Mountain Glaciers – Indicators, Resources, Hazards

- Environmental challenges
- Remote sensing of parameters

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Mountain glaciers

- Climate change
  - indicators
  - local climate
  - worldwide shrinkage
  - sea level

- Humans
- Water
  - household, agriculture, industry
  - runoff seasonality
  - 2-phase response
  - snow / climate regime

- Hazards
  - lake outbursts
  - ice avalanches
  - rock avalanches
  - slope instabilities
  - combinations/chain reactions

- Energy
  - hydropower
Glacier lake outbursts

Tam Pokari, Nepal, 1998
Challenge: temporary lakes

Macugnaga, Italy, 2002
Remote sensing of parameters

**Weather / Climate**

- Changes in length and area
- Ice depth
- Thickness/volume change

**Energy- / mass-balance**

- Ice temperature

**Ice flow**

**Run-off**

- Changes in length and area

[Image of mountainous landscape with labeled parameters]
Remote sensing of parameters

Energy- / mass-balance
Ice temperature

- stakes/pits
- snow-line
- accumulation/ablation? (thermal RS, snow-fall, modelling)
Remote sensing of parameters
ALOS PALSAR HV-HH composite (HH: yellow, HV: blue)
Thermal infrared

L7 ETM TIR day time

ASTER TIR night time

Kääb (2005)
Remote sensing of parameters

- Thickness/volume change
- Ice depth

- Optical stereo (clouds, snow: band, gain settings, sensitivity)
- SRTM
- ICESat
- Diff. SAR interferometry
- Gravimetry
ASTER along-track stereo
Interpolated elevation differences 1970 – 2002

Kääb (2008) IEEE TGARS
ALOS PRISM triplet stereo
SRTM – national mapping agency DEM

Paul & Haeberli (2008) GRL

Kääb (2008) IEEE TGARS
Remote sensing of parameters

Ice flow

- optical image matching
- SAR speckle tracking
- SAR interferometry
- spatial res, temp res, geolocation prec&accur
Optical image matching

Bhutan  Glacier speed (m a⁻¹)
Jan 2001 – Nov 2001
Optical image matching

Bhutan
Glacier speed (m a\(^{-1}\))
Jan 2001 – Nov 2001

Kääb (2005) RSE
Glacier flow / speckle tracking

Radarsat data:

Kongsberg
SAR speckle tracking (TSX)
Remote sensing of parameters

- multispectral segmentation (snow cover, debris cover, flow divides)
- Landsat continuity!
- SAR, SAR interferometry

Changes in length and area
Automatic segmentation
Automatic segmentation
Automatic segmentation
SAR-based multitemporal glacier mapping
• Increasing need for global information about glacier changes with
  - higher spatial and temporal
  - resolution and coverage

• improve SAR-based detection of mass balance

• Lidar and interferometric altimetry

• sensitivity/gain settings of optical sensors

• “global SRTM” every 5-10 years

• increase spatio-temporal resolution/coverage for ice flow

• improve geolocation precision and accuracy

• improve methods for automatic glacier inventorying

• ensure Landsat7-type continuity (GLIMS, GlobGlacier)

• RS + modelling / assimilation