VARIATIONS OF THE LEWIS AND GREGORY GLACIERS, MOUNT KENYA, 1978-86-90

With 2 figures, 2 tables and 1 supplement (XII)

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1 Introduction

The glaciers of Mount Kenya are the object of a long-term observation program motivated by problems of climate-cryosphere interaction and climatic change (HASTENRATH 1984), and are in support of international efforts at monitoring glacier fluctuations (Permanent Service on the Fluctuations of Glaciers, IUGG-FAGS/ICSU 1977, 1985). Regular assessments of changing ice extent and volume are an important part of this endeavor. A map of all glaciers of Mount Kenya has recently appeared (HASTENRATH et al. 1989), at scale 1:5,000 and with date of 3 September 1987. For the largest ice body, the Lewis Glacier, in particular, maps have been produced since 1974 at four-year intervals, and have been published in this journal at the original scale of 1:2,500 (CAUKWELL a. HASTENRATH 1977, 1982; HASTENRATH a. CAUKWELL 1979, 1989), so as to ensure a readily accessible historical documentation for glaciological purposes. The present communication is the fifth in this series. The Lewis connects with the Gregory Glacier over a gentle col. Thanks to a recently surveyed additional ground control point, it became possible to include the Gregory Glacier in the mapping, and to assess the area and volume changes since 1978.

2 The mappings

Surveys were flown by the Kenya Air Force on 13 February 1978, at a flight level of 18,400 feet; by Geosurveys, Ltd., Nairobi, on 13 March 1986, at approximately 22,000 feet; and by Photomap International (Kenya), Nairobi, on 1 March 1990, likewise at 22,000 feet. Stereo-plotting was performed at the University of Nairobi by the same photogrammetrist, on the Thompson-Watts First Order Plotter for the Lewis in 1978, and on the Wild A8 First Order Plotter for the Gregory in 1978, and the Lewis-Gregory Glaciers in 1986 and 1990. The 1990 map was compiled from two frames (6923 and 6925).

The mappings of the Lewis Glacier for 1974, 1978, 1982, and 1986 (CAUKWELL, a. HASTENRATH 1977, 1982; HASTENRATH, a. CAUKWELL 1979, 1987) had been based on a network of ground control points established by the 1GY Mount Kenya Expedition (Table 1; CHARNLEY 1959). Although these aerial photographs also covered the Gregory Glacier, it could not be mapped for lack of a suitable ground control point below the glacier. However, a mark established previously just below the Gregory Glacier for purposes of tape measurements of terminus variations, was surveyed on 30 December 1986 (Table 1; HASTENRATH et al. 1989). This was used for the present 1990 mapping of the Lewis-Gregory Glaciers. Moreover, using this additional Gregory control point, it proved possible to map the topography and extent of the Gregory Glacier from the 1978 and 1986 photographs, but not from the 1974 and 1982 flights.

On 1 March 1990 the Lewis and Gregory Glaciers were covered by fresh snow, which obliterated many of the smaller crevasses, although the photo quality was overall adequate for mapping purposes.

Table 1: Control points used in mapping. South-North (+ Y), West-East (+ X) coordinates, and elevation (h) in m

	+Y	+X	h
L 2	1,450.4	3,210.6	4,797.2
L 3	1,791.8	2,884.0	4,792.7
Lenana	1,847.9	3,622.1	4,985.0
Melhuish	1,630.6	2,742.2	4,876.5
S 3	1,206.3	2,745.5	4,600.6
Thomson	2,031.0	3,159.7	4,955.1
Gregory	2,261.3	3,303.1	4,693.5

3 Changes in ice thickness

The enclosed map at scale 1:2,500 for 1 March 1990 extends the historical documentation on variations in glacier surface topography established by our maps of the Lewis Glacier for February 1974, February 1978, March 1982, and March 1986. In addition, the topographies of the Gregory Glacier have now been reconstructed for the 1978 and 1986 epochs. On this basis, the changes in ice thickness from February 1978 to March 1986, and from March 1986 to March 1990 have been evaluated at scale

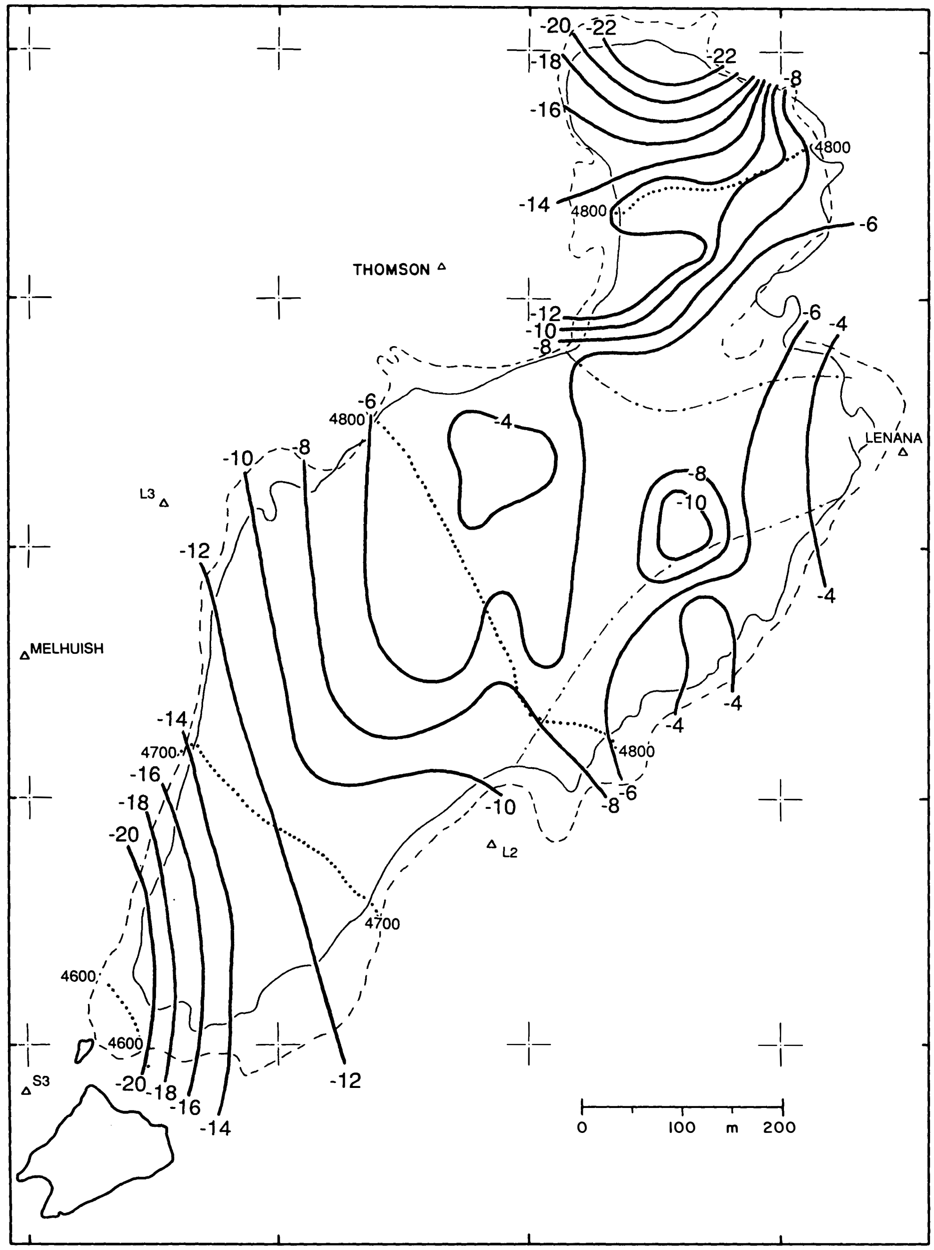

Fig. 1: Changes in ice thickness, March 1986 minus February 1978, in m. Ice rim in 1986 is shown as solid, and in 1978 as broken line. Dash-dotted lines indicate ice-flow divides to the eastern part of Lewis Glacier and to Gregory Glacier in the North, respectively. 1986 height contours are entered as dotted lines. Scale 1:7,500

1:2,500. The resulting maps of ice thickness change are reproduced in Figs. 1 and 2 at a scale of 1:7,500.

Fig. 1 depicting the differences in ice thickness March 1986 minus February 1978 shows losses for all areas of the Lewis and Gregory Glaciers, with largest differentials in their lower portions. Decreases in area are also apparent. Fig. 2 exhibiting the topography change from March 1986 to March 1990 shows further substantial thickness and area decreases for both glaciers. However, a thickness increase is indicated in a limited domain of the Lewis Glacier. This extends in a band just below a relatively steep portion of the

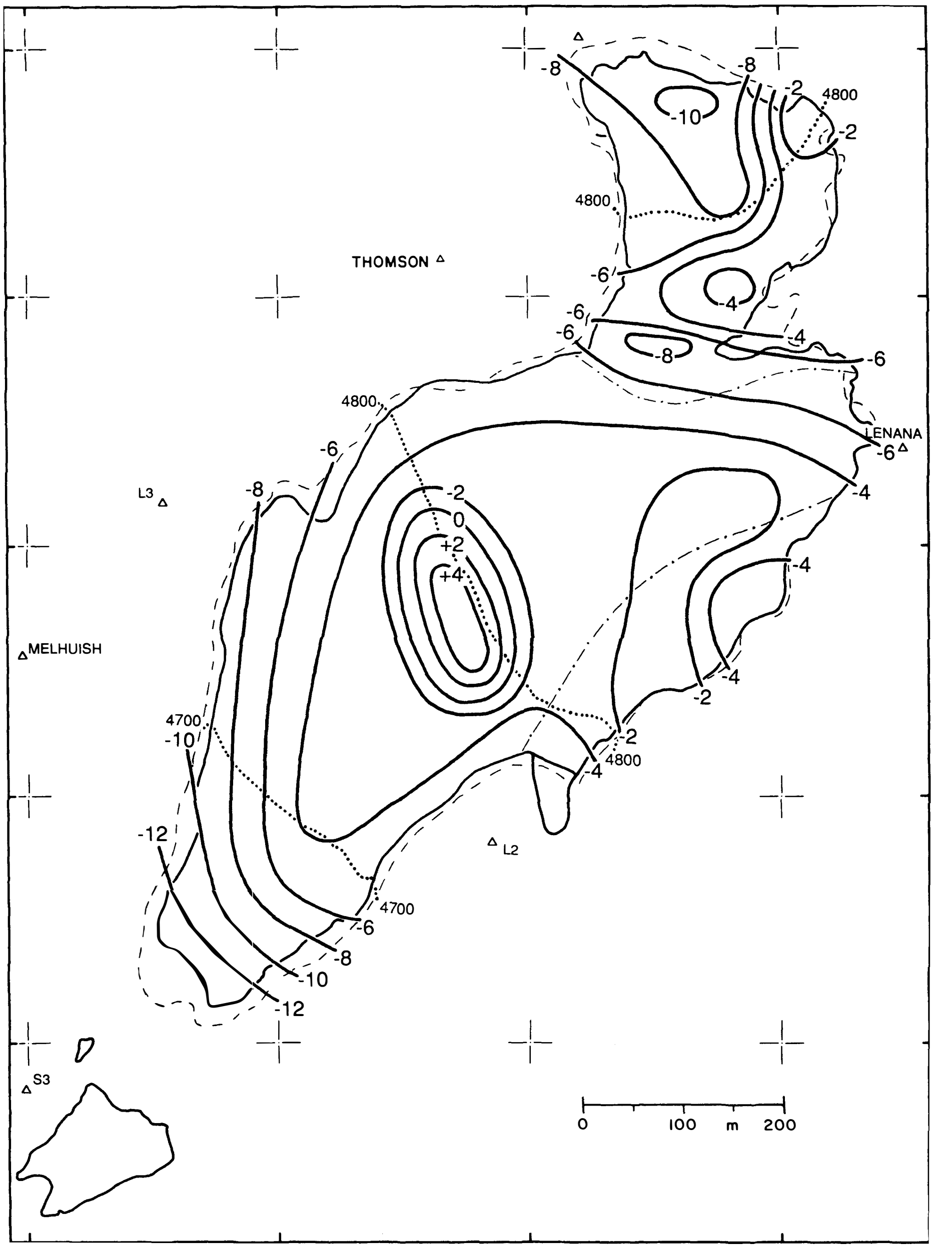

Fig. 2: Changes in ice thickness, March 1990 minus March 1986, in m. Ice rim in 1990 is shown as solid, and in 1986 as broken line. Dash-dotted lines indicate ice-flow divides to the eastern part of Lewis Glacier and to Gregory Glacier in the North, respectively. 1990 height contours are entered as dotted lines. Scale 1:7,500

glacier, suggesting a topographic effect on flow and surface change, although spurious effects due to the March 1990 snow cover cannot be excluded.

Quantitative evaluations of conditions of the 1978, 1986, and 1990 mapping epochs and of the changes over the 1978-86 and 1986-90 intervals are summarized in Table 2. This indicates the continued ice wastage on both glaciers. Thus, over the past twelve years, the Lewis Glacier has receded by 80 m and has lost nearly a fourth of its area and half of its volume. Over the same time span, the Gregory Glacier became 50 m shorter and lost a fourth of its area.

Table 2: The Lewis and Gregory Glaciers during 1978–86–90.
(a) Conditions in 1978, 1986, and 1990: area A; average ice thickness h, volume V, length L, terminus elevation E; (b) Changes Δ over the 1978–86 and 1986–90 intervals

	LEWIS 1978	LEWIS 1986	LEWIS 1990	GREGORY 1978	GREGORY 1986	GREGORY 1990
(a) Conditions at 1978, 86, and 90 epochs						
A[10³m]	295	247	231	80	70	61
h[m]	21.0	15.0	13.7	-	-	-
V[10³m]	6,200	3,940	3,170	-	-	-
L[m]	1,020	988	940	415	390	365
E[m]	4,610	4,612	4,620	4,688	4,624	4,708

(b) Changes over intervals 1978-86 and 1986-90

	LEWIS 1978–86	LEWIS 1986–90	GREGORY 1978–86	GREGORY 1986–90
ΔA[10³m]	-48	-16	-10	-9
Δh[m]	-8.2	-3.1	-10.1	-5.3
ΔV[10³m]	-2,260	-770	-811	-367
ΔL[m]	-32	-48	-25	-25
ΔE[m]	+ 2	+ 8	+ 64	+ 84

4 Crevasse pattern

As in the various earlier mappings (Caukwell a. Hastenrath 1977, 1982; Hastenrath a. Caukwell 1979, 1987), a zone of crevasses stands out in the upper glacier, extending from Point Thomson towards the rock ridge West of Curling Pond, presumably favored by the subglacial rock topography. The Southwest to Northeast oriented ice cliff in the upper glacier is found in a similar position in both mappings. Overall, the 1990 locations could be determined only for some of the crevasses, because of fresh snow cover.

5 Concluding remarks

It is interesting to compare the shrinkage rates in Table 2 with those documented (Hastenrath 1984, p. 170–171) for the Lewis Glacier over the first eight decades of the century. Note that the reconstructions for the Gregory are more limited. These rates are 7.2 ma^{-1}, 4.4 $m^2\ a^{-1}$, and $4.2 \times 10^4\ m^3\ a^{-1}$, for length, area, and volume, respectively, as compared to 6.7 $m^2\ a^{-1}$, 5.3 $m^2\ a^{-1}$, and $2.5 \times 10^4\ m^3\ a^{-1}$, over the most recent twelve years. That is, the ice shrinkage has in recent years been progressing at a rate similar to that reconstructed for the earlier part of the century. Relationships of climatic forcing and Lewis Glacier response, as deduced from numerical modelling and historical evidence is reviewed in Hastenrath (1984, p. 280–284). On these grounds, it was concluded that a drastic decrease of precipitation and cloudiness in East Africa over the last two decades of the 19th century caused the onset of glacier retreat. This adjustment to the altered climatic environment would have been completed by the 1920's, but by that time a warming trend was underway, which accounted for the recession continuing into the second half of the 20th century. A subject of concern for the most recent decades is the issue of possible effects of increasing atmospheric carbon dioxide content on longwave radiation and temperature. In this regard, tropical glaciers are of interest as particularly sensitive indications of changing climatic forcings.

It is in this regard that the continued monitoring of Lewis Glacier deserves attention in a more than regional context. The evidence presented here bears out a drastic ice wastage of the Lewis and Gregory Glaciers since 1978, and this continued over the most recent four-year interval. Based on net balance and ice flow measurements and repeated mappings from 1974 to 1986, predictions were made of the future behavior of Lewis Glacier (Hastenrath 1989). With reference to the new map of March 1990 presented here, and using the glaciological observations since 1986, these predictions shall be evaluated in relation to altered net balance conditions or climatic change. In continuation of this long-term observation effort, the next airborne mapping of the Lewis and Gregory Glacier appears desirable in 1994. However, at the time of this writing the future funding of glacier research on Mount Kenya remains uncertain.

Acknowledgements

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BUCHBESPRECHUNGEN

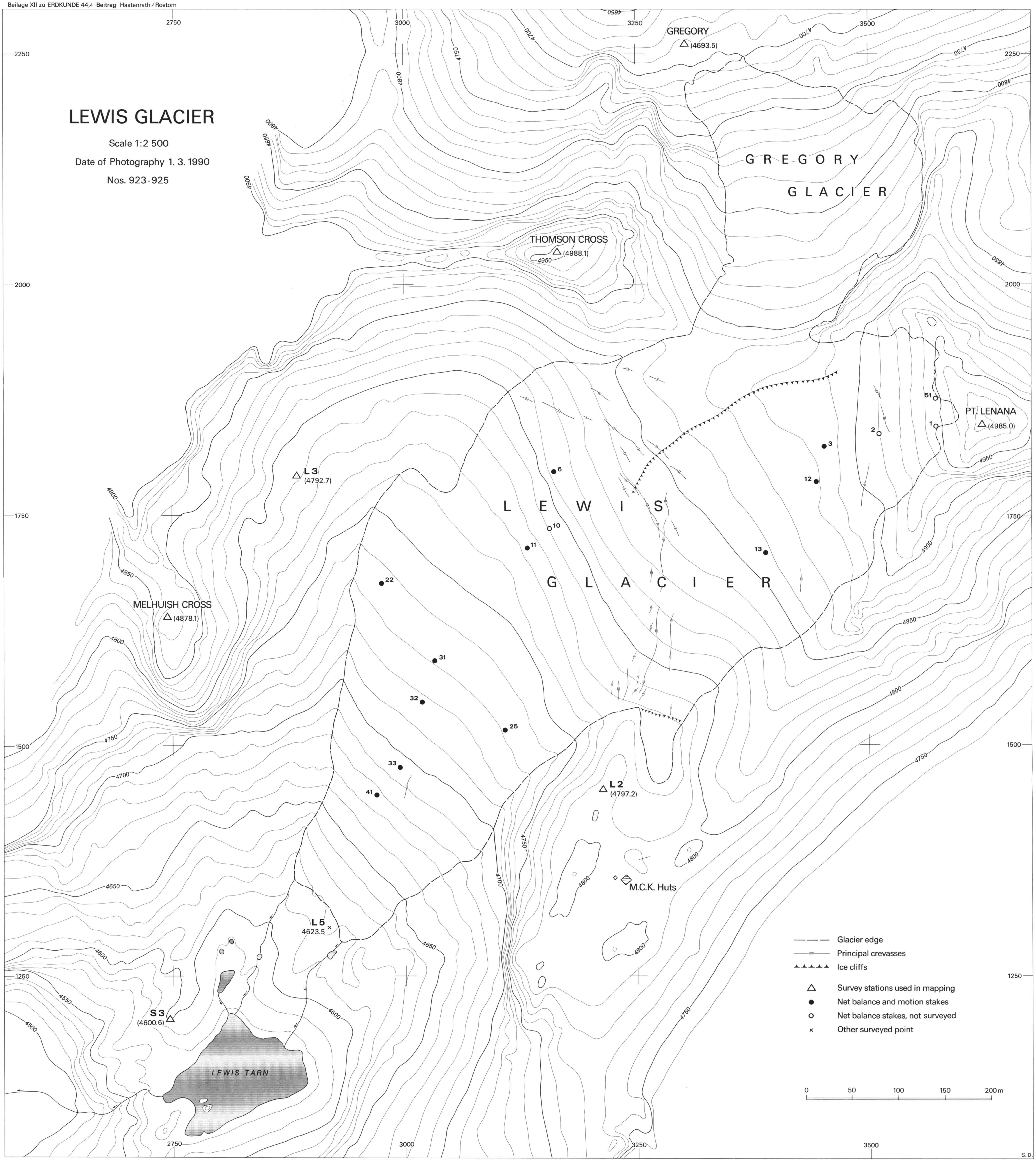
BÄHR, JÜRGEN; CORVES, CHRISTOPH und NOODT, WOLFRAM (Hrsg.): Die Bedrohung tropischer Wälder: Ursachen, Auswirkungen, Schutzkonzepte. IV u. 149 S., 27 Abb. und 9 Tab. Kieler Geographische Schriften, Band 73. Selbstverlag des Geographischen Instituts der Universität, Kiel 1989, DM 25,90

Der Band enthält neun (z. T. überarbeitete) Vorträge einer interdisziplinären Ringvorlesung. Zwei Autoren (J. H. REICHHOF und J. ESSER) stellen die Charakteristika des Ökosystems Regenwald unter biologischen Gesichtspunkten dar und leiten aus der Einmaligkeit die Schutzwürdigkeit ab. Vier Beiträge behandeln die Ursachen und die aktuelle Situation der Waldvernichtung am Beispiel Costa Ricas (L. ELLENBERG) und Brasiliens (G. KOHLHEPP) und diskutieren speziell den Einfluß des Tropenholzhandels (E. F. BRUENIG) bzw. die Rolle der politischen und ökonomischen Strukturen (M. NITSCH). H. GRASSL analysiert die derzeit möglichen Antworten seitens der Meteorologie zum Problem, ob die großflächige Vernichtung tropischer Wälder globale Klimaänderungen provozieren kann. Zwei Beiträge behandeln die Alternativen zur Waldbeseitigung auf der Basis internationaler Zusammenarbeit (U. VOLLMER) bzw. durch die Entwicklung biomasseschonender standortgerechter Landnutzungssysteme (K. EGGER). EGGER befaßt sich auch mit den Gründen, weshalb die Erfolge in ihrer Flächenausdehnung noch verschwindend gering und ökologisch noch nicht wirksam sind. Im ganzen eine sehr informative und studierenswerte, auch preiswerte Veröffentlichung.

WOLFGANG WEISCHET

HAFFNER, WILLIBALD und MÜLLER-BÖKER, ULRIKE (Hrsg.): Forschungsansätze und Forschungsergebnisse aus Agrarökologie, Geographie und Völkerkunde. 203 S., zahlr. Abb., Tab. und Photos, 1 Karte. Gießener Beiträge zur Entwicklungsforschung, Reihe I (Symposien), Band 16. Tropeninstitut, Gießen 1988, DM 35,-

Der Titel des Bandes bezeichnet das Rahmenthema des Tropentages 1988, dessen Ziel es war, „über spezielle Fragen hinaus, möglichst interdisziplinär, den Stellenwert und die Problematik der Feldforschung näher zu untersuchen", wie W. HAFFNER im Vorwort schreibt. In seinem Beitrag zur Problematik der Feldforschung meint HAFFNER, daß die Referenten des Tropentages zwei Lagern zugeordnet werden könnten. Die mit naturwissenschaftlichen Methoden arbeitenden Referenten würden ihre theoretischen Standpunkte wenig in Frage stellen. Zu ihnen gehören H. BESLER (Feldforschungen in Dünenwüsten und im tropischen Regenwald), TH. DUVE (Räumliche Differenzierung von Pflanzenkrankheiten), W. LAUER (Geoökologische Grundlagen traditioneller Agrarsysteme, Kallawaya, Bolivien), M. MEURER (Weideökologische Untersuchungen in


LEWIS GLACIER
Scale 1:2 500
Date of Photography 1. 3. 1990
Nos. 923-925
GREGORY
(4693.5)
GREGORY
GLACIER
THOMSON CROSS
(4988.1)
PT. LENANA
(4985.0)
L 3
(4792.7)
L E W I S
G L A C I E R
MELHUISH CROSS
(4878.1)
L 2
(4797.2)
M.C.K. Huts
L 5
4623.5
S 3
(4600.6)
LEWIS TARN
Glacier edge
Principal crevasses
Ice cliffs
Survey stations used in mapping
Net balance and motion stakes
Net balance stakes, not surveyed
Other surveyed point
0
50
100
150
200 m
S. D.