Towards Retrieval of Cloud Liquid Water and Precipitable Water over Sea Ice and Open Ocean using AMSR(-E) data

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Overview

- Motivation: Need for CLW data over sea ice
- Retrieval Method: *R* factor, ...
- Surface Contribution *Rs*
- Application to AMSR-E data
- Conclusions

Motivation: Need and Problems of CLW data

Need:

- Polar regions sparse data for NWP
- influence
  - radiative fluxes   - sea ice balance   - sea ice retrieval
- parameterization critical to climate models

Problems:

- high and varying surface signal
- low thermal contrast
- solution proposed by Miao et al., 2000
- recent works: Haggerty et al., 2002 (airborne PMD), Lui & Curry 2003 (surface hot spots)

Retrieval Method: *R* factor

- Radiation received at sensor (Grody, 1986)

$$T_p(f) = T_s - T_s\left[1-\varepsilon_p(f)\right]\exp\left[-2\tau(f)\sec\vartheta\right]$$

with		
	$T_p(f)$	brightness temperature
	p	polarization *h, v*
	f	frequency
	T_S	surface temperature
	$\&(f)$	nadir opacity
	'	zenith angle at surface

R factor

$$R(f_1, f_2) = \ln\frac{T_v(f_1) - T_h(f_1)}{T_v(f_2) - T_h(f_2)}$$

Retrieval Method: *R* factor (2)

- *R* factor $$R(f_1, f_2) = \ln \frac{T_v(f_1) - T_h(f_1)}{T_v(f_2) - T_h(f_2)}$$

$$= R_S(f_1, f_2) + \beta(f_1, f_2) \cdot [L + \alpha_{WL}(f_1, f_2) \cdot W] + R_d(f_1, f_2)$$

with

$R_S(f_1, f_2)$	surface contribution
L	liquid water path
W	precipitable water path
$R_d(f_1, f_2)$	dry air contribution

$$\beta(f_2, f_1) = 2\sec\theta \cdot \Delta\kappa_L$$

$$\alpha_{WL}(f_1, f_2) = \frac{\Delta\kappa_W(f_1, f_2)}{\Delta\kappa_L(f_1, f_2)}$$

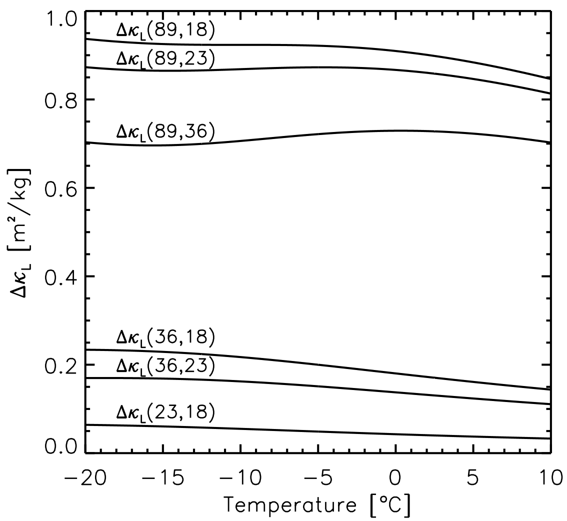
$\Delta\kappa_L(f_1, f_2)$	liquid water mass absorption coefficient difference
$\Delta\kappa_W(f_1, f_2)$	water vapor mass absorption coefficient difference

Retrieval Method: absorption coefficients

Temperature dependence and channel combinations

$\Delta\kappa_W(f_1, f_2)$: small and small dependence

$\Delta\kappa_L(f_1, f_2)$



Retrieval method: frequency combinations

Recall:

$$R = R_S + \beta \left(L + \alpha_{WL} W \right) + R_d$$

$$\beta (f_2, f_1) = 2 \sec\theta \cdot \Delta\kappa_L$$

$$\alpha_{WL} \left(f_1, f_2 \right) = \frac{\Delta\kappa_W \left(f_1, f_2 \right)}{\Delta\kappa_L \left(f_1, f_2 \right)}$$

Desired:

- α small: large CLW contribution
- β large: small surface contribution
- *Rs*: small surface contribution

Select 2 frequency combinations: 2 eqs for 2 unkowns *L, W.*

SSM/I vs. AMSR characteristics

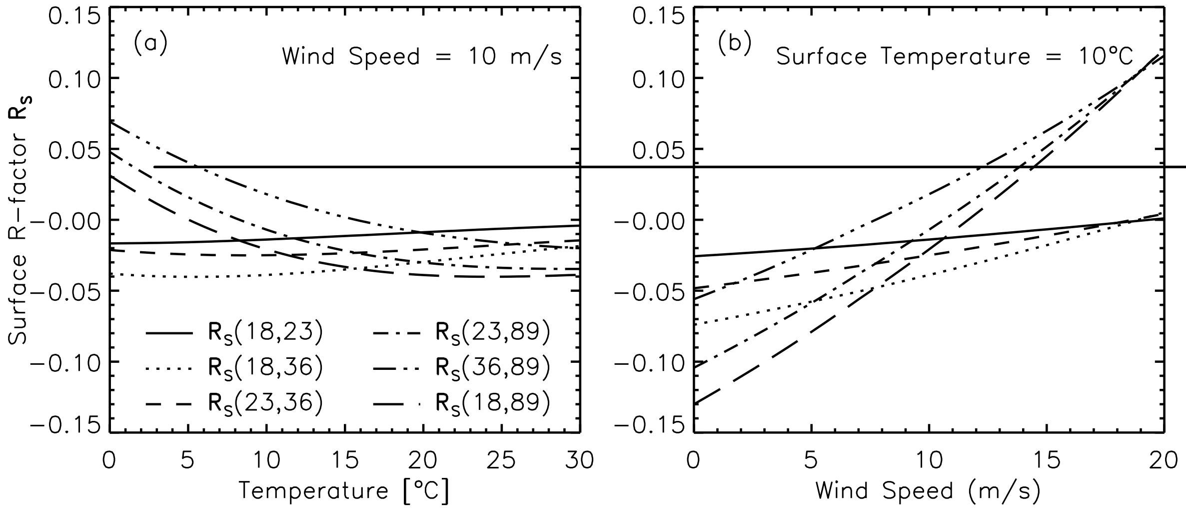
Frequency [GHz]		Resolution [km]	
SSM/I	**AMSR(-E)**	**SSM/I**	**AMSR(-E)**
-	6.9	-	71x41
-	10.7	-	46x25
19	18.7	69x43	25x15
22 V	23.8	50x50	23x14
37	36.5	37x29	14x8
85	89	15x13	6x4
-	50.3 V	-	12x6
-	52.8 V	-	12x6

All channels H + V polarisation if not indicated otherwise.
Channels near 50 GHz on AMSR only.

Surface Term *Rs*

Consider separately

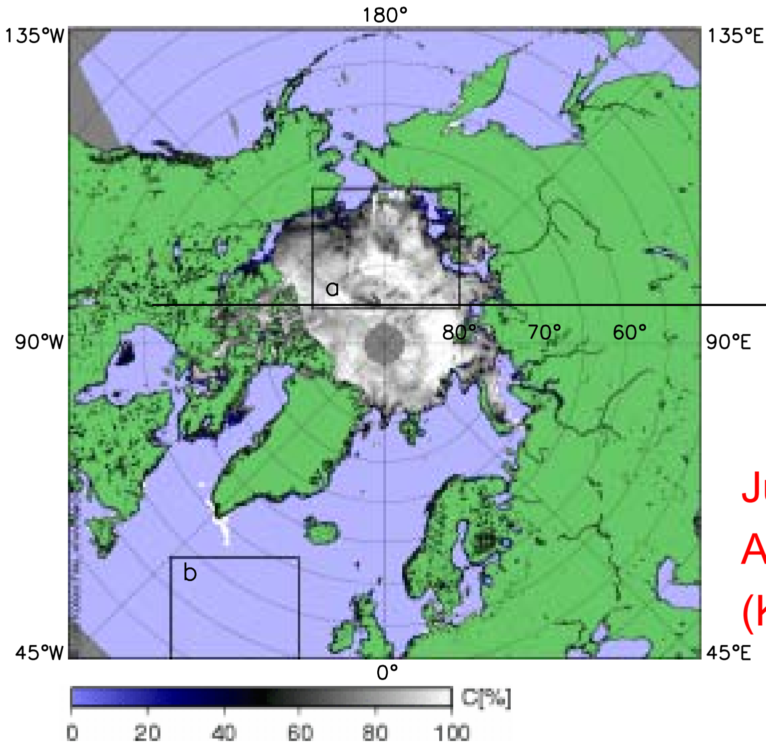
- Open Water:



Select (18,23) and (23,36)

- Sea Ice, no model available...

Regions of Interest

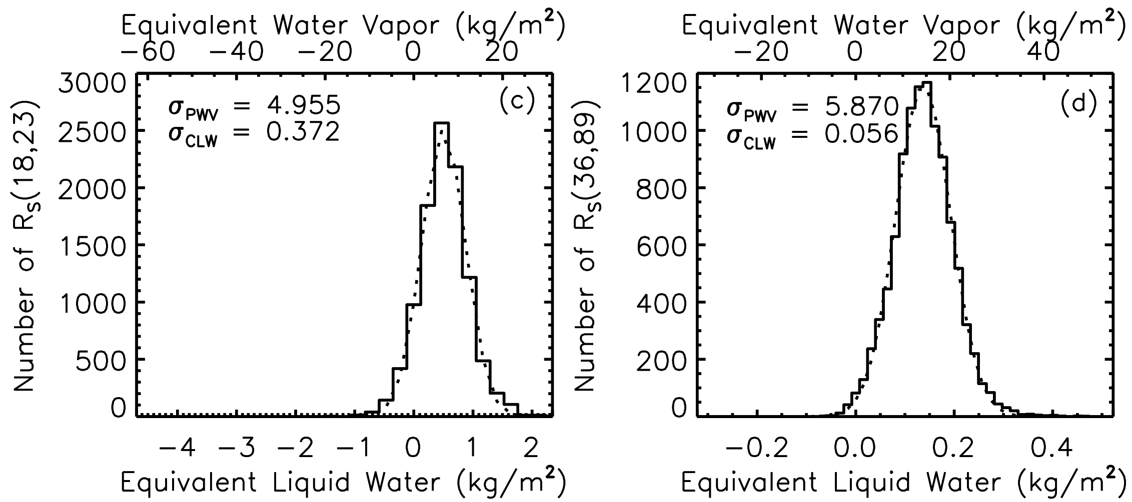


July 18, 2002,
ASI algorithm
(Kaleschke et al., 2001)

- *a*: Sea Ice
- *b*: Open Water

Surface Term *Rs* over sea ice

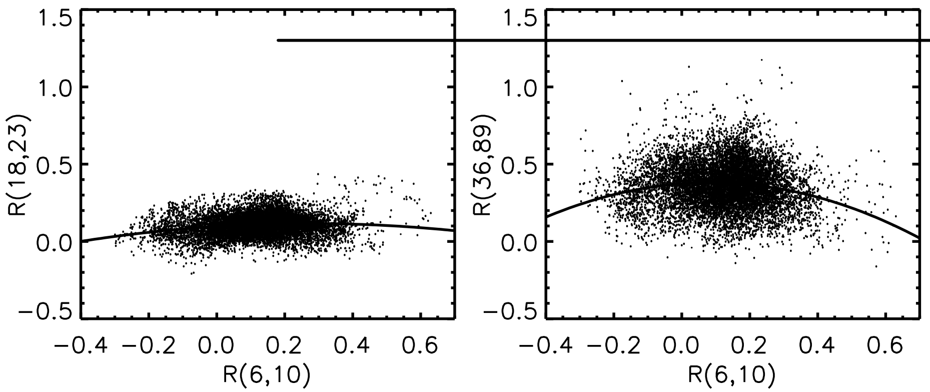
- Consider sensitivity of CLW to *Rs* variations
- Select clear sky subregion of region *a*
- all variations in *R* from *Rs*
- Convert *Rs* variations to equivalent PWV and CLW



- Select channel combination with minimum sensitivity (variance):
  (18,23), and (36,89) GHz

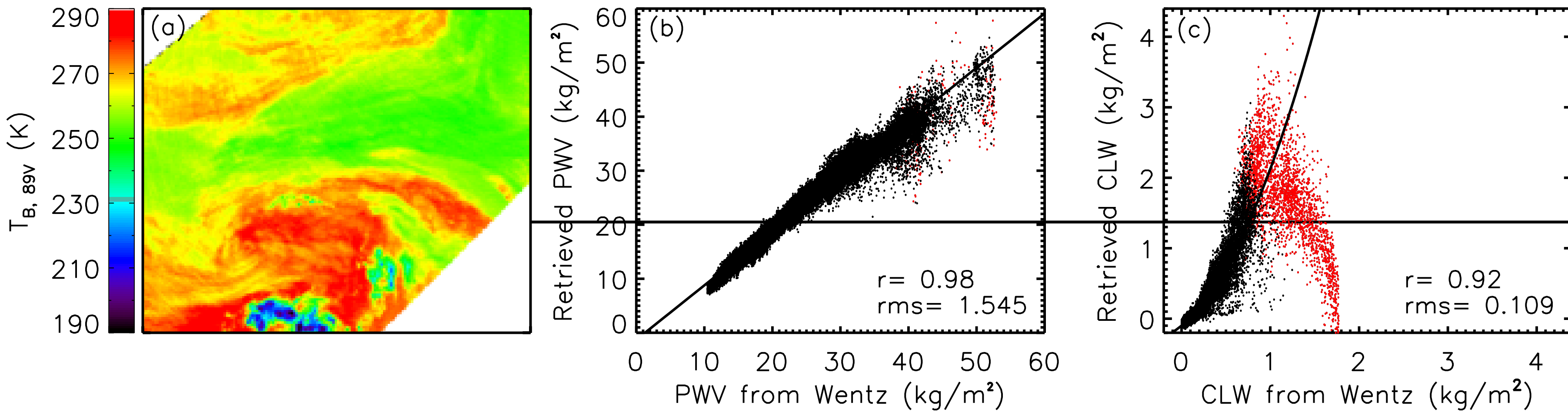
Surface Term *Rs* over sea ice

- Miao et al. (2000) temporal variability
- Use *R*(6,10) under clear conditions to estimate *R*(36,89) and *R*(18,23)
- *R*(6,10) little influenced by atmoshere



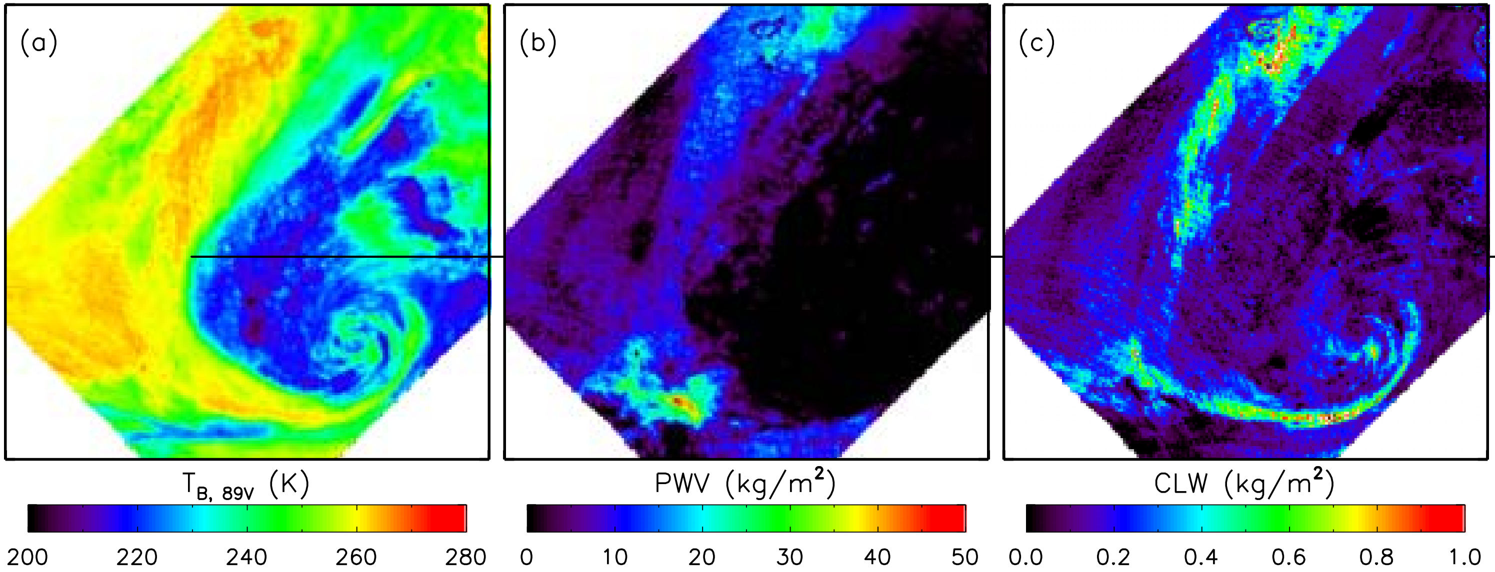
- weak dependence

Applications: Open Ocean (region *b*)



- compare to results of Wentz of July 17, 2002
- exclude precipitating cases (*Tb* (36V) > 240K)
- PWV: correlation all data r=0.98, below 35 kg/m2 stronger
- CLW: non-linear relation
- deviations potentially caused by scattering cloud ice

Applications: Sea Ice (region *a*)



- Cloud System of July 18, 2002
- CLW typical feature over meteorological front
- PWV seem low

Conclusions

Retrieval of CLW and PWV over sea ice and open ocean

- appears feasible
- more knowledge about surface influence required
- concept of *R* factor may be noise sensitive, other approaches also considered

- work continued within the framework of the EU project **IOMASA**: Integrated Observing and Modeling of the Arctic Surface and Atmosphere, participating
  - UB: University of Bremen, Institute of Environmental Physics (Co-ordinator)
  - DTU-DCRS: Danish Center for Remote Sensing, TU Denmark
  - DMI: Danish Meteorological Institute
  - met.no: The Norwegian Meteorological Institute
  - SMHI: Swedish Meteorological and Hydrological Institute

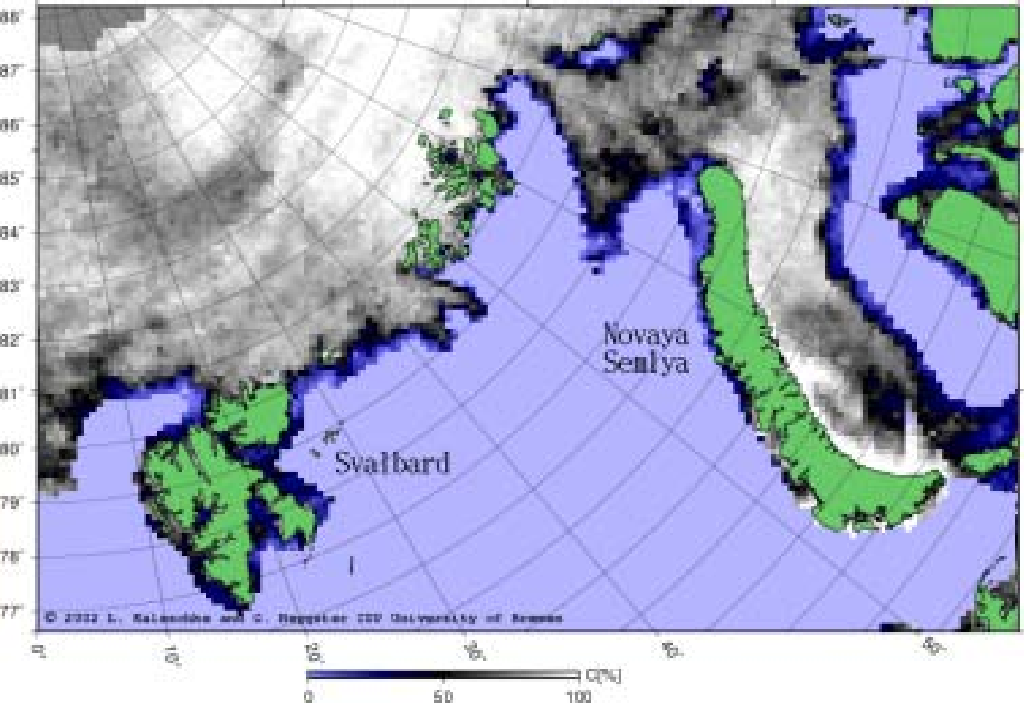
Outlook: IOMASA project parts

- Part 1: Atmospheric Remote Sensing : UB
- Part 2: Numerical Weather Prediction Models: met.no, SMHI
- Part 3: Empirical Model for emissivity and backscatter of sea ice: DTU-DCRS
- Part 4: Sea ice concentration retrieval: DMI
- Part 5: Real time processing and user interface: DTU-DCRS

IOMASA

- accounts for the interdependencies of Arctic atmosphere and surface
- improves weather forecasts and ice analyses

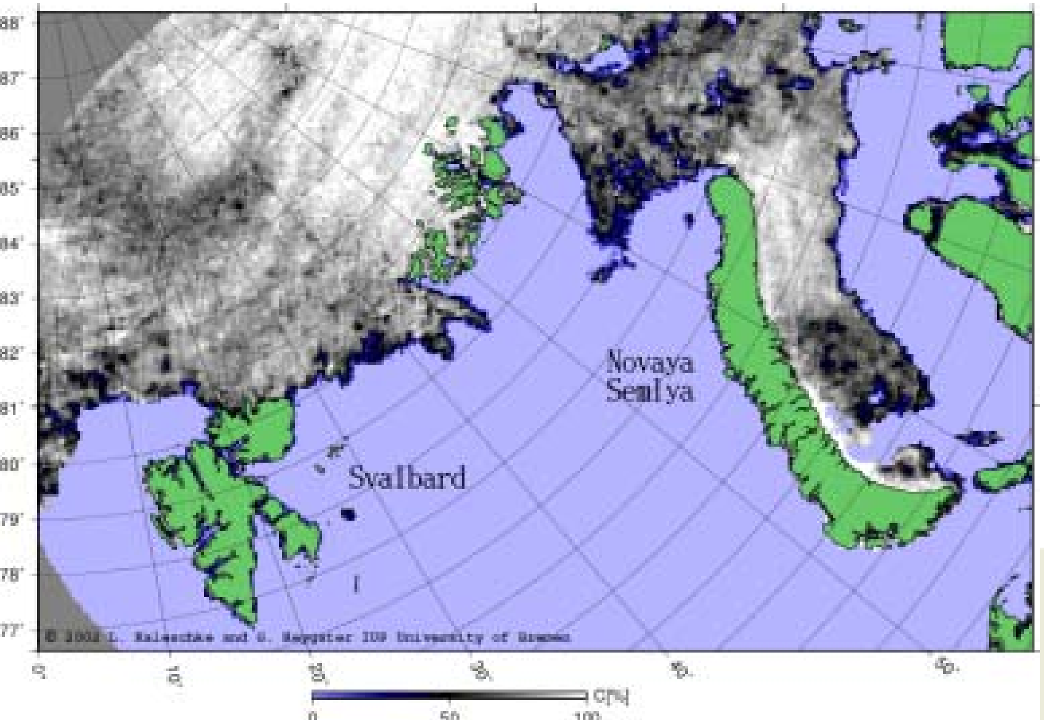
AMSR-E Sea Ice



SSM/I ASI, 15 km res. @ 85GHz

for daily data see

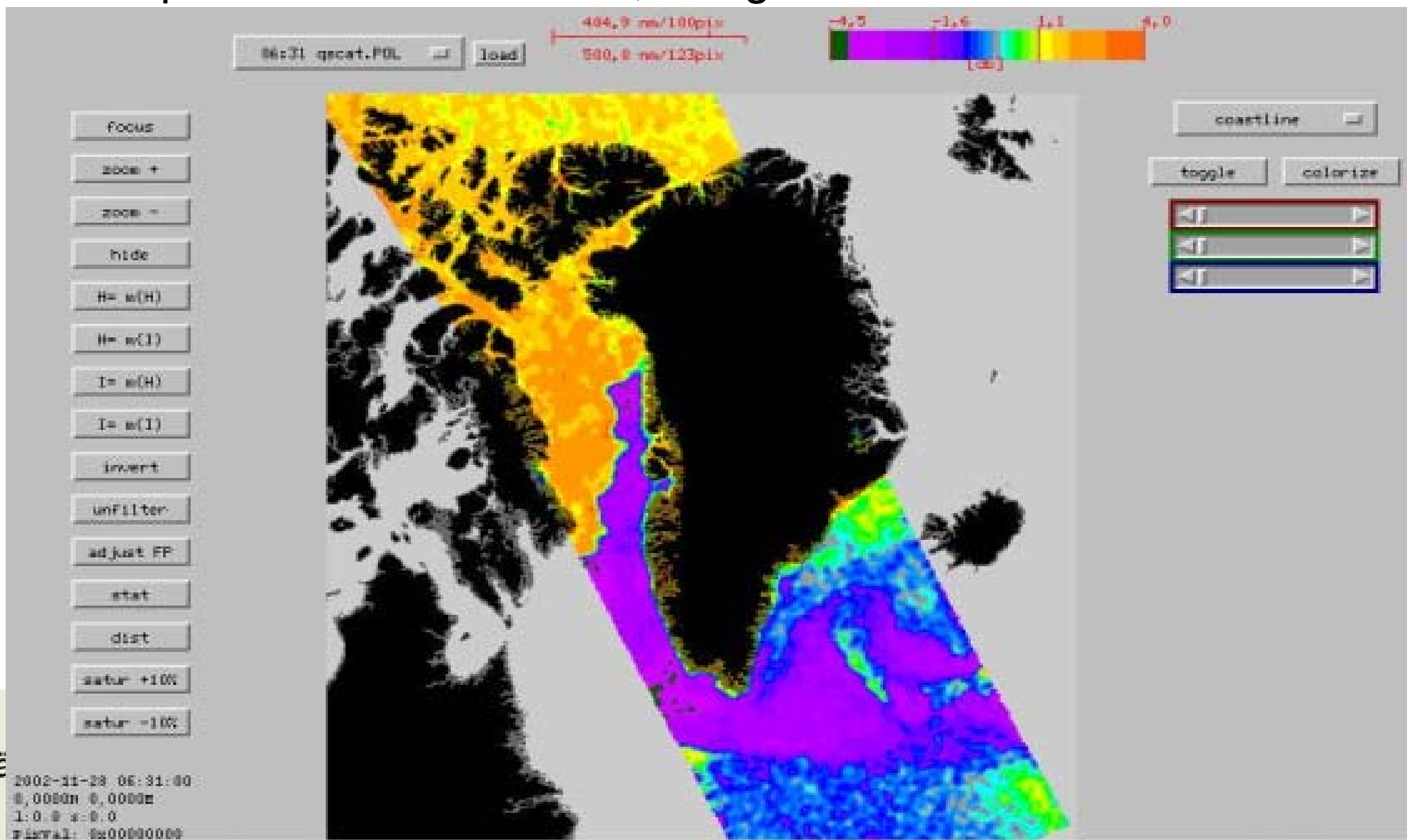
www.seaice.de



AMSR ASI, 6 km res.@ 89 GHz

Part 5 (DTU): Real Time Processing and User Interface

- NWP models: met.no, SMHI, operational chains
- Sea Ice: DMI
- Distribution to public users: DCRS, using IWICOS interface...



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