Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SCG63-01 Room:102A Time:May 25 11:00-11:15

Recent topics on ”Cryoseismology”

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Several kinds of environmental signals associated with ocean - cryosphere - solid earth system have been recently detected in bi-polar regions. Ice-related seismic motions for small magnitude events are generally named ice-quakes (ice-shocks) and can be generated by glacially related dynamics. Such kinds of cryoseismic sources are classified into the movements of ice sheets, sea-ice, oceanic tide-cracks, icebergs and the calving fronts of ice caps. Cryoseismic waves are likely to be influenced by the variations in environmental conditions, and the continuous study of their time-space variability provides indirect evidence of climate change. As glacial earthquakes are the most prominent phenomena found recently in polar regions, in particular on the Greenland in this 21st century, the new innovative studies from seismology are expected by long-term monitoring under extreme conditions in the Earth’s environment. Taking these issues into account, the recent topics on ”Cryoseismology” are introduced, including major achievements on glacial related seismic events involving characteristic phenomenon in polar regions. It is particularly focused on seismic signals associated with dynamics of ice sheets, sea-ice, icebergs and glaciers.

Keywords: cryosphere dynamics, glacial earthquakes, ice-quakes, global warming, polar surface environment

SCG63-02 Room:102A Time:May 25 11:15-11:30

Glaciation and material cycling within the overriding plate wedge: Climate-tectonics interaction in the southern Alaska

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Recent studies have revealed that climatic changes had driven tectonic perturbations. Plate subduction zones in the subpolar regions, including the southern Alaska and the southern Chile margins, have experienced proximal ice-sheet advances several times during the Late Cenozoic. Glaciers are highly efficient erosive agents and their presence and extent are known to control underlying topography. However, there is little understanding of the dynamic interplay between tectonics and glaciation-deglaciation in these settings. Moreover, the relationship between plate convergence rates and taper angles in the outer wedges of these glaciated accretionary margins deviates from the strong correlation observed in other non-glaciated accretionary margins. Herein we present mechanical variations of the tapered-wedge overriding the North American plate on the southern Alaska subduction margin coupled with glacial erosion associated with the maximum extent of the adjacent Cordilleran ice-sheet around the Mid-Pleistocene Transition. Changes in the taper-wedge geometry influence material cycling and fluid distribution as well as deformation, thermal regime, and seismicity in the wedge. We estimate the geometry of the Cordilleran ice-sheet during its maximum extent using the modified 2-D Shallow-Shelf Approximation to reconstruct approximate rates of glacial erosion. The calculated glacial erosion rates are constrained by offshore sedimentary records from recent IODP Expedition 341 as well as seismic images. We find evidence that the extent of glaciation is considered to definitely affect long-term mechanics of the outer taper-wedge. The large glaciations post-MPT promote an extensionally critical state and enhances fluid and gas escape from the wedge to the seafloor. This is likely responsible for the absence of offshore mud volcanoes and bottom-simulating reflectors indicative of marine methane hydrates in the southern Alaska margin.

Keywords: Climate-tectonics interaction, Cordilleran ice-sheet, glacial erosion, taper wedge, material cycling, Gulf of Alaska

SCG63-03 Room:102A Time:May 25 11:30-11:45

Passive seismology of ice: an overview of main seismic sources and their characteristics

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Recent 'flood' of papers and passive seismic data about ice covered areas of the planet produced a need for generalized ways to distinguish between different types of seismic sources generating ice-quakes. Basing on analysis of more than 100 publications, we make a step in this direction and attempt to take a quantitative look at key features of previously reported signals. We find that the emerging seismic 'portrait' of the Cryosphere can be mainly explained in terms of released glacial stress and external forcings. Our study presents the first sketch of criteria which could be ultimately helpful in detecting and categorizing various ice-related phenomena.

Keywords: icequake, Cryosphere, Seismology, seismic source, magnitude, stress drop

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SCG63-04 Room:102A Time:May 25 11:45-12:00

Triggered Glacial earthquake by Ocean tide

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1. Introduction

Recently, global warming melts make glacier melting in Greenland, and increase the spillage of the glacier. We are concerned a rise in sea-level, and relation between the glacier earthquake and the outflow of the glacier. The glacial earthquake occurred around the outlet of the glacier, and activity of the glacier earthquake is increasing in recent years. These phenomena may reflect the climate change. However, it is not completely understood that the relationship between the glacial earthquake and the outflow of the glacier.

2. Changes of frictional force and coefficient due to a glacier earthquake and sea-level change

Tsai and Ekstrom (2007) researched seismic wave generated by a glacial earthquake, and reported that the surface wave magnitude of almost the glacial earthquake in Greenland was about five. Source time function of the glacial earthquake is almost 50 seconds, which is longer than a typical tectonic earthquake. It means that the glacial earthquake is similar to slow earthquake. In order to understand the dynamics of the glacial earthquake, we attempt to estimate the change of the frictional coefficient between the glacier and bedrock. As a result, the change of the frictional coefficient due to the glacier earthquake is around 1.6×10^{-4}. The glacier earthquake may occur by triggering of a small perturbation.

On the other hand, we attempt to estimate the effect of sea-level change due to ocean tide. The change of sea-level makes the change of pore pressure between the glacial and bedrock. If we assume that the thickness of glacier and sea-level change are 700m and 1.5m, respectively, the ratio of the change of frictional force due to induced sea water to the effective frictional force of the steady state became about 2.1×10^{-3}, which is the same order as the change of the frictional coefficient due to the glacier earthquake.

3. The ocean tide triggers the glacier earthquake

In order to statically evaluate the triggered glacier earthquake by ocean tide, we check the relation between sea-level change and the occurrence of glacier earthquake. As a result, we find 3% of the whole glacier earthquake is affected by sea-level change. Our estimated situation of frictional state from sea-level change and the glacial earthquake is consistent with the observed glacial earthquake triggered by the ocean tide.

Keywords: Glacial earthquake, Greenland, Ocean tide

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SCG63-05 Room:102A Time:May 25 12:00-12:15

Significances of GLISN project in Global Seismology

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The Greenland Ice Sheet Monitoring Network (GLISN) project?a collaboration between Canada, Denmark, France, Germany, Italy, Japan, Norway, Poland, South Korea, Switzerland, and the United States?provides real-time broadband seismological observations to help address critical, poorly understood aspects of the Arctic system. Geodetic observations are also included at selected stations. Seismic data from GLISN record changes at high temporal resolution and reflect deformation and structures internal to the ice and solid Earth. These data complement existing observations from satellite and airborne remote sensing, ice-penetrating radar, and GPS geodesy. Launched in 2009, the GLISN project completed installation of all 33 initially planned seismic stations in August 2013. Most GLISN stations in Greenland are installed on bedrock along the ice-free coast at sparsely populated settlements to take advantage of existing power and communications infrastructure. Four stations are installed in the ice. Additional stations surrounding Greenland?in Canada, Iceland, and on several Norwegian islands?allow scientists to gain a broad view of Greenland's structure and changes in the ice. The GLISN project has already provided valuable data for multiple studies. Data from the network (Figure 1) have been used to improve analysis of glacial earthquakes, which result from calving events of about 1 cubic kilometer each. GLISN stations have also been used in automatic detection of calving events by measurement of tilt associated with seiches (standing waves) in the fjords where many glaciers terminate.

Keywords: glacier earthquake, Greenland, broadband seismograph

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SCG63-06 Room:102A Time:May 25 12:15-12:30

Seismic waveform modeling for a structural model with the Greenland ice sheet

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We calculate regional synthetic seismograms for a realistic structure model beneath Greenland, including both surface topography and ice sheet thickness. In 2009, the multinational GreenLand Ice Sheet monitoring Network (GLISN) was initiated to monitor seismic events in and around the Greenland. Japan has been sending a field team to Greenland each year since 2011, to construct and maintain the GLISN stations especially on ice. However, the thick and heterogeneous Greenland ice sheet is considered to cause various kinds of distortion on seismic waveforms observed at these ice stations. We have been working for construction of a numerical technique, which can calculate accurate regional seismic wavefields with small computational requirements.

In this work, we calculate elastic wave propagation up to 2 Hz for four structural models of the Greenland ice sheet radiated from a seismic source with various depths and mechanisms. Our computations for a realistic ice sheet model, the near-surface seismic source produced a very characteristic wave train with the group velocity smaller than the S-wavespeed in the ice, which is considered as an icesheet guided S wave, developed by a superposition of post-critical reflections between the free surface and the ice bed. We named this wave "Le" on the analogy of the Lg wave, a crustally guided S wave ("e" comes from the German word "Eisdecke", meaning the ice sheet). Furthermore, computation for a deeper seismic source resulted in reinforcement of the crustal Sg-coda wave with a group velocity range of ~3.1-2.6 km/s, which well explains the characteristic waveform observed on the Greenland ice sheet.

Keywords: Greenland ice sheet, Seismic waveform, Guided wave, Finite-difference method (FDM), GLISN project