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THE ENVIRONMENTAL DATA ABSTRACTION LIBRARY (EDAL): A MODULAR APPROACH TO PROCESSING AND VISUALISING LARGE ENVIRONMENTAL DATA

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ABSTRACT

The Environmental Data Abstraction Library provides a modular data management library for bringing new and diverse data-types together for visualisation within numerous software packages, including the ncWMS viewing service, which already has very wide international uptake. The structure of EDAL is presented along with examples of its use to compare satellite, model and in situ data types within the same visualisation framework. We emphasize the value of this capability for cross calibration of datasets and evaluation of model products against observations, including preparation for data assimilation.

Index Terms— OGC Web Map Service, Visualisation, ncWMS, videowall, geospatial

1. INTRODUCTION

The ncWMS Web Map Service software[1] has now been widely incorporated into many web portals around the world for rapid display of CF compliant NetCDF gridded fields of geospatial products in an OpenGIS manner eg. MyOcean, United States Geological Survey, Plymouth Marine Laboratory, Norwegian Institute of Marine Research, and the National Geophysical Data Centre at NOAA (see www.resc.rdg.ac.uk/trac/ncWMS/wiki/UserStories). The incorporation of a more modular approach to managing new datasets at the backend is needed to enable a greater diversity of data types to be visualised, and to enable reuse of visualisation capabilities in other pieces of software, including the software used by the University of Reading's videowall[2].

2. THE ENVIRONMENTAL DATA ABSTRACTION LIBRARY

EDAL provides a new modular approach to handling many environmental data types in an efficient manner to allow interoperable tools and displays to be developed. EDAL consists of several modules: a core data model which deals with accessing and manipulating commonly-used environmental data types including (but not limited to) gridded data, time series data, and vertical profile data; a graphics library to plot all of these data types in a flexible and configurable manner;
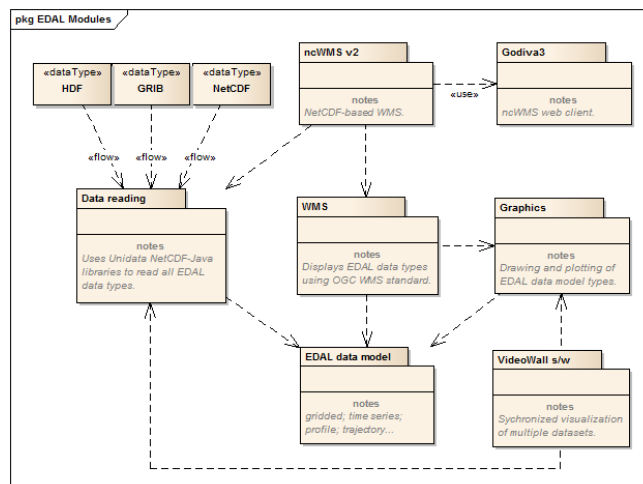

Fig. 1. Schematic of main EDAL modules and their dependencies, along with data ingest.

a general-purpose web map service (WMS) module which serves EDAL data over the OGC-standard WMS interface; a set of modules to read various data into the EDAL data model; and a new version of ncWMS built on top of these EDAL modules. The Godiva3 web interface is still under development but will use the successful Godiva2 format (http://www.reading.ac.uk/godiva2) while introducing capability for display and intercomparison of multiple data types, which can also be achieved with the videowall display (see below). The EDAL module applications with dependencies are shown schematically in Figure 1.

The advantages of this modular system are that it can be quickly adapted to cope with new data types or formats at the data injection end, or new display requests from web portal or videowall applications. Modules can be used independently with additional data analysis modules, and all libraries are digitally signed and reside in a global repository that anyone can access when building their own applications. The graphics plotting configuration, map plots, is now very configurable. We use extensions to SLD (Styled Layer Descriptor), a standard allowing fine-grained control over how an image is represented; uncertainty visualisation is an example of this (see Figure 3 below).
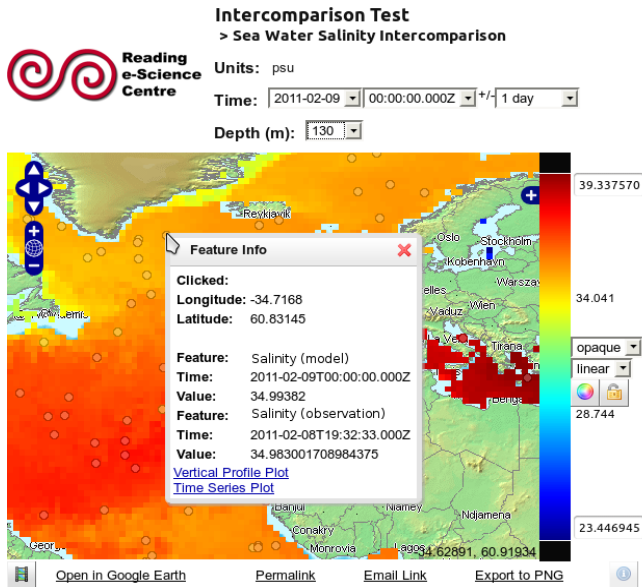
Fig. 2. Prototype portal intercomparison display containing gridded data with superimposed in situ calibration, verification data, here ocean salinity.

3. APPLICATION EXAMPLES

The EDAL implementation has been used in the development of several novel tools and visualisations which we outline here.

Firstly we have developed a prototype tool to demonstrate coordinated visualisation of satellite, model and in situ datasets based on the Godiva2 web portal frontend. Figure 2 shows gridded salinity with superimposed in situ observations on the same colour scale, which then allows interactive selection of more focussed comparisons (e.g. vertical structure or time series) at each in situ site. One potential application is to use these visualisation tools for evaluation and quality control of satellite and model reanalysis products against in situ datasets.

In presenting this paper we will demonstrate comparisons between different sea surface temperature (SST) and salinity (SSS) products against in situ observations based on the Argo profiling network. We have used the ESA Climate Change Initiative's SST data[3] as a specific example where both satellite swath data and gridded products are available, along with in situ point measurements. Both spatial and temporal variability aspects can be compared. We also demonstrate the ability to handle large in situ data sets rapidly, using an efficient spatial database of locations, for example the whole history of 11 million in situ ocean observation profiles can easily be displayed and compared with other products. The point measurements shown in Figure 2 are being selected from just such a database using the MetOffice EN3 version of historical ocean profiles, Ingleby and Huddleston (2007),
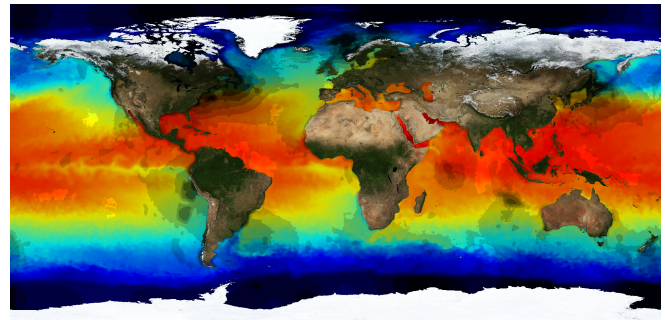

Fig. 3. Sea Surface Temperatures with uncertainty shading displayed using EDAL and ncWMS. The depth of the shading indicates the level of uncertainty of each pixel: for example uncertainties are relatively high in the Gulf Stream region in this particular image. Such displays will be available through the Godiva3 portal.

http://www.metoffice.gov.uk/hadobs/en3[4].

Uncertainty visualisation methods have been developed in the GeoViQua project (http://www.geoviqua.org[5]). Figure 3 shows an SST field with uncertainty shading overlaid. Different display methods for uncertainty are available, including shading, use of partial transparency, bivariate colour maps, glyph-based techniques and 3D rendering.

The new Godiva3 web portal interface which is under development will be used by data assimilation scientists to visually compare model and observation products along with their uncertainty information, in order to assess improvements in products as improved processing or data assimilation methods are introduced.

The EDAL model has also been used in conjunction with the NASA World Wind SDK (http://worldwind.arc.nasa.gov/java/) to create a visualisation tool for use on a large touch-screen video wall. By using the fast data extraction and image creation methods, we were able to produce software which visualises multiple datasets simultaneously on globes/maps which are synchronised in space and time.

Figure 4 shows a photograph of the multiglobe videowall software in action, showing data for sea surface temperature, sea ice, in situ observations and more. The virtual globes are synchronised spatially and temporally by using the sliders at the bottom a user can scan through time on both globes separately or together. By using a machine with enough RAM to load full datasets into memory, it is possible to scan through the time dimension perfectly smoothly, allowing on-the-fly animations which clearly showing time-dependent features in related data fields.

By using the EDAL modules, a lot of the functionality related to displaying datasets, querying datasets, and caching and cataloguing datasets was already in place. This meant that development of the multiglobe software only needed to focus on the front-end display and synchronisation of multiple
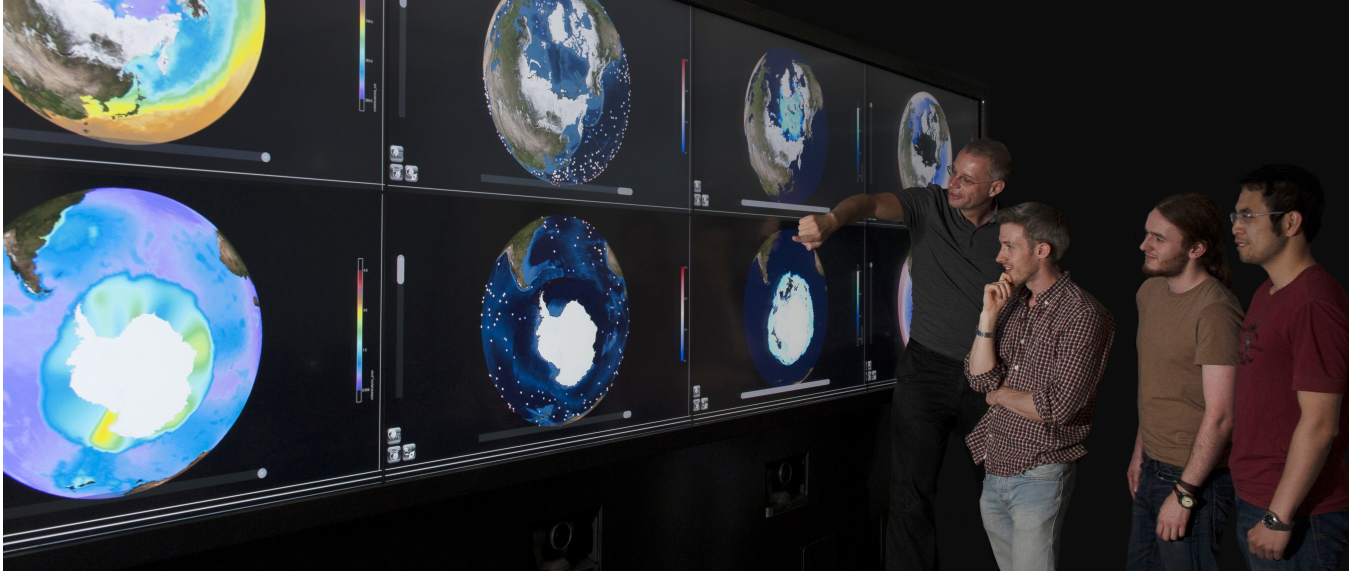
Fig. 4. Demonstration videowall software, based on EDAL, which allows simultaneous synchronised visualisation of multiple datasets using a touch screen.

globes, allowing for a very short development time.

The final example we are presenting is of using EDAL to programmatically create complex visualisations of datasets. The fine control over data which EDAL exposes, combined with the highly flexible graphics plotting capabilities, allows us to produce highly customised visualisations easily.

The ESA Climate Change Initiative (CCI) has produced high-resolution datasets of SST[3]. Since SST is a highly latitude-dependent quantity, it is difficult to pick out details in a global visualization (the wide range of the colour scale needed is not compatible with the high contrast needed to pick out small-scale features). A way to solve this is to use a colour scale that is latitude-dependent. By using EDAL we were able to create a custom colour scale that depends on the average SST at each latitude, and hence pick out fine details. Figure 5 shows an example frame from an animation showing the finer changes in SST overlain with sea ice and projected onto a Lambert Azimuthal Equal Area grid.

Using EDAL we have been able to quickly produce unique and useful animations from the CCI SST dataset, including the interaction of winds with SST. This latter uses the common EDAL model to pull together data from disparate sources to produce a scientifically useful visualisation.
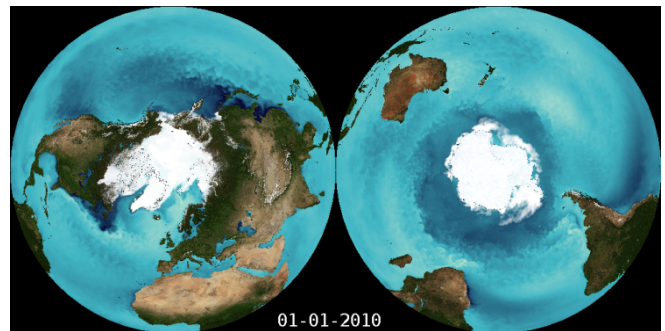

Fig. 5. Latitude dependent SST overlain with sea ice.

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