# **Geophysical Underpinnings of Global Water Stress:** *Linking Environmental Surveillance Systems, Social Science Data and Modeling*

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# Persistent Water Resource Challenges

Sanitation and access to clean water

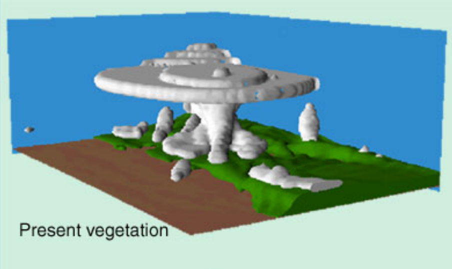
Flood hazard/response

Water for development

Food security

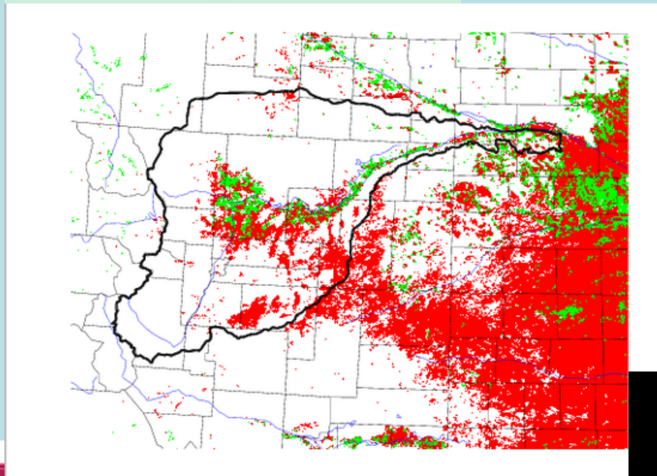
Maintaining aquatic ecosystem services

Pollution



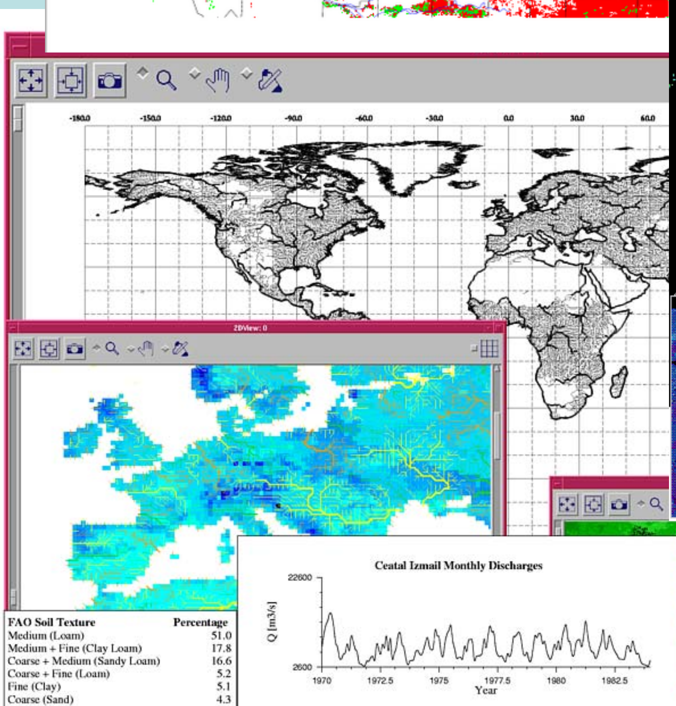

# Contributions from Earth System Science

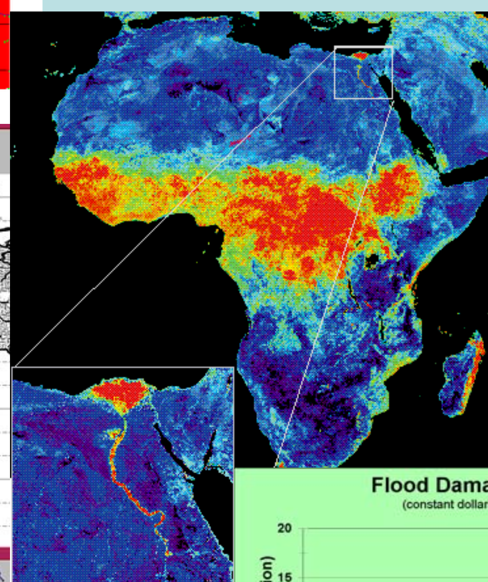
- *In situ* networks
- Operational satellite-based monitoring of the hydrosphere
- Simulation models and data analysis tools (NWP-4DDA, GCMs, RCMs, ESMs)

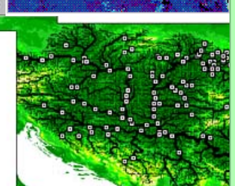


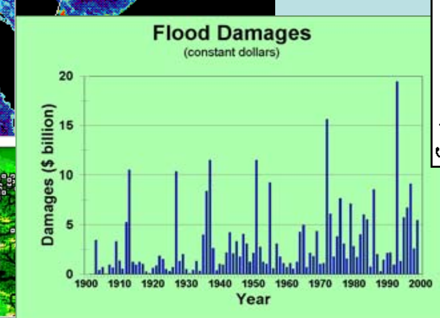
…are creating new ways to view the "global water crisis"

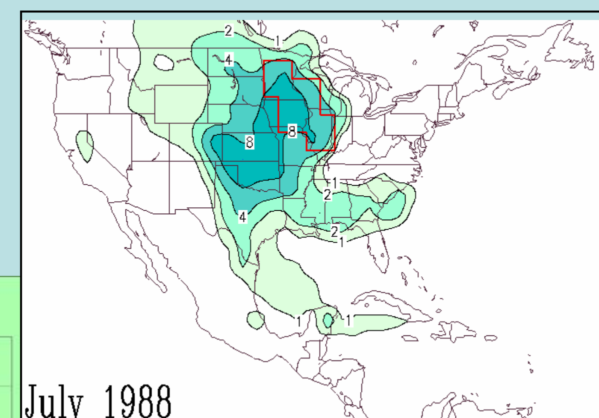
…to inform policy and improve management







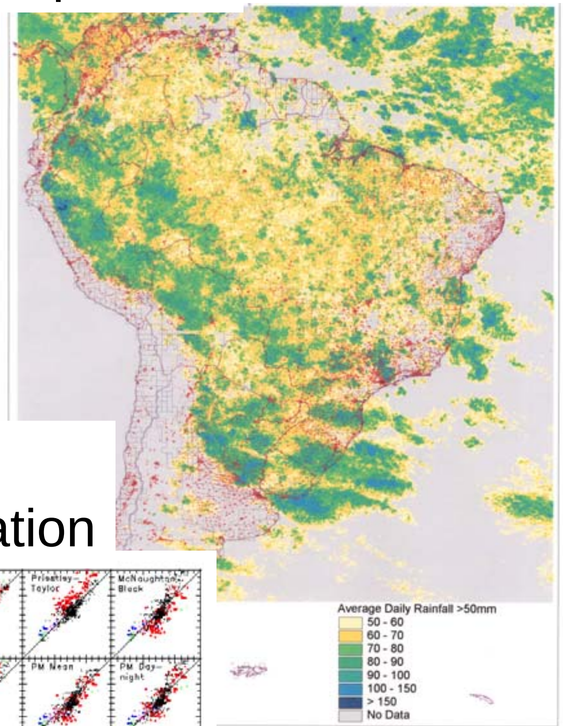



# 1970's LAVA LAMP?  No…Unprecedented Opportunities to Monitor the State of the Hydrosphere Using Observations, Data Assimilation, and Modeling Tools

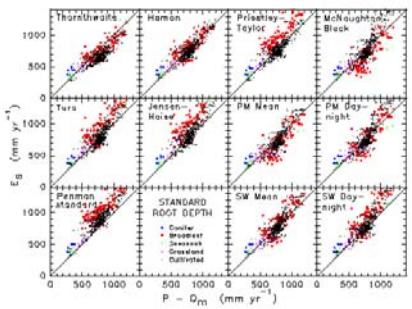
QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

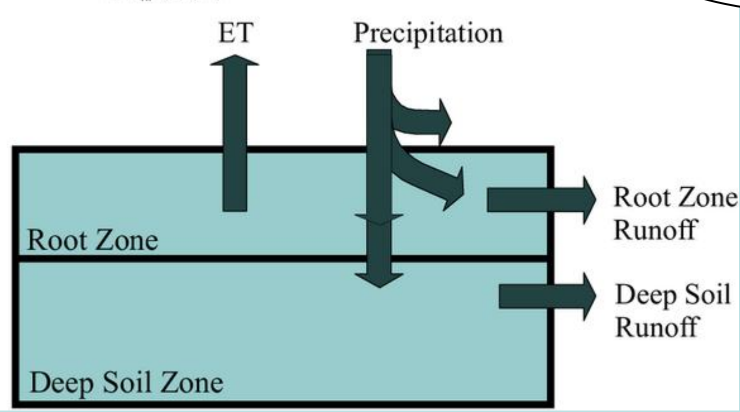
# TYPICAL CALCULATION SCHEME TO GENERATE WATER RESOURCE ESTIMATES

Precipitation

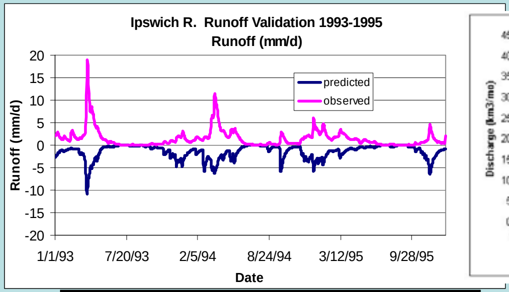


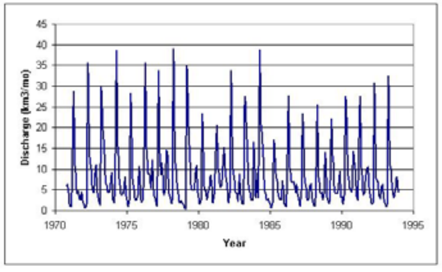

Evapo-
transpiration



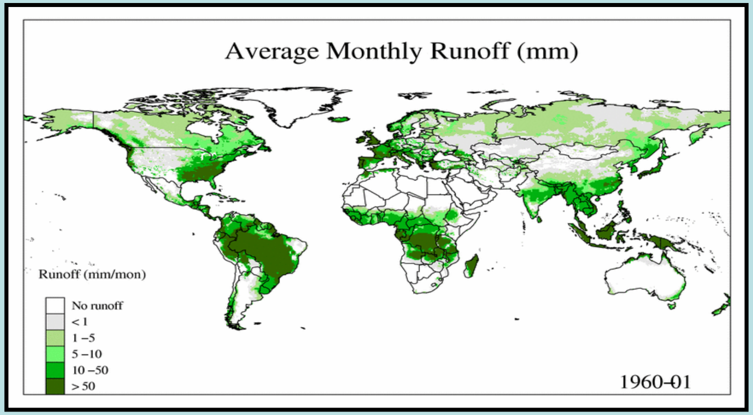

WBM/WTM



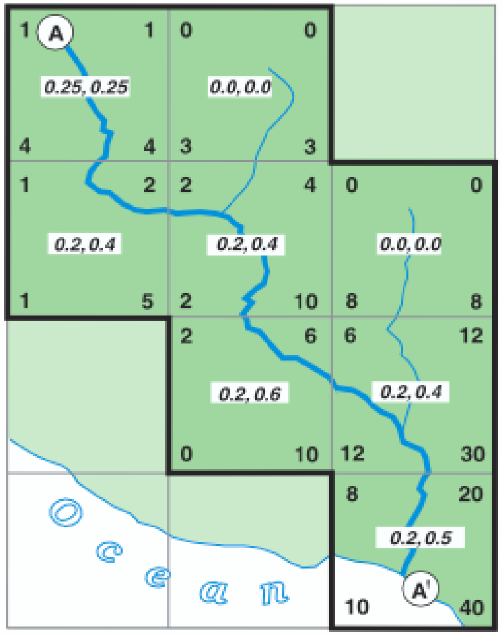

Lateral Transport

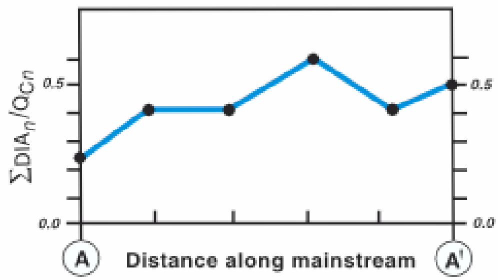
River
Networks




Runoff=
Local
Water
Resource

# CALCULATION OF KEY WATER INDICATORS




$DIA_n$ = domestic, industrial, agricultural water use ($km^3\ yr^{-1}$) in cell $n$

$\Sigma DIA_n$ = DIA in cell $n$ plus all upstream cells ($km^3\ yr^{-1}$) $= \sum_{i=1}^{n} DIA_i$

$R_n$ = locally-generated runoff (mm/yr)

$A_n$ = area of cell $n$ ($km^2$)

$Q_{Ln} = 10^6 * R_n * A_n$ = locally generated discharge ($km^3\ yr^{-1}$)

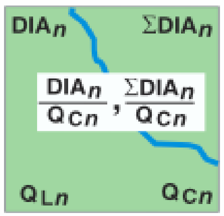
$Q_{Cn} = \sum_{i=1}^{n} Q_{L_i}$ = river corridor discharge ($km^3\ yr^{-1}$)

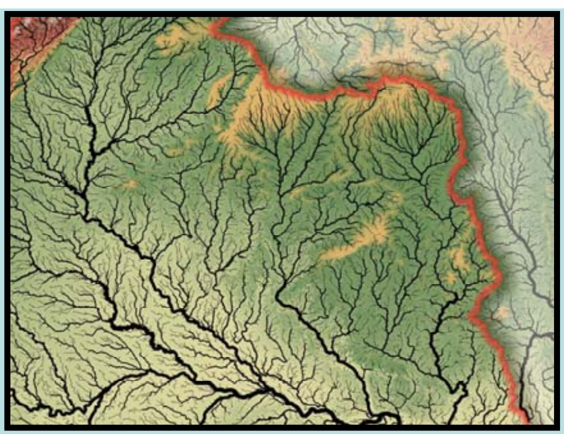
$DIA_n/Q_{Cn}$ = local relative water use (unitless)

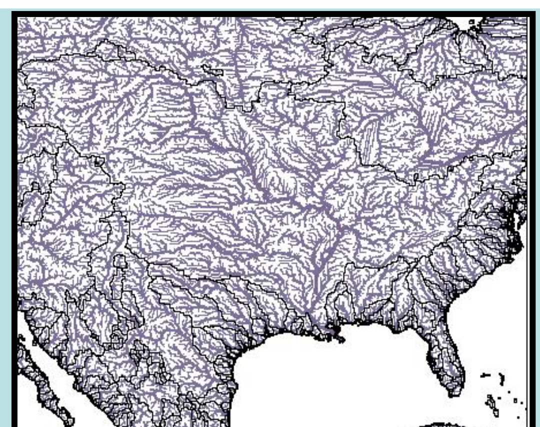
$\Sigma DIA_n/Q_{Cn}$ = water reuse index (unitless)

$n$ = position of cell in river network
= total number of upstream cells plus cell in question

Key (cell $n$)

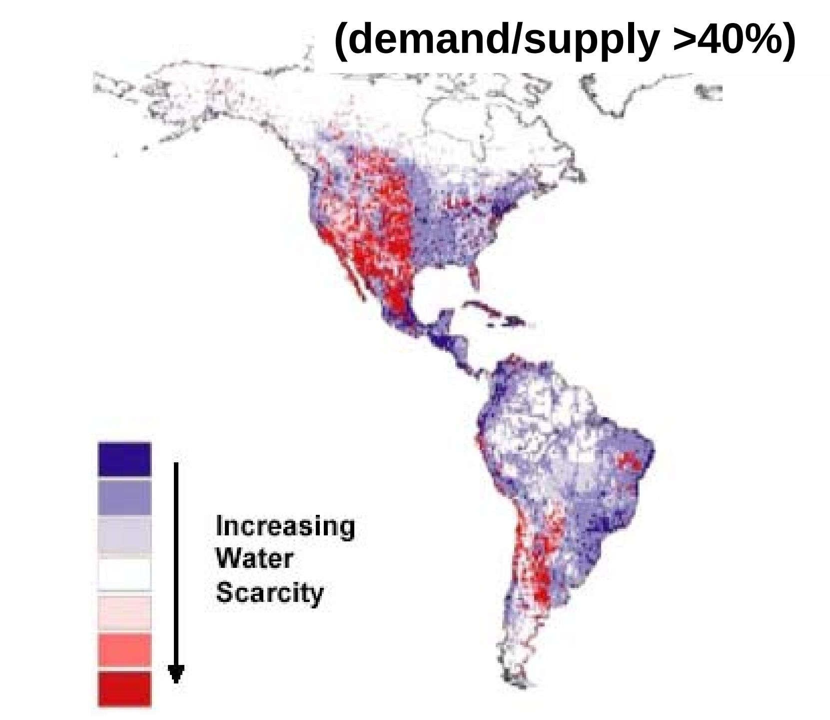




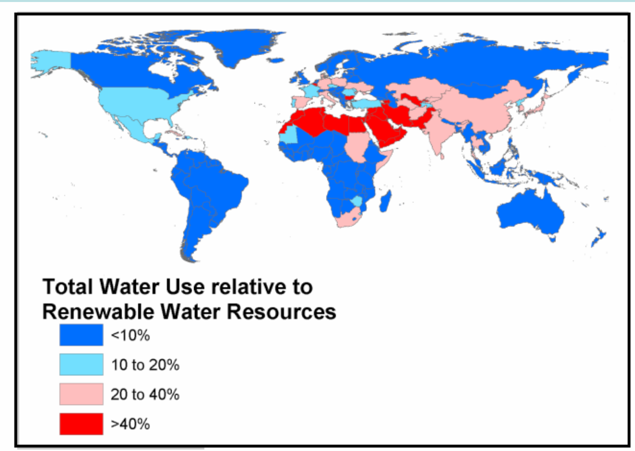
# New Geospatial Approaches Raise Estimates of Scarcity

## *Contemporary Population under High Water Stress*



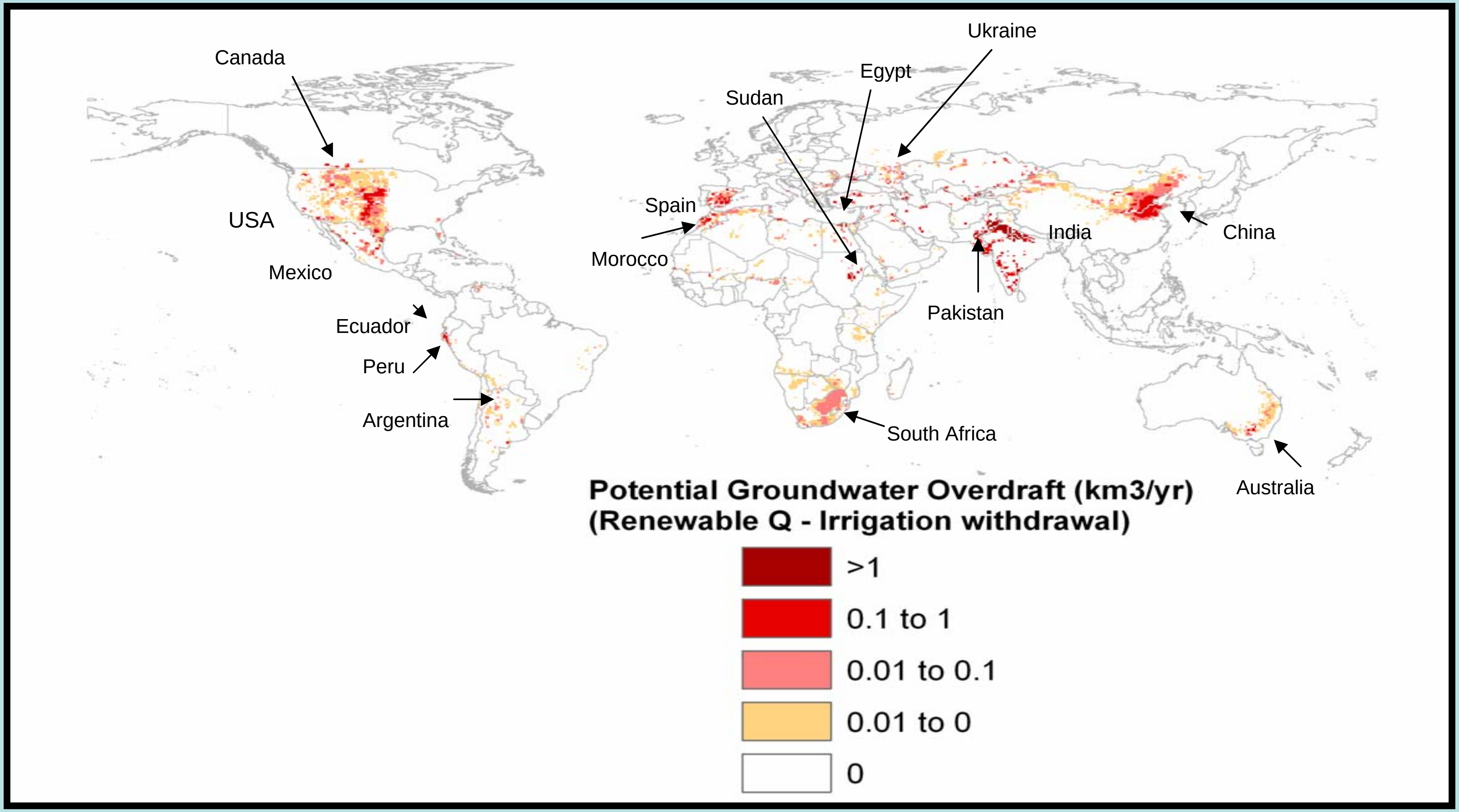

- Number highly sensitive to accounting unit
- Grid-based (30' lat/long) estimates (n > 60,000) capture spatial variability & show much higher numbers than country-level statistics (n ≈ 200)

| Water Stress | DIA/Q (unitless) | Total Population (billions): Country-level: U.N. | Country-level: Grid Sum | Grid-based: Full Resolution |
|---|---|---|---|---|
| Low | *<0.1* | 1.72 | 1.95 | 3.16 |
| Moderate | *0.1 to 0.2* | 2.08 | 1.73 | 0.38 |
| Med-high | *0.2 to 0.4* | 1.44 | 1.54 | 0.37 |
| High | *>0.4* | 0.46 | 0.45 | 1.76 |



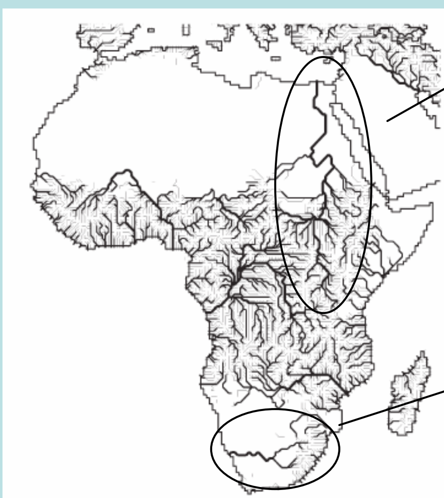

*Vorosmarty et al. 2000*

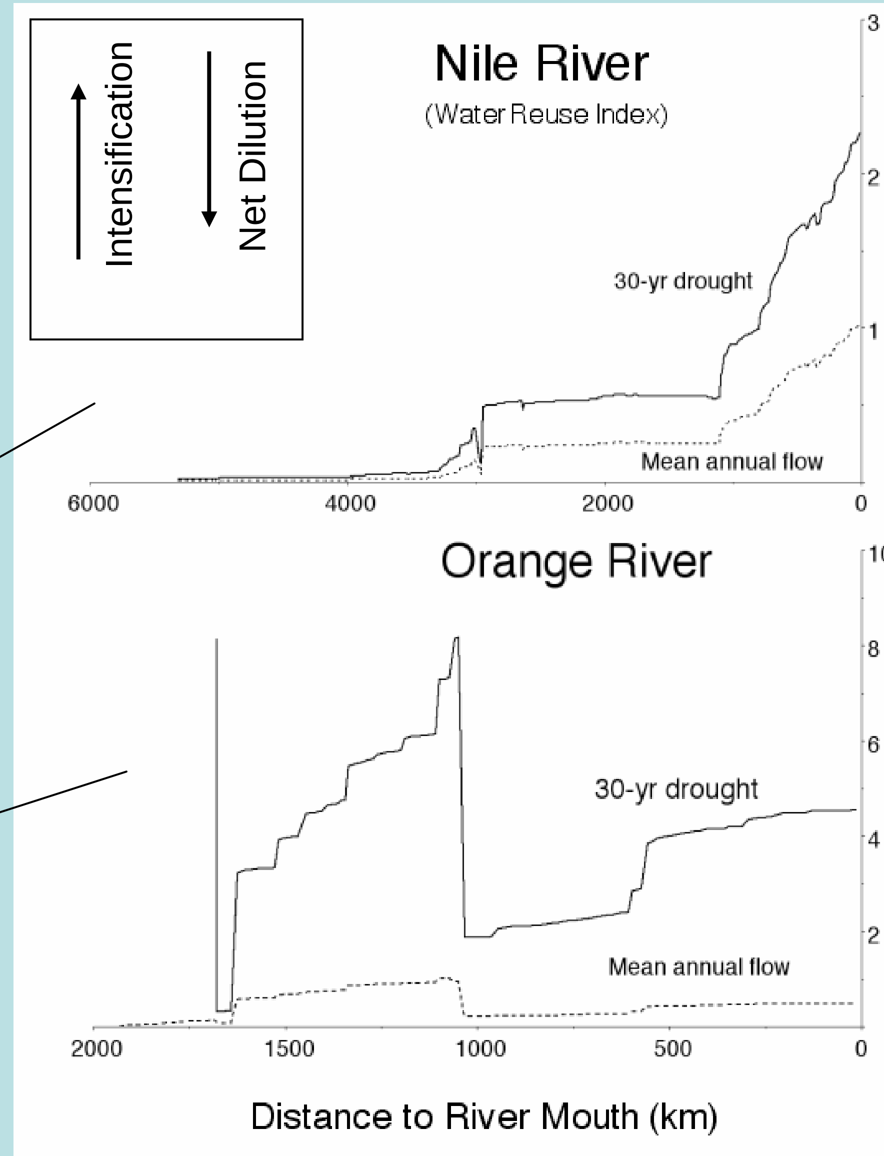
# POTENTIAL SOURCE OF CONFLICT: *Mapping Depletion of Renewable Water Supply (irrigation and cities)*



# POTENTIAL SOURCE OF CONFLICT:
# *Climate Change and Variability*

**Water stress**
**“signatures”**
**along river corridors**

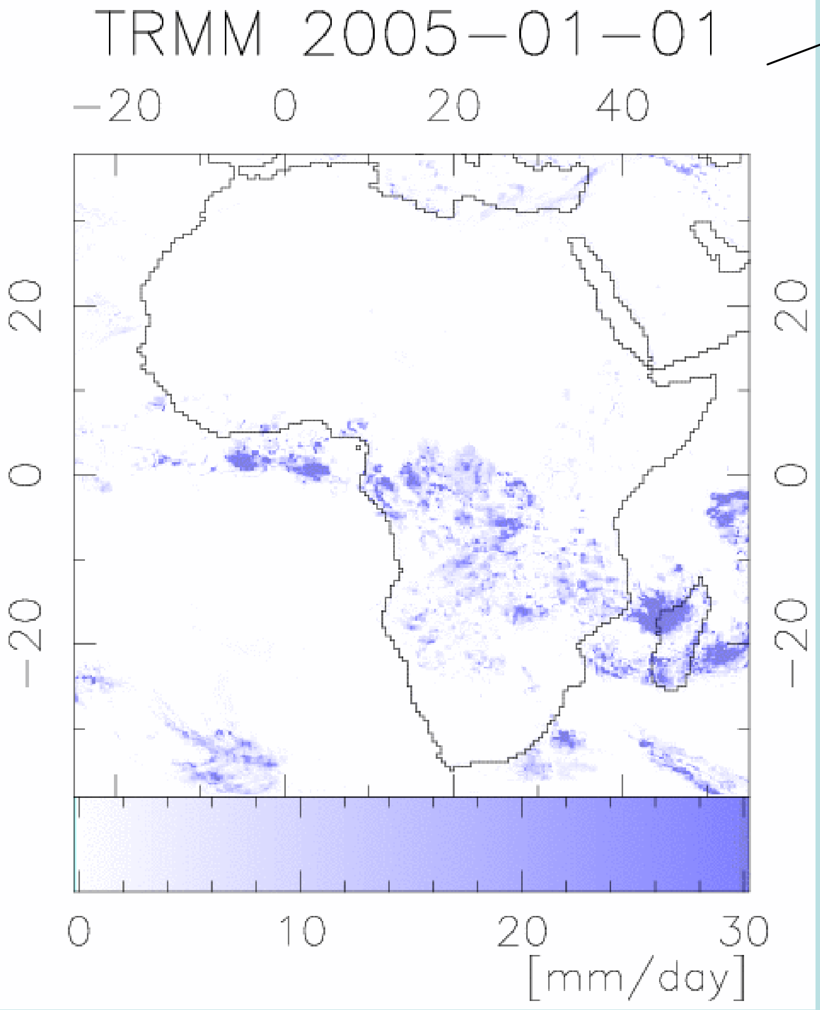





*Vörösmarty et al. 2005. AMBIO*

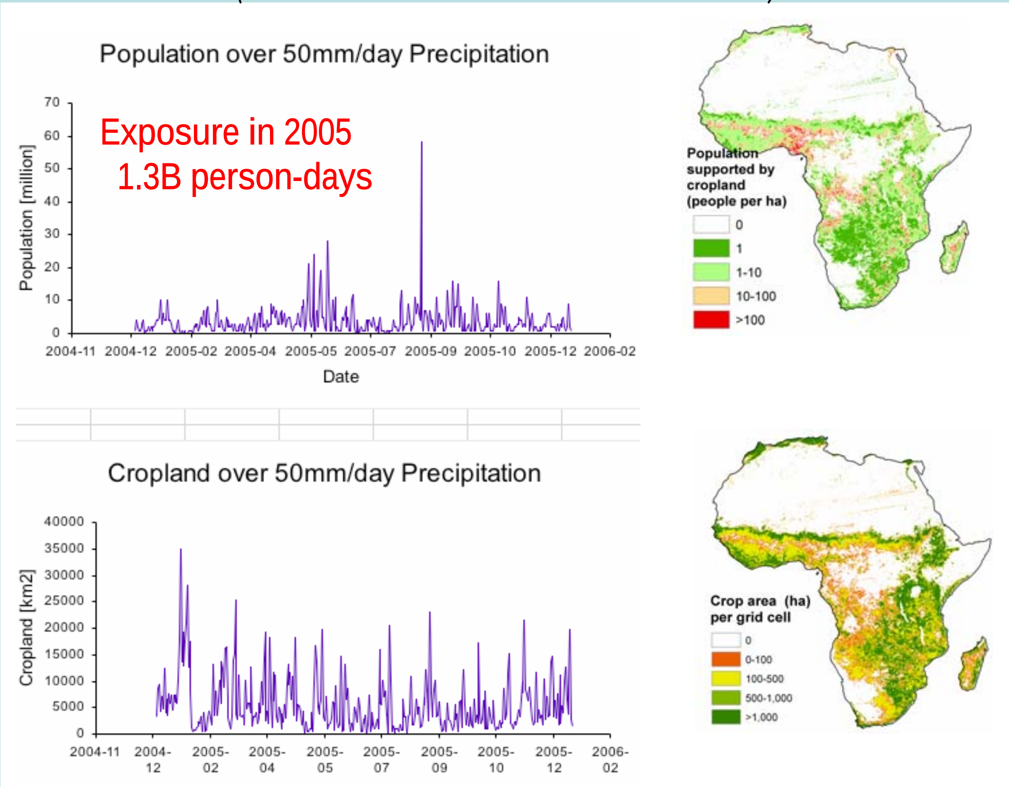
# “Operationalizing” Water Stress Indicators: Merging Near Real-Time Data with Socio-economic Information

*“GEOSS-class” Geophysical data*

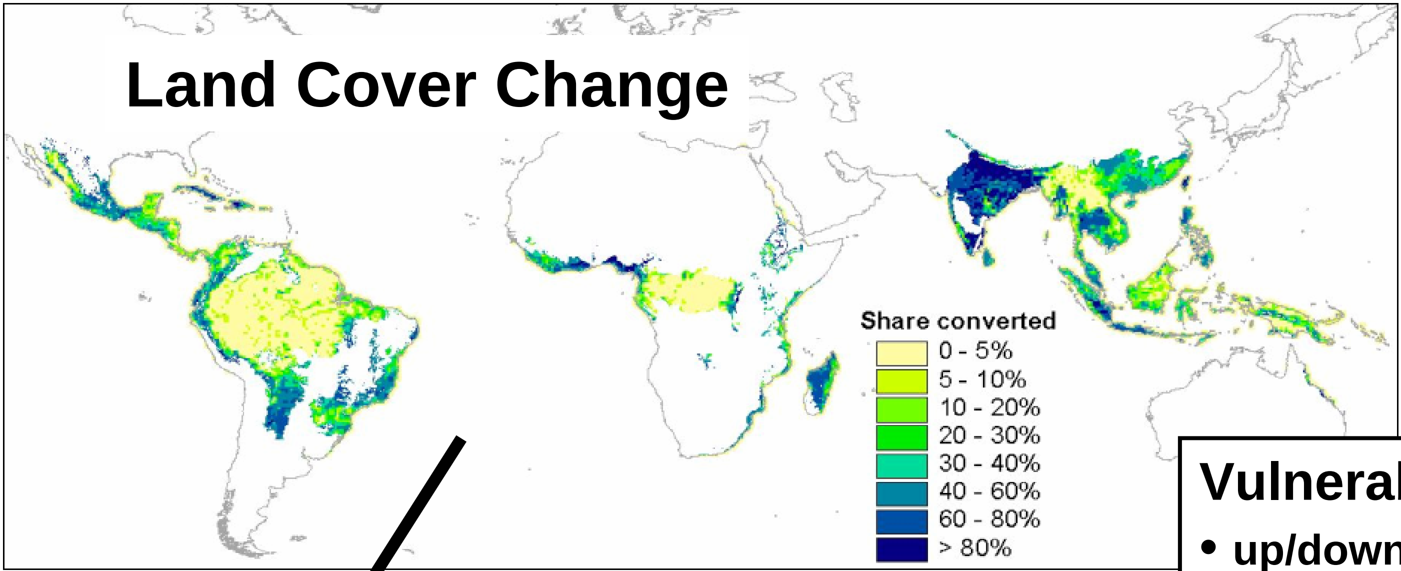



*Derived Products (e.g. hazard exposure)*

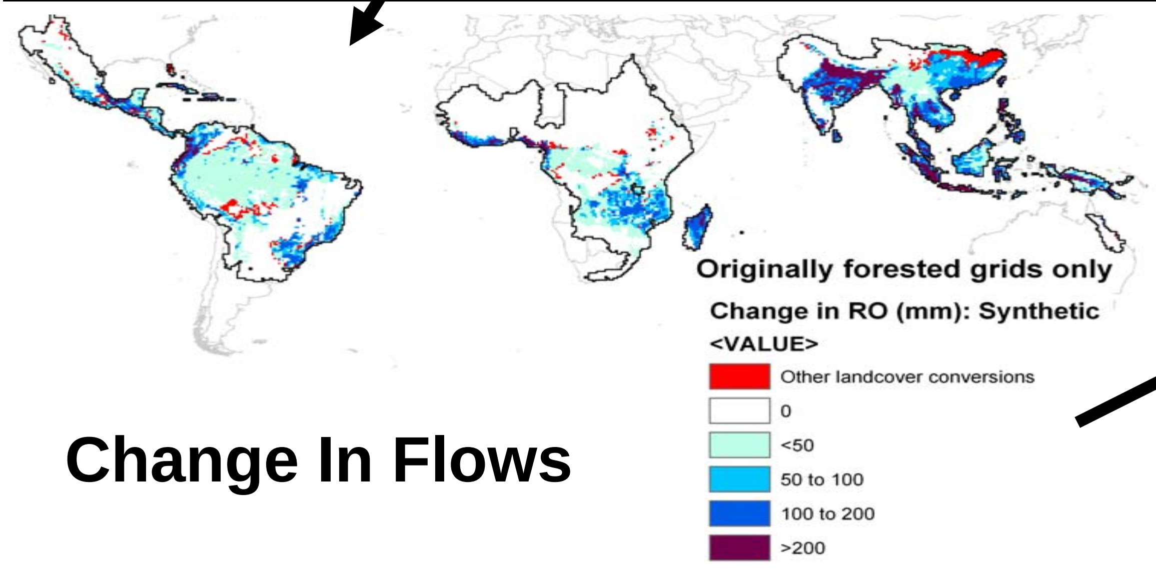
*Geospatial Socio-economics*



# POTENTIAL SOURCE OF CONFLICT: Upstream-Downsteam Links

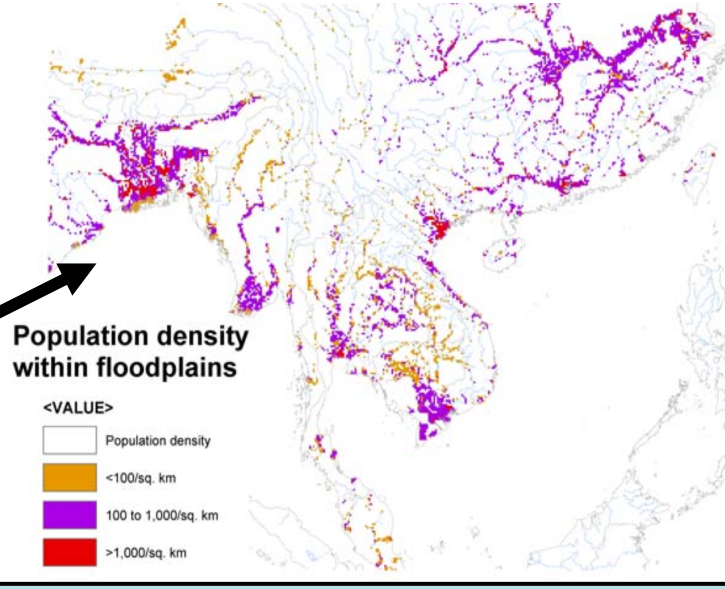



***NEW CLASSES OF "teleconnections"***




**Vulnerability Translated**

- **up/downstream stakeholders**
- **humans & nature**




*Douglas et al. 2007, WRM*