Sea ice breakup and freeze-up indicators: Coastal user and ESM perspectives

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Sea ice seasonality as key indicator

Fall freeze-up & spring break-up define the sea-ice seasonal cycle for coastal processes, biological habitat, subsistence harvests & maritime access. In coastal regions they reflect terrestrial & marine drivers of ice formation & decay. We explore their potential use as key indicators for coastal user activities & access.

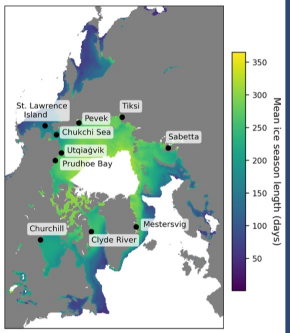
METHODS Coastal ice use observations inform remote sensing analysis

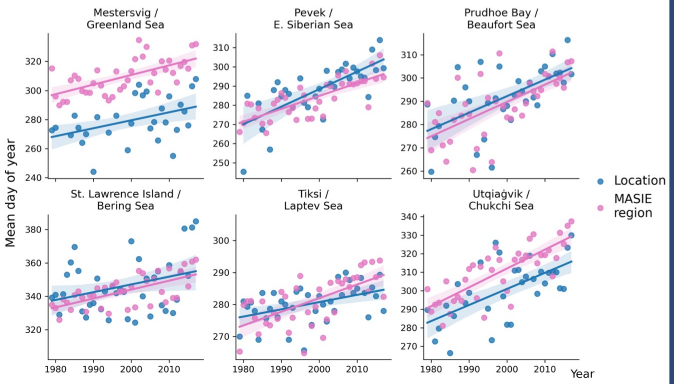
Community-based ice observations [1] informed an algorithm to extract break-up & freeze-up start & end dates at the pan-Arctic scale from passive microwave-derived ice concentration fields, 1979-2018 [2,3].

RESULTS Regional patterns & trends

Regional patterns in ice season length (right) are complex, with contrasts & similarities between coastal sites (dots) & adjacent larger offshore (MASIE) regions. Lag in break-up dates partly linked to landfast ice presence (below). Trends towards later freezeup (bottom) largely uniform.

	Landfast ice?	Breakup start (vs. MASIE)	Breakup end (vs. MASIE)
Churchill	yes	later (~ 20 d)	similar
Clyde River	yes	later (~ 10 d)	later (~ 40 d)
Prudhoe Bay	yes	later (~ 15 d)	later (~ 15 d)
Utqiaġvik	yes	later (~ 10 d)	later (~ 15 d)
Tiksi	yes	later (~ 15 d)	similar
Pevek	yes	earlier (~ 5 d)	earlier (~ 5 d)
Sabetta	yes	similar	earlier (~ 15 d)
Mestersvig	(yes)	earlier (~ 20 d)	later (~ 15 d)
St. Lawrence I.	no	earlier (~ 5 d)	similar
Chukchi Sea	no	earlier (~ 10 d)	earlier (~ 35 d)





- Later freeze-up and earlier break-up trends throughout most of Arctic – contrasts between coastal & offshore regions
- Freeze-up & break-up as key indicators for coastal users: remote sensing & earth-system model output
- Sea ice seasonality & summer warmth/vegetation linkages in Alaska require further attention: ESM-based process studies & projections?

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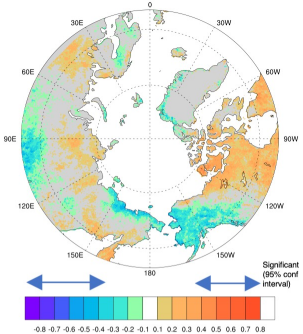
RESULTS Land-sea ice linkages

Correlations between detrended springtime E Chukchi Sea ice concentration (average for wk 22-24) and terrestrial summer warmth index (sum Apr-Sept monthly means above 0˚C) link earlier break-up of sea ice to terrestrial warming [4]. However, spatial patterns also point to regional contrasts that may align with offshore & landfast ice break-up patterns. Earth-system models & specifically E3SM are well positioned to explore this question further.



Implication& conclusions

- Majority of sites & regions shows strongly expressed trends towards ice season lengths reduced by two to three weeks per decade
- Trends & interannual variations of local sea-ice seasonality indicators similar to those of larger offshore regions – BUT with offsets of days to weeks
- Extensive landfast ice presence can delay breakup by roughly two weeks
- Shallow & riverine affected waters show earlier freeze-up compared to offshore regions
- Linkages between sea ice & terrestrial warming trends warrant further exploration in ESM framework
- Freeze-up and break-up indicators as defined here may serve as proxies for coastal activities & access trends & variability

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