Very Short-term Forecasting of Precipitation Based on Hybrid Surface Rainfall Technique in Korea

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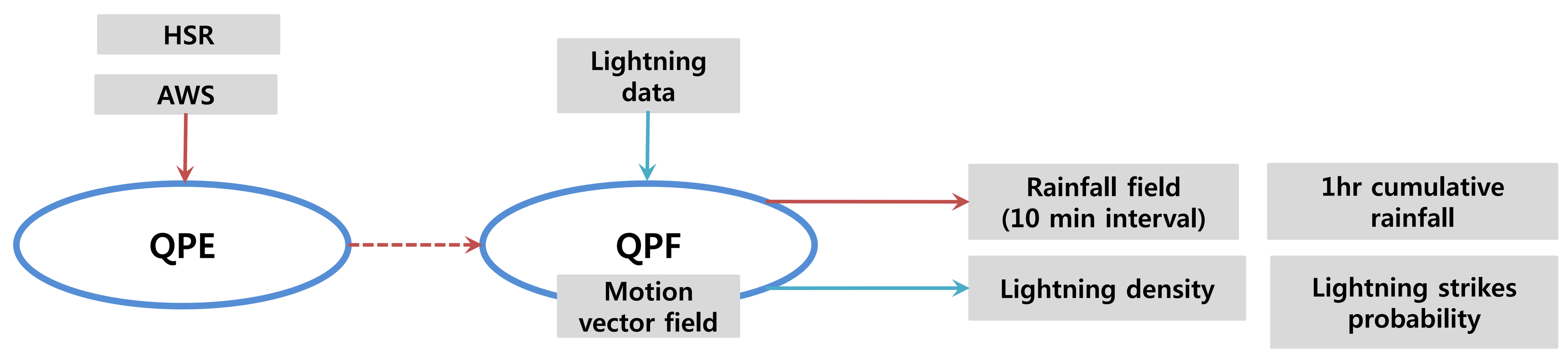
Introduction

- KMA (Korea Meteorological Adinistration) has utilized MAPLE technique as a nowcasting tool of precipitation and lightning up to 6 hours for a routine forecasting operation since 2008.
- Recently, we have developed the advanced radar-QPE technique (Hybrid Surface Rainfall, HSR) and applied raingauge adjustment technique based on multi-quadratic interpolation.
- In this study, we aim to improve the performance of operational short-term forecasting technique by combined MAPLE with two techniques and to evaluate its performance quantitatively.

Methodology

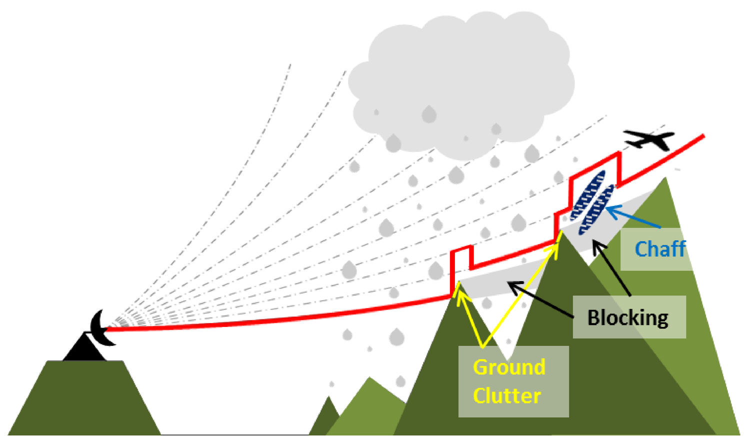
- Flow chart of nowcasting procedure

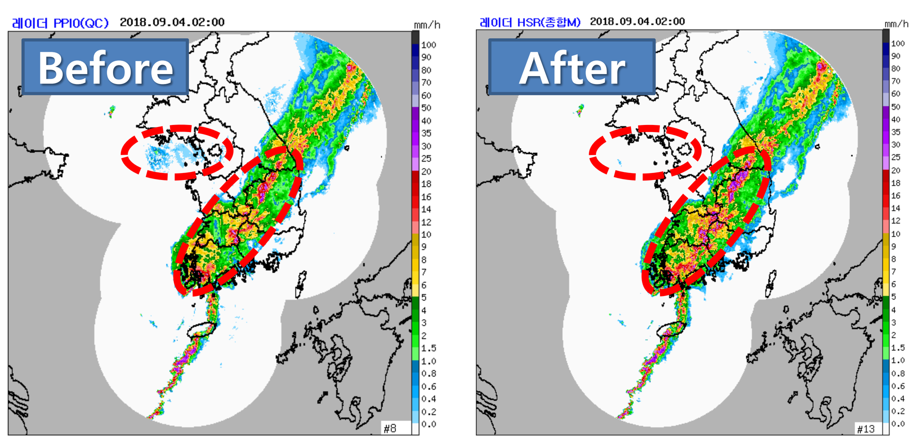


1) QPE

- Rainfall Estimation Technique based on Hybrid Surface

- the rainfall estimation technique based on the *lowest-observable elevation surface* that immune to radar beam blockage, ground clutter contamination and non-meteorological echoes in radar volume file



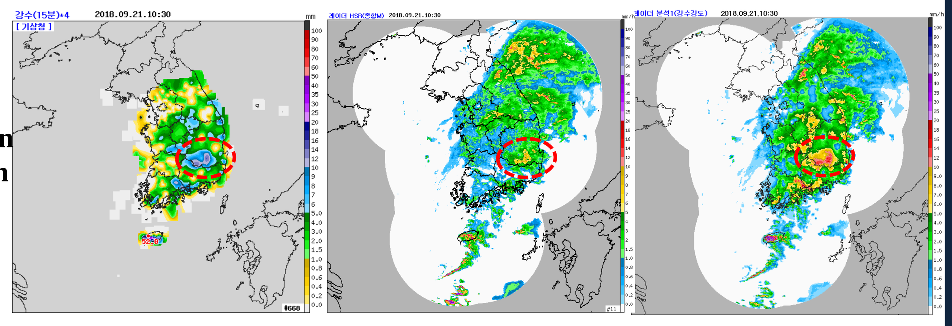


- Post -processing of QPE : Raingauge Adjustment

- Adjusted by using spatial error distribution (variance) between raingauge rainfall and radar-QPE

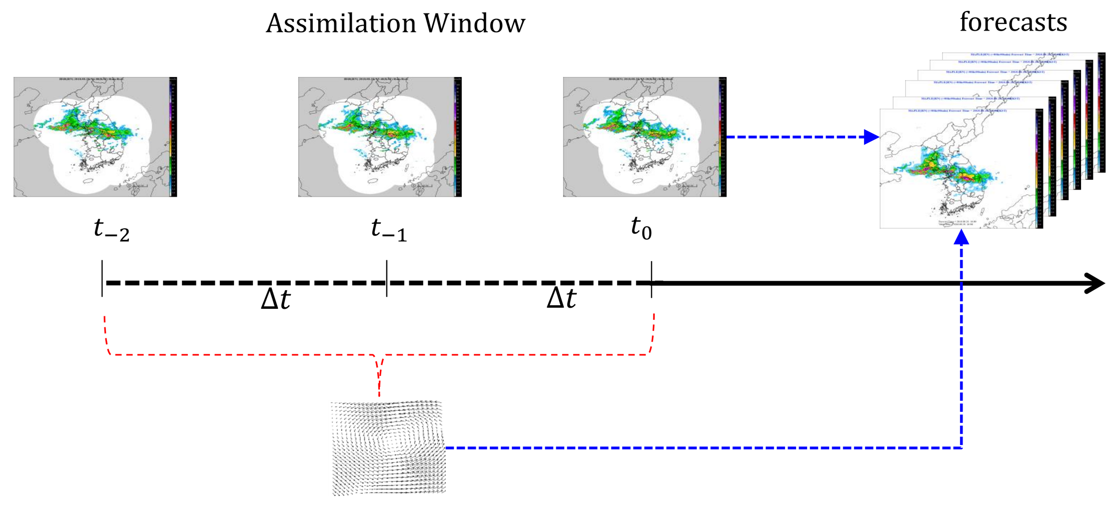
< Procedure >

Step1) INPUT : HSR / AWS rainfall
Step2) Derive a variance field of AWS Rain Rate and radar rainfall estimation
Step3) Objective analysis : Variance field derived by multi-quadric interpolation
Step4) Adjustment of radar-QPE by using variance field
Step5) Objective analysis : AWS rainfall
Step6) Merge between Adjusted radar-QPE and AWS rainfall field



AWS HSR Rainfall Corrected Rainfall

2) QPF



Motion vector field

- VET(Variational Echo Tracking)

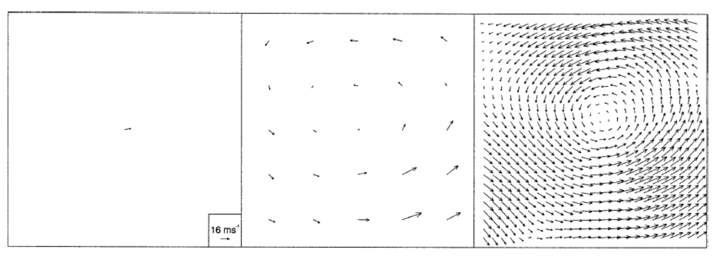
- Determine a radar echo motion vector field by minimizing cost function
- Divided into sub-domains and compute velocity vector for each sub-area by minimizing reflectivity difference or cost function between two composite maps by a certain time interval

$$J_{VET}(\vec{u}) = J_\psi + J_2$$

$$J_\psi = \iint_\Omega \beta(\vec{x})\left[\Psi(t_0,\vec{x}) - \Psi(t_0 - \Delta t, \vec{x} - \vec{u}\Delta t)\right]^2 dxdy \quad \text{: Reflectivity constraint}$$

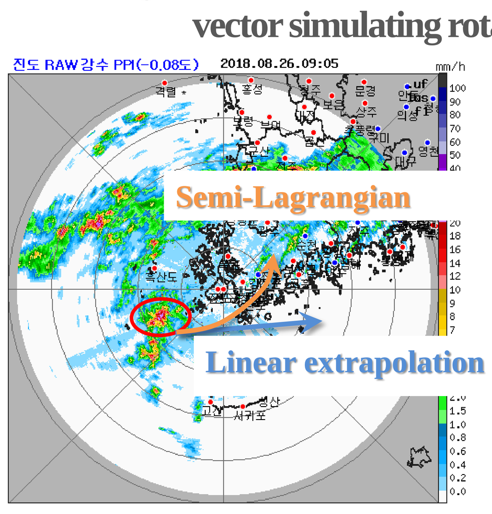
$$J_2 = \gamma \iint_\Omega \left(\frac{\partial^2 u}{\partial x^2}\right)^2 + \left(\frac{\partial^2 u}{\partial y^2}\right)^2 + 2\left(\frac{\partial^2 u}{\partial x \partial y}\right)^2 + \left(\frac{\partial^2 v}{\partial x^2}\right)^2 + \left(\frac{\partial^2 v}{\partial y^2}\right)^2 + 2\left(\frac{\partial^2 v}{\partial x \partial y}\right)^2 dxdy \quad \text{: Smoothness penalty}$$

- To solve the minimizing cost function, a conjugate-gradient algorithm was used in the global minimization of the cost function.
- To avoid converging toward secondary minima, use the scaling-guess procedure at least twice times.



- Semi-Lagrangian backward advection

- Generate future rainfall field by semi-Lagrangian backward scheme
- Advantage : allows for differential motion during the forecasting process compared with single or constant velocity vector simulating rotation at the near synoptic scale of the composite rainfall maps

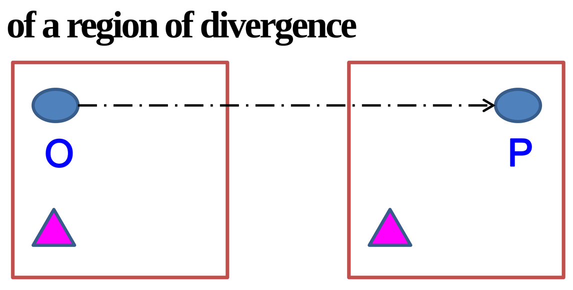


$\vec{\alpha} = \tau \vec{u}(t_0, x_p)$: Linear advection

$\vec{\alpha} = \Delta t\, \vec{u}\left(t_0, \vec{x} - \frac{\vec{\alpha}}{2}\right)$: Semi-Lagrangian advection

$\vec{\alpha}$: displacement vector,
$\vec{u}$: velocity field,
τ : lead time,
t_0 : initial time,
x_p : position at the grid point P,
Δt : time length

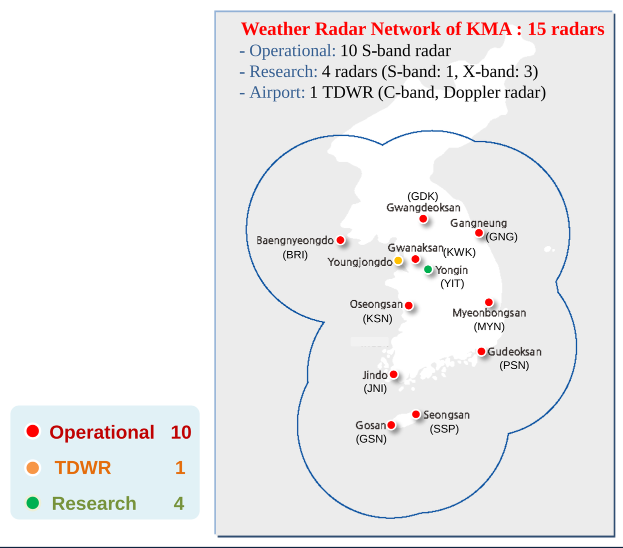
- Use backward scheme : to avoid 'holes' in forecast map because of a region of divergence

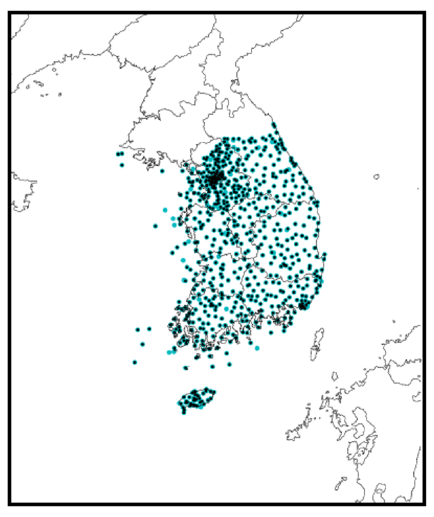


$$x_0 = x_1 - dx$$

Data

- Nationwide Weather Radar Network
  - KMA(10) : 9 S-band Dual-Polarization radars + 1 single-polariztion radar
  - Ministry of Environment(6) : 6 S-band Dual-Polarization radars
- Automatic Weather Station (AWS)
  - Dense AWS network : 854 raingauge (1 min interval update)





< AWS network in Korea >

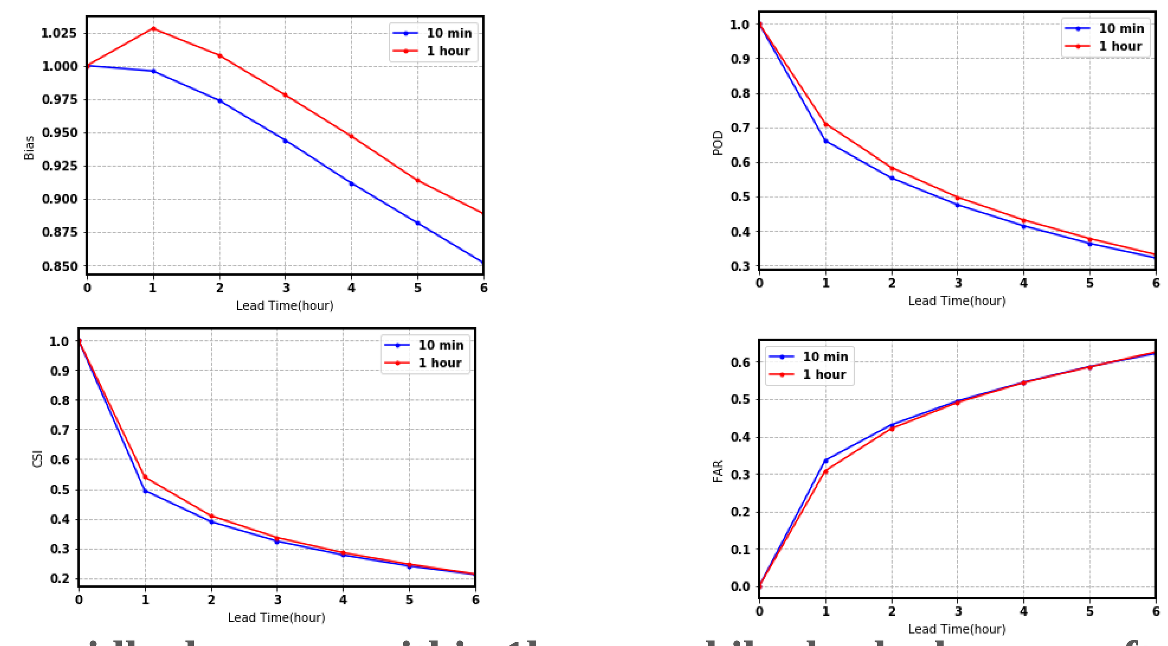
Evaluation

- Period: 1st Aug. 2018 ~ 31nd Oct. 2018

- 2x2 Contingency Table
: N = H (Hit) + M (Miss) + F (False Alarm) + C (Correctional reject)

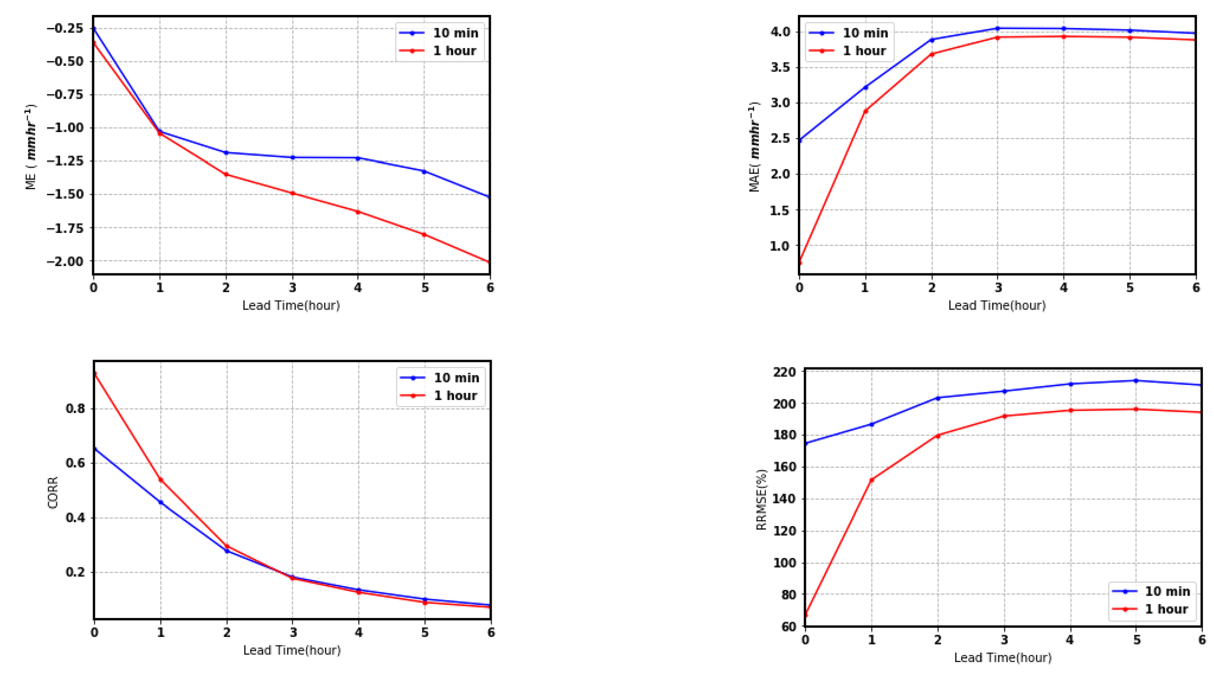
		PREDICTION	
		YES	NO
OBSERBATION	YES	H	M
	NO	F	C

- Bias (Bias score) $BIAS = \frac{F+H}{M+H}$
- POD (Probability Of Detection) $POD = \frac{H}{M+H}$
- FAR (False Alarm Ratio) $FAR = \frac{F}{F+H}$
- CSI (Critical Success Index) $CSI = \frac{H}{H+M+F}$



CSI : rapidly decreases within 1hours, while slowly decrease after 1hour
Temporal trend of CSI was similar between 10 min and 60 min

- ME (Mean Error) $ME = \frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)$
- MAE (Mean Absolute Error) $MAE = \frac{1}{N}\sum_{i=1}^{N}|F_i - O_i|$
- RRMSE (Relative Root Mean Square) $RRMSE = \frac{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)^2}}{\bar{O}} \times 100$
- CORR (Correlation coefficient) $CORR = \frac{\sum(F-\bar{F})(O-\bar{O})}{\sqrt{\sum(F-\bar{F})^2}\sqrt{\sum(O-\bar{O})^2}}$



ME : Temporal trend of ME was similar in 1hour,
While difference increase after 1 hour

Summary and future works

- Summary :
  - Improvement of radar-QPF : HSR + raingauge adjustment
  - Nowcasting of rainfall by combined MAPLE with improved radar-QPE
- Future works :
  - Evaluation of QPF in 2018 annual data
  - Improvement of prediction quality

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