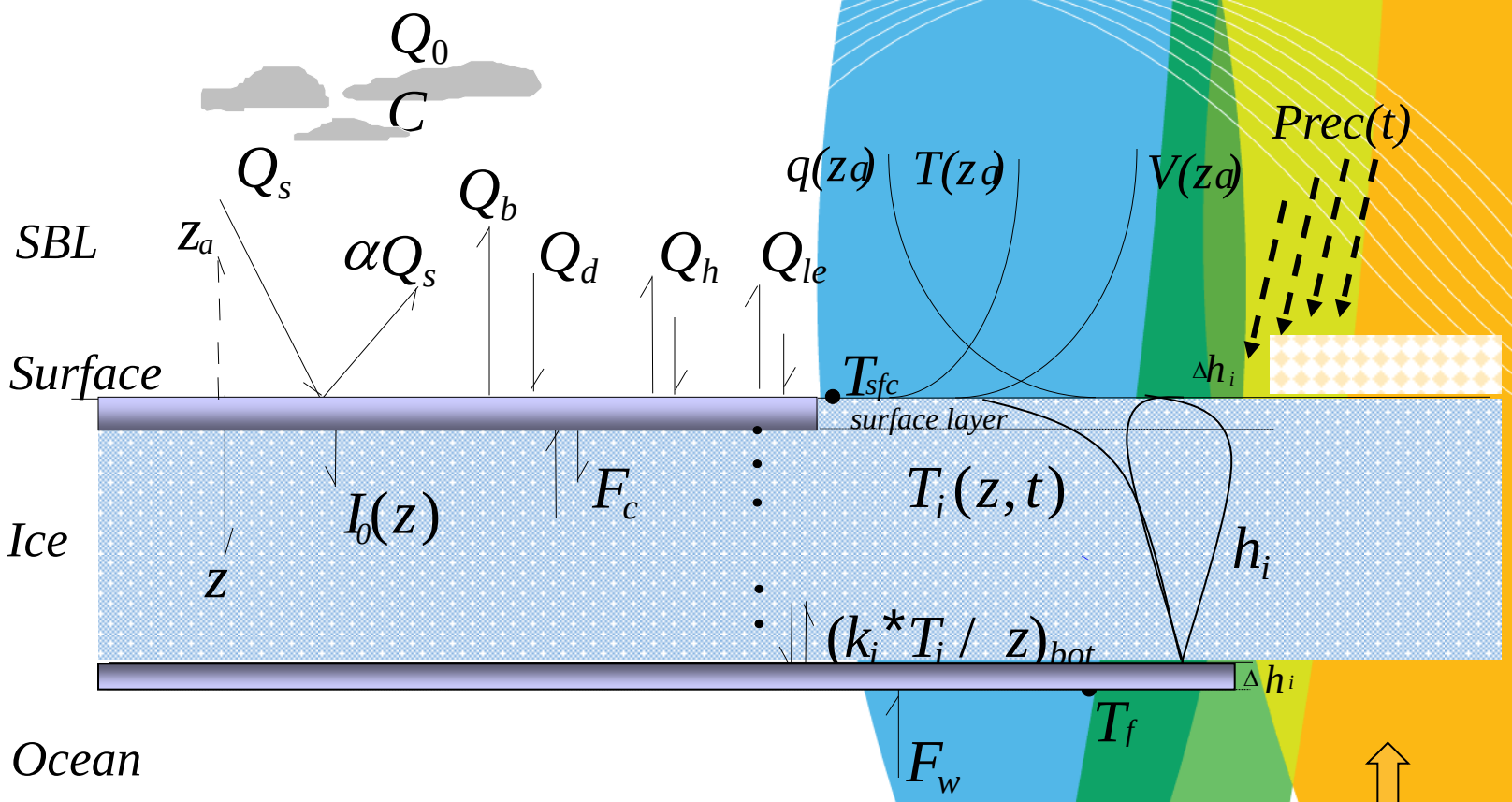
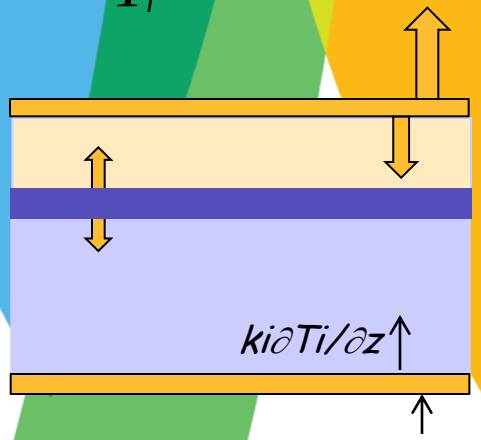
ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

SEA ICE THICKNESS FROM MODIS ICE SURFACE TEMPERATURE

Marko Mäkynen
Bin Cheng
Markku Similä

Finnish Meteorological Institute





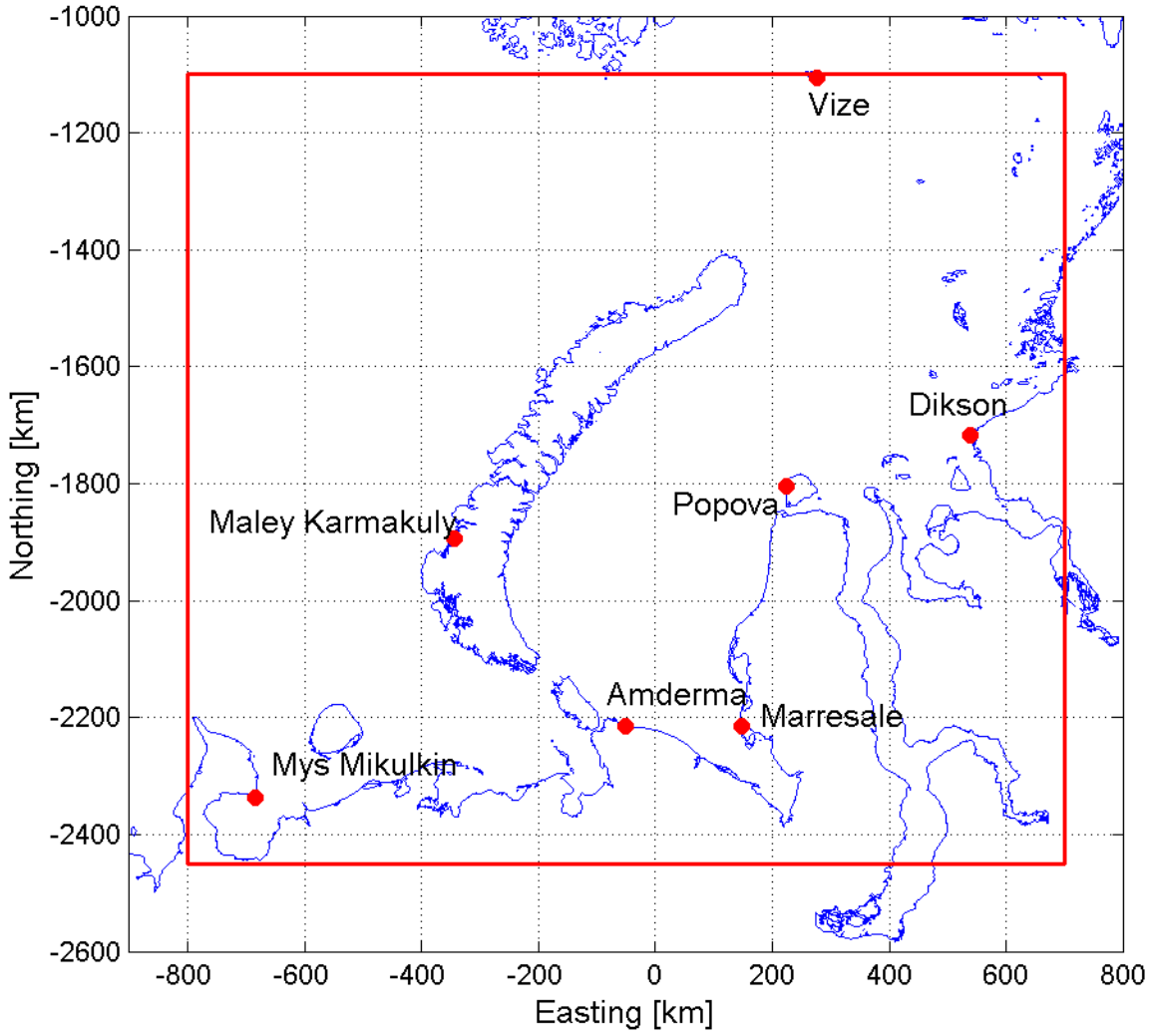
Structure of HIGHTSI model

Thin ice thickness from MODIS

- **Physical basis:** Thin ice thickness from ice surface temperature can be estimated on the basis of surface heat balance equation. Major assumptions here are that the heat flux through the ice and snow is equal to the atmospheric flux and temperature profiles are linear in ice and snow
- **Requirement:** The approach works only under **cold cloud-free weather conditions** (air temperature < -10°C).
- **Using only nighttime data:** Uncertainties related to the effects of the solar shortwave radiation and surface albedo are excluded.
- **HIRLAM as weather forcing data.**
- **Parametrizations needed:** e.g. **snow vs. ice thickness**, snow and ice thermal conductivity.

Kara and Barents Sea study area

Red dots are weather stations.



Data Sets

- **Cloud masked MODIS ice surface temperature images:**

  50 images for 1 Dec 2008 – 30 Apr 2009

  68 images for 1 Nov 2009 – 30 Apr 2010

  X images for 1 Nov 2010 – 30 Apr 2011

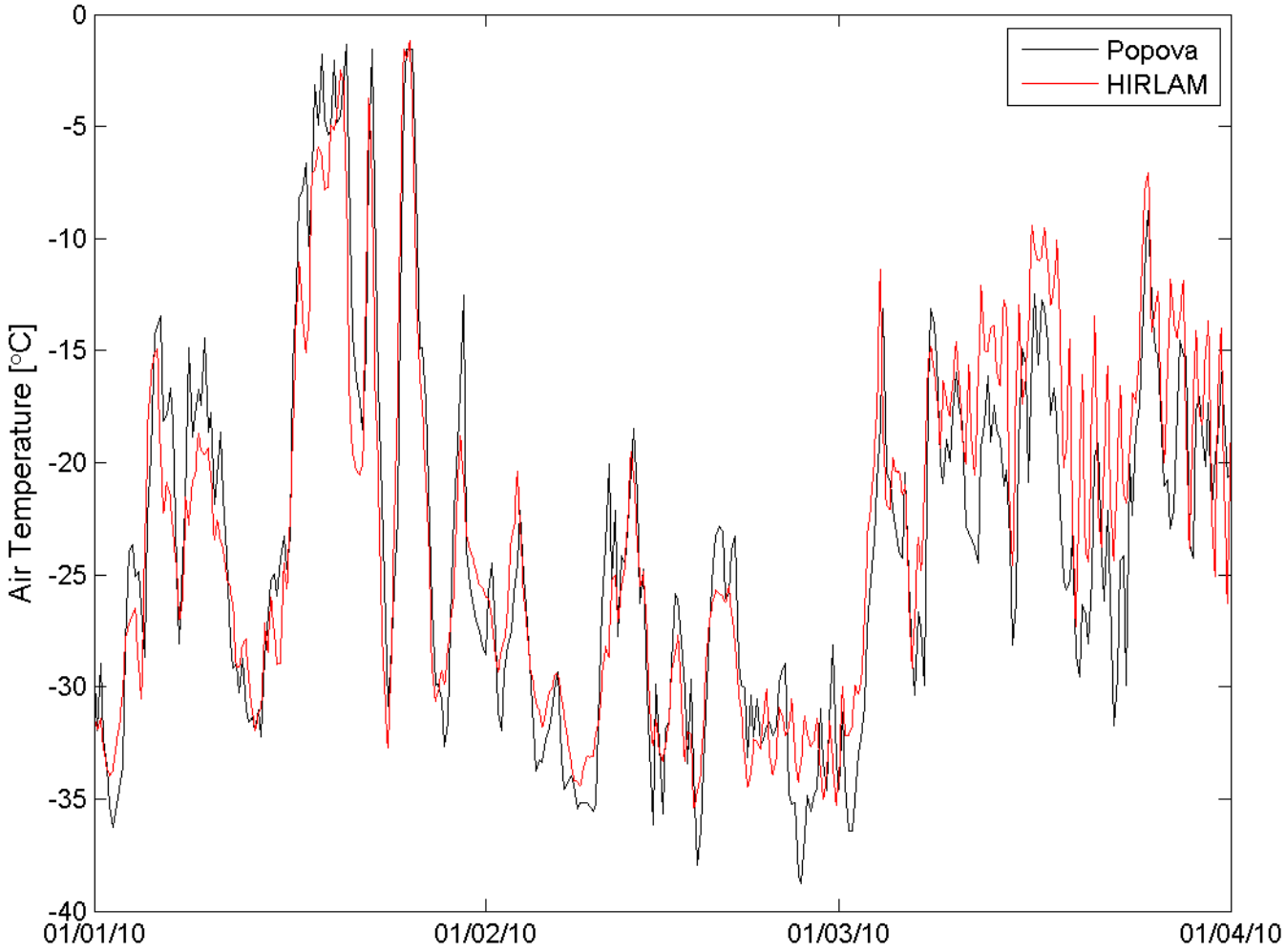
- **Images rectified to polar stereographic projection with 1 km pixel size.**
- **HIRLAM weather forcing data computed in 20 km grid.**
- **Weather station data (seven stations) for HIRLAM validation.**

Cloud masking

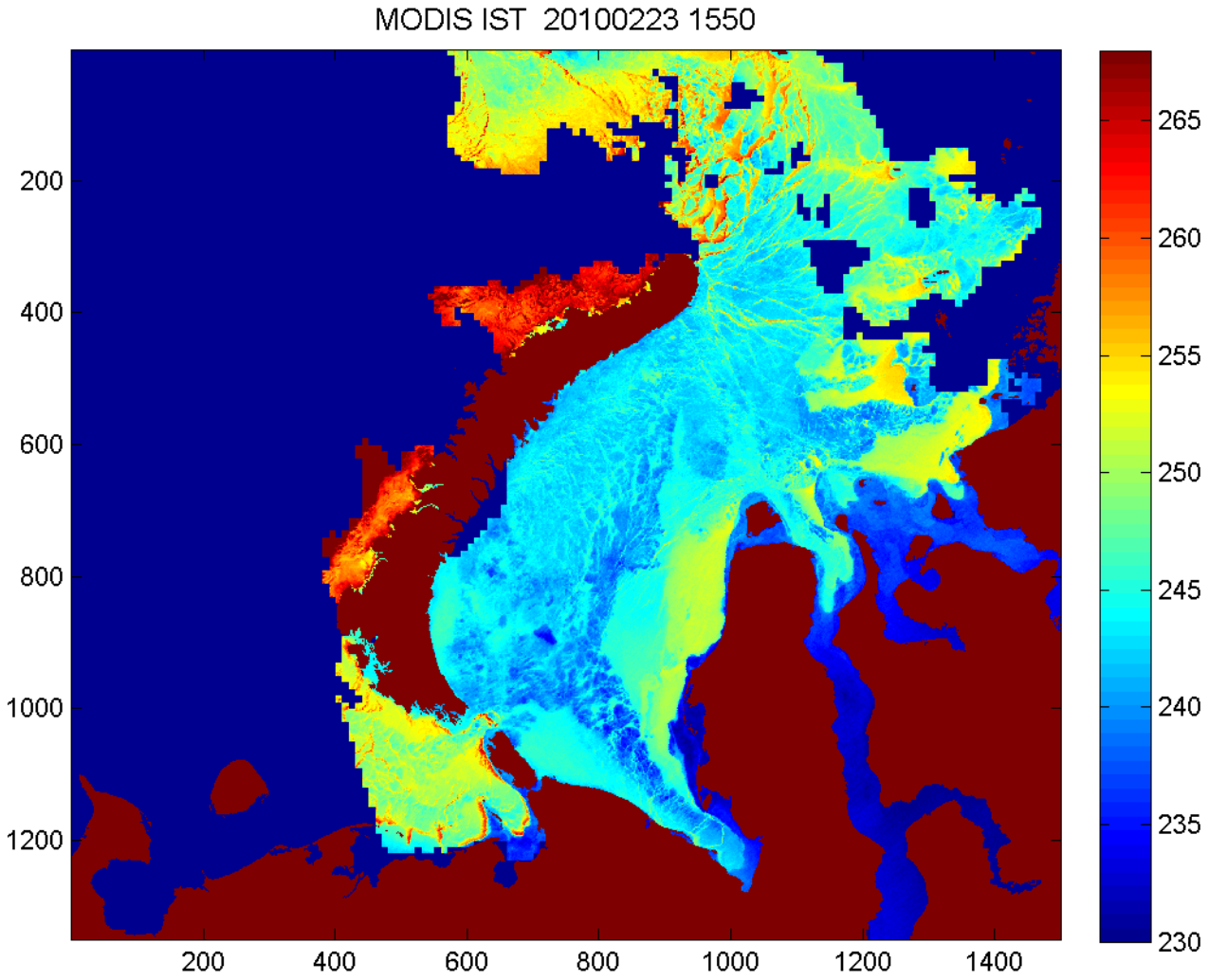
- **Three automatic cloud threshold tests:**
  - 11-3.9 μm brightness temperature difference (BTD) for low clouds
  - 3.9-12 μm BTD for high clouds
  - 6.7 μm brightness temperature (BT) for high clouds
  - The thresholds for the tests were determined using empirical BT and BTD data for clouds and cloud-free sea ice and open water.
- **After these tests following manual editing procedures can be conducted: filling holes, removing erroneous cloud mask elements, and masking arbitrary polygonal areas as cloudy or clear. Manual editing is done using thermal RGB-images.**

Comments on HIRLAM accuracy

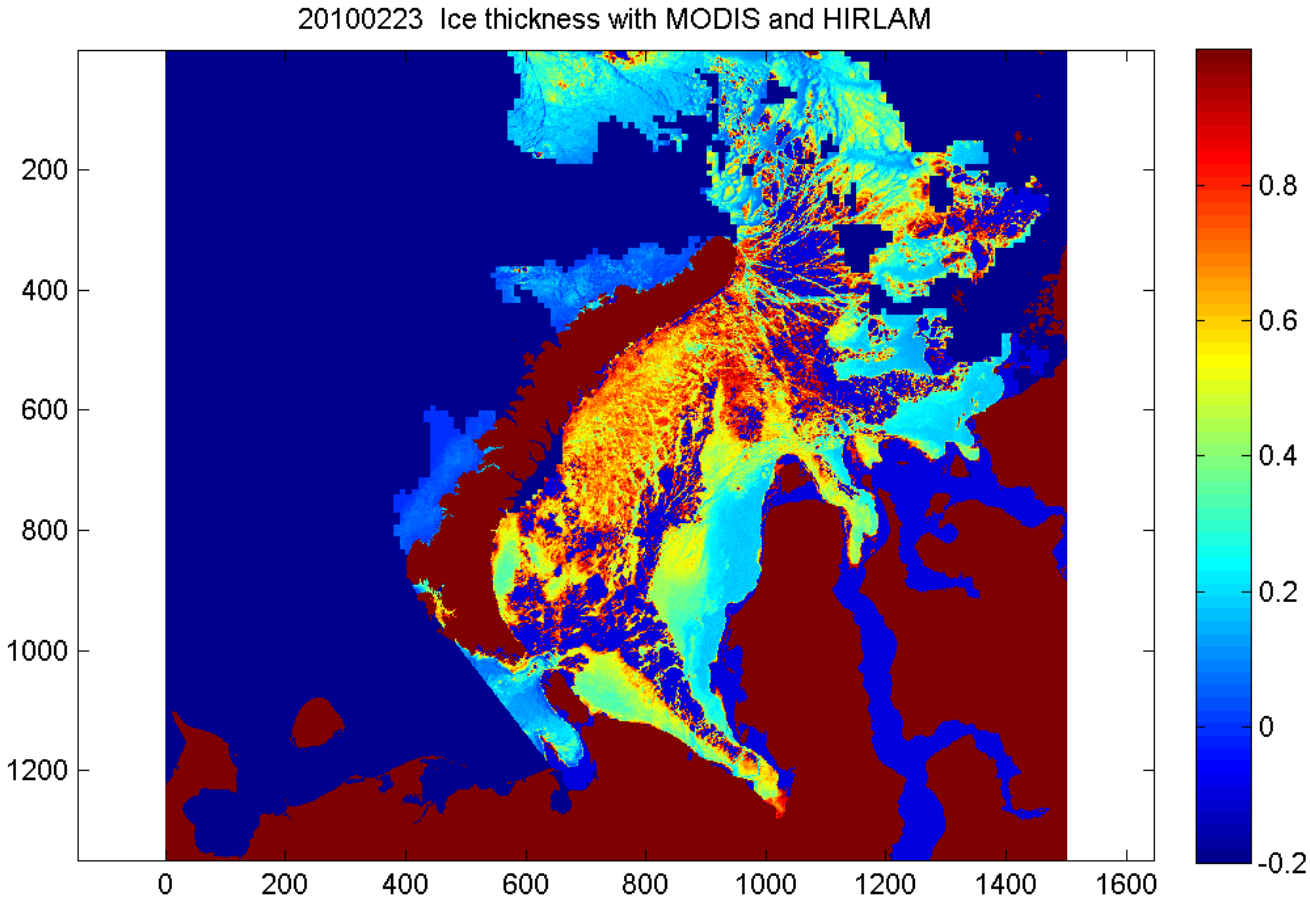
- **HIRLAM accuracy studied by comparing HIRLAM and coastal weather station data.**
- **In the Kara Sea in winter 2009-2010 the statistics for air temperature T_a : mean bias +0.6 K, rms-difference 3.9 K and correlation 0.94.**
- **For T_a the rms-difference slightly increases when T_a decreases.**
- **For the wind speed: mean bias +1.4 m/s, rms-difference 3.5 m/s, and correlation 0.68.**
- **HIRLAM typically underestimates higher wind speeds (>10 m/s).**
- **HIRLAM sea ice mask does not include thin ice and leads, only open water vs. thick ice. A modeling study has demonstrated that for sea ice concentrations > 90% small changes in the sea ice fraction have a strong effect on the near-surface T_a .(Vihma and Lüpkes)**
- ***We will study the effect of HIRLAM uncertainty in the derived ice thickness.***


Popova
HIRLAM
Air Temperature [°C]
0
-5
-10
-15
-20
-25
-30
-35
-40
01/01/10
01/02/10
01/03/10
01/04/10

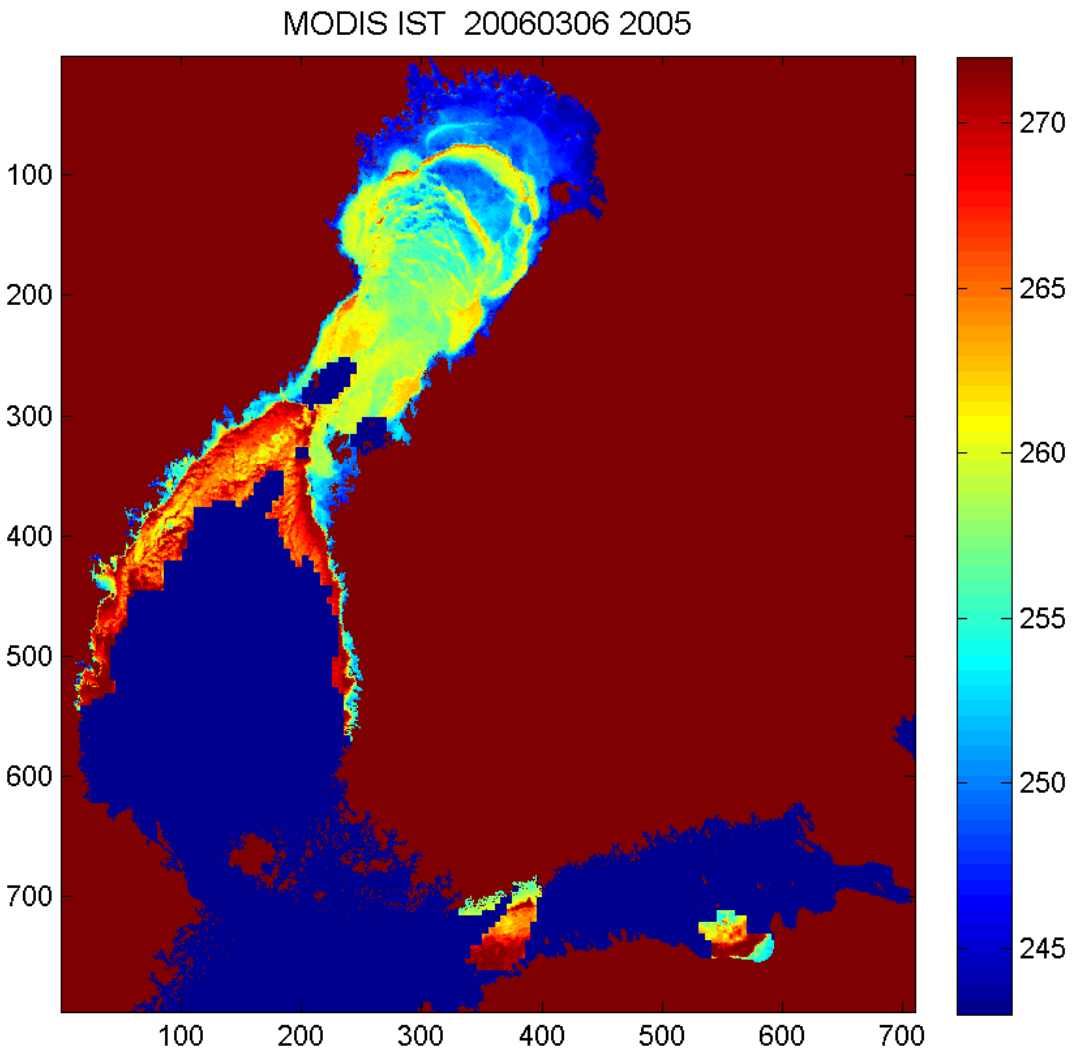
MODIS ice surface temperature

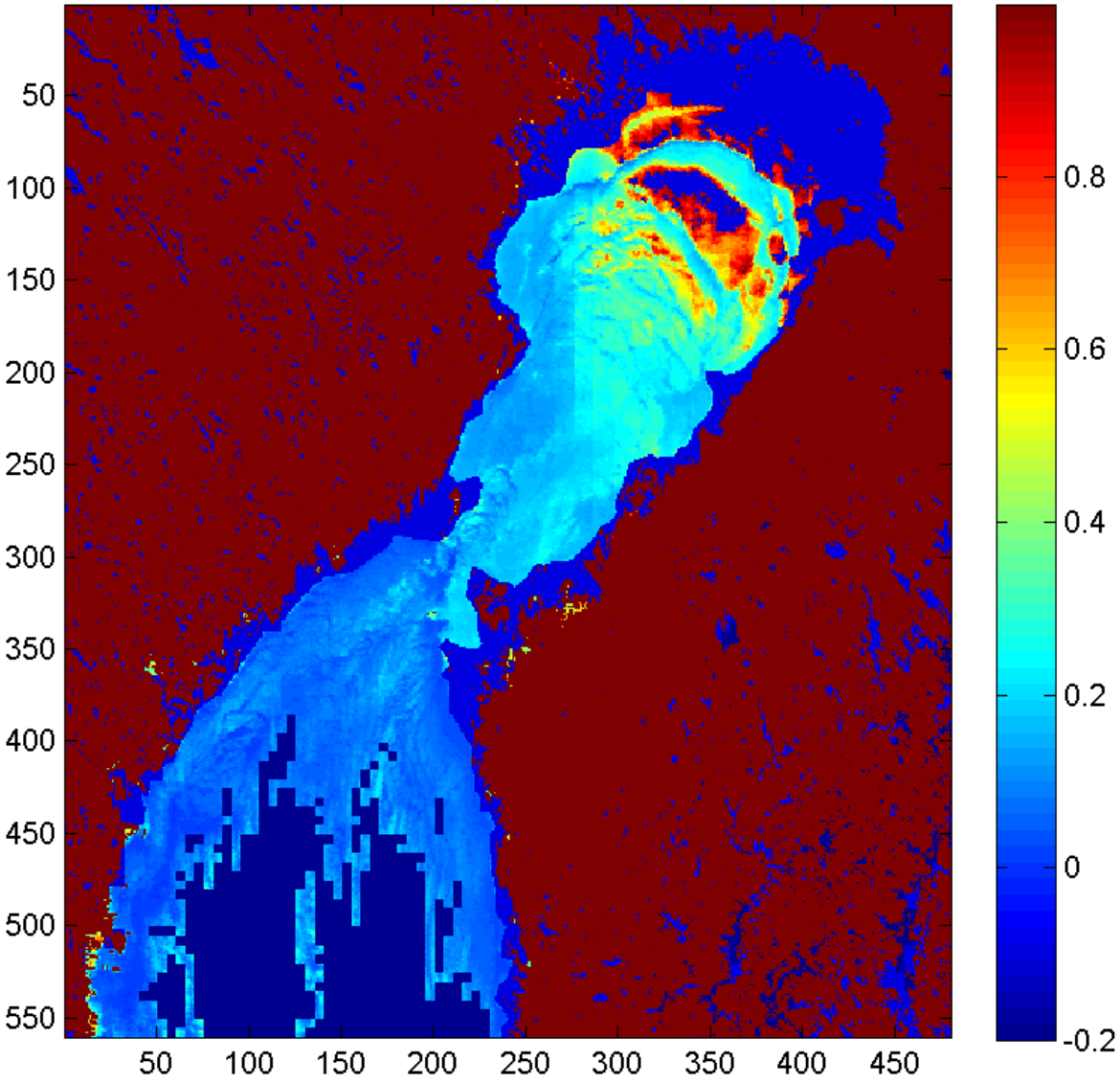


MODIS ice thickness



Baltic Sea example





MODIS derived level ice thickness.

-0.2 = cloud mask (dark blue)

-0.1 = h_i retrieval unsuccessful or retrieved h_i>1, and fast ice mask (blue)