A General Framework and System Prototypes for the Self-Adaptive Earth Predictive Systems (SEPS)

—Dynamically Coupling Sensor Web with Earth System Models

PI: Dr. Liping Di[1], Co-I: Dr. James Smith[2] and Dr. David Lary[3]

1. Center for Spatial Information Science and Systems, George Mason University, 6301 Ivy Ln, Suite #620, Greenbelt, MD 20770
2. NASA Goddard Space Flight Center, Greenbelt, MD 20771
3. Goddard Earth Science and Technology Center, University of Maryland at Baltimore County, Baltimore, MD 21228

Abstract

This project has been building up a framework to adaptively infuse live sensor observations and archive data into geospatial models. Several key technologies have been developed: (1) Standard BPEL workflow and engine to glue and re-use standard geospatial data and Web services; (2) asynchronous support to enable message notification and data pushing when time-demanding processes are required; (3) interoperation to RESTful resources to share data and services across Web implementation paradigms; (4) interoperation to ESMF to bridge earth science models and earth observations through state exchange. All these make easy integration of geospatial data, services, and resources. Two live demonstrations have showed the efficiency and advantages of the framework. Re-usability, scalability, interoperability, and variability of SEPS were demonstrated. SEPS will be further refined and verified with more scientific scenarios.

Objectives

Scientists from GMU, NASA GSFC, and UMBC work collaboratively

(1)to develop a general Self-Adaptive Earth Predictive Systems (SEPS) framework
- a) coupling between ESMs and EO,
- b) following open, consensus-based standards;

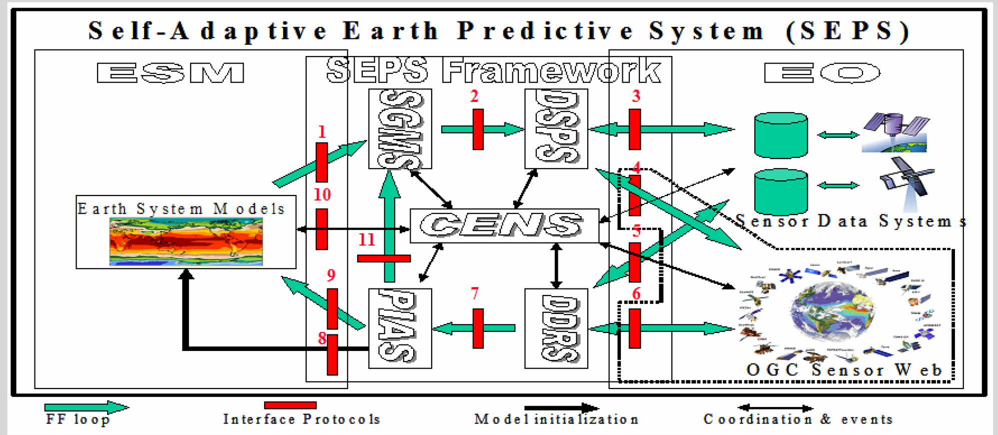
(2)to implement and deploy the framework
- a) plug in diverse sensors and data systems,
- b) demonstrate the plug-in-EO-and-play capability;

(3)to prototype two application scenarios
- a) Bird-Migration-Model-to-aid-avian-influenza-prediction SEPS
- b) AutoChem atmospheric chemistry composition SEPS

Methods and Architecture

Five sub-systems of Web services in the SEPS:
- -SGMS (science goal monitoring services)
- -DDRS (data discovery and retrieval services)
- -PIAS (pre-processing, integration, and assimilation services)
- -DSPS (data and sensor planning services)
- -CENS (coordination and event notification services).

Core technologies:
- -Open standards and specifications (ISO/TC211, OGC, ESMF, OASIS, W3C)
- -Instant plug-in models and sensors
- -Service oriented architecture
- -Standard BPEL workflow to chain services
- -Synchronous and asynchronous message notification mechanism
- -Virtual product technology to exchange states with ESMF
- -Virtual resource technology to interoperate with RESTful services
- -Feedback and Feed-forward loop to actively direct sensors

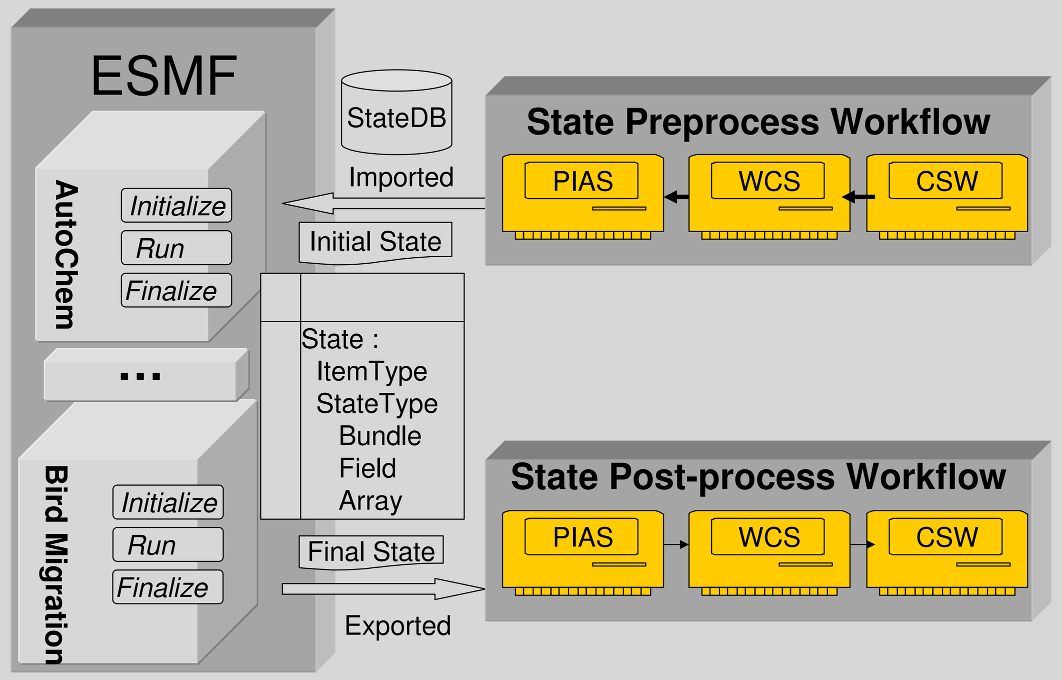


1. FTP, HTTP, WCS-T, WFS-T	5. OpenDAP, WCS, WFS	9. WCS, WFS
2. SPS	6. SOS	10. WNS
3. THREDS, ECHO, CSW	7. CSW, WFS, WCS	11. WCS, WFS
4. SPS	8. ESM state	

Interoperations between EO Web Services and ESM Models through State Exchange

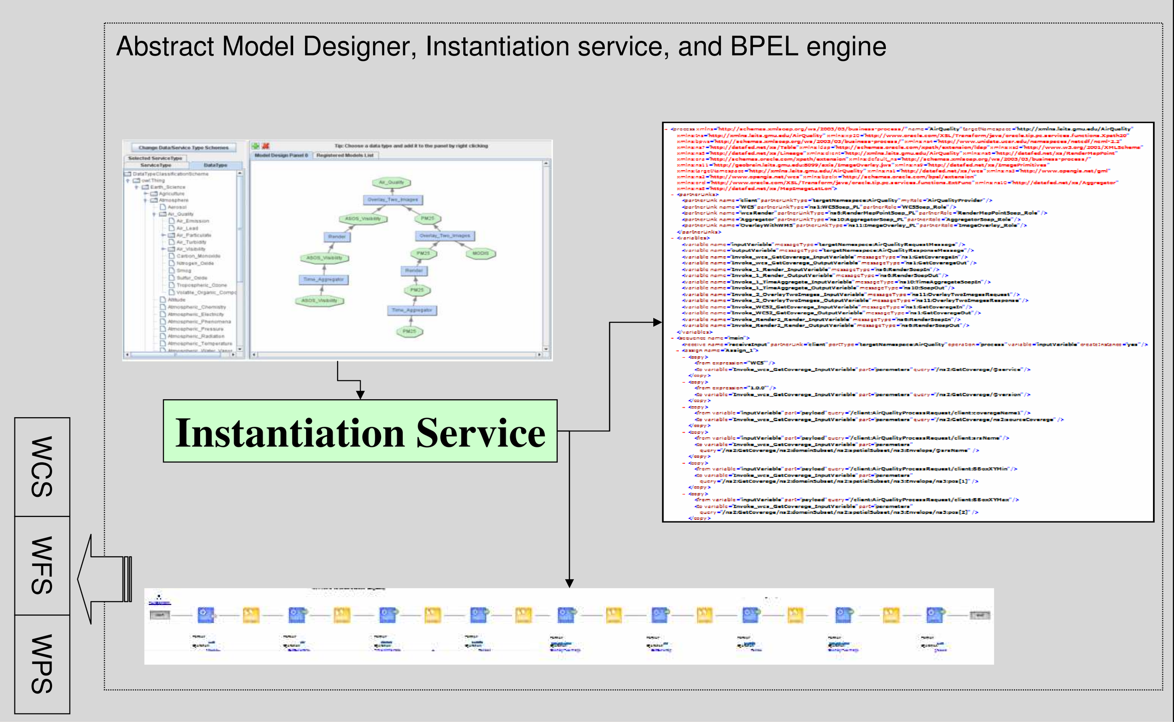
Virtual state exchange technology

- -Connect SOA and ESMF
- -Bridge EO and ESM
- -Virtual pre-processing workflow to create Import state
- -Virtual post-processing workflow to consume Export state



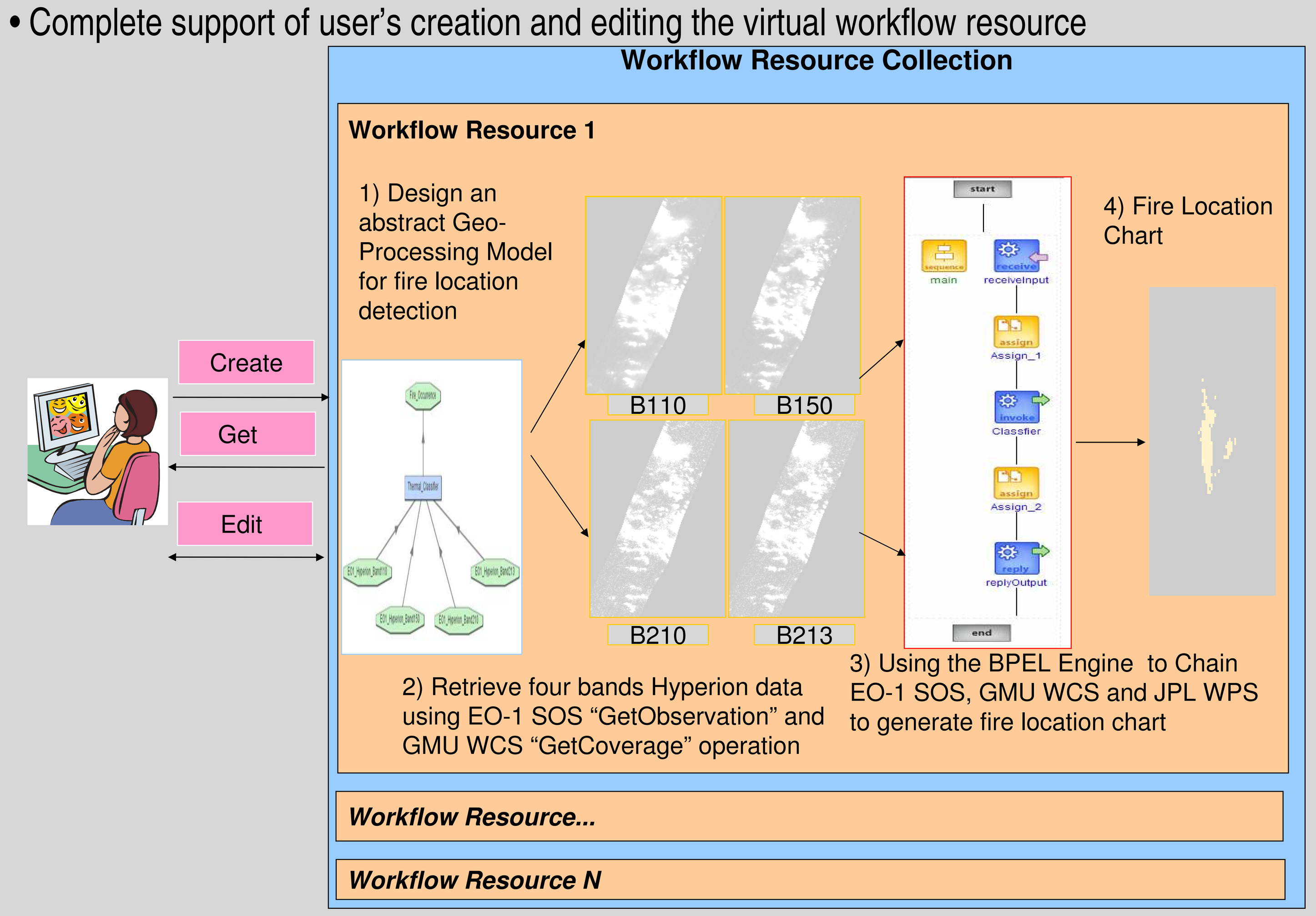
BPEL Engine and Abstract Model Designer

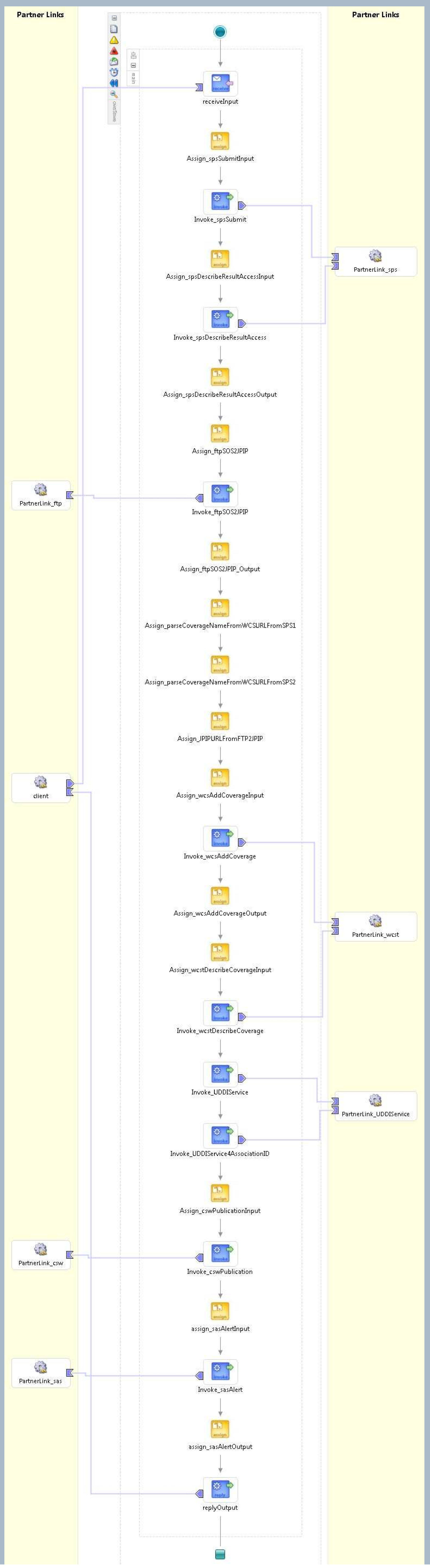
Virtual product technology
- -Standard workflow engine
- -Abstract model designer
- -Instantiation service
- -On-demand processing
- -Standard interfaces
  - -WFS
  - -WCS
  - -WPS.



Demonstration 1 – wild land fire detection workflow

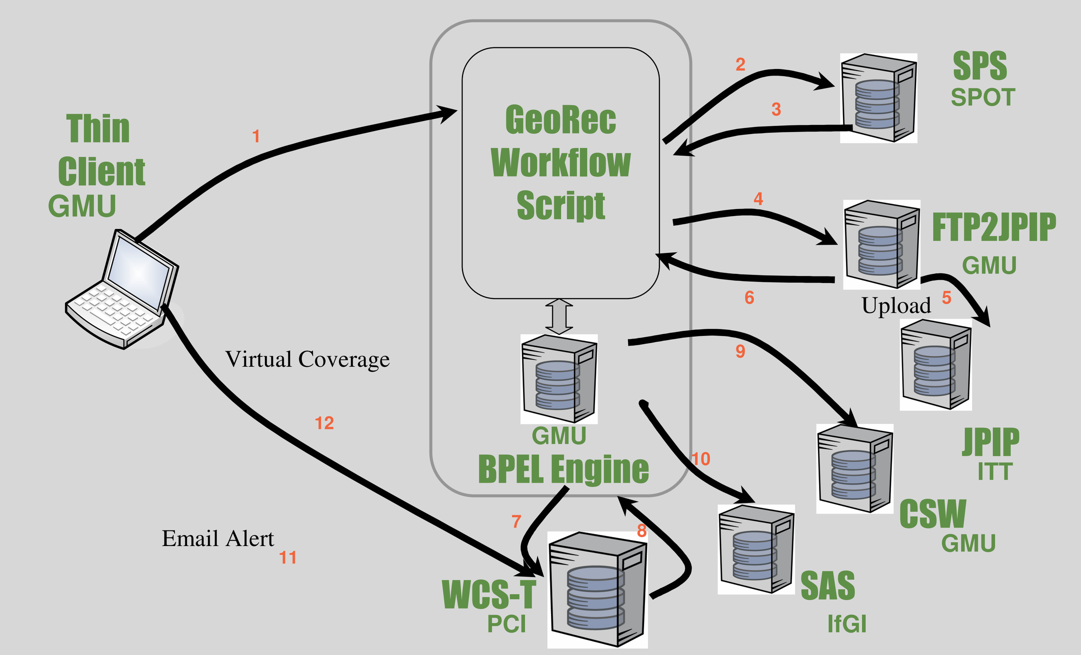
- OWS-5 collaborative effort among the AIST-supported projects
- Interoperation between RESTful web services/workflows and SOA geospatial web services/workflow
- Heavy usage of SEPS components (BPELPower BPEL execution engine, Virtual product designer, Catalogue services, WCS/WFS)
- Innovative connections between SOAP/UDDI SOA services and WfXML/ATOM ROA resources
- Complete support of user's creation and editing the virtual workflow resource





Demonstration 2 – geo-referencing workflow

- •OWS-5 international collaboration on live Sensor Web Enablement
- Standard geospatial services worldwide
- Workflow steps
  - Query of feasibilities from SPS (SPOTImage, France)
  - Acquisition request sumission through SPS (SPOTImage)
  - Asynchronous receive the notification through WS-Addressing
  - *DescribeResult* request to retrieve the data access URL
  - Data is retrieved through SPOTImage SOS and fed into JPIP server at ITT
  - JPIP virtual coverage was submitted to the WCS-T at PCIGeomatics, Canada
  - WCS coverage is further registered into the catalogue system at the CSISS of GMU
  - Alert the availability of new data and product to all registered and subscribed users through SAS at IfGI, Germany
- All the processes are automatic.



Conclusions

Wide interoperability, re-usability, scalability, and dynamic data/service capability were achieved through a service-oriented SEPS framework. SEPS bridges many worlds: (1) ESMF and OGC geospatial Web services; (2) RESTful resources and Web services; and (3) synchronous processes and asynchronous services. Two real world demonstrations in an international collaborative setting showed the advantages of SEPS. More scenarios are to be studied.

References

Bai, Y., L. Di, et al. (2007). "Towards a geospatial catalogue federation service." *Photogrammetric Engineering & Remote Sensing* 73(6): 699-708.

Di, L., Zhao, P., Yang, W. and Yue, P., 2006. Ontology-driven Automatic Geospatial-Processing Modeling based on Web-service Chaining, *Sixth Annual NASA Earth Science Technology Conference*, College Park, MD, USA, pp. 7.

ISO/TC211, 2008. *Publised standards and reports*, URL: http://www.iso.org/iso/standards_development/technical_committees/list_of_iso_technical_committees.htm

Lemmens, R., Foerster, T. and Köbben, B., 2007. Hands-on experience on OGC Web Processing Services using 52north web processing framework, Test-bed for geospatial web service interoperability, Aalborg, Denmark.

OASIS, 2008. *OASIS standards*, URL: http://www.oasis-open.org/specs/index.php

OGC, 2008. *OpenGIS® Standards and Specifications*, URL: http://www.opengeospatial.org/standards

Olsen, L.M. et al., 2007. *NASA/Global Change Master Directory (GCMD) Earth Science Keywords*. Version 6.0.0.0.0

Smith, J.A. and Deppe, J.L., 2007. Simulating Bird Migration using Satellites and Biophysics, *The Third IASTED International Conference on Environmental Modeling and Simulation*, EMS 2007, Honolulu, Hawaii, USA.

Acknowledgements

This research is funded by NASA AIST Program. The project award number is AIST-05-0064. All collaborative providers of geospatial services and data are acknowledged, including EO-1 team, SPOTImage (France), GeoBliki, ITT, NASA GSFC, JPL, IfGI (Germany), and PCI (Canada). Project team include Dr. Genong (Eugene) Yu (implementation leader), Dr. Nengcheng Chen, Ms. Min Min, Ms. Huilin Wang. Contributions were also from Dr. Peisheng Zhao, Dr. Yaxing Wei, Dr. Peichuan Li, and Dr. Yuqi Bai.