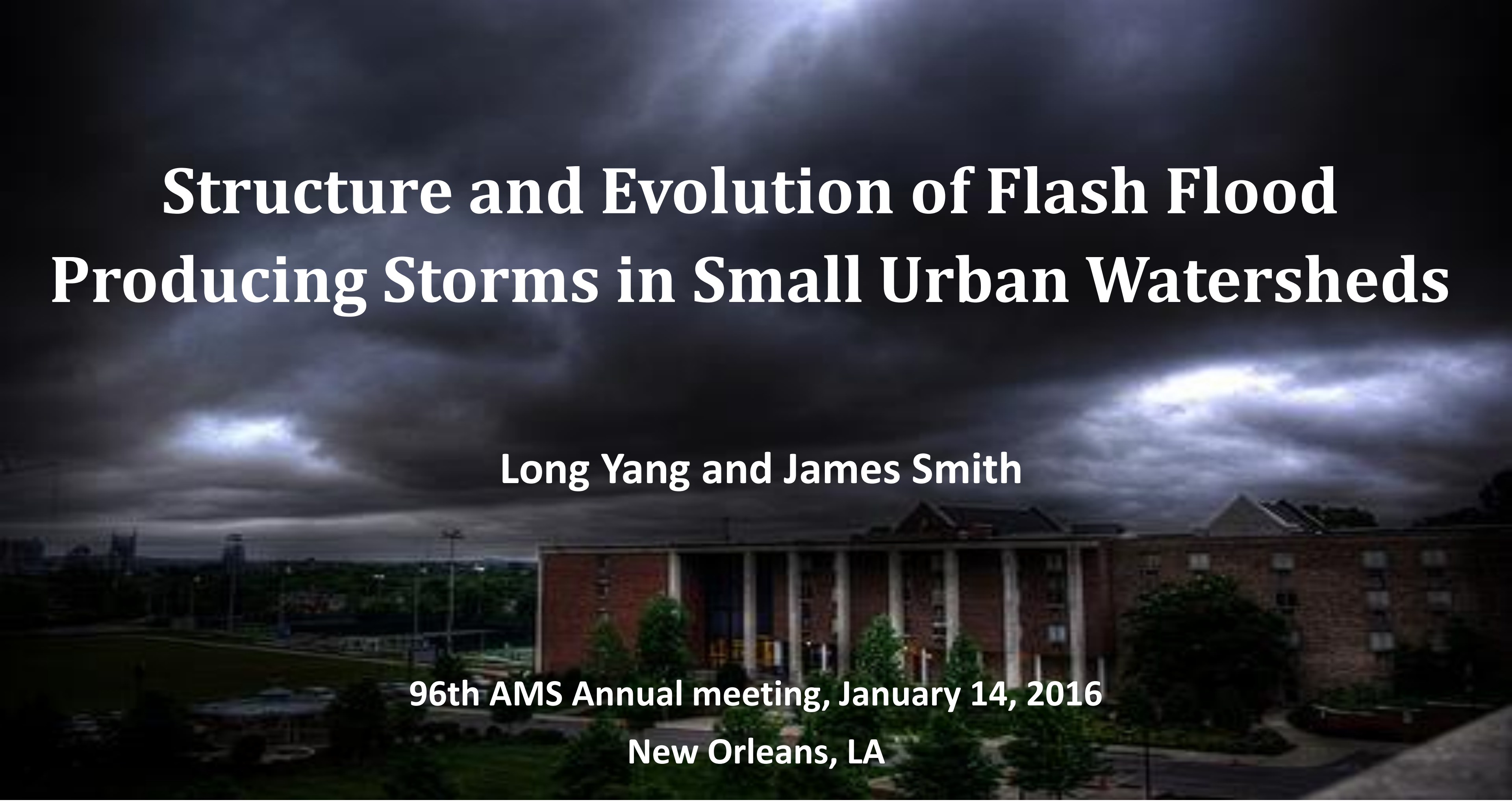

Structure and Evolution of Flash Flood Producing Storms in Small Urban Watersheds

Long Yang and James Smith

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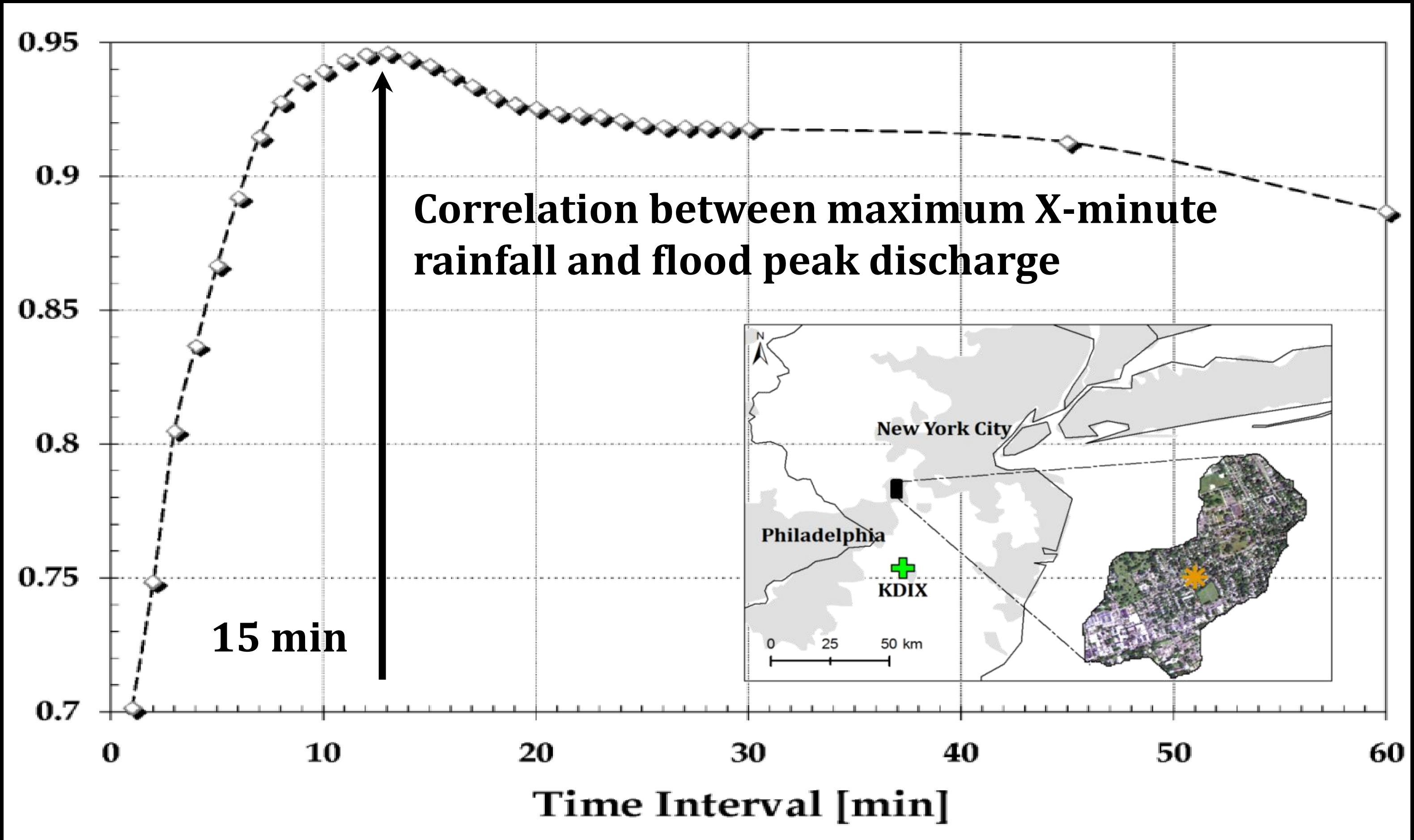
New Orleans, LA

PRINCETON UNIVERSITY | Hydrometeorology Research Group

清華大學 Tsinghua University | Hydrology and Water Resources Institute

Background



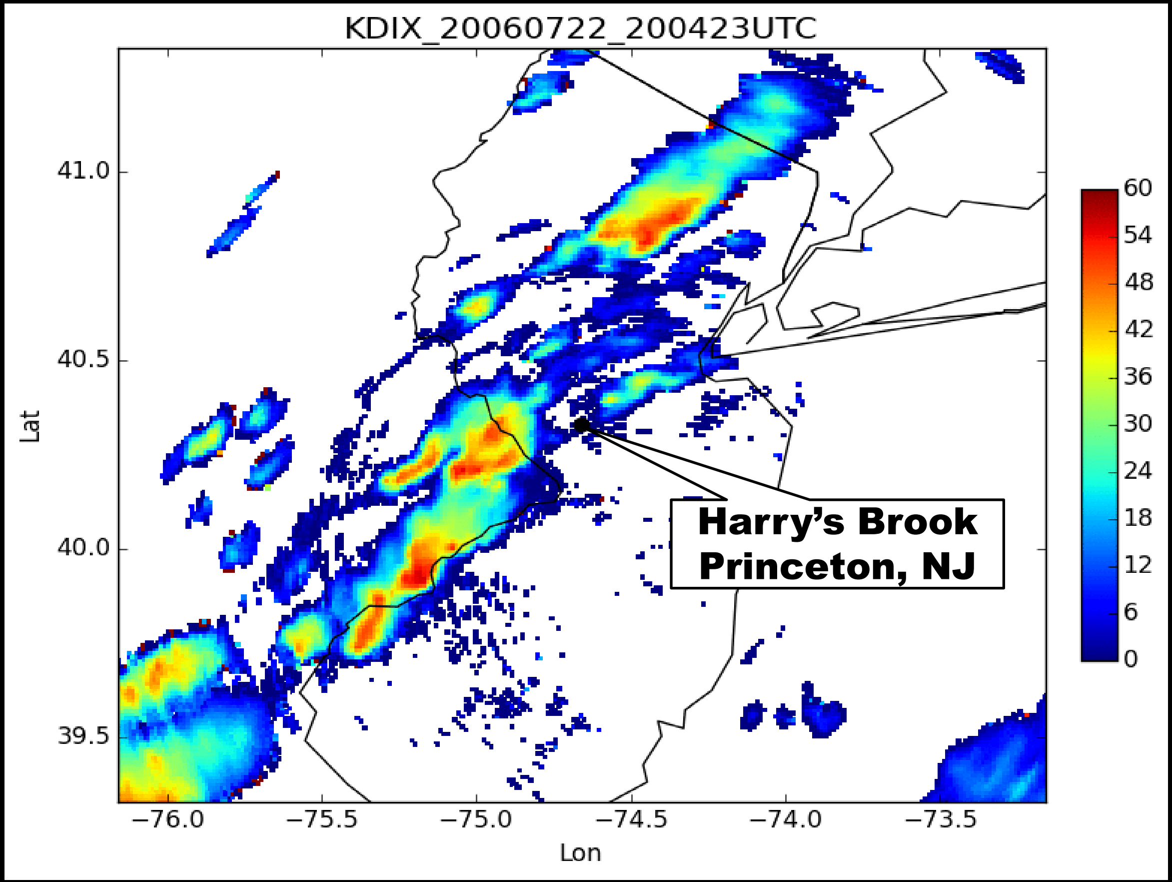
0.95
0.9
0.85
0.8
0.75
0.7
0
10
20
30
40
50
60
Time Interval [min]
Correlation between maximum X-minute rainfall and flood peak discharge
15 min
N
New York City
Philadelphia
KDIX
0 25 50 km

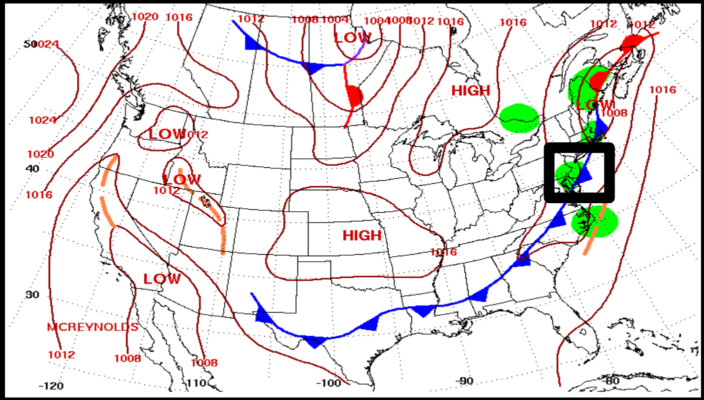
Background-cont.

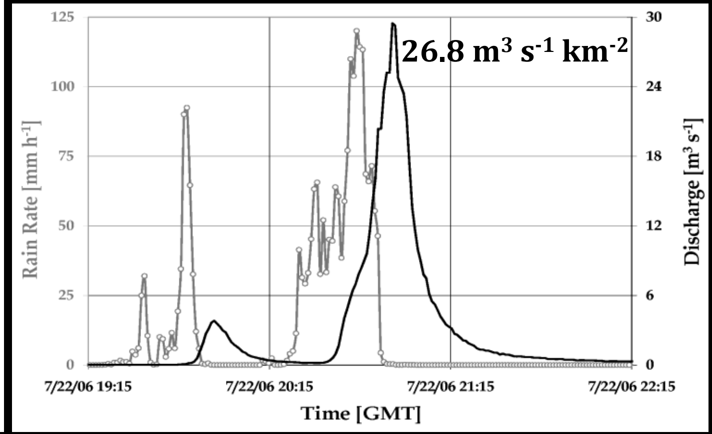
- **Flash flood response in small urban watersheds is related to rainfall variability at short time scales (<30 minutes)**
- **Smith et al. (WRR 2005, 2011, etc.): severe convective storms are responsible for extreme rainfall and flooding**
- **Hamada et al. (Nat. Commun. 2015): heaviest rain rate is not generally related to most intense convection (also Petersen et al. 1999, etc.)**

What are the key structural and evolution properties of flash flood producing storms in small urban watersheds?

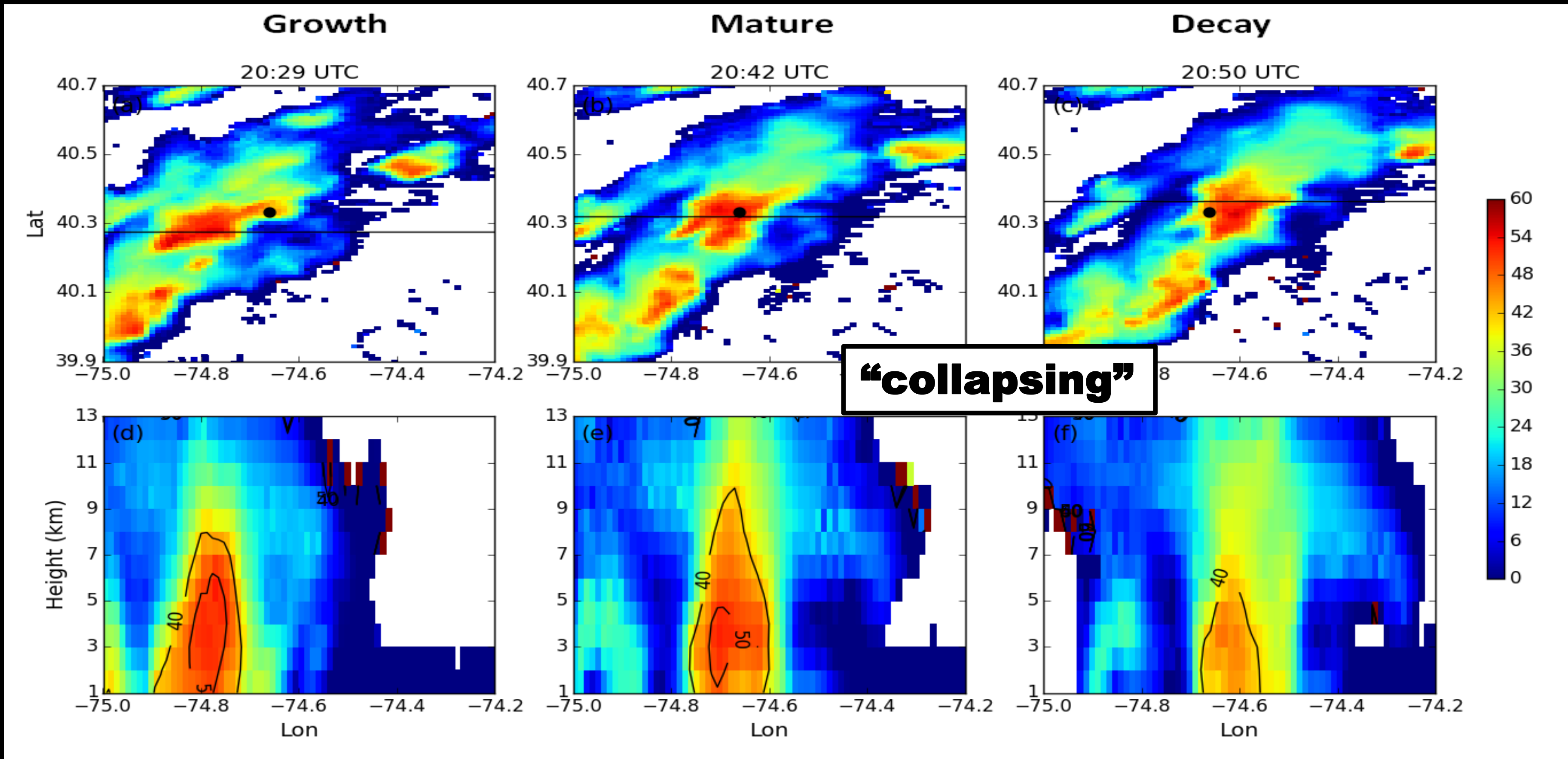
22 July 2006 storm: overview



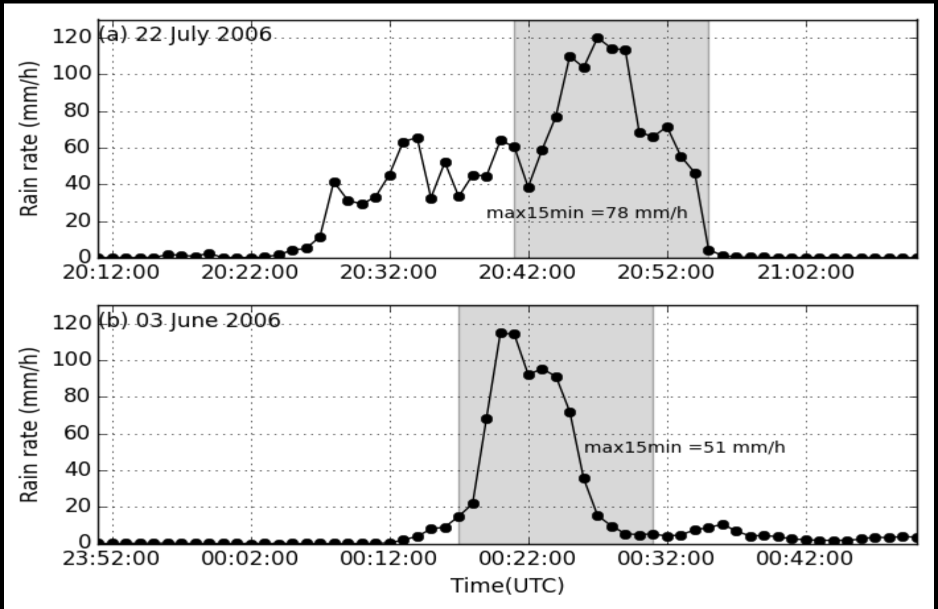


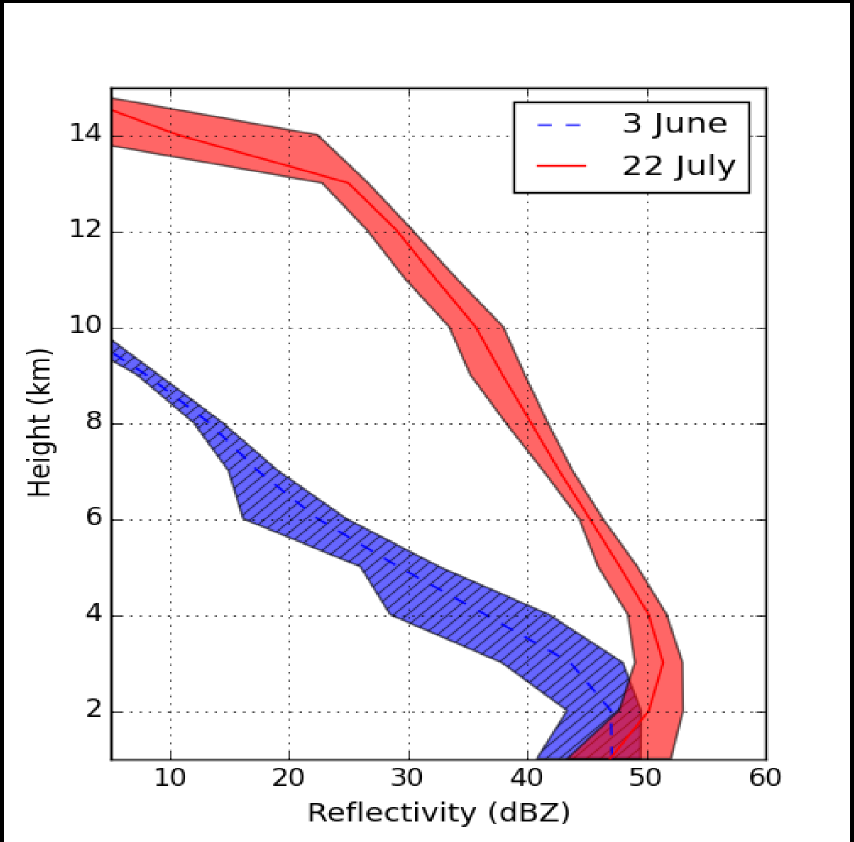


22 July 2006 storm: structure & evolution



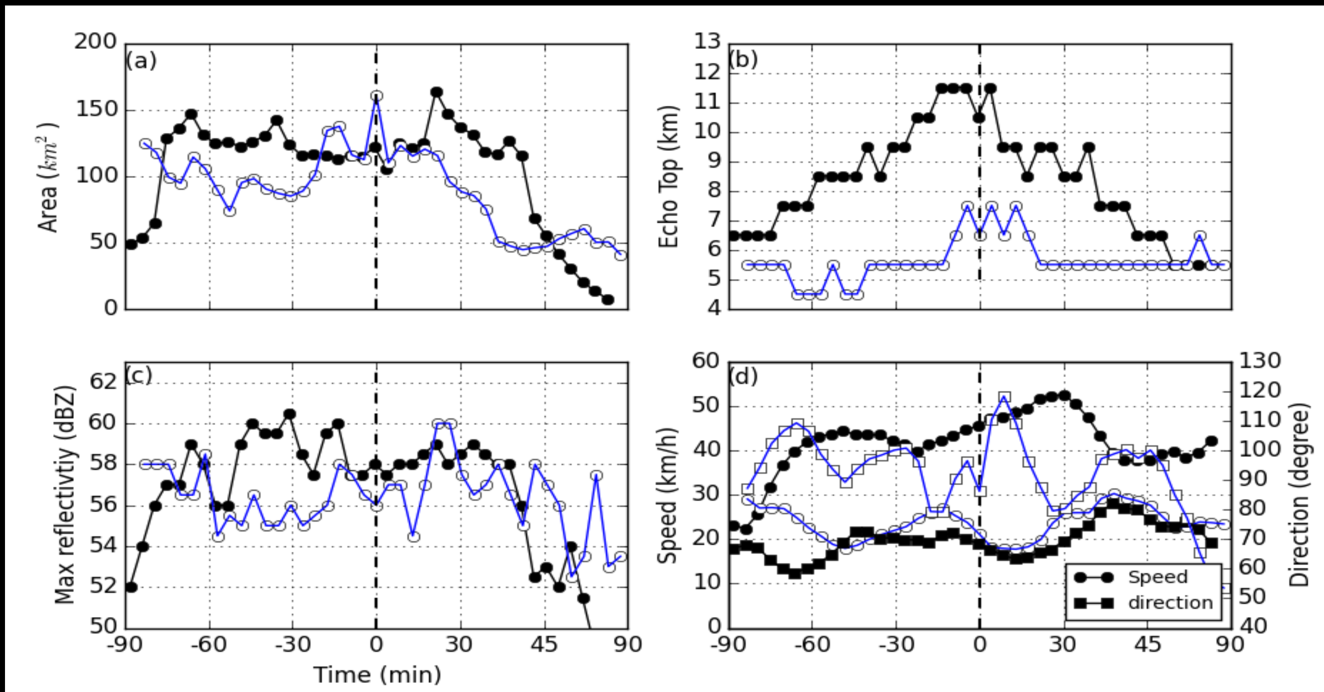
22 July VS. 3 June: structure contrast





- Comparable rain rates, contrasted storm structure
- July 22: echo top exceed 13 km
- June 3: “low-echo centroid”

22 July VS. 3 June: evolution contrast



Area	Echo Top
Max dBZ	Storm speed /direction

Black: July 22
Blue: June 3

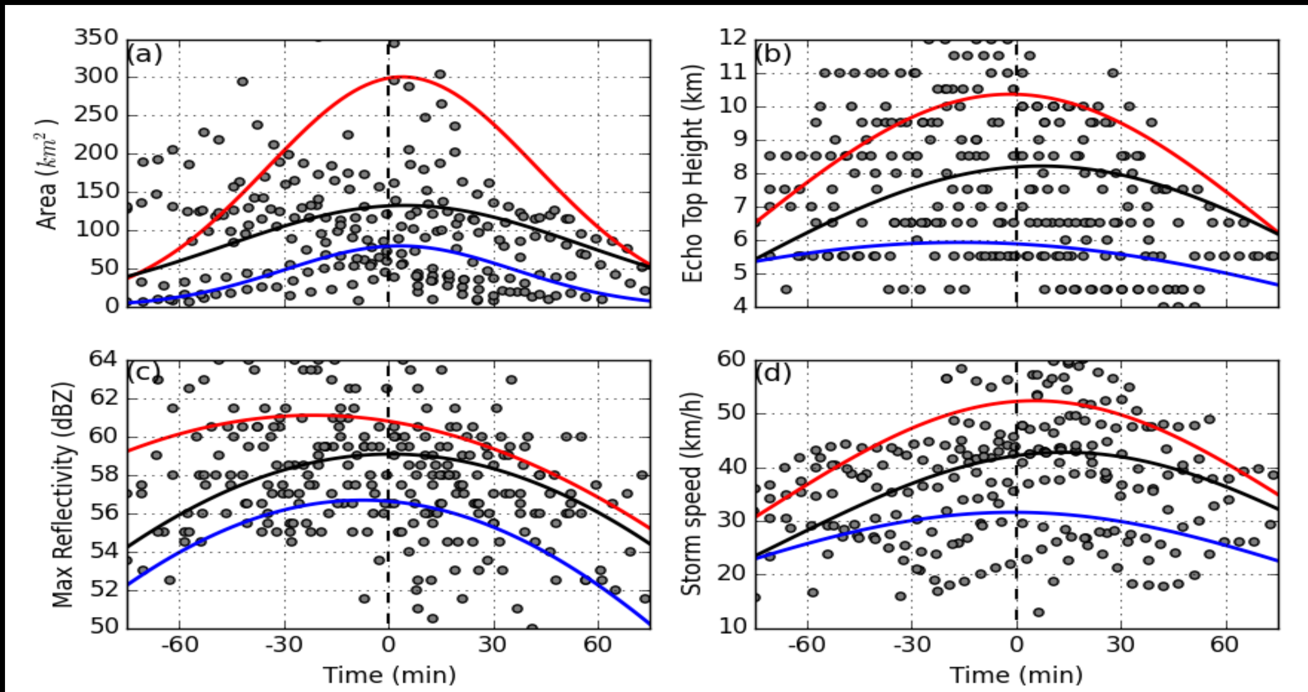
- **Based on 3D WSR-88D radar reflectivity fields and TITAN (Mike and Dixon, 1993)**

Composite analysis: storm catalog

Year	Date	Rain peak time (hhmm)	Max 1-minute rainfall (mm h^{-1})	Max 15-minute rainfall (mm h^{-1})	CG lightning flashes
2005	29 Jun	1938	78	55	5
	2 Jul	0546	93	50	17
	15 Aug	0302	66	37	0
2006	12 May	0345	57	21	0
	16 May	0043	83	26	1
	3 Jun	0021	115	51	0
	3 Jun	0359	81	49	3
	8 Jun	2318	60	35	0
	14 Jun	2327	64	36	0
	23 Jun	2314	63	32	11
	30 Jun	0246	36	17	30
	13 Jul	0234	107	38	55
	22 Jul	0006	88	61	55
	22 Jul	2047	120	78	50
	5 Oct	0401	123	66	11

- **Two-year field campaign**
- **1-minute disdrometer rain rate**
- **1-minute stream gauging observation**
- **National cloud-to-ground lightning detection network**

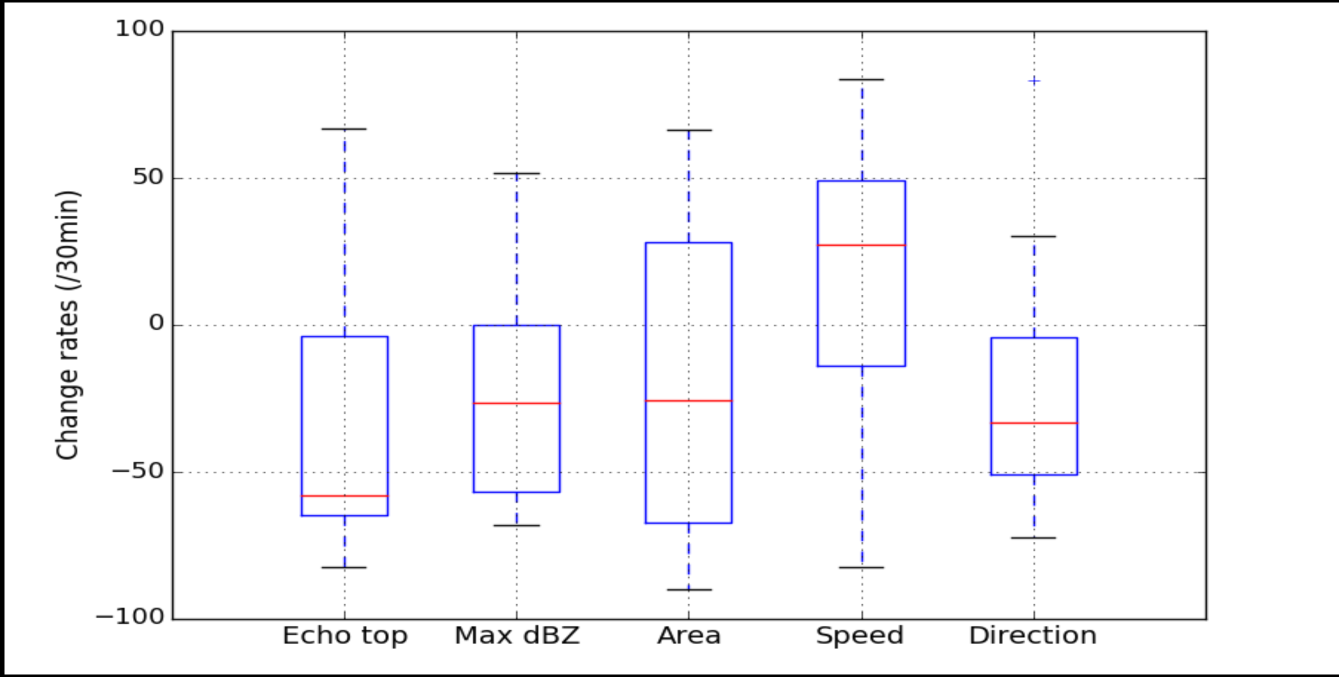
Composite analysis: entire lifecycle



Area	**Echo Top**
Max dBZ	**Storm speed**

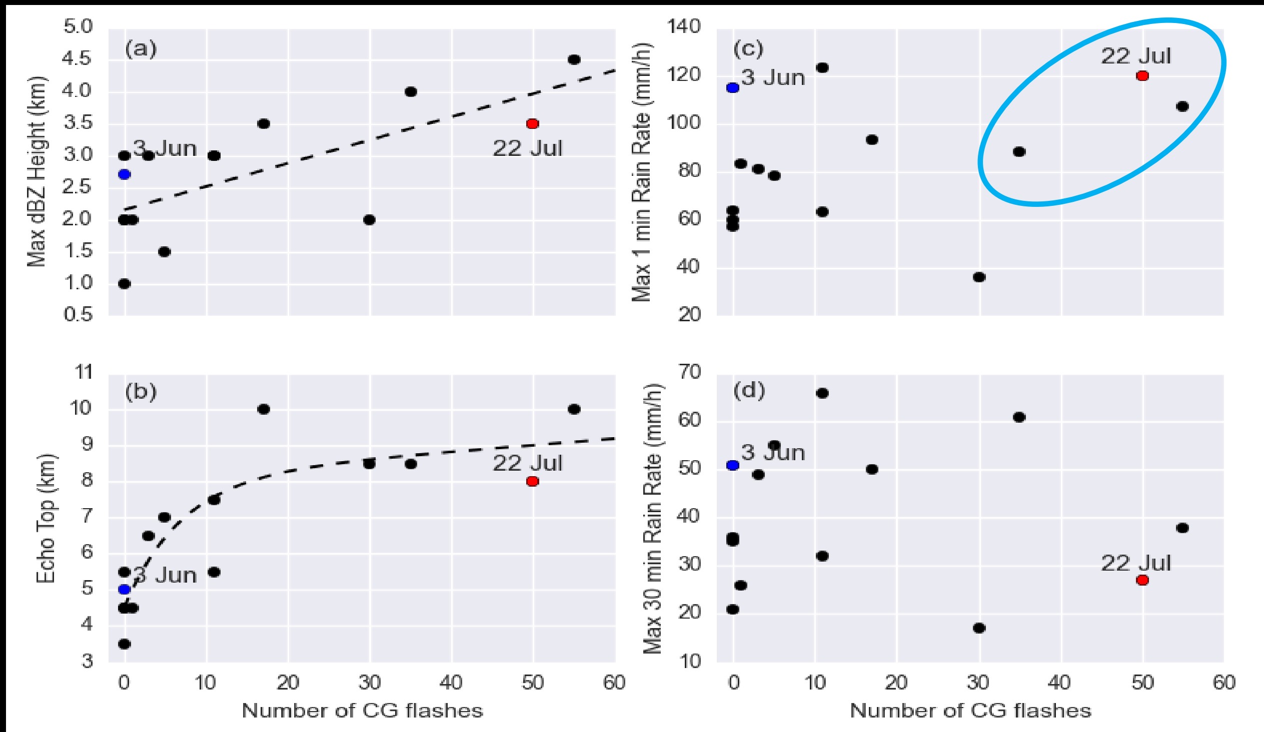
- **Drops of echo top height and maximum dBZ**
- **Slowing down of storms following peak rain rate, favorable for flash floods (Chappell, 1986; Doswell, 1996)**

Composite analysis: during peak rainfall



- **Vertical structure (Echo top, Max dBZ) ⟹ storm collapse**
- **Spatial coverage (area) ⟹ storm shrink**
- **Movement (speed, direction) ⟹ horizontal wind shear**

Lightning density and rain rates



Max dBZ	Max 1-min rain rate
Echo Top	Max 30-min rain rate

- **Good indicator of convection, but not for surface rain rate**
- **Extreme rain rate is still weakly related to lightning density**

Take-home messages

What are the key structural and evolution properties of flash flood producing storms in small urban watersheds?

- Structure: Contrasted by severe convective storms with high echo top and “low-echo centroid” storms with relatively weak convection
- Evolution: “Collapse” of storm cells is a common feature for flash flood producing storms over small urban watersheds
- Relationship between convective intensity and rain rate is not simple

Further questions

- **How do the storm properties modify microstructure of rain rates?**

- **How do storm properties together with land surface heterogeneities determine the scale-dependent flood response in urban watersheds?**

- **Urban signatures in modifying/shaping the properties of flood-producing storms?**

J20.1 Observational and modeling studies of extreme floods in urban environments, James Smith et al. Room 242 11:00

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Thanks for your attention!

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