FROM AGRO-ECOLOGICAL DATABASE TO IRRIGATION SCENARIOS: A GIS-BASED APPROACH

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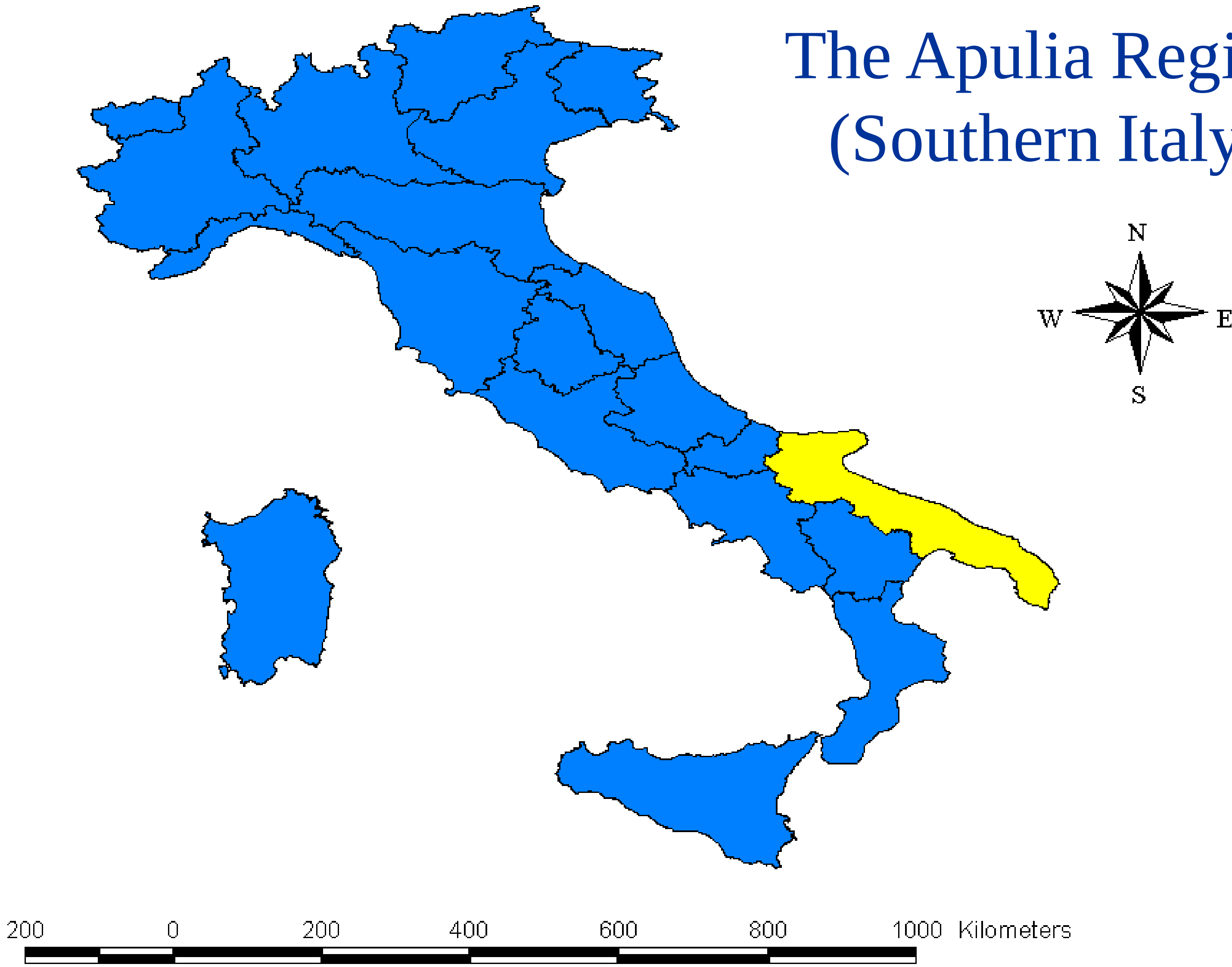
The Apulia Region (Southern Italy)



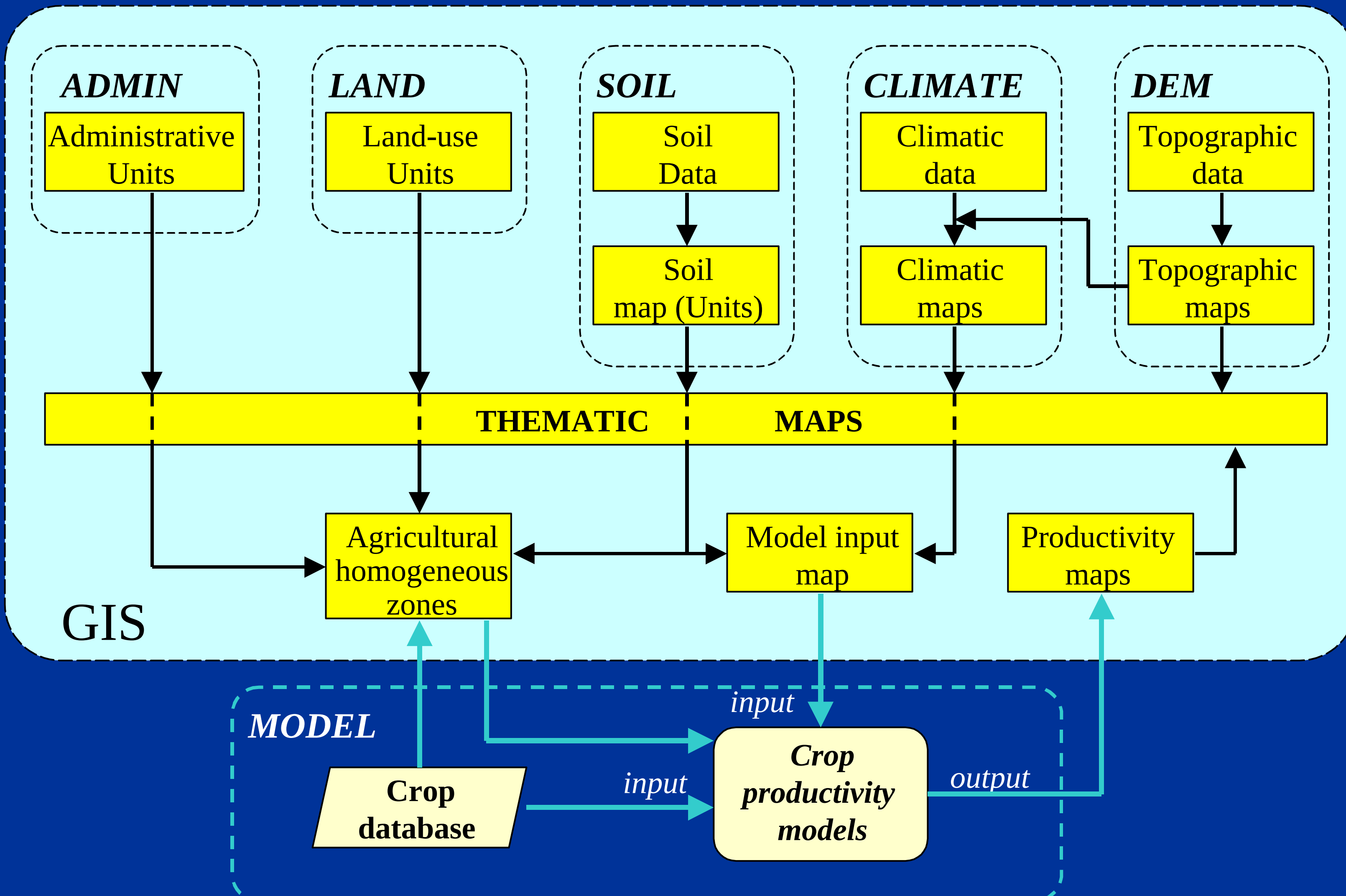
Objectives:

- to develop climatic, soil and crop databases of the Apulia region;
- to integrate and analyze databases within a GIS and to generate agro-climatic and agro-pedological maps of the region
- to develop a tool for the creation of irrigation scenarios with the aim to estimate crop irrigation requirements and irrigation water deficit under water limited conditions;
- to estimate the potential agricultural productivity of the region using a modeling approach.

Spatially-referenced queries

- by ***administrative units***, i.e. what are the plant species most suitable for growing at an administrative unit (province or commune);
- by ***crop***, i.e. what is the area most suitable for growing a certain crop;
- by ***climate requirements***, i.e. what is the area which satisfies the query-defined requirements about climatic variables;
- by ***soil requirements***, i.e. what is the area which matches the query-imposed soil characteristics;
- by ***irrigation requirements***, i.e what is the amount of water necessary for irrigation and what are water deficit and surplus areas under limited water supply

Schematic structure of the ACLA 2 database and flowchart of main operations



Workspace SOIL

soil DB structure

Primary data

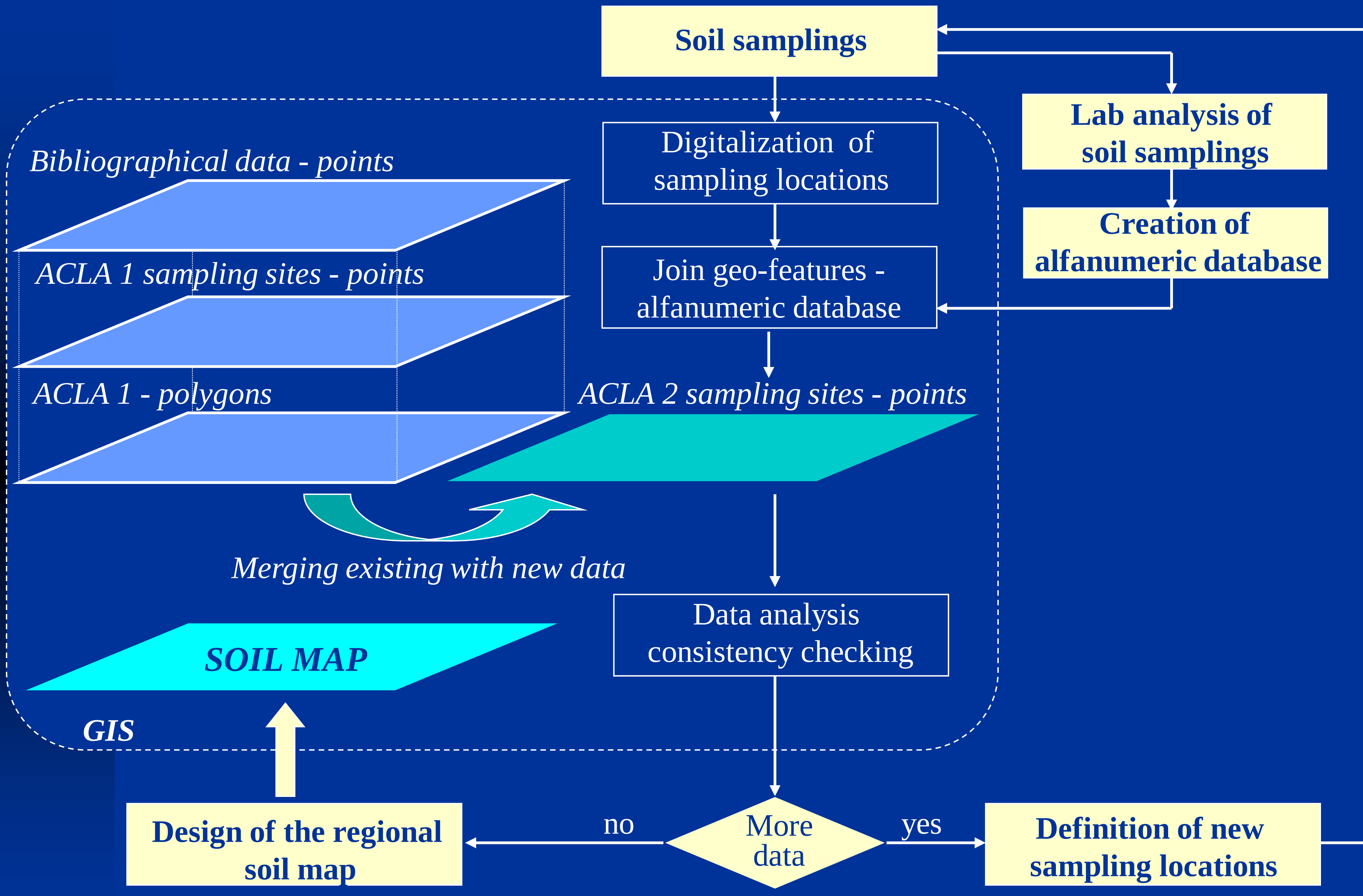
PEDA1
polygonal coverage
ACLA 1

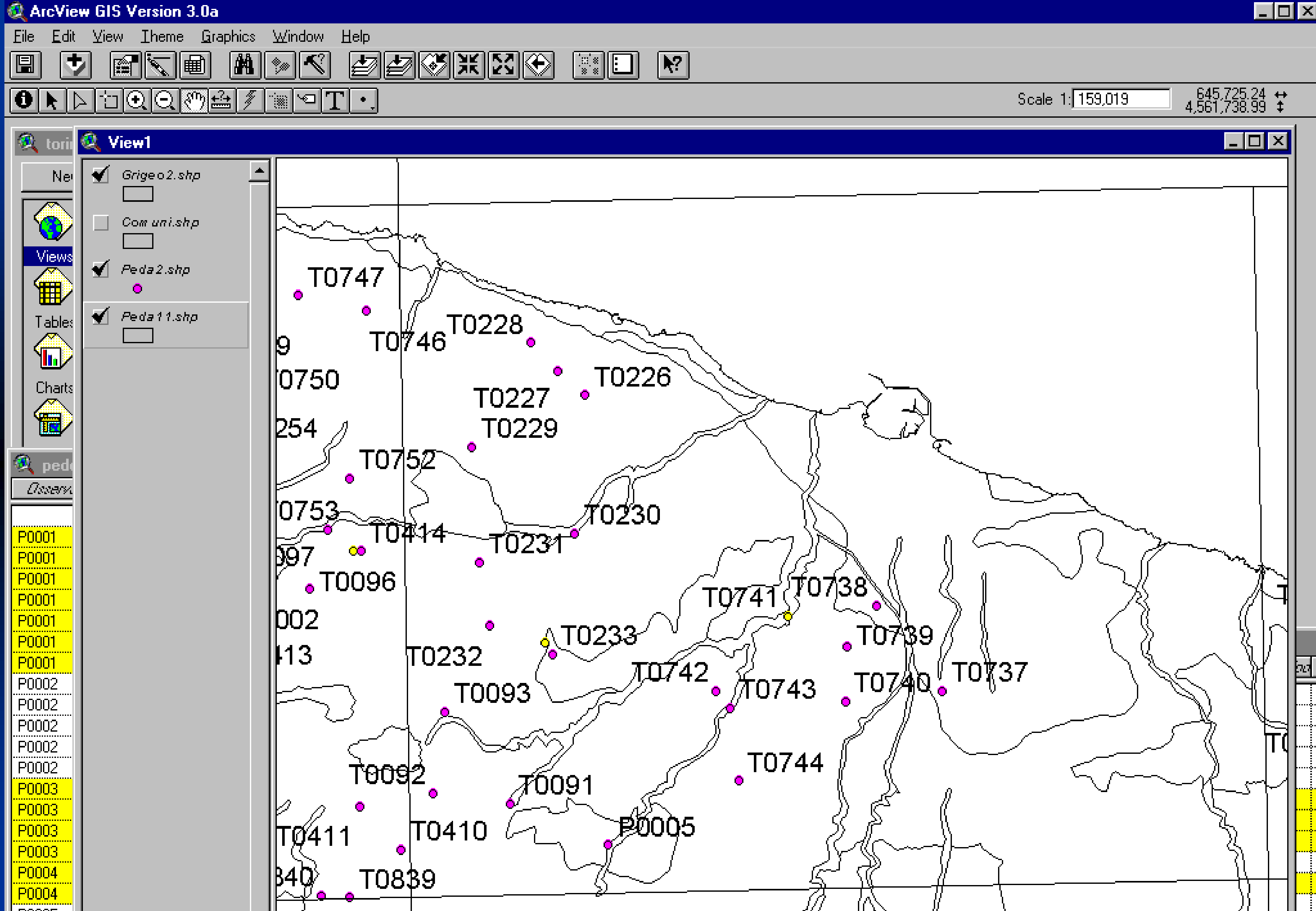
PEDA1P
point cov. samplings
ACLA 1

PEDREF
point cov. references

PEDA2P
point cov. samplings
ACLA 2

PEDA2
polygonal soil coverage
ACLA 2


Soil samplings
Lab analysis of soil samplings
Creation of alfanumeric database
Digitalization of sampling locations
Join geo-features - alfanumeric database
Bibliographical data - points
ACLA 1 sampling sites - points
ACLA 1 - polygons
ACLA 2 sampling sites - points
Merging existing with new data
SOIL MAP
Data analysis consistency checking
GIS
More data
no
yes
Design of the regional soil map
Definition of new sampling locations



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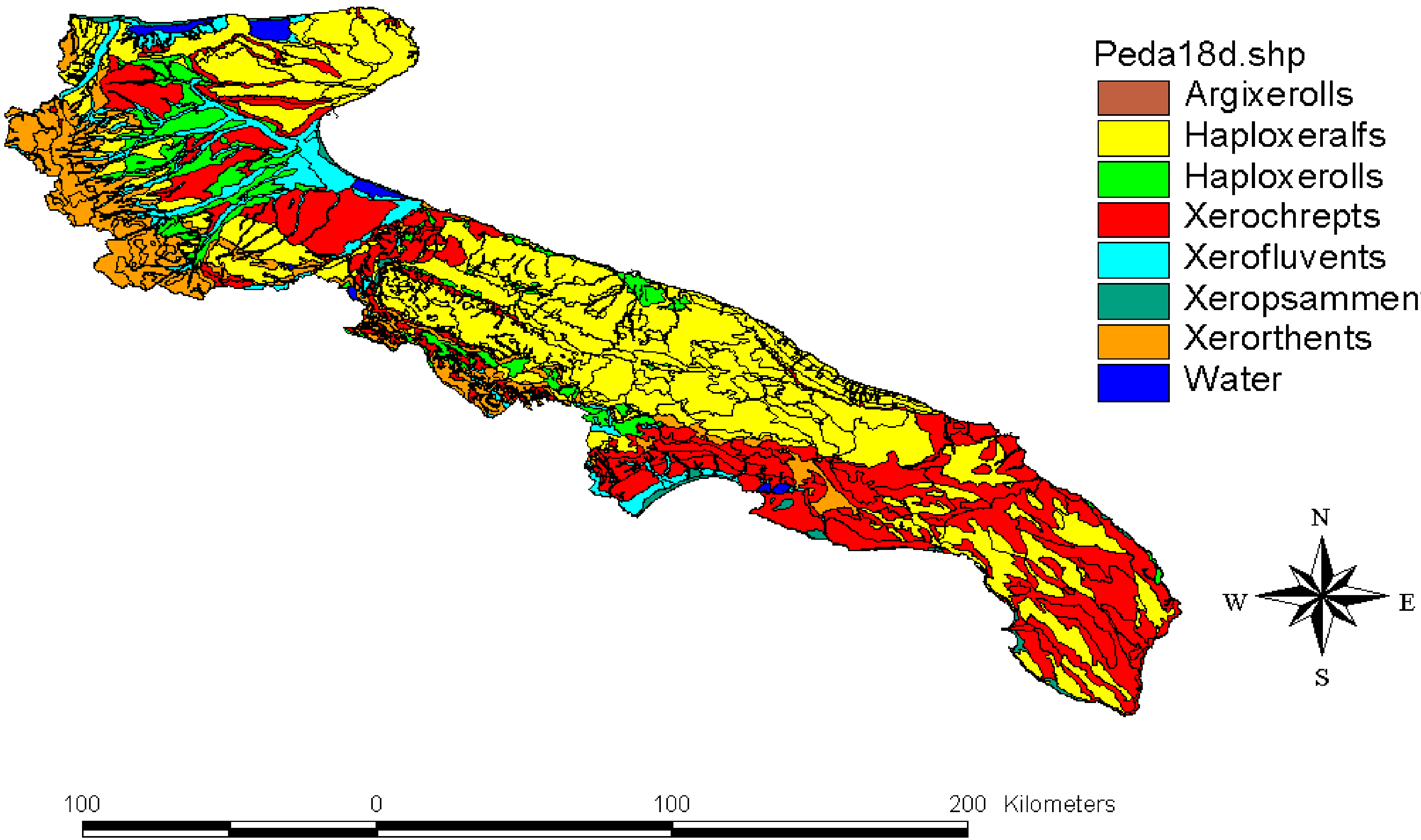
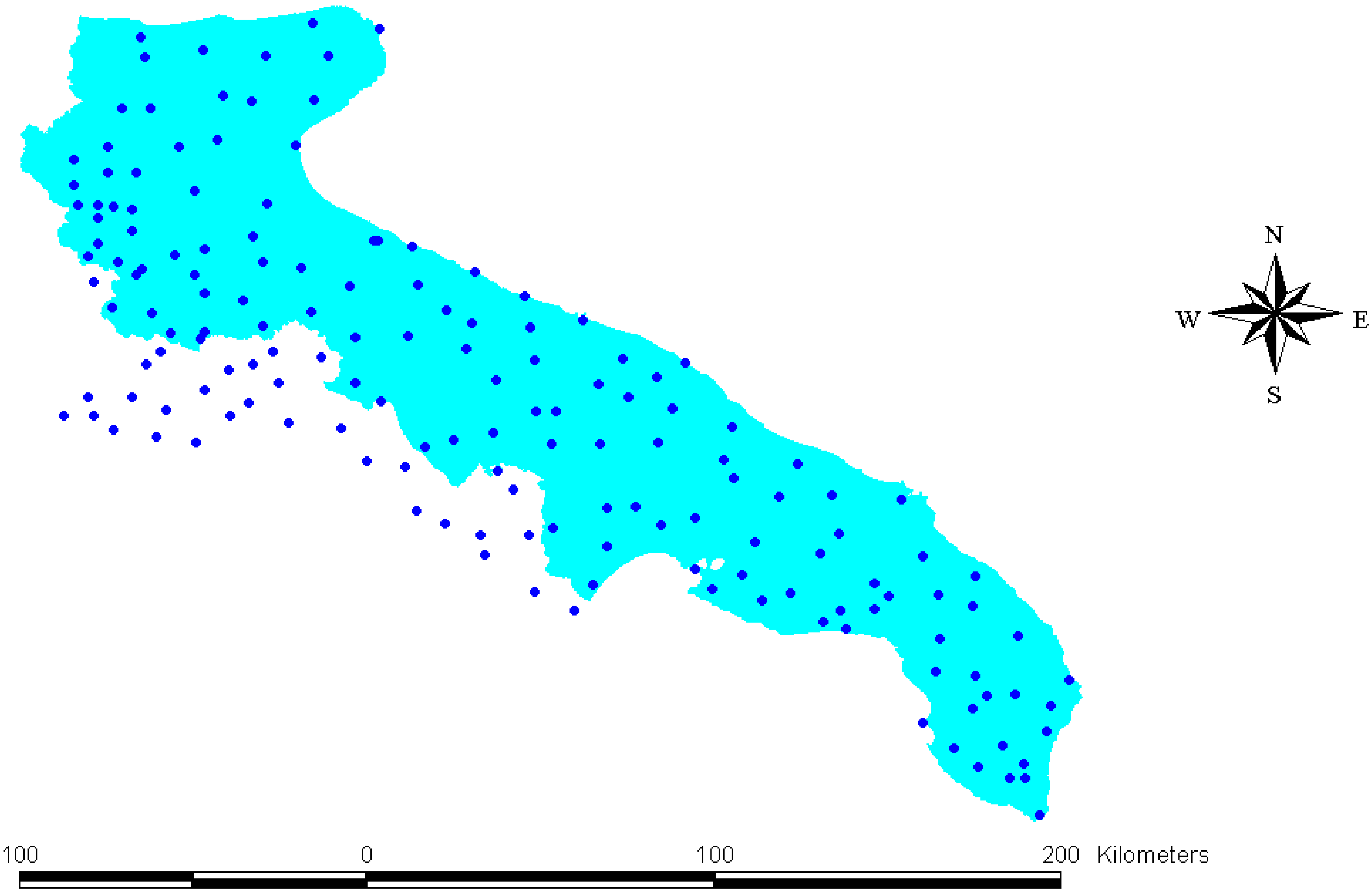
Preliminary soil map of the Apulia region - major soil groups



Climatic database

- Primary weather data set
  - monthly data of precipitation (162) and temperature (93) from 1921 to 1992
- Alternative data sets
  - daily data (P, T, RH, n/Rs, WS)
    - historical records from 1980 to 1990 at 72 sites
    - nodal points of a lattice at a distance of 20 km

The location of the pluvio-stations

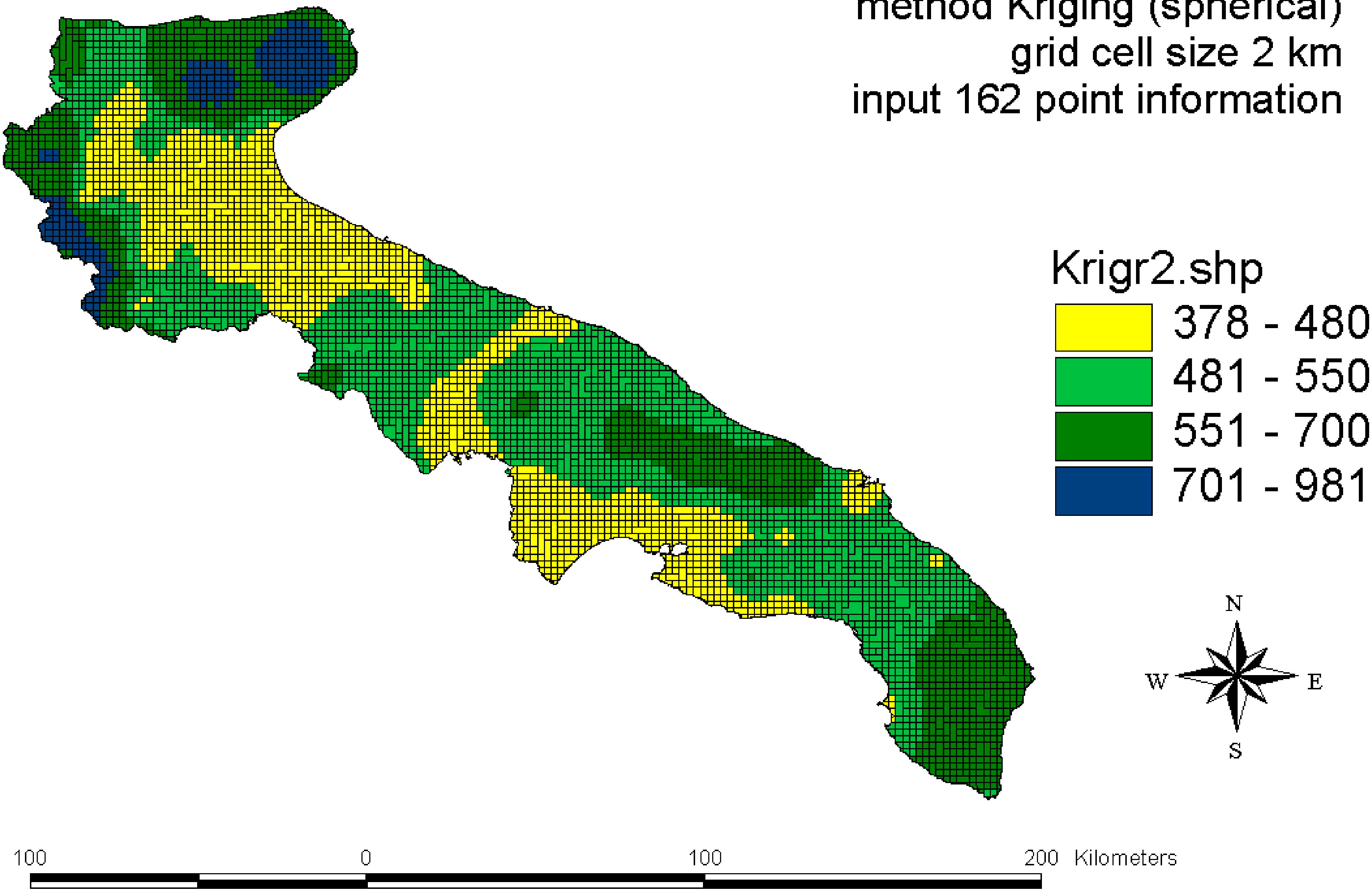


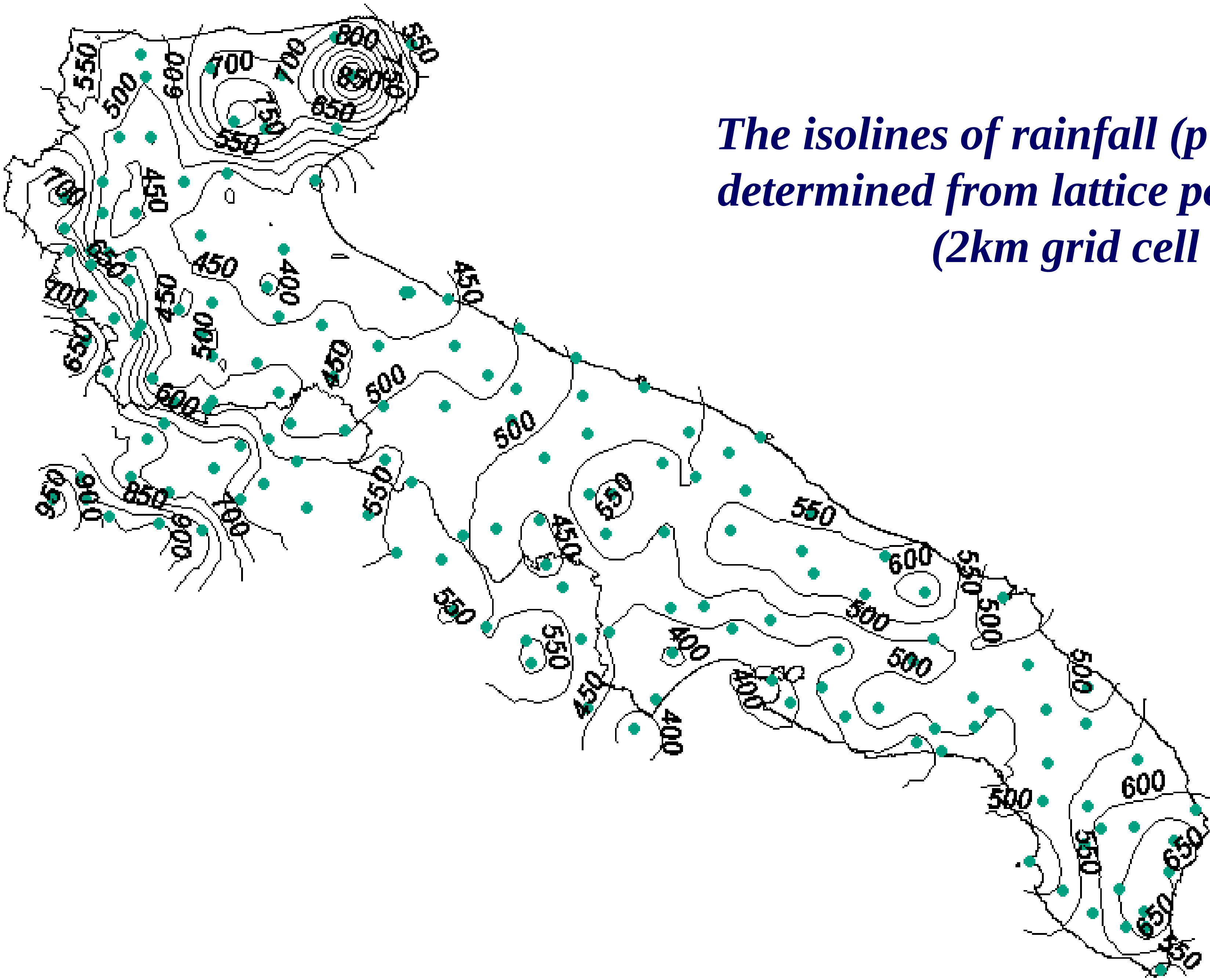
The results of interpolation of precipitation (p75%) in the Apulia region

method Kriging (spherical)

grid cell size 2 km

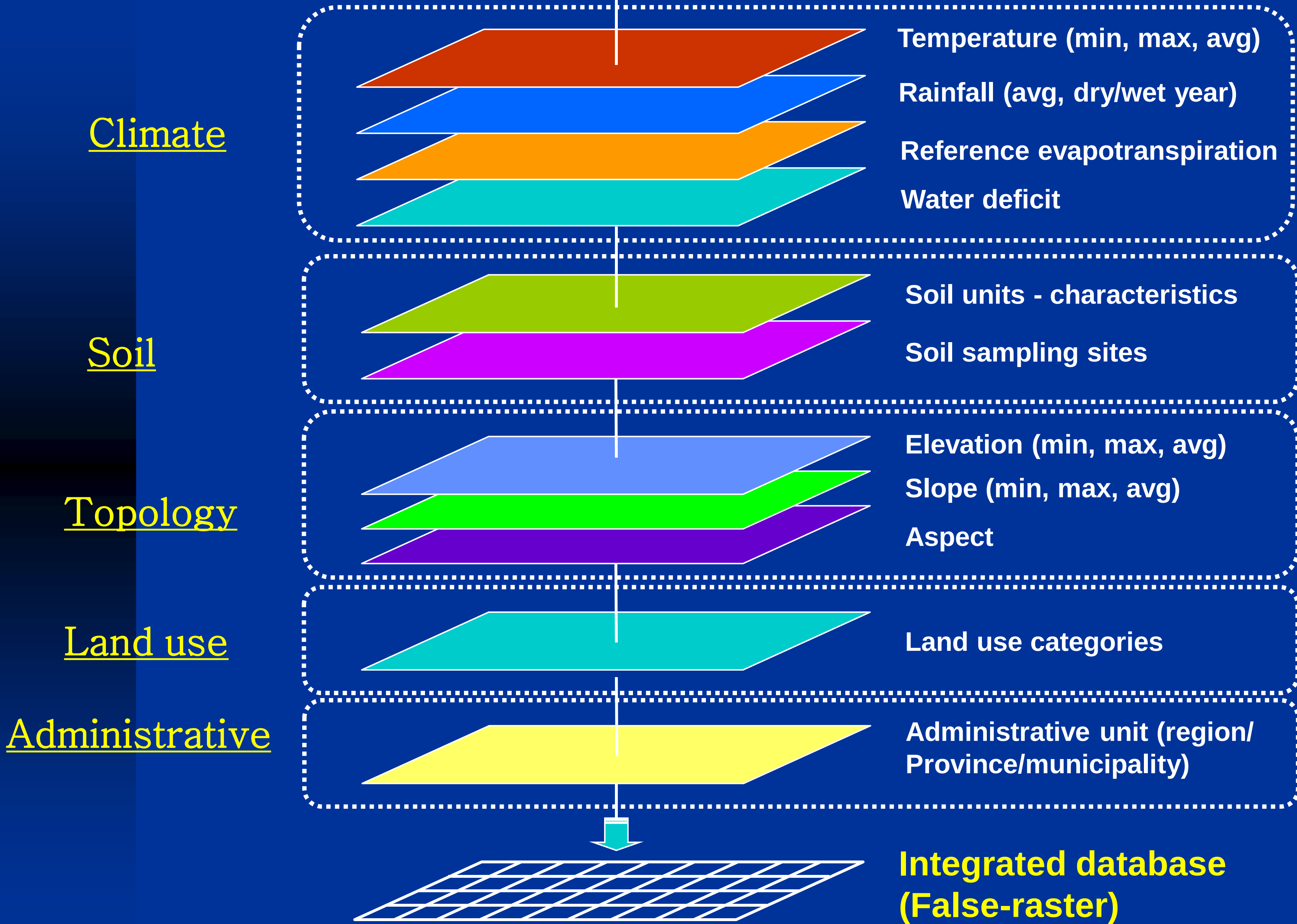
input 162 point information



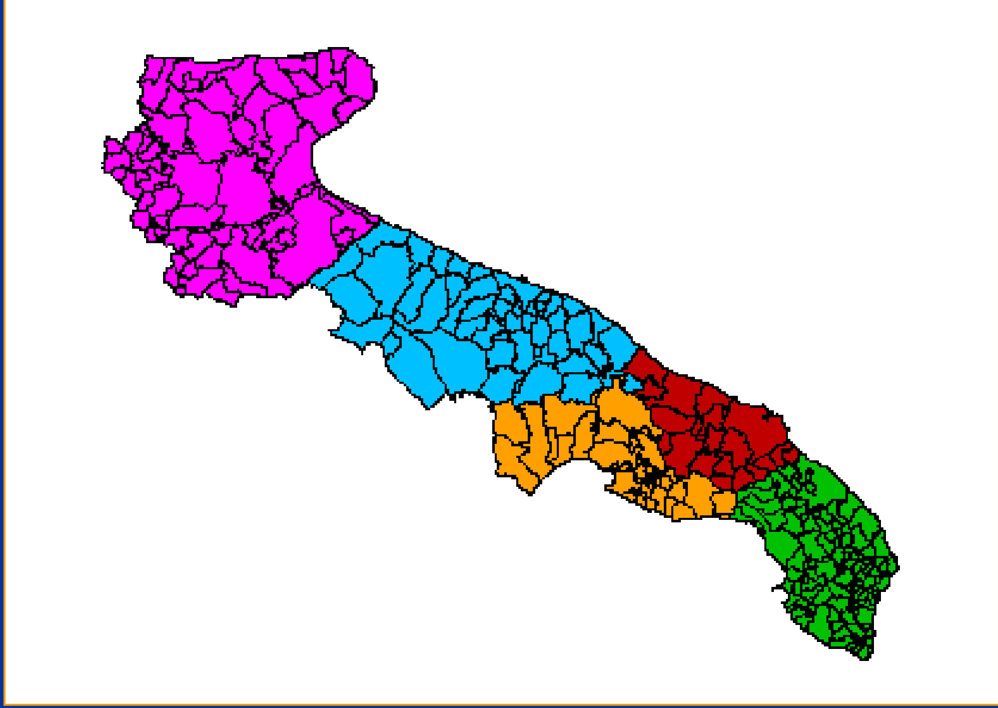


The isolines of rainfall (p75%)
determined from lattice points
(2km grid cell size)

DATA INTEGRATION

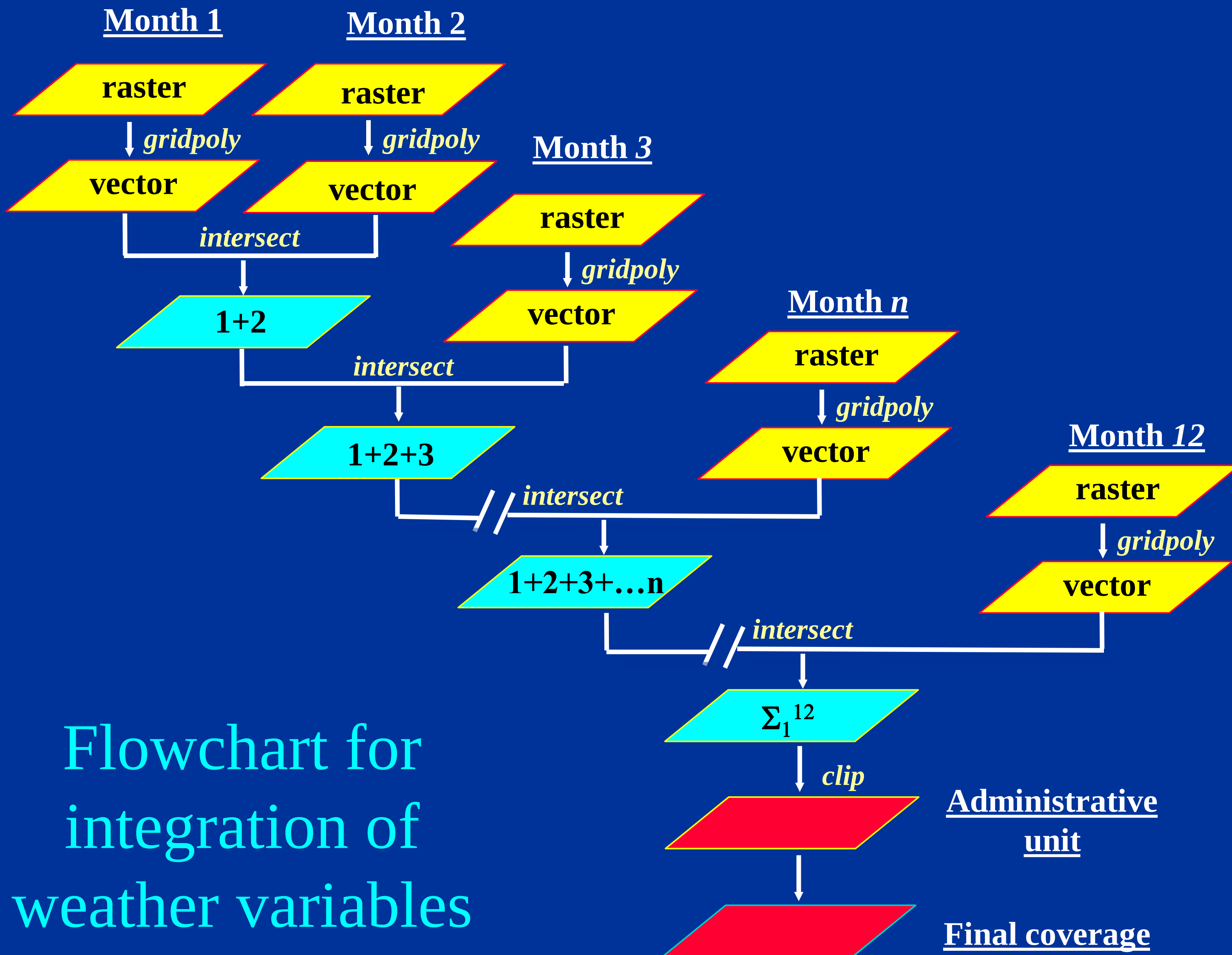


Data integration methodology



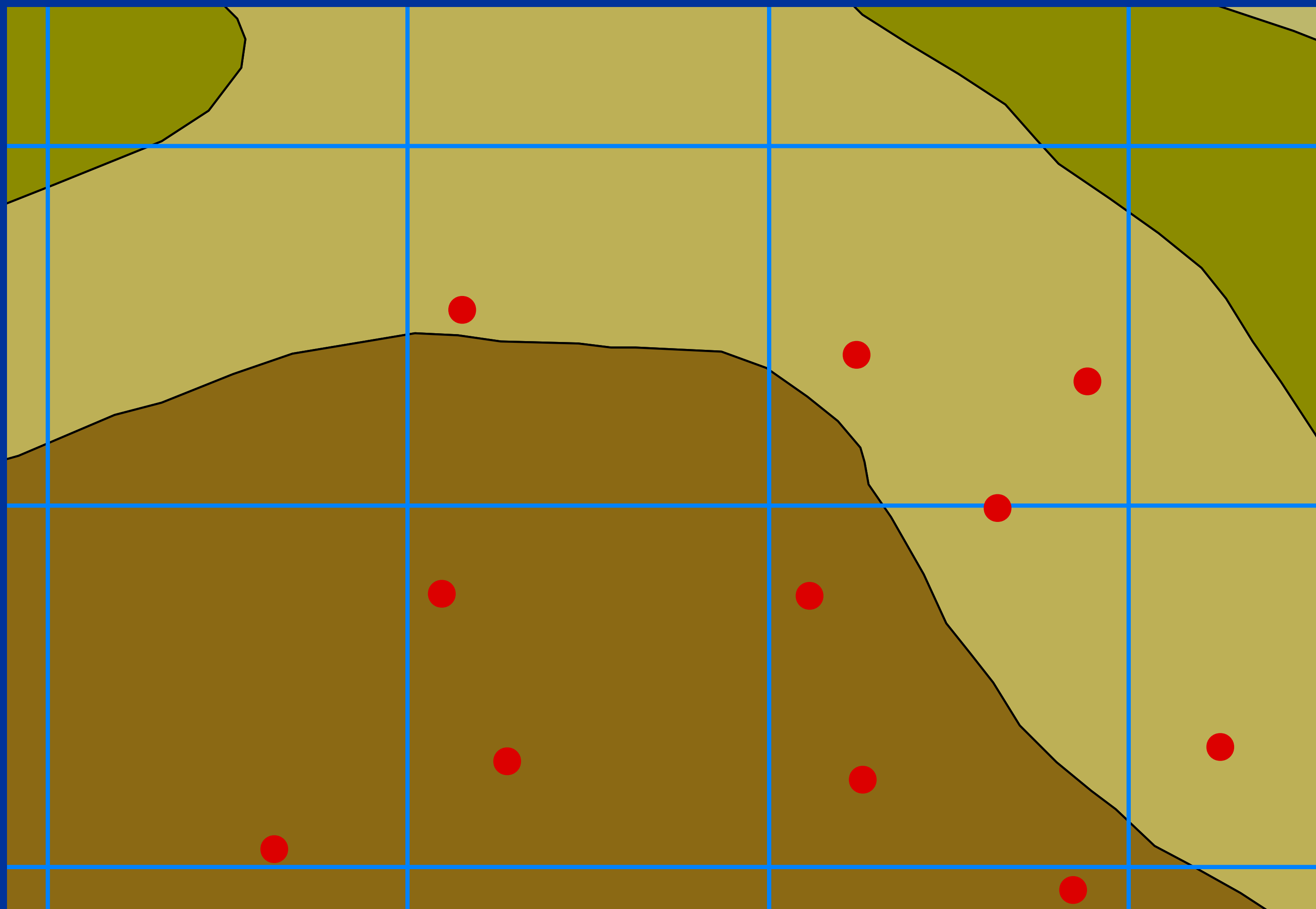
- ***"False-raster" – why?***
  - Homogeneous size of modeling units
  - ArcView software is used
- ***Scaling-up***
  - Municipality (thousands of ha) - 250x250 m;
  - Province – 500x500 m, and
  - Region (2 million ha) – 1x1 km

Flowchart for integration of weather variables

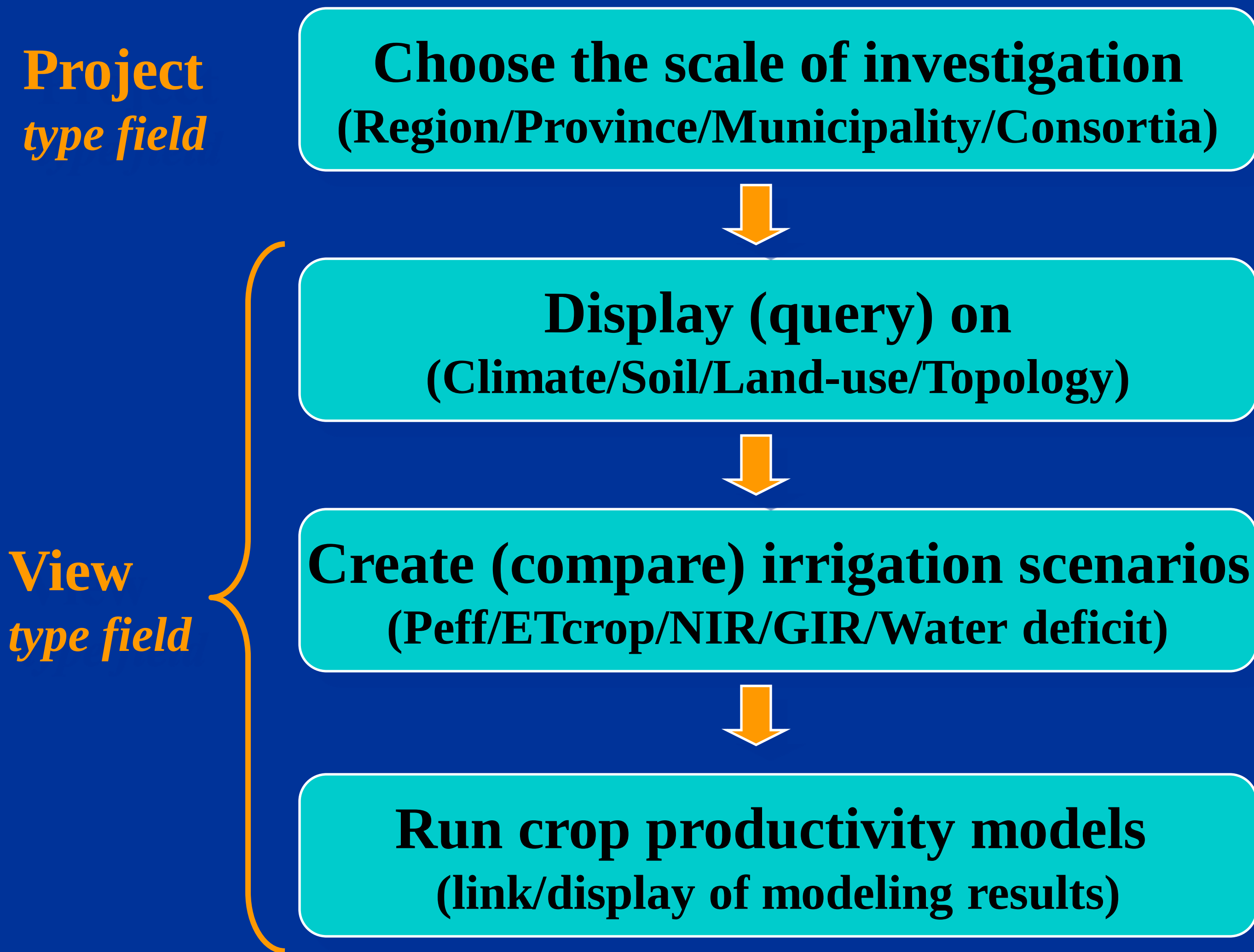


Source: Todorovic and Steduto, 2003

Soil data integration



Layout of ARCView customization



Procedure for calculation of Gross Irrigation Requirements

Calculation of effective rainfall

↓

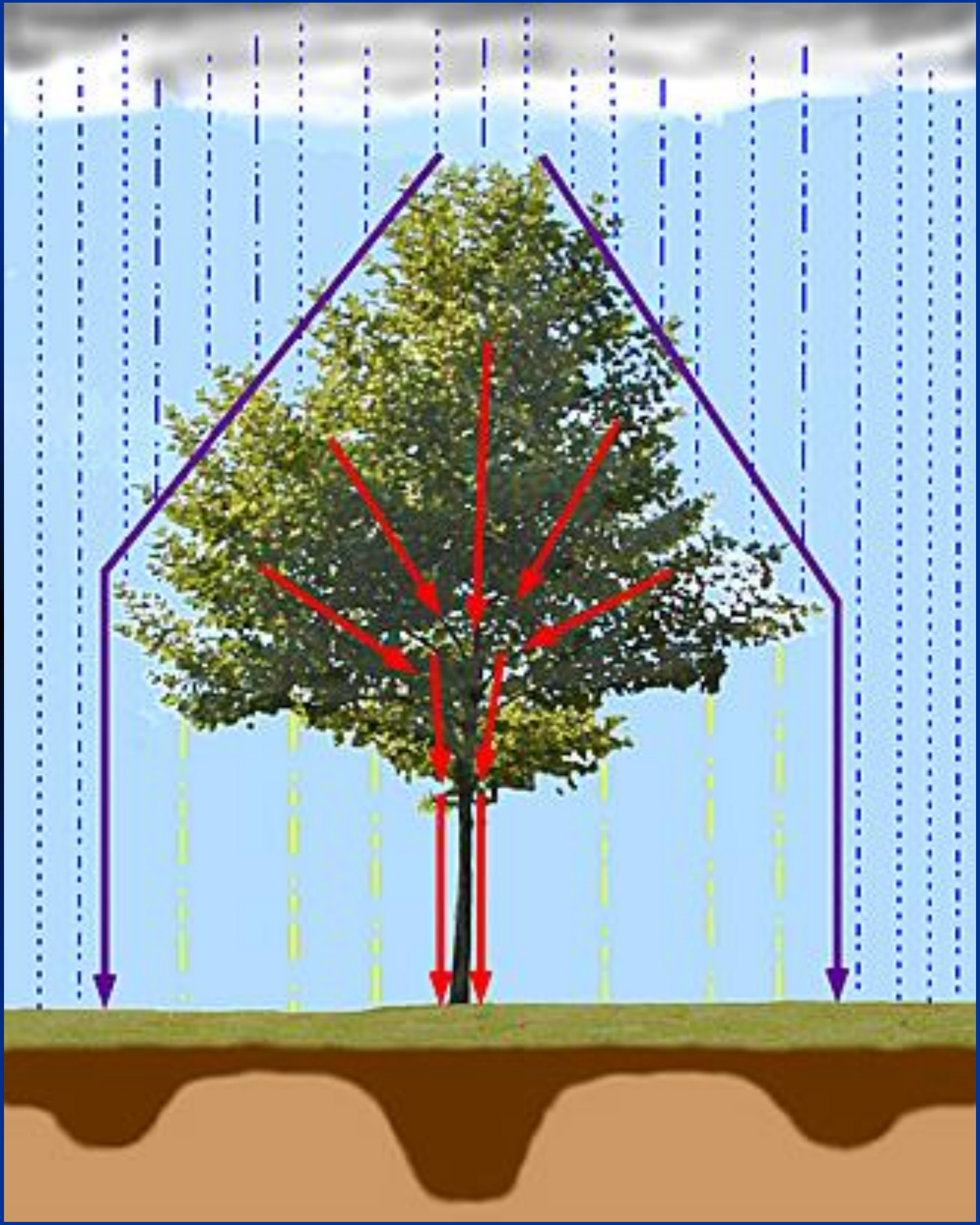
Calculation of crop evapotranspiration

↓

Calculation of Net Irrigation Requirements

↓

Calculation of Gross Irrigation Requirements



Interception and effective rainfall concept

Calculation of effective rainfall

$$P_{eff} = P_{coeff} * P$$

P_{eff} – effective rainfall – the amount of total rainfall that can be effectively used [mm]

P_{coeff} – rainfall coefficient [non-dimensional]

P – total rainfall [mm]

Calculation of Crop Evapotranspiration

$$ET_c = K_c * ET_o$$

ET_c – crop evapotranspiration [mm]

K_c – crop coefficient [non-dimensional] - varies from month to month as a function of crop under consideration and its growing stage.

ET_o – reference evapotranspiration [mm]

Calculation of Net Irrigation Requirements

$$NIR = ET_c - P_{eff}$$

NIR – net irrigation requirements [mm]

ET_c – crop evapotranpiration [mm]

P_{eff} – effective rainfall [mm]

Calculation of Gross Irrigation Requirements

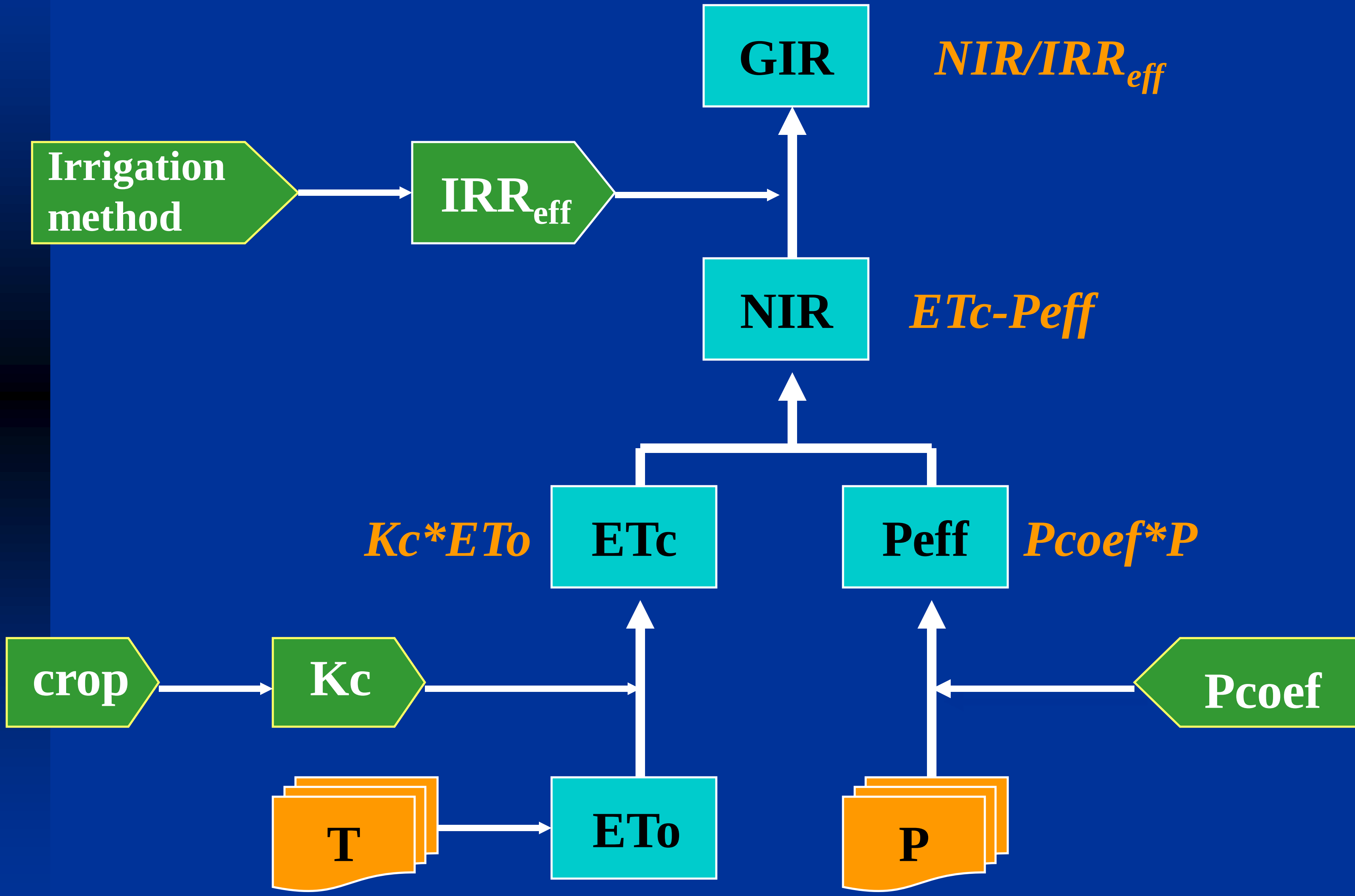
$$GIR = \frac{NIR}{IRR_{eff}}$$

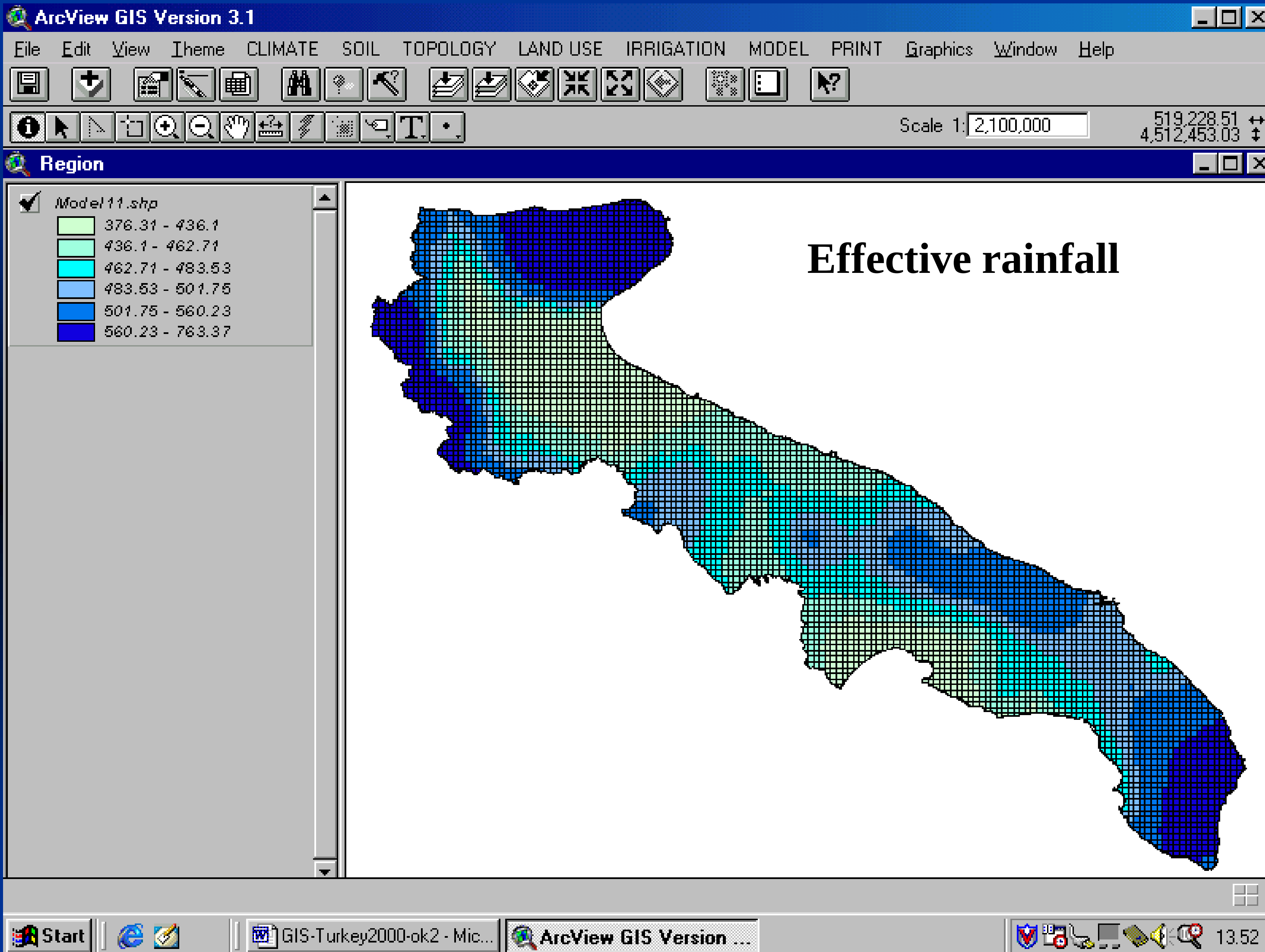
GIR – gross irrigation requirements [mm]

NIR – net irrigation requirements [mm]

IRR_{eff} – irrigation efficiency [non-dimensional], a function of applied irrigation method

Flowchart for calculation of Gross Irrigation Requirements in GIS

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519,228.51
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Region
Model11.shp
376.31 - 436.1
436.1 - 462.71
462.71 - 483.53
483.53 - 501.75
501.75 - 560.23
560.23 - 763.37
Effective rainfall
Start
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ArcView GIS Version ...
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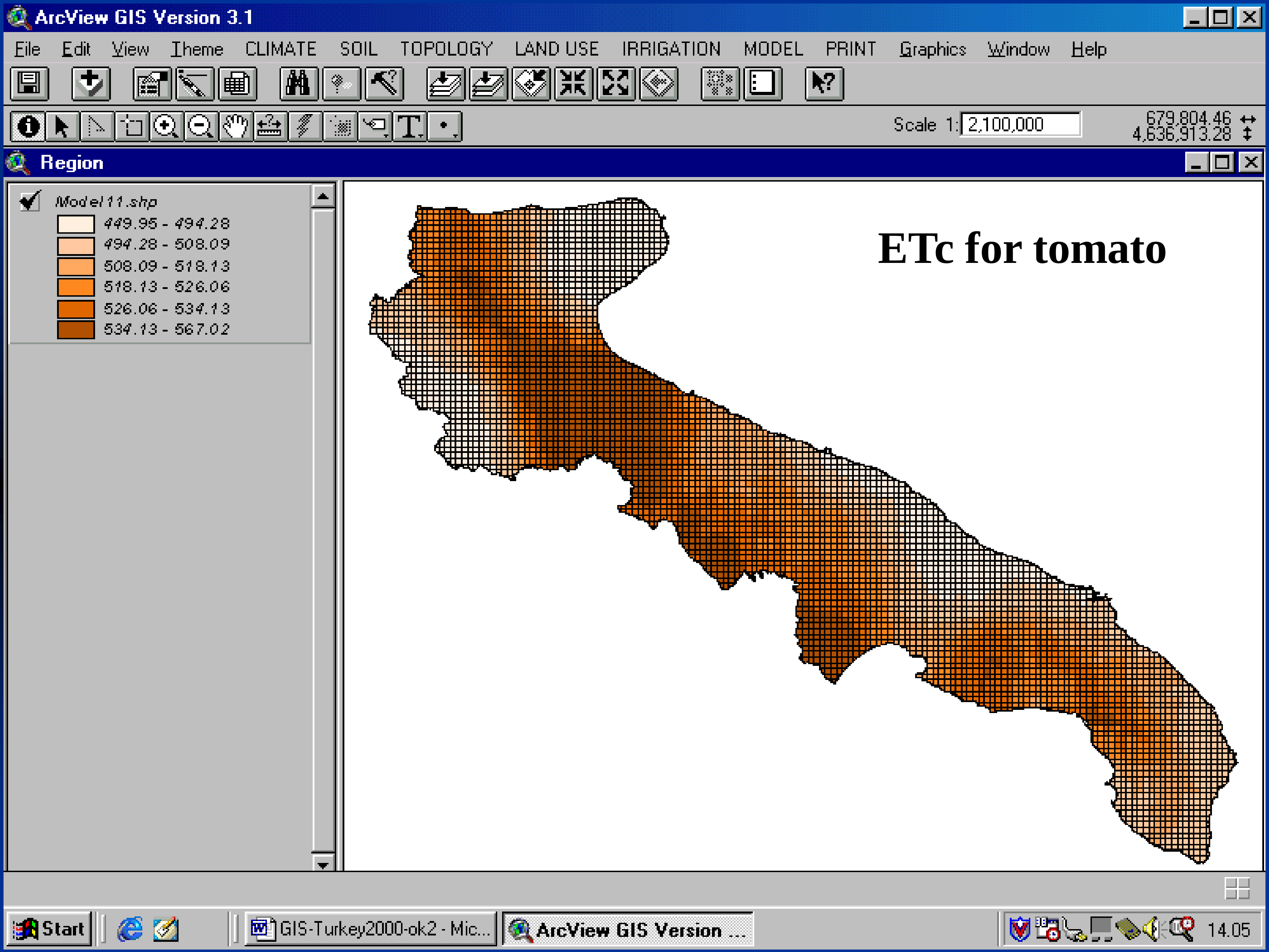
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449.95 - 494.28
494.28 - 508.09
508.09 - 518.13
518.13 - 526.06
526.06 - 534.13
534.13 - 567.02
ETc for tomato
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GIS-Turkey2000-ok2 - Mic...
ArcView GIS Version ...
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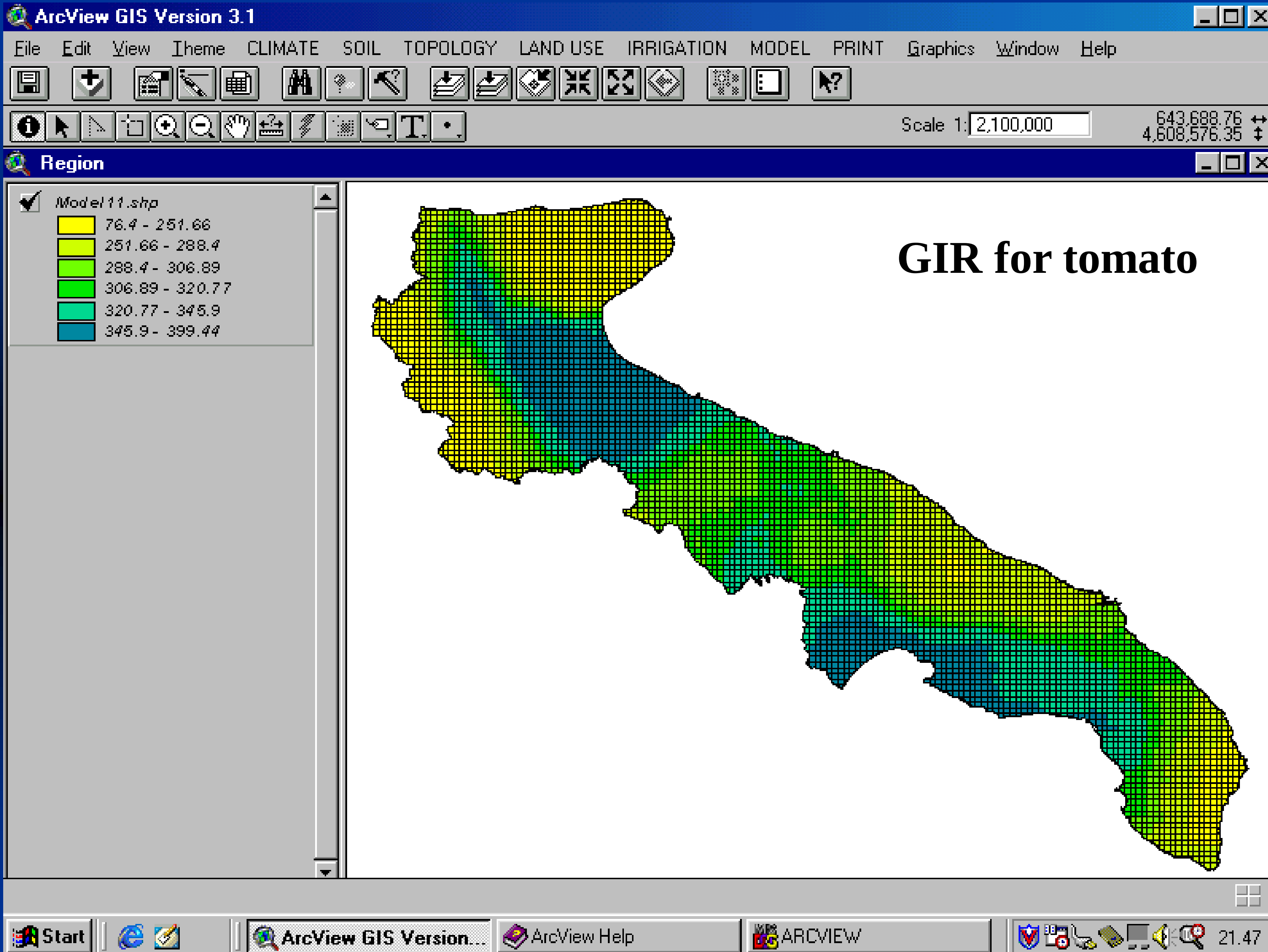
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306.89 - 320.77
320.77 - 345.9
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GIR for tomato
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ARCVIEW
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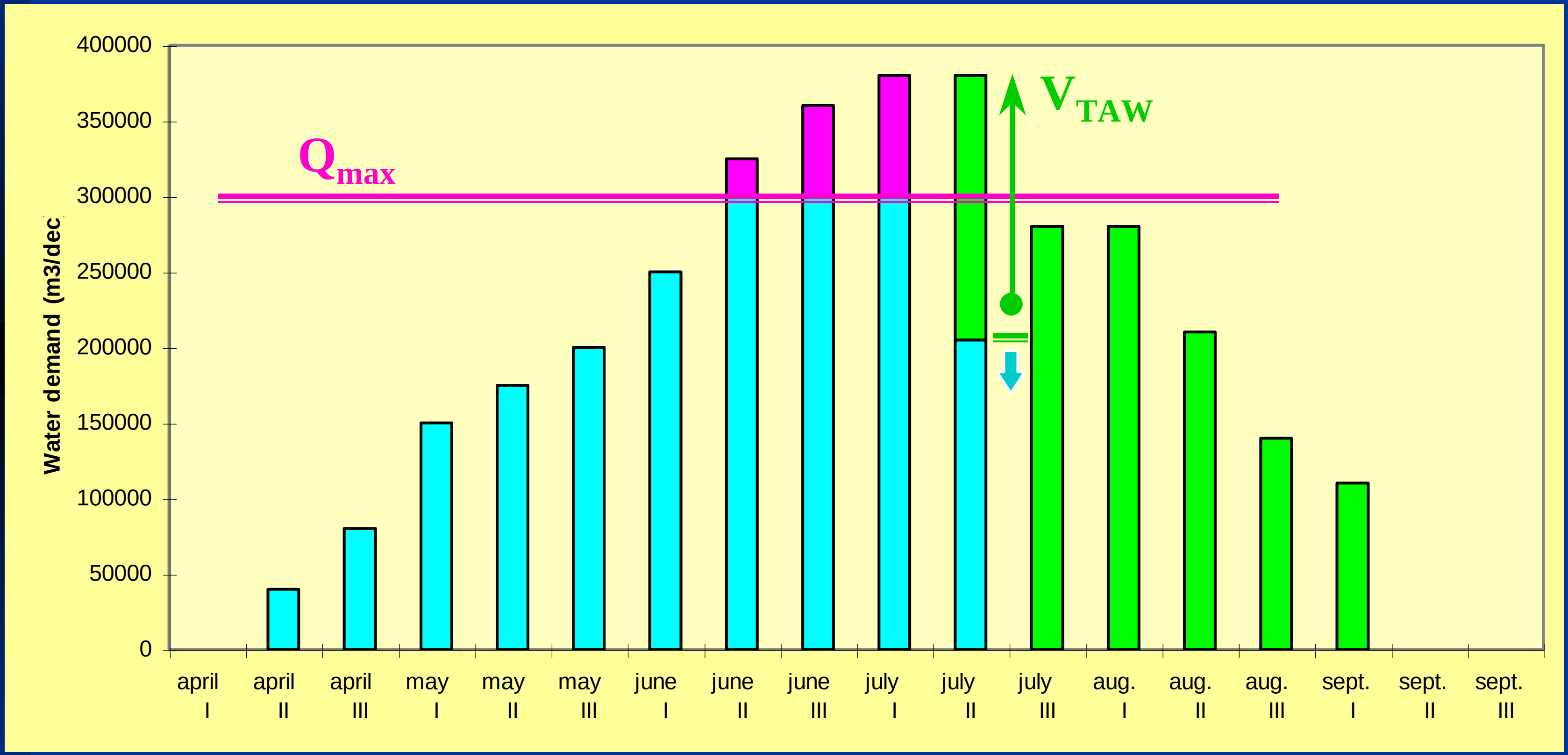
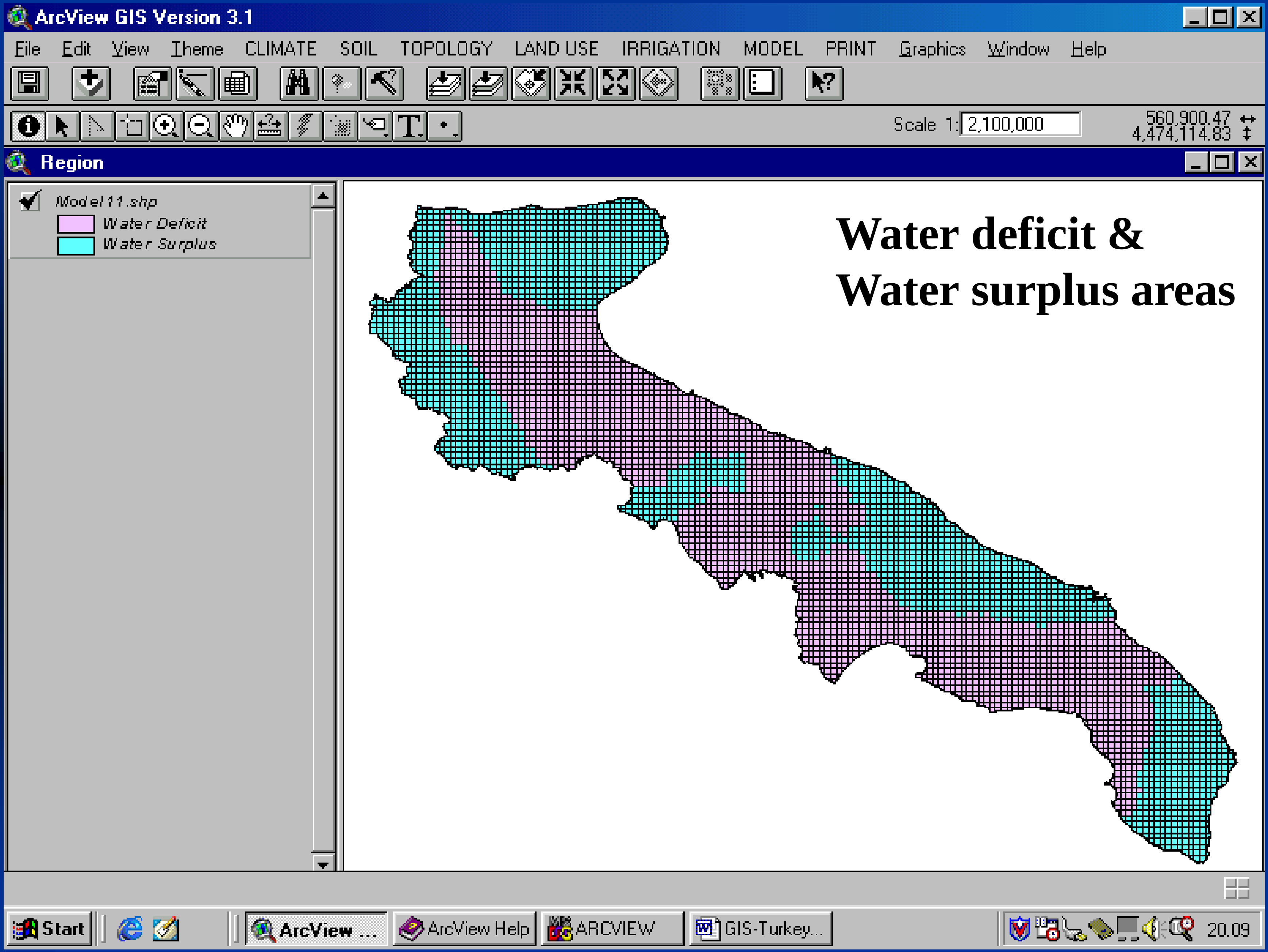
Water Demand vs. Constraints in Global Assessment Strategy



Constraints: Max. Flow Rate and Total Available Water



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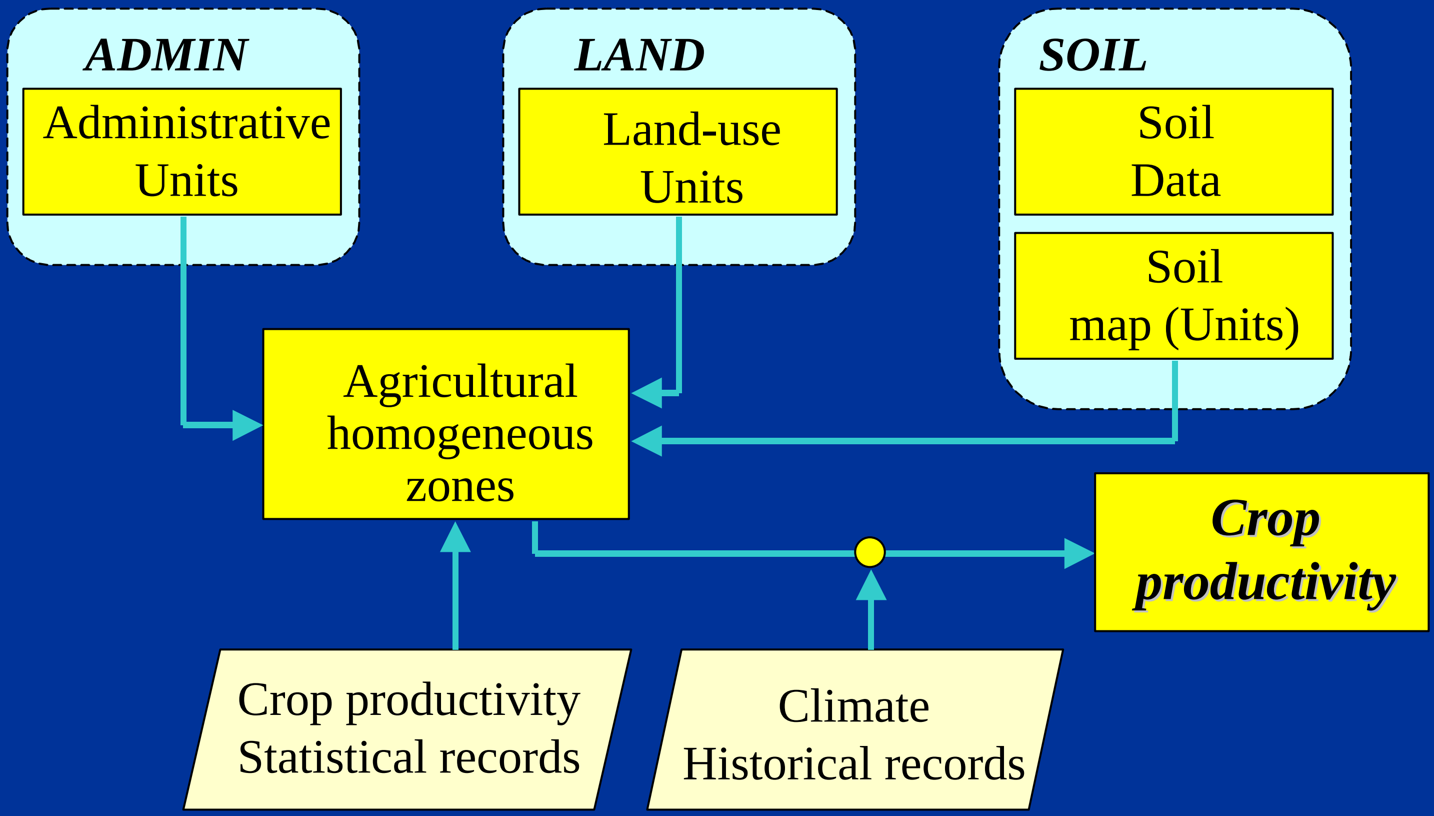
Region
Model11.shp
Water Deficit
Water Surplus
Water deficit &
Water surplus areas
Start
ArcView ...
ArcView Help
ARCVIEW
GIS-Turkey...
20.09

Modeling

- ***Statistical approach***
  - for both field and tree crops
- ***Mechanistic approach***
  - for field crops only

Statistical modeling

Input: statistical records about productivity for various crops at different sites (soil) and in different years (climate)



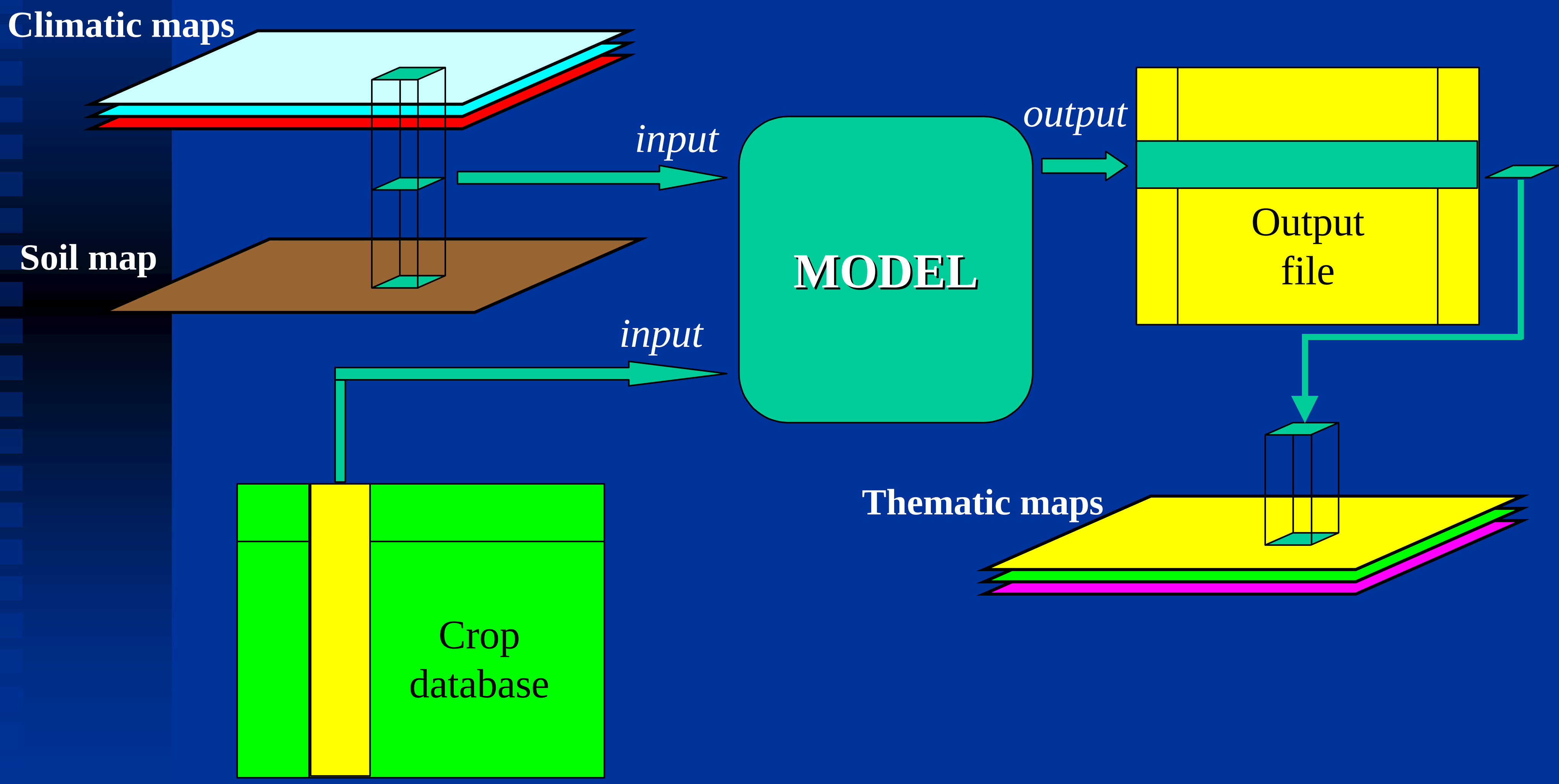
Mechanistic modeling 1

- Uses experiences of CROPSYST and EPIC
- Quantitative prediction of ***crop growth*** and ***yield*** for field crop
- Crop growth module
  - temperature
    - growth stages using degree-day accumulation or thermal time concept
  - solar radiation
    - biomass growth partitioned into roots, stems, leaves and commercial yield.
- Soil water balance module
  - effective rainfall, evaporation and transpiration - soil water content.

Mechanistic modeling 2

- Three levels of potential productivity
  - no water and nutrient deficit (potential)
  - no nutrient deficit - but with water restriction (rainfed agriculture)
  - water and nutrient constraints (actual)
- Deviations between 1st, 2nd and 3rd level
  - measures of the “amount” in terms of resource necessary to “cover” to achieve full productivity.
- Crop Ranking according to their productivity
  - naturally available resources (soil and water)
  - attitude for potential productivity

Flowchart of data for mechanistic model



Conclusions

- A-E database
  - Long-term assessment of the climatic and soil conditions
  - Spatial and temporal variability of the short-term factors (land-use, irrigation, fertilizer applications) will require continuous monitoring and updating of the system
- Irrigation module
  - Is simple at may be applied without modification at different scales and locations
  - Shorter time-step may be used ….. Running time?
  - Irrigation fields may be used instead of regular cells
  - More complex module could be developed (soil parameters) for on-field irrigation scheduling