

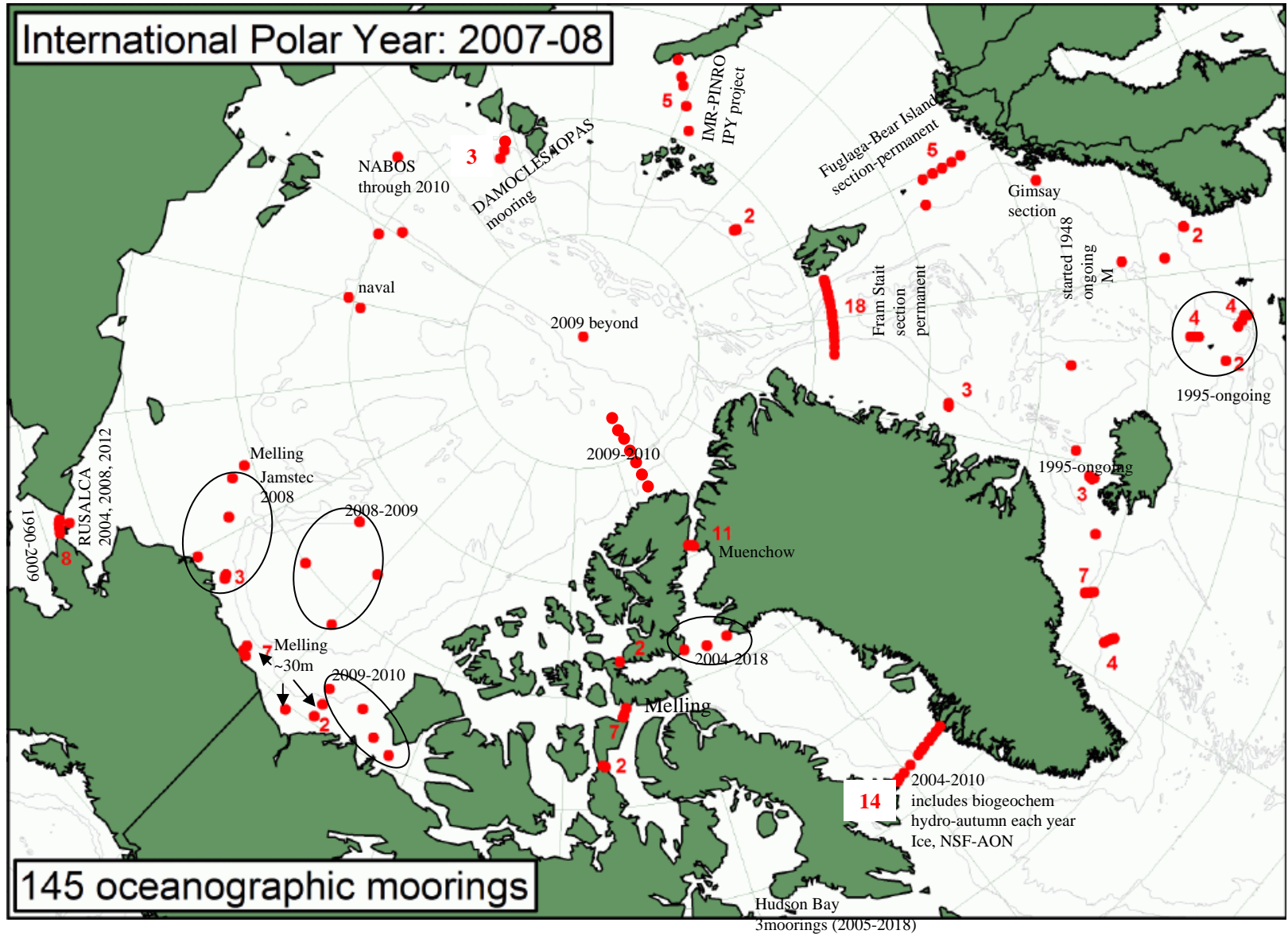
Ocean & Sea Ice Group

- Koji Shimada & Hajo Eicken (moderators),
Sang Lee (rapporteur)

Existing observing sites, systems & networks

- Process to identify existing observing sites, systems & networks:
 - Dickson (AOSB): Report on status of long-term *physical oceanography* observing programs (see attached map for sample map) > **available Feb 2008 (?)**
 - Perovich/Eicken: Provide additional information on *sea-ice* observation programs (remote sensing, buoys, transects & point measurements, coastal ice obs'ns - w/ input from Fortier-ArcticNet and others) > **available March 2008**
 - Broad overview of *biogeochemical oceanographic* observing programs (e.g., moorings w/ biogeochem. sensors, principal benefit of transects, etc.) and reference to potential *contaminant* obs. by Fortier & Stow (link to AMAP) > **January 2008**
 - Russian data sets: AARI (per web site); GLOS (sp? Proshutinsky), Sevmorgeo (? Korneev) > ?
 - Fisheries data: Nordic Seas - ICES ? Pacific - PICES ? Arctic - Census Marine Life ? Reports or contacts ? > ?
 - SEARCH(OCP)/DAMOCLES (S4D): Updated overall implementation status from S4D integration workshop and exchange > **Spring 2008**
 - Marine mammals: Potential contacts include (co-)management commissions, meeting participants (Gill), NOAA-NMFS and others > ?
 - chemical: tracers (geoTraces), AMAP for contaminants (food)

To be added: Piechura stations, ICES sites, Sevmorgeo sites



Spatial, temporal & disciplinary gaps

- (1) Different categories of gaps: (i) Environmentally constrained (e.g., thick ice North of Greenland/Canada); (ii) geopolitically constrained (e.g., parts of Siberian shelves); (iii) instrumentally constrained (e.g., satellite-based ice thickness measurements) with subcategory adaptation gaps (e.g., Lagrangian platforms not suited for seasonally ice-free ocean); (iv) logistically constrained (e.g., lack of icebreaker platform for specific year and location), (v) methodologically constrained (e.g., lack/lag of observing system design tools)
- (2) Process that identifies different types of gaps in different categories needs to take into consideration that gap depends on measurement objective, with three basic categories: (i) “state of the Arctic”, (ii) adaptation & mitigation of change, (iii) user-specified (applied) objectives
- (3) Hierarchical approach to gap identification: (i) disciplinary/user-group level (e.g., sea ice observations within CliC Sea Ice Working Group; need to identify corresponding group in oceanography community); (ii) regional level (e.g., from regional ocean observing systems such as AOOS; international groups such as Pacific Arctic Group); (iii) broader program level such as SEARCH/DAMOCLES; (iv) overarching entity to assess programmatic and regional gaps - potential role of ISAC as a caucus of national programs w/ periodic review of status of observing system?
- (4) Specific proposed action in context of process:
 - Disciplinary gaps: CliC Sea Ice Working Group > **Spring 2008**
 - regional gaps through polling of regional ocean observing programs (AOOS, others?) > ?; information needed from Canada, Russia, Japan, China, Korea > PAG or other forum?
 - SEARCH/DAMOCLES: through S4D integration process (workshop) identification of gaps starting at disciplinary level > **Spring 2008**

Arctic Ocean obs.

- Why are we better off after IPY?

We have an observing system in place that allows us to document in real time the inflow of water masses with changing properties into the Arctic and at the same time to follow the variability and change of water masses, fronts, and climate modes in the Arctic Ocean. These observations are crucial for our capability to project the transition of the Arctic into a new state and to provide information on the Arctic system needed for decisions that have to be made by stakeholders. The evolving properties will have considerable impact on the sea ice cover and the ecosystems in the upper ocean.

- What will we gain from a sustained observing system?

We will be able to follow in real time the changes imposed onto the Arctic by global and local forcing. This information will improve model predictions of the future state of the Arctic, as well as socioeconomic decisions in a changing environment. Loss of this capability would greatly limit our ability to plan responses to environmental Arctic change, including adaptation and mitigation strategies.

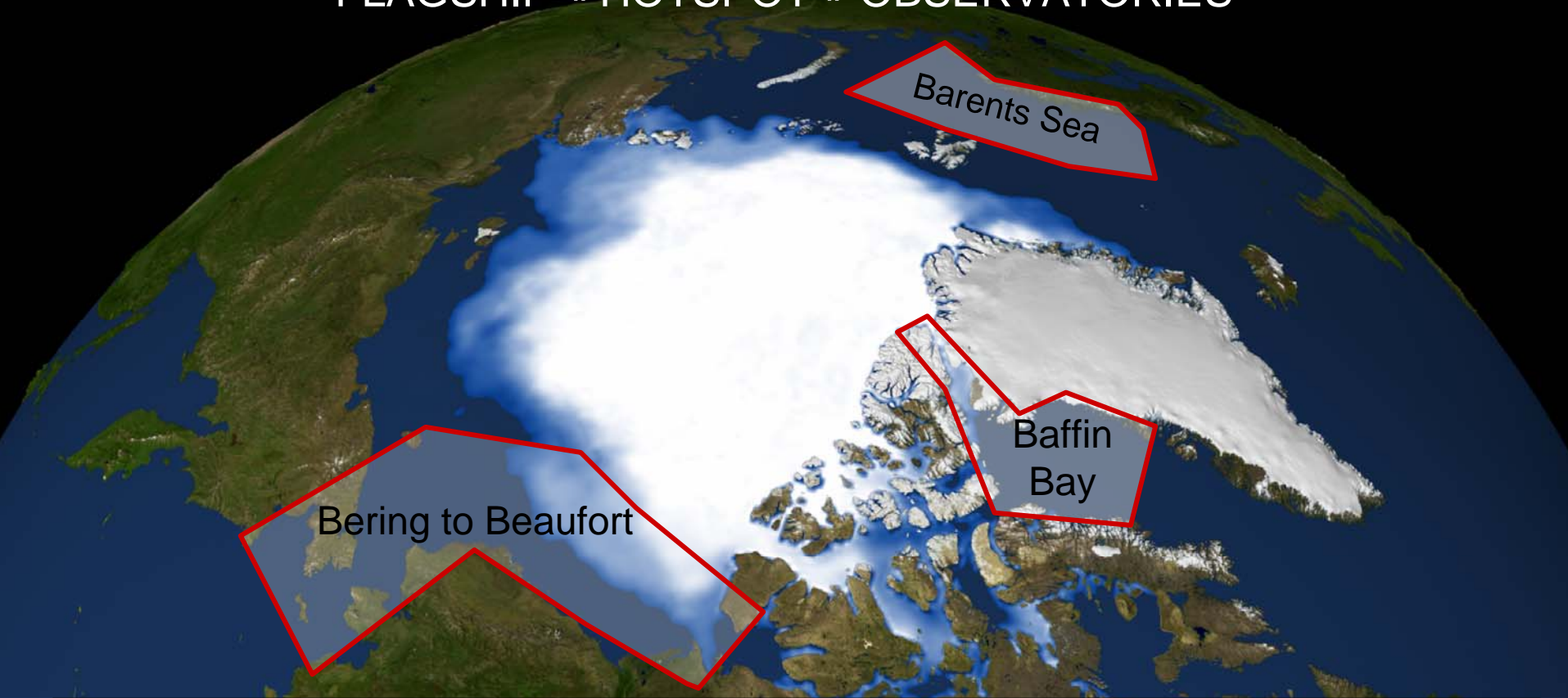
- Implementation philosophy

Efforts to implement a sustained observing system have to be guided by optimization of cross-domain, integrated system rather than by specific needs for observations by science projects dedicated to solving problems of disciplinary or intra-disciplinary scope.

- Add sea ice group material on nature of integrated, long-term, international ... observing system.

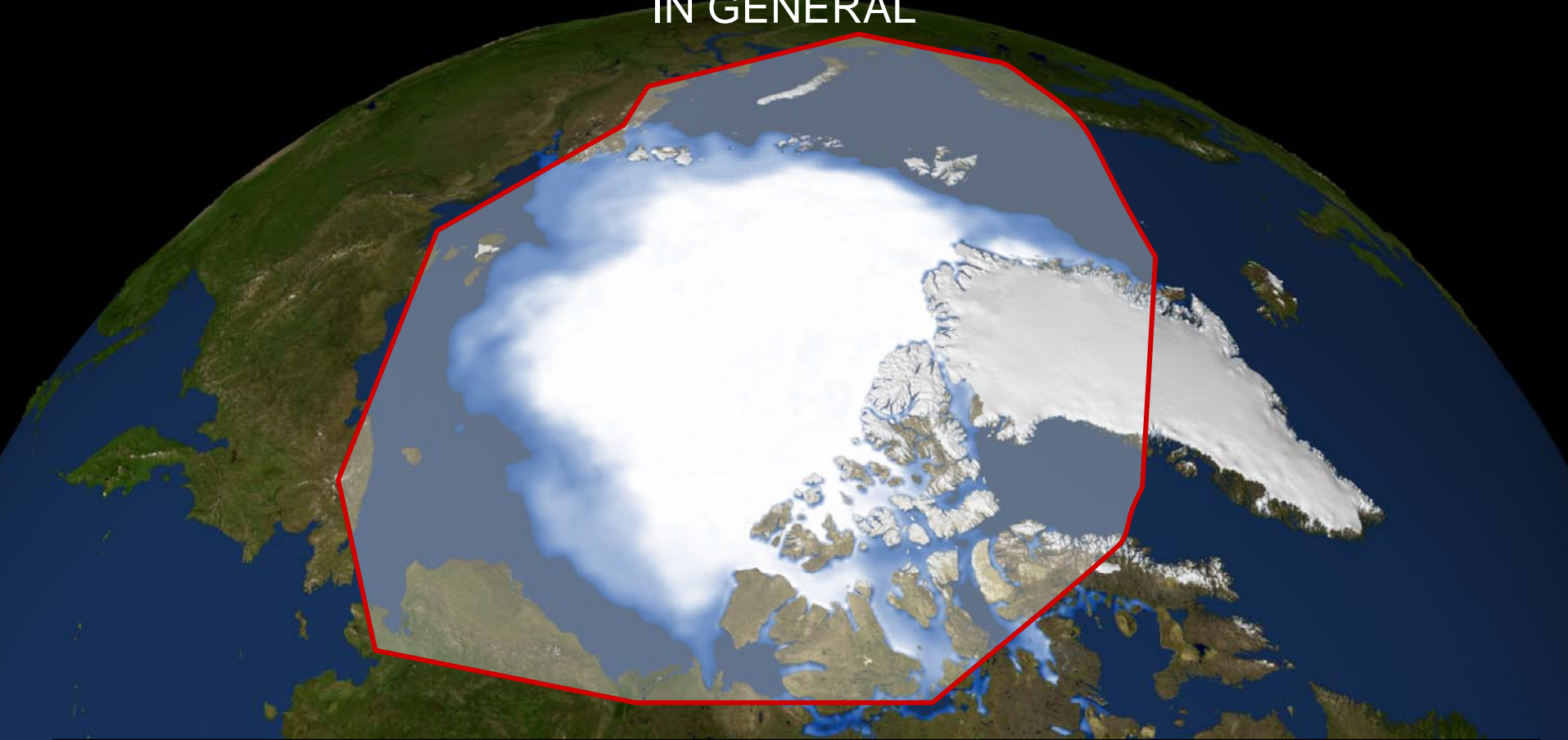
MARINE BIOGEOCHEMICAL OBSERVATORIES

FLAGSHIP « HOTSPOT » OBSERVATORIES



- Annual ship-based integrated ecosystemic surveys with associated biogeochemical & physical mooring arrays.
- Community monitoring program (marine mammals, local observations....).
- Building on already established observatories with variable extent and duration of existing observational data sets.
- Economically important zones (fisheries, oil & gaz potential...) with long term potential financial investment by harvesting countries.

MARINE BIOGEOCHEMICAL OBSERVATORIES IN GENERAL



- In general for entire Arctic, we should develop integrated physical & biogeochemical observatories (moorings).
- Biogeochemical sensors (nutrients, pH, O₂, Chla,), sediment traps, hydrophones.... need to be built-in with physical oceanography moorings

Sea Ice - Benefits:

Knowledge gained & stakeholders

- **Whole is more than sum of parts:**
 - Platform and process for integration and value-added products coming out of what might otherwise be proprietary isolated data sets (industry and others)
 - Providing a framework for interpretation and forecasts in larger spatial and temporal context, such as mid-term and long-term planning by different stakeholder groups
 - Network design and measurement/modeling activities can help stakeholders deploy limited assets more effectively
- **Understanding of pervasive change is building:**
 - Prior to IPY: ice cover is variable & changing; after IPY: attribution of change (ice-albedo feedback, dynamics), delineation of trajectory of change
 - Impact of sea-ice change on communities & ecosystems: local observations can be mapped onto large-scale change (e.g., walrus, changes in ice seasons)
- **We are better off after IPY:**
 - Understanding is increasing; options for adaptation and response

A sustained, adaptive system post-IPY

- Continued satellite coverage is key and requires high degree of international coordination, collaboration and data exchange at level of space agencies and beyond (role for SAON in 2nd Workshop: involvement of ESA, NASA, CSA, JAXA etc.); satellites key in specific design of adaptive systems
- Distributed sensor arrays: Placement and density determined by models and observations (and user needs!); Eulerian and Lagrangian components
- Surveys: key instrument in adaptation & regional integration of network
- Process studies: Model improvement and cross-disciplinary integration

- Adaptive: models, remote sensing & surveys
- Evolving: Amphibian seasonal ice sensor arrays; aerial survey techniques
- Regionally optimizing: Sampling theory studies identify high-priority areas; user needs and existing programs (industry!) govern design and integration of sub-systems; tools for regional integration (information system)
- Integrated: through modeling; drifting sensors & surveys for integration of atmosphere-ocean-ice interaction
- Sustained: Linkages & partnerships needs to be developed that integrate successful operational programs (e.g., IABP), emerging and past industry programs, environmental and resource management programs > charge for 2nd SAON Workshop to involve agencies that oversee industrial activities

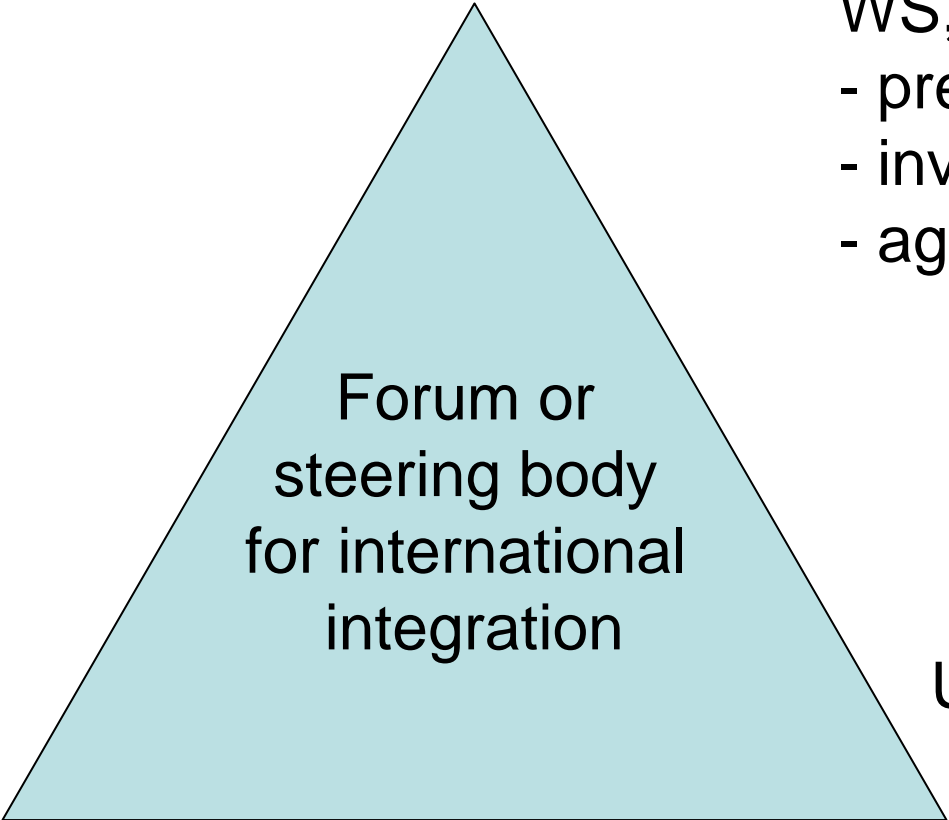
Sustained observations

- (1) Bottom-up integration at science level (underway); what is needed is international top-down integration (funding agencies, IOC, and others)
- (2) Identify (long-term) programs successful in integration that can serve as models for evolving SAON
- (3) Arctic community is expressing concern about lack of connection with other extra-Arctic observing systems & global research community: Goal for 2nd SAON WS?

Implementation &
Funding agencies

Goals for 2nd SAON
WS, key issues:

- preparations
- invitees
- agenda



Forum or
steering body
for international
integration

Observing
system

Users:

- research scientists
- agencies/gov't
- communities
- industry

Long-term sustainability:
-balance between mission,
process & observing science

Synergy, minimiz'n of overlap & integration

- (1) Nascent Ocean Observing Systems at regional and global level as a framework for coordinated measurements?
Arctic/EuroGOOS - potential and lessons learned? Include as agenda item for 2nd SAON Workshop (IOC supportive of Arctic endeavors)
 - Models for successful coordination and integration

- (2) Arctic community is expressing concern about lack of connection with other extra-Arctic observing systems & global research community
 - Suggestions for specific remediation in context of SAON (workshops, documents etc.)?

Long-term funding & user needs

- (1) Primary (scientifically and user-needs justified) case has been made for Arctic observing system over the past decade
- (2) Now urgent need for intergovernmental coordination at higher levels to ensure sustainability of network:
 - Focus on viable approaches for coordination and support during 2nd SAON Workshop by building on IPY synergies and collaborations; entrain officials from different countries able to speak to relevant issues
 - What is needed in preparation? What is goal of 2nd Workshop?
 - IABP as a model of successful balance between scientific & user needs in conjunction with commitment and support at appropriate agency or government levels
- (3) Further articulation and translation of user needs into observing strategies required?

- 2007: Peak obs? Need to understand central Arctic change (ice)
- Arctic net source or sink for carbon (C)
- Village level: lack of information on food safety (food)

O&I Group: Proposed structure

- (1) Initiate process to identify existing observing sites, systems & networks
- (2) Initiate process to identify spatial, temporal & disciplinary gaps
- (3) Identify opportunities for integration of new into existing observing networks (? Clarify)
- (4) Discuss opportunities for coordination to create synergy & avoid overlap
- (5) Comment on potential for long-term funding by better meeting user needs (? Clarify)

Total time allotted: 5 hours - 1h each? Break-out?

Open questions & items to discuss

- (1) Driving science questions & prioritization
 - (1) Directional change (Arctic moving to new state)
 - (2) Budgets of heat, freshwater (ice), nutrients, carbon
 - (3) Improvement of models (incl. reanalysis) & validation/constraining of remote sensing data
 - (4) (Eco)System services
- (2) Driving user needs
 - (1) Environmental security (impact of climate change on infrastructure & well-being)
 - (2) (Eco)System services
 - (3) Cultural needs
- (3) Use of international working groups (disciplinary or interdisciplinary) to coordinate and maximize synergy: IASC Pacific Arctic Group (PAG); WCRP Climate and the Cryosphere Program (CLiC); & others? What is the potential role of IASC (or AOSB) in these discussions?
- (4) Is the current agency framework as represented at this meeting sufficient to address ocean & ice data needs?

Addressing SEARCH Science Questions: Gaps

How are Priority 1 or other top priority questions (if <1) addressed through AON Projects?

1. Is the arctic system moving to a new state? A/B
2. To what extent is the arctic system predictable (i.e., what are the potential accuracies and/or uncertainties in predictions of relevant arctic variables over different timescales)? A/B
3. To what extent can recent and ongoing climate changes in the Arctic be attributed to anthropogenic forcing, rather than to natural modes of variability? A/B (assuming 2k BP paleo-reconstruction underway)
4. What is the direction and relative importance of system feedbacks? C
5. How are terrestrial and marine ecosystems and ecosystem services (i.e., processes by which the environment produces resources that support human life) affected by environmental change and its interaction with human activities? C (terr.) F (marine)
6. How do cultural and socioeconomic systems interact with arctic environmental change? A/C
7. What are the most consequential links between the arctic and the earth systems? A (heat/salt budget) D (glacial mass balance)

Existing observing sites, systems & networks

Mid- to long-term observation programs

Alaska Ocean Observing System

International Arctic Buoy Program

International Ice Patrol

Nansen and Amundsen Basins Observational System (NABOS)

National Ice Center

NOAA Alaska Fisheries Science Center

NOAA Fisheries Oceanography Coordinated Investigations

NOAA National Data Buoy Center – Alaska

NOAA Tides and Currents (Water Level) - Alaska

National Snow and Ice Data Center

Existing observing sites, systems & networks

NSF-supported Arctic Observing Network programs; for list of projects & data access visit Cooperative Arctic Data and Information System (CADIS):
www.eol.ucar.edu/projects/aon-cadis

Instruments & methods

The Collaborative O-Buoy Project: Deployment of a Network of Arctic Ocean Chemical Sensors for the IPY and beyond

Design and Initialization of an Ice-Tethered Array Contributing to the Arctic Observing Network

Coordination, Data Management and Enhancement of the International Arctic Buoy Programme (IABP)

Community-based observations

Bering Sea Sub-Network: International community-based observation alliance for Arctic observing network (BSSN)

ELOKA: Exchange for local observations and knowledge in the Arctic

Sea ice

Ice Mass Balance Buoy Network: Coordination with DAMOCLES

The State of the Arctic Sea Ice Cover: An Integrated Seasonal Ice Zone Observing Network (SIZONET)

Existing observing sites, systems & networks

Ocean

North Pole Station: A Distributed Long-Term Environmental Observatory

Aerial Hydrographic Surveys for IPY and Beyond: Tracking Change and Understanding Seasonal Variability

A Modular Approach to Building an Arctic Observing System for the IPY and Beyond in the Switchyard Region of the Arctic Ocean

Ocean-Ice Interaction Measurements Using Autonomous Ocean Flux Buoys in the Arctic Observing System

Toward Developing an Arctic Observing Network: An Array of Surface Buoys to Sample Turbulent Ocean Heat and Salt Fluxes During the IPY

Observing the Dynamics of the Deepest Waters in the Arctic Ocean

Comparison of Water Properties and Flows in the U.S. and Russian Channels of the Bering Strait - 2005 to 2006

The Pacific Gateway to the Arctic - Quantifying and Understanding Bering Strait Oceanic Fluxes

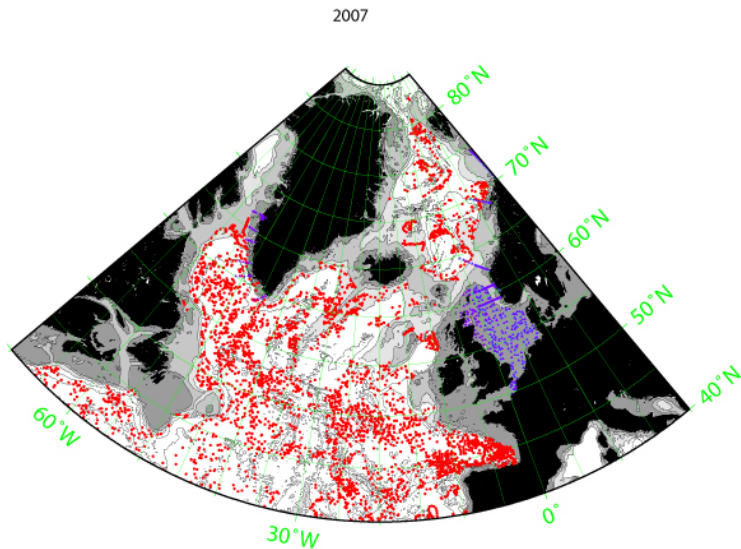
The Beaufort Gyre System: The Flywheel of the Arctic

An Innovative Observational Network for Critical Arctic Gateways: Understanding Exchanges through Davis Strait

Existing observing sites, systems & networks

DAMOCLES

(www.damocles-eu.org)



- **Core theme 1: Sea ice** (http://www.damocles-eu.org/WP1-sea_ice.shtml)
 - **WP 1.1 - Ice thickness** (http://www.damocles-eu.org/WP_1_1-Ice_thickness.shtml)
 - **WP 1.2 - Ice types and properties** (http://www.damocles-eu.org/WP_1_2-Ice_types_and_properties.shtml)
 - **WP 1.3 - Sea ice dynamics and thermodynamics** (http://www.damocles-eu.org/WP_1_3-Sea_ice_dynamics_and_thermodynamics.shtml)
 - **WP 1.4 - Thermodynamics** (http://www.damocles-eu.org/WP_1_4-Thermodynamics.shtml)
- **Core theme 2: Atmosphere and Air-Sea-Ice interaction** (http://www.damocles-eu.org/Core_theme_2_Atmosphere_and_Air-Sea-Ice_interaction.shtml)
 - **WP 2.1 - Arctic cyclones** (http://www.damocles-eu.org/WP_2_1-Arctic_cyclones.shtml)
 - **WP 2.2 - Boundary Layer turbulence** (http://www.damocles-eu.org/WP_2_2-Boundary_Layer_turbulence.shtml)
 - **WP 2.3 - Clouds, radiative fluxes and surface albedo** (http://www.damocles-eu.org/WP_2_3-Clouds_radiative_fluxes_and_surface_albedo.shtml)
- **Core theme 3: Ocean** (http://www.damocles-eu.org/Core_theme_3_Ocean.shtml)
 - **WP 3.1 - Input function** (http://www.damocles-eu.org/WP_3_1-Input_function.shtml)
 - **WP 3.2 - Shelf/Basin exchange** (http://www.damocles-eu.org/WP_3_2-Shelf_Basin_exchange_.shtml)
 - **WP 3.3 - The deep central Arctic Ocean** (http://www.damocles-eu.org/WP_3_3-The_deep_central_Arctic_Ocean.shtml)
 - **WP 3.4 - Output to the North Atlantic and global circulation** (http://www.damocles-eu.org/WP_3_4-Output_to_the_North_Atlantic_and_global_circulation.shtml)
- **Core theme 4: Integration and data assimilation in large-scale modelling and forecasting** (http://www.damocles-eu.org/Core_theme_4_Integration_and_data_assimilation_in_large-scale_modelling_and_forecasting.shtml)
 - **WP 4.1 - Model Sensitivity and studies combining models with observations** (http://www.damocles-eu.org/WP_4_1-Model_Sensitivity_and_studies_combining_models_with_observations.shtml)
 - **WP 4.2 - Predictability and improved simulation capabilities** (http://www.damocles-eu.org/WP_4_2-Predictability_and_improved_simulation_capabilities.shtml)
 - **WP 4.3 - Enhancement of observational data sets by data assimilation and analysis** (http://www.damocles-eu.org/Enhancement_of_observational_data_sets_by_data_assimilation_and_analysis.shtml)
- **Core theme 5: Impact Activity**
 - **Impact Activity 1 - Long-term projections into the 21st century with the help of improved coupled climate models** (http://www.damocles-eu.org/Impact_Activity_1-Long-term_projections_into_the_21st_century_with_the_help_of_improved_coupled_climate_models.shtml)
 - **Impact Activity 2 - Impact on CO₂ cycle and phytoplankton production** (http://www.damocles-eu.org/Impact_Activity_2-Impact_on_CO2_cycle_and_phytoplankton_production.shtml)
 - **Impact Activity 3 - Climatic Impact on Marine Ecosystems** (http://www.damocles-eu.org/Impact_Activity_3-Climatic_Impact_on_Marine_Ecosystems.shtml)

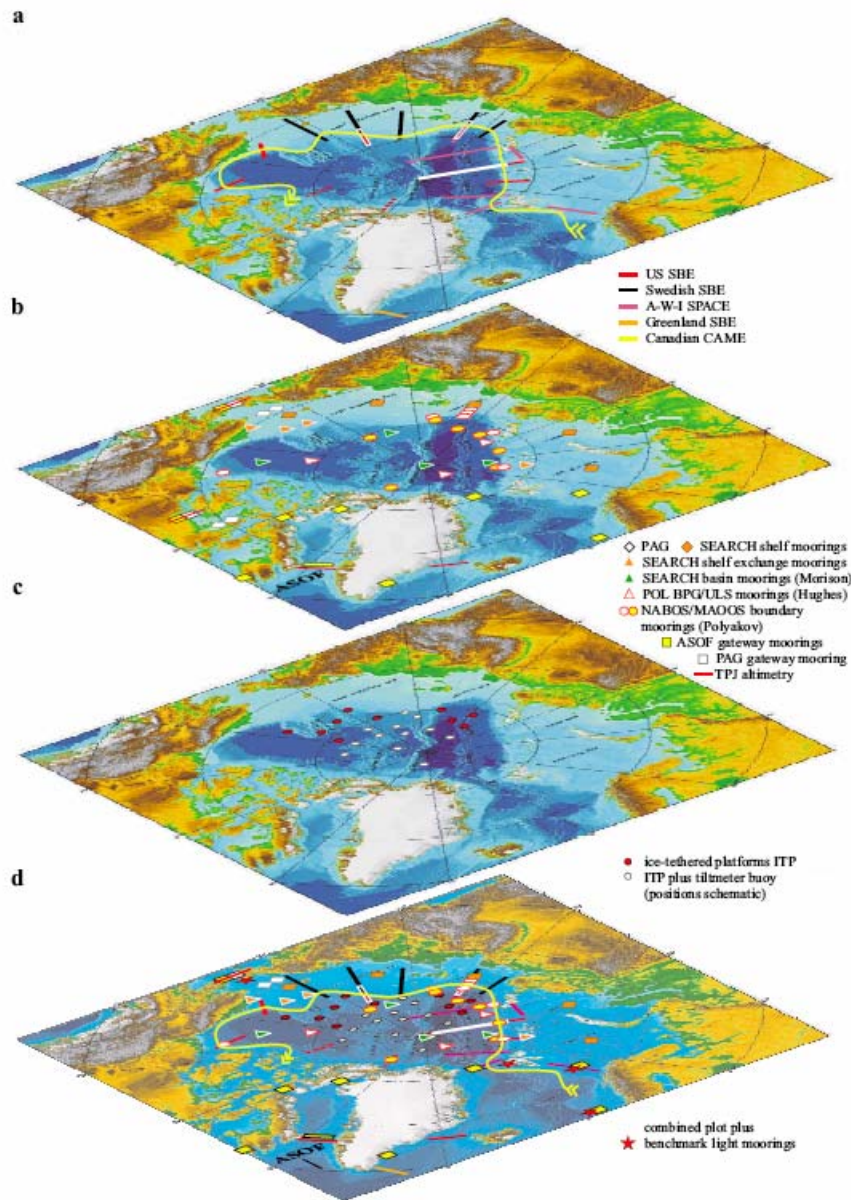


Fig. 2. The elements of an integrated Arctic Ocean Observing System showing the ship-based Shelf Basin Exchange transects (a), the proposed mooring system for Shelf, Slope, Basin and Gateways (b), grids of Ice-Tethered Platform and Tiltmeter Buoys (positions figurative) (c), and the full combined deployment (d)

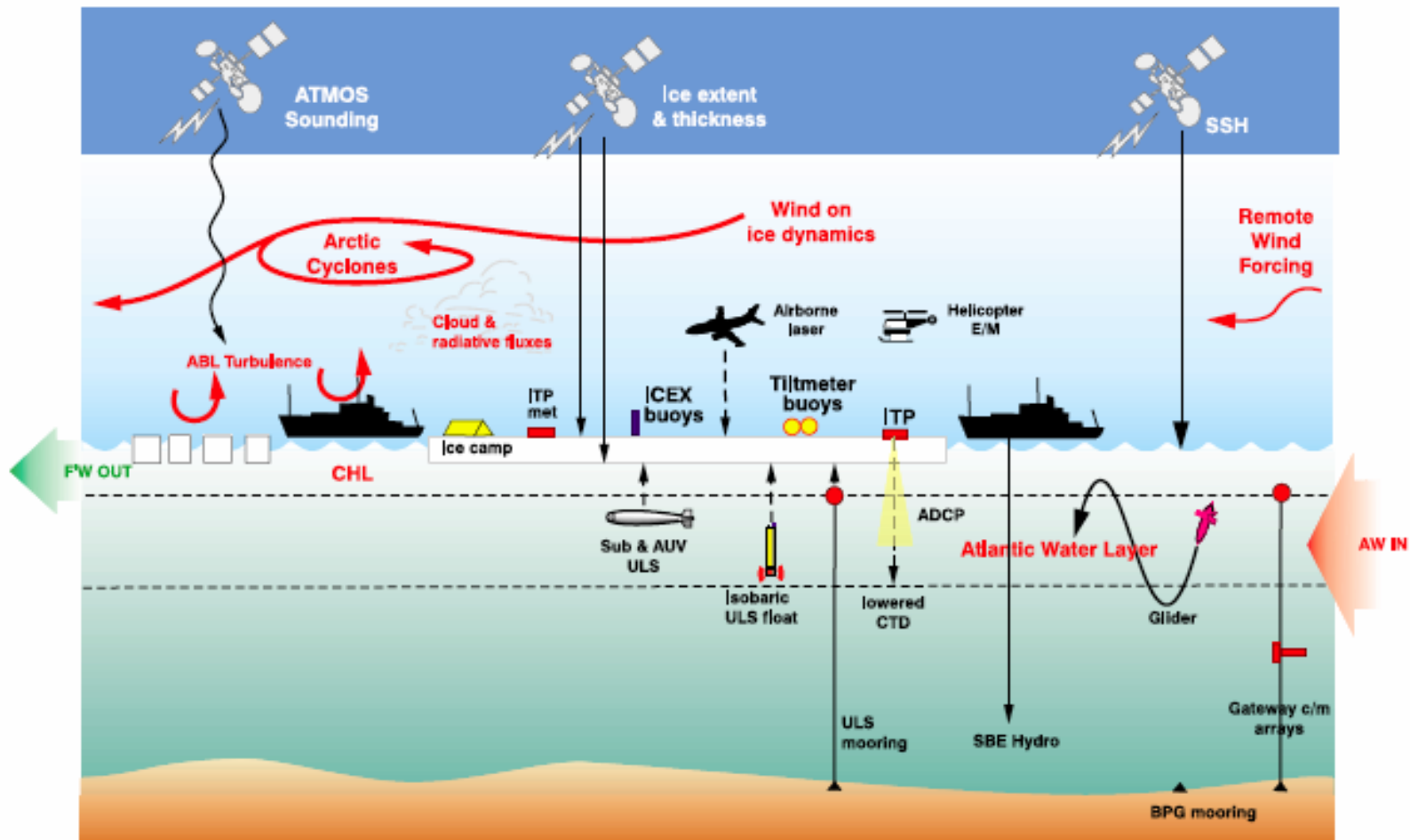
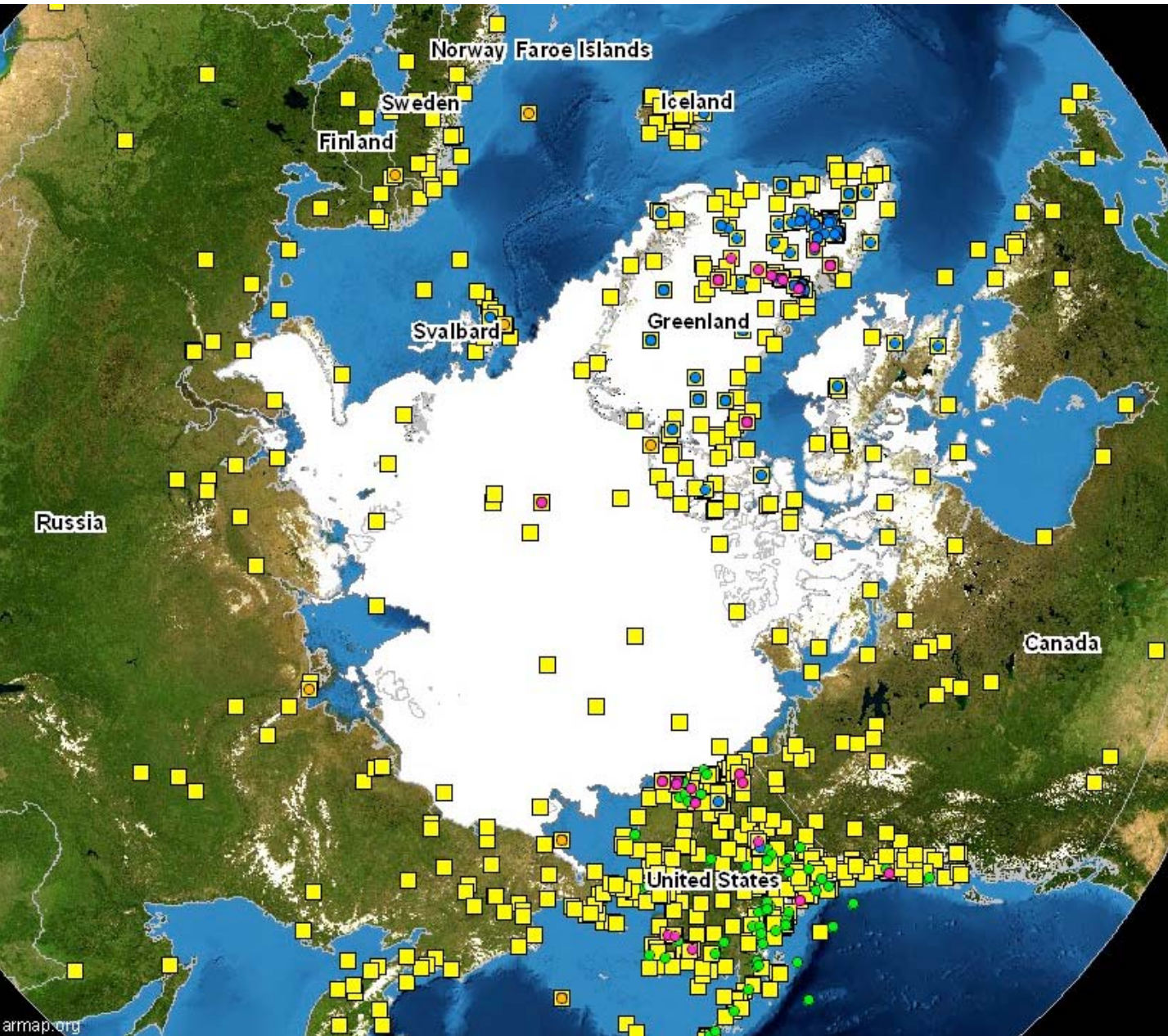


Fig. 1. Schematic of the vertical stack of observations from satellites to seabed that would be necessary to inform an iAOOS study focused on the present state and future fate of the Arctic perennial sea-ice

Map of Arctic observing activities



ARMAP, 2007



Physical & Chemical Oceanography; Sea Ice

Bering Strait

Aerial Hydrographic Surveys



Seasonal Ice Zone

North Pole Environmental Observatory

Beaufort Gyre Observatory & Deepest Waters

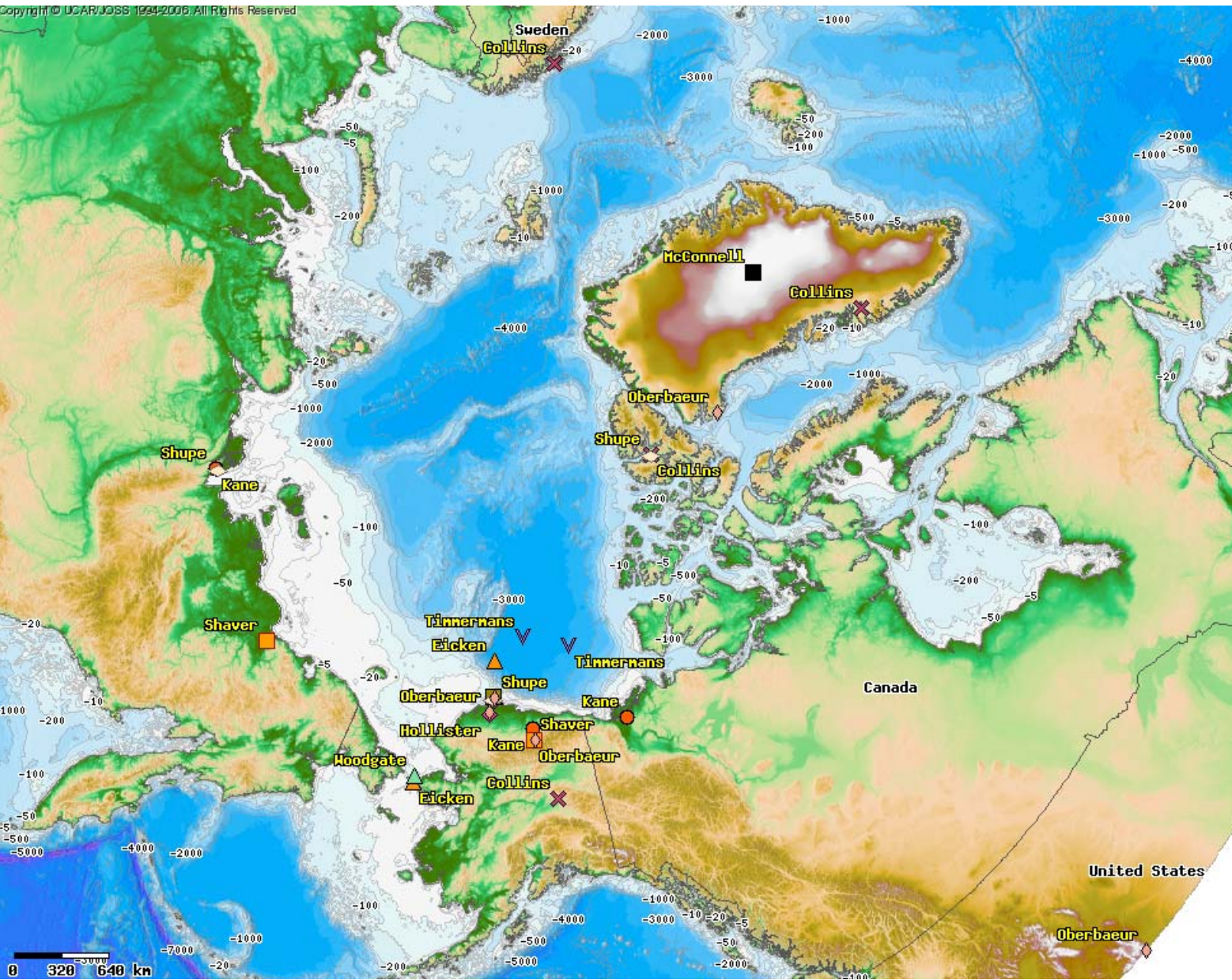
Ice-Tethered Profilers & Ice Dynamics and Weather Buoys

Davis Strait

Switchyard & Seasonal Ice Zone

M. Jeffries (NSF)

Map of AON activities (CADIS)



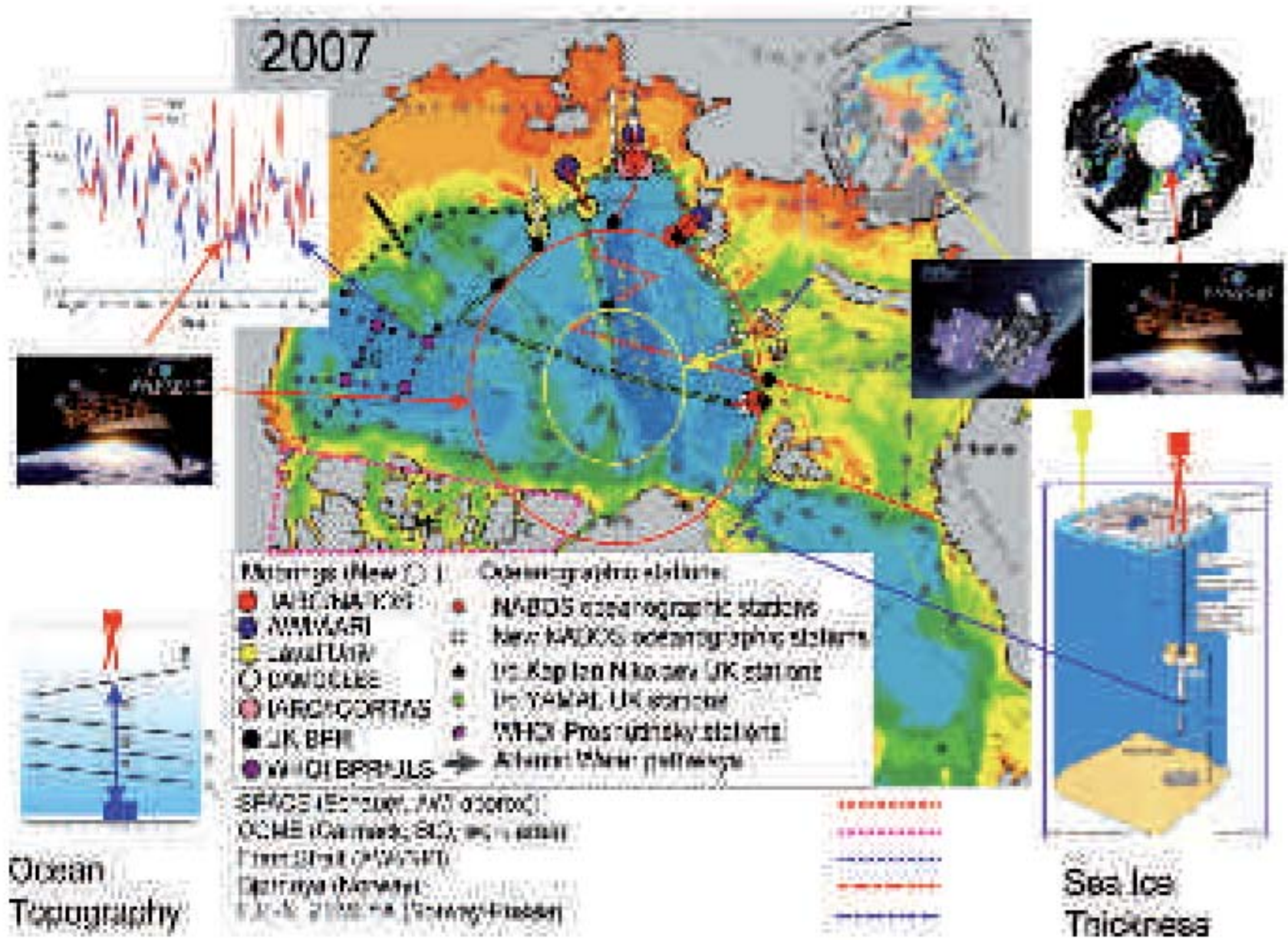


Figure 11 — Plans for iA00S collaborative oceanography across the Arctic Ocean in summer 2007

Spatial, temporal & disciplinary gaps (notes made prior to SAON Meeting)

- (1) Spatial gaps: Data over Siberian shelves?
- (2) Temporal gaps: high-resolution, seasonal, or other?
- (3) DAMOCLES identified following gaps (J.-C. Gascard):
 - (1) Lagrangian & Eulerian in situ observations with autonomous, remote & attended platforms (function in ice & open water)
 - (2) Enhancing remote sensing & ground truth validation for airborne & satellite sensors (Cryosat 2); increase coordination between space agencies
 - (3) Shortening time for accessing near-realtime data and develop advanced data assimilation & numerical modelling techniques;
 - (4) Accessing appropriate logistics (aircrafts and ice strengthened ships) and infrastructure
- (4) Disciplinary:
SEARCH program identified following gaps
 - (1) Ecosystem services (marine biogeochemistry & production)
 - (2) Paleo-perspectives
 - (3) Terrestrial ice
 - (4) Socio-economic components of observing system
 - (5) Stakeholder-relevant data acquisition and dissemination (goal of HDq, more efforts needed?)

- Arctic sea ice cover
- Marine living resources (fisheries, mammals)
- Ocean heat/salt budget

- Scientific/user drivers, what has been learned to date, what's needed and will be gained from continued activities
- Synergies w/ regulatory requirements for data acquisition

- Sustained integrated observing system as an international collaborative effort
 - Adaptive
 - Evolving (technology)
 - Regionally optimizing

 - How did systems in place for IPY benefit us?
 - E.g., sea ice: identify fundamental need but no discussion of design elements
- Why are we better off now after IPY?
 - Products/outcomes of observing system
 - Benefits in terms of knowledge gained
 - Benefits to stakeholders

 - SUBGROUPS MEET
10.30-12.30 (with lunch)

 - MEET AS WHOLE
GROUP HERE at
12.30pm

- System components: satellites (ice extent/conc); buoys (IABP) for drift, mass balance (attribution); ULS (thickness at point); sonar on subs (profiling thickness); survey cruises & process studies; models provide insight on location & type of measurement
- Integration: through modeling; drifting sensors & surveys for integration of atmosphere-ocean-ice interaction

Why are we better off after IPY?

- Prior to IPY: ice cover is variable & changing; after IPY: attribution of change (ice-albedo feedback, dynamics), delineation of trajectory of change
- Fundamental understanding has improved in two major ways: Ice-albedo feedback is happening and possibly more so than models predict; ice dynamic regime is undergoing change
- Impacts on communities & ecosystems
- mass-balance buoys - role of ocean vs atmosphere in record ice retreat; drift buoys & remote sensing indicate impact of ice dynamics; aerial thickness surveys tell us how much thick ice has been melted, improving short (week/month) and longer-term prediction of ice cover state, put into perspective & validate climate model results; help with assessment of impacts on communities and ecosystems (multiyear ice: distribution & thickness); key information on transition into different ice flow regime