The Uniqueness of AirSWOT Measurements

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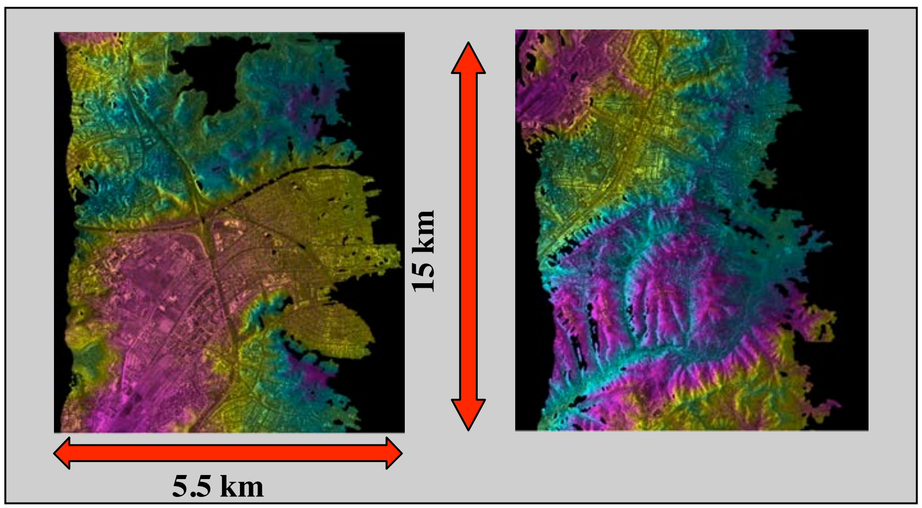
Introduction and outline

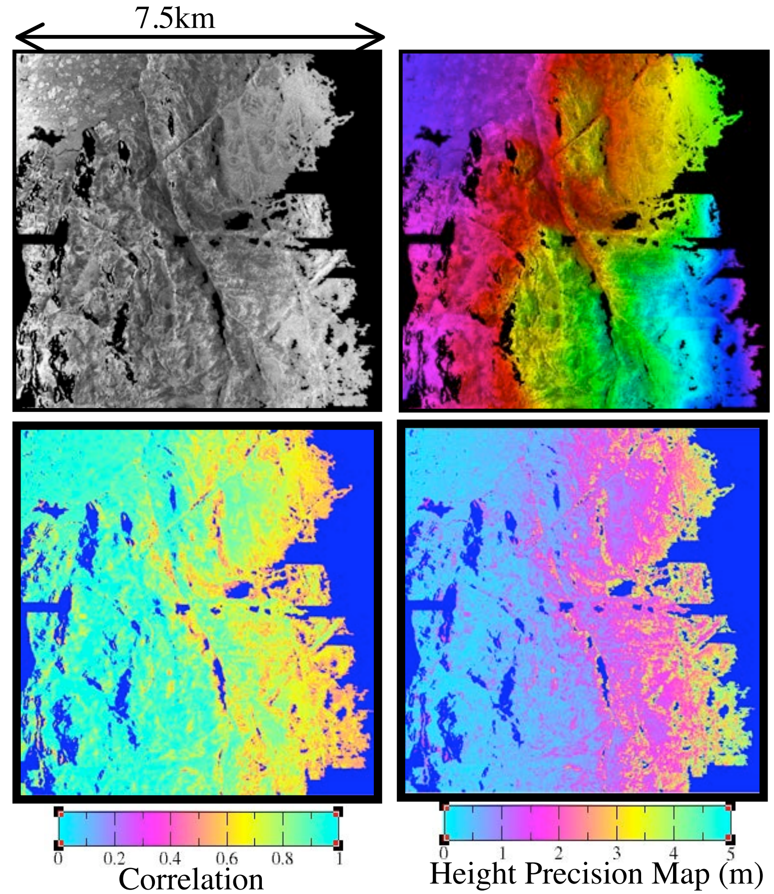
- Heritage
- AirSWOT
  - KaSPAR Instrument configuration
  - Measurements and processing
  - Auxiliary sensors
- AirSWOT phenomenology and technology support of SWOT
- Status/timeline

Heritage: GLISTIN Ka-band Airborne Interferometer

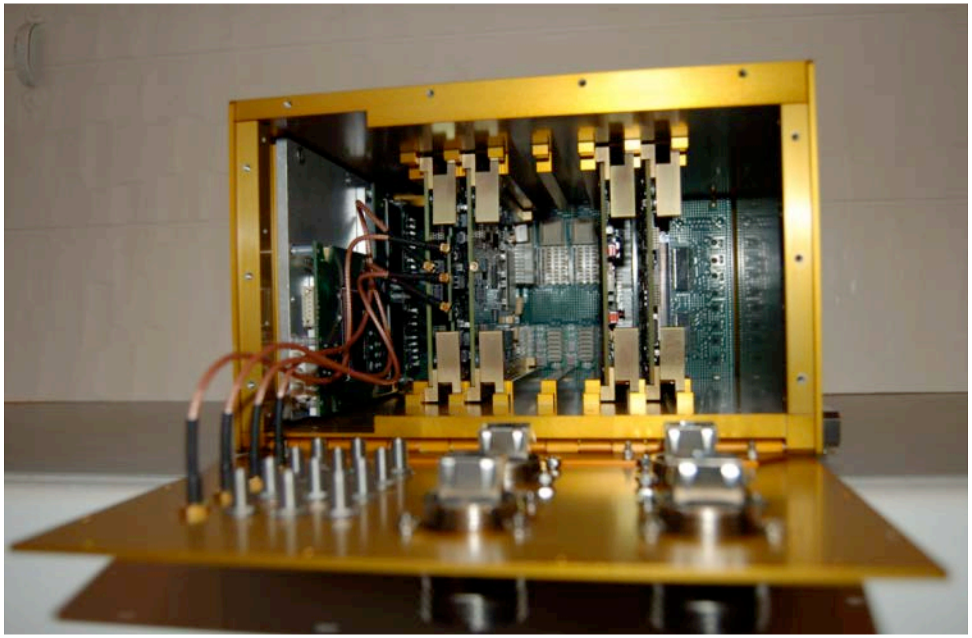
First demonstration of millimeter-wave single-pass interferometry

- Successfully deployed to Greenland May '09.
- ***Major step forward in technology development and technique demonstration***
- ***Processing refinement and development at JPL will be direct heritage for KaSPAR***
- Data collected en-route for SWOT for hydrology and sea-ice.
  - Fringes observed and good off-nadir coherence
  - 31º boresite so aircraft rolled toward nadir and "crabbed"





Other Key Technology Heritage



iRAP multichannel digital receiver system

- Currently flying on the Global Hawk UAV to support NASA HIWRAP system.
- Highly parallelized can support the seven receive channels of KaSPAR
- FPGA digital receiver which supports 400 MHz bandwidth (expandable)
- System expandable and can be linked over 4 GigE communications to another unit.
- Can update matched-filter pulse compression waveform on a pulse-by-pulse basis

Solid-state power amplifier (SSPA) development:
Significant advances in power combining solid-state modules at Ka-band over past few years (mostly supported by communications industry). The NASA D3R GPM radar will use a state-of-the-art SSPA to 40W:

- Utilize nearly identical unit for KaSPAR
- Enables unpressurized and compact airborne operation (compared with tube-amplifier)

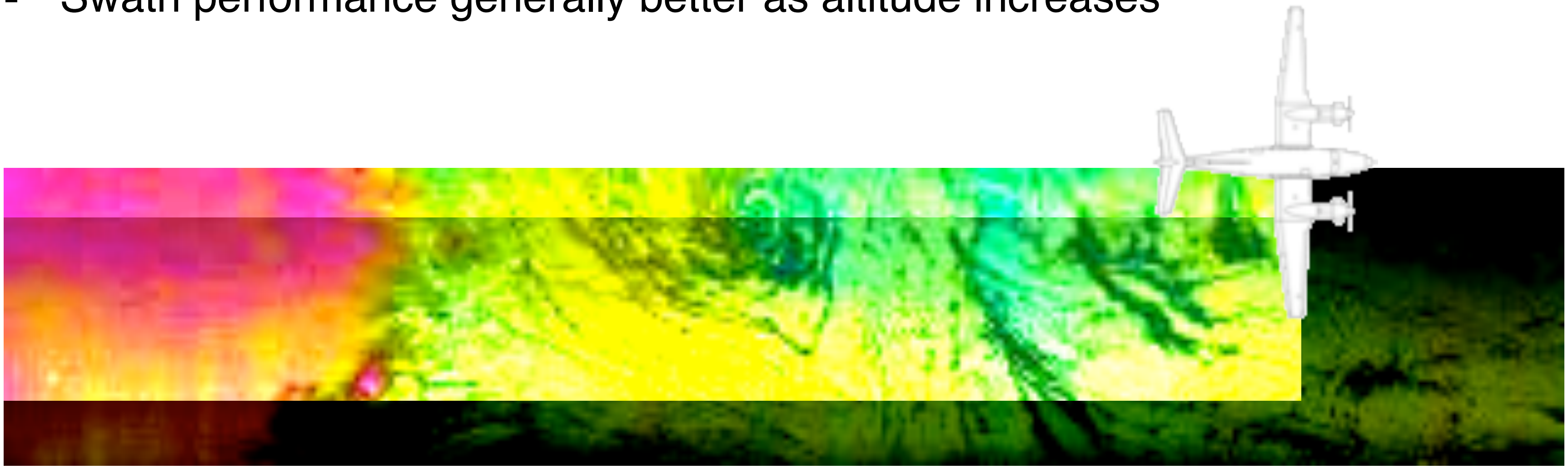
A Ka-band SWOT Phenomenology Airborne Radar (KaSPAR)

Two sets of transmit antennas:

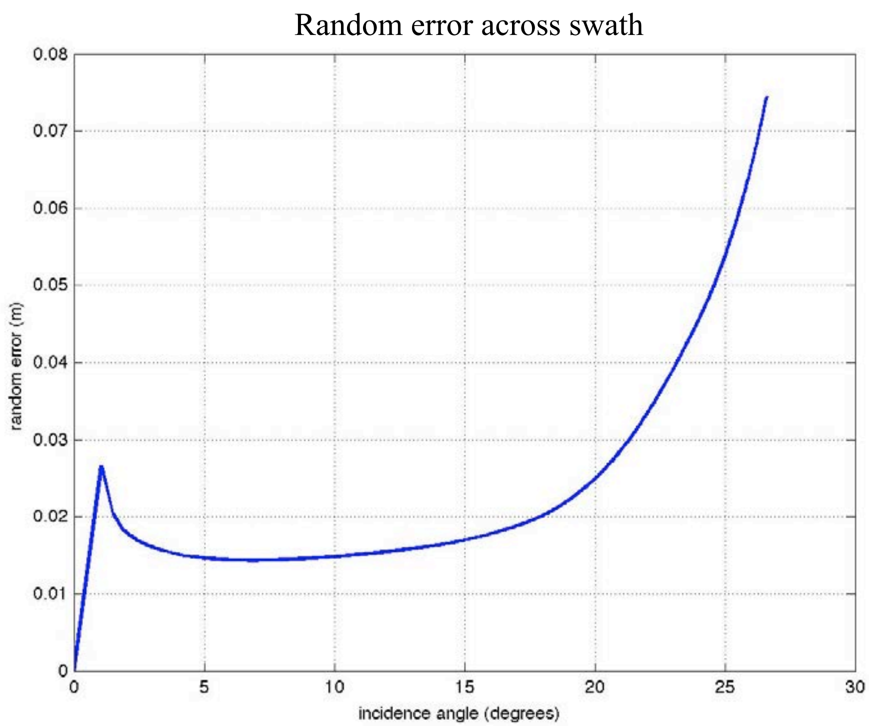
1. Illuminate inner (SWOT geometry) & outer swath to provide wide-swath coverage
2. Use inner "SWOT" swath for classification and phenomenology pre-mission algorithm development
3. Larger swath for SWOT cal/val, science and discharge retrieval development
4. Overlapping beams for inter-calibration

Initial aircraft NASA King Air but design aircraft independent

- Swath performance generally better as altitude increases



Description and Performance



Parameter	Value	Unit
Center Frequency	35.75	GHz
Peak Transmit Power	40	W
Platform Height	35	kft
Swath Coverage "inner" "outer"	1.4 5.0	km
Bandwidth "inner" "outer"	200 (min) 80 (min)	MHz
Mean height error "inner" "outer"	1.2* 2.3**	cm
Incidence angles "inner" "outer"	1-5 4-27	deg

NRCS assumes ocean 6m/s winds => azimuth resolution ~80m

* No calibration other than aircraft roll-knowledge used. Range resolution 20m

** calibrated for systematic errors using altimeter. Range resolution 50m

Measurements and Processing

KaSPAR will make the following measurements*:

1. Surface elevation maps of the water and land (land accuracy will be lessened)
   - Swath of up to 5km depending on water state
   - Resolution variable but innate instrument 1-look resolution is 10's of cm along-track and 10-5m range
   - Precision for ~50x50m posting is sub-3cm mean and assumes an ocean surface with 6m/s or greater winds
2. Surface temporal correlation estimates
3. For outer incidence angles - surface radial velocity
4. Corresponding backscattered power and correlation maps

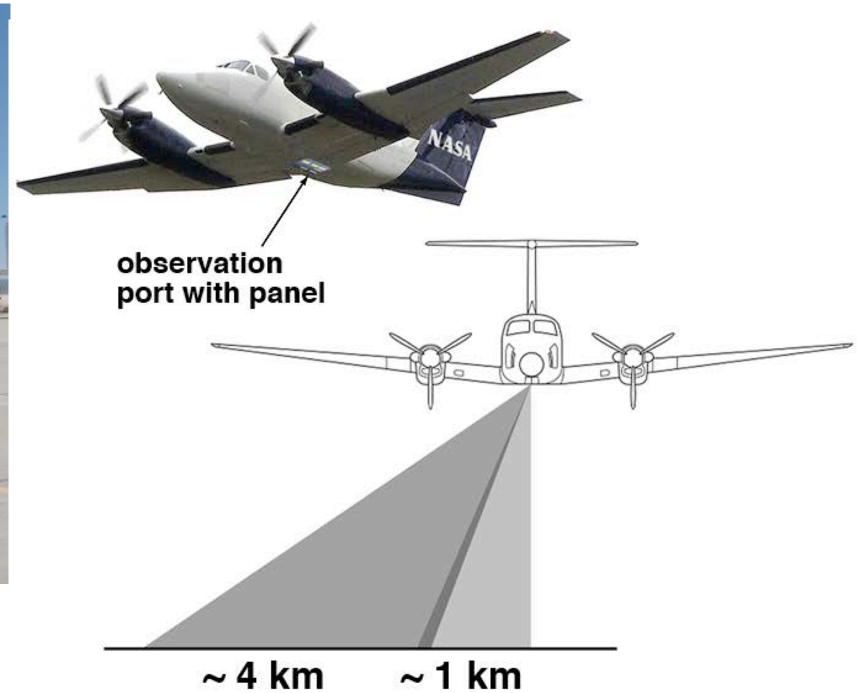
InSAR processing will build on the GLISTIN-A interferometric processor and calibration.

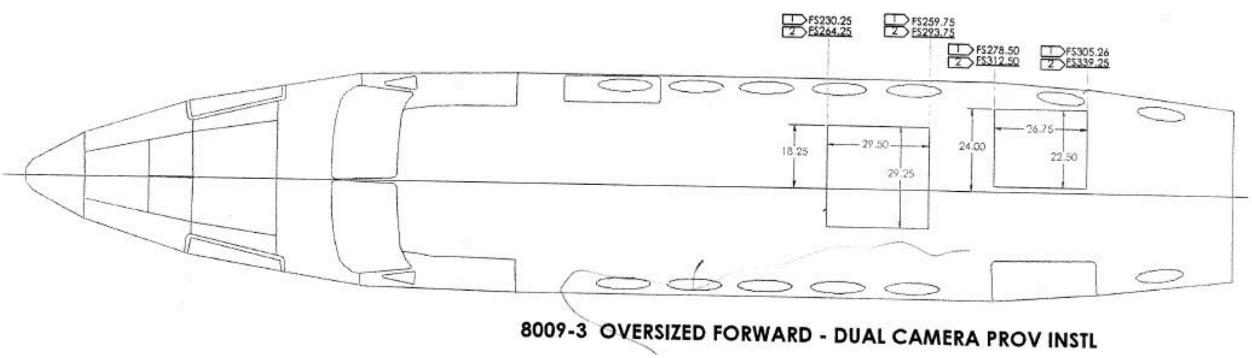
- Instrument and data calibration is very challenging to achieve the accuracies wanted.
- The instrument stability and IMU corrections for aircraft attitude are critical

In the near-term (first 2-3 years of deployments) KaSPAR/AirSWOT is not *"operational"* and will generate ***research*** data for the science team. These activities will help define what the operational products should be

*all simultaneous including both "SWOT-like" and "mapping" swaths

The Plane: NASA King Air B200





- Two available (DFRC and LARC) with nadir ports ready modified
- Altitude 35kft

Auxiliary Sensors

Two NASA airborne science facility sensors will be borrowed at no cost to SWOT for the deployments:

1. DCS Near IR camera in aft port (cover field of view of radar with meter-level pixel size at 35kft). Frames will be synchronized with the IMU and radar.
2. Applanix 510 IMU (possibly 610)

AirSWOT Technology Support for SWOT: Calibration Loop

To meet the phase calibration goals outlined above KaSPAR will implement calibration loops to verify a new technique SWOT plans to employ for channel phase calibration.

- This is to enable loopback phase calibration to greater accuracy than required strictly for KaSPAR(0.2^{o} budgeted)
- Rather this will demonstrate calibration knowledge to millidegrees
  - Matched filter tracks phase-changes in real-time by recording transmitted pulse through full transceiver path
  - SNR and stringent signal to leakage ratio requirements

Success impact in terms of SWOT:

verify proposed SWOT calibration loop which enables relaxation of phase stability requirements since the method corrects for drift

AirSWOT support for SWOT pre-mission

- Multiple (elevation & temporal) baselines replicate and fully characterize SWOT sampling and geometry
- Gather pre-mission data for SWOT over specific and varied science targets for:
  - Classification (eg: land/water, wet-land/water, ice/water etc)
  - Discharge algorithm validation
  - Water temporal correlation
  - Elevation (both land and water)
  - Surface backscatter
  - Vegetation attenuation
  - Elevation retrieval over vegetated water
  - Sea ice height measurement
  - Penetration into snow for cryospheric applications
  - …

KaSPAR Development Status

Current Status:

- System design complete including technical reviews at JPL.
- System RF design complete, antenna prototype underway and RF fabrication started
- Mechanical preliminary design underway

Schedule:

- *Assuming IIP funding* we are looking at system completion fall 2010.
- Aircraft integration late 2010
- Initial test flights beginning as early as 11/2010 or as late as 1/2010 based on funding availability and phasing

Closing Questions

- Beyond the starter list of sites from the IIP, what is missing?
- How might we ensure these data are integrated into the algorithm development and characterization activities?
- What other opportunities are there beyond the IIP? What is our fallback approach?
- Are there other sensors or auxiliary data that is not being considered?
- European collaboration and logistics (for sites in Europe) - no longer a question of when but how?

Proposed AirSWOT Deployments

These IIP sites are intended in the long-term to be the SWOT mission calibration/validation sites

Schedule:

- **Jan & Feb 2012:** Dryden local engineering checkout including Sacramento river ~ 20 hrs, 5-6 flights
- **Mar - April 2012:** Cape Hatteras. 4 flight hours/day for 30 days. Schedule is to coincide with the ONR-funded "LatMix" experiment that will share in situ data. Atchafalaya wetlands and Mississippi River confluence. 150hrs
- **June 2013:** Yukon flats & Tanana River, Alaska. 27hrs
- **Sept 2013:** Repeat Yukon flats and Tanana River, Alaska. 27 hrs