

Recent Climate Conditions over South Korea



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Outlines



- ➔ Trends in temperature and rainfall over South Korea during summer
 - Summer-mean temperature
 - Numbers of heat waves and tropical nights
 - Rainfalls in the central and southern parts of South Korea
- ➔ Decadal change in Changma rainfall around the early-2000s
(Woo et al. 2017, Atmospheric Korean Meteorological Society)
- ➔ Overview of 2017 summer climate over South Korea
- ➔ 2017 Changma characteristics
- ➔ Summary

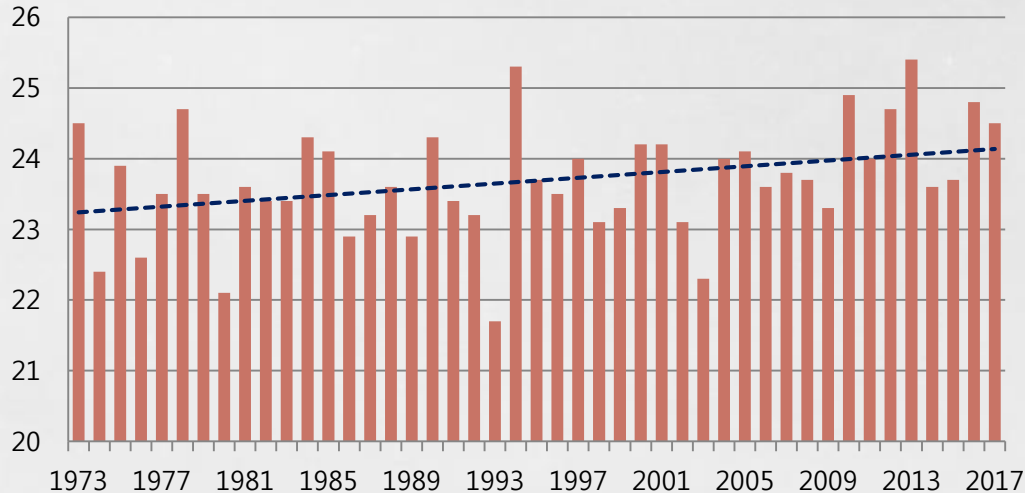
Outlines



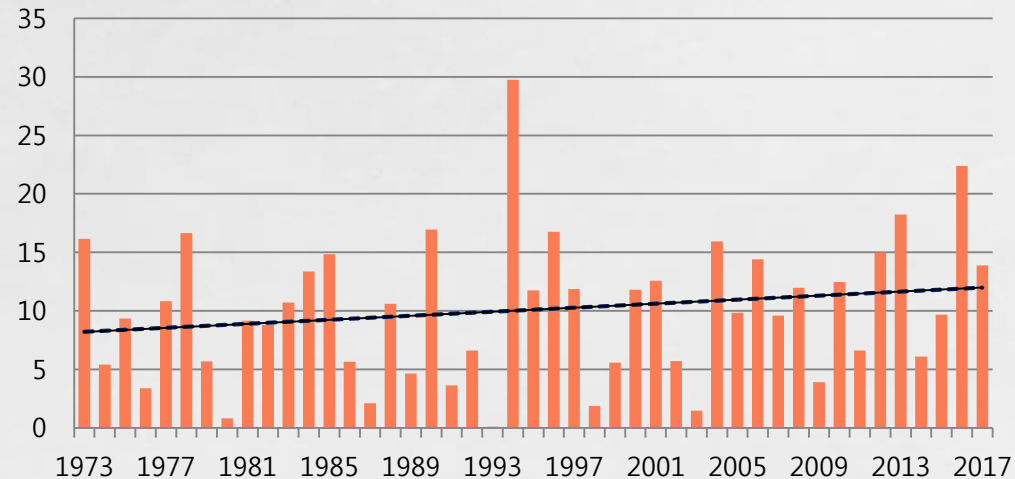
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Trend in temperature over South Korea during summer

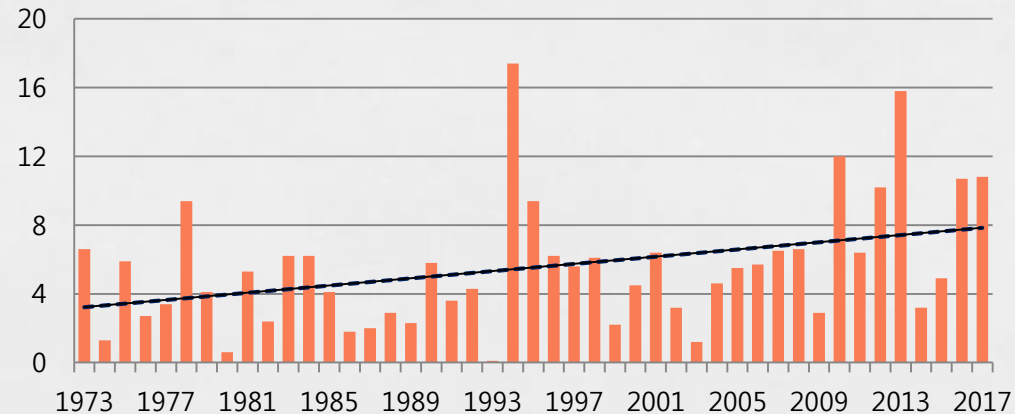
Time series of summer-mean temperature averaged over South Korea



number of heat waves averaged over South Korea



number of tropical nights averaged over South Korea



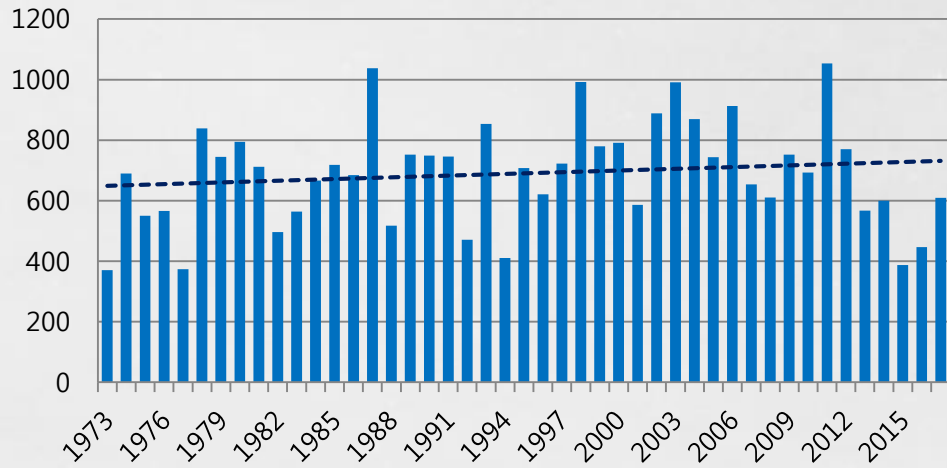
[Definition]

- Heat wave
 - when the daily maximum temperature is greater than 33°C

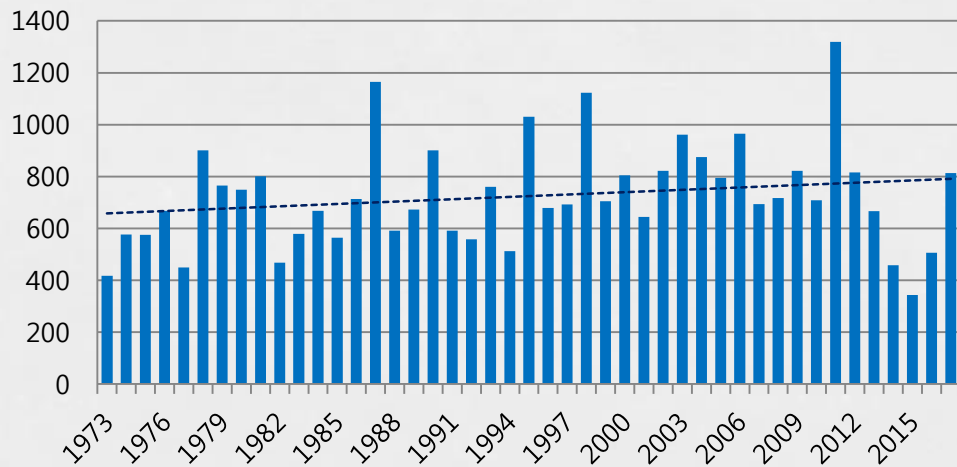
- Tropical night
 - when the daily minimum temperature during night time (18:01~09:00 next day) is greater than 25 °C

Trend in rainfall over South Korea during summer

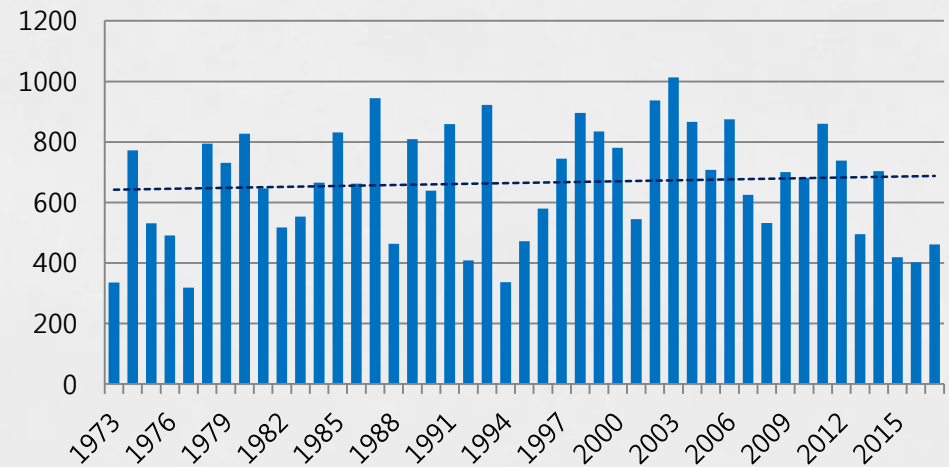
Time series of rainfall over South Korea during summer



Rainfall in the central part of South Korea during summer



Rainfall in the southern part of South Korea during summer

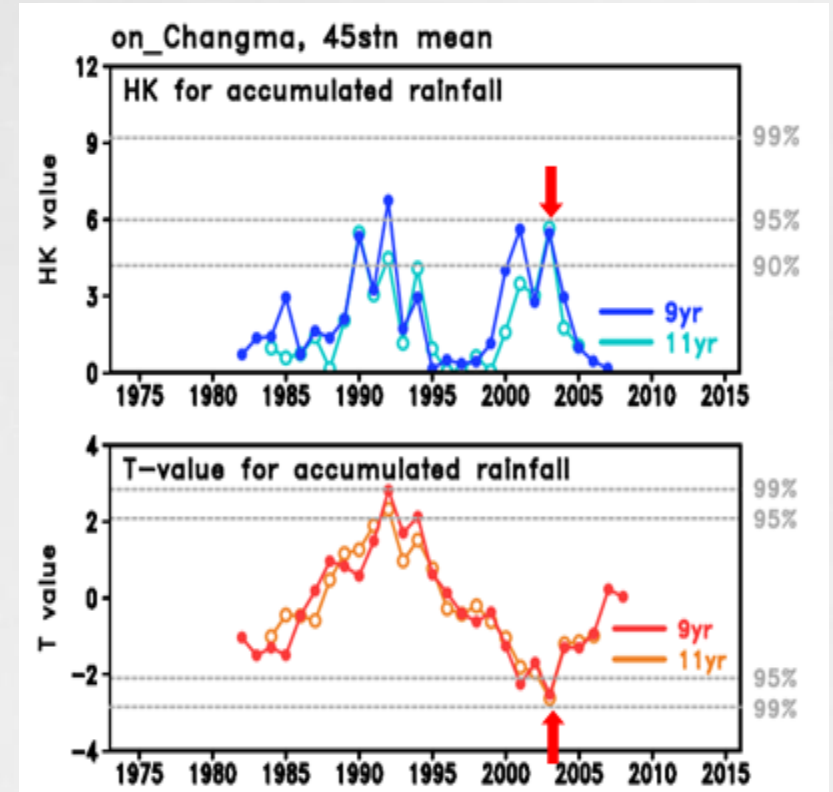
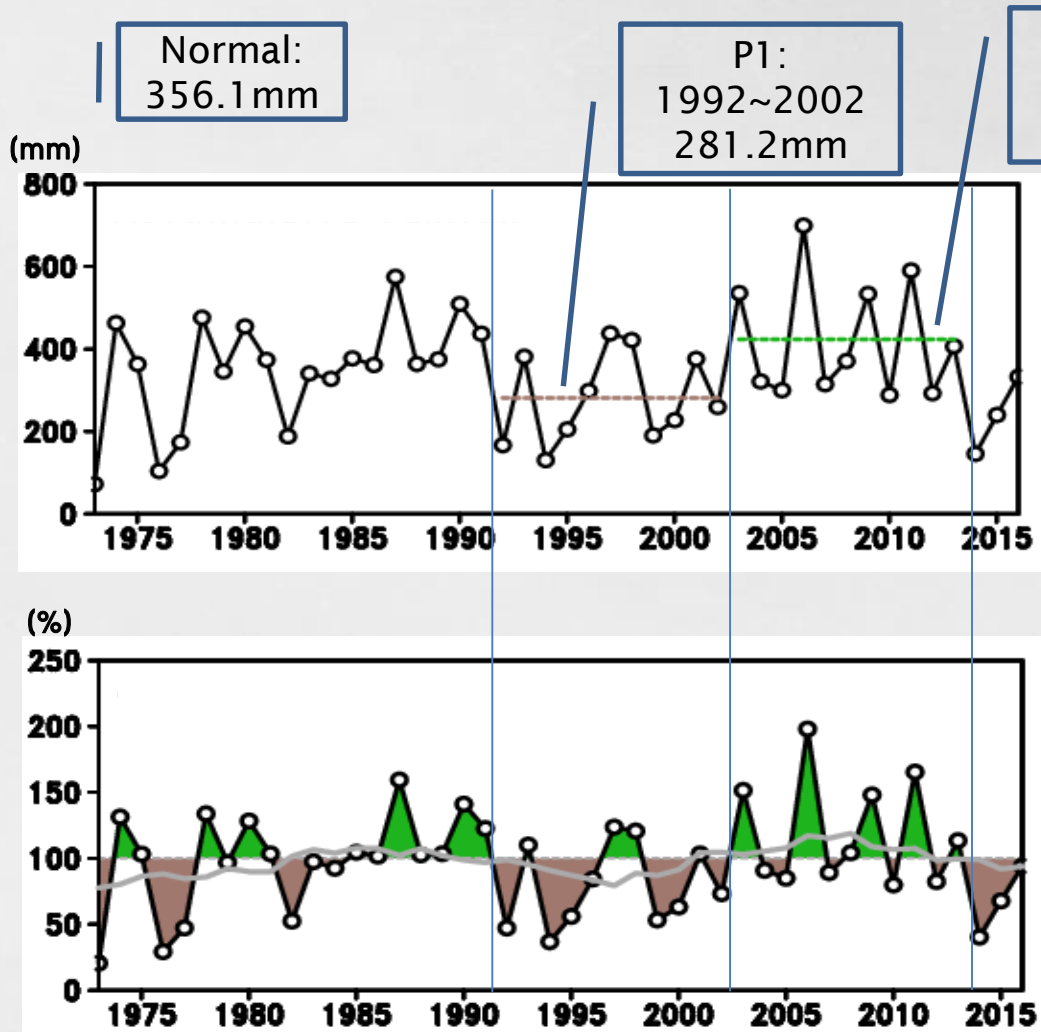


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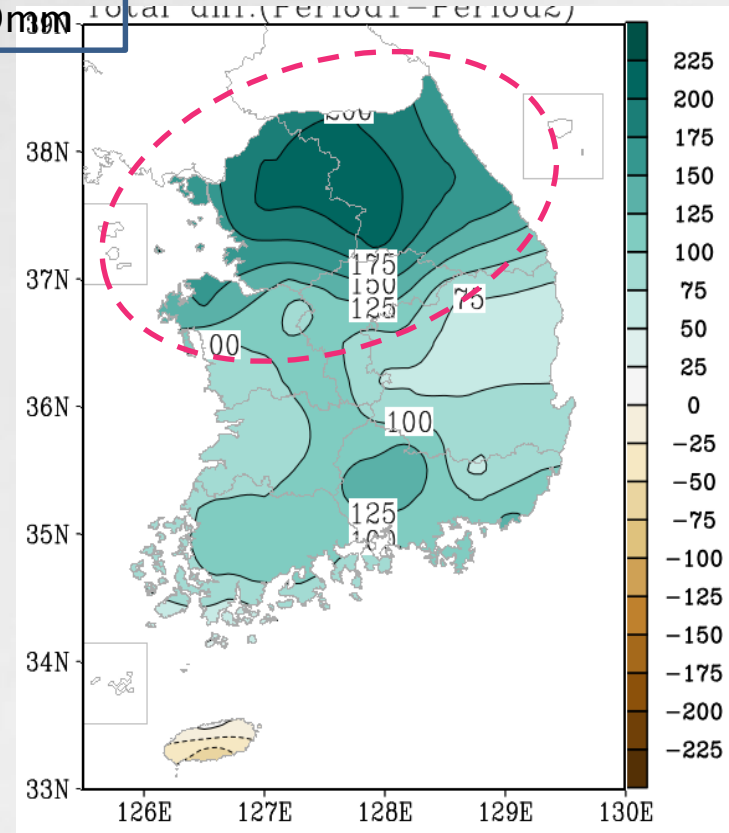
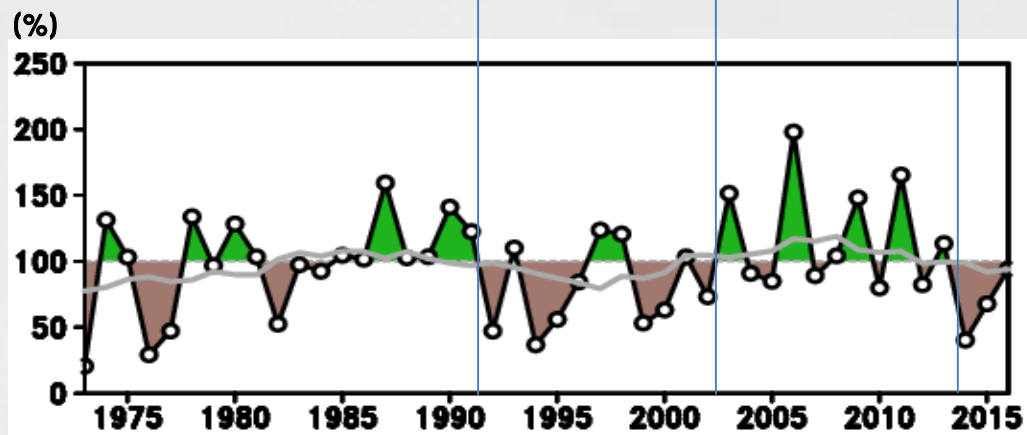
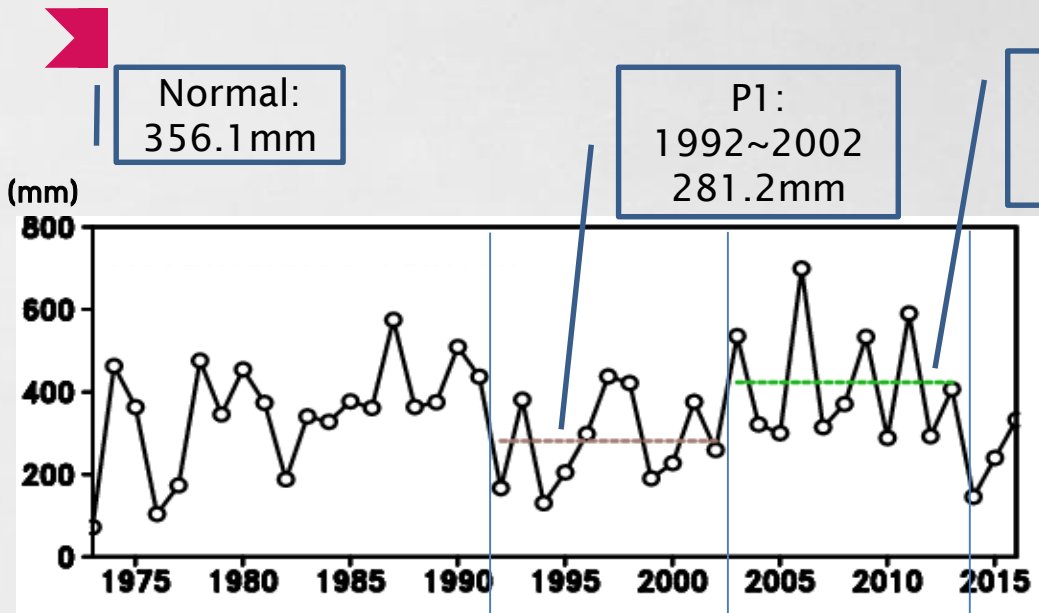
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Decadal Change in Changma rainfall around the early-2000s



- Time series of Changma rainfall(upper) and its ratio to normal(lower) during 1973–2016. In the lower panel, the grey line indicates 11–running mean time series.

- (upper) Lepage–test and (lower) moving T–test using the 9–yr and 11–yr running mean time series of Changma rainfall.



• Difference of Changma rainfall between P2 and P1

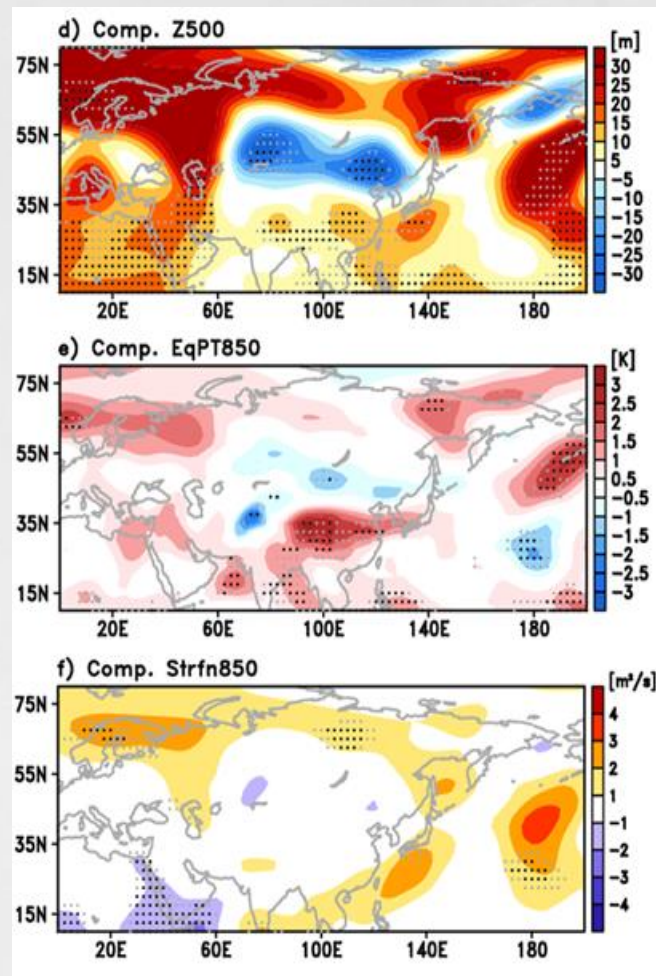
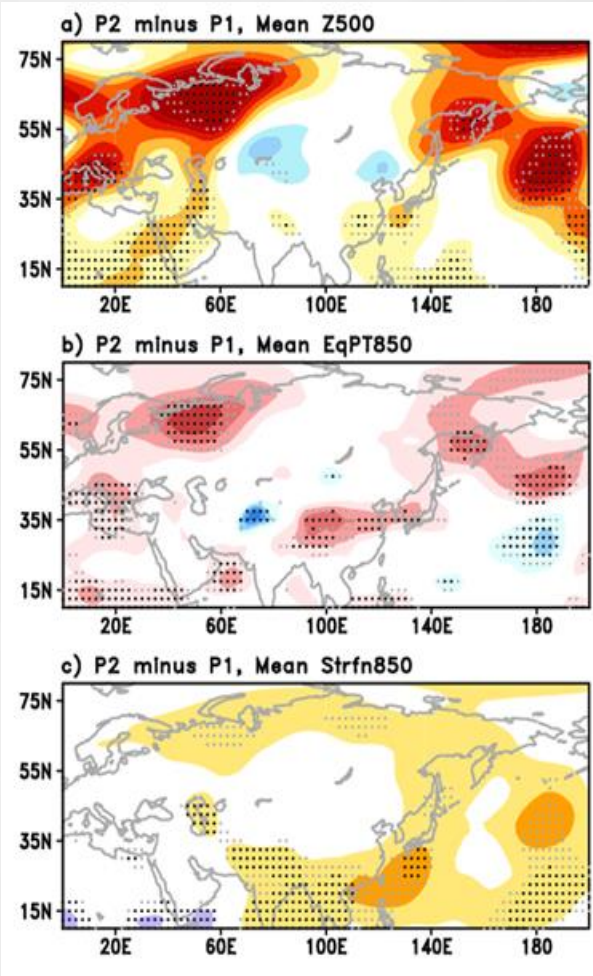
- Timer series of Changma rainfall(upper) and its ratio to normal(lower) during 1973-2016. In the lower panel, the gray line indicates 11-running mean time series.

- ✓ The increase in Changma rainfall in central region is greater than the southern region.

Change in extratropics and subtropics

Mean difference
P2 minus P1

Composite difference
between SC in P2 and WC in P1



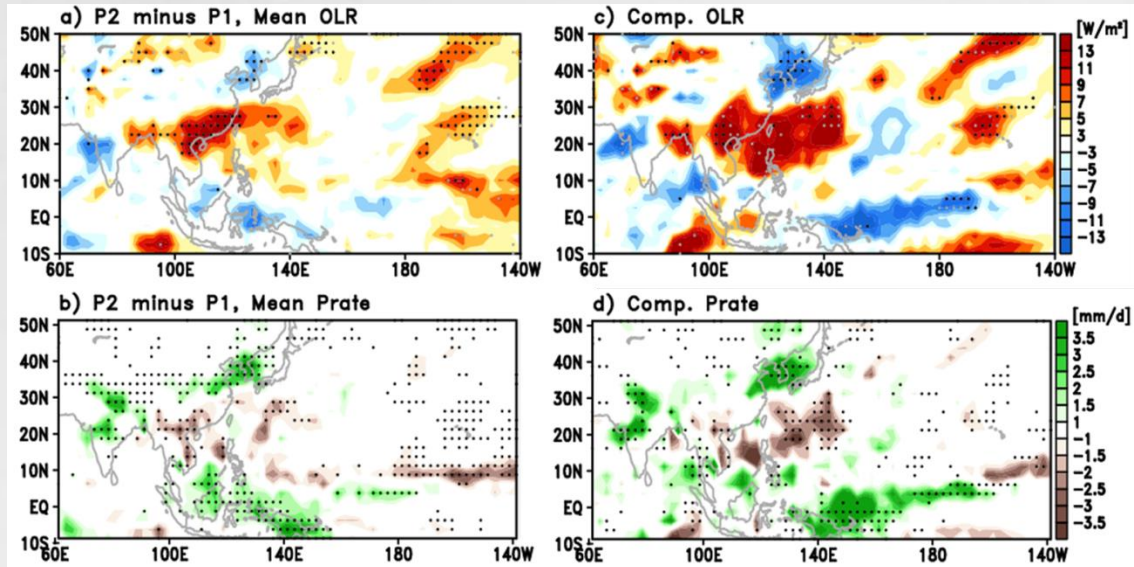
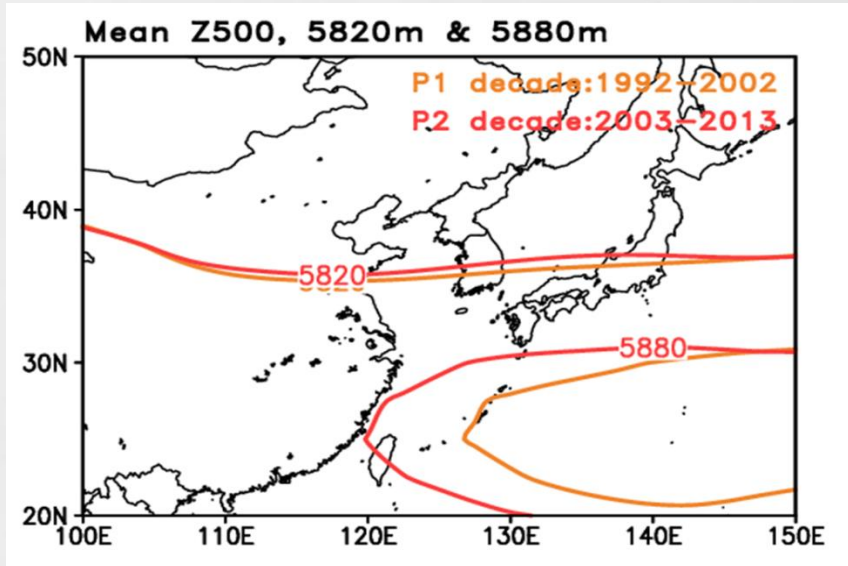
- (extratropics) There are positive anomalies over Ural mountain and Okhotsk Sea region, which indicates that cold airs can be located over the north of South Korea frequently.
 - (sub-tropics) positive anomalies over the south of the Korean Peninsula indicating strengthened North Pacific high with warm and wet air mass toward East Asia
- ⇒ Favorable condition for the development of Changma rainfall front between cold and warm airs
 ※ also supported by the EPT850

- (left) mean difference between P2 and P1 in Z500, EPT850, and STF850 and (right) composite difference of strong Changma years(SC) in P2 and weak Changma years(WC) in P1. Areas exceeding 90% confidence level are dotted.

Change in the western North Pacific subtropical High

Mean difference
P2 minus P1

Composite difference
between SC in P2 and WC in P1



- 5820m and 5880m lines of geopotential height at 500hPa averaged in P1 (orange color) and P2 (red color)
- (Western North Pacific subtropical High, WNPSH) Extended more to the northwest than the normal position \Rightarrow hot and moist airs toward the East Asia by the southwesterlies along the flank of WNPSH

- (left) mean difference between P2 and P1 in OLR and precipitation and (right) composite difference of strong Changma years(SC) in P2 and weak Changma years(WC) in P1. Areas exceeding 90% confidence level are dotted.
- (convective activities) Suppressed convective activities over the western North Pacific region were dominant in P2, which is associated the anomalous anticyclone over the same region

▶ Potential reason for changes in extratropics and tropics



- Decline in the Arctic sea ice
 - The decline in the Arctic sea ice is associated with the warmth over the Arctic region, which can generate an anomalous anticyclone in the upper troposphere(Kug et al. 2015).



- Suppressed convection activities over the southeastern part of China
 - Decrease in landfall tropical cyclone since 2003 (Ha et al, 2016)
 - Increase of SST in the tropical Atlantic region (Ham et al. 2016)

Summary 1



- ➔ Summer-mean temperature anomaly averaged over South Korea has an increasing trend since 1973, but no significant trend for rainfall.
- ➔ The decadal change in Changma rainfall is detected around early-2000s.
 - The total Changma rainfall in 1992-2002 period was remarkably increased compared to that in 2003-2013 period.
- ➔ The increased Changma rainfall during 2003-2013 period is due to two anomalous high systems over the Ural mountain and the southeastern part of China. The meet of cold air from the Ural mountain and warm air from the south of Republic of Korea provides favorable condition for wet Changma in P2.

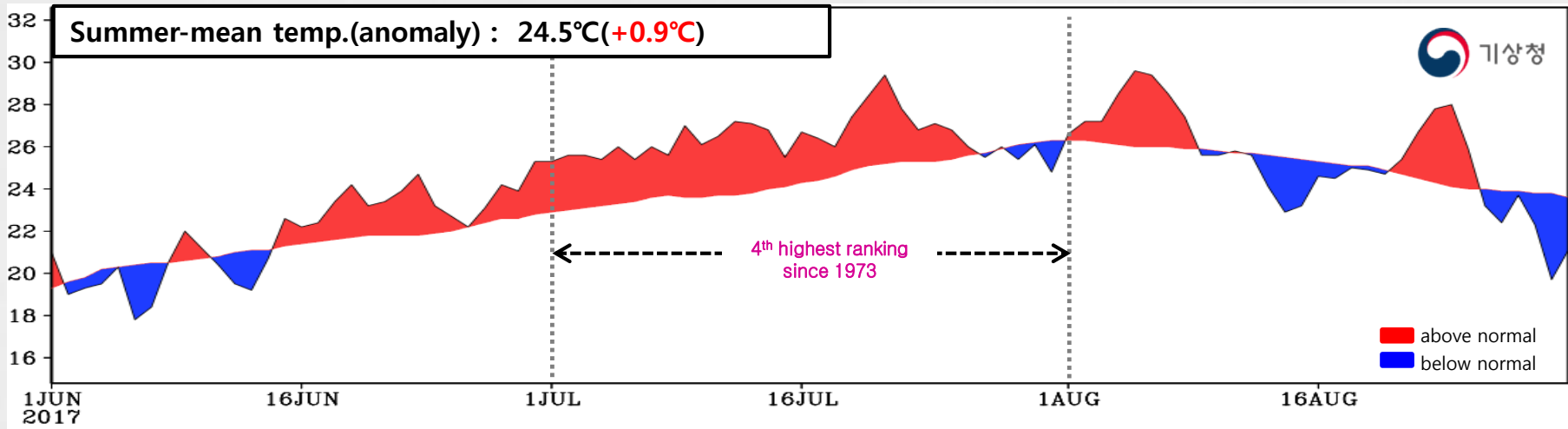
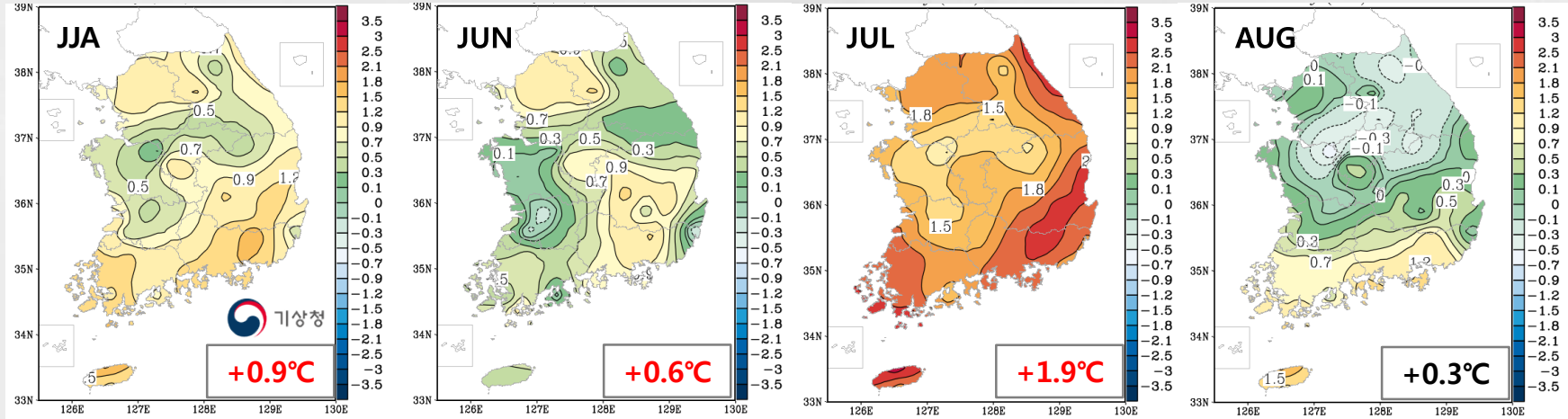
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Temperature over South Korea during 2017 summer

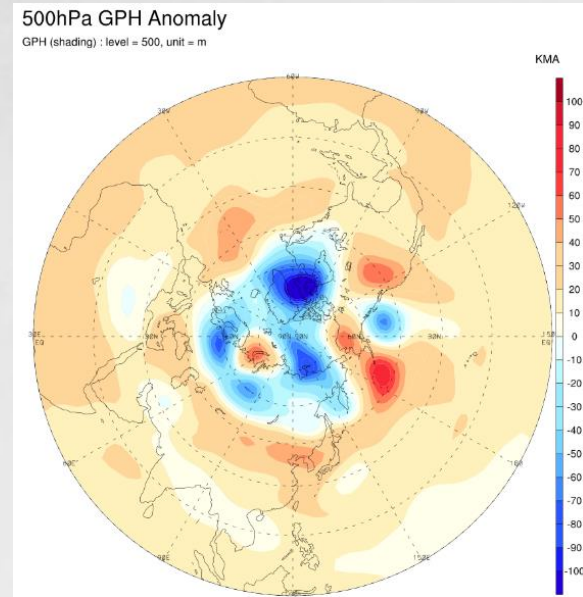
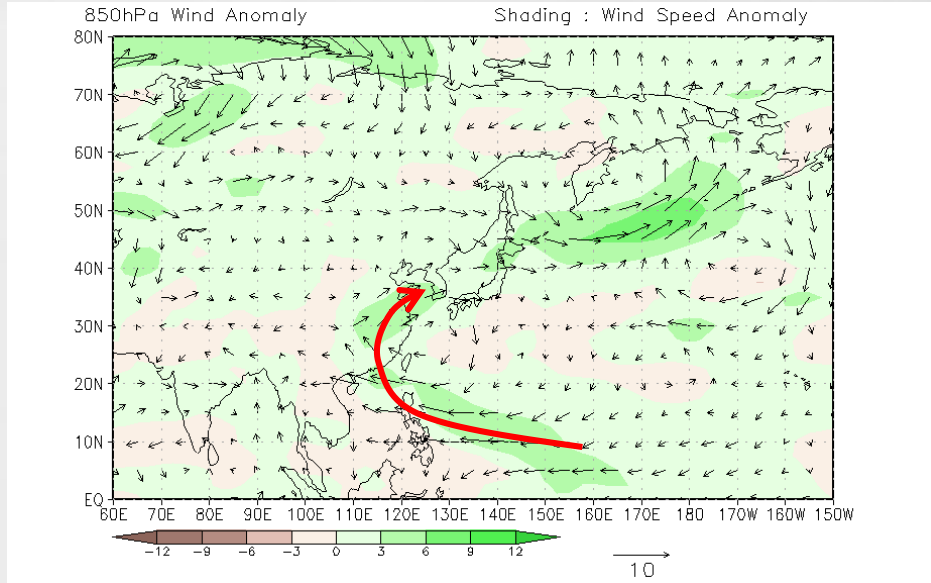
< Spatial and temporal temperature anomalies in JJA, JUN, JUL, and AUG >



45 station data, normal: 1981-2010

	June	July	August
Normal (1981~2010)	21.2°C	24.5°C	25.1°C

Circulation pattern in July (1st July to 22)

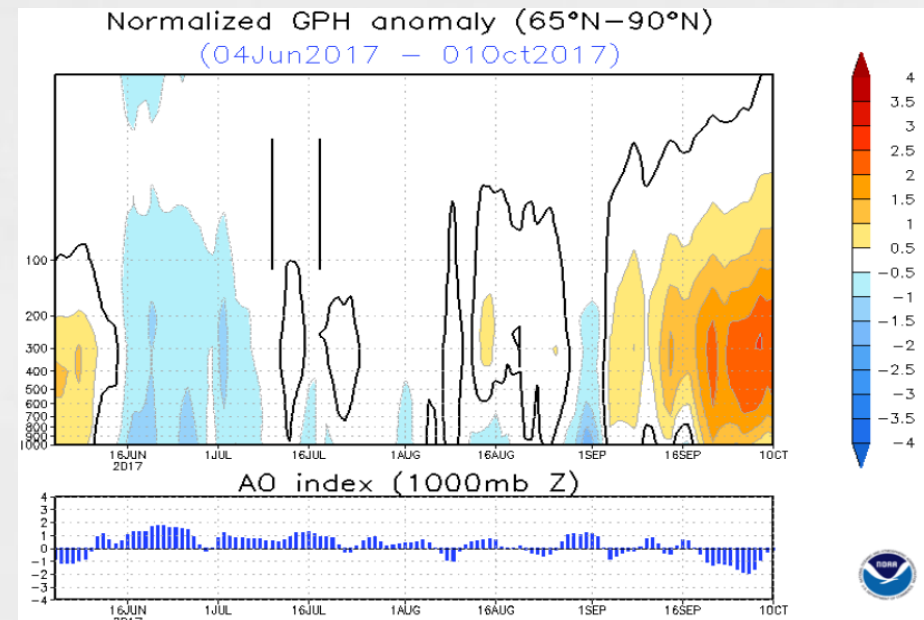


• Geopotential height anomaly at 500hPa during the period of 1st July – 22nd

- Wind vectors at 850hPa during the period of 1st July – 22nd

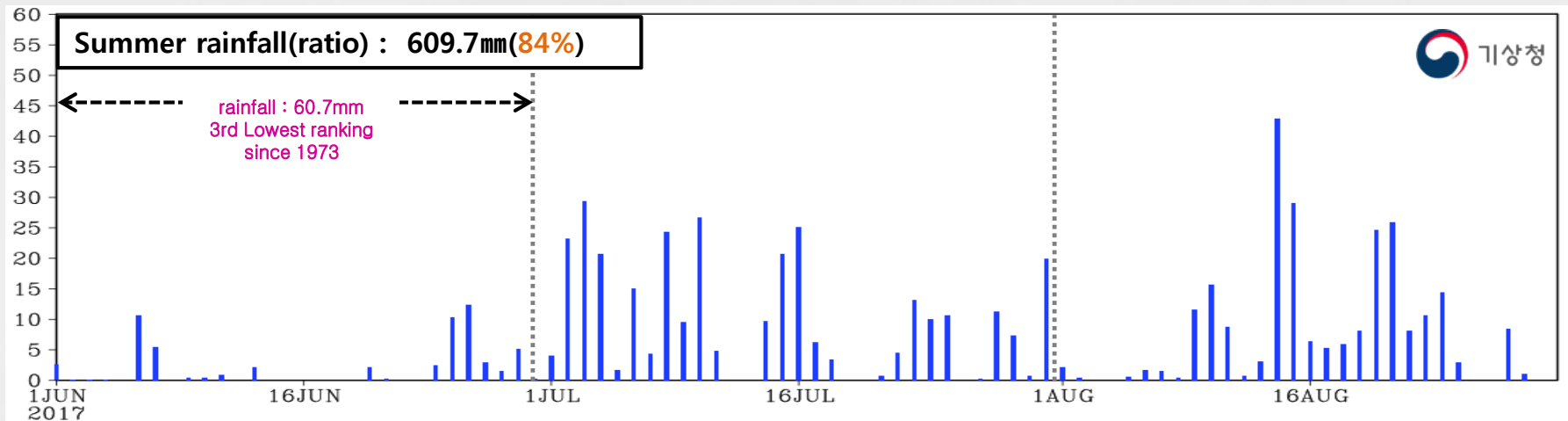
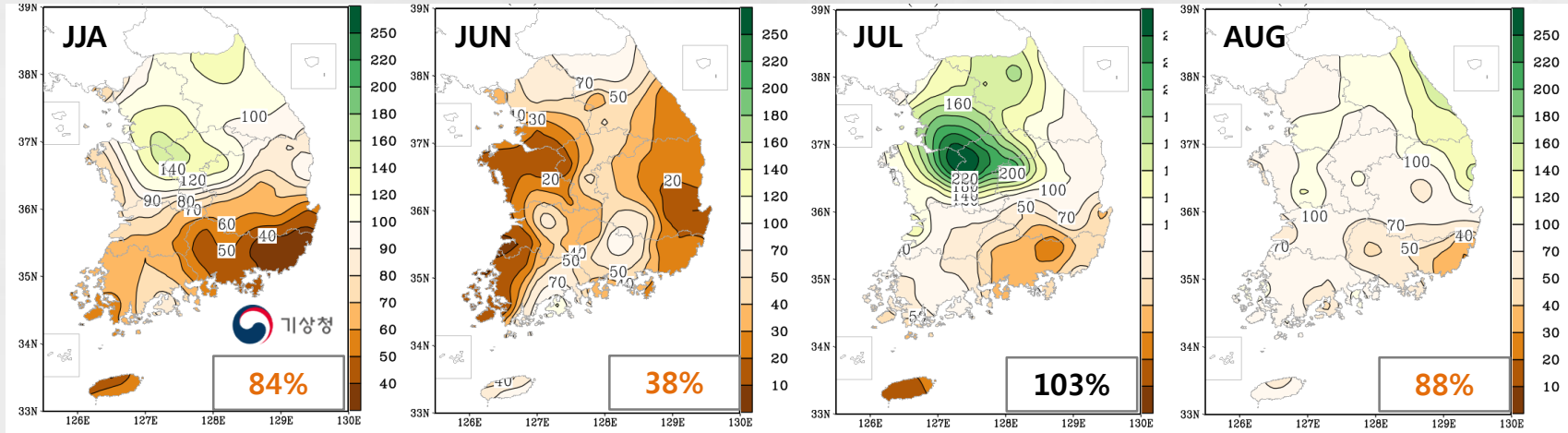
- ✓ 850hPa: The WNPSH was developed during July. South Korea in July was hotter than normal due to an inflow of hot air from the WNPSH.

- ✓ 500hPa: The dipole pattern of circulation anomaly between extratropic and North pole was apparent. This pattern looks like positive Arctic Oscillation, which was favorable condition for hot temperature in the extratropics including East Asia.



Rainfall over South Korea during 2017 summer

< Spatial and temporal precipitation amounts and ratios in JJA, JUN, JUL, and AUG >



45 station data, normal: 1981-2010

	June	July	August
Normal (1981~2010)	158.6mm	289.7mm	274.9mm

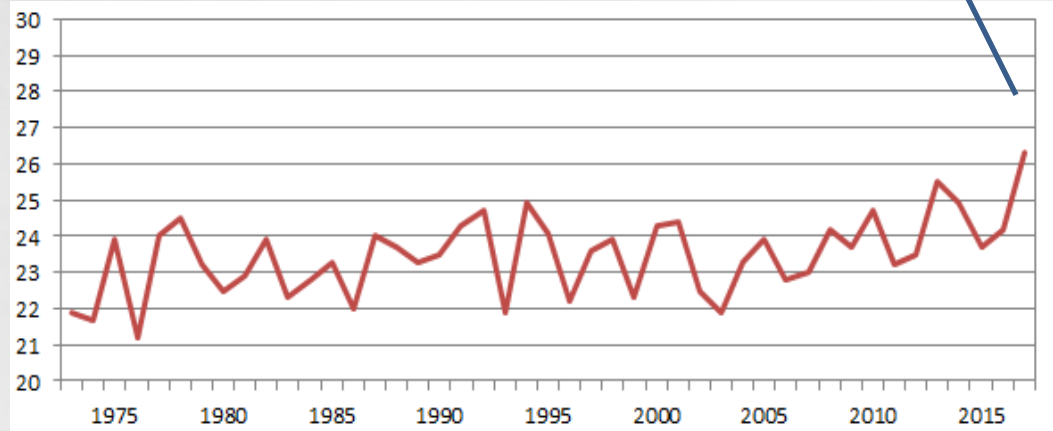
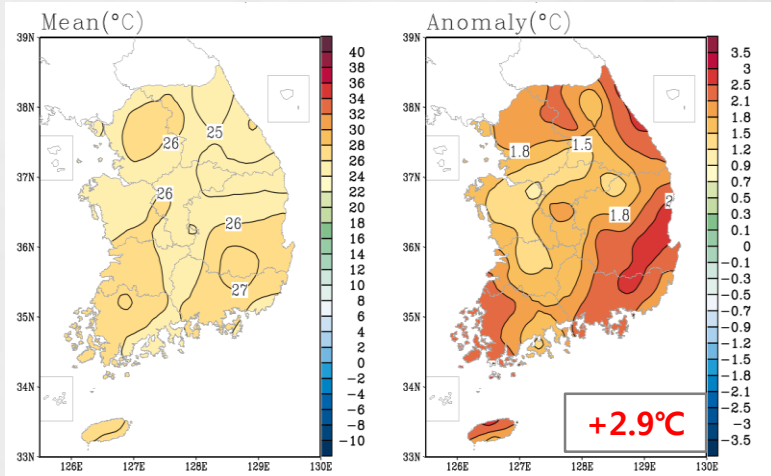
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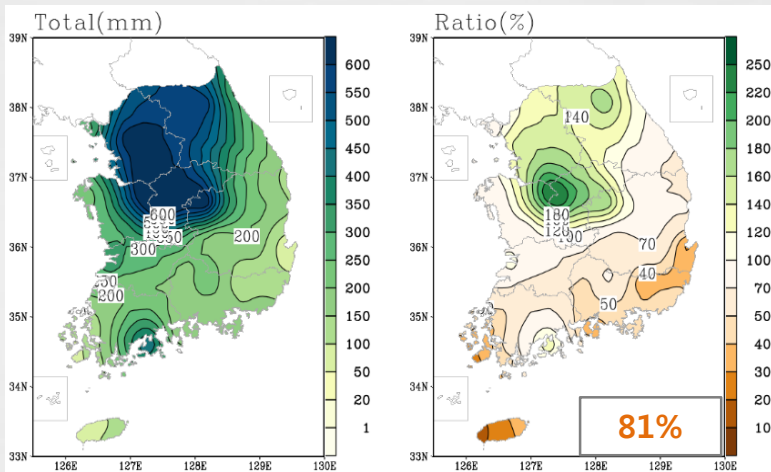
2017 Changma characteristics (1)

24th June - 29th July



- Time series of temperature averaged over South Korea during Changma period

< Rainy days and precipitation amount for 2017 Changma period >



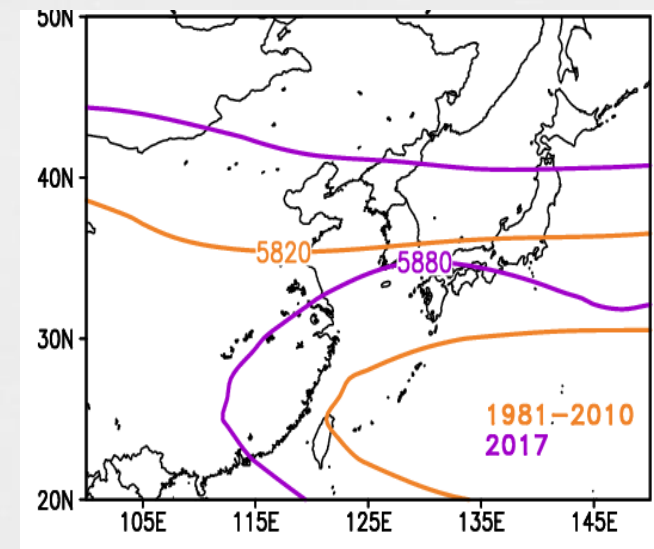
- (upper) temperature and its anomalies and (lower) accumulated rainfall amount and its ratio to normal during Changma period (24 June to 29 July)

	2017		Normal (1981-2010)	
	Rainy days	Precipitation (mm)	Rainy days	Precipitation (mm)
South Korea	16.9	291.7	17.1	356.1

▶ 2017 Changma characteristics (2)

👉 Changma started on 24th June and ended on 29th July. The onset and retreat of Changma in 2017 was later than normal.
 (normal: onset 23th June , retreat 25th July)

👉 The spatial rainfall pattern has a north-south dipole structure between central and southern regions. The WNPSH extended more northwestward during Changma period. The central region was wet because moisture transport increased due to the anomalous southwesterly from the northwestern flank of the WNPSH. On the other hand, southern region was dry due the influence of the anomalous subtropical high.

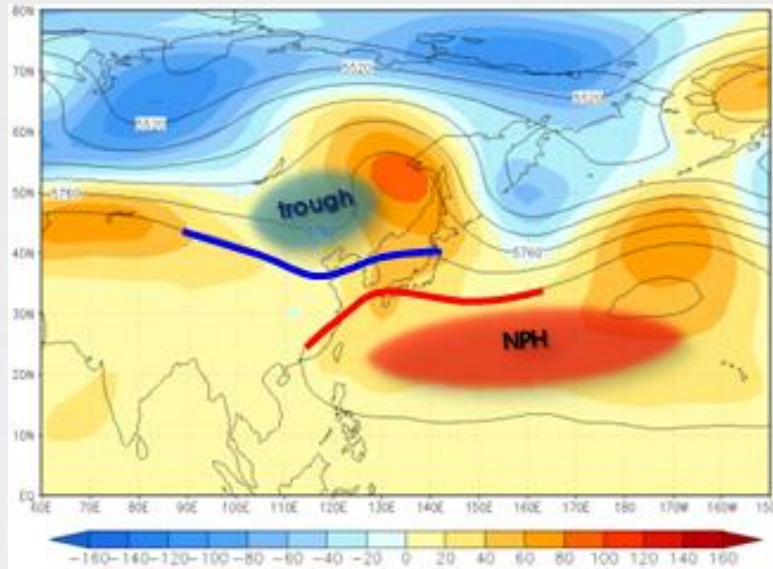


2017 Changma characteristics (3)

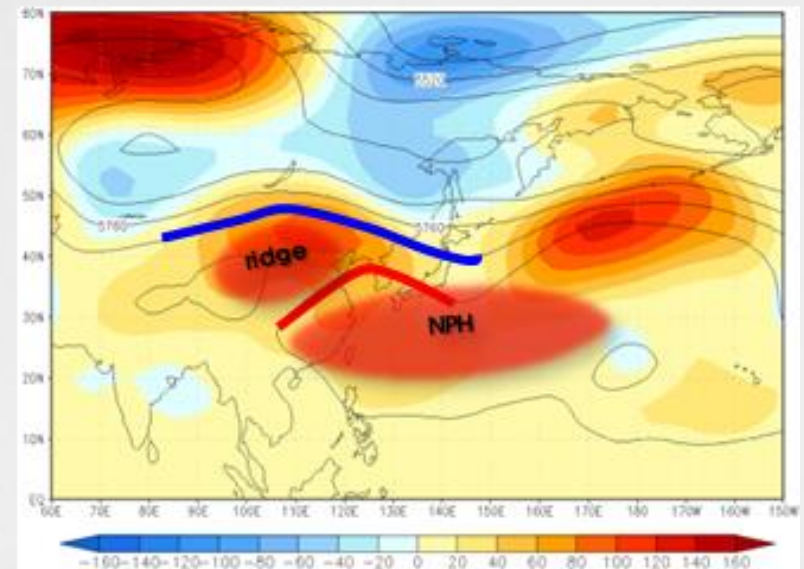


The extreme rainfall event was concentrated in the central region of South Korea.

- Sufficient moisture was supplied to the central region of South Korea owing to the northwestward expansion of WNPSH.

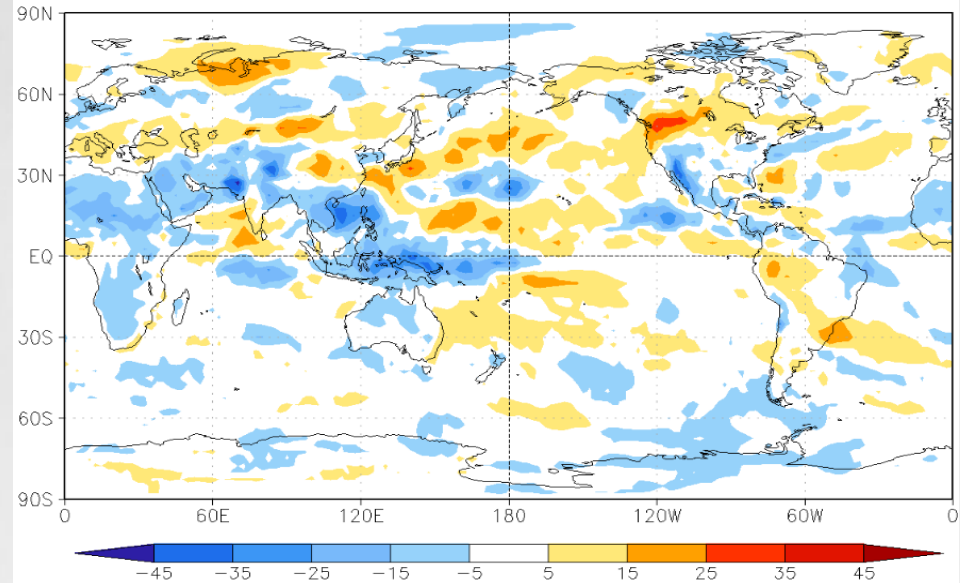
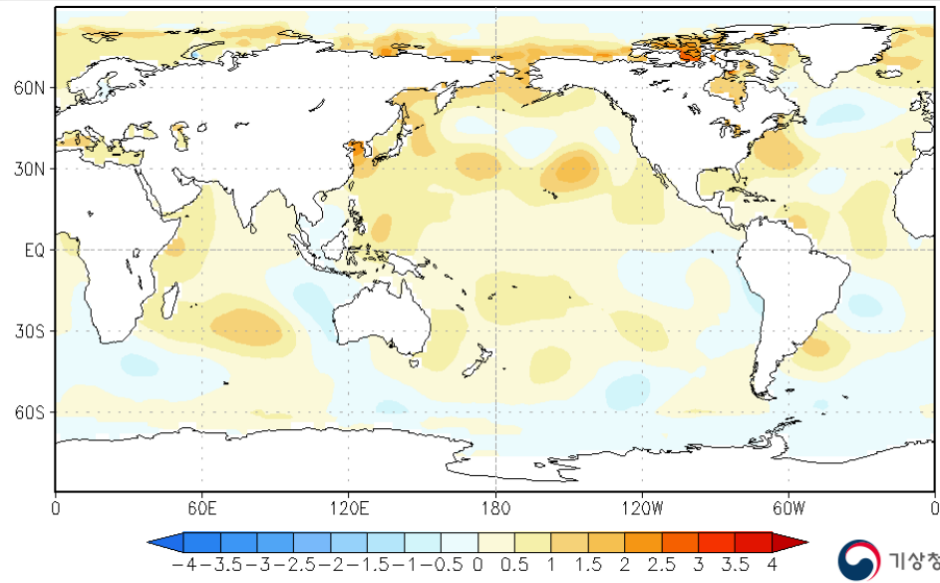


- Case 1: Circulation pattern during Changma period

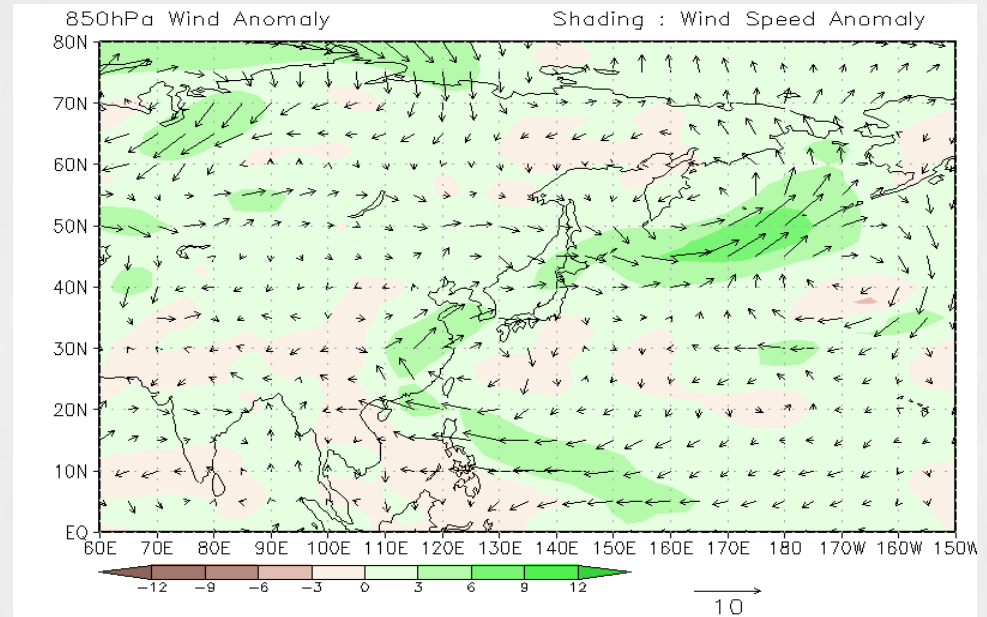


- Case 2: Circulation pattern during Changma period

Development of WNPSH during Changma period



- (SST) The SST anomalies over the tropical western Pacific - western North Pacific were above than normal.
- (Convection) The convective activities were enhanced over the tropical western Pacific and Philippine region and was suppressed over the south of Korean peninsula.



Summary 2



- ➔ South Korea experienced above-normal temperature and slightly below-normal rainfall in 2017 summer.
- ➔ The western North Pacific subtropical High(WNPSH) extended more to the northwest compared to the normal position. South Korea got supplies hot and moist airs by the southwesterlies along the flank of WNPSH.
- ➔ The southern region of South Korea was affected by the anomalous anticyclone, which led to less rainfall over that region during Changma period, on the other hand, the central region had the extreme rainfall events due to the inflow of lots of moisture along the flank of WNPSH.

 **THANK YOU** 