

# **DISTRIBUTED GEOCOMPUTATIONS AND WEB COLLABORATION**

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# **OVERVIEW**

- **Geoscience and Related IT Challenges**
- **New Cyberinfrastructure and Implications**
- **Advanced and Distributed Geocomputations**
- **Virtual Globes, Observatories and HUBs**
- **Sensor Networks and Sensorwebs**
- **Geosciences Network and Open Earth Framework**
- **Examples: Turtle Mountain, glaciers, ...**
- **Web collaboration and potentials**
- **Semantic Web and Implications**
- **Concluding Remarks**

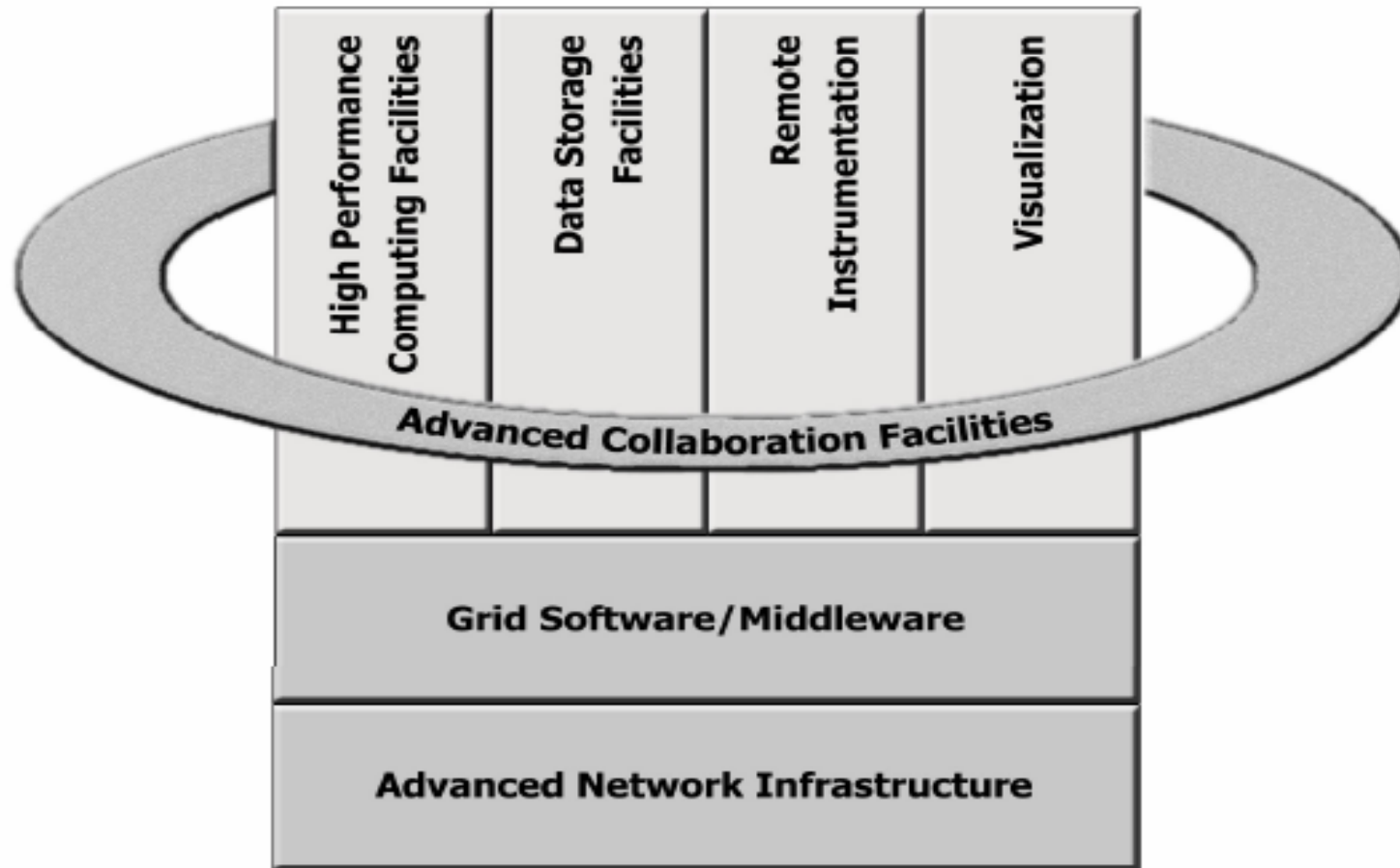
# **GEOSCIENCE & IT CHALLENGES**

- **Exponential increase in data volumes**
  - **Complexity and diversity of observations/measurements**
  - **Data processing, integration, fusion and preservation**
  - **Computational challenges and reproducibility**
  - **Advanced visualization in 3D and 4D**
  - **Archiving publications with reusable components**
  - **Web access as new pathway to scientific discovery**
- **Distributed geocomputations and web collaboration are the way of the future in the Earth (and other) sciences!**

# **CYBERINFRASTRUCTURE**

- **Classical infrastructure:**  
roads, mail service, utilities, etc.
- **New infrastructure:**  
advanced communications, high performance computers,  
advanced research networks, 3D & 4D visualization tools,  
data storage facilities, networks of remote sensors,  
advanced collaboration facilities, etc.

# CI FRAMEWORK



Source: Cyberinfrastructure Whitepaper, Alberta's Research Infrastructure, 2006

# DISTRIBUTED COMPUTATIONS

- **Defined in many different ways in different contexts**
- **Distributed computing means using resources over a network**
- **Computations include simple to complex varied tasks**
- **Closely related to parallel computing for concurrent tasks**
- **Subset of Grid Computing for HPC over extensive networks**
- **Examples:**
  - DataGrid ([www.eu-datagrid.org](http://www.eu-datagrid.org)) led by CERN and five other partners
  - Distributed Net ([www.distributed.net](http://www.distributed.net)) in cryptographic applications
  - Particle Physics Data Grid ([www.ppdg.net](http://www.ppdg.net)) by ANL, BNL, Caltech, ...
  - SETI@Home ([setiathome.ssl.berkeley.edu](http://setiathome.ssl.berkeley.edu)) for extraterrestrial life
  - BOINC ([boinc@berkeley.edu](mailto:boinc@berkeley.edu)) for volunteering computing cycles
  - LAS ([www.ferret.noaa.gov/LAS](http://www.ferret.noaa.gov/LAS)) Live Access Server at NOAA/PMEL

# VIRTUAL GLOBES/OBSERVATORIES/HUBS

**Virtual Earth Globes** for displaying and visualizing information:

- GOOGLE™ EARTH ( <http://earth.google.com> )
- Microsoft Virtual Earth ( <http://www.microsoft.com/virtualearth/> )
- Poly9 FreeEarth ( <http://freeearth.poly9.com> )

**Virtual Observatories** for sensors, data, tools and computations:

- National Virtual Astronomical Observatory ( <http://us-vo.org> )
- Virtual Geomagnetic Observatory ( <http://mist.engin.umich.edu> )

**Virtual HUBs** for Linux Apache servers with LDAP, PHP, Joomla:

- HUBzero and nanoHUB ( <http://www.hubzero.org> )
- Demo with nanoHUB ( <http://www.hubzero.org/demo.html> )

# GEOSCIENCES NETWORK

([www.geongrid.org](http://www.geongrid.org))

**GEON Project, San Diego Supercomputer Center:**

**SDSC**

Project Manager: **Christopher Crosby** ([ccrosby@sdsc.edu](mailto:ccrosby@sdsc.edu))

Project Technical Lead: **Viswanath Nandigam** ([viswanat@sdsc.edu](mailto:viswanat@sdsc.edu))

GEON Principal Investigator: **Chaitan Baru** ([baru@sdsc.edu](mailto:baru@sdsc.edu))

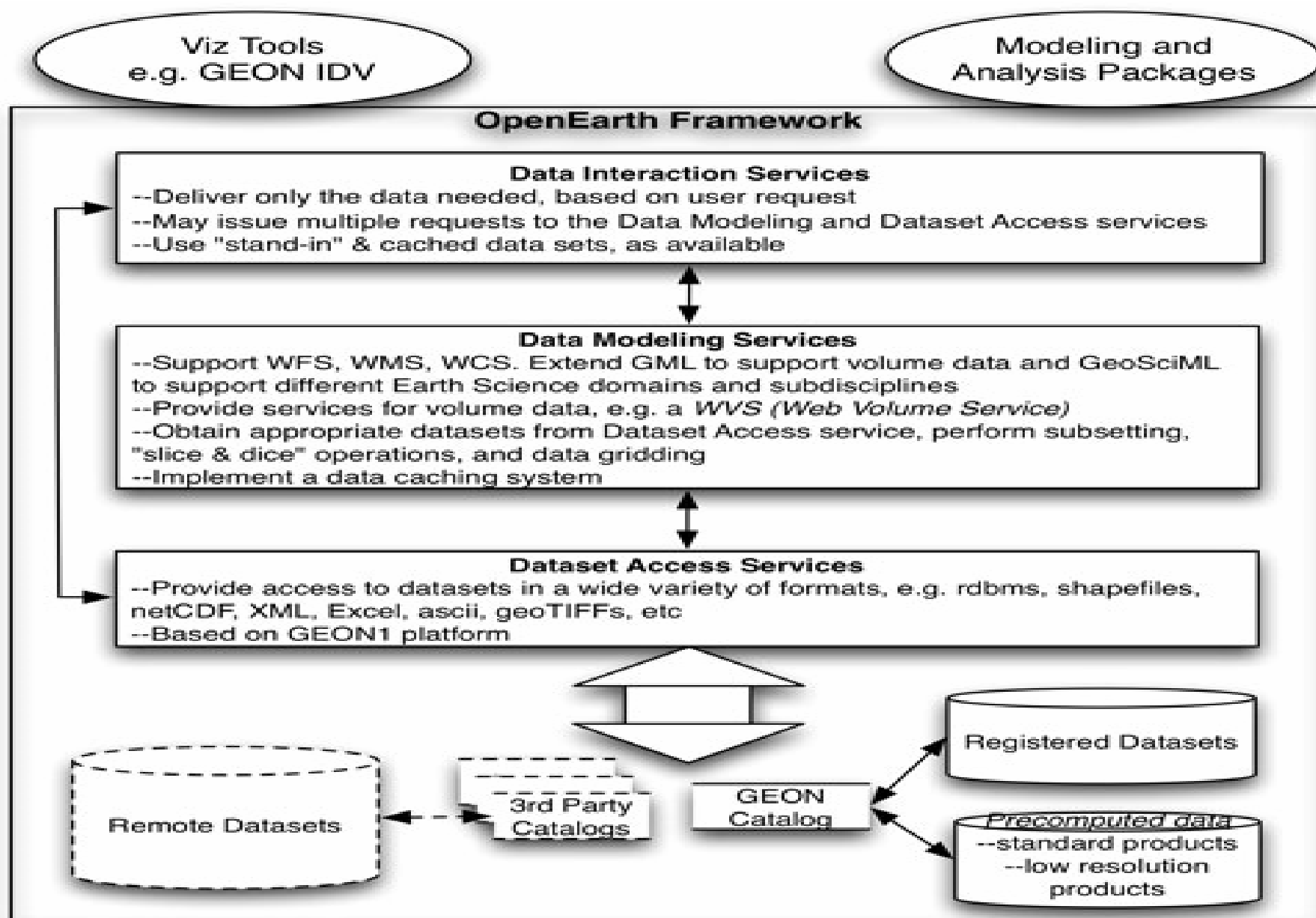
**Active Tectonics Group, Arizona State University:**

**ASU**

GEON Co-Investigator: **J Ramon Arrowsmith** ([ramon.arrowsmith@asu.edu](mailto:ramon.arrowsmith@asu.edu))

Research Developer: **Santhanakrishnan Balakrishnan** ([sbalakr5@asu.edu](mailto:sbalakr5@asu.edu))





Source: [www.geongrid.org](http://www.geongrid.org)



Create a bounding box for plotting Events and Stations

bounding box

latitude 32.826 longitude -114.932



[datasets](#)

[map](#)

[options](#)

Start Over

Clear Map

Print Map

Help

### Event:

Latitude:  
Longitude:

Depth:  
Magnitude:

### Station:

Latitude:  
Longitude:

Begin Time:  
End Time:

[info](#)

Guest Role

[control panel](#)

### Access IRIS Data

#### Define Time Range

Begin Time

End Time

☒ Retrieve Events

☐ Retrieve Stations

☐ Retrieve Waveforms

☐ Show Waveform Window

### Virtual Events & Stations

Drag and Drop an Earthquake or Station onto the map.

Earthquake

[CLEAR EVENT](#)

Stations

[SELECT ALL STATIONS](#)

[CLEAR STATIONS](#)

[Define Station\(s\)](#)

[Define Event](#)

### Run Simulation

Run Simulation

Open Job Manager



GEON is an open collaborative project that is developing cyberinfrastructure for integration of 3 and 4 dimensional earth science data

Search

Go



website



data & tools

Home

myGEON

Topography

Geophysics

Geology

**Collaborations**

Education & Training

CloudStor

EarthScope

GEO Grid

GEON India

CBEO

tDAR

GIN

NTC

[Login](#) | [Request an Account!](#)



PI Institution



Collaborations



Workshops



PI Institution & Collaborator







## Search Interface

### Map Interface



Reset Map

Stop Search

Expand Clusters

### Search [Selected Stations](#)

[Find Data](#) [Find Stations](#) [Help](#)

#### Data Classes [?](#)

- ☒ ▲ Seismic
- ☒ ● GPS
- ☒ ■ Strain
- ☒ ◆ Drillinglogs
- ☒ ● Tilt
- ☒ ■ PhysicalSample
- ☒ ▲ Environmental
- ☒ ★ MT

#### Temporal Coverage [?](#)

between     
and

#### Spatial Coverage [?](#)

Lat: min  max   
Lon: min  max

[Select This Region](#)

#### Station [?](#)

Network:   Station:



#### ➤ LiDAR Point Cloud Data

- [Northern San Andreas Fault \(NSAF\), CA](#)
- [West Rainier Seismic Zone, WA](#)
- [Fault systems in the Eastern California Shear Zone \(ECSZ\)](#)
- [B4: Southern San Andreas Fault](#)
- [GeoEarthScope Northern California LiDAR Project \(NoCAL\)](#)

#### ➤ Standard DEMs

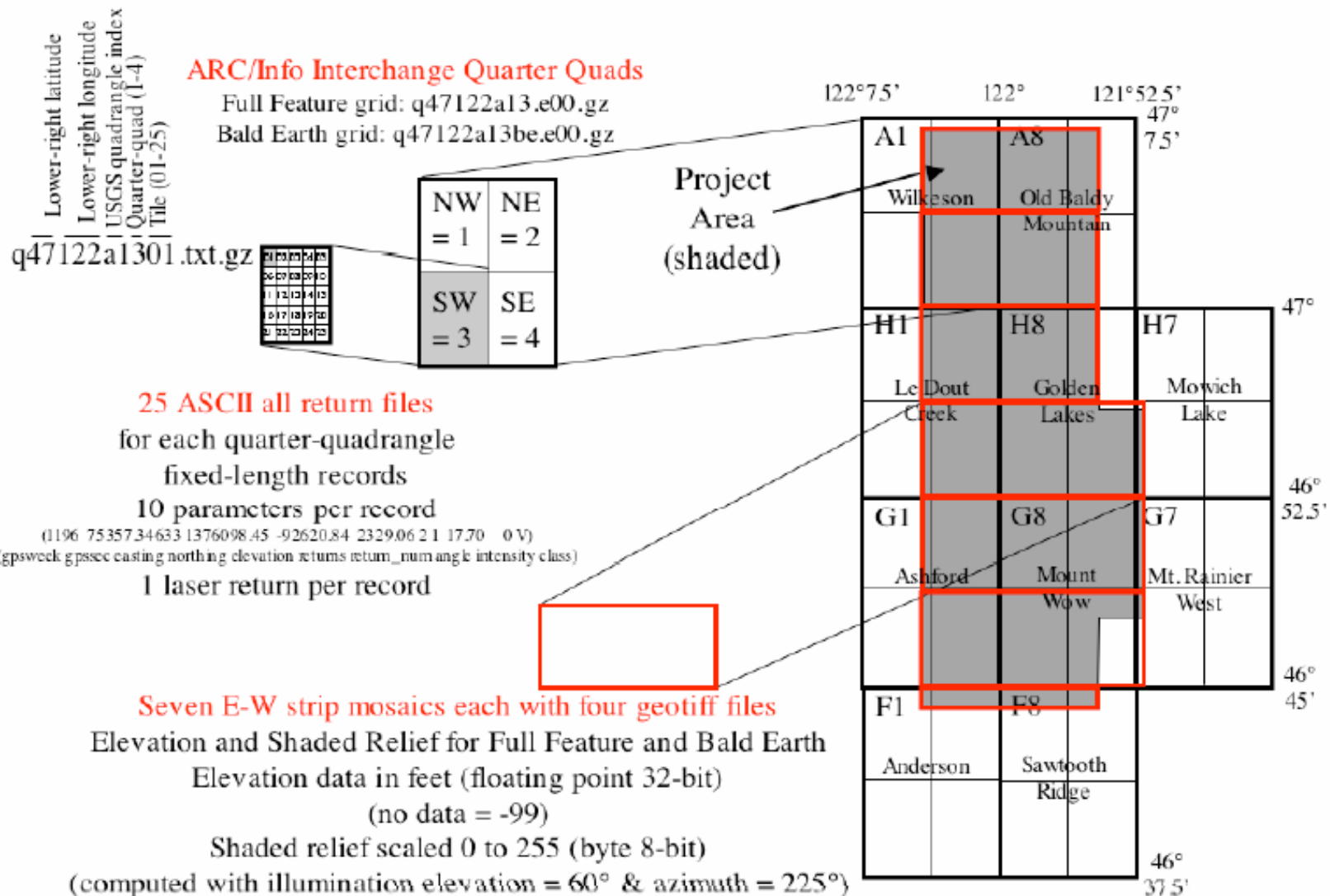
- [GeoEarthScope Intermountain Seismic Belt LiDAR Project \(ISB\)](#)
- [GeoEarthScope Southern & Eastern California LiDAR Project \(SoCal\)](#)
- [GeoEarthScope Northern California LiDAR Project \(NoCal\)](#)

#### ➤ Google Earth Files

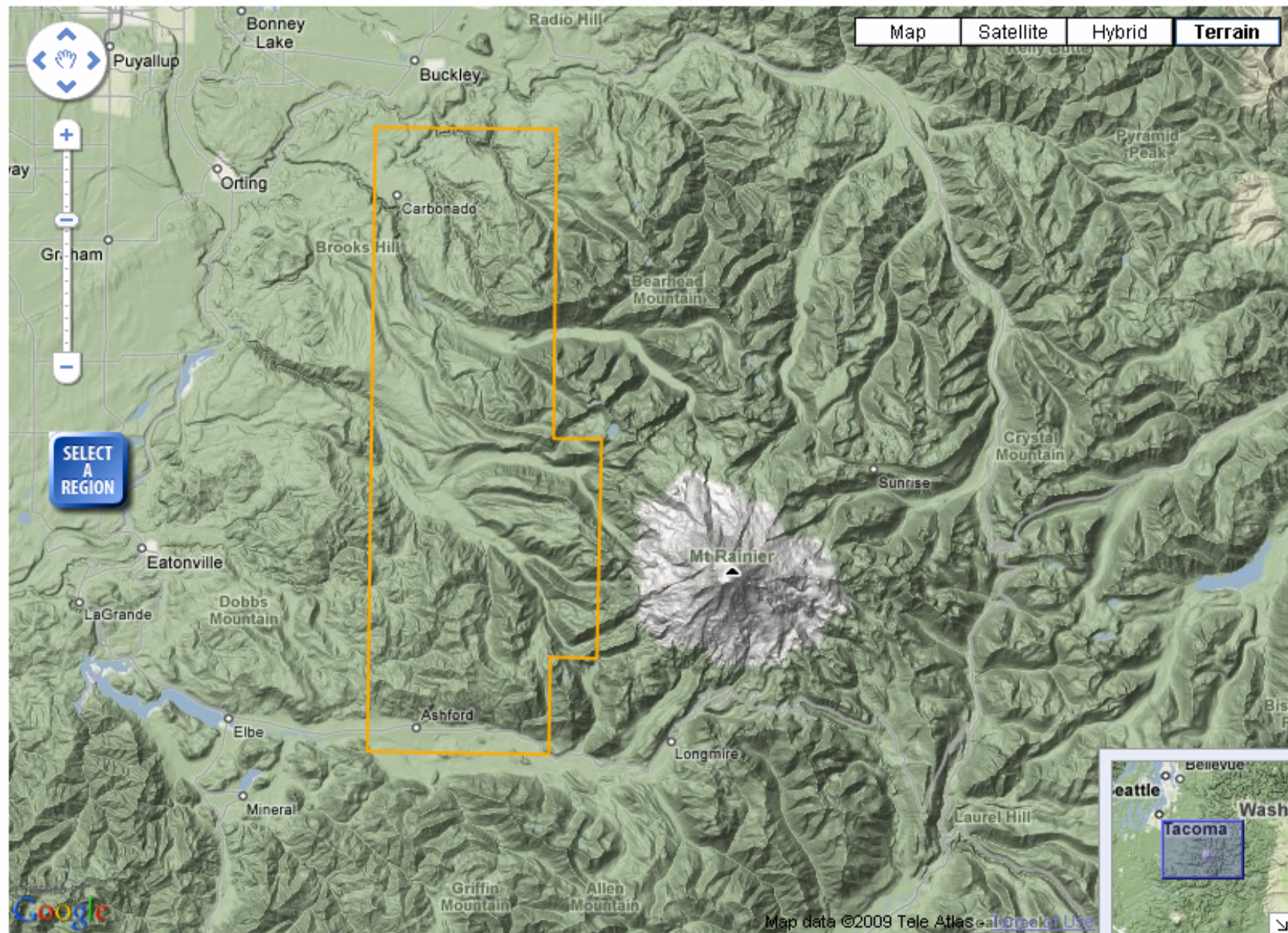
- [Intermountain Seismic Belt GeoEarthScope LiDAR Hillshades](#)
- [Southern & Eastern California GeoEarthScope LiDAR Hillshades](#)
- [Southern & Eastern California GeoEarthScope LiDAR DEM Tiles](#)
- [Northern California GeoEarthScope LiDAR Hillshades](#)
- [Northern California GeoEarthScope LiDAR DEM Tiles](#)
- [B4 Project \(San Andreas & San Jacinto Fault\) LiDAR Hillshades](#)



## Western Mt. Rainier Project Area LIDAR Data Coverage by USGS Quarter Quadrangle



# Interactive Spatial Selection of LiDAR Topography



# EUROPEAN NETWORKS

## **Distributed European Infrastructure for Supercomputing Applications**

**DEISA** ([www.deisa.eu](http://www.deisa.eu))

**(Consortium of HPC infrastructures and services)**

**EGEE** ([www.eu-egee.org](http://www.eu-egee.org)) **Enabling Grids for E-Science**

**(Largest multidisciplinary grid infrastructure in the world,  
with > 80,000 CPUs, > 300 sites, >2x10<sup>16</sup> B of data storage)**

## **DEGREE projects** ([www.eu-degree.eu](http://www.eu-degree.eu)):

**(a) GeoCluster** ([www.cggveritas.com/default.aspx?cid=4-13-1925](http://www.cggveritas.com/default.aspx?cid=4-13-1925))

**Seismic data processing, imaging and underground reservoirs**

**(b) Institut du Globe de Paris on EGEE** ([geoscope.ipgp.jussieu.fr](http://geoscope.ipgp.jussieu.fr))

**Seismic early warning system for natural hazards**

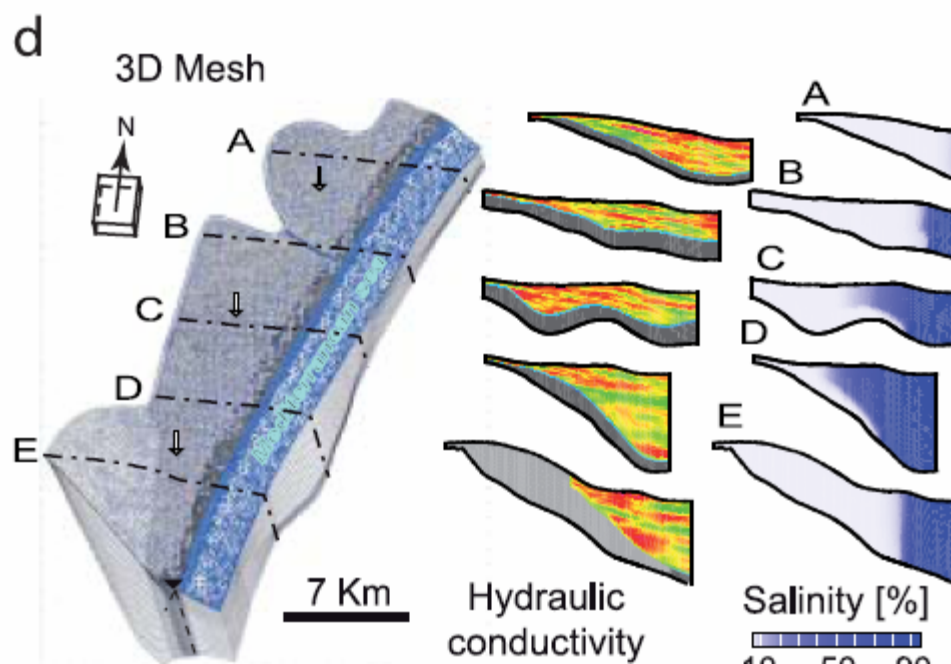
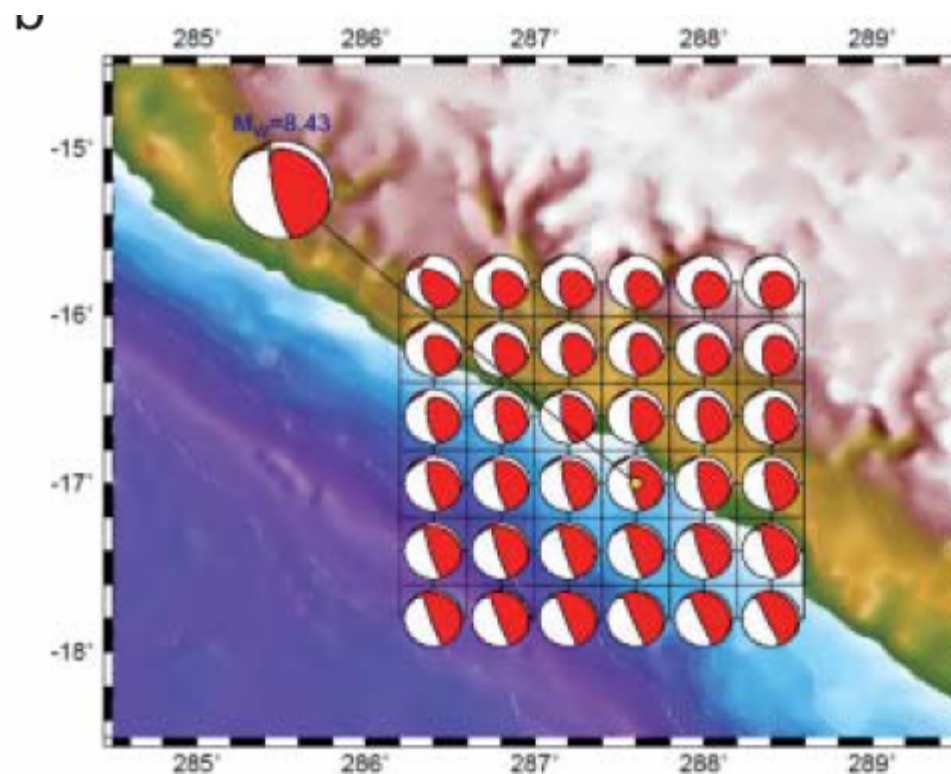
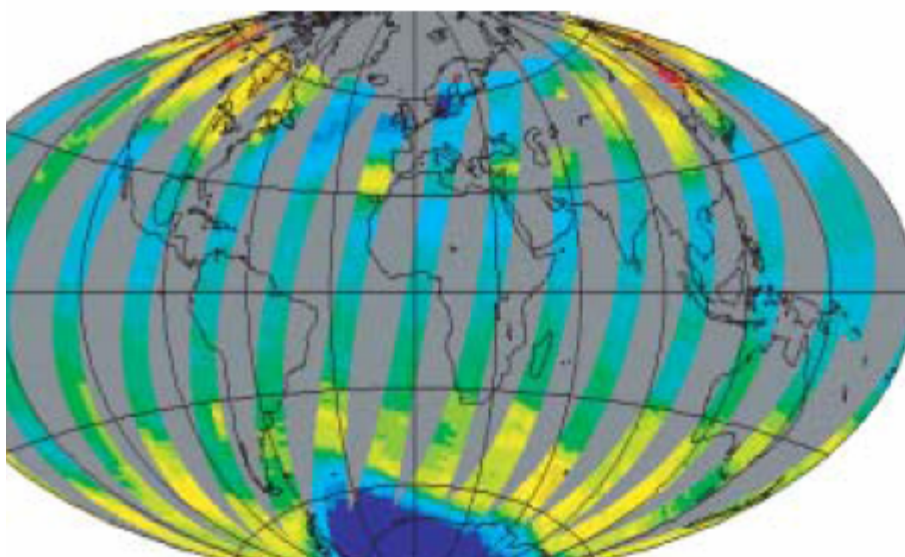
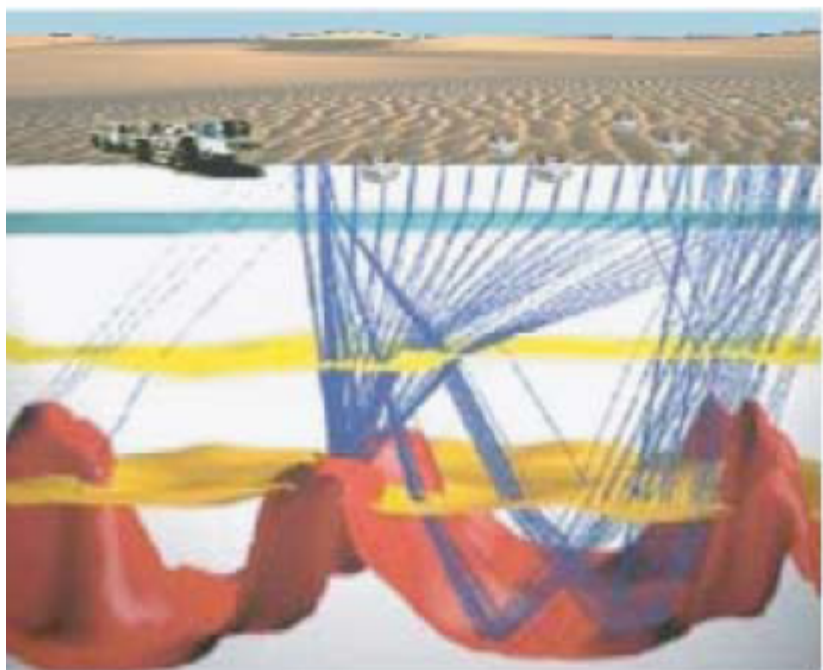
**(c) Global Ozone Monitoring Experiment on ERS**

**Neural network using atmospheric ozone profiles & LIDAR data**

**(d) Coupled Variable Density and Saturation in 3-D** ([www.eumedgrid.org](http://www.eumedgrid.org))

**Finite Element and Monte Carlo simulation experiment**





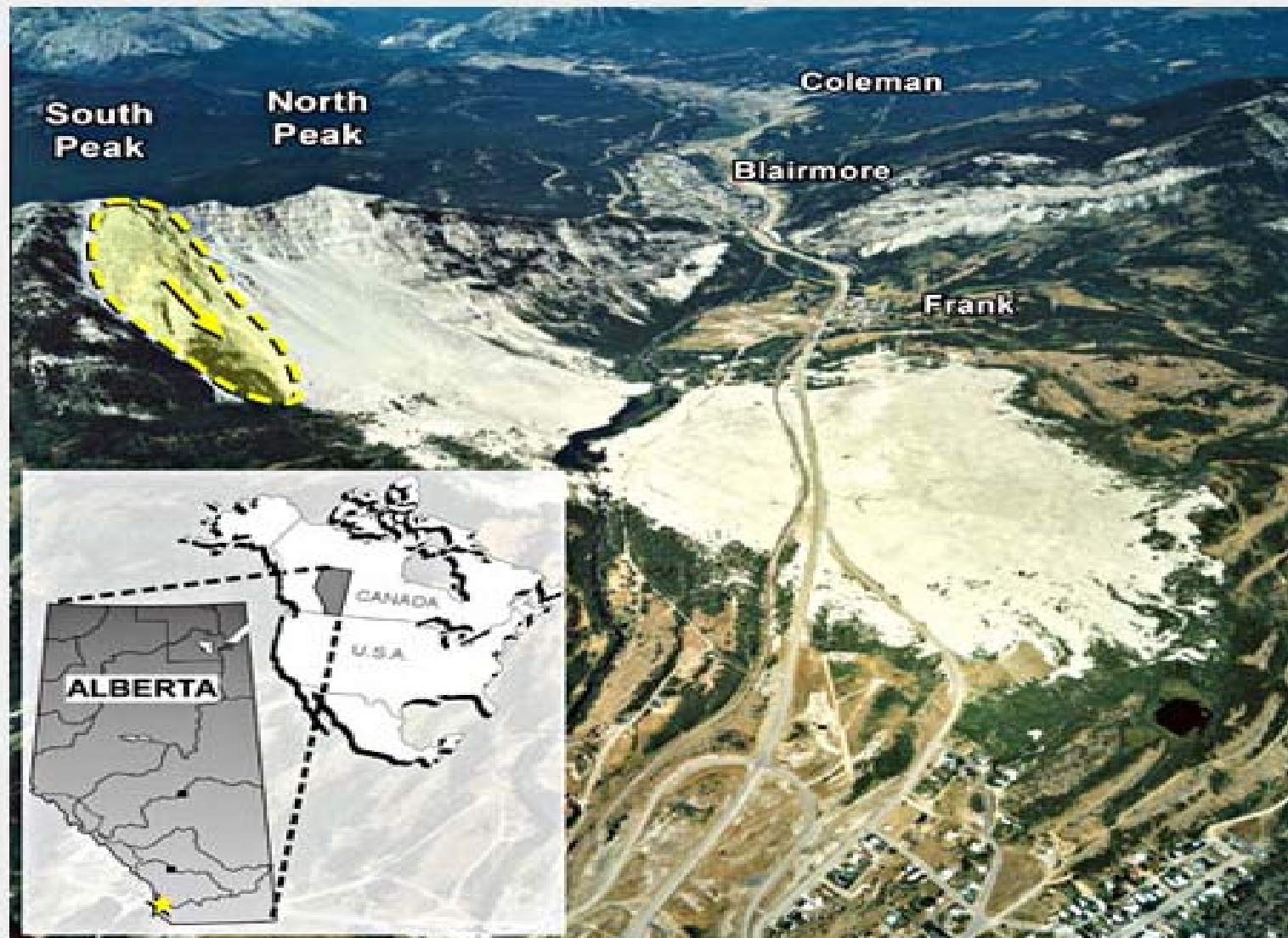
# **SENSOR NETWORKS & WEBS**

- **An amorphous network of spatially distributed sensor platforms (pods) that (wirelessly) communicate with each other [Delin, 1997]**
- **A Sensor Web also refers to sensors connected to the Internet or WWW**
- **OGC's Sensor Web Enablement (SWE) aims at interoperability standards including SensorML, an extension of XML [Reichardt, 2003]**
- **SWE supports heterogeneous sensors, models, simulations and decision support tools in compliance with SOA principles**
- **SWE has standard specifications for Encodings and Web Services**
- **Realizing visions of a worldwide Sensor Web will take some time ...**
- **Interoperability of information has enormous potential for  
the scientific community, including geoscience,  
infrastructure and environment management,  
intelligence, security and even the general public**

# **TURTLE MOUNTAIN**

**([www.ag.gov.ab.ca/geohazards/turtle\\_mountain](http://www.ag.gov.ab.ca/geohazards/turtle_mountain))**

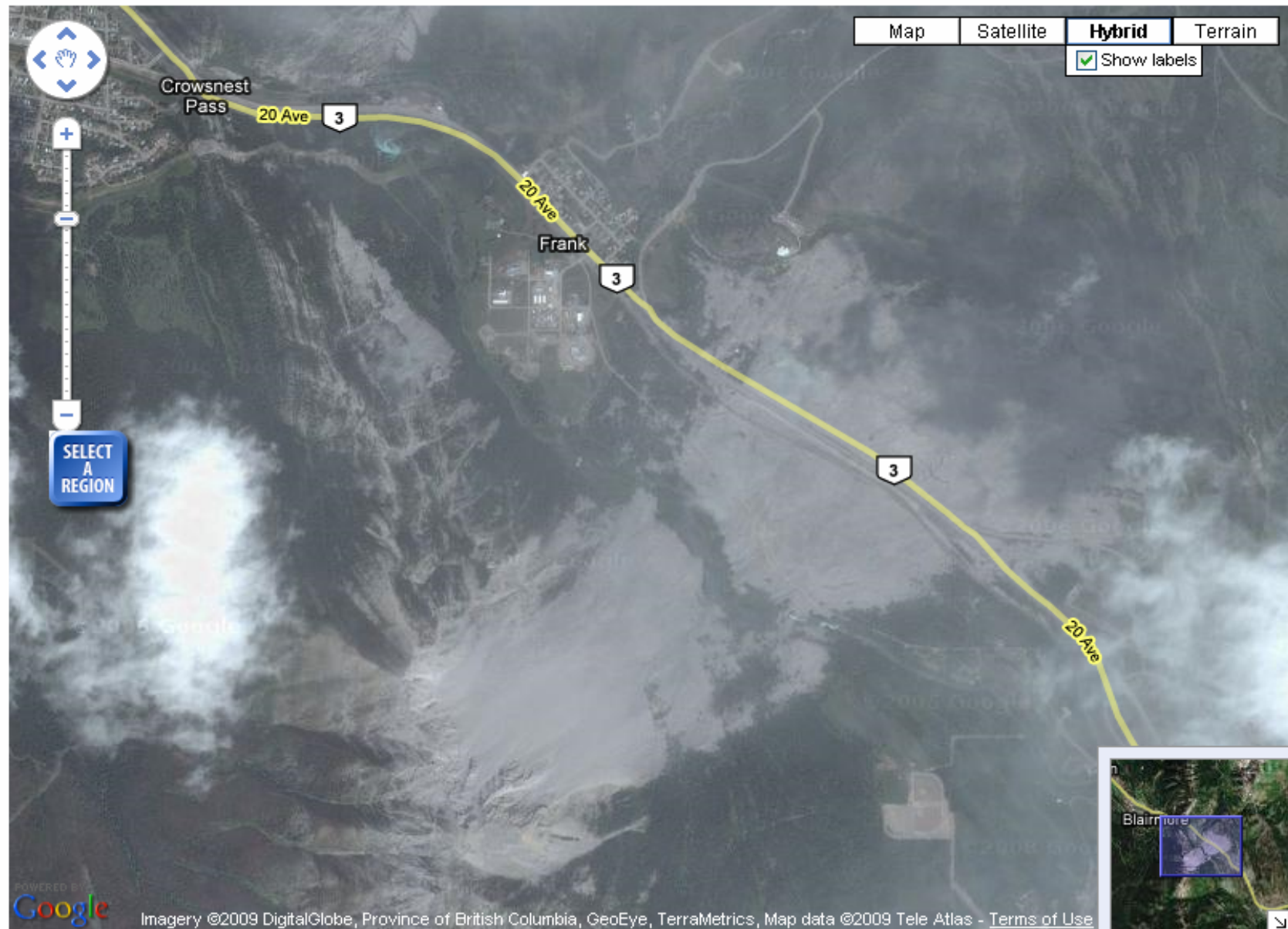
- **1903: Catastrophic rock avalanche that buried the town of Frank, AB**
- **$5 \times 10^6$  m<sup>3</sup> of rock in South Peak area are likely to fail again (J. Allan)**
- **2003-2005: Large multidisciplinary study led to Geological Report**
- **2005: Program & Budget for long-term monitoring and studies**
- **First priority: early warning for possible rock avalanche**
- **Second priority: field laboratory for research community**
- **Sensor network: some 40 state-of-the-art sensors such as**
  - **22 crackmeters, 5 extensometers, 10 tiltmeters**
  - **11 dGPS receivers, 19 reflective prisms**
  - **6 station passive seismic network, weather station**
- **Website: Geology, GIS Maps, Reports, Services, Search**
- **Online digital images and other data available for analysis**



**Aerial photo: The yellow, dashed line shows the most unstable area below South Peak on Turtle Mountain. Inset photo: The star shows the location of Turtle Mountain in Alberta.**



## Interactive Spatial Selection of LiDAR Topography





Source: [www.depiction.com](http://www.depiction.com)

## Manage Content



4 elements in this depiction

**Elements**

Needs geo-aligning

List by types



☐ Image (2)



Imagery (NASA Landsat 7)



Street Map (OpenStreetMap)

☐ Road network (1)



Road Network (OpenStreetMap)

☐ Elevation data (1)



CDED Elevation Data (Canada)

View / Edit

Export

Email

Delete

Close

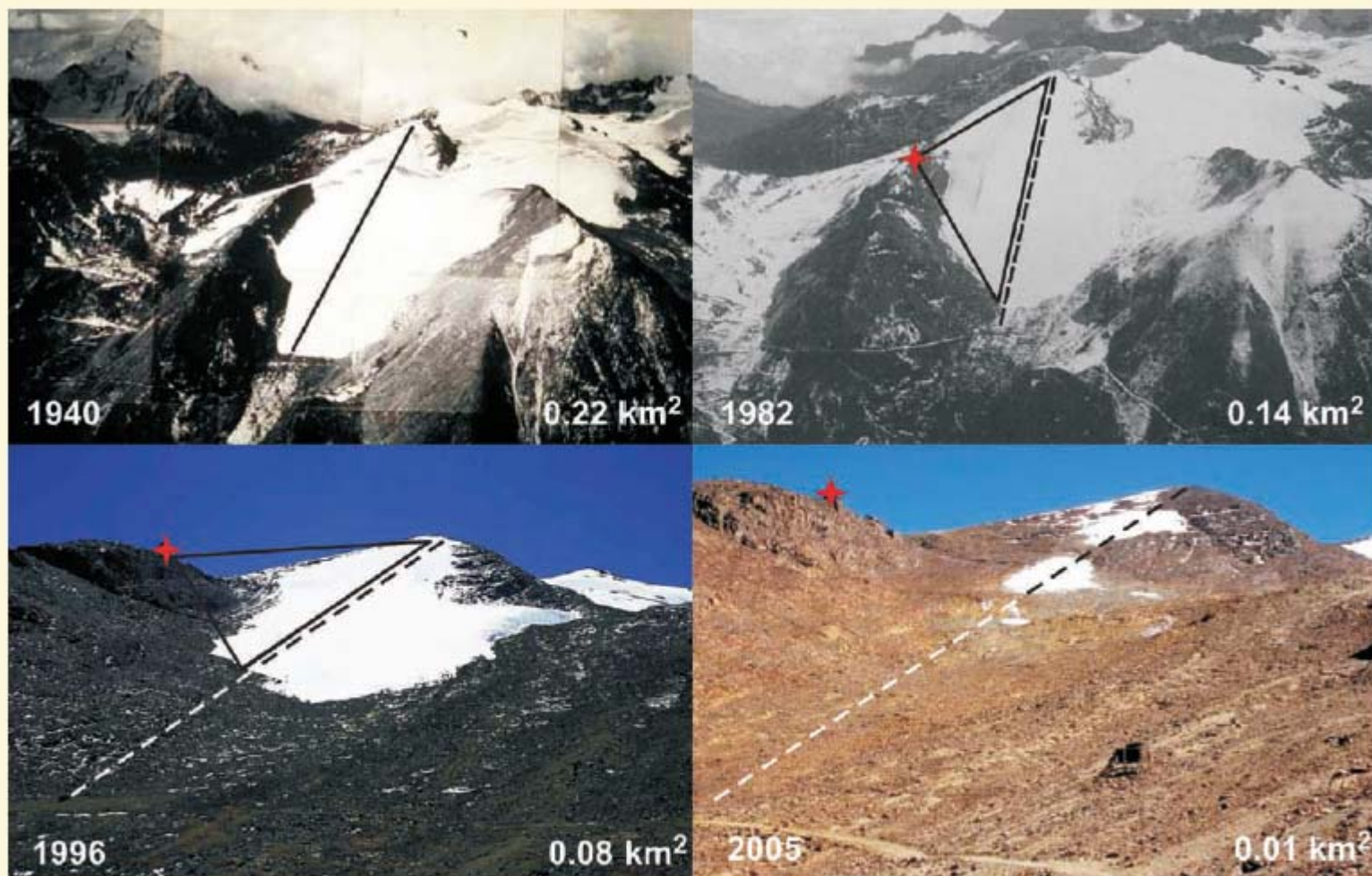






**Salmon Glacier, Northern BC**





**Figure 1.1.** Areal extent of Chacaltaya Glacier, Bolivia, from 1940 to 2005. By 2005, the glacier had separated into three distinct small bodies. The position of the ski hut, which did not exist in 1940, is indicated with a red cross. The ski lift, which had a length of about 800 m in 1940 and about 600 m in 1996, was normally installed during the summer months (precipitation season in the tropics) and covered a major portion of the glacier, as indicated with a continuous line. The original location of the ski lift in 1940 is indicated with a segmented line in subsequent epochs. After 2004, skiing was no longer possible. Photo credits: Francou and Vincent (2006) and Jordan (1991).

**Source: IPCC Working Group II Fourth Assessment Report, 2007: Figure 1.1**



LIVE ACCESS SERVER

Search dataset/variable:

Go

single  
data  
set

com-  
pare  
two

Datasets

Variables

Constraints

Previous Output

Define variable

About

Contact

LAS V7.0 Beta  
Version 6 UI

**Datasets** > **NRT - Near-real time Data** > **NRT - Global** > **NRT - Global - (Maps of) Absolute Dynamic Topography**  
Variable(s): **Maps of Absolute Dynamic Topography Merged**

Select your desired view (geometry of output) and output (type of product).  
Then set the 4-D region (lon-lat-depth-time) and any additional constraints.

[Help](#)

Select view:

Longitude-Latitude map (xy)

Select output:

Color plot

Select region:

Full Region

Go

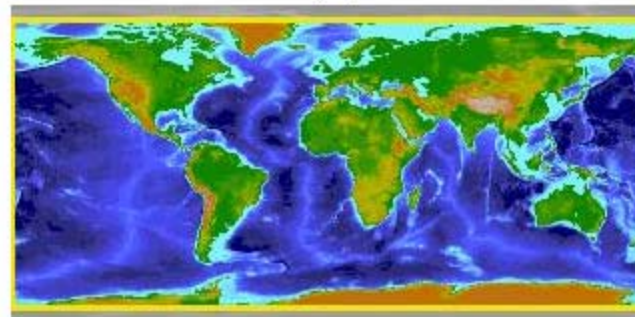
[Use the interactive map](#) [Help](#)

[Next >](#)

[Help](#)



[Reset](#)



[Zoom +](#)



[Zoom -](#)

81.9746 N  
180 W 180 E  
82 S  
[Go](#)

Select time:

13-Apr-2009 00:00:00

13-Apr-2009 00:00:00

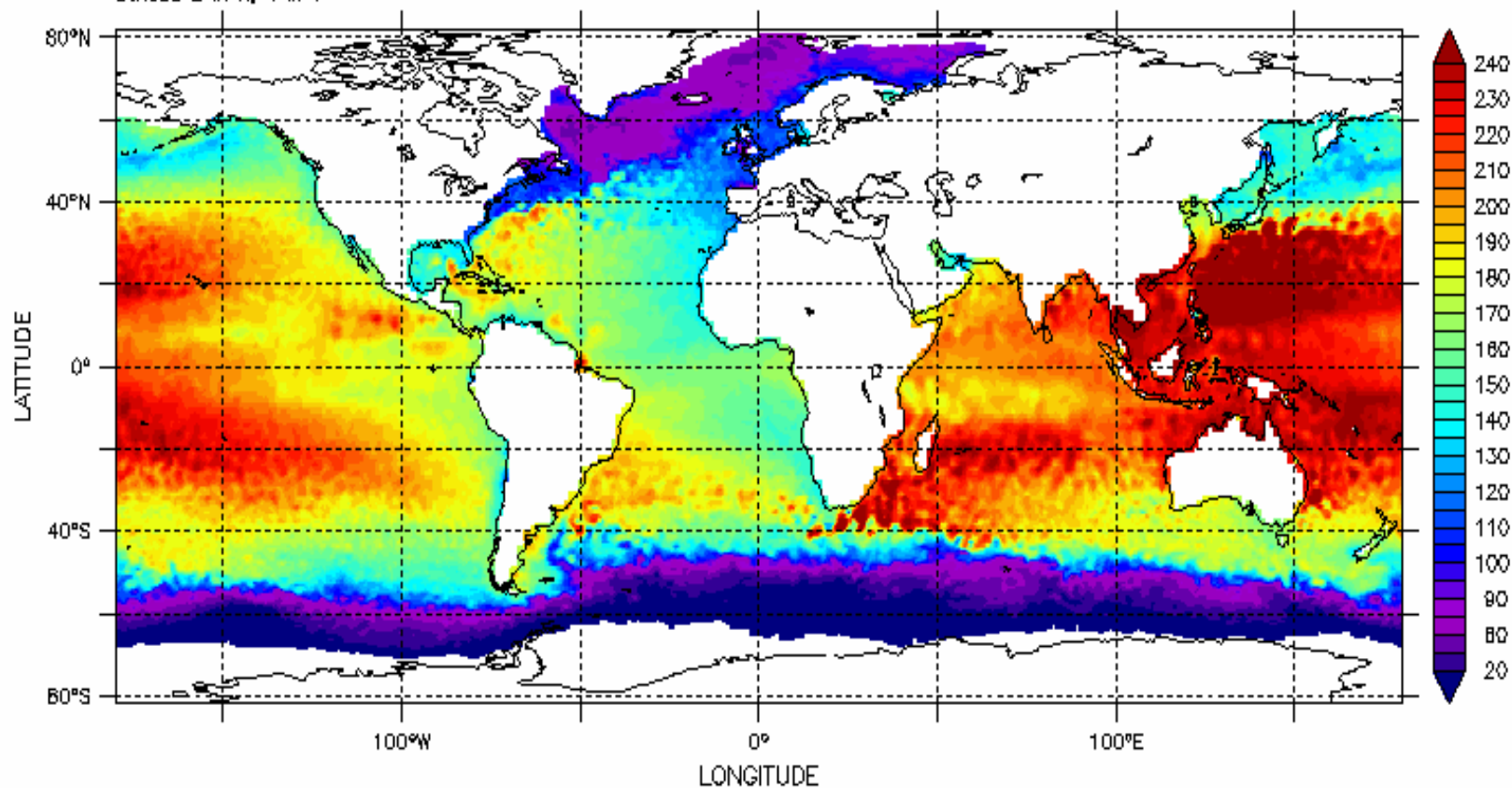


LAS 7.+/Ferret 6.1 NOAA/PMEL

TIME : 13-APR-2009 00:00

Strided 2 in X, 4 in Y

DODS URL: [http://opendap.aviso.oceanobs.com/threads/dodsC/duacs\\_global\\_nrt\\_madt\\_merged\\_h](http://opendap.aviso.oceanobs.com/threads/dodsC/duacs_global_nrt_madt_merged_h)



Maps of Absolute Dynamic Topography Merged (cm)

# **WEB COLLABORATION**

## **KEY FEATURES:**

- **Interactive Simulation Tools and Online Presentations**
- **Mechanism for uploading New Resources**
- **Tool Development Area and Usage Statistics**
- **User Groups for Private Collaboration**
- **Ratings and Citations and User Support Area**
- **News and Events, and Feedback Mechanisms**

# SEMANTIC WEB

- **Proposed by the inventor of the WWW: Tim Berners-Lee**
- **Objective: users and machines to analyze all the data on the web**
- **WWW  $\equiv$  'Information Space' with URLs  $\rightarrow$  URIs**
- **Definitions and Descriptions:**

**Machine-readable view [Degaldo, 2001]**

**Intelligent agents view [Cost et al, 2001]**

**Distributed database view [Cayzer, 2001]**

**Automated infrastructure view [Tuttle, 2001]**

**Servant of humanity view [Cranefield, 2001]**

**Better annotation view [Euzenat, 2002]**

**Improved searching view [Wuwongse et al, 2001]**

**Web services view [Klein and Bernstein, 2001]**

# SEMANTIC WEB STRATEGY

**Proposed layer architecture over XML [Berners-Lee, 2000]:**

- 7. TRUST:** authentication, reliability of information
- 6. LOGIC / PROOF:** justification, inference
- 5. ONTOLOGY:** semantics, dictionaries
- 4. RDF SCHEMA:** RDF resource types
- 3. RDF:** Resource Description Framework
- 2. XML SCHEMA:** data types and structure
- 1. XML:** common syntax of web contents

# CONCLUDING REMARKS

- **Geosciences are computation and visualization oriented**
- **New data/tools offer much potential for web collaboration**
- **Web environments are becoming more and more common**
- **Google Earth, KML and KMZ datasets for geoscience**
- **GEON and OEF offer great possibilities for all of us**
- **Caveat: more data and/or tools  $\neq$  more information!**
- **Geoscience web collaboration is up to us!**