Multiple Roles for GIS in US Global Change Research:

Annotated Bibliography

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Preface

This report was compiled for the National Center for Geographic Information and Analysis in conjunction with Initiative 15: Multiple Roles for GIS in US Global Change Research.

The bibliography consists of an annotated collection of articles concerned with the application of GIS in global change research. These papers range from reviewed articles to conference papers. An author index is included at the end of the report to assist in finding works by particular scholars.

This bibliography should not be considered in any way exhaustive. The breadth of the topics falling under either the global change or the GIS rubric is tremendous, and many of these works may possess some information pertinent to this initiative. For instance, much research concerning the application of GIS to environmental modeling has at least indirect application to global change research. For these and other applicable areas of GIS research, additional NCGIA reports may be helpful. Nevertheless, this report provides a foundation for research on the topics of Initiative 15.

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Annotated Bibliography

1. Baker, William L., Jimmie J. Honaker, Peter J. Weisberg. "Using Aerial Photography and GIS to Map the Forest-Tundra Ecotone in Rocky Mountain National Park, Colorado, for Global Change Research." Photogrammetric Engineering & Remote Sensing. 61(3) (1995): 313-320.

The authors use a GRASS GIS to map and analyze the forest-tundra ecotone in Rocky Mountain N.P. for signs of recent disturbances due to global climactic change. The authors find that a relatively low percentage of zone limit lines showed signs of recent disturbance. The paper discusses accuracy and positional error introduced in the course of database development, as well as an analysis of ecotone disturbance characteristics.

2. Beller, Aaron, Tom Giblin, V. Le Khanh, Steve Litz, Tim Kittel, David Schimel. "A Temporal GIS Prototype for Global Change Research." GIS-LIS Proceedings, Atlanta, GA, 1991. 752-765.

This paper discusses the development of a prototype GIS to handle global change problems including temporal aspects not handled well by existing GIS. The scope of the prototype project is to study the spatial effects of climactic change on vegetation across the US central grasslands. GIS architecture and a variety of temporal functions are covered which will enhance the ability of the GIS to handle and analyze data within a global change research program.

3. Billingsley, F. C., and J. L. Urena. "Concepts for a Global Resources Information System." 9th Annual Pecora, Sioux Falls, SD, 1984. 123-131.

NASAs information interface with the scientific community is evolving in the face of two factors: the ever-increasing volume and complexity of remotely sensed satellite data and the growing need for multidisciplinary global data. Several global environmental issues are reviewed in light of remote sensings applicability to them. A preliminary system, Global Resources Information System (GRIS) is proposed to manage and distribute data. A variety of functions are outlined to provide for access to a variety of distributed, independently maintained databases. Establishing common interfaces to link this distributed data is identified as a key concept for GRIS.

4. Bliss, Norman. "GIS Technology Benefits Global Change Research." GIS World 4(9) (1991): 55-58.

This article reviews general global change policy issues, modeling, and instances of GIS technology implementation in studying climate and hydrological systems, biogeochemical and ecosystem dynamics, paleoclimactic studies, and human issues in global change.

5. Bregt, Arnold. "Integrating GIS and Process Models for Global Environmental Assessment." Proceedings, International Workshop on Global GIS. Tokyo: ISPRS, 1993 1: 77-84.

Issues involving integrating GIS with process models are discussed. The characteristics of GIS are examined with respect to their applicability to stages in the modeling process. Integration is shown to be hampered by the lack of the time dimension in commercial GIS.

6. Burrough, P. A., W. van Deursen, G. Heuvelink. "Linking Spatial Process Models and GIS: a Marriage of Convenience or a Blossoming Partnership?" GIS-LIS Proceedings, San Antonio, TX, 1988. 598-607.

Process models often require large volumes of detailed location-specific data to produce adequate results. Using a GIS to manage this data is intuitive but presents its own problems. Data analysis is important to ensure reliability and applicability. These problems and their relationships to the GIS-modeling link are discussed.

7. Campari, I, A. Cumer, P. Mogorovich. "The Contribution of the GIS to the Knowledge of the Environment Conditions." Proceedings, Global Natural Resource Monitoring and Assessments: Preparing for the 21st Century. International Conference and Workshop Venice, 1990. 3: 1191-1200.

GIS has value in global environmental analysis for systematizing the collection and organization of environmental data. Without an organized approach to data collection and analysis, it will be of little value to other researchers. The paper discusses the concept that future environmental GIS functionality should aim for both local and global scales. Several illustrations of this are provided.

8. Clark, D. M., D. A. Hastings, J. J. Kineman. "Global Databases and Their Implications for GIS." Geographical Information Systems: Principles and Applications. Eds. D. J. Maguire, M. F. Goodchild, and D. W. Rhind. London: Longman, 1991. 217-231.

A variety of global databases for global system research are being developed. While GIS was originally developed for local or regional scale applications, its utility in handling the spatial size and complexity of the interdisciplinary global datasets. Several specific global programs for developing global change databases are described, along with their integration with GIS. Current GIS applications are unsuited to handling some critical aspects of global database sets. Finally the paper assesses the future directions of GIS which would enable greater functionality for dealing with global datasets.

9. Cocks, K. D., P. A. Walker, C. A. Parvey. "Evolution of a Continental Scale GIS." International Journal of Geographic Information Systems 2(3) (1988): 263-280.

The authors present experiences and lessons drawn from the Australian Resources Information System (ARIS). The development of the continental-scale project from an automated mapping system to a GIS is described, including data, technical, and institutional/management concerns. The paper outlines the current data sets and capabilities of the system. These are demonstrated through a series of projects undertaken by ARIS. A variety of problems and challenges related to the current state of ARIS are discussed.

10. Crain, Ian K. "Future Applications of GIS -- Shrinking the Globe." Proceedings, Global Natural Resource Monitoring and Assessments: Preparing for the 21st Century. International Conference and Workshop Venice, 1990. 2: 629-635.

Three areas of large scale GIS development are reviewed. Horizontal integration and vertical integration together incorporate areal extent and attribute depth. Thirdly, more application sophistication is required, so that monitoring and assessing regional and global environmental data is possible. A variety of future GIS applications are posited, along with characteristics necessary for handling and analyzing large and distributed data sets.

11. Ding, Bin-Bin, Dave L. Skole, Walter H. Chromentowski. "An ARC/INFO Data Management System for Global Environmental Change Research." Proceedings of the 12th Annual ESRI User Conference 1 (1992): 471-478.

Due to complex data requirements and distributed research efforts of global environmental change research, the authors suggest the utility of developing a Local Information Management System (LIMS) to perform functions in a distributed, rather than centralized, system. This paper presents a prototype global GIS/LIMS developed using ARC/INFO for working with remotely sensed data and metadata on tropical deforestation. The concept and interface, along with a variety of functions, are presented with examples from the prototype.

12. Duncan, Brean, Marco Painho, and Frank W. Davis. "Utilizing GIS Technology for Combining Regional Vegetation Maps." GIS/LIS Proceedings, Anaheim, CA, 1990. 2: 773-779.

Small scale vegetation maps are needed for much global change modeling research. This paper demonstrates a technique to combine floristic composition with remotely sensed vegetation structures to produce a composite test model of portions of southern California. Merits and drawbacks of this approach are discussed.

13. Estes, John E. "Technology and Policy Issues Impact Global Monitoring." GIS World 5(10) (1992): 52-55.

The challenges of global monitoring are highly complex. Many of these challenges are information science related; however, meeting these challenges effectively requires committed, coordinated effort at the policy-making level. To date, the impetus for GIS development has come from the private sector. To develop GIS tools that can handle global data issues (e.g. temporal factors, greater spatial data analysis ability, and improved handling of very large spatial databases) requires more creative cooperation between governments, industries, and academic institutions.

14. Fairbanks, Dean H. K., Kenneth C. McGwire, Kelly D. Cayocca, Jeffrey P. LeNay, John E. Estes. "Sensitivity of Floristic Gradients in Vegetation Communities to Climate Change." GIS and Environmental Modeling: Progress and Research Issues. Eds. Michael Goodchild, Louis Steyaert, Bradley Parks, Michael Crane, David Maidment, Carol Johnston, Sandi Glendenning, GIS World, Inc., Fort Collins, CO, 1995. In press.

The impact of global climate change is difficult to assess at regional and sub-regional scales. This paper examines the utility of a GIS environmental database of California to map potential vegetation change due to climactic change. Ranges of chaparral and yellow pine were correlated with current climate conditions; projections based on two GCM's were then used to examine changes in the range of these species through the GIS. Using the GIS to handle and manipulate data as well as its geographical analysis capabilities proved to be extremely helpful.

15. Fedra, Kurt. "Distributed Models and Embedded GIS: Strategies and Case Studies of Integration." GIS and Environmental Modeling: Progress and Research Issues. Eds. Michael Goodchild, Louis Steyaert, Bradley Parks, Michael Crane, David Maidment, Carol Johnston, Sandi Glendenning, GIS World, Inc., Fort Collins, CO, 1995. In press.

This paper examines methods and case studies of integrating the theoretically close relationship between GIS and environmental modeling. Embedding an object-oriented GIS structure and function within a decision support system is a tightly coupled solution. The paper describes CLIMEX, a global change modeling and assessment system which utilizes this structure.

16. Fedra, Kurt. "GIS and Environmental Modeling. "Environmental Modeling with GIS. Eds. M. F. Goodchild, B. O. Parks, L. T. Steyaert. New York: Oxford Univ. Press, 1993. 35-50.

Trends in GIS towards greater applicability in modeling, visualization, and decision support are discussed. Modeling issues examined in other papers in this volume are noted and placed in context with the roles GIS can play. Various levels of integration, along with examples and an overview of user issues, are covered. Merging GIS and environmental modeling in a fundamentally new way holds promise of creating a system capable of meeting research and policy-making objectives.

17. Fenstermaker, Lynn K. "A Proposed Approach for National and Global Scale Error Assessments." GIS-LIS Proceedings, Atlanta, GA, 1991. 293-300.

The problem of assessing large area remotely sensed imagery is significant for regional and global research. Balancing between data effectiveness and cost is important for researchers. A methodology is proposed and tested to limit errors and use pre-existing maps and data along with ground verification to build a database. This methodology is utilized in constructing a database for the Chesapeake Bay watershed using EMAP data.

18. Frew, James. "The Sequoia 2000 Project." GIS and Environmental Modeling: Progress and Research Issues. Eds. Michael Goodchild, Louis Steyaert, Bradley Parks, Michael Crane, David Maidment, Carol Johnston, Sandi Glendenning, GIS World, Inc., Fort Collins, CO, 1995. In press.

The Sequoia 2000 Project, a collaborative effort between U. C. earth and computer scientists to build a large-scale data management environment, is described. Five computational challenges are targeted: storage, retrieval, analysis, visualization, and remote access. Each of these challenges are reviewed. In particular, the massive size of the data sets presents a problem in each of these areas. Methods by which these areas are handled by Sequoia 2000 are discussed. Finally, application projects ranging from integrating a GCM model to specific data retrieval and interfacing systems are described, including GRASS.

19. Gardels, Kenn. "Sequoia 2000: New Geographic Information Management Technologies for Global Change Research." EGIS '92 Conference Proceedings Munich, 1992. 2: 922-929.

A major limitation of current global change research is the lack of available technology for information management of global data. The Sequoia 2000 Project is planned to overcome this limitation. This paper presents a review of Sequoia 2000. Major spatial data challenges, including storage, management, access and visualization, are addressed. Geographic data management in Sequoia 2000 will employ GIS functionality; the prototype utilizes GRASS and POSTGRES. Several significant research directions concerning database and interface design are indicated.

20. Goodchild, Michael F. "The Issue of Accuracy in Global Databases." Building Databases for Global Science. Eds. Helen Mounsey, Roger Tomlinson. London: Taylor & Francis, 1988. 31-48.

A variety of accuracy and precision issues arise when constructing global databases. This paper defines sources of this error and examines several methods for describing or modeling error in spatial databases. Problems with existing approaches are identified. Identifying the accuracy of data using metadata and incorporating raw data rather than cartographic data will help with the evaluation of accuracy and the elimination of multiple data abstraction. Finally it is noted that global spatial analysis will require spherical analytic techniques.

21. Goodchild, Michael F. "The State of GIS for Environmental Problem-Solving." Environmental Modeling with GIS. Eds. M. F. Goodchild, B. O. Parks, L. T. Steyaert. New York: Oxford Univ. Press, 1993. 8-15.

An introductory overview of the history and development of GIS is presented. The discrete nature of a GIS database results in two basic models, field and object, for the purposes of environmental problem-solving. The utility of both of these models is discussed. The paper presents a variety of challenges of utilizing GIS data models in environmental analysis, examines instances in which GIS can play a significant role in environmental modeling, and details others -- notably analysis -- where it can not..

22. Goodchild, Michael. "Integrating GIS and Environmental Modeling at Global Scales." GIS-LIS Proceedings, Atlanta, GA, 1991. 117-127.

The potential of GIS in global-scale environmental modeling is discussed. An overview of GIS data models and analysis capabilities, along with a summary of the development of the technology, highlights the challenges of integrating GIS with environmental modeling. GIS currently lacks the statistical integration of modern statistical packages and its most effective use in global modeling remains limited to data capture and display. Additionally, GIS's ability to transform data for transferal and analysis in a variety of non-spatial statistical packages is one strength which can make it useful in a loosely coupled modeling environment.

23. Hastings, David. "Global Research Confronts GIS Technology." GIS World 4(9) (1991): 60-68.

This article reviews the challenges of integrating GIS with global change research. In general, GIS lacks modeling techniques in global change research, but spatial functions may complement existing modeling methods. Data quality is one area in which GIS can assist global change modelers, both in compilation, data analysis, and error-checking. Temporal and volumetric concerns are also discussed. Integrating varying functions from different GIS would help with this integration challenge, as would increasing the quantity of GIS-modeling methodologies in the literature.

24. Hastings, David A., John J. Kineman, David M. Clark. (1991) "Development and Application of Global Databases: Considerable Progress, but more Collaboration Needed." International Journal of Geographical Information Systems 5 (1) (1991):. 137-146.

This paper reviews the progress of global databases and application development, including technological and institutional advances, since 1957. Current challenges regarding standards, accuracy, and accessibility, along with collaborative organizational issues, are covered. GIS, image processing and modeling tools are becoming more powerful and less expensive to use. GRASS and Idrisi are two widely available GIS packages with some utility for research.

25. Hastings, David A., Liping Di. "Modeling of Global Change Phenomena With GIS Using the Global Change Data Base. II: Prototype Synthesis of the AVHRR-Based Vegetation Index from Terrestrial Data." Remote Sensing of Environment 49 (1) (1994): 13-24.

This paper discusses an experiment to model a global vegetation index from data sets in the Global Change Data Base; this illustrates a technique to use regional modeling methods on global data in a PC or workstation environment using inexpensive software. The methodology and techniques outlined show that the analysis capabilities of GIS using global data can supplement traditional modeling methods. Modeling error results from a variety of factors, but does not detract from the general methodology advanced.

26. Hastings, David A., Liping Di. "Modeling of Global Change Phenomena With GIS Using the Global Change Data Base. I: Modeling with GIS." Remote Sensing of Environment 49 (1) (1994): 1-12.

GIS' ability to visualize and process spatial information -- even on economical PC or workstation platforms -- can assist scientists in global change research. The authors review the use of regional modeling/GIS methods with the Global Change Database. The paper also provides an example relating remotely sensed VI data with precipitation. Adding analytic functionality to GIS, particularly in data analysis and editing, could make the technology more useful in global change research.

27. Hetrick, William A., Paul M. Rich, Fairley J. Barnes, Stuart B. Weiss. (1993) "GIS-Based Solar Radiation Flux Models." ASPRS Technical Papers, New Orleans, 1993. 3: 132-143.

Solar radiation flux has a major impact on ecosystem structure and function. The authors integrate models of spatial and temporal distribution with an ARC/INFO-based GIS to derive grids of insolation. The GIS, SOLARFLUX, was tested on a theoretical test surface and on data from La Amistad Biosphere Reserve in Costa Rica. GIS technology allows for the spatial calculations of a variety of insolation effects.

28. Honea, R. B. "What's Past is Prologue: Supporting Global Change Research with Historical Data." ASPRS Technical Papers, New Orleans, 1993 2: 125-134.

Much historical data on land use and environmental characteristics is available in the form of aerial photography and satellite remote sensing. This information can be of immense value to evaluate world-wide environmental changes over the past seven decades. The author describes a number of specific data sources and touches on the role of GIS and

image analysis could play in analyzing the data. An experiment to integrate this historical data with GIS/RS analysis is described.

29. Jones, K. Bruce. "The Environmental Monitoring and Assessment Program: An Ecological Monitoring System for the '90s and Beyond." GIS/LIS Proceedings, Anaheim, CA, 1990. 2: 669-681.

Regional environmental data is lacking due to research focus on specific topics and areas without wider, more general perspectives. There is a need for regional scale assessments. The EMAP program, being coordinated by the EPA, will focus on regional scale evaluation. An overview of the program and its structure are provided.

30. Kajiwara, Koji. "Concept of Global GIS "HITIS"." Proceedings, International Workshop on Global GIS. Tokyo: ISPRS, 1993 1: 75-76.

The author briefly describes a global database concept. The paper includes a schematic of the database model.

31. Kelmelis, John. "The U.S. Geological Survey Global Change Research Program." ACSM-ASPRS Technical Papers, Denver, CO, 1990. 4: 218-227.

This paper reviews the interagency organization of the U.S. government (the Committee on Earth Sciences in particular) to research global change issues. Scientific emphases are outlined, as are data management concerns and space and ground-based data collection programs. The USGS' role cuts across all of these issues, and current topical studies are detailed. GIS will be a major tool in the effort to integrate and analyze both global data and model output.

32. Kittel, T. G. F., D. S. Ojima, D. S. Schimel, R. McKeown, J. G. Bromberg, T. H. Painter, N. A. Rosenbloom, W. J. Parton, and F. Giorgi. "Model-GIS Integration and Dataset Development for Assessing the Vulnerability of Terrestrial Ecosystems to Climate Change." GIS and Environmental Modeling: Progress and Research Issues. Eds. Michael Goodchild, Louis Steyaert, Bradley Parks, Michael Crane, David Maidment, Carol Johnston, Sandi Glendenning, GIS World, Inc., Fort Collins, CO, 1995. In press.

Ecosystem response to global change will likely occur within a spatial context; therefore, ecosystem models require geographic tools. This paper evaluates the integration of ecosystem models and GIS with statistical software for managing and evaluating model experiments. Challenges to GIS in this area include data interfacing with model software, handling and storing temporal relationships in data, dealing with data resolution issues and capturing sub-grid variability. A model of the conterminous United States was developed; the methodology for integrating and analyzing data within this spatial model is discussed and analyzed.

33. Lakhtakia, Mercedes N., Douglas A. Miller, Richard A. White, Christopher B. Smith. "GIS as an Integrative Tool in Climate and Hydrology Modeling." GIS and Environmental Modeling: Progress and Research Issues. Eds. Michael Goodchild, Louis Steyaert, Bradley Parks, Michael Crane, David Maidment, Carol Johnston, Sandi Glendenning, GIS World, Inc., Fort Collins, CO, 1995. In press.

GIS is central to the implementation of the SRBEX experiment to link various environmental models to better understand the global water cycle. Spatial data management, data conversion (i.e. vector to raster), and flexibility for meeting multiple requirements, are all key issues for GIS in SRBEX. Data management and browsing systems are being to developed to allow researchers to access data sets, including topographic, land cover, and soils data. The paper reviews three models utilizing this data, and an example of how these models are integrated with each other through GIS.

34. Lee, Jaek, Richard A. Park, Paul W. Mausel, Robert C. Howe. "GIS-Related Modeling of Impacts of Sea-Level Rise on Coastal Areas." GIS-LIS Proceedings, Atlanta, GA, 1991. 356-367.

An integrated GIS-RS system was developed to examine the impact of rising sea level on coastal areas near Jacksonville, Florida. The SLAMM3 model is described along with the procedures and methodology for processing data with the GIS for the modeling simulation.

35. Lee, Tsengdar J., Roger A. Pielke. "GIS and Atmospheric Modeling: A Case Study." GIS and Environmental Modeling: Progress and Research Issues. Eds. Michael Goodchild, Louis Steyaert, Bradley Parks, Michael Crane, David Maidment, Carol Johnston, Sandi Glendenning, GIS World, Inc., Fort Collins, CO, 1995. In press.

This paper reviews methods of using GIS in atmospheric modeling. Some solutions for interpolating measurements at differing elevation to the model grid, handling differing scales (and topographical resolution), and incorporating land cover are covered. GIS techniques are valuable to atmospheric process modeling, and more work is needed to include temporal aspects in GIS analysis.

36. Lillesand, Thomas M, Mark D. MacKenzio, John R. Vande Castle, John J. Magnusen. "Incorporating Remote Sensing and GIS Technology in Long-Term and Large-Scale Ecological Research." GIS-LIS Proceedings, Orlando, FL, 1989. 1: 228-242.

The authors developed a GIS for the Long-Term Ecological Research Program focusing on the North Temperate Lakes site. Merging GIS and remote sensing technologies results in great synergy. No one software package has the capabilities and tools to handle the research. The paper notes additionally that documentation of data quality is essential, and adapting to RS/GIS technology requires changes in the structure through which research is normally conducted.

37. Loveland, Thomas R., Donna K. Scholz. "Global Data Set Development and Data Distribution Activities at the U.S. Geological Survey's EROS Data Center." ASPRS Technical Papers, New Orleans, 1993. 2: 204-211.

The authors discuss current activities by the USGS to develop and supply global data for global environmental change research. This involves developing spatial data sets from satellite (AVHRR and MSS) and earth science (soils, elevation) sources. Some selected U.S. data are available on CD-ROM, as well as historical Landsat data. Digital elevations and soils data will also be available. GLIS is an on-line graphic query system. Other data transmission methods, including via Internet and 8 mm tape are also planned.

38. Malanson, George P., Marc P. Armstrong, David A. Bennett. "Fragmented Forest Response to Climactic Warming and Disturbance." GIS and Environmental Modeling: Progress and Research Issues. Eds. Michael Goodchild, Louis Steyaert, Bradley Parks, Michael Crane, David Maidment, Carol Johnston, Sandi Glendenning, GIS World, Inc., Fort Collins, CO, 1995. In press.

A model, MOSEL, is discussed that uses a raster-based GIS input to assess impact of climactic warming on forest species survival. A number of spatial dispersal functions are examined which may affect the ability of species to migrate under climactic change conditions. GIS aids in this research by providing for visualization and spatial analysis of the impact of the model conditions on spatial distribution of species.

39. Marble, Duane F. "Approaches to the Efficient Design of Spatial Databases at a Global Scale." Building Databases for Global Science. Eds. Helen Mounsey, Roger Tomlinson. London: Taylor & Francis, 1988. 49-65

Global database design is critical to implementation due to the wide range and complexity of the both data and its potential utility. This paper examines some of the issues inherent in spatial database design. Some design pitfalls are

noted as well as some keys to good design. Stages in the design process are discussed, and an example from a large cartographic database design is detailed.

40. Morain, Stanley A., Mark W. Harrington. "A GIS for Predicting Environmentally Induced Changes in the Rocky Mountains." GIS-LIS Proceedings, Anaheim, CA, 1990. 803-813.

A regional, floral diversity-based GIS is important for understanding current spatial patterns of Rocky Mountain flora, especially in light of direct human impact on the region and indirectly through global change factors. The global GIS GRID is discussed, and drawbacks to its regional adaptation are highlighted. Existing data sets are enumerated along with the need for much more coordinated data collection efforts. Finally, emerging technologies which may facilitate the establishment of a Rocky Mountain and North American flora GIS are examined.

41. Mounsey, H. M. "Multisource, Multinational Environmental GIS: Lessons Learnt from CORINE." Geographical Information Systems: Principles and Applications. Eds. D. J. Maguire, M. F. Goodchild, and D. W. Rhind. London: Longman, 1991. 185-200.

The development of a spatial database to serve the needs of multinational environmental modeling and assessment offers special challenges. This paper discusses the development of one such effort, the European Commission's CORINE. Difficulties of identifying and assessing user requirements and data needs within a GIS context are examined, along with implementation of CORINE. Finally, the paper relates issues relating to user access to the databases and accomplishments and future directions of the project.

42. Murakami, Hiroshi. "Global Mapping - Global Geographic Data Set for Global Environment Studies." Proceedings, International Workshop on Global GIS. Tokyo: ISPRS, 1993 1: 8-14.

This paper outlines the significance of collecting global data and explores the history of the effort to produce global data sets. In light of this background, the author reports on the Global Mapping Project in specific conceptual detail, including issues of resolution, data set content, and map and data production as well as institutional issues.

43. Nyerges, Timothy L. "Understanding the Scope of GIS: Its Relationship to Environmental Modeling." Environmental Modeling with GIS. Eds. M. F. Goodchild, B. O. Parks, L. T. Steyaert. New York: Oxford Univ. Press, 1993. 75-93.

Three perspectives for understanding GIS are introduced: the nature of GIS use, the nature of GIS work flow, and the nature of GIS architecture. Each of these perspectives is explored in relation to the state of GIS in general and in relation to functionality with environmental modeling. Concerns regarding the coupling of GIS and modeling are presented, as well as a discussion of the future direction of GIS-modeling integration.

44. Oleson, Lyndon R., Stuart W. Doescher, Thomas M. Holm. "Image Browse in the Global Land Information System." ACSM-ASPRS Technical Papers, Baltimore, MD, 1991. 3: 294-301.

The increasing volume of remotely sensed data is a challenge for data managers and global earth science researchers. GLIS, being developed by the USGS, will serve as an on-line database system using data and metadata derived from AVHRR sensors using graphical data presentation. Users will be able to query for specific data or use a graphic browse feature. Two browse prototypes --single band AVHRR and MSS -- are discussed.

45. Parks, Bradley O. "The Need for Integration." Environmental Modeling with GIS. Eds. M. F. Goodchild, B. O. Parks, L. T. Steyaert. New York: Oxford Univ. Press, 1993. 31-34.

Integrating GIS and environmental modeling is necessary to make environmental choices. The need to move GIS towards analyzing data is important, while data modeling needs to become more accessible to potential users. Integration can make both more robust.

46. Peuquet, Donna J. "Issues Involved in Selecting Appropriate Data Models for Global Databases." Building Databases for Global Science. Eds. Helen Mounsey, Roger Tomlinson. London: Taylor & Francis, 1988. 66-78

Approaches to representation of data in large GIS center on the raster vs. vector debate. This paper examines methods of representing and modeling global data. Both vector and a range of tessellation-type models are evaluated and compared. Due to the complementary nature of vector and raster data models, it is argued that techniques to integrate the two into a dual data model need to be developed.

47. Reek, Thomas and N. Guttman. "Climate Information Products Retrieval System." GIS/LIS Proceedings, Orlando, FL, 1989. 636-645.

This paper discusses a US climate database developed by the authors covering the years from 1895 to the present. It includes a graphical display system designed by the National Climactic Data Center. A wide variety of climactic data is available at different scales.

48. Sadowski, Frank G., Allen H. Watkins. "Development of Land Data Sets for Studies of Global Climate Change." ACSM-ASPRS Technical Papers, Baltimore, MD, 1991. 3: 381-388.

The USGS is developing a global land data and information management system. Goals of this effort include the development and distribution of global land data sets to global change researchers. Several steps are outlined in this paper to accomplish this. First, requirements for global land data must be identified by working with global change researchers. Methods must be implemented for developing satellite data sets (AVHRR and Landsat) and integrating them with related earth science data sets in a time efficient and accurate manner. Finally, methods of integrating, distributing, and facilitating the use of these data sets must be employed. Several possibilities including CD-ROM distribution and software for image display and analysis are discussed.

49. Schimel, David S. and Ingrid C. Burke. "Spatial Interactive Models of Atmosphere-Ecosystem Coupling." Environmental Modeling with GIS. Eds. M. F. Goodchild, B. O. Parks, L. T. Steyaert. New York: Oxford Univ. Press, 1993. 284-289.

Global and regional models analyzing interactions of land-atmosphere coupling have been developed. Three models of this type are described briefly: a global model examining interaction between vegetation and climate, a regional hydrology-ecosystem model, and a biogeochemistry model analyzing global environmental change. GIS support of these or other ecosystem models is limited.

50. Simard, Rejean. "GEOSCOPE: An Interactive Global Change Encyclopedia." ASPRS Technical Papers, New Orleans, 1993. 2: 343-352.

This paper describes GEOSCOPE, a product being prepared on CD-ROM to provide data, remotely sensed images, maps, photographs, and text. Global and regional datasets are listed, along with examples of interactive functions and uses for the available data.

51. Smith, Terence R., Sudhakar Menon, Jeffrey L. Star, John E. Estes. (1987) "Requirements and Principles for the Implementation and Construction of Large-Scale Geographic Information Systems." International Journal of Geographical Information Systems 1 (1) (1987): 13-31.

A brief overview of GIS -- its history, functional structure, data model, display, analysis, and utilization --is laid out and compared with the requirements of large scale GIS. A traditional variety of data models, spatial analytical methods, and data integration are reviewed with an eye towards future development of GIS. It is noted that the rapidly increasing volumes of data will place greater demands on the design of large scale GIS, requiring a more systematic and scientific approach to GIS development.

52. Steyaert, Louis T. "Investigating the Use of Geographic Information Systems Technology in the Computer Workstation Environment for Global Change Research." ACSM-ASPRS Technical Papers, Baltimore, MD, 1989. 4: 46-54.

This paper examines the roles that GIS technology can play in global change research, including database issues, thematic mapping, modeling, and impact assessment. GIS may play a role in large scale interdisciplinary efforts whenever spatial and temporal distribution of data (in particular water and energy) and in general circulation models. This paper discusses a variety of general data types for global GIS and some requirements for complex spatial and temporal analysis. The complex nature of both data and analysis dictates the development of an integrated systems approach utilizing GIS and other analysis tools within a high-speed, multitasking windowed workstation environment.

53. Steyaert, Louis T. "A Perspective on the State of Environmental Simulation Modeling." Environmental Modeling with GIS. Eds. M. F. Goodchild, B. O. Parks, L. T. Steyaert. New York: Oxford Univ. Press, 1993. 16-30.

The importance of using models to assess global environmental problems is discussed. Concepts behind environmental system modeling are reviewed, along with general types of environmental models. Global modeling issues and structures are covered. The temporal aspects of modeling complicate modeling structures and integration.. Linking GIS and environmental process models requires analysis of both database issues and modeling issues.

54. Sturdevant, James, Jeffery Eidenshink, Thomas Loveland. "Organizations Challenged by Global Database Development." GIS World 4(9) (1991): 73-79.

Problems associated with developing global high resolution data sets and interpreting the data to construct global land covers are complex and difficult. This article discusses the development of the 1990 conterminous US AVHRR data set to produce a vegetation index. The methodology for this effort is outlined along with requirements for developing a global land AVHRR data set with utility for global change researchers.

55. Tateshei, Ryutaro. "Global Databases/GIS for Global Environmental Research." Proceedings, International Workshop on Global GIS . Tokyo: ISPRS, 1993. 1: 1-7.

Several stages of global change research are outlined with an emphasis on GIS applicability. Several existing physical and social global databases are listed. Problems with existing global databases include projection and accuracy issues, including a lack of metadata. Requirements for a successful global database are identified, and the paper includes a conceptual example of a schema incorporating these requirements.

56. Townshend, J. R. G. "Environmental Databases and GIS." Geographical Information Systems: Principles and Applications. Eds. D. J. Maguire, M. F. Goodchild, and D. W. Rhind. London: Longman, 1991. 201-216.

Environmental data sets can be divided into four main areas: earth science data, marine data, terrestrial ecological data, and atmospheric data. These environmental data have in common their great variability. A variety of challenges to linking environmental databases are discussed, as well as improving accessibility to them. The paper also examines several case studies of applications of GIS technology in the environmental sciences. Finally, the paper notes that, while integrating environmental databases to GIS is difficult and expensive, more information handling and distribution is crucial to utilize environmental data.

57. Wanger, Len, Zahid Ahmed, Peter Kochevar. "Intelligent Browsing of Earth Science data in the Sequoia 2000 Project." GIS and Environmental Modeling: Progress and Research Issues. Eds. Michael Goodchild, Louis Steyaert, Bradley Parks, Michael Crane, David Maidment, Carol Johnston, Sandi Glendenning, GIS World, Inc., Fort Collins, CO, 1995. In press.

This paper outlines a data visualization system called Tioga being developed as part of the Sequoia 2000 Project. Due to the nature of the heterogeneous data worked with in earth science, an intelligent system is employed to automatically arrive at a proper visualization method based on the metadata for each data set. To enable interactive visualization, data are treated as objects that can be analyzed by the user in a graphic interface. Several examples illustrate some current visualization abilities of Tioga.

58. Wheeler, D. J. "A Look at Model Building with Geographic Information Systems." GIS-LIS Proceedings, San Antonio, TX, 1988. 580-589.

This paper provides an introduction to modeling by defining basic components, functions, and structures. Methods in which a GIS can be used in the modeling process are analyzed with references to specific examples. Finally, some problems with modeling, including oversimplification, incorrect variables, and the subjectivity of weighting variables are discussed.

59. Wheeler, Douglas J. "Commentary: Linking Environmental Models with Geographic Information Systems for Global Change Research." Photogrammetric Engineering & Remote Sensing 59 (10) (1993): 1497-1501.

The paper reviews a variety of issues relevant to linking environmental process models with GIS technology. Several integration projects are underway, but it's noted that that the design and complexity of GIS does not currently include effective tools for handling temporal data and performing internal process modeling. Obstacles to integration are included in three categories: data sources and formats, GIS functionality, and modeling methods. Suggestions for improving the functional relationship between GIS and global process modeling in both the long and short term are proposed.

60. Wynne, Randolph H., Thomas M. Lillesand. "Satellite Remote Sensing of Limnological Indicators of Global Change." ACSM-ASPRS Technical Papers, Baltimore, MD, 1991. 3: 496-505.

This paper discusses using seasonal trends in lake ice to monitor global change. Satellite data are integrated with meteorological and lake surface measurements in a GIS for this research. GIS may be a key to handling the increasing amount of data from different sources, but it must be able to handle this data at a variety of spatial and temporal scales.