Changes in Sea Ice Motion and Exchange in the Beaufort Sea: 1997-2012

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The Beaufort Sea

- West of the Canadian Archipelago and east of the Chukchi Sea.
- Complete ice coverage in winter growth season with retreat of sea ice edge in summer.
- Mix of seasonal and multi-year ice.
Ice Dynamics in the Beaufort Sea

- Circulates according to the anti-cyclonic Beaufort Gyre.
- Beaufort Sea a favourable location for dynamic and thermodynamic thickening.
- Surviving ice is recirculated out towards the Chukchi and East Siberian Seas.

Perovich and Richter-Menge 2009-ARMS
Recent Trends and Variability

- Observed sea ice changes in the Beaufort Sea.
  - 1968-2012 mean September area trend: $-5.4 \times 10^3$ km$^2$ year$^{-1}$.
  - Dramatic September decreases in recent years.
  - Some evidence of ice thinning.

Kowk and Rothrock 2009-GRL (right)
Research Questions and Objectives

• How has sea ice velocity and ice area exchange changed in the Beaufort Sea?
  – **Objective (i)** Estimate sea ice velocity in the Beaufort Sea using RADARSAT from 1997-2012 and compare the results with previous methods.
  – **Objective (ii)** Estimate the sea ice area flux (exchange) within and between the Beaufort Sea and surrounding regions from 1997-2012.
  – **Objective (iii)** Using the results from (i) and (ii), explore the drivers of recent variability in sea ice dynamics within the Beaufort Sea.
    • Not going to address this objective in great detail.
### Data: RADARSAT Image Acquisitions

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- **Two time periods:**
  - January to December: 1997-2007
  - July, August, September, October 1997-2012
Ice Motion Tracking using CIS-ASITS

Wohlleben et al. 2013-AO (top left)
Beaufort Sea Ice Area Exchange

- Similar ice flux estimation technique as Kwok (2006)-GRL and Howell et al. (2013)-JGR
  - Identify gates, estimate ice transport and produce net monthly exchange; uncertainty is dependent on length of gate
Results: Objective (i)

- Sea Ice Velocity
  - Monthly maps from 1997-2012 at 25 km and working on 5 km
  - Continuous time series for JASO from 1997-2012
  - 16-year mean was 4.78 km day\(^{-1}\) (±3.30 km day\(^{-1}\))
  - October showed highest monthly drift with mean of 6.5 km day\(^{-1}\)
Results: Objective (i)

- Confident (mostly) in 1997-2007 estimates and can make them available.
- Positive trend in 1997-2012 JASO sea ice drift (not shown)
  - Since 2008, CIS-ASITS picking up more problematic vectors perhaps because of more extreme melt.

Sept 24 - 25 2012
Results: Objective (i)

• Comparison with independent datasets
  – CIS-ASITS showed consistent positive mean bias ranging from 0.63 to 2.02 km/day – more work to be done here.
Results: Objective (ii) JASO Ice Flux

- Clear declines in MYI concentration at Prince Patrick and Southeast Beaufort
- Barrow gate shows variability in flux and MYI concentration, with dramatic decreases in flux after 2007
Results: Objective (ii) JASO Net Ice Flux

- Further emphasises the changes at the Barrow gate (bottom-left)
Results: Objective (iii) JASO Net Flux

September median sea ice concentration

- More melt in the Beaufort Sea during the summer

Kwok and Cunningham 2010-GRL (right)
Conclusions

- **Positive trend in sea ice drift in the Beaufort Sea**
  - Requires more investigation

- CIS-ASITS compares best with RIPS likely because of high spatial resolution
  - Investigate positive bias in more detail.

- Less ice area export via the Barrow gate 2008-2012
  - Sea ice melts before it can recirculate, overturning the conventional notion of the Beaufort Sea being a haven for ice to grow to a region where ice is lost (i.e. cemetery)
Future Work

- Update time series to include 2013 and 2014
- Further explore the positive bias in CIS-ASITS velocity estimates compared to other datasets
- Validate positive trend in JASO sea ice drift from 1997-2012 (not shown)
- Use winter month sea ice velocity estimates from 1997-2007 and look at the correlation between sea level pressure gradients at the exchange gates during the winter months to establish poxys to validate summer flux estimates.
Thank You