Sitka Geotask Force
Summaries
August 2015 Sitka Landslides

March 2016


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SITKA SOUND
SCIENCE CENTER
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March 14, 2016

Dear Reader,

On August 18, 2015, a rapid, heavy rain event caused a series of deadly and damaging landslides in Sitka. There were over 40 slides that occurred on Baranof and Chichagof Islands that day. The biggest one, on Harbor Mountain, was 1,200 feet long, killed three men and caused massive damage to property on Kramer Avenue. Over the next days, weeks and months, the community of Sitka led by our Sitka Fire Department came together to support the search for the lost men, clear the roads and repair the damage to property.

With this emergency, a new science community was also created. The Sitka GeoTask Force was formed by gathering geophysical experts from around Alaska and the country to pool existing information about the slide area, share information and help determine next steps in terms of research, synthesis and risk. Organized by the Sitka Sound Science Center, a local non-profit organization, representatives with a breadth of knowledge about the region volunteered to share existing geotechnical information and work towards understanding what gaps in knowledge need to be filled. Members of the Sitka Geo Task Force readily and openly shared their scientific expertise all in the name of supporting a community in need.

The slide was initiated on US Forest Service land and, with its expertise in soil science and geology, USFS was the first agency to respond locally to the need for scientific assessment. University of Alaska Fairbanks brought its cadre of scientists from the Geophysical Institute who in turn brought NASA on board as well. The Alaska Department of Geologic and Geophysical Survey, the National Park Service, the National Weather Service, US Geological Survey, US Coast Guard, an independent geologist, City of Sitka planners, Sitka Conservation Society, Alaska Department of Transportation, U.S Geologic Survey, a local geologist and University of Alaska Southeast all worked together to share past data sets, current studies on rain and wind, recent surveys near the road system, and respond immediately with new studies, creative ideas for synthesis and funds to continue monitoring.

The response from the science community both within and outside of Alaska was speedy and impressive. The Sitka GeoTask Force met weekly for several months and then every other week for several months. This report is an aggregate of the data shared and reports produced.

We believe this is a solid portrayal of the known information that has been collected on the slide area to date. Our hope is that it provides a good base for future scientists who want to study the area further. Some data needs have been identified, such as locating and installing 2 weather stations at elevation in the Sitka area. Additionally, we hope this information is helpful to city planners and policy makers who will no doubt be making some decisions about risk and future development of the area.
Sincerely,

Lisa Busch
Executive Director
Sitka Sound Science Center

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Katherine coordinated with the NASA JPL group regarding the AIRMOSS flight. We used GIS spatial layers to direct the crew to Sitka and worked with them to communicate the priorities established by the Sitka GeoTask Force. The priorities were discussed at the 1st GeoTask force meeting and were as follows: 1)Sitka Road System, 2)Extended to include Starrigavan and Redoubt Slides, and 3)extended along Katlian Bay for future hazard mapping of the proposed road alignment. See the Franz or NASA report for summaries of the aerial reconnaissance.

Jacqueline worked with the NRCS office in Palmer to verify that all available soil information was available to the City of Sitka. It turns out that the area near the Kramer slides was mapped by the USFS in the 1980's. This information is available at Web Soil Survey.

Katherine and Jacqueline flew an aerial survey looking for on two different dates. The original flight included Perry Edwards and extended from Sitka north around Katlian and Nawkwasina, to the north end of Kruzof, along the western edge of Kruzof, south to Redoubt Lake and back to Sitka. The second flight extended up Khaz Peninsula, across middle Chichigof Island to Hoonah Sound, southeast to Katherine Island, south along Baranof Island to Gut Bay, west through Whale Bay, and north to Sitka. We found concentrations of landslides from the August 18, 2015 event near Sitka and in the Khaz Peninsula area; however, new slides were identified from south of Sitka to north of Khaz Peninsula, and east of Khaz Peninsula (see attached Figure).

Jacque Foss and Dennis Landwehr used photos and GPS information (from the flights) along with the recently acquired aerial photos (Worldview 2 Satellite) to update the Forest Service Landslide inventory. The dates of aerial photography included Feb 2015, August 26, 2015, and September 2, 2015.

Jacob Hoffman worked with Martyn Parker, at the National Park Service to establish access to the worldview imagery. The two worked together to make it accessible to Forest Service, National Park Service, and the GeoTask Force working group. The NPS was later able to fund the access of the imagery to the public. Jacob Hofman was scheduled to fly low-elevation imagery within a week of the landslide; however, access to the World View imagery negated the need for the flight.

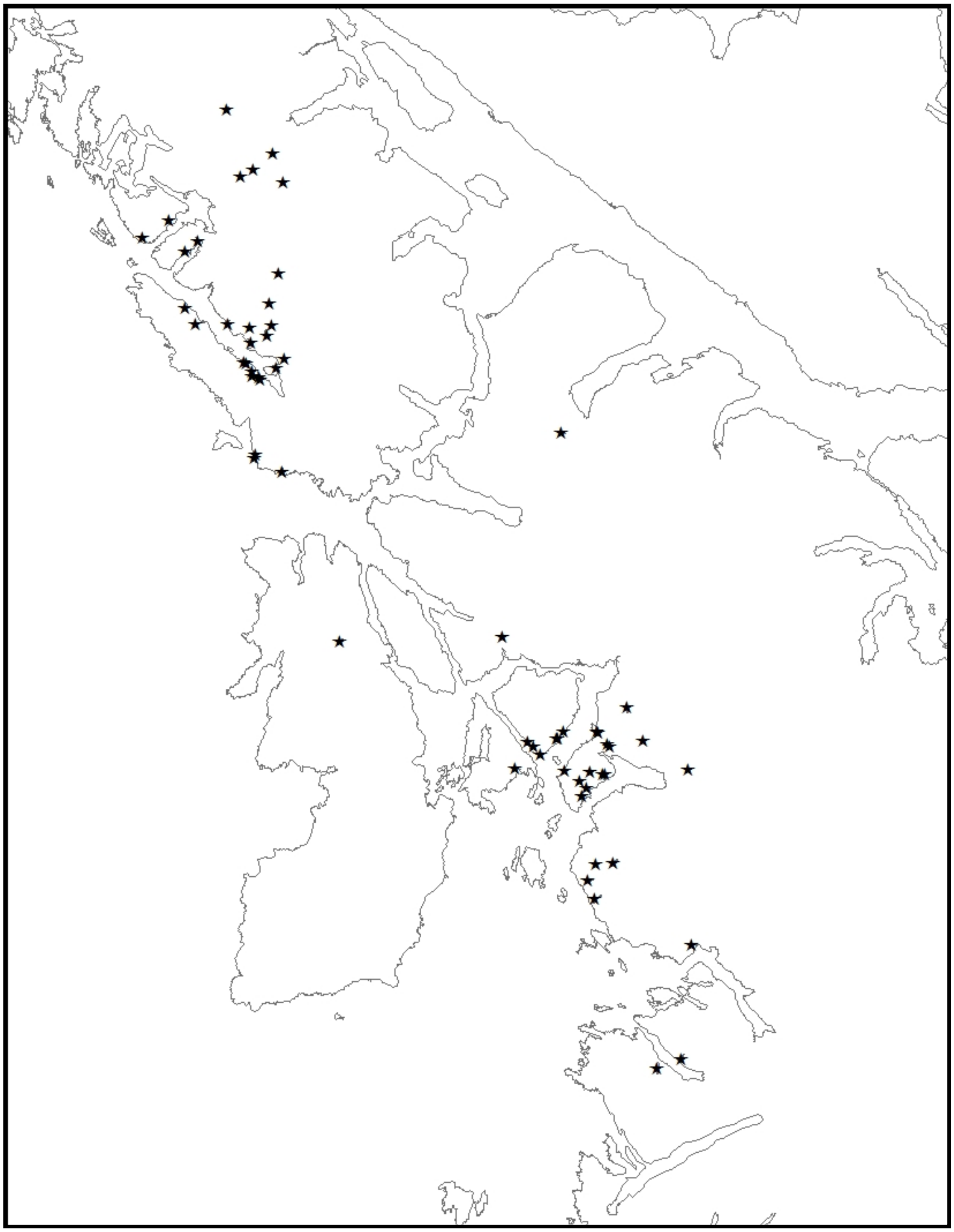
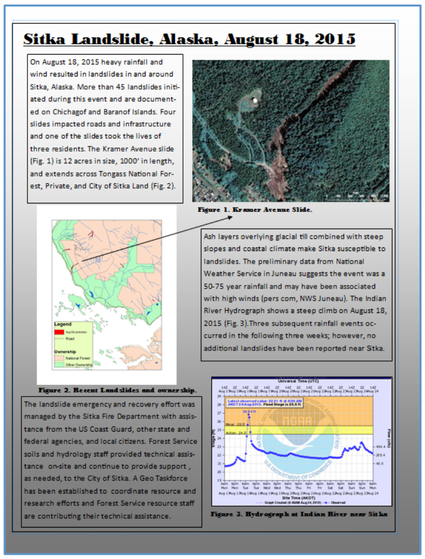


Figure 1. Location of all landslides from August 18, 2015 on the Forest Service Landslide Inventory.

While updating the landslide layer with the August 18, 2015 slides Jacquie worked with various USFS people to establish dates of other landslides in the general area from the past 20 years. This will eventually be included in the Tongass-wide database but for now, interested people should contact Jacqueline Foss directly (907-747-4246 or jvfoss@fs.fed.us).

While working with NPS to better understand the Worldview Imagery, Jacob Hoffman realized that the Forest Service and other agencies are able to task the satellite (ask for photos) at any time. In an effort to monitor slides over the next year (and possibly beyond), the USFS will continue to digitize new slides as they occur using a monthly aerial photo image taken by Digital Globe. This can be used for future modeling efforts.

In an effort to inform Forest Service leadership of the effects on the landslide on Sitka and its personnel, we created a landslide briefing paper (Fig 2.). This briefing paper can be attained from Katherine Prussian, Jacqueline Foss, or Dennis Landwehr.



Sitka Landslide, Alaska, August 18, 2015

On August 18, 2015 heavy rainfall and wind resulted in landslides in and around Sitka, Alaska. More than 45 landslides initiated during this event and are documented on Chichagof and Baranof Islands. Four slides impacted roads and infrastructure and one of the slides took the lives of three residents. The Kramer Avenue slide (Fig. 1) is 12 acres in size, 1000' in length, and extends across Tongass National Forest, Private, and City of Sitka Land (Fig. 2).

Figure 1. Kramer Avenue Slide.

Ash layers overlying glacial till combined with steep slopes and coastal climate make Sitka susceptible to landslides. The preliminary data from National Weather Service in Juneau suggests the event was a 50-75 year rainfall and may have been associated with high winds (pers com, NWS Juneau). The Indian River Hydrograph shows a steep climb on August 18, 2015 (Fig. 3).Three subsequent rainfall events occurred in the following three weeks; however, no additional landslides have been reported near Sitka.

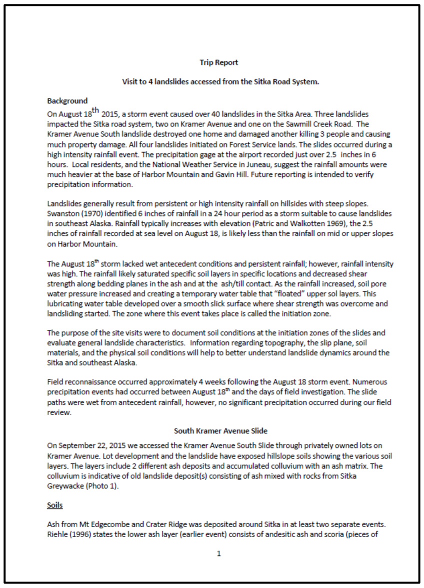
Figure 2. Recent Landslides and ownership.

The landslide emergency and recovery effort was managed by the Sitka Fire Department with assistance from the US Coast Guard, other state and federal agencies, and local citizens. Forest Service soils and hydrology staff provided technical assistance on-site and continue to provide support, as needed, to the City of Sitka. A Geo Taskforce has been established to coordinate resource and research efforts and Forest Service resource staff are contributing their technical assistance.

Figure 3. Hydrograph at Indian River near Sitka

Fig. 2. Sitka Landslide Briefing Paper

On September 22nd and 23rd, 2015, Dennis Landwehr, Katherine Prussian, and Jacqueline Foss walked the Sitka area landslides (Kramer south, Kramer north, Granite Creek, and Sawmill Creek). They also walked a transect between the south and north Kramer slides. They captured photos and information regarding hillslope gradients, soil and rock type, contributing area, vegetation, and windthrow in the initiation zone, runout and depositional areas of each slide. The information is summarized in a trip report and available by contacting any of those individuals (Fig. 2).



Trip Report

Visit to 4 landslides accessed from the Sitka Road System.

Background

On August 18th 2015, a storm event caused over 40 landslides in the Sitka Area. Three landslides impacted the Sitka road system, two on Kramer Avenue and one on the Sawmill Creek Road. The Kramer Avenue South landslide destroyed one home and damaged another killing 3 people and causing much property damage. All four landslides initiated on Forest Service lands. The slides occurred during a high intensity rainfall event. The precipitation gage at the airport recorded just over 2.5 inches in 6 hours. Local residents, and the National Weather Service in Juneau, suggest the rainfall amounts were much heavier at the base of Harbor Mountain and Gavin Hill. Future reporting is intended to verify precipitation information.

Landslides generally result from persistent or high intensity rainfall on hillsides with steep slopes. Swanston (1970) identified 6 inches of rainfall in a 24 hour period as a storm suitable to cause landslides in southeast Alaska. Rainfall typically increases with elevation (Patric and Walkotten 1969), the 2.5 inches of rainfall recorded at sea level on August 18, is likely less than the rainfall on mid or upper slopes on Harbor Mountain.

The August 18th storm lacked wet antecedent conditions and persistent rainfall; however, rainfall intensity was high. The rainfall likely saturated specific soil layers in specific locations and decreased shear strength along bedding planes in the ash and at the ash/till contact. As the rainfall increased, soil pore water pressure increased and creating a temporary water table that "floated" upper sol layers. This lubricating water table developed over a smooth slick surface where shear strength was overcome and landsliding started. The zone where this event takes place is called the initiation zone.

The purpose of the site visits were to document soil conditions at the initiation zones of the slides and evaluate general landslide characteristics. Information regarding topography, the slip plane, soil materials, and the physical soil conditions will help to better understand landslide dynamics around the Sitka and southeast Alaska.

Field reconnaissance occurred approximately 4 weeks following the August 18 storm event. Numerous precipitation events had occurred between August 18th and the days of field investigation. The slide paths were wet from antecedent rainfall, however, no significant precipitation occurred during our field review.

South Kramer Avenue Slide

On September 22, 2015 we accessed the Kramer Avenue South Slide through privately owned lots on Kramer Avenue. Lot development and the landslide have exposed hillslope soils showing the various soil layers. The layers include 2 different ash deposits and accumulated colluvium with an ash matrix. The colluvium is indicative of old landslide deposit(s) consisting of ash mixed with rocks from Sitka Greywacke (Photo 1).

<u>Soils</u>

Ash from Mt Edgecombe and Crater Ridge was deposited around Sitka in at least two separate events. Riehle (1996) states the lower ash layer (earlier event) consists of andesitic ash and scoria (pieces of

1

Fig. 2. Trip Report of the 4 Sitka Area Slide.

Jacqueine Foss and Katherine Prussian put together a landslide presentation featuring landslide characteristics, Sitka area slide information, and efforts by the GeoTask Force (Fig. 3). The presentation has been presented to the Sitka Rotary and is planned for the Chamber of Commerce and UAS science lectures. The presentation is available for others to use (contact either author) and Katherine and Jacqueline are willing to present as requested and available. Lisa Busch at the SCCC provided presentation feedback to improve communication which has been incorporated into the presentation.

Fig. 3. Landslides in Sitka, Powerpoint Presentation.

Jacque Foss and Katherine Prussian met with the City of Sitka, along with Perry Edwards, to discuss the joint ownership on lands affected by the landslide (September 2, 2015). There was discussion regarding information and resources available and technical assistance which could be provided as requested by the City of Sitka. Another meeting occurred regarding information sharing. And another meeting occurred to provide support to the geologist hired by the City of Sitka for landslide consultation (November 10, 2015). Jacque and Katherine provided the landslide inventory, reports, and photos to Bill Laprade (geology consultant) and offered assistance as needed (November 12, 2015).

Current and future efforts include working with UAS, DGGS, and any other interested parties in updating our mass movement index database by incorporating updated landslide inventories and possibly including new imagery (Lidar DEM's), climate information, and other resources through modeling.

We also have 5 days of Sitka Area Slide field inventory scheduled for summer 2016 and will provide a summary report for the August 18, 2015 event following field the reconnaissance.

Forest Service Assistance during the Disaster Recovery.

Throughout the recovery effort, Marty Becker was on-site providing technical assistance regarding drainage and stability of the landslide deposit. Marty attended daily briefings and worked directly with the IC of the landslide effort.

The following are the tasks Jacqueline Foss was involved in on a daily basis.

Tuesday 8/18/2015

- Called to the incident at about 4 pm. Looked at maps and the Indian River hydrogaph. Talked about risk to rescuers. Arranged to fly the site on Wednesday 8/19/15.
- Attended evening briefing

Wednedsay 8/19/2015

- Flew the landslides in the helicopter and took pictures of landslides.
- Briefed State geology folks on what I saw and landslides in the area.

Thursday 8/20/15

- Decided that there needed to be better maps so I worked with Joshua from the city to get the Ifsar data and start digitizing the slides.
- Spoke to Perry Edwards about safety of trailer court. Said most ok, the two closest (Serio and Leeseburg) were most at risk

Friday 8/21/15

- Flew around for an hour to look at slides outside of Sitka Proper. Found several. Another flight may be in order for more than just this area. (Flew over to Katlian, Nakwasina, St. Johns the Baptist and around Kruzof).
- Visited Blue lake road with KK, Perry, AnneMarie, and 2 city electrical workers. Discussed potential fixes. FS suggested a higher level of design than was being considered. Maintenance will be continual on this road due to the location. Was also suggested that the FS and City should discuss and work on agreement for responsibility of the maintenance/condition of the Blue Lake road.

Monday 8/24/15

- Met with Al who wanted to meet with city planners and scientists to reduce potential duplication of efforts.
- Met with Megan and Joshua from city, 2 folks from SSSC, Theresa, and KK to talk about landslide resources, science, and management.
- Conveyed need for new weather station away from airport and at elevation.

- Spoke about needs for now and into the future and possibly starting a landslide working group to synthesise all landslide resource information and collaborate on technical expertise.
- Went to NPS to talk to Brennin with KK. Talked to Johnathon from USGS landslide hazard group. He had some good thoughts about forecasts with Dave Strubel to use rainfall to warn of landslides. The USGS group is pretty booked so probably couldn't commit to anything.

Tuesday 8/25/15

- Went to the morning briefing where one of the City Admin types asked about instrumenting this landslide like the OSO slide in Washington. (USGS used "spiders" and lasers to track creep and movement at the headwall.) I said that this landslide was a different type of mass wasting event that was a earth-flow, rotational failure while this was a shallow debris slide that is rapid and usually does not slide more in the same place as before (i.e. monitoring the headwall doesn't make sense here).
- Attended the 9am landslide meeting (see notes from SSSC).

Division of Geological & Geophysical Surveys

AUGUST 18th, 2015 SITKA, ALASKA DEBRIS FLOWS: INITIAL RESPONSE SUMMARY REPORT

by
Alex Gould, Gabriel Wolken, De Anne Stevens, and Erin Whorton

OVERVIEW

- The Division of Geological & Geophysical Surveys (DGGS) responded immediately to the August 2015 Sitka debris flow events to provide rapid response geologic hazards support.
- DGGS conducted both ground and air-based investigations of the debris flows and adjacent areas.
- Aerial photographic data were acquired, from which a high-resolution orthophoto mosaic and a digital surface model (DSM) were produced for debris flow mapping and analysis.
- Ground-based fieldwork revealed past landslide scars, and allowed for general surficial mapping.

INITIAL RESPONSE

On Wednesday, August 19th, the day after the debris flows occurred in Sitka, Alaska, DGGS geologists traveled to Sitka to assist the Sitka Response Team with rescue and response efforts. For the next few days, DGGS coordinated with the Sitka Response Team and the Alaska Department of Transportation & Public Facilities (DOT) geologists to conduct both ground and air-based investigations in the areas impacted by recent mass wasting events. Initially, this work provided information to the Sitka Response Team regarding the nature of the debris flows, and if there should be any concern for additional slope failures that would pose an immediate threat to rescue personnel or the residents of Sitka. Afterwards, these data were processed and analyzed as part of a more in-depth study of the August 2015 debris flows.

Gabriel Wolken, Erin Whorton, and Alex Gould conducted airborne photogrammetric data collections, in coordination with the US Coast Guard, over both the Sawmill Creek and Kramer debris flows on August 19th and 20th, respectively. Using DGGS's mobile photogrammetry system, a total of 2,490 geotagged photographs were collected with about one-third of the photographs with a nadir perspective and the other two-thirds with an oblique perspective. These photographs were used for general landslide extent mapping and for identifying features indicting further slope instability that would endanger the public and emergency response personnel involved in the recovery effort. However, no such indications were observed and rescue efforts continued without major delays.

DOT geologist, Mitch McDonald, led ground-based investigations of the debris flows and existing geologic hazards at the Harbor Mountain and Sawmill Creek sites. Field crews examined the debris flow deposits along with the upper reaches of the flows to better understand the character of these mass wasting events and to gain insight to how these slope failures occurred. The geologists also assisted and provided recommendations to construction crews on how to manage the debris and water runoff in the effected areas. DGGS geologist, De Anne Stevens, continued ground-based investigations of the North and South Kramer debris flows on September 2nd. This included field observations and surficial mapping of the debris flow areas.

SUMMARY OF PRODUCTS AND FINDINGS

Following response work in Sitka, photographs from the aerial survey were processed using standard geodetic methods in combination with structure from motion (SfM) photogrammetric techniques to create a high-resolution orthophoto mosaic and DSM (see Fig. 1). These products allow for detailed debris flow analysis and are highly valuable because the photographs were taken two days after the events occurred. The orthophoto mosaic has a GSD of 0.07 m and the DSM has a GSD of 0.14 m.

Debris flows were mapped using the orthophoto mosaic. The areal extents were calculated to be 25,830 m^2 for the North Kramer debris flow and 33,754 m^2 for the South Kramer debris flow (see Fig. 2). The North Kramer debris flow has a source area width of 28 m, a total length of 654 m and a toe width of 41 m while the South Kramer debris flow has a source area width of 26 m, a total length of 923 m and a toe width of 32 m.

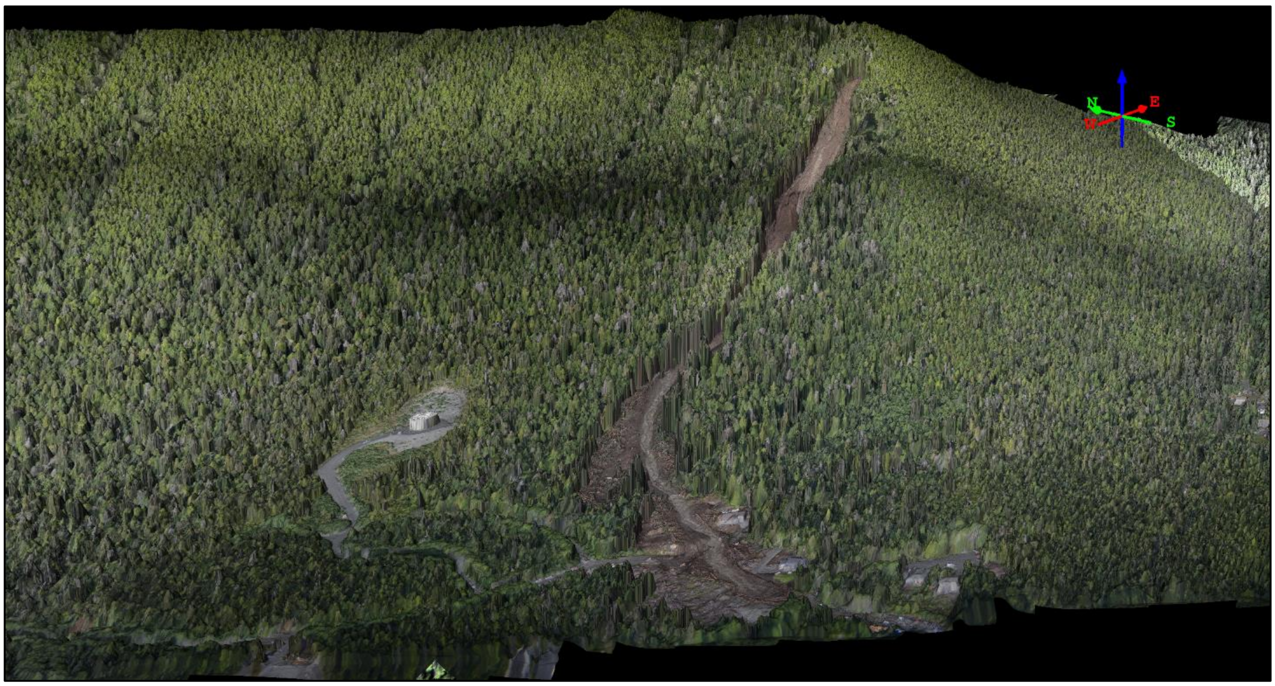


Figure 1. Orthophoto mosaic draped over the DSM created from SfM photogrammetric methods shows an oblique view of the South Kramer debris flow on August 20, 2015.

August 2015 Kramer Debris Flows

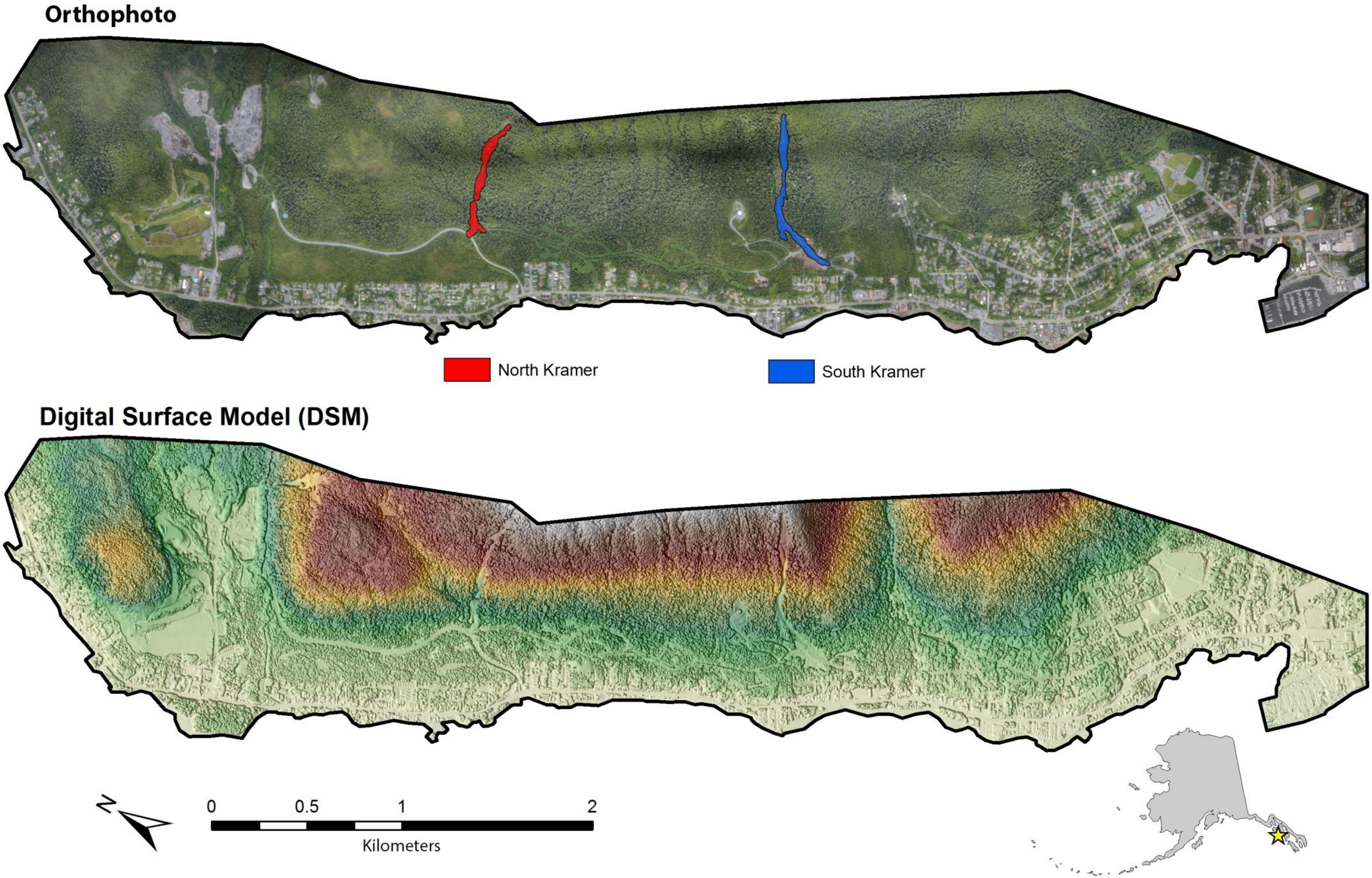


Figure 2. Orthophoto and DSM of the August 2015 Kramer debris flows produced through structure from motion photogrammetry . This aerial survey was collected by Alaska Division of Geological & Geophysical Surveys two days following the event in partnership with the US Coast Guard.

Field-based observations revealed that the August 18, 2015 mass wasting events, although referred to informally as landslides, are technically classified as debris flows. The difference between the two mass movement types lies in the mechanics of their movement which depends greatly on, among other things, the water content of the material. These flows were water-laden, fine-grained and travelled at high velocities, carrying a significant amount of large, woody debris.

Fieldwork on the North Kramer debris flow confirmed that after the event, surface runoff and drainage was diverted from its original path to a new channel south of the former stream. This necessitated the installation of a new culvert under Kramer Road. A small, older landslide adjacent to the August 18th, 2015 North Kramer headscarp that originated from higher upslope was also discovered (see Fig 3). This finding supports the idea that this area is prone to slope failures and that mass wasting events are a characteristic hillslope process for this area.

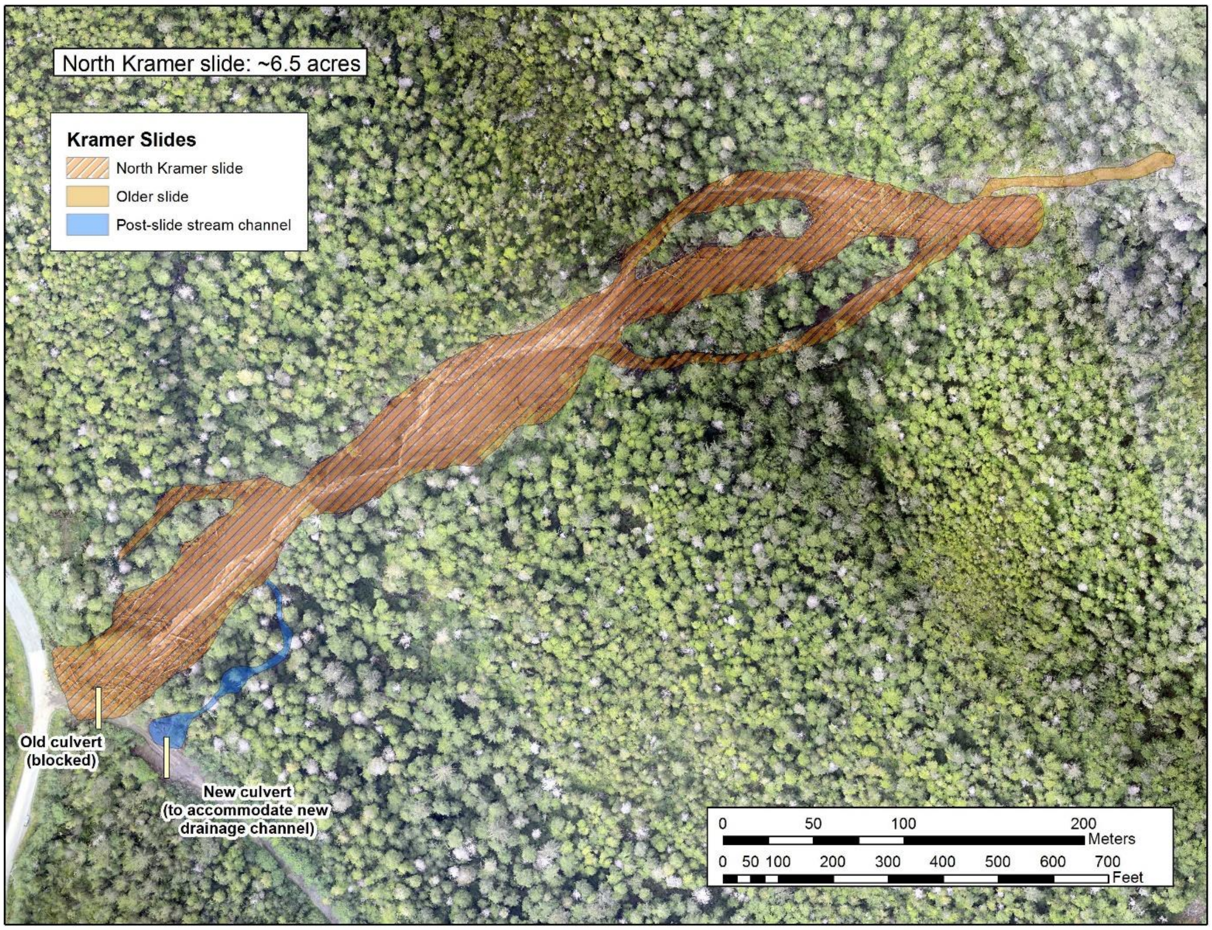


Figure 3. Mapped extent of the North Kramer August 18th, 2015 debris flow. Note the older landslide path in the top right.

Investigations on the South Kramer debris flow revealed a number of pre-existing features (see Fig. 4). Due to development in the area, there are clear cuts and pads for a subdivision construction that were established before the debris flows occurred. A large dump pile of gravel that was staged for the new construction appears to have diverted the distal portion of the debris flow down Kramer Road instead of allowing it to continue flowing straight downslope.

Figure 4. Extent of the August 18th, 2015 South Kramer debris flow and surrounding pre-existing features.

August 18, 2015 Sitka's Heavy Rain, Flooding, Mudslides
Heavy rain from a strong front along Baranof Island leads to flooding and 40+ debris flows with one causing 3 fatalities in the Sitka area.

Contributors:
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Joel Curtis, WCM NWS WFO Juneau
Eric Holloway, HAS forecaster
NWS APRFC Anchorage

Meteorological/Hydrological Highlights:

Notable synoptic and mesoscale features included:

- A blocking upper level high pressure over the North Pacific, steering moisture from the Pacific onshore over Southeast Alaska.
- A deep sub-tropical connection that transported anomalously high precipitable water values (8-10 standard deviations (std) above normal on August 18) over Southeast Alaska, satellite data showed significant plume of moisture moving into the Eastern Gulf of Alaska.
- Enhanced low level jet of 50kt from the SE at 850mb associated with a strong weather front with a significant wind shift as the front went over the area.
- 5 hours of very heavy rainfall with rain rates of greater than 0.50"/hour with a 3 hour rainfall intensity return period of around 45 years.

Debris flows resulted potentially from:

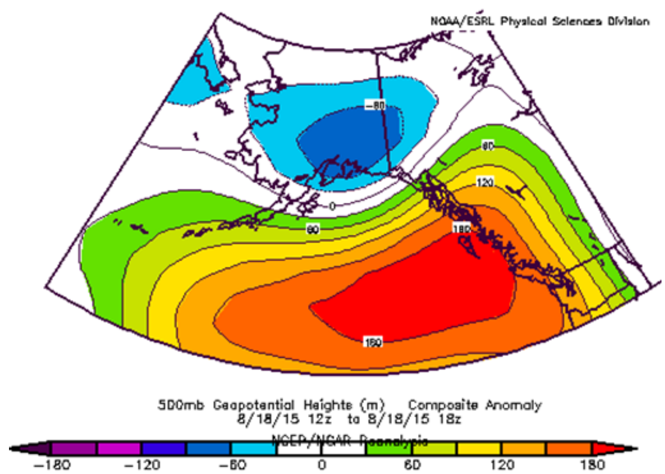
- Super saturated soil conditions from heavy rain in a short period of time, strong ridge top wind speeds and gusts (40kt+ from the Southeast).
- Kramer slide occurred during the time of frontal passage with a wind shifting from South to Southwest and rain rates decreasing. The slopes above the slide area are more exposed to Southwest winds.

Flooding:

- The Indian River gauge crested at 26.84 feet at 10 am and tied the record stage from October 19th 1998. This stage was more than a foot above flood stage and did damage to area trails and around the Totem National Park.
- A sink hole developed and a propane tank was on the edge of going in.
- Numerous roads flooded.

Synoptic pattern:

An anomalous area of upper level high pressure was positioned over the Northeastern Pacific extending into British Columbia, Canada on August 18th (Figure 1, right). This upper level pattern would steer any weather system moving out of the north Pacific into the Gulf of Alaska and over the Alaska Panhandle. The strong southwest flow aloft in this pattern is indicative of heavy rain from substantial on-shore flow at all levels of the atmosphere. Figure 1(bottom), shows a swath of high anomalous precipitable water values extending from the North Pacific and stretching across the central Alaska Panhandle during the morning hours of August 18. Figure 2, shows the amount of precipitable associated with the anomalous swath. Values range from 34mm (1.30") over the Eastern Gulf of Alaska to 30.5mm (1.20") over the central coastal areas of Southeast Alaska Panhandle which is around 140% of normal for late



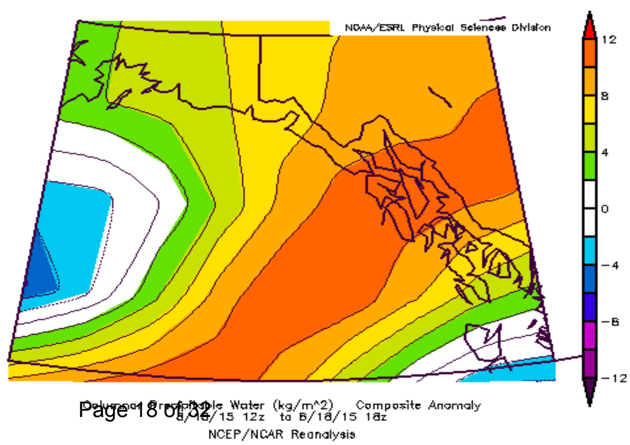


Figure 1: 500mb composite anomaly, (above) and Composite anomaly of precipitable water, (left) from 8/18/2015 at 12z to 8/18/2015 at 18z

summer. This stream of very moist air originated from the sub-tropical region of the Pacific Ocean. Figure 3, illustrates the moisture connection with the sub-tropical region of the Pacific from satellite imagery. The enhanced amount of precipitable water values over the coastal areas is indicative of a high threat for heavy rain which can be intensified more by the steep topography around the area.

A surface low pressure developed over the far Northern Gulf of Alaska on Monday August 17th as it lifted out of the North Pacific. It interacted with upper level dynamics from an upper trough moving over the Southcentral Alaska. The surface low strengthened and the central pressure dropped to 997mb by early Tuesday morning, with the surface low lifting into the Yukon by late morning on Tuesday. Figure 4 shows the progression of the surface front from West to East along with track of the surface low pressure system. Notice how tight the lines are to each other as the front approaches coastal Southeast Alaska, tighter the lines equals stronger surface winds. The strong winds were not just confined to the surface. There was an area of increased winds along the coast that ranged from 1000-5000 feet as seen in Figure 5.

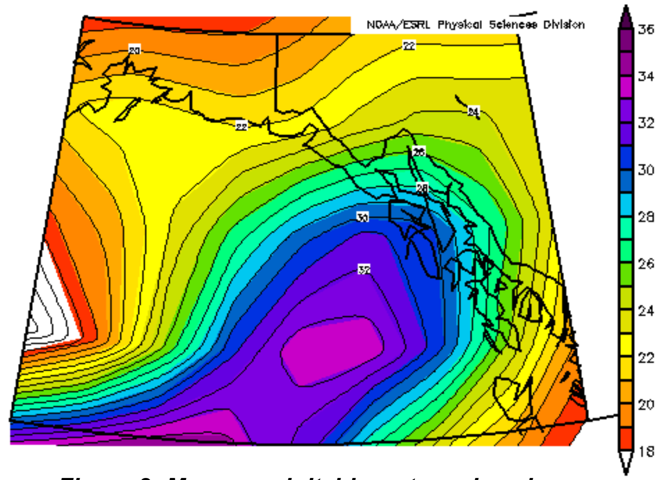


Figure 2: Mean precipitable water values in mm, 8/18/2015 at 12z to to 8/18/2015 at 18z.

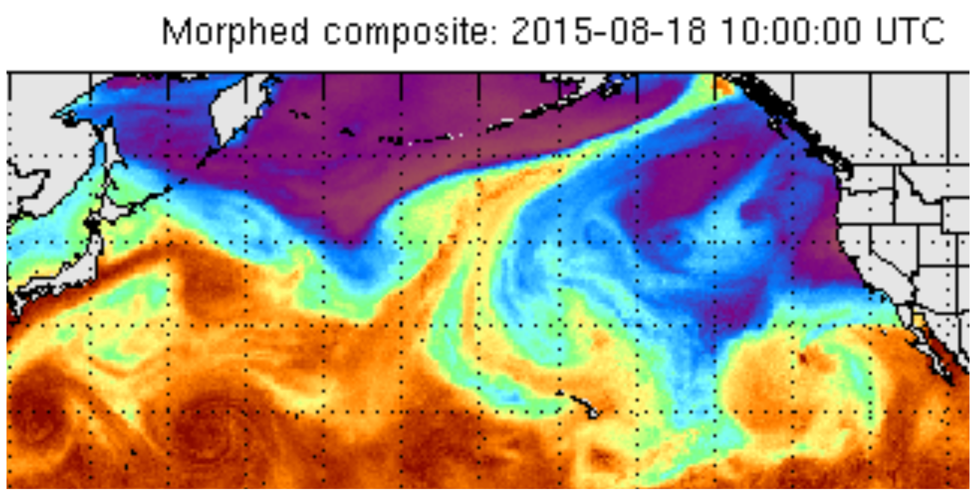


Figure 3: Total Precipitable Water – 08/18/15. Plume of sub-tropical moisture established in the Gulf of Alaska.

Figure 4(right): Surface analysis at 06z Aug 15, 12z Aug 15, 18z Aug18,

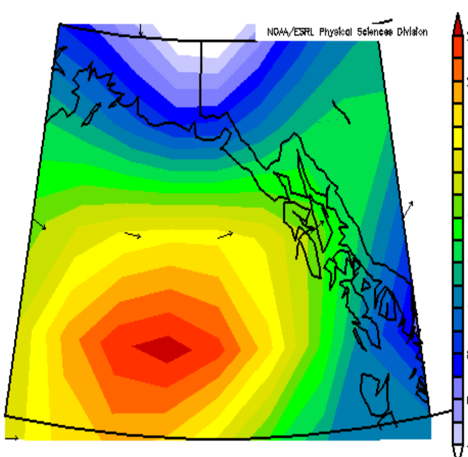
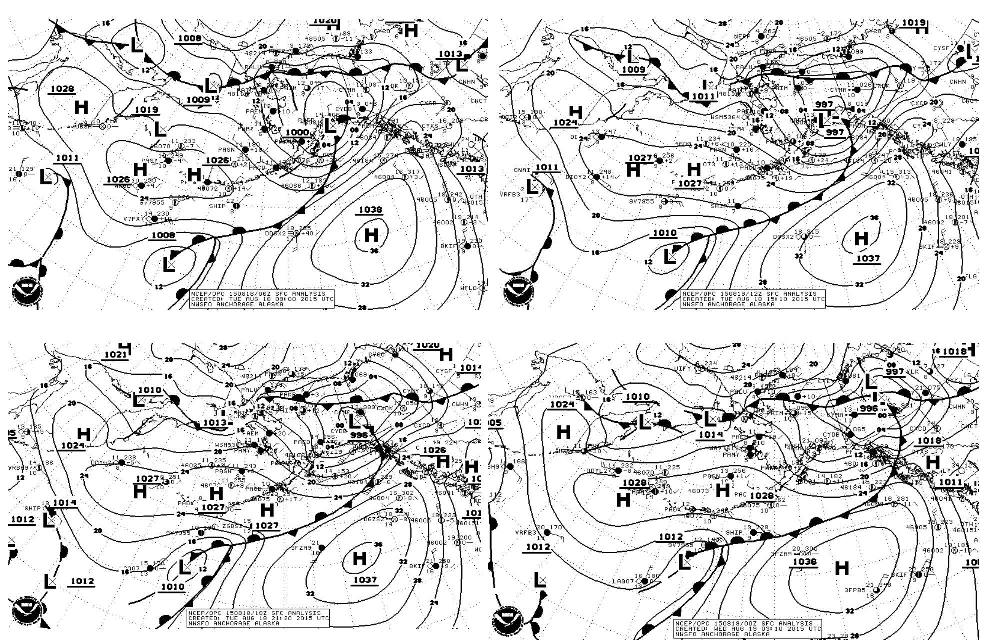


Figure 5(above): 850 mb wind composite anomaly,



Mesoscale features:

The topography around the Sitka area and Baranof Island is very steep with mountains towering 3000 to 4000 feet in less than a few miles, (figure 5).

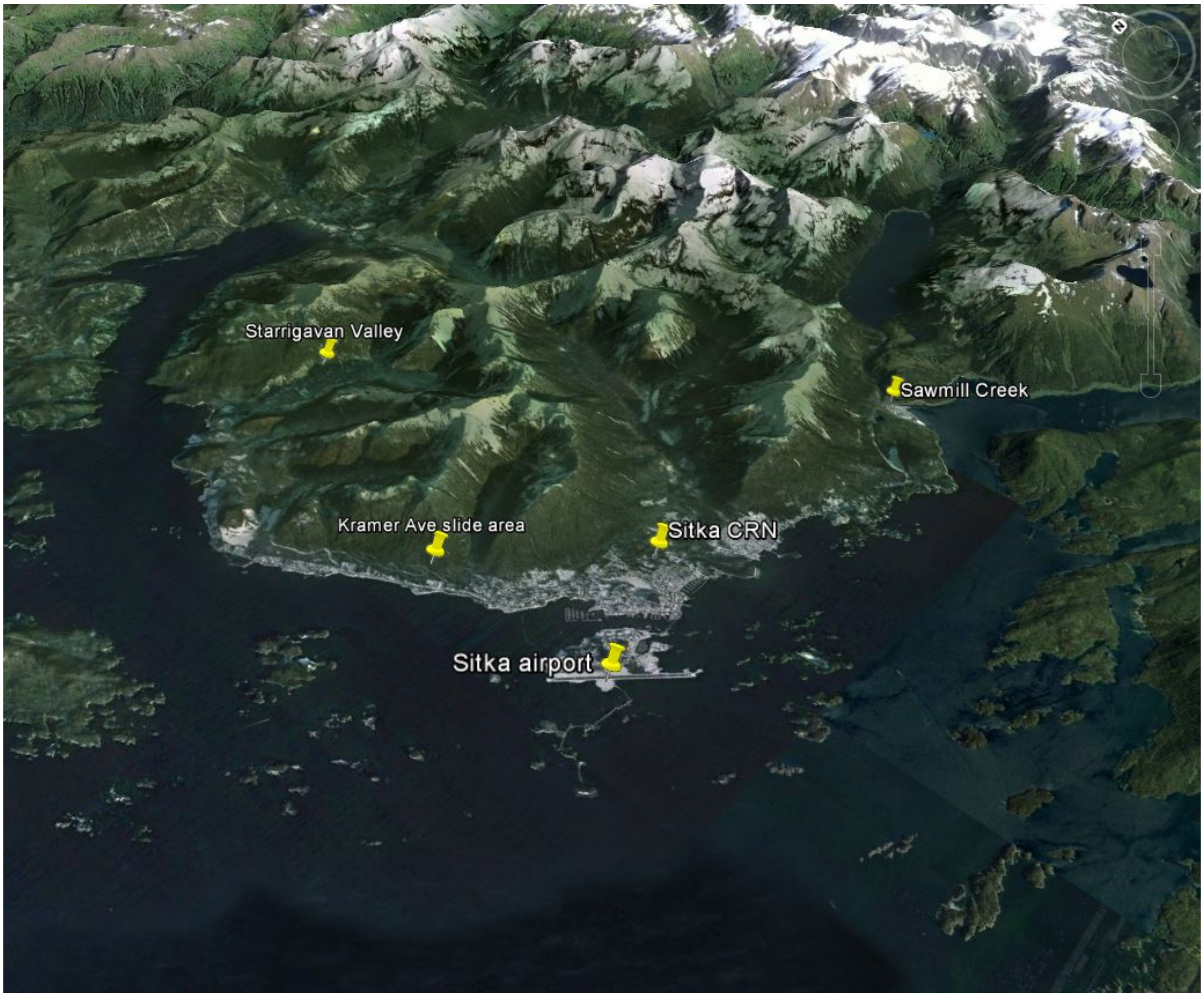
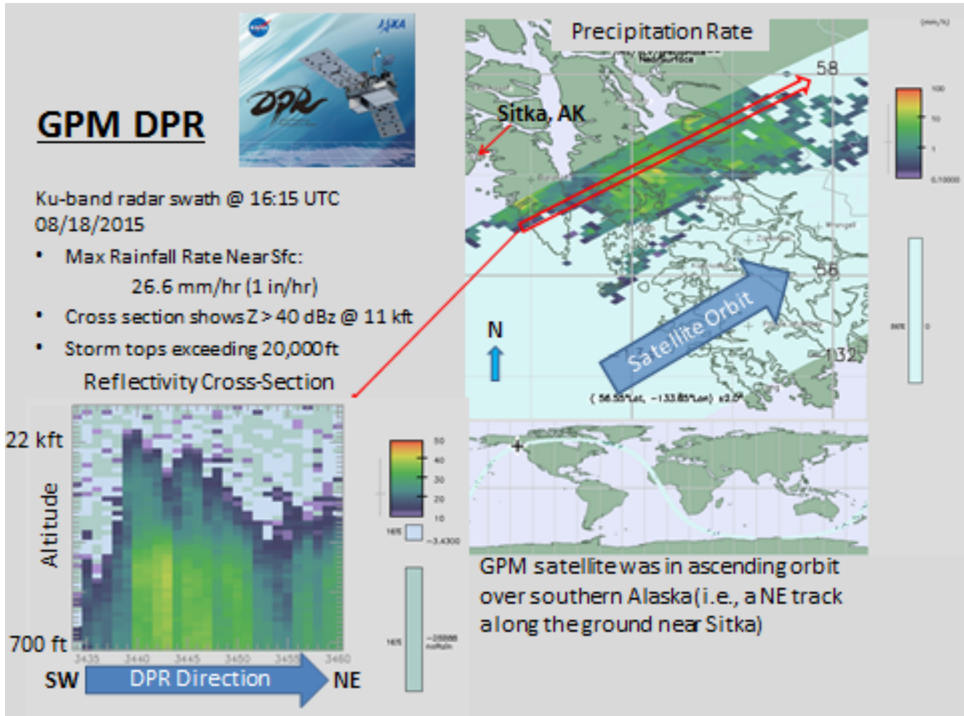


Figure 5: Topography of the Sitka area

The close proximity of the mountains to the ocean creates some small scale features that can greatly affect rainfall production along with intensities. As moist air gets pushed up these steep mountain slopes the air will condense going from higher to lower pressure, which is called orographic effect, and can increase the amount of rainfall. During the event on August 18th the mid-level wind was from the Southwest with the lower level winds from the South to Southeast. These wind directions will enhance the precipitation as the air interacts with the complex terrain around Baranof Island. By looking at a cross-section of radar returns, the orographic effect can be seen with increase rain rates at higher elevations. The new NASA Global Precipitation Measurement (GPM) polar satellite was over the area during the August 18th event. Figure 6 shows; even through it was not over the Sitka area, that there were very high rainfall rates during the peak of the event, greater that 1in/hr at the surface with even higher near 5000 feet. This enhancement of the rain rates can be contributed to the effect the mountains have on the rain parcel.

Another mesoscale effect that can amplify rain rates and amounts in the Sitka area is a convergence zone on the east side of Kruzof Island. A south geostrophic wind (going around a low/high pressure system) at the surface will move across Sitka Sound and a west wind from the gap in the topography (gradient flow) near Shelikof Bay will converge and produce uplift. This uplift will increase rain rates and then when those rain parcels hit the topography on Baranof Island it will increase even more in the Sitka area.

Figure 6: NASA Global Precipitation Measurement (GPM) polar satellite onboard radar output.



Details:

Sitka – The event that took place on August 18th 2015 was a very exceptional and extreme weather and hydrologic event. Over a 6 hour period the Sitka area received 2.5-3.25" of rain. Figure 6, from the Alaska Pacific River Forecast Center (APRFC) shows the quantitative precipitation estimate (QPE) for Baranof Island from 4am to 10 am. This is the best guess of areal precipitation distribution but the main focus of rainfall was in the Sika area along the mountains. Figure 8 also illustrates that there was more rain along the mountains. The image to the right in figure 8 is rainfall data from the Sitka CRN site located at the Magnetic observatory. From figure 5 you can see is much closer to the mountains than the Sitka airport which it the graph on the left. This is evidence that the orographic effect played a big role in the amount of rain amounts in the area.

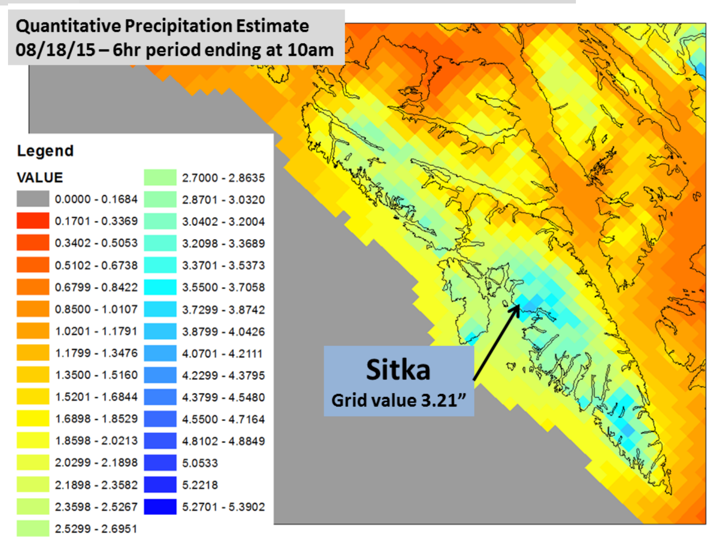


Figure 7: APRFC Quantitative Precipitation Estimate (QPE)

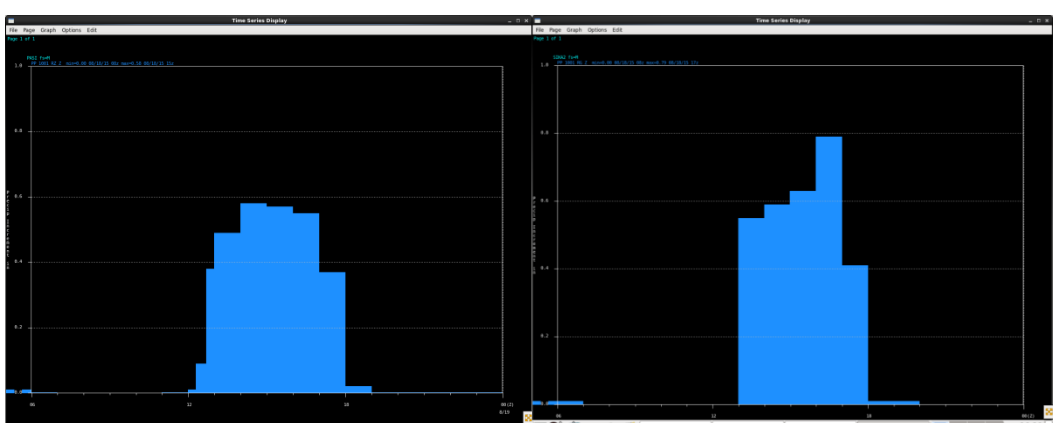


Figure 8:1hr rainfall amounts from 4am-10am from Sitka Airport (right) and Sitka CRN(left)

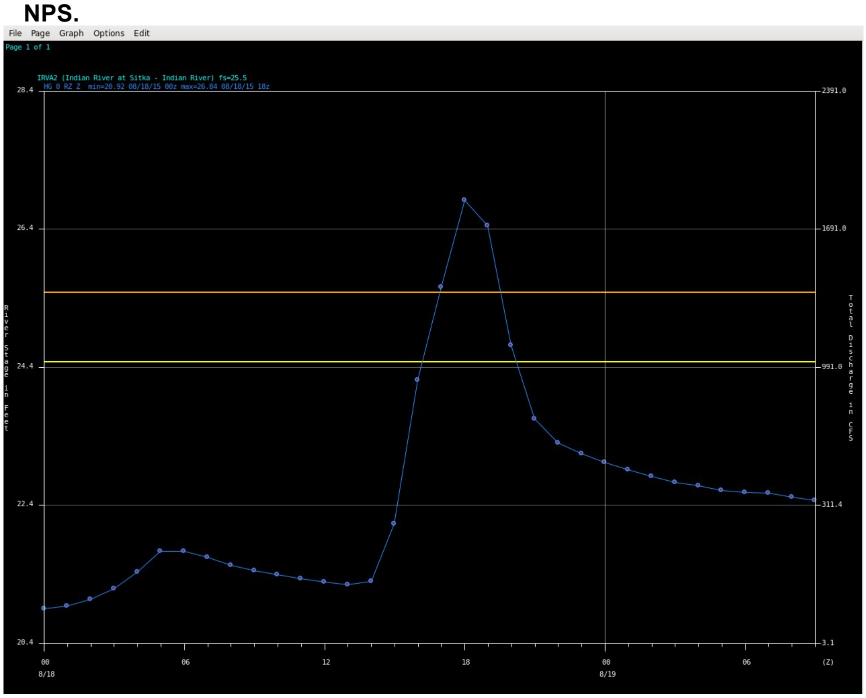
Rainfall intensities were a very big weather element that caused most of the impacts from this event in the Sitka area. Figure 9 shows how impressive these rates were. The 1hr rainfall return period at the Sitka Airport and at the CRN was notable with a 4 and 15 year return period respectively. The 3hr amount was extraordinary and the successive hours of very heavy rain caused the environment to react. The Starrigavan rain gauge and the CRN station had comparable rain amounts while the Sitka airport has less and much lower return period. This is again evidence that there was much more rainfall and higher rain rates at higher elevations due to orographic effects.

The rain came down so fast is caused the Indian River water levels to rise very rapidly. The river rose 6.8ft in 3 hours and crested at 26.84ft. This tied the record crest that the USGS reported October 19 1998 with a flow of 5,740cfs. The crest was more than 1 foot over the established National Weather Service's flood stage (orange line on figure 10). The weather front moved over the Sitka area between 930am and 10am as seen by the weather observation from the Sitka airport, figure 11. Once the rain stopped the river quickly receded and was back below flood stage in 2 hours. Also between the times the front went over the area there was a significant wind shift from south to southwest. Around that time Sitka's 911 hotline was getting calls about multiple debris flows across town.

Sitka Magnetic Observatory Climate Reference Station (CRN)		
Duration	**Precipitation (inch)**	**Return Period**
5 minute	0.09	< 1 year
30 minute (7:10am-7:35am)	0.45	~ 4 year
1 hour (7 -8am)	0.8	~15 year
3 hour (6-9 am)	2.01	~45 year
6 hour (5-10 am)	2.98	~ 25 year
Sitka Airport		
Duration	**Precipitation (inch)**	**Return Period**
1 hour (7 -8am)	0.58	~ 4 year
3 hour (6-9 am)	1.7	~ 25 year
6 hour (5-10 am)	2.58	~ 18 year
Starrigavan rain gauge		
Duration	**Precipitation (inch)**	**Return Period**
1 hour (7-8 am)	0.73	NA
3 hour (6-9 am)	1.9	NA
6 hour (5-10 am)	2.83	NA

Figure 9 (above): Rainfall intensity return period from NOAA Atlas 14 Vol.7

Figure 10 (below): Indian River hydrograph from August 18, source NPS.



8/18/2015 PASI					
Time	Wx	Temp	Dew	Wind	1Hr pcp
905am	R+F	58	58	S11G16	0.16
933am	R+F	57	57	S11G19	0.35
942am	R-F	57	57	S13G18	0.36
953am	R-	57	32	SW15G21	0.37
1016am	R-F	58	58	SW12	0.01
1030am	R-F	57	57	SW14	0.02
1041am	R-	57	57	SW10	0.02

Figure 11: Sitka airport ASOS weather observation.

Impacts:

There were more than forty debris flows that were documented from this event in and around the Sitka area. There were three fatalities in a very big debris flow that came down in a new sub-division along the south end of Kramer Avenue, the slide started just below the ridge line. The Kramer Avenue flow destroyed two homes, one was unoccupied and the other was under construction. On the north end of Kramer Avenue another big debris flow came down that blocked access in both directions, this flow also came down onto Harbor Mountain Road and blocked it. A debris flow along Saw Mill Creek Road cut off access to the cannery and Jarvis Creek power plant along with damaging an administration building at the Gary Paxton Industrial Park.

There were multiple reports of flooding across the Sika area with the Indian River going over its banks and flooding downstream into the Totem National Park trail system. There was flooding in the Sitka laundry center that opened up a sinkhole in the pavement. There were two propane tanks that hung on the edge of the sinkhole; they were removed without an incident. Several homes were flooded along with an apartment building.

The City of Sitka administrator declared an emergency when the calls began to come into 911 and that was follow-up with Governor Bill Walker declaring a State of Emergency by that afternoon. The Governor visited Sitka the day after to assess the damage done. The estimated total damage value was around 1.7 million dollars.

Photos:

Photo 1- A sinkhole had opened up beneath a pair of propane tanks on Halibut Point Road. (Rebecca LaGuire, KCAW)

Photo 2- Kramer avenue debris flow.

Photo 3- Aerial view of the Kramer Avenue debris flow. (Source: US Coast Guard)

Photo 4 – Aerial view of Kramer Avenue debris flow. (Source: US Coast Guard)

Photo 5 – Damaged done by Kramer Avenue debris flow. (Source: NWS)

Photo 6 – Aerial view of debris flow at the Gary Paxton Industrial Park, (Source: US Coast Guard)

Photo 7 - damaged administration building at the Gary Paxton Industrial Park

Photo 8-Other debris flow. (Source: US Coast Guard)

NASA Jet Propulsion Laboratory

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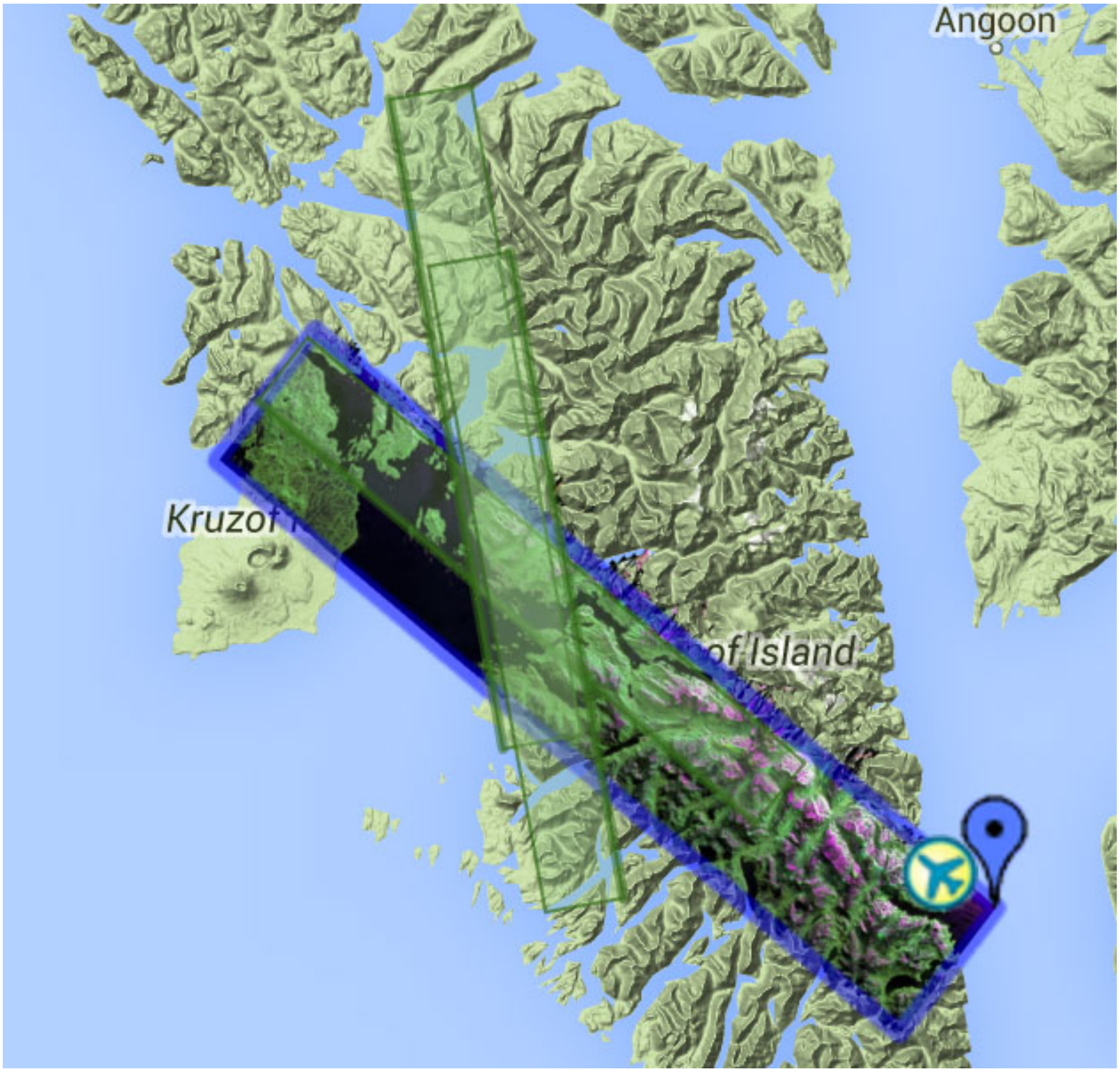
NASA flew the airborne radar system called AirMOSS, which is a P-band radar with about 68 cm radar wavelength, over Sitka on four flight lines. The flights were on 8/28, 8/31, and 9/30. One line was repeated on 8/28 and another line on 8/31, with time intervals of about an hour. The color images showing the radar reflection from the ground with different polarizations (called PolSAR for polarimetric SAR) are available from the Alaska Satellite Facility and can be found with either the ASF Vertex search tool or the JPL UAVSAR search tool (http://uavsar.jpl.nasa.gov/cgi-bin/data.pl). These are from the standard PolSAR processing of the AirMOSS data. All of the data is open to everybody. I attach a quick map of the flight lines from the UAVSAR search tool.

The JPL processing team also performed non-standard processing of interferograms between the 8/28, 8/31, and 9/30 acquisitions of AirMOSS data. The interferograms measure the change in distance between the ground and the airplane during the time interval between the images, so they are sensitive to surface motion. These interferograms are available from us at JPL and have no restrictions on use. We are planning to work with DG GS to get the interferograms into their archive for easier access, since we don’t have a standard archive for these experimental products.


Angoon
Kruzof
of Island

Preliminary modeling and analysis of landslide hazards

Brian Buma
Assistant Professor of Forest Ecology
Dept. of Natural Sciences
University of Alaska Southeast

The landslides in Sitka in August, 2015, demonstrated the need to better characterize when landslides occur and identify high risk areas, not just in Sitka but throughout southeast Alaska. Research on characterizing landslides and where they occur was already ongoing, and the Kramer slides provided an opportunity to test the results. A regional landslide initiation suitability map was constructed using data from >750 landslides around southeast Alaska, as mapped by the US Forest Service. The map identifies locations on the landslide statistically similar to known landslide initiation points in terms of slope, aspect, local topography, and exposure to high winds. This map, at 30m resolution, is now available for the entire region and the associated publication is now in review. It is useful for identifying areas likely to experience a landslide, and does identify the Kramer area as a significant slide risk, though not in the highest risk category. A potential reason for this was the wind direction just prior to the Kramer slide, which shifted to a westerly direction; the landslide suitability model uses general wind directions from the south (the predominant storm wind direction). Ongoing work with the National Weather Service hopes to create a dynamic model which can incorporate forecasted wind directions into warning systems, as opposed to the static risk map which was constructed. A major limitation is it does not map runout zones, focusing only on initiation points, and is thus not a complete map of landslide hazard.

Figure 1. New landslide suitability map for southeast Alaska. Area around Sitka, AK, is shown, with the location of the Kramer landslide circled. Old landslides used in model construction can be seen in light green.

A complimentary effort over the 2015-2016 winter identified 65 landslides (debris avalanches/ debris flows) with known occurrence times and locations across southeast Alaska with an operating weather station within ~20km and in a similar wind and precipitation regime (dates: 1936-2015). These slides were used to test the relationship between wind and rain rates and landslide occurrence. The goal was to identify thresholds of precipitation and/or wind which resulted in landslide events in both harvested and unharvested forest settings. Generally landslides occurred on similar slopes regardless of harvest history. Slides in unharvested locations were generally limited to high wind exposure areas and high wind speeds, confirming previous research (Buma and Johnson 2015) and the observations from the Sitka event. Harvested sites were not related to high wind exposure. Generally, landslides in unharvested areas were also associated with higher rainfall (24 hour average = 6.31cm) than harvested areas (5.8 cm), though it was not a significant difference. Higher precipitation and wind/wind exposure were associated with landslides on lower angle slopes, suggesting that lower landslide suitability scores can be associated with slides in extreme events (Fig. 1). Together this confirms expectations that harvesting generally destabilizes the soil and decouples wind from the landslide regime.

There was no clear threshold of wind or rain associated with landslide events, and it was difficult to disentangle the effects of wind and rain, as higher rain events were nearly always associated with higher wind events. There was not data for slides with low wind speeds but high precipitation, or vice versa. As a result, conclusions are limited as fair as the individual contribution, or interaction, of the two drivers. However, there was a slide at relatively low precipitation – 0.9 cm in 24 hours or 1.49 cm in 72 hours, totals which are not unusual for southeast Alaska at any time of year. Excluding that slide (the Redoubt Lake slide), which was atypical in terms of size and depth, and the minimum observed 24 hr rainfall was 1.7 cm (2.6 cm in 72 hours), also well within typical rainfall values. Minimum winds associated with slides had a minimum of 1.6 m/s (24 hour) with peak gusts of 5.8 m/s (minimum). These relatively low values suggest potential further work. First, identification of the functional synergies between wind and rainfall and how that varies on the landscape. The general wind exposure map used in the current generation of risk maps does not take species into account, nor how the topography influences tree rooting and tree interaction with the soil, instead only focusing on relative wind speed in isolation. Second, a need to analyze wind direction associated with historic slides. It could be that winds from unusual/atypical directions are more important in triggering landslides. Finally, precipitation and winds can vary dramatically in a short distance in the complex topography of the region. The numbers used in this analysis were from established stations, but the extent to which they represent conditions at the slide locations is unknown, and likely underestimates wind and rain as most weather stations are at sea level. Results are in review for publication, and a proposal to continue to investigate landslides in the region is in development.

United States Department of the Interior

NATIONAL PARK SERVICE
Sitka National Historical Park
103 Monastery Street
Sitka, Alaska 99835

IN REPLY REFER TO:

1.A.2 (SITK-Resource Management Planning)

March 24, 2016

Victoria O'Connell, Science Director
Sitka Sound Science Center
834 Lincoln Street, Suite 200
Sitka, Alaska 99835

Dear Ms. O'Connell,

The National Park Service has worked and contributed to the Sitka Geo-hazard Working Group from late August, 2015 until present in a number of ways. Some of those efforts will continue at least into the summer of 2016 towards the goal of responding in a proactive way to the 8/18/2015 landslides in Sitka.

Parker Martyn at our Regional Office was able to contact Brian Wright, the US Geological Survey (USGS) map coordinator for the State of Alaska, and engage the USGS Hazard Data Distribution System (http://hddsexplorer.usgs.gov/) to collect satellite imagery of the Kramer Avenue slides from 8/26/2015 until present. Currently there are 103 images and metadata files available by going to the HDDS website and searching for the "2015_Landslide_AK" event. They are available for agency use in developing hazard models or other agency use. The NPS has purchased a public/commercial license for one set of Worldview2 (WV2) images from 8/26/2015 for $3000. The purchased images have been incorporated into the NPS Enterprise GIS for Sitka National Historical Park and provided free-of-charge to members of the Geo-hazard Working Group, including the Alaska Division of Geological and Geophysical Surveys and the US Forest Service.

Sitka NHP and the Southeast Alaska Network of the Inventory and Monitoring Program (SEAN) have worked actively with the City and Borough of Sitka, the National Weather Service, the Alaska Department of Natural Resources and Department of Fish and Game to install and maintain the hydrograph that captured the flooding on August 18, 2015, illustrated in Figure 1. The National Weather Service sent staff to Sitka earlier in the summer of 2015 and---with NPS assistance---correlated the hydrograph with flood stages, providing the reference flooding levels seen in Figure 1.

In February, 2016, the SEAN, Sitka NHP, the City and Borough of Sitka (CBS), and the US Geological Survey, installed an additional hydrograph on Indian River, which is now available at http://waterdata.usgs.gov/ak/nwis/uv?site_no=15087700 . The annual cost for monitoring this station is $25,000, distributed $5,000 to CBS and $10,000 each to the NPS and USGS. Recent flows are shown in Figure 2.

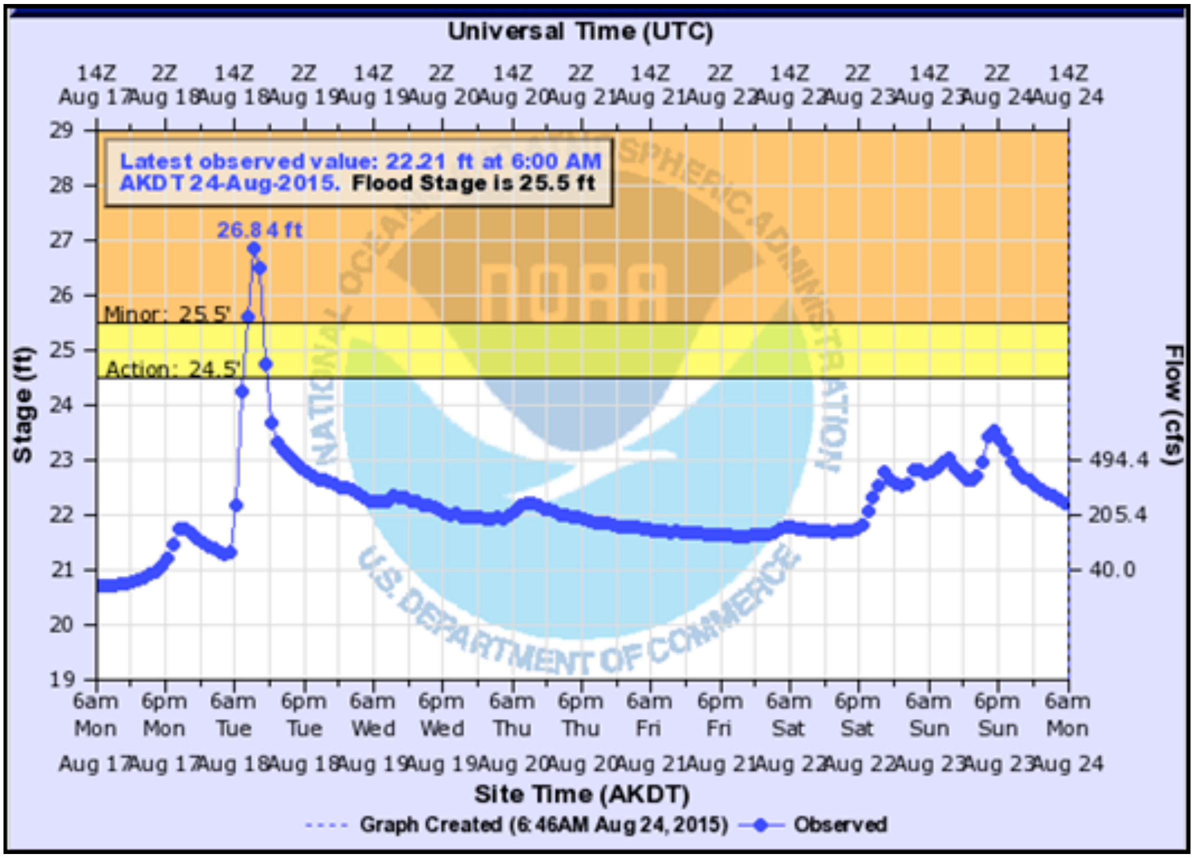


Figure 1: Visual representation of hydrographic data collected between 8/17/15 and 8/24/15 showing period of heavy flooding correlated with landslide activity in Sitka, Alaska (data from http://water.weather.gov/ahps2/hydrograph.php?gage=irva2&wfo=pajk for period shown).

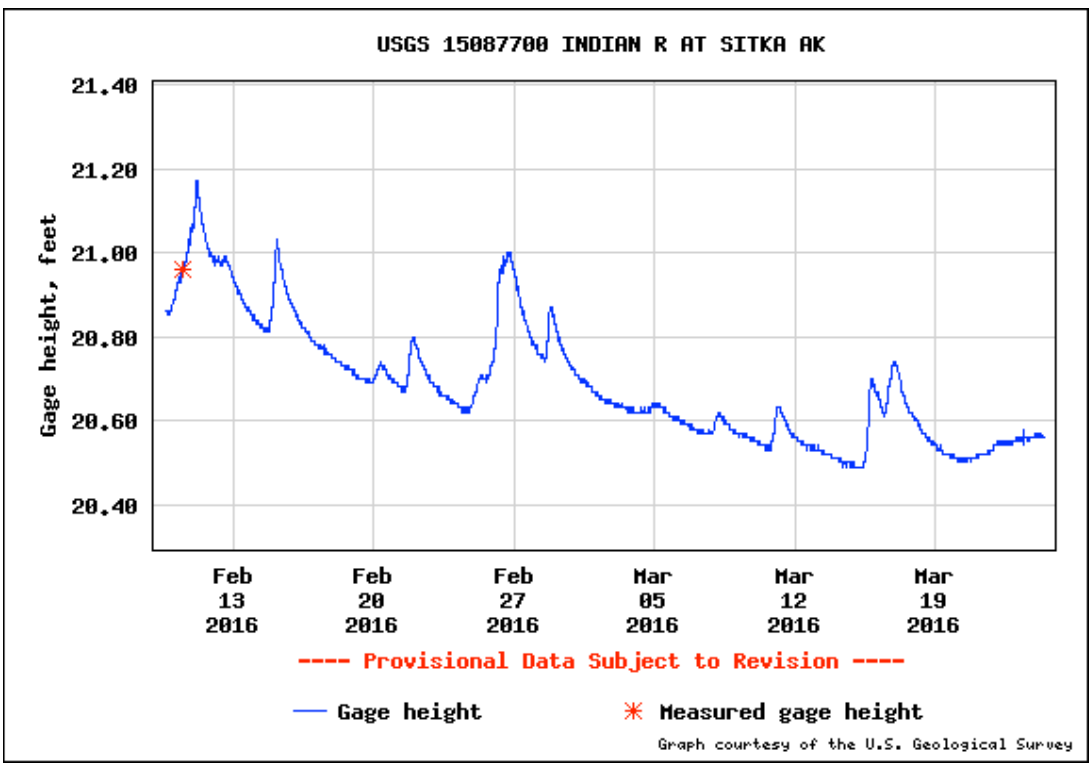


Figure 2: Indian River flow 2/9/2016 to 3/24/16. Data from http://waterdata.usgs.gov/ak/nwis/uv?site_no=15087700

2

After evaluating the current status of LIDAR data collections in Sitka in late August 2015, the Geo-Hazard Workgroup realized that there was insufficient high-quality elevation data to produce the best quality slide modeling for the developed area of Sitka, including Sitka NHP. Existing LIDAR data, most recently flown in 2014, focuses on the developed area of the city and the road system, not on the steep slopes above the developed areas administered by the US Forest Service and other landowners. In early September, 2015, NPS staff identified approximately $50,000 to conduct a LIDAR survey of Sitka NHP and other areas of the CBS that might be vulnerable to landslides and/or flood damage. In mid-September, the NPS entered into a Cooperative Agreement with the Alaska Division of Geological and Geophysical Surveys to conduct LIDAR surveys of the park and surrounding areas (Cooperative Agreement P15AC01879 -- Develop LIDAR Data set for Sitka NHP, Indian River Watershed, local National Historic Landmarks and surrounding City and Borough of Sitka and US Forest Service lands).

From mid-September to mid-December, DGGS attempted to contract LIDAR collection work with commercial vendors, but was unable to identify a responsive commercial provider at the allocated funding levels. After conferring with the SITK Resource Manager, DGGS and NPS contacted the US Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) to see if they could assist. The CRREL maintains a helicopter-mounted LIDAR instrument that can be deployed to capture high-resolution elevation data in small areas and areas with high relief. This instrument was used to capture elevation data on the terrestrial portion of the Fairweather fault in the summer of 2015 through the USGS Alaska Research office.

With the cooperation of the NPS, DGGS has entered into an agreement (ICA-16-CRL-01) with CRREL to collect LIDAR data in priority areas around Sitka (Figure 3). Anticipated fieldwork will occur in May/June 2016, with data available to DGGS/NPS and the Geo-hazard Workgroup by mid-to-late summer 2016.

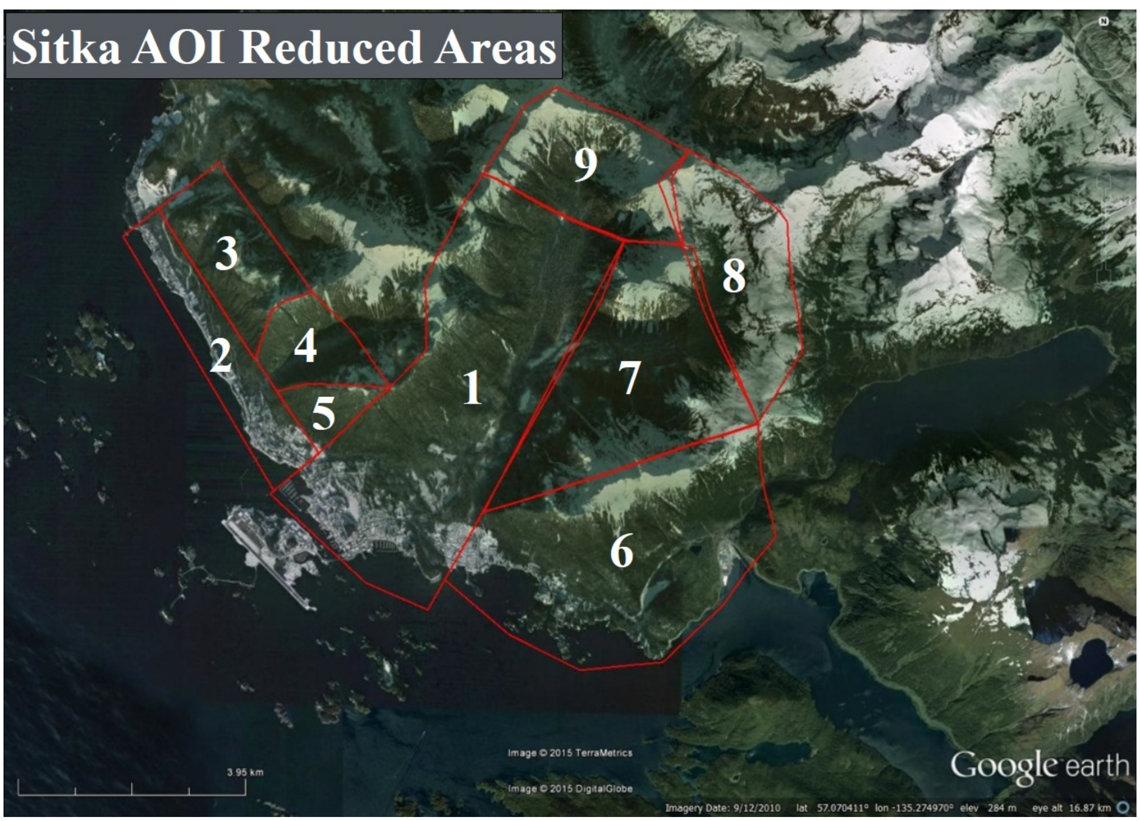


Figure 3: Prioritized LIDAR collection area specified by the DGGS/CRREL/NPS team.

3

Further LIDAR collection may be accomplished in this effort, if additional funds are identified and committed to the project.

Let me know, if you have questions.

Sincerely,

Brinnen Carter
Chief of Resources

Cc: Parker Martyn, NPS/AKRO
Wayne Challoner, Superintendent, NPS/SITK
Brian Wright, Map Coordinator, USGS/AKR
Mark Gorman, City Manager, City and Borough of Sitka

The National Park Service has contributed approximately $53,000 and 100 staff hours to the Sitka Geotask Force for collection of LIDAR data and photographic data that can be used to model both the existing landslides and to model potential landslide hazard zones. Data will be collected in May, 2016, and be available in mid-summer 2016.

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