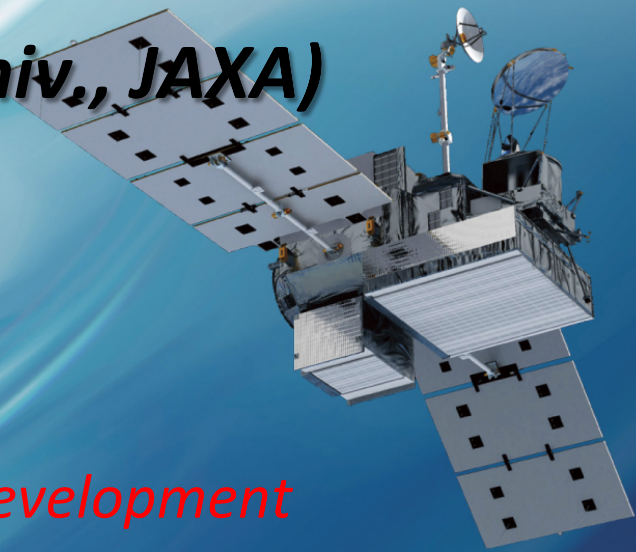
JAXA GPM Science

Kenji Nakamura (Nagoya Univ., JAXA)
and PMM science team



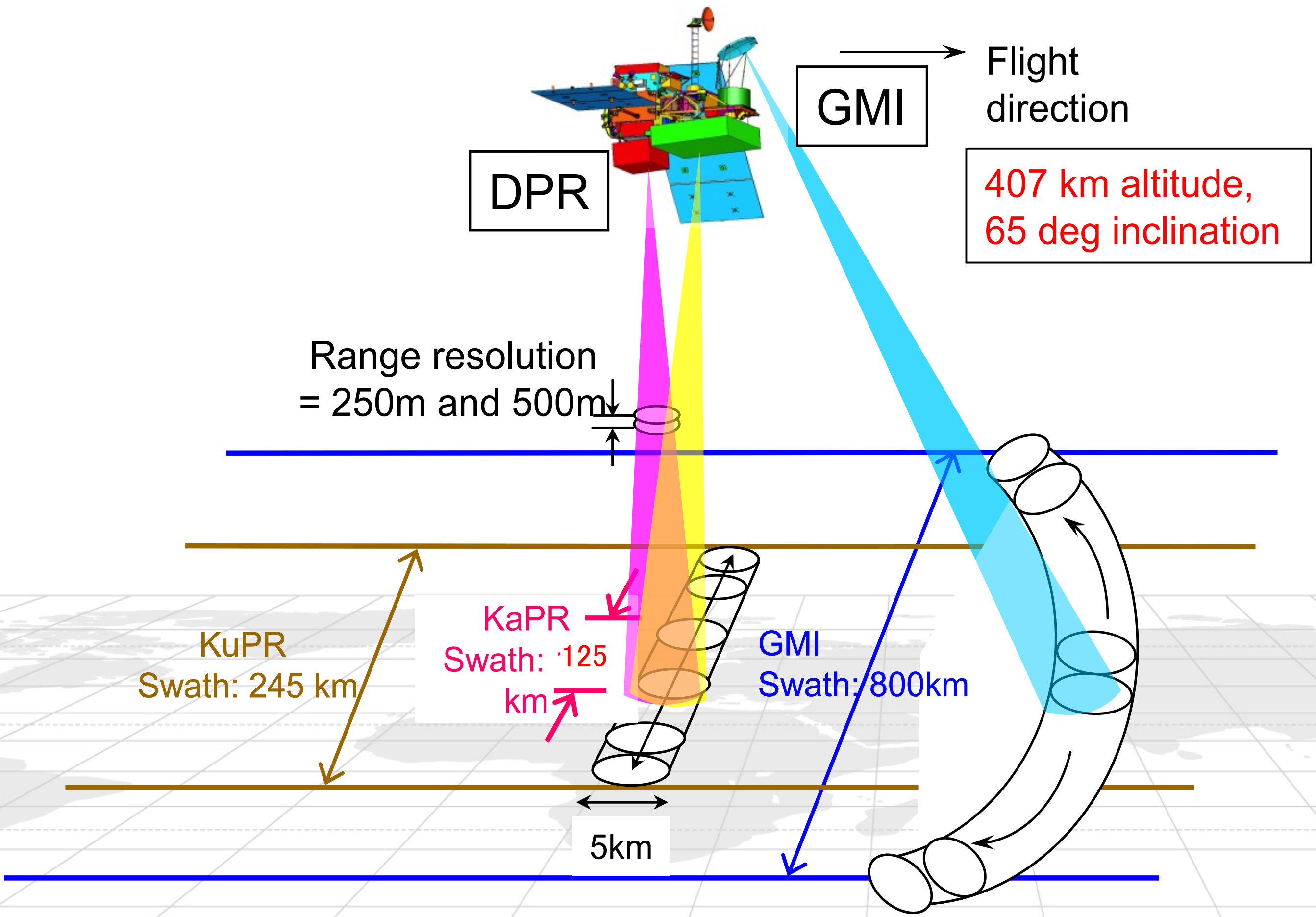
Activities in FY2012 (Feb2012-Mar2013)

- *GPM DPR algorithm developments*
- *Field experiments for DPR algorithm development*
- *Combined algorithm developments*
- *Studies for improvements of MW retrievals*
- *GSMaP evolution*
- *GPM future applications*

GPM DPR algorithm developments

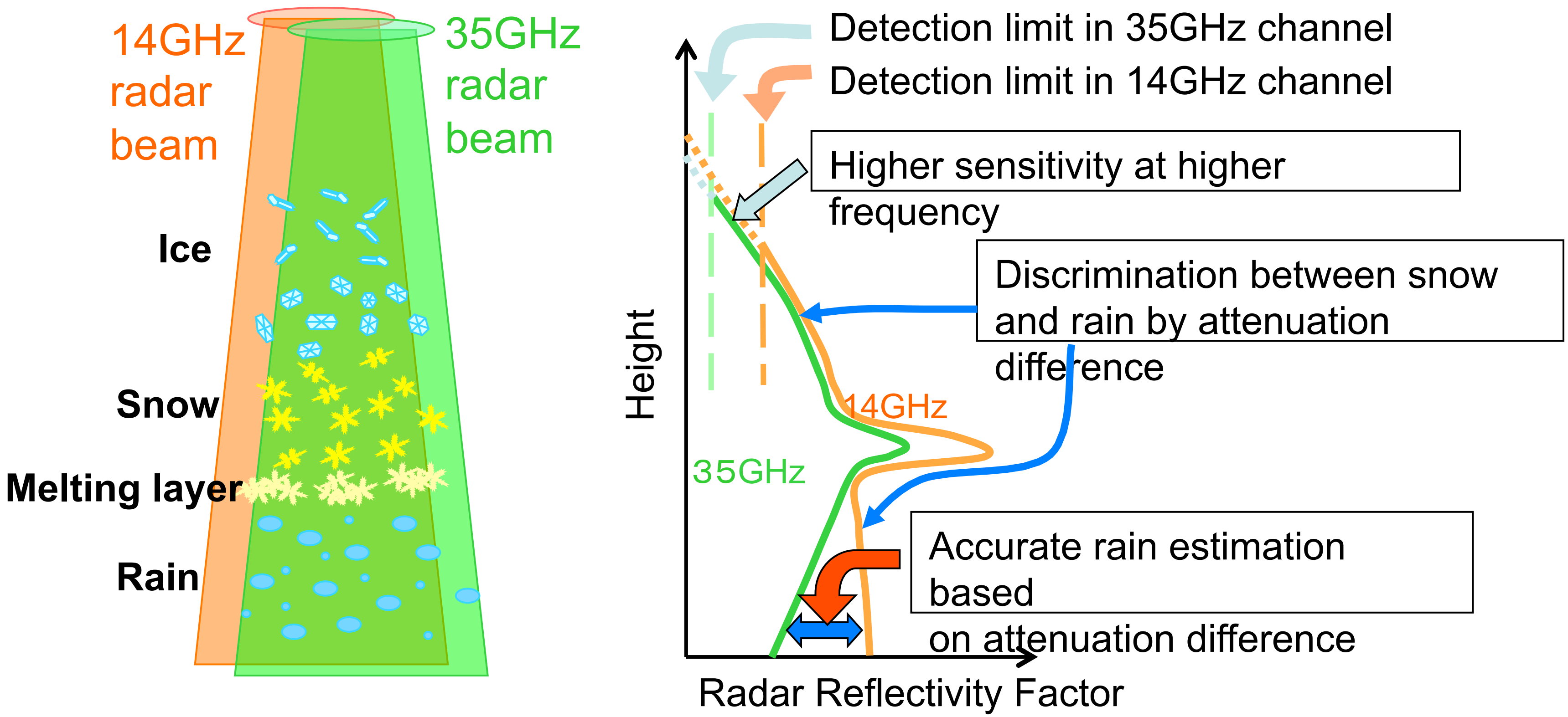
Shita Seto (Nagasaki Univ), Toshio Iguchi (NICT)

Dual-frequency precipitation radar (DPR) consists of
Ku-band (13.6GHz) radar : KuPR and
Ka-band (35.5GHz) radar : KaPR



DPR beam scanning

Dual Frequency Precipitation Radar

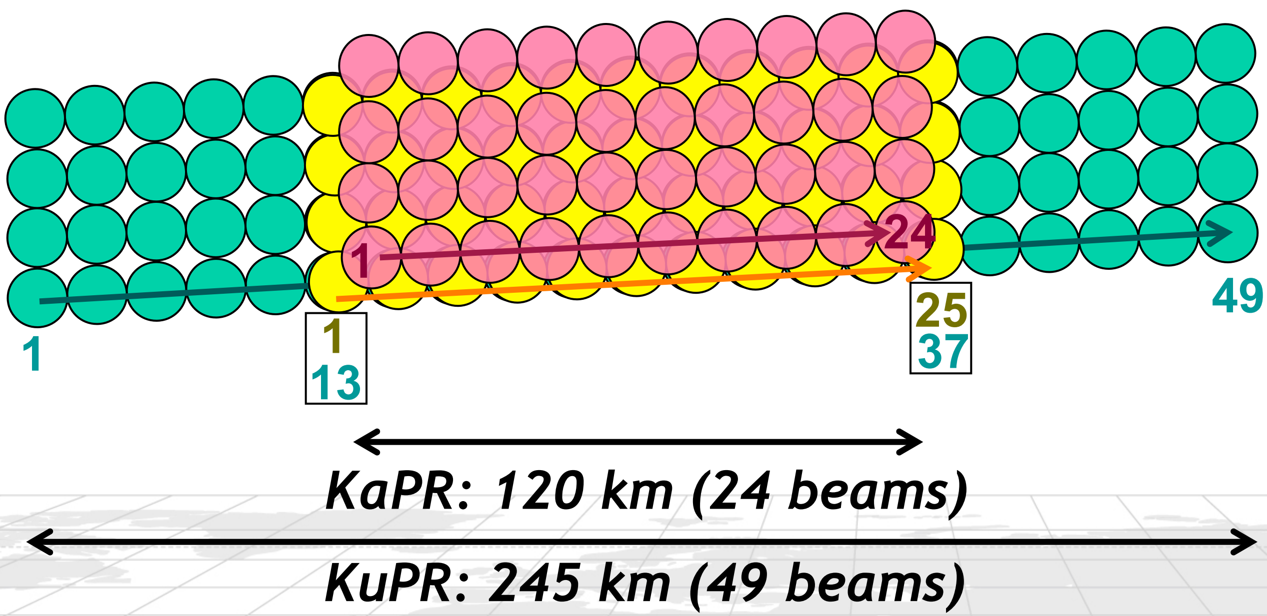


Roles of DPR

- *Accurate 3D measurements of precipitation as TRMM, but with better sensitivity*
- ***Improvement of estimation accuracy***
    - *Identification of hydrometer type, phase state*
- *Improvement of MWR algorithms*
    - *Simultaneous measurements with GMI*

Concept of the DPR antenna scan

- KuPR footprint : Δz = 250 m
- KaPR footprint (Matched-beam with KuPR) : Δz = 250 m
- KaPR footprint (High-sensitivity beam) : Δz = **500 m**



In the interlacing scan area (pink circle), the KaPR can measure snow and light rain in a high-sensitivity mode with a double pulse width.

The synchronized matched beam (yellow circle) is necessary for the dual-frequency algorithm.

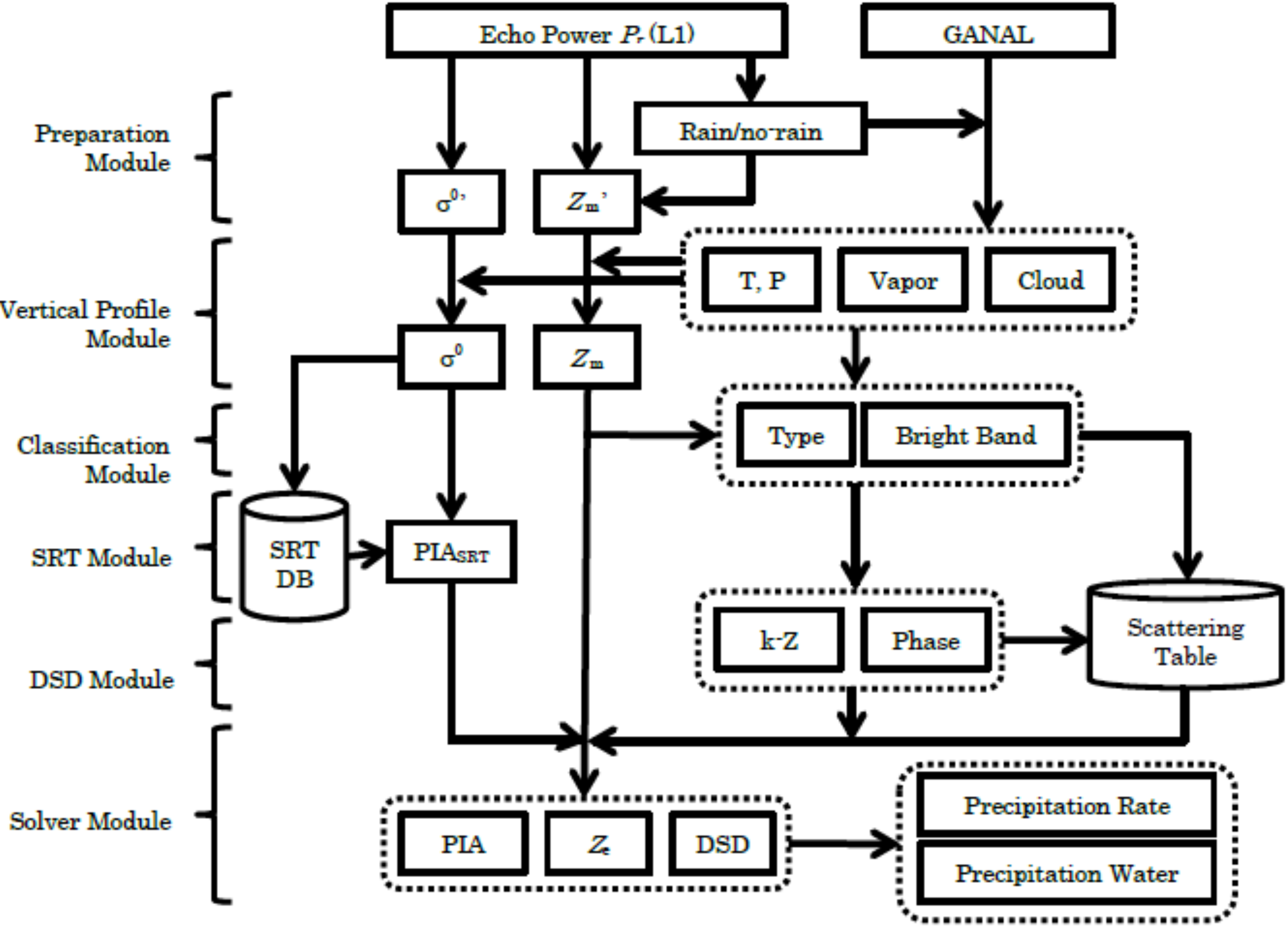


Figure 2. DPR algorithm flow.

Field experiments for the DPR algorithm development

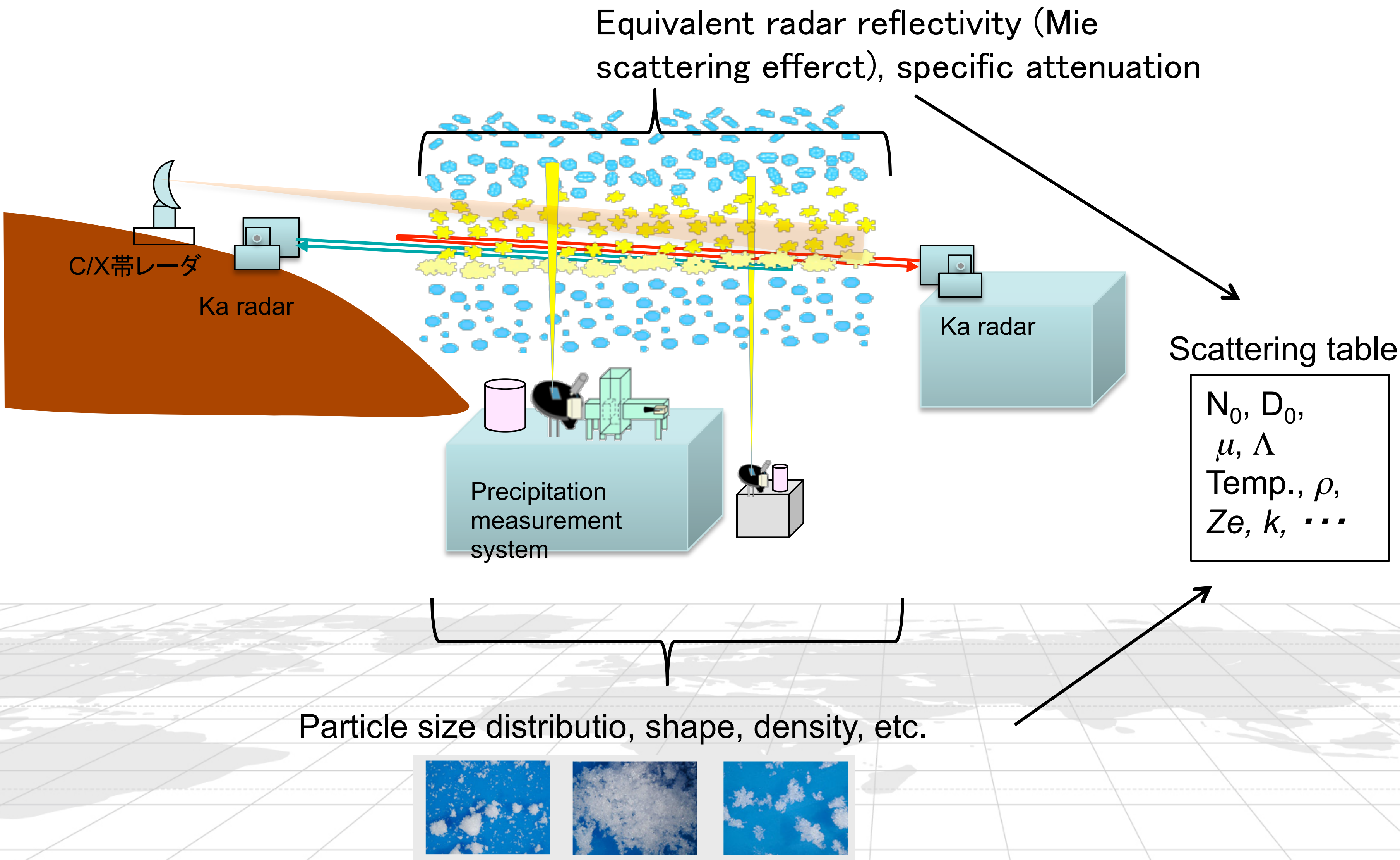
Kenji Nakamura, H. Minda
Nagoya Univ.
Y. Fujiyoshi
Hokkaido Univ.
K. Nakagawa, H. Hanado
National Institute of Communications Technology

In collaboration with

- *EORC/JAXA: Y. Kaneko, K. Komachi, K. Yamamoto, R. Oki*
- *RESTEC: Higashiuwatoko*
- *NIED: K. Iwanami, S.Nakai*

March 21, 2013

Dual Ka radar observation



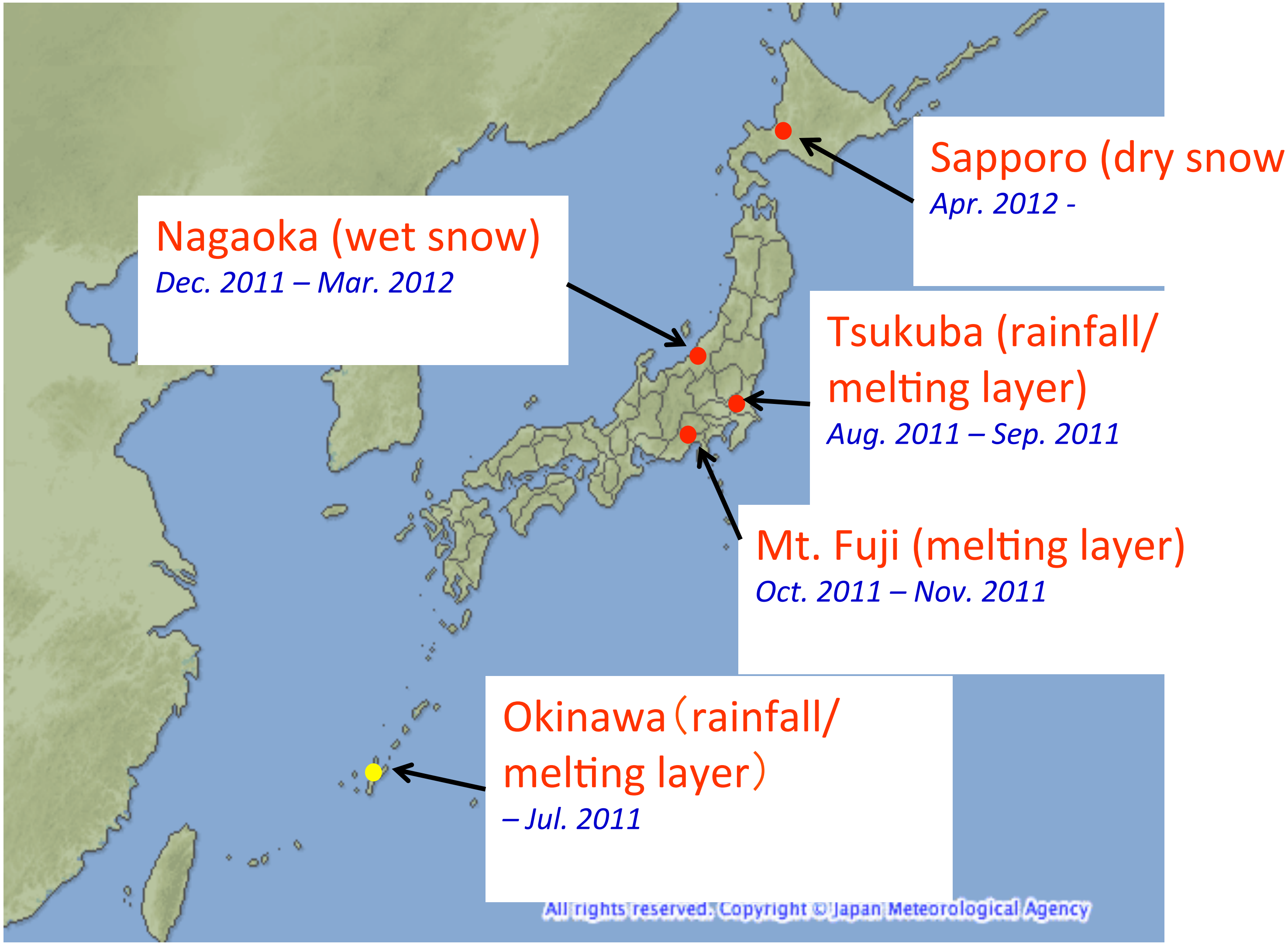
Expected results which could be incorporated in the DPR algorithm:

- k – Ze relationship(s)
- Total attenuation through melting layer

Algorithm evaluation dataset:

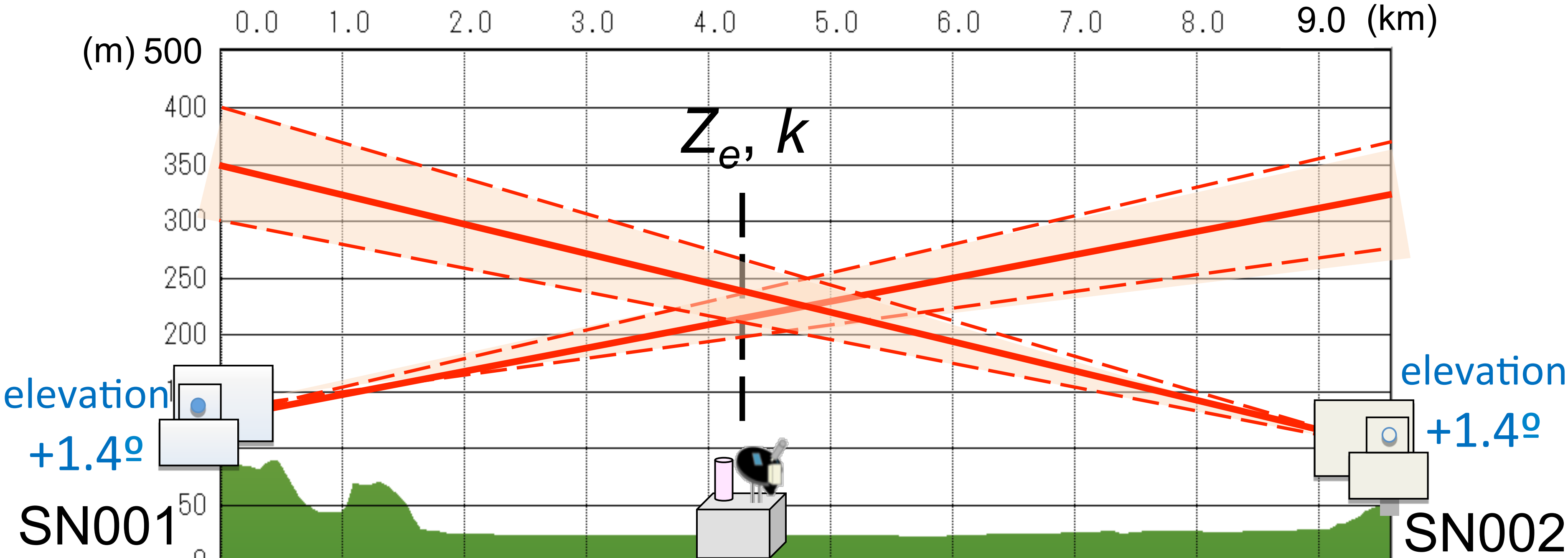
- (Ka - C) dataset: maybe obtained by Ka-COBRA data but limited.
- (Ka – X) dataset: hopefully obtained in Mt. Fuji experiment.

Japan’s ground validation plans



- Using the dual Ka-band radar system, we previously carried out a rainfall measurement in Okinawa Island, Japan.

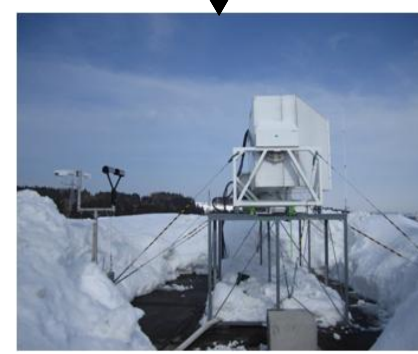
Dual Ka radar experiment in Nagaoka



Mobile precipitation observation system (MOS)

・melted fraction meter

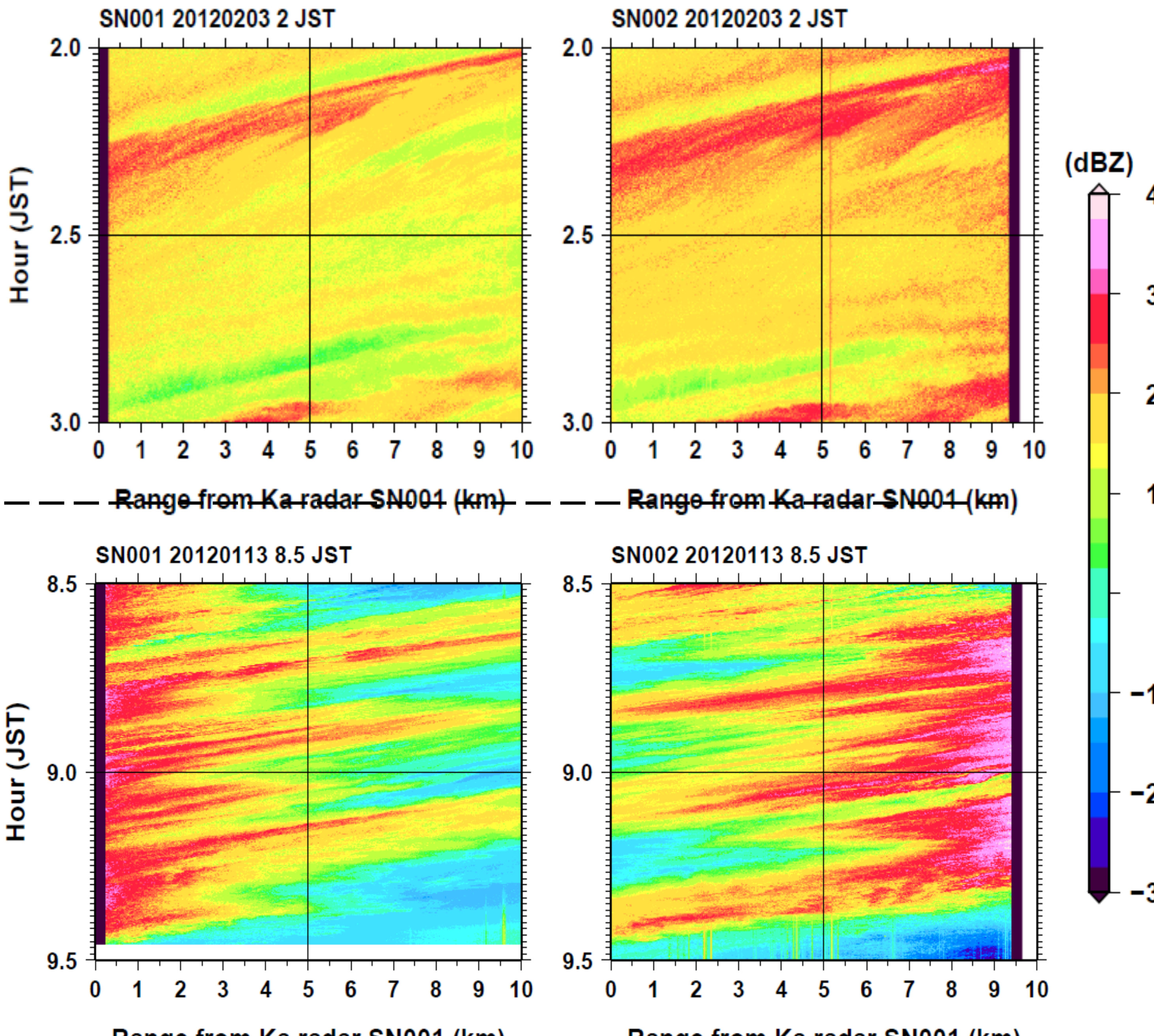
・parsivel
・Humidity and Temperature Probe (HMP155)
・2DVD



Time-range section of Z_m -snow events-

- 2012/02/03
  2:00～3:00

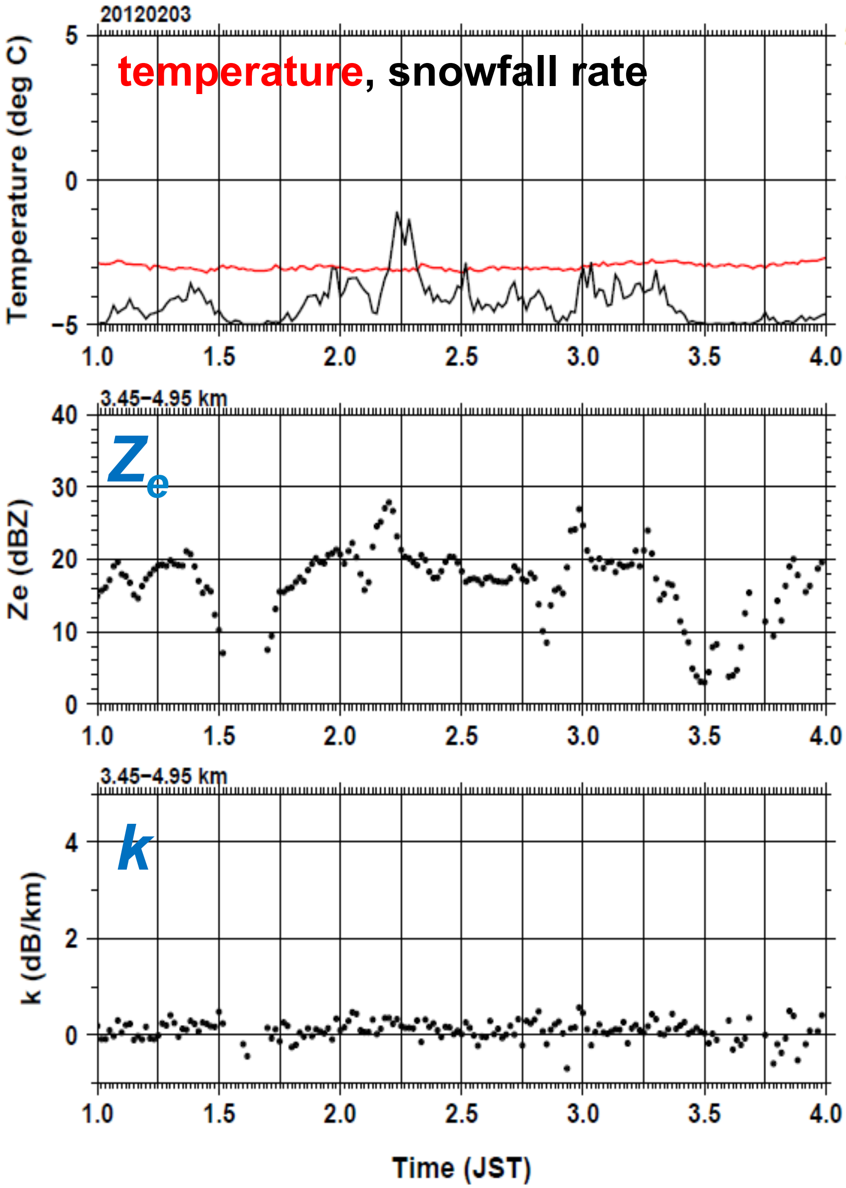
- 2012/01/13
  8:30～9:30



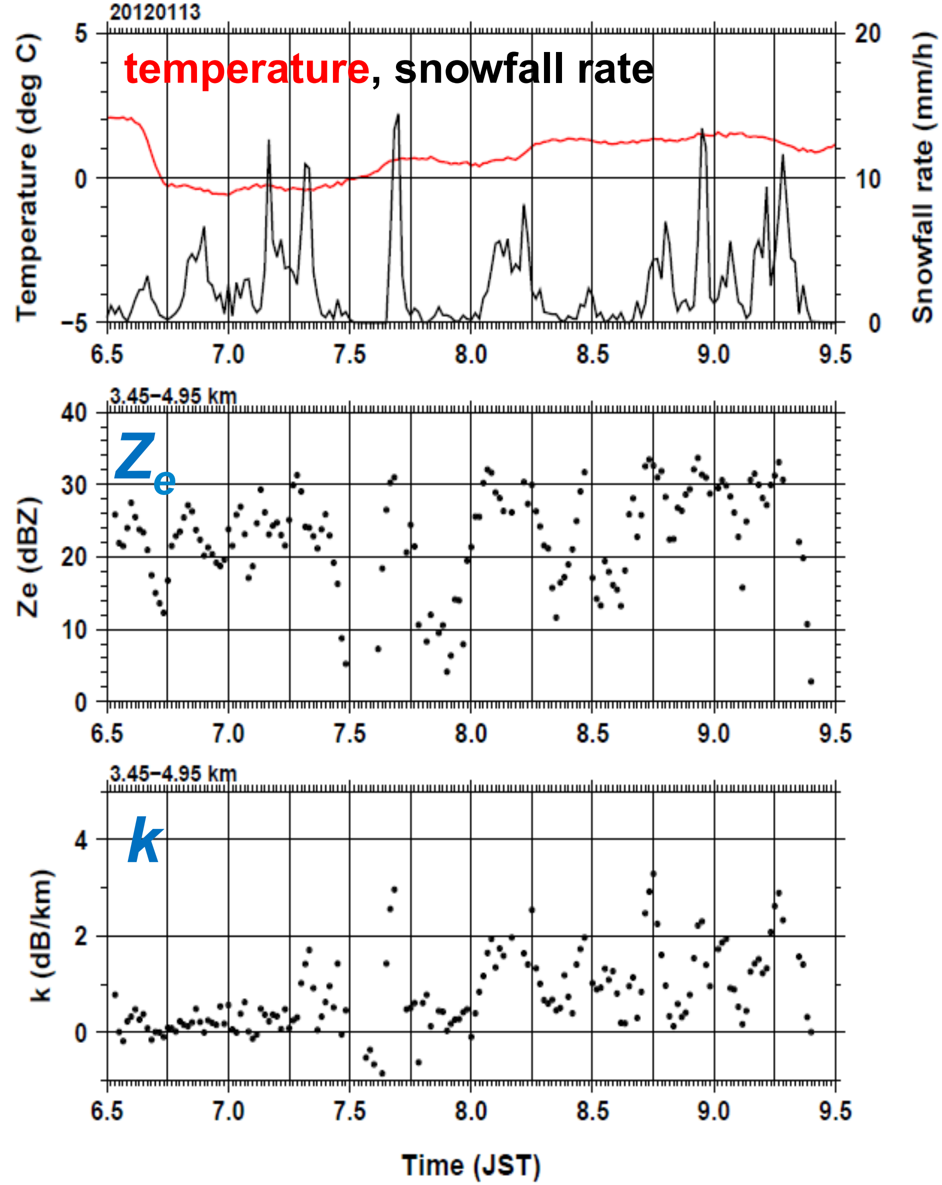
[range resolution: 12.5 m
temporal resolution: 10 s

Time series of surface temperature and snowfall rate, Z_e, and k

- 2012/02/03 1:00～4:00



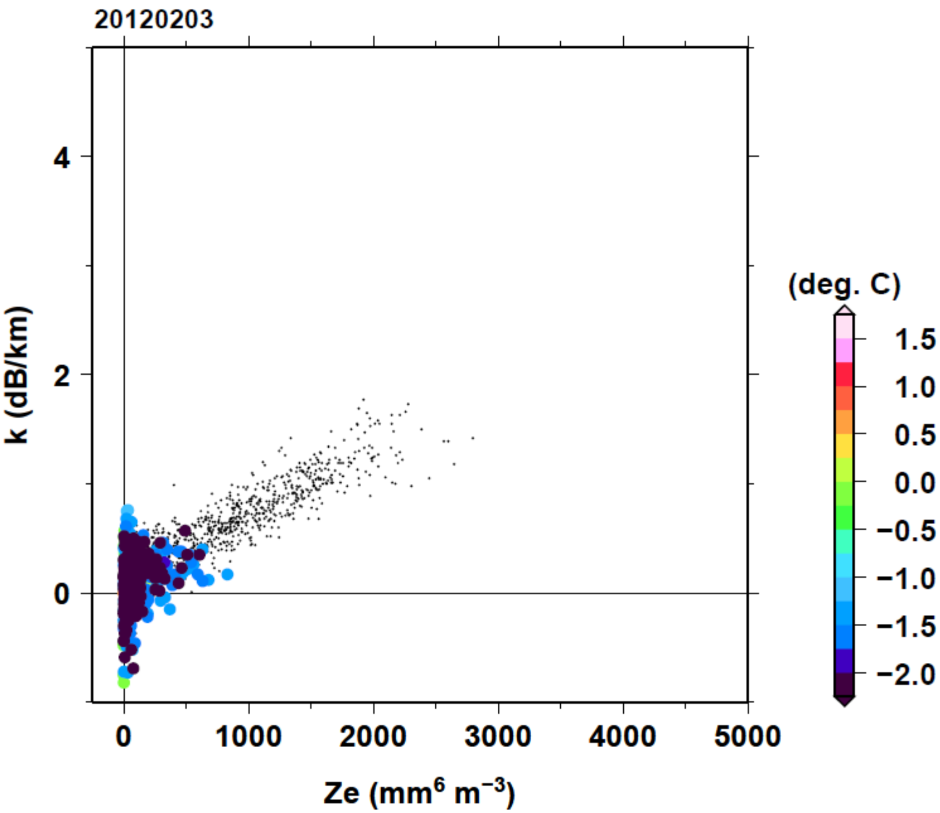
- 2012/01/13 6:30～9:30

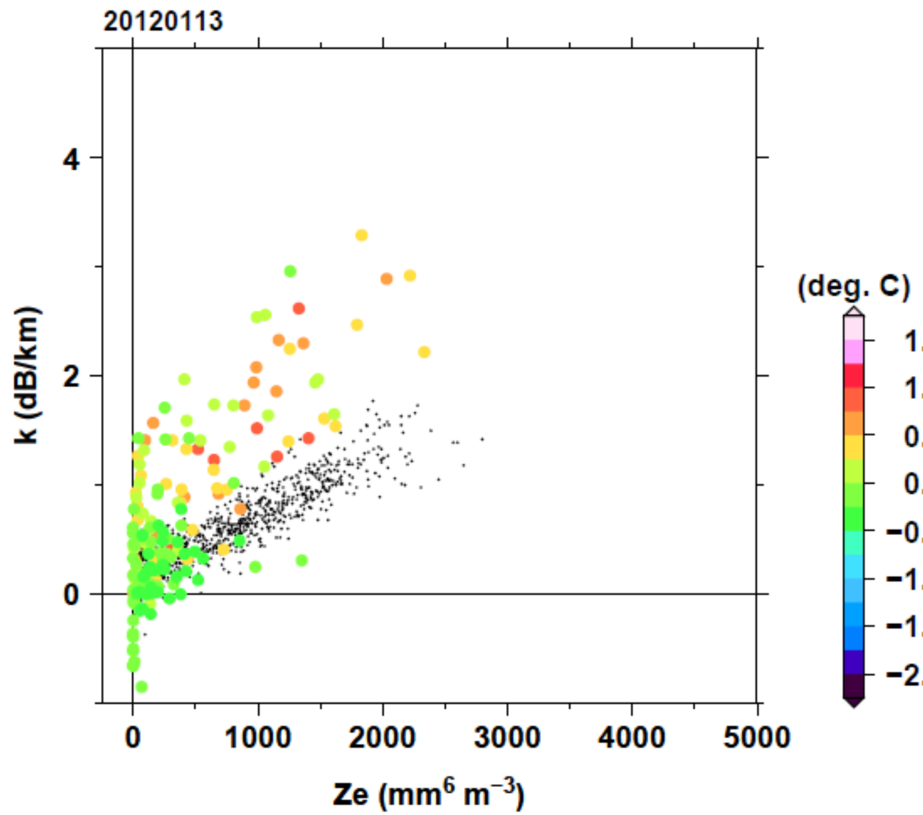


k-Z_e plots of snow and rain events*

- • : *k*-Z_e plots of rain events (2012/02/06-07)

(blue circle) : 2012/02/03 0-4, 7-14 JST (green circle) : 2012/01/13 0-9, 11-13 JST





**k*-Z_e plots of snow events are plotted for different surface temperature.

Showing wet/dry dependency of snow for k-Ze relationship

Dual Ka radar observation: Summary

k-Z_e relations of snow were measured from the dual Ka radar measurements.

Different k-Z_e relations of snow appeared depending on wet and dry snow events.

The feasibility to estimate total attenuation in melting layer from a vertical-slant direction observation was studied.

(Ongoing work)

We are conducting dry snow measurements in this winter.

SN002 (Mt. Okura, Sapporo)
2013/01/21

Ground Validation of Physical Parameters of Dry/Wet Snow Particles Based on Sophisticated Measuring System & Data Analysis Techniques

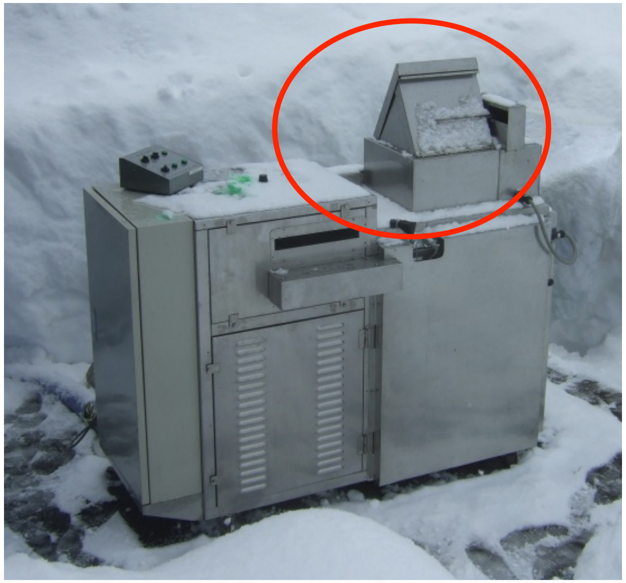
Y. Fujiyoshi

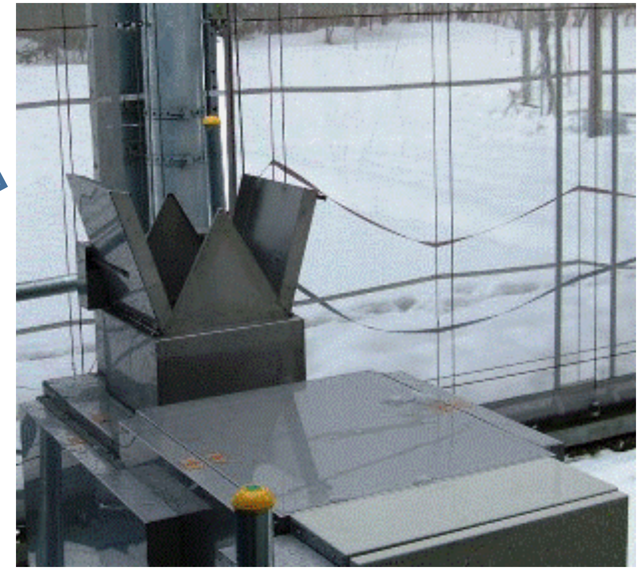
Inst. Low Temp. Sci., Hokkaido Univ.

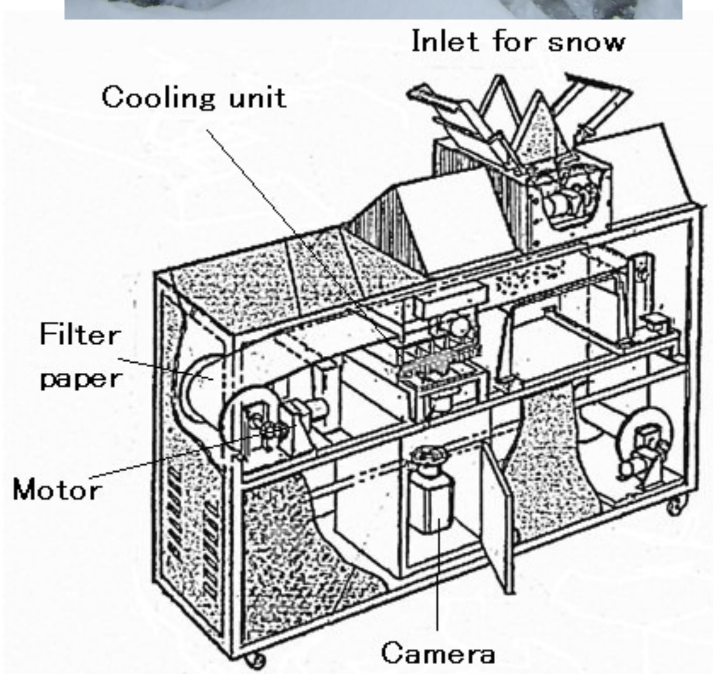
K. Muramoto, M. Kubo

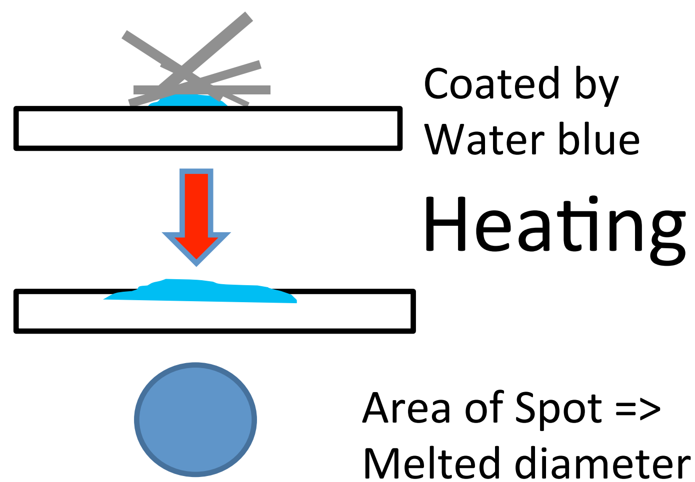
School of Electrical and Computer Engineering, Kanazawa Univ.

Measurement of Melted Fraction



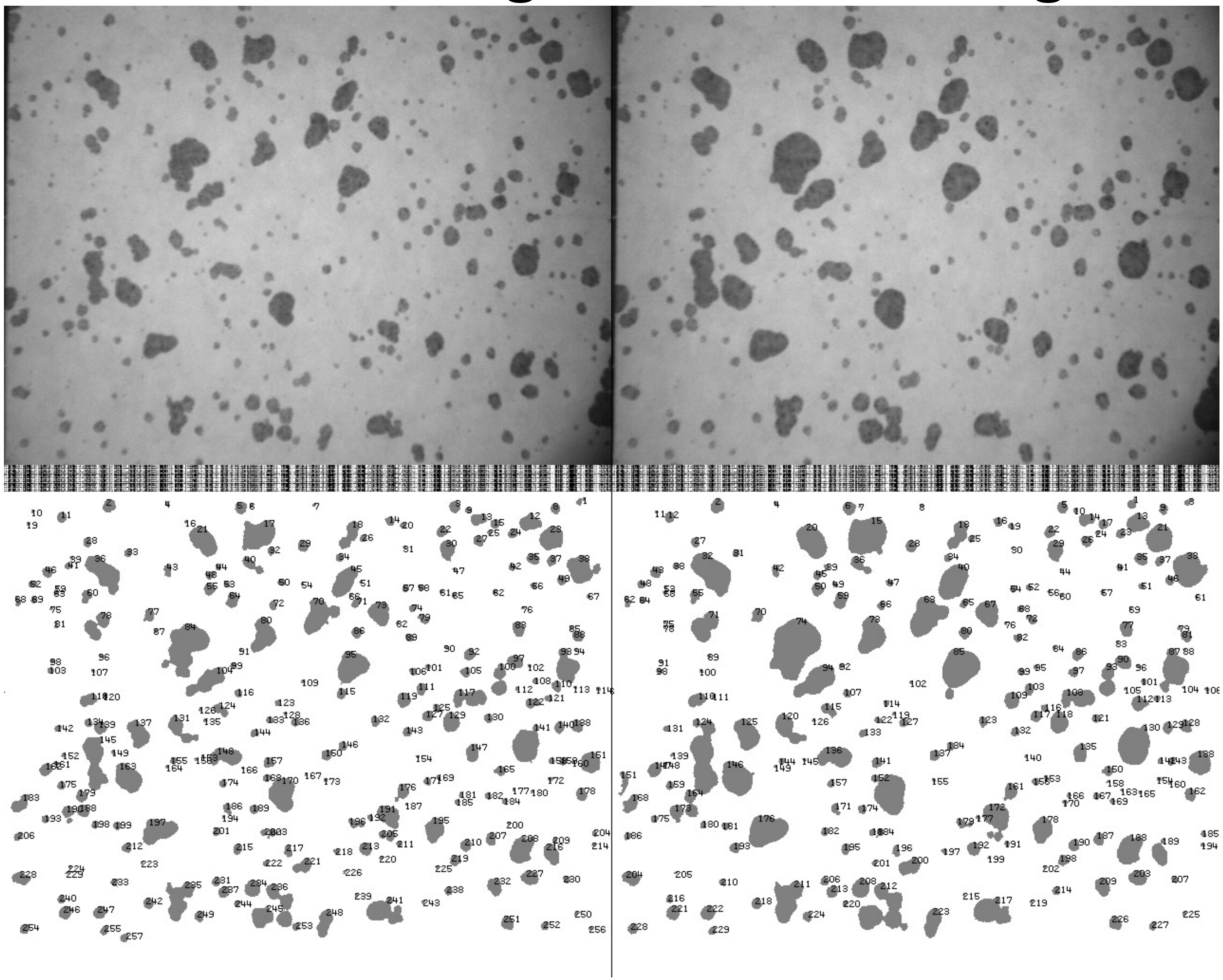






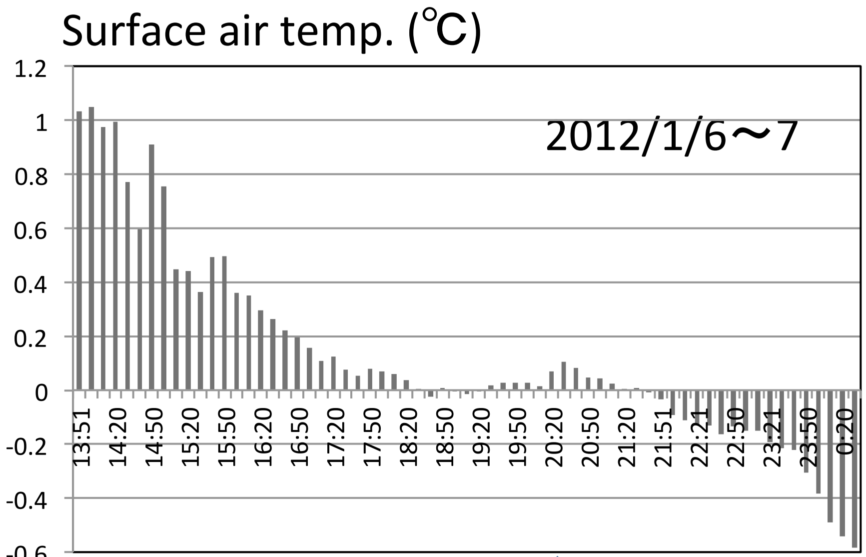
Sasyo et al. J. Met. Soc. Japan(1991)

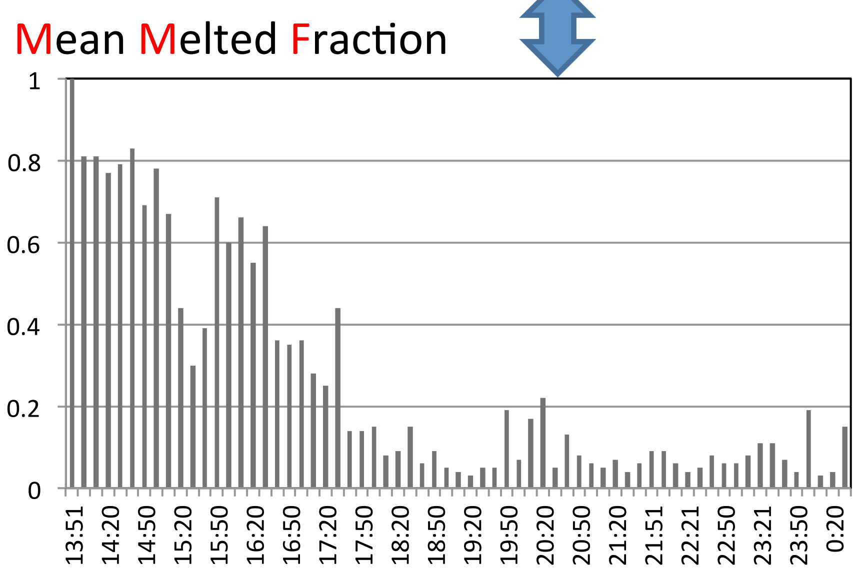
Before Heating After Heating

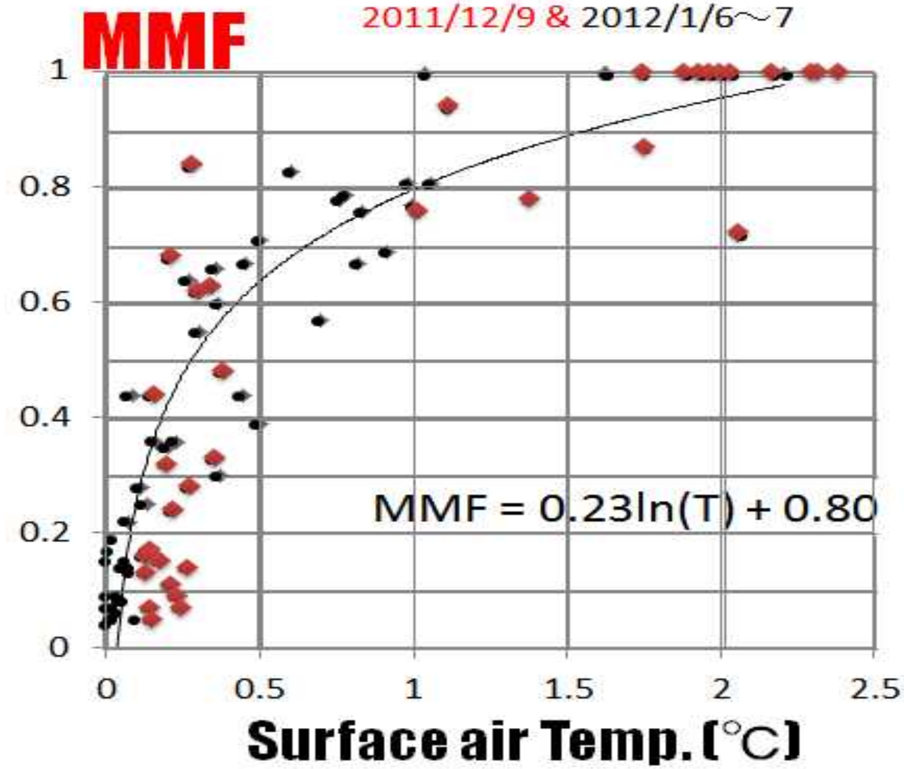


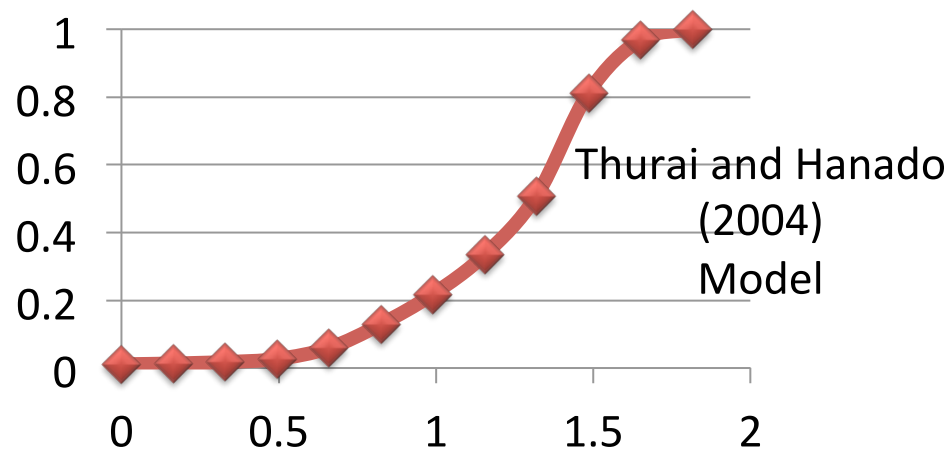
Mean Melted Fraction $(\Sigma S_{before} / \Sigma S_{after})$

Temperature dependency of Mean Melted Fraction









NIED, Nagaoka

Summary

I. Wet Snow (Melted Fraction)

Temperature & Size dependency

II. Graupel

Size dependency of fall velocity

Size Distribution

III. Snowflake/Graupel Classification

Comparison with Ka-band radar

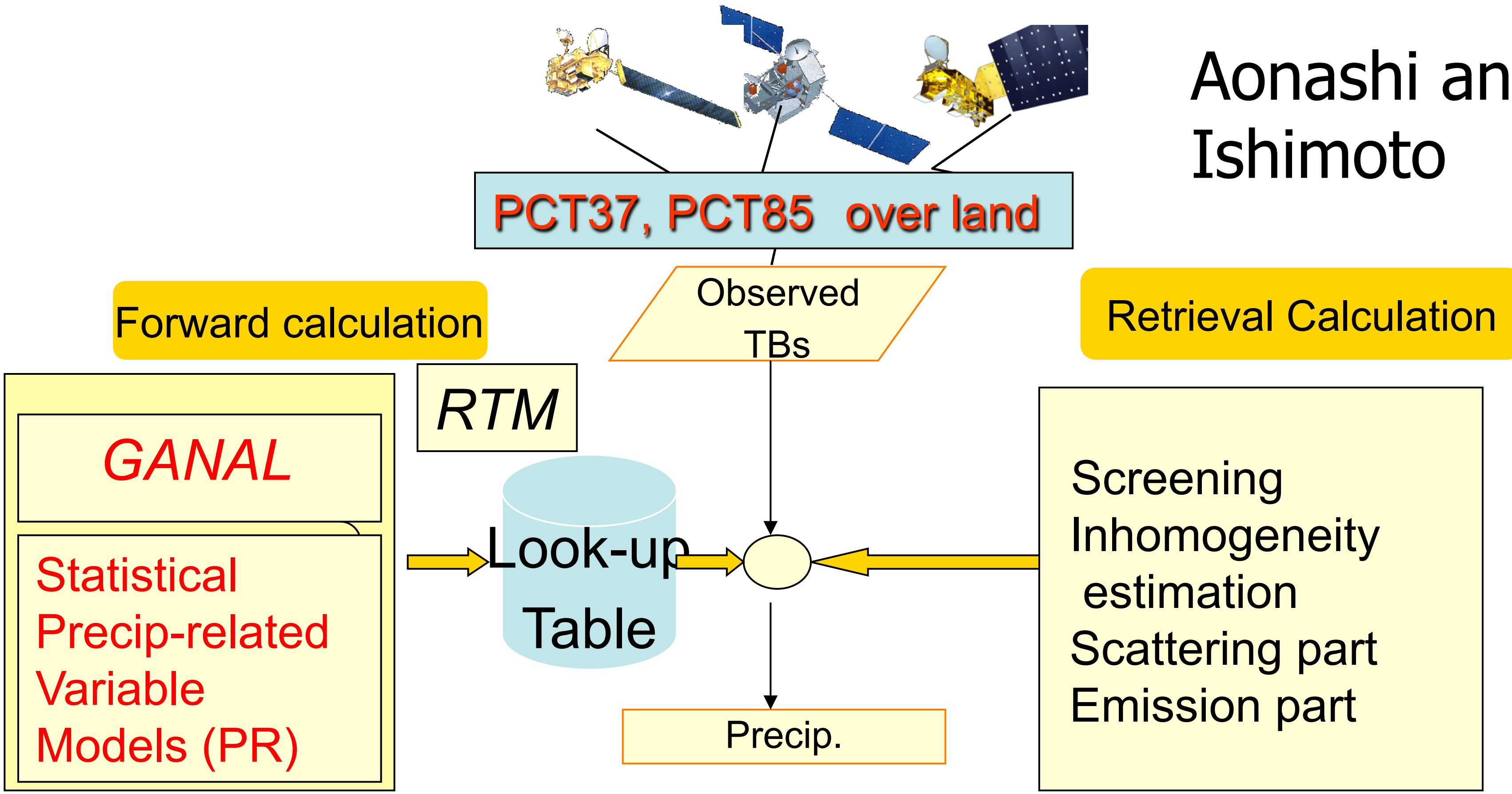
Ongoing works

- MF and MMF dependency of Shape (e.g., fractal dimension) Size distribution & Fall velocity
- Make realistic microphysical and scattering models of melting particles to satisfy numerical modelers, cloud physicists and radar meteorologists.

STUDIES FOR IMPROVEMENTS OF MW ESTIMATES

Basic Idea of the Retrieval Algorithm

Aonashi and Ishimoto

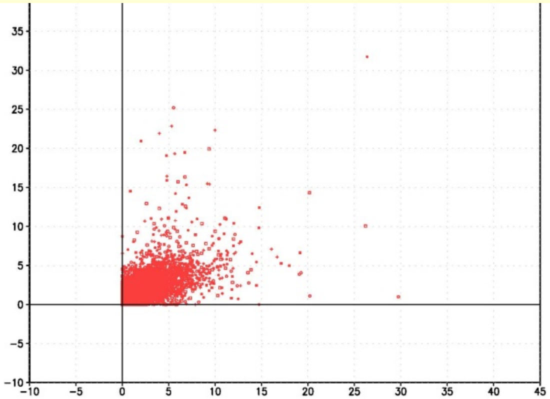


Find the optimal precipitation that gives RTM-calculated TBs fitting best with the observed TBs:

Comparison of over-land retrievals
Rainsurf vs.Rainspc over Land (Jul. ‘04)

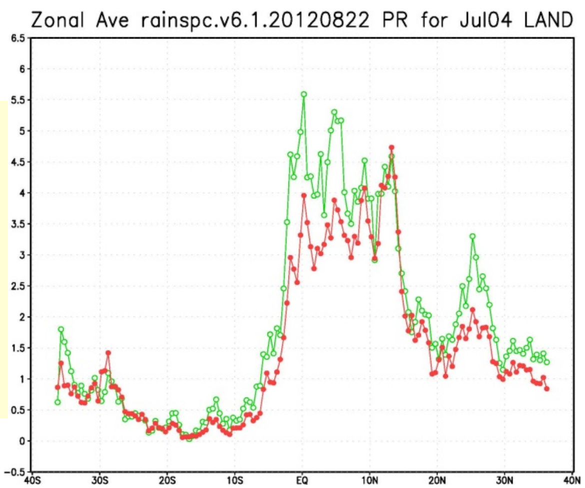
Conventional Algorithm

Rainspc (mm/hr)



PR Rainsurf (mm/hr)

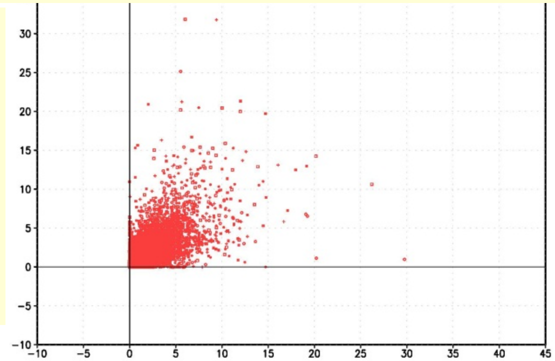
Rainspc (mm/hr)



LAT

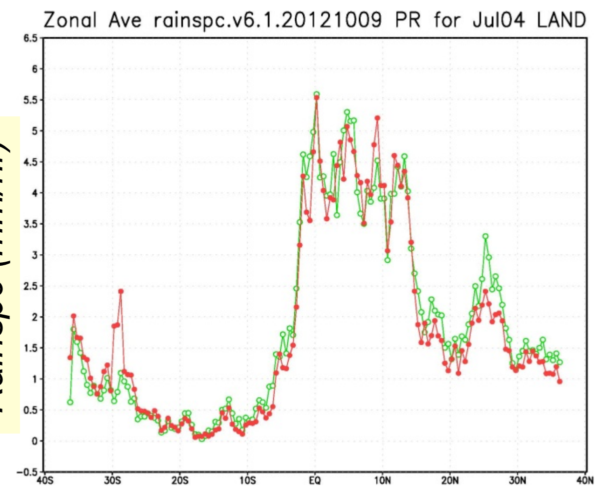
New Algorithm
(additional statistical correction)

Rainspc (mm/hr)



PR Rainsurf (mm/hr)

Rainspc (mm/hr)



LAT

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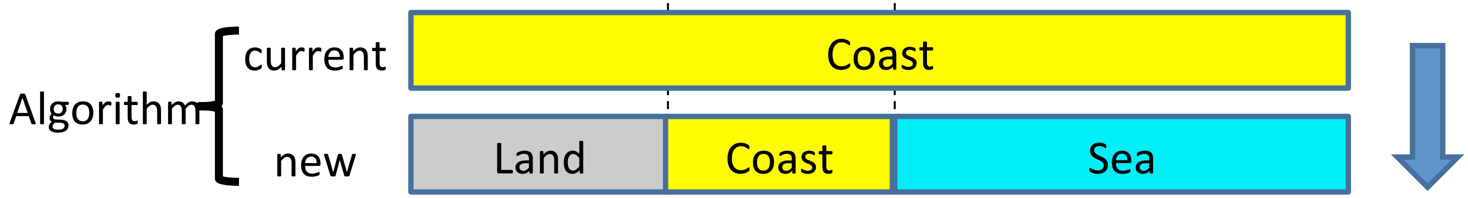
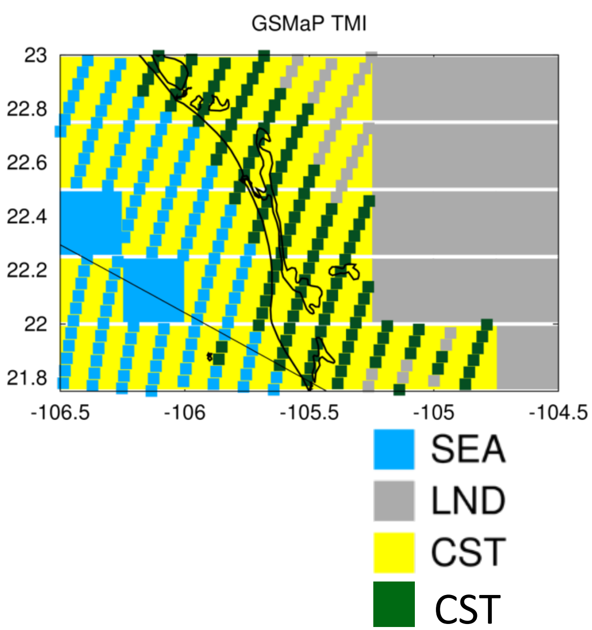
Improvements in Rain/No-rain Classification over coast, using Dynamic LO Flag : Mega and Shige

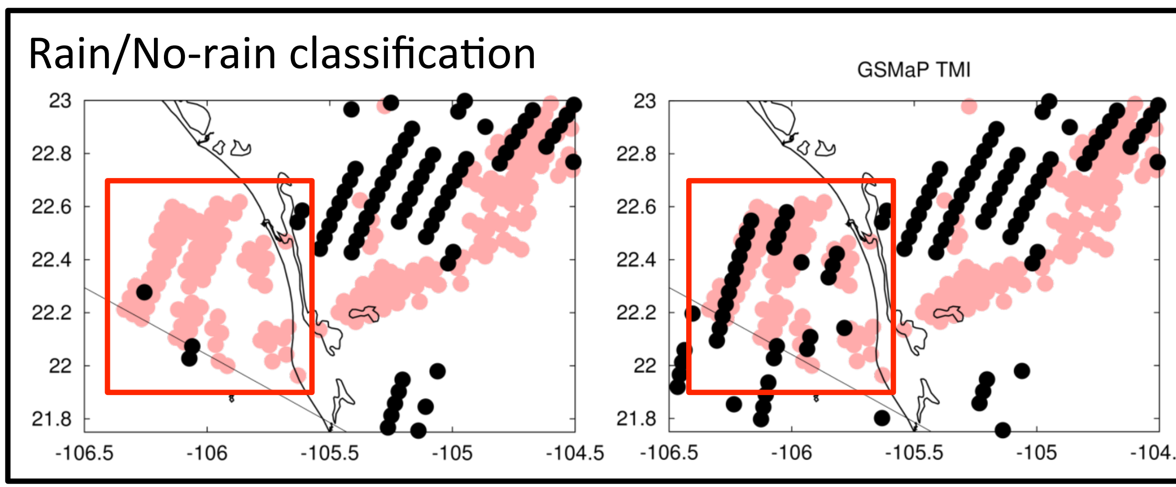
Rain/No-rain classification



If surface in 21GHz footprint is land, classification use Land algorithm.

If surface in 37GHz footprint is sea, classification use Sea algorithm.





●GSMaP rain
●PR rain certain

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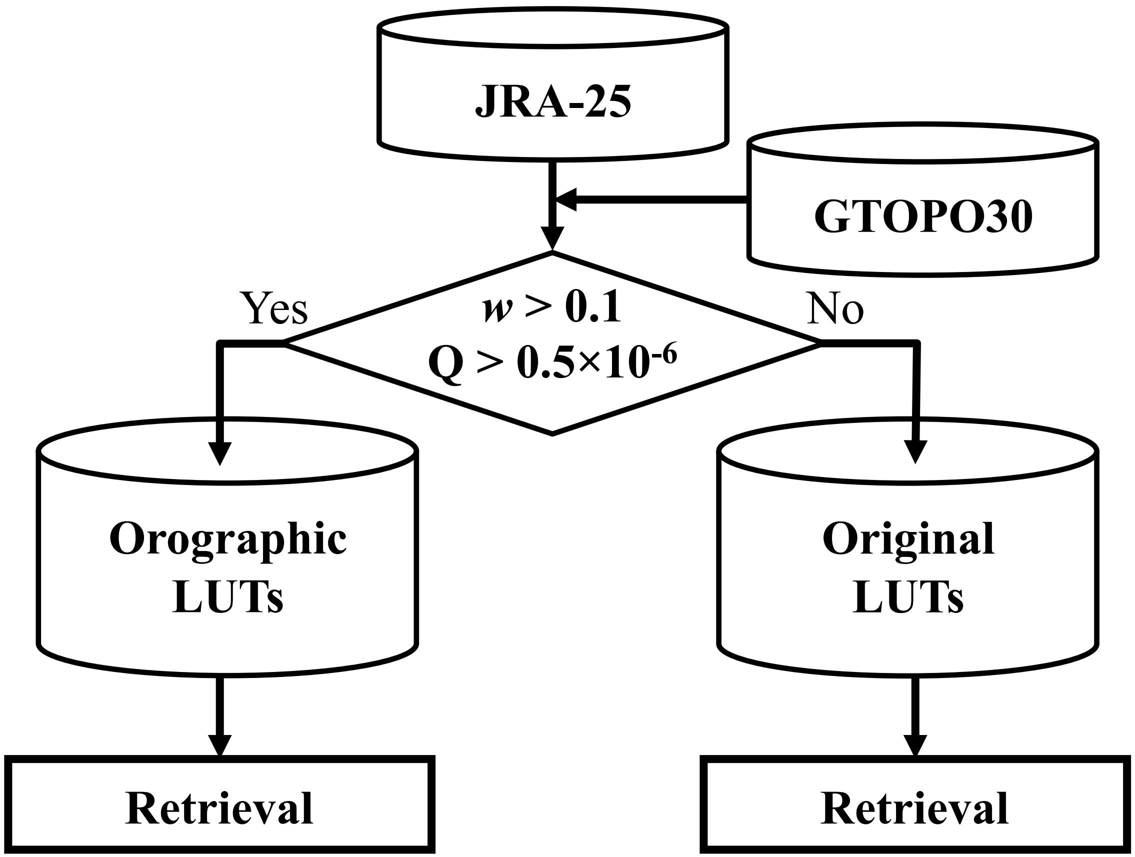
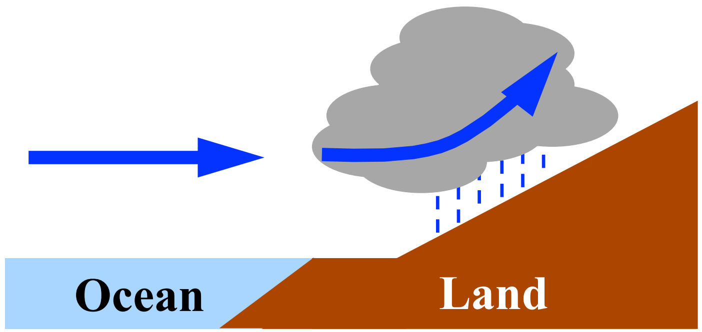
Orographic/Non-Orographic Rainfall Classification Scheme

PI: Shoichi Shige





Orographically Forced Upward Motion

$$w = \frac{Dh}{Dt} = u\frac{\partial h}{\partial x} + v\frac{\partial h}{\partial y}$$

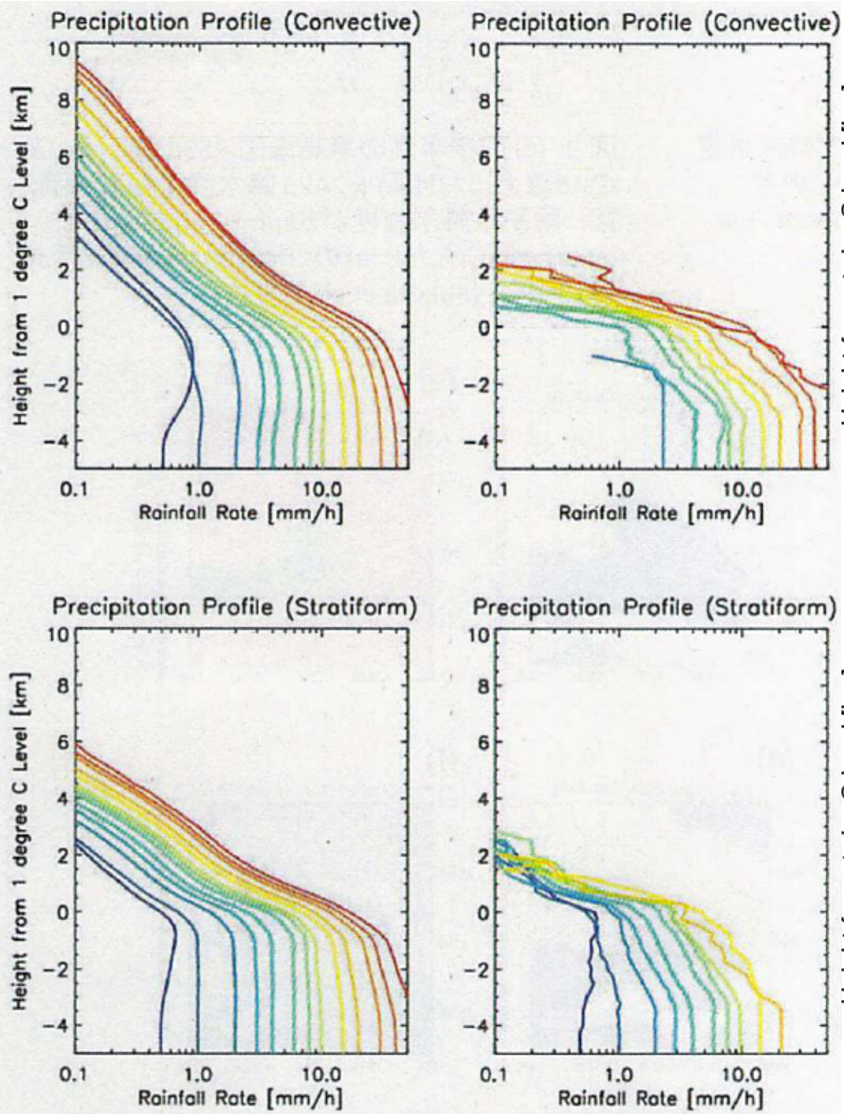
Convergence of Surface Moisture Flux

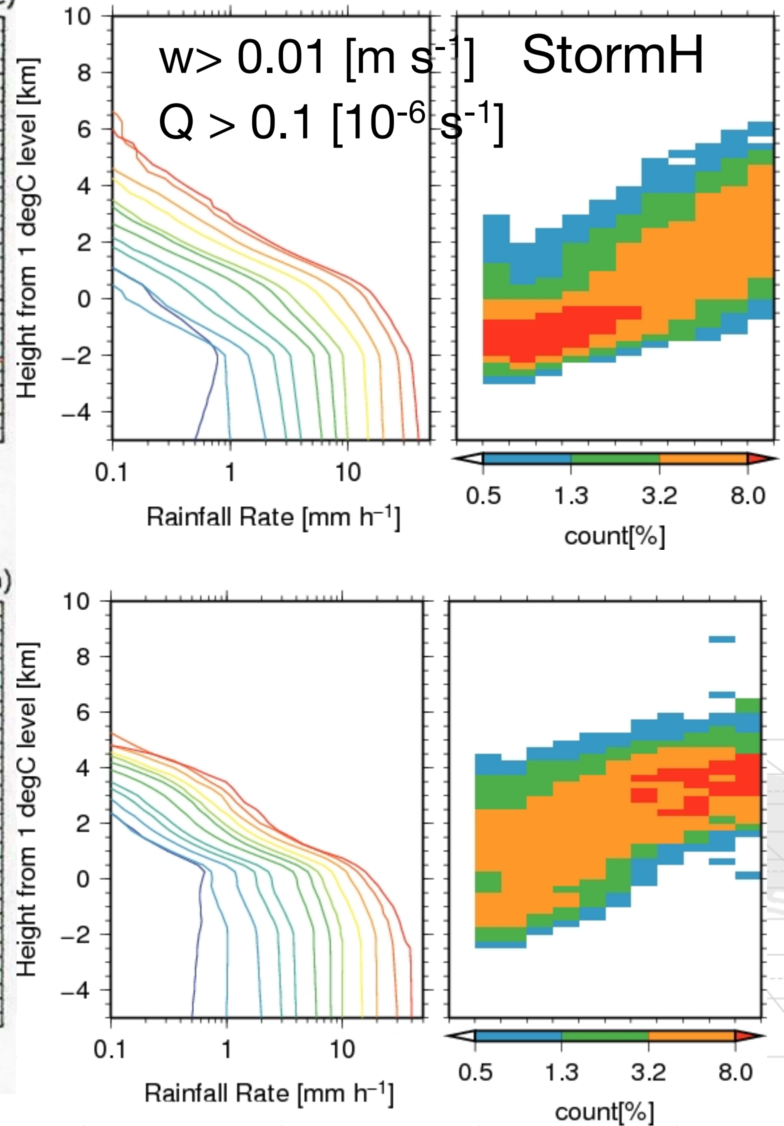
$$Q = -\left(\frac{\partial(uq)}{\partial x} + \frac{\partial(vq)}{\partial y}\right)$$

Vertical rain profile for orographic rain

Original　　A case of Kii Pen.　　Western coast of Indian sub-continent

x-axis: 0, 0.5, 1, 2, 3, 4, 6, 8, 10, 15, 20, 30, 40, 60, 80, 120, 160, 200, 400, 800 mm h^{-1} from left



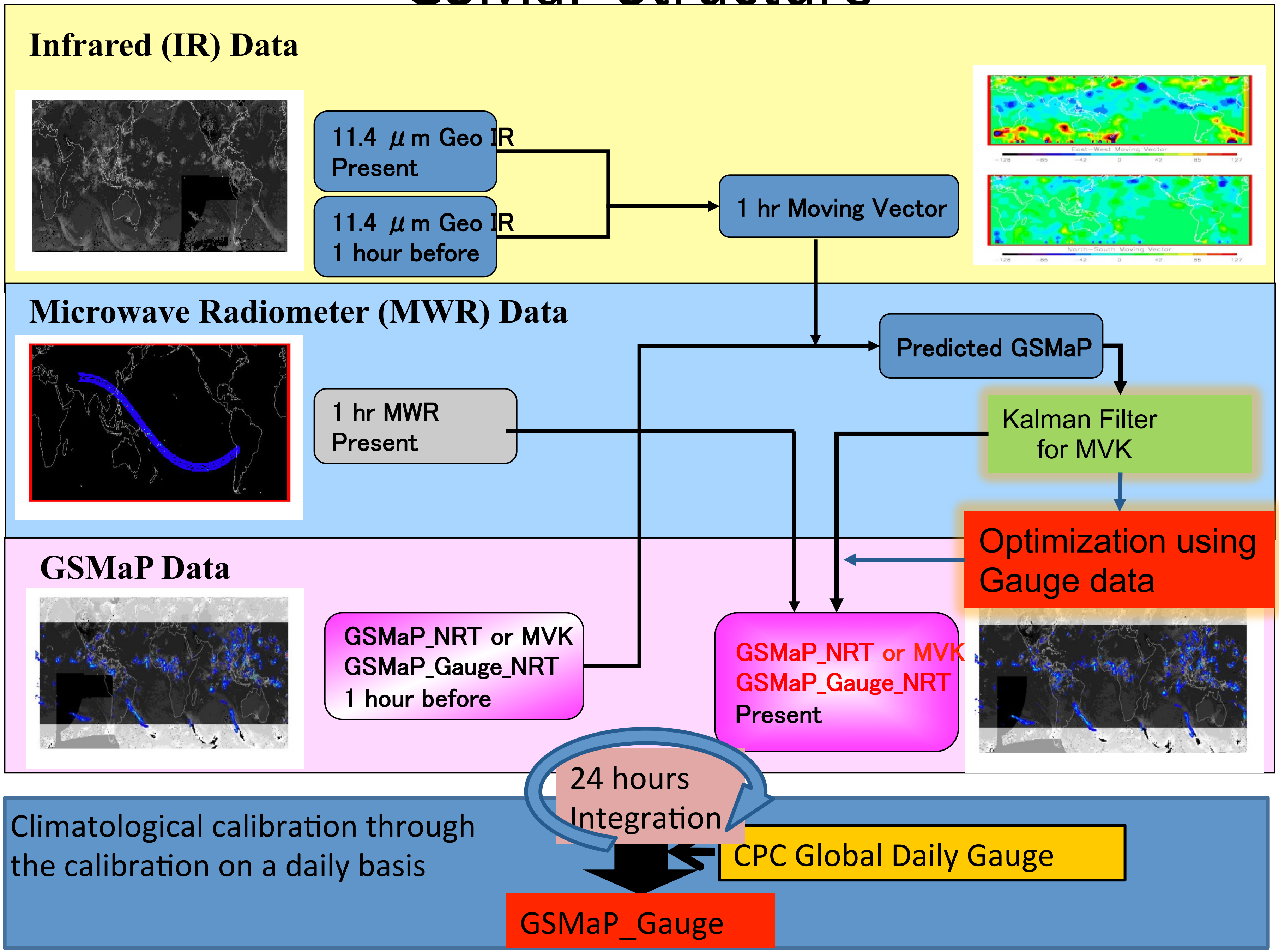


2

GSMAP EVOLUTION

T. USHIO

GSMaP Structure



Summary of the GSMaP products

- GSMaP_MVK
  - Global precipitation mapping from microwave and infrared radiometric data
- GSMaP_Gauge
  - Gauge adjusted GSMaP_MVK
- GSMaP_NRT
  - Near real time version of the GSMaP_MVK product
  - Lower precision compared to the GSMaP_MVK
- GSMaP_Gauge_NRT
  - Near real time product of GSMaP_Gauge

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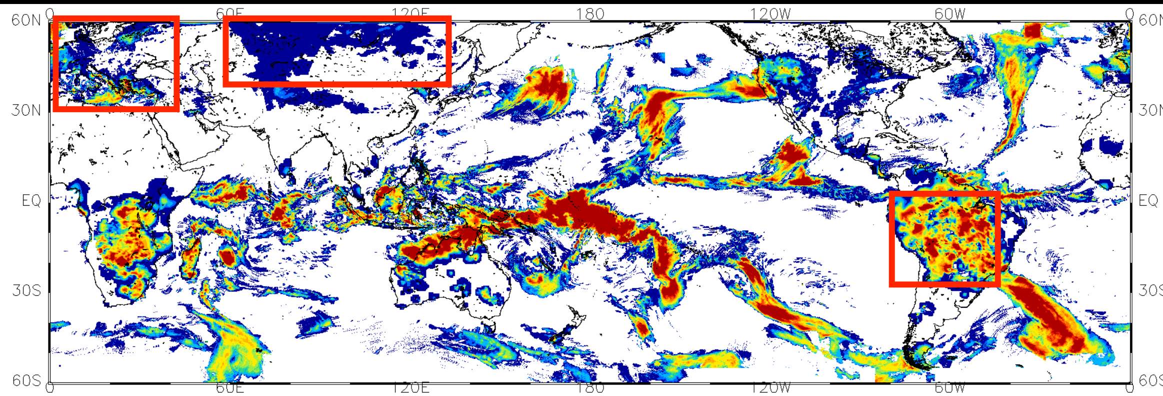
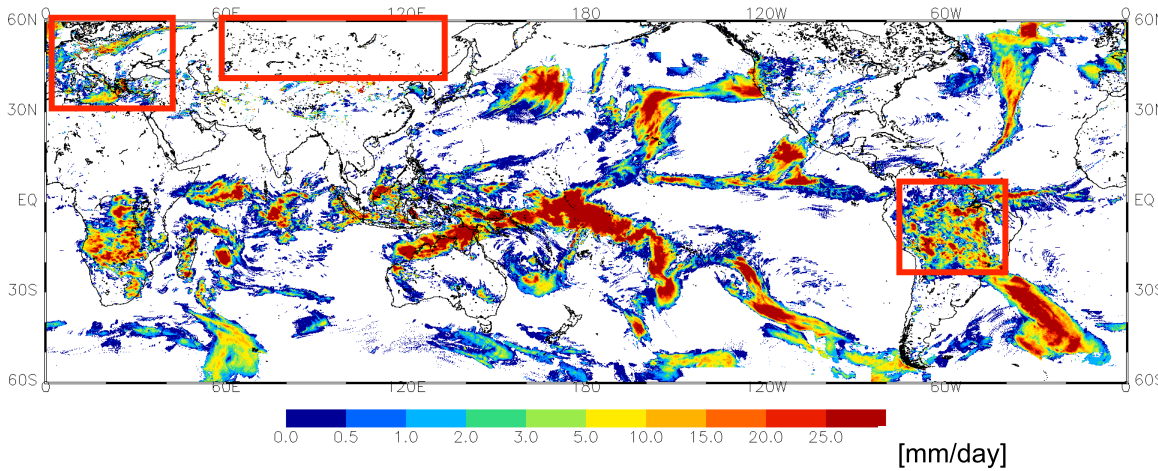
Comparison of the GSMaP_Gauge with GSMaP_MVK and CPC Gauge data

2004/01/01

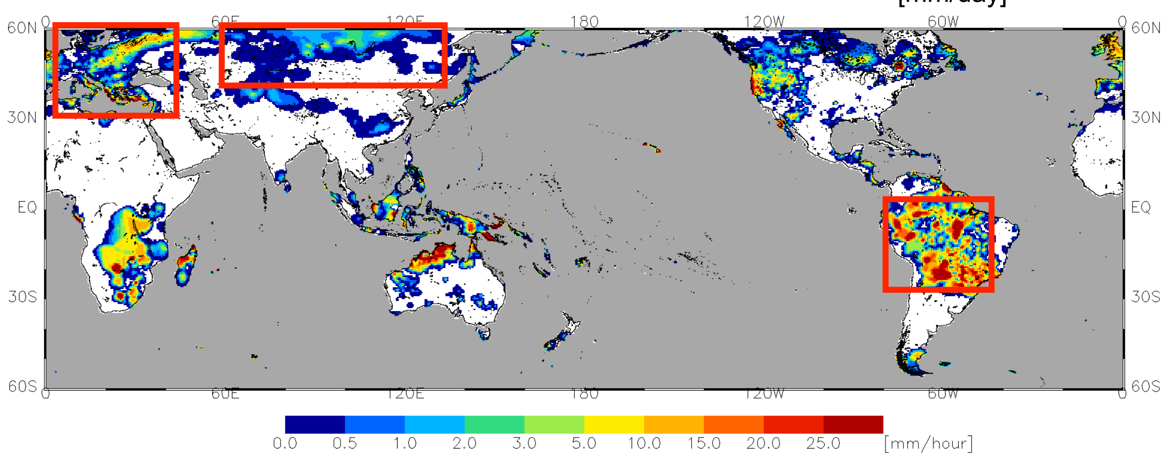
GSMaP_Gauge



GSMaP_MVK

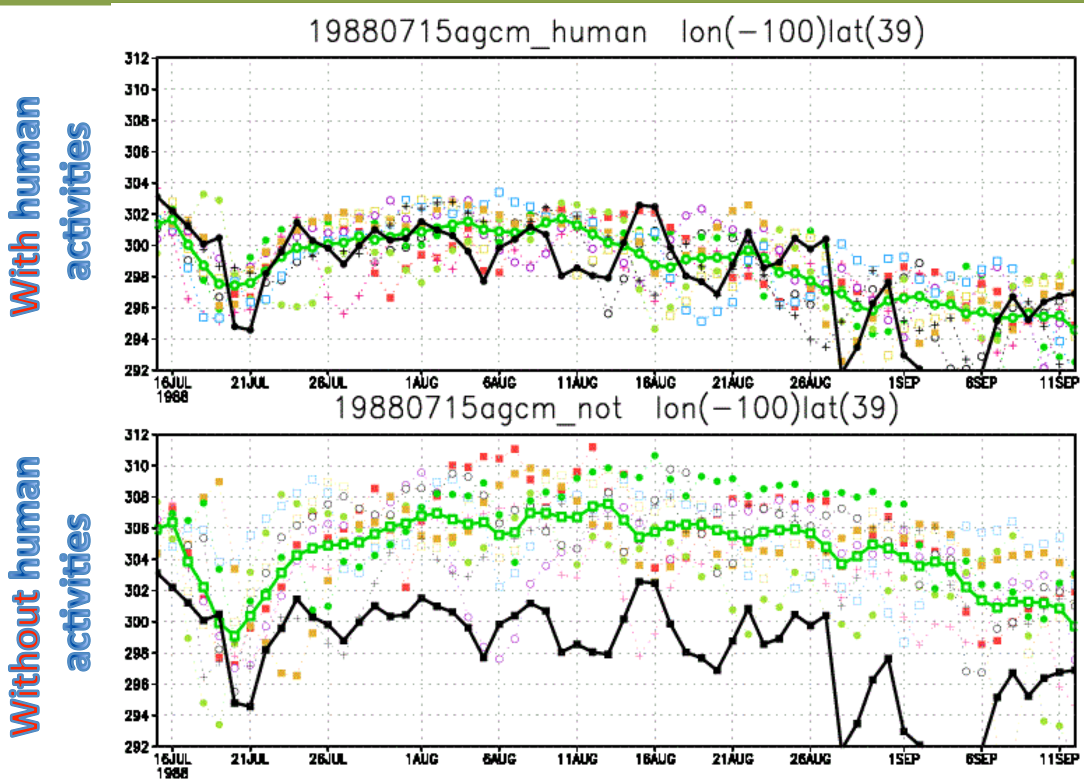


CPC Gauge



FUTURE APPLICATION OF GPM

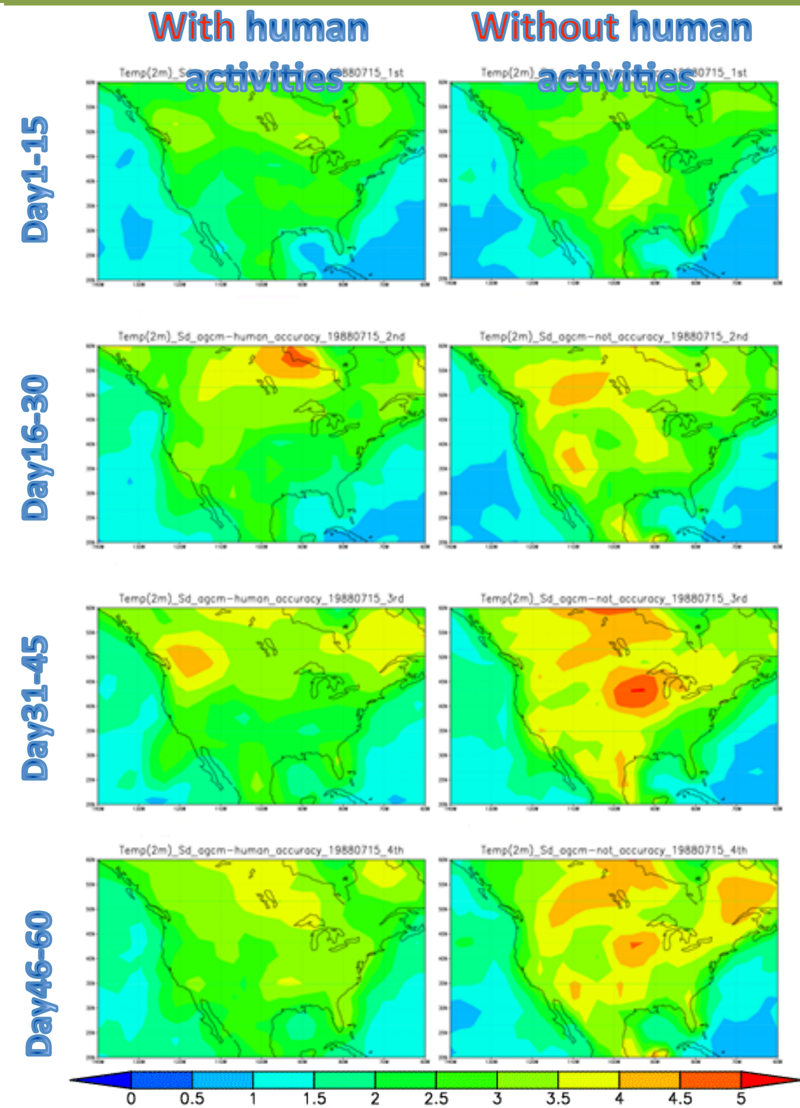
Simulation of human activity impacts of water cycle on climate with MIROC-ESM PI: Tomo Yamada



T2m forecast results (colors, **green: ensemble mean** and **observation: black**)

GPM is expected to be utilized for accurate estimation of human activities in water cycles (irrigation, groundwater pumping , etc.)

Yamada et al. (to be submitted)



Spread among 10 ensemble members for T2m.
Spread is decreased with human activities.

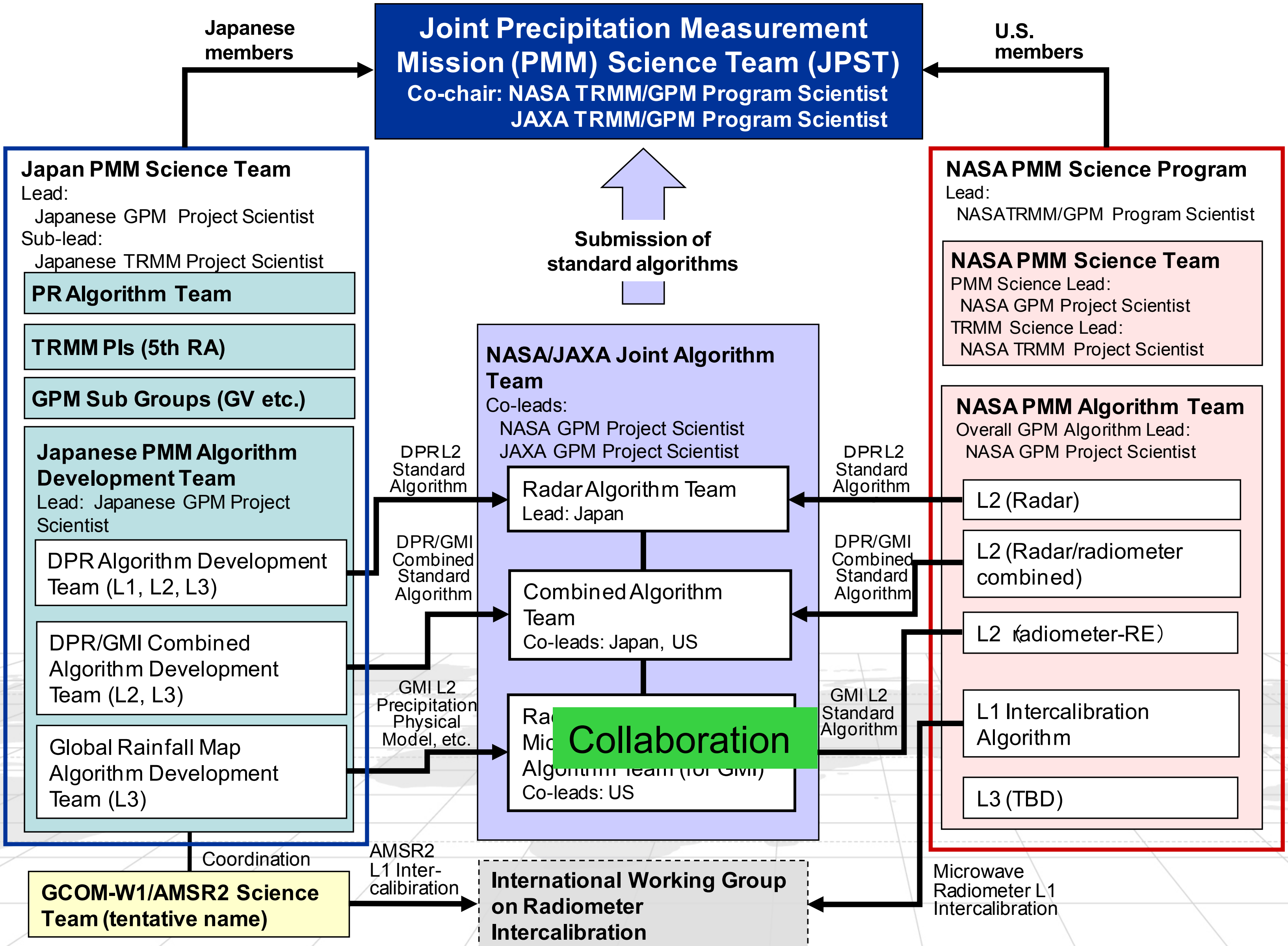
Thank you for your attention

Main Characteristics of DPR

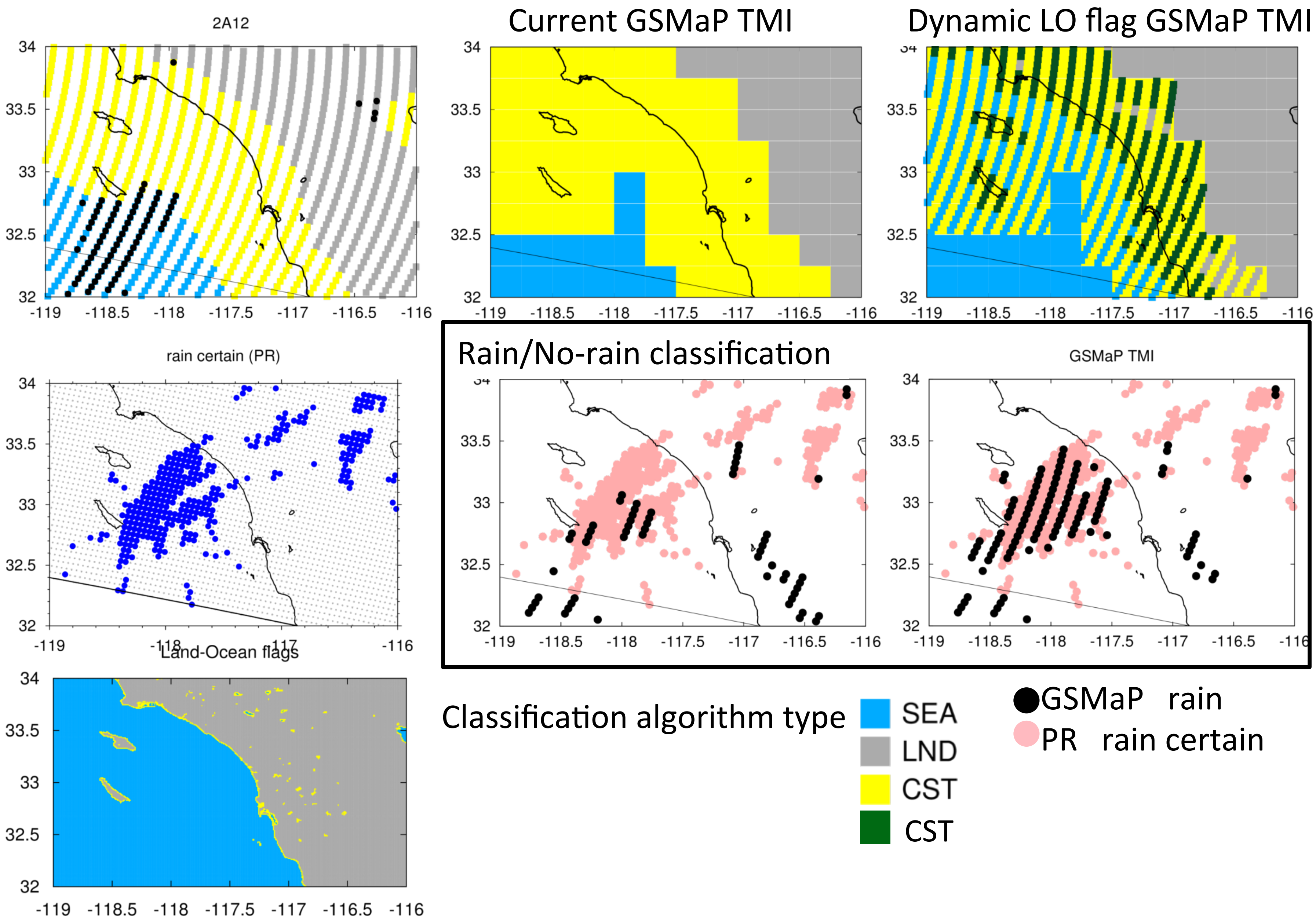
Item	KuPR	KaPR	TRMM PR
Antenna Type	Active Phased Array (128)	Active Phased Array (128)	Active Phased Array (128)
Frequency	13.597 & 13.603 GHz	35.547 & 35.553 GHz	13.796 & 13.802 GHz
Swath Width	245 km	120 km	215 km
Horizontal Reso	5 km (at nadir)	5 km (at nadir)	4.3 km (at nadir)
Tx Pulse Width	1.6 μs (x2)	1.6/3.2 μs (x2)	1.6 μs (x2)
Range Reso	250 m (1.67 μs)	250 m/500 m (1.67/3.34 μs)	250m
Observation Range	18 km to -5 km (mirror image around nadir)	18 km to -3 km (mirror image around nadir)	15km to -5km (mirror image at nadir)
PRF	VPRF (4206 Hz±170 Hz)	VPRF (4275 Hz±100 Hz)	Fixed PRF (2776Hz)
Sampling Num	104～112	108～112	64
Tx Peak Power	> 1013 W	> 146 W	> 500 W
Min Detect Ze (Rainfall Rate)	< 18 dBZ (< 0.5 mm/hr)	< 12 dBZ (500m res) (< 0.2 mm/hr)	< 18 dBZ (< 0.7 mm/hr)
Measure Accuracy	within ±1 dB	within ±1 dB	within ±1 dB
Data Rate	< 112 Kbps	< 78 Kbps	< 93.5 Kbps
Mass	< 365 kg	< 300 kg	< 465 kg
Power Consumption	< 383 W	< 297 W	< 250 W
Size	2.4×2.4×0.6 m	1.44 ×1.07×0.7 m	2.2×2.2×0.6 m

* Minimum detectable rainfall rate is defined by $Ze=200 R^{1.6}$ (TRMM/PR: $Ze=372.4 R^{1.54}$)

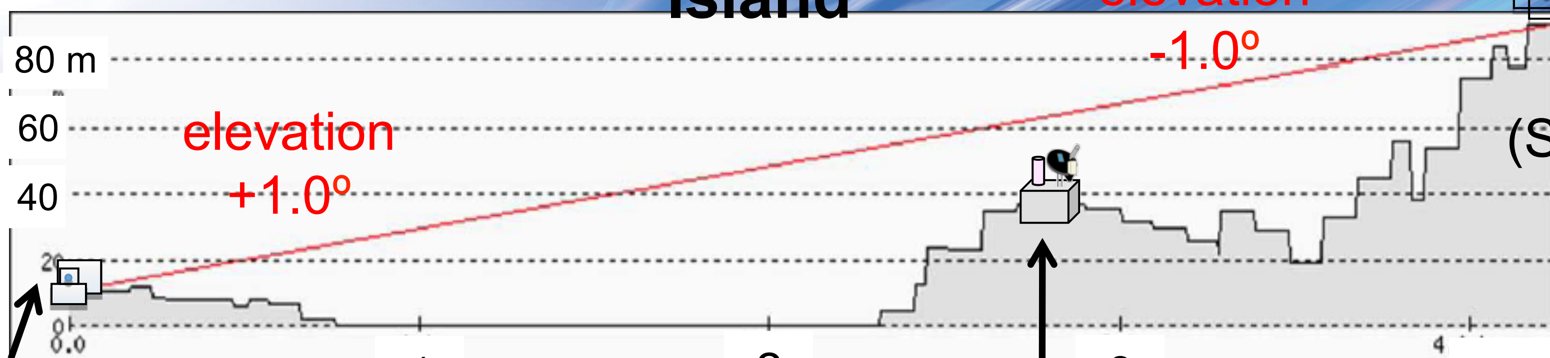
Japan and U.S. PMM Science Framework



Event 3 January 19, 2004

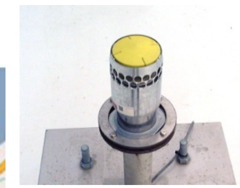


Details of the dual Ka radar measurement in Okinawa Island

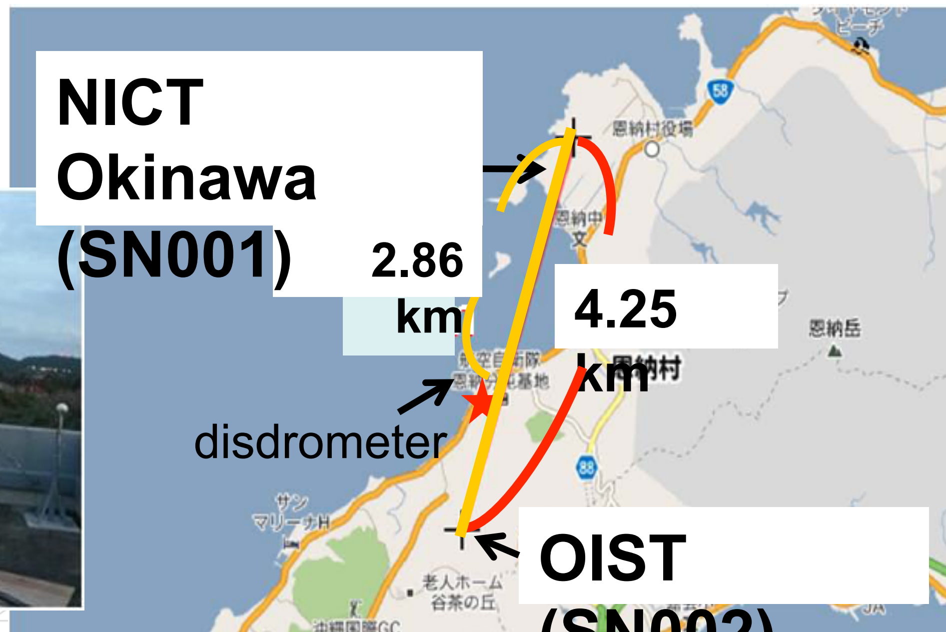


NICT Okinawa (SN001)

Mobile precipitation observation system sdrometer)



SN001

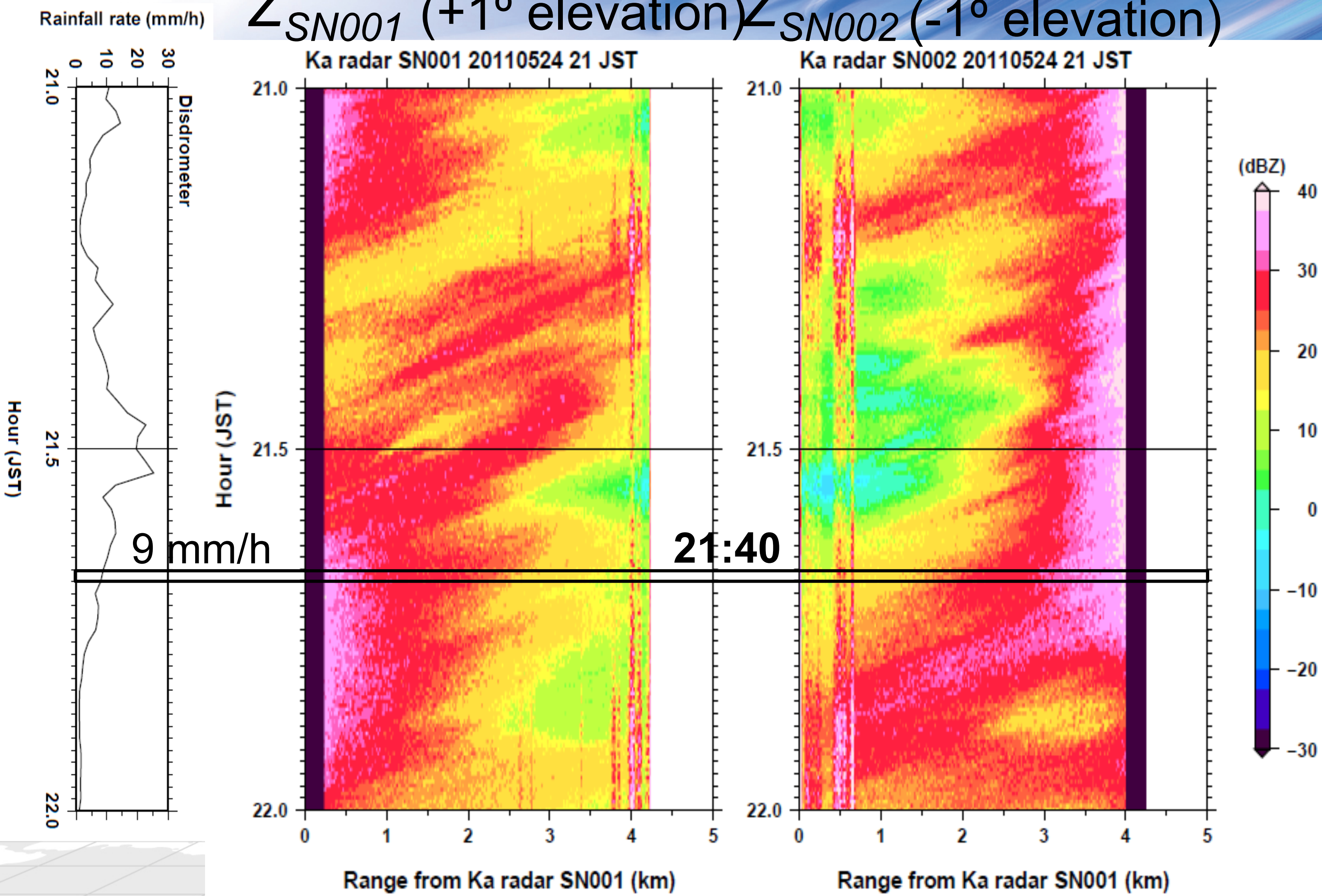


SN002

NICT: National Institute of Information and Communications
OIST: Okinawa Institute of Science and Technology

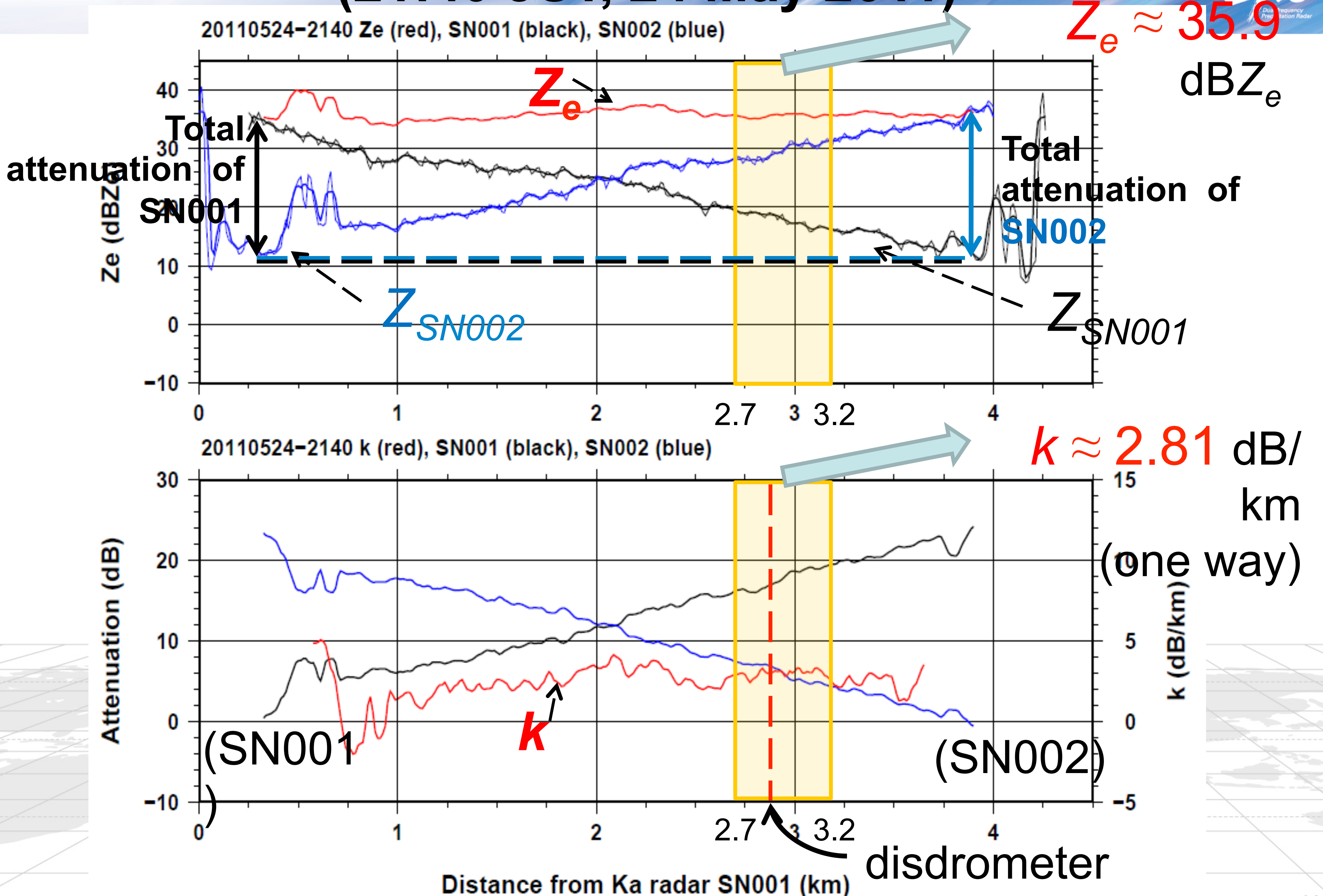
Time-range section of Z (21-22 JST, 24 May 2011)

Z_{SN001} (+1º elevation) Z_{SN002} (-1º elevation)

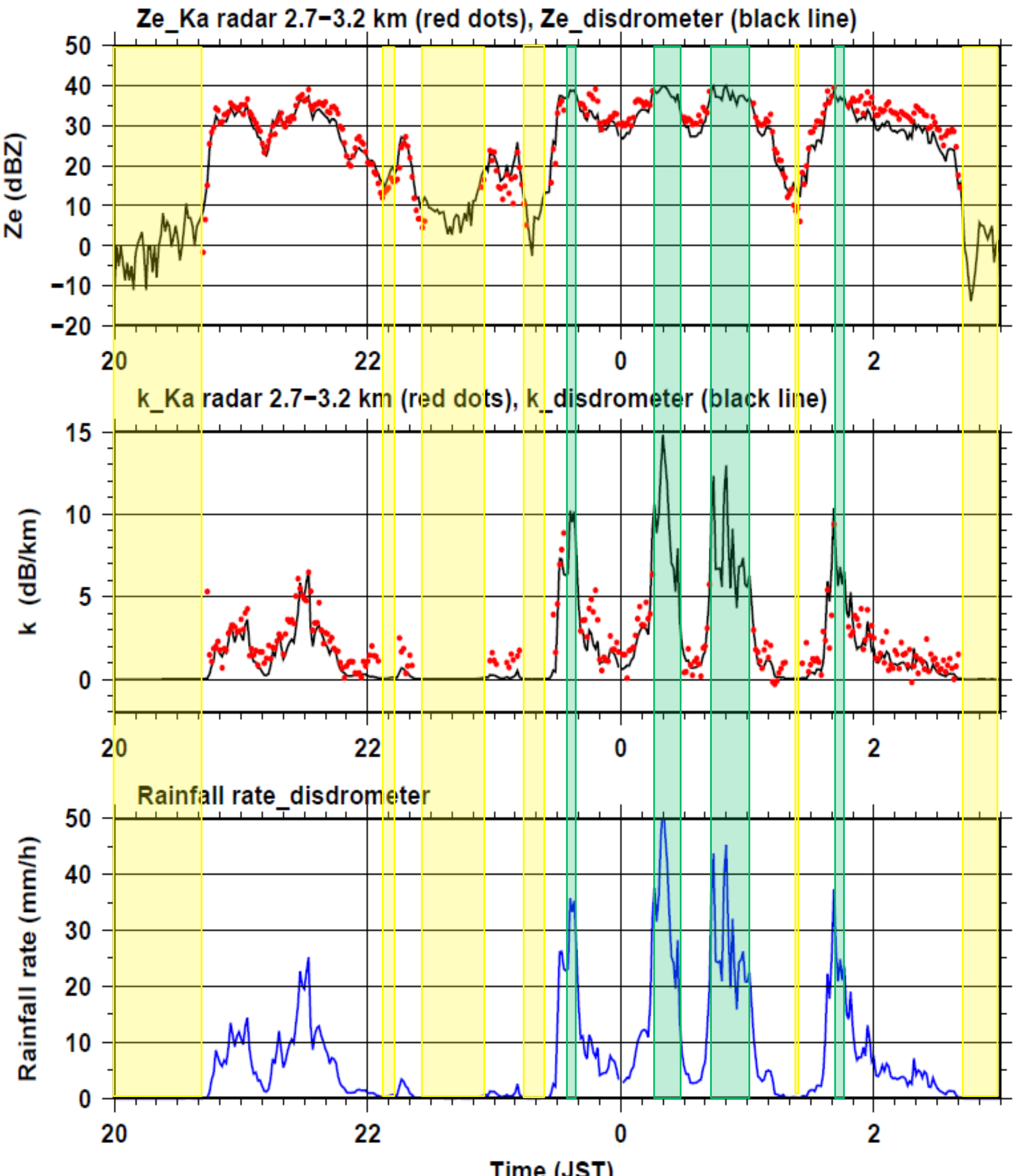


[range resolution: 12.5 m

Estimation of Z_e and attenuation (21:40 JST, 24 May 2011)



Time-series of Z_e, k and rainfall rate (20 JST, 24 May - 3 JST, 25 May, 2011)



: weak rain

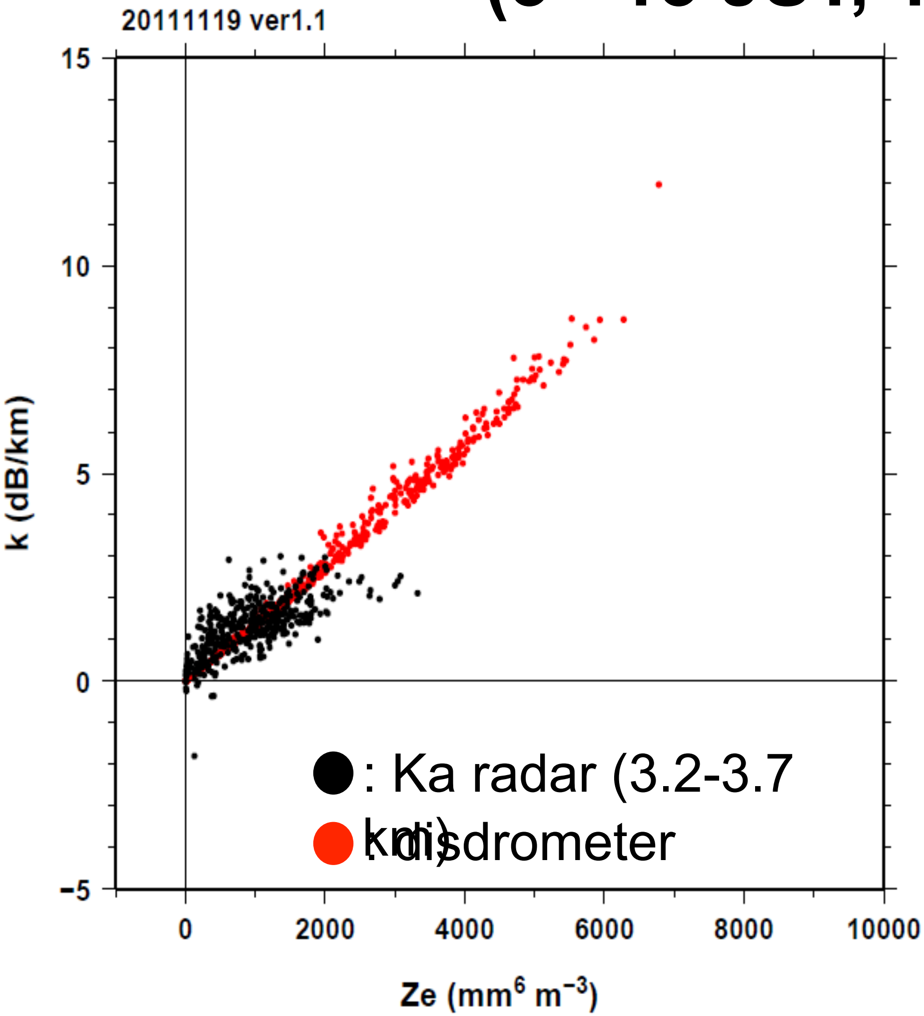
: too strong rain attenuation

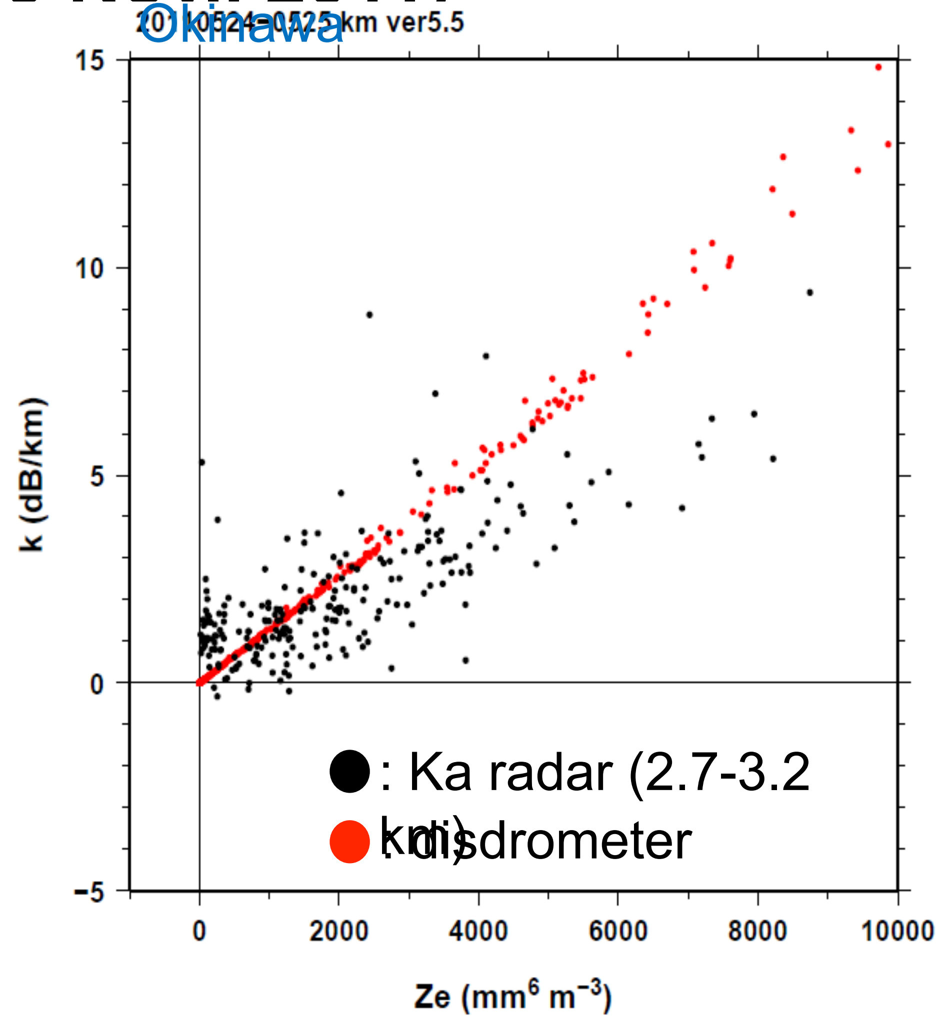
● : Ka radar (2.7-3.2 km)

— : disdrometer

k- Z_e relation estimated from Ka radar and disdrometer (3 - 13 JST, 19 Nov.. 2011)

Estimated k-Z_e relation in Okinawa





Ka radar: Weak rain and too strong rain attenuation events are

disdrometer: All rain events are plotted.

Development of a combined DPR and GMI precipitation algorithm

Hirohiko Masunaga and Combined algorithm team

Hydrospheric Atmospheric Research Center, Nagoya University

Current status and future plans

- Joint US-Japan combined algorithm team
  - Will maintain collaboration with the US combined team.
  - Our emissivity data are included in the US LSWG archives.
- (In-house) combined algorithm development
  - will be completed this fiscal year.
- Land surface emissivity estimate
  - EOF analysis
    - An initial version of the algorithm is working and being tested.
    - Breakdown into different surface types will be investigated.
    - Cloud mask scheme needs to be refined.
  - AMSU emissivity estimates
    - A Match-up dataset with TRMM is currently used as a proxy of GMI WV sounding channels.

Summary

- Rain/No-rain classification algorithm for AMSU has been improved, resulting in better agreement between AMSU and PR estimates.
- Dynamic Land-Ocean (LO) flag has been introduced to Rain/ No-rain classification algorithm for TMI and AMSU (submitted to JAXA).
- Size Reduction of lookup tables by fitting has been AMSU algorithm (submiited to JAXA).
- Orogoraphic/Non-orographic classification scheme has been introduce to GSMaP NRT system with modification for its global application (submitted to JAXA).
- Japanese IPWG validation website has been maintained.

Shige, S., S. Kida, H. Ashiwake, T. Kubota, and K. Aonashi, 2013: Improvement of TMI rain retrievals in mountainous areas. *J. Appl. Meteor. Climatol.*, **52**, 242-254 .

Contents

I. Wet Snow (Melted Fraction)

Temperature & Size dependency

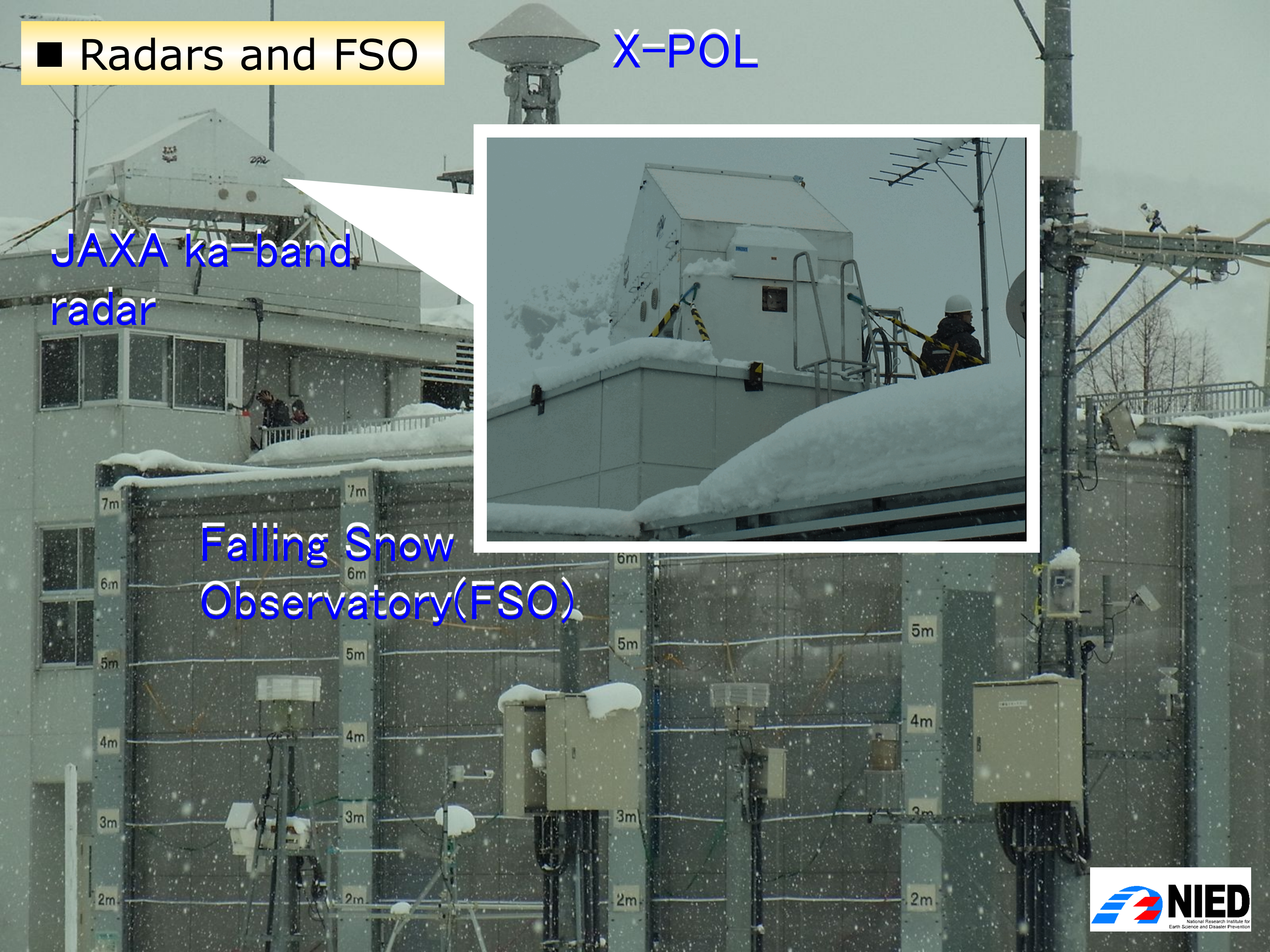
II. Graupel

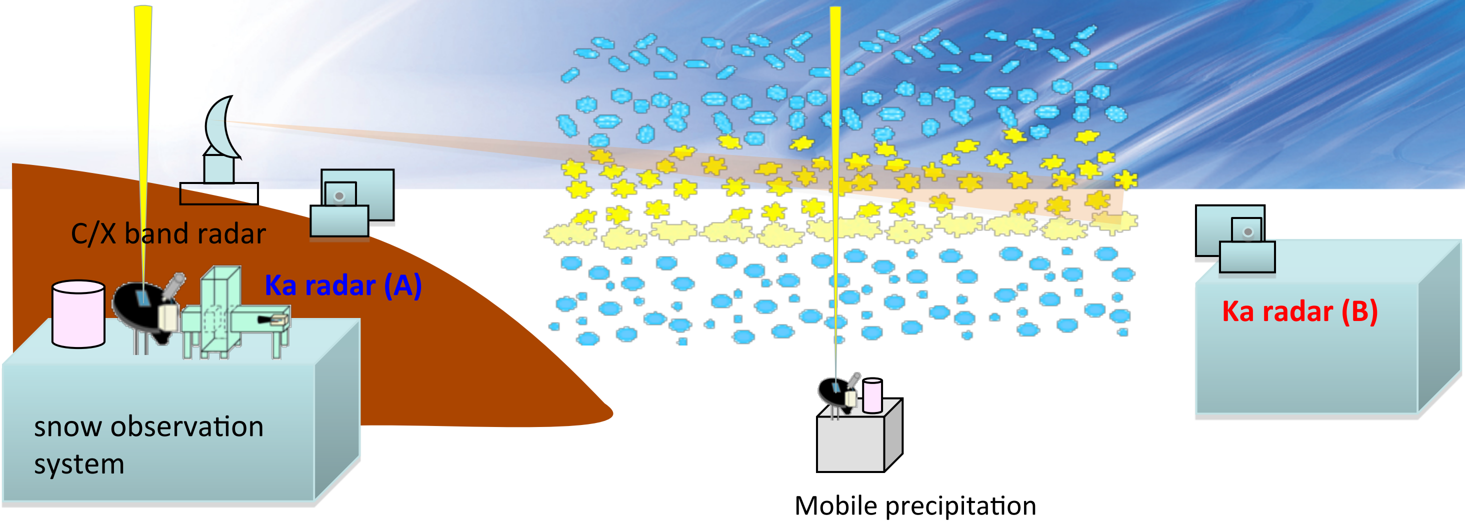
Size dependency of fall velocity

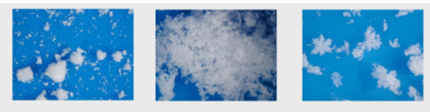
Size Distribution

III. Snowflake/Graupel Classification

Comparison with Ka-band radar

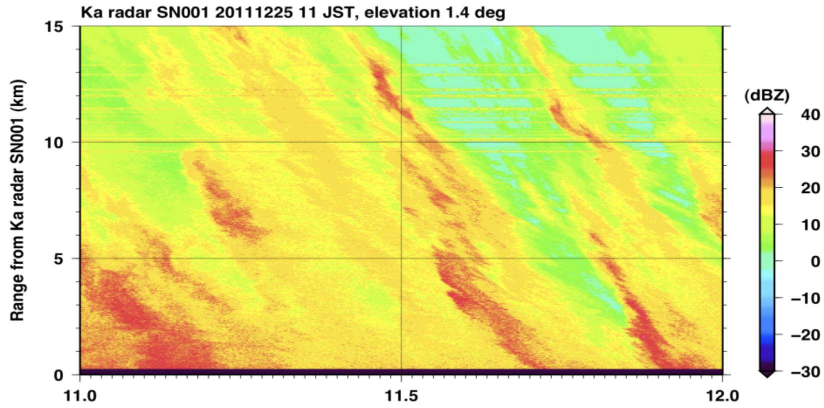

■ Radars and FSO
X-POL
JAXA ka-band
radar
Falling Snow
Observatory(FSO)

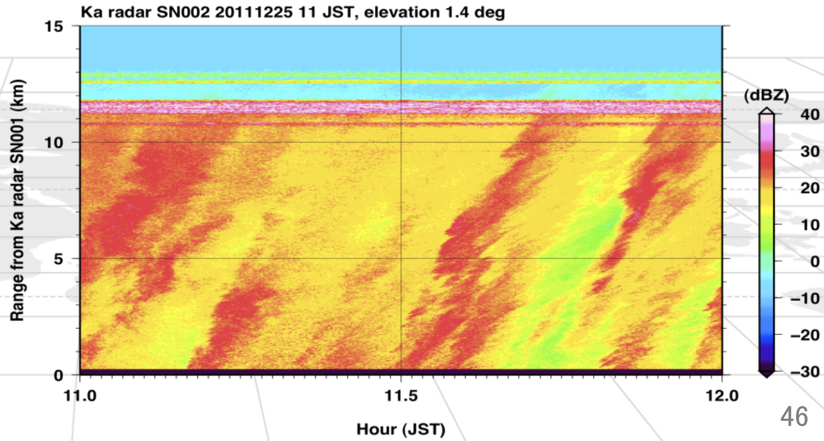




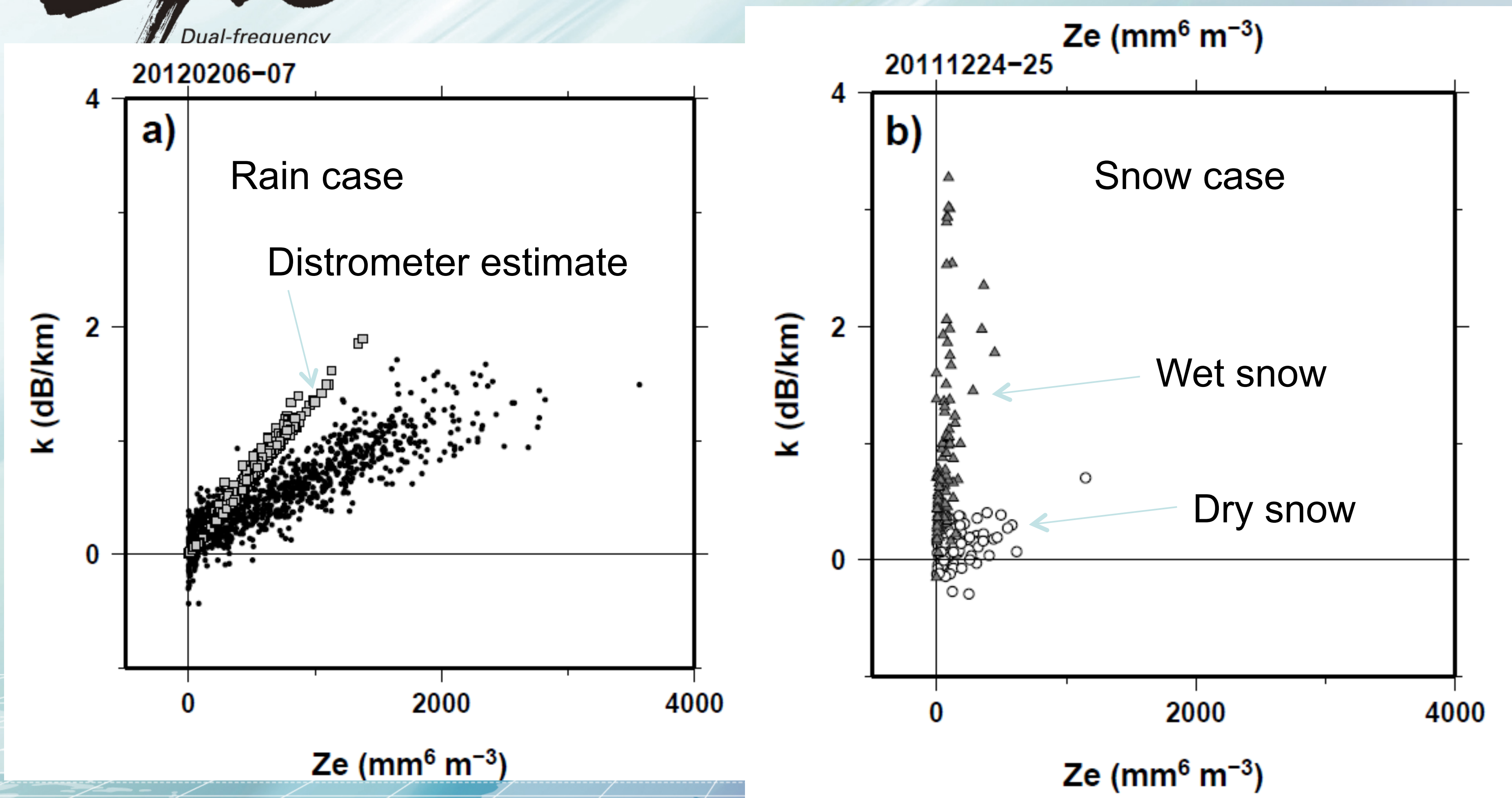
Snow observation at Nagaoka

Only weak attenuation appears.

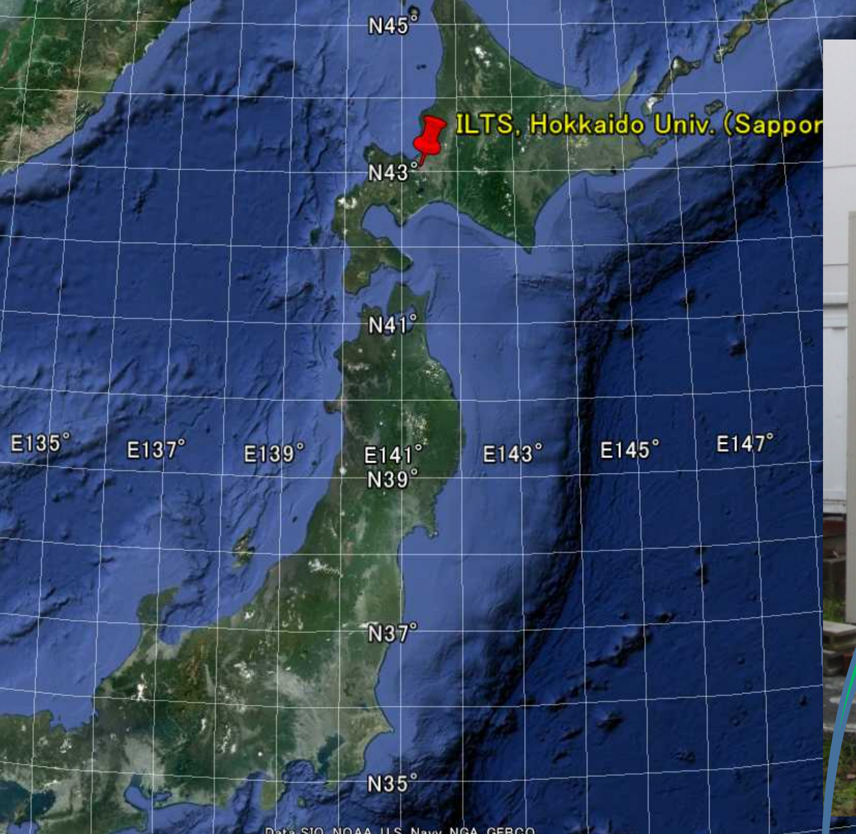




Nagaoka snow experiment



Field Works in FY2012



Snow Depth Meter

Weighing Snowfall Amount (Electro Balance)

Summary 1

Using the dual Ka-band radar system, k-Z_e relations of snow were measured in Nagaoka, Japan.

- <u>k-Z_e relations of snow</u>

  Different k-Z_e relations of snow were appeared.

  Surface temperature indicated that the difference was attributed to characteristics of wet and dry snow.

(Ongoing work)

We are conducting dry snow measurements in this winter.

SN002 (Mt. Okura, Sapporo)
2013/01/21

GSMaP

- *An algorithm that adjusts the GSMaP_MVK estimates to the CPC global gauge estimates was proposed and tested.*
- *The proposed method takes the optimal estimates with the regularization term in second order.*
- *It is shown that the proposed optimal method basically works well from some case studies.*
- *The gauge adjusted near real time product (GSMaP_Gauge_NRT) is under discussion and firstly implemented.*

Development of the new forward calculation method for microwave brightness temperatures

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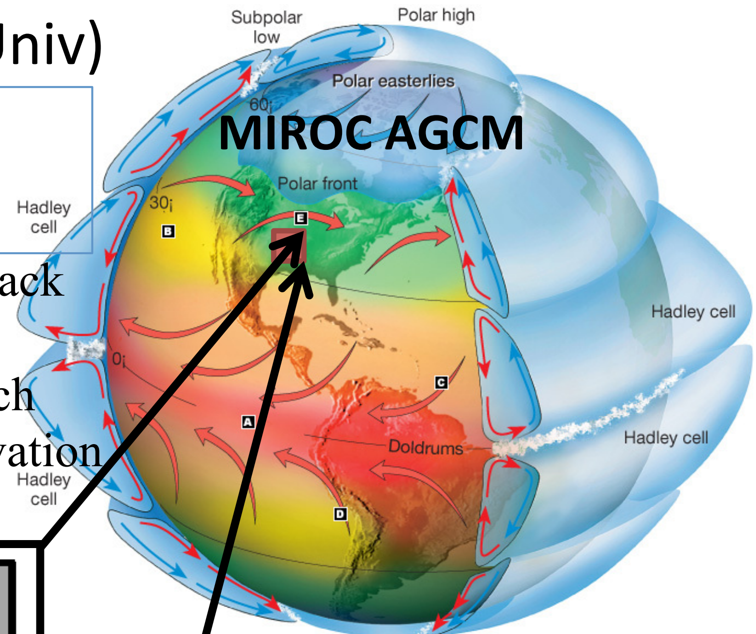
Meteorological Research Institute
Japan Meteorological Agency

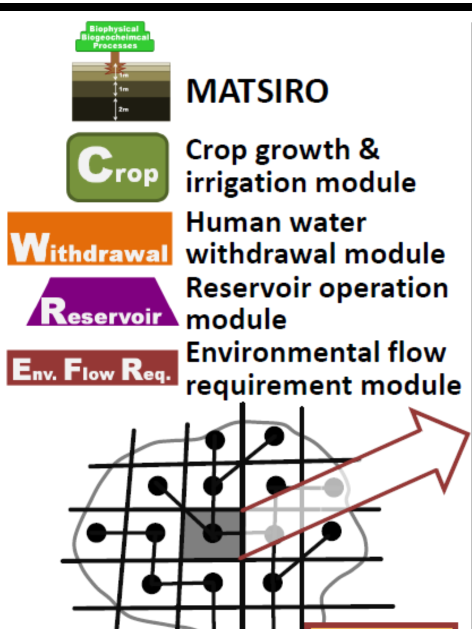
Coupled MIROC AGCM with MATSIRO land surface model including several human impact modules. Land-atmosphere interactions and hydromet prediction skills

PI: Yamada (Hokkaido Univ)

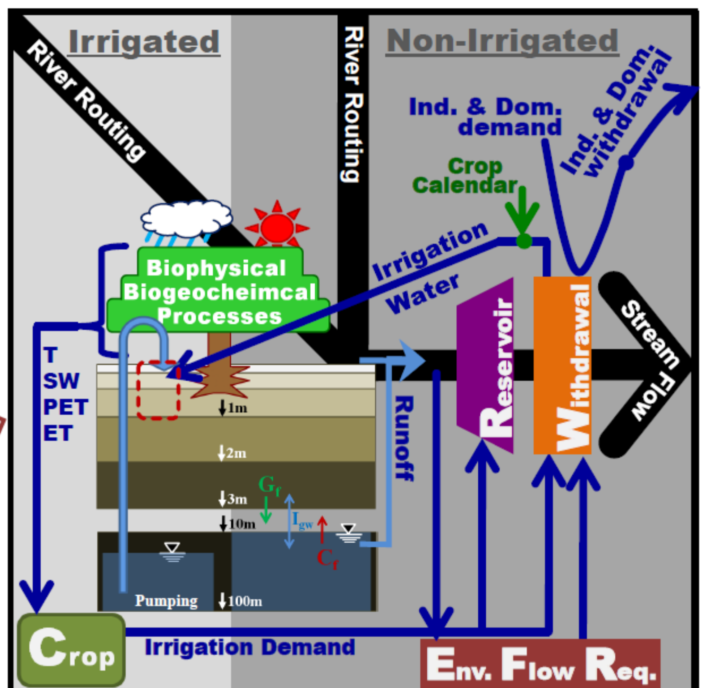
MIROC AGCM + MATSIRO including human impact modules (irrigation, groundwater pumping dam operation, domestic and industrial water use, environmental flow).

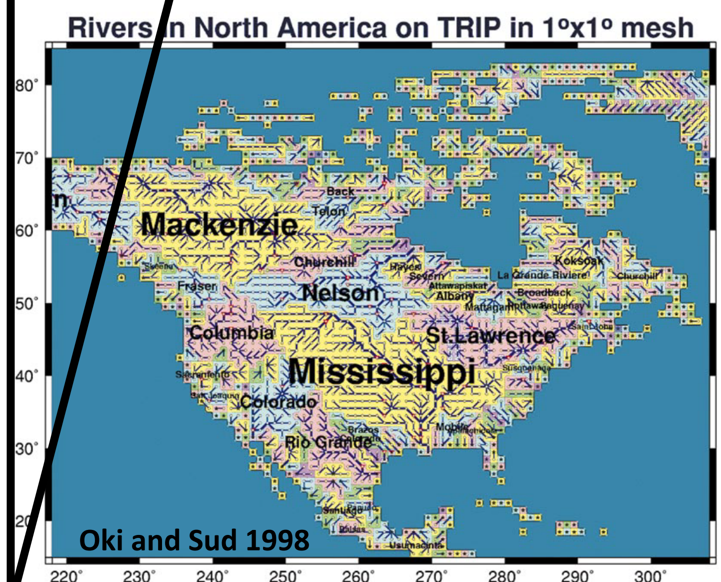
Groundwater pumping (GWP) data is lack globally. Therefore GWP data was prescribed by offline LSM output, which was simulated with atmospheric observation including satellite precipitation.





Hanasaki et al. 2008
Pokhrel et al. 2012





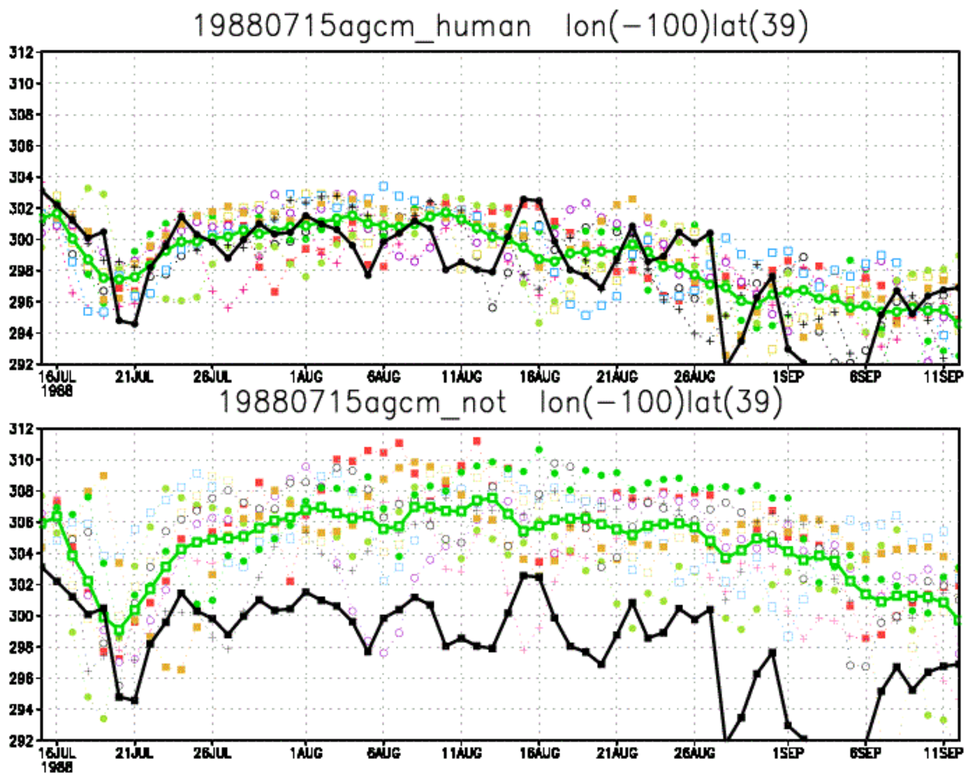
Forecast results and spreads among 10 ensemble members with a) human impact (mainly irrigation) and b) without human impact modules PI: Yamada

Colder colors indicate that forecast results (T2m) have small spread among ensemble members.

The MIROC with MATSIRO including human impact modules reduces degree of spread among members.

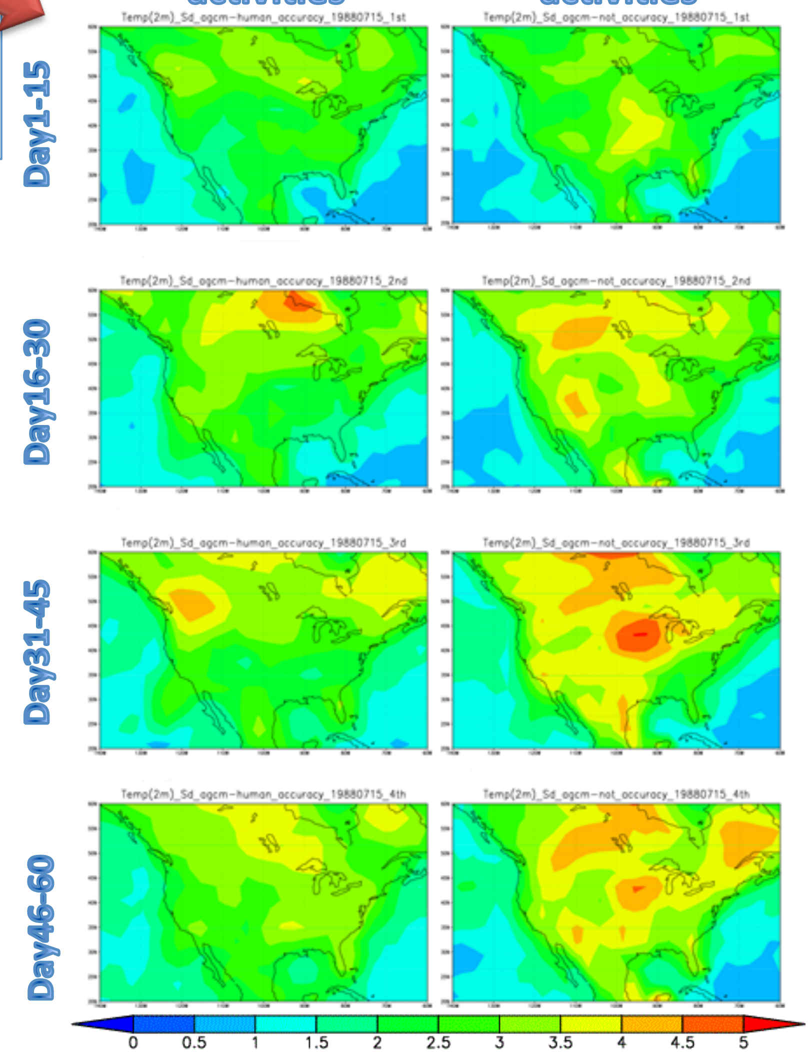
With human activities

Without human activities



T2m forecast results (colors, **green: ensemble mean** and **observation: black**)

With human activities | Without human activities



Spread among ensemble members for T2m.

Yamada et al. (to be submitted)

Event1 January 1, 2004