Report on Earth Observation Portals

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TABLE OF CONTENTS

1 INTRODUCTION

This report is supported by research involving over 175 working examples of Earth Observation portals. These are websites that expose information and functionality related to Earth observation data that has been acquired. The information provided may include, but is not limited to, descriptions of the data, how it is acquired, how it is used, and how it is validated. The functionality may include, but is not limited to, applications that use the data, services that allow the data to be downloaded, searching against the data, and visualization engines to display the data graphically.

In addition to the portal websites providing the means to learn about, and manipulate, the data they provide, they also are a user interface. In this regard, the portals must address issues such as usability, accessibility, degradability, etc. The details of these will be discussed later in this report.

The portals surveyed were identified by members of the IEEE Committee on Earth Observations Standards Working Group (ISWG) over a one year period from July 2005 to July 2006. When an ISWG member discovered an Earth observation portal, they would add it to a page on the del.icio.us bookmarking site [http://del.icio.us/EOPortals], where portals have been continually added since the initial survey. For reference the full list of analysed portals is included in Appendix A1. It must be stressed that the aim of this report is not to discuss the merits of the individual portals listed but to provide a synthesis of portal characteristics leading to general recommendations for the GEO Web Portal, as well as Earth Observation portals in general.

1.1 Supporting Evidence

The initial survey of the sample portals identified a set of recommended characteristics for an effective portal and also revealed a number of characteristics to be avoided or minimised. With the initial set of characteristics established through this analysis the next step was to identify supporting evidence, either as international or national standards or as the result of independent research (e.g. cited articles, books, or statements made by experts). Where the results of the survey are confirmed by other sources confidence in the validity of the characteristic can be considered very good. The supporting evidence is drawn from studies on earth-observation and other fields such as e-commerce and e-learning. It is important not to omit evidence from other disciplines, especially since, as reported by Pollach et al. [2006], "environmental web sites have not yet fully tapped the Internet's potential since only few … meet the overall technical, functional and design related standards their commercial counterparts have adopted."

1.2 Goal

The main goal of this report is to deliver a set of characteristics that can be used to qualify a website as an "acceptable" Earth Observation portal. "Acceptable," as used in this report, will mean that the portal satisfies the following criteria:

1. It can deliver the data and functionality that it claims to be able to deliver;

2. It can deliver the data and functionality in a fairly straightforward manner, so that a user, who is unfamiliar with the data, can navigate the portal and achieve their goals for connecting to the portal;
3. It satisfies the set of characteristics that should be adopted in order to benefit acceptance, as well as those that should be avoided in order to benefit acceptance.

These sets of characteristics will be further identified as to their role in providing an "acceptable" portal.

Related research in this area is described in Pollach et al [2006] and references therein, who analyzed 226 environmental web sites (as opposed to earth observation portals here). The goals of the previous research were to assess the state of the art or to conduct specific case studies. Pollach et al. [2006] used Navigation/Orientation, Interaction, Information Exchange/Timeliness, Accessibility as objective metrics for their evaluation. These metrics correspond closely to the characteristics discussed in this report.

2 PORTAL CATEGORIZATION

General Definition [e.g. Chaoying Ma et al, 2006]; "A portal is a web presence that consolidates a variety of information and services e.g. Searching, news, e-mail, discussion groups, and e-commerce."

The GEOSS architecture as described in the GEOSS Core Architecture Implementation Report [GEOSS, 2007b] includes two distinct types of portals, the GEO Web Portal and GEOSS Community Portals. In so far as this report is concerned, the important difference is that the GEO Web Portal does not provide processing capacities other than those required to retrieve and display metadata or to portray image files. The full functions of catalogue management, data order, download and storage are handled by the GEOSS registries, GEOSS Clearinghouse and respective GEOSS Community Portals. This is well described in [GEOSS, 2007a], however this point is clarified here since many of the portals in the sample survey include features out-of-scope of the Geo Web Portal, and the particular Geo Web Portal requirements defined in [GEOSS, 2007a] have an impact on specific recommendation, e.g. choice between thin or fat client architecture (See Below). Nevertheless, a lot can be learned from analysing all the different types of portals present in the sample list [Appendix A1].

3 RECOMMENDED CHARACTERISTICS

For each of the characteristics discussed below a further qualification of whether it is considered required, strongly suggested or optional is given. All the recommended characteristics are desired in an acceptable portal. The three levels of classification are given in order to help prioritise each parameter when they need to be compared (or, for example, in a development scenario when decisions about which characteristics are to be implemented have to be made).

3.1 Usability Characteristics

Usability is a broad topic and it is a requirement for a successful interface [Nielsen 1994a, Cooper et al. 2007, Tognazzi, 1992]. There are both applicable standards and reference works to support the specific aspects of usability presented below.

3.1.1 Access to Supporting Data (Required)

Portals should always have well-defined links to internal and external pages to support the role and usability of the portal. However, a special consideration is the access to information that supports the main data, and the main functionality, of the portal, such as (in the case of the GEO Portal):

1. metadata;
2. data quality;
3. application availability;
4. system status;
5. other related data sources.

Navigation to the content can be made available via links, tabs, logical page sequencing and dynamic content. However, the most usable designs keep all the options and statuses visible to the user with a minimalist design without access to important information requiring navigation away from the main content. [e.g. Farkas. and Farkas, 2000].

3.1.2 Consistency in look and feel (Strongly Suggested)

The look and feel of a portal takes into account many sub-characteristics. These include color scheme, type fonts, menu design, navigation options, form design, information categorization and segregation. Since these sub-characteristics are primarily aesthetic in nature, each one, individually, will not be indicated as required, strongly suggested, or optional. The overall characteristic of look and feel is a very subjective one. There exists research that discusses how colors affect attitude, how type fonts can affect readability, how proper information display can affect understandability, etc., however this report will not include these results as a required set of characteristics.

This is based upon the fact that, in practice, these sub-characteristics tend to be very subjective and usually not a source of great frustration to users. Also, these sub-characteristics are of secondary concern to the user, who is going to be focused on data, and the use of the data.

The main suggestion is to have a consistent and uniform look and feel, regardless of the colors or fonts used. There should be enough white-space utilized to allow the information to be easily categorized and understood in the user's mind.

It is most important that the portal design has internal consistency [McCarthy et al., 2003] with the adopted look and feel oriented to optimising the portal's desired functionality, i.e. earth observation data and services in this case. A special concern will be the interface between the Portal and community portals, needing to be handled in a way so not to introduce discontinuity in the discovery and exploitation of the provided services. A generalised portal framework is specified in the OASIS 2003 WSRP specification 1.0, and now OASIS 2008 WSRP 2.0. In such models the user interface is considered as a set of portlets and the portal

framework can manage such features as default appearance as well as the navigation between and within the portlets. The [OASIS 2003, 2008] standard supports the integration of both local and remote portlets into the user interface. Further to this, to provide workflow support, e.g. handling of data orders with respect to Community Portals and feedback to end users, consideration of a Web Service Notification Specification [e.g. Graham et al. 2004] is important.

3.1.3 Consistency in terminology and behaviour (Strongly Suggested)

The arguments for consistency in look and feel also extend to consistency in terminology and behaviour of functional parts of the interface [e.g. see Nielsen 1994a]. The portal must adopt its own set of conventions and follow them.

3.1.4 Help (Required)

An important aid to usability is help documentation. A completely intuitive and self-describing interface would not need any additional help documentation, however this is a virtually impossible goal and one or more of the following help mechanisms are necessary.

Site Help (Required): general documentation providing a general insight to the nature of the portal and a basic description of how to use it.

Context Sensitive Help (Strongly Suggested): specific documentation which is accessed during operation of the portal and provides information on the actual task being carried out. This can be implemented with glosses e.g. [Zellweger et al. 2000], tool-tips and automatic navigation to the appropriate part of the full documentation.

Use Cases (Optional): may comprise worked examples of using the portal. Often a detailed Use Case can provide or support the content of the general Site Help.

Feedback (Required): may be implemented as Support Form, Email Tool, or as a minimum a clear indication to host organisation contact information.

FAQ (Optional): This is ideally generated from objective analysis of real feedback from users [Jarrett, 2007]. The creation of a FAQ can be dynamic and evolve with the portal lifetime.

Another help feature is a site map which we discuss in more detail.

Site Map (Strongly Suggested): Portals can be very heavily populated with information. In particular, a data portal has the additional burden of providing functionality to discover data and render it, as well the possibility of executing applications against it. Very often it can be confusing to navigate a portal in order to achieve a desired goal. To address this many sites use what is called a site map. Typically, this is just a listing of the pages on the site, where each page name is hyperlinked to itself. It would be very beneficial to include with the page names a short description of their purpose so a user can navigate more successfully from a site map. Nielsen Norman Group: “A site map's main benefit is to give users an overview of the site's areas in a single glance by dedicating an entire page to a visualization of the information architecture”. Even though “Help” characteristics are required they have to be used with caution. For example, studies on the case of Site Maps in particular, e.g. [Russel

2002] report that although an explicit map of a site's structure should allow visitors to navigate more efficiently a sitemap's utility is lessened if it does not reflect the user's (or domain's) conceptual structure or mental model.

Help functionality is required because users need to have access to information that guides them in their understanding of how to use the portal. This is especially pertinent to a data portal, since it is not just a site of static information. It includes applications, search capabilities, and other functionality that is not always readily understandable to a user. Providing appropriate help is a challenge in a user interface and, notably, studies of usability indicate that users prefer human web assistants [Åberg and Shahmehri , 2000] to be part of the help experience.

3.1.5 Good Response Time (Strongly Suggested)

Usability of a site is directly linked to the time that it takes a web page to load, and, consequently, to the repeat visitation of users. There have been studies done that suggest that about 10 seconds is the limit that a user will allow before becoming frustrated. Of course, load time is a function of access medium, and it is assumed that broadband, high speed access is being used. A data portal will probably have no issues with serving up content pages. The problem will arise when data requests are made. When database searches are executed, the user may be waiting quite a while for a result to be displayed. It is the responsibility of the portal to gauge the requirements of the request and to handle it properly. This is especially important in the GEOSS setting, where interoperability plays a key role. The user must be made aware when there is a delay expected or when a delay is occurring. Failure to do this will create a situation where the user chooses to not return to the portal. This characteristic is supported by [Nielsen 1994a, Card et al. 1991, Miller 1968].

3.1.6 Multi-lingual Support (Optional)

Multi-language support should be a target for portals with a global outreach, failing this the minimum requirement is to support English for a portal with global reach.

Although English is used all over the scientific world, it is not always the language of choice for business, government, and education. Many successful portals give the user a choice as to which language they wish to see content in, and dramatic improvement in accessibility can be obtained by including a core set of the most widely used languages. This characteristic affords the user a comfortable interface that is readily understood. However, it is a heavy burden on the portal, since all text must be available in all supported languages. This includes images and visualization applications that may have text in image form, which requires multiple renderings of the images or graphics. Unfortunately, there still does not exist a flawless dynamic translator that a portal or application can employ. If the portal achieves other goals that are required or strongly suggested, such as an intuitive user interface, more visualization, and minimized use of language, then the burden of multi-language support is also minimized. However, there will remain a requirement for it to some degree, such as in Help content, explanations of data usage and descriptions of societal benefits.

Additional language recommendations are to avoid jargon [Zazelenchuk and Boling, 2003] and to keep the language plain and simple.

3.1.7 Size (Optional)

The size of the portal is an important characteristic for accessibility; in general and especially for users that are visually impaired. Although the browser usually provides functionality to increase and decrease the text size, it is done without any knowledge of the site being rendered. This means that images don't change size, plug-in areas don't change size, and the layout of the site can be damaged. For these reasons, leaving the browser in charge of dealing with this aspect of accessibility is unwise. This characteristic is supported by [Nielsen, 2002].

For accessibility in general ISO/TS 16071:2003, Ergonomics of human-system interaction -- Guidance on accessibility for human-computer interfaces, is applicable and also the Web Accessibility Initiative [WAI].

3.1.8 Finalize Portal Based on User Testing (Required)

With respect to usability issues the involvement of real users in testing scenarios cannot be understated. An effective return on the identification of problematic usability issues is obtainable with as little as five real users, running many small tests [Nielsen and Landauer, 1993 and Nielsen 2000].

To generate objective results from usability tests it is recommended to follow a standard reporting procedure, e.g. a "usability Testing Metric" such as the Common Industry Format (CIF) for usability test reports. The CIF became an ANSI standard in December 2001 (ANSI/NCITS 354-2001) and became an international standard in 2006 (ISO/IEC 25062:2006 "Common Industry Format (CIF) for usability test reports").

3.2 Technology Characteristics

A trade-off between web applications (i.e. thin client, browser only based designs) and smart/fat clients for web portals was considered by [Magennis, 2005], reporting that such: "applications are both viable and effective architectures when used appropriately. When offline usage and rich user interfaces are required, smart client applications are the clear design choice. When broad reach and zero-touch deployment is a requirement, Web applications have the winning design". Considering the GEO Web Portal is intended to have global reach and act as a gateway to other services a Browser Based solution is recommended. Veeramani, [2006] also provides an assessment of the trade-off between smart clients and browser based solutions (albeit focussing the discussion on the example of Microsoft .NET).

3.2.1 Browser-Based (Strongly Suggested)

This characteristic is ideally realized when the portal requires nothing but a browser to deliver all of its content and functionality. Browser plug-ins are considered browser-based. However, it is sometimes the case that portals require that a user install a special application in order to perform certain functionality; especially when the portal is dedicated to something that is, to a large degree, application dependent, such as Earth Observation data. Sometimes the required application is a commercial application that is not freely available.

It shall be noted that browser-based functionality puts a burden on the portal server and thus limits the complexity and performance of tasks which can be carried out at each client, requiring more server power and network bandwidth for the complex tasks to be completed for each user. This can be hard to achieve but in the case of the GEOSS architecture the GEO

Web Portal is not responsible for all the processing functions so a browser based-solution /thin client solution is viable. It will improve adoption and use of the portal, as well as the data it provides. Another important benefit of being browser-based is the avoidance of certain security issues, such as network firewalls. (Note thin client solution may still include the local caching of data to improve performance, but this data is usually never retained between sessions).

Extension of the technology to provide a service for mobile technology is also something to consider.

3.2.2 Degradability (Required)

This characteristic is primarily a user interface issue, but can bleed over into functionality. It is based on the idea that a portal should be designed to function as well as possible with the available technology, but should be able to gracefully service those users who cannot avail themselves of that newer technology.

The best example to show this is browser version. Many websites are made available to the public that use the latest WSRP technology [OASIS, 2003, 2008] that only the newest versions of browsers can support. When someone goes to that website using an earlier version browser, they are either unable to view the site properly, or they can view it in an undesirable way.

Degradability should allow a portal to be used by the newest technology and older technology simultaneously. The extent of how old technology should be before it can be ignored is a different discussion, but when older technology is taken into account, it should be taken into account properly, and not as an afterthought. Users who visit a portal should not experience a wholly different site just because they don't have the latest technology

The adoption of a browser-based solution ameliorates the difficulties in meeting degradability requirements. Alternatives such as smart clients can restrict the choice of client platform [Veeramani, 2006].

By analysis of the target user community it is possible to ascertain the minimum requirements for hardware and software that need to be supported. It may appear a difficult requirement but is mitigated by knowing the exact nature of the user community (e.g. are the users employees of national institute or are they the general public?). Practically the requirement may be considered met if are large majority of the target users are satisfied.

3.3 Functional Characteristics

3.3.1 Content Search (Required)

Data Search is a principal requirement of the RFI for GEOSS Web Portal Solutions [GEOSS, 2007a]. It is the basic functionality that all data portals should have. The data portal's main reason for existence is to make discoverable the data that has been acquired and aggregated, either locally or remotely (i.e. the community portals). There are many different ways to implement data search functionality. First of all, the system must ascertain what the users wish to search for. Second, the results of the search must be rendered to the user. In between

is the method used for executing the search. All that will be considered here is the user input and the results display, both of which are required. For output, there are two general requirements that a data portal should support. These are providing data in a text format and in a graphical format. Text formats can include column-based text, XML, etc. Graphics formats can include static images, interactive maps, data plots, etc. Some form of text and graphics must be provided. A portal could conceivably also deliver data directly via web services such as OpenDAP, WFS and WCS.

For input, the user must specify the parameters that define the search. Typically, there are three requirements for specifying a search: content, space and time [e.g. Dobinson and Raskin 1998]. Choices within these categories can provide whatever granularity of search is supported by the portal and the data that are available. Even though the basic search will rely at some level on such content, space and time parameters query options may also be presented as thematic topics, or collections to the end user. One such collection concept is the Societal Benefit Areas themselves. The W3C Recommendation 2004 for the OWL Web Ontology Language is one standard to support thematic domain searches.

3.3.2 Content (Required)

The data content may be described in terms of the data provider or characteristic of the data itself and can include any combination of such parameters (but at least one). The possible parameters include:
1. observables, e.g. global surface temperature,:
2. sensor ID;
3. platform ID, such as a ship call sign or satellite name;
4. data matching criteria, such as relational expressions that must be satisfied.
Ranges or multiple selections for the above parameters can be used, where appropriate.

3.3.3 Spatial (Required)

The spatial parameter must identify a region or location for which the data apply.
This can include any combination, but at least one, of the following:
1. Point location (latitude, longitude, altitude);
2. land region, such as continent, country, named place, etc.;
3. oceanic region.
Ranges or multiple selections for the above parameters can be used, where appropriate.

3.3.4 Temporal (Required)

The temporal parameter must identify a point in time from which the data should come from.
This can include any combination, but at least one, of the following:
1. date of data acquisition;
2. time of data acquisition (should be specified in UTC form);
3. season of data acquisition.
Ranges or multiple selections for the above parameters can be used, where appropriate.

3.3.5 Data Visualization (Required)

In general terms, once data has been searched for, the results of the search must be presented to the user. Although text presentation is easy and efficient, graphical presentation can often convey more information in a smaller amount of space. This is accomplished using color, interaction, and animation. Even when a graphical format is chosen to visualize the data, there

must still be a way to observe the associated information (e.g. metadata or actual data values) as text. This can be accomplished using pop-ups after clicking on a graphic position, by providing hover text when hovering the mouse over a data point's graphical position, etc.

Some of the visualization options for rendering data are as follows:

1. imagery to show static rendering of data;
2. thematic maps;
3. line plots, scatter plots, bar graphs, etc.;
4. contour maps, geographic maps, etc.;
5. animation to show the data dynamics temporally.

For the case of the GEO Web Portal, since there is the recommendation to adopt a Browser Based client, caution must be exercised with the adoption of complicated imaging functions, e.g. animations, since this may impose a performance penalty on the portal server.

3.3.6 News (Optional)

Many portals provide an opportunity for users to gain knowledge about the research area or industry involved in the data acquisition, validation, and dissemination of the supported data. This may be done via RSS news feeds or links to important stories, articles, etc. Up-to-date news improves the quality of a web site [HSS, 2006] so connection to news services reporting GEO events is important.

4 CHARACTERISTICS TO BE AVOIDED

After studying the portal examples gathered for this report, many characteristics have been identified as being undesirable for an acceptable portal. These will be discussed and indicated as to whether each is to be **Avoided** or needs to be **Minimized**.

4.1 Difficult Information Access (To Be Avoided)

When a portal makes access to information difficult, it defeats the main goal of the portal, which is data and information dissemination. It is a judgment call as to what is difficult, since one can argue that enough experience using a portal is all that is required to adequately access information. However, the goal of the GEO Web Portal is to make data, and associated information, readily available to the global community.

Precise metrics determining whether information access is too difficult are not available since it is dependent on the characteristics of the data itself. Possibilities include the number of navigation links that must be activated and the amount of information that must be collected from the user in order to disseminate data. The solution is to return to consideration of usability related issues during the creation of the portal; including the context within which users will be visiting the portal; the experience levels of the users; the types of tasks users will perform on the site; the types of computer and connection speeds used when visiting the site; evaluation of prototypes; and the results of usability tests [see HHS, 2006 and references therein].

4.2 Requirements on User Registration (To Be Minimised)

This is not an altogether undesirable characteristic. Its nature is dependent on how it is implemented. Registration for the sole purpose of putting up an obstacle to the portal, or to just gather information about individuals to put into a database, is highly undesirable. This is the nature of registration that is being assumed here. Selective registration, at the choice of the user, in order to provide a more personal interface or to provide value-added services, is desirable. The important point is that it needs to be a choice made by the user. The default operation of a portal within the GEOSS context should be open and freely available.

User registration is one technique to provide access control according to agreements made with specific data providers. However, this can also be managed by access control on cross-site HTTP requests which, at the time of writing, is the subject of a W3C working draft, [W3C, 2008].

4.3 Too Much Text (To Be Minimized)

A data portal that depends on text exclusively is undesirable. Measuring the amount of text, and deciding if there is too much, is a subjective matter. There do not seem to be metrics available for this, this being one of those "you know it when you see it" Issues. Graphics and imagery should play a key role on a data portal. A clear indication that there is too much text is when something is being read, and the thought comes up that it would be much easier to "see" if there was a picture. It is acceptable to have text associated with graphics and imagery, such as instructions, captions, or explanations, as long as there is not too much required to be read to understand how to get the data and understand it at a user level [Nielsen, 1994b].

5 CONCLUSION

The analysis of some 175 sample portals in the Earth Observation domain led to the breakdown of characteristics into three important areas: general usability, adopted technology and desired functionality.

Functionality is the overall driver with the features such as data search and data visualisation as required characteristics. Such a result in functionality is obvious, however, the relationship between functional behaviour and aspects of general usability is important. Conclusions drawn from testing the existing sites combined with evidence in the supporting literature emphasize the need for on-site help and good access to supporting data by well designed navigation. Only with some degree of dedicated usability testing and communication with the target communities can this be achieved.

Technological choices for web portals are dependent on the required performance, range of functions which need to be supported and the nature and distribution of the users and the client platforms available. It is essential that technological choices do not obstruct the access to information by the target user community.

Corporate enterprises have demonstrated the benefit of adopting the latest internet standards in developing effective portal solutions [Pollach et al. 2006] and generic portal frameworks are under construction [Chaoying Ma et al., 2006]. To draw on the acquired knowledge and experience from other disciplines and the lessons learnt from existing earth observation portals and web sites is an important step to optimise the characteristics of future user-interfaces like the GEO Web Portal.

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W3C, Access Control for Cross-site Requests, http://www.w3.org/TR/access-control/ , W3C Working Draft 14 February **2008**.

[WAI] Web Accessibility Initiative, http://www.w3.org/WAI/

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7 Appendix A1

The portals studied in the initial research phase are listed below. The list is also available at http://del.icio.us/EOPortals, which remains a dynamic site.

http://www.earthportal.org/ EarthPortal Â» Home
http://www.soda-is.com/eng/services/index.html SoDa - Application Domains
http://www.scarmarbin.be/ SCAR-MarBIN Portal
http://www.fao.org/gtos/tems/ GTOS :: TEMS database
http://www.eogeo.org/ Welcome to EOGEO â□" EOGEO
http://www.agirn.org/ AGIRN - African Geo Information Researcher Network
http://simdat-cn.ecmwf.int:8080/wis-portal/home SIMDAT Meteo Portal
http://www.fao.org/geonetwork/srv/en/main.home FAO GeoNetwork- The portal to spatial data and information
http://www.nodc.noaa.gov/cgi-bin/gtspp/gtsppform01.cgi GTSPP Data Base Query Form
http://www.usgodae.org/ GODAE: Global Ocean Data Assimilation Experiment
http://www.mersea.eu.org/ Mersea IP Marine EnviRonment and Security for the European Area-Integrated Project
http://seacoos.org/ SouthEast U.S. Atlantic Coastal Ocean Observing System â□" SEACOOS
http://eu-geoportal.jrc.it/ European Geo-Portal
http://taurus.caf.dlr.de:8080/index.html Cluster AF Earth Observation Data
http://ies.jrc.cec.eu.int/dbanks.html IES: Data Portals
http://www.biomareweb.org/ BIOMARE
http://faostat.fao.org/ FAOSTAT
http://www.who.int/ncd_surveillance/infobase/web/InfoBaseCommon/ WHO Global InfoBase Online: Introduction
http://www.eionet.eu.int/ European Environment Information and Observation Network - EIONET
http://dataservice.eea.eu.int/dataservice/default.asp?refid=911B582A-806E-4758-892E-9AB9AFB47B84 European Environment Agency - Data service
http://apdrc.soest.hawaii.edu/ Asia-Pacific Data-Research Center
http://www.apl.washington.edu/programs/ASIAEX/index.html ASIAEX â□" East China Sea: Welcome
http://www.eoportal.org/ eoPortal: sharing earth observation resources
http://www.ngdc.noaa.gov/maps/interactivemaps.html NOAA/NESDIS/NGDC - Interactive Map Services
http://onearth.jpl.nasa.gov/ OnEarth, server of the Landsat 7, WMS Global Mosaic
http://wgiss.ceos.org/eodp/ EO Data Portal HomePage
http://www.digitaluniverse.net/experience/portals/ Digital Universe Domain Portals
http://iceds.ge.ucl.ac.uk/viewer/iceds/index.html ICEDS Web Portal
http://www.oceaninfo.ru/ ÐœÐ¸Ñ□Ð¾Ð²Ð¾Ð¹ Ð¾ÐºÐµÐ°Ð½
http://gcmd.gsfc.nasa.gov/KeywordSearch/Home.do?Portal=amd&MetadataType=0 Antarctic Master Directory Web Site
http://www.esfs.org/ The International Year of the Earth
http://ihy.gsfc.nasa.gov/ The International Heliophysical Year
http://www.egy.org/ The electronic Geophysical Year
http://www.ipy.org/ The International Polar Year
http://www.polartechnologyconference.org/ Polar Technology Conference
http://geodynamics.jpl.nasa.gov/workshop/autonomous_systems/ Autonomous Systems in Extreme Environments Workshop
http://www.polarpower.org/ PolarPower.org
http://www.unavco.org/ UNAVCO - Global Plate Deformation Measurements
http://www.cse.dmu.ac.uk/EAPRS/iag/ International Digital Elevation Model Service
http://icgem.gfz-potsdam.de/ICGEM/ICGEM.html International Center for Global Gravity Field Models
http://www.astro.oma.be/ICET/ International Center for Earth Tides
http://www.iges.polimi.it/ International Geoid Service
http://bgi.cnes.fr:8110/ International Gravity Bureau
http://earth-info.nima.mil/GandG/ National Geospatial Intelligence Agency
http://www.igfs.net/ International Gravity Field Service
http://www.iag-aig.org/ International Association of Geodesy
http://www.comnap.aq/ Council of Managers of National Antarctic Programs - verification stage 1
http://www.antec.scar.org/ SCAR Antarctic Neotectonics Expert Group (ANTEC)
http://www.geoscience.scar.org/geodesy/giant.htm SCAR GSSG - Geodetic Infrastructure in Antarctica Expert Group (GIANT)
http://www.geoscience.scar.org/ SCAR Geoscience Standing Scientific Group
http://www.polarnet.cnr.it/ CNR - The National Research Council Polar Network
http://www.aosb.org/ Arctic Ocean Sciences Board
http://www.iasc.no/ International Arctic Science Committee
http://www.arctic-council.org/ Arctic Council
http://www.wmo.int/ World Meteorological Organisation -verification stage 1
http://www.scar.org/ Scientific Committee on Antarctic Research
http://www.icsu.org/ International Council for Science
http://www.ciesin.org/ Center for International Earth Science Information Network (CIESIN)
http://gisdata.usgs.net/Website/CEOS/viewer.php CEOS WG on Information Systems and Services provides free online data with NED,SRTM,Landsat,maps,orthoimagery,elevation and more.
http://gos2.geodata.gov/wps/portal/gos GOS - Geospatial One Stop
http://www.neodc.rl.ac.uk/ NERC Earth Observation Data Centre
http://www-argo.ucsd.edu/ Argo Home page - Global Temperature/Salinity Profiling Floats

http://www.nodc.noaa.gov/GTSPP/gtspp-home.html GTSPP Home Page
http://www.pol.ac.uk/psmsl/programmes/gloss.info.html PSMSL - GLOSS information
http://ioc.unesco.org/goos/ UNESCO Global Ocean Observing System
http://ocean-partners.org/ POGO - Partnership for Observation of the Global Oceans
http://www.natcomindia.org/web_climate.htm Natcom India, Climate Change, UNFCCC, IPCC
http://www.nerc.ac.uk/ NERC United Kingdom
http://www.marshall.org/subcategory.php?id=9 The Marshall Institute - Climate Change
http://www.st.northropgrumman.com/capabilities/space/eors/eors.html Northrop Grumman - Earth Observations Satellites
http://www.hko.gov.hk/wxinfo/intersat/modis/sat.html Hong Kong Observatory - EOS Satellite Images
http://www.logicacmg.com/countries/United_Kingdom/Markets/Space/What_we_do/Earth_observation_systems/page5104 LogicaCMG UK : Earth observation and meterology - Information Systems
http://en.wikipedia.org/wiki/Earth_Observing_System Earth Observing System - Wikipedia, the free encyclopedia
http://www.eos-ids.sr.unh.edu/ NASA Earth Observing System - University of New Hampshire
http://earthobservatory.nasa.gov/ NASA Earth Observatory
http://terra.nasa.gov/ NASA: TERRA (EOS AM-1)
http://www.agiweb.org/gap/legis109/earthobservation.html American Geological Institute - Serving the Geosciences Since 1948
http://isis.dlr.de/ Cluster AF Earth Observation Data
http://www.fas.org/spp/guide/india/earth/irs.htm IRS (Indian Remote Sensing Satellite) - India and Earth Observation Systems
http://edcdaac.usgs.gov/main.asp Land Processes Distributed Active Archive Center
http://www.ametsoc.org/atmospolicy/EarthObservationSystem.html Earth Observation System Policy Forum
http://go-essp.gfdl.noaa.gov/ GO-ESSP home page
http://nomads.ncdc.noaa.gov/nomads.php?name=about NOAA National Operational Model Archive & Distribution System - About NOMADS
http://www.csiro.au/ Welcome to the Commonwealth Scientific and Industrial Research Organisation
http://www.eohandbook.com/eohb05/ceos/part3_2.html CEOS - Earth Observation Plans
http://www.belspo.be/belspo/links/space_en.stm Belgian Science Policy - Links : Space Research
http://portal.rosa.ro/index.php?item_id=35 Romanian Space Agency (ROSA)
http://www.ceos.org/ CEOS_homepage
http://eosl.eas.ualberta.ca/ Earth Observation Systems Laboratory
http://www.noaa.gov/eos.html NOAA Home Page - Earth Observation System
http://earthobservations.org/ Group on Earth Observations
http://www.epa.gov/geoss/ U.S. EPA | Global Earth Observation System of Systems
http://edc.usgs.gov/ USGS (U.S. Geological Survey) EROS, Sioux Falls, SD
http://www.ird.fr/ Research Institute for Development - Institut de Recherche pour le DÃ©veloppement
http://www.cites.org/ Welcome to CITES
http://www.globalforestwatch.org/english/index.htm Welcome to Global Forest Watch
https://www.eoc.jaxa.jp/iss/en/index.html Earth Observation Data and Information System
http://acsys.npolar.no/adis/adis.php Arctic Climate System Study (ACSYS)
http://clic.npolar.no/disc/index.html Data and Information Serivce for CliC - DISC
http://www.wmo.int/web/www/OSY/GOS.html GOS - WWW Global Observing System
http://www.class.noaa.gov/nsaa/products/welcome NOAA's Comprehensive Large Array-data Stewardship System
http://www.nesdis.noaa.gov/datainfo.html USDOC/NOAA/National Environmental Satellite, Data, and Information Data Home
http://www.ncep.noaa.gov/ National Centers for Environmental Prediction
http://data.ecmwf.int/data/ ECMWF Data Server
http://ehp.niehs.nih.gov/members/2005/113-2/focus.html Terra Cognita: Using Earth Observing Systems to Understand Our World
http://www.esa.int/esaEO/GGGQE9F3AEC_index_0.html ESA - Observing the Earth - Space technology fights forest fires in Canada this summer
http://www.space.gc.ca/asc/eng/apogee/2005/02_earth_environment.asp CSA - Earth and Environment
http://www.spie.org/ SPIE--The International Society for Optical Engineering. The Optics, Photonics, Fibers, and Lasers Resource.
http://www.cgeo-gcot.gc.ca/about/overview_e.htm Canadian Group on Earth Observations | Le groupe canadien des observations de la Terre
http://www.coral.noaa.gov/ NOAA's Coral Health and Monitoring Program
http://www.smebd.org/index.php?option=com_frontpage&Itemid=1 Society for the Management of European Biodiversity Data - Home
http://www.natureserve.org/prodServices/biodatamodel.jsp NatureServe: Standards & Methods > Biodiversity Data Model
http://biodiversity-chm.eea.eu.int/information/database European Community Biodiversity Clearing House Mechanism
http://www.fishbase.org/home.htm FishBase : A Global Information System on Fishes
http://www.reefbase.org/download.asp ReefBase: Data Download: - A Global Information System On Coral Reefs
http://www.unep.net/ UNEP.Net, the United Nations Environment Network
http://pubs.wri.org/datasets.cfm?SortBy=1 World Resources Institute - Datasets
http://nationalzoo.si.edu/ConservationAndScience/MAB/biomon/ BIOMON - Biodiversity Monitoring Database - National Zoo| FONZ
http://www.waterandnature.org/eatlas/ Water Resources eAtlas - Watersheds of the World
http://www.iucnredlist.org/ The 2004 IUCN Red List of Threatened Species
http://sea.unep-wcmc.org/wdbpa/ World Database on Protected Areas
http://www.gbif.org/ GBIF portal: Home
http://portal.chronos.org/gridsphere/gridsphere CHRONOS Portal
http://wdc.nbii.gov/ma/partners.htm MA Data portal
http://www.gogeo.ac.uk/ Go-Geo : Home Page
http://go-essp.gfdl.noaa.gov/web_portal_projects.html Web Portal Projects
https://www.earthsystemgrid.org/ Earth System Grid
http://www.ngdc.noaa.gov/wdc/ USA Home, World Data Center System
http://www.ngdc.noaa.gov/ngdc.html USDOC/NOAA/NESDIS/National Geophysical Data Center (NGDC) Home Page
http://tao.atmos.washington.edu/data_sets/ JISAO Climate Data Archive

http://grid2.cr.usgs.gov/datasets/datalist.php3 UNEP/GRID - Sioux Falls
http://earthwatch.unep.net/index.php United Nations System-Wide Earthwatch
http://www.oceanlab.abdn.ac.uk/research/esonet.shtml ESONET
http://gcmd.gsfc.nasa.gov/ Earth Science data and services directory: Global Change Master Directory Web Site
http://gislab.cifor.cgiar.org/fsic/index.jsp Forest Spatial Information Catalog
http://mercury.ornl.gov/cdiac/ CDIAC Search
http://tornado.badc.rl.ac.uk/home/ The British Atmospheric Data Centre
http://www.eol.ucar.edu/data.html Earth Observing Laboratory (EOL)
http://www.geo-one-stop.gov/ Geospatial One-Stop
http://nationalmap.gov/ USGS Geography: The National Map
http://seamless.usgs.gov/ Seamless Data Distribution System provides DOQQ, SRTM, NED, Orthoimagery, Landsat, elevation and much more for free download.
http://gisdata.usgs.net/website/disaster_response/ Hazards Data Distribution System provides free online data with DOQQ,NED,SRTM,Landsat,maps,orthoimagery,elevation and more.
http://eospso.gsfc.nasa.gov/ NASA's Earth Observing System Project Science Office Homepage
http://glcf.umiacs.umd.edu/data/gimms/ GLCF: Global Inventory Modeling and Mapping Studies
http://www.esipfed.org/data_center/index.html Federation of Earth Science Information Partners
http://www.esa.int/esaCP/index.html ESA Portal
http://www.ieee.org/portal/cms_docs/education/setf/index.html IEEE SETF Web Portal: Portal Welcome
http://frf.usace.army.mil/ Field Research Facility, waves, coastal studies
http://www.nasa.gov/centers/goddard/home/index.html NASA - Goddard Space Flight Center
http://www.cbos.org/ Chesapeake Bay Observing System
http://www.co-ops.nos.noaa.gov/dbports/dbports.html NOAA/NOS/CO-OPS: Delaware River and Bay PORTSÂ®
http://www.udel.edu/dbos/ DBOS - Delaware Bay observing System
http://www.iwindsurf.com/support.iws?topic=About+Us iWindsurf.com - iWindsurf.com Support: About Us
http://nerrs.noaa.gov/ChesapeakeBayVA/welcome.html Chesapeake Bay Reserve, Virginia
http://nerrs.noaa.gov/ChesapeakeBayMD/welcome.html Chesapeake Bay Reserve, Maryland
http://nerrs.noaa.gov/Delaware/welcome.html Delaware Reserve
http://nerrs.noaa.gov/JacquesCousteau/welcome.html Jacques Cousteau Reserve, New Jersey
http://nerrs.noaa.gov/HudsonRiver/welcome.html Hudson River Reserve, New York
http://nerrs.noaa.gov/NarragansettBay/welcome.html Narragansett Bay Reserve, Rhode Island
http://nerrs.noaa.gov/WaquoitBay/welcome.html Waquoit Bay Reserve, Massachusetts
http://esg.gsfc.nasa.gov/ Earth Sun Gateway
https://cdp.ucar.edu/ NCAR Community Data Portal (CDP)
http://cdmo.baruch.sc.edu/ Welcome to the Centralized Data Management Office
http://www.marine.rutgers.edu/mrs/codar.html Coastal Ocean Observation Lab - Rutgers University
http://www.marine.rutgers.edu/cool/ Coastal Ocean Observation Lab - Rutgers University
http://140.90.121.76/nyports/nyports.html NOAA/NOS/CO-OPS: New York/New Jersey Harbor PORTSÂ®
http://onr.dl.stevens-tech.edu/webnyhos3/ Stevens Institute of Technology: Urban Ocean Observatory
http://140.90.121.76/nhports/nhports.shtml NOAA/NOS/CO-OPS: New Haven PORTSÂ®
http://sunysb.edu/soundscience Sound Science
http://glovis.usgs.gov/ USGS Global Visualization Viewer
http://daac.gsfc.nasa.gov/ Goddard Earth Sciences (GES) Data and Information Services Center (DISC)
http://www.mysound.uconn.edu/mys_links.html UConn - MYSound Project - Links
http://www.co-ops.nos.noaa.gov/nbports/nbports.html NOAA/NOS/CO-OPS: Narragansett Bay PORTSÂ®
http://mvcodata.whoi.edu/cgi-bin/mvco/mvco.cgi Martha's Vineyard Coastal Observatory
http://www.deos.tudelft.nl/ Department of Earth Observation and Space systems DEOS Delft Netherlands
http://spsosun.gsfc.nasa.gov/eosinfo/Welcome/index.html EOSDIS Welcome Page
http://earthobservatory.nasa.gov/Newsroom/ Earth Observatory: News
http://www.epa.gov/geoss/eos/txt_mm_air.html U.S. EPA | Global Earth Observation System of Systems
http://www.climatechange.gc.ca/english/ Climate Change, Government of Canada