15B.4

Development of Nowcasting Method Based on Spatial Scale Analysis of Precipitation Distribution Observed by X-band Polarimetric Radar

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Introduction

- Recently, numbers of disasters are caused by localized heavy rainfall in urban areas in Japan.
- To watch these localized heavy rainfall, MLIT* in Japan provides X-band polarimetric (multi parameter) RAdar Information Network(XRAIN) from 2010.

* MLIT : Ministry of Land, Infrastructure and Transport and Tourism

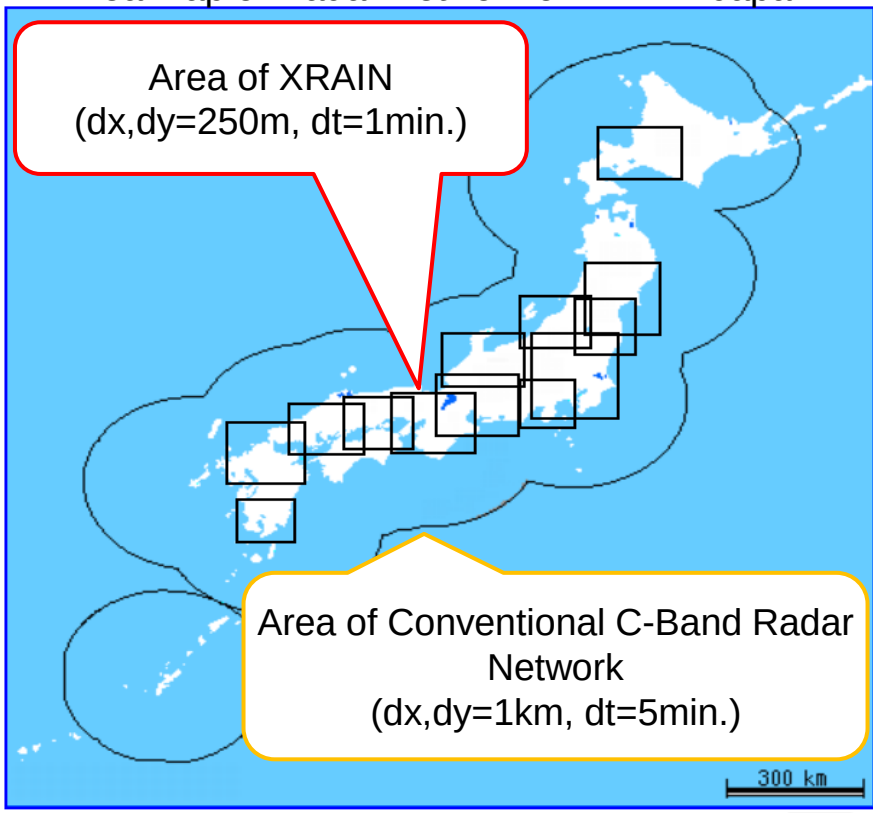
- XRAIN has an advantage over conventional C-band radar network in point that it has higher resolution in space and time.

Comparison of Radar Specifications

Item / Radar	XRAIN	Conventional C-band Radar Network
Grid Interval	250 m	1 km
Time Resolution	1 min.	5 min.
Element	*Z*,*ZDR*,*KDP*,ρ*hv*	Z

By utilizing the characteristics of XRAIN, an advanced extrapolating nowcasting method based on spatial scale analysis has been developed, to improve accuracy until 1 hour ahead.

Area Map of Radar Network of MLIT in Japan



Viewpoint

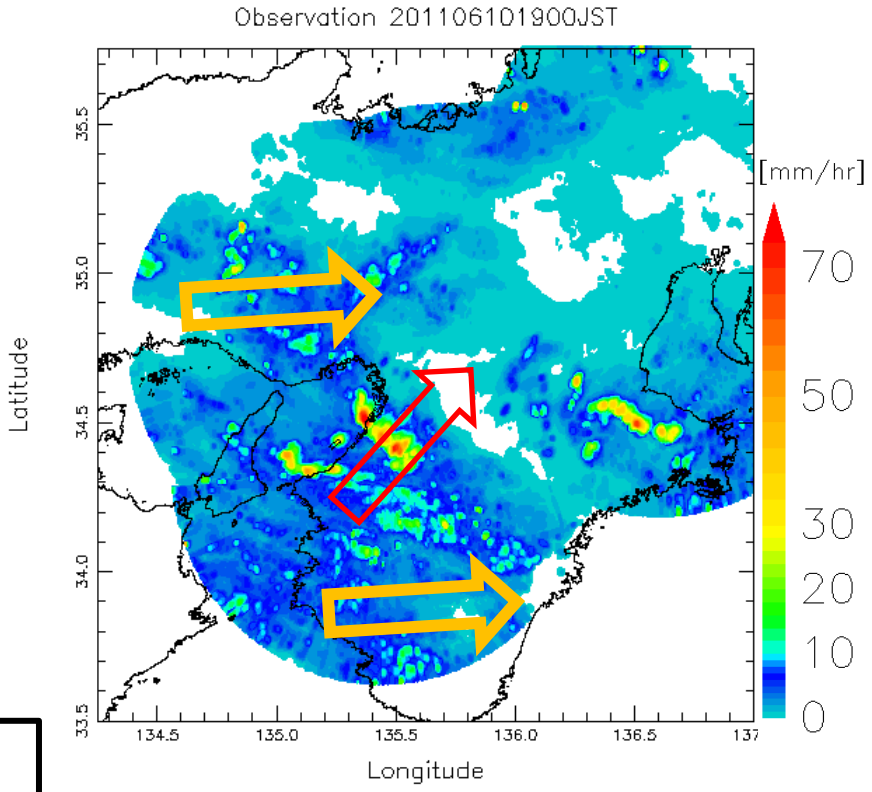
Difference of characteristics of convective and stratiform precipitation

Characteristics of convective and stariform precipitation

	Convective Small-scale	Stratiform Large-scale
Precipitation Intensity	Strong	Weak
Spatial Scale	-30km	About 100km -
Time Scale	- 2hours	Few hours -
Moving Characteristics	Affected by Upper and lower wind field	Mainly moved by upper wind field (3,000 – 5000m)

- Separate precipitation distribution to small-scale(convective) and large-scale(stratiform)
- Apply suitable moving method for each distribution

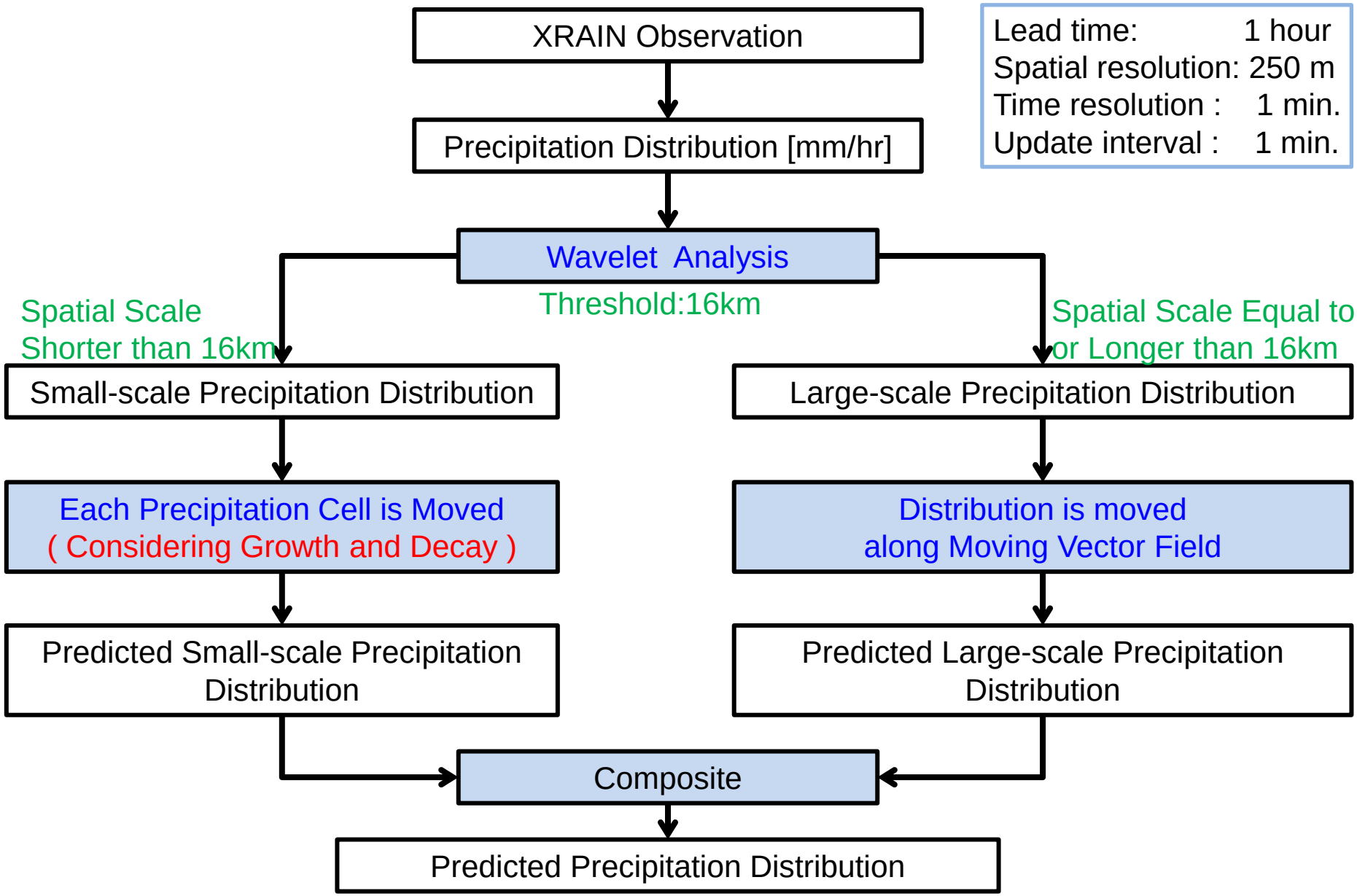
→ Improve Nowcasting Prediction Model



Precipitation Distribution Observed by XRAIN (2011.6.10 19:00 - 20:00JST)

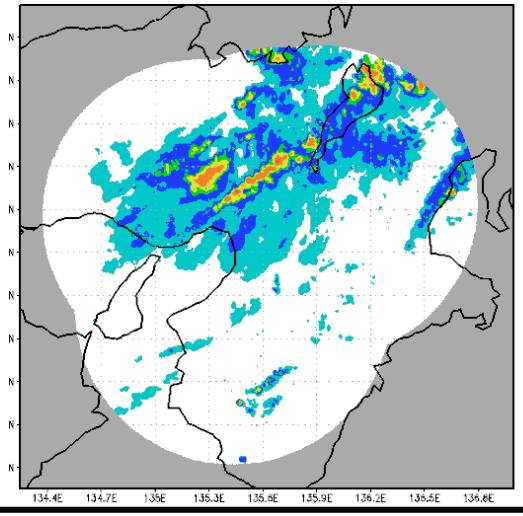
- Movement of whole precipitation is in the direction of ⇨
- Movement of each cell differs from the direction.

Calculation Flow of Developed Nowcasting Method



Separation of Precipitation distribution by Wavelet

Precipitation Distribution Observed by XRAIN



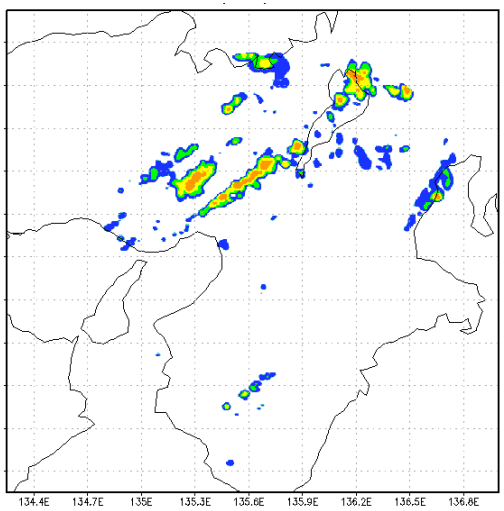
Considering spatial characteristics of precipitation phenomena, wavelet method is used in spatial analysis, instead of Fourier method.

Wavelet Analysis

Threshold:16km

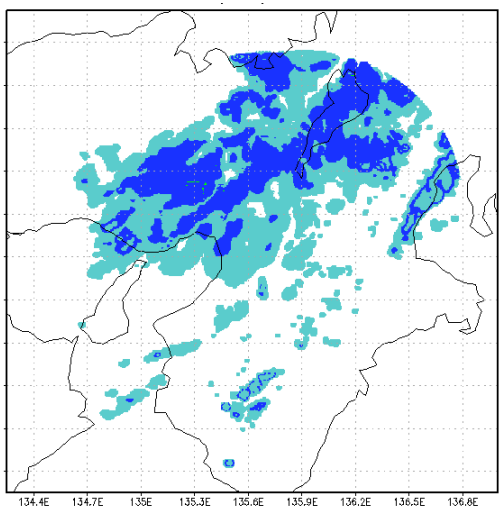
Small-Scale Precipitation Distribution

(Spatial Scale < 16km)



Large-Scale Precipitation Distribution

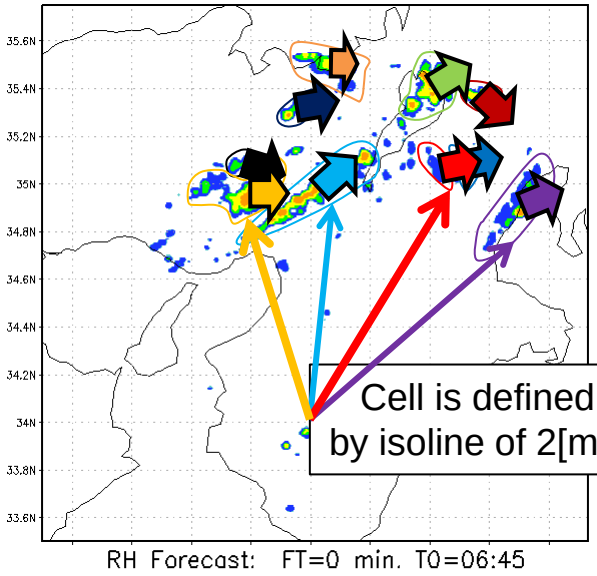
(Spatial Scale ≧ 16km)



Prediction Method

Small-scale Precipitation Distribution(SPD)

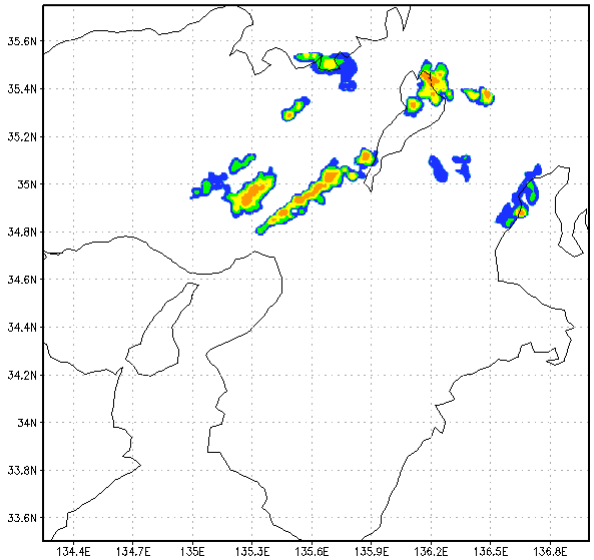
- Each precipitation cell is moved



(1)SPD is divided to precipitation cells

(2)Identify moving vector of each precipitation cell

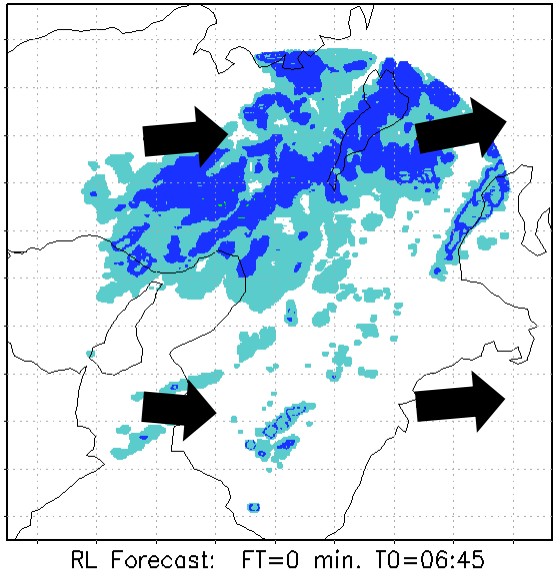
Cell is defined as area surrounded by isoline of 2[mm/hr]



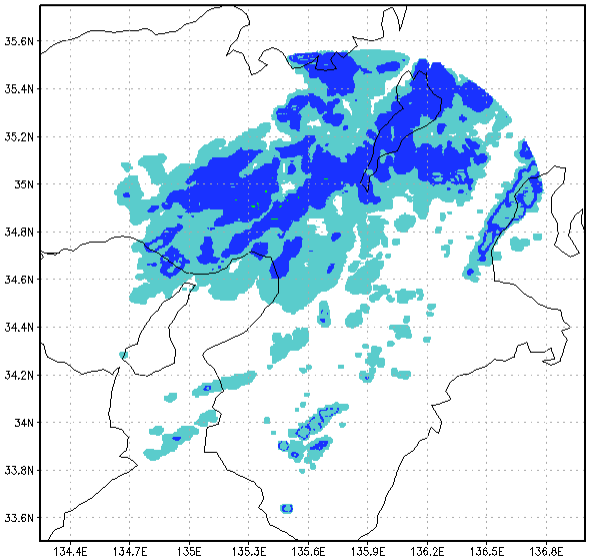
(3)Each cell is moved by each vector

Large-scale Precipitation Distribution(LPD)

- Distribution is moved along moving vector filed.



(1) Identify moving vector field of LPD by TRED method (Laroche and Zawadzki 1995)



(2)LPD is moved along moving vector field by Semi-Lagrange backward method (Germann and Zawadzki 2002)

Characteristic Analysis of Convective Precipitation

Quantities about convective precipitation which are considered to be important for nowcasting

1) Area of precipitation cell : A [km^2]
2) Maximum precipitation Intensity of a cell: P_{max} [mm/hr]
3) Total precipitation in a cell at an instant :V [m^3/hr]

From the relationships between above quantities, predicted cell:$P_{cell}(t)(A,p_{max},V)$ is modeled

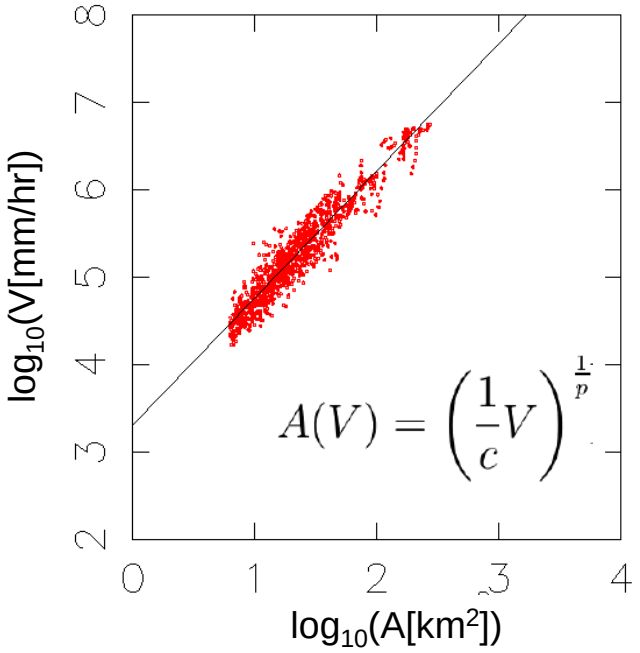
A and P_{max} are considered to be function of V

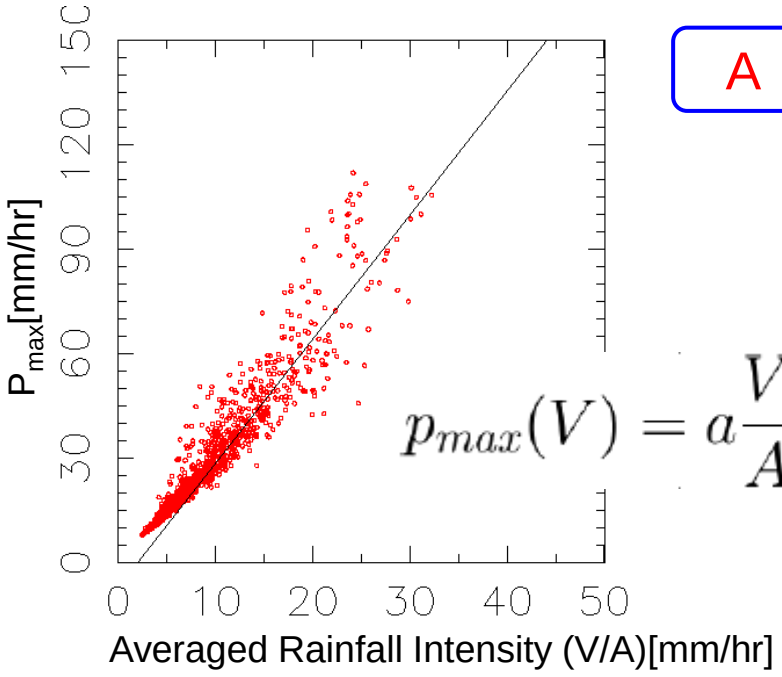
$P_{cell}(t) = P_{cell}(t)(A, p_{max}, V) = P_{cell}(V(t))$

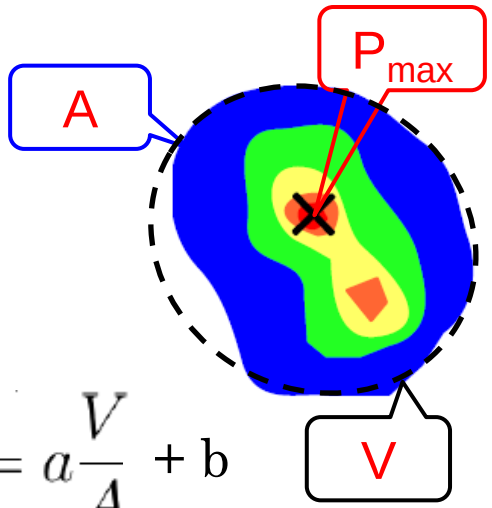
By predicting V(t),

$P_{cell}(t)$ can be predicted.

Relationships between quantities







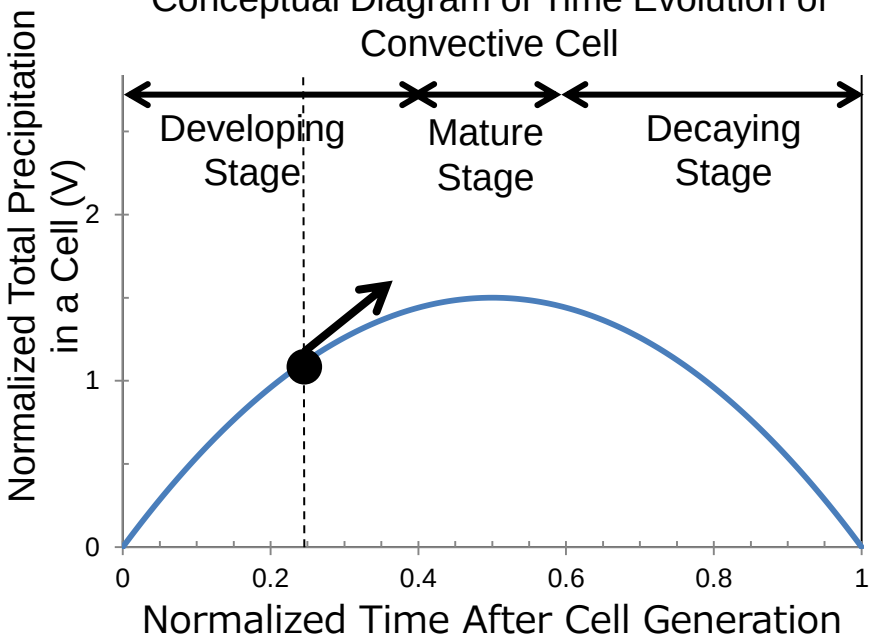
Relationships between quantities of Convective Cells (2012.7.30 12:00 - 20:30)

Modeling Growth and Decay Process of Convective Precipitation

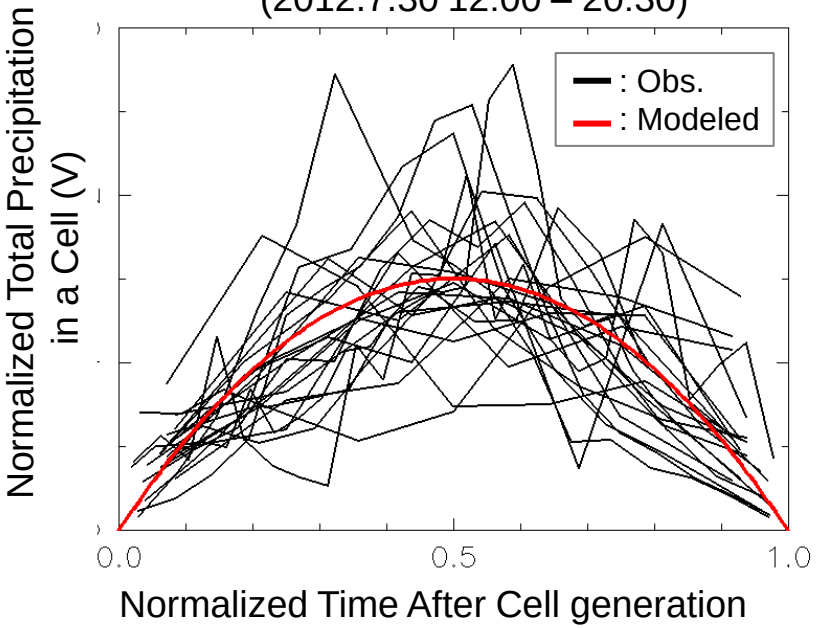
Modeling Time Evolution of Convective Cells

- Time evolution of total precipitation in a cell is modeled as quadratic function.
- By tracing cells, the stage of each cell (Developing / Mature / Decaying) is identified.
- By applying time evolution model to each cell, SPD is predicted.

Conceptual Diagram of Time Evolution of Convective Cell



Relationships between time after cell generation and total precipitation in a cell (2012.7.30 12:00 – 20:30)

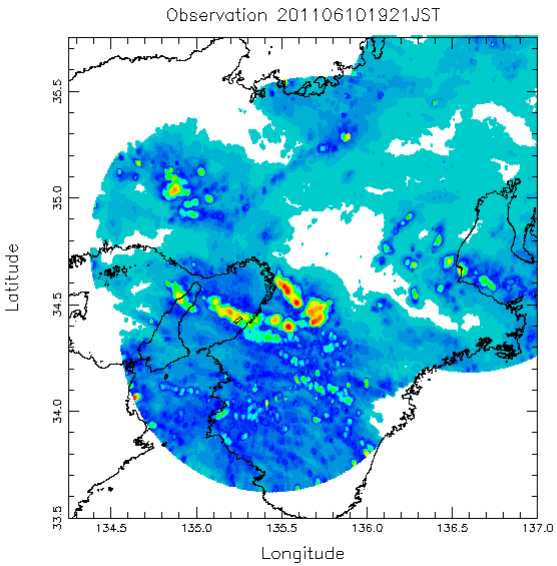


Applied Example

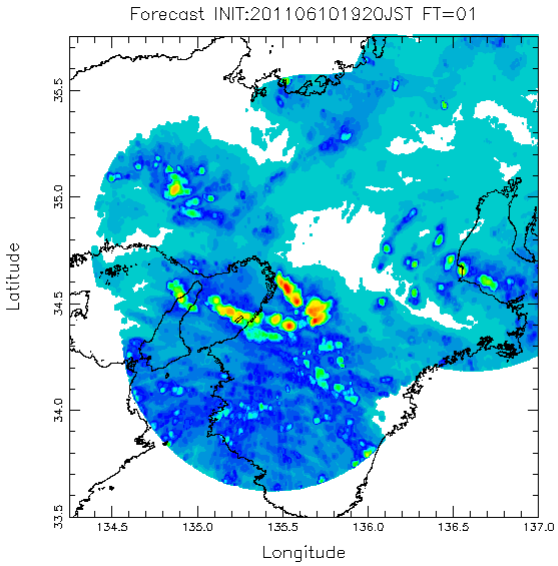
(Prediction Initial Time: 2011.6.10 19:20)

Comparison of Precipitation Distribution (1 - 30 min. lead time)

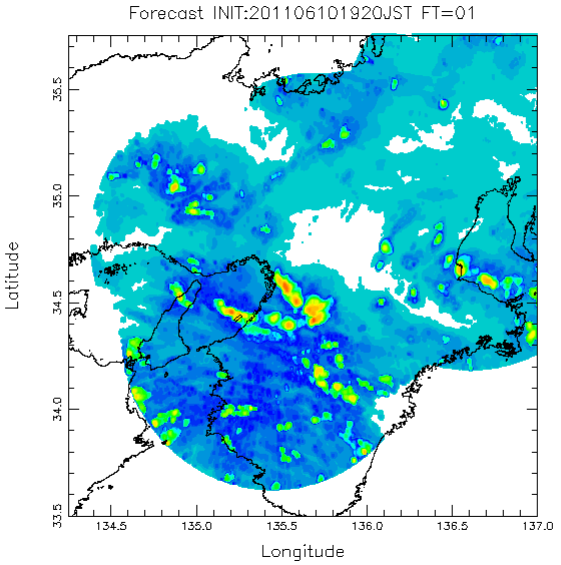
XRAIN Observation

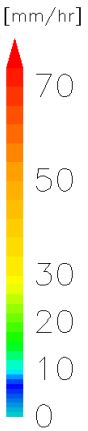


Developed method with separation (SPRT)



Developed method considering growth and decay (DVLP)



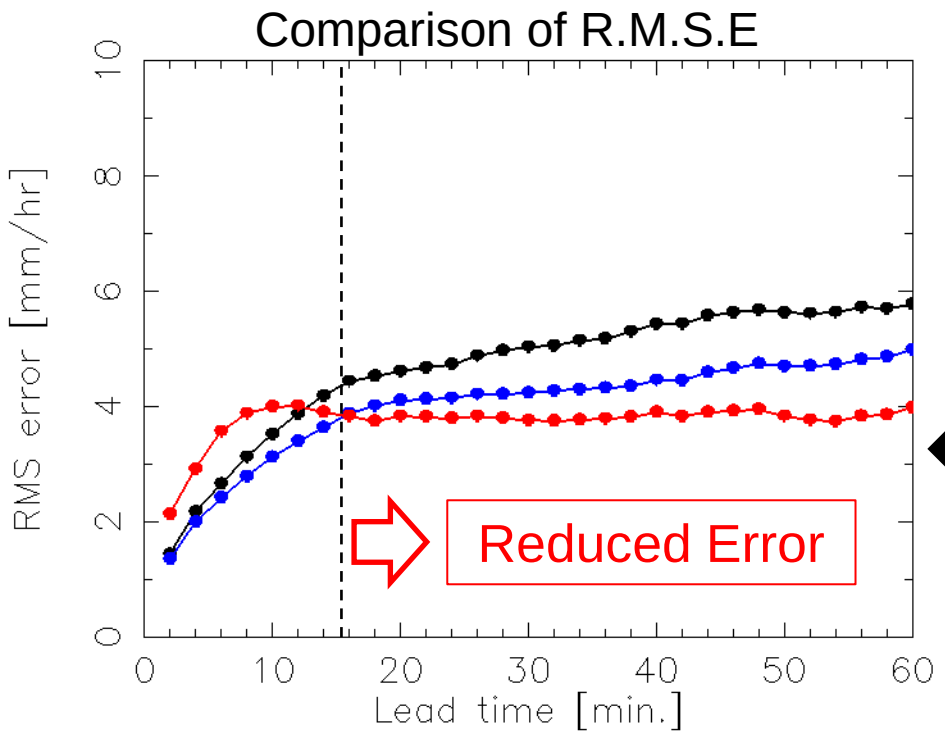


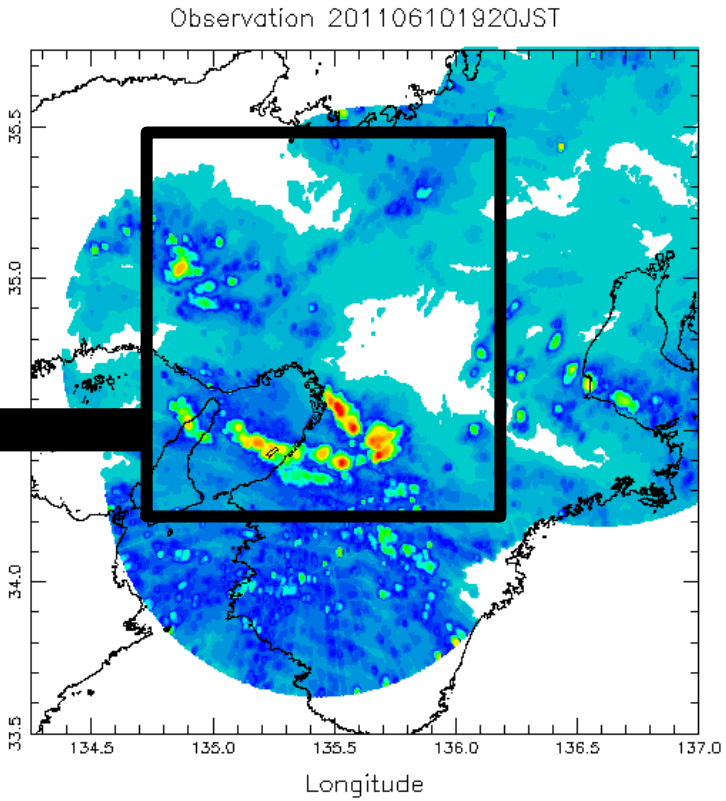
- By separating precipitation distribution to small and large scale, movements of convective cells are represented.
- By considering growth and decay process of precipitation cell, time evolution of cells are well represented.

Evaluation of developed Method

(Prediction Initial Time: 2011.6.10 19:20)

- DVLP shows higher accuracy after lead time of 16 minutes.





Calculation Area of R.M.S.E. between Observation and Prediction

:Conventional method without separation (CONV)

:Developed method with separation (SPRT)

:Developed method considering growth and decay (DVLP)

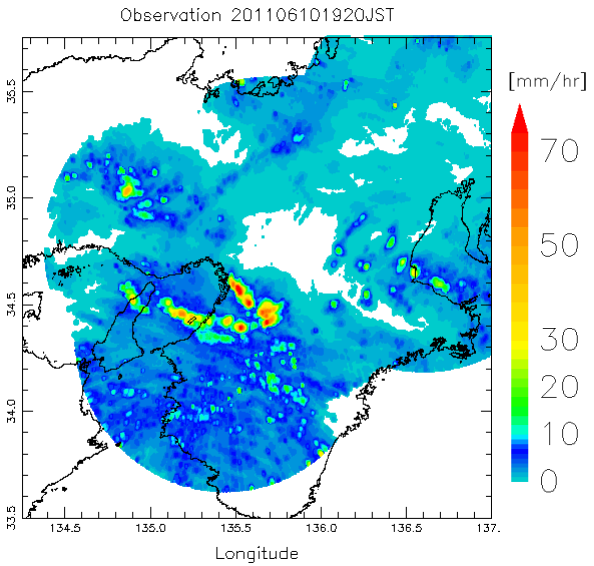
Evaluation at a Point (2011.6.10 19:20-20:20)

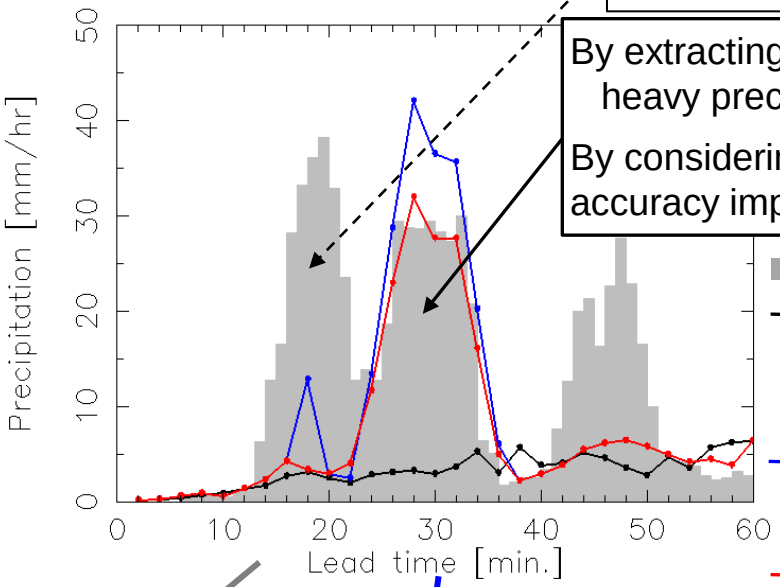
Convective precipitation generated after initial time (Target of future works)

By extracting convective precipitation, heavy precipitation became predictable.

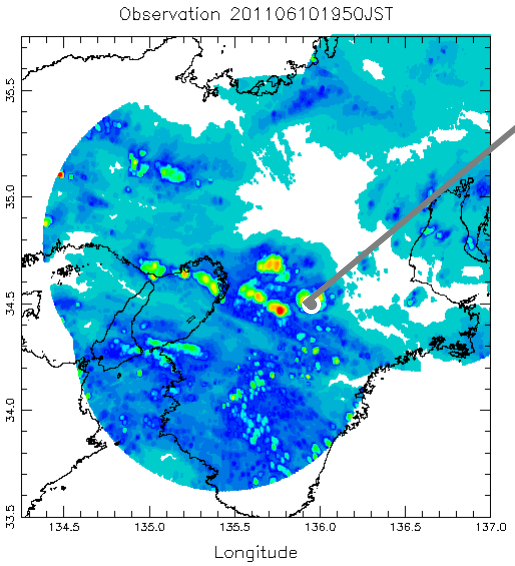
By considering growth and decay of cells, accuracy improved.

XRAIN Observed (Initial)

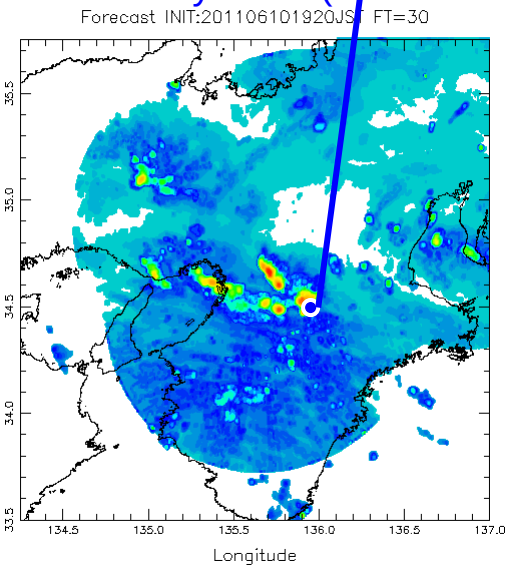




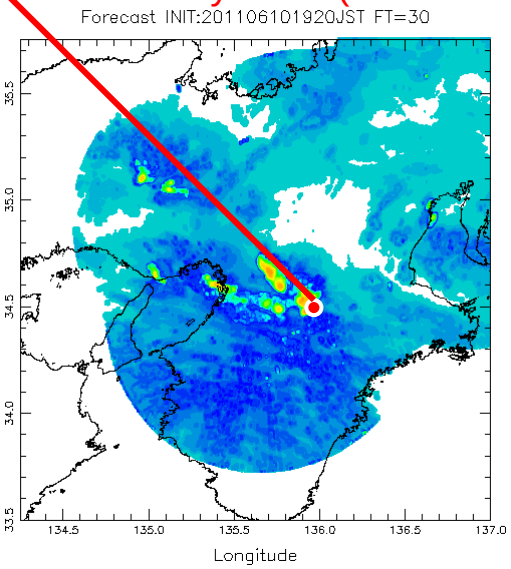
XRAIN Observed (30min. After)



Predicted by SPRT(30min. After)



Predicted by DVLP(30min. After)



Conclusions

- By utilizing the characteristics of XRAIN with high resolution in space and time, advanced nowcasting method based on spatial scale analysis has been developed.
- Extracting method of convective precipitation from total precipitation distribution has been developed.
- By applying suitable moving method for convective and stratiform precipitation distribution, prediction accuracy has improved.
- By considering growth and decay of convective precipitation, accuracy of prediction model has further improved.

Future Works

- Improve growth and decay model of convective precipitation.
- By combining with outputs of meso-scale meteorological model, develop precipitation nowcasting system until 1 hour ahead of high accuracy.

Acknowledgement

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Thank you !