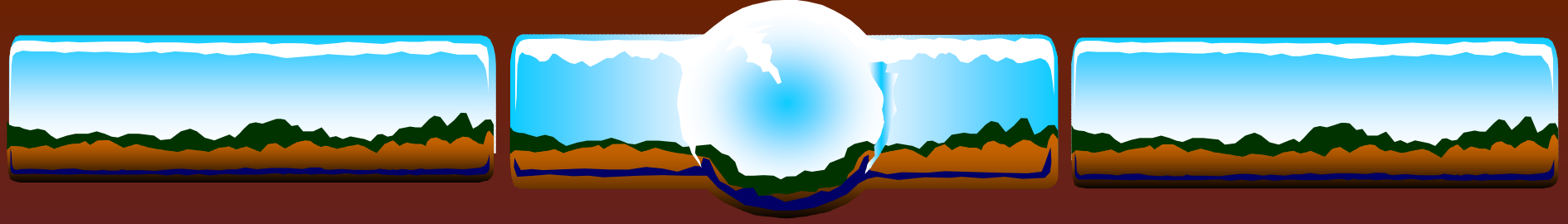
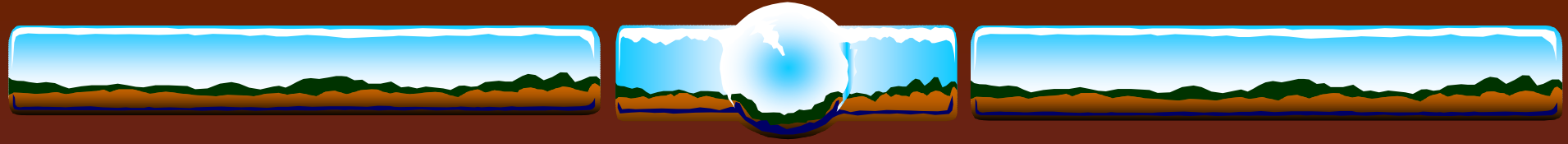


Algorithm performance tests for the future developments

Masahiro Hori, NASDA/EORC

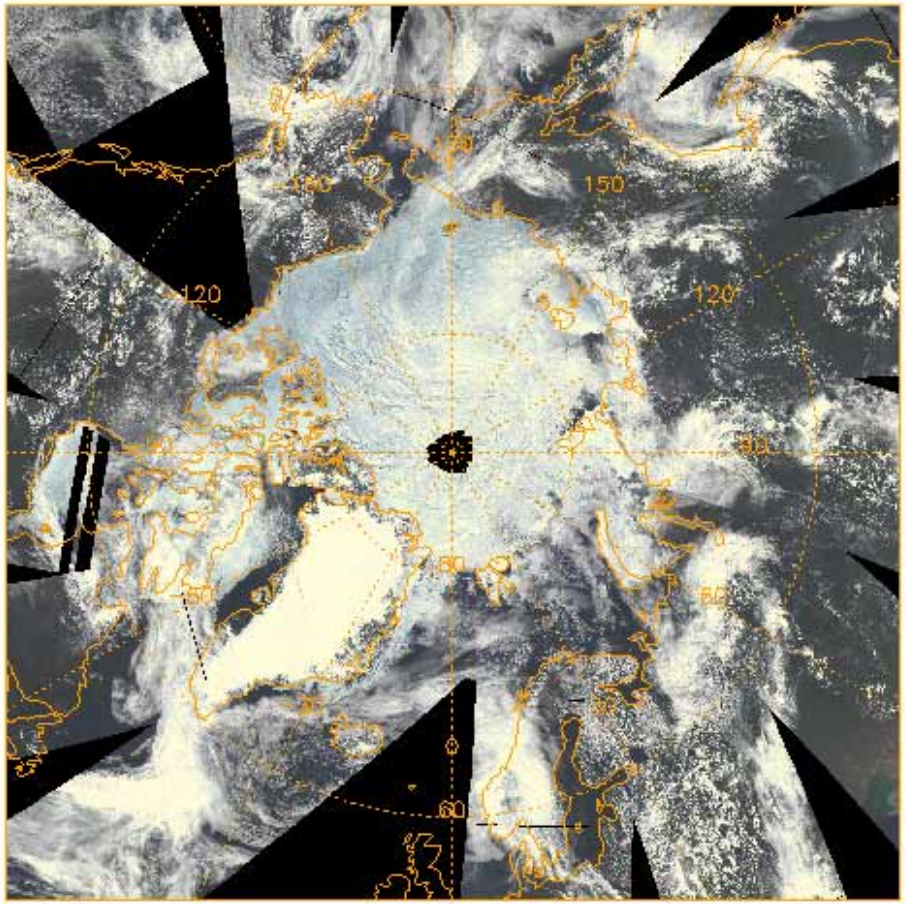
Algorithm/Validation Parallel Sessions (Cryosphere Group)
FY2001 GLI Workshop at Triton Square, Tokyo, November 15, 2001



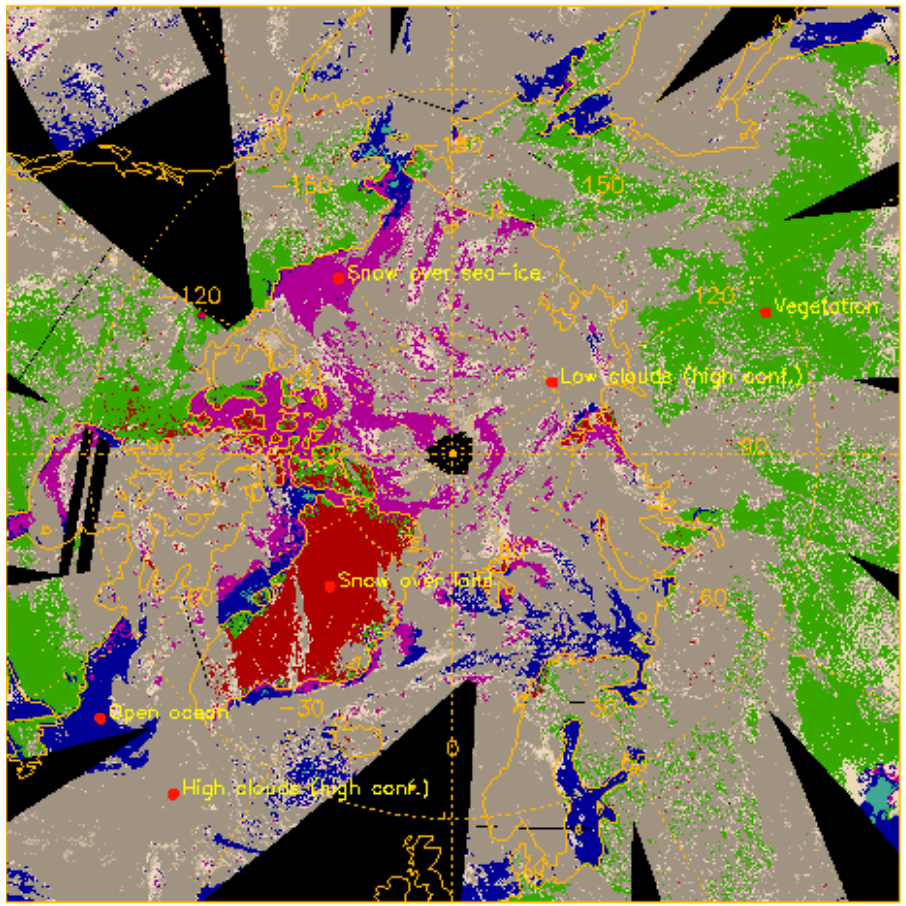
GLI Standard Algorithms

- Algorithm1:
  - Code: CTSK1
  - Name: Cloud/Clear and Snow/Sea-Ice discriminator
  - Parameters: cloud (2bit) & surface classification (3bit) flags
    snow/sea-ice cover extent (included in surface classification flag)
- Algorithm2:
  - Code: CTSK2b1
  - Name: Retrieval of snow grain size and impurities
  - Parameters: snow grain size
    mass fraction of impurities mixed in snow

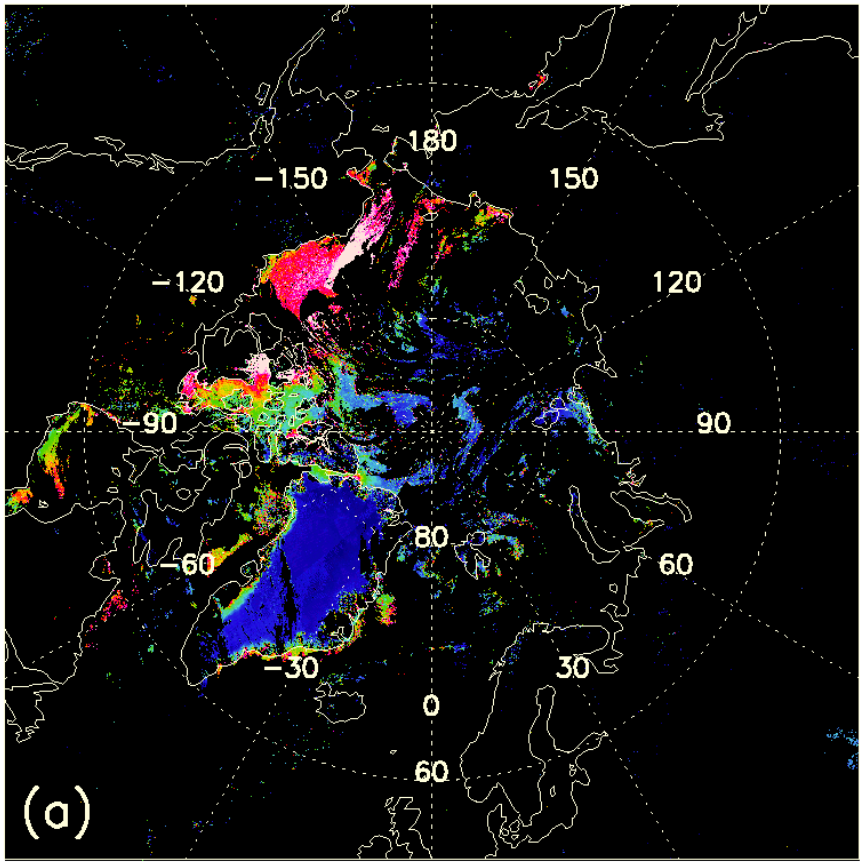
Example(1): Cloud mask & Snow/Sea-ice cover extent around the North Pole from MODIS snapshot data

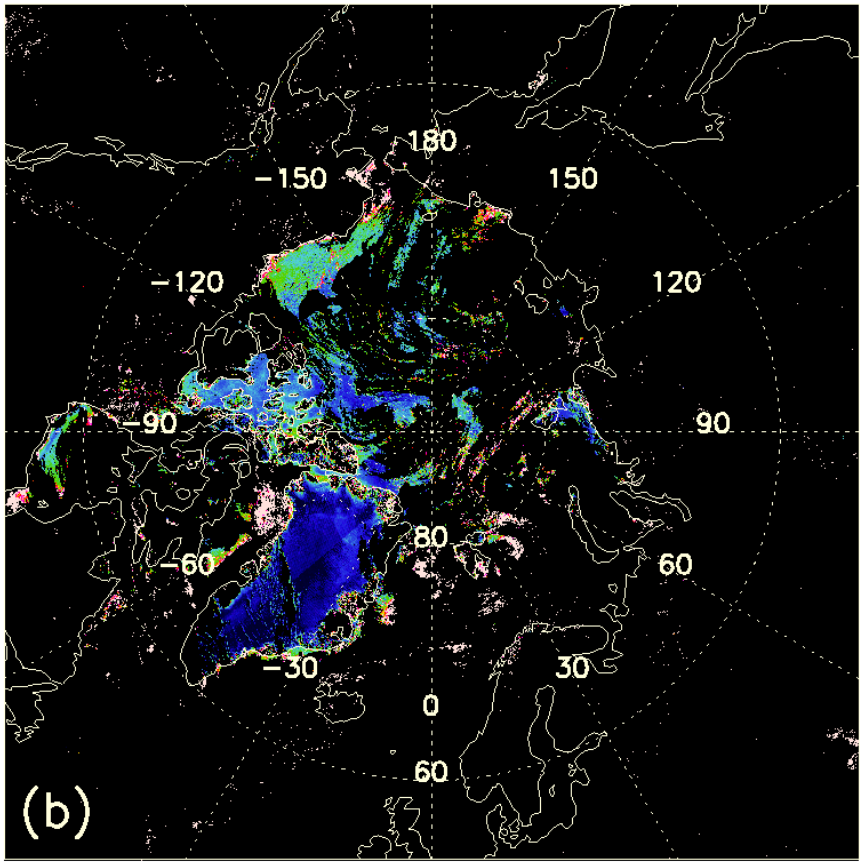


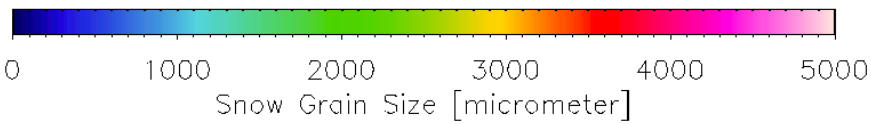
June 18, 2000 RGB:ch1, 4, 3

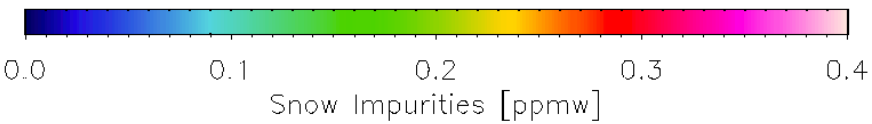


Example(2): Snow grain size & Snow impurities





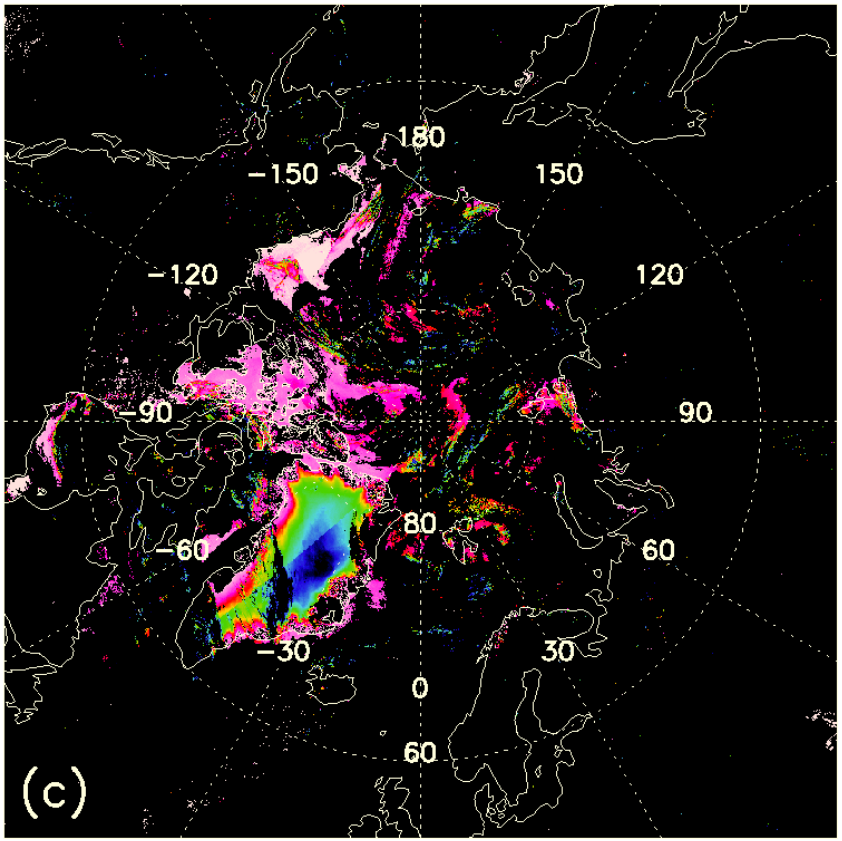


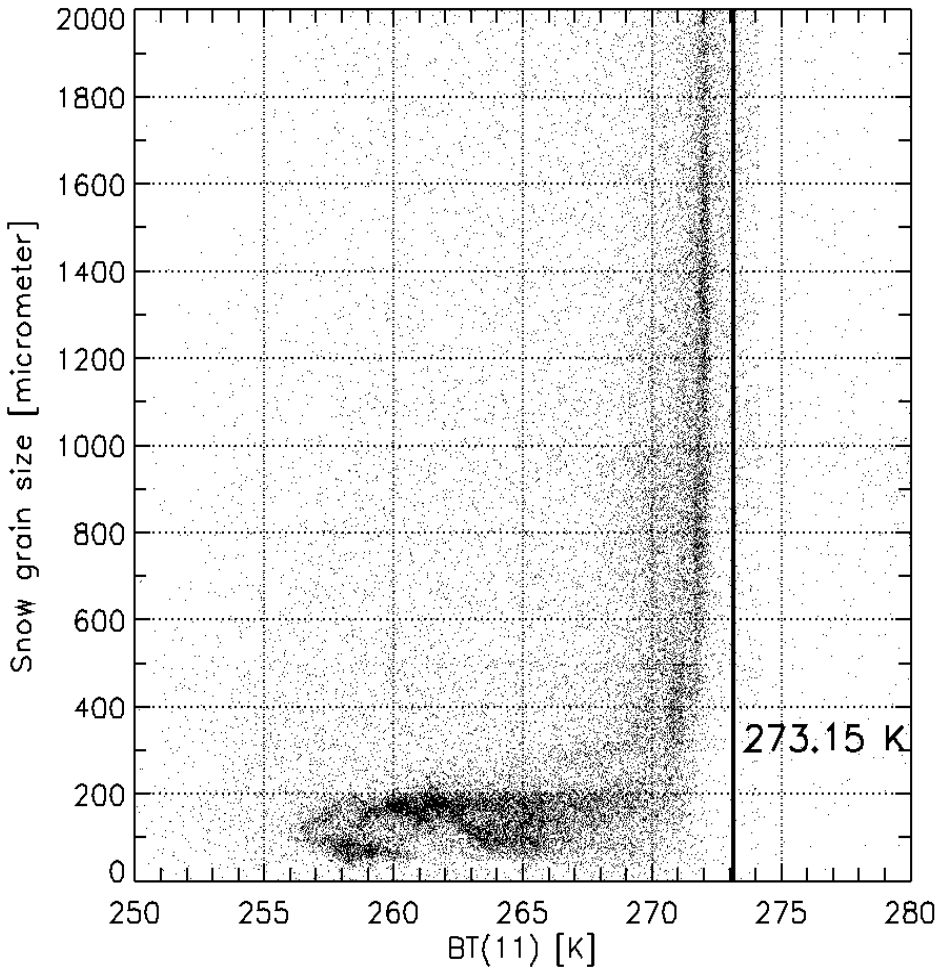


Snow grain size

Mass fraction of snow impurities

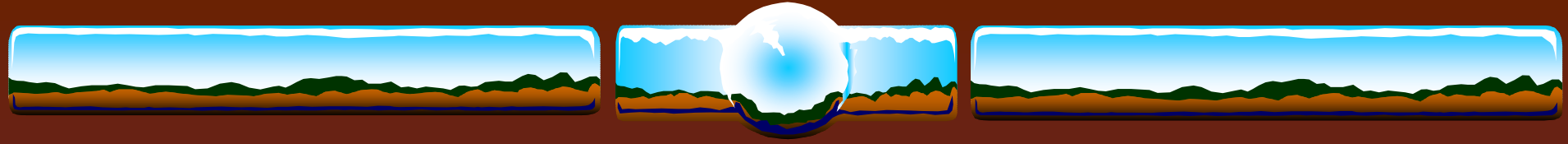
Example(3): Snow surface temperature (BT11)





Brightness temperature at 11um

BT11 vs. Snow grain size



Consideration items after the preliminary validation

① Is the expansion of value ranges of snow parameter defined in the lookup tables (CTSK2b1) necessary for global application ?

② Evaluation of the effects of sub-pixel contamination by non-snow pixels such as clouds, forest and open ocean on the accuracy of the retrieved snow parameters

③ Evaluation of the validity of the atmospheric and aerosol models in CTSK2b1 for atmospheric correction in various observation conditions

④ Evaluation of the effect of non-spherical snow grains on the retrieval of snow parameters

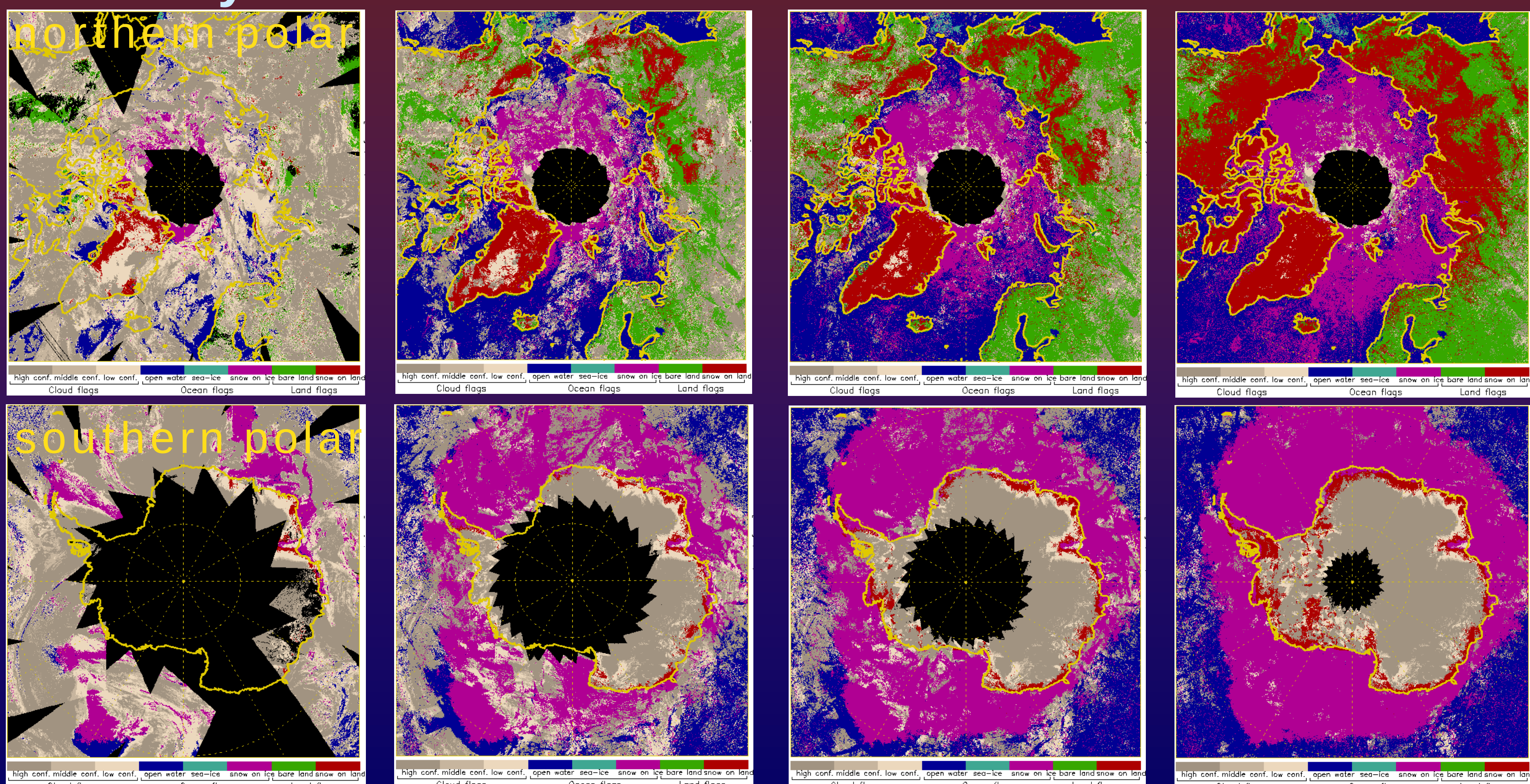
⑤ Evaluation of the effect of surface roughness on the retrieval of snow parameters in real snow fields

Example(4): How many days are necessary for cloud screening ?

Data period : Sep. 13 ~ Oct. 12, 2000

Cloud detection method : brightness temp. difference (3.7 μ m − 11 μ m)
reflectance of 1.38 μ m

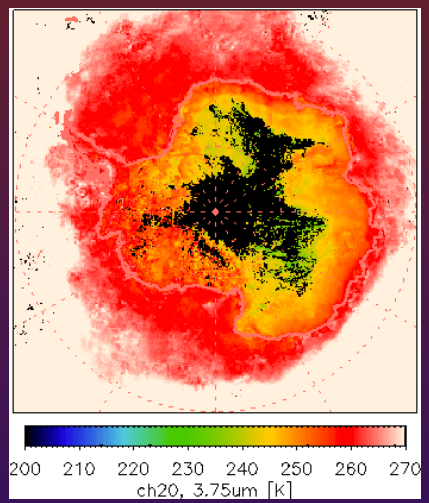
1day → 1week → 2weeks → 1month



Monthly averaged brightness temperature/reflectance images of the Antarctica (only clear pixels are used)

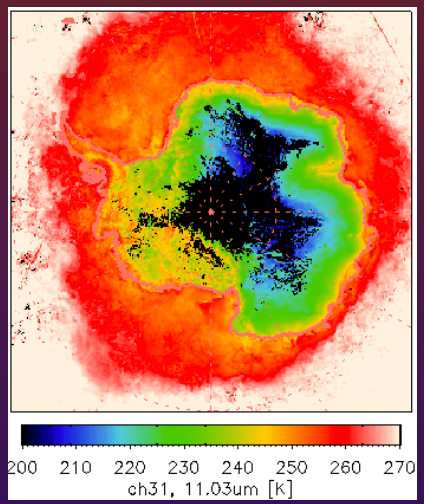
Data period : Sep. 13 ~ Oct. 12, 2000

Cloud detection method : reflectance of 1.64 μ m



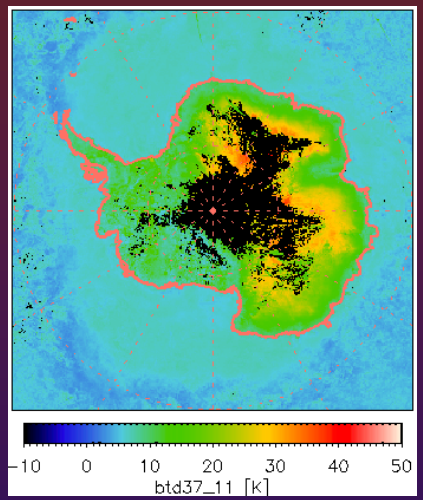
BT3.75

—

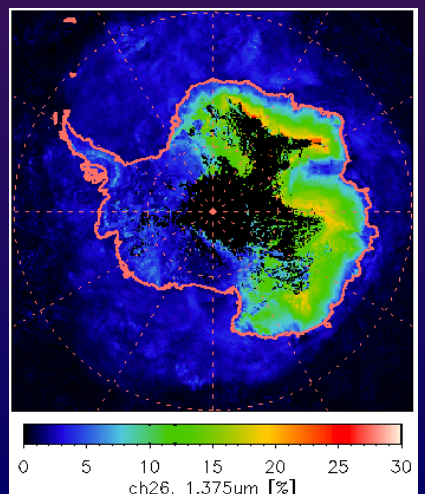


BT11

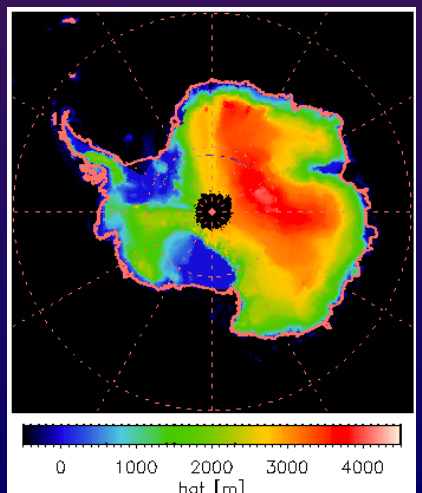
=



BT3.75 − BT11



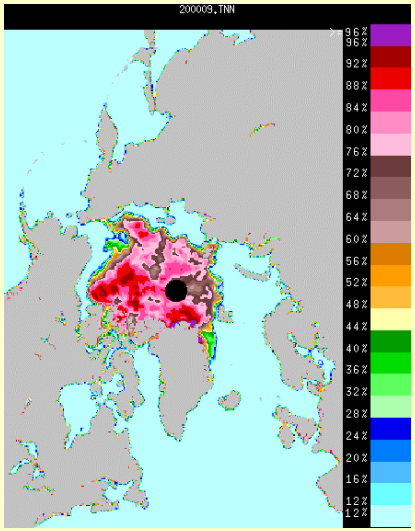
Ref1.38

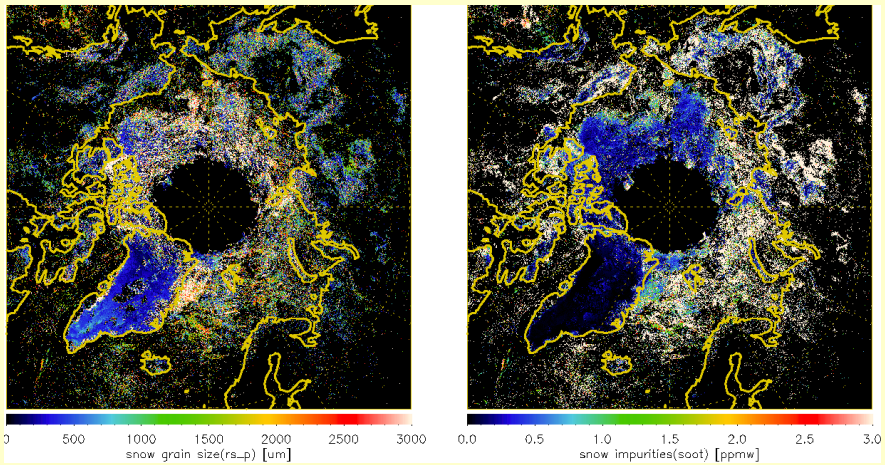


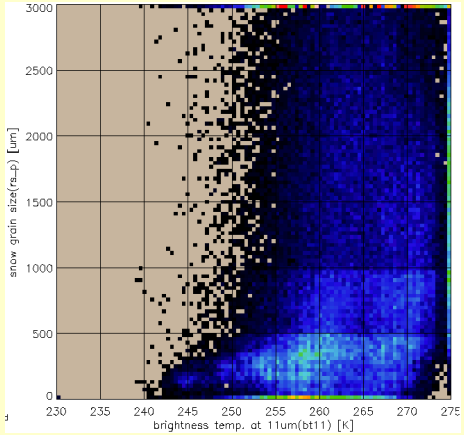
Elevation

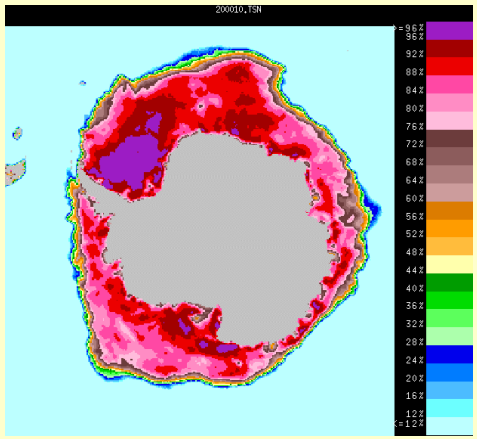
southern polar

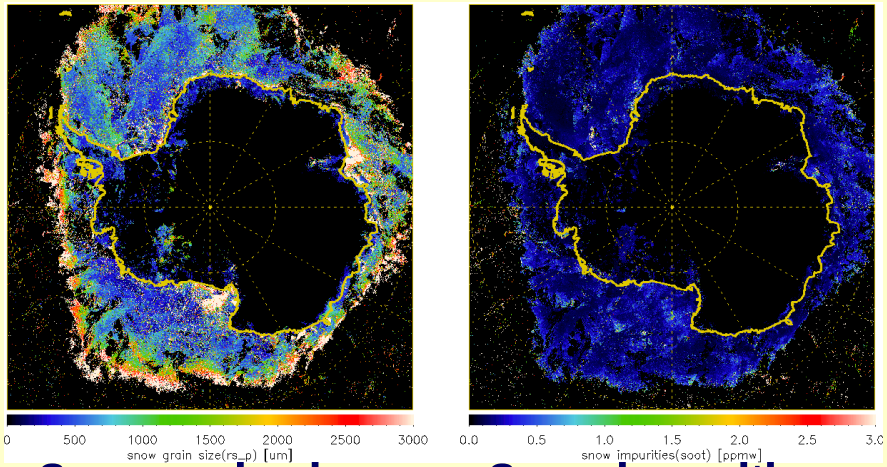
Example(5): Snow grain size and impurities from 2weeks data (upper:Sep.13–26, lower:Sep.27–Oct.11)

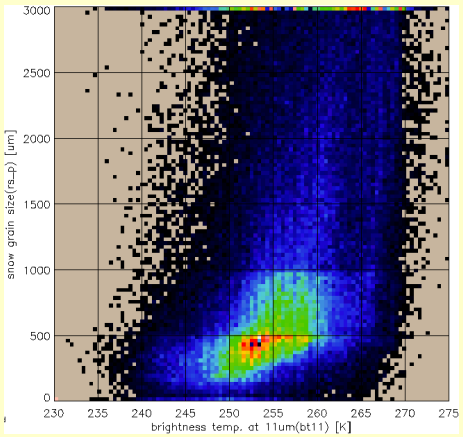








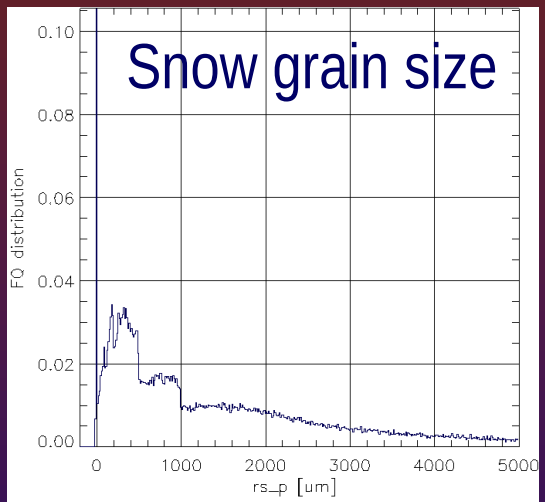


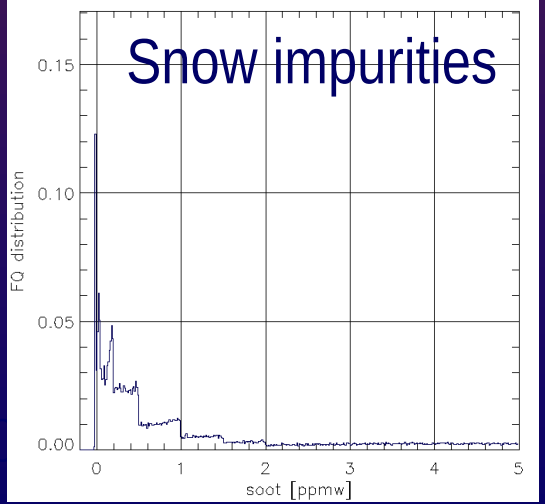


Sea-Ice conc.(SSM/I) **Snow grain size** **Snow impurities** **BT_{11}vs.Snow grain size**

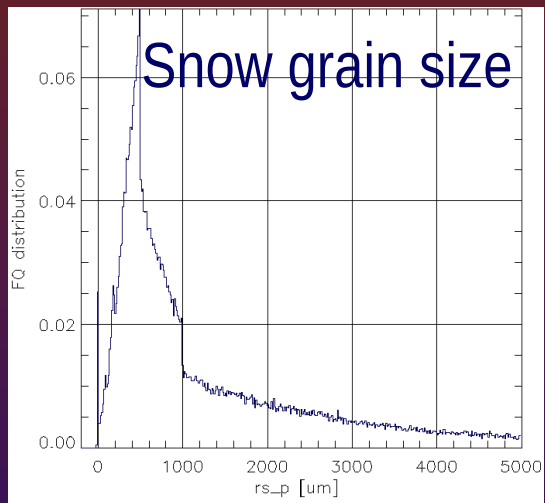
Example(6): Histogram of Snow grain size (rs_p) and Snow impurities (soot)

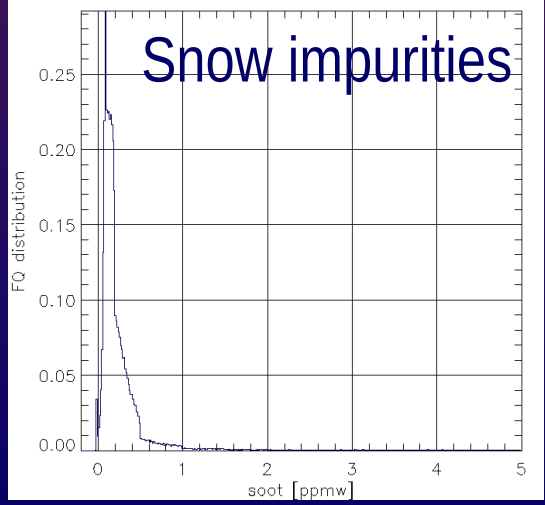
Sep.13~26, Northern Polar region





Sep.27~ Oct.11, Southern Polar region

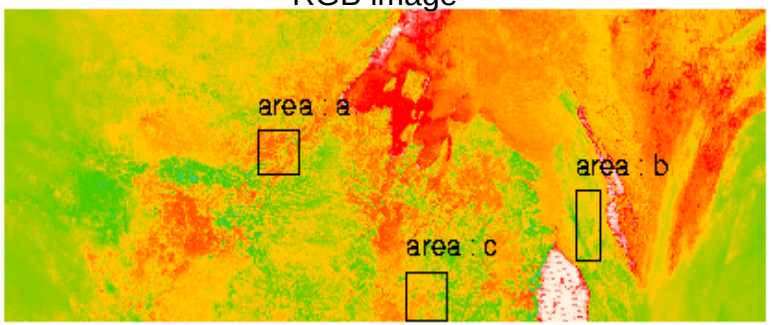




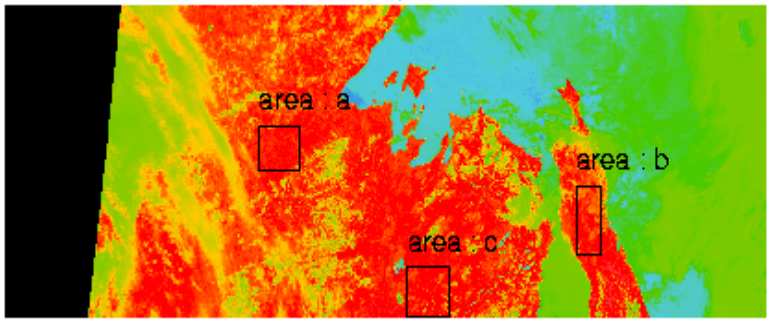
Example(5): Snow detection in forest area

The Far East

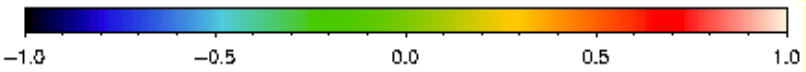
RGB image



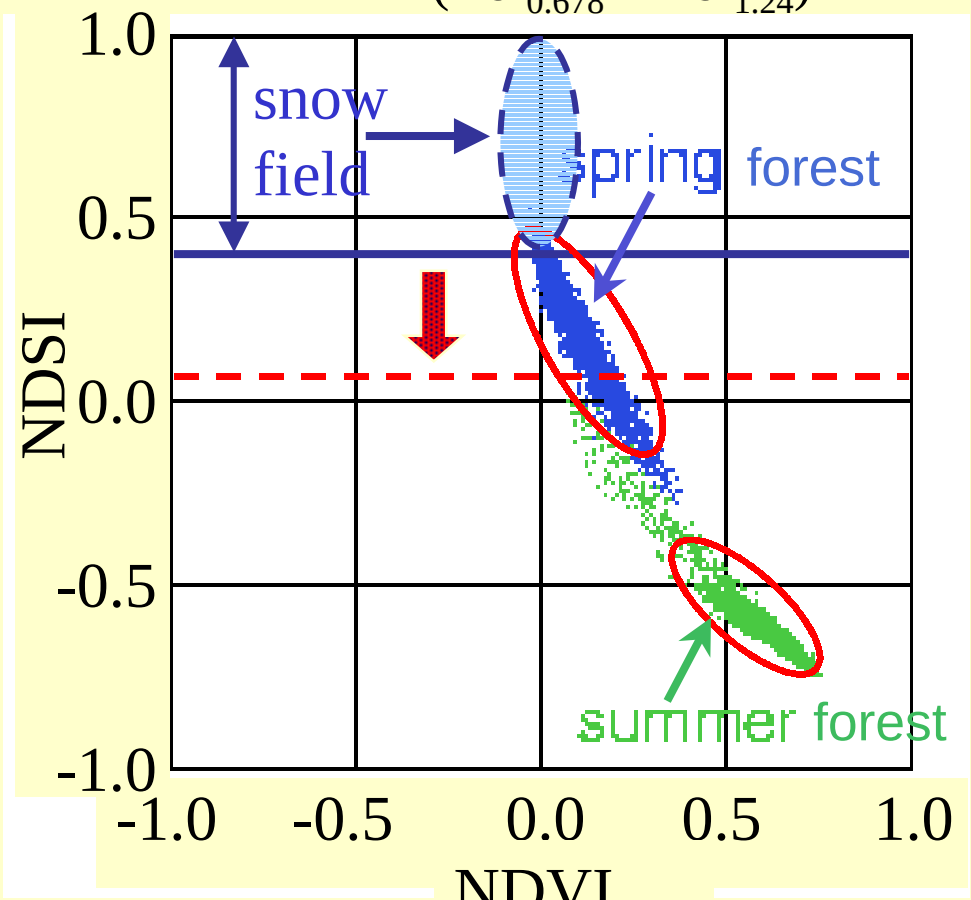
NDSI1 (spring)



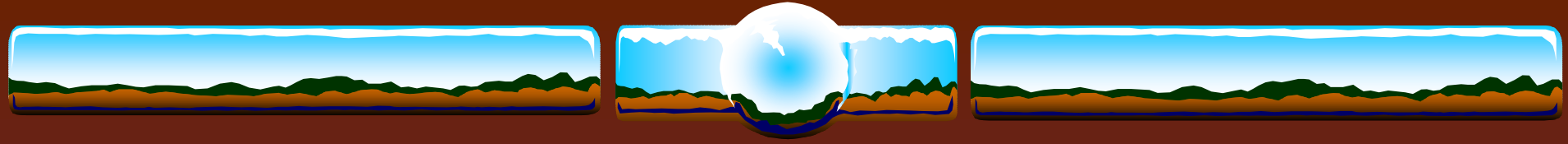
NDVI1 (summer)



$$NDSI = \frac{(Ref_{0.678} - Ref_{1.24})}{(Ref_{0.678} + Ref_{1.24})}$$



NDSI vs. NDVI



Consideration items after the preliminary validation

① Is the expansion of value ranges of snow parameter defined in the lookup tables (CTSK2b1) necessary for global application ?

→ For snow grain size retrieval more wide range is helpful.

② Evaluation of the effects of sub-pixel contamination by non-snow pixels such as clouds, forest and open ocean on the accuracy of the retrieved snow parameters

→ Contamination by open ocean or cloud in the Arctic sea

→ Contamination by vegetation at low altitude land area

→ Cloud detection over the thick ice sheet in the Antarctica

③ Evaluation of the validity of the atmospheric and aerosol models in CTSK2b1 for atmospheric correction in observation conditions

→ Advanced method is presented by Prof. Stamnes.

④ Evaluation of the effect of non-spherical snow grains on the retrieval of snow parameters

→ Under investigation by Dr. Aoki.

⑤ Evaluation of the effect of surface roughness on the retrieval of snow parameters in real snow fields

→ To be investigated.

Others

- Default solar irradiation data (Thuillier 2001)

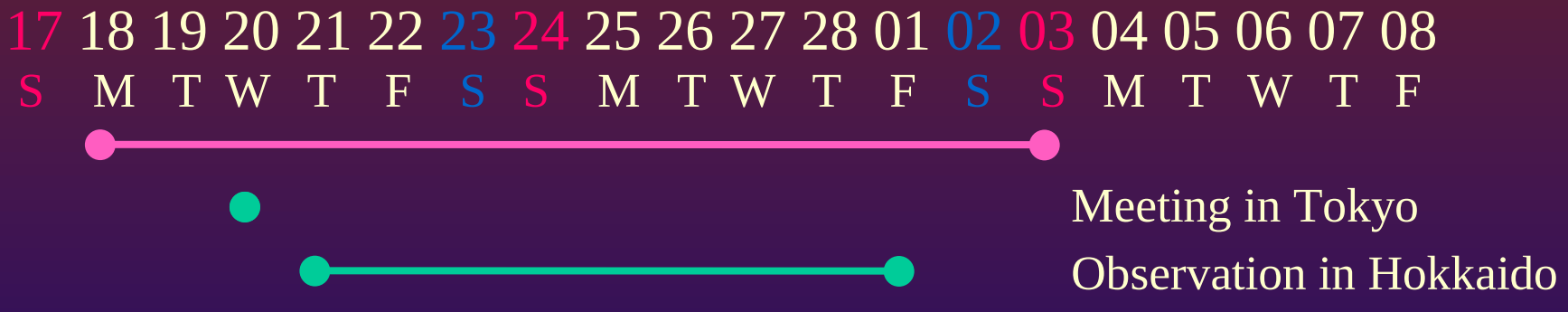
  → refer to Jens Nieke's presentation
- On the joint field experiment at Saroma, Hokkaido in 2002

On the joint field experiment at Saroma, Hokkaido in 2002

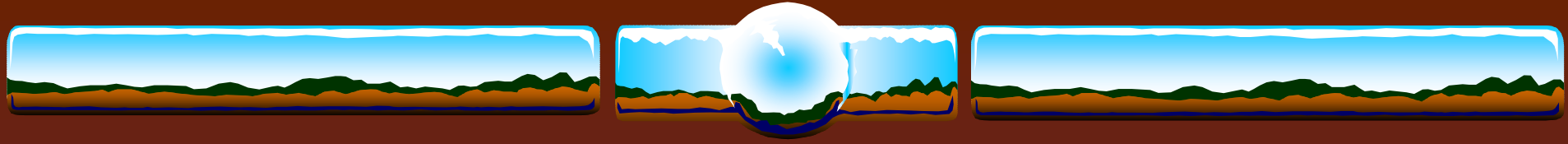
Place: Saroma lagoon and around, Hokkaido, Japan

Schedule (Tentative plan):

Period: Feb. 18 ~ Mar. 3, 2002



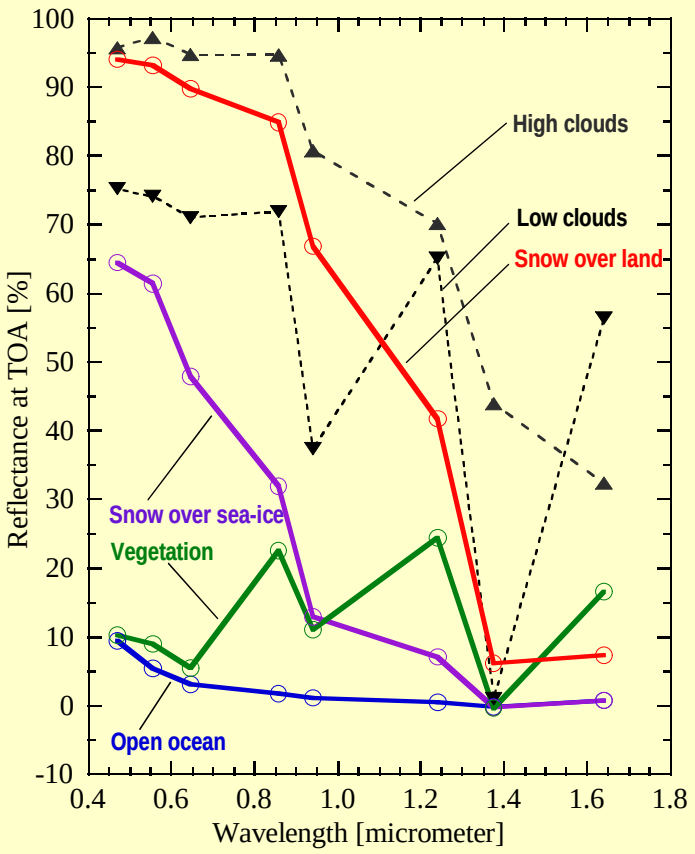
Members: Teruo Aoki (MRI)
Masahiro Hori (NASDA/EORC)
Tomonori Tanikawa (Univ. of Tsukuba)
Hans Eide (Stevens Institute of Technology)
one student (Stevens Institute of Technology)
logistic supports by a contractor (Restec or other)



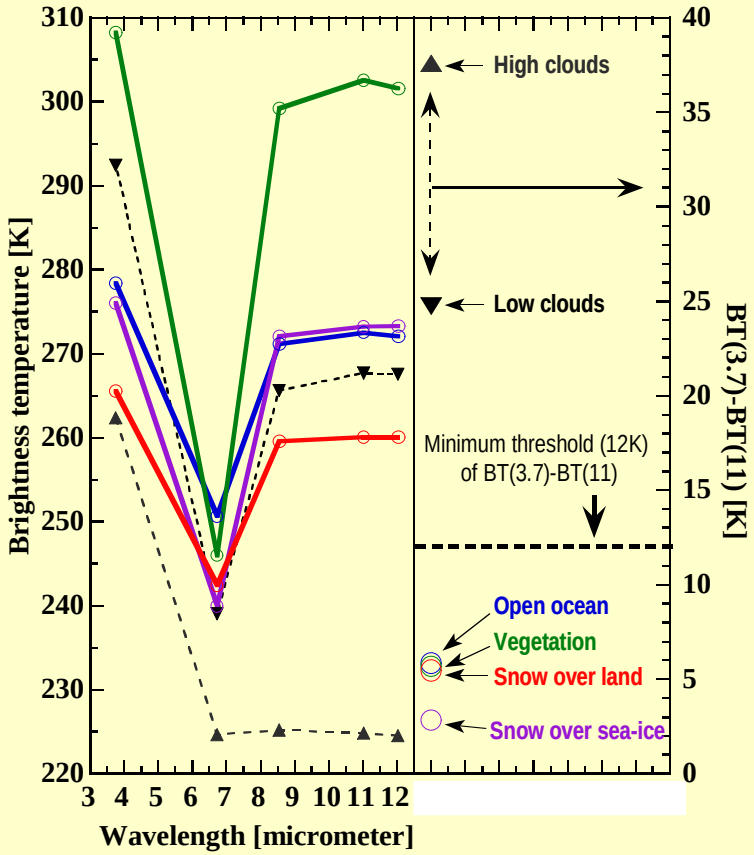
Notes

Spectral features of various targets

VNIR&SWIR



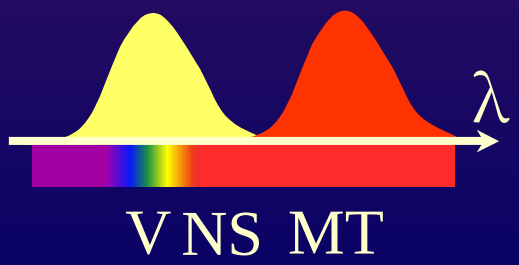
MTIR & ΔBT(3.7-11um)



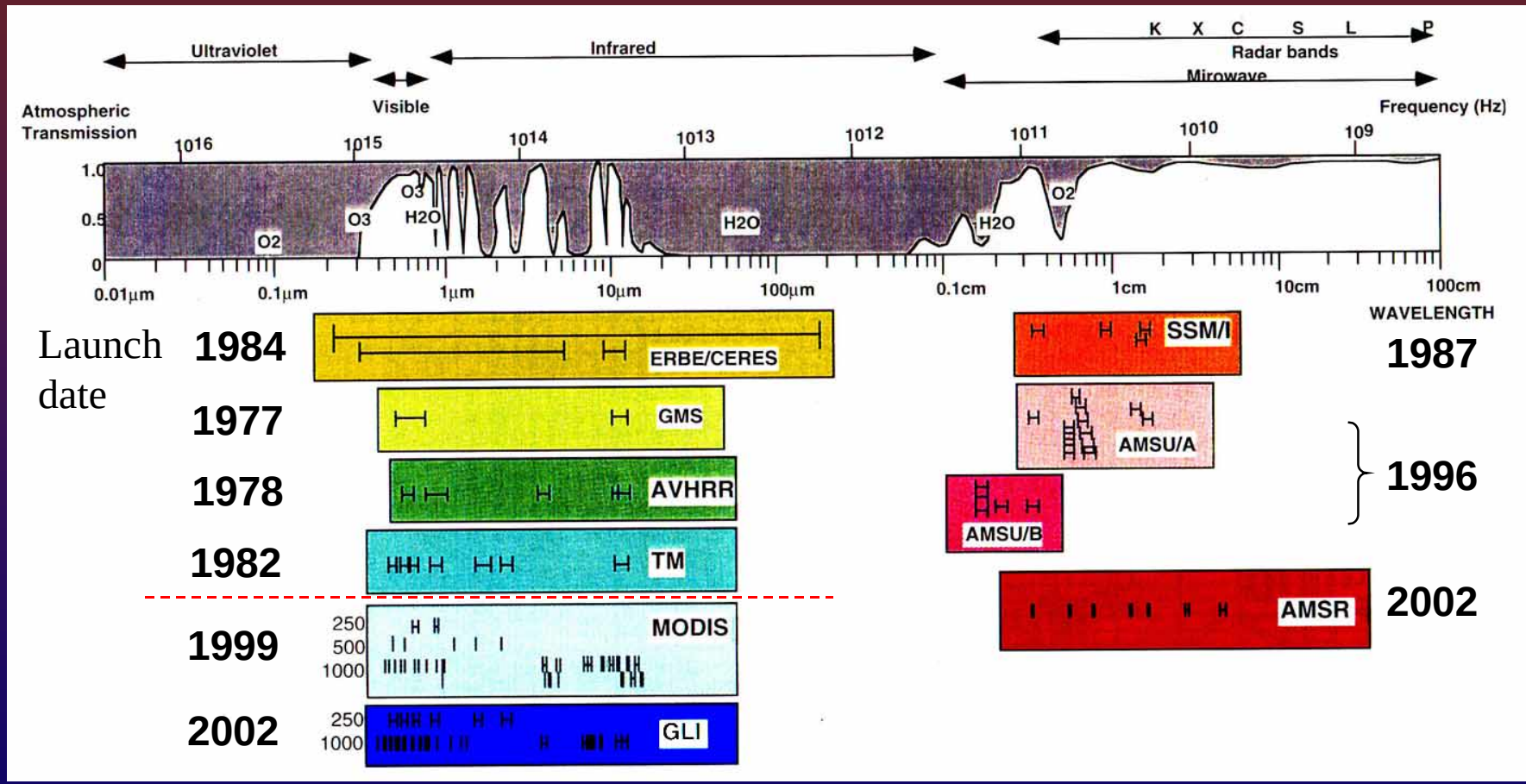
Targets

Spectral band	Snow(/Ice) parameters
■ VISIBLE(V):	snow/sea-ice cover extent*
	mass fraction of snow impurities*
■ NIR/SWIR(NS):	discrimination of cloud/snow (with other chs.)
	snow grain size*
	discrimination of sea-ice type (new ice, nilas)
	detection of snow in forest area using NDVI&SI
■ MTIR(MT):	snow surface temperature
	snow density or other (?)

*: GLI standard products



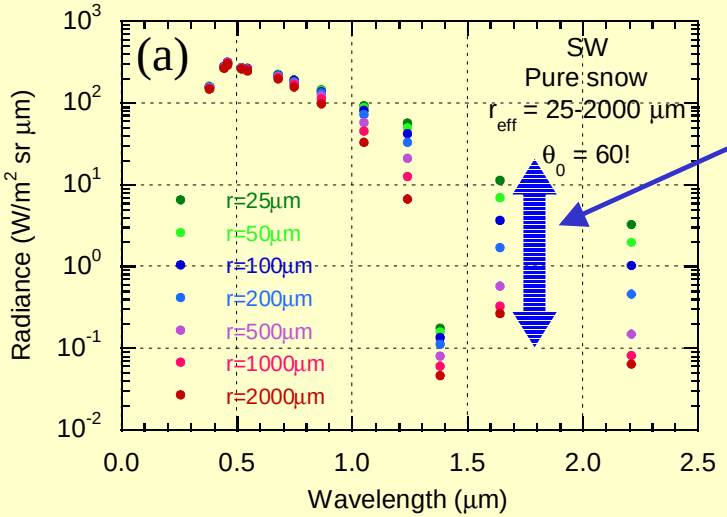
Spectral bands of satellite radiometers

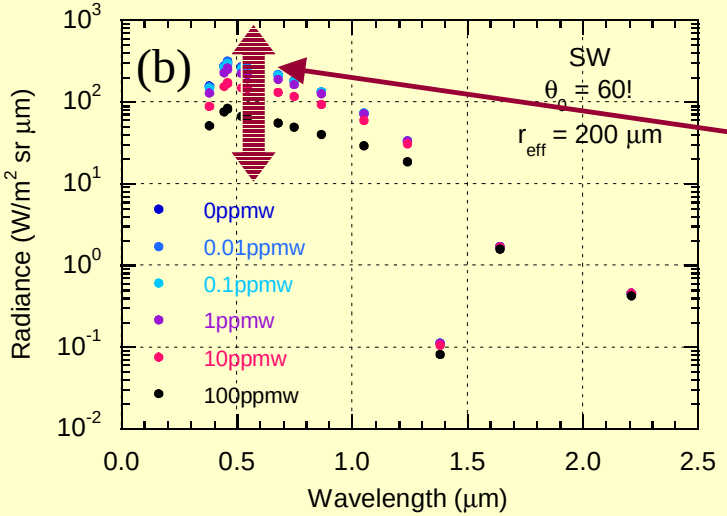


Optical sensor

Microwave sensor

Dependence on snow grain size & impurities





Snow albedo in the near infrared region depends on **snow grain size**.

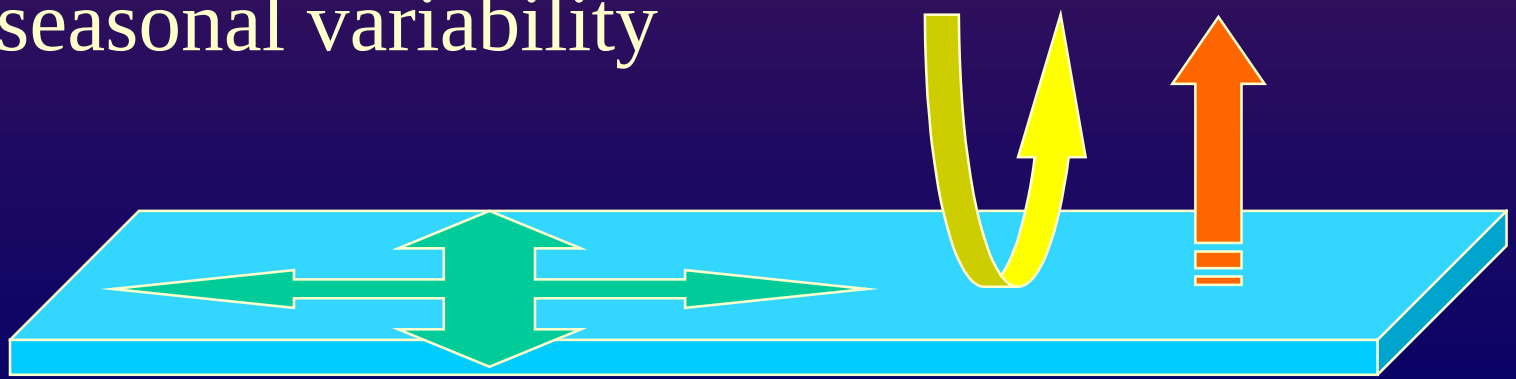
Snow albedo in the visible region depends on **mass fraction of impurities mixed in snow layer**.

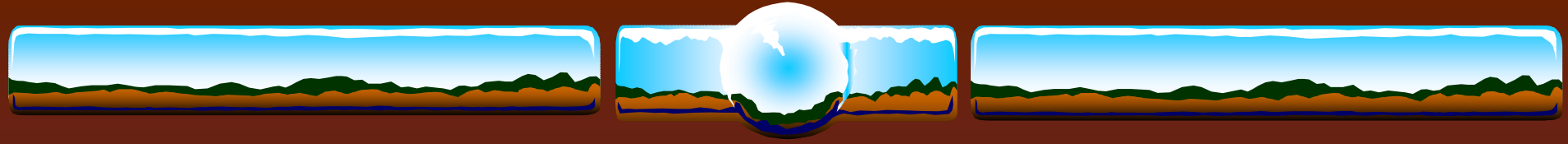
Figure. Spectral radiance of snow in visible and near infrared region as a function of (a) snow grain size and (b) mass fraction of impurities mixed in snow.

Purposes & Applications (1)

Snow cover has a large impact on the daily weather and the climate system due to …

- High reflectance in shortwave wavelength region
- High emissivity in longwave wavelength region
- Large spatial extent and volume with large daily/seasonal variability





Purposes & Applications (2)

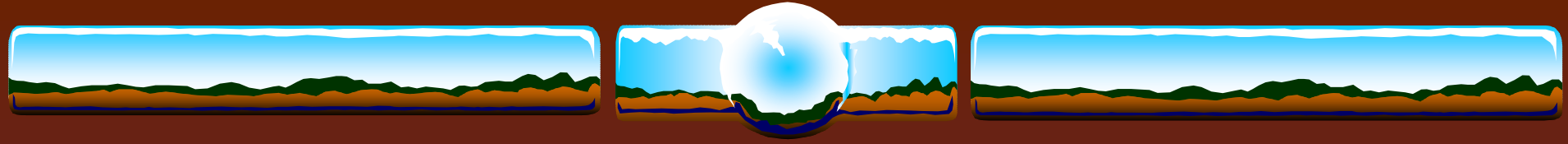
Snow surface physical properties such as *snow grain sizes*, *mass fraction of impurities*, *density*, *and temperature* *etc.* are closely related to the optical properties of snow …

- Reflectance in the visible and near infrared region
- Emissivity in the thermal infrared region

thus can affect to …

- Radiation budget in the atmosphere-snow system
- The amount of melting water and evaporation, and thus hydrological cycle

Snow surface properties ⟺ Environmental factor (air temperature, air pollution etc.)



Purposes & Applications (3)

The monitoring of the snow surface properties from space is of great importance for …

- Forecast of daily/seasonal weather
- The studies the climate, particularly on the response of the earth climate to the global warming phenomena
- The studies on the hydrological fresh water cycle

NDSI（Normalized Difference Snow Index）

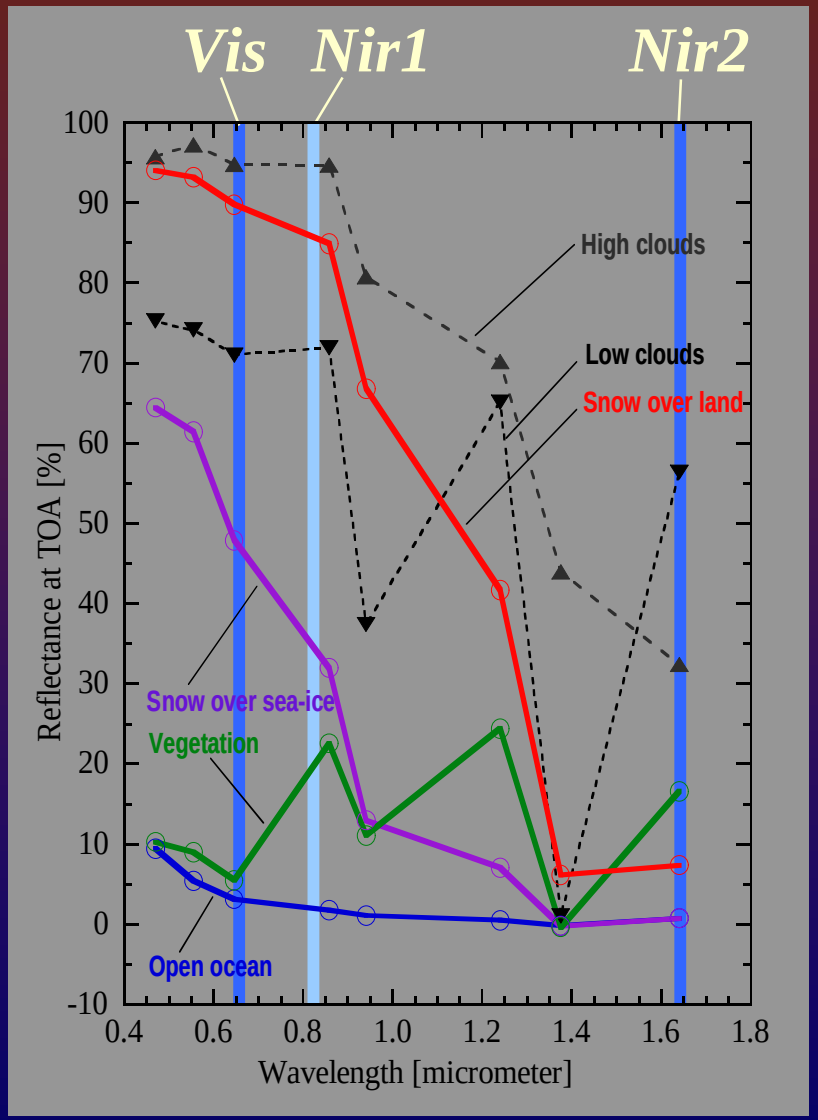
$$S1 = \frac{Vis - Nir2}{Vis + Nir2}$$

$$S2 = \frac{Vis\,(Nir1 - Nir2)}{(Nir1 + Vis)\,(Nir1 + Nir2)}$$

$$S3 = \frac{Nir1\,(Vis - Nir2)}{(Nir1 + Vis)\,(Nir1 + Nir2)}$$

（from Saito and Yamasaki, 1999）

	波長帯（nm）	チャンネル
Vis	630–690	22
Nir1	770–880	23
Nir2	1540–1740	28



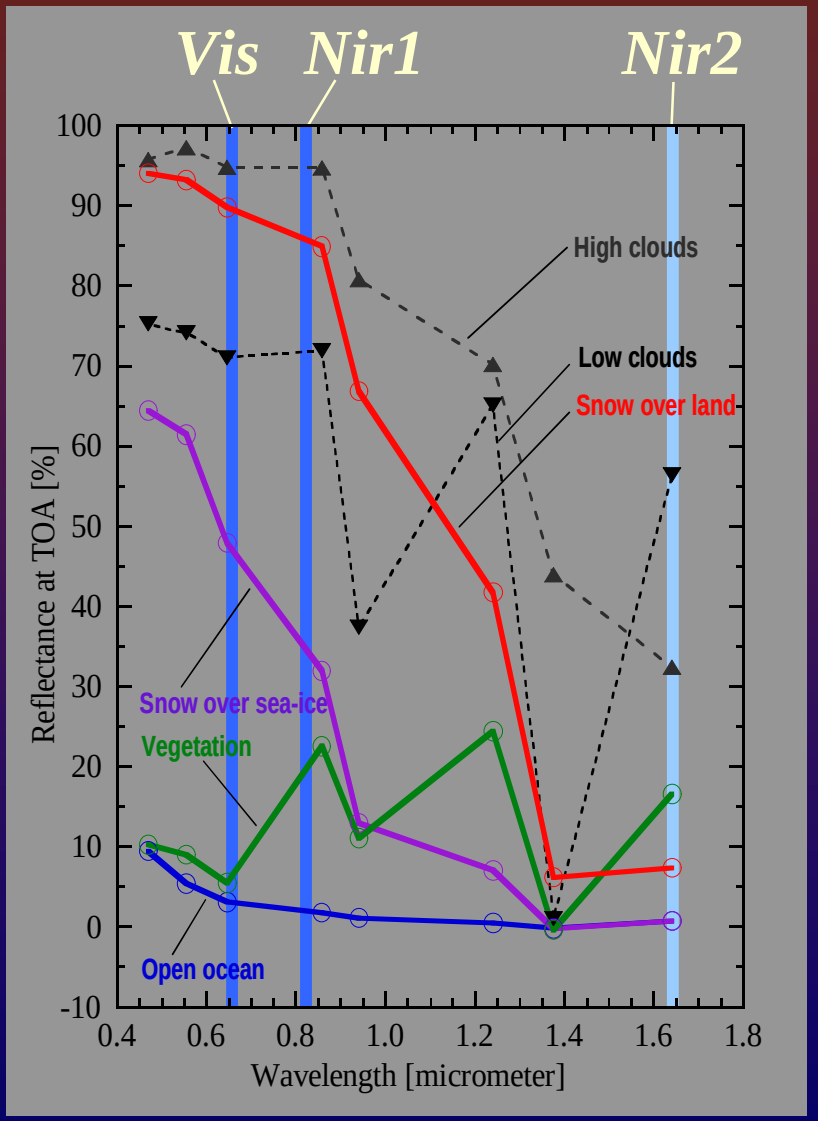
NDVI（Normalized Difference Vegetation Index）

$$V1 = \frac{Nir1 - Vis}{Nir1 + Vis}$$

$$V2 = \frac{Nir1 - Vis}{Nir1 + Nir2 + Vis}$$

（from Saito and Yamasaki, 1999）

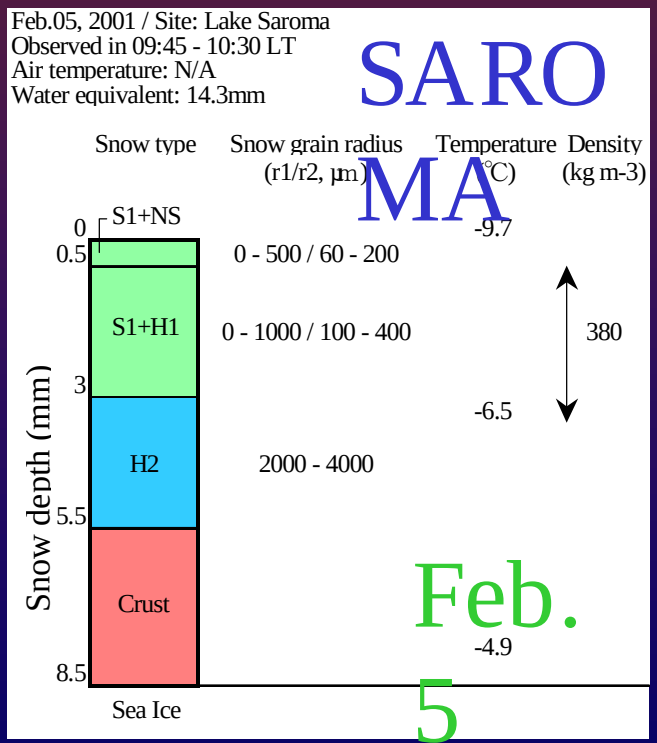
	波長帯 (nm)	チャンネル
Vis	630–690	22
Nir1	770–880	23
Nir2	1540–1740	28

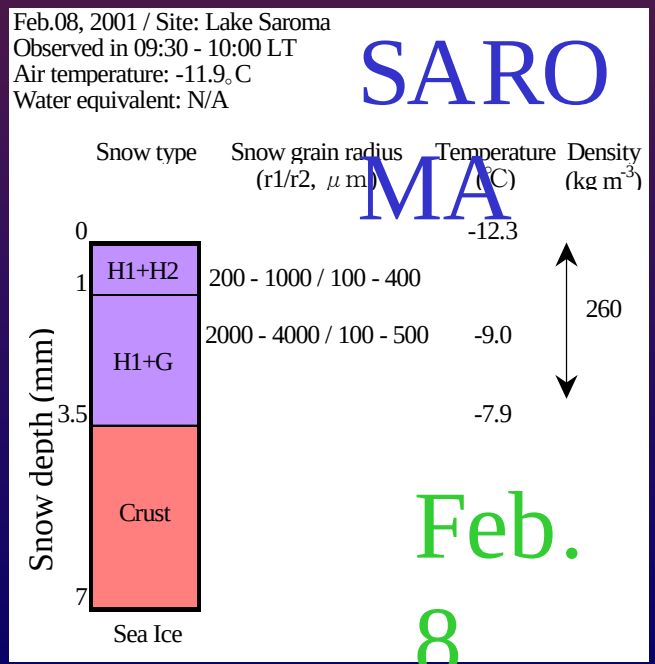


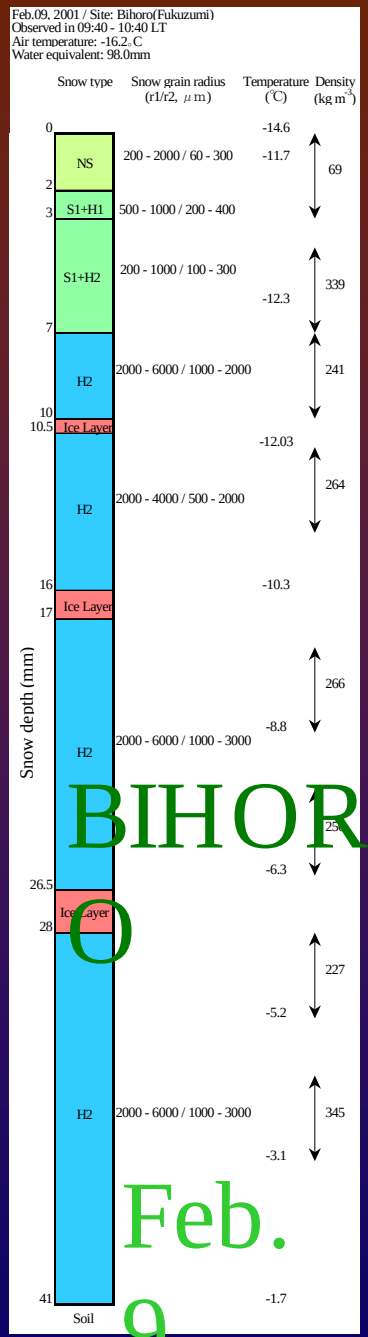
Snow pit work

Snow type

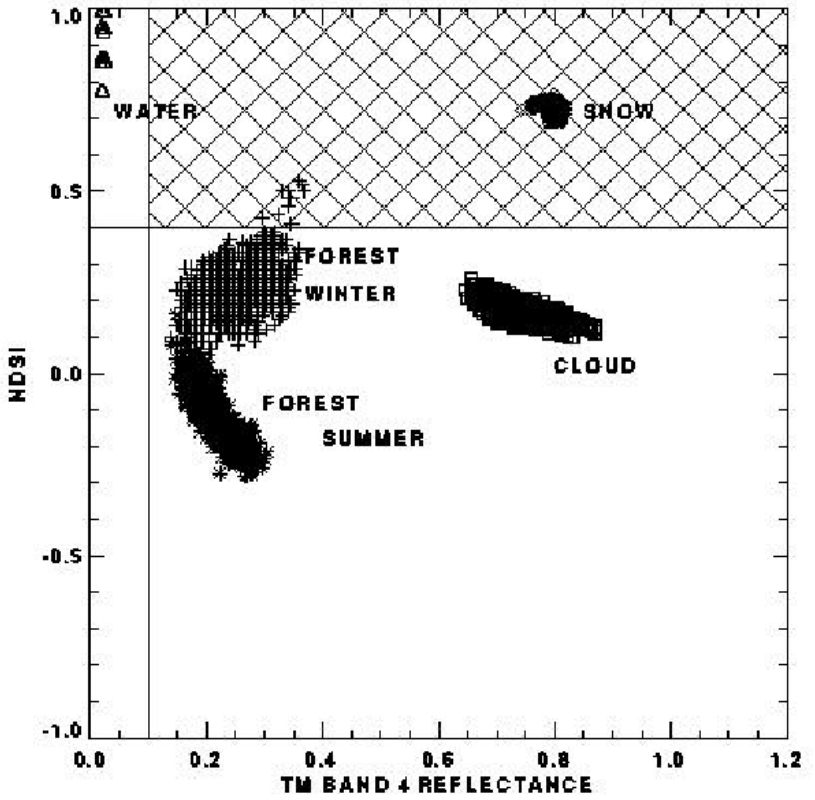
- New Snow
- Fine-grained old snow
- Faceted crystals
- Depth hoar
- Ice layer and Crust



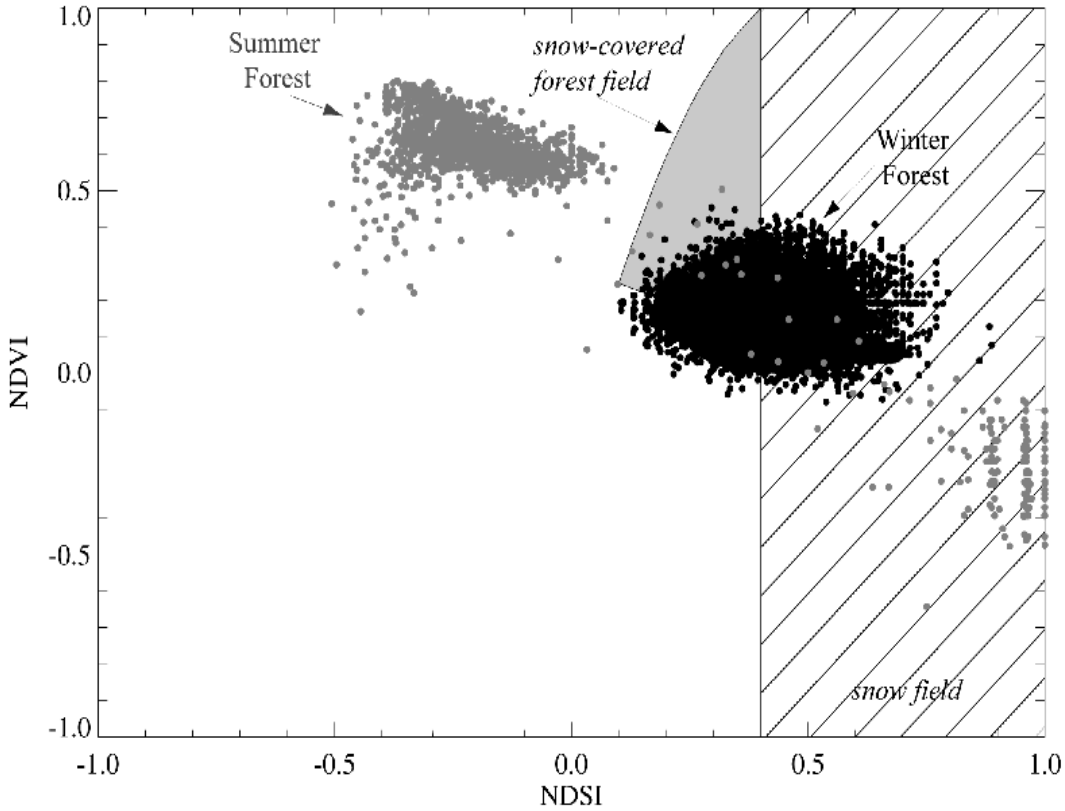




The relationship between NDSI and NDVI in the vegetation area



TM4（0.76~0.9μm）vs. NDSI



NDSI vs. NDVI

（from MODIS MOD10ATBD）