UAVSAR

Uninhabited Aerial Vehicle Synthetic Aperture Radar

An Overview of UAVSAR's New Capabilities

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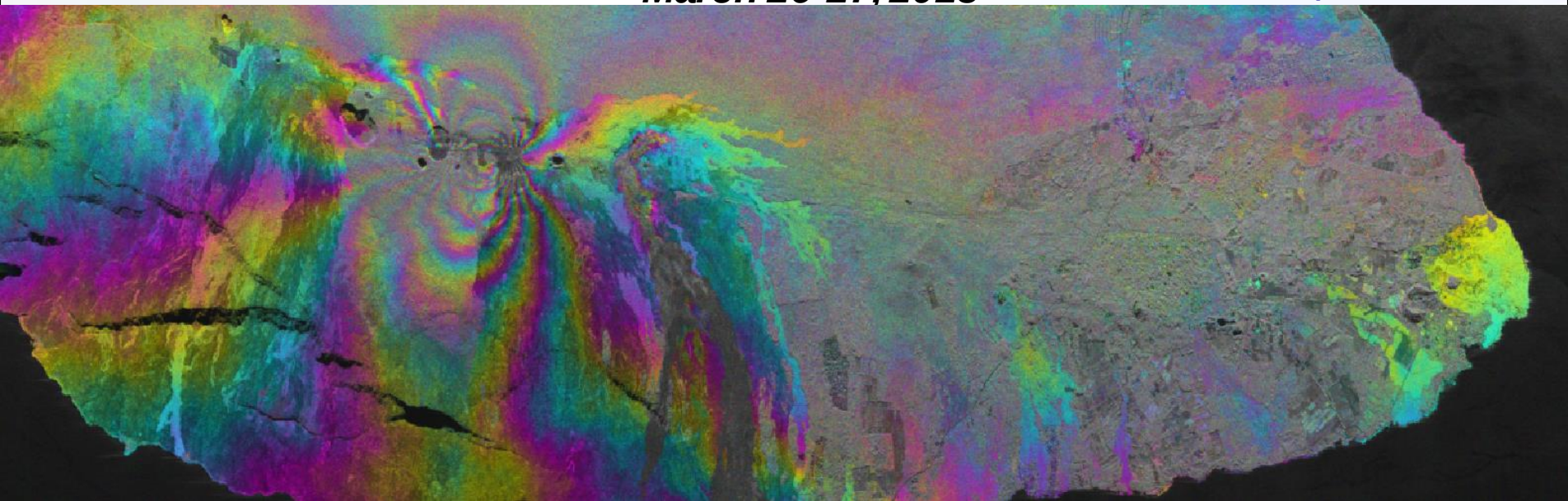
UAVSAR Workshop

March 26-27, 2013



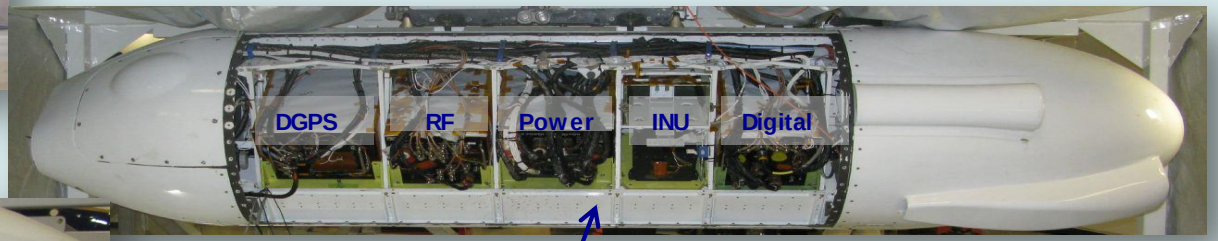
Kilauea Volcano Eruption in March 2011

Agenda

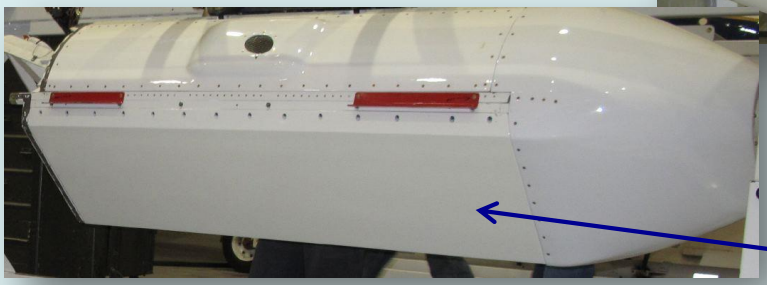
- UAVSAR Overview
- New Instrument Capabilities
- New Platform Capabilities
- UAVSAR Technology Roadmap

UAVSAR Overview

- UAVSAR was developed under NASA ESTO funding to support **repeat-pass radar interferometry** and was designed to also serve as a **radar technology testbed** for future spaceborne imaging radar missions.
- Instrument in the non-pressurized pod is compact, modular, and adaptable to support multiple airborne platforms and frequency upgrades.



Electronics bay common to all frequencies



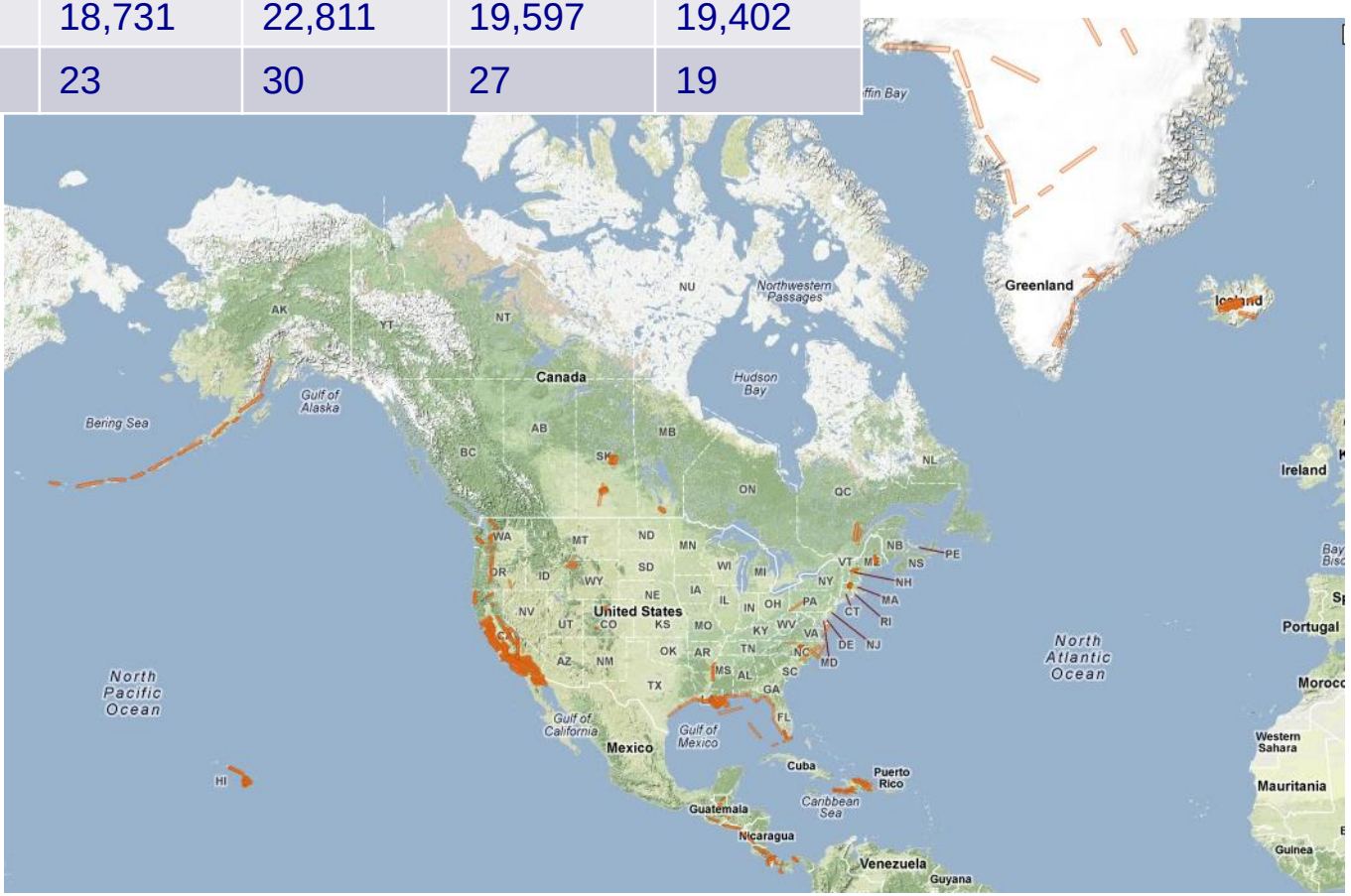
Frequency-specific antenna bay

Initial Capabilities (since 2009)

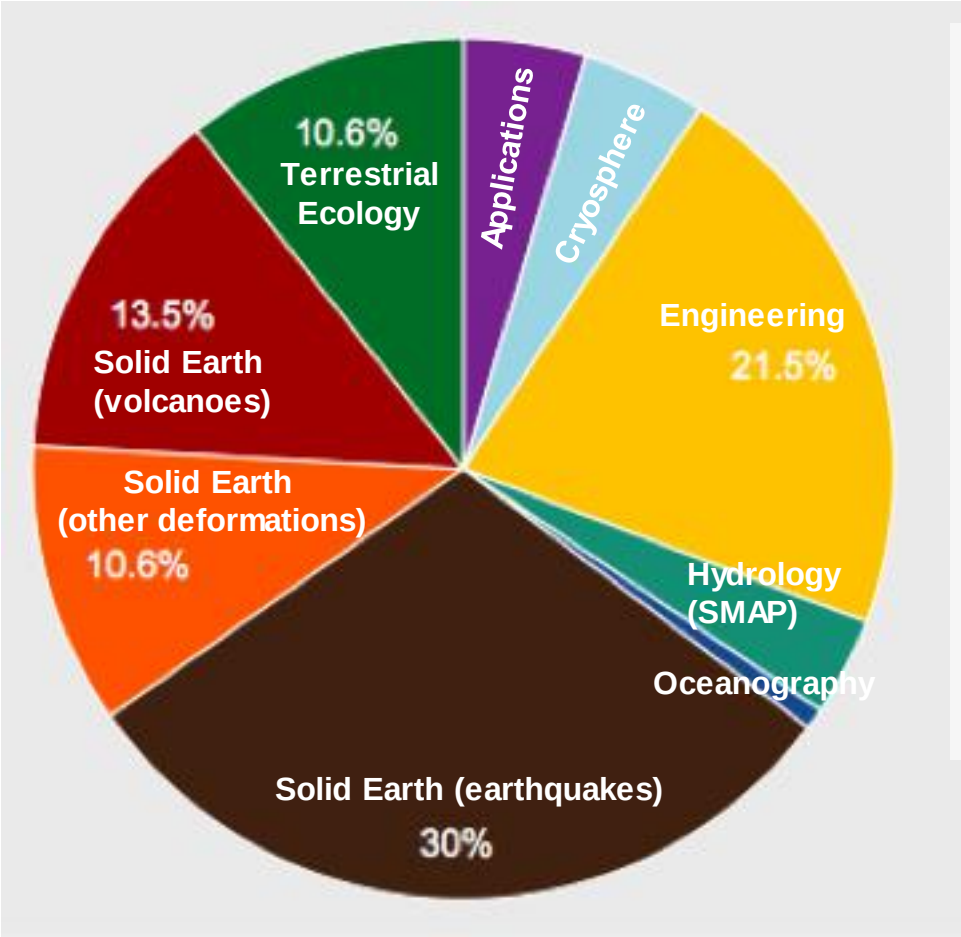
- L-band repeat-pass polarimetric interferometry enabled by electronically scanned antenna and precision autopilot that can repeat tracks to within a 5 m tube.
- Applications include surface deformation for solid earth, cryospheric studies, vegetation mapping and land use classification, archeological research, soil moisture mapping, geology and cold land processes.

UAVSAR L-band Flight Statistics

	FY 2009	FY 2010	FY 2011	FY 2012
Flights	65	84	86	76
Flight Hours	350	447	396	433
Flight Lines	649	925	735	764
Raw Data Volume (GB)	18,731	22,811	19,597	19,402
Flight Requests	23	30	27	19



Data Acquisition by Discipline



- Most campaigns are multi-year efforts:
  - San Andreas fault monitoring
  - Sacramento Delta levee study
  - Hawaii & Aleutian volcano monitoring
  - Gulf of Mexico oil spill impact study
  - Iceland temperate glacier study
- Other major campaigns included:
  - SMAP 2010 and 2012 algorithm validation experiments in Canada
  - Terrestrial ecology studies in temperate forests (New England) and tropical forests (Costa Rica)

Central and South America 2013 Deployment

- North America: Arizona and Gulf Coast
  - 12 Hours, 2 sorties
- Central and South America:
  - 112 hours, 20 sorties
- Science objectives
  - Volcanic crustal deformation
  - Aquifer and coastal subsidence
  - Levee condition and seepage
  - Mountain glacier motion
  - Archaeology
  - Coastal mangroves
  - Soil moisture
  - Biodiversity and forest structure
  - Wetlands, inundation

March 7th through April 4th

Evolution of UAVSAR Development

NASA Earth Science Division's airborne imaging radar testbed is used to develop, validate, and improve new radar technologies and algorithms for modeling geophysical phenomena for future Earth-observing satellite missions including SMAP, DESDynI, and SWOT.

	2004 - 2008	2009 - 2012	2011 - 2012	2009, 2011 - 2012
	DFRC Gulfstream-III	Global Hawk	JSC Gulfstream-III	DFRC Gulfstream-III
				
Technology	2 complete L-band radars; electronically steered antennas; G-III precision auto-pilot	Repackage L-band radar in GH payload bay; build a third pod	Modify new pod and build P-band antenna and RF front-end electronics; modify JSC G-III for AirMOSS missions	Build Ka-band antennas and RF front-end electronics
Science	L-band repeat-pass InSAR for surface deformation, vegetation structure, soil moisture mapping, land use classification, cryospheric studies, and archaeological research	L-band polarimetry for land use and vegetation classification, and soil moisture mapping	P-band polarimetry for measuring subsurface and sub-canopy soil moisture	Ka-band single-pass InSAR for observing glacier and land ice topography

UAVSAR Instrument Parameters

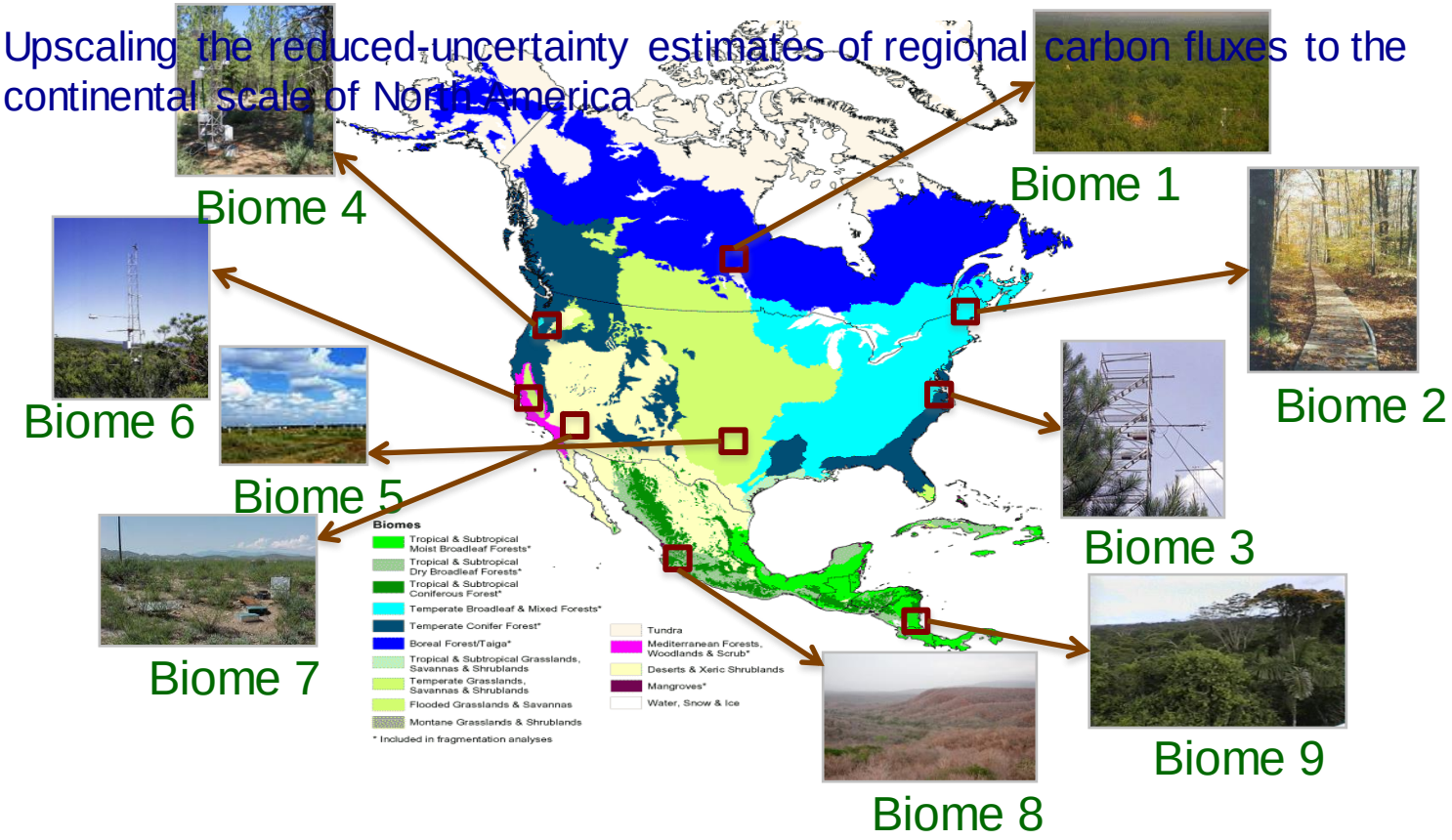
	P-band/UHF	L-band	Ka-band
Frequency (MHz)	280 - 440 MHz	1217.5-1297.5	35,620-35,700 MHz
Nominal Bandwidth (MHz)	20	80	80
Selectable Bandwidths (MHz)	6, 20, 40, 80	80	80
Polarization	Quad-pol	Quad-pol	Horizontal
Peak Transmit Power (kW)	2.0	3.1	0.0
Maximum Duty Cycle	10%	8%	10%
Look Angle Range	25 – 45 deg	25-65 deg	15-50
Nominal Range Swath (km)	7	22	10
Noise Equivalent Sigma0 (dB)	< -40	< -50	TBD
Radiometric Accuracy (dB)	< 1 absolute	< 1 absolute	TBD
Height Precision (30x30 m posting)	N/A	N/A	0.1 – 0.5 m

AirMOSS Mission

PI: Mahta Moghaddam, University of Southern California

AirMOSS, a 5-year project funded by NASA's Earth Venture Program, will provide a new Net Ecosystem Exchange estimate for North America with reduced uncertainty by:

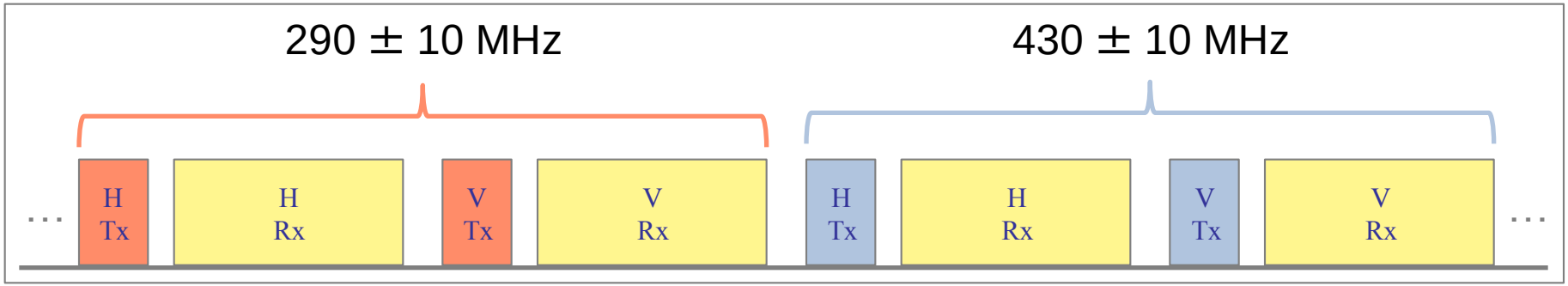
- Developing a P-band radar for *100 m resolution observations of Root Zone Soil Moisture (RZSM)* over regions representative of the major North American biomes
- Quantifying the impact of RZSM on the estimation of regional carbon fluxes
- Upscaling the reduced-uncertainty estimates of regional carbon fluxes to the continental scale of North America



AirMOSS P-band SAR

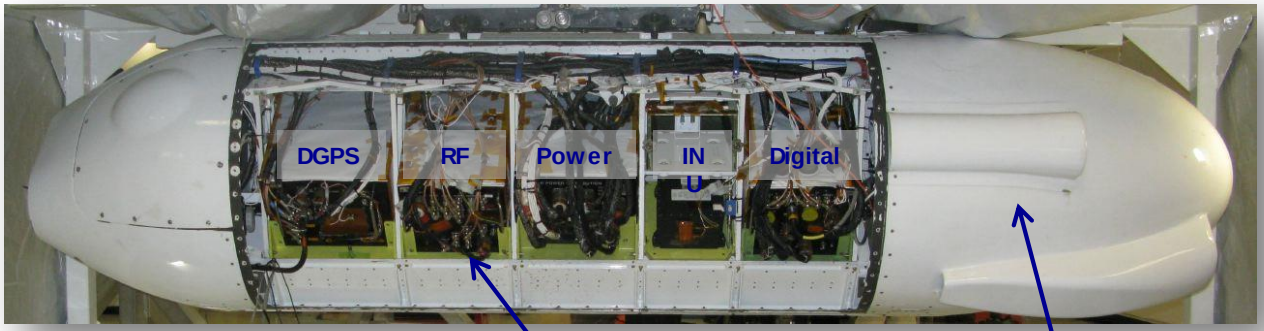
- Hardware is capable of 80 MHz maximum contiguous bandwidth within 280-440 MHz band – frequency *permission* is a limiting factor
  - Currently have regional permissions to transmit 420-440 MHz in AZ, CA, KS, ME, MA, NE, NH, NC, OR, TX, UT
- Direct Digital Synthesizer (DDS) which generates signal to mix L-band chirp down to P-band commandable to generate any center frequency between 280 and 440 MHz on a pulse by pulse basis.
- Can double Pulse Repetition Frequency (PRF) and concurrently collect polarimetric strip map SAR image data at multiple frequencies

For example:



UAVSAR in P-band Configuration

Backend electronics common to all radar frequencies

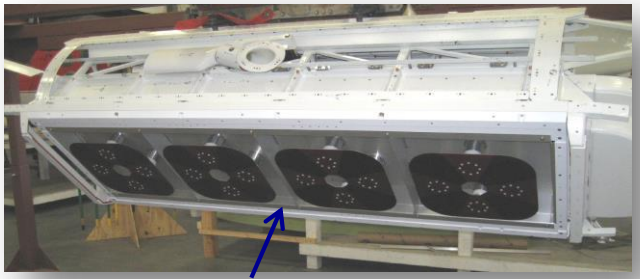


Antenna bay to house frequency specific antenna

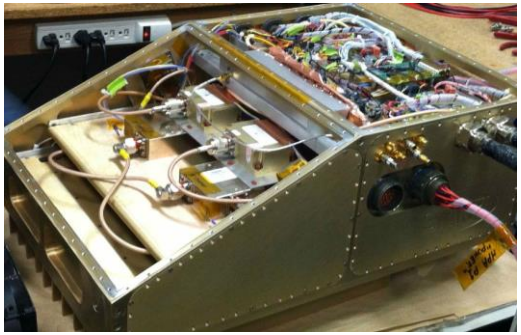
Add electronics for frequency up/down conversion between L-band and P-band

P-band high power amplifier in the nosecone (~15" x 22")

EV-1 AirMOSS Configuration:
Completed flight testing in Fall 2012



P-band antenna

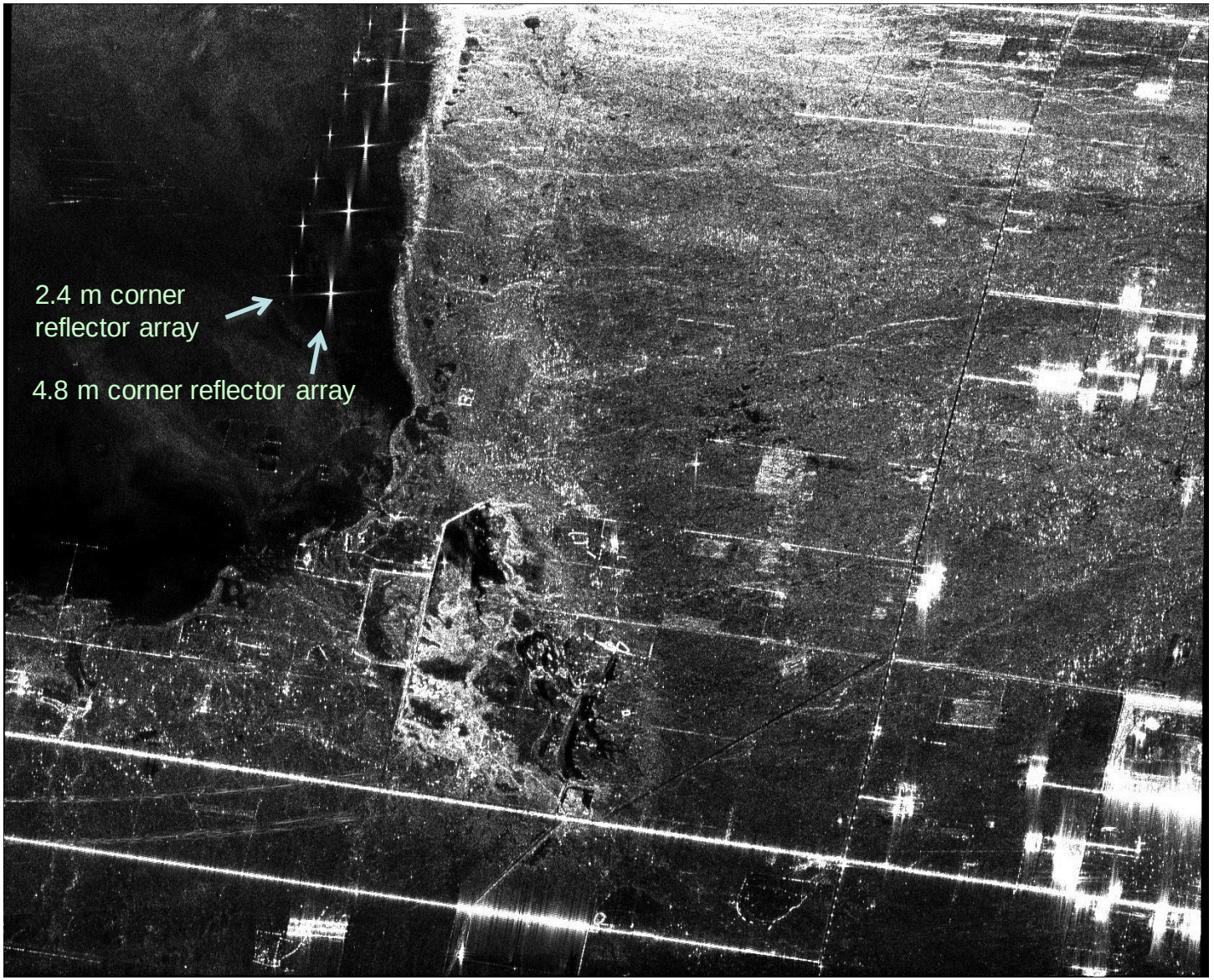


P-band 2 kW high power amplifier in bench testing

Deployment of 4.8 m Corner Reflectors

AirMOSS team posing with the corner reflector after completion of the fifth reflector under 100ºF weather.

First P-band Imagery

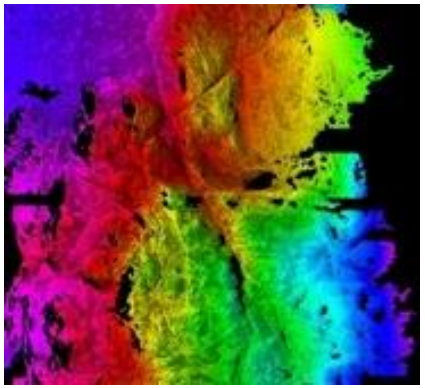


The Airborne Glacier and Land Ice Surface Topography Interferometer (GLISTIN-A)

PI: Delwyn Moller, Remote Sensing Solutions, Inc.

- Provide an ice surface topography, swath mapping sensor capable of operationally supporting NASA cryospheric science campaigns including potential IceBridge participation and ICESat-II augmentation - especially in coastal regions.
- Transition the Ka-band interferometer capability developed under the NASA International Polar Year (IPY) to a permanently available Ka-band UAVSAR configuration.
- Improve IPY configuration to provide enhanced performance and swath-mapping capability.
- Enable compact “plug and play” reconfiguration between L-band UAVSAR and Ka-band.

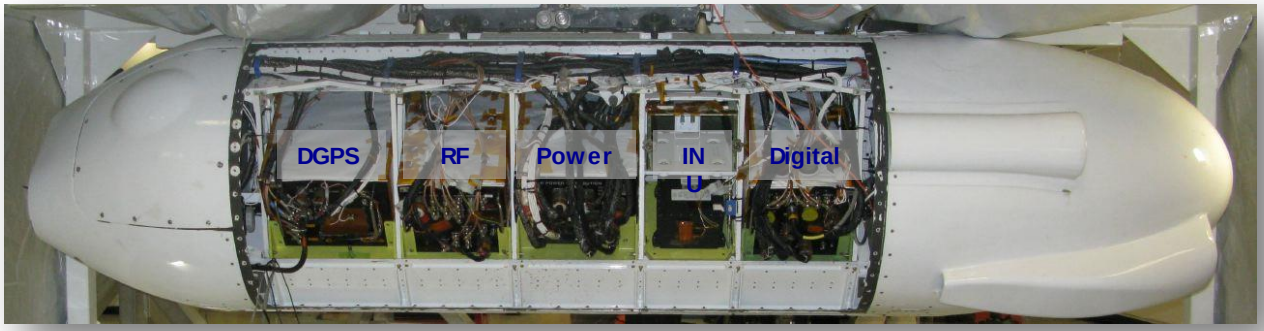
Ka-band antennas on the NASA GIII for single-pass interferometry



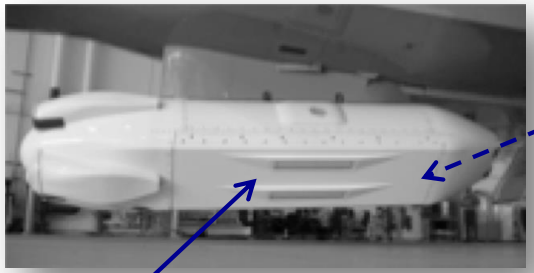
Example height map over Greenland’s coast collected 5/1/2009. Color wrap is 800 m and swath is 7.5km. GLISTIN-A will improve swath coverage to >10km.

UAVSAR in Ka-band Configuration

Backend electronics common to all radar frequencies

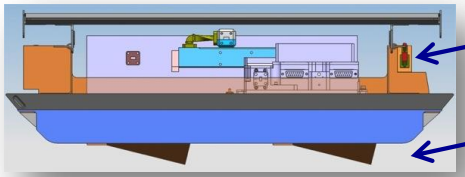


Antenna bay to house frequency specific antenna



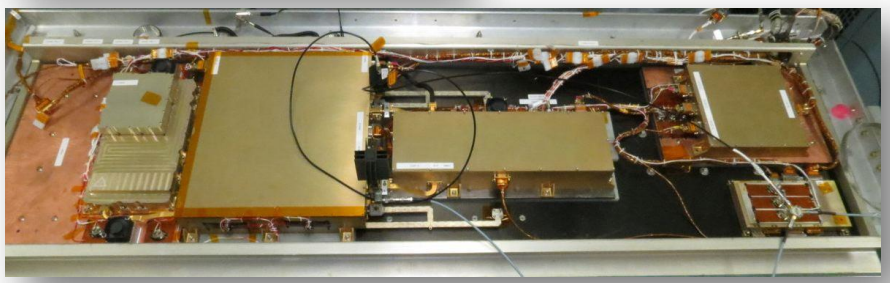
Ka-band antennas

AITT GLISTIN-A Configuration:
Ka-band flight testing in August 2012



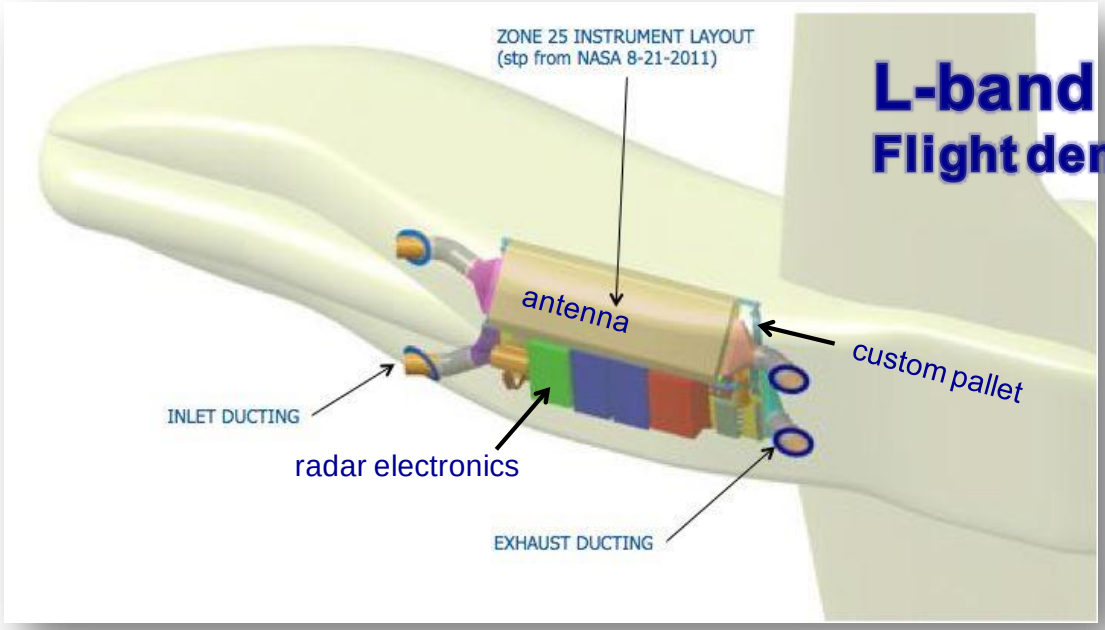
RF Electronics

Ka-band antennas protruding from L-band radome



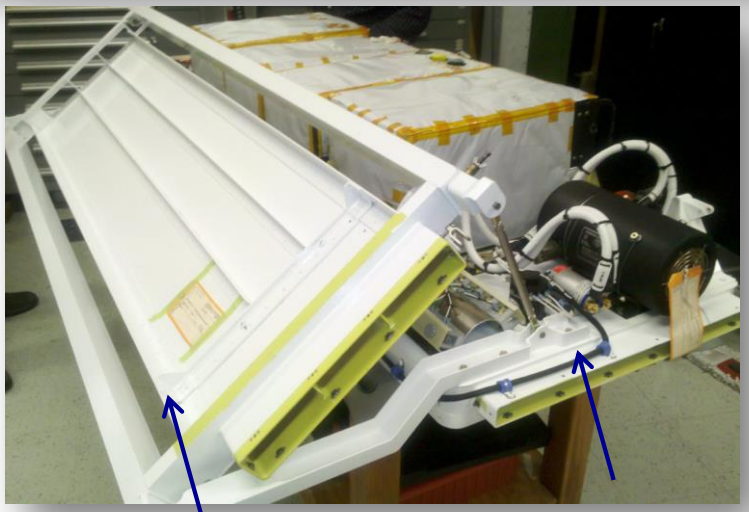
Ka-band high power amplifier and RF electronics are mounted to the backside of the antenna baseplate

UAVSAR: Global Hawk Payload Bay 25 Configuration



L-band GH Configuration:
Flight demonstration in May 2013

- Provide POLSAR data from the Long Range, High Endurance Global Hawk Uninhabited Aerial Vehicle (UAV).
- Provide long range (~ 9000 nmi) to enable data collection of distant areas of interest without complicated deployments.
- Provide long term persistent observations of major events like earthquakes and volcanoes.



L-band antenna frame

Custom pallet

Radar backend electronics are mounted upside down to the custom pallet

Summary of Instrument Upgrade Status

- UAVSAR Program now has 3 pod-based radars, capable of operating in repeat-pass P-band polarimetry, L-band polarimetry, and Ka-band single pol. topographic interferometry.
- *With 2 G-IIIs capable of precision autopilot, we could potentially have near simultaneous multi-frequency radar observations or formation flying with 2 L-band radars.*
- P-band POLSAR flight testing onboard the JSC G-III was completed in September 2012.
  - ✧ New capability will enable root zone soil moisture measurements and other subsurface and sub-canopy measurements.
- Ka-band HH pol single-pass interferometry began flight testing in August 2012 onboard the DFRC G-III and will begin flight testing in late 2013 onboard the Global Hawk
  - ✧ New capability will enable ice sheet and river topographic mapping.
- L-band POLSAR will begin flight testing in April 2013 onboard the NASA Global Hawk UAV.
  - ✧ New capability will enable long range and long duration observations.

Operational Scenario

Two G-IIIs, One Global Hawk (flight testing only), 3 complete radars, 3 pods

L-band I

or

Ka-band

P-band*

or

Ka-band

L-band II

or

Ka-band

Total # of flight hours	~ 500	~ 350	~ 30 for 2013 ?? for 2014

UAVSAR Technology Roadmap



Technology Options

Develop 2 smaller GH wing pods to house L-band antennas

Vegetation and Ice Structure Monitoring System

Assessment of forest structure and ice sheet thickness

Robust RPI processor algorithm*

Coherence detection onboard processor with high speed data downlink*

Rapid Response with Coherent Change Detection

Real-time assessment of rapidly evolving events

Ka-band radar and Lidar on GH

Ka-band TopSAR capability in pod*

Port Ka-band radar to GH zone 25

Ice Sheet and River Topographic Mapping System

Monitoring of polar ice sheet and river hydrology

P-band POLSAR capability in pod*

Canopy and Ground Penetrating Radar

Monitoring of sub-surface soil moisture and forest biomass

Port L-band radar to GH zone 25*

Precision autopilot for the GH

Long Range and Long Duration Airborne Observing System

Monitoring of polar regions

2011 **2013** **2015**

* Already funded and currently under development

UAVSAR Team

PI: Scott Hensley, PM: Yunling Lou

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