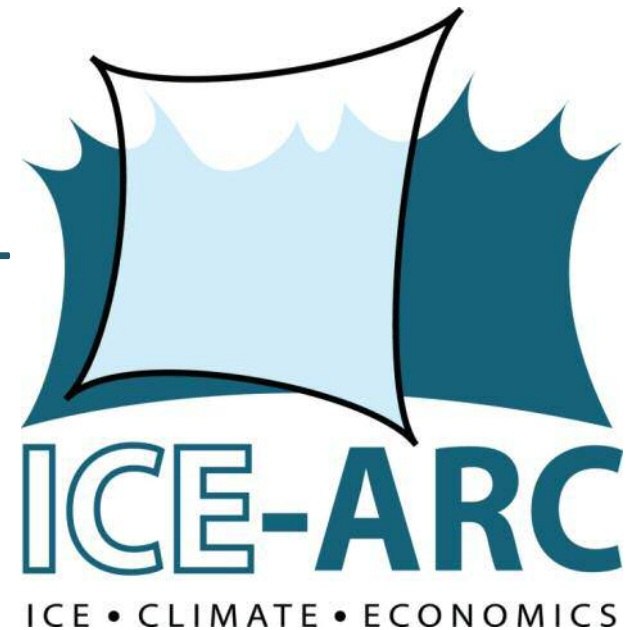


Ice, Climate, and Economics – Arctic Research on Change



Arctic Ocean observations, modelling, and assessment of the social and economic impact of Arctic **sea-ice** loss

GCOS/GOOS/OOPC Essential Climate Variable

Sea ice is an Essential Climate Variable



OOPC Ocean Observations Panel for Climate
 Scientific and technical recommendations for a **sustained global ocean observing system for climate** and operational oceanography

Surface composite network: satellite observations

Component satellite network	ECVs	International coordination
Infrared (IR)	SST, sea ice	CEOS IGOS CGMS
AMSR-class microwave	SST, wind speed, sea ice	CEOS IGOS CGMS
Surface vector wind (two wide-swath scatterometers desired)	Surface vector wind, sea ice	CEOS IGOS CGMS
Ocean colour	Chlorophyll concentration Biomass of phytoplankton	IOCCG
High-precision altimetry	Sea-level anomaly from steady state	CEOS IGOS CGMS
Low-precision altimetry	Sea level	CEOS IGOS CGMS
Synthetic aperture radar (SAR)	Sea ice, sea state	CEOS IGOS CGMS

Surface composite network: in situ observations

Component network	ECVs	International coordination
Global surface drifting buoy array with 5° resolution (1250 total)	SST, SLP, Current (based on position change)	JCOMM Data Buoy Cooperation Panel (DBCOP)
Global tropical moored buoy network (~120 moorings)	typically: SST and surface vector wind <i>can include:</i> SLP, Current, Air-sea flux variables	JCOMM DBCOP Tropical Moored Buoy Implementation Panel (TIP)
Volunteer Observing Ship (VOS) fleet	all feasible surface ECVs	JCOMM Ship Observations Team (SOT)
VOSclim	all feasible surface ECVs plus extensive ship metadata	JCOMM Ship Observations Team (SOT)
Global reference mooring network (29 moorings)	all feasible surface ECVs	OceanSITES
GLOSS core sea-level network, plus regional/national networks	sea level	JCOMM GLOSS
Carbon VOS	pCO ₂ , SST, SSS	IOCCP
Sea ice buoys	sea ice	JCOMM DBCOP IABP and IPAB





Overview

- Summary of Arctic sea ice change
- Impacts of sea ice loss on different sectors
- Need for a holistic (multi-sector) view
- Outline the ICE-ARC (observing) program

Arctic sea ice at a glance



Winter 1980



www.nasa.gov



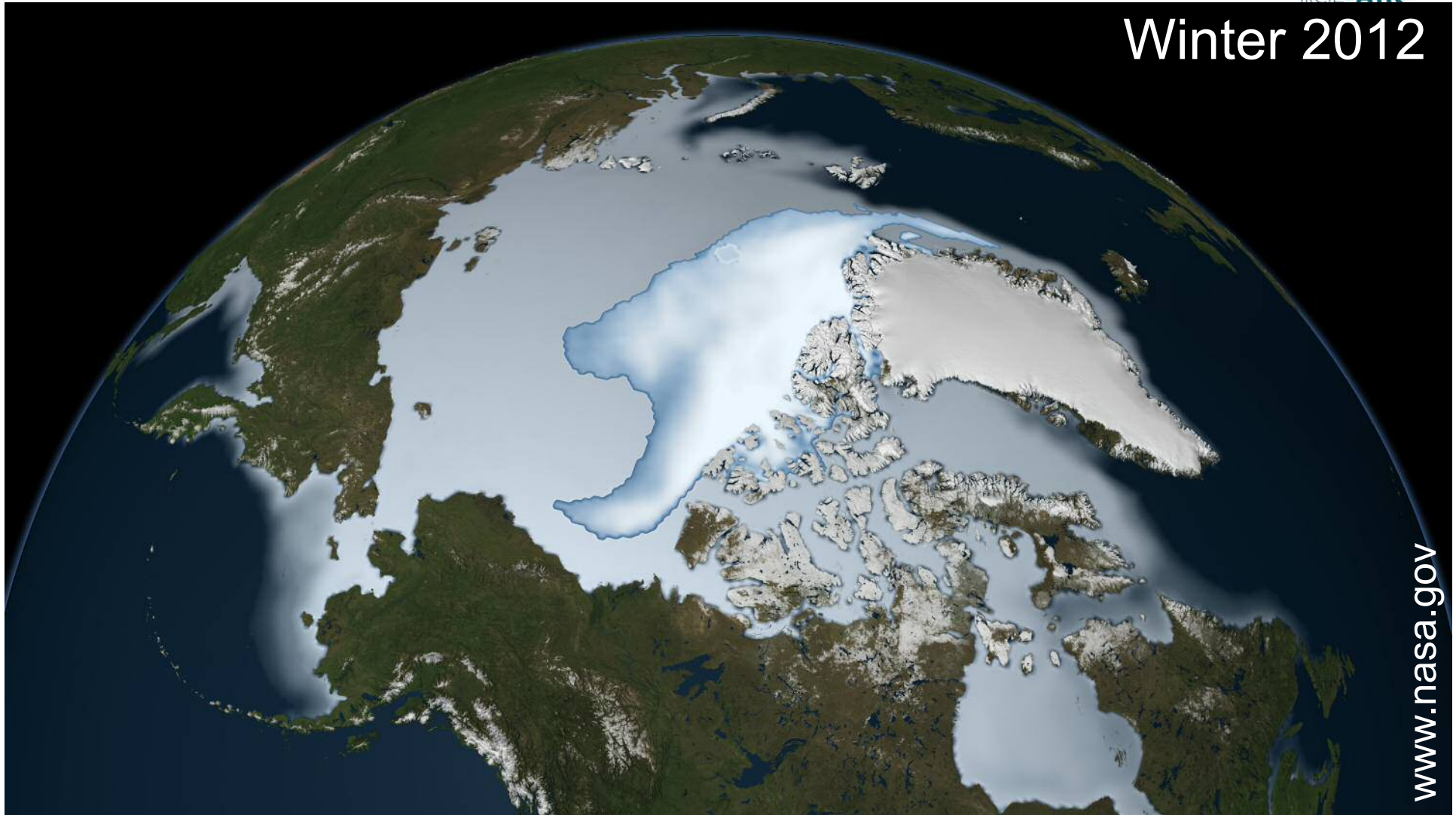
www.ice-arc.eu



Arctic sea ice at a glance



Winter 2012



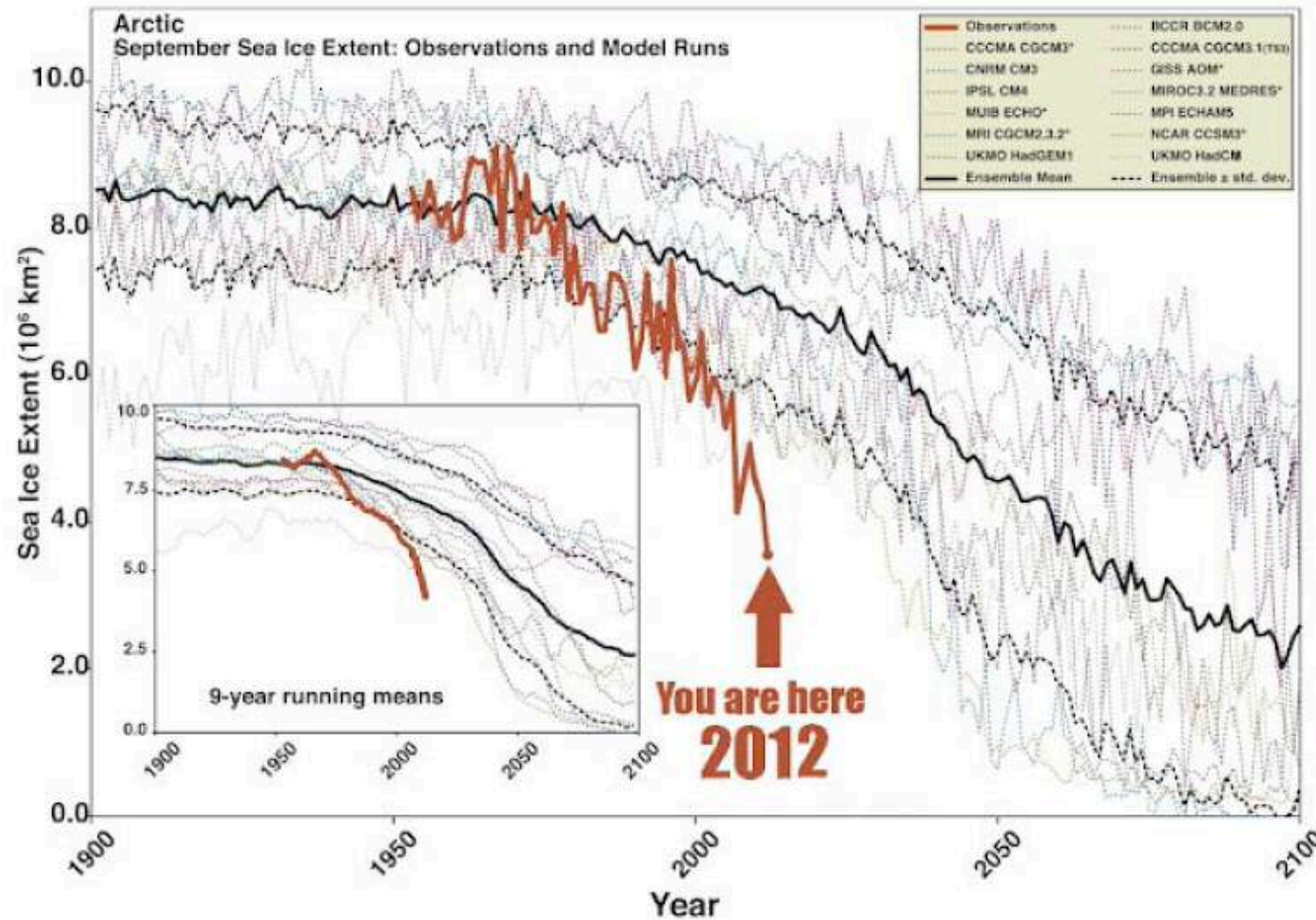
www.nasa.gov



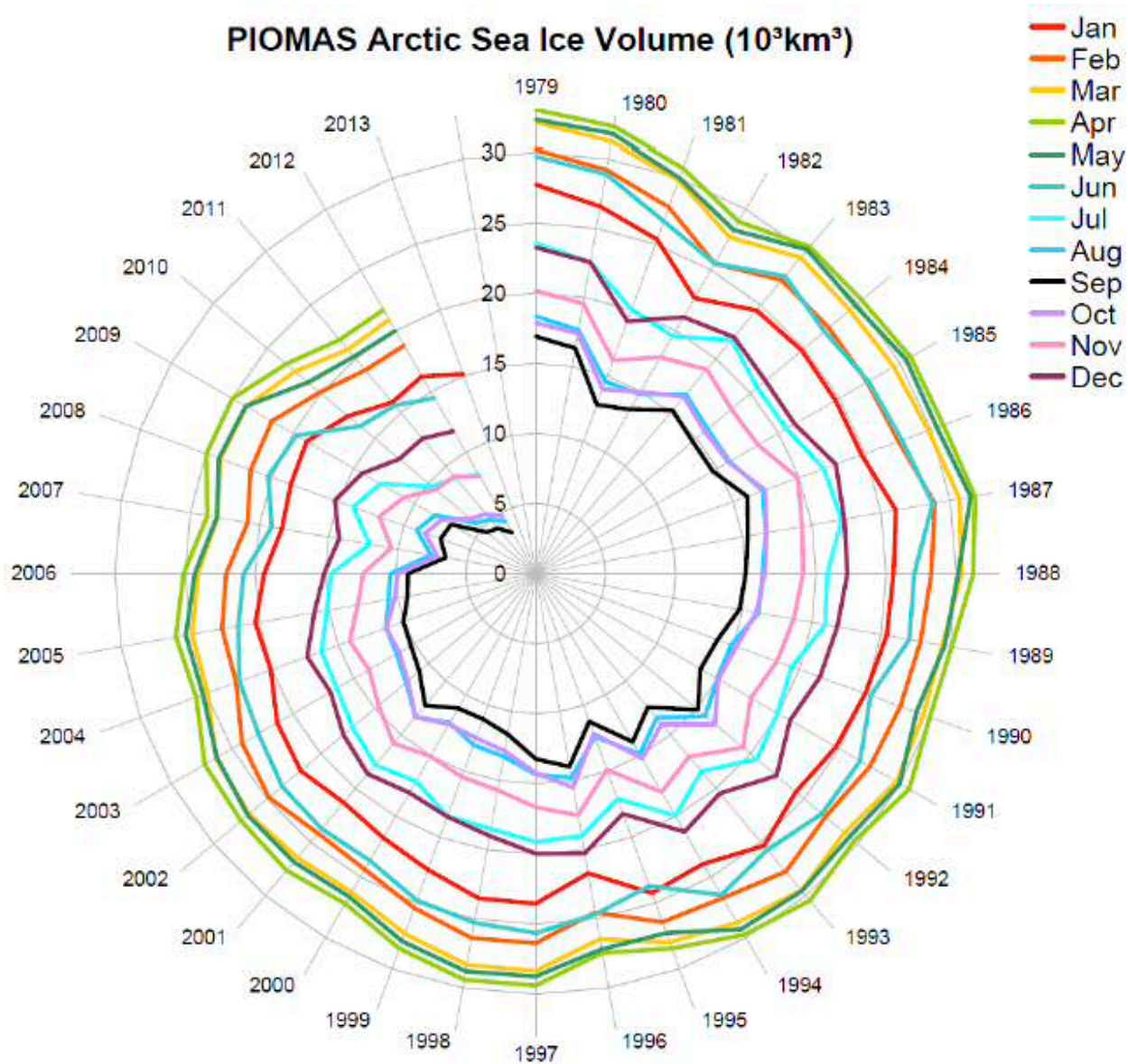
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September Minimum Observations and Models



The “Death Spiral” of Arctic Sea Ice

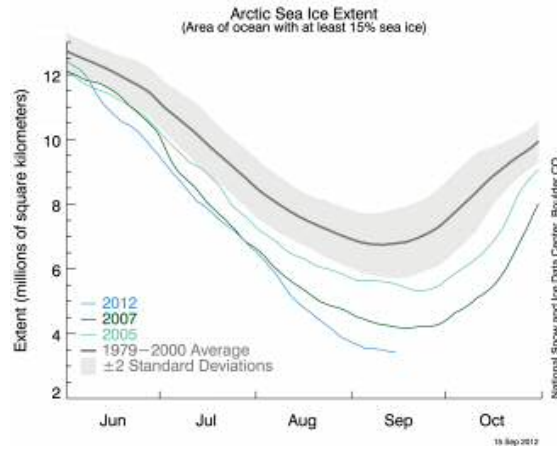


Monthly Averages from Jan 1979 to Jan 2013

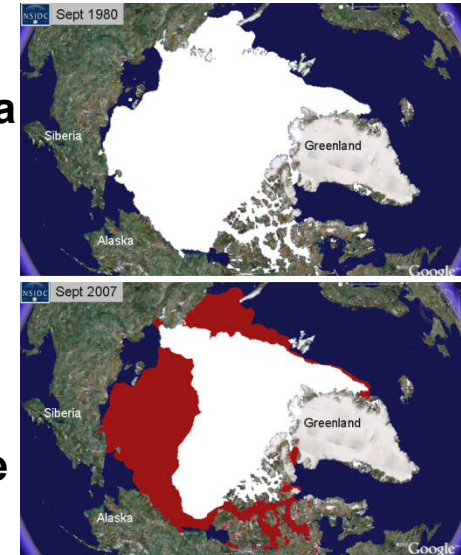
Andy Lee Robinson andy@haveland.com



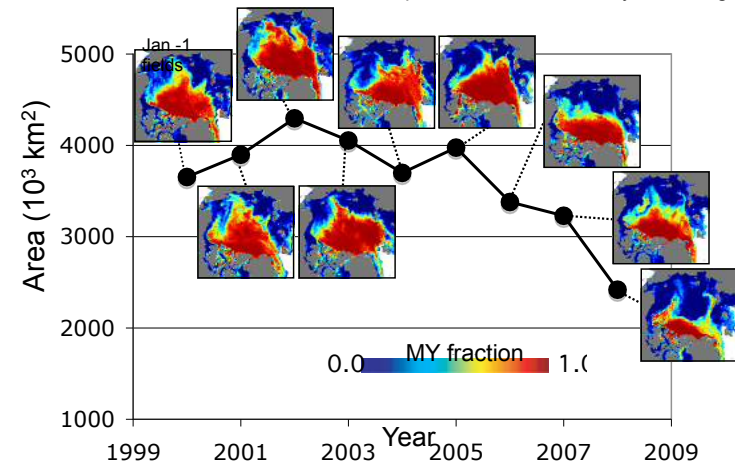
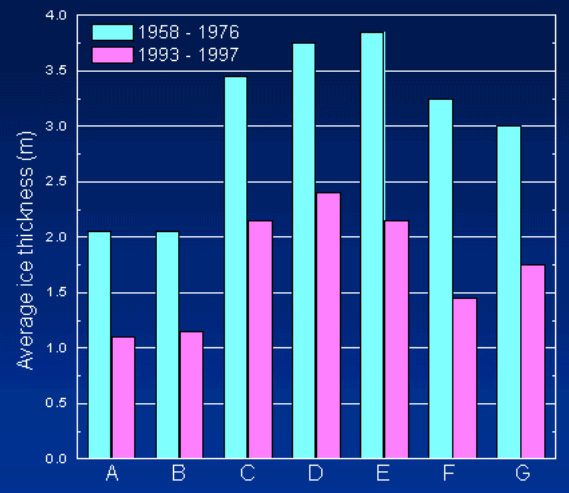
The top of the world is changing...



- **Reduction of over 50% in summer sea ice extent since the 1970s**
 - 7 million km² in the 1970s
 - 4.2 million km² in 2007
 - 3.4 million km² in 2012
- **Reduction over 40% in thickness**
- **Regime shift: from a multi-year ice dominated regime to a first-year regime**



<http://imb.crrel.usace.army.mil/change.htm>



(Kwok, 2008)



Multifaceted impacts....

- **Indigenous communities**
 - Loss of traditional way of life
- **Coastal changes**
 - Coastal erosion due to enhanced wave energy
- **Environmental pressures**
 - Loss of habitat/species
 - Increase in ocean acidification
 - Change in ocean properties



Multifaceted impacts....

- **Climate**

- Global links, for example changes in atmospheric circulation linked to heat and drought to the US and cold stormy weather to Europe

- **Industry**

- Shipping, oil/gas, minerals, fisheries, tourism...

- **Economics**

- UK Stern Review on the Economics of Climate Change (2006), £3.68 trillion
- What is the cost of Arctic change?



NEWS SCIENCE & ENVIRONMENT
 Home World UK England N.Ireland Scotland Wales Business Politics Health Education Sci/E
 27 February 2012 Last updated at 20:05

Melting Arctic link to cold, snowy UK winters

By Richard Black
 Environment correspondent

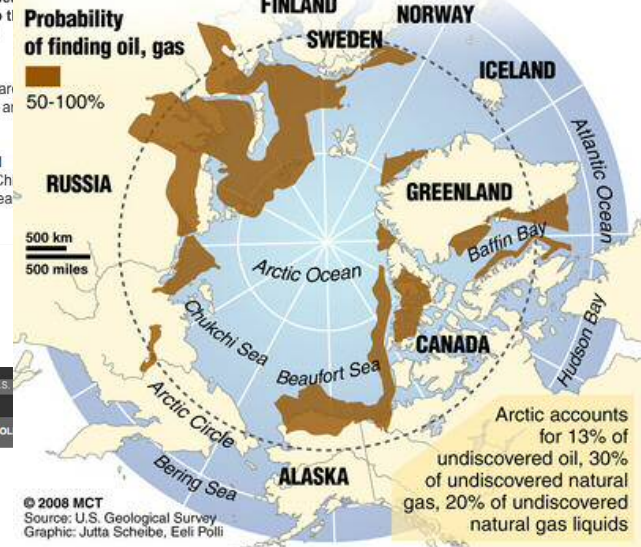
The progressive shrinking of Arctic sea ice is bringing colder, snowier winters to the UK and other areas of Europe, North America and China, a study shows.

As global temperatures have risen, the area of the Arctic Ocean covered by ice in summer and autumn has been falling.

Writing in *Proceedings of the National Academy of Sciences (PNAS)*, a US/Chinese team show this affects the jet stream and brings cold, snowy weather.

Oil and gas in the Arctic

Area north of the Arctic Circle has an estimated 90 billion barrels of undiscovered oil.



REUTERS EDITION: U.S.
 HOME BUSINESS MARKETS WORLD POL

Arctic methane release could cost economy \$60 trillion -study

Wed Jul 24, 2013 9:09am EDT
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ANALYSIS & OPINION

Political risk must-reads

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- * Reservoir of methane under East Siberian Sea
- * Release could accelerate ice melting, global warming
- * Risks include extreme weather, poorer health, lower crop output

By Nina Chestney

LONDON, July 24 (Reuters) - A release of methane in the Arctic could speed the melting of sea ice and climate change with a cost to the global economy of up to \$60 trillion over coming decades, according to a paper published in the journal

Nature.





Joined up thinking

How can we better understand the impacts of Arctic Change?

- Incredibly complex
- No one country has the expertise
- Expensive
- Engagement and dissemination activities to a diverse range of stakeholders

A Multi-sectorial approach is needed

Policy-makers, industry, and the public must have the most up-to-date and robust science available on Arctic change and its socio-economic consequences.

Evidence-based decision-making is fundamental to ensure that informed policy decisions can be reached.



EU Arctic Programme: ICE-ARC



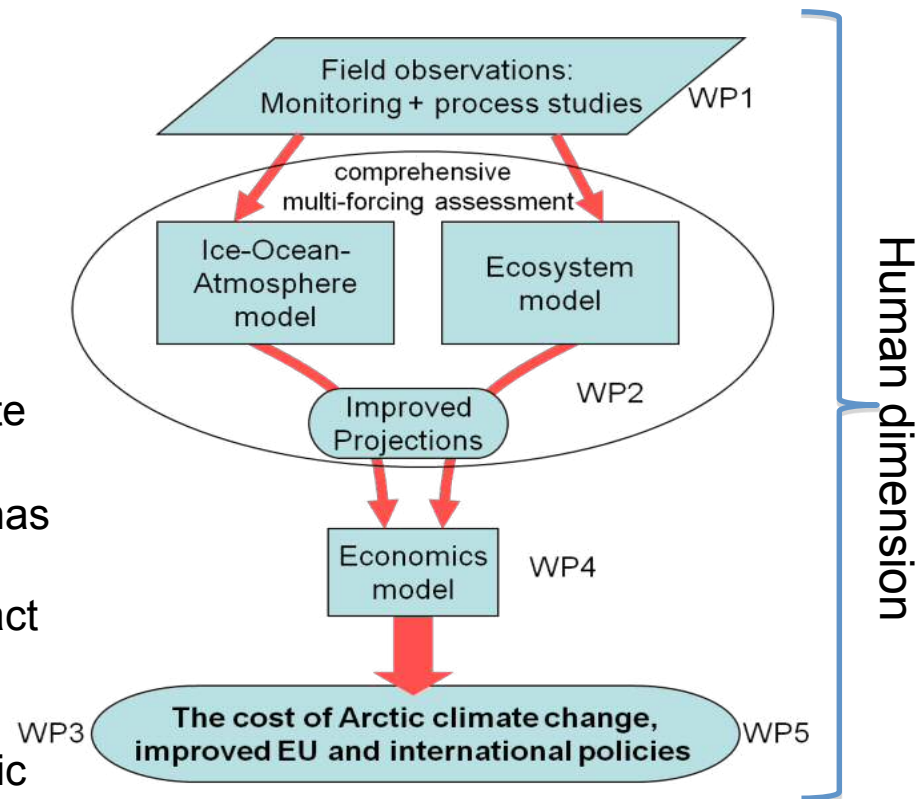
Ice, Climate, and Economics:- Arctic Research on Change
Coordinator: Jeremy Wilkinson, British Antarctic Survey, UK

Key facts:

- 21 institutions participating
- 11 European Union countries and Russia
- Project budget: €12 millions
- Project duration: 4 years (2014 - 2017)

Four interconnected objectives:

- ① Reduce uncertainties in Arctic marine climate predictions.
- ② Elucidate the impact Arctic marine change has on the ecosystem and human communities.
- ③ Understand the global socio-economic impact of Arctic marine change.
- ④ Provide concrete evidence-based policy measures in response to change in the Arctic marine system.

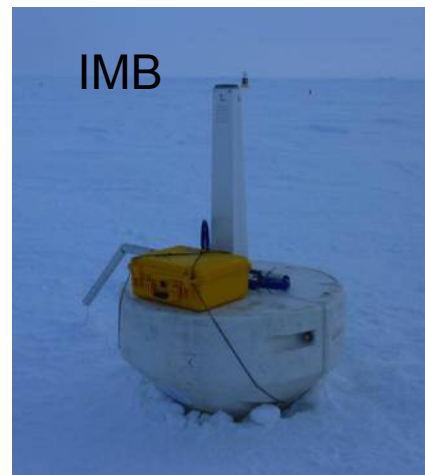
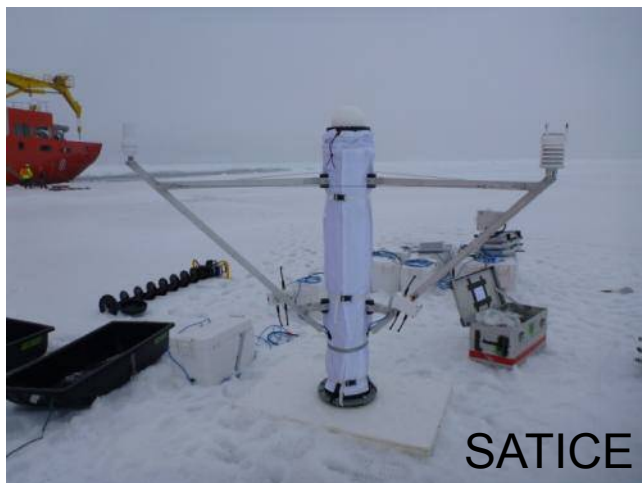
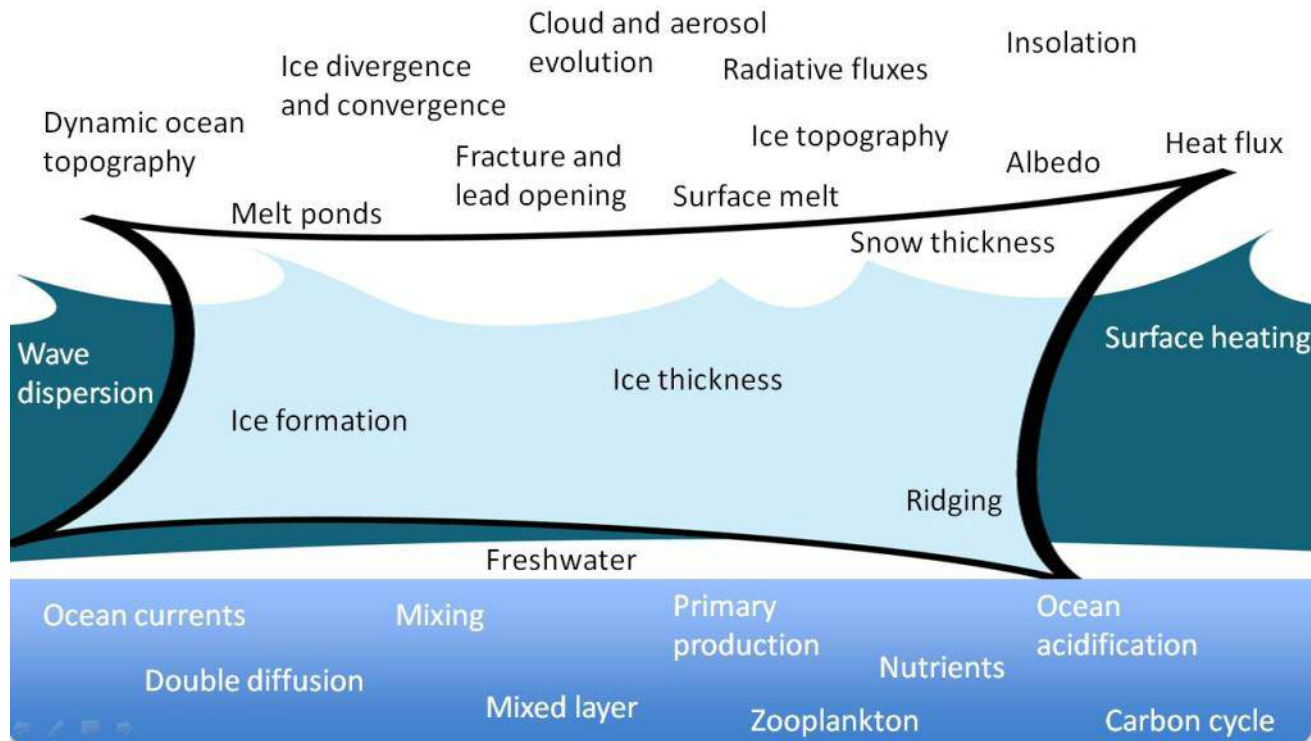


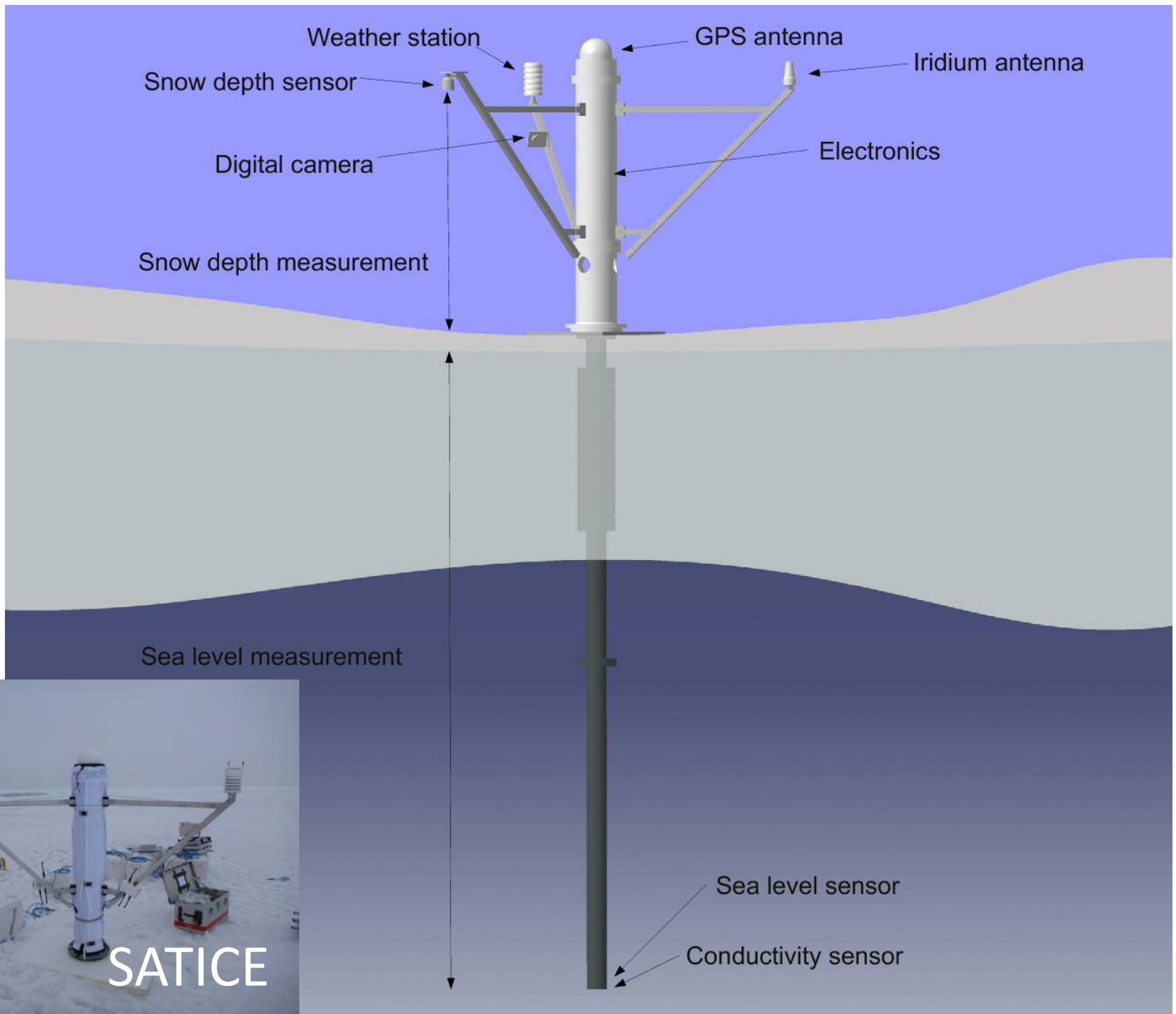
ENV.2013.6.1-1- Climate-related ocean processes and combined impacts of multiple stressors on the marine environment.

www.ice-arc.eu



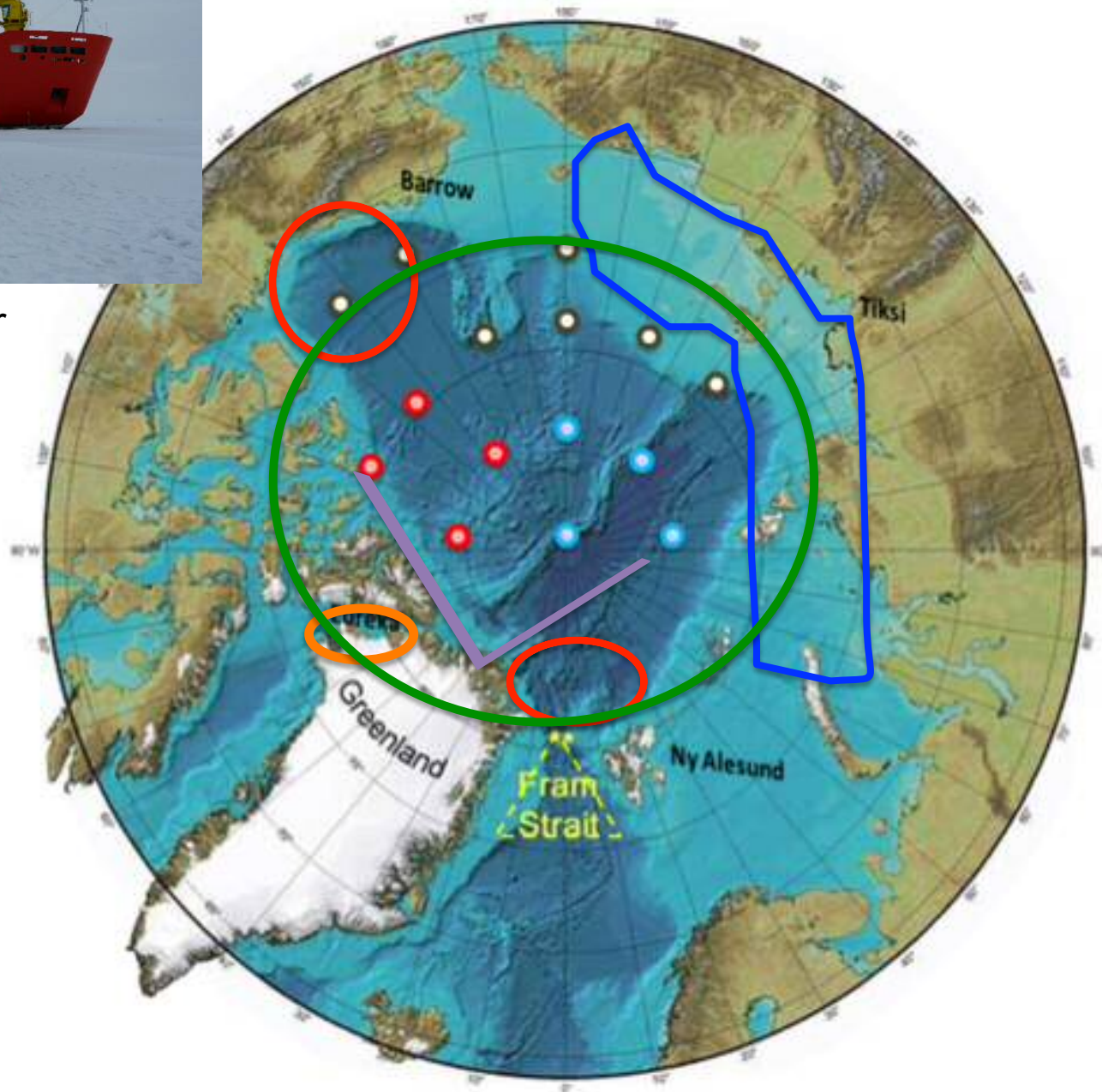
Arctic Ocean observing system





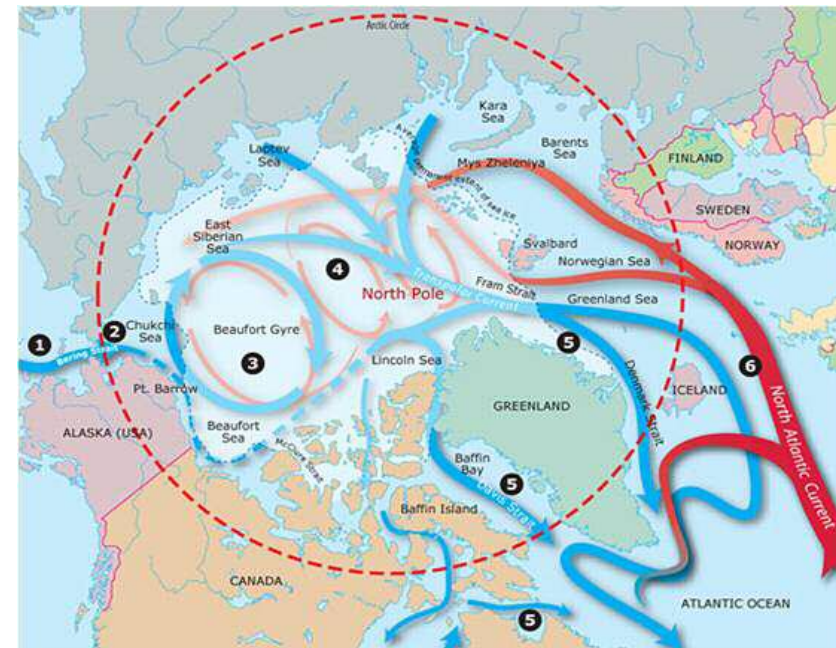
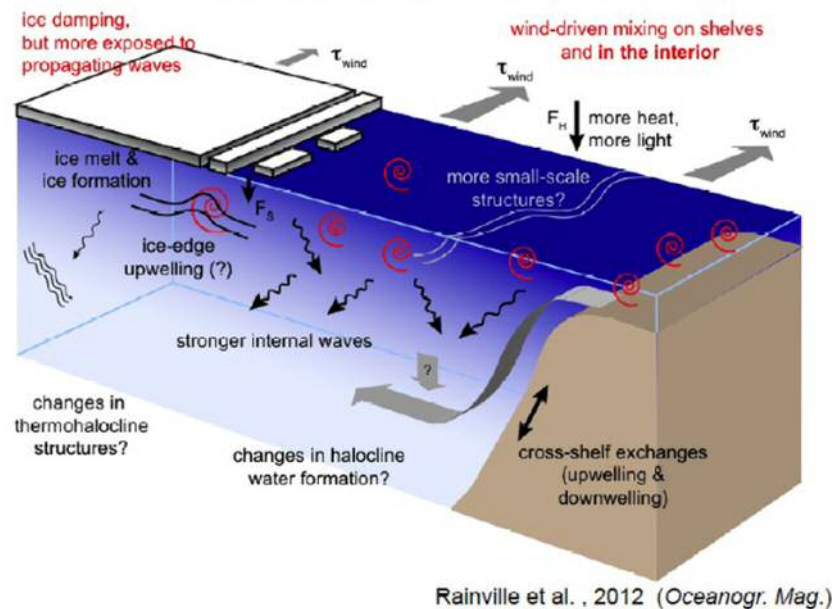


Korean icebreaker
Beaufort Sea
August 2014



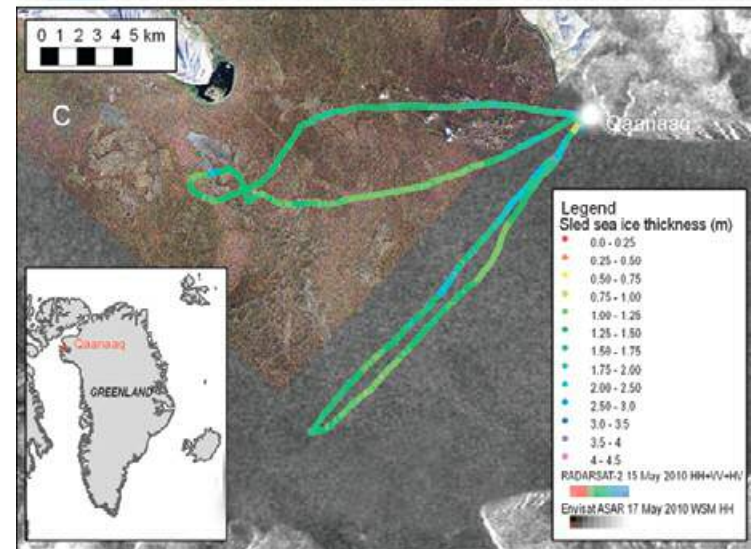
Arctic Ocean modelling

- Reducing uncertainties
- Improved climate model
- Increased understanding: couple atmosphere, cryosphere, ocean – physical and biological - and climate



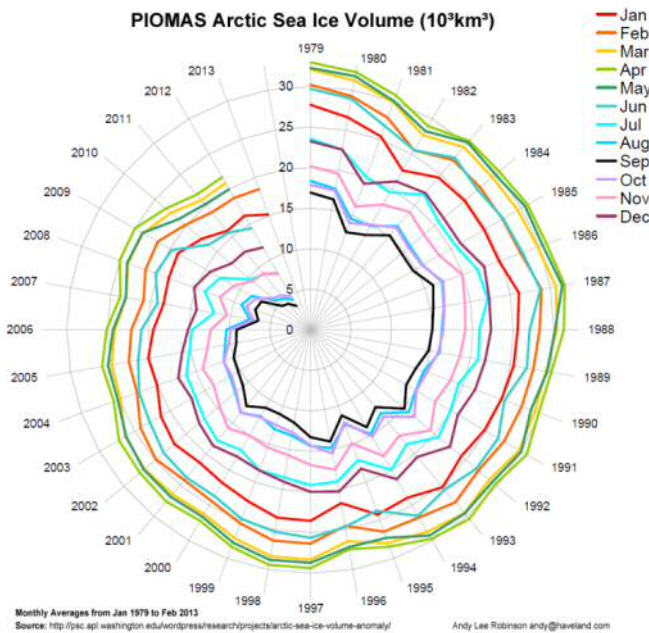
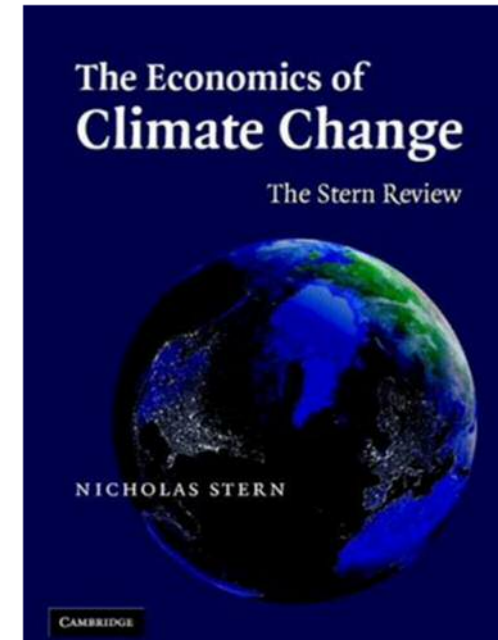
Social Impacts

- Past changes
- Impacts on communities
- Future capacity



Economic Impacts

- Adapting Integrated Assessment Model PAGE to include main influences of changes to the Arctic marine environment
- Assessing social & economic impacts of changes
- Identify key socio-economic vulnerabilities and opportunities globally and regionally
- Value the impacts of Arctic-related climate change
- Value costs of mitigate and adaptation policies



www.ice-arc.eu

Summary

- Arctic sea ice is changing
- Impacts many sectors beyond climate
- Holistic international approach is needed
- ICE-ARC trying to understand the costs and uncertainties of Arctic Change
- ICE-ARC observations of value to GOOS/OOPC

More information



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