The Global SEDIBUD (Sediment Budgets in Cold Environments) Programme: Coordinated Studies of Sedimentary Fluxes and Budgets in Changing Cold Climate Environments

Achim A. Beylich[*,1,2]

[1]*Geological Survey of Norway (NGU), Quaternary Geology & Climate group, Trondheim, Norway*

[2]*Norwegian University of Science and Technology (NTNU), Department of Geography, Trondheim, Norway*

Abstract: Projected climate change in cold climate environments is expected to alter melt-season duration and intensity, along with the number of extreme rainfall events, total annual precipitation and the balance between snowfall and rainfall. In addition, changes to the thermal balance are expected to reduce the extent of permafrost and seasonal ground frost and increase active layer depth. These effects will change surface environments in cold climate environments and alter the fluxes of sediments, nutrients and solutes, but the absence of data and coordinated quantitative analysis to understand the sensitivity of the surface environment are acute in cold environments. The I.A.G/A.I.G. SEDIBUD (Sediment Budgets in Cold Environments) Programme, building on the ESF SEDIFLUX (Sedimentary Source-to-Sink-Fluxes in Cold Environments) Network, has been formed to address this key knowledge gap. Coordinated efforts are carried out to quantify, compare and model sedimentary fluxes and budgets in 38 selected SEDIBUD Key Test Sites (cold environment catchments) worldwide.

Keywords: Sediment fluxes, sediment budgets, geomorphic process monitoring, inter-site comparisons, cold climate environments.

INTRODUCTION

Amplified climate change and ecological sensitivity of polar and cold environments have been highlighted as a key global environmental issue [1]. Projected climate change in cold regions is expected to alter melt season duration and intensity, along with the number of extreme rainfall events, total annual precipitation and the balance between snowfall and rainfall. Similarly, changes to the thermal balance are expected to reduce the extent of permafrost and seasonal ground frost and increase active layer and thaw depths. These effects will undoubtedly change surface environments in cold environments and alter the fluxes of sediments, nutrients and solutes, but the absence of data and analysis to understand the sensitivity of the surface environment are acute in cold climate environments.

THE I.A.G./A.I.G. SEDIBUD PROGRAMME

The *SEDIBUD (Sediment Budgets in Cold Environments)* Programme of the International Association of Geomorphologists (I.A.G./A.I.G.) was formed in 2005 to address this key knowledge gap [2, 3].

SEDIBUD has currently about 400 members worldwide and the Steering Committee of this international programme is composed of ten scientists from nine different countries:

Achim A. Beylich (*Chair*) (Norway), Armelle Decaulne (*Secretary*) (France), John C. Dixon (USA), Scott F. Lamoureux (*Vice-Chair*) (Canada), John F. Orwin (New Zealand), Jan-Christoph Otto (Austria), Irina Overeem (USA), Þorsteinn Sæmundsson (Iceland), Jeff Warburton (UK), and Zbigniew Zwolinski (Poland).

The central research question of this global group of scientists is to;

> *Assess the contemporary sedimentary fluxes in cold climates, with emphasis on both particulate and dissolved components.*

Initially formed in 2004 as the European Science Foundation (ESF) Network SEDIFLUX (Sedimentary Source-to-Sink-Fluxes in Cold Environments) (2004-2006) [4, 5] SEDIBUD has further expanded to a global group of researchers with field research sites located in polar and alpine regions in the northern and southern hemisphere. Research carried out at each site varies by programme, logistics and available resources, but typically represent interdisciplinary collaborations of geomorphologists, hydrologists, ecologists, and permafrost scientists and glaciologists with different levels of detail. SEDIBUD has developed a key set of primary research data requirements intended to incorporate results from these varied projects and allow analysis across the programme. SEDIBUD Key Test Sites provide data on annual climate conditions, total discharge and particulate and dissolved fluxes as well as information on other relevant denudative surface processes. A number of selected SEDIBUD Key Test Sites is providing high-resolution (hourly) data on climatic conditions, runoff and fluvial fluxes, which in addition to the annual data contribute to the SEDIBUD Metadata Database. To support these efforts, the SEDIFLUX Manual and field protocols [6]

*Address correspondence to this author at the Geological Survey of Norway (NGU), Quaternary Geology & Climate group, Trondheim, Norway;
Tel: ++47 73 90 4117; E-mail: achim.beylich@NGU.NO

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Table 1. Compiled Annual Data from SEDIBUD Key Test Sites

Required Annual Data from SEDIBUD Key Test Sites (Protocol Available at http://www.geomorph.org/wg/wgsb.html [9])

Name of SEDIBUD Key Test Site: **Erdalen (Norway)** **Principal Investigator: Achim A. Beylich**	**Period of Investigations (Years): 2005 – 2009** **(Hydrological Year (HY) or Calender Year (CY);** **Published Data (PD) or Unpublished Data (UPD))**
Mean annual temperature (ºC)	6.1
Total annual precipitation [mm]	1452
Total annual runoff [mm]	1413
Annual suspended sediment yield [t km^{-2}]	7.8
Annual solute yield (atmospherically corrected) [t km^{-2}]	3.3

Required Annual Data from SEDIBUD Key Test Sites

Name of SEDIBUD Key Test Site: **Hrafndalur (Iceland)** **Principal Investigator: Achim A. Beylich**	**Period of Investigations (Years): 2002 – 2007** **(Hydrological Year (HY) or Calender Year (CY);** **Published Data (PD) or Unpublished Data (UPD))**
Mean annual temperature (ºC)	3.6
Total annual precipitation [mm]	1719
Total annual runoff [mm]	1344
Annual suspended sediment yield [t km^{-2}]	18.5
Annual solute yield (atmospherically corrected) [t km^{-2}]	29.3

Required Annual Data from SEDIBUD Key Test Sites

Name of SEDIBUD Key Test Site: **Austdalur (Iceland)** **Principal Investigator: Achim A. Beylich**	**Period of Investigations (Years): 1996 – 2007** **(Hydrological Year (HY) or Calender Year (CY);** **Published Data (PD) or Unpublished Data (UPD))**
Mean annual temperature (ºC)	3.6
Total annual precipitation [mm]	1431
Total annual runoff [mm]	1130
Annual suspended sediment yield [t km^{-2}]	42.0
Annual solute yield (atmospherically corrected) [t km^{-2}]	8.0

Required Annual Data from SEDIBUD Key Test Sites

Name of SEDIBUD Key Test Site: **Latnjavagge (Sweden)** **Principal Investigator: Achim A. Beylich**	**Period of Investigations (Years): 2000 – 2007** **(Hydrological Year (HY) or Calender Year (CY);** **Published Data (PD) or Unpublished Data (UPD))**
Mean annual temperature (ºC)	-2.0
Total annual precipitation [mm]	852
Total annual runoff [mm]	717
Annual suspended sediment yield [t km^{-2}]	2.3
Annual solute yield (atmospherically corrected) [t km^{-2}]	4.6

Required Annual Data from SEDIBUD Key Test Sites

Name of SEDIBUD Key Test Site: **Kidisjoki (Finland)** **Principal Investigator: Achim A. Beylich**	**Period of Investigations (Years): 2002 – 2007** **(Hydrological Year (HY) or Calender Year (CY);** **Published Data (PD) or Unpublished Data (UPD))**
Mean annual temperature (ºC)	-2.0
Total annual precipitation [mm]	415
Total annual runoff [mm]	324
Annual suspended sediment yield [t km^{-2}]	0.3
Annual solute yield (atmospherically corrected) [t km^{-2}]	3.1

The five examples Erdalen (Norway) [10], Hrafndalur (Iceland) [11, 12], Austdalur (Iceland) [12], Latnjavagge (Sweden) [13, 11] and Kidisjoki (Finland) [11]. Time series of these mean annual data are published in [10, 11 and 12] and [13].

have been produced to establish common methods and data standards [2, 3] in press [7]. In addition, a framework paper for characterizing fluvial sediment fluxes from source to sink in cold environments has been published by the group [8]. Comparable datasets from different SEDIBUD key test sites will be analysed to address key research questions of the SEDIBUD programme as defined in the SEDIBUD Working Group Objective [9]. Table **1** shows compiled annual data, as required from defined SEDIBUD Key Test Sites, from five selected SEDIBUD research field sites as examples. The generation and compilation of directly comparable data sets from the defined SEDIBUD Key Test Sites in the SEDIBUD Metadata Database will be the basis for modelling effects of climate change on sedimentary fluxes and yields in cold climate environments by using space-for-time substitution [2-6]. Currently SEDIBUD has identified 38 SEDIBUD Key Test Sites worldwide [9] with the goal to further extend this network to about 40-45 sites that possibly cover the widest range of cold environments.

Additionally, it is expected that collaboration within the group will act as a catalyst to develop new sites in underrepresented regions. The SEDIBUD Key Test Site Database [14] and the SEDIBUD Fact Sheets Volume [15] provide significant information on SEDIBUD Key Test Sites. SEDIBUD is open for proposals for possible additional SEDIBUD Key Test Sites to be included in the programme.

Coordination and collaboration with a number of international research programmes, including: International Tundra Experiment (ITEX), Circumpolar Active Layer Monitoring (CALM) and Arctic Coastal Dynamics (ACD/ACCO Net) will provide further opportunities for collaborative research to address broader polar environmental research issues [16-18].

Individual research projects being headed by SEDIBUD Members, using datasets generated at SEDIBUD Key Test Sites and targeting at defined SEDIBUD Key Research Questions, using SEDIBUD as umbrella programme, are encouraged by the SEDIBUD Steering Committee. More detailed information on the I.A.G./A.I.G. SEDIBUD Programme is available at http://www.geomorph.org/wg/wgsb.html [9].

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