Subseasonal-to-seasonal extreme rainfall scenarios for the Caribbean Basin*

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General Research Questions

+ Can we represent rainfall regimes in the Caribbean through particular daily atmospheric circulation patterns (or "weather types", WTs)?

+ Are WTs more frequent during/after particular sea-surface temperature (SST) configurations? (predictability)

+ How well can dynamical models predict the observed characteristics of WTs? (predictability) [see (N. Vigaud and A. Roberton)'s poster on Friday]

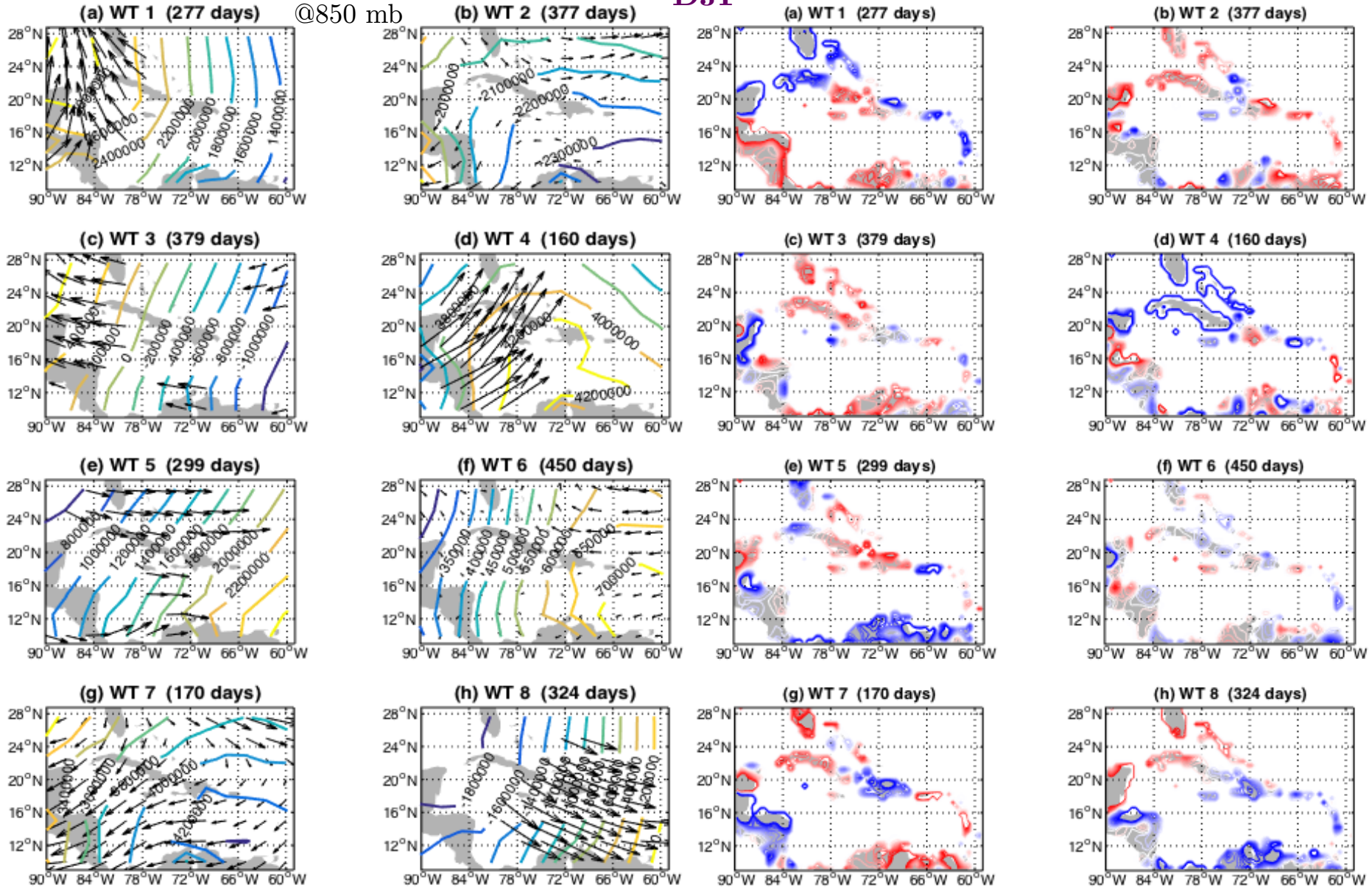
+ Can we associate sequences of WTs with particular extreme rainfall distributions (temporal and spatial)? Can we build forecast models for that?

+ What is the predictive skill of such models?

Velocity Potential and Moisture Fluxes @850 mb

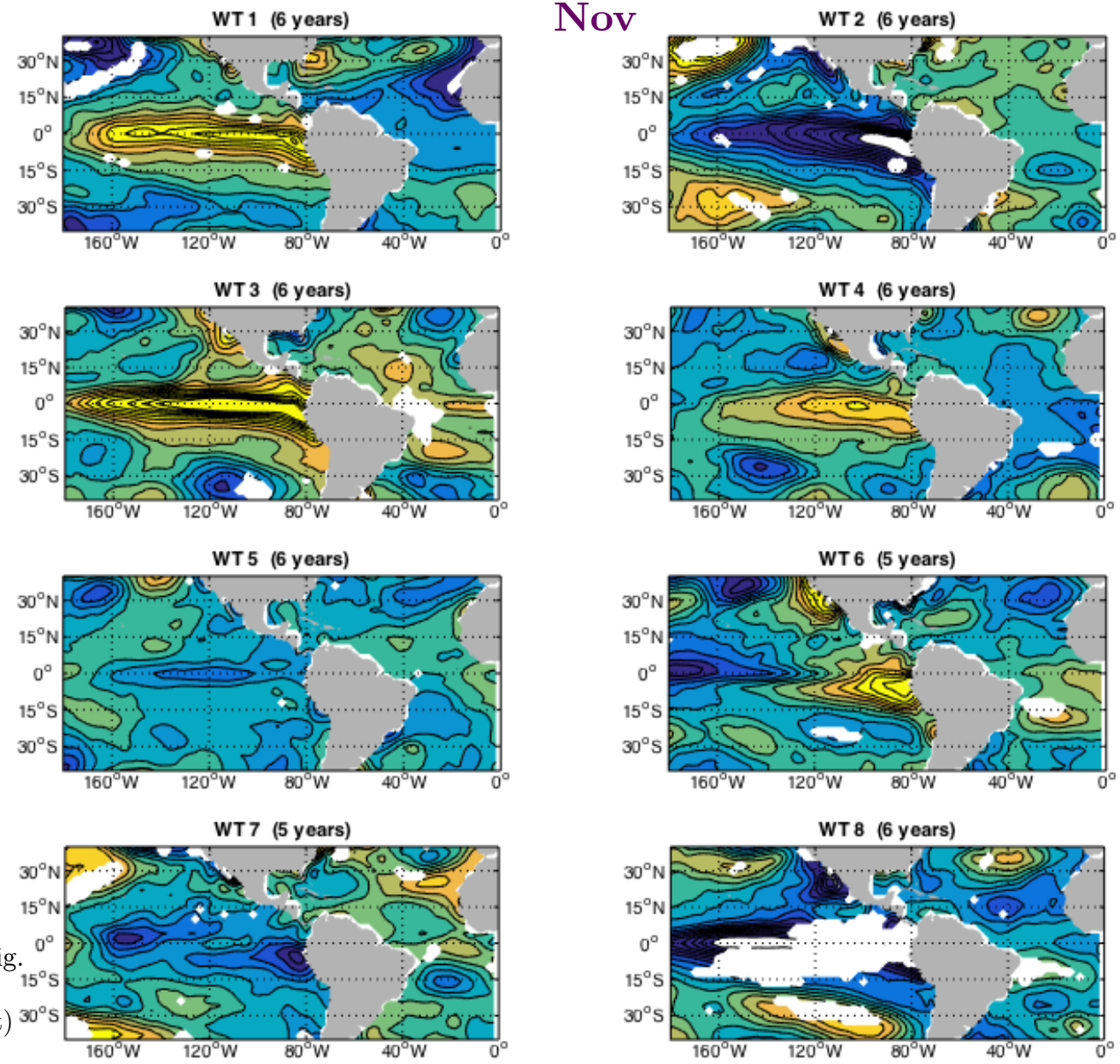
DJF

Rainfall Anomalies (blue is positive)



SSTa composite for years with WT frequency exceeding 80th percentile

Nov



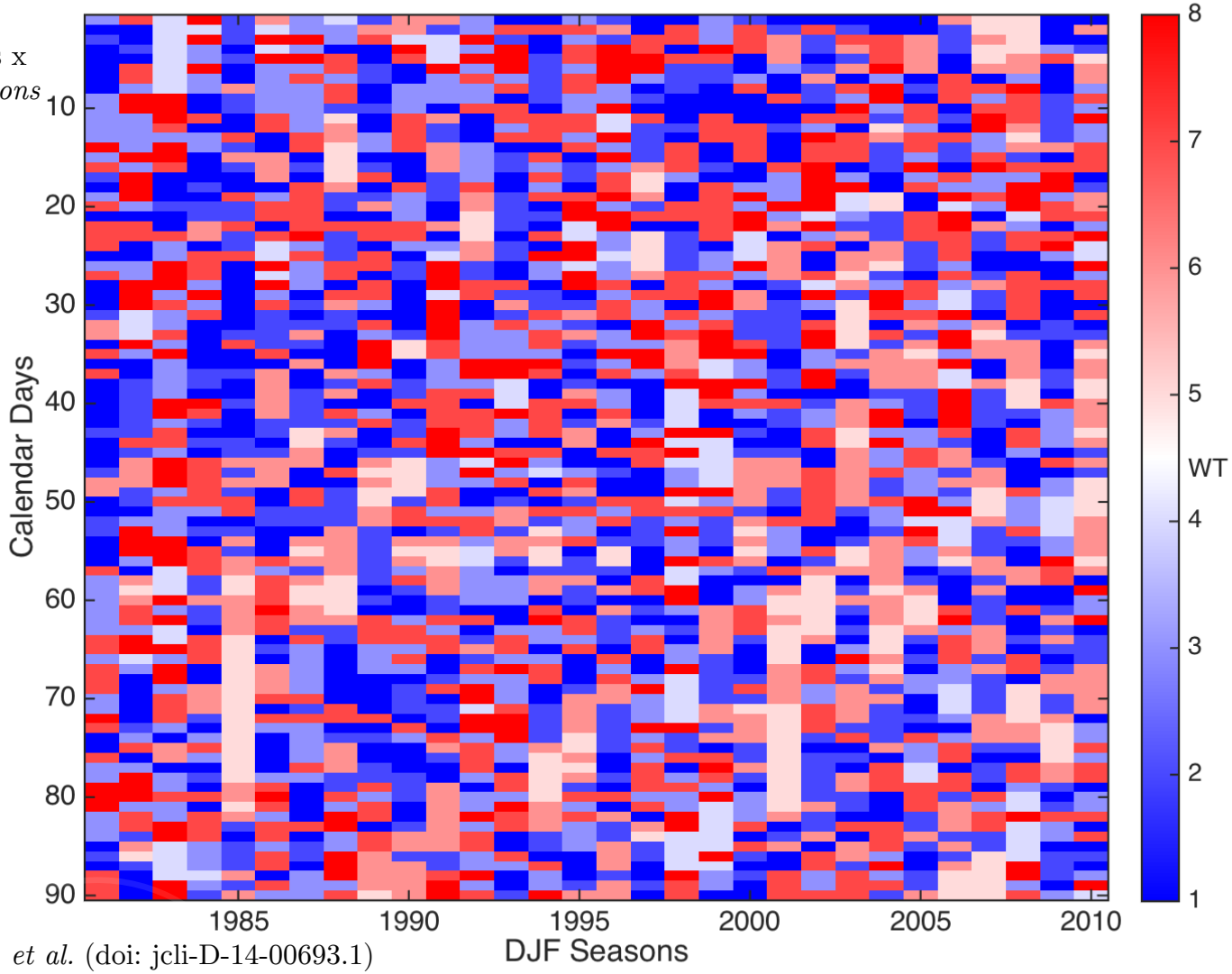
(White: not stat. sig. at p<0.05, using hipergeometric test)

Klee and his exploration of color sequences

Paul Klee (1879-1940)

Klee diagram

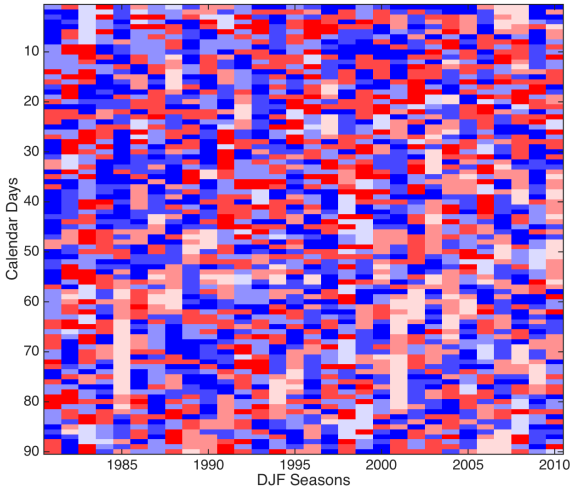
WTs:
90 days x
30 seasons



Paul Klee (1879-1940)

Muñoz, *et al.* (doi: jcli-D-14-00693.1)

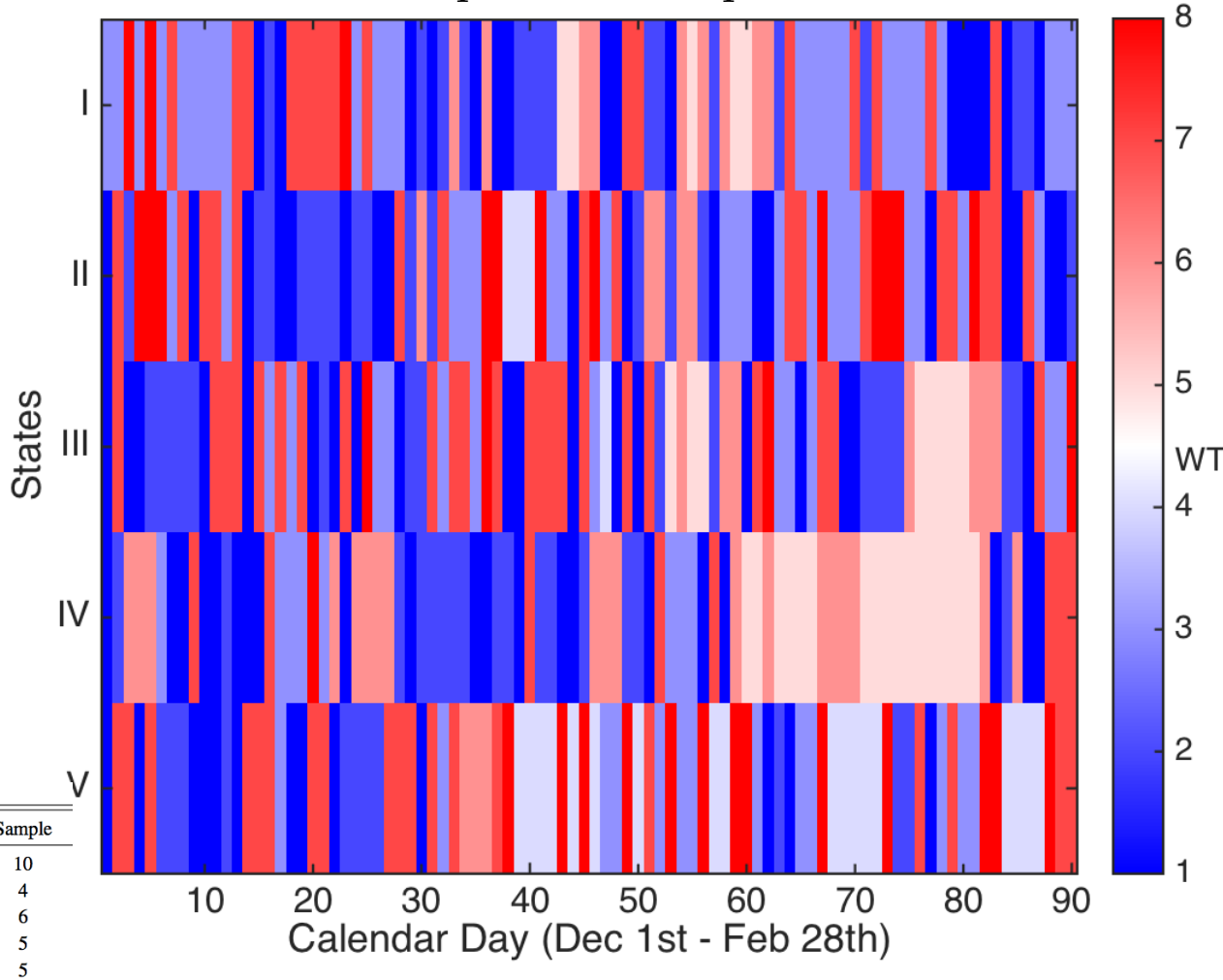
Subseasonal-to-seasonal (s2s) states



Categorical classification algorithm (Hamming distance), repeated multiple times

k-medoids

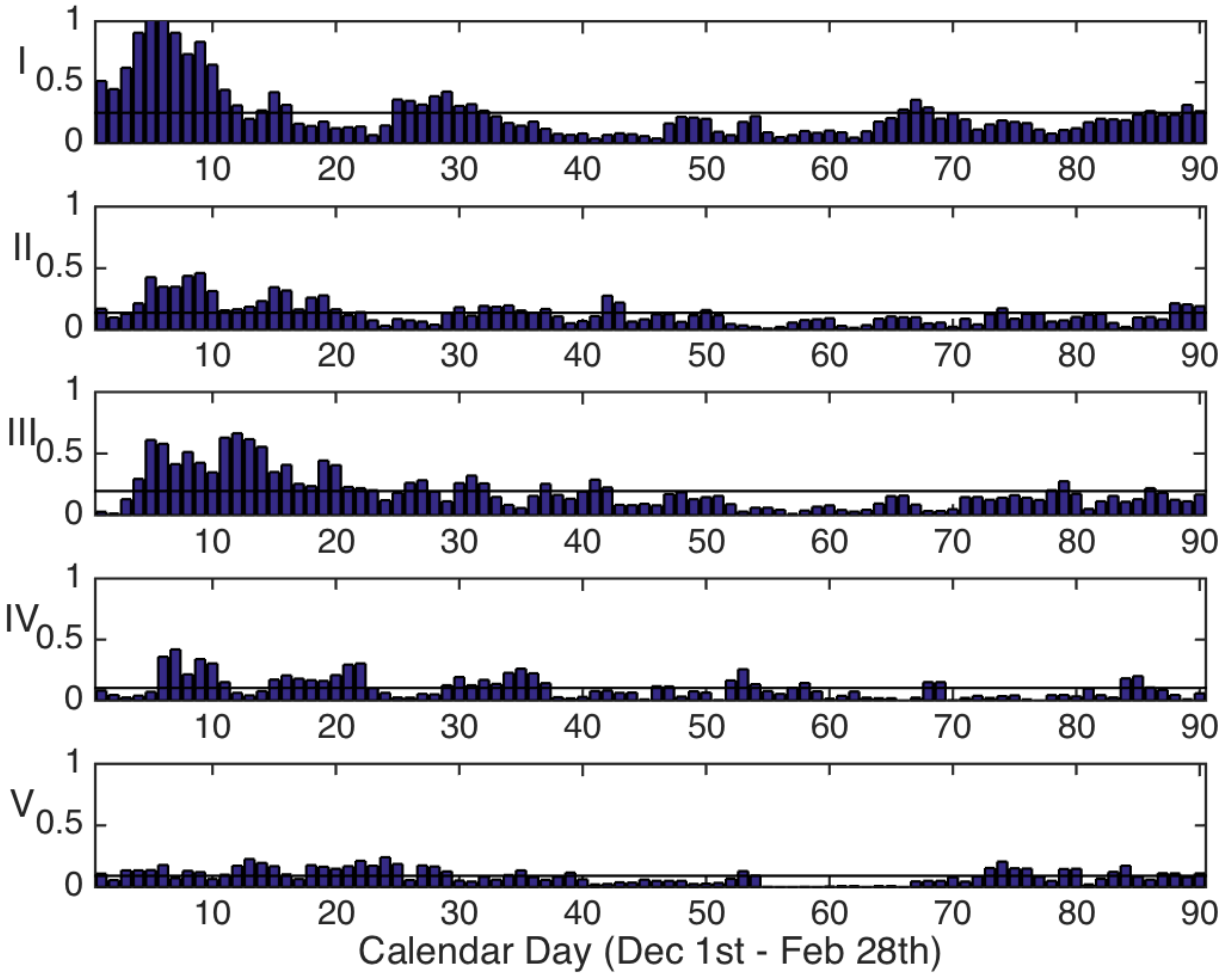
States = particular sequences of WTs



s2s state	Years	Sample
I	1981, 1982, 1984, 1986, 1987, 1988, 1990, 1995, 2004, 2010	10
II	1989, 1993, 1997, 2000	4
III	1991, 1994, 1996, 1999, 2002, 2006	6
IV	1985, 2001, 2003, 2007, 2009	5
V	1983, 1992, 1998, 2005, 2008	5

s2s extreme rainfall *scenarios*

Frequency of days exceeding the 95th percentile (per grid box)



22.5 days/season

12.4 days/season

17.6 days/season

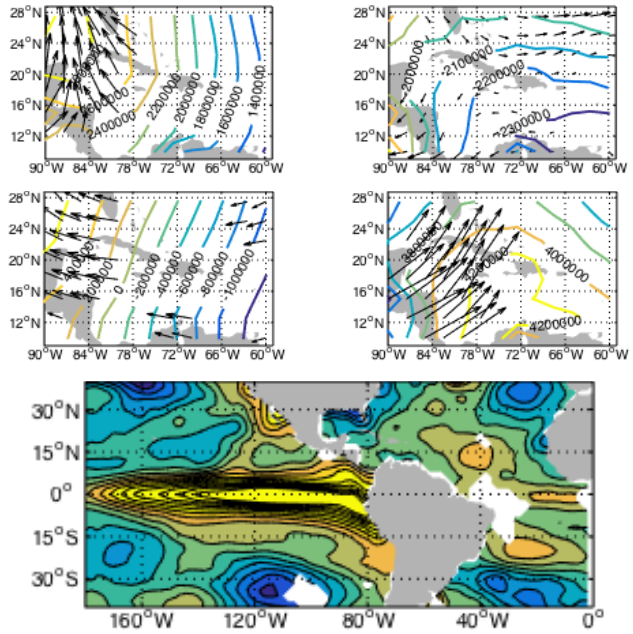
9.3 days/season

8.1 days/season

Interested in a particular week/ month?

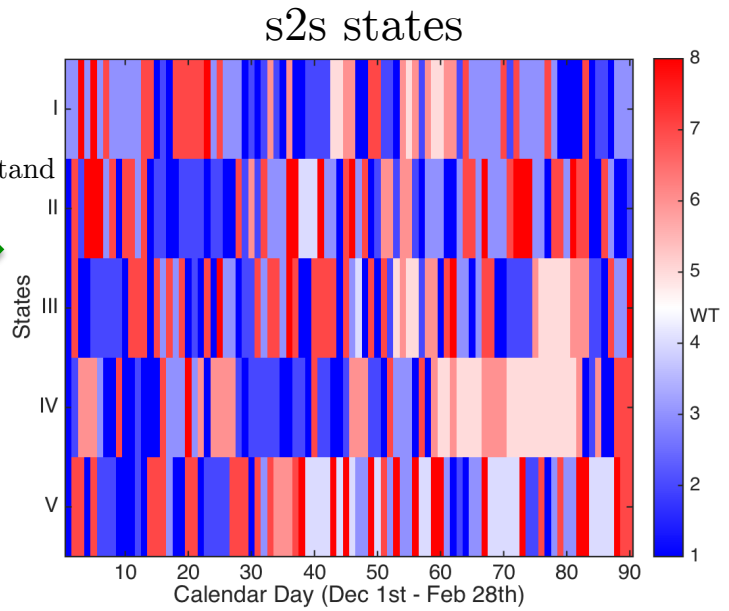
A Typical Forecast

WTs sequences/frequencies for next season (GCM), or observed SST+MJO phases



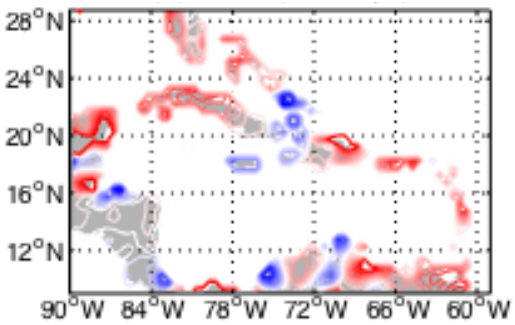
Predictor → Predictand

Multinomial logistic model



s2s state's probabilities

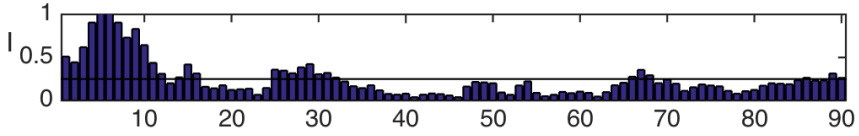
s2s extreme rainfall scenario



Spatial distribution

More extremes during first 10 days of the season

Example most likely scenario(s): I



Temporal distribution

Selection: 95th, 99th,...

Composite analysis

Muñoz, Goddard & Robertson, (in prep.)

Cross-validation (3-yr window)

TABLE 3. Cross-validated forecasted probabilities (in %) for each scenario, and observed category. Results are shown for the best-guess multinomial logistic model. Probabilities have been rounded to the closest integer.

Year	I	II	III	IV	V	Observed	Hit(1)/Miss(0)
1981	36	64	0	0	1	I	0
1982	68	17	1	7	7	I	1
1983	0	0	1	0	99	V	1
1984	43	48	3	0	7	I	0
1985	0	0	0	100	0	IV	1
1986	13	2	24	0	61	I	0
1987	95	4	0	0	1	I	1
1988	82	10	2	6	0	I	1
1989	49	49	1	0	1	II	1
1990	61	38	0	0	0	I	1
1991	27	0	21	0	52	III	0
1992	8	0	0	0	92	V	1
1993	65	14	1	0	20	II	0
1994	60	17	12	0	11	III	0
1995	72	5	8	0	15	I	1
1996	88	5	1	0	5	III	0
1997	54	44	1	0	1	II	0
1998	0	0	41	0	59	V	1
1999	1	0	42	0	56	III	0
2000	81	12	3	0	4	II	0
2001	0	0	0	100	0	IV	1
2002	10	2	30	0	57	III	0
2003	82	2	3	13	0	IV	0
2004	93	1	3	0	3	I	1
2005	81	6	4	0	9	V	0
2006	1	0	43	0	56	III	0
2007	0	0	0	100	0	IV	1
2008	5	0	58	0	37	V	0
2009	6	8	0	86	0	IV	1

Predictor: frequency of WTs
Predictand: s2s states

Skill metrics:
Kendall's $\tau = 0.371^{*}$
Hit score $= 48.27\%$
HSS $= 0.353$

* denotes statistically significant value at $p<0.05$

Muñoz, Goddard & Robertson, (in prep.)

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1990	61	38	0	0	0	I	1
1991	27	0	21	0	52	III	0
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TABLE 4. Contingecy table (in % of the total number of years) for the hindcasts reported in Table 3.

Forecasted / Observed	I	II	III	IV	V
I	20.69	10.34	6.90	3.45	3.45
II	6.90	3.45	0	0	0
III	0	0	0	0	3.45
IV	0	0	0	13.80	0
V	3.45	0	13.80	0	10.34

Muñoz, Goddard & Robertson, (in prep.)

Summary

+ Can we represent rainfall regimes in the Caribbean through particular daily atmospheric circulation patterns (or "weather types", WTs)?

Yes. Through particular WTs and sequences of WTs (better).

+ Are WTs more frequent during/after particular sea-surface temperature (SST) configurations? (predictability)

Yes. And a combination of SST and MJO

+ How well can dynamical models predict the observed characteristics of WTs? (predictability) [see N. Vigaud poster on Friday]

Well enough (some bias). Better than rainfall!

+ Can we associate sequences of WTs with particular extreme rainfall distributions (temporal and spatial)? Can we build forecast models for that?

Yes. Categorical models (multinomial logistic models).

+ What is the predictive skill of such models?

Not bad. HS: ~50% (climatological: 20%), HSS: 0.35, $\tau = 0.37$ (for rainfall: ~0.1-0.2!)

Model is better for state IV, good with I (but sometimes confused), bad for III.

Extra Slides

Multinomial Logistic Models

$$\pi_i = |\langle Y_i|X\rangle|^2 = P(Y_i|X)$$

$$\log \frac{\pi_i}{\tilde{\pi}} = \alpha_i + \beta_{ij} X_j$$

$$\pi_i = \frac{\exp(\alpha_i + \beta_{ij} X_j)}{1 + [\exp(\alpha_k + \beta_{kj} X_j)]_k}$$

$$\tilde{\pi} = \frac{1}{1 + [\exp(\alpha_k + \beta_{kj} X_j)]_k}$$

What about mean rainfall?