PIOMAS and USIABP status

Pan-arctic ice-ocean modeling & assimilation system

U.S. interagency arctic buoy program

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...and some cool stuff about arctic sea ice retreat

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University of Washington
Seattle, WA, USA
• BA Physics (*Reed College, 1981*)

• PhD Geophysical Fluid Dynamics (*Princeton Univ., 1987*)

• Physical Oceanographer (*U of WA, 1987-present*)

Arctic Oceanography & Sea Ice

• Models

• Field work

• Satellite data
What about sea ice thickness?
Sea ice thickness obs

Kwok, IPCC-AR5, summarizing: Rothrock, Lindsay, Schweiger, Haas, Kwok, etc.

-0.62 m/decade

IceBridge, ICESat2, CryoSat/2

Submarine obs (Central Arctic)
EM Surveys (North Pole area)
ICESat (≥86°N)
What about ice VOLUME?

\[ \text{thickness} \times \text{extent} = \text{volume} \]

(sorta)

**PIOMAS/BIOMAS/MIZMAS**

- Coupled arctic sea ice & ocean models
- \(~22 \text{ km mean resolution (min. } \sim 3 \text{ km)}\)
- 30-40 vertical levels \((\text{min. } 5 \text{ m near surface)}\)
- Assimilation of satellite ice conc. and SST
- Plankton ecosystem component

[http://psc.apl.washington.edu/zhang/IDAO](http://psc.apl.washington.edu/zhang/IDAO)

zhang@apl.washington.edu
A consistent ice **VOLUME**
time series from **PIOMAS**

- **Trend**: $-3.0 \pm 1.0 \times 10^3$ km$^3$/decade
- **Last day**: 6/30/2015

Also declining, w/ some recent “recovery”

http://psc.apl.uw.edu/research/projects/arctic-sea-ice-volume-anomaly/
How do models simulate ice floe geometry?

“50% ice concentration; 1 m thick”

Get across?

no way…

maybe!

They don’t!
Floe diameter in PIOMAS

...preliminary results

Mean Floe Diameter (km) = \[ \int g_l(l) l \, dl \]

- Zhang et al. (JGR, Feb. 2015): theory
- Zhang et al. (JGR, in prep. 2015): first pan-arctic simulations
- Stern et al. (JGR, in prep. 2015): floe diameter obs from MODIS, SAR, hi-res visible
- Future: Extensive model-obs intercomparison, impact on ocean properties, ??
Buoy program web updates

Pressure: weather
...used in PIOMAS forcing...
Buoy program web updates

Wendy Ermold, PSC/APL/UW

Pressure: weather
...used in PIOMAS forcing...

GPS: ice motion
...used in PIOMAS tuning...

http://iabp.apl.washington.edu

2015 - 07-13
60 day tracks
Buoy program web updates

Pressure: weather
...used in PIOMAS forcing...

SST: air-sea xΔ
...used in PIOMAS assim....

GPS: ice motion
...used in PIOMAS tuning....
Ice Retreat & Upper Ocean Warming

Anomaly of Summer = JAS Sea Surface Temperature (°C)
(relative to 1982-2007 mean)

Most of this is local solar input
Steele et al. JGR (2010)

SST: daily NCDC OI.v2
(AVHRR+AMSRE + some in situ obs)
The **UpTempO** buoy

**M. Steele & I. Rigor** *(PIs)*  
**W. Ermold** *(data, web)*  
**K. Colburn** *(logistics, field)*

*Upper Temperature of the polar Oceans*

- **Surface**: SLP, **SST**, GPS, Iridium  …*[anemometer]*
- **Cable**: 12-16 x **T** (± 0.1°C), 3 x **P** (± 1 dbar)  …*[S]*
- **Deploy**: in ice or water by ship, ice camp, air

**Euphotic Zone**

- **60 m**

**Thermistors**: ± 0.1°C  
2.5, 5, 7.5, 10, 15, 20, 25, 30, 35, 40, 50, 60 m depth

**Pressure**: ± 1 dbar  
20, 40 m, 60 m depth
The **UpTempO** buoy

**Upper Temperature of the polar Oceans**

- **Surface**: SLP, **SST**, GPS, Iridium  
  
  [**SSS**, anemometer]

- **Cable**: 12-16 x **T** (± 0.1°C), 3 x **P** (± 1 dbar)

- **Deploy**: in ice or water by ship, ice camp, air

- **Hourly** sampling

- **Observe**: surface layer, → top of Pacific Water

- **Cost**: US $8-40k  
  (Marlin-Yug, Pacific Gyre, MetOcean)

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**data & info:**  
Ice Retreat & Upper Ocean Warming

...two new studies
Feb 2015 JGR Steele et al.: “Seasonal ice loss in the Beaufort Sea: Toward synchrony & prediction”

1979-2012 passive µwave

DOO mean

DOO = Date of Opening (ice conc < 80%)

Late opening

Early opening

easterly winds

thick ice

Alaska

Arctic Sea Ice Retreat
Feb 2015 JGR Steele et al.:
“Seasonal ice loss in the Beaufort Sea: Toward synchrony & prediction”

DOO = Date of Opening
(ice conc < 80%)

Net result:
More synchronous (early) opening across the Beaufort Sea
Feb 2015 JGR Steele et al.: “Seasonal ice loss in the Beaufort Sea: Toward synchrony & prediction”

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DOO mean

DOO trend

DOO = Date of Opening
(ice conc < 80%)

Δ(E. Beaufort – W. Beaufort)
40 days ➔ 20 days

Net result:
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**Arctic Sea Ice Retreat**

Feb 2015 JGR Steele et al.:

“Seasonal ice loss in the Beaufort Sea: Toward **synchrony & prediction**”

**DOO mean**

- Late opening
- Earlier opening

- Early opening
- Thick ice
- Easterly winds

**DOO trend**

- DOO = Date of Opening (ice conc < 80%)

\[ \Delta (E. \text{ Beaufort} - W. \text{ Beaufort}) \]

- 40 days \( \Rightarrow \) 20 days

**Implications for:**

- Shipping, migration

**Net result:**

More **synchronous** (early) opening across the Beaufort Sea
Feb 2015 JGR Steele et al.: “Seasonal ice loss in the Beaufort Sea: Toward synchrony & prediction”

DOO = Date of Opening (ice conc < 80%)

\[ \Delta (E. \text{Beaufort} - W. \text{Beaufort}) \]
40 days \( \Rightarrow \) 20 days

Net result:

More synchronous (early) opening across the Beaufort Sea

...and:
Prediction of seasonal ice loss date from easterly wind strength
July 2015 JGR Steele et al. (submitted): “Loitering of the retreating sea ice edge in the Arctic Ocean”

- **Loitering-prone areas**: E. Beaufort, N. Chukchi, Laptev, N. Baffin.
- **Loitering-unlikely areas**: ESS, Central Canada Basin during rapid-retreat years
- **Loitering scales**: 4-10 days, 20-25% of the SIZ

**Explanation?**

*Interplay of off-ice winds & warm SSTs*

Ops, eco implications...
Sea ice is retreating!

Thank You

Retreating with:
• regional differences “synchrony”
• temporal variability “loitering”
• geometric variation “floe diameter”

Impacts on:
• operations
• climate (ocean, atmos, terrestr)
• ecosystems