Rainfall Variability in Taiwan modulated by Tropical Cyclone and Monsoon

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Large-Scale Climatology (July-September)

Major TC season in Taiwan



Rainfall Separation

TC rainfall (P_{TC}):

The parts of rainfall induced by TC's surrounding flows when a TC has its center in a region close to Taiwan within 2.5 degrees of longitude and latitude (117.50-124.50E, 19.50-27.50N).

Seasonal monsoon rainfall (*P*_{SM}):
Other than TC rainfall, the rest parts of July-September rainfall are considered to result from seasonal monsoon climate background.

Puzzles in Rainfall Analysis

- Why does anomalous wet year correspond to anomalous low in one case, but to anomalous high in another case?
- Is excessive rainfall in Taiwan contributed by TC, monsoon, or both?
- Is it appropriate to directly predict total rainfall in the statistical climate prediction? Is there any alternative to do it?

Interannual Variability



Major rainfall variability types

year	Ptc	Рѕм	S850	Туре
1961	313	-118	С	
1977	467	-199	С	
1982	260	-262	С	
1984	208	-149	С	T+S-
1990	389	-127	С	
1994	397	-119	С	
2001	609	-134	С	
AVG	378	-158		
1950	-407	274	С	
1978	-265	115	С	
1972	-187	395	С	
1976	-202	123	С	T-S+
1999	-193	282	С	
2002	-193	145	С	
AVG	-241	222		
1957	-182	-119	AC	
1993	-256	-176	AC	T-S-
AVG	-219	-148		

0.7 SD:

 $P_{TC}(151mm)$

 $P_{SM}(114mm)$

Rainfall Composite



Low-Level Circulation Anomalies



Mechanisms Affecting P_{SM}



Mechanisms affecting P_{TC}

TC Frequency Anomalies



TC Formation

	120E- 150E	To the southeast of Taiwan
TYPE	EQ-21N	
T+S-	6.9	More TCs to form
T-S+	3.5	Less TCs to form
Climate mean	6.1	

TC formation Environments



TC formation Environments



Strong upward motion

Weak upward motion

TC Track: Steering Flows



Major variability types of total rainfall

year	Р	P _{TC}	P _{SM}	S850	tuno		
				anomaly	type		
	1960	212	240	-28	AC		
	1968	254	221	33	С		
	1990	262	389	-127	С		
	1977	268	467	-199	С		
	1994	278	397	-119	С		
	1956	386	384	2	AC	TL+	
	2001	475	609	-134	С		
	1988	206	-127	333	AC		
	1972	208	-187	395	С		
	1955	262	-106	368	AC		
	AVG	281	229	52			
	1993	-432	-256	-176	AC		
	1980	-352	-146	-206	AC		
	1957	-301	-182	-119	AC		
	1983	-390	-318	-72	AC		
	1967	-329	-256	-73	AC	TT	
	1964	-265	-273	8	AC	IL-	
	1954	-257	-245	-12	AC		
	1965	-297	-128	-169	AC		
	1998	-226	-129	-97	AC		
	AVG	-317	-215	-102			

1 SD (207mm)

Low-level Circulation Anomalies





Application in Climate Prediction:

- The current approach can take the advantage of more coherent circulation patterns sorted by rainfall subcomponents to make more skillful statistical climate prediction.
- The predicted subcomponents can be added together to make total rainfall predictions.
 - It is anticipated that this indirect prediction approach may be more skillful than the direct prediction of the total rainfall.

Interdecadal Variability



P_{TC} and TC frequency



TC frequency has an increasing trend

0.031/yr → 1.80 during 1950-2008

62% of mean 2.88





Second interdecadal rainfall mode in Taiwan 20% C1-P_{SM}: 0.18 C1-P_{TC}: 0.46



Large-scale heating

(a)SST



Tropical warming

(b)X850



Large-scale regulatory processes





Large-Scale Processes TC frequency anomaly

(a) \widetilde{TC}_{FO}



 Large-Scale Processes
To the south of an anomalous low → decreased vertical wind shear
Warm SSTA → upward motion
Increased TC formation → more P_{TC}

(b)VWS

(a)W500





Concluding remarks

P_{TC} and P_{SM} in Taiwan tend to vary reversely on interannual and interdecadal timescales.

An anomalous low to the east or across Taiwan to determine two different interannual rainfall variability types.

Interdecadal SST warming in the tropics results in reverse variability between P_{TC} and P_{SM} on the interdecadal timescale.

Thanks for your Attentions

Objectives:

To measure the relative contributions of TC and monsoon to total rainfall in Taiwan?

To classify major interannual rainfall variability types induced by TC and monsoon? To delineate their corresponding large-scale processes?

To compare rainfall analyses between approaches with the separation of the two rainfall subcomponents and with total rainfall?

Steering Flows(850-400 hPa): Climatology

