Sensor Web Enablement (SWE) Intro and V2.0 Directions

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What is SWE?

- SWE is technology to *enable* the realization of Sensor Webs
  - much like TCP/IP, HTML, and HTTPD enabled the WWW
- SWE is a suite of standards from OGC (Open Geospatial Consortium)
  - 3 standard XML encodings (SensorML, O&M, SWE Common)
  - 4 standard web service interfaces (SOS, SAS, SPS, WNS)
- SWE is a Service Oriented Architecture (SOA) approach
- SWE is an open, consensus-based set of standards

Sensors are Everywhere

Why SWE?

- Break down current stovepipes

- Enable interoperability not only *within* communities but *between* traditionally disparate communities
  - **different sensor types:** in-situ vs remote sensors, video, models, CBRNE
  - **different disciplines:** science, defense, intelligence, emergency management, utilities, etc.
  - **different sciences:** ocean, atmosphere, land, bio, target recognition, signal processing, etc.
  - **different agencies:** government, commercial, private, Joe Public

- Leverage benefits of open standards
  - competitive tool development
  - more abundant data sources
  - utilize efforts funded by others

- Backed by the Open Geospatial Consortium process
  - 380+ members cooperating in consensus process
  - Interoperability Process testing
  - CITE compliance testing

What are the benefits of SWE?

- Sensor system agnostic - Virtually any sensor or modeling system can be supported
- Net-Centric, SOA-based
  - Distributed architecture allows independent development of services but enables on-the-fly connectivity between resources
- Semantically tied
  - Relies on online dictionaries and ontologies for semantics
  - Key to interoperability
- Traceability
  - observation lineage
  - quality of measurement support
- Implementation flexibility
  - wrap existing capabilities and sensors
  - implement services and processing where it makes sense (e.g. near sensors, closer to user, or in-between)
  - scalable from single, simple sensor to large sensor collections

Basic Vision

- Quickly discover sensors and sensor data (secure or public) that can meet my needs – based on location, observables, quality, ability to task, etc.
- Obtain sensor information in a standard encoding that is understandable by my software and enables assessment and processing without a-priori knowledge
- Readily access sensor observations in a common manner, and in a form specific to my needs
- Task sensors, when possible, to meet my specific needs
- Subscribe to and receive alerts when a sensor measures a particular phenomenon

SWE Specifications

- Information Models and Schema
  - **SWE Common –** common data models used throughout SWE specs
  - **Sensor Model Language (SensorML) for In-situ and Remote Sensors** - Core models and schema for observation processes: support for sensor components and systems, geolocation, response models, post measurement processing
  - **Observations and Measurements (O&M)** – Core models and schema for observations; archived and streaming

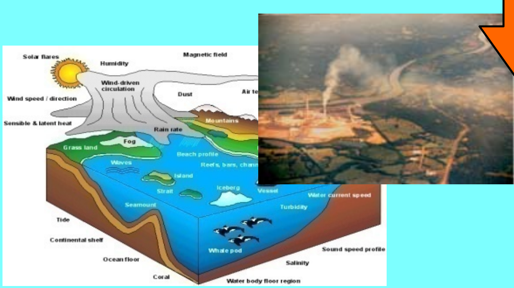
- Web Services
  - **Sensor Observation Service** - Access Observations for a sensor or sensor constellation, and optionally, the associated sensor and platform data
  - **Sensor Alert Service** – Subscribe to alerts based upon sensor observations
  - **Sensor Planning Service** – Request collection feasibility and task sensor system for desired observations
  - **Web Notification Service** – Manage message dialogue between client and Web service(s) for long duration (asynchronous) processes
  - **Registries for Sensors** (ebRIM)– Discover sensors and sensor observations

Sensor Web Enablement Framework

Heterogeneous sensor network

- sparse
- disparate
- mobile/in-situ
- extensible

Models and Simulation



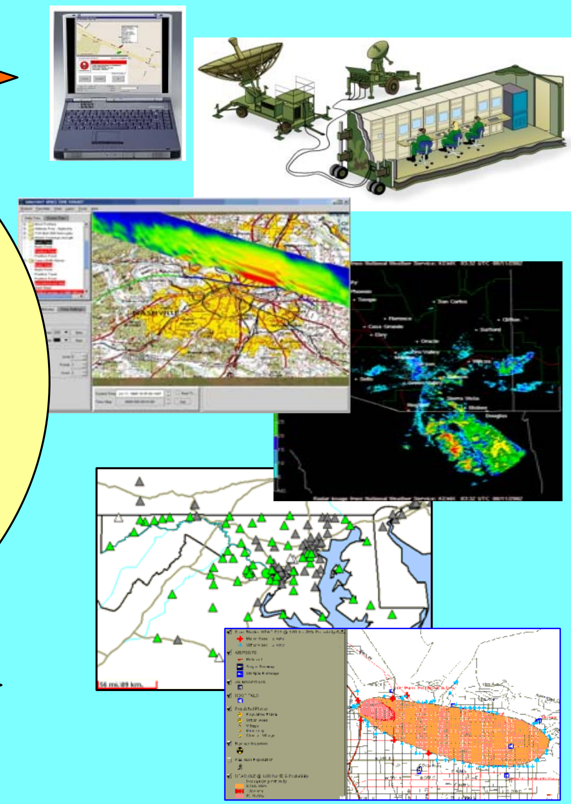
- nested
- national, regional, urban
- adaptable
- data assimilation

Sensor Web Enablement

- discovery
- access
- tasking
- alert notification

web services and encodings based on Open Standards (OGC, ISO, OASIS, IEEE)

Decision Support Tools



- vendor neutral
- extensive
- flexible
- adaptable

Why is SensorML Important?

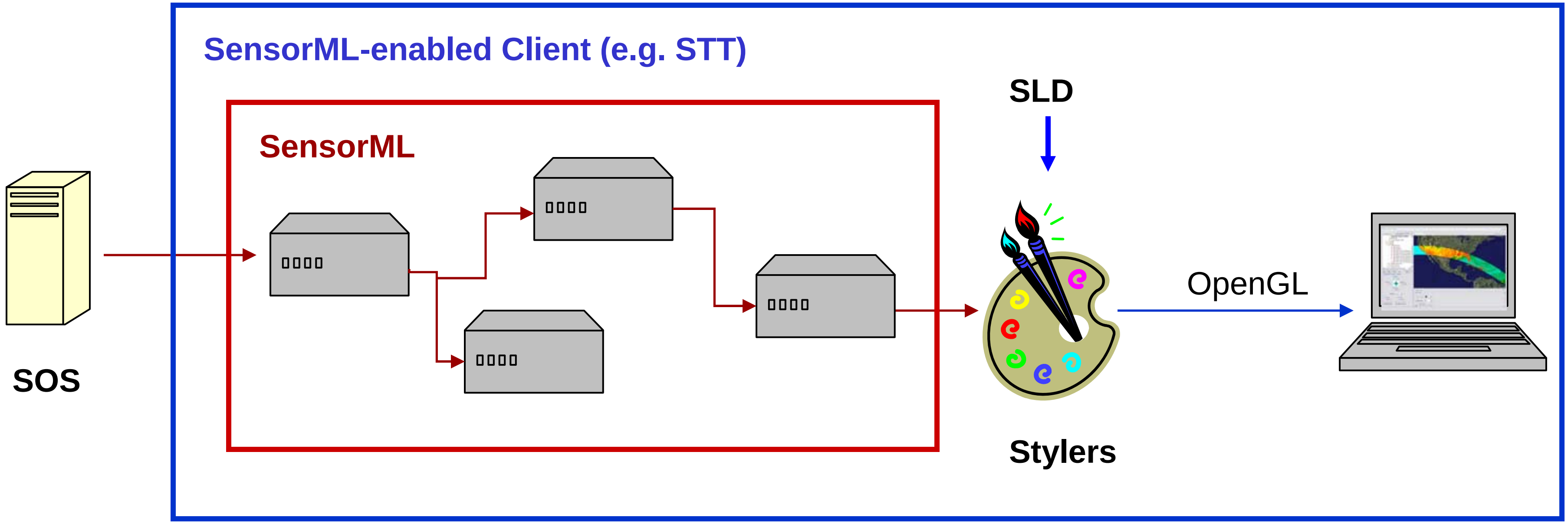
- **Discovery of sensors and processes / plug-n-play sensors** – SensorML is the means by which sensors and processes make themselves and their capabilities known; describes inputs, outputs and taskable parameters

- **Observation lineage** – SensorML provides history of measurement and processing of observations; supports quality knowledge of observations

- **On-demand processing** – SensorML supports on-demand derivation of higher-level information (e.g. geolocation or products) without *a priori* knowledge of the sensor system

- **Intelligent, autonomous sensor network** – SensorML enables the development of taskable, adaptable sensor networks, and enables higher-level problem solving anticipated from the Semantic Web

SWE provides data content that be portrayed through various means



For example, Space Time Toolkit executes SensorML process chain on the front-end, and renders graphics on the screen based on stylers (uses OGC Style Layer Description standard)

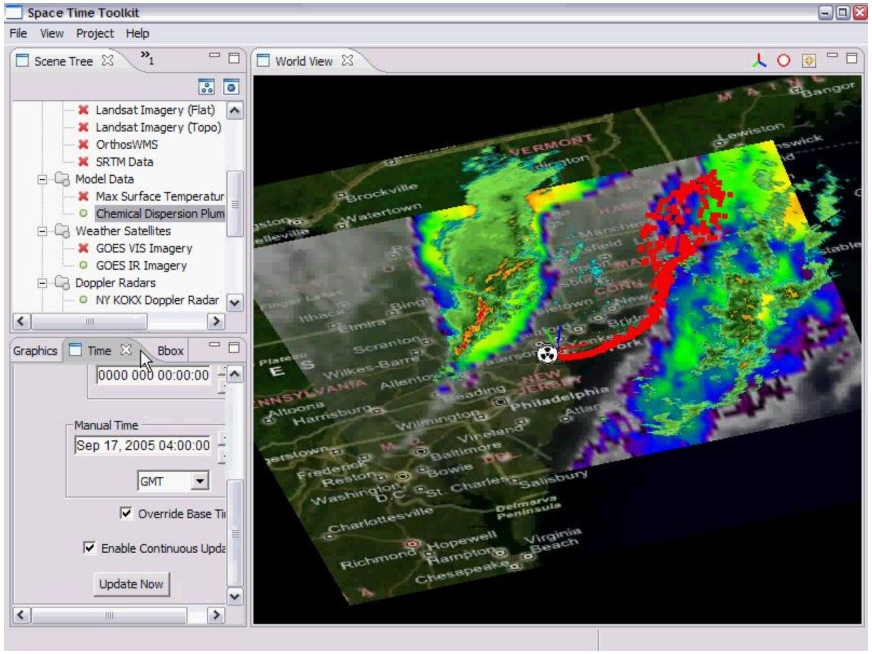
Current Status

- Current specs are in various stages (V1.0 specs approved 2007)
  - SensorML/SWE Common – Version 1.0.1 (V2.0 underway)
  - Observations & Measurement – Version 1.0 (V2.0 underway)
  - WNS – Request for Comments
  - SOS – Version 1.0 (V2.0 underway)
  - SPS – Version 1.0 (V2.0 underway)
  - SAS – Ready for final vote (may skip V1.0 for V2.0; may incorporate into SOS and Event Service)

- Approved SWE standards can be downloaded:
  - Specification Documents: http://www.opengeospatial.org/standards
  - Specification Schema: http://schemas.opengis.net/

Demo: Radiation Attack on NY

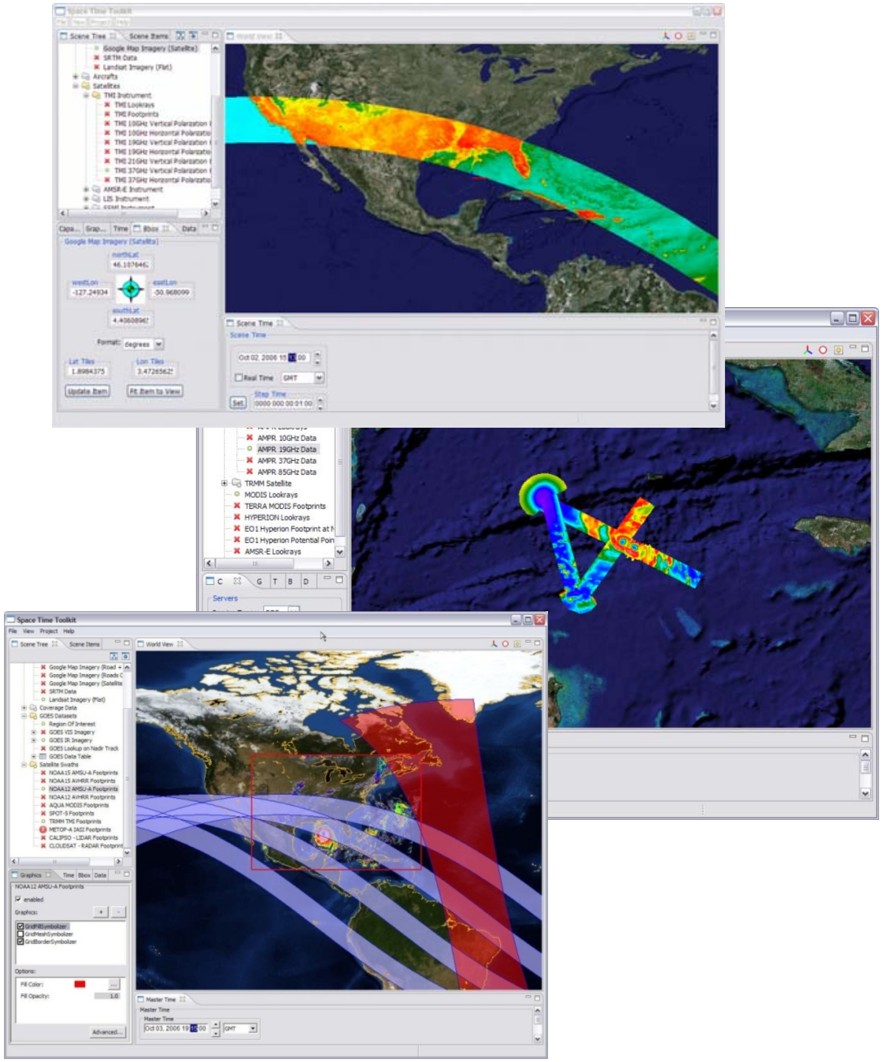
- OWS4 Demonstration Project (Fall 2006)
  - Purpose of Demo: illustrate discovery, access to and fusing of disparate sensors
  - Client: UAH Space Time Toolkit
  - Services:
    - SOS – in-situ radiation sensors
    - SOS – Doppler Radar
    - SOS – Lagrangian plume model
    - WCS – GOES weather satellite
    - SensorML – discovery and on-demand processing
    - WMS – Ortho Imagery
    - Google Earth – base maps



  - [See all OWS4 demos](interactive)(interactive)
  - [Download this demo](AVI: 93MB)(AVI: 93MB):

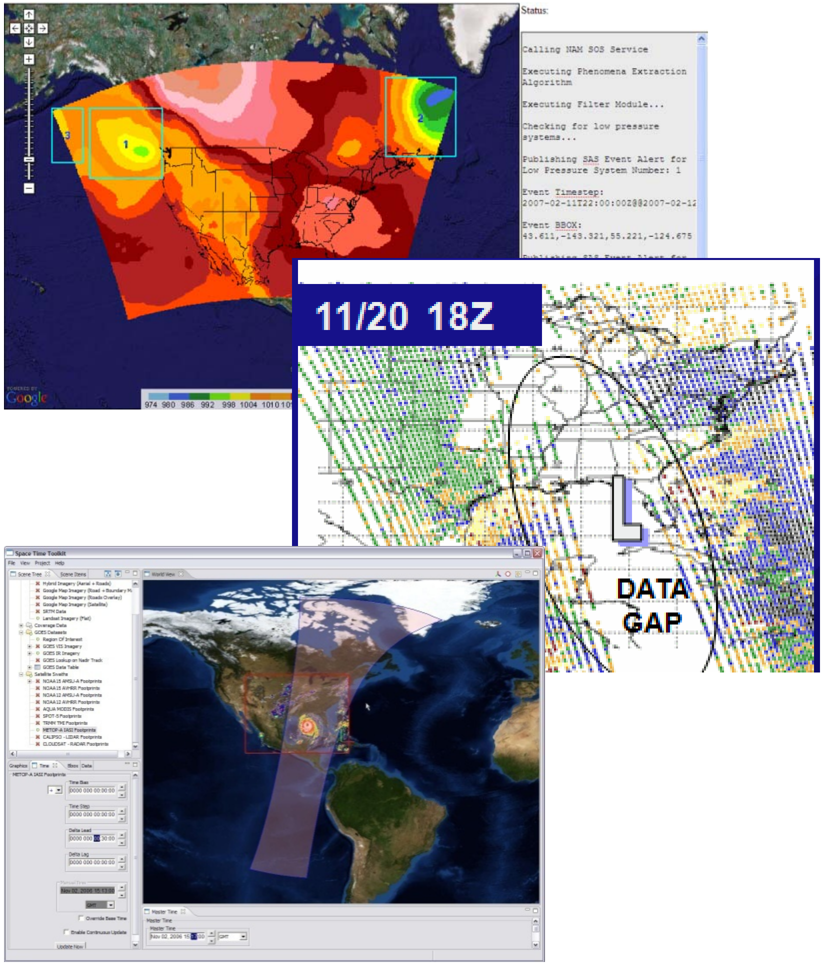
On Demand Geolocation of Satellite Data

- NASA
  - Purpose of Demo: illustrate access to satellite observations and on-demand geolocation
  - Client: UAH Space Time Toolkit
  - Services:
    - SOS – satellite footprints (UAH)
    - SOS – aircraft observations (NASA)
    - SOS – satellite observations (UAH)
    - SensorML – on-demand processing (UAH)
    - Virtual Earth – base maps
  - Download this demo



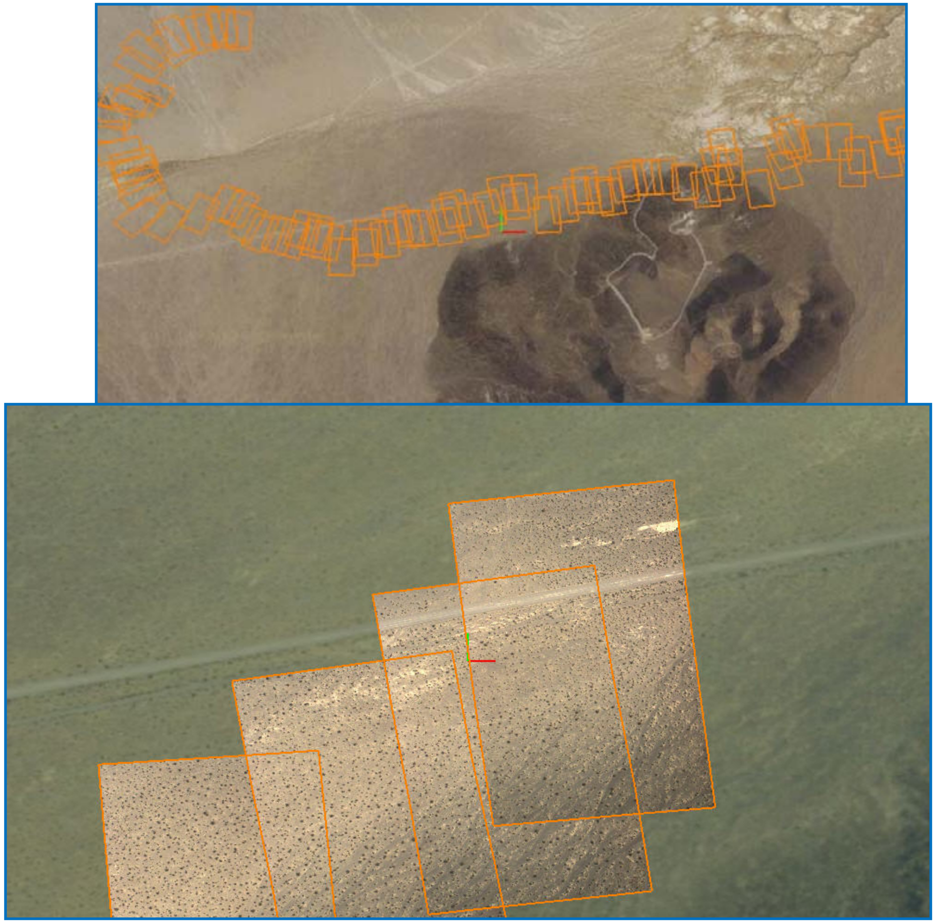
Application: NASA/NWS Forecast Model

- NASA assimilation of AIRS satellite data into weather forecast model
  - Purpose of Demo: illustrate the refinement of regional forecast models based on SensorML and SWE services
  - Client: Web-based client (NASA)
  - Services:
    - SOS – NAM forecast model
    - SOS – phenomenon miner(NASA)
    - SAS – phenomenon miner (NASA)
    - SOS – AIRS satellite observations (UAH)
    - SOS – footprint intersections (UAH)
    - SensorML – On-demand processing (UAH)
  - Download this demo



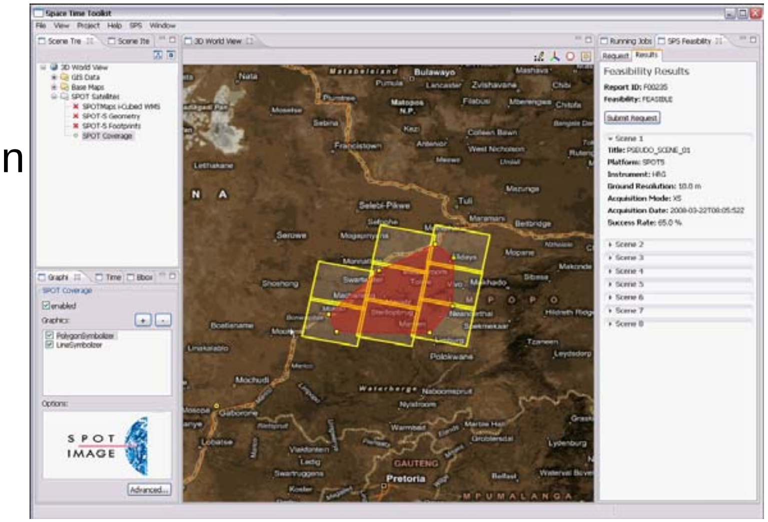
Application: Tigershark UAV-HD Video

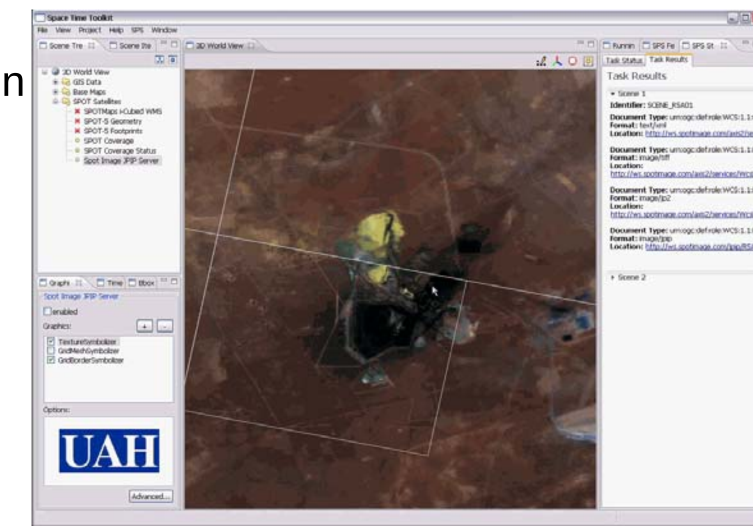
- Empire Challenge 2008
  - Purpose of Demo: illustrate on-demand geolocation and display of HD video from Tigershark UAV
  - Client: UAH Space Time Toolkit
  - Services:
    - SOS – Tigershark video and navigation (ERDAS)
    - SOS – Troop Movement (Northrop Grumman)
    - SensorML – On-demand processing (Botts Innovative Research, Inc.)
    - Virtual Earth – base maps
  - Download this demo



Application: SPOT Image

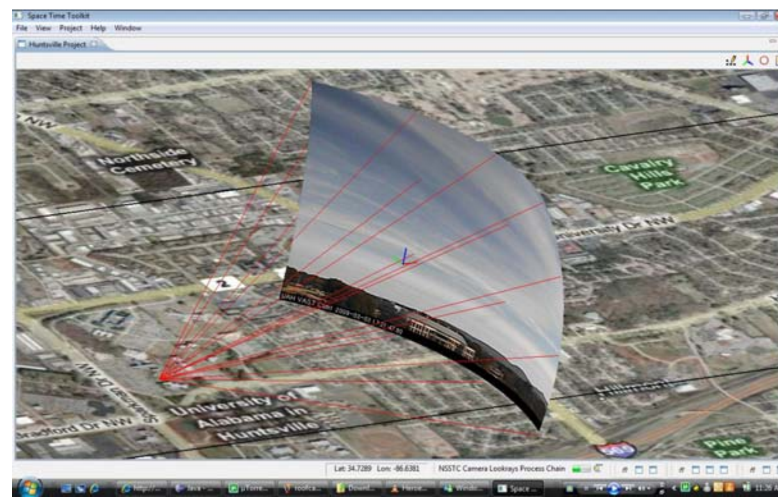
- SPOT SPS and JPIP server
  - Purpose of Demo: illustrate dynamic query of SPS; show on-demand geolocation of JPIP stream using SensorML
  - Client:
    - UAH Space Time Toolkit
  - Services:
    - SPS – satellite imagery feasibility [archived or future] (SPOT)
    - WCS/JPIP server – streaming J2K image with CSM parameters encoded in SensorML (SPOT)
    - SensorML – On-demand geolocation (UAH)
    - Virtual Earth – base maps
  - [Download this demo](AVI-divx:16MB)



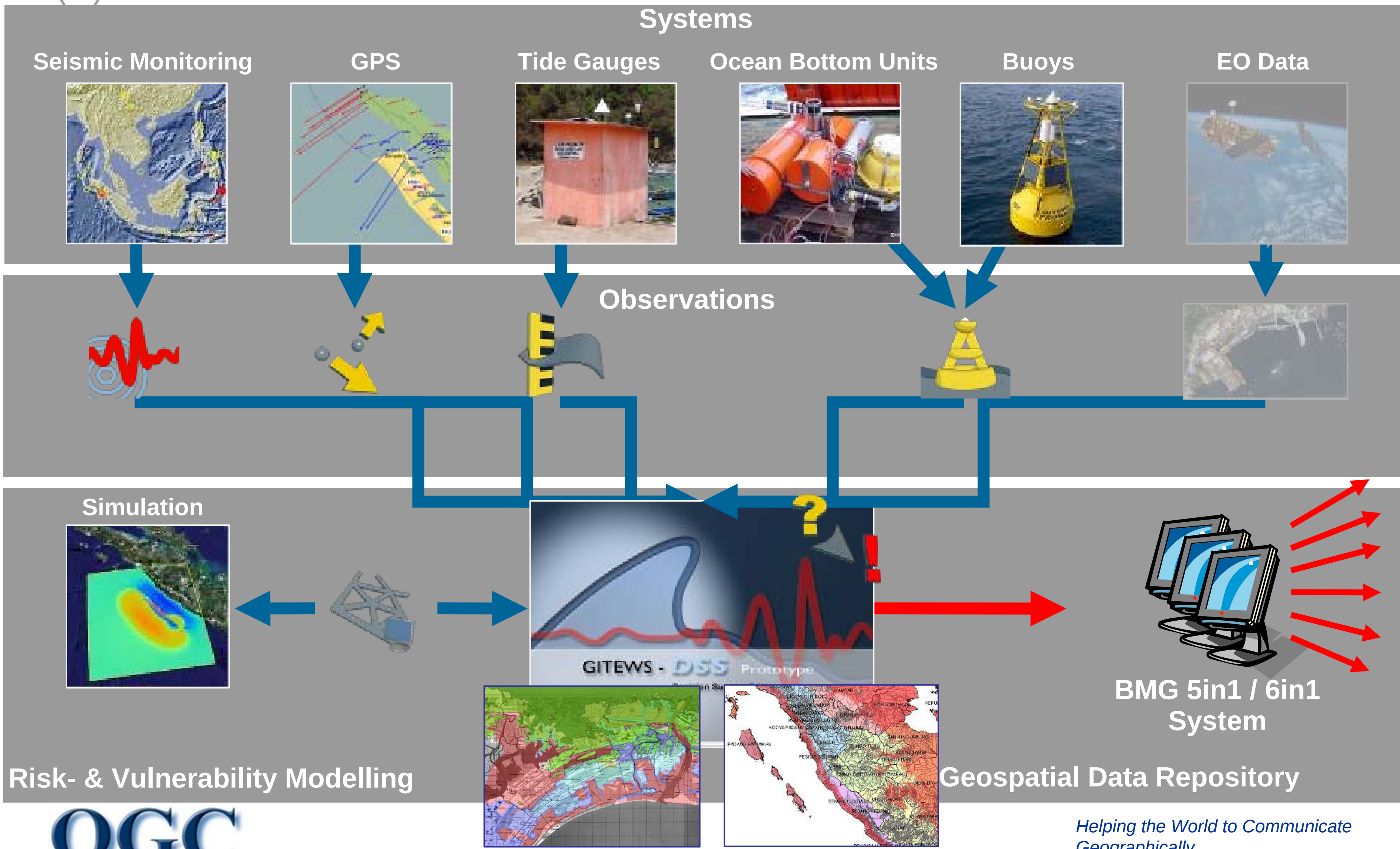


Demo: Real-time Video streaming

- UAH Dual Web-based Sky Cameras
  - Purpose of Demo: demonstrate streaming of binary video with navigation data; on-demand geolocation using SensorML
  - Client:
    - 52 North Video Test Client
    - UAH Space Time Toolkit
  - Services:
    - SOS – video and gimbal settings (UAH, 52 North)
    - SPS – Video camera control (52 North, UAH)
    - SensorML – On-demand processing (UAH)
    - Virtual Earth – base maps
  - Download this demo



DLR: Tsunami Early Warning & Mitigation Center



Debris Flow Monitoring System

GiS.FCU

rain gauge

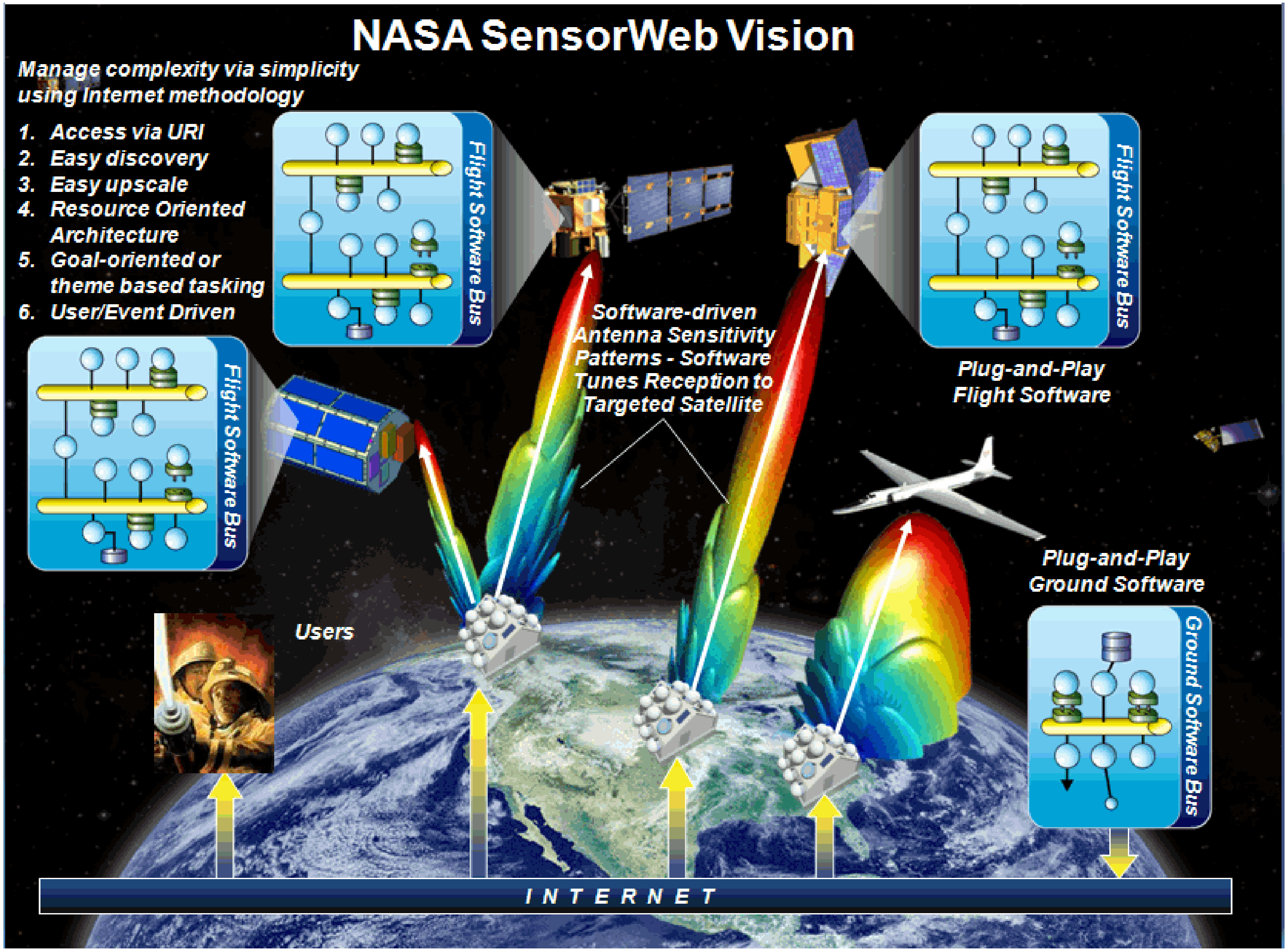
geophone

CCD camera

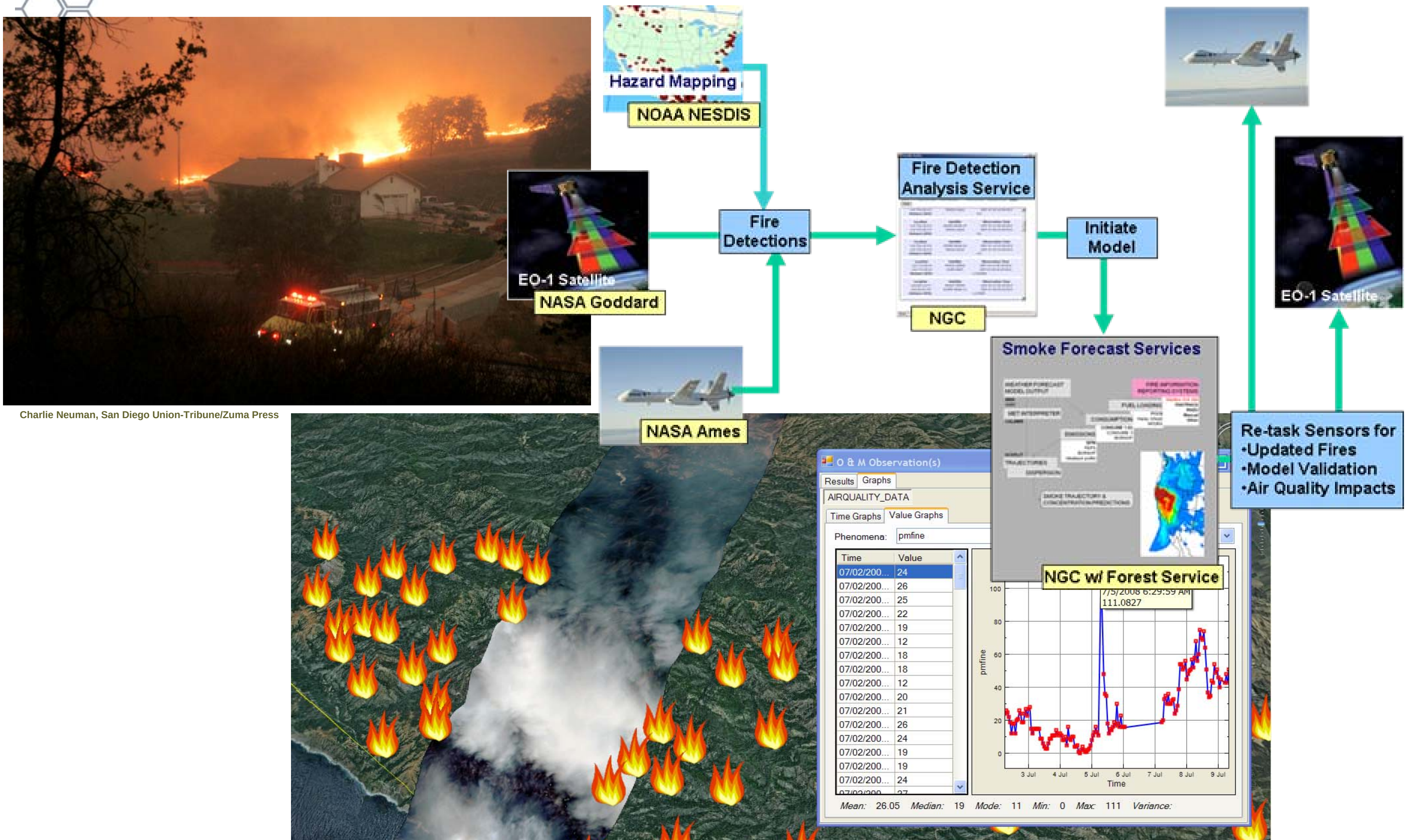
Satellite

ITRI
Industrial Technology
Research Institute

Application: NASA Sensor Web



PULSENet™ Applications: Atmospheric/Air Quality – Fire Monitoring/Smoke Forecasting



Charlie Neuman, San Diego Union-Tribune/Zuma Press

Application: Sensors Anywhere (S@NY)

SANY Consortium

Project acronym	SANY
Project reference	IST-2006-033564
Project type	Integrated Project
Start date	01/09/2006
Duration	36 months
Budget	11,2 M€
EC contribution	7,0 M€

SWE in the Oceans Community

SURA SCOOP

WITH FUNDING FROM

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

OFFICE OF NAVAL RESEARCH

IOOS

OGC

SWE v2.0

- General Directions
  - SWE Common becomes its own standard (currently within SensorML)
  - All SWE standards to be better harmonized using SWE Common data types and services
  - Better support for streaming data using SWE Common, SensorML, and SOS (no current plans to take TML to v2.0)
  - Greater harmonization and modularity between SWE services (conformance classes for partial implementation)
  - Improvement for finer-grained and dynamic discovery for sensors and observations
    - "find all UAV-borne video cameras that viewed this 50mx50m area between 9:15–9:30 this morning"
    - "as I drive through Baghdad, keep me informed in real-time of all sensor static and dynamic assets available within a 10 km radius"
- Time Frame
  - SWE Common, SPS in Request for Comment
  - Targeting approval of all by mid Summer to early Fall

Conclusions

- **SWE has been tested and has proven itself**
  - Useful, flexible, efficient, extensible
  - Simple to add to both new and existing legacy systems
  - Enables paradigm shifts in access and processing of observations
- **SWE is getting buy-in from scattered sensor communities**
  - Commitments from larger communities provide the inertia to realize the full benefits
  - Commitments from smaller grassroots communities provide additional data and tools from the public and industry sectors
  - With a few exceptions, sensor vendors will contribute directly to Sensor Web only after user community commitment (or due to big government demands)
  - SWE open to improvements by the user communities
- **Tools are being developed to support SWE**
  - Tools will ease buy-in
  - Tools will assist in realizing the full benefits of SWE
- **OGC is looking for input on how to improve SWE v2.0 to better meet your needs**

Relevant Links

Open Geospatial Consortium

http://www.opengeospatial.org

Sensor Web Enablement Working Group

http://www.ogcnetwork.net/SWE

SWE Public Forum

http://mail.opengeospatial.org/mailman/listinfo/swe.users

SensorML Public Forum

http://mail.opengeospatial.org/mailman/listinfo/sensorml

Additional Slides

Sensor Web Vision -1-

- Sensors will be web accessible
- Sensors and sensor data will be discoverable
- Sensors will be self-describing to humans and software (using a standard encoding)
- Most sensor observations will be easily accessible in real time over the web

Sensor Web Vision -2-

- Standardized web services will exist for accessing sensor information and sensor observations
- Sensor systems will be capable of real-time mining of observations to find phenomena of immediate interest
- Sensor systems will be capable of issuing alerts based on observations, as well as be able to respond to alerts issued by other sensors

Sensor Web Vision -3-

- Software will be capable of on-demand geolocation and processing of observations from a newly-discovered sensor without *a priori* knowledge of that sensor system
- Sensors, simulations, and models will be capable of being configured and tasked through standard, common web interfaces
- Sensors and sensor nets will be able to act on their own (i.e. be autonomous)

History -1-

1999 - 2000

SensorML initiated at University of Alabama in Huntsville: NASA AIST funding

2001

OGC Web Services Testbed 1.1:

- Sponsors: EPA, NASA, NIMA
- Specs: SensorML, SOS, O&M
- Demo: NYC Terrorism
- Sensors: weather stations, water quality

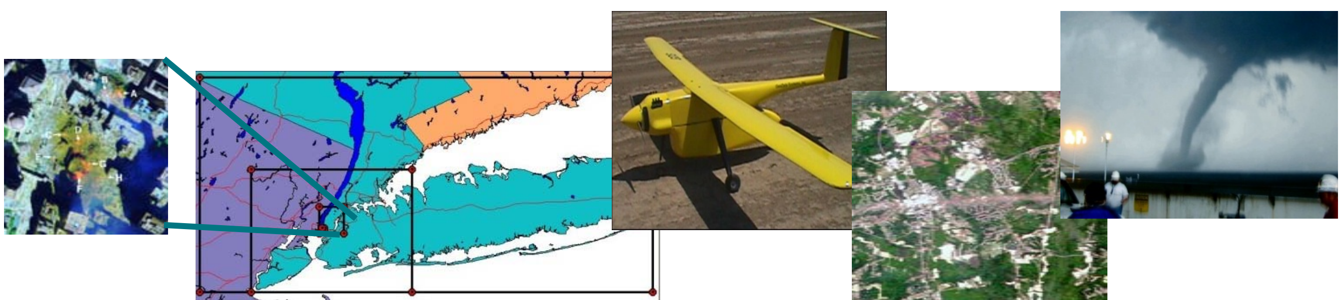
2002

OGC Web Services Testbed 1.2:

- Sponsors: EPA, General Dynamics, NASA, NIMA
- Specs: SOS, O&M, SensorML, SPS, WNS
- Demo: Terrorist, Hazardous Spill and Tornado
- Sensors: weather stations, wind profiler, video, UAV, stream gauges

2003-2004

- Specs advanced through independent R&D efforts in Germany, Australia, Canada and US
- SWE WG established
- Specs: SOS, O&M, SensorML, SPS, WNS, SAS



History -2-

OGC Web Services Testbed 3.0:

- Sponsors: NGA, ORNL, LMCO, BAE
- Specs: SOS, O&M, SensorML, SPS, TML
- Demo: Forest Fire in Western US
- Sensors: weather stations, wind profiler, video, UAV, satellite

SAS Interoperabilty Experiment

OGC Web Services Testbed 4.0:

- Sponsors: NGA, NASA, ORNL, LMCO
- Specs: SOS, O&M, SensorML, SPS, TML, SAS
- Demo: Radiation, Emergency Hospital
- Sensors: weather stations, wind profiler, video, UAV, satellite

SWE Specifications approved:

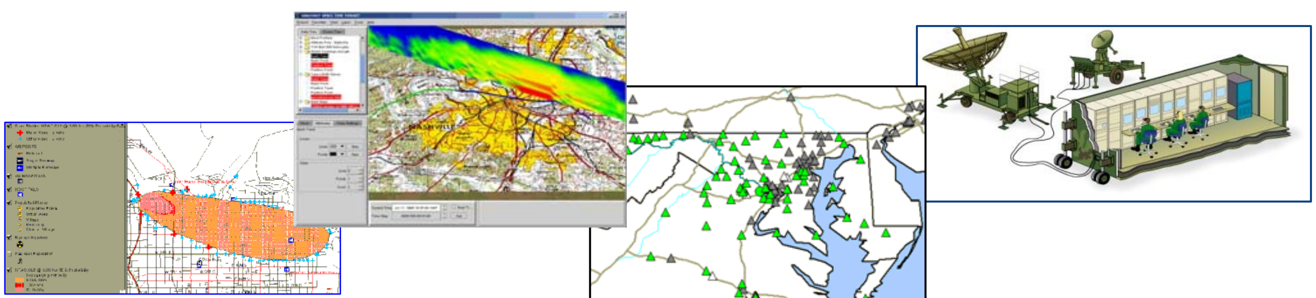
SensorML – V1.0.1
TML – V1.0
SOS – V1.0
SPS – V1.0
O&M – V1.0
SAS – V0.0
WNS – Best Practices

OGC Web Services Testbed 5.1

- Sponsors: NGA, NASA,
- Specs: SOS, SensorML, WPS
- Demo: Streaming JPIP of Georeferenceable Imagery; Geoprocess Workflow
- Sensors: Satellite and airborne imagery

EC07: in-situ sensors, video

2005 **2006** **2007**



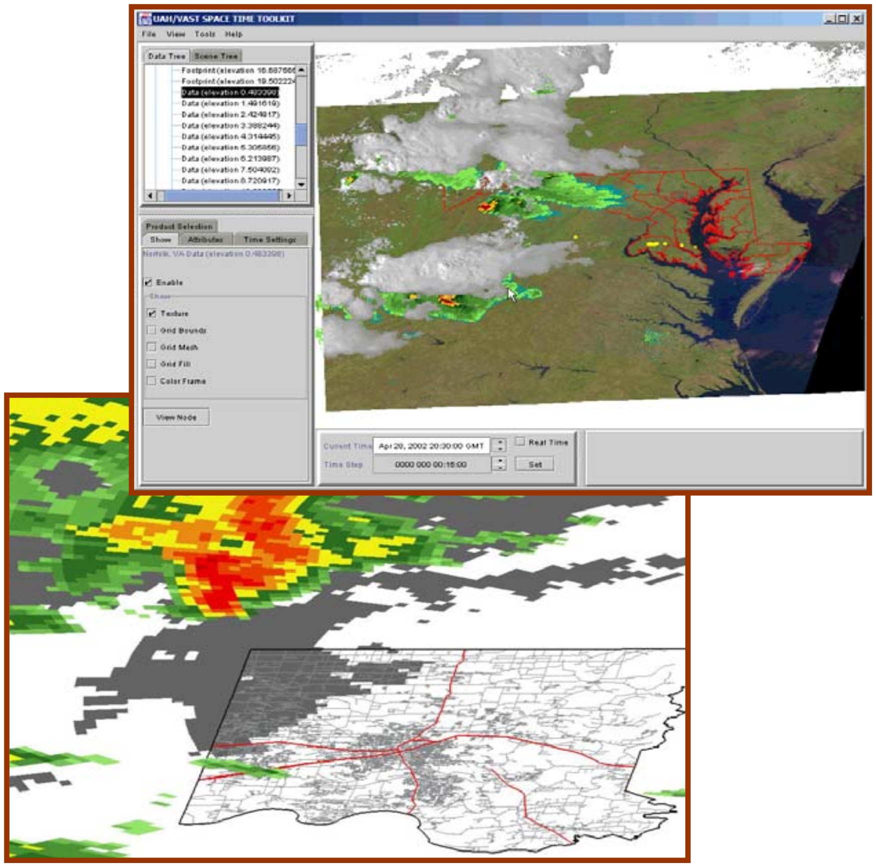
OGC

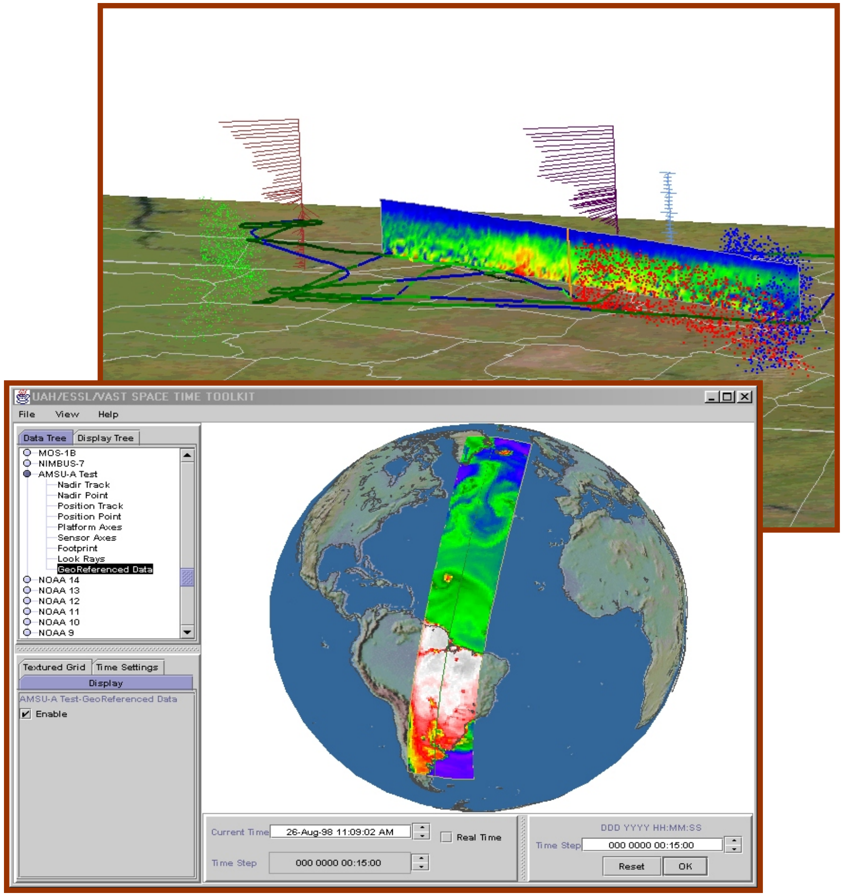
OGC Open GIS Consortium, Inc.

Incorporation of SWE into Space Time Toolkit

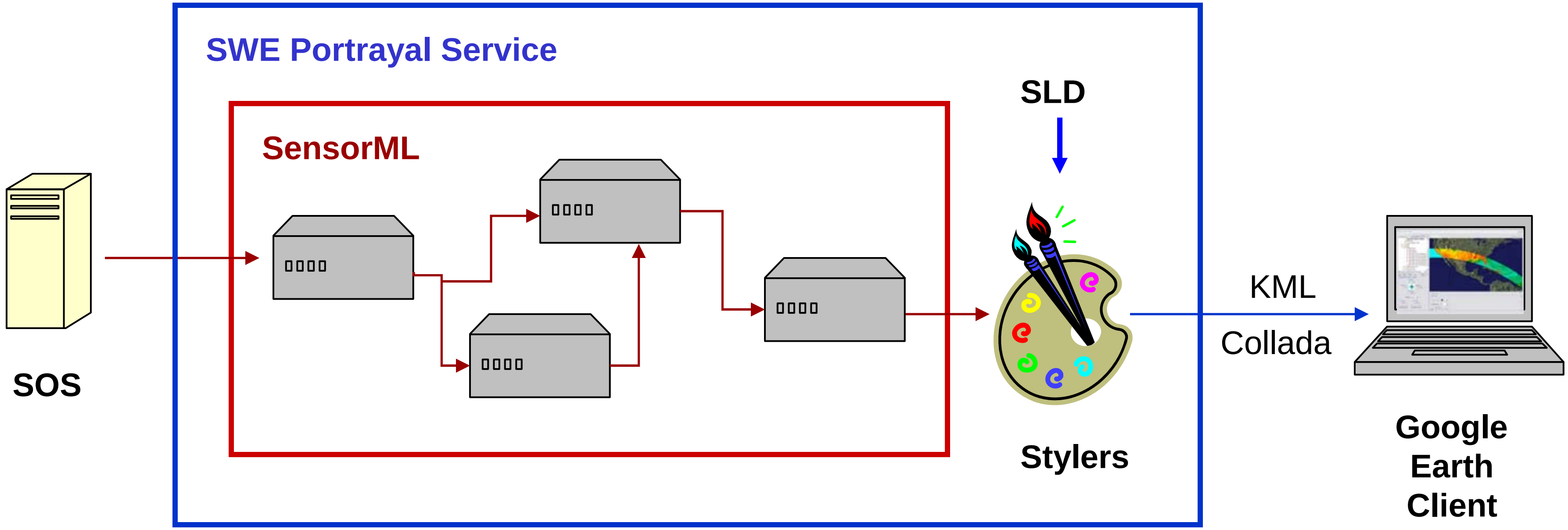
UAH The University of Alabama in Huntsville

Space Time Toolkit has been retooled to be SensorML process chain executor + SLD stylers





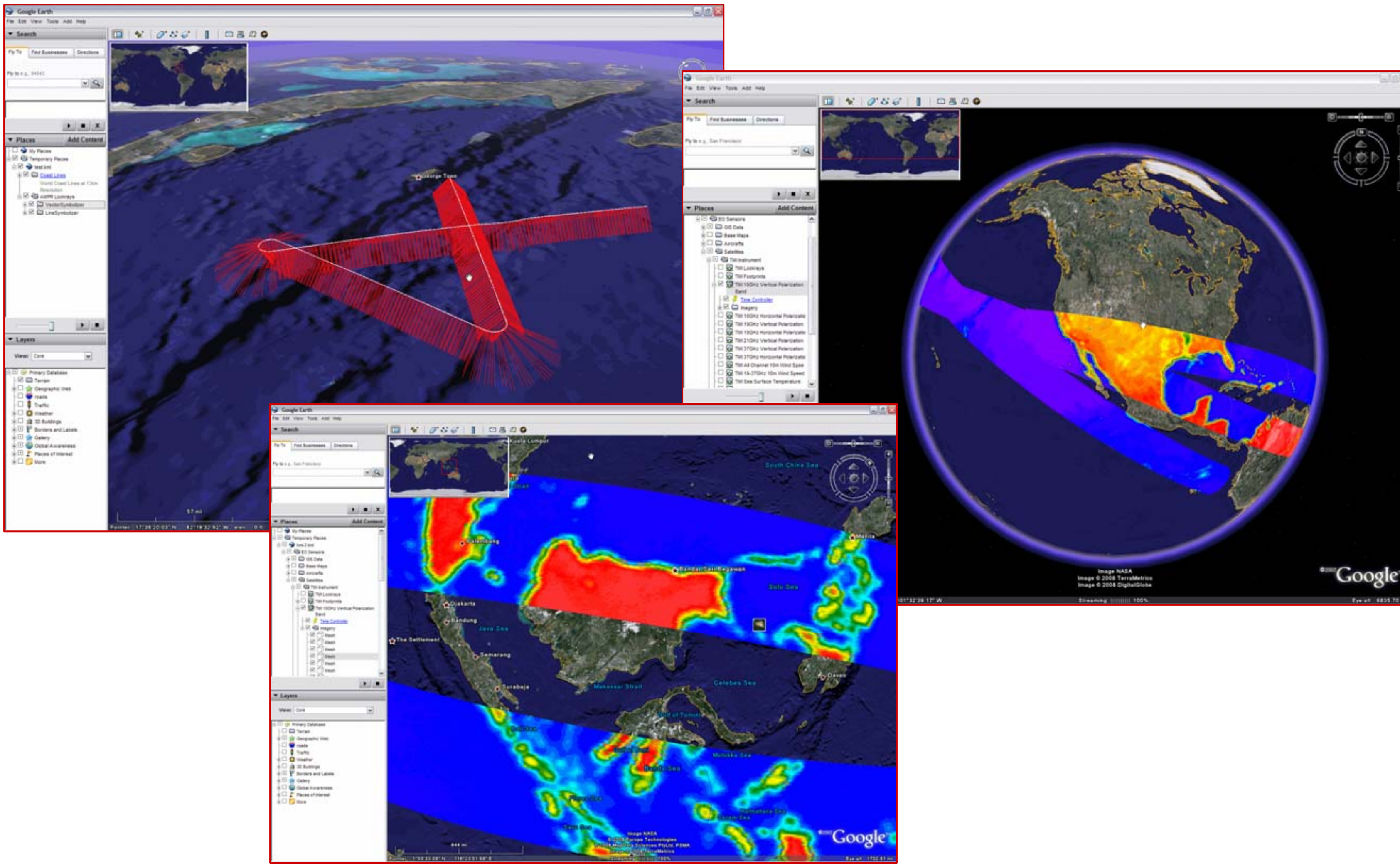
A SWE Portrayal Service can “render” to various graphics standards



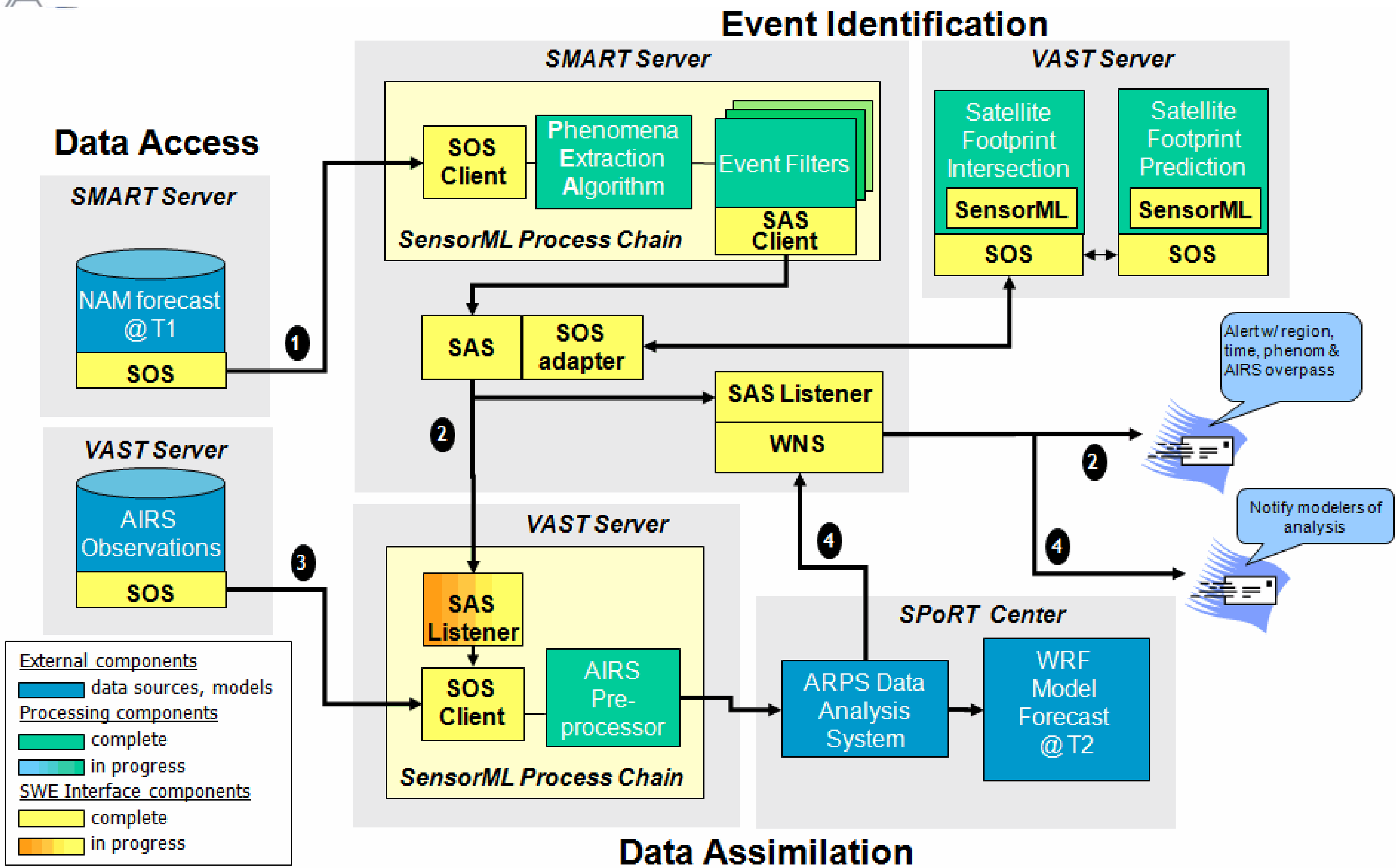
For example, a SWE portrayal service can utilize a SensorML front-end and a Styler back-end to generate graphics content (e.g. KML or Collada)

However, it’s important that the data content standards (e.g. SWE) exist to support the graphical exploration and “drill-down” exploitation !

SWE to Google Earth (KML – Collada)



NASA/NWS Forecast Model Augmentation



GEOSS SENSOR WEB WORKSHOP

May 15/16, 2008. Geneva, Switzerland

40+ participants

17 nations

4 continents

Sensor Web: Foundation Layer of GEOSS