

GEOS 657 – MICROWAVE REMOTE SENSING
GRADUATE-LEVEL COURSE AT THE UNIVERSITY OF ALASKA FAIRBANKS

Lecturer:
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Lecture 1: Introduction to the Course

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Let Us Start with some SAR Data
 What do you see in this SAR Time Series Dataset?

- SAR Time Series: **Dome Growth** at Cleveland Volcano

Changes in topography can lead to weird effects

Image Copyright 2011, German Remote Sensing Data Center (GRS), German Aerospace Center (DLR)

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Let Us Start with some SAR Data
 What do you see in this SAR Time Series Dataset?

Radar Image Time Series capturing 2020 South Asia monsoon floods

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Let Us Start with some SAR Data
 What do you see in this SAR Time Series Dataset?

Radar Image Time Series capturing 2020 South Asia monsoon floods

Surface Water Information extracted from SAR time series

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Hot Off the Press
 What's Happening In this Time Series?

The German town of Lutzerath is slated to be demolished in favor of further expansion of the Garzweiler surface mine

2017-03-27


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Let Us Start with some SAR Data
 What do you see in this Time Series Dataset?

- InSAR deformation - Galapagos Islands

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FAIRBANKS



MOTIVATION & BACKGROUND

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A Short Introduction About Myself

UAF
UNIVERSITY OF ALASKA
FAIRBANKS

Until 2007



For studying here

MSc & PhD in Engineering, Technische Universität Muenchen, Munich Germany



TerraSAR-X Team, German Aerospace Center

Since 2007

Professor of Remote Sensing

UAF ALASKA UNIVERSITY

University of Alaska Fairbanks, Fairbanks, AK

Chief Scientist

UAF ALASKA SATELLITE FACILITY

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Short Survey

Mentimeter UAF
UNIVERSITY OF ALASKA
FAIRBANKS

- <https://www.menti.com/ali9hz36yn74>



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Exciting Developments in SAR:
New Sensors, Free-And-Open Regularly-Sampled Data, Application-Ready Data (ARD) Products

Sentinel-1
Frequency: C-band
Launch Date: 2015 & 16

NISAR
Frequency: L-band
Launch Date: Early 2025

TanDEM-L
Frequency: L-band
Launch Date: 2023

October 2016
November
December
January 2017
February
March
April
May

Arctic Sea Ice Export through Nares Strait

Copyright contains modified Copernicus Sentinel data 2015-16, processed by David Small

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Radar Systems with Operational Character

- **Sentinel-1 (2014 - today): First SAR satellite system with operational mission**
 - Regular reliable observation according to operational requirements
 - Imaging all landmasses, coastal zones and shipping routes every six days
 - Specifically designed for InSAR

FREE AND OPEN DATA!

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Sentinel-1 Constellation – Acquisition Concept

- Sentinel-1 uses a constellation of two sensors (Sentinel-1A and B) to achieve:
 - 6-day sampling over Europe and selected hazard locations
 - 12-day sampling globally
- Unfortunately, Sentinel-1B had a failure in Dec 2021, resulting in reduced imaging capacity until a replacement (Sentinel-1C) was launched in Spring 2023.

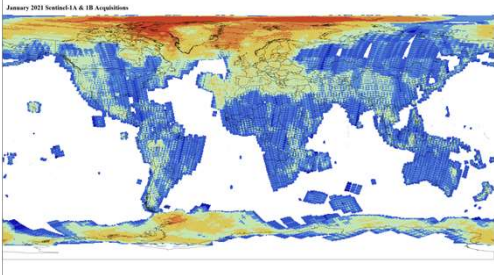
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Sentinel-1 Global Coverage Maps
Year 2021

2021 Coverage Maps

- Combined coverage from Sentinel-1A and -1B
- 6-day coverage over Europe and some hazard regions
- Maximum coverage over Arctic ocean
- 12-day coverage elsewhere



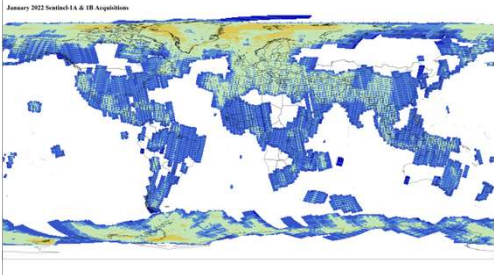
January 2021 Sentinel-1A & 1B Acquisitions

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Sentinel-1 Global Coverage Maps
Year 2022


2022 Coverage Maps

- Coverage only by Sentinel-1A after failure of Sentinel-1B in Dec 2021
- Reduced temporal coverage globally including HKH
- Coverage holes over Siberia, Canada, South America, and Africa



January 2022 Sentinel-1A & 1B Acquisitions

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Sentinel-1C was launched Dec 5, 2024 to recover full capability of the constellation

2025, the Year of NISAR
 NASA-ISRO SAR (NISAR) Radar Earth Observation Satellite Project

LAUNCH SPRING 2025

- First spaceborne L- and S-band SAR
- Full global coverage in 12 days
- 150 Petabyte of Earth Observation data / year

ALL DATA FREE AND OPEN!

NISAR INVOLVEMENT

- NISAR Data Center
- NISAR Ground Station
- NISAR Science Team Member
- NISAR L2 Algorithm Development

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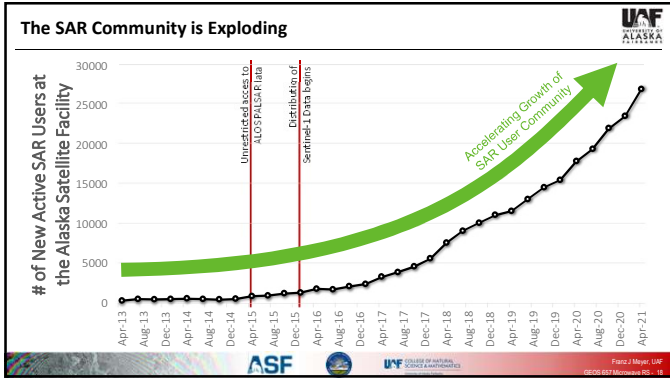
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An Insight into the Upcoming NISAR mission

Learn more about NISAR at:
<https://nisar.jpl.nasa.gov/>

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**Unprecedented Data Volumes → Huge Potential for Earth Observation
But Require Different Approaches for Data Access and Analysis**

Year	Volume
2014	1PB
2020	10PB
2026	~180PB

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COURSE OUTLINE

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The Workshop Concept

• Outline of the Class (<https://radar.community.uaf.edu/syllabus/>):

- 1. Microwave Signals** (microwave spectrum; properties; advantages)
- 2. The Basics** (Active and Passive systems; SAR; InSAR; polarimetry)
- 3. Radar Applications** (geophysical & hazard applications of radar data)
- 4. Limitations Error Sources** (Interpret radar data; limitations; error sources)
- 5. Advanced Concepts** (overcoming limitations; boosting accuracy)
- 6. Data/Model Integration** (observation networks; integration in models)

• Introduction to Cloud-based and Python-based SAR data processing:

- No data download and no local compute hardware needed → High-performance computing from any internet-connected device
- Full access to the global Sentinel-1 (now) and NISAR (soon) archive
- Use as you need – only download what you need
- Jupyter Notebook tools for algorithm development and use

Opensarlab.asf.alaska.edu

- Full performance lab
- End-user processing with moderate local compute & internet infrastructure

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This is Why Radar Systems Are Important

1. Microwave Signals (microwave spectrum; properties; advantages)

0% Average Cloud Coverage [%] 100%

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Advantages of Microwave Signals

Microwaves can Penetrate Clouds and Fog

Seasonal Flooding in the Amazon Region

1. Microwave Signals (microwave spectrum; properties; advantages)

[SAR] Sentinel-1 (2021-01-01 - 2021-07-30)

[Optical] Sentinel-2 (2021-01-01 - 2021-07-30)

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Microwave Scattering Mechanisms

1. Microwave Signals (microwave spectrum; properties; advantages)

smooth surface rough surface

Specular scattering Bragg Scattering

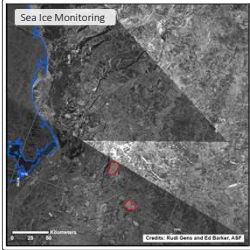
Edge and Corner Reflectors Diffuse Scattering

vegetation

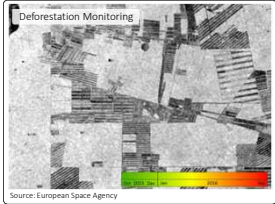
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Applications of SAR Change Detection









Sea Ice Monitoring



Deforestation Monitoring

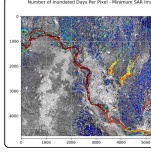
Source: European Space Agency

3. Radar Applications
(geophysical & hazard applications of radar data)

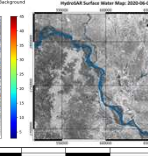







Monitoring Severe Weather Events Using Radar Data

- Area of nearly 1000km² regularly observed
- Within hours of data reception
- Production fully automatic









Number of Populated Days per Year - Western US (1980-2010)

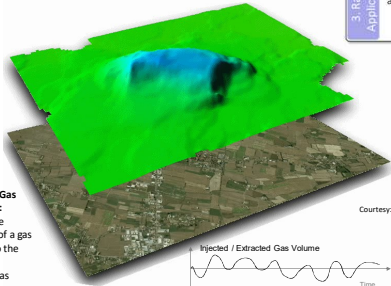


Hydrologic Surface Water Map 2000-2010

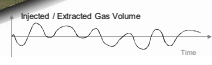
3. Radar Applications
(geophysical & hazard applications of radar data)

InSAR can Measure Surface Deformation Related to Natural Hazards and Resource









Managing Underground Gas Storage (UGS): Vertical surface displacement of a gas field related to the injection and extraction of gas volumes

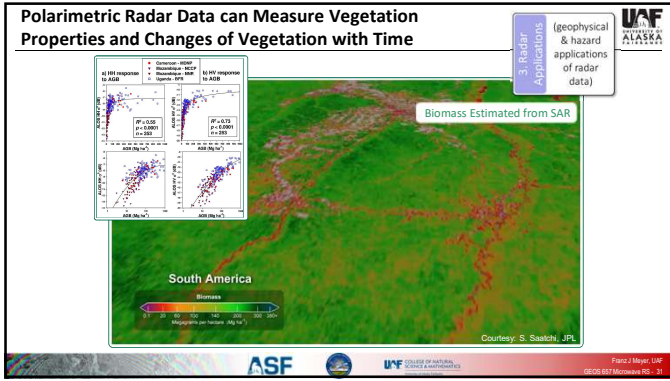


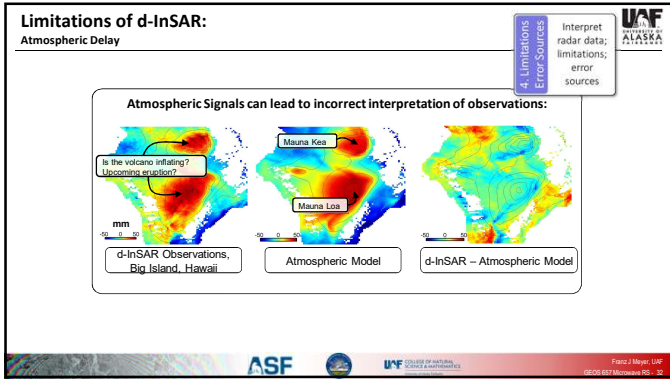
Injected / Extracted Gas Volume

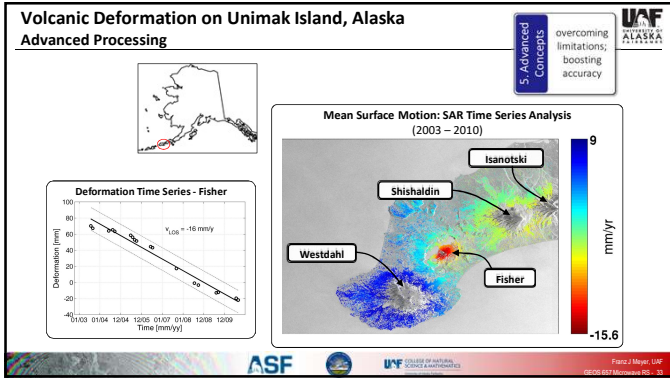
Time

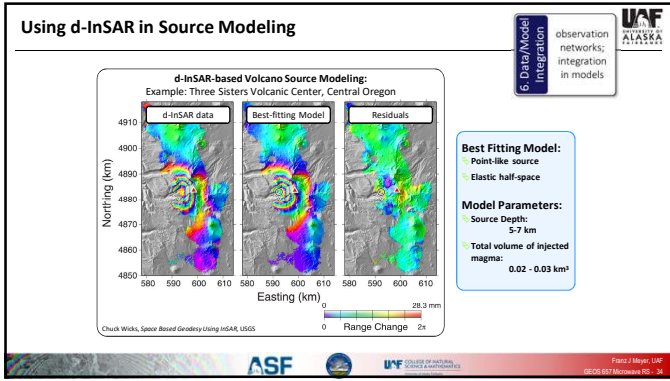
3. Radar Applications
(geophysical & hazard applications of radar data)









COOLSTUFF

TOOLS TO MAKE COURSE CONTENT ACCESSIBLE

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Classroom Tools

Lectures and Board work

Reading Assignments

Collaborative Computer Labs


THINK. PAIR. SHARE. Group Discussions

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Technology to Support the Course


Modern Open-Source Tools to enable big SAR data analysis from (almost) anywhere

<https://geos657.asf.alaska.edu/>



Tools to Stay in Touch

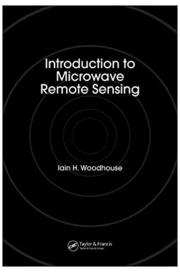
<https://radar.community.uaf.edu/stayconnected/>



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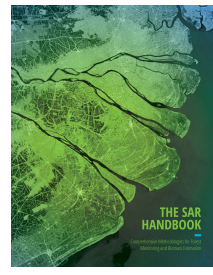
Reading Materials

Woodhouse:
Microwave Remote Sensing

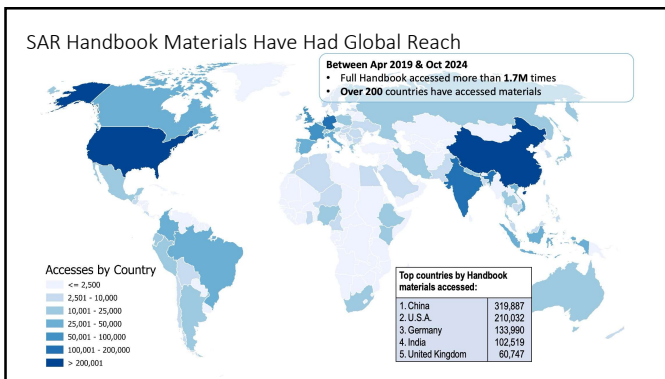


The SAR Handbook

Download the complete book [here!](#)



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Class Project Information

- Students will complete a class project on SAR
- Wide range of options available
- Some information at radar.community.uaf.edu/classprojectideas/
- Group work for class project is allowed but should be discussed with me
- Several class projects in recent years led to publications

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Questions?

NEXT:
 HISTORY OF MICROWAVE RS & MATHEMATICAL BACKGROUND

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