A basic study on a new satellite algorithm for snow

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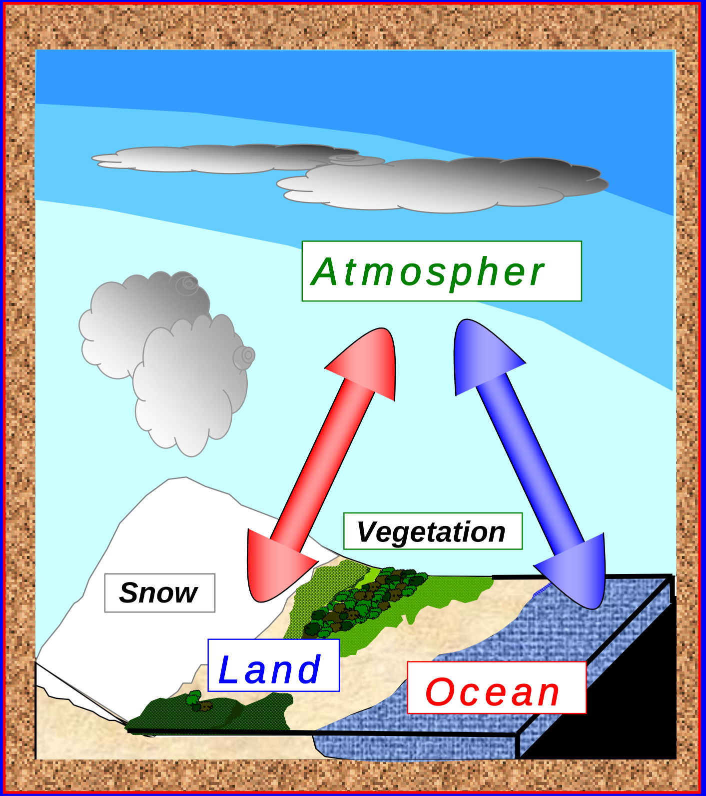
1. Introduction

The climate conditions that exist in various regions of earth are formed by water cycle on the scale of earth on land, atmosphere and ocean.



1. Introduction

The water cycle between land and atmosphere causes climate variations on the scale of earth as result of significant hydrological variations over both long term and short term over land.

Moreover, over land, various land surface conditions are formed by vegetation and snow.

Hence, it is difficult to grasp hydrological variations of land in a quantitative way.

1. Introduction

The water cycle between the land and the atmosphere causes climate variations on the scale of the earth as a result of significant hydrological variations over both the long term and short term over the land.

Moreover, over land, the various land surface conditions are formed by vegetation and snow.

Hence, it is difficult to grasp the hydrological variations of land in a quantitative way.

Particularly, snow has the characteristic as follows.

1) Snow has high reflectance (albedo)

2) Soil moisture increase by the melted snow water

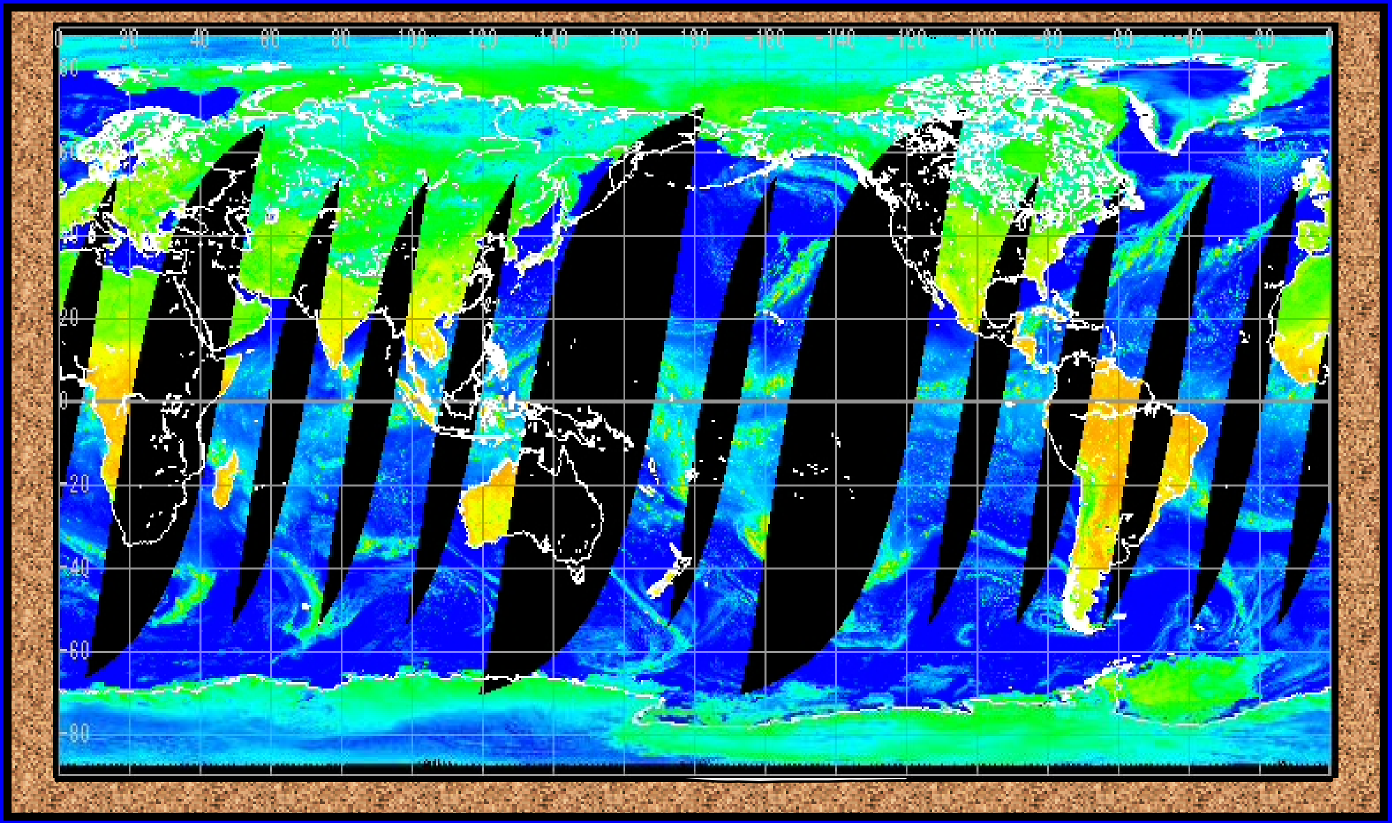
suppresses the rise of heat in the soil surface at spring and summer.

Accordingly, snow is greatly affecting water cycle on the scale of earth.

Hence, it is most important subject that grasps the snow quantity in a quantitative way for the earth northern hemisphere.

In order to quantify snow conditions in some way, it is important that the snow observation instruments are arranged uniformly.

However, this way is unrealistic from the point of view of observation scale.



This study devised a satellite algorithm which automatically estimates snow quantity based on microwave radiative transfer basis theory and satellite remote sensing technique.

2. Existential snow satellite algorithms

In the past, many satellite algorithms based on microwave radiative transfer models has been developed for calculating snow depth.

However, these existential microwave radiative transfer models and snow satellite algorithms has the following problems.

Problems in existential microwave radiative transfer model

Model problem 1

Limitation of applicable frequency, snow grain size and snow density.

Since the setting range is restricted, existential models cannot apply various frequency, snow grain size and snow density.

Model problem 2

Extreme scattering effects, extreme attenuation effects and the estimate limitation of deep snow.

Existential models has the extreme attenuation effects and the extreme scattering effects.

Hence, estimation to deep snow is limited in existential models.

Problems in existential snow satellite algorithm

Algorithm problem 1

Assuming the fixed snow grain size.

Existential algorithms must assume the fixed snow grain size to snow grain with temporal variation.

Algorithm problem 2

Detections of the condition under snow.

Existential algorithms cannot detect the condition under snow.

In this study,
I solved these problems of microwave radiative transfer models and snow satellite algorithms by using the following solution.

PLOBLEMS

SOLUTIONS

(1) Existential microwave radiative transfer model

Model problem 1

Limitation of applicable frequency, snow grain size and snow density.

Introducing
4-stream fast radiative transfer model

Model problem 2

Extreme attenuation effects,
Extreme scattering effects,
and the estimate limitation of deep snow.

Introducing
Dense media radiative transfer model

(2) Existential snow satellite algorithm

I solved the model problem 2 by introducing the dense media radiative ... 2).

Algorithm problem 1

Assuming the fixed snow grain size.

Application of
high frequency (89GHz) brightness temperature.

... 1 by applic...

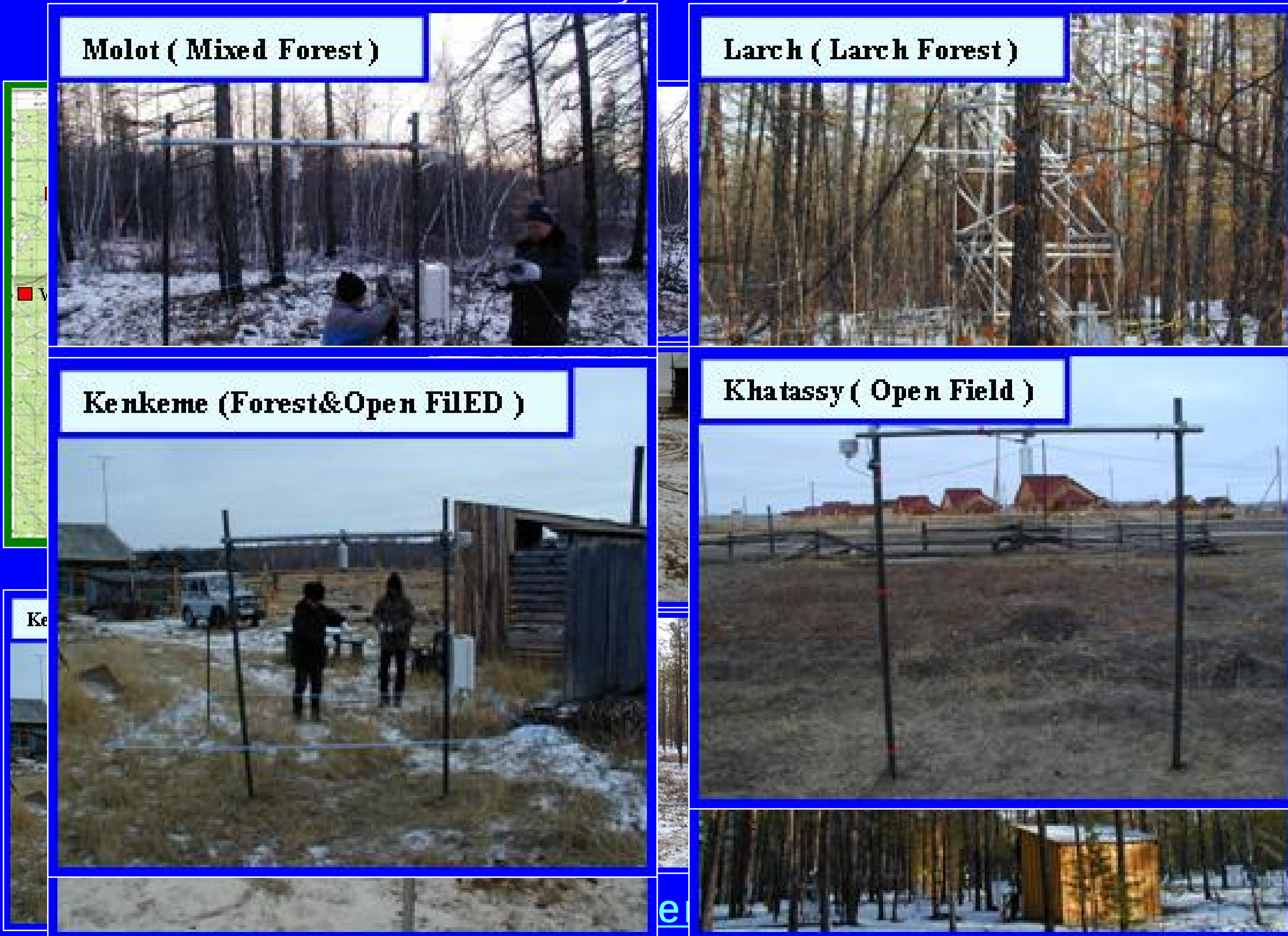
Algorithm problem 2

The problem about detections of the condition under snow.

Application of
low frequency (6GHz) brightness temperature.

I solved the algorithm problem 2 by application of low frequency (6GHz) brightness temperature.

In addition, when solving these problems, the observation activities of CEOP reference site siberia were very useful.



3. New snow satellite algorithms

New satellite algorithm structure flow (1)

I explain the structure of the new satellite algorithm devised in this study.

using this relationship,
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on the basis of 6GHz sat
ness temperature.
skip to the flow of the
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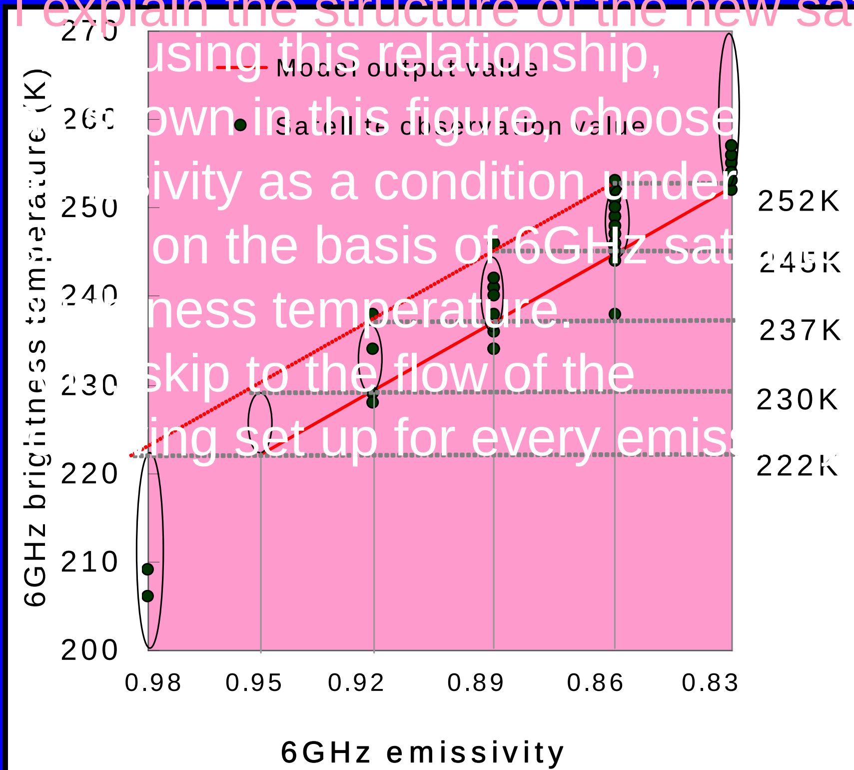
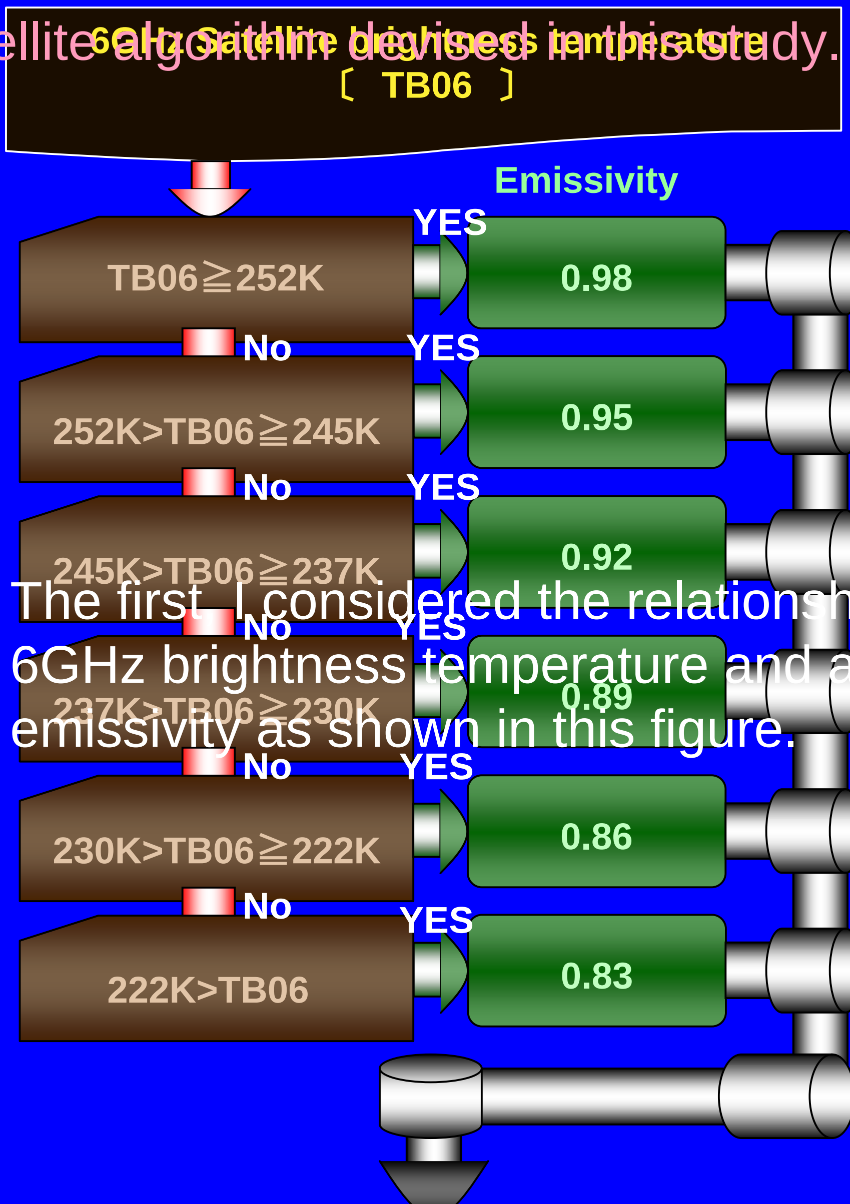
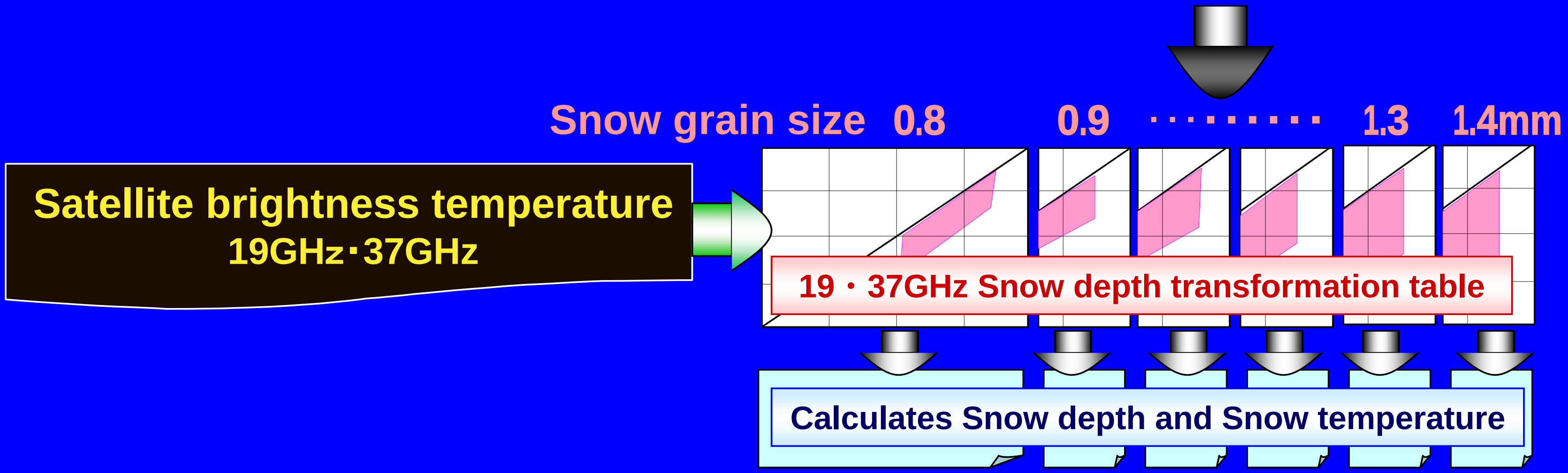


The first, I considered the relationship of 6GHz brightness temperature and an emissivity as shown in this figure.

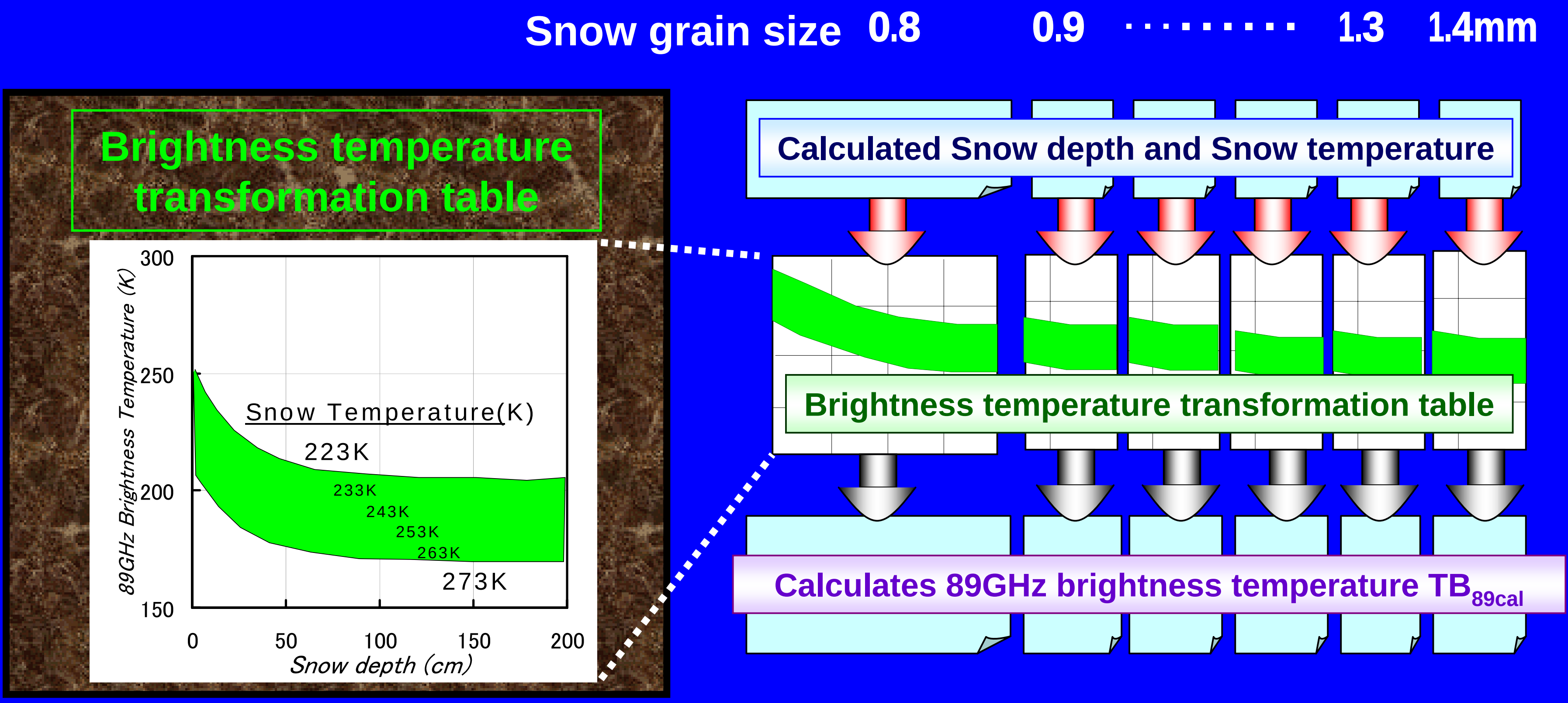


New satellite algorithm structure flow (2)



Next, inputs satellite brightness temperatures of 19・37GHz to snow depth transformation table of the seven kinds of snow grain sizes.
And, calculates snow depth and temperature of each snow grain size.

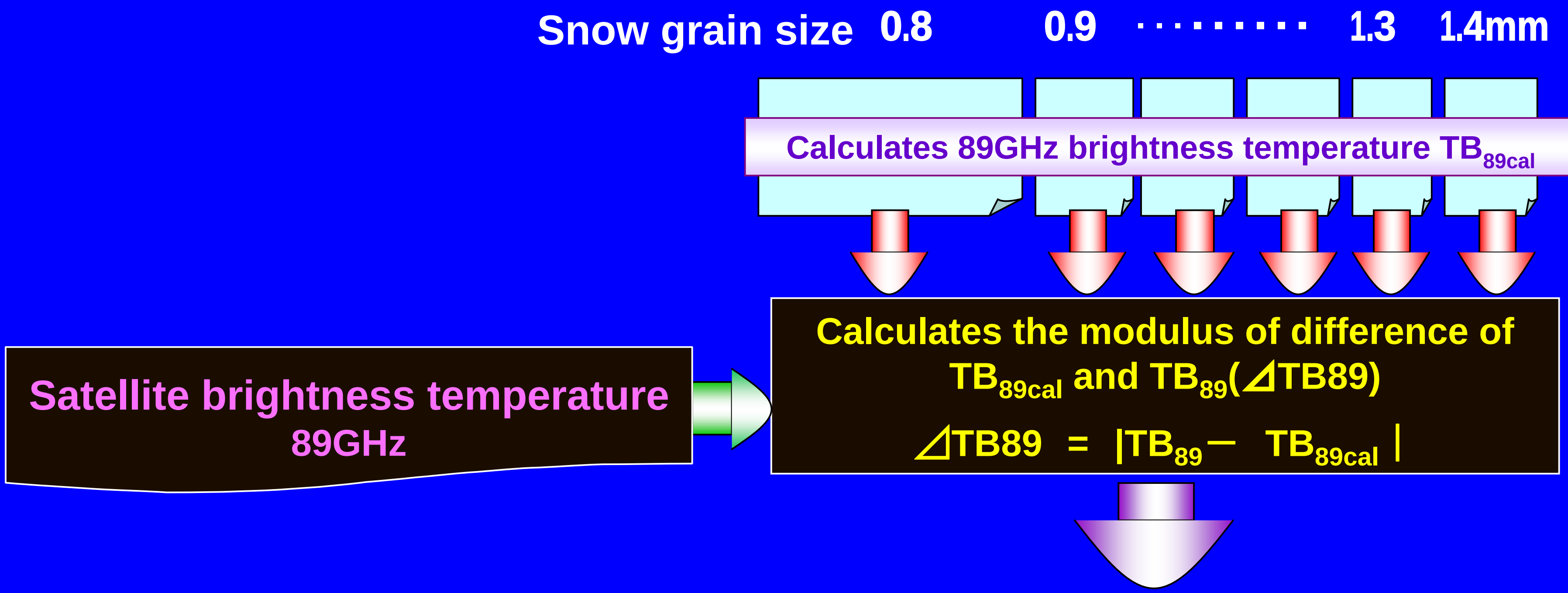
New satellite algorithm structure flow (3)



Next, inputs the calculated snow depth and temperature to 89GHz brightness temperature transformation tables of seven kinds of snow grain sizes.
And, calculates 89GHz brightness temperatures of each snow grain size.

New satellite algorithm structure flow (4)

Next, calculates the modulus of difference of the calculated 89GHz brightness temperature and 89GHz satellite brightness temperature (⊿TB89) .



New satellite algorithm structure flow (5)

Compares ⊿TB89 corresponding to each grain size, and selects the 89GHz minimum brightness temperature difference (⊿TB89min).

Decides on optimum snow grain size corresponding to the selected ⊿TB89min.

Decides on

optimum snow depth

optimum snow temperature

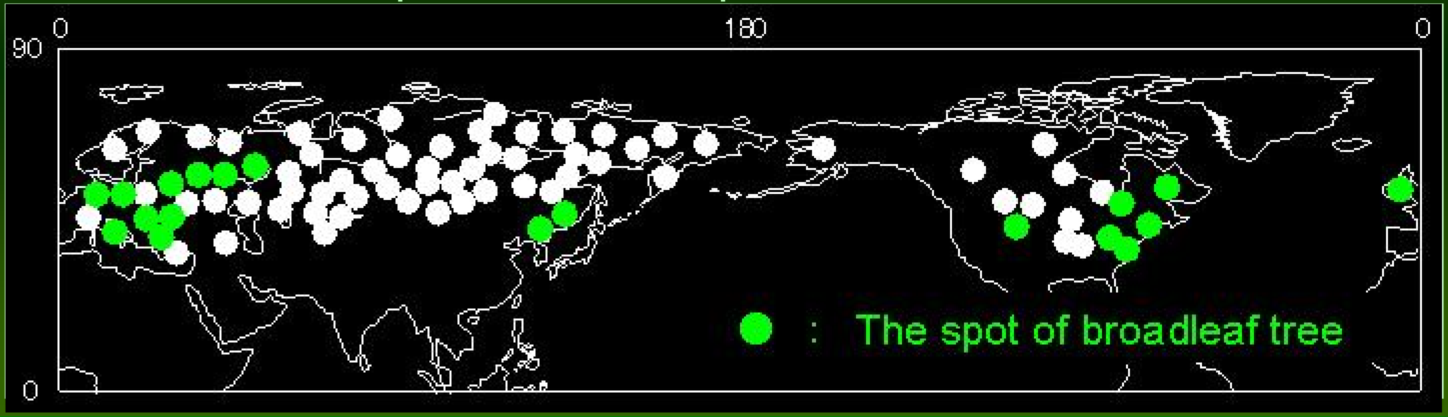
by using optimum snow grain size.

4. The estimation result of snow depth by new satellite algorithm

Explain about the estimation result of snow depth by using new satellite algorithm.

I estimated the accuracy of new satellite algorithm by comparing the estimated snow depth and the in-situ snow depth.

I except that investigated the spot of broadleaf tree with the remarkable influence of vegetation using the NDVI information.
And, as the in-situ data, I used the in-situ snow depth data (2002.11～2003.3) at the ground-based stations in the northern hemisphere (GTS snow depth data) of 62 sites from which these spots were excepted.



As the satellite data, I used the AMSR-E brightness temperature (2002.11～2003.3) on Aqua launched by NASA in 2002.

Comparison based on the compatibility criterion

The first, compared snow depth in the northern hemisphere based on the compatibility criterion. Then, I used the average of modulus of difference in estimated snow depth and in-situ snow depth as the estimation index (⊿SD) .

****** Estimation index ******

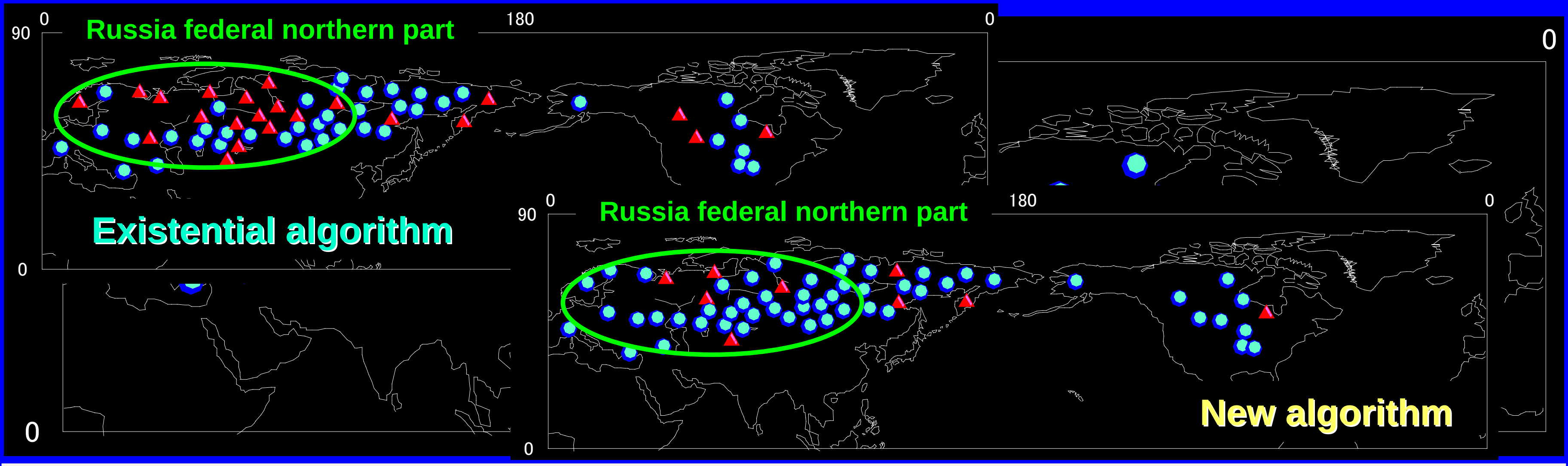
⊿SD：Average（2002.10-2003.3）of ｜SD estimation －SD observation ｜

And, I considered as follows the compatibility criterion.

****** Compatibility criterion ******

When ⊿SD is 20cm or less ⇒ Compatible.（●）

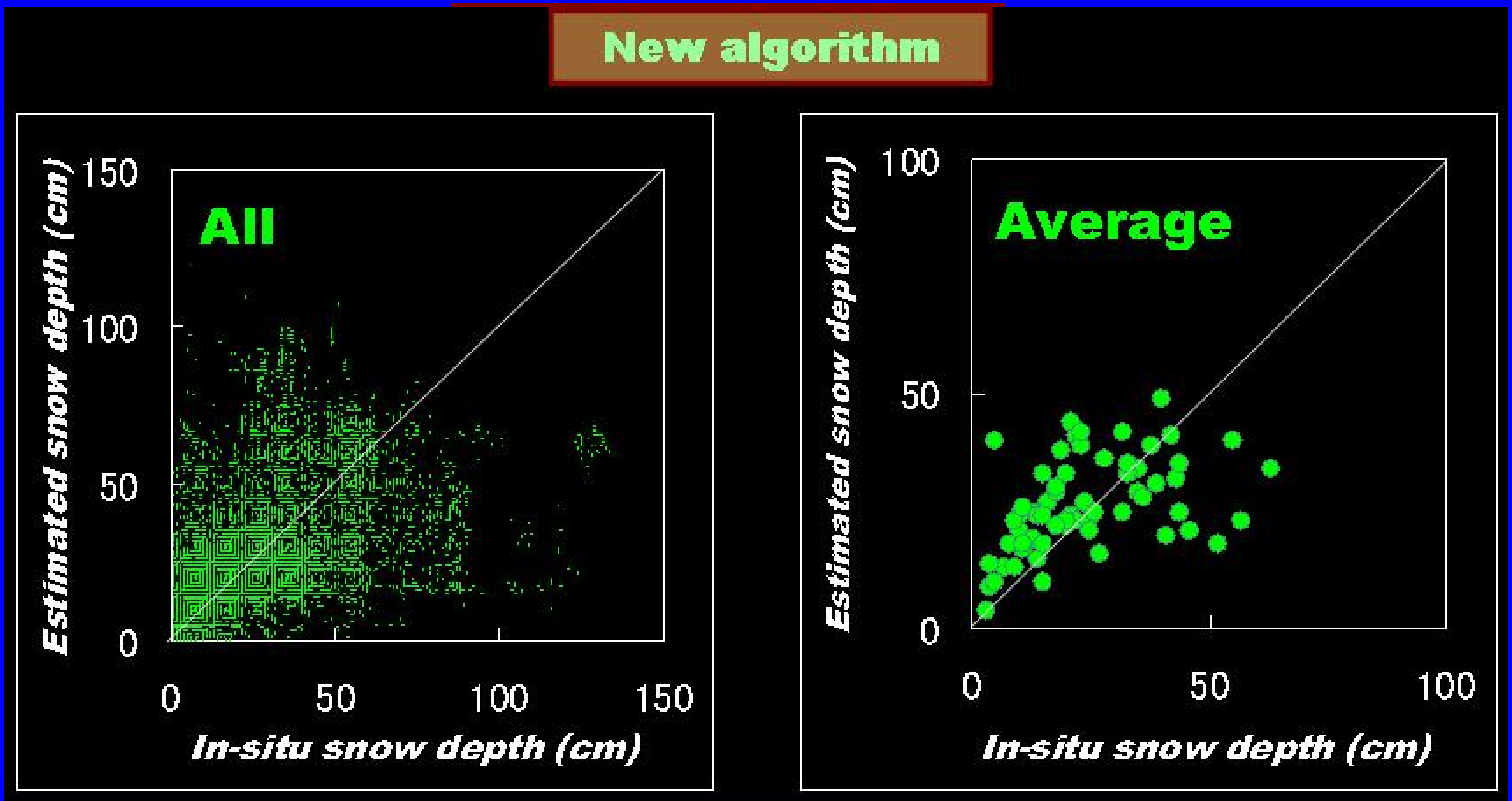
When ⊿SD exceeds 20cm ⇒ Incompatible.（▲）



On the other hand, as shown in this figure, when using new algorithm then the compatibility of Russia federal northern part which has deep snow was improved.

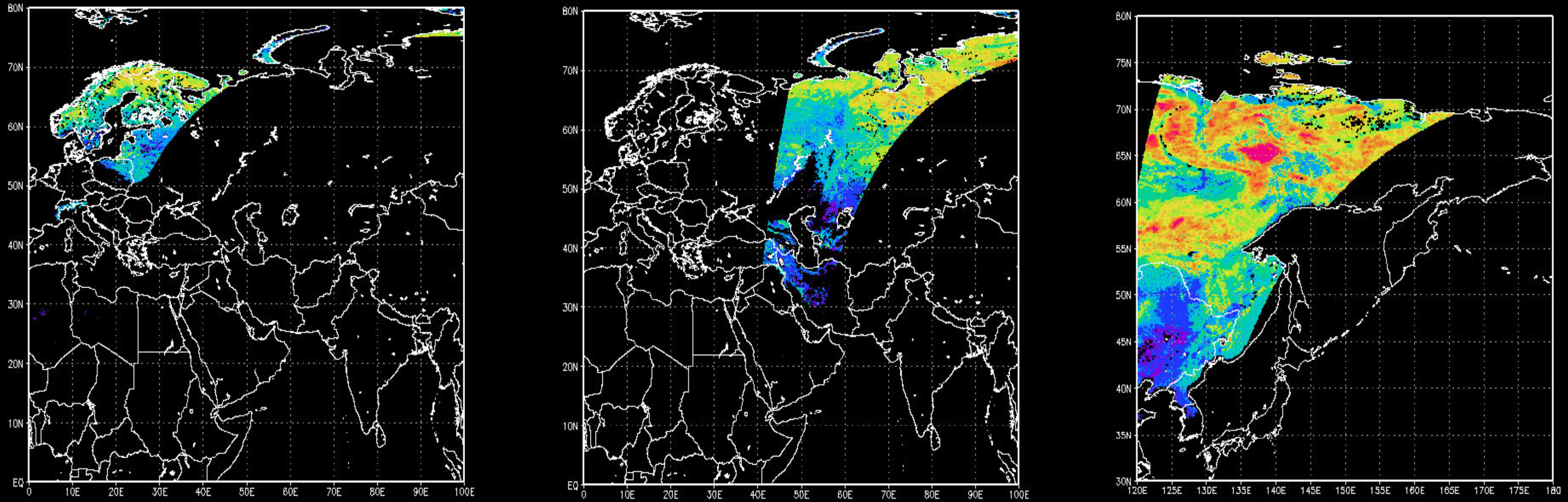
Correlation

Moreover, Investigated the correlation between estimated snow depth and in-situ snow depth.

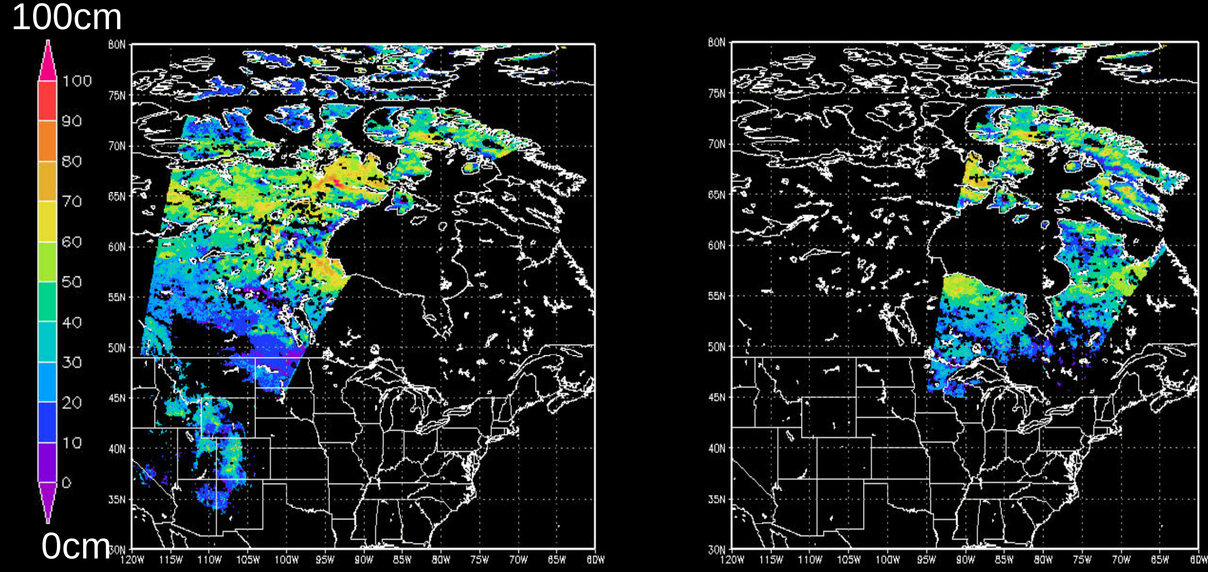


On the other hand, the correlation of deep snow was improved by using the new algorithm.

In addition, shows the result of estimated snow depth for the earth northern hemisphere using the AMSR-E brightness temperature at Dec.31.2002.



As shown in this figure, The deep snow became estimated by using new algorithm.

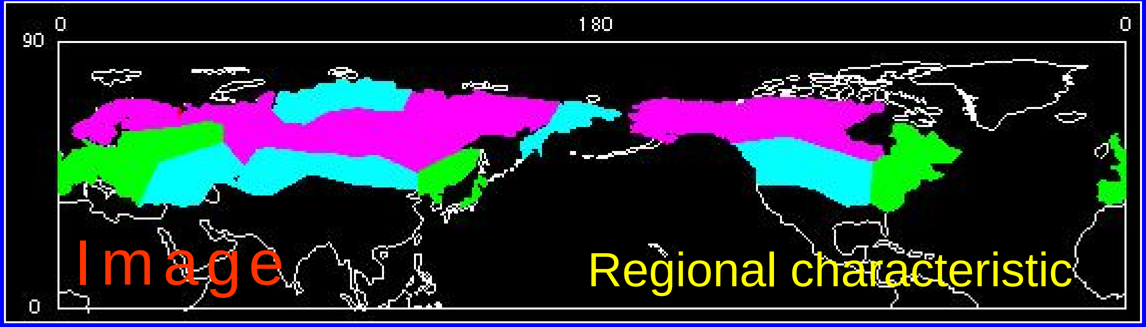


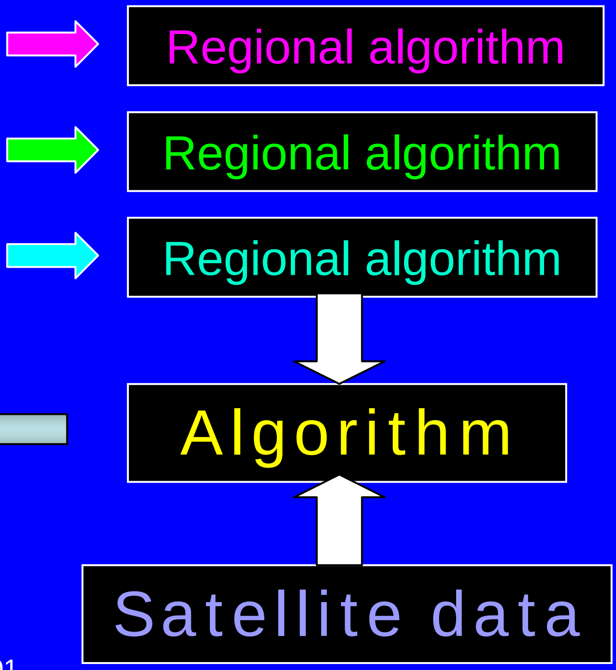
New algorithm
Dec.31.2002

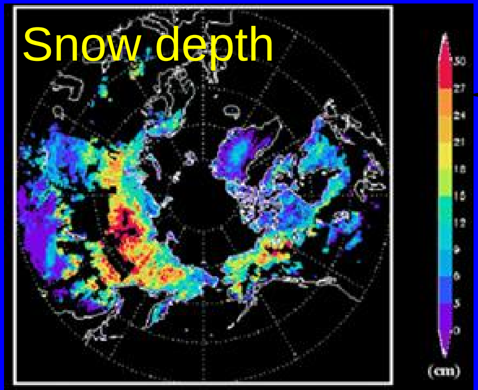
6. Conclusion

The snow region on the earth has various regional character - istics by ground surface condition under the snow, such as soil and vegetation.

The technique of dividing a snow region with this regional characteristic and introducing this information as initial parameter into an algorithm is the one technique of algorithm development.

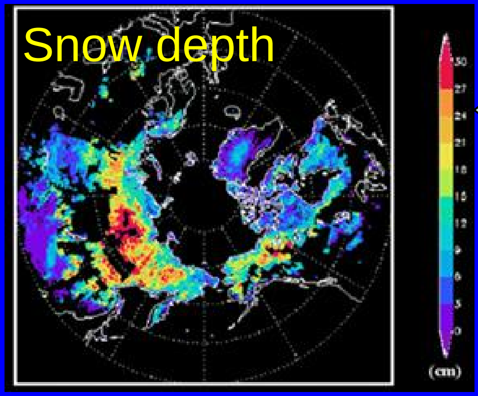






http://sharaku.eorc.jaxa.jp/ADEOS2/library/2001/010824_j.html

However, in this study, I developed the simple new algorithm applicable throughout the earth without this information on regional characteristics.

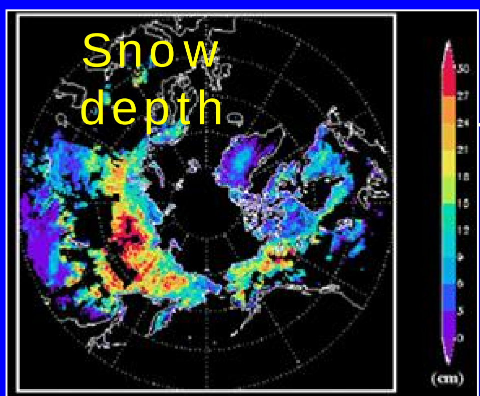


Simple new algorithm ← Satellite data

http://sharaku.eorc.jaxa.jp/ADEOS2/library/2001/010824_j.html

And, although the subject about vegetation (broadleaf tree area) remains, I think that progressed the estimated accuracy of deep snow with difficult estimation by using this new algorithm.

Moreover, although the subject remains still more, new algorithm in this study can calculate snow grain size and snow temperature in the process which calculates snow depth on algorithm calculation.



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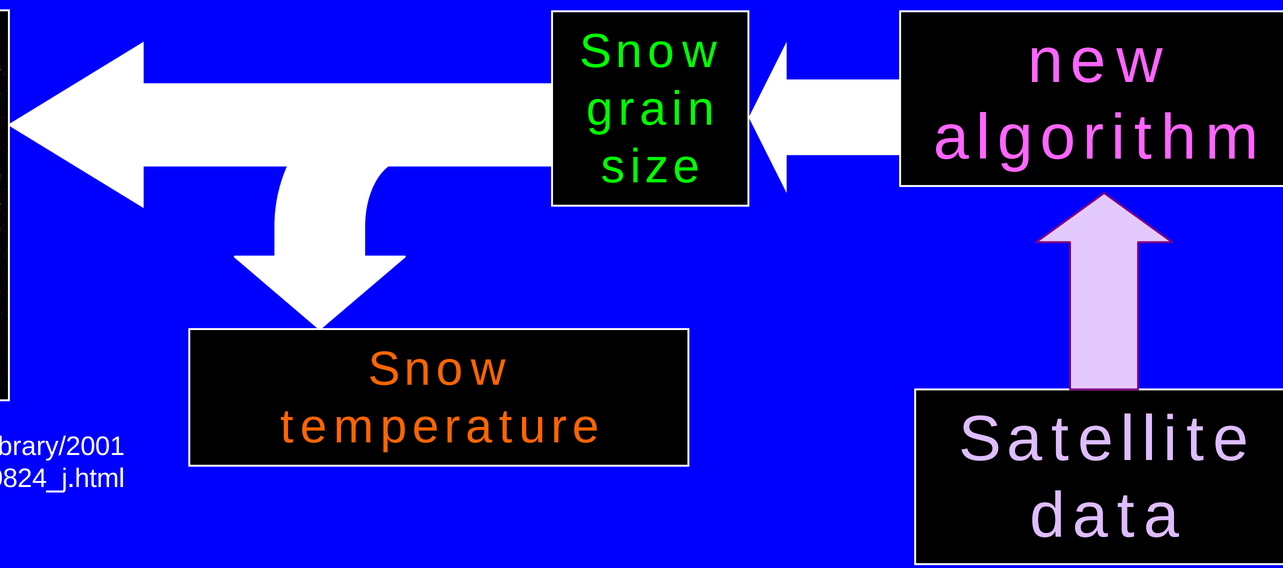

That all