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Observation system experiments using intensive upper-air observation(ProbeX-2014) for Changma rainfall event over South Korea

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Contents

Introduction

- Upper-air Observation
  - It is useful to investigate the **dynamic structure** on rainfall events and to improve **predictability of numerical model** about high-impact weather.
  - Observation data play key role in minimization of the initial condition errors in numerical model. Especially, Upper-air observation data are essential for **modeling atmospheric processes**.
  - Sonde observation is traditionally the privileged way to obtain upper atmospheric information.
    - limitation : high cost, few launch times(one or two in a day), etc.

- Field Campaigns
  - Various field campaigns have been performed for improvement of predictability in regions where observations are not enough(target observation).
    ex) FASTEX, NORTHEX WSRP, THORPHEX, DOTSTAR, etc.

Introduction

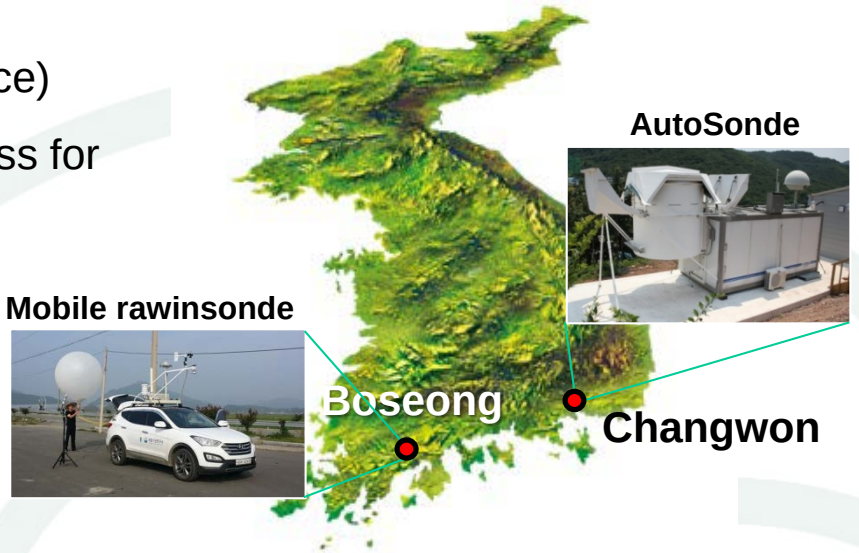
- Evaluation of observation impact on forecast
  - Observation System Experiment(OSE)
    - OSE is conventional method **to verify the upper-level data assimilation for forecasting the precipitation.**
    - Necessary to add or remove observations from the assimilation to estimate their impact on forecast.
    - **The repetitive assimilation effect can be considered in numerical system.**

- **Objective of Study**

This study is a goal to **evaluate the effect of upper-air observation assimilation for predictability of summer rainfall** using regional data assimilation prediction system

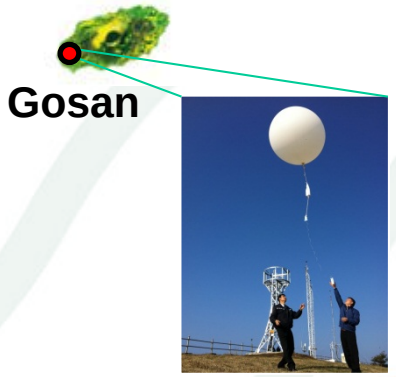
ProbeX : PRedictability and OBservation EXperiment of Korea

- Objective
  - To obtain the high resolution data(time and space)
  - To investigate characteristic and physical process for high impact weather phenomenon
  - To improve the short-term prediction



- Period : 30 days(16 June 2014 ~ 15 July 2014)
- 3 Sites (Boseong, Changwon, Gosan)
- Interval : 6 hours (00, 06, 12, 18 UTC)

※ Intensive Observing Period(IOP) : 3 hours interval

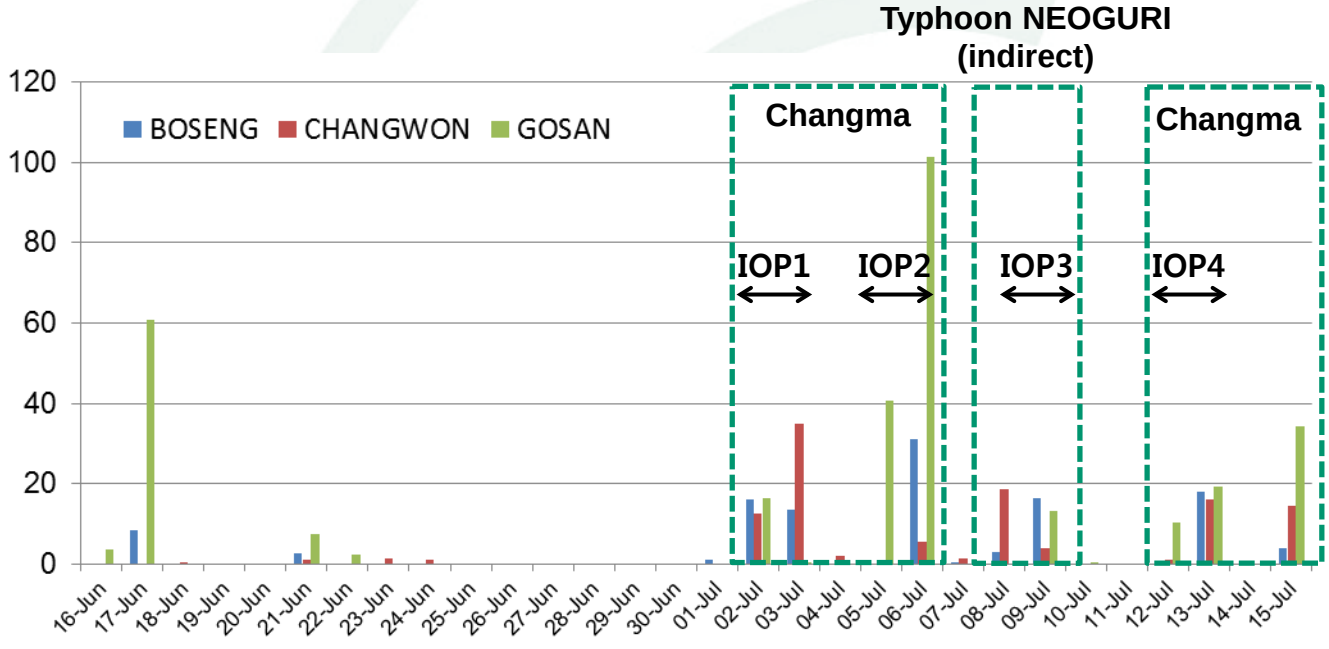


ProbeX-2014

- Intensive Observing Periods(IOPs)
  : 3hr-interval observation at Boseong and Changwon

	IOP-1	IOP-2	IOP-3	IOP-4
Initiation-time(UTC)	1800 1 JUN 2014	1800 4 JUN 2014	0600 8 JUN 2014	1200 12 JUN 2014
End-time(UTC)	0000 3 JUN 2014	1200 6 JUN 2014	0000 10 JUN 2014	0600 13 JUN 2014
Frequency(times)	11	15	15	7

- Four IOPs and daily amount of precipitation during ProbeX-2104



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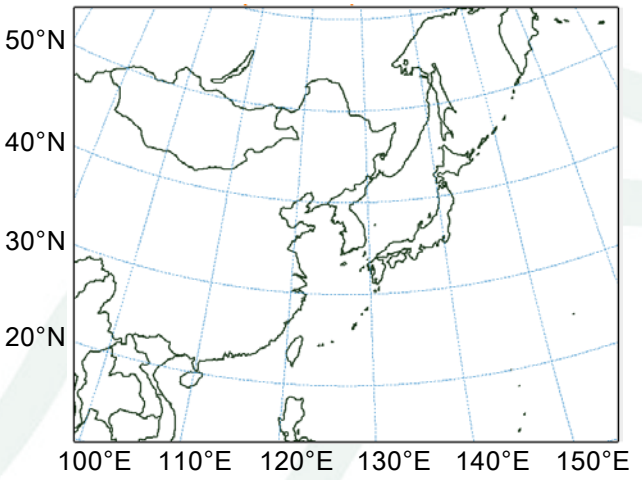
Observation System Experiments

- Regional Data Assimilation Prediction System(RDAPS)
  - For OSEs, the operational regional model of KMA(Korea Meteorological Administration) based on Unified Model(UM) are used as numerical model.
  - KMA regional model have 12km horizontal resolution and 70 levels(top:80km) in the vertical.
  - 4DVAR assimilation system is performed to assimilate observation data.

RDAPS description

Data Assimilation system	Method	4DVAR	
	Resolution	12 km (540 X 432)	
	Assimilation Window	6 hours (∓ 3)	
Forecast model UM 12kmL70	Resolution	12 km (540 X 432)	
	Vertical layers	70 sigma level(Top : 80km)	
	Forecast time	87 hours (6 hours intervals)	
	Initial/boundary conditions	UM N512 (25 km resolution)	
	Physical Process	Microphysics	Mixed phase precipitation
		Convection	Mass flux convection with CAPE closure
		Radiation	Edward-Slingo general 2-stream scheme
		Gravity wave drag	G.W. drag due to orography(GWDO)
		Boundary layer	MOSES-Ⅱ Non-Local PBL
		Land-surface	MOSES-Ⅱ land-surface scheme

model domain



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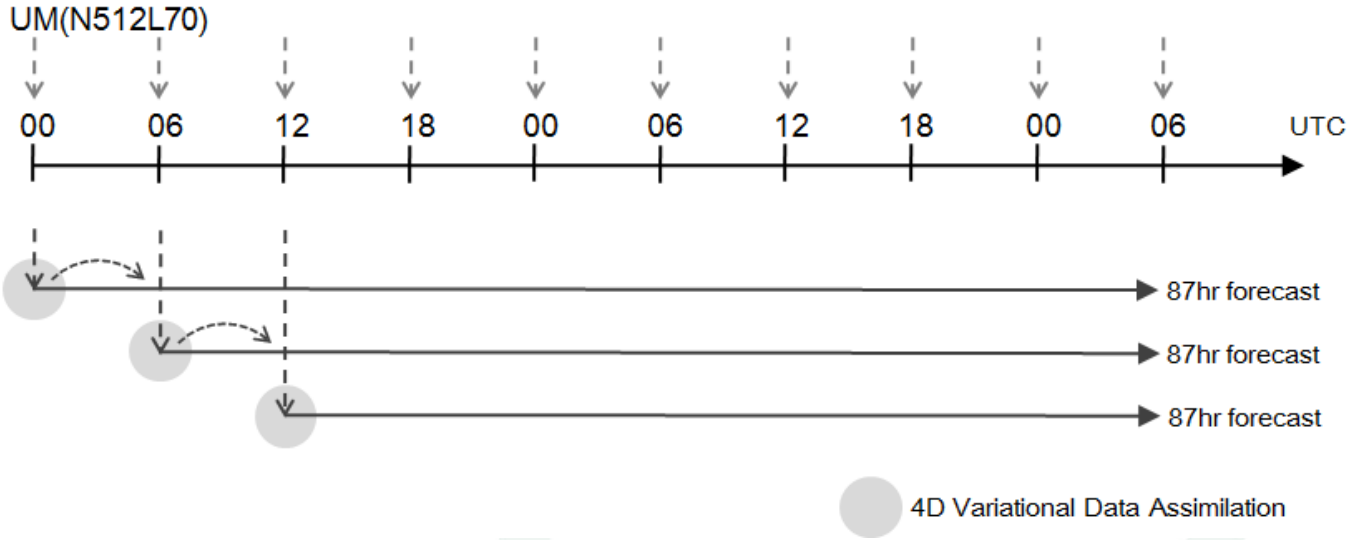
Observation System Experiments

- Regional Data Assimilation Prediction System(RDAPS)
  - The repetitive 6 hours cycle is performed for analysis and forecast.

Schematic diagram of analysis and forecasting system



Observation System Experiments

- Experiment setup

  • Four experiments are simulated to evaluate observation impact on forecast.

Experiments	Observations	
	KMA_data	Rawinsonde(3 sites)
CNTL	○	X
EXP	○	○ (all rawindsonde contained 3 interval data)
EXP_6h	○	○ (only 6hours interval data)
EXP_12h	○	○ (only 12hours interval data)

  • KMA data : observations used in KMA operational numerical model

    (AWS, AMDAR, AMEDAS, METAR, MTSAT, etc.)

  • Model run period

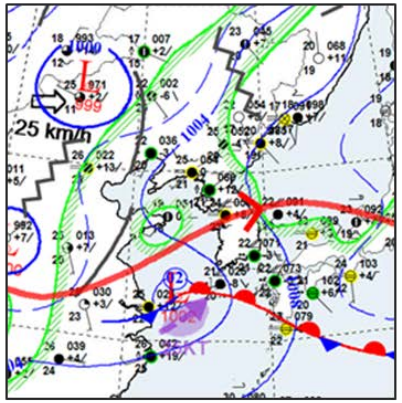
  - Case1(IOP1) : 00 UTC 01 ~ 18 UTC 03 July 2014.

Rainfall event(IOP1)

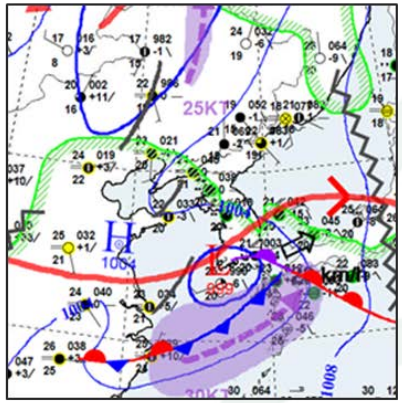
- Rainfall event(03 JUL 2014)
  - Changma front and low pressure are located on southwest region of Korea.
  - As time passed, Changma front and low pressure move toward south sea of Korea.
  - Heavy rainfall is occurred in southestern region of Korea.

Surface weather chart

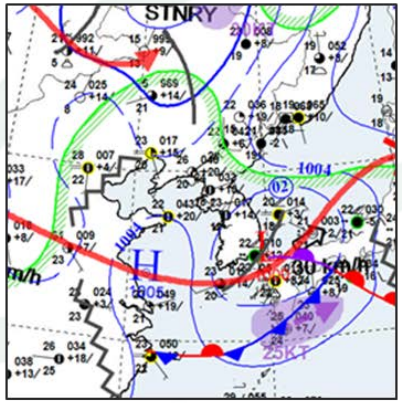
12 UTC 02 July 2014



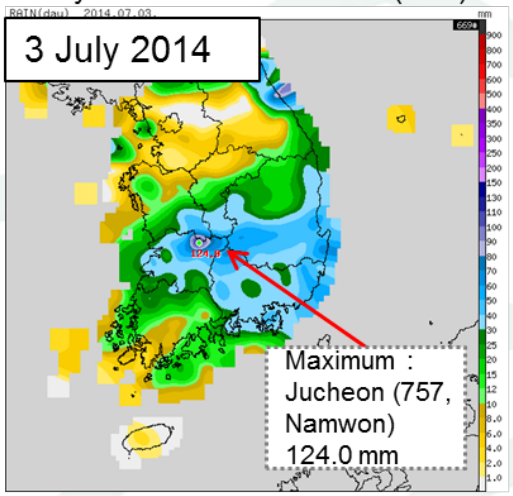
00 UTC 03 July



12 UTC 03 July

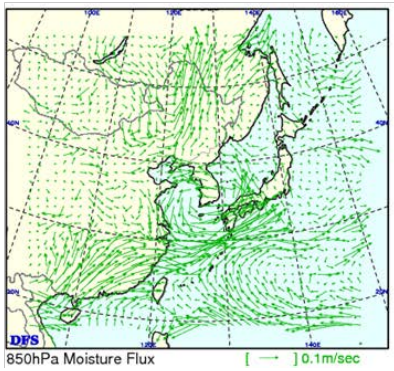


1-day accumulative rainfall (mm)

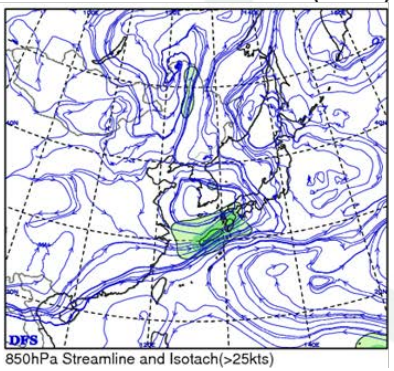


00 UTC 03 July 2014

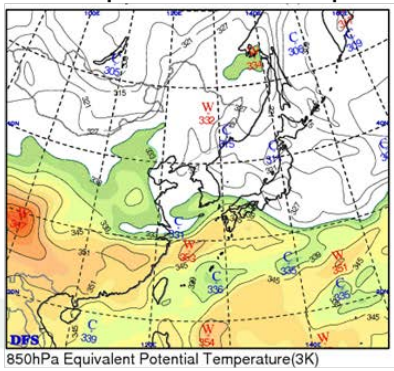
850hPa Moisture Flux



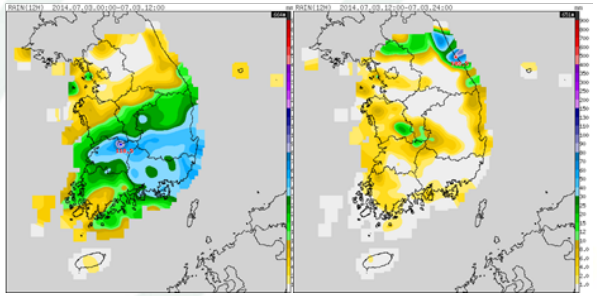
850hPa Streamline and Isotach(>25kts)



850hPa Equivalent Potential Temperature

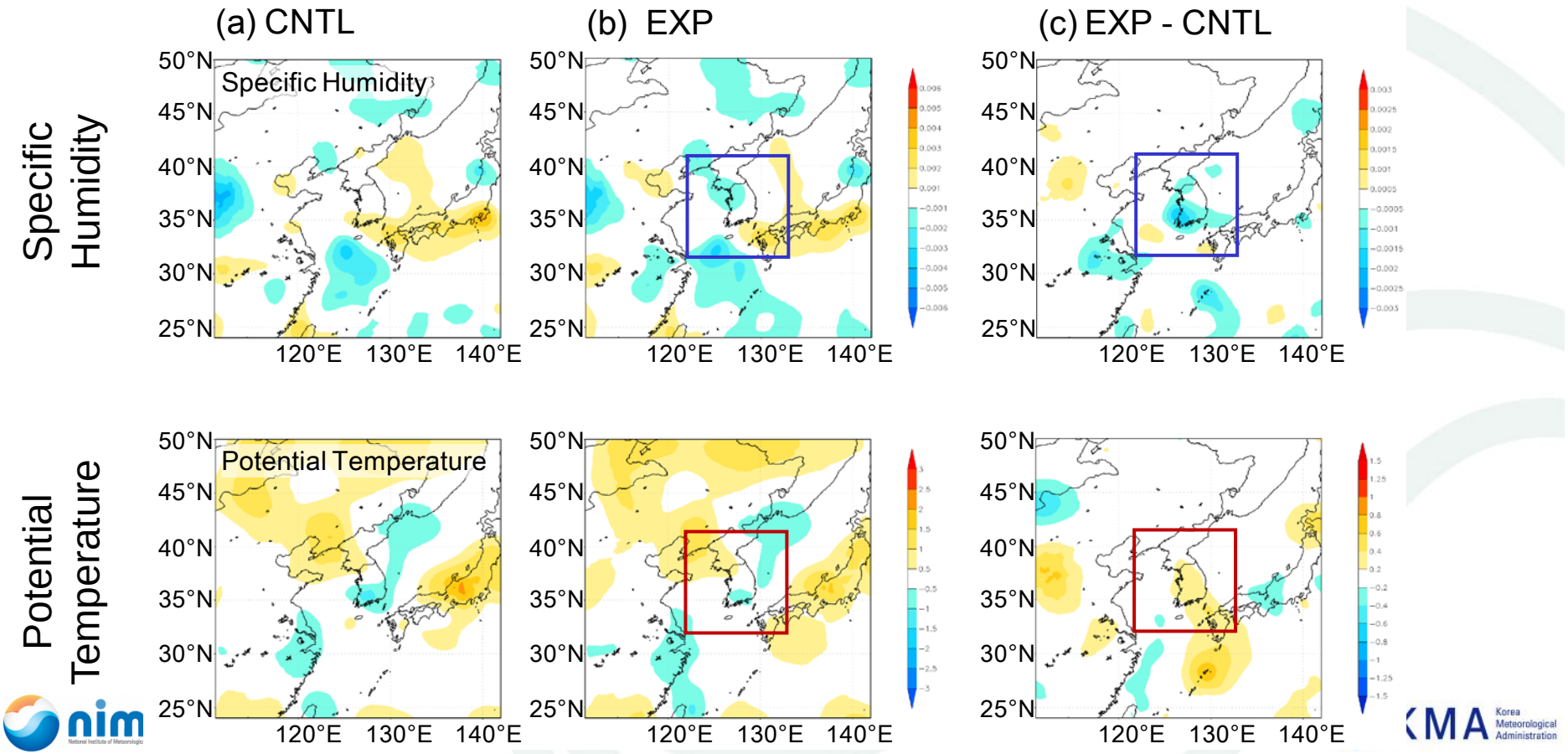


00 ~ 12 LST 3 July | 12 ~ 24 LST 3 July



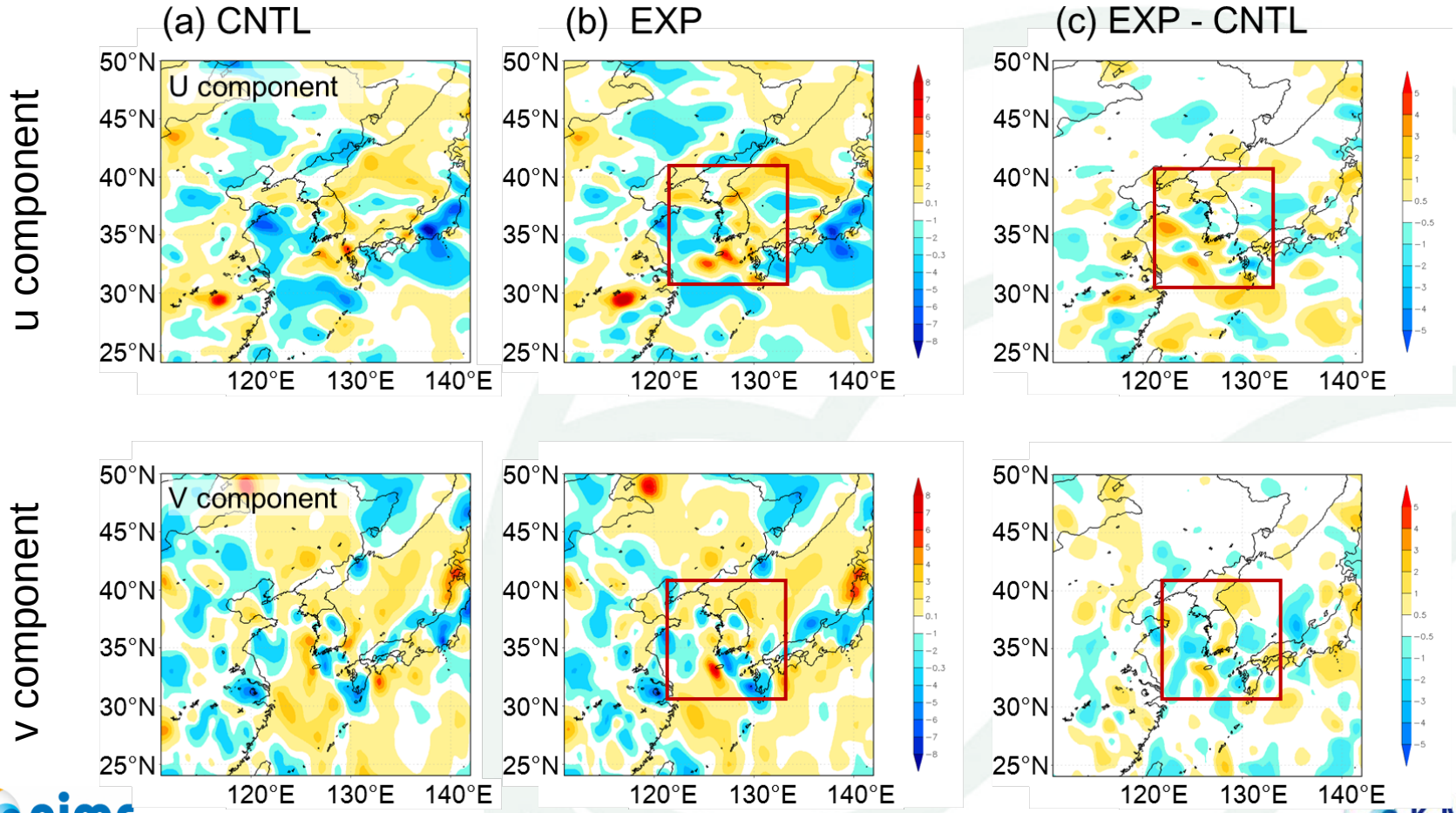
Analysis increment(1500m height, 2014.07.02.12 UTC)

- Positive increment on specific humidity in CNTL(without adaptive obs.) appears nearby southern coastal region of Korea.
- The analysis increments in EXP(with adaptive obs.) are decreased in northwestern and southern region.
- Negative increment on temperature in EXP is weaker than CNTL.



Analysis increment(1500m height, 2014.07.02.12 UTC)

- Changes of increment on u and v component appear at all area over the model domain.
- Especially, difference of CNTL from EXP shows large values in Yellow sea and nearby Jeju island.



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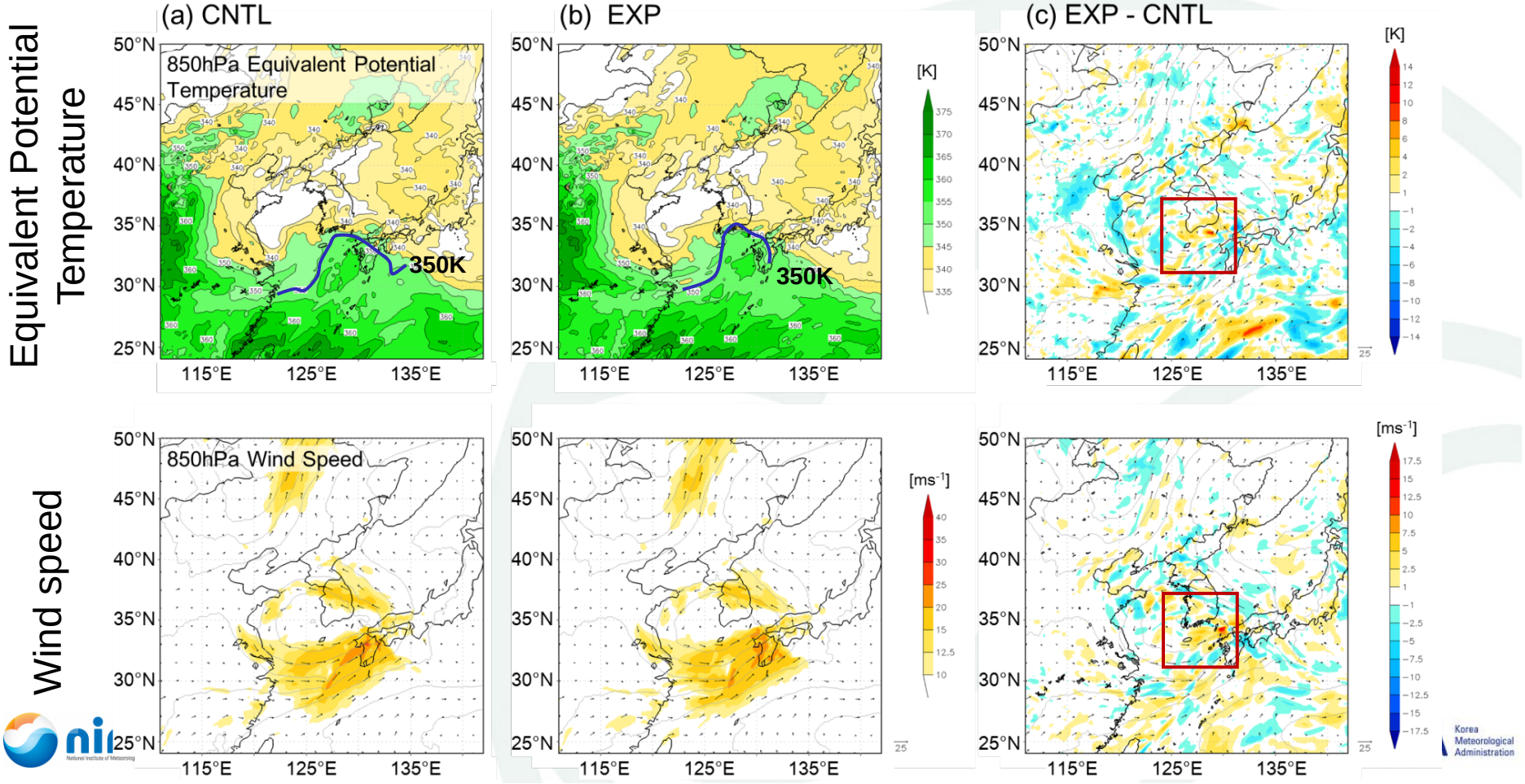
850hPa 12hr-forecast fields(initial: 2014.07.02. 12 UTC)

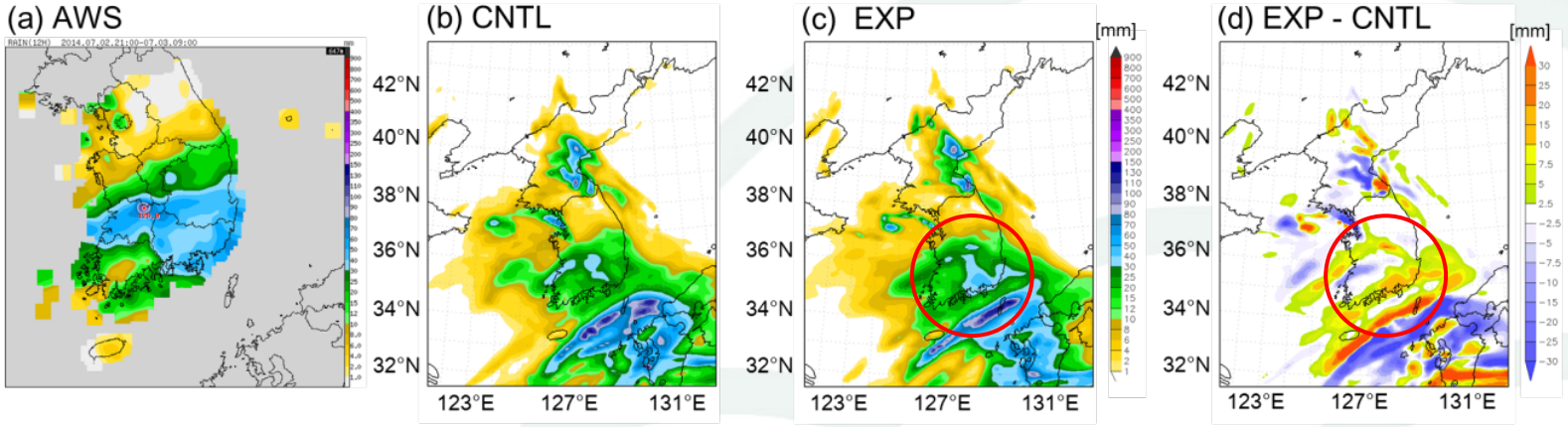
- 350 K- line of EPT at 850 hPa displays a tendency to move northwards in EXP.
- Cyclonic rotation presents over Korea and wind speed is strong(> 15m/s).
- More moist and warm air at 850hPa inflow into southern region of Korea in EXP.



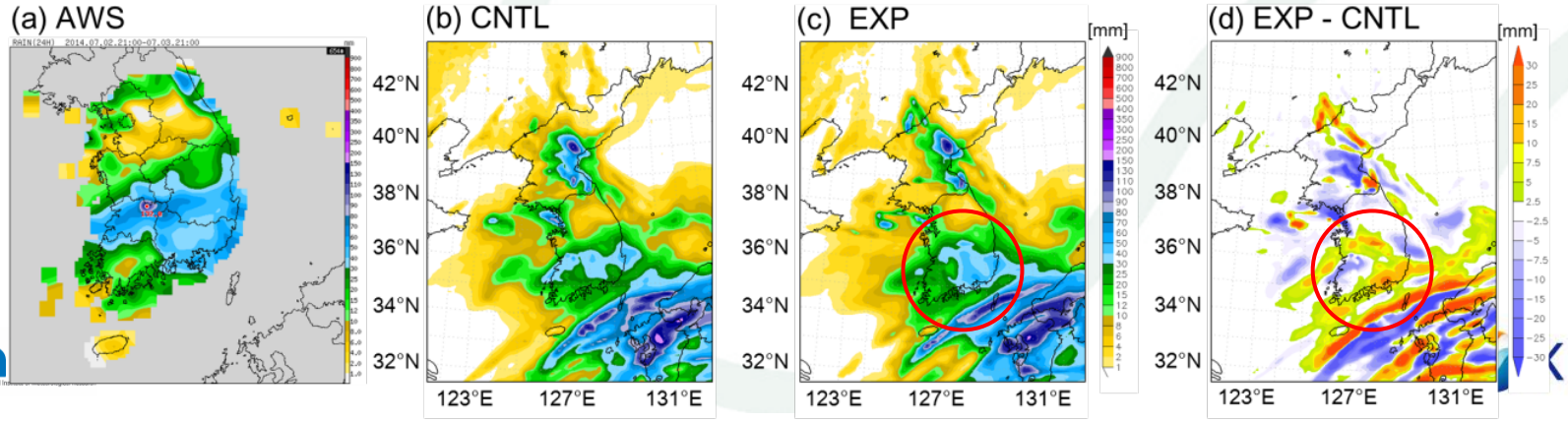
Precipitation forecasts(initial: 2014.07.02. 12 UTC)

- EXP is simulated more rainfall amount than CNTL for 12hr and 24hr accumulated rainfall in the southern region of Korea. Accumulated rainfall is increased with more than 10mm in the EXP.
- The cause of precipitation increment is considered to inflow of more warm and moist air than CNTL.

- 12hr accumulated precipitation(00 UTC 3 JUL 2014)



- 24hr accumulated precipitation(12 UTC 3 JUL 2014)



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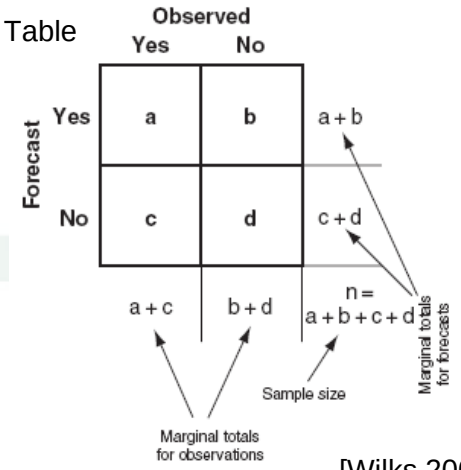
Verification of precipitation forecasts

- Equitable Threat Score(ETS)
  - ETS is used to evaluate precipitation forecasts quantitatively.

$$ETS = GSS = \frac{a/(a+b+c) - a_{ref}/(a+b+c)}{1 - a_{ref}/(a+b+c)} = \frac{a - a_{ref}}{a - a_{ref} + b + c}$$

$$a_{ref} = (a+b)(a+c)/n$$

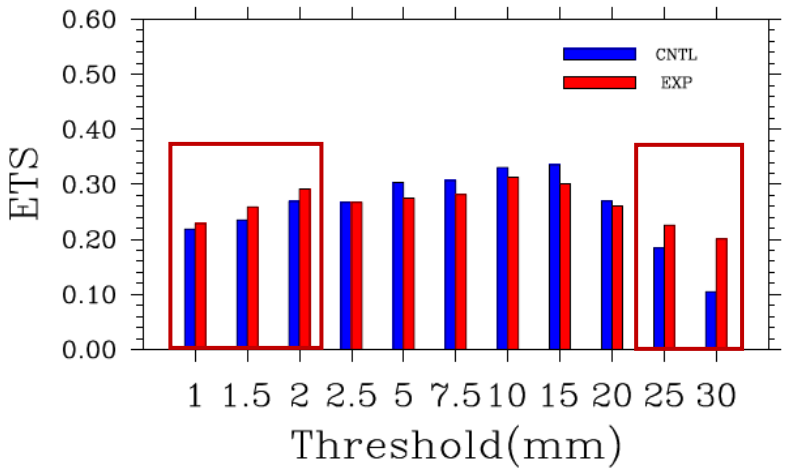
Contingency Table



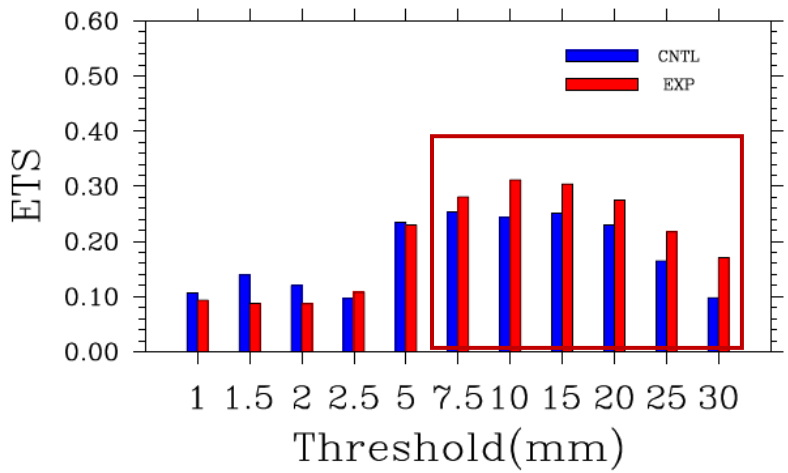
[Wilks 2006]

  - Verification period : 18 hours (00 UTC ~ 18 UTC 02 July 2014)
  - Evaluated on Automatic weather System(AWS) rain-gauge sites(610 points) over Korea

ETS(12hr accumulated precipitation)



ETS(24hr accumulated precipitation)



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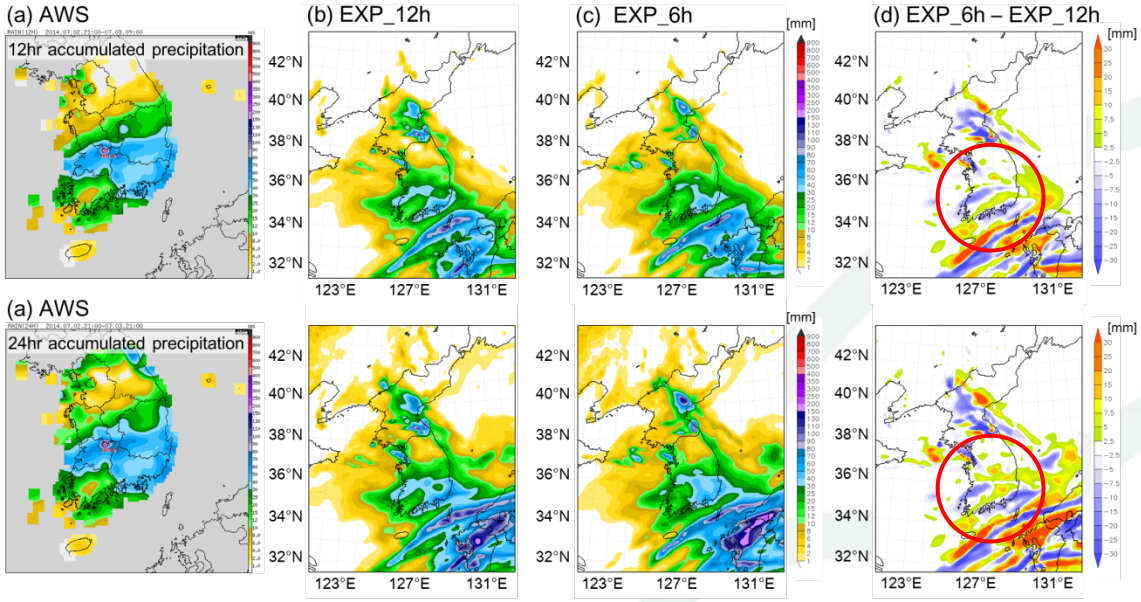
Result: Time interval experiments

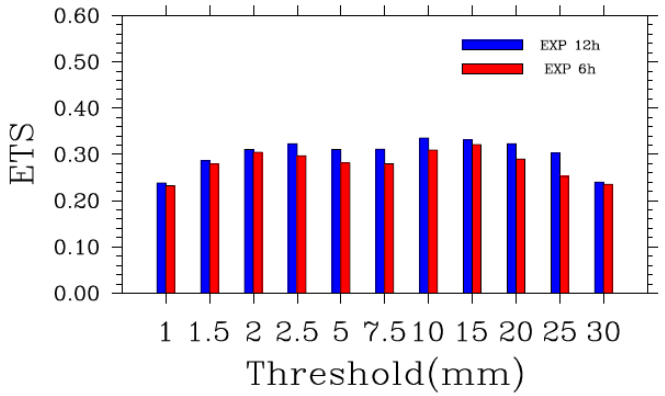
- Distribution of accumulated precipitation
  - initial time : 12 UTC 02 JUL 2014



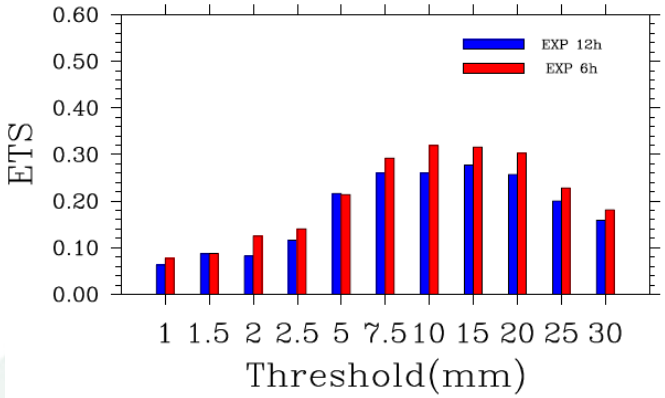
- Distribution of pattern in EXP_12h and EXP_6h is similar to one of AWS.
- Accumulated precipitation in EXP_6h shows positive anomaly in southern region and negative anomaly in western coastal region by comparison with EXP_12h.
- ETSs for 12hr accumulated rainfall in EXP_12h appear better performance than EXP_6h.
- In contrast, ETS for 24hr in EXP_6h has larger values as compared with EXP_12h for all threshold.

- Equitable Threat Score(ETS)
  - verification period
    : 00 UTC 02 ~ 18 UTC 02 JUL 2014

ETS(12hr accumulated precipitation)



ETS(24hr accumulated precipitation)



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Summary

- The summer intensive observation program(ProbeX-2014) using rawinsonde is carried out from 16 June 2014 to 15 July, 2014 over South Korea.
- OSEs with operational RDAPS are performed to investigate the upper-level observation data impact during short-range forecast about rainfall event.
- As a result of sensitivity experiments, EXPs with adaptive observation data show that more warm and moist air inflow into southern region of Korea.
- Forecasts of the 12hr & 24hr accumulated precipitation in EXPs are improved near Jeju island and southern region of Korea.
- ETSs of EXPs show neutral or positive impacts in rainfall forecast. Especially, ETSs(24hr accumulated rainfall) of the EXP_6h has larger values than EXP_12hr.

Thank you for your attention!!

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