Surveillance Camera-based Rainfall Estimation

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Masaryk University
10/03/2022

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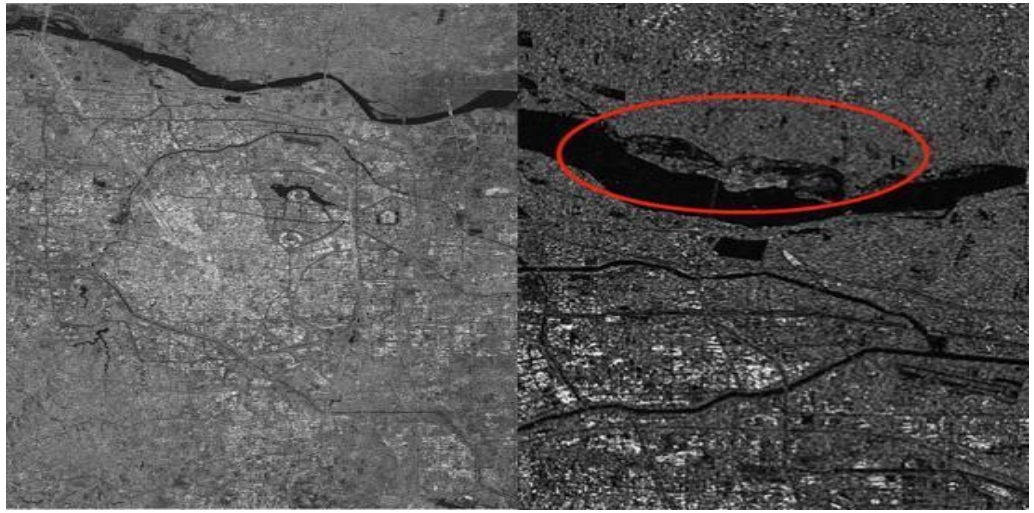
ENGAGE
Geomorphological Systems & Risk Research

1. Background

2. Video-based rainfall estimation

3. Audio-based rainfall estimation

4. Conclusion



2021.07. 20 Zhengzhou，China

2016.08.15 Louisiana，USA

2020.08. 18 Chongqing，China

2021.07.10 Ahrweiler，German

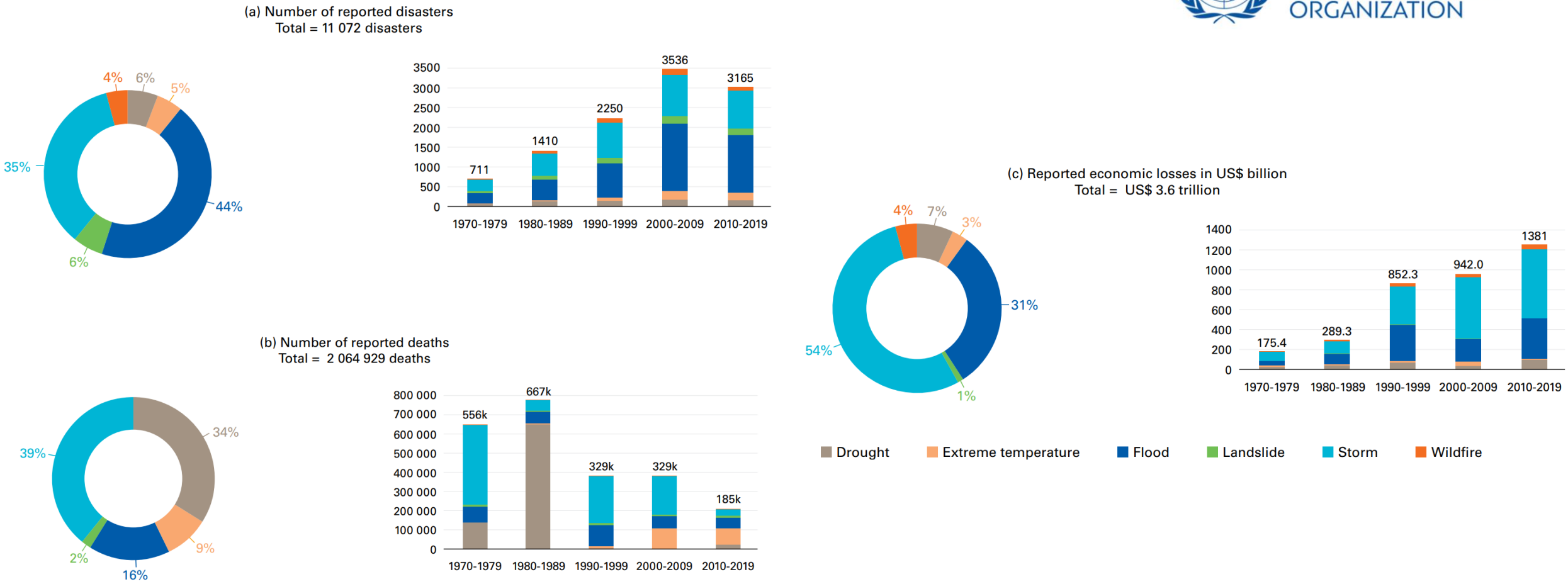
Links:

https://www.dw.com/zh/%E5%BE%B7%E5%9B%BD%E8%A5%BF%E9%83%A8%E6%B4%AA%E7%81%BE%E6%83%A8%E7%83%88%E9%98%B2%E7%81%BE%E7%B3%BB%E7%BB%9F%E5%93%AA%E5%8E%BB%E4%BA%86/a-58316881

https://www.climate.gov/news-features/event-tracker/global-warming-increased-risk-intensity-louisianas-extreme-rain-event

(a) number of disasters, (b) number of deaths and (c) economic losses during 1970–2019 from all hazards.

published by World Meteorological Organization (WMO).



Reasons for more frequent extreme rainfall events:

1) Global warming

2) Urbanization

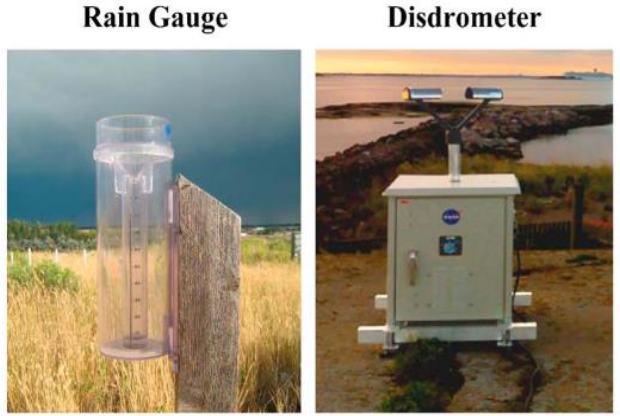
Rainfall observation/prediction system

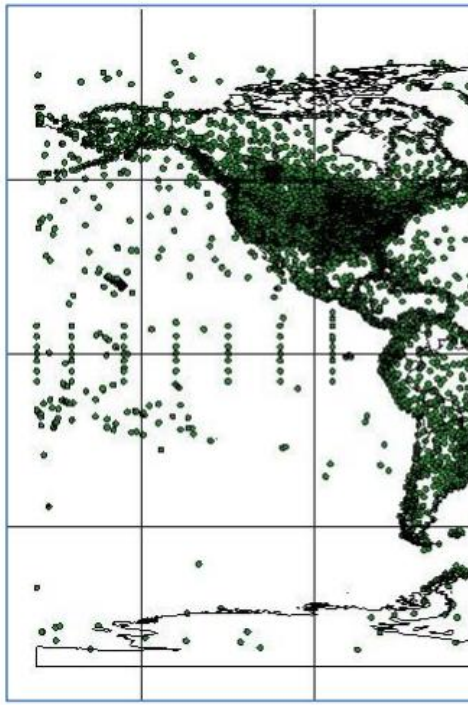
https://www.worldweatherattribution.org/heavy-rainfall-which-led-to-severe-flooding-in-western-europe-made-more-likely-by-climate-change/

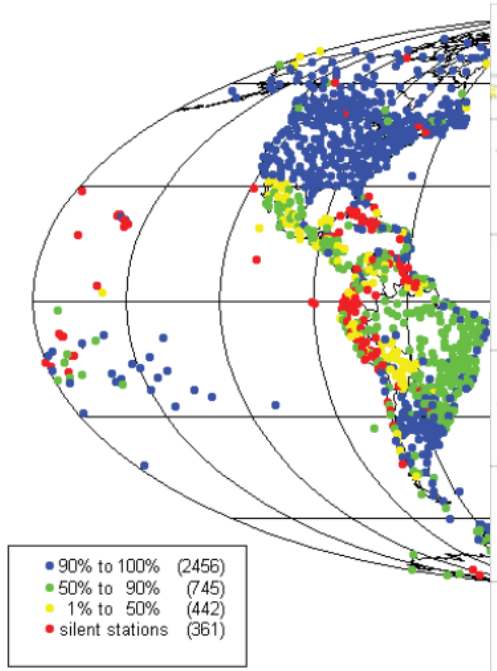
Ground-based rainfall observation

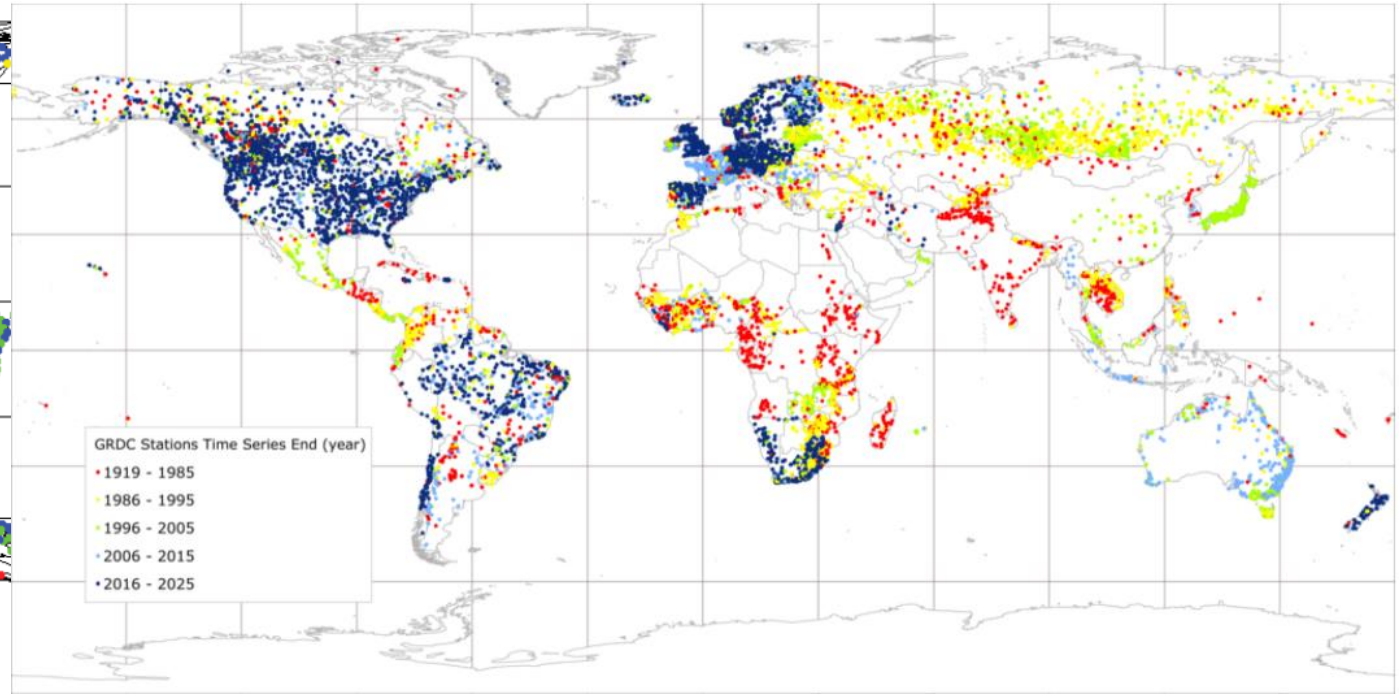
Problems:

1). Reduction in the number of observation resources.





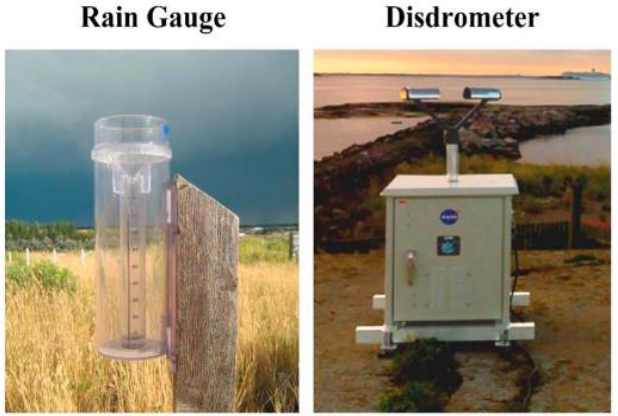




Data collected by： WMO

Sheffield J, Wood E F, Pan M, et al. Satellite remote sensing for water resources management: Potential for supporting sustainable development in data-poor regions[J]. Water Resources Research, 2018, 54(12): 9724-9758.
Ben H.P. Maathuis. Constraints and opportunities for Water Resources Monitoring and Forecasting using the Triple Sensor approach. 2018
https://public.wmo.int/en/resources/bulletin/hydrological-data-exchange

Ground-based rainfall observation



2). Unevenly distribution of observation resources;

WMO Secretary-General Prof. Petteri Taalas:

"In an era of cutting-edge satellite technology and artificial intelligence, there are countries which still lack basic rain gauges"

Shortcomings: insufficient spatial representation

Remote Sensing-based rainfall observation

Radar & Satellite

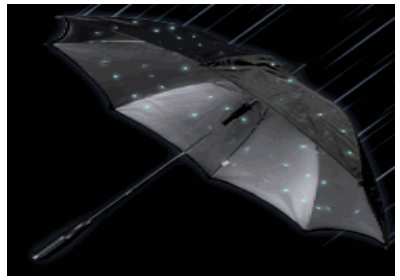
Shortcomings:

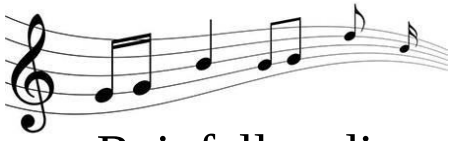
1) need for ground-based measurements for correction
2) not satisfied for the fast hydrological response applications

Lack Spatial and Temporal resolution

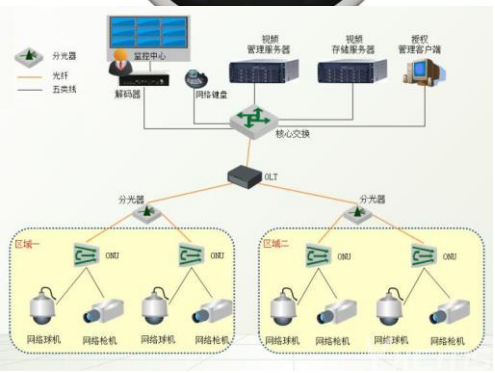
Ground-based, low cost, high resolution

WMO, Intergovernmental Hydrological Programme (IHP), NOAA, NASA



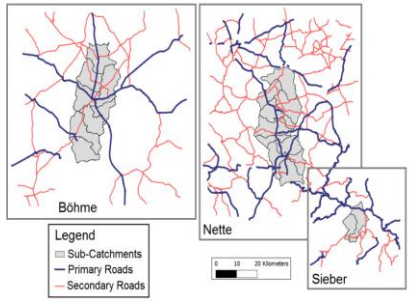


Rainfall audio



Microwave links

Rain gauge from car



Hardware

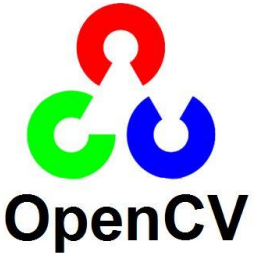
> 400 million surveillance cameras in China

Spatial resolution

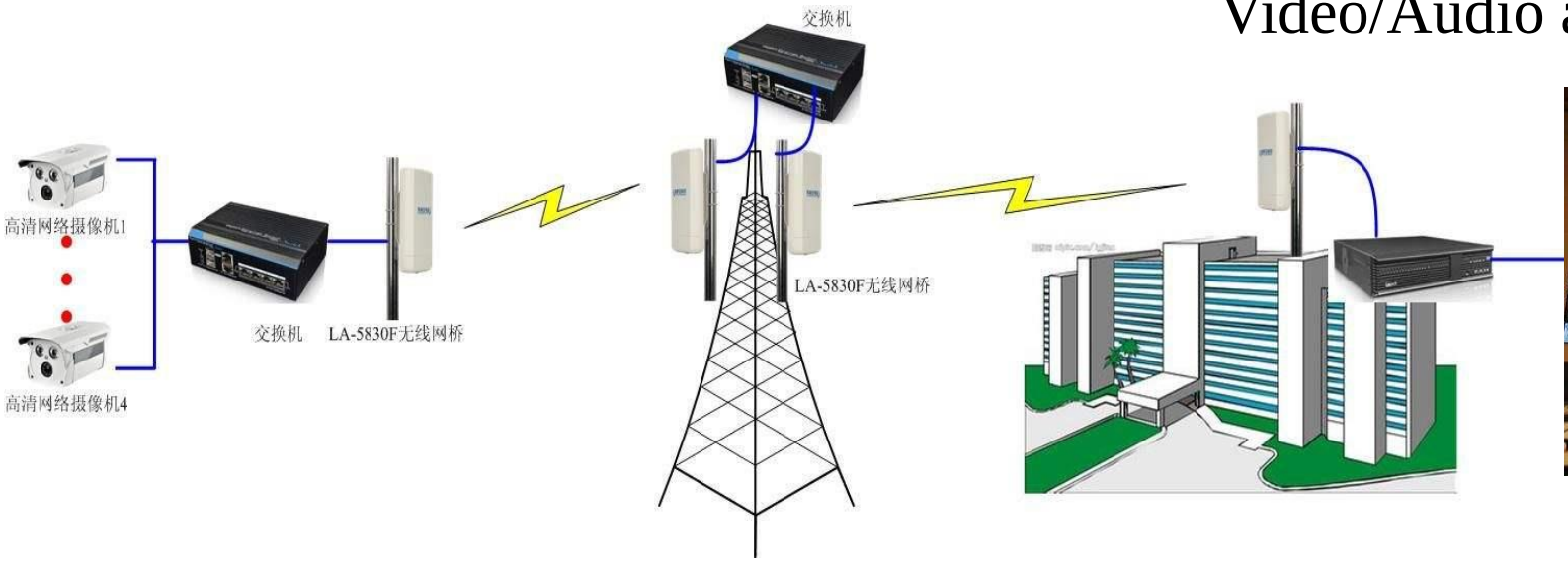
https://www.comparitech.com/vpn-privacy/the-worlds-most-surveilled-cities/

Software

Temporal resolution

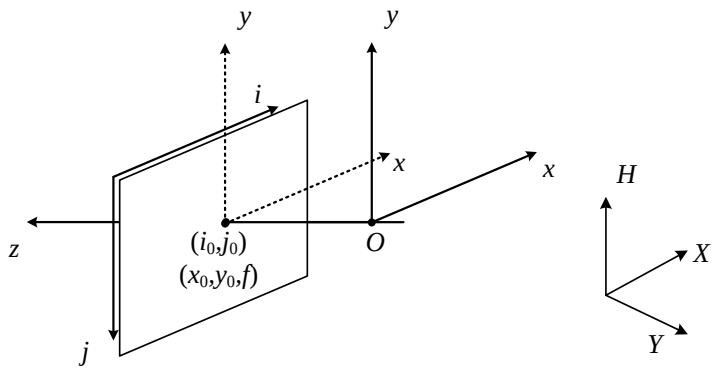


Video/Audio analysis and processing



Video/audio transmission by 4G and 5G

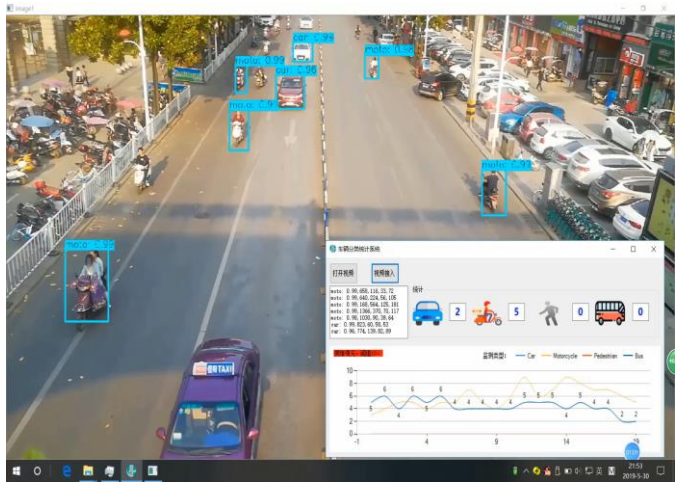
Video-GIS team



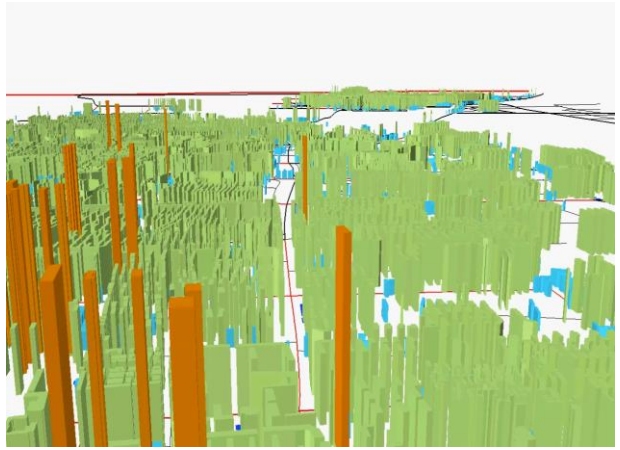
AQI & PM 2.5 estimation

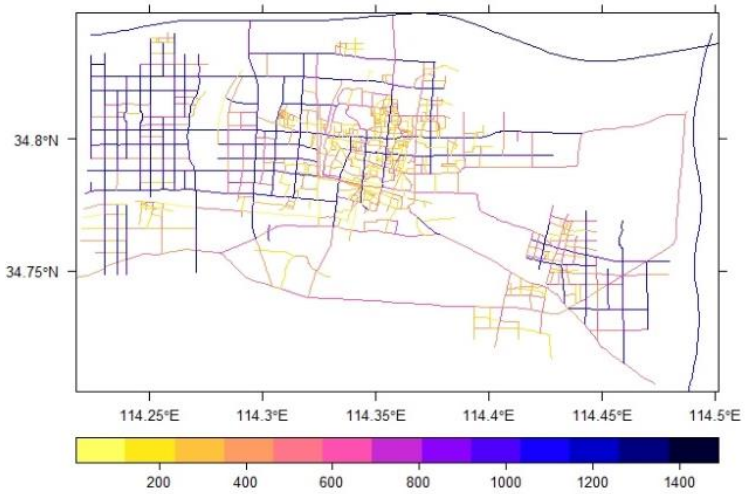
Video-GIS team

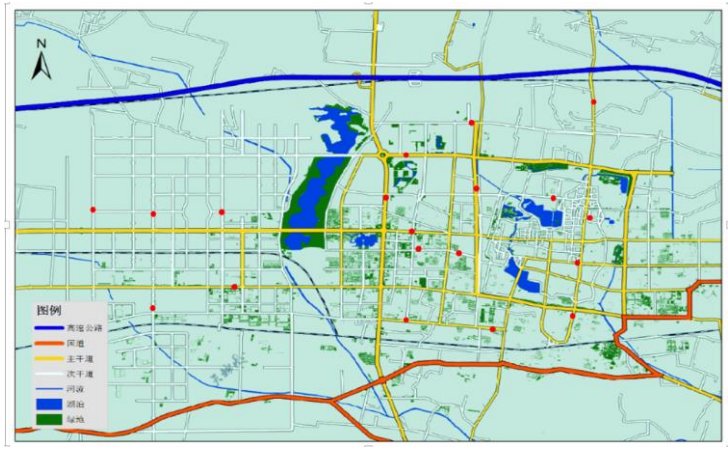
Air pollution modeling in urban street canyons



Vehicles are the main source of air pollution







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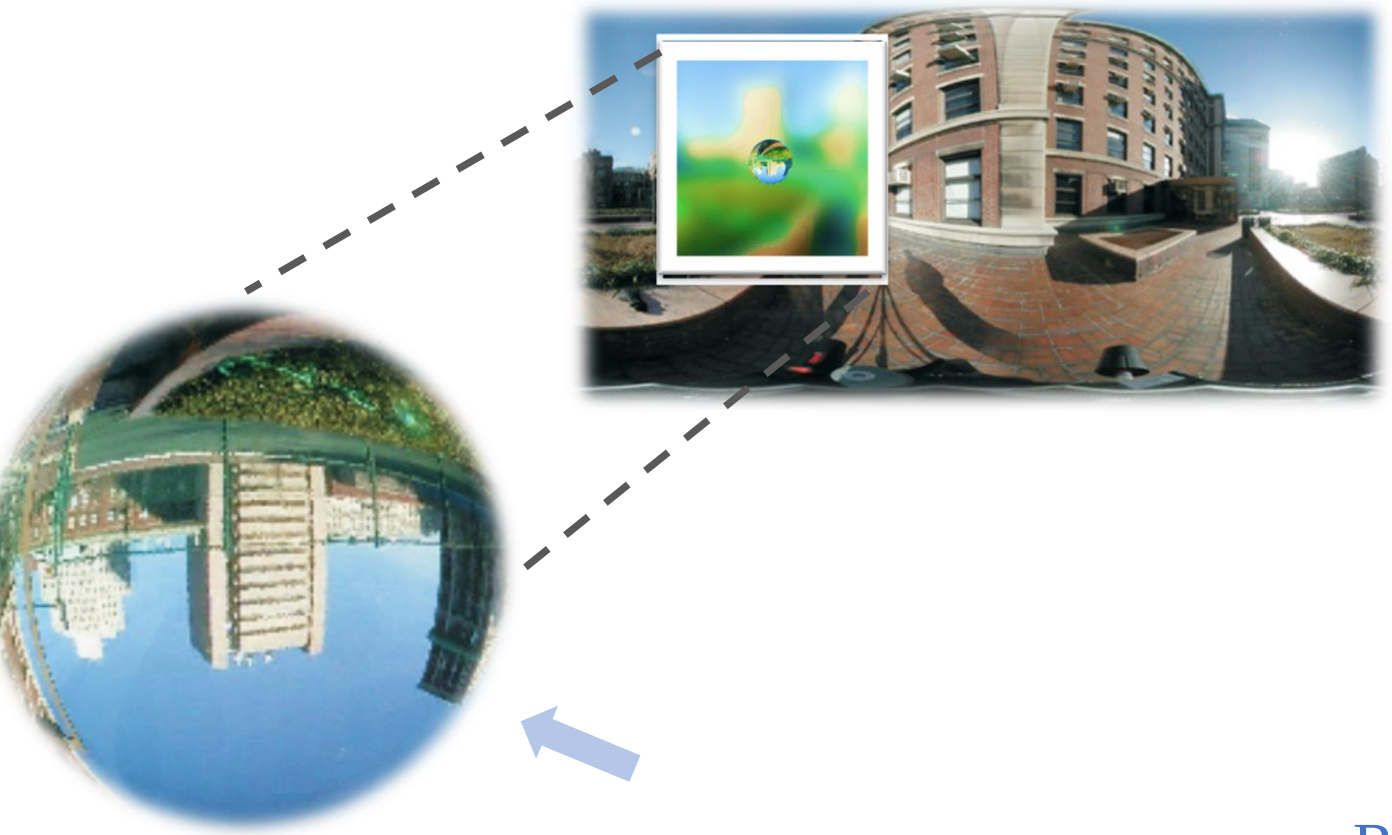
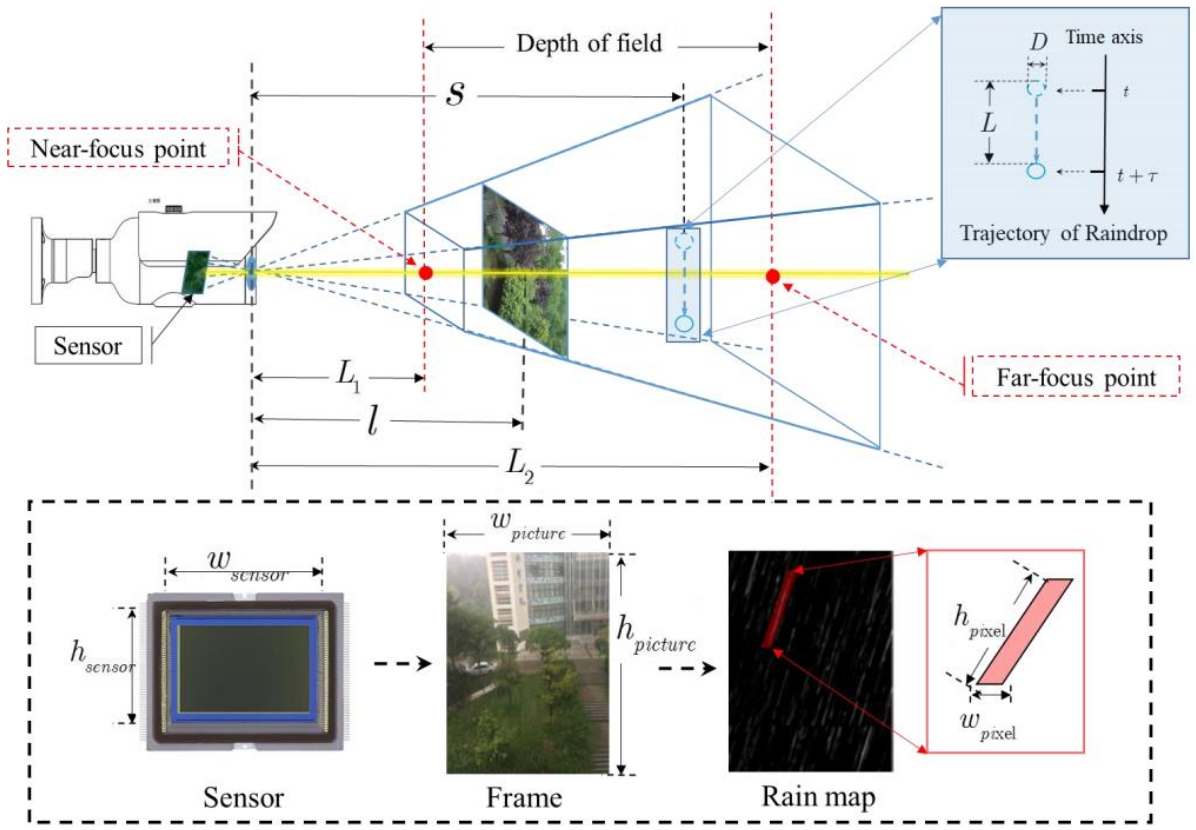
2.1 Rainfall calculation based camera collaboration



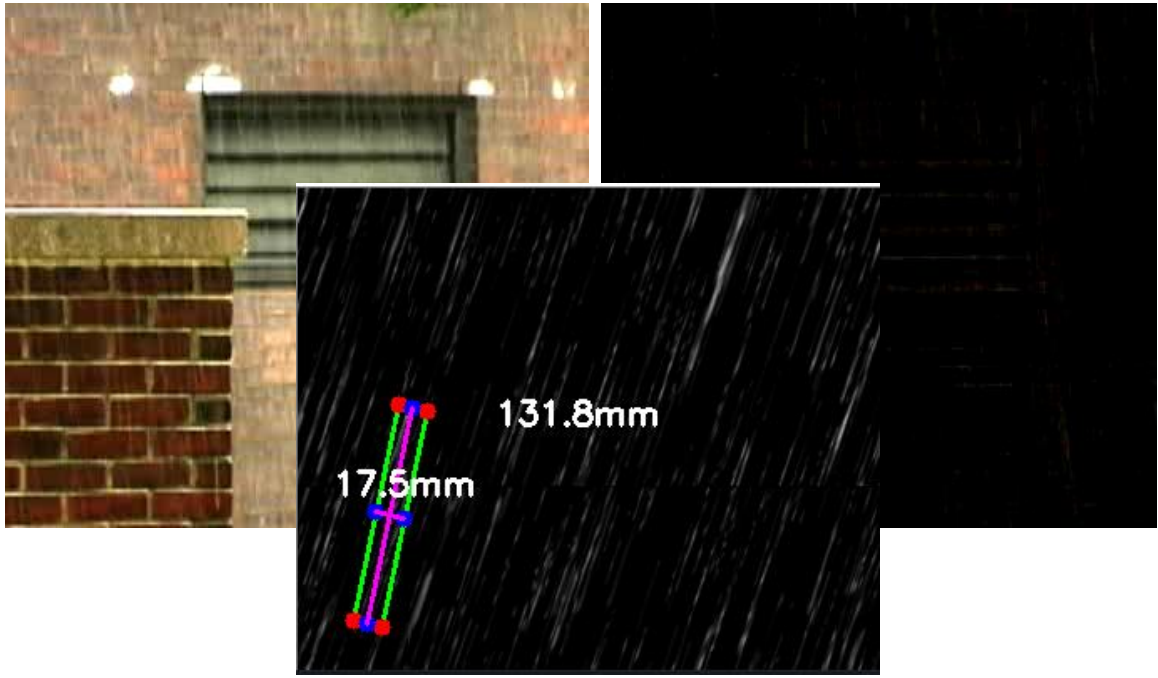
Rain streaks: the blurred pixels by raindrops

Rainfall intensity: is defined as the ratio of the total amount of rain (rainfall depth) falling during a given period. It is expressed in depth units per unit time, usually as mm per hour (mm/h).

2.1 Rainfall calculation based camera collaboration



Camera imaging model
(Pinhole imaging)



Step 1: Rain streaks detection from videos;

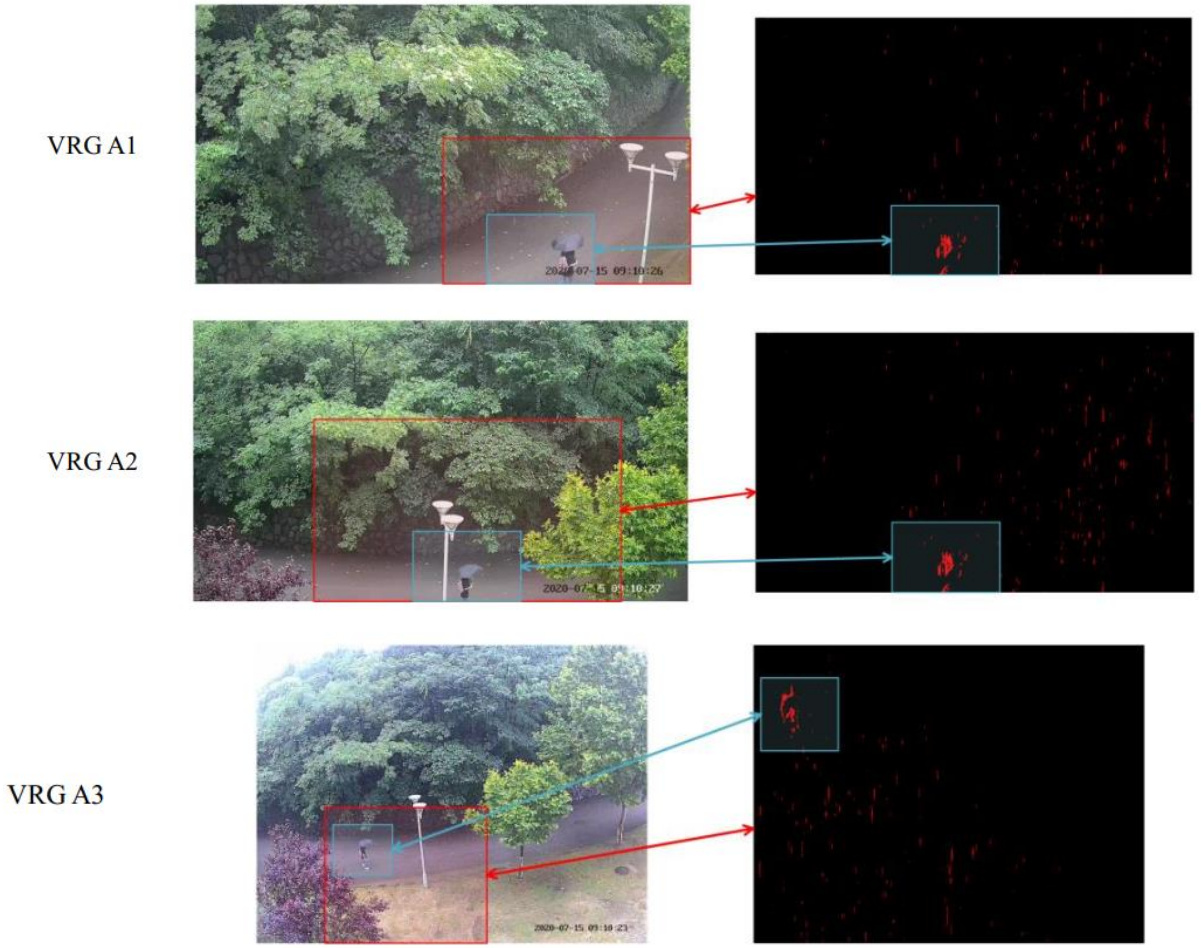
Step 2: Raindrop size and speed calculation;

Step 3: Rainfall intensity estimation.

rain streaks: the blurred pixels by raindrops

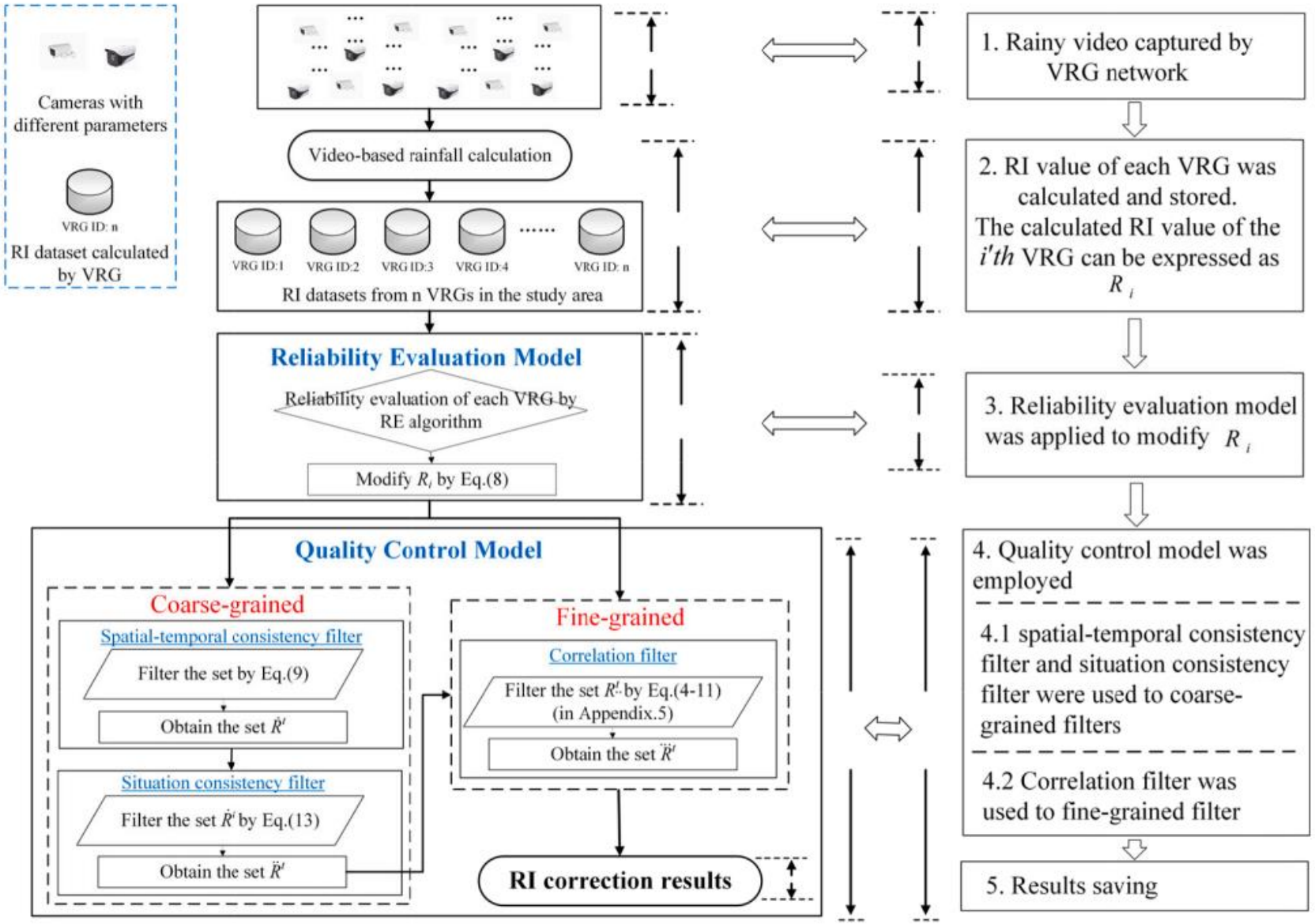
Shortcomings of surveillance Video-based Rain Gauge (VRG):

Non-cooperative surveillance scenarios

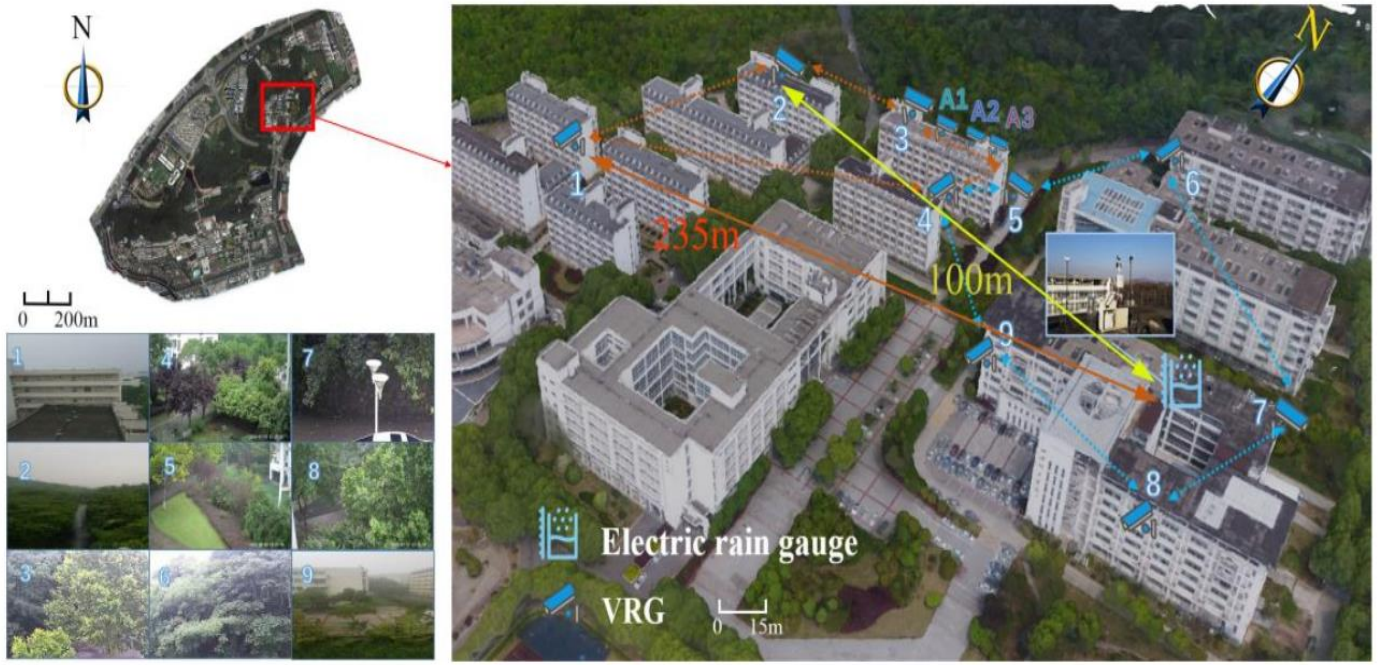


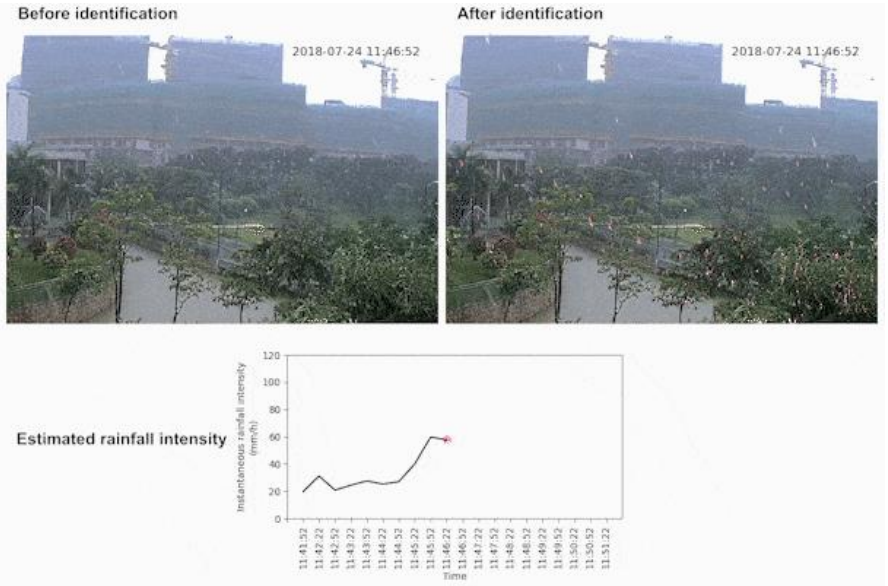
Moving objects

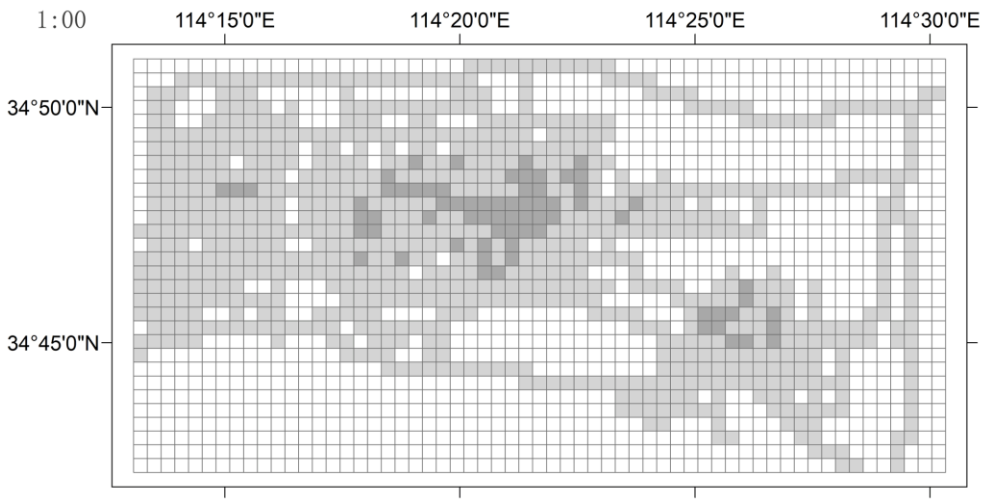
Precision control model of rainfall inversion based on VRGs collaboration:



Experiments (in Nanjing Normal University)

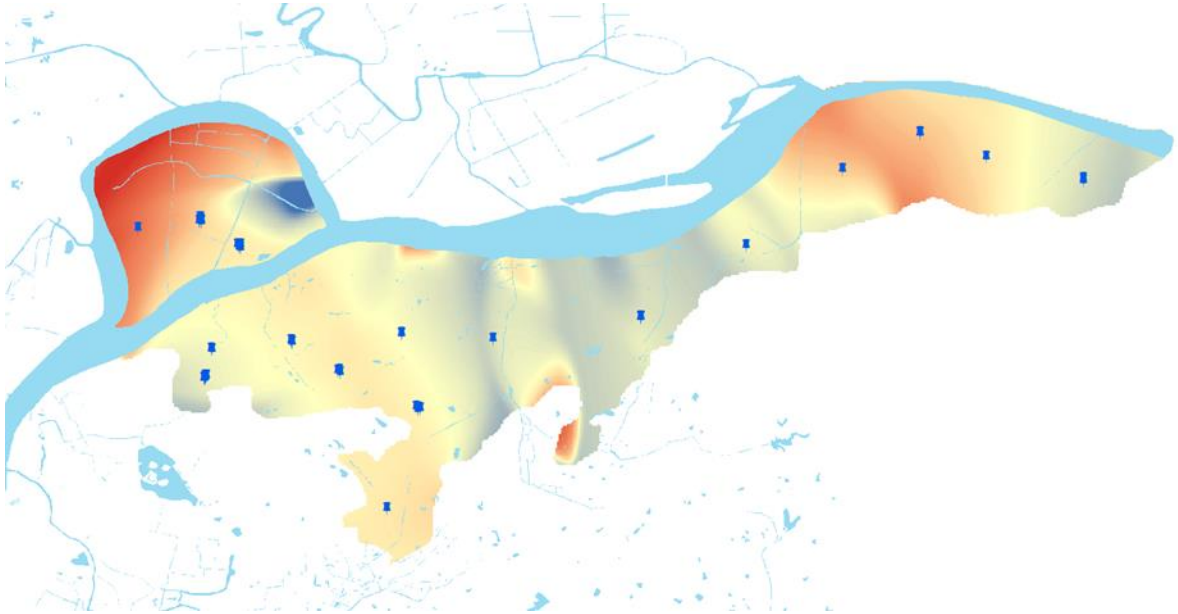


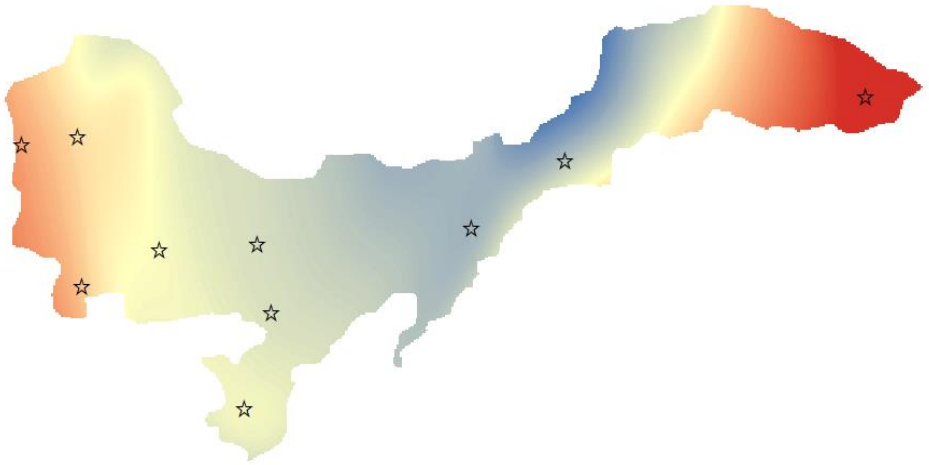


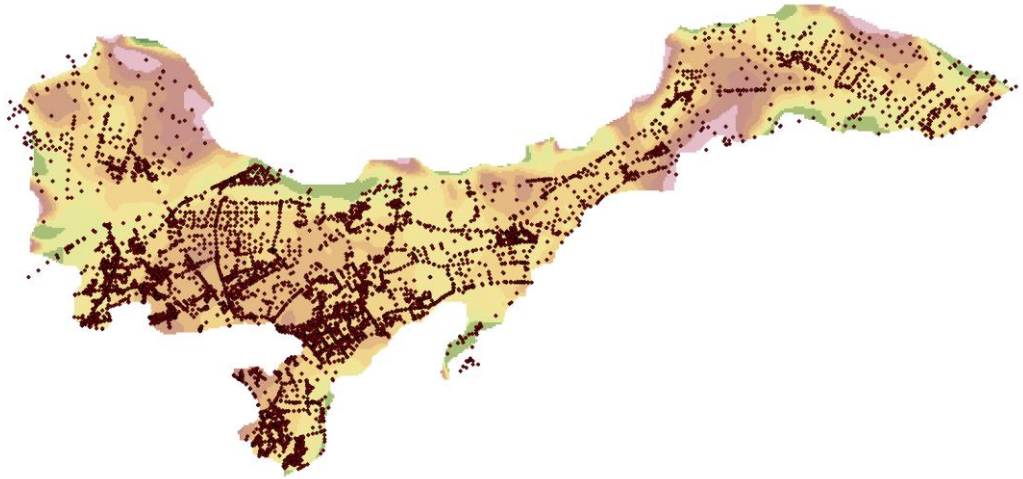


Wang X, Wang M, Liu X, et al. A novel quality control model of rainfall estimation with videos–A survey based on multi-surveillance cameras[J]. Journal of Hydrology, 2022, 605: 127312.

Simulation Experiments (in Nanjing)







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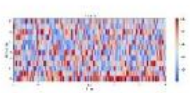
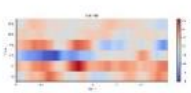
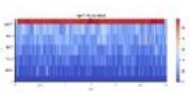
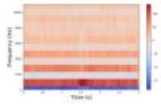
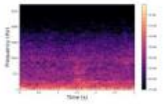
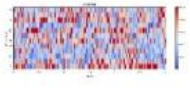
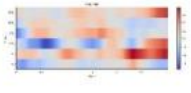
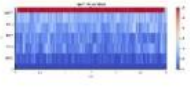
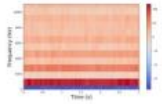
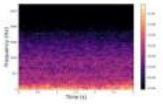
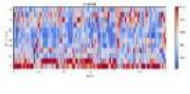
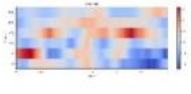
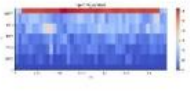
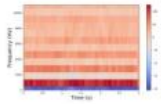
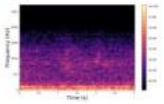
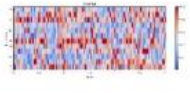
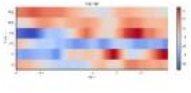
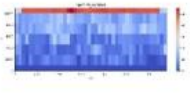
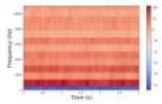
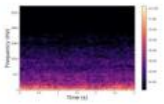
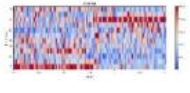
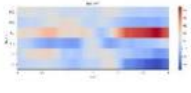
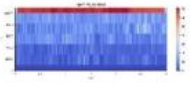
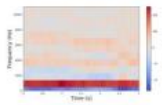
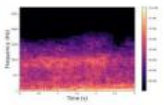
3.1 Parallelizing rainfall level classification network

Rainfall Events	Chroma	Tonnetz	C	MFCC	Mel
Violent					
Heavy					
Middle					
Small					
No-Rain					

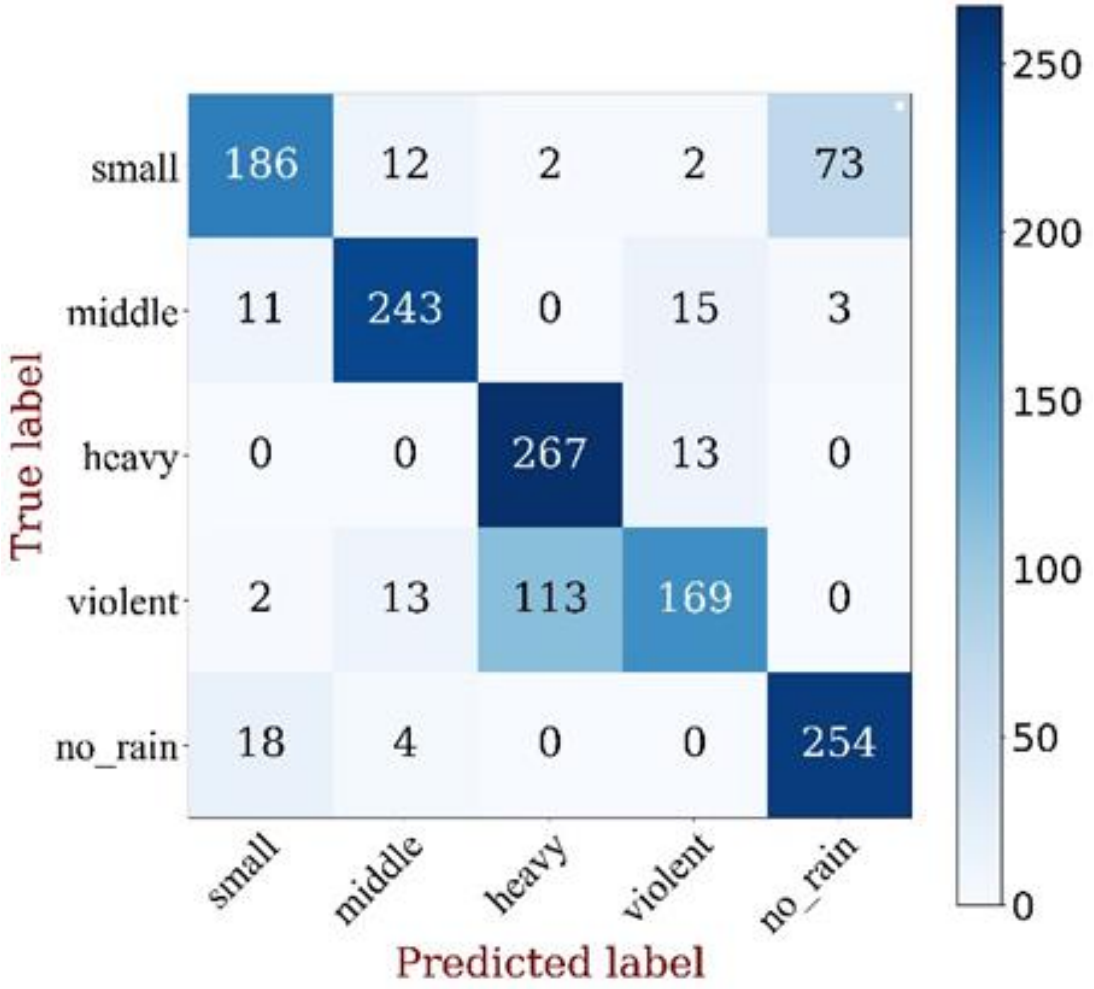
(i) The acoustic features of different rainfall-level audio are similar;

(ii) Background noise in surveillance sound space significant.

3.1 Parallelizing rainfall level classification network

(i) The proposed algorithm achieves optimal performance compared to some existing relevant models, indicating that the proposed algorithm can effectively determine the rainfall level from ordinary surveillance audio.

(ii) However, there is still much room for enhancing. In particular, the classification of “no_rain” and “small rain” scenarios and the distinction of “violent rain” and “heavy rain” need to be improved.



Wang X, Wang M, Liu X, et al. Rainfall observation using surveillance audio[J]. Applied Acoustics, 2022, 186: 108478.

1. Background

2. Video-based rainfall estimation

3. Audio-based rainfall estimation

4. Conclusion

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ENGAGE
Geomorphological Systems & Risk Research

1) Single camera → Surveillance camera-sensor network

2) Video + GIS → Keeping GIS active

Video-GIS

GIS

Video

Thank you!

Xing WANG

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Masaryk University
10/03/2022