Autogenic dynamics of debris-flow fans

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Abstract

Autogenic dynamics are driven by two interconnected feedback mechanisms: (1) backfilling, (2) avulsion and (3) channelization. The autogenic cycles of debris-flow fans are symmetric, and debris-flow length and width are similar prior to backfilling and avulsion.

Introduction

Autogenic dynamics

- Alluvial fans develop their semi-circular shape by cycle-analyses of their geomorphologically active sector from a fixed fan apex. These analyses have been attributed to both allogenic and autogenic forcings.
- Autogenic dynamics on debris-flow fans have neither been modelled nor experimentally simulated, in contrast to fluvial fans. Furthermore field studies at relevant spatiotemporal scales are hardly available.

Objectives

- We aim to:
  - Study the autogenic dynamics of debris-flow fans under constant allogenic forcings.
  - Provide insight in the processes that govern the autogenic dynamics of debris-flow fans.
  - Compare the dynamics of debris-flow fans to those on other fan types.

Approach

- We experimentally created a debris-flow fan by consecutive stacking of debris flows under constant extrinsic forcings (i.e., constant topography, debris-flow magnitude, composition and morphology).
- See EGU2015-3370 by De Haas et al. for further details on the experimental debris-flows.

Experimental setup

- Stacking of 55 debris flows.

Fan morphology

- Distinct depositional lobe's, up to a few centimeters in thickness.

Fan cross-section

- The experimental debris-flow fan formed by two autogenic cycles. These cycles involved a sequence of (1) backfilling, (2) avulsion and (3) channelization (Fig. 3, 4, 5).
- The autogenic cycles are symmetric, and debris-flow length and width are similar prior to backfilling and avulsion (Fig. 4).

Autogenic cycles

- The experimental debris-flow fan formed by two autogenic cycles. These cycles involved a sequence of (1) backfilling, (2) avulsion and (3) channelization (Fig. 3, 4, 5).
- The autogenic cycles are symmetric, and debris-flow length and width are similar prior to backfilling and avulsion (Fig. 4).

Driving mechanisms

- The autogenic dynamics are driven by two interconnected feedback mechanisms:
  - Feedbacks of fan morphology (Fig. 5).
  - Feedbacks of debris-flow flow-dynamics (Fig. 6).

Fan morphology

- Autogenic cycles of debris-flow fans and fluvial fans both involve cycles of channelization, backfilling and avulsion.
- Alluvial fans have been attributed to both autogenic and allogenic forcings. Furthermore field studies at relevant spatiotemporal scales are hardly available.

Discussion

- Comparison: The experimental autogenic cycle on the debris-flow fan has been compared to the autogenic cycle on the experimental alluvial fan. In detail, the autogenic cycle on the alluvial fan is initiated by the formation of a leveed channel.

Conclusions

- We experimentally created a debris-flow fan in the absence of extrinsic forcings.
- This debris-flow fan formed by autogenic cyclic avulsions.
- The autogenic cycles comprised backfilling, avulsion and channelization.
- The autogenic cycles were driven by interconnected feedbacks in morphology and flow-dynamics.
- Over large space-temporal scales, autogenic dynamics of debris-flow fans and fluvial fans are similar.
- Topographic compensation (i.e., compensational avulsions) appears to be an overarching mechanism in the formation of fans, regardless of their depositional process.