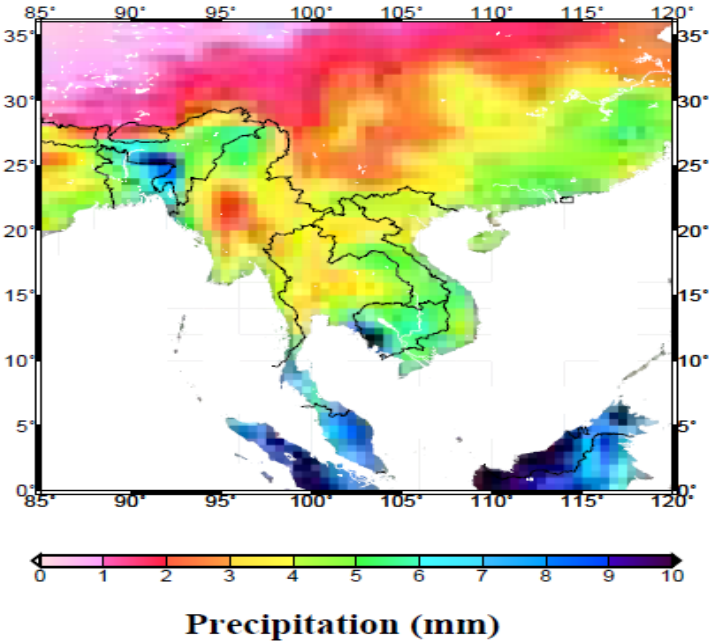
Carbon Balance

Hydropower

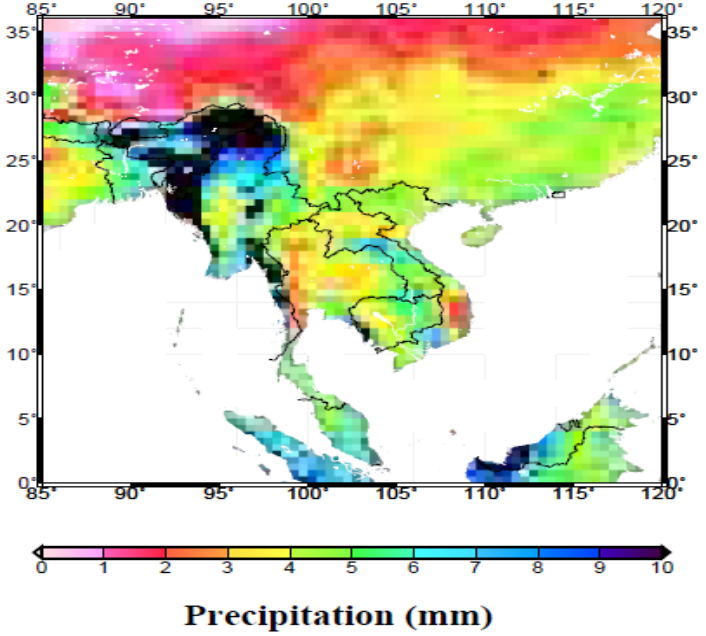

Annual Precipitation Average
Sonessa et al in prep.

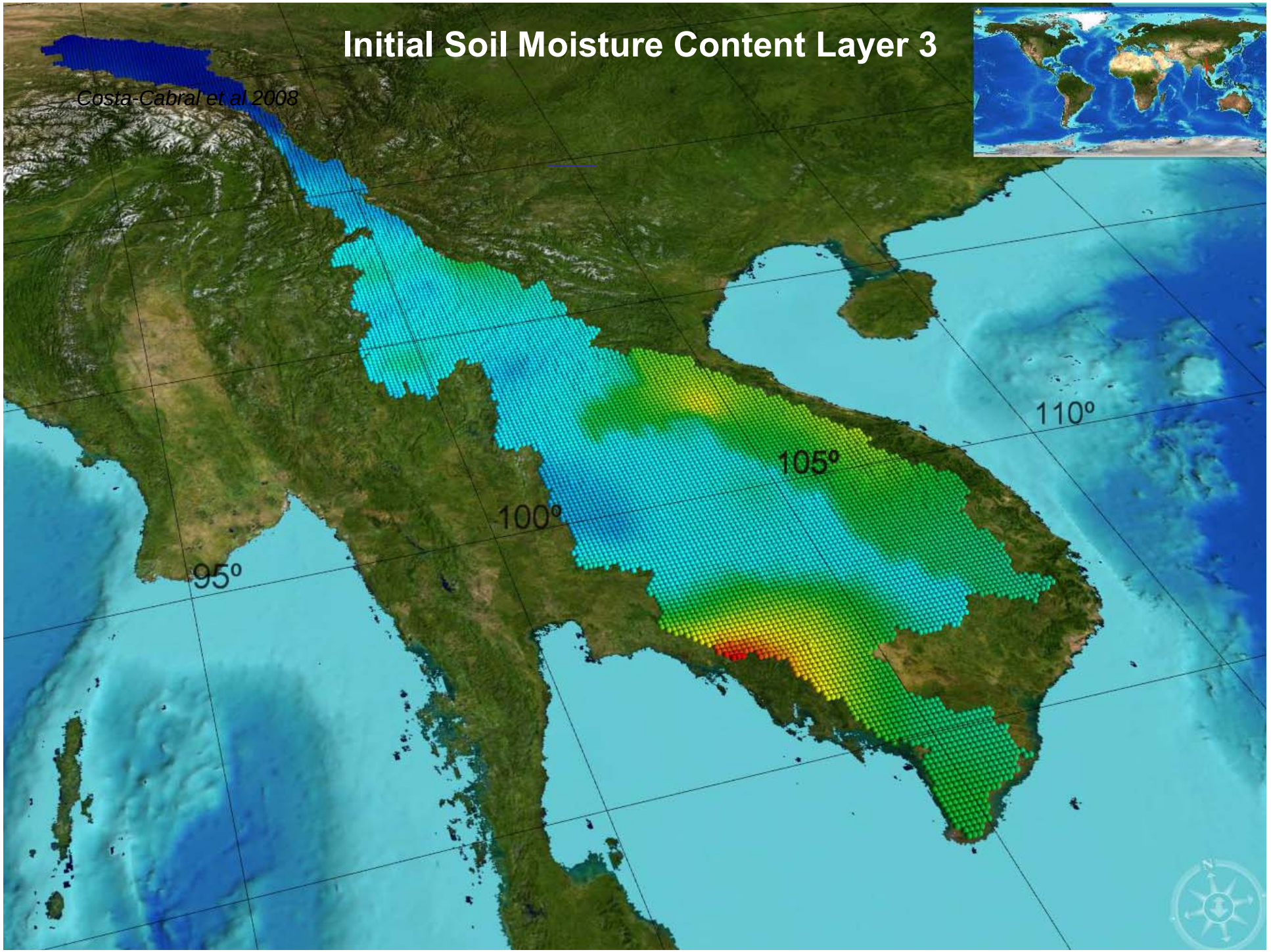
Mean Daily Precipitation

TRMM (1998-2008)

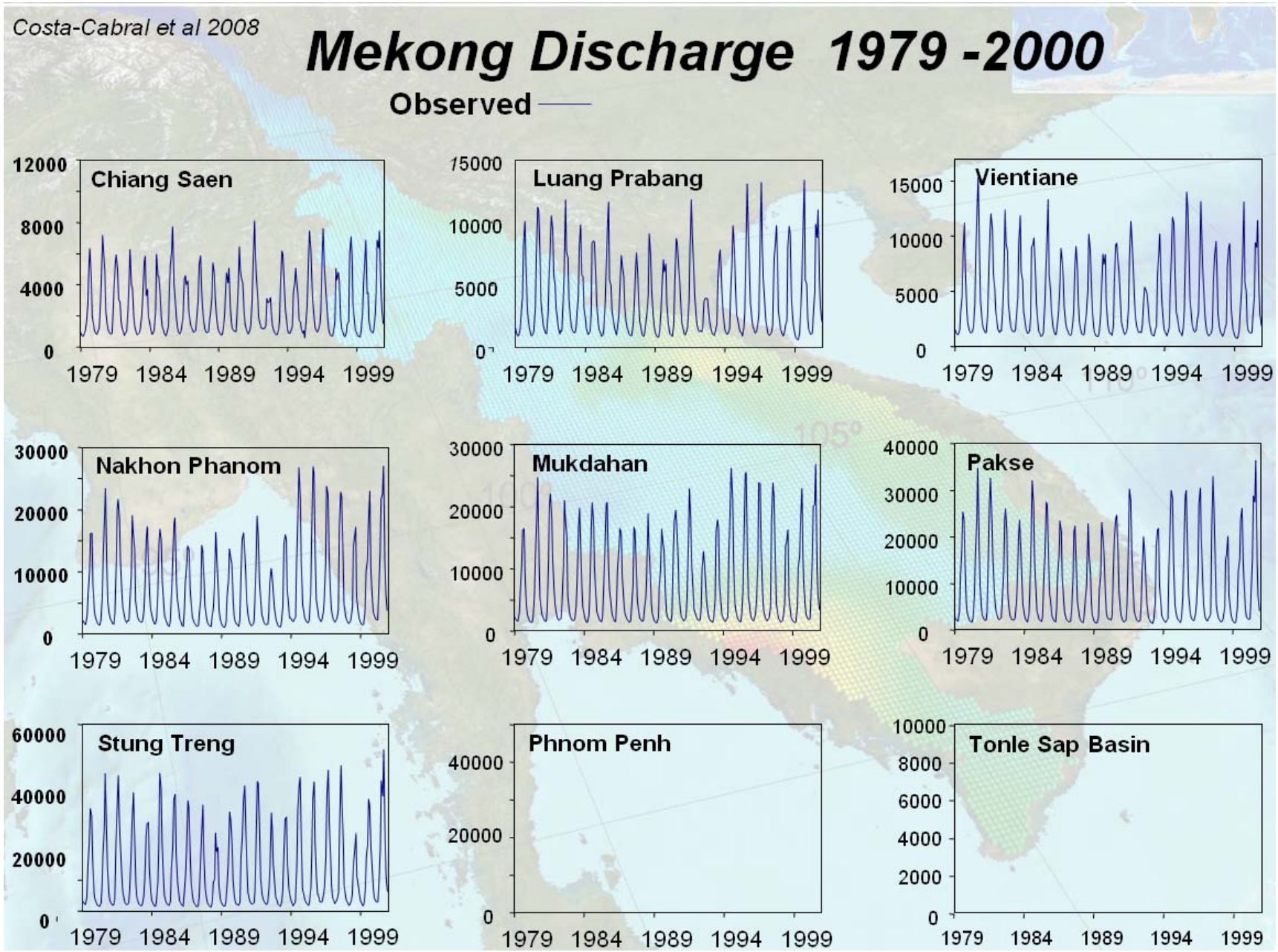


NCEP/NCAR (1948-2007)

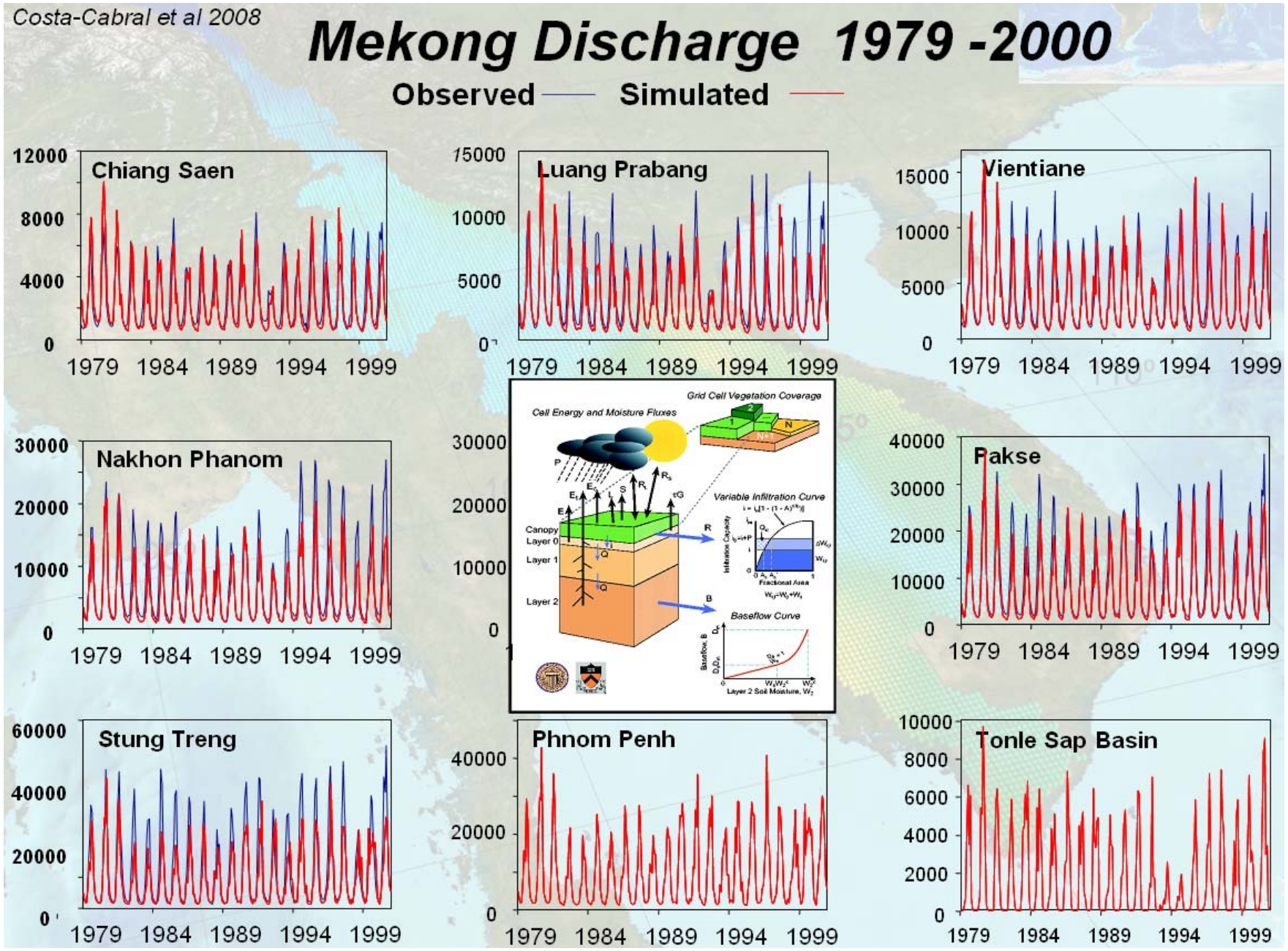



Initial Soil Moisture Content Layer 3
Costa-Cabral et al 2008
110º
105º
100º
95º

Initial Soil Moisture Content Layer 3

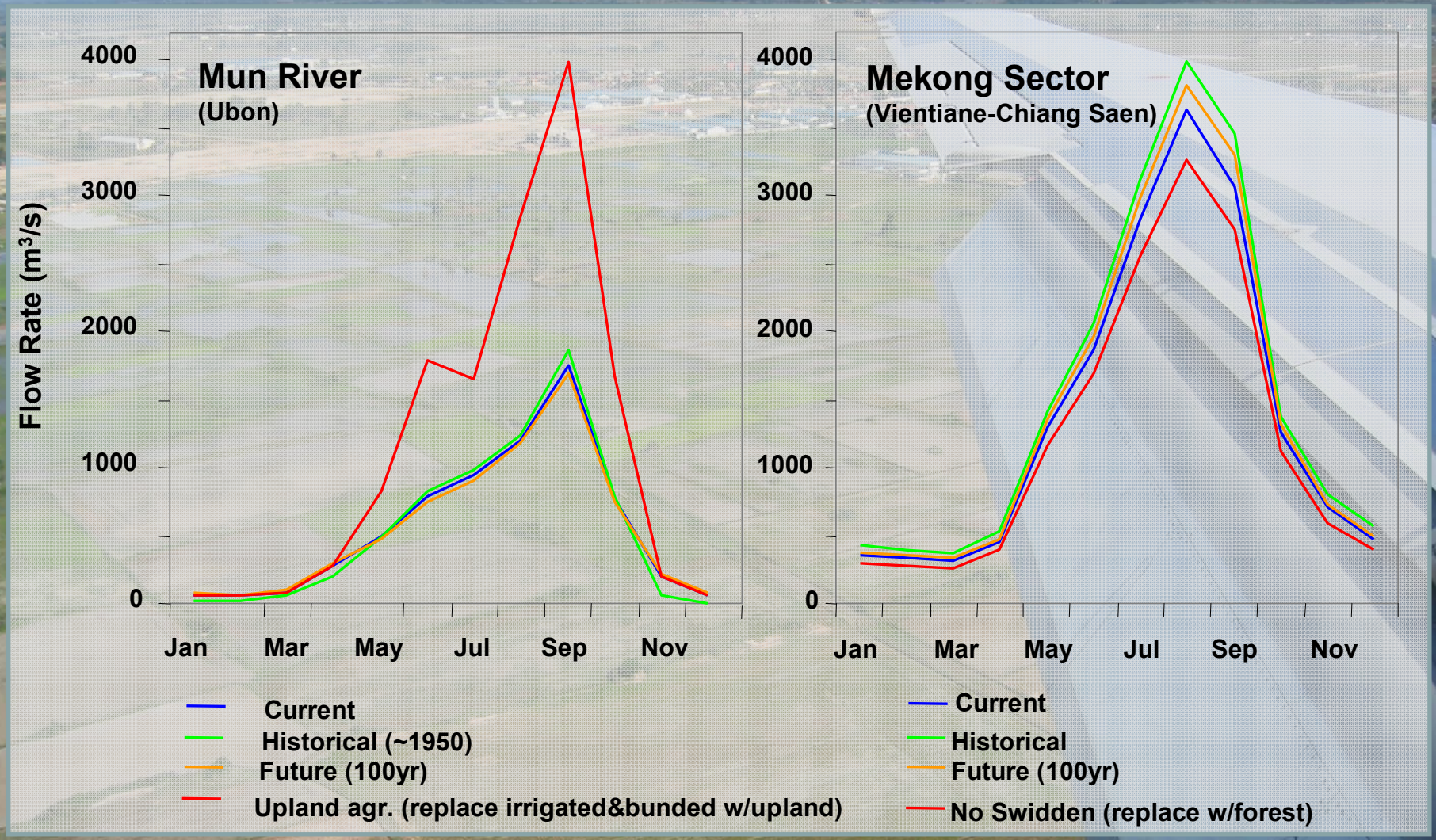


Initial Soil Moisture Content Layer 3



Landuse Scenarios

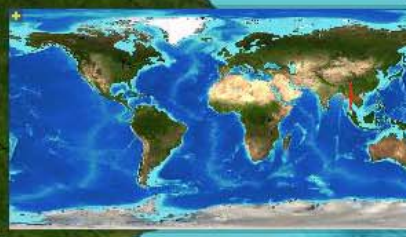
Average Monthly Streamflow, 1980-2000

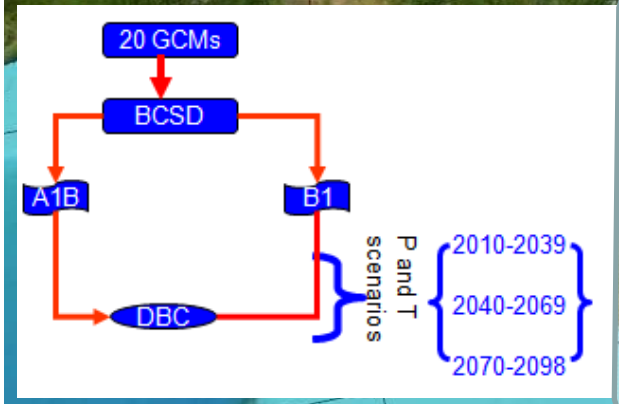


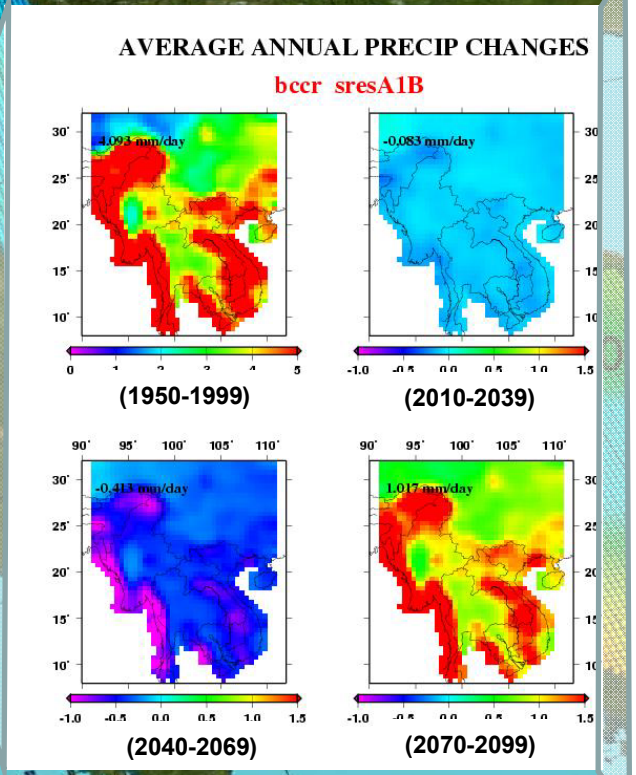
Richey et al in prep.

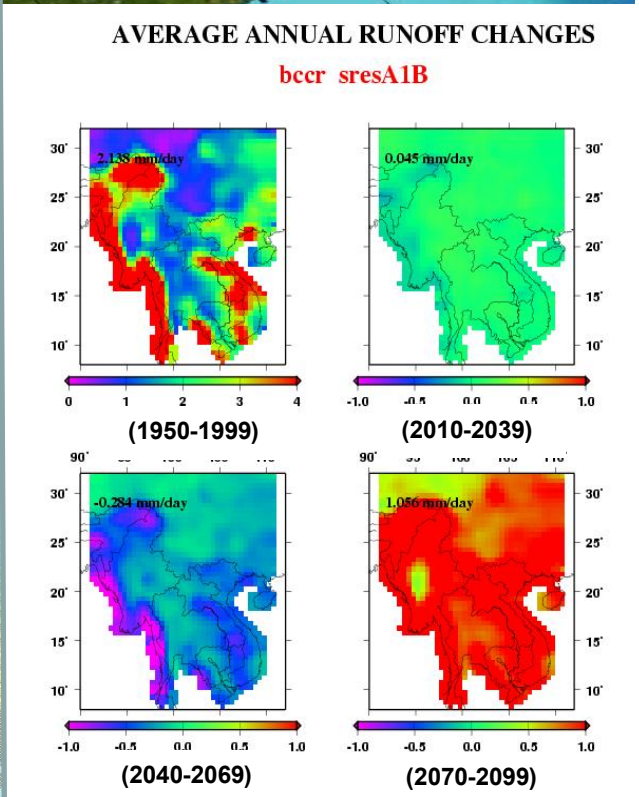
Climate Scenarios

Mekong Discharge 2010 – 2098:



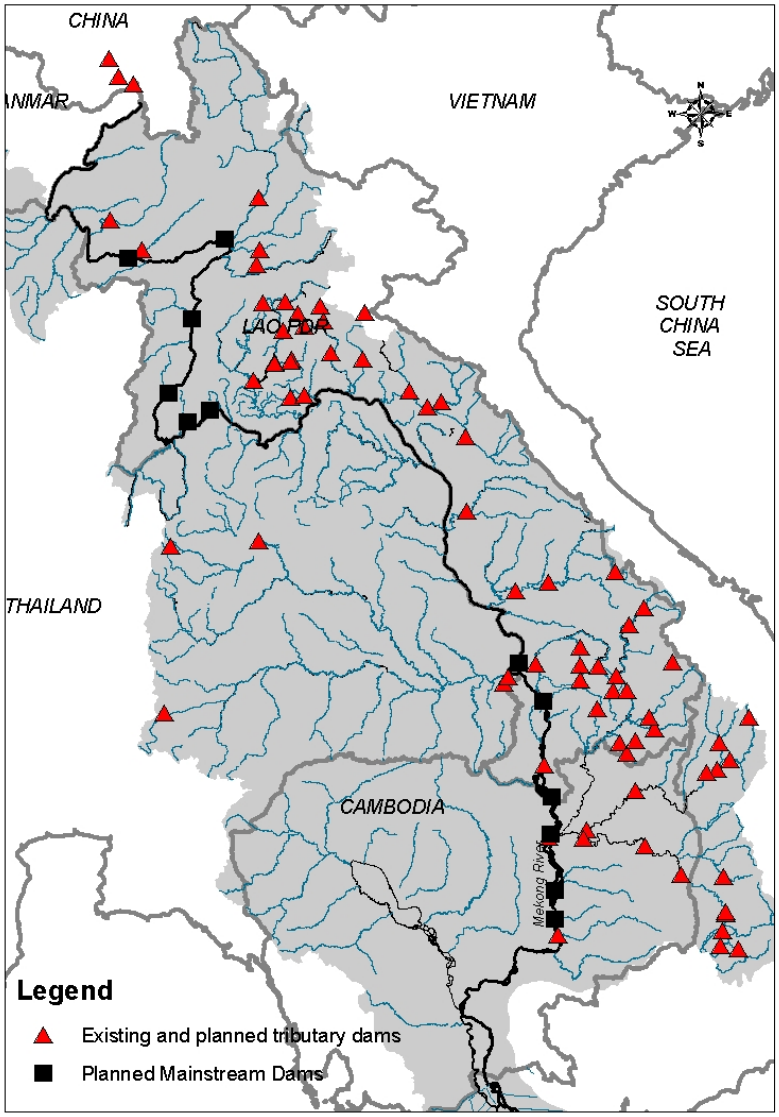


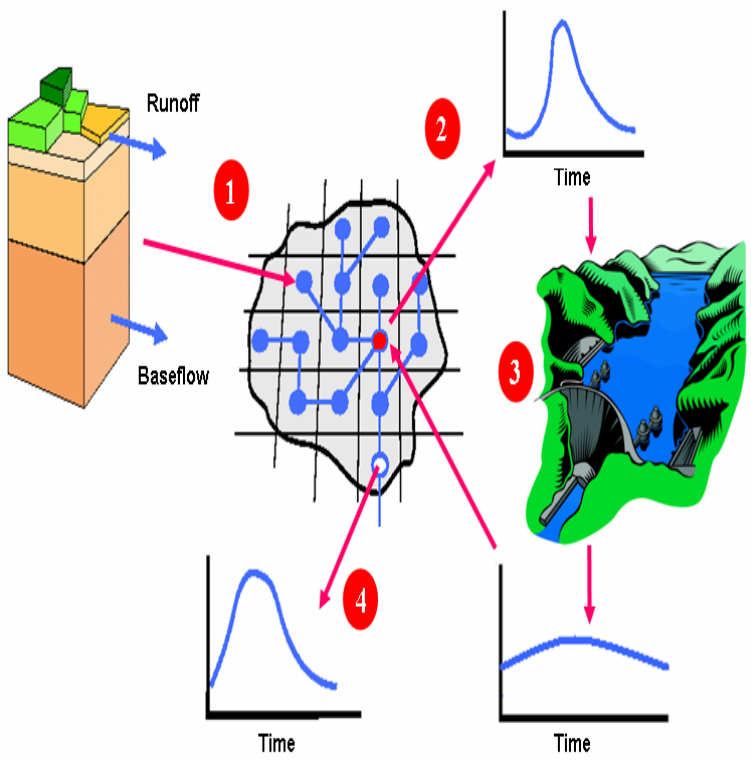




Bayenne et al in prep.

Hydropower Scenarios

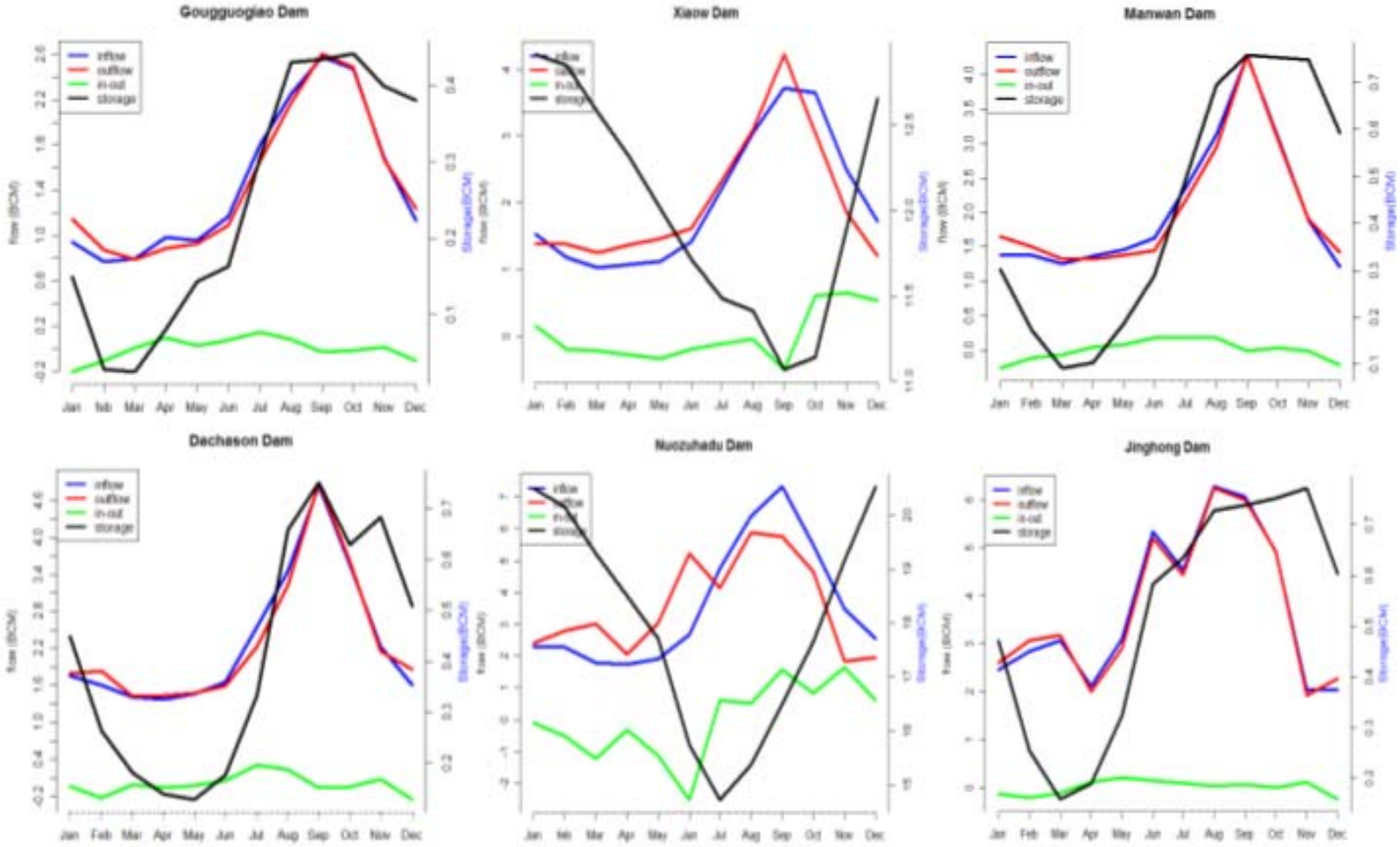




Bayenne et al in prep.

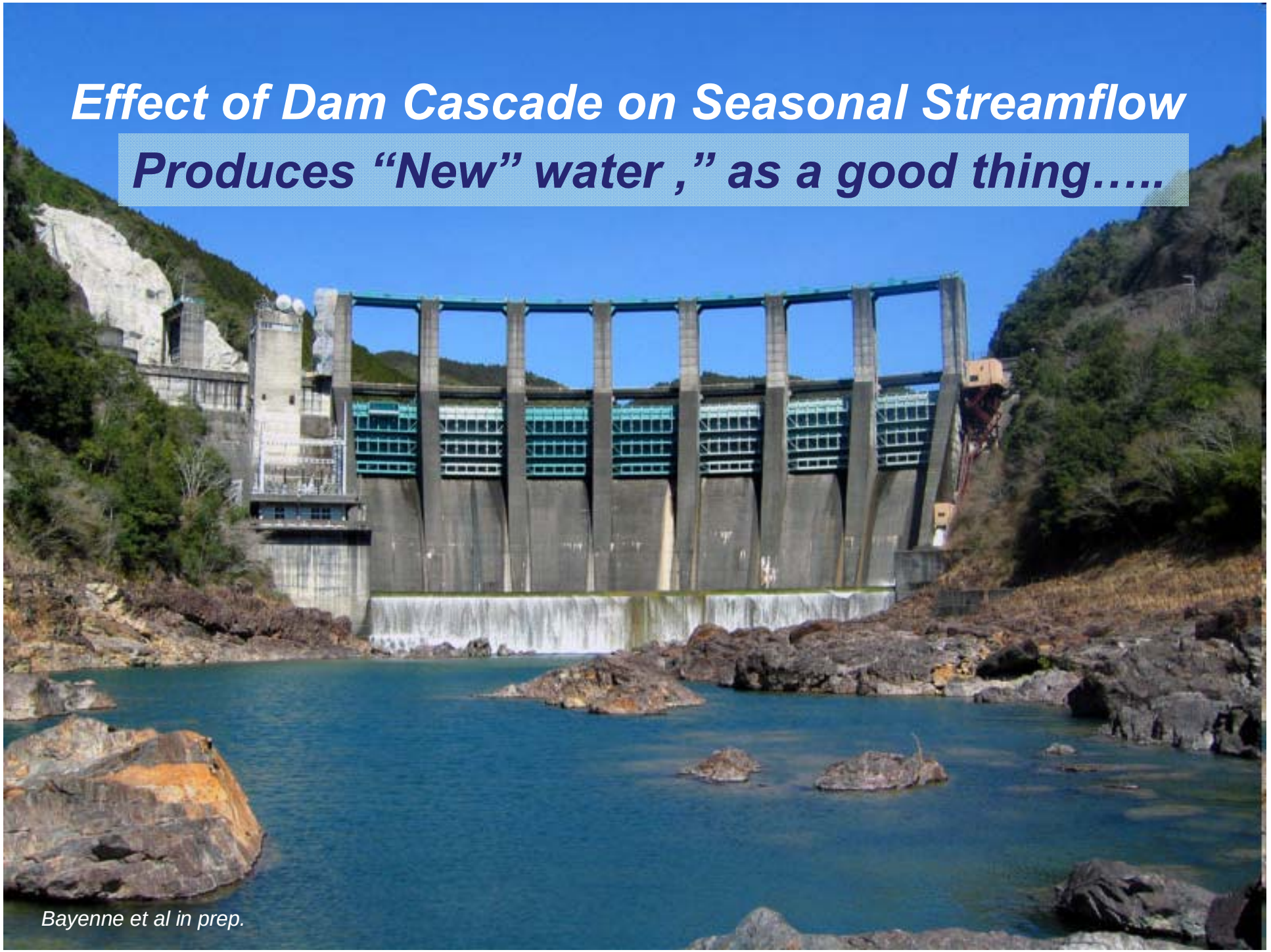
Hydropower Scenarios

Simulated and optimized, release, storage and inflow at 6 Chinese dams (Base climate scenario).

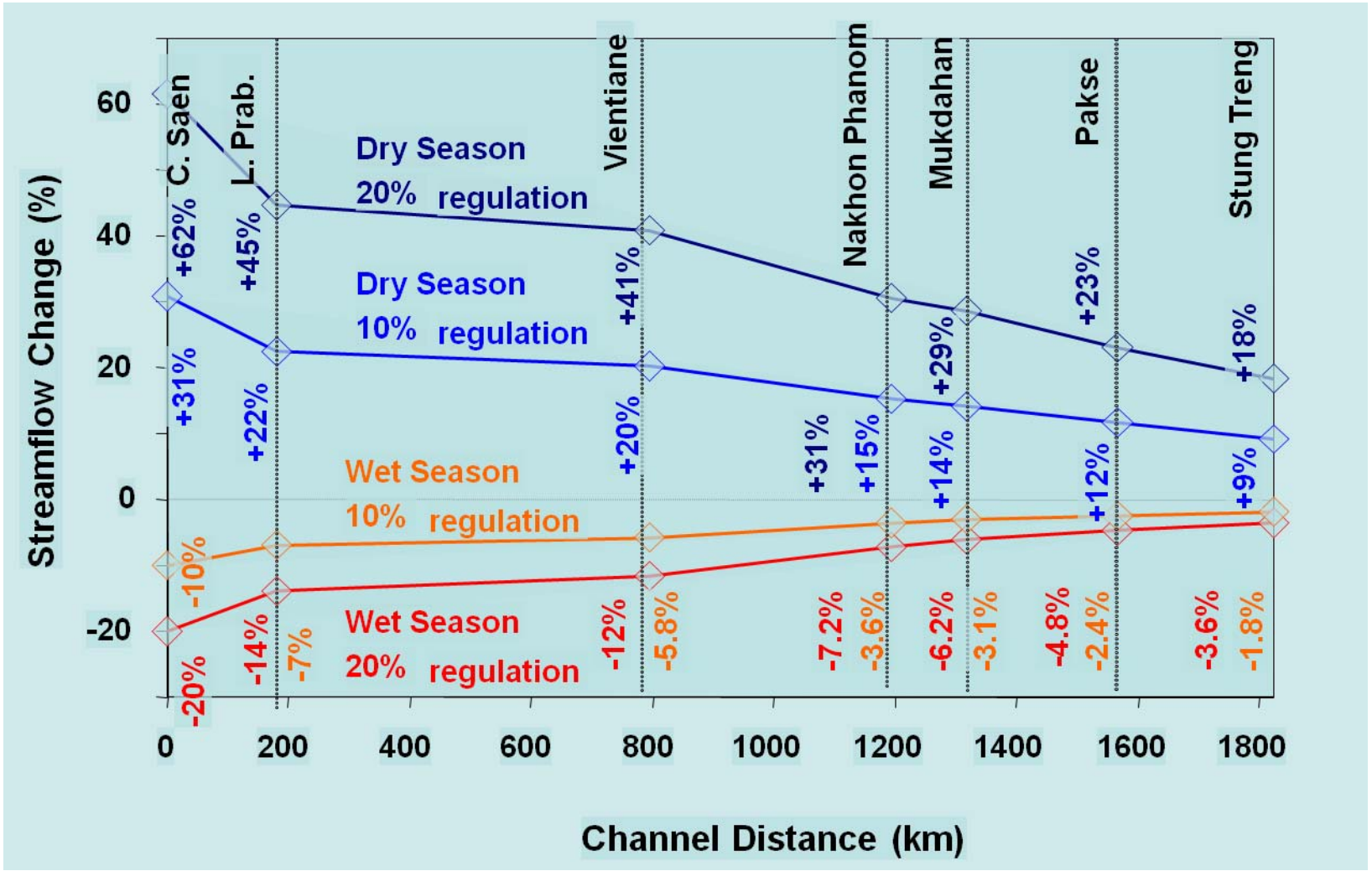


Effect of Dam Cascade on Seasonal Streamflow

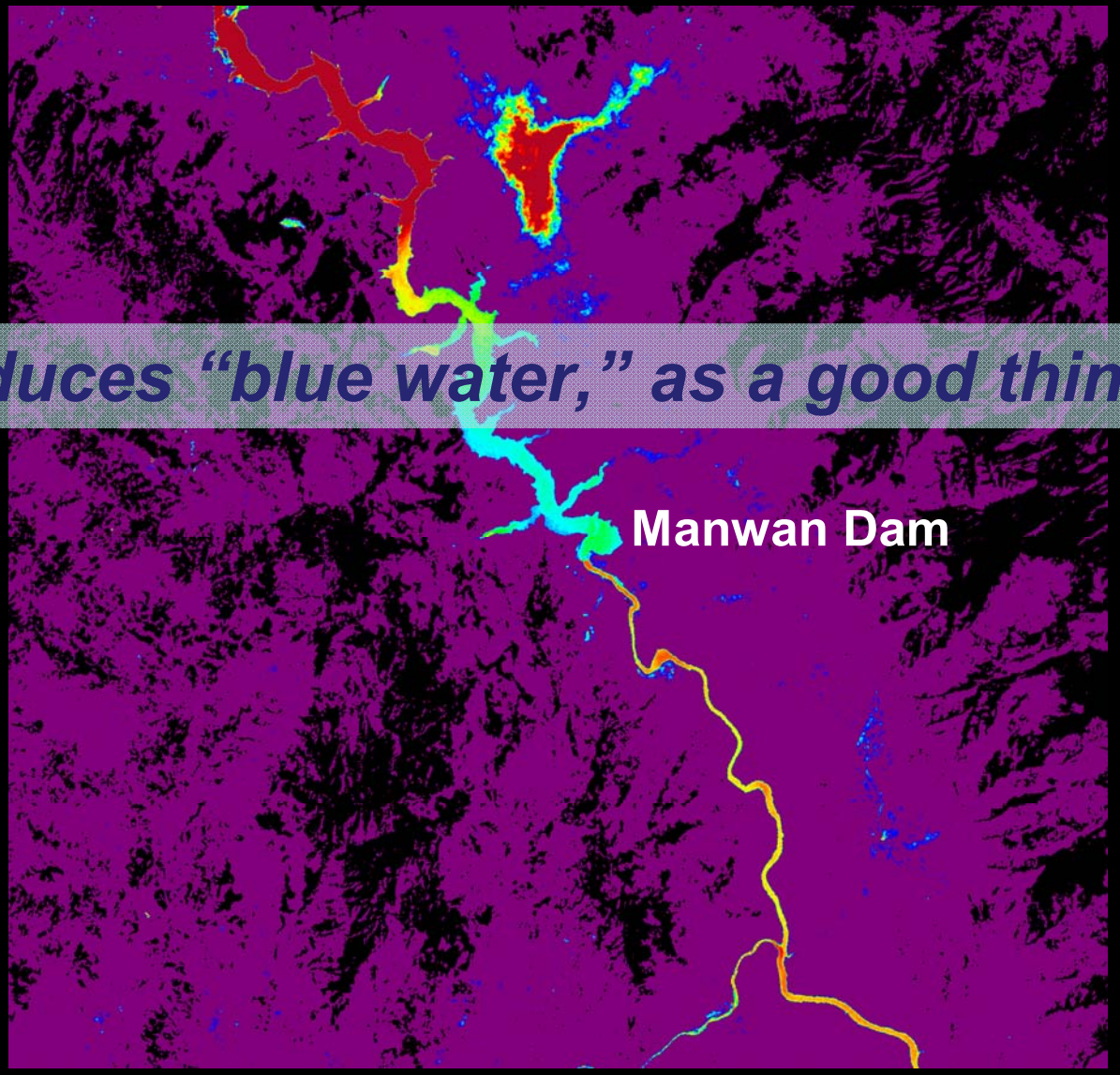
Produces "New" water ," as a good thing…..



Bayenne et al in prep.


Streamflow Change (%)
60
40
20
0
-20
0
200
400
600
800
1000
1200
1400
1600
1800
Channel Distance (km)
C. Saen
L. Prab.
Vientiane
Nakhon Phanom
Mukdahan
Pakse
Stung Treng
Dry Season
20% regulation
Dry Season
10% regulation
Wet Season
10% regulation
Wet Season
20% regulation
+62%
+45%
+41%
+23%
+18%
+31%
+22%
+20%
+31%
+15%
+29%
+14%
+12%
+9%
-10%
-20%
-14%
-7%
-12%
-5.8%
-7.2%
-3.6%
-6.2%
-3.1%
-4.8%
-2.4%
-3.6%
-1.8%

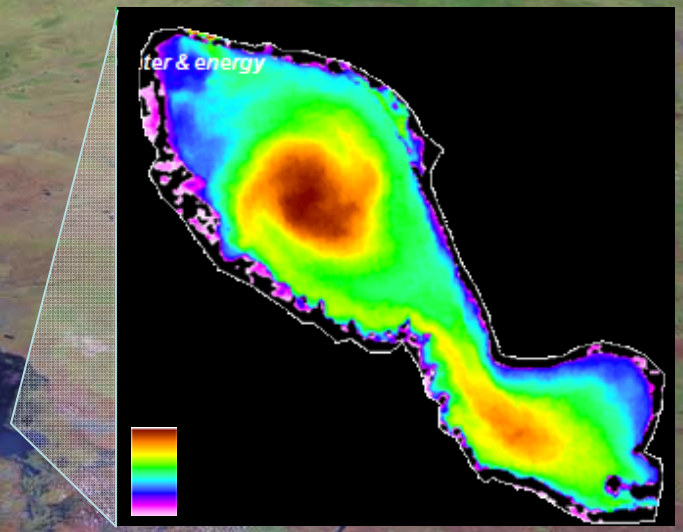
Turbidity (upper Mekong)
ASTER March 14, 2009

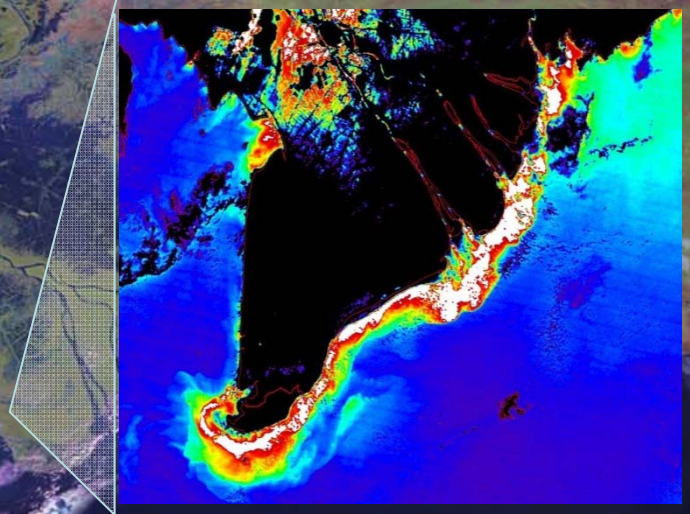


Produces "blue water," as a good thing…..

Kirschke et al in prep.

Turbidity (Lower Mekong)
MODIS, Nov 2006



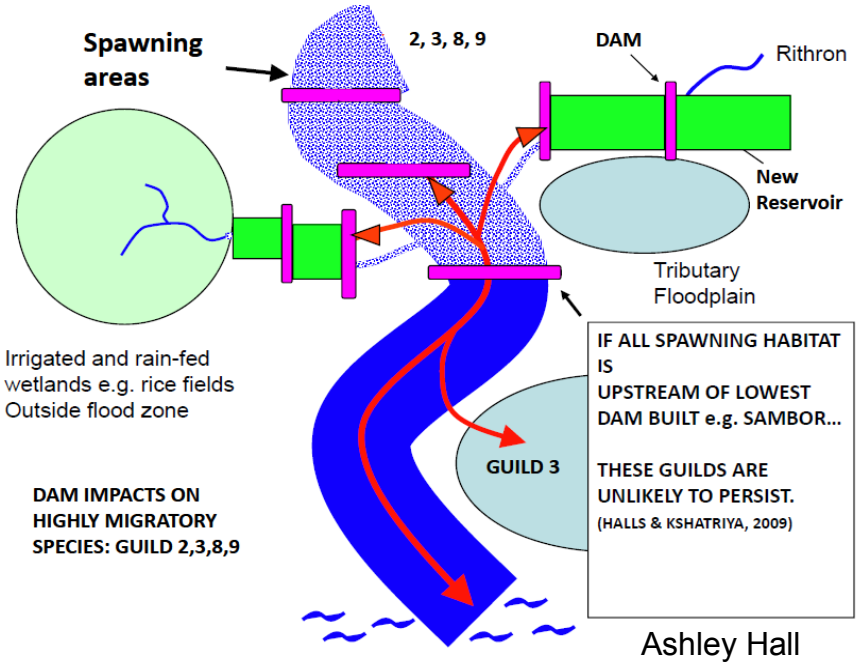


Kirschke et al in prep.

IPL OnEarth WMS Global Mosaic, a high resolution global image mosaic of the earth, produced from more than 8200 individual Landsat7 scenes.

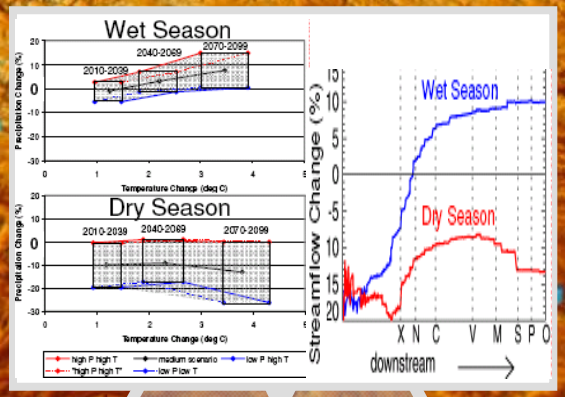
MEKONG FISHERIES – what effects dams?

~2.5 MT/y – by far largest freshwater fisheries in the world.
2% of total global fish catch

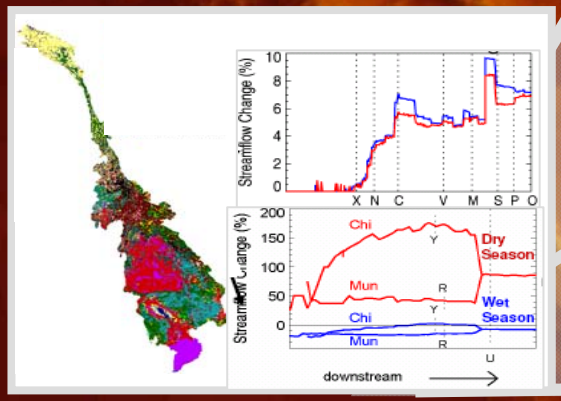


Ashley Hall

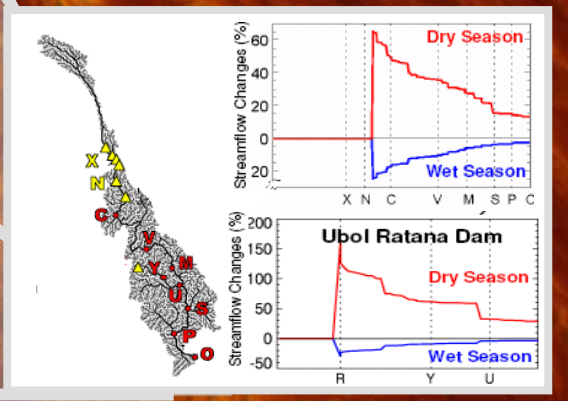
CLIMATE CHANGE



Synergy: Cumulative Uncertainty in Impacts & Outcomes



LAND USE



DAMS