Dynamic response of glaciers on the Tibetan Plateau to climate change
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Glaciological field studies at Zhadang Glacier, Tibetan Plateau

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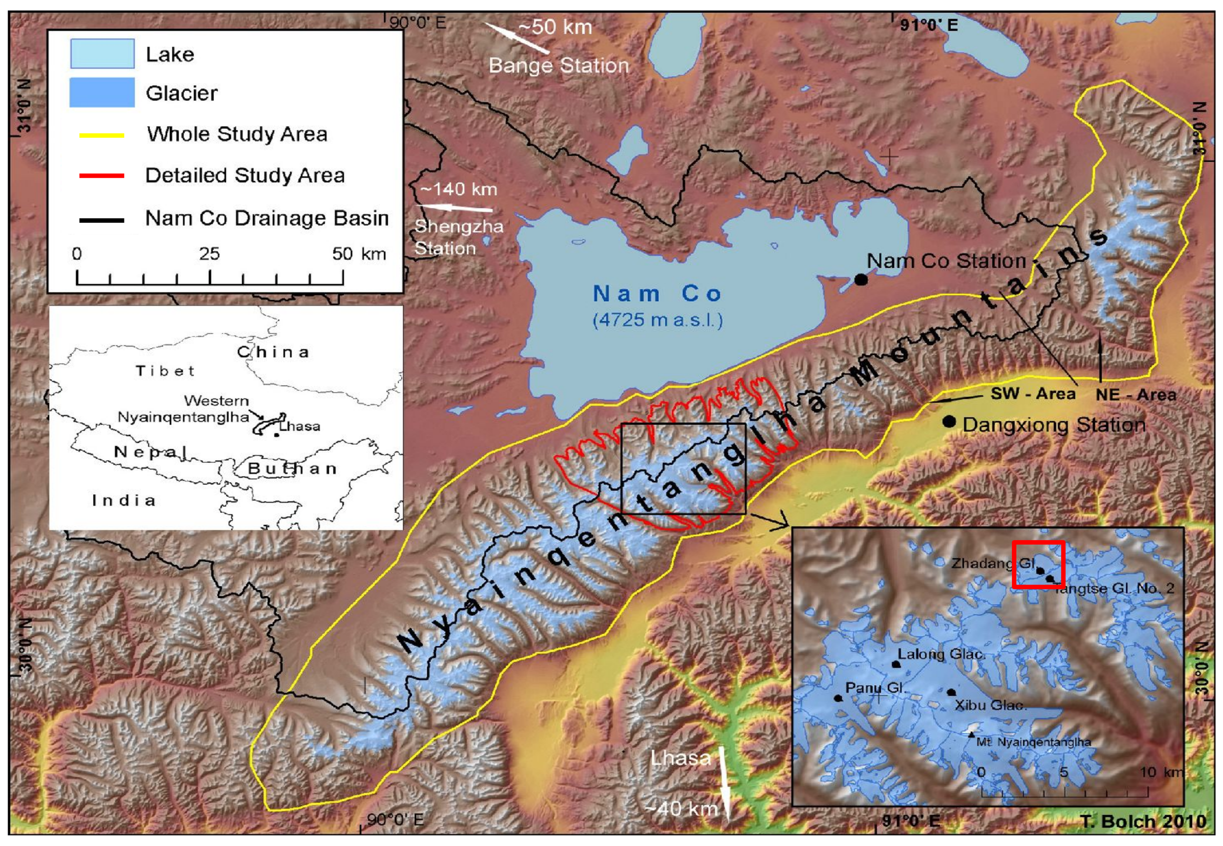
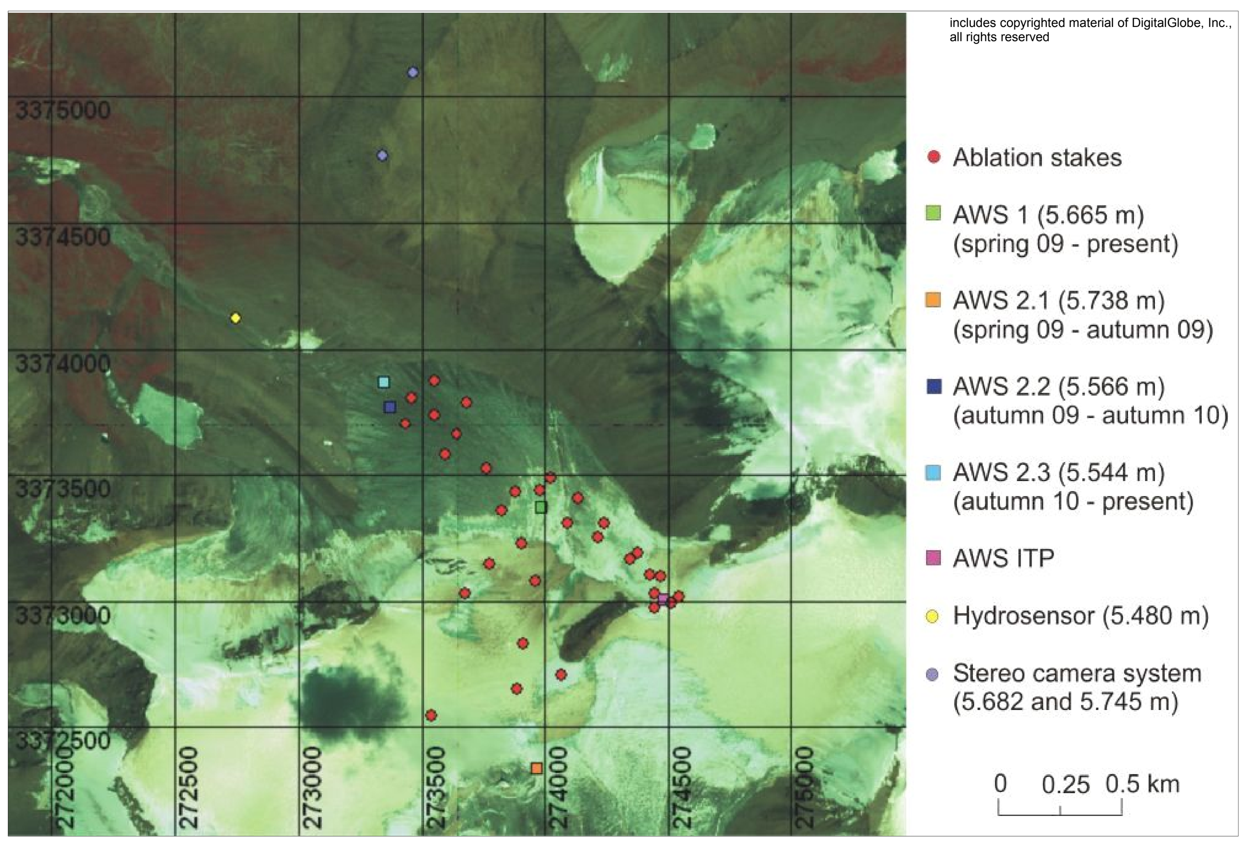
1 Study area and overview



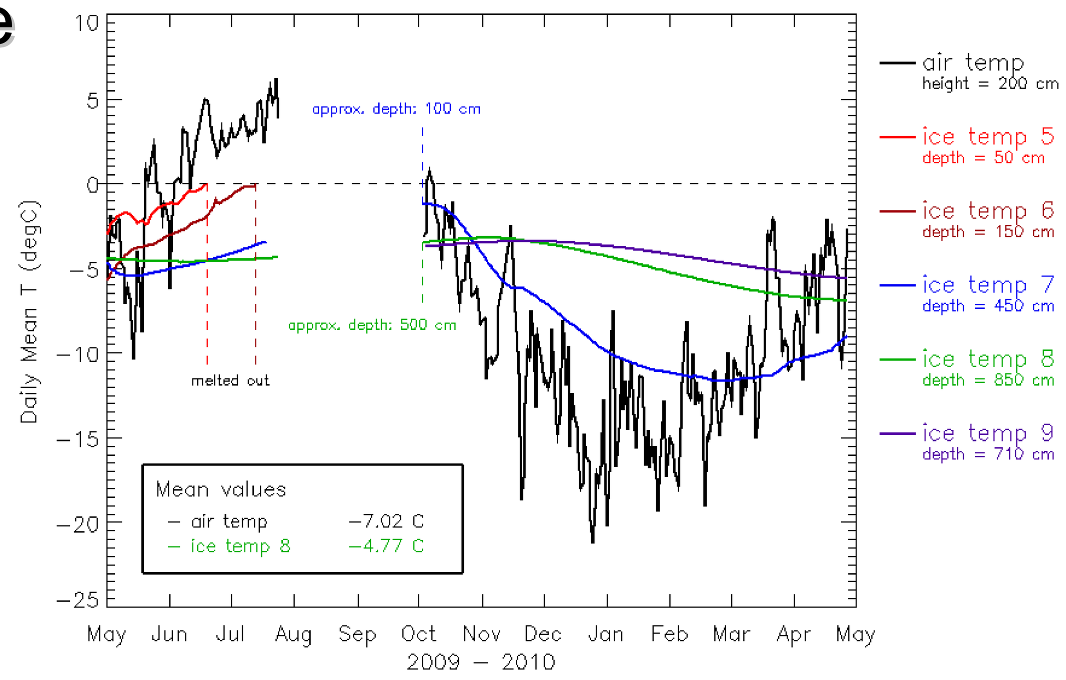


AWS1

Table	Measured	Unit	Instrument	Measurement Freq	Storage	Storage Freq
Control	Bat 12V	V	CR1000	10 Min	Sample	10 Min
	Solar Panels	V	Panels			
	Case Temp	°C	CR1000			
Meteo	Temp/Hum Top	°C-%	CS215 Cambell	10 Min	Sample	
	Temp/Hum Bottom	°C-%	CS215 Cambell			
	Pressure	hPa	AirPre			
	Net Radiation	W/m²	NR-Lite			
	Incoming Short Wave	W/m²	CS300 Campbell			
	Outgoing Short Wave	W/m²	CS300 Campbell			
	Outgoing Long Wave	°C	Apogee IRTS			
	Soil Hum 1-2	m³/m³	CS616 Campbell			
	Soil Temp 1-8	°C	107TP Campbell			
	Sonic Range	m	SR50			
Wind	Wind Vector Speed	m/s	Young	-	Average	
	Wind Vector Dir	Deg	Young	10 Sec		
	Wind Vector Dir Std Dev	Deg	Young			
Fluxes	Sonic Wind Speed uvw	m/s	Gill Sonic	05 Hz (200 mSec)	Average, Covariance	
	Sonic Temp	°C	Gill Sonic			
	Covariance					
	Wind Vector Speed	m/s	Gill Sonic			
	Wind Vector Dir	Deg	Gill Sonic			
	Wind Vector Dir Std Dev	Deg	Gill Sonic			

Fig 1: Left: location of the study area; middle: locations of AWS, ablation stakes, hydrosensor and camera system at Zhadang Glacier during DynRG-TiP Phase I and II; right: climate variables measured at AWS 1

2 Measurements on snow and ice



- Vertical profiles of ice temperatures prove that Zhadang Glacier has cold ice throughout the year.
- Annual mean ice temperatures in the upper ice layers are several Kelvin higher than the annual air temperature (Fig. 2 middle).

  → latent heat release by refreezing melt water
- Records of SR50 show annual ablation rates of more than 2.5 m (ice loss approx. 2 m) during the short summer season (Fig. 2 right). Accumulation of approx. 40 cm in winter 2009/10 cannot compensate for ablation.

  → negative annual mass balances are expected in the future

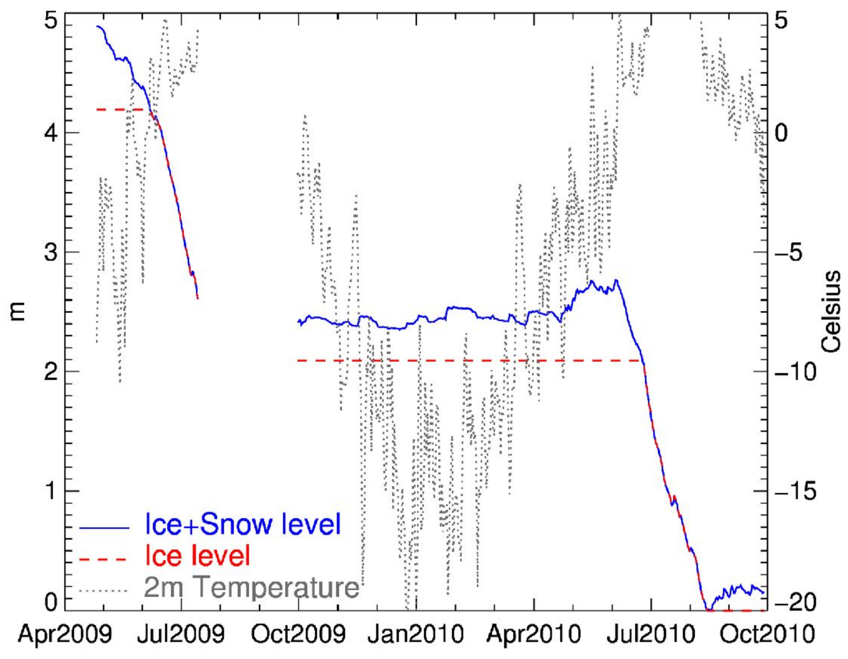
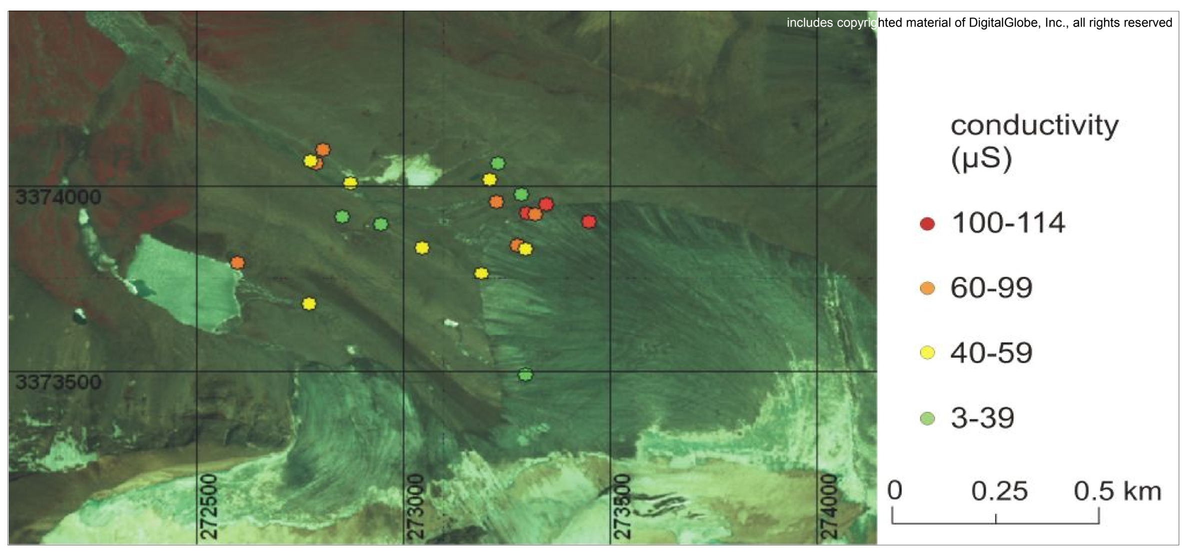


Fig 2: Left: AWS 1 with SR50 on Zhadang Glacier in May 2010; middle: air and ice temperatures measured at AWS 1 over one year; right: daily means of snow accumulation and ablation at AWS 1 in 2009 and 2010 from an ultra-sonic depth sensor (Campbell SR50)

3 Electrical conductivity measurements



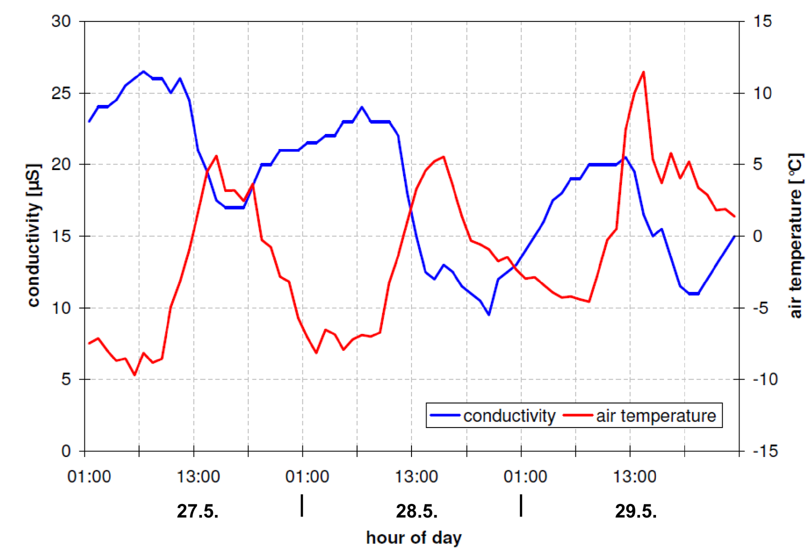
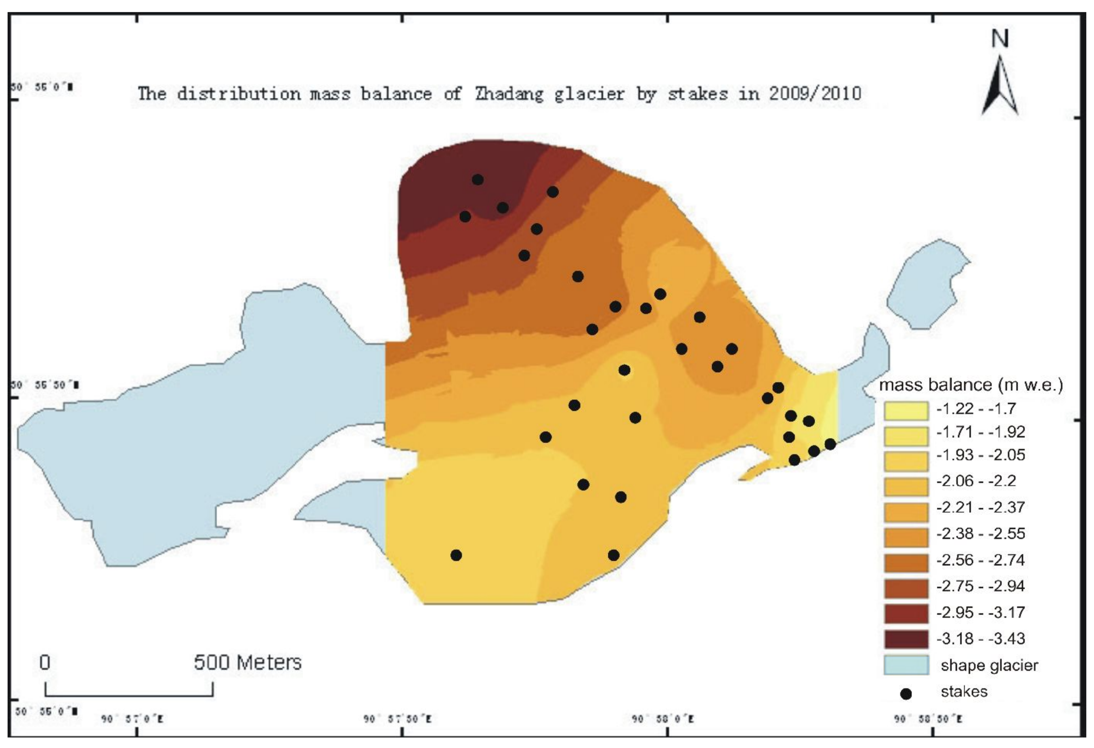


Fig 3: Electrical conductivity measurements in May and September 2010 in the forefield of Zhadang Glacier; middle: manual measurements show a pattern of higher conductivity north of the glacier tongue, where permafrost melt water from the south exposed slopes joins with glacial melt water; right: diurnal cycles of conductivity recorded by the automatic hydrological sensor (see Fig. 1 middle) and air temperature at AWS 1. Lower air temperature leads to less glacier runoff and therefore higher conductivity.

4 Mass balance measurements



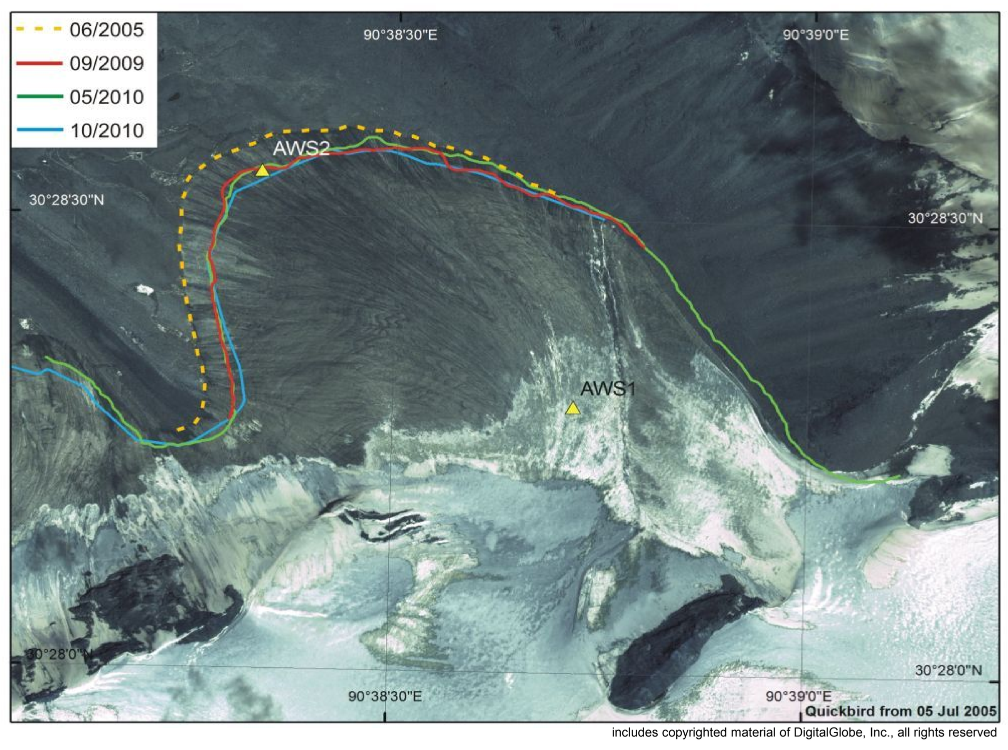


Fig 4: Left: mass balance measurements on Zhadang Glacier; middle: spatial interpolation (depending on altitude) of measured mass balance for 2009/2010, the melt rate pattern follows the temperature gradient with higher melt rates in the lower areas of the glacier tongue; right: GPS tracks along the glacier outline in 2009 and 2010, the glacier retreated by approx. 100 m from 2005 (Quickbird image) to 2010

5 Terrestrial high-resolution remote sensing

Fig 5: Two images of the camera time series of summer 2010; left: 22.5.2010 (GCP positions are marked by red triangles); right: 13.8.2010

- An automatic stereo camera system was installed nearby Zhadang Glacier at 5600 m a.s.l. to investigate glacier surface and volume changes (Fig. 6).
- The system, mounted on a tripod, consists of a Canon EOS 50D, a timer remote control and a 12 V battery, charged by a solar panel.
- Data is stored and collected during each field campaign.
- Three pictures are taken per day (8:00 am, 4:00 pm and 0:00 Beijing time).
- In order to measure glacier tongue variations (Fig. 4 right) the pictures will be orthorectified by GCPs measured in May 2010 (Fig. 5).
- Highly valuable documentation allowing detailed validation of the mass balance model (see poster Huintjes et al. „Mass balance modelling").

Fig 6: Camera system installed on the lateral moraine of Zhadang Glacier

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