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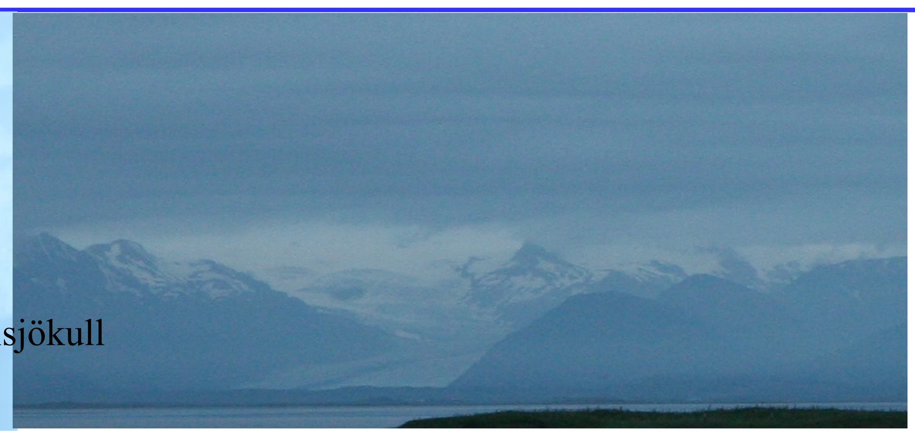
Under the glacier, the groundwater - the case of Skálafell area, Iceland



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(1) Avignon University, France (2) University of Southampton, UK

GlacAq project The present study is the first step of a wider project, GlacAq, aiming at characterizing the particular hydrogeology encountered under and downstream of glaciers of alpine type, i.e. sub-, pro- and periglacial hydrogeology, and its sensibility to climate change.

Objectives

Groundwater hydrodynamic understanding

Hydrodynamic response to climate change?

Role in the formation of offshore fresh groundwater stocks in littoral areas?

Available data

- Englacial-subglacial flux from Glacsweb probes, 1 year daily data 2012-2013 (Hart et al., 2015)
- Surface flow (river) from time-lapse camera, 1 year daily data 2012-2013, 0-3.5m^3/s (Young et al., 2015)
- Topographic data (National Land Survey of Iceland)
- Rivers network (National Land Survey of Iceland)
- Lakes mapping (National Land Survey of Iceland)
- Climatic data (Höfn station, Icelandic Met Office)
- Geology: mainly Upper Tertiary grey basalt, till layer at the top, thickness 0-20m, average 10m

Hypotheses

- Rivers and lakes connected to groundwater, hypothesis sustained by underlying material (till) and regional studies (Levy et al., 2015; Dochartaigh et al., 2016);
- Basalt underlying the till: considered as (semi-)impermeable bedrock i.e. aquitard; to be checked by geophysic measurements;
- At the coastline: hydraulic barrier vs continuity, chosen here: continuity;
- Precipitation recharge downstream of the glacier: half of the (recharge + runoff) total.

Hydrological balance

Glacier area

M: Glacial melt (mm/y) minus sublimation, ie en- and subglacial flow
R: Runoff (mm/y)
RCH: recharge (mm/y)

2012-2013:
M – R = 803 - 118
= **685 mm/year**
Recharge to groundwater

Ice-free area

P: precipitation (mm/y)
ETP: evapotranspiration (mm/y) from Thornthwaite
S: soil storage

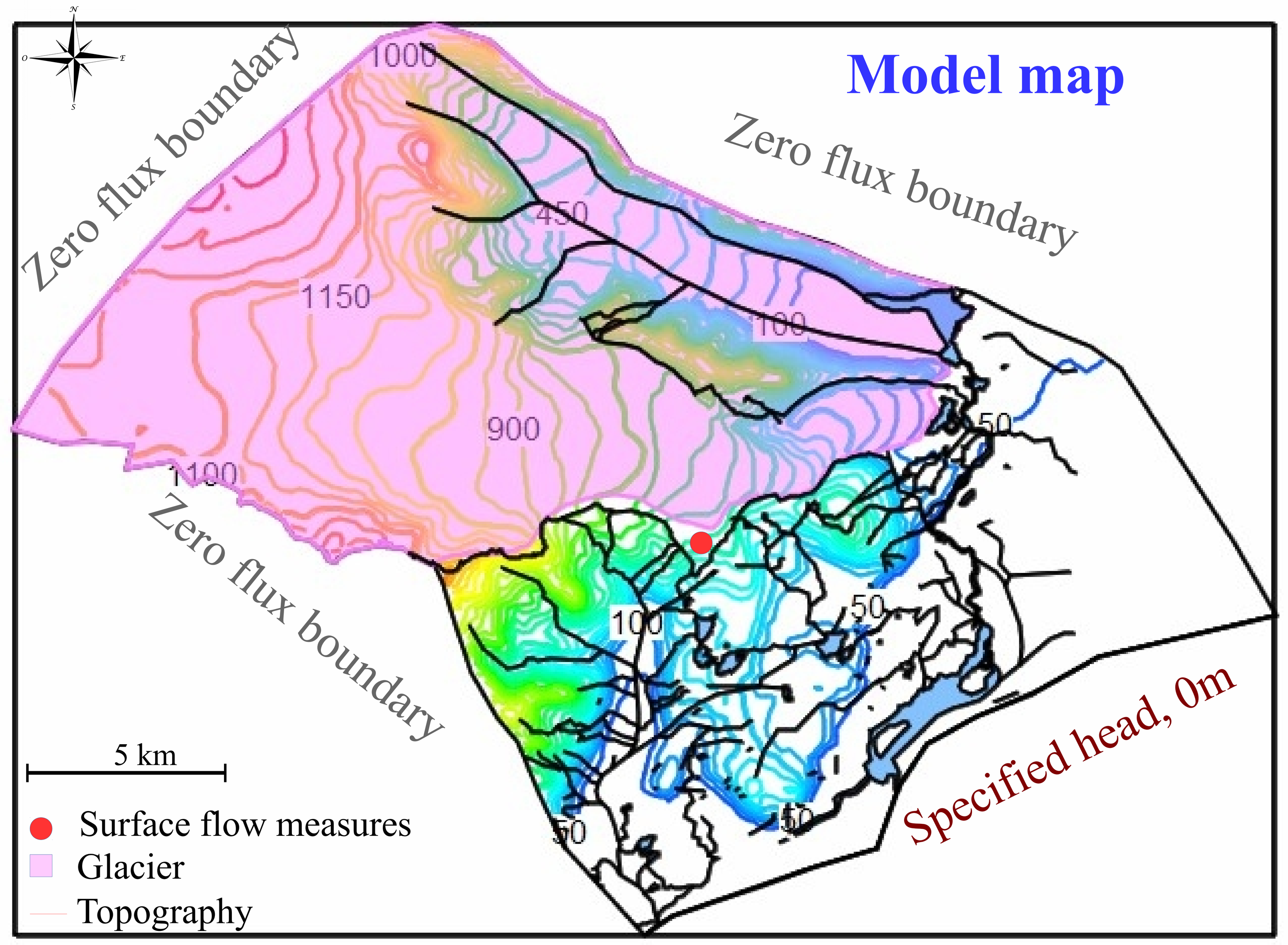
2012-2013:
P – ETP - S = 1283 -172 -70
R+ RCH = **1043 mm/year**

Model results

- Reasonable piezometry with **K = 2.10^{-4} m.s^{-1}**
- Rivers network correction thanks to topographic map and satellite image, necessary to get a reasonable piezometry, and extrapolation of a drain under the glacier: **Strong surface hydrology-hydrogeology coupling**
- Water going to the sea through offshore spring or forming an offshore freshwater stock: **16 Mm^3/year**

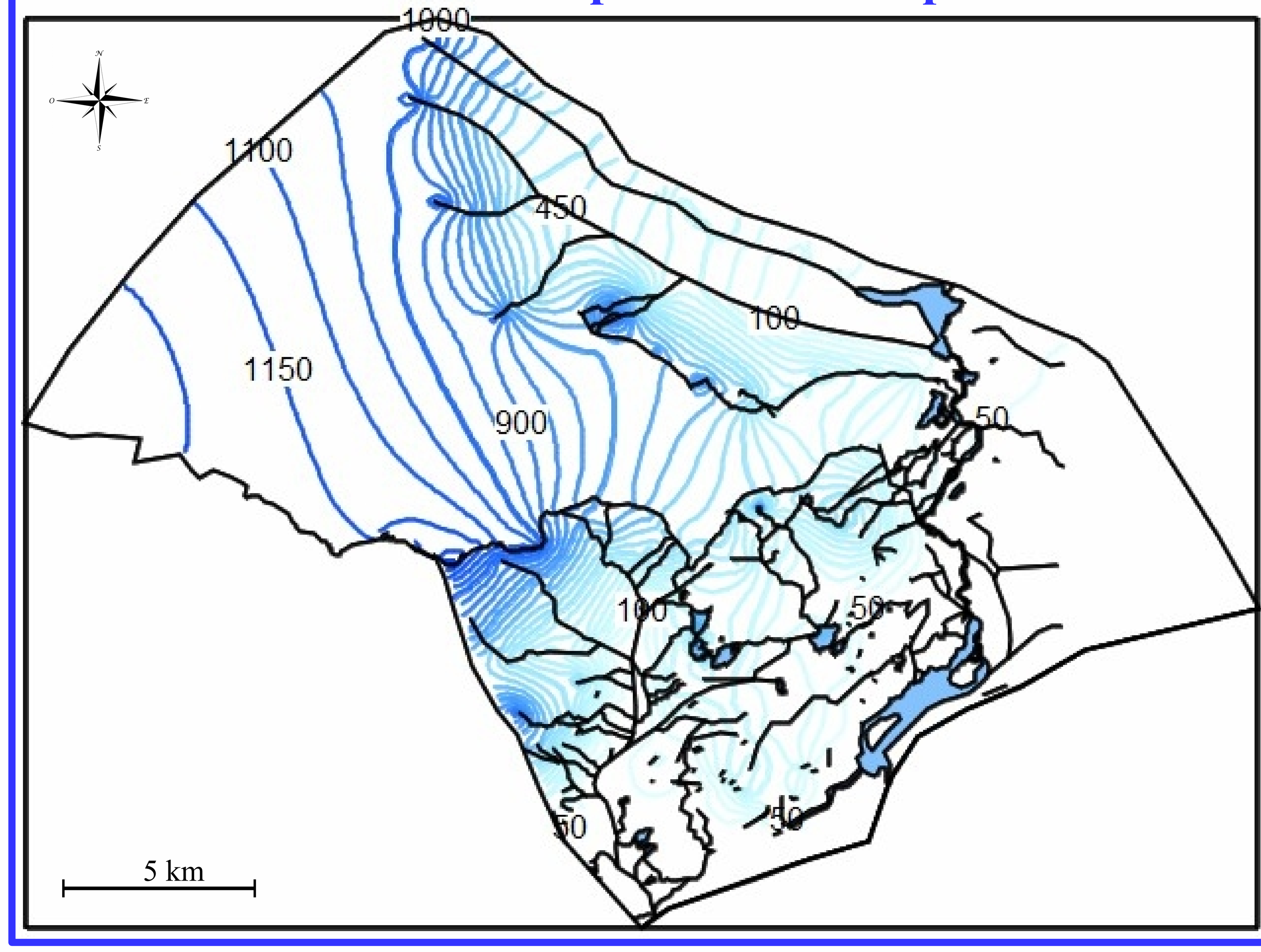
Model

Modflow and Modpath, ModelMuse interface (USGS)
Steady-state run; 200m wide mesh



Surface = 350 km²
Rivers and lakes: specified heads = topography
Recharge under the glacier: 2.10^{-8} m.s^{-1}
Recharge on the ice-free area: 1.6.10^{-8} m.s^{-1}

Simulated piezometric map



Perspectives

Till grain texture currently studied: precision of permeability value
Field observations and measurements to be carried out: Onland/offshore springs? Piezometry? Geological geometry?
Effective connection of lakes and rivers to groundwater?
Further modelling: precision and test of others hypothesis, e.g. existence of a regional groundwater reservoir inland, under the Vatnajökull?
Ongoing application for funding (ANR): GlacAq project.