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VARIABILITY OF SURFACE TRANSPORT PATHWAYS AND HOW THEY AFFECT ARCTIC BASIN-WIDE CONNECTIVITY

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Making Sense of Changing Seas for a Sustainable Future





Key points

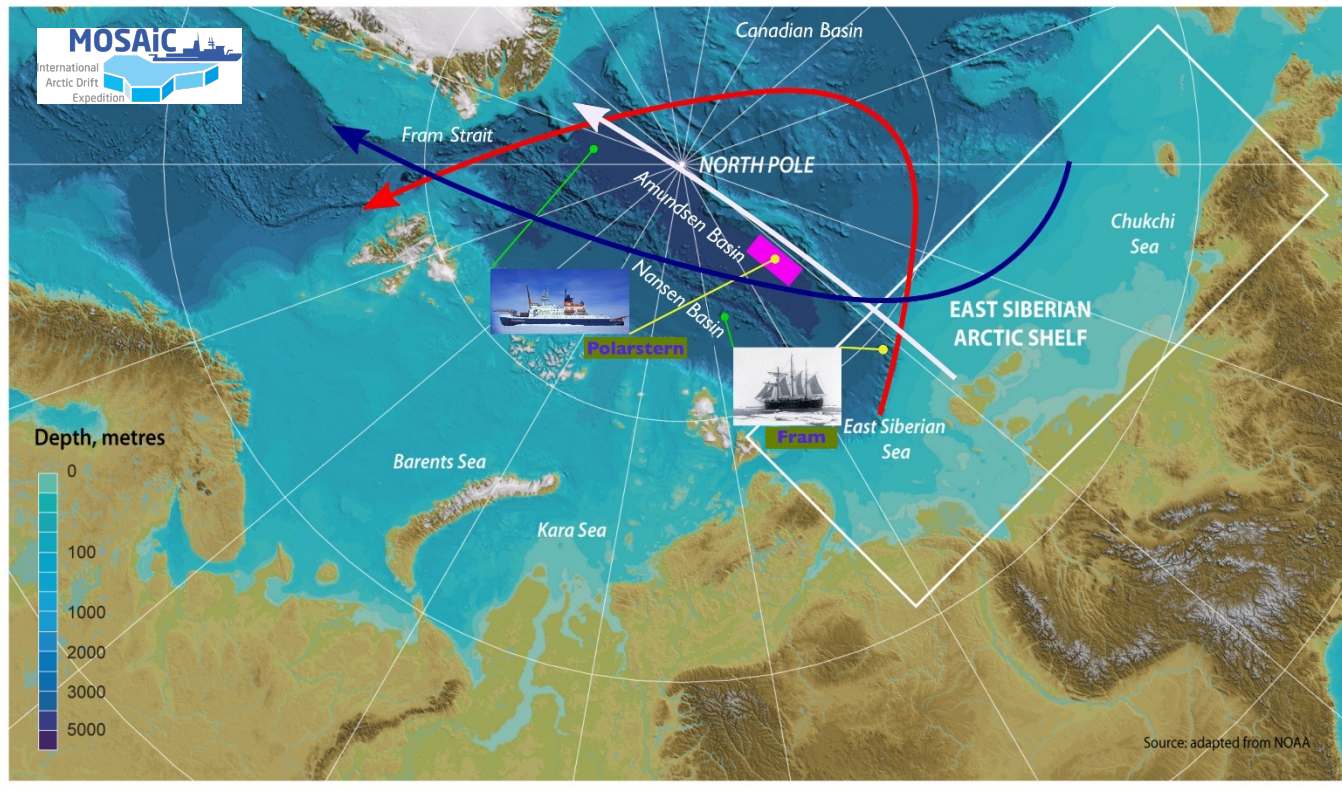
- Surface pathways transport nutrients, freshwater, carbon & contaminants between sources & sinks
- Recent inter-annual variability of pathways
- Predictability of drifting material spread
- Link basin connectivity to tracer dispersion and flow topology
- Start from the Arctic Transpolar Drift Current
- Then, look at the wider Arctic connectivity



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Large-, decadal-scale Transpolar Drift

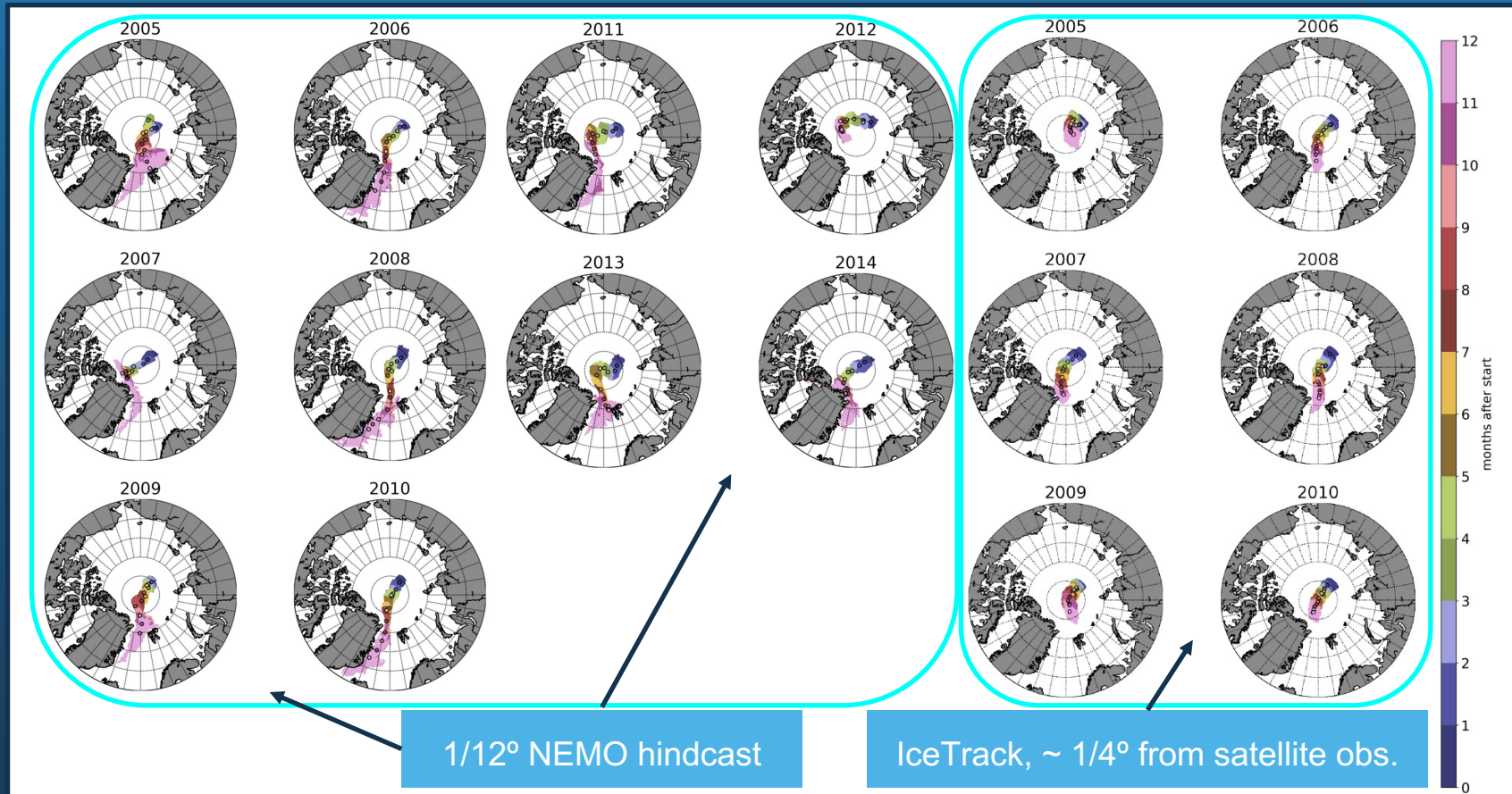
Fig. 1: Canonical view of the Arctic Transpolar Drift



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- 25 x 25 grid of particles released on 6 Oct. each year; advected forward by ARIANE for 1 year
- Large interannual variability; Bifurcation of pathways; Fast dispersion in Fram Strait

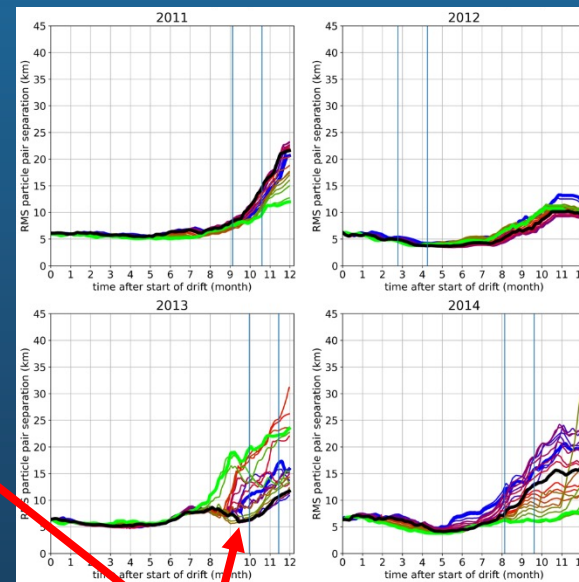
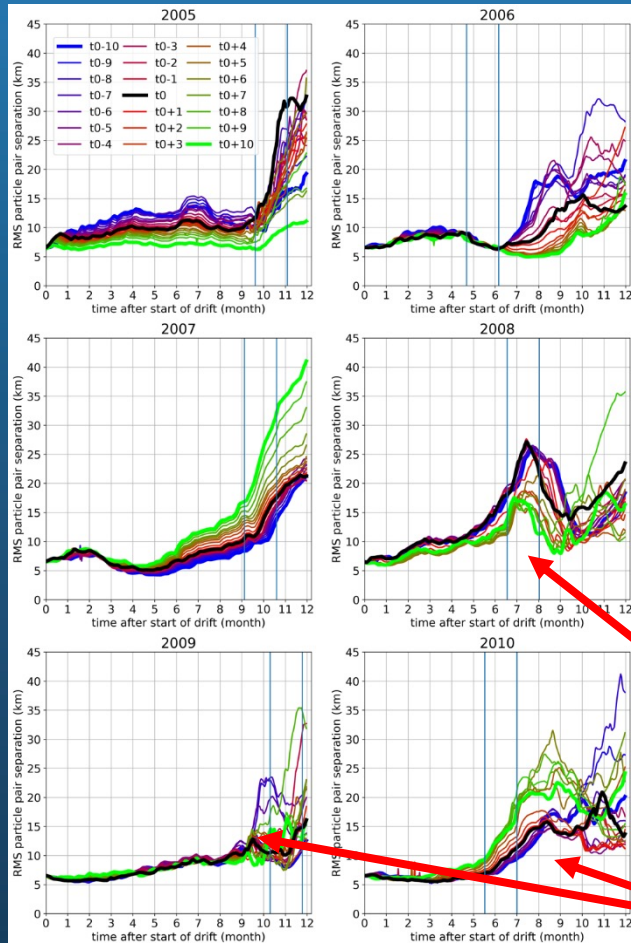


- NEMO agrees with IceTrack on direction
- Transit times are shorter
- Bifurcations in 2005 & 2007 not present in IceTrack
- Satellite time-and space sampling issues: missing mesoscale



The root-mean-squared particle pair separation (RPPS), equivalent to the square-root of cloud dispersion⁴, is a measure of the variation about the mean position:

$$RPPS(t) = \left(\frac{1}{2N(N-1)} \sum_{i \neq j} (x_i(t) - x_j(t))^2 \right)^{1/2}.$$



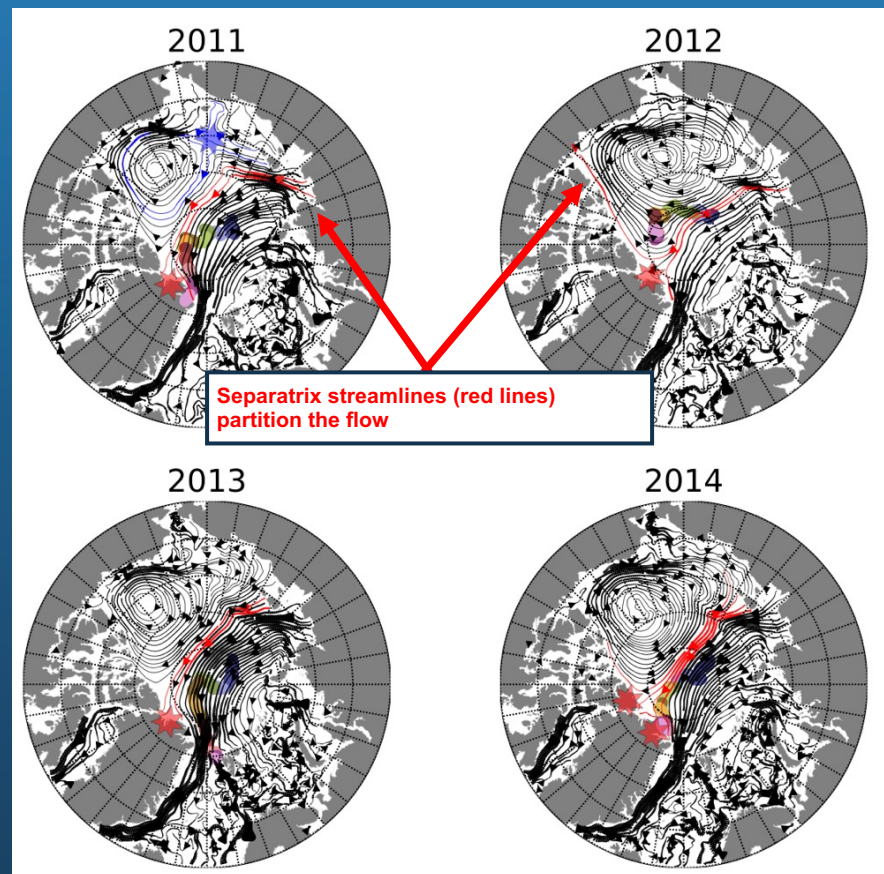
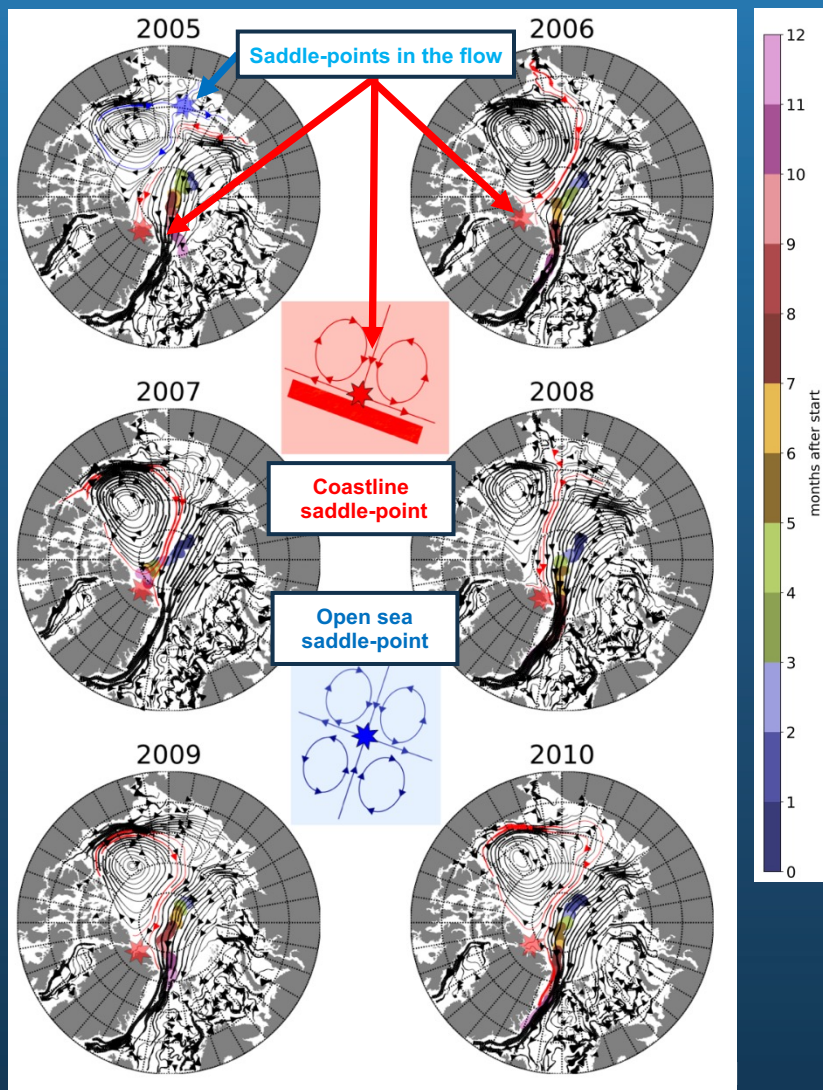
Predictability barrier



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Interannual variability of surface drift

Ensemble-mean surface trajectory and streamlines in 1/12° NEMO hindcast



AO	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SCI	+1.29	-1.26	-2.04	+1.11	-2.90	-2.53	+1.28	+1.07	+1.09	± 1.05

Our new metric - the Separatrix Curvature Index (SCI) more informative than Arctic Oscillation (AO) & Arctic Ocean Oscillation (AOO) for Shelf-Arctic Ocean-North Atlantic connectivity

- Coherent flow structures govern pathways
- Saddle points - are critical for bifurcation

Tracking Arctic sources of Fresh water, nutrients & carbon



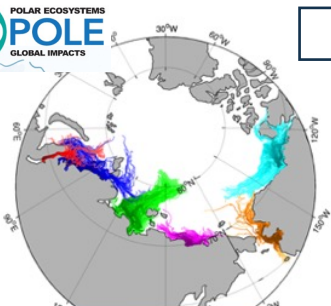
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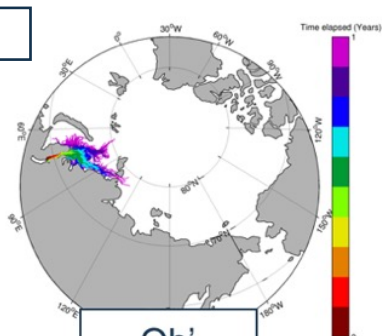


Water sources from Lagrangian off-line tracking, eddy-admitting 1/12° NEMO (3.5 km)



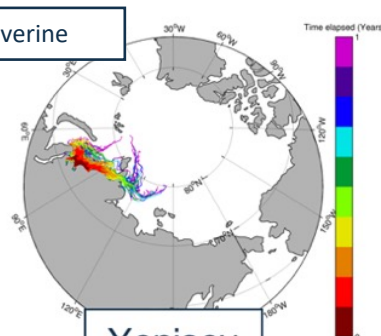
All Rivers

Riverine

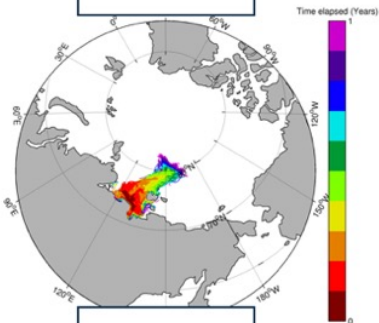


Ob'

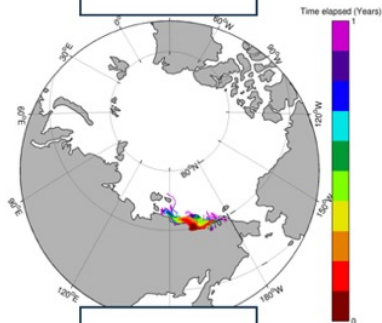
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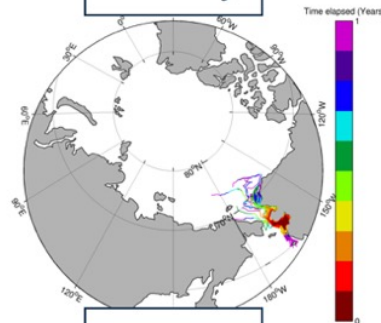
Yenisey



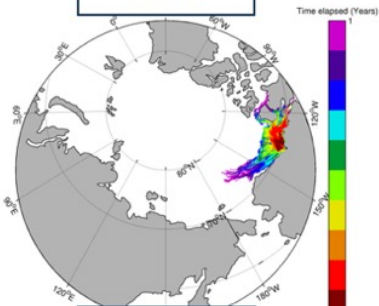
Lena



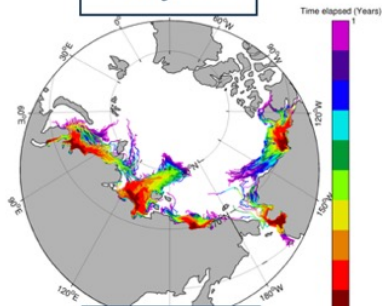
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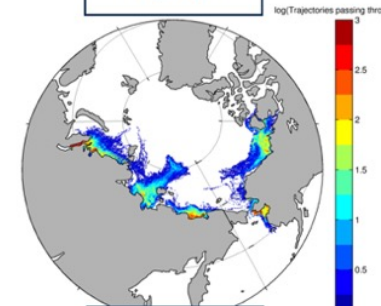
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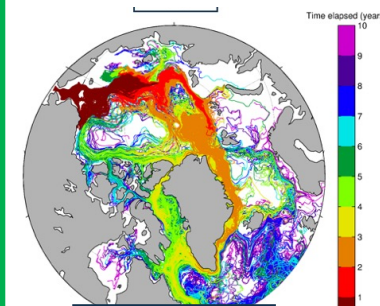
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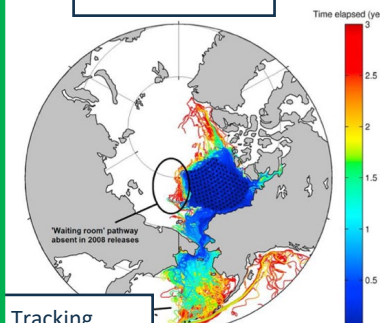
All Rivers



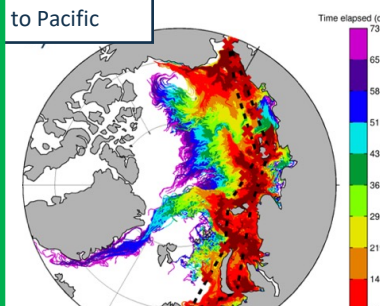
All Rivers



Pacific



Tracking
back to
Pacific



Shelf-to-ocean

EGU22-1782 Shelf-Basin connections: Marine Ecosystems



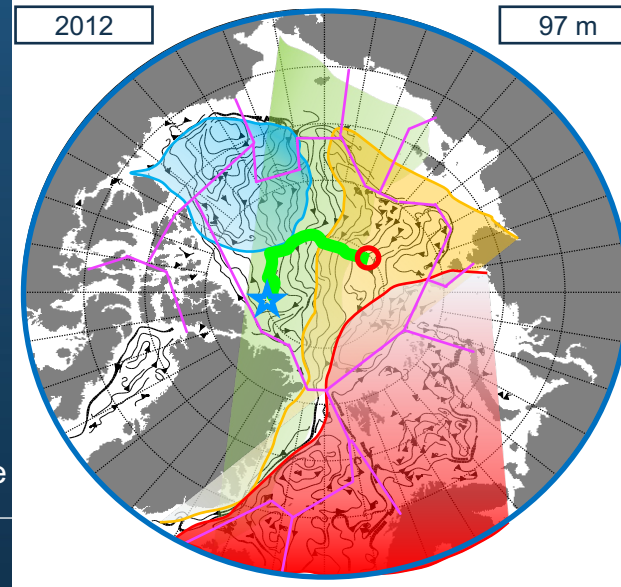
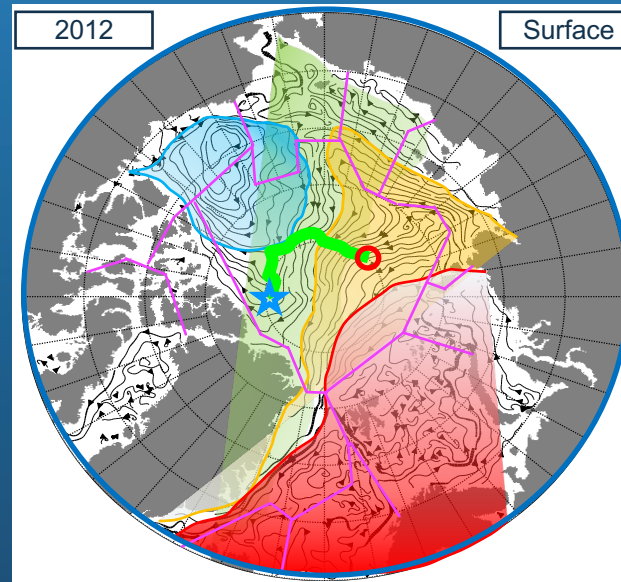
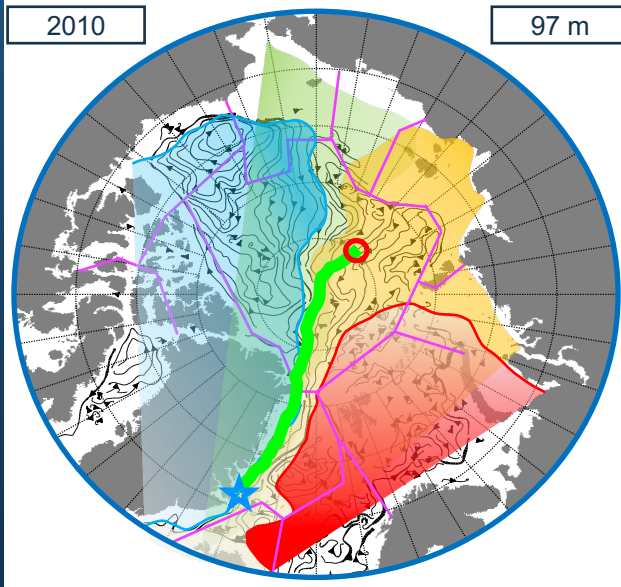
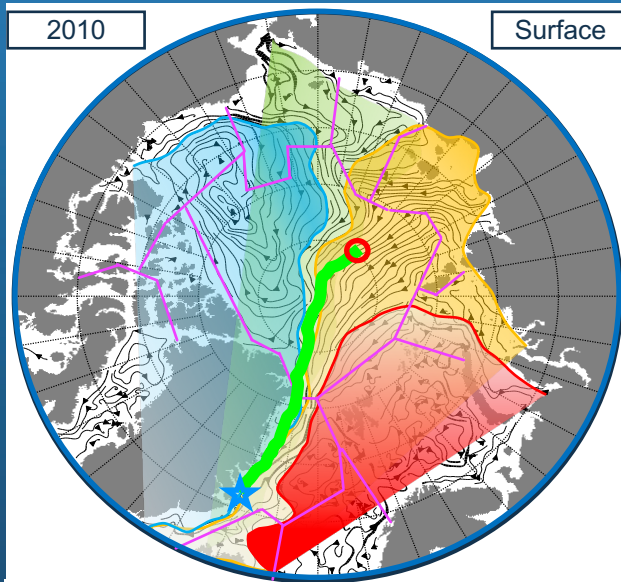
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EGU General Assembly 2022

Nitrate Transport Streamlines & Arctic Dynamical Ecosystem Provinces, 1/12° NEMO

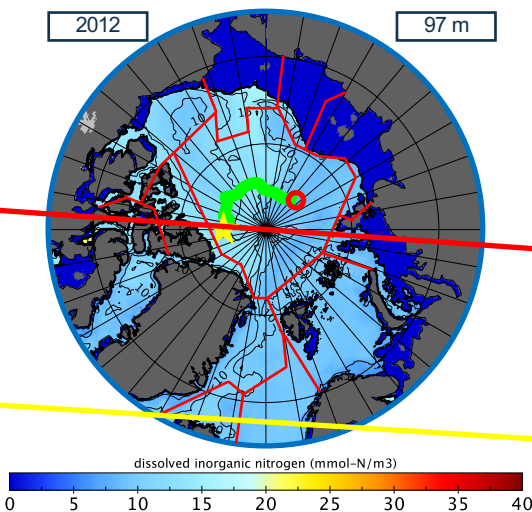
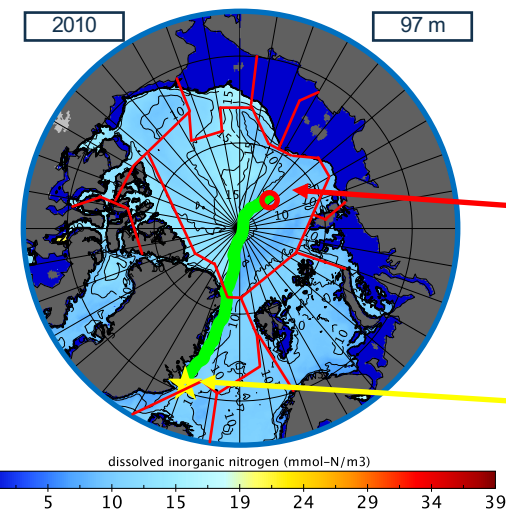
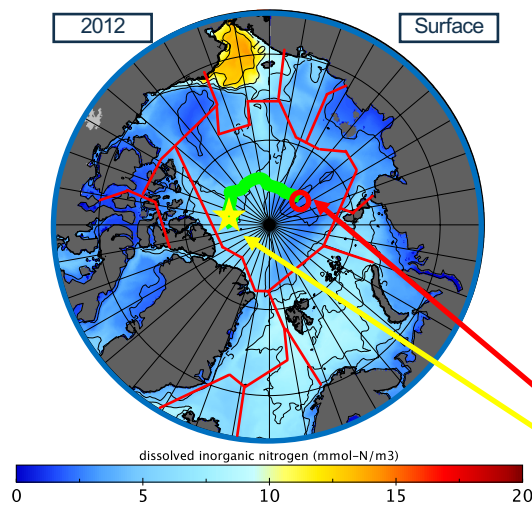
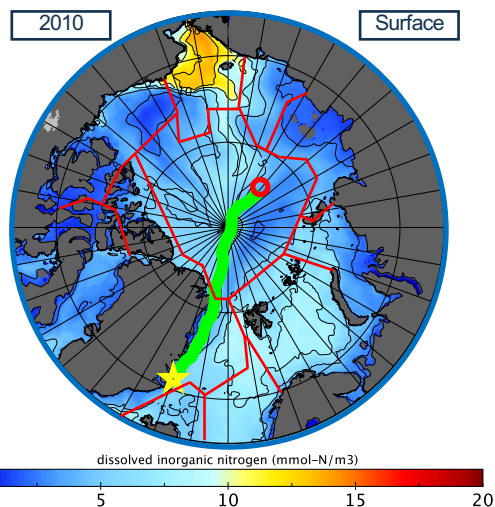


- DIN streamlines show mean annual nutrients pathways
- Ocean transport changes affect marine connectivity & nutrient transports (streamlines)
- Dynamical provinces (filled colour) are not fixed & span across fixed Arctic Large Marine Ecosystems (LME, PAME)
- Provinces: **Red** – Atlantic; **Yellow** – West-Siberian; **Green** – Pacific; **Blue** – Beaufort Gyre

Sustainable

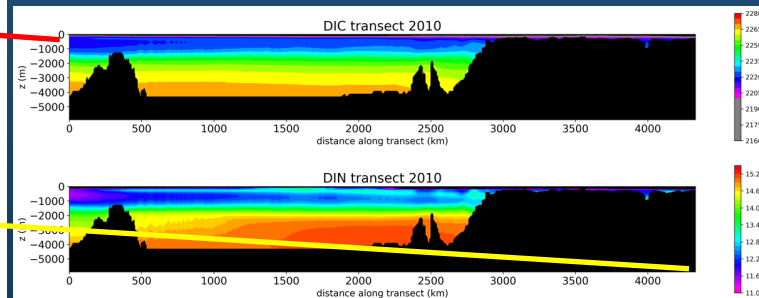
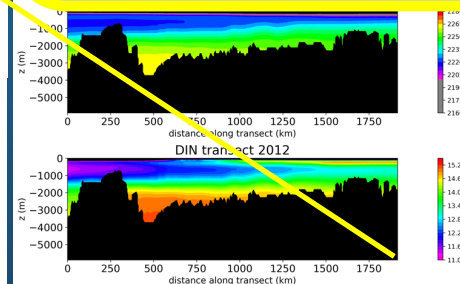
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DIN & DIC for virtual drift across Arctic Dynamical Ecosystem Provinces, 1/12° NEMO

EGU General
Assembly 2022

Sampling Marine Provinces

- Annual DIN in 2010 & 2012; virtual MOSAiC drift is green line; start – red circle; end – yellow star. Magenta lines are LMEs. NEMO-MEDUSA-2 1/12 deg.
- Drift trajectories cross DIN pathways & LMEs/LMPs boundaries
- Sampling of LMEs/LMPs is possible.



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In summary



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- **Large interannual variability in Trans Polar Drift in 2004–14**
- **Saddle-flow structures and fine-scale velocity gradients are important for basin-wide connectivity, crossing time, pathway bifurcation, predictability of tracer dispersion**
- **Saddle-points in the flow and their neighbouring streamlines define flow separatrices, which partition the Arctic into separate regions of connected transports**
- **Separatrix streamlines identify periods when the East Siberian Arctic Shelf (source of terrigenous minerals, carbon and nutrients) is either connected or disconnected with Fram Strait and the North Atlantic**
- **Our new metric - the Separatrix Curvature Index –is arguably more informative than either the Arctic Oscillation or Arctic Ocean Oscillation indices for Arctic-North Atlantic connectivity**
- **Dynamical provinces are not fixed & span across fixed Arctic Large Marine Ecosystems (PAME)**

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Reference: Wilson, C., Y. Aksenov, S. Rynders, S.J. Kelly, T. Krumpen and A. C. Coward (2021). Significant variability of structure and predictability of Arctic Ocean surface pathways affects basin-wide connectivity. *Nat. Comms. Earth & Environment*, 2(1), 1-10. <https://doi.org/10.1038/s43247-021-00237-0>.



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Thank you!