New measurements techniques

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Outline

• Definition of “New”

• Some relative newly-used techniques in China
  -- Eddy covariance on glaciers
  -- InSAR
  -- Integrated observation system
  -- Wireless monitoring network
  -- 3D Laser Scanner
  -- Glacier watch tower

• Collects of truly new techniques
How new is new?

- Appeared last several years
- Advanced: automatic, high-resolution, real time, ...
- Used for long but rarely used on cryosphere before
- Trying on snow and ice, but don’t know good or bad yet
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1. AWS and eddy covariance: glacier

Elements: air temperature, relative humidity, wind speed and wind direction at two levels (1.5 m and 3 m), downward and upward solar/longwave radiation at one level (1.5 m)

Location: 2 AWS.

Period: 2009—2015 (Annual mass balances were manually measured at same time)
Model description

Energy balance

\[ Q_M = S \downarrow (1 - \alpha) + L\downarrow + L\uparrow + H + LE + Q_G \]

Mass balance

\[ B = \int \left( \frac{Q}{L_m} + \frac{Q}{L_v} + C_{en} + P_{snow} \right) dt \]
Primary results

The figure showed the annual mass balance gradients along with elevation of year 2010/2011 and 2011/2012. For the two years, the annual mass balances were -376 mm and -236 mm w.e., respectively.

During the summer season (from May to September), for the entire glacier the net solar radiation was the primary source of the surface energy balance (80%), followed by sensible heat flux (20%); Net longwave radiation (57%) was primary output of surface energy balance, the rest of energy was consumed by the energy for melt (30%) and latent flux (13%).
2. The application of InSAR technique in permafrost landform

Linking **remote sensing features** and **knowledge of specific ground conditions**, i.e. ice content, moisture, vegetation, and ground water salinity to determine the surface deformation in permafrost regions.
3. Integrated permafrost observation system

- Permafrost distribution change
- Validation
- Borehole temperatures measurement
- Simulation of heat and moisture exchanges in active layer
- Simulation of permafrost dynamics under climatic warming
- Soil parameters; Geomorphologic parameters; Vegetation parameters
- Automatic weather station measurements
- Long term air temperature & surface temperature data
- Evaluation of CO₂ emission
- Feedback to climate system
- Climate changes
Ground temperature measurements
Active Layer Monitoring
Observations of climatic variables in permafrost regions

- Air temperature (at 2, 5, 10 m high)
- Precipitation
- Evaporation
- Relative humidity
- Wind speed and direction
- Radiation

- Sensible heat, latent heat, water vapor, and CO₂ flux were measured.
Geophysical investigation of permafrost

The components of GPR (Pulse-EKKO 100)

The principle of GPR

The interpreted GPR image (Hinkel et al., 2001)

Parameters for GPR surveys

- Impulse power: 400 V
- Center frequency of antennae: 50, 100, 200 MHz
- Length of antennae: 2.0, 1.0, 0.5 m
- Measurement step: 1.0 m
- Recording time window: 400 ns
- Sampling interval: 800 ps
- Number of stacks: 32
- Battery power supply: 12 V
4. Wireless monitoring on Koxkar glacier

Distribution of WLAN routers

- WLAN network is composed of nine core routers which are interconnected using UBNT AP pairs. An outlet router is set to bridge the WLAN to the Internet. Working in 2.4G Hz frequency, the WLAN is able to transmit data and images in a speed as high as 150 Mbps.
Overlay of the WLAN network

- All automated devices including AWS, precipitation gauges and net cameras are connected in WLAN network, which facilitate remote data collecting and real-time data or events monitoring. Net cameras are deployed to record changes in supraglacial morphology, ice ponds, stakes, snowfall and water level of discharge. Real-time videos or images will be stored in net recorder located in basecamp.
Problems and future development

The Koxkar glacier is a large valley glacier that extends 25.1 km and covers an area of 73.2 km$^2$. Automatic monitoring and data recording based on WLAN network reduce or avoid manual involvements of regular measurements, and make synchronized observations of glacial or meteorological events become feasible and convenient. The major problems is the signal stability among routers as they are all wireless connected over a long distance. Direct connection using optical cables will be implemented to avoid echo failure of remote routers and devices.
5. Monitoring the glacier mass balance with 3D ultra long-range terrestrial laser scanner system

The new high speed, high resolution terrestrial 3D Laser Scanner RIEGL VZ-6000 offers an extremely long measurement range of more than 6000 m for topographic (static) applications, which can be use for study the glacier mass balance.
Monitoring the glacier mass balance with 3D Laser Scanner RIEGL VZ-6000 at the Urumqi Glacier No.1, Tienshan
6. Glacier watch Tower: a platform

To promote the observation of Glacier No.1 at the Headwater of Urumqi River, a 30 m tower was built at 3800 m a.s.l. near the terminus of the Glacier No.1.
This tower will become a platform of real-time observation and online data transmission for Urumqi Glacier No.1 monitoring, after equipped with an AWS, video camera, wireless data transmission, as well as other advanced glacier monitoring equipment.
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Essential and urgent

• Collects new tech. worldwide

• Both in-situ and remote sensing techniques

• Developed countries/regions should lead this, and share information and techniques: if there is a “CryoTech” sharing system, like cryolist, might be helpful

• Reduce the cost of sensors, instruments, etc.