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SEI+II Information Integration Through Events

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Final Report for Period: 10/2009 - 09/2010
Principal Investigator: Beard-Tisdale, Mary-Kate .
Organization: University of Maine
Submitted By:
 Beard-Tisdale, Mary-Kate - Principal Investigator
Title:
 SEI+II Information Integration through Events

Submitted on: 12/30/2010
Award ID: 0429644

Project Participants

Senior Personnel

Name: Beard-Tisdale, Mary-Kate
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Stefanidis, Anthony
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Pettigrew, Neal
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Worboys, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Name: Elston, Susan
Worked for more than 160 Hours: Yes
Contribution to Project:

Dr Susan Elston started on the project in January as a post doctoral associate. Her responsibilities to the project include data analysis and preparation of research papers. She is supported full time on the project.

Graduate Student

Name: Deese, Heather
Worked for more than 160 Hours: Yes
Contribution to Project:

Heather is a PhD student in oceanography hired as a research assistant for this project. She is a physical oceanographer and is working on developing both an ontology of primitive time series events as well as the broader ontology for oceanographic events

Name: Vijayasankaran, Nagafakshmy
Worked for more than 160 Hours: Yes
Contribution to Project:

Naga has been hired as a research assistant on the project. She is responsible for the event extraction from time series imagery

Name: Jiang, Jixiang
Worked for more than 160 Hours: Yes
Contribution to Project:

Jixiang started the project in September 2005 and is supported full time on the project as a research assistant.

Name: Emerson, Raymond

Worked for more than 160 Hours: Yes

Contribution to Project:

Developed time series database, revised events database,

Name: Rude, Avinash

Worked for more than 160 Hours: Yes

Contribution to Project:

Developed algorithms for event detection

Name: Devine, Jon

Worked for more than 160 Hours: Yes

Contribution to Project:

This student has been working as a graduate research assistant on methods for event extraction from scalar data fields using Support vector machines.

Undergraduate Student

Name: Green, Blaine

Worked for more than 160 Hours: Yes

Contribution to Project:

Blaine has been hired as an undergraduate assistant. He is responsible for software development on the event explorer

Name: Saraf, Parang

Worked for more than 160 Hours: Yes

Contribution to Project:

Parang Saraf is a summer intern undergraduate student supported on this project and responsible for the web accessible events database

Name: Gross, Alexander

Worked for more than 160 Hours: Yes

Contribution to Project:

Alex Gross has been hired part time as a programmer for the Event Viewer

Name: Semich, Karl

Worked for more than 160 Hours: Yes

Contribution to Project:

Developed eventviewer

Name: Belanger, Joshua

Worked for more than 160 Hours: Yes

Contribution to Project:

Josh has been a member of the undergraduate team working on software development for the Eventviewer

Technician, Programmer

Name: Frank, Chris

Worked for more than 160 Hours: Yes

Contribution to Project:

Chris Frank was hired as a full time programmer - database developer for the project

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Antony Galton
School of Engineering, Computer Science and Mathematics
University of Exeter

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

- ? Evaluation and formal specification of changes in topological properties of events.
- ? Identification of important features necessary for classifying topological change.
- ? Design of distributed algorithms for capturing and classifying topological change using real-time detection.
- ? Development of support vector methods for high-level event extraction from point data and scalar fields.
- ? Development of code for identifying multiple types of events (threshold events, max/min, first difference events) over multiple temporal granularities (hourly, daily, seasonal events), from sensor based time series.
- ? Analysis of associations between events observed at different sensor locations and across different input data streams (e.g. salinity, temperature, and wind events)
- ? Automated event categorization according to likely underlying physical processes (based on hydrographic event signatures)
- ? Development of an approach for composite event specification from primitive events demonstrated using meteorological data from the Gulf of Maine to identify storms based on primitive events obtained from time series.
- ? Development of a metadata specification for primitive events
- ? Development of a GoMOOS events database
- ? Development of the Eventviewer prototype for viewing and exploring events from the database.
- ? Collaboration with undergraduate students in New Media to design the Eventviewer. A paper coauthored with undergrad students was submitted to GEOWS 2009: The International Conference on Advanced Geographic Information Systems & Web Services. The undergraduates on the project presented their work at the on-campus undergraduate research exposition in May 2010

Presentations, Workshops, and Conferences

- ? Jixiang, Jiang. 2006. Specifying Events by Changes in Topological Properties. Presentation at Geographic Information Science-Fourth International Conference GIScience 2006, Germany, September, 2006.
- ? H. E. Deese and S. A. Elston Attended Gulf of Maine CAF? Workshop III, Portland, ME, November 2006 (CAF?: Climate-based Assessment and Forecasting for Ecosystems).
- ? S. A. Elston, K. Beard-Tisdale, and N. R. Pettigrew, Atmosphere/Ocean Event Detection and Characterization Using data from the Gulf of Maine Observing Network.' Presentation: American Geophysical Union Fall Meeting, San Francisco, CA, December 2006
- ? H. E. Deese, M. K. Beard-Tisdale, and N. R. Pettigrew entitled 'Event Oriented Analysis of Ocean Observing System Data ? Insights into Annual and Interannual Change in the Gulf of Maine' Presentation: American Geophysical Union Fall Meeting, San Francisco, CA, December 2006.
- ? K. Beard. Exploratory Environment for Events. IGERT seminar, SUNY Buffalo, Buffalo, NY. March 2, 2007. Invited Presentation.
- ? J. Jiang, Exploring locally basic topological changes during evolution of areal objects. Presentation at Atlantic Institute Graduate Research Forum. June, 2007
- ? Deese, H.E. 'Seasons and weather in the ocean', COMPASS Ecosystem-Based Management communication training workshop for early-career scientists, Portsmouth, NH, December 12-14, 2007.
- ? Deese, H.E. , K. Beard, N.R. Pettigrew, 'An Event Based Approach for Ocean Observing Data: A case study on Stratification processes in the Gulf of Maine'. Ocean Sciences. Orlando, Florida, 2-7 March, 2008.
- ? Beard, K. 2008. Exploring Events From Sensor Networks. IGERT Symposium. University of Illinois-Chicago, Chicago, IL. April 21, 2008. Invited Presentation.
- ? H.E. Deese, 'Salinity and temperature contributions to stratification in the Gulf of Maine: seasonal and interannual patterns and causes', School of Marine Sciences annual symposium, University of Maine, Walpole, ME, May 12-13, 2008.
- ? Devine J, Support Vector Machines for Event Extraction in Geosensor Networks, Atlantic Institute Research Colloquium, May 2008. Quebec City, Quebec, CA.
- ? Devine J. and A. Stefanidis, Support Vector Machines for Spatiotemporal Analysis in Geosensor Networks, Spatial Data Handling '08, June 2008. Montpellier, France.

- ? Deese, H.E., N.R. Pettigrew, K. Beard, 'Seasonal and Interannual Variability in Stratification in the Gulf of Maine: Salinity and Temperature Contributions and Climatic Forcing'. American Geophysical Union. December 2008.
- ? J. Jiang, 'Preliminaries for topological change detection using sensor networks', GSN 2009: paper presentation.
- ? H. Deese, 'The role salinity plays in stratification in the Gulf of Maine and the influence of inflowing Scotian Shelf Water on salinity', University of Maine School of Marine Science Graduate Symposium. May 2009.
- ? Emerson J. 2009. Spatiotemporal Events: Identity Assignment and Instance Selection Presentation for IGERT Summer Institute, University of Maine, Orono, ME June 8-9 2009.
- ? Beard, K. 2009. Visualizing and Exploring Events from Sensor Networks. Workshop on Human Environment and Mobile-Based Interactions. MIT Cambridge MA. September 15-16, 2009.
- ? Emerson J. 2010. Spatiotemporal Events: Identity Assignment and Instance Selection Presentation for IGERT Summer Institute, University of Maine, Orono, ME June 10 2010.
- ? Beard, K. 2010. Visualization of Events from Sensor Networks. University of Arkansas, Little Rock, AK. October 22, 2010. Invited Presentation.

Findings: (See PDF version submitted by PI at the end of the report)

Findings:

Informatics findings:

Identified a complete set of primitive topological changes in which evolving area objects can participate and proved an important property of topological change, namely that any topological change can be formed as an ordered composition of primitive topological changes. The primitive topological changes include: appear, disappear, merge, split, and no change. The results can be applied to the implementation of a sensor network monitoring system, which is able to track dynamic geospatial phenomena and form qualitative reports describing the evolution of a phenomena in terms of topological changes. With the formal model, primitive types of topological changes can be incorporated into query languages which makes possible the formation of queries on dynamic topological properties of phenomena. For example such queries might include: retrieve information on appearance of warm water gyres in the Gulf of Maine, and if they merged with other gyres.

Support vector clustering and support vector machines can be adapted to provide objective methods for obtaining the spatial boundaries of high-level events from space-time fields (e. g the clouds of points that might constitute a disease cluster or regions exceeding thresholds in scalar field data.

Primitive events represent states of observed variables and indirectly partial states of complex multivariate processes. Primitive events form useful building blocks to specify complex high level events and they provide effective temporal abstractions for classification of high level events as demonstrated in a classification of storms from their constituent primitive events.

The conceptual framework of the Eventviewer provides a new modular information display paradigm that allows visualization of spatial, thematic, and temporal patterns within the same framework. The Eventviewer has application as a graphic front end for On-Line Analysis and Processing (OLAP) and SOLAP systems as well as a graphic display tool for events extracted from sensor networks. The EventViewer has application for a wide range of domain areas including crime analysis (paper submitted for Association of American Geographers Conference 2011), and health care diagnostics and analysis (paper in preparation).

Oceanographic findings:

Through objective identification of event periods, we are able to compare event characteristics (duration, magnitude), across variables, locations, seasons, and years. The event-oriented analysis complimented standard time series analysis and supported detailed investigation of the temporal evolution of hydrographic variations. The event based approach led to a number of new scientific results regarding: the arrival and advection of freshwater pulses through the Gulf of Maine from both river and oceanic sources; the timing and character of seasonal density stratification events in spring and fall (which are critically important for biological events including the spring and fall phytoplankton blooms and Harmful Algal Bloom 'red tide' events); and the spatio-temporal nature of a major interannual negative salinity anomaly that occurred during 2004-2006 and the likely causes of this anomaly. Results provided insights into the strength and number of change events that contribute to variability at different locations and time-scales. Similar events identified at neighboring locations provided evidence of both large-scale processes that affect broad areas of the gulf of Maine and advection of hydrographic features between observation sites.

Training and Development:

Graduate research assistants and undergraduate students were involved in all research team meetings and functioned as active participants in the

research process. The participating students gave formal reports on their research progress to the faculty PIs at regularly scheduled meetings. The graduate students made several oral presentations of their work at professional conferences and workshops.

Student presentations:

Jixiang, Jiang. 2006. Specifying Events by Changes in Topological Properties. Presentation at Geographic Information Science-Fourth International Conference GIScience 2006, Germany, September, 2006.

? H.E. Deese, 'Seasons and weather in the ocean', COMPASS Ecosystem-Based Management communication training workshop for early-career scientists, Portsmouth, NH, December 12-14, 2007

? J. Jixiang, Detecting and Classifying Topological Changes in Sensor Networks. University of Maine Graduate Expo. April 15, 2008.

? H.E. Deese, 'Salinity and temperature contributions to stratification in the Gulf of Maine: seasonal and interannual patterns and causes', School of Marine Sciences Annual Symposium, University of Maine, Walpole, ME, May 12-13, 2008

? Devine J, Support Vector Machines for Event Extraction in Geosensor Networks, Atlantic Institute Research Colloquium, May 2008. Quebec City, Quebec, CA.

? Devine J. and A. Stefanidis, Support Vector Machines for Spatiotemporal Analysis in Geosensor Networks, Spatial Data Handling '08, June 2008. Montpellier, France.

H. Deese, 'The role salinity plays in stratification in the Gulf of Maine and the influence of inflowing Scotian Shelf Water on salinity', University of Maine School of Marine Science Graduate Symposium. May 2009.

Emerson J. 2009. Spatiotemporal Events: Identity Assignment and Instance Selection Presentation for IGERT Summer Institute, University of Maine June 8-9 2009.

Heather E. Deese successfully completed her doctoral degree in May 2010. Thesis title: Salinity and Stratification in the Gulf of Maine 2001-2009.

Jixiang Jiang: Completed doctoral degree: May 2009 Thesis title: Specifying and detecting topological changes to areal objects

Jon Devine: Completed masters degree. May 2009. Title : 'Support Vector Methods for Higher-Level Event Extraction in Point Data.'

Avinash Rude: expected Masters Degree May 2011. Title: Temporal Data Abstraction and Classification from Space Time series

Outreach Activities:

The project post doc, graduate students and faculty attended several meetings and workshops and presented to various groups over the course of the project research (summarized in activity report). The event approach we are taking is novel to many of these groups and has been well received.

Journal Publications

Beard, K., Deese, H., Pettigrew, N.R., "A framework for visualization and exploration of events.", Information Visualization, p. 133, vol. 7, (2008). Published,

Jiang, J. and Worboys, M., "Event-based topology for dynamic planar areal objects.", International Journal of Geographic Information Science, p. , vol. , (2008). Submitted,

Beard, K. Emerson, J. Deese, H.E. Rude, A. Scott, M. and Pettigrew, N.R., "Use of the EventViewer for visualizing and exploring events extracted from Ocean Observing System Data", Marine Technology Journal, p. , vol. , (2011). Accepted,

J. Jiang, M.F. Worboys and S. Nittel, "Qualitative change detection using sensor networks based on connectivity information", Geoinformatics, p. 1, vol. 1384-61, (2009). Published, 10.1007/s10707-009-0097-0

Books or Other One-time Publications

Beard, K., "Modeling Change in Space and Time: An Event Based Approach", (2007). Book, Published

Editor(s): J. Drummond, R. Billen, E. Joao, D. Forrest

Collection: Dynamic and Mobile GIS

Bibliography: CRC Press, ISBN 0-8493-9092-3

J. Jiang and Worboys, M.F., "Specifying Events by Changes in Topological Properties (Extended Abstract)", (2006). Book, Published

Editor(s): M. Raubal, H. Miller, A. Frank, and M. Goodchild, Eds.

Collection: Proceedings Geographic Information Science-Fourth International Conference GIScience 2006,

Bibliography: Geographic Information Science - Fourth International Conference, GIScience 2006, Mⁿster, Germany. Lecture Notes in Computer Science 4197. Springer, Berlin.

Deese, H. E., Beard-Tisdale, M. K., and Pettigrew, N. R., "Event Oriented Analysis of Ocean Observing System Data ? Insights into Annual and Interannual Change in the Gulf of Maine", (2006). Book, Published

Collection: EOS Transactions AGU, 87(52)

Bibliography: EOS Trans. AGU, 87(52), Fall Meeting Suppl., Abstract IN43B-0910, AGU 2006, San Francisco, CA.

Elston, S. A., Beard-Tisdale, M. K., and Pettigrew, N. R., "Event Exploration and Characterization using data from the Gulf of Maine Observing Network.", (2007). Book, Published

Bibliography: Estuarine Research Federation 2007 International Conference

Elston, S. A., Pettigrew, N. R., and Beard-Tisdale, M. K., "Weather Events and Harmful Algal Blooms in the Gulf of Maine", (2007). Book, Published

Bibliography: The Fourth Symposium on Harmful Algae in the U.S. submitted abstract, Woods Hole, MA.

Elston, S. A., Pettigrew, N. R., and Beard-Tisdale, M. K., "An Updated Tidal Climatology for the Gulf of Maine using assimilated data from the GoMOOS Network", (2007). Book, Published

Bibliography: The 88th Annual Meeting of the American Meteorological Society. submitted abstract, New Orleans, LA.

J. Devine & A. Stefanidis, "Support Vector Machines for Spatiotemporal Analysis in Geosensor Networks", (2008). Conference Proceedings, Published

Editor(s): A. Ruas & C. Gold

Collection: Proceedings, Spatial Data Handling '08

Bibliography: Montpellier, pp. 197-216.

A. Croitoru, K. Eickhorst, A. Stefanidis, and P. Agouris,, "Spatiotemporal Event Detection and Analysis over Multiple Granularities", (2006). Conference Proceedings, Published

Editor(s): A. Riedl, W. Kainz & G. Elmes

Collection: Spatial Data Handling 2006

Bibliography: Springer Verlag, pp. 229-245

Jiang, J. and Worboys, M., "Detecting Basic Topological Changes in Sensor Networks by Local Aggregation", (2008). Conference Proceedings, Accepted

Collection: Proceedings, International Conference on Advances in Geographic Information Systems (ACM GIS 2008)

Bibliography: 16th ACM SIGSPATIAL

Stell, J. and Worboys, M.F., "A Theory of Change for Attributed Spatial Entities.", (2008). Book, Published

Editor(s): T.J. Cova, H. J. Miller, K. Beard, (Editor), A. U. Frank, M. Goodchild

Collection: Proceedings, International Conference on Geographic Information Science (GIScience 2008)

Bibliography: Lecture Notes in Computer Science. Utah, USA, 2008. 308-319.

Farah, C., Zhong, C., Worboys, M., and Nittel, S., "Detecting Topological Change Using a Wireless Sensor Network.", (2008). Book, Published

Editor(s): T.J. Cova, H. J. Miller, K. Beard, (Editor), A. U. Frank, M. Goodchild

Collection: Proceedings, International Conference on Geographic Information Science (GIScience)

Bibliography: Lecture Notes in Computer Science Utah, USA, September 23-26. 2008. pp. 55-69.

S. Nittel, A. Labrinidis and A. Stefanidis, "Advances in GeoSensor Networks", (2008). Book, Published

Editor(s): S. Nittel, A. Labrinidis and A. Stefanidis

Collection: Advances in GeoSensor Networks

Bibliography: Lecture Notes in Computer Science, Springer, Vol. 4540 (272 pages).

P. Agouris, D. Gunopulos, V. Kalogeraki, & A. Stefanidis,, "Knowledge Acquisition and Data Storage in Mobile Geosensor Networks," (2008). Book, Published

Editor(s): S. Nittel, A. Labrinidis, & A. Stefanidis

Collection: Advances in GeoSensor Networks

Bibliography: Lecture Notes in Computer Science, Vol. 4540, Springer Verlag, pp. 86-108.

A. Croitoru, K. Eickhorst, A. Stefanidis & P. Agouris, "Spatiotemporal Event Detection and Analysis over Multiple Granularities", (2006). Book, Published

Editor(s): A. Riedl, W. Kainz & G. Elmes

Collection: Spatial Data Handling 2006

Bibliography: Spatial Data Handling, Springer Verlag, pp. 229-245.

N.R. Pettigrew, C.S. Roessler, F.Neville, H.E. Deese., "An Operational Real-Time Ocean Sensor Network in the Gulf of Maine", (2006). Book, Published

Editor(s): S. Nittel, A. Labrinidis, A. Stefanidis

Collection: Proceedings Geosensor Networks

Bibliography: Springer-Verlag. Boston, USA, October 1-3, 2006

J. Devine & A. Stefanidis, "A Support Vector Clustering Based Approach for Spatiotemporal Analysis in Security Informatics", (2008). Book, Published

Collection: In Security Informatics, Int. Archives of Photogrammetry & Remote Sensing

Bibliography: Int. Archives of Photogrammetry & Remote Sensing Vol. 37, Part B4, Beijing, pp.1-5.

Heather Deese Riordan, "Salinity and stratification in the gulf of maine: 2001-2008", (2009). Thesis, Published

Bibliography: Deese-Riordan, H. PhD Thesis (Ph.D.) in Oceanography. University of Maine, 2009 pp. 194.

Jixiang Jiang, "Specifying and detecting topological changes to an areal object", (2009). Thesis, Published

Bibliography: Jixiang Jiang, Specifying and detecting topological changes to an areal object. Thesis (Ph.D.) in Spatial Information Science and Engineering. University of Maine, 2009. pp. 156.

Jon Devine, "Support Vector Methods for Higher-Level Event Extraction in Point Data", (2009). Thesis, Published

Bibliography: Jon Devine. Support Vector Methods for Higher-Level Event Extraction in Point Data. Thesis (M.S.) in Spatial Information Science and Engineering-University of Maine, 2009. pp.116.

Web/Internet Site

URL(s):

http://www.spatial.maine.edu/~beard/Event_integration_project.htm

<http://eventviewer.asap.um.maine.edu/evviewer3/#>

Description:

The first URL presents a project overview.

The second site provides a link to the prototype eventviewer,an interface for viewing and exploring event patterns. The NSF acknowledgement has not yet been added to this page as it is still in a testing phase.

Other Specific Products

Product Type:

Software (or netware)**Product Description:**

An event viewer is being developed as a user friendly front end to view events from the events database

Sharing Information:

The Eventviewer will be accessible from the web

Product Type:**Data or databases****Product Description:**

The UMaine SEI+II research group has developed the Event PostgreSQL database integrated with a PostGIS spatial database to temporally and spatially catalog near real-time data from the Gulf of Maine Ocean Observing System (GoMOOS) buoy network. The schema for the Event database was designed and developed for data from the GoMOOS buoy network and has been extended to accommodate open-source data from additional US and Canadian governmental agencies. To date, the database accommodates data from the following sources ? the GoMOOS buoy network, the National Data Buoy Center (NDBC) buoy and C-MAN station network, Environment Canada Marine Environmental Data Service (MEDS) data network, Environment Canada climate and surface water data network, Fisheries and Oceans Canada ? Ocean and Ecosystem Science Division data network, the NOAA National Ocean Service (NOS) water level/tide data network, the Environment Canada Air Quality Division, the Maine DEP Bureau of Air Quality, the Maine Geological Survey data network on earthquakes and cryoseisms, and data from the National Climatic Data Center (NCDC) storm events database. As of June 26, 2007, the Event database contains events from four realms (Atmospheric, Oceanic, Terrestrial, and Atmospheric/Oceanic), eleven different Event Categories (e.g., air quality events, GoMOOS events, NCDC events, storm events, and harmful algal bloom (HAB) events), over 75 different Event Groups (e.g., ozone events, particulate matter events, wind events, tide events, and earthquakes), and 694,717 individually determined events, which include but are not limited to coastal flood events, winter weather events, non-storm (high pressure) events, extreme water level events, growing, heating, and cooling degree day events.

Sharing Information:

The event database is still under development but can be accessed currently at:<http://eventviewer.asap.um.maine.edu/phpPgAdmin>

A user-friendly web interface for searching the Event database is underdevelopment with expected deployment fall 2007

Product Type:**Software (or netware)****Product Description:**

The Eventviewer is a graphical user interface for exploring spatial, temporal, and thematic patterns in events. The Eventviewer allows users to simultaneously visualize and explore the three dimensions of space, theme, and time through the assignment of spatial, temporal, and thematic categories to a set of graphic elements called event bands, stacks, and panels. The spatial, temporal, and thematic categories are functionally similar to the concept hierarchies of multidimensional databases as they identify aggregation pathways for events. The interface was designed to explore events extracted from the GoMOOS ocean observing sensor system but can be generalized to other domains and contexts.

Sharing Information:

The eventviewer is web accessible at: <http://tok.asap.um.maine.edu/eviewer4/#>.

Contributions**Contributions within Discipline:**

The conceptual framework of the Eventviewer provides a new information display paradigm that allows visualization of spatial, thematic, and temporal patterns within the same framework. The Eventviewer has particular application as a graphic front end for OLAP and SOLAP systems as well as for displaying data from sensor networks that has been transformed to events.

A primitive event ontology provides a new shareable description and characterization for events extracted from sensor networks.

Contributions to Other Disciplines:

The Eventviewer has value as an information visualization tool for a range of disciplines. Oceanographers in the School of Marine Science are using it to explore a range of physical oceanographic processes and events. We are in the process of extending functionality to work with

epidemiological events under the Maine Cancer GIS project with Maine Institute for Human Genetics and Health, as a tool for the analysis of crime events, and as a tool for visualization of events associated with emergency response.

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Our event database is the start of a comprehensive database of oceanographic and atmospheric events that will be a resource for other oceanographic scientists, and teachers and students generally.

Contributions Beyond Science and Engineering:

Conference Proceedings

Categories for which nothing is reported:

Organizational Partners

Contributions: To Any Human Resource Development

Contributions: To Any Beyond Science and Engineering

Any Conference

Summary of key findings

A. Findings on: Systematic evaluation and formal specification of changes in topological properties of events

Applying the concepts of the event-oriented model, changes are treated as objects, and form classes of changes with common properties. The topological properties of dynamic areal objects we call topological changes. Key findings are:

1. *Topological changes in continuous evolution can be represented and classified using a tree model.*

The topological properties between the regions and holes in an areal object can be represented by a tree. The topological changes of the areal objects can be represented by tree morphisms between the representation trees before and after the change. Four basic classes of topological changes, namely insert, delete, split and merge, can be identified according to the types of the tree morphisms. The composition of the four basic changes in a particular sequence can form all the topological changes.

2. *The 2-tree model can represent richer topological properties and help specify and distinguish more classes of topological changes.*

A combination of two trees can be employed to represent richer topological properties. In addition to the topological properties represented in (1), the two-tree representation allows us to distinguish weakly and strongly connectedness. More types of topological changes can be specified according to the types of the morphisms between the corresponding trees before and after the change.

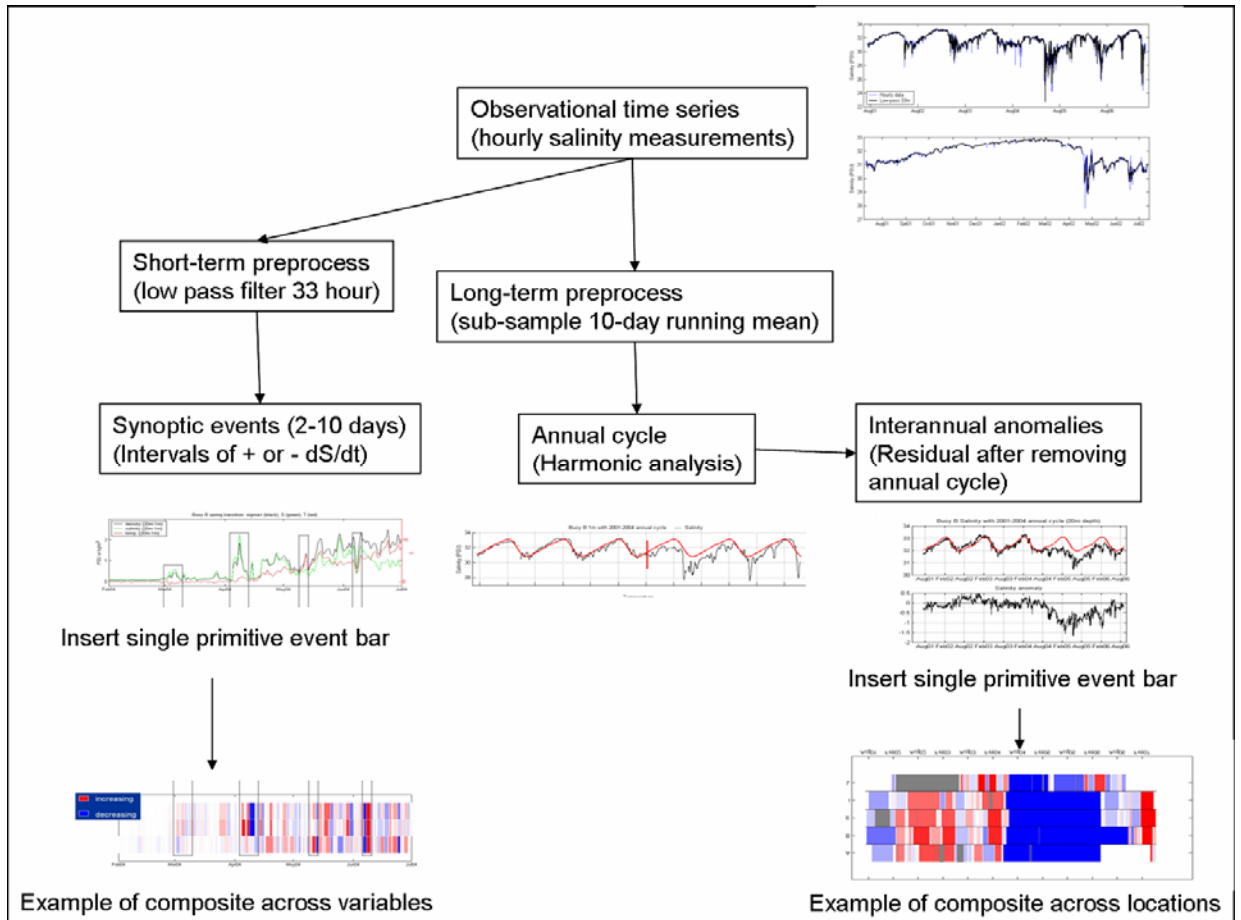
B. Findings on: specification and extraction of oceanographic and atmospheric events from time series

Events are evidence of physical processes acting at various time scales. Events are extracted from observational time series as change sequences with common properties.

Key findings:

1. *Event extraction is most dependent on variable and temporal granularity.*

There is no one size fits all event extraction method. Characteristics of an observed variable over different time intervals dictate different event extraction methods. For example for variables with an annual cycle we use harmonic analysis to extract the annual scale (max, min) events. Interannual anomalies (residuals after removing annual cycle) may be considered another set of events or further processed to extract synoptic scale (2-10 day) events (see Figure below).



2. *Processes of interest (events to be captured) are not self similar at different temporal scales.*

Wavelets analysis has been applied in a number of domains to segment time series at different scales but assumes self similarity across scales. For our purposes wavelets may be part of a suite of event detection methods but are not a complete solution.

C. Findings on: the connection(s) between changes in and among atmospheric, oceanic, and combined atmospheric/oceanic properties in the Gulf of Maine (GoM) domain are still preliminary. Hypotheses about relationships between different types of physical events and between physical and biological events are emerging as we build the database of events.

The major research activities of the UMaine SEI+II research group have been several fold. The central activities this year have been: 1). Systematic evaluation and formal specification of changes in topological properties of events, 2) exploration, classification, and investigation of the connection(s) between changes in and among atmospheric, oceanic, and combined atmospheric/oceanic properties in the Gulf of Maine (GoM) domain. 3. specification and extraction of oceanographic and atmospheric events from GoMOOS and several additional open source databases, 4) design, development and implementation of an open-source spatially-enabled database for event viewing and exploration, 5) development of a user friendly web application for event viewing

SEI+II Workshops, Conference Attendance, & Presentations (reverse chronology):

PASI course on Contemporary Issues in Estuarine Physics, Transport, and Water Quality, August 2007
(*PASI: Pan-American Advanced Studies Institutes Program*)

Attendance and participation by S. A. Elston. [Course website: <http://pasi.coastal.ufl.edu>]

J. Jiang, Exploring locally basic topological changes during evolution of areal objects. Presentation at *Atlantic Institute Graduate Research Forum*. June, 2007.

Beard, K. Framework for exploration of events. Invited presentation for IGERT Symposium. Buffalo, NY March 2, 2007.

American Geophysical Union Fall Meeting, San Francisco, CA, December 2006

Poster presentation (and attendance) by H. E. Deese, M. K. Beard-Tisdale, and N. R. Pettigrew entitled “Event Oriented Analysis of Ocean Observing System Data – Insights into Annual and Interannual Change in the Gulf of Maine.” [PDF]

Poster presentation by S. A. Elston, M. K. Beard-Tisdale, and N. R. Pettigrew entitled “Atmosphere/Ocean Event Detection and Characterization Using data from the Gulf of Maine Observing Network.” [PDF]

Gulf of Maine CAFÉ Workshop III, Portland, ME, November 2006

(*CAFÉ: Climate-based Assessment and Forecasting for Ecosystems*)

Attendance and participation by H. E. Deese and S. A. Elston

Biological & Technological Research for Offshore Aquaculture, Portsmouth, NH, November 2006

Attendance by H. E. Deese

Jixiang, Jiang. 2006. Specifying Events by Changes in Topological Properties. Presentation at *Geographic Information Science-Fourth International Conference GIScience 2006, Germany*, September, 2006.