Consequences of an Ice-Diminished Arctic Ocean

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The Situation

- Passive microwave satellite observations have documented a 30-40% reduction in the end-of-summer ice cover since the late 1970s.

September Arctic Ice Extent, 1979-2011

Trend = -13.0%/decade

Data from NSIDC Sea Ice Index, Fetterer et al. 2002
Regional Ice Losses

- The last decade has seen ice loss off both the Eurasian and North American coasts.
- Since 2007, either the NWP or the NSR has opened during summer, sometimes both.
Ice Thickness has also Declined

- Thickness observations from submarine records and satellite altimetry show thinning ice cover.
Thinner Ice is Reflected in a Younger Ice Cover

Data from Maslanik, Fowler and Tschudi 1985-2012

In 2012, less than 3% of the ice cover is 5 years or older

Ice Age for week 9 (Feb 27 to Mar 4)

% of Total Amount of Ice

% Extent (million sq-km)

Year


NSIDC
NASA
NSF
Future Projections from CMIP5

September Ice Extent (RCP4.5)

- CanESM
- GISS E2-R
- INMCM4
- MIROC5
- MPI ESM-LR
- NorESM1
- CNRM3
- HadCM3
- HadGEM2-CC
- IPSL-CM5A-LR
- IPSL-CM5A-MR
- MIROC ESM
- MIROC ESM-CHEM
- MRI CGCM3
- NCAR CCSM4
- GFDL
- HadGEM2-ES
- GISS E2-H
- Observations
- Ensemble Mean

CMIP5 models versus observations
**September Ice Extent: CMIP5 vs CMIP3**

1953-2011 rate of decline:
-6.3%/decade
-3.1%/decade
-4.6%/decade

1979-2011 rate of decline:
-13.0%/decade
-5.0%/decade
-8.1%/decade
Climate Impacts of Reduced Sea Ice Cover

- Arctic Amplification has been a common feature of climate model predictions.
- Large fluxes of heat and moisture during fall/winter from loss of sea ice contribute to amplified warming in the Arctic.
Recent Sea Ice Loss has Warmed the Atmosphere

- Arctic Basin sea ice and $T_{\text{m}}$ air temperature anomalies
- Warming most pronounced during autumn.
Impacts on Autumn Precipitable Water

Anomalies in SON precipitable water during low/high ice years

Figure from Stroeve et al., 2011
Impacts on Cyclone Associated Precipitation

- While positive precipitable water anomalies occur where ice has retreated, CAP anomalies dominate GNB region.

Change in Total SON CAP due to a change in event mean output or event frequency (2004-2008) – (1999-2003)

Figures from Stroeve et al., 2011
Coastal Communities are Threatened

• Lack of sea ice exposes shoreline communities to waves and storms that are creating severe erosion problems.

Upper right photo credit: Craig George
Impacts on Marine Activity

Hard Minerals
Maritime Tourism
Major Fisheries
Oil and Gas
Summer Sea Lift
Exploration/Science

In 2004, ~6,000 ships
Summary Statements

• Sea ice thickness and extent has declined during the 2\textsuperscript{nd} half of the 20\textsuperscript{th} century/early 21\textsuperscript{st} century.
• Models simulate continuing retreat of the ice cover and summer ice-free conditions as early as 2050.
• Climate impacts are already being felt.
• Increased development of Arctic natural resources (hydrocarbons, hard minerals, fisheries) will increase marine activity and risk of oil spills.
Observational Needs

- Accessibility and interoperability of products, through consistent formatting and metadata and/or easy to use freeware tools.
- Need for climate data records.
- For satellites, continuity is critical. This includes not only the PM record, but also VIS/IR, SAR, Scatterometer, and altimetry.
- For in situ, ice mass buoys (including FYI), cameras, sensors that conduct staring-mode observations of change.