Utilizing UAS in of support NOAA river ice breakup forecasting in Alaska

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River forecasting background of ice conditions in Alaska and events

- NOAA UAS River Forecasting Workshop (2/2012)
- Galena flood (5/2013)
- NOAA UAS Arctic and River Forecasting Workshop (9/2014)
- Alaska Center for UAS (ACUASI) deployed to Circle (4/2016).

Galena on the bank of the Yukon River

Galena flood

The reports recommendations regarding river break-up

- NOAA 1st workshop data requirements:
  - Ice flow- size, motion- near real-time
  - Ice Jams height in near real time
  - Water Inundation /flooding
  - Jam location, thickness, height

- NOAA 2nd workshop
  - Lack of data (Carven Scott)
    - Cover an area that is 20 times larger that average NWS in the lower 48
    - Very sparse precipitation and river gauges in Alaska
    - Need real time data

  - In the case of an ice jam
    - Height of ice jam
    - Longitudinal extent of ice jam
    - Water height above and below the ice jam

  - Requirements for UAS
    River ice information , channel ice conditions, ice movement, ice structure, ice jams

Alaska Hydrology UAS requirements

- Geophysical questions related to river ice
  - General ice condition along the river
  - Location of breakup front
  - Presence and severity of current flooding
  - Ice integrity
  - Locations of strain and stress
- Community reconnaissance (+/- 20 miles above and bellow the town)

**Galena flood

Alaska Hydrology UAS requirements

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- DEM around villages for better flood modeling

Spring breakup timeline

- Mission overview (April 5)
  Yukon rive at Circle
  1. On the road system
  2. NWS/DHSEM river-watch team fly that stretch
  3. Compliment large fix wing mapping by Dr. Jessica Cherry
  4. Circle has experienced flooding due to ice jams in the past.
  5. Yukon river is wide an adequate to compare with new satellite data sets

- Alaska Center for UAS Integration (ACUASI): deployed fix wing and rotor craft
  - Maximum endurance of about 40 minutes
  - Maximum cruising velocity 33 mph
  - Potential of total distance to cover 20 miles
  - **But-** FAA limitation to UAS within line of sight ≈2 miles

- **Proposed schedule**
  - **Budget enabled about three operation days**
  - **Breakup running 1-2 weeks early (average May 10, earliest April 30)**
  - **Five days notice (from the time ice breaks in Eagle)**

Continue

- Data collection requirements:
  - Multiple sensor Infrared
  - Visible- orthomosaic and DEM (structure from Motion)
  - Multiple flights over several days are important to NWS to get a time series of data and observe differential changes in ice conditions.
  - NWS interested in observing pre-breakup signatures (thermal and elevation changes) that are directly related to ice movement (breakup), to improve lead time for forecasting ice breakup, and ultimately ice jams and ultimately flooding.
  - Would to like to improve DEM of the Circle area for flood prediction

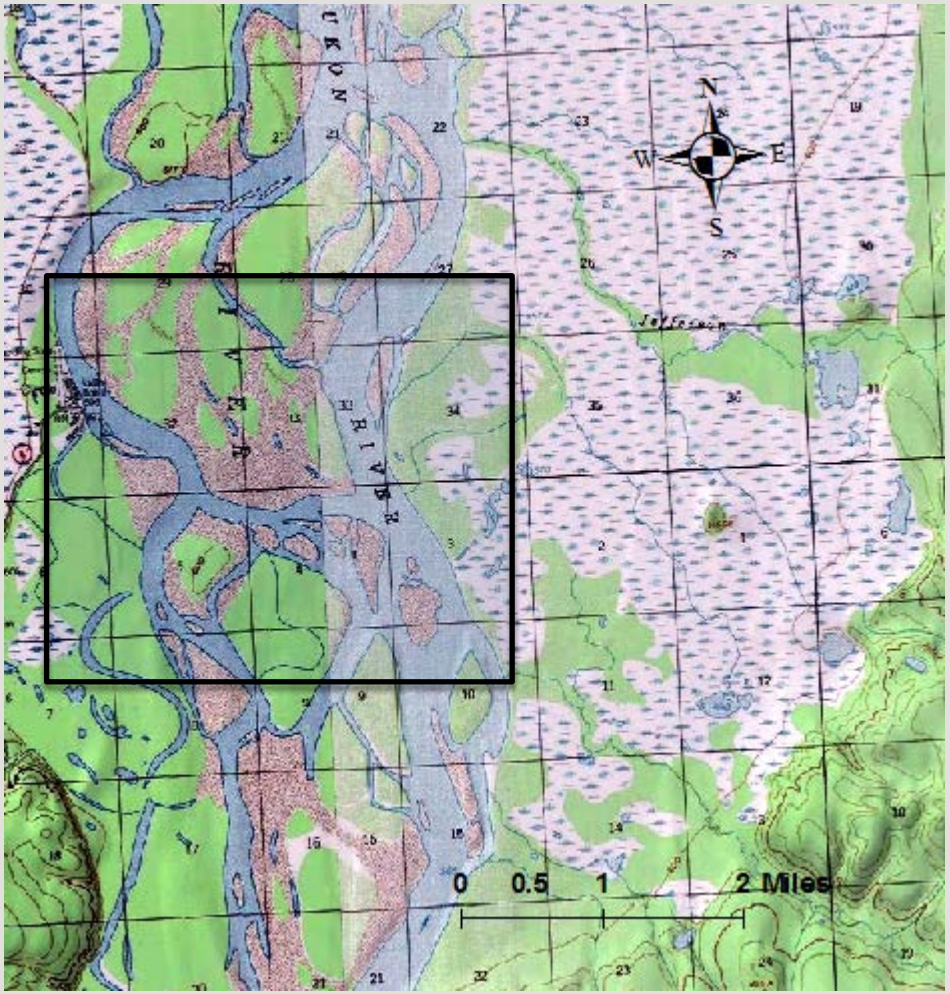
Supporting Aircrafts

- Responder-
  - Single rotor electrical craft
  - Payload several pounds
  - Cruising speed 30 mph
  - Endurance 40 min
- Aeromapper
  - Fix wing
  - Payload: Close to a pound
  - Cruising speed 30 mph
  - Endurance 40 min

Continue chronology

- Defining Area of Interest (AOI)

  About 3X3 square miles



Mission Spread Sheet

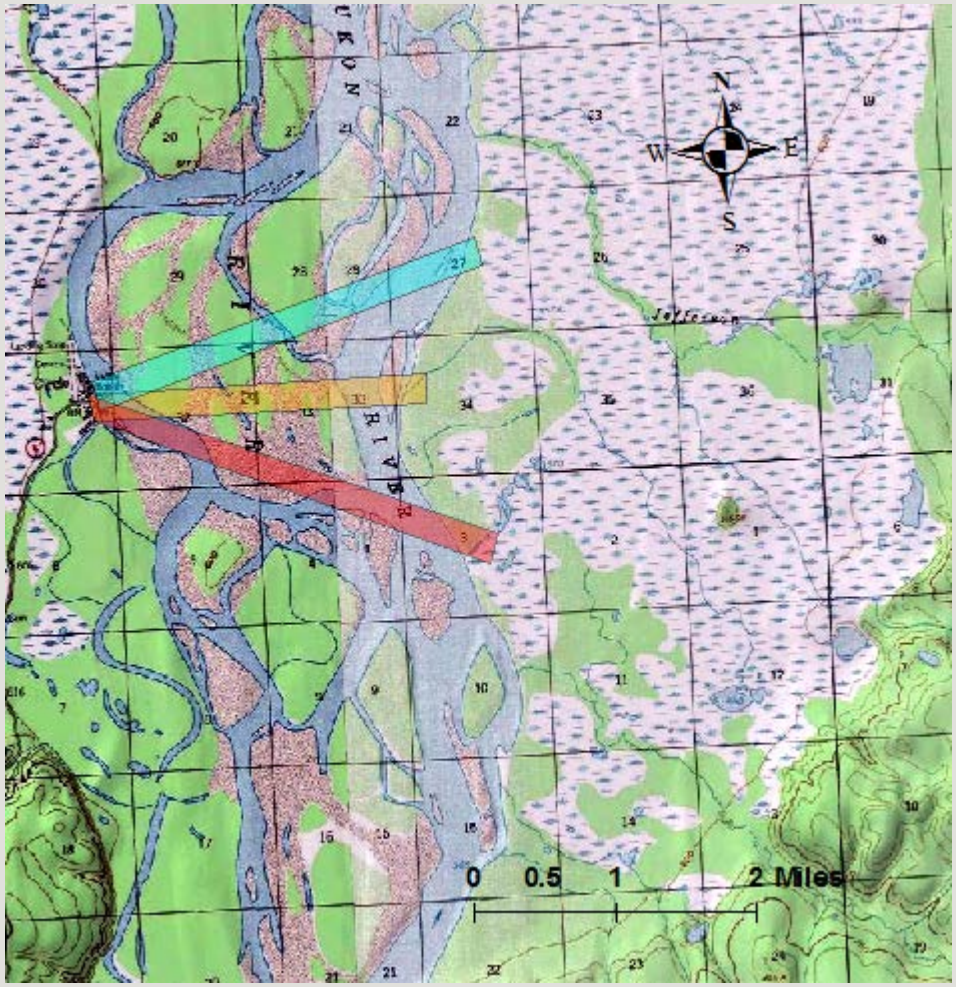
	X	Y	Toal pixels		
Number of pixels ir	6000	4000	24000000		
Size of the sensor	23	16.5	mm	(Wiki)	
Size of the pixel	3.833333	4.125	µm		
Focal Length	24	24	mm		
Field of view					
At altitude	121.92	meters			
Altitude in feet	400	Ft			
Field Of View	51.20438	37.94082	°		
Foot print	116.84	83.82	m		
Foot print	38.94667	27.94	ft		
pixels/m	34.23485	71.58196			
Centimeters/pixel	2.921	1.397			
#pixels per square r	2450.60				
AOI					
Length	3	miles	4828.044	m	
Width	3	miles	4828.044	m	
Area	9	Mile^2	23.30978	Km^2	
Overlap					
Froward Overlap	0.8	Y			
Side overlap	0.6	X			

Transects					
Long side transect width	70.10	m	70.10		
# of transects	68.87	n	68.87		
Flight Profile					
Velocity	55.00	Km/h			
Velocity	916.67	meter/min			
Velocity	15.28	m/s			
Velocity	34.375	mph			
Total flight path (n transsects+ 1	342162.21	m			
Total Flight path	342.16	Km		116	m
Mission duration (based on airc	373.27	minutes		0.116	
Camera intervelometer				0.0725	
Inetervelometer (often we choo	2	sec			
Advance during one lapse (base	16.76	m			
Maximum V	8.38	m/s			
	30.1752	km/hr			
	18.8595	mph			
Data size					
Number of pictures	11198.04				

Continue chronology

- Defining Area of Interest (AOI)

  About 3X3 square miles
- Break down the AOI into three AOI : 2 X0.25 square miles
  - Priority 1
  - Priority 2
  - Priority 3



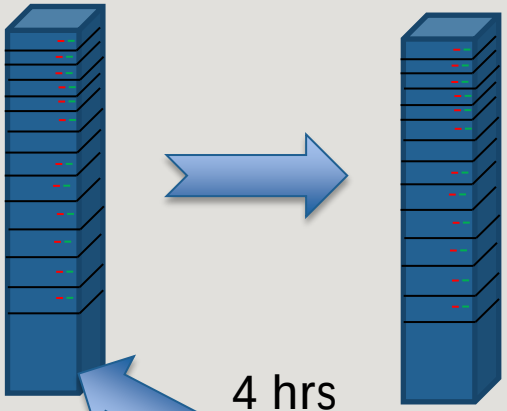
Sequence of events

- April 22 Break up in Dawson
- April 24, 8 pm Ice broke in Eagle
- April 26, Mission readiness and deploy within 48 hr.
- April 28, 8:00 am departed UAF (Fairbanks)
  - 12:00 stuck be a flooded road section
  - 15:00 reach Circle
  - 18:00 Flight priority 1
- April 29
  - Morning fly priority 2
  - Noon fly priority 2
  - Evening fly priority 2 –about an hour after landing the ice broke

Data Scheme (after each flight)

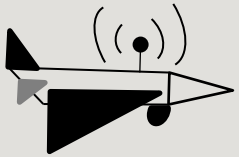
UAF Geophysical Institute Server

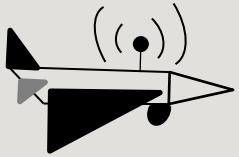
ERMA server



4 hrs

30 min



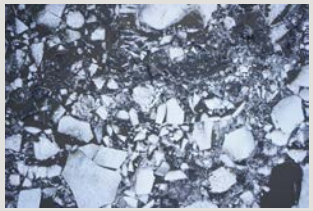


Ortho mosaic and 3D modeling of river ice

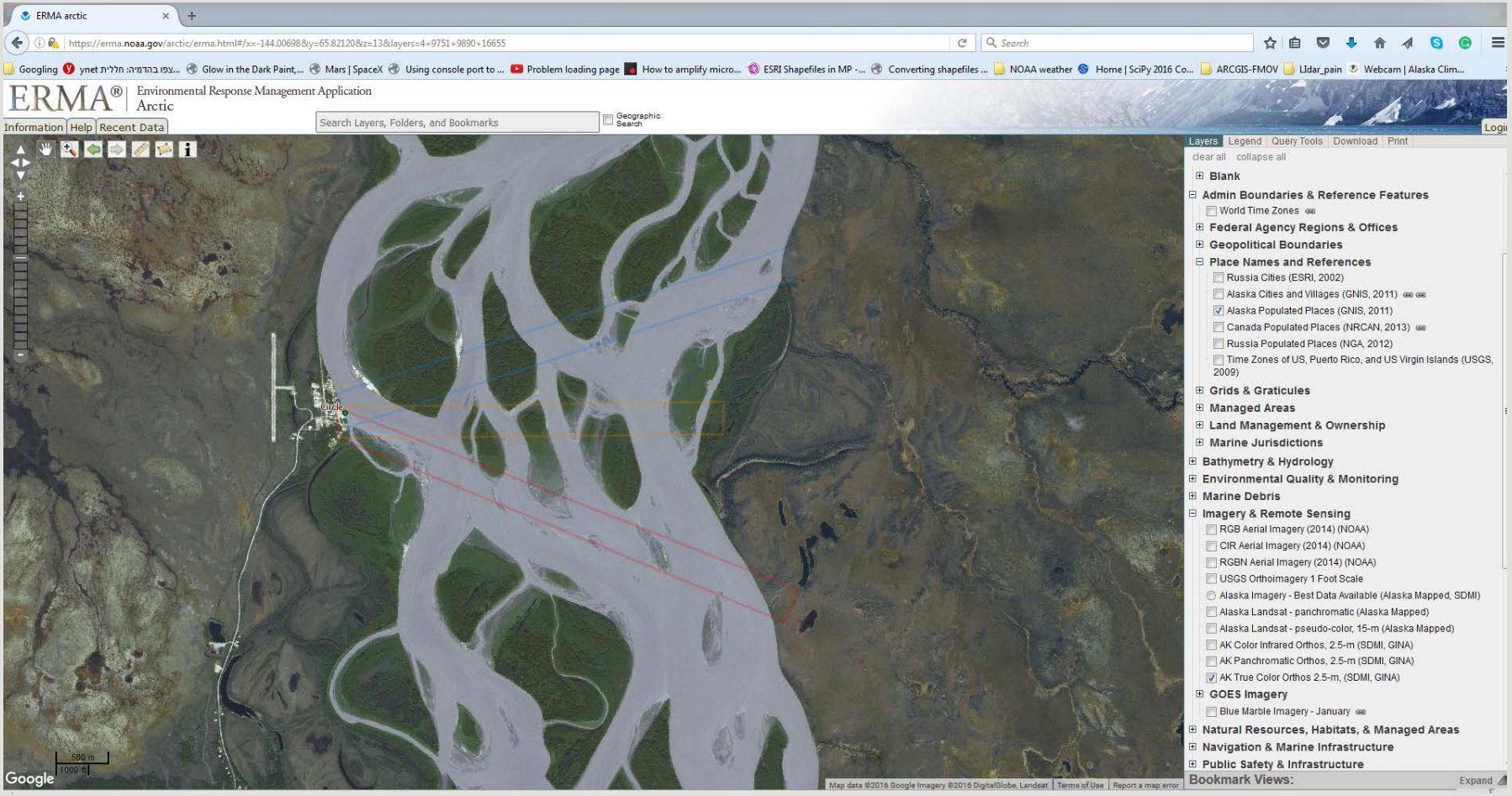
Data recipient

NOAA HQ, DC

RFC Anchorage , AK

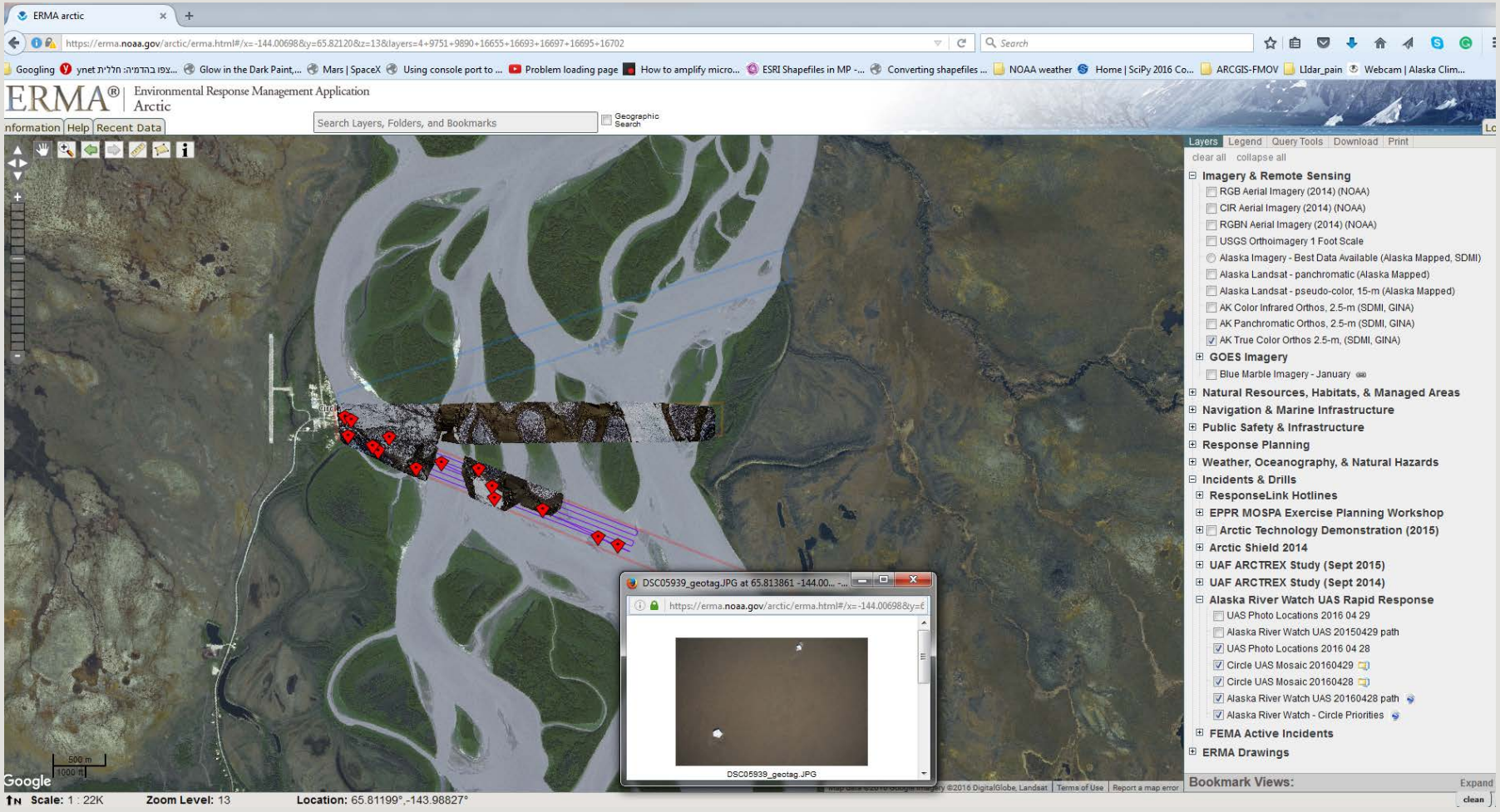


ERMA server host



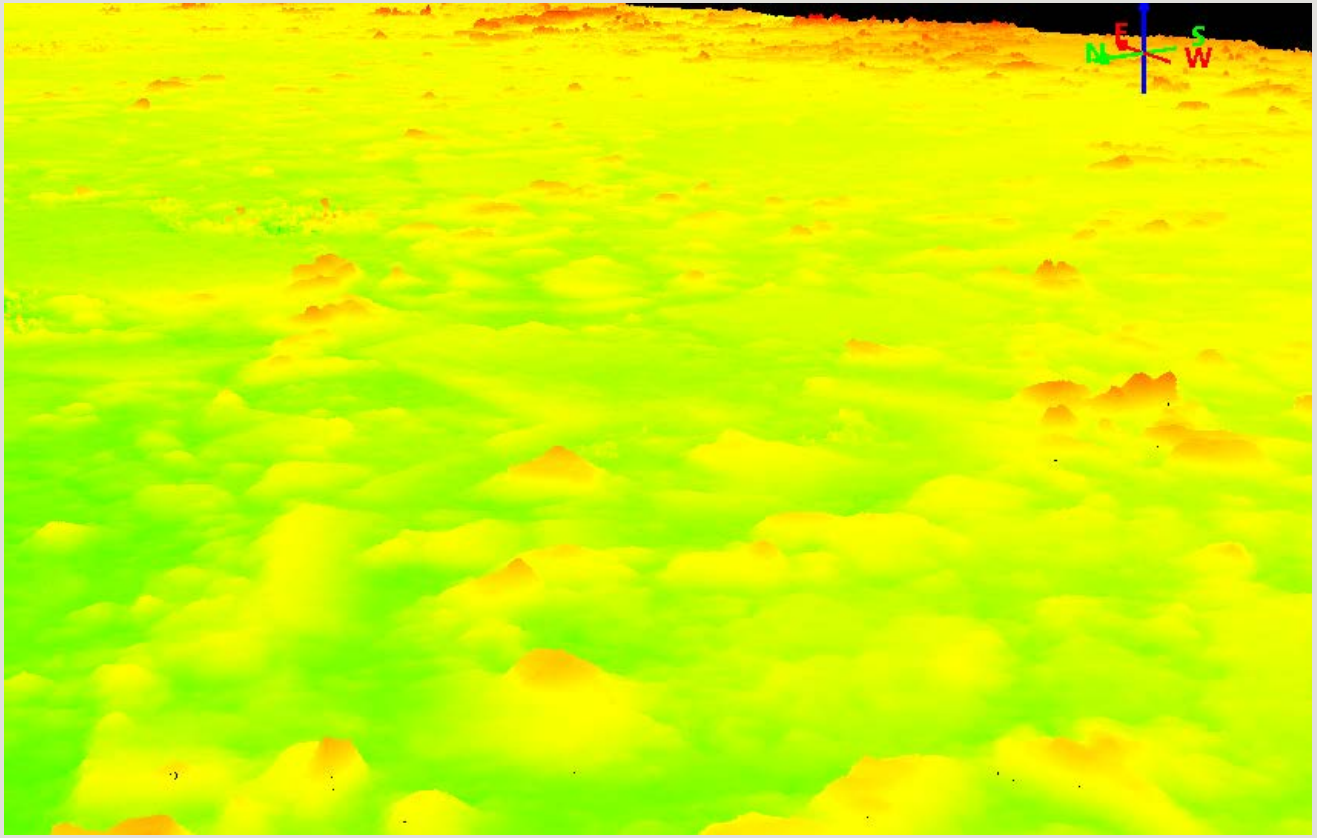
ERMA server host

Plotting some of the data on ERMA



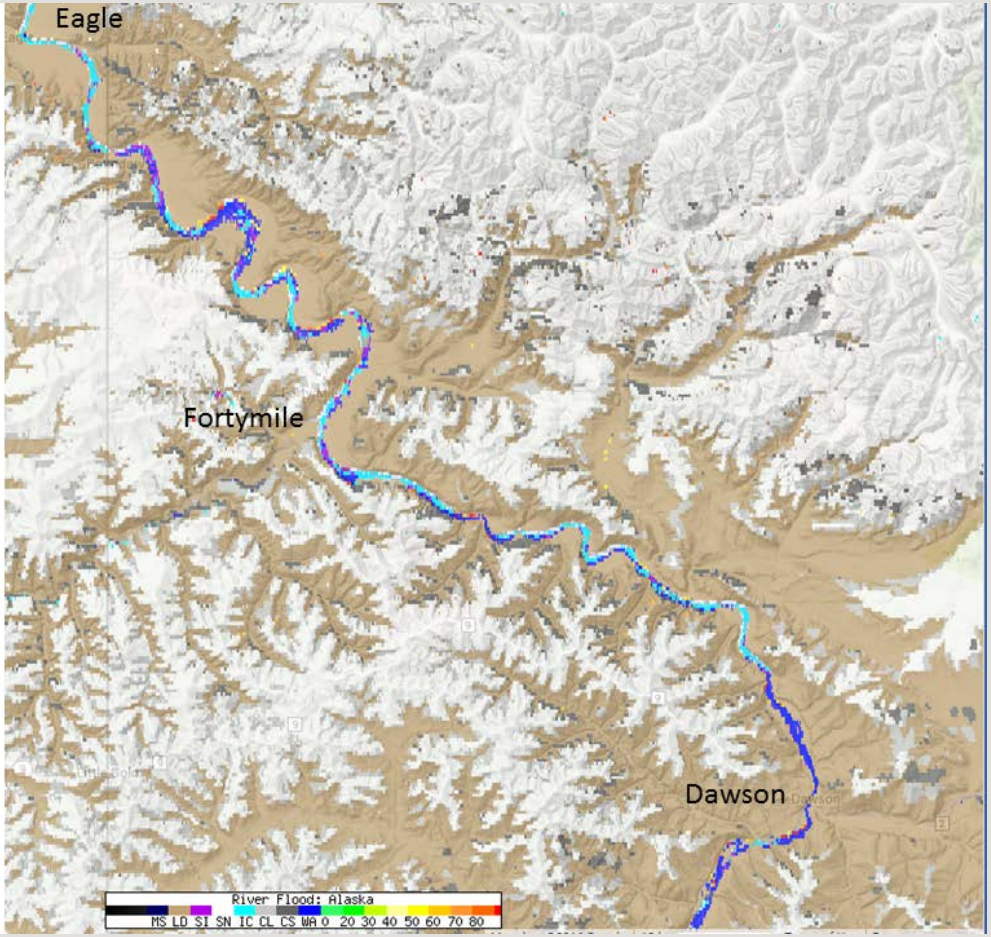
Ice blocks point cloud

Ice Blocks Point Cloud



VIIRS data products (Dr. Sanmei Li)

Flood Map:
04/24/16



Responder surveying the Yukon river ice

Working closely with local school

Notes and conclusion

- ACUASI deployed within 48 hours- aircraft was in the air within 60 hours
- Data was provided to ERMA almost real time (<60 min from landing)
- For each discussed scenario, in the NOAA reports, research and practice need to take place in order to be effective in responding to a disaster (NSF, Homeland Security)
- Future missions should be deployed at similar altitude to manned airborne
- Motion Video- Although motion video is making large strides into a useful geospatial tool. The file is often big, requires human interpretation, and hard to compare two data sets of different time.
- Data products such as the ice/liquid by are often very compact and the easiest to send under poor communication protocol.
  - Perhaps ACUASI find a grant to develop a small payload to produce similar data product to the VIIRS data set
- A report is in the work(comparison to the SUOMI VIIRS ice/water product)

Special Thanks

- Robbie Hood and John Coffey (JC) for the support in developing UAS support in Arctic and river monitoring.
- Circle School
- ACUASI engineering and logistical support
- The university of Alaska Fairbanks and the Geophysical Institute

Reference

- UAS RFC Workshop Summary final

  https://drive.google.com/open?id=0B6vqMOQTeLkIZVFQV21SemJWSTFrUnUtYk90QWIoNDRiVU9v

- UAS RFC Workshop II Report

  https://drive.google.com/open?id=0B6vqMOQTeLkINkxiMDRhcnJ1UU9vdUJJRlBhTldjZWFPNG9N