Planning for New PAG Climate Observations in Chukchi Region

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PAG Report to DBO Workshop

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Seattle, Washington USA

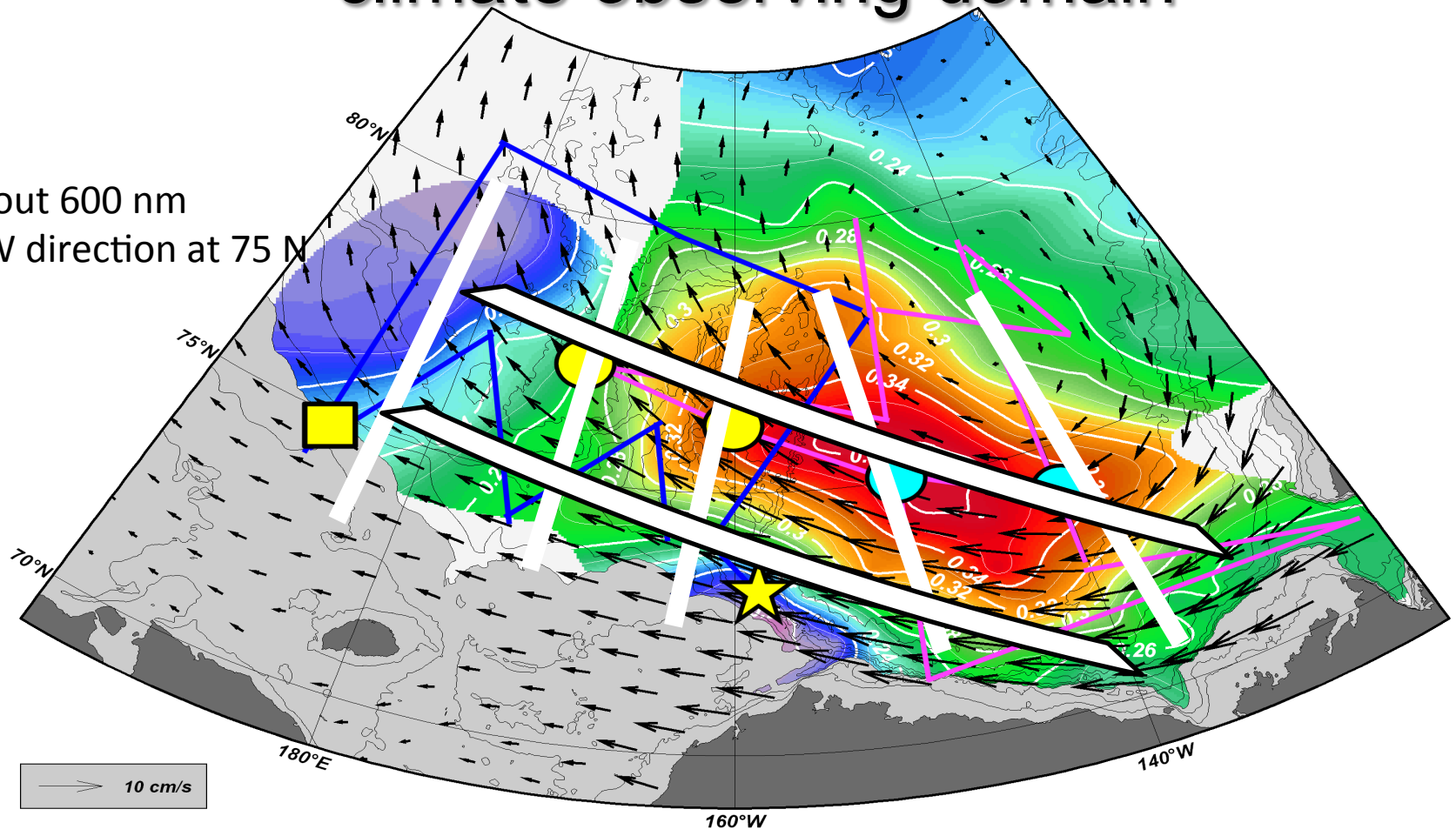
Emerging Research Questions* Relevant to PAG Science

- How much of the variability of the Arctic system is linked to ocean circulation?
- How will primary productivity change with decreasing sea ice and snow cover?
- How will species distributions and associated ecosystem structure change with the evolving cryosphere?
- How will the rapid arctic warming change the jet stream and affect weather patterns in lower latitudes?
- How will climate change affect exchanges between the Arctic Ocean and sub-polar basins?

*The Arctic in the Anthropocene, US National Research Council, 2014

Proposed international Pacific Arctic climate observing domain

About 600 nm
E-W direction at 75 N

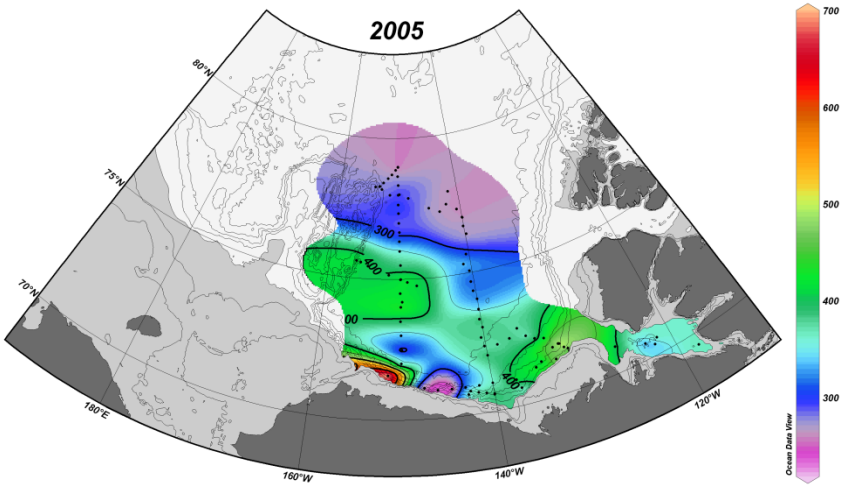


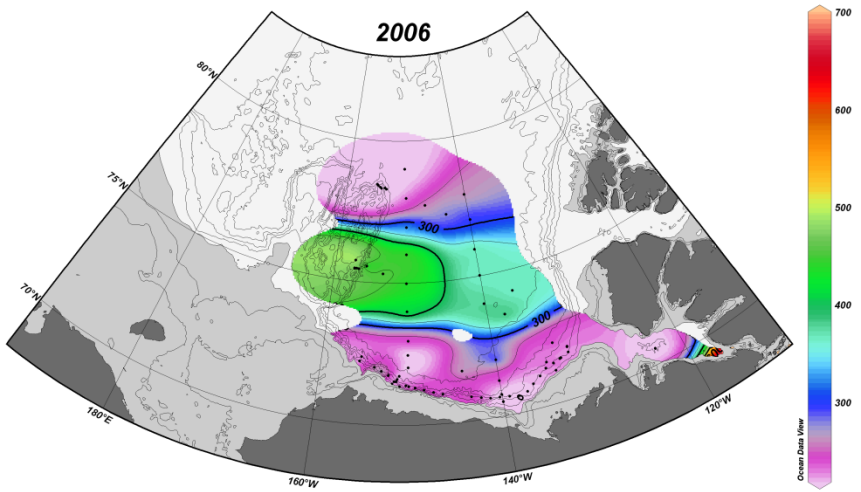
Background color: dynamic height at 100dbar relative to 800dbar from Mirai and Louis S. St-Laurent 2008 cruises (Oceanic Beaufort Gyre)
Black vectors: average sea ice motion vectors for Nov. 2007- Apr. 2008 (Sea Ice Beaufort Gyre)
Symbols: Mooring array in 2012-2013 (TUMSAT/KOPRI/NIPR & WHOI)

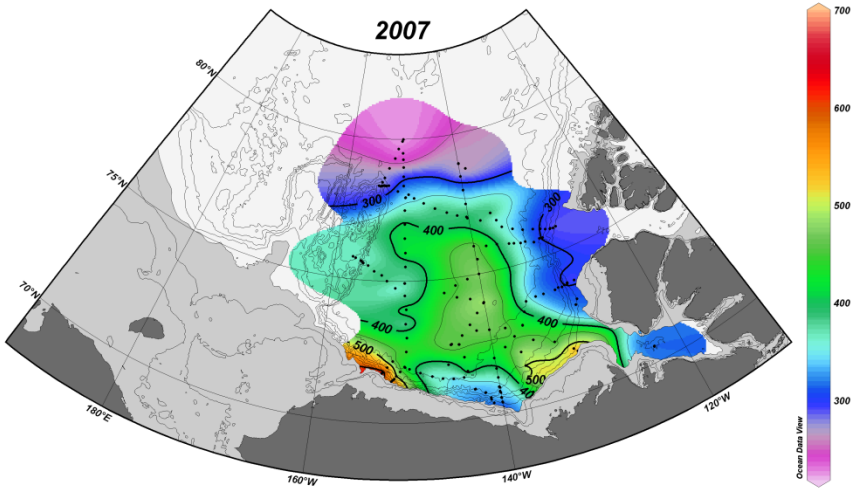
Existing Supporting Comments for Northerly Climate Observations

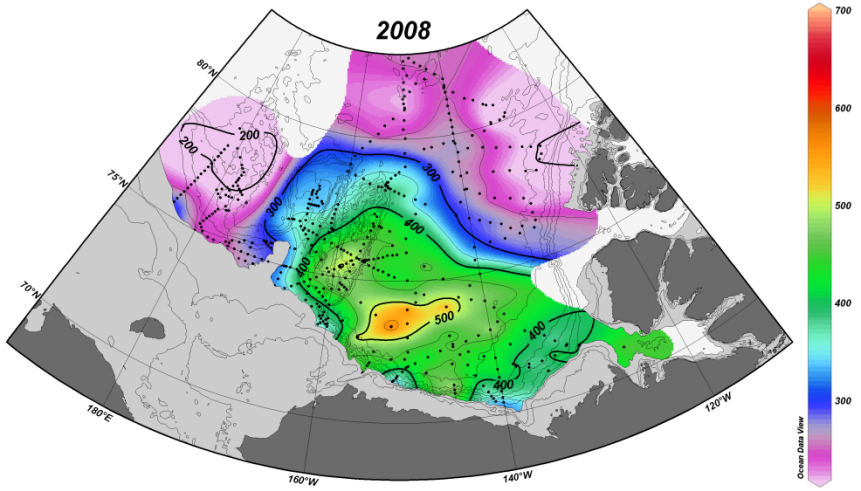
- Arctic ocean is vigorous and links to climate changes (K. Shimada, PAG, April 2014)
  - Upper ocean heat content a major factor in sea ice loss and regrowth (e.g., much sea ice loss in 2007/2008 from ocean heat
  - Positive feedbacks on sea ice loss exist from altered atmospheric circulation and increased ocean heat
  - Ocean heat enters from atmosphere, Pacific inflow and possibly Atlantic water
- Opportunity to decipher how the changing atmosphere, ice, ocean, ecosystem and benthic flux system is altering in response to increasing heat flux from the northward flowing Pacific Water, the eastward flowing Atlantic Water, enhanced mixing of surface waters, and increased solar radiation (reaching ocean surface) (K. Crane, NOAA call for proposals 2014)

Heat content (20-150m)









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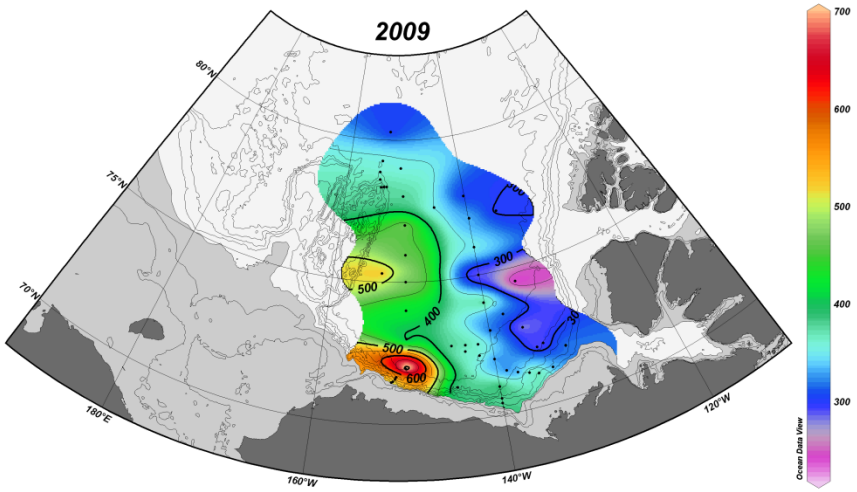

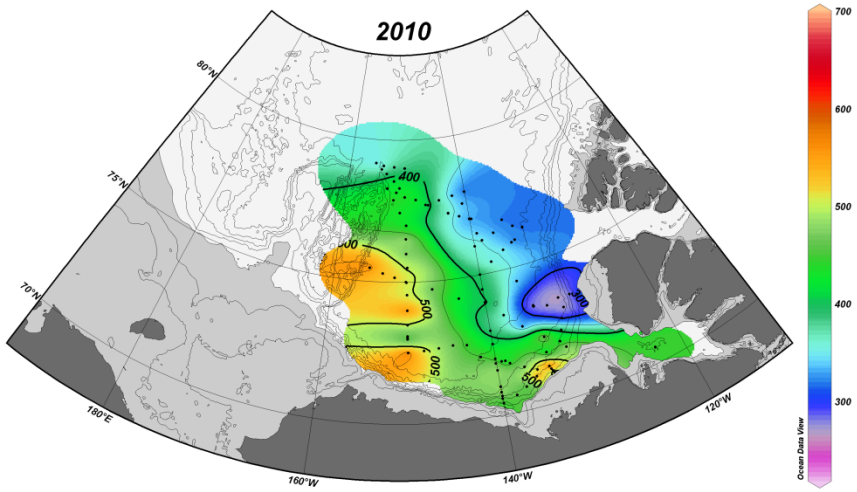

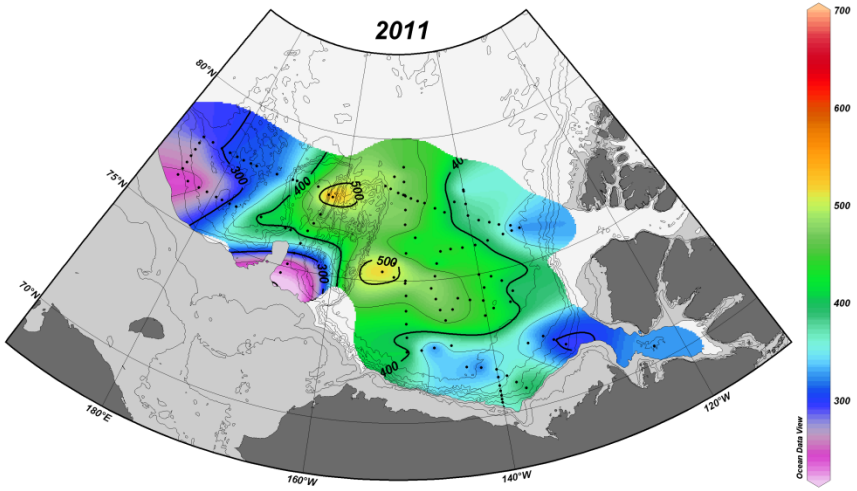

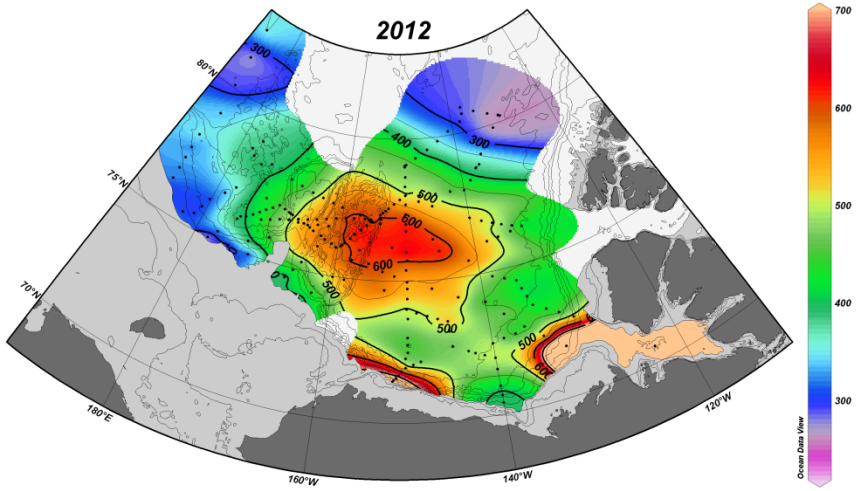

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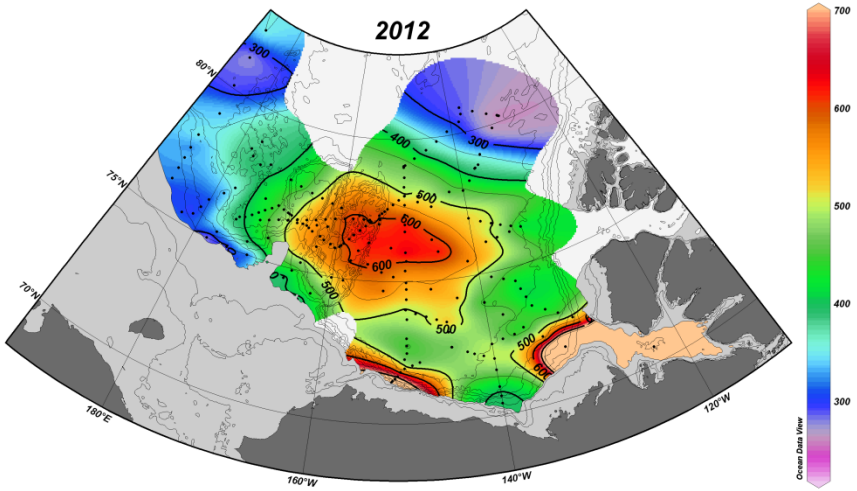
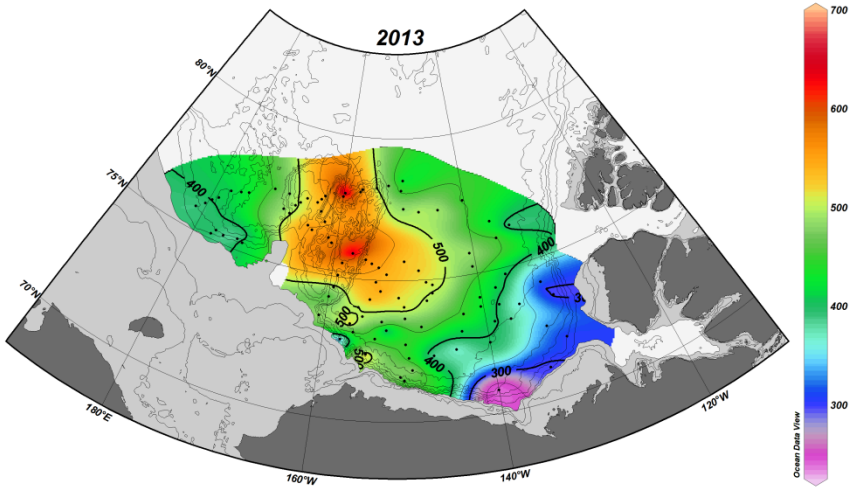
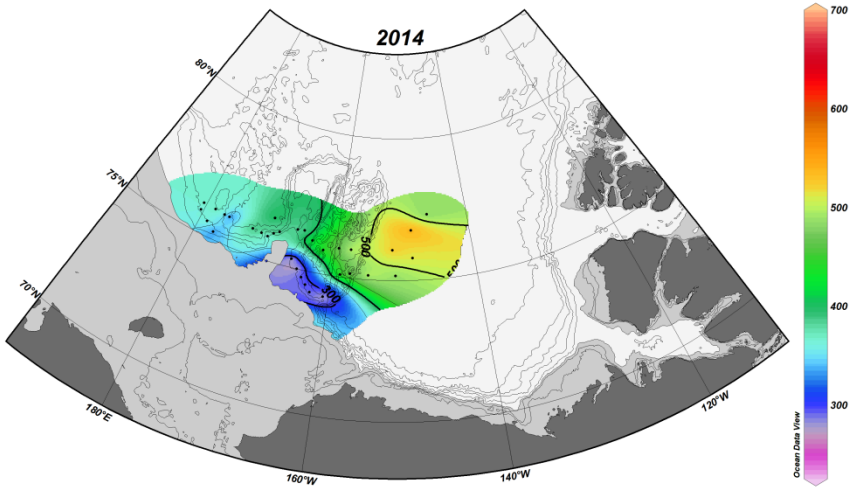
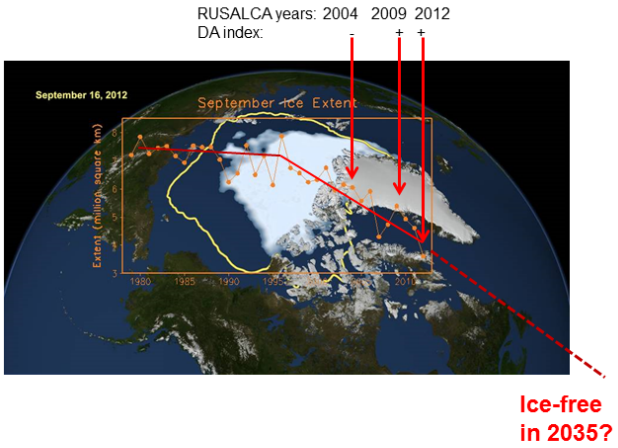
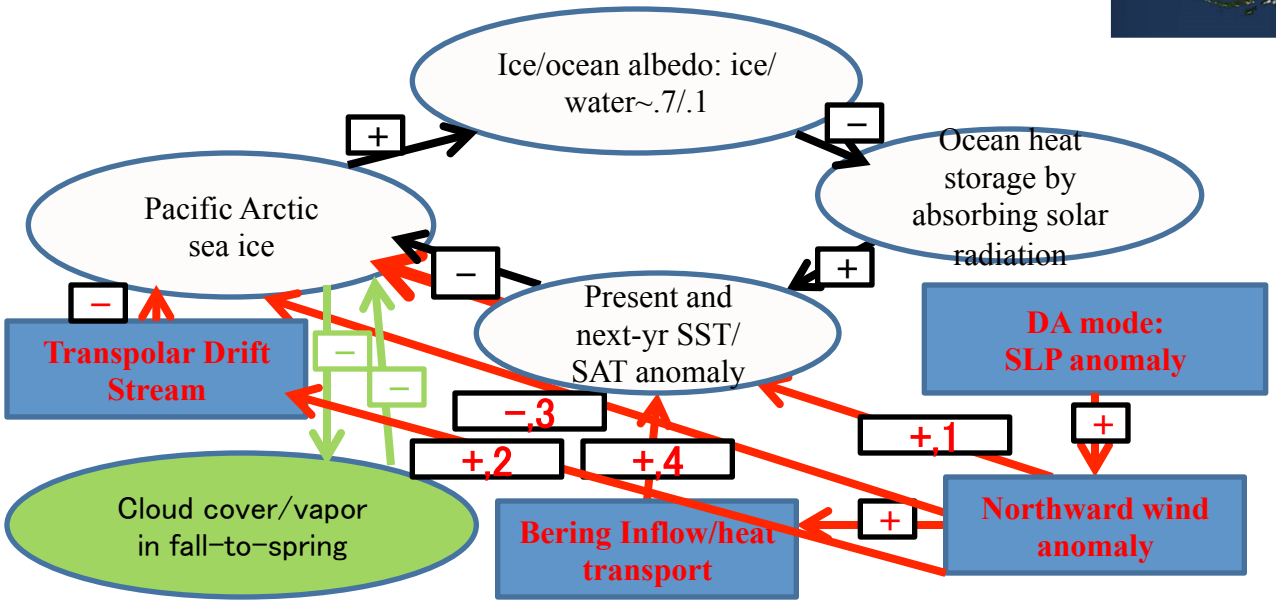






DA accelerates the ice/ocean albedo feedback annual loop/wheel/cycle by intermittent impulses





Wang et al. (2014b, Springer Book, chapter 4)

An ice/ocean albedo feedback loop and ice/cloud feedback loop are accelerated by a series of intermittent +DA forcings. The red arrows are associated with +DA forcing, which applies the positive feedback to the SST/SAT, or negative feedback to the sea ice, causing the unprecedented loss of Arctic summer sea ice and a series of record-breaking ice minima. + and – signs denote the positive and negative feedback, respectively. The positive feedback means that a change in one item (say *A*) affects the other item (say *B*), which feeds back so that *A* makes the change in the same direction as the original change. Note that associated with +DA, red arrow 1 indicates the northward advection of warmer SAT in the northern North Pacific to the Arctic by the anomalous meridional wind; Red arrow 2 denotes that anomalous meridional wind directly accelerates the TDS, which promotes export of more ice out of the Arctic; Red arrow 3indicates the direct advection of sea ice by the anomalous meridional wind; and red arrow 4 denotes the warming impact of the ocean heat transport from the Bering Sea promoted by the anomalous northward (or meridional) wind.

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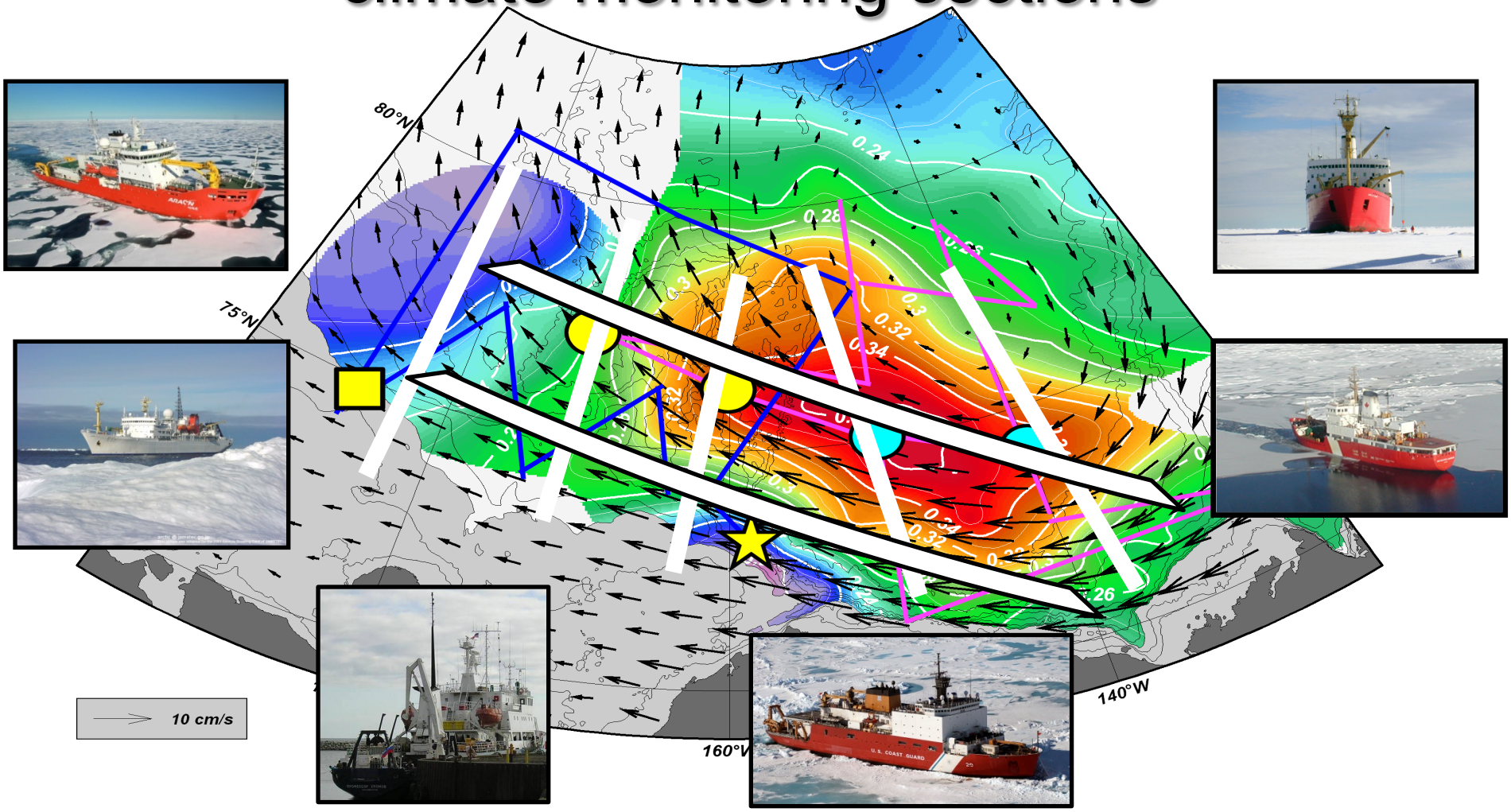
International Cooperation Required

- Size of domain requires multiple vessels from multiple countries
- All PAG countries operate research cruises into the domain
- If all agree to a certain level of cooperation and data integration, the domain can be observed adequately to develop improved understanding of the physical processes of the coupled atmosphere-ice-ocean system
- A companion biology focus would allow understanding of the ecological response to the changing physical state

Proposed international Pacific Arctic climate monitoring sections



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Suggested Approach to Implementation

- Segment the domain into smaller units consistent with PAG countries' interests and capabilities
- Coordinate logistics and science to the maximum extent possible
- Employ OSSEs and other techniques to fine tune observing activities
- Complexity of system requires multi-disciplinary approach to ship-based work (i.e., atmosphere-ice-ocean, physics-chemistry-biology)

Potential Outcomes

- Advancement in scientific knowledge, with direct application to:
  - Improved regional weather and sea ice forecasts
  - Improved hemispheric weather and climate models and forecasts
  - Improved regional ecosystem understanding, leading to more effective conservation and management

Immediate Next Steps

- Two or more abstracts to be prepared for ICARP III conference in Toyama, Japan
  - Ocean observations – Crane, Shimada, Kang
  - Atmospheric observations – Kim, Uttal (+ Japan and Canada)
  - Ecosystem observations – hope something will be submitted
- A "Letter of Intent" to be developed among interested countries/program managers to layout the proposed roles of the participants (Crane and Kang to initiate)
- Full presentations for ICARP III will provide scientific rationale and updates on plans
- Workshop in Tokyo (hosted by TUMSAT) prior to Toyama meeting to fine tune presentations and plans (to be announced by PAG chair)

Near Term Needs

- Consider small workshops or telepresence
  - Dialogue between modelers and field scientists to develop plans for OSSEs and other model-based effort
  - Establish “core” data requirements and set up framework for data assembly and analysis
  - Lay out specific transects/stations

Risks to be Managed

- Success depends to large degree on international cooperation/agreement for logistics, measurement protocols, scientific exchanges, data sharing, and joint publication of synthesis reports
- The usual political and bureaucratic barriers exist, requiring persistence of effort and sustained positive relations with international colleagues
- This is why PAG is so important