POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Climate change reduces winter overland travel across the Pan-Arctic even under low-end global warming scenarios*

Anne Gädeke, Moritz Langer, Julia Boike, Eleanor Burke, Jinfeng Chang, Melissa Head, Christopher Reyer, Sibyll Schaphoff, Wim Thiery, Kirsten Thonicke

Leibniz Association

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NEWS · 22 SEPTEMBER 2020

Arctic sea ice hits second-lowest level on record

Heat waves, winds and thin ice contribute to a ‘new normal’ in the north’s climate.

Human access to the Arctic via the sea will improve as sea ice declines.

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER
10.1002/2016GL069315

Special Section:
The Arctic: An AGU Joint Special Collection

Key Points:
- Arctic shipping routes to open more frequently and become increasingly faster due to shorter distances and thinner ice
- Considerable interannual variability in sea route accessibility will be present for the whole 21st century
- Arctic sea route projections use calibrated sea ice results with improved spatial sea ice distributions

Supporting Information:
- Supporting Information S1

Correspondence to:
N. Melia,
n.melia@reading.ac.uk

Sea ice decline and 21st century trans-Arctic shipping routes

N. Melia[1], K. Haines[2], and E. Hawkins[3]

[1]Department of Meteorology, University of Reading, Reading, UK, [2]National Centre for Earth Observation, Department of Meteorology, University of Reading, Reading, UK, [3]NCAS-Climate, Department of Meteorology, University of Reading, Reading, UK

Abstract The observed decline in Arctic sea ice is projected to continue, opening shorter trade routes across the Arctic Ocean, with potentially global economic implications. Here we quantify, using Coupled Model Intercomparison Project Phase 5 global climate model simulations calibrated to remove spatial biases,

PNAS

New Trans-Arctic shipping routes navigable by midcentury

Laurence C. Smith[1] and Scott R. Stephenson

Department of Geography, University of California, Los Angeles, CA 90095

Edited by Ellen S. Mosley-Thompson, Ohio State University, Columbus, OH, and approved January 25, 2013 (received for review August 21, 2012)

Recent historic observed lows in Arctic sea ice extent, together with climate model projections of additional ice reductions in the future, have fueled speculations of potential new trans-Arctic shipping routes linking the Atlantic and Pacific Oceans. However, numerical studies of how projected geophysical changes in sea ice will realistically impact ship navigation are lacking. To address this deficiency, we analyze seven climate model projections of sea ice properties, assuming two different climate change scenarios [representative concentration pathways (RCPs) 4.5 and 8.5] and two vessel classes, to assess future changes in peak season (September) Arctic shipping potential. By midcentury, changing sea ice conditions enable expanded September navigability for common open-water ships crossing the Arctic along the Northern Sea Route over the Russian Federation, robust new routes for moderately ice-strengthened (Polar Class 6) ships over the North Pole, and new routes through the Northwest Passage for both vessel classes. Although numerous other nonclimatic factors also limit Arctic shipping potential, these findings have important economic, strategic, environmental, and governance implications for the region.

best reproducing observed total sea ice extent and volume over the period 1979–2010 (5). The seventh GCM (CCSM4) was selected owing to its realistic representation of Arctic sea ice interannual variability and radiation physics (4, 12).

To control for seasonality, simulations were restricted to the peak navigation month of September, when open water reaches its maximum annual extent. For each September of every year, the optimal least-cost navigation route, narrowly defined as the most temporally expedient navigation course minimizing total voyage travel time while also avoiding sea ice sufficiently thick and/or concentrated so as to obstruct a particular vessel class, was identified for hypothetical ships seeking to traverse the Arctic Ocean between the North Atlantic (Rotterdam, The Netherlands and St. John's, Newfoundland) and the Bering Strait (*Materials and Methods*). Note that the word optimal, as used here, refers simply to any technically feasible navigation route that most minimizes total transit time (i.e., through optimization of geographical distance with advantageous sea ice thickness and concentration conditions), with no consideration of economic, regulatory, jurisdictional, or other factors also important to transit time and/or route selection. All simulations were obtained in a Lambert

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Human access to the Arctic via the sea will improve as sea ice declines.

But what about overland access and transport under climate change?

Overland winter travel in the Arctic

Only very little permanent infrastructure exists in the Arctic

Overland travel in the Arctic is most cost effective and least environmentally damaging during winter

Crucial for

- infrastructure development and maintenance (e.g. transportation of heavy equipment)
- natural resource exploration and extraction
- supplying remote communities

Two modes of winter travel:

off-road overland travel, ice roads

Example of a constructed ice-road on the North Slope of Alaska

Traces of seismic trails (for oil and gas exploration) across the tundra

Snow pre-packing activities prior to ice-road construction

Indices for assessment changes in winter tundra travel

Overland Travel Days (OTDs)

Prerequisites: Ground is frozen (soil temperature < soil-type dependent ground freezing temperature in upper 50 cm of soil column) and snow covered (>20 cm)

Ice Road Construction Days (IRCDs)

Prerequisites: Ground is frozen and very cold mean daily air temperatures (-28°C)

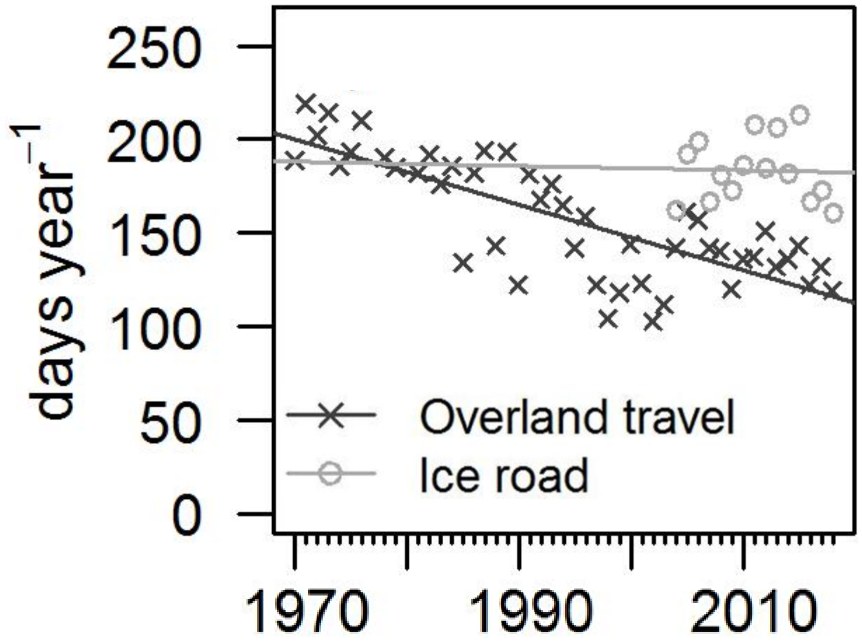
Assessment carried out using ISIMIP2b simulations that contributed to the permafrost sector (ORCHIDEE-MICT, CLM4.5, LPJmL, JULES)

Domain: Pan-Arctic - continuous permafrost region north of 60° latitutde

Time period: 1860-2100

Model evaluation for Alaska (>60°N, continuous permafrost)

What changes are already observed (1970-2018)?



- Decrease of overland travel season by 1.7 days year^{-1} on the North Slope of Alaska over the period 1970-2018 (~80 days in total, on average 157 days year^{-1})
- The ice road season remained nearly constant (2004-2018)

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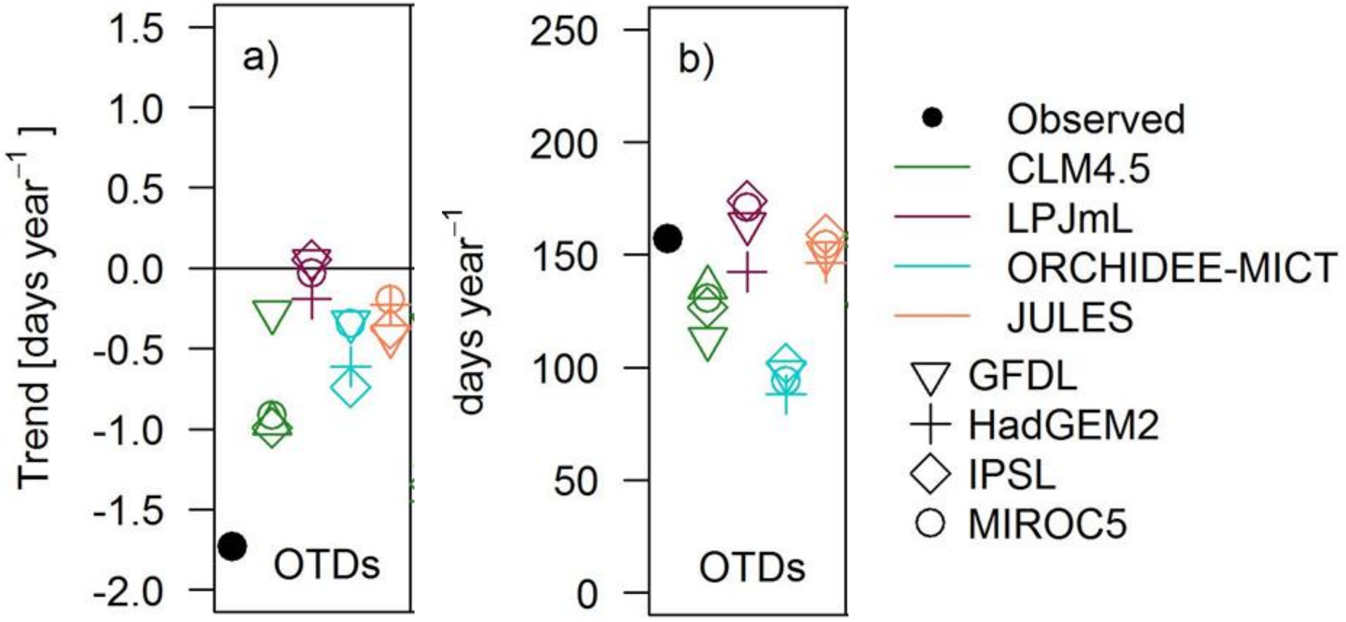
Model evaluation for Alaska (>60°N, continuous permafrost)

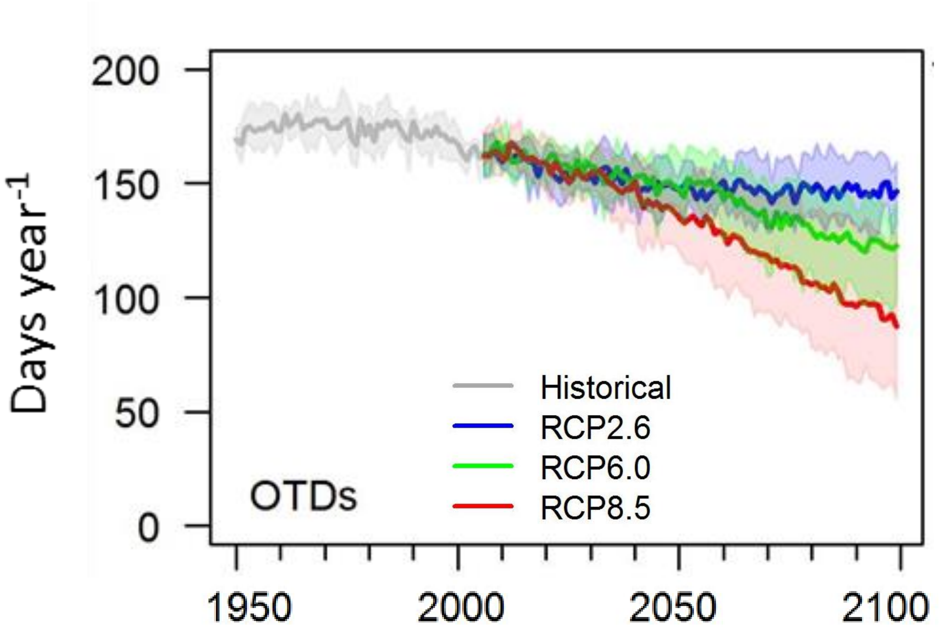
How well do the models reproduce the observed changes (1970-2018) ?



- The LSMs reproduce the decreasing number in annual OTDs, but underestimating the trend
- Deviation to average number of OTDs (157 days year^{-1}) ~ ranges from -61 days year^{-1} (ORCHIDEE-MICT) to +6 days year^{-1} (LPJmL)

Changes in Overland Travel Days (OTDs) across the Arctic

Pan-Arctic average (1950-2100)



Reduction in OTDs compared to the reference (1971-2000)

- Near future (2021-2050): by average -13%
- Far future (2070-2099):
  - → -15% (RCP2.6)
  - → -26% (RCP6.0)
  - → -40% (RCP8.5)

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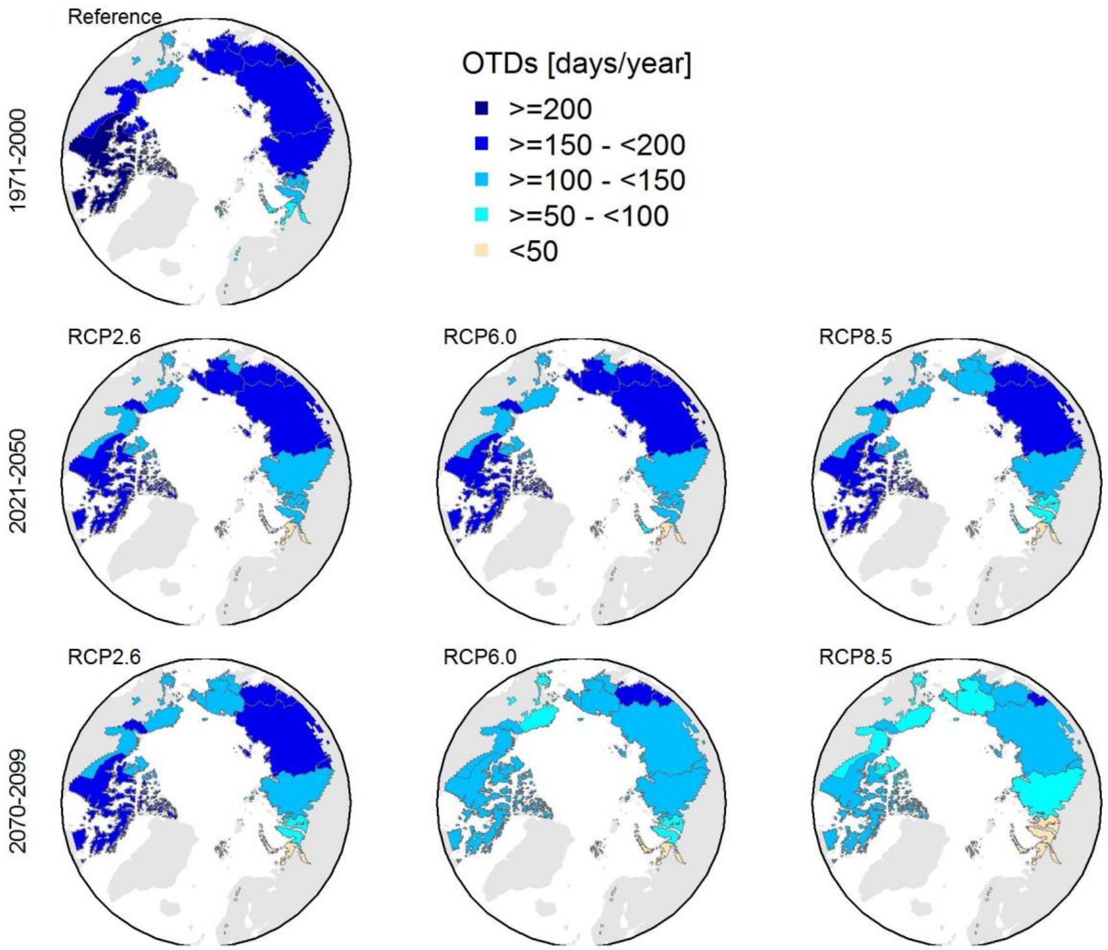
Changes in Overland Travel Days (OTDs) across the Arctic



- Most vulnerable to climate change: Alaska (USA), the Northwestern Russian regions (Yamalo, Arkhangelsk Oblast, Nenets, Komi, Khanty-Mansiy), Northern Europe and Chukotka
- Most resilient to climate change: Eastern Siberia (Sakha (Yakutia), Khabarovsk Krai, Magadan Oblast

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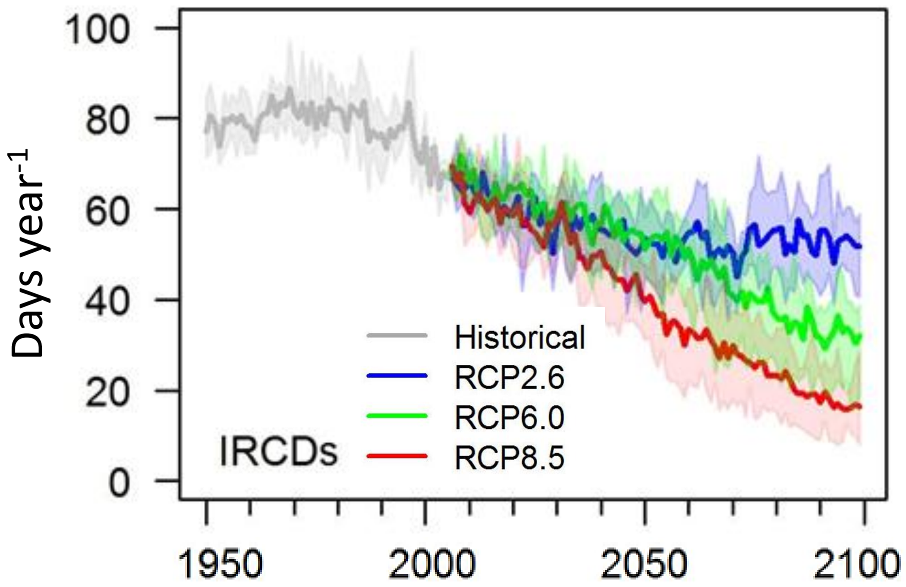
Changes in Ice-Road Construction Days (IRCDs) across the Arctic

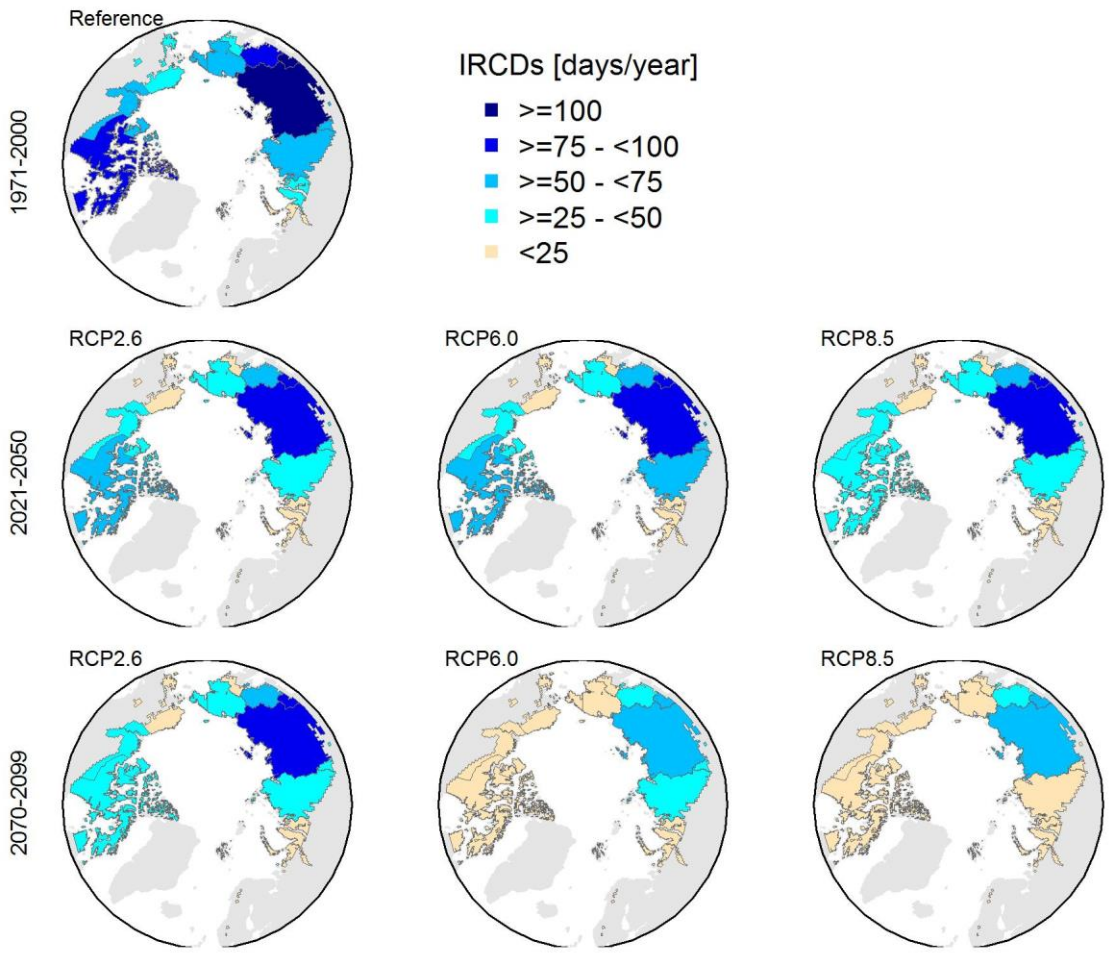
Pan-Arctic average (1950-2100)



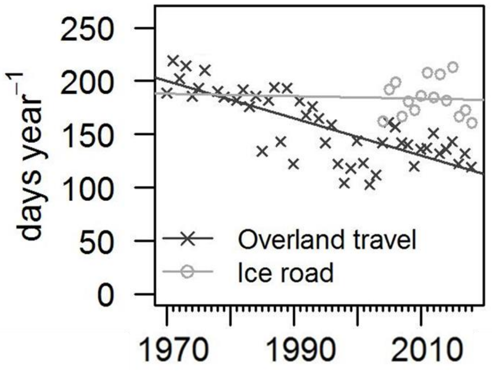
Reduction in IRCDs compared to the reference (1971-2000)

- Near future (2021-2050): by average -30%
- Far future (2070-2099):
  - → -33% (RCP2.6)
  - → -54% (RCP6.0)
  - → -72% (RCP8.5)

Changes in Ice-Road Construction Days (IRCDs) across the Arctic



- Similar patterns compared to OTDs
- Stronger decline already by mid-century compared to OTDs
- To a certain degree, climate induced changes in IRCDs may be counterbalanced by improved engineering techniques –> increasing costs



Summary

- Climate will considerably impact winter overland travel across the Arctic with large socio-economic consequence (for industries and remote villages)
- Stringent climate mitigation policies have the potential to stabilize the impact of climate change on winter overland travel after 2050
- Even under RCP2.6, substantially reduced winter overland travel (OTDs -13%, IRCDs -30%) -- implying a severe threat to livelihoods of remote communities and increasing costs for resource exploration and transport across the Arctic
- By end of century, differences (based on RCPs) in OTDs/IRCDs large
- Change in OTDs is most pronounced in the shoulder season, particularly in autumn

Thank you!

Anne.Gaedeke@pik-potsdam.de