Cal/Val Plan of Cryosphere Group

Targets (Geophysical parameters)

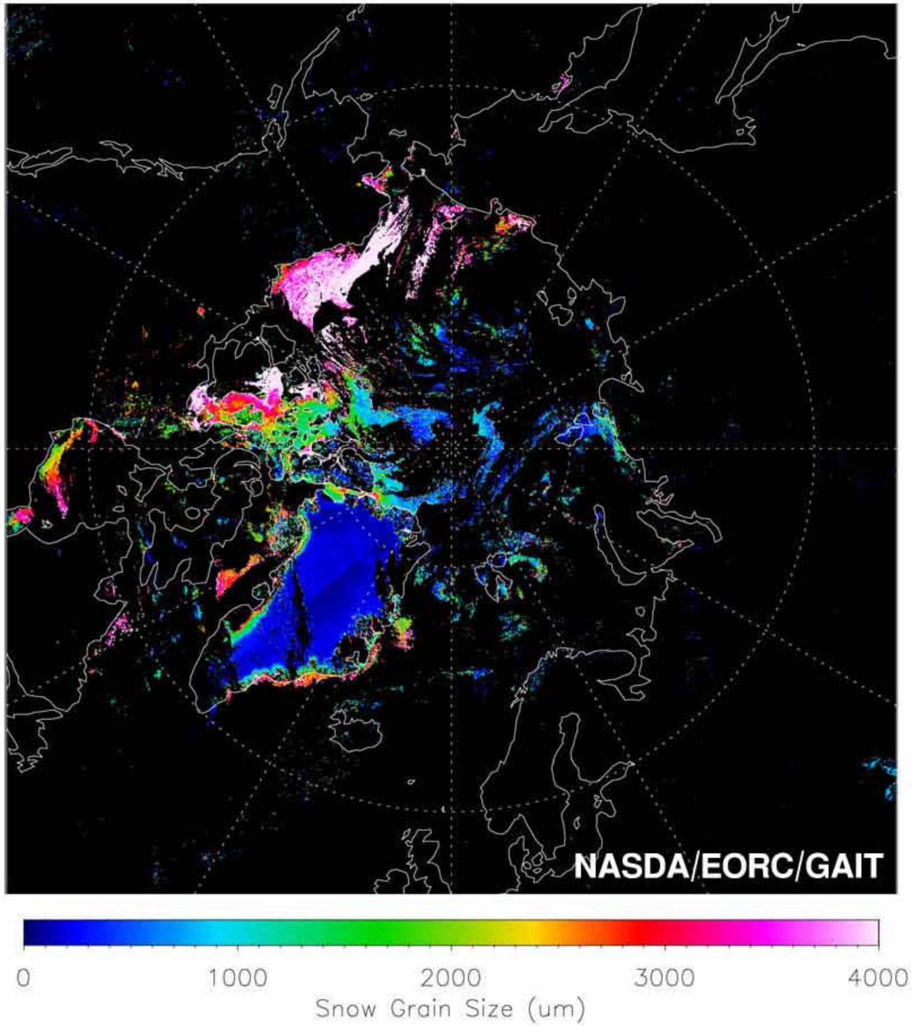
T1. Snow grain size (CTSK2b1)
T2. Snow impurities (CTSK2b1)
T3. Snow and sea ice extent (CTSK1)
T4. Detection of cloud over snow and ice (CTSK1)

Works

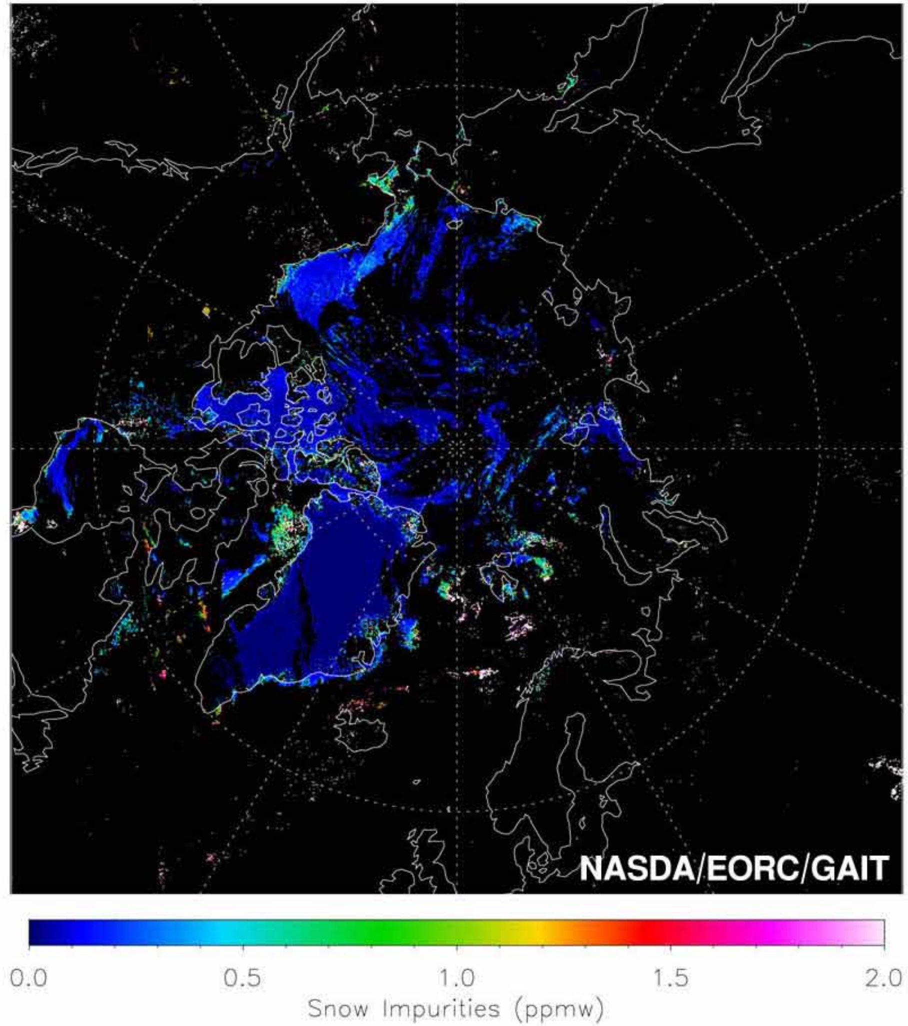
W1. Snow pit work (vertical profiles of snow parameters)
W2. Spectral measurements of snow and ice optical properties (radiance, flux, BRDF albedo and emissivity)
W3. Reanalysis of AMSS (Airborne Multiple Spectral Scanner) data
W4. Receive the MODIS and GLI 250m data in Antarctica
W5. Comparison with the other products and sensors (ENVISAT etc.)

Effective snow grain size and impurities retrieved with MODIS data

(June 19, 2000)



Effective snow grain radius (µm)



Concentration of impurities (ppmw)

Val/Cal experiment

Measurement	Parameter	Instrument
(*In situ* / Optical method)		
Spectral albedo	Upward and Downward flux	Spectrometer (0.35 - 2.5 μm)
Spectral BRDF	Radiance	Spectrometer (0.35 - 2.5 μm)
		Sky radiometer
Emissivity	Brightness temperature	FTIR (2 - 5, 8 - 14 μm)
Radiation budget	SW up/down, LW up/down	Pyranometer, Pyrgeometer
(*In situ* / Glaciological method)		
Microphotograph	Size distribution of snow grains	Macro camera
Snow pit work	Snow temperature, snow density,	Snow pit work tools
	Snow layer structure,	
	Snow grain size and snow type	
Snow sampling	-> Laboratory measurement	
(Laboratory / for snow impurities)		
Filtering	-> Weight measurement	Filtering tools
Weight	Mass fraction of impurities	Valance
Electron micrograph	Size distribution	Electron micrograph
Transmittance and reflectance of sample filter		
	Refractive index	Spectrometer (0.35 - 2.5 μm)

Solar spectral region

FieldSpec FR

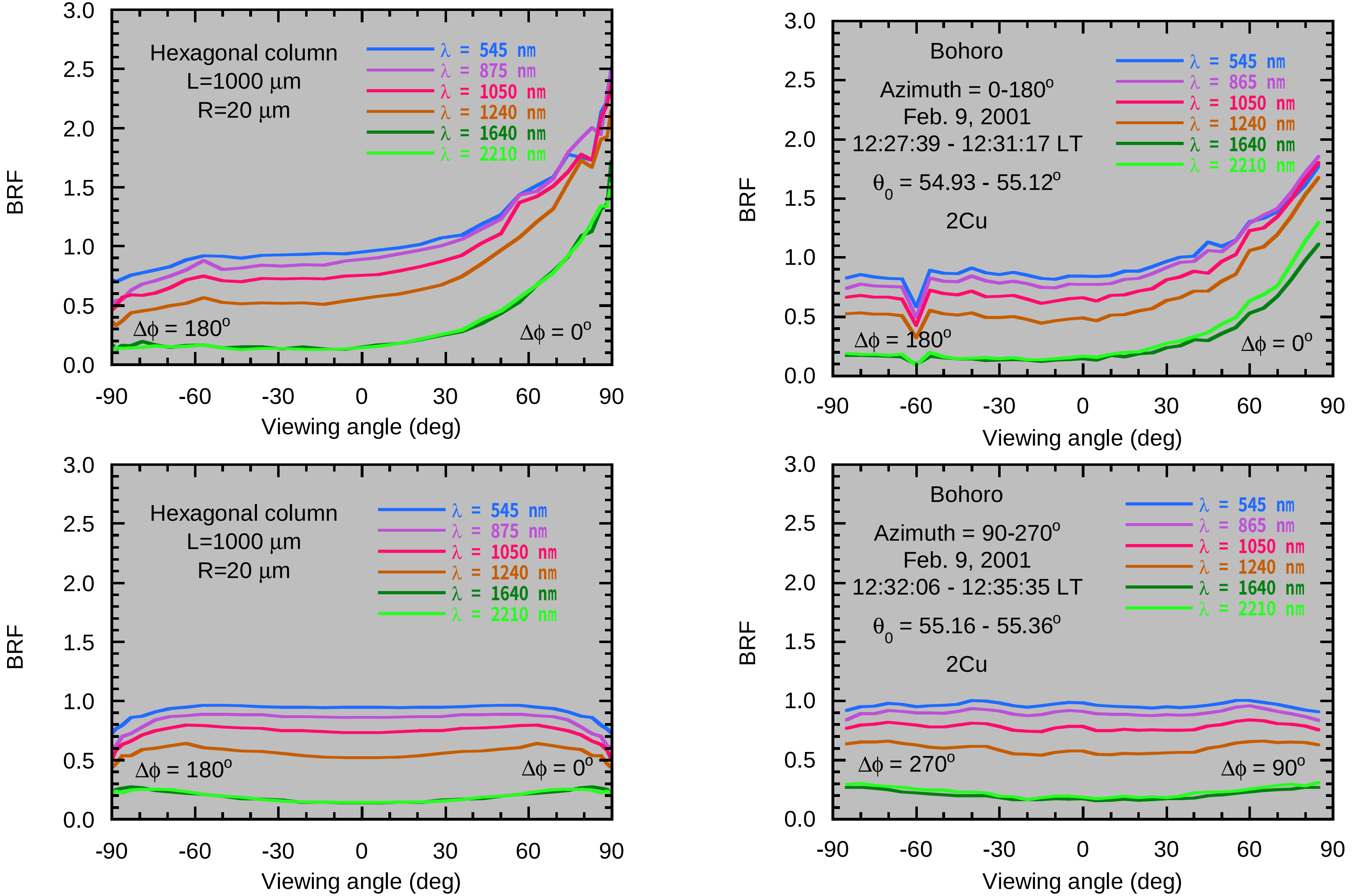
- Spectral BRDF and albedo
- λ = 0.35-2.5 μm
- $\Delta\lambda$ = 10 nm

Snow pit work

- Snow grain size
- Impurities, etc

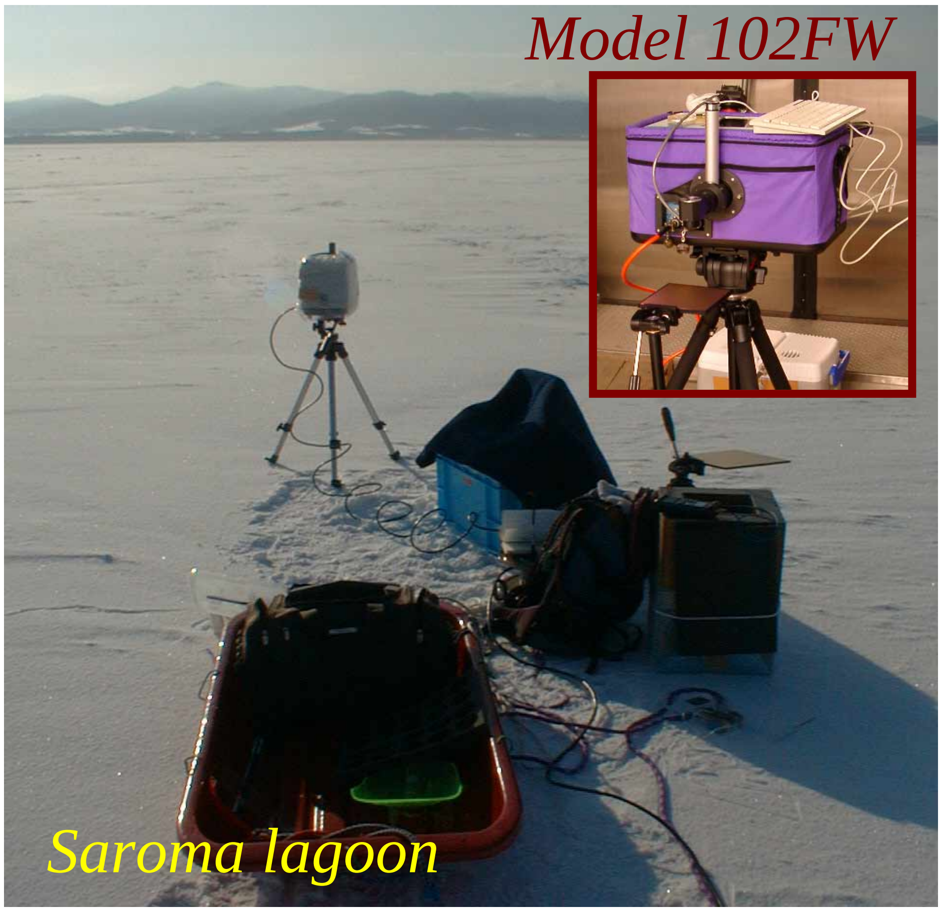
Simulation

Measurements



Measurement of snow emissivity in the thermal IR using μ FT-IR on the snow field

FT-IR and Saroma lagoon



FT-IR Specification

Micro FT-IR Spectrometer

(Designs and Prototypes, Ltd.)

Model:	102FW
Range:	2~14 μm (InSb/MCT)
Resolution:	4, 8, 16 cm^{-1}
Scan rate:	1 scan/sec.
FOV:	0.016 sr
Weight:	6.8 kg

An example of FT-IR measurements
~ SAROMA field experiments in 2000~

Simulation

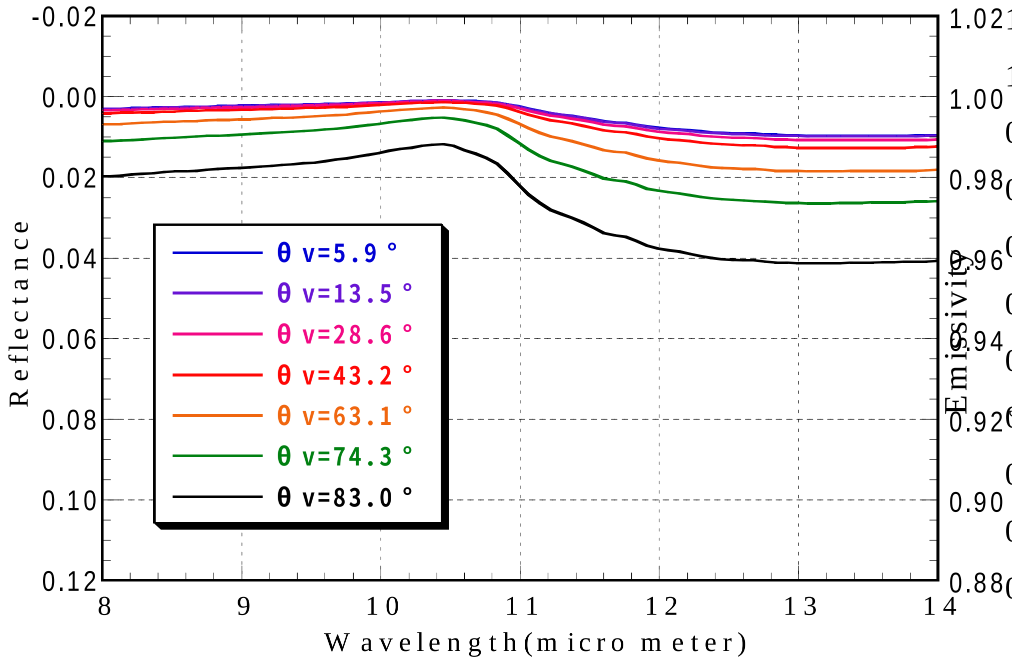


Figure 6. Simulated directional-hemispherical reflectance for grain size r_{eff}=200μm at viewing angles θ_v between 5 and 83°.

Measurement

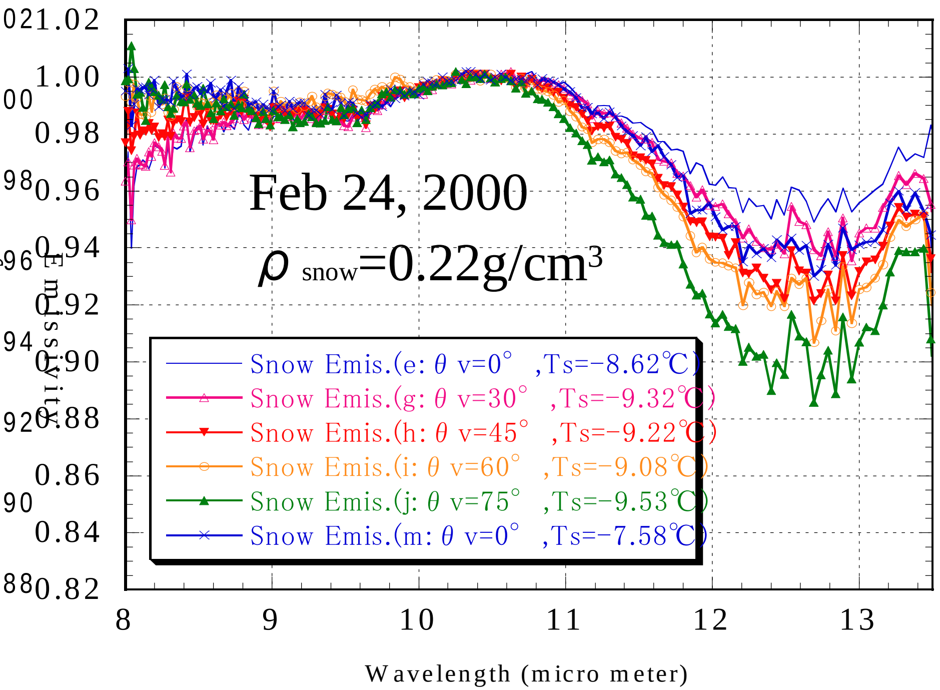
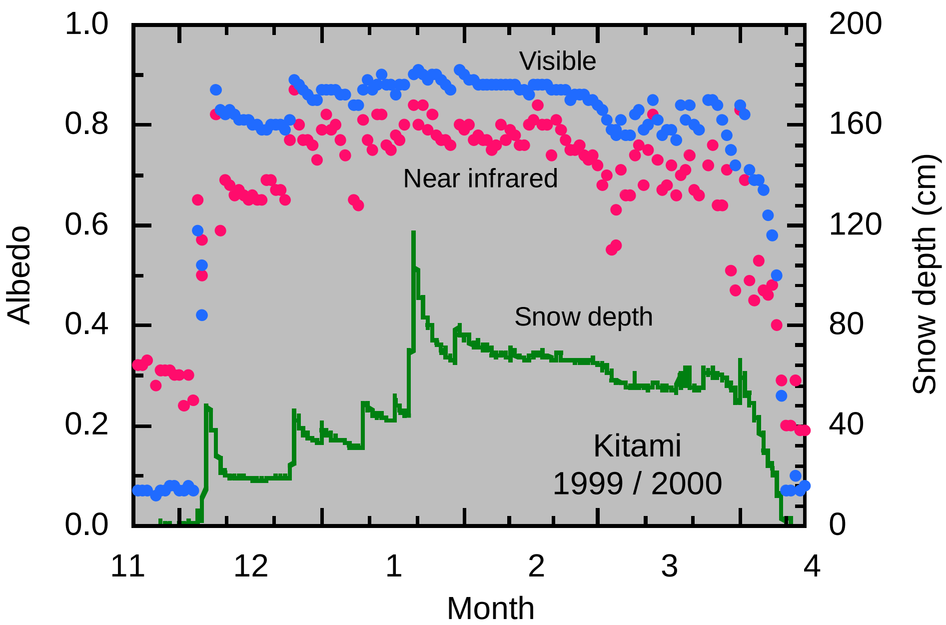
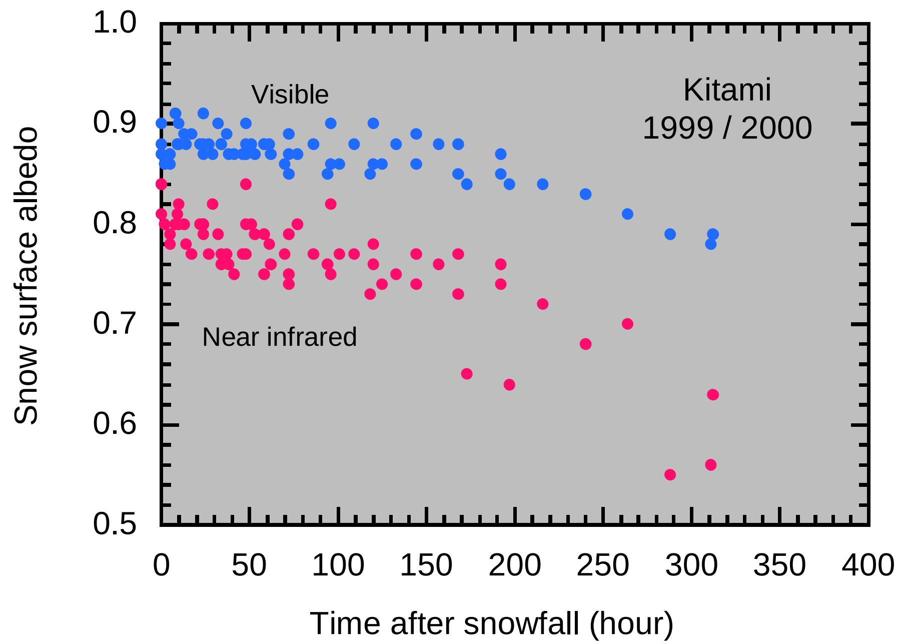


Figure 5. Directional emissivity of snow surface at various viewing angles (θ v). "Ts" in legend indicates the adjusted snow surface temperature used in the calculation of emissivity (see text).

Radiation budget and snow pit work observations at Kitami in 1999/2000 winter

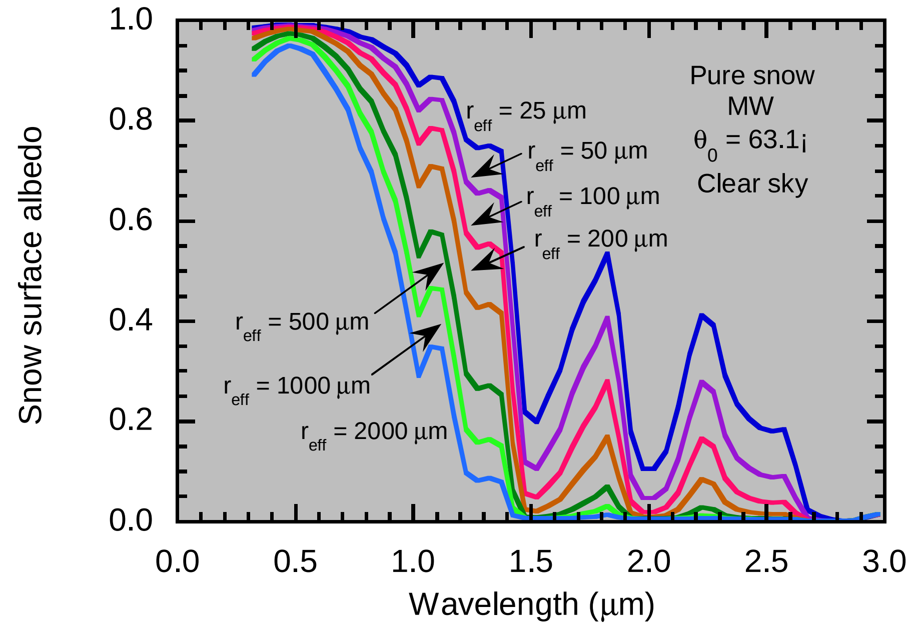
Albedo increases with snowfall and decreases with the time after snowfall. Albedo reduction in the near infrared region is more sensitive than that in visible region.



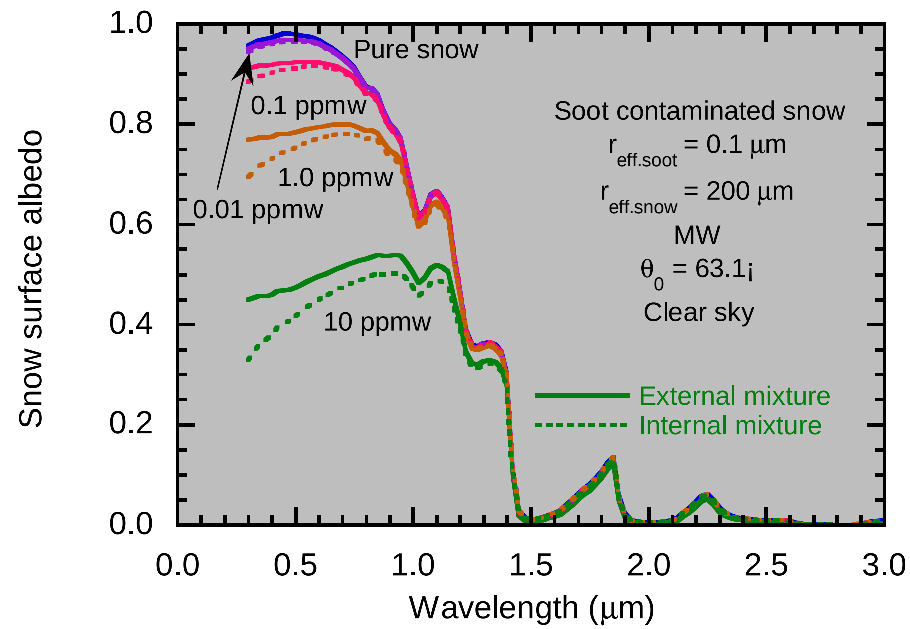


Effects of snow grain size and impurities on albedo

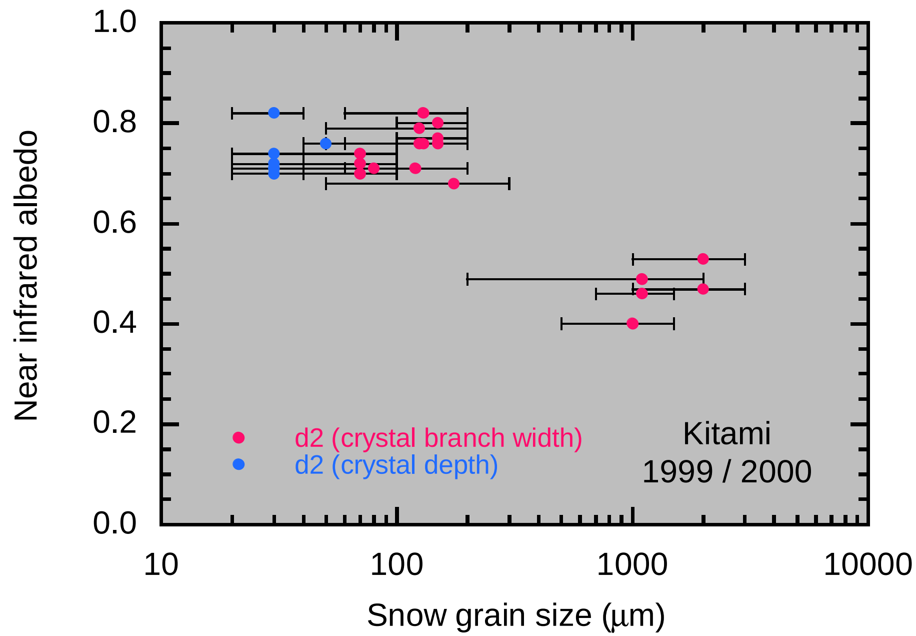
Near infrared albedo depends on snow grain size.



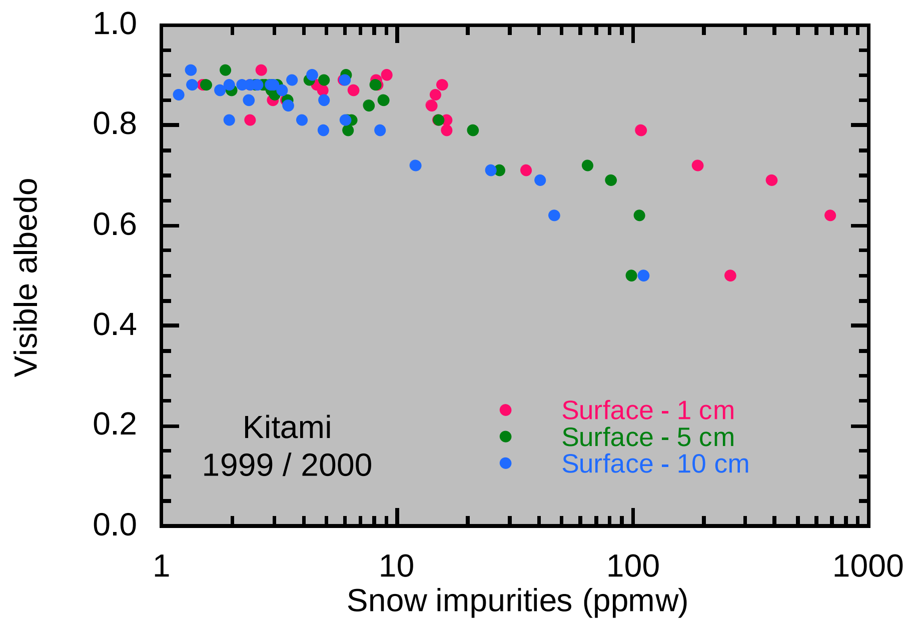
Visible albedo depends on snow impurities. Internal mixture is effective for albedo reduction than external mixture.



Near infrared region:
Near infrared albedo depends on the snow grain size. Snow grain size is increased by the "sintering" phenomenon after snowfall.



Visible region:
Visible albedo depends on the snow impurities. The source of snow impurities would be the atmospheric aerosols.



Validation sites

S1. Eastern Hokkaido for T1, T2, T3 and T4

S2. Barrow and Fairbanks, Alaska for T1, T2 and T3

S3. Antarctica for T1, T3 and T4 (Base station = Syowa)

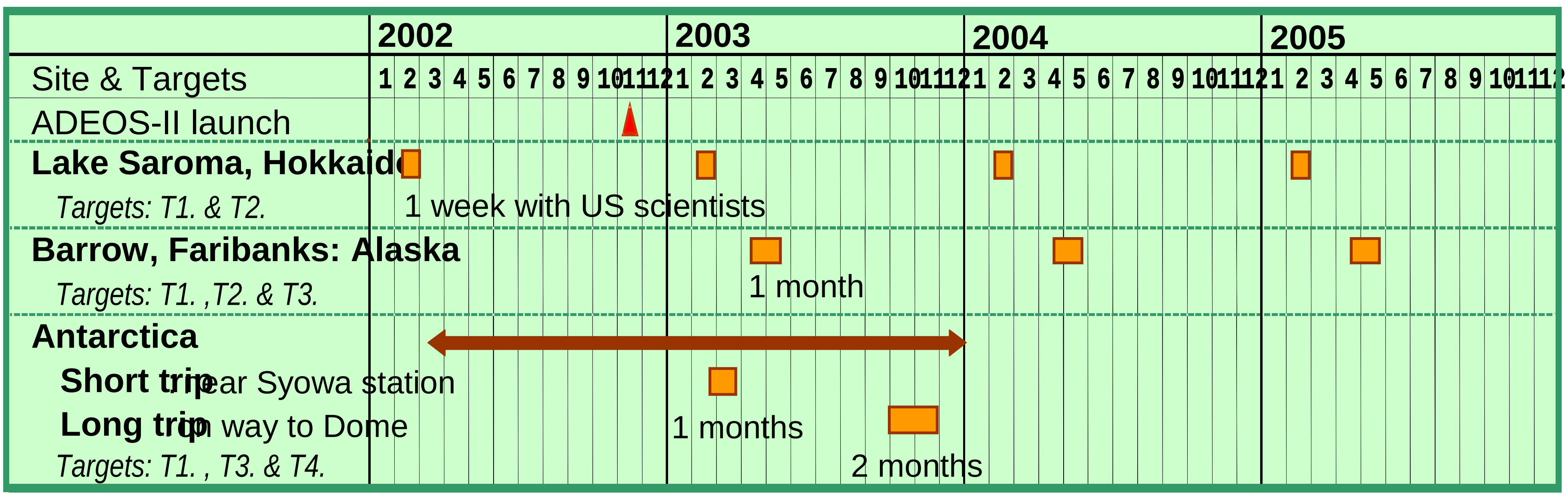
T1. Snow grain size (CTSK2b1)

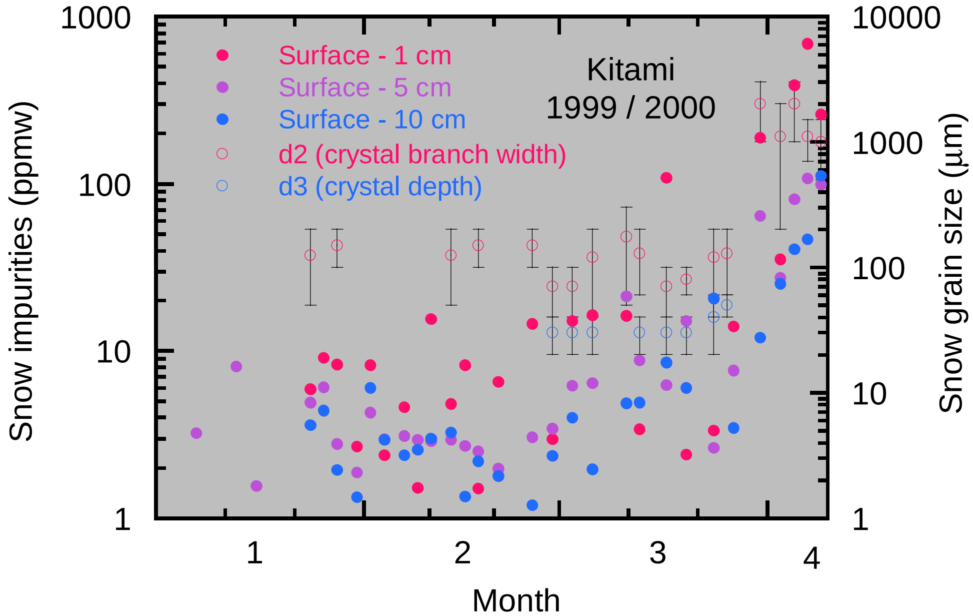
T2. Snow impurities (CTSK2b1)

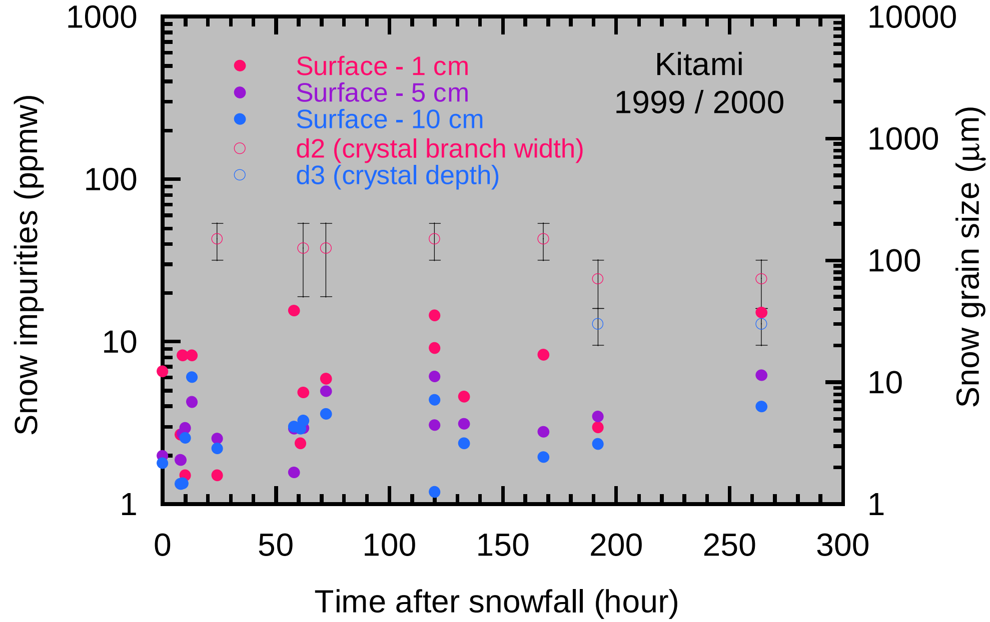
T3. Snow and sea ice extent (CTSK1)

T4. Detection of cloud over snow and ice (CTSK1)

Schedule

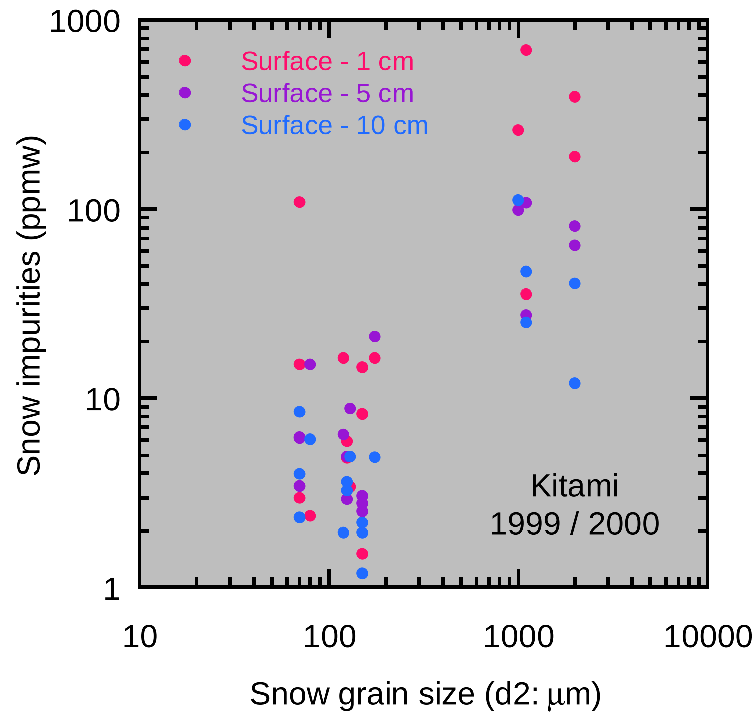






- Snow grain size decreases with time, while, impurities do not depend on time after snowfall.
- Concentration of impurities is higher at snow surface than those at deeper layers.

=> This suggests the dry deposition of atmospheric aerosols on snow surface.



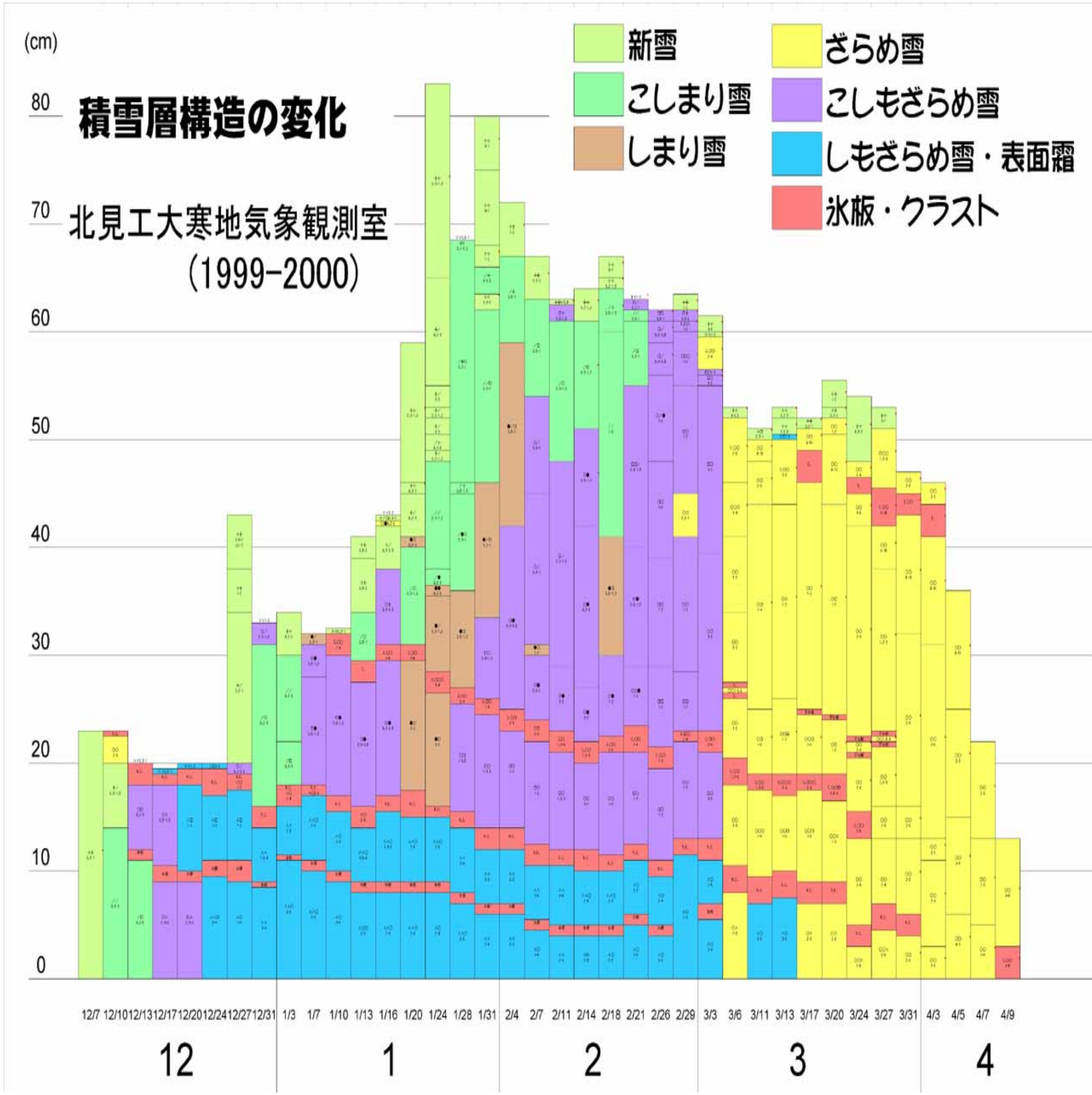
観測データによる 積雪層構造の 時系列変化

１２

２

１２

３



Crocusによる
積雪層構造の
時系列変化

12
rain crust

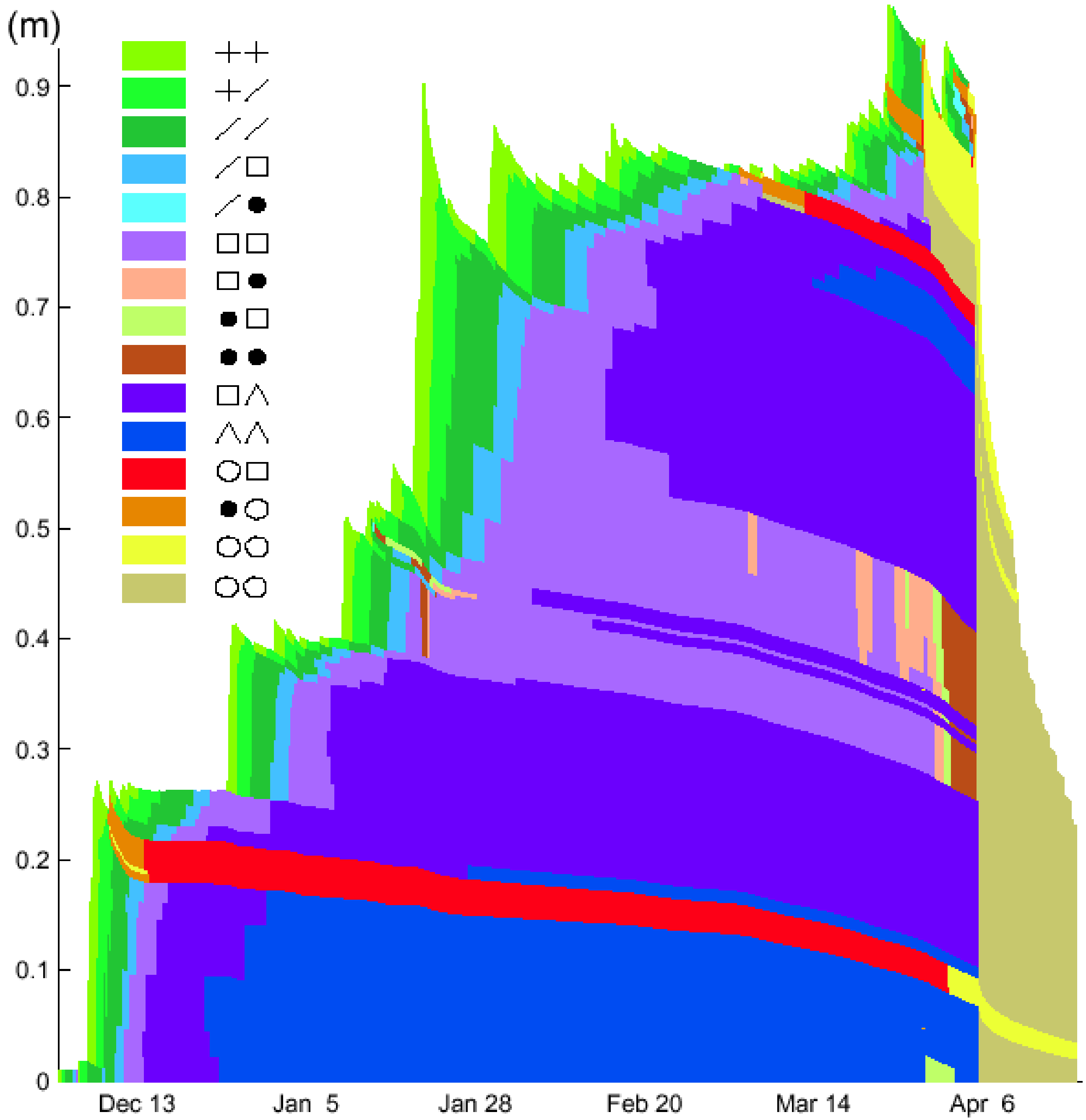
2

4/20

4/11

3

4

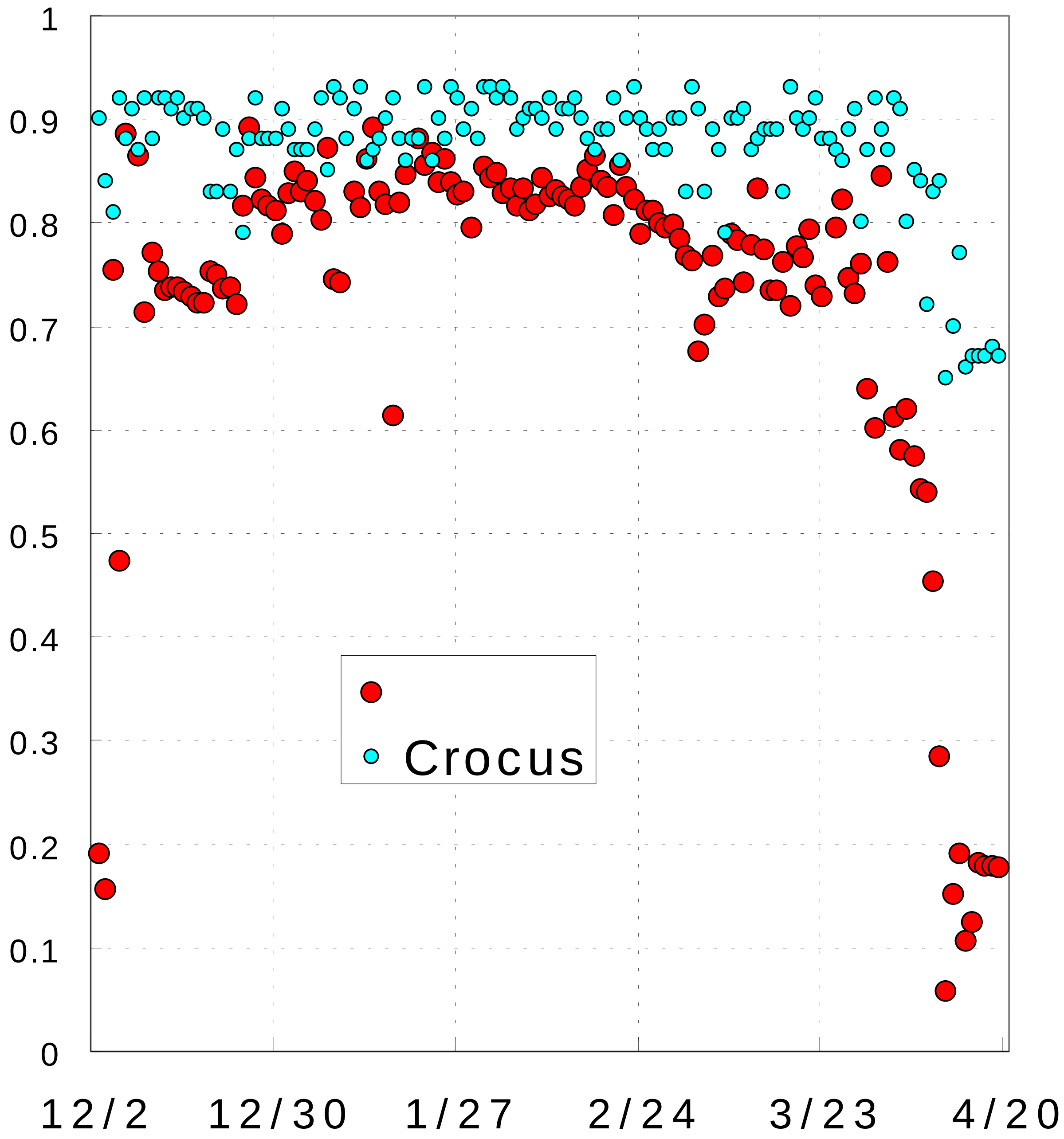


Crocusは雪面アルベド（可視＋近赤外）をかなり過大評価している。

Crocus

Crocus

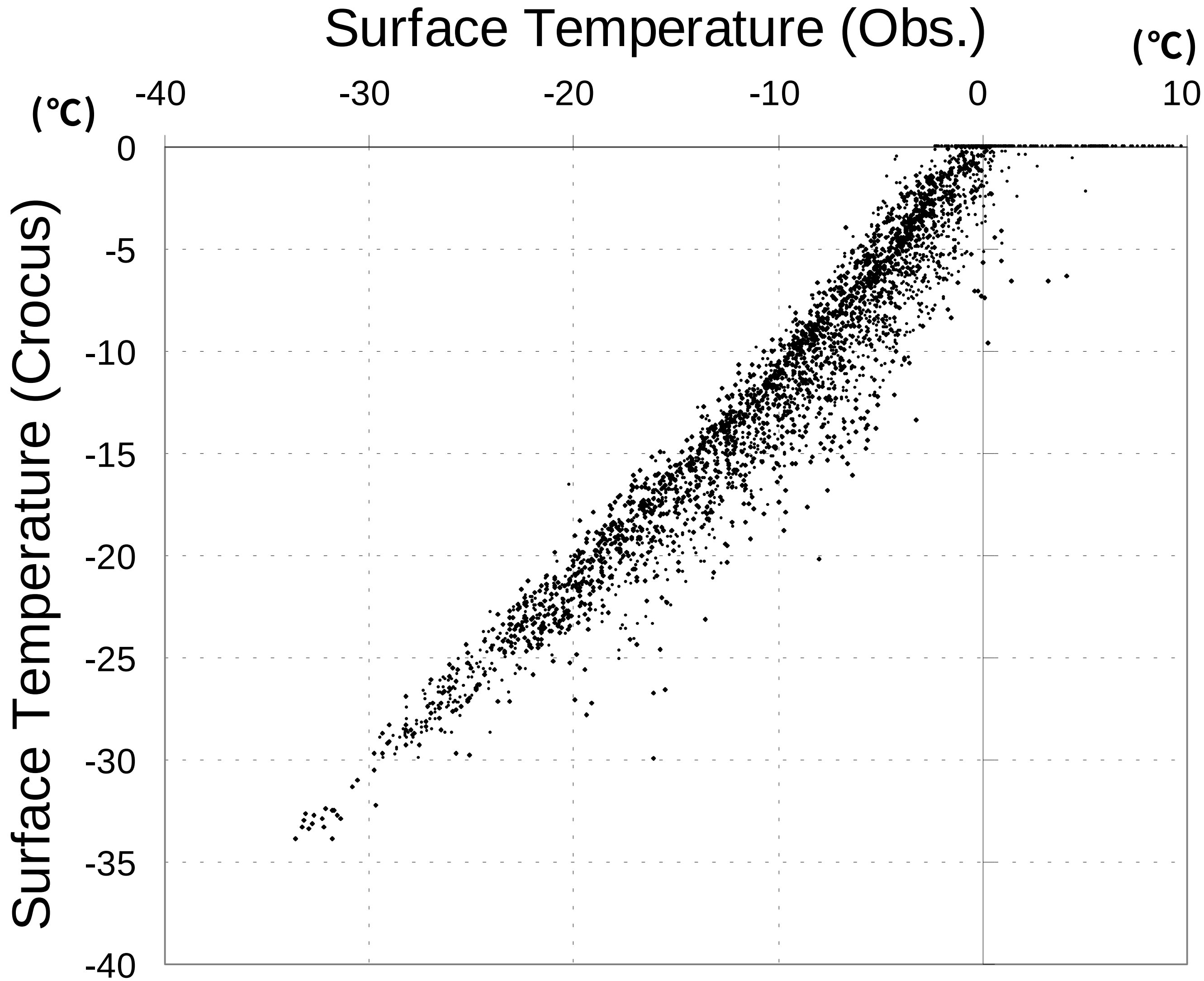
Crocus

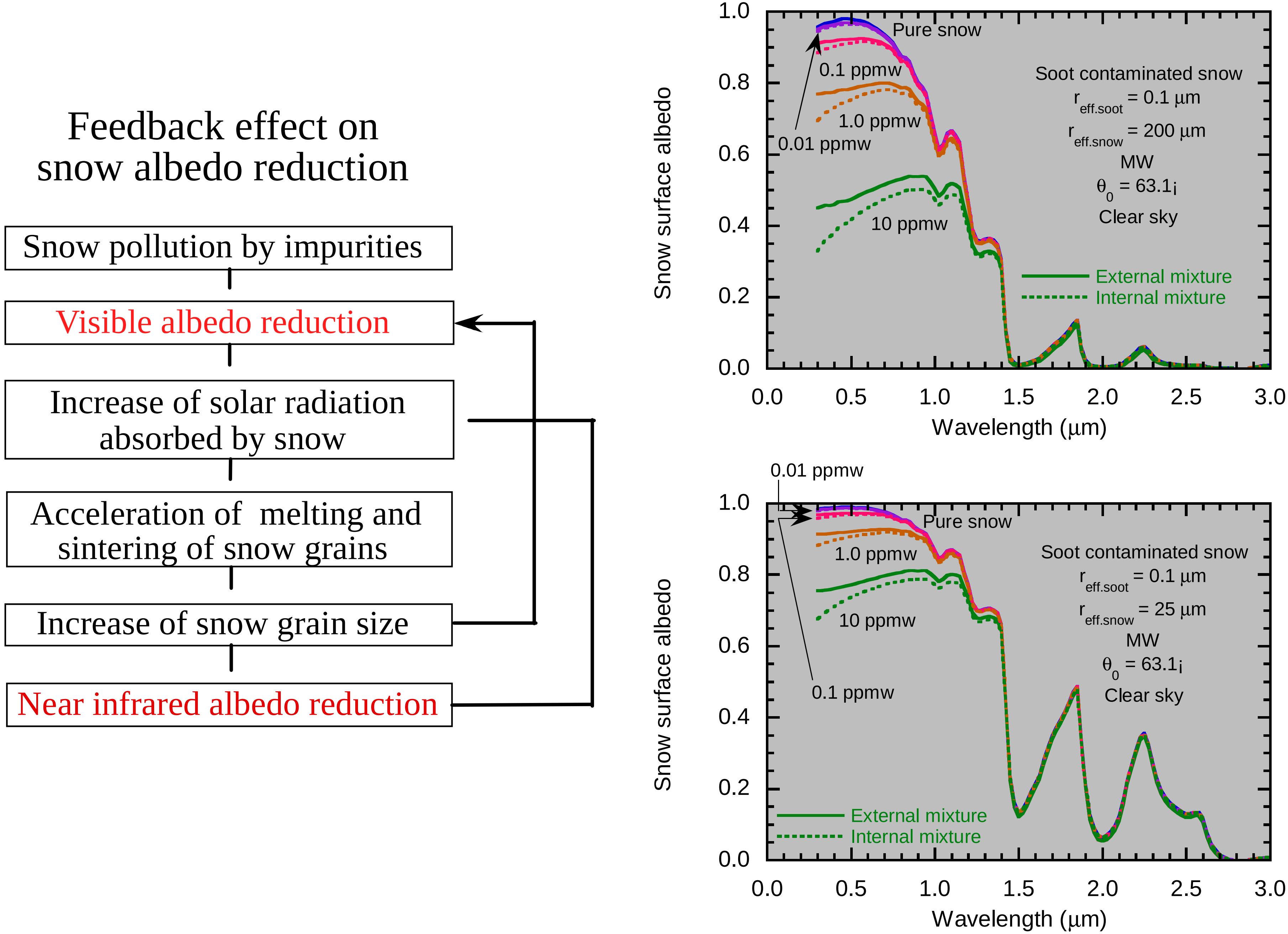


Crocusは、平均して約2.2℃、雪面雪面温度を過小評価する傾向が見られる。

Crocus

Crocus





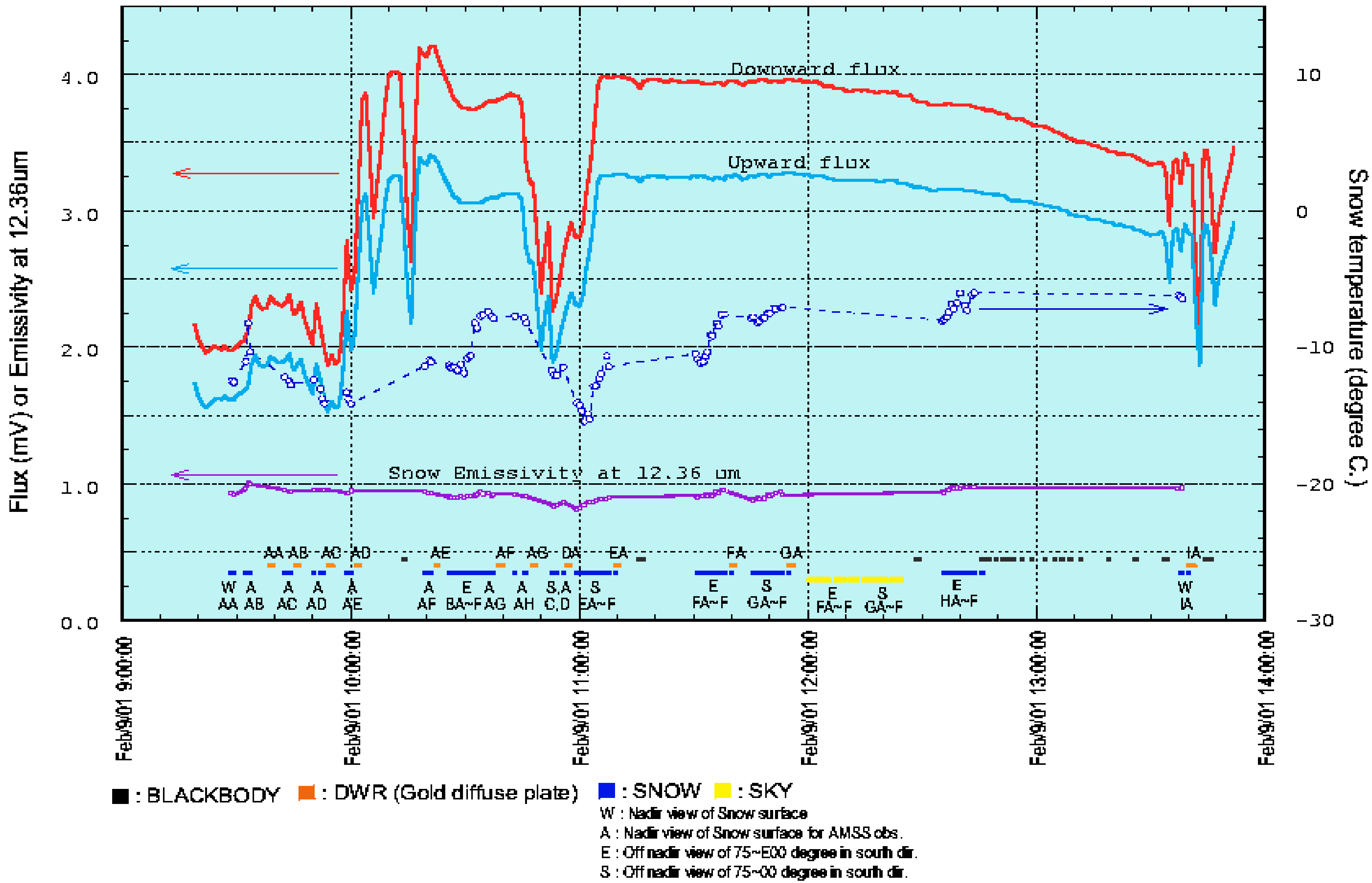
Feedback effect on snow albedo reduction
Snow pollution by impurities
Visible albedo reduction
Increase of solar radiation absorbed by snow
Acceleration of melting and sintering of snow grains
Increase of snow grain size
Near infrared albedo reduction
Snow surface albedo
Wavelength (µm)
Pure snow
0.1 ppmw
1.0 ppmw
0.01 ppmw
10 ppmw
Soot contaminated snow
r eff.soot = 0.1 µm
r eff.snow = 200 µm
MW
θ0 = 63.1¡
Clear sky
External mixture
Internal mixture
0.01 ppmw
Pure snow
1.0 ppmw
10 ppmw
0.1 ppmw
Soot contaminated snow
r eff.soot = 0.1 µm
r eff.snow = 25 µm
MW
θ0 = 63.1¡
Clear sky
External mixture
Internal mixture

For the improvement of land process in GCM

Snow albedo could be simulated by snow grain size and impurities.
Snow albedo depends on the wavelength and layer structure.

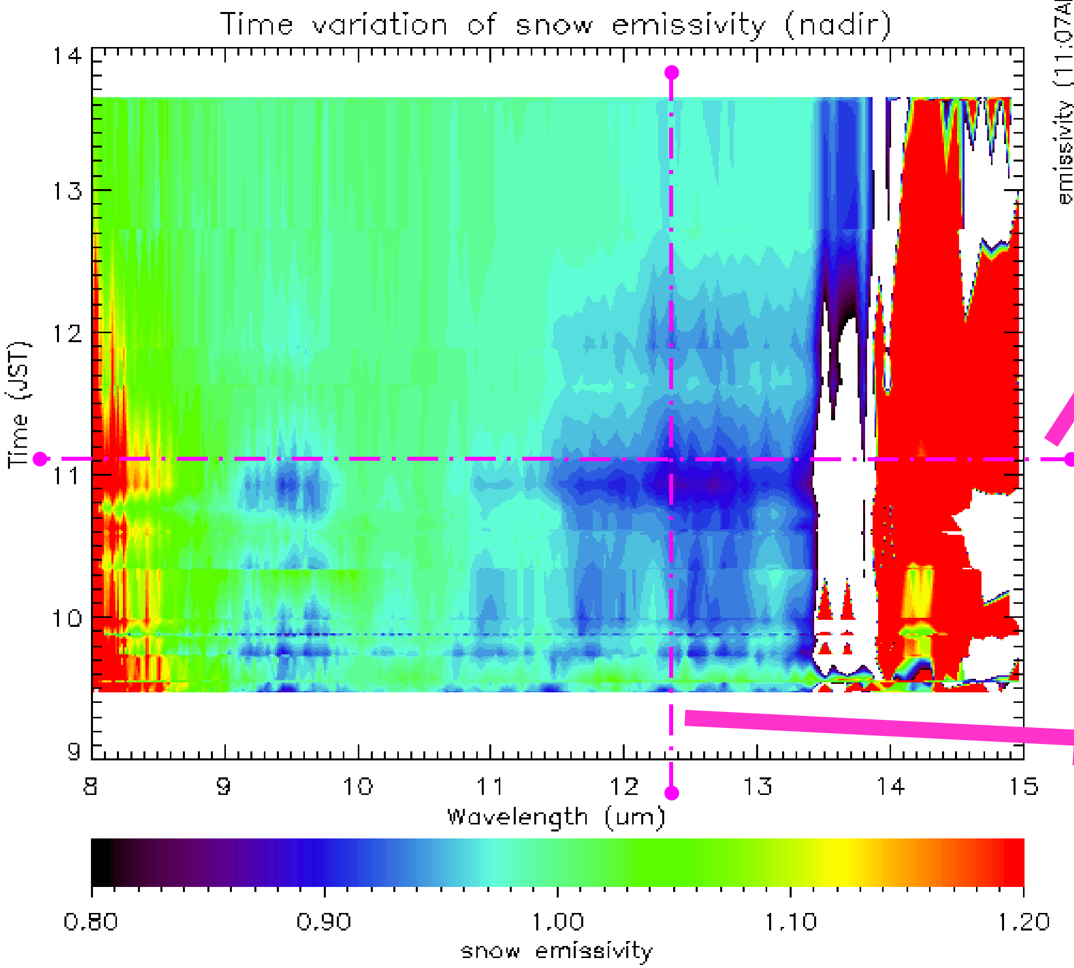
● Snow grain size is simulated by land process model such as "Crocus Model".
● Snow impurities are estimated by the deposition process of atmospheric aerosols on snow surface. → Atmospheric aerosols need to be simulated accurately in GCM.
● Three snow layers and two wavelength regions in the shortwave are necessary.
● Accurate snowfall and cloud amount are important.

サロマ湖におけるFT-IR観測（例：2/9美幌）

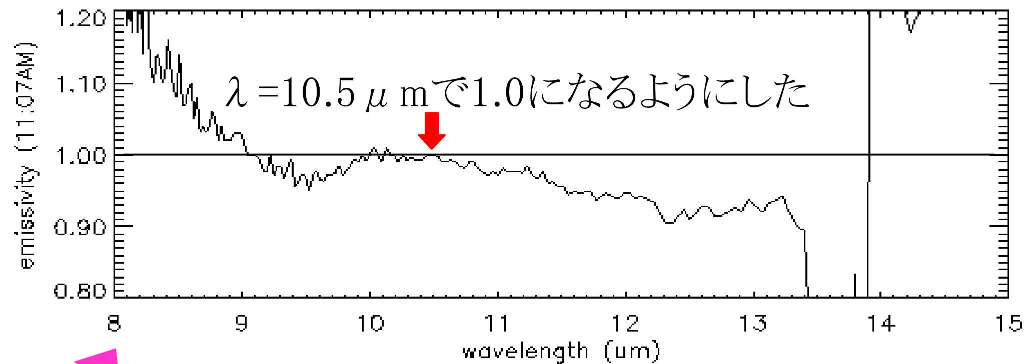


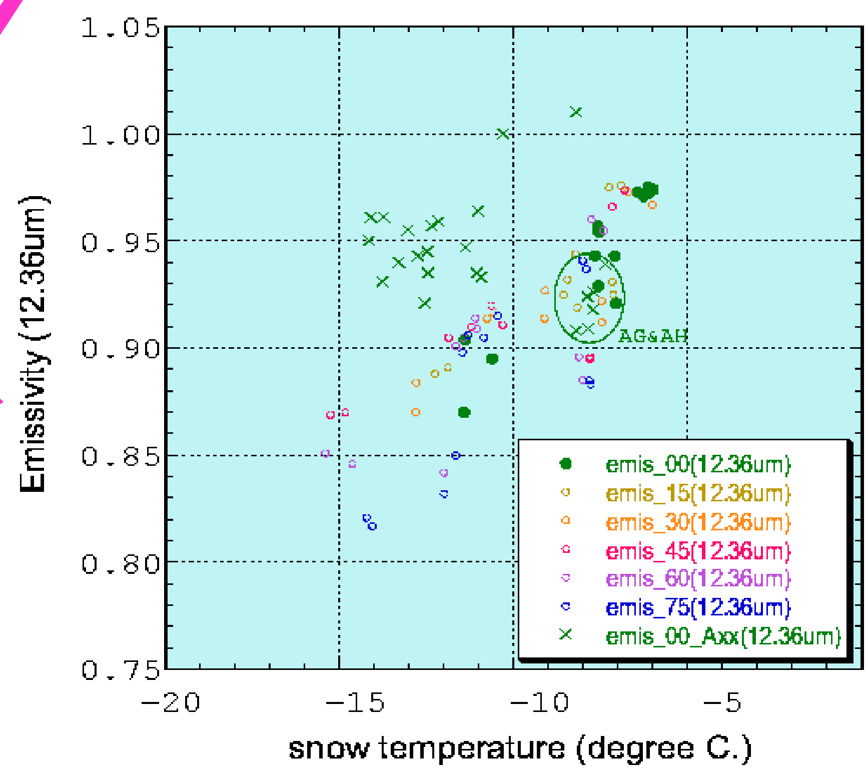
サロマ湖におけるFT-IR観測結果（例：2/9美幌）

熱赤外放射率の時系列変化：9:30～13:40



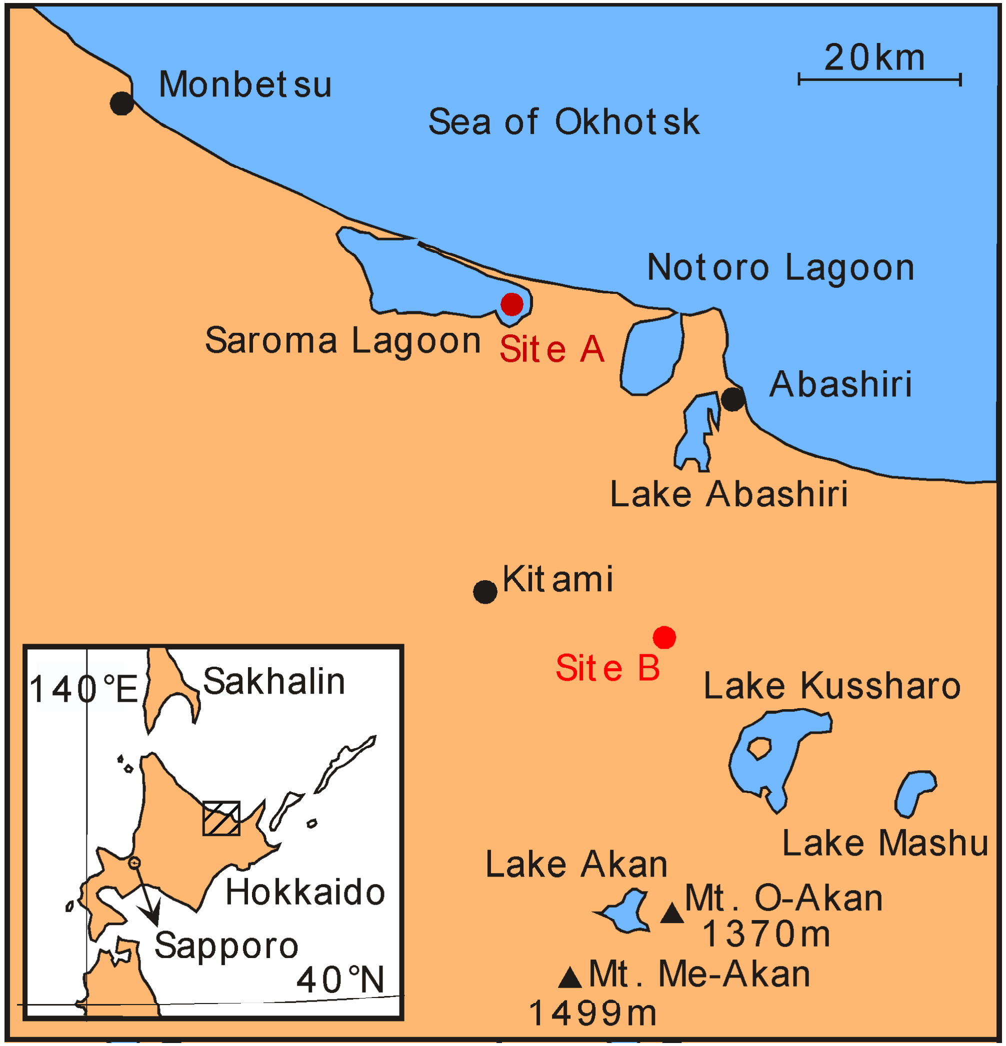
Snow emissivity at Bihoro site, Feb 9, 2001



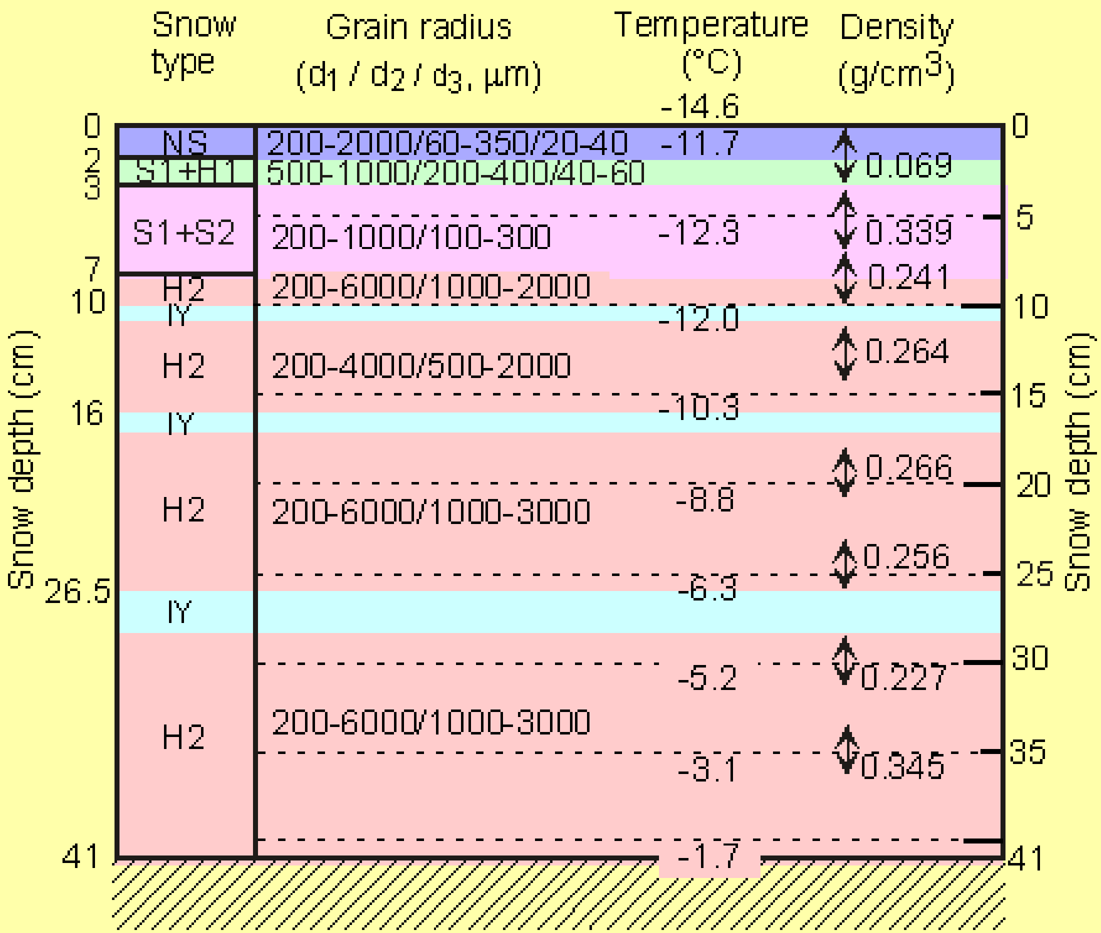


Field Campaign on February 5-9, 2001 in Hokkaido

- Cold (-10°C) and enough snow (>40cm)
- Homogeneous sea ice (Saroma)
- AMSS (Airborne Multiple Spectral Scanner)
- FieldSpec FR (λ = 0.35-2.5 μm, BRDF, albedo)
- FTIR (λ = 2-14 μm, emissivity)
- Snow pit work (grain size and impurities)



Snow pit work result

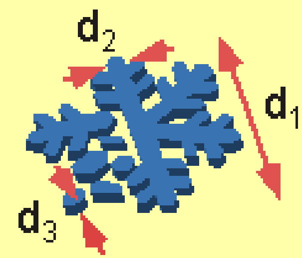


February 9, 2001 / Site B
Observed at 09:00 - 10:30 LT
New snowfall: Feb. 8 = 2 cm

Snow types:

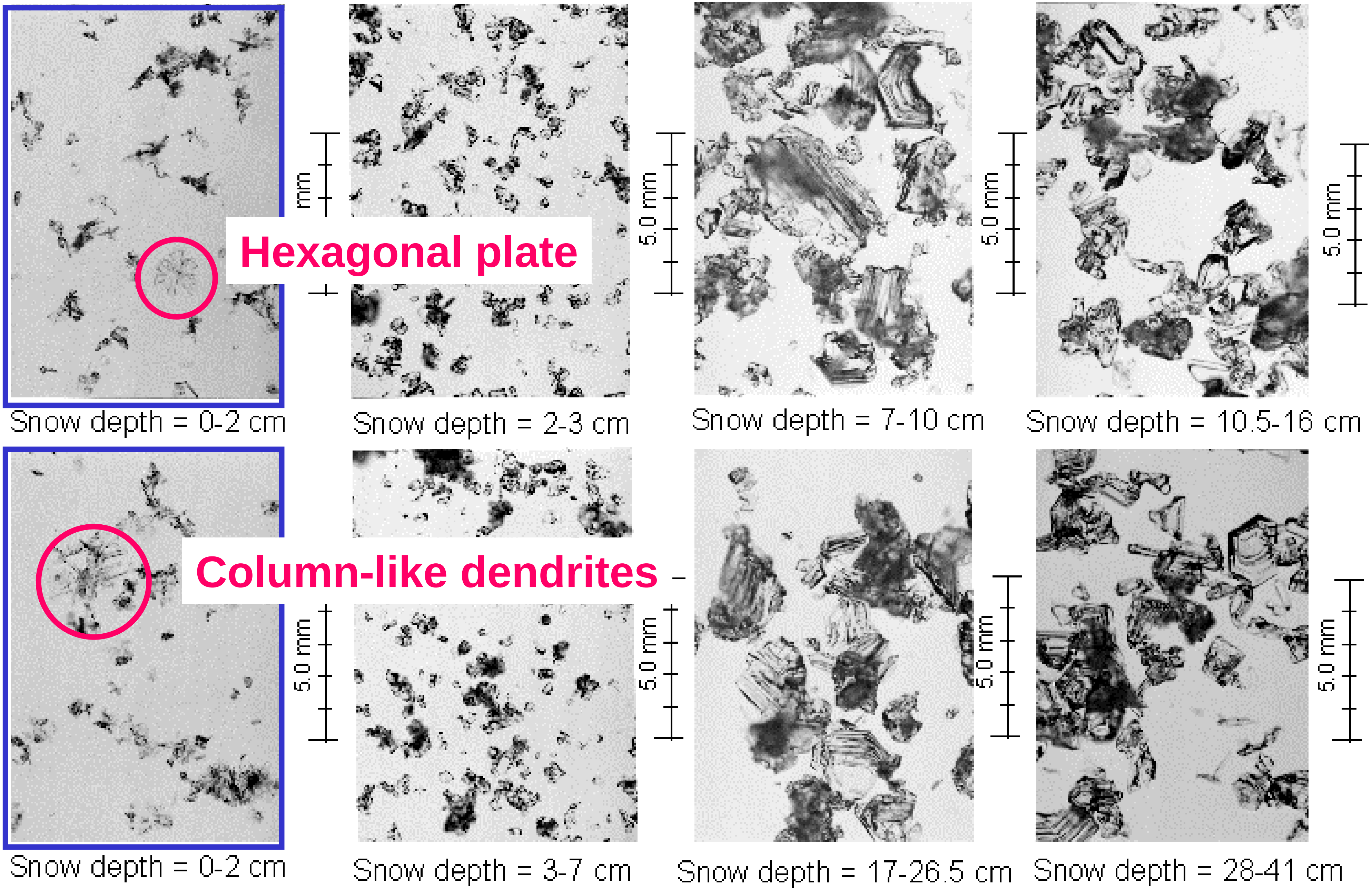
NS: New snow
S1: Fine-grained old snow
H1: Faceted crystals
H2: Depth hoar
IL: Ice layer

Snow grain size



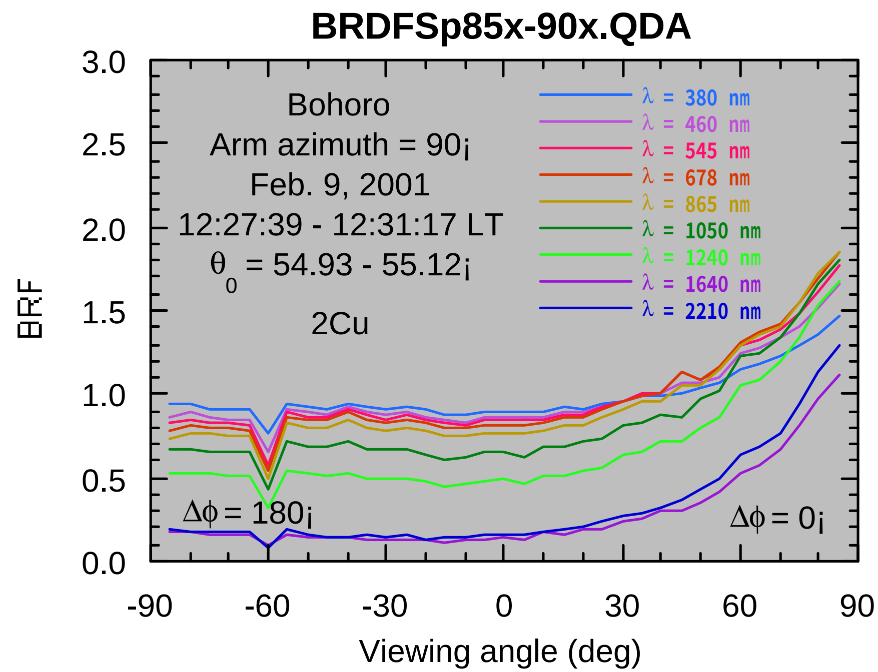
Crystal full size = 200-2000 μm, Branch width = 60-350 μm, Crystal thickness = 20-40 μm for dendrites at snow surface

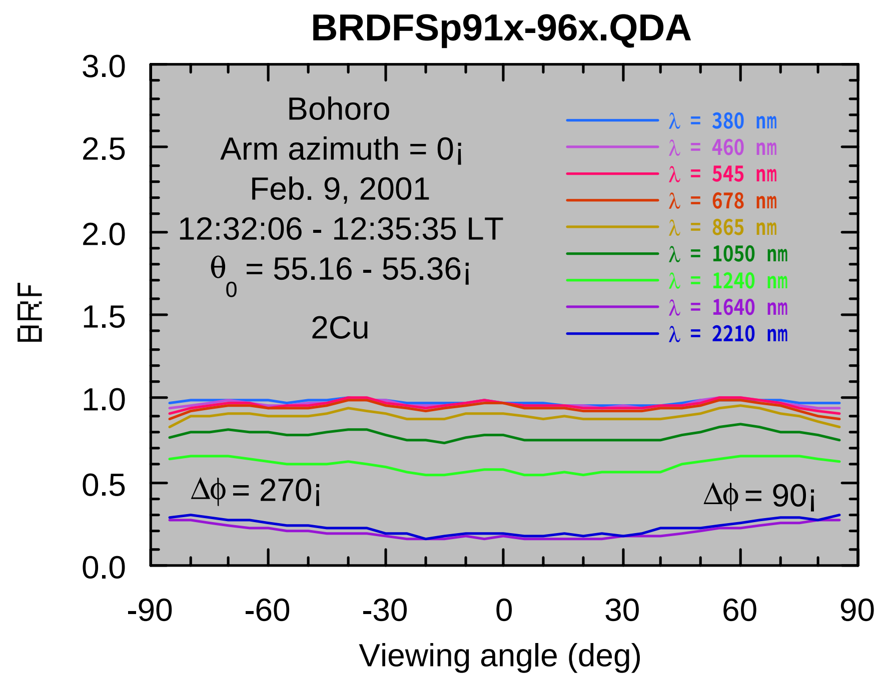
Micrographs of snow crystals taken on February 9, 2001 at site B

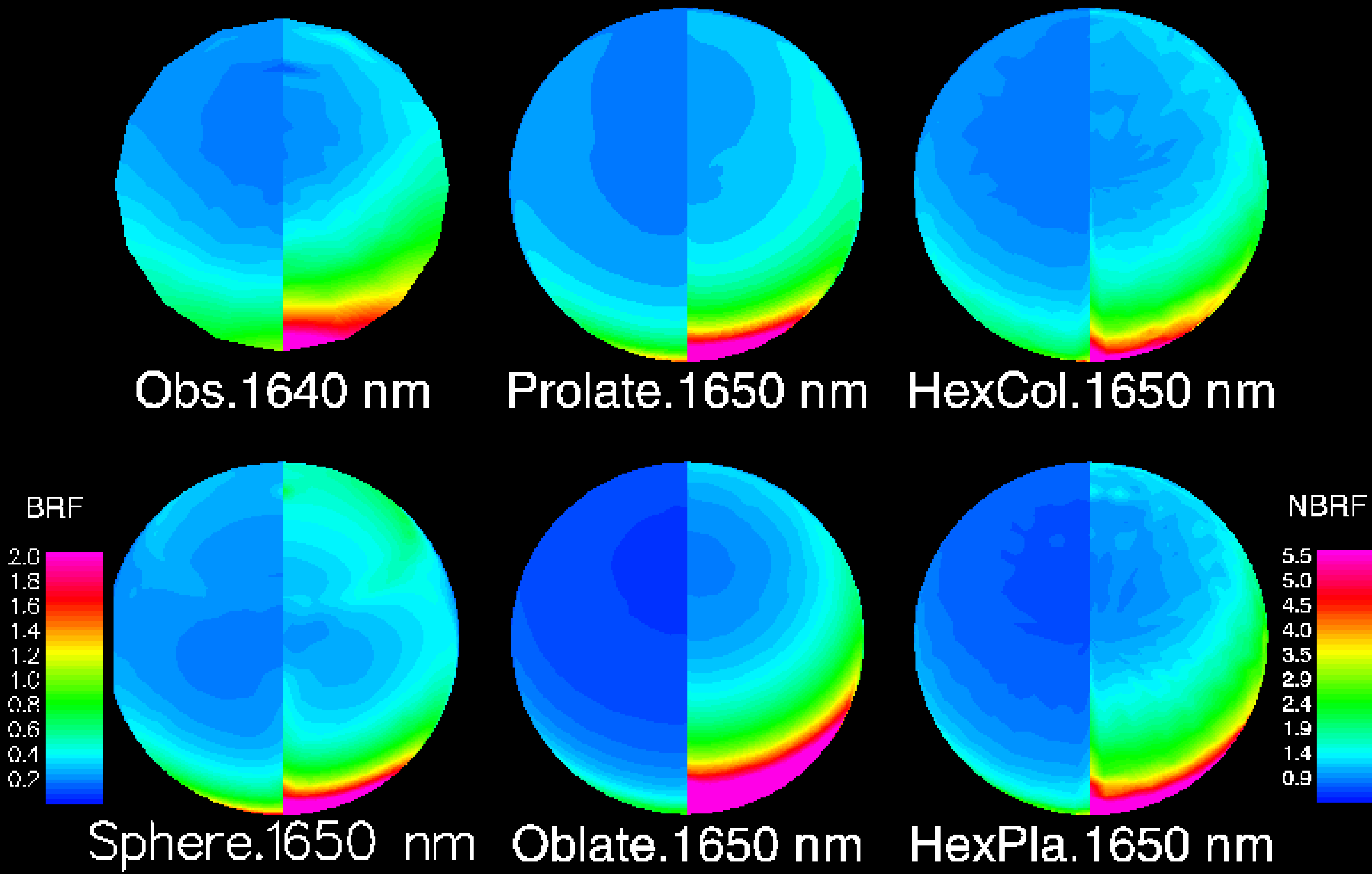


Measured BRDFs along azimuth = 0-180º and 90-180º

- Anisotropic reflection properties at near infrared wavelengths
- Flat pattern in backscattering region at any wavelength
- Increasing tendency in side scattering region at near infrared wavelengths







Obs.1640 nm
Prolate.1650 nm
HexCol.1650 nm
BRF
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Sphere.1650 nm
Oblate.1650 nm
HexPla.1650 nm
NBRF
5.5
5.0
4.5
4.0
3.5
2.9
2.4
1.9
1.4
0.9