Sub-Theme: Glacier mass balance at key Alaska sites and hydrological services

The ongoing works and optional plans to monitor the Kennicott Glacier, McCarthy, Alaska, USA

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Outlines

• Research objectives
• Why Kennicott Glacier?
• Original work plan for 2018
• The NPS permitted Works have done in 2018
• New knowledge acquired from 2018 field work
• Optional plans for 2019-2020
Research objectives

• The changes of typical glacier in Circum-Arctic
  – Regional Climate change
  – Mass balance of typical glacier
  – Contributions of glaciers to regional hydrological cycles

• Anthropogenic source depositions on glaciers
  – Types and amounts of the anthropogenic depositions
  – The sources of these depositions
  – Their impacts on glacier ablation
Why Kennicott Glacier?

- Location of Kennicott Glacier

- Fairbanks (UAF) to Kennicott: ~600 km
Why Kennicott Glacier?

• Basic information for Kennicott Glacier
  – Area: 375 km² (RGI 6.0)
  – Debris cover: 85 km²
  – Length: 43.6 km
  – Four main branches
    • Root Glacier
    • Gates Glacier
    • LaChapelle Glacier
    • Kennicott Glacier

• High representativeness
  – Typical Alaska-type glacier

• Easier access
Why Kennicott Glacier?

• Major limitations working on Kennicott Glacier
  – Within Wrangell-St. Elias National Park
    • National Park Service (NPS) Research Permits are always needed to do scientific works in the park territory
    • Many operations are not allowed
      – No digging and drilling in ground and rocks
      – No installation of eye-catching objects
      – No drones (near McCarthy Airport, busy sky)
  – Not realistic to work on it fully depends on man power due to its big size
Original work plan for 2018

- Climate monitoring
  - Two AWSs
- Mass balance
  - 15 ablation stakes
- Other works
  - GPS
  - Automatic camera
  - GLOF monitoring
The NPS permitted works have done in 2018

- NPS has approved a short-term (1 year) permit on very limited works
  - One Weather Station
    - At the lower site
  - Two ablation stake sites
    - Two stakes on each site, one in clean ice, one in debris-cover
- Also collected some water/Ice samples

![Map with markers for Weather Station, Ablation Stakes, and Water/Ice Sample locations]
The NPS permitted works have done in 2018

- 2018 Field work duration: August 25 to September 9
- Team member:
  - From SKLCS, CAS: Wanqin Guo, Haidong Han, Donghui Shangguan, Ruitang Yang
  - From Glacier Group, UAF: Pascal Buri
The NPS permitted works have done in 2018

• Climate Monitoring
  – Installed a weather station on the lower site
    • Double layers WTH
      – 1 and 3 meters
      – Wind Direction + Speed
      – Air Temperature
      – Relative Humidity
    • Air pressure
    • Radiation (longwave + shortwave, income + outcome)
    • Snow depth (ultrasonic)
    • Precipitation
The NPS permitted works have done in 2018
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- Mass balance measurements: 4 ablation stakes
The NPS permitted works have done in 2018

- Mass balance measurements: 4 ablation stakes
  - Stake installation on 2 sites on the lower glacier reach, with two stakes at each site:
    - One in Clean Ice (C), another in Debris-covered Ice (D)
The NPS permitted works have done in 2018

- Ice/water sampling
New knowledge acquired from 2018 field work

- Large variation of glacier ablation over debris-covered area, comparing to clean ice region
  - Extraordinary surface roughness of the debris-covered glacier surface
  - Large number of supra-glacial lakes and rivers
New knowledge acquired from 2018 field work

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New knowledge acquired from 2018 field work

- Large variation of glacier ablation over debris-covered area, comparing to clean ice region
  - Implications to mass balance measurement
    - Surface factors should have enormous influences on ablation
      - Surface type (flat or hilly, debris-covered or ice cliff)
      - Surface topography (orientation)
      - Thickness of the debris
    - The limited representativeness of stake site mass balance
      - May significantly differ from surrounding regions
      - Convert from site scale to regional mass balance will be problematic
      - May not be improved even by careful site selection
Optional plans for 2019-2020

- **Plan A**: field work based, mainly by helicopter
  - Mainly follows the original plan for 2018
    - Weather station
      - On an upper glacier site above 2000 m
    - Ablation stakes
      - Up to 6 along the central flowline
      - 2 more transversal stakes on 3 sites
    - GPS measurements
      - For surface velocity at stake site
    - Hidden Creek Lake GLOF monitoring
      - Lake level
      - Water temperature
      - Time-lapse camera
Optional plans for 2019-2020

• Plan A: field work based, mainly by helicopter
  – Details and expenses: installation in April, 2019
    • Helicopter time and expenses needed
      – AWS transportation (R66)
        » 2-3 round trips from McCarthy to upper glacier (2+ hours)
      – Stake installation (R66 for first day and R44 for second day)
        » 0.75 hour per stake (9 hours in total for 12 stakes)
        » 1 hour on GLOF site
        » 1 additional hour on AWS site
      – Finished in 2 days
      – Gross cost: ~$16670

• Group member needed
  – 2 for AWS site, 1 for stakes (with pilot), and 2 for GLOF site
Optional plans for 2019-2020

- **Plan A**: field work based, mainly by helicopter
  - Details and expenses: **data collections (3 in 2019-20)**
    - Helicopter time and expenses needed (R44)
      - AWS site
        » Maintenance and data downloading (0.5 hour)
      - Stake sites
        » 10 minutes per stake (2.6 hours in total for 16 stakes)
      - GLOF site
        » Maintenance and data downloading (0.5 hour)
      - Finished in 1 days
      - Gross cost: ~$4424 per field campaign, ~$13272 in total
    - Group member needed: 1-2 persons each time
Optional plans for 2019-2020

• **Plan A:** field work based, mainly by helicopter
  
  – **Advantages:**
    
    • Most effective, and easier to be carried out (minimum man power involvements)
    
    • More ground truth data collection, and precise mass balance at ablation stake sites
  
  – **Disadvantages:**
    
    • May out of budget (totally ~$29942 for two years work besides living and travelling expenses)
    
    • Will facing the representativeness problems (point scale mass balance measurements vs. regional scale’s)
Optional plans for 2019-2020

- **Plan B:** same as Plan A, but mainly by manpower
  - Details and expenses: **installation in April, 2019**
    - Additional materials/loads needed
      - Water, food, alpine tent, sleeping cushions and bags (for 6 persons)
    - Minimum number of group member needed: 6 in all
      - 2 for AWS site, 4 for stakes and GLOF site
    - Total time needed: 4-5 days
      - 3 hours per stake, 3-4 stakes per day, 3-4 days in total
      - 1 additional day on GLOF site
    - Helicopter time needed (R66)
      - 2-3 round trips from McCarthy to AWS site (2+ hours)
      - 1 additional hours to upper most stake site
      - Gross cost: ~$3950
  - Helicopter expenses: **data collection (3 times in 2019-20)**
    - same as Plan A, ~$4424 per field campaign, ~$13272 in total
Optional plans for 2019-2020

• Plan B: **field work based, but mainly by manpower**

  – Advantages:
    • Most funding effective (totally ~$17222 for two years works besides living and travelling expenses)
    • Same as Plan A, more ground truth data and precise mass balance at ablation stake sites

  – Disadvantages:
    • Most time and manpower consuming
    • Heavy individual loads, and hardest logistic supports (food, accommodation, device recharging, etc.)
    • Same as Plan A, will facing the representativeness problems of the point measurements
Optional plans for 2019-2020

- Plan C: **RS based, validate by stake measurements**
  - Details and expenses:
    - Equipment installation
      - Reduced new stakes: 4 in total
      - Helicopter time needed (R66)
        - AWS: 2+ hours
        - Stakes: 2+ hours
        - GLOF site: 0.5+ hours
      - Gross cost: ~$5135
    - Data collection
      - AWS: 0.5 hour
      - Stakes: 1.3 hour for 8 stakes
      - GLOF site: 0.5 hour
      - Gross cost: ~$3400 each time, $10200 in total
Optional plans for 2019-2020

• Plan C: RS based, validate by stake measurements
  – Invest little more than normal remote sensing based studies to reveal regional glacier changes
    • Mainly on purchasing high resolution satellite images
  – Usable stereo optical satellite images:
    • WorldView/Geo-Eye (100 km² minimum per order)
      – 0.3-0.5 m resolution
      – Achieve price: $28/km², ~$2800 in total
      – Tasking price: $48/km², ~$4800 in total
    • SPOT-6/7 (500 km² minimum per order)
      – 1.5 m resolution
      – Achieve price:￥36/km², ~￥18000 for whole glacier
      – Tasking price:￥60/km², ~￥30000 for whole glacier
    • ZY3:
      – 2.1 m resolution
      – Achieve price:￥4000/scene
      – Tasking price: ~￥6000/scene
Optional plans for 2019-2020

- **Plan C**: RS based, validate by stake measurements
  - **Advantages**:
    - Funding effective on the field work (minimum field works expenses, totally ~$15335 for two years work)
    - Regional rather than point scale mass balance, no needs on transformations
  - **Disadvantages**:
    - Less accurate than stake measurements (meters level vs centimeters scale)
    - Can only applied to retrieve yearly or even 2-3 years’ mass balance (larger uncertainties for shorter period)
Thank you!
Optional plans for 2019-2020

- Helicopter rental price
  - From **VS Helicopters Service Company** in Valdez
    - Distance between McCarthy and Valdez: 180 km
    - Known nearest spot has helicopter rental service
  - Two choices
    - R44:
      - Start Price: $3160 (with fuels for four hours), $790 for additional hour,
      - Loads: 371 kg (pilot, passenger, and baggage all together)
      - With limited cargo compartment, best for stake installation
    - R66:
      - Start Price: $ 4780 (with fuels for four hours), $1195 for additional hour
      - Loads: 420 kg (pilot, passenger, and baggage all together)
      - With good sized cargo compartment, best for AWS installation
  - Time consuming scale
    - Round trip from Valdez to McCarthy: ~2.2 hours
    - Round trip from McCarthy to upper glacier: 0.5 hour
Some RS-based research topics on Kennicott Glacier

- The recent surface mass balance of Kennicott Glacier derived from high resolution remote sensing
  - *Study the surface mass balance using high resolution optical (stereo) or microwave (InSAR) remote sensing*

- The evolvement of surface landforms of Kennicott Glacier and the impacts on its mass balance
  - *To study the fundamental mechanisms driving larger variations of mass balance among different parts of this glacier*

- The remote sensing retrieval of debris cover thickness of Kennicott Glacier and the influences on surface mass balance
  - *Thermal infrared remote sensing based methods*

- Evolutions and GLOF forecast on the Hidden Creek Lake aside Kennicott Glacier
  - *Using methods similar to Merzbacher glacial lake of Central Tienshan to study and forecast the GLOF of Hidden Creek Lake*

*All the studies can be combined with and validated by field mass balance and debris thickness measurements*