Solutions Network Formulation Report

Visible/Infrared Imager/Radiometer Suite and Landsat Data Continuity Mission Simulated Data Products for the Great Lakes Basin Ecological Team

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1. Candidate Solution Constituents

a. Title: Visible/Infrared Imager/Radiometer Suite and Landsat Data Continuity Mission Simulated Data Products for the Great Lakes Basin Ecological Team

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c. Identified Partners: USGS (U.S. Geological Survey) and USFWS (U.S. Fish and Wildlife Service)

d. Specific DST/DSS: USGS and USFWS – GLBET (Great Lakes Basin Ecological Team) DST

e. Alignment with National Application: Coastal Management, Public Health, and Water Management

f. NASA Research Results – Table 1:

Missions	Sensors/Models	Data Product
LDCM (Landsat Data Continuity Mission)	ETM+ type	ETM+ 30 m VNIR (visible near-infrared) bands, Pan 15 m
NPP (NPOESS (National Polar Orbiting Environmental Sensor Suite) Preparatory Project)	VIIRS (Visible/Infrared Imager/Radiometer Suite)	Ocean Color (e.g., Turbidity)

g. Benefit to Society: Monitor Great Lakes water quality, longshore sediment transport, and pollution discharge mapping.

2. Abstract

The proposed solution would simulate VIIRS and LDCM sensor data for use in the USGS/USFWS GLBET DST. The VIIRS sensor possesses a spectral range that provides water-penetrating bands that could be used to assess water clarity on a regional spatial scale. The LDCM sensor possesses suitable spectral bands in a range of wavelengths that could be used to map water quality at finer spatial scales relative to VIIRS. Water quality, alongshore sediment transport and pollutant discharge tracking into the Great Lakes system are targeted as the primary products to be developed.

A principal benefit of water quality monitoring via satellite imagery is its economy compared to field-data collection methods. Additionally, higher resolution satellite imagery provides a baseline dataset(s) against which later imagery can be overlaid in GIS-based DST programs. Further, information derived from higher resolution satellite imagery can be used to address public concerns and to confirm environmental compliance. The candidate solution supports the Public Health, Coastal Management, and Water Management National Applications.

3. Detailed Description of Candidate Solution

a. Purpose/Scope

The Great Lakes region composes the largest body of fresh water in the world, holding about 20 percent of the world's fresh surface water (Rabe and Zimmerman, 1992). It drains 288,000 square miles and covers 95,000 square miles with 9,000 miles of shoreline, 5,000 tributaries, 300,000 acres of wetlands, and over 35,000 islands (Quinn, 1988). The shoreline of the Great Lakes is longer than the U.S. East Coast and the Gulf Coast combined. Forty million people live near or are impacted by the Great Lakes watershed.

Several problems currently plague Great Lakes waters: 1) water quality issues, 2) invasive species, 3) toxic pollutants, and 4) habitat loss (Williams, 1992; Allan and Ball, 1990). The Great Lakes GIS/DST working group has realized a strategic plan for using geospatial data in a GIS-based DST. Initially, the working group focused on Lake Michigan and developed a Lake Michigan Islands Pilot DST built by the USGS for the USFWS. A GIS/DST first used on the Upper Mississippi River served as the model for the USFWS Great Lakes DST creation. The tool was produced based upon commercially available Environmental Systems Research Institute (ESRI) GIS software. Connections between GLBET and the Great Lakes Information Network have been put in place for ready information exchange.

This candidate solution will concentrate on detecting, monitoring, and producing maps of water quality, sediment transport, and point pollution source outfalls in the Great Lakes. However, other areas impacted by water quality related issues could be considered, such as adjacent wetland areas and salient catchment basins (Caldwell, 1987; Donahue, 1987). The suggested solution would aid in the tracking of sediments that can directly affect public health due to the entrainment of pollutants as part of longshore currents (Ross et al., 1992). The candidate solution aligns with the Public Health, Coastal Management, and Water Management National Applications. The USGS and the USFWS GLBET DST would both benefit from the inclusion of VIIRS and LDCM imagery as part of the data layers presented to potential users of the DST.

b. Identified Partners

The Great Lakes water quality agreement between Canada and the United States was first formulated in 1972 and was amended in 1978 and 1987. This agreement expresses the commitment of each country to restore and maintain the chemical, physical, and biological integrity of the Great Lakes Basin Ecosystem (Donahue, 1986; Allee and Dworsky, 1990). The agreement includes a number of objectives and guidelines to achieve these goals. Thus, two federal governments, eight states, and two provinces share the basin, and hundreds of governmental entities are charged with some aspect of the resource management task. The primary U.S. Federal entities associated with this candidate solution are the USGS and the USFWS.

Ecological stressors, such as agricultural sources of erosion and pesticide/fertilizer runoff, complicate the water quality state of the Great Lakes (Richards and Baker, 1993). Also, urban runoff in the form of combined sewer flows and impervious surfaces further stress the Great Lakes environment (Vallentyne and Beeton, 1988). As an example, the Genessee River enters into Lake Ontario and must be monitored continually for various contaminant levels. The concentrations of lead, mercury, cadmium, arsenic, DDT and metabolites, dieldrin, alpha-BHC, lindane, mirex, toxaphene, benzopyrene, dioxins and furans, Hexachlorobenezene, Hexachlorobutadiene, and Polychlorinated biphenyls are found in Great Lakes water, sediments, invertebrates, fish, wildlife, and humans (Bicknell, 1992). Dangers posed by these pollutants are recognized widely (Strachan, 1988).

The GLBET GIS-based DST provides access to data needed for decision-making (USFWS, 2004). The system includes the following features: 1) spatial data viewing, 2) map export, 3) table export, 4) length and area measurement tools, 5) feature and table queries, 6) metadata viewer, 7) links to Great Lakes information documents, 8) feature labeling and identification, and 9) links to textual summary documents. Embedded within the GLBET DST is the Great Lakes Islands DSS (USFWS, 2004). The Great Lakes Islands DSS aids managers in dealing with various questions regarding islands in the Great Lakes (e.g., land acquisition, environmental assessments, and resource planning) and it provides an important tool for public outreach efforts.

The GLBET DST would benefit from the use of VNIR and TIR (thermal infrared) band image data for mapping Great Lakes waters, islands, and shoreline areas for use as base map overlays. VIIRS and the LDCM simulated imagery would be shown to provide relevant data layers for use in the GLBET DST.

c. NASA Earth-science Research Results

The National Oceanic and Atmospheric Administration CoastWatch program for the Great Lakes has previously provided remote sensing derived products for resource managers and policy makers. Imagery involving surface water temperature was derived from the Advanced Very High Resolution Radiometer (AVHRR) satellite (Schwab et al., 1992). Subsequent analysis has shown acceptable correlation of satellite-derived temperatures and field-collected water temperature measurements from both boats and buoys. Additionally, other remotely sensed products of sediment movements, water quality – and, if desired, seasonal movement of thermal bars and ice mapping – are products that might be generated as GLBET DST data layers.

The instruments of choice for supplying Great Lakes imagery to the USGS and USFWS DST are VIIRS and LDCM (a joint mission by NASA and the USGS). The NPP to be launched in about 2011 will have the VIIRS onboard. The NPP satellite will be placed at an altitude of 824 km in a sun-synchronous orbit with 1030 local equator crossing time. Through the follow-on NPOESS program, VIIRS data will be a primary source of systematic remote sensing imagery until about 2022 (Yu and Privette, 2005).

VIIRS possesses 22 spectral bands, including 16 moderate-resolution (750-m pixels) and 5 imagery resolution (375-m pixels) bands, plus 1 panchromatic band. The central wavelengths of the VIIRS TIR bands (10.8 and 12.0 m) are used for water temperature retrievals and are similar to those of the MODIS (Moderate Resolution Imaging Spectroradiometer) (11.0 and 12.0 m) and AVHRR (10.8 and 12.0 m). It possesses spectral band passes that are appropriate for lake water penetration.

The objective of the LDCM mission is a continuation of the Landsat family of sensors mission. The LDCM is scheduled to launch in the 2011 timeframe. It will collect imagery from an 838 km altitude, sun-synchronous orbit, revisiting with a period of 101 minutes. The data archived will be consistent with data and applications from the previous Landsat satellites. The deployment of LDCM will fill an expected gap of Landsat data. Landsat 5 and Landsat 7 are operational, fulfilling their missions—but Landsat 5 is 22 years old. Landsat 7, launched in 1999, has lost the use of its Scan Line Corrector and gyro backup.

LDCM data would be acquired in 30 m multispectral VNIR bands and the higher resolution 15-m pan imagery. These products are delivered in an HDF or GeoTIFF format. The higher resolution pan images can be used to sharpen the multispectral data to achieve higher spatial resolution for better mapping fidelity. These images can be processed to highlight sediment movements, varying water quality, and pollution outfalls (Bauer et al., 2001).

d. Proposed Configuration's Measurements and Models

Satellite data has proven itself valuable for observing water quality parameters, waterborne sediment movements, and environmental impacts of point and non-point contamination sources (Bauer et al., 2001; Olmanson et al., 2000). Using the VIIRS sensor, thermal imagery and basin-resolution, water-quality imagery would be collected. Moreover, higher spatial resolution satellite imagery provided by LDCM would be used to refine water quality and sediment transport maps. Since the candidate DST operates from a database that searches and fetches data layers, processed sensor image layers should be easily accommodated with little or no difficulty.

4. Programmatic and Societal Benefits

A straightforward societal benefit exists in the form of protecting public health and welfare from waterborne pollutants and their associated hazards. Moreover, environmental concerns show that the impact of water quality and sediment movements on the local fish and wildlife can be quite dramatic (Johnson, 1984). Moreover, benthic faunal communities can be adversely affected by persistent exposure to contaminated sediments (Napela, 1991).

Further, an economic advantage accrues in using satellite imagery to monitor water quality related issues. For instance, VIIRS sensor imaging provides synoptic views of water quality at basin scales without absorbing the costs of field collection teams and equipment. Satellite imagery is often used to provide a baseline for various agencies so that resource managers can plan, evaluate, and perform environmental recovery operations. Information resulting from spaceborne imagery can also be used to evaluate environmental compliance.

5. References

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