



# Remote Sensing in Water Accounting and Water Planning

Delft 13-Feb-2008

Peter Droogers  
Walter Immerzeel  
FutureWater  
Wageningen

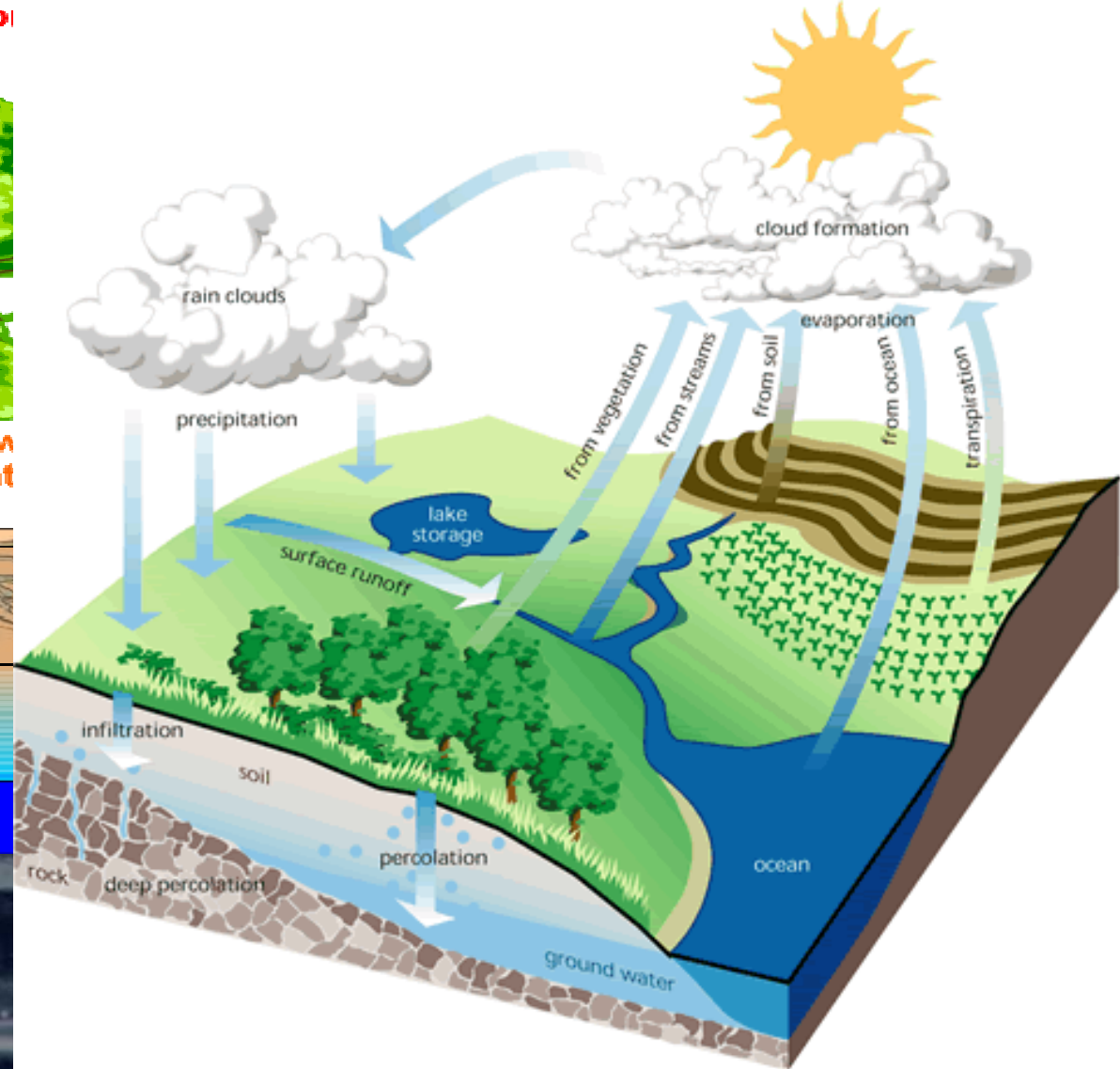
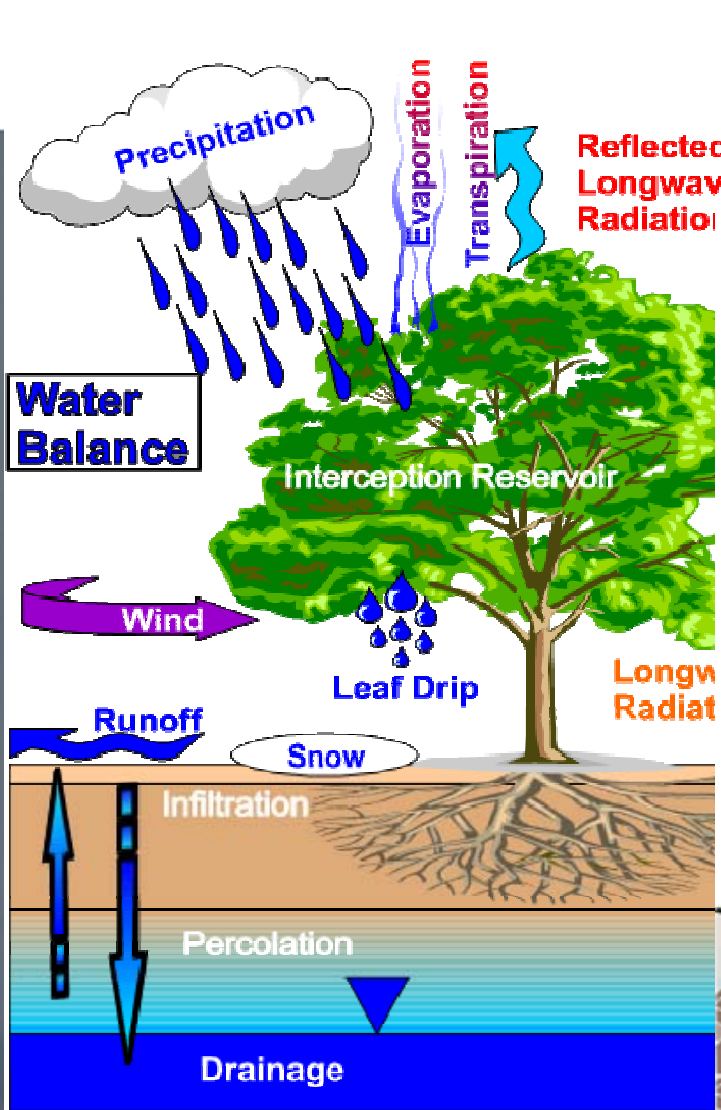
 **FutureWater**

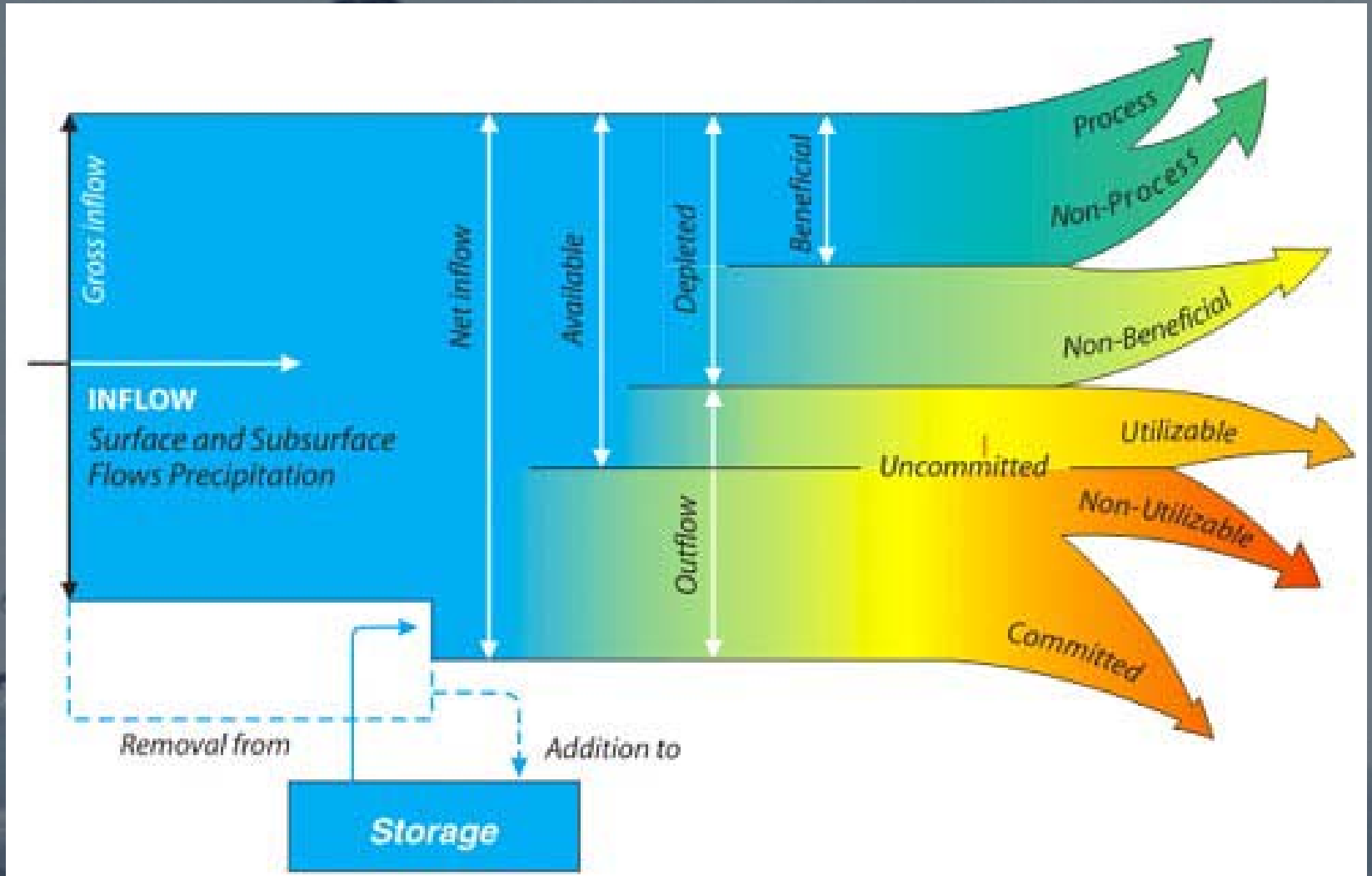
(Prof) Wim Bastiaanssen  
TU Delft



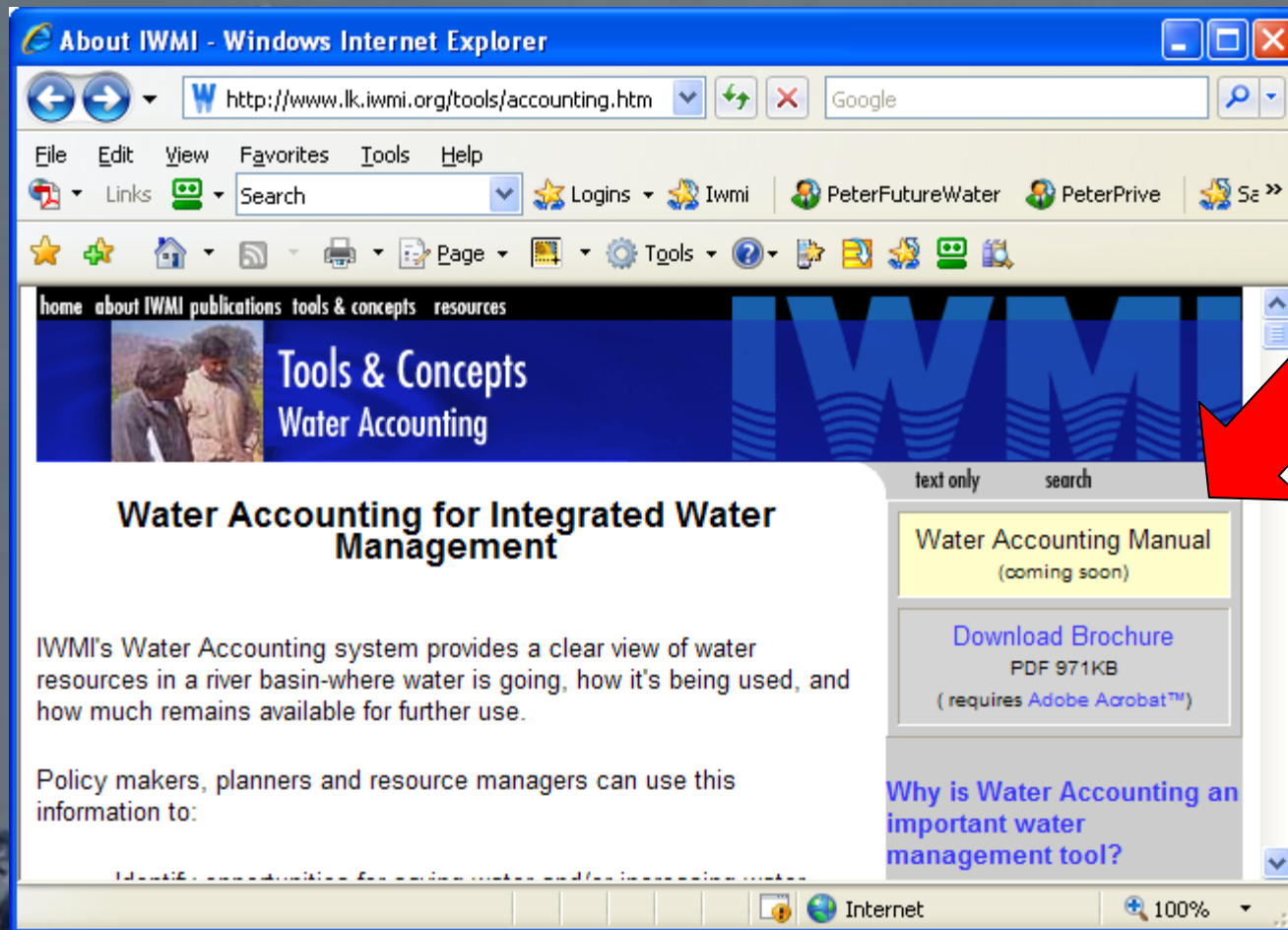
- Some history
- Water accounting and water planning
- Practical examples
  - Downscaling precipitation
  - Scenario based modeling
  - Groundwater from space
- Future outlook







# IWMI website 1997 - 2009

A screenshot of the IWMI website as it appeared in 1997-2009, viewed through a Windows Internet Explorer browser. The browser window title is "About IWMI - Windows Internet Explorer". The address bar shows the URL "http://www.lk.iwmi.org/tools/accounting.htm". The browser's menu bar includes "File", "Edit", "View", "Favorites", "Tools", and "Help". The toolbar contains various icons for navigation and utility. The website content features a navigation menu with "home", "about IWMI", "publications", "tools & concepts", and "resources". A large blue banner displays the IWMI logo and the text "Tools & Concepts Water Accounting". Below the banner, the main heading reads "Water Accounting for Integrated Water Management". The introductory text states: "IWMI's Water Accounting system provides a clear view of water resources in a river basin-where water is going, how it's being used, and how much remains available for further use." Below this, it says "Policy makers, planners and resource managers can use this information to:". On the right side, there is a search box with "text only" and "search" options. Below the search box, there are three main content blocks: "Water Accounting Manual (coming soon)", "Download Brochure PDF 971KB (requires Adobe Acrobat™)", and "Why is Water Accounting an important water management tool?". The browser's status bar at the bottom shows "Internet" and "100%". A large red arrow points from the right side of the page towards the search box area.



# Gediz Basin location map



**IWMI** International Water Management Institute  
**GDRS** General Directorate of Rural Services

**Gediz  
basin**



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# Combining Remote Sensing and Hydrological Models to Enhance Spatial and Temporal Resolution

*Peter Droogers, Wim Bastiaanssen*

(IWMI-Sri Lanka, -Holland)

# Introduction

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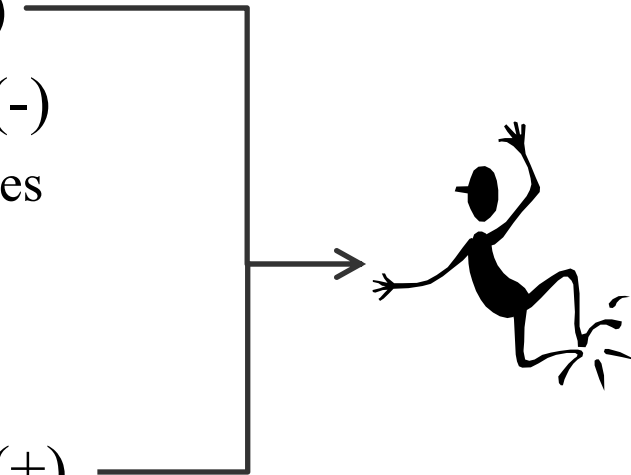
➤ Evapotranspiration (ET) as integrated characteristic of irrigation performance

➤ Remote Sensing ET:

- high spatial resolution (+)
- low temporal resolution (-)
  - only past, limited overpasses

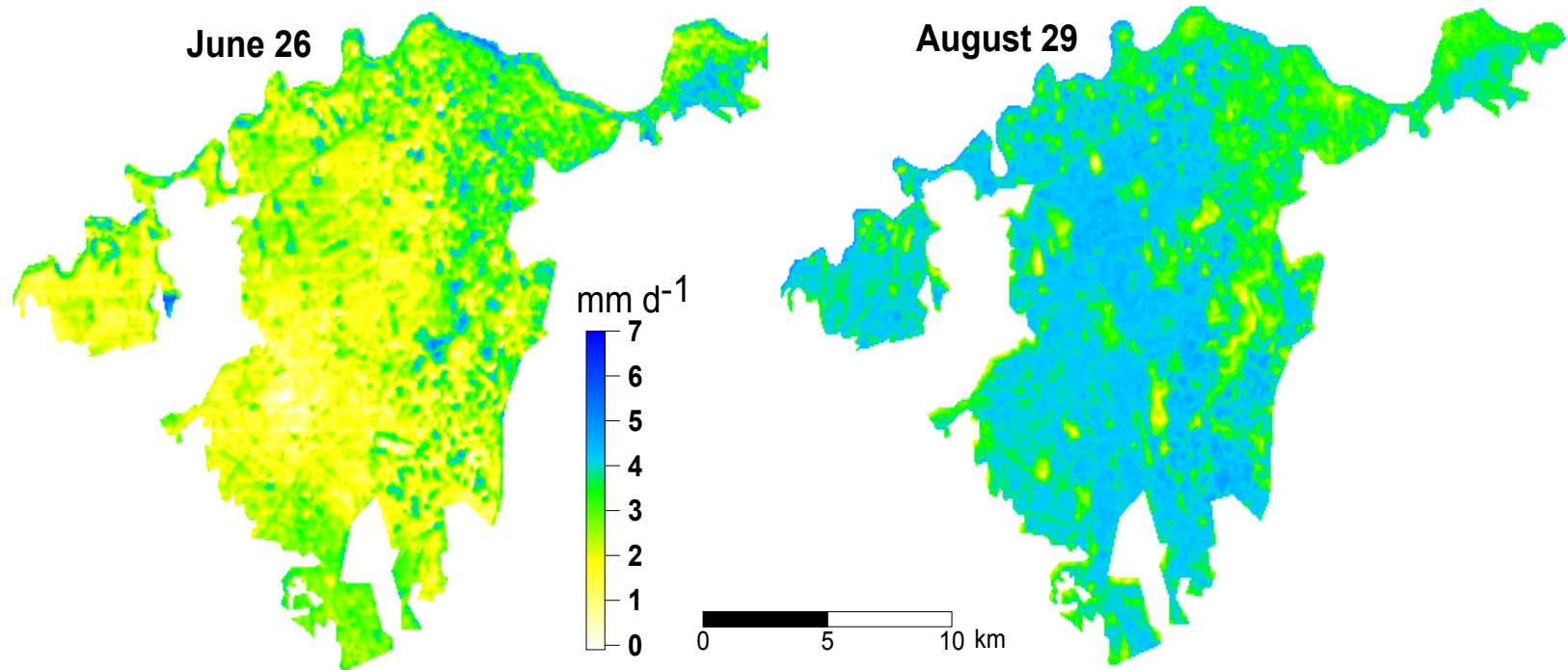
➤ Simulation models

- low spatial resolution (-)
- high temporal resolution (+)
- data requirements (-)

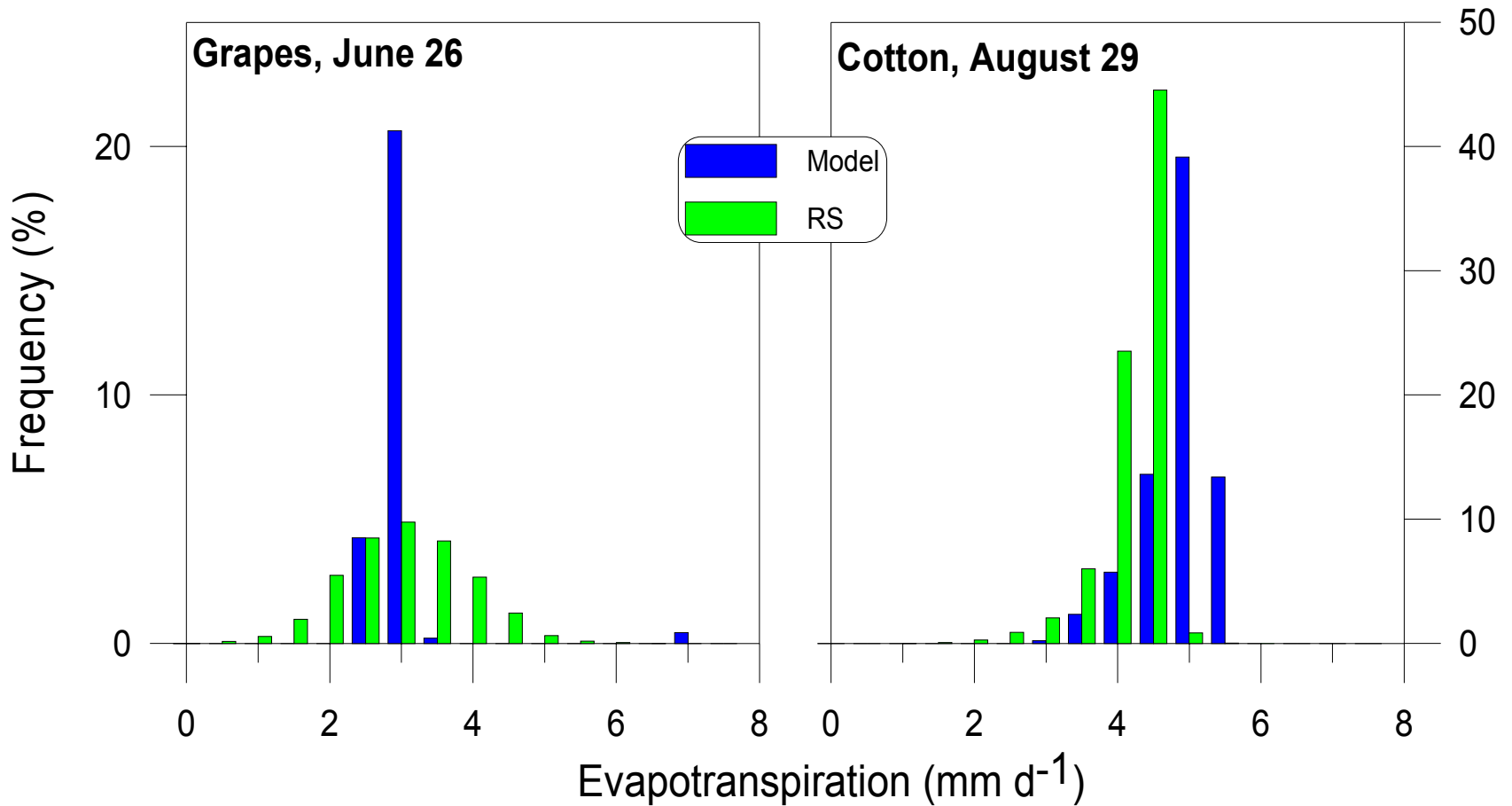


# Results RS

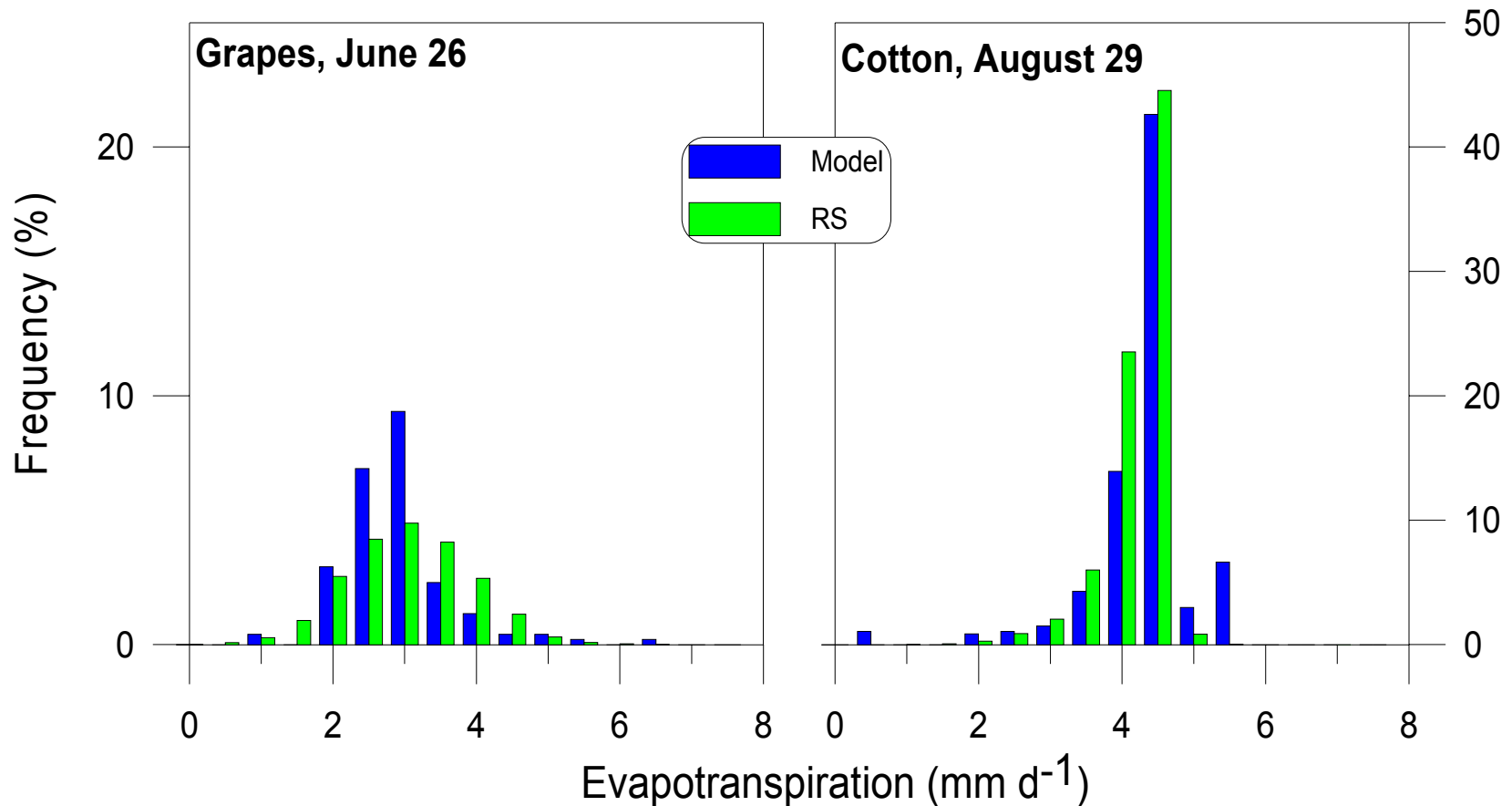
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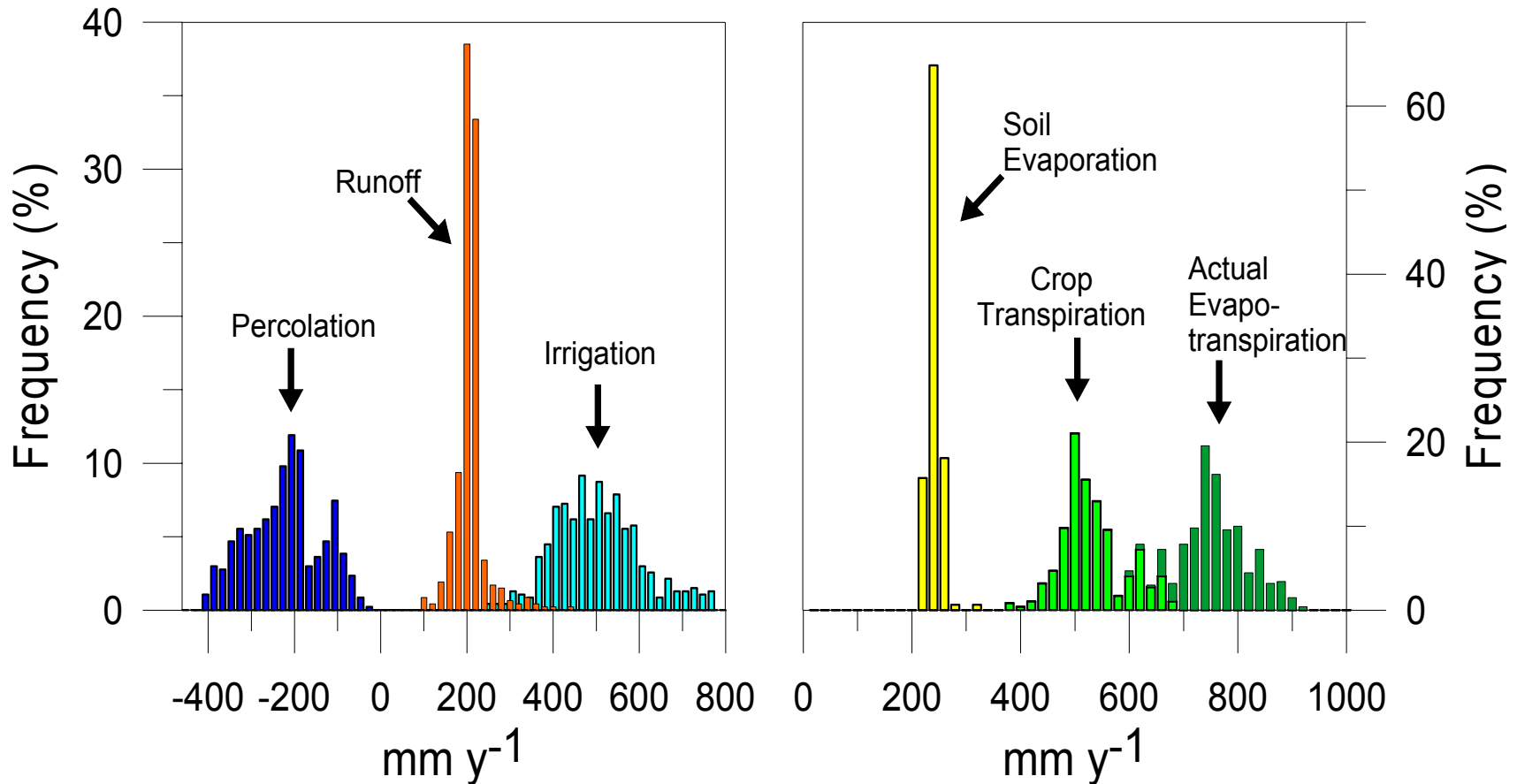
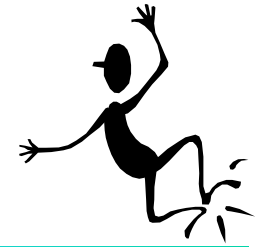
# Model vs. RS



# Model (stochastic) vs. RS

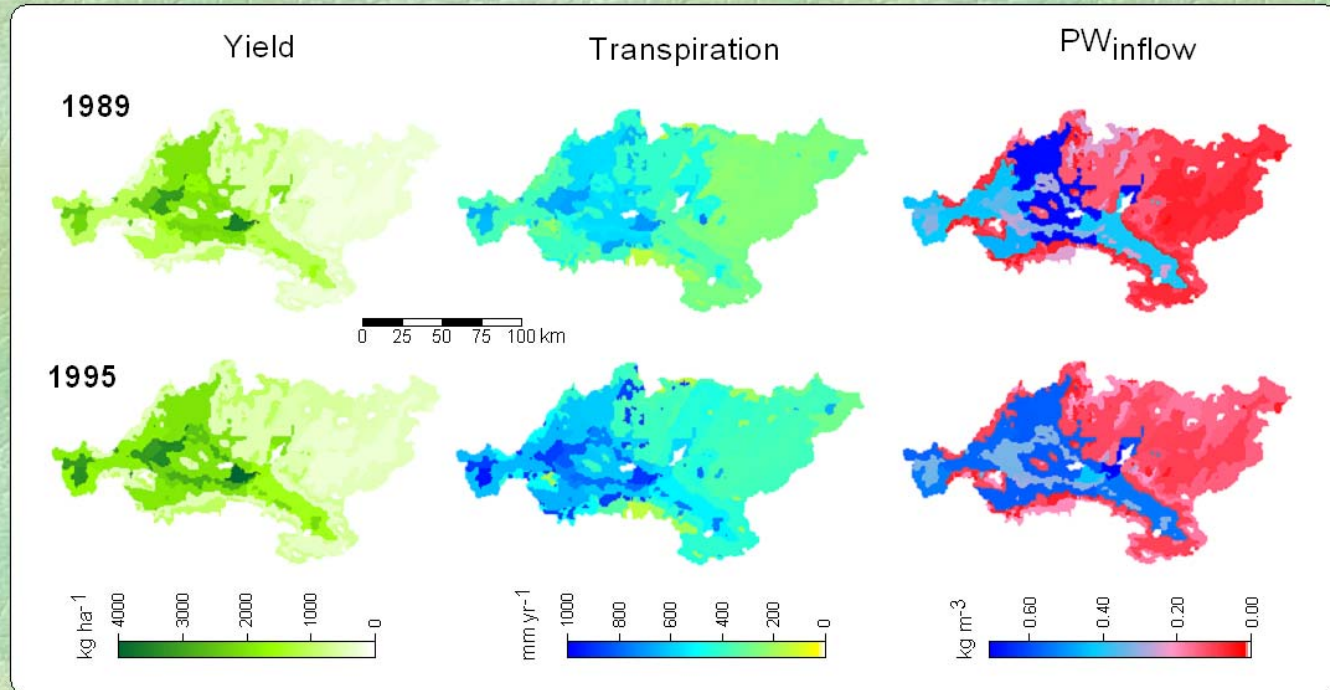


# High Spatial and Temporal Water balance





# $PW_{inflow}$ Basin Scale

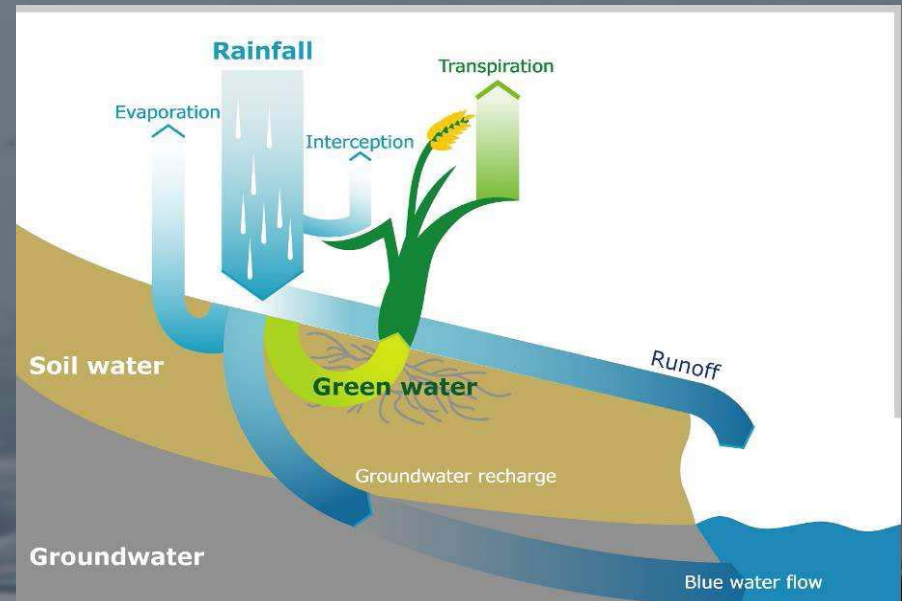
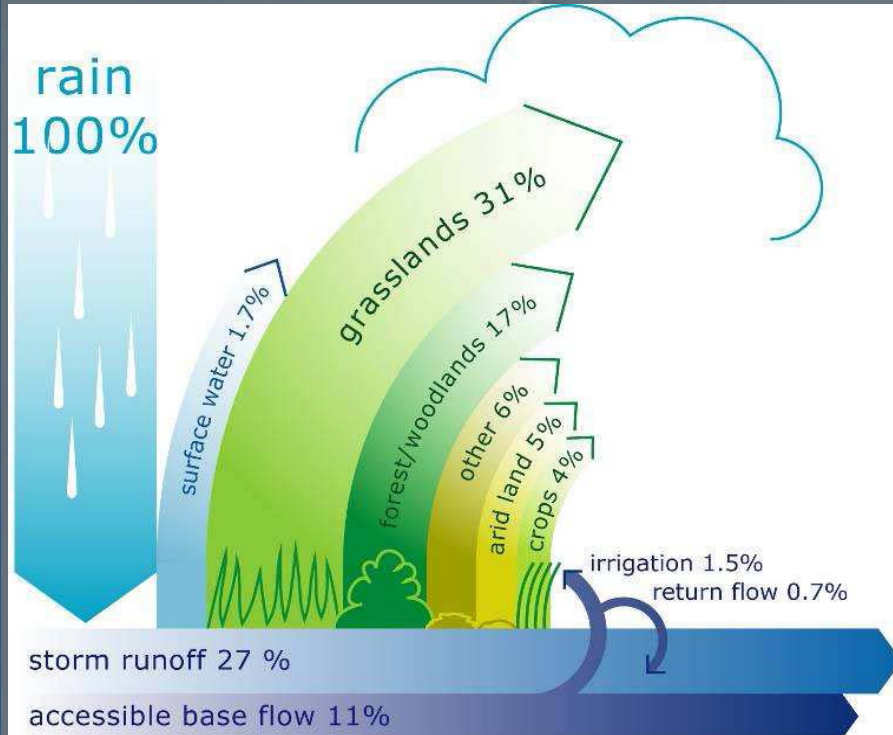




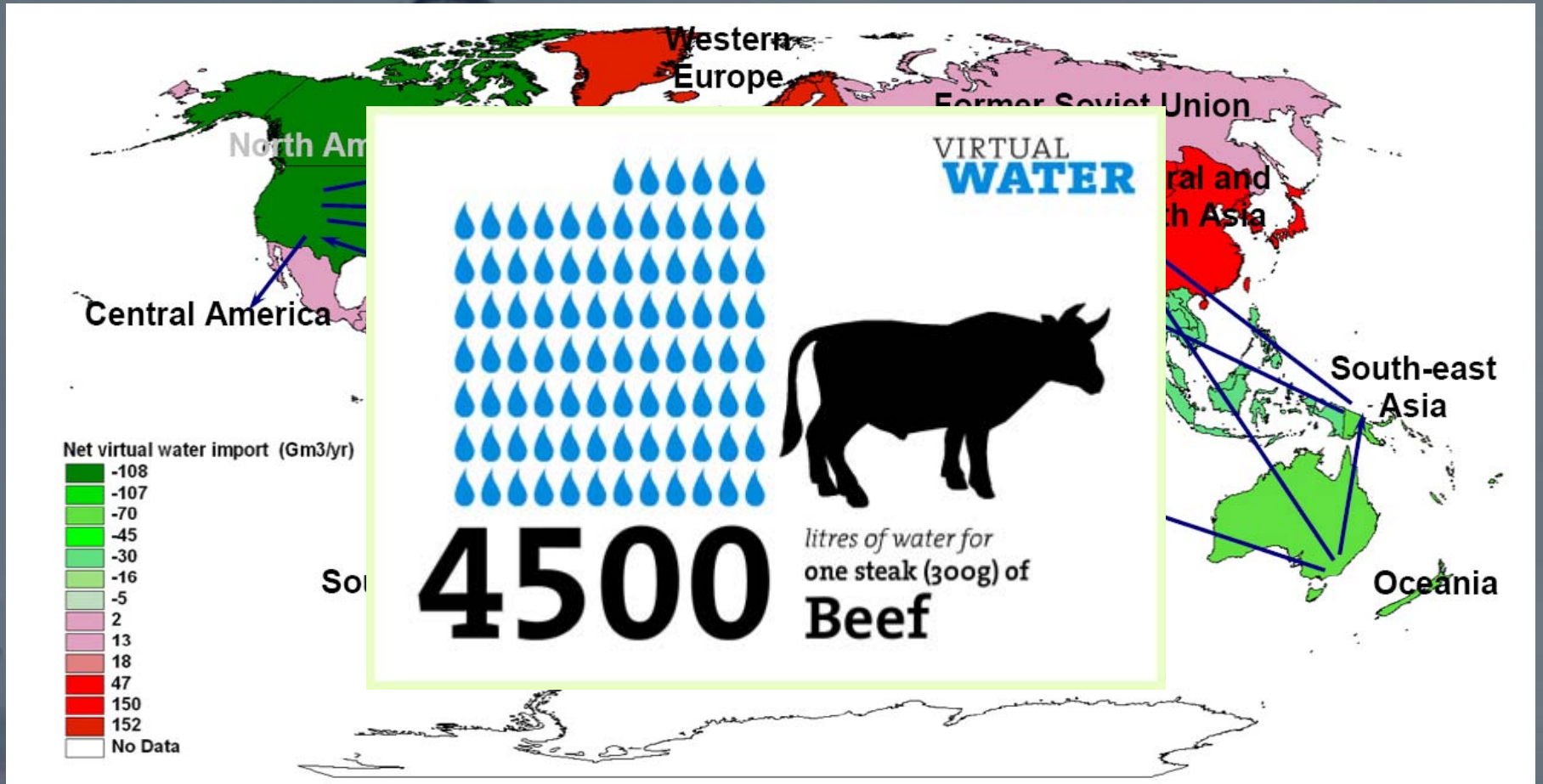
# PW comparison

	Yield kg ha <sup>-1</sup>	PW <sub>irrigated</sub>	PW <sub>inflow</sub>	PW <sub>depleted</sub>	PW <sub>process</sub>
		----- kg m <sup>-3</sup> -----			
Field (MLB)	2289	0.47	0.24	0.24	0.38
Field (SRB)	2800	0.57	0.30	0.39	0.54
Irrigation scheme	2614	0.75	0.30	0.32	0.40
Basin	874	-	0.16	0.16	0.21

# Green and blue water, global flows



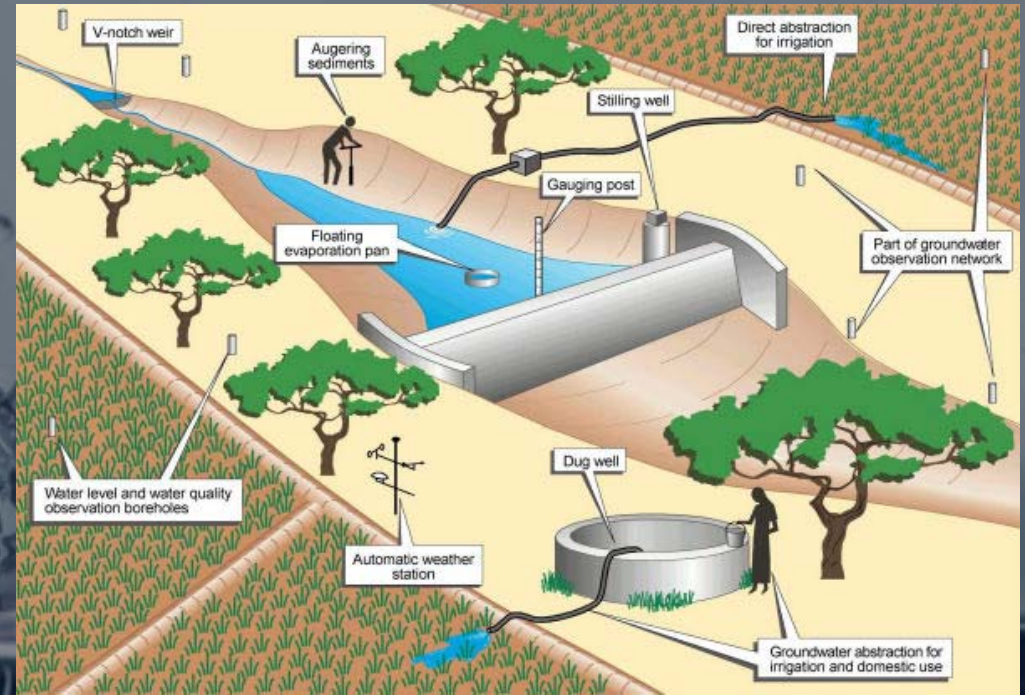
# Virtual Water



# Irrigation Techniques



# Groundwater Recharge Dams



# Water Conservation / Reforestation







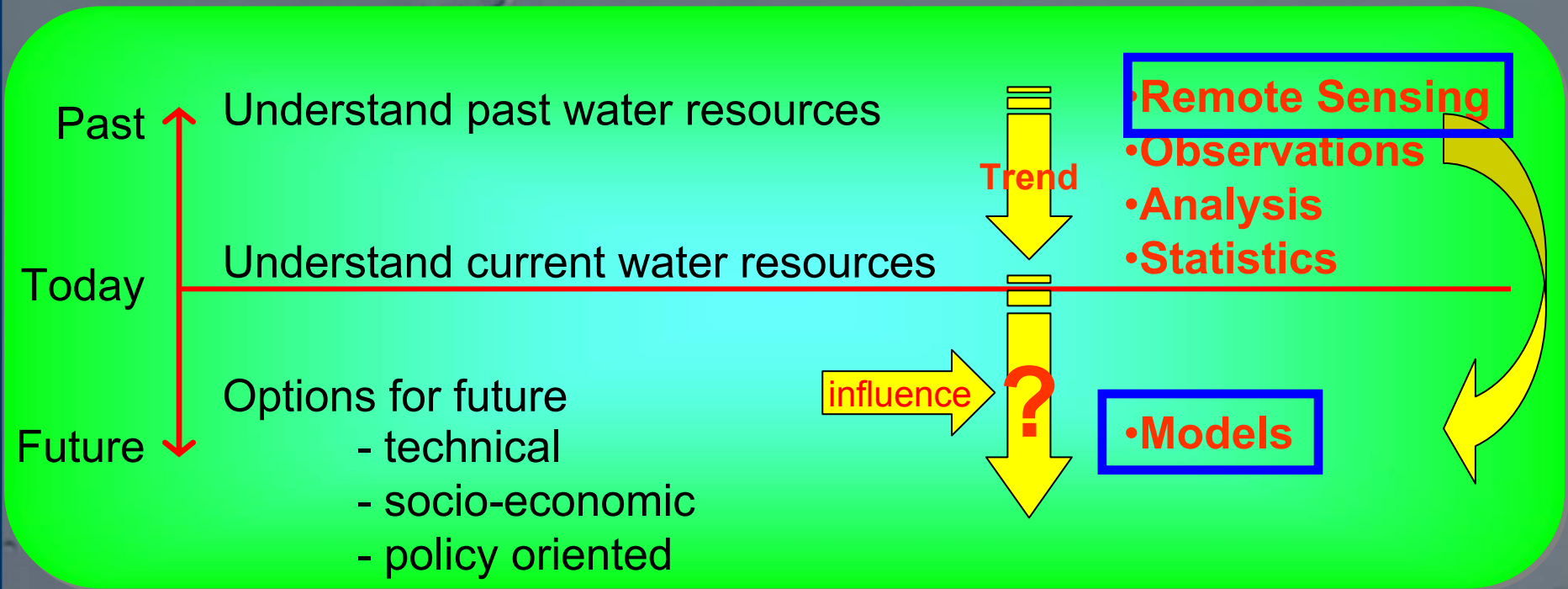
- Actual water use = water supplied.
- Water efficiency vs. water productivity.
- Water consumption (=evaporation and transpiration) from rainfed, natural vegetation or bare soils is not considered.
- Water plans: preferred policies vs. unbiased analyses.
- Forests produce water.
- **Understand better, explain clearer**



# Water Accounting vs...and Water Planning

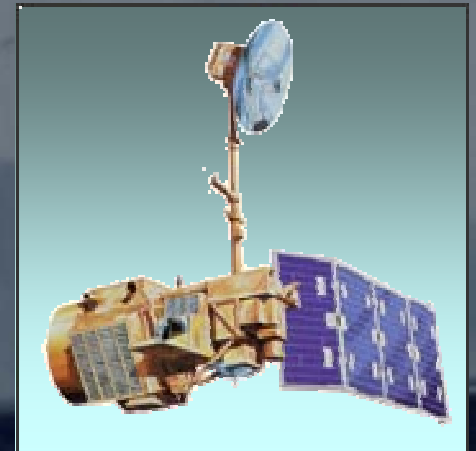


# Appropriate Tool Selection

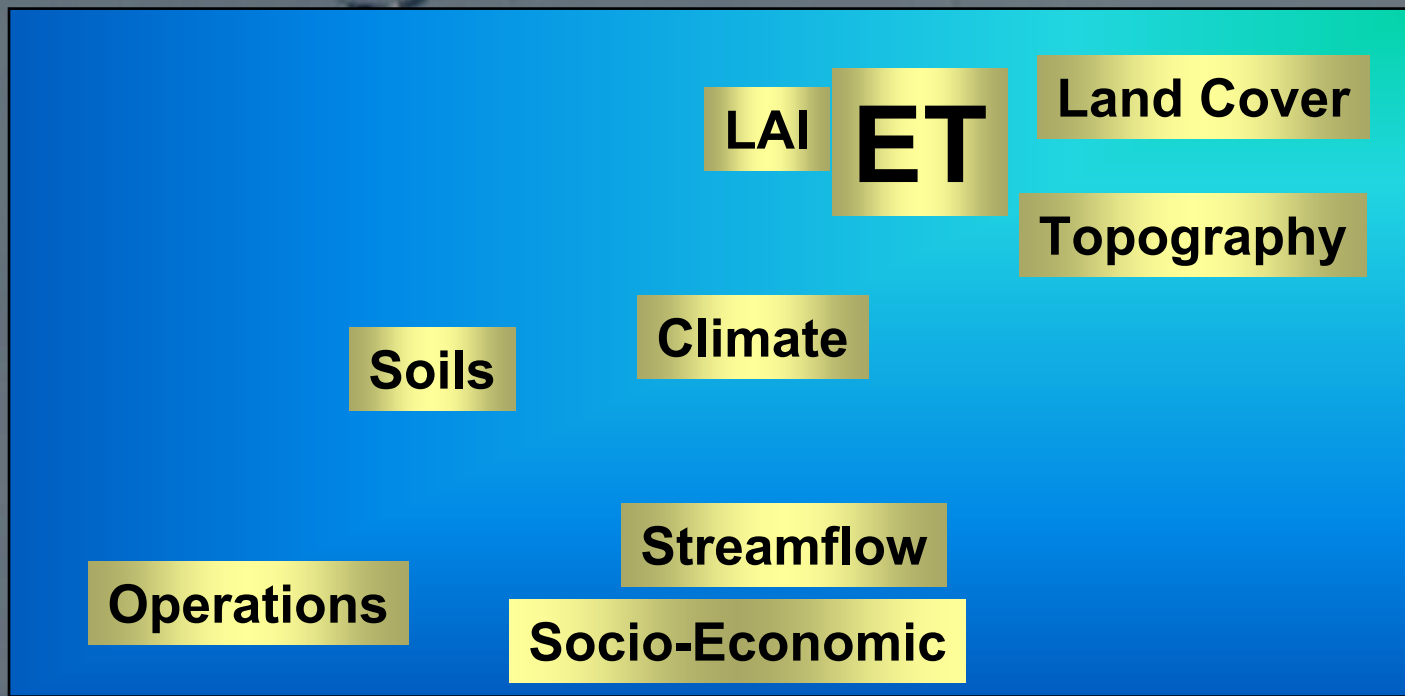




# Remote Sensing in Water Planning



# Data Sources

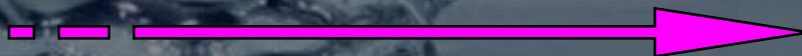


RS

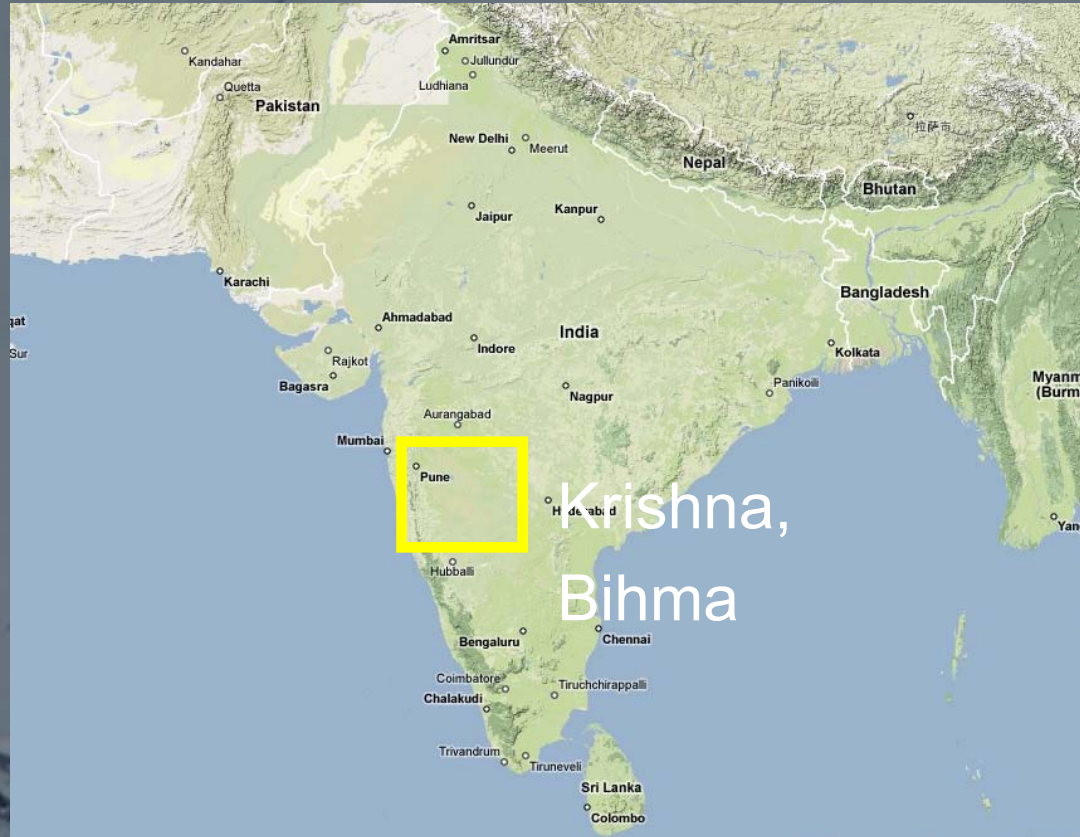


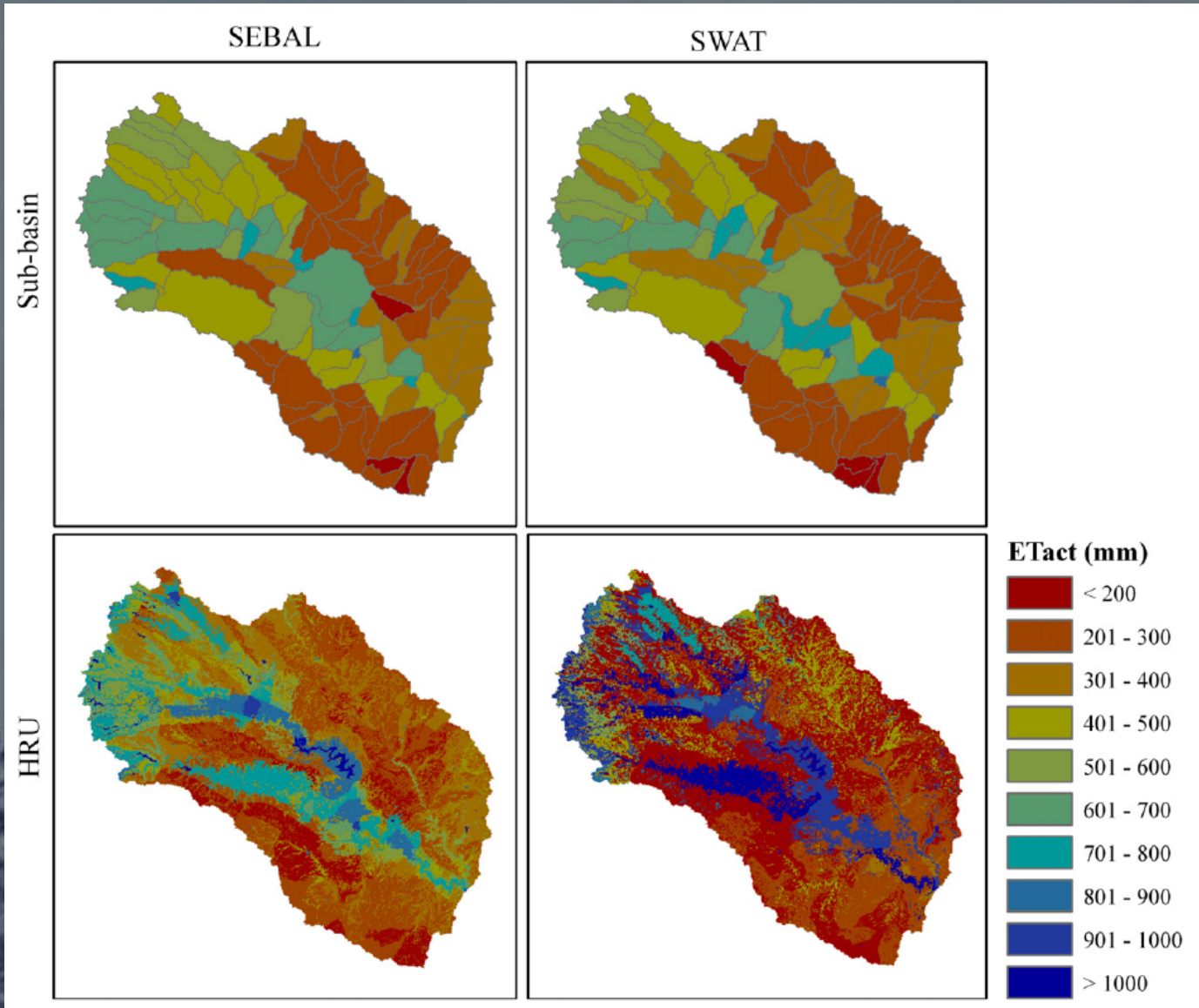
non-  
RS

locally-  
sourced

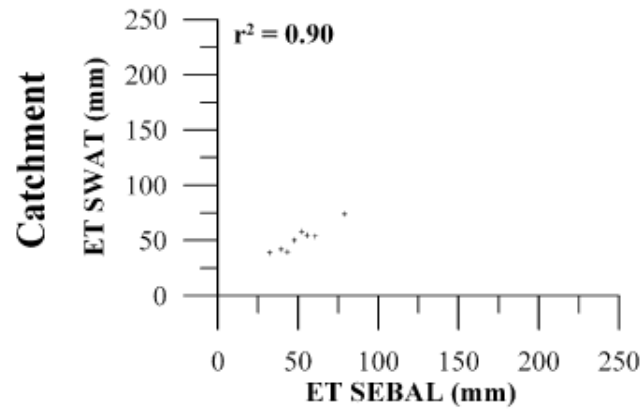


global  
public-domain

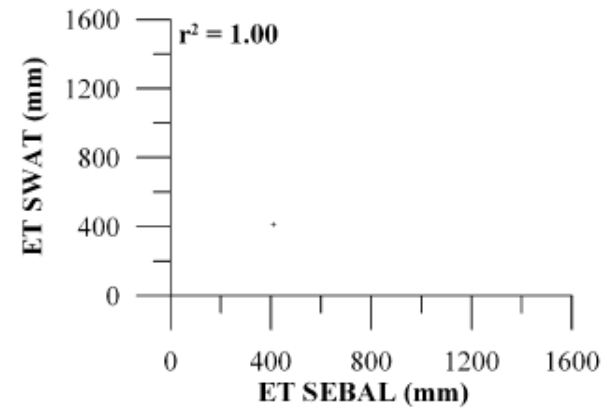




## Monthly ET<sub>act</sub>



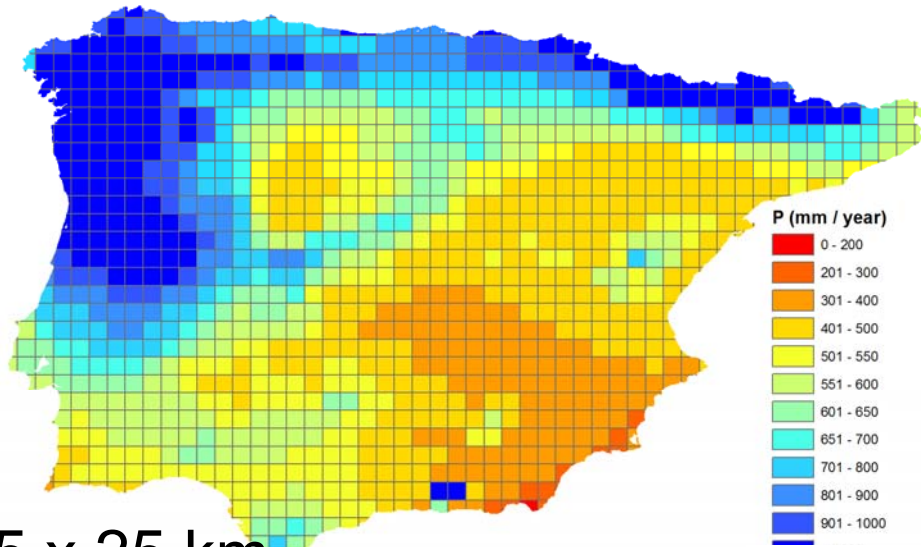
## Sum ET<sub>act</sub>



# Iberian Peninsula



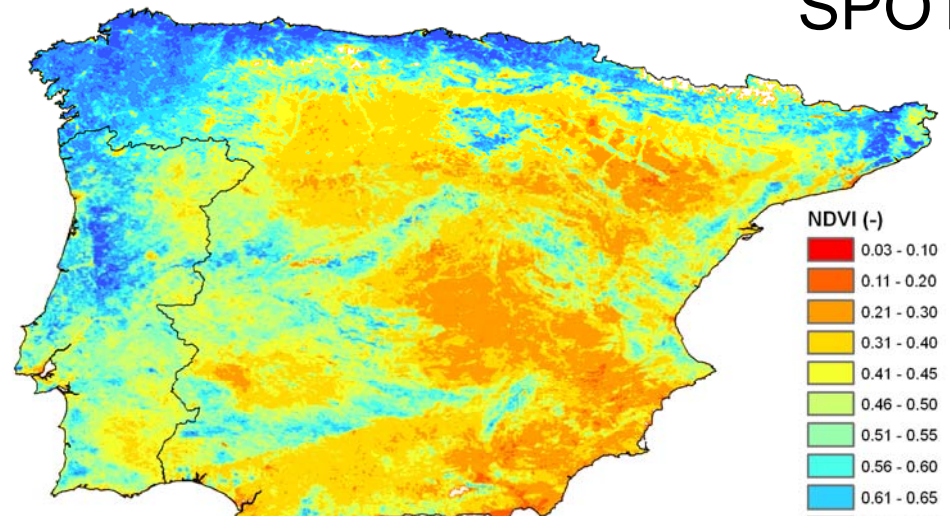
## TRMM



25 x 25 km

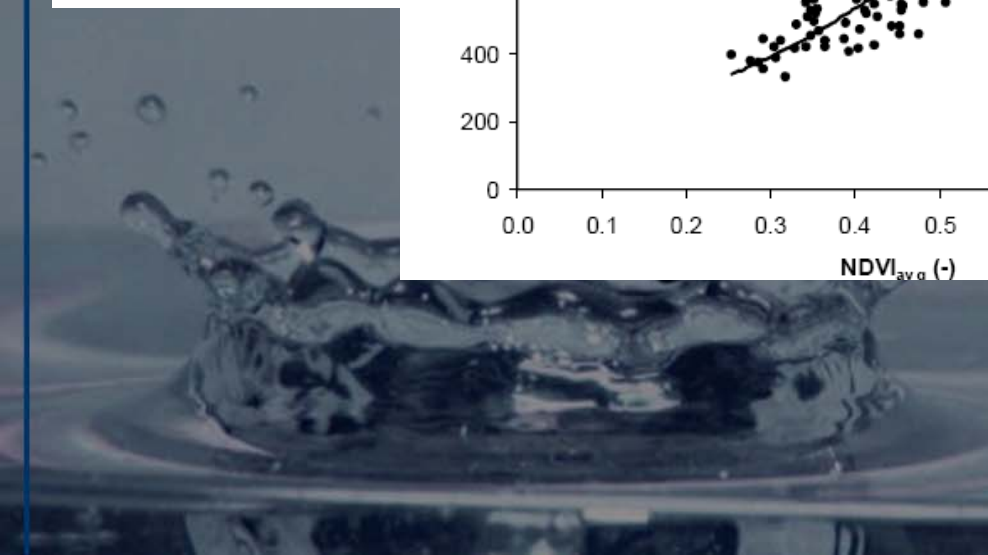
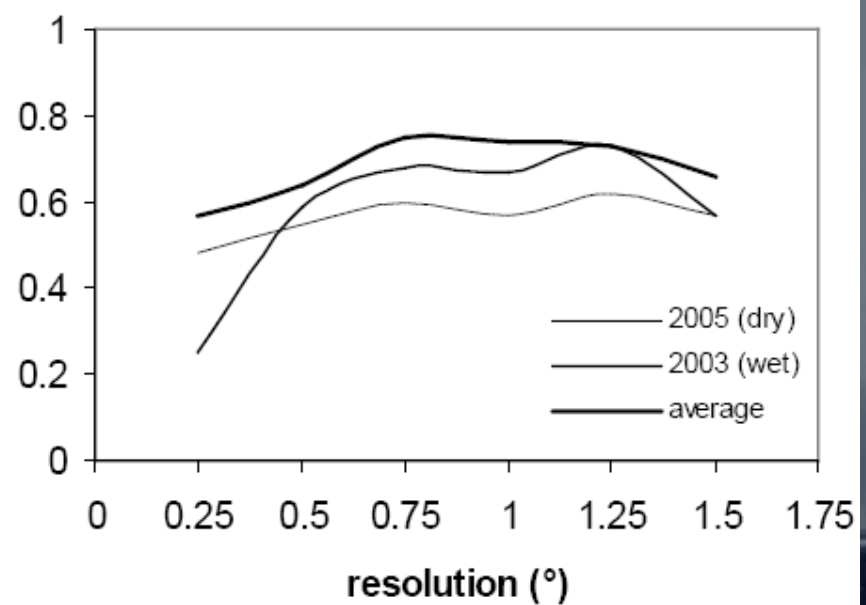
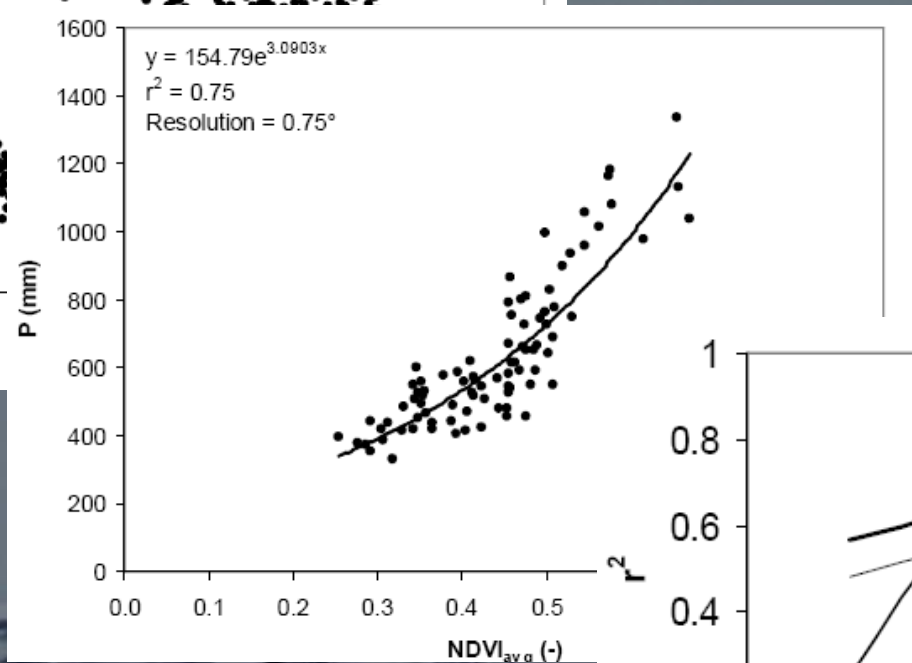
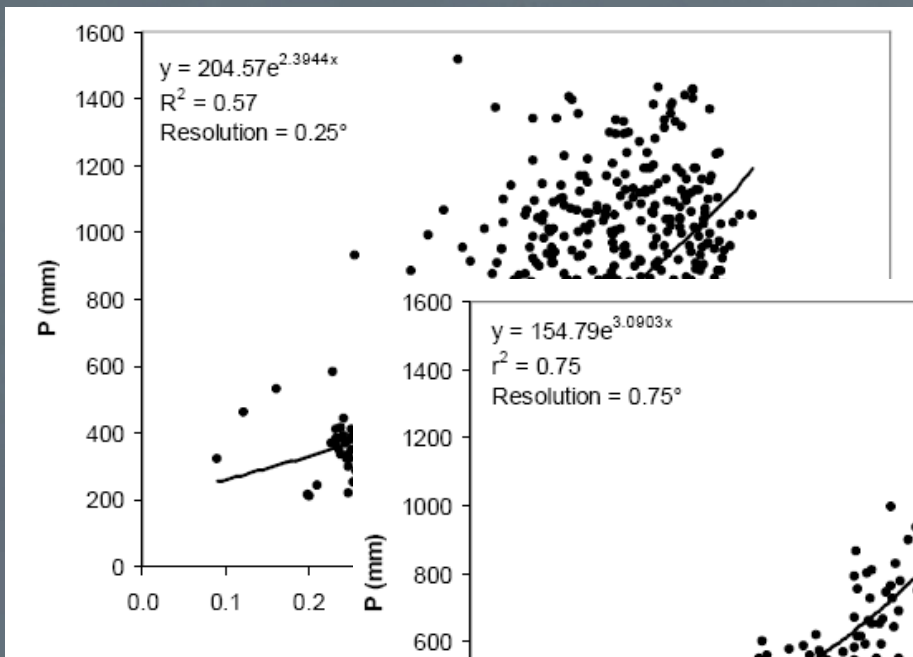


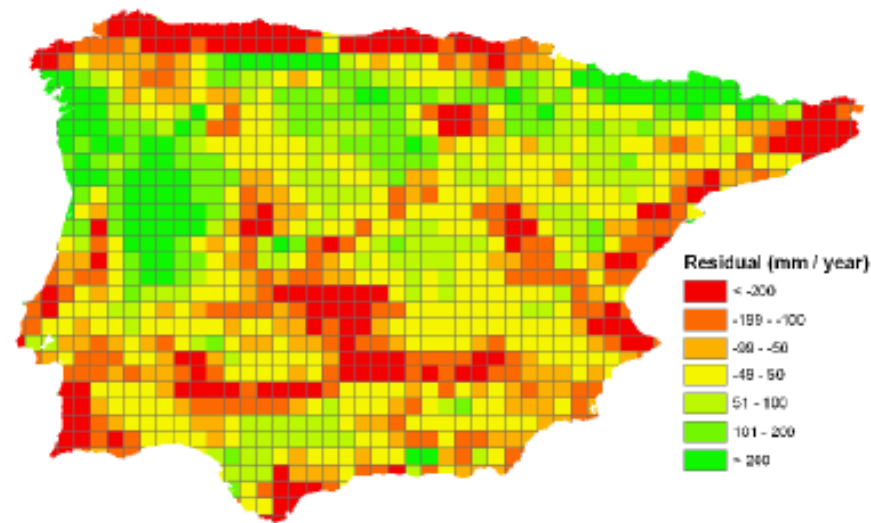
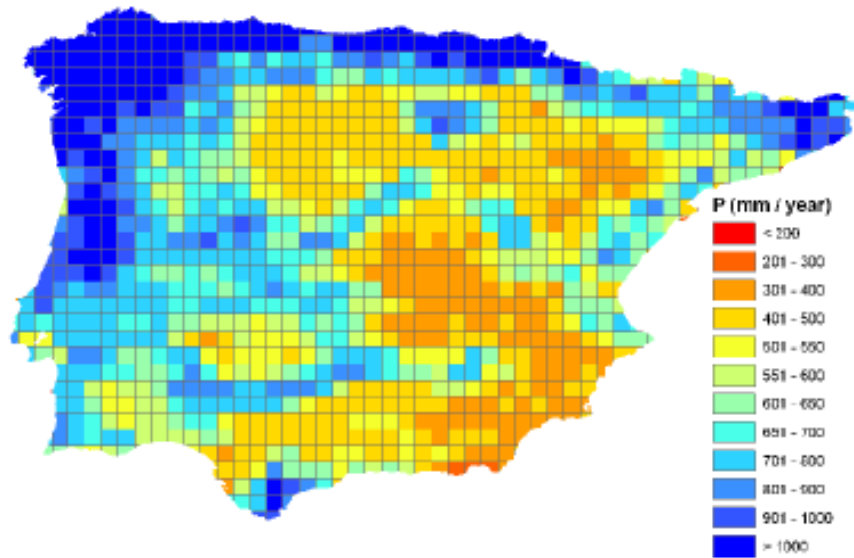
## SPOT



1 x 1 km

# Correlation TRMM - NDVI

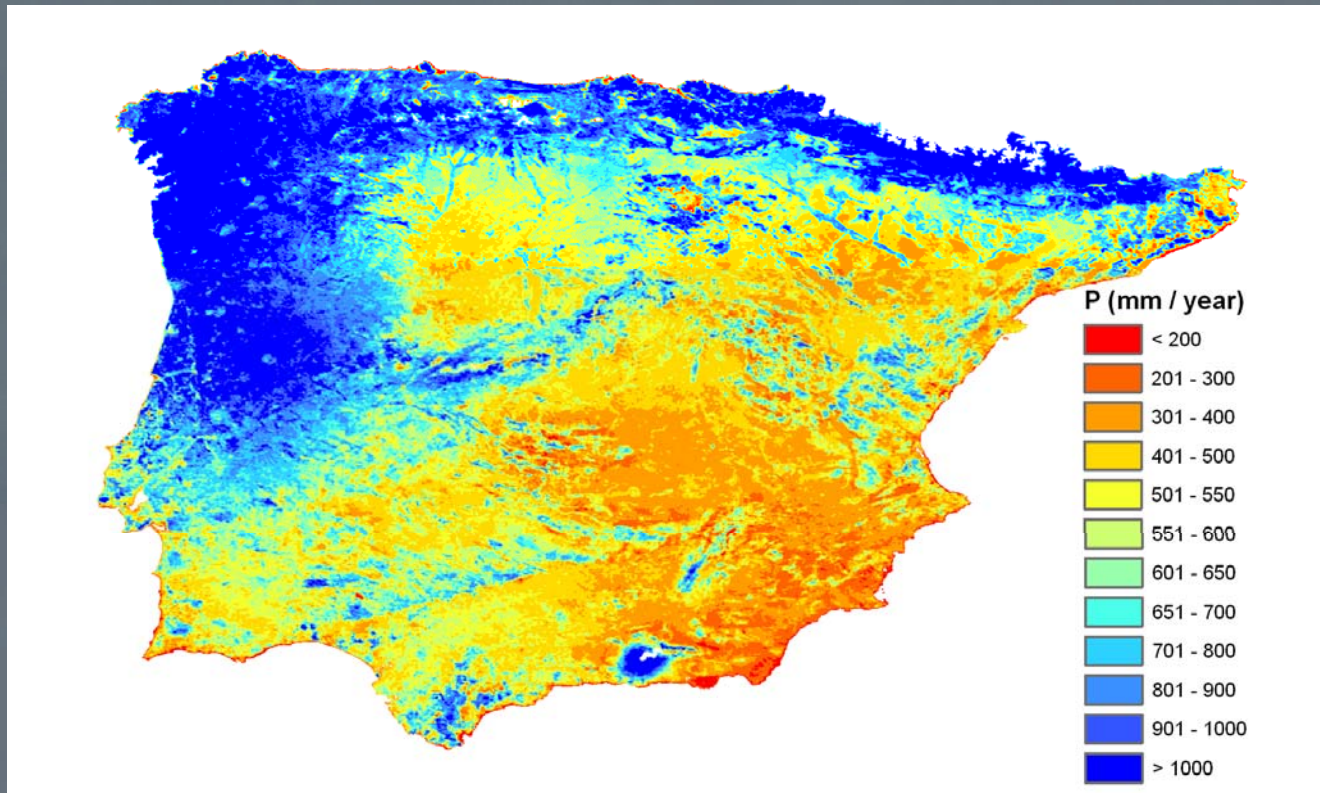




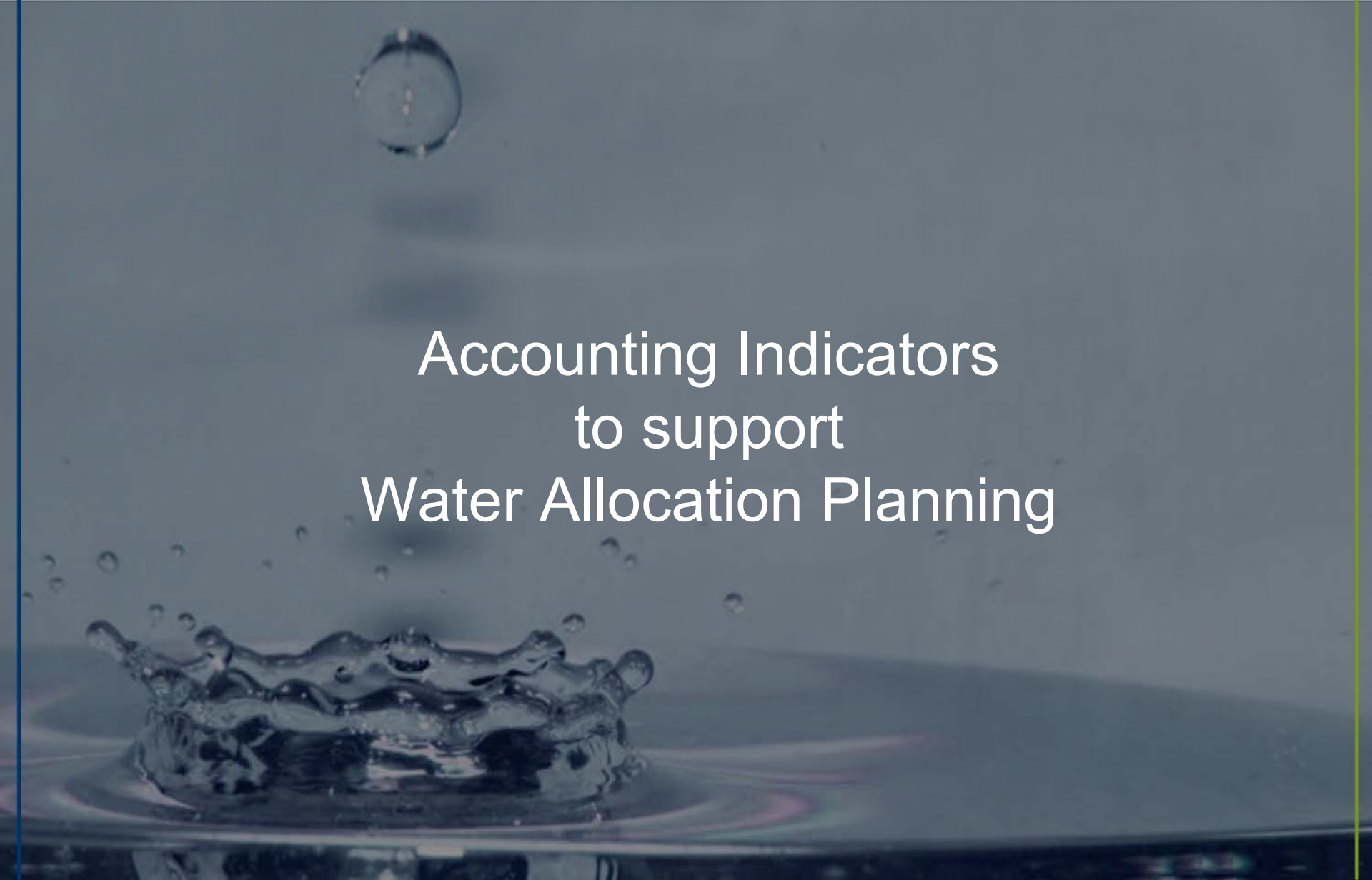
P(NDVI)

Residual =  
TRMM - P(NDVI)

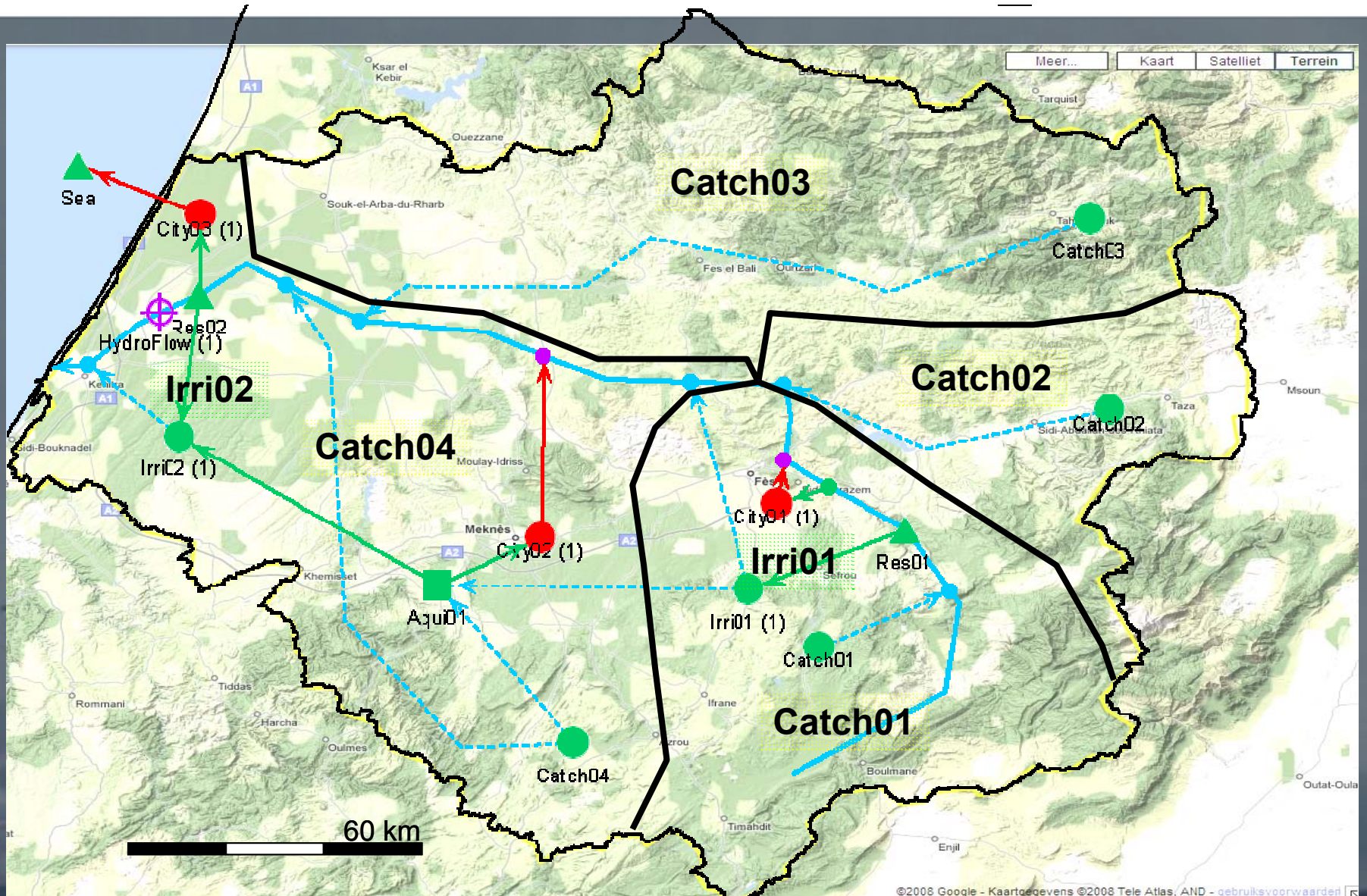
Red: unexplained high green areas  
Green: unexplained low green areas



	<b>28 stations</b>	$P_{ds}$	$P_{3B42}$
2003	$r^2$	0.78	0.47
	Bias	-0.01	-0.23
	RMSE (mm)	188	331
2005	$r^2$	0.95	0.70
	Bias	-0.03	-0.18
	RMSE (mm)	70	194

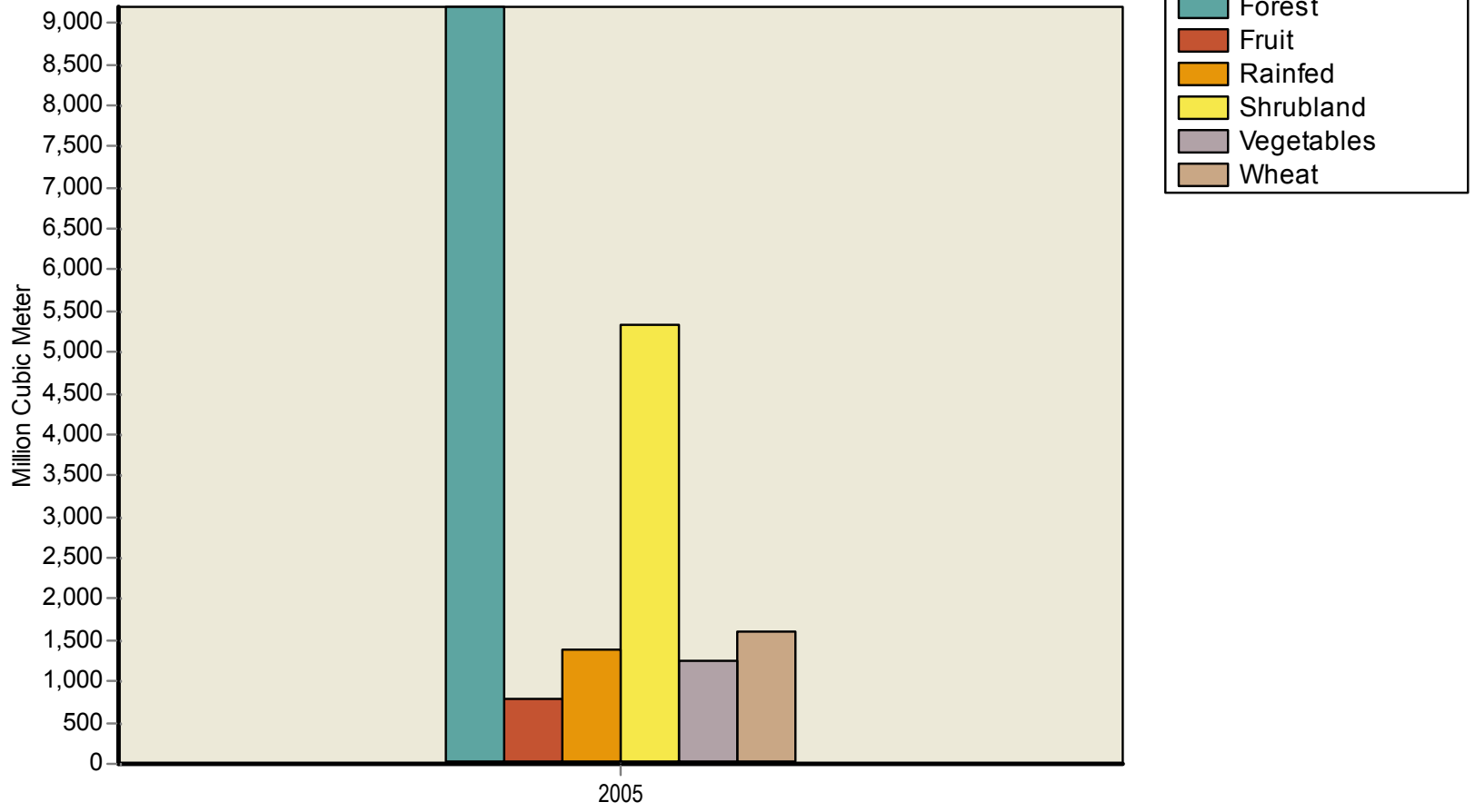
The background of the slide is a dark, monochromatic image of water splashing. A large, clear water droplet is suspended in the air above a splash of water that has just hit a surface, creating ripples and smaller droplets. The lighting highlights the texture and movement of the water.

# Accounting Indicators to support Water Allocation Planning



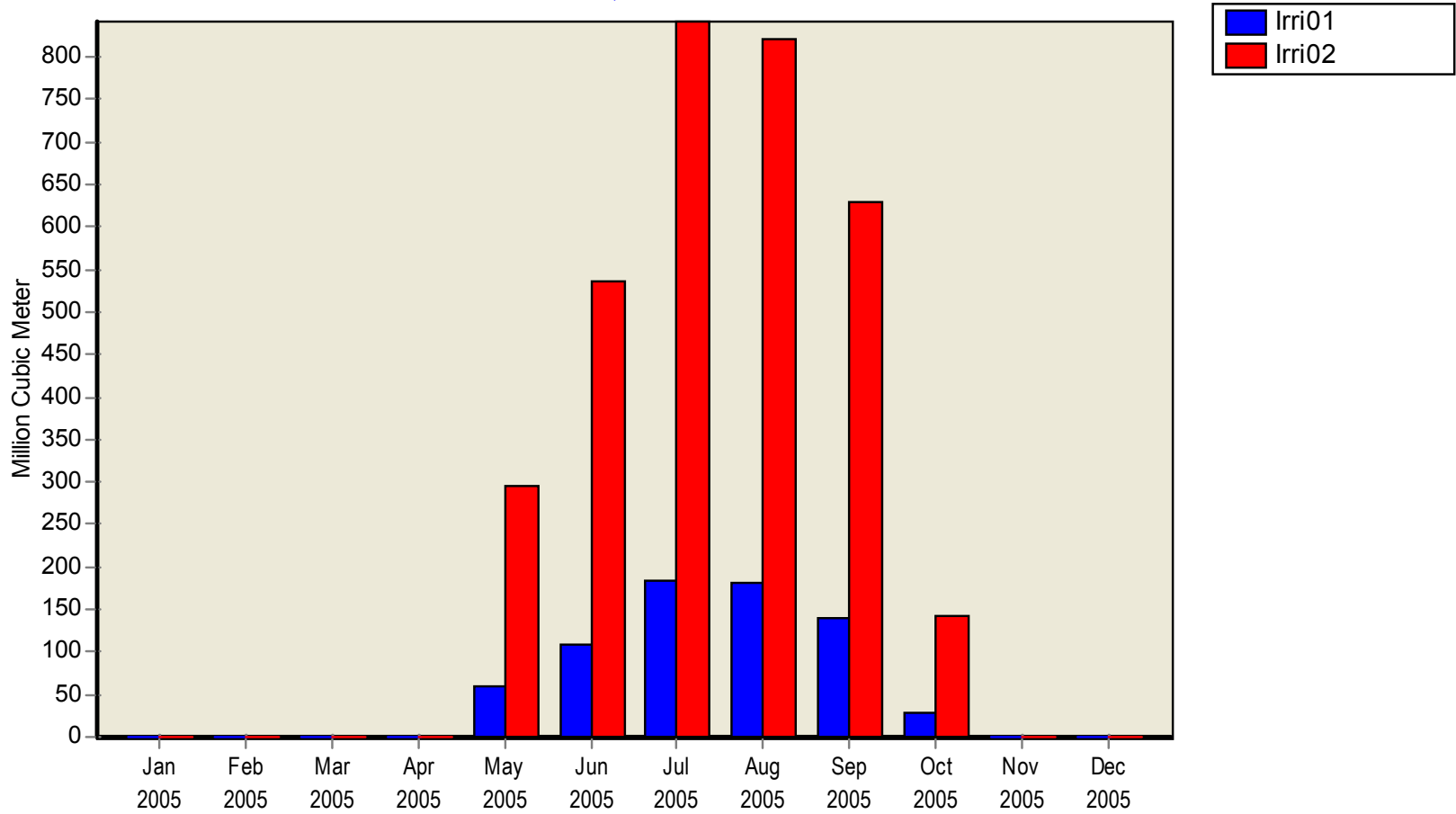


ETActual (including irrigation)  
Scenario: Actual, All months



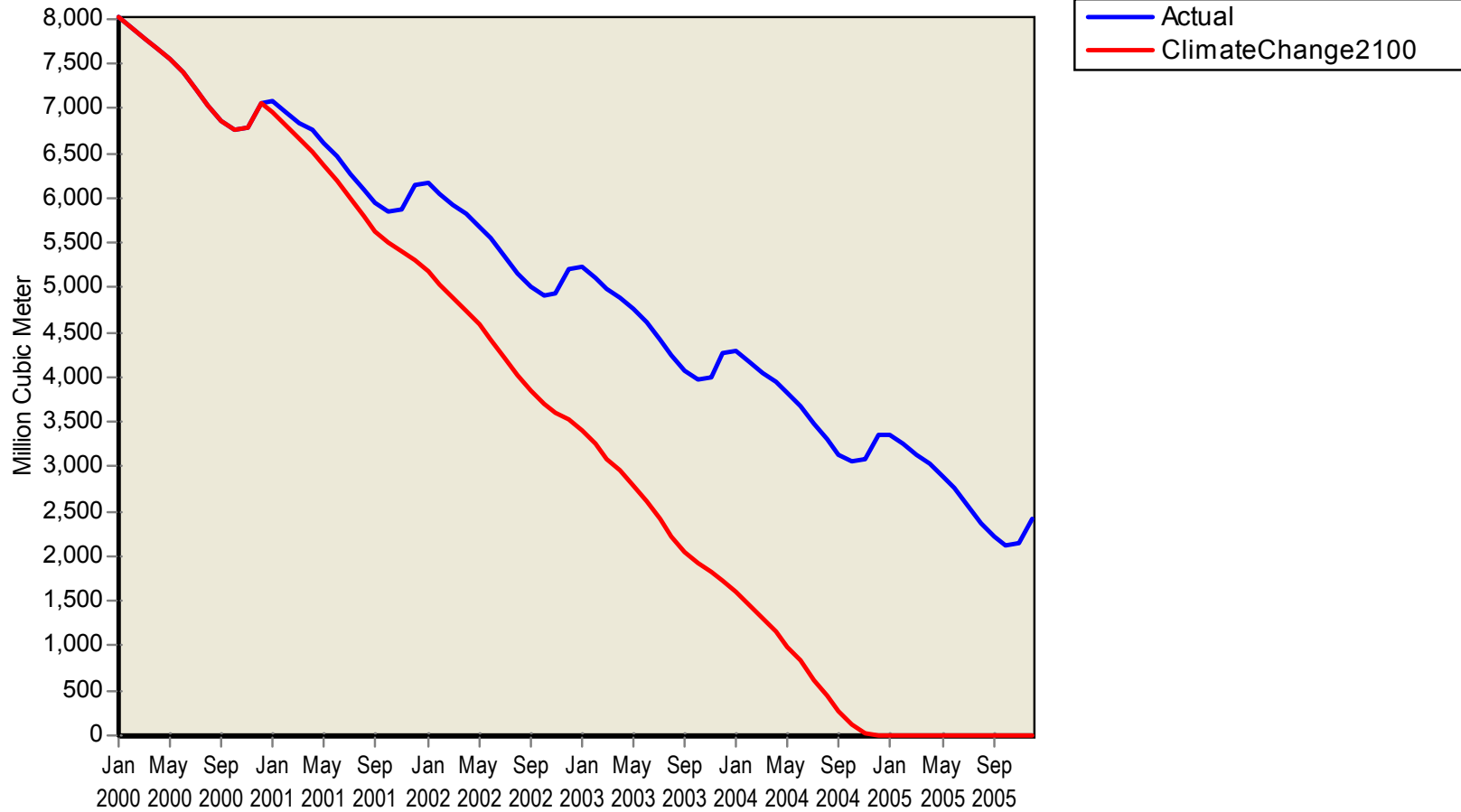


Unmet Demand  
Scenario: Actual, All months





Groundwater Storage  
All Aquifers, All months



# Indicators



<b>Basin wide</b>	<i>Base Line</i>
Total precipitation (MCM/y)	21,600
Basin outflow (MCM/y)	2,659
Reservoir changes (MCM/y)	0
Aquifer changes (MCM/y)	-931
Total consumption (MCM/y)	18,011
Unmet demand (MCM/y)	38,614
<hr/>	
<b>Irrigation</b>	
ETpotential (MCM/y)	5,076
Tactual (MCM/y)	3,094
Eactual (MCM/y)	841
Unmet (MCM/y)	1,982
<hr/>	
<b>Domestic</b>	
Demand (MCM/y)	256
Unmet demand (MCM/y)	79

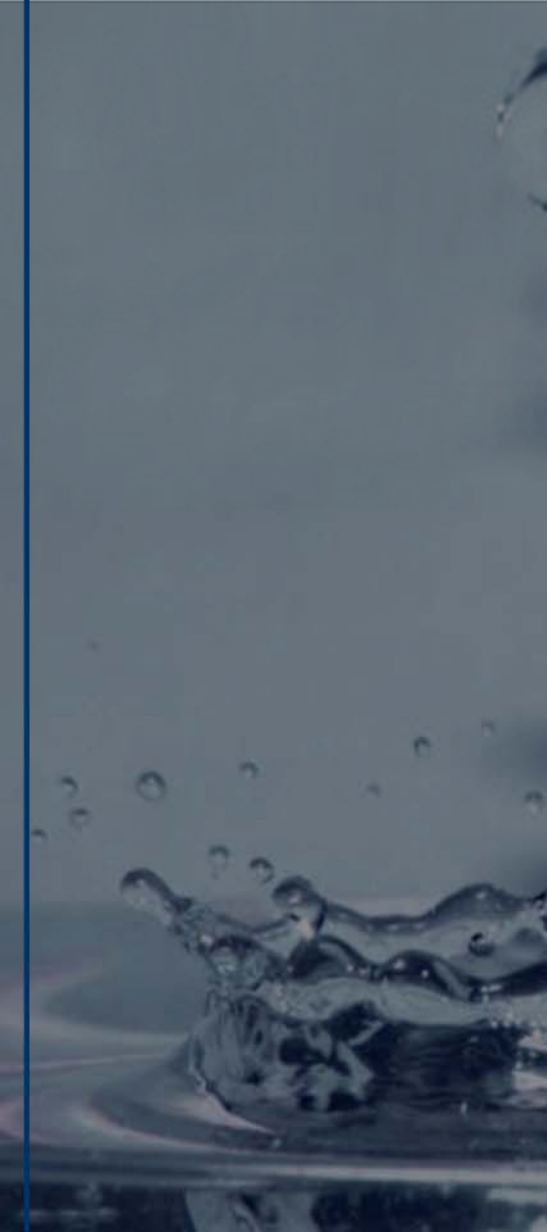


# Future Outlook





**Al Khufrah Oasis, Libya**

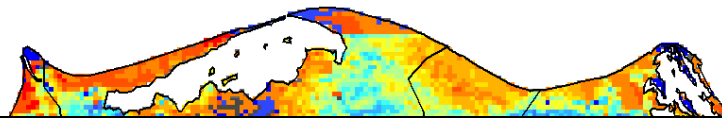




	MINISTERIO DE AGRICULTURA, PESCA Y ALIMENTACIÓN	SECRETARÍA GENERAL DE AGRICULTURA Y ALIMENTACIÓN
		DIRECCIÓN GENERAL DE DESARROLLO RURAL
<b>PLAN NACIONAL DE REGADÍOS</b> <b>PROGRAMA DE REGADÍOS EN EJECUCIÓN</b>		
PUESTA EN RIEGO DE LOS SECTORES XII AL XVI DE LA ZONA REGABLE GENIL-CABRA (CORDOBA). DESGLOSADO Nº 2 RED DE PRESIÓN.		
PLAZO DE EJECUCIÓN: 45 meses    PRESUPUESTO: 39.917.311,24 €    CONSTRUYE: 		
	<b>PROYECTO COFINANCIADO POR LA UNIÓN EUROPEA</b> FEOGA ORIENTACIÓN	

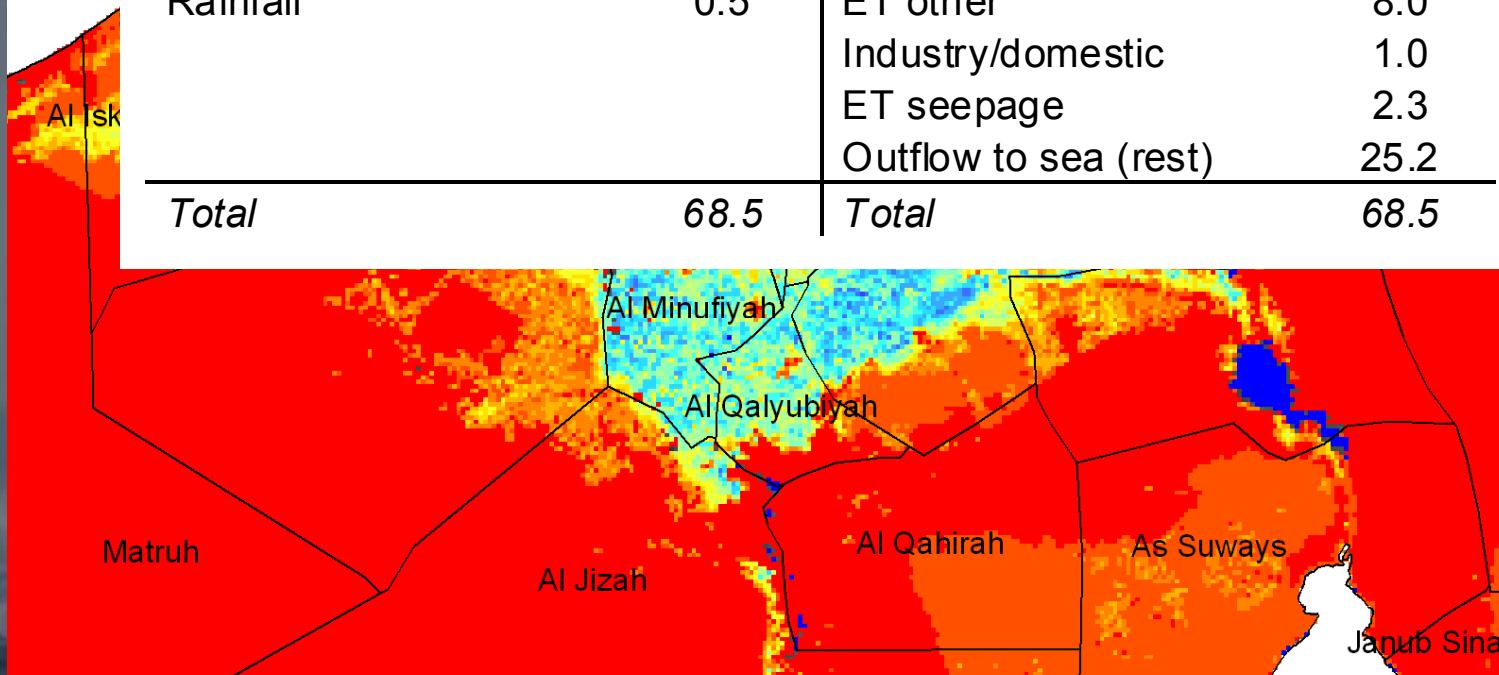


# Nile Basin, Egypt



In (km <sup>3</sup> )		Out (km <sup>3</sup> )	
Outflow Aswan	68.0	ET irrigation	32.0
Rainfall	0.5	ET other	8.0
		Industry/domestic	1.0
		ET seepage	2.3
		Outflow to sea (rest)	25.2
<b>Total</b>	<b>68.5</b>	<b>Total</b>	<b>68.5</b>

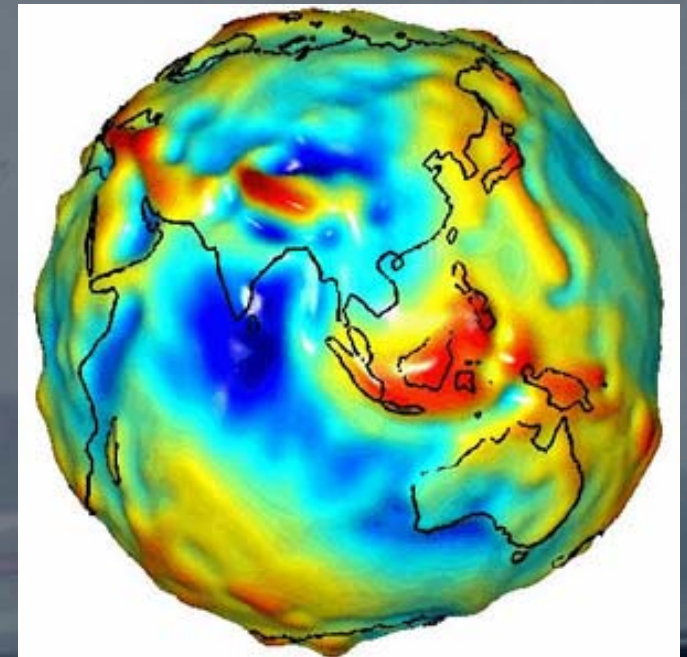
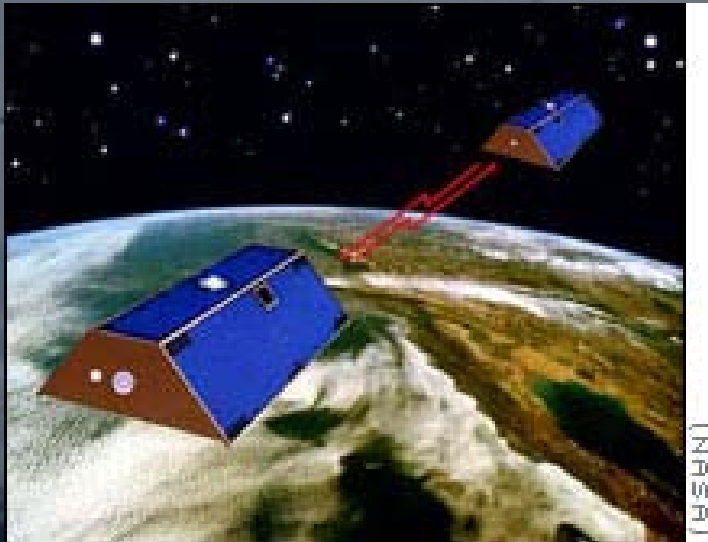
mm / year



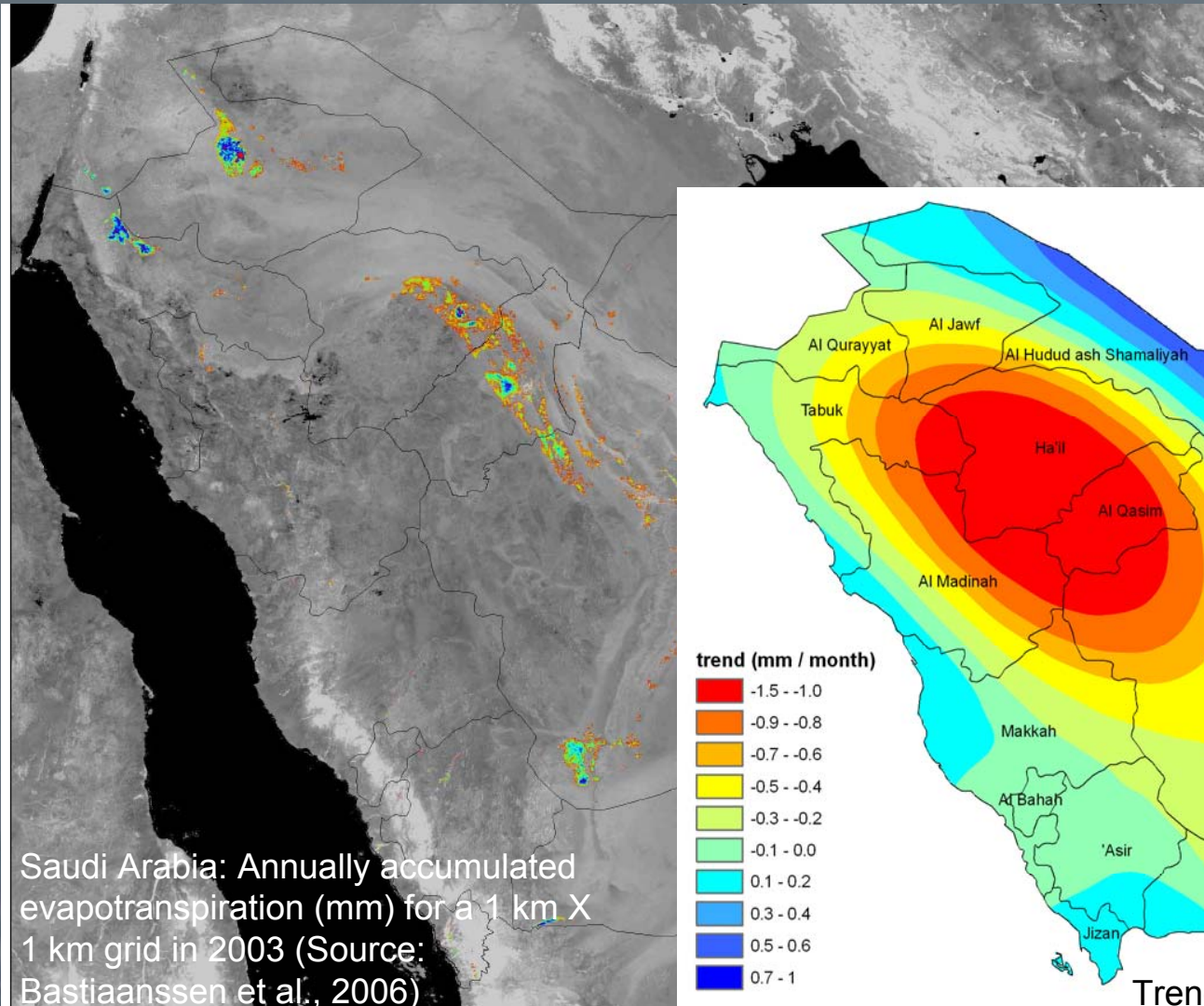
# Satellite observations: groundwater (GRACE)



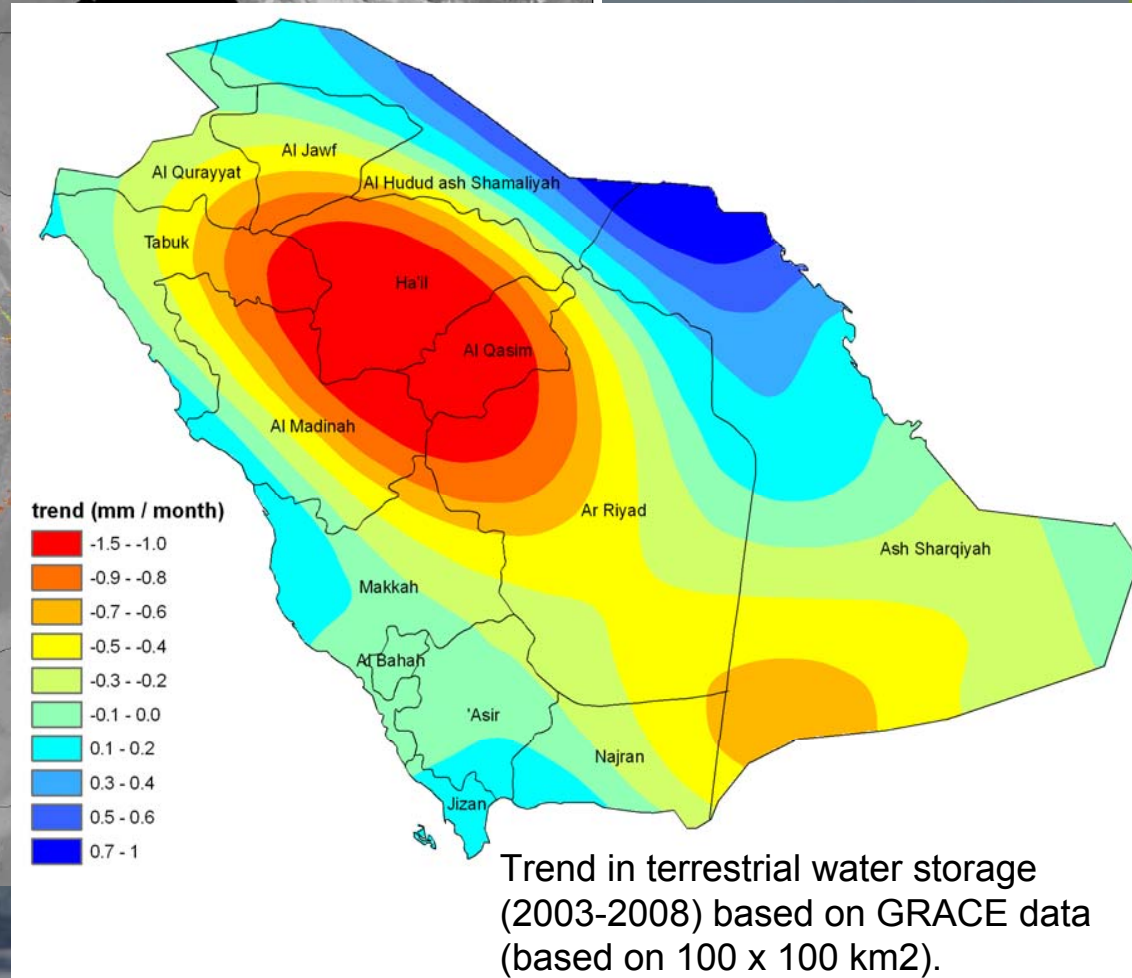
- GRACE: Gravity Recovery and Climate Experiment
  - NASA satellite
  - Two satellites, co-orbiting at 300-500 km altitude
  - Separated along track by 220 km
  - Launched March 2002



# Saudi Arabia



Saudi Arabia: Annually accumulated evapotranspiration (mm) for a 1 km X 1 km grid in 2003 (Source: Bastiaanssen et al., 2006)





- Lack of understanding (by confusing terminology)
- Backward – forward approach
- Scenario approach
- Water accounting vs. Future accounting



Thank You

