Divergent long-term trajectories of human access to the Arctic

Gunnar Sander, April 2012

1. Project/publication	Stephenson, S.R., L.C. Smith and J.A. Agnew 2011: *Divergent long-term trajectories of human access to the Arctic*. Nature Climate Change 1, 156–160 (2011), doi:10.1038/nclimate1120 URL: http://dx.doi.org/10.1038/nclimate1120 Supplementary discussion with presentation of model and better maps: http://www.nature.com/nclimate/journal/vaop/ncurrent/extref/nclimate1120-s1.pdf
2. Initiator	The authors, with financial support as referred in acknowledgements.
3. Objectives	To make quantitative assessments of how climate change may affect transportation systems in the Arctic, both at sea and on land. The background for the analysis is that the sea ice is an obstruction to maritime transport in the Arctic. Access is best achieved in summer. On the other hand, transportation on land in many Arctic territories is best achieved in winter when wet and/or environmentally delicate surfaces freeze sufficiently to provide a viable driving surface. “Winter roads” are then temporarily constructed across frozen grounds, rivers and lakes. Whereas many analyses of Arctic climate change have pointed to changes in accessibility due to melting sea ice and thawing grounds/increased snow depths, there have been few attempts to quantify such changes.
4. Geographical delimitation	The Arctic north of 40^{o}N.
5. Time horizon	Mid century. More precisely: changes in 2045-2059 compared with baseline 2000-2014.
6. Thematic focus	Changes in accessibility on Arctic transport systems due to climate change.
7. Images of the future	Results are shown for what can be seen as one scenario, resulting from the model calculations (see method). Major conclusions are: By 2045-2059, a broad pattern of declining winter road accessibility potential on land and rising ship accessibility potential in the Arctic Ocean is observed in all simulations. Most of the Arctic Ocean basin becomes newly accessible to Type A class vessels for eight months of the year (July-February). Losses in winter road potential occur from October to May. Little change is projected between July and September as these months are already too warm to support winter roads today. Reduction of accessibility in km^2 land climatically suited for winter road construction is calculated. The eight Arctic states are expected to suffer declines in accessible areas inland between –11 to – 82%. Mining, energy and timber industries will face shorter time windows for transportation of equipment and products and risk becoming unecon-omic in some areas. Increased transport costs due to shift to air transport and building of permanent roads are other likely consequences. Similar calculations are done for km^2 increased accessibility to the Exclusive Economic Zones at sea. The Arctic coastal states will experience from +5 to +28% increases in accessible areas for the existing EEZs. The Northern Sea Route, Arctic Bridge (Churchill - Murmansk) and North Pole routes are projected to become fully accessible from July–September, averaging 11, 15 and 16 days to traverse, respectively. The Northwest Passage will not. Travel times to nearest settlements are also calculated. It increases in many inland

	areas (Northern Canada and Alaska, Russian West Siberian lowlands and Far East), whereas it declines (faster travel time) in the ocean. Changes are strongly seasonal; more on land than at sea, where sizeable areas will experience faster travel year-round.
8. Key driving forces	Climate change. The study is based on the A1B SRES scenario.
9. Uncertainties / wildcards	No particular uncertainties or wildcards are mentioned. In the end of the article, the authors state that this is a first attempt to adapt classic transportation accessibility modelling to address physical changes in landscapes and oceans due to climate change. Among the numerous factors that they say can improve the modelling, they mention improvements in sea ice modelling, improved spatial resolution of the CCSM3 climate model (ap 1,4^{o} today), inclusion of climate induced effects on permanent infrastructure (deeper snow accumulation, soil destabilization, changes in surface water extent) and more realistic assumptions about transport system and eligible vehicle.
10. Accomplishment and collaboration	Research work by the authors.
11. Method	The authors have developed a new modelling framework they call the Arctic Transport Accessibility Model (ATAM). This adapts a transport model to integrate projections of air temperature, snow depths and sea ice from the Community Climate System Model 3.0 (CCSM3). Input data to the transport model from CCSM3 were calculated under the A1B SRES-scenario averaged over two 15-year time periods (2000-14 and 2045-59). The transport model also included static datasets of land cover, topography (elevation, slopes), hydrography (lakes, rivers), existing transportation infrastructure (permanent roads, rail) and locations of human settlements. These latter data were kept unchanged to isolate the effects of climate change, even though the model can be run also with changes in for example infrastructure or hydrography. Accessibility simulations were done for: • Winter road suitability: a 2000 kg passenger vehicle and criteria for elevation, slope, surface temperature and snow depth for crossing land, and ice thickness sufficient to support the vehicle on rivers and lakes. • Inland waterways: an ordinary vessel without ice-strengthened hull. • The Arctic Ocean: a Type A vessel; below Polar Class icebreakers, but capable of limited icebreaking.
12. Sources of information	Not specified in the main article that I have read apart from the reference list, that include both scientific publications and news articles. Details are probably included in the supplementary discussion.
13. Strengths	The study encompasses various disciplines put together in one analysis. The modelling combining a global climate model with an access model is innovative. Results seem highly relevant for further strategic discussions of future developments of Arctic transport networks and economic activities.
14. Weaknesses	Whereas the results of the simulations seem intuitively plausible, one must be aware of the limitations in the application of one climate scenario, one climate model and the other assumptions. Rather than a precise prediction of what will happen, the study should be viewed as *one* possible scenario for future access among a range of other possible outcomes. An improved discussion of uncertainties and sensitivity analysis of the results would have improved the article.
15. Attention and significance	The publication in Nature online has probably contributed to good dispersion of results.
16. Relevance for the Fram Centre	High relevance for study of future transport developments.