Welcome to the ACCAP’S Alaska Climate Webinar Series

Tuesday, December 17, 2013

Webinar Moderated by:
Tina Buxbaum
Assessment of climate impacts and climate vulnerability in the Aleutian / Bering Sea Region

John Walsh (UAF) & Nick Bond (NOAA PMEL)

More at: http://ABSILCC.org
Aleutian and Bering Sea Islands Region

Key Resources
- Seabirds
- Marine Mammals
- Fishes
- Invertebrates/Shellfish
- Coldwater Corals
- Cultural Artifacts/Sites
- Terrestrial Vegetation

Key Ecosystem Services
- Commercial Fishing
- Subsistence Culture
- Trophic Function
- Human Community Sustainability
What climate information does the ABSI region need?

• Among other things, climate data and projections
  – Downscaled future climate scenarios and knowledge of their uncertainty
  – Climate-driven physical, oceanographic, and ecological scenarios
Goal of this webinar:

Introduce the ABSI community to new products focused on the region that may be useful for:

- Climate impacts assessment
- Vulnerability assessment
- Prioritizing ABSI future investments
A “T” shaped approach

Expertise from both J. Walsh and N. Bond on the climatic, oceanographic, and ecological changes in the ABSI region gives us access to both a “breadth” of scenarios and a “depth” of impacts from those scenarios.
**Walsh et al:** Using multiple GCMs to develop statistical and dynamical downscaled climatic and hydrologic responses

**Hermann, Bond, et al.:** Using a few GCMs to develop downscaled oceanographic and biophysical responses

<table>
<thead>
<tr>
<th>IPSLCM5 GCM</th>
<th>CGCM3.1 GCM</th>
<th>CCSM4 GCM</th>
<th>GFDL CM3 GCM</th>
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CMIP 5 Statistical Downscaling (quantile)

Dynamical Downscaling (WRF)

Many variables, physically consistent:

- Wind, pressure, temperature, precipitation, humidity, sea ice etc.

Projected climatic and physical parameters

Extremes
- Wind
- Temperature
- Sea Ice

Projected biological parameters

**NPZ biophysical model**

**1970-2010  2020-2040**

[Images of oceanographic and biophysical models]
Climate scenarios and vulnerabilities in the Aleutian and Bering Sea islands

John Walsh, University of Alaska Fairbanks

Nick Bond, NOAA Pacific Marine Environmental Laboratory
Why do we need to downscale the output from climate models?
Motivation: Most of the population lives in areas having sharp climatic gradients: along coastlines, lakes, mountains/valleys… *Alaska has them!*

Climate model downscaling “bridges the gap” between what is provided by coarse-resolution global climate models and what is needed by decision-makers and impact assessors.

Two approaches: statistical (e.g., MOS in NWP) dynamical (regional climate models)
Sources of uncertainty in Arctic climate projections

Alaska annual temperature anomalies

PDO Index

Pacific Decadal Oscillation Index
Emission scenario is major factor in *global* temperature rise, especially from mid-century onward
[from *U.S. National Climate Assessment, 2013*]
Downscaling of global climate models by SNAP (Scenarios Network for Alaska and Arctic Planning)

- A set of 20+ models were compared with data (1958-2000) for surface air temperature, sea level pressure, and precipitation

- Models that perform best over Alaska have been selected

- Two statistical downscaling methods: one for monthly means by decade, one for changes in extremes
Statistical downscaling approaches used by ACCAP/SNAP

1) *Delta method*: Differences between GCM future and historical periods are added to high-resolution historical data.
   – *applied by SNAP/ACCAP to monthly output (CMIP3, CMIP5)*
Historical and projected temperatures for Adak: 5 time-slices

A1B (mid-range) scenario; range lines show inter-model spread

http://www.snap.uaf.edu/charts.php
Historical and projected precipitation for Adak: 5 time-slices

A1B (mid-range) scenario; range lines show inter-model spread
Decadal temperatures, historical and projected: Savoonga, AK

**Average Monthly Temperature for Savoonga, Alaska**

*Historical PRISM and 5-Model Projected Average, Low-Range Emissions (B1)*

- **1961-1990**
- **2010-2019**
- **2040-2049**
- **2060-2069**
- **2090-2099**

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**Average Monthly Temperature for Savoonga, Alaska**

*Historical PRISM and 5-Model Projected Average, High-Range Emissions (A2)*

- **1961-1990**
- **2010-2019**
- **2040-2049**
- **2060-2069**
- **2090-2099**

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*Due to variability among climate models and among years in a natural climate system, these graphs are useful for examining trends over time, rather than for pinpointing monthly or yearly values. For more information on derivation, reliability, and availability among these products, please visit: [www.snap.uaf.edu](http://www.snap.uaf.edu)*
Decadal temperature and precipitation, **A2 scenario**: Attu, AK
Statistical downscaling approaches used by ACCAP/SNAP

1) *Delta method*: Differences between GCM future and historical periods are added to high-resolution historical data

   – *applied by ACCAP/SNAP to monthly output (CMIP3, CMIP5)*

2) *Quantile mapping*:

   -- each quantile of model-derived distribution is given an adjustment which is difference between model-simulated quantile value and corresponding value from observed distribution for recent decades
   -- removes model biases
   -- used with *daily values*
   -- enables capture of changes in entire distribution, including extremes
Quantile mapping used in BCSD downscaling approach
Bering Sea: days $-15^\circ\text{C}$ or colder (RCP 8.5)

<table>
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<tr>
<th>Period</th>
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<td>1971-2000</td>
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<td>2031-2060</td>
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<td>2071-2100</td>
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[Graph showing the number of days with temperatures below $-15^\circ\text{C}$ for the Bering Sea for the periods 1971-2000, 2031-2060, and 2071-2100.]
Bering Sea: days 10°C or warmer (RCP 8.5)

1971-2000            2031-2060            2071-2100
Website

User menu provides options for:

- coastal/marine grid cells,
- variables,
- calendar months,
- future timeslice,
- “best” CMIP5 models for AK,
- RCP scenarios
Web interface for plotting occurrences of threshold temps/winds vs. time

http://spark.rstudio.com/uafsnap/temp_wind_events/
Sample plots: # of days with average windspeed $>10.8$ m/sec
Bering Sea, Sep-Oct 1981-2099, 3 models (RCP 8.5)

-- increase in autumn storminess
Sample plots: # of days with average windspeed >10.8 m/sec
Bering Sea, Jan-Feb 1981-2099, 3 models (RCP 8.5)
-- slight decrease in winter storminess
Sample plots: # of days with average windspeed >10.8 m/sec
Adak, Jul-Sep 1981-2099, 3 models (RCP 8.5)

-- slight increase in summer storminess
Sample plots: # of days with average temperature > 12°C
Bering Sea, Jun-Aug 1981-2099, 3 models (RCP 8.5)
-- large increase in summer days warmer than 54°F
Sample plots: # of days with average temperature < -4ºC
Bering Sea, Jan-Feb 1981-2099, 3 models (RCP 8.5)
-- large decrease in winter days colder than 25ºF
Ongoing work at UAF

- Variables best suited to needs of users, e.g., ecosystem modelers, coastal communities
- Aggregate metrics based on intersection of variables, e.g., wind and presence/absence of sea ice
- Greater emphasis on uncertainties in distributed products
The Response of the Ecosystem of the Bering Sea to Global Climate Change

• Empirical Results

• Dynamical Projections

• A Cautionary Note
Factors determining the survival of walleye pollock

Spring conditions
- Timing of ice retreat
- Spawning

(Late) summer conditions
- Spring SST
- Early larvae (spring)
- Summer SST
- Late larvae (fall)
- Stability
- Wind mixing
- Age-1 recruits

Predation
- Biomass
- Consumption rate
- Prey composition

Spatial distribution
Arrowtooth flounder tend to avoid the Bering Sea cold pool
Dynamical Modeling

Higher trophic levels  
(Pollock etc.)

Secondary Producers  
(Zooplankton)

Primary Producers  
(Phytoplankton)

Nutrients  
(NO$_3$, NH$_4$...)

Physical Forcing  
(Wind, temp, sun)

Economic/ecological model

FEAST Higher trophic level model

NPZ  
Lower trophic level ecosystem model

ROMS  
Physical Oceanography

Climate scenarios

Nested models

BEST

BSIERP
• Horizontal resolution: ~10km, vertical resolution: 60 layers
• Computes physical properties i.e. temperature, salinity, currents
• BEST-NPZ model coupled to ROMS at every grid point and time-step
Surface Temperature Changes (August) from Present to 2030s

CCCMA

MIROC
Near surface concentrations of euphausiids in August

Present

CCCMA (2030s)

ECHOG (2030s)

MIROC (2030s)
Domain 8 (outer northwest shelf)

Week of year

Age 0 foraging potential

Colors: stock-assessment year-class strength

Blue: weakest
Red: strongest
A short period of calm, clear weather on the Bering Sea shelf in early summer 1997 led to conditions favoring a coccolithophore bloom.
Niche established in 1997 persisted into 1999
A Couple of Takeaways

• Dynamical downscaling not necessarily superior to empirical approaches in some applications

• Extreme/episodic events can be a key aspect of the climate forcing of a system, complicating long-term projections