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Building an ecoinformatics platform to support climate change adaptation in Victoria

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ABSTRACT

Our research is focused on developing an ecoinformatics platform to support climate change adaptation in Victoria. A multi-disciplinary, cross-organisational approach was taken in developing a platform of collaboration to support the understanding of climate change impact and the formulation of adaptation strategies.

The platform comprises a number of components including: (i) a metadata discovery tool to support modelling, (ii) a workflow framework for connecting climate change models, (iii) geographical visualisation tools for communicating landscape and farm impacts, (iv) a landscape object library for storing and sharing digital objects, (v) a landscape constructor tool to support participatory decision-making, and (vi) an online collaboration space for supporting multi-disciplinary research and cross-organisational collaboration.

In this paper we present the platform as it has been developed to support collaborative research and to inform stakeholders of the likely impacts of climate change in southwest Victoria, Australia. We discuss some of the drivers for research in developing the ecoinformatics platform and its components. We conclude by identifying some future research directions in better connecting researchers and communicating scientific outcomes in the context of climate change impact and adaptation.

1. Introduction

Over the last decade e-Science has emerged as a field of research focused on middle-ware grid applications to support a multitude of fields of research, including for example, particle physics and astronomy, biotechnology and biological sciences, environmental science and economic social research [1]. In our experiences, e-Science enables flexibility in conducting scientific research, provides early access to data, increases capacity of performing complex research by connecting heterogeneous resources, and supports multi-disciplinary science teams. e-Science requires scientific workflows to perform iterative and repeatable tasks [2]. Scientific workflows allow the use of a wide range of different data and the performance of complex analyses on these data [3]. In this work, we demonstrate an ecoinformatics platform comprising a number of loosely coupled components including: a data repository, Wiki, visualisation and scientific workflow tools. The benefits of using these e-Science tools are: an increased efficiency, technology reusability, and better support of collaborative planning and decision making. However, challenges remain in a range of different activities, such as data integration, data discovery, modelling

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and analysis, visualisation approaches using graphical or scripting environments, and the migration to open source technologies and open standard data formats. Cultural barriers and inhibitors also present significant challenges for data sharing, collaboration and the adoption of supporting e-Science infrastructure and tools. This phenomena is known as 'e-uptake' [4]. In our experience these barriers and inhibitors exist across government and research institutes alike.

As reported by Hey and Trefethen [1] the term e-Science was first introduced by Dr. John Taylor, Director General of Research Councils in the UK Office of Science and Technology. As defined by the UK National e-Science Centre, e-Science refers to:

> "the large scale science that will increasingly be carried out through distributed global collaborations enabled by the Internet. Typically, a feature of such collaborative scientific enterprises is that they will require access to very large data collections, very large scale computing resources and high performance visualisation back to the individual user scientists" [5].

Ecoinformatics is an e-Science approach that focuses on the concept of virtual collaboration for managing and sharing environmental data and information products across organisations. Ecoinformatics provides an integrated technology systems approach for supporting multi-disciplinary research in addressing complex problems. Within the broad field of environmental science, a number of ecoinformatics initiatives have, or are in the process of developing software tools and products to support data discovery, access, management, analysis, modelling and visualisation. These are identified as priority development areas for e-Science by funding bodies like NCRIS in Australia [6], the European Research Council in Europe [7], NSF in the US [8] and JISC in the UK [9].

The ecoinformatics platform can be characterised as a Virtual Research Environment (VRE). A VRE can be described as a set of web applications, online tools, systems and processes interoperating to facilitate or enhance the research process within and without institutional boundaries; it enables collaborative research activities beyond geographical barriers [10,11]. Several other terms can be used instead of VRE, such as CVE (Collaborative Virtual Environment), Cyberinfrastructure/e-Infrastructure, Collaborative eResearch Communities, VRC (Virtual Research Community), and VO (Virtual Organisation).

Despite the range of terms defining an electronic web-based infrastructure, a common set of characteristics are featured: (i) access to data, tools, resources, and other researchers; (ii) co-operation or collaboration with other researchers at the same or different institutions; (iii) co-operation at the intra- and inter-institutional levels; and (iv) preserving or taking care of data and other digital outputs.

There are a number of ecoinformatics initiatives being undertaken internationally. Some of the key activities in this space include: the National Centre for Ecology and Synthesis Ecoinformatics program [12], Ecoinformatics.org [13], the Long Term Ecological Research Network [14], the Science Environment for Ecological Knowledge project [15], Global Lake Ecological Observatory Network [16], the Coral Reef Observatory Network [17] and Natural Environment Research Council [18] projects and within the UK e-Science Program: Global Coastal Ocean Modelling and Grid Enabled Integrated Earth system modelling. Some Australian National Collaborative Research Infrastructure Strategy (NCRIS) related initiatives include: the Integrated Marine Observing System, electronic Marine Information Infrastructure [19], AuScope Spatial Information Service Stack [20] and Terrestrial Ecosystem Research Network—Ecoinformatics Portal [21].

In addition, there are relevant specific developments targeted to support scientific interoperability at an international level associated with climate models and future climate change including: the Agricultural Model Intercomparison and Improvement Project [22], the European Union CORDIS Seventh Framework Program and the Common Metadata for Climate Modelling Digital Repositories (METAFOR) project [23]. Furthermore, Spatial Data Infrastructures (SDIs) have been particularly supported by major government mandates such as the INSPIRE European Directive [24] that recommends standards for sharing resources (such as data and processes) across trans-boundary contexts with the aim of improving environmental and associated decision making [25].

These combined e-Science and SDI efforts are relatively recent, emerging in the last five to ten years, but they are assuming an ever greater part of the agenda of research funding agencies and policy makers. Regardless of the different labels, the policy documents and guidelines for research are in agreement about promoting 'openness', collaboration and sharing. The latter can take place between research groups, between projects, between institutions, between disciplines and between different geographical locations.

As presented in this paper, our research is focused on the development of a demonstrator of e-Science capabilities to support climate change adaptation in Victoria, Australia. Specifically we applied a case study approach focused on the impacts of climate change and adaptation options in southwest Victoria. An ecoinformatics platform was developed to support multi-disciplinary, cross-organisational collaboration in dealing with the complex problem of climate change. We believe there is a need for initiatives such as the Climate G-Portal [26], the Collaborative Climate Community Data and Processing Grid (C3Grid) [27] and our ecoinformatics platform, which endeavour to support multi-disciplinary and geographical-distributed research addressing climate change.

2. Methods

We developed an e-Science platform focused on climate informatics as a subset of ecoinformatics—see Fig. 1. Underpinning this platform is a SDI which supports climate and risk modelling. These climate change impact (risk) models need to be communicated to practical end-users (land managers, regional planners and policy makers) and hence geographical visualisation provides an important component to the proposed technology stack. Throughout the paper we endeavour to illustrate the usefulness of particular e-Science tools by discussing use-case scenarios, predominantly from a regional planner's perspective.

A number of technologies have been developed and coupled together to create the ecoinformatic platform which has been applied in Victoria for modelling and communicating the likely impact of climate change and adaptation options in southwest Victoria. These include:

(i) a model metadata tool—the Model Information Knowledge Environment (MIKE) has been developed to record and discover model instances
(ii) a model workflow framework—the workflow supports the dynamic link of datasets and simulation models
(iii) geographical visualisation tools—a suite of visualisation tools to communicate localised climate change scenarios including Google Earth and the Spatial Information Exploration Visualisation Environment (SIEVE)
(iv) a landscape object library—an online database for storing, sharing and managing digital objects used to create visualisation products
(v) a landscape constructor tool—a participatory planning and decision-making tool for supporting end-users in creating and exploring climate change adaptation scenarios
(vi) an online collaboration space—a confluence Wiki tool to store documents, data, models and support program management and information exchange.

In this paper we introduce these technology components and discuss the drivers of research in developing them.