

WHAT CAN THE MASS BALANCE OF LEWIS GLACIER TELL US ABOUT EAST AFRICAN AND TROPICAL CLIMATE DYNAMICS?

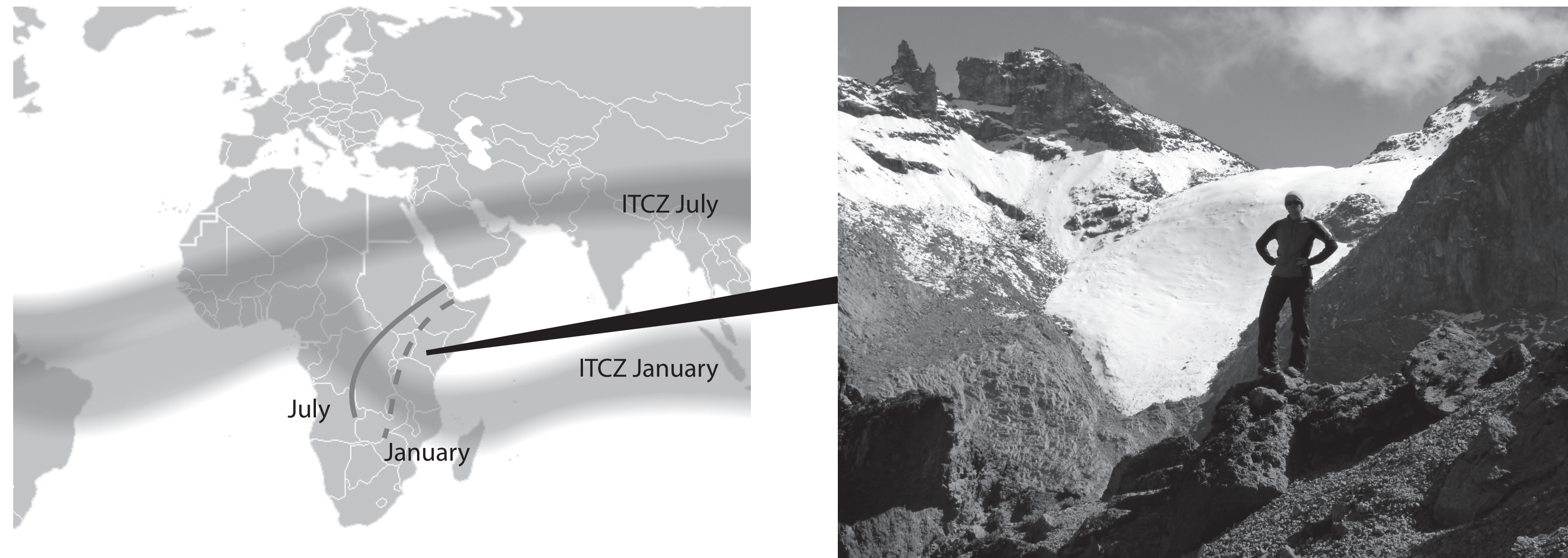
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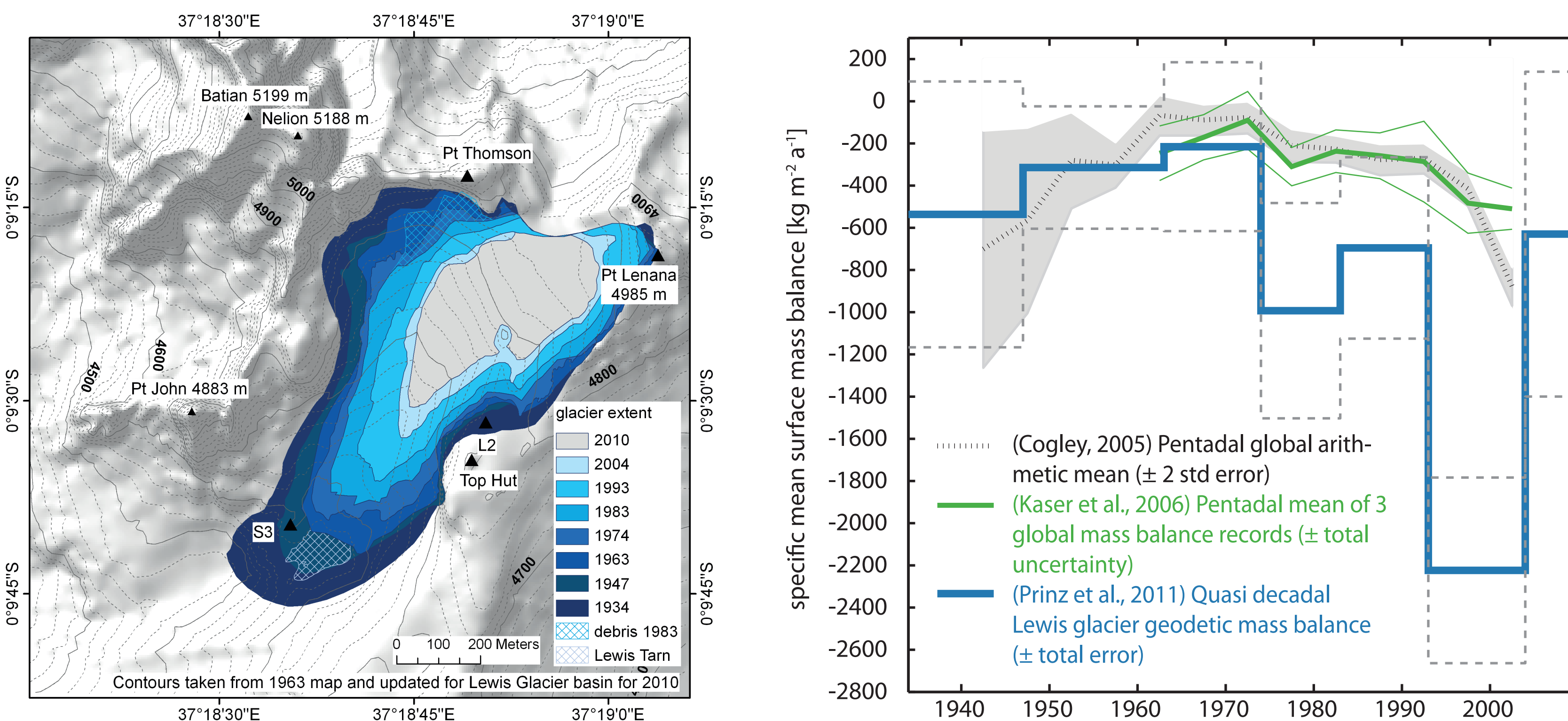
INTRODUCTION

Low latitude glaciers offer potential for providing evidence of conditions in the tropical mid-troposphere, and how they have changed over recent decades.



(1) Location of Lewis Glacier (00°09'S; 37°30'E) with respect to key tropical convergence zones (image modified from wikigraphics). On the right is the glacier as it was after a snowfall in 2010.

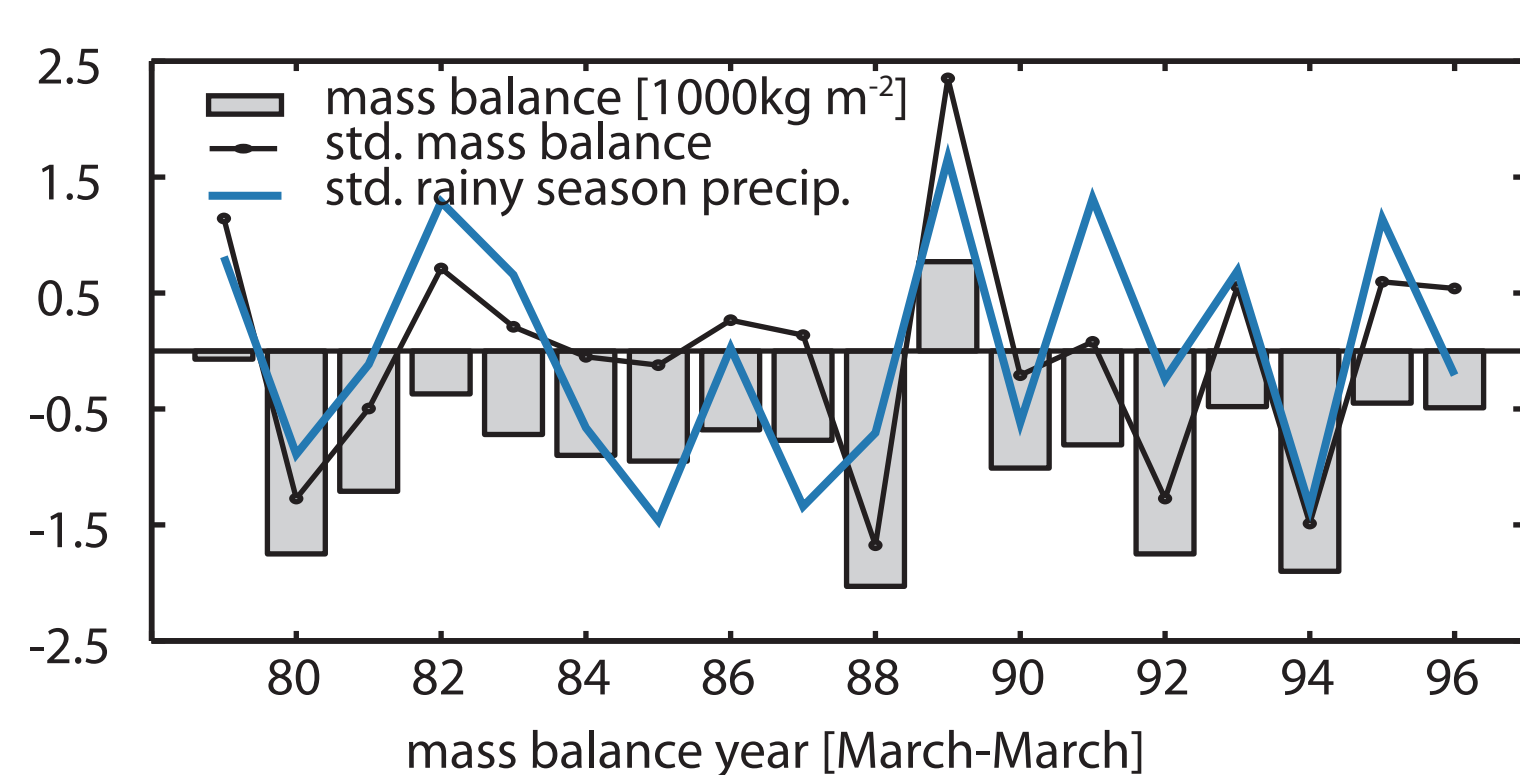
HISTORICAL RECORDS OF LEWIS GLACIER IN THE CONTEXT OF GLOBAL MASS BALANCE



(2) Lewis Glacier margins mapped at ca. 10 year intervals since 1934 and the resultant geodetically determined specific mass balance (Prinz et al., 2011), indicate mass balance was broadly in-line with global estimates up until 1974, when a period of much more rapid mass loss ensued until 2004.

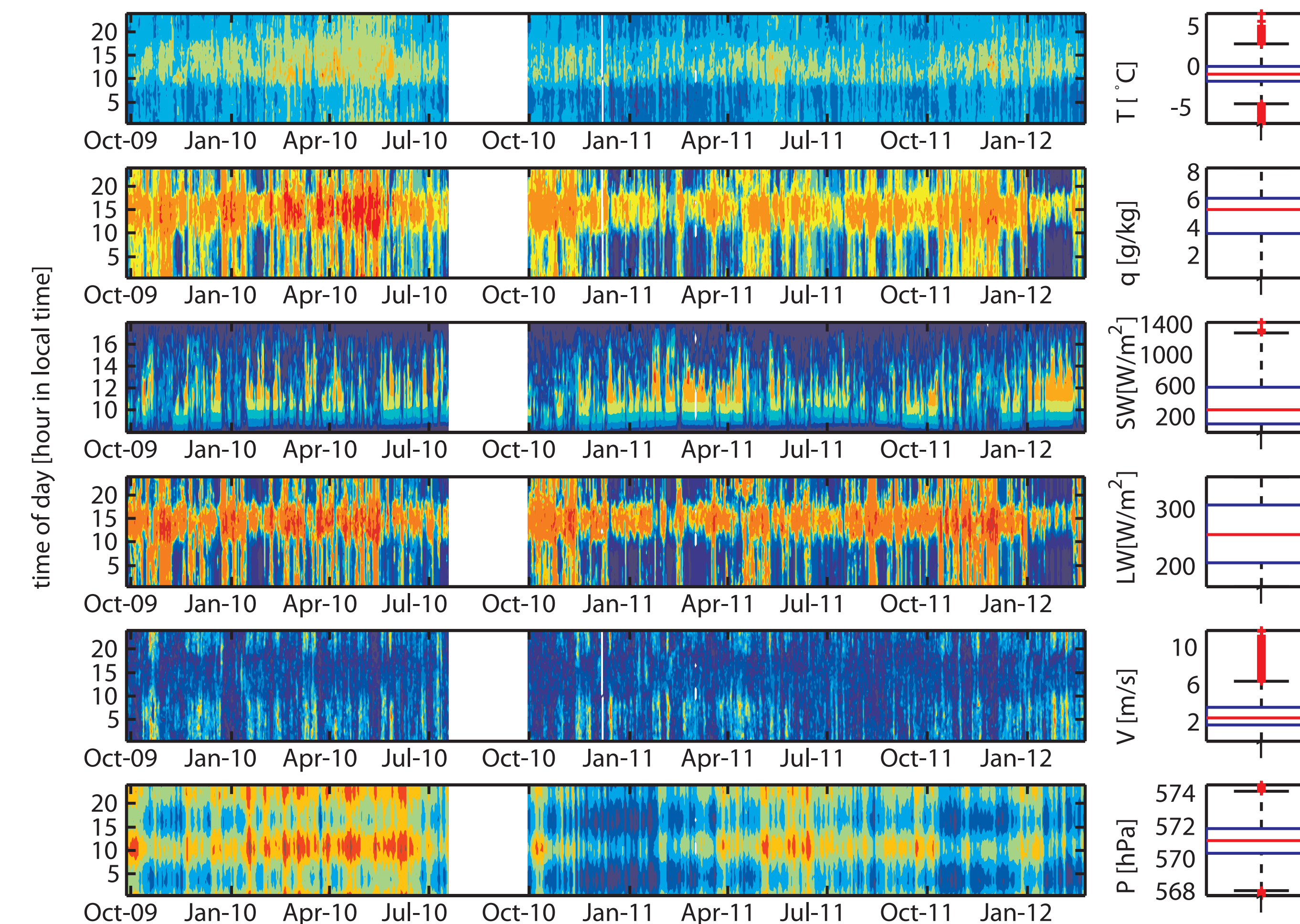
Lewis glacier in 2010: total ice volume = $1.90 \pm 0.30 \times 10^6 \text{ m}^3$, ice area = $0.105 \pm 0.001 \times 10^6 \text{ m}^2$, mean (max) thickness = $18 \pm 3 \text{ m}$ ($45 \pm 3 \text{ m}$).

RELATIONSHIP OF HISTORICAL MASS BALANCE WITH PRECIPITATION RECORDS



(3) Interannual variability of directly measured mass balance measurements 1978-1996 (Hastenrath, 2005), is strongly related to total rainy season (MAM and OND) precipitation at 4800m, but precipitation at this elevation is not well correlated with regional precipitation records.

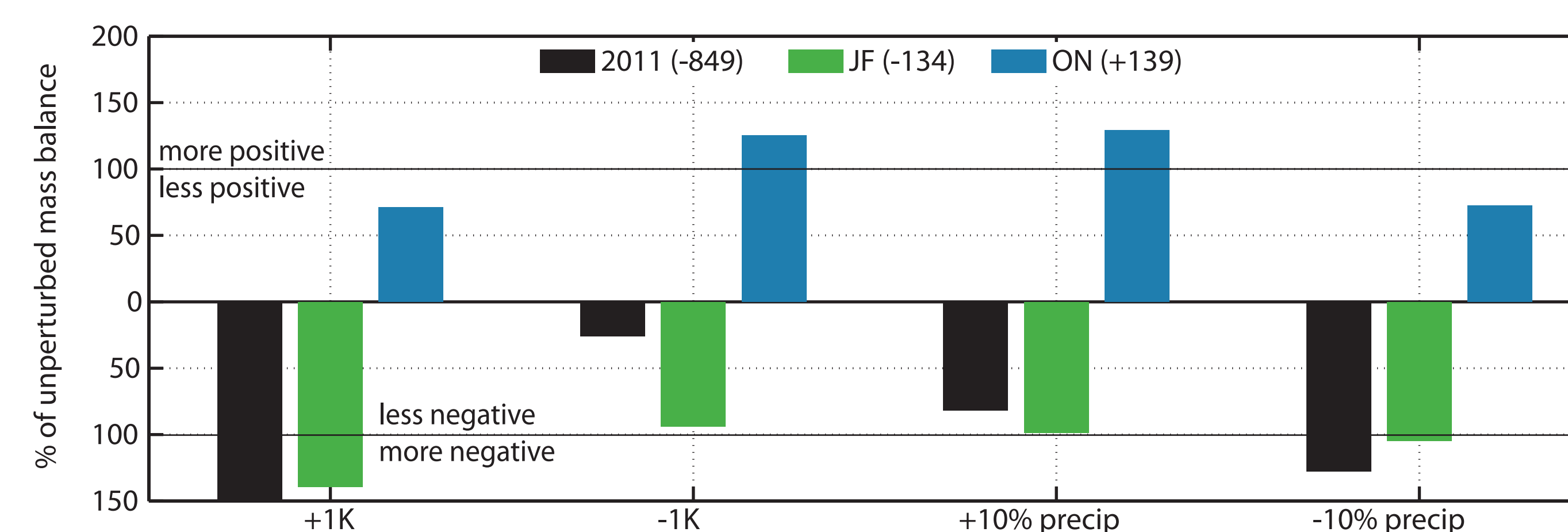
CHARACTERISTIC METEOROLOGICAL CONDITIONS



(4) Day-hour isopleth plots of meteorological records from the glacier surface (4830m) show that afternoon cloud cover is a persistent feature throughout the year with maximum specific humidity at 15:00. The regional wet (MAM & OND) and dry (JF & JJAS) seasons are not strongly evident in the available records.

The box plots show median values, with boxes extending to the interquartile range and whiskers to 1.5 times the interquartile range. The color scale in the isopleth diagram is adjusted to the full range of the data shown in the boxplots.

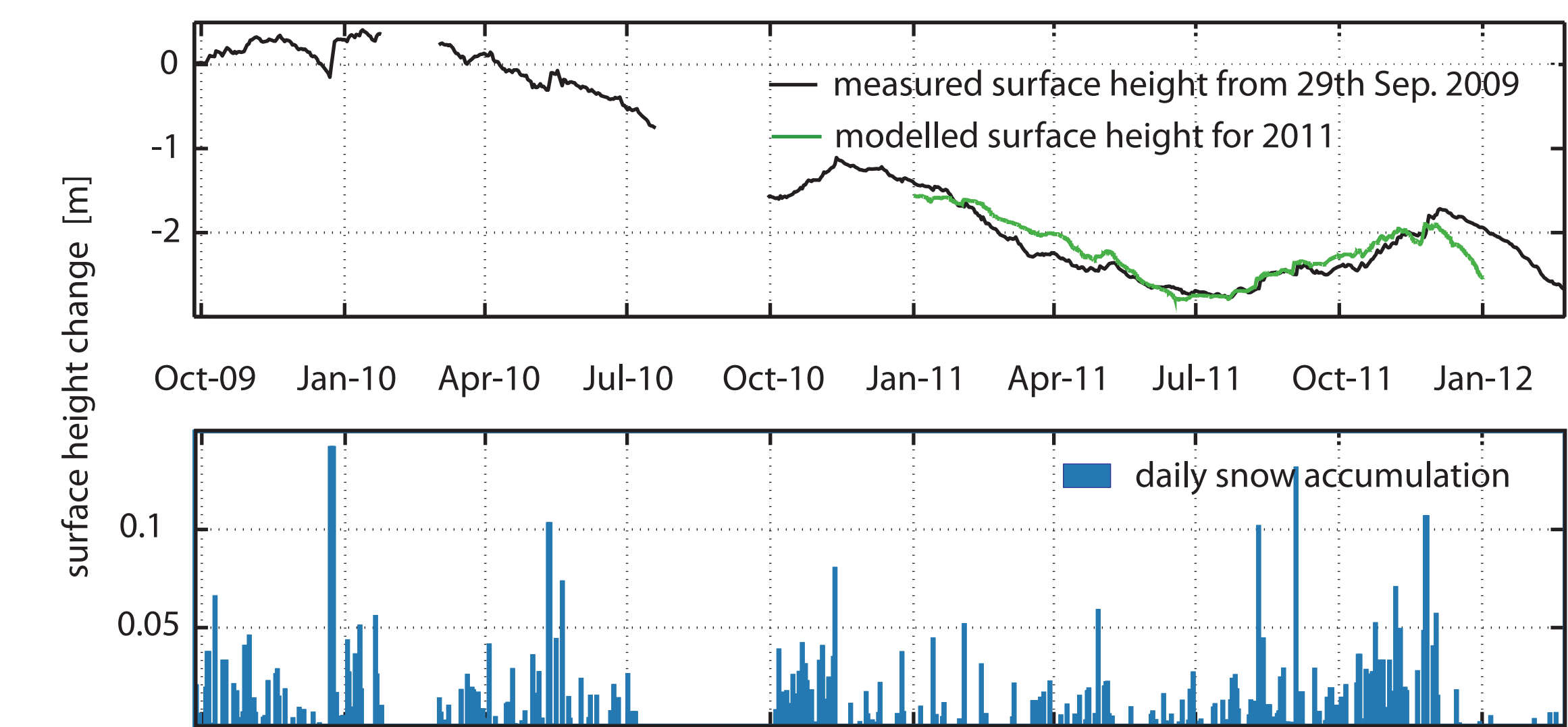
SURFACE ENERGY BALANCE SENSITIVITY



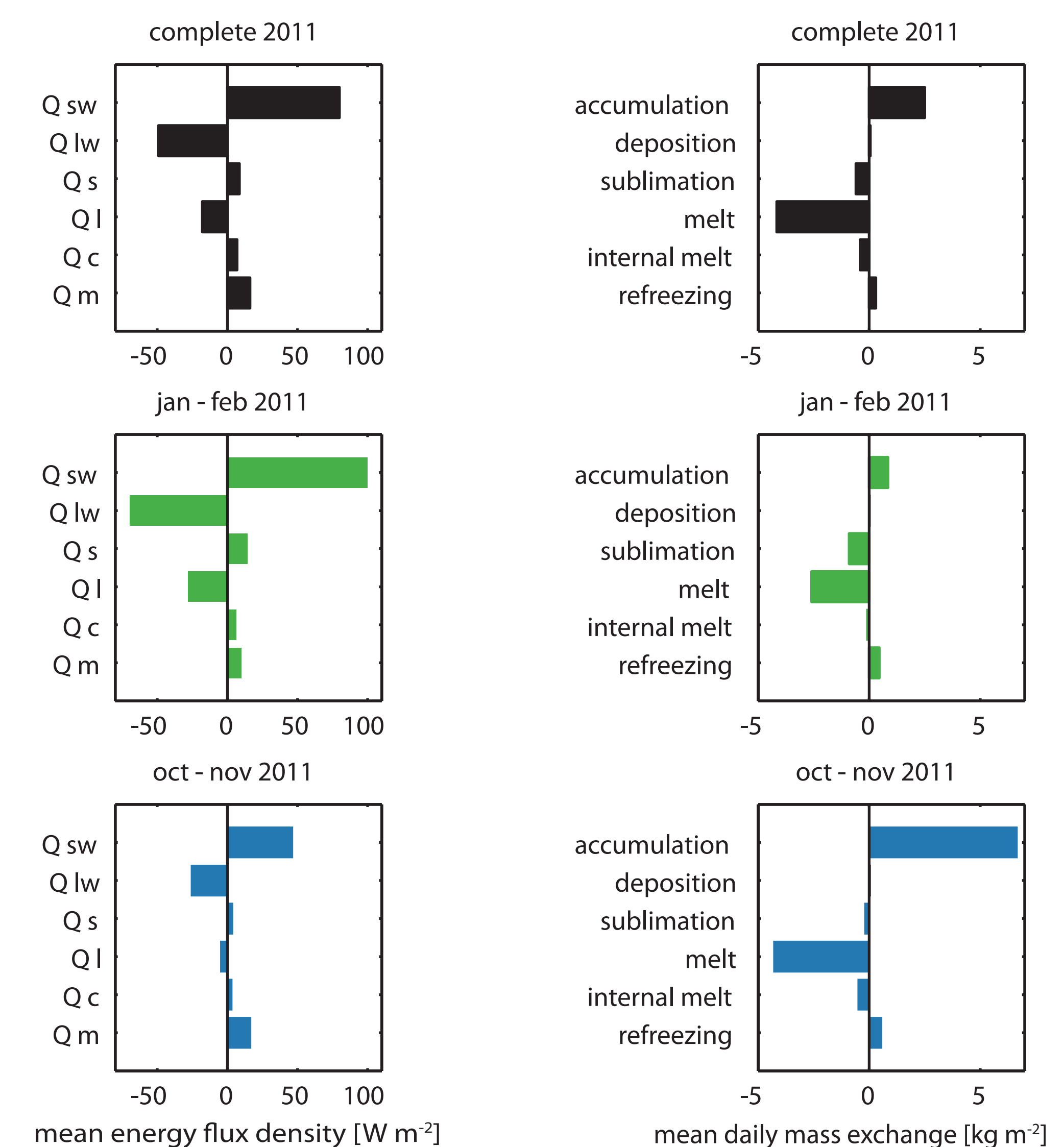
(7) Sensitivity to 4 single parameter perturbations are shown expressed as mass balance totals as a % of that modelled using unperturbed meteorological inputs. The unperturbed mass balance total in kg m^{-2} is given in parenthesis in the legend. Note that all y axis values are positive and the bars below the x axis simply indicate changes in mass balance for periods of mass loss.

Mass balance over 2011 appears more sensitive to changes in temperature than precipitation. However, the meteorological records and the energy flux suggest that Lewis glacier annual mass balance is likely to be strongly affected by the distribution and duration of wet and dry conditions experienced at the glacier throughout the year.

SURFACE ENERGY BALANCE MODELLING



(5) Results from a point surface energy and mass balance model (Mölg et al., 2008) shows generally good correspondence to the measured surface change. Deviations between the measured and modelled surface changes are related to occasionally poor performance of the albedo module within the model.



(6) Modelled energy (left) and mass (right) fluxes for all of 2011 and a sub-sample with dry conditions (JF in green) and wet conditions (ON in blue) show that:

Shortwave radiation is the dominant energy source

Sublimation and melt consume almost the same amount of energy on an annual scale, but QI dominates in the dry season, while Qm dominates in the wet season.

Melt rate is higher during the wet season than the dry season