

多種衛星降水產品對臺灣降水特色的表現能力評估與應用

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Outline

1. 衛星降水可以如何應用在台灣的日子夜變化降水研究

Huang, W.-R.* and S.-Y. Wang, 2014: Impact of Land-Sea Breezes at Different Scales on the Diurnal Rainfall in Taiwan. *Climate Dynamics*, 43, 1951–1963.

2. 多種衛星降水的評估

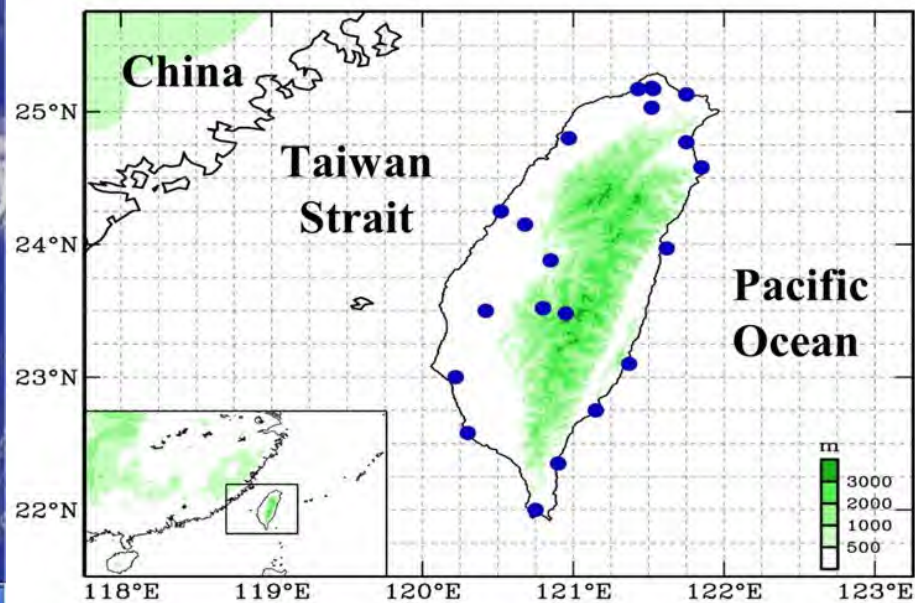
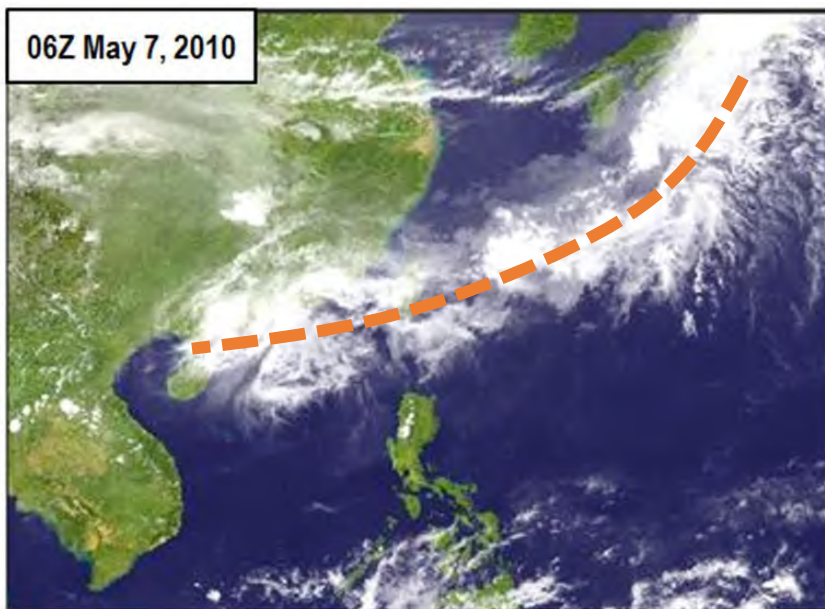
Chen, S.-Y. and W.-R. Huang*, 2017: Evaluation on the Performance of **TRMM**, **CMORPH**, and **PERSIANN** in Depicting the Diurnal Precipitation Variation in Taiwan. *Atmospheric Sciences*, 45, 167-191. (in Chinese with an English abstract)

Huang, W.-R.*, Y.-H. Chang and P.-Y. Liu, 2018: Assessment of **IMERG** precipitation over Taiwan at multiple timescales. *Atmospheric Research*, 214, 239-249.

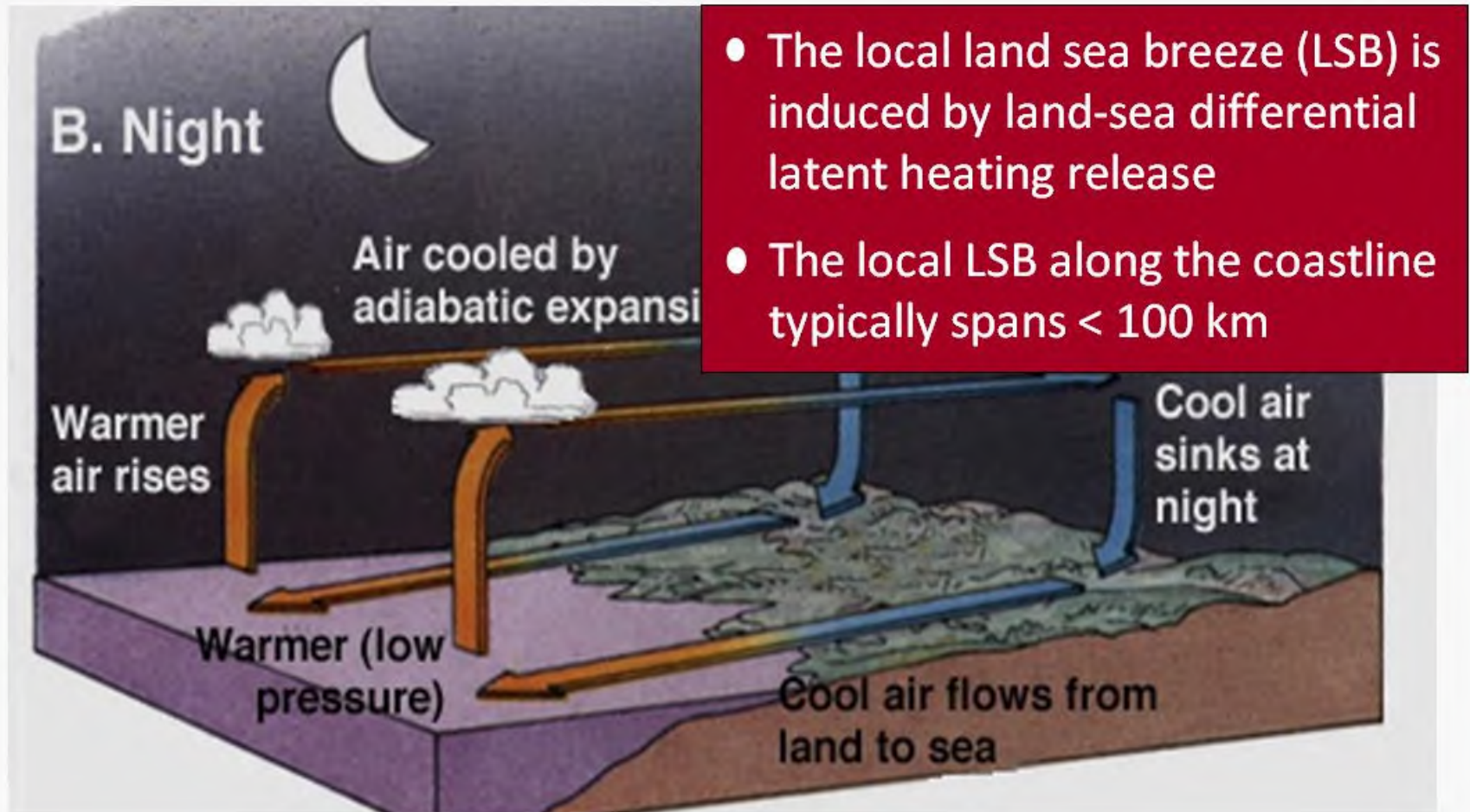
3. 台灣冬季的日子夜降水變化機制 (非衛星降水相關)

Huang, W.-R.* and Y.-H. Chang, 2018: Characteristics and Mechanisms of the Diurnal Variation of Winter Precipitation in Taiwan. *International Journal of Climatology*, 38, 3058-3068.

■ 研究動機

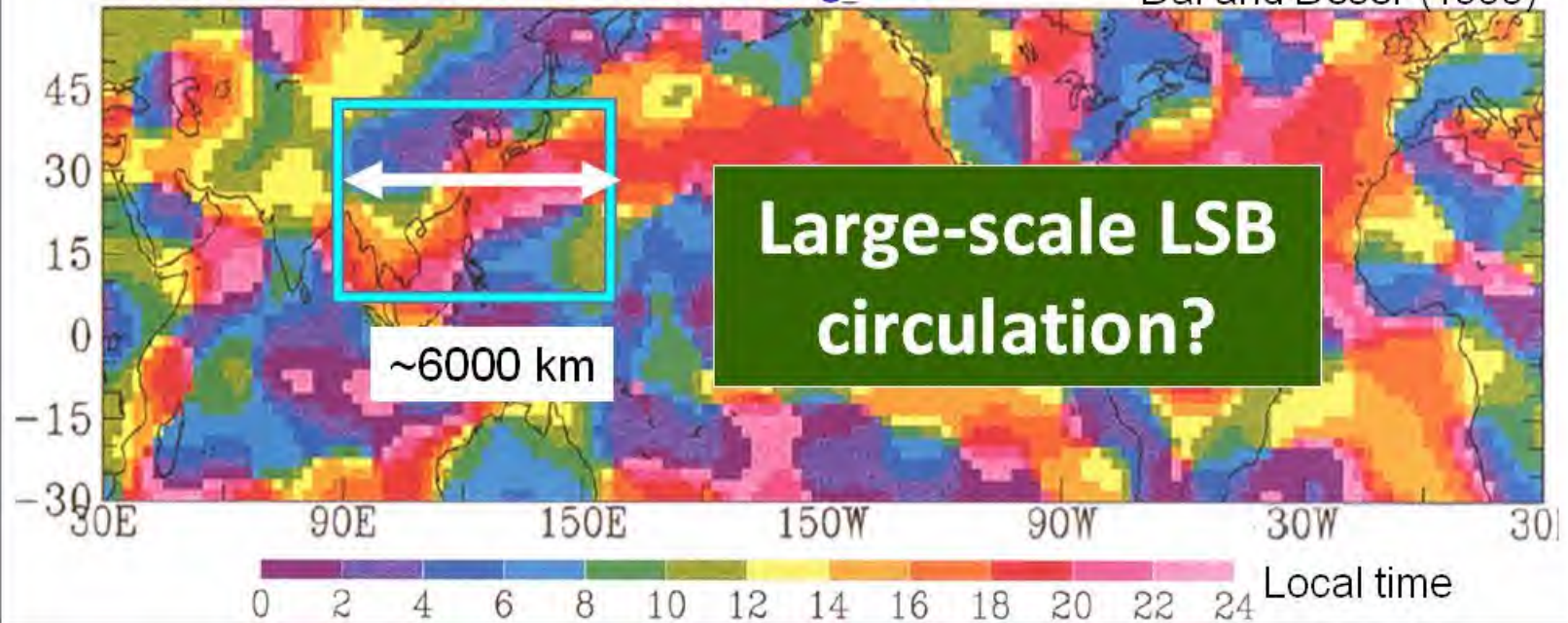


General concept of diurnal rainfall variation



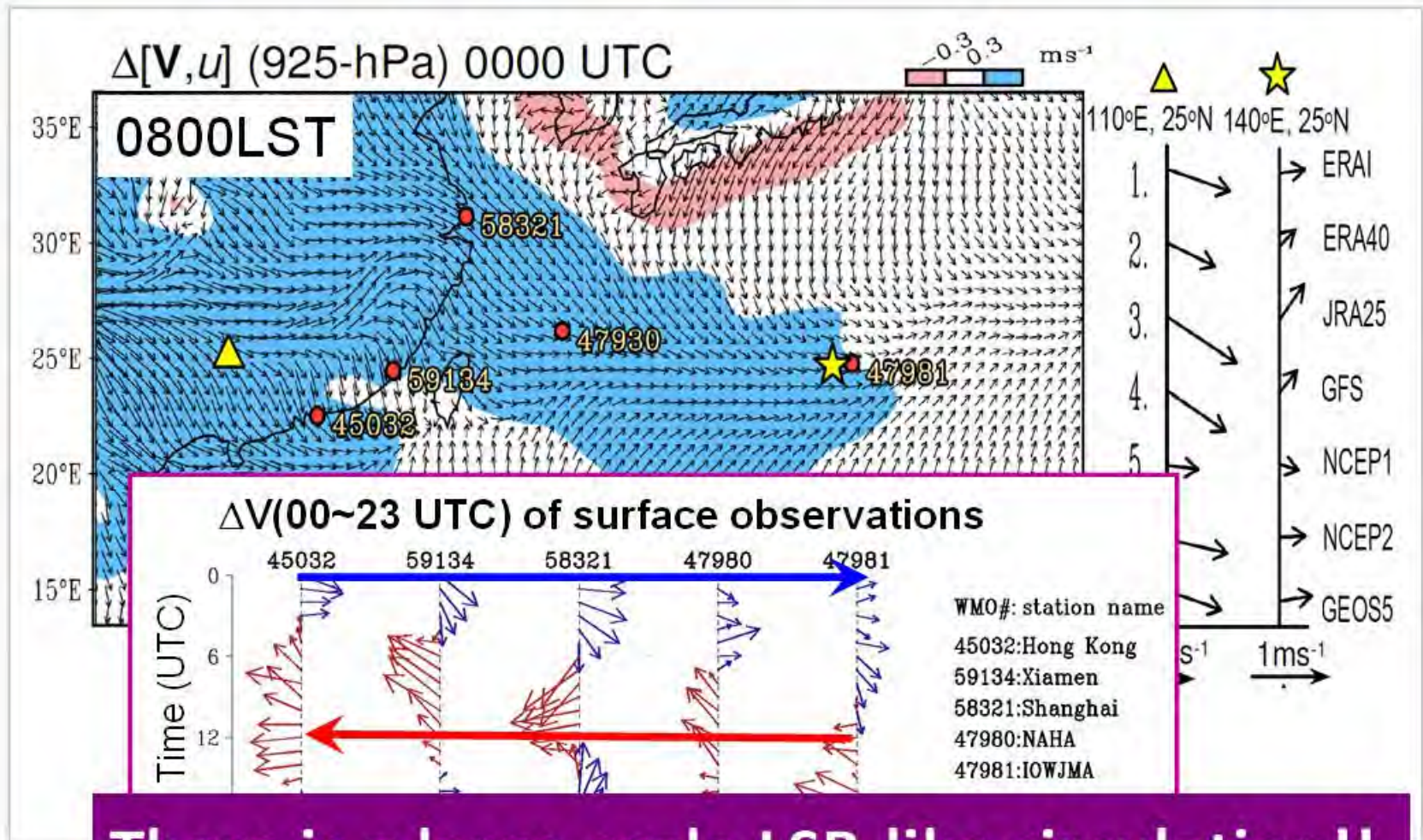
Tmax of S1 of Surface Wind Divergence

Dai and Deser (1999)



S1: Diurnal component

Does the large-scale LSB circulation exist?



There is a large-scale LSB-like circulation!!

Huang et al. (2010, QJRMSS)

What is the impact of land-sea breezes at different scales on the diurnal rainfall in Taiwan?

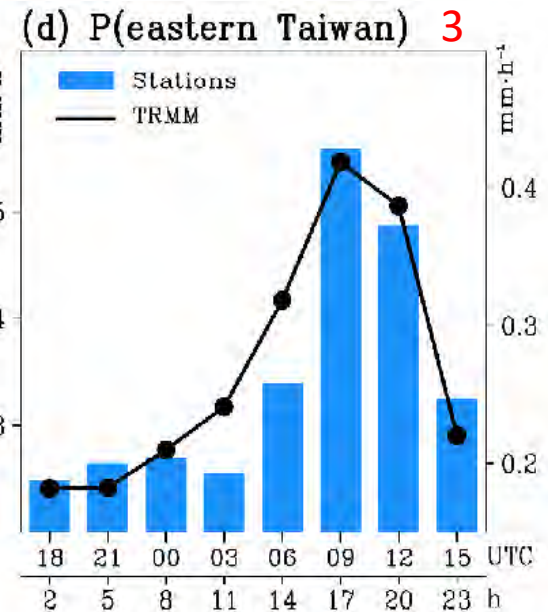
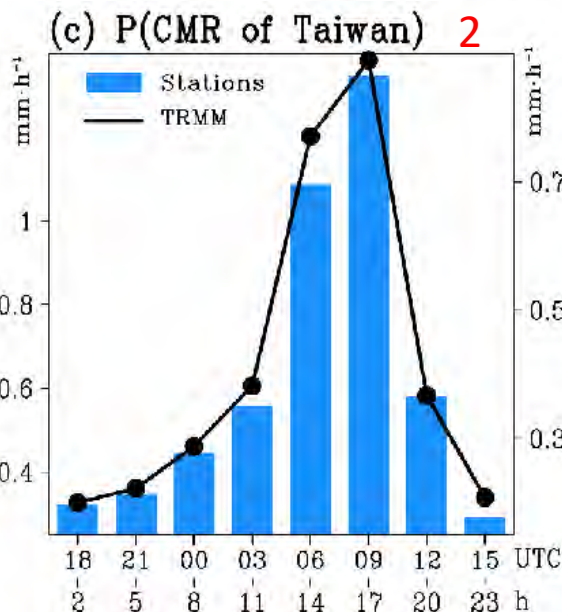
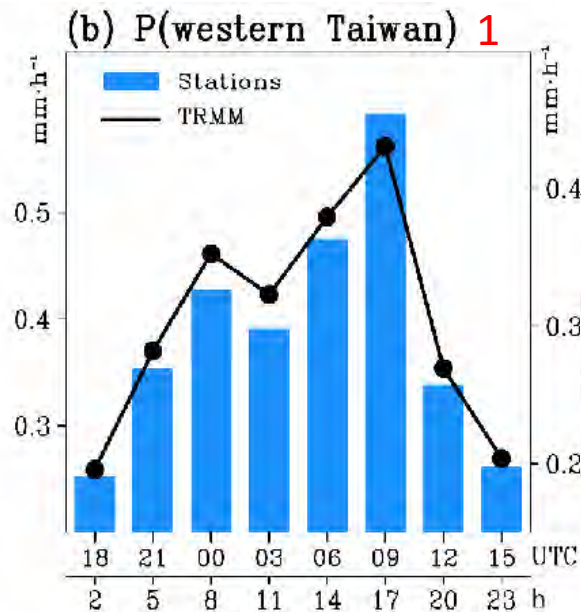
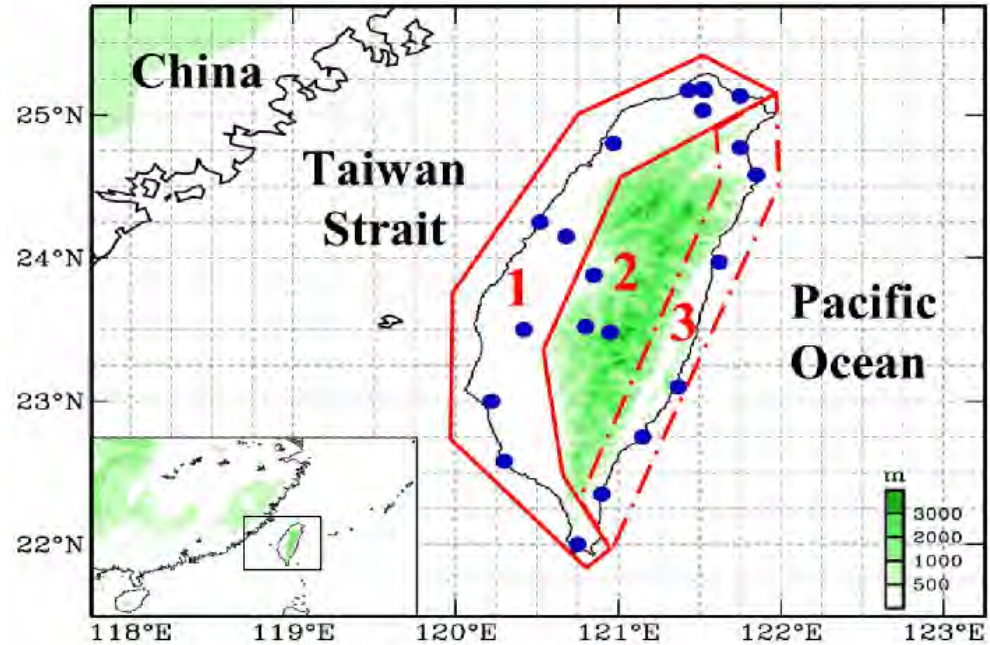
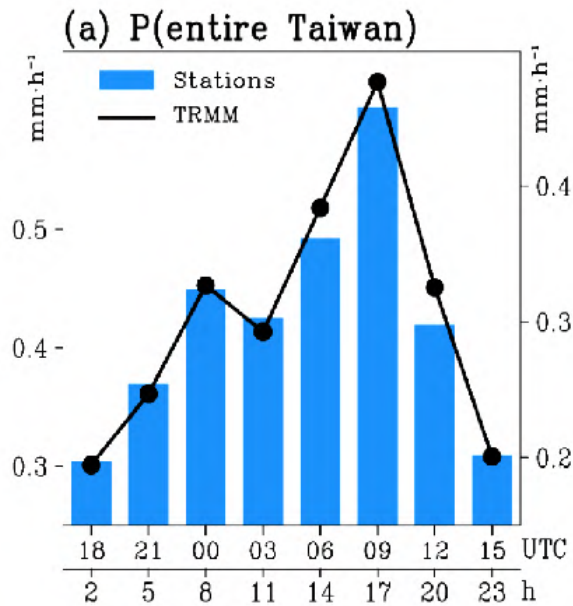
Clim Dyn (2014) 43:1951–1963
DOI 10.1007/s00382-013-2018-z

Impact of land–sea breezes at different scales on the diurnal rainfall in Taiwan

Wan-Ru Huang · Shih-Yu Wang

Precipitation Data: TRMM 3B42, CWB gauges
Reanalysis Data: MERRA reanalysis
Studying Periods: 1998~2012 May and June

1. 衛星降水應用在台灣的日子夜變化降水研究

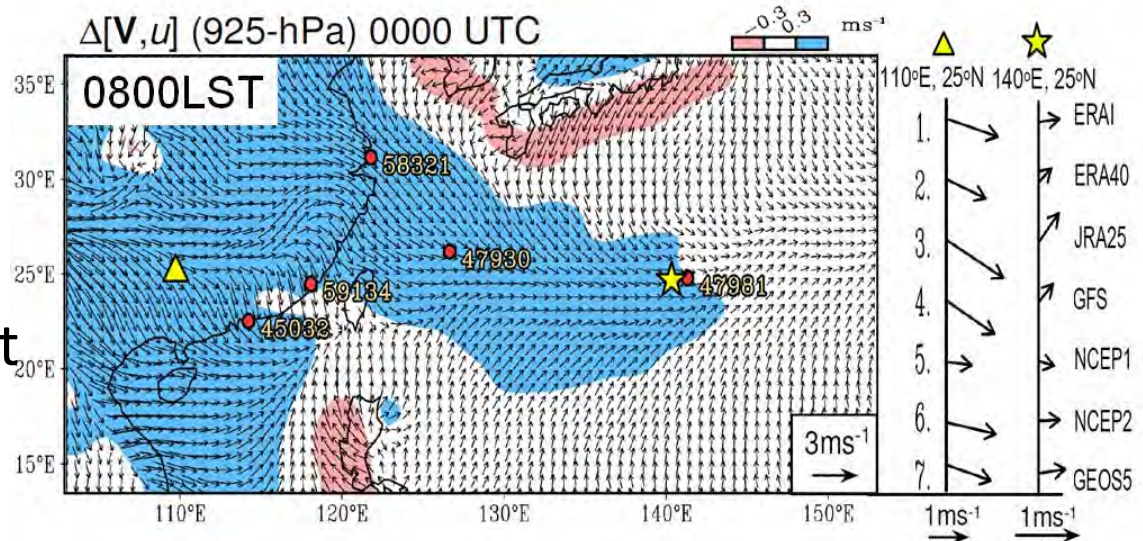


■ Literature review

- The formation mechanism of diurnal rainfall in Taiwan is commonly recognized as a result of local forcing involving **solar thermal heating** and **island-scale land-sea breeze (LSB)** interacting with orography.

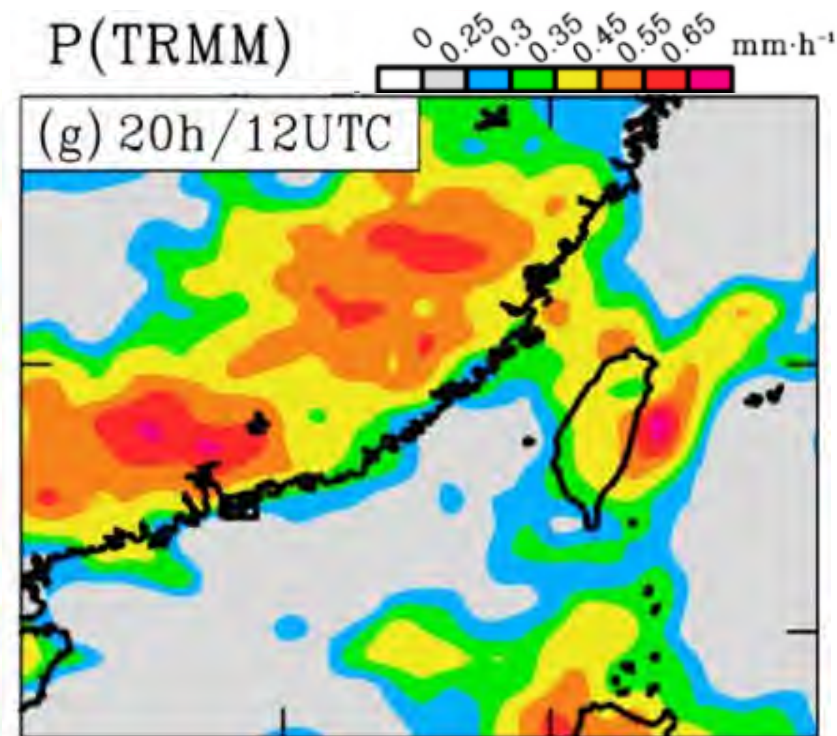
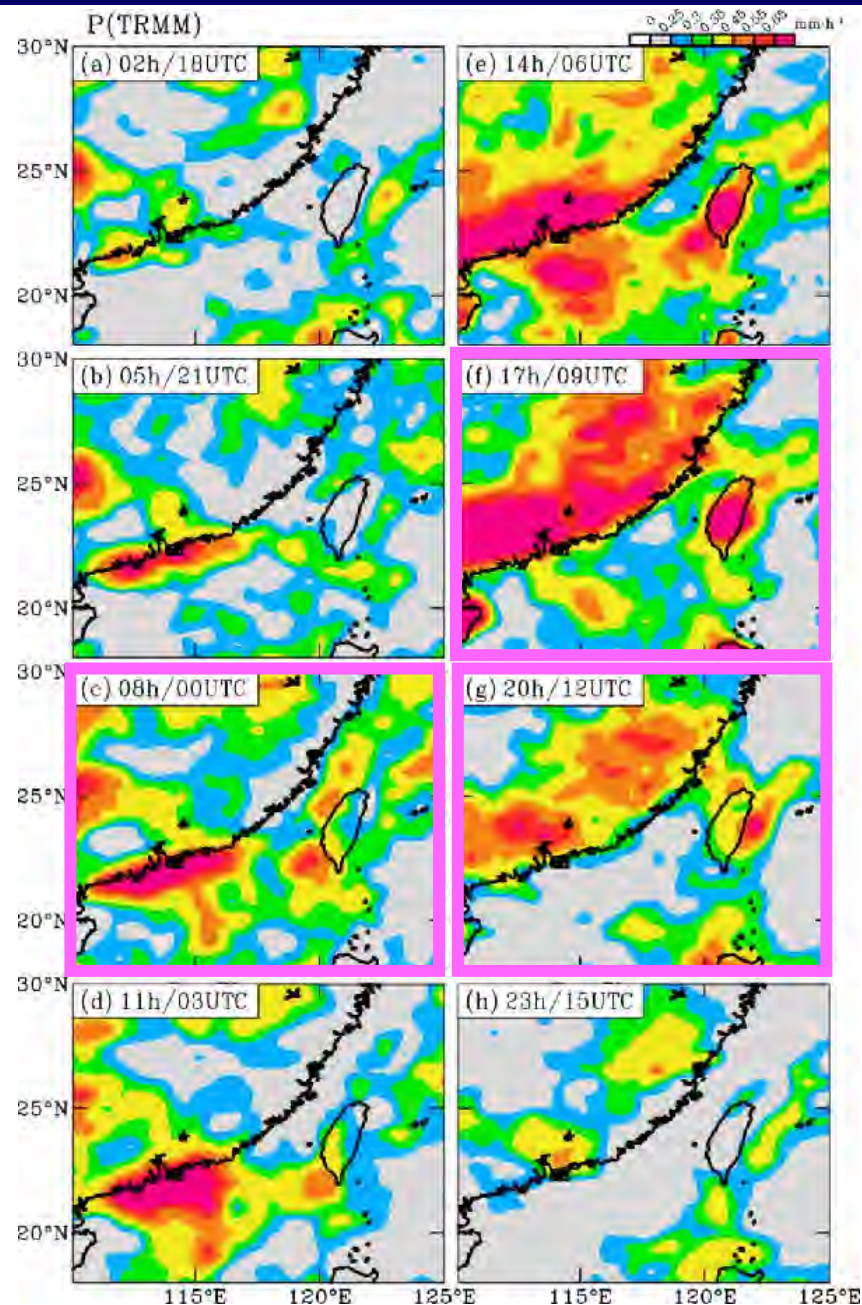
Problem: This mechanism alone cannot explain the observed regional differences of diurnal rainfall in Taiwan

- The existence of **large-scale land-sea breeze like circulation** (Huang et al. 2010)



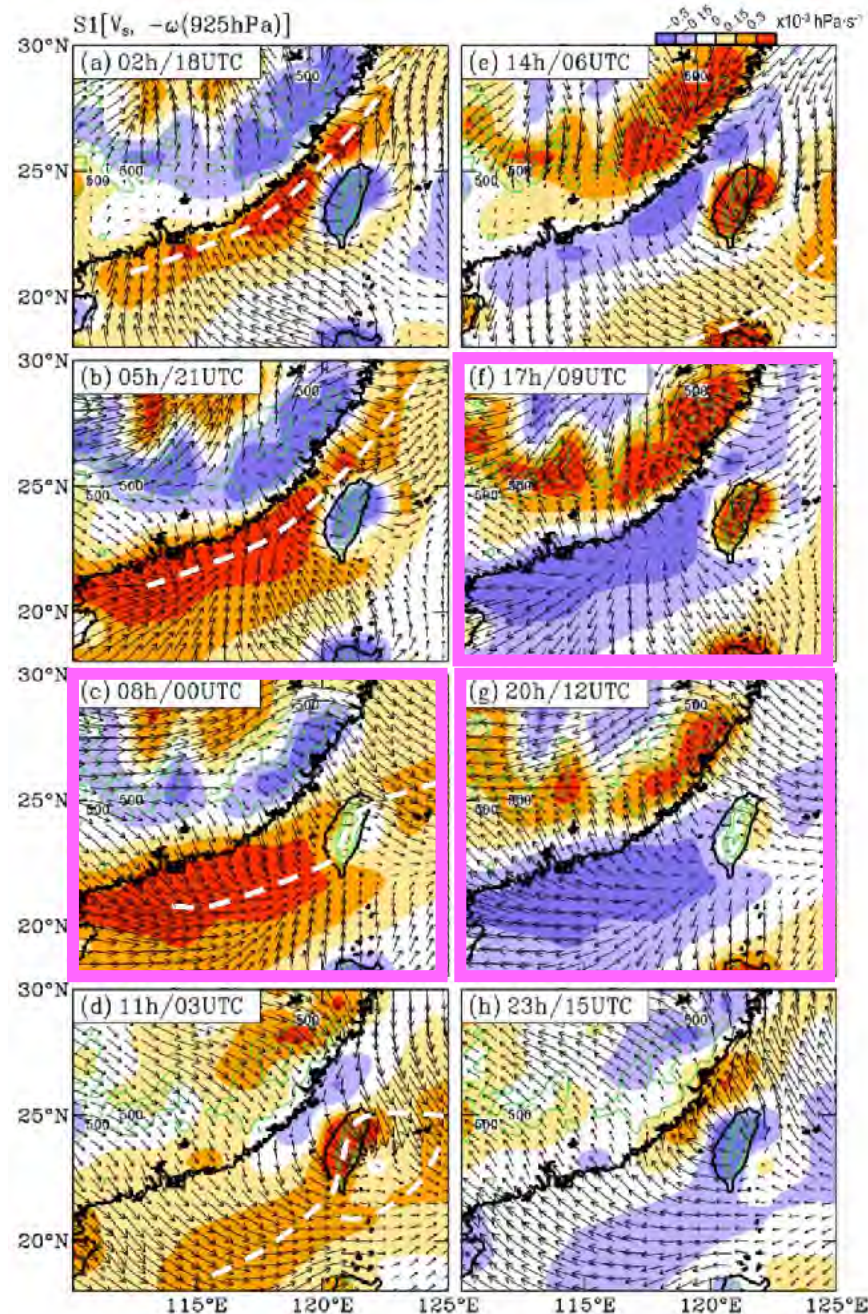
Δ : anomalies, i.e. daily mean has been removed
Blue color: zonal wind (u) > 0

■ Spatial - temporal variation of P(TRMM)



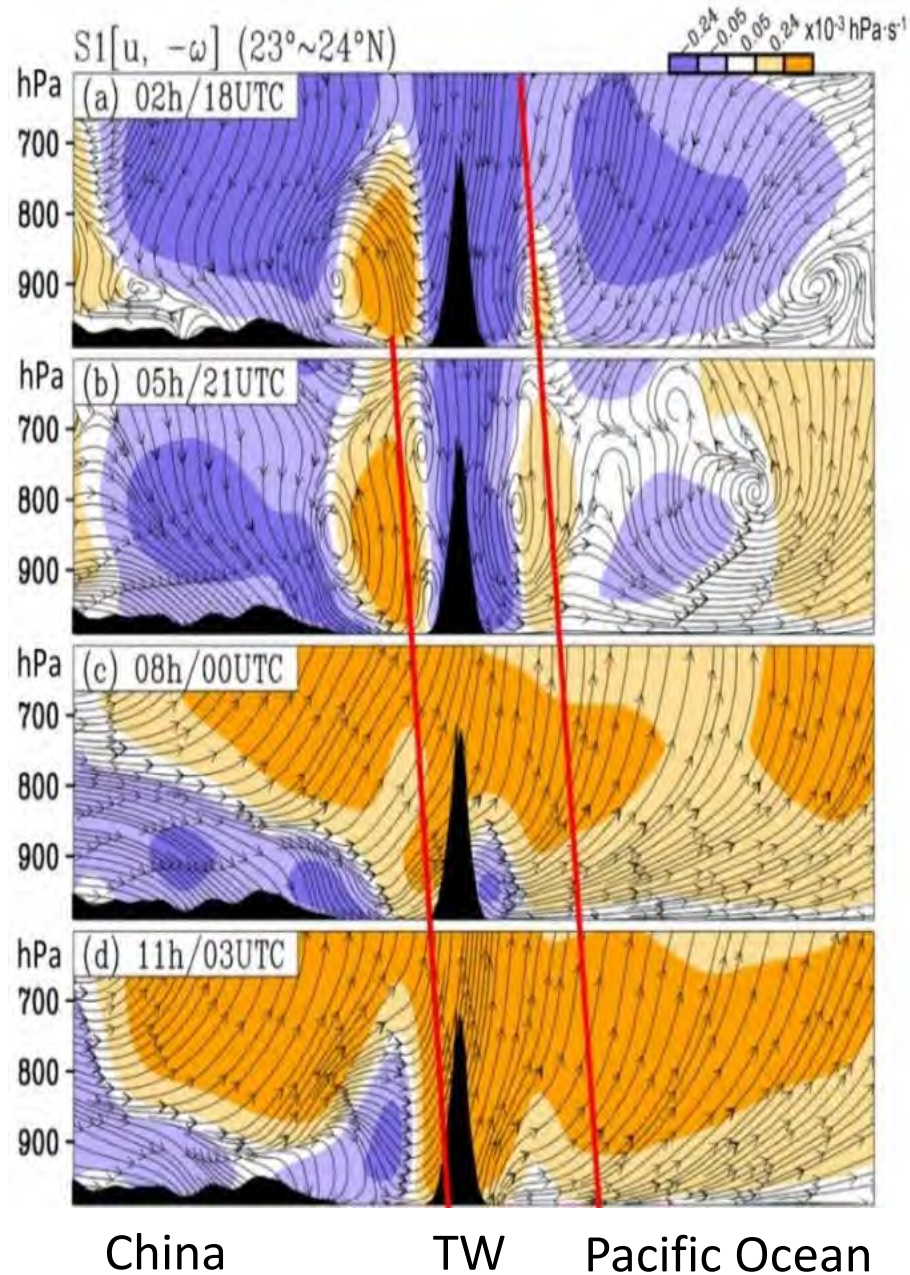
Climatology: averaged during 1998-2012 MJ
Local time in Taiwan is universal time + 8 h

■ Diurnal variation (S1) of wind and vertical motion

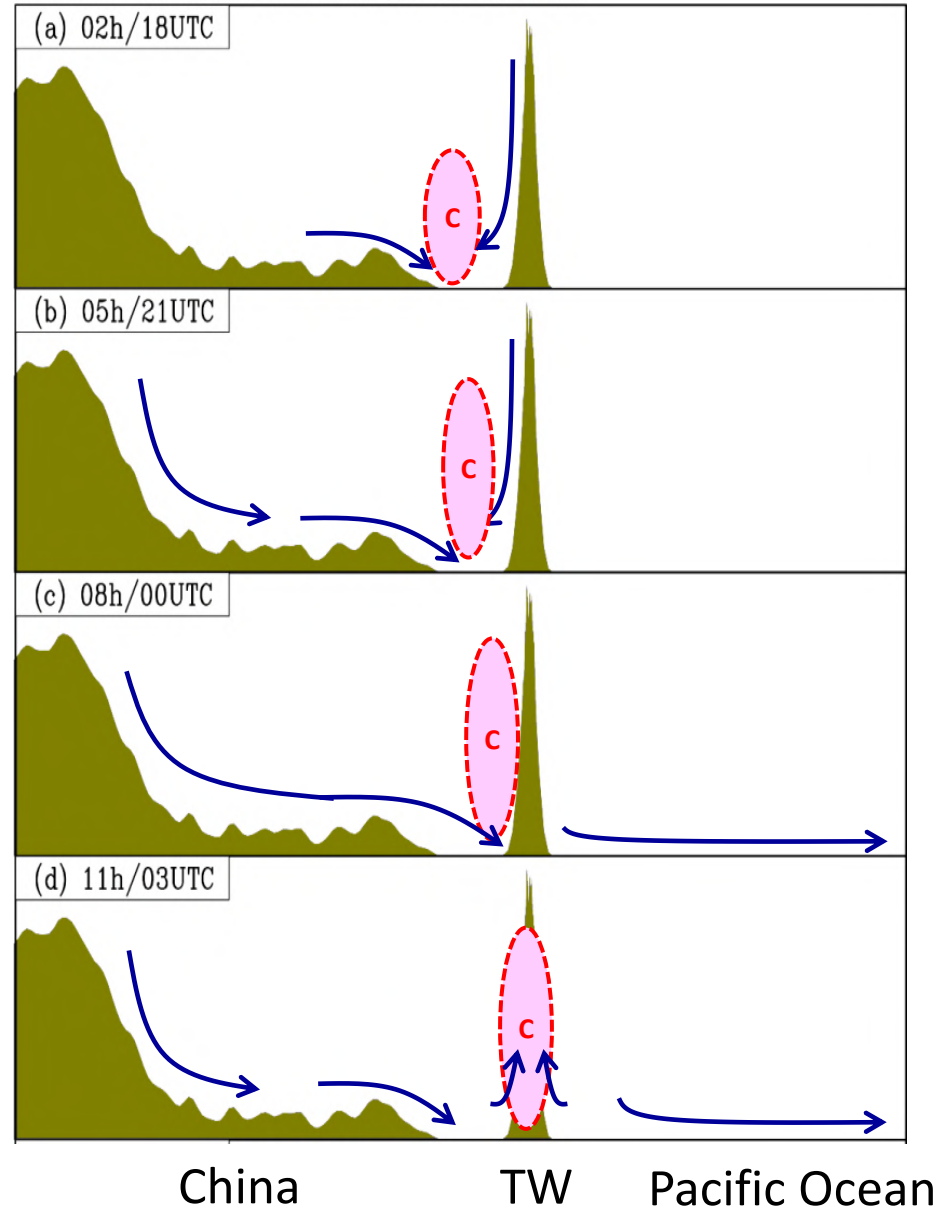


Orange color: upward motion
Green color: mountains

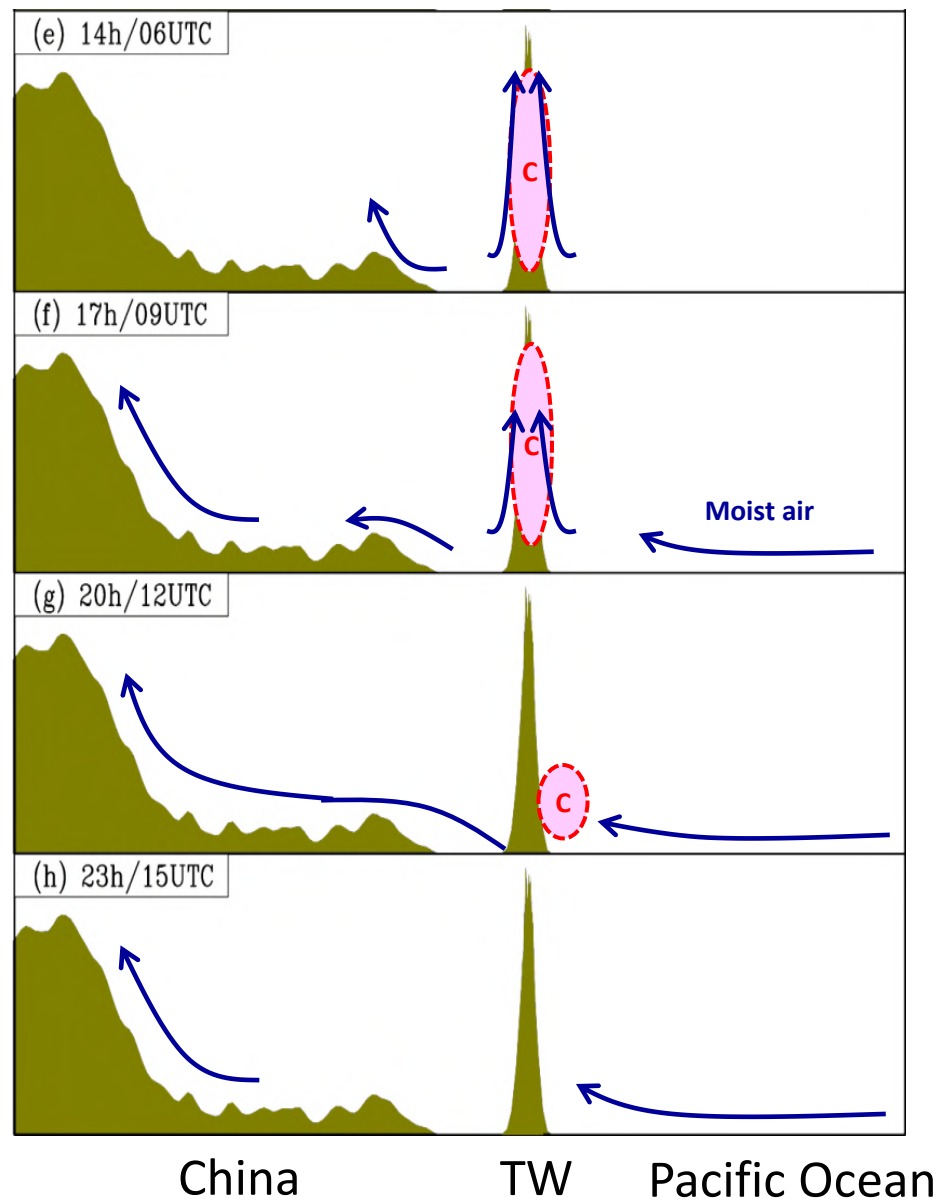
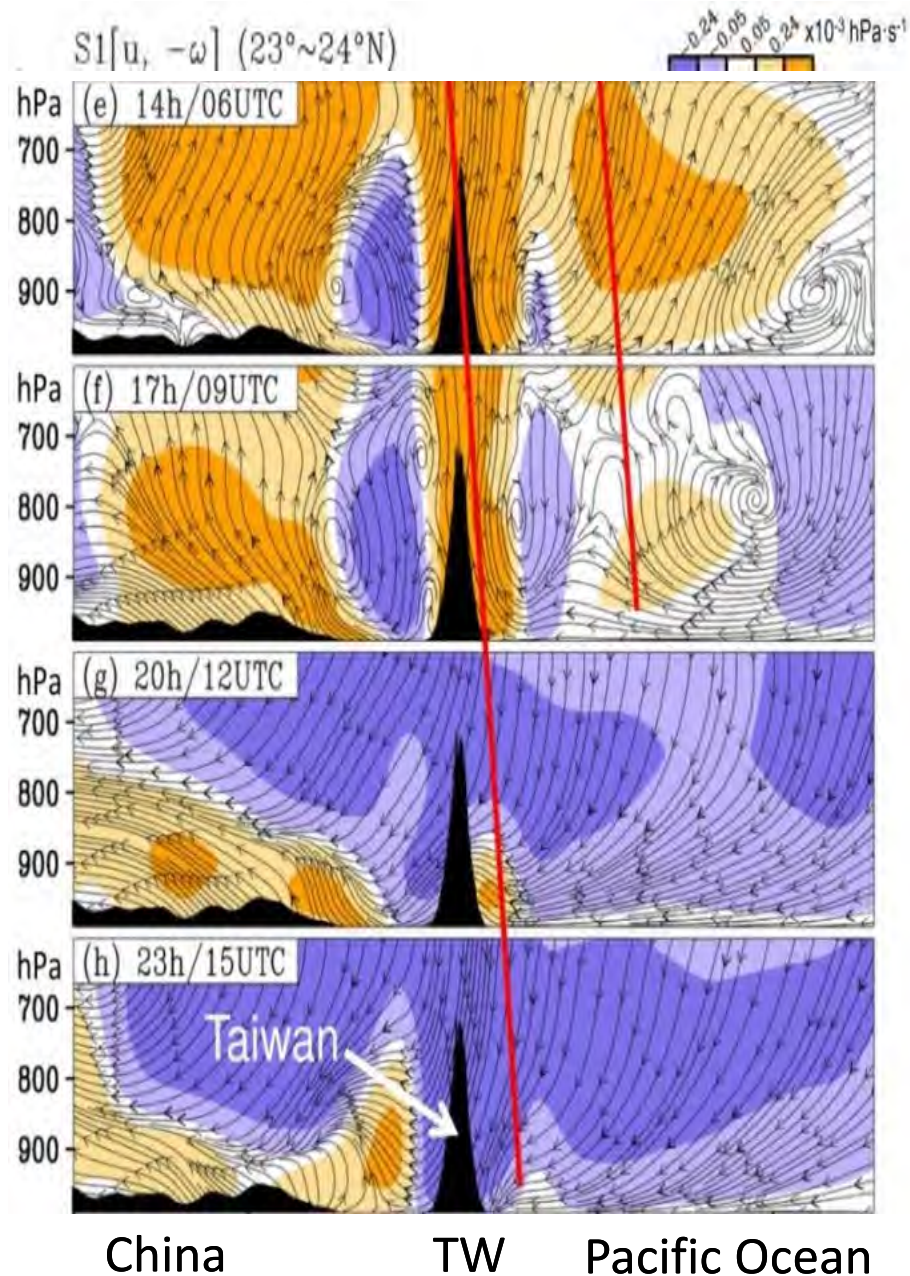
■ Diurnal (S1) of east-west circulation; 02-11 h



Causes of diurnal rainfall in Taiwan



■ Diurnal (S1) of east-west circulation; 14-23 h



2. 衛星降水的評估-TRMM、CMORPH、PERSIANN

大氣科學

第四十五期第二號

TRMM、CMORPH、PERSIANN 三組衛星資料 對臺灣降雨日變化特色的表現能力評估

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表一、衛星資料全名

縮寫	全名
TRMM	Tropical Rainfall Measuring Mission
CMORPH	Climate Prediction Center Morphing method
PERSIANN	Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks

空間解析度為 $0.25^{\circ} \times 0.25^{\circ}$ ，
時間解析度為每 3 小時一筆。

Studying Periods: 1998~2015

春(Mar、April、May)

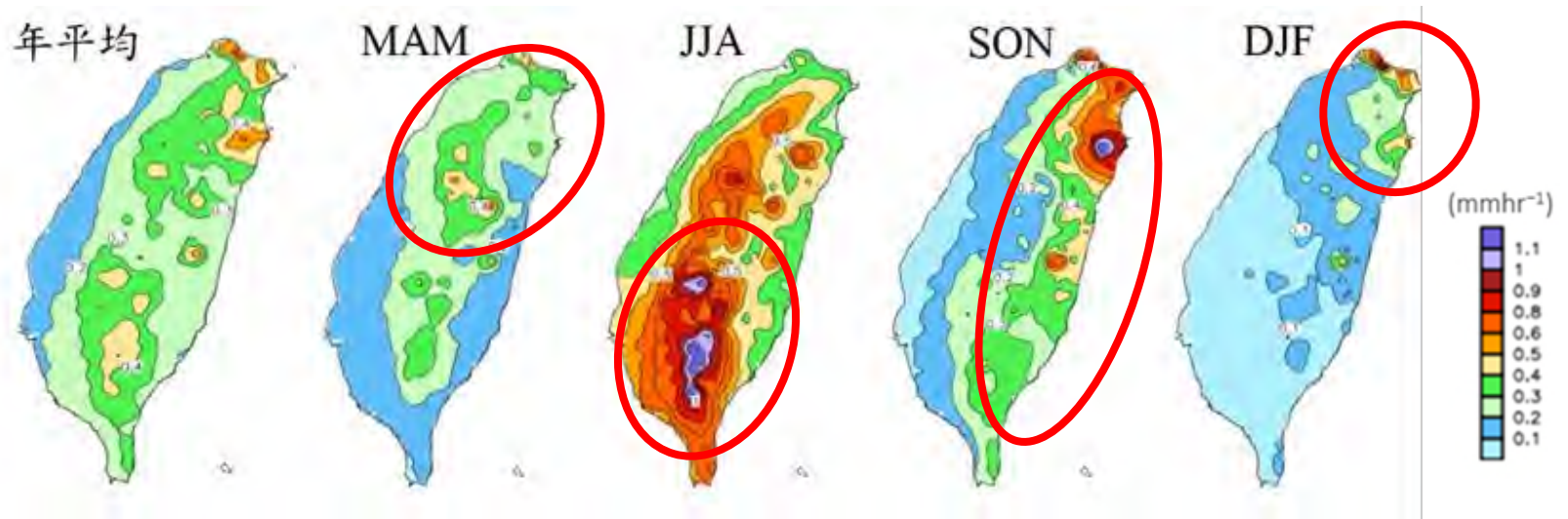
夏(June、July、August)

秋(September、October、November)

冬(December、January、February)

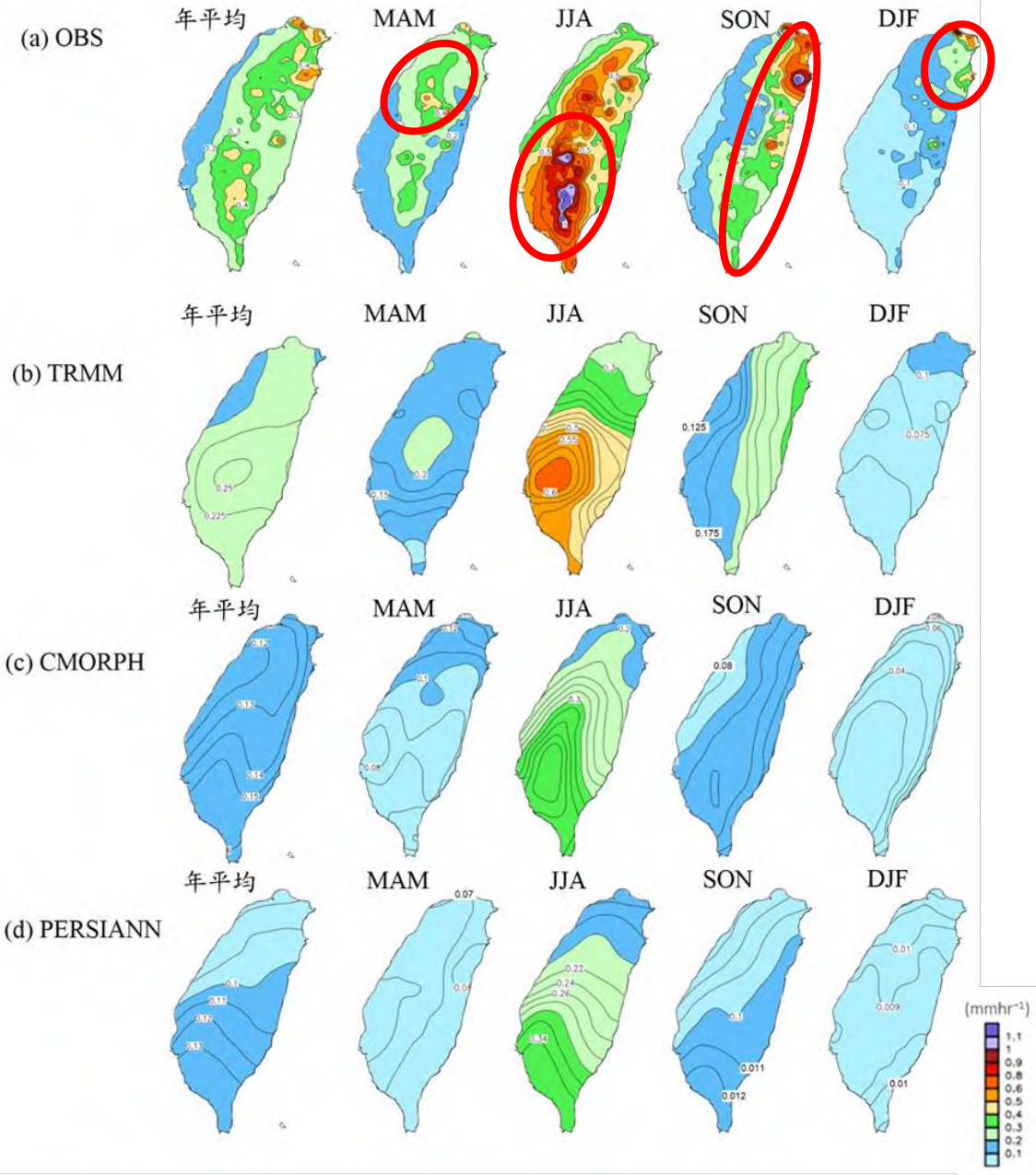
■ Spatial distribution of Precipitation

Climatology, gridded data using CWB-gauge



Anti-clockwise rotation (Yen and Chen, 2000)

<https://tccip.ncdr.nat.gov.tw/v2/index.aspx> , 其空間解析度為 $0.0125^{\circ} \times 0.0125^{\circ}$ 。



表二、地面觀測資料與三組衛星資料之四季氣候平均降雨(圖 1)空間相關係數統計表。

季節 資料	MAM	JJA	SON	DJF
TRMM	0.65	0.64	0.81	0.83
CMORPH	0.63	0.62	0.67	0.74
PERSIANN	0.16	0.59	0.60	0.35

表三、地面觀測資料與三組衛星資料之四季氣候平均降雨(圖 1)所估算出之臺灣區域降雨日平均值統計表，單位為mm hr⁻¹。

季節 資料	MAM	JJA	SON	DJF
OBS	0.37	0.90	0.46	0.19
TRMM	0.17	0.43	0.21	0.07
CMORPH	0.11	0.27	0.15	0.05
PERSIANN	0.08	0.25	0.10	0.01

圖1. 臺灣年平均降雨量及四季氣候平均場降雨水平空間分布。(a)地面觀測資料，(b)-(d)為三組衛星觀測資料:(b) TRMM (c) CMORPH及(d)PERSIANN。色標如圖所示。

降水的日夜變化: 春季

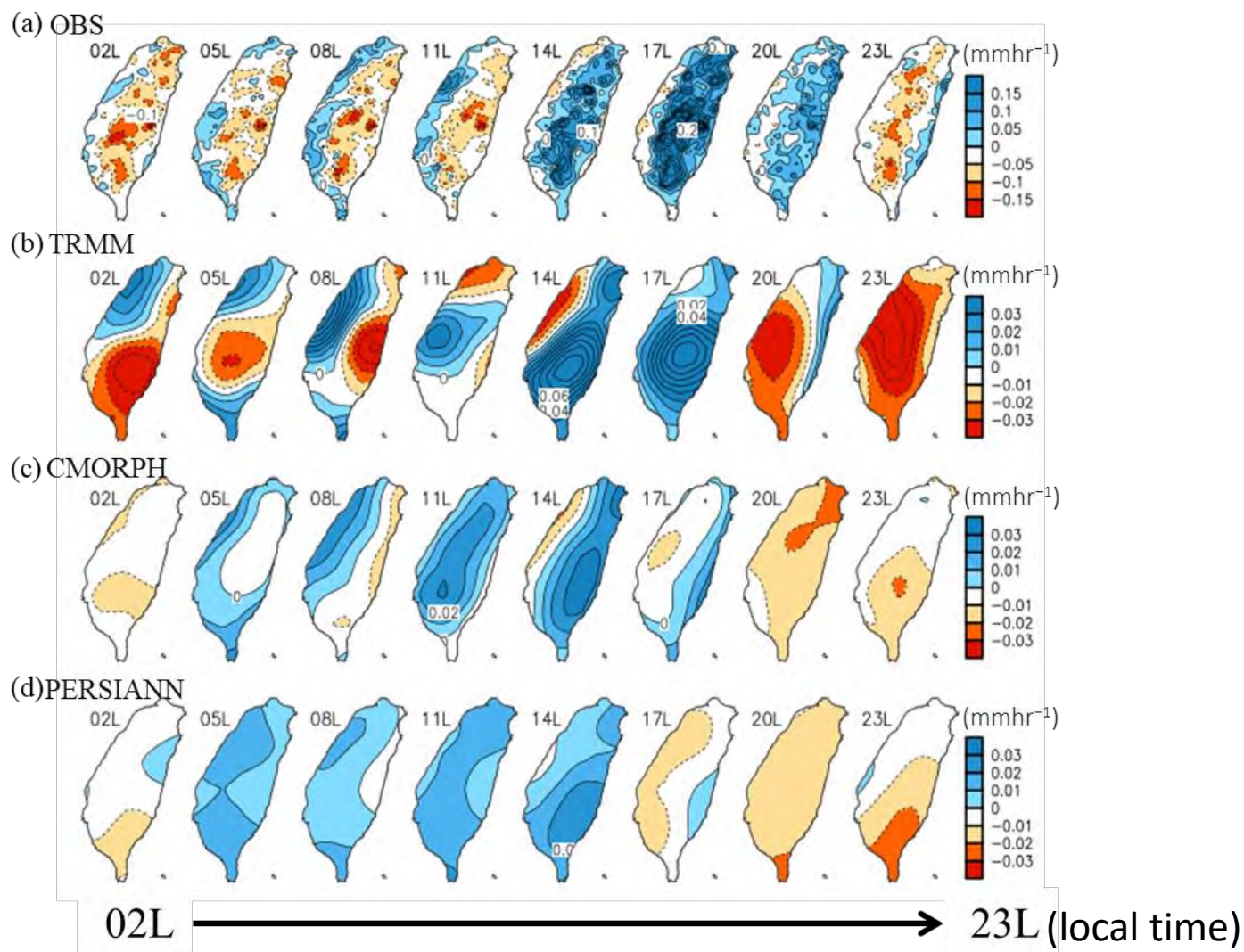


圖2. 春季降雨距平時時間序列之空間分布。(a)為地面觀測資料，(b)-(d)為三組衛星觀測資料：(b) TRMM (c) CMORPH及(d)PERSIANN。色標如圖所示，時間為當地時間L。

降水的日夜變化: 夏季

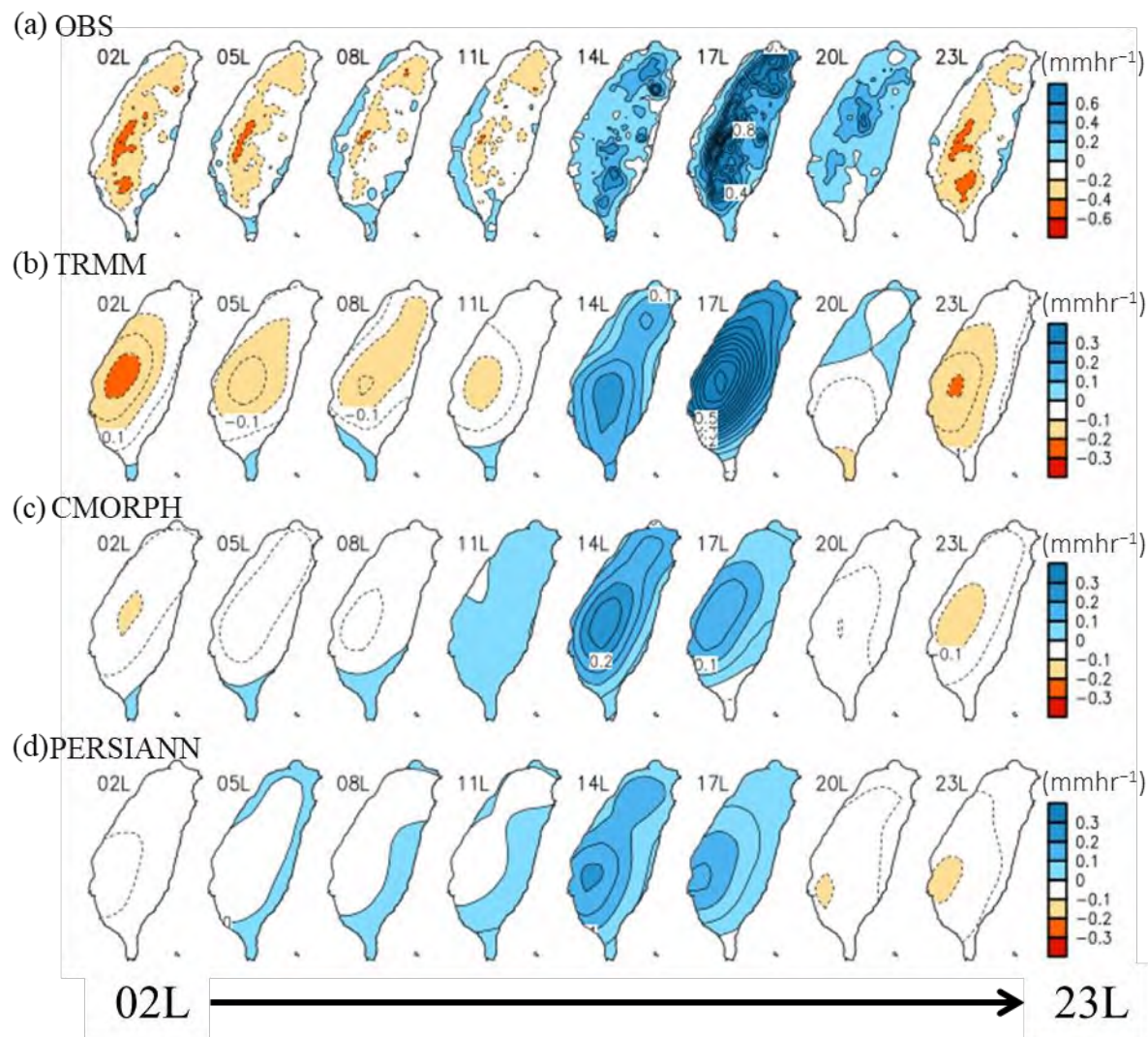


圖3. 類似圖2，但為夏季降雨距平時時間序列之空間分布。

降水的日夜變化: 秋季

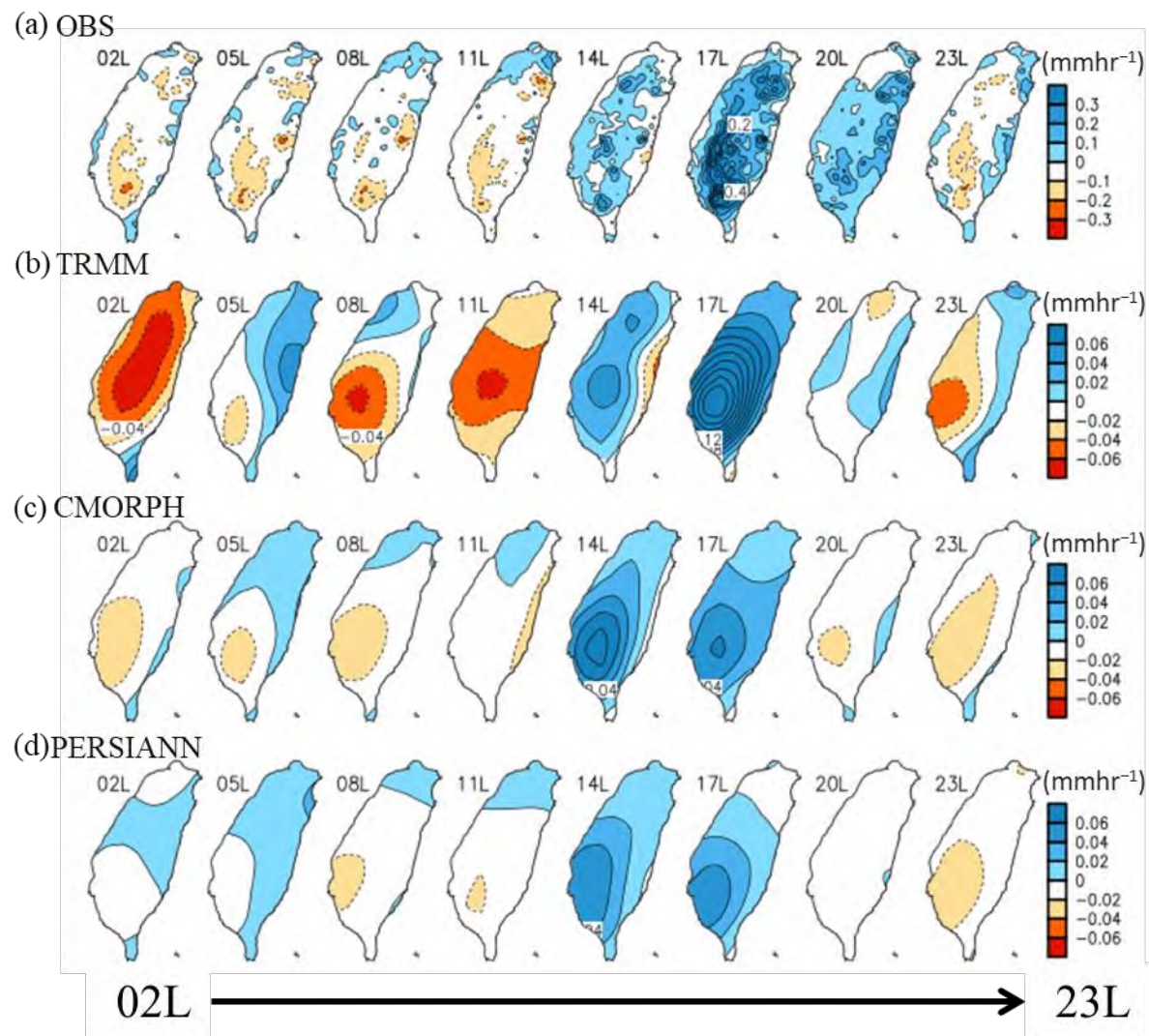


圖4. 類似圖2，但為秋季降雨距平時時間序列之空間分布。

降水的日夜變化: 冬季

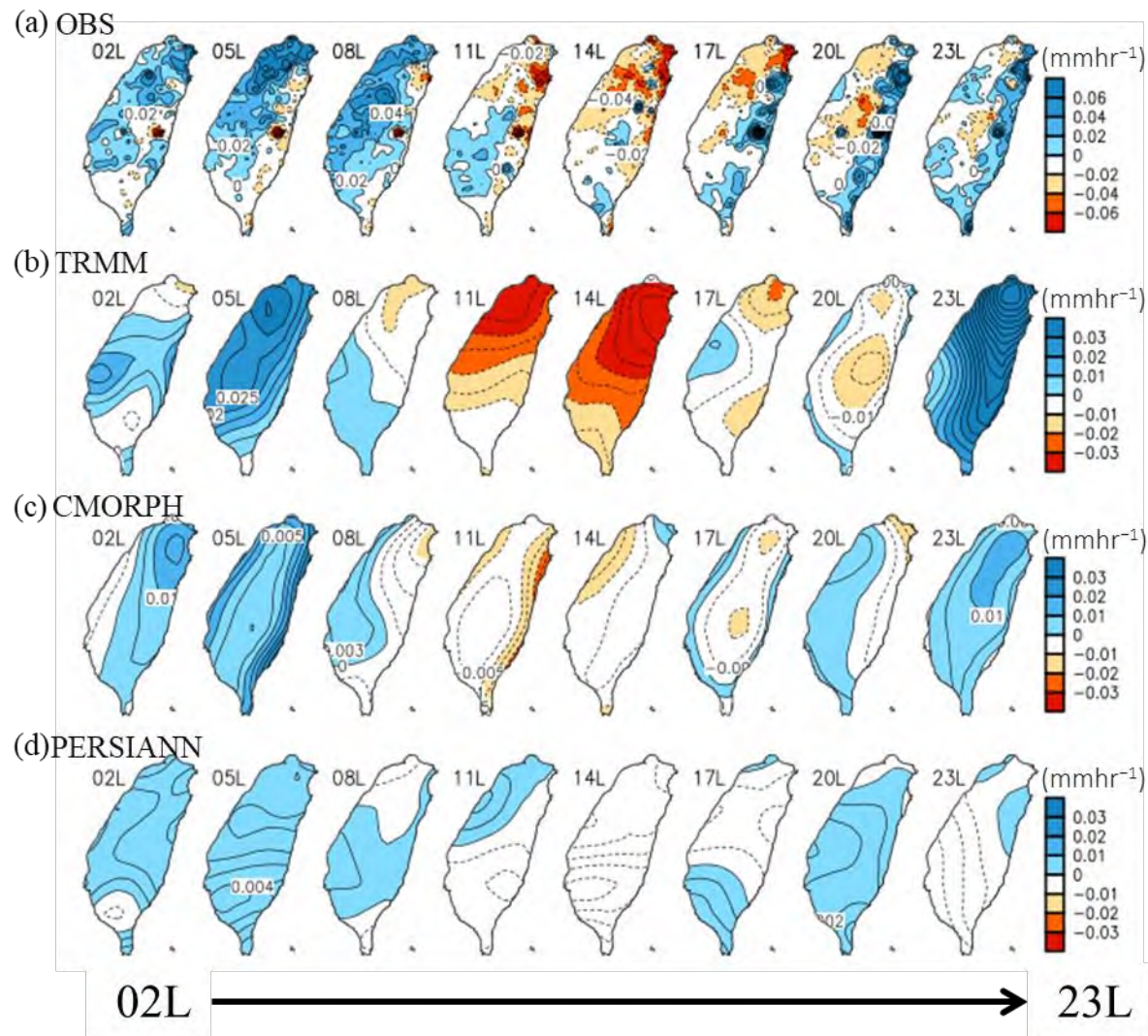


圖5. 類似圖2，但為冬季降雨距平時時間序列之空間分布。

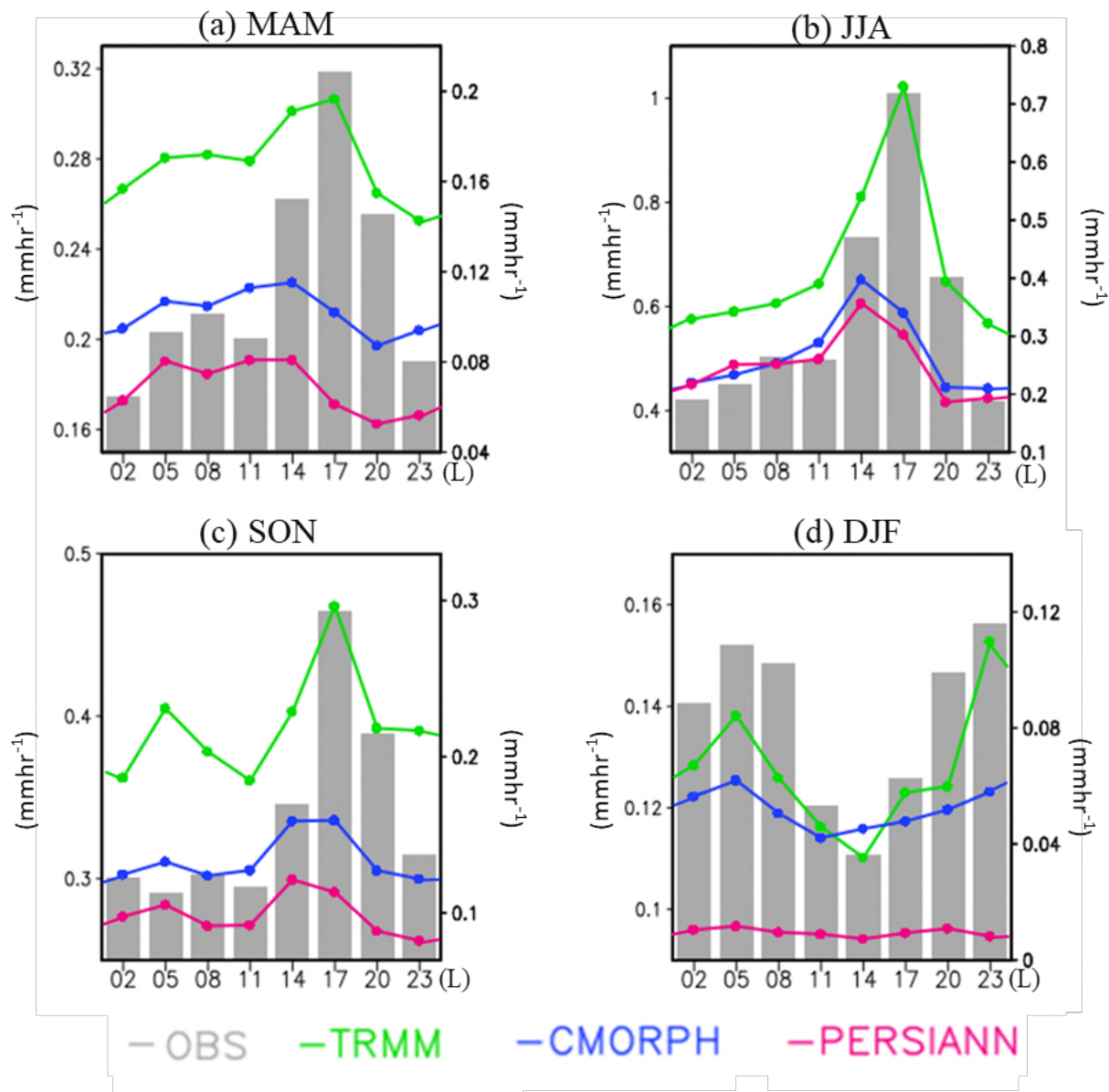


圖6. 臺灣區域平均後之逐時降雨時間變化。(a)春季(b)夏季(c)秋季(d)冬季。左縱軸表示地面觀測資料(灰柱)雨量值，右縱軸表示衛星資料雨量值，單位如圖所示(綠線為TRMM，藍線為CMORPH，紅線為PERSIANN)。

降水的日夜變化空間、時間相關係數分析

表四、地面觀測資料與三組衛星資料在MAM(圖2)、JJA(圖3)、SON(圖4)、DJF(圖5)季節中的日變化量空間相關係數統計表。

資料 \ 季節	MAM (圖2)	JJA (圖3)	SON (圖4)	DJF (圖5)
TRMM	0.60	0.73	0.57	0.18
CMORPH	0.21	0.60	0.60	-0.07
PERSIANN	0.25	0.58	0.53	-0.06

表五、地面觀測資料與三組衛星資料在四季中之平均一日內的每3小時變化(圖6)時間相關係數統計表。

資料 \ 季節	MAM	JJA	SON	DJF
TRMM	0.67	0.98	0.89	0.84
CMORPH	-0.05	0.71	0.70	0.82
PERSIANN	-0.27	0.62	0.47	0.57

時間序列波譜分析

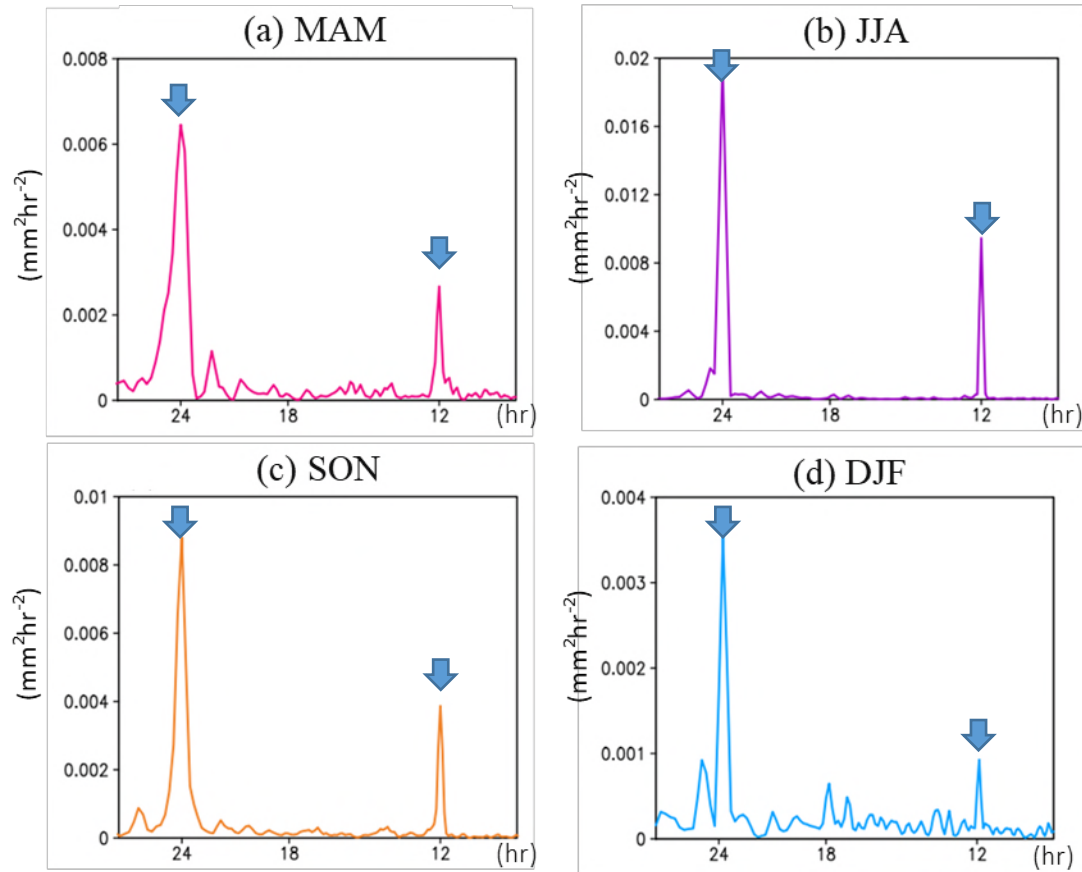


圖7. 針對圖6中，地面觀測之臺灣區域平均後之逐時降雨時間變化，所做的波譜分析。(a)春季(b)夏季(c)秋季(d)冬季。縱軸為振幅，橫軸代表週期，單位如圖所示。

日週期 (diurnal cycle)的比對

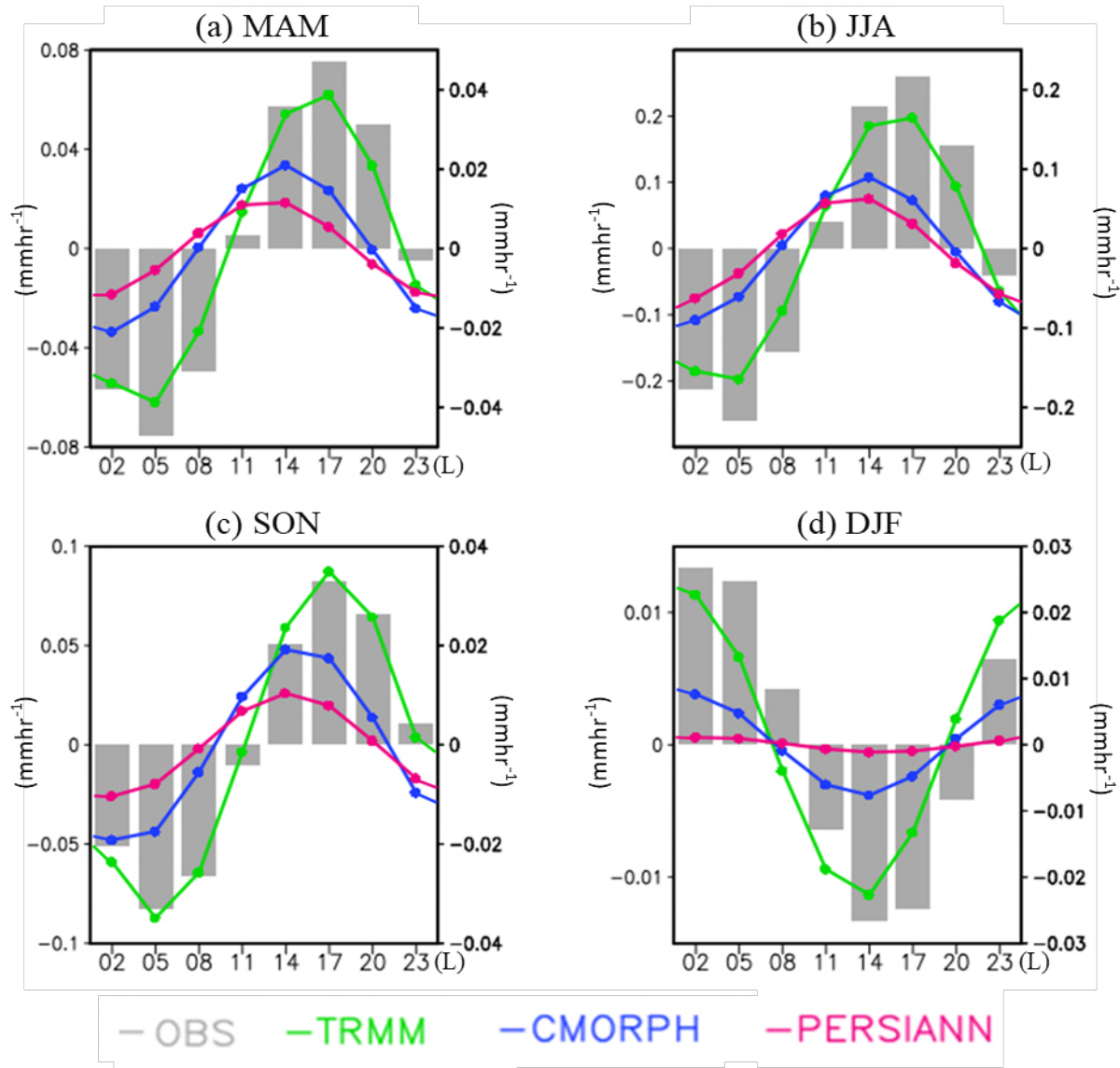


圖8. 類似圖6，但為日週期變化分量之比較。

半日週期 (semidiurnal cycle)的比對

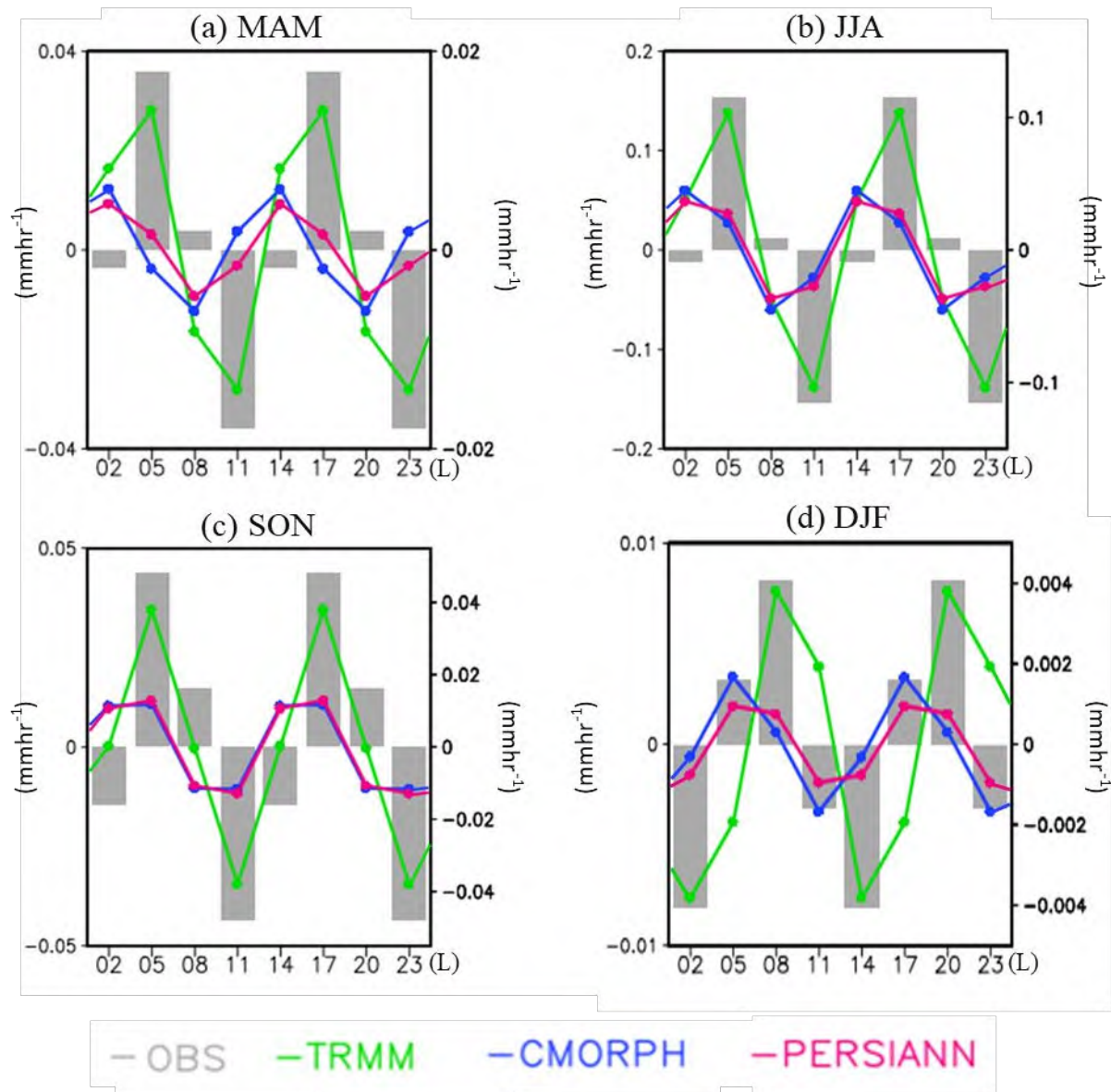


圖9. 類似圖6，但為半日週期變化分量之比較。

降水的日夜變化 移動特性比對： 春季

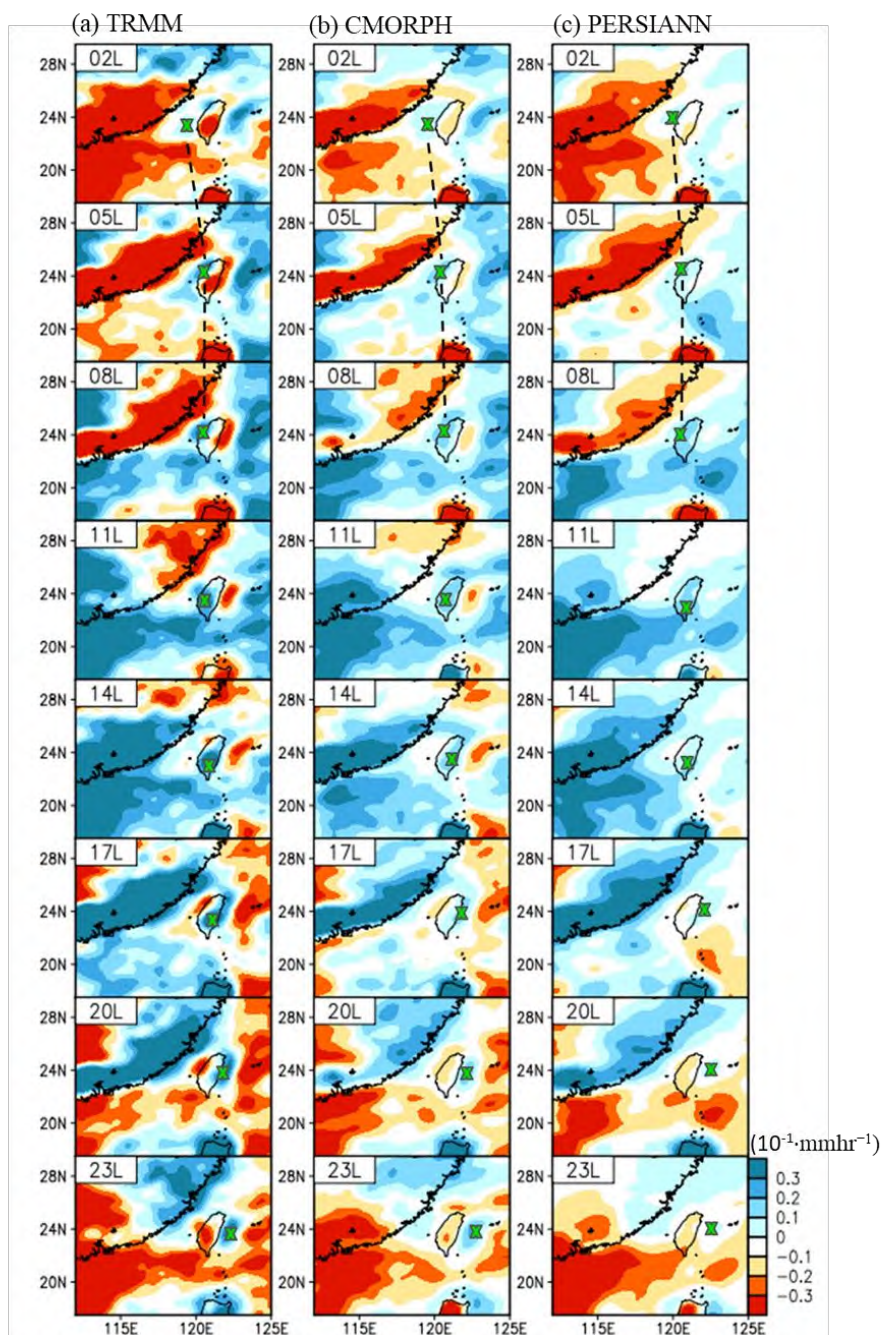


圖 10. 春季降雨日週期水平空間分布。(a) TRMM (b) CMORPH 及 (c) PERSIANN。色標如圖所示。綠色x之標示，代表影響臺灣降雨之主要雨帶位置，黑色虛線代表文中所提之清晨雨帶移動之連線。

降水的日夜變化
移動特性比對：
夏季

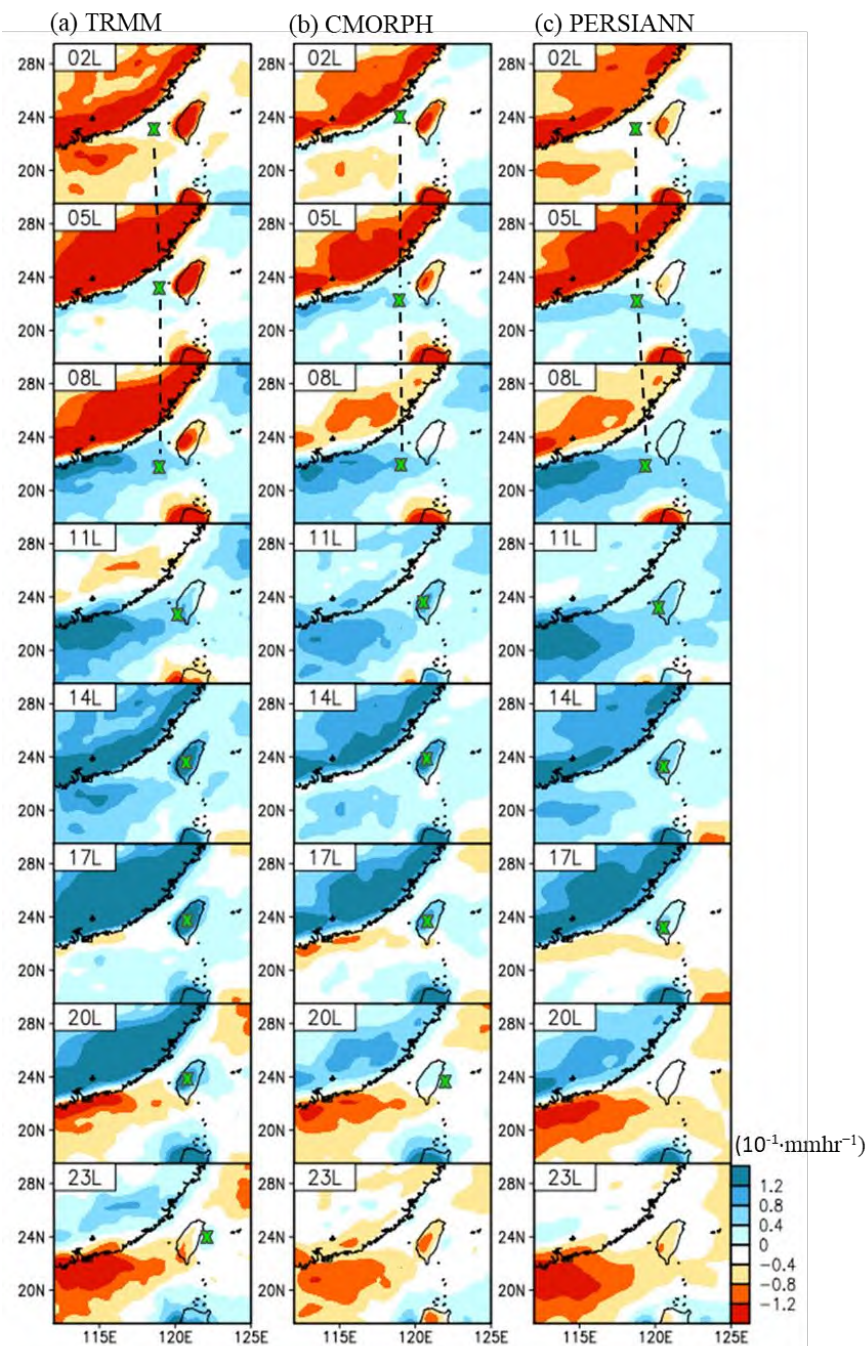


圖11. 類似圖10，但為夏季降雨日週期水平空間分布。

降水的日夜變化
移動特性比對：
秋季

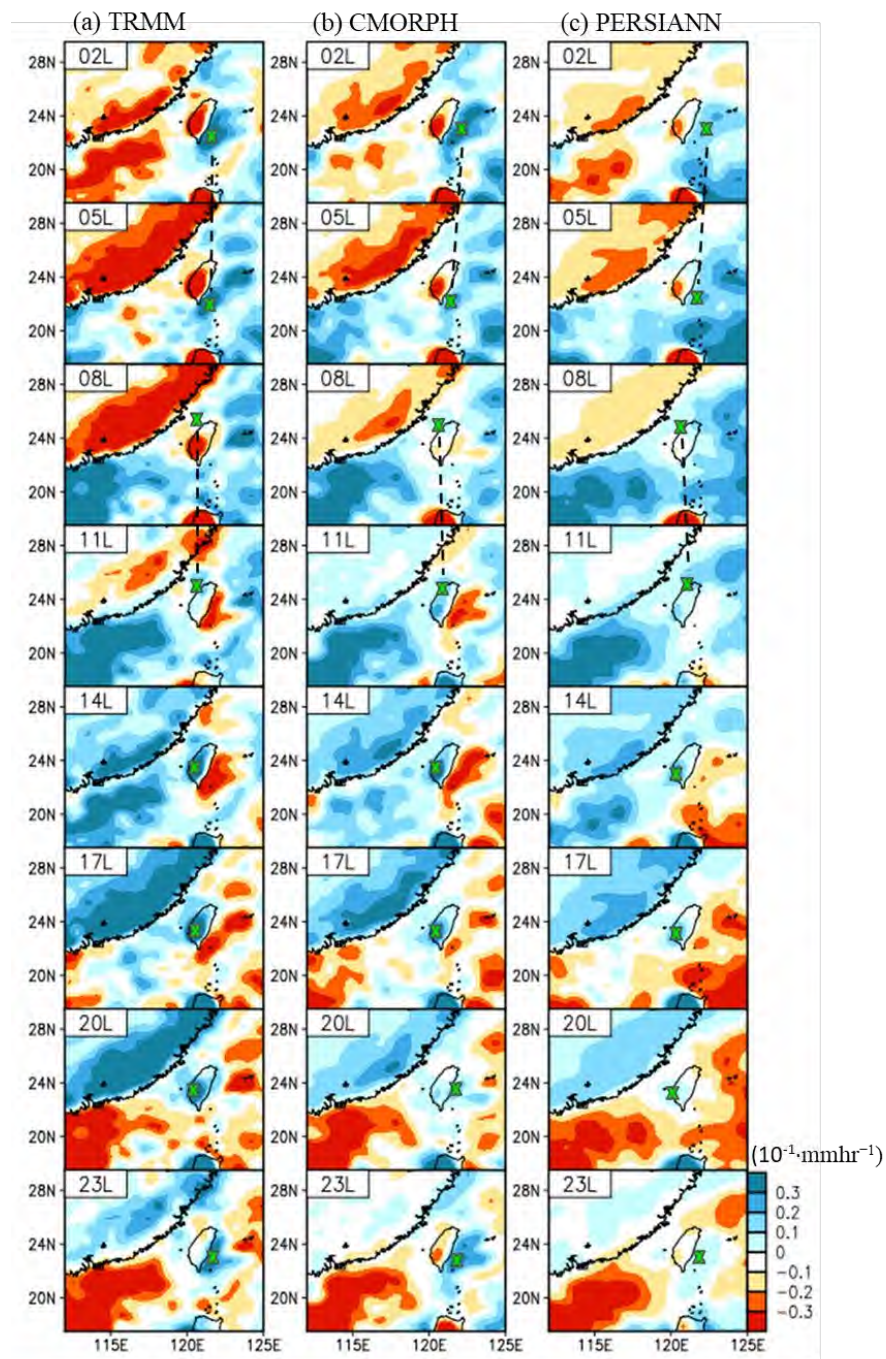


圖12. 類似圖10，但為秋季降雨日週期水平空間分布。

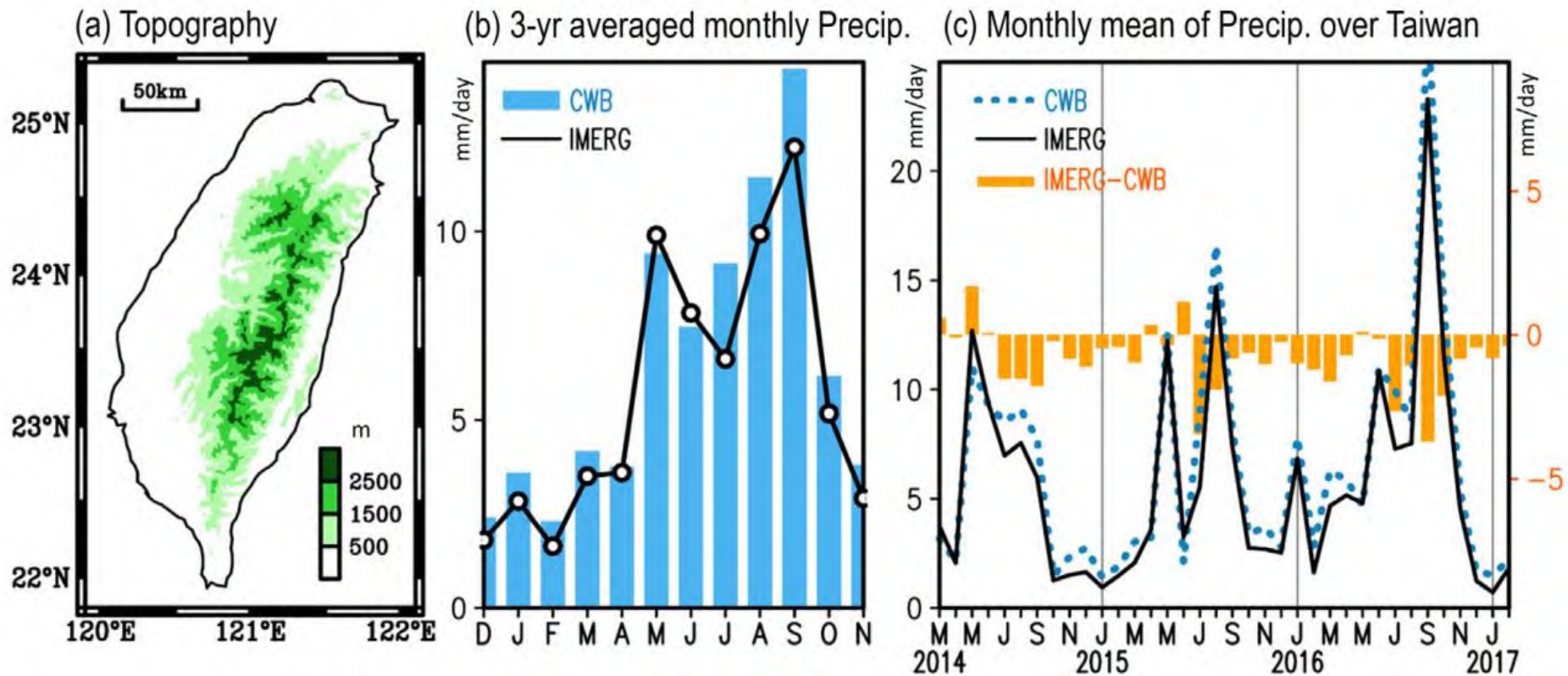
2. 衛星降水的評估-GPM IMERG version 5

Assessment of IMERG precipitation over Taiwan at multiple timescales

Wan-Ru Huang*, Ya-Hui Chang, Pin-Yi Liu

(Atmospheric Research 2018)

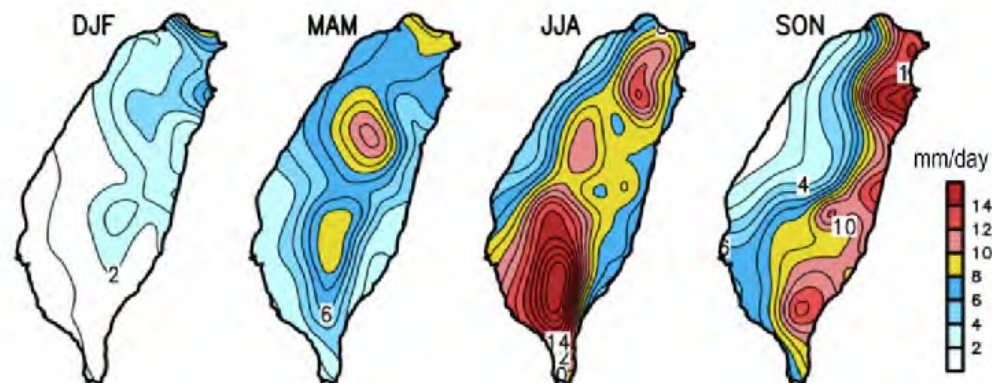
Department of Earth Sciences, National Taiwan Normal University, Taipei, Taiwan



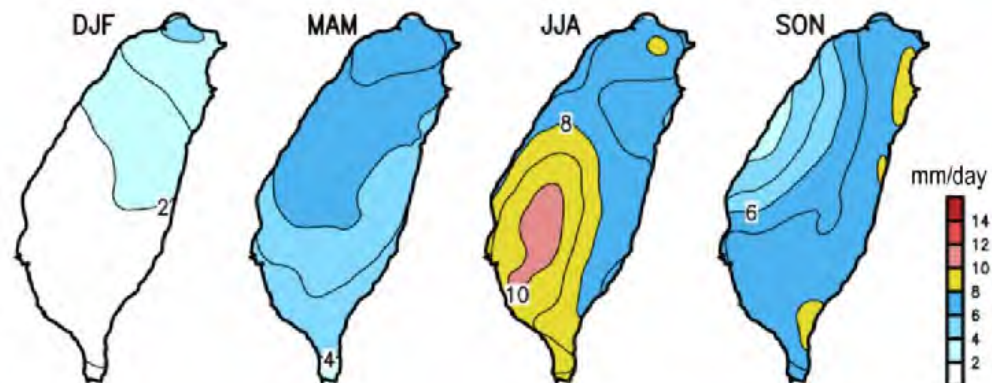
Studying Period: March 2014 to February 2017
Precipitation data: GPM IMERG-Final version 5

降水的氣候平均值
比對

(a) CWB precipitation



(b) IMERG precipitation



(c) Difference between IMERG and CWB precipitation



降水的月平
均值時間序
列比對

Grid-to-Grid comparison for monthly mean precipitation

(a) Tcorr of (CWB vs. IMERG) (b) RMSE of (IMERG-CWB)

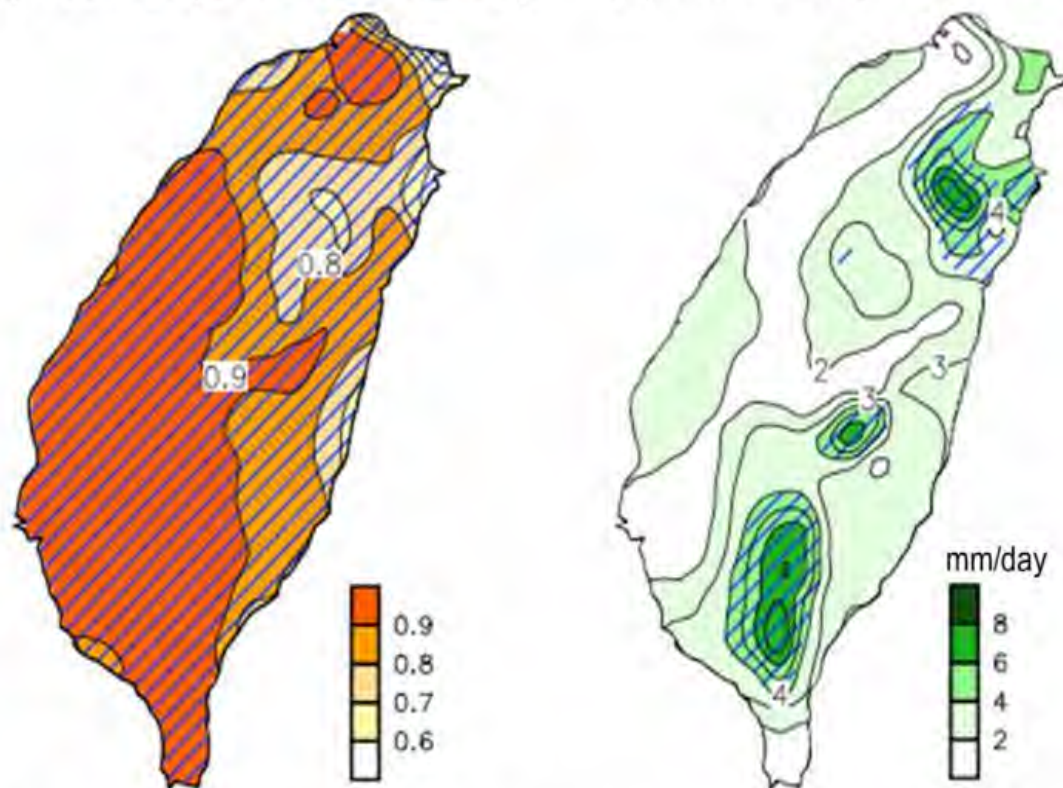
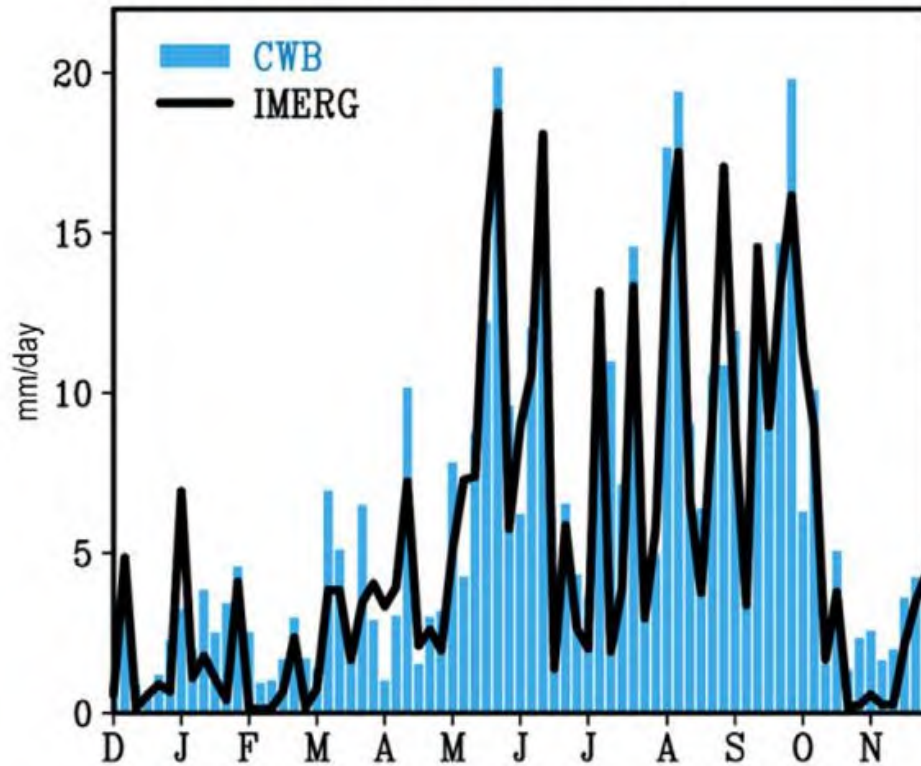


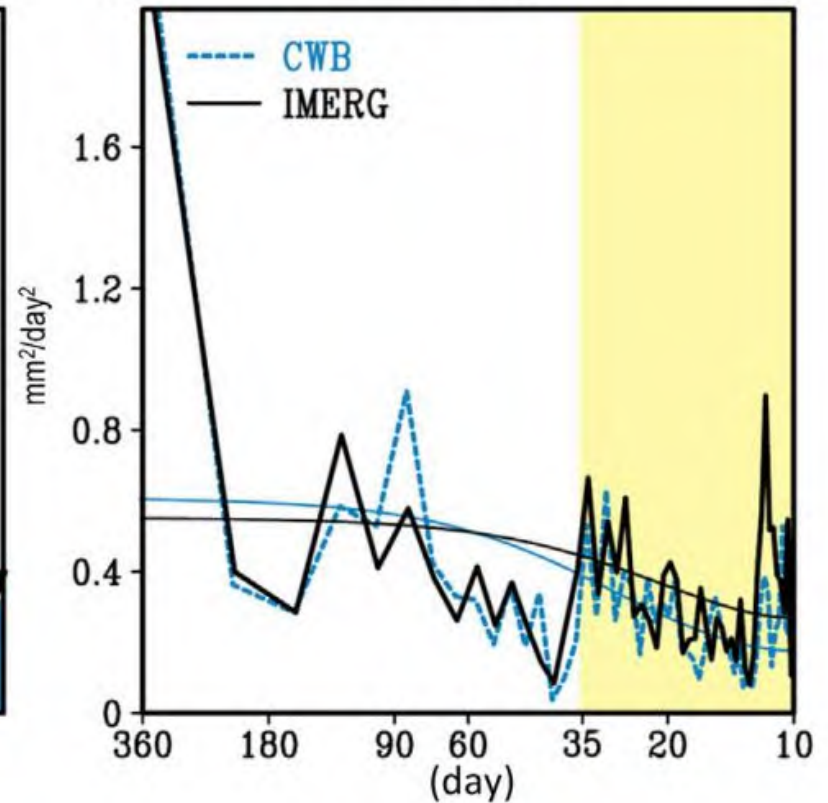
Fig. 3. Horizontal distribution of the (a) grid-to-grid temporal correlation (Tcorr) between the monthly precipitation time series estimated by CWB and IMERG during the period of March 2014 to February 2017 and the (b) grid-to-grid root-mean-square error (RMSE; see manuscript for the calculation method) of the monthly precipitation estimated by the difference between IMERG and CWB during the period of March 2014 to February 2017. In (a)-(b), the areas passing the 95% significant test are marked by tilted lines.

5日平均 (pentad) 降水的時間序列比對與波譜分析

(a) CWB vs. IMERG (pentad)

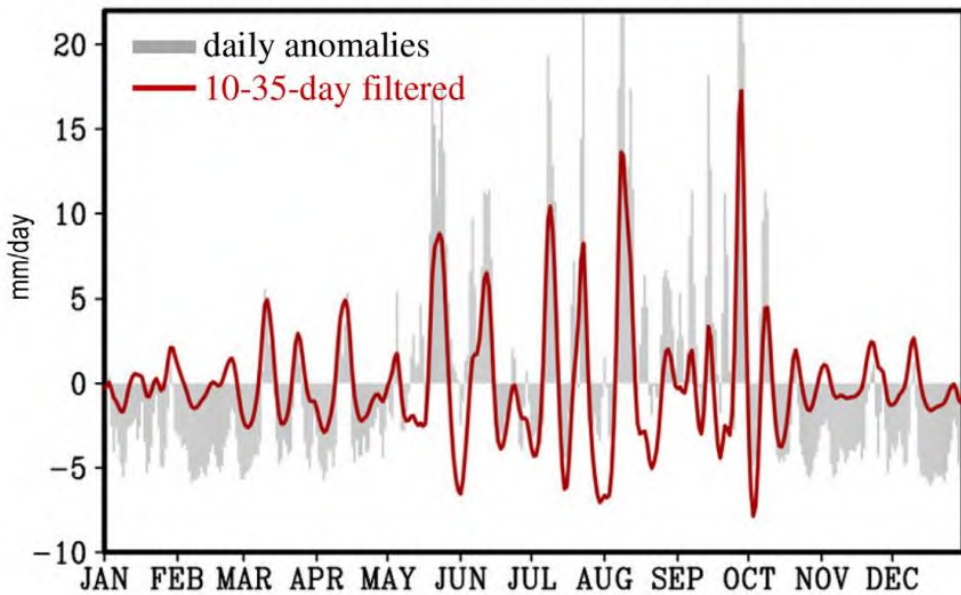


(b) Power Spectrum (CWB vs. IMERG)

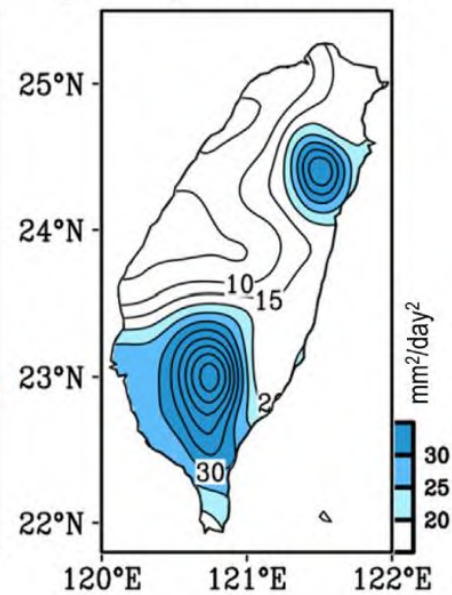


降水的季內
震盪時間序
列比對

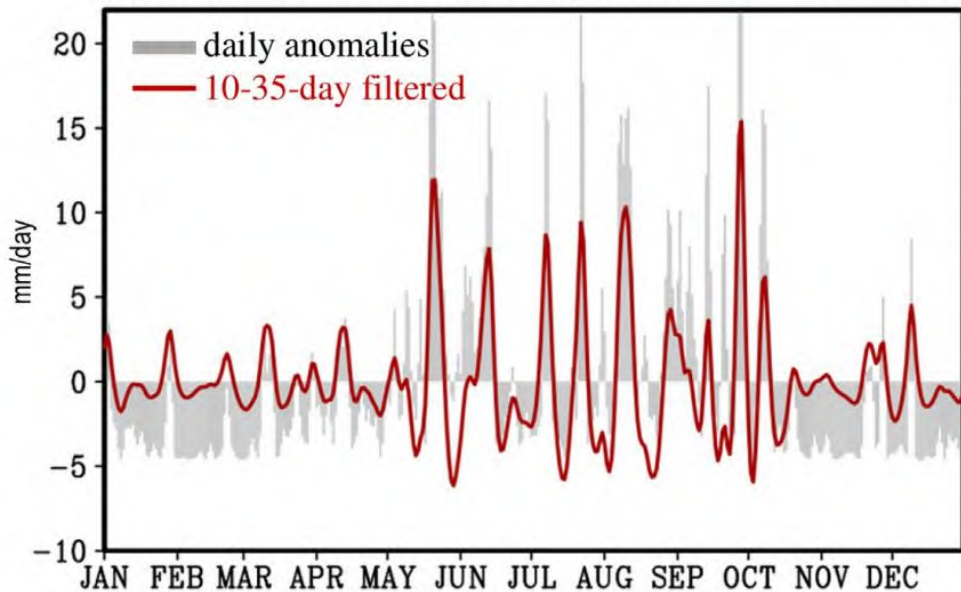
(a) Anomalies and filtered daily precipitation; CWB



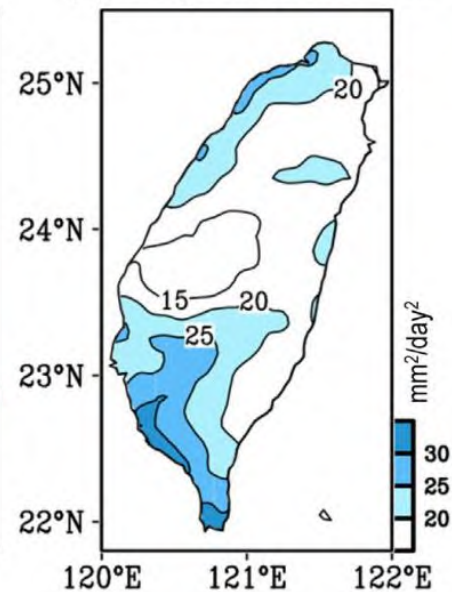
(b) Daily variance; CWB



(c) Anomalies and filtered daily precipitation; IMERG



(d) Daily variance; IMERG



Grid-to-Grid comparison for 10-35-day filtered precipitation

(a) Tcorr of (CWB vs. IMERG)

(b) RMSE of (IMERG-CWB)

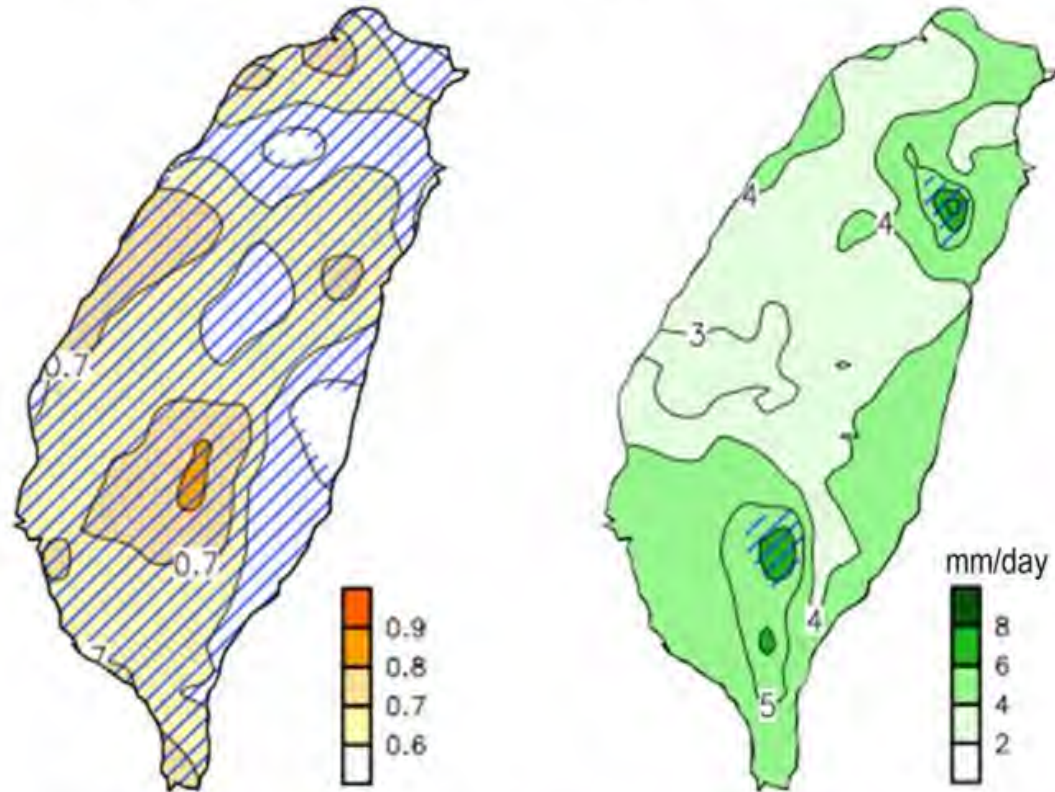
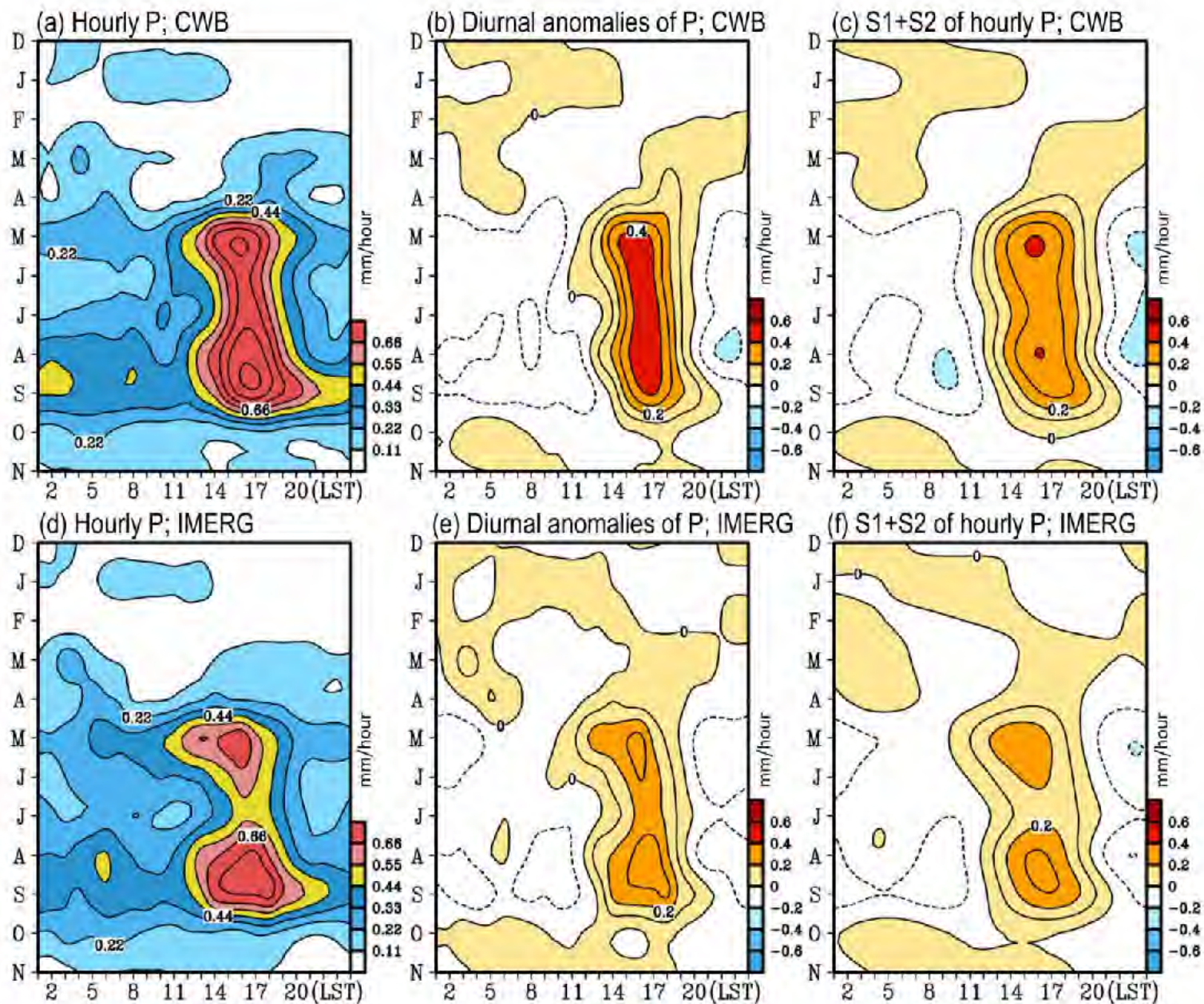


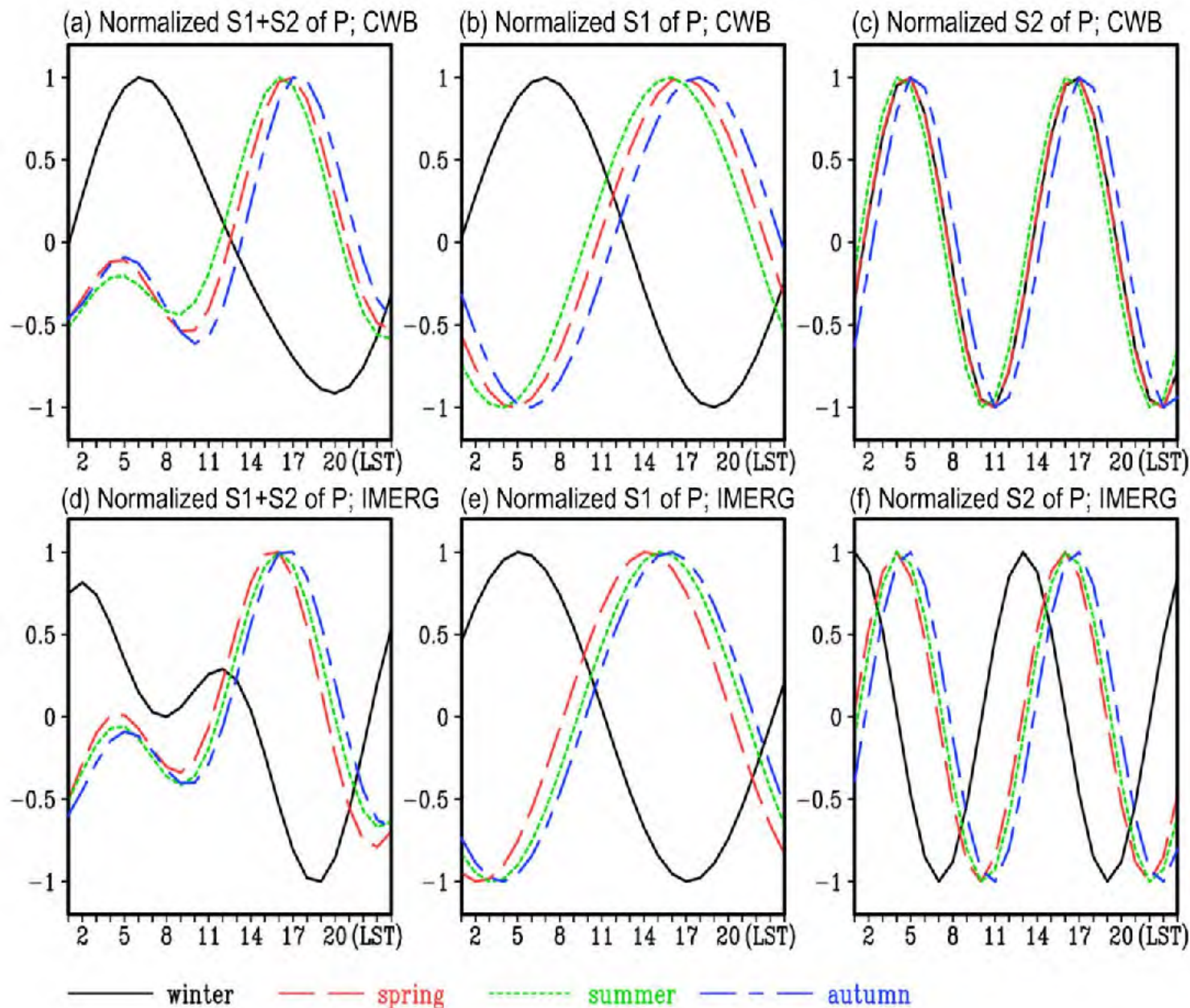
Fig. 6. Horizontal distribution for (a) the grid-to-grid temporal correlation (Tcorr) between the time series of the 10–35-day filtered precipitation estimated by CWB and IMERG during the period of March 2014 to February 2017 and the (b) grid-to-grid root-mean-square error (RMSE; see manuscript for the equation) of the 10–35-day filtered precipitation estimated by the differences between IMERG and CWB during the period of March 2014 to February 2017. In (a)-(b), the values passing the 95% significance test are marked by tilted lines.

降水的季內
震盪時間序
列比對

降水的日夜變化比對

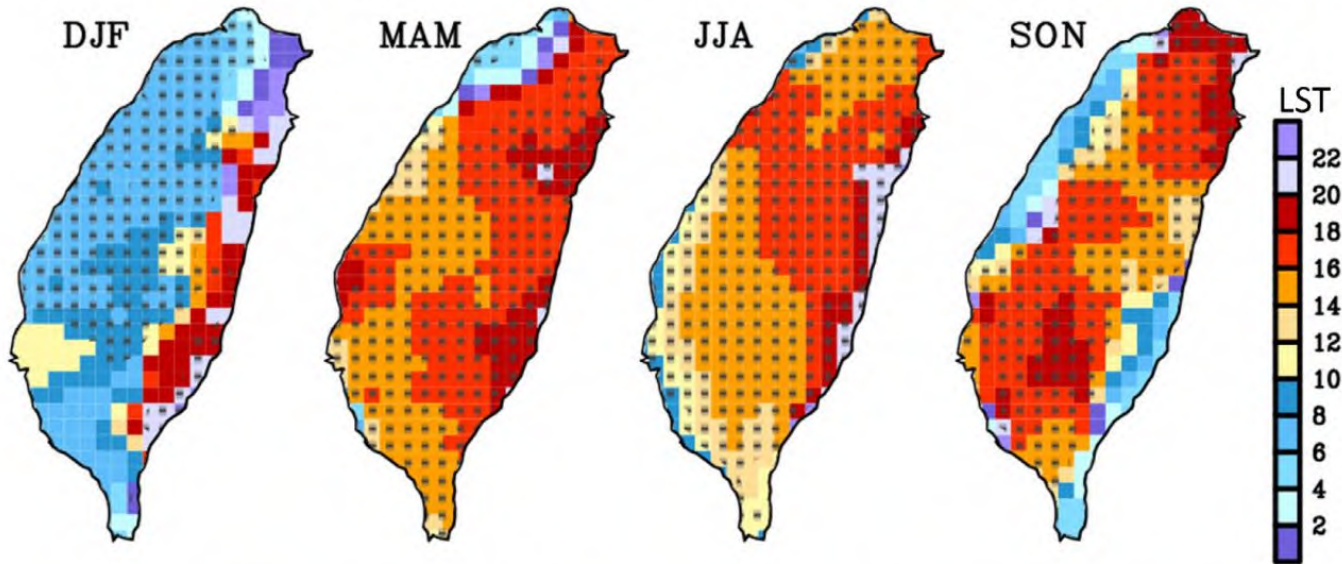


降水的日週期(S1) 和半日週期 (S2) 比對

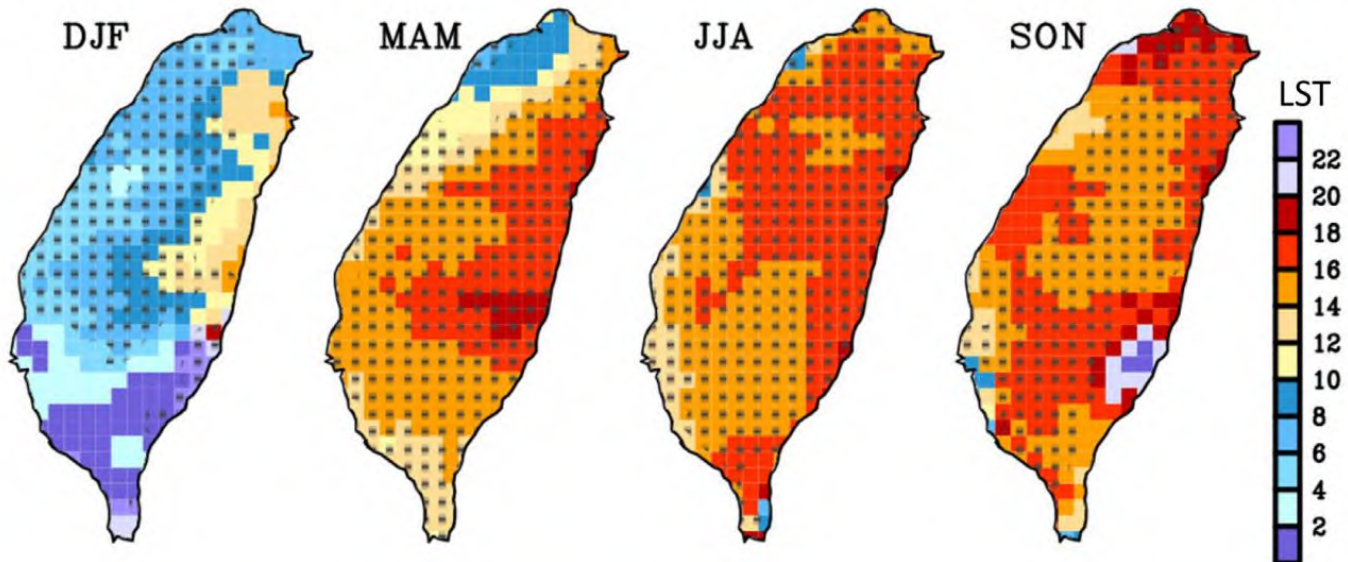


降水的日週期(S1) 最大值時間比對

(a) Timing of the appearance of maximum value of S1 of precipitation; CWB

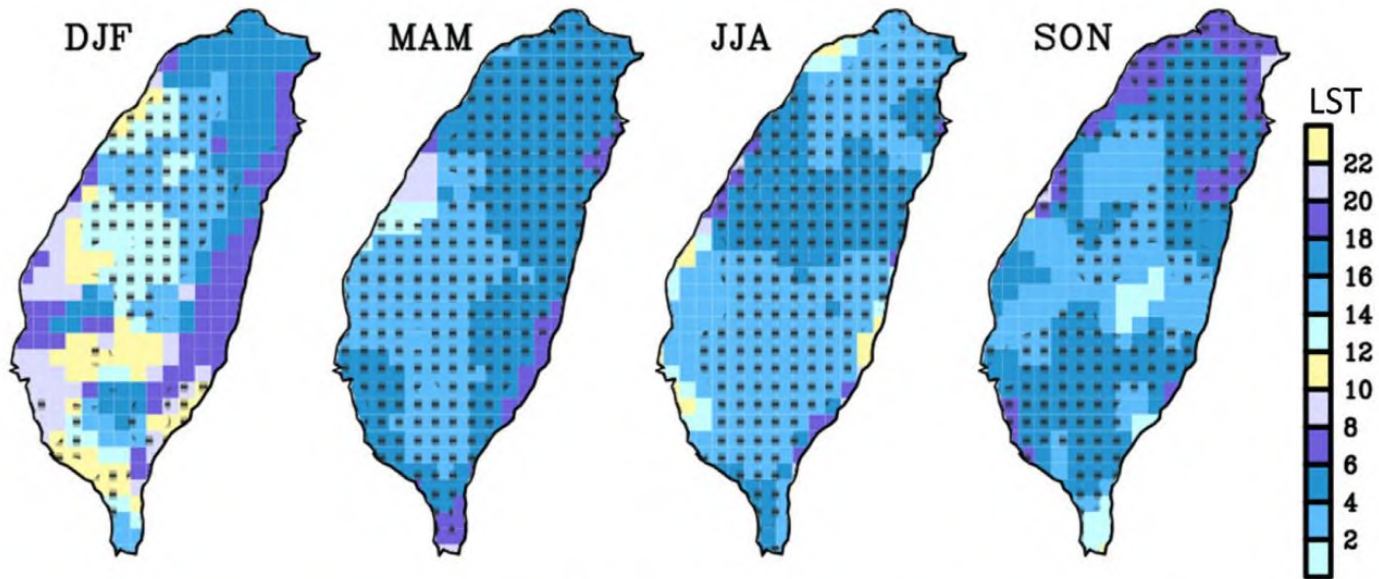


(b) Timing of the appearance of maximum value of S1 of precipitation; IMERG

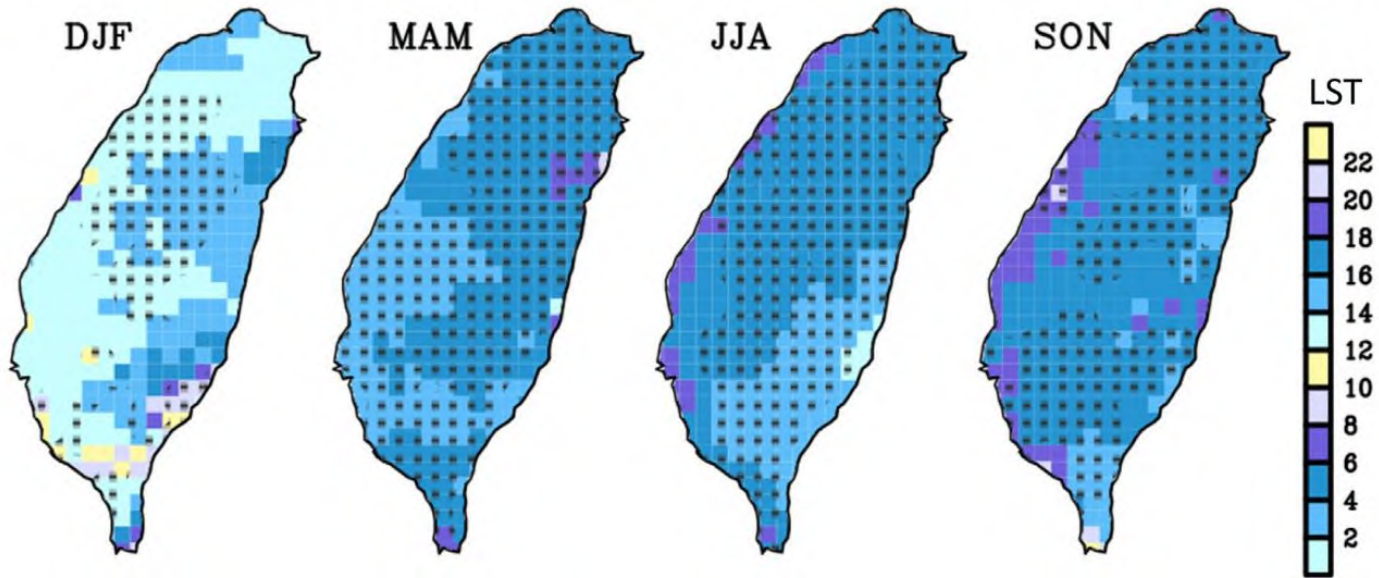


降水的半日週期(S2) 最大值時間比對

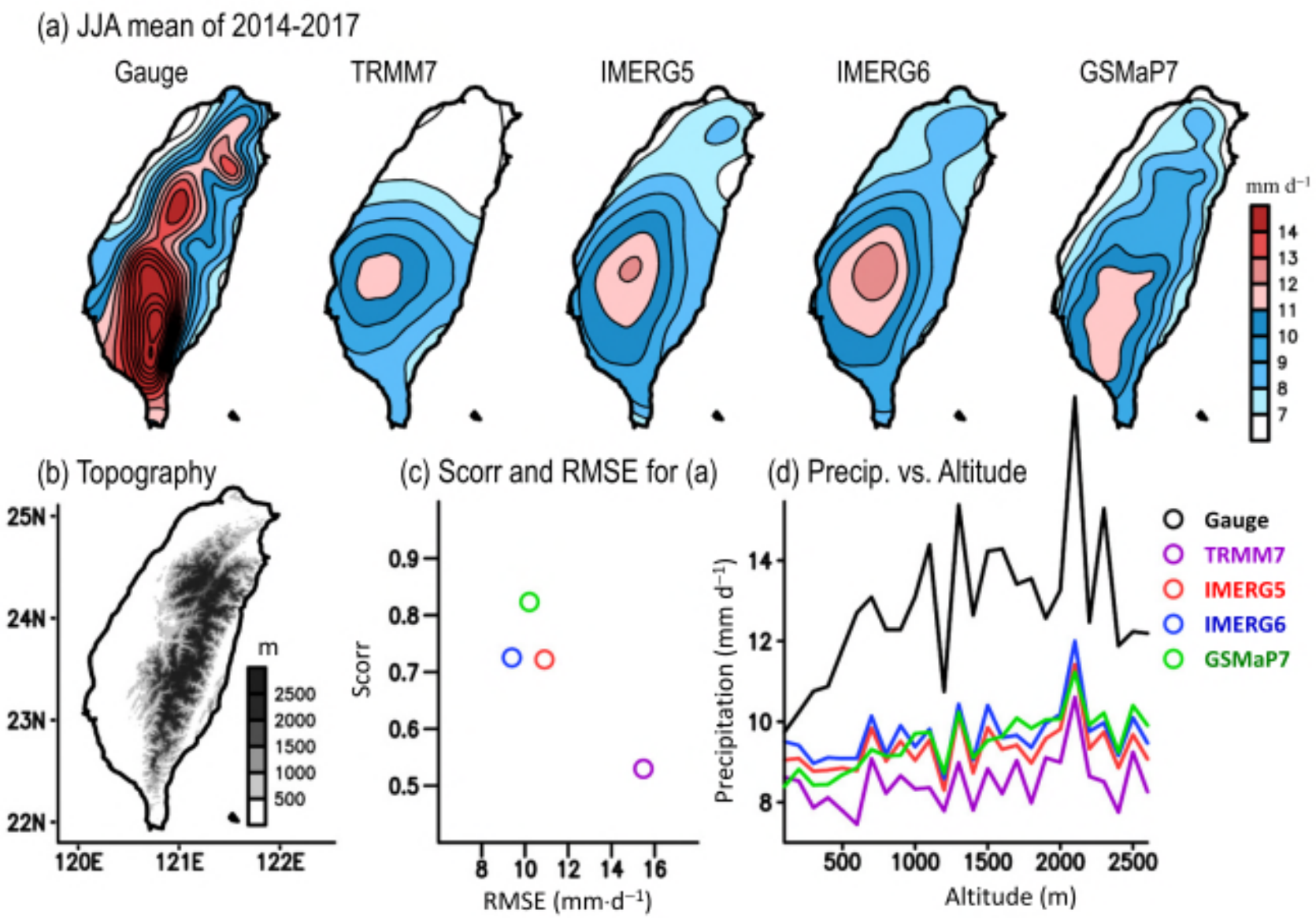
(a) Timing of the appearance of maximum value of S2 of precipitation; CWB



(b) Timing of the appearance of maximum value of S2 of precipitation; IMERG



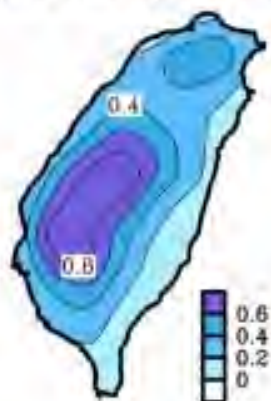
Huang, W.-R.*, P.-Y. Liu, Y. H. Chang and C.-Y. Liu, 2019: Comparison of the Boreal Summer Precipitation Estimations from TRMM-3B42 v7, IMERG-Final v5, IMERG-Final v6, and GSMaP-Gauge v7 over Taiwan. (under review)



(a) E1; ΔP (Gauge)



(b) E1; ΔP (TRMM7)



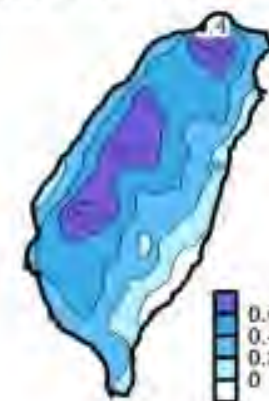
(c) E1; ΔP (IMERG5)



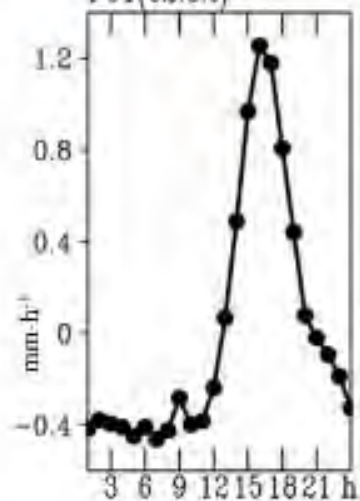
(d) E1; ΔP (IMERG6)



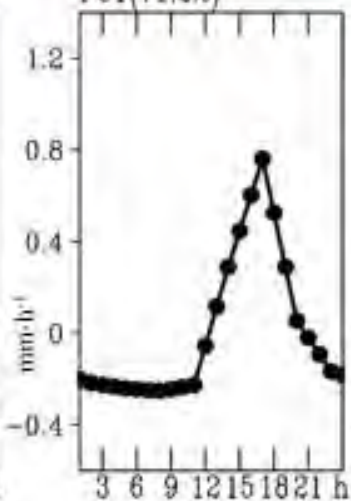
(e) E1; ΔP (GSMaP7)



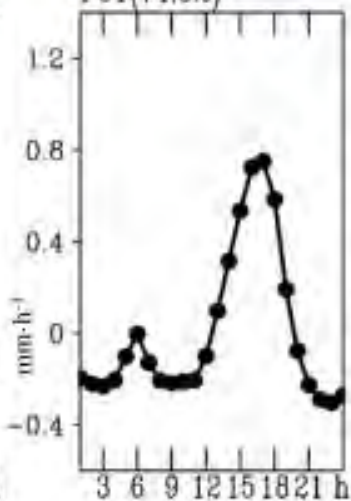
PC1(62.6%)



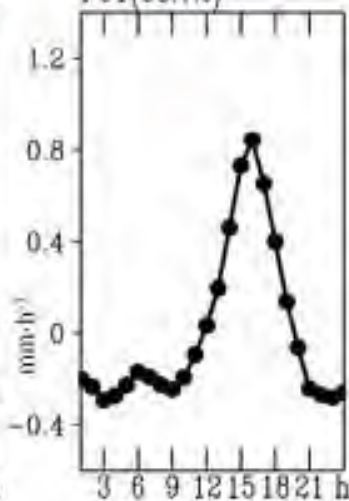
PC1(71.2%)



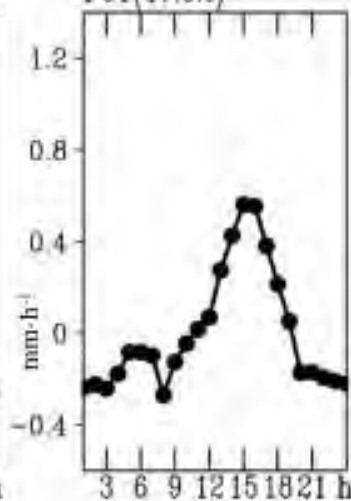
PC1(74.5%)



PC1(63.7%)



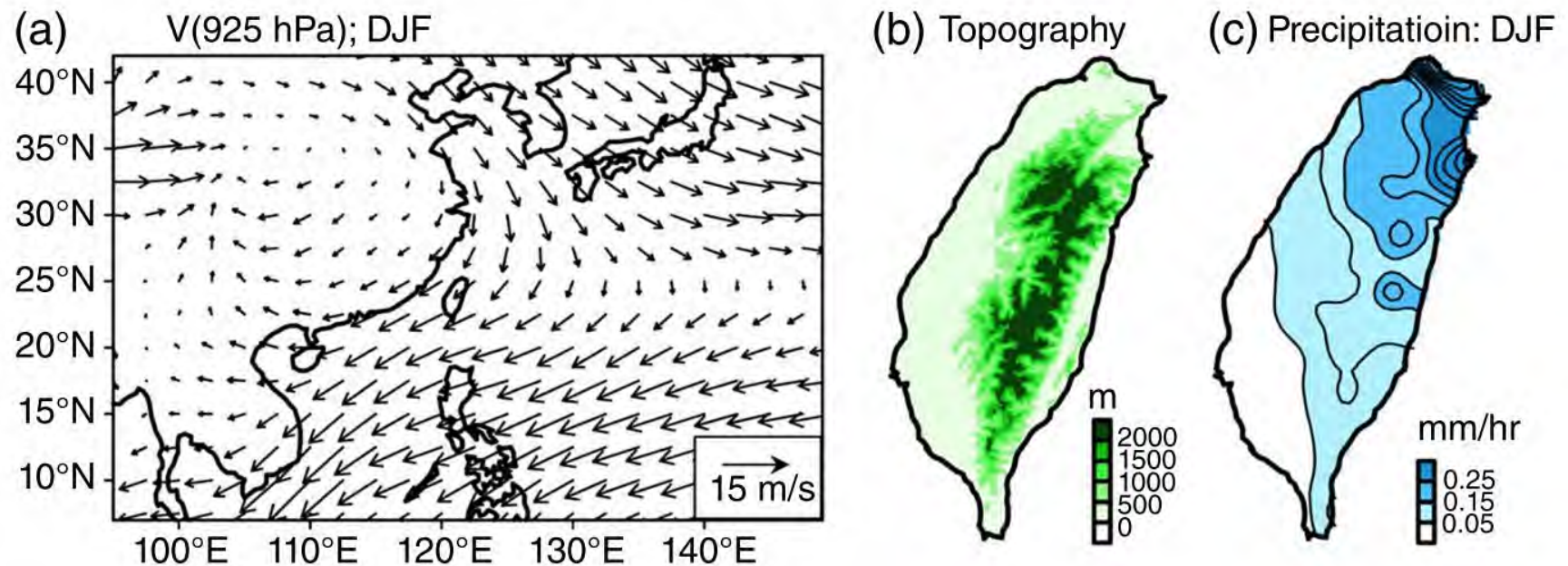
PC1(47.0%)



3.台灣冬季的日夜降水變化機制(非衛星降水)

Characteristics and mechanisms of the diurnal variation of winter precipitation in Taiwan

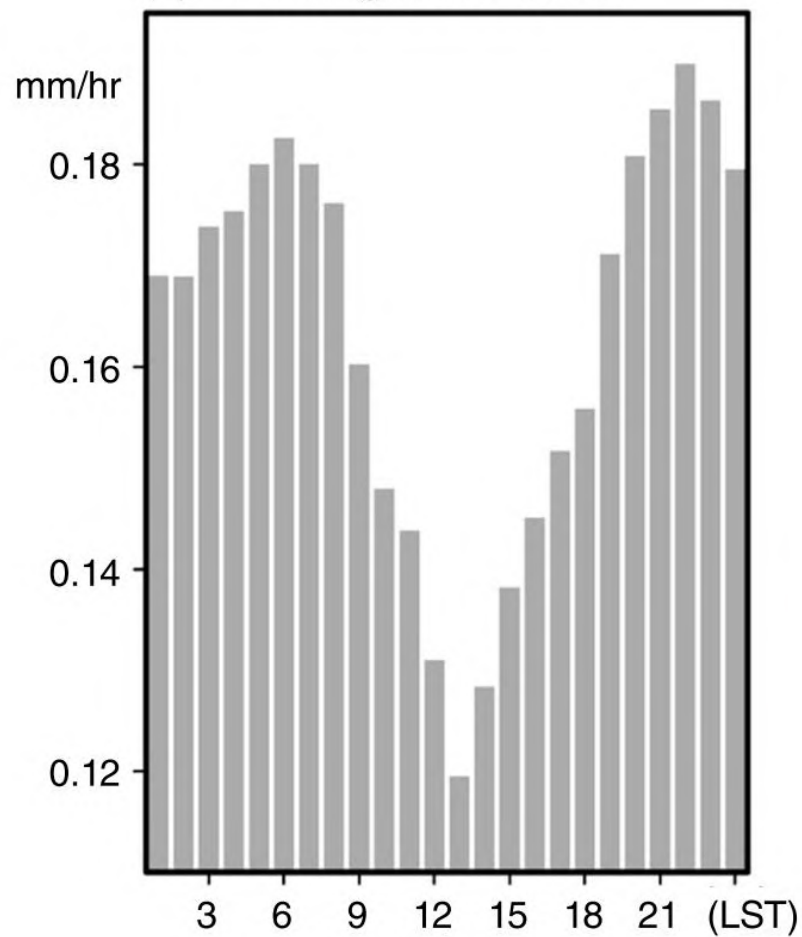
Wan-Ru Huang  | Ya-Hui Chang (International Journal of Climatology 2018)



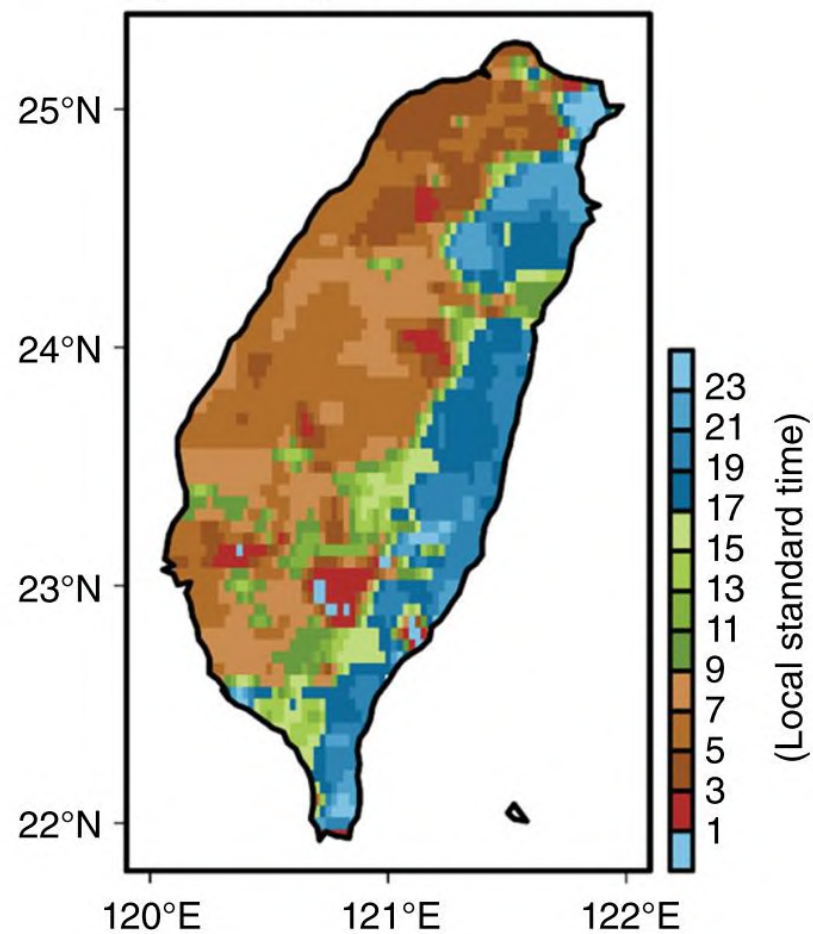
Studying Periods: 2001~2015 DJF

Precipitation data: gridded data from more than 400 CWB-gauges

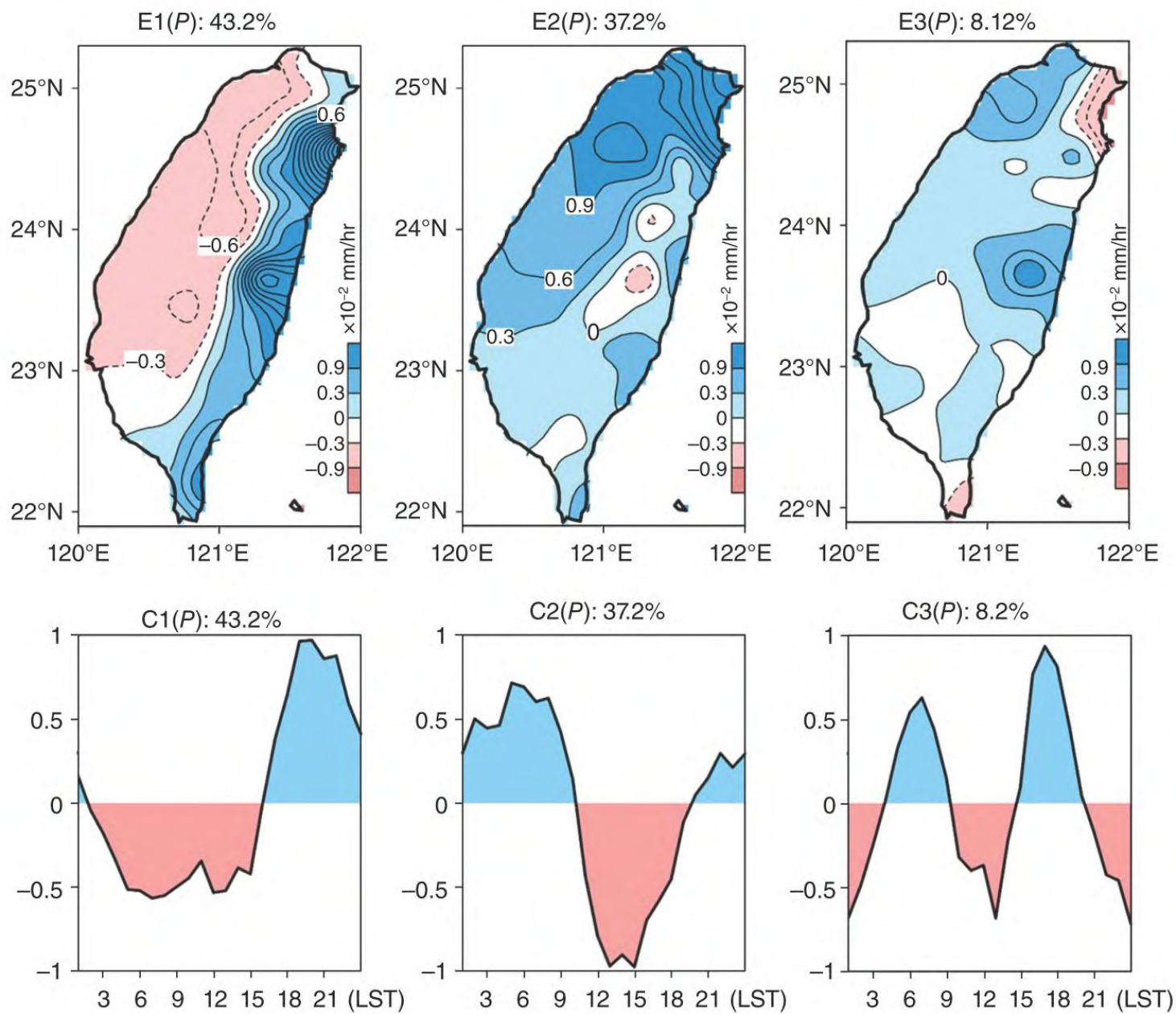
(a) P averaged over Taiwan



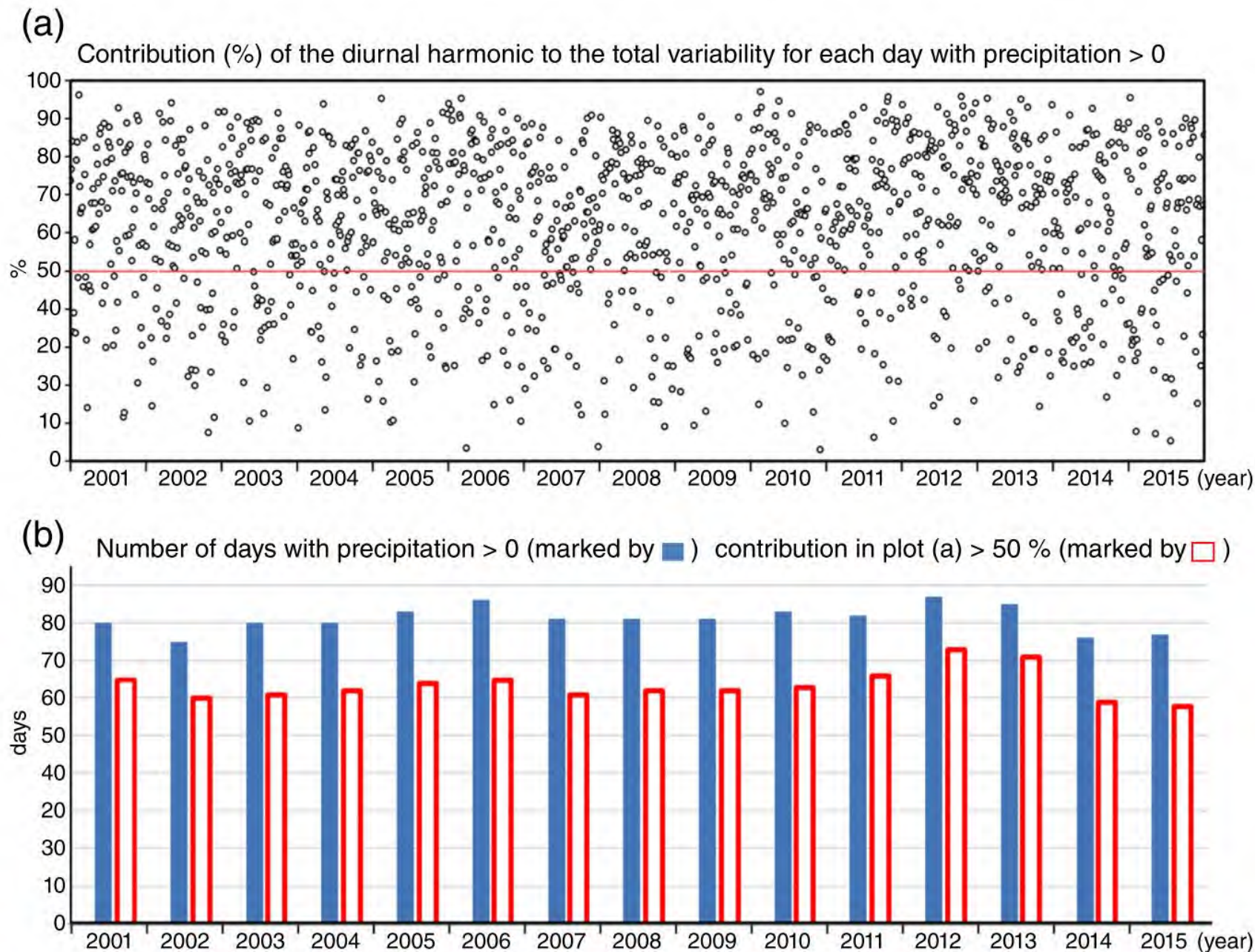
(b) Timing of Maximum P



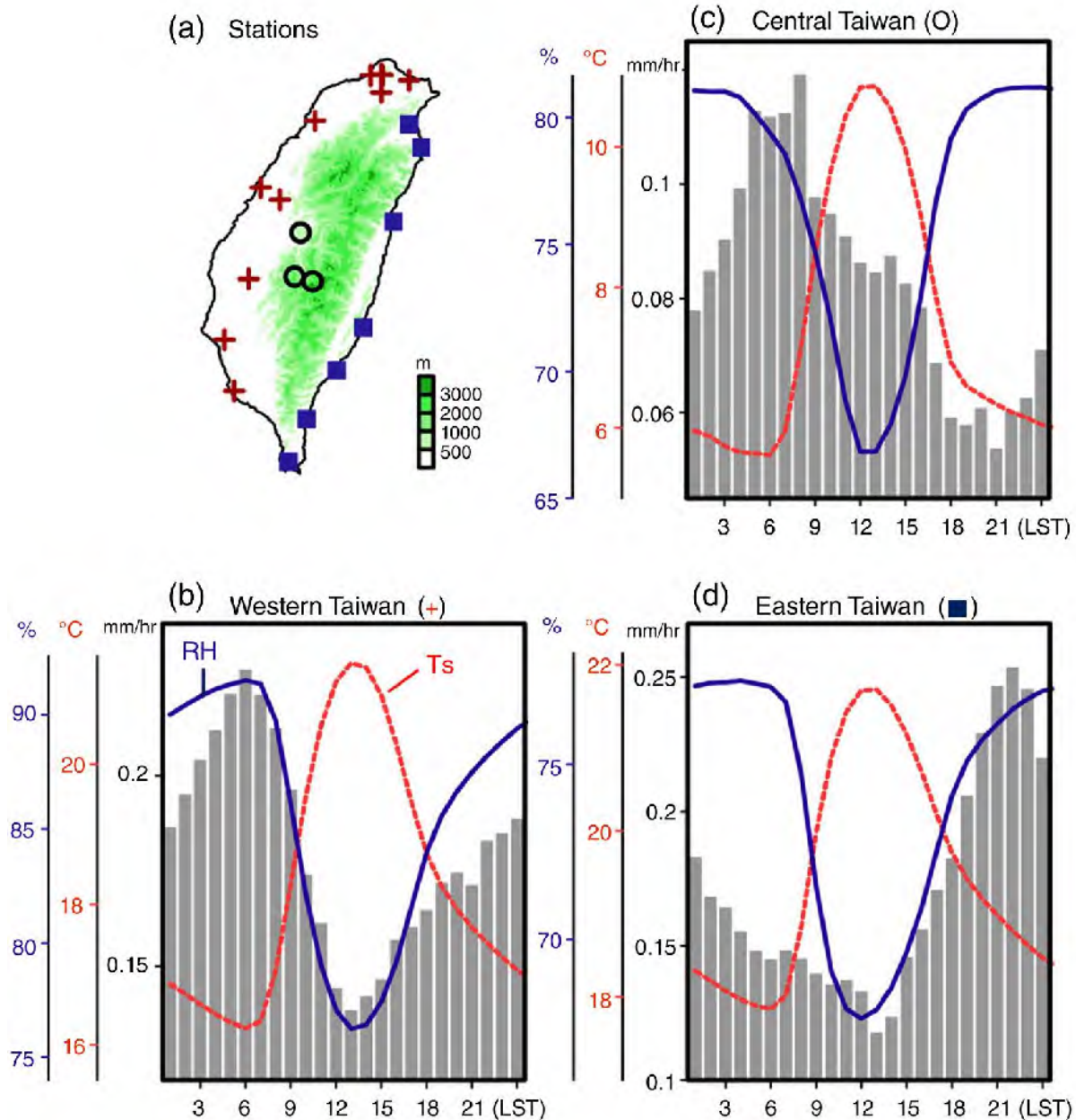
EOF 分析



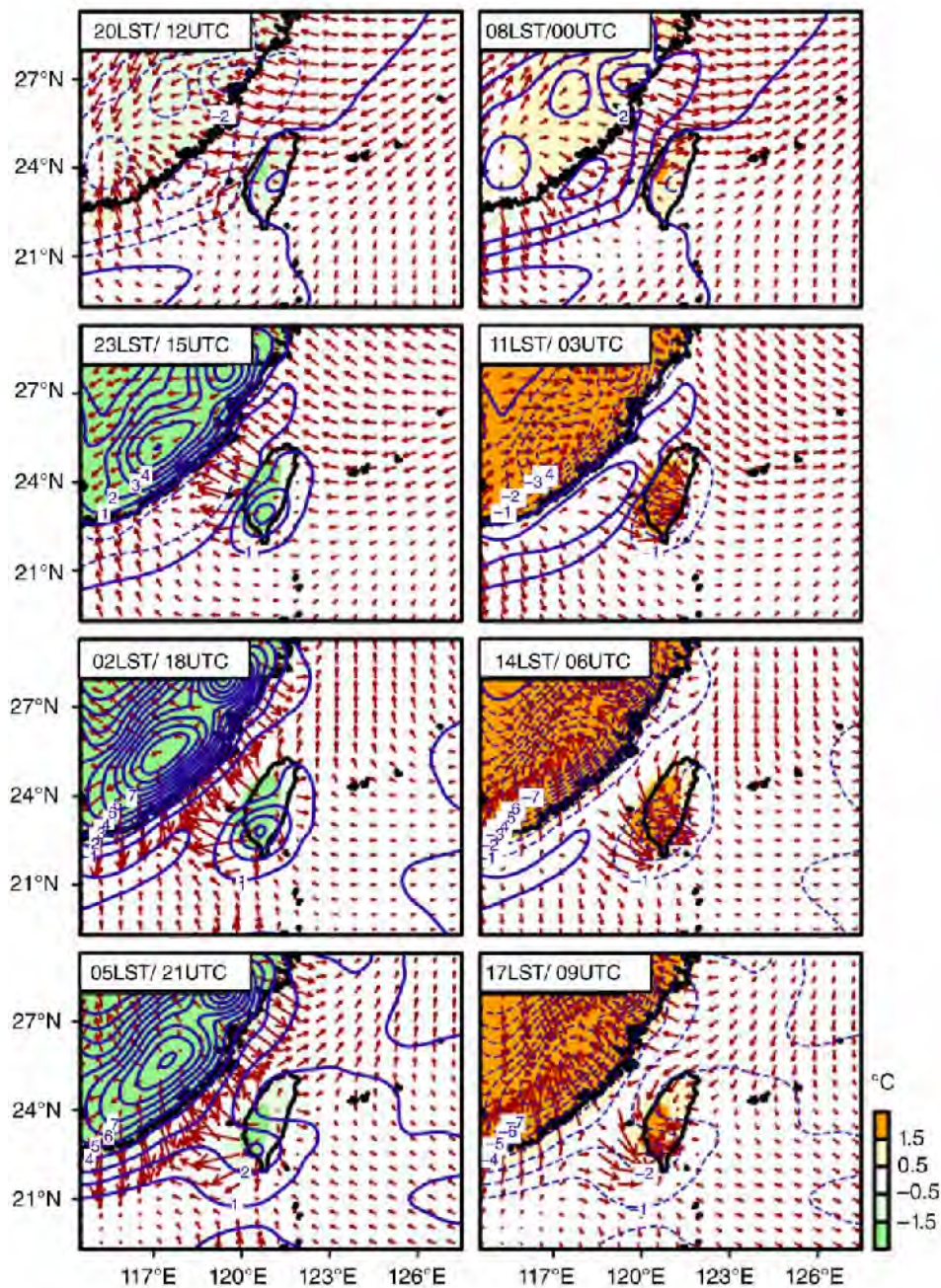
Diurnal 降水主宰的天數與貢獻



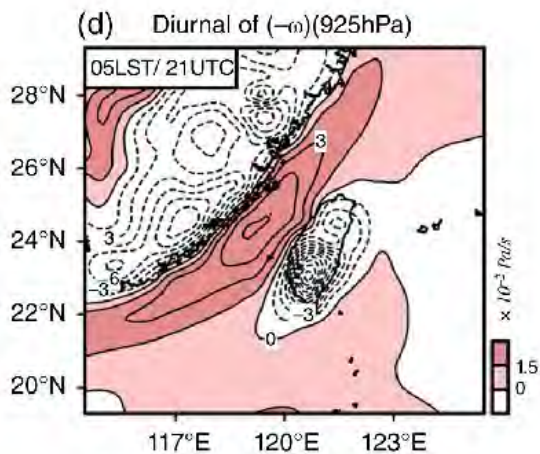
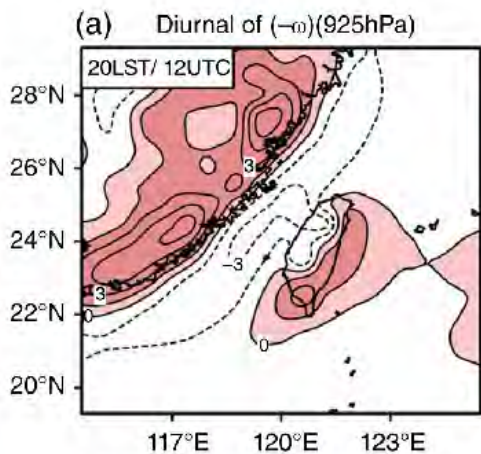
降水、溫度、濕度的日夜變化比對



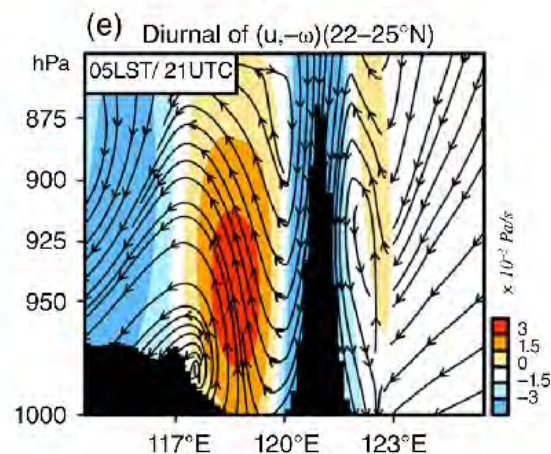
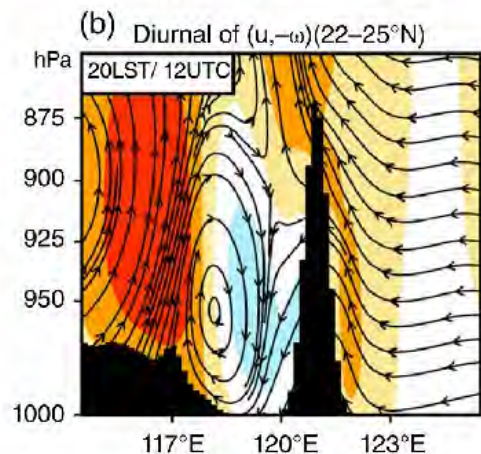
925hPa 溫度 (shaded)、風場(vectors)、相對濕度 (contours)



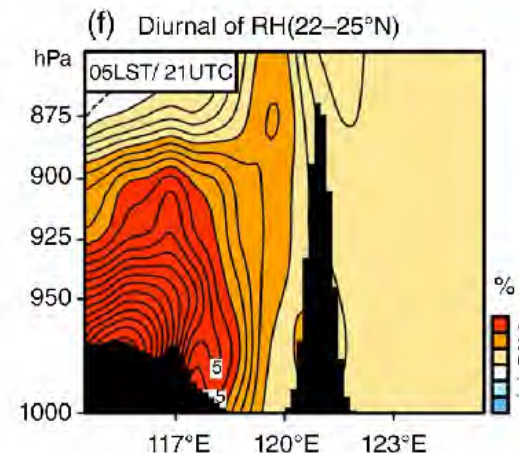
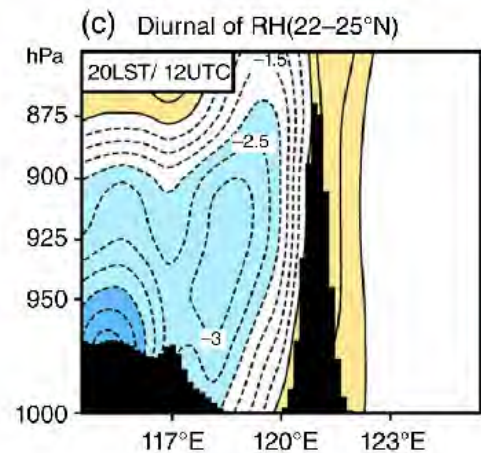
垂直速度



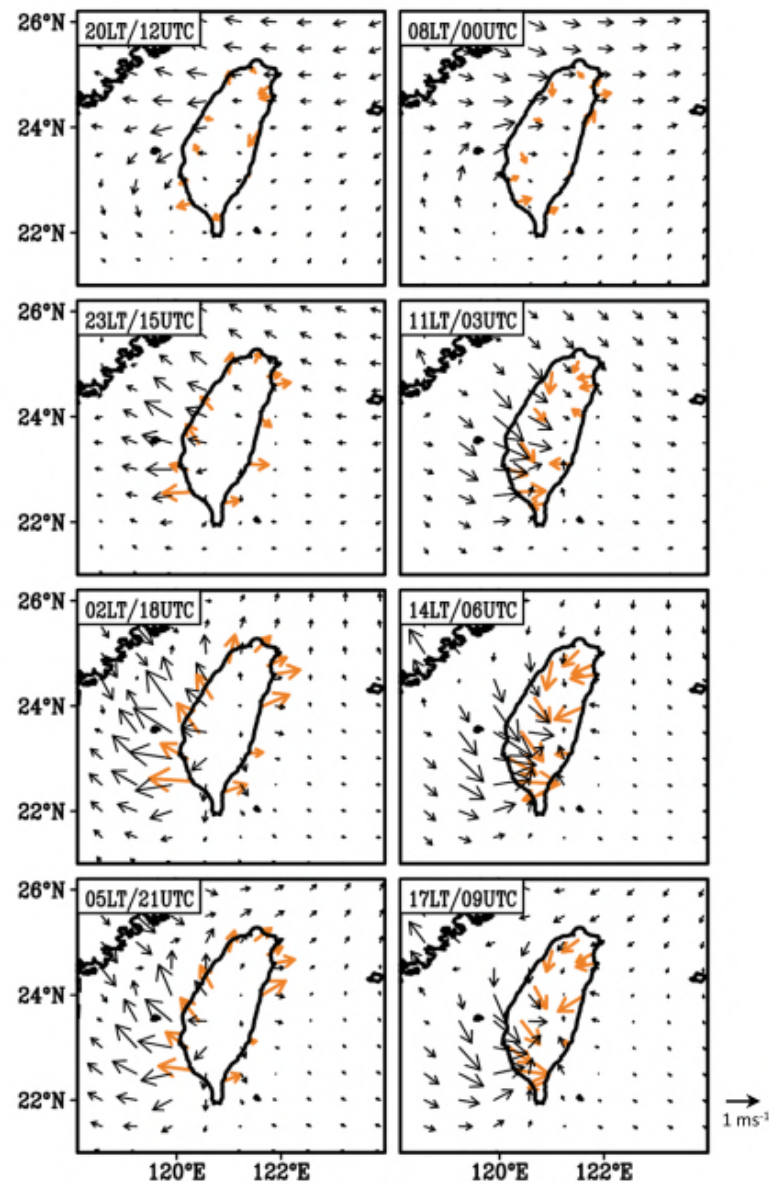
東西向環流



相對濕度



MERRA vs. in-situ observation wind vector



The spatio-temporal evolution of the diurnal harmonic component of the surface wind extracted from the MERRA reanalysis (vectors in black color) and the in-situ observations (vectors in orange color) averaged over the winter seasons of the period of 2001-2015.

冬季和夏季降水類型比較

Seasonal variation of diurnal and semidiurnal rainfall over Southeast China

Wan-Ru Huang · Johnny C. L. Chan

Clim Dyn (2012) 39:1913–1927
DOI 10.1007/s00382-011-1236-5

(a) Variance of 3hourly P for 1998–2009

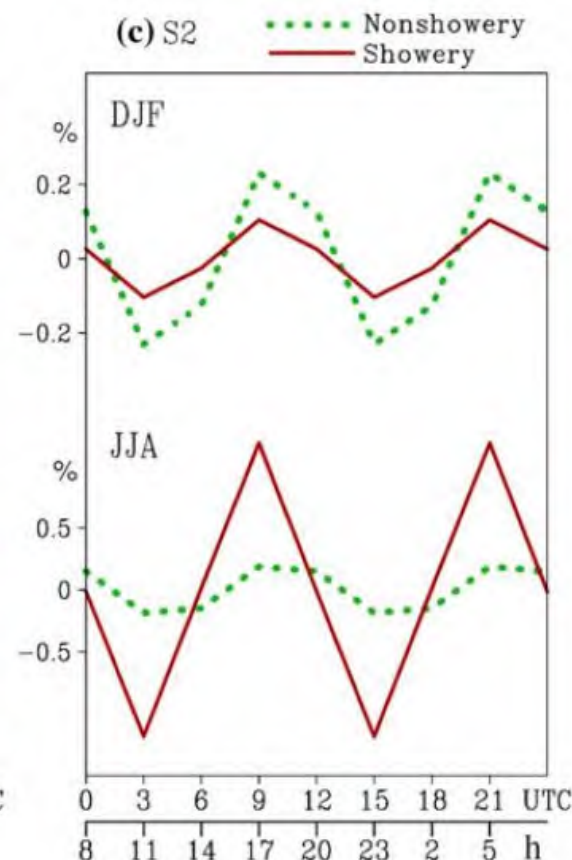
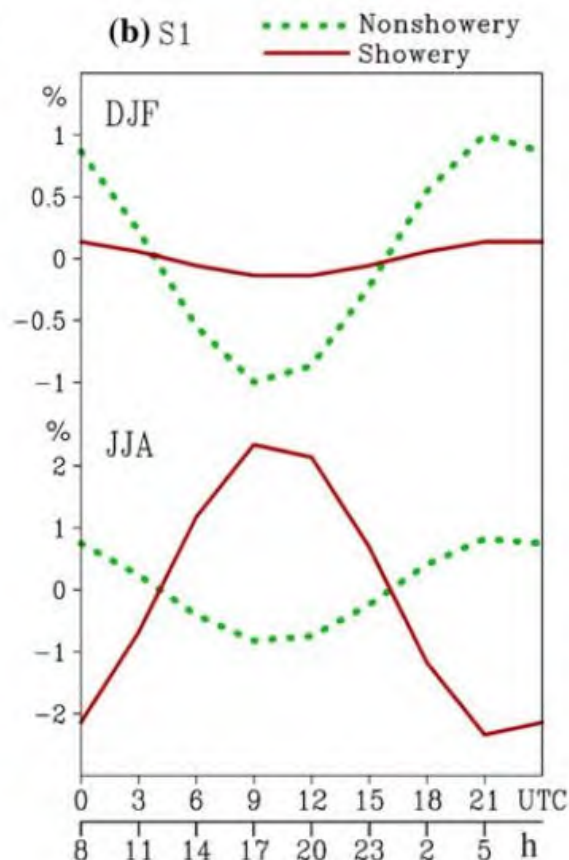
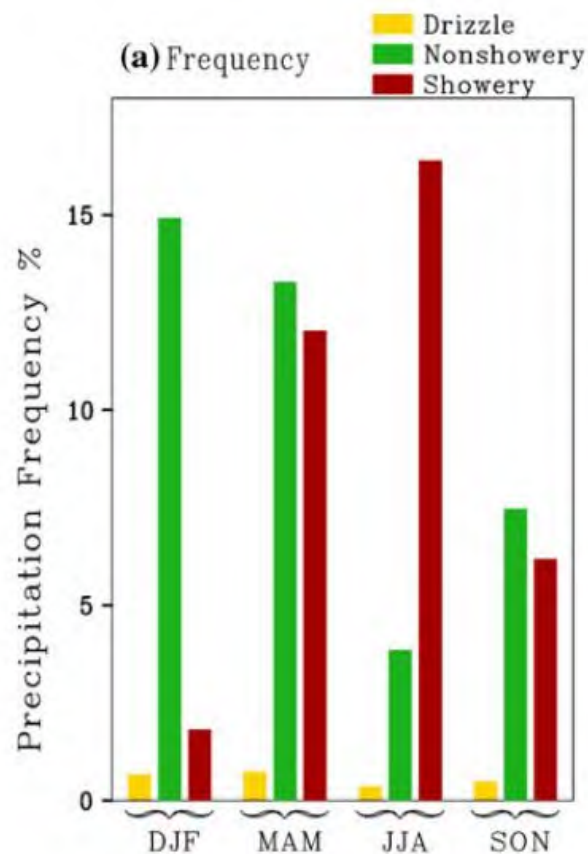
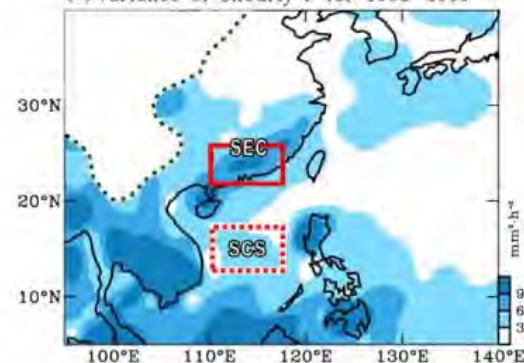


Fig. 3 **a** Seasonal mean frequency of occurrence for drizzle (yellow bar), non-showery (green bar) and showery (red bar) type of precipitation area-averaged over SEC. **b** Diurnal harmonic of DJF and

JJA mean frequency of occurrence for showery (red solid line) and non-showery (green dotted line) type of precipitation. **c** is similar to **b** but for the semidiurnal harmonic component

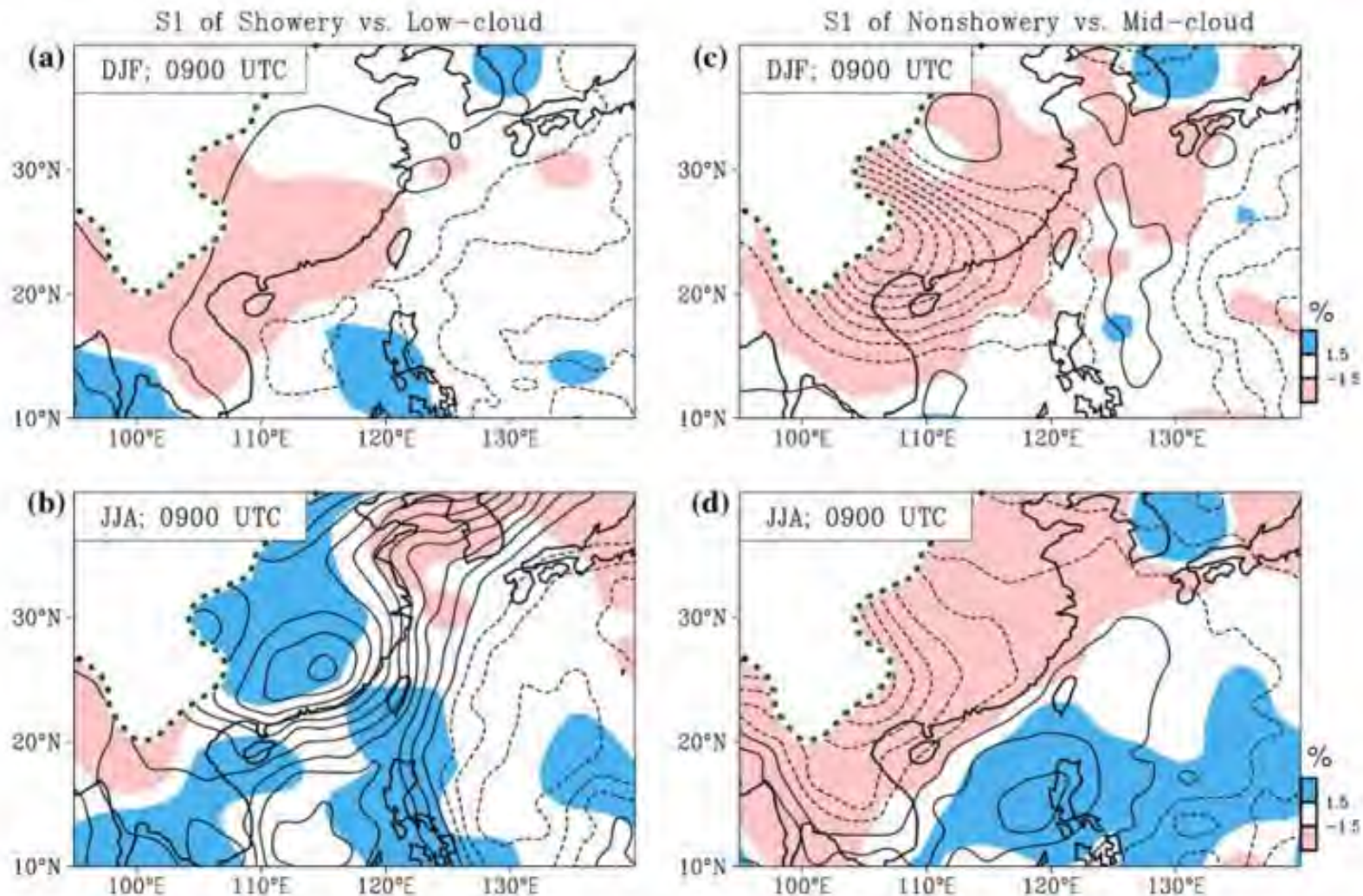
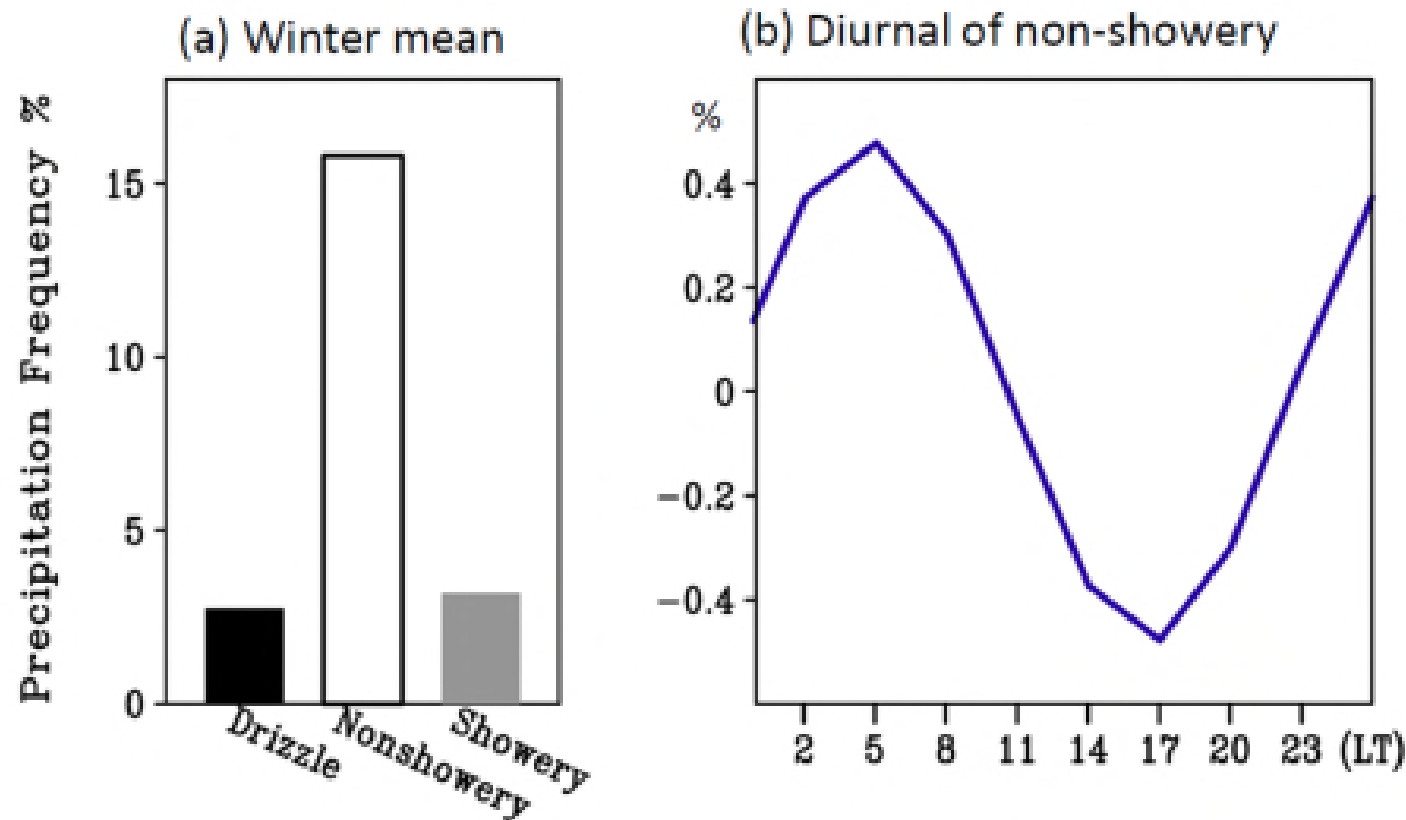


Fig. 4 Diurnal harmonic of **a** DJF and **b** JJA mean frequency of occurrence for showery precipitation (contours) superimposed with the low cloud amount (i.e. C_L ; shadings) at 0900 UTC (i.e. 1700 h for SEC). **c** and **d** is similar to **a** and **b** but for the non-showery

precipitation superimposed with the middle level cloud amount (i.e. C_M). The contour interval of **a–d** is 0.2%. The mountain areas in **a–d** are blocked



Huang et al. (2018)
for Taiwan, DJF

Following Fig. 3 of Huang and Chan (2012) but for the climatological mean and winter mean of various variables, area-averaged over Taiwan (120° - 122° E, 21.5° - 25.5° N). (a) The climatological winter mean for drizzle (black bar), non-showery (white bar) and showery (gray bar) types of precipitation frequency (%), area-averaged over Taiwan. (b) The temporal evolution of the diurnal harmonic component of 3-hourly, non-showery precipitation during the winter, averaged over Taiwan. For details on the method and data used in constructing this figure, please refer to Huang and Chan (2012).

總結

1. 衛星降水的應用有助於了解台灣暖季降水日夜變化的機制
2. 衛星降水對台灣暖季降水，能掌握大部分的特色，但是量值的部分都有低估的現象
3. 有關台灣冬季的降水日夜變化特色，目前衛星降水仍有較大的誤差存在
4. 討論台灣的日夜變化降水特色，需考慮大尺度及區域尺度的海陸風交互作用

Thank You!

Diurnal harmonic component of Ts (shaded) and SLP (contoured)

