ArchaeoGRID, a GRID for Archaeology
Preliminary Report

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Why an ArchaeoGRID ?

Production, Storage and Use of Archaeological Information and Knowledge is increasing in Volume. The images from 3D scanned objects and excavation areas, from remote sensing, the data from laboratories and from computer simulation produce petabytes

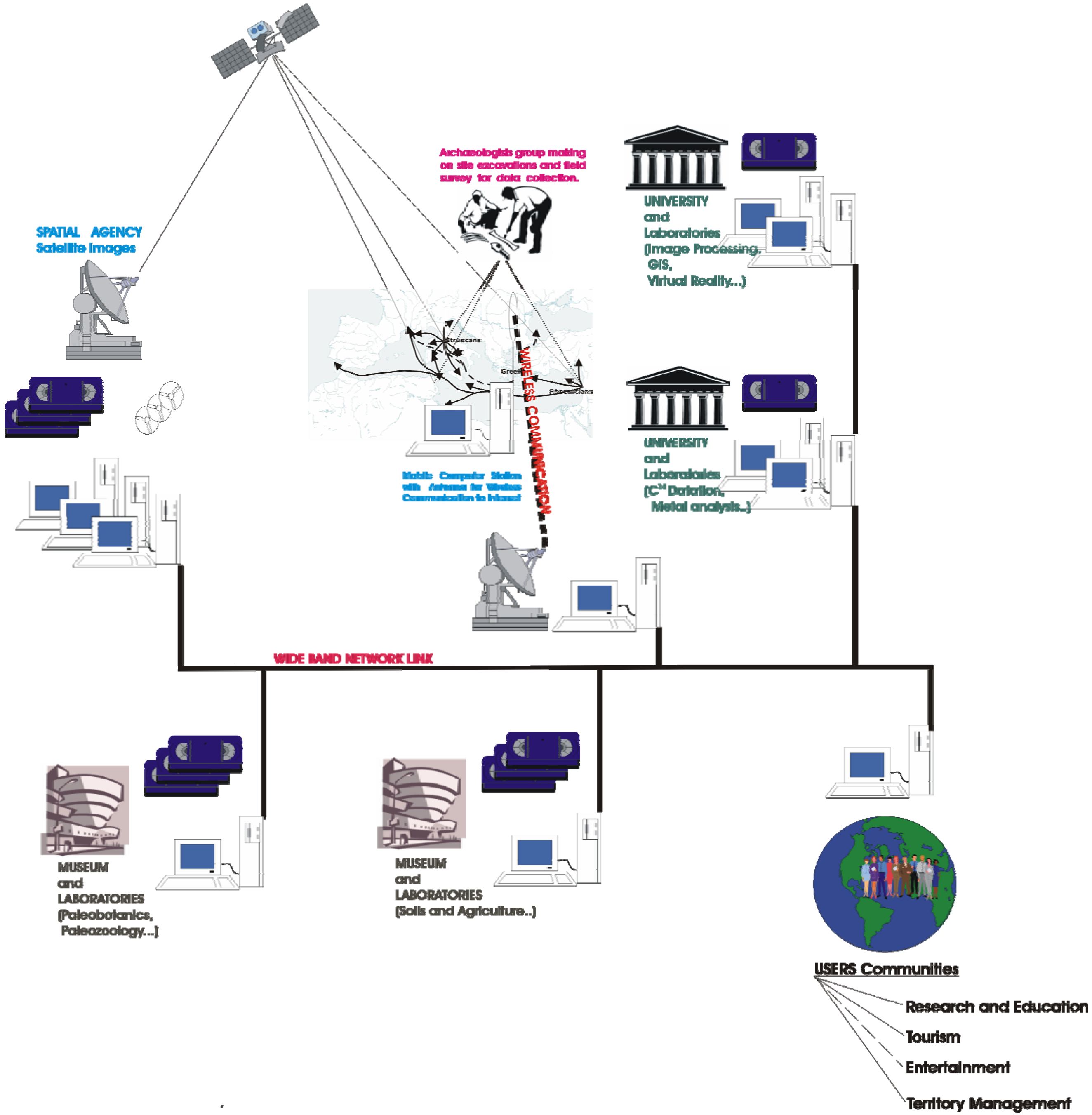
Archaeological data are getting not only larger and larger, but also their complexity is increasing, so that the extraction of meaningful knowledge requires more and more computing resources

Archaeological Digital Heritage Technologies, now in a very advanced stage of development, provide the technical background for starting an ArchaeoGRID prototype

ArchaeoGRID enables the possibility to use a very large amount of digital data from past and present bibliography, excavations and field surveys, stored in large distributed DataBase and Archives. Any new present excavation must rely on past data and knowledge

ArchaeoGRID enables the possibility for a large number world-wide spread communities of Archaeologists from Universities, Research Centers, Museums, to work together on a same project

Emergence
of
e-Archaeology
Global
Knowledge
Community
for Exploitation
of Advanced
Computational
Methods
to generate,
curate and
analyse research
data and
to develop and
explore models
and simulations



ArchaeoGRID for which Projects ?

Archaeological Heritage Management

from Preservation to Access.

Archaeological Research

Production, Sharing and Diffusion of Archaeological Information and Knowledge

Economical Exploitation of the Archaeological Information and Knowledge

ArchaeoGRID for Archaeological Research

Production, Sharing and Diffusion
of Archaeological Knowledge

by methods of

Topography
Field Survey and Excavation
Archeometry
Simulation
Telearchaeology
Visualization and Narration

ArchaeoGRID Application
for
LARGE REGIONS ARCHAEOLOGY

Origin of the City in the Mediterranean Area between XI-VIII Centuries B.C.

Study of the process bringing, in complex societies, to the origin of the cities in Mediterranean area, a central area where the identity of Europe was born, during the protohistory

Application

Origin of the City in the Mediterranean Area between XI-VIII Centuries B.C.

Aims:

Reconstruction of Paleoenvironment
and Paleoproduction Landscapes

Simulation of Social Process related
with the Urbanization Process

in the areas along the coasts of Mediterranean sea where
the Cities originated, between XI-VIII Centuries B.C.

XI – VIII Century B.C.

Origin of the City-State in the Mediterranean Area
An important subject in the present research in Archaeology

Mediterranean area during this age started as a global trade and market area. Urban centres originated and previous villages disappeared in few tenths of years. In Etruria this phenomenon is known like the "Villanovan revolution"

Origin of the City

The Origin of the City (and of the State) is a central problem of the present research in Archaeology

The previous slide example demonstrates the amplitude and the complexity of such a problem. The area to be analysed is all the Mediterranean area, and any aspect related with the situation during XI-VIII centuries B.C. must be evaluated.

In the South Etruria territory, this fenomenon has been defined "***synecism***", and produced, in the late phases of Final Bronze Age, a transition from the scattered settlements of the older Bronze Ages to the concentration of few urban centers on the large, unitarian and well defended plateaux.

Origin of the City

Huge amount of data

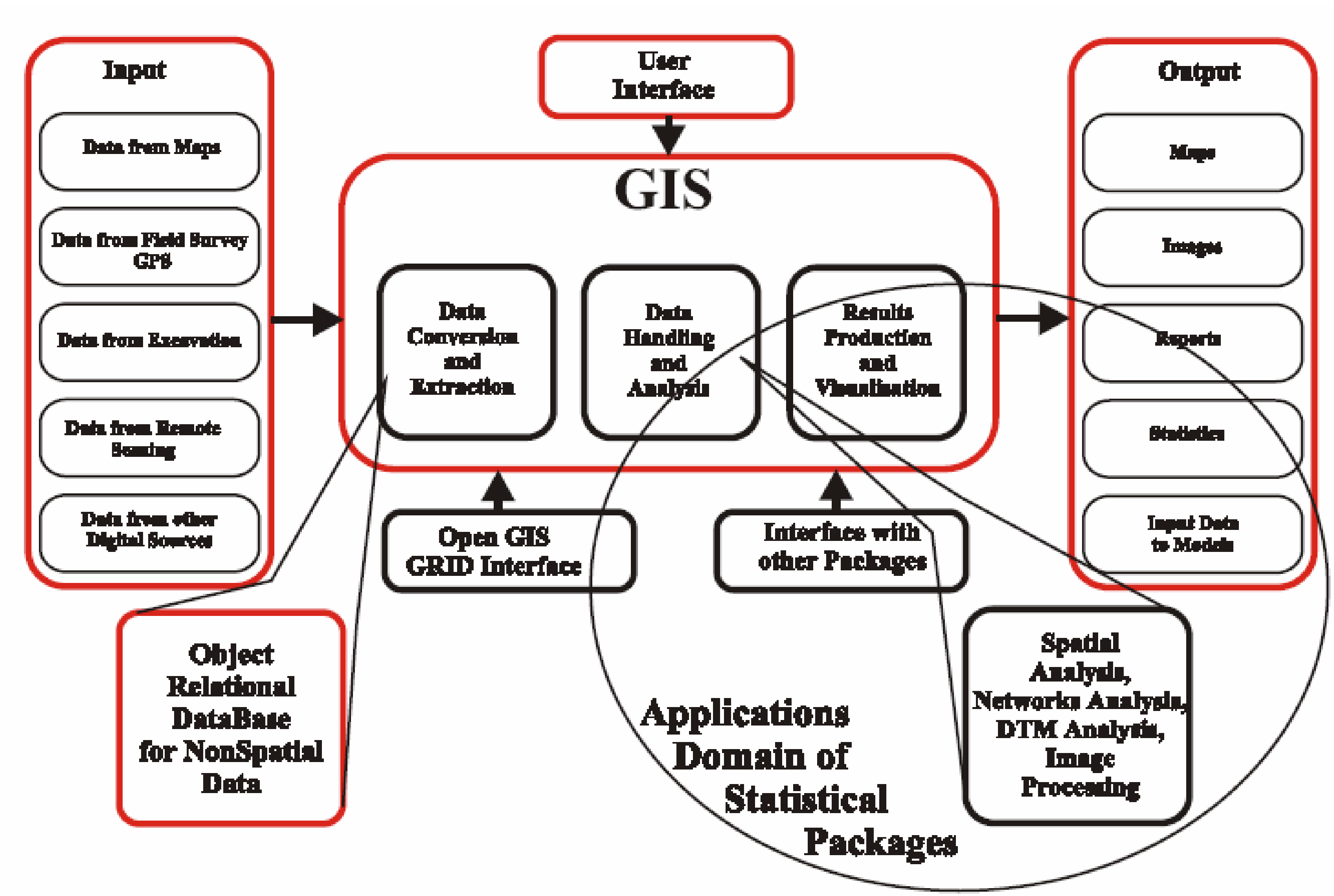
From past research: this area has been studied from many archaeologists for a long time.
From present research: the new technologies give us the possibility to complete with new more precise data the previous scenarios, but simulations outputs will produce very large data.

Advanced Analysis Methods

Origin of the City as a Dynamic System. From simple dynamic model to complex dynamic model. From “simple” society to “complex” society:

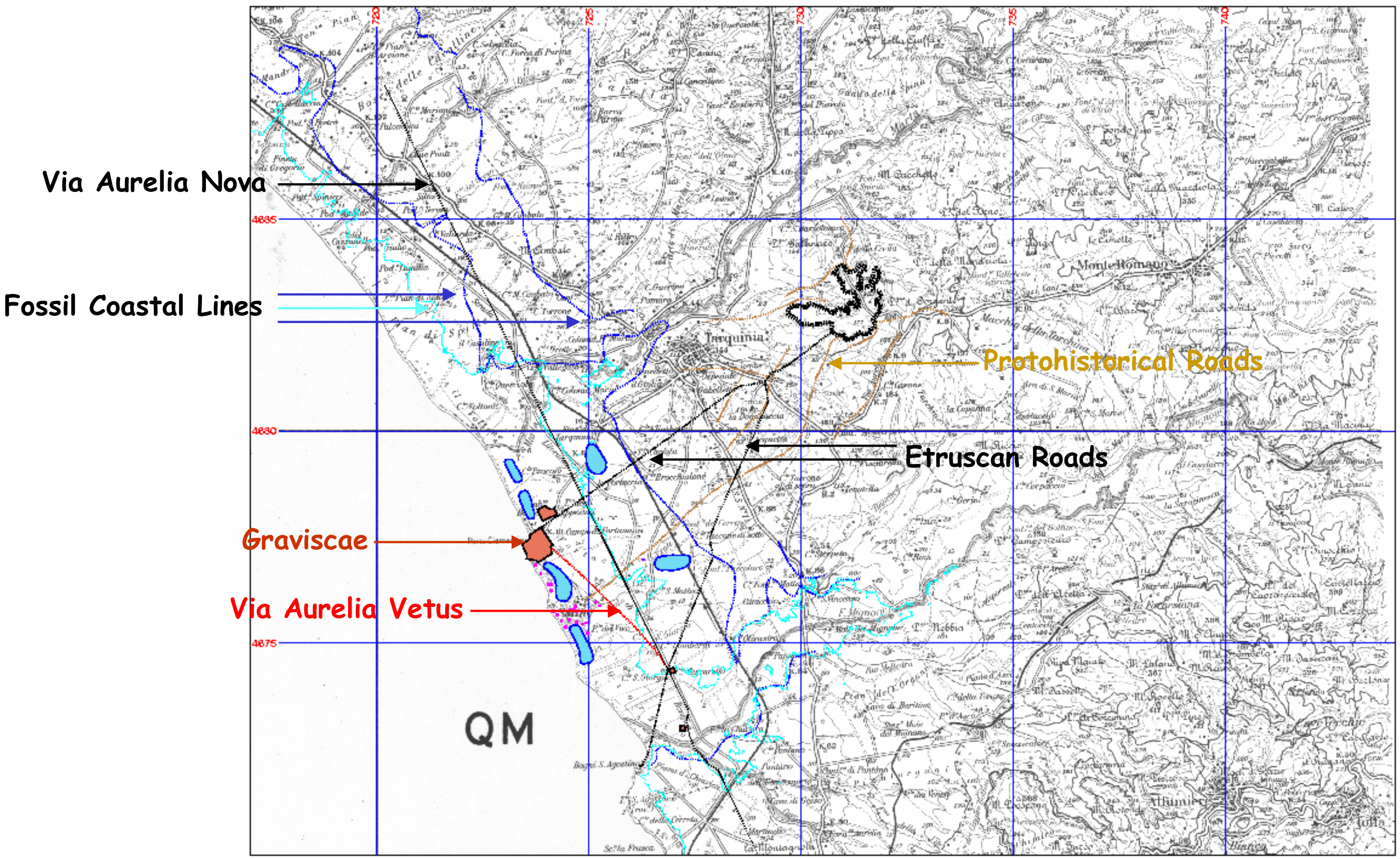
Archaeological GIS coupled to Multi Agent-Based Model

Archaeological GIS



Lagoons

Coastal Lagoons with Etruscan Roads, Roman Via Aurelia Nova and Vetus, the Graviscae Emporium and the Fossil Coast Lines



Archaeological Land Evaluation

Many authors and ancient sources underlined the role of the agriculture as the primary source of the economical prosperity in Etruria. Reconstruction and evaluation of Suitability of Ancient Landscape to the basic testified crops (Spelt and Cereals Cultivation), has been done through tables and maps related to every specific land use, taking into account the average dimension of the agrarian family property in the villanovan age (areas of middle size).

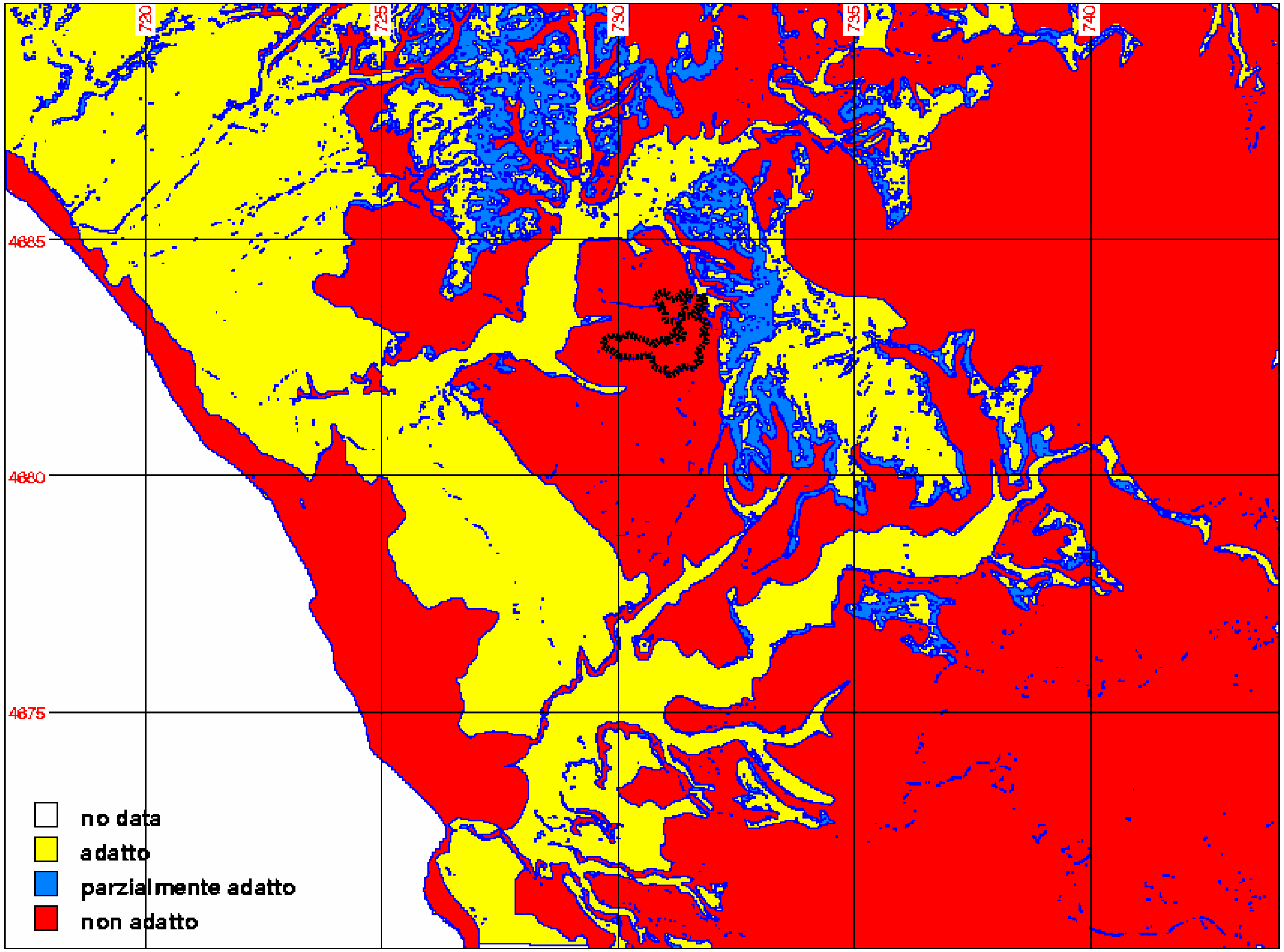
It have been used for the Land evaluation the FAO rules and criteria, adapted to the ancient soils.

Land quality, characteristics evaluation and landscape reconstruction are performed on the basis of hydrology, sedimentology, geomorphology and geology of the Tarquinia territory.

It have been also considered data as: hydrography, hydrographic basins, surface waters and water-bearings (soils moisture); rains and isohyets; climate and temperature changes (cool and humid variations); amount of rains and climatic instability.

Land Evaluation

Map of soils suitable ☐, partially suitable ☐ and not suitable ☐ for spelt cultivation



Reconstruction of the Paleoenvironment and Paleoproduction Archaeological Landscapes and Landuses

Available data on climate, geomorphology, hydrography, land use, etc. will be used for a reconstruction of global and local ancient paleoenvironment and paleoproduction landscapes:

- Reconstruction of the resource distribution, as soils for agriculture and farming, as mines for metal production, as forest for wood, as fauna, as techniques, etc.
- Reconstruction of the activity areas for artifact production, for fishing, for any other production.
- Reconstruction of the terrestrial communication road, the fluvial ways and the maritime routes and harbours based on the archaeological remains and on the reconstructed geomorphological, hydrographical and oceanographical situation

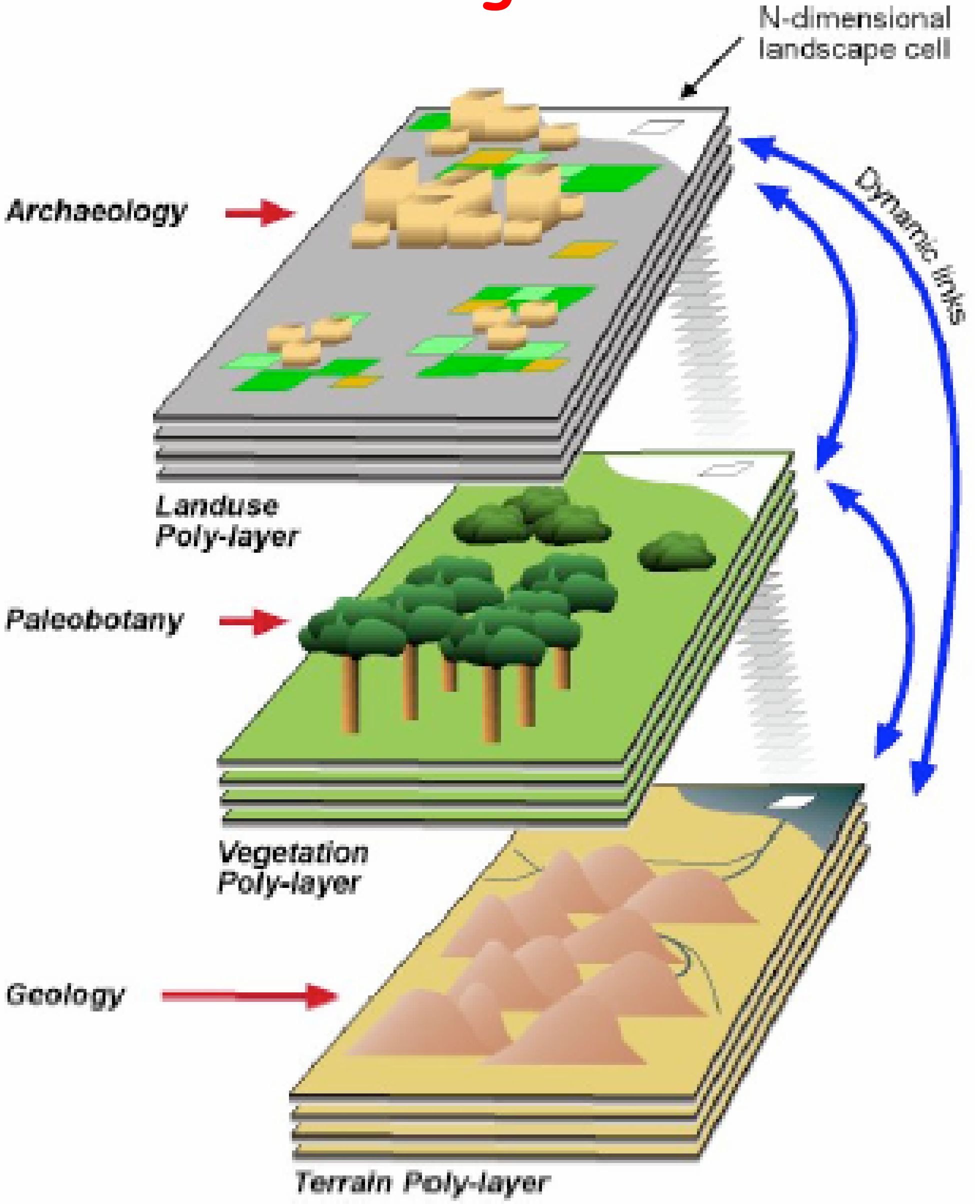
Poly-layer as Landscape Chronological Sequence

The Chronological Sequence of the studied period will have a minimum interval length, depending from the available data and from their time calibration precision.

Landscape poly-layer will be created as chronological sequence of the urbanization process and of the its effect on the landscape changes.

High resolution DEM's from satellite images allow high precision geospatial modeling of erosion and deposition, and digitally trace ancient streams from channel fills, and expose ancient surfaces now buried under alluvial fans.

Archaeological Paleoproduction Landscapes
vs
Archaeological Time



Coupling of Archaeological GIS and MultiABM

The best way for representing data and process could be the coupling of the Archaeological Spatial Data Model, the Archaeological GIS, with the Spatial Process Model for a real description of the process, as the Multi Agent-Based Model.

GIS tools are limited in process knowledge
essentially static views and little description of process (e.g. specify changes at a given location and place, not the process)

MABM tools are limited in spatial knowledge
much of the development is already in GIS systems

Coupling Archaeological GIS and MABM
Agents, mapped to spatial features, request information from the Archaeological GIS, then take appropriate actions.
MABM should be in control of temporal dynamics and synchronize its temporal dynamics with the ones of Archaeological GIS.
GIS has a richer spatial expression, and thus should be in control of the topological dynamics

Modelling a City community in the Mediterranean Area

- Take an existing settlement landscape system for which it can be estimated population, cultivated area, etc.

- Set up a demographic model based upon that landscape, as well as the social make-up of the community (s).

- Run a climate simulation using existing climate packages for Regional Climate Model – (required by EGAAP Committee)

- Each household (or agent) goes about its daily life, farming, exchanging goods, marrying etc.

- Measure the results in terms of input (land, rainfall, previous population etc) and output (grain, livestock, no. of household, population etc).

- Calculate the influence of trade and exchanges on the city economy and social organization.

Scope and Scale of the City Simulations

Scope: from individual settlement to city up to whole region

Entity Level Resolution and Granularity:

Individual cropped fields
Individual households and persons as independent social agents
Livestock herds and individual fauna
Households exchange
City commercial activities

Temporal and Process Resolution:

Daily updates to weather, hydrologic and soil processes, and vegetation dynamics
Long term and long distance commercial activities

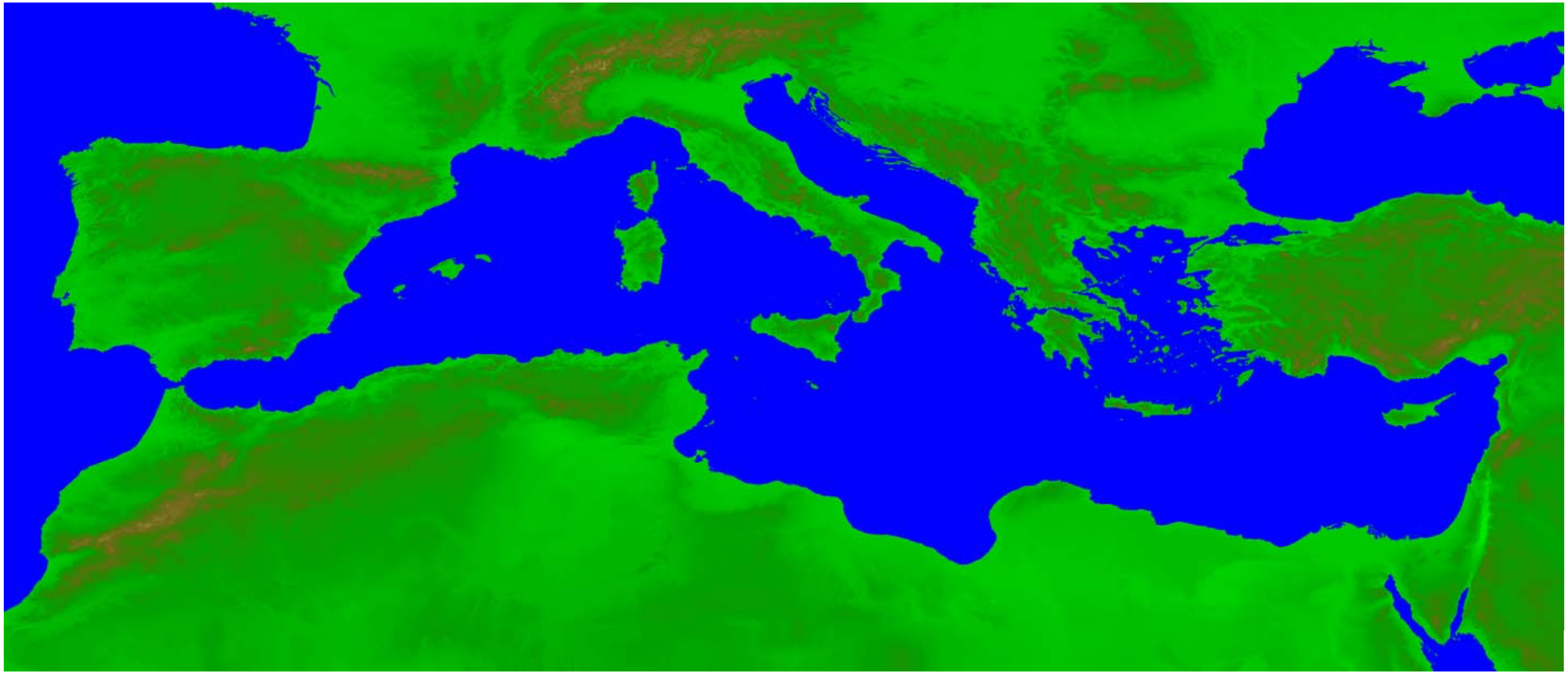
Static (Archaeological GIS) vs Dynamic Models (MABM)

A *static* model (Archaeological GIS) of the landscape, derived from archaeological data and written sources, gives the spatial effects of the social action at a time (*spatial analysis*).

The Multi Agent Based models can be used to simulate the development of population, farming, exchanges etc. using individuals (households, villages, etc) as "agents". Each agent has a behavior set on the basis of known historical and ethnographic data.

DEM of the Mediterranean Area

GTOPO30 – lat. long. res.1Km



Archaeoclimatology

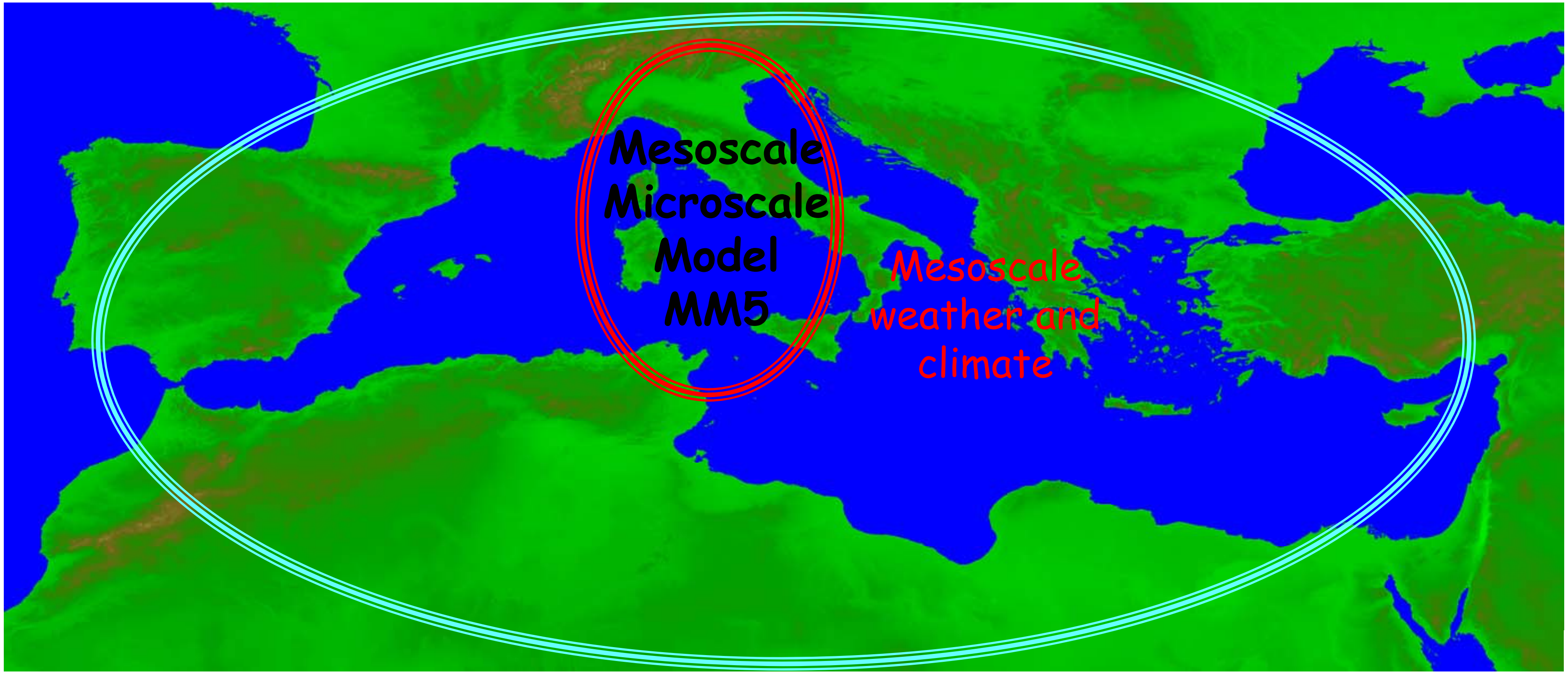
The term "**Archaeoclimatology**" was coined by Reid A.Bryson, about 1990, to designate a particular approach to the estimation of past climates along time according to the spatial scales appropriate for the use of Archaeologists.

Because cultures change on less than the millennial scale, and because people live in relatively restricted areas, whatever data or model is used must be nearly site-specific and of high time-resolution.

Ideally, the method should be rather economical, since archaeology tends to be funded at a low level !!

This subspecialty of paleoclimatology is largely concerned with bringing together various sources of estimation of past climates, models, and proxy estimates from field studies, to provide the most consistent estimates of the past climatic environment at particular places and times.
The study of proxy records has been well advanced by various other earth and biological sciences, so that Archaeoclimatology thus far has been concerned with climatic models designed with this particular goal in sight, rather than on studies of the atmosphere itself.

Paleoclimate Simulation (only free software !) for the Mediterranean Area around 900 B.C.



General Circulation Model – CCSM3.0

Use paleoclimate General Circulation Model – CCSM3.0 – runs to force mesoscale weather model – MM5 - to produce regional weather and climate

Temporal and Spatial Fine Scale Weather Simulation

For single settlement modeling studies, it will be derived daily weather model climates from a Markov process weather generator - SWAT -, that constructs daily weather sequences from climatological summary data. Climate summaries used to feed this process, can use actual local climates or can use climate analogs, or purely synthetic climates intended to stress-test the modeled settlements. For the pan-Mediterranean studies, it has been planned to add fine-scale distributed climates derived from the MM5 mesoscale weather forecast model simulations, using derived 1st millennium BC surface cover estimates. Long-run general circulation model - CCSM3 - paleoclimate analyses can be used to help provide boundary conditions for the mesoscale climate simulations. Monthly average CCSM3 results can guide selection of representative finer-scale climate analog datasets to provide the requisite boundary conditions for MM5. Alternatively, if CCSM3 paleoclimate results are available at sufficiently fine temporal resolution, they can be used directly to drive the MM5 runs.

It will need to develop a cluster computer-based MM5 system, that will likely be utilized in this effort.

Earth System Grid – https://www.earthsystemgrid.org

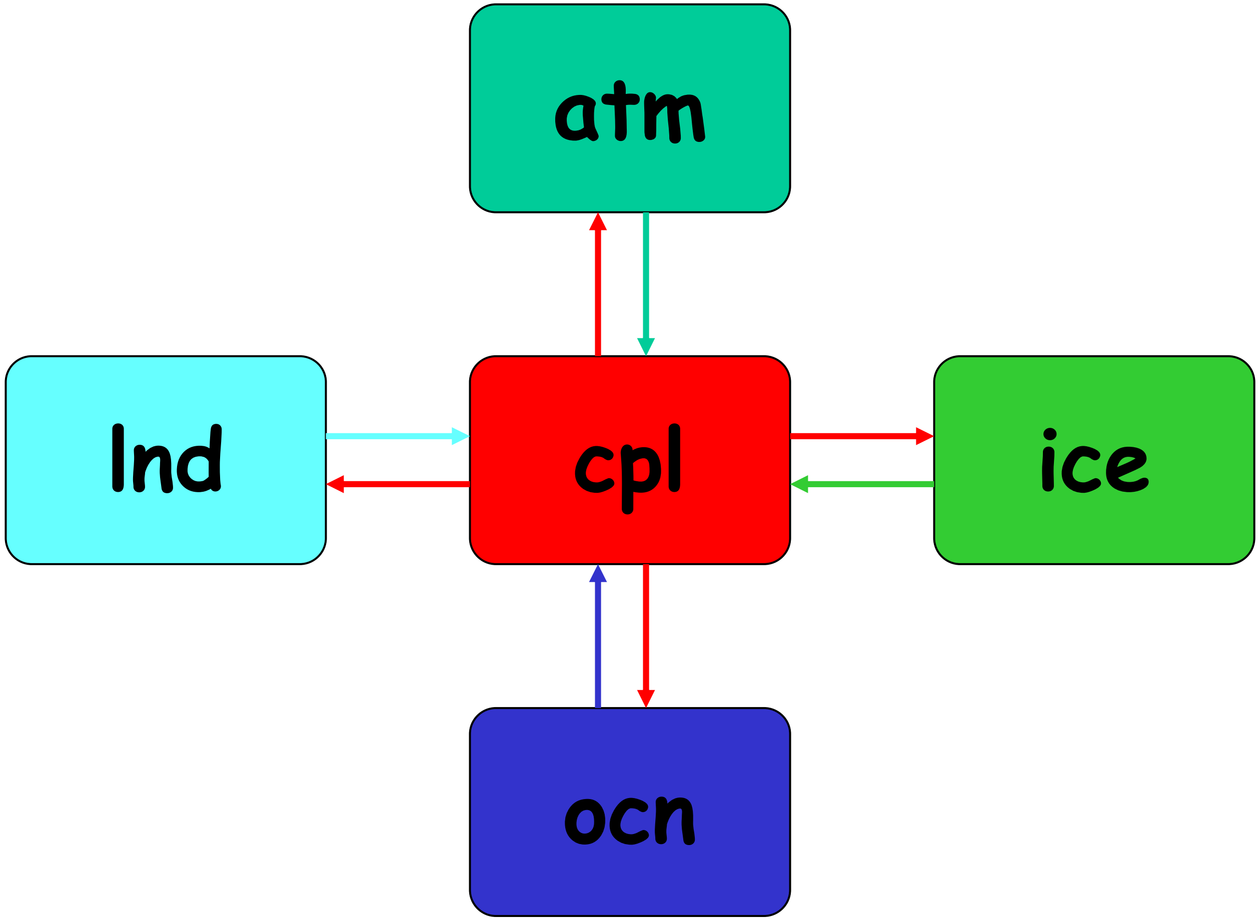
CCSM Model overview

The **Community Climate System Model (CCSM)** is a coupled climate model for simulating the earth's climate system. Composed of four separate models simultaneously simulating the earth's atmosphere, ocean, land surface and sea-ice, and of one central coupler component, the CCSM allows researchers to conduct fundamental research into the earth's past, present and future climate states.

CCSM3 Model Components

- **atmosphere**:– cam (cam3) : fully active atmospheric model– datm (datm6): standard data atmospheric model– latm (latm6): climatological-data atm model – xatm (dead) : dead atmospheric model
- **land**:– clm (clm3) : fully active land model– dlnd (dlnd6): standard data land model– xlnd (dead) : dead land model
- **ocean**:– pop (pop) : fully active ocean model– docn (docn6): standard data ocean model– xocn (dead) : dead ocean model
- **ice**:– csim (csim5) : fully active ice model– dice (dice6): standard data ice model– xice (dead) : dead ice model
- **coupler**:– cpl (cpl6) : coupler

CCSM Models



Component Resolutions

- **Atmosphere, Land**
  - T85 - gaussian grid, 256 longitudes, 128 latitudes [cam, clm]
  - T42 - gaussian grid, 128 longitudes, 64 latitudes [cam, clm, datm, dlnd]
  - T31 - gaussian grid, 96 longitudes, 48 latitudes [cam, clm, datm, dlnd]
  - 2x2.5 - type C grid, 144 longitudes, 91 latitudes [cam-FV dycore, clm]
  - T62 - gaussian grid, 192 longitudes, 94 latitudes [latm, dlnd]
- **Ocean, Ice**
  - gx1v3 - 320 longitudes, 384 latitudes
  - gx3v5 - 100 longitudes, 116 latitudes

Software Requirements

- **Compilers**: Fortran 90, C
- **Libraries**: MPI, netCDF

CCSM3 Component Parallelization

CAM, CLM, CSIM, POP, CPL need MPI library

CCSM3 Supported Machines/Platforms

Machine	Description	OS	Compiler	Network	Queue Software	RL
bluesky	IBM Pow4 8-way	AIX	IBM XL	IBM	Load Leveler	1
bluesky32	IBM Pow4 32-way	AIX	IBM XL	IBM	Load Leveler	1
blackforest	IBM Pow3 4-way	AIX	IBM XL	IBM	Load Leveler	1
cheetah	IBM Pow4 8-way	AIX	IBM XL	IBM	Load Leveler	1
cheetah32	IBM Pow4 32-way	AIX	IBM XL	IBM	Load Leveler	1
seaborg	IBM Pow3 16-way	AIX	IBM XL	IBM	Load Leveler	1
chinook	SGI	IRIX64	MIPS	NumaLink	NQS	2
jazz	Intel Xeon	Linux	PGI	Myrinet	PBS	2
anchorage	Intel Xeon	Linux	PGI	Gbit Ethernet	SPBS	3
bangkok	Intel Xeon	Linux	PGI	Gbit Ethernet	SPBS	3
lemieux	Alpha	OSF1	Compaq	Myrinet	PBS	3
moon	NEC Earth Sim	NEC	NEC	NEC	PBS	3
phoenix	Cray X1	Unicos/mp	Cray	CrayLink	PBS	4
calgory	Intel Xeon	Linux	PGI	InfiniBand	SPBS	4
rex	AMD Opteron	Linux	PGI	Myrinet	PBS	4
lightning	AMD Opteron	Linux	PGI	Myrinet	LSF	4

- RL=1 corresponds to machines where climate validations have been performed.
- RL=2 corresponds to machines that have passed the CCSM restart test for the fully active componentset
- RL=3 corresponds to machines where the CCSM has been built successfully but where the resultingmodel may or may not have been run successfully, and where if the model ran, restartvalidation may or may not have been successful.
- RL=4 implies that this machine may be supported sometime in the future.

Setting Up a New Machine

Look for supported machine(s) with

- GILDA CPUs
- GILDA architecture
- GILDA compilers
- GILDA interconnect
- GILDA batch process
- GILDA storage strategy

May need to combine from more than one “supported” configuration

The CCSM3.0 distribution

Model code and scripts:

ccsm3.0.tar.gz

Input data (e.g. for T42_gx1v3):

ccsm3.0.inputdata.atm_lnd.tar.gz

ccsm3.0.inputdata.T42.tar.gz

ccsm3.0.inputdata.gx1v3.tar.gz

ccsm3.0.inputdata.cpl.tar.gz

Output data available from CCSM3.0 previous runs

http://www.ccsm.ucar.edu/models/ccsm3.0

Mesoscale and Microscale Models – MMM -

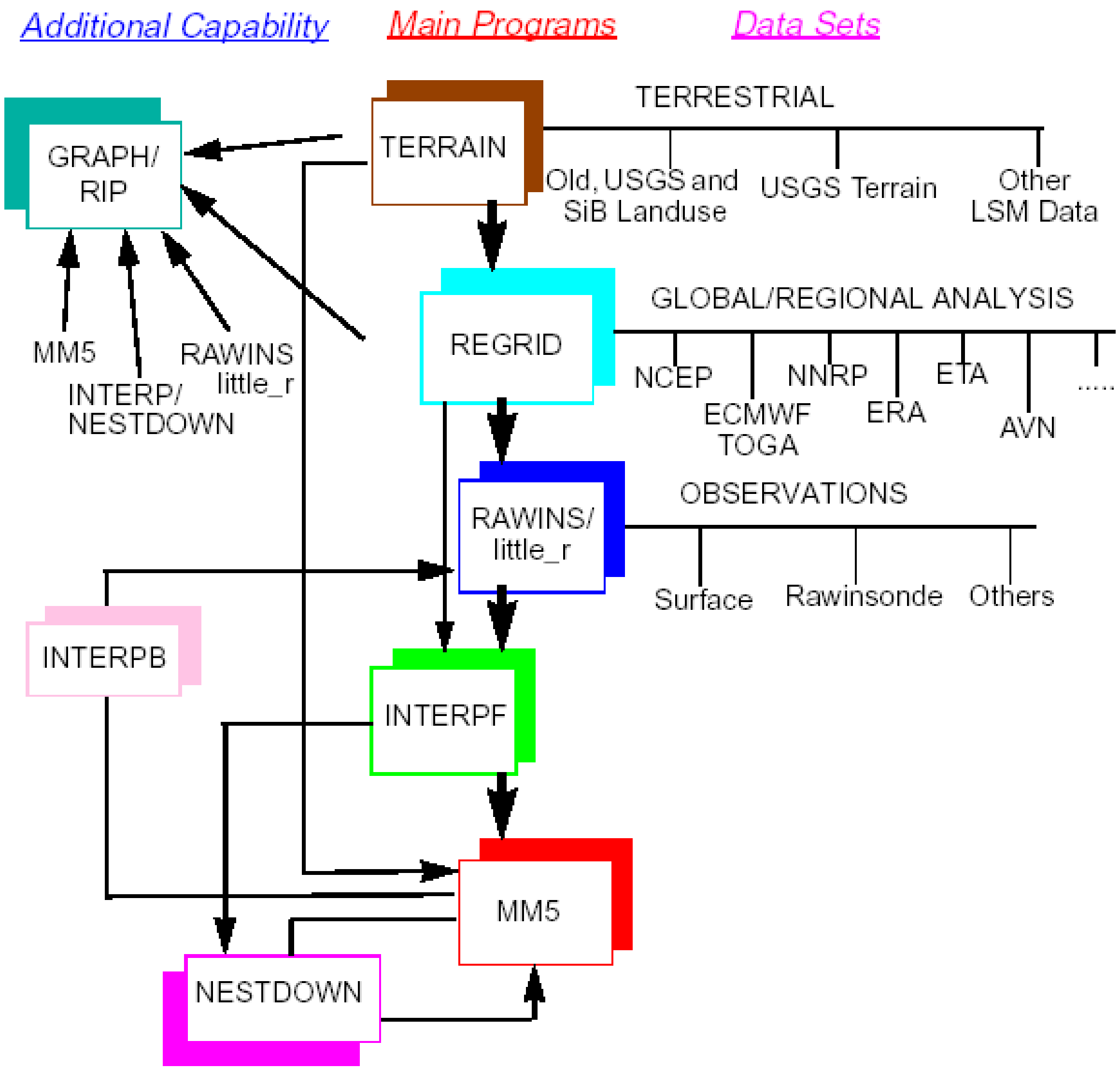
MM5 Modeling System Programs

Programs portability

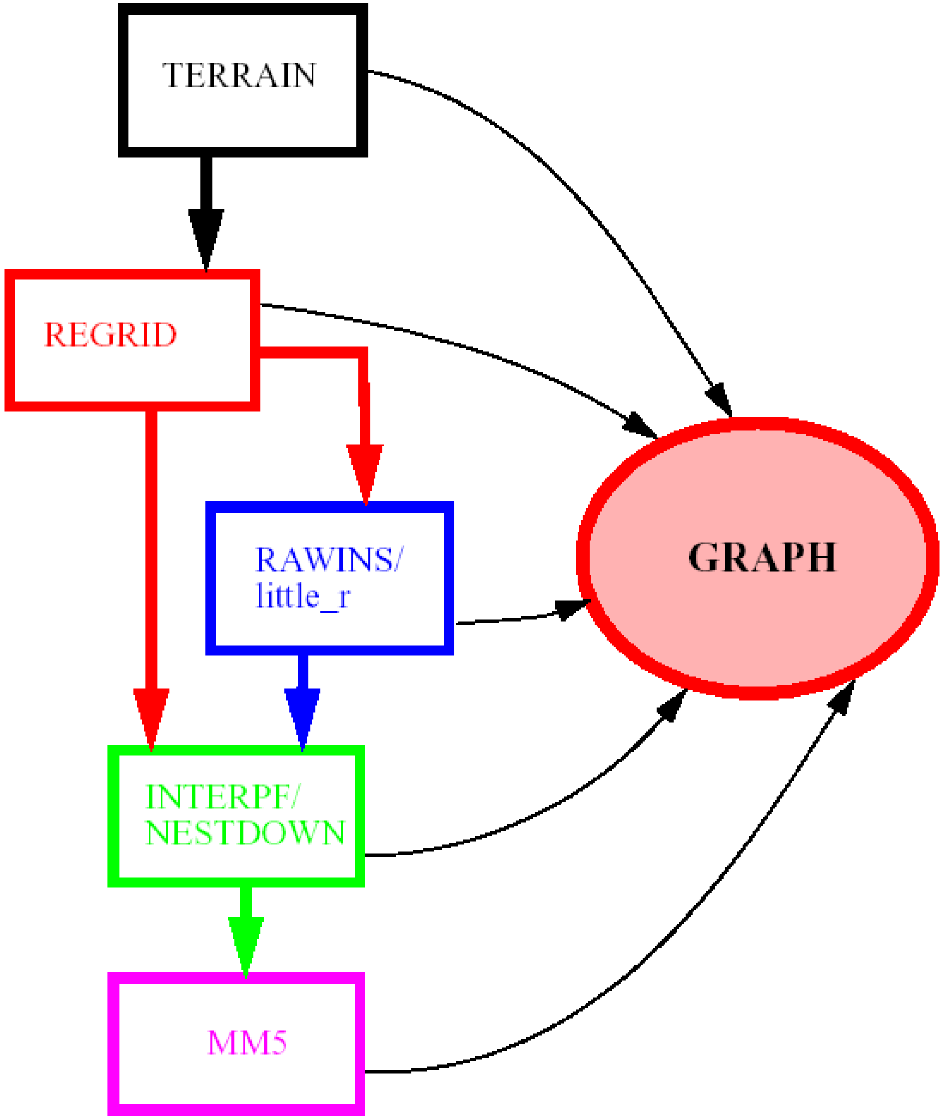
TERRAIN, REGRID, LITTLE_R/RAWINS, INTERPF, NESTDOWN, INTERPB, RIP/GRAPH and MM5,

can all be run on Unix workstations, **PC running Linux**, Cray's and IBM's. Running MM5 programs on a Linux PC requires either the **Portland Group, or INTEL Fortran and C compilers**.

MM5 Modeling System Flow Chart



Schematic Diagram showing GRAPH accepting Data from Outputs of MM5 Modeling System



NCAR Graphics

MM5 programs do not require NCAR Graphics to run.
It is a matter of convenience to have it, since a few programs use it to help you configure model domains and prepare data.
Some of the virtualization software that come with the MM5 system (RIP and GRAPH programs) is based on NCAR Graphics.
NCAR Graphics is a licensed software, but part of it has become free and this is the part that MM5 modeling system requires.
NCAR Graphics at the Web page: **http://ngwww.ucar.edu/**

GILDA testbed at INFN-Catania

November 15-18th, 2005

Florence Group visited the INFN GILDA Group in Catania, for a Tutorial Stage in view of a paleoclimate application on GILDA testbed, as suggested by EGAAP Committee in Pisa, and received a full collaboration.
Two certificates have been done for the Florence Group and the first approach to GILDA started running simple examples.
In view of the paleoclimate application, the GRASS60 GIS and the packages R for statistical analysis have been installed on GILDA.
Research started about free software for paleoclimate application running on GILDA testbed and about other utilities needed for data acquisition and management.

December 2005

Installation of Fedora Core 4, Certificates and UI PnP on PCs in Florence.
Acquisition of new PC with the needed performance by the Florence INFN.
Research of free software and data for archaeological paleoclimate application: CCSM3.0 and MM5 Models seem to satisfy also the archaeological needs.
Contacts with CETP-France (Monique Petitdidier)
Contact and discussion with the UAB-Barcelona ArchaeoGRID Group.

Simulation, Visualization and Narration

Simulation, Visualization and **Narration** of the research results are interlaced and represent the work in progress of the working group. The purpose is to exceed the static approach given from the GIS analysis, through an open methodological tool suitable for simulations in a larger territorial scale and context. In fact 3D Graphics, VR and AR technologies can be used in the different phases of research, for simulation and narration:

a-in preparing the research project

b-in acquiring data and in making the first raw analysis

VR and AR technologies could help, during the analysis, to understand if the results, also partial, have some coherence with data and if the emergence of new aspects do not depend from errors in calculation or in our hypotheses

c-in final analysis and in writing the final paper

Conclusions

ArchaeoGRID enables the possibility to exploit Advanced Computational and Storage Methods in Archaeology for generating, curating and analysing big amount of data from field surveys, excavations, laboratories, bibliography, and for developing and explore models and simulations from data with a very large number of variables, needed for the analysis of the emerging large region archaeology

Archaeological knowledge building is a collective work. The explanation process needs knowledge as a raw material, and this knowledge doesn't exist in mind of one individual scientist. Knowledge is distributed in the community of researchers, on a global scale. To be able to interpret the data, every researcher needs a previous knowledge on which he will make a specific reference

In the vision of the **"Knowledge Grid"**, the ArchaeoGRID acts as an unifying agent between applications and non homogeneous data. Access and management of data and software are an advantage for a completely new way of producing archaeologically relevant knowledge.

ArchaeoGRID becomes the medium for the cognitive process in Archaeology and for advancing in Archaeological Knowledge Unification and Integration through the use of advanced technological platforms