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

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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* — only biological/physical aspects
- *Realized Niche* — interaction between species

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OpenModeller

Creation of an ENM

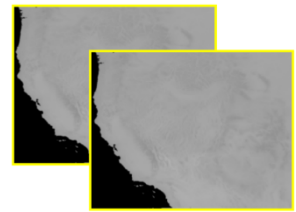
Environmental Data Layers

Species Occurrences

Algorithm [parametric]

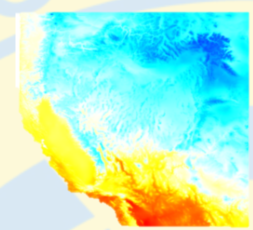
ENM

Projection of an ENM



Environmental Data Layers

ENM



Species distribution projection

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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:

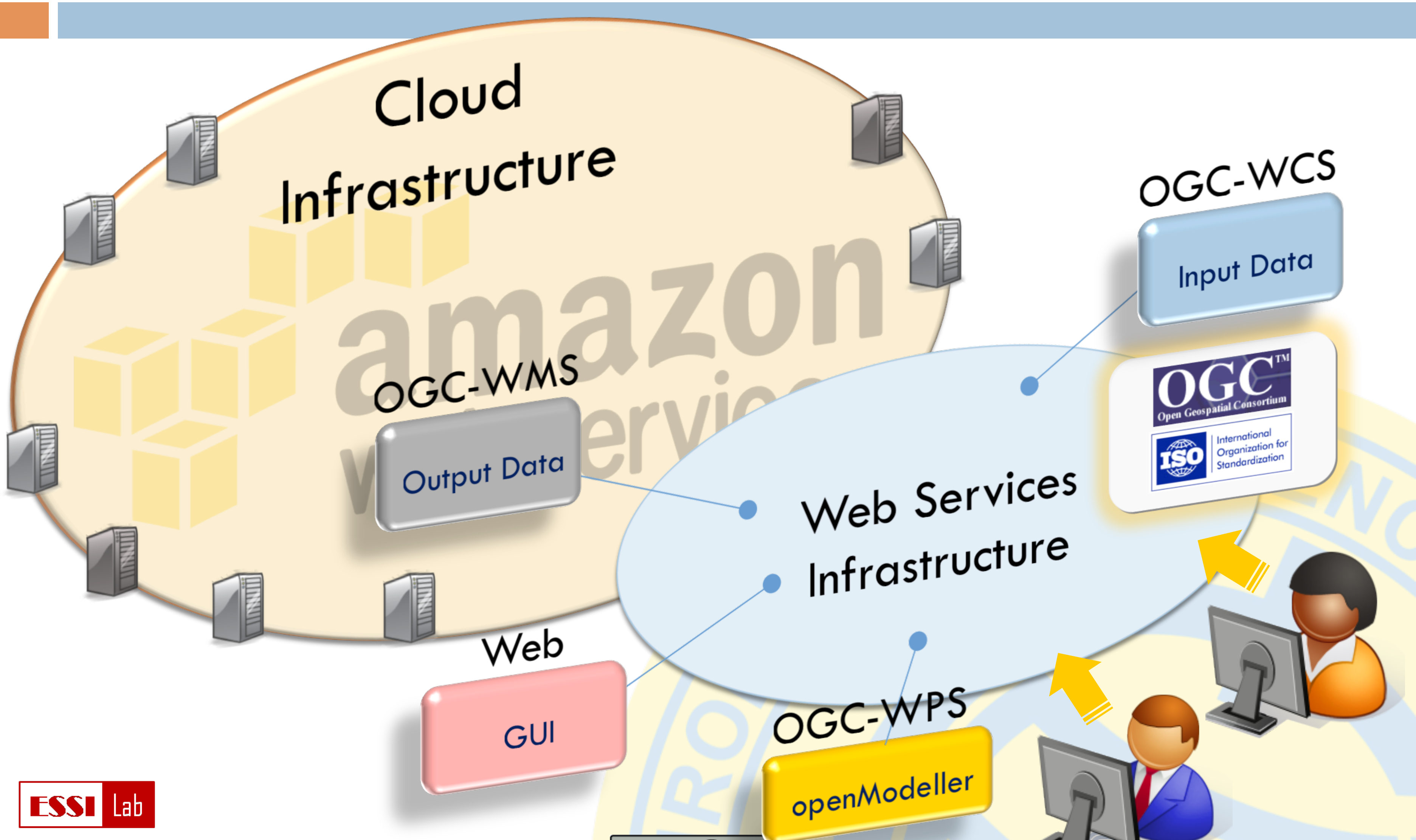
STORE and ***PROCESS***

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



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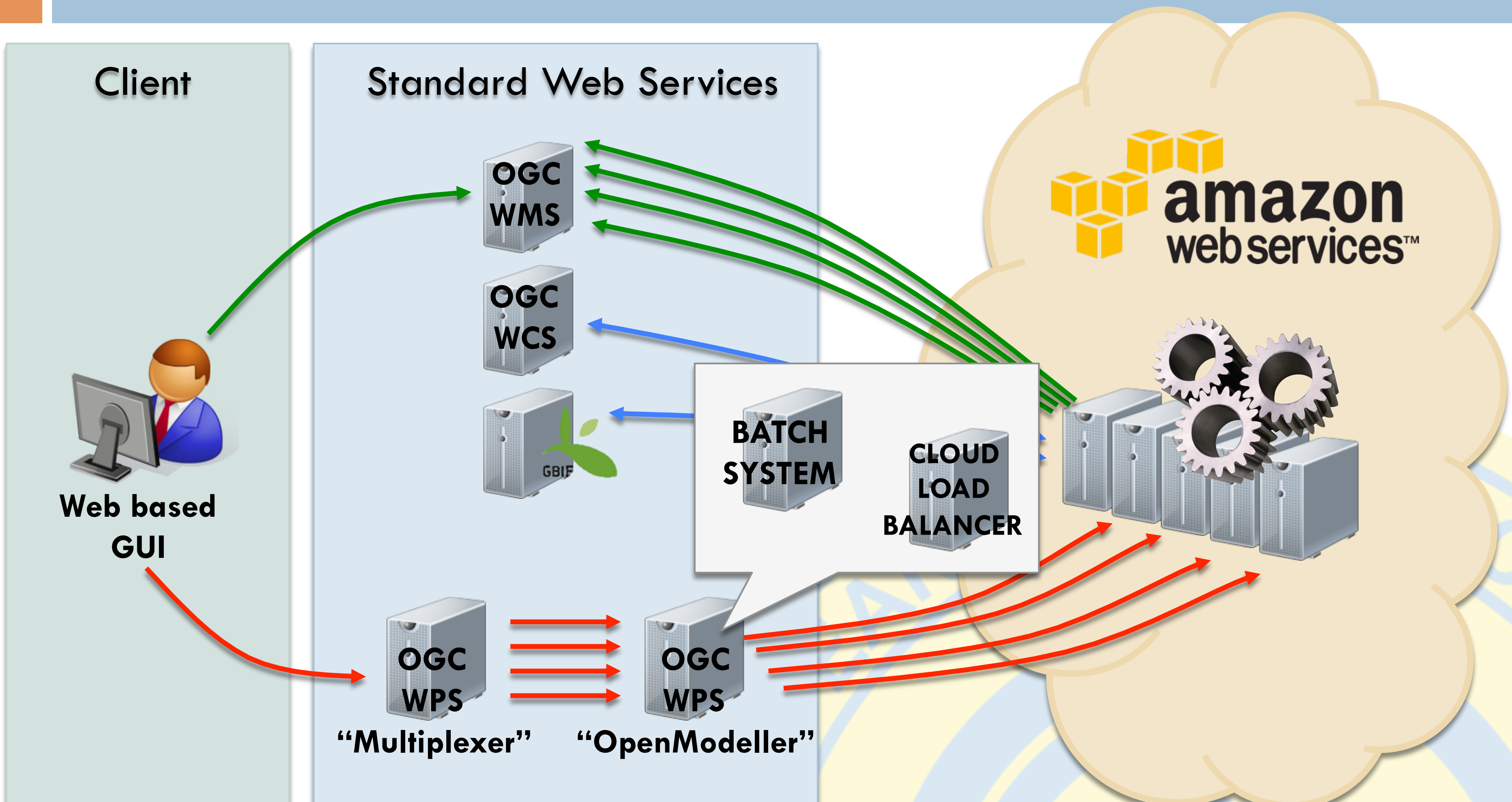
Detailed prototype workflow



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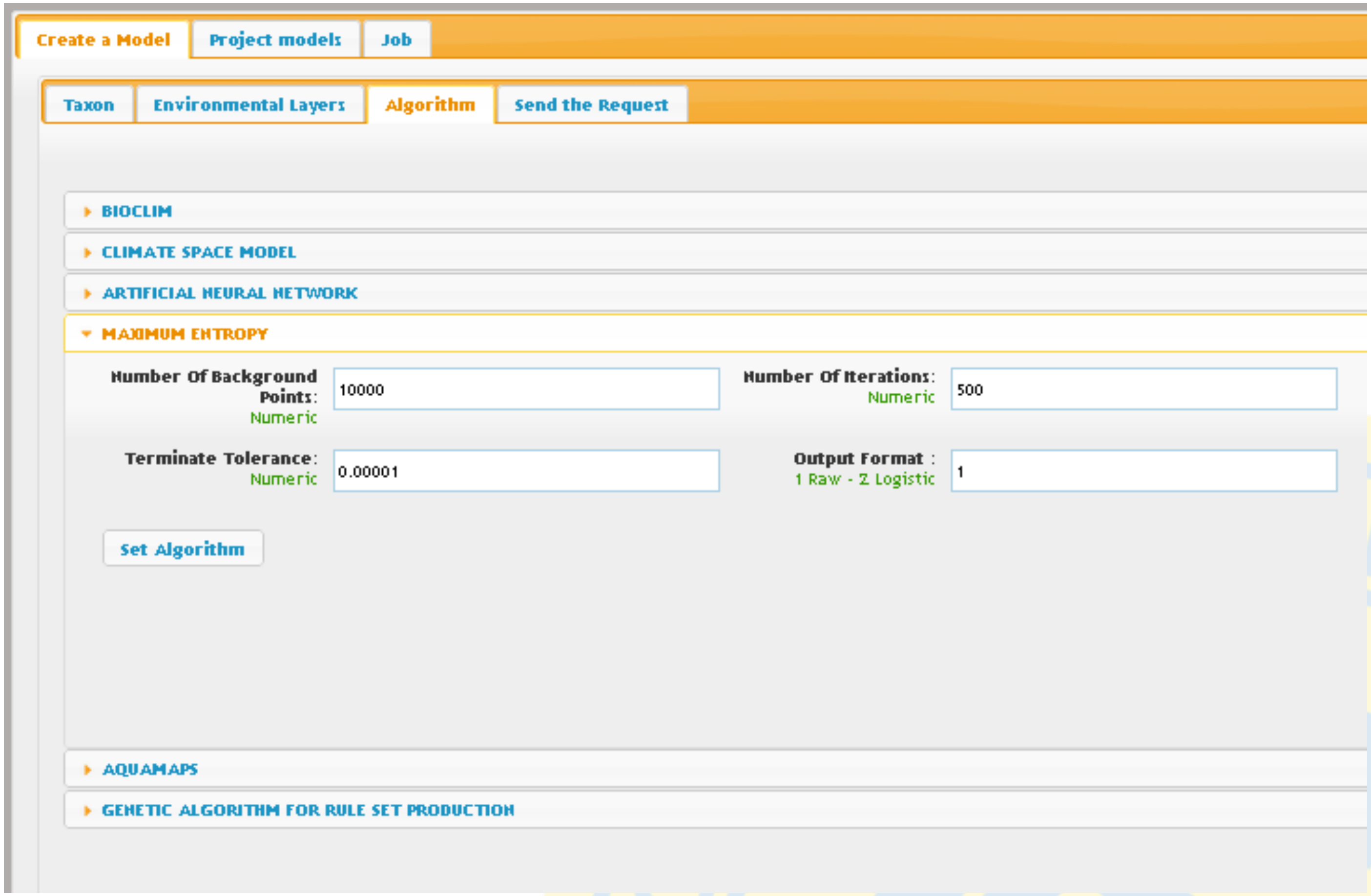
Screenshots



ENM Algorithm Selection

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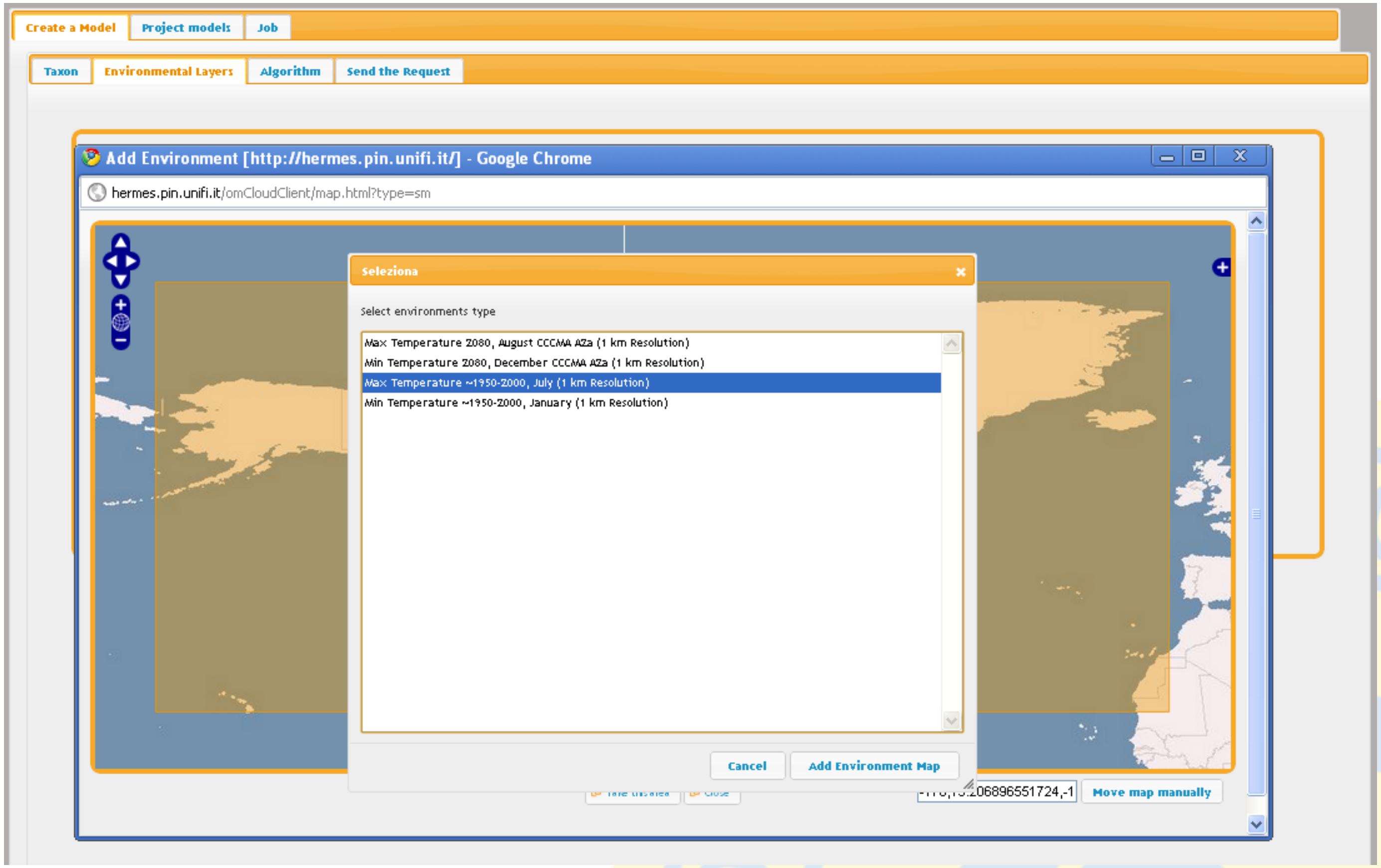
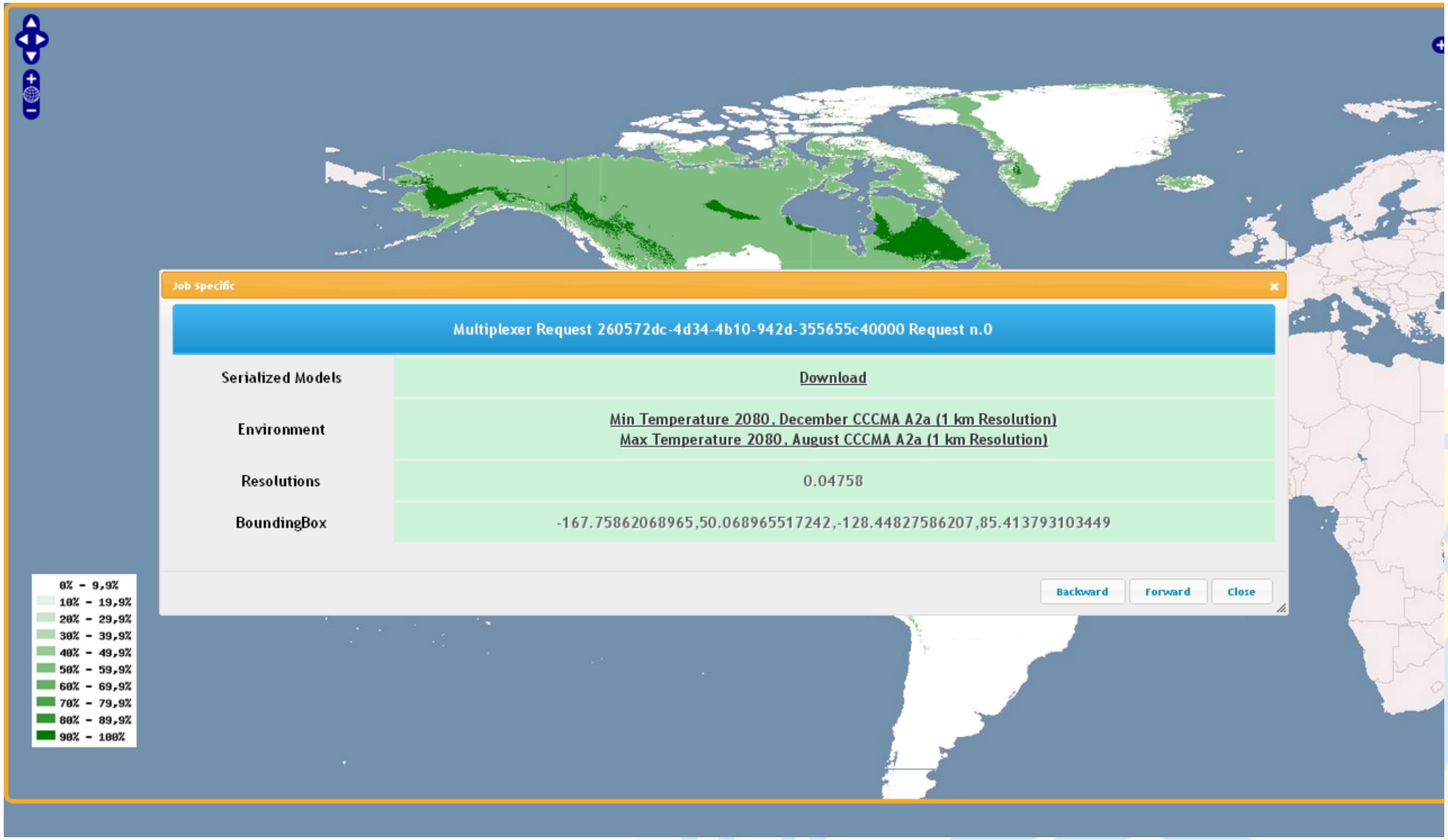
Screenshots



Env. Layers Selection from OGC WCS

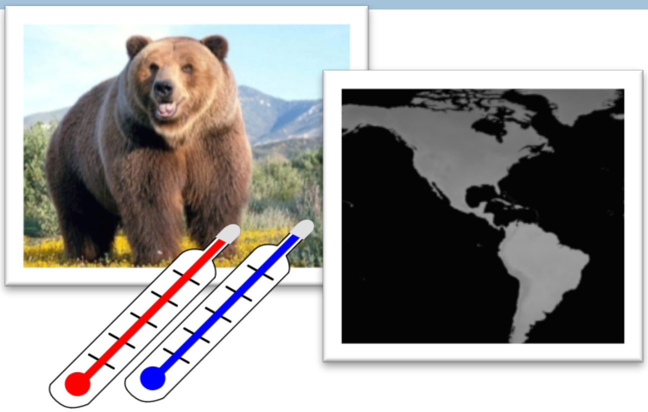
Screenshots



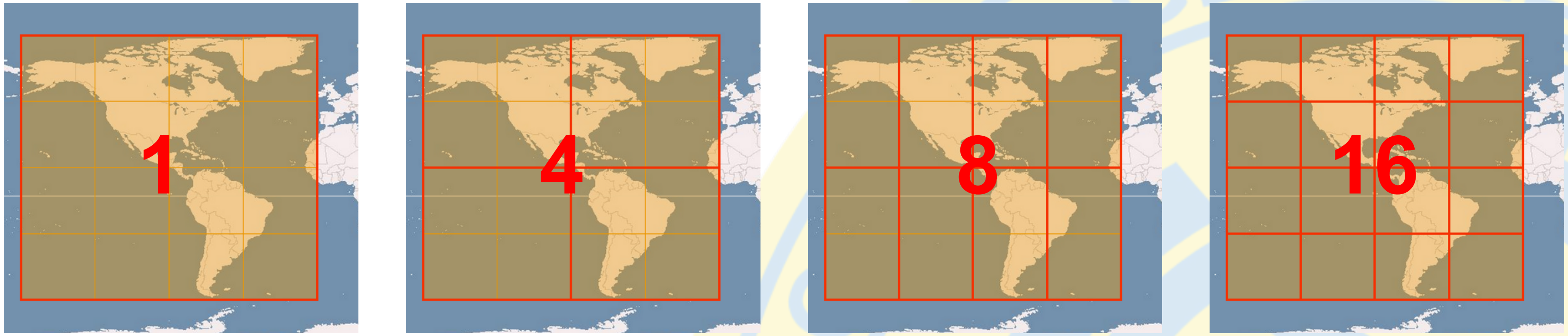
Species projection visualisation through OGC WMS

Test environment

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

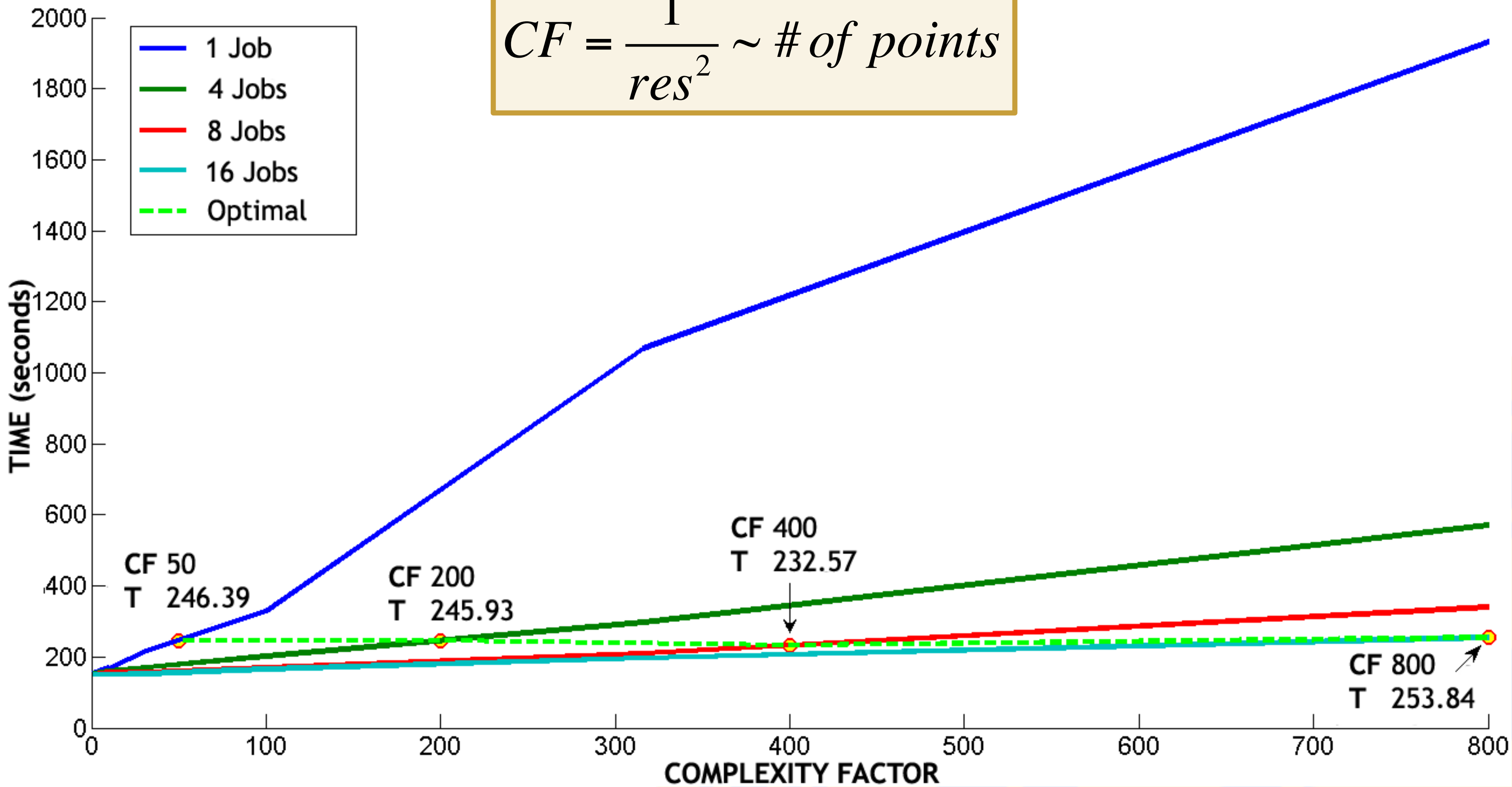


- To enable the execution parallelisation the domain has been split in various sub-regions



Performance evaluation

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



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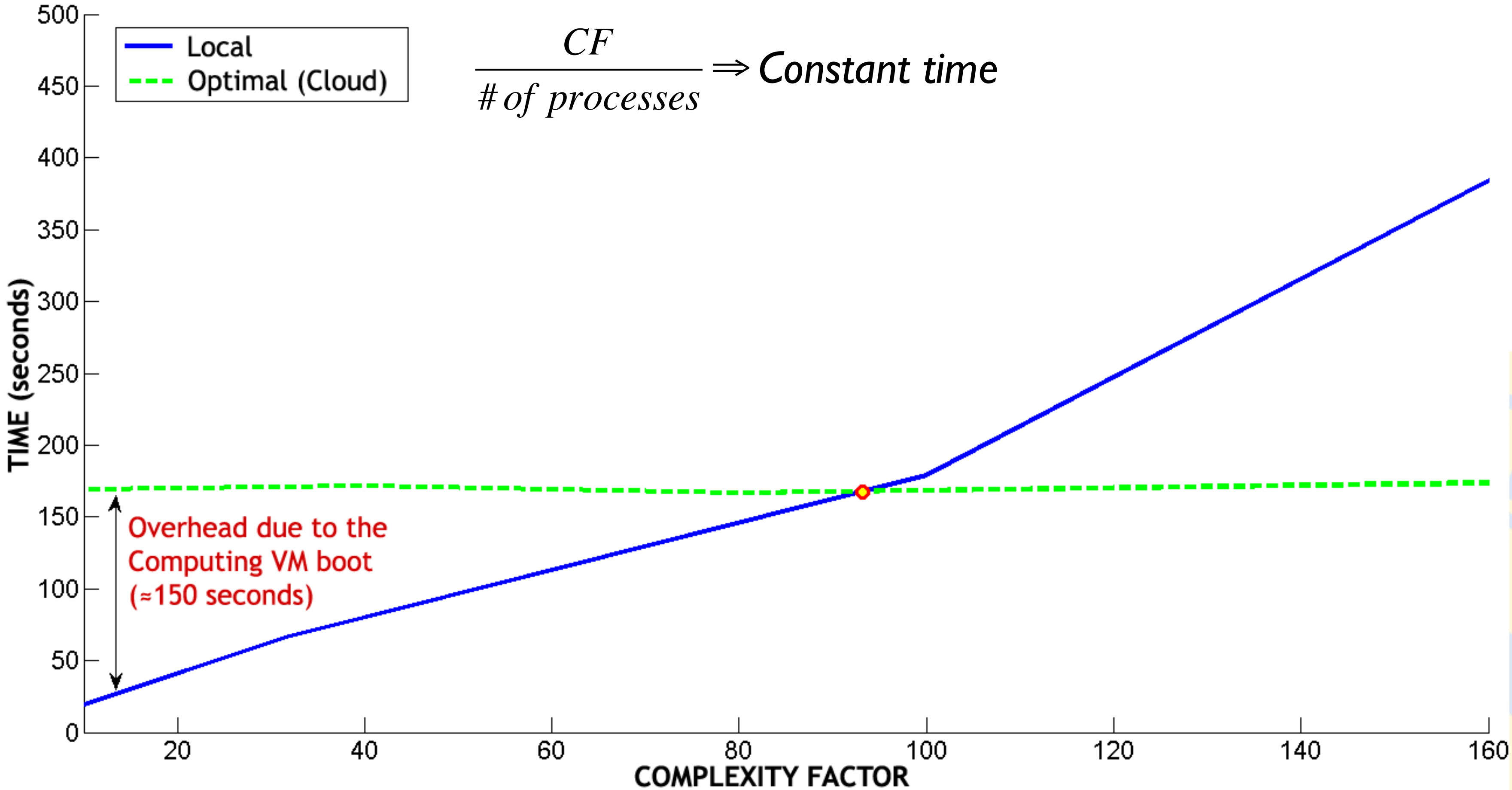
Performance evaluation

Processing time becomes ***independent*** from the execution complexity



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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