

# Report of the 2007 Meeting of the GCMD Science Users Working Group

## GCMD Science Users Working Group Report September, 2007

### **Executive Summary**

The Global Change Master Directory Science Users' Working Group (UWG) met June 19 and 20, 2007 for an update on progress and status of the GCMD, as well as to consider strategic plans under development, and to make recommendations for future direction. The GCMD continues to play a vital role in NASA's Earth science data management, as noted by NASA Headquarters and GSFC directors and managers in attendance.

Overall the UWG was extremely impressed by the dedication and professionalism of the entire GCMD team, which operates with the energy and enthusiasm of a startup company dedicated to providing its users with high quality services while keeping in touch with changing technologies and trends. Lola Olsen is once again to be commended for her leadership of the group.

The GCMD has a successful track record of being largely self-directed, with constant awareness of and accountability to the community it serves. GCMD's long term success stems from its good relationship with this community. GCMD management has also successfully walked the fine line of balancing sustaining engineering vs development to keep up with the rapidly changing Internet technology. GCMD management must continuously prioritize activities to remain effective within tightening fiscal boundaries.

The meeting consisted of a series of short presentations by GCMD team members describing status, progress and strategies while seeking UWG member input in discussion along the way. In summary, the UWG recommends that the GCMD:

- Continue to be community leaders in providing high quality Earth science metadata, and active contributors to keyword development, standards definitions and the semantic web
- Work towards greater inclusion of current NASA data sets and research so that virtually all of NASA's Earth science efforts can be found through GCMD, without neglecting other key data
- Extend metadata holdings to include popular data sets such as climate change indicators to maintain relevance to users, and develop priorities for adding new metadata
- Continue to make the GCMD known through papers, posters and booth attendance at professional society meetings, and work to better understand who the GCMD users are
- Continue to encourage a culture of provider-maintained metadata, with appropriate checks and balances, through DocBuilder and web interface enhancements
- Continue to develop a strategic plan in resonance with sponsor and community needs

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### **GCMD Science Users Working Group Report**

The Global Change Master Directory Science Users' Working Group (UWG) met June 19 and 20, 2007 for an update on progress and status of the GCMD, as well as to consider strategic plans under development, and to make recommendations for future direction.

Overall the UWG was extremely impressed by the dedication and professionalism of the entire GCMD team, which seems to operate with the energy and enthusiasm of a startup company dedicated to providing its users with high quality services while keeping in touch with changing technologies and trends. Lola Olsen is once again to be commended for her leadership of the group. Team members are challenged to grow and reinvent themselves as needs demand, clearly a successful strategy as evidenced by the lengthy tenure and increasing responsibilities of many of the staff. Each of the team members made presentations to the UWG, a strategy that convincingly demonstrated team ownership and dedication to the GCMD mission. Lola and the GCMD team did an outstanding job arranging meeting logistics and ensuring that the time spent was productive, focused on the key questions facing the GCMD.

The GCMD plays a vital role in NASA's Earth science data management, as noted by NASA Headquarters and GSFC directors and managers in attendance. Frank Lindsay, NASA Headquarter Science Mission Directorate, noted the important role that user groups have in connecting data system projects to the community. Jeanne Behnke, Manager of the ESDIS Science Operations Office, observed that the overall data system has matured to the point that the high priority now is finding useful data, not just entering it into the system. GCMD is a key portal technology to find the data. Customers want to know HOW to find data and WHAT they can do with it when it's found – the goal is simpler access to get the data needed. Steve Wharton, Global Change Data Center Director at GSFC, reiterated that the GCMD is on the cutting edge of metadata management, and that UWG recommendations have been vital. Andrew Mitchell, ECHO Operations Manager at GSFC, noted that the ECHO metadata clearinghouse that provides granule level data has been collaborating closely with the GCMD.

The meeting consisted of a series of short presentations by GCMD team members describing status, progress and strategies while seeking UWG member input in discussion along the way. The agenda and presentation materials are available at online at the GCMD UWG web site. GCMD staff also provided a specific list of questions for the UWG, seeking specific guidance and suggestions following discussion.

The following section of the report highlights specific topics of discussion resulting from the GCMD presentations, followed by UWG recommendations or comments.

## UWG Observations and Recommendations

The GCMD has a successful track record of being largely self-directed, with constant awareness of and accountability to the community it serves. GCMD's long term success stems from its good relationship with this community. GCMD management has also successfully walked the fine line of balancing sustaining engineering vs development to keep up with the rapidly changing Internet technology. GCMD goals towards providing comprehensive Earth science metadata while developing state of the art systems may not always be possible due to financial and personnel constraints. GCMD management must continuously **prioritize** their activities to remain effective. The GCMD efforts to define a strategic plan should continue with input from the community, which also looks to the GCMD for direction. As members of the community, the UWG recommends that GCMD:

- Maintain high quality metadata standards, and avoid sacrificing accuracy for completeness. Quality metadata are useful even if not 100% complete. However, attempt to provide data quality indicators wherever possible.
- Work towards greater inclusion of current NASA data sets and research so that virtually all of NASA's Earth science efforts can be found through GCMD
- Prepare a priority list of new programs, missions or data sets to catalog in GCMD, based on their relevance to sponsor and community needs
- Develop a strategy for how to engage data provider partners to distribute the metadata entry and update workload while being mindful of quality control and security issues.
- Develop a white paper, perhaps jointly with FGDC, that openly addresses the complementary between GCMD, FGDC and ISO metadata approaches
- Develop a proactive relationship with the NASA ESG and GIO programs to maintain metadata leadership
- Consider broadening docBUILDER capabilities to support FGDC and ISO record creation through external partnerships and support
- Work to better understand who the GCMD users are, what they are looking for, and how they use the results of their searches
- Continue to improve the GCMD user experience with an easy to use web front end that enables searching in multiple ways
- Take measures to clarify data provider responsibilities to avoid search results that are less than meaningful and reflect poorly on GCMD
- Remain active leaders and contributors to the keyword taxonomies and re-establish keyword subscription services as soon as possible
- Remain active leaders and contributors to semantic web discussions and RDF framework development for Earth science data
- Continue to keep educational uses of GCMD in mind, and maintain a GCMD presence at professional society meeting through posters, talks and booths
- Communicate with providers and users in advance about system upgrades and changes that may impact their GCMD experience
- Maintain currency with state of the art database server and web practices, but carefully consider the division of metadata vs data services such as GIS tools
- Select partnerships carefully to keep them functional and in phase with GCMD goals
- Consider opportunities to play a larger international role, and strengthen US GEO, GEOSS and CEOS connections

These points are addressed in further detail in the following section of the report.

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### NASA Priorities

A very simple measure of the GCMD's value, from the NASA management point of view, is the completeness of records held by GCMD that point to NASA mission and research data. What percentage of NASA Earth science data are accessible through the GCMD? NASA management believes that the GCMD should aim to include records for 99% of NASA Earth science mission and research data. To achieve this goal, the UWG recommends that the GCMD:

- Create a prioritized list of known NASA datasets it wishes to add, with the goal of understanding the completeness of the NASA data available through GCMD
- Continue to seek top level endorsement from NASA management to urge or require new NASA missions and projects to contribute metadata records, and to include links to GCMD from NASA data centers
- Emphasize current data.
- Expand climate change indicators as indicated in user survey analysis. Also, additional climate predictions (seasonal to decadal) should be included along with climate indicators. Start with NASA and NOAA climate predictions.
- Emphasize NASA science data first, then foremost non-NASA data sets such as described in Science and Nature. Data sets in other federal agencies with larger scale applications should also be highlighted. GCMD should consider the scientific merit of the requests, where necessary, and not necessarily respond to all requests.

### Strategic additions to GCMD records

The popular search for climate indicators was used as an example of increasing community interest where the GCMD has relatively few records. The GCMD should actively seek records that help to fill this gap, and others that may arise with increasing popular interest in global climate and sustainability issues. GCMD should also broaden its collection of records for Earth system models and high quality modeling products (such as the North American Carbon Analysis) and climate predictions.

NASA management recognizes the need for a NASA-wide science bibliography and projects summary, as a way to highlight the results from NASA research dollars. While such a bibliography is beyond the scope of GCMD, the GCMD might consider a partnership with another organization to help structure such a bibliography and make it available. The NASA Applied Sciences Program has similar goals to highlight NASA research results and it would be useful for GCMD to coordinate related activities with them.

### Community participation in GCMD data input and update

A consistent theme throughout the meeting was the desire to get data providers more involved in the process of populating and updating the GCMD database. Greater provider involvement could grow GCMD holdings more rapidly and free up GCMD staff to do more creative things. However, quality control of the GCMD records must be maintained. One of the strengths of the GCMD, and the reason that it has achieved the success that it has, is the quality of the metadata and the quality of the search that users have come to expect. Points to consider include:

1) Ease of use of the tools used to create DIFs and SERFs may not be the main reason limiting provider participation. Strategies to improve the data entry experience should be carefully considered if resources are limited. It may be more useful to customize data entry by portal for existing providers, providing explicit direction for how to submit metadata for certain

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projects to save GCMD staff time (i.e. rather than improving docBUILDER as tool for general or popular use).

2) NASA scientists and other Earth scientists typically do not place high priority on providing access to data. Encouragement and direction from agency sponsors and managers may be the most effective way to improve scientist participation. Consider formal requests to Franco Einaudi, Martha Maiden and others to encourage/direct scientists to contribute records to the GCMD, or to incorporate GCMD as part of their metadata plans from the beginning of a project or mission. Solicit more NASA data set inputs through NASA-HQ Program Managers (e.g., Land Use and Land Cover; Terrestrial Ecology and Hydrology) and also NASA Earth Science Centers (i.e., GSFC, MSFC, Stennis and Ames).

3) Scientists may find useful a citation index that would help give credit to the primary data providers and track how often the data are used. While such a service would be very useful, it would be difficult to implement by the GCMD alone since there are many pathways besides GCMD to discover and access data. Perhaps the GCMD could explore such a service with other data access and archiving organizations, bringing the GCMD metadata framework to the table.

4) Quality of the metadata must remain high, and the current system of vetting community input of metadata before going public seems to work well, though is labor intensive. The GCMD may wish to formalize the process for organizations that routinely contribute data to become “trusted providers”, defining requirements, controls and security issues, again to share the burden of populating GCMD with the data provider community while improving the quality of contributed metadata.

5) If the volume of data provider input increases, and the user interface to enter or update data remains public, the GCMD may wish to require user authentication to avoid unnecessary exposure and security risk.

### Handling public criticism of the GCMD contribution to metadata efforts

Recent public criticism of the GCMD DIF metadata standard in favor of the FGDC standard should be addressed plainly with a public white paper or statement that describes the relationship of the GCMD standards to FGDC, ISO 19115, XSLT etc., laying out a brief history of efforts, their individual contributions, and their planned convergence. It may also be helpful to discuss this issue with Sharon Shin, the FGDC point of contact at USGS and counterpart to GCMD, and possibly issue a joint statement.

The community is aware that ISO 19115 will be slow to be adopted. The community should also be aware that none of the standards are adequate for all users all the time (e.g. they don't address scientific reproducibility), and that standards alone do not provide quality control. The DIF is widely accepted within the community, and the GCMD should be proud of its high quality metadata. FGDC metadata can be very sparse, missing keywords or even an abstract. It is important to understand what the GCMD users need, and understand what incremental gain can be found from including new metadata fields. The core FGDC fields are all covered by the DIF. Multiple standards broaden interdisciplinary involvement – compromise makes the task tractable since no standard can cover 100% of all possible metadata. It is also suggested that the GCMD actively participate in metadata forums and discussions groups to raise awareness of the issues and DIF contributions. The Metadata Open Forum is an international effort to promote work that has been done in the metadata arena. (<http://metadataopenforum.org/>)

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As part of GCMD's strategic planning document, the GCMD should identify which systems it WANTS to be interoperable with. FGDC and ISO 19115 are mandatory, but it is not always possible to be 100% compatible due to differing data parameters. It may be most effective to consider making the DIF a profile on top of the ISO 19115, perhaps on top of the North American profile. All profiles would build upon the base standard, which will help the standards evolve.

### Interaction with other NASA metadata services such as ESG and GIO

The GCMD should take a proactive and positive role in communicating with the Earth Science Gateway and Geospatial Interoperability Office projects, emphasizing the unique contributions that GCMD can bring to these efforts and the benefits of multiple pathways to data, rather than trying to compete with them directly. GCMD already contributes important information to ESG for OMB reports, etc. The MIRADOR interface at the GES DISC is a good example of cooperation between the GCMD and other NASA data centers, as well as the relationship with ECHO. The GCMD may be able to help identify NASA products for use in user Decision Support Systems (i.e., Solutions Networking) and assist with their interoperability, two major activities of the NASA Applied Sciences Program.

The UWG suggests that the GCMD seek clarification from NASA HQ, possibly from Teresa Fryberger, about metadata standards and the current and future roles of ESG, GIO and GCMD in the larger scheme of meeting the needs of the user community. A proactive approach will help to solidify GCMD's leadership in the NASA metadata community.

### Broadening the docBUILDER user base

The docBUILDER authoring tools provide the capability to create and modify metadata descriptions for the GCMD. docBUILDER is a powerful and mature tool that helps to demonstrate the advantages of the GCMD DIF and SERF standards - using unique identifiers, keywords, service training, a machine to machine interface - overall providing a tool that encourages people to document their metadata.

Similar authoring tools do not exist for the FGDC or ISO standards. Broader use of docBUILDER could help competing standards work more closely and converge on common ground more quickly. The UWG suggests that GCMD consider options that would extend the docBUILDER as a common gateway for metadata creation to generate Dublin Core, FGDC or ISO19115 records. Such an extension could be accomplished by the GCMD team through partnerships and proposals for external support, or by making docBUILDER code publicly available.

Consider an extension of docBUILDER that could analyze records being submitted from alternate standards. Each record could be quality controlled automatically, perhaps suggesting GCMD keywords based on the existing incoming record content. The records could then be adjusted to GCMD quality control protocols by the contributor. The question may become how many records an organization might be willing to contribute based on the need to adjust the records for stricter quality control, however the more docBUILDER could 'suggest' in assistance with the record, the easier this process could be for the contributor. Finally, the contributor would likely recognize the superior search and retrieval quality of the GCMD and wish to contribute the extra work to maintaining that level of excellence.

The GCMD should consider the importance of interacting with the federal standards. Although the DIF standard has been around much longer than FGDC, since 1994 the FGDC standard has

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been the official federal standard for all geospatial metadata. Because federal agencies are required to use the FGDC standard for documenting datasets (in particular those with a geospatial reference), the GCMD should embrace the idea that docBUILDER could become a leading tool in the metadata industry – and could be an influence in the much needed use of controlled vocabulary within records to enhance discovery capability.

Many of the fields for FGDC standard metadata already exist in docBUILDER. The GCMD might consider creating a “mirror” version of docBUILDER in which the elements are mapped to FGDC, and would appear to a user as an FGDC tool. This type of arrangement would allow GCMD to promote the tool within federal government agencies that are currently producing metadata using inefficient methods. It would also spread the use and awareness of GCMD keywords, consequently broadening the user base for GCMD. Finally, the Biological Data Profile (BDP) is a profile (extended elements) that the biological community requires for developing a record that includes taxonomies and documentation of methods and analytical tools used in research. This profile should be included in docBUILDER as well, to capture metadata related to Biology to help enhance the GCMD biological focus area.

Also something to consider – the NBII has had a longstanding contract with GCMD to create FGDC metadata for USGS Science Centers and NBII nodes/node partners. These records are also converted to DIFs, however the job of the metadata creator would be greatly enhanced if he/she could use docBUILDER for all the necessary work.

Development of the ISO standard has been a lengthy process. However, the ISO 19115 standard with the North American Profile (NAP) will become the next version of the FGDC standard. When that occurs (it is predicted to occur later this year (2007)), then GCMD should consider being poised to allow users to create ISO metadata thru docBUILDER. Once the NAP is approved through ANSI, the FGDC says they will be offering all of the new ISO – NAP standard documentation from their website without a charge. It is difficult for any organization building a metadata entry tool to know how long it will be before the ISO standard is approved in full. Therefore, based on the idea of forward progress, it may behoove GCMD to adapt docBUILDER to FGDC and later to ISO. Similarities will be abundant in the standards. Additionally, the biological profile to the NAP will be very similar to the current FGDC profile.

### Who are the users?

Top level statistics of unique users and .gov, .edu, .com etc. distributions are not enough to give the GCMD a firm handle on who the users are and how they use the system. The GCMD showed excellent statistical summaries of inquiries versus data sets. However, the actual data usage of the large number of web hits is unknown. What are users looking for and why? The GCMD should explore ways to expand customer feedback results. It should be possible, without violating government web tracking guidelines, to get a more meaningful profile of typical user classes, either through statistical means by tracking search terms used and resulting navigation, or by self identification of users who are willing to assist the GCMD by sharing their search and use habits. Accurate user statistics will help make the case for continued GCMD development and will help to refine the overall user experience. The UWG recommends that the GCMD be more explicit in its request for inputs and continue to characterize GCMD user needs to help set priorities.

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### The User Experience

The GCMD has done an excellent job keeping up with changing user expectations as the web has matured during the past ten years. The strategy of updating the web design every few years has resulted in continuous improvement of the GCMD user experience. Some points to consider:

1) Continue exploring ways to optimize the visual appearance of the web sites to make the user experience friendly and efficient. Web design tools such as AJAX may be effective, but should be carefully examined for broad compatibility and bandwidth requirements. As the Web becomes more sophisticated it will be important to improve features that differentiate the GCMD site – features such as posted use scenarios, more visible help, small tutorials, data search examples, education examples of how the data can be used for teaching and learning, etc. Consider using a Content Management System (CMS) such as Joomla, Mambo or Drupal to help manage your complex web structure, or derive pages automatically from the underlying GCMD ontology.

2) Consider multiple pathways to find GCMD holdings – not everyone searches in the same way. The hierarchical structure that is in place for cataloging metadata may not be the best way for users to search, who typically think more horizontally. For example, the current front page assumes the user will want to search by the fourteen listed disciplines. Searches by Keyword, Centers, Instruments, Platforms, Projects, Map or Location might be more appropriate for some, and should be seen in some way as parallel to the searches by topic.

3) Consider an interface that offers a “MyGCMD” custom experience with saved searches, data input options, etc, tailored for the needs of repeat users and data providers. Such a service may require user registration to avoid web cookies.

4) Maintain and improve links to NASA’s 6-focus science areas, 12 national application areas, and the 9 GEOSS societal benefit areas. It would also be beneficial to color code or somehow improve the NASA access data icon to make it more visible to the user.

### Avoiding empty searches

Some data providers occasionally contribute GCMD records that are incomplete, or refer to non-available data, for the sake of meeting sponsor requirements. Users whose search returns these less than useful records will likely fault the GCMD. The GCMD can help avoid a bad user experience and combat this problem by:

1) Screening data providers for accountability. In general, individuals should not be listed as a data provider, and in some cases even departments are not able to make long-term commitments to maintaining metadata. Institutional representation should be sought.

2) Develop a policy, with the awareness of sponsoring agencies, for what is required of data providers, what constitutes a valid entry, including a schedule for metadata delivery and the plan and policy for making the metadata available.

3) Consider using a personal, group and public flag for metadata records to help keep not quite ready for public data records out of the search results of general users.

4) Consider a disclaimer that separates data providers’ availability policies from the metadata service that the GCMD provides.

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### Keywords

One of GCMD's major contributions to the community is the constantly growing and evolving keyword taxonomy system. The community looks to GCMD for leadership in defining taxonomies, and the subscription service for keywords should be brought back online as soon as it is ready.

The UWG concurs that a new five-level metadata hierarchy should be adopted to enable GCMD to properly catalog new records from the biological sciences. The process of re-keying the existing 18,000 records should be carefully considered if the effort will be very time consuming, focusing on those records that require five levels (i.e. biological classification).

With the new five level taxonomy in place, the GCMD should consider embracing the NBII biocomplexity thesaurus and the LTER Ecological Metadata Language (EML) that could enhance the existing GCMD keyword list.

Information about the Biocomplexity Thesaurus is available on the NBII website at the following link:

[http://www.nbio.gov/portal/server.pt?open=512&objID=578&&PageID=1798&mode=2&in\\_hi\\_u\\_serid=2&cached=true](http://www.nbio.gov/portal/server.pt?open=512&objID=578&&PageID=1798&mode=2&in_hi_u_serid=2&cached=true)

The Biocomplexity Thesaurus Web service provides the capability for direct use of the thesaurus within a user's own applications, rather than requiring the user to come to the NBII's Biocomplexity Thesaurus site for each individual use of our Thesaurus. Using the Biodiversity Thesaurus Web Services, the user's application can query the thesaurus for matching terms, retrieve all related terms, or retrieve only terms related in specific ways (e.g. broader terms only).

The NBII thesaurus is a combination of 5 complete thesauri including the CSA Aquatic Sciences and Fisheries Thesaurus, the CSA Life Sciences Thesaurus, the CSA Pollution Thesaurus, the CSA Sociological Thesaurus, and the CERES/NBII Thesaurus. Try out the thesaurus at the following link: <http://thesaurus.nbio.gov/portal/server.pt>

The following thesauri are currently being added: E.V. Komarek Fire Ecology Thesaurus, Tall Timbers Research Station, Fire Effects Information System (FEIS) Glossary, Northwest and Alaska Fire Effects Clearinghouse Glossary, National Wildfire Coordinating Group Glossary of Wildland Fire Terminology, Encyclopedia of Southern Fire Science, Wildland Fire Lessons Learned Center Topics.

The NBII Clearinghouse (<http://mercury.ornl.gov/nbio/>) currently holds 5,122 metadata records from the Long Term Ecological Research (LTER) program. These records are converted from the Ecological Metadata Language (EML) to the FGDC standard format. This could be a partnership opportunity that GCMD may want to explore to enhance its Biological section. Such a partnership could provide an interesting "prototype" test environment for GCMD's ability to receive a plethora of records into the system, while maintaining a high-level of quality control.

### Semantic web involvement

The UWG recommends that the GCMD remain active with the semantic web community, in part by making more visible GCMD's involvement in projects such as SWEET (Semantic Web for Earth and Environmental Terminology) and MMI (Marine Metadata Interoperability) and IDN (International Directory Network). The semantic web community is coming to GCMD for their

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keyword taxonomies, and the GCMD should engage and work with this community to help develop consistent hierarchies between disciplines. For example, SWEET does not span the entirety of the GCMD, but the GCMD should be helping to identify the doi namespaces being used, terms, datasets, keywords and relationships. The GCMD should explore the use of the SKOS (Simple Knowledge Organization System) which provides a standard way to represent knowledge organization systems using the RDF (Resource Description Framework), a lightweight ontology system supporting the exchange of knowledge on the Web. RDF classes, concepts and relationships will be foundational elements of the next generation of Earth science metadata. This work ought to fit with other GCMD priorities, e.g. an RDF underlying structure for docBuilder may make it feasible for docBuilder to easily support the multiple standards recommended earlier, or make it easier to implement a search that allows multiple pathways through the GCMD database.

### Education, outreach and visibility

Educators are an important segment of the GCMD user base. The GCMD should continue to partner with educators who may want to use GCMD data as part of their lesson plans, helping to attract future users.

GCMD should be represented at major science (e.g., AGU, AMS) and user meetings (e.g., ASCE) and try a variety of presentation modes to reach optimal distribution. This includes poster presentations, NASA demonstration booths, and oral presentations. GCMD should also consider publication of their system in a major peer reviewed journal.

There was some discussion regarding the acronym GCMD and whether the name was still appropriate. Despite the fact that “Global Change” can be confusing to some, and that the GCMD serves content much broader than climate and environmental change, it was generally agreed that name recognition of GCMD at this point is pervasive among the community, and a name change would not necessarily be productive.

### Communication with GCMD users and data providers

The GCMD expressed interest in exploring ways to communicate with its users, for the purpose of expanding its user base. Popular Wiki, social bookmarking, folksonomies and cyberinfrastructure solutions were discussed. The UWG suggests a go slow approach here to avoid taking on the burden and possible distraction of Wiki maintenance until we know that it is likely to be beneficial in our context. Do we know that there is a “market” the GCMD is missing? Or is GCMD mature enough and already well exposed to have saturated the market? An alternate solution might be to encourage users external to the GCMD to independently operate a truly community-based forum or discussion group dealing with GCMD and other topics.

As the GCMD software and metadata framework are embraced by more users and partners worldwide, care should be taken when performing updates to match partner ability to respond in whatever way is required to use the new system. Users care about version number, and should be given advance warning of the scope and timing of planned updates, as well as some guideline about what might be impacted.

To assist with database maintenance, data providers should be given an option to register for automatic notification via email to check their metadata records at some predetermined time in the future.

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### System software and GIS capabilities

The GCMD has done a good job keeping its systems and software current, constantly exploring new architectures and tools that will improve performance, lower costs and add capabilities. The current examination of alternatives to Oracle is a good example of this, and the analysis of MySQL, Berkeley DB XML, etc. should continue.

The proliferation and complexity of metadata necessitate the development of machine to machine metadata transactions to avoid the bottleneck of human intervention. The GCMD should continue to explore machine to machine interactions using web services as a way to lead the way in metadata interoperability. RDF technologies also should help to address this problem.

Another intriguing direction is Web Mapping, and GCMD's prototype use of ArcIMS to serve maps and data which can help users better visualize what data are available. Though this area seems to have great potential in this digital globe era, the UWG recommends careful consideration of what services should be routinely offered, and a clear understanding of the boundary between metadata services and data services (though indeed, such a boundary may be artificial). This consideration should extend to the serving of "use level metadata", e.g. metadata at the data granule level. Low level of effort exploration of these capabilities should continue, with frequent user and data provider feedback. Another feature to consider is the automatic generation of KML files of accurate data set boundaries that can be exported to visualization tools such as Google Earth.

### International Co-operation.

For many years the GCMD Team has been making a major contribution to the CEOS Working Group on Information System and Services (WGISS). In particular, Lola has been leading the International Directory Network Task team within WGISS. This participation has increased the international awareness of the GCMD and has encouraged organizations around the world to contribute information in the form of DIFS to the GCMD. The support provided by the GCMD Team is very much appreciated by the international EO community. The GCMD benefits from this interaction through the strengthening of the GCMD content, thus ensuring that the GCMD maintains its international status as the world's leading repository of EO Directory-Level information. It is recommended that the GCMD Team continues to support CEOS WGISS and continues to encourage organizations from other countries to create and deposit DIFs in the GCMD.

As GCMD is now recognized as a major repository of international metadata, it is able to make a major contribution to the GEOSS. It is recognized that the GCMD Team has already shown how specific portals could be created for many of the GEO Themes and it is recommended that the Team continue to explore how they might contribute to the GEOSS Tasks (with full endorsement of US GEO).

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### Acronyms

AD	GCMD Ancillary Description <a href="http://gcmd.nasa.gov/User/suppguide/">http://gcmd.nasa.gov/User/suppguide/</a>
AGU	American Geophysical Union <a href="http://www.agu.org">http://www.agu.org</a>
AMS	American Meteorological Society <a href="http://www.ametsoc.org">http://www.ametsoc.org</a>
ANSI	American National Standards Institute <a href="http://www.ansi.org">http://www.ansi.org</a>
ArcIMS	ESRI web-based dynamic map and GIS software <a href="http://www.esri.com/software/arcgis/arcims/index.html">http://www.esri.com/software/arcgis/arcims/index.html</a>
ASCE	American Society of Civil Engineers <a href="http://www.asce.org/asce.cfm">http://www.asce.org/asce.cfm</a>
BDP	FGDC Biological Data Profile <a href="http://www.nbio.gov/portal/server.pt?open=512&amp;objID=255&amp;&amp;PageID=337&amp;mode=2">http://www.nbio.gov/portal/server.pt?open=512&amp;objID=255&amp;&amp;PageID=337&amp;mode=2</a>
CEOS	Committee on Earth Observation Satellites <a href="http://www.ceos.org/">http://www.ceos.org/</a>
CERES	California Resources Environmental Evaluation System <a href="http://www.ceres.ca.gov/">http://www.ceres.ca.gov/</a>
CMS	Content Management System <a href="http://en.wikipedia.org/wiki/Content_management_system">http://en.wikipedia.org/wiki/Content_management_system</a>
CSA	A worldwide information company <a href="http://www.csa.com/aboutcsa/company.php">http://www.csa.com/aboutcsa/company.php</a>
DIF	GCMD Data Interchange Format <a href="http://gcmd.nasa.gov/User/difguide/">http://gcmd.nasa.gov/User/difguide/</a>
ECHO	NASA Earth Observing System Clearinghouse <a href="http://www.echo.nasa.gov/">http://www.echo.nasa.gov/</a>
EML	Ecological Metadata Language <a href="http://knb.ecoinformatics.org/software/eml/">http://knb.ecoinformatics.org/software/eml/</a>
ESDIS	NASA Earth Science Data and Information System <a href="http://eosdismain.gsfc.nasa.gov/eosinfo/Welcome/">http://eosdismain.gsfc.nasa.gov/eosinfo/Welcome/</a>
ESG	NASA Earth Science Gateway <a href="http://esg.gsfc.nasa.gov/web/guest/home">http://esg.gsfc.nasa.gov/web/guest/home</a>
FEIS	USDA Forest Service Fire Effects Information System <a href="http://www.fs.fed.us/database/feis/">http://www.fs.fed.us/database/feis/</a>
FGDC	Federal Geographic Data Committee <a href="http://www.fgdc.gov/">http://www.fgdc.gov/</a>
GCMD	NASA Global Change Master Directory <a href="http://gcmd.nasa.gov">http://gcmd.nasa.gov</a>
GEO	Group on Earth Observations <a href="http://www.earthobservations.org/index.html">http://www.earthobservations.org/index.html</a>
GEOS	Global Earth Observing System of Systems <a href="http://www.epa.gov/geoss/">http://www.epa.gov/geoss/</a>
GES DISC	Goddard Earth Sciences Data Information and Services Center <a href="http://daac.gsfc.nasa.gov/">http://daac.gsfc.nasa.gov/</a>
GIO	NASA Geospatial Interoperability Office <a href="http://gio.gsfc.nasa.gov">http://gio.gsfc.nasa.gov</a>
GOS	Geospatial One Stop <a href="http://geodata.gov">http://geodata.gov</a>
GSFC	NASA Goddard Space Flight Center <a href="http://gsfc.nasa.gov">http://gsfc.nasa.gov</a>

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IDN	CEOS International Directory Network <a href="http://idn.ceos.org/">http://idn.ceos.org/</a>
ISO	International Organization for Standardization <a href="http://www.iso.org">http://www.iso.org</a>
ISO 19115	ISO GIS metadata standard being prepared by Technical Committee 211 <a href="http://www.isotc211.org/">http://www.isotc211.org/</a>
KML	Keyhole Markup Language, Google Earth standard <a href="http://code.google.com/apis/kml/documentation/index.html">http://code.google.com/apis/kml/documentation/index.html</a>
LTER	Long Term Ecological Research Network <a href="http://www.lternet.edu/">http://www.lternet.edu/</a>
MIRADOR	NASA Earth science data search tool <a href="http://mirador.gsfc.nasa.gov/">http://mirador.gsfc.nasa.gov/</a>
MMI	Marine Metadata Interoperability <a href="http://marinemetadata.org/">http://marinemetadata.org/</a>
MSFC	NASA Marshall Space Flight Center <a href="http://msfc.nasa.gov">http://msfc.nasa.gov</a>
MySQL	Opensource database <a href="http://www.mysql.com/">http://www.mysql.com/</a>
NAP	FGDC North American Profile <a href="http://www.fgdc.gov/standards/projects/incits-11-standards-projects/NAP-Metadata">http://www.fgdc.gov/standards/projects/incits-11-standards-projects/NAP-Metadata</a>
NASA	National Aeronautics and Space Administration <a href="http://www.nasa.gov">http://www.nasa.gov</a>
NBII	National Biological Information Infrastructure <a href="http://www.nbio.gov">http://www.nbio.gov</a>
NOAA	National Oceanic and Atmospheric Administration <a href="http://www.noaa.gov">http://www.noaa.gov</a>
OGC	Open Geospatial Consortium <a href="http://www.opengeospatial.org/">http://www.opengeospatial.org/</a>
RDF	Resource Description Framework <a href="http://www.w3.org/RDF/">http://www.w3.org/RDF/</a>
SERF	GCMD Service Entry Resource Format <a href="http://gcmd.nasa.gov/User/serfguide/">http://gcmd.nasa.gov/User/serfguide/</a>
SKOS	Simple Knowledge Organization System <a href="http://www.w3.org/2004/02/skos/">http://www.w3.org/2004/02/skos/</a>
SWEET	Semantic Web for Earth and Environmental Terminology <a href="http://sweet.jpl.nasa.gov/ontology/">http://sweet.jpl.nasa.gov/ontology/</a>
US GEO	US Group on Earth Observations <a href="http://usgeo.gov/">http://usgeo.gov/</a>
USGS	United States Geological Survey <a href="http://www.usgs.gov">http://www.usgs.gov</a>
UWG	Global Change Master Directory Science Users' Working Group <a href="http://gcmd.gsfc.nasa.gov/Aboutus/UWG/uwg.html">http://gcmd.gsfc.nasa.gov/Aboutus/UWG/uwg.html</a>
WGISS	CEOS Working Group on Information System and Services <a href="http://wgiss.ceos.org/">http://wgiss.ceos.org/</a>
XSLT	Extensible Stylesheet Language Transformations <a href="http://www.w3.org/TR/xslt">http://www.w3.org/TR/xslt</a>

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