Application of NASA ESE Data and Tools
to
Air Quality Management

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Washington University in St. Louis

Project Period: 2004-9

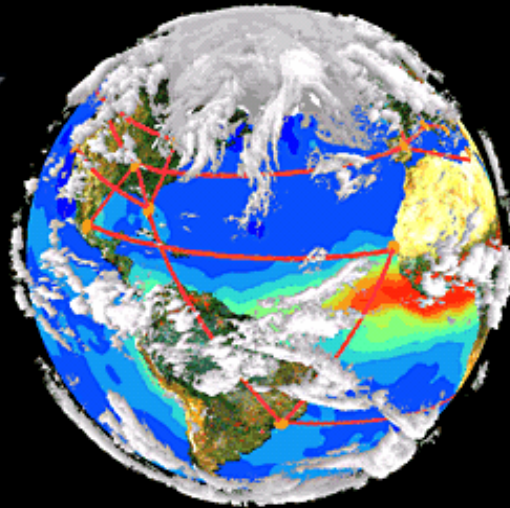**NASA Applied Sciences Program Air Quality Team Meeting**
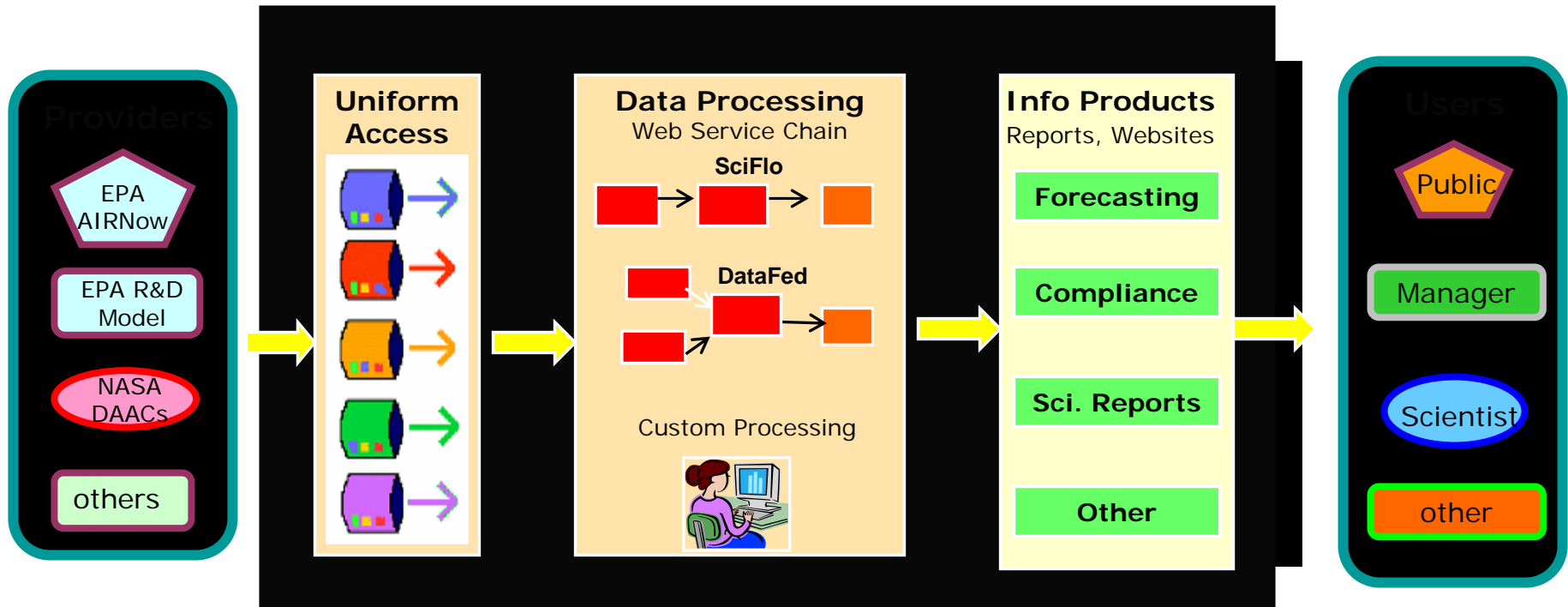
June 18-20, 2007, The Bolger Center, Potomac, MD

## Approach: Mediation Between Users and Data Providers

DataFed assumes spontaneous, autonomous data providers
Non-intrusively *wraps* datasets for access by web services
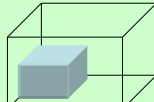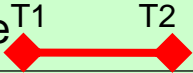Mediates, homogenizes data views. e.g. geo-spatial, time…

Agile Information System:
Data Access, Processing and Products

Providers
- EPA AIRNow
- EPA R&D Model
- NASA DAACs
- others

Uniform Access

Data Processing
Web Service Chain

SciFlo

DataFed

Custom Processing

Info Products
Reports, Websites
- Forecasting
- Compliance
- Sci. Reports
- Other

**Users**
- Public
- Manager
- Scientist
- other

- The info system transforms the data into info products for each user
- In the first stage the heterogeneous data are prepared for uniform access
- The second stage performs filtering, aggregation, fusion and other operations
- The third stage prepares and delivers the needed info products
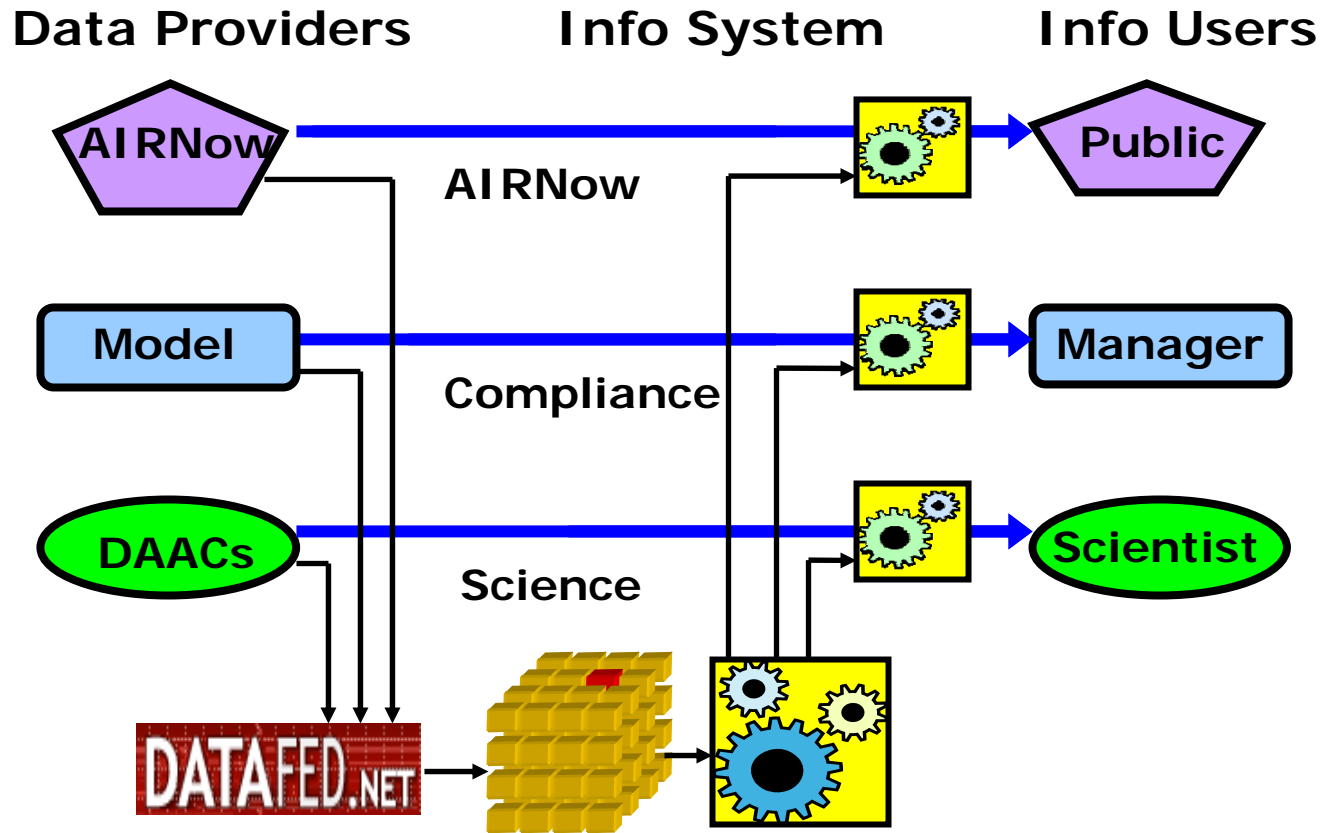
WCS/WMS Space-Time-Parameter queries

What few things **must be the same** so that everything else can be different?
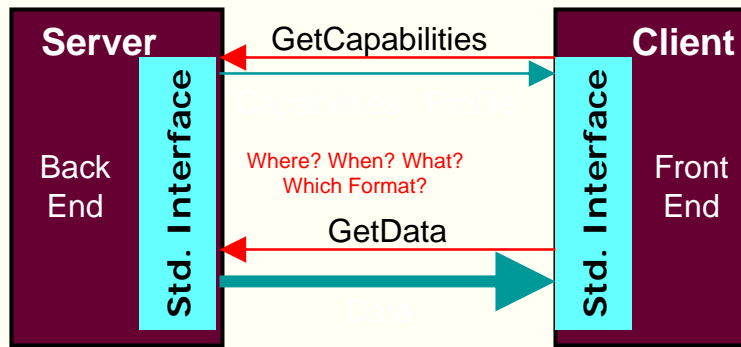
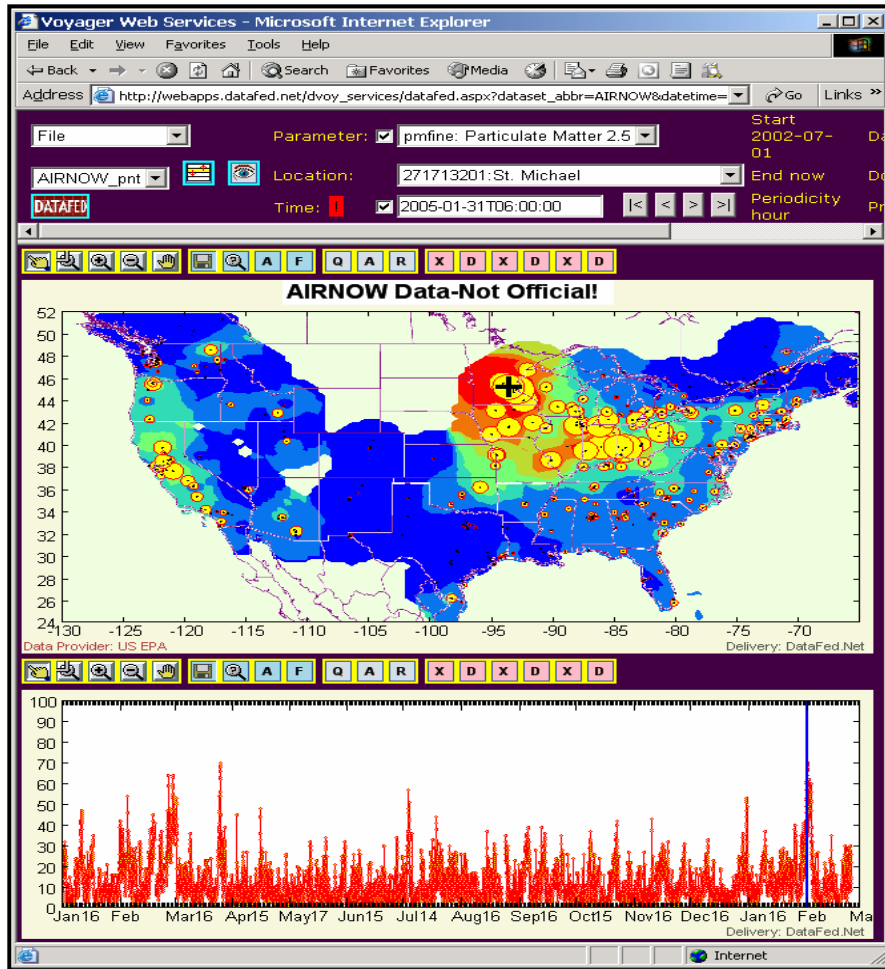| Query	GetData	Standards
Where?	BBOX	OGC, ISO
When?	Time^{T1} ^{T2}	OGC, ISO
What?	Temperature	CF
Format	netCDF, HDF..	CF, EOS, OGC
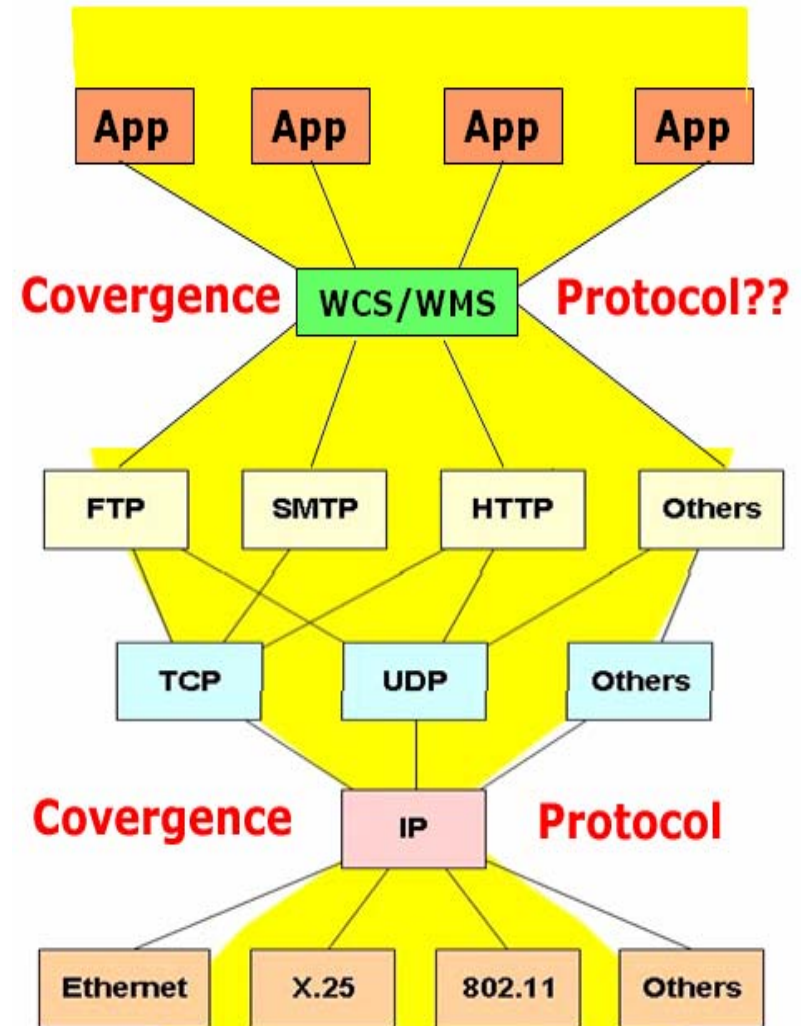
# 'Stovepipe' and Federated Usage Architectures Landscape

- Current info systems are **project/program oriented** and provide end-to-end solutions
- Part of the data resources of any project can be **shared for re-use** through DataFed
- Through the Federation, the **data are homogenized** into multi-dimensional cubes
- **Data processing** and rendering can then be performed **through web services**
- Each project/program can be **augmented by Federation data and services**
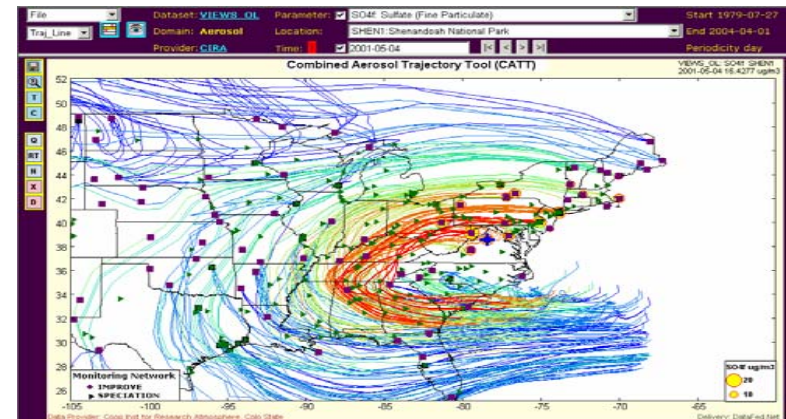
DataFed User Tools

Consoles: Data from diverse sources are displayed to create a rich context for exploration and analysis

- PlumeSim, Animator
- Combined Aerosol Trajectory Tool (CATT)

Viewer: General purpose spatio-temporal data browser and view editor applicable for all DataFed datasets
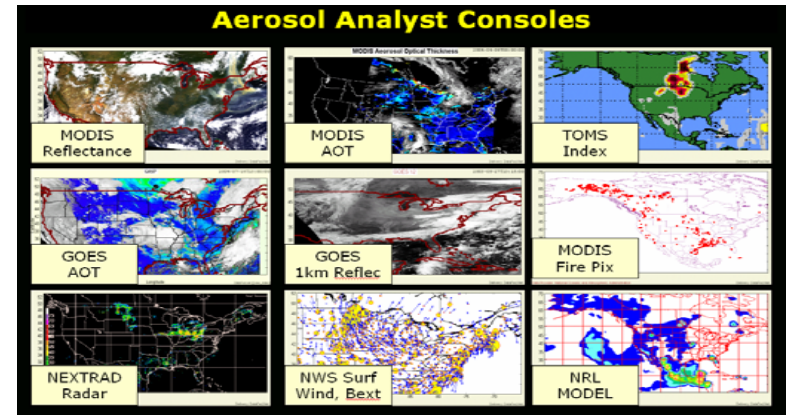
CATT: Combined Aerosol Trajectory Tool for the browsing backtrajectories for specified chemical conditions

DataFed User Tools

Viewer: Google Earth spatio-temporal data browser and view editor applicable for all DataFed datasets

Consoles: Data from diverse sources are displayed to create a rich context for exploration and analysis
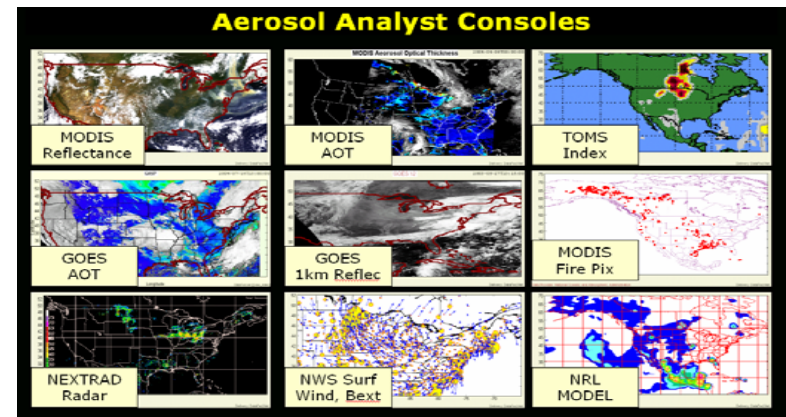

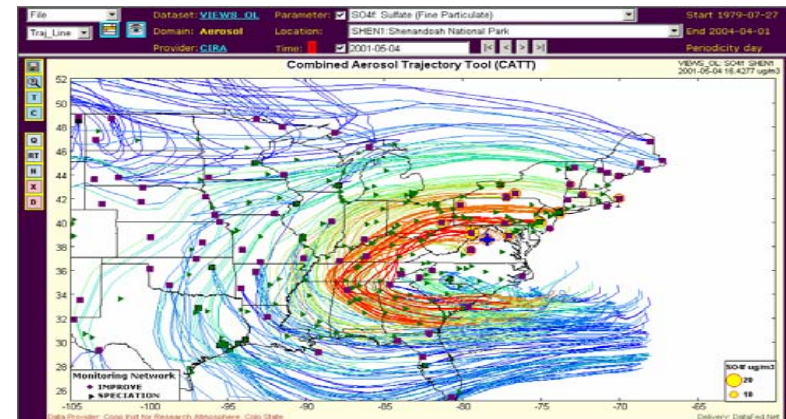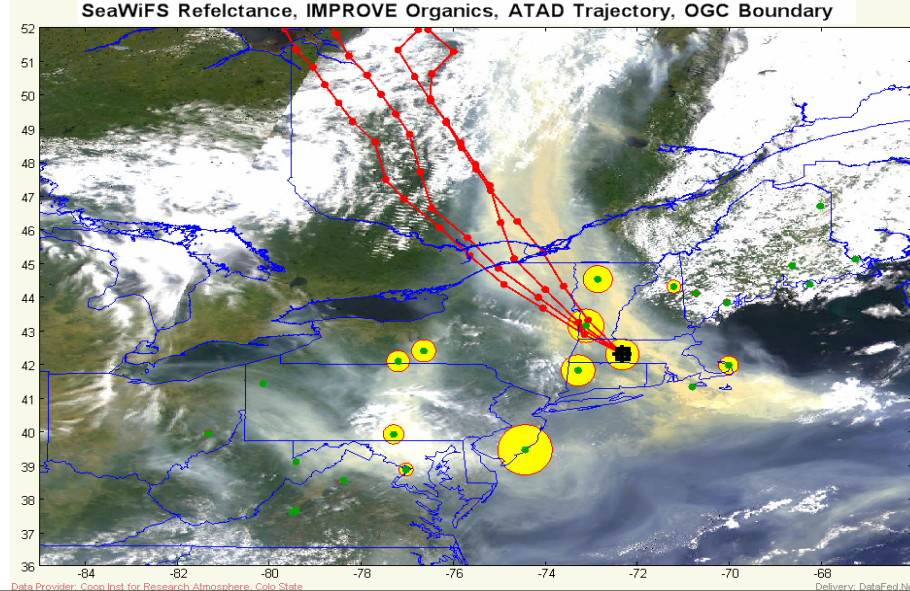**CATT:** Combined Aerosol Trajectory Tool for the browsing backtrajectories for specified chemical conditions

Web Services:
Building Blocks of DataFed Programming

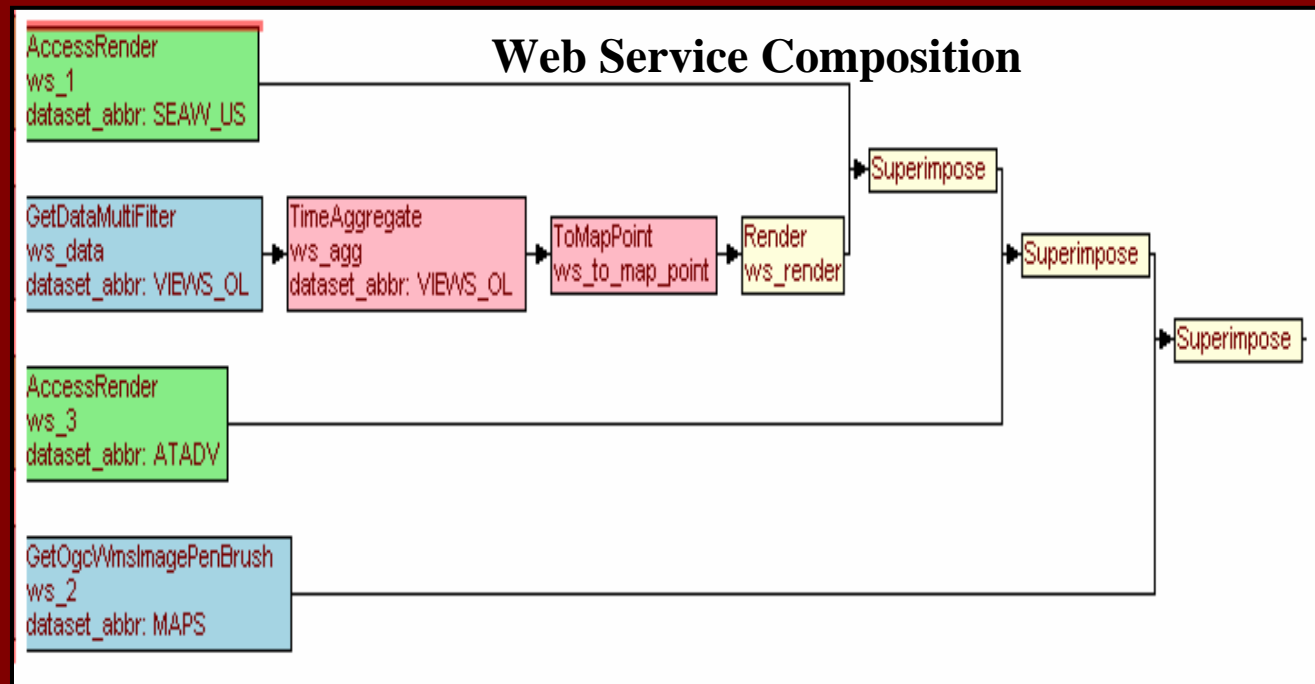## Access, Process, Render Data by Service Chaining

SeaWiFS Refelctance, IMPROVE Organics, ATAD Trajectory, OGC Boundary

LAYERS	Data Access	Data Processing	Layer Overlay

Web Service Composition

NASA SeaWiFS Satellite

AccessRender
ws_1
dataset_abbr: SEAW_US

RPO VIEWS Chemistry

GetDataMultiFilter
ws_data
dataset_abbr: VIEWS_OL

TimeAggregate
ws_agg
dataset_abbr: VIEWS_OL

ToMapPoint
ws_to_map_point

Render
ws_render

Superimpose

Superimpose

Superimpose

NOAA ATAD Trajectory

AccessRender
ws_3
dataset_abbr: ATADV

OGC Map Boundary

GetOgcWmsImagePenBrush
ws_2
dataset_abbr: MAPS

Over 50 Federated Datasets

Near Real Time Data Integration
Delayed Data Integration

Surface Air Quality
AIRNOW	O3, PM25
ASOS_STI	Visibility, 300 sites
VIEWS_OL	40+ Aerosol Parameters
METAR	Surface Visual Range

Satellite
MODIS_AOT	AOT, Idea Project
OMI	AI, NO2, O3, Refl.
TOMS	Absorption Indx, Refl.
SEAW_US	Reflectance, AOT

Model Output
NAAPS	Dust, Smoke, Sulfate, AOT
WRF	Sulfate

Emissions Inventories
NEI	Point, Area, Mobile
EDGAR	SO2,NOx,CO2

Fire Data
HMS_Fire	Fire Pixels
MODIS_Fire	Fire Pixels

- **Data are accessed from autonomous, distributed providers**
- **DataFed 'wrappers' provide uniform geo-time referencing**
- **Tools allow space/time overlay, comparisons and fusion**
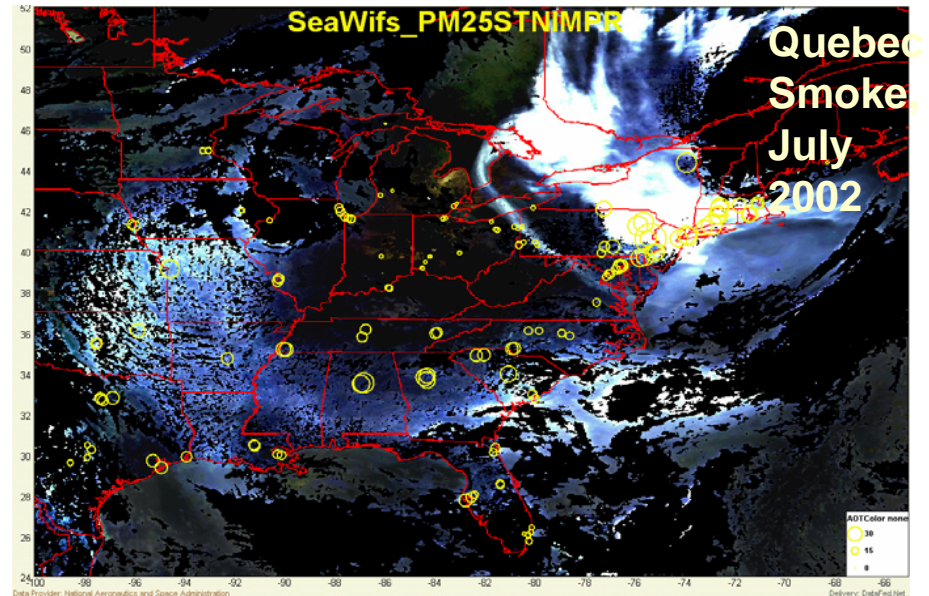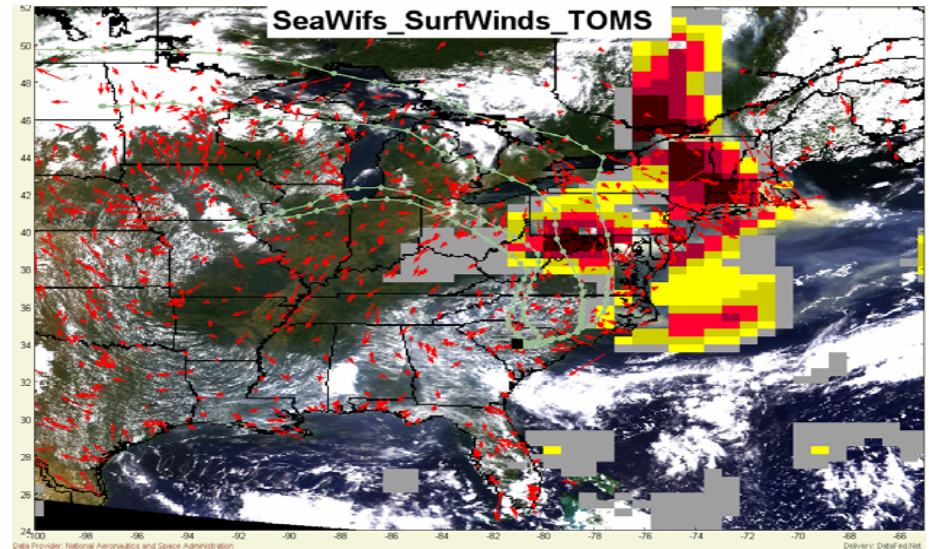
AQ Research/Management Example
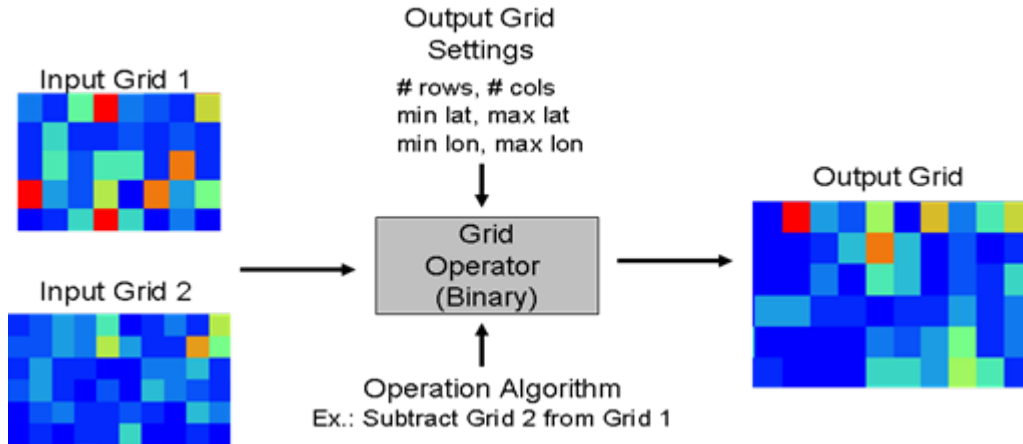

Federal Register

Environmental Protection Agency

40 CFR Parts 50 and 51

Treatment of Data Influenced by Exceptional Events; Final Rule

Satellite evidence for Exceptional Event (smoke, dust) is now permissible by the EE Rule!

SeaWifs_SurfWinds_TOMS

SeaWifs_PM25STNIMPR

Quebec Smoke July 2002

Analysis Services

Output Grid Settings
rows, # cols
min lat, max lat
min lon, max lon

Input Grid 1

Input Grid 2

Grid Operator (Binary)

Output Grid

Operation Algorithm
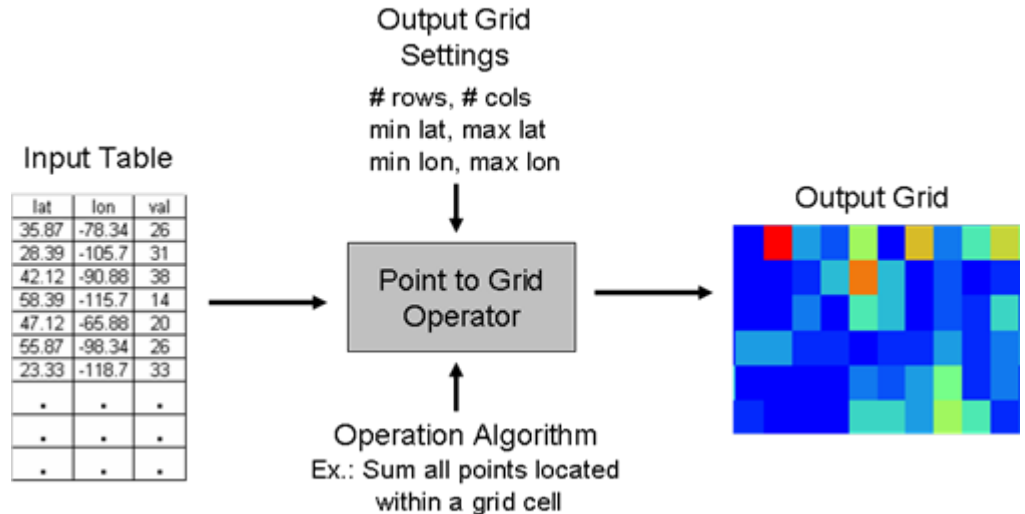Ex.: Subtract Grid 2 from Grid 1

Grid Operator Service

takes two grids as input, conducts a mathematical operation using their values, and creates a single grid output

Point-to-Grid Service

takes a set of latitude, longitude points and sums the associated values for all points that fall within each grid cell of an output grid

Input Table

lat	lon	val
35.87	-78.34	26
28.39	-105.7	31
42.12	-90.88	38
58.39	-115.7	14
47.12	-65.88	20
55.87	-98.34	26
23.33	-118.7	33
.	.	.
.	.	.
.	.	.

Output Grid Settings
rows, # cols
min lat, max lat
min lon, max lon

Point to Grid Operator

Output Grid

Operation Algorithm
Ex.: Sum all points located within a grid cell

Standards-based Interoperability

Standards for finding, accessing, portraying, and processing geospatial data are defined by the **Open Geospatial Consortium (OGC)**.

- ***Web Map Server (WMS)*** for exchanging map images
- ***Web Feature Service (WFS)*** retrieves discrete feature data
- ***Web Coverage Service (WCS)*** allows access to multidimensional data that represent coverages, such as grids.
- ***Sensor Observation Service (SOS)*** multidimensional access to measurement data

While these standards are based on the geospatial domain, many are designed to be extended to support non-geographic data "dimensions," such as time and pollutant species.

Geospatial One-Stop
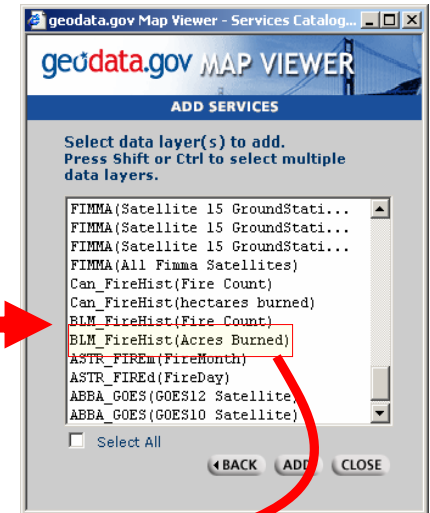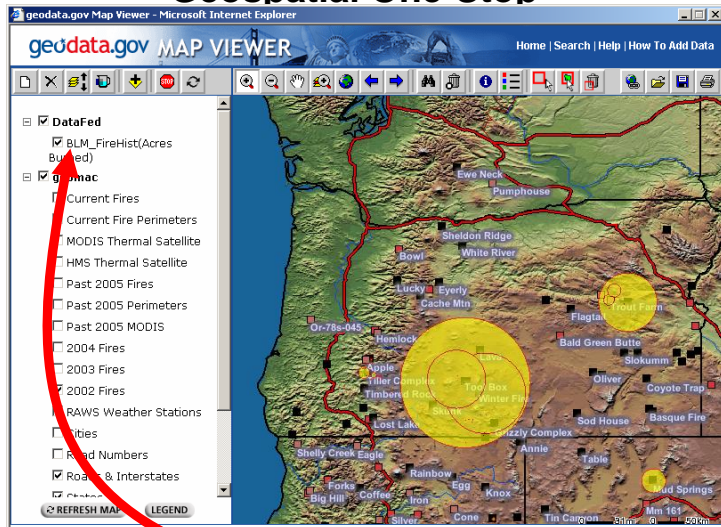
Web Application Framework

Web services are modular components that gain value when connected to form a **chain of services**, thereby creating a web application.

The services can be **geographically distributed** among servers. The services come together by way of a **workflow**, which constructs and manages a set of services chained together.
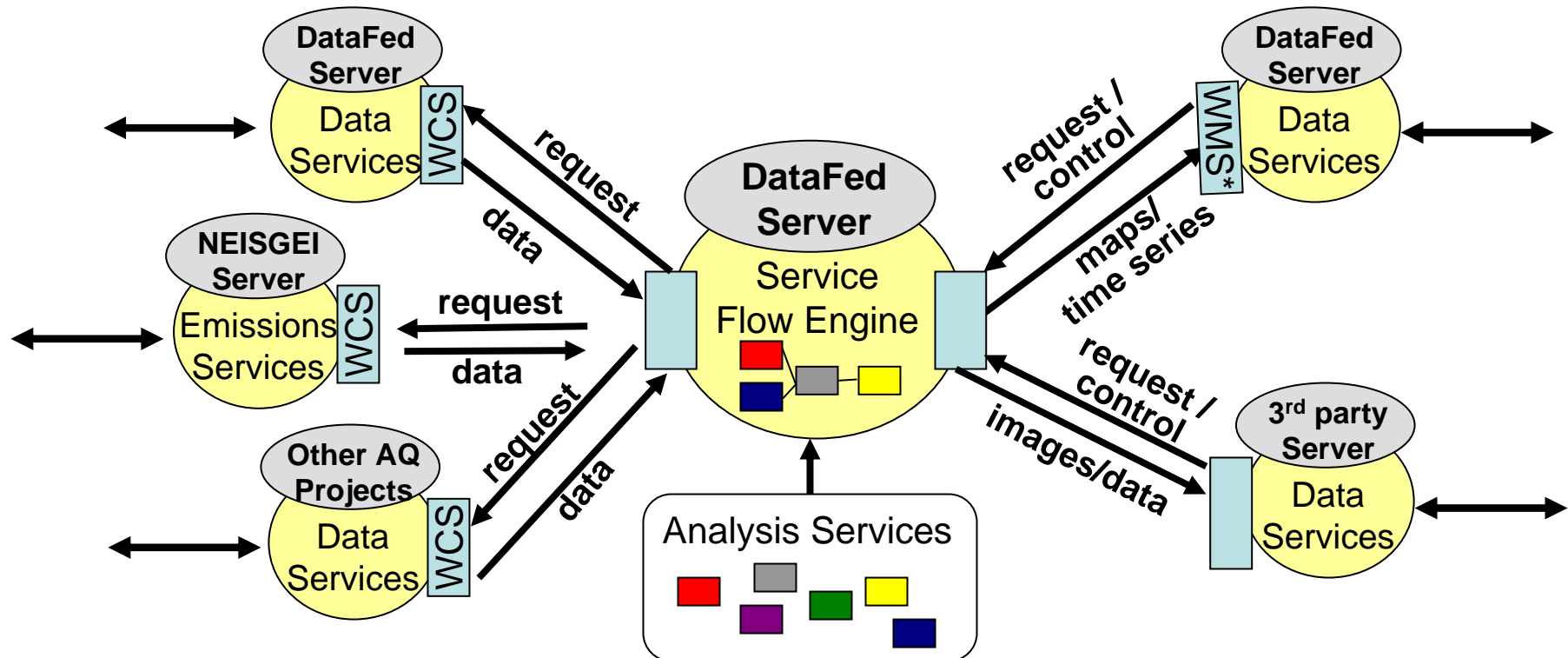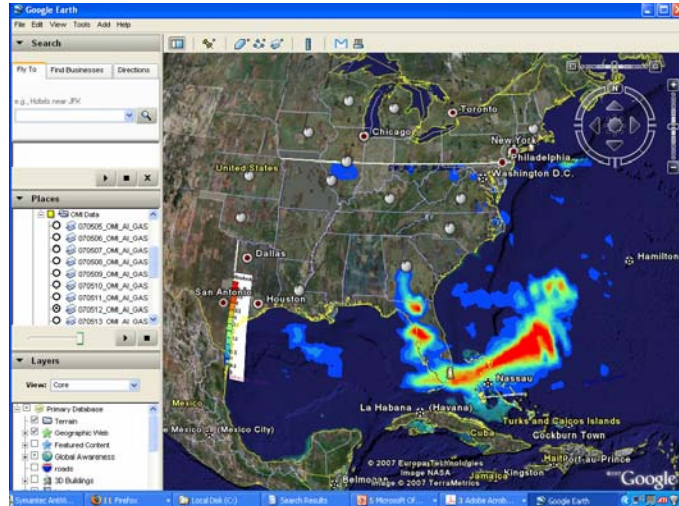

*The WMS request from the web application is extended to include non-standard WMS elements that control the service flow.
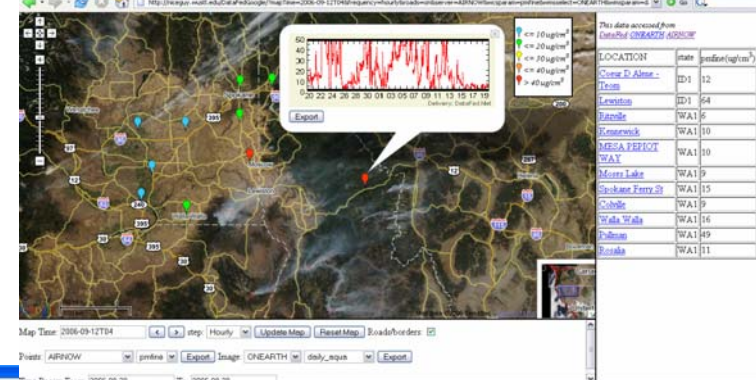
OMI NO2 Interoperability Network
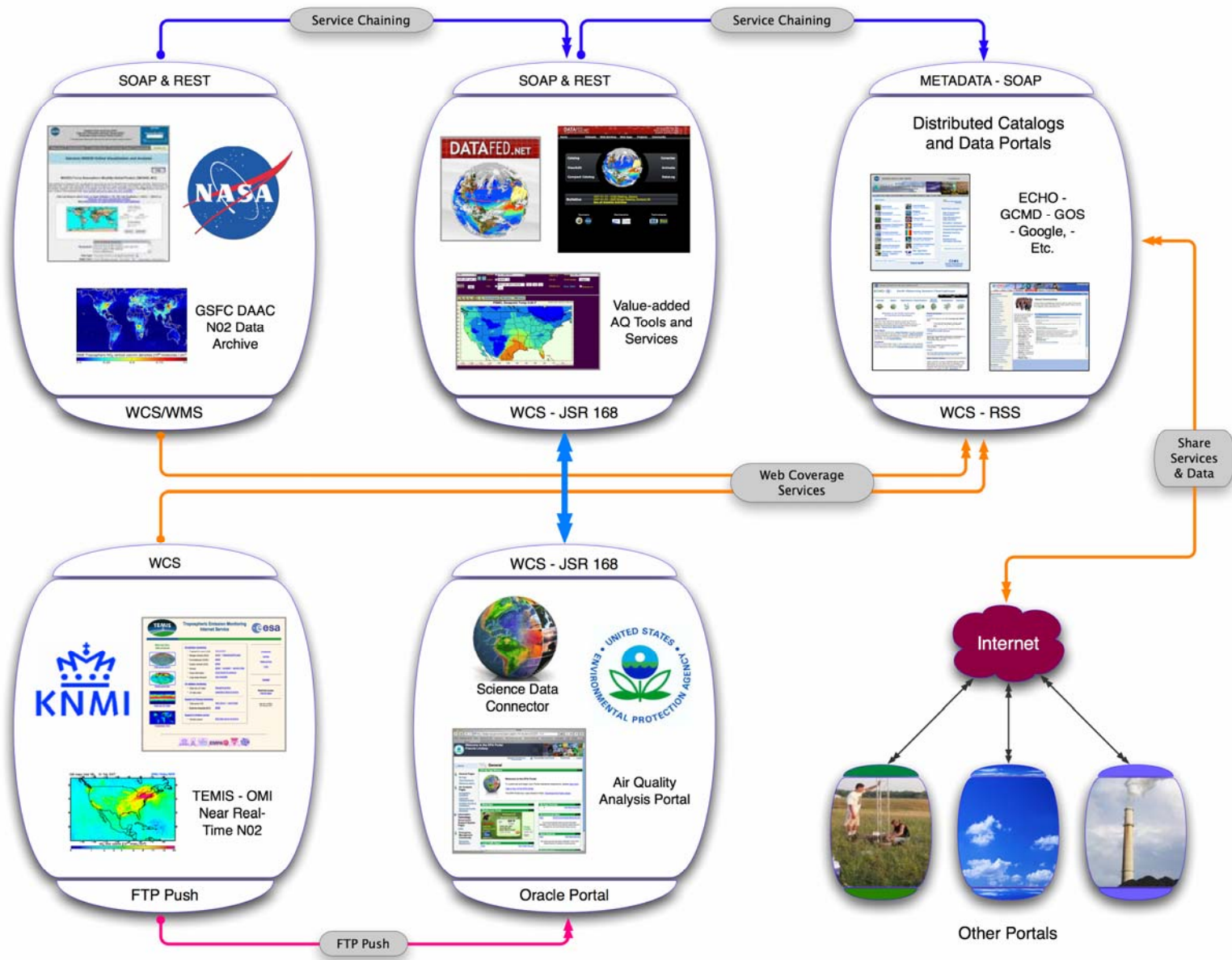
Interoperable Data and Analysis Services for Multiple Web Applications
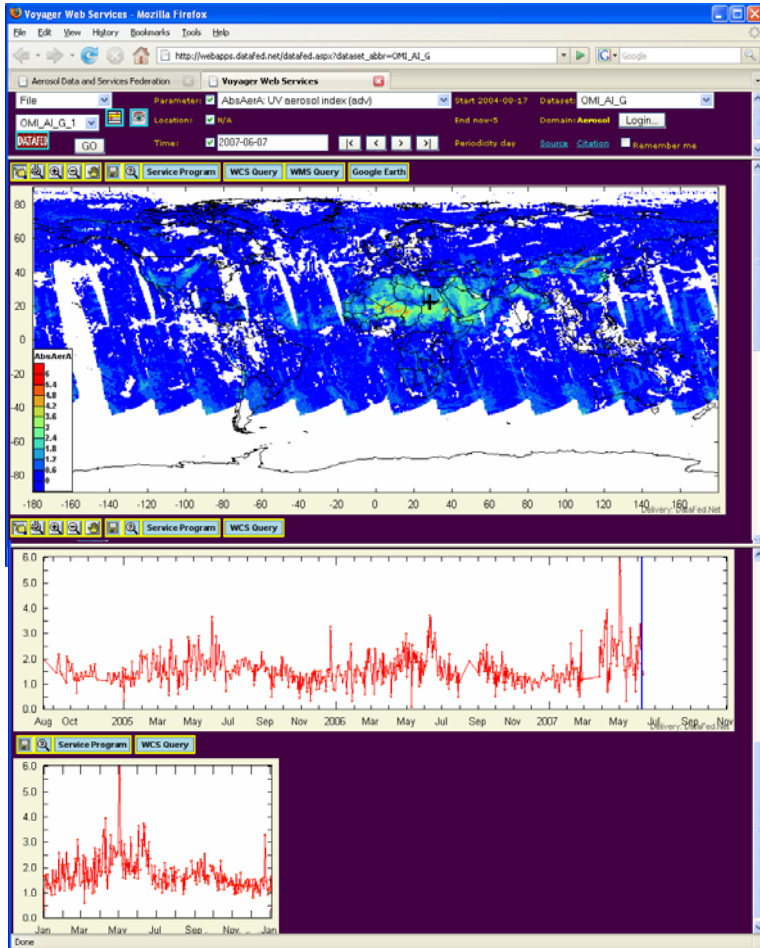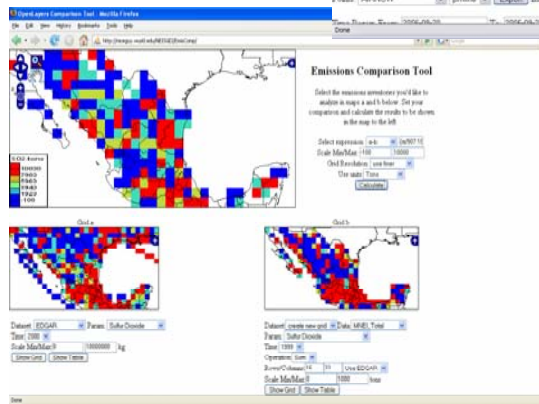

Visualization Application using GoogleEarth

Visualization Application using GoogleMaps

Data Comparison Application using OpenLayers

Visualization and Analysis Application using DataFed Browser