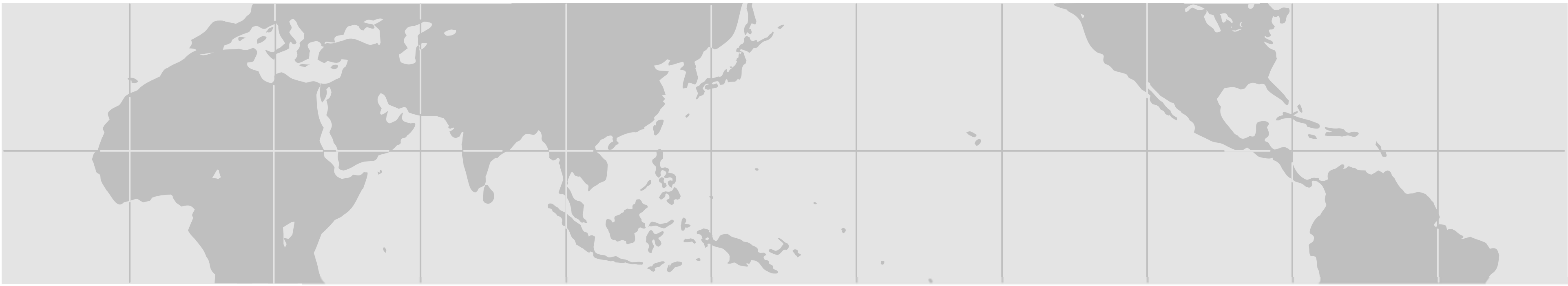

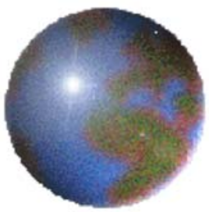

Intelligent Assimilation of Satellite Data into a Forecast Model Using Sensor Web Processes and Protocols

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SMART-ODM Collaboration

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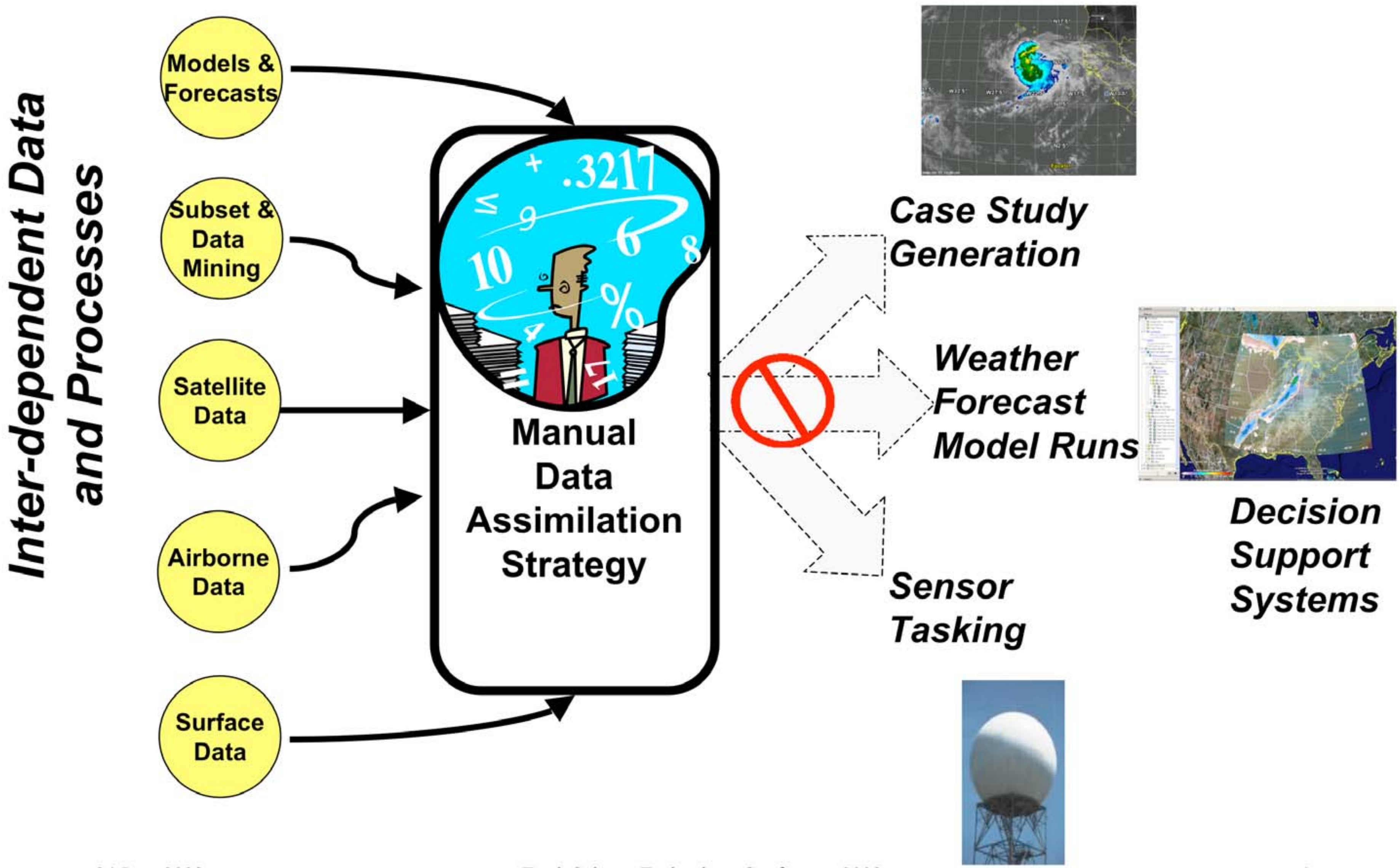
  - *Mike Botts, Gregoire Berthiau*
- UAH Information Technology & Systems Center (ITSC)
  - *Helen Conover, Xiang Li, Manil Maskey, Jessica Lu, Kathryn Regner*
- NASA Short-term Prediction Research and Transition center (SPoRT)
  - *Gary Jedlovec, Bradley Zavodsky*

SMART Project Objectives

- Develop and demonstrate the readiness of Open Geospatial Consortium (OGC) Sensor Web Enablement (SWE) technologies
  - Leverage OGC SWE experience of VAST partners to build knowledge and skills among the team
  - Feed back lessons learned and recommendations
- Use SWE protocols and standards to assimilate NASA satellite observations and retrievals into a regional weather forecast model over the southeastern U.S.
  - Prototype a scalable, extensible, reconfigurable and reusable architecture for atmospheric data assimilation
  - Facilitate data assimilation decisions while minimizing any required changes to forecast models

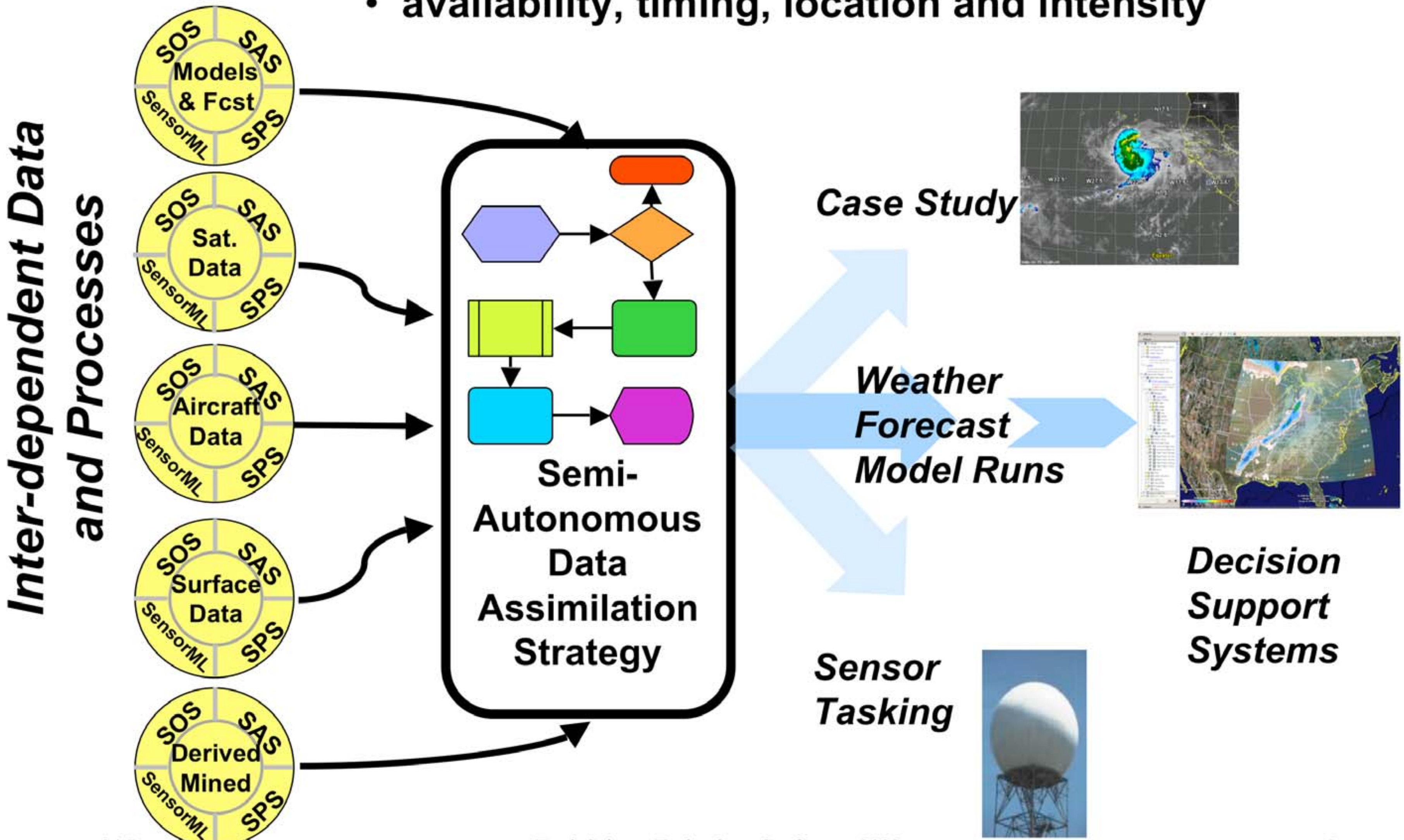
Data Integration Is Complicated



Sensor Web Enabled Integration

Sensor Web Enabled system eases data integration

- **availability, timing, location and intensity**



OGC Sensor Web Enablement

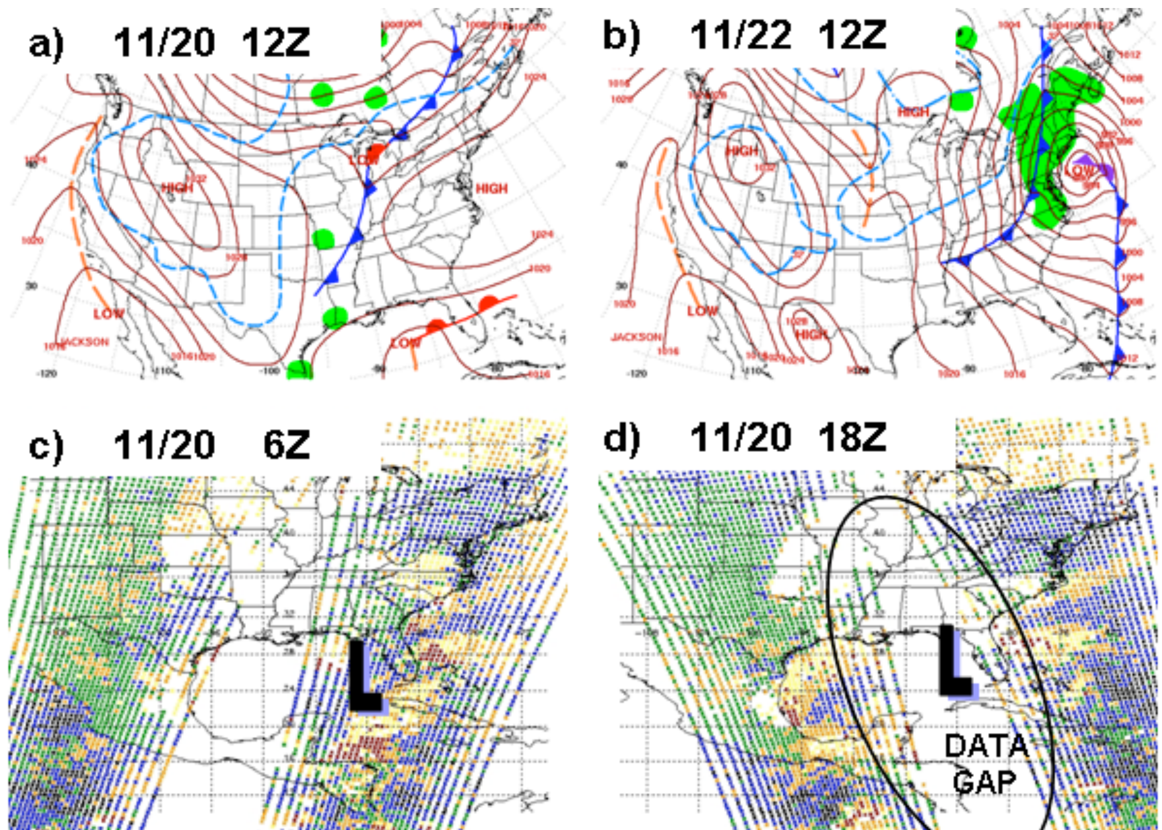
- OGC Sensor Web Enablement (SWE) standards provide specifications for interfaces, protocols and encodings that are designed to enable implementation of interoperable, service-oriented networks of sensors and applications.
  - Standard interfaces to sensor data can minimize the custom software required for management, visualization and analysis of different types of sensors and observations.
- SWE services implemented for this project include:
  - Sensor Observation Services (SOS): web service interface for requesting, filtering and retrieving sensor system information and observations
  - Observations and Measurements (O&M) Schema: an XML schema for encoding sensor data objects
  - Sensor Alert Services (SAS): web service interface for advertising, publishing and subscribing to alerts from sensors
  - Sensor Model Language (SensorML): an XML schema for describing a functional model of a sensor system and related processes. Multiple processes can be combined with SensorML to form an executable process chain.

AIRS Data Assimilation in Models

Problem / Challenge

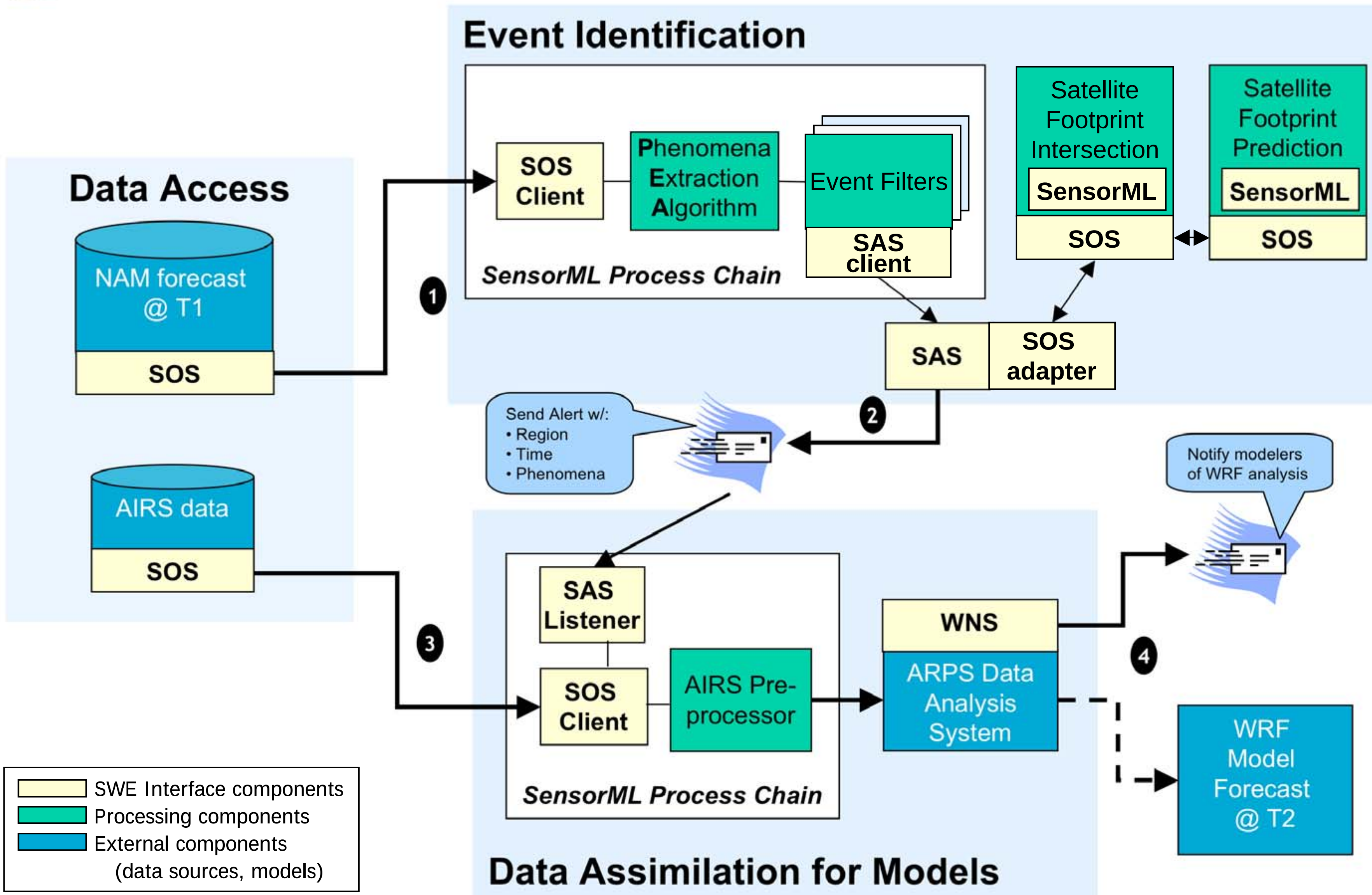
Assimilation of satellite observations such as AIRS can improve forecasts, but is computationally expensive

- Swath coverage, storm position, data volume and availability all constrain assimilation decisions
- SMART Assimilation: select only AIRS profiles that will have greatest impact – those that are co-located with significant weather



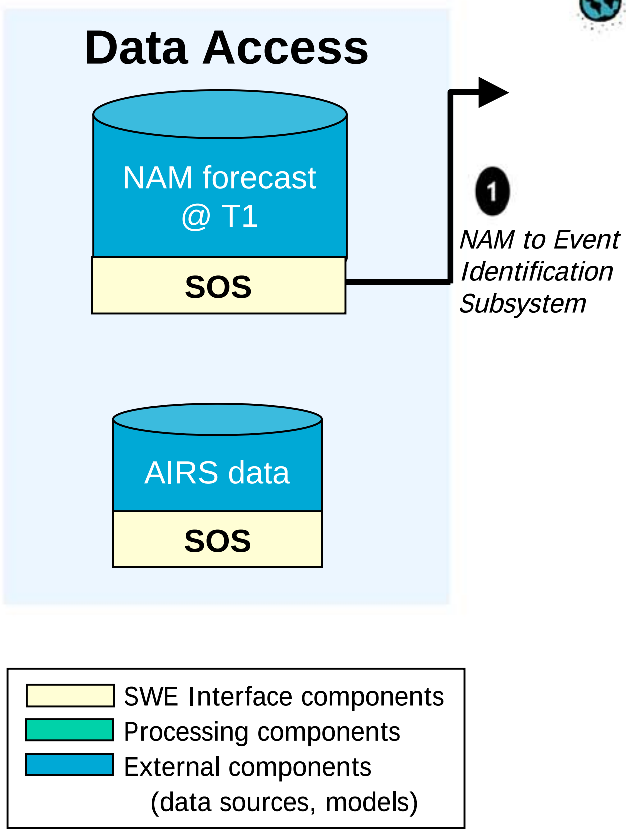
AIRS SWATH AND DATA DISTRIBUTION

SMART Assimilation of AIRS Data into a Weather Forecast Model



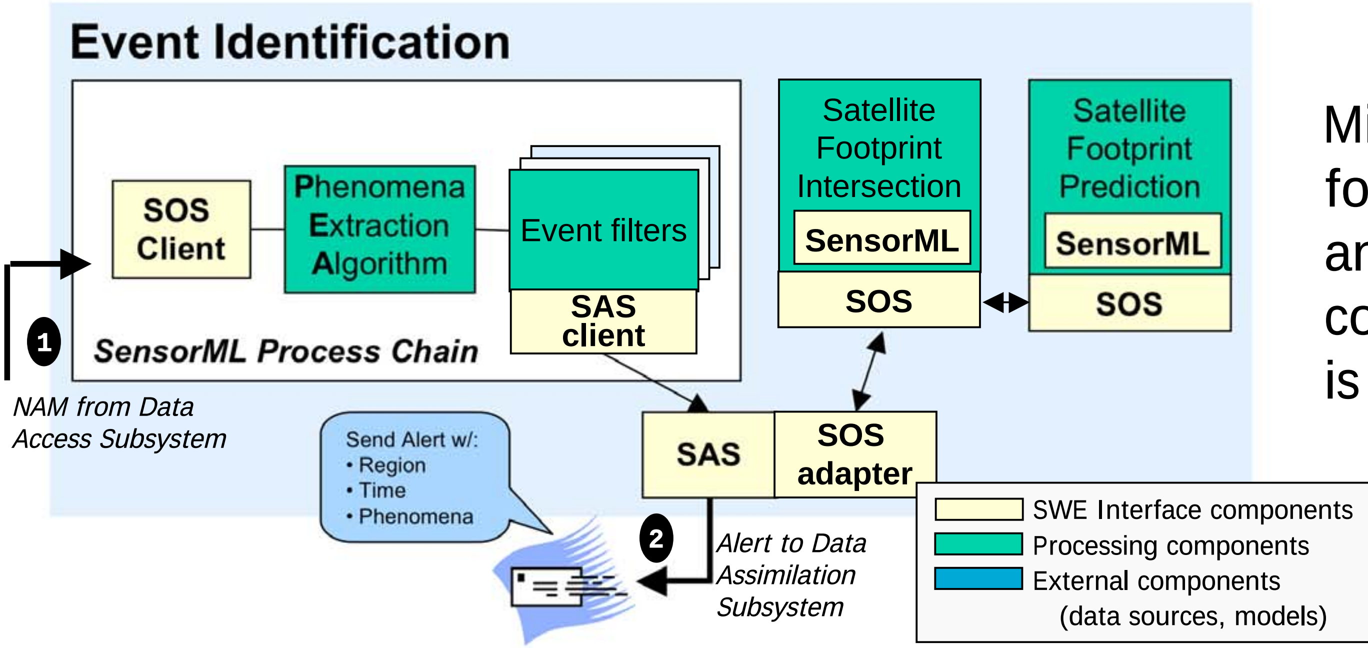
Data Access Subsystem

- Data products acquired in near real time and made available by Sensor Observation Services



- SOS provides a standard access interface to data products
  - Can subset the data by parameter, as well as spatial and temporal range.
  - Converts data from native format to O&M format with either ASCII or Binary attachment.

Event Identification Subsystem (1)

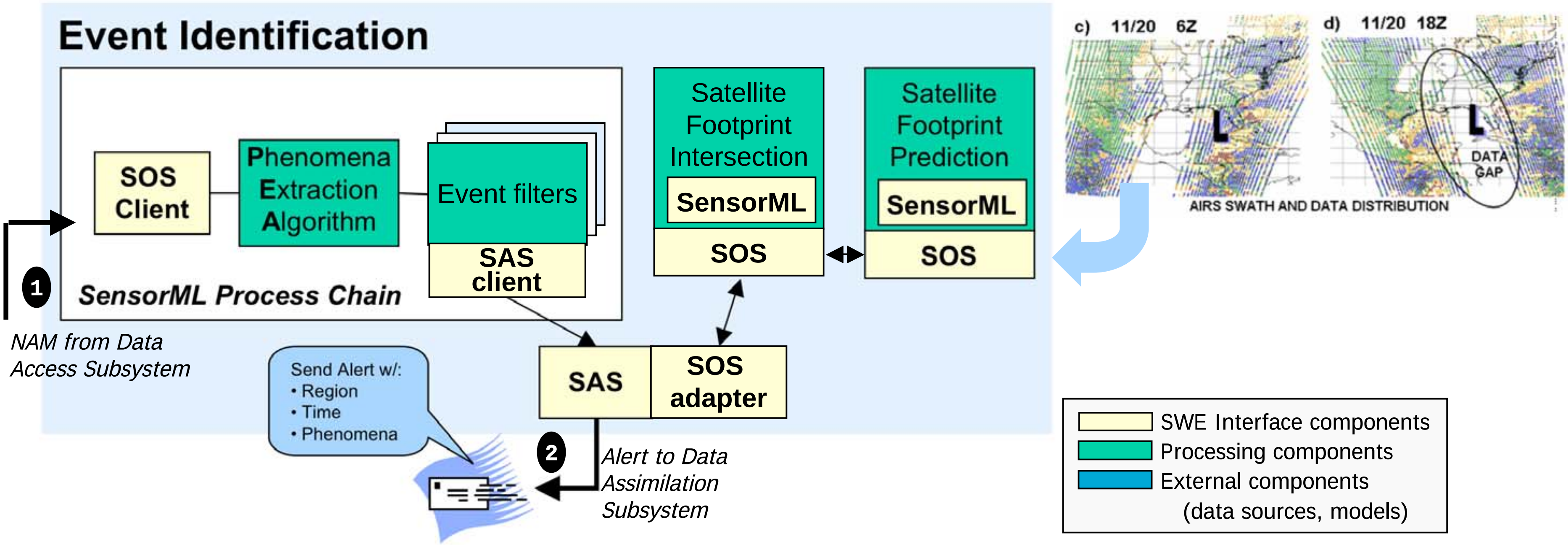


Mine NAM forecasts for weather events and determine if coincident AIRS data is available

<u>SensorML Process Chain</u>

- Retrieves and mines NAM forecasts
- Leverages earlier data mining research for *Phenomena Extraction Algorithm*. Initially configured to detect low pressure systems
  - relatively easy to detect in NAM forecasts
  - valuable in deciding whether to assimilate AIRS data
- *Event Filters* distinguish low pressure from high pressure systems

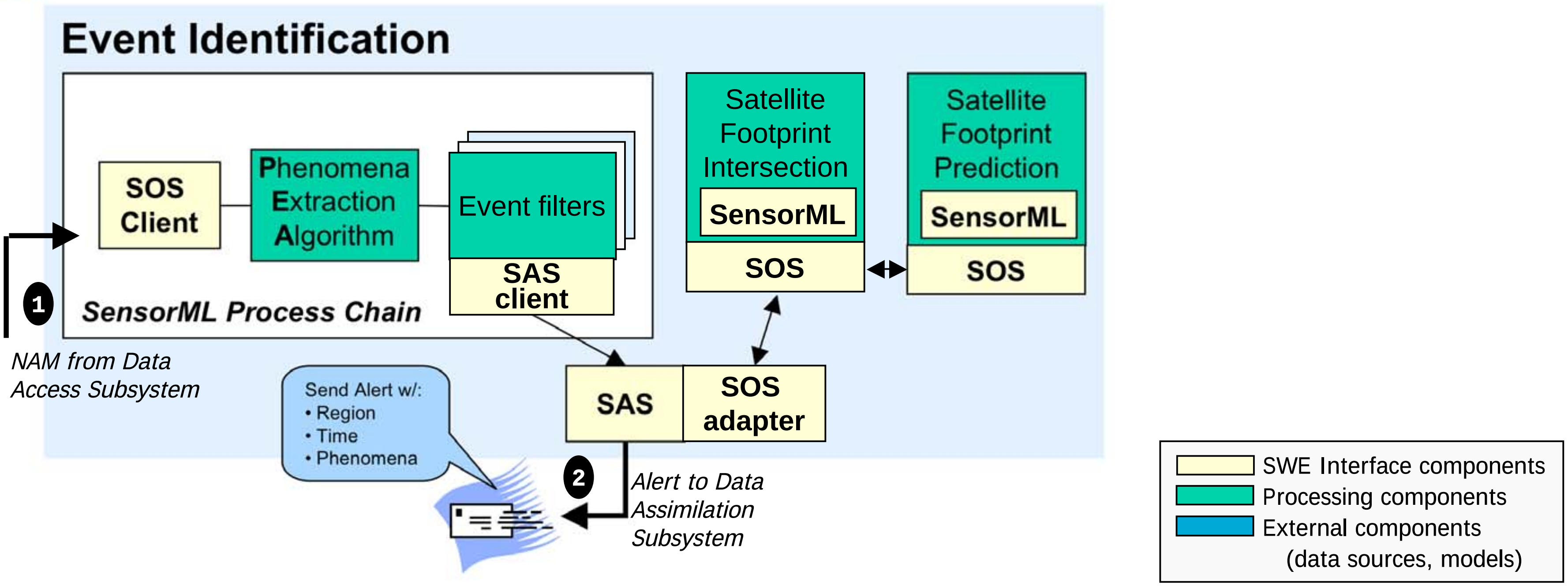
Event Identification Subsystem (2)



Sensor Observation Services

- *Satellite Footprint Prediction SOS* uses SensorML to determine satellites' locations and instruments' footprints at any given time
- *Satellite Footprint Intersection SOS* determines whether a given instrument footprint intersects a specified spatio-temporal region of interest.

Event Identification Subsystem (3)



Sensor Alert Service

- Event filters publish weather "Phenomena" alerts
- SAS-SOS adapter queries the Satellite Footprint Intersection SOS for AIRS overpasses coincident with identified weather events
- SAS publishes "Phenomena / AIRS Intersection" alerts

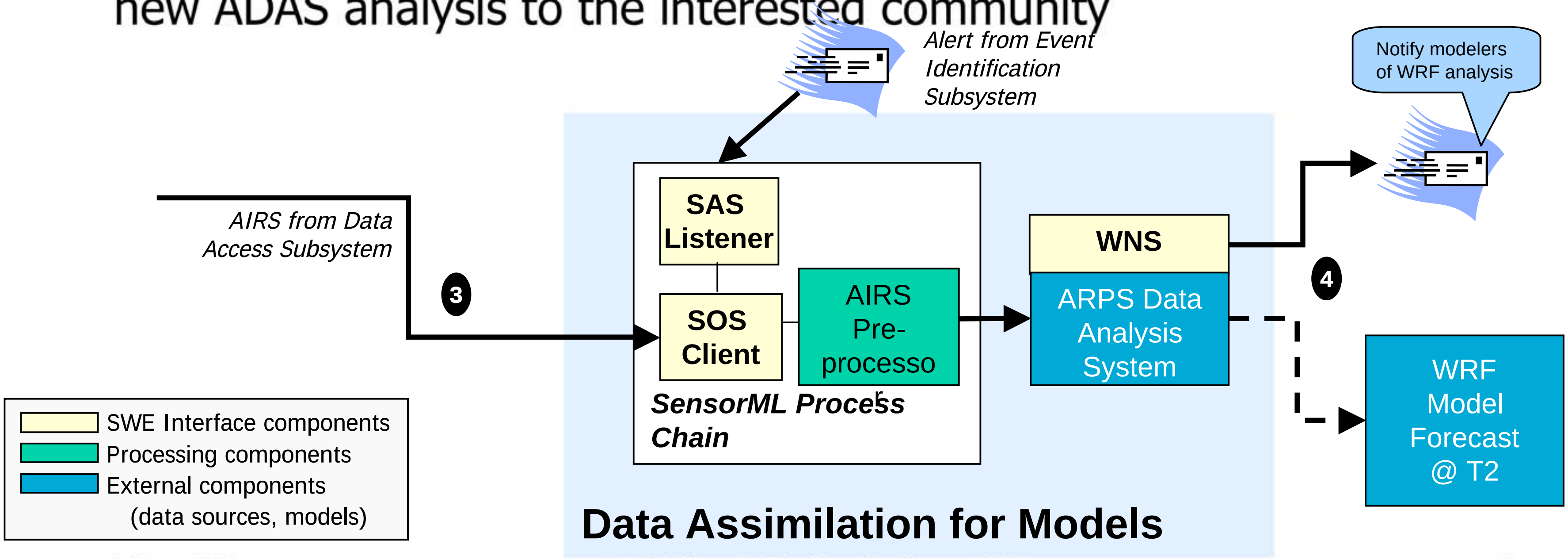
Data Assimilation Subsystem

SensorML Process Chain

- Triggered by a "Phenomena/AIRS Intersection" alert from the Event Identification SAS
- SOS client retrieves the AIRS data
- AIRS preprocessor translates AIRS data into the ASCII format required by the ADAS assimilation process

ADAS produces the analyses used to initialize the regional WRF model runs at SPoRT

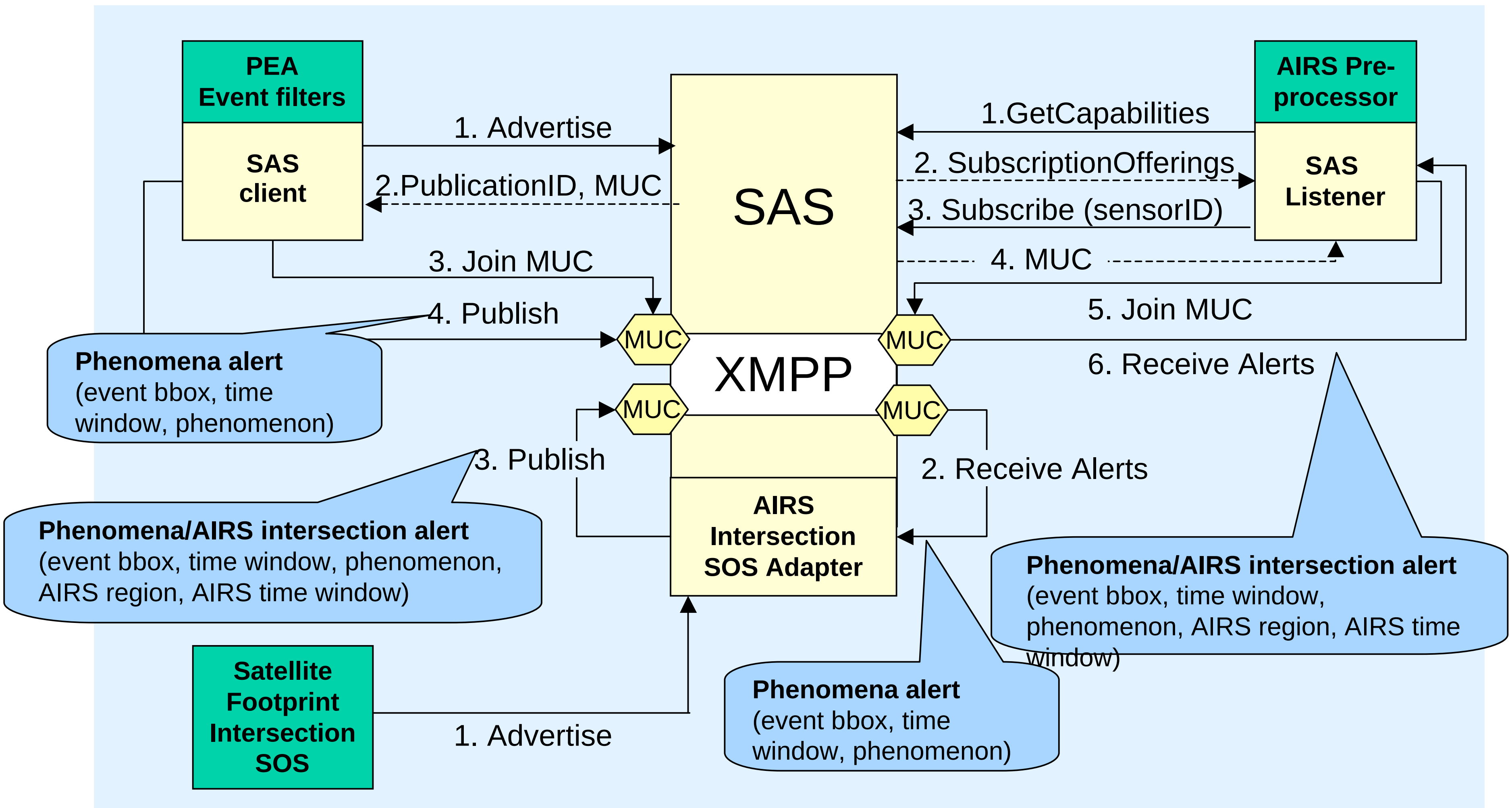
A Web Notification Service (WNS) can broadcast the availability of each new ADAS analysis to the interested community



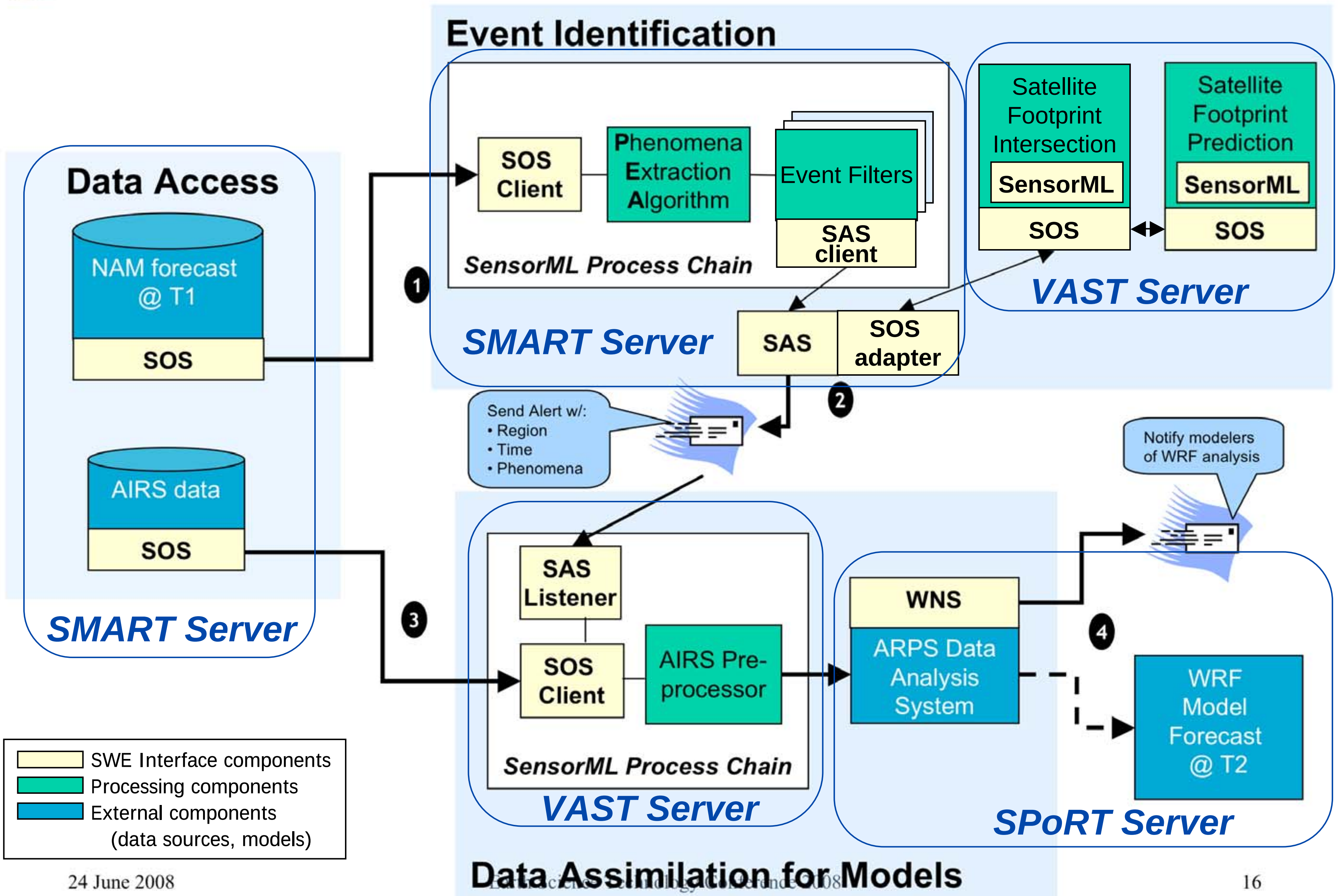
Sensor Alert Services - Overview

- An SAS is a registry for cross referencing different types of alerts and their subscribers
  - Not in itself an event notification system
  - Sensors advertise capabilities and publish alerts
  - Users subscribe to and listen for alerts
- SMART is leveraging the SAS package from 52°North
  - XMPP implementation – alerts are communicated via Multi-User Chat spaces (MUC)
  - Modified by SMART team to make it possible to send geographical information (i.e., bounding box) in an alert

SAS Interfaces



Year 2 Science Scenario Definition:
SMART Assimilation of AIRS Data into a Weather Forecast Model



Lessons Learned (1)

- Because SWE technologies are continuing to evolve, various SWE components must be upgraded and tested as new versions of standards are approved (e.g., SOS 1.0)
  - It can be difficult to balance exploration of evolving technology developments against need to build stable demonstration applications
  - If upgrades are not carefully coordinated, distributed applications will break
  - Upgrades to new standards must be factored in to the overall project schedule in order to meet milestones.

Lessons Learned (2)

- Reference implementations of many OGC SWE technologies are available
  - Oceans Interoperability Experiment is developing reference SOS implementations and cookbooks for in situ sensor platforms such as buoys.
  - SMART has been successful in adapting SAS from 52°North
  - New projects must take time to discover what is available and take advantage of existing work
- Science/IT collaboration is critical to an advanced technology project such as SMART.
  - A team comprising both scientists and software engineers will result in a more scientifically viable, real world result than a team of only scientists or only software engineers.