

Cross Sector & Landscape Scale

Natural Resource Management for Climate Resilience

Application of Earth Systems Analytical Tools –
International Examples
& AralDIF

Erick Fernandes,
The World Bank
Latin America & the Caribbean

Climate change real economic risk, World Bank tells G20

By: [AFP](#) | February 17, 2013

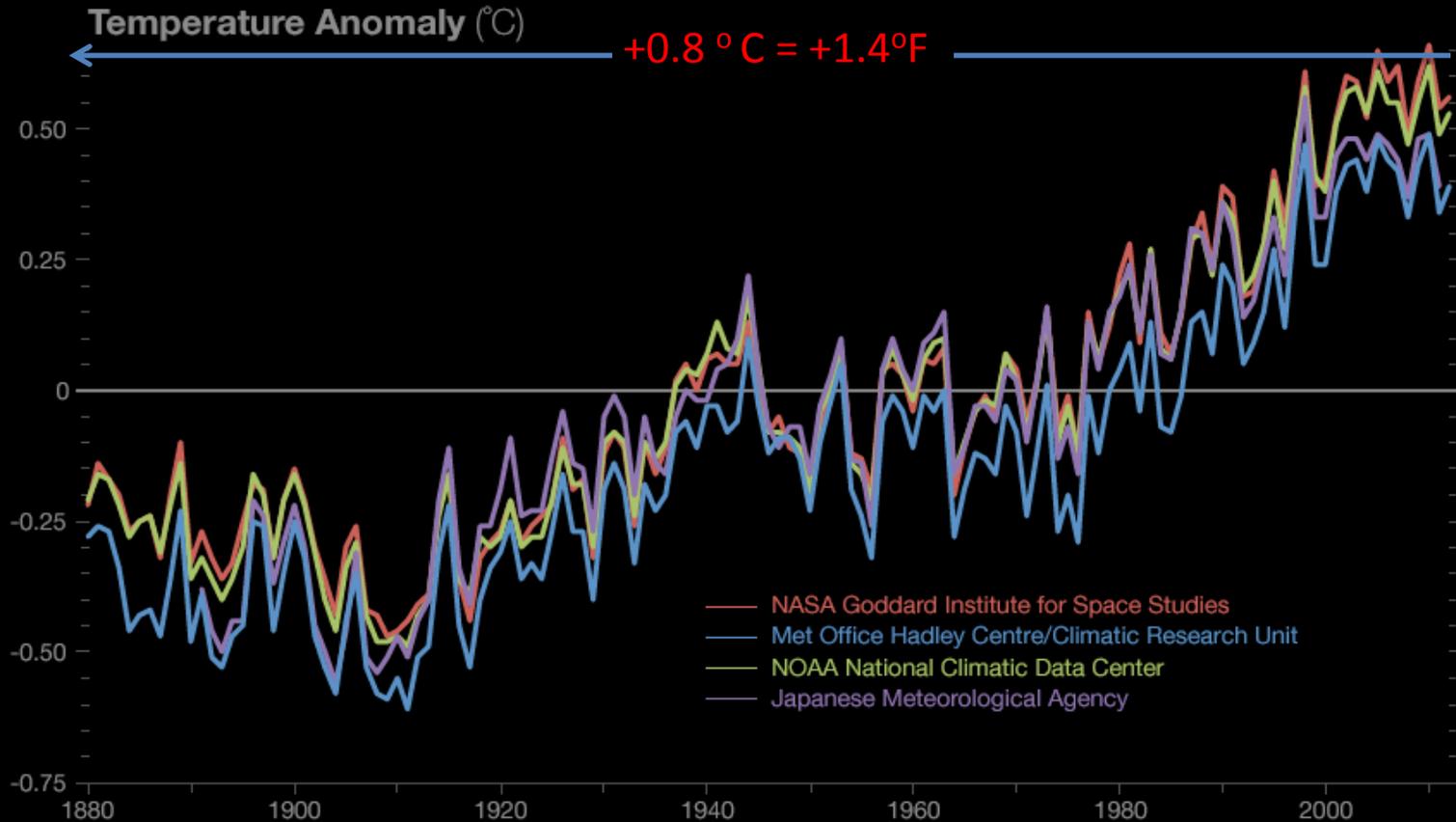


World Bank Group President Jim Yong Kim, IMF President Christine Lagarde

The president of the World Bank warned the finance chiefs of the world's leading economic powers that global warming is a real risk to the planet and already affecting the world economy in unprecedented ways.

Addressing the G20 finance ministers at their meeting in Moscow, Jim Yong Kim called on the world powers to “tackle the serious challenges presented by climate change.”

Some say scientists can't agree on Earth's temperature changes.

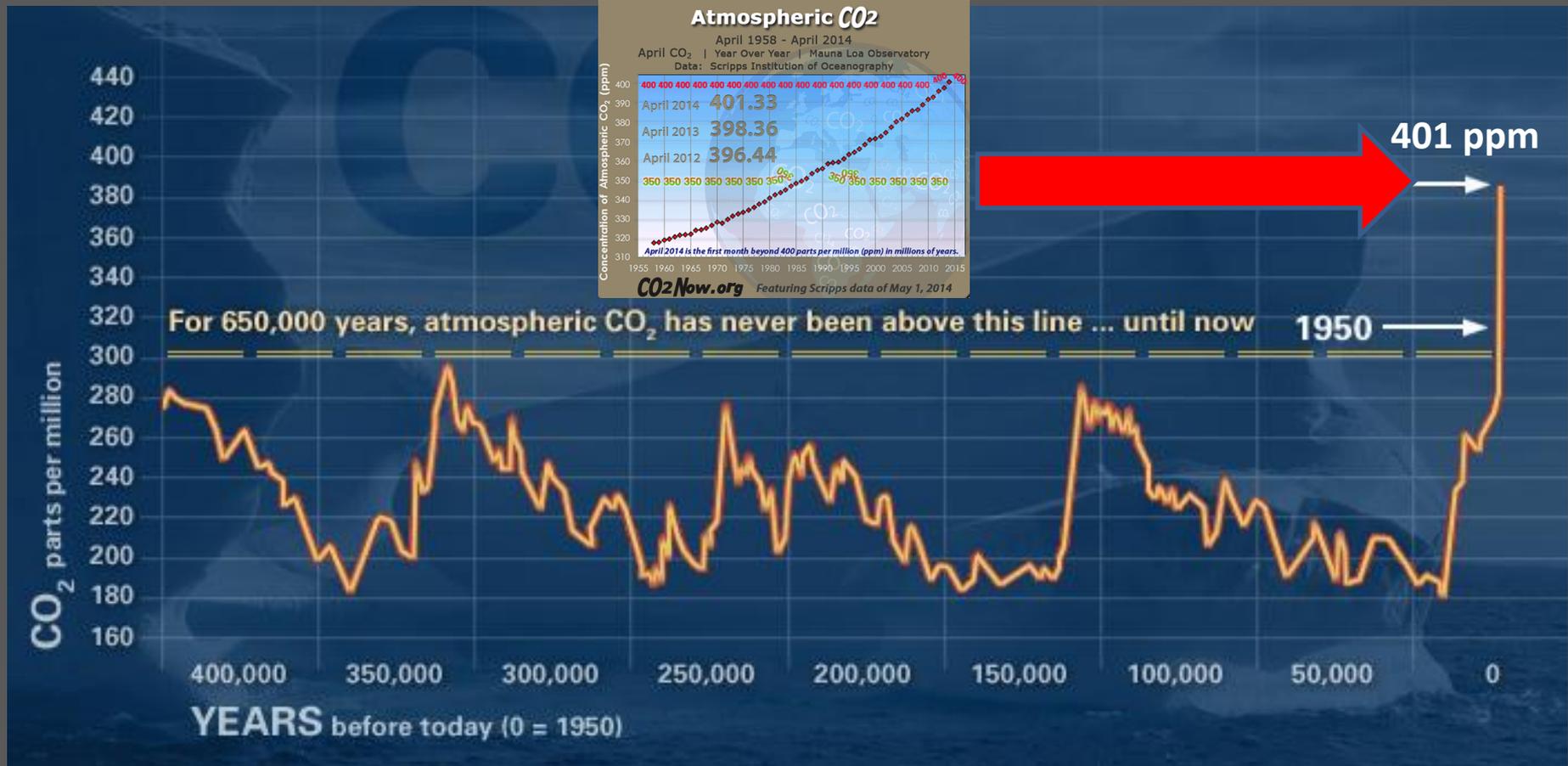


Here's what “disagreement” looks like.



CLIMATE 365

Atmospheric CO₂ is now higher than it's been for 650,000 years and increasing rapidly



This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO₂ has increased since the Industrial Revolution. (Source: NOAA)

Sources and Sinks for Humanity's CO₂

Where humanity's CO₂ comes from

91% 33.4 billion metric tonnes



Fossil Fuels & Cement 2010

9% 3.3 billion metric tonnes



Land Use Change 2010

Where humanity's CO₂ goes

50% 18.4 billion metric tonnes



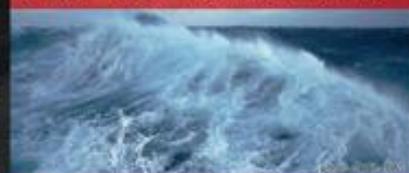
Atmosphere 2010

26% 9.5 billion metric tonnes



Land 2010

24% 8.8 billion metric tonnes



Oceans 2010



2010 data updated from:
Le Quéré et al. 2009, Nature Geoscience
Canadell et al. 2007, PNAS

CO₂Now.org

Turn Down the Heat

Why a 4°C Warmer World
Must be Avoided

4° Turn Down the Heat

Climate Extremes, Regional
Impacts, and the Case for Resilience



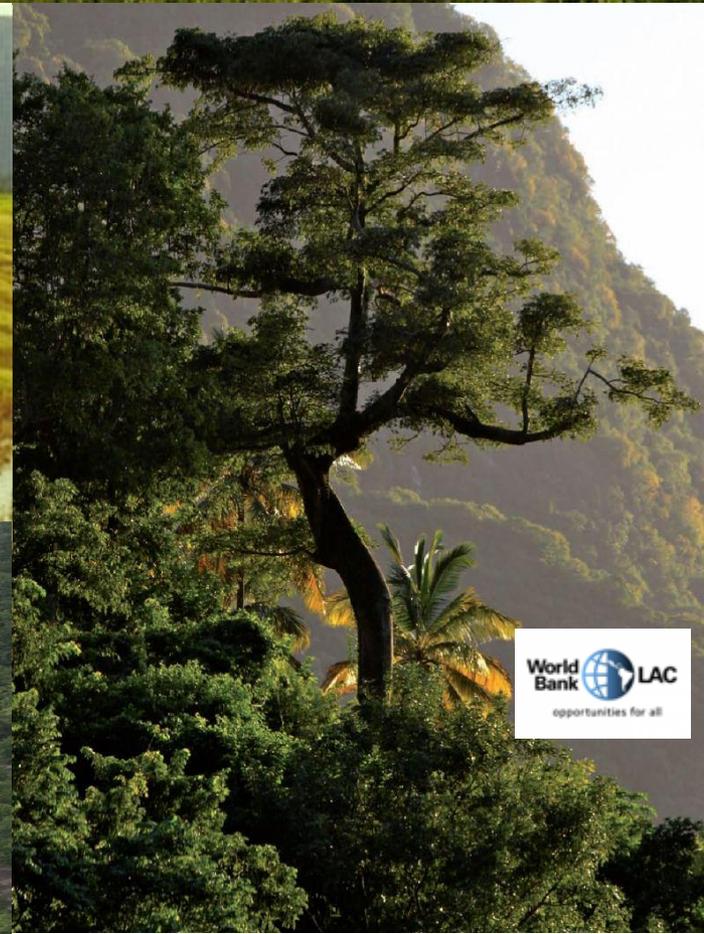
Public Disclosure Authorized

Public Disclosure Authorized

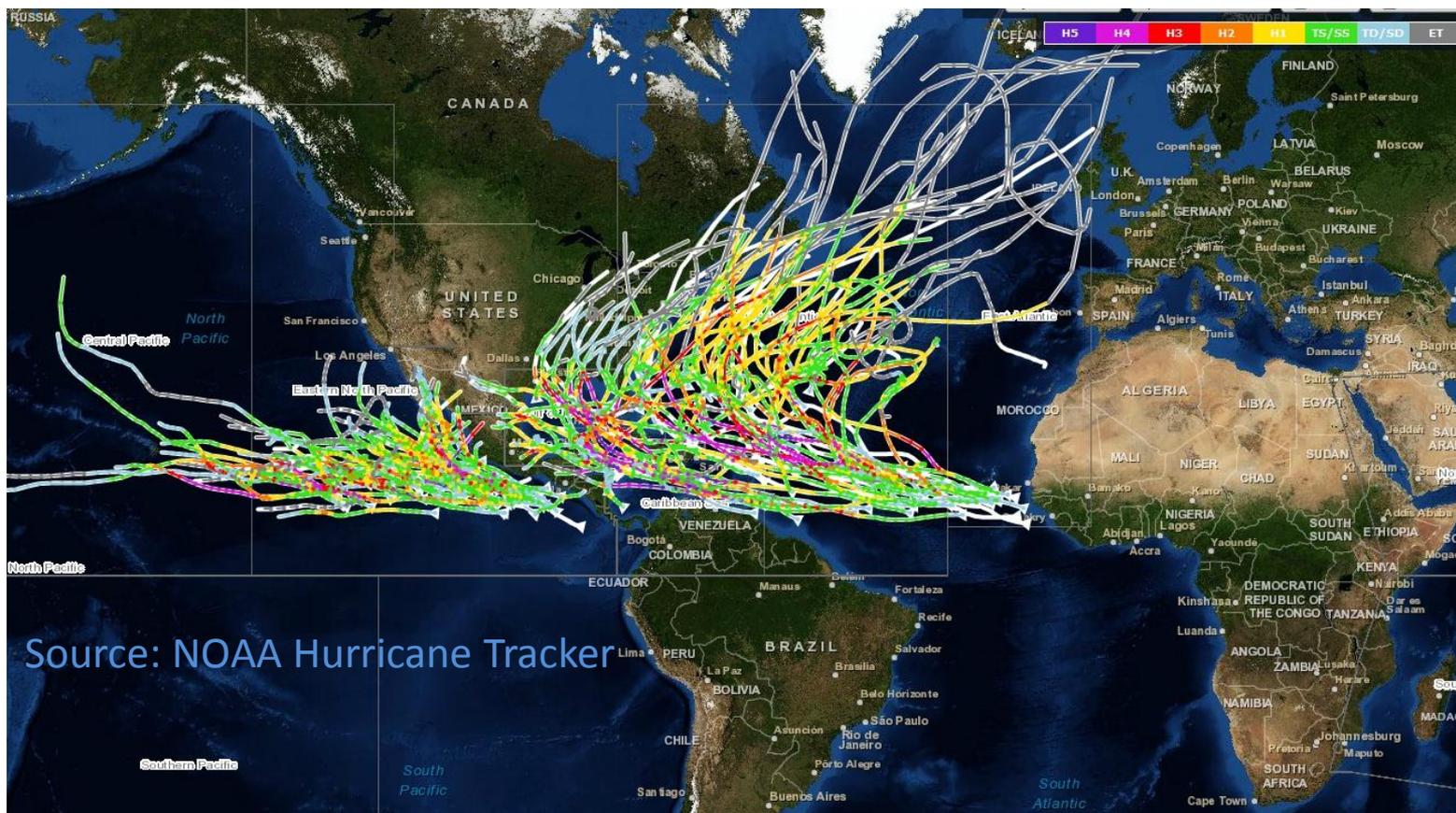
Public Disclosure Authorized

Public Disclosure Authorized

Climate Change, Land Rights, and Natural Resources Management



From 2000-2011 there were 154 Hurricanes (H1-H5) recorded in the Atlantic and Pacific



Source: NOAA Hurricane Tracker

Central America & the Caribbean are increasingly vulnerable if the projected increase in Hurricane Intensity (more H4&5s) happens over the next 3-5 decades



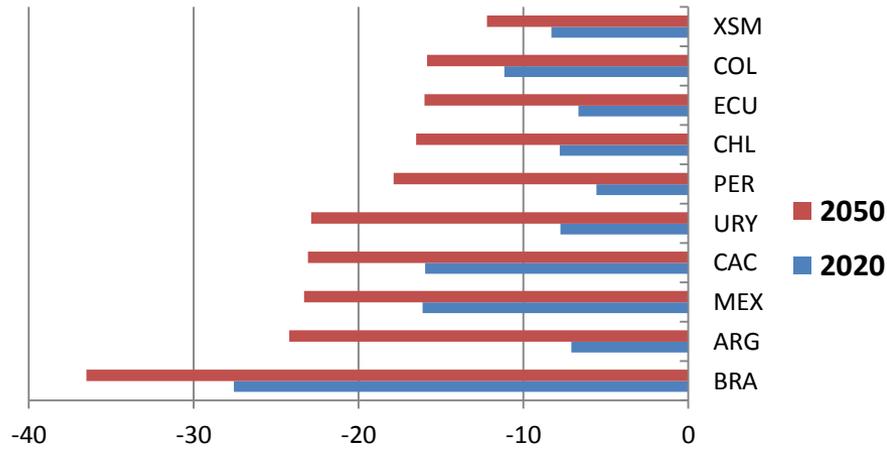
AMERICA AND THE
CARIBBEAN REGION

AGRICULTURE AND RURAL
DEVELOPMENT TEAM

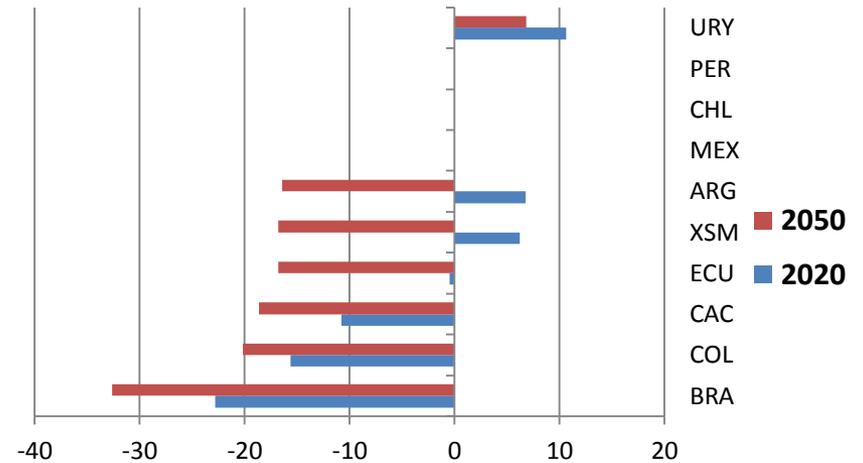
THE WORLD BANK

Impact of CC on Cereals in Latin America

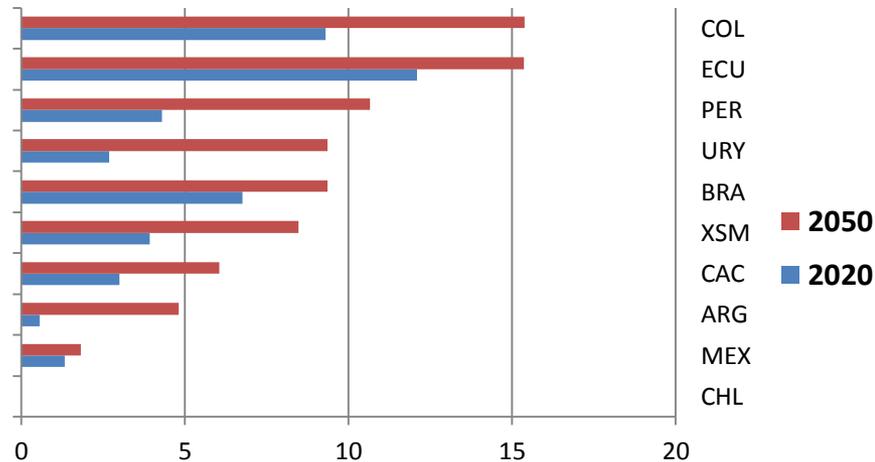
Corn



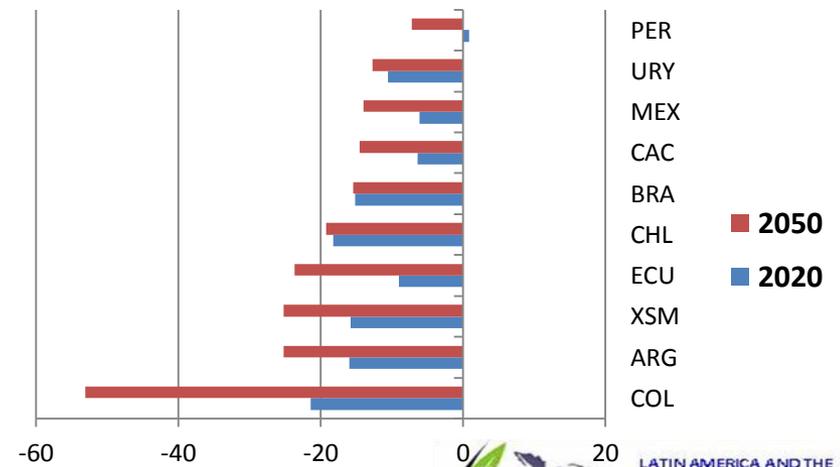
Soybean



Rice



Wheat

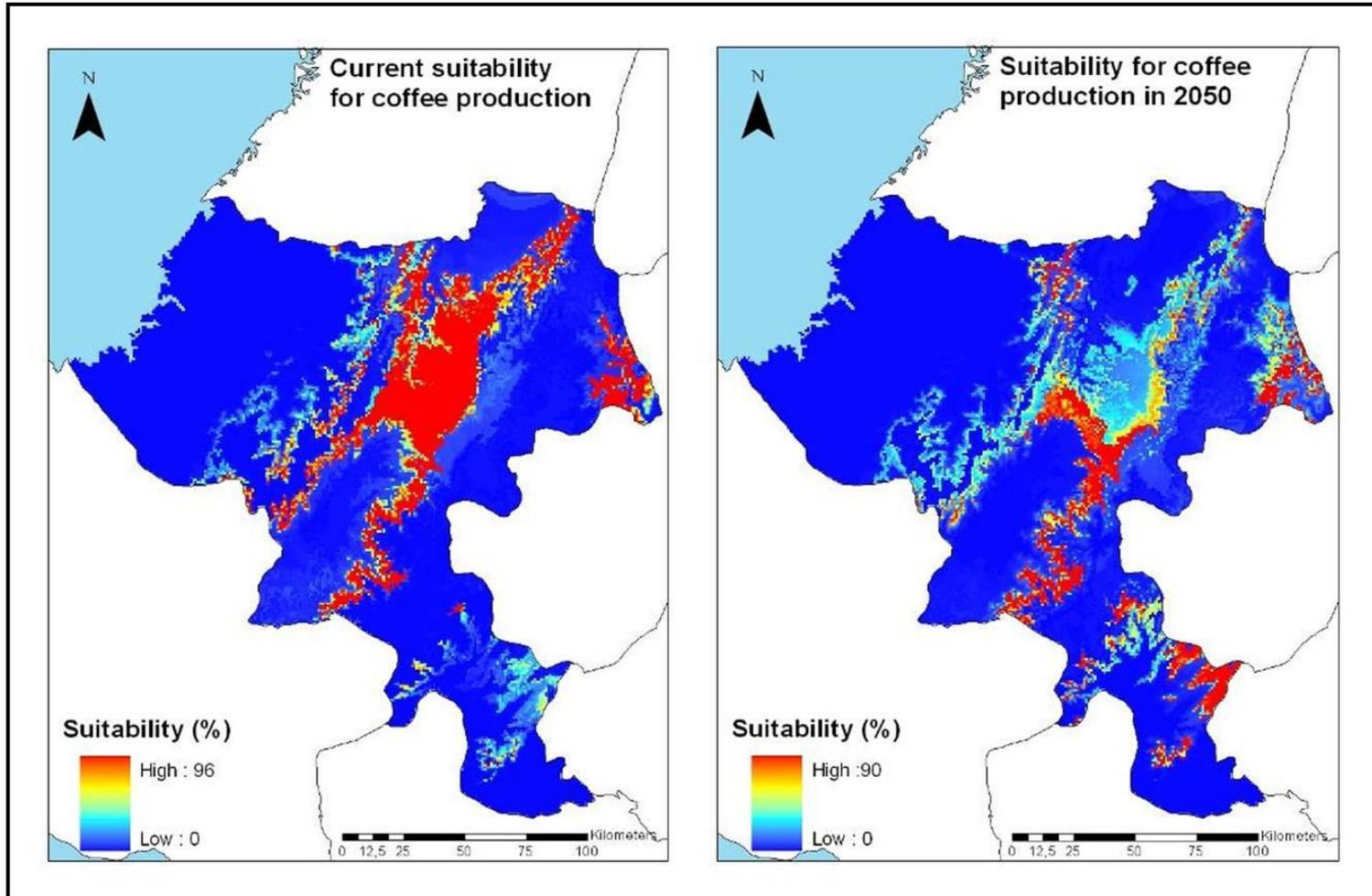


Source: World Bank, 2012



High Value Crops: Will Coffee be viable in Central America?

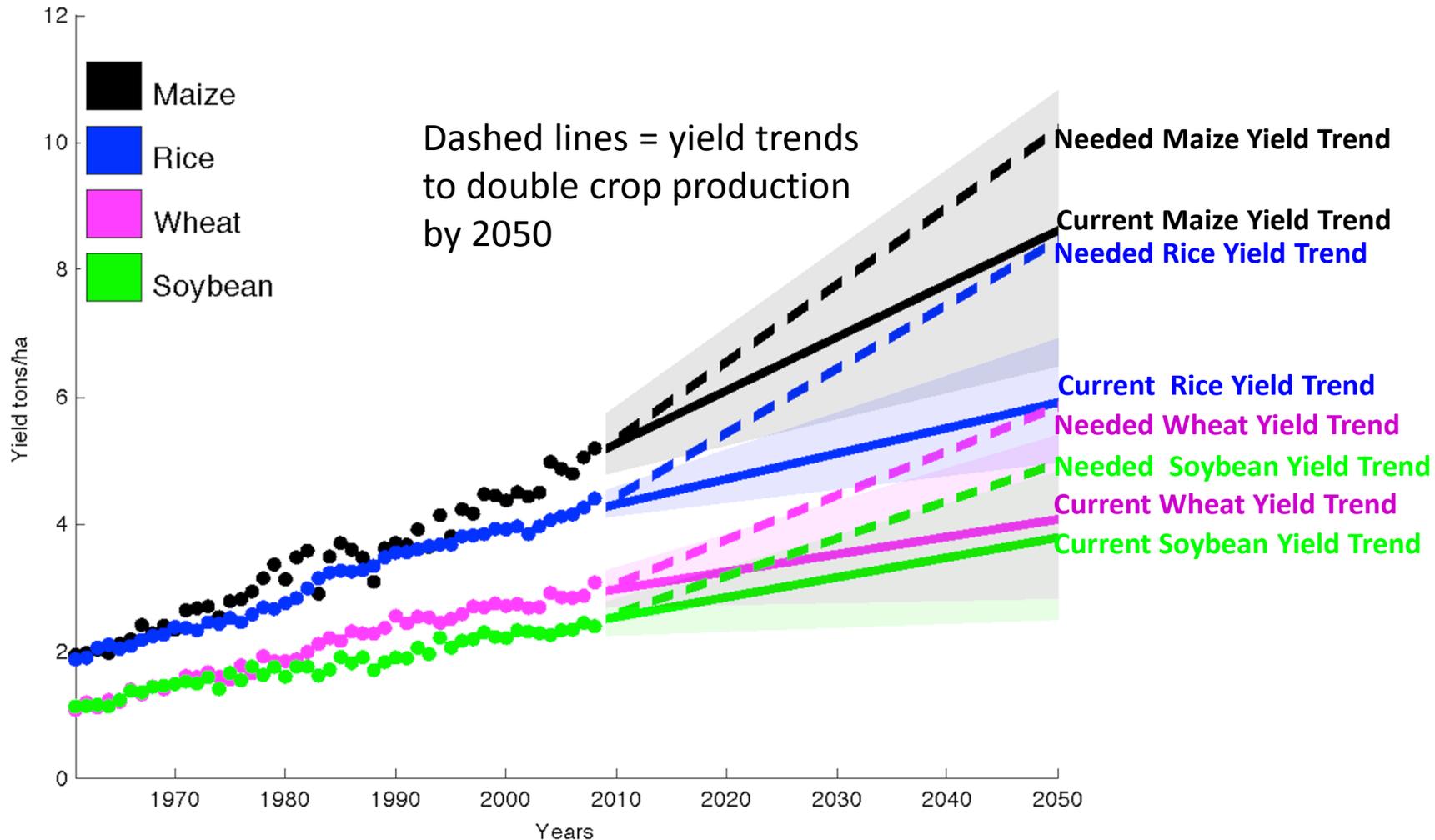
Example of projections for Colombia due to temperature & precipitation changes



Source: Jarvis, CIAT (2012)



Yield Trends Are Insufficient to Double Global Crop Production by 2050



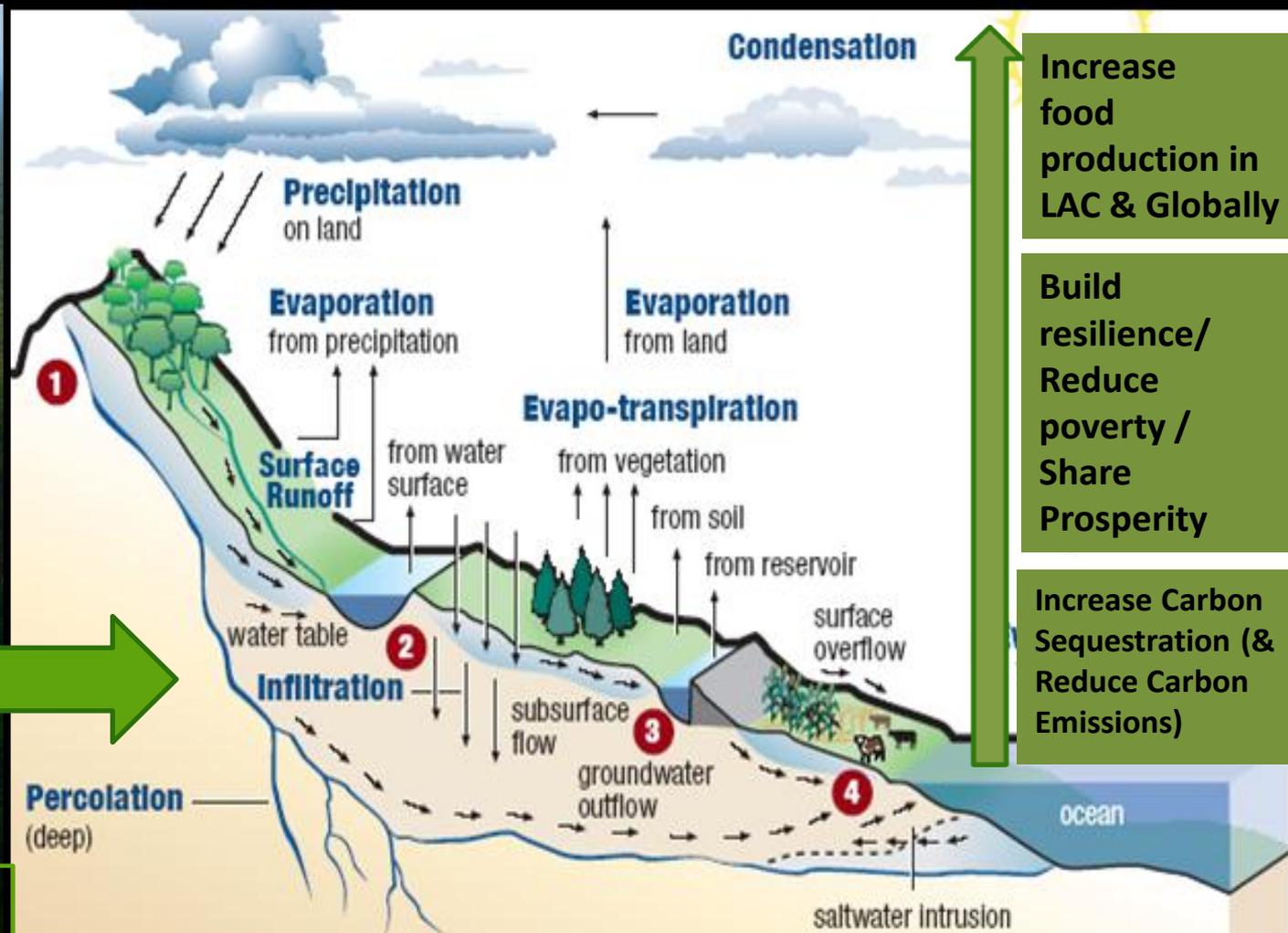
Sustainable Development in the Face of Climate Change

Big Picture, Big Data, Big Analytics

Example from Latin America

Landscapes & people, food, forestry, land, water National, Regional, Global

**Forests & Agroforests:
Wood + Fuel &
Carbon + Water +
Biodiversity**



Increase food production in LAC & Globally

Build resilience/ Reduce poverty / Share Prosperity

Increase Carbon Sequestration (& Reduce Carbon Emissions)

Ecosystem Services for Resilient Landscapes

Land Insecurity, Uneven Tenure, Land Rights, Indigenous Communities, Competition

Developing a Decision Support System To Facilitate Field to Basin Scale Natural Resource Management

A Decision Support System Framework
To address cross sectoral issues and linkages

Via "earth system modeling"

Data
Modules

The
Computation
Engine
*Models &
Calculations*

Output
Variables

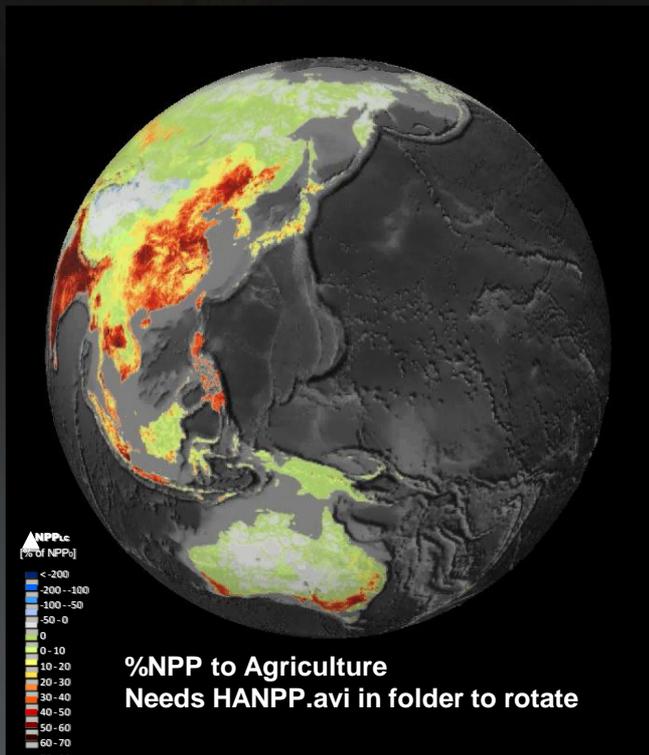
Policy
Interface

Integrated
Policy
Planning
and
Budgeting

THEMES: Convergent evolution of ...

- **Earth System Science** - How to get to “high-or-at-least-useful” resolution of hydrology and landscape dynamics, in regions where information is sparseDriven by serious “need-to-know,” which in turn pushes the basic science
- **“Cyber-informatics”** - Actually doing this requires quite serious attention to the cyber part, of acquiring, processing, and disseminating information (key – visualization, how information is presented)
- **“Geo-politics”** - How to incorporate important information into decision processes in real-life ministries, agencies, transboundary organizations, at high enough levels to be useful (role of World Bank, and related organizations)

Challenges & Opportunities



Data source: <http://www.uni-klu.ac.at/socec/inhalt/1191.htm>

- Breaking out of information lack and “silos”
- Support/provide community assessment and monitoring of multiple ecosystem services
- Provide resource agencies with tools to evaluate environmental conditions, particularly in a changing world.
- Support to regions which are internally data limited , and constrained by bandwidth (literally, but especially capacity)

Geospatial Gateways:

Data to Information to Policy to Action

Issues of concern (water, carbon, biodiversity, ecosystem services) are intrinsically linked, in a geospatial, scaled world (where mass is conserved)

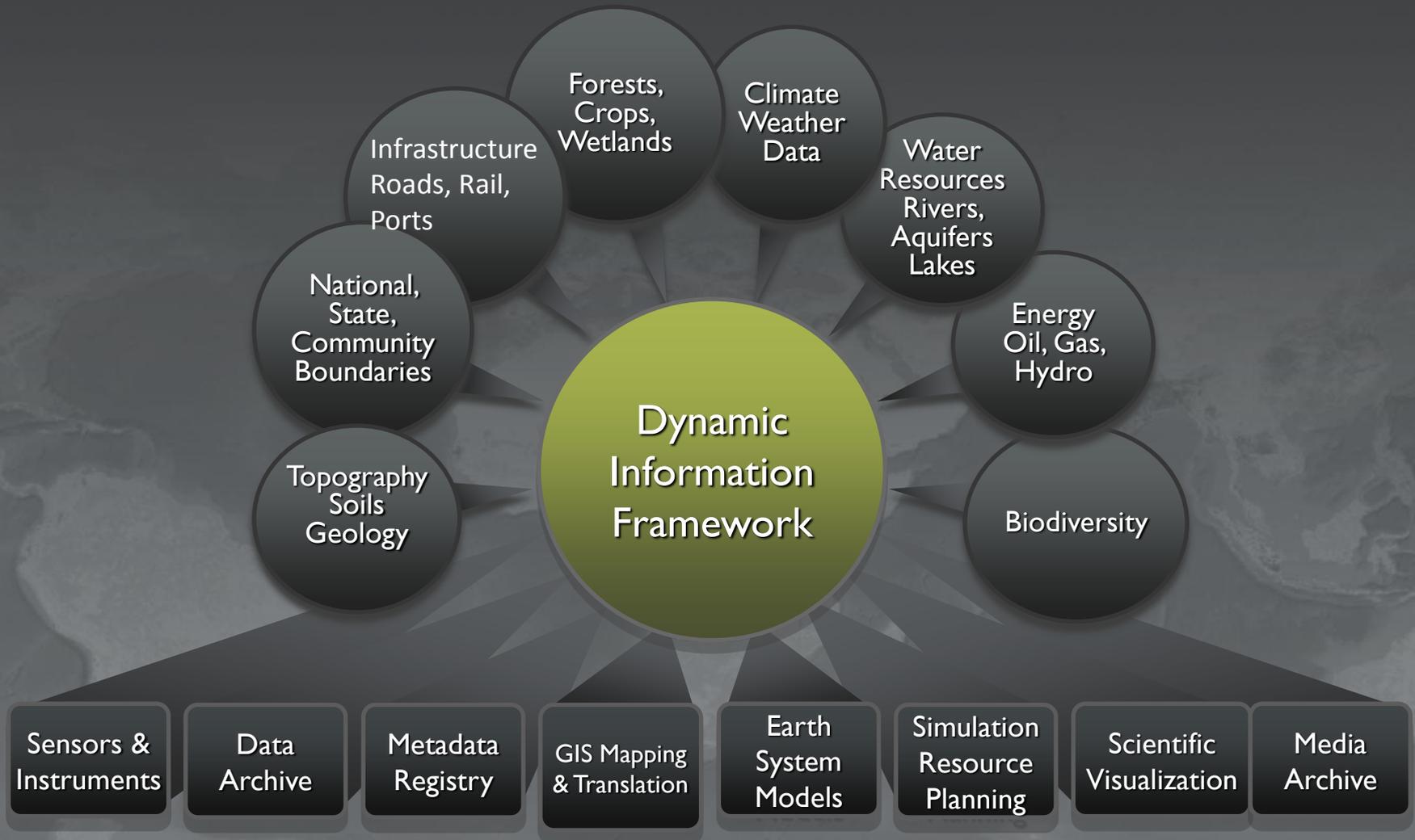
Data from multiple sources can serve to constrain, not confuse

Embedded models that couple sector information layers, integrate key drivers, and “bring data to life.”

Capable of evaluating multiple options , scenario generation, and outcome simulations

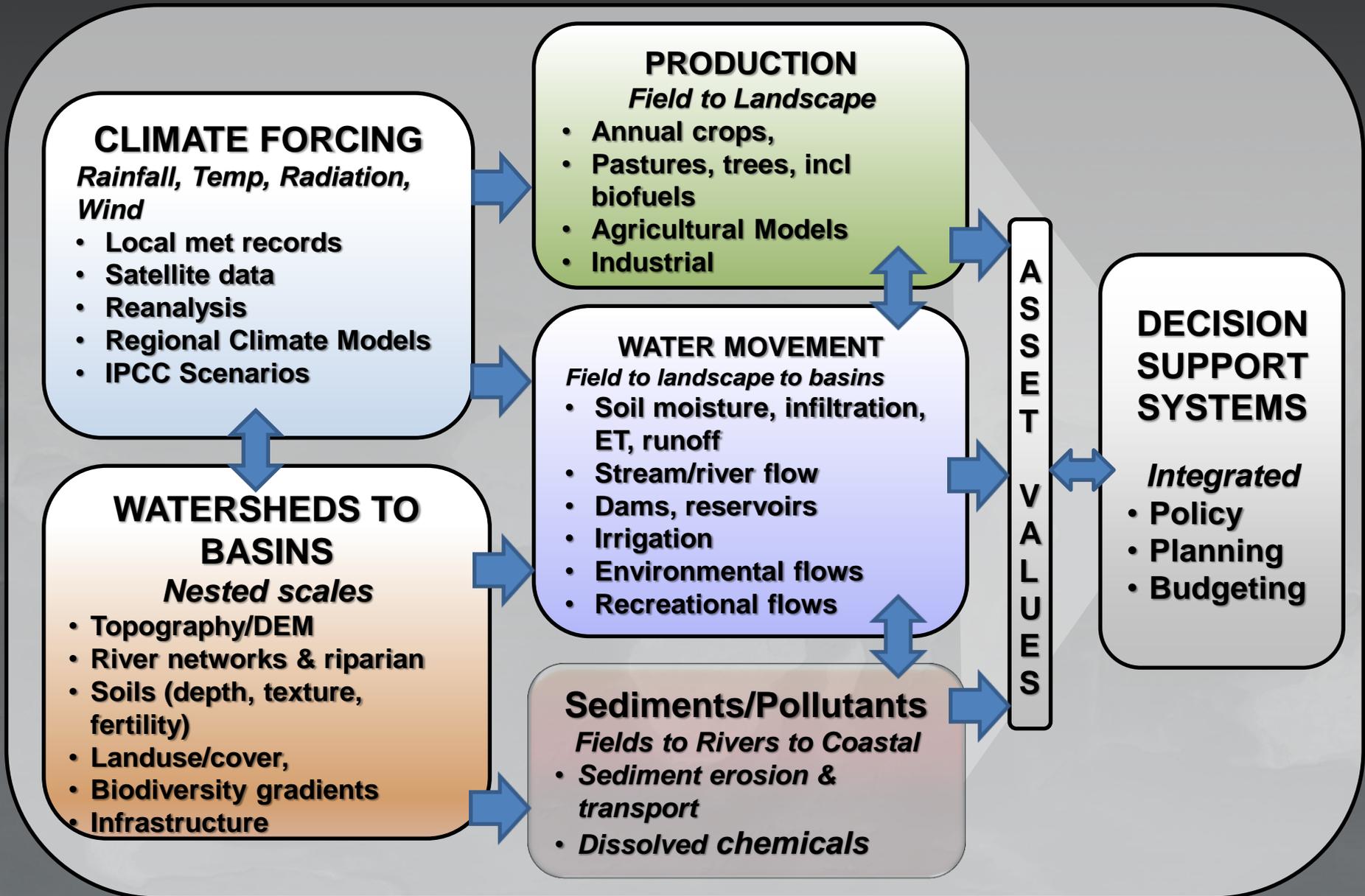
To be relevant, must can convey information in accessible and compelling manner to multiple audiences .

Cross Ministry Data Sharing For National & Regional Planning



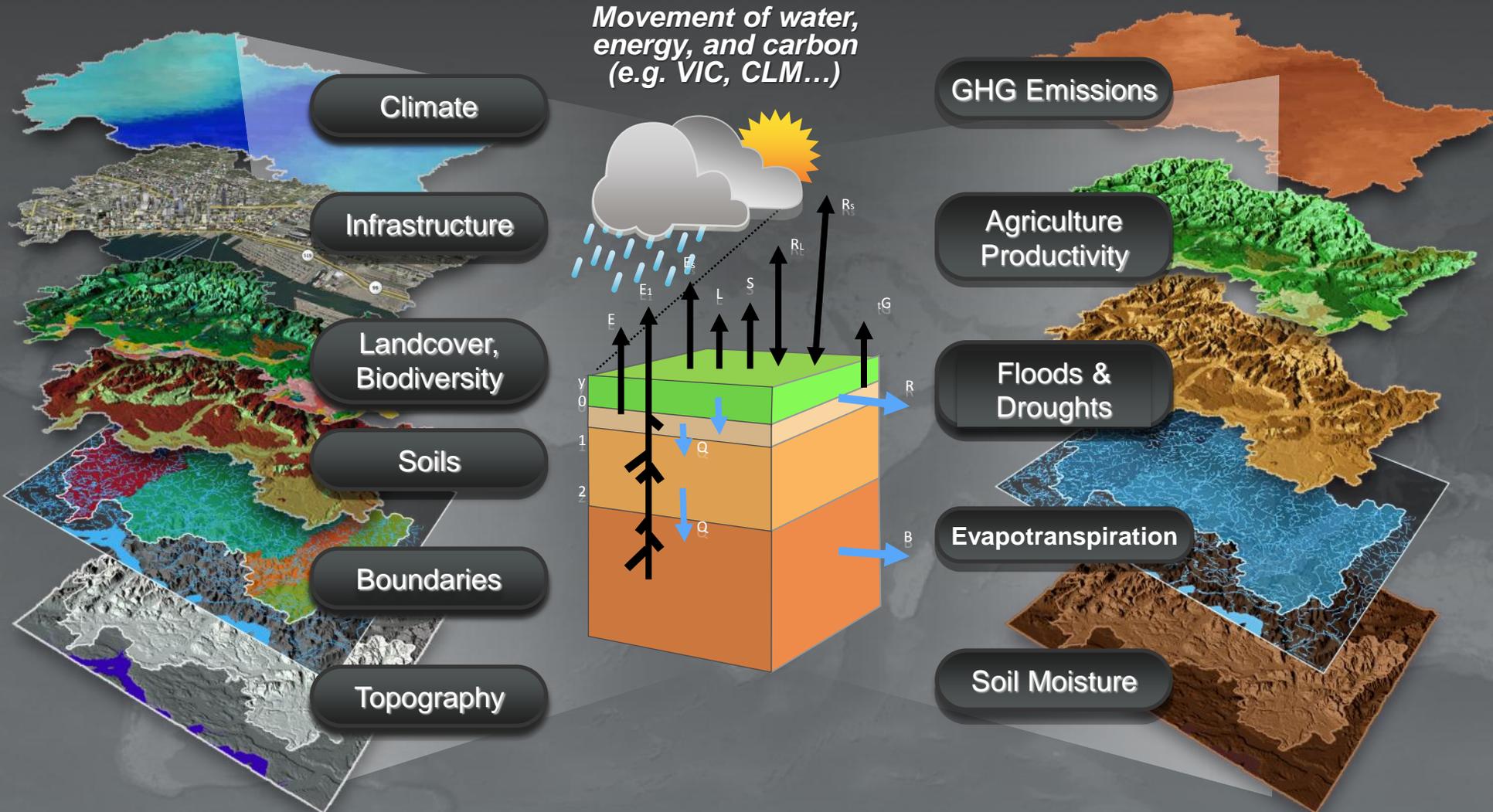
CONCEPTUAL FRAMEWORK FOR LANDSCAPE SCALE PLANNING

Observations, Measurements, Models

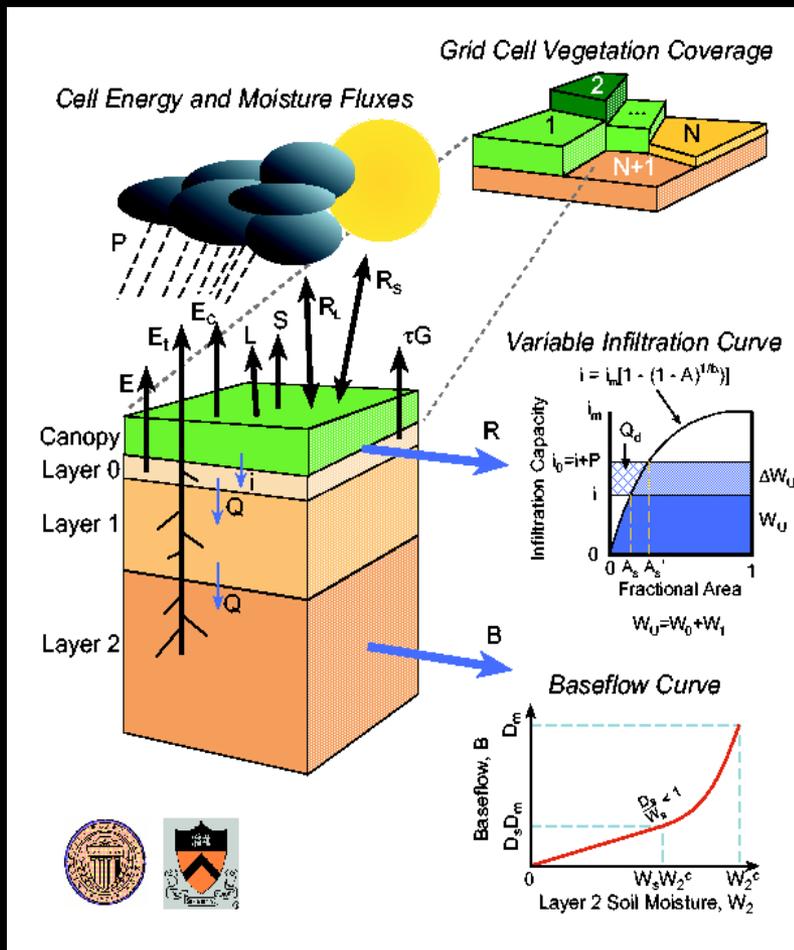


The Framework – “Earth System Models”

Moving from Data to Decision Support

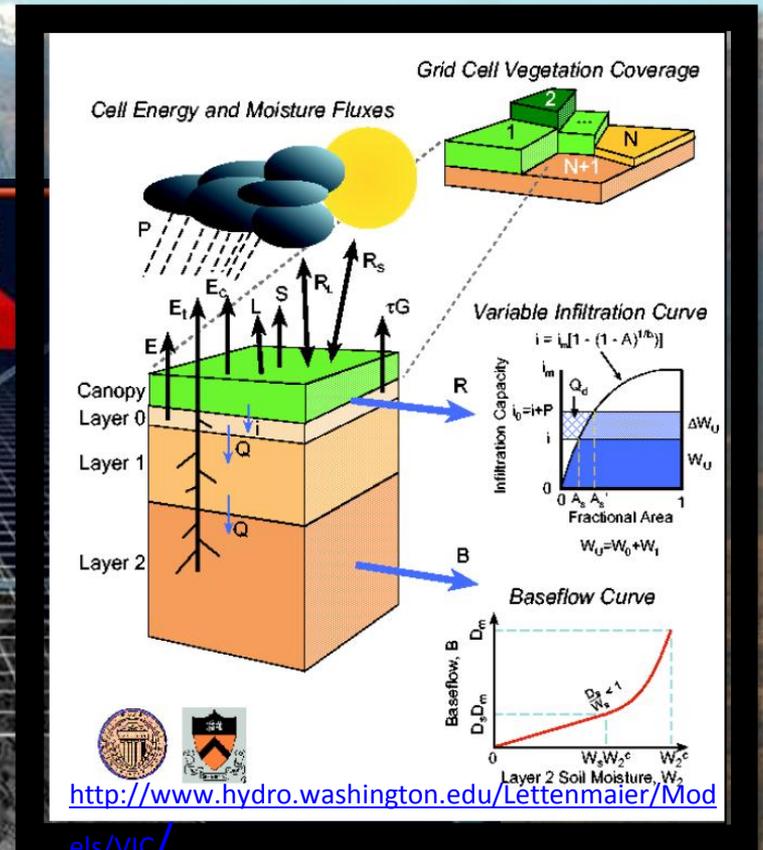
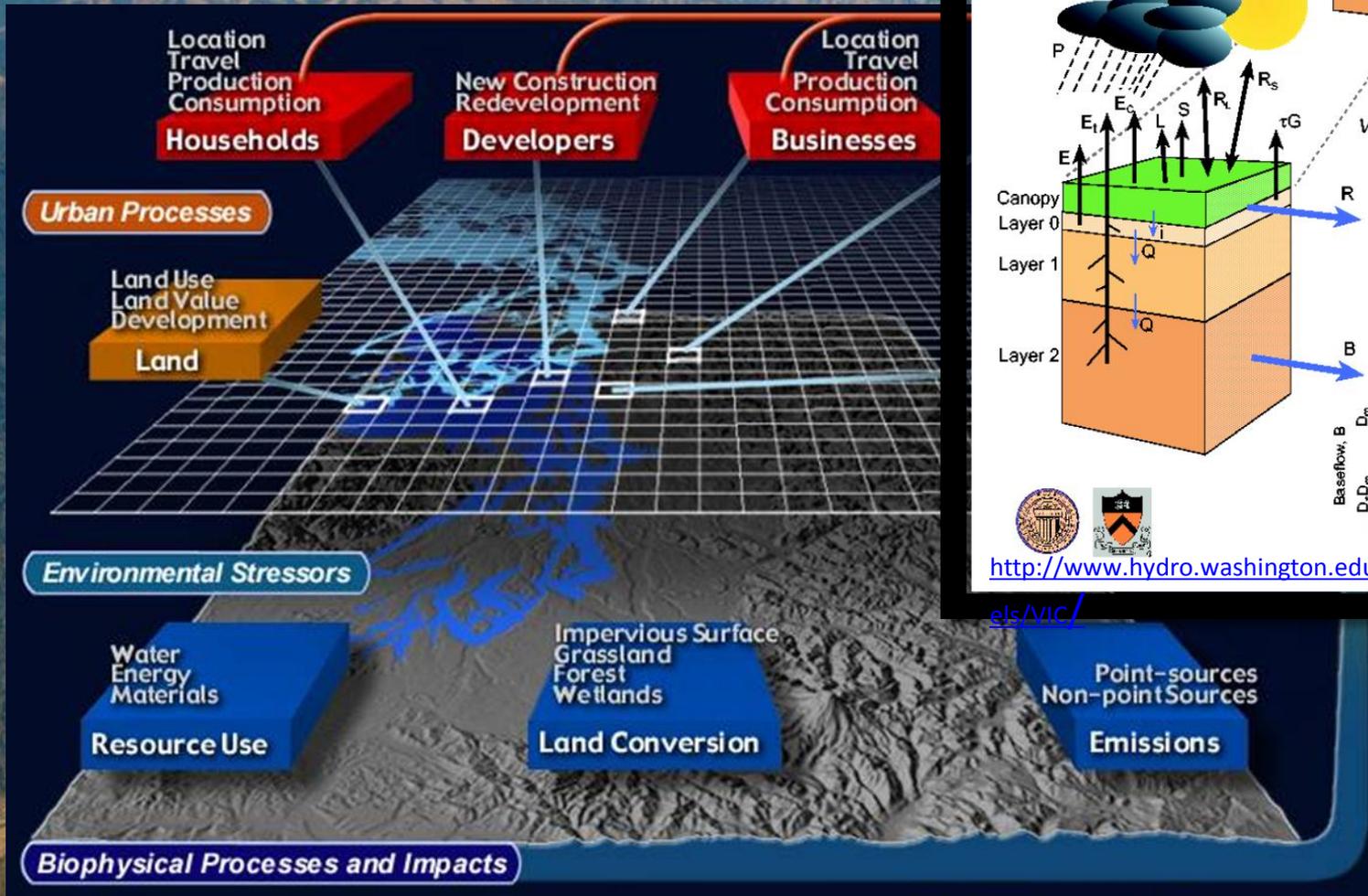


Computation-Engines



- Based on “first principles” mechanics, and not statistics. They can be used more reliably for changing conditions, in a non-stationary world.
- Developed in public academic forum, has been applied to many watersheds globally
- Software preferably open source !!

Biophysical, Economic, Political, Social Data



Examples of the DIF Approach Globally



MAIN TOPICS



PRISM involvement in integrated studies and regional issues

MISSION



Advancing the Integration of research, education, and regional cooperation on the environment of Puget Sound...

[more...](#)

LATEST CONTENT

PUBLICATIONS



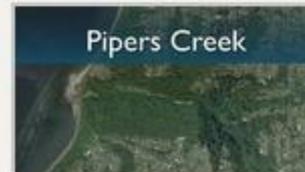
[Ocean 260 Lab Page](#)

Wednesday, September 29, 2010



[Lab 1: Google Earth Pro and the Puget Sound Watershed](#)

Friday, September 17, 2010



[FT 1: Pipers Creek](#)

Thursday, September 16, 2010

[Forest Development, Wood Jams, & Restoration of Floodplain Rivers](#)

[An Extensible, Modular Architecture for Simulating Urban Development, Transportation, and Environmental Impacts](#)

[Urban Land-Use Change](#)

HOME

BASIN
STRUCTURE

LANDCOVER
LANDUSE

UPSTREAM
FLOW

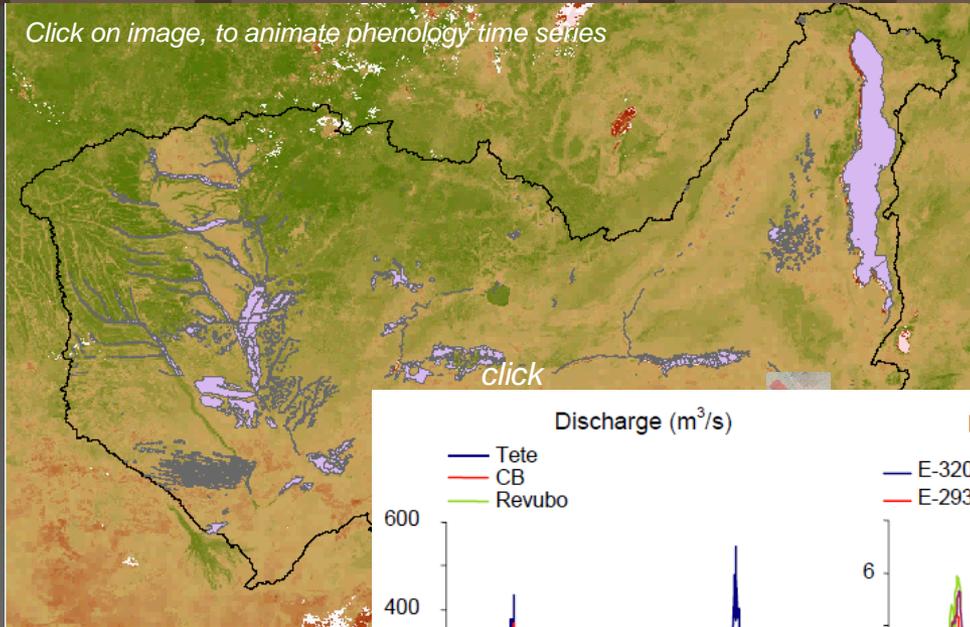
CAHORA BASSA
OPERATIONS

DOWNSTREAM
FLOW

DELTA
REGION

FLOOD
FORECASTING

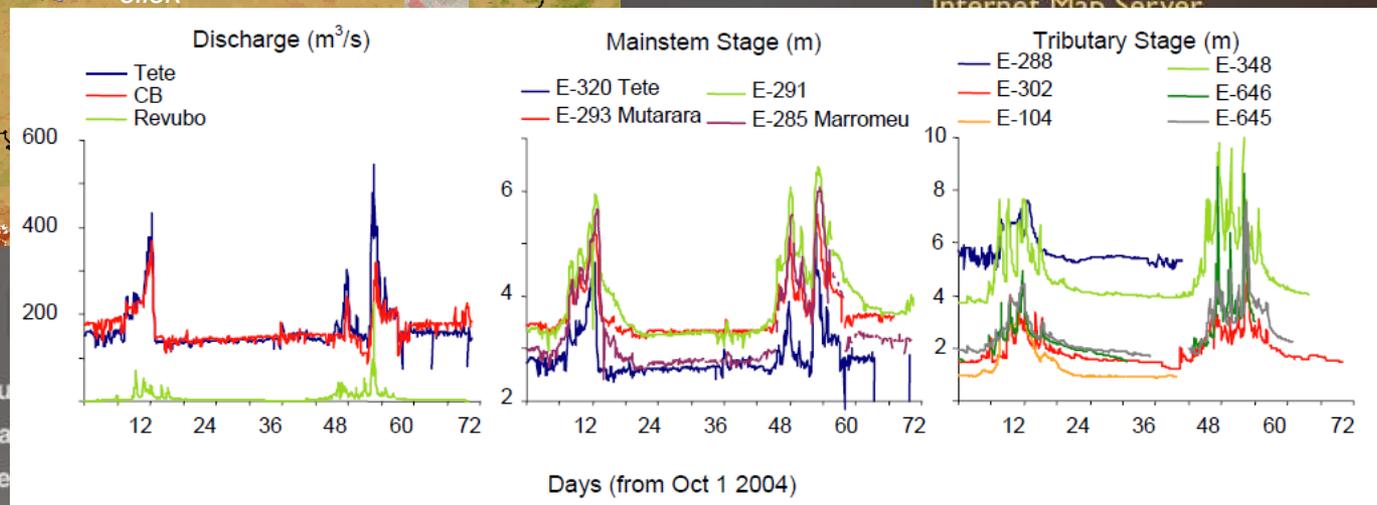
Click on image, to animate phenology time series



Internet Map Server

The Zambezi

Combining landscape structure
an analytical capability to examine
dynamics of the lower Zambezi



- ▶ How will changes in climate and resources practices in the upper Zambezi basin impact routine flow and flood conditions in the lower basin
- ▶ How do Cahora Bassa operations impact downstream flow and floodplain agriculture?
- ▶ How would climate changes project in the lower basin, with what impact on agriculture?
- ▶ How do upstream practices impact the Delta?





DRUK DIF

DRUK DYNAMIC INFORMATION FRAMEWORK

<http://www.drukdif.ocean.washington.edu/>

[Click on link](#)

HOME

TOPOGRAPHY

LANDCOVER

LANDUSE

BIODIVERSITY

WATER

SCENARIOS

SEARCH



DRUKDIF APPLICATIONS BY AGENCY

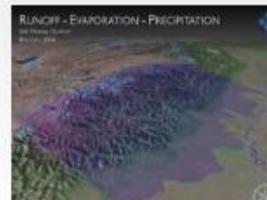
- ▶ Gross National Happiness Commission
- ▶ Druk Green Power Corp
- ▶ Hydro-met Services Div. Dept. of Energy/MOEA
- ▶ National Soil Services Centre/MOA
- ▶ Renewable National Res. RC
- ▶ National Biodiversity Centre
- ▶ WWF

- ▶ RSPN
- ▶ Nature Conservation Division DoF/MOA
- ▶ National Land Commission Secretariat
- ▶ Watershed Management Div./MOAF
- ▶ PPDs
- ▶ National Statistics Bur.
- ▶ National Environment Commission

WHAT IS DRUKDIF?

DrukDIF is being developed to provide a robust dynamic Information framework of datasets and computer models that can be utilized by staff of National Agencies to address the cross-sector resource challenges of Bhutan **more...**

NEW CONTENT



Bhutan animation showing runoff, evaporation, and precipitation from VIC Model Output.





Visual Mekong Basin

HOME

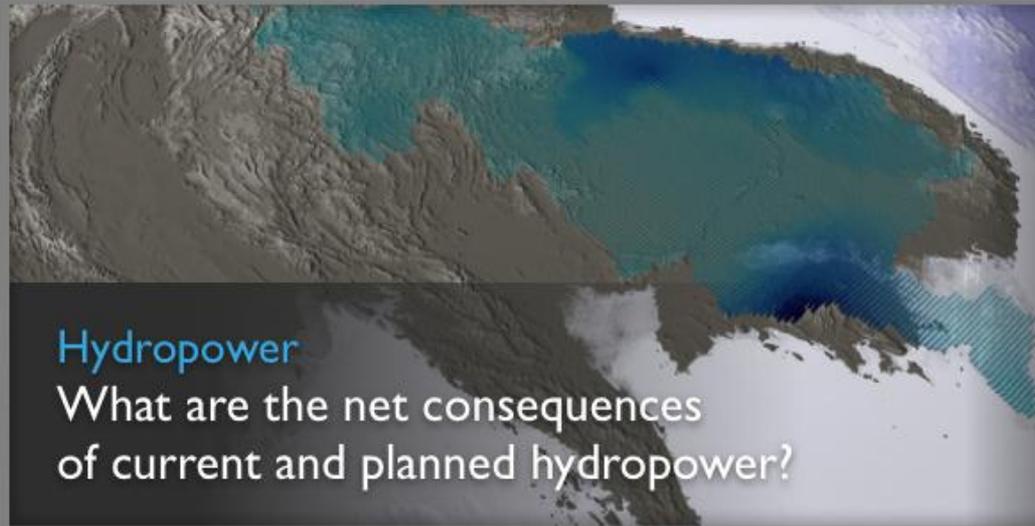
STAKEHOLDERS

DEV SPACE

BASINS

FRAMEWORK

RESOURCES



Hydropower

What are the net consequences of current and planned hydropower?

Our Mission...

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

more ▶





IMISOZIDIF

DYNAMIC INFORMATION FRAMEWORK

About

Climate Forcing

LWH Project

Drainage Basin

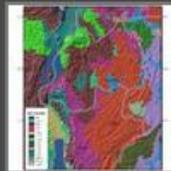
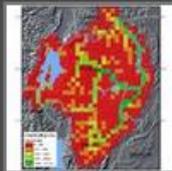
Water Movement

Partners

IMISOZIDIF OVERVIEW

WHAT IS A DIF?

(DYNAMIC INFORMATION FRAMEWORK)

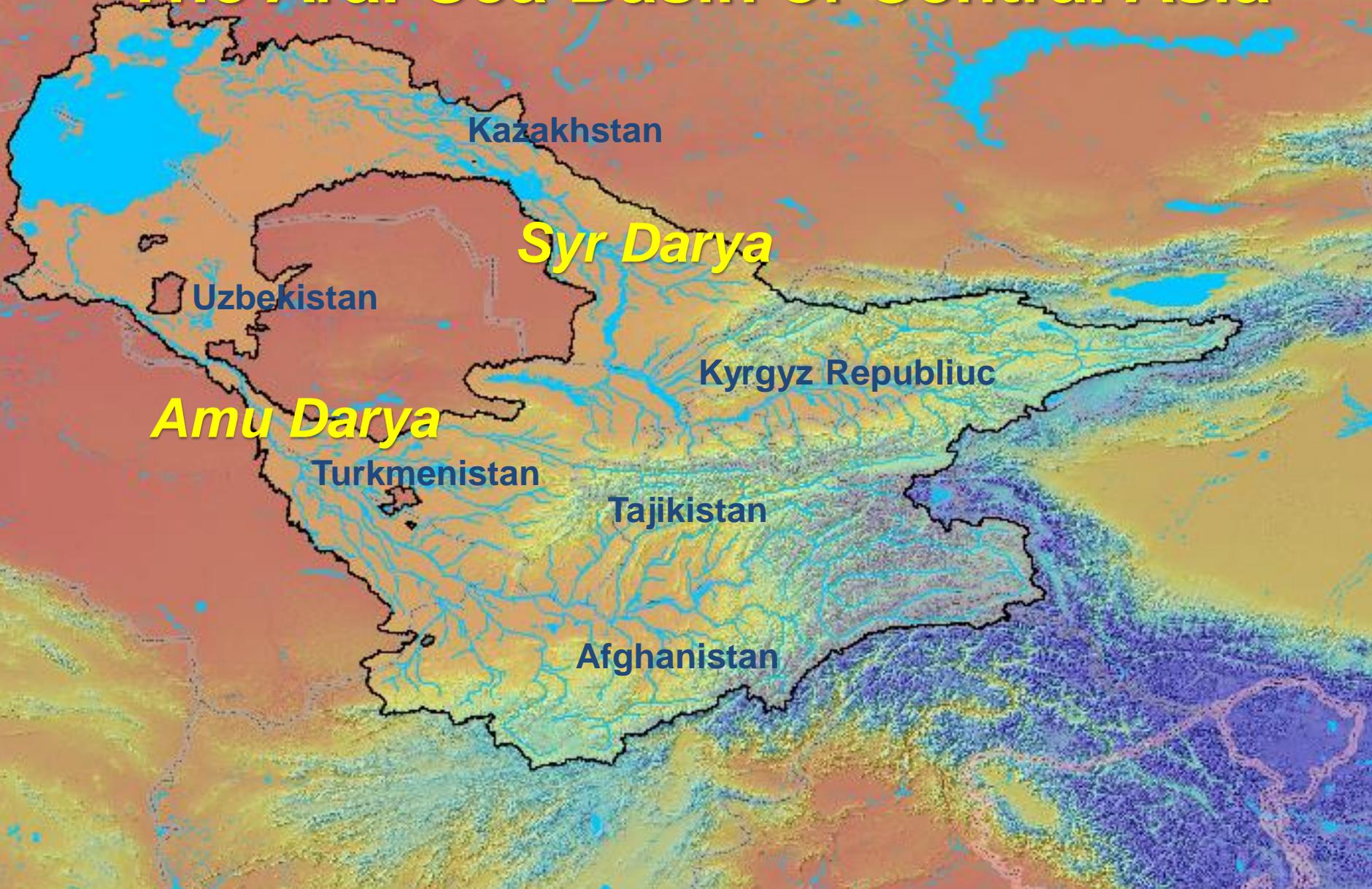


A prototype GIS based information portal

To address the critical agenda of hillside intensification, the Government of Rwanda designed and developed a Land H ...

[more](#)

The Aral Sea Basin of Central Asia



Strategy for Data Model Development

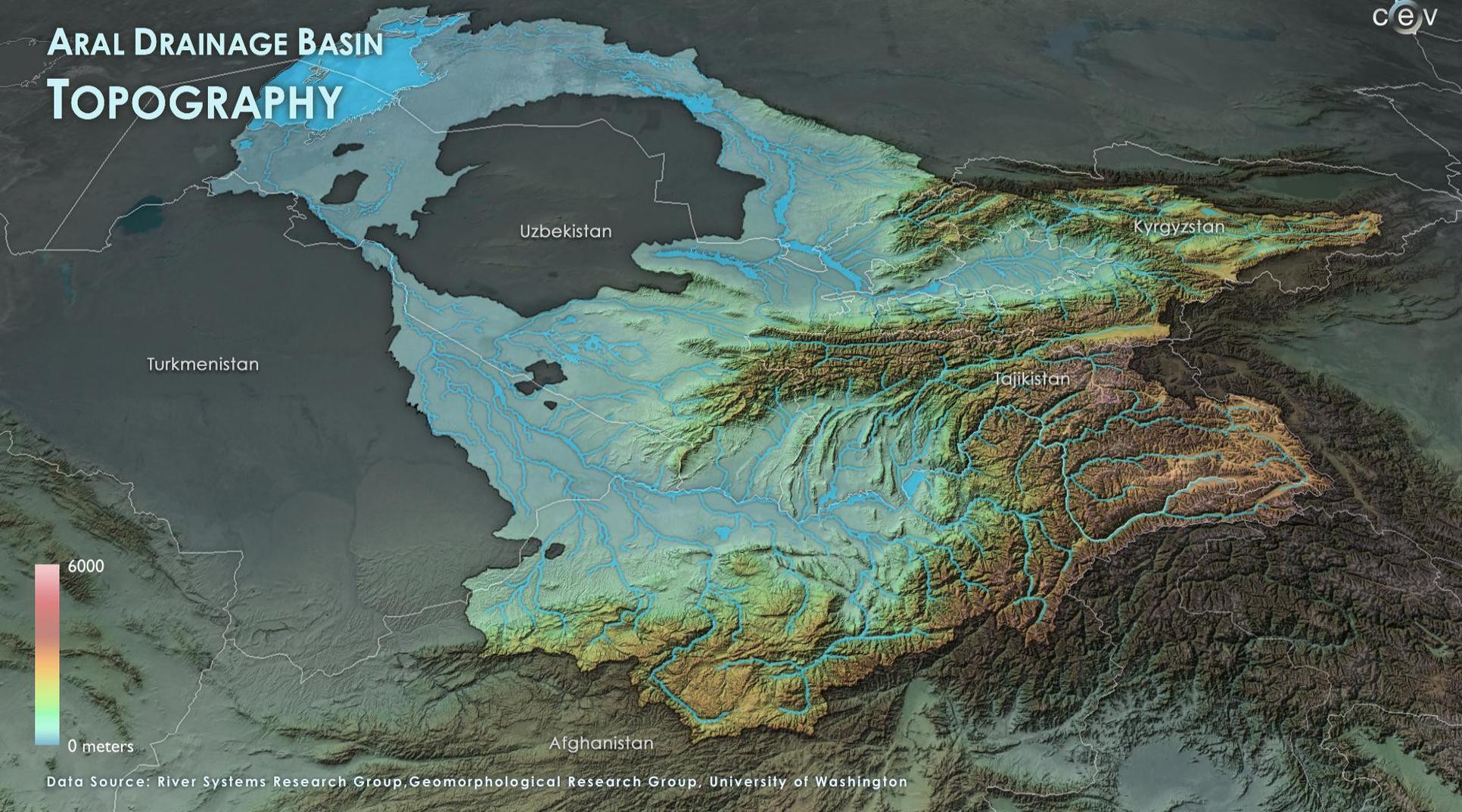
The basic premise is to develop the data layers (top down/bottom up) needed to model and simulate NRM dynamics e.g. the movement of water through the Amu Darya and Syr Darya river systems. **4 principles:**

- ① The data to develop the model is **fully transparent and publically-available**, to provide **a neutral and transparent platform** for simulating and visualizing possible scenarios and resolutions,
- ② The full **mass-balance of water** is accounted for across the entire basin, as the basis of the hydrologic cycle,
- ③ Energy and water linkages are then **superimposed** on the basic hydrological cycle,
- ④ The model is **scalable** (in space and time), and able to illustrate water and energy linkages.

Assemble All Relevant Data
(local, national, regional, global)

Example of what Aral Basin countries
are doing??

ARAL DRAINAGE BASIN TOPOGRAPHY

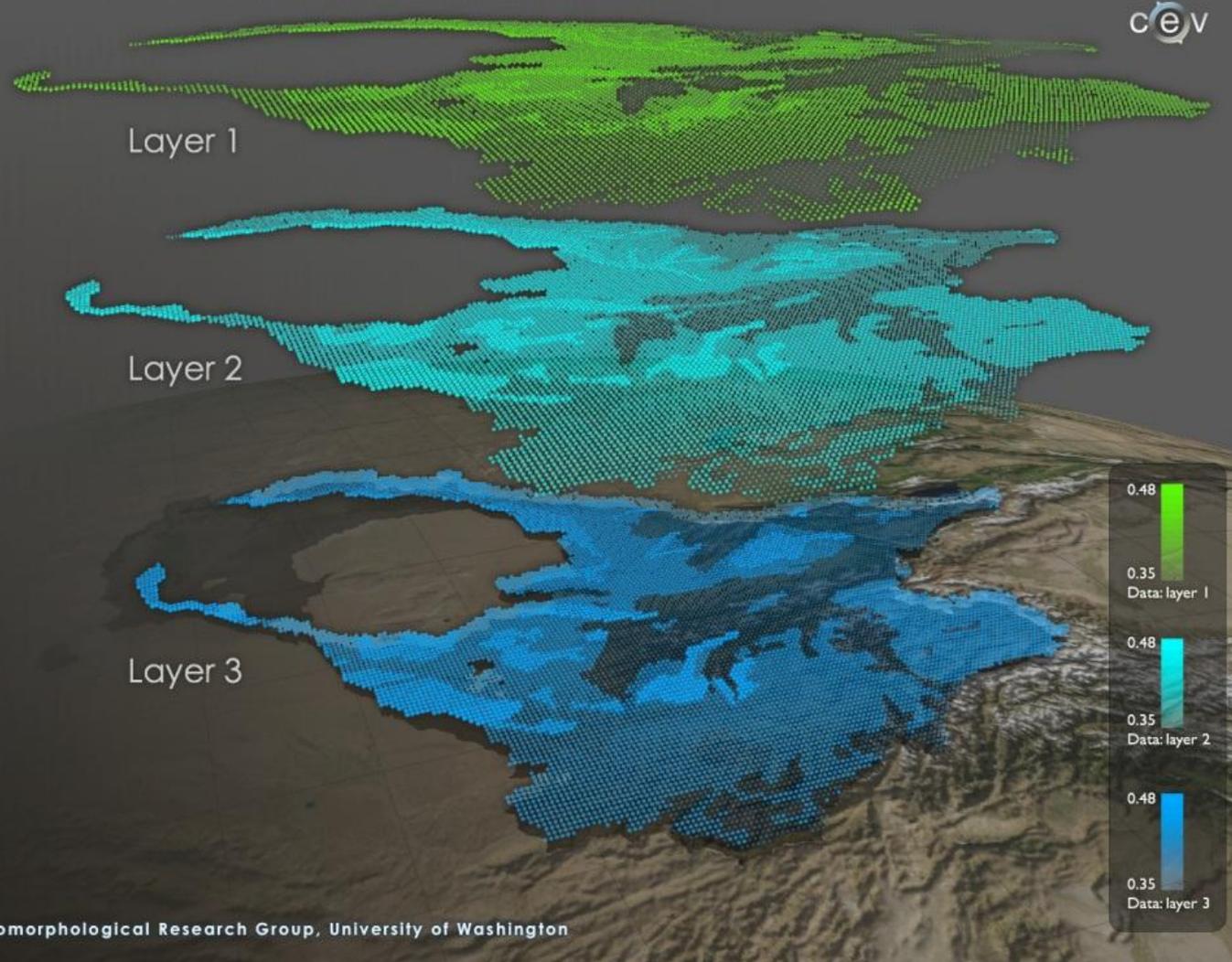


HydroSHEDS version of the NASA SRTM 3" (~90 m) DEM as developed by the Conservation Science Program of World Wildlife Fund with the USGS.

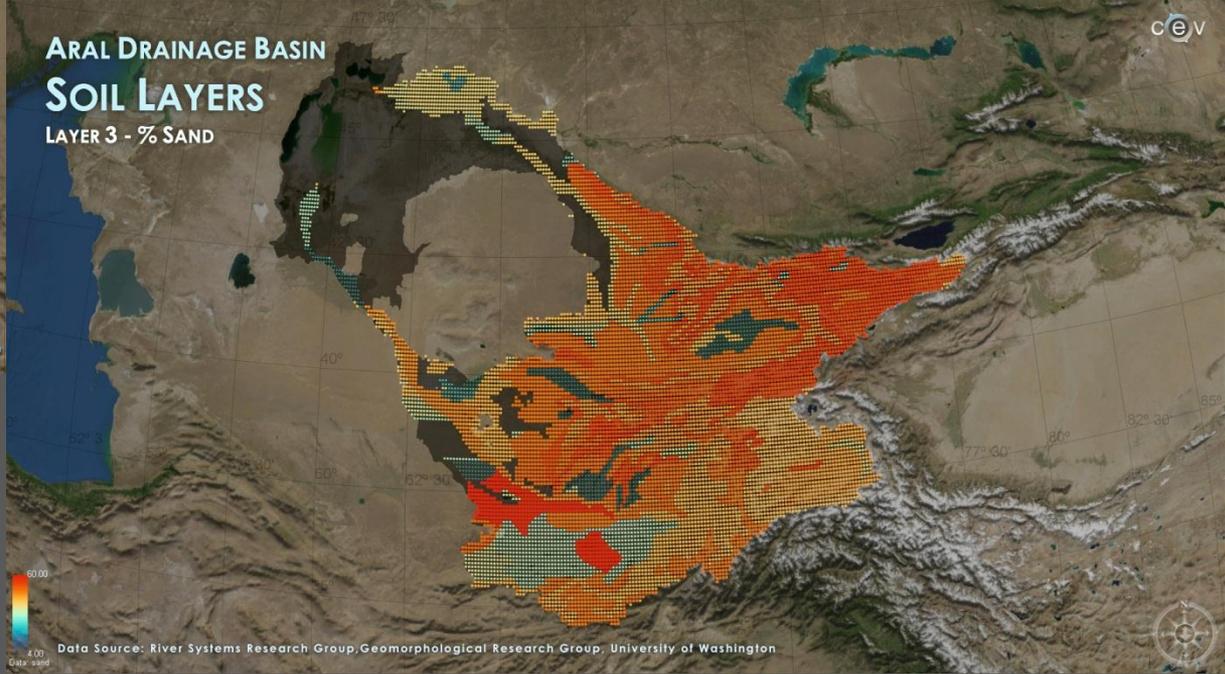
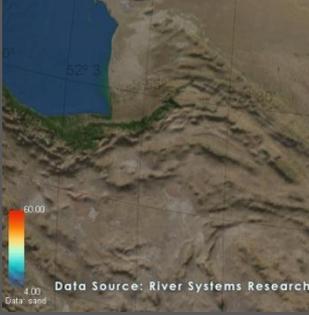
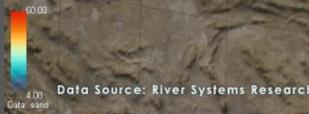
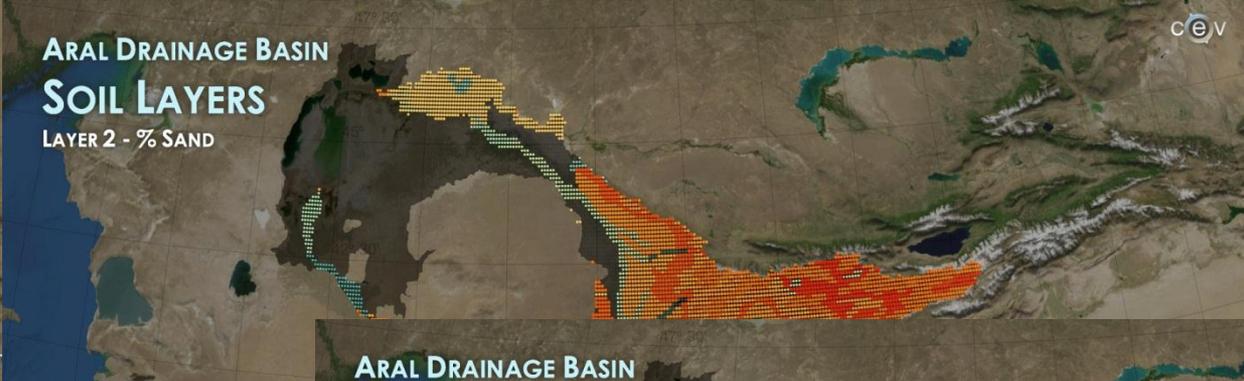
ARAL DRAINAGE BASIN

SOIL LAYERS

LAYERS 1, 2, & 3 - POROSITY



Soil properties from the FAO Soil Program (bulk density, sand and clay content), with each $1/12^\circ$ degree pixel grid cell assigned to one of the 12 FAO soil textural classes. Soil hydrologic parameters (porosity, saturated hydraulic conductivity, field capacity and wilting point) were estimated from the USDA soil texture class.



ARAL DRAINAGE BASIN

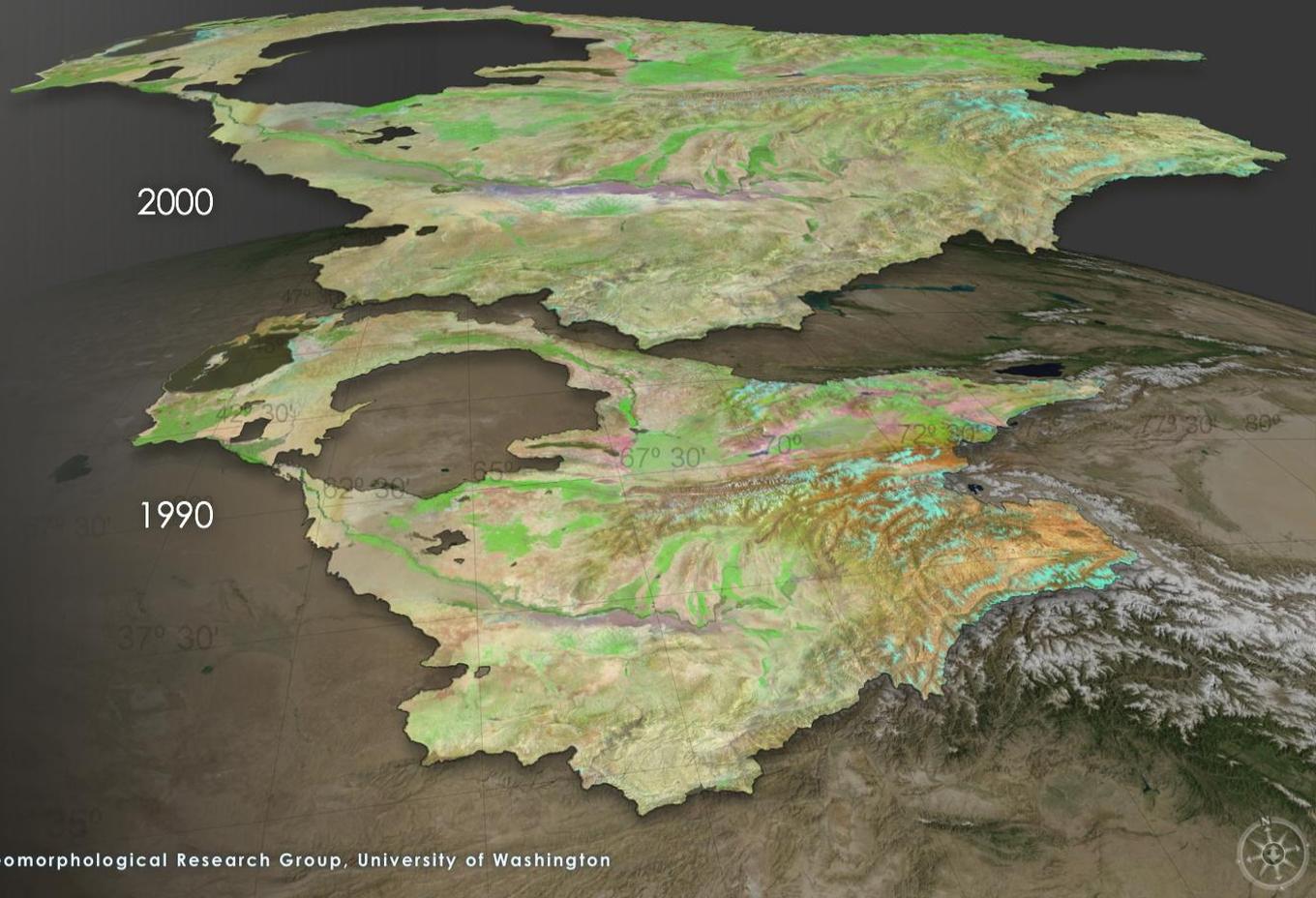
VEGETATION

MODIS



- The MODIS tiles were mosaiced for the region, with supervised IGBP classifications (with some reclassified to match classes and attributes used elsewhere). Validation by regional knowledge is essential!!
- Cell basin mask was created, with the % of each different land cover area for every cell extracted in tabular form for use for model inputs.

ARAL DRAINAGE BASIN VEGETATION LANDSAT MOSAIC - 1990, 2000

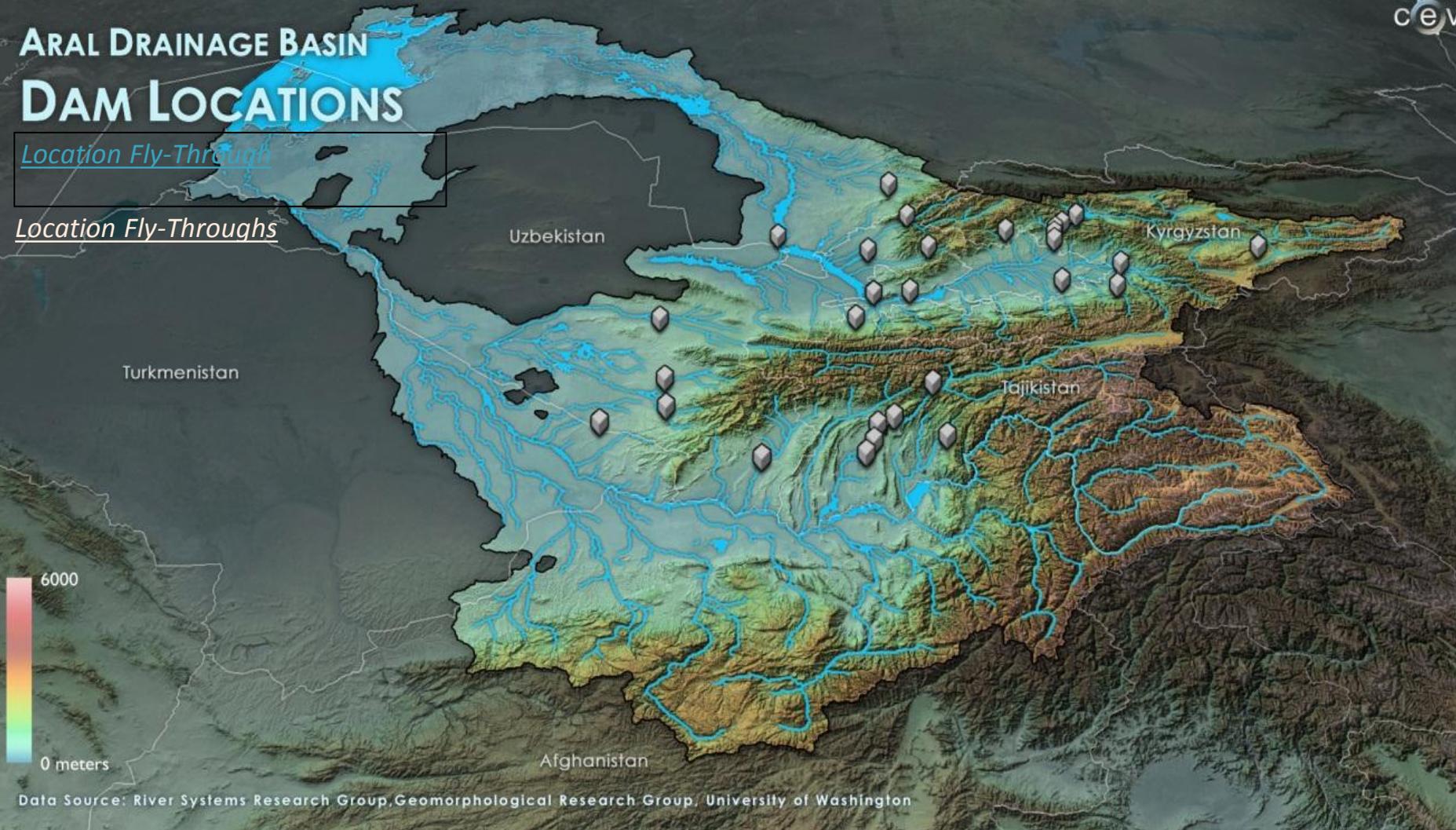


Data Source: River Systems Research Group, Geomorphological Research Group, University of Washington

ARAL DRAINAGE BASIN DAM LOCATIONS

Location Fly-Through

Location Fly-Throughs



Data Source: River Systems Research Group, Geomorphological Research Group, University of Washington

ARAL DRAINAGE BASIN
WATER MOVEMENT

AMU DARYA AND THE SYR DARYA BASINS

FLOW NETWORK

Syr Darya

cev

cev

ARAL DRAINAGE BASIN

SO
LAYER

ARAL DRAINAGE BASIN

VEG
MODI

ARAL DRAINAGE BASIN

VIC MODEL

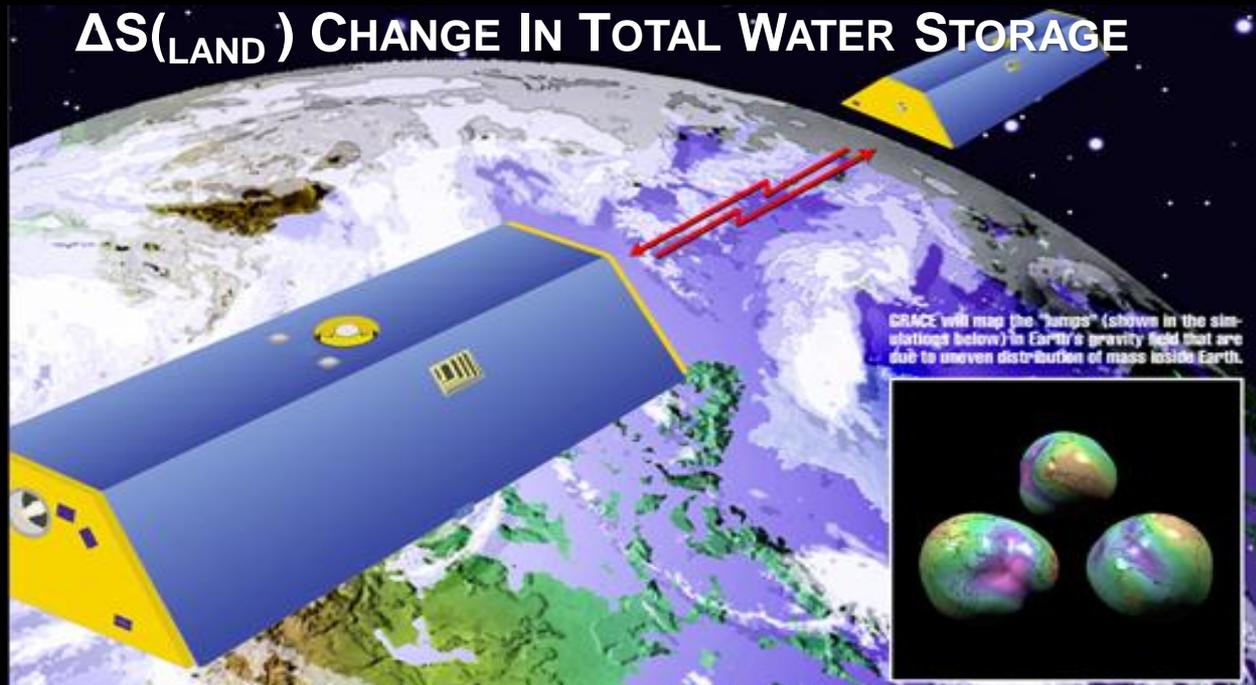
PRECIPITAT

CLIMATE FORCING

Precip, Temp, Wind

RIVER DISCHARGE

$\Delta S_{(LAND)}$ CHANGE IN TOTAL WATER STORAGE



GRACE will map the "lumps" (shown in the simulations below) in Earth's gravity field that are due to uneven distribution of mass inside Earth.

- Wat
- Ever
- Ever
- Deci
- Deci
- Mixe
- Woc
- Woc
- Spar
- Meat
- Gras
- Inun
- Agri
- Urbi
- Croj
- Snov
- Barr



Data Sou

Data Sou

cev

cev

cev

cev

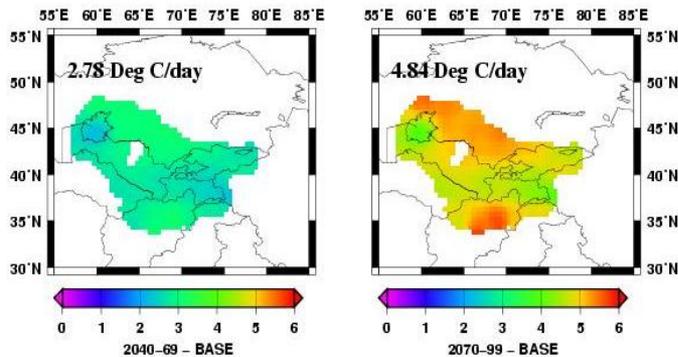
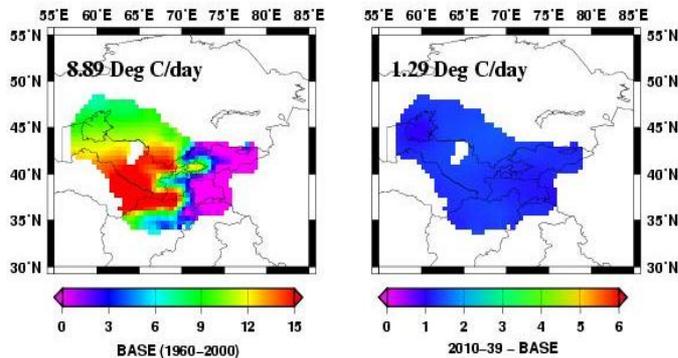
ABILITY TO INCORPORATE CLIMATE SCENARIOS INTO ARALDIF MODEL RUNS

Multi (7)- Model Ensemble : **A2** Emissions Scenario

Average Projected Changes: Base (1960-2000), 2010-39, 2040-69, 2070-2100

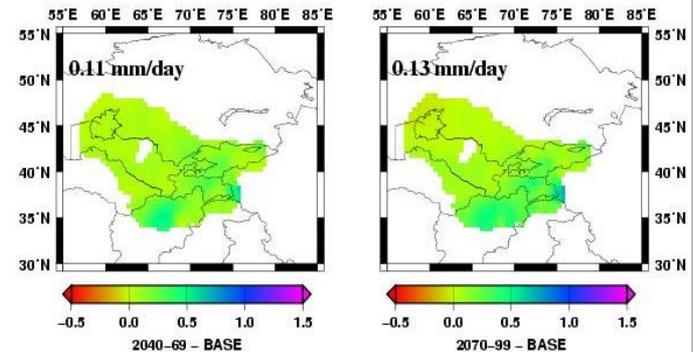
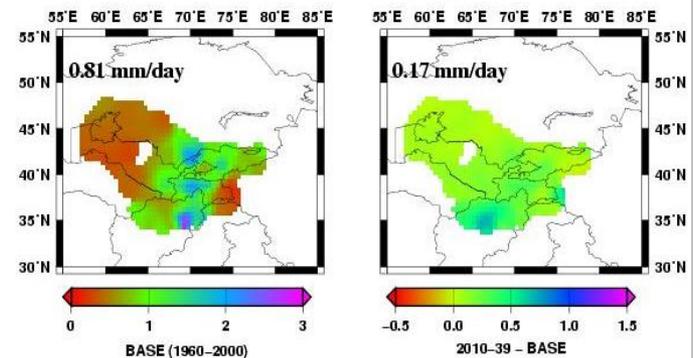
MULTI-MODEL AVERAGE ANNUAL TEMP CHANGE

A2



MULTI-MODEL AVERAGE ANNUAL PRECIP CHANGE

A2



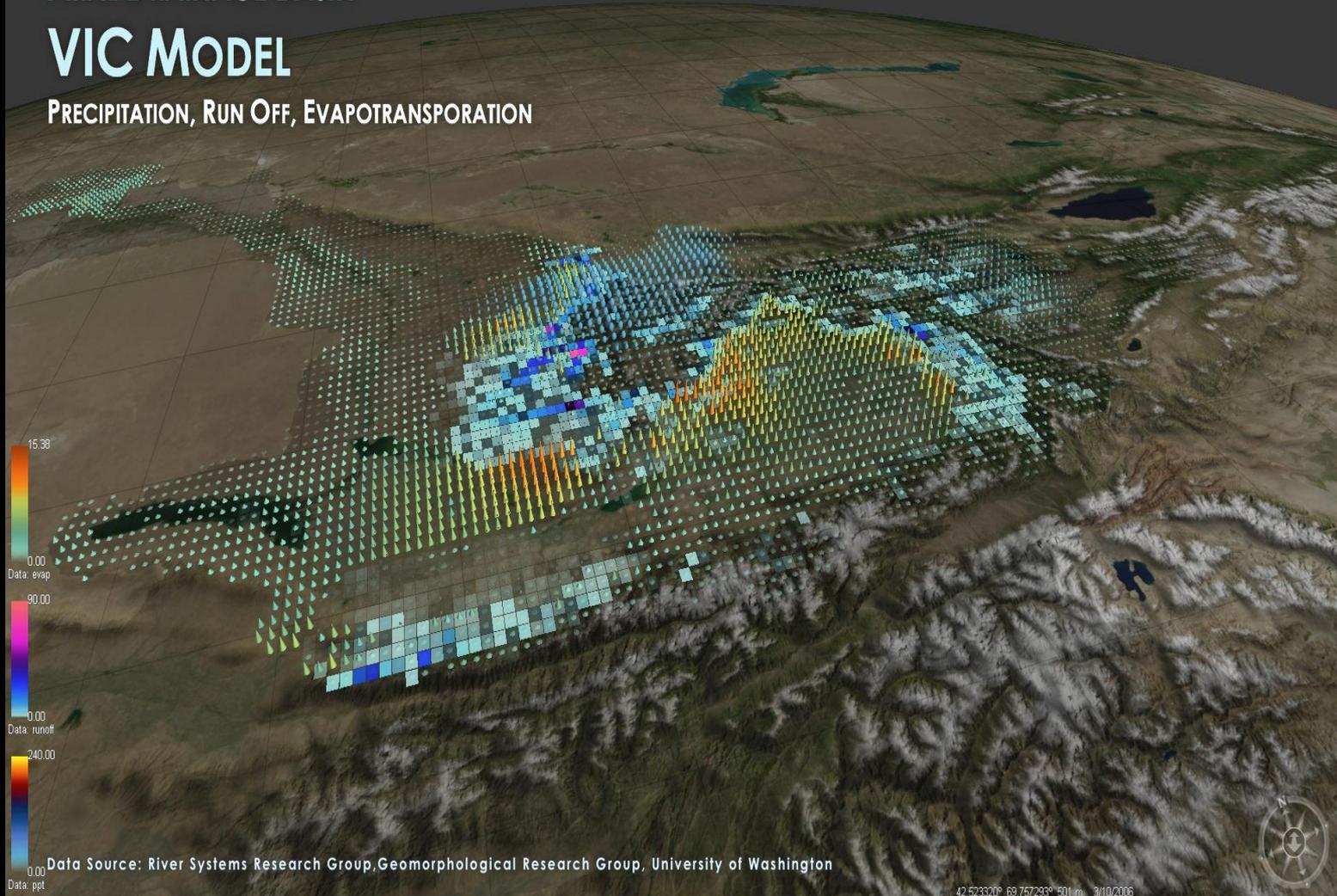
Scenarios & Simulations



ARAL DRAINAGE BASIN

VIC MODEL

PRECIPITATION, RUN OFF, EVAPOTRANSPIRATION



Take Home Lessons

1. Landscape Scale Planning and Decision Support Frameworks are practical and necessary tools for governments and policy makers
2. Cross sector (inter Ministry) data integration and linkages are essential for effective local to regional to national analysis, synthesis, and decision-making
3. Many countries in Latin America, Central Asia, South Asia, and Africa are implementing Dynamic Data and Information Frameworks for Landscape Scale Resource Management and Planning
4. Climate Change and Population Growth require that countries undertake appropriate simulations of likely impacts on critical sectors for economic development at relevant spatial and time scales
5. The World Bank is providing technical assistance and financing to assist client countries to develop their own Dynamic Information Frameworks for Landscape Scale Management of Natural Resources and to conduct impact simulations for prioritizing investments for Enhanced Resilience to Climate Change



Спасибо, друзья