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
  - 31° 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)
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
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)
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° 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
  - …
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