Keeping an Eye on Alaska
Cutting Edge Remote Sensing Activities in the State

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1) Earth & Planetary Remote Sensing, University of Alaska Fairbanks
2) Alaska Satellite Facility (ASF)
**My Qualifications**

- **Technical Expertise:**
  - A decade of radar remote sensing research
    - More than 80 publications
    - Four professional awards
    - Chair of several committees and working groups (incl. IEEE Alaska Section GRSS Chapter)
  - Involved in large number of satellite missions

- **Experience in Science from Radar:**
  - PI of 7 active science projects (~$1.8 M)
    - Volcano Monitoring
    - Atmospheric Mapping
    - Ice Dynamics
    - Ionospheric Science
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Oil Spills appear dark in radar imagery of oceans.

Applications of Remote Sensing for Alaska

Monitoring of Oil Spills

Spaceborne Radar Image of Prestige Spill, 2002

EXXON VALDEZ
WILMINGTON DEL

Oil Spills

Bristol Bay
Applications of Remote Sensing for Alaska

Monitoring Cryospheric Change
Measuring centimeter-scale ice motion from Space
Applications of Remote Sensing for Alaska

Watching Volcanoes “Breath” from Space

Mt. Peulik, AK observed from space:
17-cm inflation 9/1996 – 11/97

Oil Spills

Cryospheric Change

Volcanoes

Bristol Bay

Mount Peulik volcano

Becharof Lake

Ugashik caldera
Applications of Remote Sensing for Alaska

Oil Spills

Volcanoes

Earthquakes

Cryospheric Change

Processed by:
LSGI/PolyU, Hong Kong Polytechnic University

Near Sendai:
~ 2.5m total motion

Mapping the Motion of Japan, 2011
Applications of Remote Sensing for Alaska

Flood Mapping

Mapping Flooded Regions in Australia, 2010

Radar image of Flooded Areas

Flood Mask created from Radar Data

Oil Spills

Cryospheric Change

Weather

Volcanoes

Earthquakes

Bristol Bay
Applications of Remote Sensing for Alaska

Sea Ice Monitoring

Monitoring Sea Ice Motion with Radar

Sea Ice motion in the Beaufort Sea
Remote Sensing Assets in Alaska
Alaska’s Remote Sensing Assets

• Alaska hosts world class assets in (1) spaceborne, (2) airborne, and (3) ground-based remote sensing.
Example of Ground-Based Remote Sensing Tools
Contributions to SIZONet (Seasonal Ice Zone Observing Network)

Saroma-ko, Sakhalin
Alergund

Ice observations
Mass-bal/met/property station
Coastal radar
Oceanographic mooring
Mass-balance buoy
Thickness/property survey

Perennial ice extent, September 2007
Seasonal ice extent, February 2007

NSF funded observing network with international collaborators from Germany, Canada, Norway and Japan (www.sizonet.org)
Example of Ground-Based Remote Sensing Tools
Contributions to SIZONet (Seasonal Ice Zone Observing Network)

- Barrow Coastal Sea Ice Observatory
  - Webcam and sea ice radar
  - Mass balance site
  - Ocean moorings
  - Local ice observations
Ground-based Remote Sensing for Near-Shore Ice Analysis

- Winter Ice Shove, Feb 17/18, 2011
  - Simultaneous observations by webcam and radar imagery
Alaska’s Unmanned Aerial Vehicle Program

- Managed by the Poker Flats Research Range, University of Alaska Fairbanks (manager: Greg Walker)
- Large number and variety of UAVs operated and tested in Alaska

**Example UAV Platforms in Alaska**

- **Gatewing X100** (3 foot wingspan)
- **INSITU ScanEagle** (10 foot wingspan)

- Large number of remote sensing sensors are currently tested on these platforms
Application of UAVs for Wildfire Mapping

Unburned forest

Burned forest (individual trees down)
The Alaska Satellite Facility – Largest Data Center for Spaceborne Radar Remote Sensing Data in the US

Alaska Satellite Facility (ASF)

- Operated by Geophysical Institute of University of Alaska Fairbanks since 1991
- NASA SAR Data Center: member of NASA DAAC Alliance
- ASF Satellite Tracking Station
- Main SAR data processing, archiving, and distribution center of the US
- Support of US SAR science community in processing and data analysis
ASF Satellite Tracking Station

ASF operates two antennas:

- 10m X-band
- 11m X- and S-band

ASF Radar Remote Sensing Mission Portfolio:

ERS-1: ESA-owned C-band
supported for NASA 1991-2000

JERS-1: JAXA-owned L-band
supported for NASA 1992-1998

ERS-2: ESA-owned C-band
supported for NASA 1995-present

AIRSAR & UAVSAR: NASA-owned airborne SAR archive data

R-1: CSA-owned C-band
supported for NASA 1995-2008

ALOS: JAXA-owned L-band supported 2006-now.
ASF is the Americas ALOS Data Node

Other Supported Systems:

Quikscat; AIM; COSMIC; SAMPEX; CHAMP; GRACE-1,2; SCISAT
GINA Capabilities:

- Satellite data reception
- Real-time product generation
- Geospatial data management
- Rapid, large-scale data distribution
- Web interfaces

www.gina.alaska.edu
Station Masks of Alaska’s Remote Sensing Data Centers

• Unique access to spaceborne remote sensing data over Arctic Regions
• Near real-time coverage of Alaska as well as large parts of Canada and the American North West
Example Station Mask for Multispectral Sensor MODIS
Example Remote Sensing Applications for Alaska
Remote Sensing-Based Volcano Monitoring – The Alaska Volcano Observatory (AVO)

A collaborative program of the USGS, the ADGGS and the UAF/GI
## AVO Remote Sensing Data Center

The AVO Remote Sensing Data Center provides access to various satellite data sets for monitoring volcanic activity. The data center includes information on the current status of volcanic eruptions and past events. The website is located at [http://avo.images.alaska.edu/tools/datacenter/](http://avo.images.alaska.edu/tools/datacenter/).

### Website Features
- **AVHRR**: A list of available data sets for advanced very high-resolution radiometer (AVHRR).
- **MODIS**: A list of available data sets for moderate resolution imaging spectroradiometer (MODIS).
- **GOES**: A list of available data sets for geostationary operational environmental satellite (GOES).
- **MTSAT**: A list of available data sets for meteorological satellites (MTSAT).
- **HS**: A list of available data sets for high-spectral resolution instruments (HS).
- **AA**: A list of available data sets for advanced atmospheric sounders (AA).
- **DBASE**: A list of available data sets for database (DBASE).

### Data Access
- **Monitoring**
  - AF - Dalton
  - PM - Stensnes

- **Duty**
  - RS: Peter Webley
  - DJ: Kristi Wallace

- **RS Reports**
  - 2011-05-14 AM
  - 2011-06-13 PM
  - 2011-06-15 AM

### Links
- Image Flipper
- Weekly Report
- Observation Database

### Contacts
- Web Tools
- Contacts

### Slides
Slides courtesy of Peter Webley, UAF-GI and AVO; pwebley@gi.alaska.edu.
Example of Remote Sensing-Based Volcano Monitoring
Kasatochi Volcano, Alaska: 2008, Air Traffic issue

Ash was caught in a gyre, but enough passed over southeast to disrupt air traffic.

Slides courtesy of Peter Webley, UAF-GI and AVO; pwebley@gi.alaska.edu
The Importance of Radar Remote Sensing

Radar observations of current activity at Mount Cleveland

- Optical sensors yield little information due to cloud cover
- Radar data can see through clouds, ash, and smoke
- Active radars can operate day and night

Image: 2011 Dome Growth of Mount Cleveland from SAR

Image Copyright 2011, German Remote Sensing Data Center (DFD), German Aerospace Center (DLR)
Example of a 1-m Resolution Spaceborne Radar Image

Islands of the Four Mountains, Central Aleutian Chain, Alaska
Imaged by TerraSAR-X, German Aerospace Center
Sea Ice Dynamics from Radar Remote Sensing Data

- Ice Dynamics from Multi-temporal Radar Images:
  - Large coverage Radar data (500km swath)
  - Cooperation with JPL

- Landfast Ice Monitoring:
  - Mapping and monitoring landfast ice from C-band SAR and L-band InSAR data
  - Cooperation with BOEMRE, Shell, Conoco Phillips

[Images showing ice dynamics and landfast ice extent]
Oil Spill Monitoring with Spaceborne Radars

- Brightness of oceans in Radar images driven by roughness of ocean surface
- Wind-driven oceans appear bright in radar
- Oil spills change roughness of water surface and show up dark in SAR images
- SAR tool for detecting and tracking of spill

“Prestige” disaster, Envisat-ASAR, Nov 20, 2002
Deep Water Horizon Spill Mapping with Spaceborne Radars

http://blog.skytruth.org
Deep Water Horizon Spill Mapping with Spaceborne Optical Imagery

http://blog.skytruth.org
• ... records both **Amplitude** and **Phase** of the reflected microwave signals

**Amplitude forms SAR Image**

**Phase measures the range to objects on ground**
The Concept of Interferometric SAR (InSAR)

- Calculation of Phase Difference between Pairs of Radar Remote Sensing Images acquired from similar vantage points

Phase difference measurement (interferometric phase) is sensitive to:

**Surface Topography**
InSAR-derived DEM, Cotopaxi Volcano, Ecuador
Alaska Statewide Digital Mapping Initiative

- Create high-quality digital elevation models (DEMs) for the state using InSAR and stereo-photogrammetry
  - Areas for InSAR (IfSAR) coverage are shown
InSAR DEM Results

- Mount Foraker & Kahiltna Glacier; Denali National Park
- 2010 SDMI Fugro InSAR
Resolution/content significantly better than the National Elevation Dataset (NED)

InSAR (left) and NED (right)
The Concept of Differential InSAR (d-InSAR)

- Calculation of Phase Difference between Pairs of Radar Remote Sensing Images acquired from similar vantage points.

Phase difference measurement (interferometric phase) is sensitive to:

1. Surface Topography
2. Surface Deformation
3. Terrain motion or subsidence

*d-InSAR*: extraction of deformation signal from interferometric phase.
Monitoring Volcanoes with d-InSAR

- Surface inflation and deflation with changes of magma pressure
- Surface deformation often precedes volcanic eruptions
- Surface deformation observable with d-InSAR

Westdahl Volcano Deformation Movie
Deformation of Mount Peulik, AK from d-InSAR


Volcanic Deformation on Unimak Island, Alaska
Advanced Processing

Mean Surface Motion: SAR Time Series Analysis
(2003 – 2010)

Optical Image: Courtesy of AVO
Volcanic Deformation on Unimak Island, Alaska
Advanced Processing

Deformation Time Series - Fisher

\[ v_{\text{LOS}} = -16 \text{ mm/y} \]

Surface Motion: SAR Time Series Analysis
(2003 – 2010)

Optical Image: Courtesy of AVO
Sub-Milimeter Surface Analysis
Building Deformation in Berlin, Germany

Central Railway Station Berlin

(c) 2011 S. Gernhardt
TUM, DLR

Railway Station Berlin

(c) 2011 S. Gernhardt
TUM, DLR
• Remote Sensing Technology Development and Application essential for ecologic and economic development of Alaska
• Alaska hosts a wide range of world class remote sensing assets and
• Alaska can assume a national leadership role in the application of remote sensing in management and decision making

• The IEEE Alaska Section Geoscience and Remote Sensing Society (GRSS) Chapter is working on increasing the remote sensing activities in the state