Future Use of NASA Airborne Platforms to Advance Earth Science Priorities

Surface Dynamics, Geological Hazards, and Disasters

by

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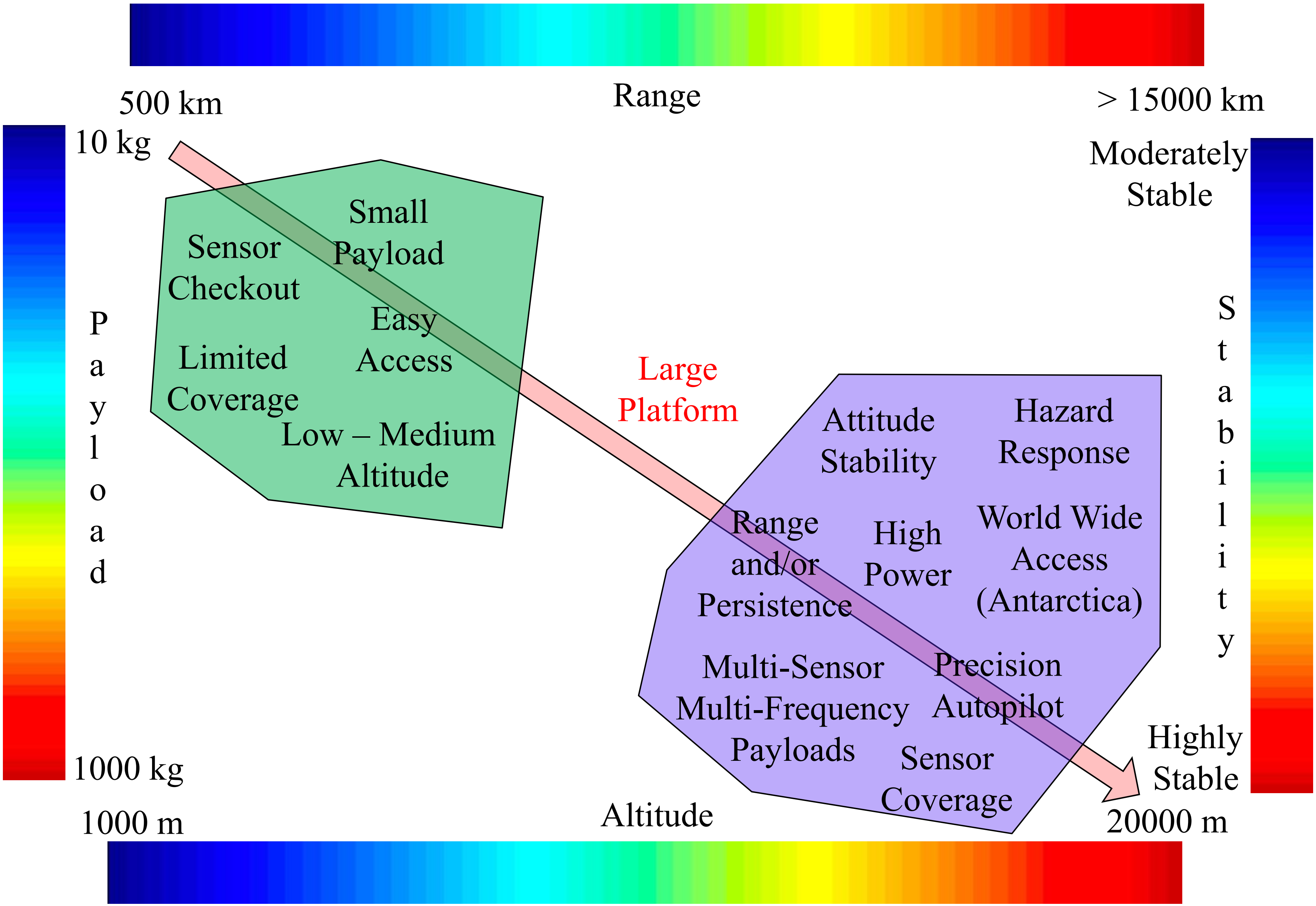
July 29, 2020

Platform and Sensor Synergism

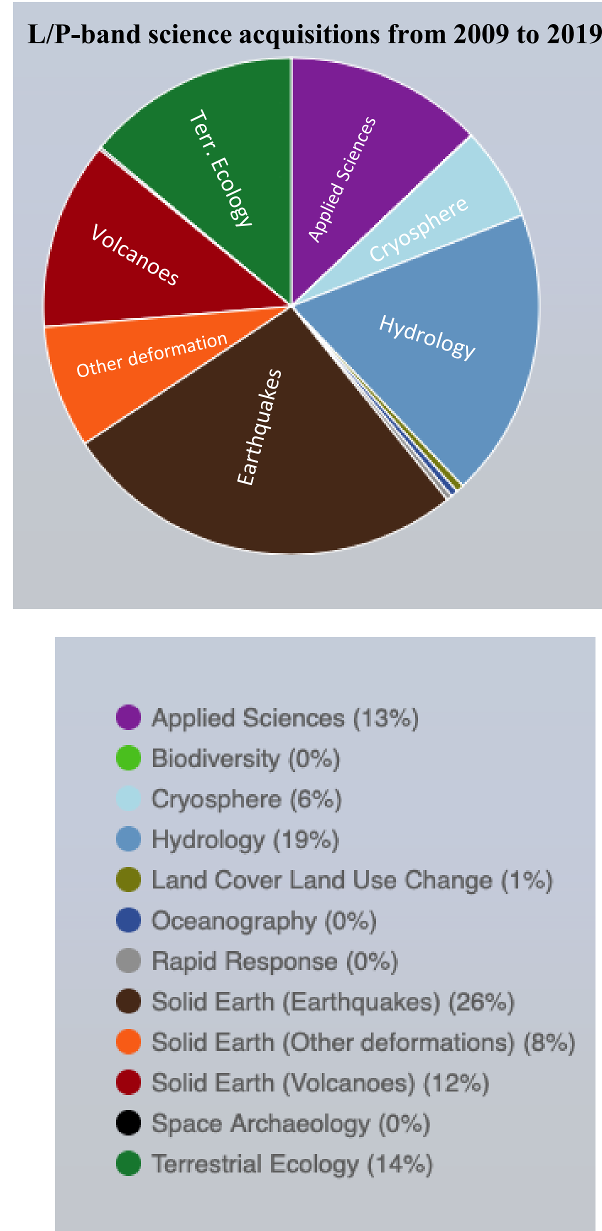
- The quality, quantity and diversity of remote sensing science and measurements are a synergistic combination of the characteristics of the sensor and platform.
- Airborne platforms serve as testbeds for future spaceborne sensors.
  – Often used to collect data similar to planned spaceborne missions to develop, refine and demonstrate proposed mission science.
  – Used in calibration and validation campaigns of spaceborne sensors.
- Airborne platforms provide valuable science data with attributes not easy or possible with spaceborne assets.
  – Increased observation flexibility with regard to aspect angle, temporal and spatial baselines or increased sensor performance like better resolution.
  – Have increased flexibility for configuring payloads and optimizing observing time for hazard response.
- A range of platform attributes is essential for meeting NASA Earth observing science objectives that are mission dependent.
  – Early sensor prototype and testing may only need a small platform with limited capability.
  – Sensors that collect large or wide ranging data sets may require platforms with more extensive capabilities.

Attributes Driving to Larger Platforms

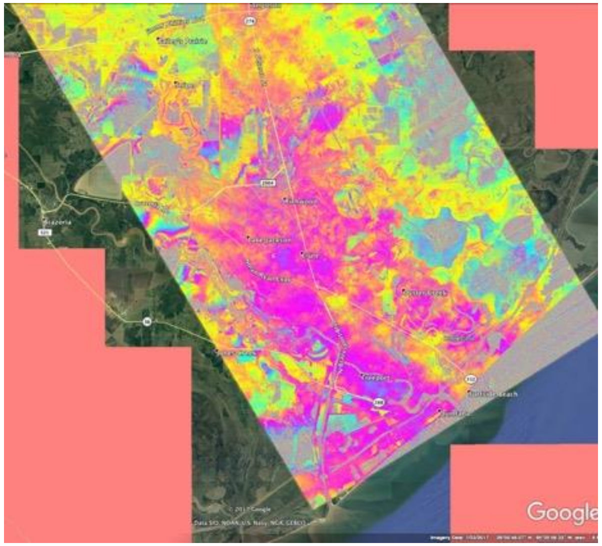


Platform Attributes for Radar Sensors

- SAR Systems – Need is Science and Application Dependent
  - Good ephemeris and attitude knowledge and control
    - Shorter wavelengths tend to require greater attitude control and knowledge
  - Power
    - SAR systems often require more power than other instruments
  - Data Volume
    - SAR system generate large data volume
  - Antenna
    - Space to mount one or more antennas and a clear radiating path for them
- Single Pass Radar Interferometry
  - Room to separate two antennas. Longer wavelengths require longer baselines
  - Accurate platform attitude knowledge
- Repeat Pass Radar Interferometry
  - Very accurate platform trajectory control – precision autopilot
  - Good attitude stability and control or sensor compensation
  - Accurate ephemeris and attitude knowledge



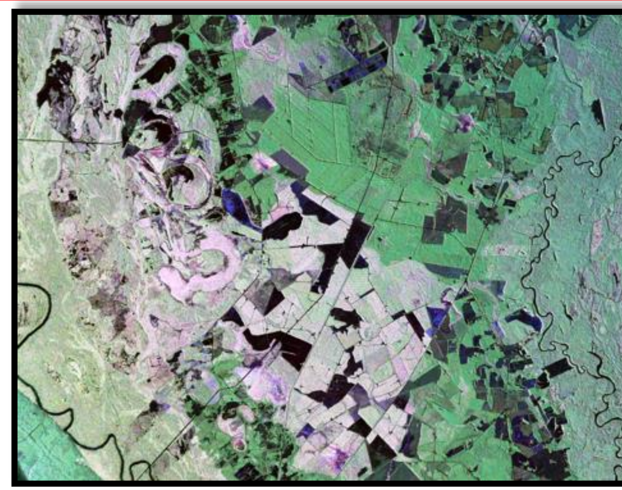
Hazard Response



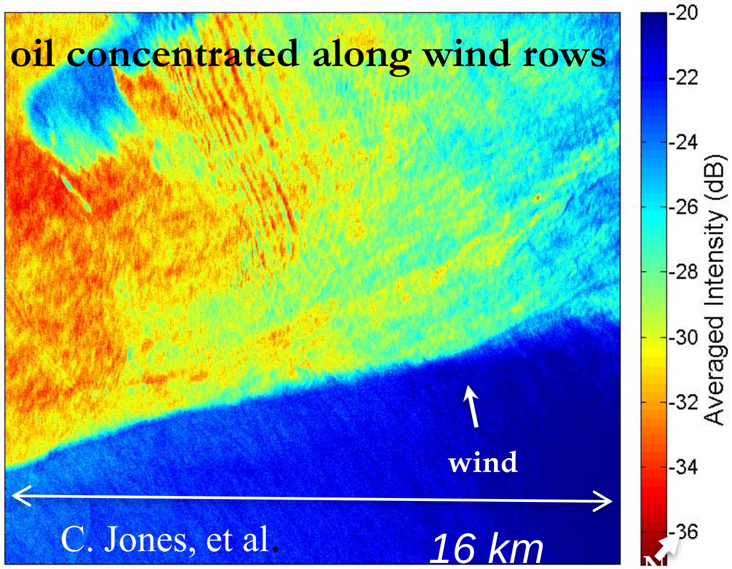
South of Houston near Gulf coast & Freeport, TX: Fringe pattern shows change in water depth over a 1-day period, Aug. 31 – Sept. 1, 2017

Data source : UAVSAR, 7-m resolution
Color wrap = 12 cm change in line-of-sight distance, or approximately 5”-7” change in water depth

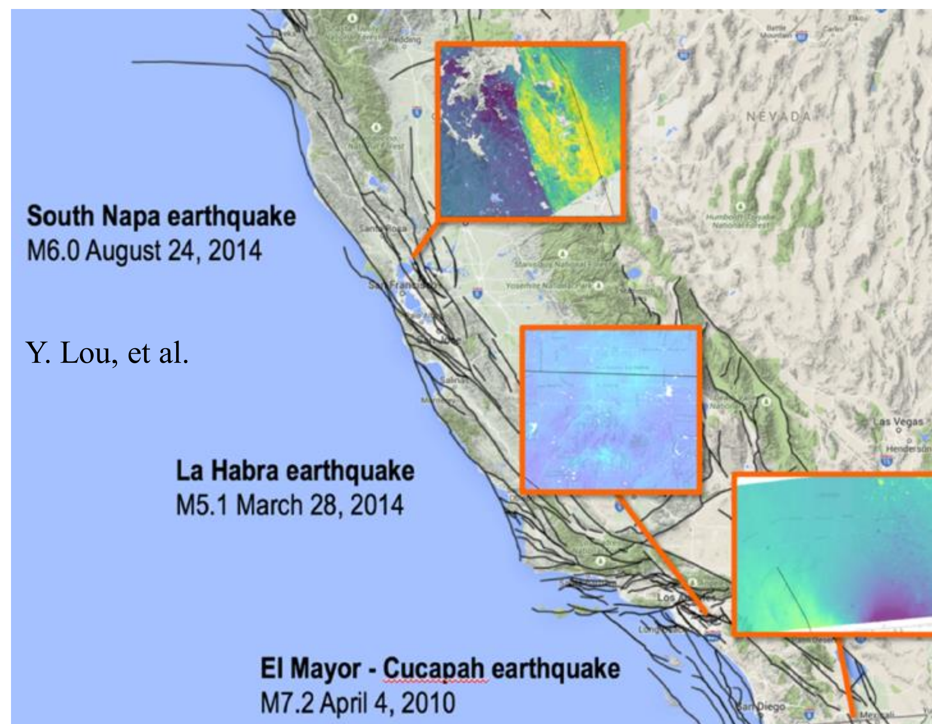
Tracking Inundation – Brazos River, Hurricane Harvey



Hurricane Florence flood mapping



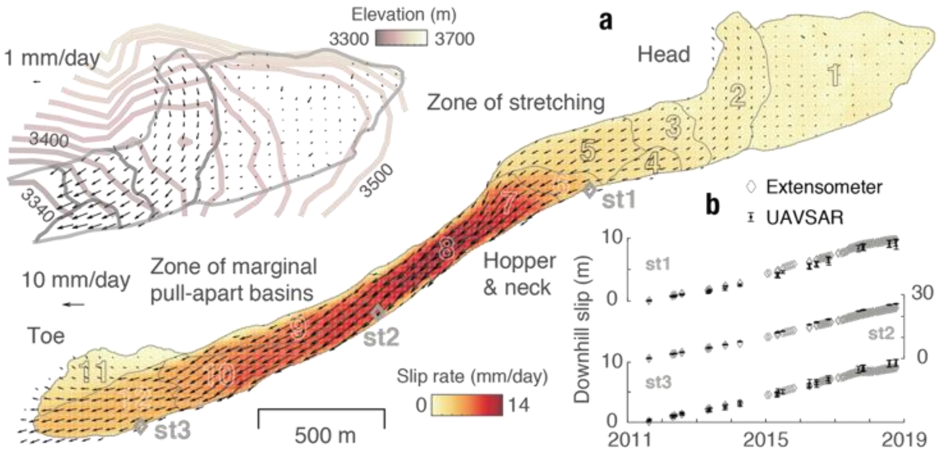
Oil Spills



Surface Change

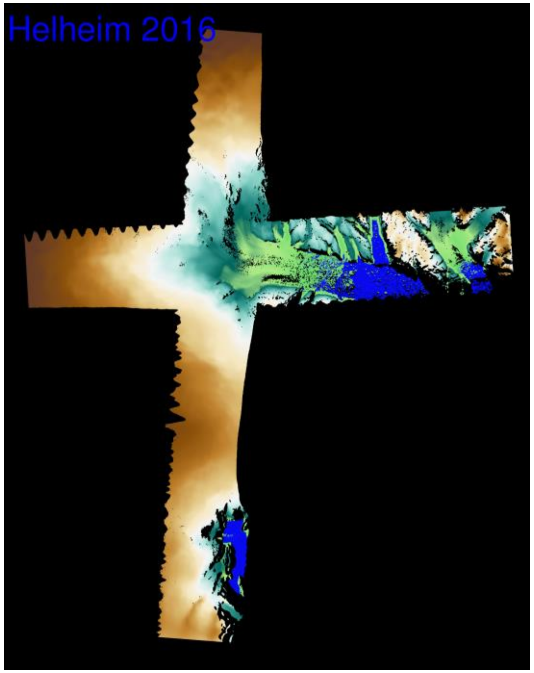
Slumgullion 3D velocity

Hu, Bürgmann, Schulz, Fielding,
Nature Communications (accepted)



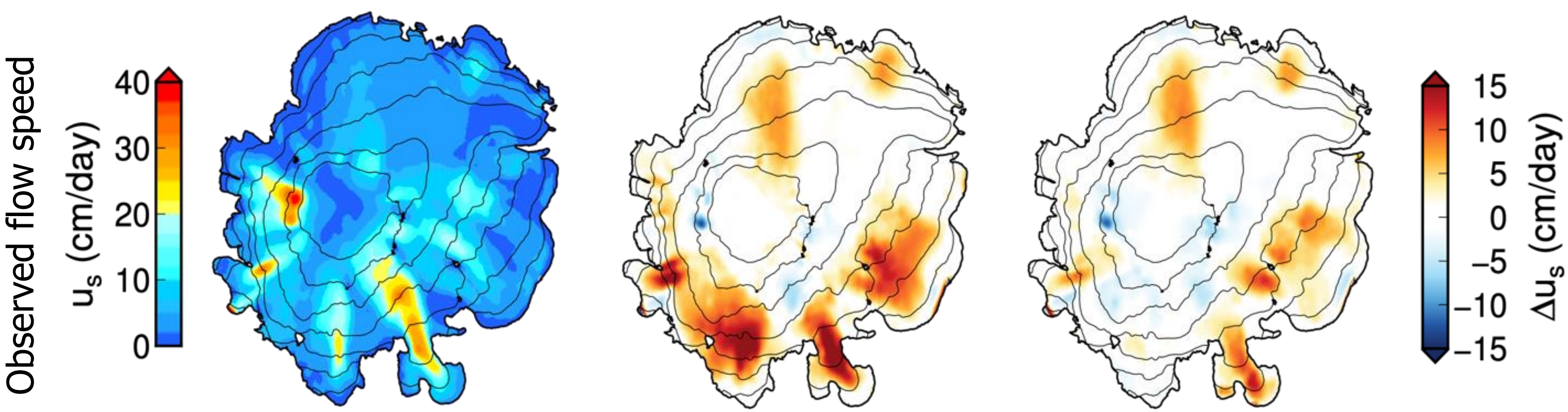
OMG
Greenland Glaciers
Ka-band
Interferometry

Started and an IIP as using the platform and much of the L-band sensor electronics as a testbed.



Muellerschoen, et al.

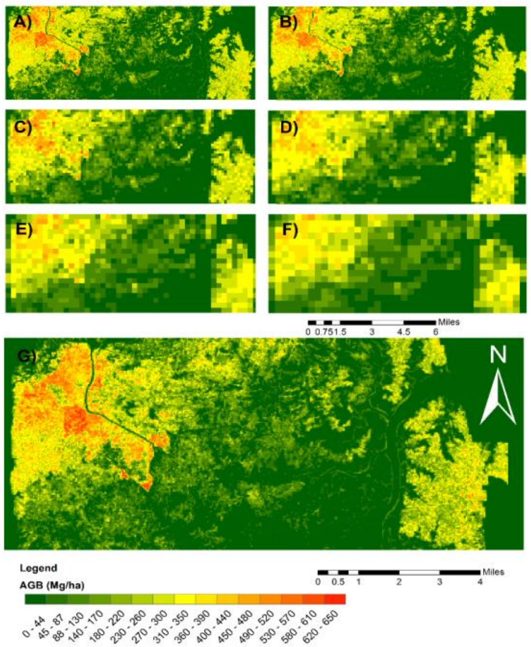
Iceland Ice Sheets – Repeat Pass Radar Interferometry



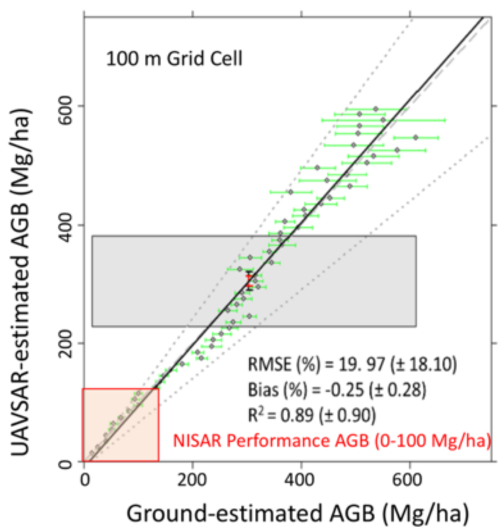
Brent Minchew, et al.

Support to NASA Earth Observing Missions

NISAR Above Ground Biomass



S. Saatchi, et al.

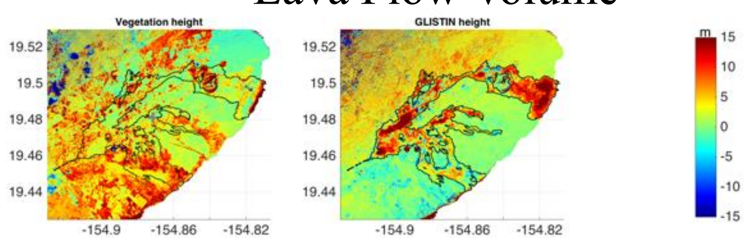


NISAR Crop Identification – Time Series

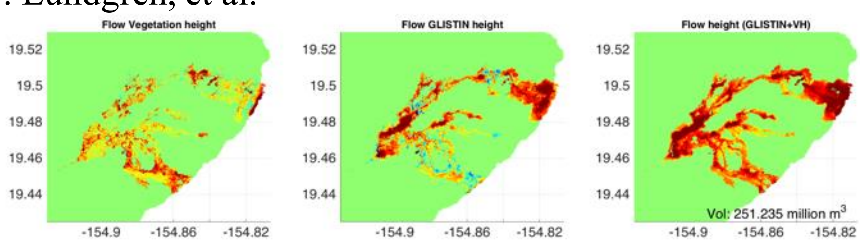
P. Siqueira, et al.

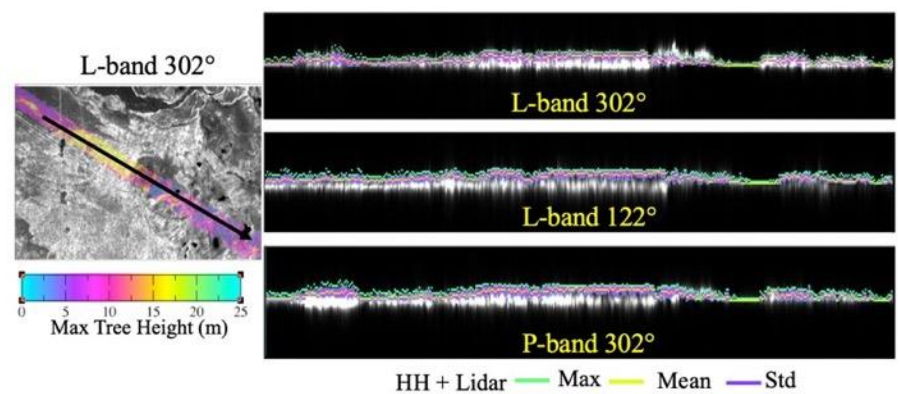
Time Series: Aug

Lava Flow Volume



P. Lundgren, et al.





Multi-Frequency L and P-band Tomography

Backup

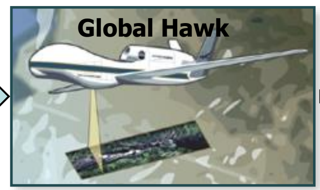
Evolution of UAVSAR Development

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, NISAR, and SWOT. UAVSAR also supports science investigations that are not otherwise possible with spaceborne observations.

2004 - 2008
ESTO IIP, R&A

L-band repeat-pass InSAR for surface deformation, vegetation structure, soil moisture mapping, land use classification, glaciology, and applied science

2009 - 2014
ESTO



L-band polarimetry for land use and vegetation classification, and soil moisture mapping

2011 - 2012
EV-1 AirMOSS

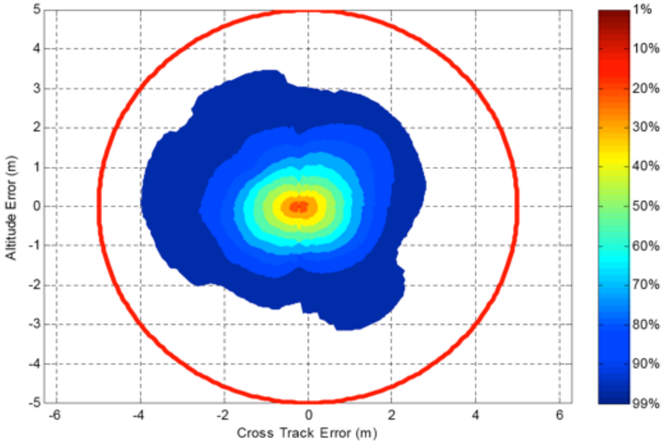
P-band polarimetry for measuring subsurface and sub-canopy soil moisture

2009, 2011 - 2013
IPY, ESTO AITT GLISTIN-A

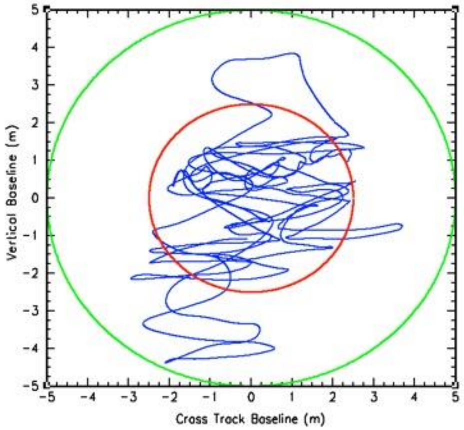
Ka-band single-pass InSAR for observing glacier and land ice topography

- Repeating tracks < 10 m diameter, enabling repeat-pass interferometry

Precision Autopilot Hardware



Flight data: 10 m tube performance



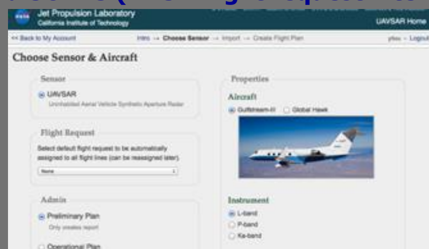
San Andreas Fault Repeat-Pass Baseline
80 km Datatakes on
February 12 & 20, 2008

UAVSAR Facility Instrument Suite

ALL THREE INTRUMENTS SHARE COMMON HARDWARE, GROUND DATA SYSTEM, AND TRAINED STAFF

FLIGHT PLANNING

Choose frequency in Flight Planning Tool And SOFRS (NASA flight request interface)



INSTRUMENT

Back-end electronics (3 sets) and spares common to all frequencies

L-band

P-band

Ka-band

FLIGHT AND PROCESSOR OPERATIONS

Common Flight Operations

Ground Data System

Perform SAR processing at Ames' Pleiades supercomputing facility

DATA DISTRIBUTION AND ARCHIVE

UAVSAR Instrument Parameters

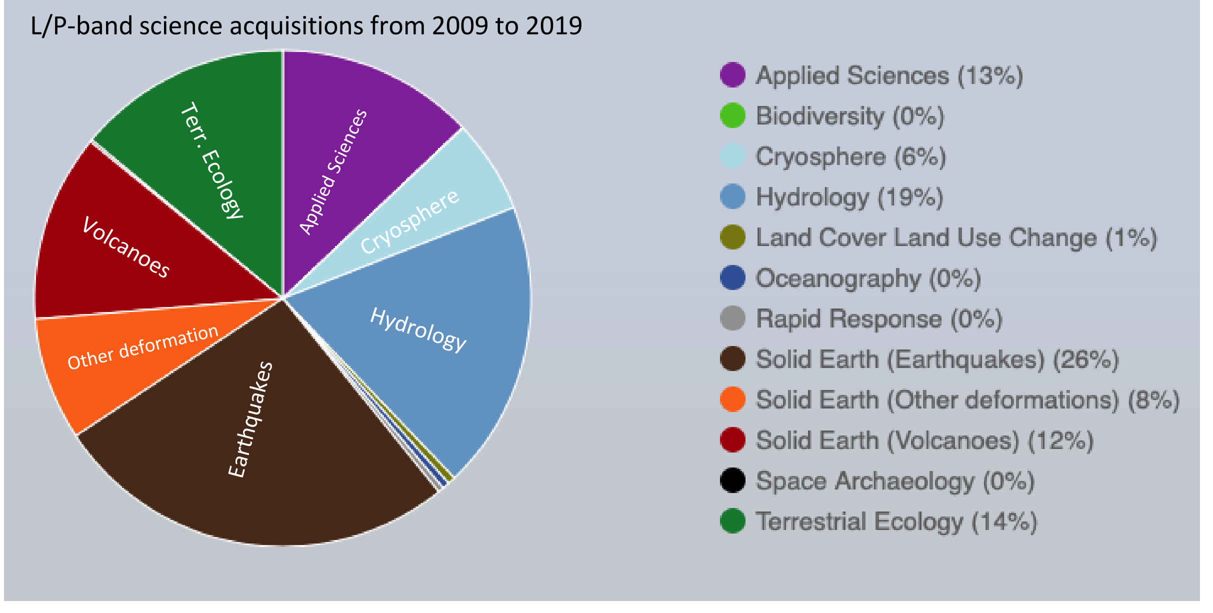
	P-band/UHF	L-band	Ka-band
Frequency (MHz)	280 – 440	1217.5-1297.5	35,620-35,700
Nominal Bandwidth (MHz)	20	80	80
Selectable Bandwidths (MHz)	6, 20, 40, 80	80	80
Polarization	Quad-pol	Quad-pol	Horizontal
Peak Transmit Power (W)	2000	3100	55
Maximum Duty Cycle	10%	8%	10%
Nominal Look Angle Range	25 – 55 deg	25-65 deg	15-50 deg
Nominal Range Swath (km)	15	22	10
Noise Equivalent Sigma0 (dB)	< -40	< -50	TBD
Radiometric Accuracy (dB)	< 1 absolute	< 1 absolute	TBD
One-look Slant Range Resolution (m)	7	1.8	1.8
One-look Azimuth Resolution (m)	0.8	0.8	0.25
Spatial Posting (m)	15	6	30
Height Precision (30x30 m posting)	N/A	N/A	0.1 – 0.5 m

Unique Features:

- High resolution
- Low noise floor
- Well calibrated radiometry
- Multi-squint angle imaging (L-band)
- TomoSAR (L&P-band)
- Programmable TX bandwidth & waveform
- Flexible imaging geometry
- Fast/flexible revisit time
- Onboard processor for rapid response
- Low data delivery latency

UAVSAR's Current Performance

- Meeting science metrics: supporting ~500 flight hours of R&A requests per year, with increasing demand
- Generated ~200 peer reviewed publications; supported many students/Post-Docs
- Raw science data volume: ~200 TB, distance: ~1 mil. Km
- Demonstrated P/L-band repeat-pass PolInSAR & TomoSAR, Ka-band topo. InSAR



Non-pressurized pod with air inlets for cooling the radar electronics