The Joint PI Meeting of JAXA Earth Observation Missions FY2021

January 17 , 2022

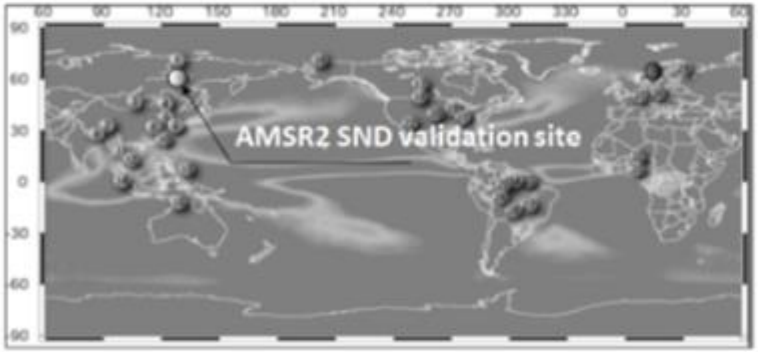
Snow depth observation at Siberia site and applied research on passive microwave remote sensing

International Centre for Water Hazard and Risk Management (ICHARM)

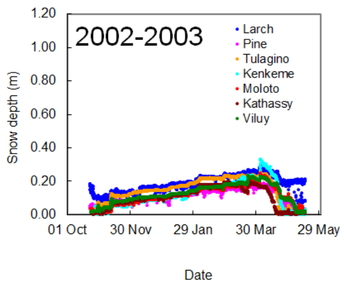
Public Works Research Institute (PWRI)

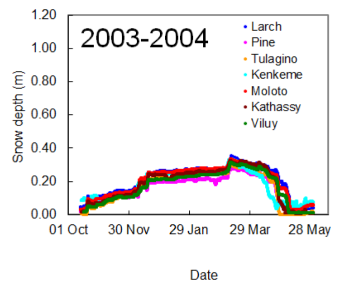
Hiroyuki Tsutsui

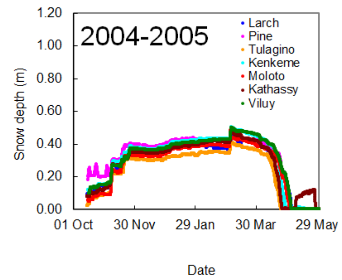
Snow depth observation at the seven Siberia AMSR2 snow depth validation site

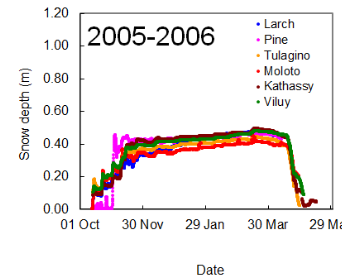


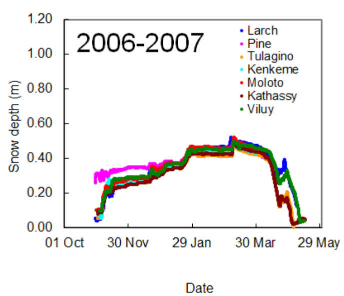
Snow depth data has been acquired since 2002

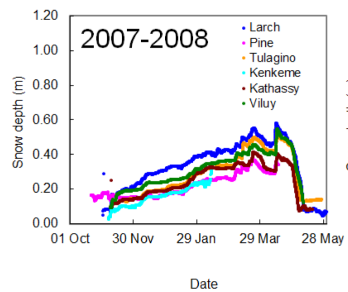


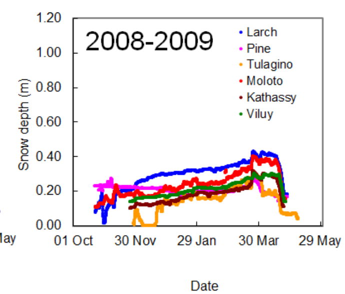


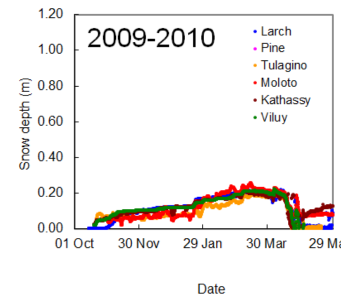


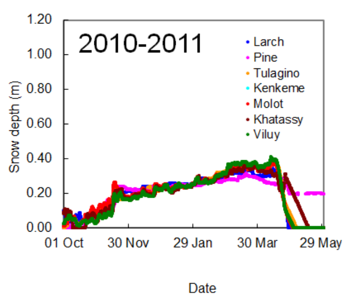


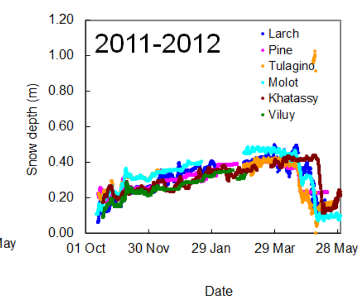


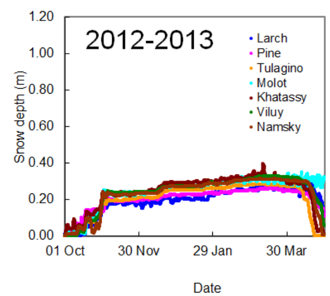


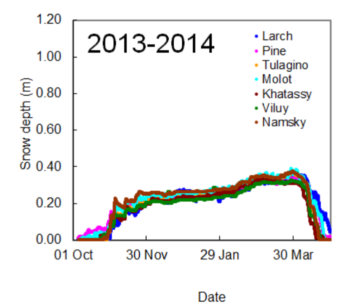






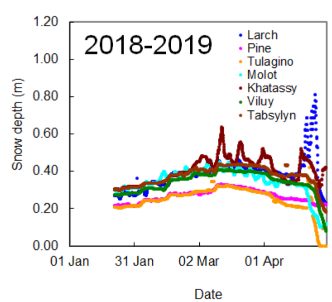


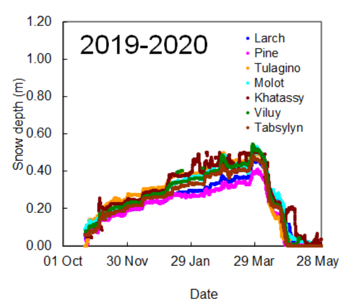


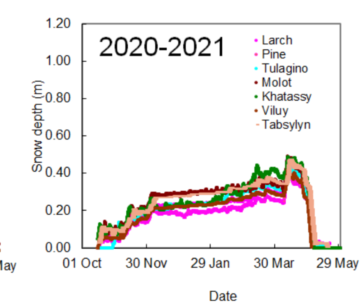


2014-2017

Snow depth data was not acquired because the Russian government did not allow data provision.







Cooperation and activities of the Institute for Biological Problems of Cryolithozone

Institute for Biological Problems of Cryolithozone Siberian Branch of RAS (IBPC)

IBPC SB RAS

41, Lenina ave., Yakutsk, Russia, 677000

Phone: +7(411-2) 33-56-90

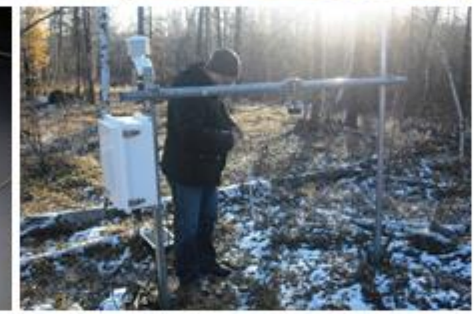
Fax: +7(411-2) 33-58-12

E-mail: bio@ibpc.ysn.ru

WWW: http://ibpc.ysn.ru/

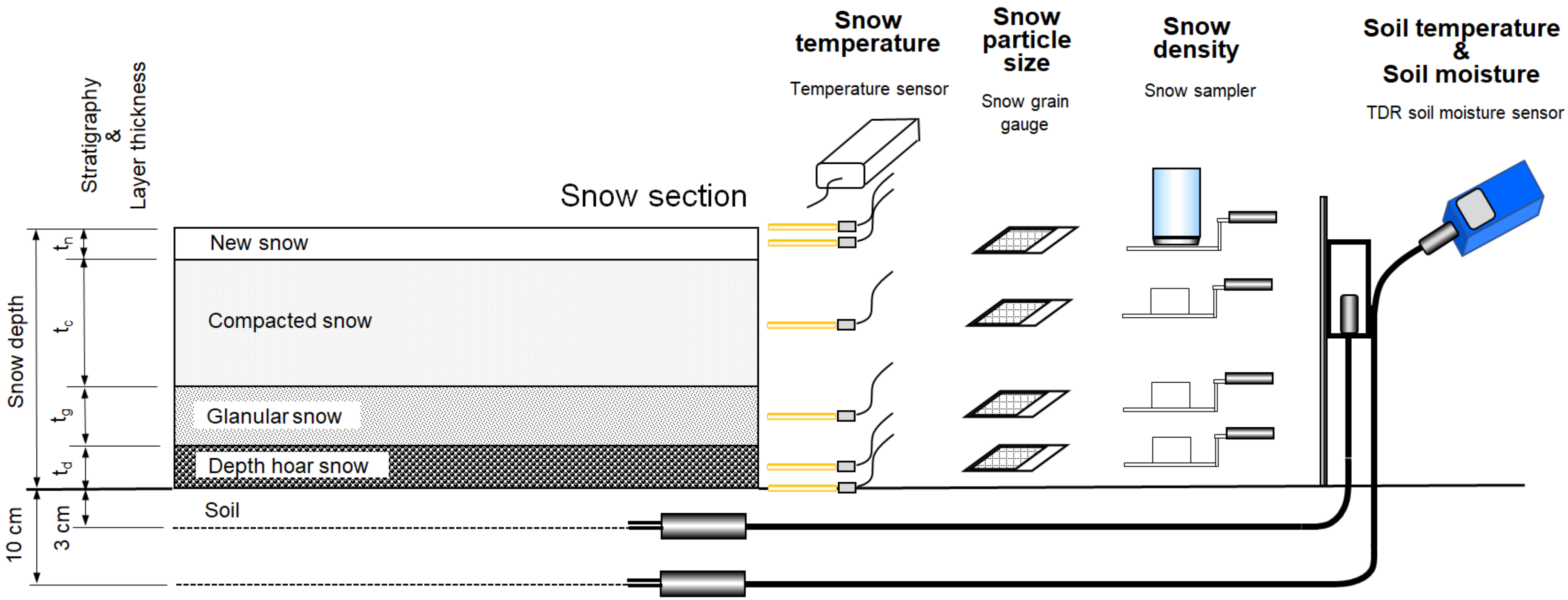
Date of editing information: 23.01.2019

http://ibpc.ysn.ru/

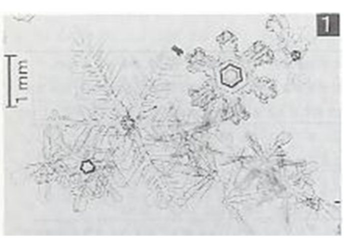


Current observation situation

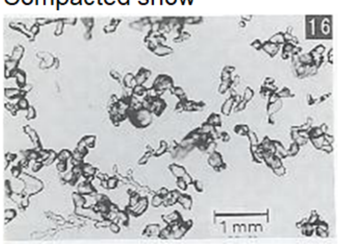
Cancellation of expansion plan for observation framework due to COVID-19



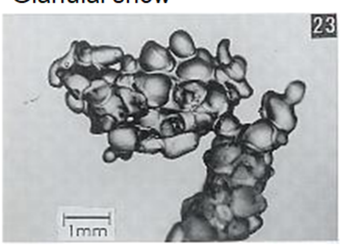
New snow



Compacted snow



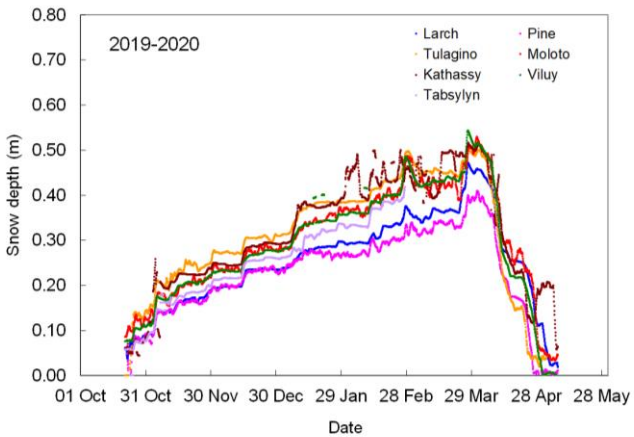
Glanular snow



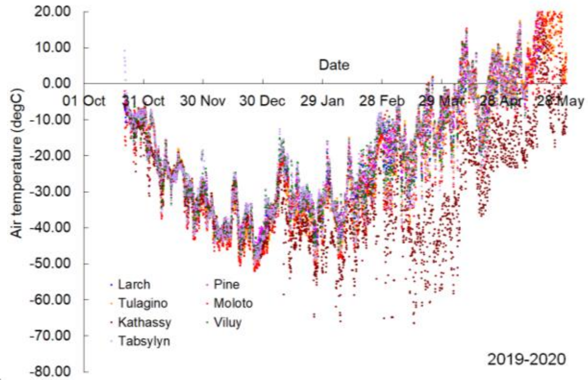
Depth hoar snow

2019.10-2020.5

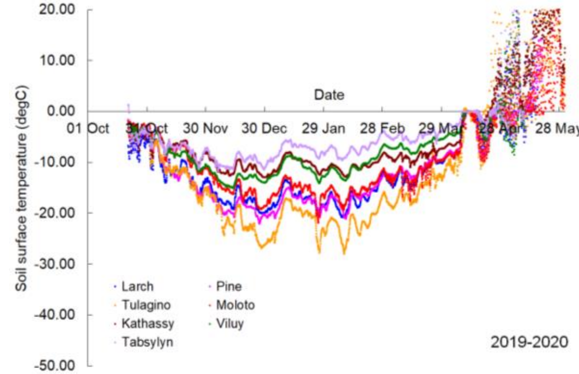
Snow depth



Snow surface temperature

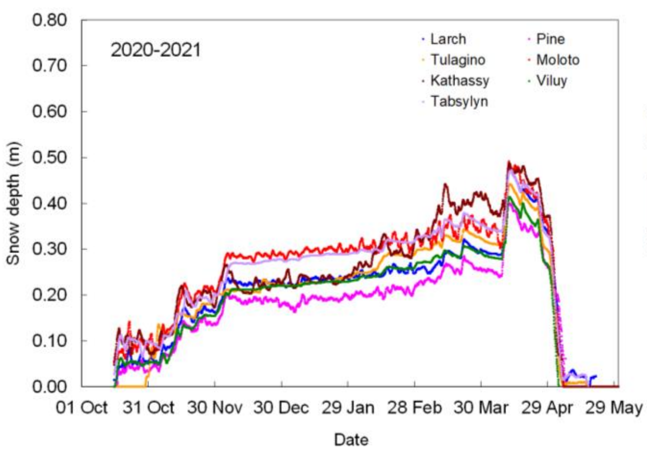


Soil surface temperature

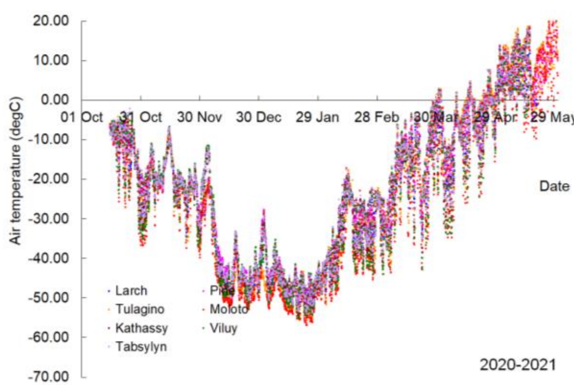


2020.10-2021.5

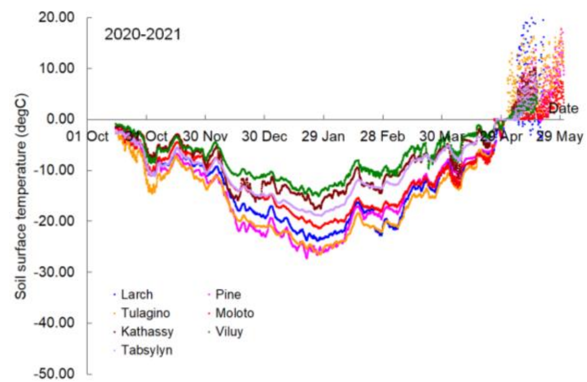
Snow depth



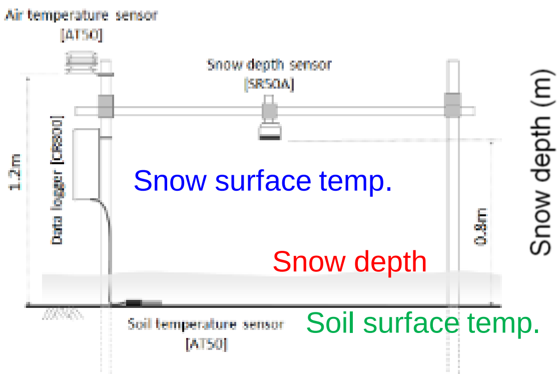
Snow surface temperature



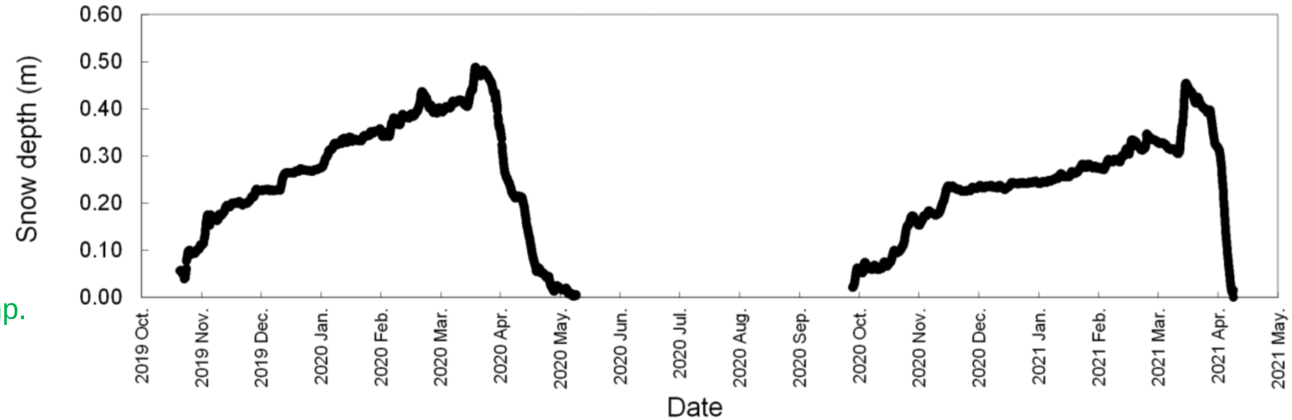
Soil surface temperature

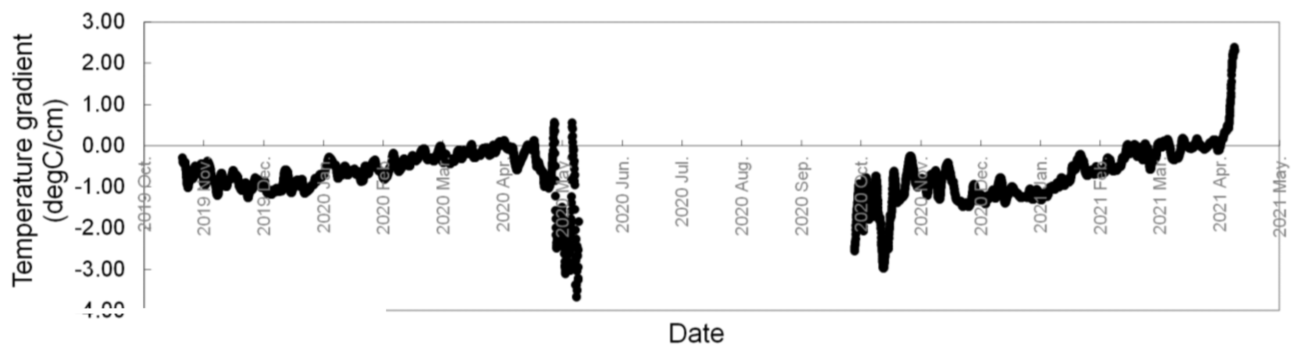


Snow temperature gradient



2019.10-2020.5 2020.10-2021.5



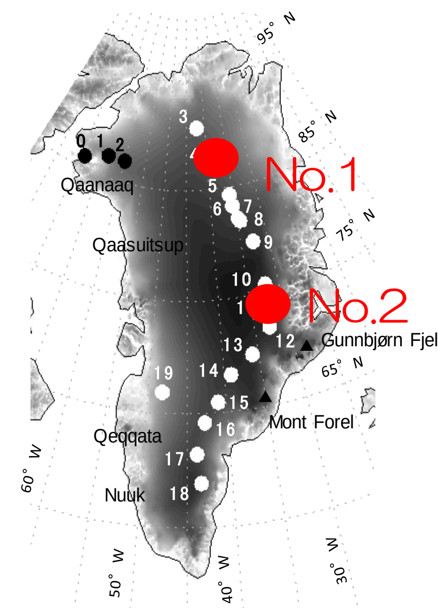


$$Temperature\ gradient = \frac{Snow\ surface\ temperature\ - Soil\ surface\ temperature}{Snow\ depth}$$

Study on the estimation of snow depth on the ice sheet using the passive microwave remote sensing

Effectivity of the microwave radiative transfer model for snowpack on ice sheet

López Moreno et al. (2016)

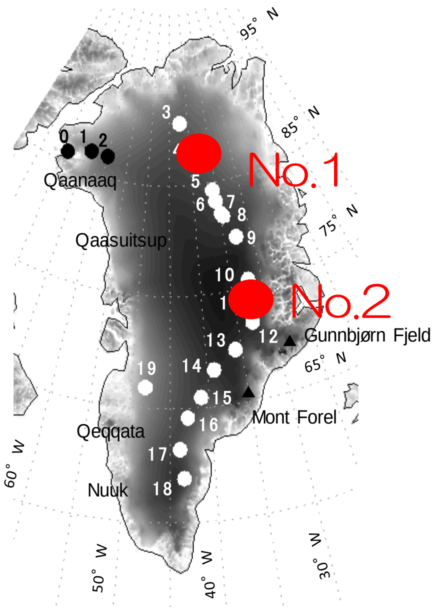


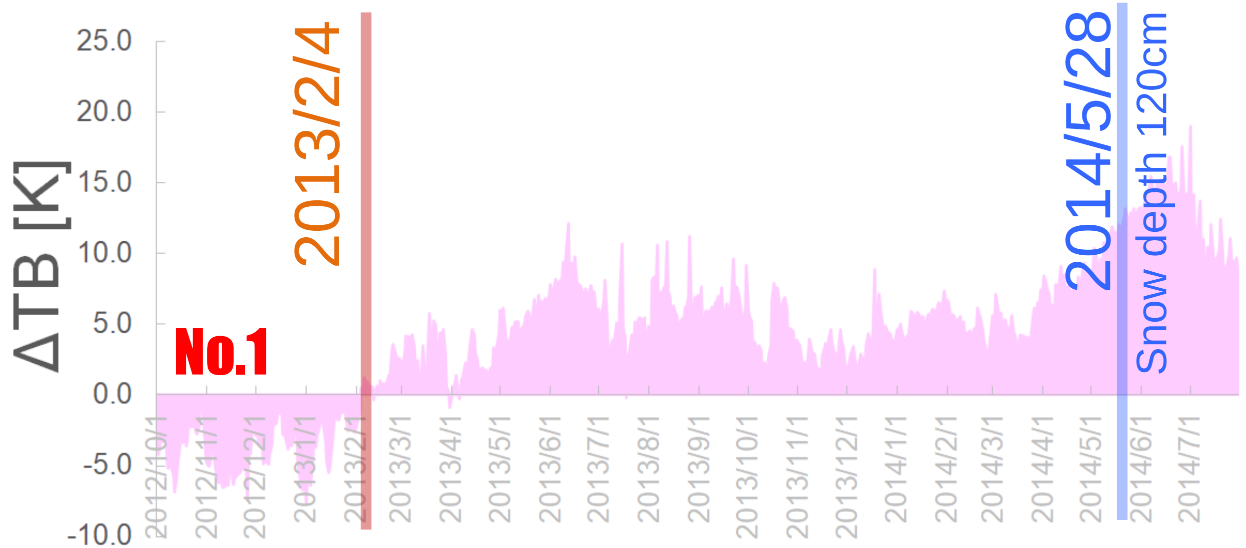
J. I. López Moreno, M. Olivera-Marañón, J. Zabalza, R. H. de Larramendi: Snowpack observations from a circumnavigation of the Greenland ice sheet (Spring 2014), CUADERNOS de INVESTIGATIÒN GEOGRÀFICA, Vol 42, No2, pp.369-381, 2016.
INUIT WINDSLED http://greenland.net/windsled/expedition-diary/

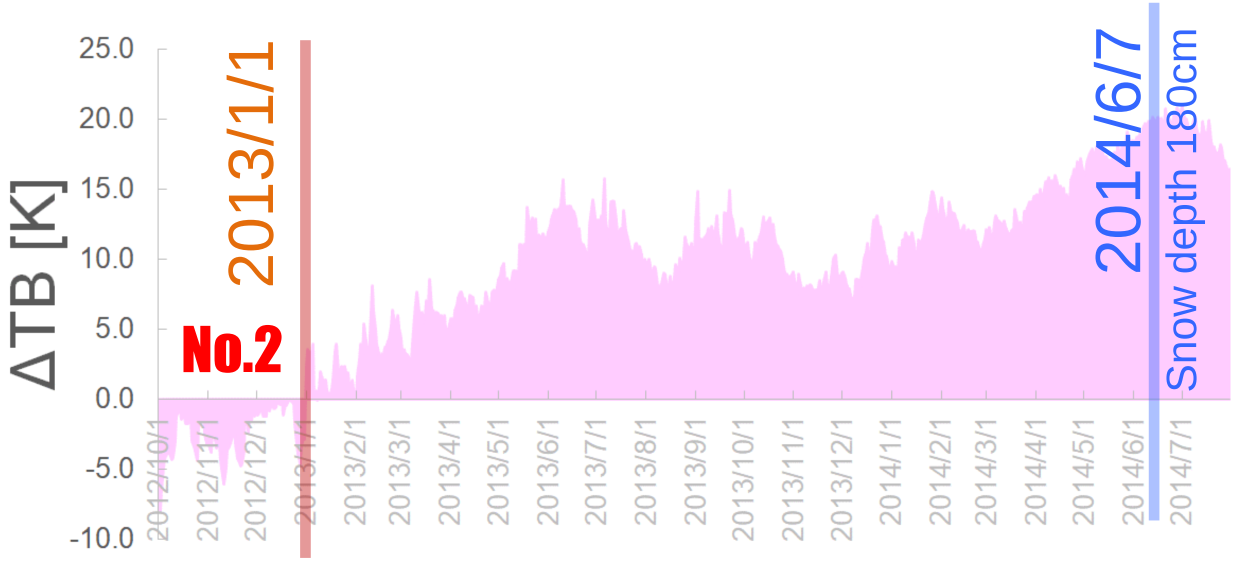
Target points

	Site No	Project	Date	Latitude	Longitude	LAT	LON	Snow depth [cm]
No.1	4	INUIT WINDSLED	May 28 ,2014	77 ° 70 ' 0 "N	38 ° 7 ' 0 "W	78.1666	38.1166	120 - 180
No.2	11	INUIT WINDSLED	June 7 ,2014	71 ° 19 ' 0 "N	32 ° 14 ' 0 "W	71.3166	32.2333	180 - 240

Investigation and setting of the beginning date of snow accumulation based on the difference between 19 and 37 GHz(ΔTB)

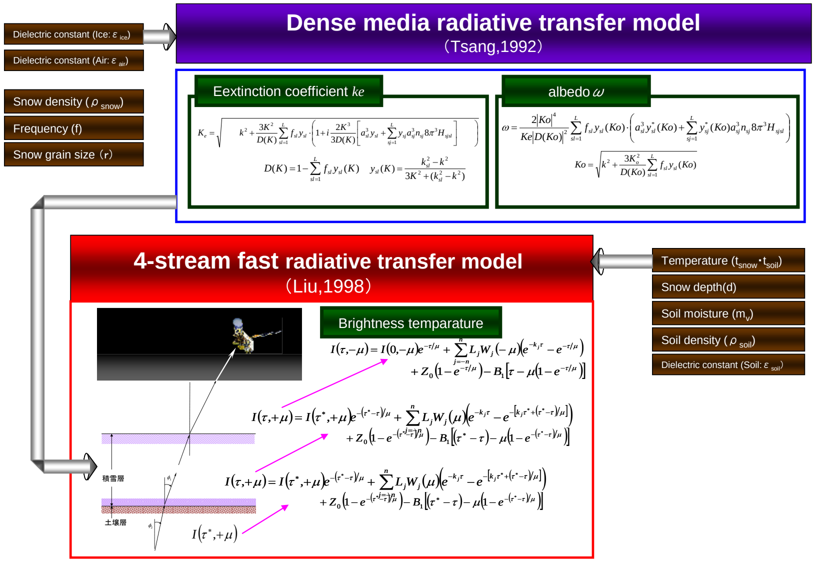




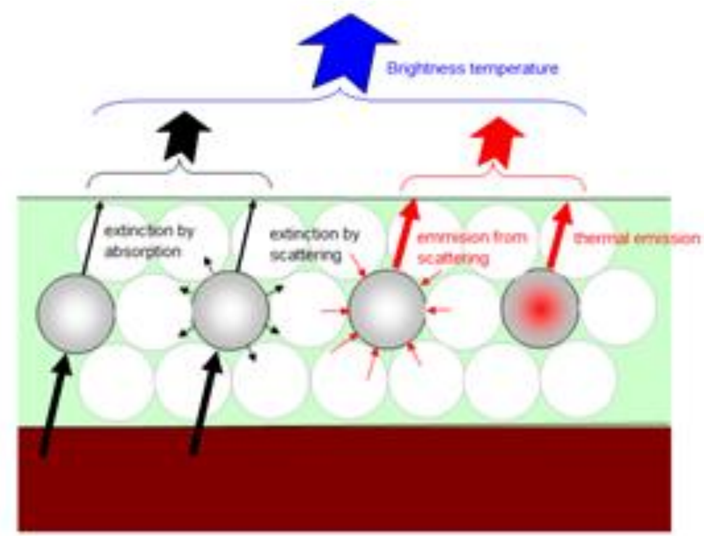


Assumption of snow physical parameter

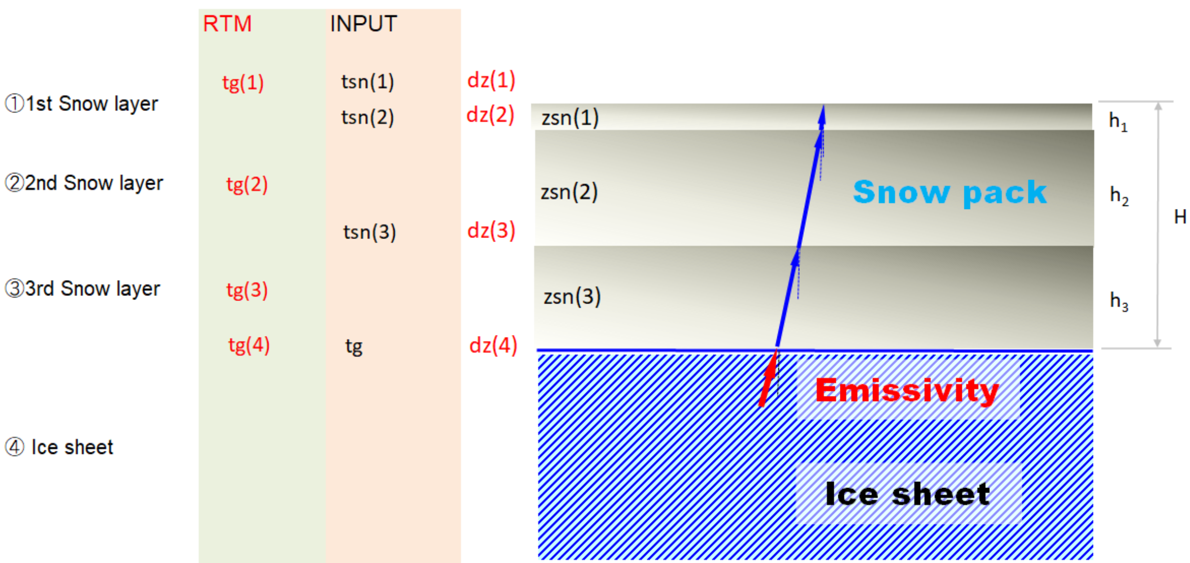
Current our microwave radiative transfer model



Single snow layer model



3 snow layer model



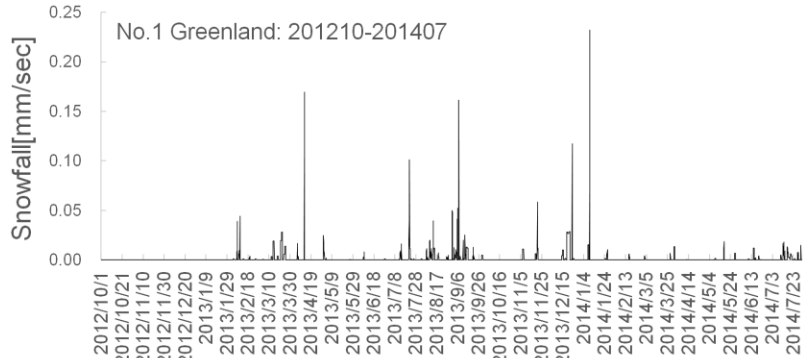
- ○ Snow depth
- ○ Snow layer thickness
- ○ Snow temperature
- ○ Snow particle size
- ○ Snow density
- ○ Snow wetness (=0%)
- ○ Emissivity from ice sheet

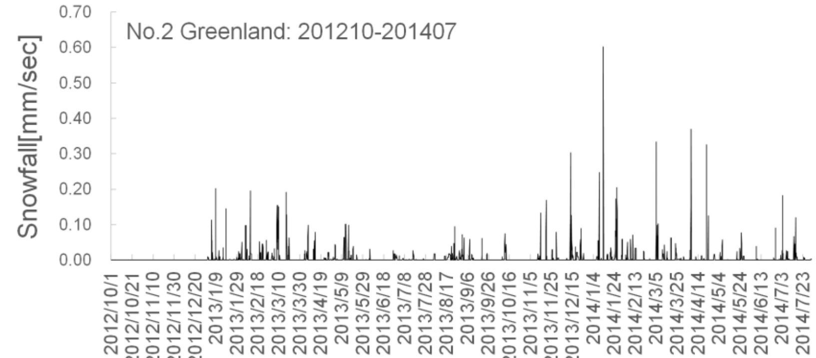
Investigation and assumption of snow depth variation

No.1

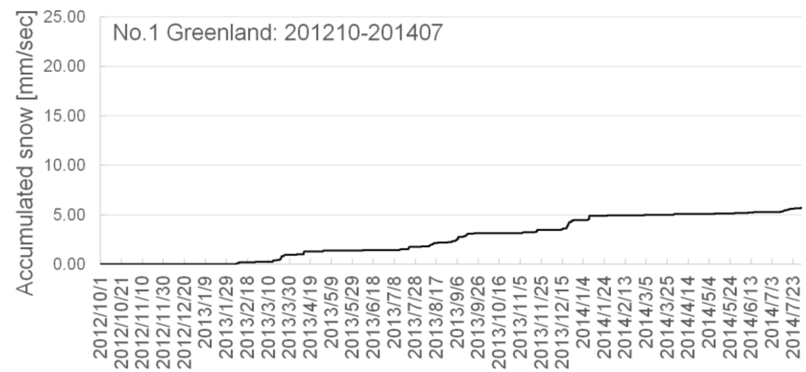
No.2

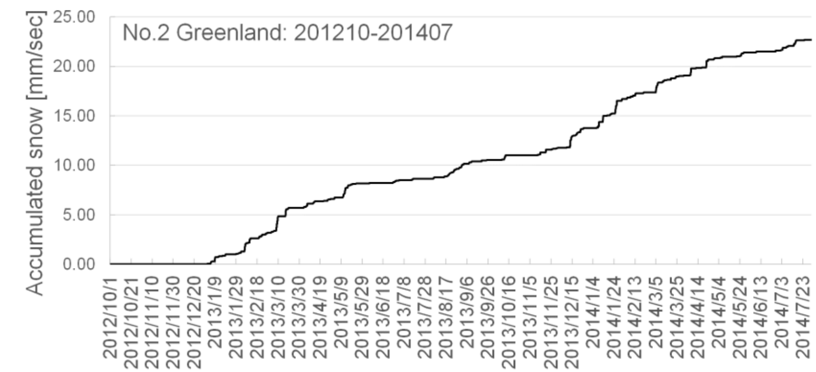
Snowfall



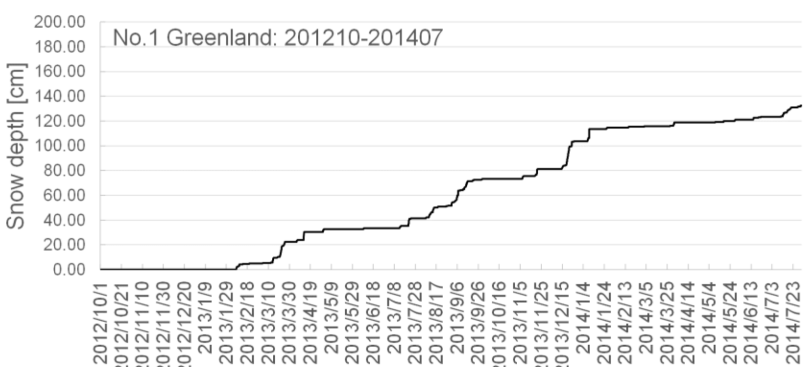


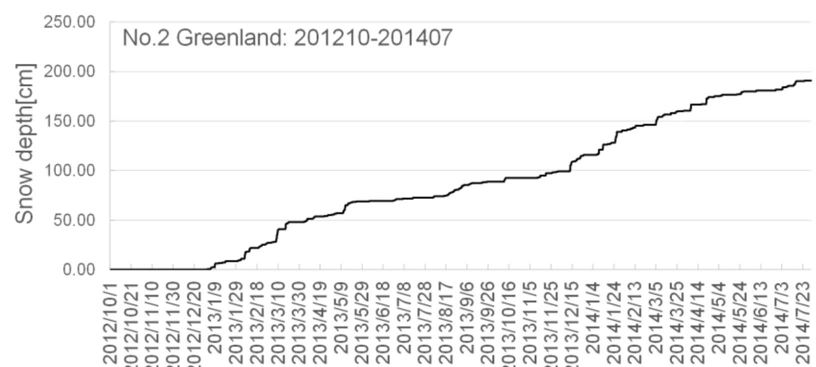
Accumulated snowfall





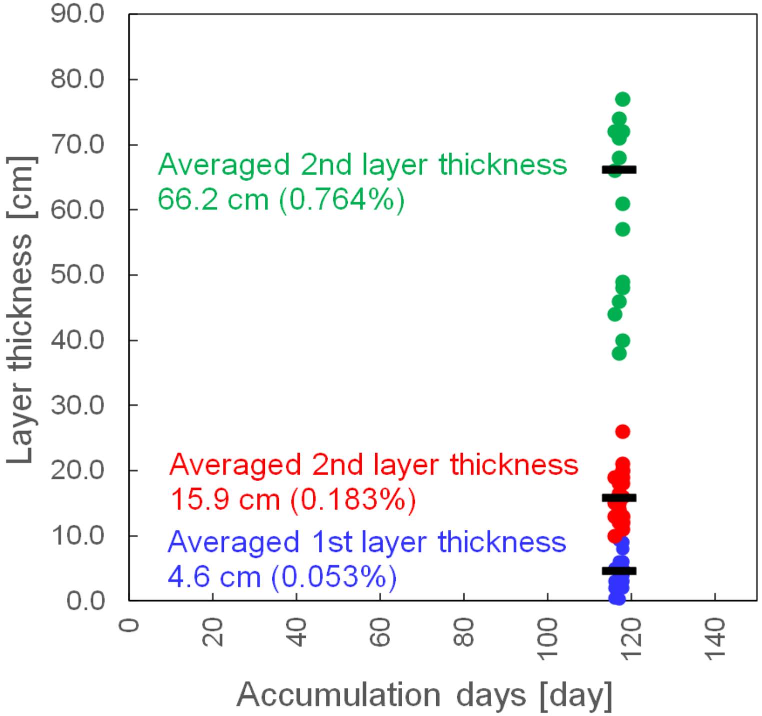
Assumed snow depth

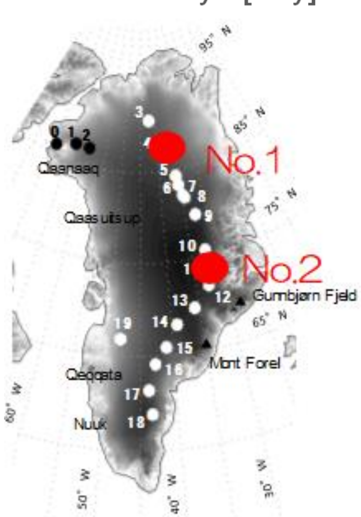


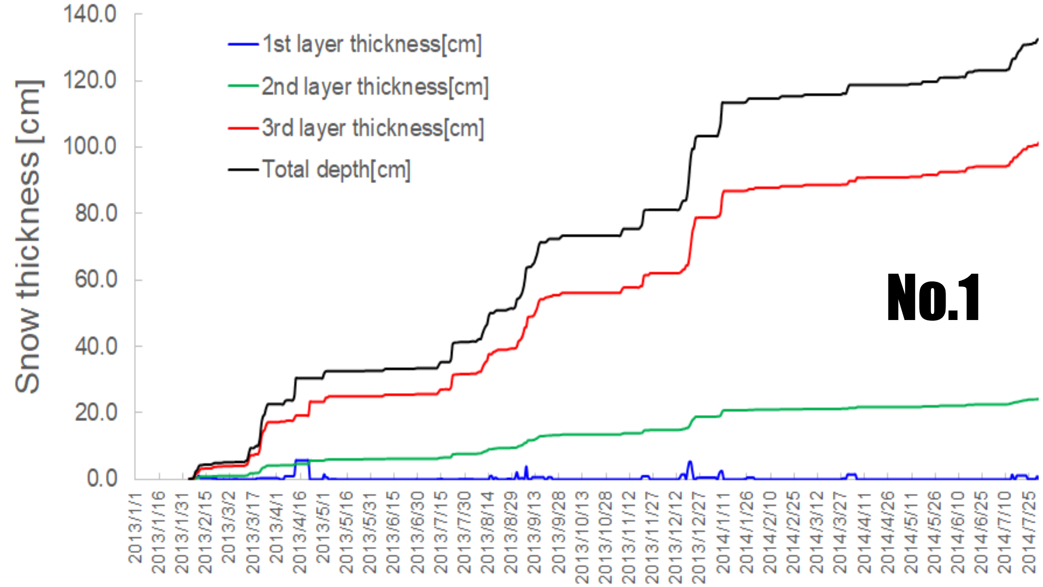


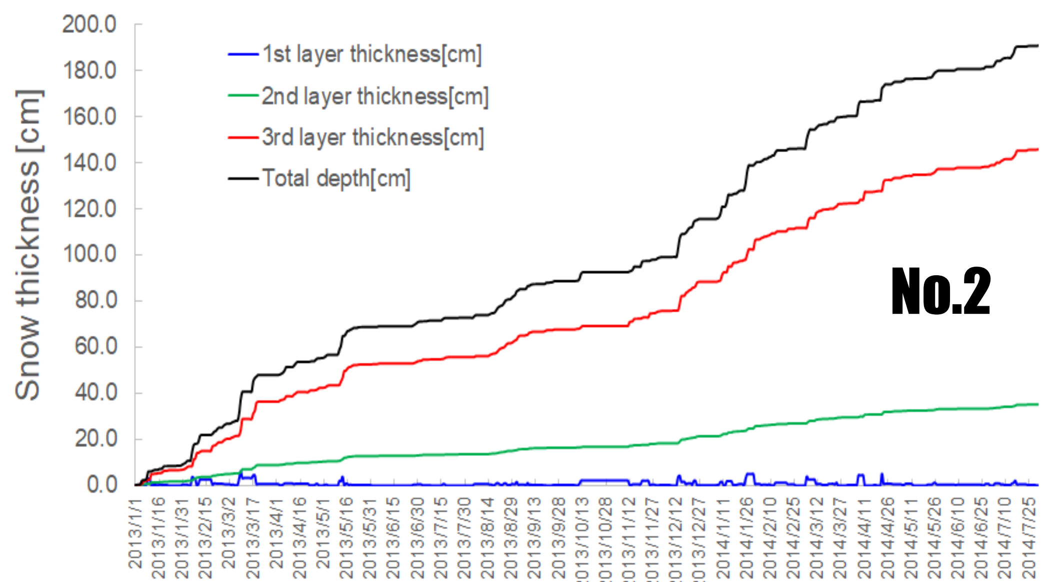
Investigation and assumption of snow layer thickness

Siberia snow observation data



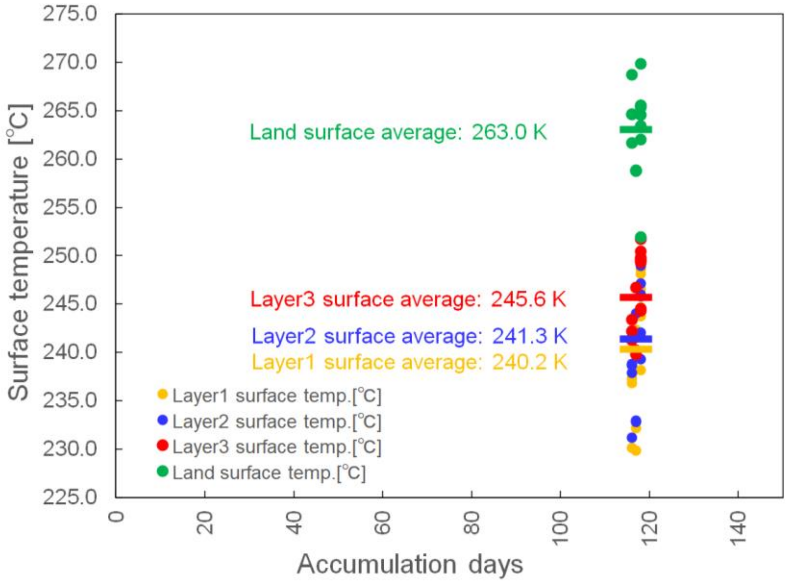


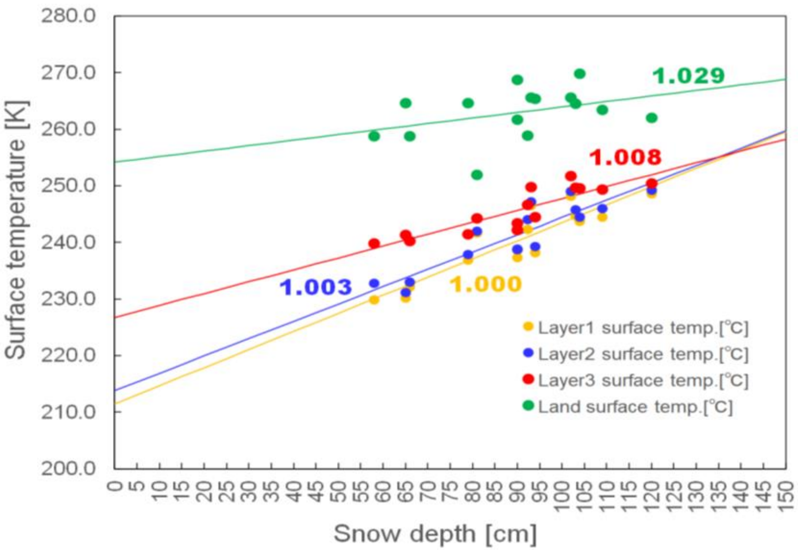


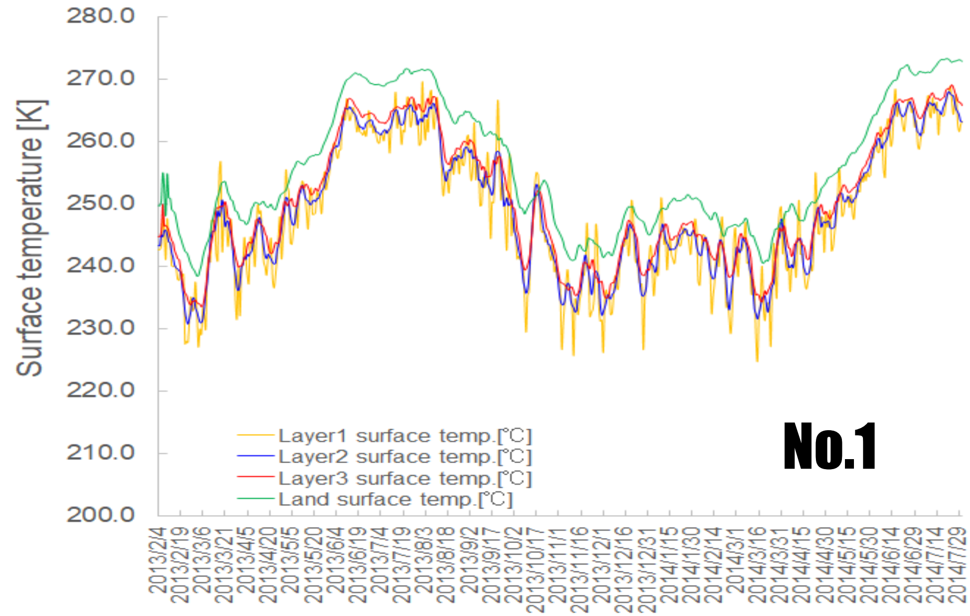


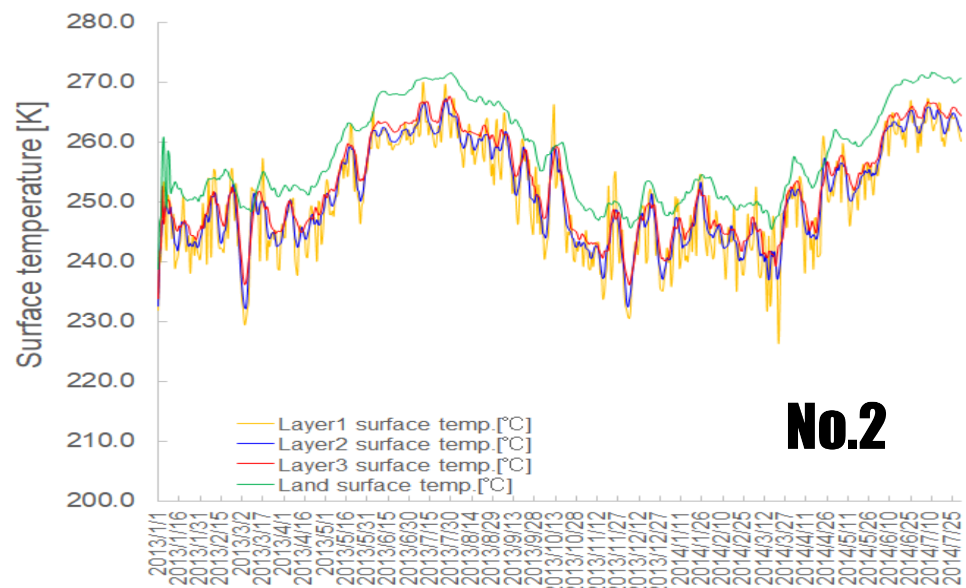
Investigation and assumption of snow temperature

Siberia snow observation data



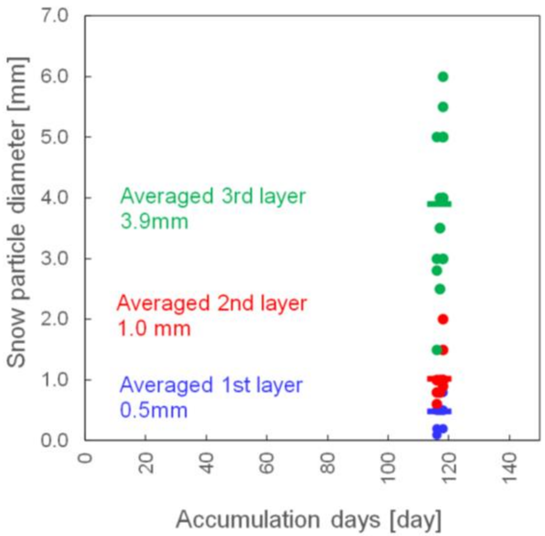






Investigation and assumption of snow particle size

Siberia snow observation data



Sturm, M., and C. S. Benson (1997)

$$r(t) = r_\infty - (r_\infty - r_0)e^{-\alpha t}$$

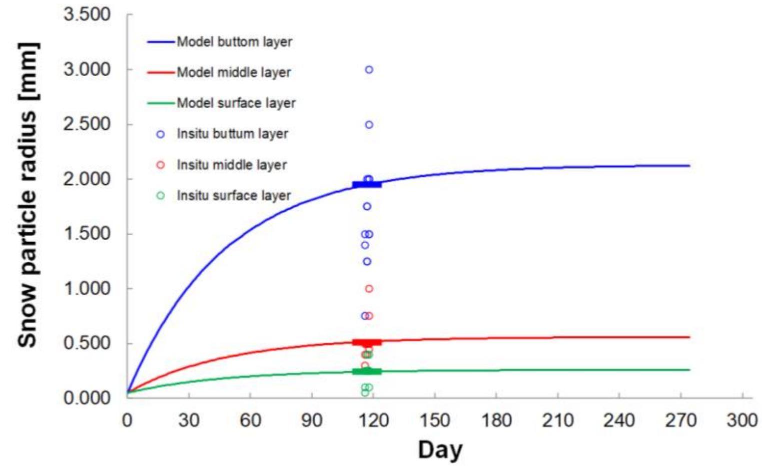
1st layer : $r_\infty = 0.56$

2nd layer : $r_\infty = 1.93$

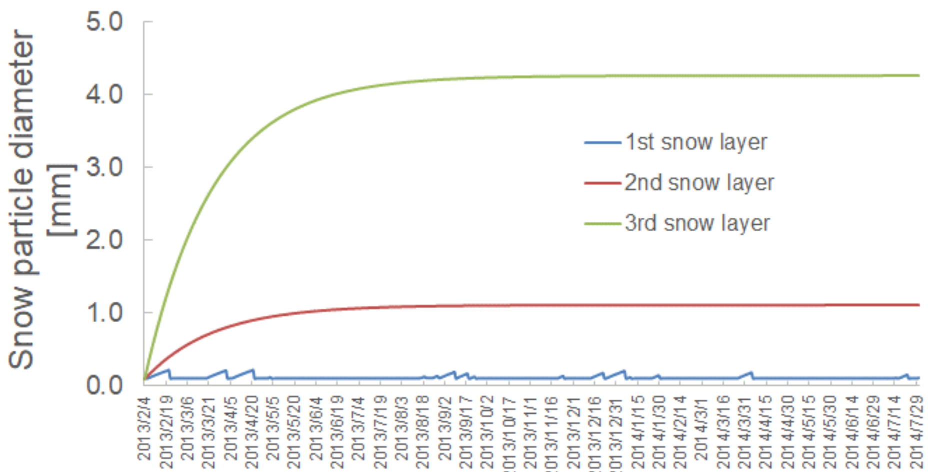
3rd layer : $r_\infty = 2.13$

$r_0 = 0.05$

$\alpha = -0.0209$



No.1



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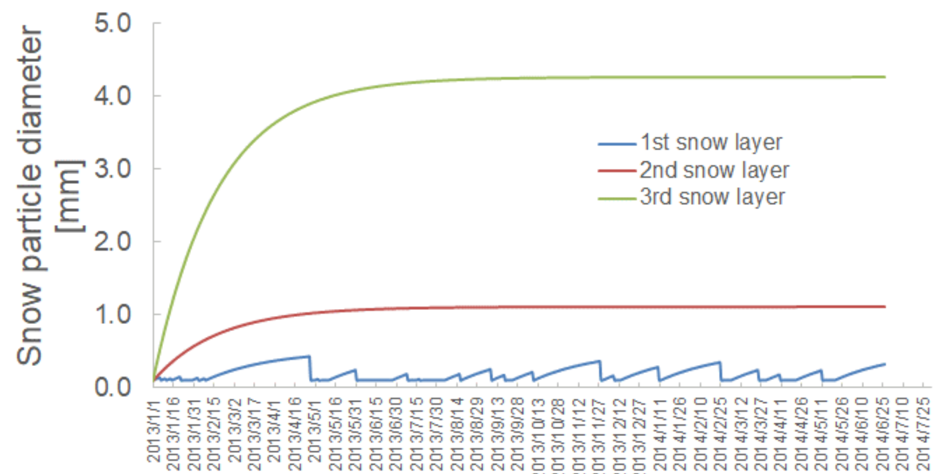


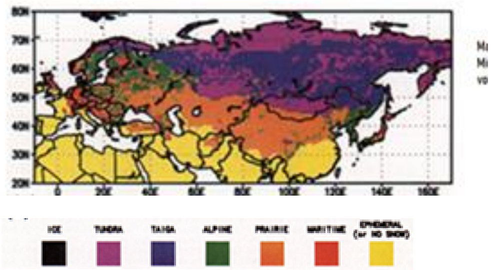
Investigation and assumption of snow density

Snow density
Sturm, M., and C. S. Benson (1997)

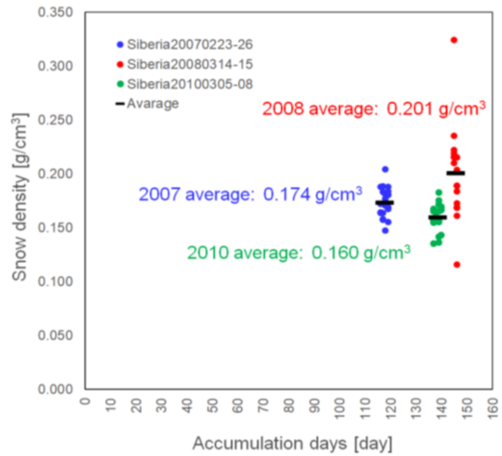
$$\rho=\rho_{max}-(\rho_{max}-\rho_{min})\times exp(-volgr\times d)$$

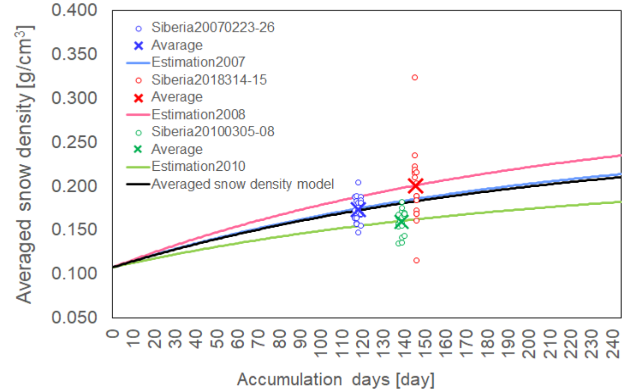
ρ: Snow density
ρ_{max}: Maximum density
ρ_{max}: Minimum density

d : Snow days
volgr :constant

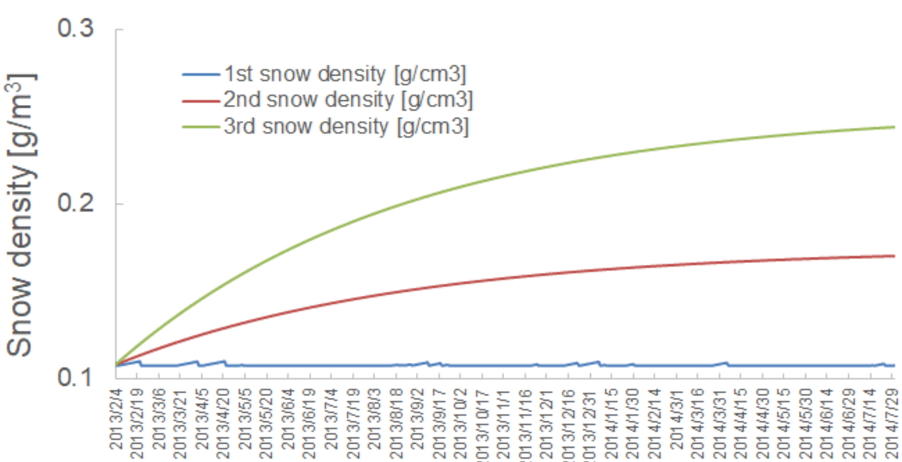


Siberia snow observation data





No.1



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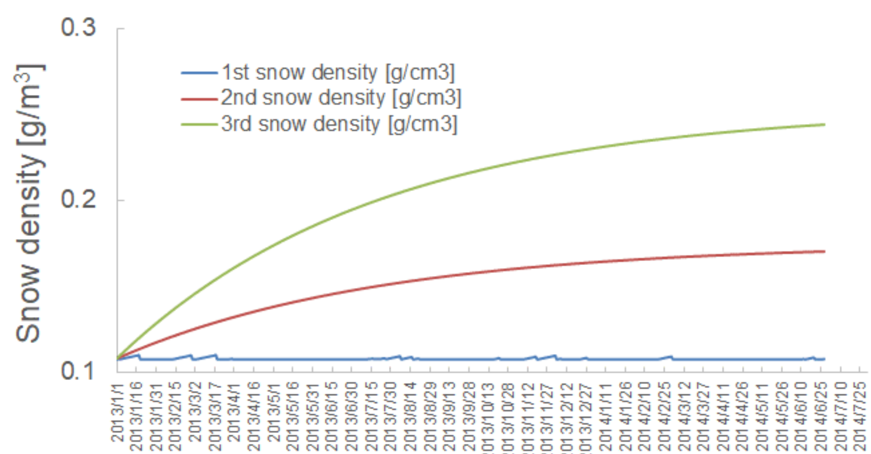
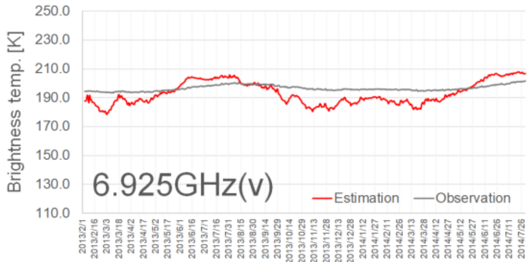


Performance validation of RTM based on the brightness temperature

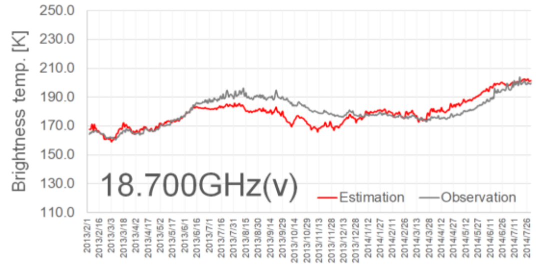
No.1

Vertical

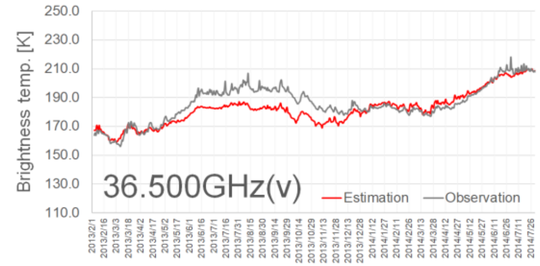
RMSE= 7.17 [K]



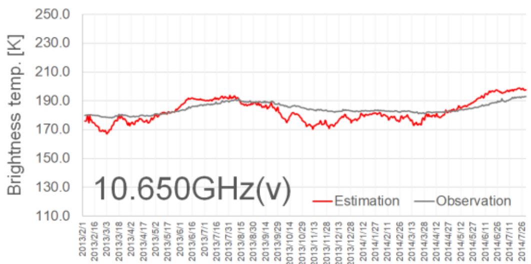
RMSE= 6.10 [K]



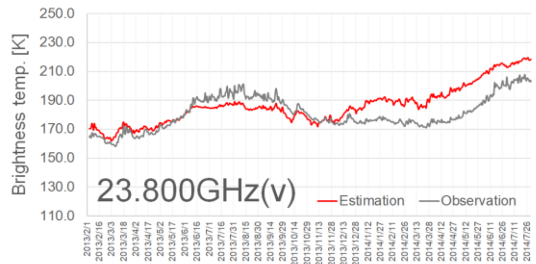
RMSE= 7.39 [K]



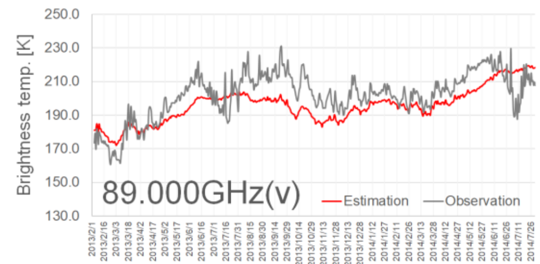
RMSE= 5.31 [K]



RMSE= 10.76 [K]

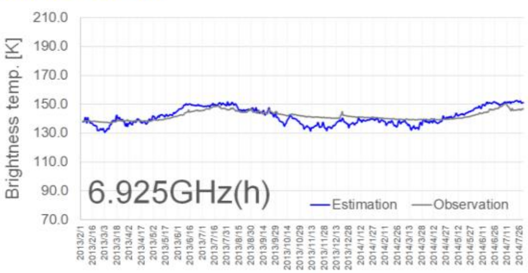


RMSE= 11.00 [K]

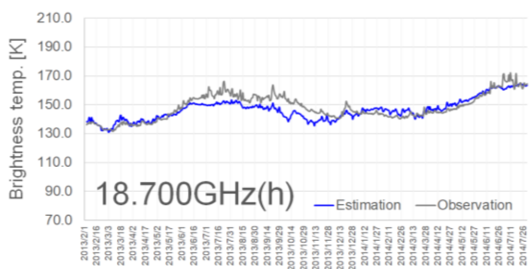


Horizontal

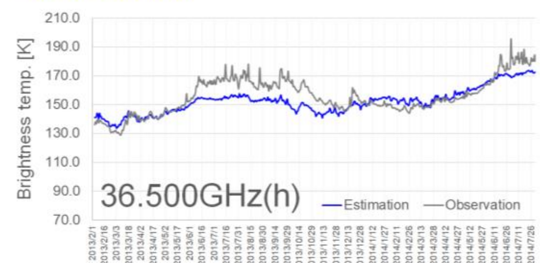
RMSE= 3.62 [K]



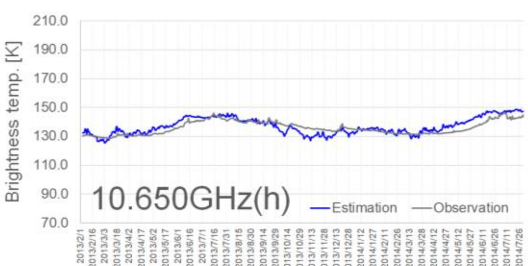
RMSE= 4.91 [K]



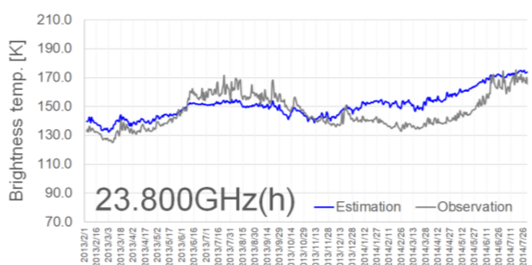
RMSE= 8.01 [K]



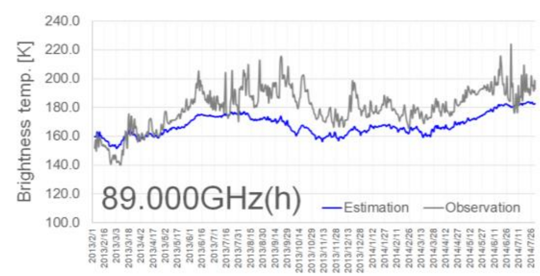
RMSE= 3.41 [K]



RMSE= 9.74 [K]



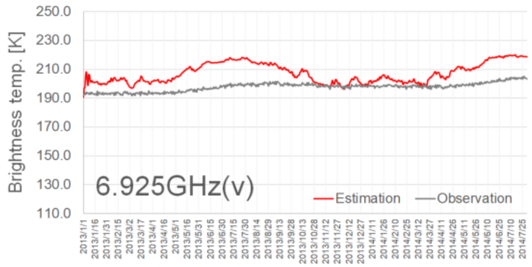
RMSE= 15.72 [K]



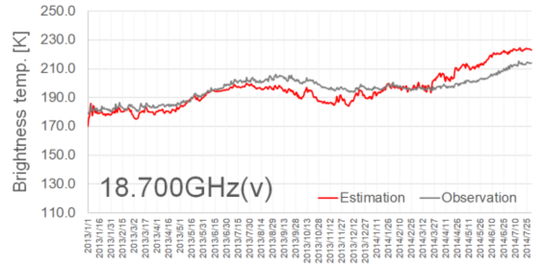
No.2

Vertical

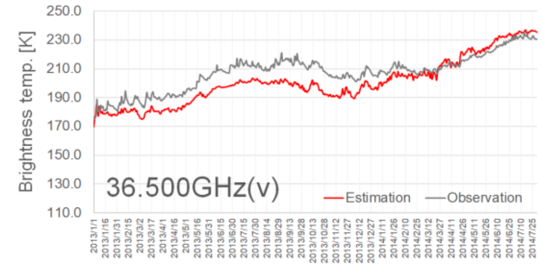
RMSE= 11.05 [K]



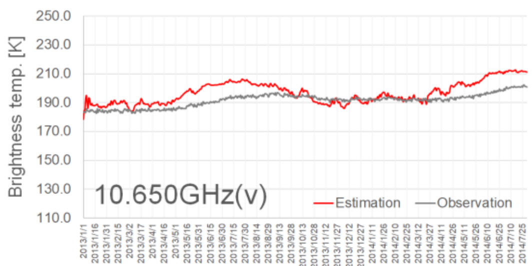
RMSE= 6.76 [K]



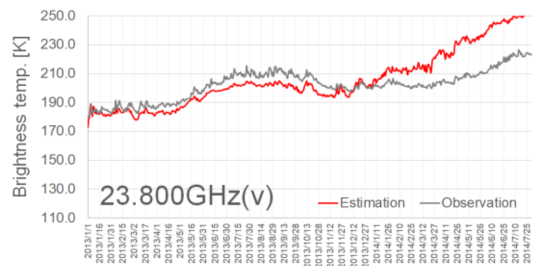
RMSE= 9.42 [K]



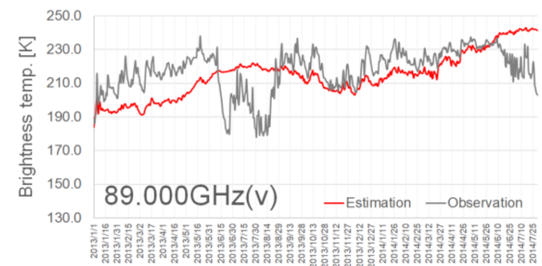
RMSE= 7.27 [K]



RMSE= 13.32 [K]

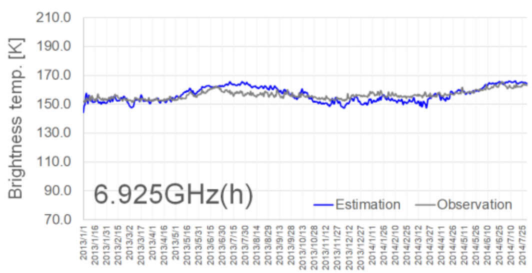


RMSE= 15.56 [K]

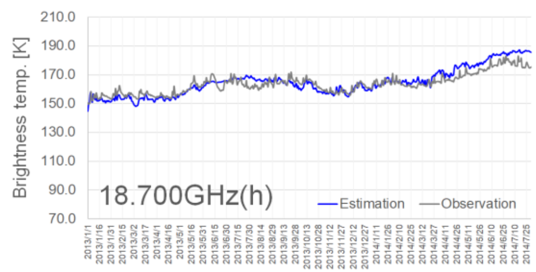


Horizontal

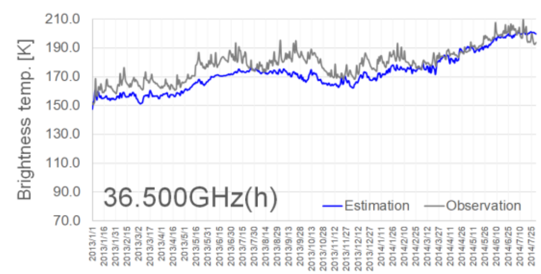
RMSE= 3.39 [K]



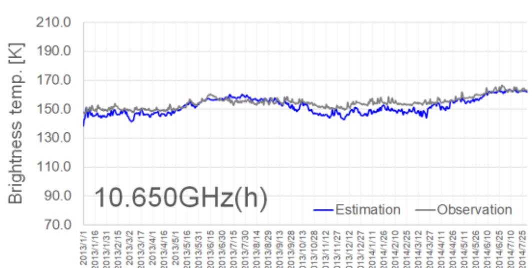
RMSE= 4.21 [K]



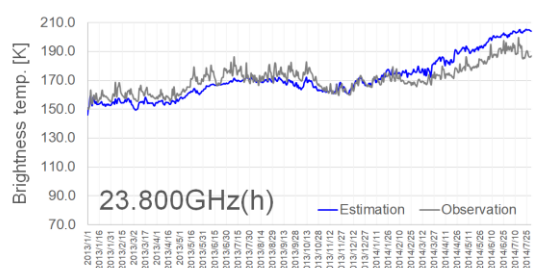
RMSE= 8.47 [K]



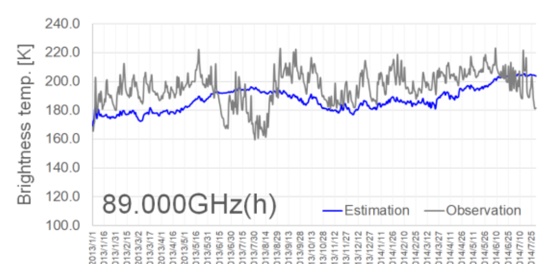
RMSE= 3.99 [K]



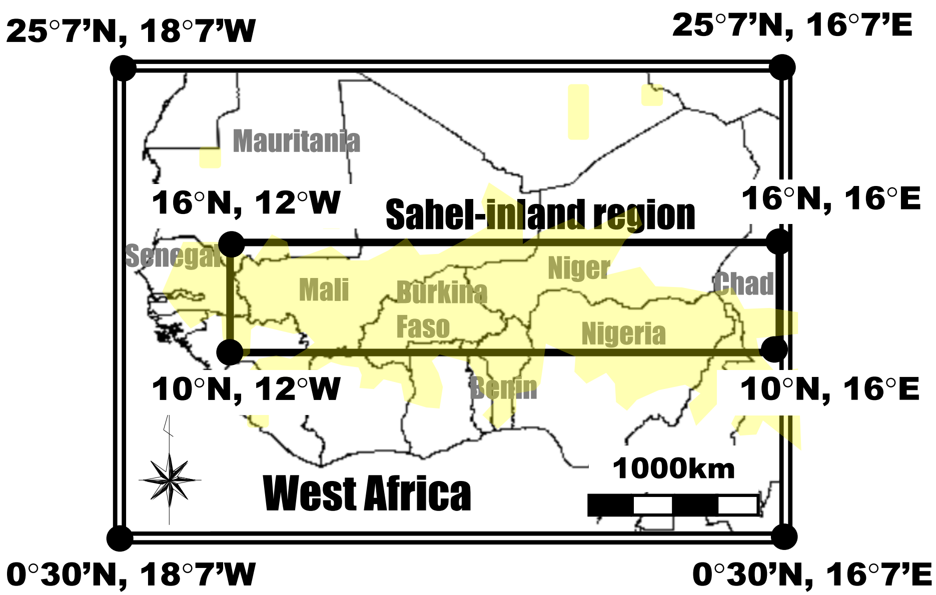
RMSE= 7.47 [K]



RMSE= 15.22 [K]



Agricultural drought assessment over West Africa using the Coupled Land and Vegetation Data Assimilation System (CLVDAS)



1914 : Widespread famine caused by drought occurred.

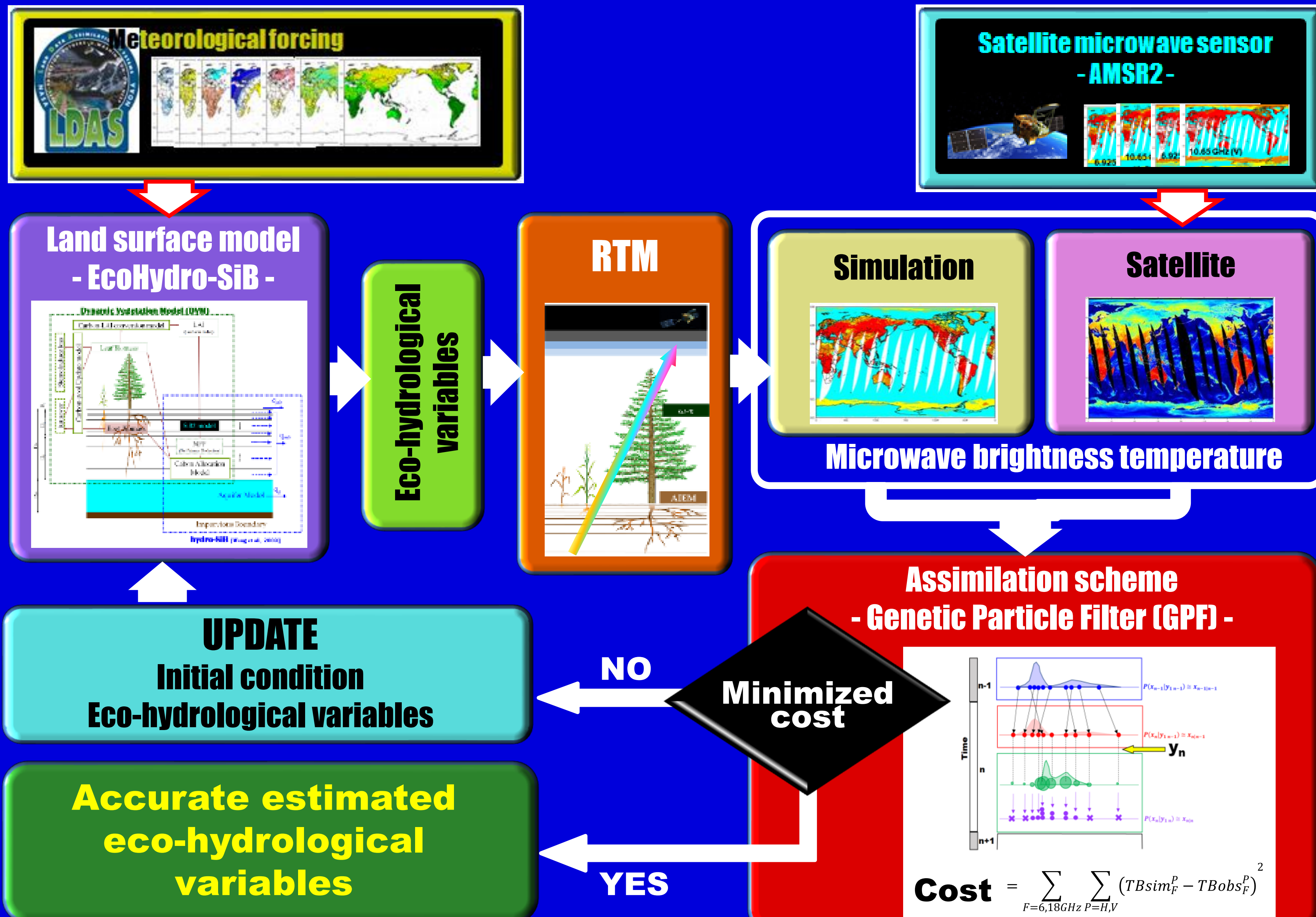
1968-73: One million people have died in Mauritania, Mali, Chad, Niger and Burkina Faso.

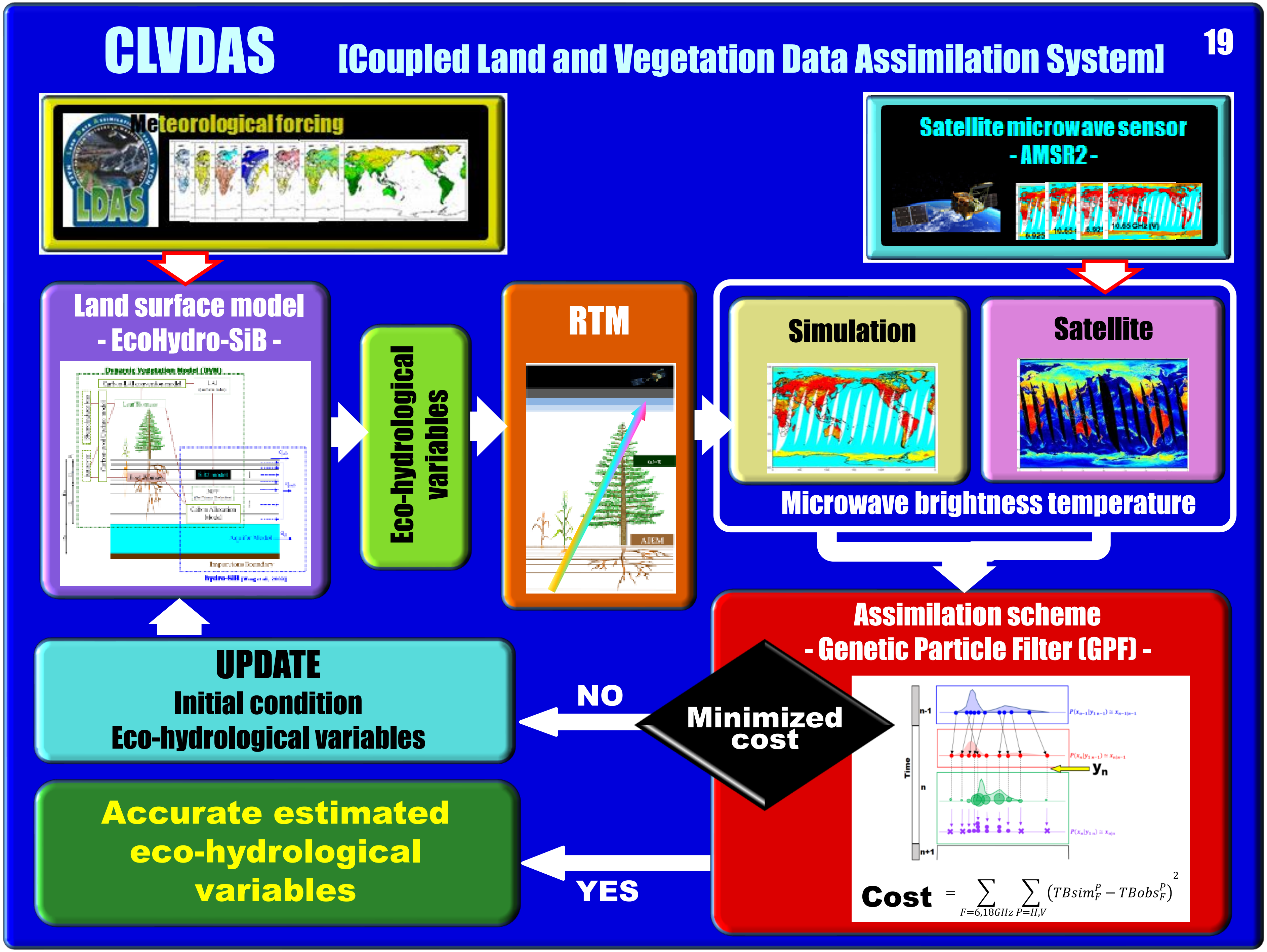
1982-84: Famine killed 3 million people in the Sahel region.

2017: Drought broke out in the Sahel region, damaging livestock and crops

2020: Drought caused more than 3 million people to face hunger in Burkina Faso.

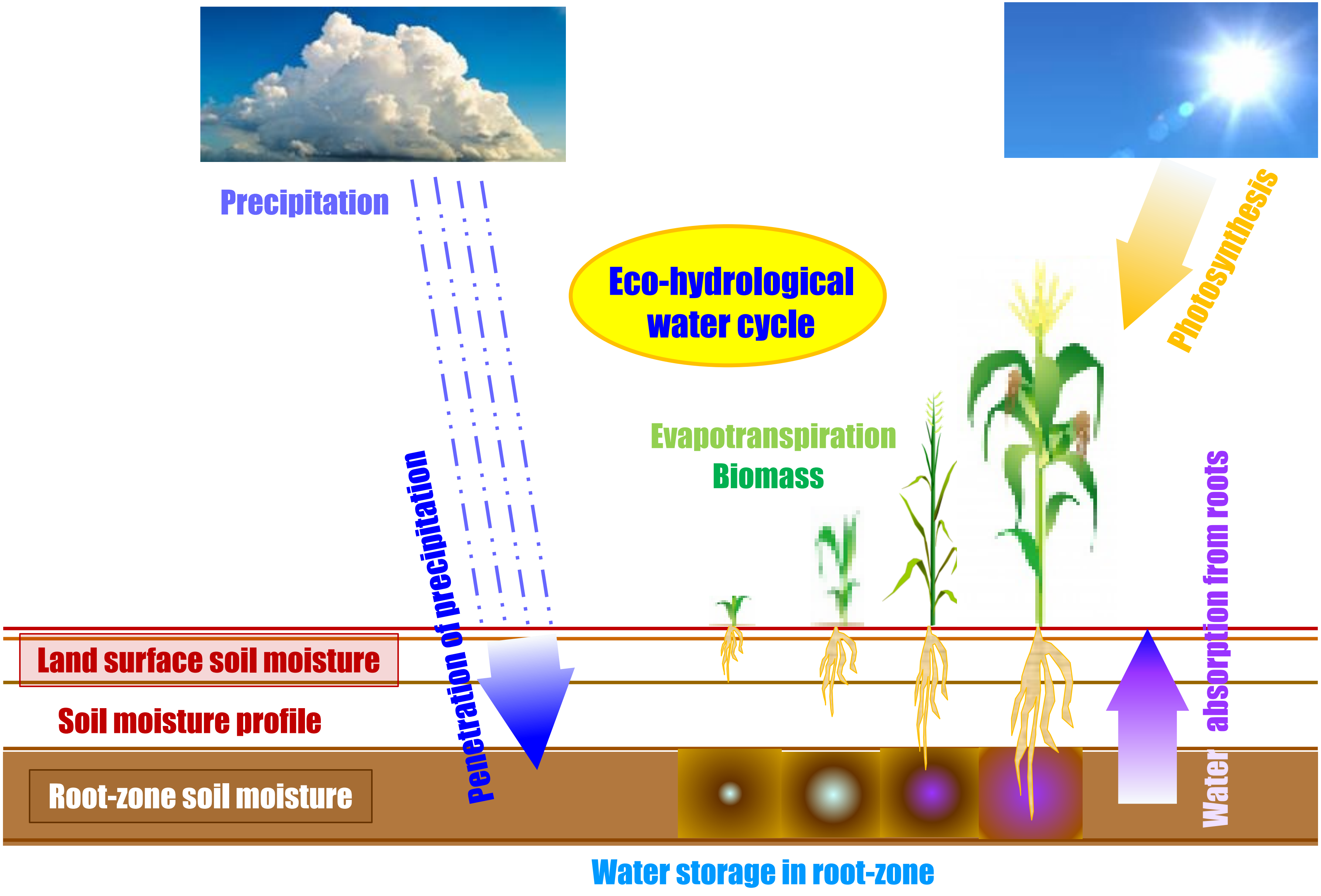
CLVDAS [Coupled Land and Vegetation Data Assimilation System]



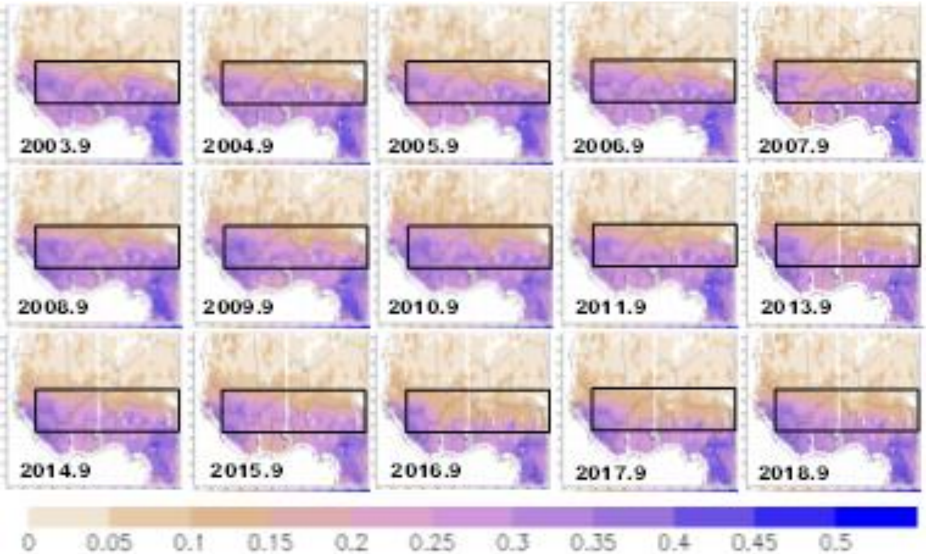


CLVDAS [Coupled Land and Vegetation Data Assimilation System]
19
Meteorological forcing
LDAS
Satellite microwave sensor
- AMSR2 -
Land surface model
- EcoHydro-SiB -
Dynamic Vegetation Model (DVM)
hydro-SiB
Eco-hydrological variables
RTM
AIEM
Simulation
Satellite
Microwave brightness temperature
Assimilation scheme
- Genetic Particle Filter (GPF) -
n-1
n
n+1
Time
y_n
Minimized cost
NO
YES
UPDATE
Initial condition
Eco-hydrological variables
Accurate estimated eco-hydrological variables
$$\text{Cost} = \sum_{F=6,18GHz} \sum_{P=H,V} \left(TBsim_F^P - TBobs_F^P\right)^2$$

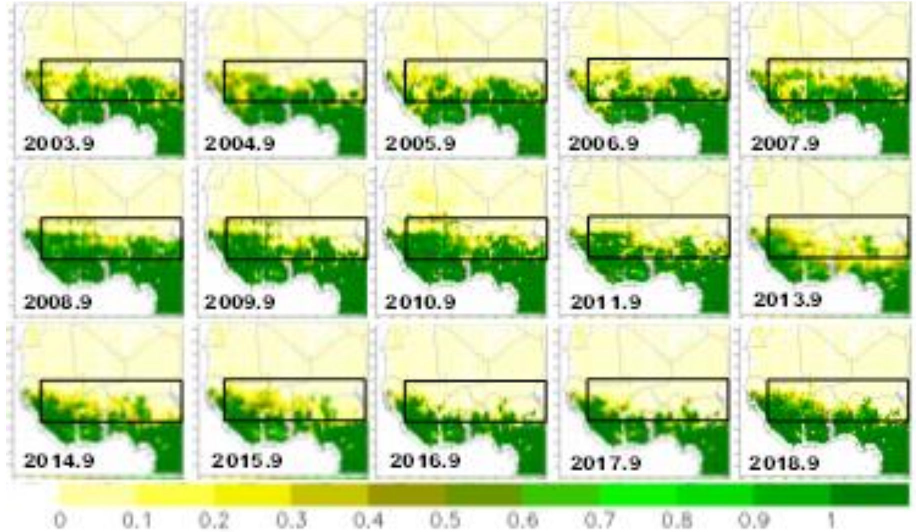
Land surface model : Eco-HydroSiB



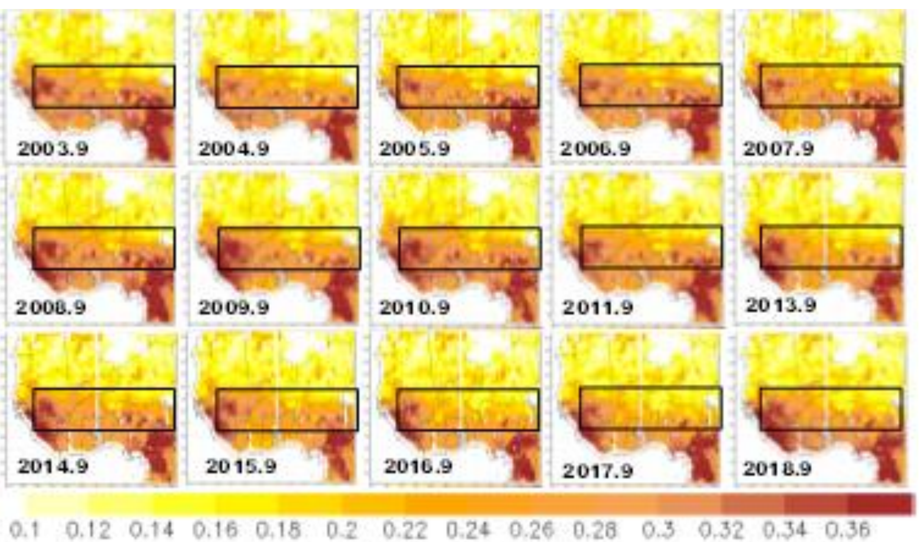
Eco-hydrological variables



Land surface soil moisture content

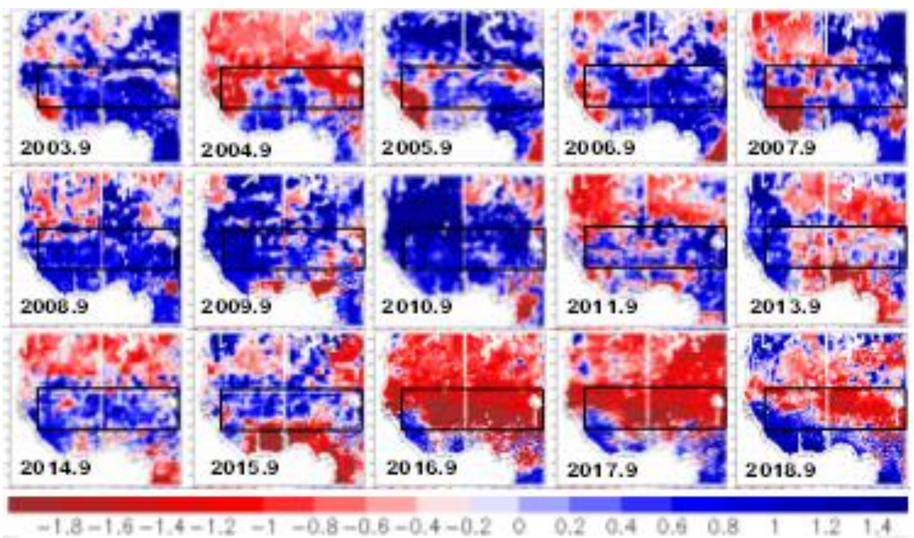


Vegetation water content

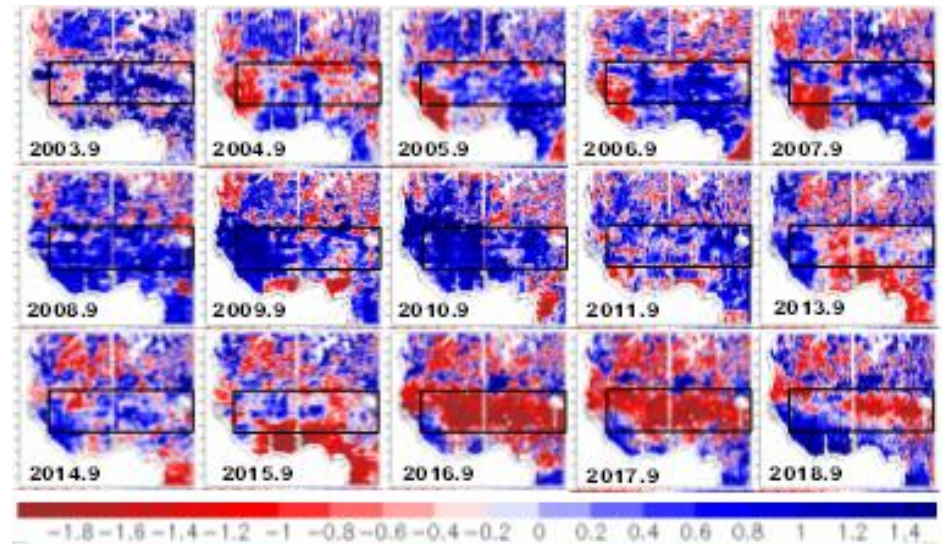


Root-zone soil moisture content

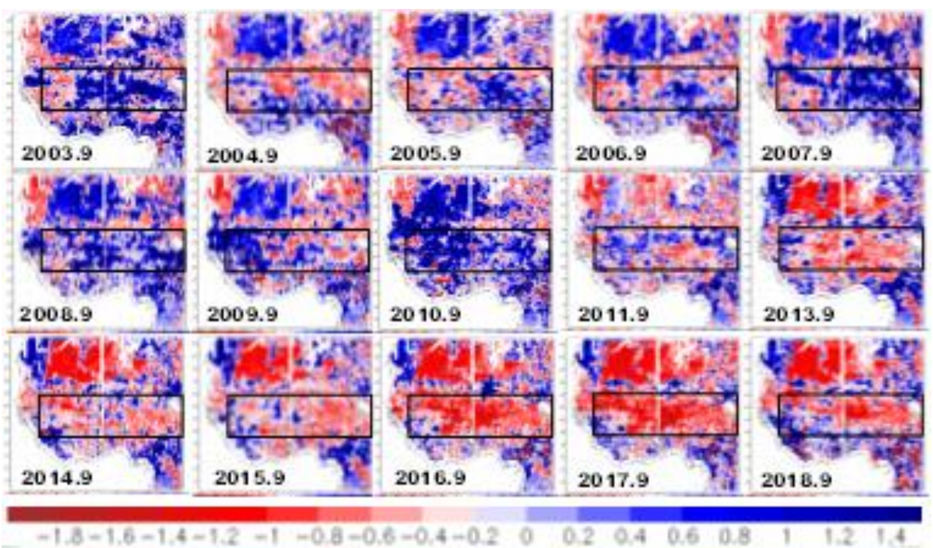
Normalized index (NIi) based on Z-score theory



Land surface soil moisture content



Vegetation water content



Root-zone soil moisture content

Normalized index (NIi) based on Z-score theory

$$NI_i = \frac{x_i - \mu}{\sigma},$$

Where, x_i is the variable on an arbitrary date (i), μ and σ are the average and standard deviation for x_i on an arbitrary date (i).

Agriculture in West Africa

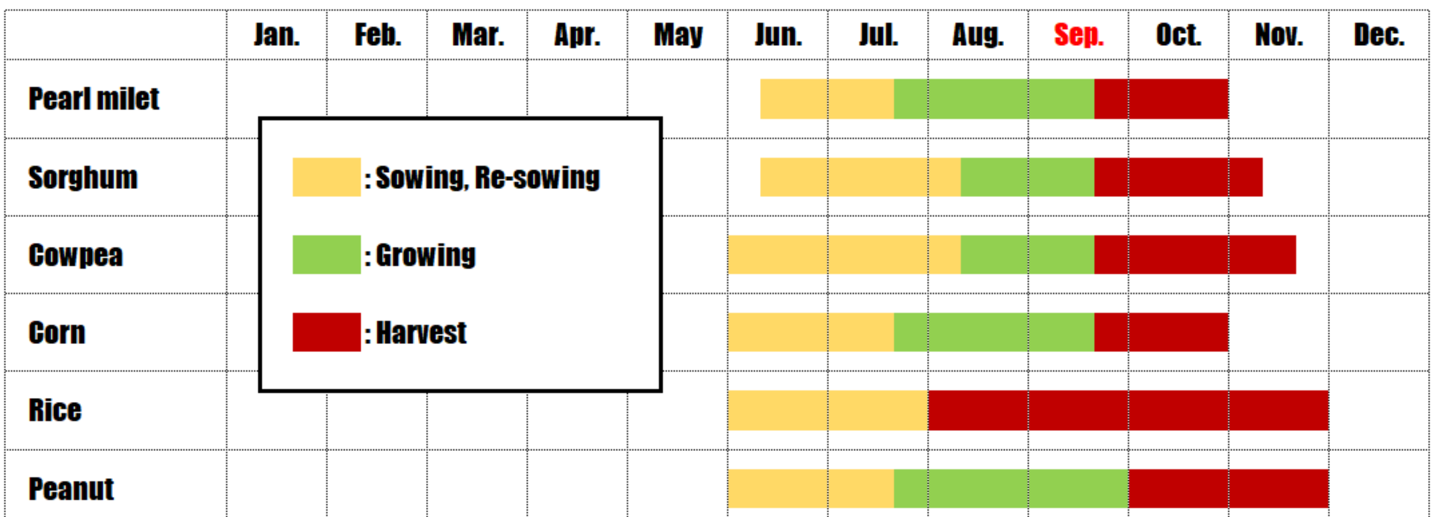
Major crop

Main crop in West Africa

Pearl milet

Crop calendar

Agricultural calendar in West Africa



Source: Référentiel commenté des prix des produits agricoles du Niger, Août 1999

Comparison result between vegetation water content in September and pearl millet yield