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Perturbation of dynamic response at short outlets glaciers of Jostedalsbreen, maritime South Norway?

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Mountain glaciers are key indicators of global climate change. Changes in glacier volume, area, and length are determined by the climate and related mass flux/glacier flow. For several aspects of sustainable development in high-mountain regions (hydro-electric energy, water supply, tourism, etc.) it is crucial to estimate future glacier variations. Therefore, the interactions and relationships between individual meteorological and glaciological parameters need to be known before any model can be applied. Due to their steep mass balance gradient and high mass turnover, maritime mountain glaciers might respond very sensitively to changes of predominant weather or climate conditions.

The steep outlet glaciers of Jostedalsbreen, western South Norway, underwent two fairly contrasting periods during the past 20 years. Interpretation of this 'extreme' behaviour presented here deserved special attention. Detailed analysis of mass-balance, length variation, and climate data from maritime Southern Norway reveals their variations are not entirely determined by air temperature changes. A considerable increase in ice mass and related frontal advance during the AD 1990s was caused by increased winter precipitation. By contrast, a frontal retreat starting around AD 2000 continued and accelerated in recent years. Although above-average summer air temperatures unambiguously were responsible for this retreat, its proportion significantly exceeded the slight contemporary glacier mass loss. Since 2000, length variations at the short outlets of Jostedalsbreen seem to be decoupled from the net mass-balance data series. Additionally, the dynamic response of the glacier front to net balance and mass flux variations has been disturbed. Previously applicable terminus reaction times of 3 to 4 years have been replaced by an immediate response to higher summer air temperatures.

The correlation of net balance to length variation dropped significant since AD 2000. Comparable changes between long-term means and the most recent retreat phase take place between selected meteorological parameters and length variation. This analysis reveals substantial changes in the interrelation within the 'glaciological regime'. The pure dynamic response of the glacier front to mass-balance changes obviously is disturbed by high rates of summer meltback. Hence, alteration of terminus reactions times can be used as indicator. If the terminus response is mainly driven by changes of the mass flux, a specific terminus reaction time (tr $\geq$ 1 yr.) will be in place. If enhanced ablation at the terminus crossed a specific threshold, this terminus reaction time will be replaced by an immediate response (tr = 0) independent of the mass flux determined by the net mass-balance situation during the preceding years. Whereas mass balance and dynamic response of the glacier front might be modelled with existing knowledge and available conventional mass-balance data, to quantify these surplus ablation/additional enhanced summer meltbacks might be a methodological task for the future. As a consequence, different terminus reaction times for advance/retreat, precipitation/air temperature, or dynamic response/disturbed dynamic response have to be introduced.

The recent development at the steep outlets of Jostedalsbreen gives a clear warning to the common procedure of averaging long-term data series of glaciological and meteorological parameters as input for existing glacier models. These inputs must not automatically be considered as constant. As it is crucial to understand the response of the glacier tongues to future climate change, short-term extreme situations – rather than long-term constant developments – need to be the focus of new studies. The concept of possible regime shifts and multi-phase

patterns of causal interactions between meteorological parameters and glacier length changes has to be accepted as hypothesis in future work.

References:

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