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Key Points:
- Increased seasonal discharge into the Hudson Bay Complex is 3% greater or more for 2.0 °C warming than 1.5 °C warming but lower in summer
- Projected discharge increases from 1986–2005 are greatest furthest north (into Foxe Basin, Ungava Bay, and Hudson Strait) and during spring
- Discharge projections are most uncertain in the Western Hudson Bay region due to lower and more uncertain precipitation projections

Supporting Information:
- Supporting Information S1
- Figure S1
- Figure S2
- Figure S3
- Figure S4
- Figure S5
- Figure S6
- Figure S7
- Figure S8

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Impacts of 1.5 and 2.0 °C Warming on Pan-Arctic River Discharge Into the Hudson Bay Complex Through 2070

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Abstract Discharge projections into the Hudson Bay Complex to 2070 are investigated for global mean temperature warming levels of 1.5 and 2.0 °C. Median precipitation increases from 1986–2005, ranging from 2% during summer to 19% during winter, are projected to increase discharge in all seasons except summer. The rise in discharge is greatest furthest north, into Foxe Basin, Ungava Bay, and Hudson Strait, exceeding 10% above historical annual means. A 2.0 °C warming results in higher discharge than 1.5 °C warming owing to greater precipitation (e.g., 6.5% greater spring discharge increase); however, summer discharge for 2.0 °C warming is lower due to enhanced evaporation and lower precipitation increase from historical (4.0% lower summer discharge increase). Extreme daily high flows are projected to be greater than historical, more so for 2.0 °C warming than 1.5 °C warming, and this is greatest in the eastern and northern regions. These projections suggest continued increasing river discharge into pan-Arctic coastal oceans.

Plain Language Summary In 2016, participants in the Paris climate agreement pledged to hold the global average temperature rise to less than 2.0 °C above preindustrial levels and to pursue limiting the rise to 1.5 °C. Northern regions, such as the 4 million-km^2 Hudson Bay Drainage Basin that discharges into the Hudson Bay Complex, are highly sensitive to climate change. We quantify changes in river discharge into the Hudson Bay Complex under future climate (2020–2070) and assess the impacts of 1.5 and 2.0 °C warming on discharge. The region is projected to warm at a rate greater than the global average, causing greater precipitation and discharge compared to historical. A 2.0 °C warming would increase discharge beyond that of 1.5 °C warming, but summer discharge may be lower due to higher evapotranspiration. Discharge increases are greatest furthest north, where there are no active streamflow gauges. Changing discharge has implications for the hydroelectric industry, with respect to managing possible increased spring flood risk but lower summer flows. Rising discharge impacts sea ice and the biological productivity of coastal ocean systems such as the Hudson Bay. Global carbon budgets may be impacted as coastal ocean systems are more active organic cycling sites than open oceans.

1. Introduction

Participants in the Paris climate agreement pledged to hold the global mean temperature (GMT) increase to less than 2.0 °C above preindustrial levels and to pursue limiting the increase to 1.5 °C (United Nations Framework Convention on Climate Change, 2015). From a global perspective, hydrological change resulting from rising temperatures will be regionally dependent (Held & Soden, 2006; Schleussner et al., 2016). There have to date been relatively few regionally focused impact studies on the relative effects of 1.5 versus 2.0 °C warming. High-latitude regions are highly sensitive to the impacts of climate change (Hinzman et al., 2005; Schleussner et al., 2016), and northern indigenous communities are among those most impacted by climate change (Intergovernmental Panel on Climate Change [IPCC], 2014).

Recent climate change has altered a suite of hydrometeorological and ecological variables across northern regions: precipitation, river discharge, snow cover, glaciers, permafrost, freshwater and saltwater ice cover, and biota (Arheimer & Lindström, 2015; DeBeer et al., 2016; Haine et al., 2015; Rawlins et al., 2010). With respect to river discharge, several studies project increased flows across northern regions compared to historical means (e.g., Koirala et al., 2014; Shkolnik et al., 2017), and these increases are more pronounced than the global trend (Alkama et al., 2013).

Relatively few studies have presented the outcomes of 1.5 versus 2.0 °C warming on northern hydrology. Annual discharge in Russia's Lena River is projected to rise nearly 20% for 2.0 °C GMT warming, whereas only a small rise is projected for 1.0 °C warming (Gosling et al., 2017). Donnelly et al. (2017) project more spatially extensive 0.15-mm/day runoff increases across Scandinavia for 2.0 °C warming than 1.5 °C warming. Contrast these results to those for two catchments in China, where Liu et al. (2017) project decreases in mean annual runoff but increased 25-year flood magnitudes for both 1.5 and 2.0 °C. In a global-scale study, warming of 2.0 °C is shown to reduce (increase) annual runoff in several subtropical (high-latitude northern) regions compared to 1.5 °C warming (Schleussner et al., 2016).

The Hudson Bay Drainage Basin (HBDB) comprises over a third of the Canadian landmass, accounts for over a fifth of freshwater exports into the pan-Arctic Ocean system via the Hudson Bay Complex (HBC; McClelland et al., 2006) and contains important hydroelectric infrastructure and agriculture (Abelson, 1985; Hassanzadeh et al., 2014). HBDB discharge, which has increased since the late-1980s (Déry et al., 2016), also influences circulation, sea ice dynamics, and biological and biogeochemical processes within the HBC (Macdonald & Kuzyk, 2011). Such coastal ocean systems are considered among the most sensitive marine environments to climate change (Macdonald et al., 2010; Mackenzie et al., 2004). Moreover, parts of the HBDB have been identified as priority areas for future hydrometric monitoring due to high projected discharge changes (both increases and decreases), low agreement in projections, or lack of nearby gauges (Bring et al., 2017).

Given the sensitivity of northern regions to climate change, the policy interest in 1.5 versus 2.0 °C GMT warming, and the importance of the HBDB, this paper seeks to determine the relative impacts of the two warming levels on discharge into the HBC. Discharge projections are quantified for four regions discharging into the HBC on annual, seasonal, and daily bases.

2. Data and Methods

Hydrological simulations are performed over the 4.4 million-km^2 HBDB with a modified version of Arctic-HYPE (Arctic-HYdrological Predictions for the Environment; Andersson et al., 2015; Gelfan et al., 2017), which was improved and calibrated for the HBDB. The HBDB is set up as 6,668 subbasins consisting of eight land cover and seven soil types (with process representation of subsurface frozen soils; refer to the supporting information). Calculations are performed daily, driven by precipitation, and mean, minimum and maximum air temperature. Current flow regulation (including reservoirs) is held constant through projections to focus analyses on the direct climate-driven impacts on discharge. Details of the Arctic-HYPE processes, setup, and calibration/validation results are presented in the online supporting information (Figures S1 and S2; Tables S1 and S2).

Arctic-HYPE simulations are forced by output from the fifth Coupled Model Intercomparison Project (CMIP5; Taylor et al., 2012). Representative concentration pathways (RCP)4.5 and RCP8.5 scenarios are considered (van Vuuren et al., 2011). The goal is to span the range of projected changes, without being restricted to either equal representation of RCP4.5 and RCP8.5 simulations in the ensemble or using RCP4.5 and RCP8.5 simulations from each model. *k*-means clustering is used to select 19 CMIP5 members (Table S3) that span approximately 90% of the full ensemble's uncertainty range (Casajus et al., 2016). The 10 clustering criteria are annual and seasonal changes in temperature and precipitation, spatially averaged over the HBDB and comparing 2041–2070 averages to 1981–2010 averages. The bias correction of daily values of precipitation and maximum and minimum temperature is based on the daily translation quantile-mapping approach by Mpelasoka and Chiew (2009). The Natural Resources Canada gridded observation data set (Hopkinson et al., 2011; Hutchinson et al., 2009; McKenney et al., 2011) is used as the reference in the bias correction of simulated data for the historical (1981–2010) and future periods (2021–2070). Mean daily temperature is the average of daily maximum and minimum. Arctic-HYPE simulations driven by CMIP5 output (hereafter AHYPE-CMIP5) are performed for 1981–2010 and 2021–2070, each with synthetic 10-year model spin-ups.

The impacts of 1.5 and 2.0 °C GMT increases above preindustrial levels (1850–1900) are considered; however, bias-corrected forcing data for the preindustrial period are unavailable for simulations. Therefore, 1986–2005 is used as baseline as in the Fifth Assessment Report (AR5) of the IPCC (2013) and in Schleussner et al. (2016). The 1986–2005 GMT is 0.6 °C warmer than the preindustrial period (IPCC, 2013). The projected warming levels considered are therefore 0.9 and 1.4 °C above 1986–2005, but the GMT differences are expressed in this paper

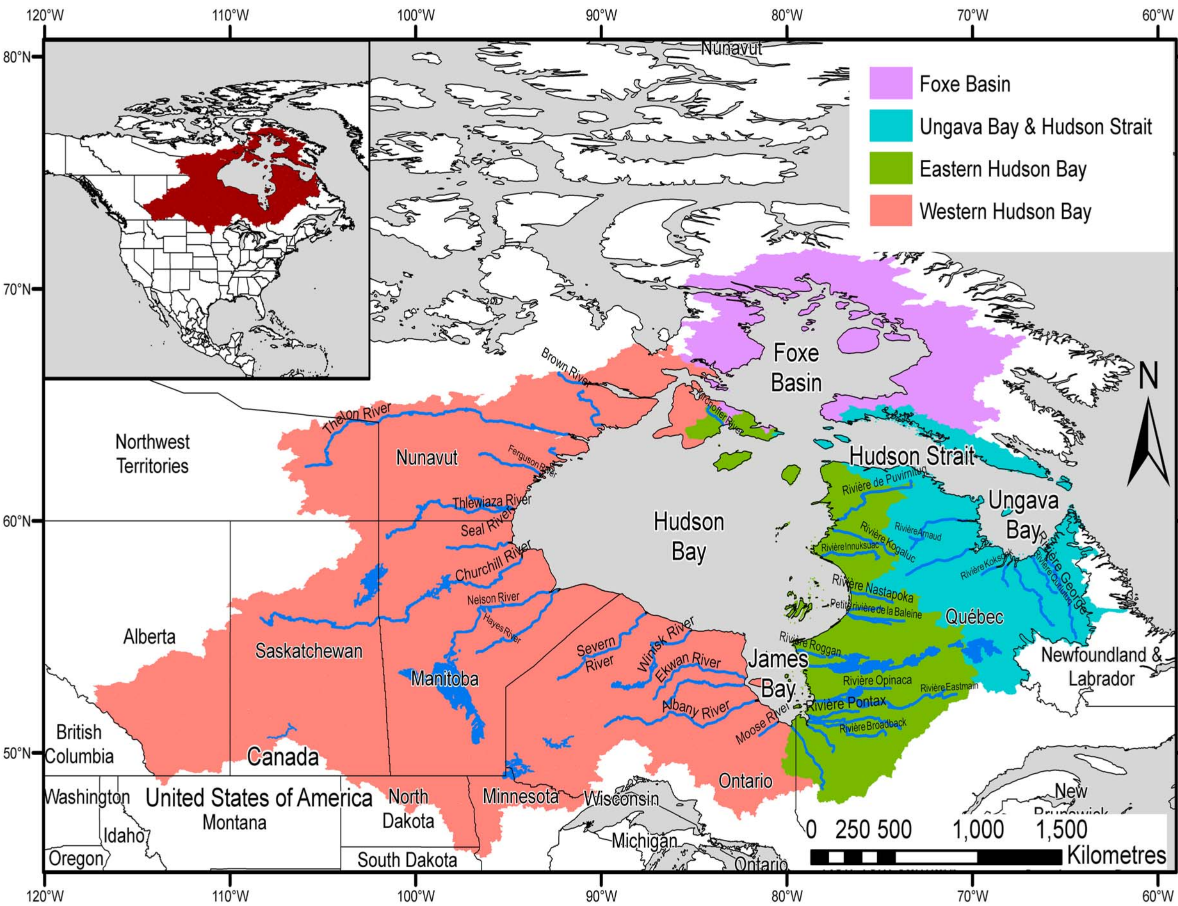

Figure 1. Regions and waterways of the Hudson Bay Drainage Basin.

as their implied preindustrial warming levels of 1.5 and 2.0 °C. GMTs are extracted from the CMIP5 data set used in IPCC AR5 (IPCC, 2013; http://climexp.knmi.nl/). AHYPE-CMIP5 simulations are extracted for 20-year time slices of GMT increases of 1.5 and 2.0 °C above preindustrial levels for each of the 19 CMIP5 simulations. The 20-year approach was used in IPCC AR5, and its advantages are summarized by Schleussner et al. (2016), that is, reduced intermodel spread due to transient climate responses and smaller year-to-year deviations from mean warming than for 30-year periods. The approach assumes that changes in climate are driven primarily by GMT changes and that time-lagged changes such as oceanic circulation are of little importance over 20-year periods.

Future 20-year time slice simulations are compared to 1986–2005 simulations on annual, seasonal, and daily bases (Winter: December–February, Spring: March–May, Summer: June–August, and Fall: September–November). Analyses are conducted for four regions of the HBDB that discharge into the HBC: Western Hudson (and James) Bay, Eastern Hudson (and James) Bay, Ungava Bay and Hudson Strait, and Foxe Basin (Figure 1). Hudson and James Bays carry large freshwater inputs with storage over years, the Foxe Basin conveys water into northern Hudson Bay, and the Hudson Strait exchanges water between Hudson Bay and the North Atlantic Ocean (Macdonald & Kuzyk, 2011).

Nonparametric Mann-Whitney tests are performed to assess differences in air temperature, precipitation, evaporation, and discharge caused by 1.5 and 2.0 °C warming. The two samples used in each Mann-Whitney test are output from the AHYPE-CMIP5 simulations for 1.5 versus 2.0 °C warming (Table S3). Statistically significant differences are presented as having $p < 0.05$. The percent agreement of simulations in the sign of change from baseline is discussed using IPCC (2013) likelihood terminology: *virtually certain* > 99%, *very likely* > 90%, *likely* > 66%, and *more likely than not* > 50%. Daily flow duration curves are presented for baseline, 1.5 and 2.0 °C warming slices. Correlations between annual GMT increases and

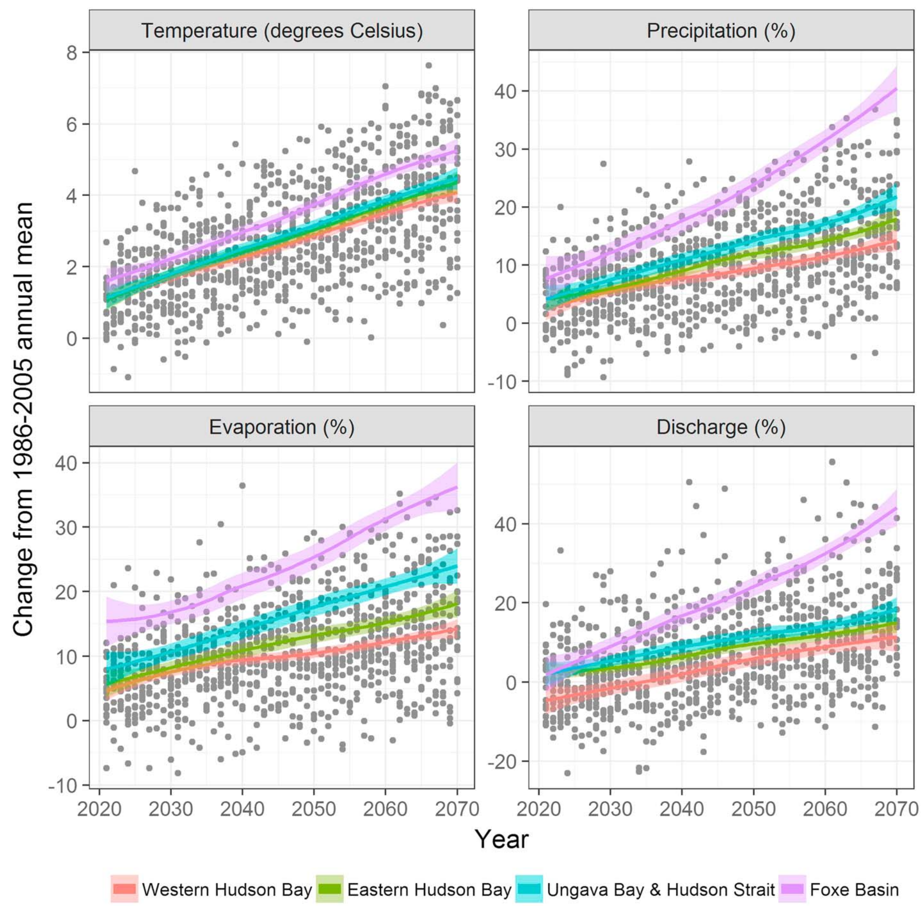

Figure 2. Projected changes in annual temperature, precipitation, evaporation, and discharge from 1986–2005 annual means using the 19 AHYPE-CMIP5 simulations. Black data points are for the entire HBDB. Colored locally weighted scatterplot smooth curves are shown for the four regions (gray shading indicates 95% confidence intervals).

projected changes are also presented with significance of Pearson's *r* indicated at $p < 0.05$ (all variables pass the Shapiro-Wilk test for normality at $p < 0.01$).

3. Results

Mean annual 1986–2005 temperature, precipitation, evaporation, runoff, and discharge over the HBDB are −2.7 °C, 511 mm, 309 mm, 217 mm, and 800 km^3, respectively. These variables are projected to increase through to 2070 but fall below historical means in some years (Figure 2). Across regions, the largest increases are projected for the Foxe Basin, with annual temperature rising by 5 °C and precipitation, evaporation, and discharge each increasing by over 30% before 2070. Lowest increases are projected for the Western Hudson Bay, with mean increases under 15% for precipitation, evaporation, and discharge by 2070.

Of the 19 CMIP5 simulations, eleven 20-year time slices are found for each of 1.5 and 2.0 °C GMT increases (Table S3). These slices are used for comparing projected differences between 1.5 and 2.0 °C GMT warming. Certain CMIP5 simulations do not reach 20-year mean GMT warmings of 1.5 and/or 2.0 °C and are not analyzed further. The ensemble median year at which the 1.5 °C 20-year time slice is projected to occur is 2038 (standard deviation = 8.9 years) and 10 years later for the 2.0 °C slice (2048; standard deviation = 7.8 years). The median 20-year 1.5 °C warming slice for RCP8.5 simulations (2034) is projected to occur 5 years earlier than for RCP4.5 simulations, whereas it is projected to occur 10 years earlier for 2.0 °C warming (2041 versus 2051). Intermodel agreement across AHYPE-CMIP5 projections is stronger for 2.0 °C warming than 1.5 °C GMT warming for all variables, regions, and seasons, except summer precipitation in the Western Hudson Bay (Figure S3).

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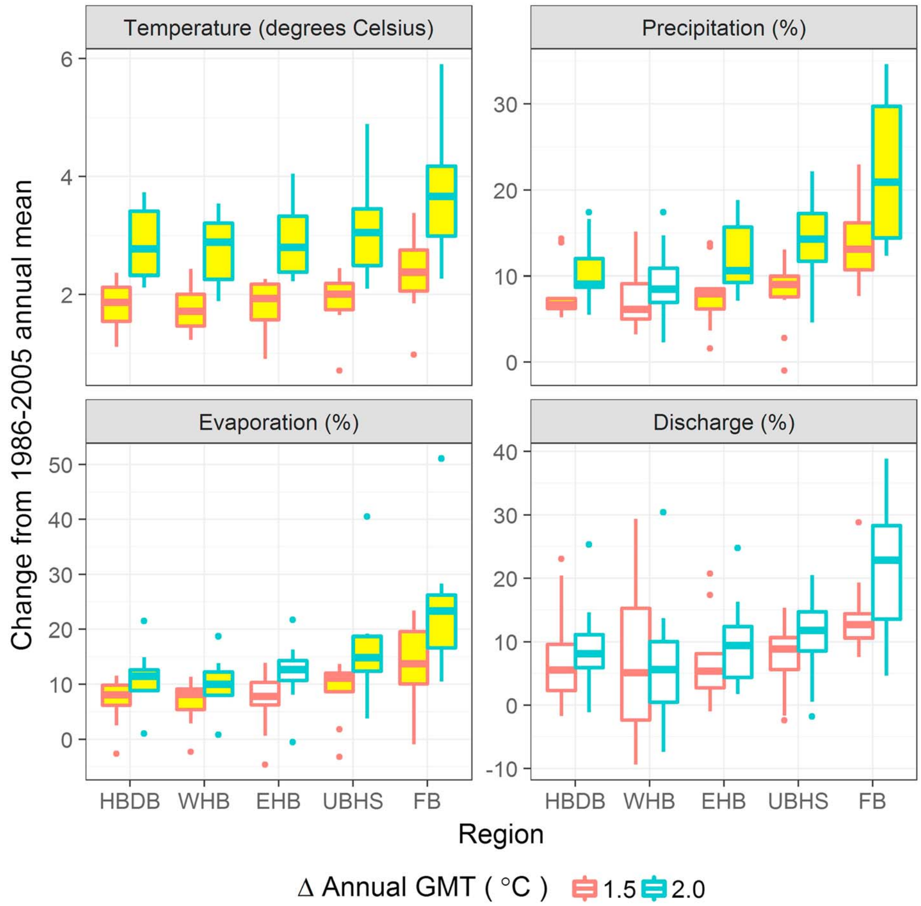

Figure 3. Projected changes in annual temperature, precipitation, evaporation, and discharge from 1986–2005 for 20-year time slices of GMT increases of 1.5 and 2.0 °C above preindustrial level. Statistically significant differences resulting from 1.5 versus 2.0 °C GMT warming are highlighted in yellow. Boxplots show the median and 25th and 75th percentiles at the hinges, and the whiskers extend to show a 95% confidence interval. EHB = Eastern Hudson (and James) Bay; FB = Foxe Basin; HBDB = Hudson Bay Drainage Basin; UBHS = Ungava Bay and Hudson Strait; WHB = Western Hudson (and James) Bay.

Annual and seasonal air temperature increases across HBDB regions are *virtually certain* (except one model member during spring) and greater than the corresponding global mean increases, for example, annual HBDB increases of 1.9 and 2.8 °C correspond to 1.5 and 2.0 °C GMT increases, respectively (Figure 3). GMT increases of 1.5 and 2.0 °C produce statistically significantly different temperature increases across nearly all regions annually and seasonally, with the exception of Foxe Basin during fall (Figure S3). Greatest (lowest) temperature increases are projected for the winter (summer).

Increased precipitation from baseline is *very likely* to *virtually certain*, with greater increases for 2.0 °C warming than 1.5 °C warming (Figure 3). Statistically significant differences are most widespread during spring, with 9.8% greater HBDB precipitation for 2.0 °C warming than 1.5 °C warming. Strongest agreements are projected for fall and winter (Figure S3). There are no significant differences and agreement is weakest (as low as *likely*) during summer, particularly for Western Hudson Bay. Annually, significant differences in precipitation are projected for all regions except Western Hudson Bay.

Annual evaporation increases are *virtually certain*, and significantly greater across nearly all regions for 2.0 °C warming than 1.5 °C warming (Figures 3 and S3). Spring evaporation is most impacted by 2.0 °C GMT warming, with the HBDB average evaporation increase 7.4% greater than for 1.5 °C warming.

Annual discharge is projected to increase, an outcome ranging from *more likely than not* into Western Hudson Bay for 1.5 °C warming, to *virtually certain* for the Foxe Basin. Agreement in discharge projections is weaker than for other variables. Discharge increases are greater for 2.0 than 1.5 °C warming, except during summer when median HBDB discharge is projected to be 4.0% lower (Figure S3). No region exhibits significantly

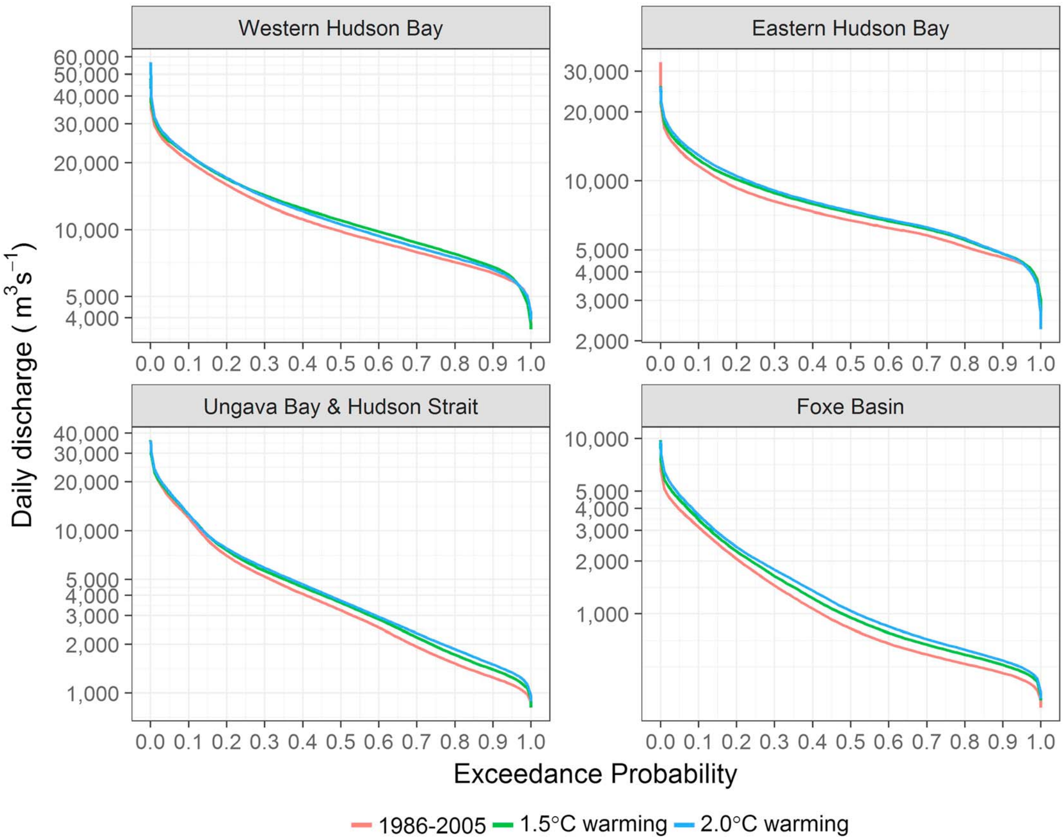

Figure 4. Daily flow duration curves for regions of the Hudson Bay Drainage Basin. The 1986–2005 and 20-year time slices of 1.5 and 2.0 °C warming are shown.

different annual discharge; however, all regions, except for Western Hudson Bay, show significantly different spring discharge. Differences in discharge are greatest for Foxe Basin, Ungava Bay, and Hudson Strait, with 2.0 °C warming causing 13–17% more spring discharge than 1.5 °C warming. The Western Hudson Bay region, as a whole, is the only to not show significantly different discharge during any season; however, there is greater internal spatial variability in projections in this region than others (results not shown).

An additional analysis is included to determine if interannual variability in natural runoff is projected to change with 1.5 and 2.0 °C GMT warming. Mann-Whitney tests show no statistically significant changes in interannual runoff coefficient of variation for either warming slice compared to 1986–2005 for any region. Statistically significant increases in mean annual runoff are found for both 1.5 and 2.0 °C warming for the HBDB and all regions except Western Hudson Bay (the region with lowest precipitation increase). Ensemble median mean annual historical runoff values are projected to increase as follows, HBDB: 216.8 mm (+4.9% for 1.5 °C warming and +9.1% for 2.0 °C warming), Western Hudson Bay: 154.5 mm (+3.0% for 1.5 °C and +6.6% for 2.0 °C), Eastern Hudson Bay: 417.2 mm (+5.0% for 1.5 °C and +9.0% for 2.0 °C), Ungava Bay and Hudson Strait: 391.7 mm (+9.1% for 1.5 °C and +11.7% for 2.0 °C), and Foxe Basin: 162.4 mm (+14.0% for 1.5 °C and +25.6% for 2.0 °C). In addition, both minimum and maximum annual runoff are greater than baseline for both warming levels.

The flow duration curves in Figure 4 indicate a shift toward higher discharge from baseline for both 1.5 and 2.0 °C warming across all regions, with 2.0 °C warming generally causing higher discharge than 1.5 °C warming. Discharge into Foxe Basin, Ungava Bay, and Hudson Strait is greater than baseline for both warming levels at all exceedance probabilities, with discharge for 2.0 °C warming exceeding that for 1.5 °C warming at all probabilities. Discharge for 50% exceedance probability is 11.6% greater than baseline for 1.5 °C and 14.6% greater for 2.0 °C warming when averaged across the four regions. The Western Hudson Bay differs in that 2.0 °C warming causes lower 50% probability flows than 1.5 °C warming, with some simulations providing summer evaporation increases that overwhelm precipitation increases. Greater high flows (e.g., 10% or lower exceedance probability) are projected for 2.0 °C warming than for 1.5 °C, particularly into Eastern Hudson Bay and Foxe Basin. Conversely, little change in extreme high flow magnitudes (<1% exceedance) into Ungava Bay and Hudson Strait are projected. Low flows (e.g., 90% or greater exceedance) are greater than baseline, most notably into Ungava Bay, Hudson Strait, and Foxe Basin. Both 1.5 and 2.0 °C warming result in lower magnitude extreme low flows than baseline in the Western Hudson Bay, upward of 96% exceedance. Little changes in low flows (>90% exceedance) from baseline are projected for the Eastern Hudson Bay.

Annual HBDB temperature, precipitation, evaporation, and discharge are each projected to increase from 1986–2005 with GMT warming from 1 to 4 °C (Figure S4). The HBDB is projected to warm at a rate greater than the global mean, for example, projected 2 °C GMT warming coincides with 2 to 4 °C HBDB warming. Annual precipitation is projected to increase along with GMT warming; however, the intermodel spread is large, for example, 2% to 10% increases for 1 °C warming and 8% to 22% increases for 3 °C warming. Precipitation changes in the Foxe Basin are most sensitive to increasing GMT, with up to nearly 40% increases for 2 °C warming. In contrast, 2 °C warming is projected to result in <20% increase to Western Hudson Bay precipitation. Annual HBDB evaporation and discharge are projected to increase with GMT, with similar percent changes and spread as precipitation projections. As shown by the small magnitude changes (±2%) in evaporation/precipitation and runoff/precipitation ratios, the spread of projected evaporation and discharge changes are largely caused by the intermodel spread in precipitation projections for the HBDB and its regions (Figures S4 and S5).

4. Discussion

With the Paris climate agreement signaling an effort to limit GMT increases to 2.0 or 1.5 °C, the results herein outline the impacts of these efforts on northern river discharge. GMT warming of 2.0 °C results in greater discharge into the HBC compared to 1.5 °C warming. Increased annual discharge into the HBC from baseline ranges from *virtually certain* into the Foxe Basin to *more likely than not* into the Western Hudson Bay. Increased spring discharge, a season with high natural flows due to snowmelt, is *virtually certain* for 2.0 °C warming compared to *very likely* for 1.5 °C warming. Summer discharge is the only season for which reduced discharge for 2.0 °C warming is projected, owing to enhanced evaporation; however, reduced summer discharge projections are most uncertain (ranging from *more likely than not* to *likely*). Increased discharge projections are most uncertain in the Western Hudson Bay (predominantly *more likely than not* to *likely*), affirming the results of Bring et al. (2017). This is due to its relatively dry and warm climate and lowest agreement in the direction of precipitation projections. The projections indicate a shift in the seasonality of discharge across the HBDB from historical, with greatest (lowest) discharge increases projected to occur during spring (summer) across all regions.

These results show that continued increasing annual discharge into the HBC is expected, as in recent observations (Déry et al., 2016). Discharge is likewise projected to increase across other northern regions (Canadian Arctic, Québec, Eurasia, and Scandinavia) through the 21st century (Guay et al., 2015; Koirala et al., 2014; Shkolnik et al., 2017). Interannual and interdecadal variability in discharge into the HBC is largely explained by the Arctic Oscillation (AO; Déry & Wood, 2004), which brings relatively cool and dry air during its positive phase and relatively warm and moist air during its negative phase. The CMIP5 GCMs have demonstrated mixed skill in simulating the AO (Gong et al., 2017; Zuo et al., 2013). Therefore, simulations of discharge trends into the HBC may be improved with better representations of the AO in GCMs, particularly in light of projected Arctic amplification by 2100 (Barnes & Polvani, 2015).

Limitations of this study are noted. Present-day flow regulation is held constant through projections. The two largest river systems (the Nelson River and La Grande Rivière) are heavily fragmented with diversions and storage for hydroelectric generation. Although these systems have the potential to modify streamflow seasonality in the future, it is impossible to simulate changes to regulation without details of Manitoba Hydro's and Hydro-Québec's operations and predictions of future developments and export markets. A comprehensive understanding of the impacts of climate change on streamflow should consider the effects of regulation, due to its strong influence in snow-dominated regions (Arheimer et al., 2017). Projected land cover changes are not included in this modeling. Northern Canada is considered a hot spot of future ecological change (Bergengren et al., 2011; Prestele et al., 2016), which could impact both volumes and spatial patterns of runoff and evapotranspiration. Frozen soils are represented in the hydrological model; however, dynamic drainage pathways resulting from permafrost thaw are not, as is the case of most models. As thawing permafrost can modify the routing, storage, and evaporation of water across arctic landscapes (Quinton & Carey, 2008; Rowland et al., 2010), the modeling community should strive toward representing such dynamic hydrological pathways. Furthermore, these results rely on a single hydrological model. An ensemble modeling approach can account for uncertainties in model structure (Krysanova et al., 2017). Also, the Arctic-HYPE evaporation calculations depend on air temperature, prescribed extraterrestrial radiation (function of day of year and latitude) and albedo parameters with no direct input of humidity, radiation, or wind forcing. The Priestley and Taylor (1972) evaporation model is used with both downward radiation and the slope of the saturation vapor pressure curve estimated from daily maximum and minimum temperature.

Changing discharge necessitates an evaluation of existing infrastructure. This study affirms *very likely* increasing streamflow for hydroelectric generation for Hydro-Québec in the Eastern Hudson Bay region and *likely* increasing streamflow for Manitoba Hydro in the Western Hudson Bay region. Existing infrastructure should be evaluated to determine if the increased potential can be harnessed for the range of projections and if reservoirs can manage the increased flood risk. There is greater potential for higher magnitude floods, with 1.5 and 2.0 °C respectively causing 6.6% and 9.0% greater magnitude daily discharge for 1.0% exceedance probability in Western Hudson Bay and 5.1% and 11.4% greater daily discharge in Eastern Hudson Bay. Also of interest are the small, yet statistically significant, projected increases (decreases) in evaporation/precipitation (runoff/evaporation; Figures S4 and S5). Although precipitation and runoff are both projected to increase, a lower fraction of precipitation is projected to be available for use. Also of note are projected increased evaporation rates from Hydro-Québec reservoirs in the Eastern Hudson Bay region (not presented as they have not been directly validated).

Increased northern discharge impacts sea ice and biological productivity of coastal ocean systems. High HBDB river discharge years have been linked to lower salinity and increased sea ice thickness (Saucier & Dionne, 1998). With warming projected to increase the duration of the Hudson Bay ice free season (Castro de la Guardia et al., 2013), ice thickness and coverage can be impacted by the volume and seasonality of discharge among other factors. Rivers are a source of nitrate input into the HBC, but the volume of discharge is more important as it augments primary production (Kuzyk et al., 2010) and phytoplankton communities (Anderson & Roff, 1980; Harvey et al., 1997). As such, increased northern discharge has implications for global carbon budgets as coastal ocean systems are more active organic cycling sites compared to open oceans (Smith & Hollibaugh, 1993). Rising discharge may be enhanced by permafrost loss, which can also raise nutrient and sediment loads into rivers and coastal oceans (Rowland et al., 2010).

Increasing discharge has implications for hydrometric gauging in northern Canada. The HBDB is relatively well gauged south of 60°N; however, there are neither active gauges north of 65°N nor are there discharge estimates from the Surface Water and Ocean Topography satellite mission suitable for the small streams on the majority of Baffin Island (Pavelsky et al., 2014). Thus, the land discharging into Foxe Basin, the region projected to experience the greatest change, is completely ungauged. This underscores the need for additional pan-Arctic modeling.

5. Conclusion

As participants in the Paris climate agreement seek to limit GMT warming to 1.5 °C above preindustrial levels, it is important to understand the regional impacts of different warming levels. The pan-Arctic land discharging into the HBC is projected to warm at rates greater than the global mean, resulting in rising streamflow. GMT warming of 2.0 °C is largely projected to increase discharge beyond that of 1.5 °C warming, with implications of increased hydroelectric potential but also increased flood magnitudes and possible reduced summer water supplies.

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