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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- BA **Physics** *(Reed College, 1981)*
- PhD **Geophysical Fluid Dynamics** *(Princeton Univ., 1987)*
- **Physical Oceanographer** *(U of WA, 1987-present)*

MIZ modeling

Arctic Oceanography & Sea Ice

- **Models**
- **Field work**
- **Satellite data**

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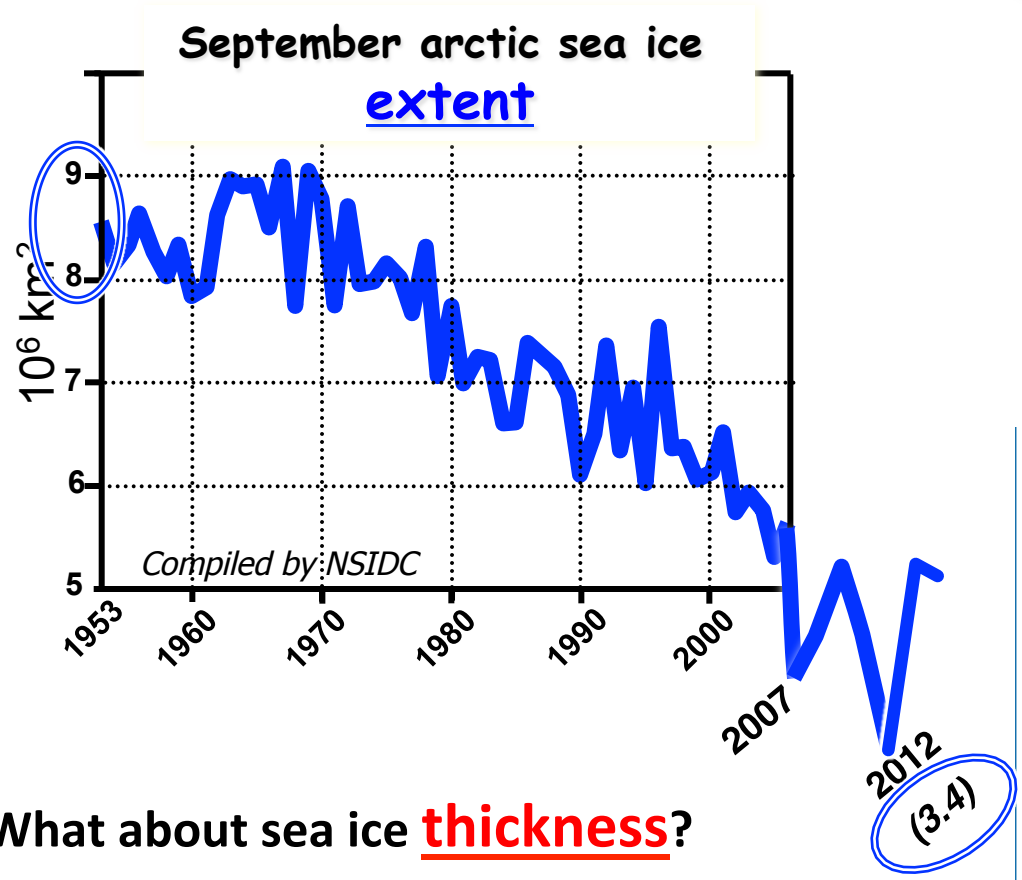
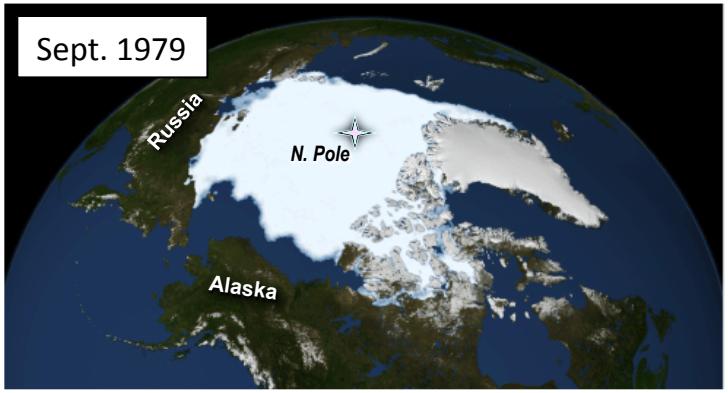
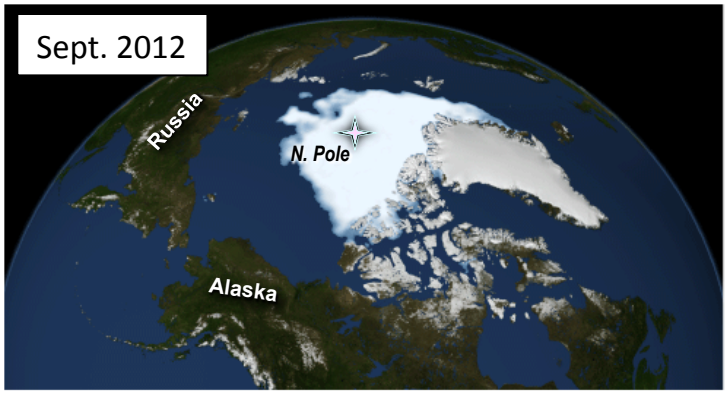
Sea Ice Decline

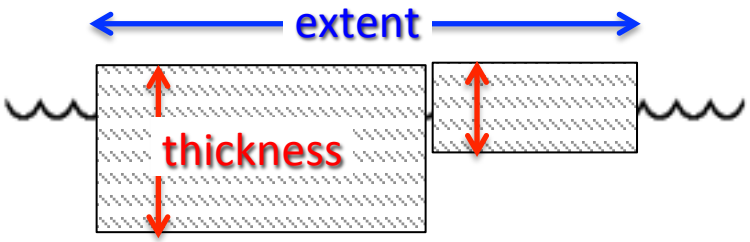


passive µwave





What about sea ice thickness?



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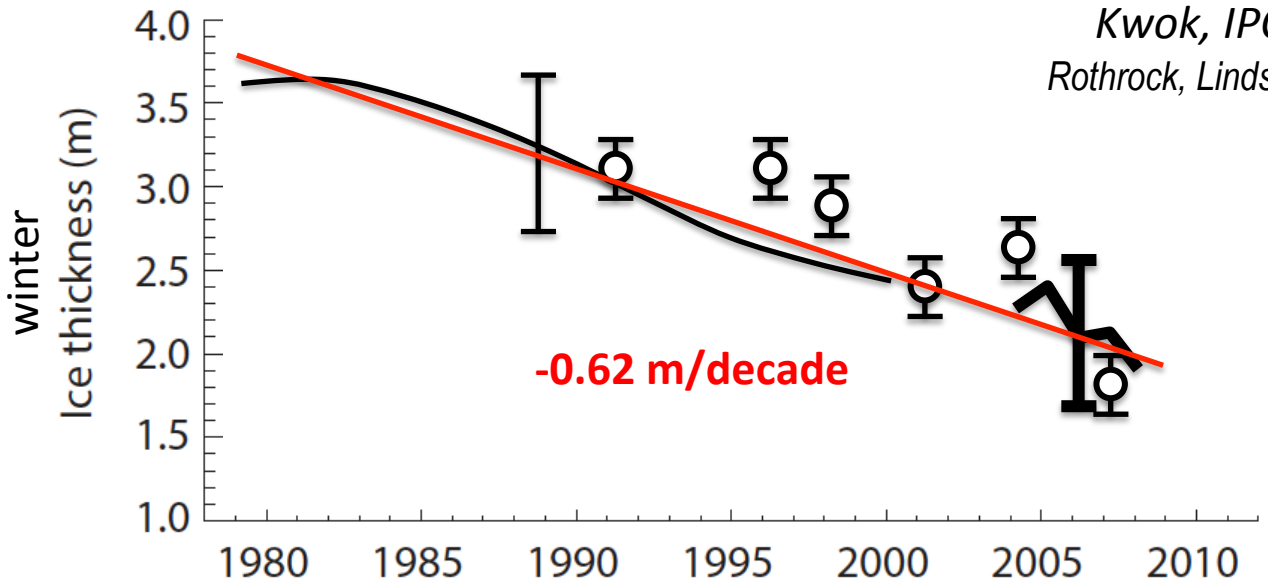
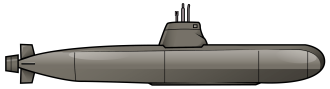
Sea ice thickness obs

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



Declining...

Submarine obs
(Central Arctic)



EM Surveys
(North Pole area)

ICESat
(→86°N)

IceBridge,
ICESat2,
CryoSat/2

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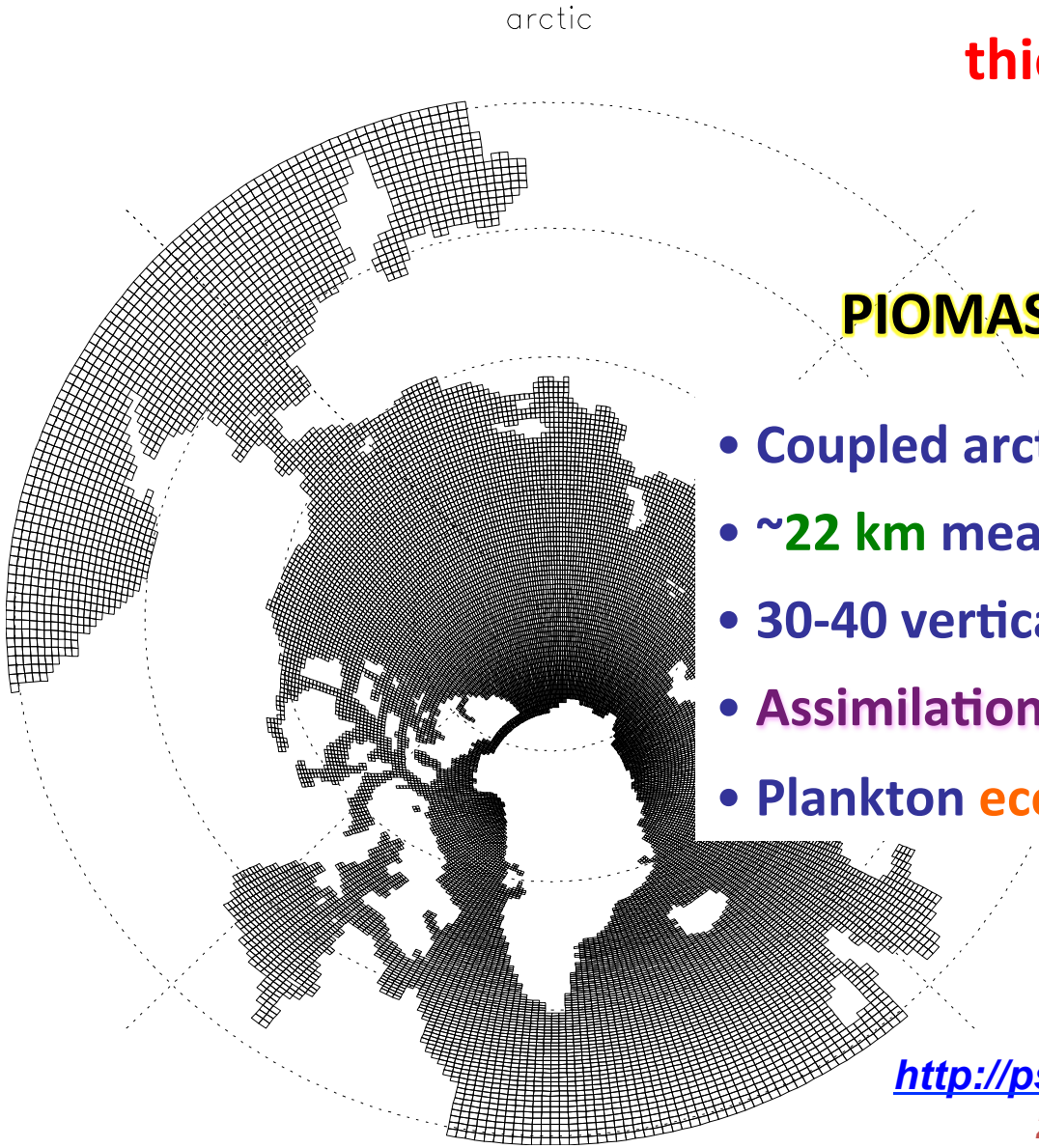
What about ice VOLUME?



thickness × extent = volume

(sorta)

PIOMAS/BIOMAS/MIZMAS

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

http://psc.apl.washington.edu/zhang/IDAO
zhang@apl.washington.edu

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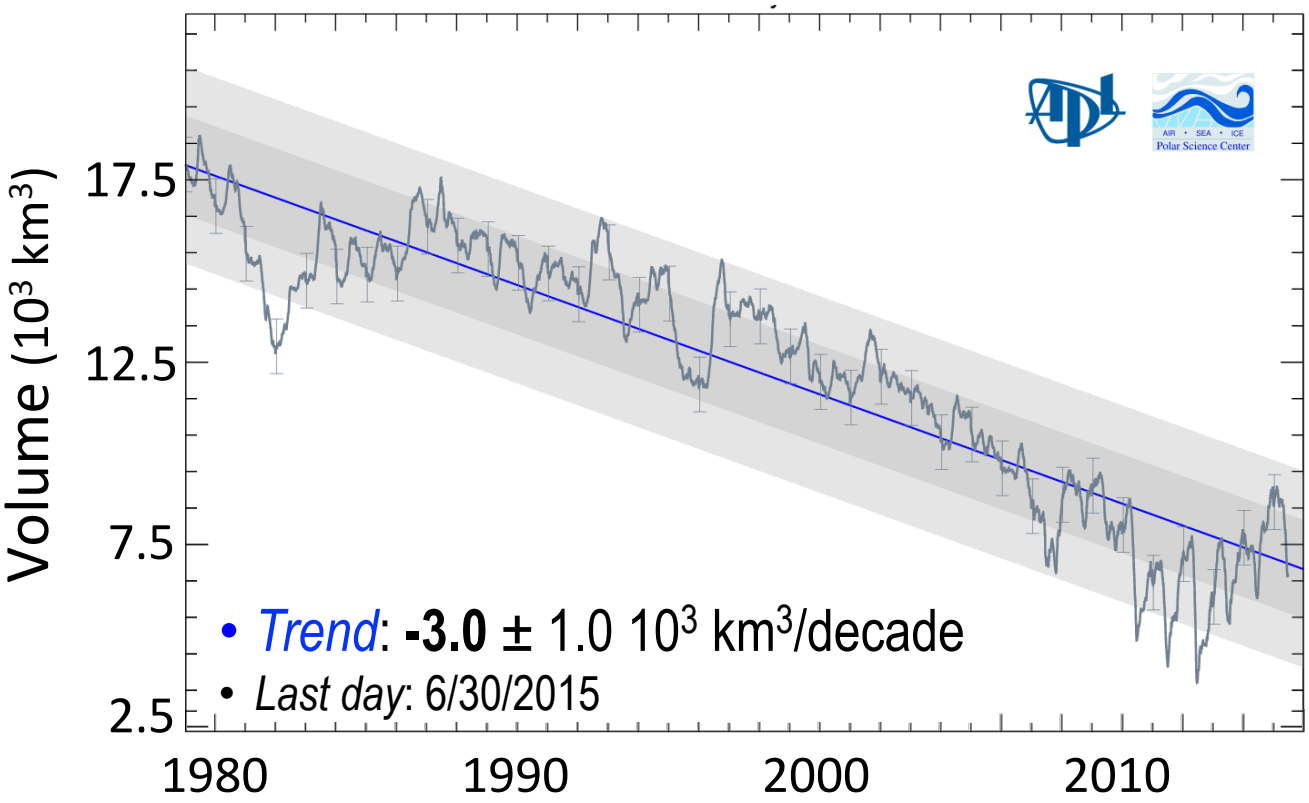
A consistent ice VOLUME time series from PIOMAS



Also declining, w/ some recent "recovery"

http://psc.apl.uw.edu/research/projects/arctic-sea-ice-volume-anomaly/

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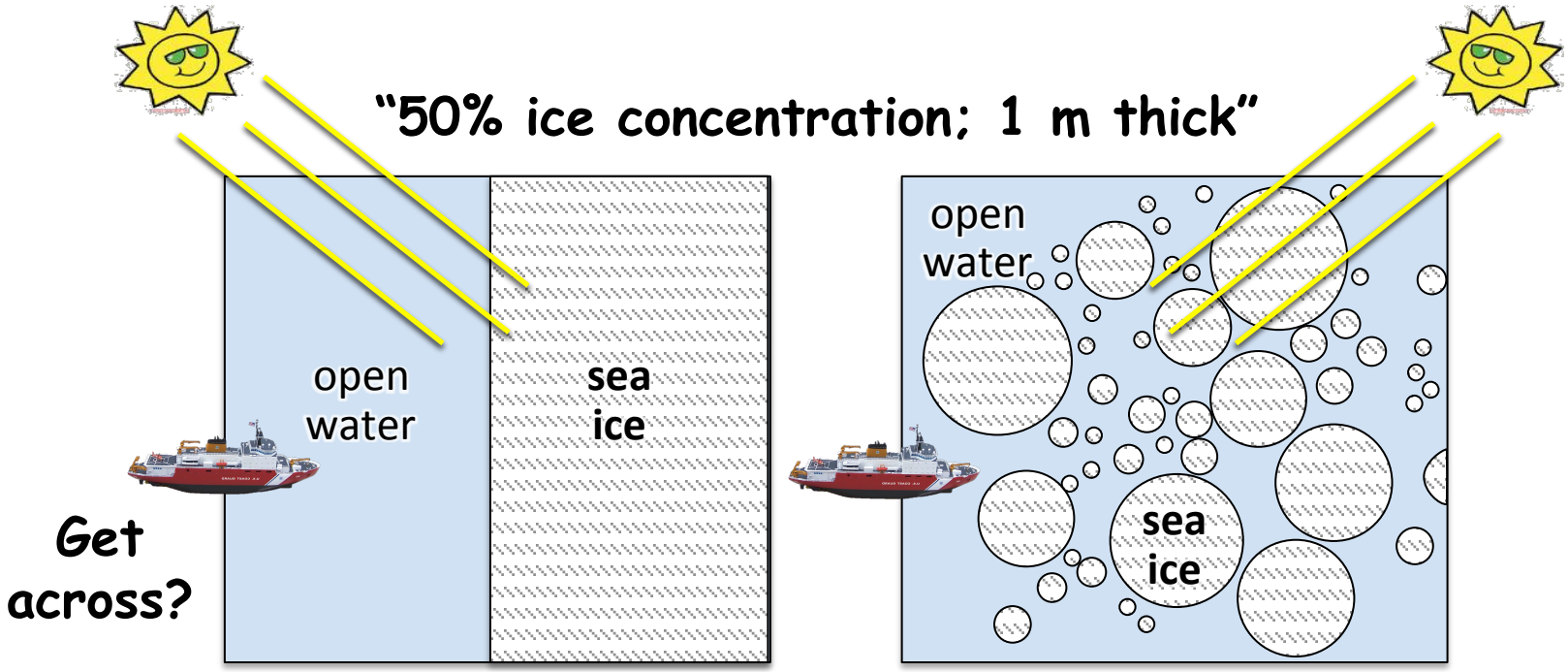
How do models simulate ice floe geometry?



no way… *maybe!*

They don't!

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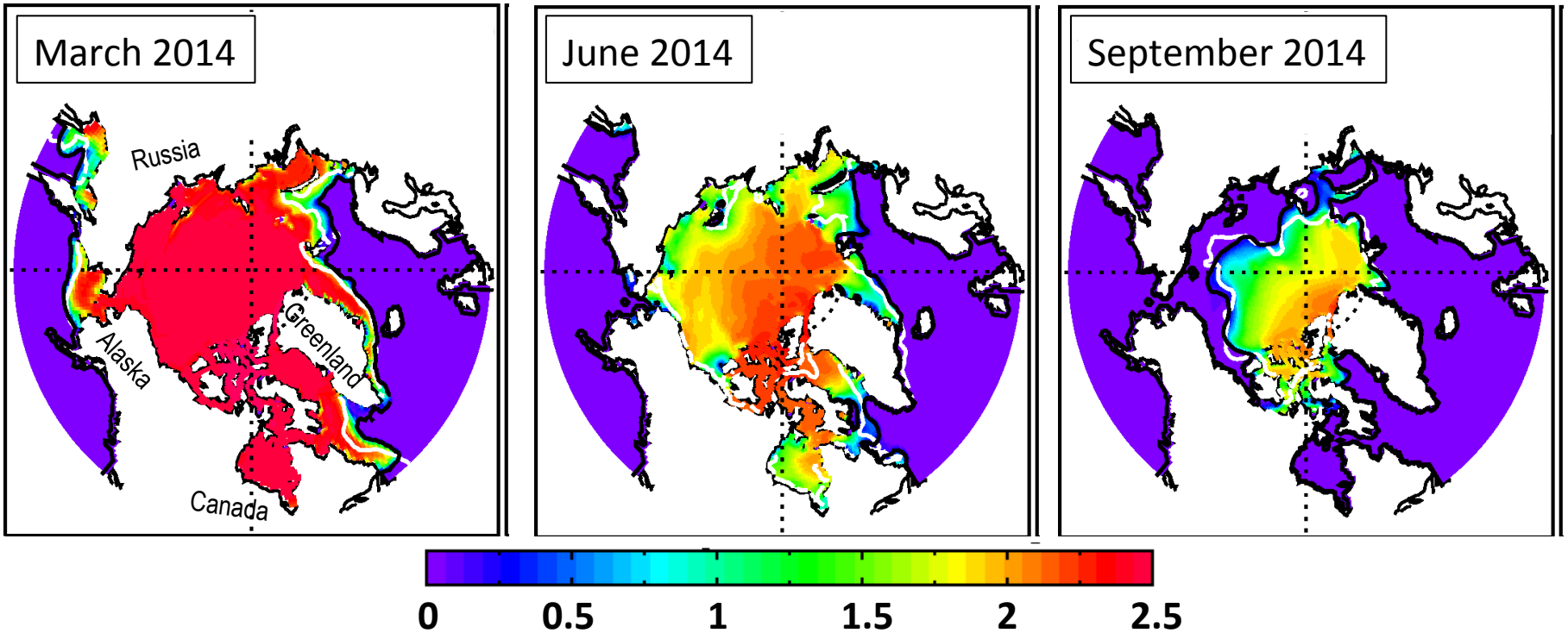
Floe diameter in PIOMAS

...preliminary results



Mean Floe Diameter (km) = $\int_{\text{12 sizes}} g_l(l)\,l\,dl$

10 cm ➔ 3 km

- *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, ??

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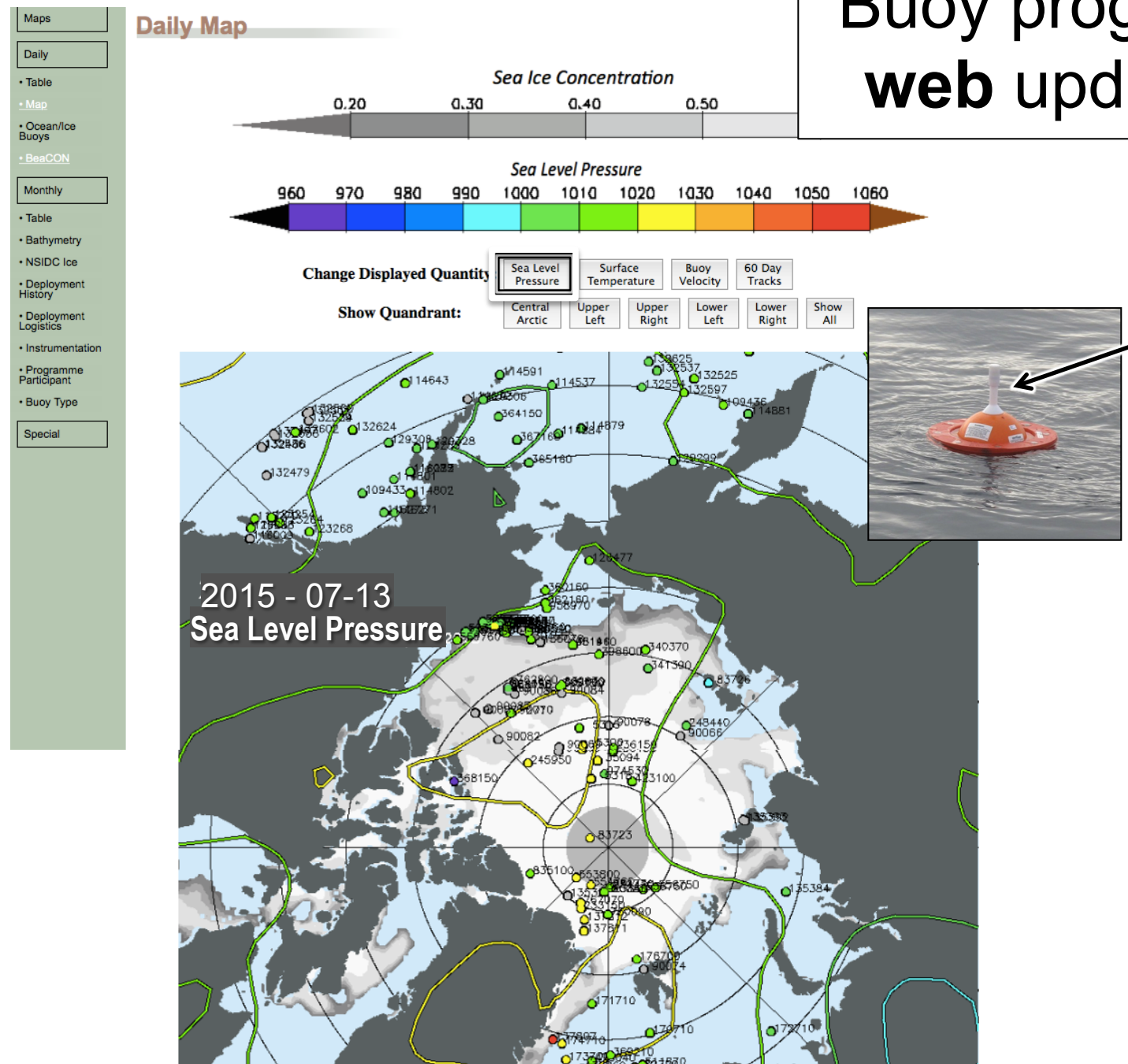
http://iabp.apl.washington.edu

Buoy program **web** updates

Wendy Ermold,
PSC/APL/UW



Pressure: *weather*

…used in PIOMAS forcing…

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Buoy program **web** updates

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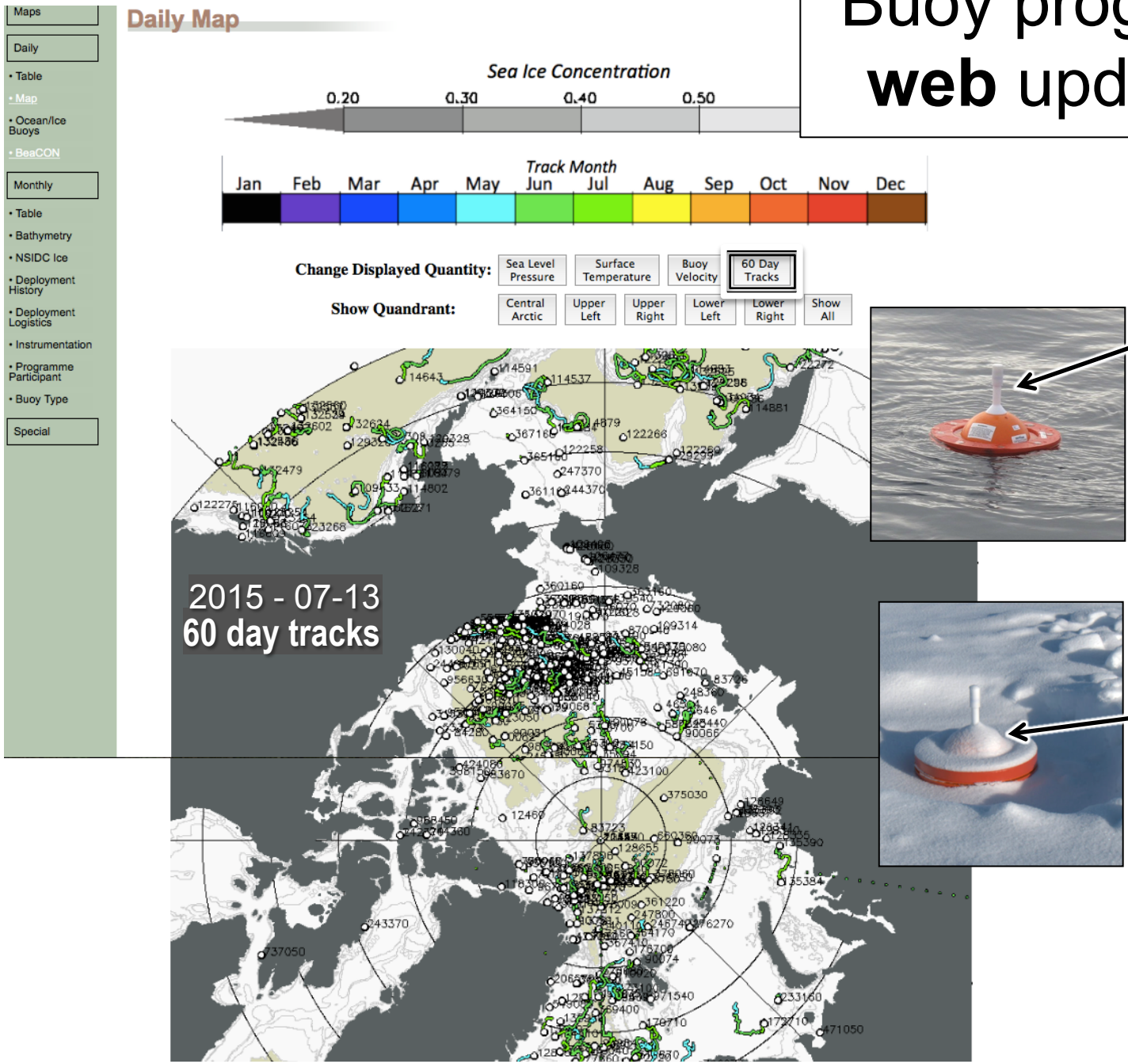

Pressure: *weather*

…used in PIOMAS forcing…

GPS: *ice motion*

…used in PIOMAS tuning…

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Buoy program **web** updates

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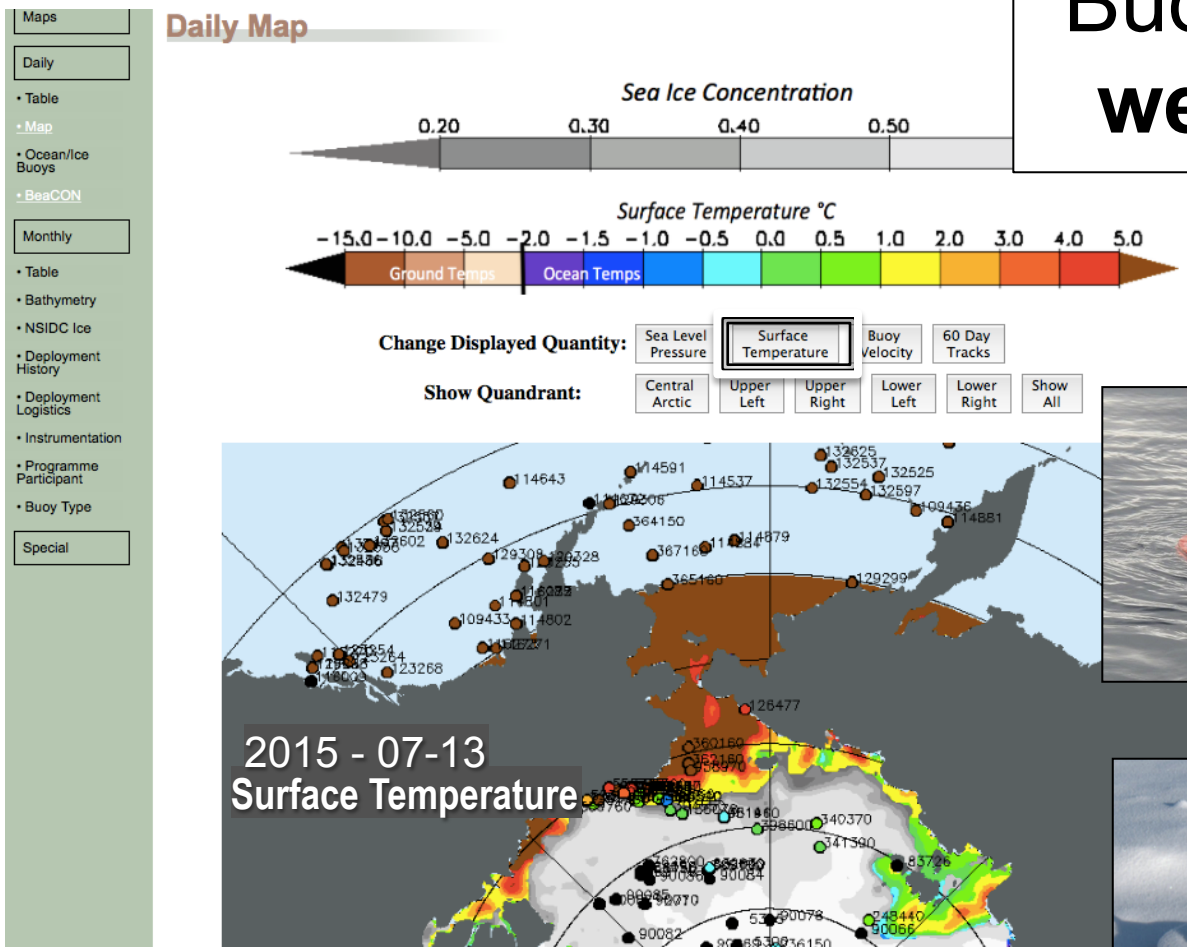
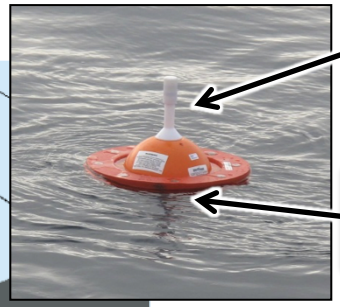


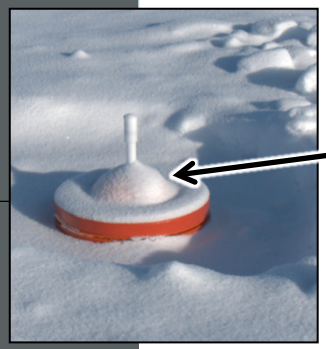


Pressure: *weather*

…used in PIOMAS forcing…

SST: *air-sea xΔ*

…used in PIOMAS assim….

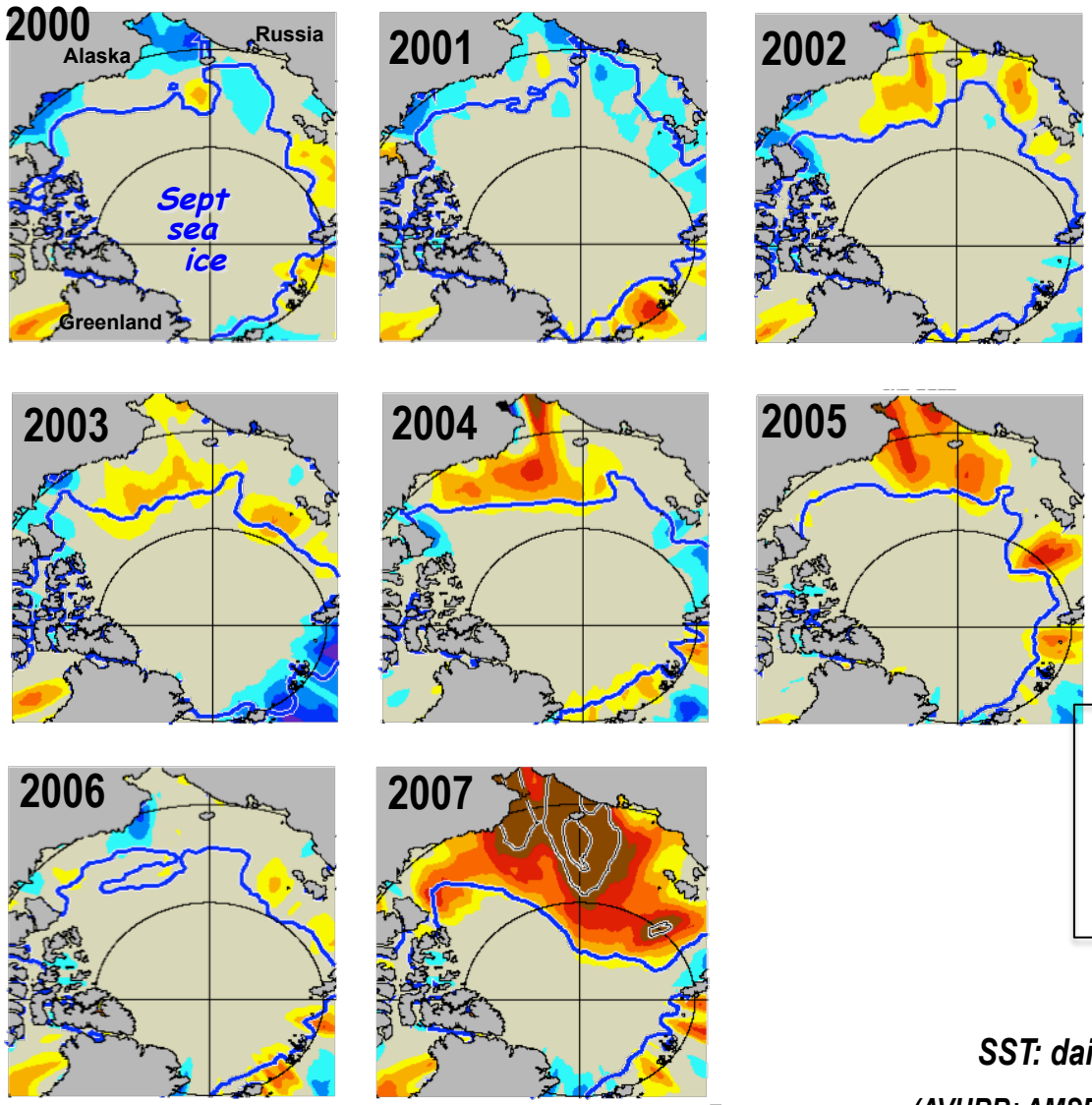


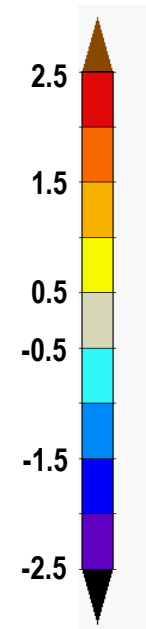
GPS: *ice motion*

…used in PIOMAS tuning…

Ice Retreat & Upper Ocean Warming

Steele et al., GRL 2008





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)

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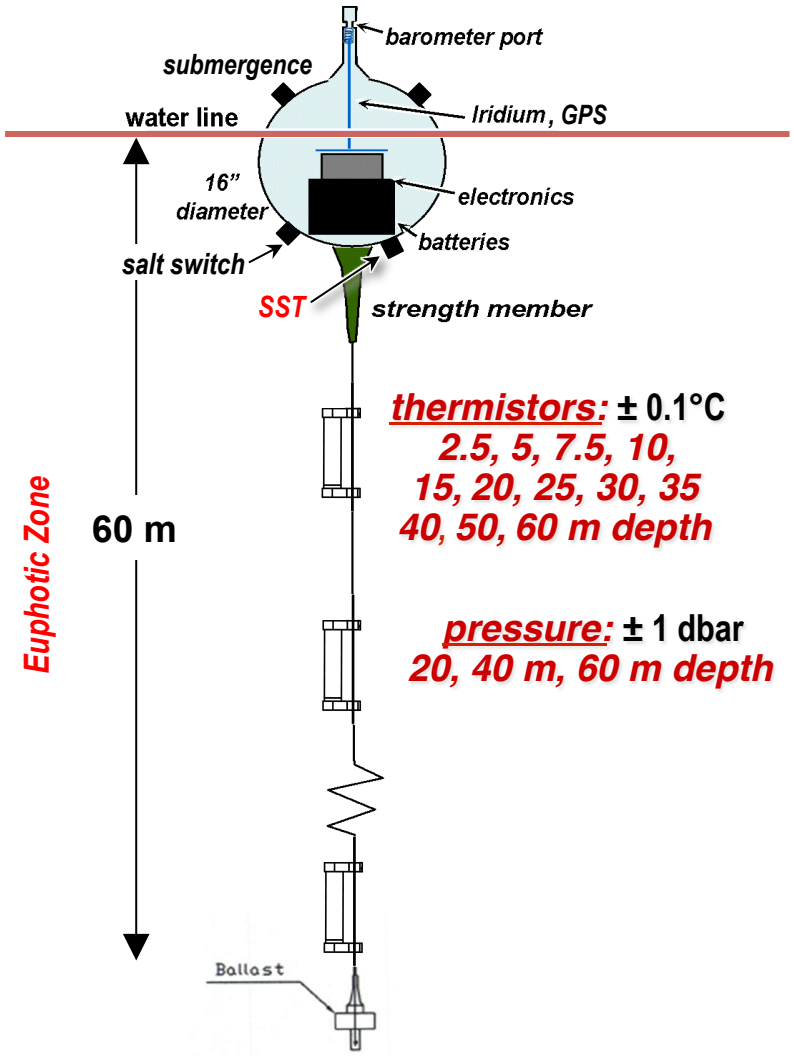
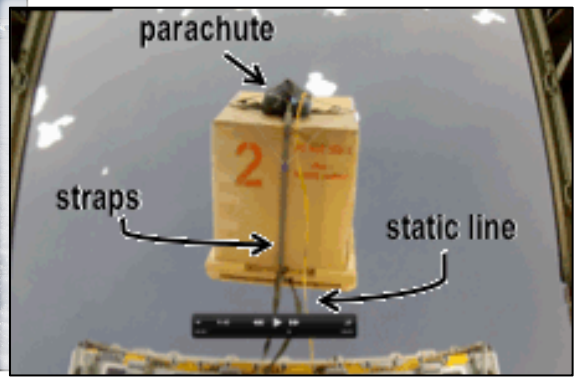
The UpTempO buoy

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



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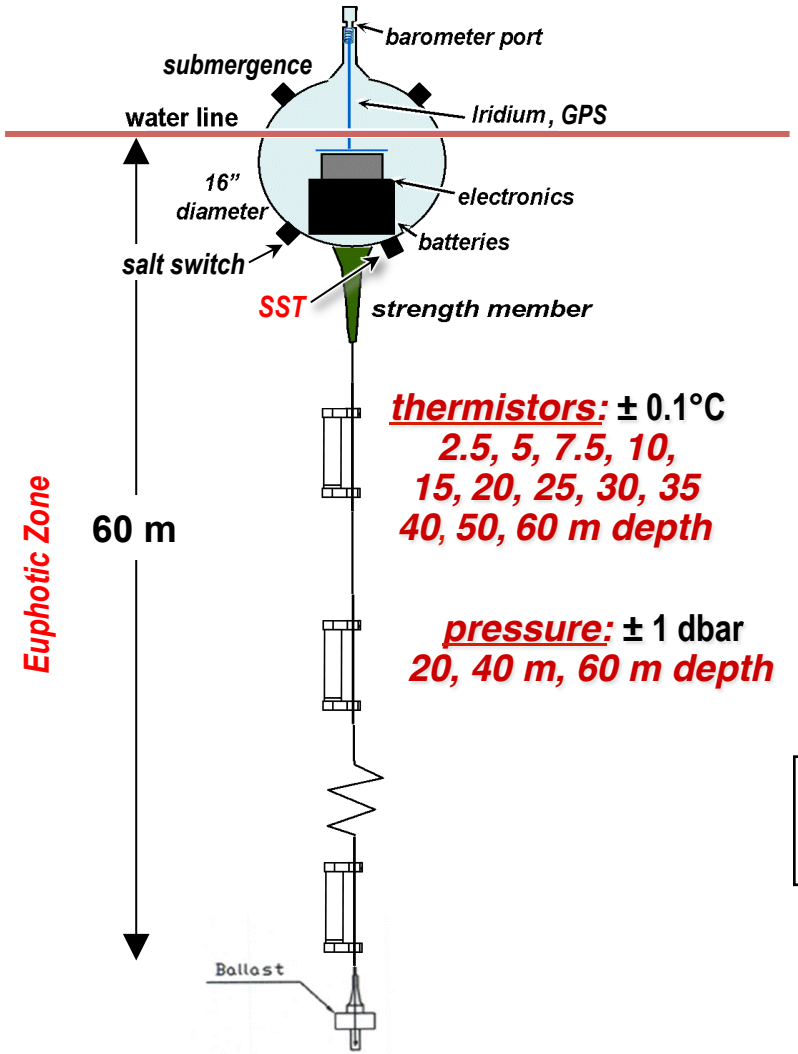
The UpTempO buoy

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)*

data & info:

http://psc.apl.washington.edu/UpTempO/

Ice Retreat & Upper Ocean Warming

…two new studies

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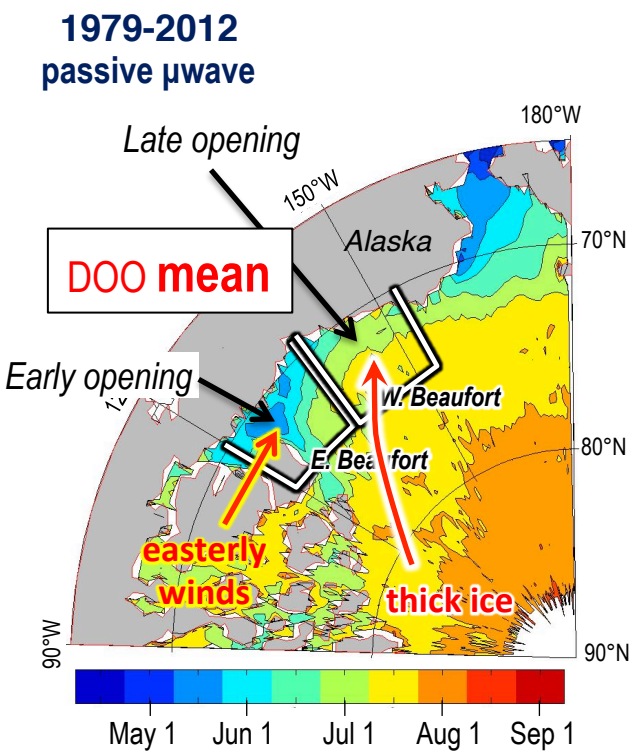
Arctic Sea Ice Retreat

Feb 2015 JGR Steele et al.:

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



DOO = **D**ate **o**f **O**pening

(ice conc < 80%)

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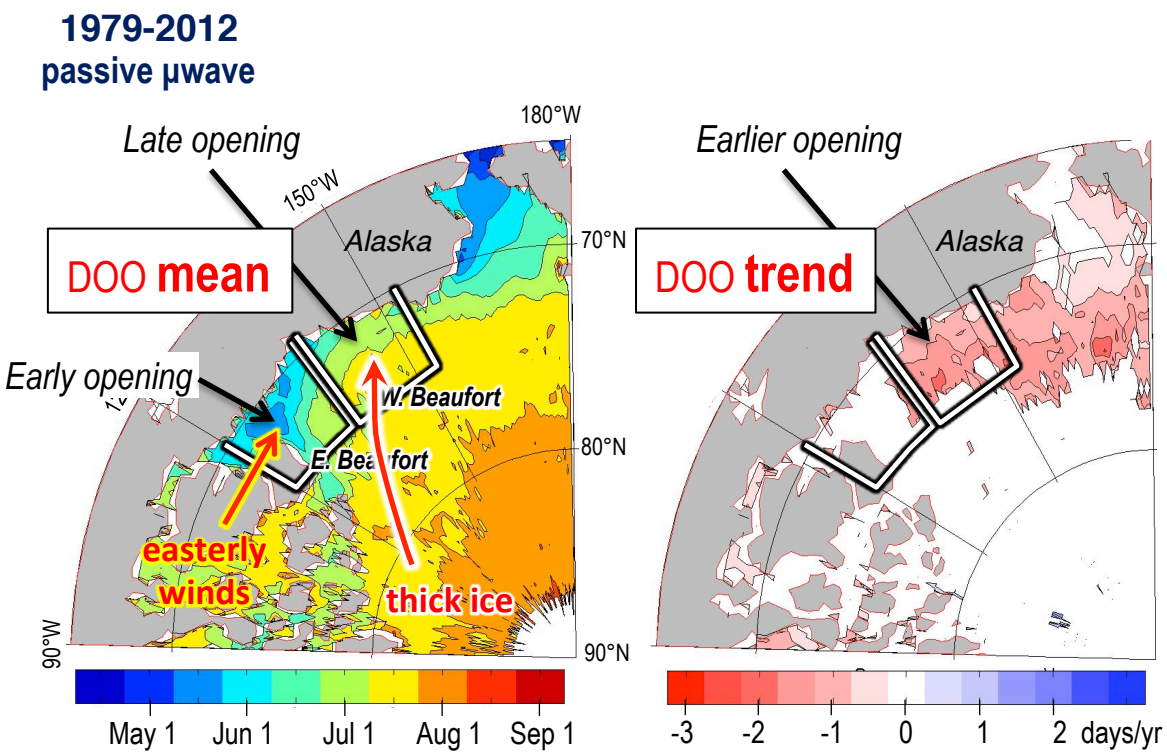

DOO = **D**ate **o**f **O**pening

(ice conc < 80%)

Net result:

More synchronous (early) opening across the Beaufort Sea

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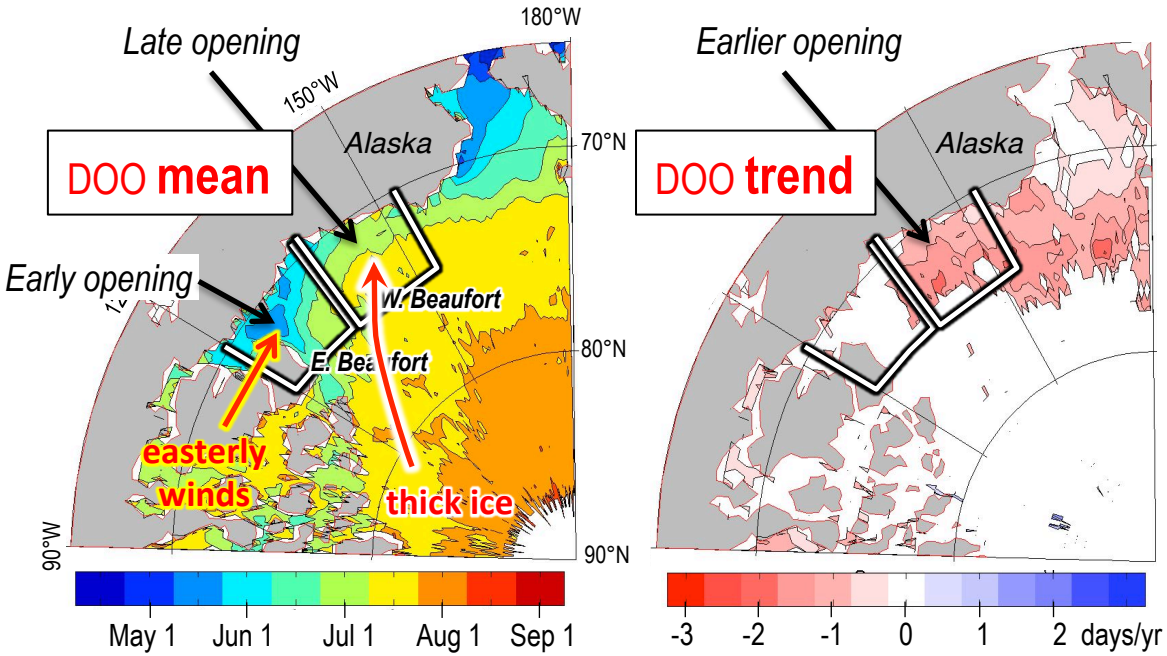
Arctic Sea Ice Retreat

Feb 2015 JGR Steele et al.:

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

1979-2012
passive µwave



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(ice conc < 80%)

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

Net result:
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Arctic Sea Ice Retreat

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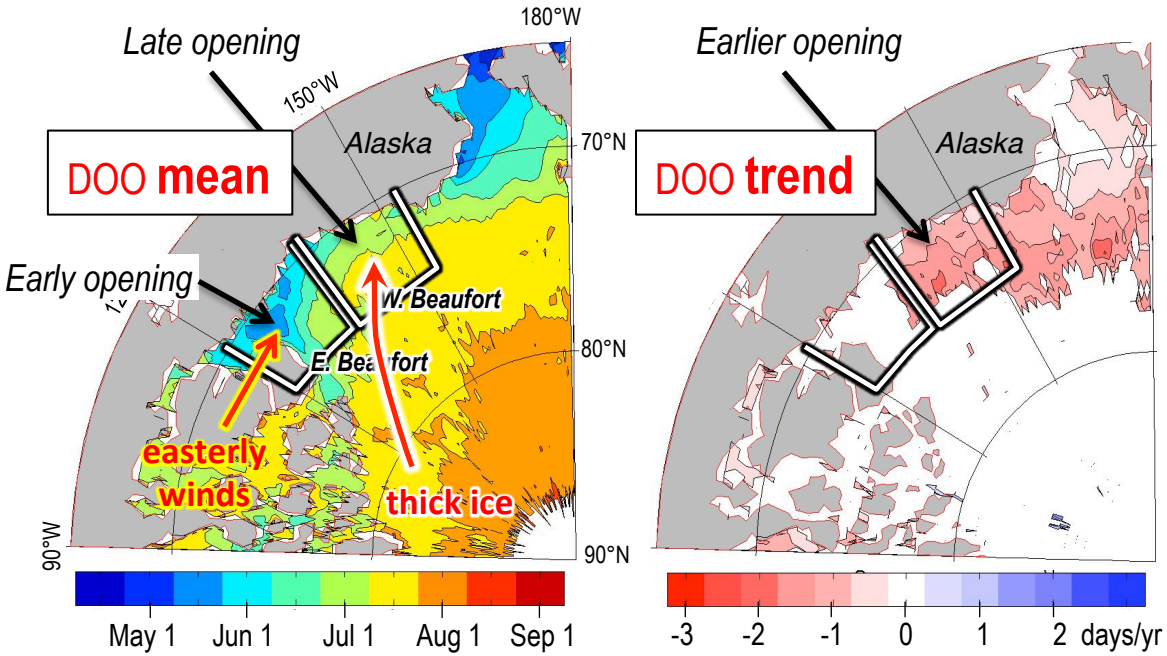

DOO = **D**ate **o**f **O**pening
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Δ(E. Beaufort – W. Beaufort)
40 days ➔ 20 days

Implications for:
Shipping, migration

Net result:
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Arctic Sea Ice Retreat

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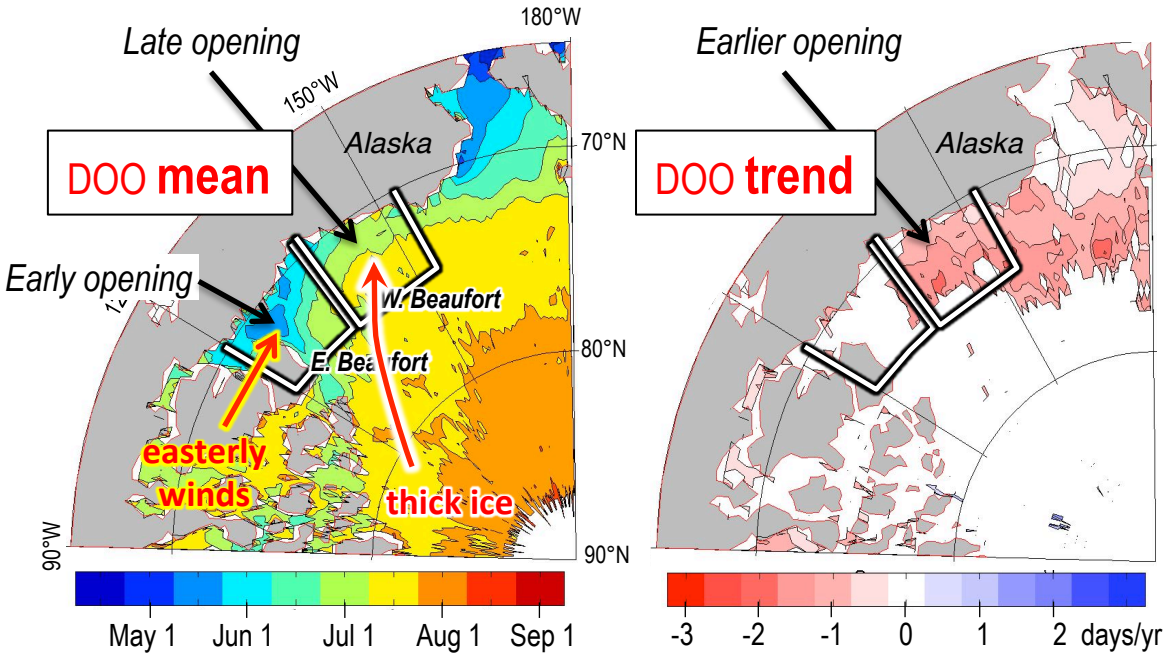

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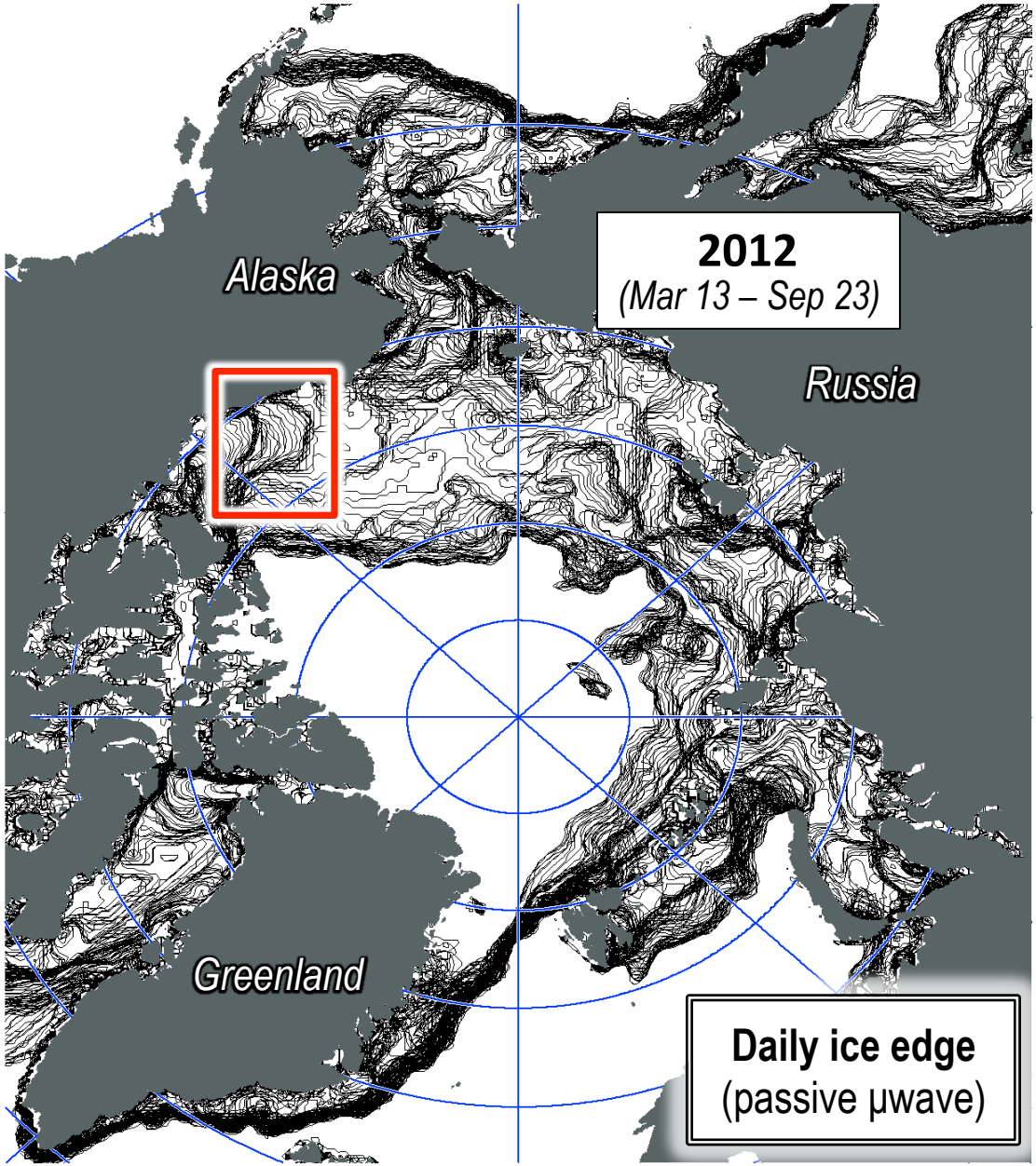
40 days ➔ 20 days

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…

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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