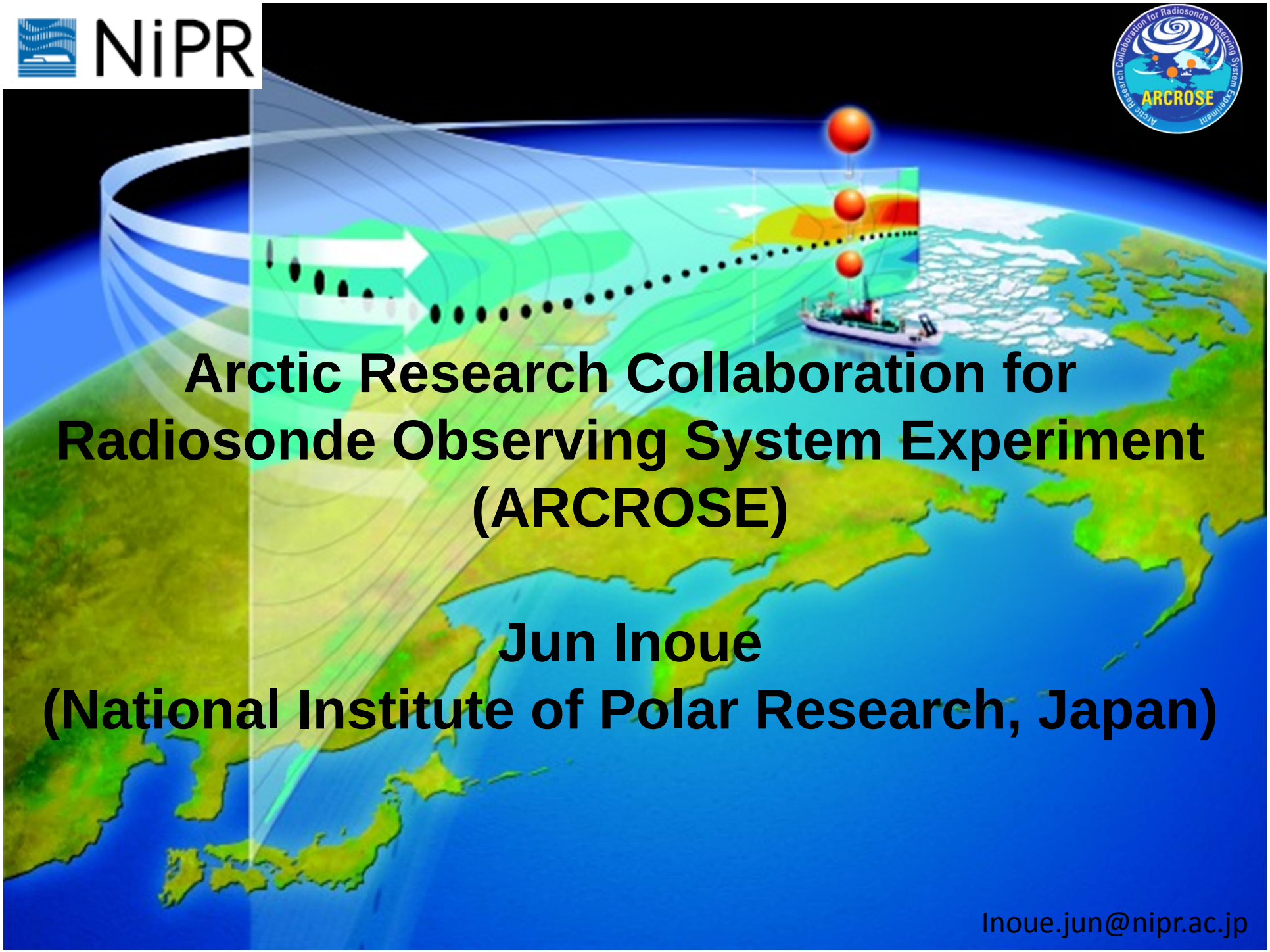


Arctic Research Collaboration for Radiosonde Observing System Experiment (ARCROSE)

Jun Inoue

(National Institute of Polar Research, Japan)

Inoue.jun@nipr.ac.jp

Why are Arctic radiosonde data important ?

- ✓ improvements of weather & sea-ice forecasts over NSR
  - ➢ strong winds, high waves, icing caused by Arctic cyclones
- ✓ understanding the linkage between Arctic and mid-latitudes
  - ➢ extreme events over Eurasia (e.g. severe winter)

Arctic Research Collaboration for Radiosonde Observing System Experiment

Additional Observations

Modeling

Better predictions

Predictability studies for YOPP & MOSAiC

✓ Frequent radiosonde obs. from ships & land stns.

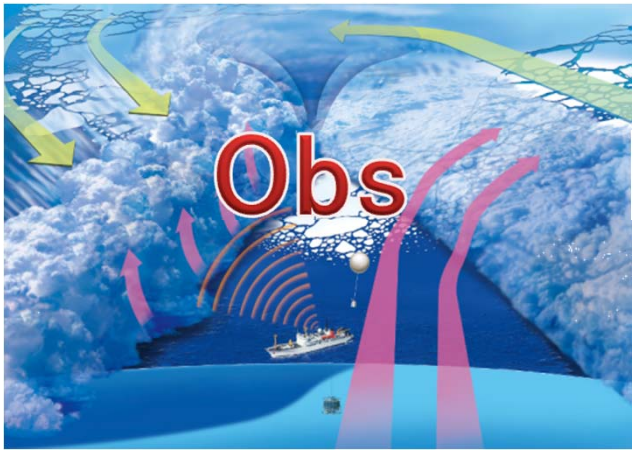
R/Vs Mirai & Polarstern, Ny-Alesund, etc.

→ Improvements of NWPs and reanalyses

✓ Data assimilation (DA)

Observing System Experiment (OSE)

→ Evaluating the effect of intensive obs., and proposing a future observing network



×

Each country has each policy for soundings …

Canada: Two additional soundings at Alert & Eureka during September 2014, and continuing several months (P. Edwards, personal comm.)
Soundings from ice breakers are also active (but offline data)

Norway: Two additional soundings at Bear Island & Jan Mayan during winter after IPY-THORPEX (Kristjansson et al. 2011 BAMS)

US: Two additional soundings at Barrow by ARM, but offline data

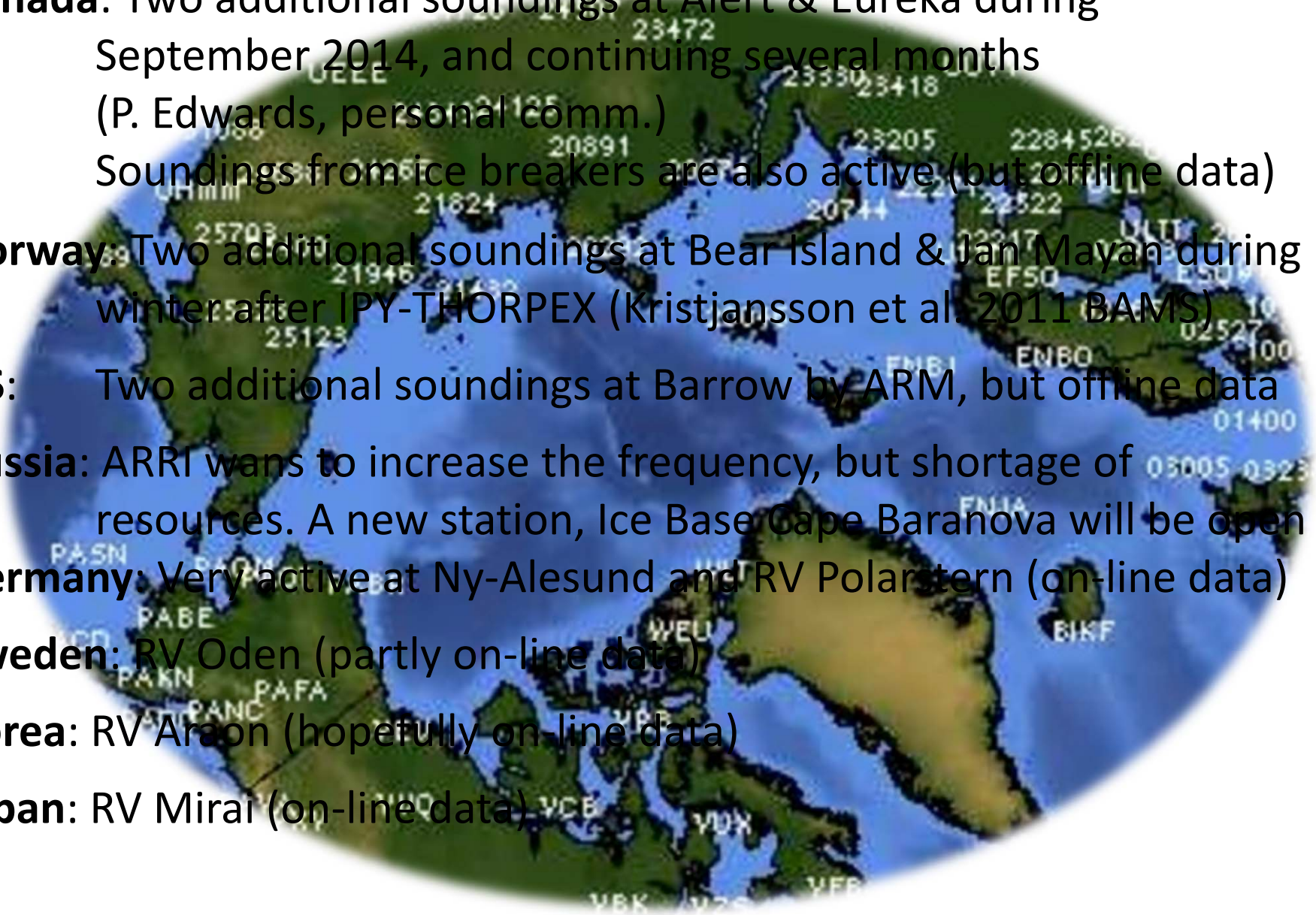
Russia: ARRI wans to increase the frequency, but shortage of resources. A new station, Ice Base Cape Baranova will be open

Germany: Very active at Ny-Alesund and RV Polarstern (on-line data)

Sweden: RV Oden (partly on-line data)

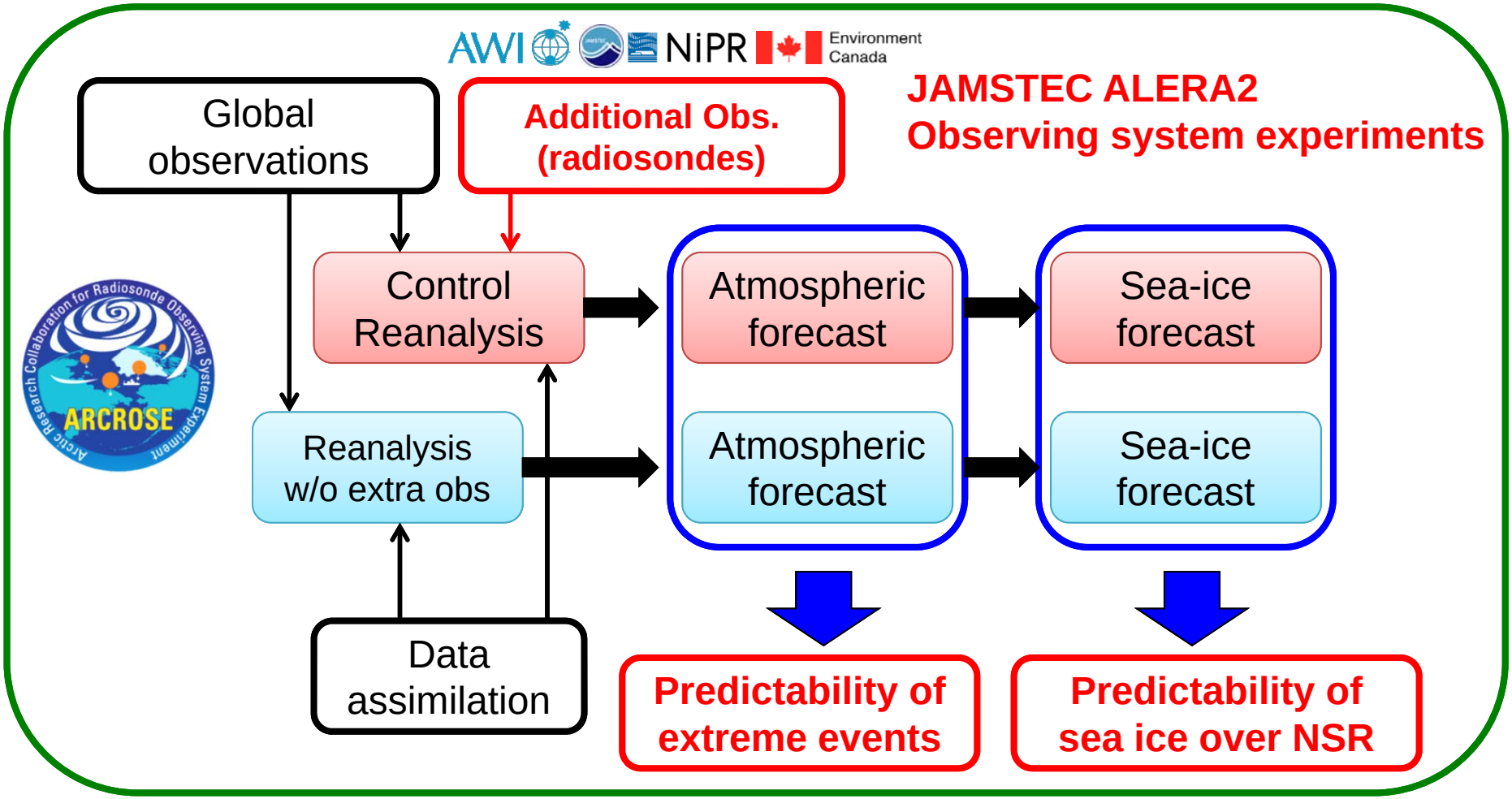
Korea: RV Araon (hopefully on-line data)

Japan: RV Mirai (on-line data)

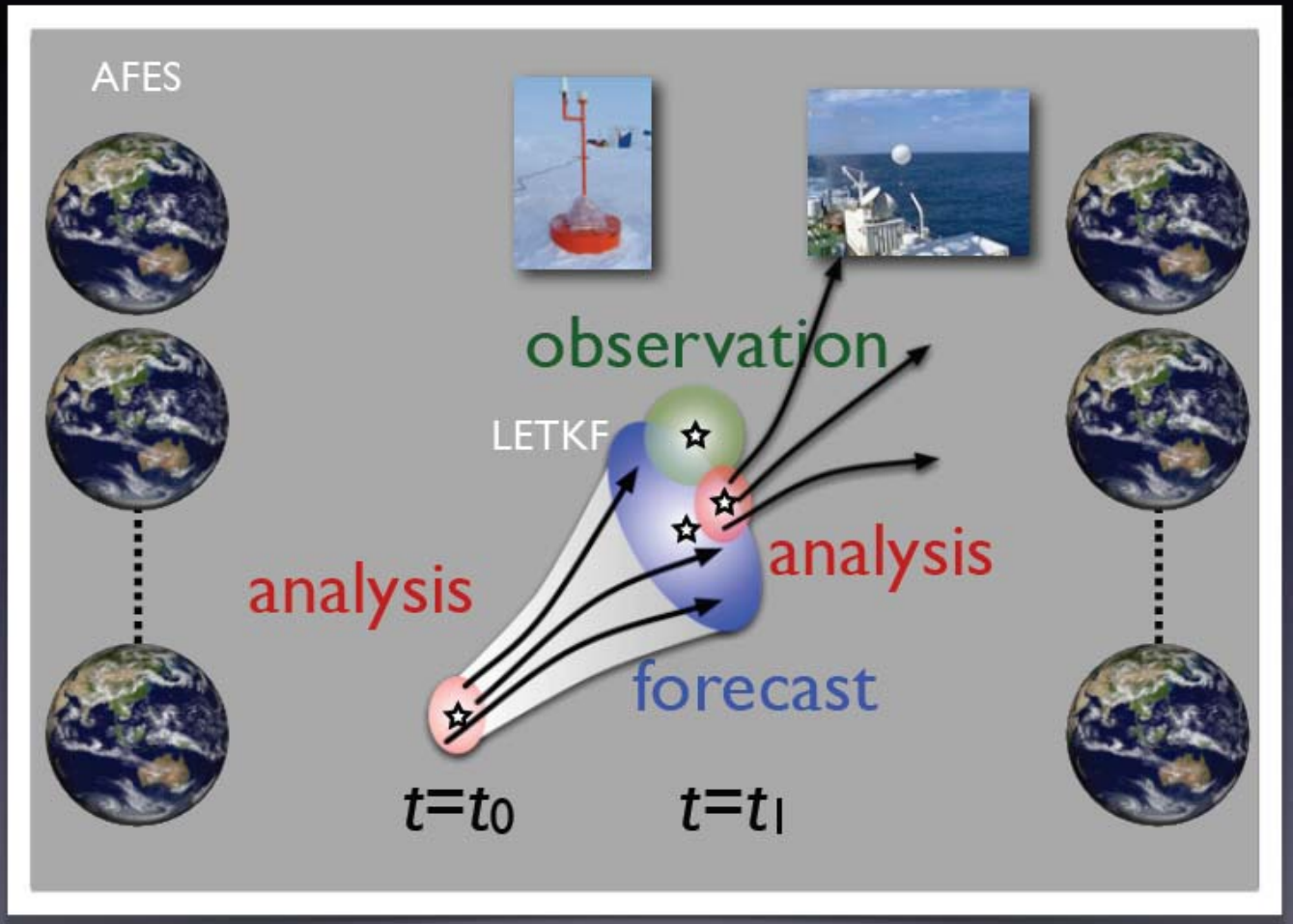


Pilot Studies for YOPP & MOSAiC

- Aug 2012 (RV Polarstern: a great cyclone case)
- Sep 2013 (RV Mirai, Ny-Ålesund, Alert & Eureka)
- Sep 2014 (RVs Polarstern, Mirai, & Oden; Ny-Ålesund, Alert & Eureka)



ALEDAS: AFES-LETKF Ensemble Data Assimilation System



LETKF: Hunt et al. 2007; Miyoshi and Yamane 2007; Miyoshi et al. 2007

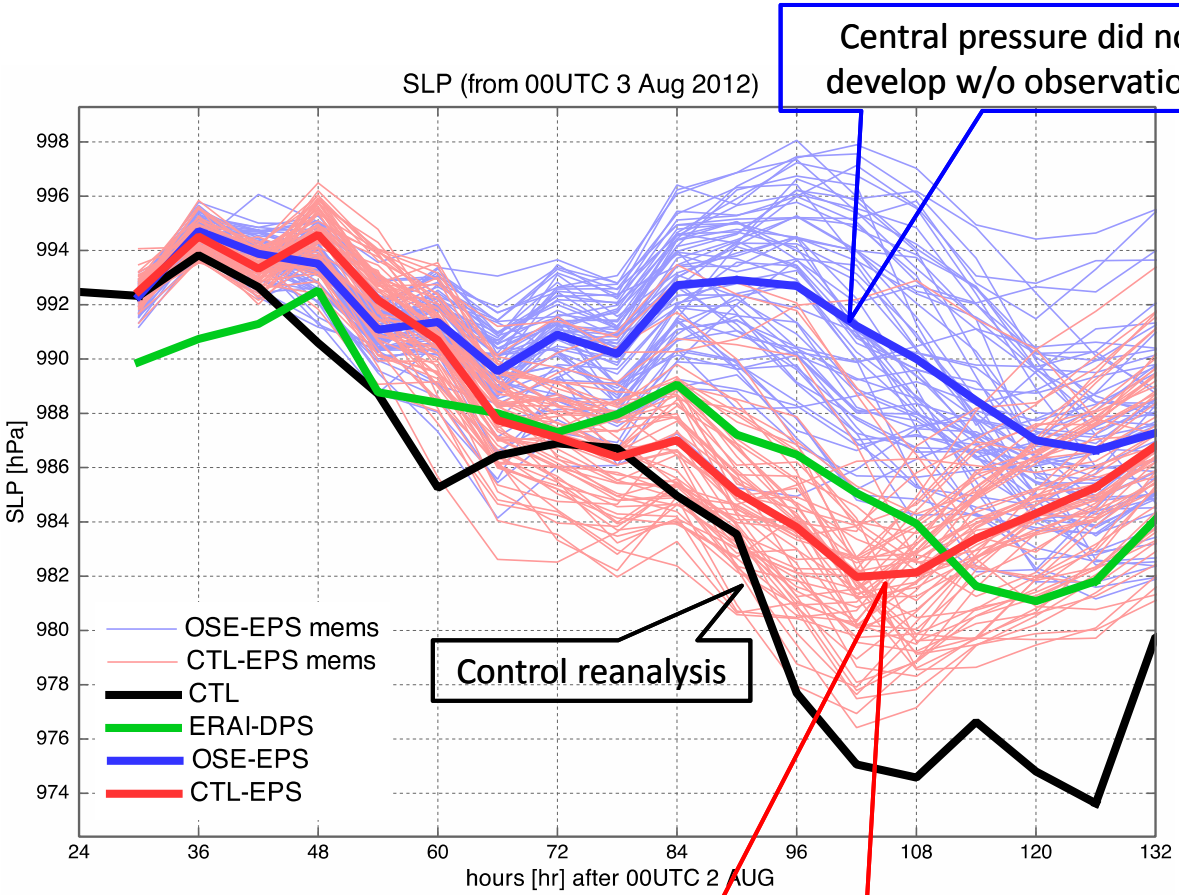
AFES: Numaguti et al. 1997; Ohfuchi et al. 2004; Enomoto et al. 2008

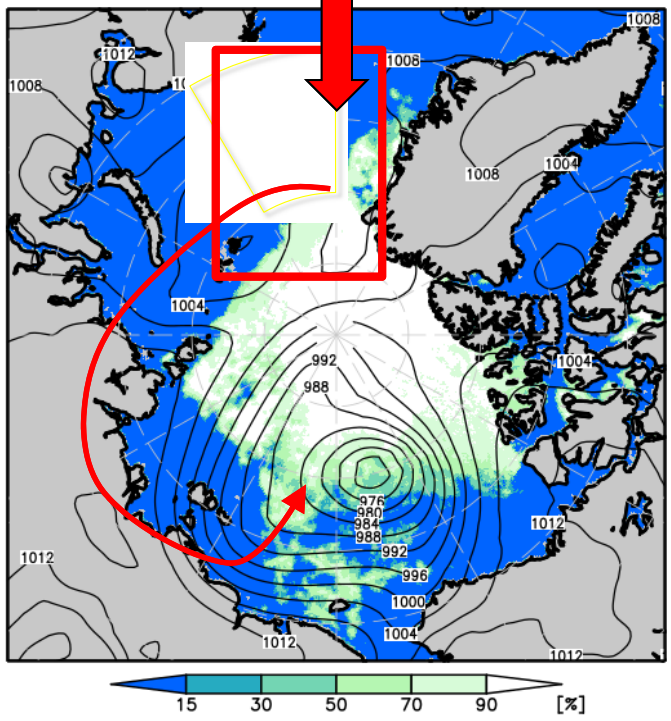
ALERA2 features

- Larger ensemble size (from 40 to 63)
- Improved model physics (cloud and land surface etc)
- Covariance localization by distance
- High-res SST and ice (NOAA daily 1/4° OI SST)
- Publicly obtainable observations (prepbufr)
- Forecast values (precip, radiative and surface fluxes)

Application to forecasting Arctic cyclones

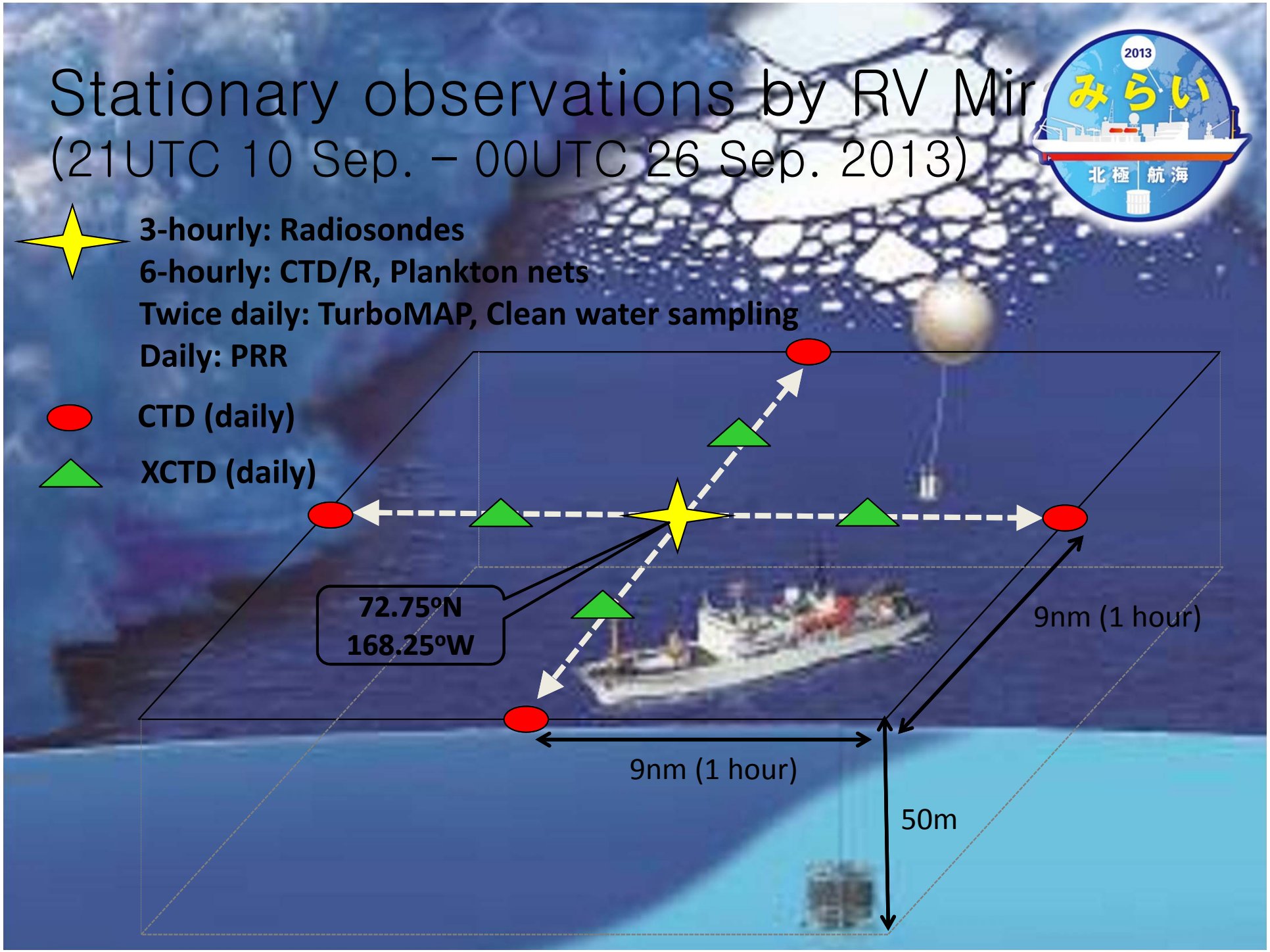
Special observations from R/V Polarstern improves the predictability of the great Arctic cyclone on Aug. 6, 2012.



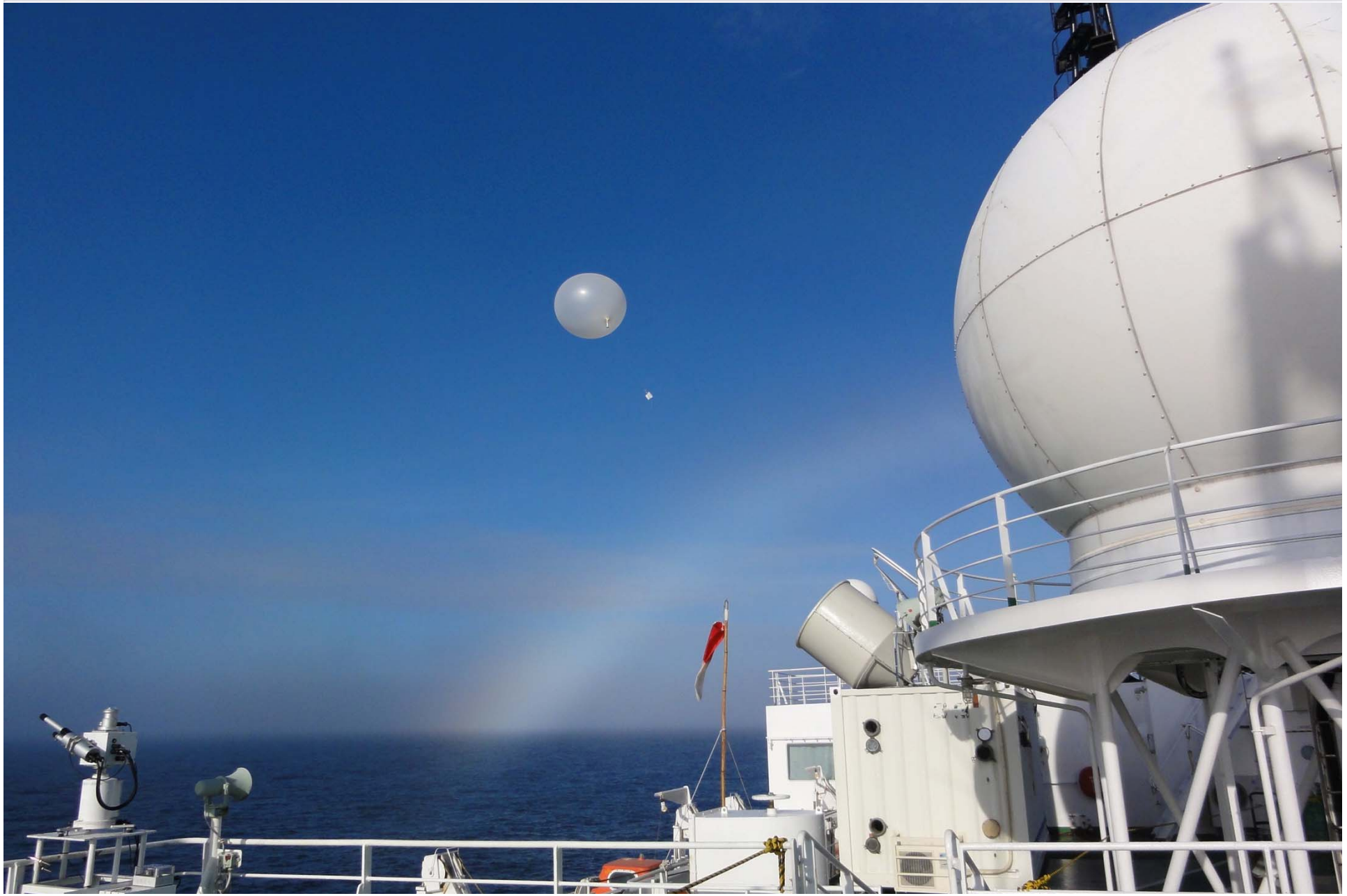


Yamazaki et al. (2015 JGR-A)

Stationary observations by RV Mirai
(21UTC 10 Sep. – 00UTC 26 Sep. 2013)

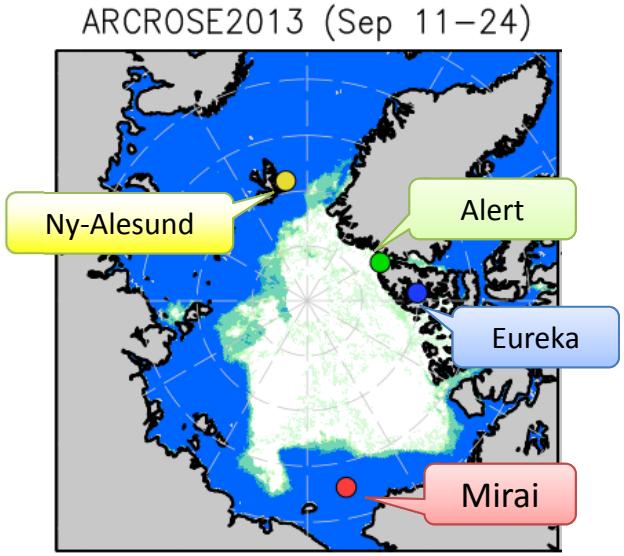


Arctic Ocean Research using R/V Mirai

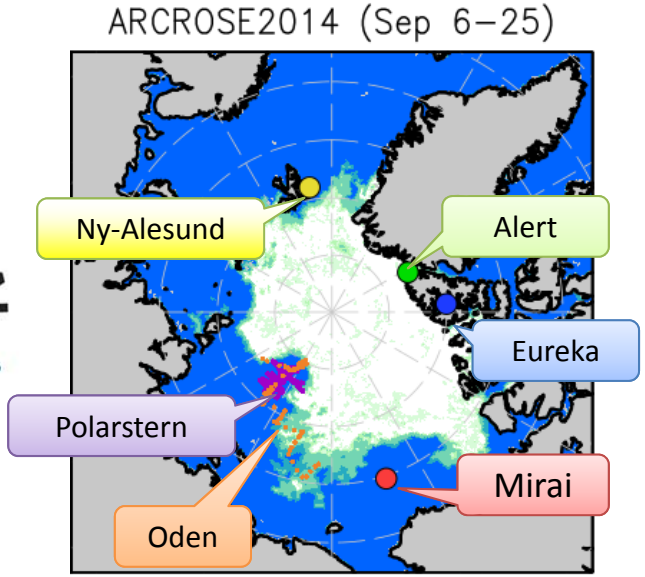


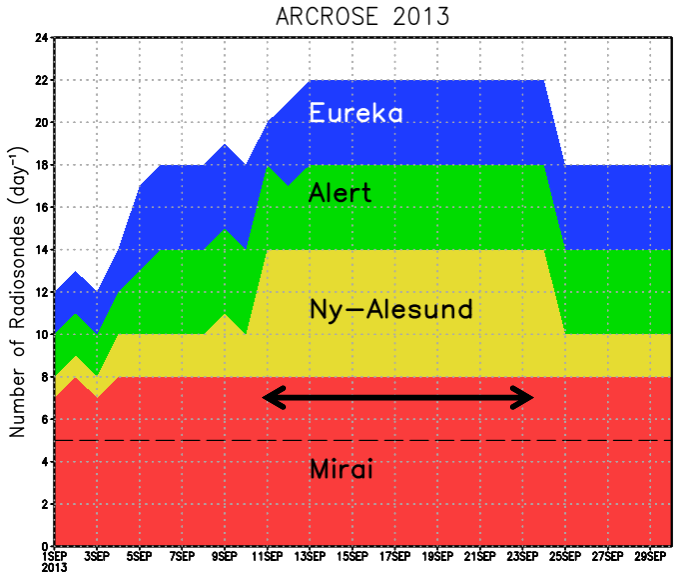
ARCROSE2013 & 2014

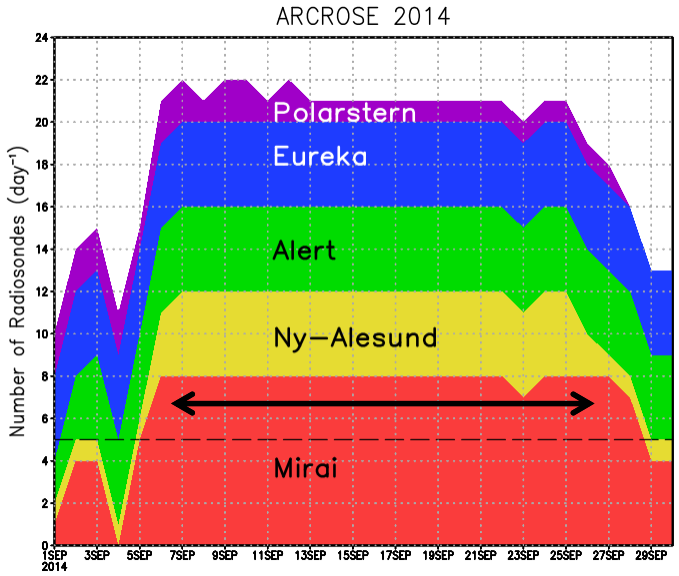
Sep. 2013



Sep. 2014



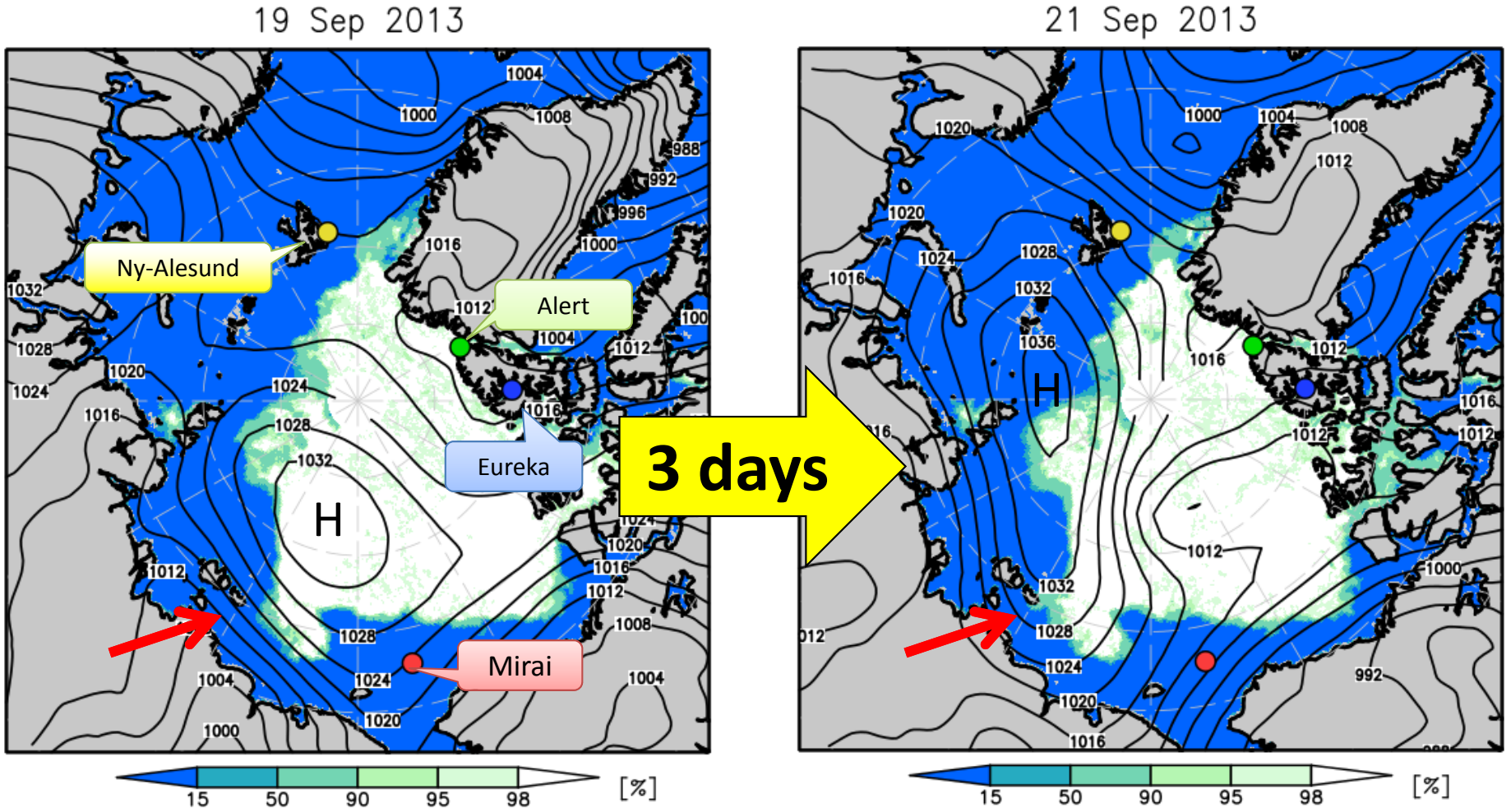




GTS status in NCEP ADP Global Upper Air Observations
→**22 launches per day** during ARCROSE

Northern Sea Route was closed during ARCROSE2013

- A good case to investigate the impact of ARCROSE data on the predictability of high pressure system



Setting for Observing System Experiments (OSE)

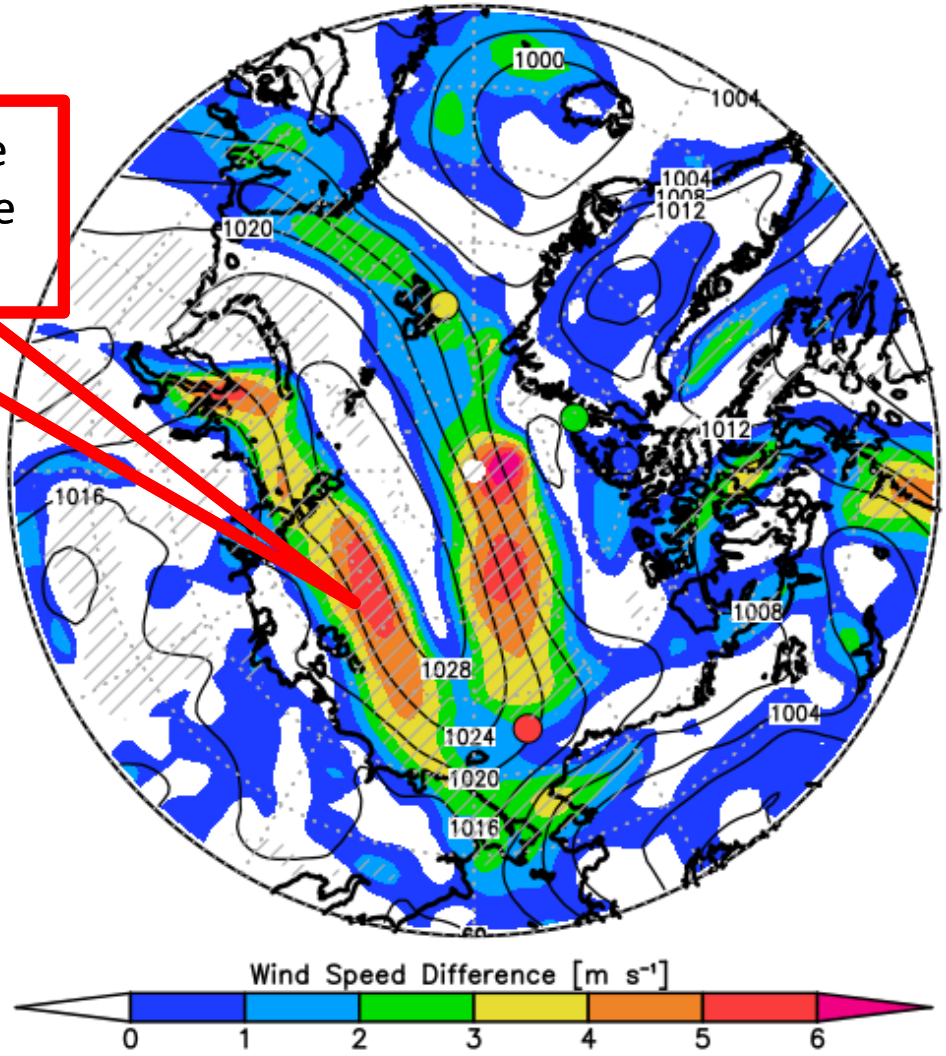
- Control reanalysis (63 members) was made by assimilating all ARCROSE data
- Observing System Experiment (OSE) reanalyses were made
- Ensemble forecast runs were conducted by using each reanalysis

The daily number of radiosondes used in OSE

	Mirai	Eureka		Alert		Ny-Alesund	
	IOP	IOP	operational	IOP	operational	IOP	operational
CTL	8	2	2	2	2	5	1
OSE_{MEAN}	0	0	2	0	2	0	1
OSE_{M}	0	2	2	2	2	5	1
OSE_{EA}	8	0	2	0	2	5	1
OSE_{N}	8	2	2	2	2	0	1

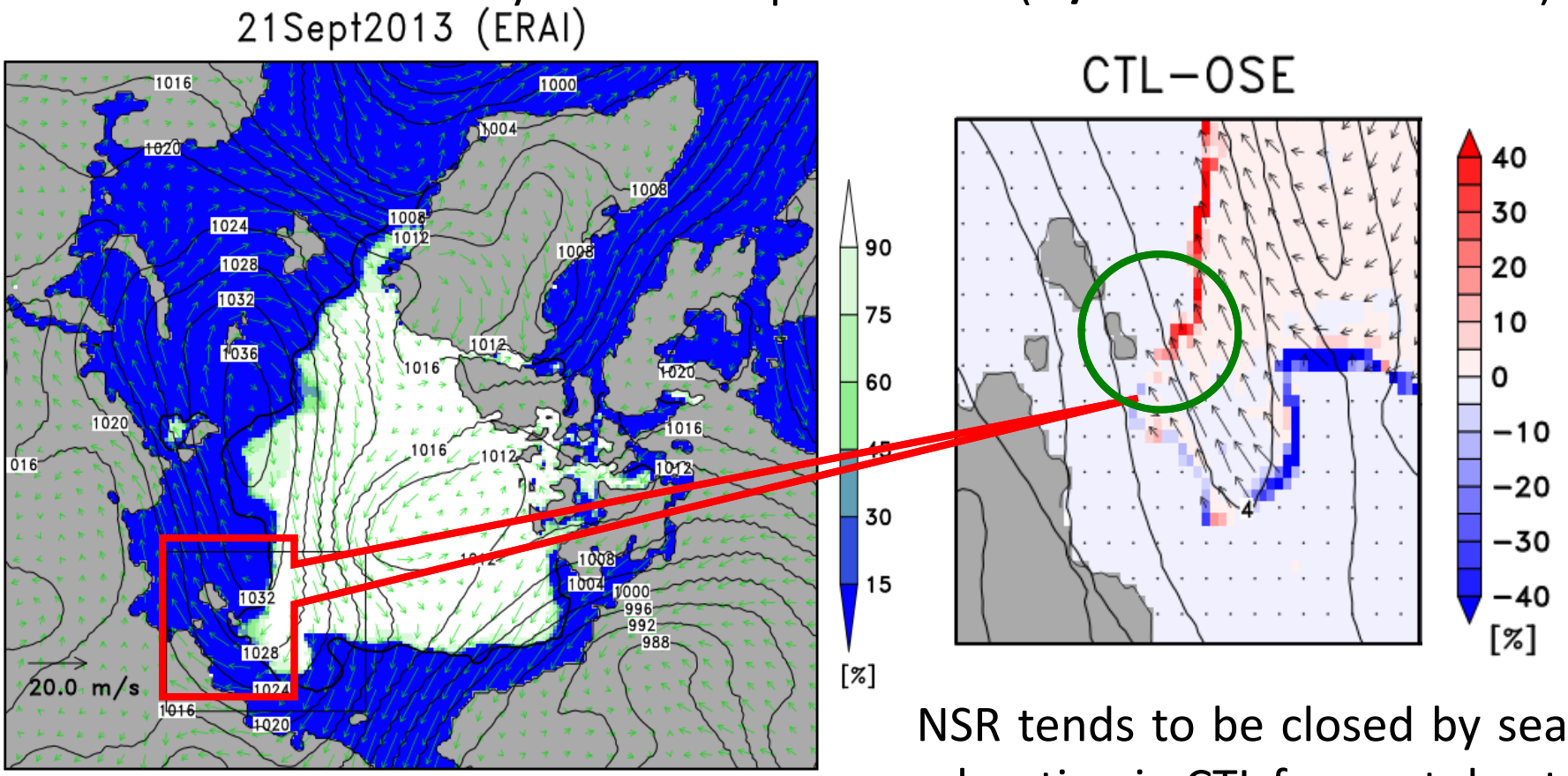
Difference in SLP & winds between CTL and OSE_{MEAN}

Difference in surface wind speed along the NSR exceeds 4 m s^{-1}



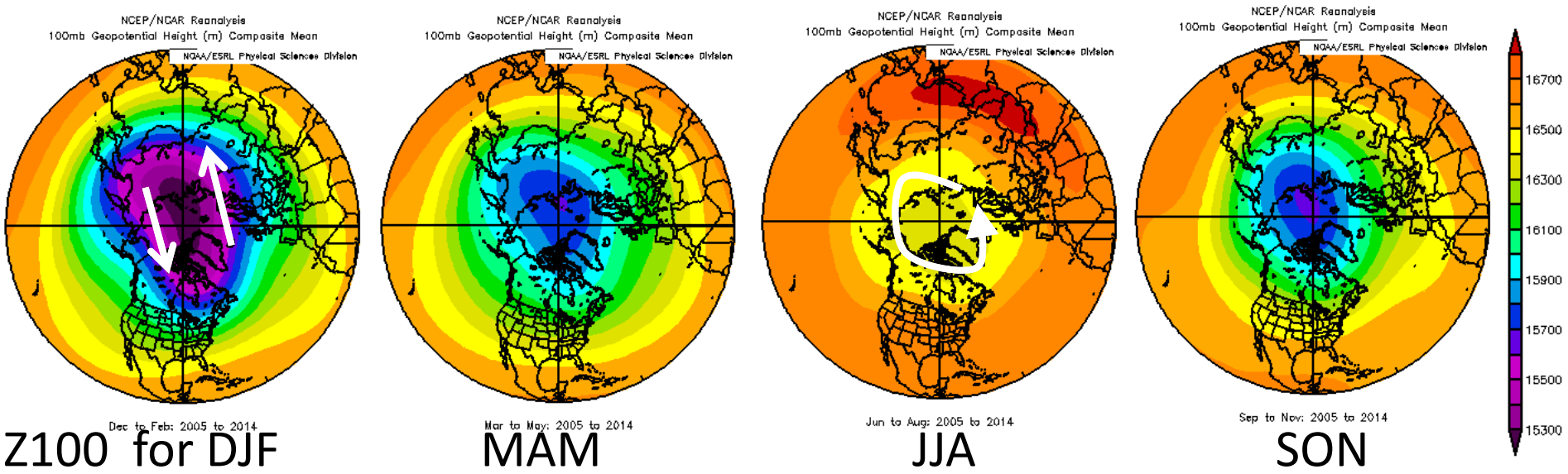
Prediction of sea-ice distribution (6 days forecast)

- ✓ Only sea-ice drift is considered (**no thermodynamic** sea-ice growth)
- ✓ CTL forecast: forced by CTL atmospheric field (**with** ARCROSE2013 data)
- ✓ OSE forecast: forced by OSE atmospheric field (**w/o** ARCROSE2013 data)



NSR tends to be closed by sea-ice advection in CTL forecast due to stronger wind speeds

When and Where ?



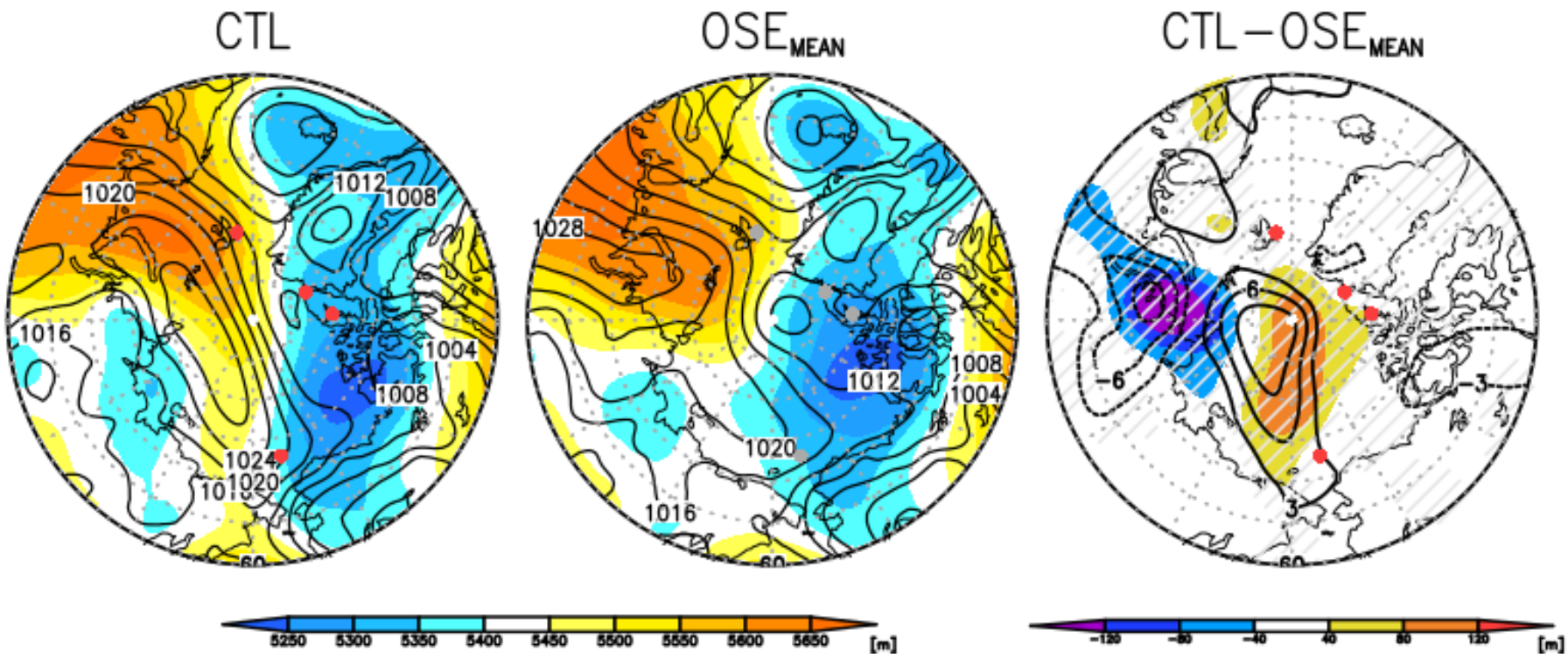
Z100 for DJF MAM JJA SON

- JJA: Local effect over the Arctic
  (local obs over the Arctic Ocean and coastal stations)
- DJF: Remote effect from the Arctic to midlatitudes
  (obs at southern stations are desired too)

Challenges towards YOPP/MOSAiC

- ✓ Understanding seasonality in particular winter (e.g. N-ICE2015)
  - ➢ predictions of extreme cold winters
- ✓ Collaboration with operational agencies (ECMWF, NCEP, etc)
  - ➢ They must have opinions for additional observations (e.g. Cost effective number of stations or obs frequency)
- ✓ Coordination of land stations (e.g. Alert & Eureka)
  - ➢ Russian stations ?
- ✓ Impact of atmospheric forecasts on sea-ice forecasts
  - ➢ More applied challenging works

6 days forecast for SLP (cont.) and Z500 (color)



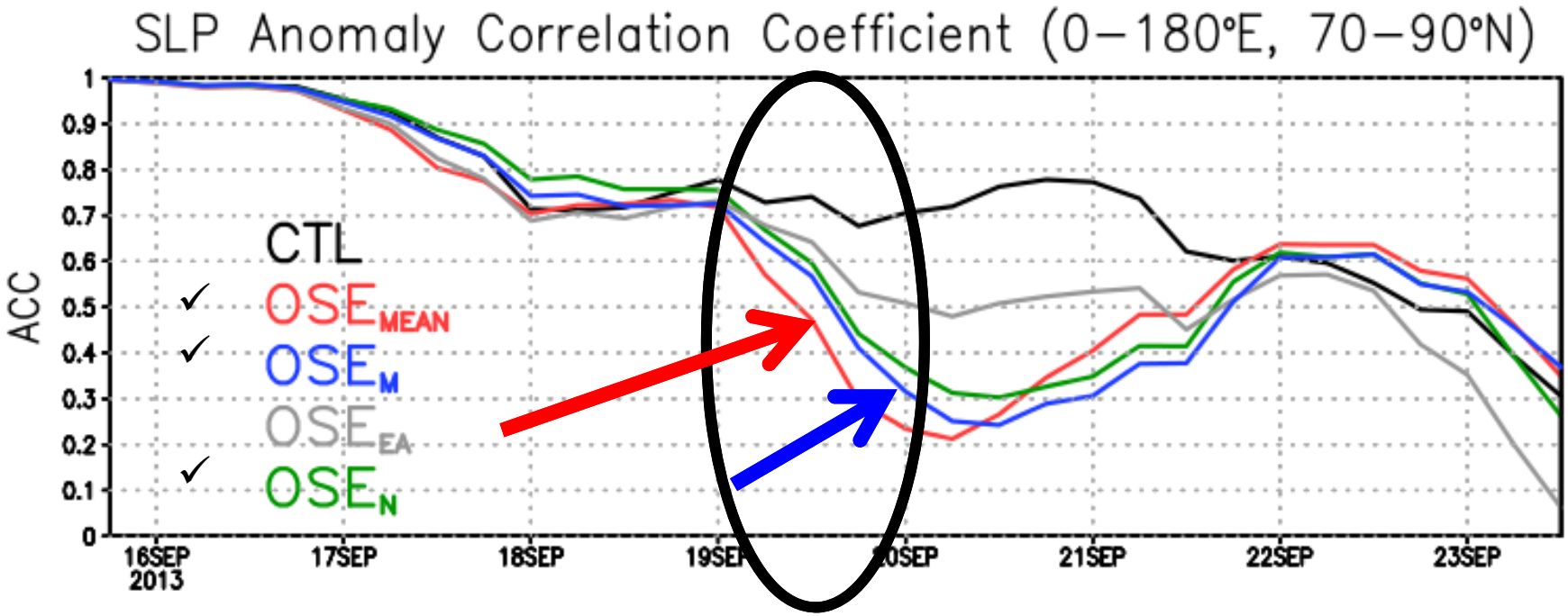
The difference between CTL & OSE was found at different place from ARCROSE stations

- Flow-dependent feature

Difference in prediction skills among the OSEs

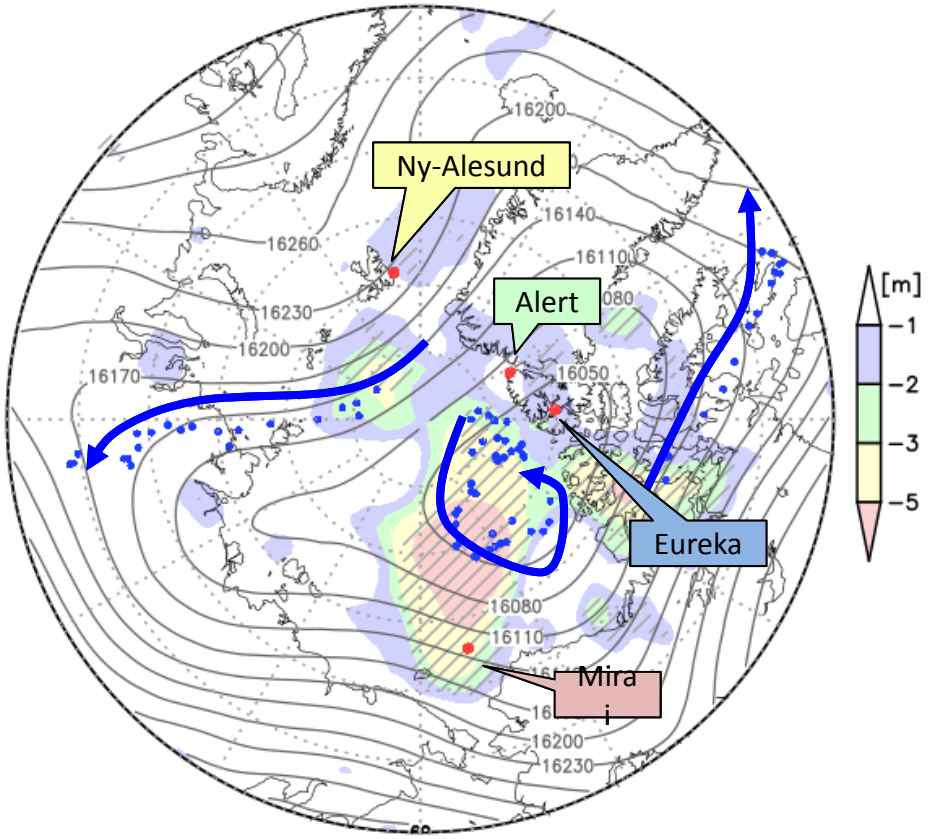
Low skill cases: OSE_{MEAN}, OSE_M & OSE_N

- Data from Mirai and Ny-Alesund is critical in this case



Flow-dependent observation signals at 100 hPa

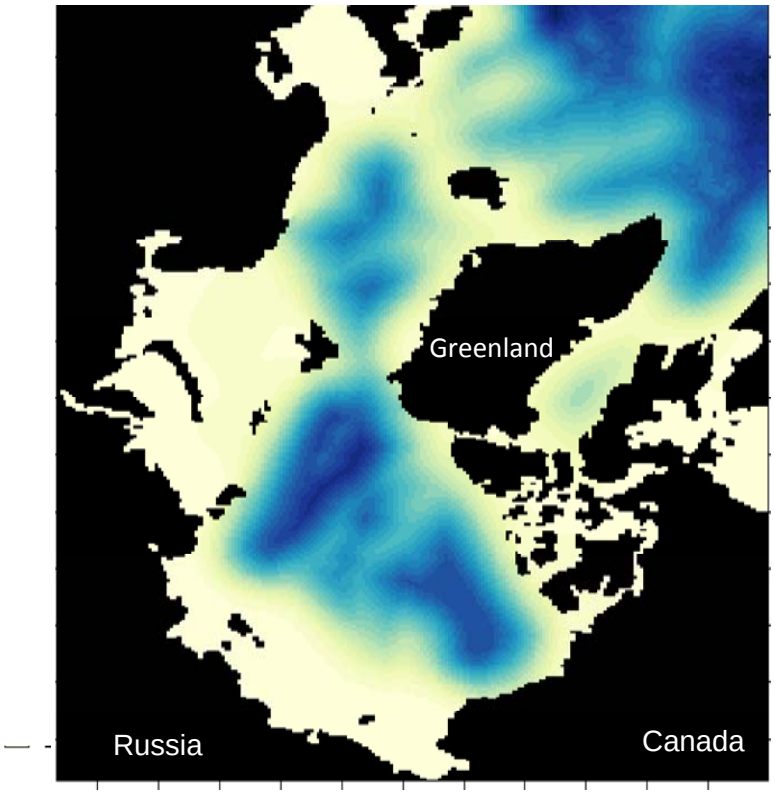
- Ensemble spread originated from ARCROSE stations traveled along the polar vortex (e.g. at 100hPa)
- Impacts of additional observations likely reach at midlatitudes



Cont.: $Z100_{CTL}$
Color: Ens. sprd diff between $Z100_{CTL}$-$Z100_{OSE\_MEAN}$
Dots: trajectories of difference in ensemble spread between $Z100_{CTL}$ and $Z100_{OSE\_MEAN}$

Ice-Ocean coupled model

- **Ice component**
  - two category
  - EVP (Hunke and Dukowicz, 1997) rheology
  - Ice bunch & semi-Lagrangian scheme
  - Without thermodynamics of sea ice
- **Ocean component**
  - Princeton Ocean Model
  - 3D, primitive and continuum Eqs. with a hydrostatic approx.
  - Horizontal resolution: 25 km
  - Vertical level: 33 sigma layers
  - Horizontal viscosity & diffusion: Smagorinsky (1963)
  - Vertical viscosity & diffusion: Mellor and Yamada (1982)
  - Drag coefficient between atmosphere and ocean: 3.7×10^{-3} (Overland, 1985)



Model bathymetry (IBCAO+ETOPO1) and domain