
Monitoring Change to Know the Earth

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“Today’s generation needs to prove that it can meet the challenges of the 21st century.”

German Chancellor Angela Merkel, 3 November 2009

“Rather than collection itself, change detection and interpretation will become the norm.”

CEO Kevin O’Connell, Innovative Analytics, 19 October 2009

The challenges are many, and it will be a tall order for decision makers writ large to deal with the pace and impact of forthcoming change. According to Global Trends 2025 by the National Intelligence Council, “The international system...will become almost unrecognizable by 2025 owing to the rise of emerging powers, a globalizing economy, an historic transfer of wealth and economic power from West to East, and the growing influence of nonstate actors”. Specifically,

- Resource issues will gain prominence on the international agenda.
- Demand for food will rise by 50 percent by 2030.
- Climate change is expected to exacerbate scarcities.

What about solutions? According to Global Trends, “new technologies could again provide solutions.” But, “the pace of technological innovation will be key.” The number and variety of earth observing sensors, for example, is increasing. Innovative ways are required to portray to analysts what is changing as captured by instruments with various spatial and spectral imaging capabilities. Ten years ago, former Vice President Al Gore used declassified black and white satellite images to point out that “our intelligence and scientific communities are advancing vital research that will help us understand critical challenges”. Major advances in space-based sensors have occurred in the fifty years since the first successful CORONA mission in August 1960, and future capabilities hold even more promise, such as Germany’s EnMAP hyper-spectral imager with over 200 imaging channels able to collect data relevant to changes forecast in Global Trends.

More collection for its own sake, of course, is not the answer. Analysis of data from earth observation instruments to extract and compare data from new and previous observations is crucial. Single observations seldom provide all the answers. Assessing the meaning of the differences, separating significant from irrelevant data, integrating the findings into an analytic context, and judging their significance is core to advancing knowledge. Automating this work would ease the analytic burden, but according to ***Photogrammetric Engineering and Remote Sensing*** in an August 2009 special issue on change analysis, “Currently there is no automated system to detect and map the changes to a satisfied quality as expected by a skilled analyst.”

Fast, automatic aids to analysis are vital, especially aids that cope with comparative data registration errors, take into account illumination differences from various observations, allow for tracking of changes on consistent spatio-temporal maps, and reduce analytic uncertainty.

- The University of Maryland’s Global Land Cover Facility (GLCF) focuses its work on global land cover and land cover change. According to their website, “Determining where, when, how much and why change occurs with land cover is a crucial scientific concern.” They say that “It is imperative that appropriate tools be made available to better manage and adapt to change.”
- The United States Global Change Research Program also places effort in this area, noting that the program is to help to “understand, assess, and predict global change.”

Change detection using remote sensing data is the process of identifying and assessing temporal, spatial, and spectral changes in the pixel signal captured by the sensor. While the use of two images may be the means to identify change, the use of multiple images is required to characterize the rate and dynamics of change. For this reason, the challenge in algorithm design is to create and use automated (unsupervised) approaches that can process inputs from multiple sources, and provide meaningful output on what has changed.

- Companies such as Observera, Inc., for example, have a Change Detection Server that has been tested successfully with 20 different sensor / platforms. According to Observera’s website, the Change Detection Application (CDA) is designed to easily allow an analyst to compare a recent image with a previous one. What is not clear is whether it can work with multiple images and output dynamic changes.
- Companies such as Sanborn – Total Geospatial Solutions, claim to have “pioneered the development of remotely sensed change detection methods”, and “completed change detection projects covering millions of acres throughout the world.”

- According to various sources, the German satellite known as TerraSAR-X has been used to monitor changes in the number of vehicles in parking lots, changes along borders that could increase the awareness of border guards, changes to the surface caused by vehicles or grading, and subsidence caused by subsurface activity.
- Monitoring of dynamic, temporal phenomena is increasingly possible due to the combined use of multiple satellites, according to presentations at the September 2008 “International Summer School on Very High Resolution Remote Sensing” in France.

Many programs and techniques in remote sensing that focus on the environment also have security applications relevant to Global Trends challenges. For this reason, an Intelligence Community effort is needed to document and fully utilize these techniques.

- MDA Federal, Inc., for example, uses a technique called Cross Correlation Analysis (CCA) for updating land cover information. The company’s website notes that inverse CCA, or automated updating of the change area, theoretically reduces the human subjectivity in labeling the change areas.
- As of 2006, according to *Geoscience and Remote Sensing*, feature-level change detection algorithms, vice pixel-level, were in the preliminary design stage. Remote sensing education and tool development have advanced quickly, however. Fall Semester 2009 projects, for example, at the School of Polytechnique in Lausanne, Switzerland include change detection and tool development.
- In 2003, according to a study at Wuhan University in China published in *Geospatial Information Science*, the “currency” of geospatial data is the key factor in GIS development. The authors noted that “the digital battle status and battle damage effects need accurate, fast change detection techniques”.

United States space policy is to “Enable a dynamic, globally competitive domestic commercial space sector in order to promote innovation, strengthen U.S. leadership, and protect national, homeland, and economic security.” Innovation in the use of large-scale change data from earth observation satellites is important to know the Earth.

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