An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data

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\section{Introduction & Motivation}

Heavy rainfall (10 mm / h) cases over the Korean peninsula were divided into two types; cold-type characterized by strong updraft, high cloud top altitude and large amount of ice crystal, and warm-type characterized with weak updraft, lower cloud top height, more of liquid water (Song and Sohn 2013). On the other hand, Takahashi (2015) divided two cloud regimes into two groups: Graupel Regime vs. Frozen-Drop Regime which show strong contrast graupel content and frozen drops. Based on those classifications we classified the heavy rainfall into two types (Cold-type vs. Warm-type) using AWS rain gauge and IMPACT-LDAR II (Improved Accuracy from Combined Technology-Lightning Detection And Range II) data. Then UM forecasts on the rainfall over the Korean peninsula were validated against the AWS surface rain gauge measurements, but depending on the rain types.

\section{Data & Methodology}

\textbf{Data}

- AWS : Rain rate [mm / h]
- UM RDAPS : 12 hour forecast field / 3 h accumulated precipitation [mm / 3h]
- IMPACT-LDAR II : Location of lightning flash

\textbf{Research area & period}

- Period for rain type classification : 2002 - 2013 (12 years)
- Period for validation : 2012 – 2013 (2 years)
- Research area : Korean peninsula

\textbf{Collocation & interpolation}

- Spatial collocation
  - All data are collocated into new grid (0.1° x 0.1°)
  - To avoid interpolation error, AWS locations in small island area are ignored.
  - Lightning flashes are counted in the nearest new grid.

- Temporal collocation
  - Lightning frequencies are accumulated in hourly. [ # / h]
  - UM RDAPS 6 hourly data have just 3 hour precipitation (temporal discontinuity).
  - To validate between AWS and UM RDAPS, AWS data are temporal matched in UM RDAPS time field.

- Interpolation
  - In the spatial collocation process, blank values over land area are interpolated using around values.

\section{Result 1 : Climatology}

- Monthly mean of rainfall is the highest in July.
- The central part (above 37°N) and the southern part (below 36°N) are main rainfall area over the Korean peninsula.
- Most of lightning flashes are occurred in inland area.

- Small rain (RR < 1 mm / 3h) area of AWS and UM RDAPS is about 95%, 91% respectively.
- When rain rate is lower than 30 mm / 3h, frequency of AWS rain rate is higher than UM RDAPS forecast.
- Heavy rain frequency (RR > 50 mm / 3h) of AWS rain rate is slightly higher than UM RDAPS forecast.

\section{Result 2 : Categorization of rainfall type}

- Mean lightning frequency is proportional to rain rate.
- The percentage of cold type for all rainfall grid of bin is about 15 – 20 % when rain rate is higher than 10 [mm / h].
- In this research, mean lightning frequency is used as a threshold for categorization of rainfall grid type into two types (cold-type, warm-type).

\section{Result 3 : AWS vs. UM RDAPS with rainfall type}

- In cold-type, rainfall region of UM RDAPS forecast is similar to AWS rain rate, but rainfall area is over-estimated in UM RDAPS.
- UM RDAPS underestimates warm-type rainfall over the central part, but rainfall over the southern part is over-estimated.
- Warm-type rainfall forecast accuracy of UM RDAPS is lower than cold-type.

\section{Summary and conclusion}

- Rainfall rate is high in the central part and southern part of the Korean peninsula.
- Statistic values (mean lightning frequency with rain rate bin, the number of rainfall grid) are calculated and used to categorize rainfall type
- UM forecasts on the rainfall over the Korean peninsula is validated against AWS surface rain gauge measurements.
- Warm-type rainfall forecasts seem to be more difficult compared to the cold-type rainfall.

\section{Future work}

- Study about why warm-type rainfall forecast is difficult in UM.
- Synoptic field research for each rainfall type.

\section{Reference}


\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data}
\end{figure}

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure4.png}
\caption{An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data}
\end{figure}

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure5.png}
\caption{An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data}
\end{figure}

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure6.png}
\caption{An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data}
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\includegraphics[width=\textwidth]{figure7.png}
\caption{An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data}
\end{figure}

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure8.png}
\caption{An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data}
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\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure9.png}
\caption{An analysis of the forecast performance from UM model for heavy rainfall over the Korean peninsula with rain types classified by AWS rain gauge and lightning data}
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