

Modelling Climate Change effects on species distribution using a Cloud Computing infrastructure

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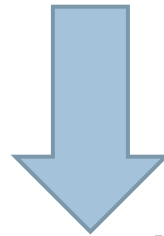
EGU GA, Vienna, 8/4/2001

Outline

- Brief introduction to the scientific use case
- Technological solution adopted:
 - ▣ Cloud Computing IaaS platform
 - ▣ Open Web Services
- Explanation of the developed prototype
- Performance evaluation

Scientific use case

We predict, on the basis of mid-range climate-warming scenarios for 2050, that 15–37% of species [...] will be ‘committed to extinction’ [Thomas04]



There is an urgent need to investigate such phenomena, assess their possible impact on the distribution of species and propose solutions to mitigate such effects

Ecological Niche Model (ENM)

Definition:

*“...an N-dimensional hypervolume, every point in which corresponds to a state of the environment which would permit the examined species to exist indefinitely.
[Hutchinson, 1957].”*

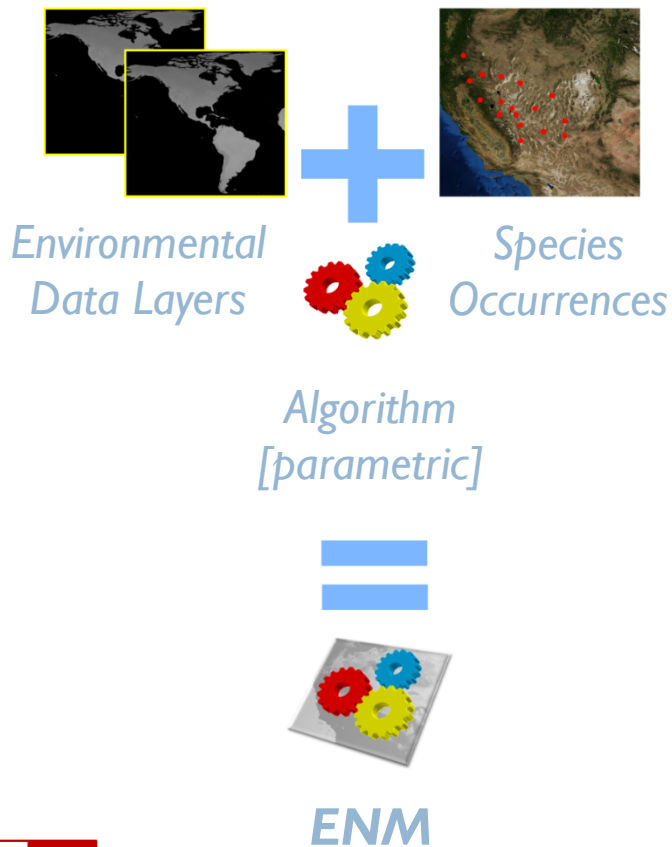
Types:

- *Fundamental Niche*
- *Realized Niche*

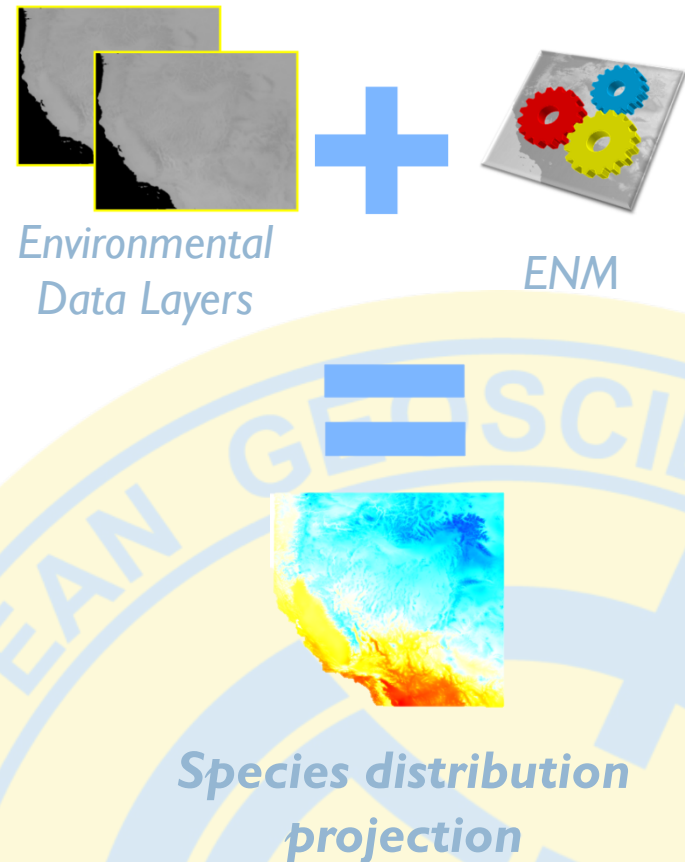
only biological/physical aspects
interaction between species

OpenModeller

Creation of an ENM



Projection of an ENM



Technological problem

- Many different geographical areas;
- Many different environmental/climatological scenarios;
- Many different living species;
- Many different processing algorithms.

Need for TECHNOLOGICAL INFRASTRUCTURES
suited for:

STORE and PROCESS

Huge amounts of environmental data

Previous works

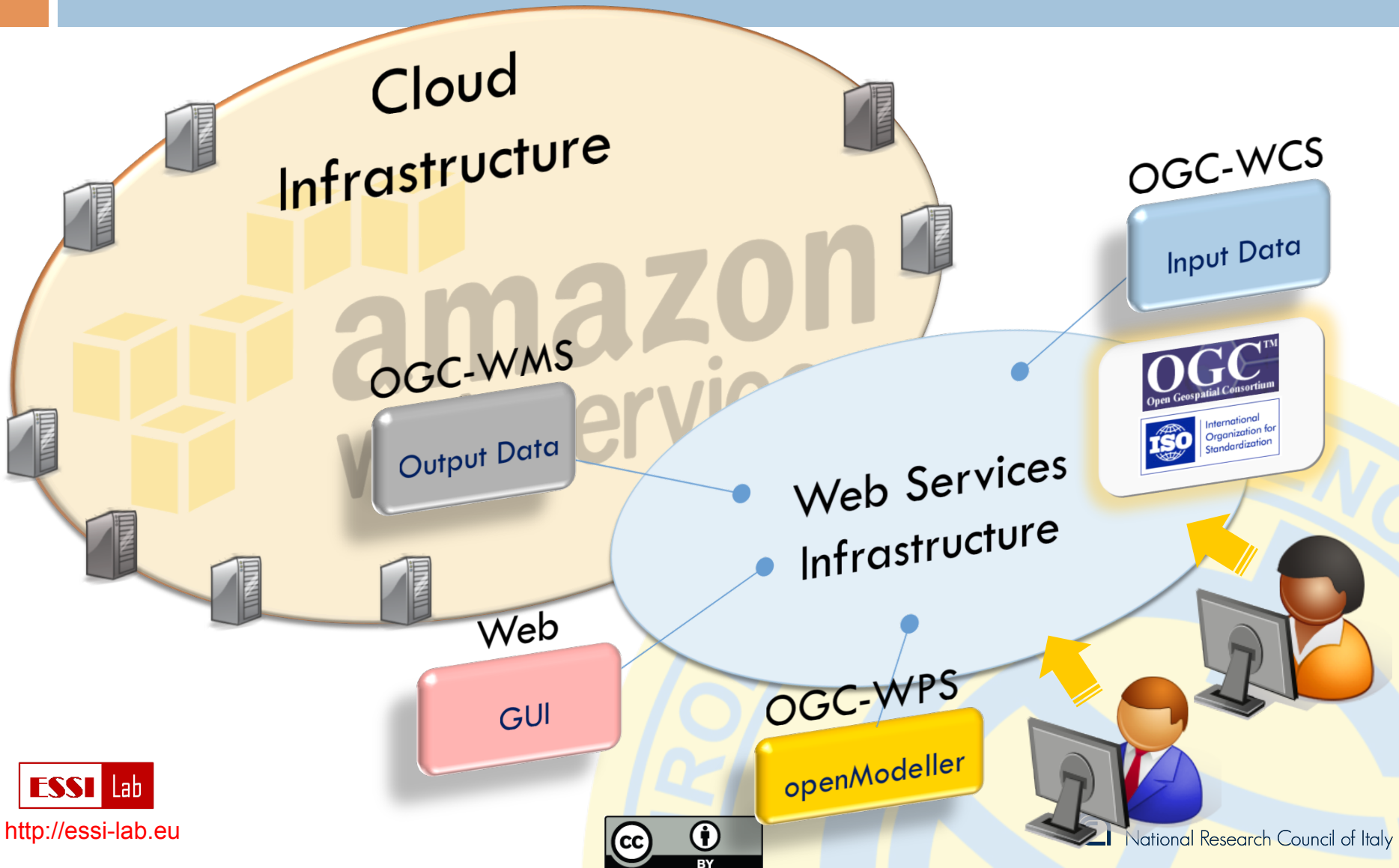
- Scenario

- ▣ Climate Change and Biodiversity use scenario GEOSS AIP-2 [GEOSS09]

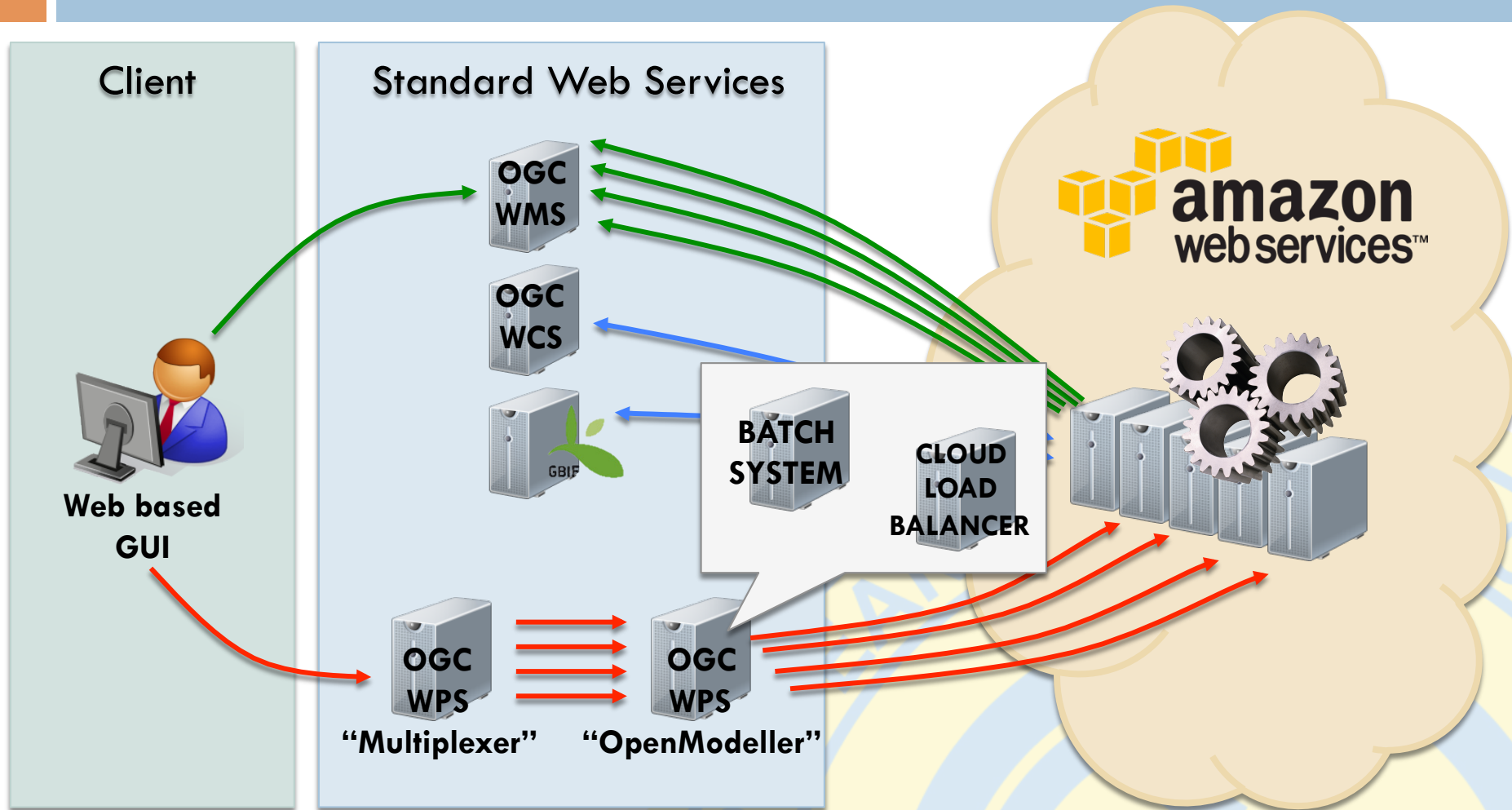
- Architectural framework

- ▣ Cyclops FP6 Project [Mazzetti09]
 - ▣ G-OWS - <https://www.g-ows.org/>

Our proposed architecture



Detailed prototype workflow



Screenshots

The screenshot shows a web interface for selecting an algorithm. At the top, there are three tabs: "Create a Model", "Project models", and "Job". Below these, there are four sub-tabs: "Taxon", "Environmental Layers", "Algorithm", and "Send the Request". The "Algorithm" tab is currently selected. Under this tab, there is a list of algorithms: "BIOCLIM", "CLIMATE SPACE MODEL", "ARTIFICIAL NEURAL NETWORK", "MAXIMUM ENTROPY" (which is expanded), "AQUAMAPS", and "GENETIC ALGORITHM FOR RULE SET PRODUCTION". The "MAXIMUM ENTROPY" section contains four input fields: "Number Of Background Points:" with a value of 10000, "Number Of Iterations:" with a value of 500, "Terminate Tolerance:" with a value of 0.00001, and "Output Format :" with a value of 1. Each input field has a "Numeric" label below it. A "Set Algorithm" button is located below the input fields.

Create a Model Project models Job

Taxon Environmental Layers Algorithm Send the Request

▶ BIOCLIM

▶ CLIMATE SPACE MODEL

▶ ARTIFICIAL NEURAL NETWORK

▼ MAXIMUM ENTROPY

Number Of Background Points: 10000
Numeric

Number Of Iterations: 500
Numeric

Terminate Tolerance: 0.00001
Numeric

Output Format : 1
1 Raw - 2 Logistic

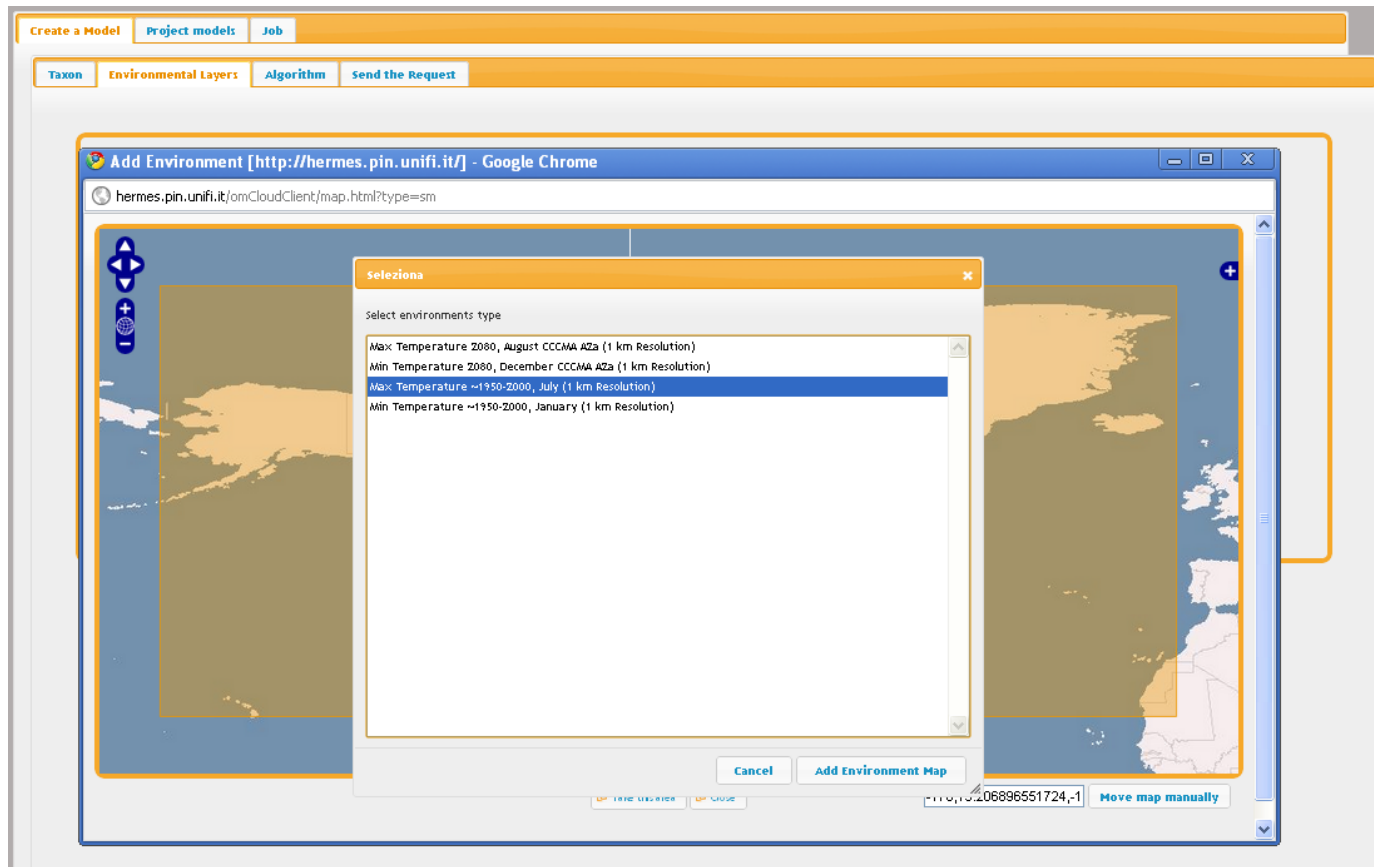
Set Algorithm

▶ AQUAMAPS

▶ GENETIC ALGORITHM FOR RULE SET PRODUCTION

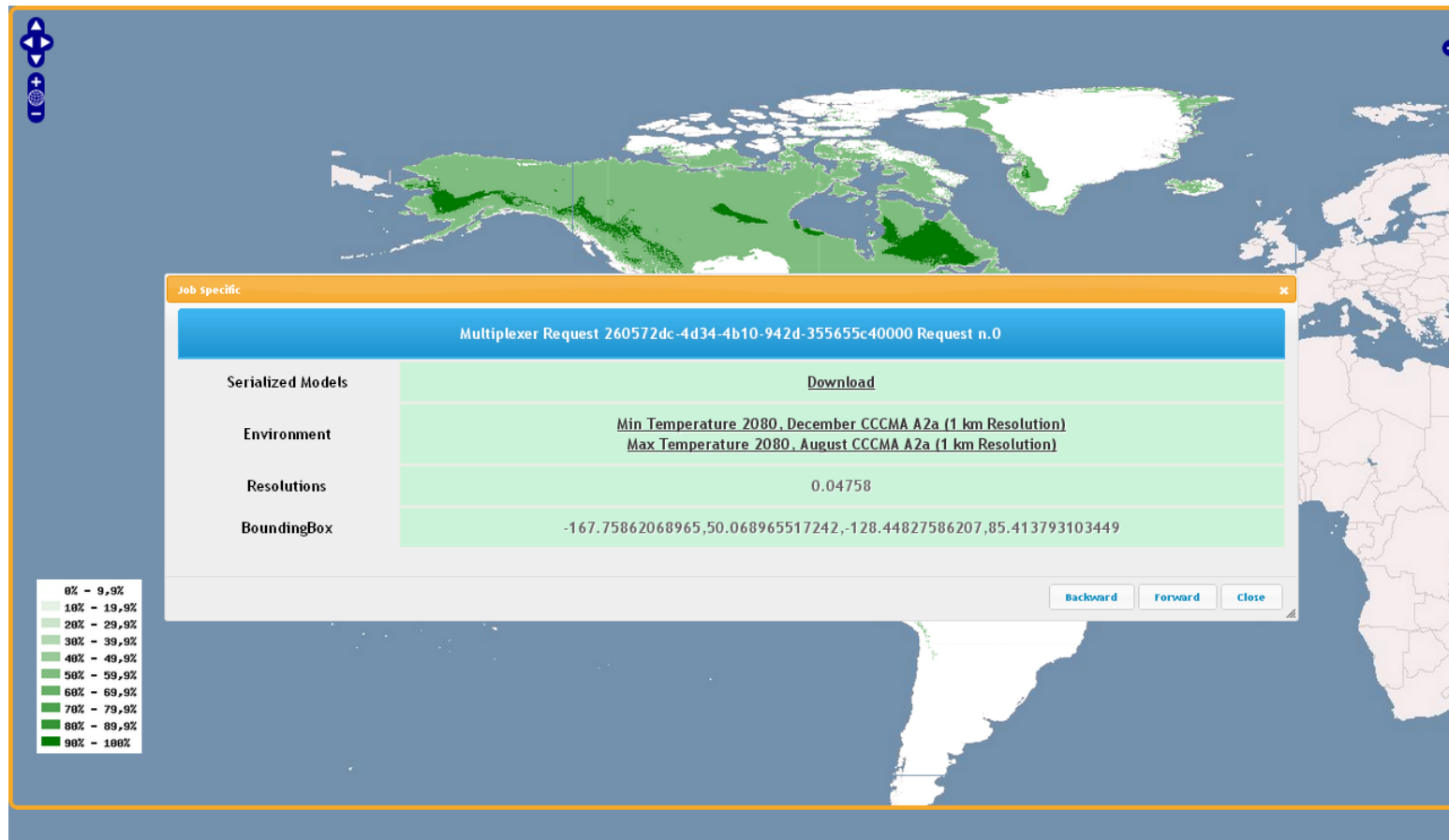
ENM Algorithm Selection

Screenshots



Env. Layers Selection from OGC WCS

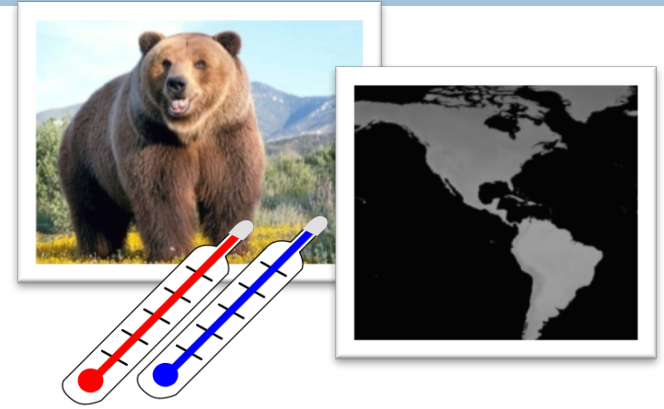
Screenshots



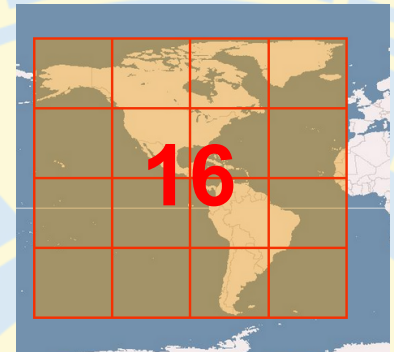
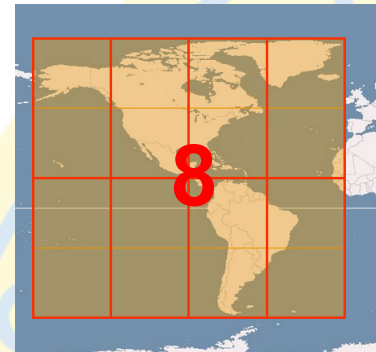
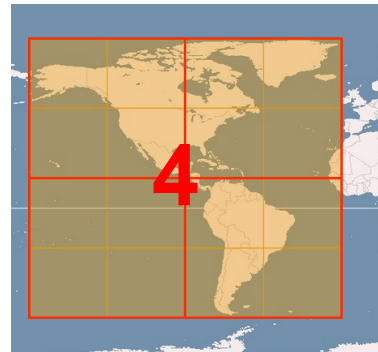
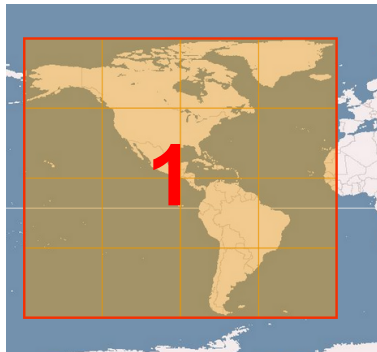
Species projection visualisation through OGC WMS

Test environment

- Species: **Ursidae**
- Region: **American Continent**
- Env. Layers: **Max and Min temperature 2080 [IPCC]**

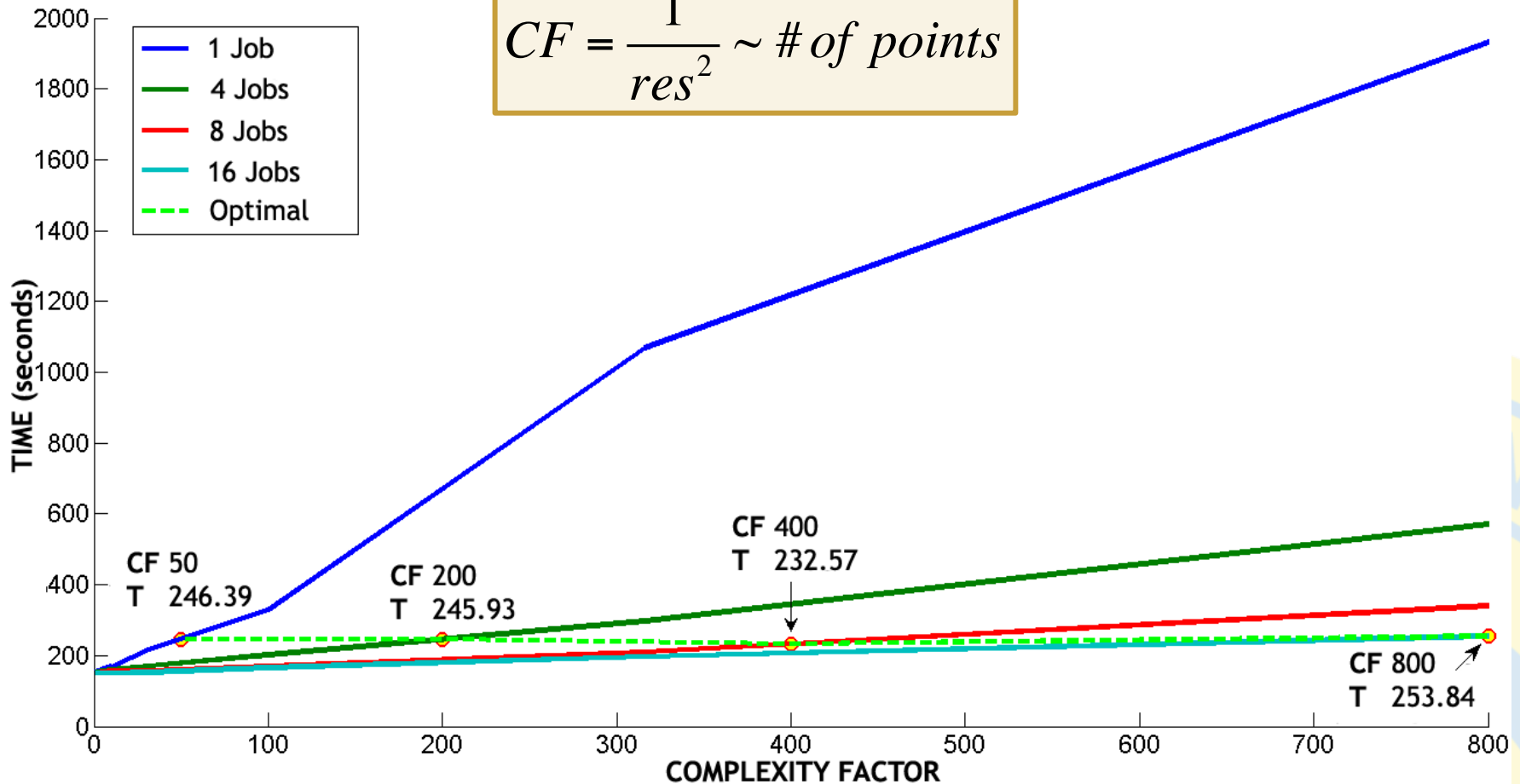


- To enable the execution parallelisation the domain has been split in various sub-regions



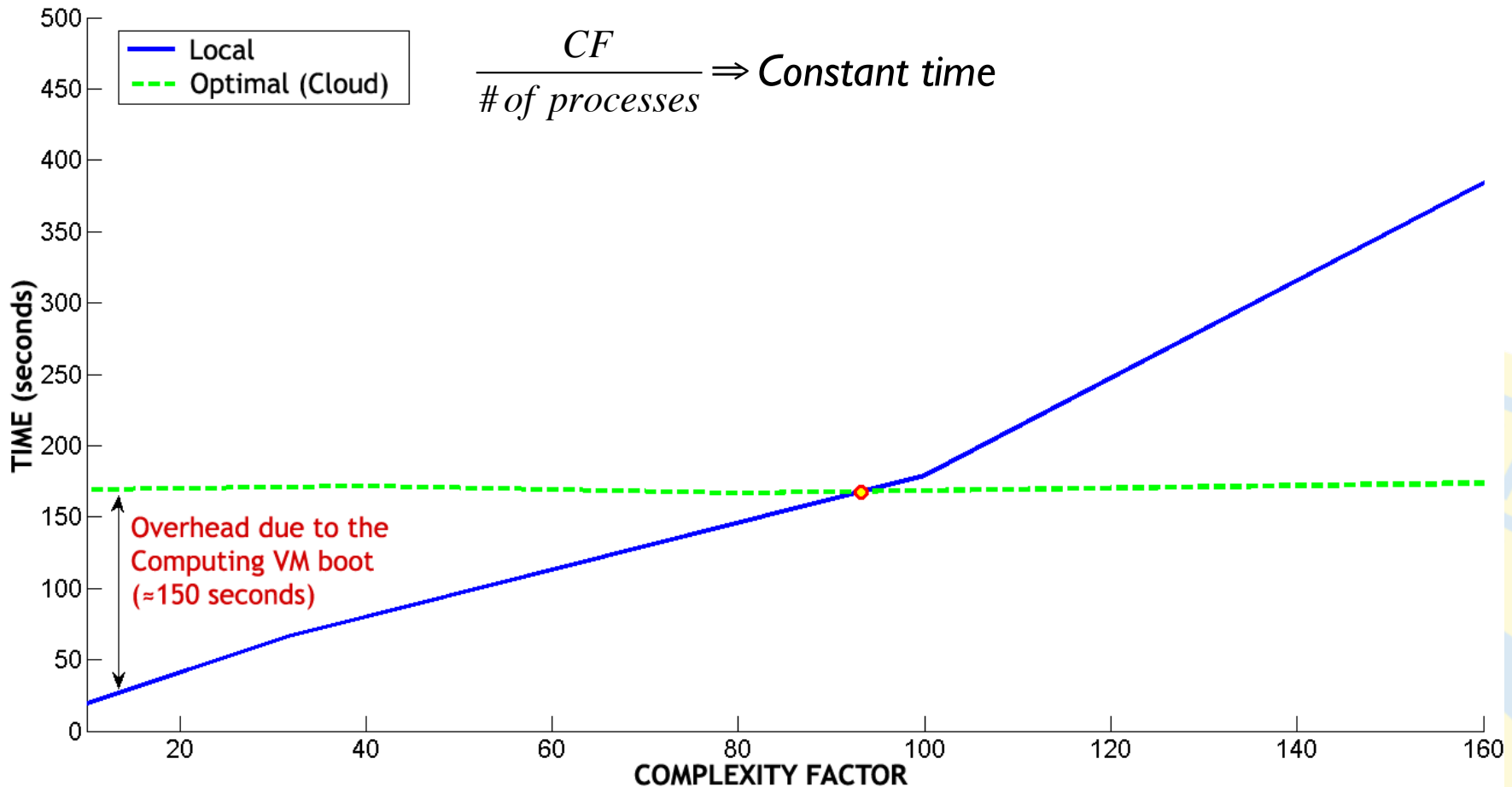
Performance evaluation

$$CF = \frac{1}{res^2} \sim \# \text{ of points}$$



Performance evaluation

Processing time becomes independent from the execution complexity



Conclusions

- **Interoperability:** the adoption of open standards (e.g. OGC WCS, WPS, WMS) assures in principle interoperability with standard based resource sharing infrastructures
- **Scalability:** the adoption of on-demand Cloud services makes possible to scale up computing power and storage space
- **Total Cost of Ownership:** often the cost are very reduced compared to the TCO of a private cluster
 - ▣ Adoption of the Pay-per-Use pricing model

Thank you for your attention!

□ References

- [Thomas04] Thomas et al., *Extinction risk from climate change*
Nature, vol. 427, 8 January 2004
- [GEOSS09] Nativi et al., *Climate Change and Biodiversity WG Use Scenario Engineering Report GEOSS AIP-2*
July 2009
- [Mazzetti09] Mazzetti et al., *A Grid platform for the European Civil Protection e-Infrastructure: the Forest Fires use scenario*
Earth Science Informatics, 2009. DOI: 10.1007/s12145-009-0025-8