AirSWOT Technology and Campaign Logistics

Presented by Delwyn Moller

Acknowledgements: Ernesto Rodriguez, James Carswell, Doug Alsdorf, Larry Smith, Tamlin Pavelsky, Daniel Esteban-Fernandez, collaborators at USGS, NASA Airborne Science and NASA Dryden

Introduction and outline

Purpose today is to give an overview of AirSWOT and think about what is needed, particularly over the next few years to support the pre-mission SWOT and VM activities:

- Where (sites, then how often, seasons)?
- What (ground truth, auxiliary sensors, KaSPAR "data products")?
- How (aircraft logistics,funding)?

AirSWOT

- KaSPAR Instrument configuration
- Measurements and processing
- Auxiliary sensors

Proposed deployments/sites (IIP summary)

- Timeline
- Aircraft logistics
- Ground truth

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REMOTE SENSING SOLUTIONS

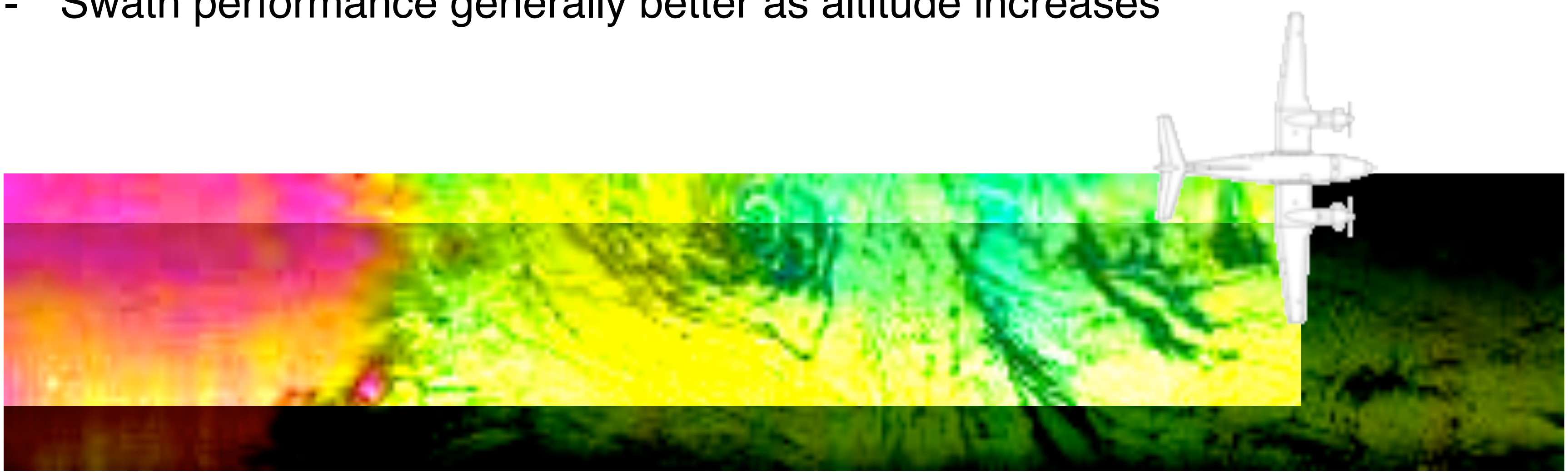
A Ka-band SWOT Phenomenology Airborne Radar (KaSPAR)

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



JPL SBIR STTR REMOTE SENSING SOLUTIONS

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

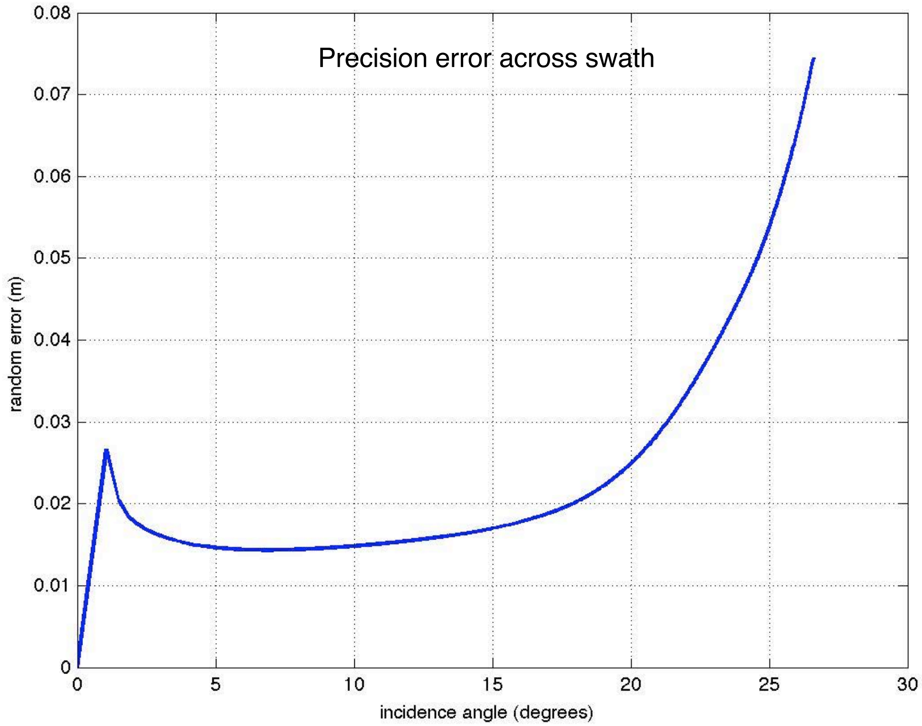
InSAR processing will build on the GLISTIN-A interferometric processor and calibration.

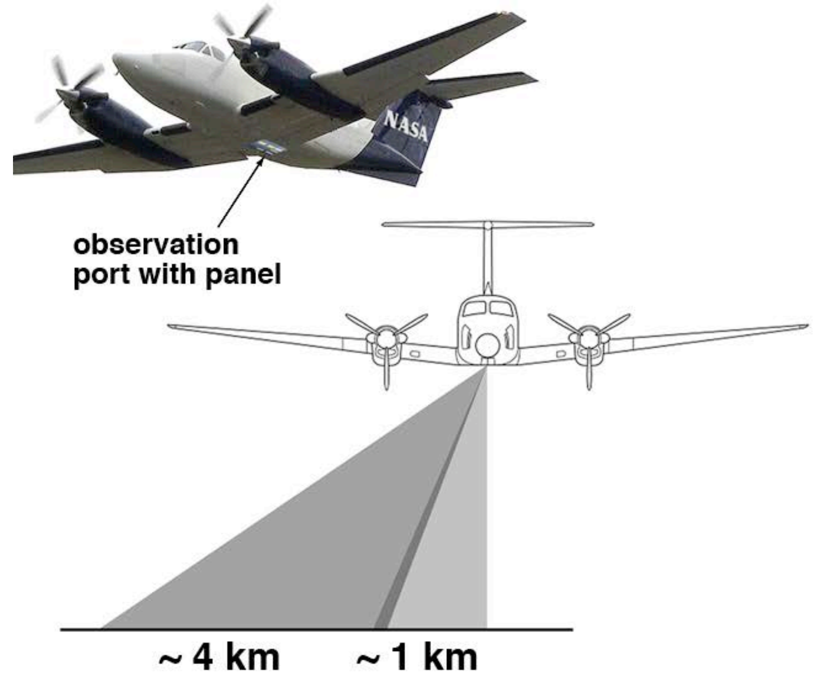
- Instrument and data calibration is very challenging to achieve the accuracies wanted.
- The instrument stability and IMU corrections for aircraft attitude are critical (to be discussed Friday).

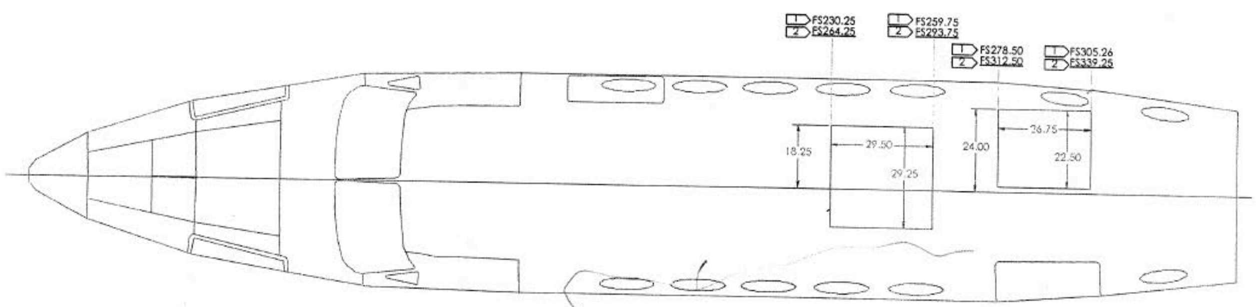
In the near-term (first 2-3 years of deployments) KaSPAR/AirSWOT is not *"operational"* and will generate ***research*** data for the VM and science team. These activities will help define what the operational products should be

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

The Plane: NASA King Air B200







8009-3 OVERSIZED FORWARD - DUAL CAMERA PROV INSTL

- 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:

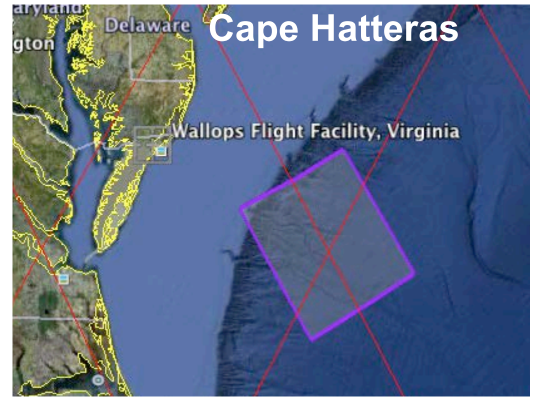
1. DCS Near IR camera in aft port (cover field of view of radar with meter-level pixel size at 35kft). Frames will be synchronized with the IMU and radar.
2. Applanix 510 IMU (possibly 610)

Proposed AirSWOT Deployments (IIP)

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



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REMOTE SENSING SOLUTIONS

Aircraft Logistics

The King Air B200's at DFRC and Langley are targeted for several reasons:

1. Cost (~$2k/flight hour) and performance. For a small aircraft it can fly high - to 35kft. After this the next step is into jet aircraft which have definite advantages but availability and/or configuration issues.
2. The ports are already available so there is no aircraft modification cost
3. Versatility. We can fly into small airports with a small crew.

However, aircraft duration is a limiting factor and a cost driver.

- Some standard aircraft modifications could significantly enhance duration, reduce transit times, maintenance constraints, and increase time-on-site.
- If comprehensive campaigns will occur with this aircraft, the modifications will more than pay for themselves in flight hours and reduction in maintenance cost.

A final note: rivers don't follow straight lines but for accurate data the aircraft has to!

Hydrology Campaigns

To achieve SWOT mission goals campaigns AirSWOT will retire two key risks:

1. Verify correct mapping of the water surface (h, dh/dt, dh/dx and classification)
   - Includes assessment of ability to detect water surfaces through riparian and aquatic vegetation
   - For different surface wind and flow conditions
2. Validation of river discharge-retrieval algorithms

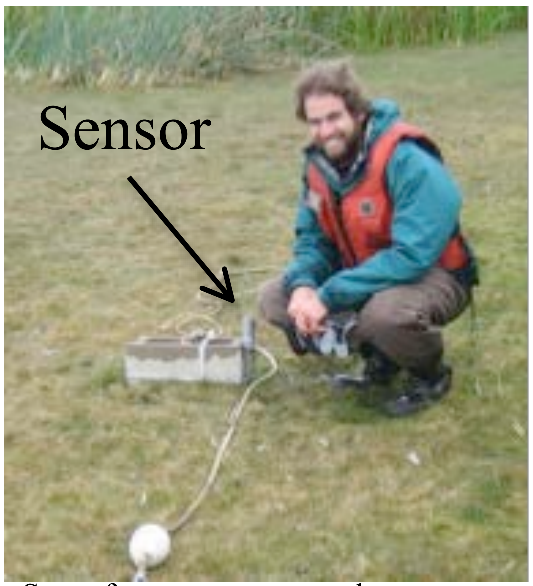
Contemporaneous with AirSWOT we (in collaboration with the USGS) will collect ground measurements:

- River discharge and flow depths
- Water surface heights and slopes
- Inundation widths along rivers
- Vegetation surveys including species identification, bole density and diameter, canopy closure and height

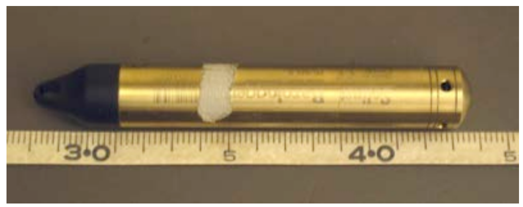
Strategies for Validation of KaSPAR Hydrologic Measurements

Water Level and Slope:

- Install pressure transducer water level loggers in rivers and lakes, recording water level changes every 15 minutes with mm-level precision.
- Use differential GPS to obtain absolute elevations for each sensor.
- Compare temporal and spatial variations in water surface elevation between KaSPAR and field data.

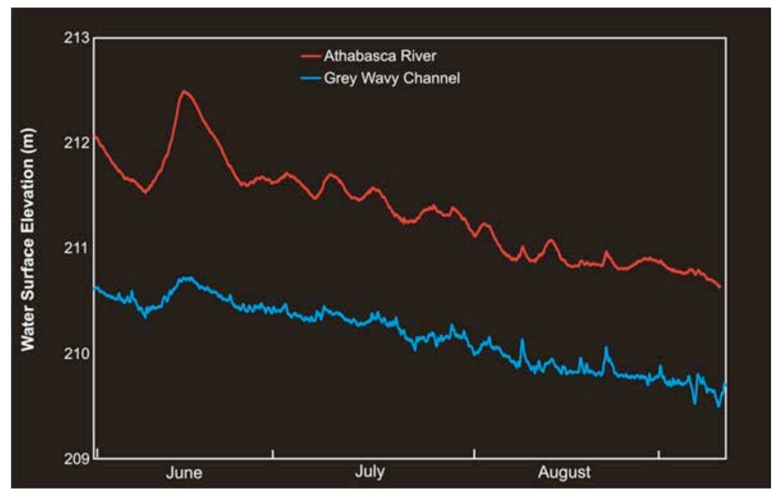


Setup for a pressure transducer sensor installed in a lake



Solinst Pressure Transducer Water Level Logger

Examples of pressure transducer data for two river channels, Peace-Athabasca Delta, Canada



Differential GPS Equipment used for surveying water levels in rivers and lakes.

Viewgraph credit: Tamlin Pavelsky UNC-Chapel Hill

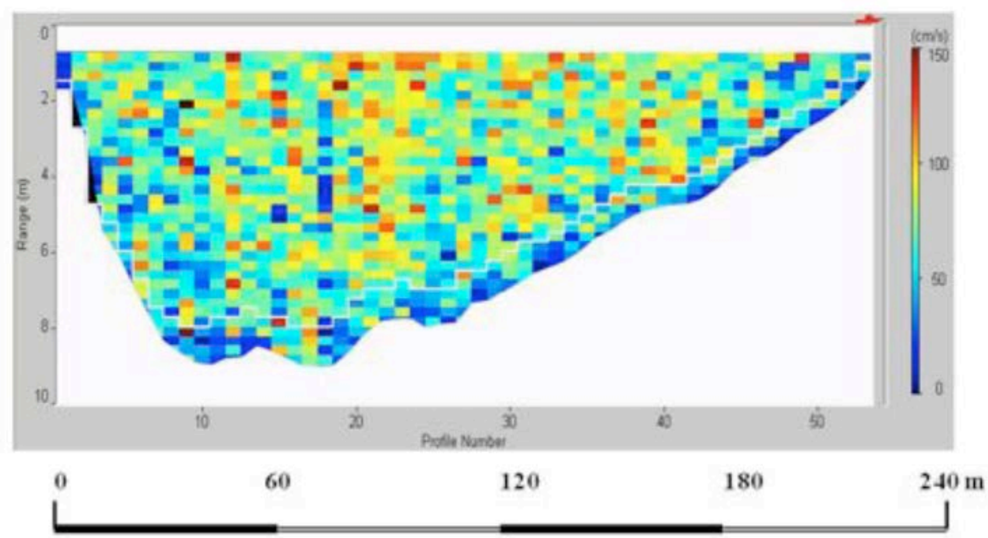
Strategies for Validation of KaSPAR Hydrologic Measurements

River Discharge and Flow Velocity:

- With help from the U.S. Geological Survey, obtain Acoustic Doppler Current Profiler (ADCP) measurements of river discharge coincident with AirSWOT data collection.
- Use discharge measurements from existing river gauging stations to validate AirSWOT discharge algorithms.

Photo courtesy USGS

An Example of ADCP Data

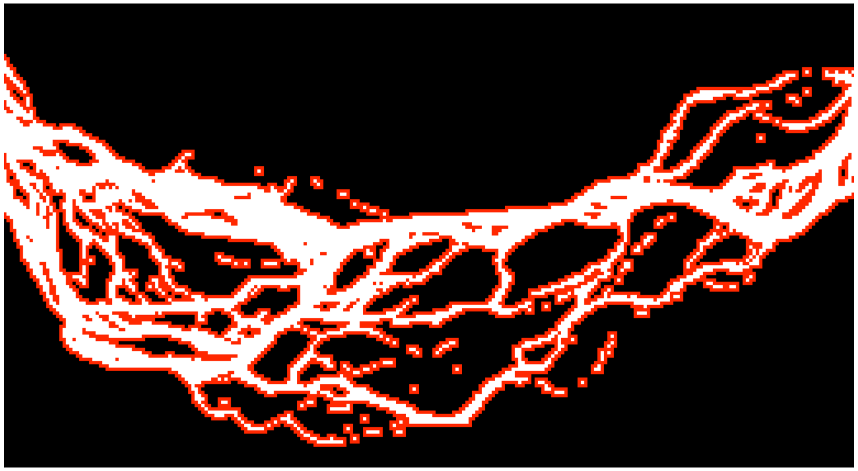


Viewgraph credit: Tamlin Pavelsky
UNC-Chapel Hill

Strategies for Validation of KaSPAR Hydrologic Measurements

Inundation Extent:

- Map inundation extent using both KaSPAR and the high-resolution Digital Cirrus Camera (DCS) that will be included on AirSWOT.
- The DCS will collect data at spatial resolutions of 50 cm – 1 m. It will include a near-infrared band, which will be ideal for mapping inundation.
- Additionally, cross-river transects of inundation extent will be surveyed in the field using traditional surveying techniques.



Map of water-land interface pixels for the Tanana River, Alaska At each red pixel, there is potential for classification error in KaSPAR data.

Digital Cirrus Camera to be included on AirSWOT

Viewgraph credit: Tamlin Pavelsky
UNC-Chapel Hill

Strategies for Validation of KaSPAR Hydrologic Measurements

Where vegetation is present, the parameters we are wish to measure are:

1. Canopy closure (can be measured with a fish-eye camera). Ideally you want canopy closure as a function of height.
2. Tree height (can be obtained by triangulation)
3. Diameter at breast height (DBH)
4. Species
5. Is it over water? If not, what does the ground look like? (bare, shrubs).

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 VM 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 for sites in Europe?