Decadal variation of heavy rainfall frequency in Kyushu, Japan and associated synoptic weather patterns

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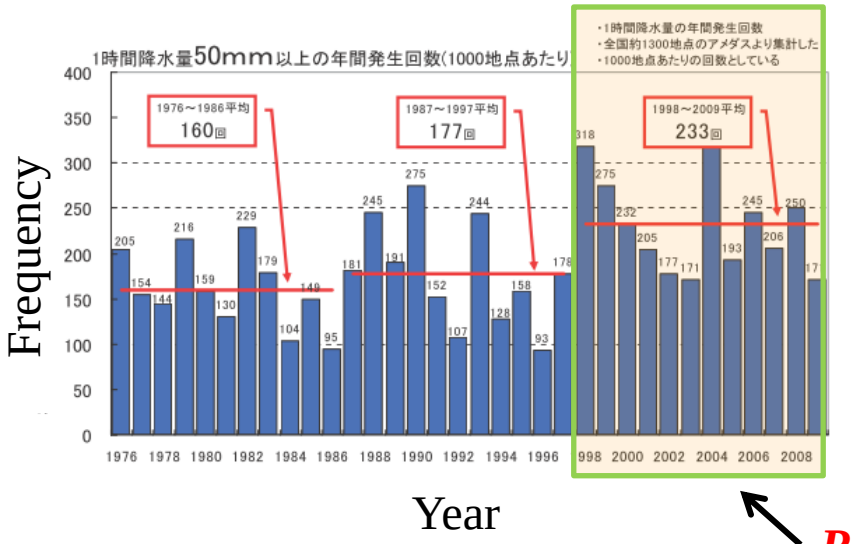
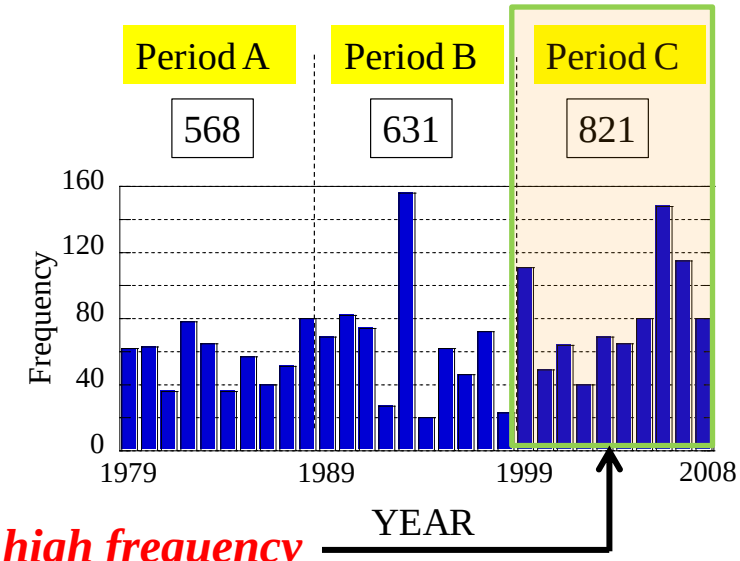
Background

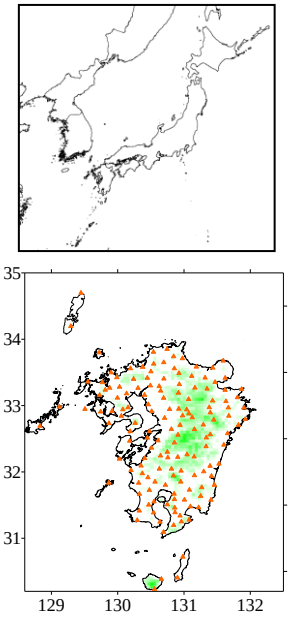
All areas in Japan

Frequency of R >= 50mm/h

Kyushu, Japan







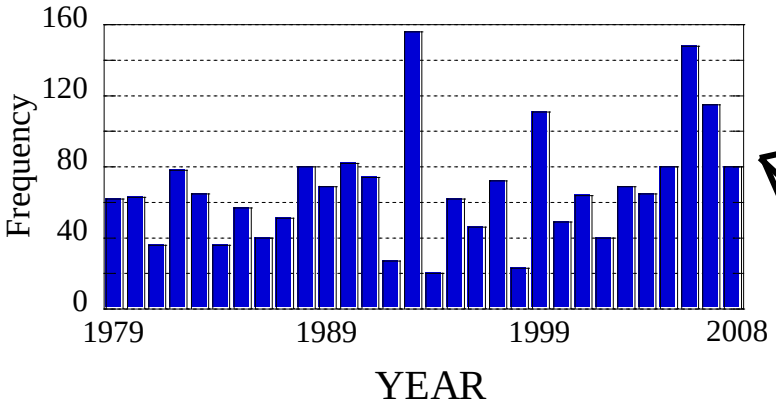
Recent high frequency

Many types of synoptic fields make up decadal trend of heavy rainfall frequency

Complicated !!

What types of patterns contribute strongly to the formation of decadal variation of heavy rainfall frequency ??

Research objective



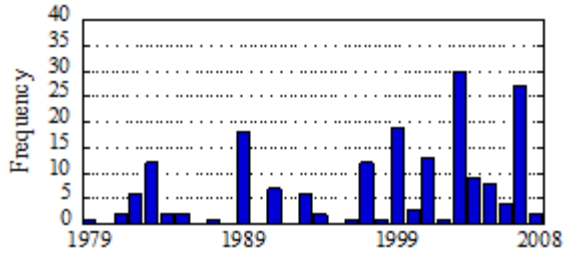
Main topic

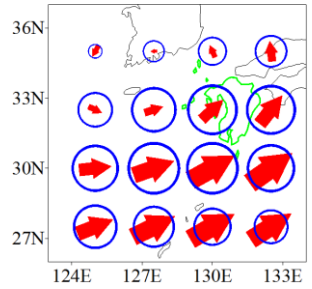
What kinds of patterns cause increasing trend of heavy rainfall ??

Methodology

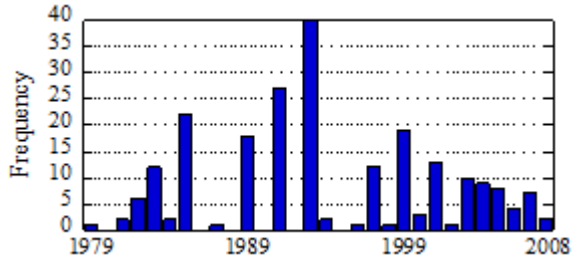
Pattern recognition using the Self-Organizing Map(SOM)

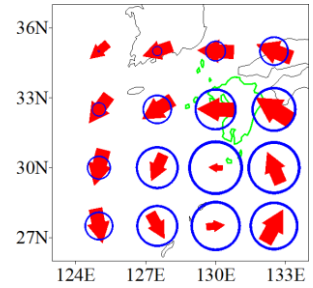
Heavy rainfall freq for pattern 1





Heavy rainfall freq for pattern 2





Heavy rainfall freq for pattern N

Self-Organizing Map (SOM) : Kohonen (1995)

High dimensional data assembly ***are non-linearly classified into***

Visually-recognizable patterns in the two dimensional array

Each unit (pattern)

(1) Reference vector showing a pattern
(2) Samples classified by SOM training

Called as
'***unit***', representing '***pattern***'

*Unit*32

Sample 1
Sample 5

Different features (distant)

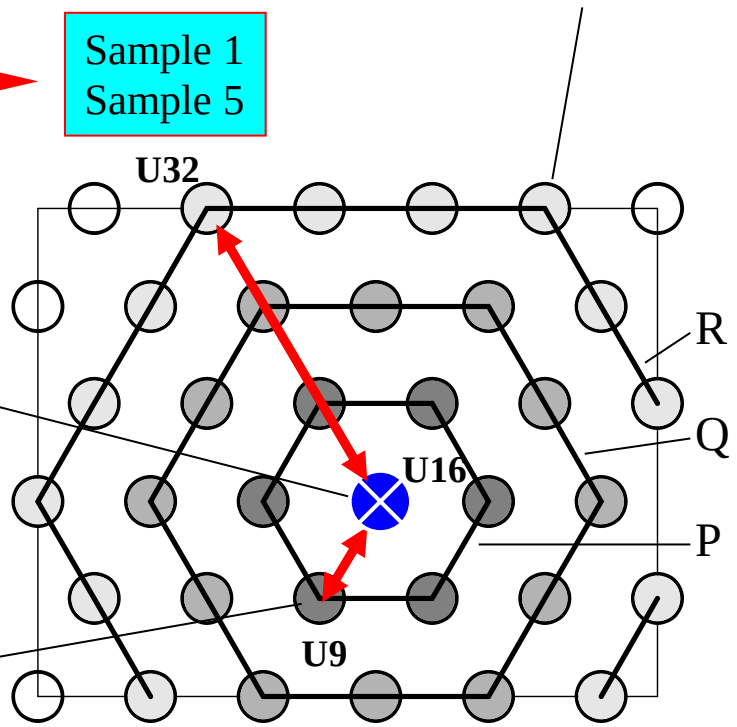
Sample 17
Sample 34

*Unit*16

Similar features (close)

Sample 76
Sample 51

*Unit*9



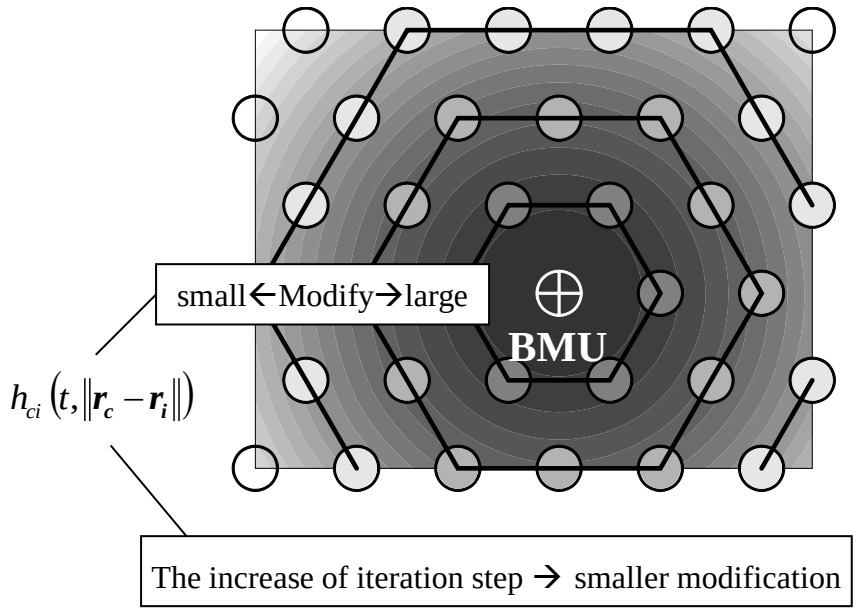
SOM training algorithm

(a) Input of sample vector for SOM training

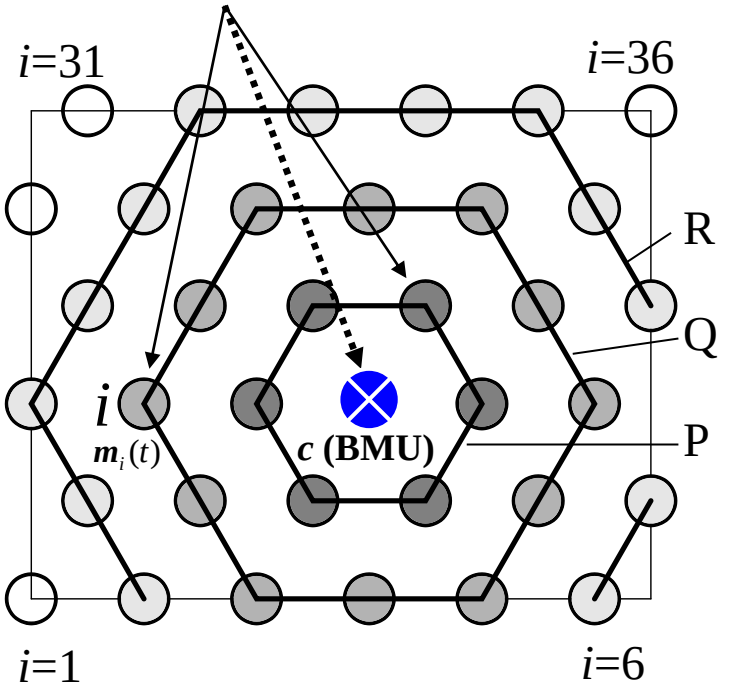
(b) Determination of BMU（Best Matching Unit）

(c) Modification of reference vector $m_i(t)$ depending on Neighboring function h_{ci}

$$\mathbf{m_i}(t+1) = \mathbf{m_i}(t) + h_{ci}\left(t, \|\mathbf{r_c} - \mathbf{r_i}\|\right)\left[\mathbf{x}(t) - \mathbf{m_i}(t)\right]$$



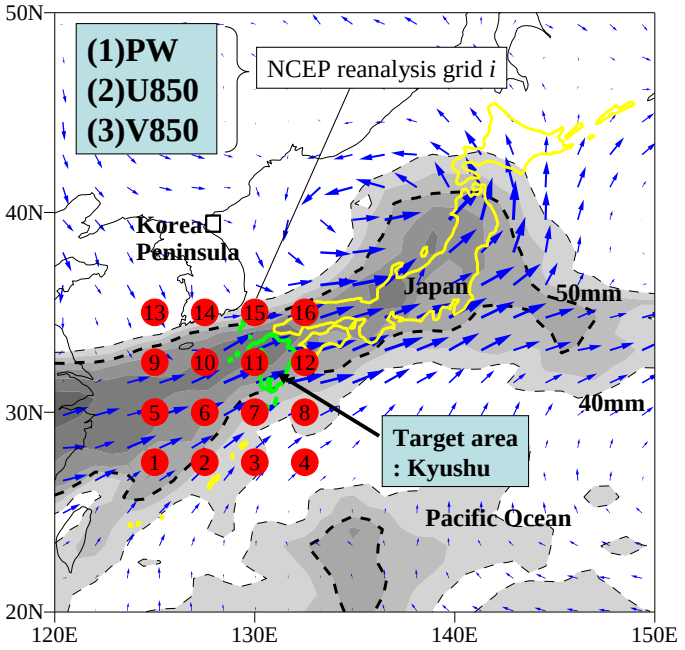
$$\boldsymbol{x}(t) = (x_1(t), x_2(t) \cdots x_n(t)) \quad (t = 1, ..., T)$$



$$\|x(t) - m_i(t)\| \rightarrow Min \ (i = c(\mathrm{BMU}))$$

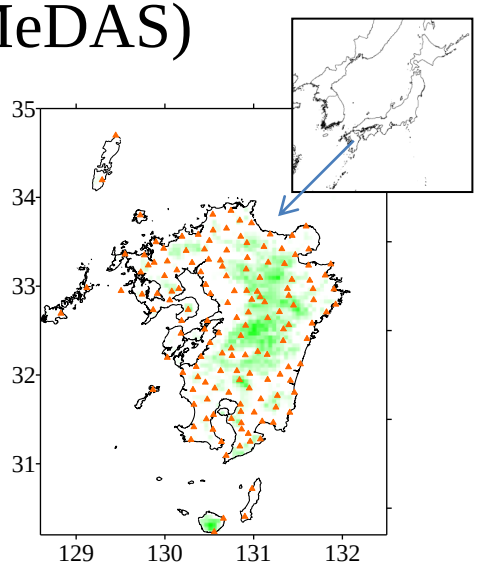
Synoptic field and rainfall obs area

Synoptic field for the SOM



Linking

Rainfall observation (AMeDAS)



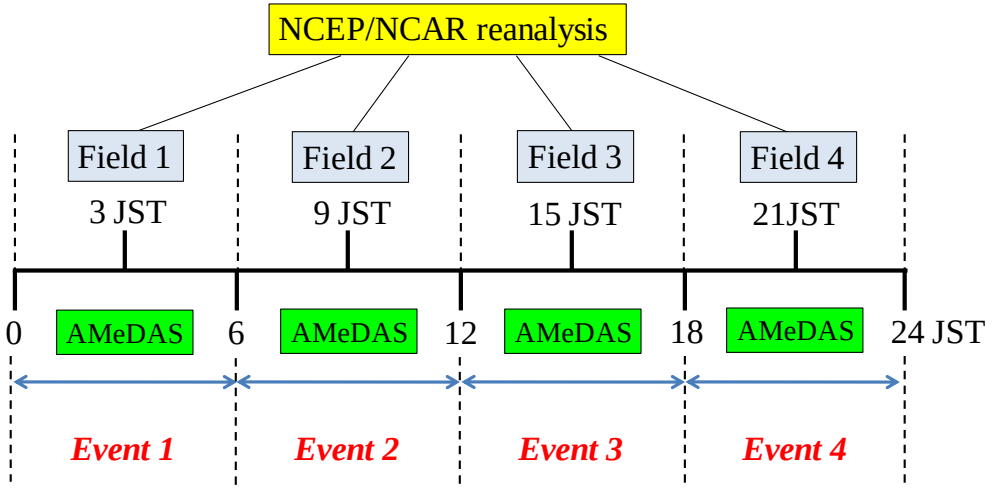
1979～2008 (30 years)
（June～September）
14648 samples
(4 times per day)

NCEP/NCAR Reanalysis

Feature	Index
Moisture inflow into Japan	PW (Precipitable Water)
Low level Jet	*u*, *v* (850hPa)

Input vector for the SOM training

$\boldsymbol{x}=(PW_1 \sim PW_{16}, U_1 \sim U_{16}, V_1 \sim V_{16})$

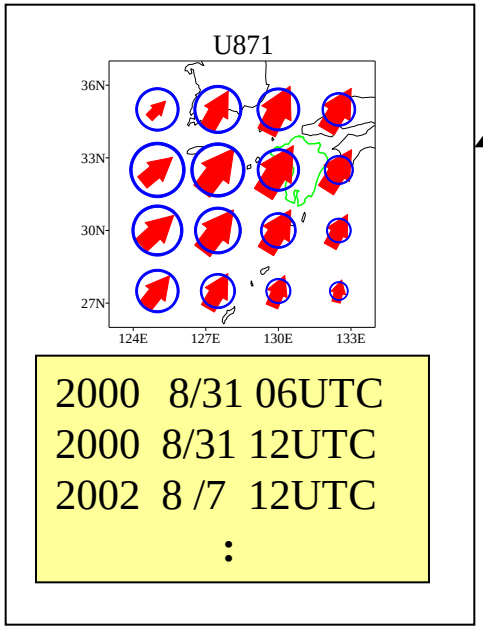


AMeDAS : Automated Meteorological Data Acquisition System

Specification of the SOM structure

All samples for 30 years (14648 fields)

900 patterns (25 groups)



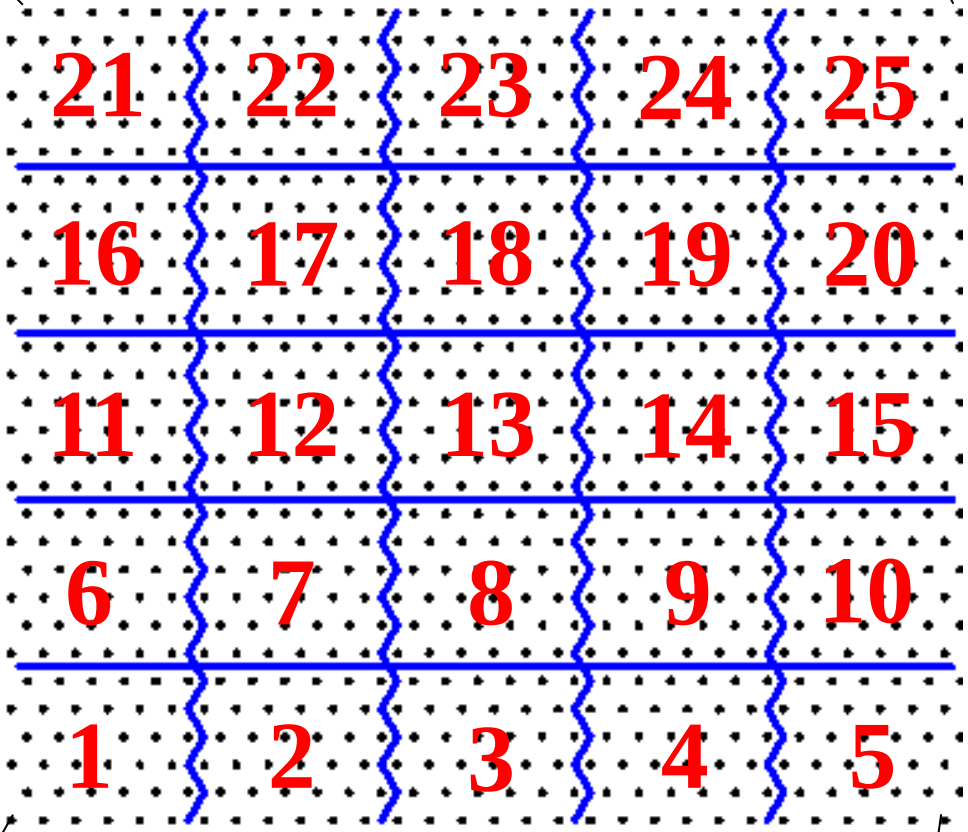
Heavy rainfall frequency

Map structure

***Groups* :1~25**

Unit 871

Unit 900

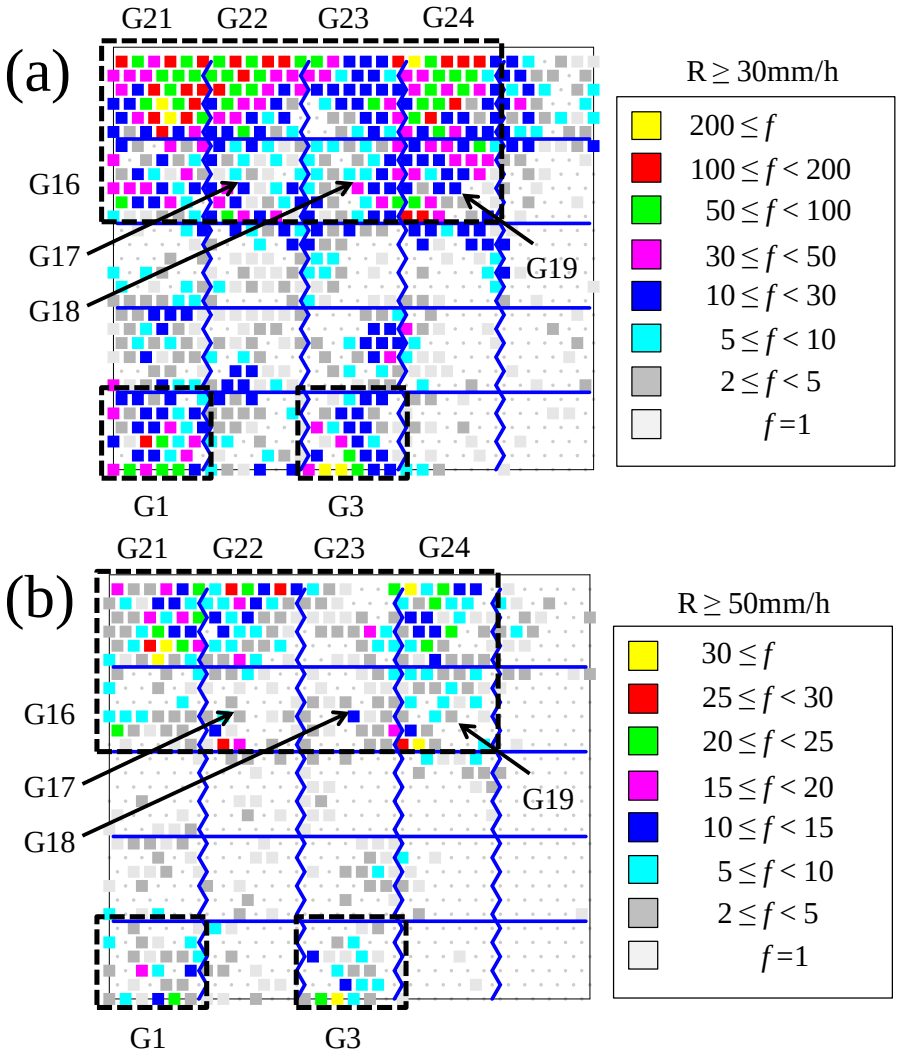


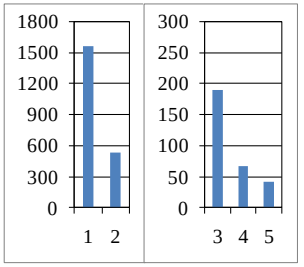
***Units* : 1~900→ dots●**

Unit 1

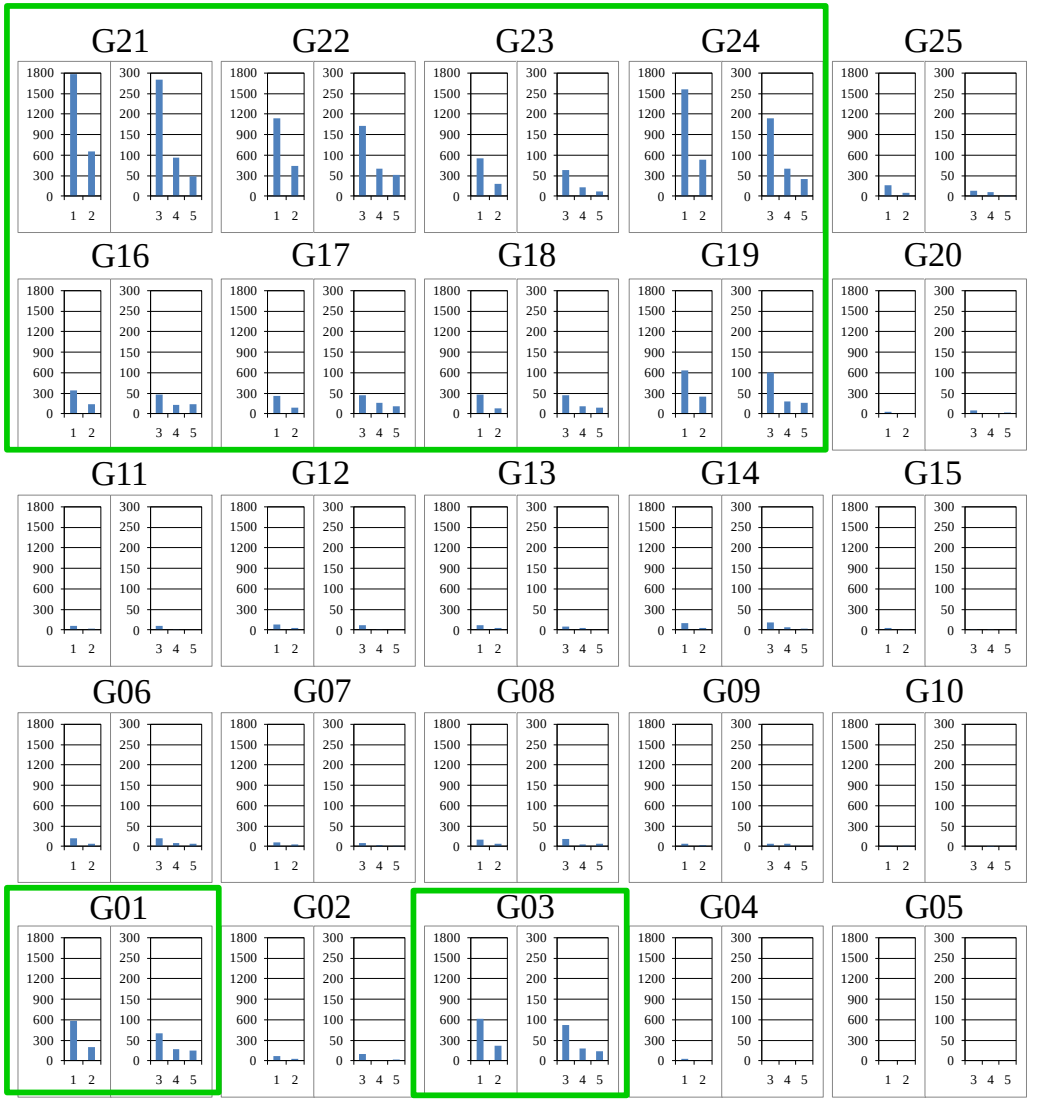
Unit 30

Heavy rainfall frequency per each unit and each group





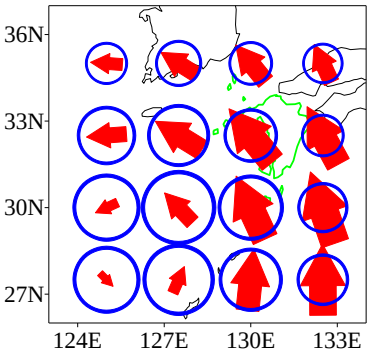
1: 30mm/h =< R < 40mm/h
2: 40mm/h =< R < 50mm/h
3: 50mm/h =< R < 60mm/h
4: 60mm/h =< R < 70mm/h
5: R >= 70mm/h



Synoptic field patterns constructed by the SOM (25 groups)

plots :

Average reference vector in each group

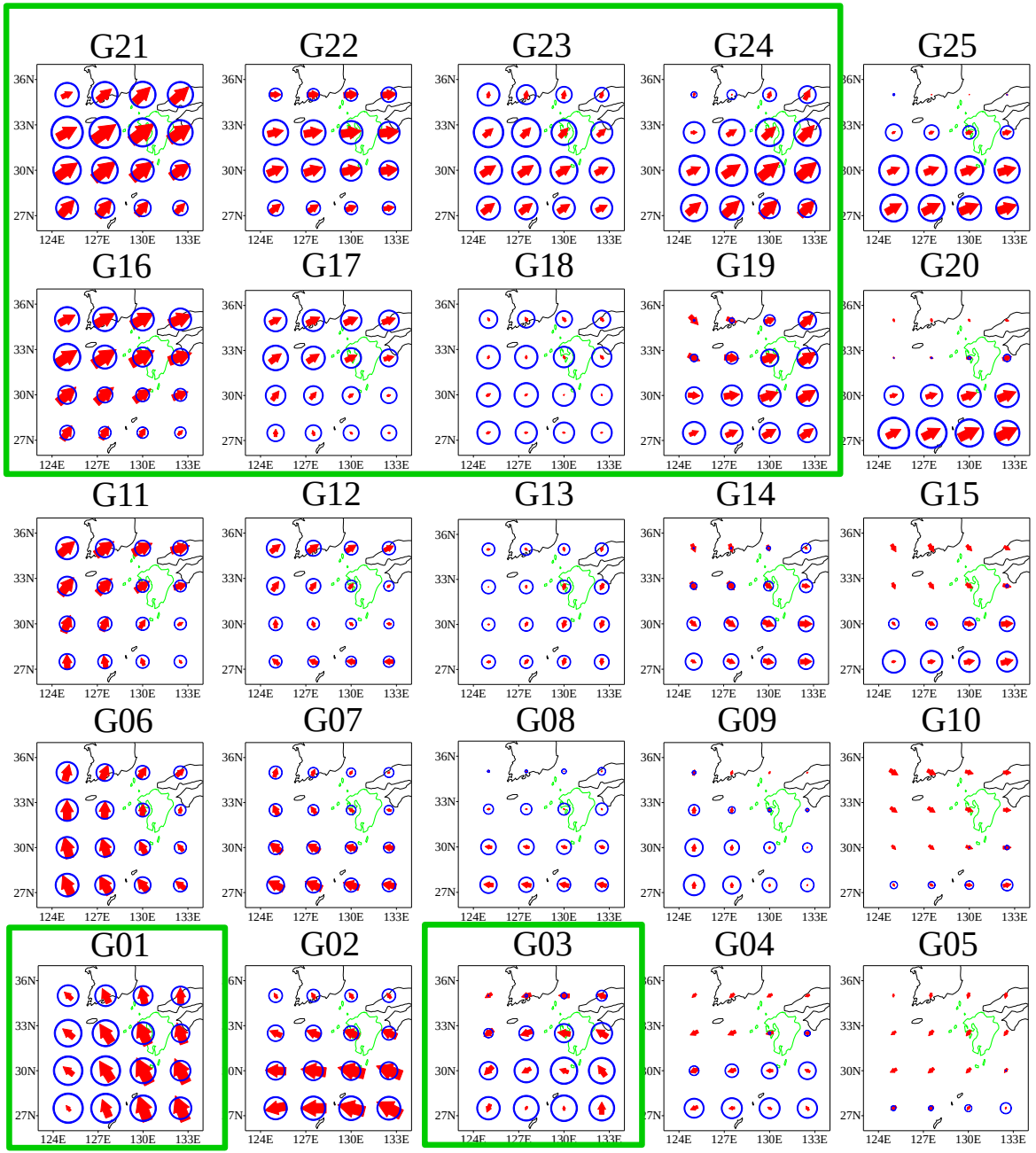


PW (Precipitable Water):

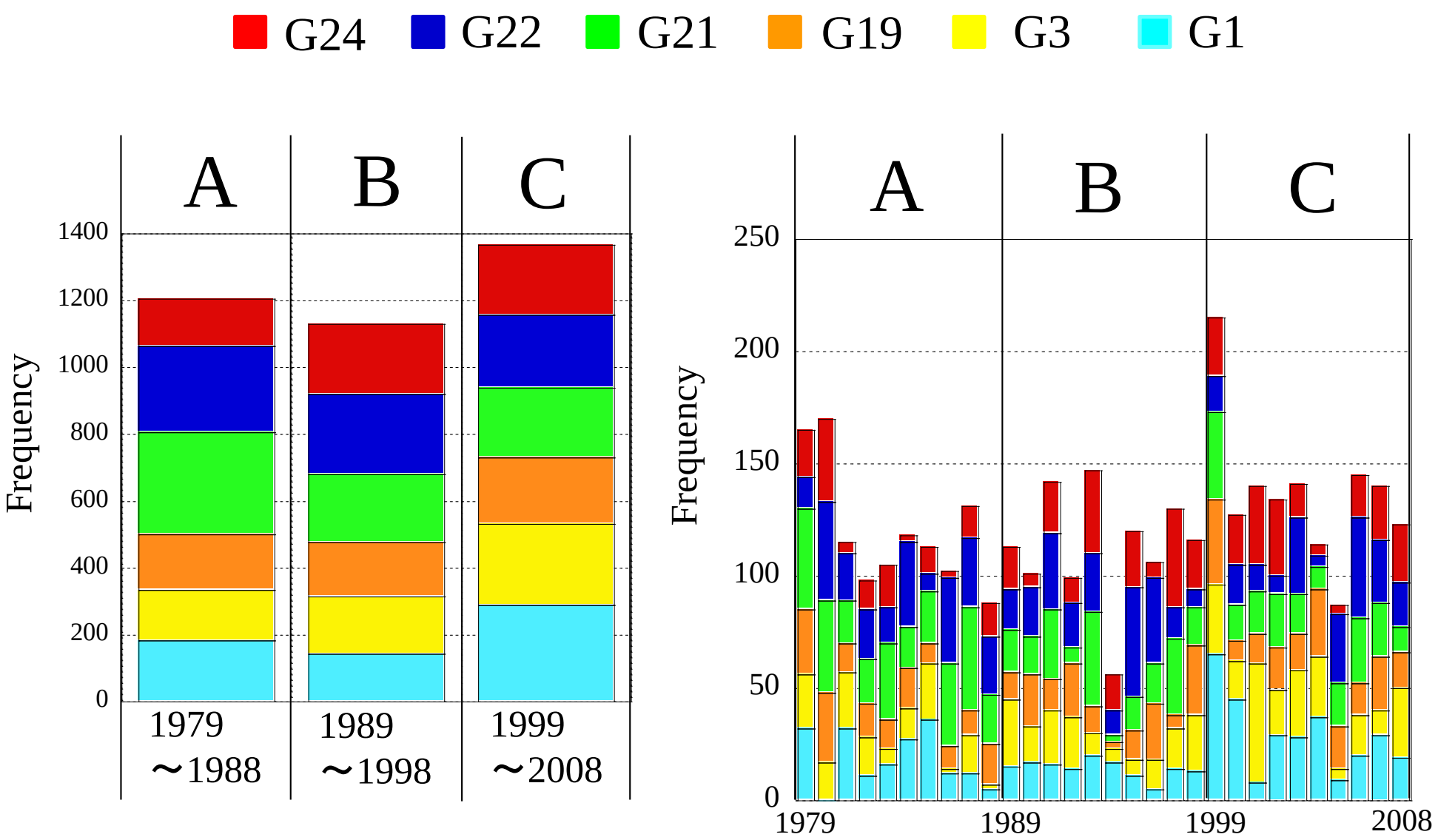
- An index of convective activity
- large value → ample water vapor

WIND850 (u, v):

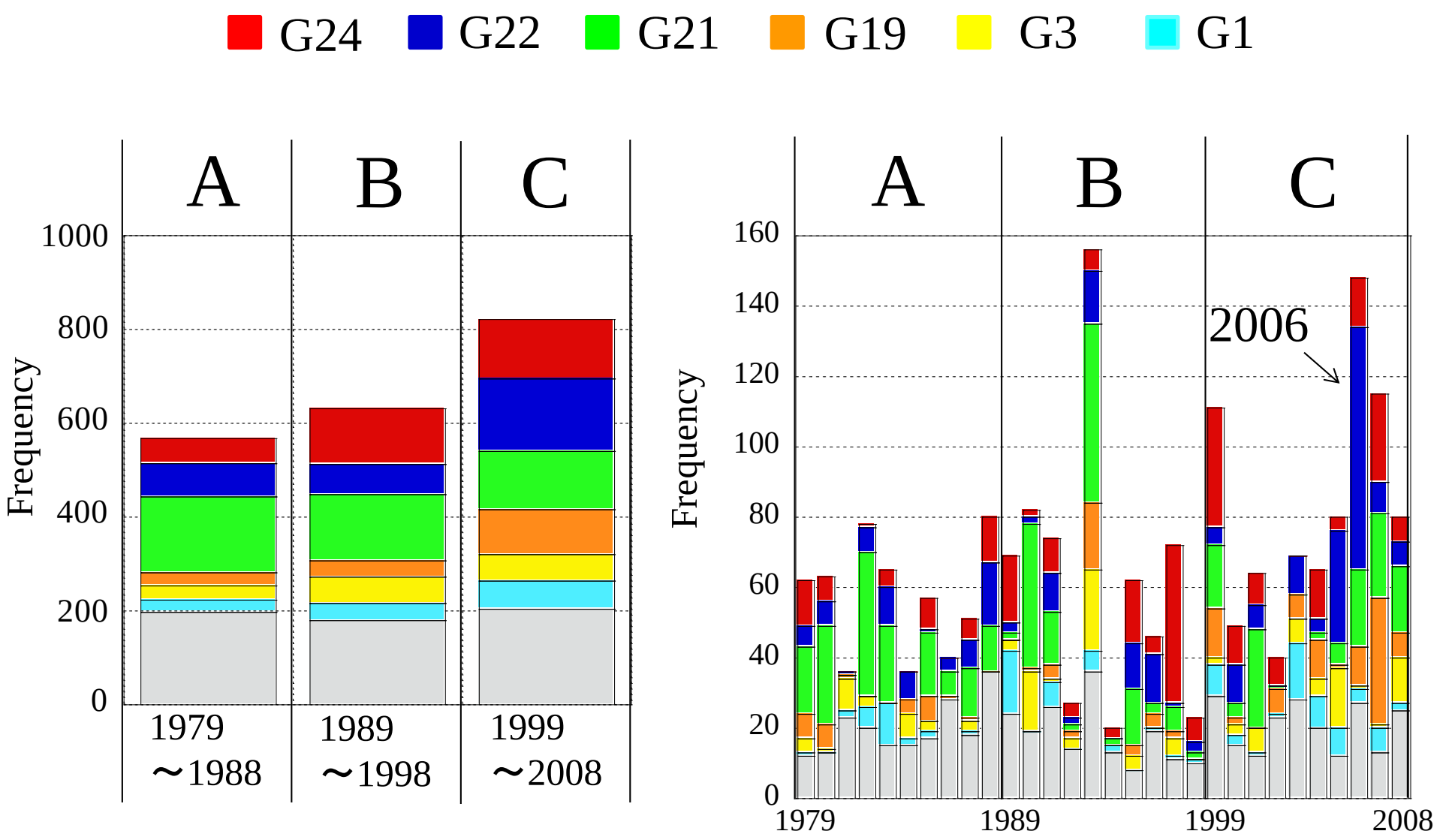
- Low Level Jet (LLJ)
- Monsoon



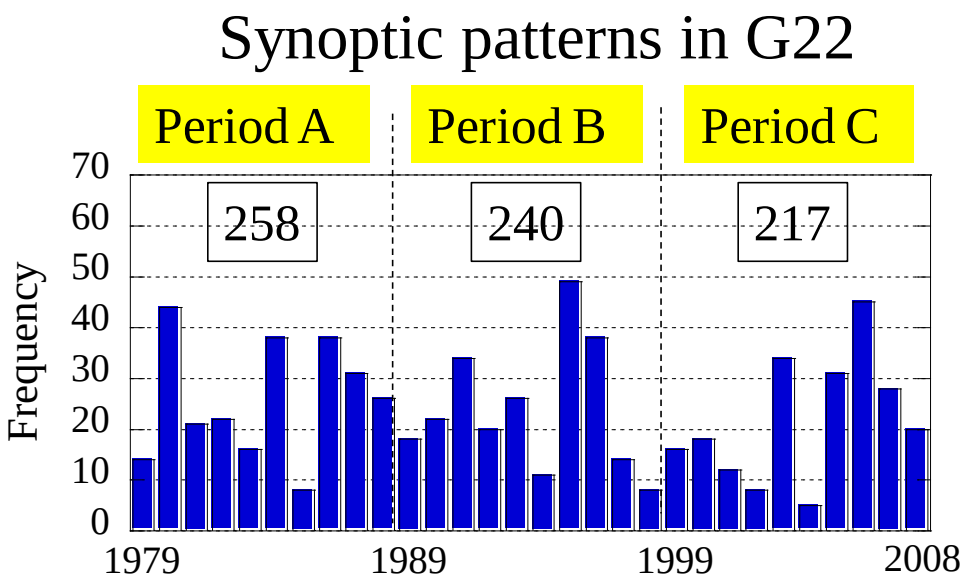
Decadal variation in synoptic pattern frequency of 6 HR groups

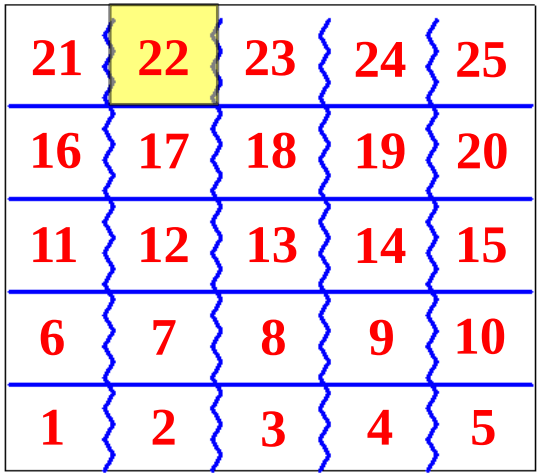


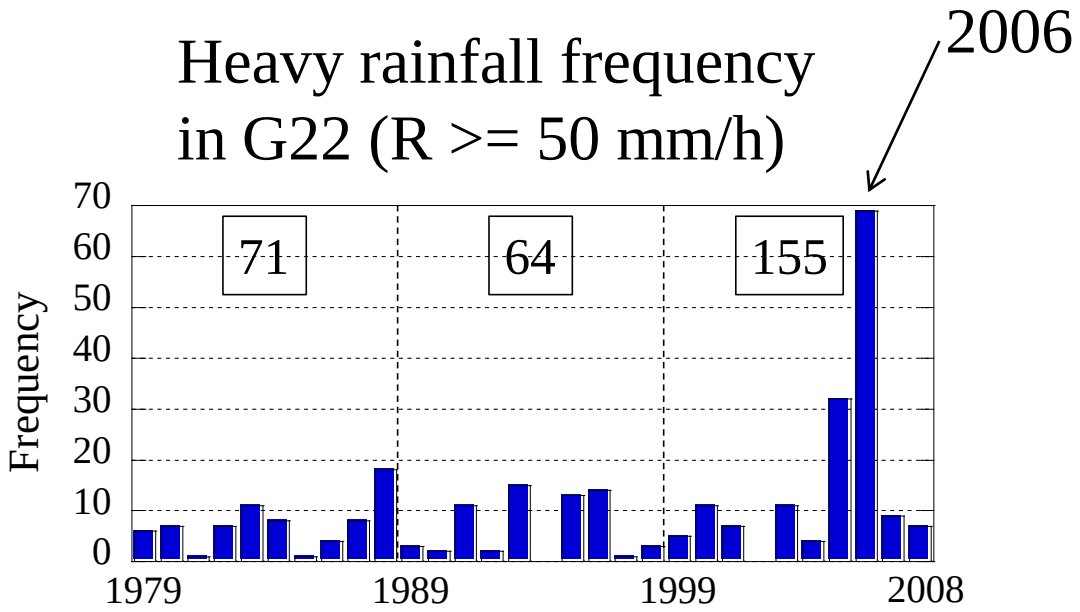
Decadal variation in heavy rainfall frequency of 6 HR groups

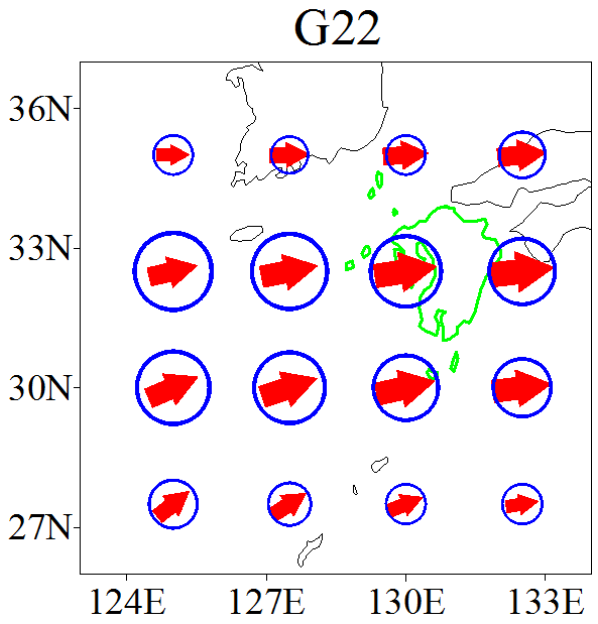


Decadal variation in synoptic patterns and HR frequency in G22



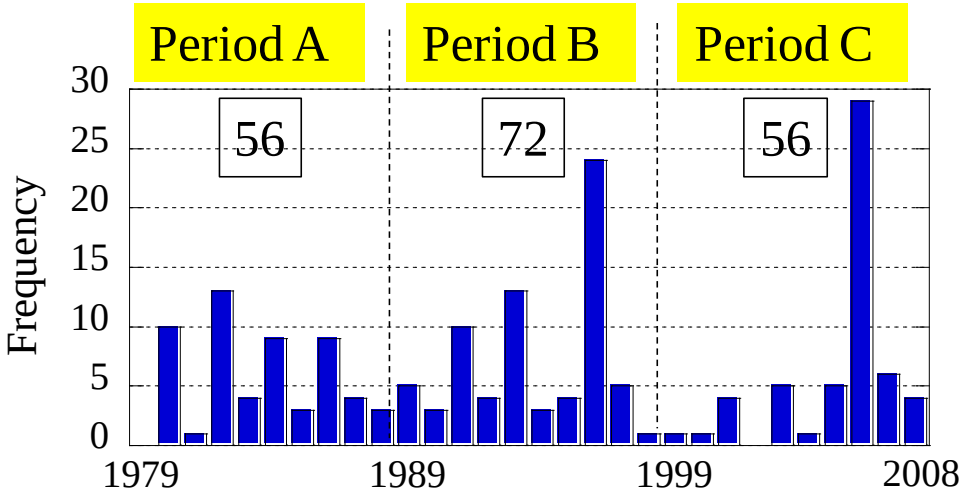






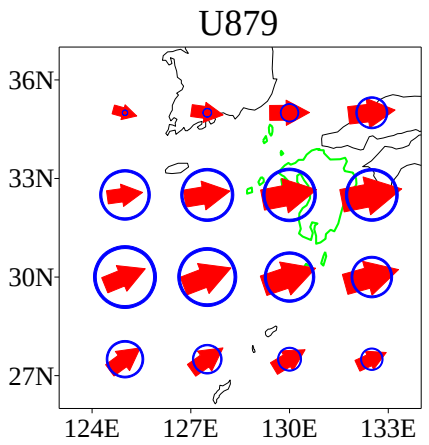
Decadal variation in synoptic patterns and HR frequency in G22

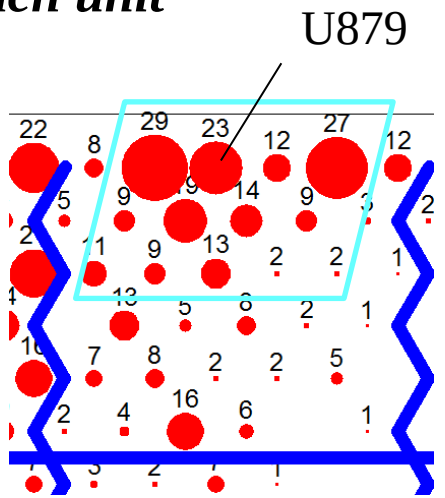
Synoptic patterns in G22
(dominant patterns)



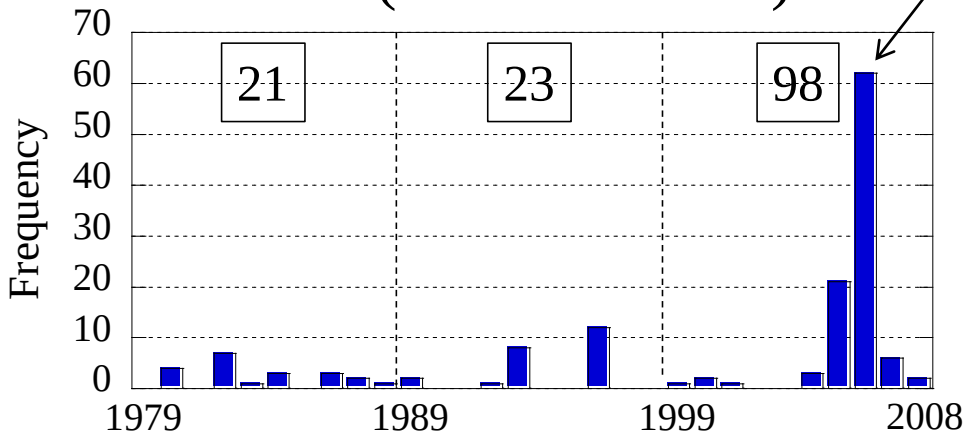
G22

Heavy rainfall frequency in each unit

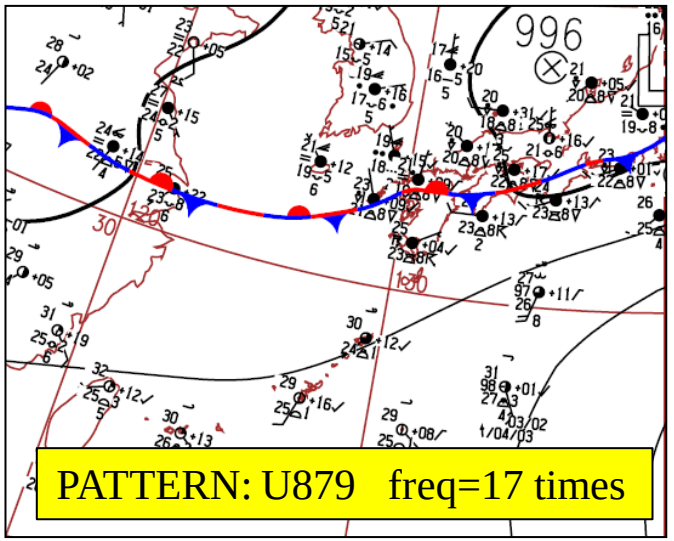




Heavy rainfall frequency
in G22 (R >= 50 mm/h)

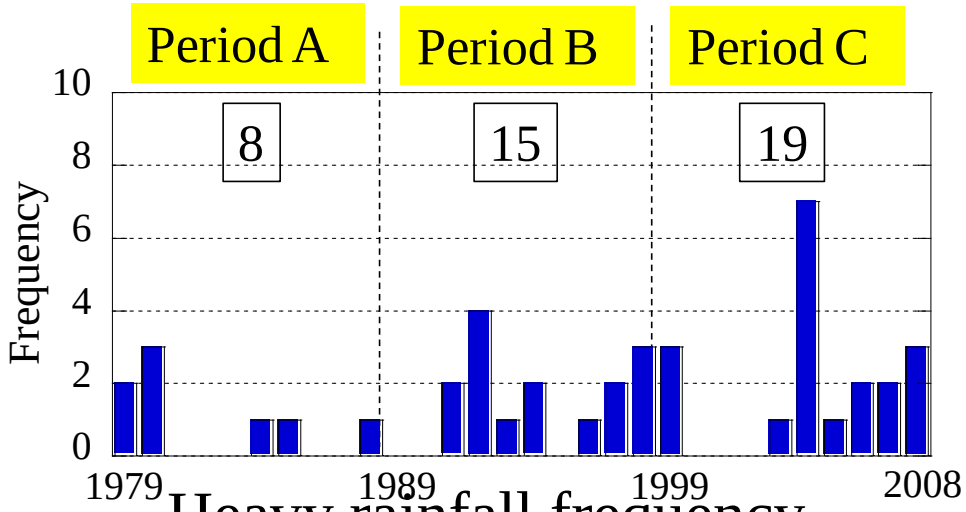


2100JST, July 5, 2006

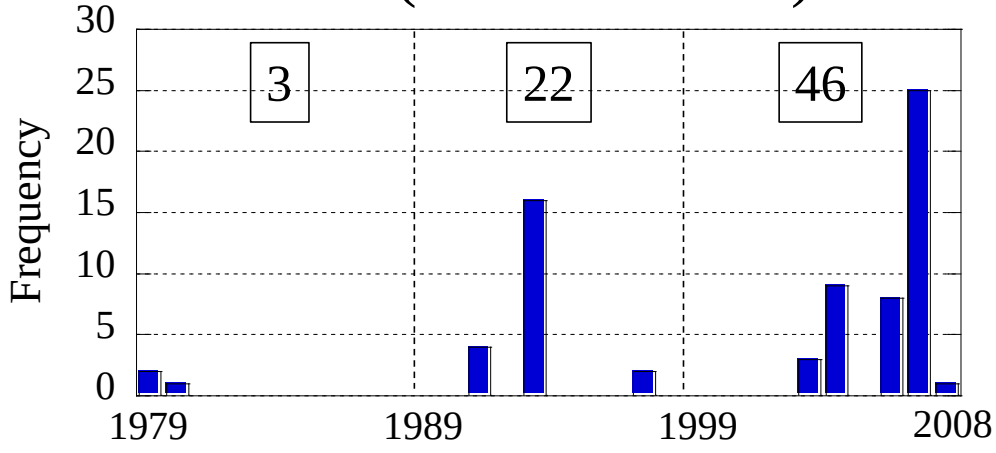


Decadal variation in synoptic patterns and HR frequency in G19

Synoptic patterns in G19
(dominant patterns)

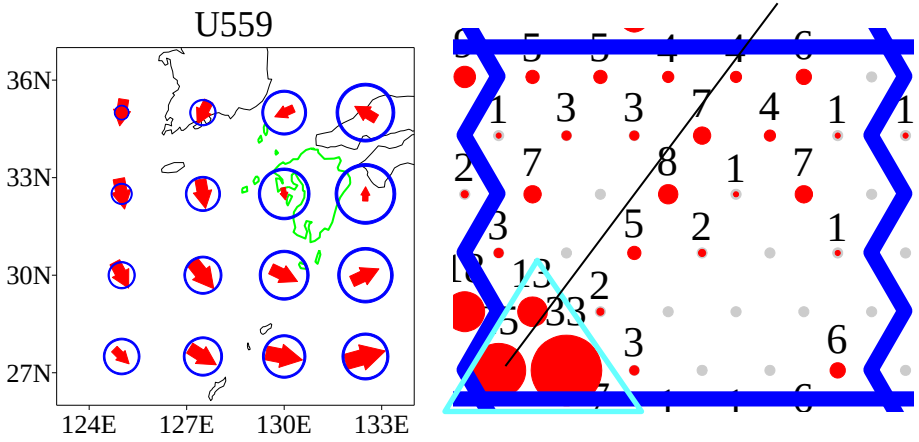


Heavy rainfall frequency
in G19 (R >= 50 mm/h)

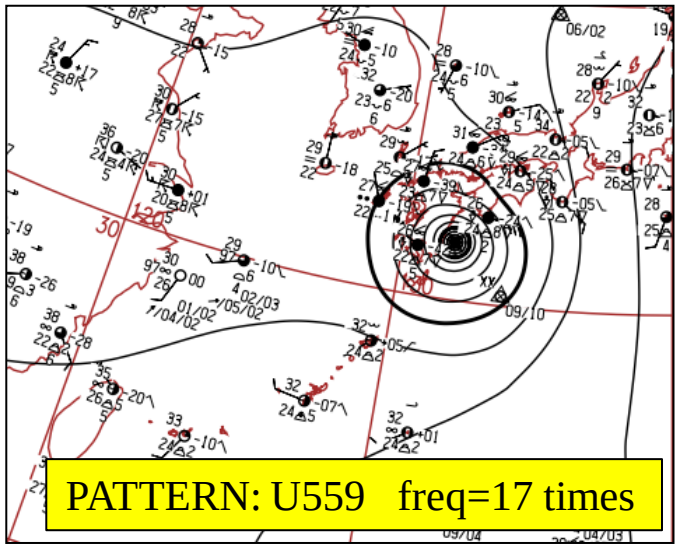


G19

Heavy rainfall frequency in each unit



1500JST, Aug 2, 2007



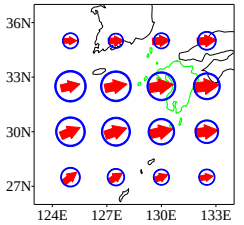
Conclusion

Heavy rainfall frequency during recent 10 years (Period A: 1999-2008) is higher than during past periods (B, C) in Kyushu Japan

Groups (G19, 22) show ***higher*** heavy rainfall frequency

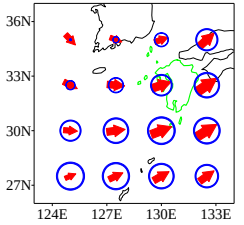
G22

Group characterized by humid region with eastward low-level jet and a large gradient of PW (the existence of front)



G19

Including the patterns related to Typhoon centers passing through Kyushu



G21 shows ***lower*** heavy rainfall frequency

G21

Group characterized by humid region with northeastward low-level jet