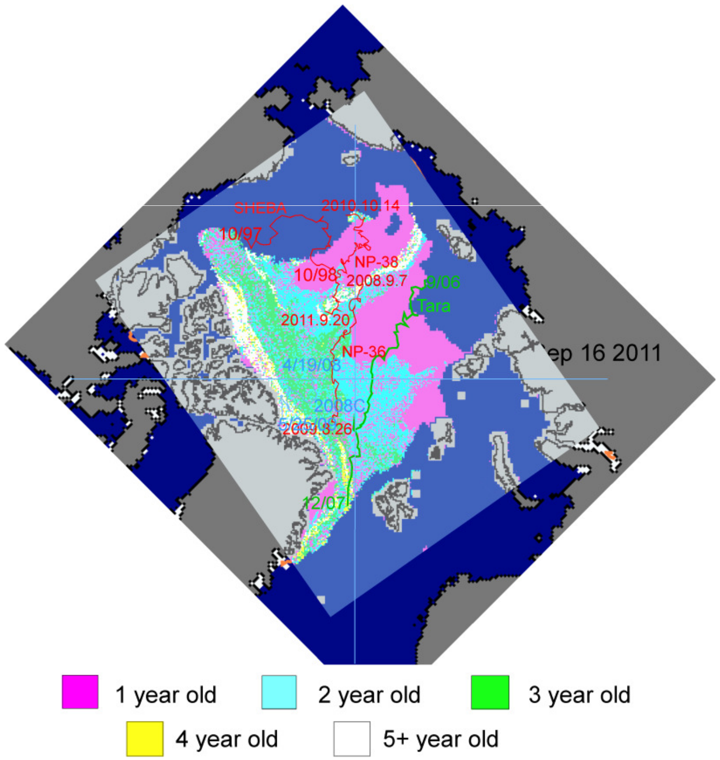
International Arctic Science Committee

The proposed

Multidisciplinary drifting Observatory for Studies of Arctic Climate (MOSAiC)

O. Persson, M. Shupe, M. Tjernström, K. Dethloff, D. Perovich (& many others)



September 2011 sea ice extent and ice age (courtesy NSIDC and J. Maslanik). Drift tracks of stations installed in autumn of 2006-2010 with at least 1-year longevity are shown to suggest possible observatory put-in locations and tracks

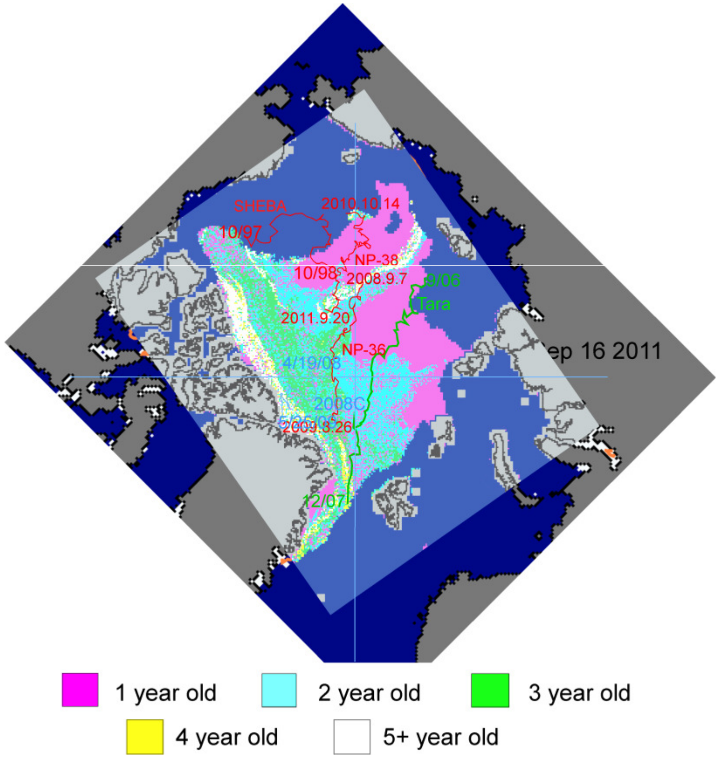
- **What:** Deployment of a heavily instrumented, manned, Arctic Ocean observatory to provide observations addressing key science questions associated with the Arctic atmosphere, cryosphere, and ocean along with their interactions
- **When:** Approximate timeline: start 2016-2017, covering several annual cycles
- **Where:** Central Arctic basin drift will allow measurements in regions with limited instrumentation, include different ice and weather regimes, and provide a multi-year data set
- **Who:** International participation (e.g. US, Germany, Sweden, Russia, Finland, …) through IASC coordination, synchronized international funding, and use of international infrastructure
- **Outcomes:** Improved process level understanding of Arctic system components and their interactions; Improved GCM parameterizations; Improved satellite remote sensing techniques; Arctic Ocean observational impact test bed; expand terrestrial climate observations

Why ?

1) ”New Arctic”

- large regions of first-year ice and seasonally open water instead of primarily multi-year ice – regional and global impacts

- commercial interests increasing



2) Lack of understanding of many disciplinary processes
   - Atmosphere
   - Cryosphere
   - Oceans
   - Biosphere

3) Lack of understanding of interdisciplinary interactions/processes

Why ? – Science Questions

What are the primary causes of recent sea-ice loss? – key interdisciplinary focus question

a) enhanced energy fluxes from ocean or atmosphere? If so, what is the relative contribution from atmosphere and ocean? Which processes are changing? Why? Where are these process changes occurring? What are the primary energy fluxes, and what is their spatial and temporal variability?

b) advective ice losses from changes in atmospheric circulation/ocean currents? If so, what changes? Where? When? Are these circulation changes linked to changes at lower latitudes?

c) combination of above: imbalance between formation, melt, advective export? If so, all processes need to be quantified and above questions addressed.

What are key consequences of recent sea-ice loss?

a) processes producing local, regional, and global atmospheric circulation changes
b) changes in the oceanographic structure and circulation
c) changes in biosphere

Numerous related (and some unrelated) disciplinary science questions

Why? – What?

Highest order objective is to **understand why & how the Arctic sea-ice is melting** within the context of related regional climate system changes

- To address these issues, progress must be made towards **better understanding** of many contributing and interacting processes
- To build the required process-level understanding **requires a comprehensive, continuous, multi-perspective observational effort** within the sea-ice environment that is closely guided by, and coordinated with, **modeling studies** at a variety of scales

What ?

A**tmospheric measurements** (very preliminary):

1) Vertical structure (soundings, surface-based remote sensors, towers)

2) Heat, moisture and momentum turbulent transport through PBL

3) Cloud macro and microphysical properties (cloud fraction & boundaries, cloud phase, ice and liquid water content, droplet size distributions)

4) Radiative fluxes (up- and down longwave and shortwave radiation, at surface and under the ice, broadband and spectrally-resolved)

5) Concentrations of key gases (H_2O, CO, CO_2, O_3, CH_4 , BrO etc)

6) Key aerosol physical and chemical properties (CN, CCN, IN, size distributions, composition, hygroscopicity, volatility)

7) Precipitation occurrence (including spatial distribution), phase, and rate;

8) Spatial distribution of some variables

What ?

Sea-ice & Ocean observations (very preliminary):

1) Profiles of temperature, density, salinity (through snow, ice & upper ocean)
2) Surface type distributions (fractions of open ocean, melt ponds, first-year ice, multiyear ice, ridge fractions etc)
3) Snow and ice mass budget (thickness, melt and growth, compaction, and deformation)
4) Turbulent exchange of momentum, heat and salt from the surface down through the pycnocline
5) Spatial broadband and spectral albedo & transmission through various surface types
6) Top and bottom surface energy budgets, including conductive
7) Drift velocity, trajectories;
8) Biology in ice and ocean, dissolved gases, bubble sizes, and biological sources of atmospheric particles
9) Deposition of aerosols on snow and ice, i.e. black carbon

How ?

1) A minimum of one year deployment
2) Floating platform, either proper icebreaker or other vessel able to survive but not necessarily navigate in the Arctic Ocean (smaller icebreaker; ice-strengthened vessel; barge?)
   - For deploying expensive and heavy surface remote sensing equipment
   - Workshops, maintaining equipment, storage, generators…
   - Lodging and feeding crew
3) Ice-camp for deployment of instruments that needs to be away from man-made disturbances. Ice quality an issue (some instruments on MYI, while studies of FYI important)
4) Near-field areal coverage (multiple surface stations, UAVs etc)
5) Far field additional areal cover (MIZ etc by other R/Vs or Russian drifting station)
6) Intensive campaigns e.g. airborne (Polar-5 etc.) or additional R/V's (e.g., R/V Mirai) - deployment, redeployment, extraction, etc

Previous experience

- **Soviet/Russian drifting stations:**

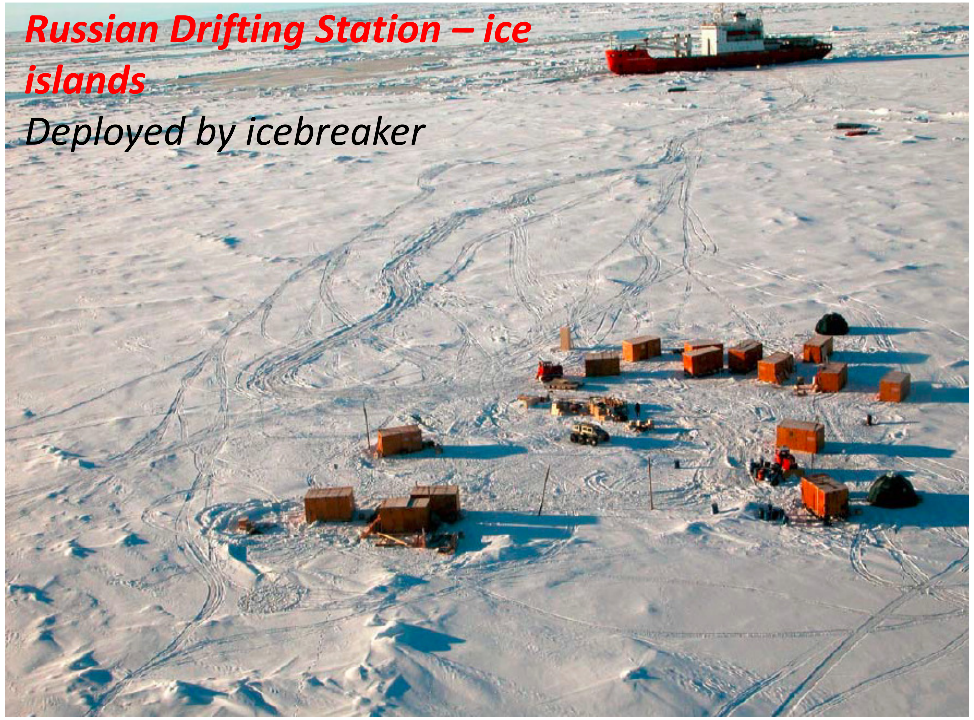
Great temporal & spatial sampling. Lack many important sophisticated instruments for understanding processes related to clouds, aerosols, boundary layer, etc.

- **SHEBA:**

Covered full annual cycle with some sophisticated instrumentation and good ice-mass/ energy budgets. Failed to characterize aerosols, trace gases, boundary layer structure, cloud dynamics, and broader dynamical context for local measurements. Some oceanographic measurements.

- **Short-term deployments (LEADEX, AOE-2001, ASCOS, …)**

e.g., ASCOS: Sophisticated gas, aerosol, cloud, boundary layer, and energy budget observations. Lacked sufficient observations of the ice mass budget and ocean contributions. Most importantly, it lasted for only 3-5 weeks.

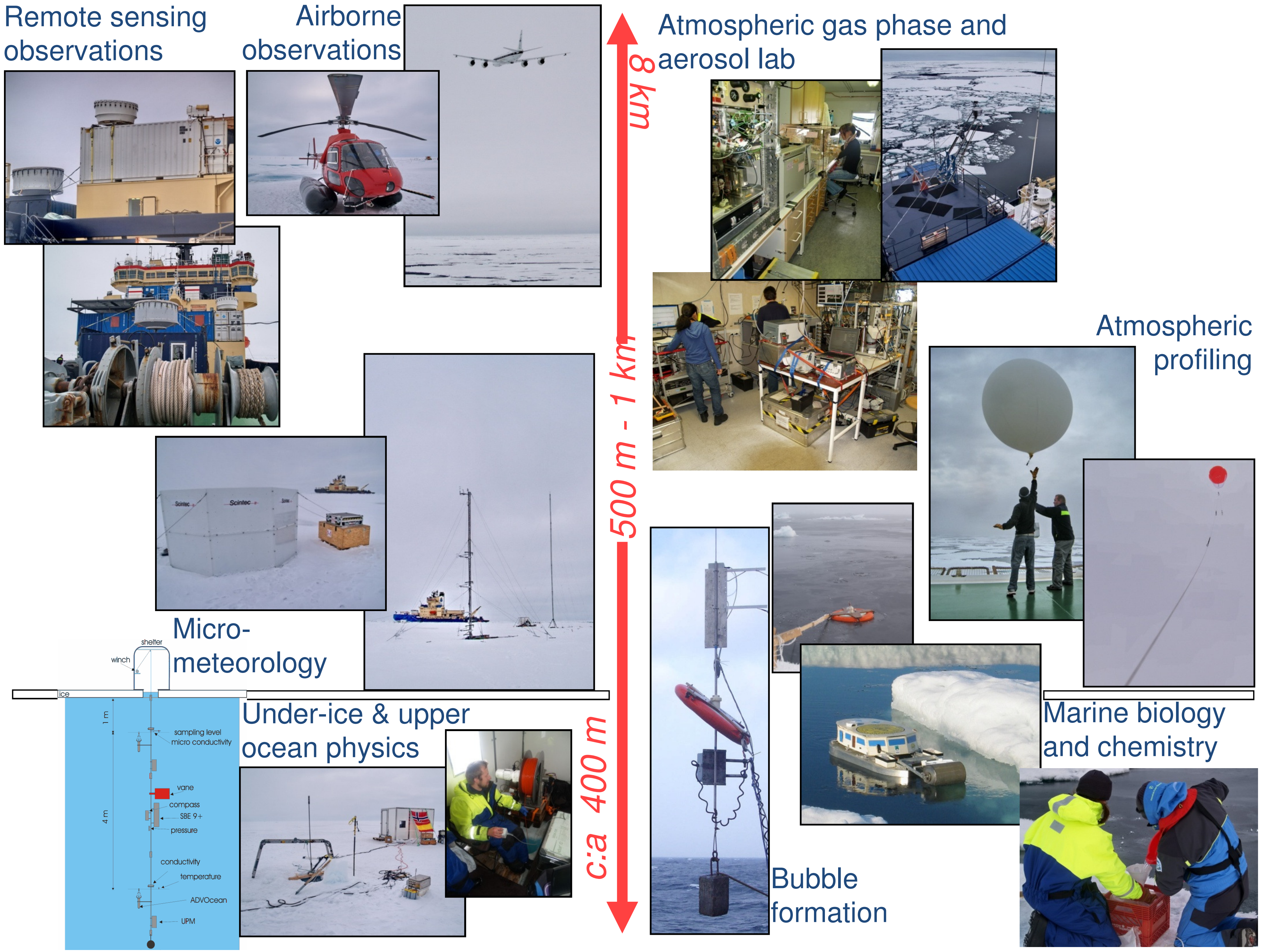


Russian Drifting Station – ice islands

Deployed by icebreaker

Surface Heat Budget of the Arctic Ocean (SHEBA; 10/1997-10/1998)

Continuous icebreaker facility and on-ice deployment



Remote sensing observations
Airborne observations
Atmospheric gas phase and aerosol lab
8 km
Atmospheric profiling
500 m - 1 km
Micro-meteorology
shelter
winch
ice
Under-ice & upper ocean physics
1 m
sampling level
micro conductivity
vane
compass
SBE 9+
pressure
4 m
conductivity
temperature
ADVOcean
UPM
c:a 400 m
Bubble formation
Marine biology and chemistry

Previous experience – why insufficient?

- **Not comprehensive enough:** Must observe many important systems together, ultimately process interactions and feedbacks are important (and more difficult to understand!)
- **Not long enough:** Important processes often vary with season AND the system has memory that impacts future responses. Short campaigns will miss many of the important contextual details
- **Not representative:** Observations at a single location or time of year may not characterize other times or locations. Spatial and temporal variability are likely important. Some processes likely to have different significance in the "New Arctic"

Where ?

Issues:

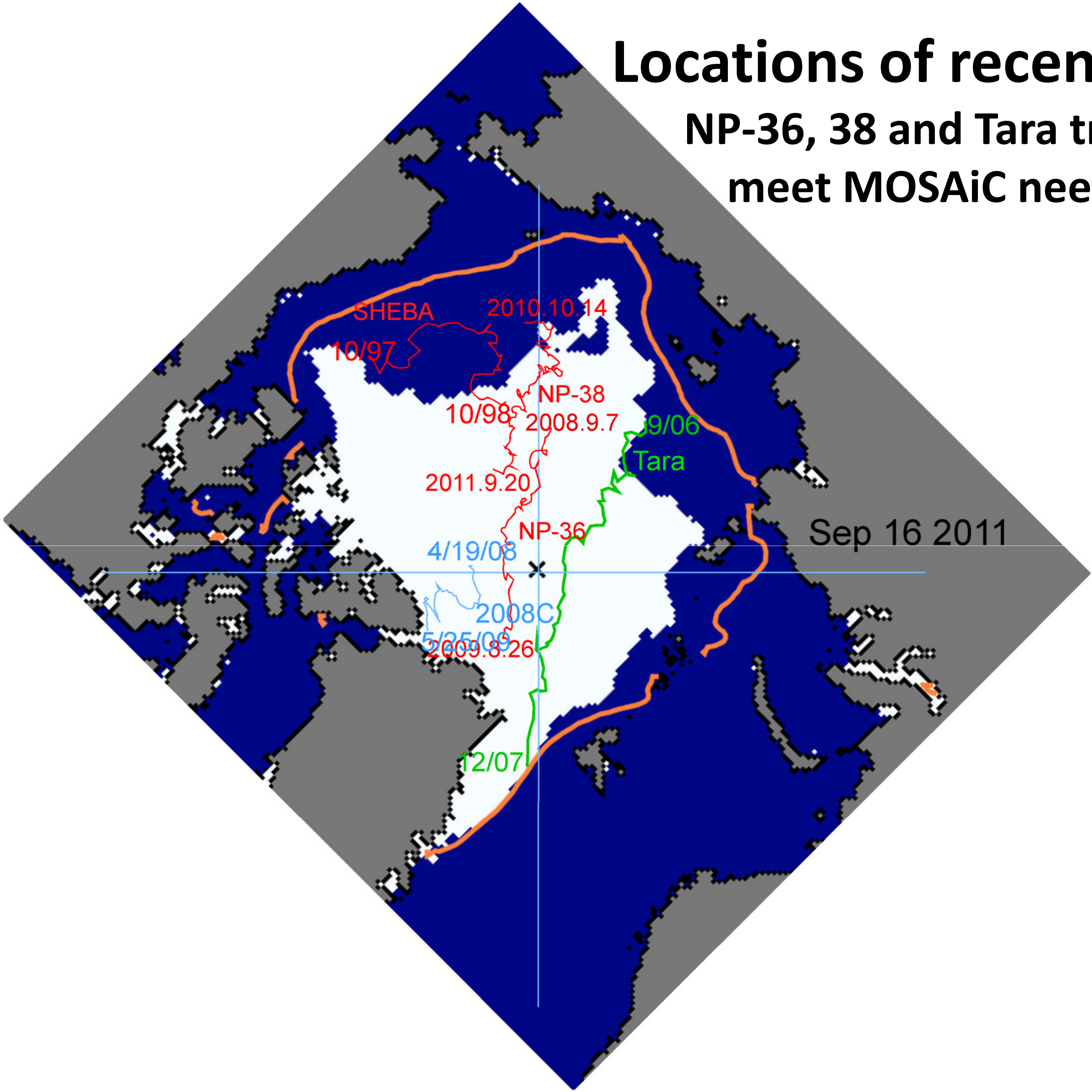
1) Scientific issues (understanding the "new", predominantly FYI, Arctic)!
2) Length and mode: Needs to be drifting for at least a year
3) Ice quality: Ice needs to be strong enough to hold heavy equipment safely, not deform to easily and still be representative for the science to be done – FYI vs MYI
4) Maintenance, resupply and some of the science: Needs to be within flight range (for some critical) portions of the deployment
5) Satellite cover: i.e. A-Train < 82°N

Alternatives discussed:

1) **Trans-Arctic drift**
2) Beaufort Sea
3) North of Canadian archipelago

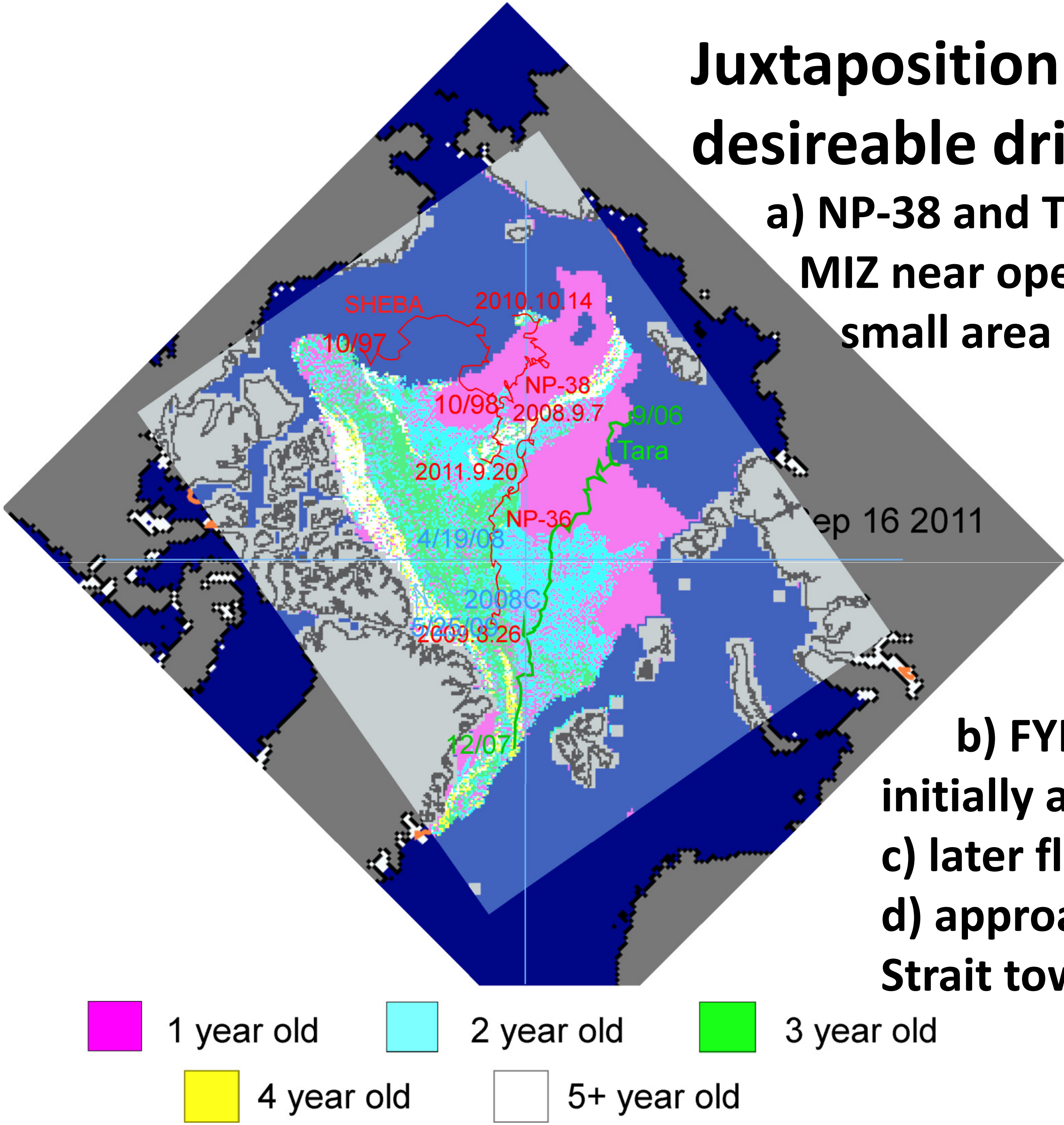
Locations of recent drifts

NP-36, 38 and Tara tracks would meet MOSAiC needs



Juxtaposition of ice age with desireable drift tracks

a) NP-38 and Tara tracks start in MIZ near open water (NP-38 on small area of MYI; Tara on FYI)



b) FYI and open water initially accessible;

c) later floe becomes MYI

d) approaches MIZ in Fram Strait towards drift end

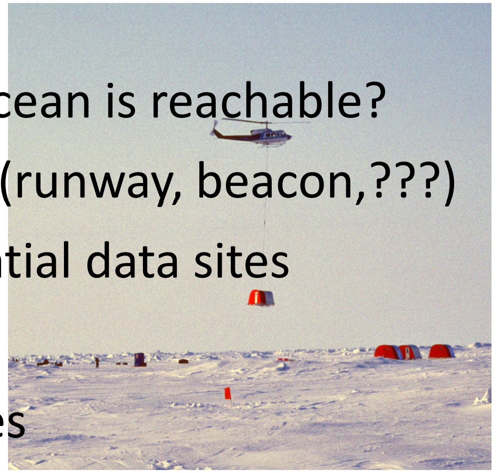
Anticipated Logistical Issues

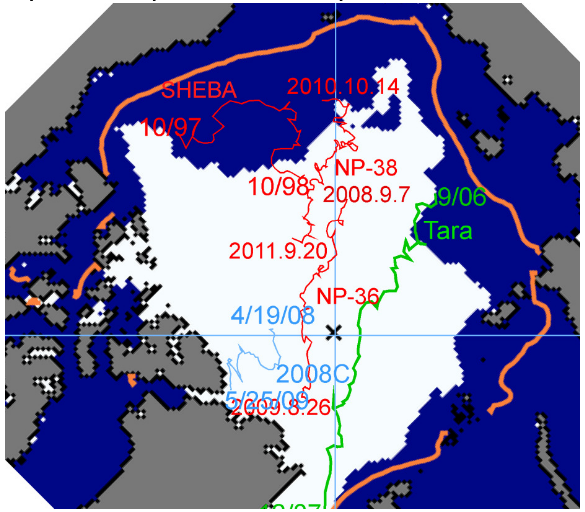
1) Set-up in MIZ in the fall – require floating platforms (icebreaker, barge?)
2) Start-location close to territorial waters – prior approval & collaboration
3) Resupply, crew, & science staff exchange; emergency evacs

   - what land departure points would be available? Russia, U. S., Canada, Greenland, Norway

   - how far out over the Arctic Ocean is reachable?

   - infrastructure at observatory (runway, beacon,???)





4) Deployment/maintenance of spatial data sites

   - ice, MIZ, water locations

   - need for helicopter, flight rules

5) array of R/V for intensive observational periods
   – international coordination?

6) on-ice safety: polar bears, "ice tectonics"

7) Logistics provider – individual preexisting group
   or international team?

What now?

Issues:

1) Scientific issues – develop a science plan
2) Collaboration – interdisciplinary, nationally, internationally (science, agency support)
3) Preparatory modeling activities
4) Funding possibilities, logistics providers (Finland, Canada, US, Russia, others?)
5) “Organizational home”?
    - endorsed by IASC (atmosphere, cryosphere, and marine), CliC, AON
    - presented to NSF by J. Overland (November 2011)

Next steps:

1) Write “white paper” from the Potsdam/Denver workshop; already started
2) Science workshop – (interdisciplinary; June 27-29, 2012, Boulder)
3) Science plan development (draft by Oct. 31, 2012?), developing steering groups
4) Discuss with funding agencies; Consider logistics & deployment issues
5) Implementation Workshop (winter/spring 2013?), develop Implementation Plan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