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Cloud screening method particularly feasible for snow cover mapping

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LPVE Workshop
ESA, Esrin
28-30 Jan 2014

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due
data user element

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Motivation

- Need for cloud screening algorithm in ESA DUE-GlobSnow project (2009 -)
- Project team could not identify a suitable method for Envisat/AATSR, particularly for fractional snow mapping purposes
- Undetected clouds usually lead to false snow identification
- Very conservative cloud mask may reduce the area for snow mapping
  - Problems over snow-covered boreal forests and at the edges of snow-covered terrain or at thin snow cover
- Official AATSR cloud mask (provided in level 1b) presents severe false cloud commissions over land areas

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Framework for method development

- No need to identify all (small/semi-transparent) clouds in confident snow-free areas
- Cloud screening is targeted, not cloud classification → binary information, no classes, no propabilities

- Must be relatively simple and computationally fast
- Must be applicable for Northern Hemisphere, no regional/local tuning
- Must not confuse between fractional snow and clouds (it's the fractional snow we want to see!)
- Should work particularly over seasonally snow-covered areas and throughout the potential snow season

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Major features of SCDA2.0

- Simple Cloud Detection Algorithm
- Designed to work with only a few spectral bands
  - common for Terra/MODIS, Envisat/AATSR, ERS-2/ATSR-2, NPP Suomi/VIIRS → R550, R1.6, BT3.7, BT11, BT12
- Based on empirically determined thresholds for single bands and their ratios
  - Driven by BT11-BT3.7
  - Ratio NDSI / R550 important in avoiding false cloud commissions
  - Several other test for BT12, R550 and NDSI

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GlobSnow Snow Extent Product

Daily Fractional Snow Cover (DFSC)

Version 2.0

Fractional Snow Cover (FSC) - Steps of 1% in product

100% 75% 50% 25% 0%

Layer-1 values when FSC is not retrieved

Water | Glacier | Not mapped in product time frame | Too low solar angle for snow retrieval | Missing or invalid satellite data | Cloud | Snow retrieval algorithm breakdown | No snow retrieval algorithm applicable

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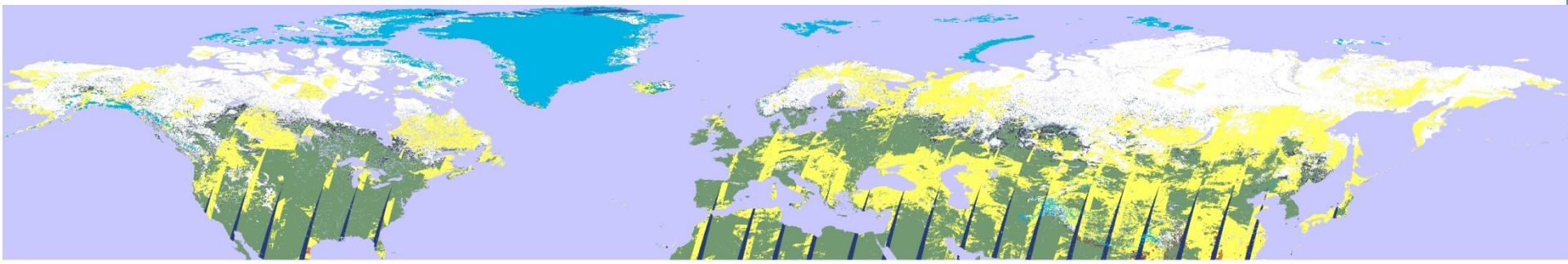

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GlobSnow Snow Extent Product

Weekly Aggregated Fractional Snow Cover (WFSC)

Version 2.0

Fractional Snow Cover (FSC) - Steps of 1% in product

100% 75% 50% 25% 0%

Layer-1 values when FSC is not retrieved

Water | Glacier | Not mapped in product time frame | Too low solar angle for snow retrieval | Missing or invalid satellite data | Cloud | Snow retrieval algorithm breakdown | No snow retrieval algorithm applicable

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GlobSnow Snow Extent Product

Monthly Aggregated Fractional Snow Cover (MFSC)

Version 2.0

Fractional Snow Cover (FSC) - Steps of 1% in product

100% 75% 50% 25% 0%

Layer-1 values when FSC is not retrieved

Water | Glacier | Not mapped in product time frame | Too low solar angle for snow retrieval | Missing or invalid satellite data | Cloud | Snow retrieval algorithm breakdown | No snow retrieval algorithm applicable

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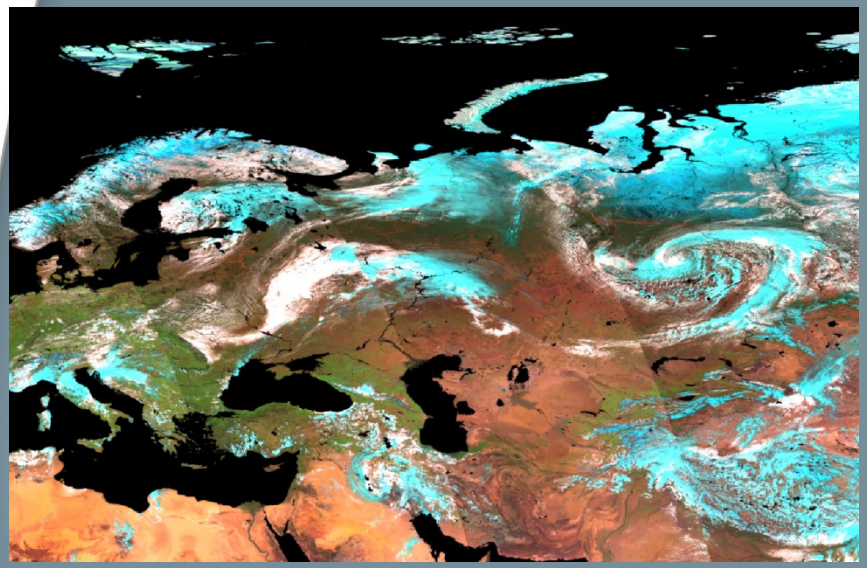
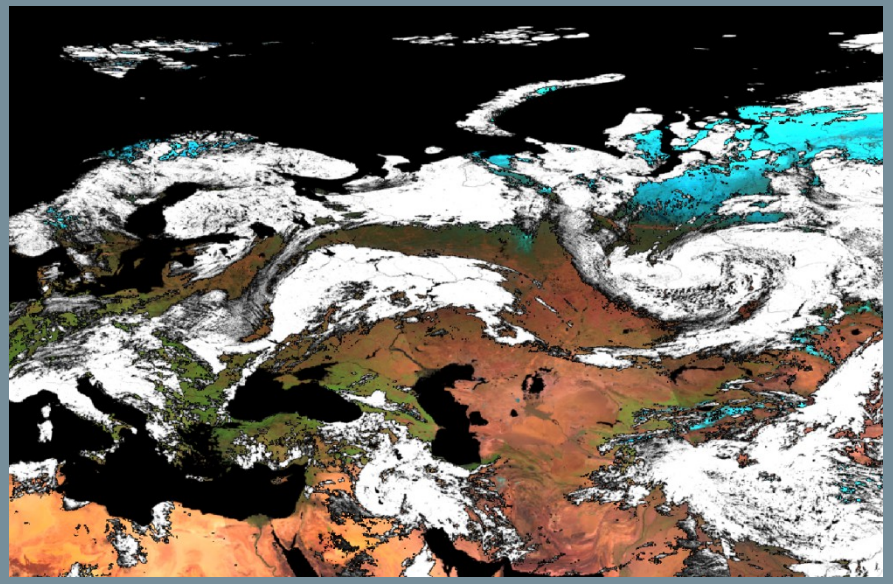
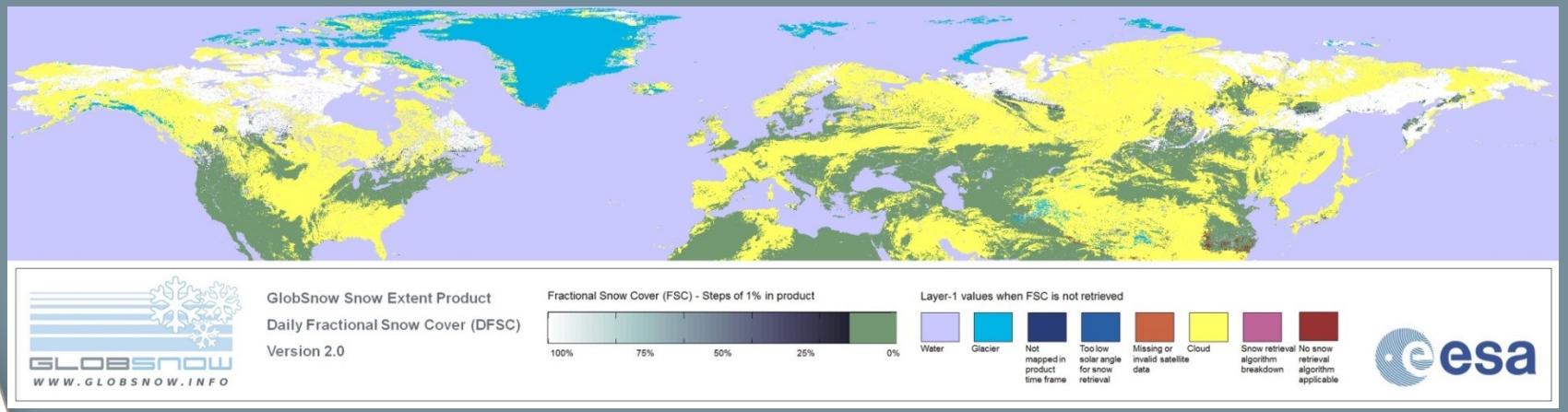
Cloud masks for GlobSnow-2 SE-product from NPP Suomi/VIIRS







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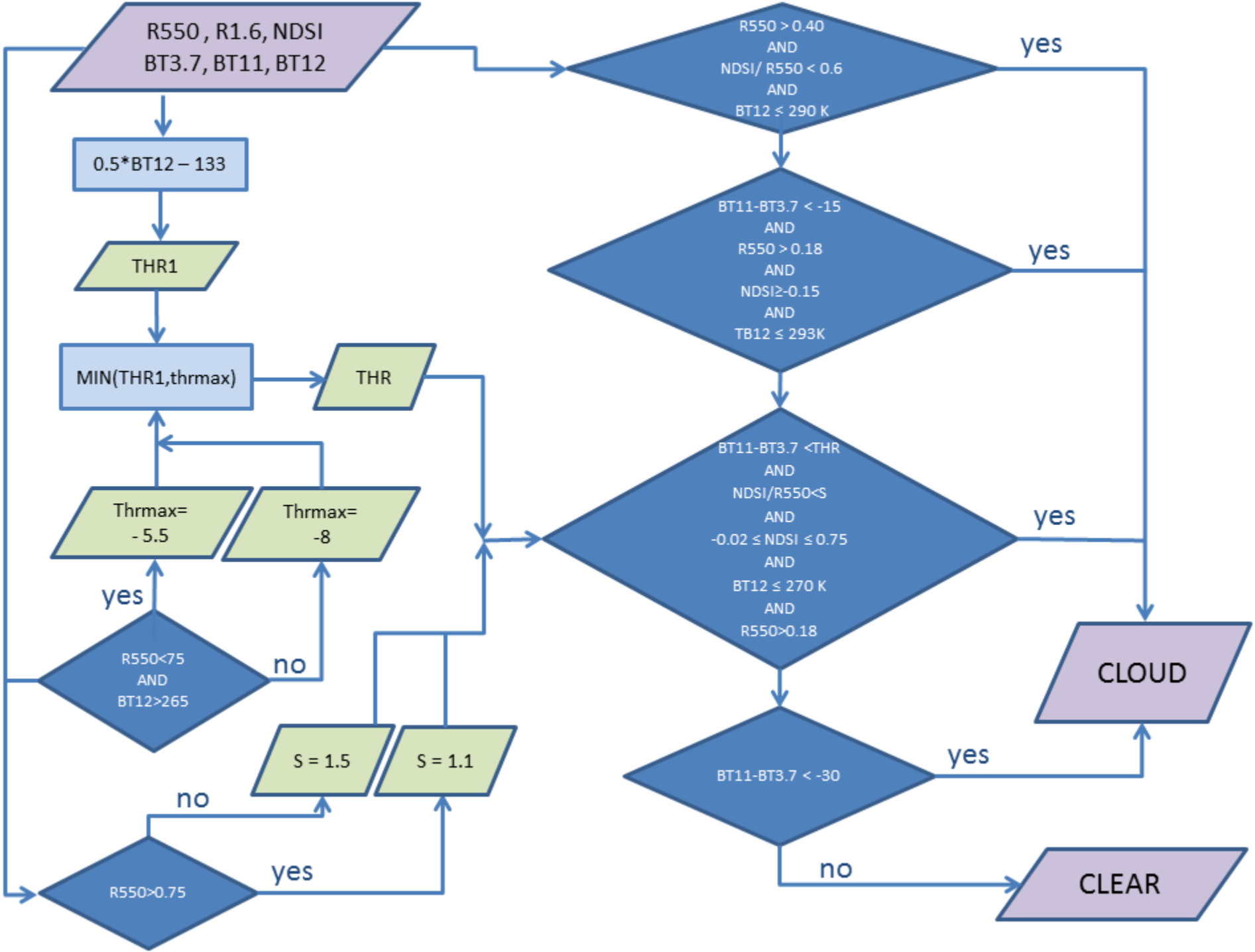
R550 , R1.6, NDSI
BT3.7, BT11, BT12
0.5*BT12 – 133
THR1
MIN(THR1,thrmax)
THR
Thrmax=
- 5.5
Thrmax=
-8
yes
R550<75
AND
BT12>265
no
S = 1.5
S = 1.1
no
R550>0.75
yes
R550 > 0.40
AND
NDSI/ R550 < 0.6
AND
BT12 ≤ 290 K
yes
BT11-BT3.7 < -15
AND
R550 > 0.18
AND
NDSI≥-0.15
AND
TB12 ≤ 293K
yes
BT11-BT3.7 <THR
AND
NDSI/R550<S
AND
-0.02 ≤ NDSI ≤ 0.75
AND
BT12 ≤ 270 K
AND
R550>0.18
yes
CLOUD
BT11-BT3.7 < -30
yes
no
CLEAR

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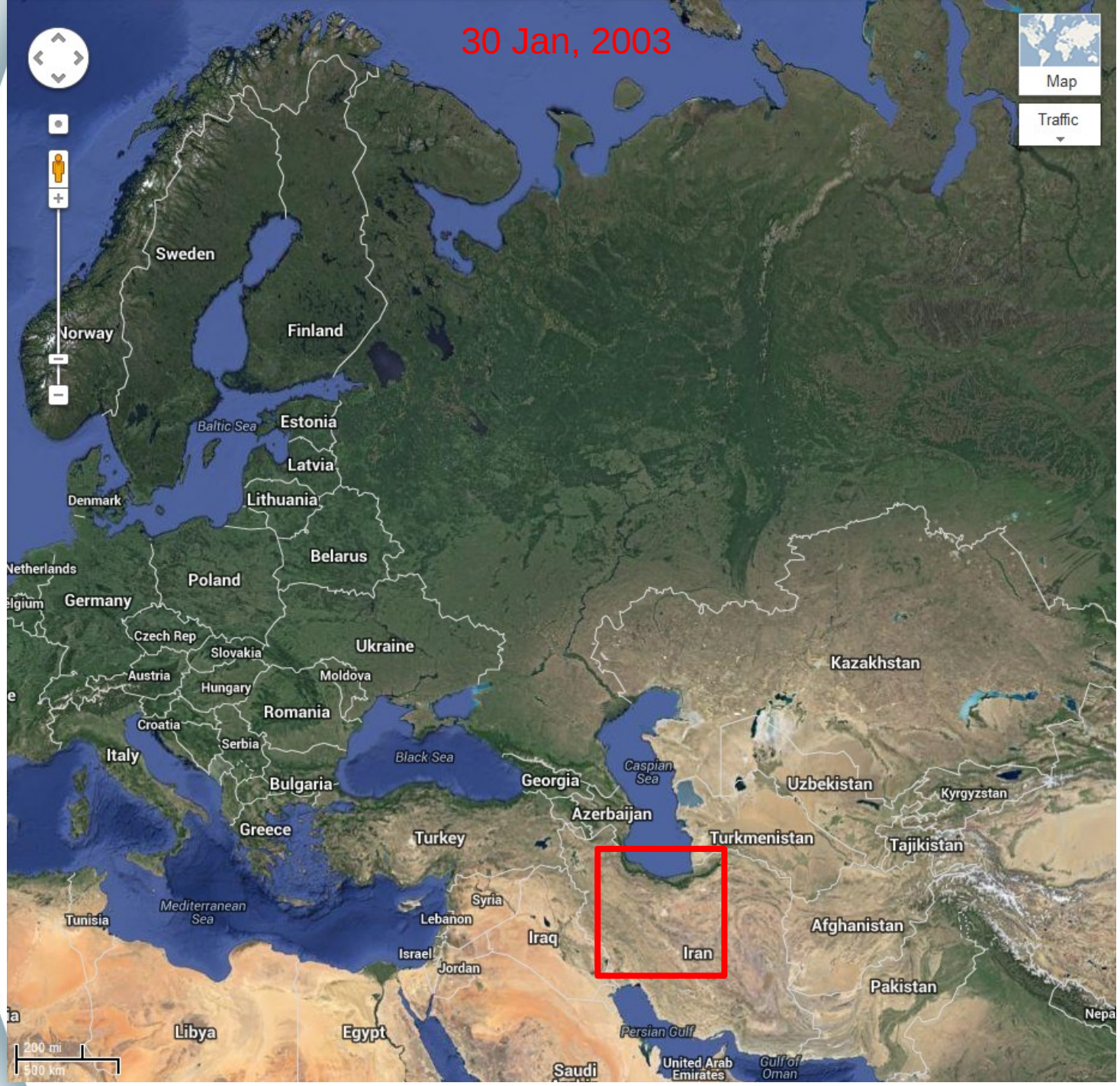

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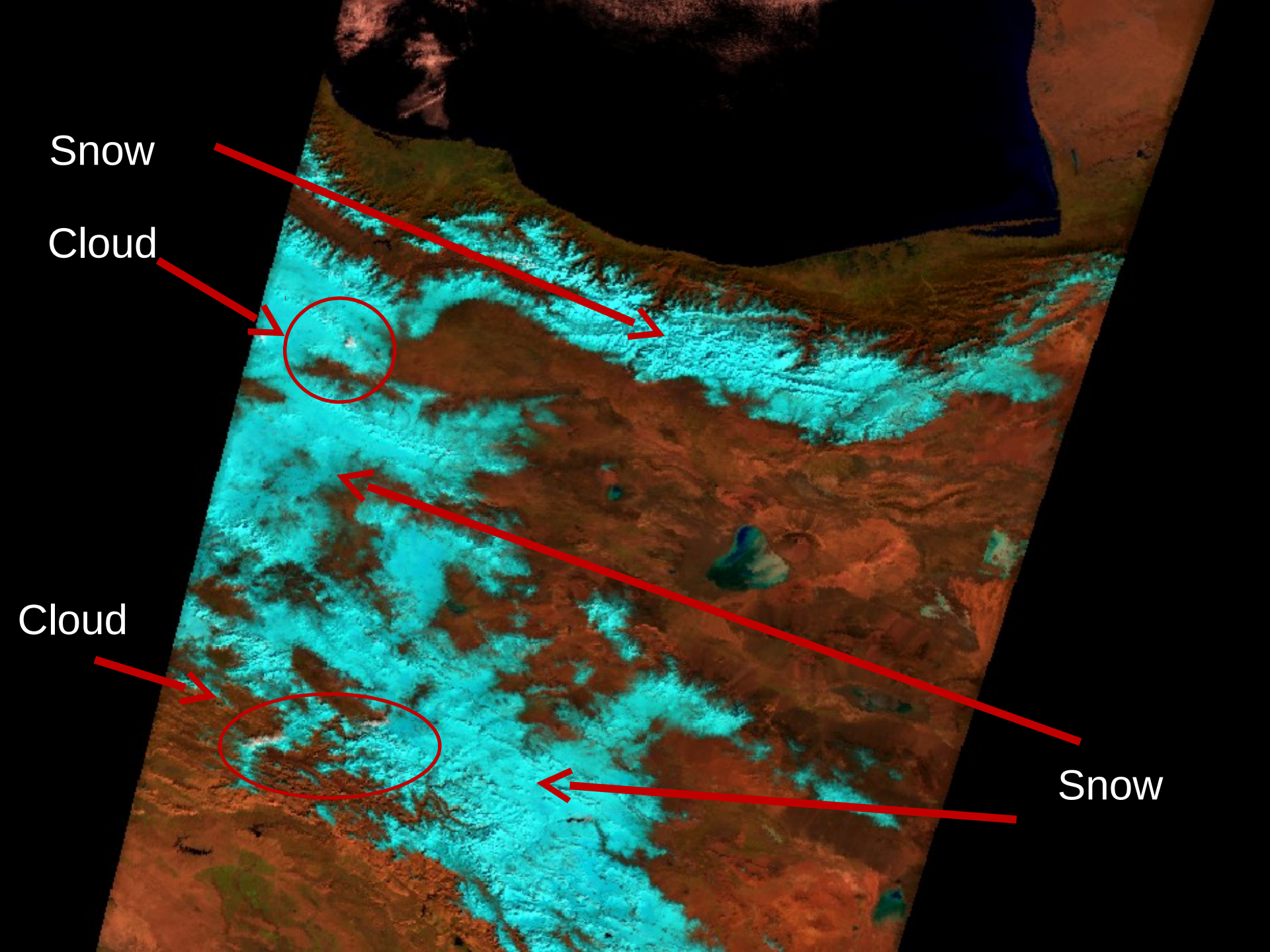
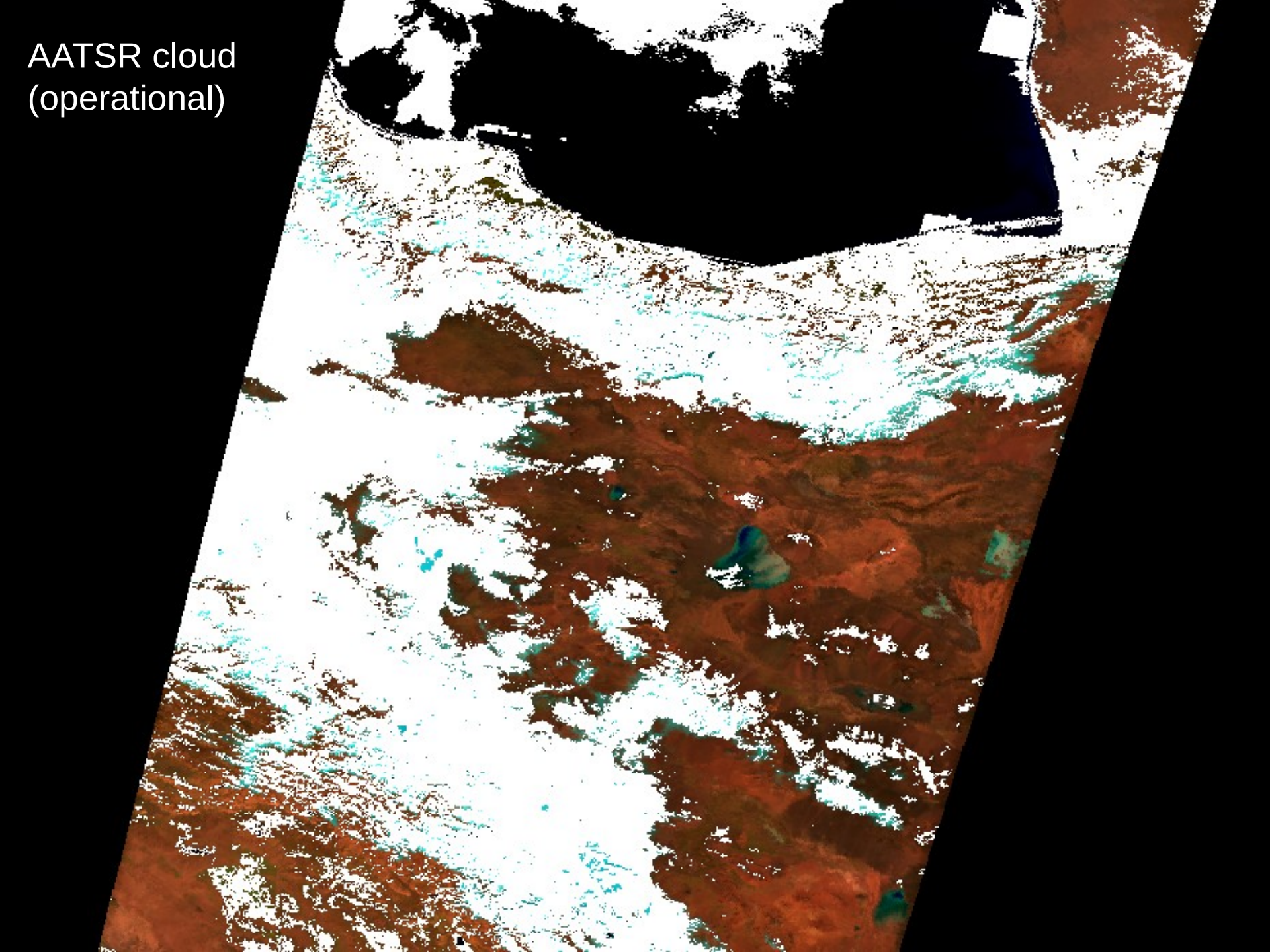
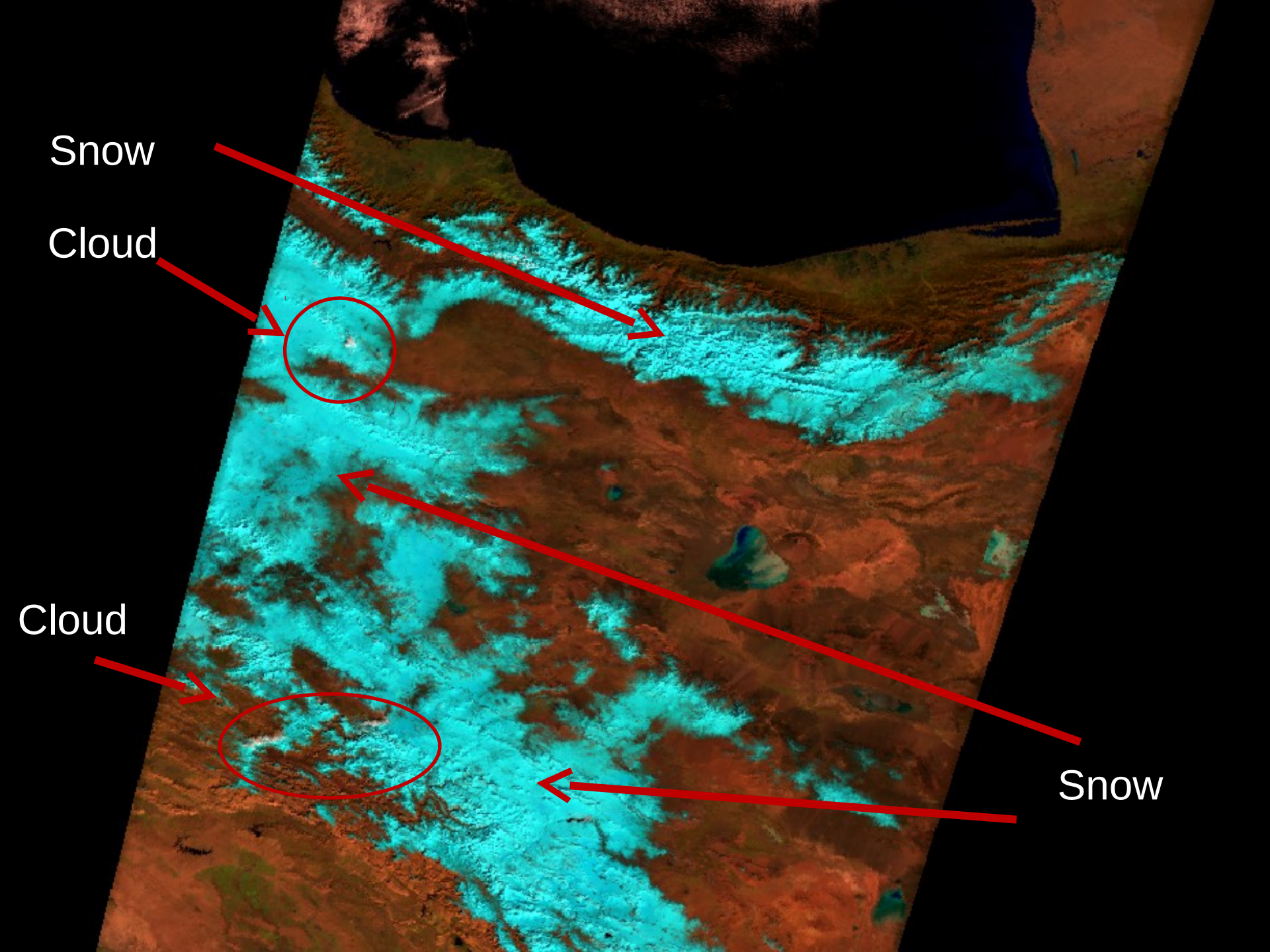
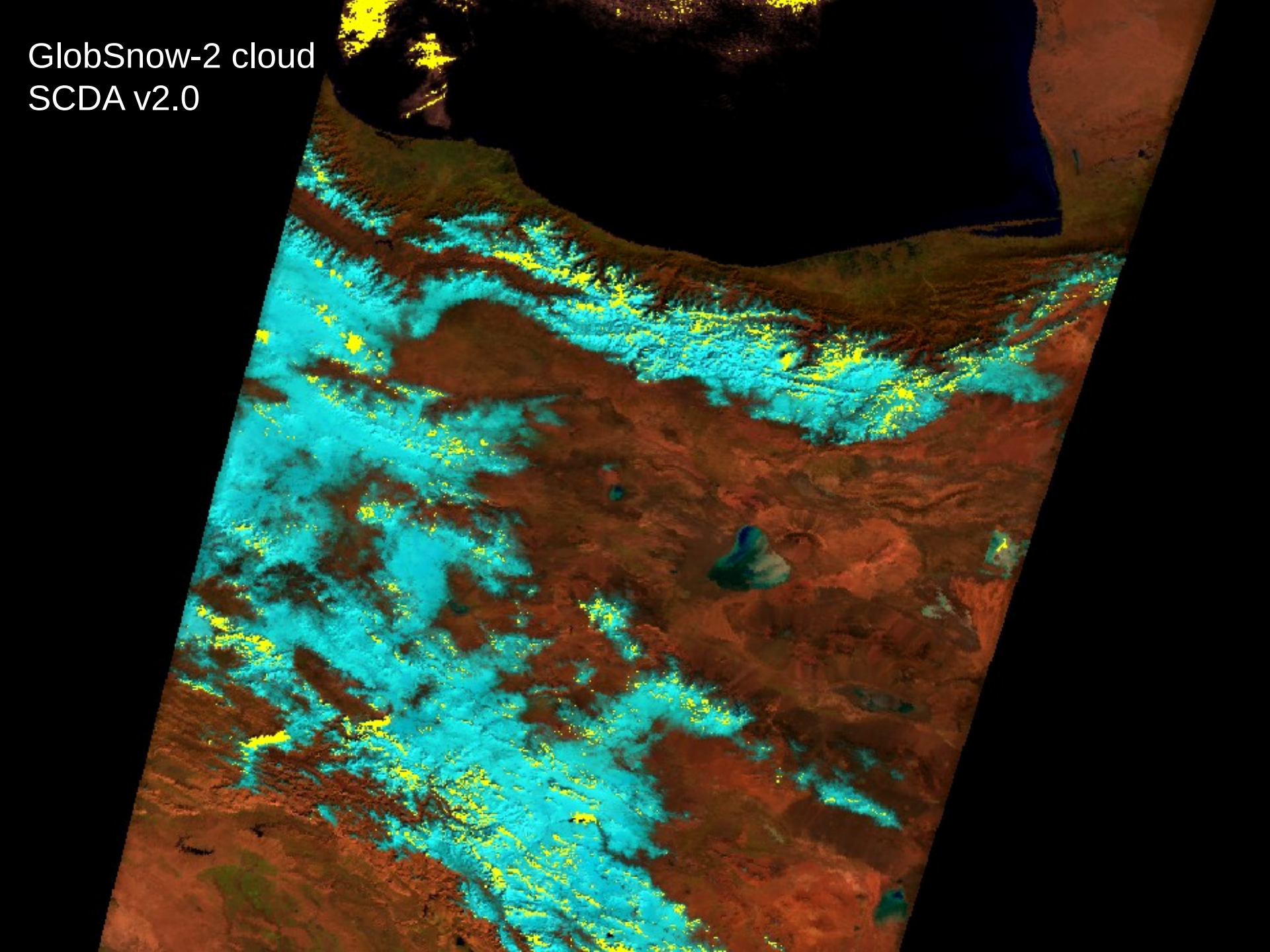
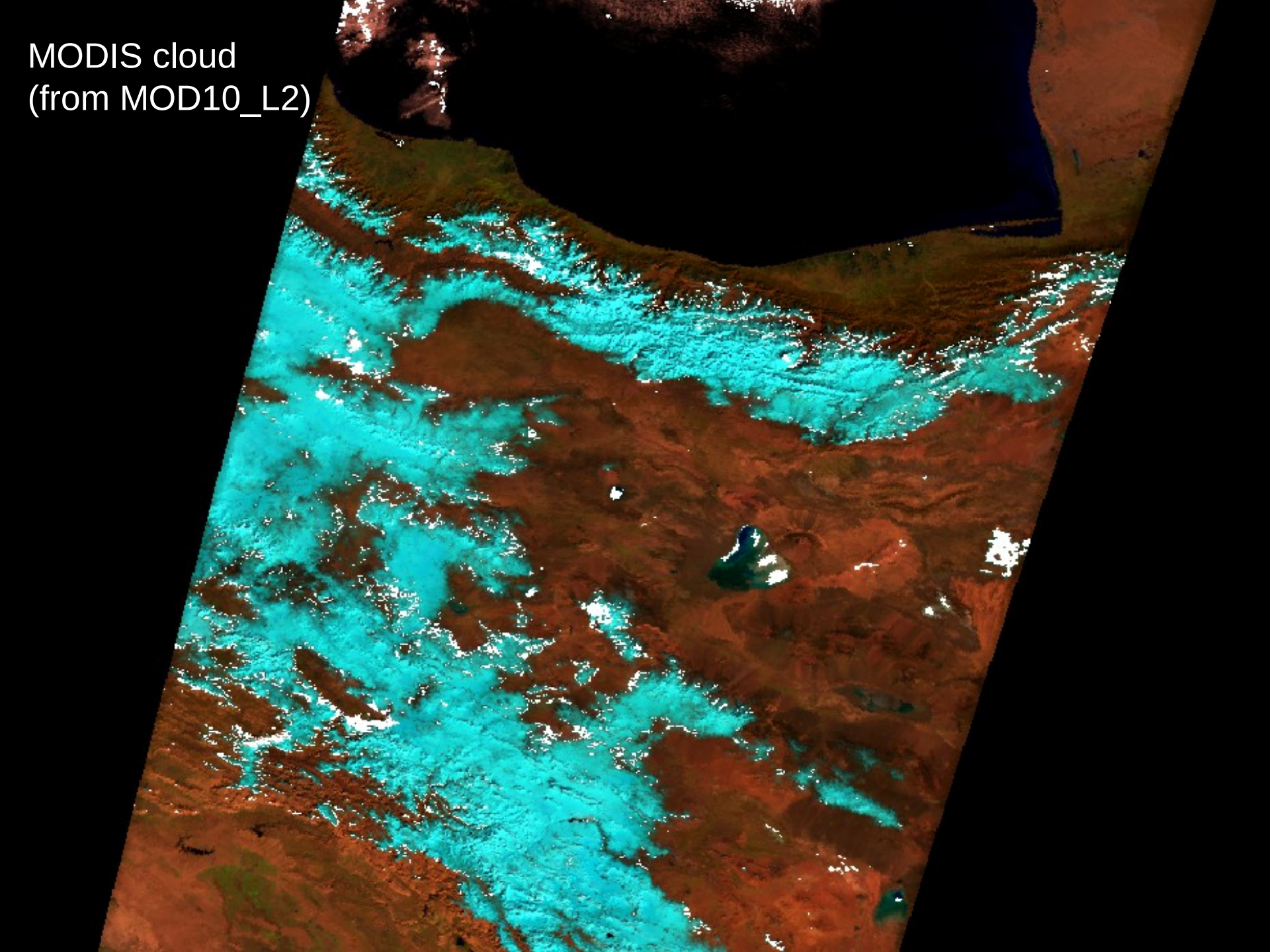

Snow
Cloud
Cloud
Snow


AATSR cloud
(operational)

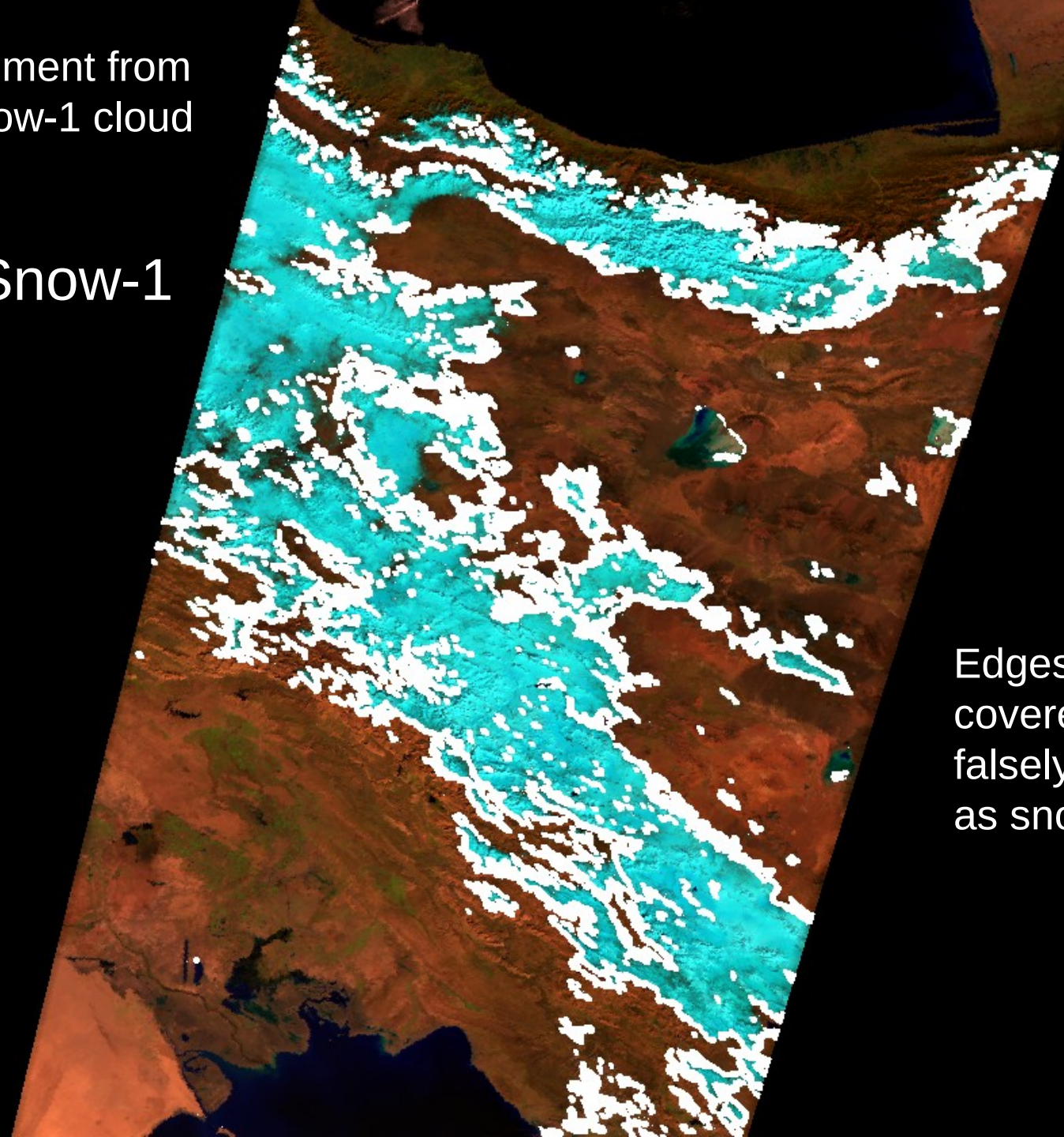

Snow
Cloud
Cloud
Snow


GlobSnow-2 cloud
SCDA v2.0


MODIS cloud
(from MOD10_L2)

Improvement from GlobSnow-1 cloud mask :

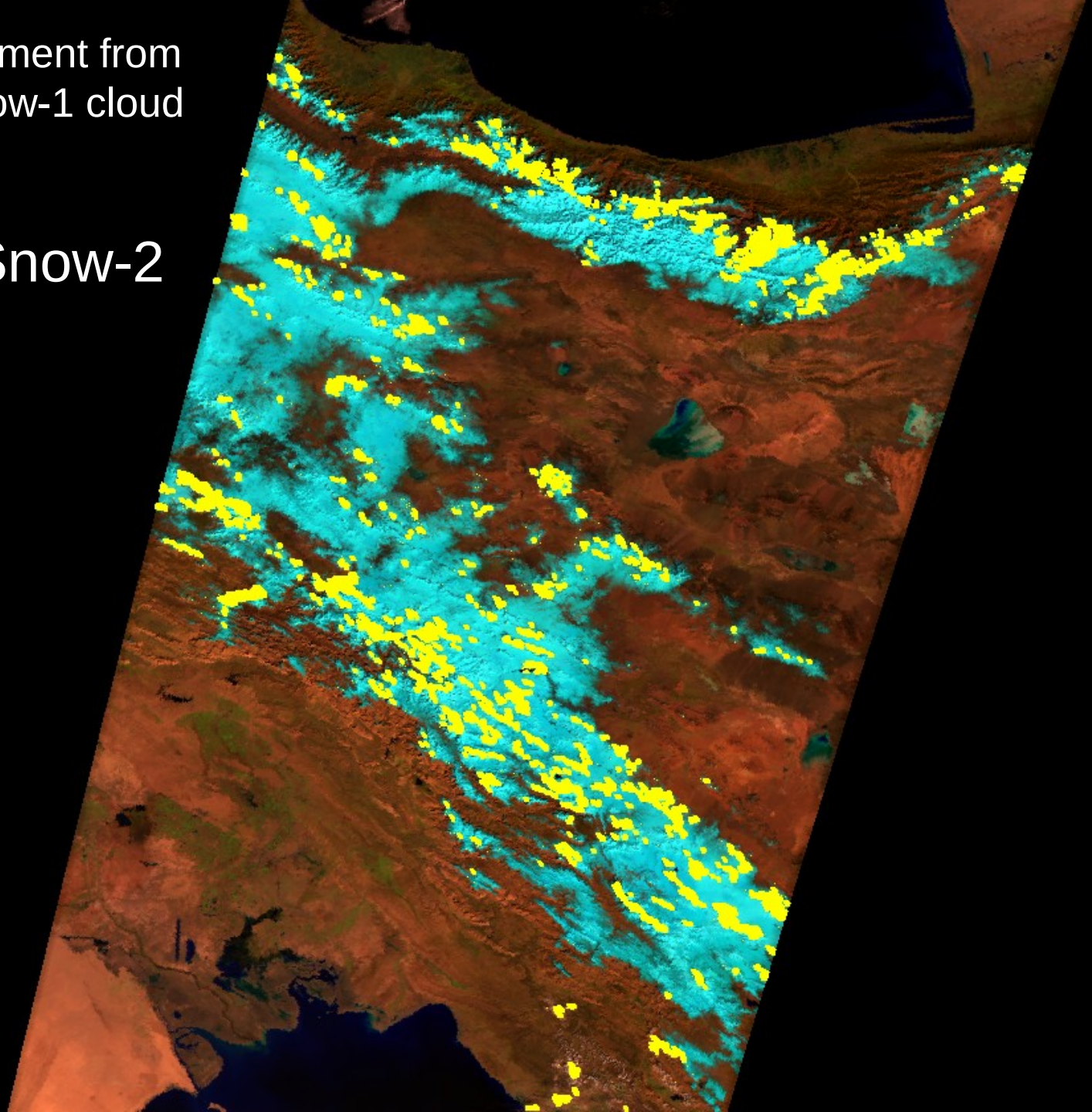
GlobSnow-1



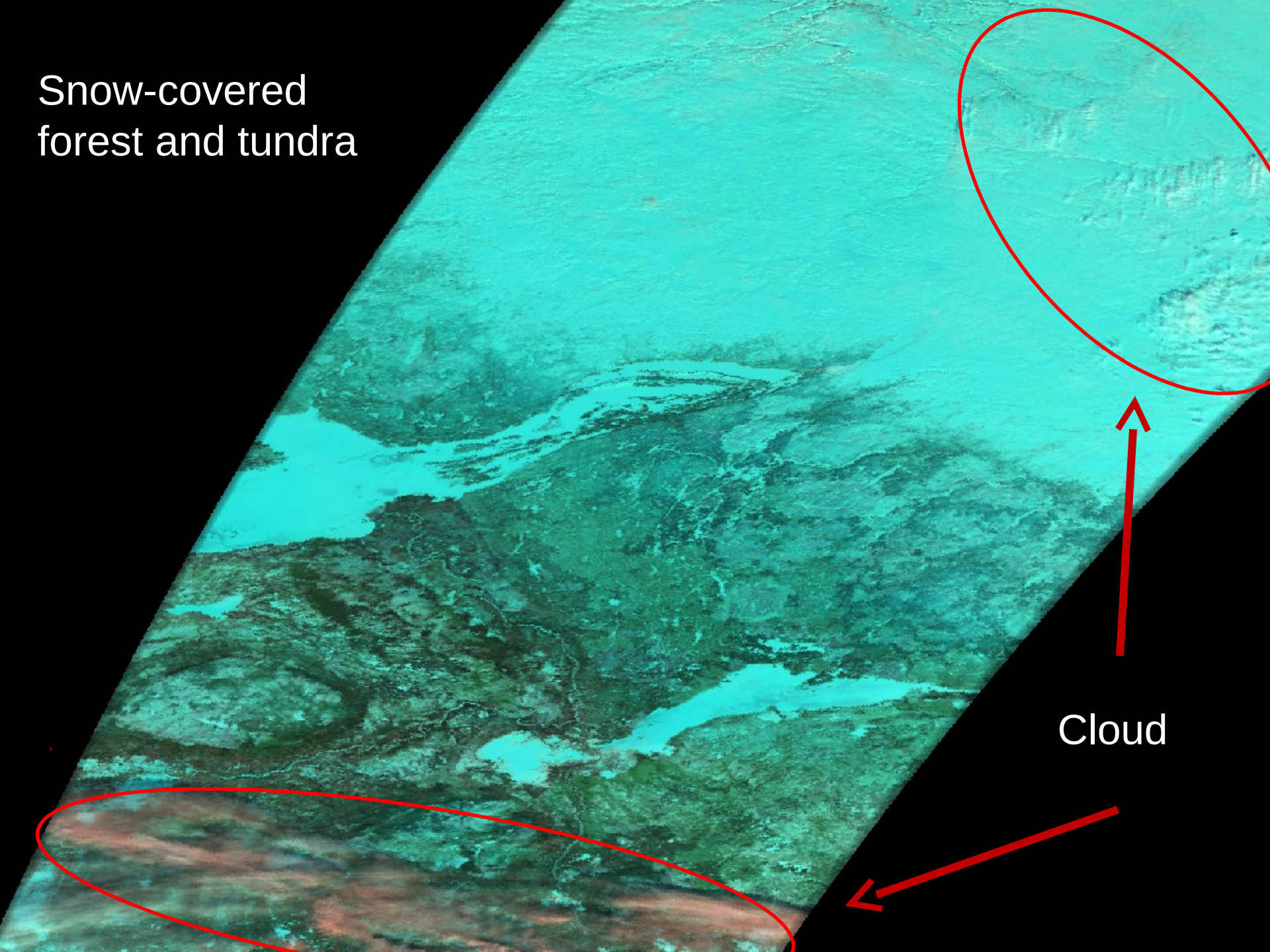
Edges of snow-covered area falsely interpreted as snow

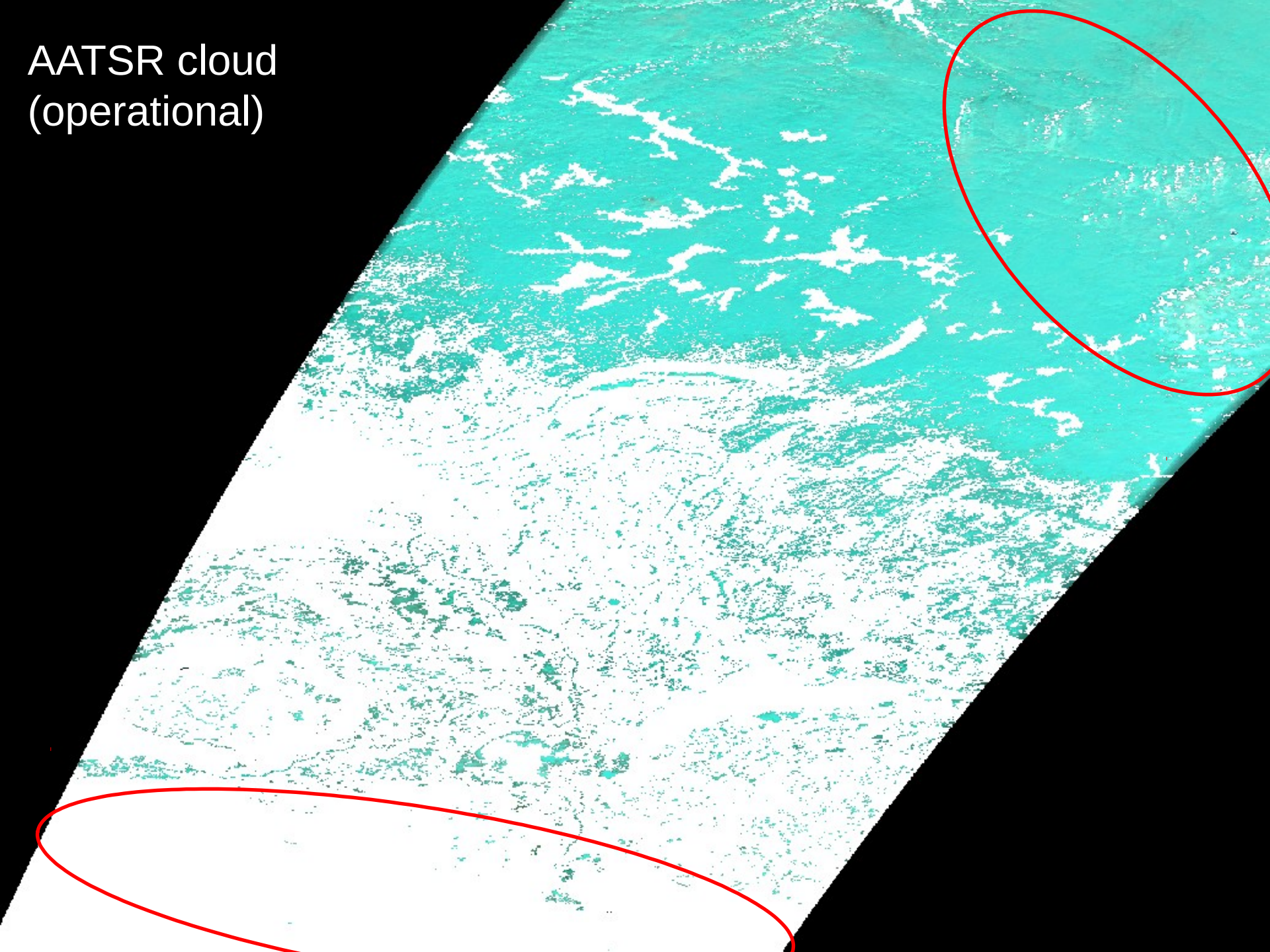
Improvement from GlobSnow-1 cloud mask :

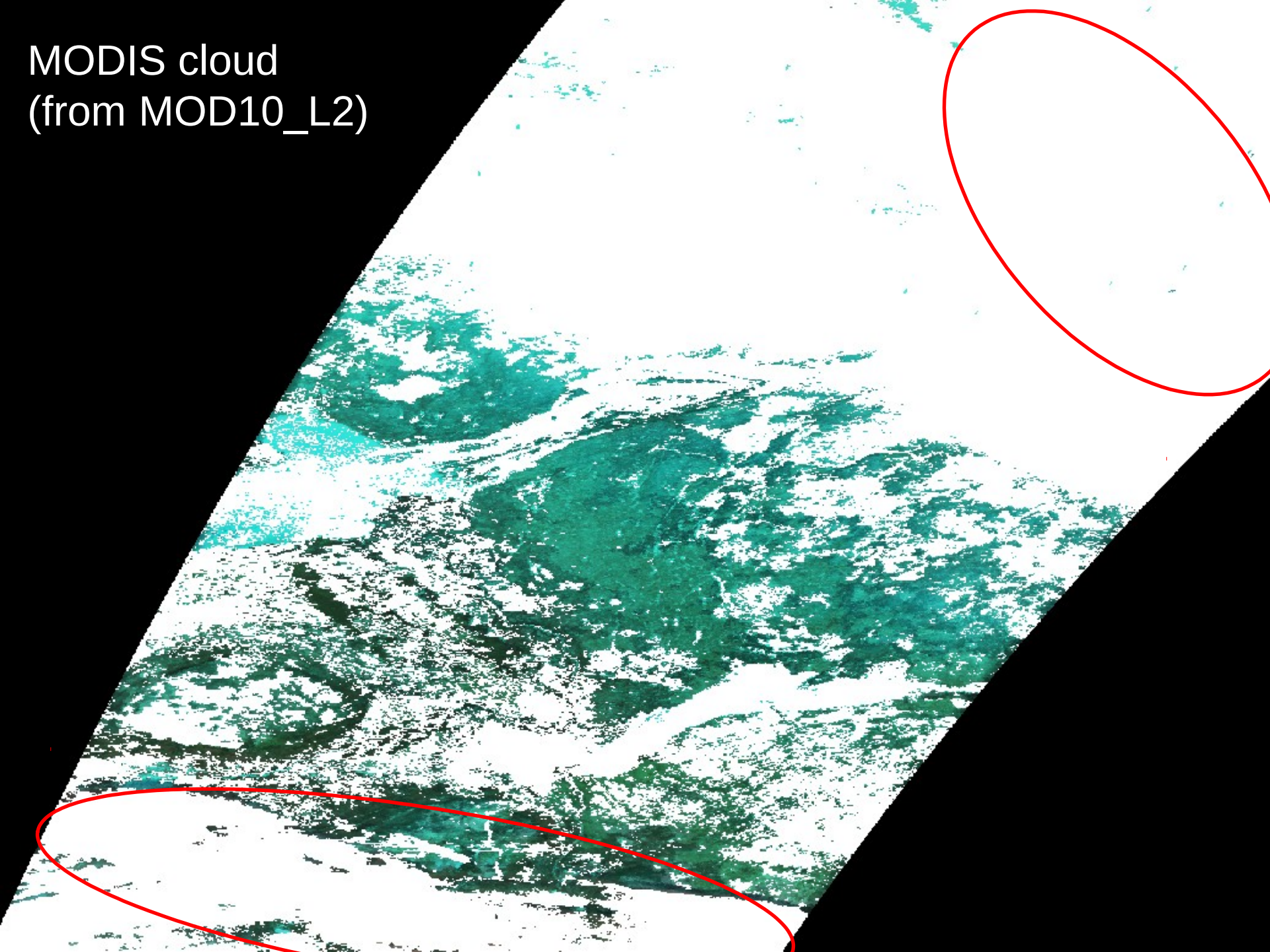
GlobSnow-2

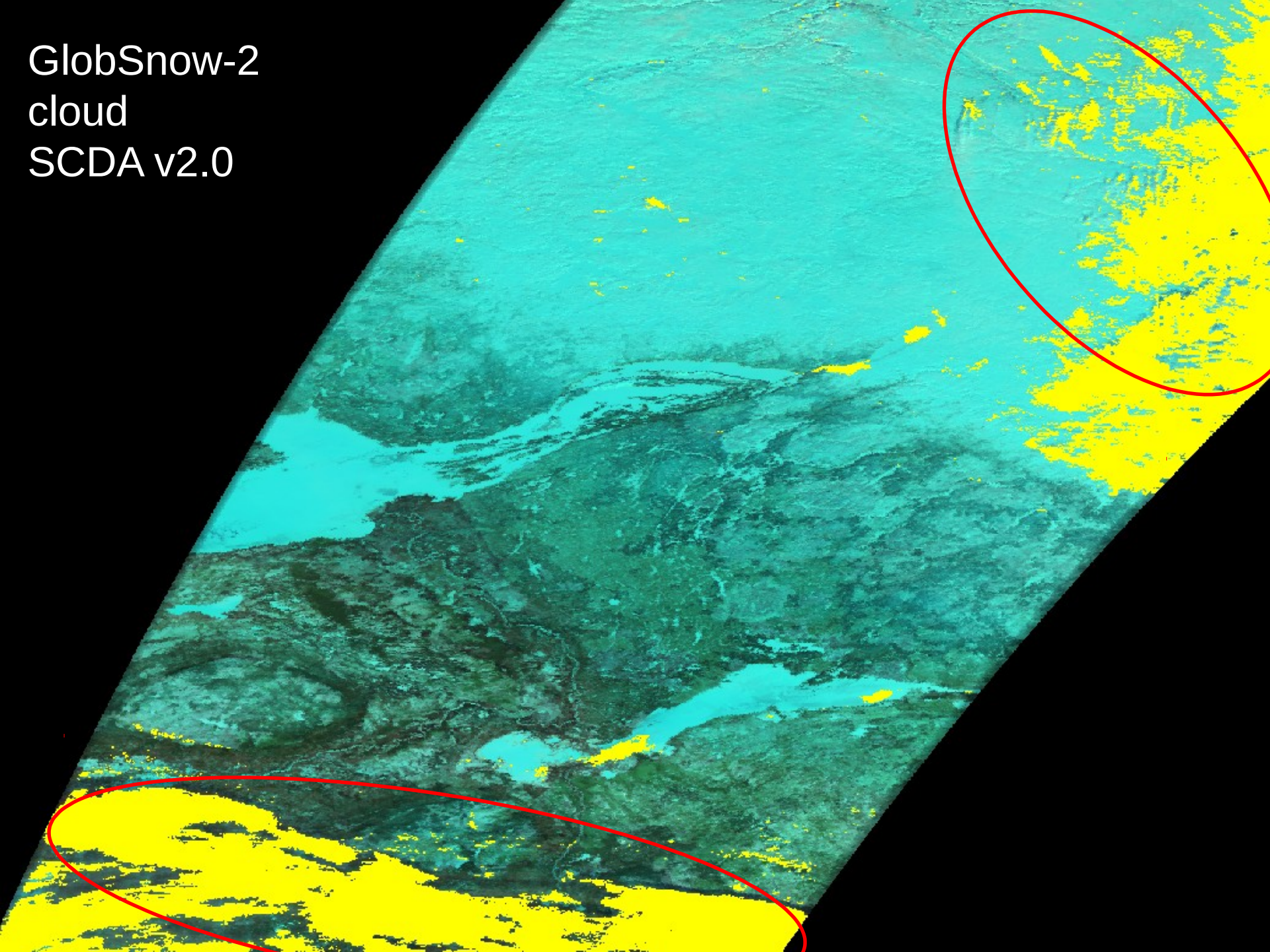


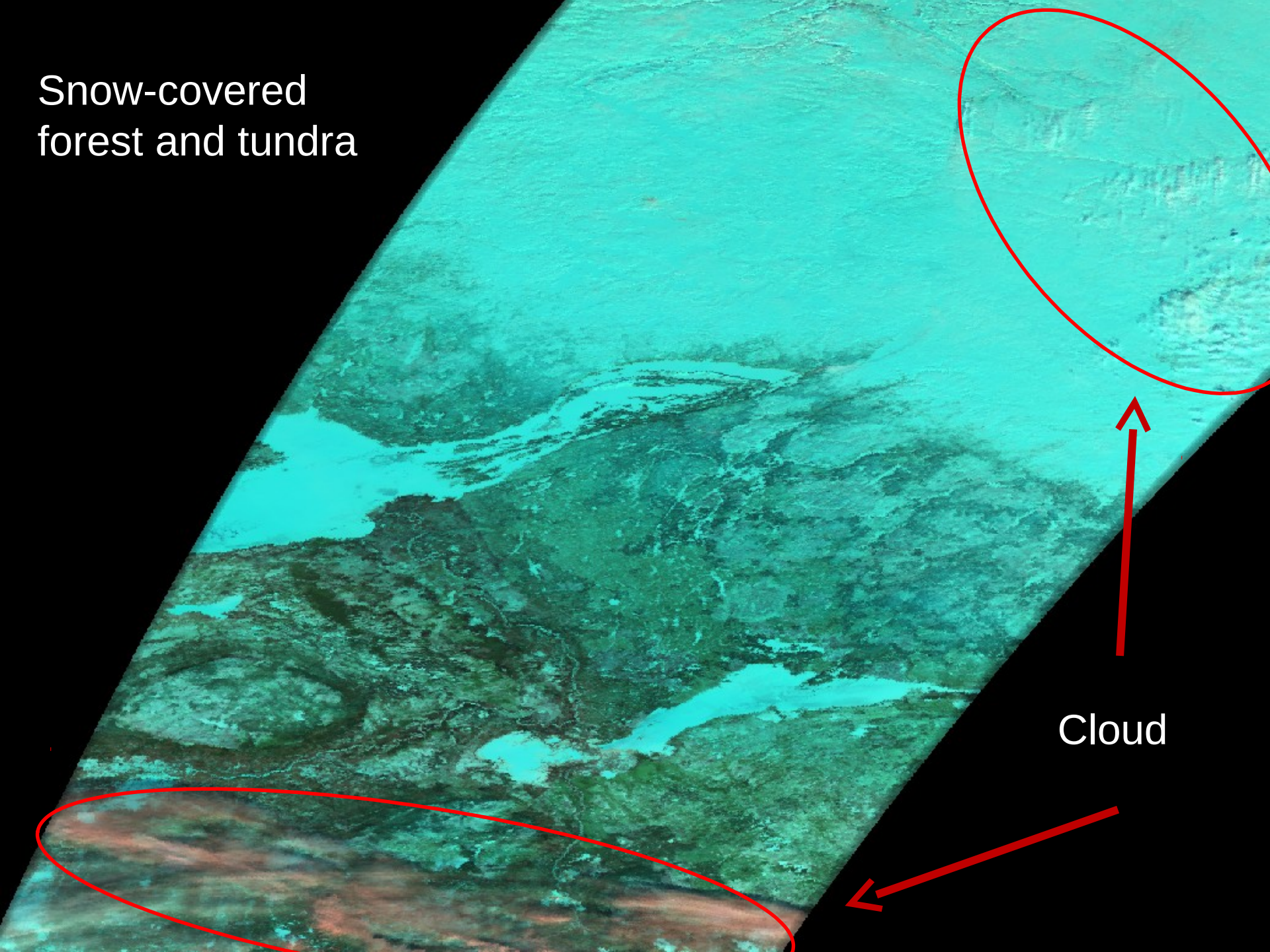
Map
Traffic
Northwestern Passages
Hudson Bay
28 Feb, 2003
United States
200 mi
500 km

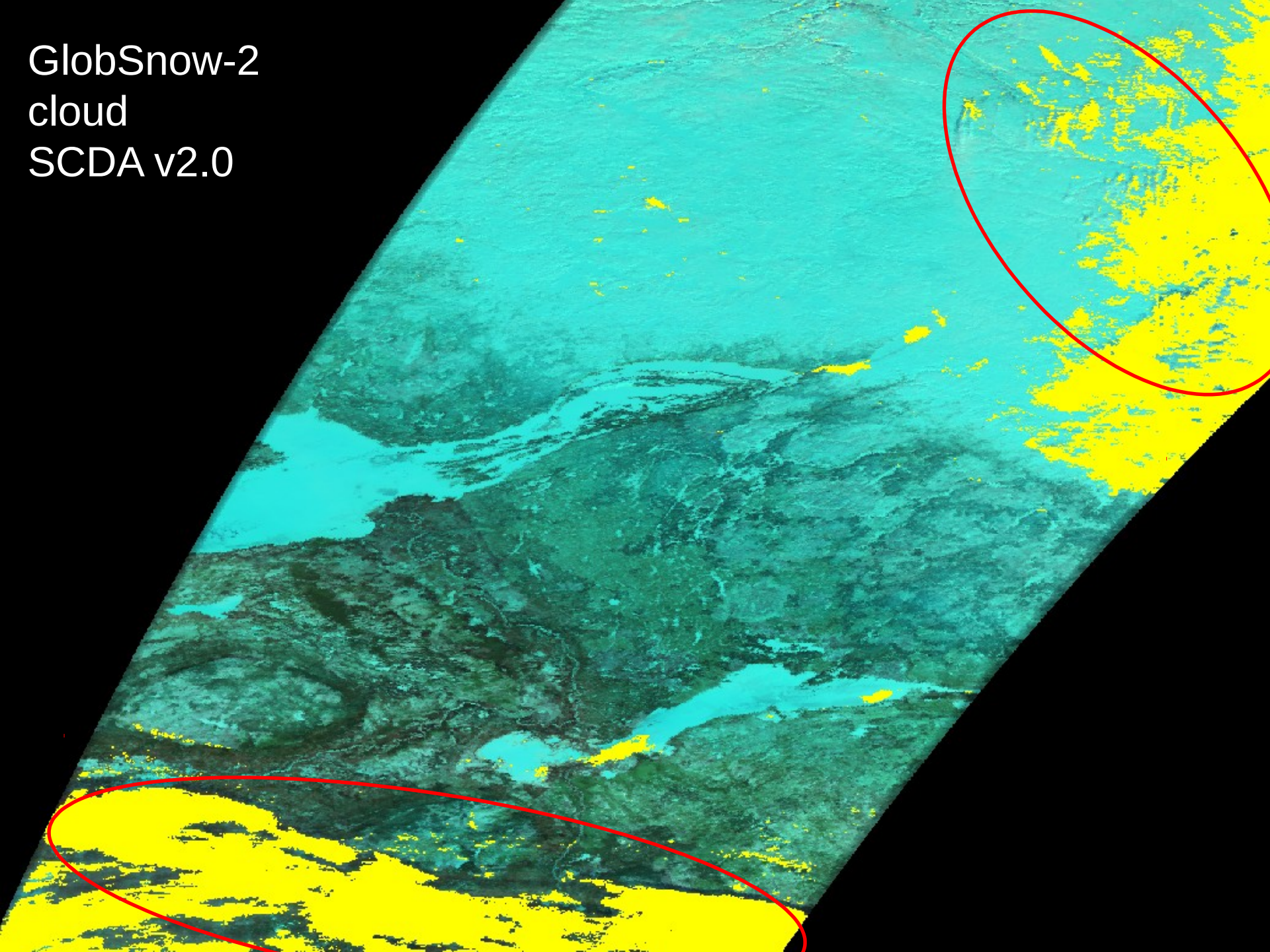

Snow-covered
forest and tundra
Cloud

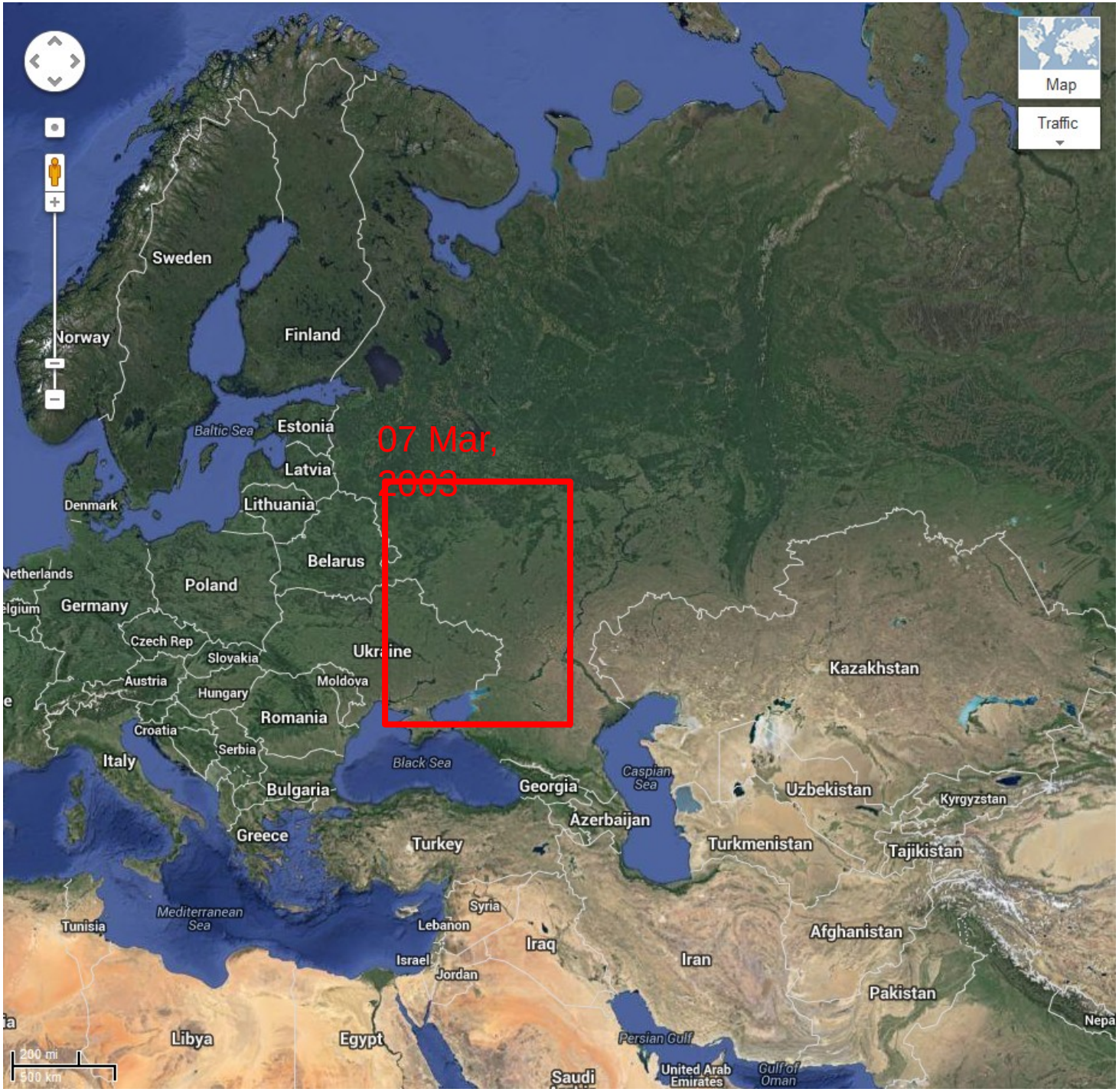

AATSR cloud
(operational)

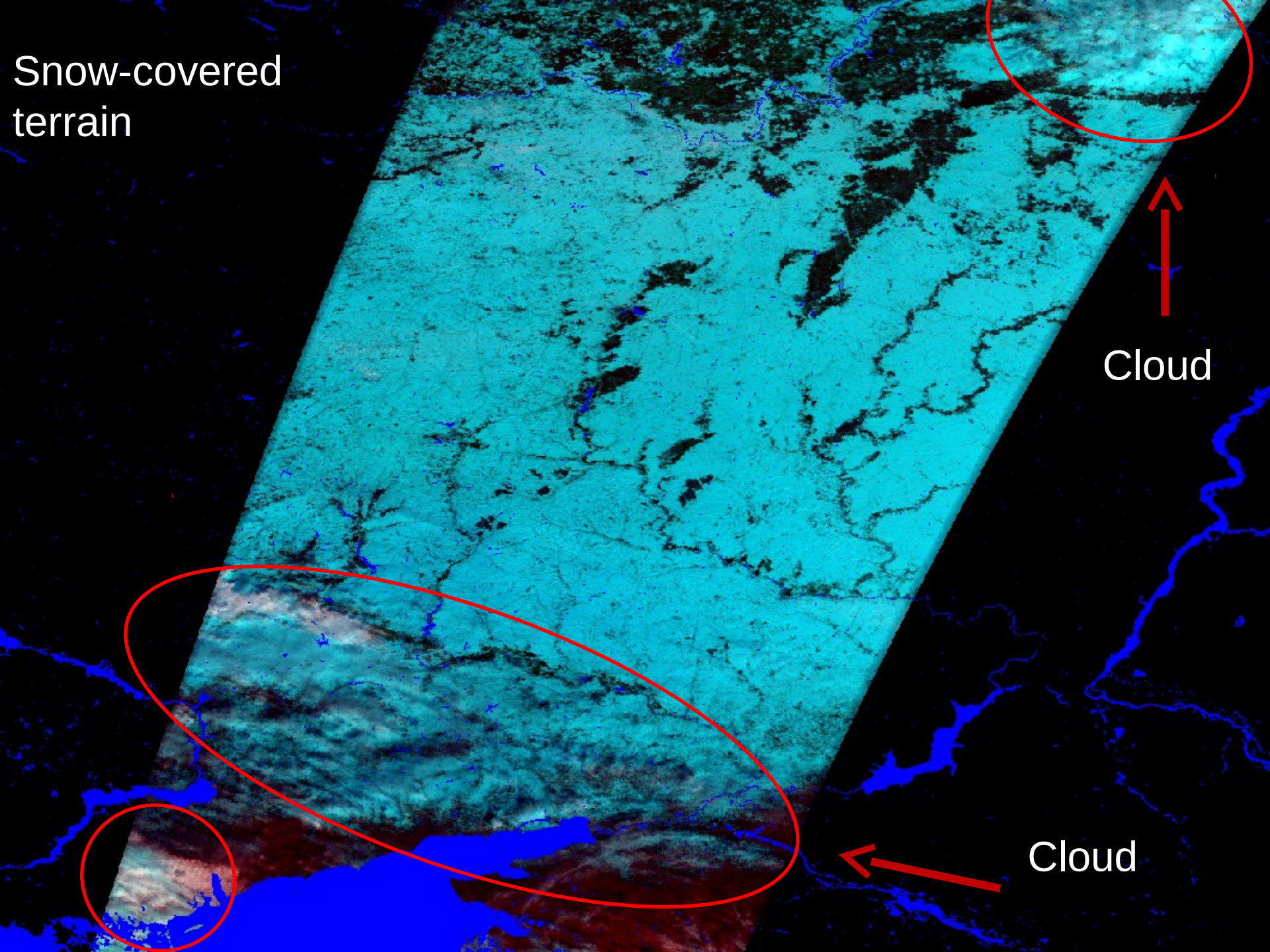

MODIS cloud
(from MOD10_L2)

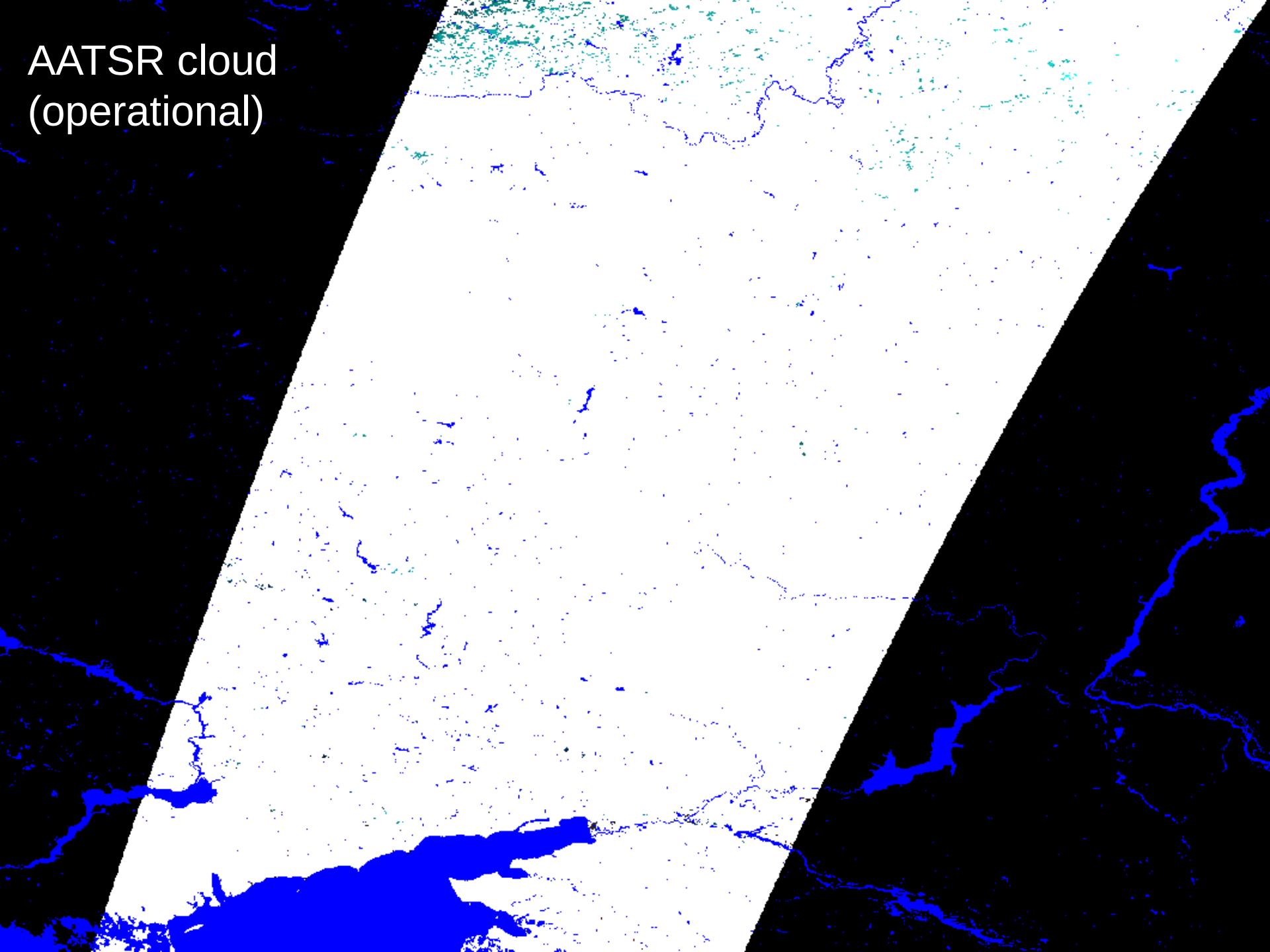

GlobSnow-2
cloud
SCDA v2.0

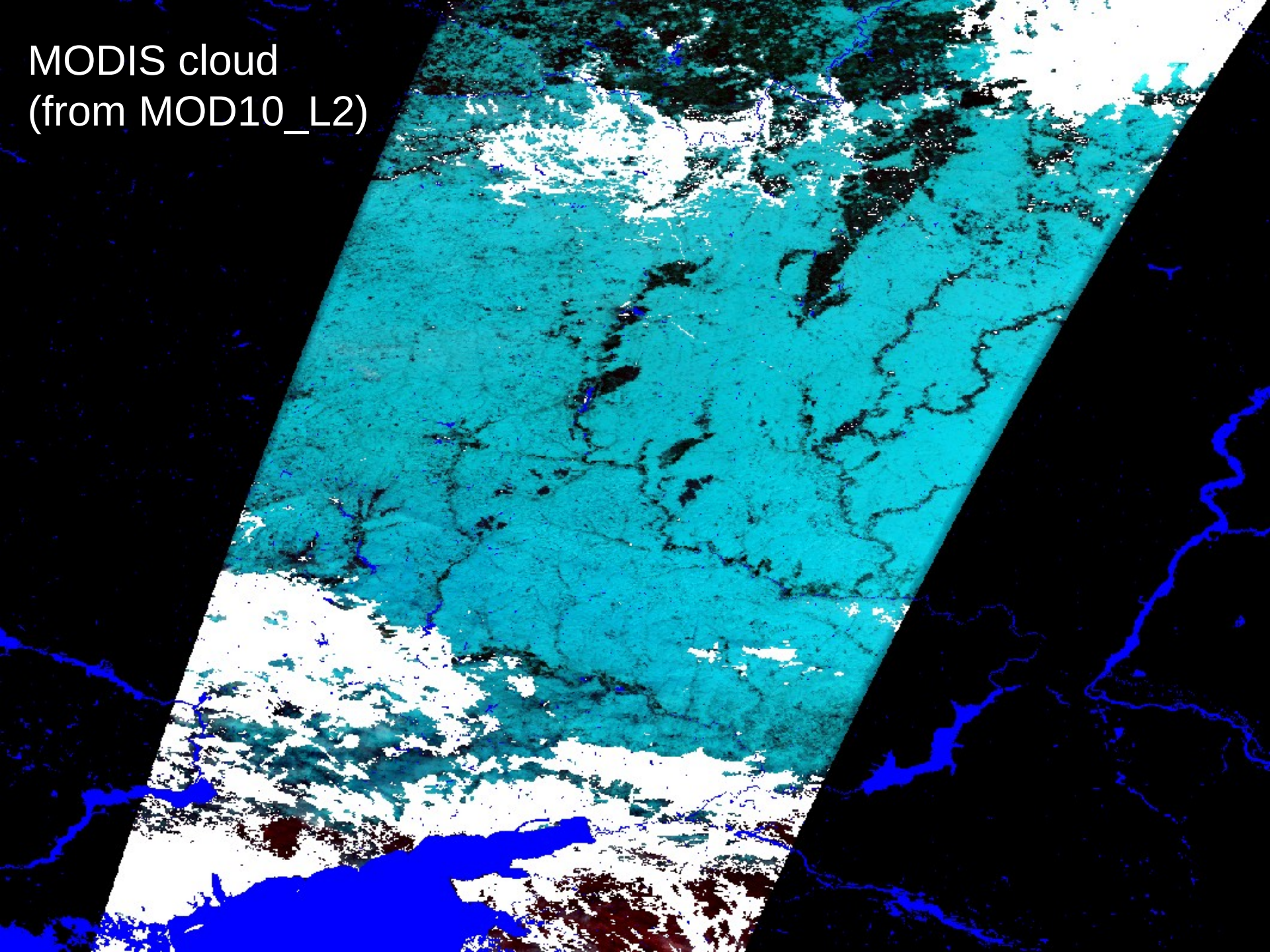

Snow-covered
forest and tundra
Cloud

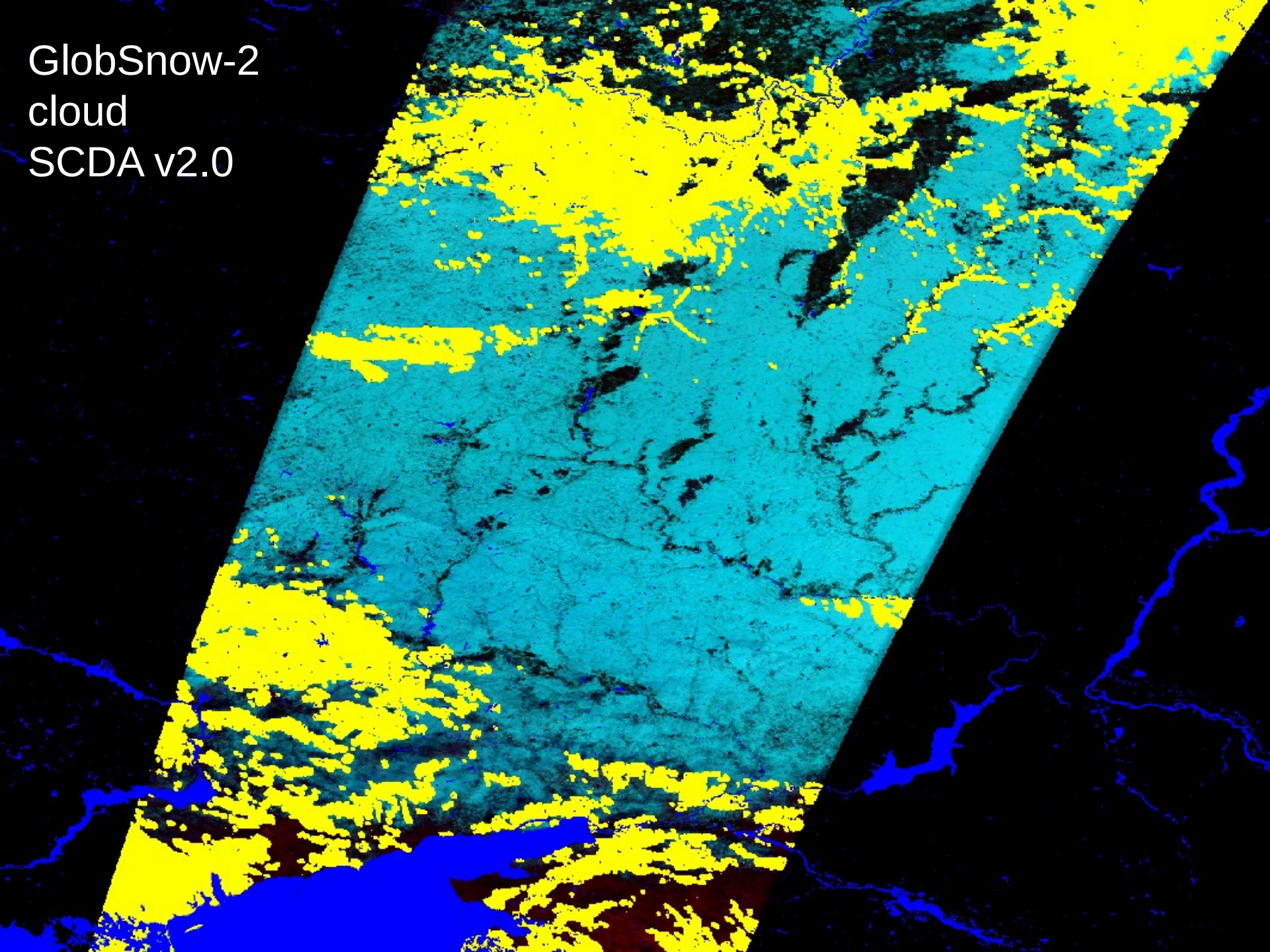

GlobSnow-2
cloud
SCDA v2.0

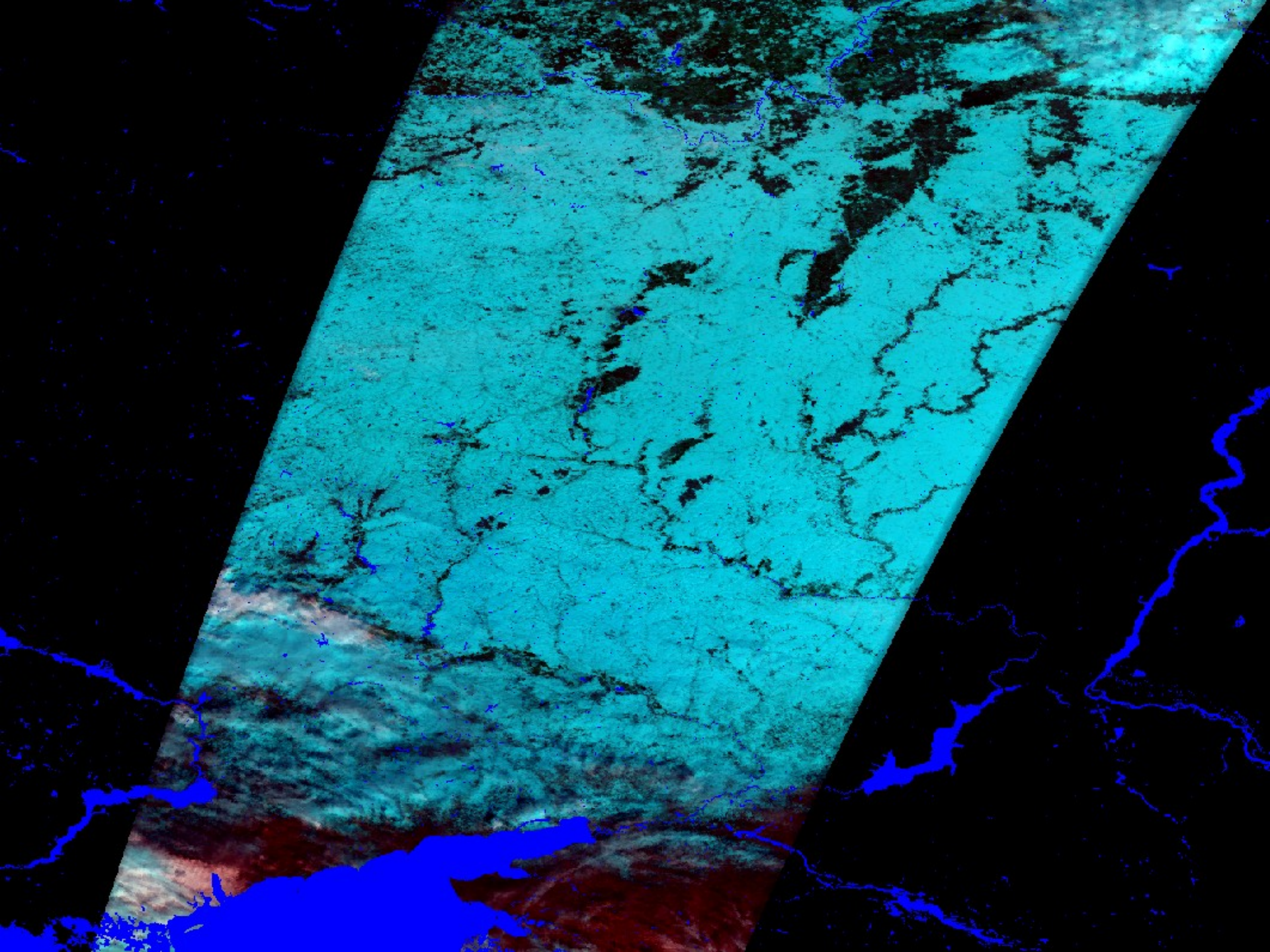

Map
Traffic
07 Mar, 2003
Sweden
Norway
Finland
Baltic Sea
Estonia
Latvia
Lithuania
Denmark
Belarus
Poland
Germany
Czech Rep
Slovakia
Austria
Hungary
Moldova
Romania
Croatia
Serbia
Italy
Black Sea
Bulgaria
Greece
Turkey
Georgia
Caspian Sea
Azerbaijan
Kazakhstan
Uzbekistan
Kyrgyzstan
Turkmenistan
Tajikistan
Afghanistan
Iran
Pakistan
Iraq
Syria
Lebanon
Israel
Jordan
Mediterranean Sea
Tunisia
Libya
Egypt
Persian Gulf
United Arab Emirates
Gulf of Oman
200 mi
500 km

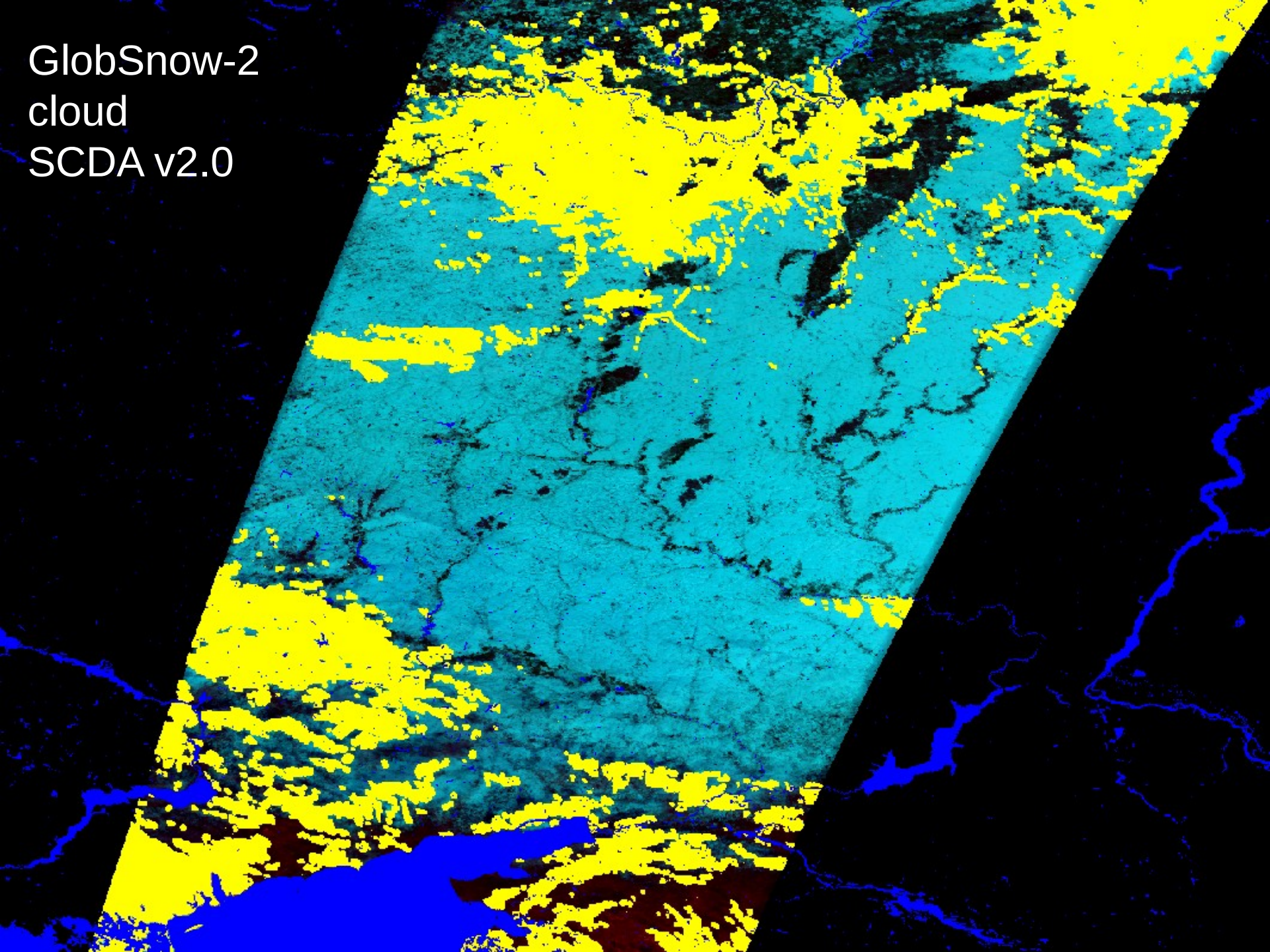

Snow-covered terrain
Cloud
Cloud


AATSR cloud
(operational)

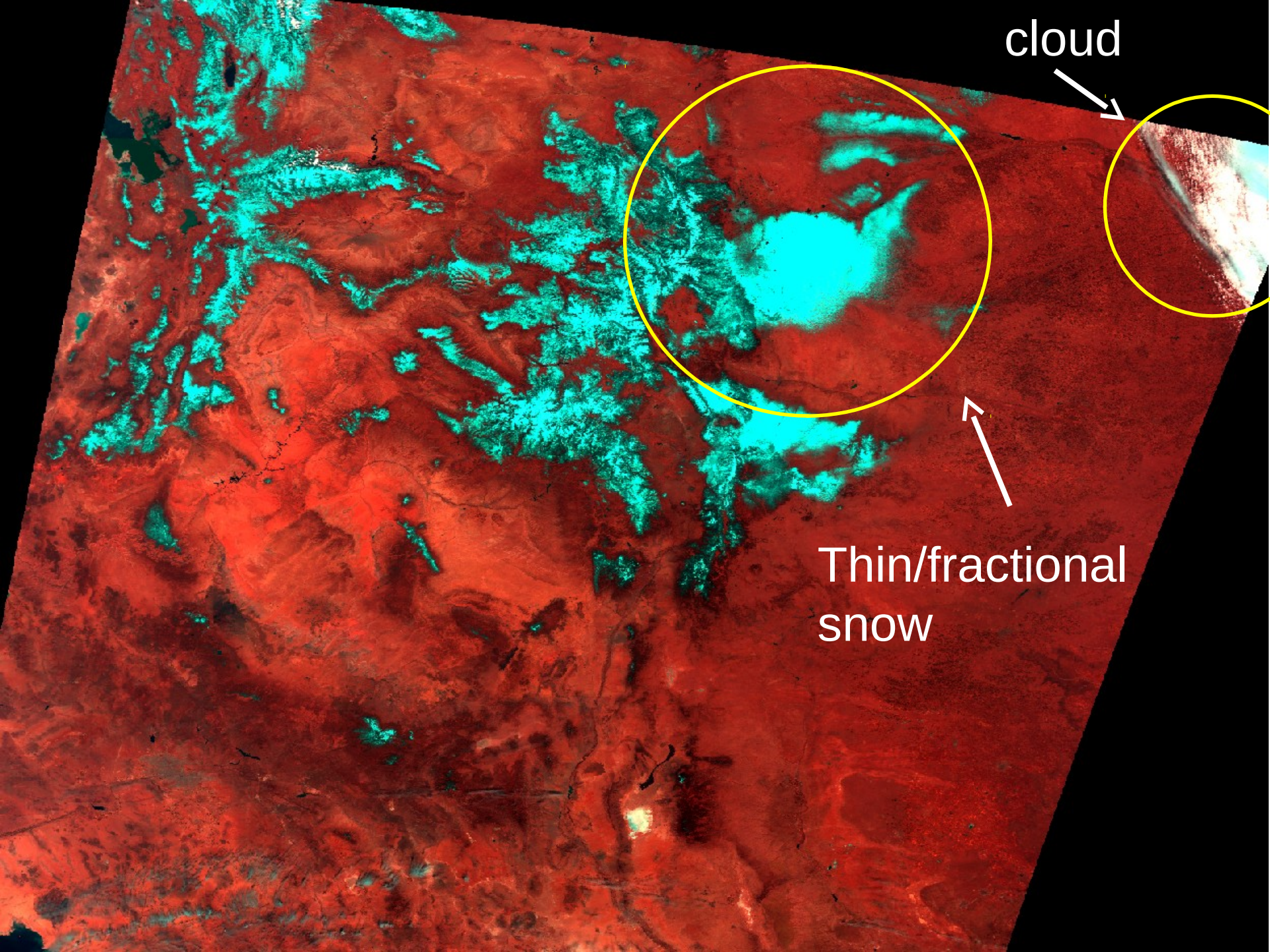

MODIS cloud
(from MOD10_L2)

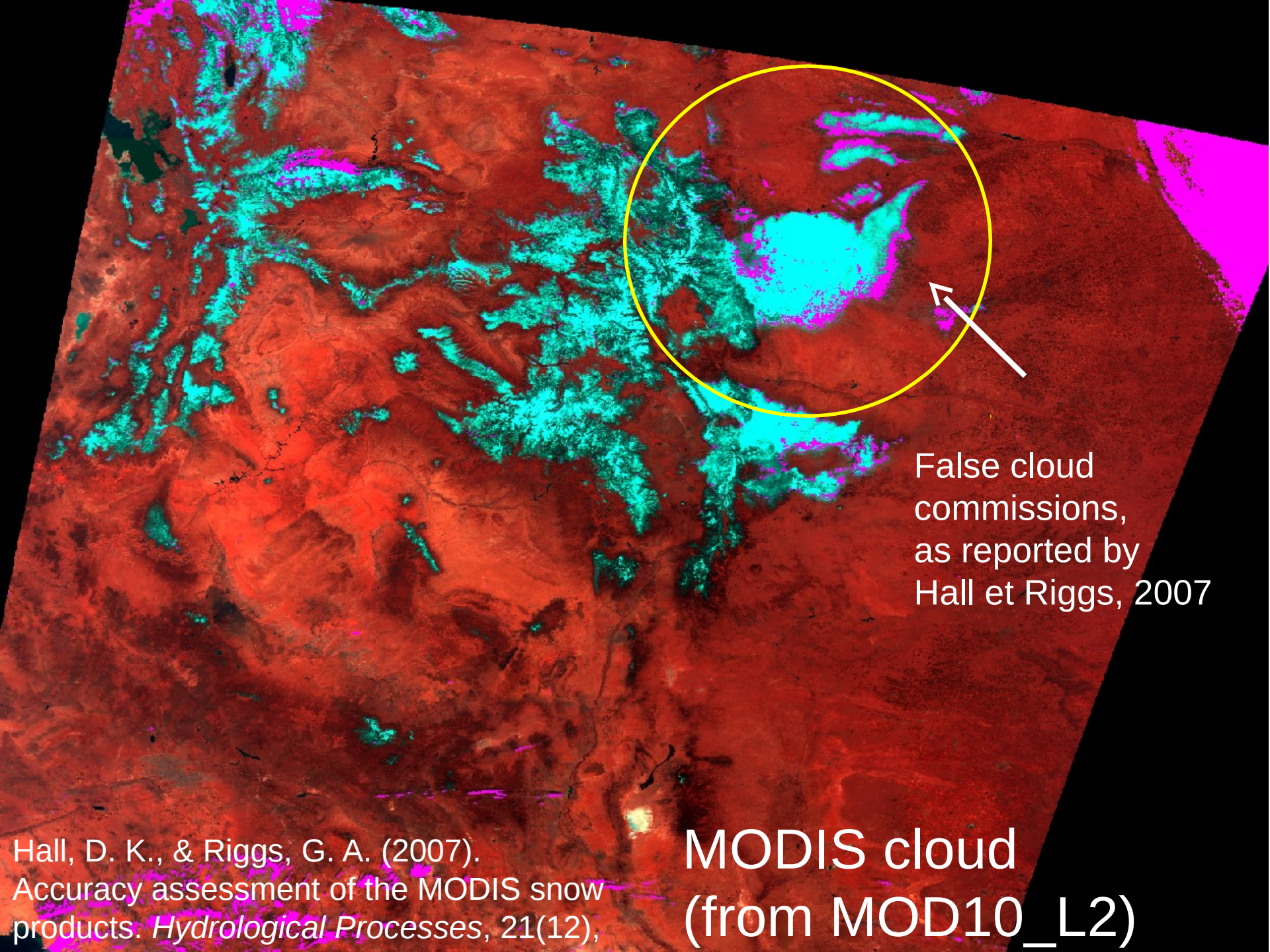

GlobSnow-2
cloud
SCDA v2.0




GlobSnow-2
cloud
SCDA v2.0

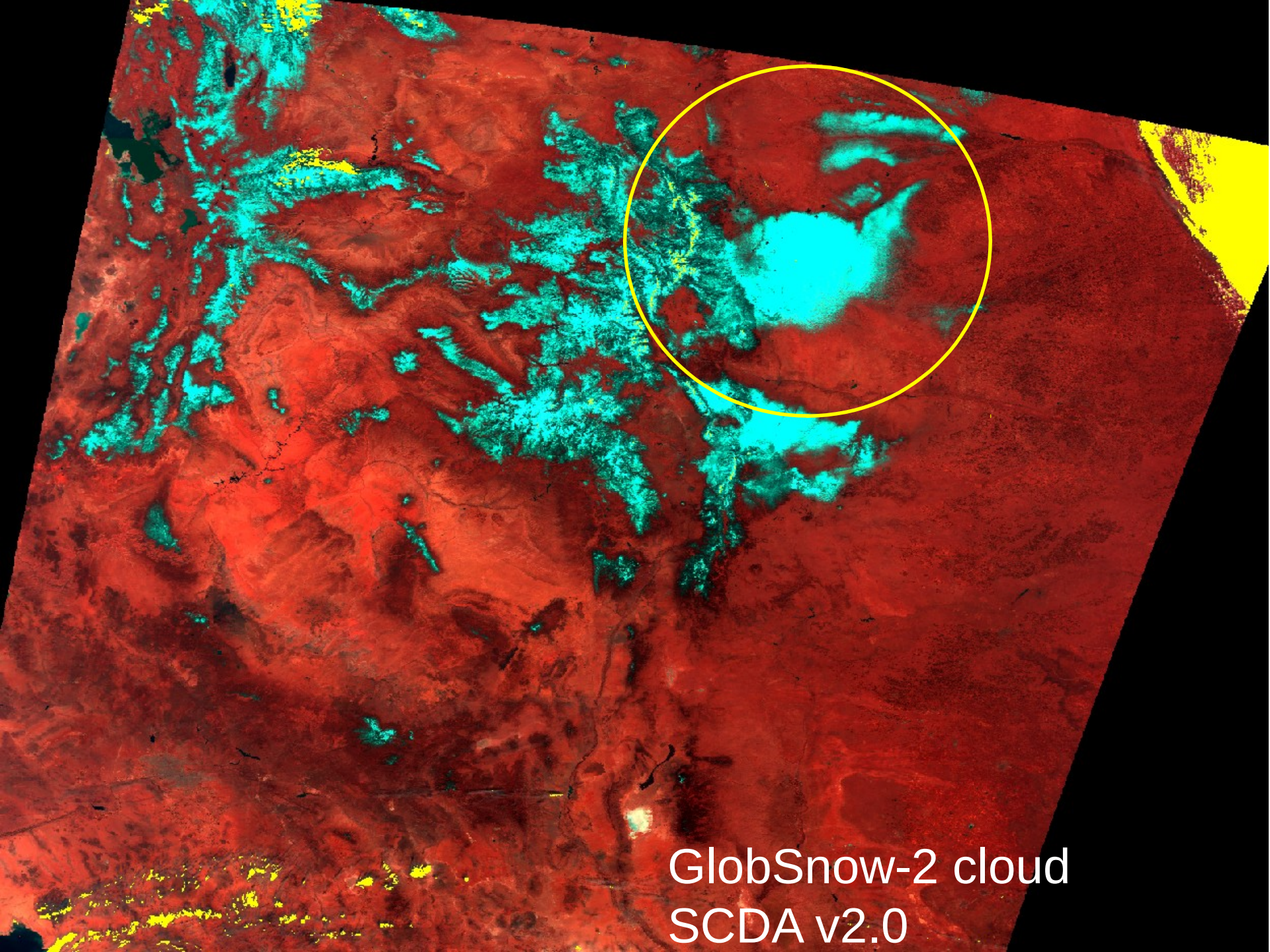
Washington
Montana
North Dakota
Map
Traffic
South Dakota
Oregon
Idaho
Wyoming
Nebraska
Nevada
United States
Utah
Colorado
Kansas
California
Oklahoma
Arizona
New Mexico
12 Apr, 2005
Texas
Gulf of California
Mexico
200 mi
200 km


cloud
Thin/fractional
snow



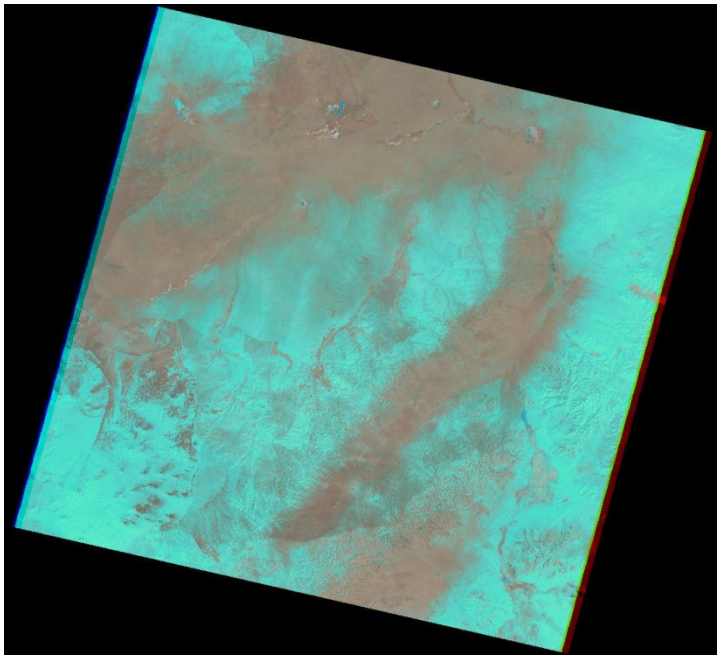
Hall, D. K., & Riggs, G. A. (2007). Accuracy assessment of the MODIS snow products. *Hydrological Processes*, 21(12),

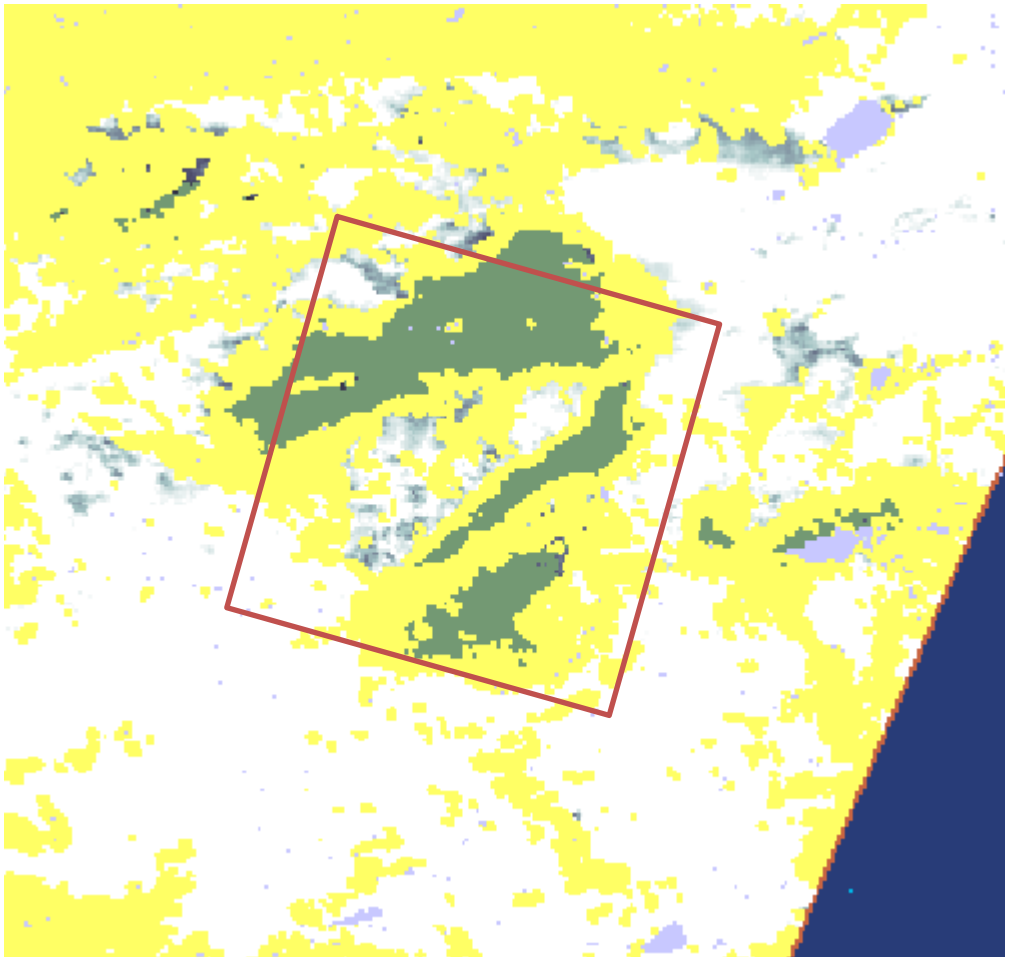
MODIS cloud (from MOD10_L2)


GlobSnow-2 cloud
SCDA v2.0

False cloud commissions for Mongolia still a concern (1)

Fractional snow at the edge of snow-covered areas are easily misclassified as cloud (yellow here)





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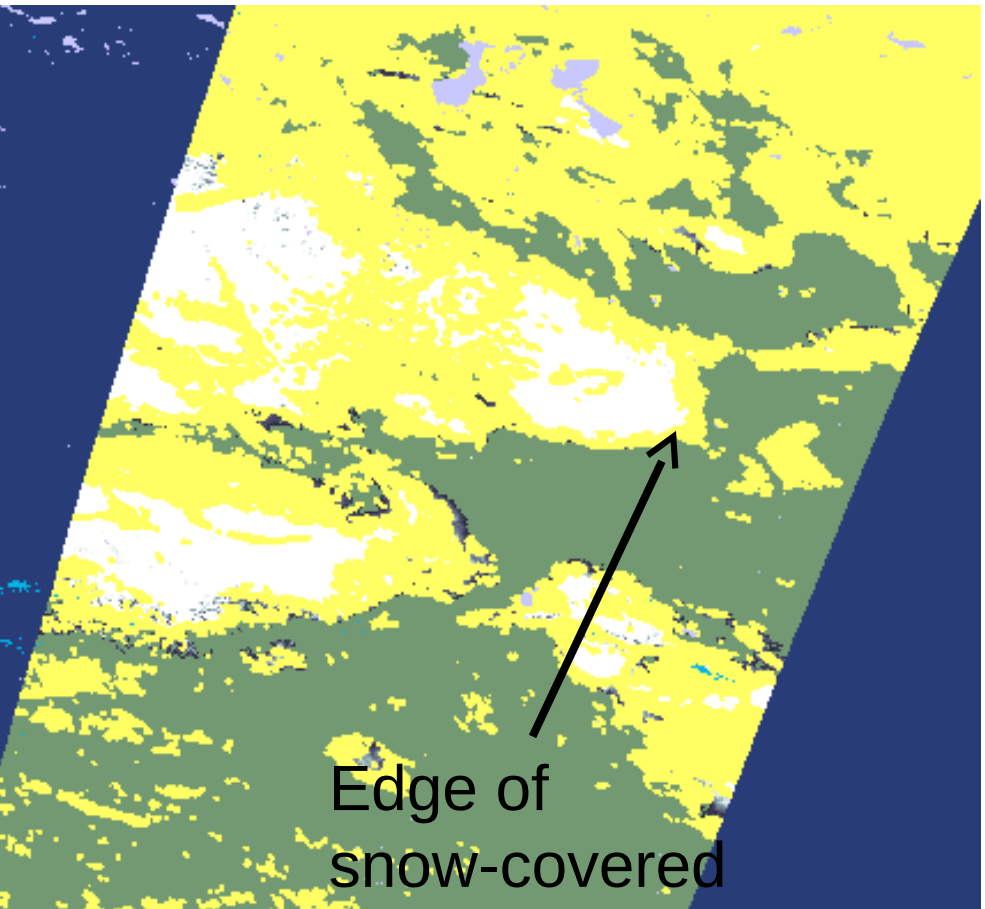
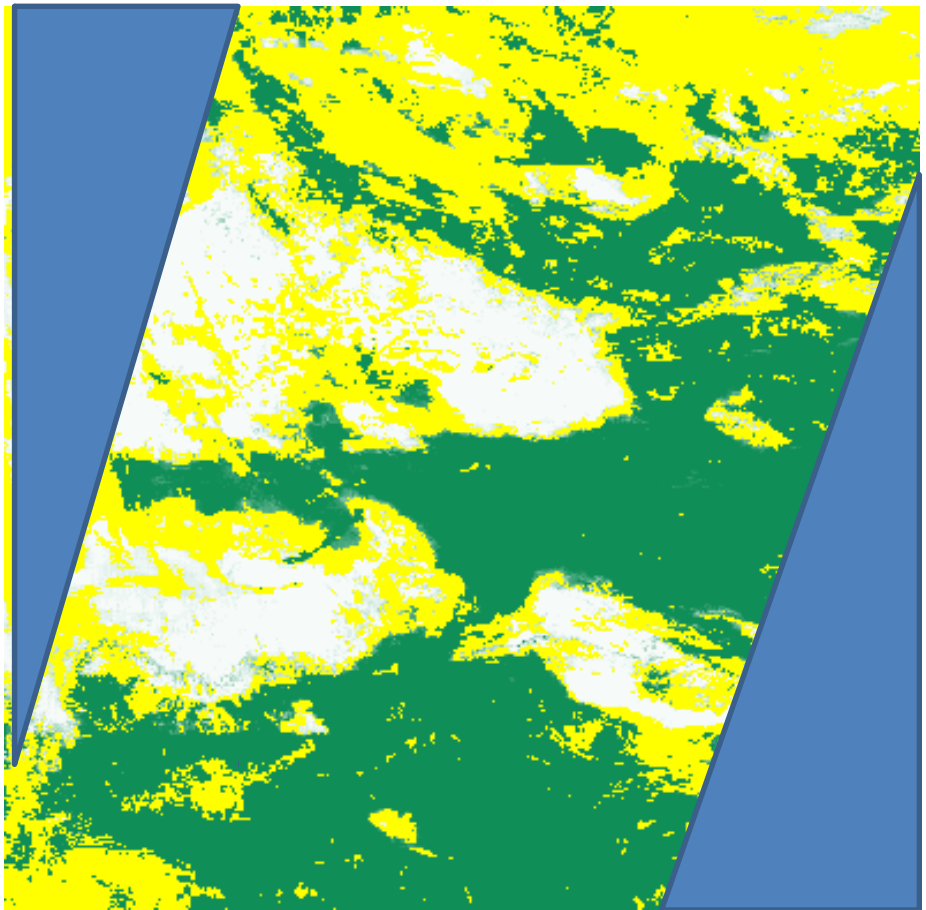
False cloud commissions for Mongolia still a concern (2)

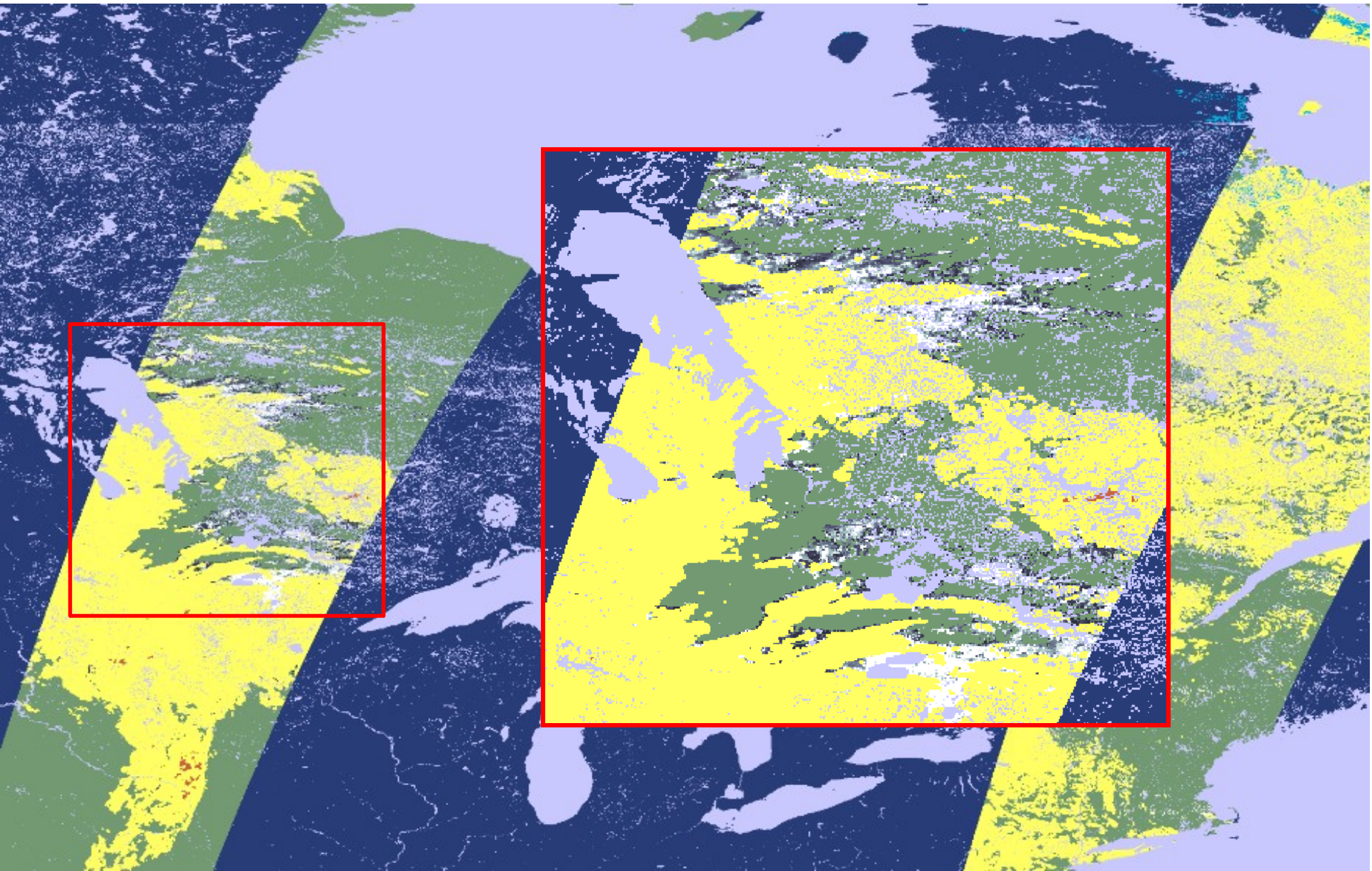
GS-2 SE, Feb 20, 2009



NASA MOD10_L2, Feb 20, 2009



Occasional cloud omissions in summer months for some cloud types



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Way forward

- Improvements are allways welcome! Issue with clouds is not solved…
- On-going work: better detection of summertime clouds
  - Reference image approach is investigated (based on *SCAmod* FSC retrieval method)
  - Expansion of teaching data set for decision rules
- Cloud shadows currently not considered in SCDA2.0
  - 1-2 pixels buffering does not completely solve this problem
- In situ observations on cloudiness could help the method development and validation: e.g. sky-cameras
- Need of proper cloud screening method for snow mapping purposes from Sentinel-3 SLSTR
  - SCDA2.0 is a good basis for that

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Thank you for your attention!

Acknowledgement to

- Finnish Meteorological Institute (FMI)
- Gamma Remote Sensing AG

for GlobSnow-processings

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