ULTIMATE：
数値モデルの雲検証評価を目的とした関東圏ウルトラサイト観測連携

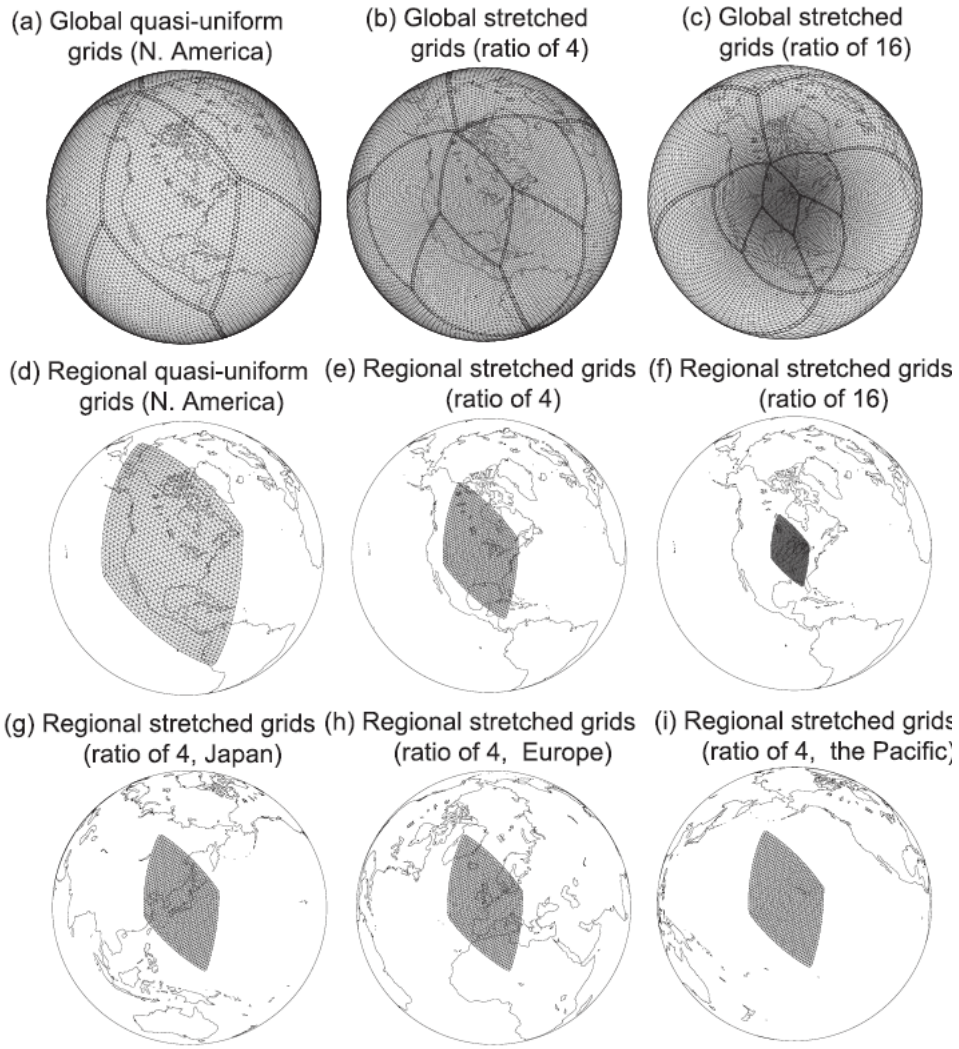
佐藤正樹

Courtesy of Woosub Roh, Tempei Hashino, Toshi Matsui

Yuichi Ohno (NICT), JMA/MRI

気候コロキウム 2020.9.30

Evaluations and improvements of clouds with a seamless approach



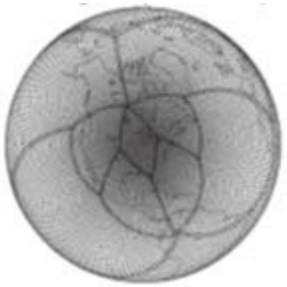
- Use of the global, the stretched, and the regional models which possess the same dynamical core and physics.
- Evaluation and improving of clouds in local domains.
  - ✓ Use of various kinds of observations, including satellite observations and ground remote sensing data.
- Testing the improved scheme in the global domain.

Uchida, J., Mori, M., Hara, M., Satoh, M., Goto, D., Kataoka, T., Suzuki, K., Nakajima, T. (2017)
Impact of lateral boundary errors on the simulation of clouds with a non-hydrostatic regional climate model.
Mon. Wea. Rev., 145, 5059-5082.
https://doi.org/10.1175/MWR-D-17-0158.1

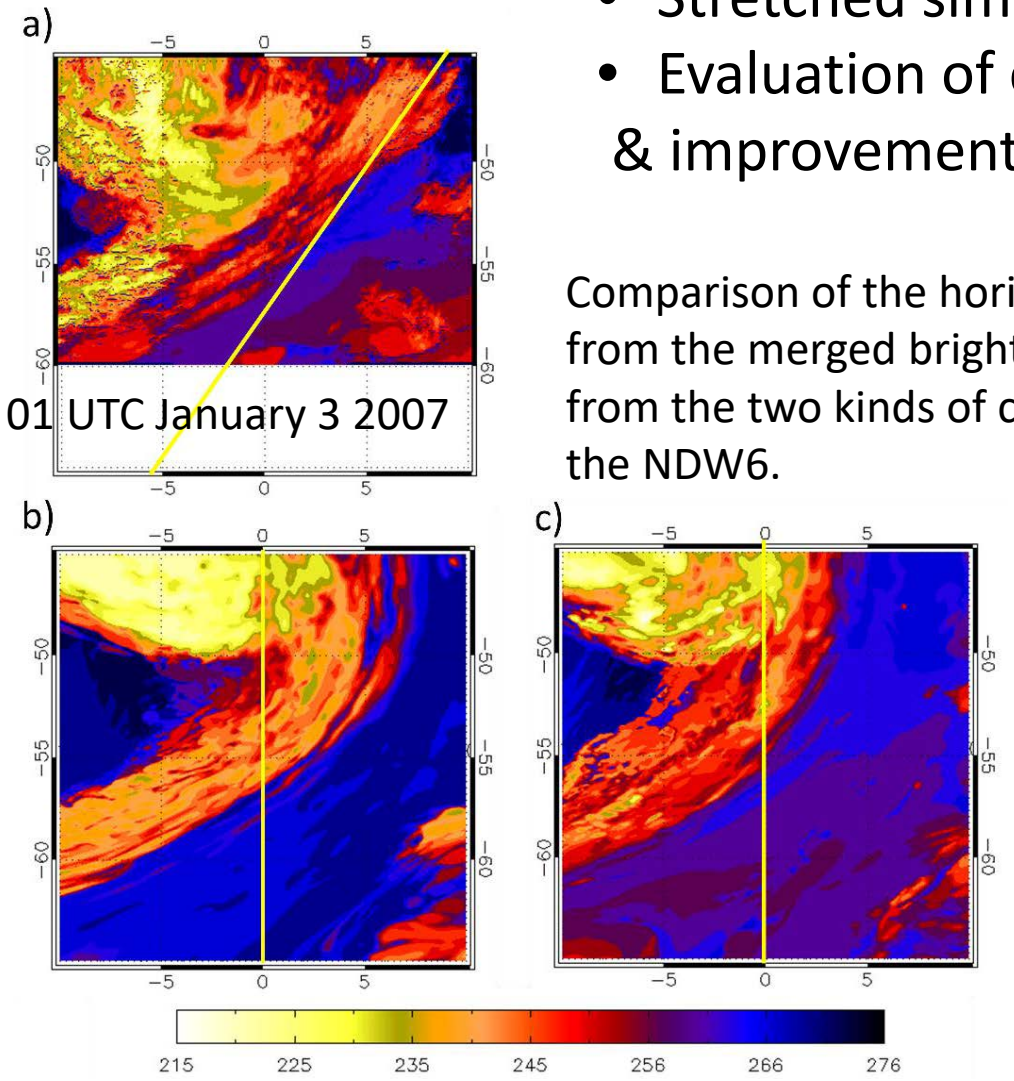
Cloud Evaluations/Improvements by using Stretch NICAM

- Roh, W., Satoh, M., Hashino, T., Okamoto, H., Seiki, T. (2020) Evaluations of the thermodynamic phases of clouds in a cloud system-resolving model using CALIPSO and a satellite simulator over the Southern Ocean. J. Atmos. Sci., https://doi.org/10.1029/2020MS002138
- Seiki, T., Satoh, M., Tomita, H., Nakajima, T. (2014) Simultaneous evaluation of ice cloud microphysics and non-sphericity of the cloud optical properties using hydrometeor video sonde and radiometer sonde in-situ observations. J. Geophys. Res. Atmos., 119, 6681-6701. doi:10.1002/2013JD021086.
- Roh, W., and Satoh, M. (2014) Evaluation of precipitating hydrometeor parameterizations in a single-moment bulk microphysics scheme for deep convective systems over the tropical open ocean. J. Atmos. Sci., 71, 2654-2673. http://dx.doi.org/10.1175/JAS-D-13-0252.1
- Satoh, M., Inoue, T., and Miura, H. (2010) Evaluations of cloud properties of global and local cloud system resolving models using CALIPSO/CloudSat simulators. J. Geophys. Res., 115, D00H14, doi:10.1029/2009JD012247.

Evaluations and improvements of clouds



- Stretched simulation over the southern ocean
- Evaluation of cloud phase using depolarization of CALIPSO & improvement



Comparison of the horizontal distribution of the 11-□m brightness temperatures from the merged brightness temperatures from (a) geostationary satellites and that from the two kinds of cloud microphysics simulations by NICAM (b) NSW6 and (c) the NDW6.

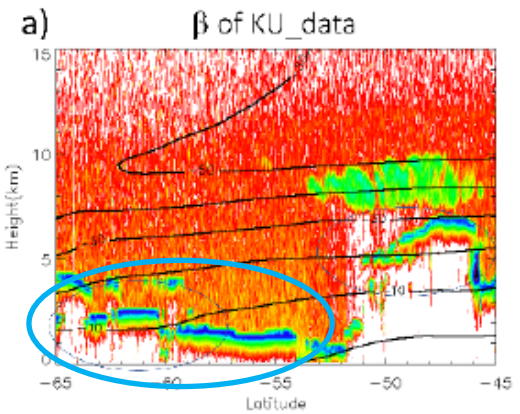
- Roh, W., Satoh, M., Hashino, T., Okamoto, H., Seiki, T. (2020) Evaluations of the thermodynamic phases of clouds in a cloud system-resolving model using CALIPSO and a satellite simulator over the Southern Ocean. J. Atmos. Sci., https://doi.org/10.1029/2020MS002138
- Seiki, T., Roh, W. (2020) Improvements in super-cooled liquid water simulations of low-level mixed-phase clouds over the Southern Ocean using a single-column model. J. Atmos. Sci., in review.

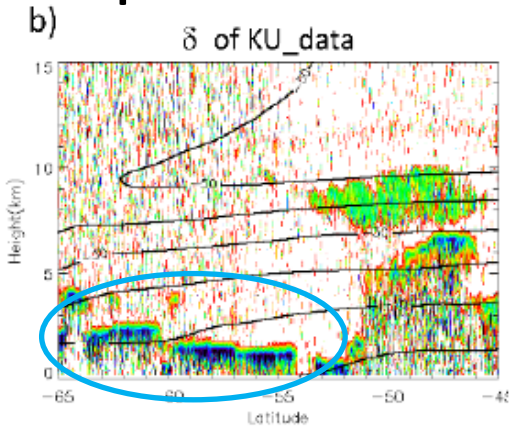
backscatters

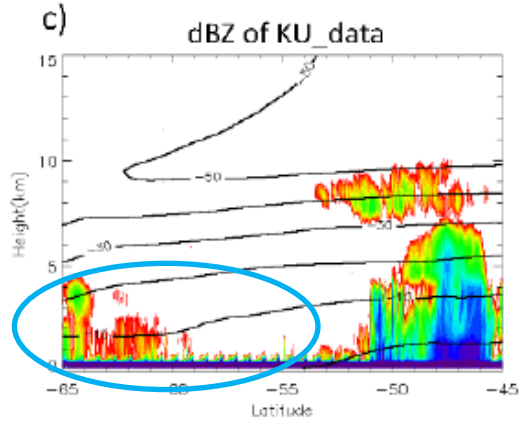
depolarization ratio

radar reflectivities

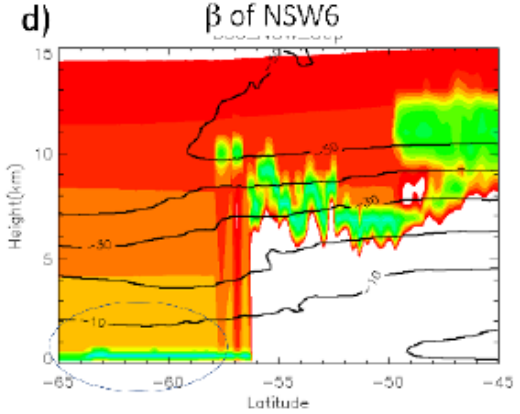
Observation

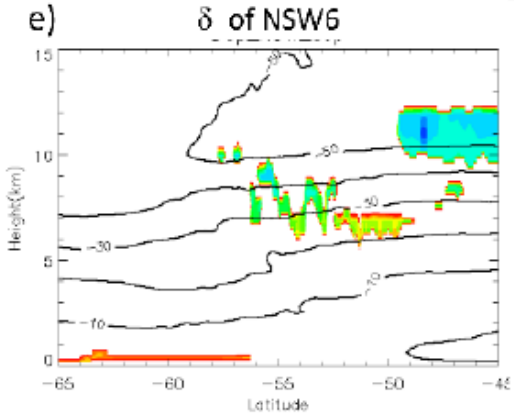


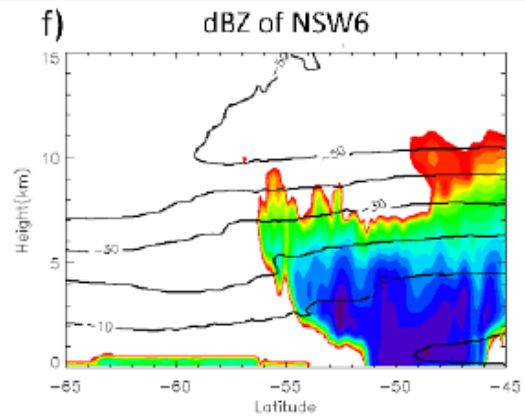




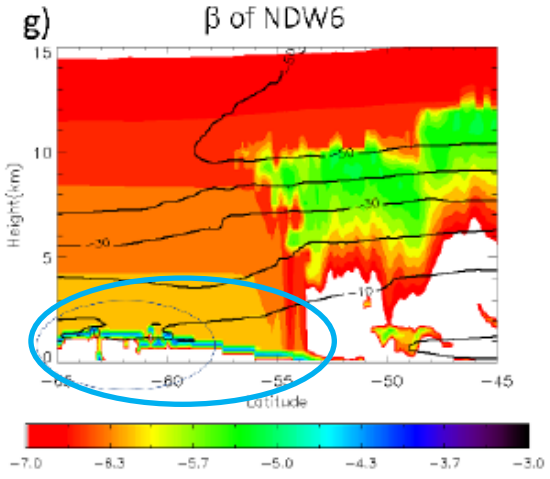
NICAM
single moment scheme
(NSW6)

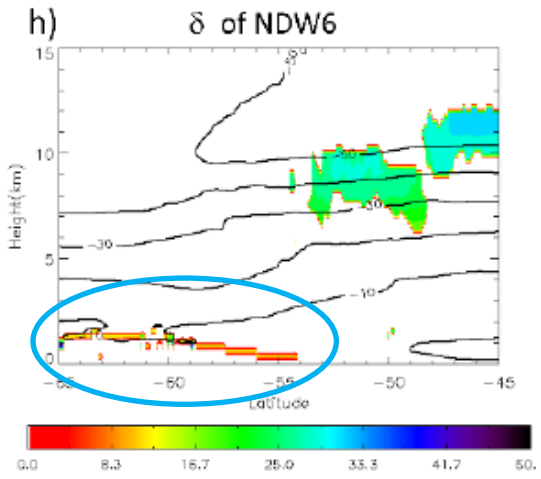


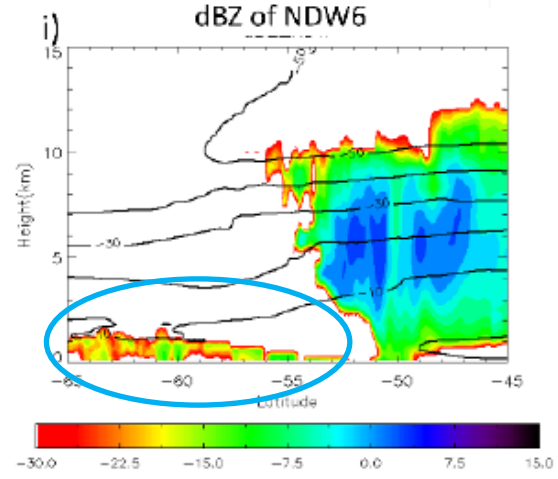




NICAM
double moment scheme
(NSW6)

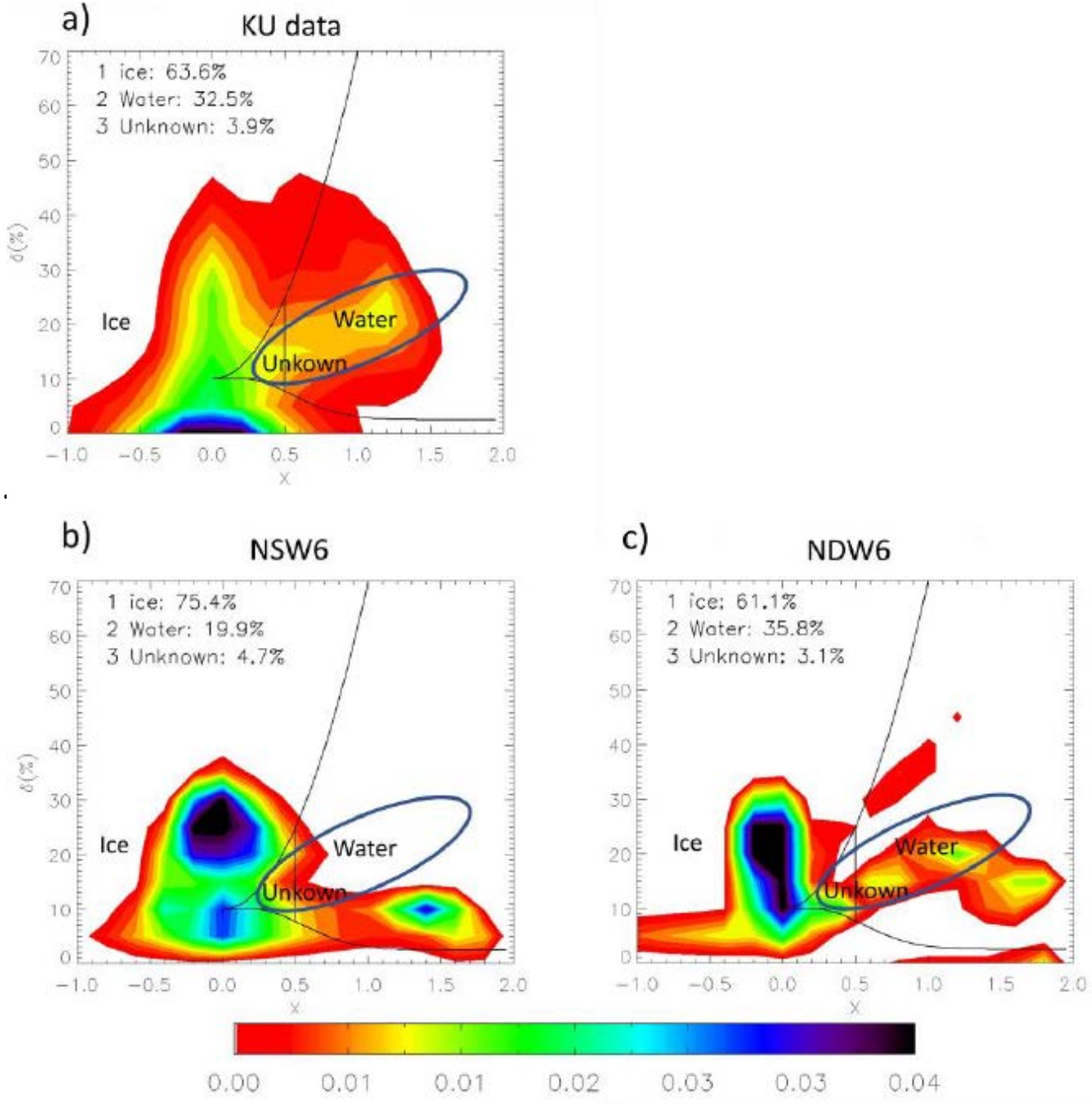




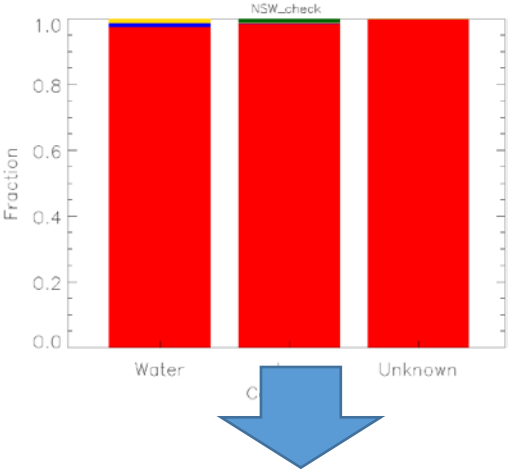


Evaluation method

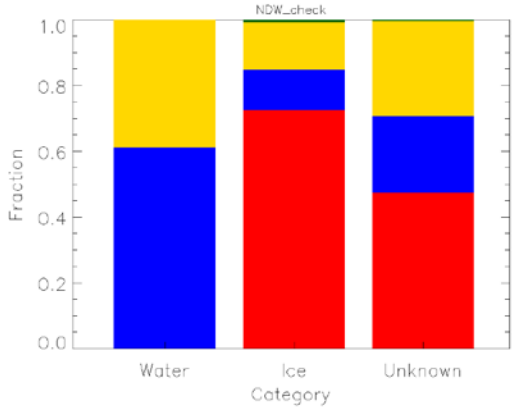
- Yoshida diagram: Yoshida et al. (2010,JGR)
- Cloud type classification in the join histogram of Depolarization vs attenuation of backscatters



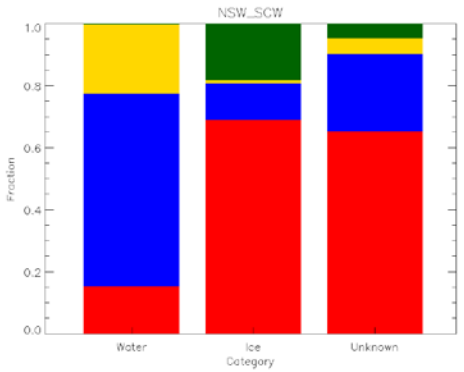
NSW6

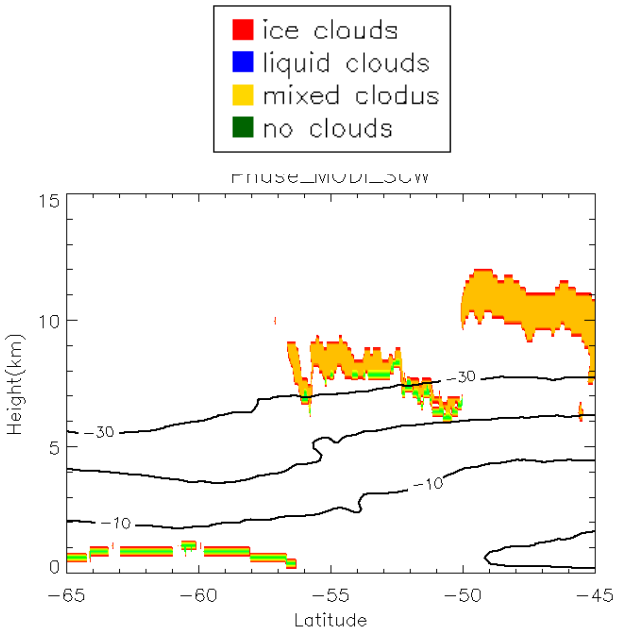


NDW6



NSW6_SCW

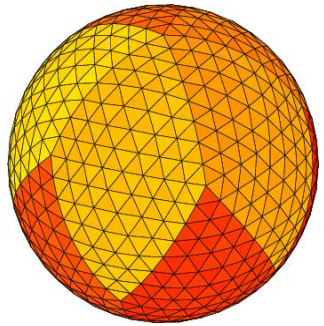




NSW6_SCW is developed by reduction of ice clouds in mixed-phases cloud

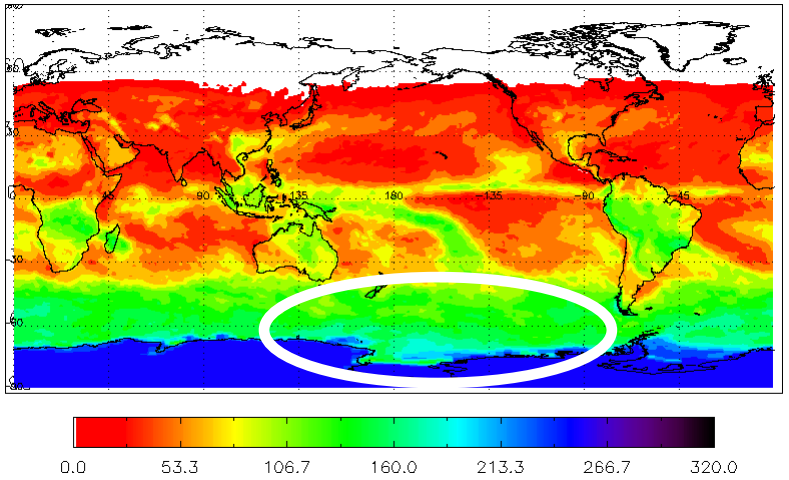
- The autoconversion and accretion schemes (Berry, 1968) were replaced by recent ones (Khairoutdinov and Kogan, 2000).
- A diagnosis method of ice number concentration (Hong et al., 2004) was replaced by a heterogeneous ice nucleation scheme that was a function of temperature and of ice supersaturation (Phillips et al., 2007).
- Vapor deposition by snow and graupel was switched off when their mixing ratios were smaller than a certain threshold.
- A cut-off diameter was used for riming. The cut-off diameter is validated by the past experimental data that collision efficiency is notably small for smaller ice particles.

Seiki and Roh (2020,JAS,in review)



Global model simulation:
Impact on Outgoing Shortwave Radiation (OSR)

OBS.



- Global experiment:

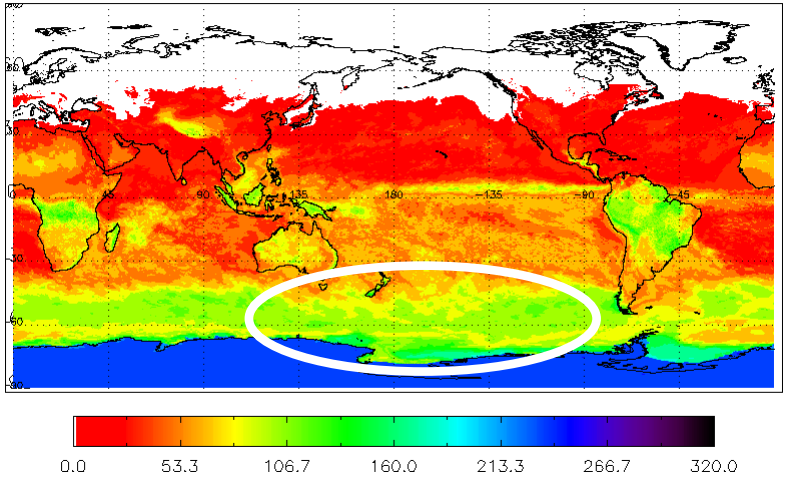
✓ 14 km horizontal resolution

✓ Integration time: January 2007

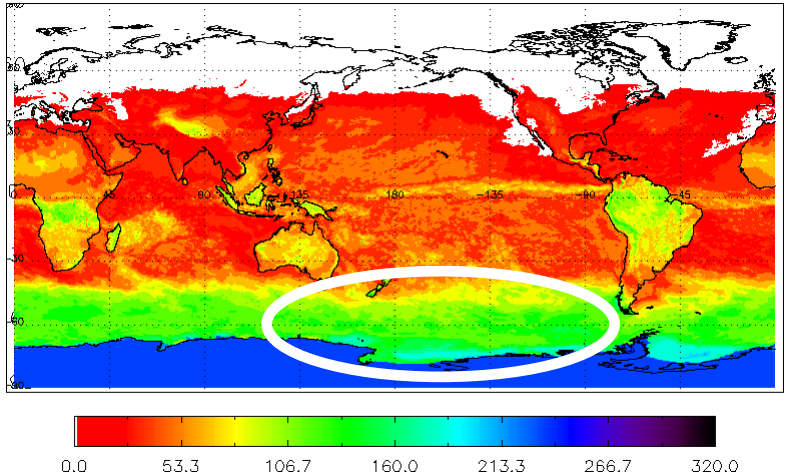
- Observation data: CERES daily data

The improved scheme (NSW6_SCW) increases OSR over the Southern Ocean.
A good agreement with CERES observation.

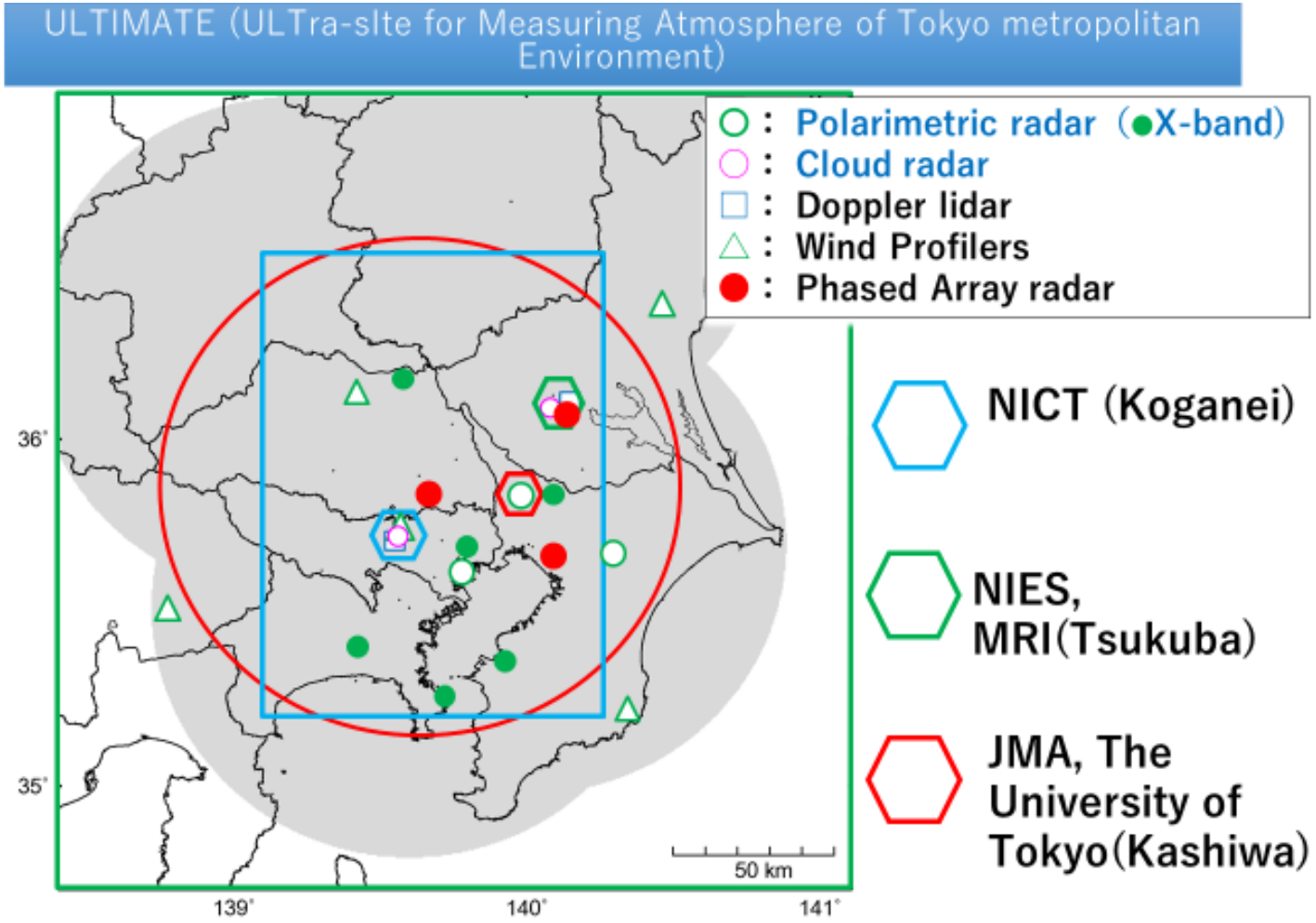
NSW6



NSW6_SCW

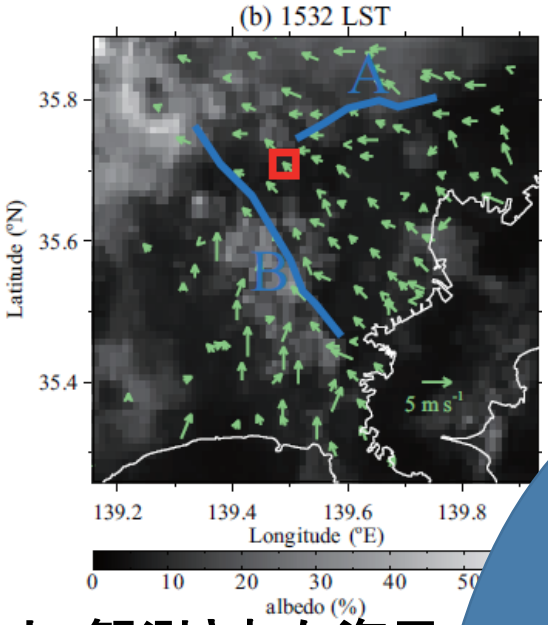


ULTIMATE: ULTra-sIte for Measuring Atmosphere of Tokyo metropolitan Environment

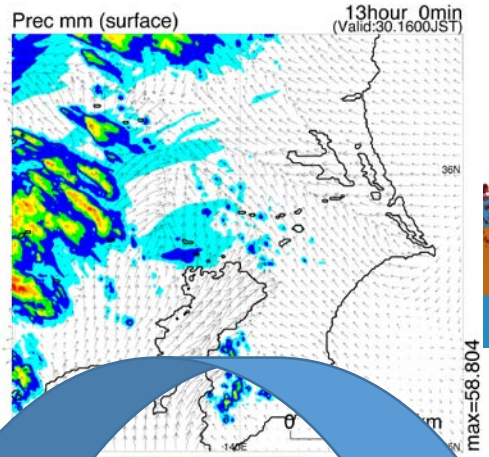


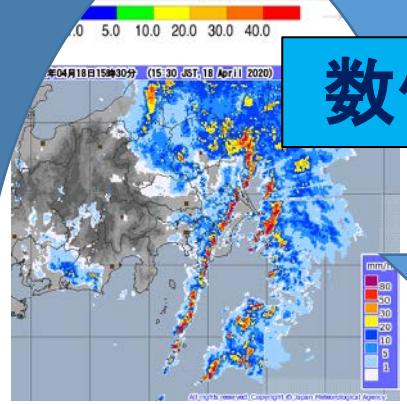
- EarthCARE (2022 launch) Ground Validation sites (NICT)
- ULTIMATE2020: 科研B 2020-2022
- 交通運輸技術開発推進制度課題 2020-2022

交通運輸技術開発推進制度課題「関東圏の航空機の効率的な運航のための極端気象予測の高度化」2020-2022



上：観測された海風前線と対流の発生（四角）

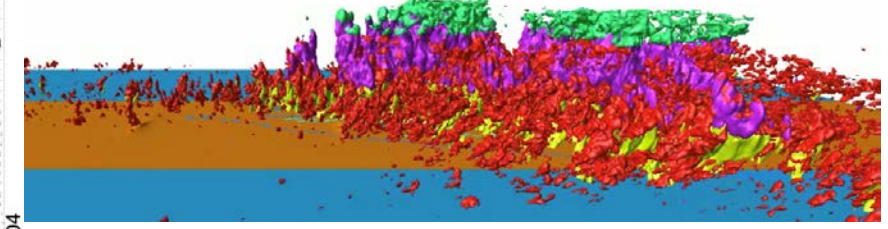




観測

数値予測

左：局地気象モデルによる数値予測
下：計算された積乱雲の3次元構造



飛行経路の例

航空機の運航の効率化

中央：観測されたシビアストームのレーダー画像、右：二重偏波ドップラー気象レーダー（柏）

- 二重偏波ドップラー気象レーダー等の関東圏における新しい観測の活用
- 高解像度の局地気象モデルの雲・降水シミュレーションの高度化：　asuca, NICAM ~2km mesh model
- 数時間から1日先までの気象予測情報の精度を向上: 雲物理改良によるMCSへの効果　-> 全球、気候感度
- 過密化する関東圏の航空機のより効率的な運航に資するための手法を確立

ULTIMATE plan

- EarthCARE衛星検証チーム観測データ:

  多視野角多重散乱変更ライダ(355nm, 10ch), 高スペクトル分解ライダ(355nm)、ドップラーライダ(355nm)、コヒーレントドップラーライダ、HG-Spider 94GHz ドップラーレーダ、ウィンドプロファイラ、つくば(国立環境研)におけるミー偏光ライダ(532nm偏光, 1064nm)、多視野角多重散乱偏光ライダ（532nm）、高スペクトル分解ライダ(532nm)等

- 気象庁
  - ✓ Windas ウィンドプロファイラー
  - ✓ 二重偏波ドップラーレーダ（成田、羽田、柏）
- 衛星シミュレータ Joint-Simulator for Satellite Sensors
  - POLARRIS の適用 Matsui et al. (2018)
  - 雲判別手法 iPOLARRIS vs 気象研雲判別手法
- 雲物理 evaluations
  - Bringi et al. (2020): Riming, Rain drop breakup
- 検証対象
  - Synoptic system に伴う降水現象：低気圧とそれに伴う前線
  - 台風、熱帯性の対流雲
  - 下記の雷雲・積乱雲
  - ライダー：薄い雲：前線の前後

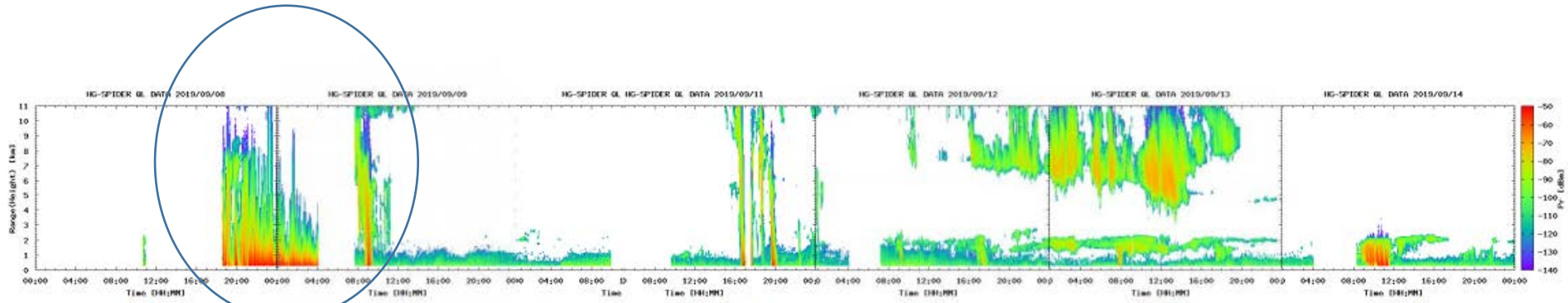
Simulations for ULTIMATE project

- Candidate cases
  - 2019/11/18
  - 2019/11/22
  - Reasons: HSRL, Doppler lidar, WINDAS

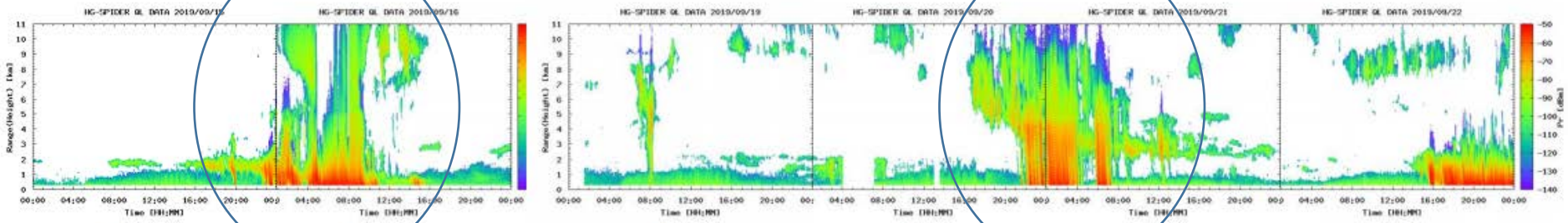
- Stretched NICAM using NCEP FNL data
  - GL8: minimum 2.8 km (done)
  - GL9: minimum 1.4 km (done)
  - GL10: minimum 700 m (planning)

  The center of the stretched grid is in the NICT (Kogane)

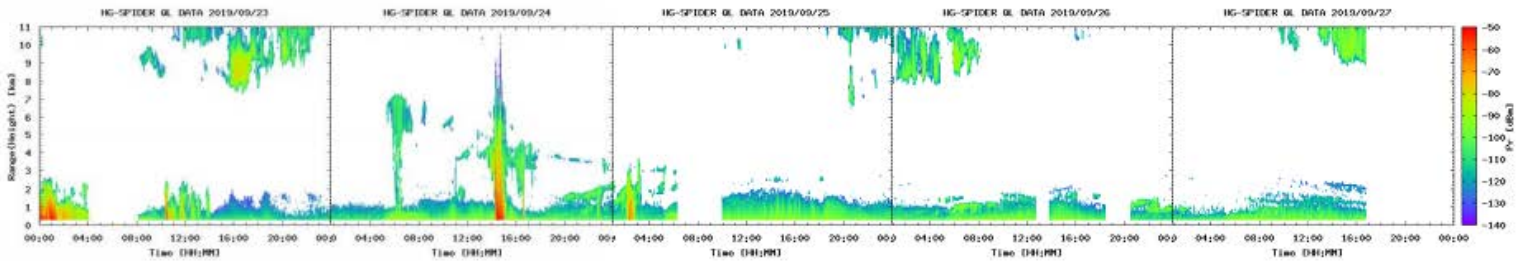
CPR observation in Sep. 2019 at NICT (Koganei)



9/8 9/9 9/10 9/11 9/12 9/13 9/14



9/15 9/16 9/19 9/20 9/21 9/22



9/23 9/24 9/25 9/26 9/27

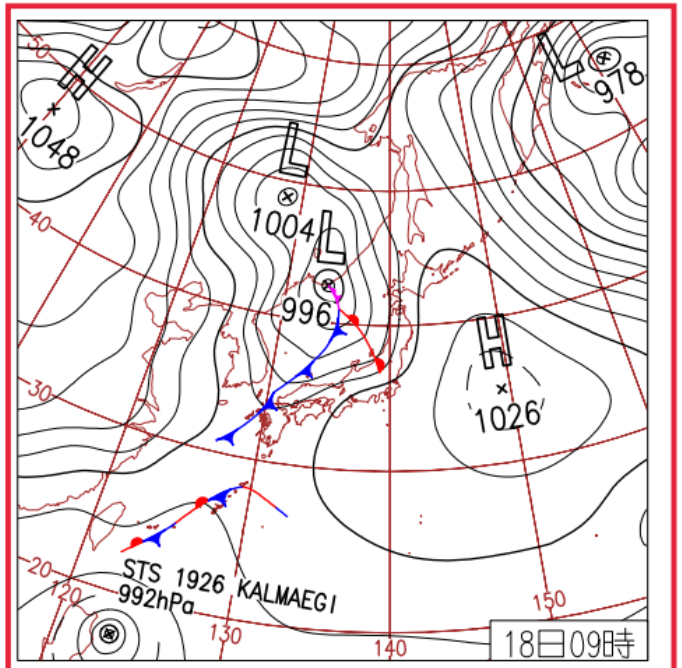
Simulations for ULTIMATE project

- Candidate cases
  - 2019/11/18
  - 2019/11/22
  - Reasons: HSRL, Doppler lidar, WINDAS

- Stretched NICAM using NCEP FNL data
  - GL8: minimum 2.8 km (done)
  - GL9: minimum 1.4 km (done)
  - GL10: minimum 700 m (planning)

  The center of the stretched grid is in the NICT (Koganei)

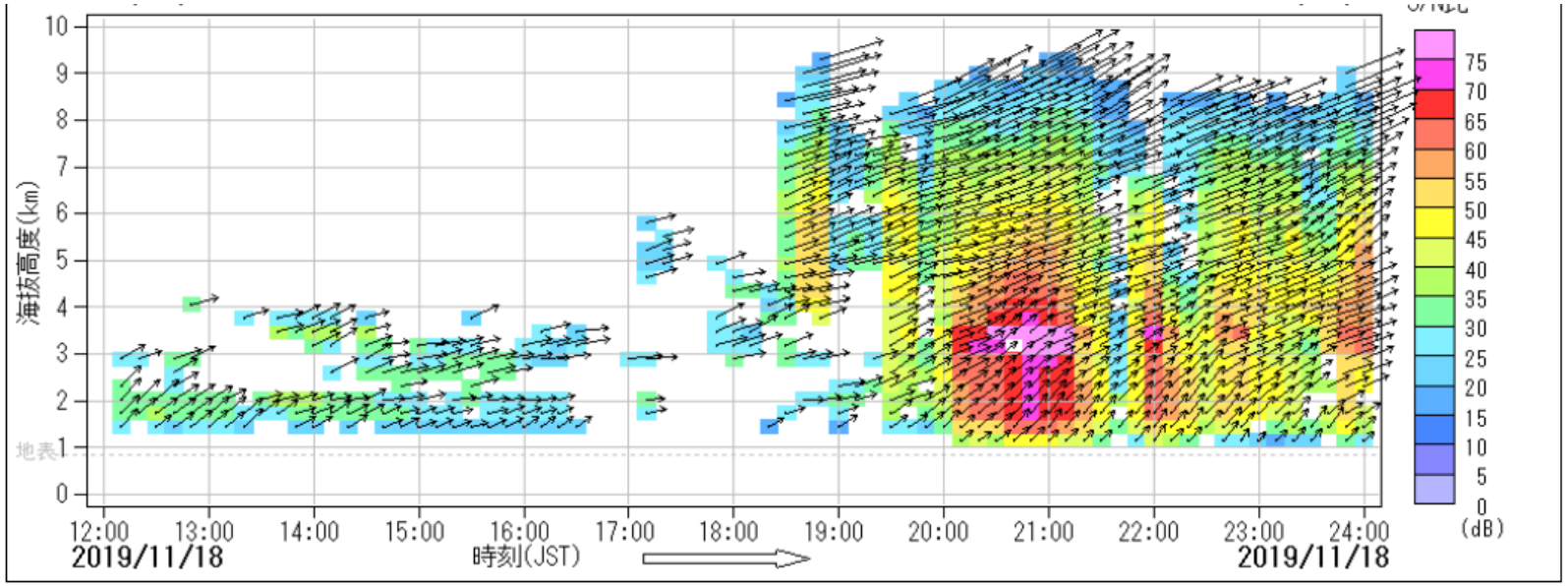
Case1: 2019/11/18

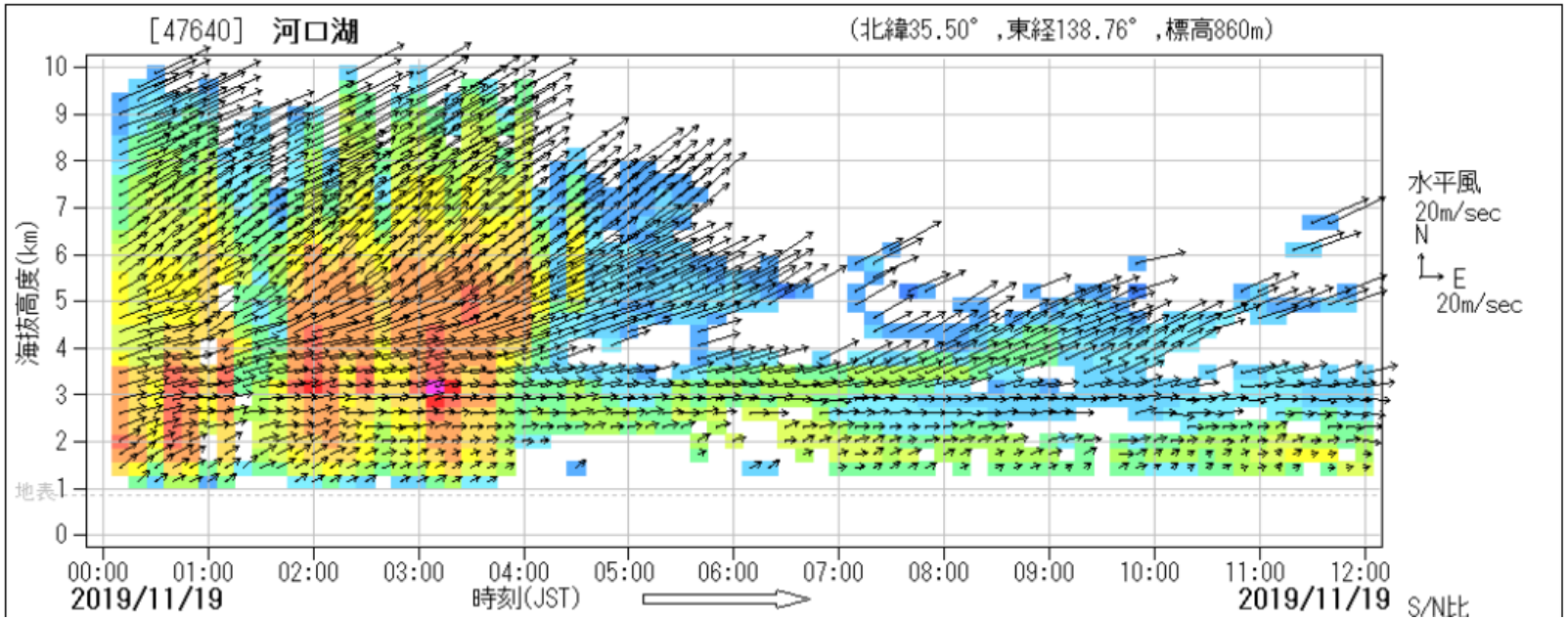


18日(月)前線通過で広く雨や雪

低気圧が日本海を発達しながら北東進。全国的に雨で北海道は雪。新潟県糸魚川で27.0℃など、四国瀬戸内側や北陸では夏日となり、11月の1位を更新した所も。秋田で初氷。

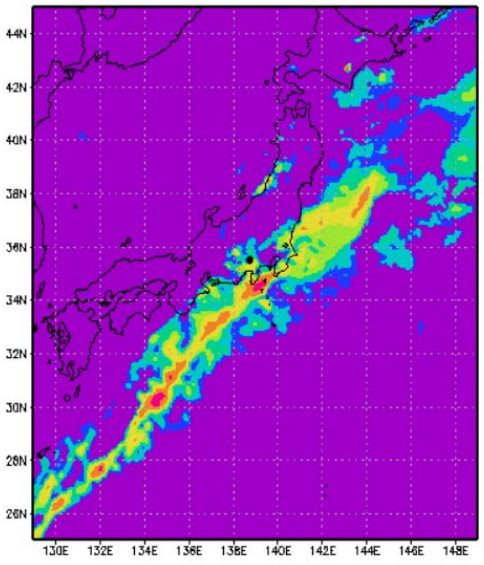
WINDAS data in Kawaguchiko



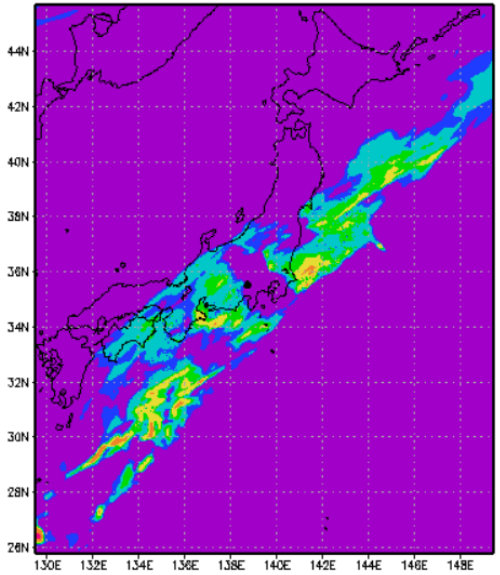


Impacts of initial conditions on the distribution of precipitation
: Snapshot of 18UTC 18th Nov.

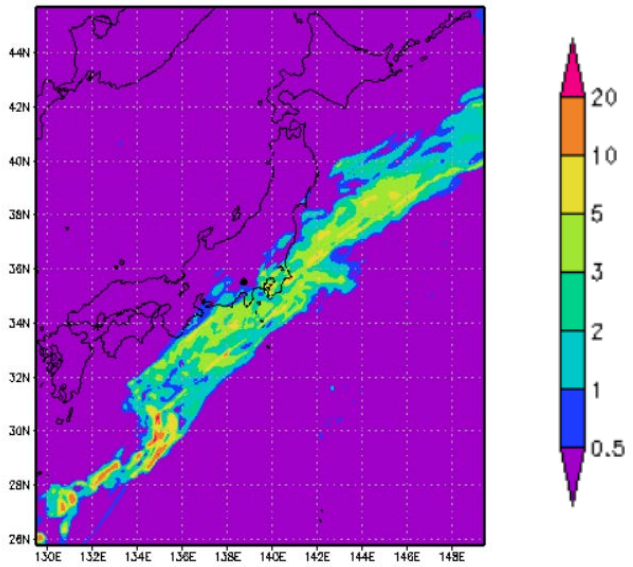
GSMAP



NICAM
Initial condition:
00UTC 17th Nov. 2019

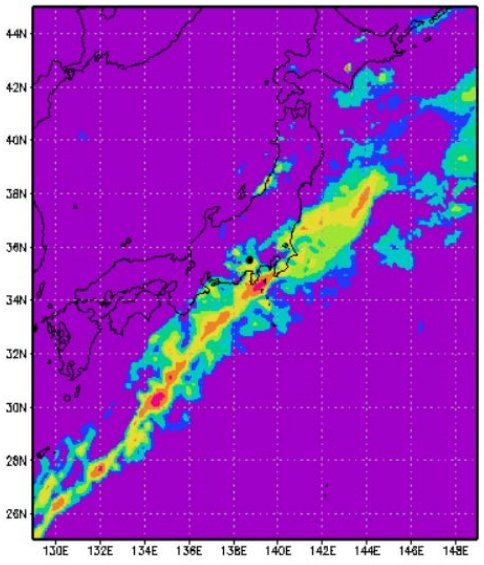


NICAM
Initial condition:
00UTC 18th Nov. 2019

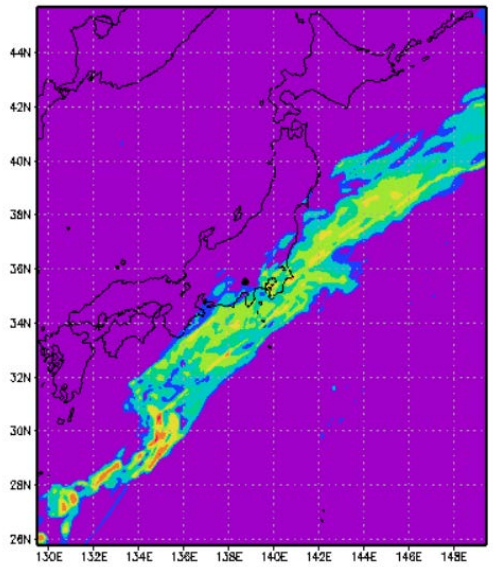


Impacts of initial conditions on the distribution of precipitation
: Snapshot of 18UTC 18th Nov.

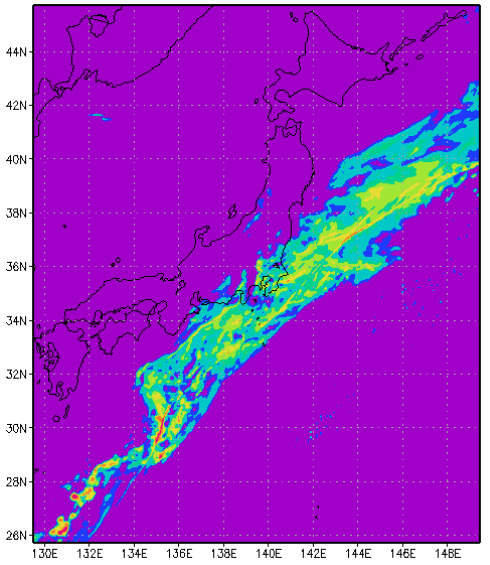
GSMAP



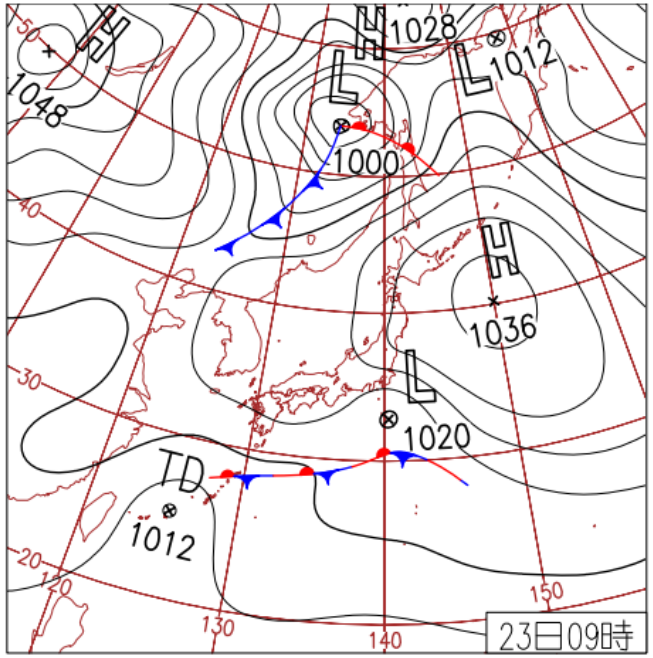
NICAM: GL8
Minimum 2.8 km



NICAM: GL9
Minimum 1.4 km



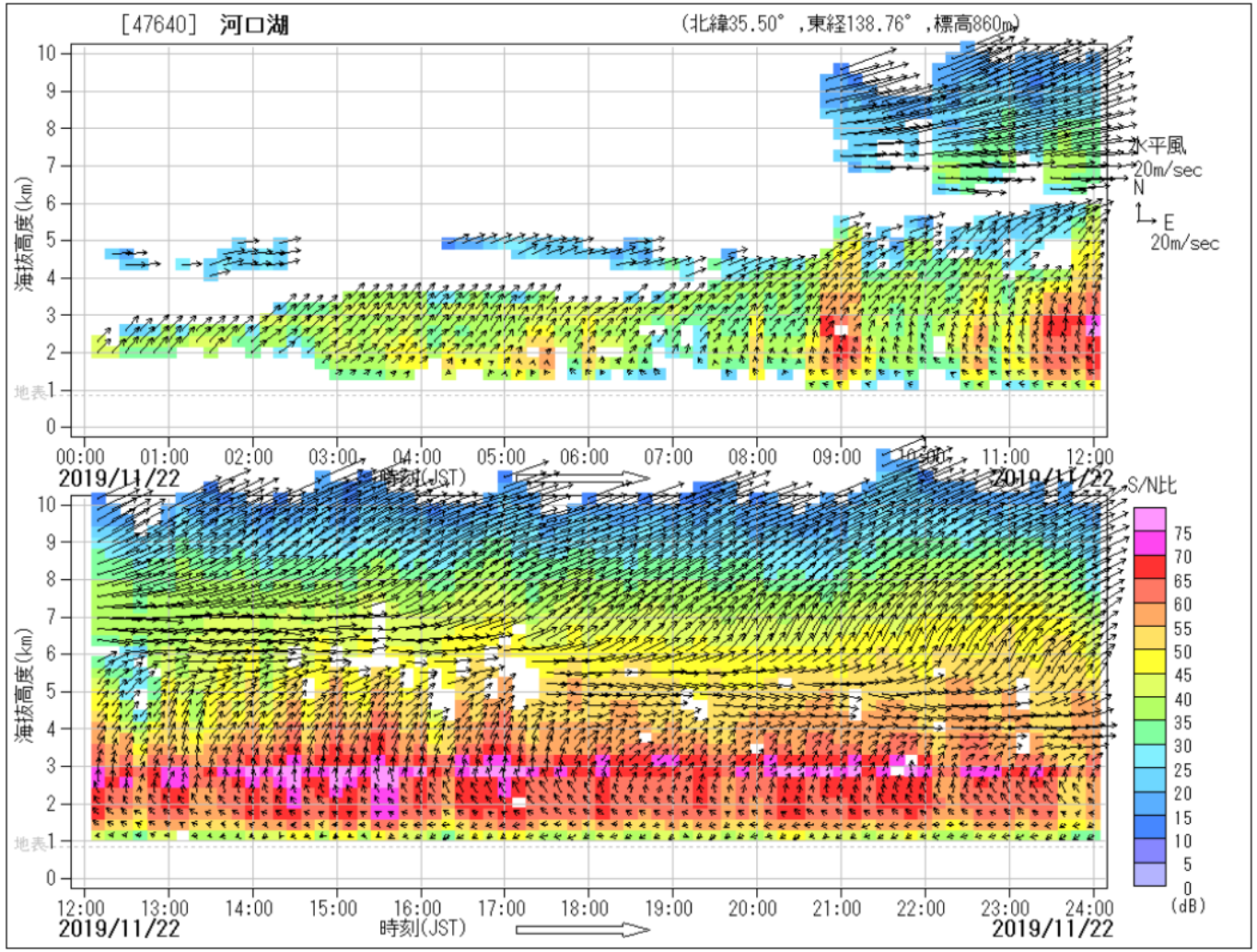
Case2: 2019/11/22



23日(土)関東で大雨の所も

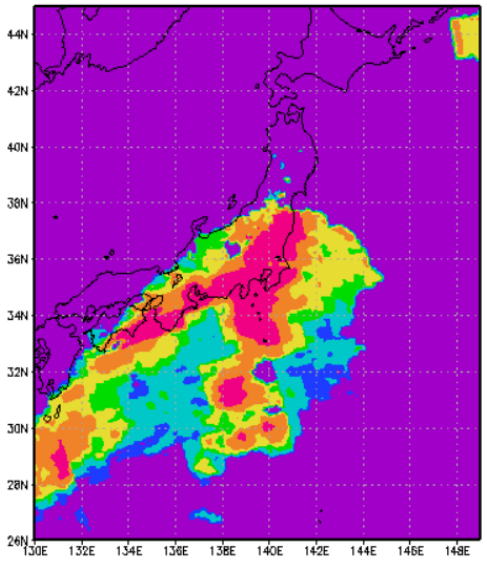
西日本、北海道は高気圧に覆われ晴れ。沖縄・奄美は熱帯低気圧の影響で、関東甲信と東北太平洋側は低気圧の影響で雨や曇り。茨城県鹿嶋の日降水量131mmは11月の1位。

WINDAS data in Kawaguchiko

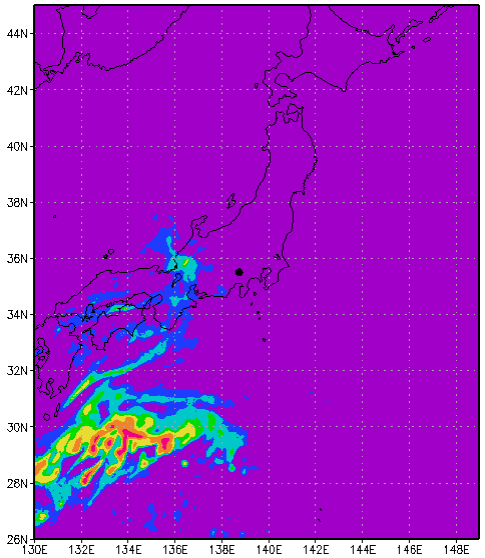


Impacts of initial conditions on the distribution of precipitation
: Snapshot of 11UTC 22th Nov.

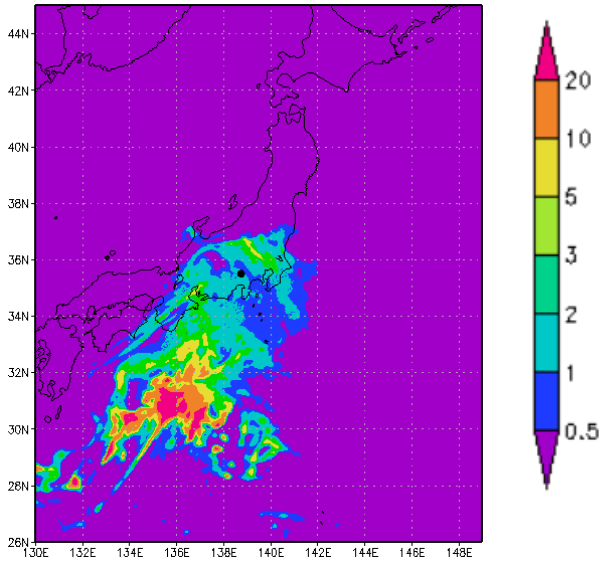
GSMAP



NICAM
Initial condition:
00UTC 21th Nov. 2019

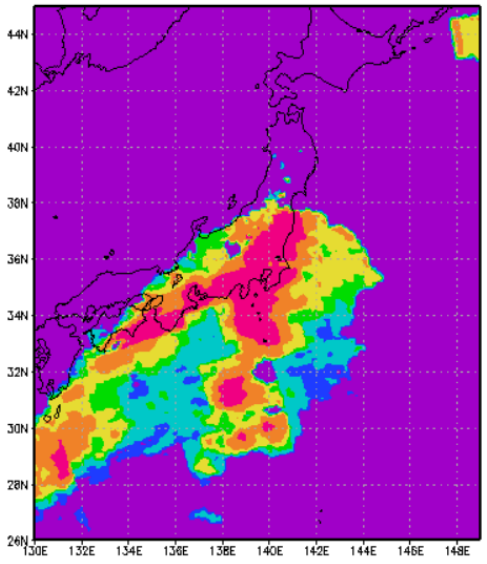


NICAM
Initial condition:
12UTC 21th Nov. 2019

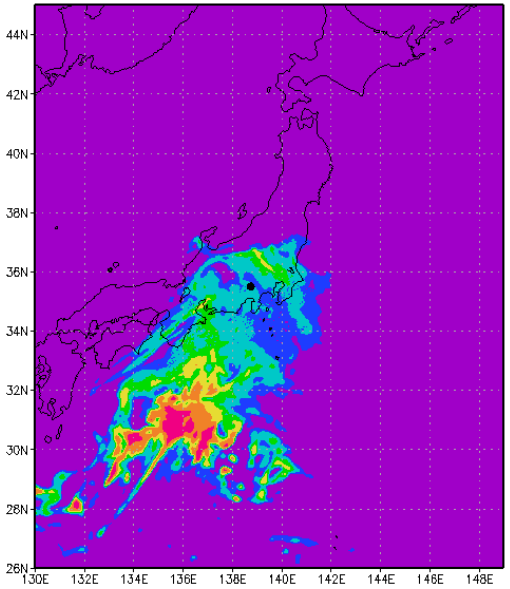


Impacts of Horizontal resolution on the distribution of precipitation : Snapshot of 11UTC 22th Nov.

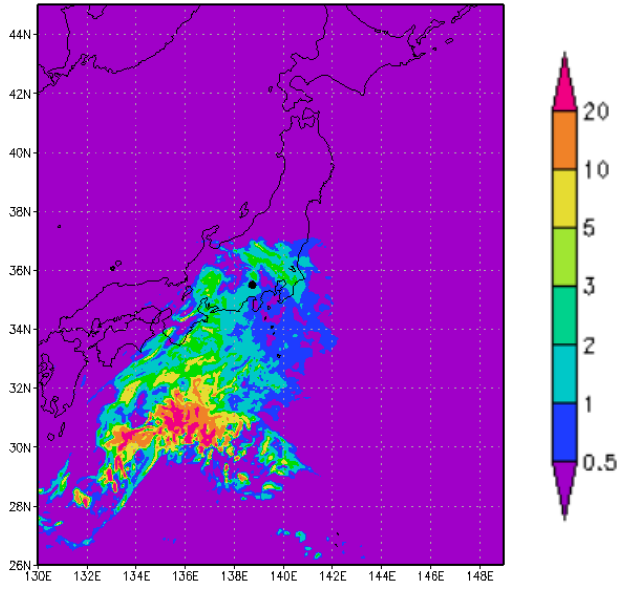
GSMAP



NICAM: GL8
Minimum 2.8 km



NICAM: GL9
Minimum 1.4 km



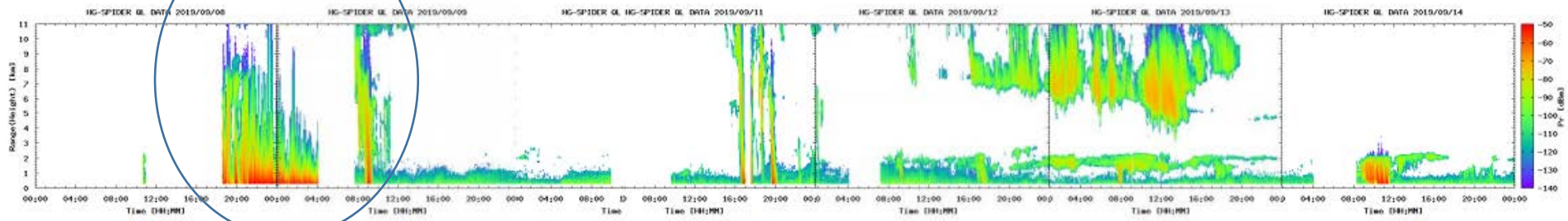
Simulations for ULTIMATE project

- Candidate cases
  - 2019/09/08-09
  - 2019/09/15-16
  - Reasons: Cloud Radar

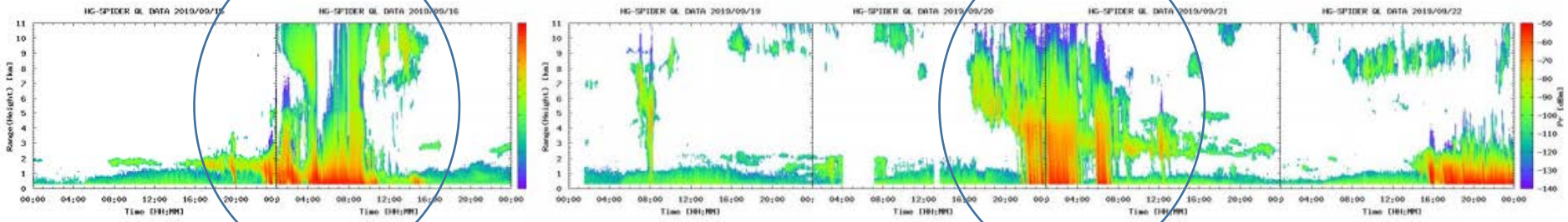
- Stretched NICAM using NCEP FNL data
  - GL8: minimum 2.8 km (done)
  - GL9: minimum 1.4 km (done)
  - GL10: minimum 700 m (planning)

  The center of the stretched grid is in the NICT (Kogane)

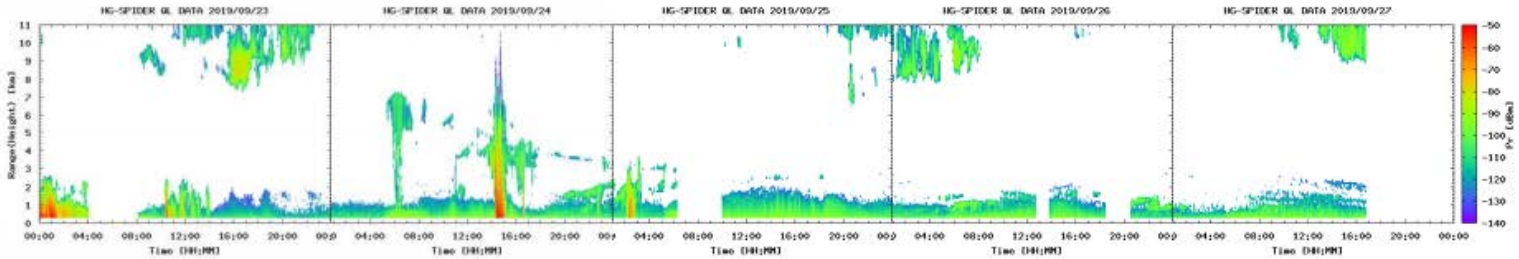
Alternative cases
CPR observation in Sep. 2019
(From Ohno-san's slides)



9/8 9/9 9/10 9/11 9/12 9/13 9/14

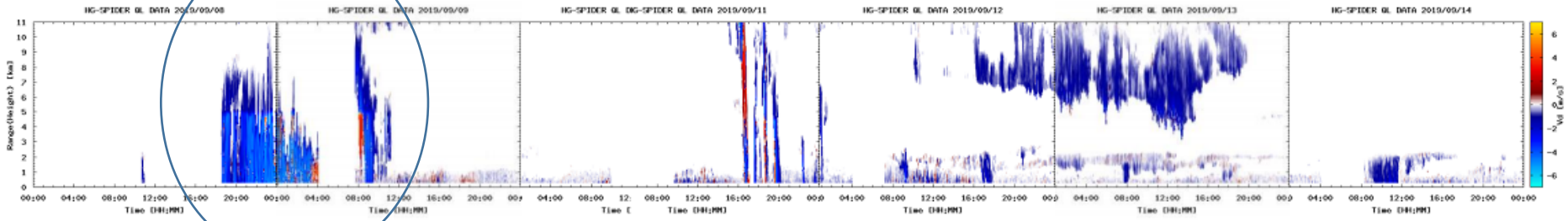


9/15 9/16 9/19 9/20 9/21 9/22

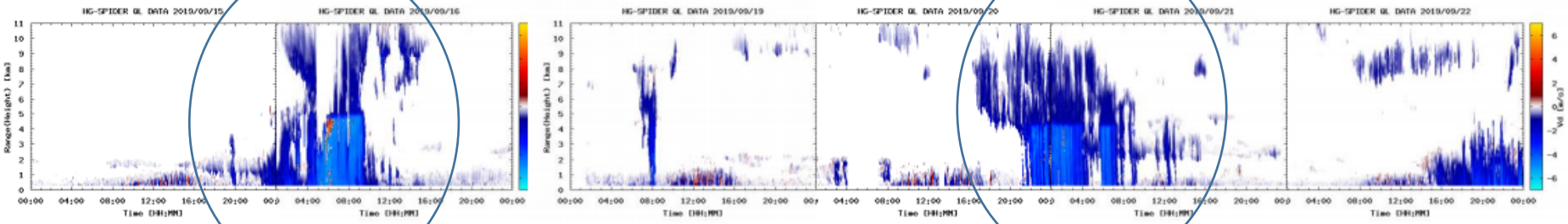


9/23 9/24 9/25 9/26 9/27

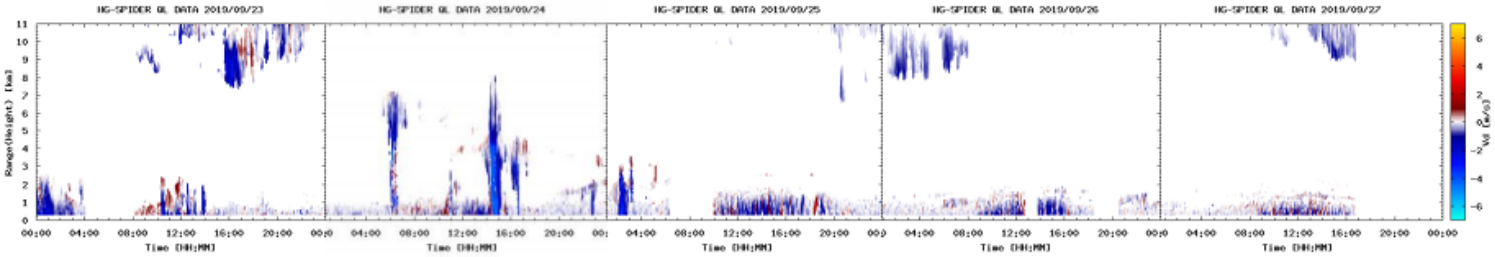
Alternative cases
Doppler velocity of CPR in Sep. 2019
(From Ohno-san's slides)



9/8 9/9 9/10 9/11 9/12 9/13 9/14



9/15 9/16 9/19 9/20 9/21 9/22

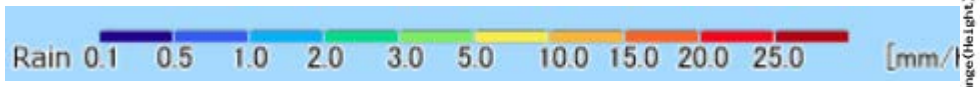


9/23 9/24 9/25 9/26 9/27

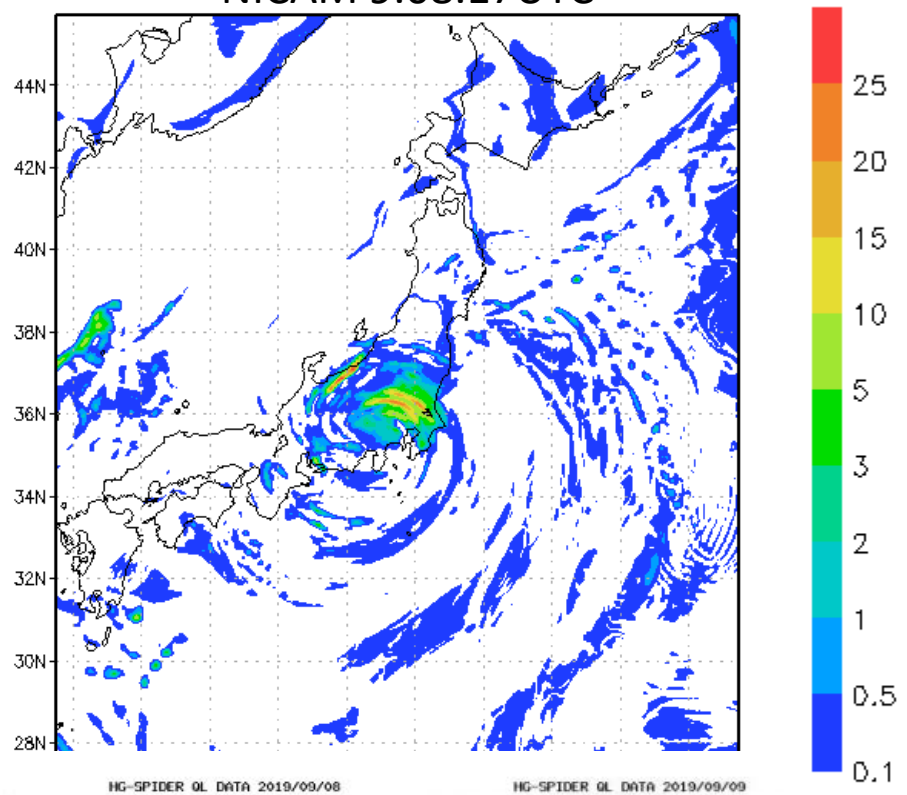
The first case: 8th Sep. 2019

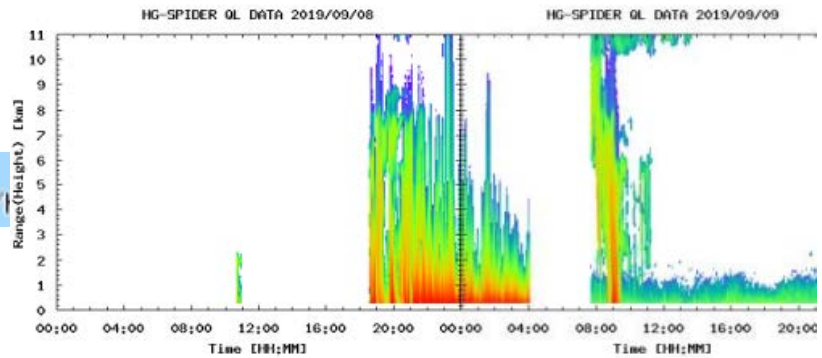
Initial condition: 190908_00UTC

GSMAP 9.08.17UTC



NICAM 9.08.17UTC

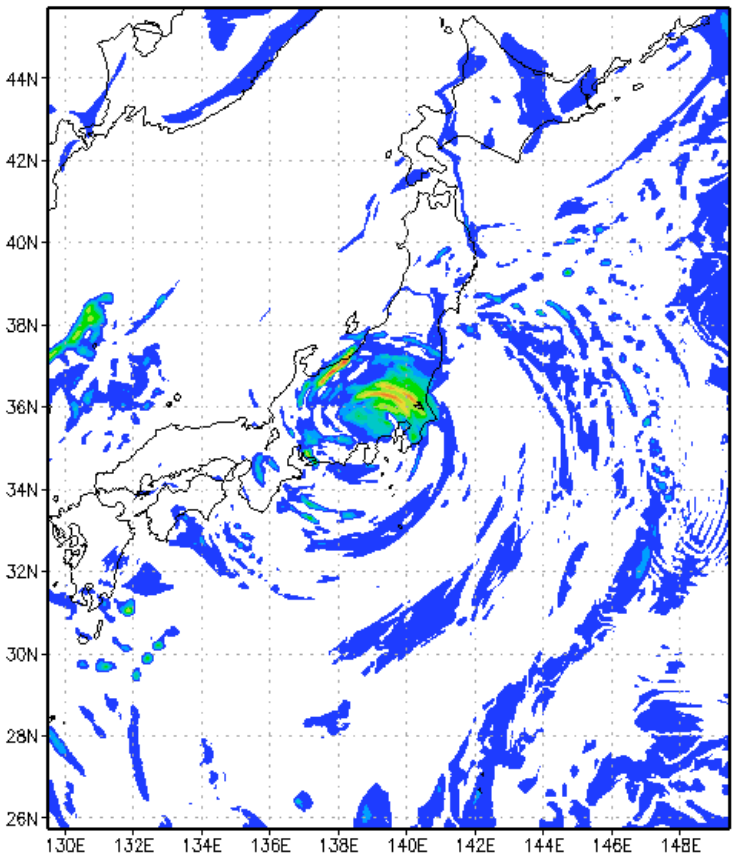




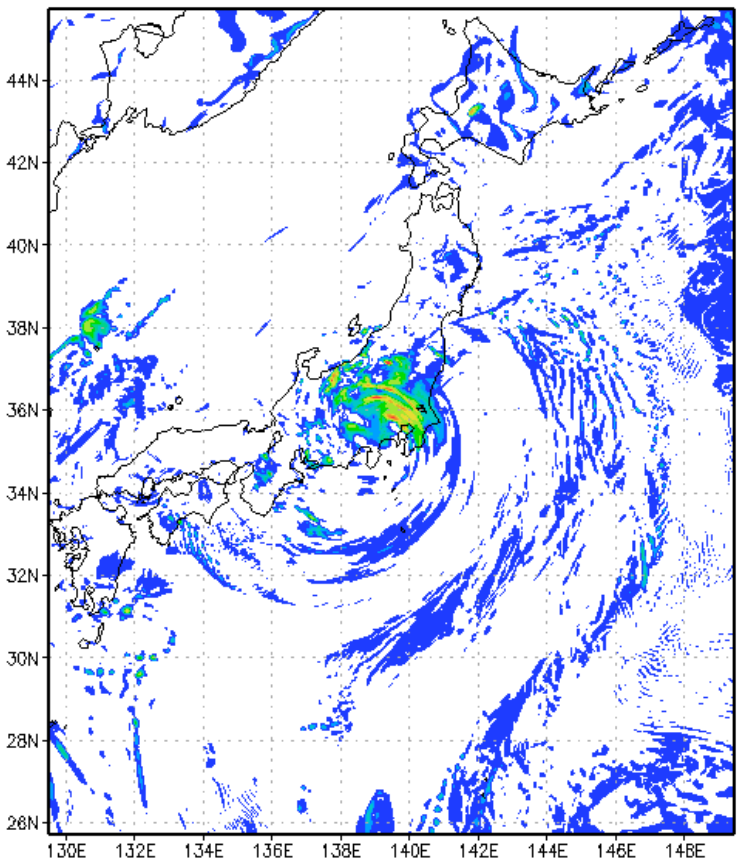
9/8 **9/9**

The first case: 17 UTC 8th Sep. 2019

GL8



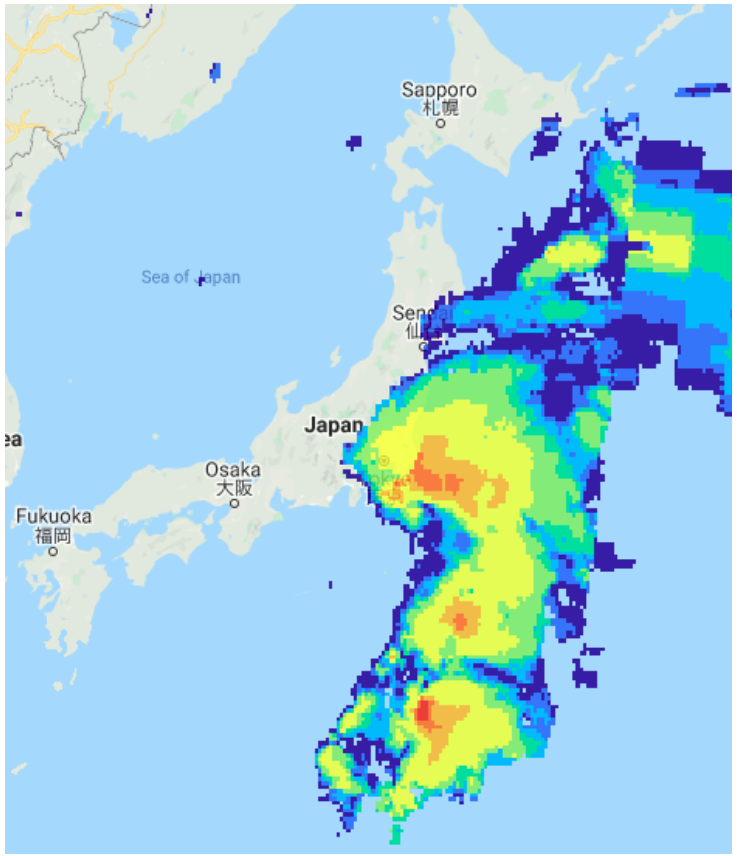
GL9



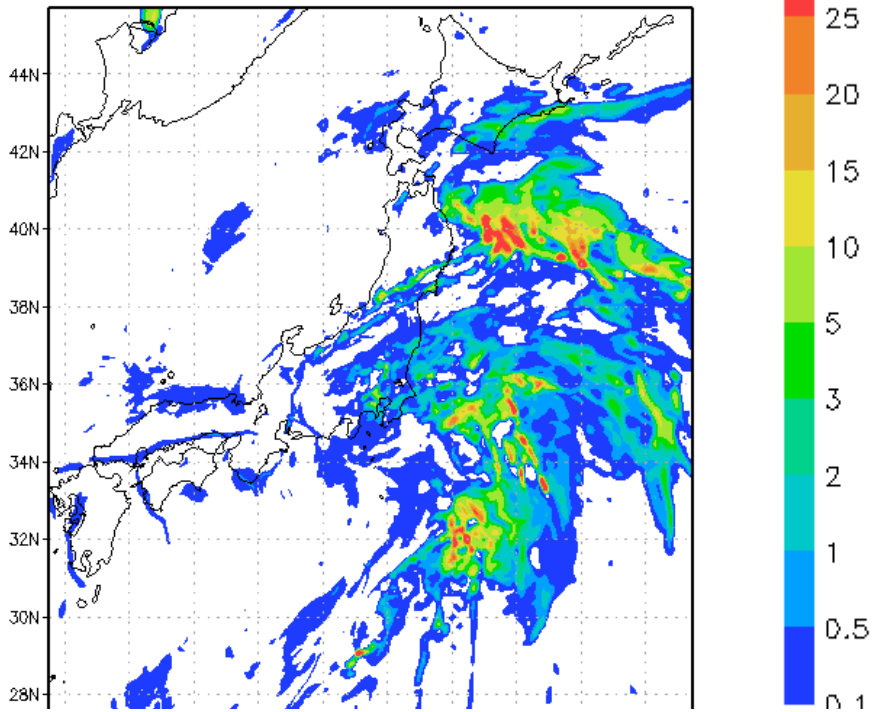
The second case: 16th Sep. 2019

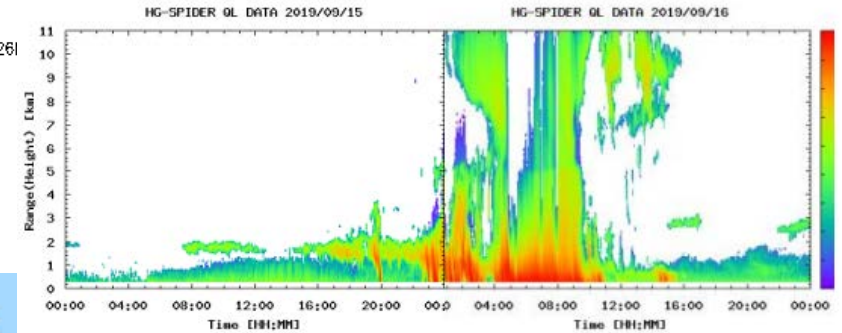
Initial condition: 190915_06UTC

GSMAP 9.15.22UTC



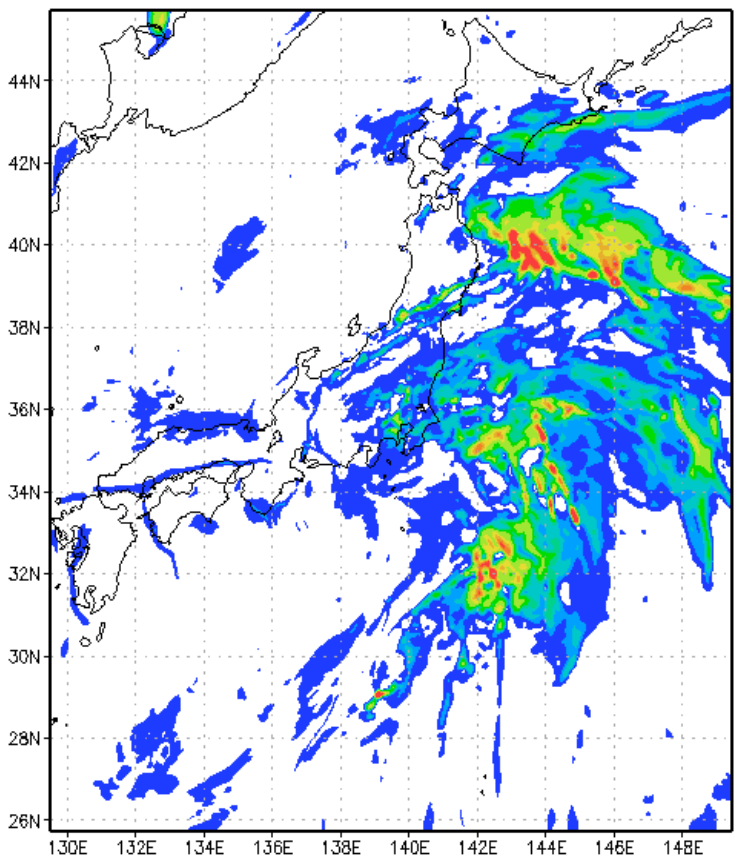
NICAM 9.15.22UTC



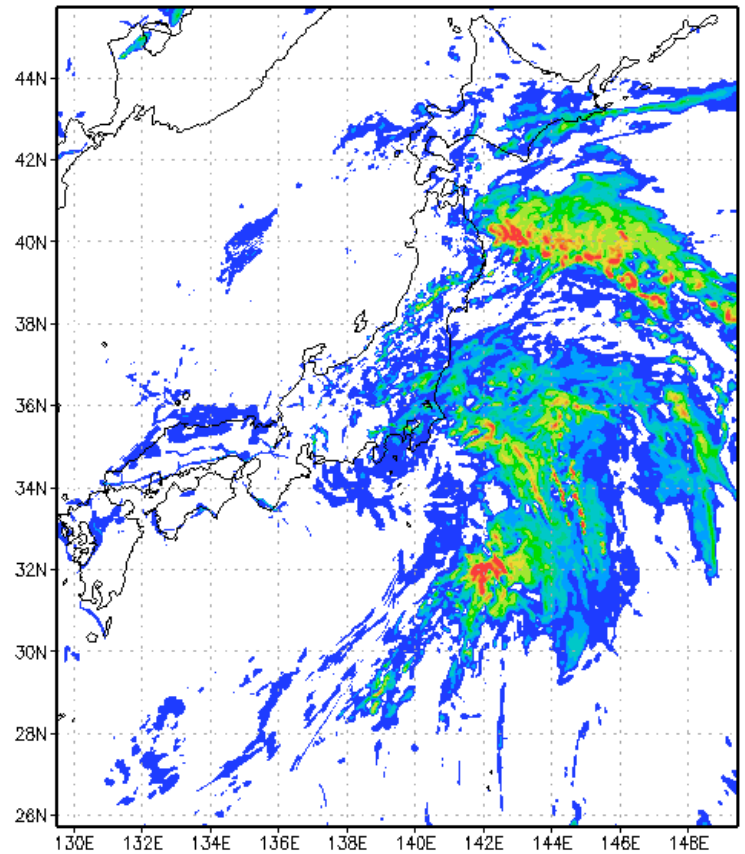


9/15 **9/16**

GL8


44N
42N
40N
38N
36N
34N
32N
30N
28N
26N
130E
132E
134E
136E
138E
140E
142E
144E
146E
148E

GL9

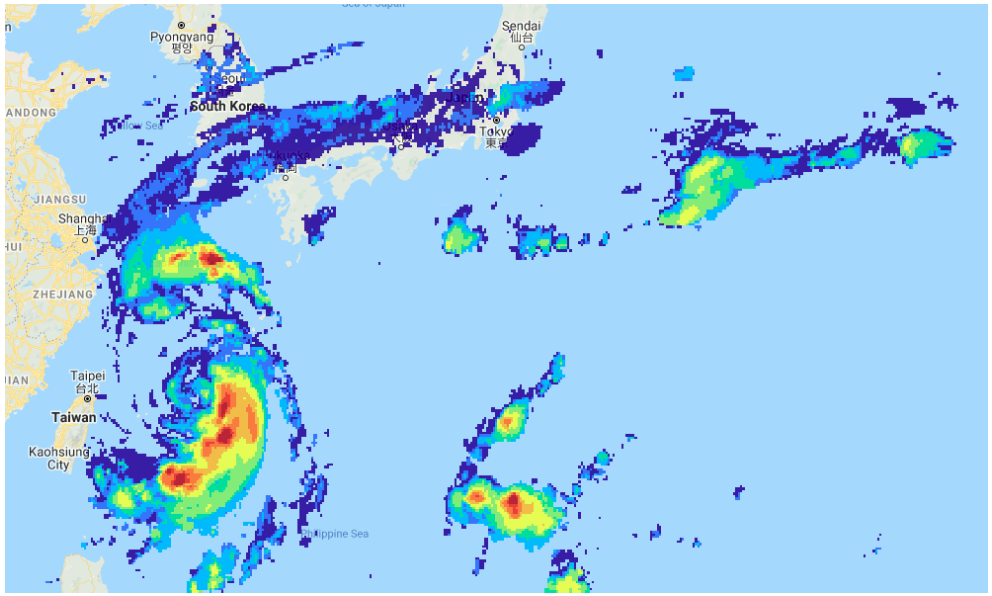

44N
42N
40N
38N
36N
34N
32N
30N
28N
26N
130E
132E
134E
136E
138E
140E
142E
144E
146E
148E

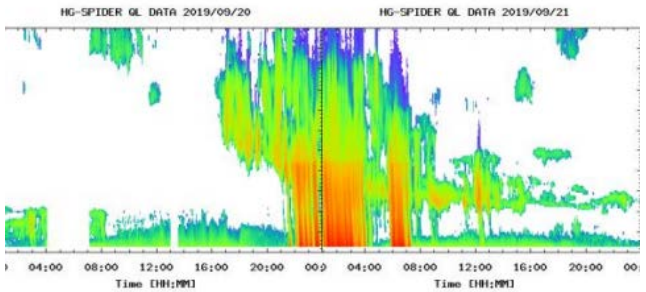

25
20
15
10
5
3
2
1
0.5
0.1

The third case: 21th Sep. 2019

Initial condition: 190920_00UTC

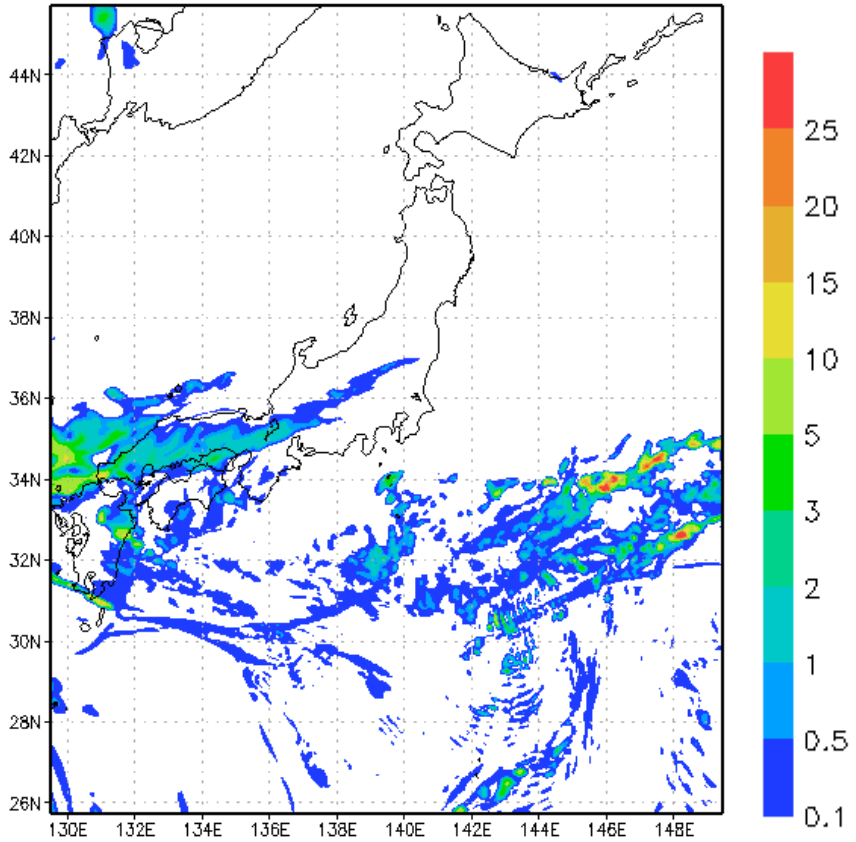
GSMAP 9.20.18UTC





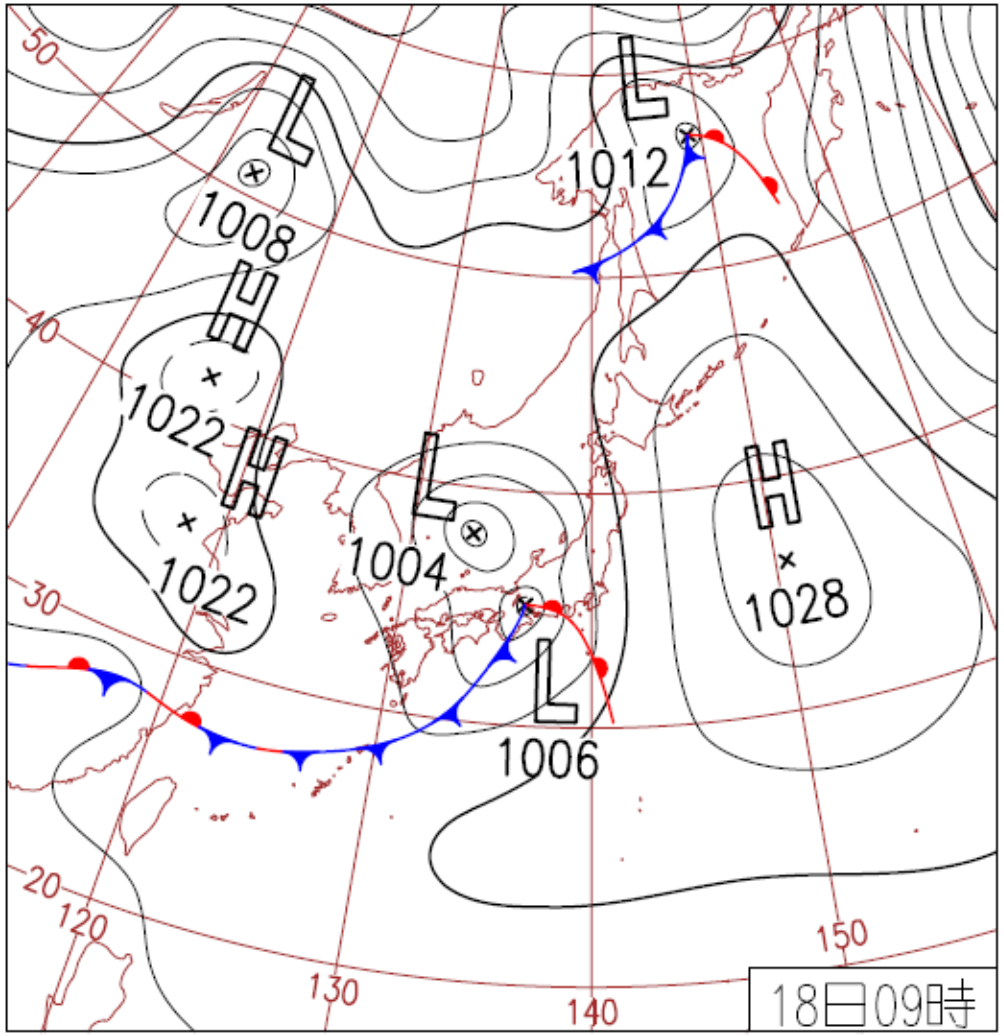
9/20 **9/21**

NICAM 9.20.18UTC



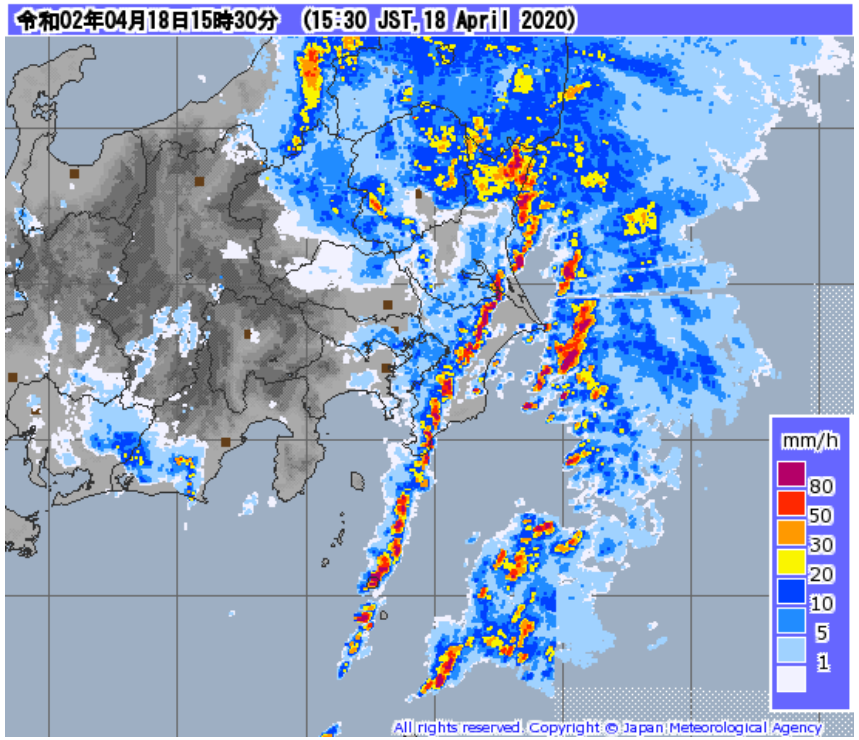
Case 3

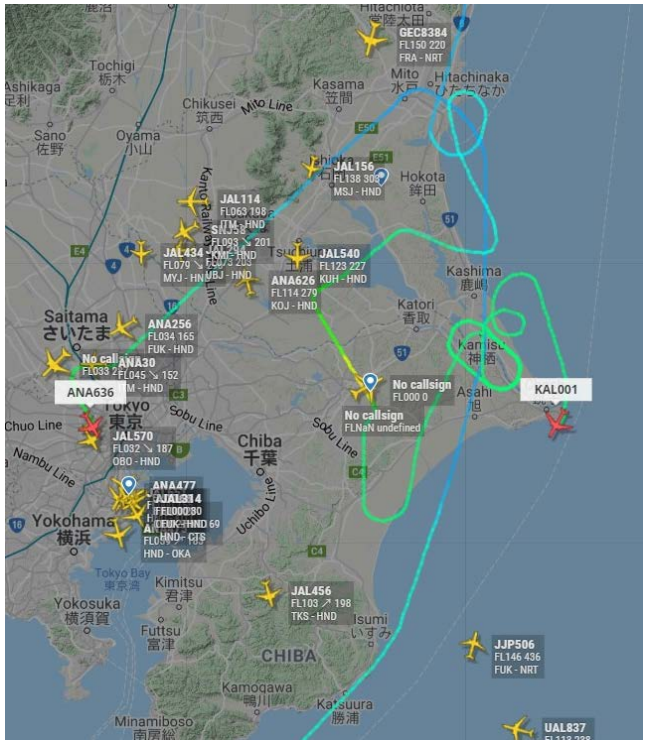
- 2020/04/18



18日(土)東日本～北日本で大雨

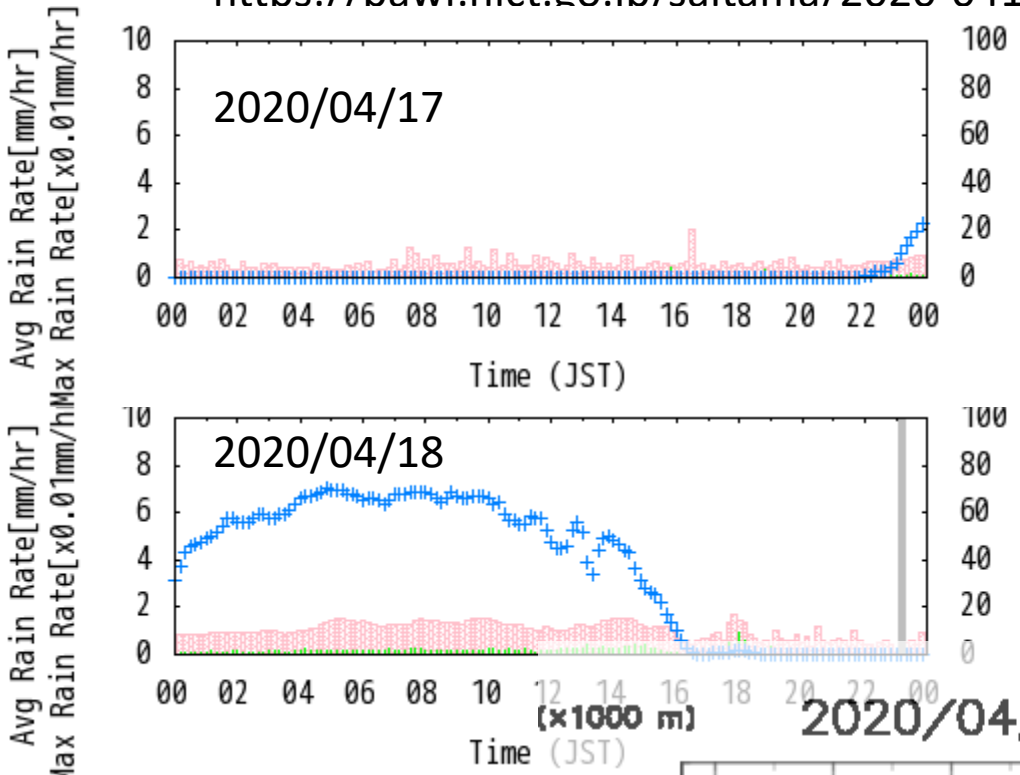
低気圧や前線の影響で中国・四国～東北は広く雨。茨城県花園で54.5mm/1hの非常に激しい雨。静岡県天城山の日降水量256.5mm。東～北日本では日降水量が4月1位の所も。

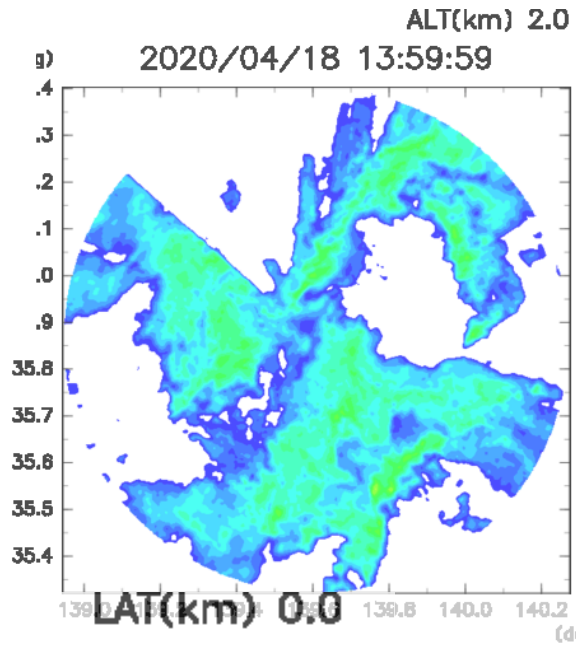


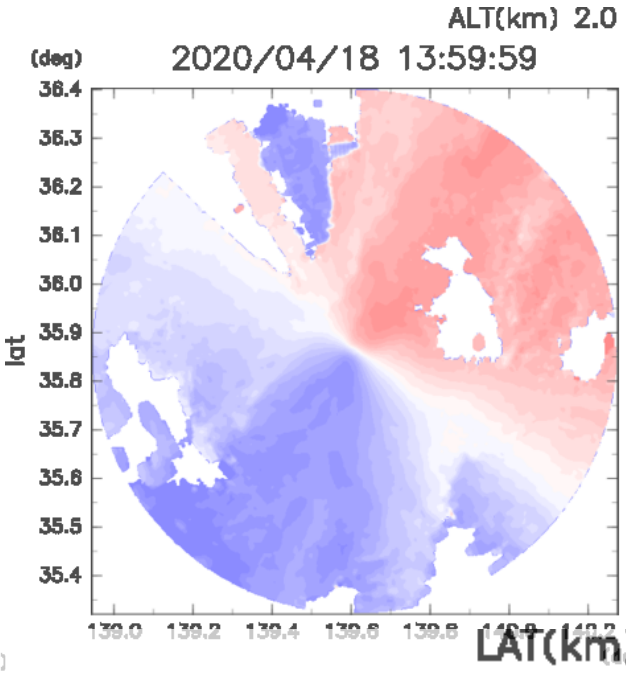


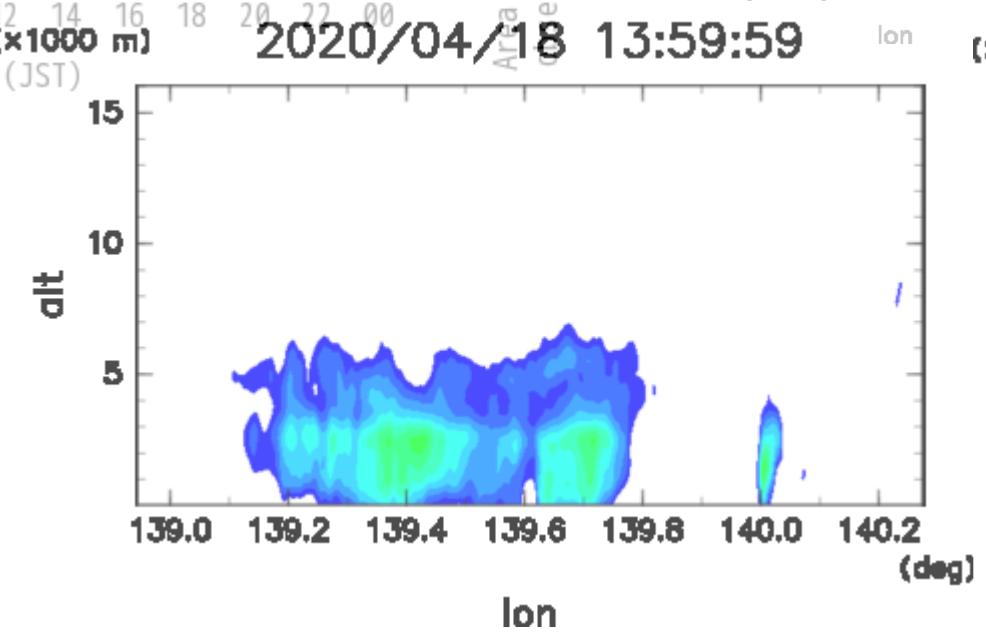
気象レーダーによって解析されたシビアストームと航空機経路(2020年4月18日）

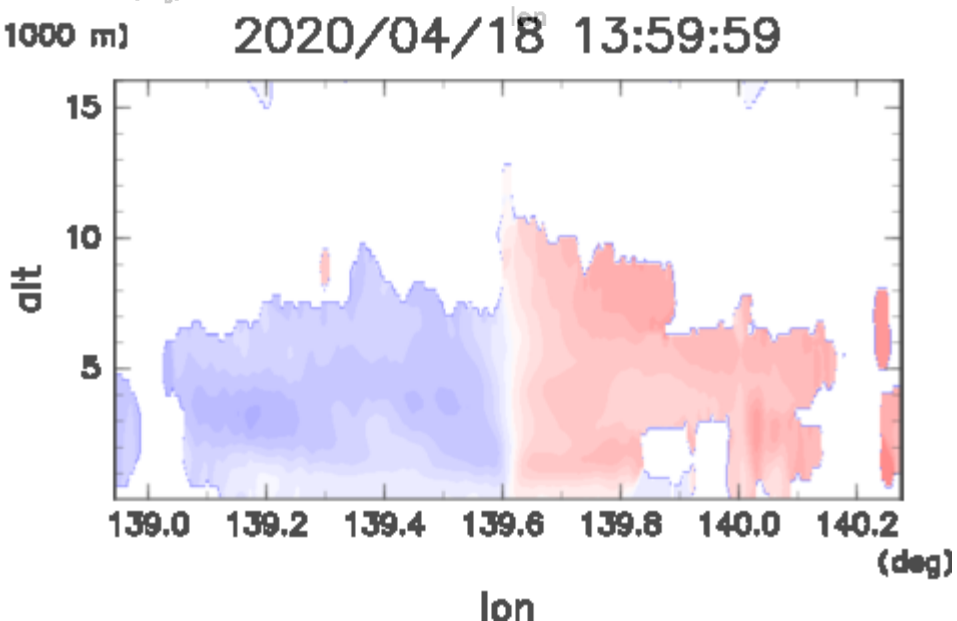
https://pawr.nict.go.jp/saitama/2020-0418/coastline.html











2020 JpGU Presentation

Preliminary Formulation of the

BiLateral Operational Storm-Scale Observation and Modeling (BLOSSOM) Project

Core Team: T. Matsui, D. Wolff, K. Mohr, S. Lang

Collaborators: M. Zhang, S. Xie, B Dolan, V. Chandra

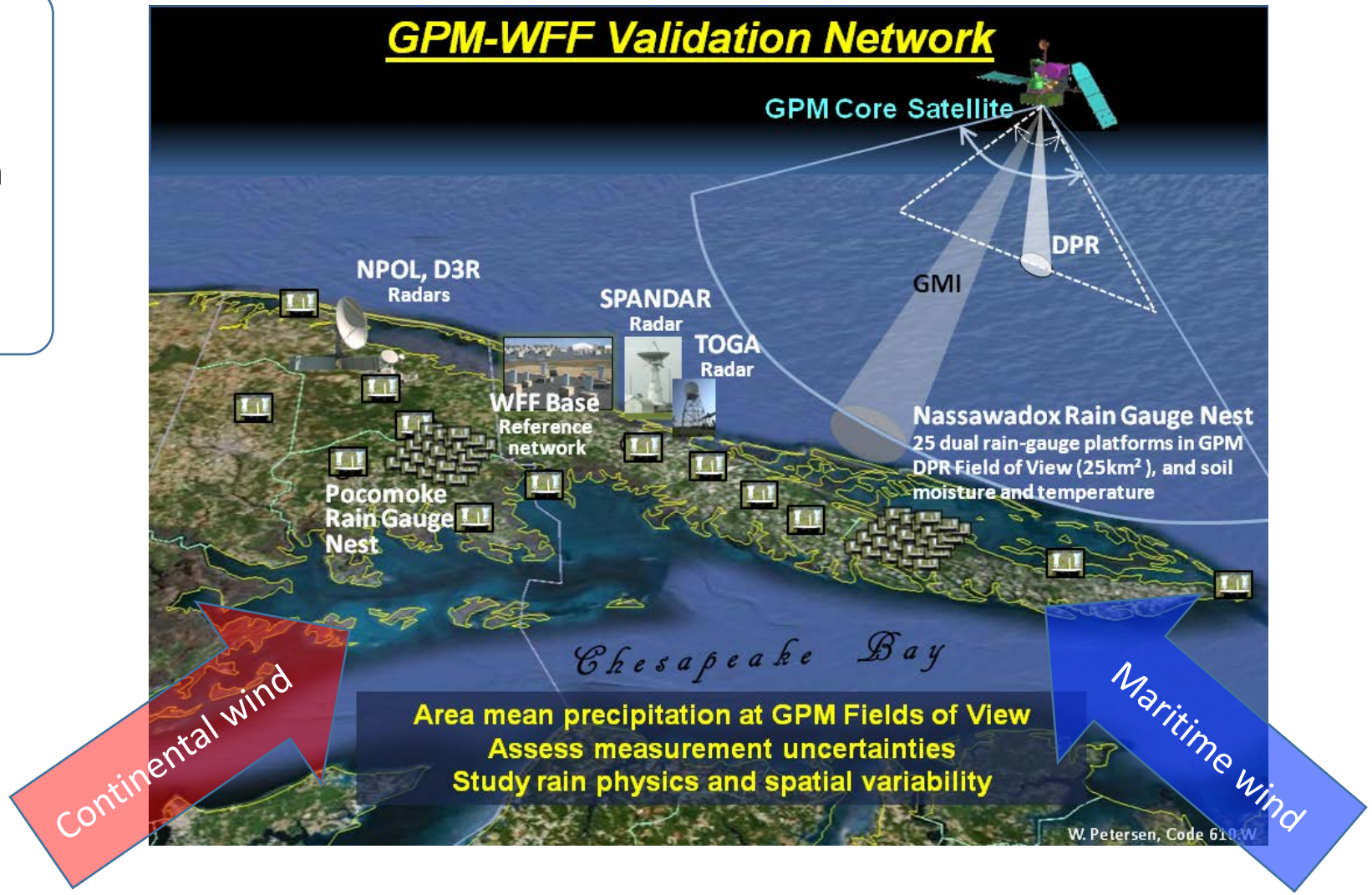
NASA Wallops Flight Facility (WFF)

Precipitation Systems

- Continental and maritime organized convection
- Sea-breeze-driven convection
- Mid-latitude frontal systems
- Winter-time nor'easters
- Tropical cyclones

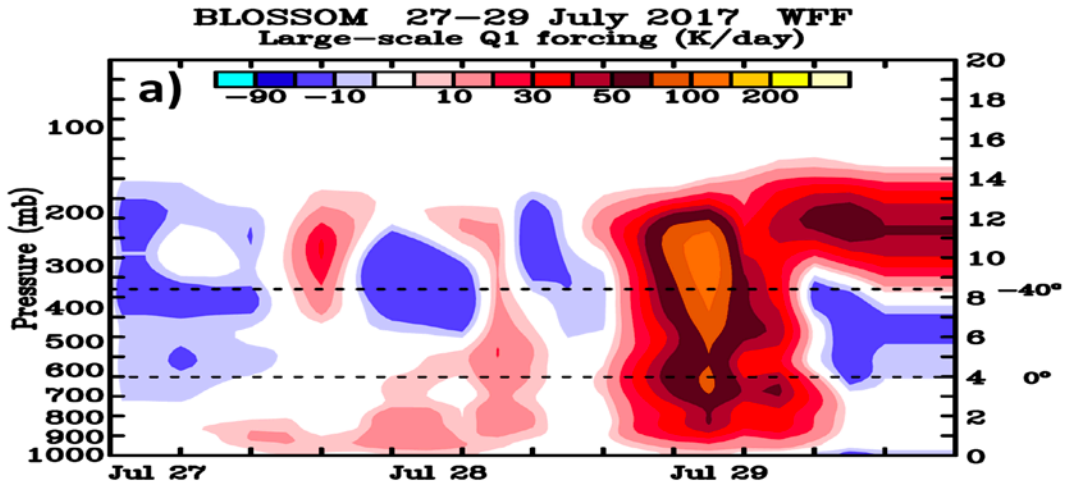
World-Class instruments

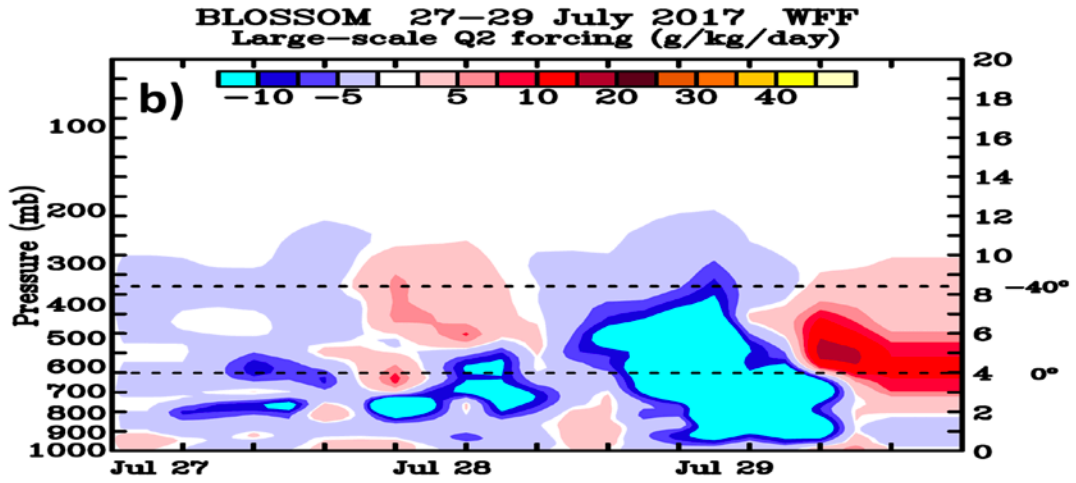
- **Radar**: NPOL, D3R, MRR
- **In-situ**: 2DVD/Parsivel/PIP, Gauge, All-in-One
- **Satellites**: GPM, GOES-R, Terra/Aqua/Suomi
- **Trailers**: SMART, COMMIT, and ACHIEVE

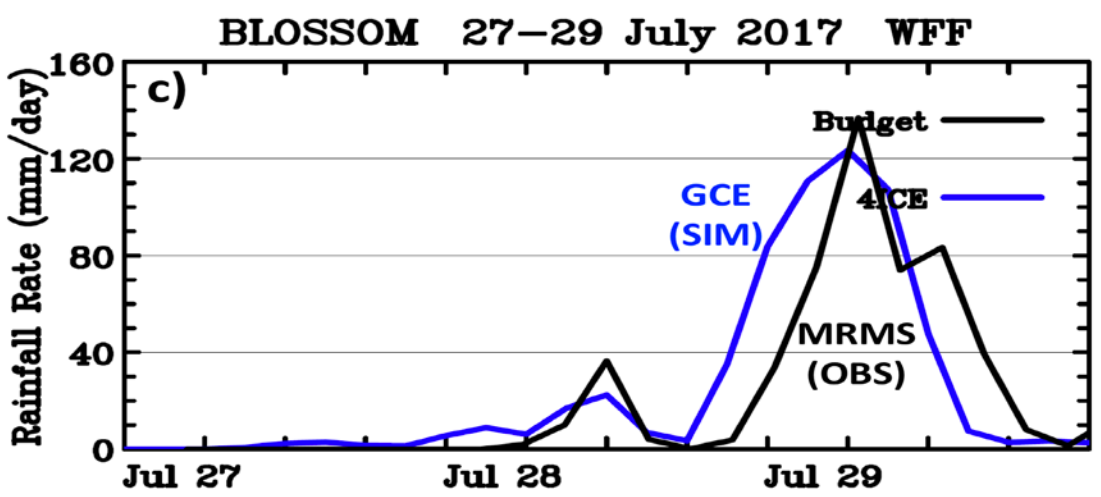


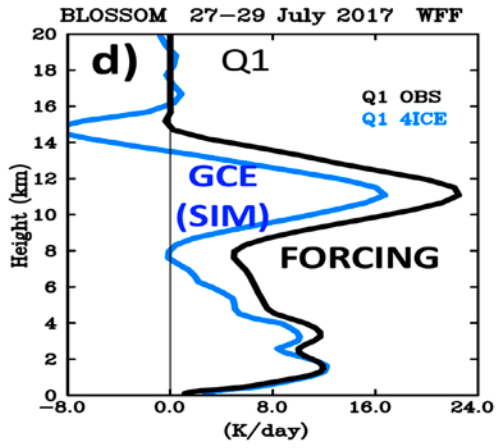
Generating Large Scale Forcing through VARNAL

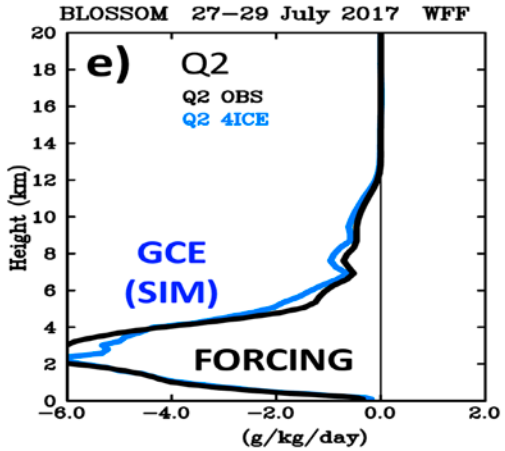
MERRA2+MRMS +CERES











MERRA2-based large-scale forcing of a) Q1 and b) Q2 budget profiles from VARNAL.

c) Time series of surface rainfall generated by Goddard Cumulus Ensemble (GCE) simulations and observed by the MRMS rainfall data. Time integrated d) Q1 and e) Q2 profiles from the GCE simulation and large-scale forcing.

Model Validation Flow

GCE Output

G-SDSU frame

GCE Interface

Account DSD, density, phase, shape of original microphysics

GPM Simulator

POLARRIS*f*

GV Simulator

Statistical composites for convective and stratiform pixels

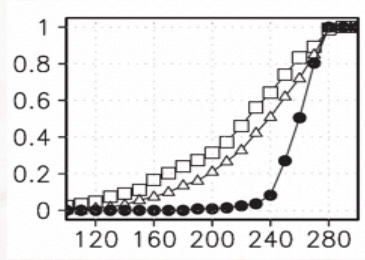
C/S

*i*POLARRIS

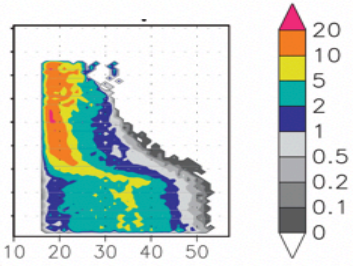
C/S

statistical composites for convective and stratiform pixels

Tb histogram

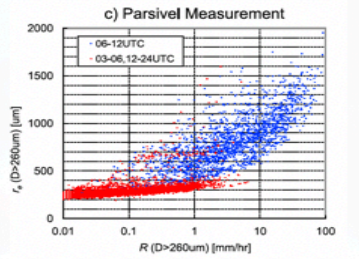


DPR CFAD

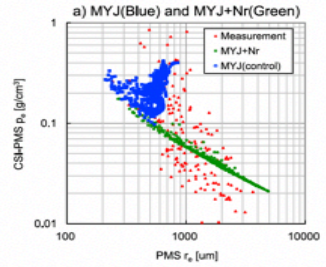


Matsui et al. 2009

P-re diagram

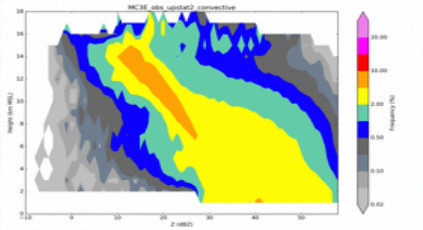


re-ρ diagram

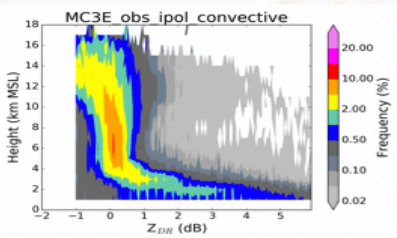


Iguchi et al. 2012a.b

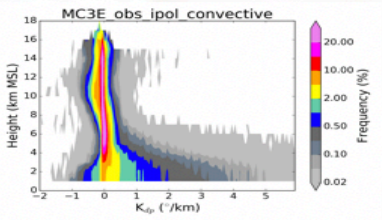
Z CFAD



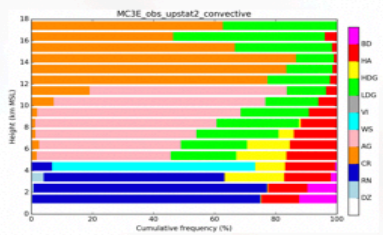
Zdr CFAD



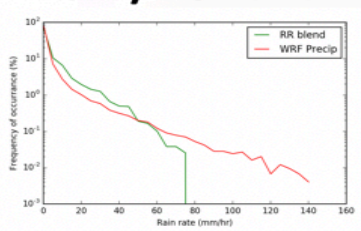
Kdp CFAD



HID SFAD



Rain / DSD PDF



Matsui et al. 2018

Applications of BLOSSOM

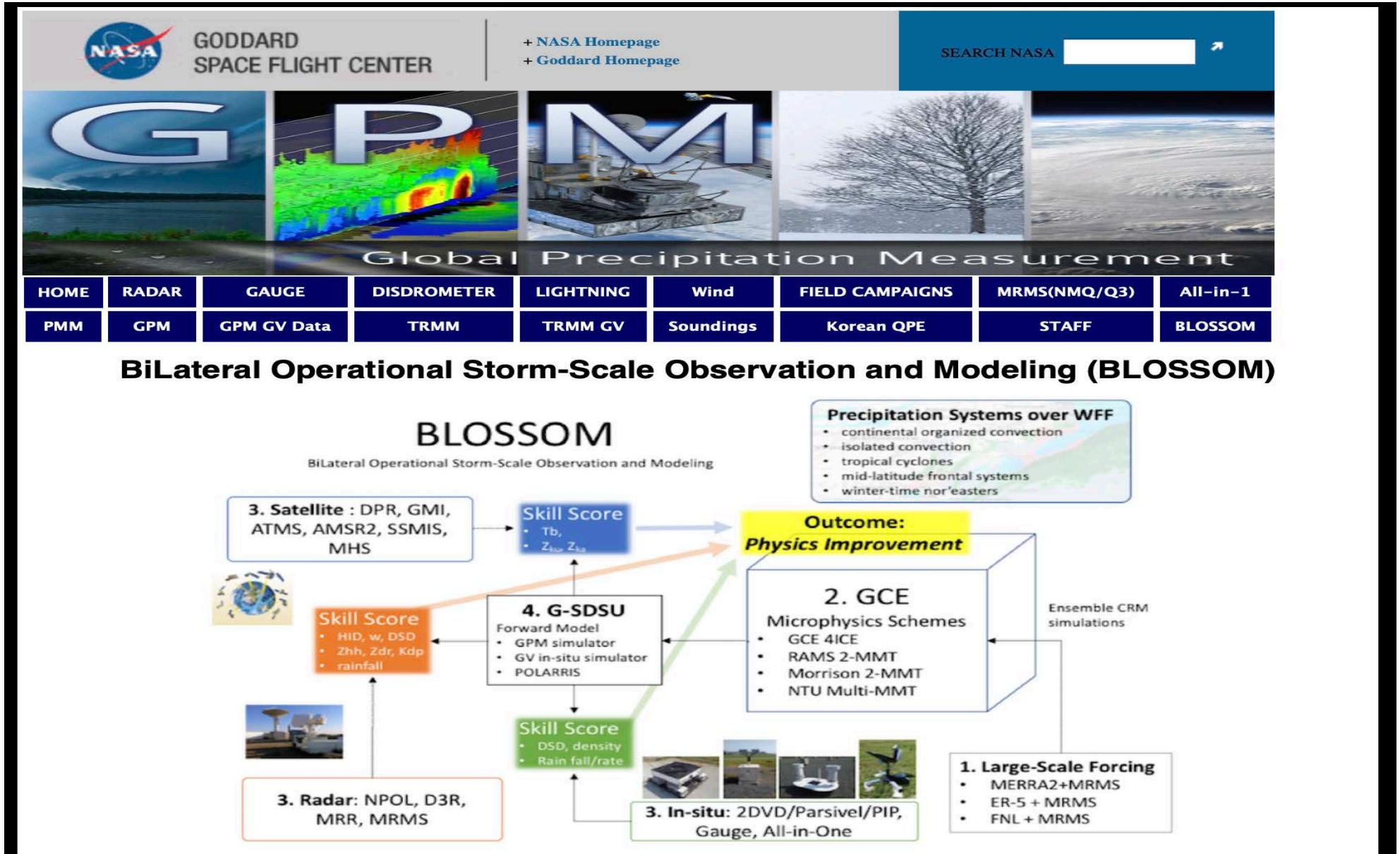
Remote Sensing

- For Satellite Remote Sensing
  - Verify operational satellite products from ground-based observations.
  - Design future satellite missions from the ground-based radar and CRM modeling using satellite simulators.
- For Ground-based remote sensing
  - Elucidate unobservable cloud processes and properties from process models
  - Develop more complex algorithms from the process modeling and forward models.

Atmospheric Modeling

- Process Modeling (CRM, LES)
  - Microphysics evaluation and development.
  - Study dependency of resolution and turbulence.
  - Study convection process (thermal, PBL, and microphysics).
- Climate Modeling (SCM)
  - Evaluate mean state parameters from remote sensing data with different parameter spaces.
  - Develop physics parameterization and sub-grid co-variability through SCM-LES comparison.

https://wallops-prf.gsfc.nasa.gov/BLOSSOM/index.html



Summary

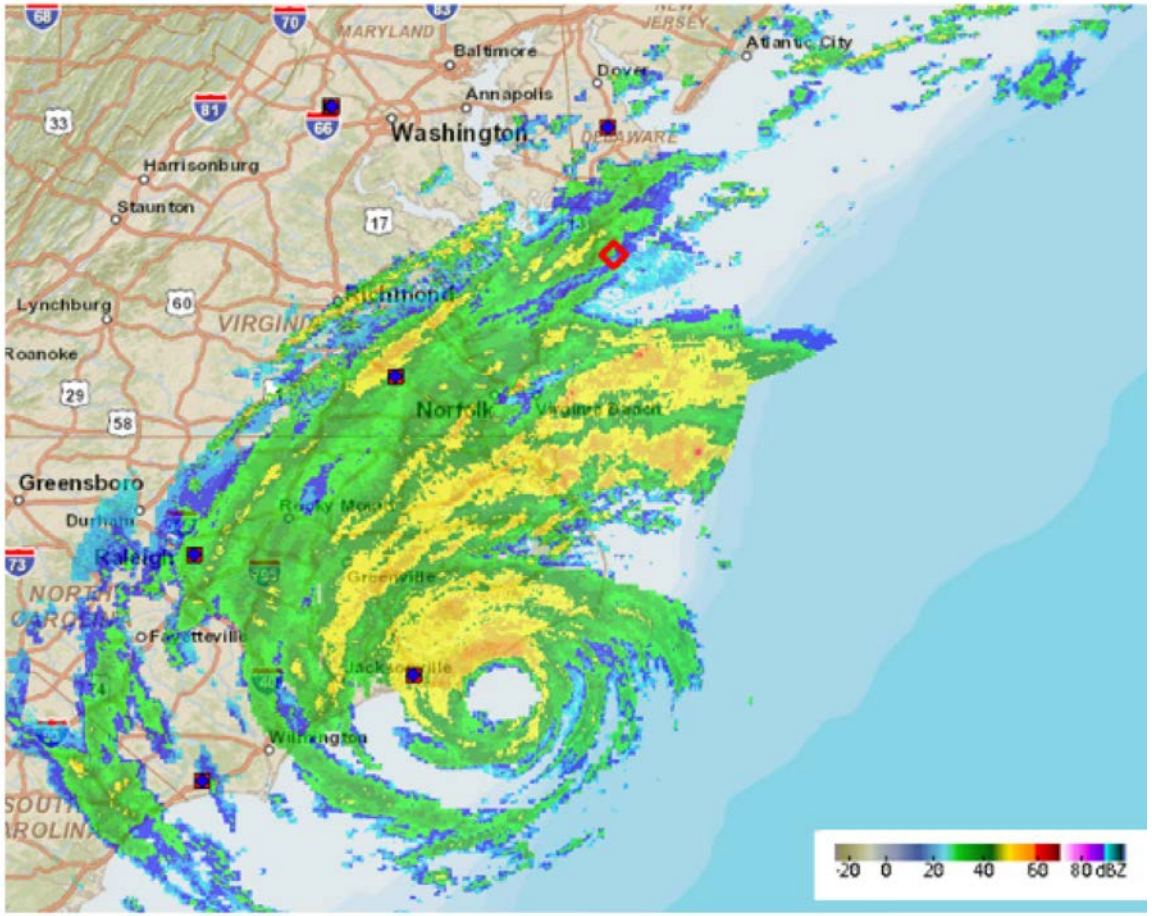
- Robustness and uncertainties of GCRMs
- Comparison of clouds and precipitation across the DYAMOND models
- All models look good cloud distribution compared to Himawari, OLR, and precipitation.
- However, a lot of variability exists for vertical structure of clouds.
- Cloud evaluations using various observations are required.

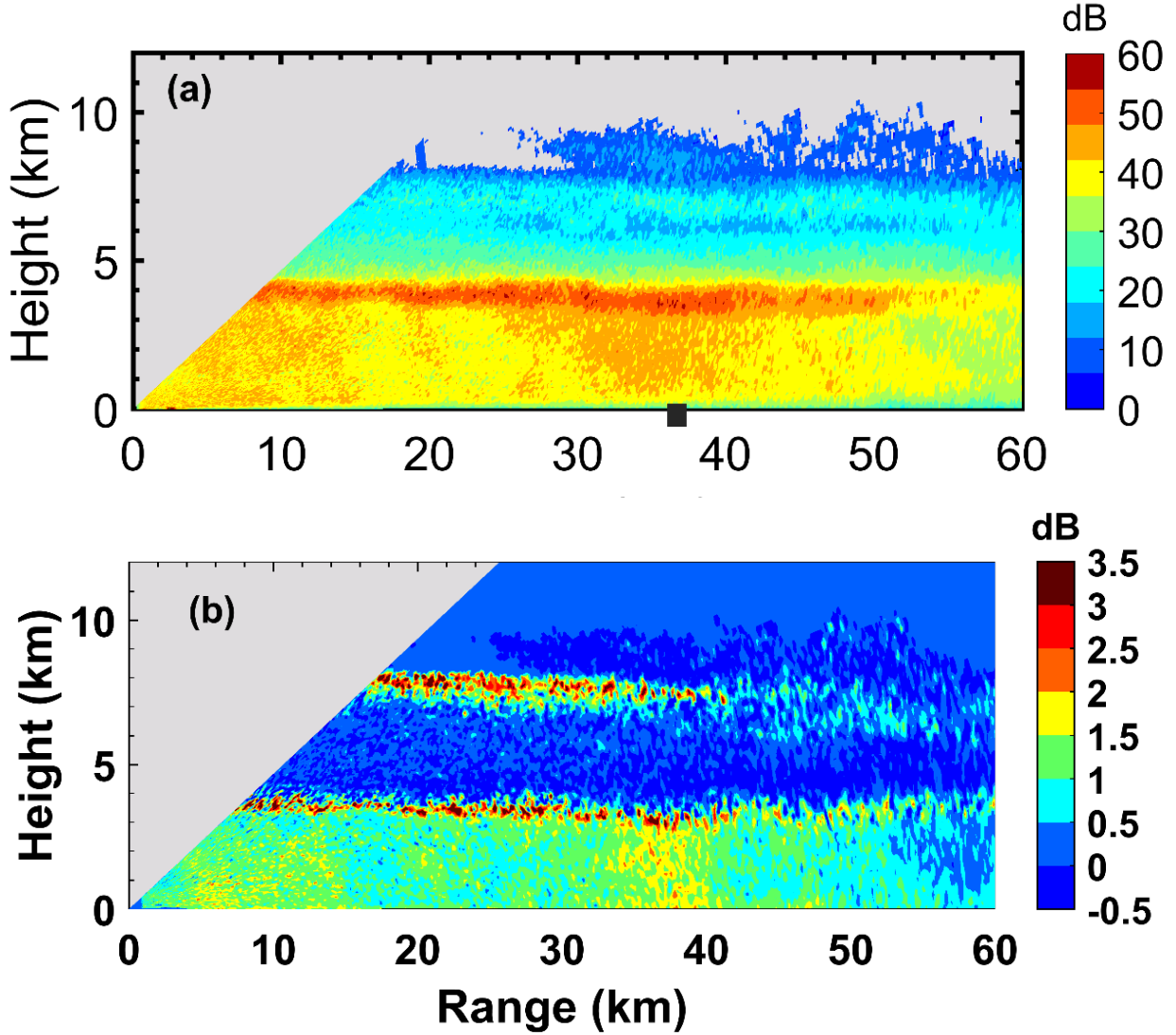
Evaluation and improvement of clouds

- Use of multiple satellite observations and satellite simulators
- Use of grand observations, remote sensing and in situ data
- Use of the seamless approach with a unified global and regional model
- The ULTIMATE initiative is proposed

Hurricane Dorian Outer Rain Band Observations and 1D Particle Model Simulations: A Case Study

Viswanathan Bringi , Axel Seifert, Wei Wu, Merhala Thurai, Gwo-Jong Huang and Christoph Siewert

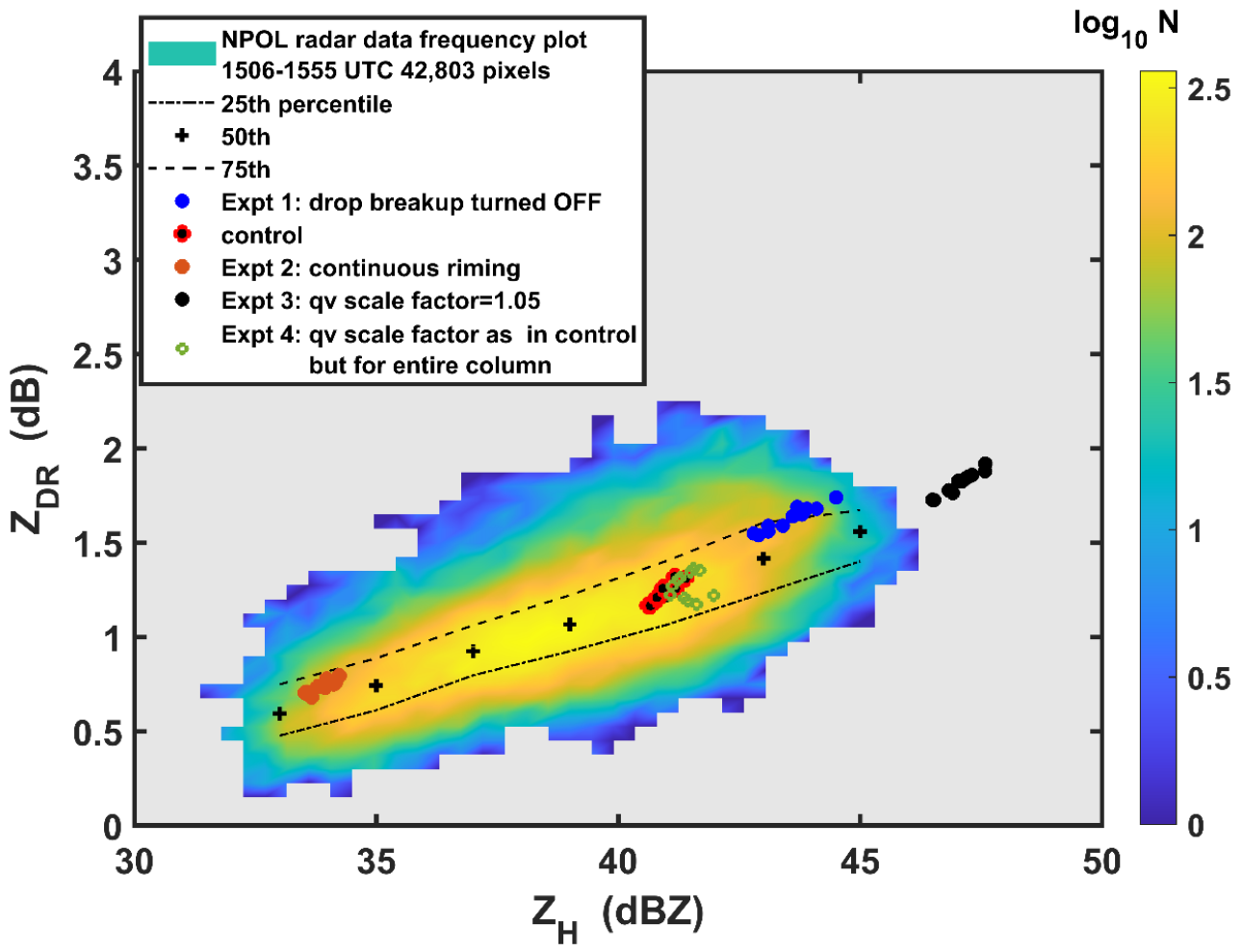




Bringi et al. (2020, Atmosphere)

Table 1. Description of the control run and the numerical "experimental" runs (1 through 4).

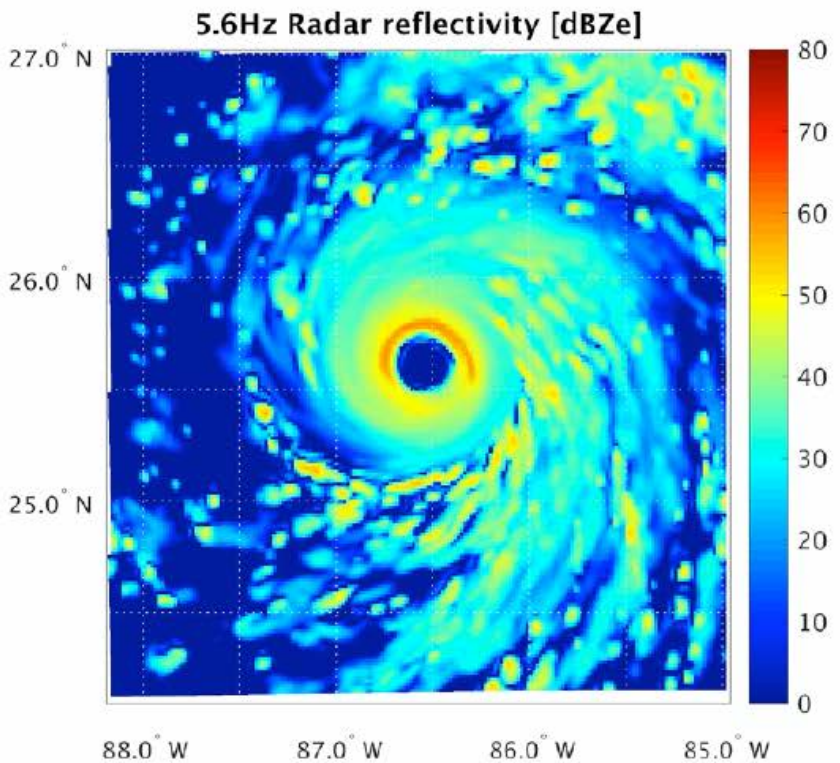
	Drop Break-up	Riming	Scale Factor Applied to the Moisture Profile (or qv Scale Factor)	Height in Column above Which the qv Scale Factor Is Applied
Control	†McFarquhar [29]	stochastic	1.035	2000 m
Experiment 1	Turn OFF breakup	"	"	"
Experiment 2	†McFarquhar [29]	continuous	"	"
Experiment 3	"	stochastic	1.05	"
Experiment 4	"	"	"	0 (i.e., applied to entire column)



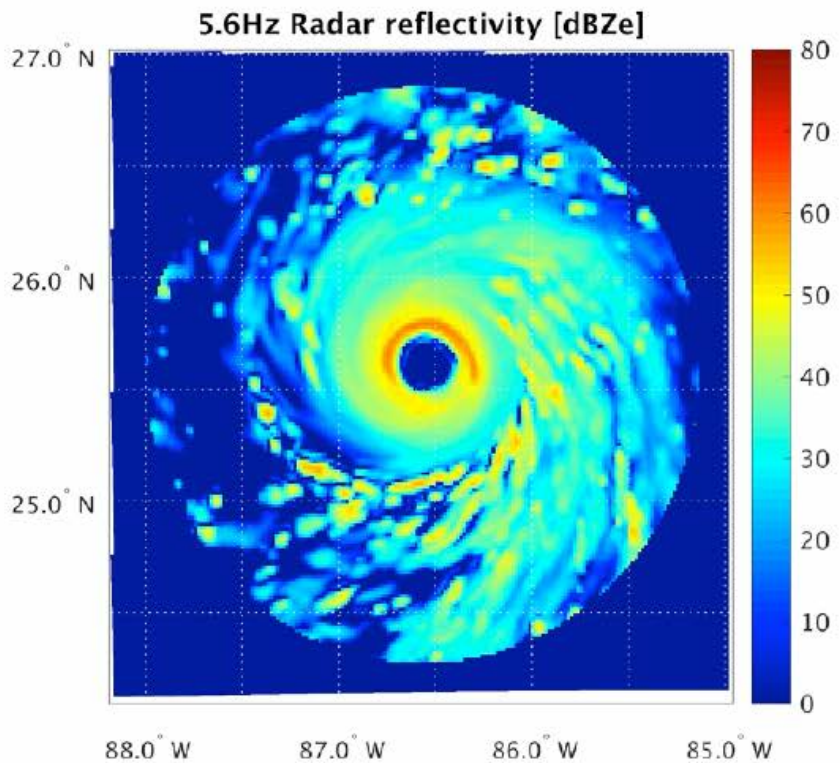
Polarris-f applied to KATARINA simulation (preliminary test)

Radar reflectivity at 3 km

Radar simulator



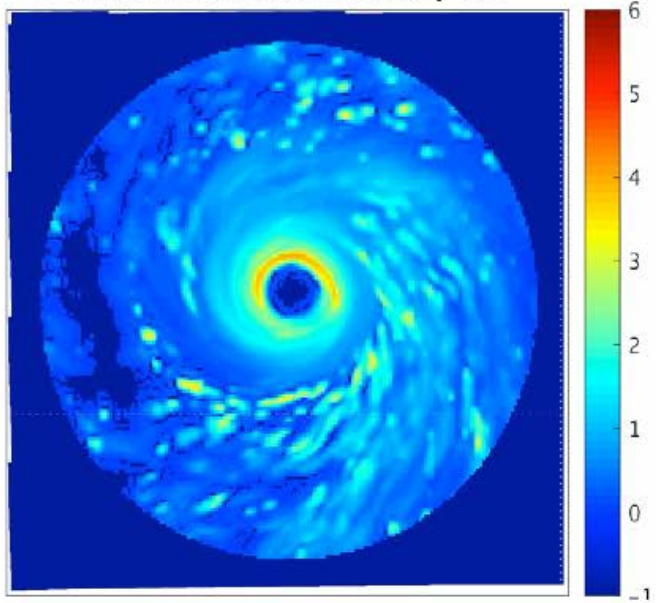
Polarris-f



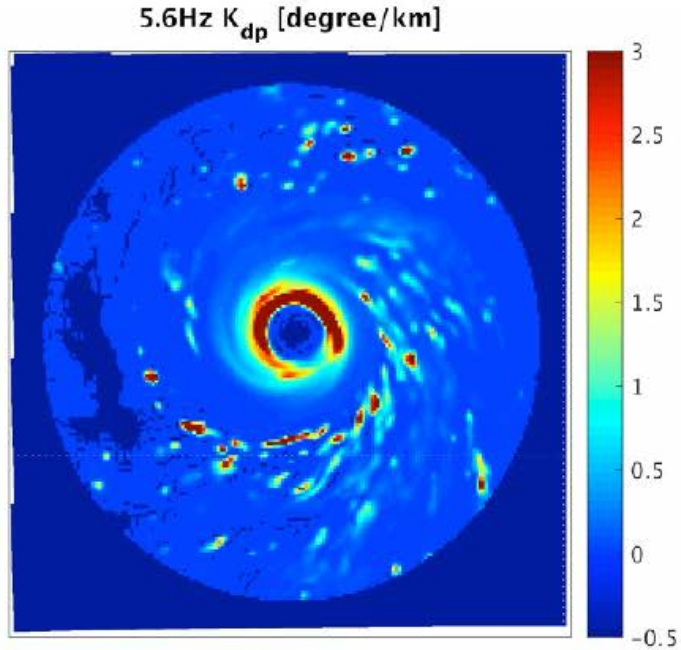
Polarris-f is working correctly in Joint-Simulator.

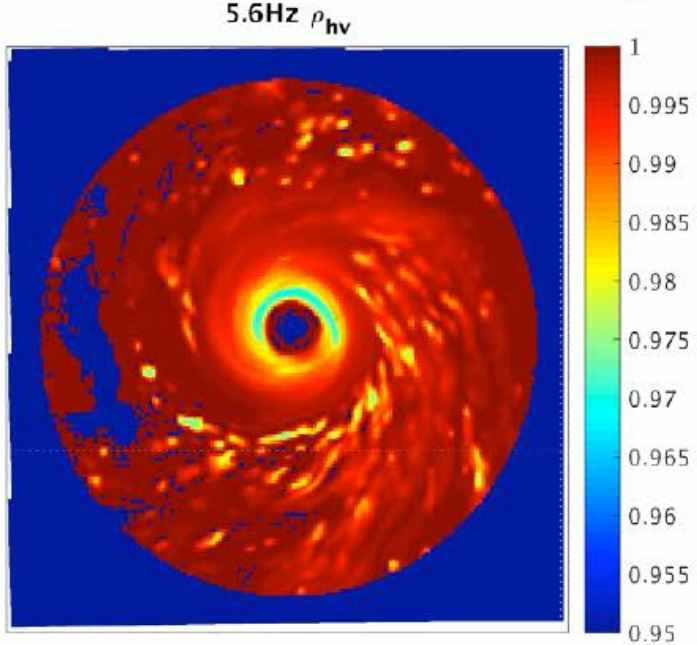
T. Matsui, T. Hashino

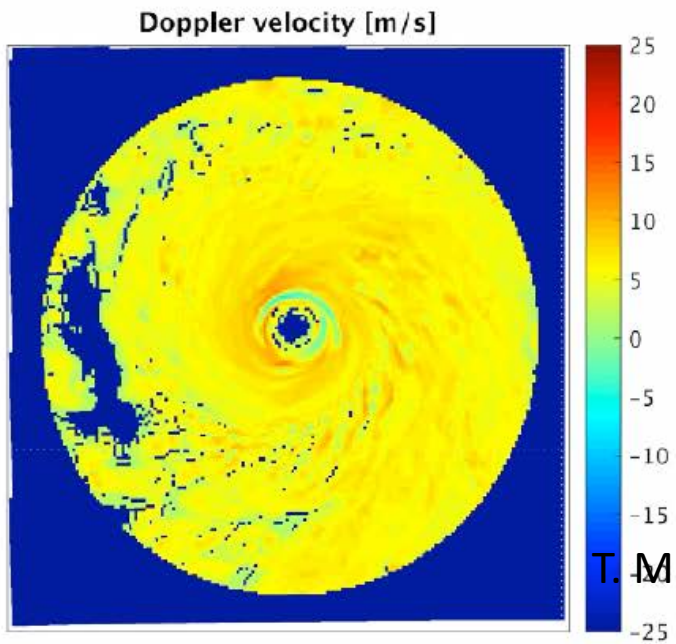
Example of polarimetric variables at 3 km



Z>60 dBZ, Zdr>3 dB, Kdp~2.5 deg/km -> large oblate raindrops and appreciable water contents.

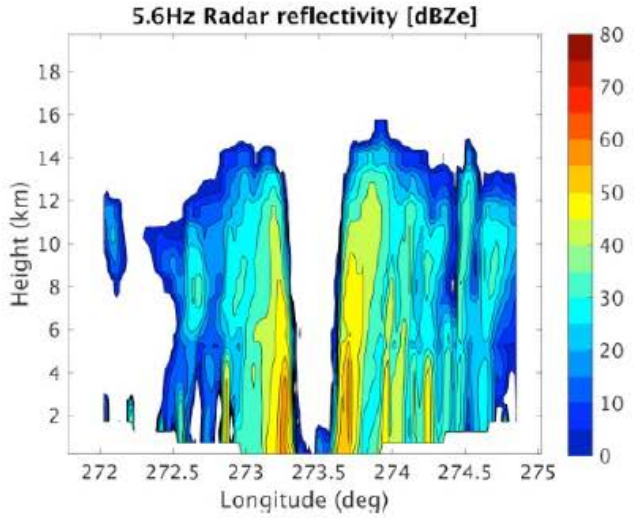


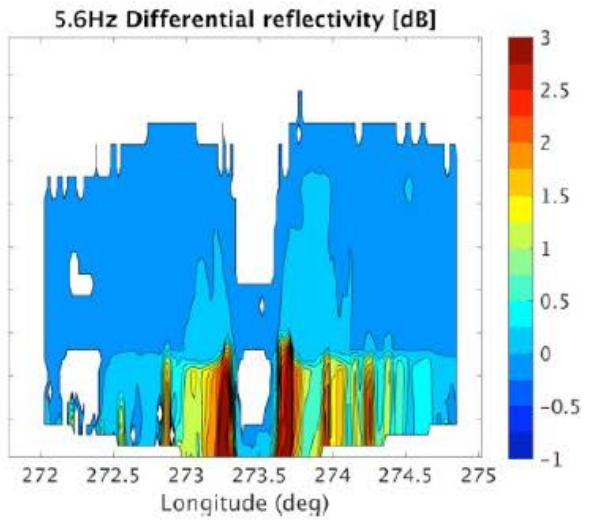




T. Matsui, T. Hashino

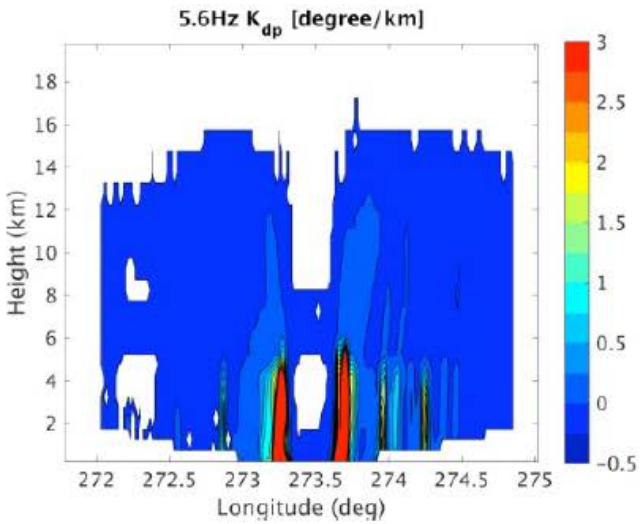
Example of polarimetric variables at 3 km

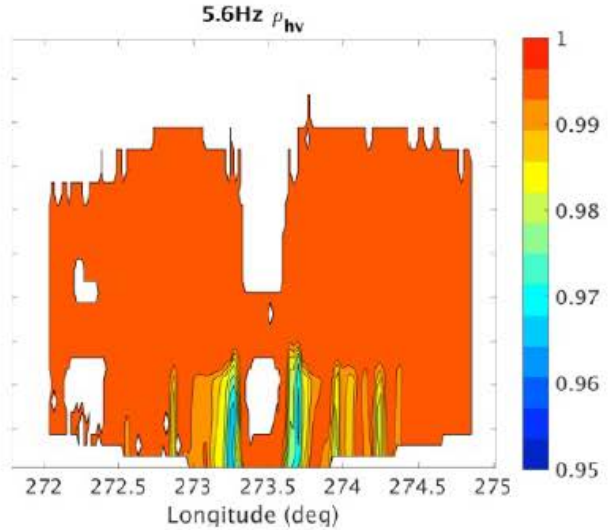


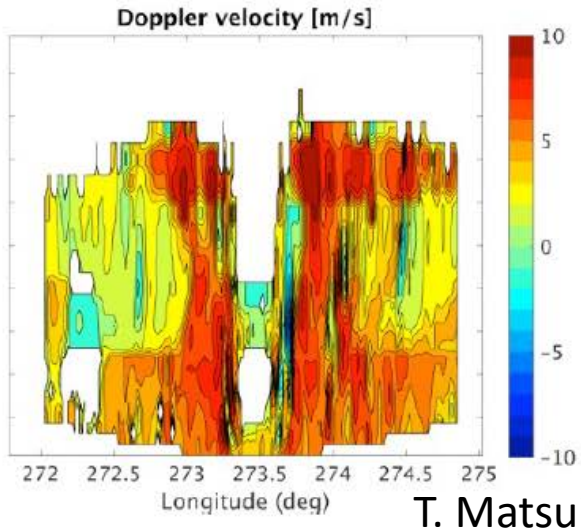


Zdr is slightly positive and Kdp as well above freezing level, probably due to graupel particles.

Sensitivity experiments are necessary for the ice particles.





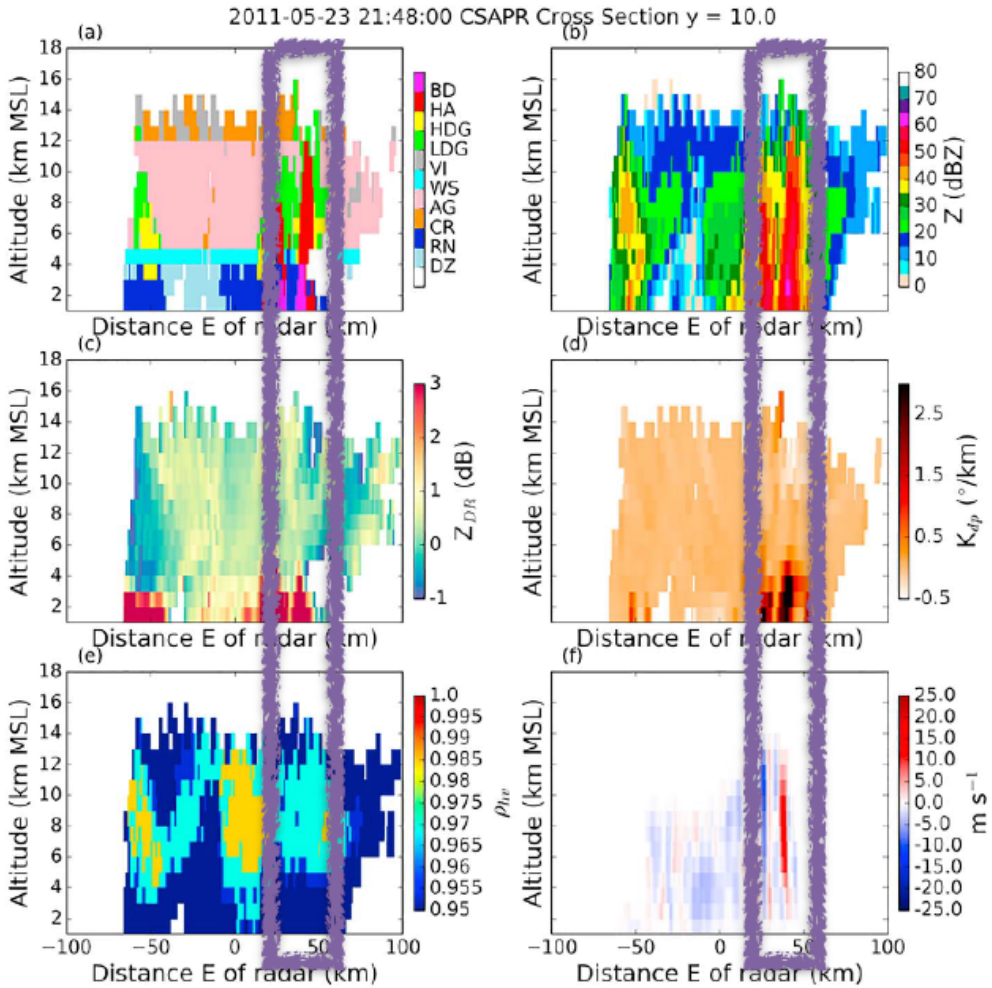


T. Matsui, T. Hashino

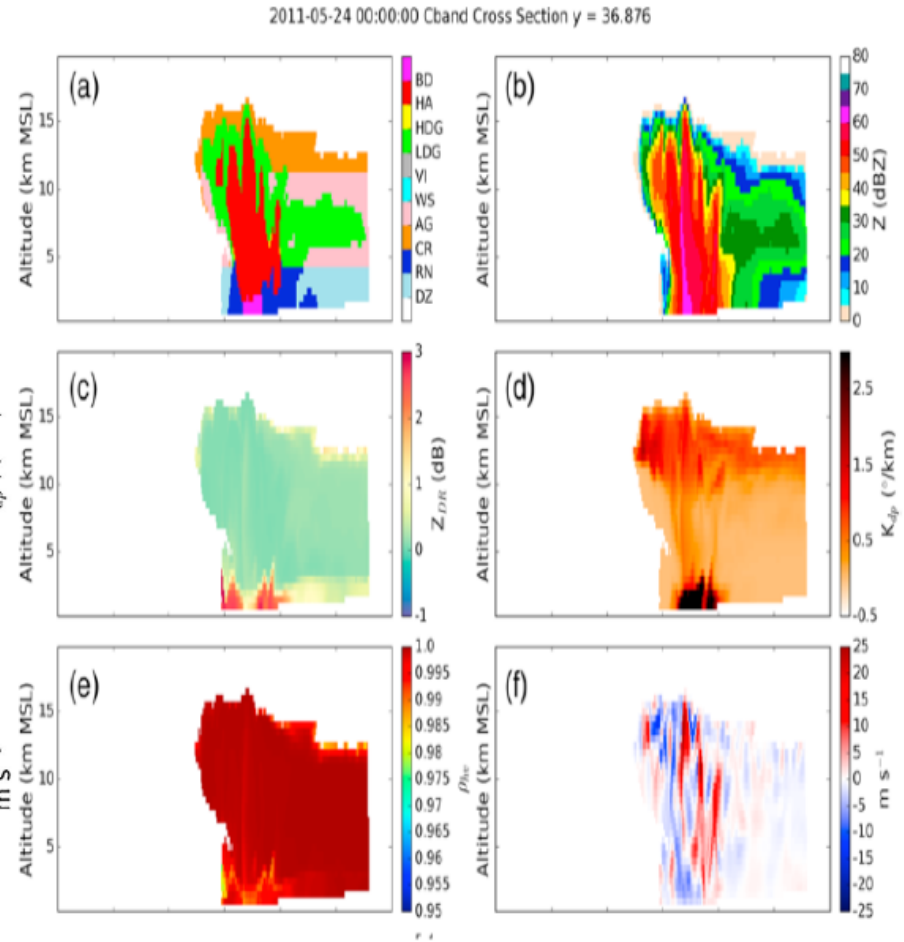
Example of POLARRIS

Matsui et al. (2019)

CSAPR radar observation



WRF-SBM output

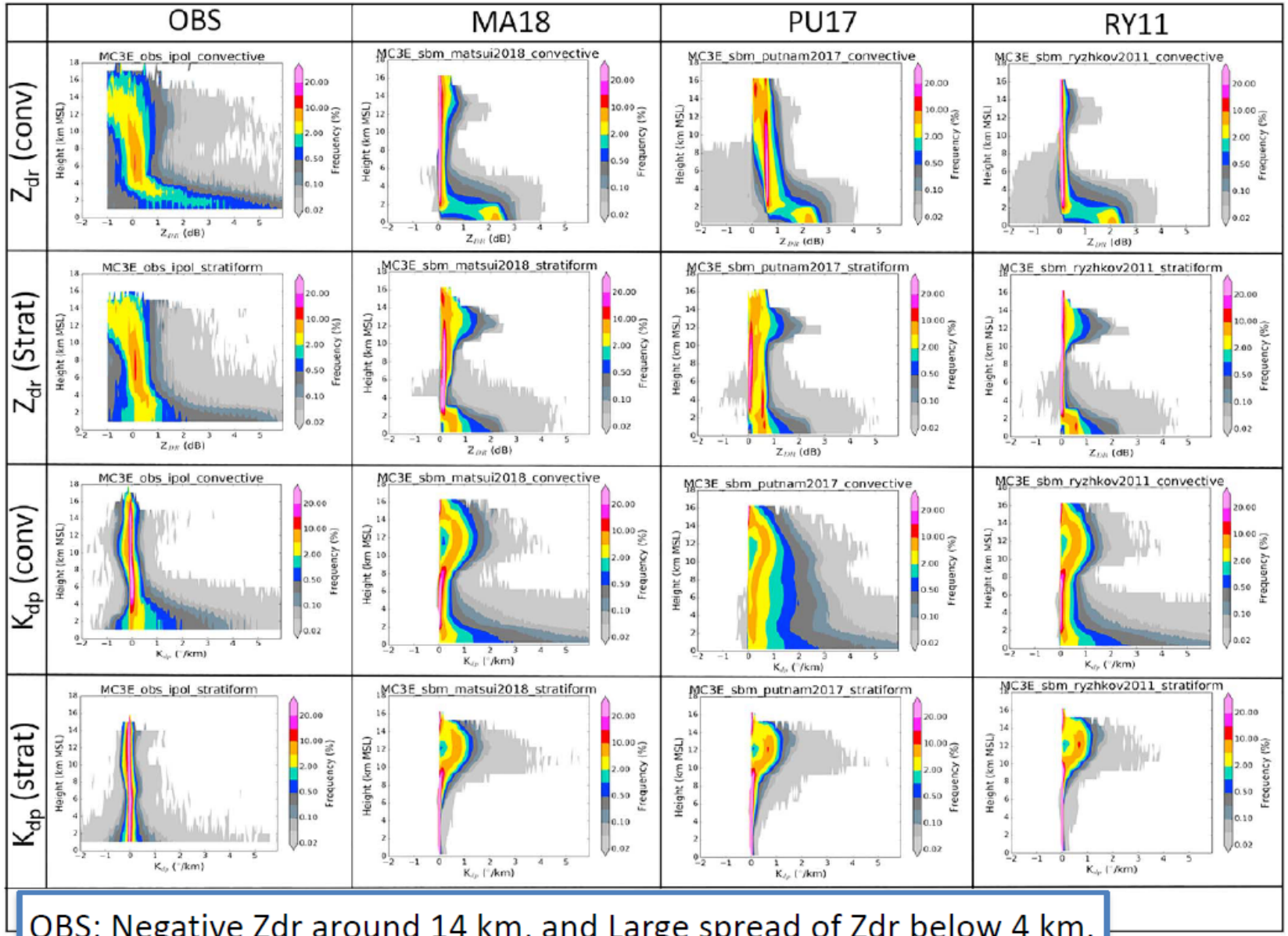


Clear differences in magnitudes of vertical velocity and hydrometeor categories in OBS.

Even though vertical velocity and Z are comparable, large differences in rho_hv exists.

CFADs of Zdr and Kdp

Matsui et al. (2019)

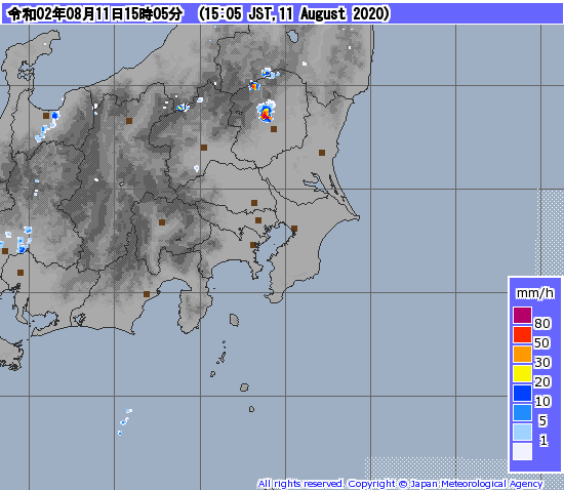


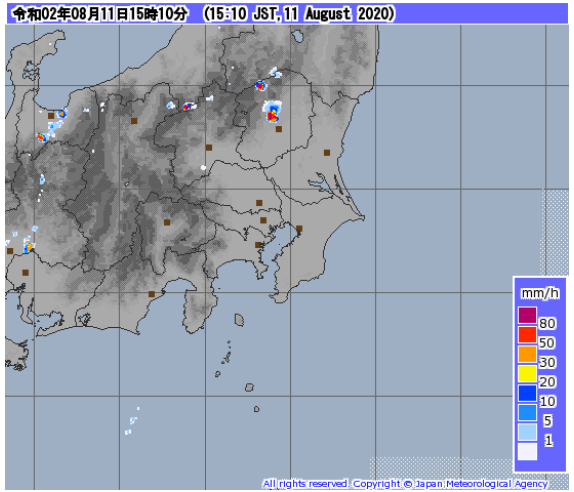
OBS: Negative Zdr around 14 km, and Large spread of Zdr below 4 km.

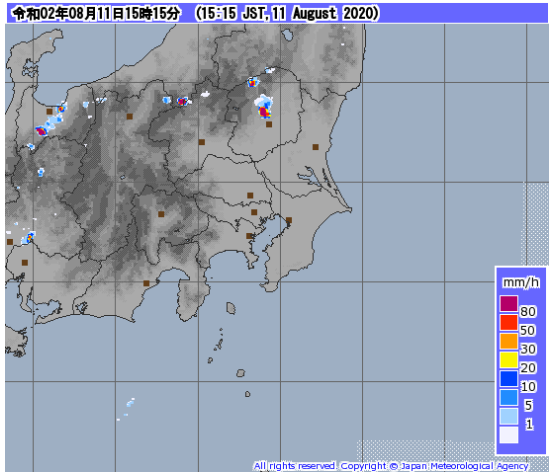
SIM: Kdp is quite positive due to horizontally oriented plates.

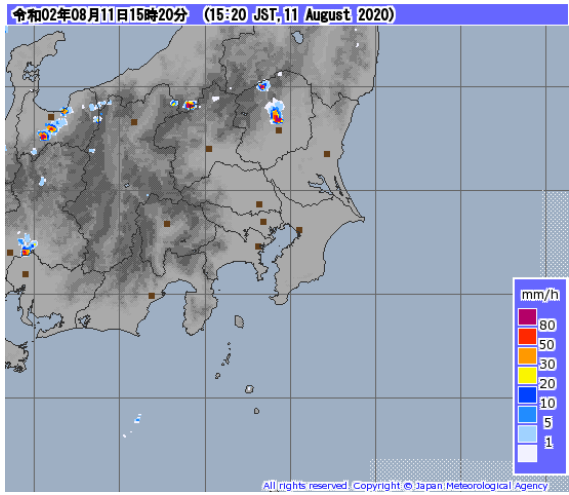
TODO AORI他からのカメラ観測

2020.8.11: 15:05-15:20JST







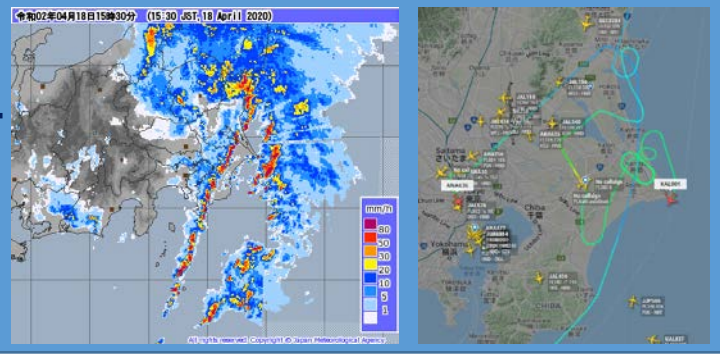


交通運輸技術開発推進制度課題 ： 研究の背景及び目的

本研究では、関東圏における新しい観測の活用等により数値気象予測モデルを高度化し、数時間から1日先までの気象予測精度を向上し、それにより過密化する関東圏の航空機のより効率的な運航に資するための手法を確立することを目的とする。

- 羽田空港では2020年3月より新飛行経路の運用が開始され、首都圏における航空機運航が過密化している。これに伴い航空機運航への悪天時の影響が増大している。
- 近年、雷・雹・竜巻を伴う「シビアストーム」等の極端気象が頻発しており、航空機の効率的な運航やより的確な交通流管理を確立するため、高精度の気象予報の重要性が高まっている。
- 2020年3月には、気象庁により新型の二重偏波ドップラー気象レーダー（今後二重偏波レーダーと呼ぶ）が柏市に設置され、全国展開が予定されている。
- 新しい観測情報を利用することで、日々の気象予測や極端気象研究に用いられる局地気象モデルを先進化する。雲・降水シミュレーションの問題点を把握し、改良につなげ、「シビアストーム」の再現性・予測精度を向上する。
- 数時間から1日先までの気象予測情報の精度を向上させ、航空機のより効率的な運航への活用法を提案する。

気象レーダーによって解析されたシビアストームと航空機経路(2020年4月18日）



現状：局地的な悪天により、飛行経路の変更等、航空交通流への影響

将来：数値予報モデル向上により、離陸時間調整や飛行経路選択等による効率的な運航が可能