DATA REPOSITORY 2014355

Climatic limits to headwall retreat in the Khumbu Himalaya, Eastern Nepal'

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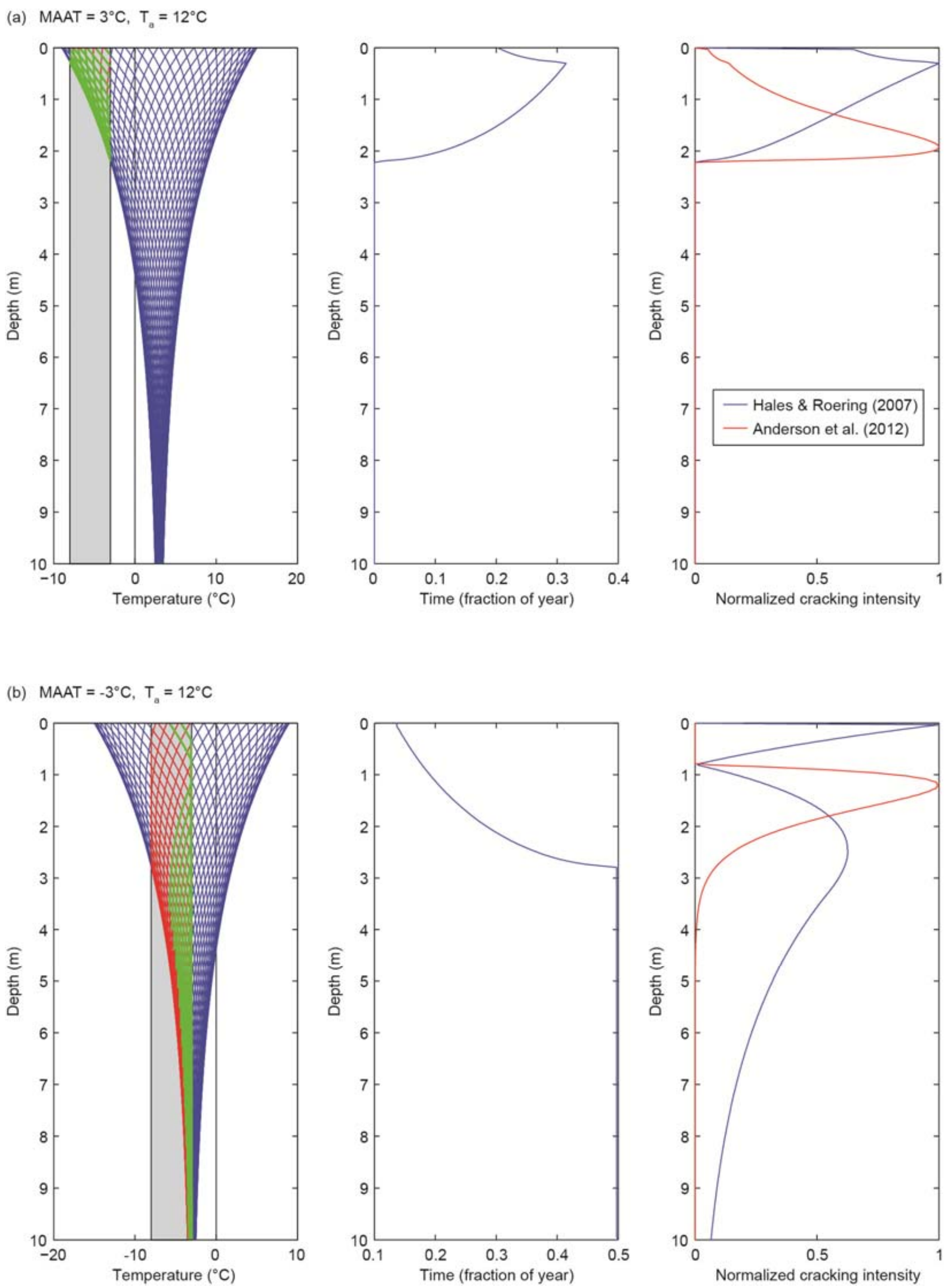

Figure DR1: 1-D thermal diffusion and frost cracking model for a mean annual air temperature (MAAT) of 3°C (a) and -3°C (b). Both models are based on annual temperature amplitudes (T_a) of 12°C, but no diurnal temperature amplitudes to maintain readability, and a thermal diffusivity of the bedrock of 1 $mm^2 s^{-1}$. Left columns show distribution of temperature along depth in the bedrock for each week during a full year. Temperature profiles are colored red where temperatures are within the frost-cracking window, between -8 and -3°C, and colored green if additionally there exists a positive temperature gradient that connects a given point on the profile to a source of liquid water ($T > 0$°C). I assume that the water supply is not limited and derived from thawing permafrost at depth and from snowmelt at the surface. Middle columns shows fraction of the year spent in the frost-cracking window. Right columns show normalized frost-cracking intensity (FCI), based on model of Hales and Roering (2007) and Anderson et al. (2012). The results shown in this figure reproduce Fig. 6 in Anderson et al. (2012).

Table DR1: Automatic weather station data summary.

Station name	**Elevation**	**Latitude**	**Longitude**	**Time period**	**Measurement interval**	**Data gaps**	**MAAT**	T_a	T_d ***(observed)***	T_d ***(from fit)****
	(m)	**(°N)**	**(°E)**	**(m/d/y)**		**(%)**	**(°C)**	**(K)**	**(K)**	**(K)**
Lukla	2660	27.696	86.723	11/2/2002 – 12/31/2009	1 hr	16.8	10.1	11.8	9.2	6.7
Namche	3560	27.802	86.715	10/1/2002 – 12/31/2009	1 hr	11.4	5.8	11.7	7.8	5.3
Syangboche	3833	27.810	86.720	10/1/2002 – 3/29/2005	20 min	4.2	3.1	12.6	7.5	4.5
Pheriche	4258	27.895	86.819	10/1/2002 – 12/31/2009	1 hr	8.8	1.1	14.5	10.9	8.3
Pyramid	5035	27.959	86.813	10/1/2002 – 12/31/2009	1 hr	4.7	-2.3	11.3	7.4	5.5
Kala Patthar	5585	27.995	86.829	1/1/2011 – 12/31/2011	1 day	0	-5.4	11.1	-	-
South Col	7986	27.967	86.933	5/15/2008 – 12/31/2008 6/1/2011 – 9/17/2011	1 day	0	-20.9	17.6	7.6[#]	-

* Values obtained from fitting Eq. 1 to the observations.

[#] Value represents average T_d from the months of May, July, October; after Moore et al. (2012).

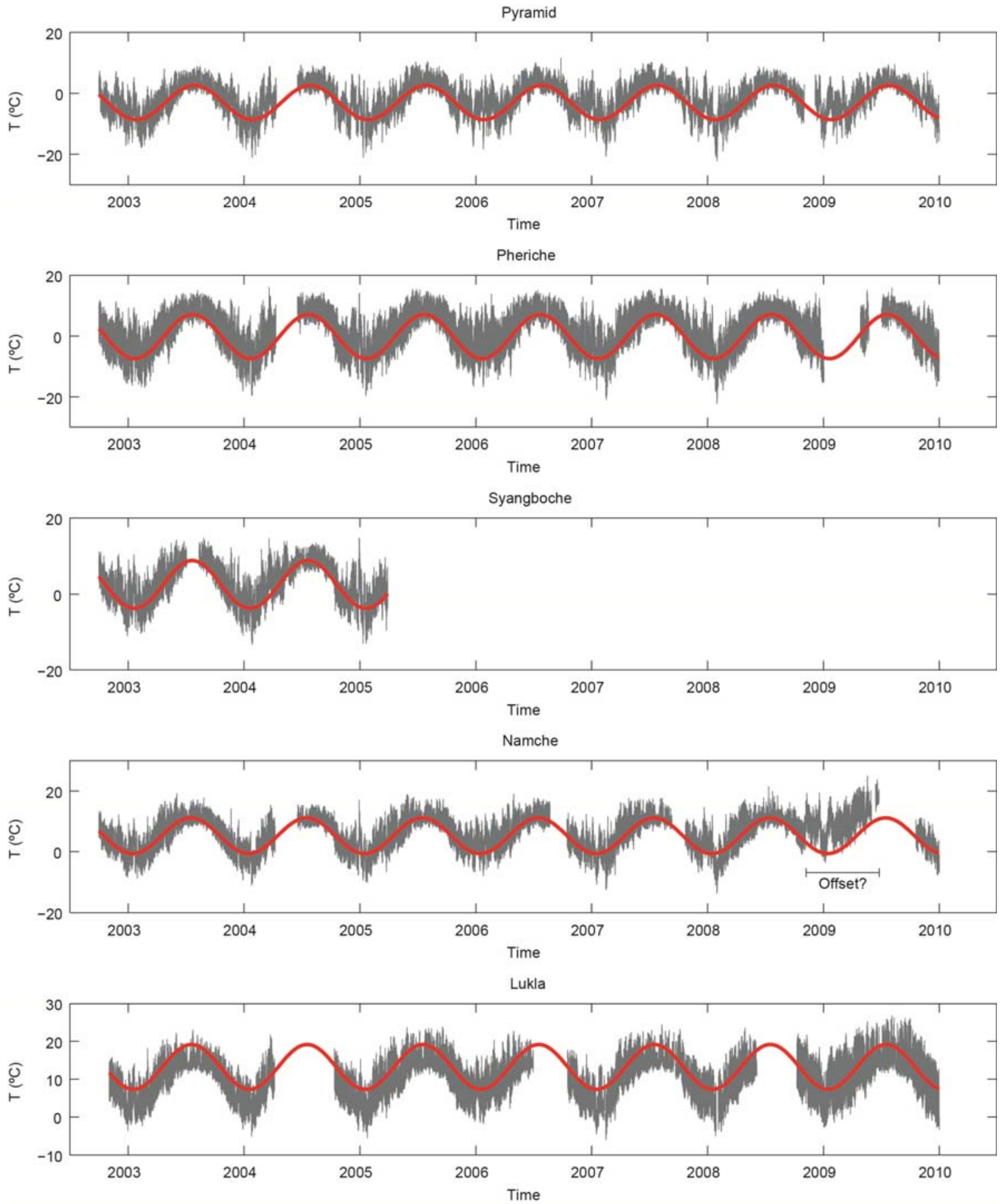

Figure DR2: 2 m air temperatures at five automatic weather stations in the Khumbu Himalaya. The gray lines represent the observations. The red lines depict the mean annual air temperatures (MAAT) and the annual temperature variations (T_a), as obtained from fitting Eq. 1 of the main text, to the observations. Despite some periods with longer lasting deviations from the modeled trend, all stations exhibit a clear sinusoidal temperature cycle. The diurnal temperature variations (T_d) in the fitted lines were omitted for clarity.

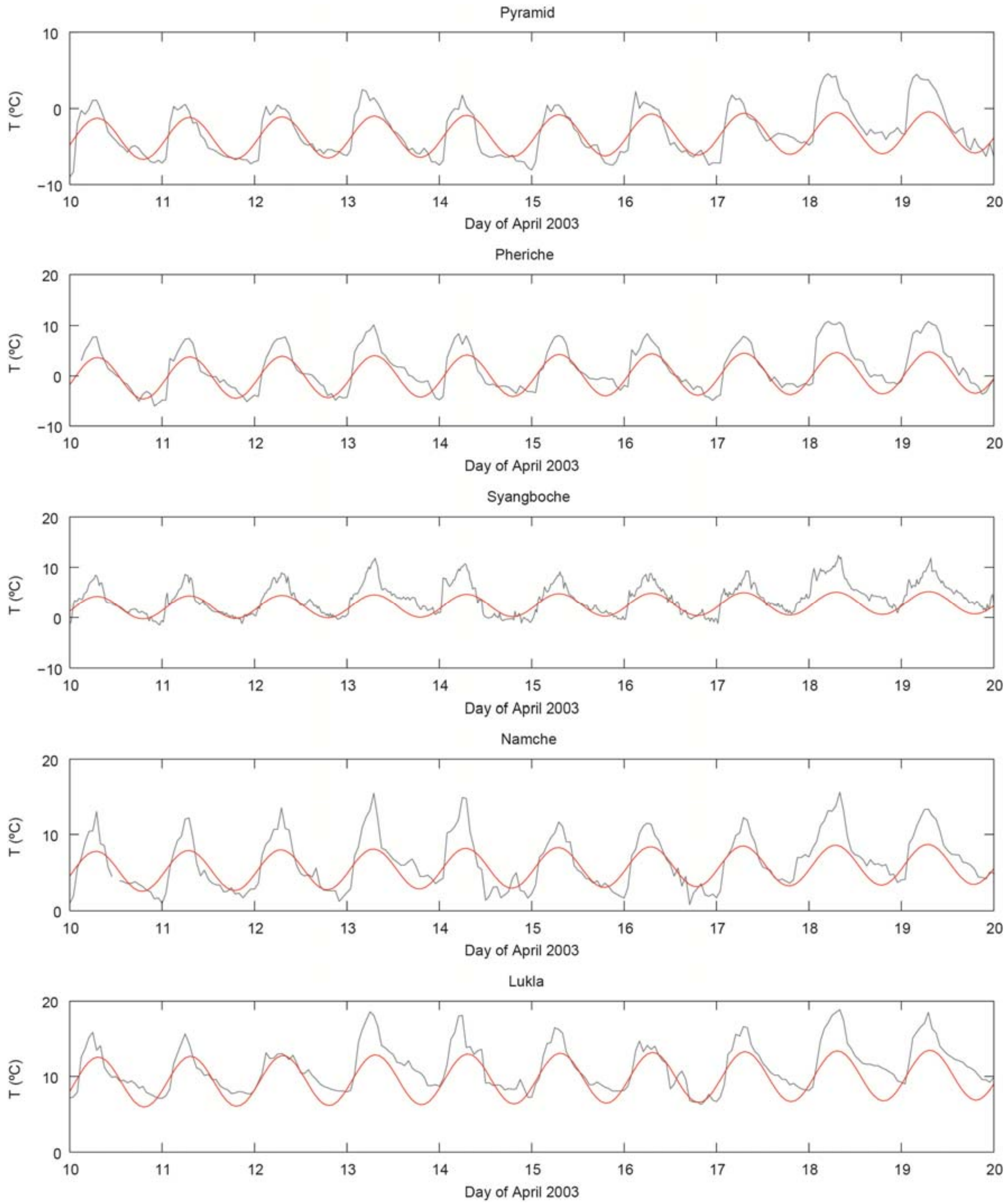

Figure DR3: Observed (gray) versus modeled (red) 2 m air temperatures at five automatic weather stations in the Khumbu Himalaya between 04/10/13 and 04/20/13. Sampling interval is at least hourly and every 20 minutes for the station in Syangboche. Note that the best-fit sinusoidal temperature model yields a lower diurnal temperature variation (T_d) than observed.

Supplementary References

Anderson, R.S., Anderson, S.P., Tucker, G.E., 2012, Rock damage and regolith transport by frost: an example of climate modulation of the geomorphology of the critical zone: Earth Surface Processes and Landforms, v. 38, p. 299-316, doi:10.1002/esp.3330.

Hales, T.C., and Roering, J.J., 2007, Climatic controls on frost cracking and implications for the evolution of bedrock landscapes: Journal of Geophysical Research, v. 112, F02033, doi:10.1029/2006JF000616.

Moore, K., Semple, J., Cristofanelli, P., Bonasoni, P., Stocchi, P., 2012, Environmental conditions at the South Col of Mount Everest and their impact on hypoxia and hypothermia experienced by mountaineers: Extreme Physiology & Medicine, v. 1, doi:10.1186/2046-7648-1-2.