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FINNISH METEOROLOGICAL INSTITUTE

Operational sea ice forecasting in the Barents and Kara Seas with NEMO-LIM3

Andrea Gierisch, Robinson Hordoir (IMR), Iiro Kokkonen, Jonni Lehtiranta, Jari Haapala
andrea.gierisch@fmi.fi
Finnish Meteorological Institute
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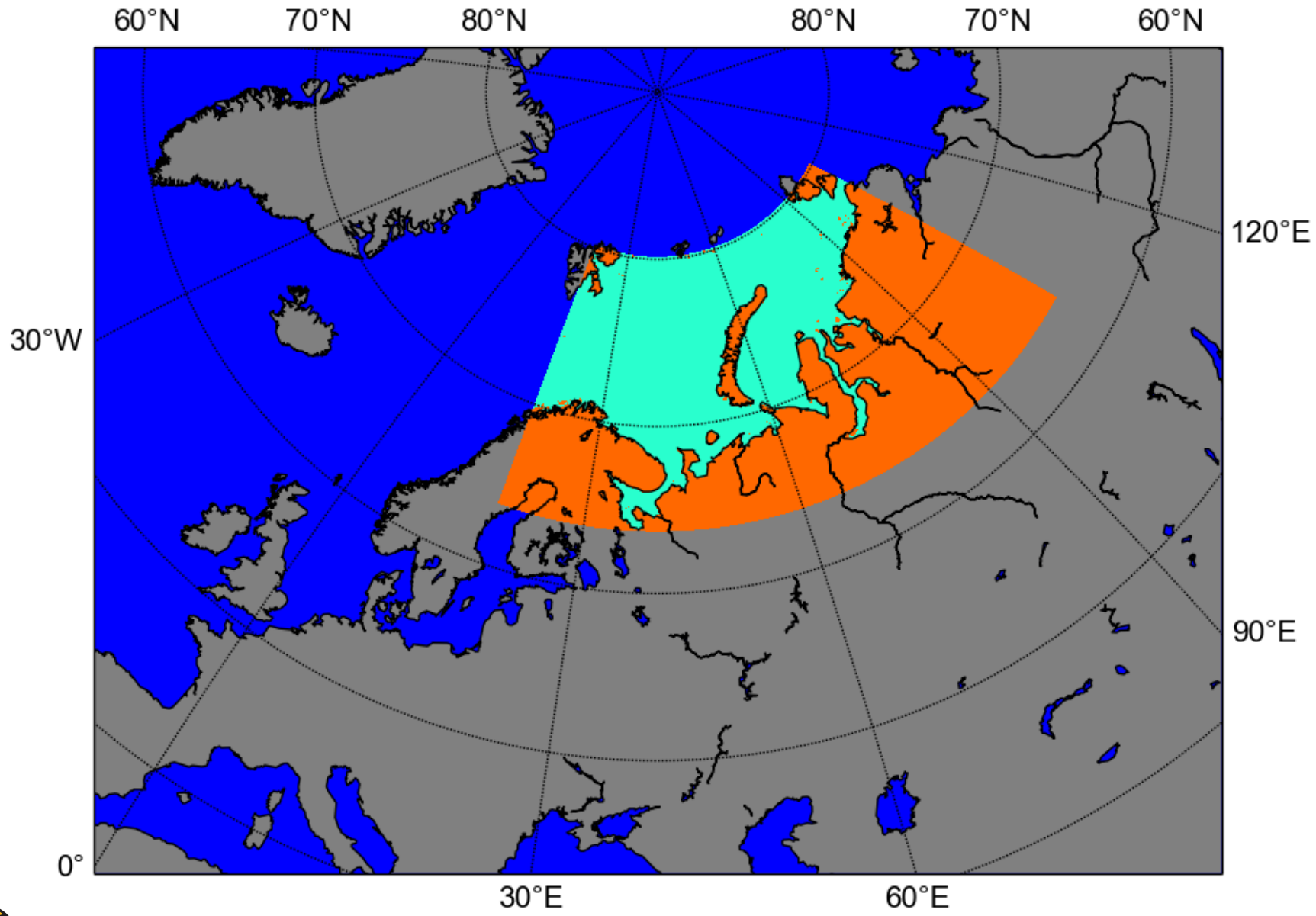
Motivation...

Ship traffic in the Kara Sea is expected to increase.

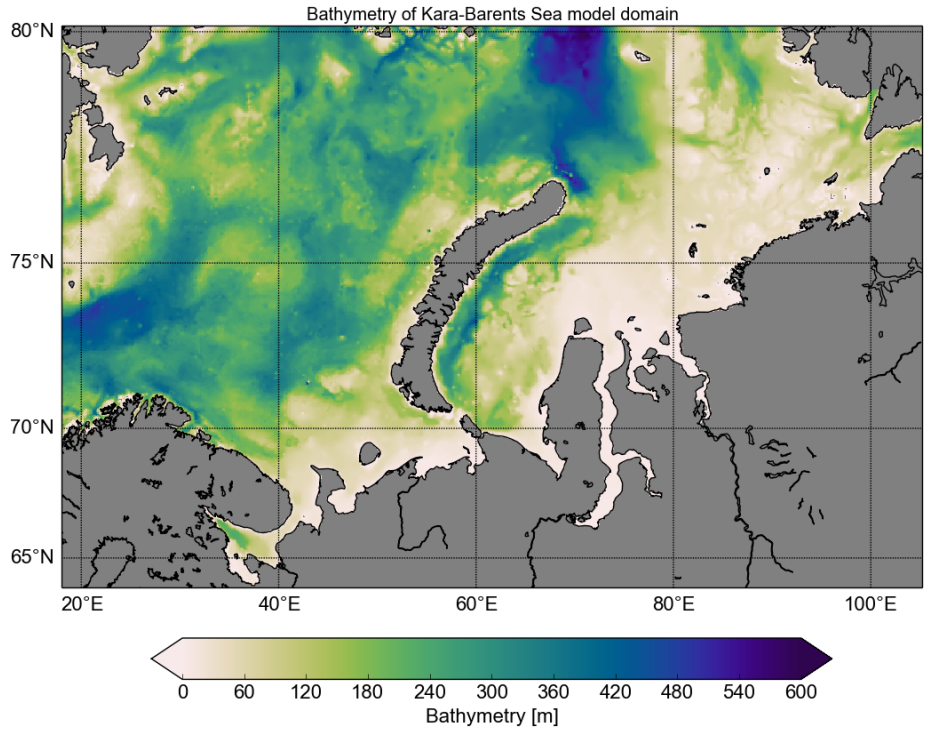
Model domain covering Barents and Kara Sea



Model setup for sea ice simulations

... thanks to Robinson Hordoir for support

- Geographical grid with high resolution: ≈4 km
- Bathymetry: From ETOPO1, lakes filled
- NEMO 3.6 stable, r8195
- Simple landfast ice parameterisation (Robinson)
- Mapping of ice categories at lateral boundaries (Clement)

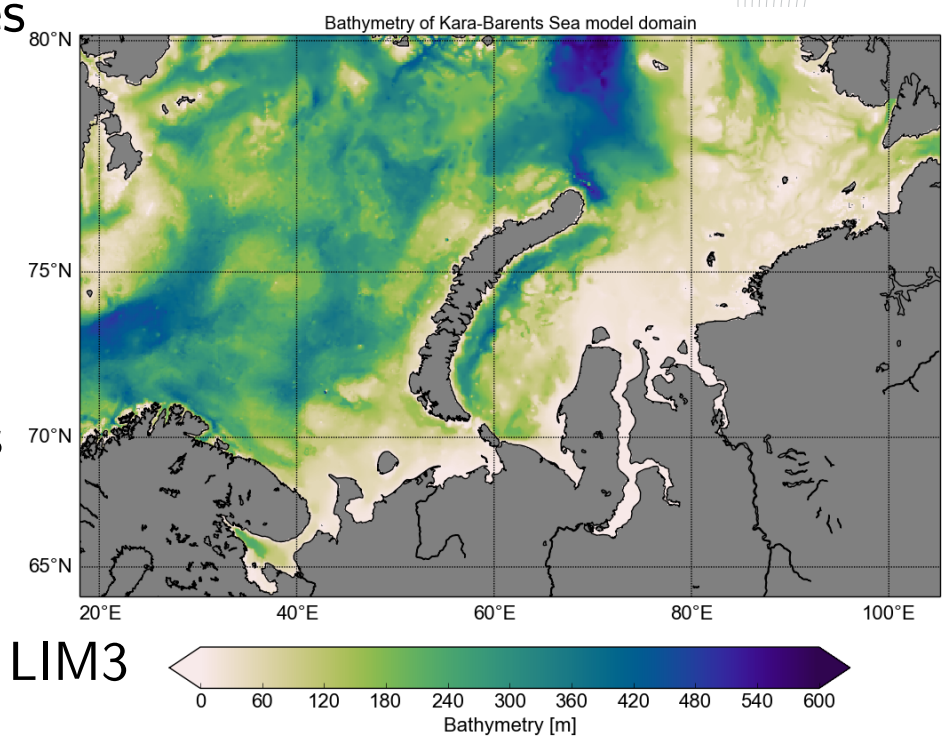


Surface boundary conditions (CORE)

- 10-day weather forecasts from ECMWF
- Parameters:
  - 2-meter temperature
  - 2-meter dew point
  - 10-meter wind velocity
  - Precipitation & Snowfall rates
  - Longwave and shortwave radiation
  - (Sea surface pressure)
- De-accumulate precipitation and radiation
- Hourly/3-hourly/6-hourly until 90h/144h/240h
  $\rightarrow$ interpolate to 1-hourly
- On-the-fly interpolation to Kara grid by weights (SCRIP)

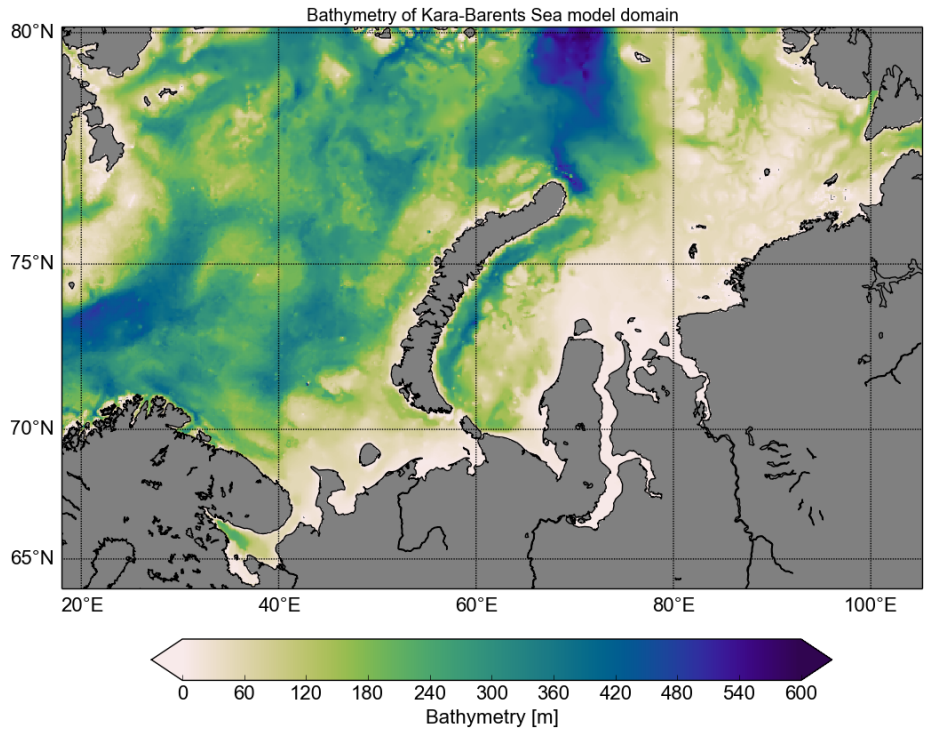
Lateral boundary conditions (BDY)

- Global ocean+ice forecast by Mercator Ocean, available from Copernicus Marine Services
- Paramters:
  - Sea surface height
  - Barotropic ocean current
  - Sea water temperature + salinity
  - Ice concentration + thickness
- NEMO 3.1 - LIM2, ORCA12
  - → Assign ice thickness to corresponding ice category in LIM3
  - Snow thickness set to 0
- Interpolate to Kara grid using SOSIE
- Create bdy-files using a Python script



Some settings for the Kara Sea

- River runoff climatology
- Tidal harmonics from OTPS added at lateral boundaries
- 5 ice thickness categories (for expected ice thickness of 1.2 m)
- Time step: 6 minutes for ocean, 18 minutes for sea ice



Hindcasting

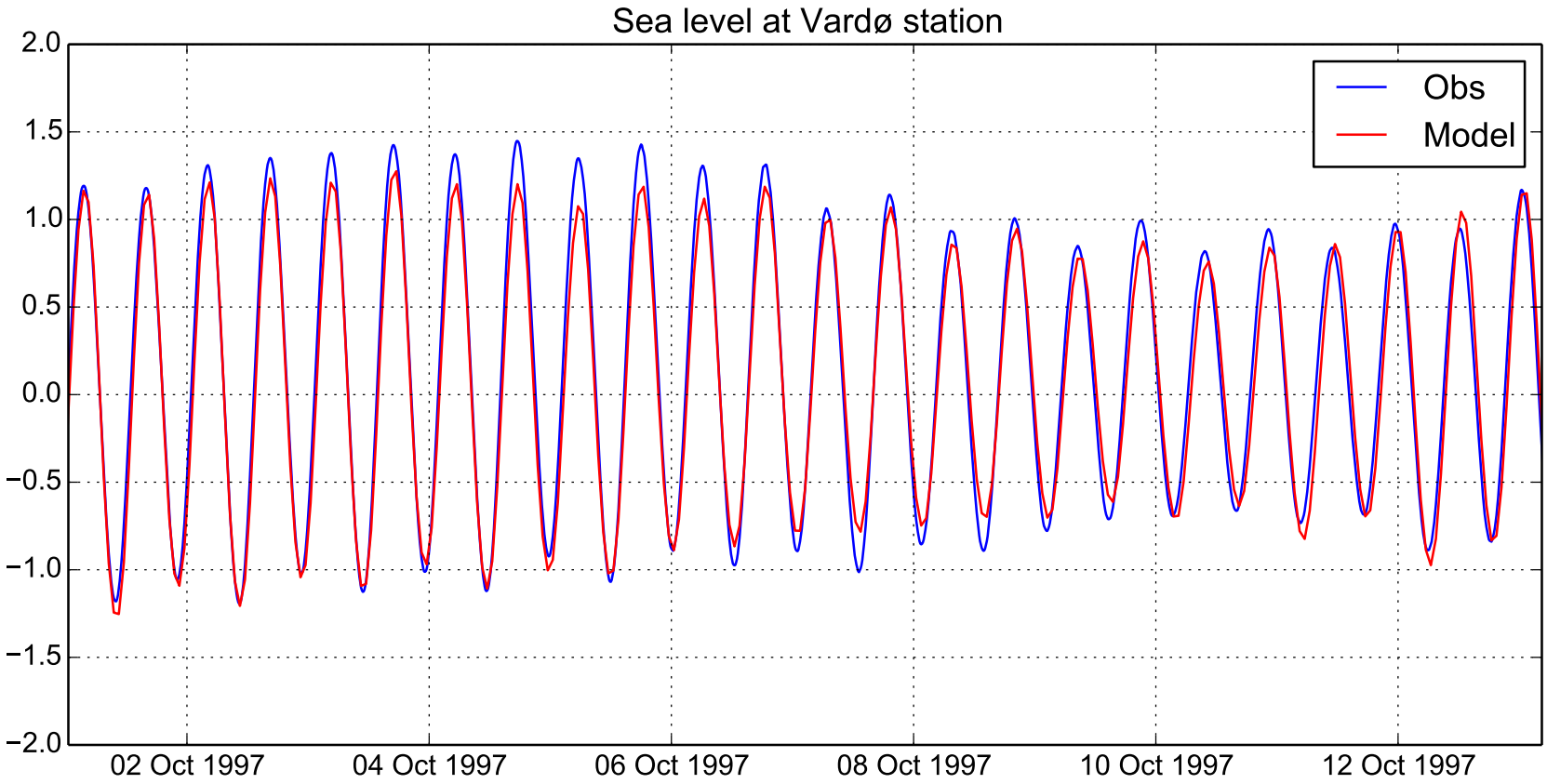
To get initial conditions for the forecasts.

- Hindcast 1996-2018
- Atmospheric forcing data from DRAKKAR and ERA-INTERIM
- Lateral boundary conditions from a global eORCA025 simulation

Some results...

Model evaluation: Sea surface height

Vardø station (Oct 1997)

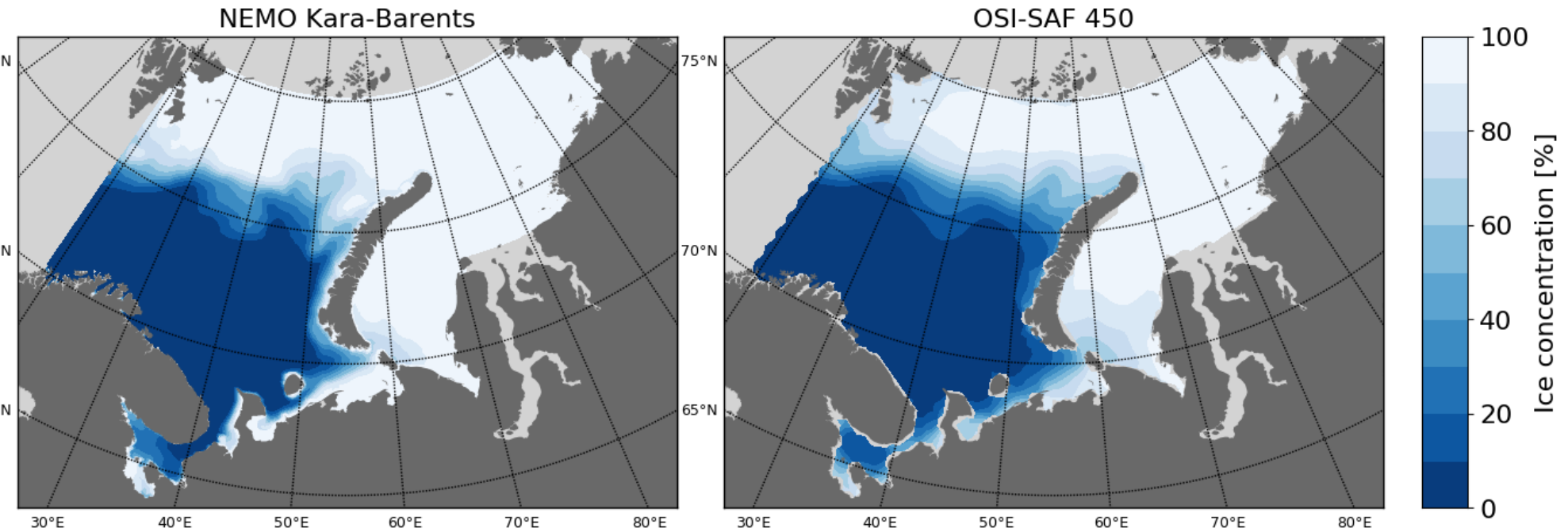


Comparison of simulated sea surface height to measurements

http://www.gloss-sealevel.org/station_handbook/stations/323/#.Wg8Ha0emAUE

Model evaluation: Sea ice concentration

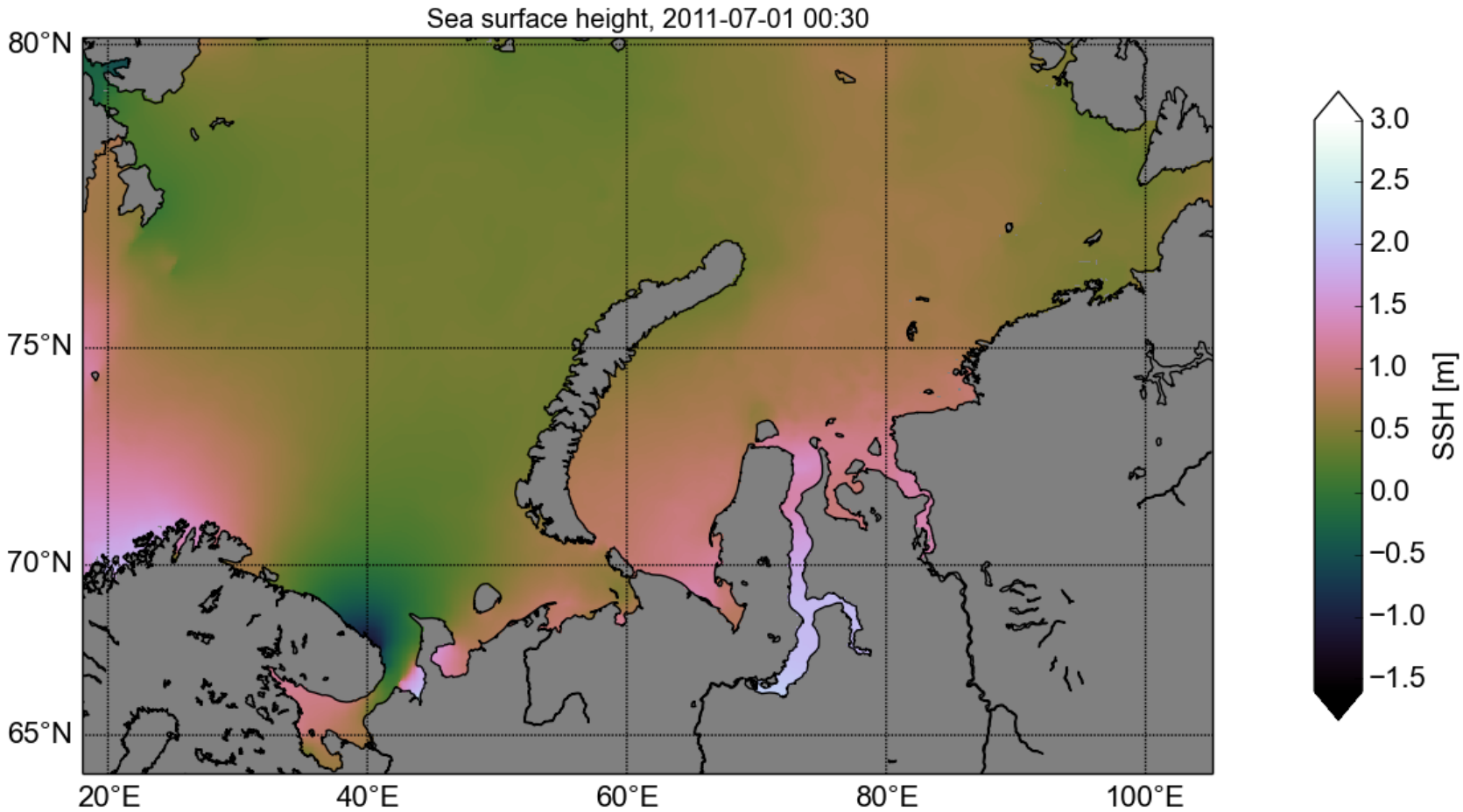
Mean simulated Dezember sea ice concentration (1979-2015) vs. satellite observations



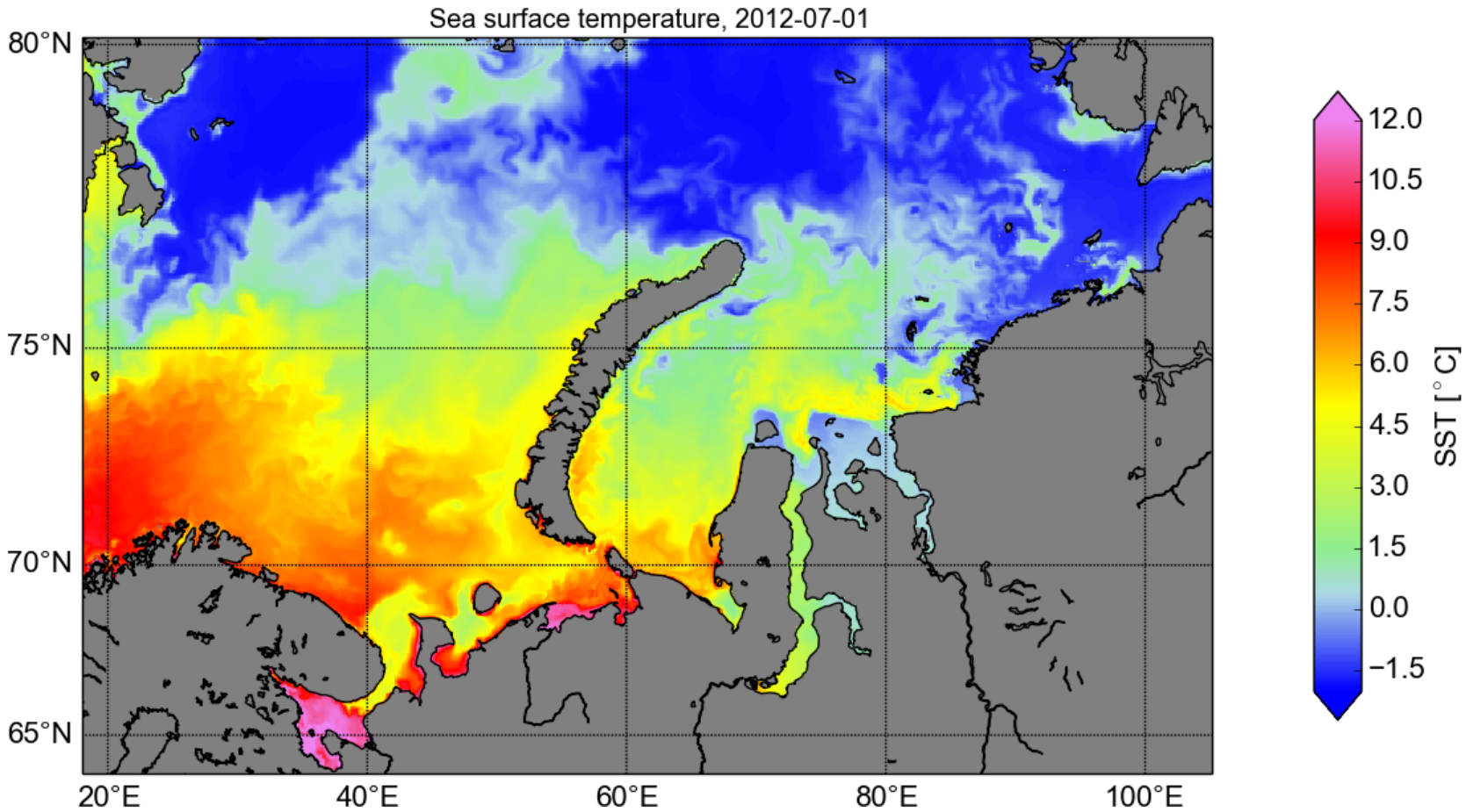
Courtesy: Iiro Kokkonen

Impressions of the model simulations...

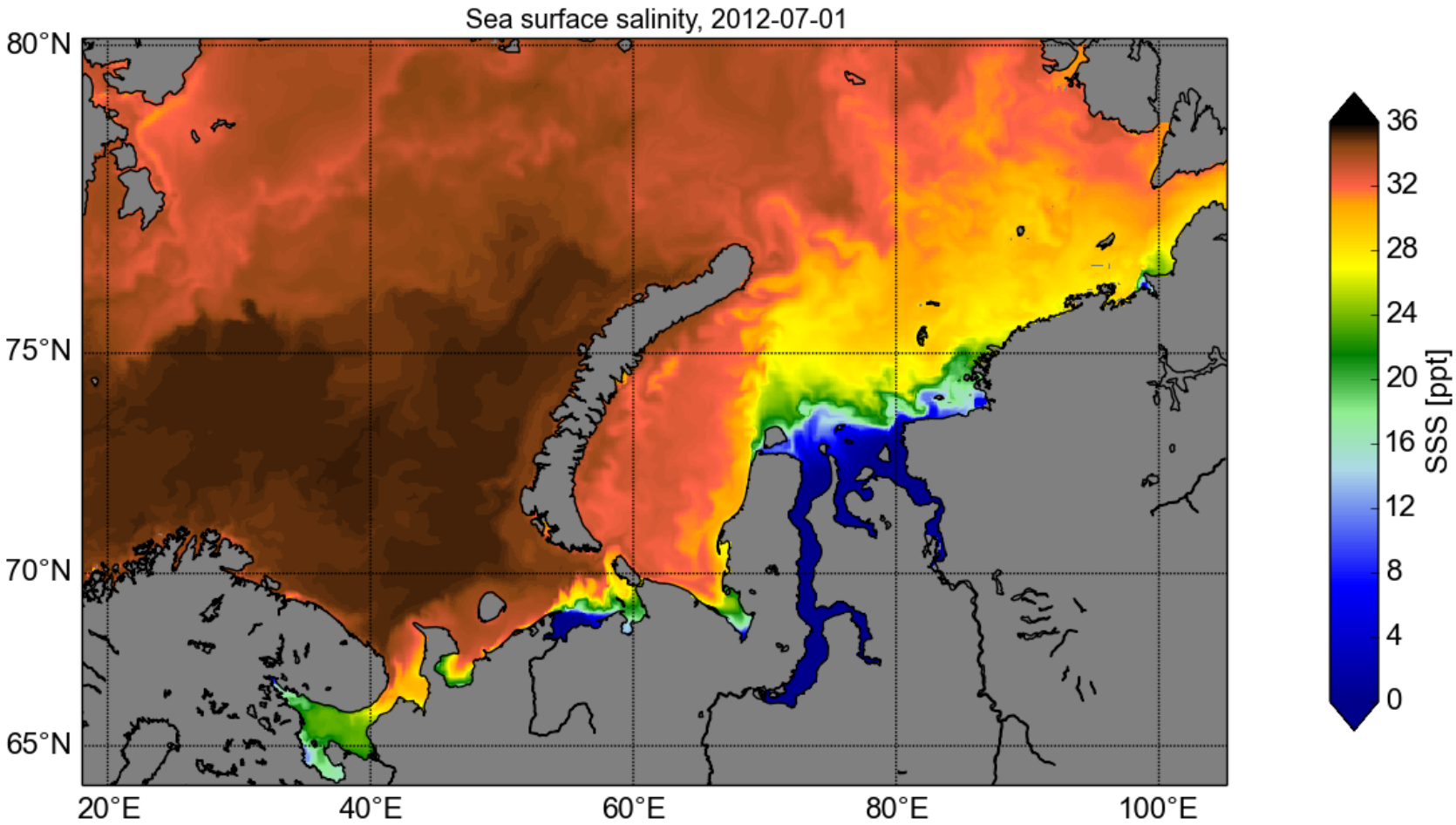
Tides July 2011



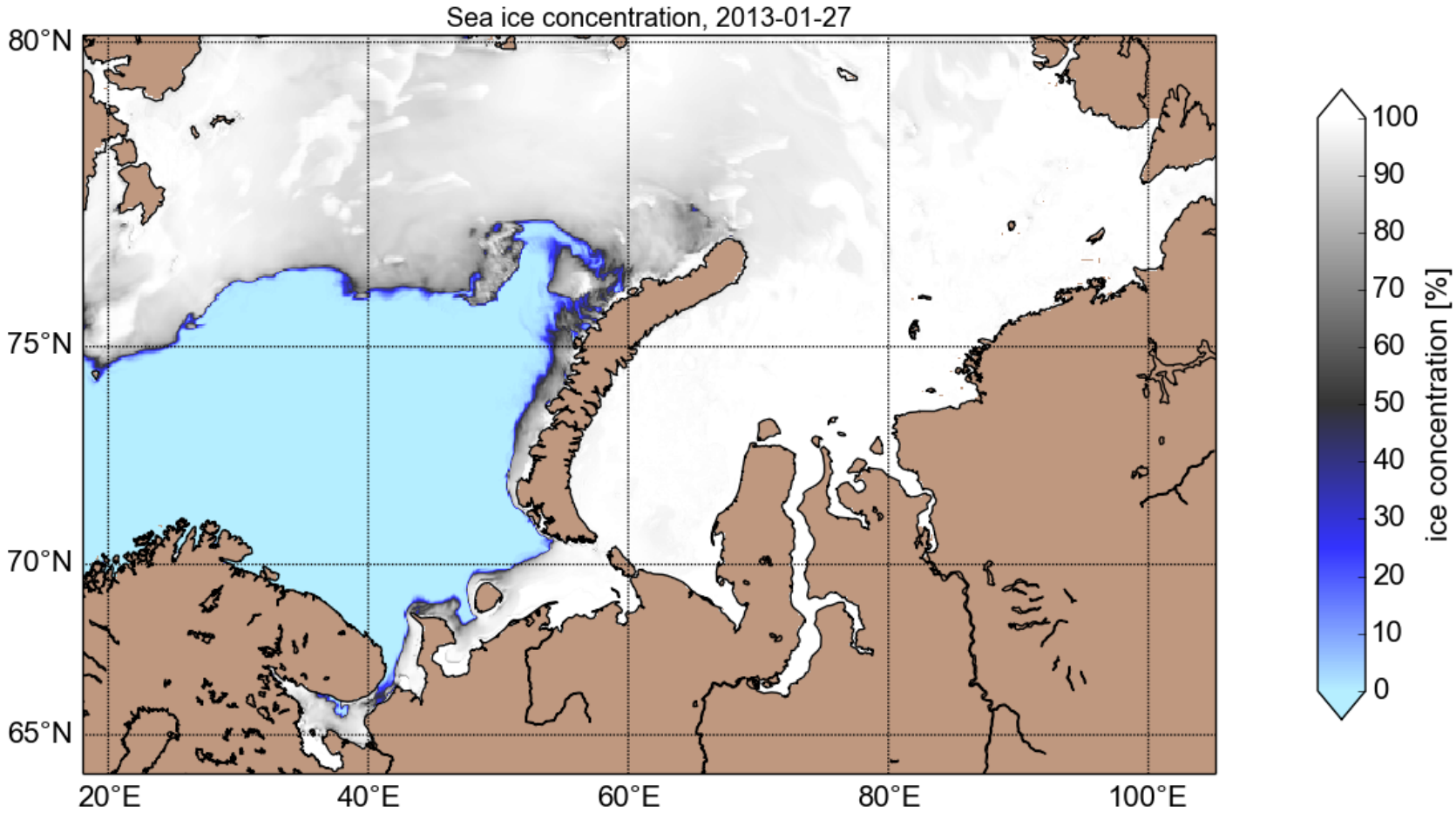
Sea surface temperature Jul 2012 – Jun 2013



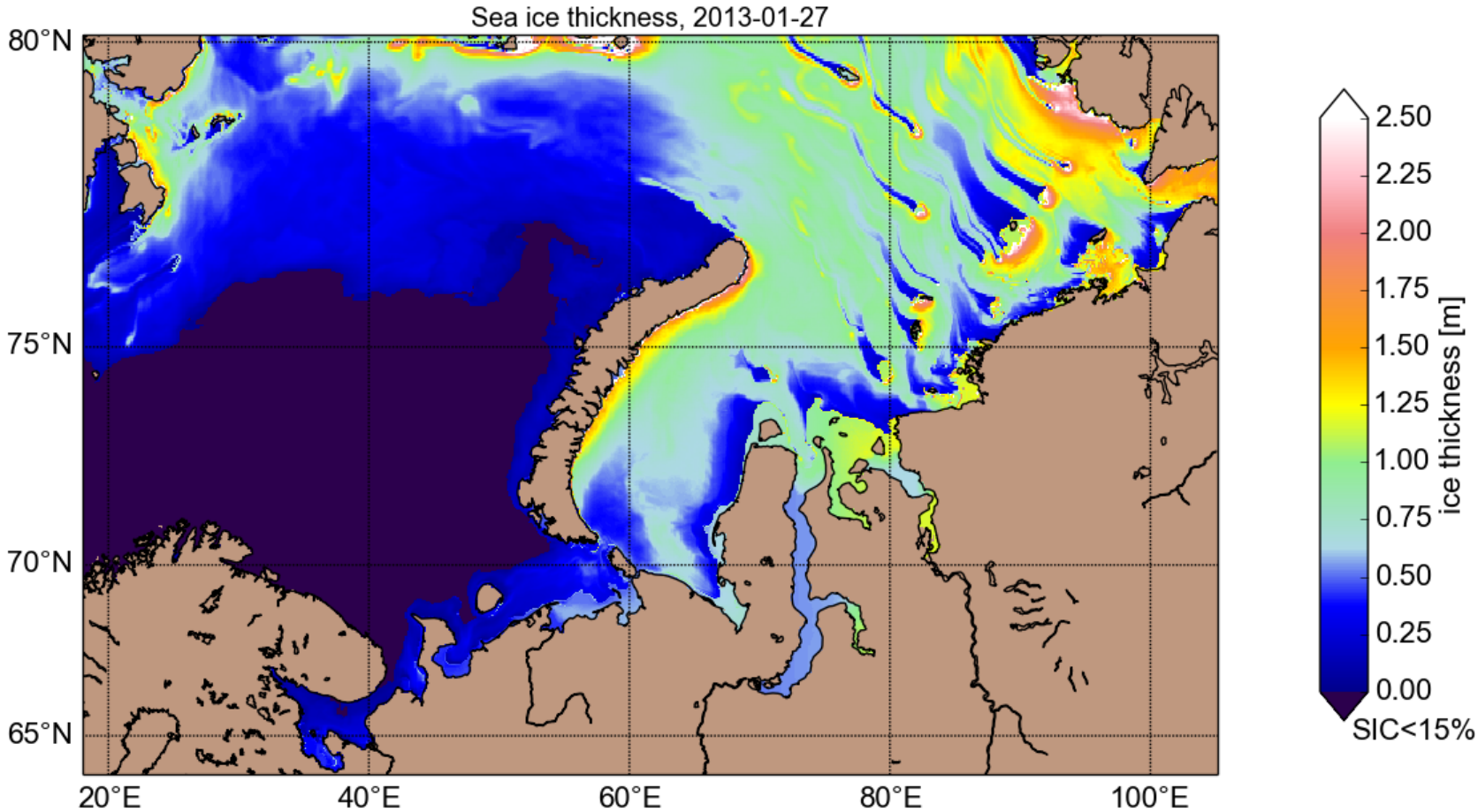
Sea surface salinity Jul 2012 – Jun 2013



Ice concentration Oct 2012 – Jun 2013



Ice thickness Oct 2012 – Jun 2013

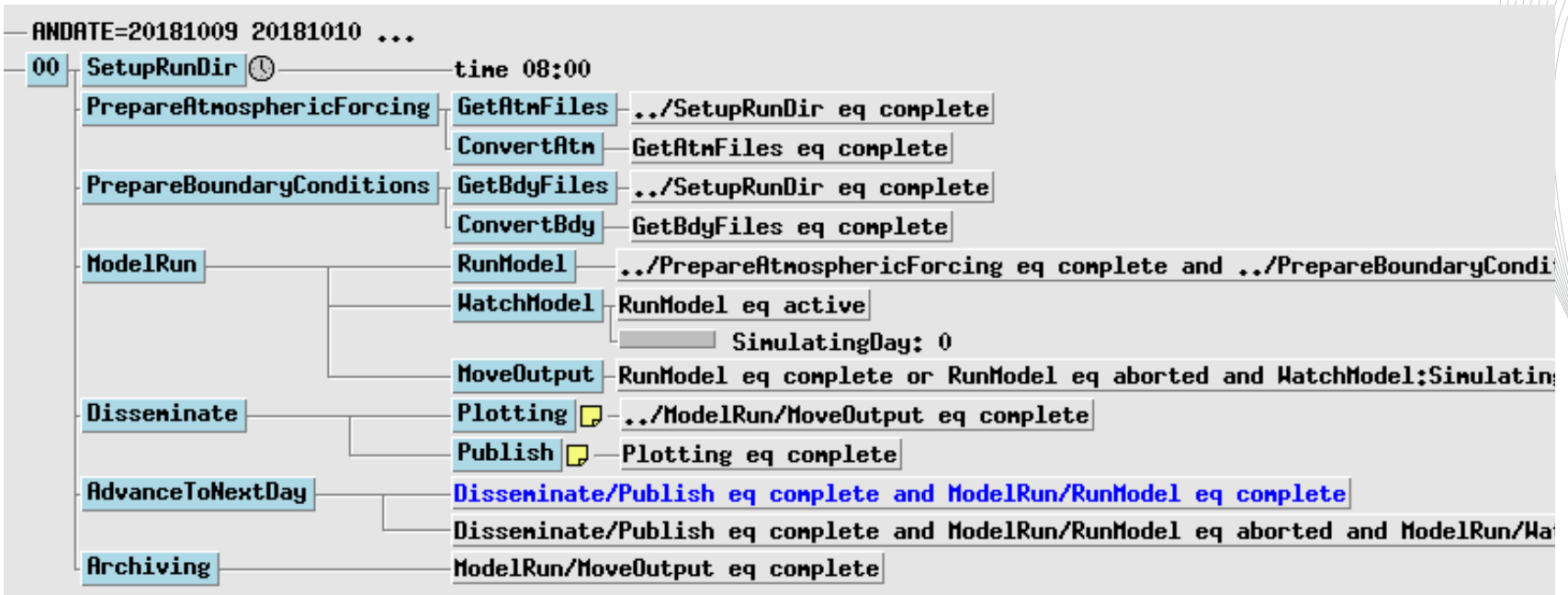


Pre-operational forecasting

- Initial conditions for 01 Jan 2018 from hindcast simulation
- Since 2018: Initialized from yesterday's 1-day forecast
- 9-day forecast
- Automatic scheduling of preprocessing, simulation, and postprocessing by ecflow

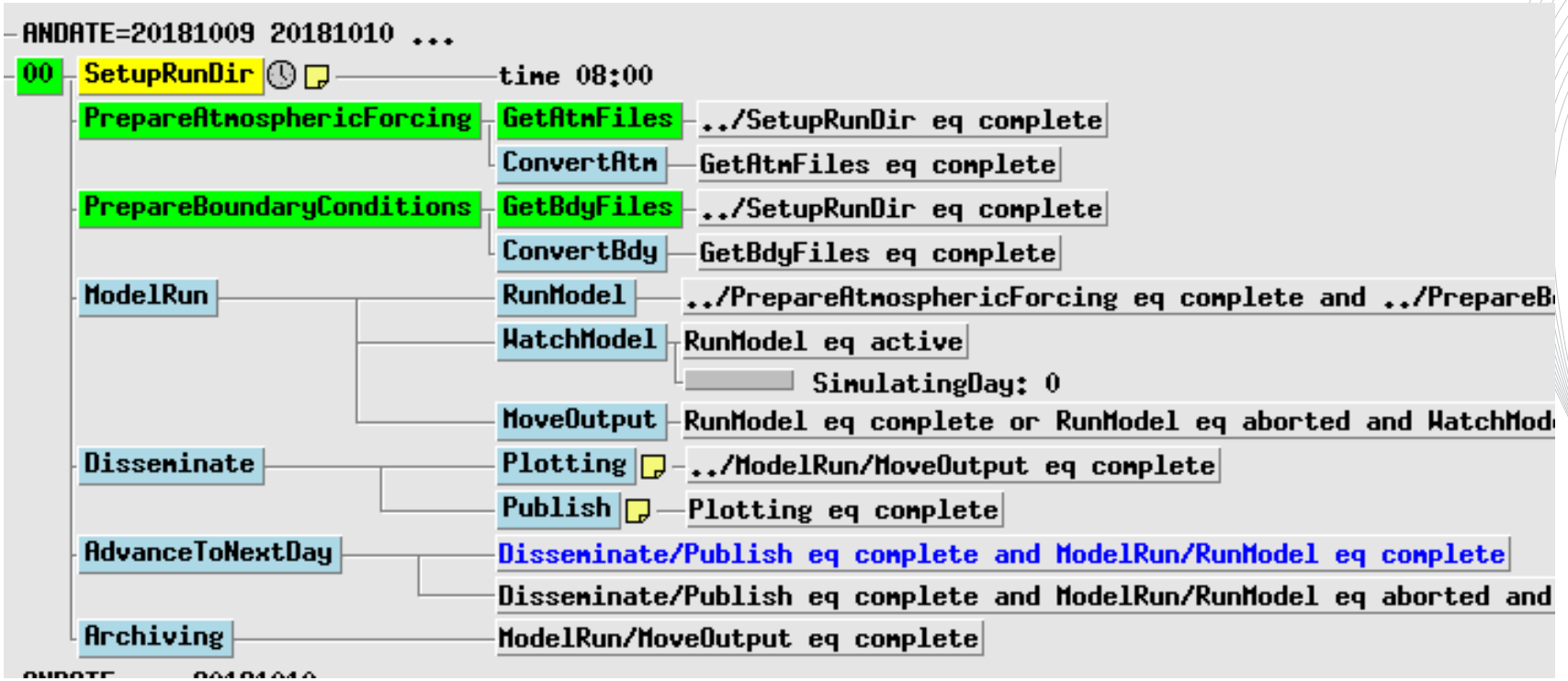
Scheduling with Ecflow

Similar to pre-operational NEMO Nordic setup at FMI (Jonni)

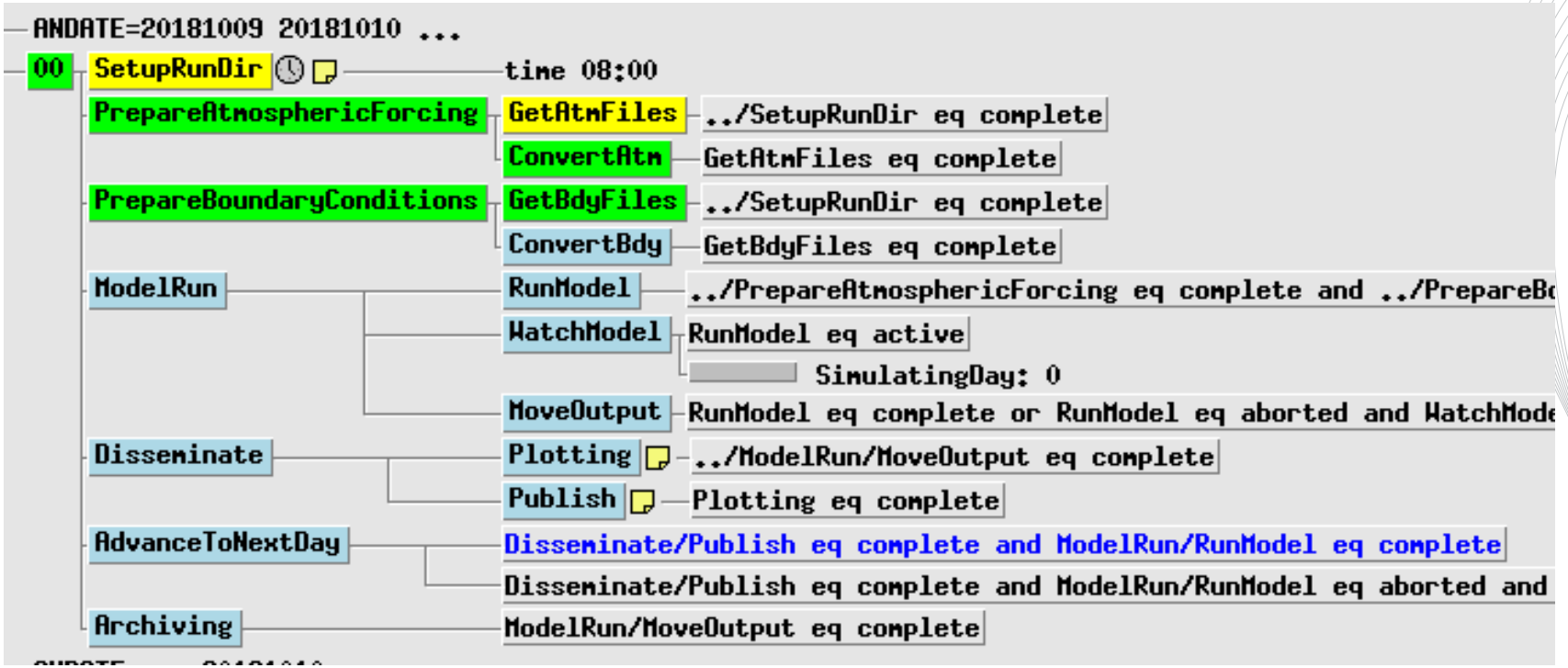


- Different TASKs for all (pre/post)-processing scripts
- Dependencies between TASKs

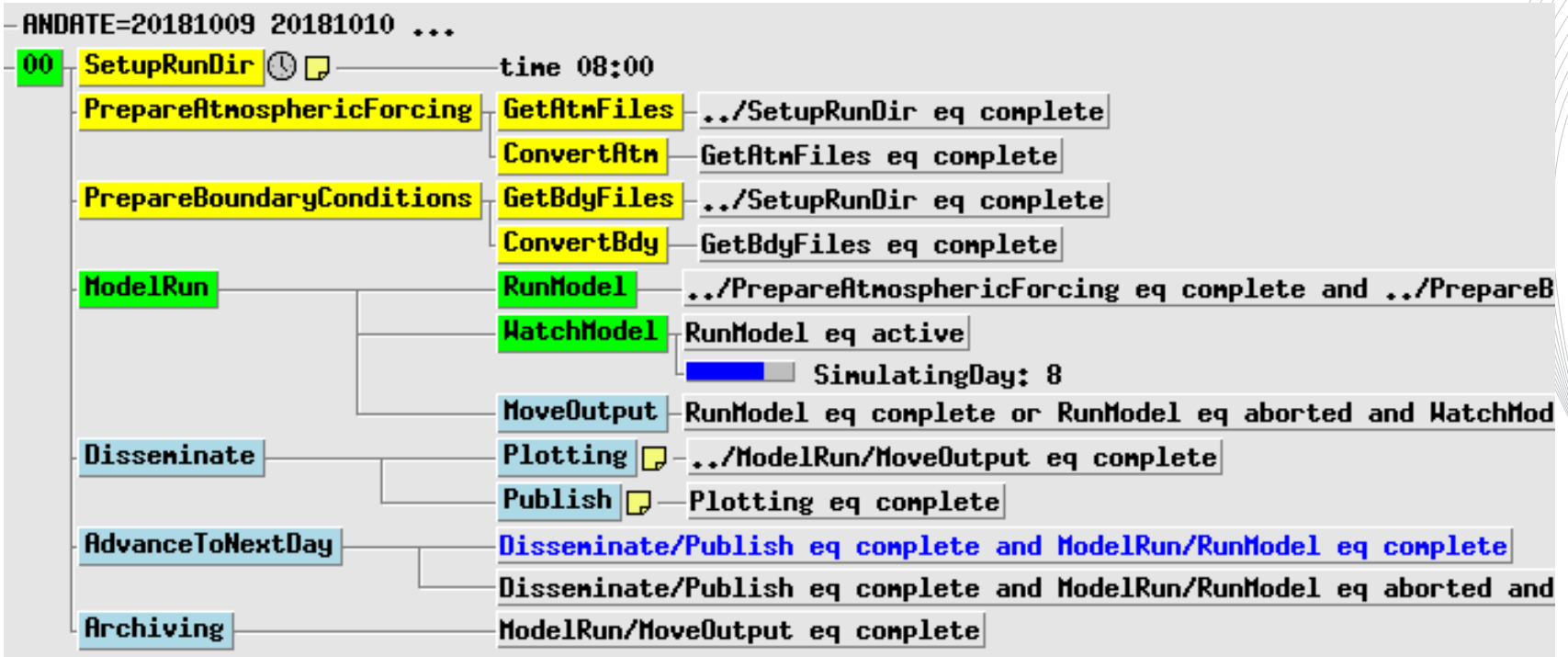
Scheduling with Ecflow



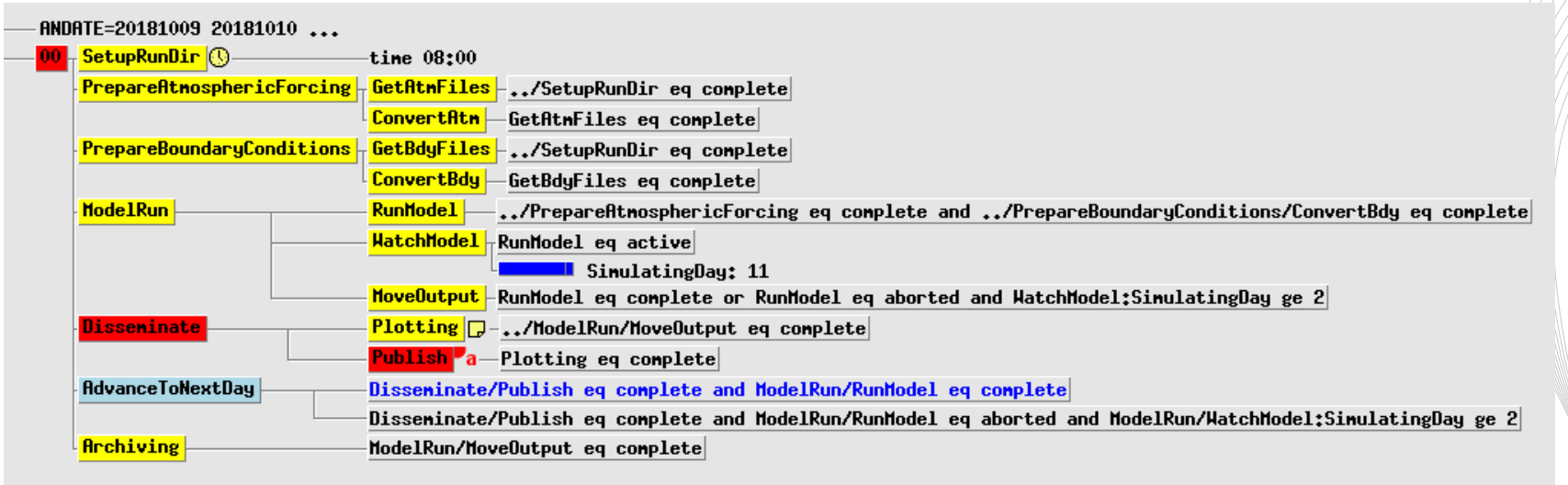
Scheduling with Ecflow



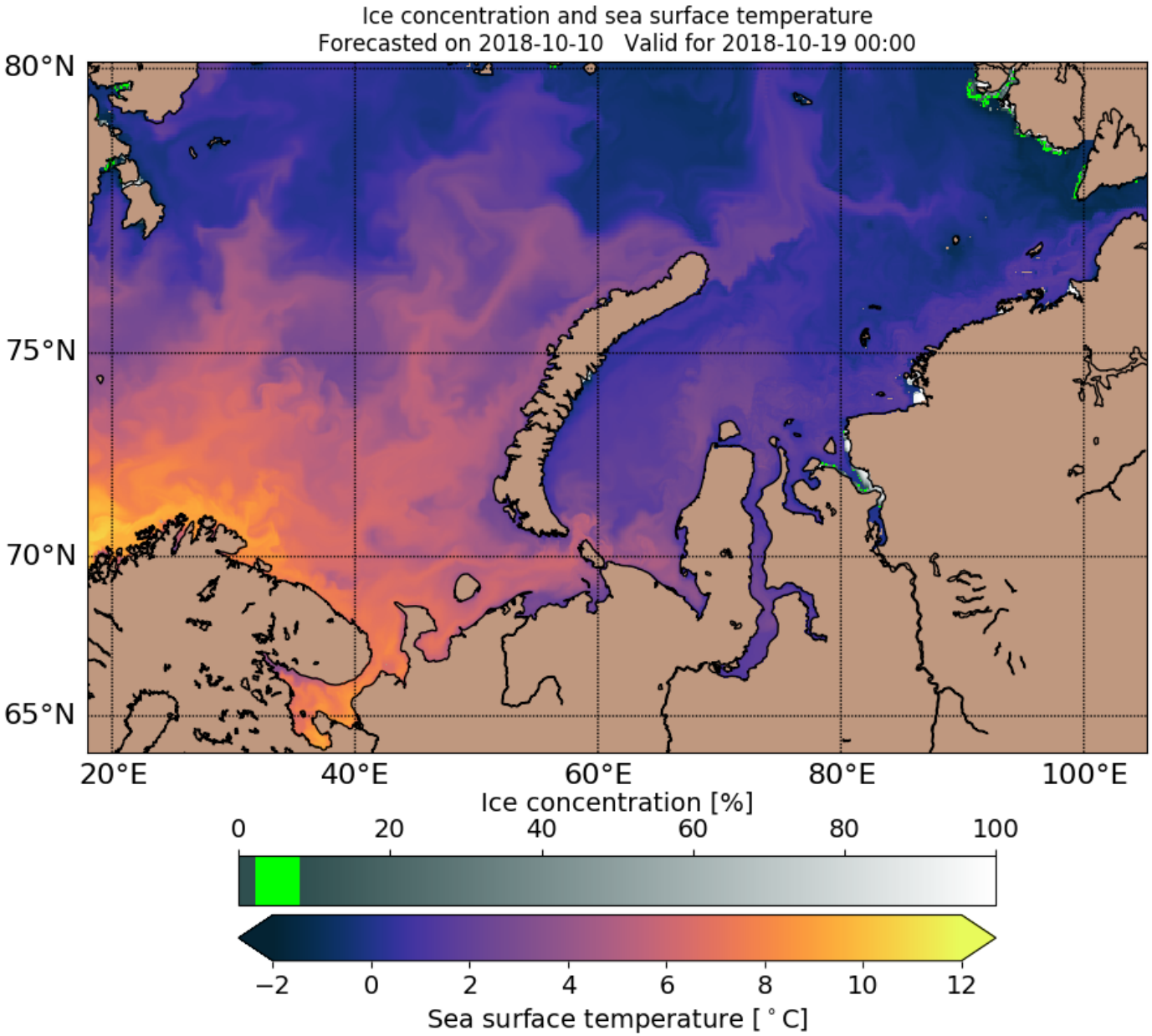
Scheduling with Ecflow



Scheduling with Ecflow

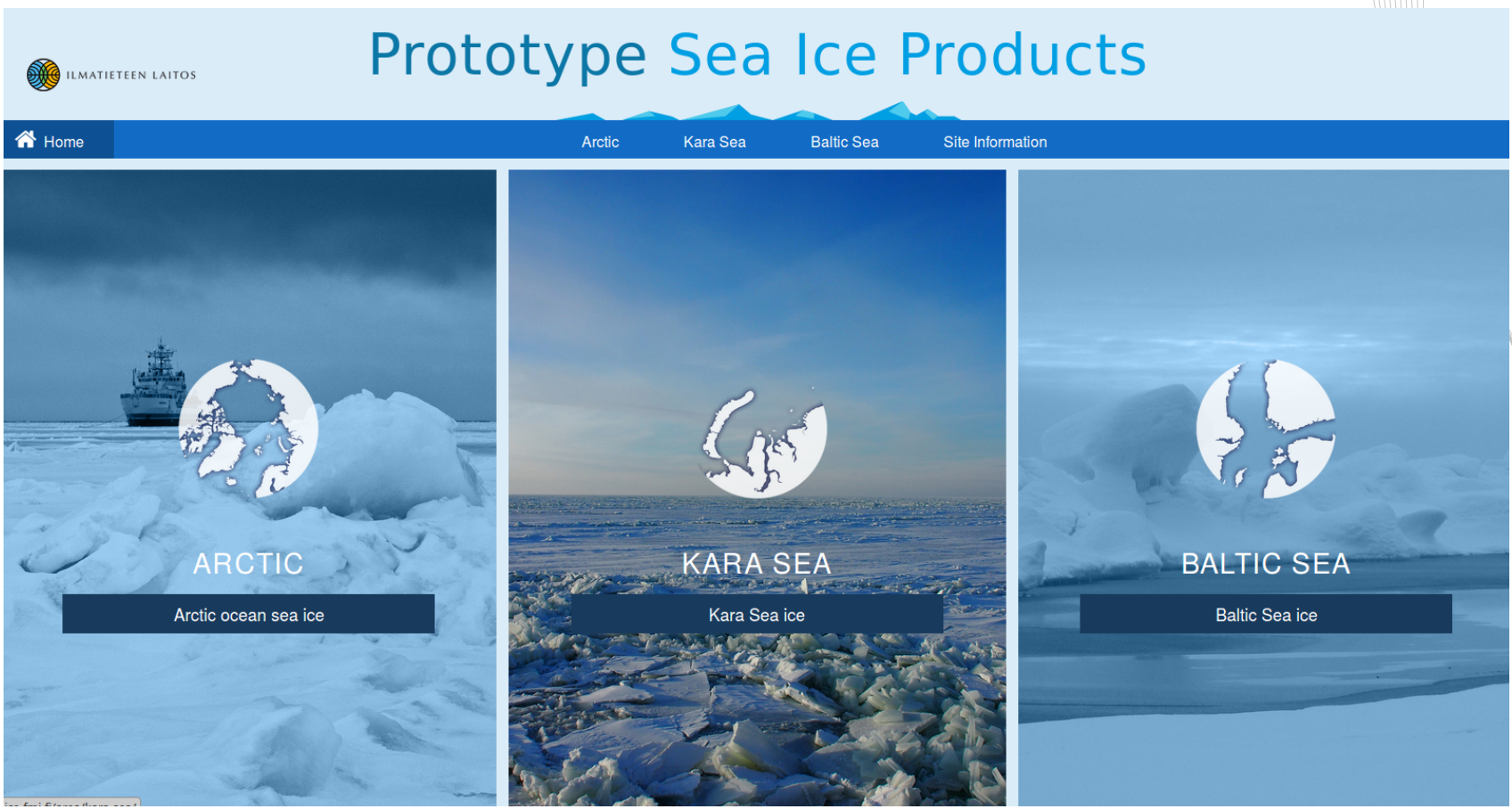


Forecast for 19. October 2018



Webpage ice.fmi.fi

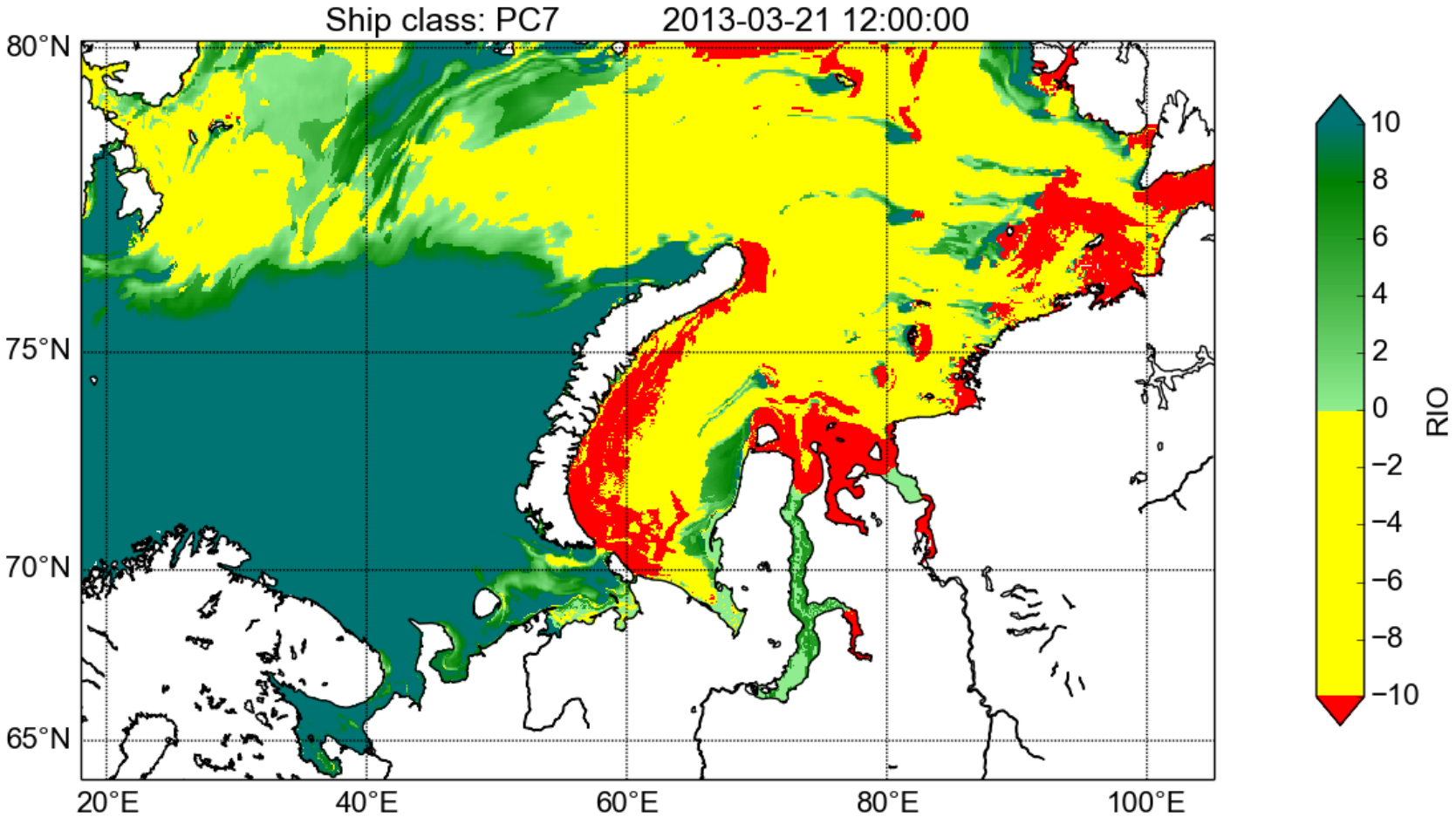
- FMI's webpage to display ice-related products
- Still under development...



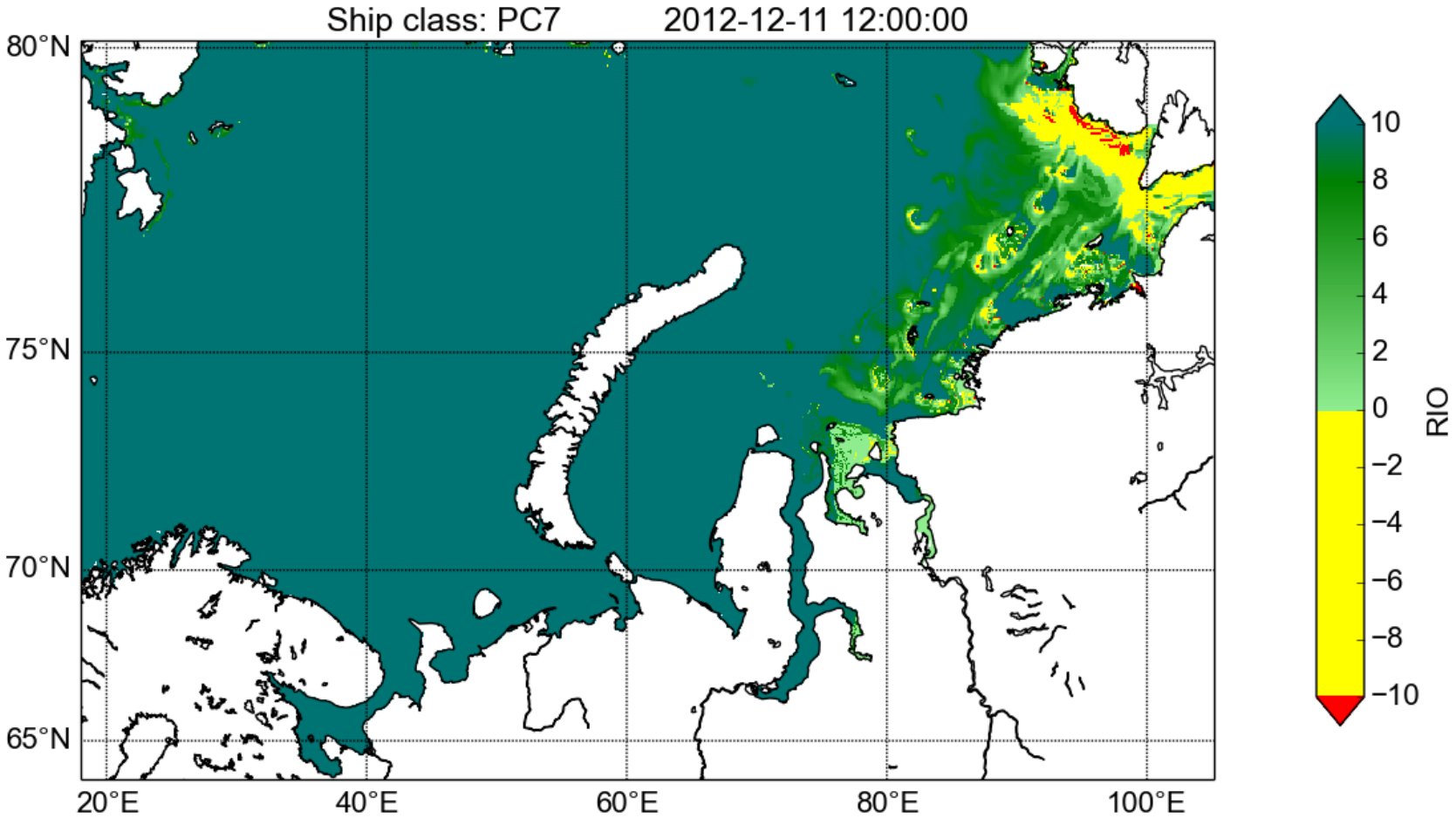
Summary

- FMI has a sea ice forecast model for the Barents and Kara Seas
- 9-day forecasts are run pre-operationally every day
- First evaluations show that the model results are mostly reasonable
- Plots are available on ice.fmi.fi

Ship navigability in 2012/2013



Ship navigability in 2012/2013



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METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Ilmatieteen laitos
Erik Palménin aukio 1
00560 Helsinki
PL 503, 00101 Helsinki
puh. 029 539 1000

Meteorologiska institutet
Erik Palméns plats 1
00560 Helsingfors
PB 503, 00101 Helsingfors
tel. 029 539 1000

Finnish Meteorological Institute
Erik Palménin aukio 1
00560 Helsinki
P.O.Box 503, 00101 Helsinki
tel. +358 29 539 1000

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