Design for geospatially enabled climate modeling and alert system (CLIMSYS)

Citation for published version:
Bhattacharya, D & Painho, M 2018, Design for geospatially enabled climate modeling and alert system (CLIMSYS): A position paper. in S Winter, A Griffin & M Sester (eds), *10th International Conference on Geographic Information Science, GIScience 2018.* Leibniz International Proceedings in Informatics, LIPIcs, vol. 114, Schloss Dagstuhl- Leibniz-Zentrum fur Informatik GmbH, Dagstuhl Publishing, 10th International Conference on Geographic Information Science, GIScience 2018, Melbourne, Australia, 28/08/18. https://doi.org/10.4230/LIPIcs.GIScience.2018.22

Digital Object Identifier (DOI):
10.4230/LIPIcs.GIScience.2018.22

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Publisher's PDF, also known as Version of record

Published In:
10th International Conference on Geographic Information Science, GIScience 2018

Design for Geospatially Enabled Climate Modeling and Alert System (CLIMSYS): A Position Paper

Devanjan Bhattacharya[1]
Nova Information Management School, Universidade Nova de Lisboa, Campus de Campolide, Lisbon, Portugal
dbhattacharya@novaims.unl.pt
https://orcid.org/0000-0002-3382-9523

Marco Painho
Nova Information Management School, Universidade Nova de Lisboa, Campus de Campolide, Lisbon, Portugal
painho@novaims.unl.pt
https://orcid.org/0000-0003-1136-3387

Abstract

The paper brings the focus on to multi-disciplinary approach of presenting climate analysis studies, taking help of interdisciplinary fields to structure the information. The system CLIMSYS provides the crucial element of spatially enabling climate data processing. Even though climate change is a matter of great scientific relevance and of broad general interest, there are some problems related to its communication. Its a fact that finding practical, workable and cost-efficient solutions to the problems posed by climate change is now a world priority and one which links government and non-government organizations in a way not seen before. An approach that should suffice is to create an accessible intelligent system that houses prior knowledge and curates the incoming data to deliver meaningful results. The objective of the proposed research is to develop a generalized system for climate data analysis that facilitates open sharing, central implementation, integrated components, knowledge creation, data format understanding, inferencing and ultimately optimal solution delivery, by the way of geospatial enablement.

2012 ACM Subject Classification Information systems → Geographic information systems, Information systems → Expert systems, Information systems → Sensor networks

Keywords and phrases Spatial enablement, climate modeling, natural hazards, spatial data infrastructure, sensor web

Digital Object Identifier 10.4230/LIPIcs.GIScience.2018.22

Category Short Paper

Funding D. Bhattacharya has been funded by the European Commission through the GEO-C project H2020-MSCA-ITN-2014, Grant Agreement number 642332, `http://www.geo-c.eu/`

1 Introduction

The focus is growing sharper than ever on climate research activities. Now is the time to respond with a global system about generalized climate modeling at any scale and expert decision support. With the advent of sensors for monitoring, data collections for any event are at unprecedented levels. For example, in climate data processing the major hurdles are

[1] Supported by GEO-C-H2020-MSCA-ITN-2014-642332

10th International Conference on Geographic Information Science (GIScience 2018).
Editors: Stephan Winter, Amy Griffin, and Monika Sester; Article No. 22; pp. 22:1–22:6
Leibniz International Proceedings in Informatics
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

that the different research groups globally are processing their data in silos, most of the time repeating same processes at each location, creating similar metadata each time, duplicating data, thereby falling behind the rushing stream of more incoming data. The solution could be addressed through integrating data source, spatial data platform, data understanding, knowledge base, inferencing and visualization into a single, well-connected online real-time system. Such a spatial decision support system (DSS) with expert knowledge bases will not only serve the critical research of climate modeling but do so to any research relying on real-time data capture and analysis with spatial domain of data being the unique enabler[8].

The objective of the proposed research is to develop a generalized system for climate data analysis that facilitates open sharing, central implementation, integrated components, knowledge creation, data format understanding, inferencing and ultimately optimal solution delivery, all through open-source development. It should enable a climate scientist located anywhere to utilize data sources, create algorithms, models and output layers of climate information. The core of the system development will be to design optimal knowledge base (KB) and expert system (ES) for climatic scenarios. The research questions to be answered through this research are: i) how to build open source spatial ontologies for climate phenomenon using causative factors ii) how to connect ontologies for climate to intelligent inferencing logics iii) how to build specialized knowledge bases for a generalized climate modeling DSS iv) how to apply the system to automate procedures such as climate extreme indices and downscaling urban climate extremes v) how to integrate sensor web(SW), other data sources and spatial data infrastructure(SDI) with open source technologies.

2 Background Literature Review

Several studies [5, 2] over the years and recently [9, 1] have heavily stressed the need for developing a system capable of encapsulating the entire essence of climate studies in one platform which can be open, shareable, knowledgeable, and contributable globally. CLIMSYS aims to address these challenges through developing a framework that houses data, metadata, understanding of the data, knowledge to be applied on the data, and output from the data. CLIMSYS would enable a distributed spatial framework that targets to deliver climate based decisions to start with but would be capable of administering spatial functionalities to a variety of social needs.

Climate data are dramatically increasing in volume and complexity, just as the users of these data in the scientific community and the public are rapidly increasing in number. A new paradigm of more open, user-friendly data access is needed to ensure that society can reduce vulnerability to climate variability and change, while at the same time exploiting opportunities that will occur. The burgeoning types and volume of climate data alone constitute a major challenge to the climate research community and its funding bodies. Institutional capacity must exist to produce, format, document, and share all these data, while, at the same time, a much larger community of diverse users clamors to access, understand, and use climate data [8]. Fig 1 shows the interoperability issues, due to multi-input types, in the engineering processes due to the application of many sets of domain data that stresses the multidisciplinary nature of the problem. The engineering process is based on reusing the existing knowledge representation models.

Research to action has been the clarion call from several climate critiques, wherein the papers have concluded that scientists need to relay the valuable work they are doing through impactful interfaces[3]. Through the present paper we want to convey that such an interface is imminently possible through the integration of sensor web and SDIs on top of

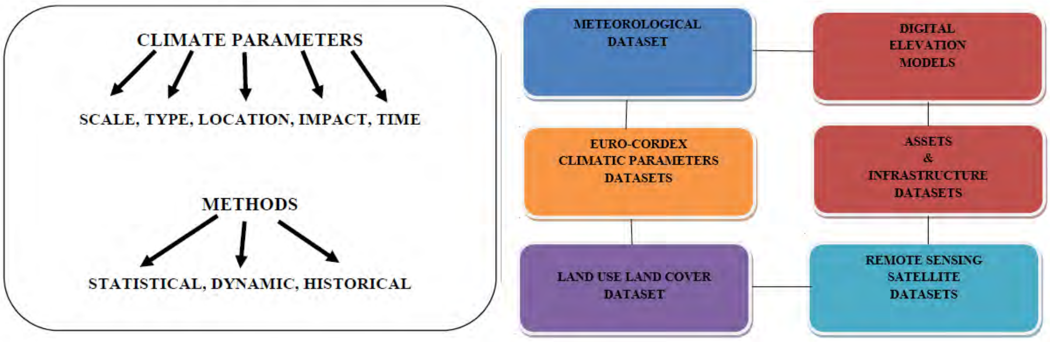

Figure 1 Input Parameters of Climate Data and Methods Adopted.

pertinent expert knowledge bases. We can now delve into the background of SDIs and sensor web. Considerable research and development has been carried out in SDI in recent years. Some are trying to develop high-level middleware services and domain-specific services for problem-solving and scientific discovery in infrastructures [4]. For example, the Group on Earth Observation (GEO) Model Web initiative proposes to provide environmental models as services and integrating distributed models in infrastructures. With these systems it is seen that they tend to be case-specific and restricted. Also the design is not broad enough to accommodate increasing number of formats. Hence CLIMSYS is to be designed to be more generalized, integrable with multiple domains and formats and the biggest addition will be the availability of pluggable KBs that infuse better understanding of the data. With the integration with sensor web CLIMSYS will provide long term benefits.

3 Methodology

CLIMSYS utilizes a distributed SDI including data models, applications and services based on OGC standards and their benchmarking and evaluation are the objectives of this proposed research. The initial architecture as shown in Fig 2a for the shared data concept has been implemented to categorize and modularize input domains, sensor-web module, data understanding module, expert KB, inferencing, and output. In Fig 2b the GIS graphical user interface(GUI) has been expanded to show the implementation of GEONODE structure. It handles the spatial database and spatial analysis. GeoNode provides the distributed SDI environment (Fig 2b). The concept of plug-ins to interact amongst themselves from one framework to another makes the integration of SDI and sensor web possible. The web-enablement in Fig 3a is where the architecture to capture geospatial elements and transmitting over the web is taken care of by webGIS standards and the open interfaces are utilized for latching on to the sensor network through a set of GML Clients. Therefore, a consistent set of encoding and interface standards are mandatory for adapting and integrating sensor networks into an SDI application. In CLIMSYS, we present how the reused models were interconnected, starting from the analysis of the interoperability needs of the existing and planned data sources, the use of a core ontology as integration strategy, and the modeling of concepts that carry out the interconnection among the reused models. The work then must solve the key interoperability issues using visualization tools and representative scenarios. Experiments on an information recovery study stress the potential of the proposed ontology, its limitations, and future challenges in the modeling process. We expect to contribute with ideas about an ontology engineering process for semantic interoperability of multidisciplinary

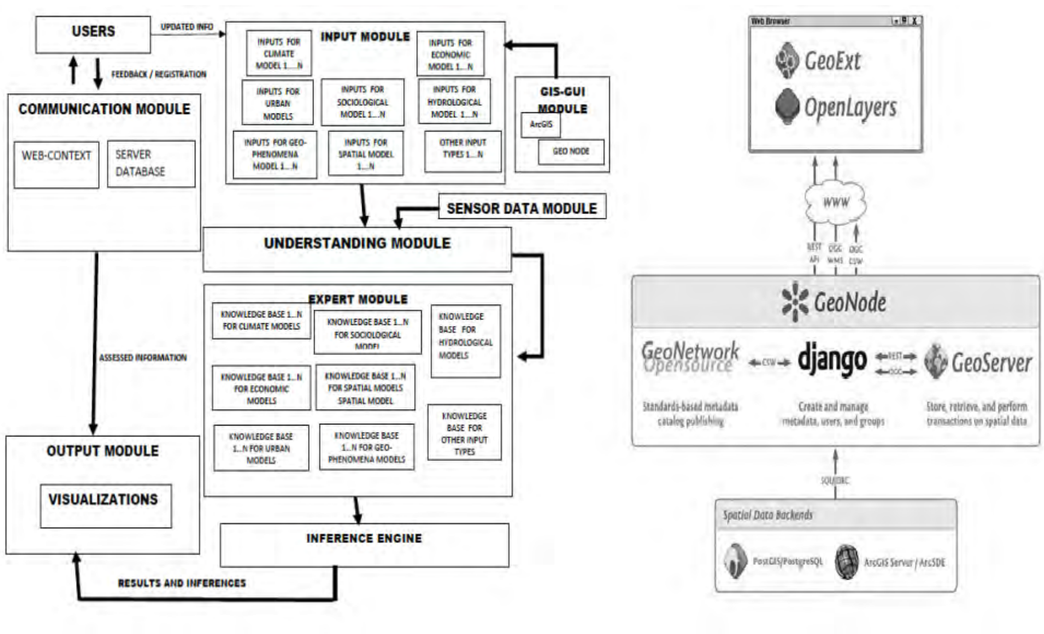

Figure 2 a) CLIMSYS Proposed Architecture b) GeoNode and database functionalities.

domains (Fig 3a, b), as well as to present experiences from applying this process. As can be ascertained from Fig 1, the disparity in data formats in sensor web (Fig 3a) needs proper ontology to understand the data contents and semantic context (Fig 3b). The joining of sub-systems happens at corresponding levels like input module with data layer of sensor web and database backend of GeoNode, understanding module and expert module interface with web service layer of sensor web and middleware of GeoNode. The Output module intefaces with the application layer and front end of GeoNode.

4 Results

The joining of geospatial datasets and knowledge bases has been done to utilize the complete set of information available in each of them. There are many open source geospatial datasets available such as GeoNames, Open Street Map, Natural Earth and to get a comprehensive dataset with the union of all available information it is important that such datasets are linked optimally without redundancy or loss of information. The multi-interfacing that is captured by Fig 2a allows for spatial interface, input, storage, incremental upgrades, and output communication. The interfaces use Java apps with Python codes. The Geonode architecture has PostGIS and PostGresql backend, and HTML frontend (Fig 2b). The HTML frontend of GeoNode displays the global basemap (Fig 4) and the sensed data[6, 7] input and processed by CLIMSYS is layered on top of the basemap. By clicking on the place-name (Czech Republic) the temperature data and snowing data for the region (Jan-Mar 2018) are displayed.

5 Discussions and Conclusions

A gamut of information about the environment - land, air, water, weather, climate and natural and man-made risks can be harnessed by seamless and rapid access to sensors. In addition, sensors are critical components of building, transportation, utility and industry

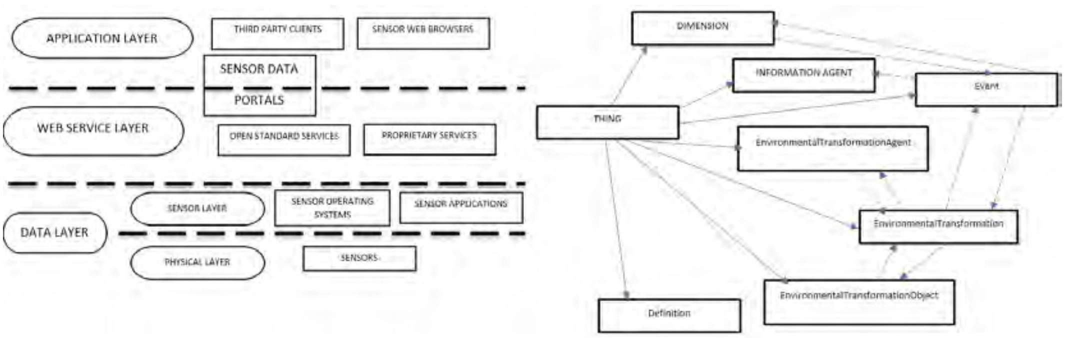

Figure 3 a) The layers for integration of sensor web with SDI b) Ontological snapshot of an environmental process for system development.

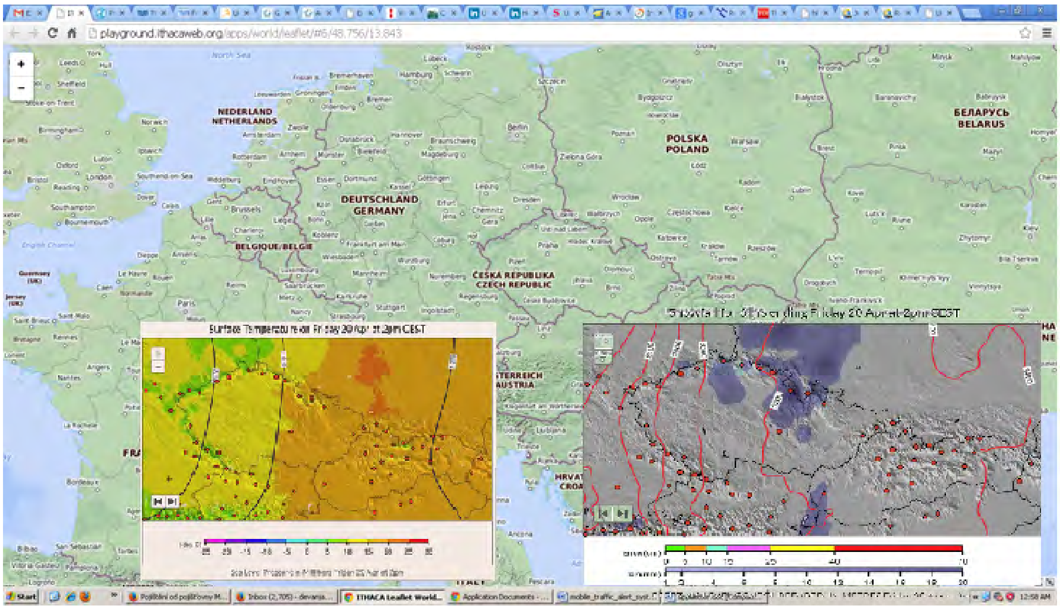

Figure 4 Integrated sensor data for temperature(left box) and snowing(right box) in Czech Republic over GeoNode basemap.

infrastructure. The ability to harness and render this information in a location context is a major challenge. Until recently though, there were no facilitating standards to make it easier to discover, access and integrate this information. Therefore, a consistent set of encoding and interface standards are mandatory for adapting and integrating sensor networks into an SDI application. Both, SDI (web mapping) standards and sensor web enablement standards from OGC, have to meet at a common ground and connect together. The integration of sensor web and SDI in open source domain could be achieved possibly by setting up one to one correspondence between their services through functions calling and methods calling.

CLIMSYS can deliver an integrated sensor web and SDI which can solve a lot of challenges that stand-alone, disconnected, case-specific, and customized systems lack. The next level of capability for both SDI and sensor web would be to evolve into a new realm of a location enabled and semantically enriched Geospatial Web or Geosemantic Web but additionally with spatial analytics capabilities. The SDI has the capacity to integrate with distributed computing and database platforms and enable the Geospatial Web with capabilities of data democratization. Hence in conclusion, it is of pressing importance to geospatial studies to integrate SDI with Sensor Web. The integration can be done through merging the common OGC interfaces of SDI and Sensor Web. Through CLIMSYS, Sensor Web and SDI are going to keep expanding in the next decade. Sensors are going to be so ubiquitous that similar to the world wide web the addition of vast number of sensors will keep happening like new data sources of present internet. The concept of CLIMSYS has to keep evolving to help overall development.

References

1 Gregory Giuliani, Stefano Nativi, Andre Obregon, Martin Beniston, and Anthony Lehmann. Spatially enabling the global framework for climate services: Reviewing geospatial solutions to efficiently share and integrate climate data and information. *Climate Services*, 8:44–58, 2017. doi:10.1016/j.cliser.2017.08.003.

2 C.S.B. Grimmond, M. Roth, T.R. Oke, Y.C. Au, M. Best, R. Betts, G. Carmichael, H. Cleugh, W. Dabberdt, R. Emmanuel, E. Freitas, K. Fortuniak, S. Hanna, P. Klein, L.S. Kalkstein, C.H. Liu, A. Nickson, D. Pearlmutter, D. Sailor, and J. Voogt. Climate and more sustainable cities: Climate information for improved planning and management of cities (producers/capabilities perspective). *Procedia Environmental Sciences*, 1:247–274, 2010. doi:10.1016/j.proenv.2010.09.016.

3 J.N. Lavis, J. Lomas, M. Hamid, and N.K. Sewankambo. Assessing country-level efforts to link research to action. *Bulletin of the World Health Organization*, 84(8):620–626, 2006.

4 Steve H.L. Liang and Chih-Yuan Huang. Geocens: A geospatial cyberinfrastructure for the world-wide sensor web. *Sensors*, 13(10):13402–13424, 2013. doi:10.3390/s131013402.

5 S. Nativi, M. Craglia, and J. Pearlman. Earth science infrastructures interoperability: The brokering approach. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 6(3):1118–1129, June 2013. doi:10.1109/JSTARS.2013.2243113.

6 NOAA. NOAA national centers for environmental information. https://www.ncdc.noaa.gov/data-access/quick-links#dsi-3505 (accessed on 20 Apr 2018).

7 NOAA. NOAA national ice center. http://www.natice.noaa.gov/Main_Products.htm (accessed on 20 Apr 2018).

8 Jonathan T. Overpeck, Gerald A. Meehl, Sandrine Bony, and David R. Easterling. Climate data challenges in the 21st century. *Science*, 331(6018):700–702, 2011. doi:10.1126/science.1197869.

9 O. Rössler, A. M. Fischer, H. Huebener, D. Maraun, R. E. Benestad, P Christodoulides, P. M. M. Soares, R. M. Cardoso, C. Pagé, H. Kanamaru, F. Kreienkamp, and D. Vlachogiannis. Challenges to link climate change data provision and user needs–perspective from the cost-action value. *International Journal of Climatology*, 0(0), 2017. doi:10.1002/joc.5060.