LOOKING FORWARD LOOKING BACK

Building Resilience Today

Community Report

Kotlik, AK

September 30 - October 2, 2019

Village of Kotlik
P.O. Box 20210
Kotlik, AK 99620
907 899-4326 Phone
907 899-4790 Fax

Kotlik Yupik Corporation
4th Birch Street
Kotlik, AK 99620
907-899-4634 Phone

APIA
ALEUTIAN PRIBILOF ISLANDS ASSOCIATION

AK CASC
Alaska Climate Adaptation Science Center

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ACKNOWLEDGEMENTS

Community Partners:
Village of Kotlik and Kotlik Village Council - Philomena Keyes, Victor Tonuchuk Jr.
Kotlik Yupik Corporation - Lorrena Prince

This report describes the results of a community visit to Kotlik that included multiple meetings. The *Looking Forward, Looking Back: Building Resilience Today* (LFLB BRT) project leaders would like to thank the community partners, community leaders, and community meeting participants for their participation and contribution to this project and for sharing their knowledge and wisdom. We would also like to thank them for their time and support during the community visits and meetings that were central to the success of this work.

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*Corresponding Author: jlittell@usgs.gov

Layout and Design - Michael Delue

Village of Kotlik
P.O. Box 20210
Kotlik, AK 99620
907 899-4326 Phone
907 899-4790 Fax

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COMMUNITY DESCRIPTION*

Kotlik is community located in the western part of Alaska and lies in the northern part of the Yukon River Delta, at the confluence of the Kotlik and Little Kotlik Rivers. Kotlik's traditional place name is Qerrullik, which means "pair of pants" in Yup'ik, and is named for the adjoining river's shape. The current population is 650. Kotlik is governed by three federally recognized Tribes, the Village of Kotlik, the Native Village of Hamilton and the Village of Bill Moore's Slough. Kotlik incorporated as a second-class city in 1970, and has a city government. The 1971 Alaska Native Claims Settlement Act established the Kotlik Yupik, Nunapiglluaq and Kongnikilnomiut Yuita corporations.

There is no road access to Kotlik, instead small commercial aircraft is used to get in and out of the village year-round and the village is accessible by barge. Residents use the river for commercial and private travel. There is an extensive boardwalk system in the community. Local residents travel in privately owned boats during the summer and use snow-machines and small all-terrain vehicles for travel during the winter. The village connects to many rivers and sloughs, and the Bering Sea, providing ready access to key subsistence resources, such as a variety of marine life and large game from the land that support a local mixed subsistence-cash economy. Kotlik is one of the last villages to still use a traditional atlatl, or spear thrower, to hunt seals, and many Kotlik women actively provide for their families and the community by driving boats, hunting, and fishing.

With a warming climate, Kotlik is highly threatened by the multiple effects of frequent storm surge, permafrost degradation and erosion that are rapidly and significantly impacting health and safety, infrastructure stability, travel and transportation, food security, the practice of Yupik traditions and a perpetuation of local cultural knowledge.

*Compiled from P. Keyes' draft community description during the LFLB BRT Intensive Work Session, March 5, 2020. Anchorage, AK and the State of Alaska Division of Community and Regional Affairs Community Database Informational Portal.

PROJECT DESCRIPTION

The Alaska Climate Adaptation Science Center (AK CASC), in partnership with the Aleutian Pribilof Islands Association (APIA), designed the Looking Forward, Looking Back: Building Resilience Today (hereafter 'BRT') project as a series of trainings and workshops with tribal community leadership and members. The overarching goal of the project was to collaboratively develop the Indigenous knowledge and western science knowledge for adaptation planning. We worked with five community teams consisting of up to four leaders from communities that chose to participate in the project: Iliamna, Kotlik, Kwigillingok, Quinhagak, and St. Michael. Community teams were developed through the application process and the project duration. Community teams were encouraged to have involvement from multiple governing bodies within the community that could include the Tribal Council, the city governments, and the village corporations. The project title, with its references to the future (Looking Forward), past (Looking Back), and present (Building Resilience Today), refers to the idea that adaptation planning relies on all three perspectives. Equally important, however, is the dialogue to exchange past and present information, context, and what we expect in the future. Accordingly, two training sessions held at the International Arctic Research Center in Fairbanks, Alaska at the beginning and near the end of the project were developed to provide community team interaction with each other and with university and federal science partners. The project team also traveled to the partner communities and held a series of onsite events with community members to document locally-relevant information and share climate science tailored to the needs and conditions of each community. This report represents the community information shared during those onsite events. The Meeting Announcement (page 5) shows the date and description of the outreach events.

The purpose of these events was to: 1) facilitate mapping of a Traditional Use Area to refine an area for climate projections; 2) construct current and past seasonal Subsistence Calendars to identify important species and times of the year; 3) document Indigenous and local knowledge from current community members about environmental changes they have observed over their lifetimes; and 4) assist with documenting what the community perceived to be climate-related issues through photos and interviews. The agenda of the visits was co-produced with the community team. In each community, the community team and the project team co-hosted an open-to-the-public meeting and met with various groups. The community team advertised the meetings by posting community fliers, making announcements on the community radio, and reaching out to individuals that would contribute to the engagement discussions. Each community meeting focused on activities to develop seasonal Subsistence Calendars, map Traditional Use Areas, and document observed environmental changes. Community members spent time at stations dedicated to each of these activities working with project team members. The project team also met with various groups of individuals that included village corporation, tribal council, and city representatives where additional information about observed environmental changes was gathered. This community report presents some of the information developed in these activities.

MEETING ANNOUNCEMENT

CLIMATE CHANGE IN KOTLIK

Share your experiences.

A team of Kotlik community leaders, along with the Aleutian Pribilof Islands Association and the Alaska Climate Adaptation Science Center, invites you to attend a series of community events on **September 30th- October 2nd** to discuss climate change impacts and gather information on changes to local lands, waters, and fish and wildlife.

Schedule

Event	Time & Location	Description
Work session with local community team	Monday, Sept. 30th, 3 - 5pm Location: Tribal office	Review schedule of events and activities with community team.
Meeting with City, Tribe, and Corporation leadership	Tuesday, Oct. 1st, 1pm Location: City Hall	Visiting partners and community team meet with city, tribal, and, corporation leadership.
Community meeting	Tuesday, Oct. 1st, 7pm Location: City Hall	Hear about future climate change impacts projected for the Y-K area and share information on community change.
Outreach to high school and junior high students	Wednesday, Oct. 2nd, 9 - 10am Location: Kotlik School	Explore the Arctic food web through Eco-Chains card game.

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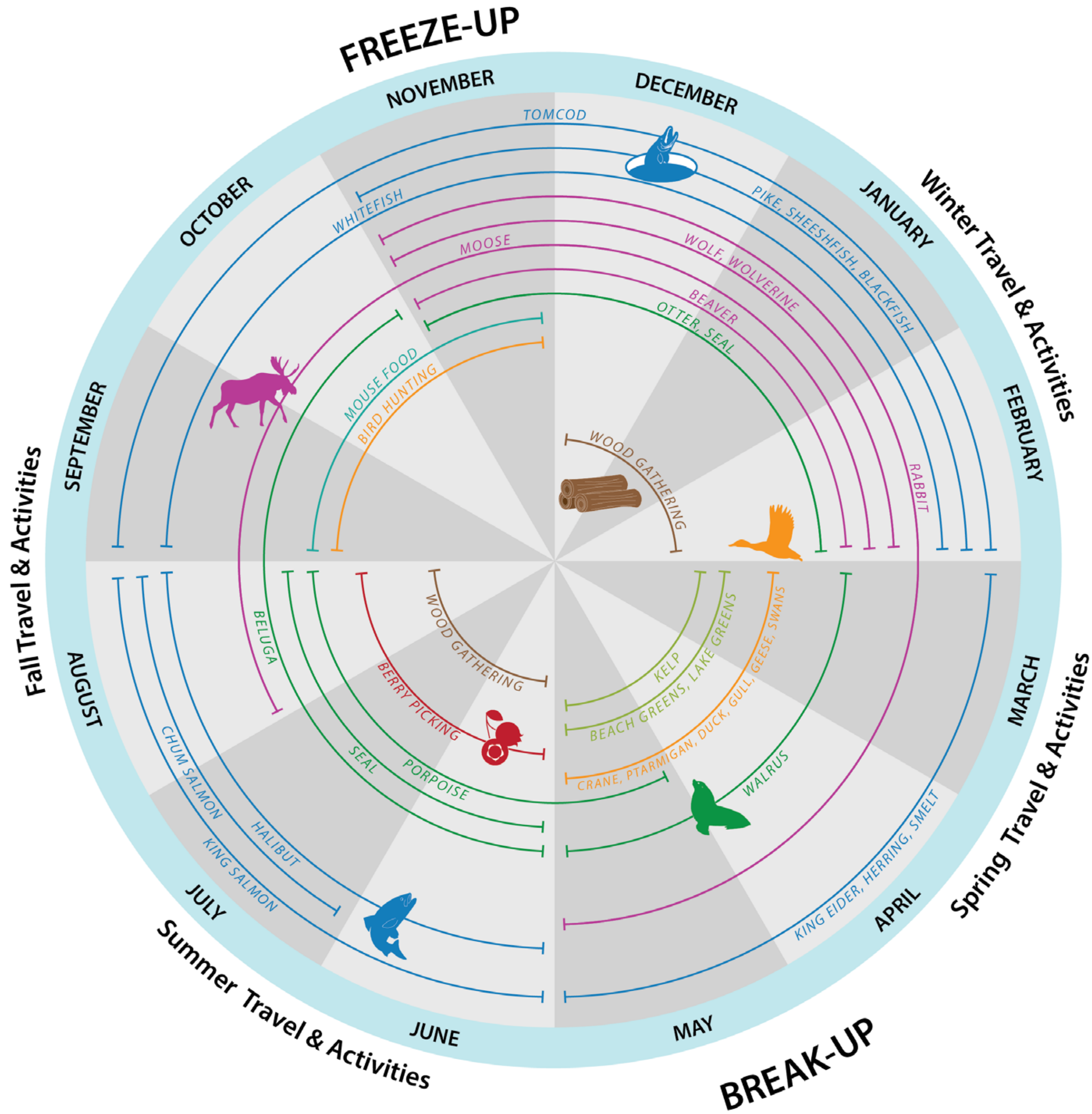


SUBSISTENCE CALENDAR

At the Subsistence Calendar station participants worked on two separate sheets of paper to list the many plant, marine mammal, fish, bird and animal species they rely on and harvest. One list focused on the current subsistence species while the other list focused on subsistence species in the past. After the list of species had been completed, participants then placed the species on a circular calendar during the time of year the species were harvested. In order to document observed changes, participants were asked to list past and current subsistence hunting or gathering practices, identifying any observed changes in the arrival, harvesting or hunting time of key species. This exercise provided an opportunity to recognize the variety of species that each community depends on and has concerns about. Participants also had further opportunities to share brief stories and observations of change.

KOTLIK COMMUNITY MAP

Kotlik community members working on the Kotlik community map.

Each Alaska Native community in Alaska historically had a Traditional Use Area, or traditional territory, prior to the 1971 passage of the Alaska Native Claims Settlement Act (ANCSA). Alaska Native communities still have common use areas that may be based on current land use and ownership, or historical land use. For this exercise, we asked communities to identify these areas. In addition, we asked communities to identify anywhere they traveled by foot, boat, ATV, or snow machine for purposes beyond subsistence that included potlatches, basketball tournaments, and other travel.

At the Traditional Use Area activity station, the project team provided the community teams and participants with large scale maps of the land and area around their villages (United States Geological Survey topographic maps) and various colored markers. Working in their teams, they identified a use area by drawing directly on the large paper maps. Each community constructed their own legend that described the map they drew. The project team then used these maps to develop detailed regional climate projections for each community. Many communities identified general subsistence areas and routes taken to access these areas and other communities.

Footprint of Kotlik Tradition Use Area as defined by participating community members.

DIGITIZED COMMUNITY MAP

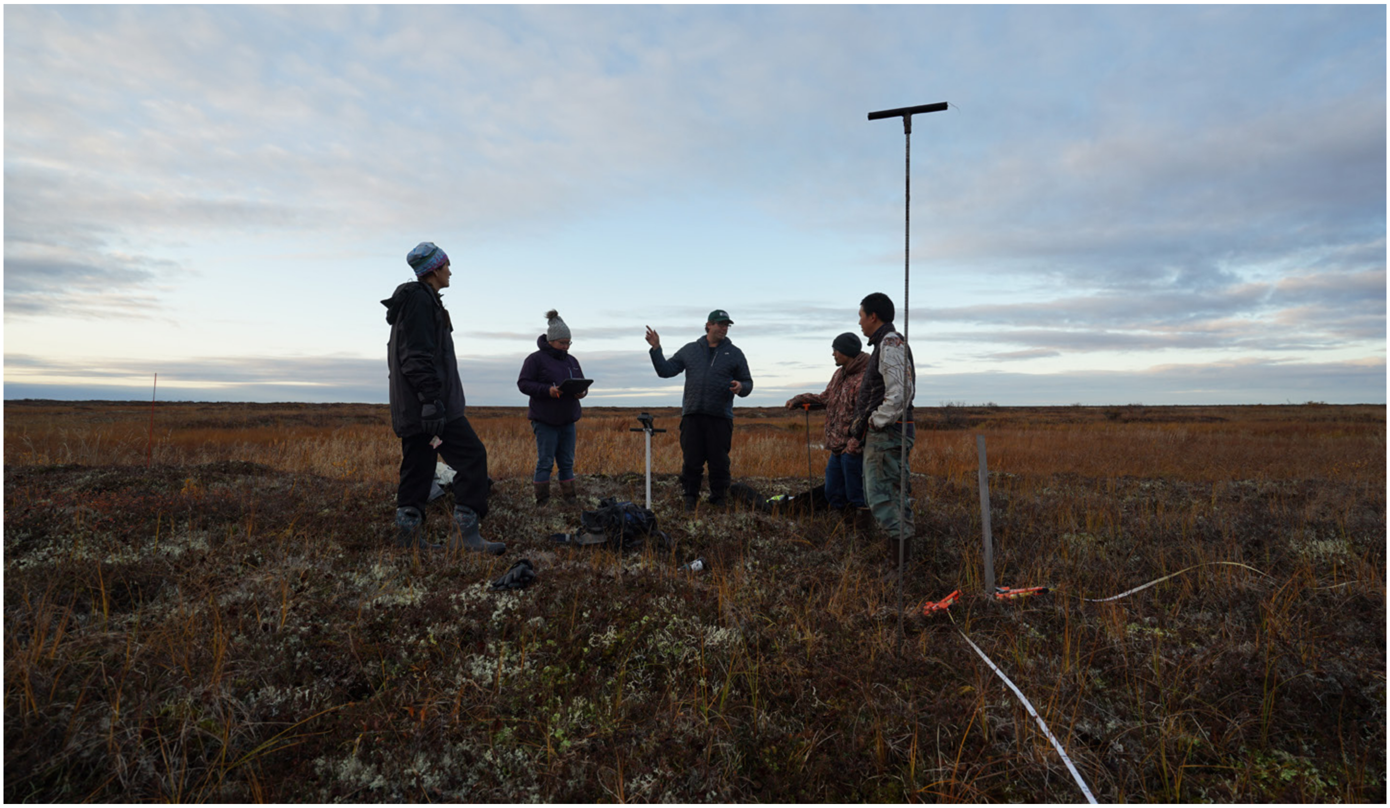
Kotlik community members working on the Kotlik community map.

The community members outlined a Traditional Use Area during community meetings. Areas and trails were drawn on a printed USGS map. These were transferred to a digital representation using computer Geographical Information System (GIS) software (ESRI ArcMap within the GIS). A 'footprint' of the area was also created that encompassed the entire Traditional Use Area. Participants have a digital version of their Traditional Use Area for future purposes. These digitized 'footprints' were then used to refine the spatial extent of the climate projections averaged for the region of interest.

ENVIRONMENTAL OBSERVATIONS

During the public community meetings and the smaller group meetings during the community visits, participants were asked if they had observed any environmental changes throughout their lifetime. These observations were documented and attributed by the project team during the community visit. After the community visit, project team member R. Toohey organized observations into themes by one or more topics (traditional methods, subsistence, weather and climate, etc. – see below, pages 10-15) using a process called 'coding'. The same observation could belong to several different themes as long as it pertained to the theme in some way. These themes were developed from the observations so that community members could quickly find Indigenous and local knowledge that pertained to a certain subject. The community teams reviewed and agreed on these themes when they reviewed the draft documented observations during the second team training (see Project Description above, page 3).

Notes on observations were taken rapidly by hand in a necessarily informal form and were reviewed and approved by the community. In the interest of preserving the words of the community as closely as possible to this original form, editing in the following section was kept to a minimum and only utilized to preserve space and increase readability.



Victor Tonuchuk, Jr., Philomena Keyes, Bernard Hunt, Malinda Chase, Jeremy Littell, and Ryan Toohey traveling out to do Active Layer Network monitoring near the cemetery.

OBSERVATIONS

Collecting active layer depths at the Active Layer Network sites.

Weather & Climate

- For three days it was almost 90 degrees F. We usually have a high of 80 degrees F. - Benny & Winnie
- Warming air is moister. - Winnie
- Our winter is getting shorter and shorter - Benny

Snow

- Snow used to be taller than me, lots of snow. Used to get dug out. Grasses height tells how much snow. - Unattributed
- In the 1950s, a long time ago, we used to have big snows. Snowbanks would reach over my height and cover doorwars. There would be 'pipes' in the snow to windows. - Winnie, Hilma & Mary Andrews
- Now it will snow, melt, and become solid ice. - Jamal

Ice

- No more ice along the coastlines. St. Michael didn't have any ice. - Winnie
- No ice all winter long, even Stebbins didn't have ice. Early breakups. River and ocean ice don't get thick anymore. - Benny
- Yukon River travel with ice is more risky. - Victor
- Ice thickness not as thick. - George
- Thin ice for potlatches. Ocean ice so thin, you can feel the waves under the ice. - Hilma
- Always use to go to St. Michael and Stebbins on ocean ice. Now, we use land routes. - Lorrena
- Ice fishers go up Yukon, travel now   is scary because of thin ice. - Hilma
- River ice was around longer than ocean ice - Philomena
- No more exciting icebreak – used to be big event. "Pogghkkkghhkkkk pogghkkkghkkkkk". Happening from the ocean and river now. Melts in before melts down. - Unattributed
- Easier to pick ice – to break through - Unattributed

Wind

- More winds. - Winnie

Vegetation

- At camp, lots more grass, lots of tree growth (dwarf birch); growing taller grasses. - Benny

Water

- Some ponds, lakes dried up. - Hilma
- Water temperature really high, lethal for fish. - Petra
- Orange brown murky stuff on top of the water. - Lorrena

Flooding

- Lots of water everywhere, more flooding, "Keep having lots of water - flood water" - Winnie
- Flooding is coming in different month (fall/spring). Mid-winter floods and August flood. - Andrew
- No mouse food, no mice-all drowned-even black berries didn't grow. - Winnie
- Around my house full of water-grasses getting taller-lots of snails, fish swimming around. - Hilma
- I'm kind of not looking forward to November. That's when we have floods. Especially with all the rain we have had. - Philomena
- This side (school side) is higher ground. During the last really big flood (2013), Victor came and brought us up here before the flood. During the flood, the current was so strong that we almost lost two people. The water pushed a four wheeler off the board walk with an Elder on it! And the water current was so strong that you could hear it moving ice underneath the boardwalk. It destroyed the infrastructure. Water was off for two years in some parts of town. - Unattributed
- I don't like where Bucky is staying with lots of little kids – it's scary. How come they didn't put it up like these other houses? I guess they didn't know about flooding then. - Mary Andrews

- It is kind of scary. We have swampy ground, flooding, high rate of change. I almost lost my boy. He was in waders and pushing a tote. His waders filled with water. Six people nearly died. - Winnie
- The Elders used to tell us stories – when they had really bad floods, when the ice piles up and comes in from the ocean, that's the most dangerous time. - Unattributed

Travel

- November till last part of May for winter travel. Early breakups. River and ocean ice don't get thick anymore. - Benny
- Yukon River travel with ice is more risky. A couple years ago someone's snow machine was having problems, backfired and started a small grass fire. - Victor
- By beginning of May, we were going by boat. We usually don't go by boat till June. - Unattributed
- This year they had the ocean, from Stebbins and St Michael, the ice went out so early – most of the winter, they had no ice. St Michael is worse than Stebbins because the ground was brown – no snow. - Unattributed

Land

- Land is getting scarier to walk on. When I was digging, there was so much water in the hole. - Winnie
- Where I used to walk, it's getting really swampy. - Unattributed

Erosion

- High banks from erosion, mud slides, cave ins along the river, dripping water, on the coast and up the Yukon River. - George

Subsistence

- We've seen things earlier than before, fish, animals, plants. - Winnie
- Our subsistence resources are getting scarcer and scarcer - HIlma
- "Anything that the animals eat, we can eat." - Winnie
- Buttercups blooming in November (2018). We eat them before they flower. Not long after, they died. I got happy, then I got sad. - Unattributed

Salmon

- The summer Chums were early then late. The Kings and Chums didn't mix. - Hilma
- King salmon come in first. Usually summer chums come in after the Kings but they didn't come. - Benny
- Water temp really high, lethal for fish - Petra
- Some fish kills, "dead fish floating by" - Winnie
- Fish had pus, more parasites. - Winnie & Victor
- Mixed quality of fish (summer chums). - Winnie
- Catching Kings, chums, pinks, reds, white fish all at the same time (subsistence). Maybe hanging out in cooler waters. - Victor
- Really hot, lots of flies, but they didn't lay eggs. - Benny

- Not enough air flow for fish drying-some fish spoiled. - Philomena
- Fish aren't right,-more puss, liver is bad. - Winnie

Other Fish

- Herring kelp – hard to find – herring that spawn on kelp. - Unattributed

Small Mammals

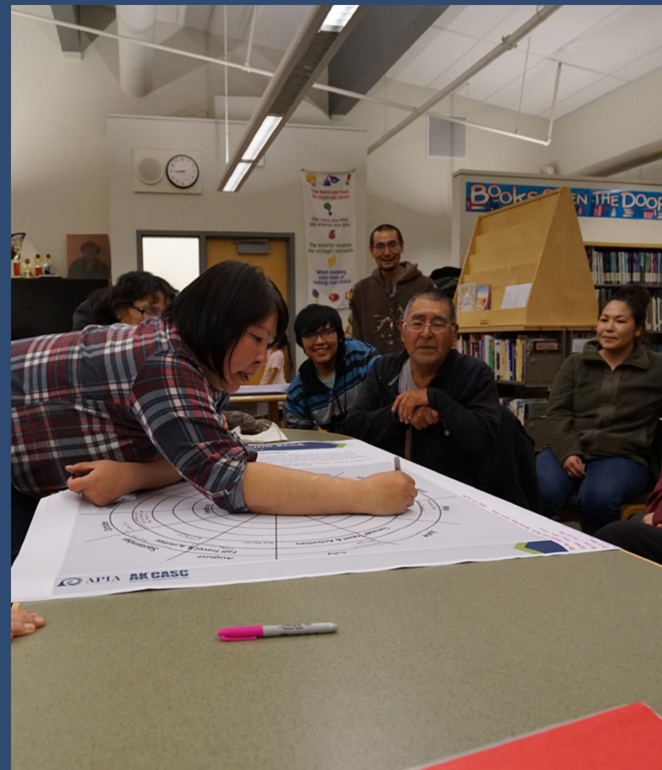
- Muskrats reappearing, but no rabbit after 2013 flood. Used to be lots of snipes; we don't even see them anymore. We don't have rabbits like we used to. - Unattributed

Muskox

- There was a muskox the last couple years – near Hamilton. - Unattributed

Caribou

- Used to have caribou that came through, but they haven't for many years (1970s-1980s) - Unattributed



Kotlik community members developing a subsistence calendar.

Moose

- More puss, botflies in moose. - Winnie & Philomena
- Moose showing up this year. Used to have to go to hills – now they're everywhere (moose). - Unattributed

Berries

- Little black berries. - Lorrena, Philomena & Winnie
- Stebbins/St. Michael-lots of blackberries right now. - Hilma
- Lots of cranberries. - Lorrena
- Black berry picking usually occurs after first frost. - Benny
- Uneven ripening with mixed berry quality, tundra very dry. - Lorrena
- Mixed sized berries. Some were ripe and some hard. Salmonberry flowers in May this year, usually in June. - Unattributed

Birds

- Birds came early (April); hardly any. - Winnie
- Not singing as much. - Benny
- Starting to see eagles chasing away ducks. - Winnie
- Eagles are usually further up river. Migratory birds patterns changed-arrived early, staying later. - Victor
- There are no seagulls, "they are all in Emmonak (laughter)". Rabbits/ptarmigan not too many, Never see woodpecker. More owls. Another bird, osprey? (grey and black) - Unattributed
- Eggs were early this year in the third week of May. - Unattributed
- We haven't seen ptarmigans since the 2013 flood. We only get them up in the hills. Ptarmigan and rabbits are getting hard to catch. Elder ladies used to snare them close by.
- We see animals, especially birds, that we haven't seen for a long time, but starting to see them again. Owls upriver – black owls. Bigger eagles. A new eagle too – not bald eagle, not young eagle.

Seals

- This year, we had a spring seal die-off. - Winnie
- Lots of dead seals, lots of dead baby seals. - Mary Andrews
- Ringed seals found in/on top of river ice (rather than ocean). River ice was around longer than ocean ice. - Philomena

Traditional Methods

- There was not enough air flow for fishing drying. Some fish spoiled this summer. - Philomena
- We had a wet summer. We didn't dry fish. We put them in the smoke house right away. We used willows for smoking. - Benny
- Straight to smokehouse. Turned out good, lots of work (needed to flip fish while drying). - Mary Andrews

Frogs

- Lots of frogs around. - George
- Frogs are getting bigger. - Benny

Infrastructure

- Buildings shake from airplanes and vehicles. The ground is sinking. - Winnie
- Stuff sinking in the tundra behind school. - All
- Recently had a fire drill, 50 students on the board-walk, started sinking into the tundra. - Jamal

Fire

- A couple years ago someone's snow machine was having problems, backfired and started a small grass fire. - Victor
- Lots of smoke from fires around St. Michael. - Win-nie

Adaptations

- Wet summer, didn't dry fish, put them in the smoke house right away. Willows used for smoking - Ben-ny
- Straight to smokehouse, turned out good. Lots of work (needed to flip fish while drying). - Mary Andrews

Insects

- New big black beetle. - Lorena
- Spring time (during egg hunting) ponds looked like they had some kind of dark gas above them (May), it was all mosquitoes. - Philomena
- Really hot, lots of flies, but they didn't lay eggs. - Benny
- We found bumble bees in January. - Heidi

Miscellaneous

- If you miss the season, you miss out; you got to go right now. Right now.
- Beaver/mice will let the animals know. - Winnie
- Elders told us we would start to see things we never saw before. They also told us we'd be talking to people on the other side of the world. - Unattributed
- Kotlik river used to be narrow enough to talk across (or throw rocks across the river), but it is much wider now. - Unattributed

Bernard Hunt on the way to the Active Layer site.

SNAP ONLINE TOOLS

Overview

The second Fairbanks training (see project description, page 4) introduced community teams to online climate information tools developed by The Scenarios Network for Alaska and Arctic Planning (SNAP) at University of Alaska Fairbanks, where the training was held. The goal of these sessions was to introduce community team members to how they might use these tools to develop information for their planning efforts and to learn more about potential impacts in their regions. For this report, the region around each community was considered and a specific narrative for that region was developed to illustrate the potential changes and impacts indicated by each tool. The following pages illustrate the results from each tool for Kotlik.

To explore how climate change might affect you, use the SNAP web tools at https://www.snap.uaf.edu/tools to get a hands-on, user-friendly overview of how climate change may affect regions or resources of concern to you. Many of these tools were introduced during the BRT Training 2 in Fairbanks. All of them can be freely shared. The summaries below help explain the results from each tool for Kotlik.

Questions & Feedback

SNAP is always seeking feedback about the usefulness of our online tools, and about the way we share climate change information. As you read through this document and explore these online tools, it may help to keep following questions in mind – and to think about how your feedback might help us improve:

1. How do changes in average temperatures affect your experience on the land in both the short-term and the long-term? Are short-term effects such as extremely hot days more important, or are long-term trends such as loss of permafrost and river ice more important?
2. What effects that you are experiencing can be linked to changes in vegetation? Which aspects of climate (e.g. hotter summers, fewer cold winter days, drying soils) do you think are most important in causing these changes in vegetation?
3. Is loss of sea ice important to your community? Directly, or only indirectly? What do you think would happen if sea ice almost entirely disappeared in the Bering Sea?
4. What would you like to measure and track in your community (e.g. water temperature, berry crops, dates of seasonal events, numbers of animals sighted) in order to get better data on climate change?

About SNAP

The Scenarios Network for Alaska and Arctic Planning (SNAP) is a climate change research group in UAF's International Arctic Research Center (IARC). Since 2007, SNAP has used climate data to create and share ideas of what a future Northern climate could look like. SNAP works with people, communities, and organizations to plan for a changing climate. To learn more about climate models, methods and projects in Alaska visit SNAP's website at www.snap.uaf.edu. Some of these data were used to create climate projections for the BRT project.

SNAP

Community Climate Charts

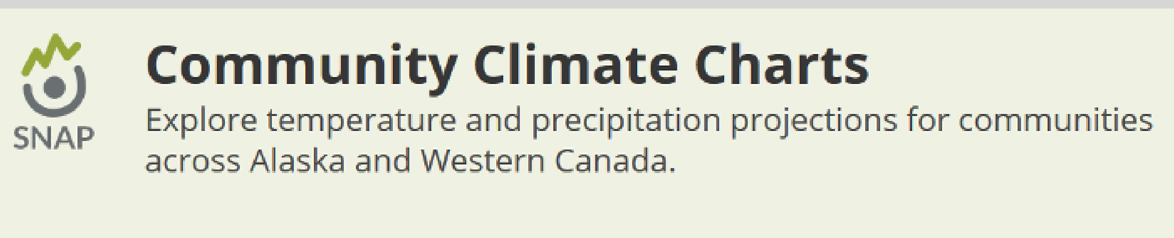
https://snap.uaf.edu/tools/community-charts

The Community Climate Charts allows users to select their own community, and view a graph of temperature or precipitation projections by decade, as compared to historical baseline values. In this case, Kotlik has been selected, and the graph shows temperature for the past, for the approximate present, and for future decades.

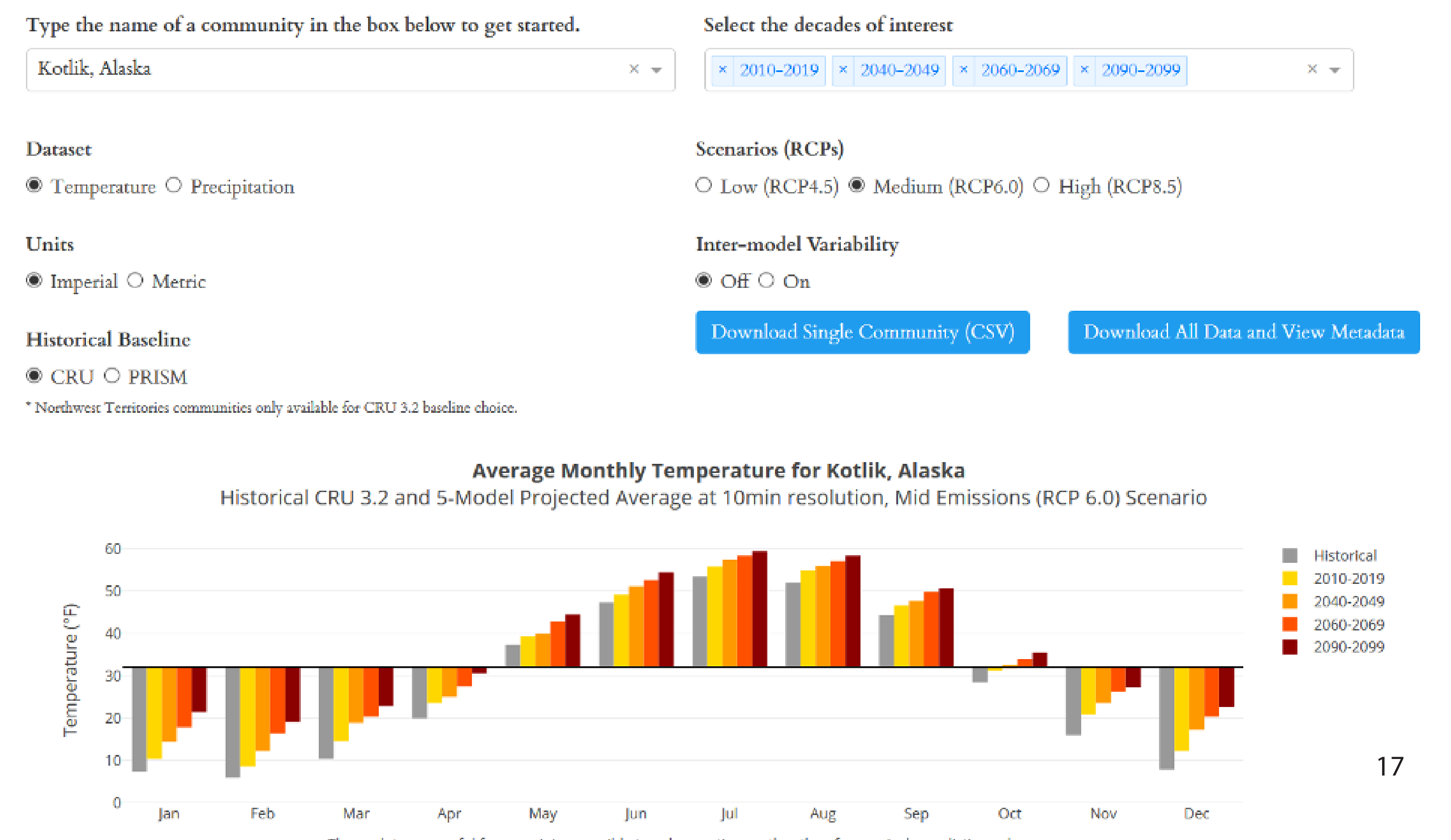
Note that overall changes in temperature tend to be greatest in winter, but shifts in fall and spring freeze and thaw may prove to have the greatest impacts. For example, although historically the month of October had average temperatures well below freezing, by the end of this century October is projected to average well above freezing.

Connections to changes described in Kotlik BRT community meetings and activities:

- Very hot temperatures
- Hard to dry fish, too hot, flies



CRU (Climatic Research Unit, University of East Anglia, UK) and PRISM (http://www.nacse.org/prism/) refer to historical climate estimates made using weather station data and computer modeling of what climate would be between weather stations. RCPs refer to pathways of future climate that would likely occur under different concentrations of greenhouse gases (see page 23 for explanation).



Community Permafrost Data

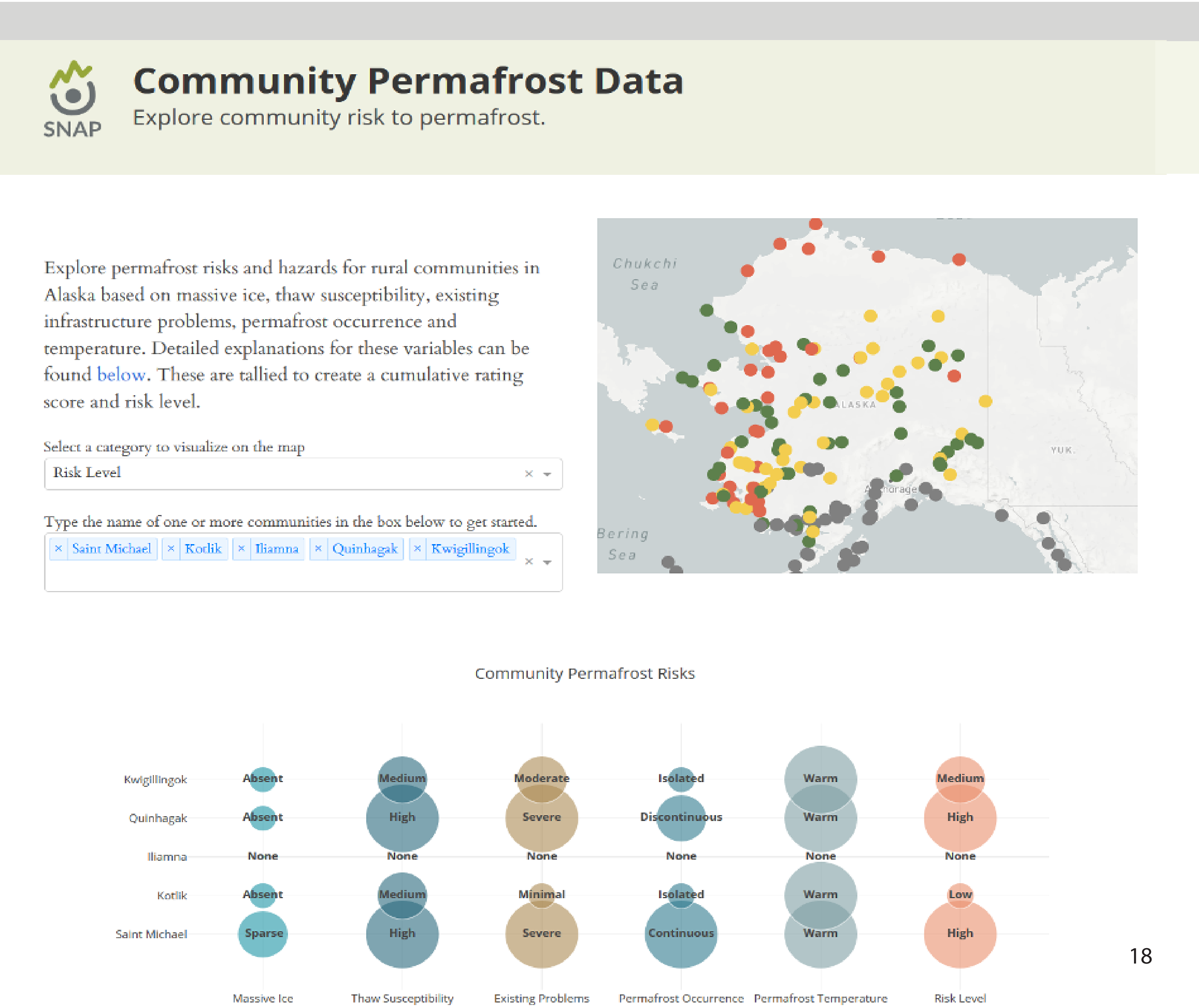
https://snap.uaf.edu/tools/permafrost

The Community Permafrost Data tool allows users to select one community or multiple communities, and to see relative conditions for several permafrost characteristics including: massive ice, thaw susceptibility, existing problems, permafrost occurrence, permafrost temperature, rating score, and risk level. Here, the project team selected all the communities that participated in the BRT project so that community team members can see the differences.

Note that variables are linked. For example, where permafrost has already been lost, risks are generally considered lower than where active loss is occurring. In Kotlik, overall risk level is ranked as "medium". Discontinuous permafrost is present, but has already become isolated. Remaining permafrost is warm and at great risk of thaw in the near future. The community risk level for Kotlik indicates the tool characterizes existing problems as "minimal" compared to some of the other communities in the project.

Connections to changes described in Kotlik BRT community meetings and activities:

- Erosion, cave-ins, and scarier to walk on, wet, flooding, in all seasons



Historical Sea Ice Atlas

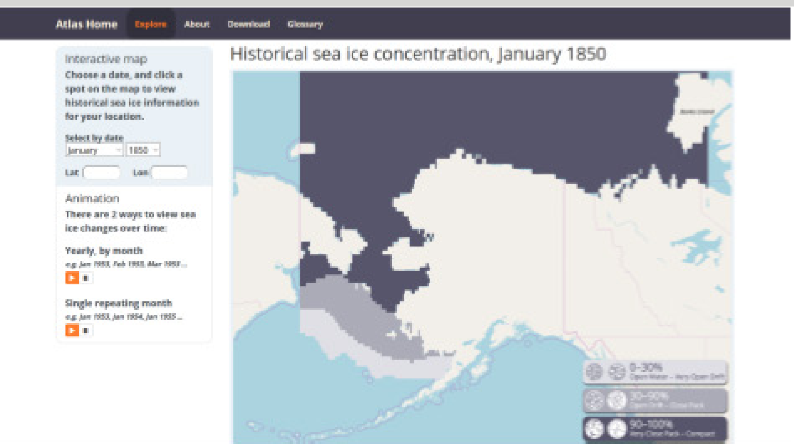
http://seaiceatlas.snap.uaf.edu/explore

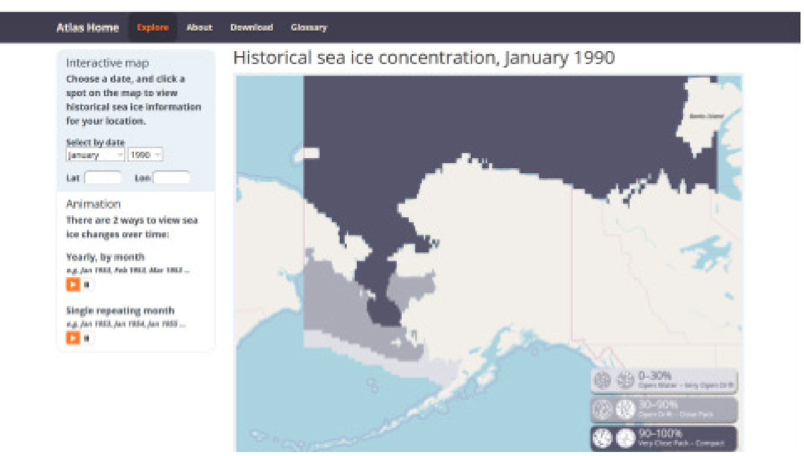
The Historical Sea Ice Atlas shows historical sea ice for any month of any year from 1850 to the present. It can be animated to show change over time by month or by year. This tool does not provide future projections, but can be a useful visualization for showing trends that are expected to continue.

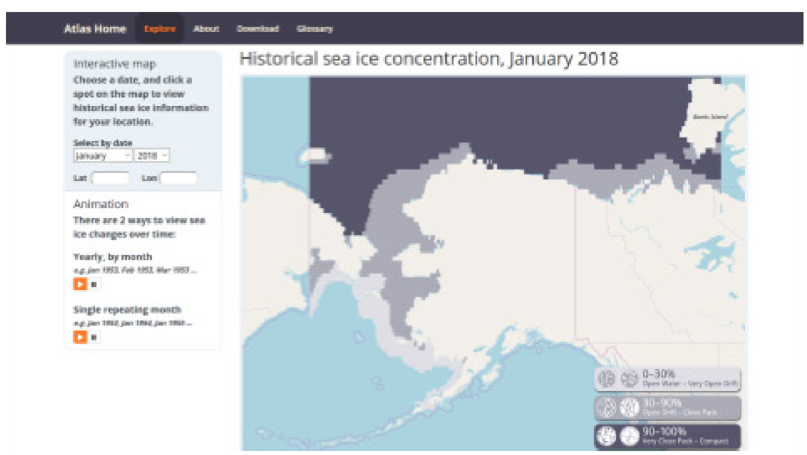
As shown in the figure and supported by local observations and memories, ice coverage used to be consistent, decade after decade. Declines started in the 1970s, and have continued thereafter. Around Kotlik, areas that reliably had substantial or total ice coverage are now seeing poor ice coverage or open water. Seasons are becoming shorter in both spring and fall. Shorter ice seasons disrupt many species and many traditional activities.

Connections to changes described in Kotlik BRT community meetings and activities:

- No snow, no ice or thinner, later ice on river or ocean – affects travel, have to go by land, can't fish on ice
- Altered salmon seasonality/availability, different types at the same time
- Warm water, lethal for fish







Alaska Garden Helper

https://snap.uaf.edu/tools/gardenhelper

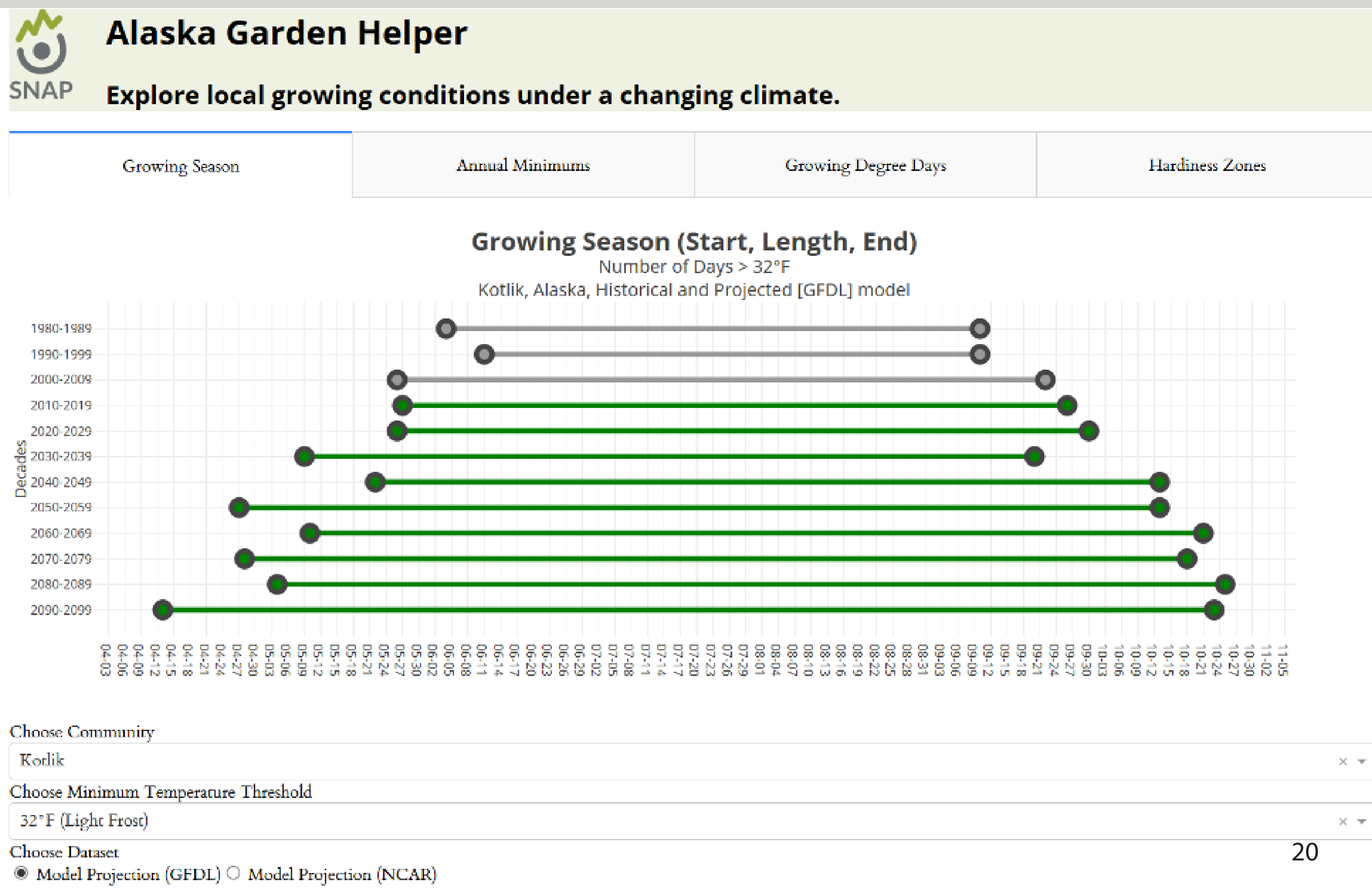
Though designed for gardeners and farmers, this Alaska Garden Helper tool provides useful projections of warm season length and extreme winter cold – variables that also affect natural ecosystems. Longer summers, hotter summers, and loss of limiting cold in winter can greatly change the plants and animals on the land and in the water – changes that community members are already reporting in Kotlik.

Users can select their community and can choose from several tools and temperature thresholds, including 28°F, 32°F, 40°F, and 50°F. Each selection will generate a new graph.

Summer season length in Kotlik, as measured by the precise dates of last frost and first frost, will continue to be highly variable, since a difference of one degree can register as a large shift. However, on average the summer season will expand greatly into the fall and spring. Coldest winter temperatures will become much warmer, as shown by the "Annual Minimums" and "Hardiness Zones" tabs within this tool.

Connections to changes described in Kotlik BRT community meetings and activities:

- Earlier seasonality for many plants and animals
- More grass and shrubs
- Blackberries didn't grow, or altered berry crops, different seasonality

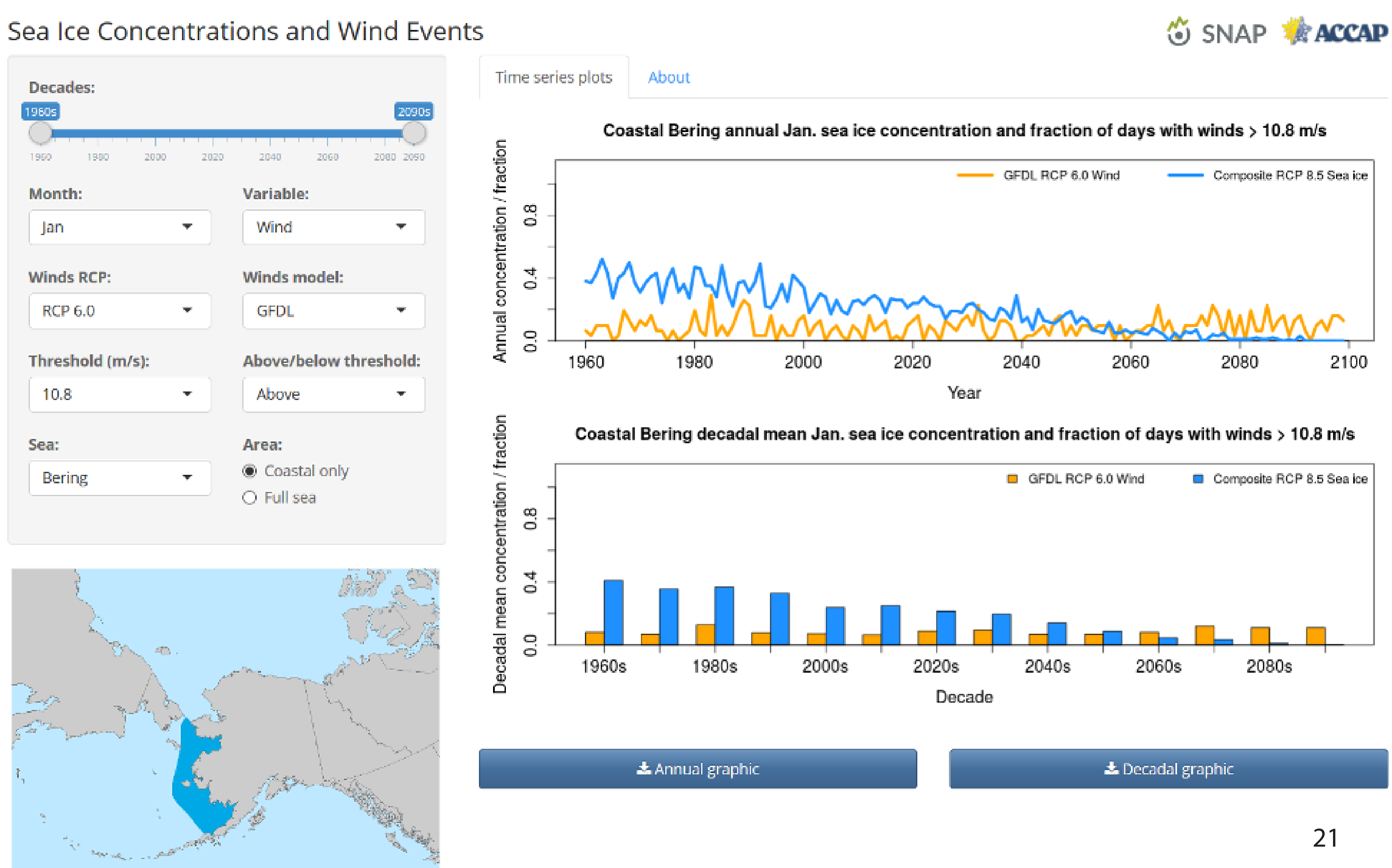


Sea Ice and Wind

https://uasnap.shinyapps.io/sea_ice_winds/

This Sea Ice and Wind tool explores the interactions of wind and ice. Users can select a sea – in this case, the Bering Sea – and generate graphs for selected months and time periods.

Outputs for wind are highly variable, and may not indicate clear patterns of change, but outputs for ice show obvious severe declines, ongoing and into the future. These results are averaged across the area of the Bering Sea shown in the map, and thus are not specific to any one community. However, with normal variability in winds and wind events, loss of ice can lead to severe erosion throughout coastal regions.



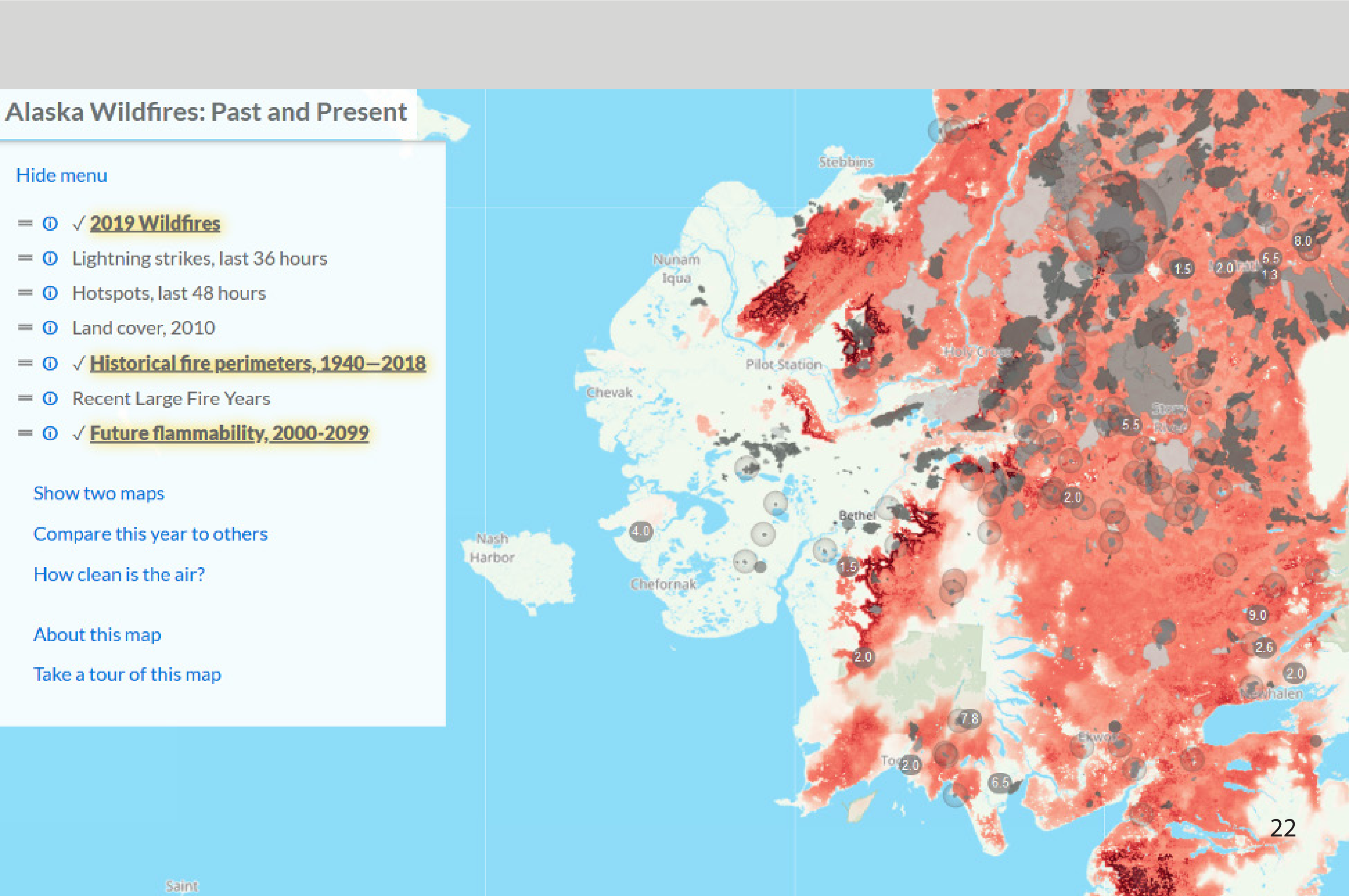
Wildfire in Alaska

http://mapventure.org/#/map/fires

This Wildfire in Alaska map tool explores past and future fires statewide. The map is zoomable, and offers multiple features that can be turned on or off.

The map below shows eighty years of past fire scars, shown as gray patches. The summer fires of 2019 are shown as small gray circles. Note that many 2019 fires occurred in areas much farther southwest and much closer to the coast than typical historical fires. This map also shows modeled future flammability, with darker reds indicating larger changes in future flammability. See page 45 for traditional use area scenarios for changes in flammability. Due to hotter temperatures and expansion of shrubs and trees, flammability is spreading closer to areas such as Kotlik that have little or no history of fires.

Smoke from fires can affect areas that are not themselves on fire or fire-prone. Thus, an increase in fires – particularly fires that are relatively close -- can affect the health, activities, and quality of life of community members in Kotlik.



CLIMATE CHANGE AND IMPACTS PROJECTIONS

Overview

In each community workshop, we reviewed potential future climate conditions and some changes in the environment that we would expect from those conditions. These future conditions are called "scenarios" because we don't know exactly what the weather and climate will be like, so we look at a range of possibilities from some warming to more warming. We also use two time ranges for these futures, 2040-2069 and 2070-2100, because different climate effects might take different lengths of time to happen. We learned in the Fairbanks trainings how scientists use complicated computer climate models to work out what the climate might be and how it affects fire, plants, and permafrost. We also learned that there are a lot of these models, and while all of them are scientifically reasonable, the future climates they project vary. So we also use the average of five different climate models for future climate scenarios. For the fire, land, and permafrost changes, two different climate models (a warmer one and one with less change) were used. At the community visits, we brought maps of these changes for the region and talked about them with community members.

For temperature, precipitation, and snow, the historical and future climate used to map changes came from University of Alaska Fairbanks Scenarios Network for Alaska and Arctic Planning (SNAP). Climate models simplify the real world, and this computer version of the world can be too simple for community planning because the model can only see detail for larger areas (like a square with 50 or more miles on a side). The climate for this project has been mapped to smaller areas (like squares less than a mile on a side). This information is available for five climate models that work well in the Arctic – they describe sea ice and the atmosphere in ways that look like historical weather we know occurred. The average changes from these five models are shown for two futures: one where there is moderate warming, but eventually it slows down because of less coal, oil and gas use (which cause an increase of climate warming gases in the atmosphere) and one where there is higher warming that continues to increase. These are called "representative concentration pathways" or RCPs for short - RCP4.5 is medium warming and RCP8.5 is higher warming. Lower rates of warming are possible with large changes in global policy and changes in coal, oil, and gas use, but we are currently heading for the moderate or high warming future so we did not choose a low warming scenario (RCP 2.6). The climate changes in the maps are compared to the 1970-1999 historical climate. The numbers in the upper left of each map page are the scenario averages for the four panels over the community-defined Traditional Use Area.

During the Fairbanks training we talked about when climate models do a pretty good job and when and why they are more uncertain. The scenarios that result in the maps in the next section address three main kinds of uncertainty. Using several climate models accounts for differences in climate models. Using a medium warming future and a high warming future addresses the uncertainty in how much change from climate warming gases we think may happen. Using thirty-year averages decreases the effect of warmer or cooler, wetter or drier decades that happen for natural reasons. Together, these three things (using 5 climate models, using a medium and high warming scenario, using multiple decades) give us a more reliable range of future climates we can expect.

Permafrost futures (average yearly ground temperature at 3 feet deep) were available for two climate models under an older scenario (called A1B), which is in between the medium and high warming futures for the climate, fire, and land changes. The fire and land changes were available for two climate models used to provide temperature and precipitation to a land model that simulates vegetation and fire under the higher warming future.

Specific questions about any of the projections mapped here? Contact Jeremy Littell, Alaska Climate Adaptation Science Center, jlittell@usgs.gov. Further details on variables can be found in the SNAP data archives:

http://ckan. snap.uaf.edu/dataset

SNAP AK CASC

Kotlik projected climate changes and impacts

For the near future, about 2040-2069, Kotlik Traditional Use Area average annual temperatures are expected to increase +5.9 °F under medium warming and +7.8 °F under higher warming compared to 1970-1999. For the later future, about 2070-2099, Kotlik average annual temperatures are expected to increase +7.6 °F under medium warming and +11.6 °F under higher warming compared to the period 1970-1999. Warming will probably be greater in autumn and winter than spring and summer. Annual average precipitation (rain and snowfall) is expected to increase about +18% under medium warming and about +24% under higher warming for the near future 2040-2069 relative to 1970- 1999. Annual average precipitation is expected to increase about +21% under medium warming and about +36% under higher warming for the later future 2070-2099 relative to 1970-1999. Precipitation increases will probably be greater in autumn and winter than spring and summer. However, in northern forests like those in Alaska, it has been found that about 15% more precipitation is needed to keep up with the increase in water demand of about 2 °F. So it is possible that even with more rainfall, water in plants during the warm season could decrease because precipitation increases would not be enough to keep up with the amount of water the heat can evaporate from the land and plants. For 2040-2069, the amount of water available in April 1 snowpack (October to March snowfall water) is not expected to decrease (0%) under medium warming, but decrease 8% under higher warming, compared to 1970-1999. For 2070-2099, the amount of water available in April 1 snowpack is expected to decrease 3% under medium warming and 22% under higher warming, compared to 1970-1999. Averaged across the Kotlik region, average winters are still expected to be snow dominant, which means that snowmelt will still usually be the main driver of streamflow responses. However, more winters than in recent times could have a shorter snow season or more mixed rain and snow. Some areas of permafrost might stay until the 2050s under a lower warming climate model (called ECHAM5), but decrease under all other scenarios.

Areas to the east of Kotlik become good for spruce growth, mostly in places that were shrub tundra. More spruce growth is expected under the moderate climate model (called CGCM3) than the warmer climate model (called CCSM4). Future computer model land changes suggest spruce could become more common to the south and east of Kotlik, along the coast toward Unalakleet, and in areas farther up the Yukon River. In the central part of the region, south of Kotlik, some shrub tundra birch/willow/alder forest may become grass tundra for the warmer climate model or some spruce under the moderate climate model. Fire could become more common to the east and southeast of Kotlik, with the number of fires per century on each part of the landscape increasing. The darker brown areas in the maps on page 44 indicate places where fire would burn too often for spruce to remain the dominant species. Changes in vegetation are new kinds of plants growing where different plants used to be. These changes happen as new areas become good for plants, either because the climate is better for them or after fire or other disturbance. Both models project large landscape changes, especially under the CCSM4 climate model.

Descriptions of variables

Temperature

Annual averages (12 months) as well as four seasons (Spring – March to May; Summer – June to August; Autumn – September to November; Winter – December to February). Maps (pages 28-32) show "deltas", or future projected changes, in surface air temperature from climate models compared to the same historical months or three-month seasons. The mapped changes are averages of 5 climate models and are displayed for two time periods as well as for both moderate and high warming scenarios.

Precipitation

Annual totals (12 months) as well as four seasons (Spring – March to May; Summer – June to August; Autumn – Septem¬ber to November; Winter – December to February). Maps (pages 33-37) show future percent change in precipitation (rain and snow) projected by climate models compared to the same historical months or three-month seasons. The mapped changes are averages of 5 climate models and are displayed for two time periods as well as for both moderate and high warming scenarios.

Snowfall, or snowfall water equivalent

October to March amount of snowfall, measured by the amount of water it contains. Maps (page 38) show future percent change in total snowfall derived from climate model projections compared to the same historical months or three-month seasons. The mapped changes are averages of 5 climate models and are displayed for two time periods as well as for both moderate and high warming scenarios.

Snow Index

October to March amount of total precipitation that is snowfall, measured by the amount of water it contains. These are displayed as a percent; a value of 55% would mean that 55% of the total precipitation falls as snow between October and March. 55% means that 55% of the precipitation was snow, while 45% was rain. Values greater than 40% are snow dominated; values between 10% and 39% are transitional; values between 0% and 9% are rain dominated.

Ground temperature at 1m (3.3ft) depth

Annual average ground temperature at 1 meter (3.3 feet) deep in the ground. This is an index of permafrost stability or thaw. The colder it is the more likely permafrost is to persist. Near freezing (0 °C or 32 °F), the permafrost is more likely to thaw. Above freezing, it is unlikely to persist into the future.

Changes in fires per century

The times an area burned under simulated historical (1901 – 2000) conditions is compared to the number of times an area burned under simulated future (2001-2100) conditions. Numbers over 0 mean an increase in fire (e.g., 2 would mean a doubling of fire frequency); numbers less than 0 mean a decrease in fire.

Changes in vegetation per century

The times the dominant vegetation in an area changed under simulated historical (1901 – 2000) conditions is compared to the number of times vegetation changes under simulated future (2001-2100) conditions. Numbers over 0 mean an increase in landscape change (e.g., 2 could mean a change from shrub tundra to spruce followed by a change to deciduous forest).

Descriptions of variables (Continued)

Current probability of permafrost

This map shows the current probability that the area has permafrost under it. Darker blue indicates a higher probability of permafrost.

Thermokarst predisposition

Thermorkarst occurs where permafrost thaws and causes the ground to slump or cave in. Dark blues indicate areas where a model designed to predict thermokarst potential indicates it is likely. **If the graphic is absent, the model indicated no thermokarst predisposition in the region, so the map was not printed.**

Change in months of reliable snow

For this map, a month with "reliable snow" was defined as a month where, on average, more than 70% of the precipitation arrived as snow. The historical (1970-1999) months of reliable snow were compared to the future (2040-2069) months of reliable snow for RCP 8.5 (higher emissions), and the change calculated as future minus historical.

Map picture file abbreviations

All maps in this file are also in a folder with each map by itself. There are "small" maps that you can use in Word or PowerPoint (or other software) documents for reading. There are also "big" high resolution maps that could be printed off as posters or zoomed in on the screen and keep higher detail. The file names are abbreviations– here is what they mean:

dPann – change in annual (January to December) precipitation
dPdjf – change in winter (December, January, February) precipitation
dPjja – change in summer (June, July, August) precipitation
dPmam – change in spring (March, April, May) precipitation
dPson – change in autumn (September, October, November) precipitation

dTann – change in annual (January to December) temperature
dTdjf – change in winter (December, January, February) temperature
dTjja – change in summer (June, July, August) temperature
dTmam – change in spring (March, April, May) temperature
dTson – change in autumn (September, October, November) temperature

dswe – change in snowfall water amount, October to March
dFireCen – changes in numbers of fires per century
dVegCen – changes in vegetation per century
sno – snow index, the range between rain dominated and snow dominated
t1 – temperature at 1m ground depth

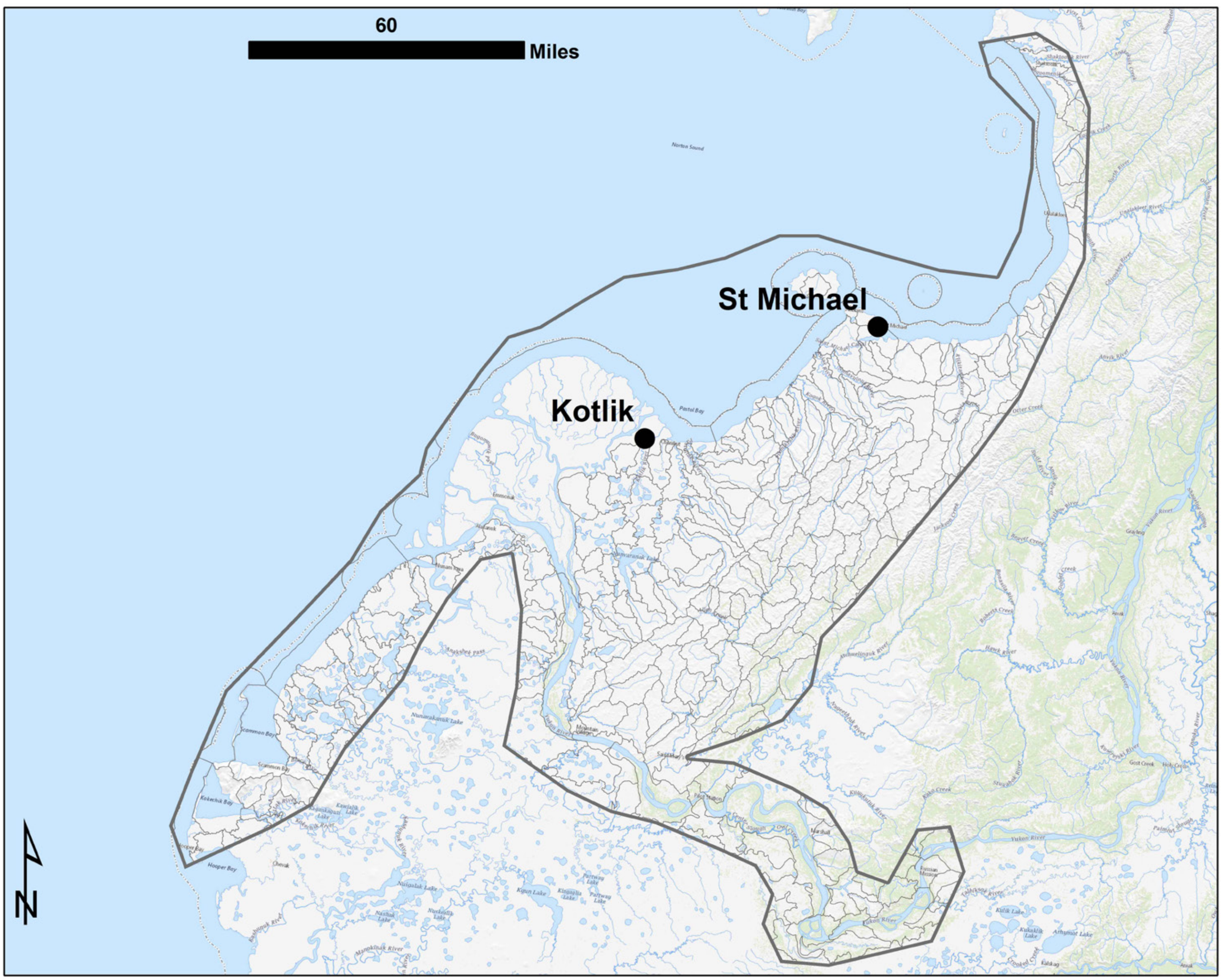
5045 – 2050s (2050-2069), RCP 4.5 (mid century, medium emissions)
5085 – 2050s (2040-2069), RCP 8.5 (mid century, higher emissions)
8045 – 2080s (2050-2069), RCP 4.5 (late century, medium emissions)
8085 – 2080s (2040-2069), RCP 8.5 (late century, higher emissions)

CCMA and ECHAM5 refer to climate models used in permafrost work. CGCM3, GFDL CM3, GISS E2R, IPSL CM5A LR, and CCSM4 refer to climate models used in the projections of temperature, precipitation, and snow. CGCM3 and CCSM4 are used in the vegetation and fire projections.

Kotlik region and watershed boundaries

Kotlik region outlined includes the areas defined by community workshop participants as important. The many lines within the region show watershed boundaries (called hydrologic units or HUC12s). Many of the following maps show average conditions for climate change and its effects within each watershed.

Background map: United States Geological Survey National Map



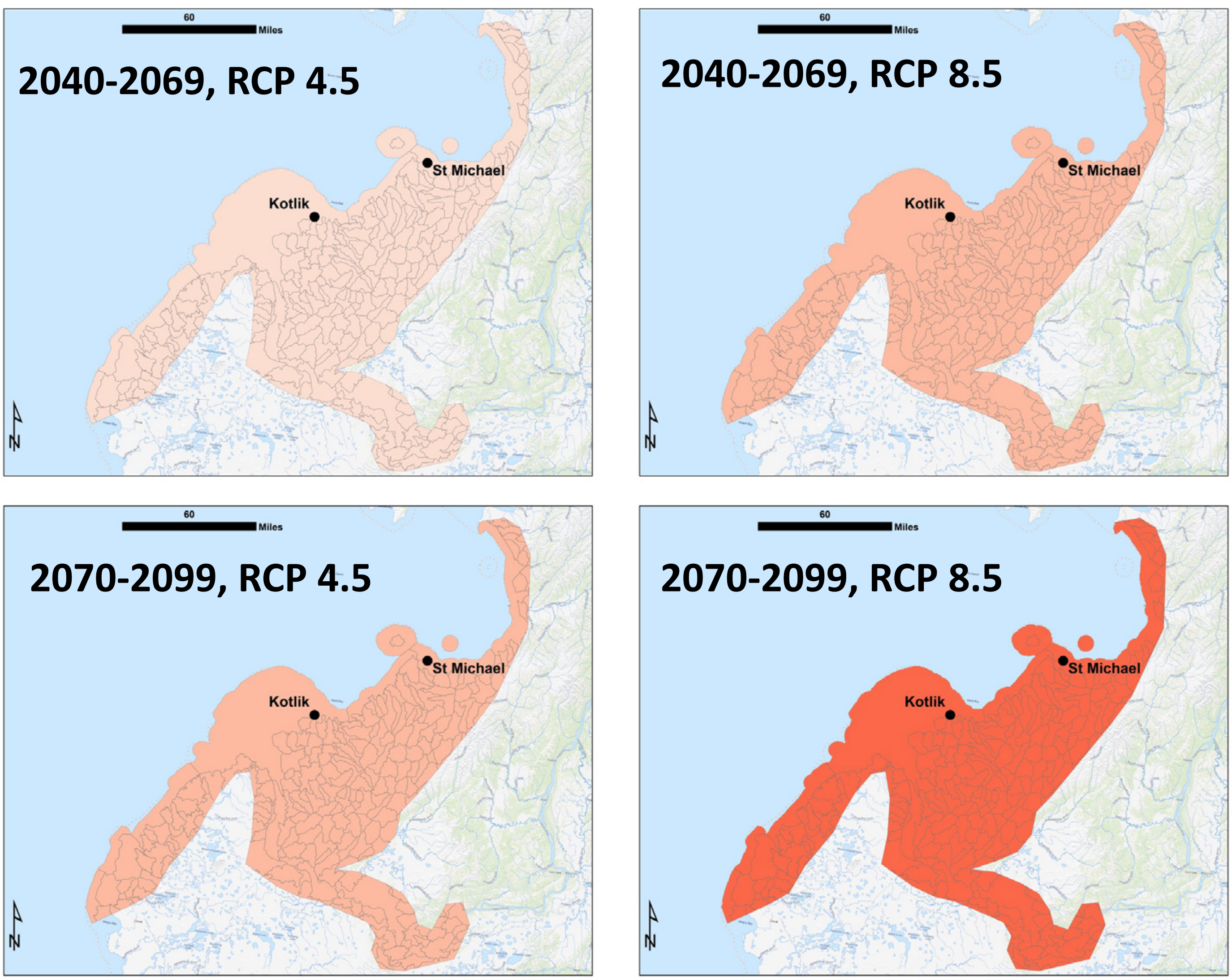
Annual temperature change, relative to 1970 - 1999

Annual temperature is projected to increase under all scenarios:

+ 5.9 °F (2050s, RCP 4.5)
+ 7.8 °F (2050s, RCP 8.5)
+ 7.6 °F (2080s, RCP 4.5)
+ 11.6 °F (2080s, RCP 8.5)

Change in temperature (ºF)

1.8 – 3.6
3.6 – 7.2
7.2 – 10.8
10.8 – 14.4
14.4 - 18
18 – 21.6

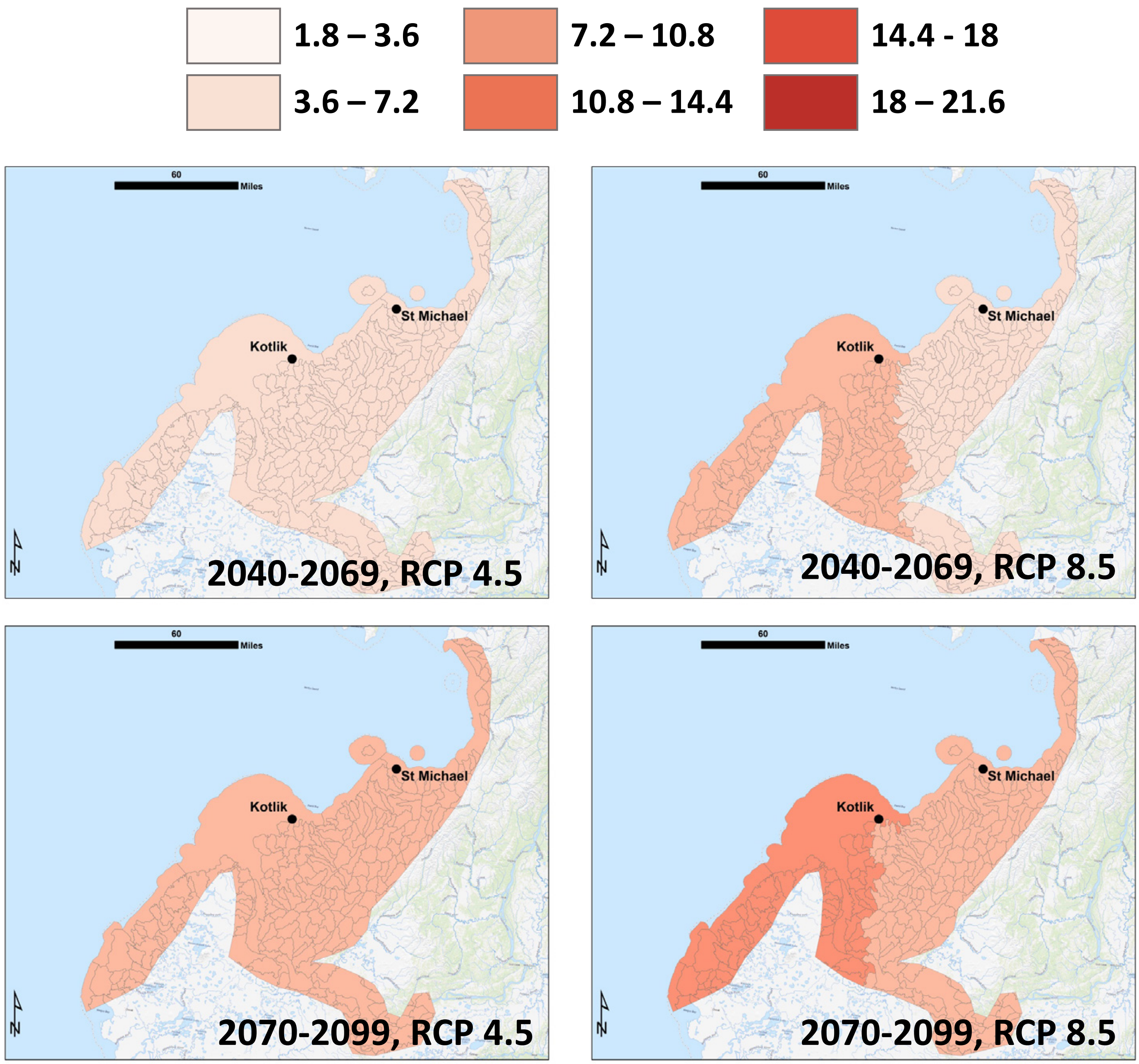


Spring (Mar - May) temperature change, relative to 1970 - 1999

Spring temperature is projected to increase under all scenarios:

+ 5.5 °F (2050s, RCP 4.5)
+ 7.2 °F (2050s, RCP 8.5)
+ 6.7 °F (2080s, RCP 4.5)
+ 10.6 °F (2080s, RCP 8.5)

Change in temperature (°F)

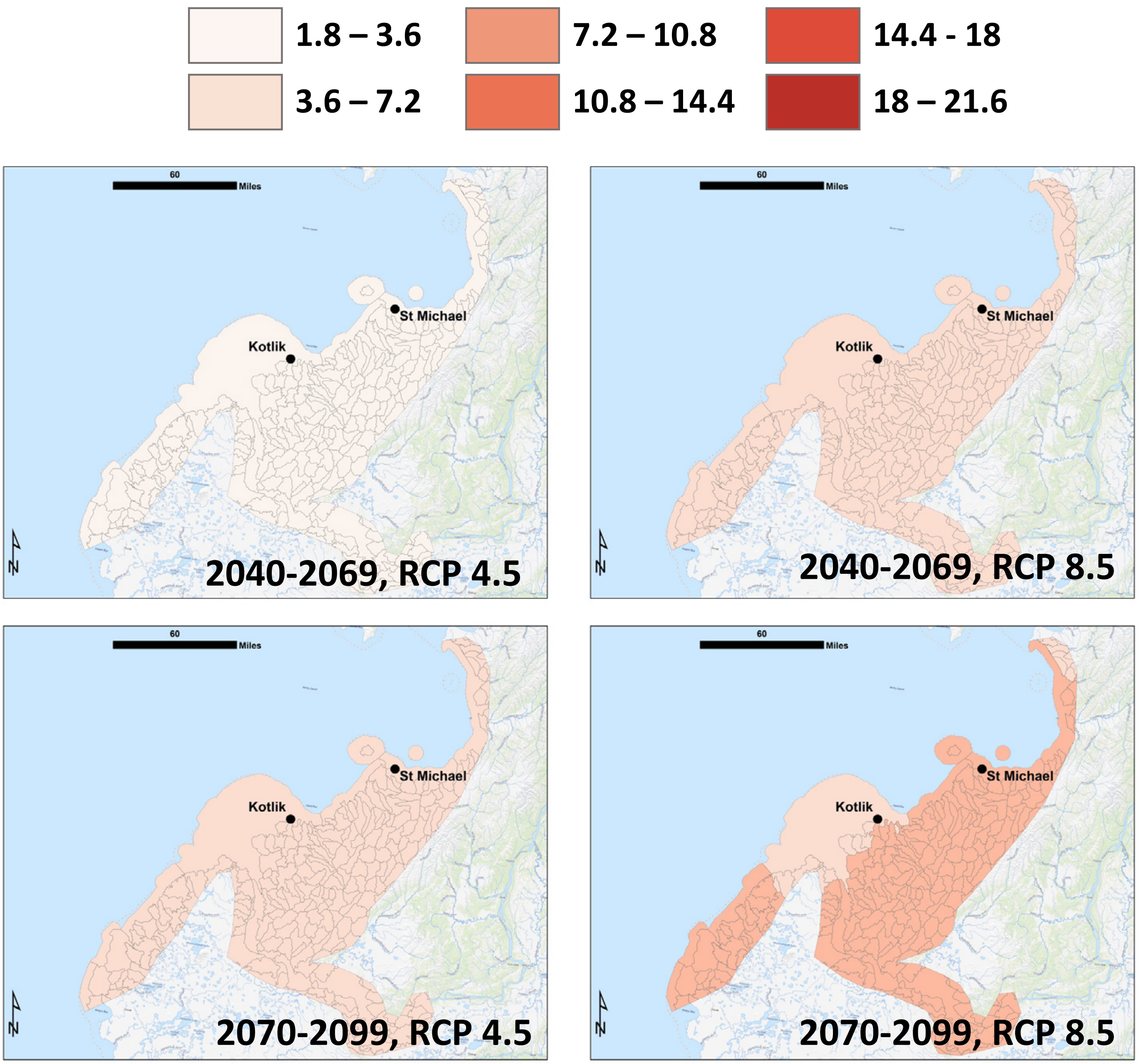


Summer (June - Aug) temperature change, relative to 1970 - 1999

Summer temperature is projected to increase under all scenarios:

+ 3.3 °F (2050s, RCP 4.5)
+ 4.6°F (2050s, RCP 8.5)
+ 4.5 °F (2080s, RCP 4.5)
+ 7.4 °F (2080s, RCP 8.5)

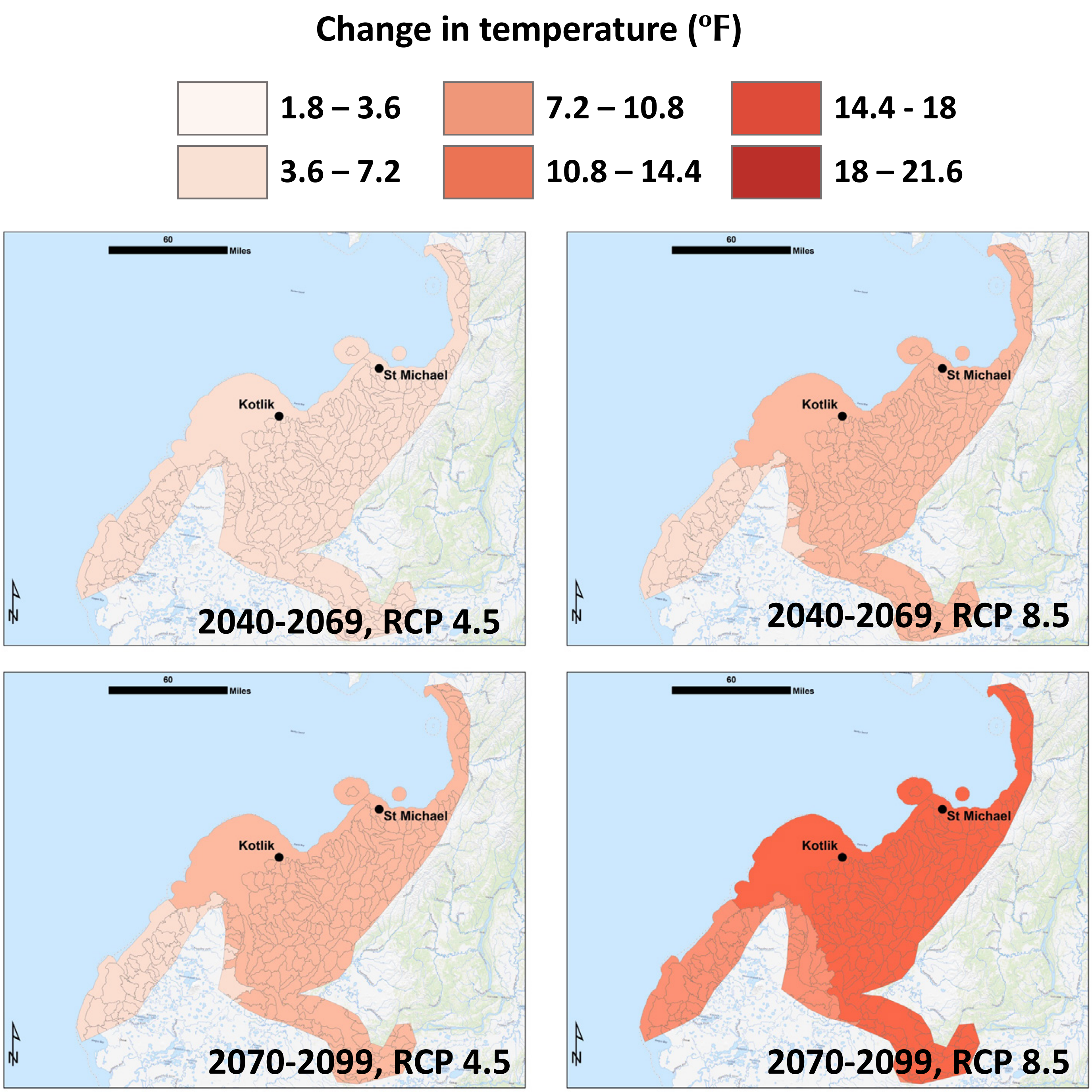
Change in temperature (°F)



Autumn (Sep - Nov) temperature change, relative to 1970 - 1999

Autumn temperature is projected to increase under all scenarios:

+ 5.8 °F (2050s, RCP 4.5)
+ 7.4 °F (2050s, RCP 8.5)
+ 7.4 °F (2080s, RCP 4.5)
+ 11.0 °F (2080s, RCP 8.5)

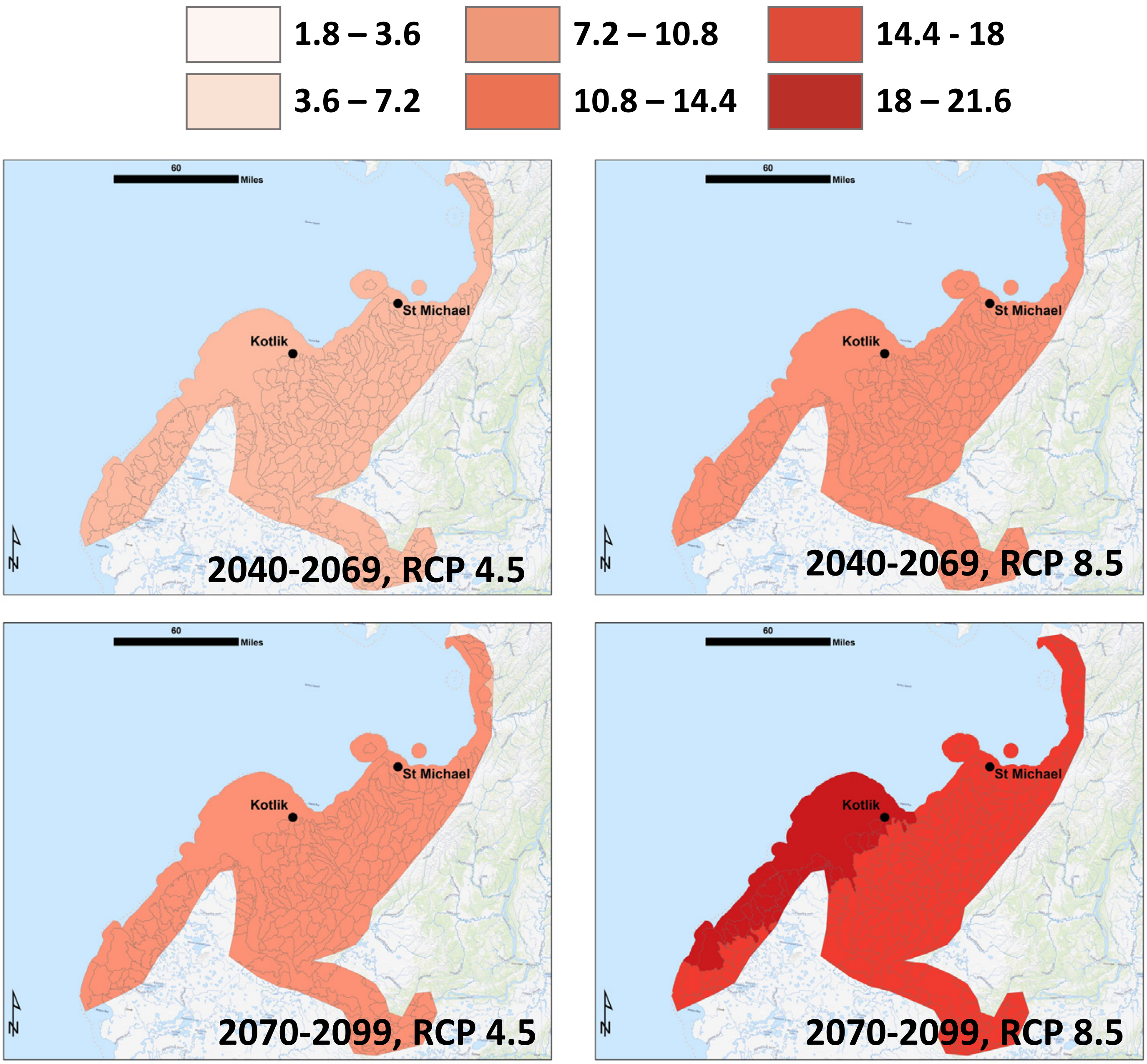


Winter (Dec - Feb) temperature change, relative to 1970 - 1999

Winter temperature is projected to increase under all scenarios:

+ 8.6 °F (2050s, RCP 4.5)
+ 11.9 °F (2050s, RCP 8.5)
+ 11.6 °F (2080s, RCP 4.5)
+ 17.3 °F (2080s, RCP 8.5)

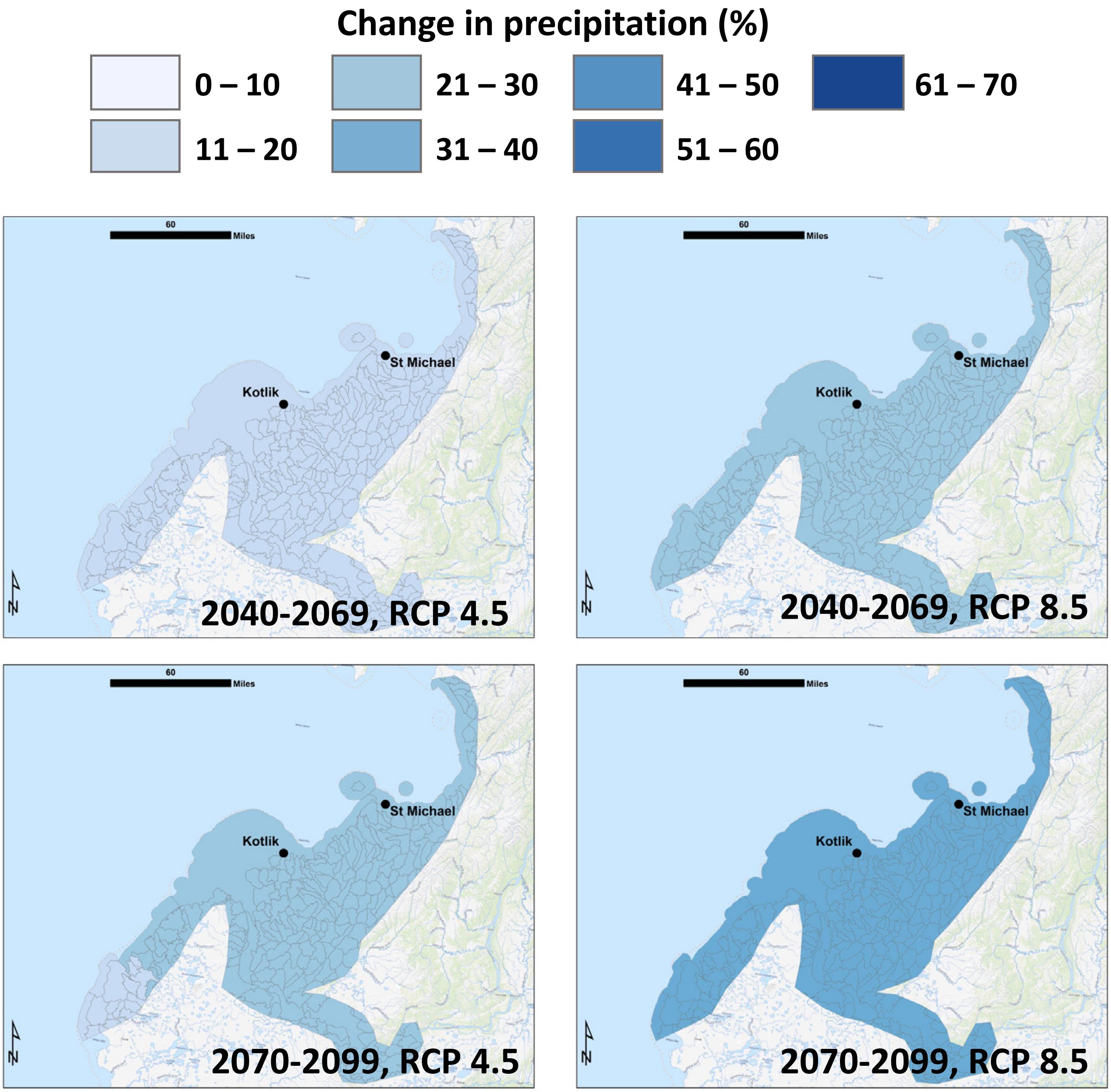
Change in temperature (°F)



Annual precipitation change, relative to 1970 - 1999

Annual precipitation is projected to increase under all scenarios:

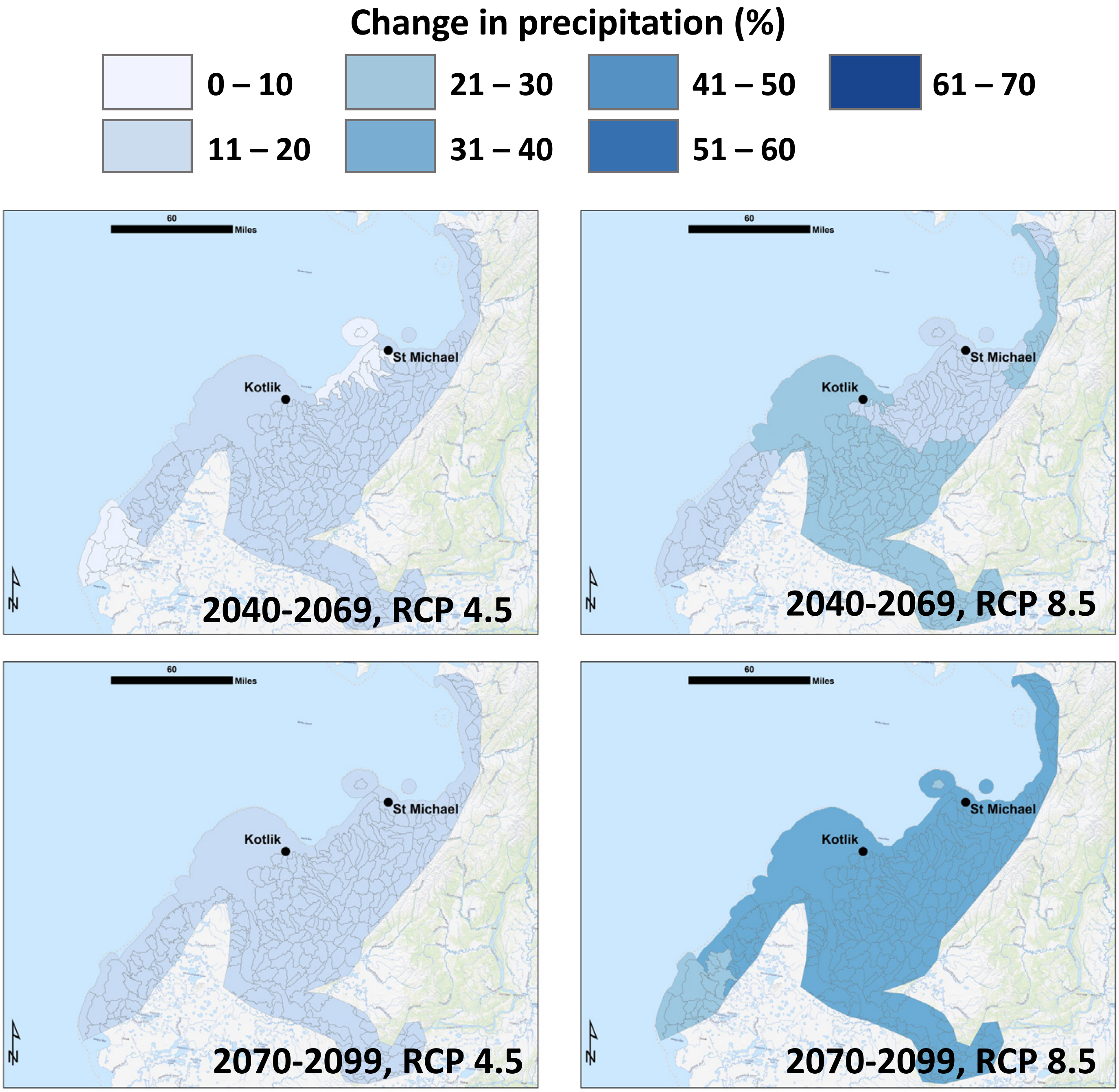
+ 18 % (2050s, RCP 4.5)
+ 24 % (2050s, RCP 8.5)
+ 21 % (2080s, RCP 4.5)
+ 36 % (2080s, RCP 8.5)



Spring (Mar - May) precipitation change, relative to 1970 - 1999

Spring precipitation is projected to increase under all scenarios.

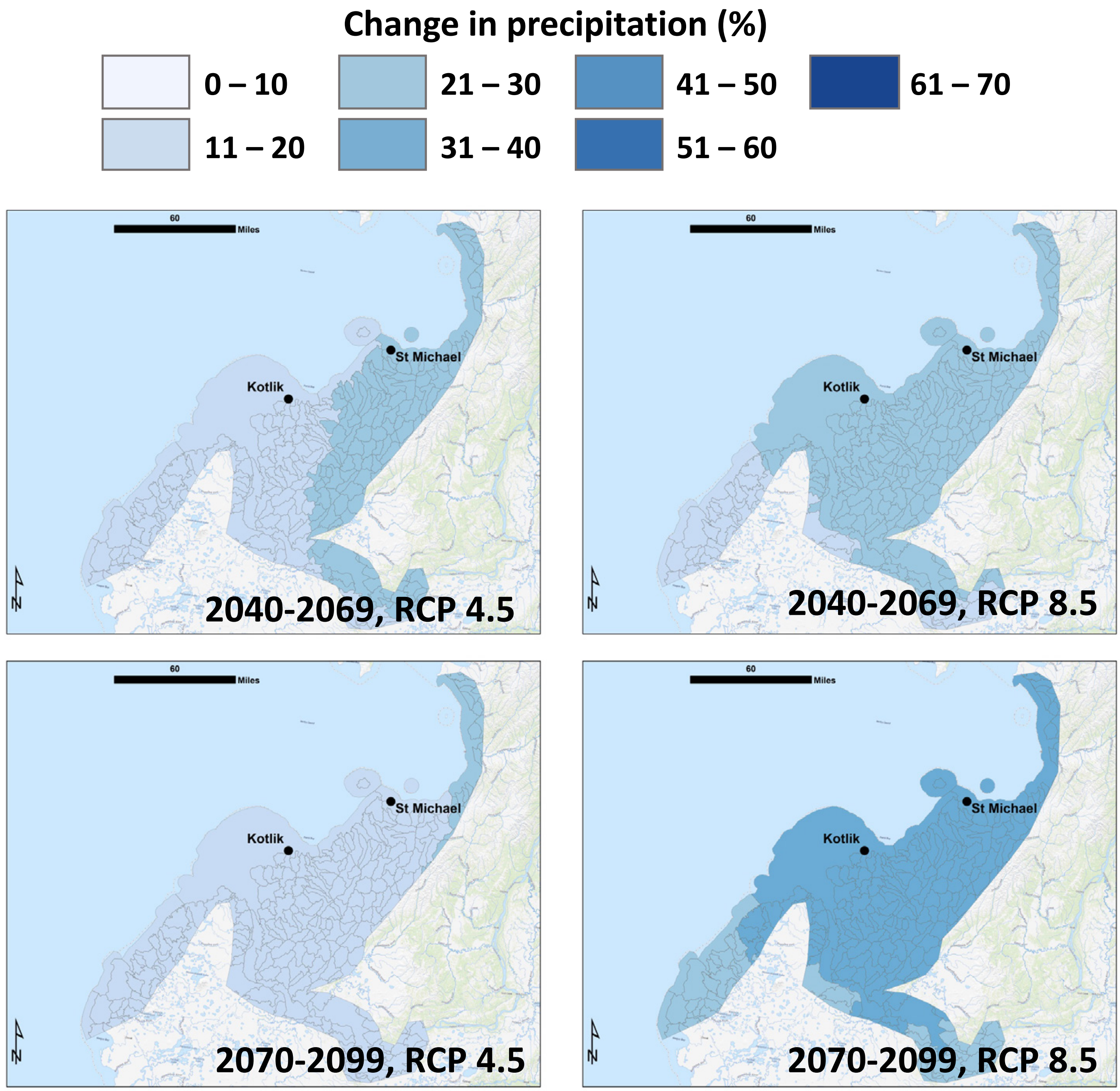
+ 12 % (2050s, RCP 4.5)
+ 20 % (2050s, RCP 8.5)
+ 16 % (2080s, RCP 4.5)
+ 32 % (2080s, RCP 8.5)



Summer (June - Aug) precipitation change, relative to 1970 - 1999

Summer precipitation is projected to increase under all scenarios.

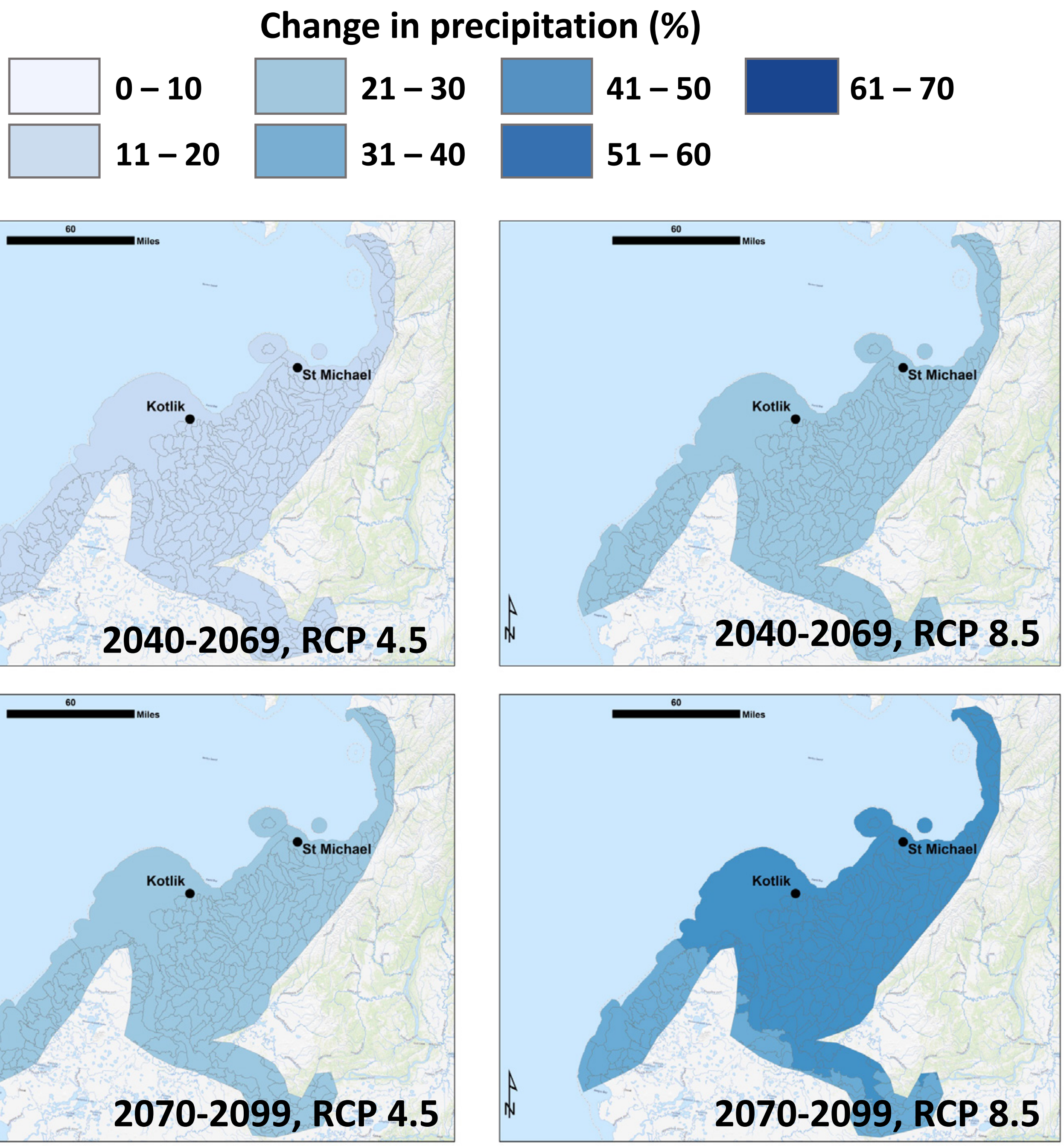
+ 19 % (2050s, RCP 4.5)
+ 22 % (2050s, RCP 8.5)
+ 18 % (2080s, RCP 4.5)
+ 32 % (2080s, RCP 8.5)



Autumn (Sep - Nov) precipitation change, relative to 1970 - 1999

Autumn precipitation is projected to increase under all scenarios.

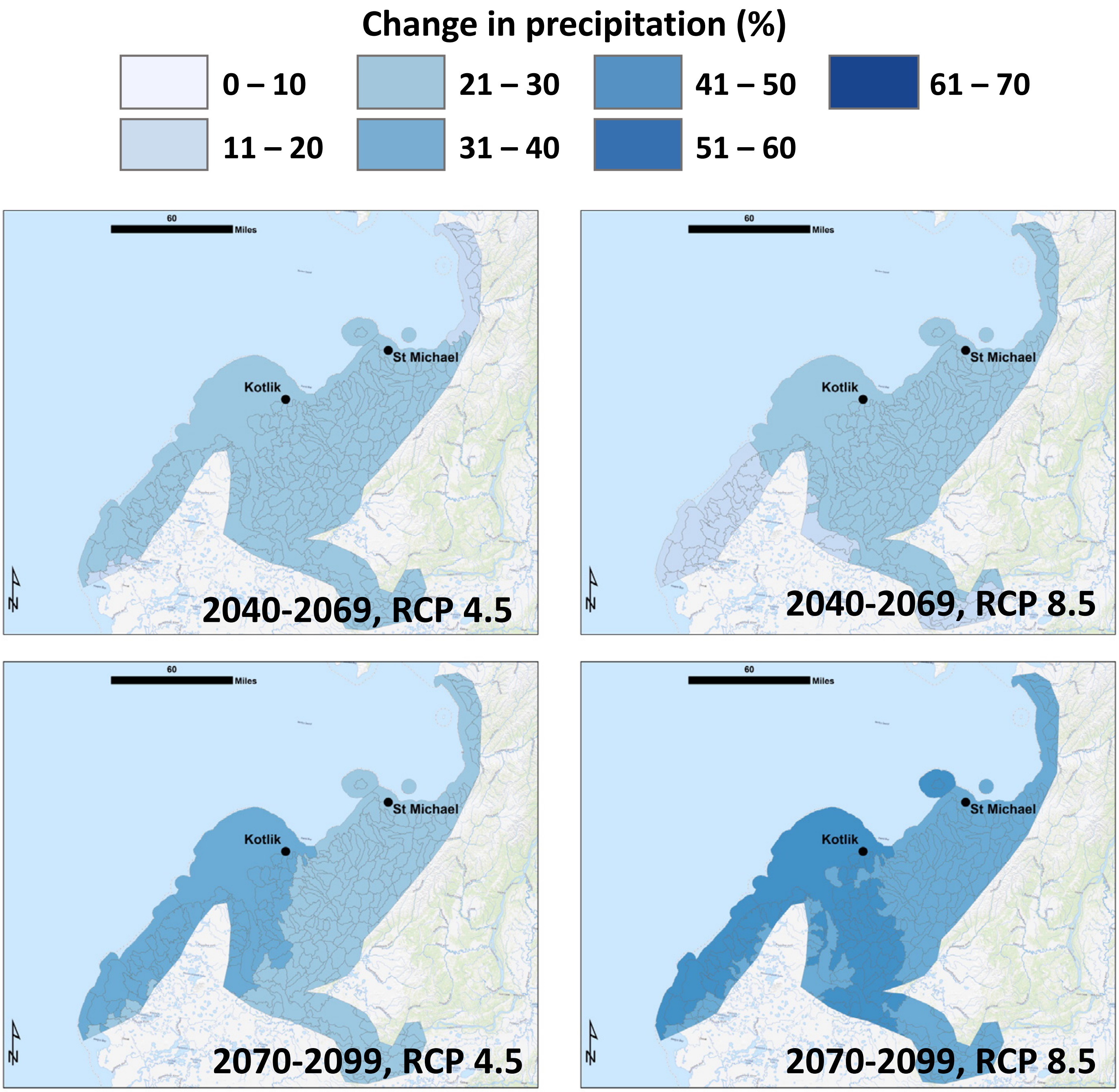
+ 18 % (2050s, RCP 4.5)
+ 28 % (2050s, RCP 8.5)
+ 25 % (2080s, RCP 4.5)
+ 41 % (2080s, RCP 8.5)



Winter (Dec - Feb) precipitation change, relative to 1970 - 1999

Winter precipitation is projected to increase under all scenarios.

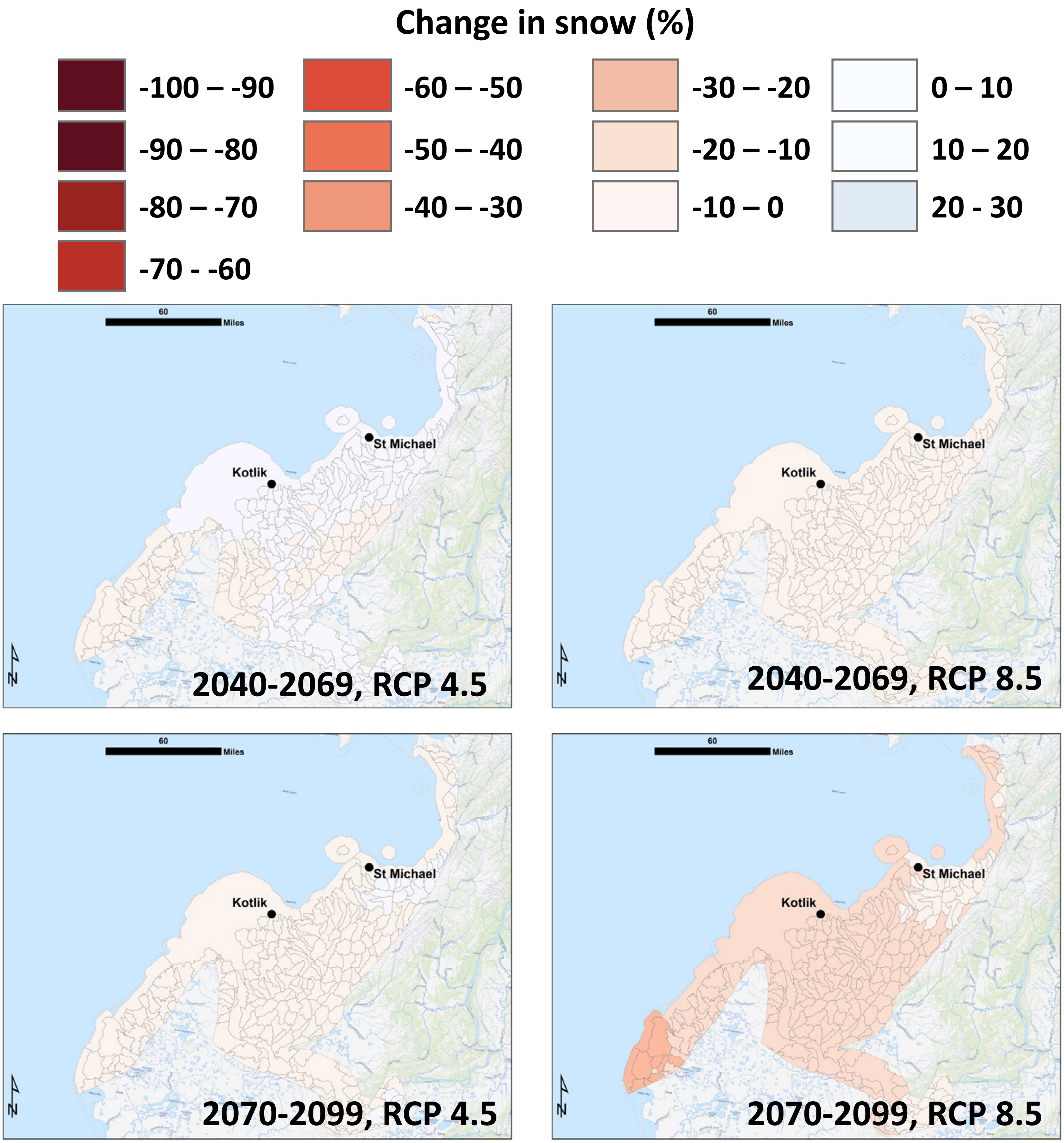
+ 21 % (2050s, RCP 4.5)
+ 24 % (2050s, RCP 8.5)
+ 28 % (2080s, RCP 4.5)
+ 39 % (2080s, RCP 8.5)



Snowfall water equivalent (snowfall) change in October to March, relative to 1970 - 1999

This is the change in the amount of snow that falls.

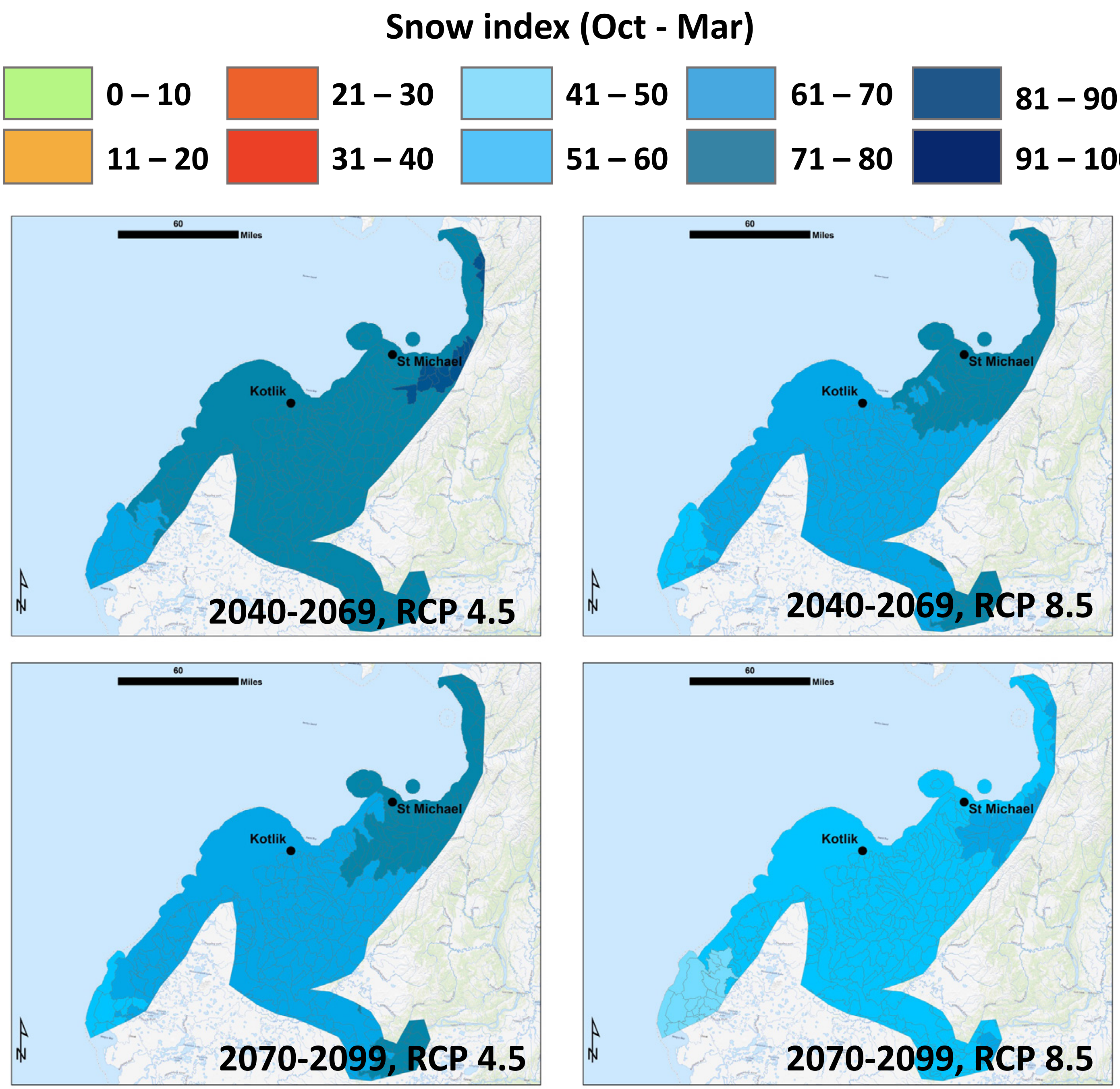
0 % (2050s, RCP 4.5)
-8 % (2050s, RCP 8.5)
-3 % (2080s, RCP 4.5)
-22 % (2080s, RCP 8.5)



Snow index, October to March % of precipitation in April 1 snow, relative to 1970 - 1999

This is a measure of how snow-dominated the climate is. Blues indicate snow dominated, reds and oranges are in between snow dominated and rain dominated. Greens represent rain dominated. Iliamna was historically snow dominated. Under all scenarios, Kotlik is projected to remain snow dominated, but the degree of snow domination decreases with the increase in temperature.

74% (2050s, RCP 4.5)
69% (2050s, RCP 8.5)
69% (2080s, RCP 4.5)
55% (2080s, RCP 8.5)

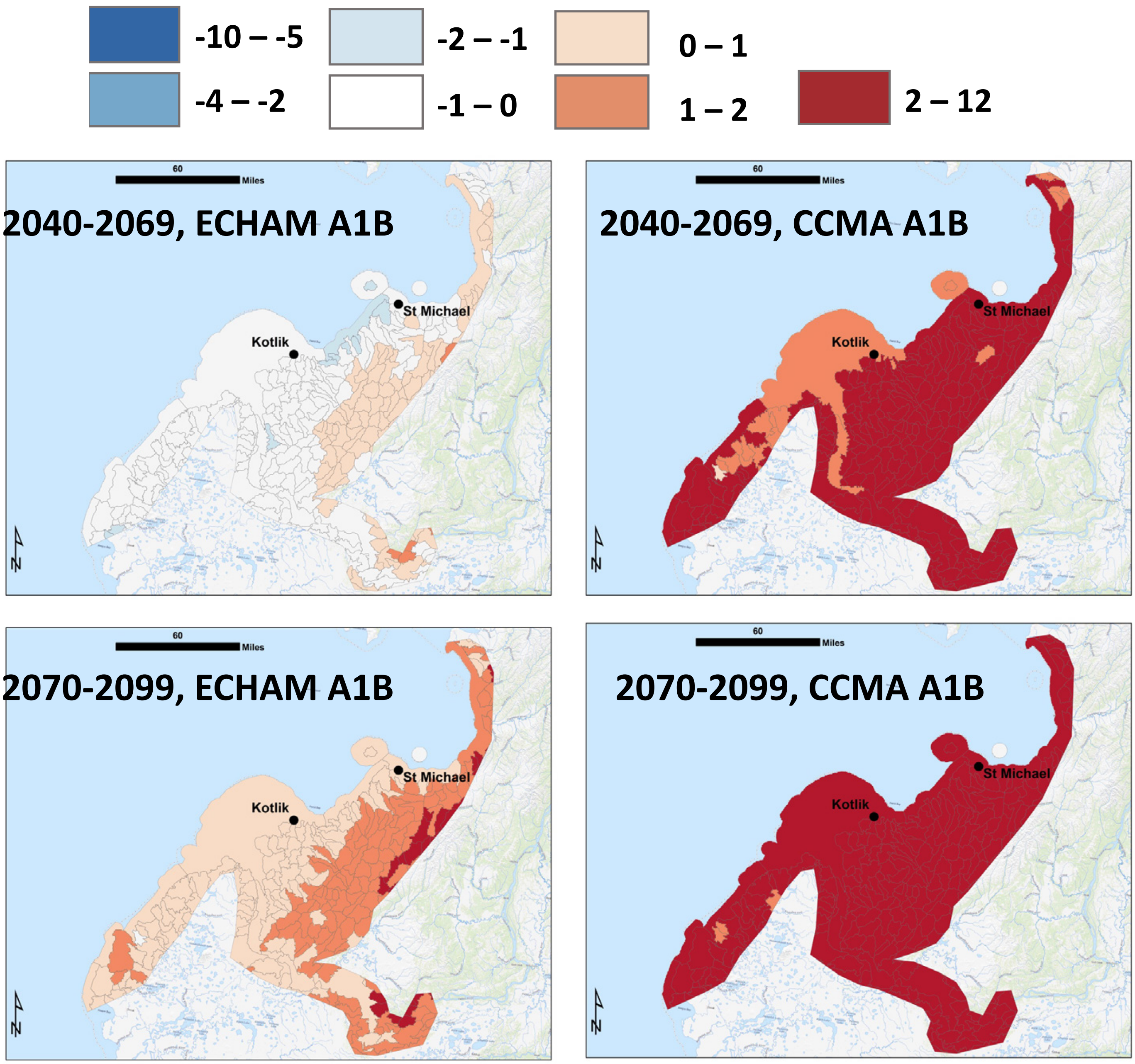


Annual average ground temperature at 1m (3.3ft) deep

This is an index of how likely permafrost is to remain under climate change. Once annual average temperatures rise above freezing (0°C) permafrost thaw likely increases. Some areas of permafrost might persist until the 2050s under the ECHAM model, but decrease under all others.

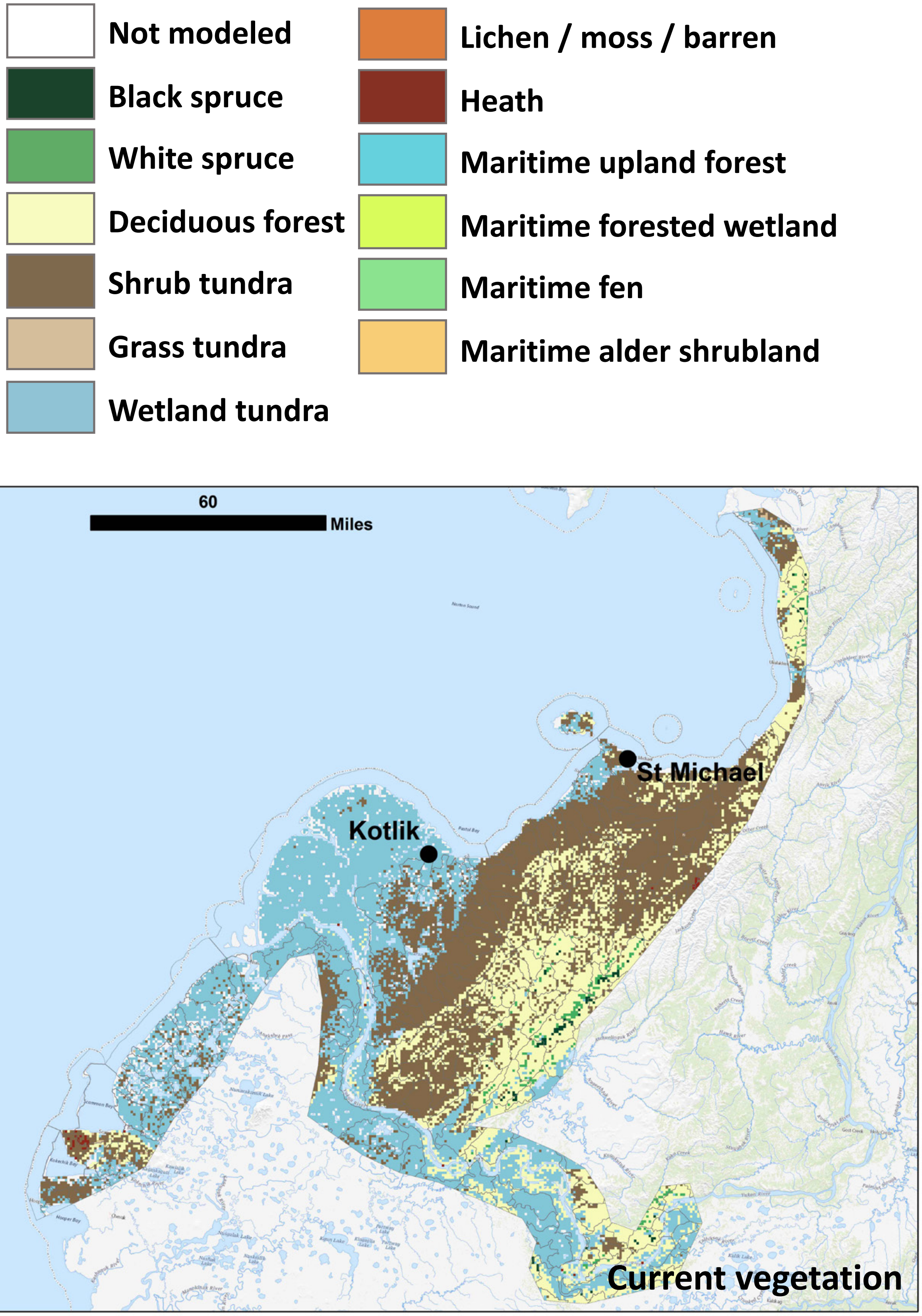
0.1°C (2050s, ECHAM A1B)
0.2°C (2050s, CCMA A1B)
1.8°C (2080s, ECHAM A1B)
2.1°C (2080s, CCMA A1B)

Ground temperature at 1 m depth (°C)



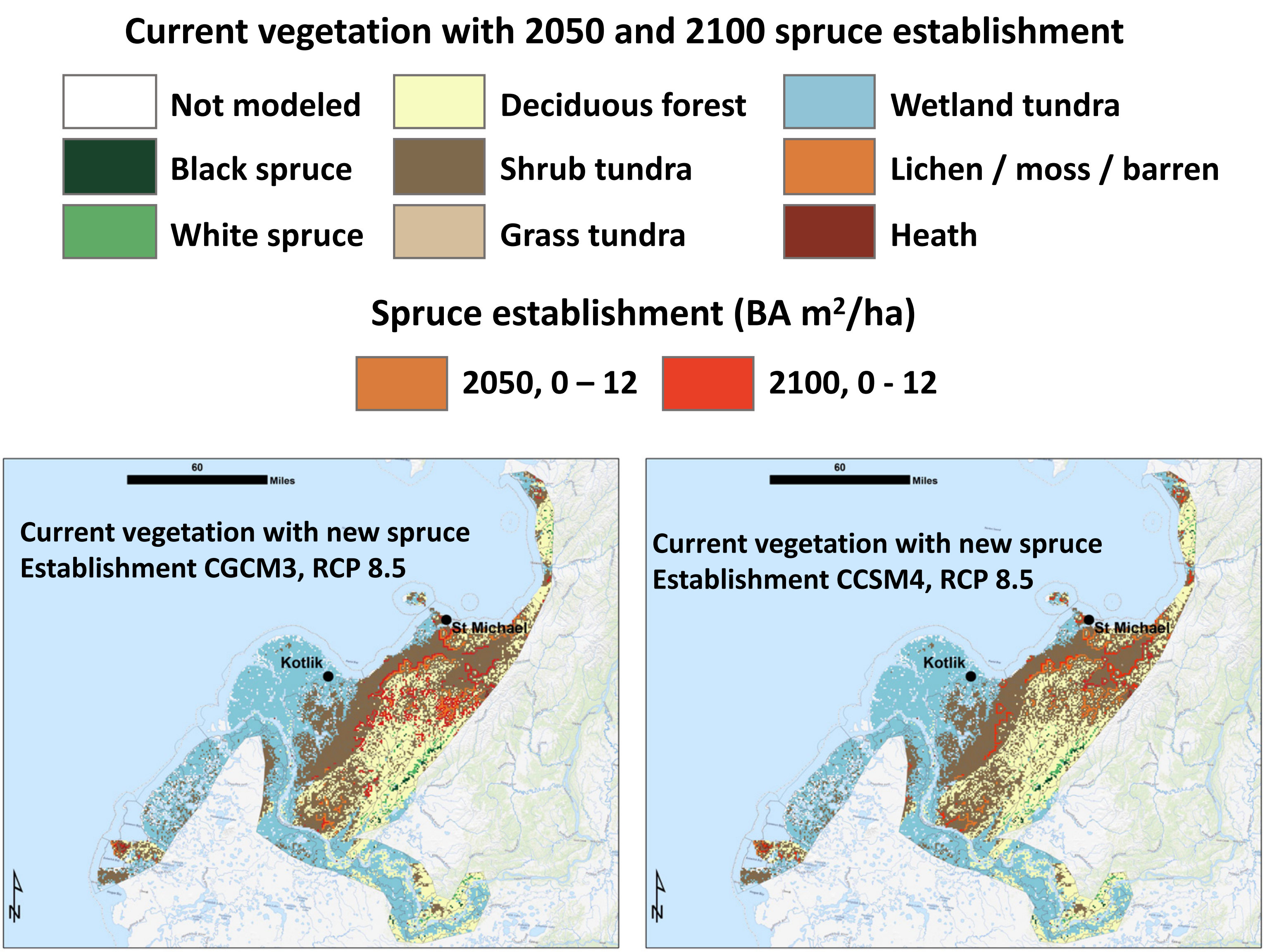
Current vegetation

Deciduous forest is birch, aspen, willow, cottonwood and/or alder.



Current vegetation with 2050 and 2100 spruce establishment

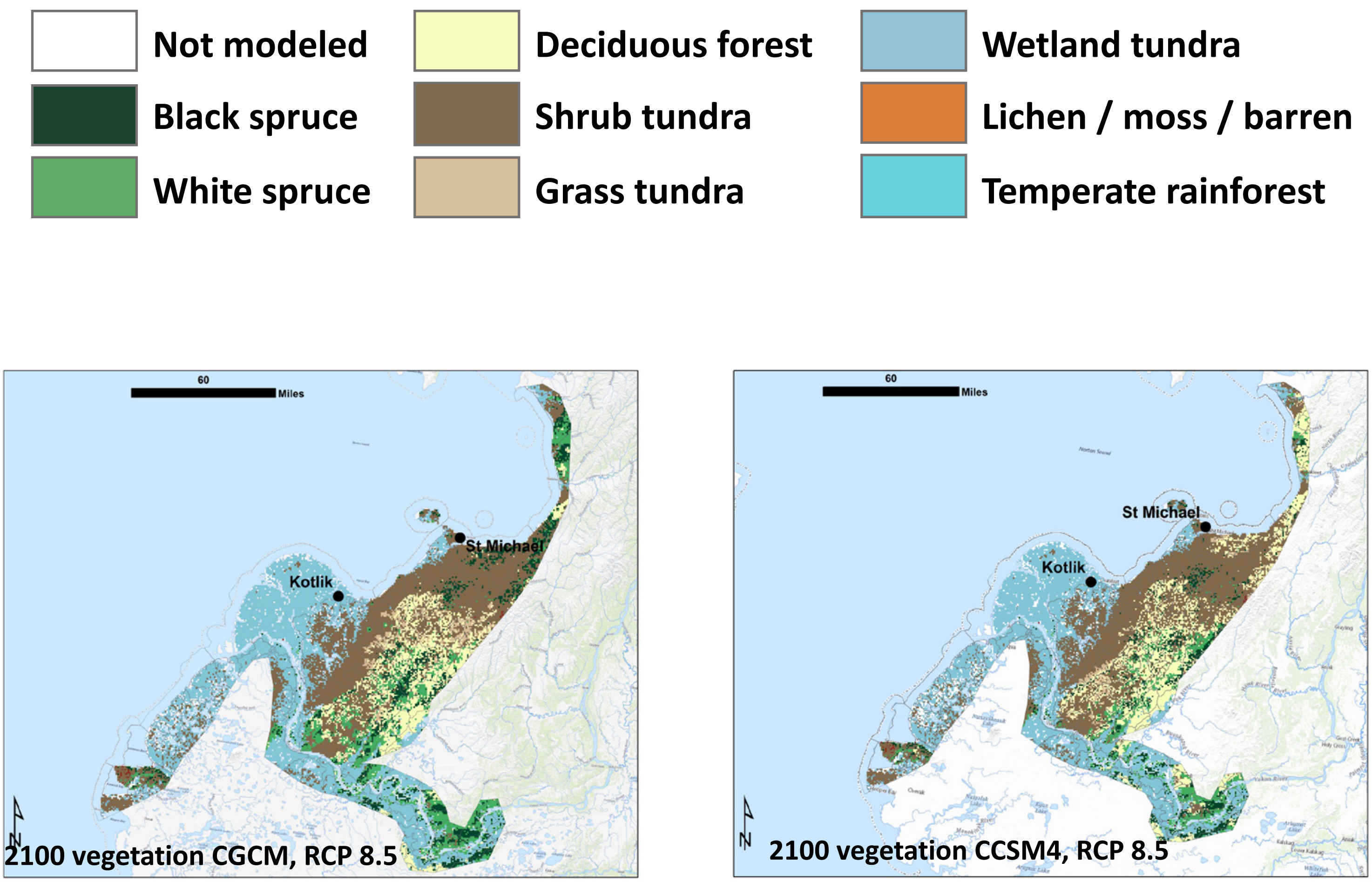
Areas (in red) to the east of Kotlik become favorable for spruce establishment, generally in what was historically shrub tundra. More establishment is projected under the CGCM3 climate model than the CCSM4 climate model.



2100 vegetation

Future vegetation changes simulated by a vegetation model project spruce will establish to the south east of Kotlik, along the coast toward Unalakleet, and in areas further up the Yukon River. More establishment is projected under the CGCM3 climate model than the CCSM4 climate model. In the north central part of the region, some shrub tundra and deciduous forest transitions to grass tundra.

2100 vegetation

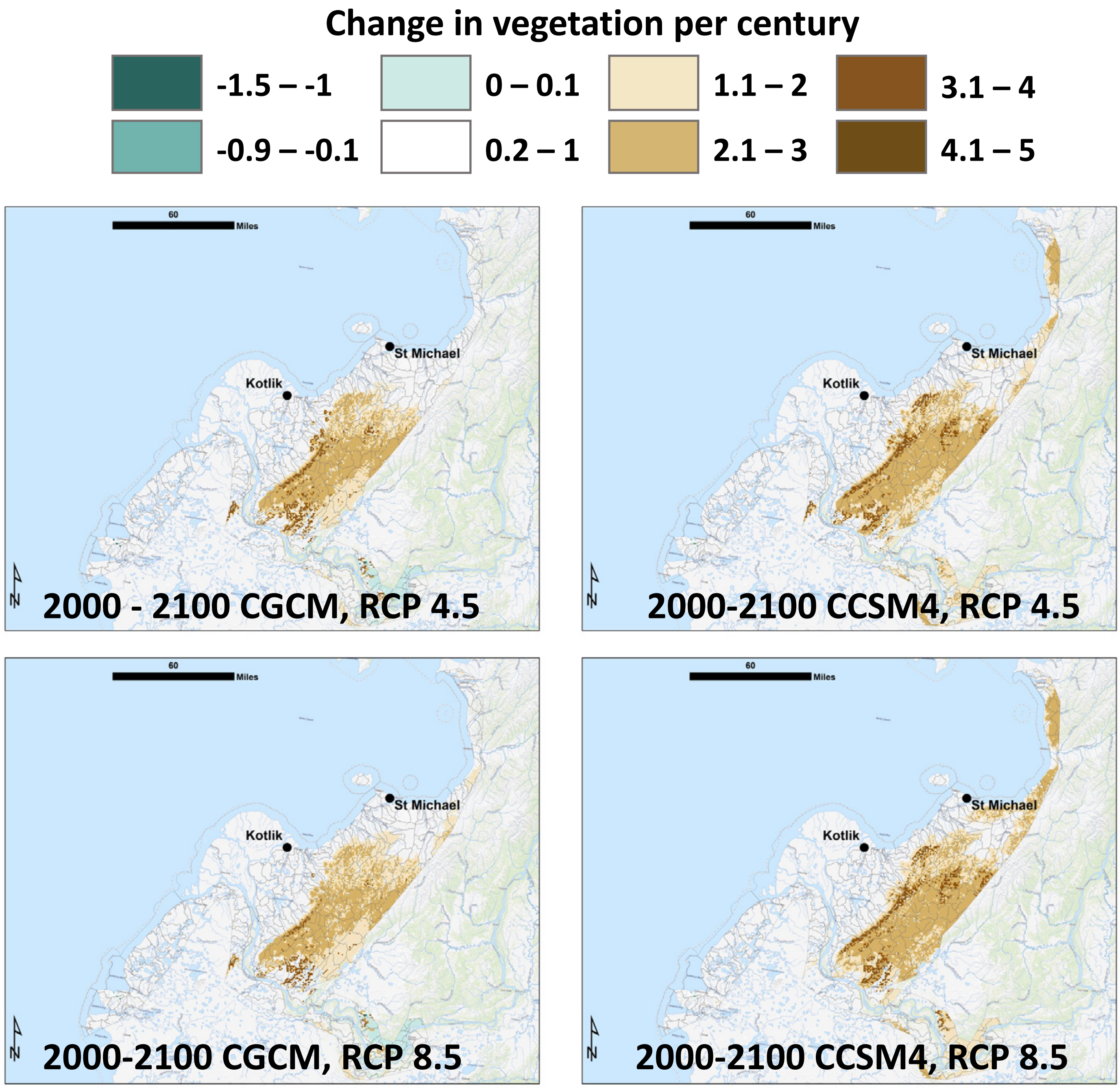


2100 vegetation CGCM, RCP 8.5

2100 vegetation CCSM4, RCP 8.5

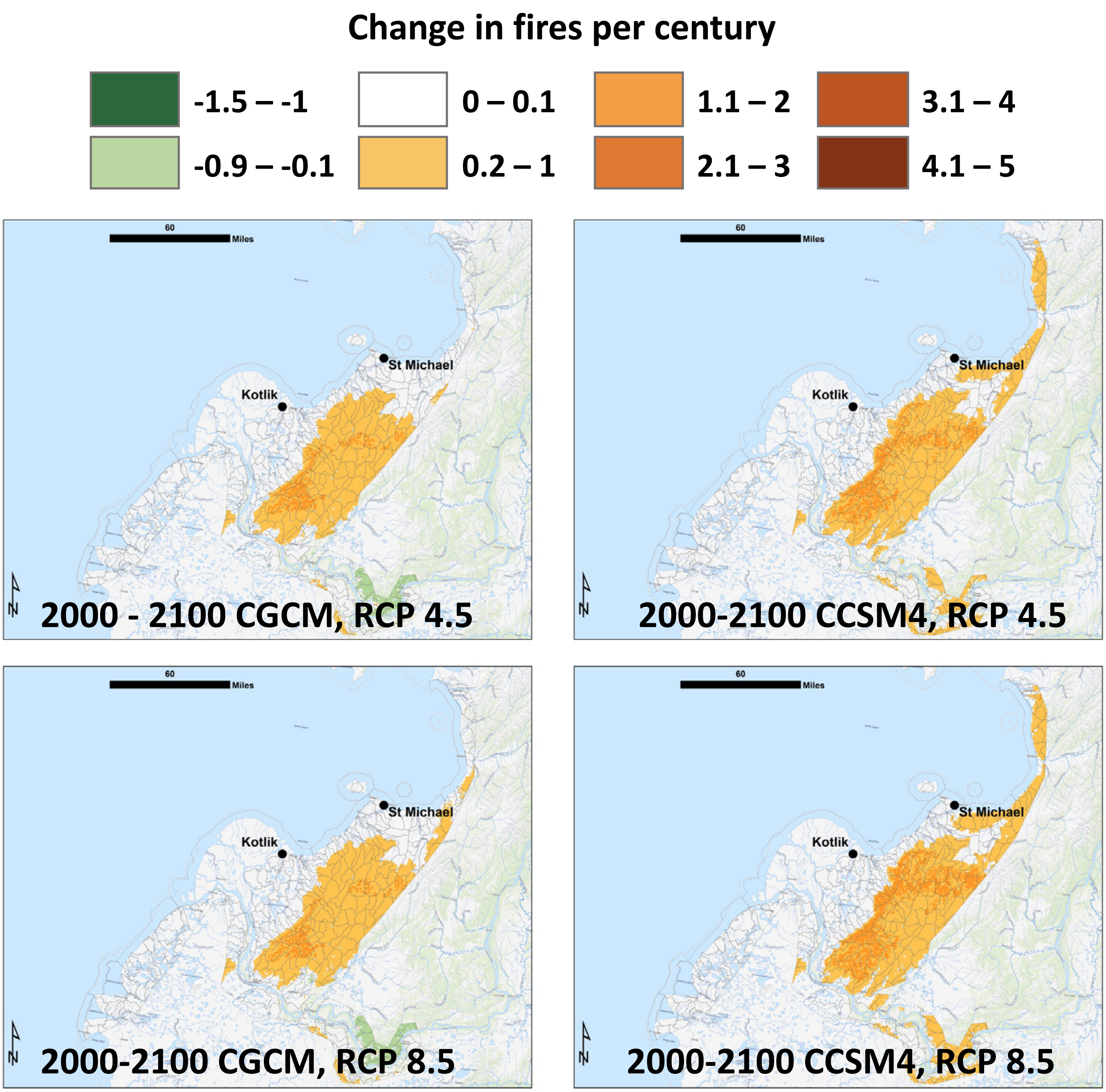
Change in vegetation per century, relative to 20th century

Changes in vegetation are new kinds of plants establishing where different plants used to be. These changes happen as new areas become favorable to plants, either due just to climate changes or after fire or other disturbance. Both models project significant landscape changes , especially under the CCSM4 climate model.



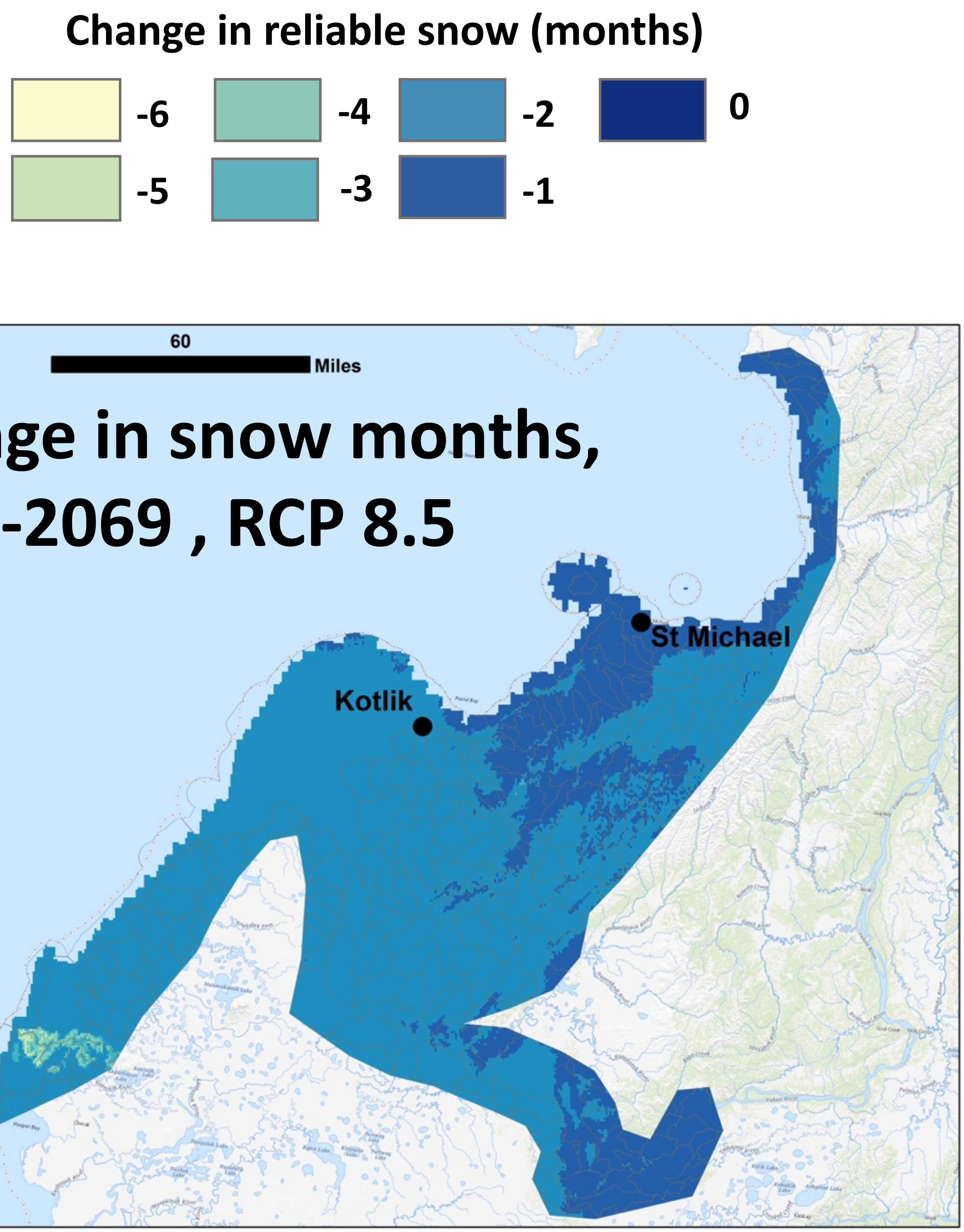
Change in fires per century, relative to 20th century

To the east and southeast of Kotlik, the number of fires per century is projected to increase by 1 (light orange) to 2 (darker orange) fires per century on average. The darker areas indicate places where fire would burn too often for spruce to remain the dominant species.



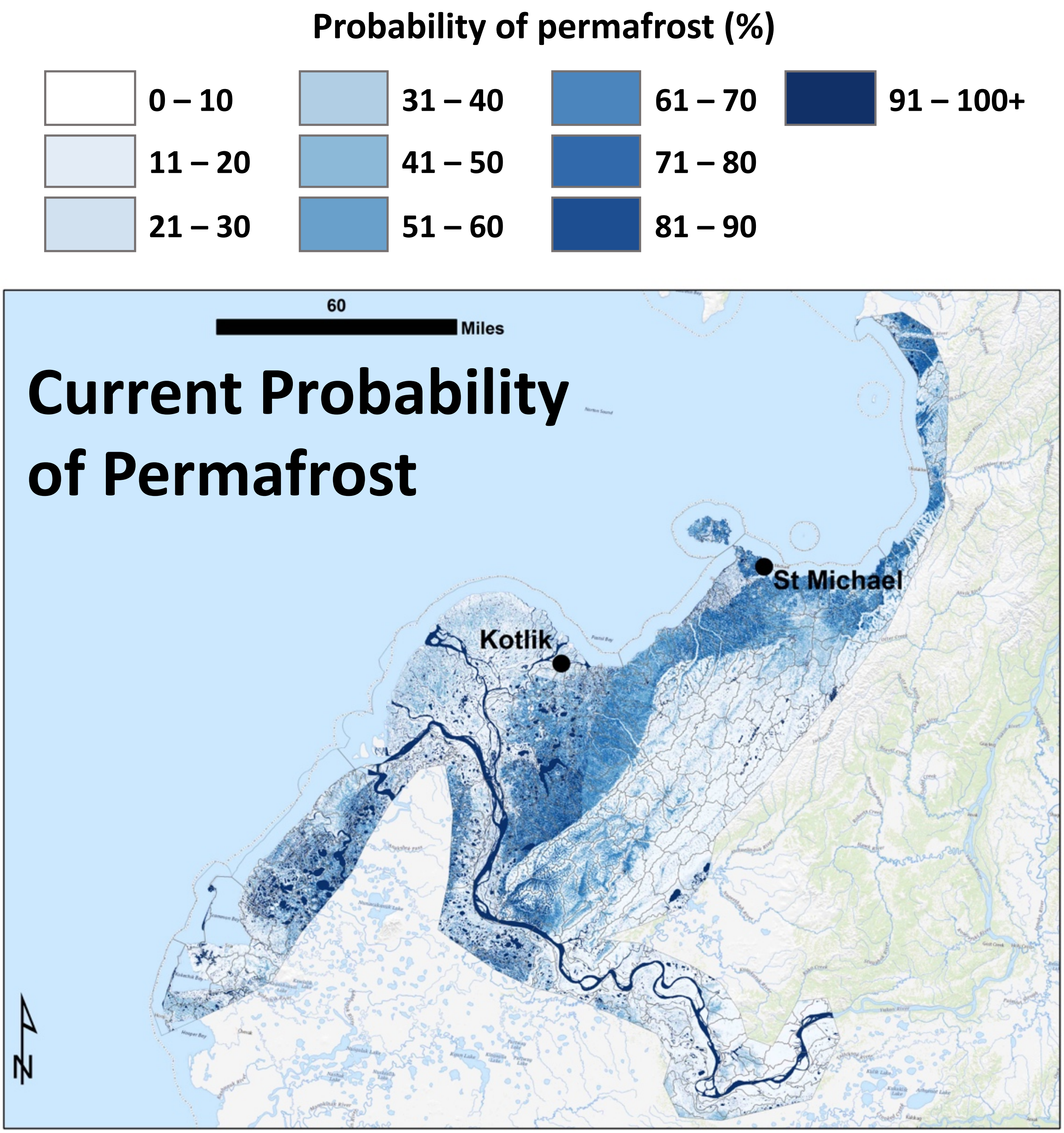
Change in reliable snow (months)

Snow months decrease by 1 to 2 months across much of the region, with largest decreases in the east and north of the region.



Probability of permafrost (%)

Currently, permafrost in the region is thought to be patchy but locally important.



Data tables

PRECIPITATION CHANGES – Percent (%) change averaged over the Kotlik region

	2040 - 2069				**2070 - 2099**			
	RCP 4.5		**RCP 8.5**		**RCP 4.5**		**RCP 8.5**	
	Average	Range	Average	Range	Average	Range	Average	Range
Annual	**18**	**15 - 19**	**24**	**21 - 26**	**21**	**19 - 23**	**36**	**32 - 39**
Spring	12	9 - 14	20	17 - 23	16	14 - 19	32	28 - 36
Summer	19	13 - 22	22	17 - 28	18	14 - 22	32	27 - 38
Autumn	18	17 - 20	28	24 - 30	25	21 - 28	41	36 - 45
Winter	21	19-23	24	20 - 28	28	22 - 32	39	36 - 42

TEMPERATURE – Change (in °F) averaged over the Kotlik region

	2040 - 2069				**2070 - 2099**			
	RCP 4.5		**RCP8.5**		**RCP 4.5**		**RCP 8.5**	
	Average	Range	Average	Range	Average	Range	Average	Range
Annual	**5.9**	**5.7 - 6.0**	**7.8**	**7.7 - 8.0**	**7.6**	**7.4 - 7.8**	**11.6**	**11.4 - 11.9**
Spring	5.5	5.2 - 5.8	7.2	6.9 - 7.5	6.7	6.3 - 7.1	10.6	10.2 - 11.1
Summer	3.3	3.1 - 3.6	4.6	4.4 - 4.9	4.5	4.3 - 4.8	7.4	7.1 - 7.8
Autumn	5.8	5.3 - 6.5	7.4	6.8 - 8.3	7.4	6.8 - 8.2	11.0	10.0 - 12.0
Winter	8.6	7.8 - 9.5	11.9	11.2 - 12.9	11.6	10.8 - 12.7	17.3	16.3 - 18.4

SNOWPACK - Percent (%) change (snowfall) and percent (%) (snow index) averaged over the Kotlik region

	2040-2069				**2070 - 2099**			
	RCP 4.5		**RCP 8.5**		**RCP 4.5**		**RCP 8.5**	
	Average	Range	Average	Range	Average	Range	Average	Range
Snowfall water	0	-8 - +5	-8	-17 - -1	-3	-13 - +3	-22	-34 - -15
Snow index	74	64 - 83	69	57 - 78	69	57 - 78	55	43 - 65

*Averages are for five climate models. Ranges are across HUC 12 (12 digit Hydrologic Unit Code) watersheds. See the PowerPoint with the regional maps file for descriptions of the variables.

Village of Kotlik
P.O. Box 20210
Kotlik, Alaska 99620
Phone: (907) 899-4326   Fax (907) 899-4790

June 2, 2020

Malinda Chase, AK CASC-APIA , LFLB BRT Project Co-Lead
Ryan Toohey, AK CASC-USGS, LFLB BRT Project Co-Lead
Alaska Climate Adaptation Science Center (AK CASC)
University of AK Fairbanks
PO Box 757245
Fairbanks, AK 99775

Regarding: Review of the BRT Kotlik Community Report, Training One and Training Two reports

Dear Building Resilience Today Project Team,

This letter acknowledges that the Village of Kotlik received the BRT Kotlik Community Report, BRT Training One and BRT Training Two reports as submitted to us by the BRT Project Team. I have specifically reviewed the BRT Kotlik Community report with Philomena Keyes our BRT Team Leader for the project.

Like the rest of the world, responding to the COVID pandemic impacted conducting tribal business, and it's been a challenge for our full council to review these project documents.

In order to assist with routing and finalizing these documents, the Village of Kotlik Tribal Office has discussed this with our leadership. We support the following:

1) Approves the final drafts of these documents for general publication and to submit to the Bureau of Indian Affairs Tribal Resilience Program for reporting, to the US Geological Survey for review of the climate science, and to the Alaska Climate Adaptation Science Center to highlight as a partnership project with the Village of Kotlik.

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P.O. Box 20210
Kotlik, Alaska 99620
Phone: (907) 899-4326   Fax (907) 899-4790

I recognize with our approval of the final drafts of these documents for general publication that all three reports will be submitted to the US Geological Survey for internal review of the science contained within these documents.

Sincerely,

Pauline Okitkun, Tribal Administrator

Village of Kotlik