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Ice Surface temperatures, status and utility

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Center for Ocean and Ice, DMI



Outline

- **IST from satellite**
 - Infrared
- **IST from in situ**
 - Examples
 - Comparison with satellites
- **Challenges for users**
 - Representativeness
- **Examples of applications**
- **Summary**





Existing IST products

- **Modis Aqua and Terra**
- **AVHRR Polar Pathfinder dataset**
- **Metop_A**
- **ATSR**
- **AMSR-E**
- **VIIRS**
- **Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)**
- **IASI**
- **Enhanced Thematic Mapper Plus (ETM+)**



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Modis IST observations

- Produced by NSIDC
- 1 km spatial resolution
- Aqua and Terra
- Using Modis cloud mask
- Data available since 2000



[Hall, D. K., J. Key, K. A. Casey, G. A. Riggs, and D. J. Cavalieri \(2004\), Sea ice surface temperature product from MODIS, IEEE Trans. Geosci. Remote Sens., 42, 1076–1087, doi:10.1109/TGRS.2004.825587](#)

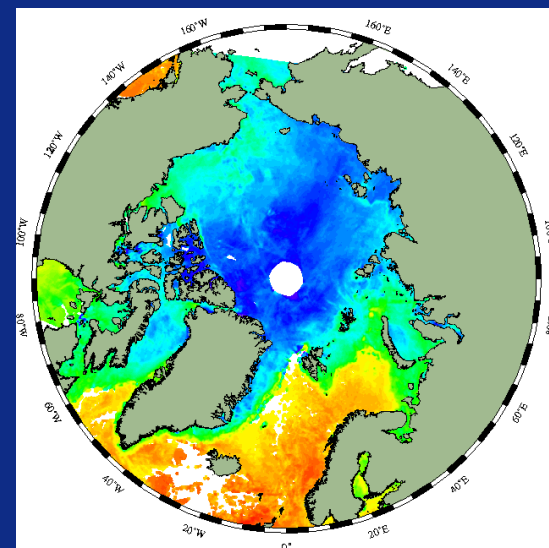
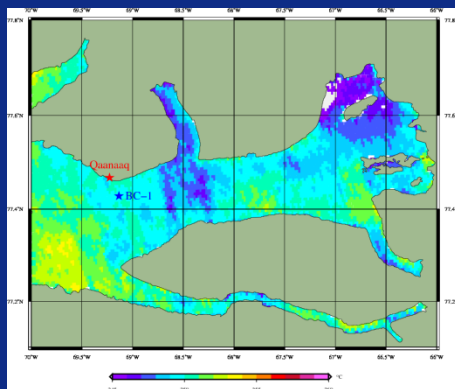
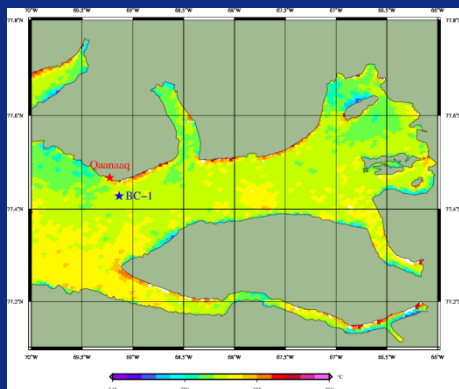


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OSI-SAF Metop-A IST product

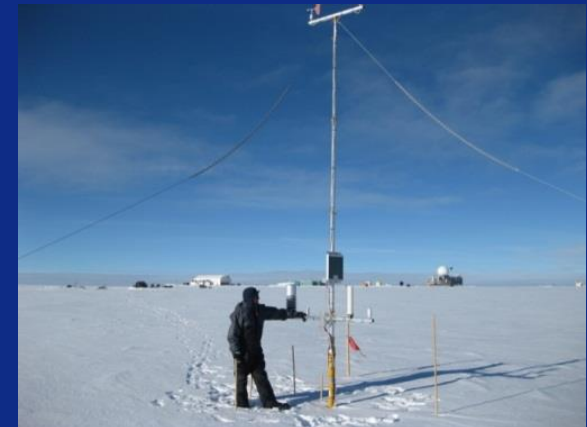
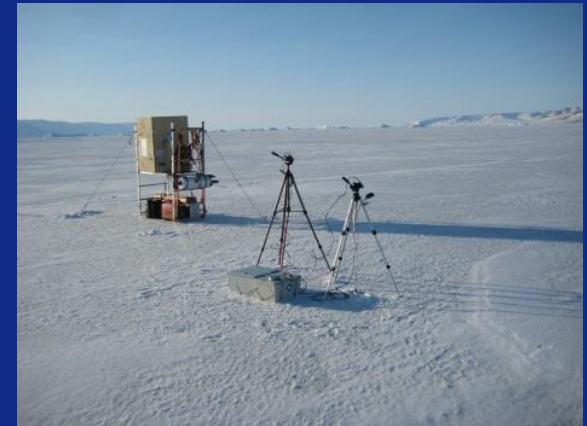
- 3 minute granules of 1 km AVHRR data from the NWC SAF PPS software.
- Integrated HL SST, IST and Marginal Ice Zone Temperature product, based on Metop AVHRR
- SST for HL
 - **Regional algorithm coefficients (separate day/night)**
- IST
 - As Key et al., 1992, compared with buoys
- MIZ
 - Scaled linearly between IST and SST, using T4
 - Vincent et al., 2008





In situ observations

- **Challenging to obtain a good coverage of accurate validation data.**
 - Infrared radiometers (broad band, narrow band, sky correcting or not)
 - Drifting buoys
 - Thermocrons
 - Ice mass balance buoy (thermistor string)
 - AWS (T2m + skin)
- **Each type of observations has specific sampling characteristics**





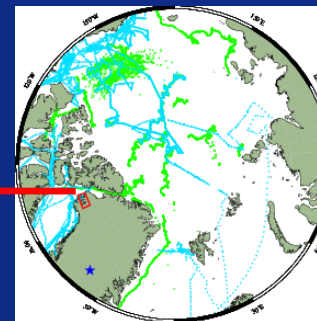
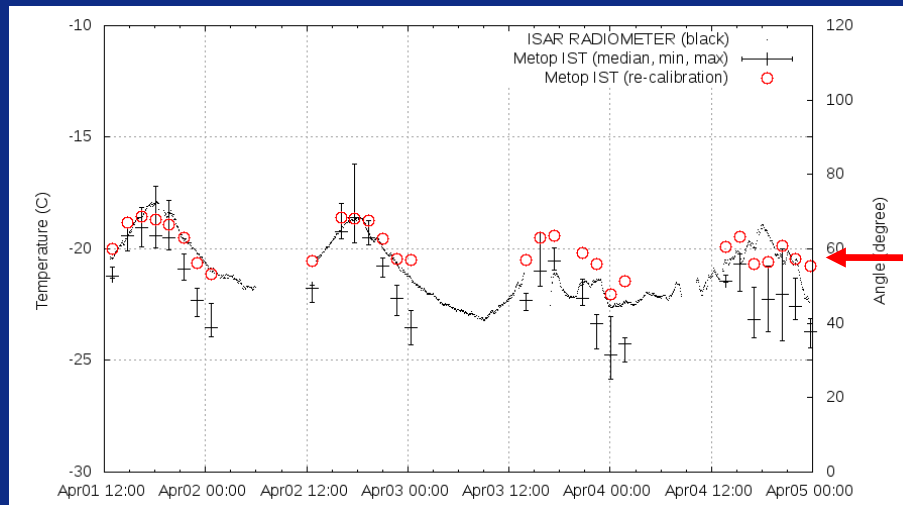
Comparison, Satellite vs in situ

- **Validation studies carried out**
 - Modis: Hall et al., 2004, 2012 + Scambos et al., 2006
 - AVHRR: Key and Haefliger, 1992, Key et al., 1997, Scambos et al., 2006,
 - Metop_A: Dybkjær and Høyer, 2012, Dybkjær et al., 2012
- **Compared to AWS stations + drifting ice buoys:**
 - Typical cold bias in the IST products: 1-3 °C
 - Typical standard deviations: 1-3 °C
- **Improved results obtained with:**
 - Infrared radiometers (Scambos et al, 2006, Dybkjær et al., 2012)
 - Multisatellite intercomparisons (Modis vs. ASTER vs. ETM+) (Hall et al., 2008)
 - Additional cloud masking (Dybkjær et al., 2012)

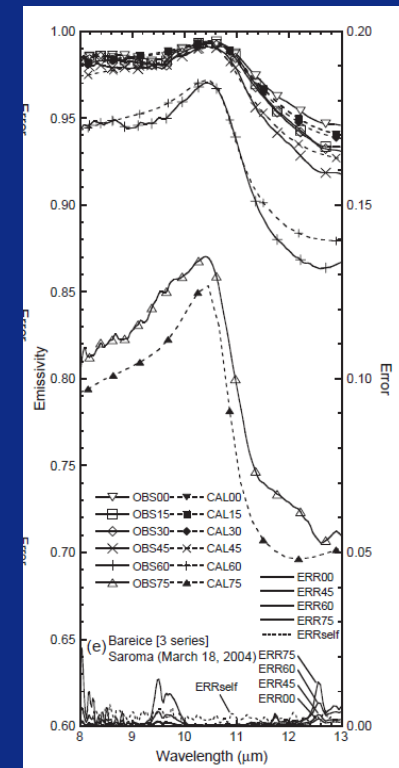


Infrared Radiometer observations

- Radiometers deployed on ships, ice stations & AWS on land
- Validation results significantly better than temperature sensors and T2m
- Very cold sky temperature (173 K in Qaanaaq) results in underestimation of up to 1.3 K if no skycorrection is performed
- $T_{\text{skin}} = (T_{\text{Bice}} - (1-\epsilon) \cdot T_{\text{Bsky}}) / \epsilon$



Directional emissivity



Hori et al., 2006

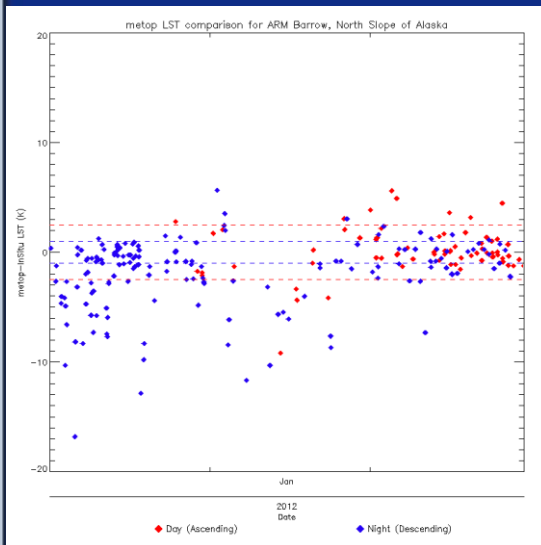


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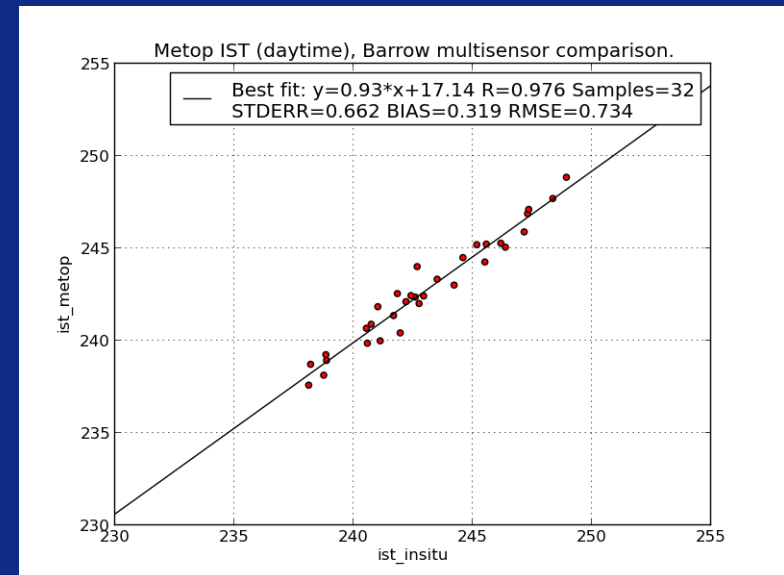
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Multisensor Match-up dataset

- Very useful to explore strength and weaknesses in the different data set
- Until now only one point for 3 months. Sea ice and Ice sheet MDs needed.
- Ensure right data is put in and extracted !



Same MD, correct
use of cloud flags





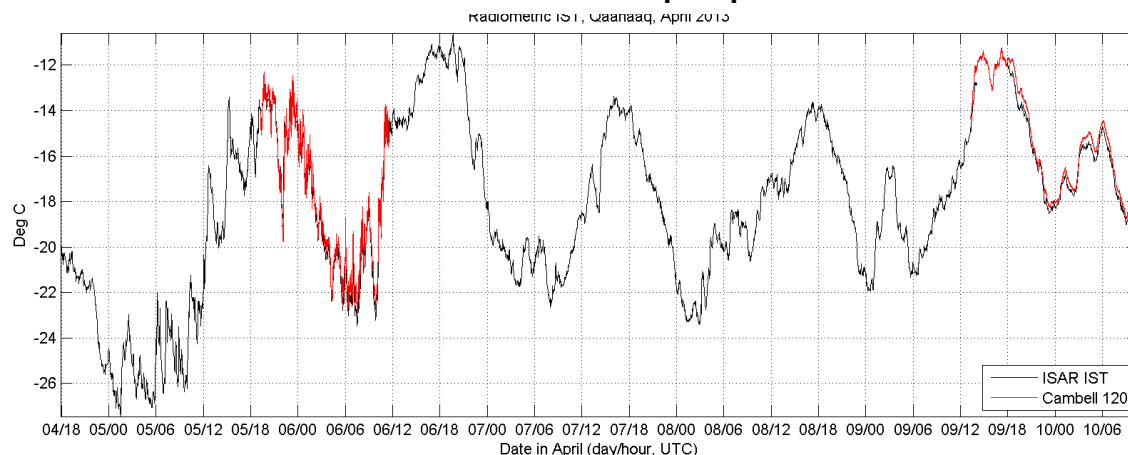
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Representativeness

- Large diurnal variation, even on hourly scale
- Uneven sampling with large diurnal and hourly IST variations
- Clear sky bias

ISAR Radiometer IST, Qaanaq, April, 2013





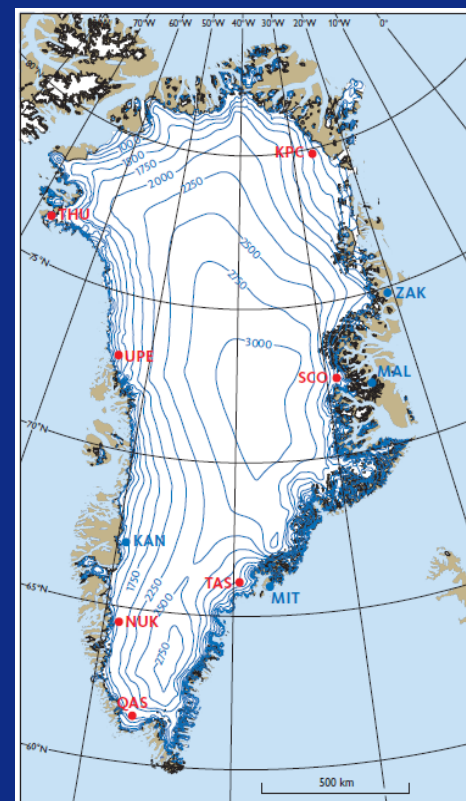
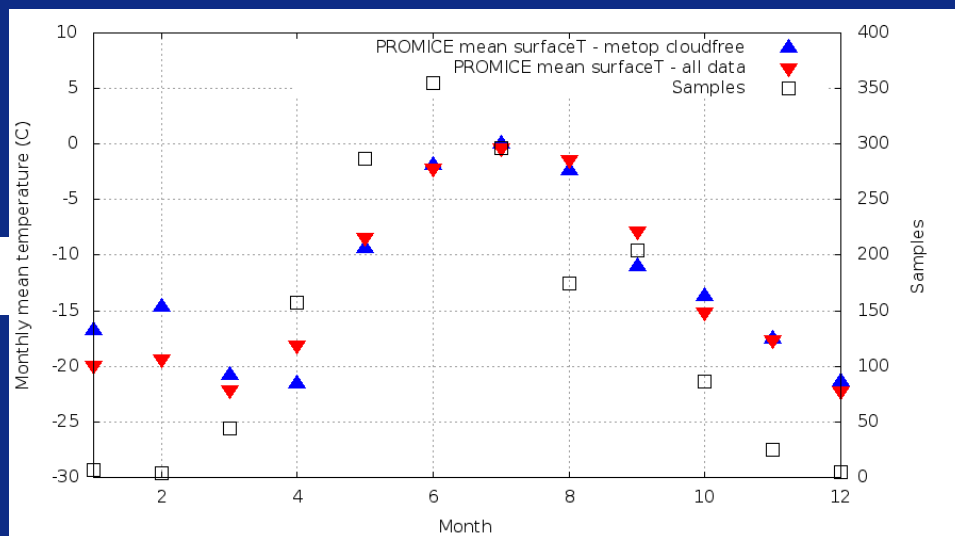
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Representativeness

- Clear sky bias from satellite ?
- Promice monthly mean surface temperature
 - All observations
 - Subsampled to Metop_A clear sky
- Needs more attention

www.promice.org



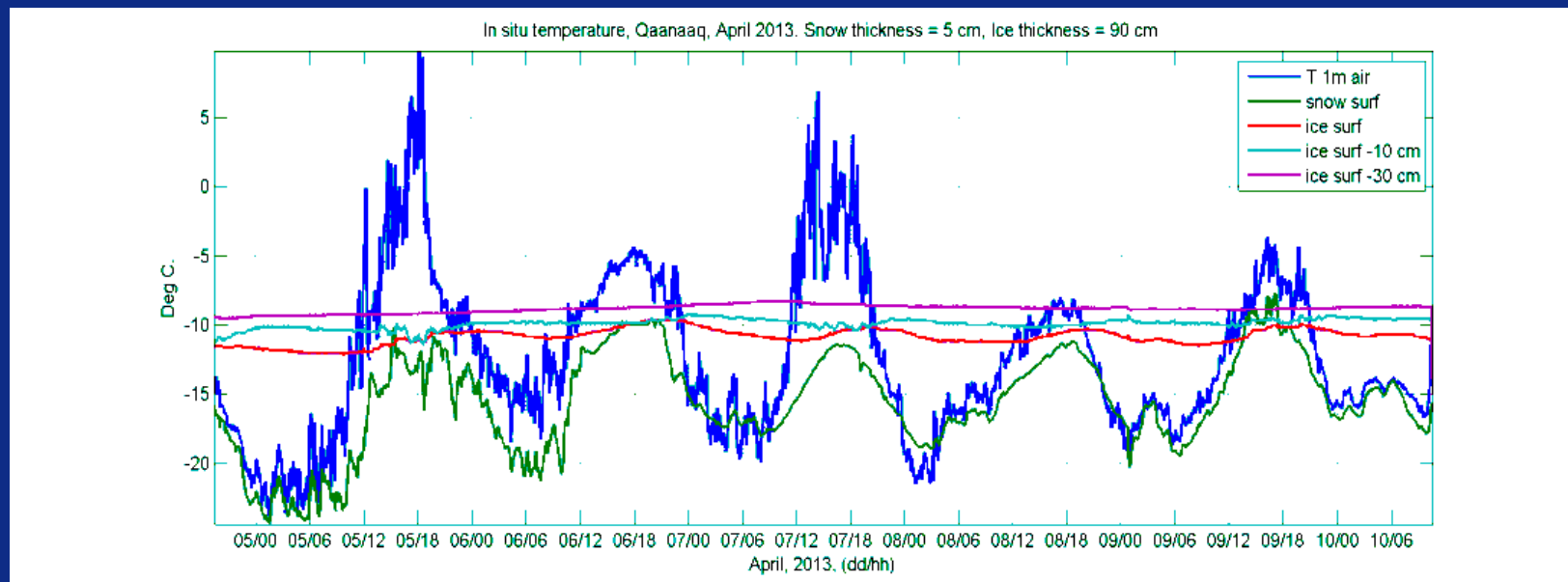
De otte områder på Indlandsisen, hvor der står målestationer, som drives af PROMICE. I hvert område står der to eller tre stationer på ben i forskellige højder. I Sydgrønland på station QAS står der tre stationer. Station QAS_L står i 310 meters højde på isen.



Vertical Temperature variability

- Large gradients within snow and sea ice
- T2m often used as proxy for IST
- Snow very effective insulator

In situ temperature at different levels



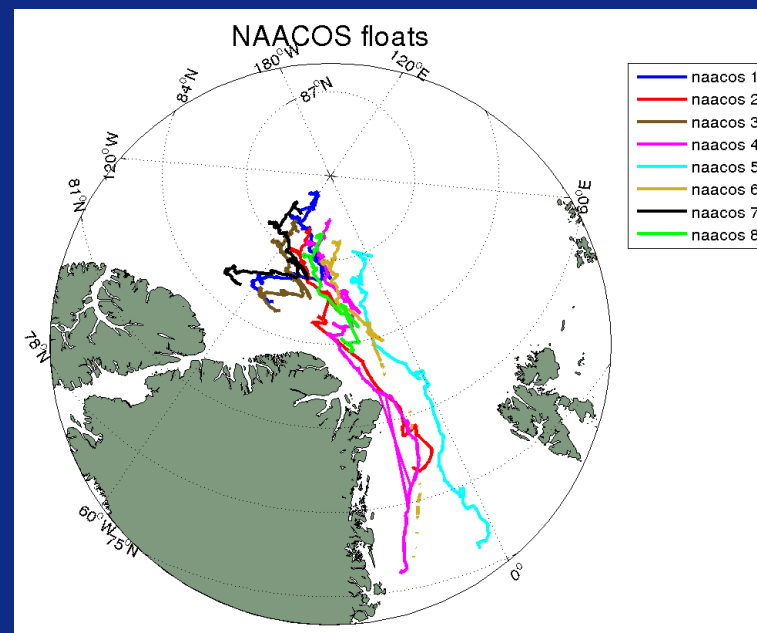
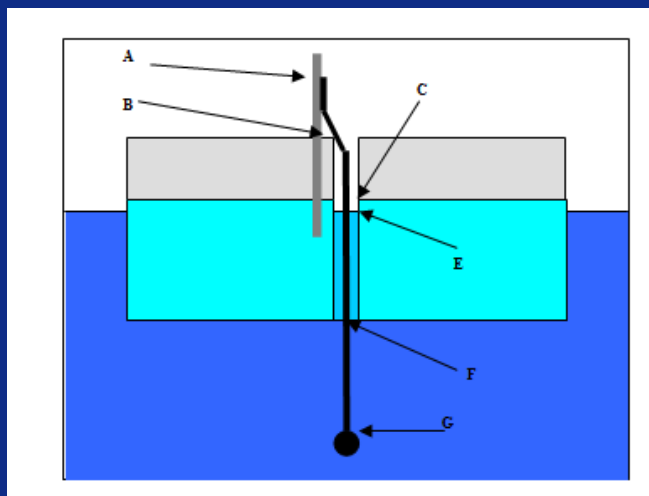


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Ice mass balance buoys

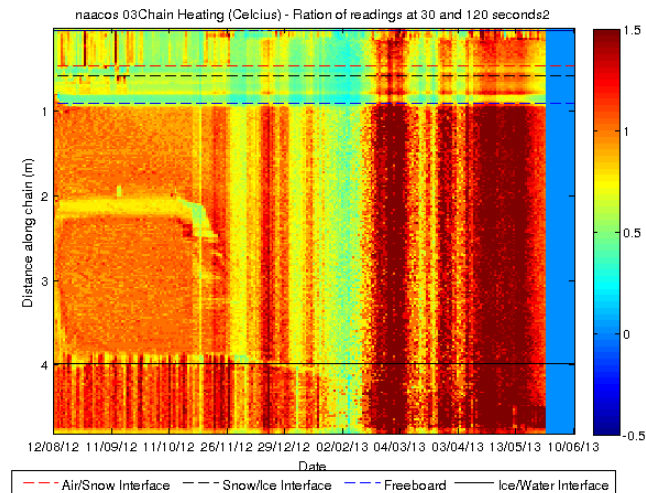
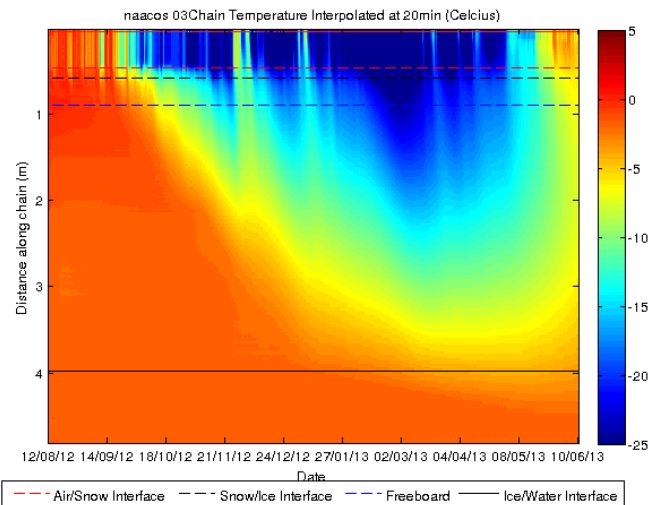
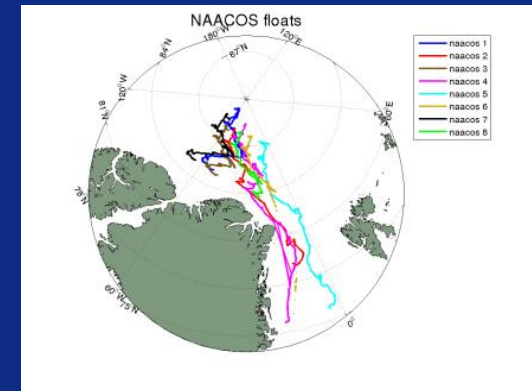
- 8 ice mass balance buoys deployed North of Greenland, summer 2012 (2-3 still alive)
- SAMS IMBs
- Sensor interval: 2 cm
- Observation: water, ice, snow and air
- Transmit data in NRT





Vertical Temperature variability

- Temperature observations from Multiyear ice floe
- 10 months data
- Initial conditions
 - ice thickness: 3.4 meters
 - 12 cm snow
 - 45 cm air





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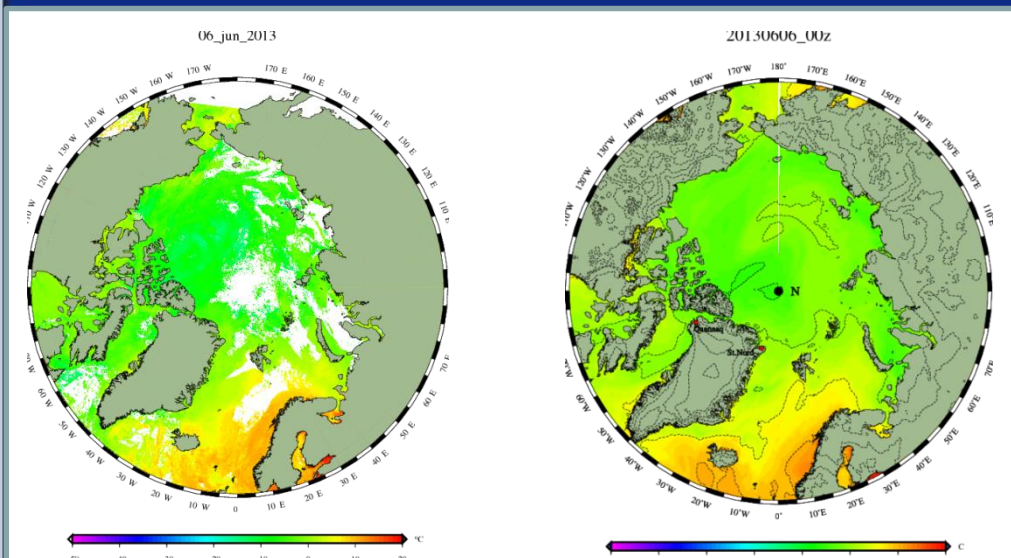
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Daily monitoring of Arctic surface temperatures

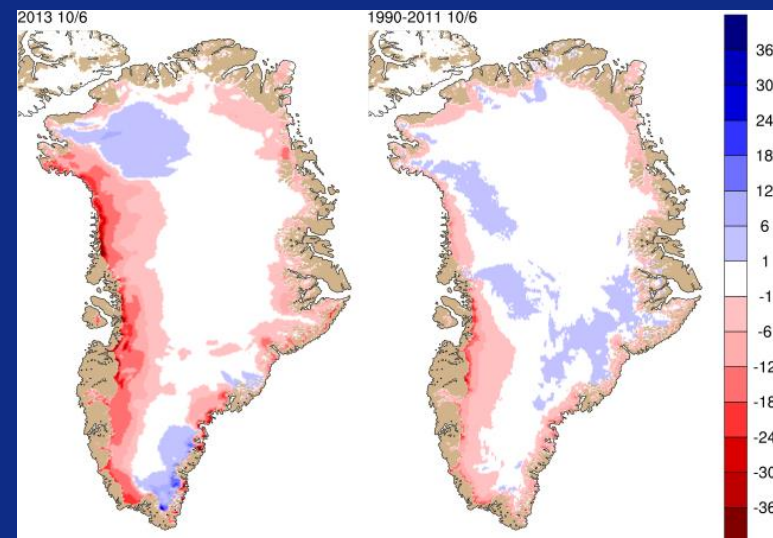
- At: ocean.dmi.dk and dmi.dk
- Figures updated every day
- New website available 21st June: polarportal.dk

Metop_A surface temp

ECMWF T 2m



Ice sheet mass balance
(climate model)





Summary

- **Several IST products out there (IR + PMW)**
- **Challenging to use the observations due to measurement uncertainty and sampling characteristics**
- **Validation results depend upon in situ observations**
- **Need for proper validation and intercomparisons**
- **Large potential for inclusion in models and reanalysis but sampling characteristics complicate assimilation**