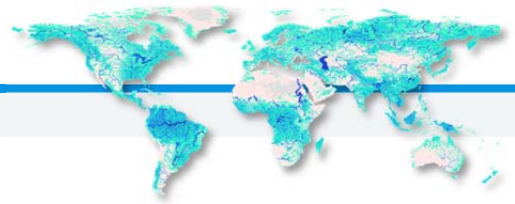

Arctic-HYPE version: 3.0.26
HYPE model version: HYPE_CryoProcesses_rev14282_20160420
Geographical domain: Drainage basin of the Arctic Ocean

User community:
The pace of change in the arctic system during recent decades has captured the world's attention. Both observations and model simulations indicate that the Arctic experiences an amplified response to climate forcing relative to that at lower latitudes. River monitoring show increase in annual discharge from the largest Arctic rivers , and snow observations show that the spring snow-cover is reduced at a higher rate than estimated by climate projections. However, about 30% of the Arctic basin is still ungauged and there is a need for a complete pan-Arctic hydrological model, assimilating existing observations a simulating ungauged basins, to enable a consistent monitoring of the arctic hydrological system. The overall goal for Arctic-HYPE is to increase the understanding of climate impact on fine-scale hydrology in the entire drainage basin of the Arctic Ocean, with the aim to improve predictions of river discharge into the ocean in present and future climate. The model is also a Swedish contribution to the WMO Arctic-HYCOS project and an operational application is under development of prediction of ungauged basins and total flux to the Arctic Ocean , as well as near-real time simulations and eventually forecasts.
Table 1. Data sources and characteristics of the Arctic-HYPE v.3.0 model setup.

Characteristic/Data type	Info/Name	Provider
Total area (km2)	23 million	-
Number of sub-basins	32599 (mean size 715 km2)	-
Topography (routing and delineation)	USGS: Hydro1K	https://lta.cr.usgs.gov/HYDRO1K
Soil characteristics	Harmonised World Soil Database (HWSD) 1.2	Nachtergaele et al. (2012)
Land use characteristics	ESA CCI LU 2010 v1.4	ESA Climate Change Initiative – Land cover project 2014
Lake and wetland	Global Lake and Wetland Database (GLWD)	Lehner and Döll (2004)
Lake depths	Global Lake Database v 2	Kourzeneva (2010)
Reservoirs	Global reservoir and Dam database	Lehner et al. (2011)

	(GRanD) v1.1	
Discharge	1. R-ArcticNet 2. Global Runoff Data Centre 3. Environment Canada, HYDAT (National Water Data Archive) 4. USGS (National Water Information System) 5. Ymparisto (Finland) 6. The Norwegian Water Resources and Energy Directorate (Norway) 7. Icelandic Met Office	www.r-arcticnet.sr.unh.edu www.bafg.de/GRDC waterdata.usgs.gov/nwis waterdata.usgs.gov/nwis Ymparisto (Finland) NVE (Norway) Icelandic Met Office
Precipitation	Global Forcing Data (GFD)	SMHI
Temperature	Global Forcing Data (GFD)	SMHI
Snow	1. GlobSnow 2. Former Soviet Union Hydrological Snow surveys	1. www.globsnow.info 2. Krenke, A. (1998, 2004)
Glacier fluctuations	World Glacier Monitoring Service (WGMS)	Zemp, M. et al. (2012)
Evapotranspiration	FLUXNET	fluxnet.ornl.gov

Calibration/Model structure:

Initially, model structure as well as parameter values for land use water balance, soil hydraulic properties and lake and river routing dynamics were adopted from the S-HYPE (2014) and E-HYPE (v3.0) models.
Secondly, the model structure was adapted to arctic conditions improving the processes representation for evapotranspiration (potential transpiration using temperature and radiation driven Priestly-Taylor function), snow and glacier melt (radiation and temperature driven melt and sublimation), evapotranspiration (impact of low temperature) and reduced infiltration in frozen soil.
Parameters governing snow melt was calibrated using long term data sets on snow water equivalent in forested and open areas from Former Soviet union snow courses (FSUS, source: www.nsidc.org). 436 FSUS snow stations were splitted into two spatially evenly distributed groups for calibration (216+37) and validation (220+40).
Glacier area-volume relationships were established by calibrating scaling coefficients for glaciers and ice caps taking into account the number and individual areas of glacier within each subbasin based on glacier area from RGI v4, matching on a regional level the total glacier and ice cap volumes to the volumes estimated by Huss and Farinotti (2012).

Parameters governing evapotranspiration were calibrated using in-situ observations from the FluxNet database (fluxnet.ornl.gov). The FluxNet free-fair-use dataset covers 20 sites within the Arctic-HYPE model for the time period 1994-2010. All sites were used for calibration.

Parameters governing water balance of the land use classes including elevation correction of precipitation and hydraulic response of soil type classes were calibrated using river discharge data from upstream sub-basins without so called outlet lakes (lakes on the main stream).

Rating curve parameter governing lake discharge was calibrated separately for 4 classes of internal lakes (lakes not on the main stream) and 3 classes of outlet lakes, using river discharge data in upstream areas without outlet lakes and river discharge data downstream of outlet lakes, respectively.

Individual rating curve parameters were calibrated for the largest lakes using river discharge data from the nearest downstream stations.
Average annual glacier mass balance functions were established for each RGI region in the model domain using the available mass balance data from World Glacier Monitoring Service (WGMS, source: www.wgms.ch) which provide data from 74 glaciers stations covering the time period 1961-2010. These functions were used to correct the initial glacier volumes, by backwards integrating from the date of the glacier area information from RGI v4 to the starting date of the model simulations.
Parameters governing glacier melt were finally calibrated using the same WGMS data.

Validation:
Evaluation was made using 79 Arctic-HYCOS flow-to-ocean stations and 540 Arctic HYCOS upstream stations for the entire simulation period 1971-2010.

Contact person
For further information, please contact David Gustafsson

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