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WATERE RESOURCES IN COASTAL AREA

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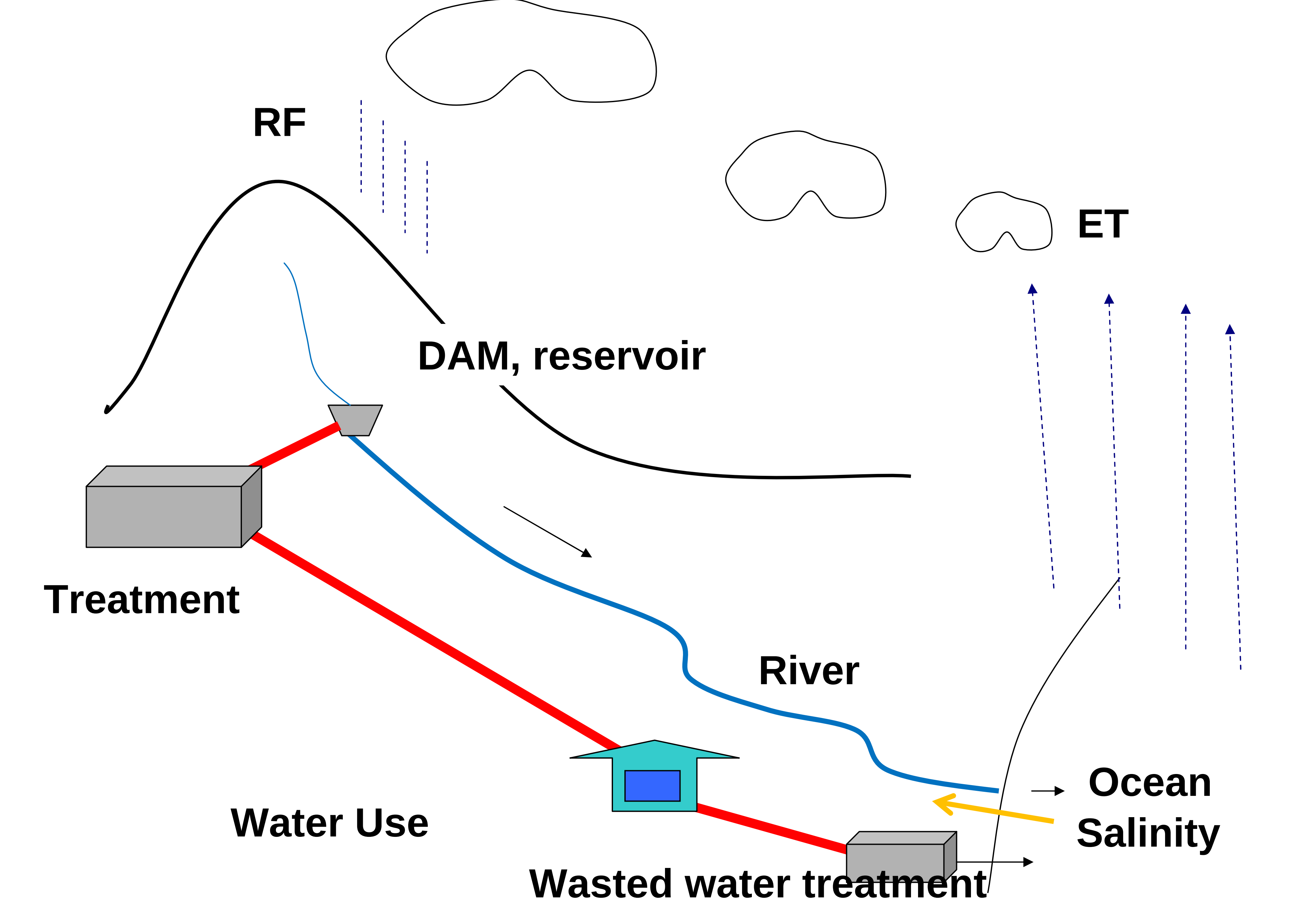
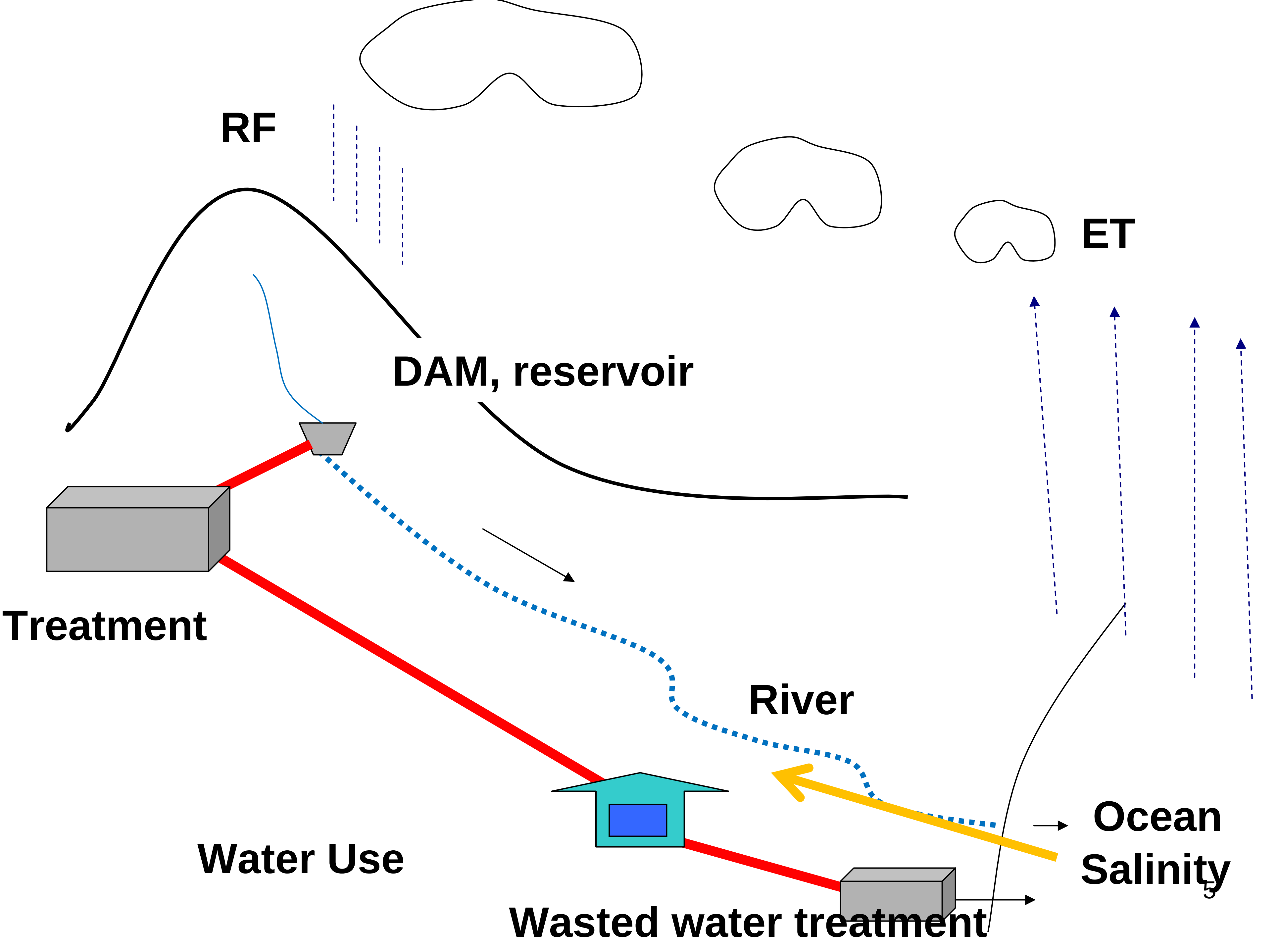
1. Introduction

- Coastal areas are :
- Fertile lands are suitable for agriculture and much food production in delta areas.
- Dense population produces industrial production with high economic system for long time.
- Developments demand more water resources and groundwater because of stable amount and quality.


Industrial areas
Port
Fish culture
Rich Ecosystem
七北田川
Blackish water
南蒲生

Photo: MLITT


RF
ET
DAM, reservoir
Treatment
River
Ocean
Salinity
Water Use
Wasted water treatment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1. Introduction

- Potential effects of global climate change and urbanization on groundwater resources are tried to investigated.

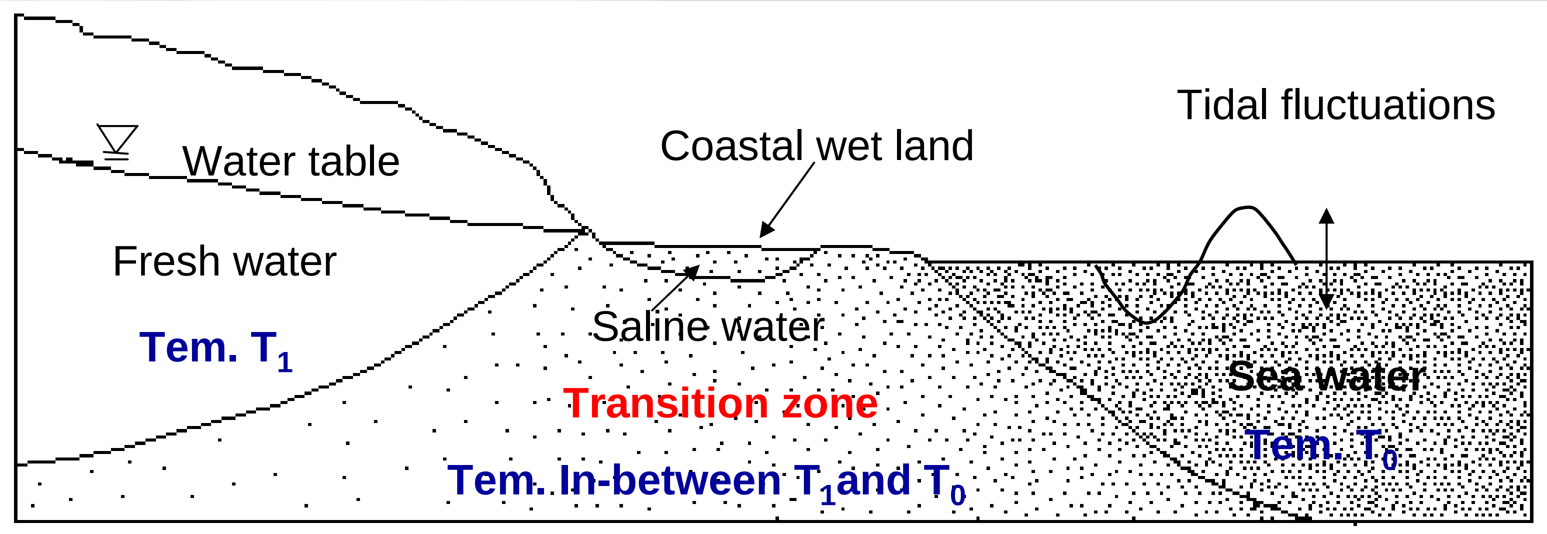
- From an ecological point of view, the metabolic rates of organisms and the overall productivity of ecosystems are directly regulated by fresh and salinity waters.

- Change in groundwater level will alter fundamental ecological processes and the geographic distribution of aquatic species in groundwater-dominated coastal wetlands, estuaries and ponds

(Lee and Bell 1999, Oltra and Todoli 1997, Oie and Olsen 1993).

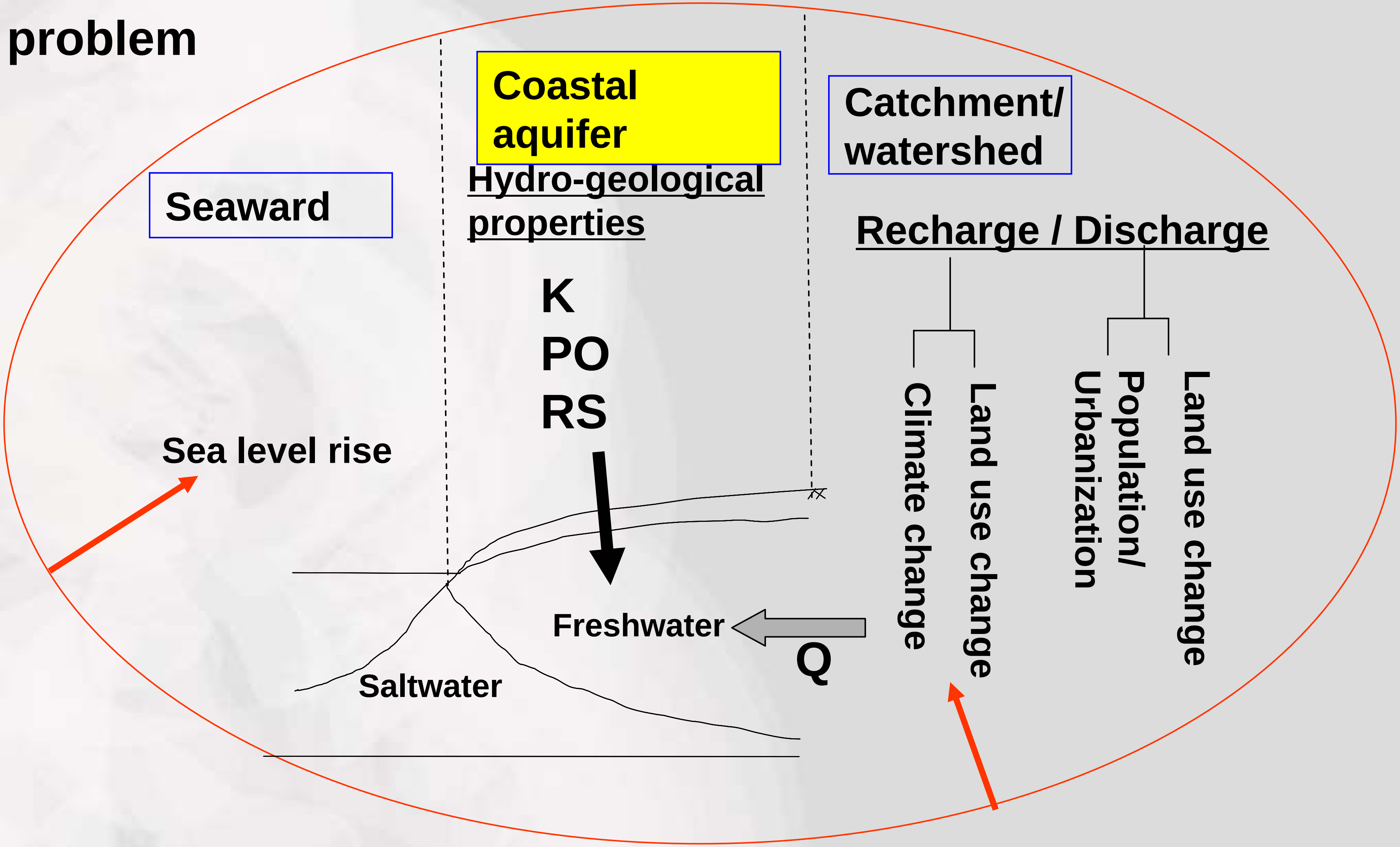
- Factors that regulate the groundwater resources
  - Hydrological processes due to land use change
  - Sea water intrusion due to tidal effects

The freshwater and saltwater within coastal aquifers are separated by a transition zone within which there is mixing between freshwater and saltwater



To proposed a methodology to evaluate the climate change effects on coastal aquifers.

Overview of the problem



Global warming

Suitable approach for a global scale evaluation…????

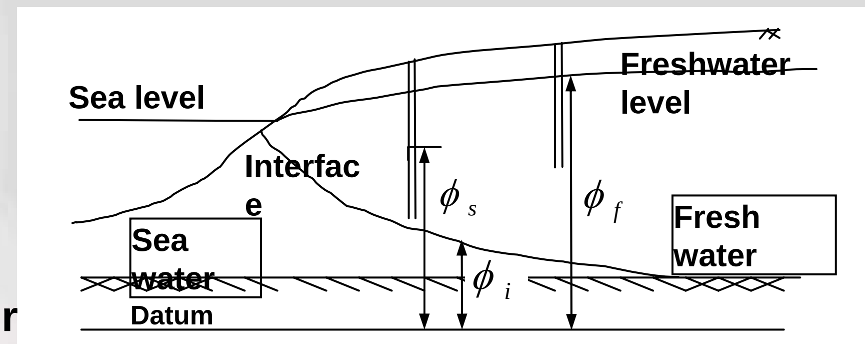
Numerical modeling of sharp interface

- Two fluids are separated by a sharp interface
- Continuity of flux and pressure (Groundwater flow principles)

$$\left[S_f B_f + n(\alpha+\delta)\right]\frac{\partial \phi_f}{\partial t} - n(1+\delta)\frac{\partial \phi_S}{\partial t} = \frac{\partial}{\partial x}\left(B_f K_{fX}\frac{\partial \phi_f}{\partial x}\right) + \frac{\partial}{\partial y}\left(B_f K_{fy}\frac{\partial \phi_f}{\partial y}\right) + Q_f + Q_{1f}$$

$$\left[S_S B_S + n(1+\delta)\right]\frac{\partial \phi_S}{\partial t} - n\,\delta\frac{\partial \phi_f}{\partial t} = \frac{\partial}{\partial x}\left(B_S K_{SX}\frac{\partial \phi_S}{\partial x}\right) + \frac{\partial}{\partial y}\left(B_S K_{Sy}\frac{\partial \phi_S}{\partial y}\right) + Q_S + Q_{1S}$$

$$\phi_i = \frac{\rho_s}{\rho_s - \rho_f}\phi_s - \frac{\rho_f}{\rho_s - \rho_f}\phi_f$$



ρ_f, ρ_s - specific weight in fresh and salt water

ϕ_f ϕ_s - piezometric heads of freshwater and saltwater

Q_f , Q_s - flow rate in fresh and salt water respectively

K_f , K_s - hydraulic conductivity in fresh and salt water

B_f , B_S - freshwater and saltwater saturated thickness

S_f , S_s - storage coefficient in fresh and salt water

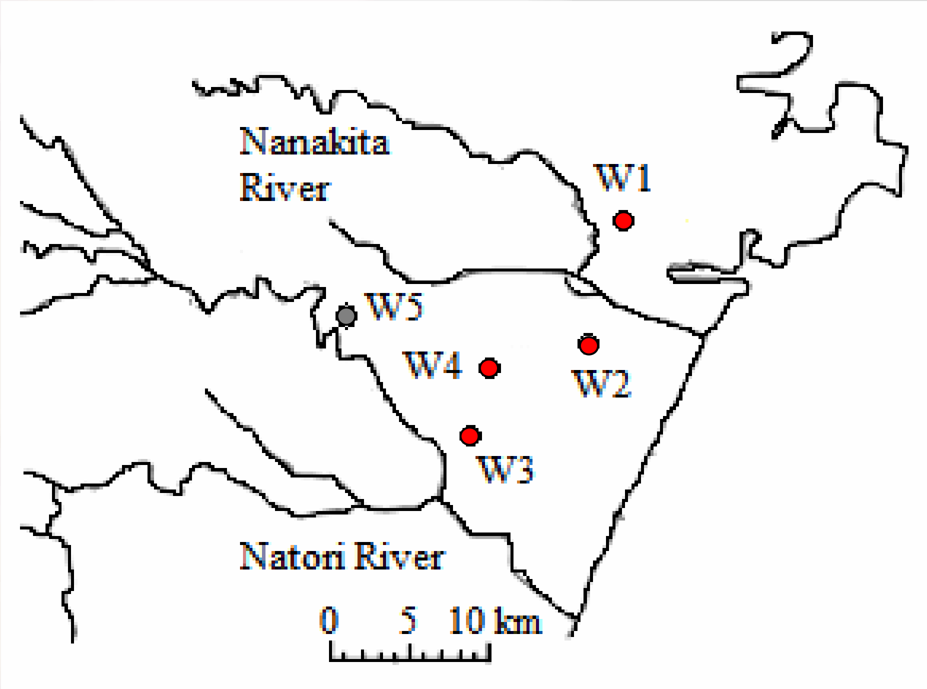
θ - porosity of the aquifer media

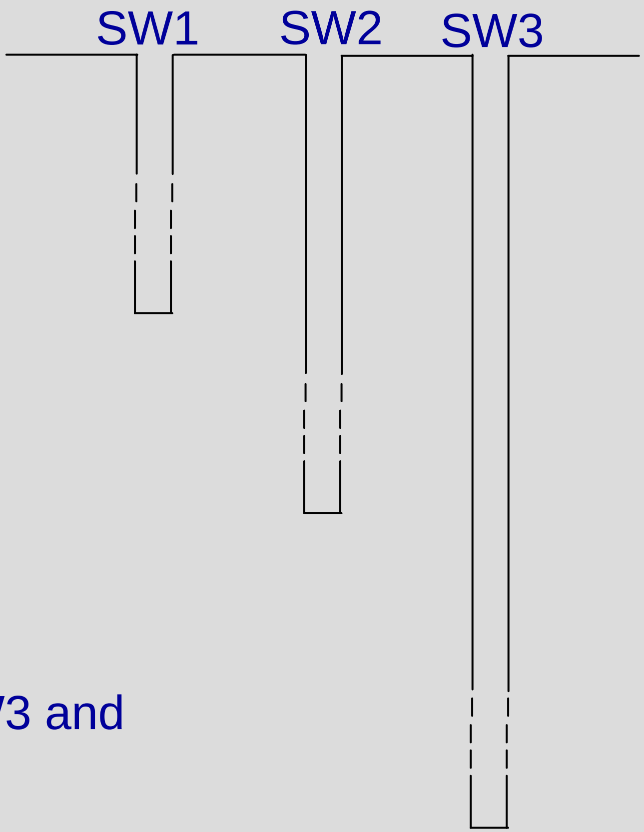
Numerical methods..

- Strongly Implicit Procedure (SIP) Remson (1971)

convenient in computational point of view with rapid convergence

1. *Natori River Basin, Japan*

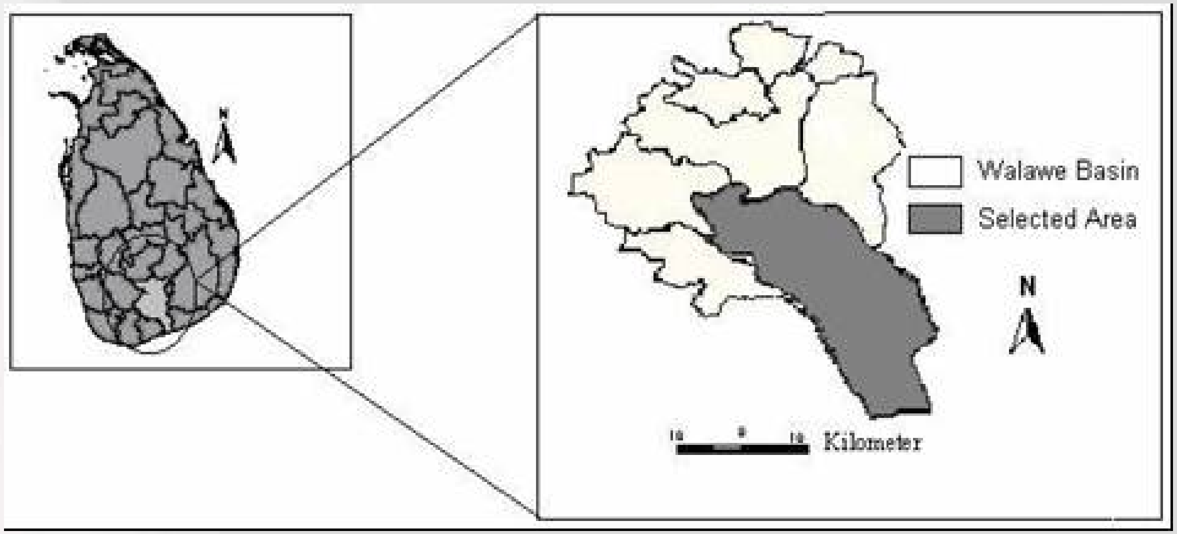




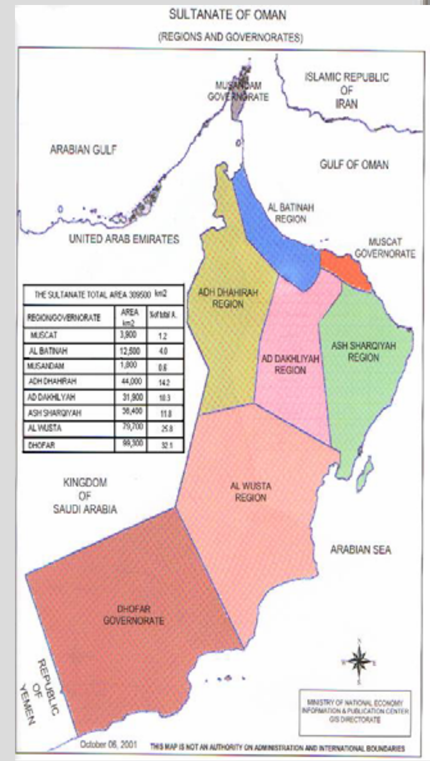
- 1-Hr temperature and quality records at W1, W2, W3 and W4
- 1-Hr water level records at all well points

2. Walawe river basin, Sri Lanka (semi arid area)

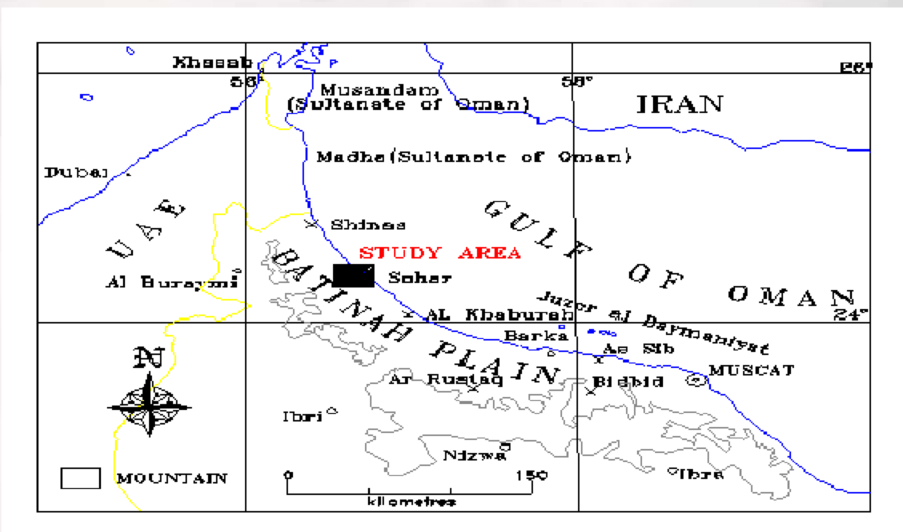
- The lower part of the Walawe river basin located in the southern coastal aquifer
- 'Coastal Plains' : coastal alluvial soils and laterites cover the area parallel to the coast (unconsolidated alluvial includes river sediments and fine to medium sand, quartzite sand, silty sands and grey to dark grey beach sands)
- Hydraulic conductivity : $10^{-3} \sim 10^{-4}$ m/s (10m/day ~ 100m/day)



3. *Al Batinah coastal plain, Oman*



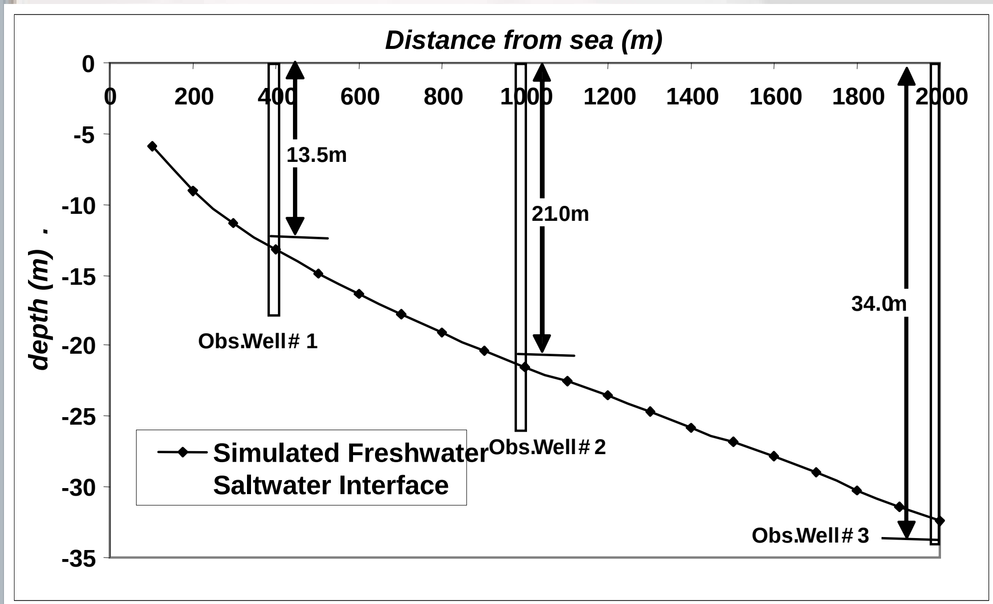
- Al Batinah coastal plain extends 270 km along the Gulf of Oman from Muscat to UAE border.
- The Batinah Coast is the most important area and the main agricultural area of Oman, where one third of the population and half of the farm land are concentrated.
- The lowland and coastal plain areas consist mainly: coarse sand, gravels, and boulders with occasional cemented beds.



Walawe river basin

Model Calibration

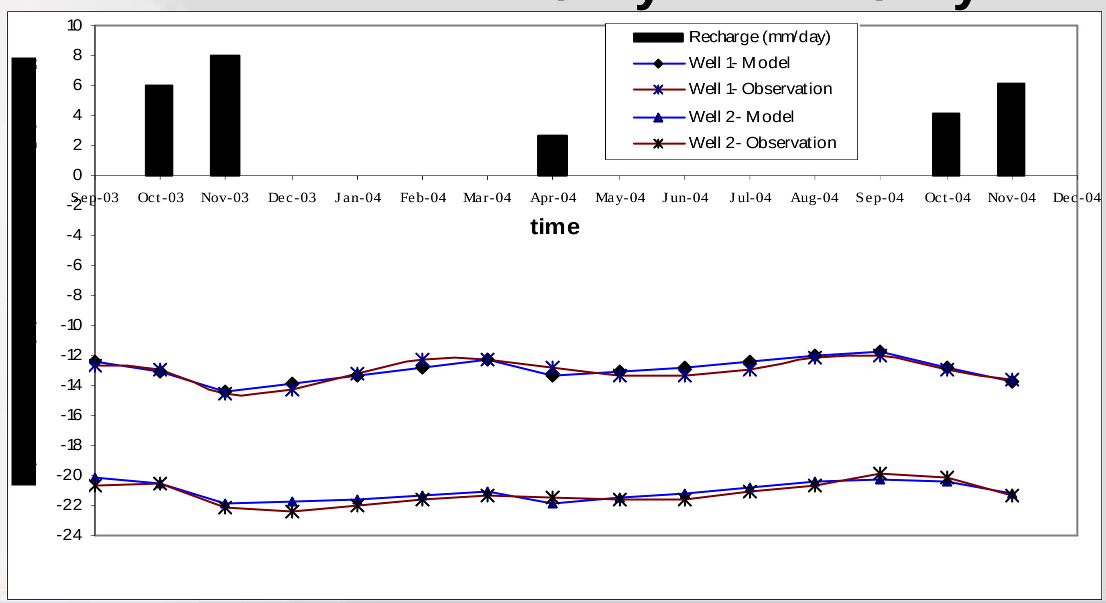
Average profile of Sep-Dec 2003



- **Sharp interface is represented by 50% salinity profile**
- **Hydraulic conductivity was adjusted to match the modeled interface with field observation.**
- **K : 10m/day ~ 100 m/day**

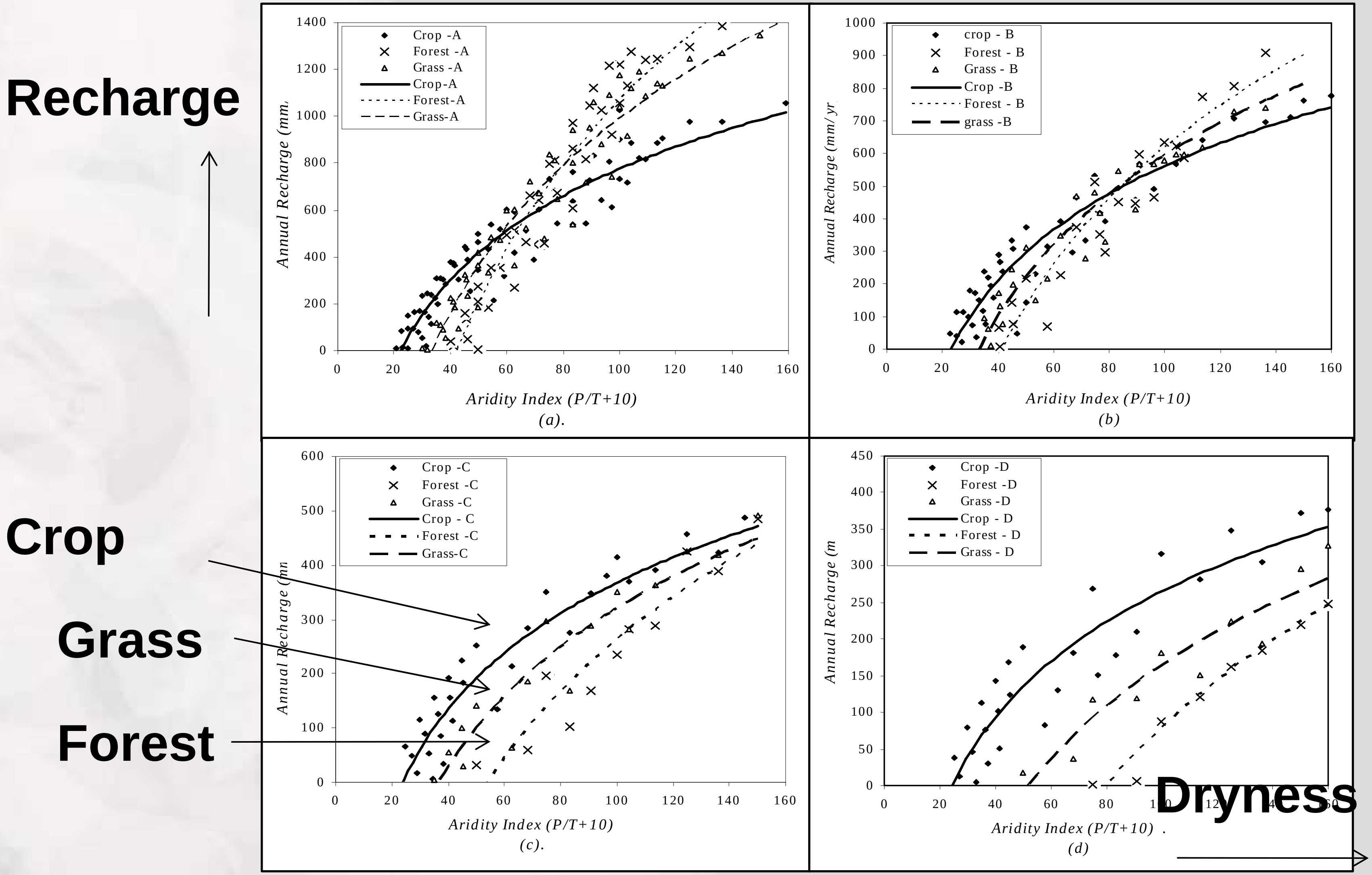
Verification with long term observation

(Sep 2003 – Nov 2004)



Recharge events associated to lower the interface

Groundwater recharge R = *f* (AI, LU, Soil)



Relation between aridity index and groundwater recharge for land use patterns and hydrologic soil groups (a) A, (b) B, (c) C and (d) D

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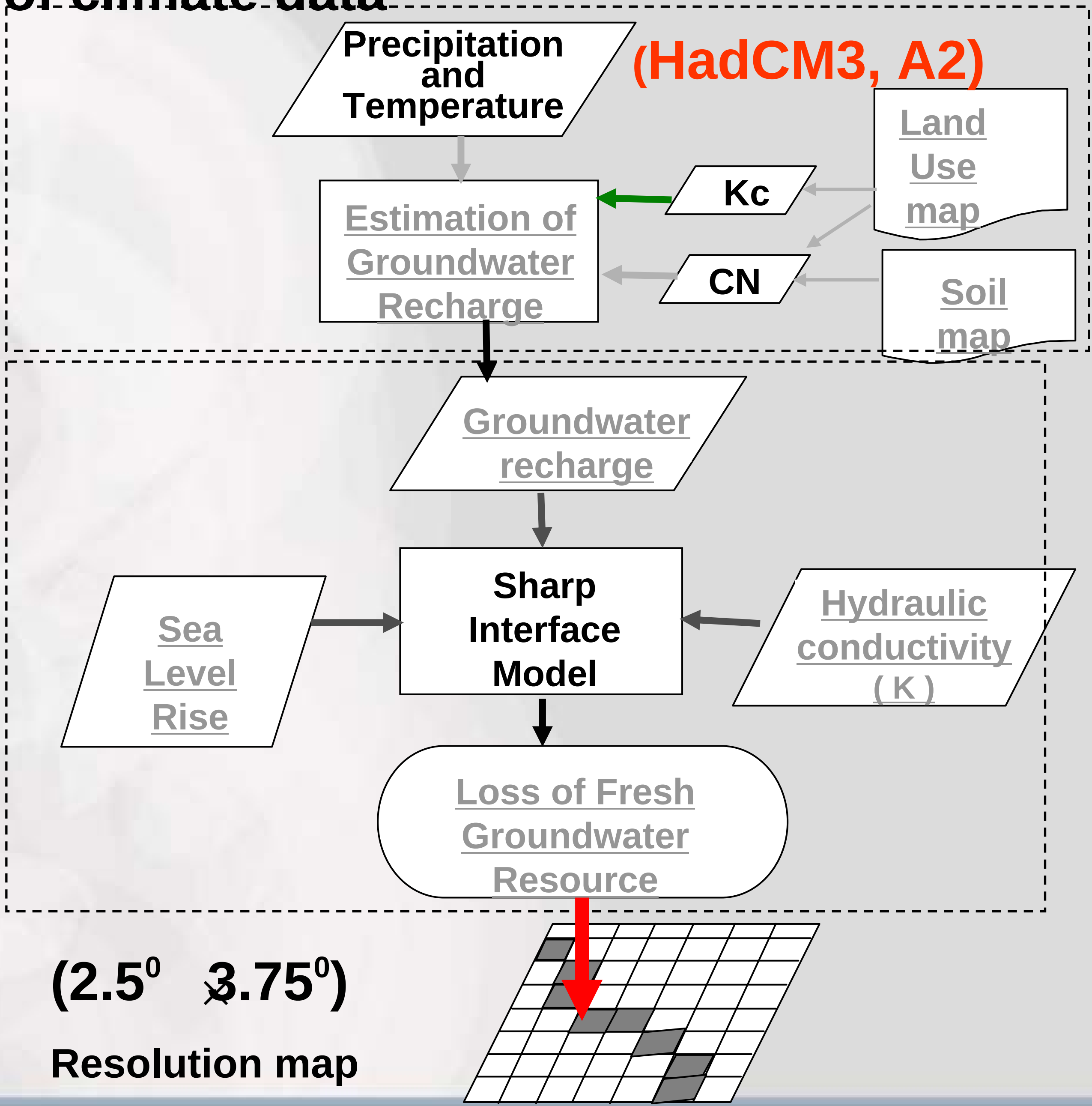
Global groundwater assessment

- Model application for world wide analysis
- To understand GW situation

Methodology

- GCM use
- Numerical map information contribution

To overcome the restrictions of lack of the availability of climate data

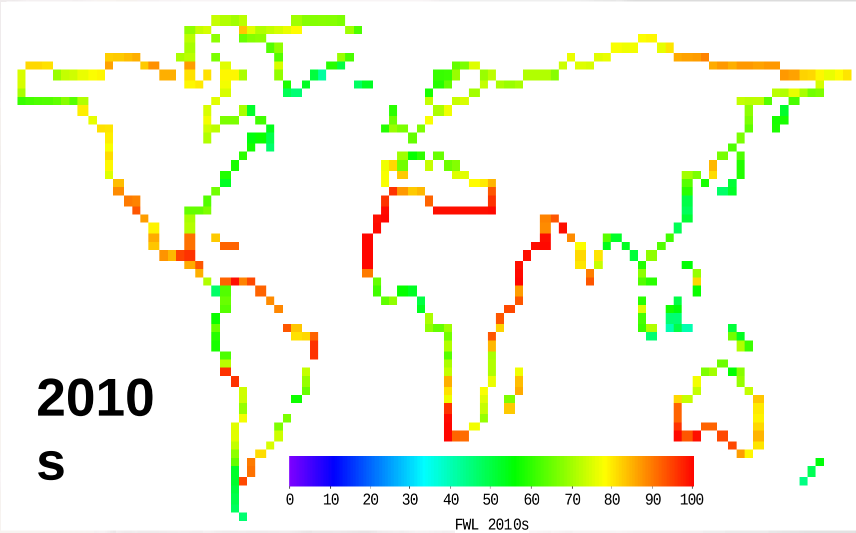


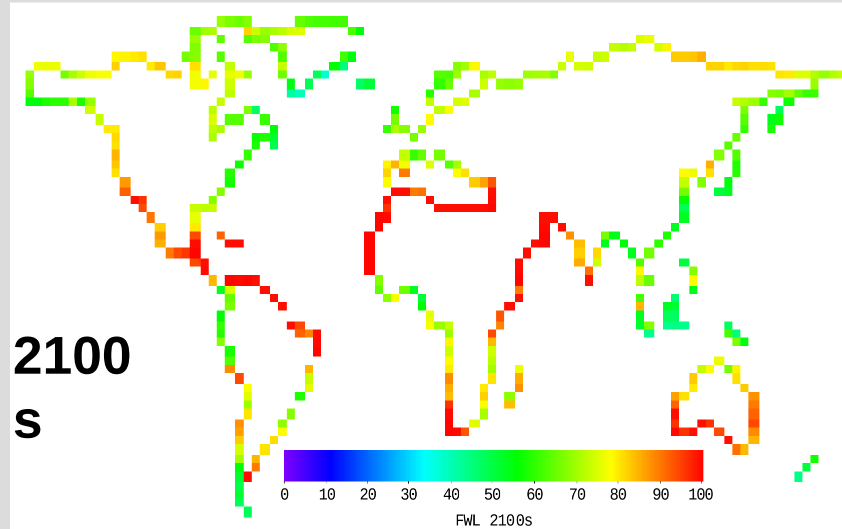
Sharp Interface concept

$(2.5^0 \times 3.75^0)$

Resolution map

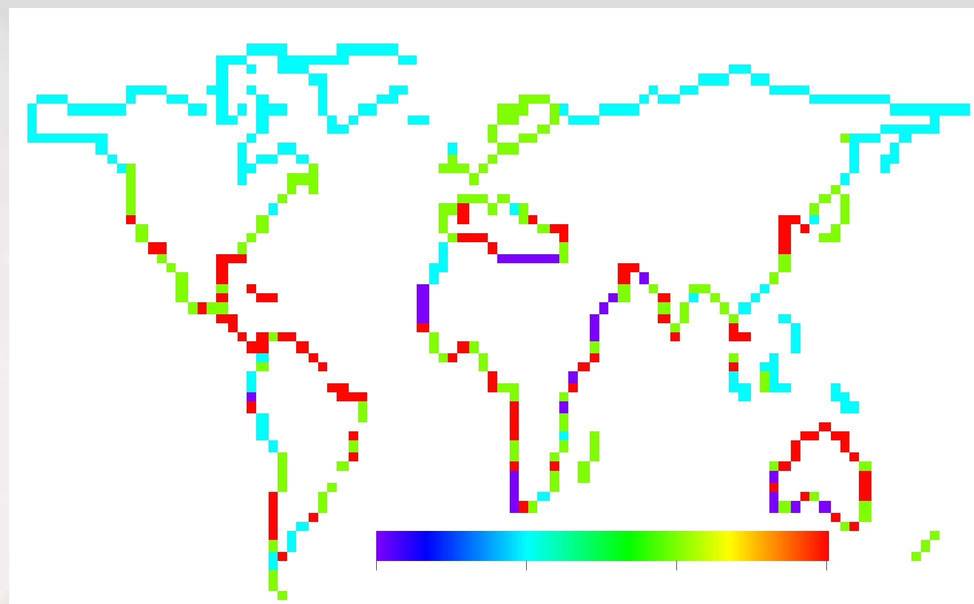
Coastal fresh groundwater resources over the next century





Change in the availability of fresh groundwater resources between 2010s and 2100s

No change – reduction is 0%
Increased– change in loss is minus
(loss than 0%)
Low reduction – change in loss between 0% to +5%
Higher reduction- change in loss higher than +5%



Overall summary & conclusions

- **Motivation** of this research was to **find a suitable methodology** to evaluate the effects of sea level rise on coastal fresh groundwater resources in coastal regions.
- **A numerical model has been developed** based on **sharp interface** approach to evaluate the saltwater intrusion in coastal aquifer systems.
- Integrated effect of **sea level rise** (i.e. climate change) and **anthropogenic stress** (i.e. land use change) on the coastal groundwater resources **has been evaluated** using the developed methodology.

- **Global evaluation of coastal groundwater resources shows that the future climate changes would creates a severe reduction in coastal fresh groundwater resources in Central America, north eastern parts of South America and all over the African and Australian continents whereas, most of the areas in Asia and Europe show a medium reduction. There is an increase in upper latitudinal areas**

- **Outcome of this research would assist the planners and decision makers to come up with control measures for ongoing surface and groundwater developments ensuring its long-term sustainability in coastal fresh groundwater resources.**

- ***Reference: Ranjan, Kazama, etc. , Ocean & Coastal Management, 2008.***