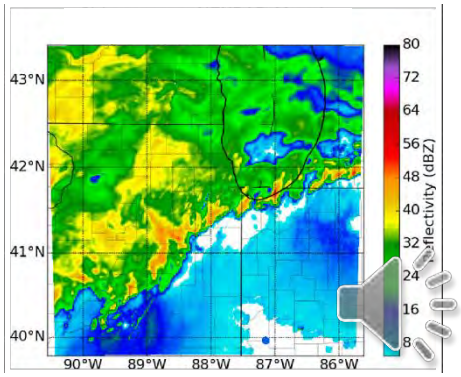
Brown AND Caldwell

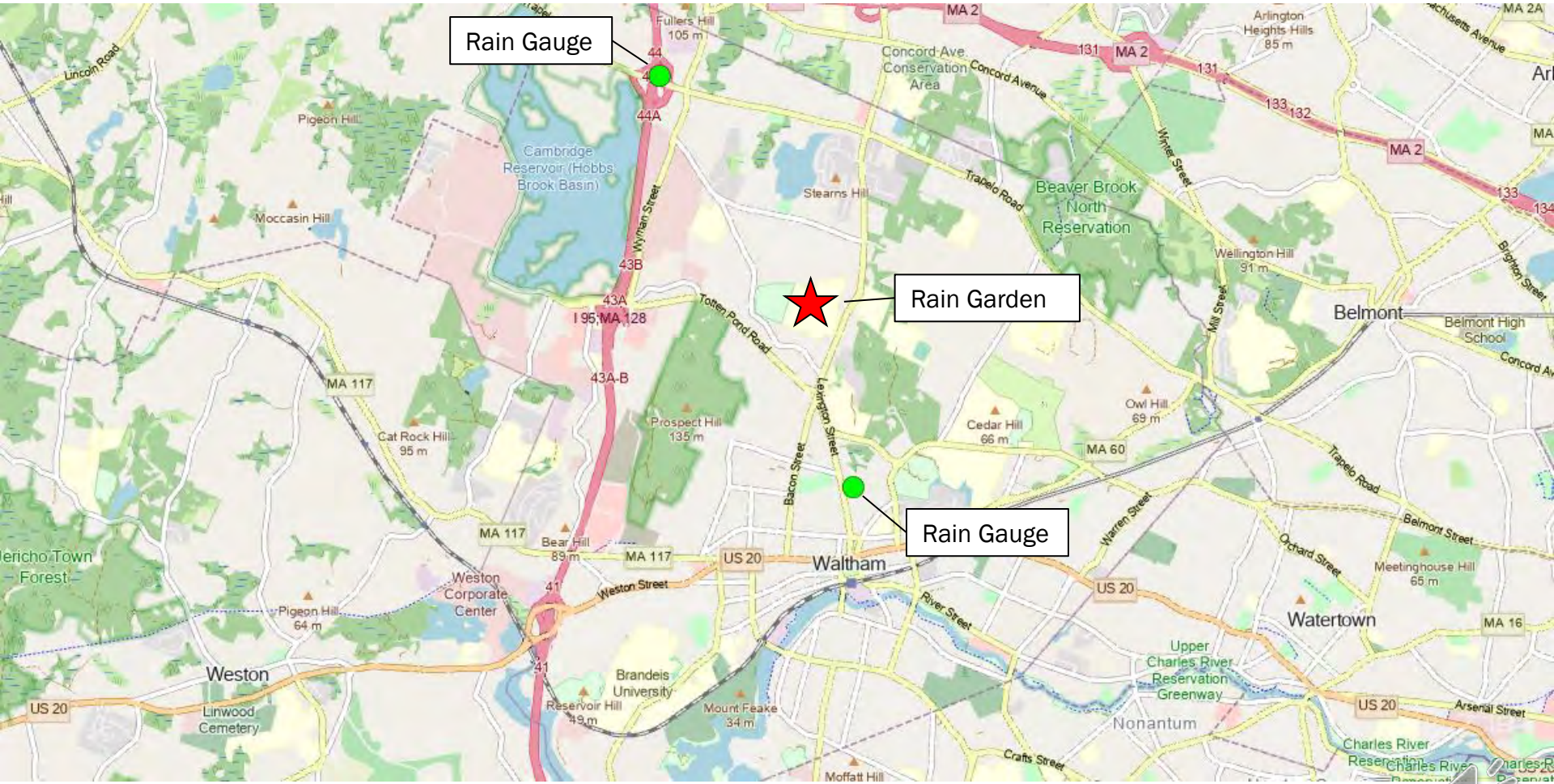
NEWEA Annual Conference and Exhibit | January 2022

Quantifying the Accuracy of Various Rainfall Spatial Interpolation Techniques

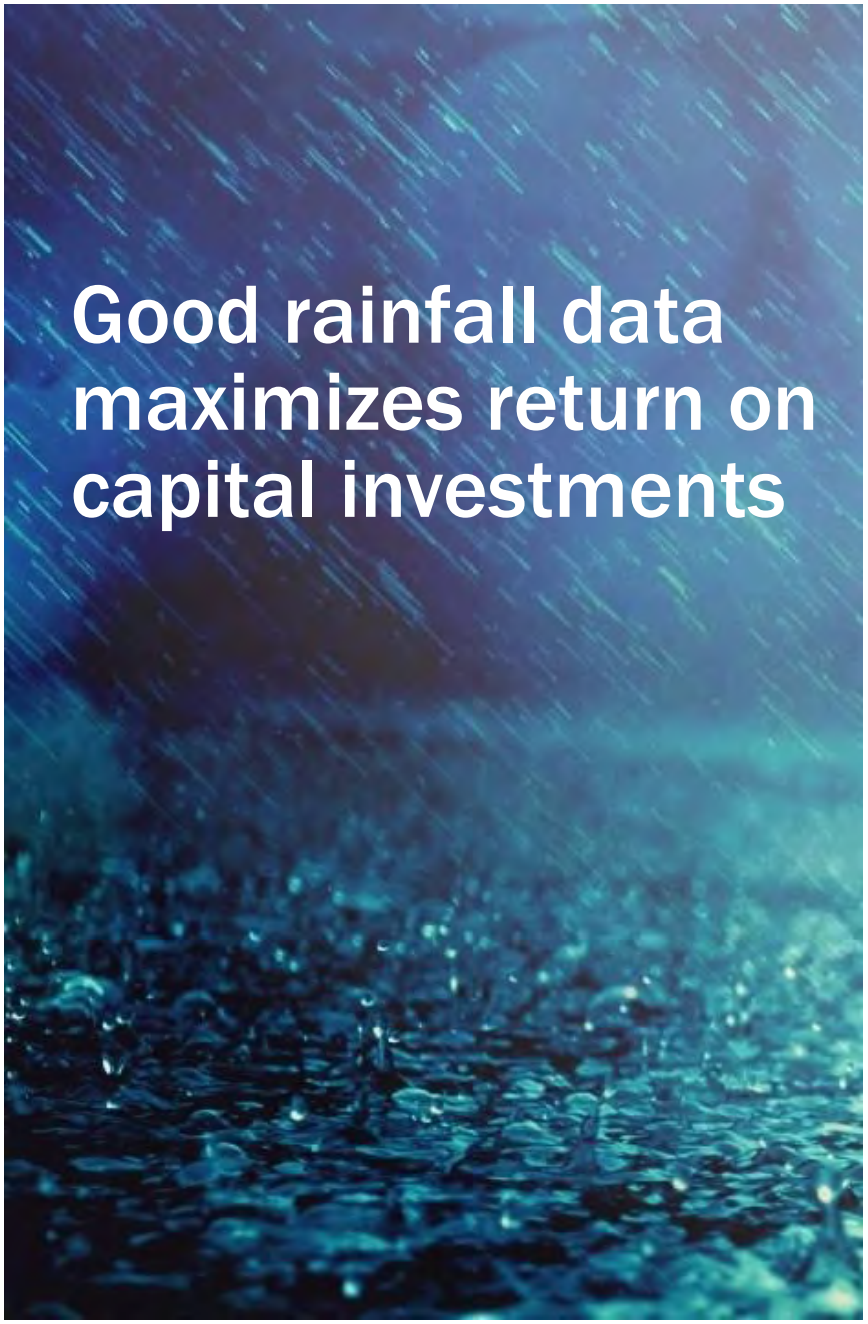
Matt Davis, P.E.



How to estimate rainfall at an ungauged location?



How to estimate rainfall over a geographic area (like a sewershed)?



Collection System Modeling Process

Rainfall data

Build/ calibrate collection system model

Evaluate system capacity

Develop and test solutions

Capital improvement plan ($$)

When rainfall data is inaccurate

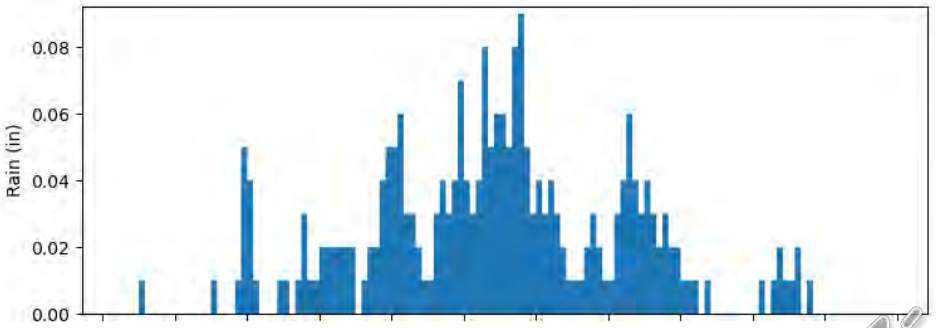
Model may not accurately simulate flows

Location and extent of capacity problems may be incorrect

Wrong solutions may be selected, or solutions may be incorrectly sized

Capital investments may be misspent

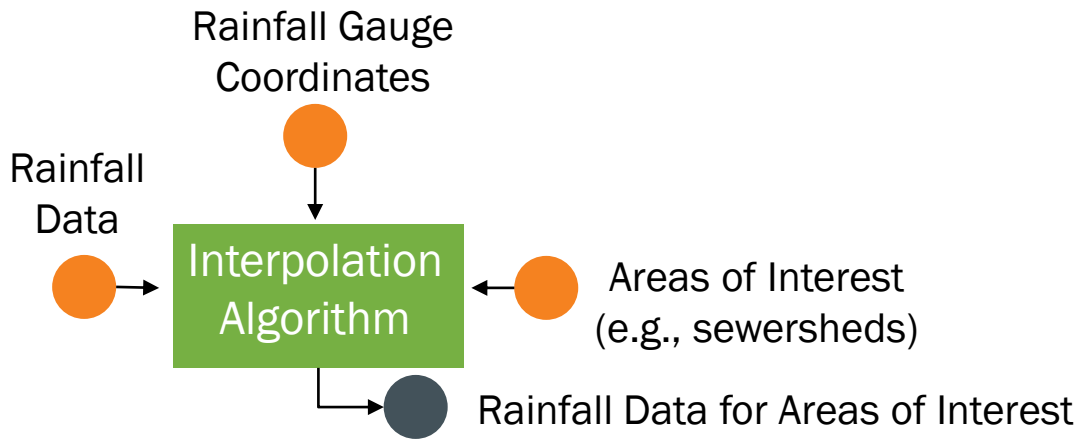
Tipping bucket rain gauge



Evaluation four rainfall estimation techniques

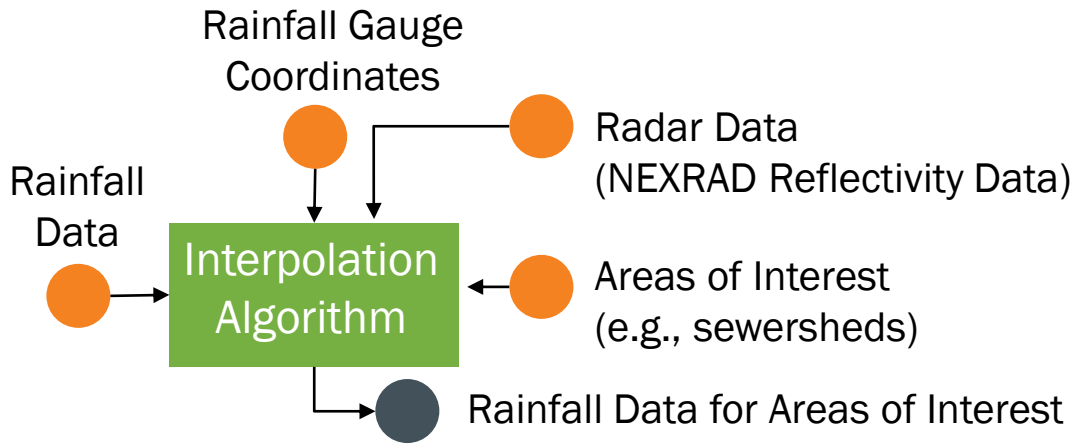
"Pure" Spatial Interpolation:

- Nearest neighbor
- Inverse distance weighting
- Ordinary kriging

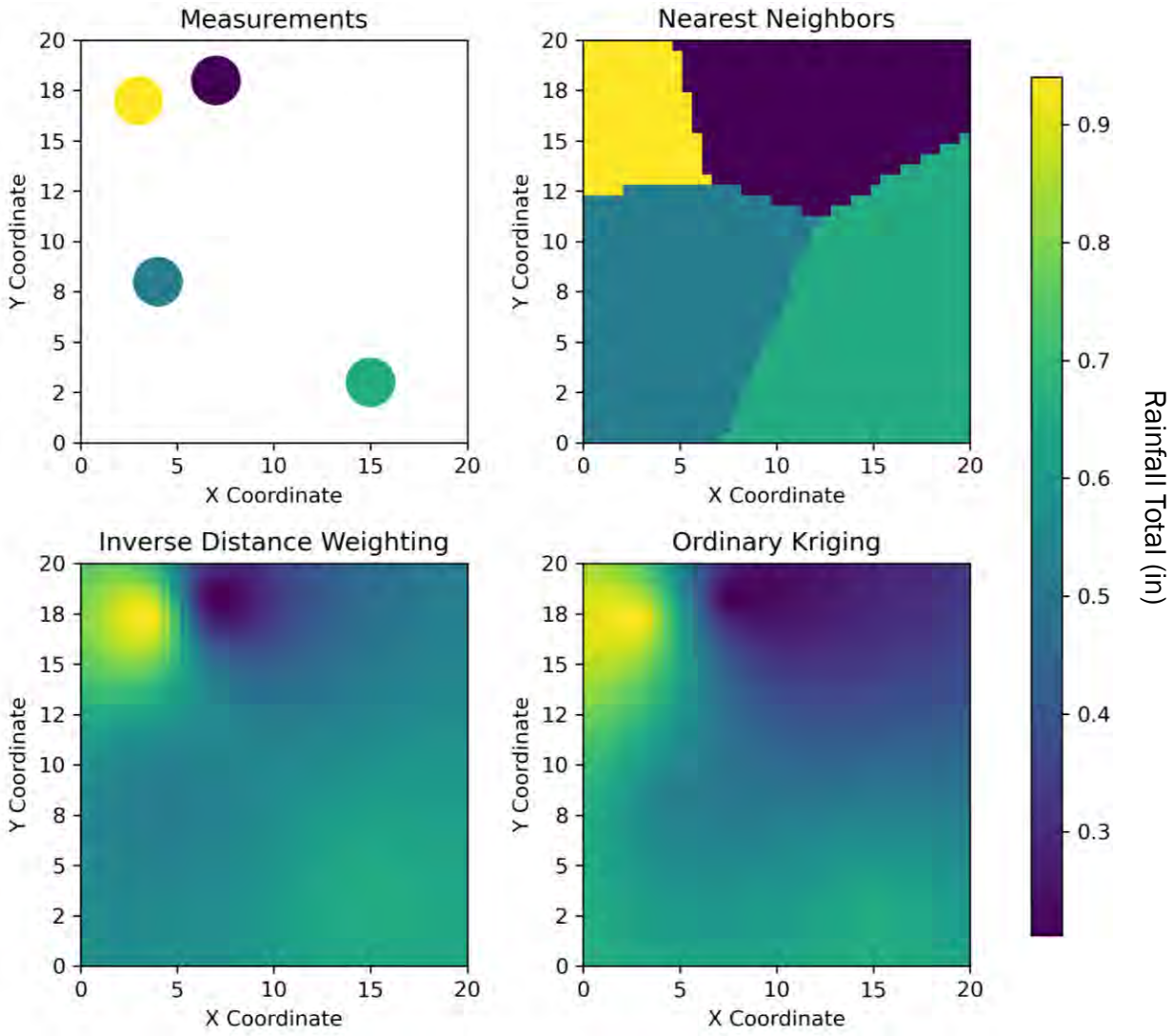


"Radar-Assisted" Spatial Interpolation:

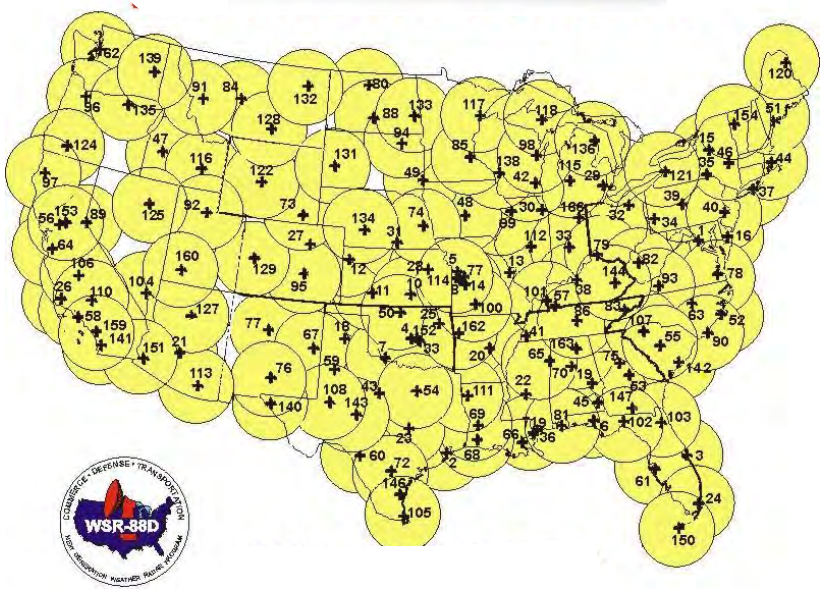
- Gauge Adjusted Radar Rainfall Data



Examples of “Pure” Spatial Interpolation



Gauge Adjusted Radar Rainfall Data uses NEXRAD Reflectivity Data to Assist with Interpolation



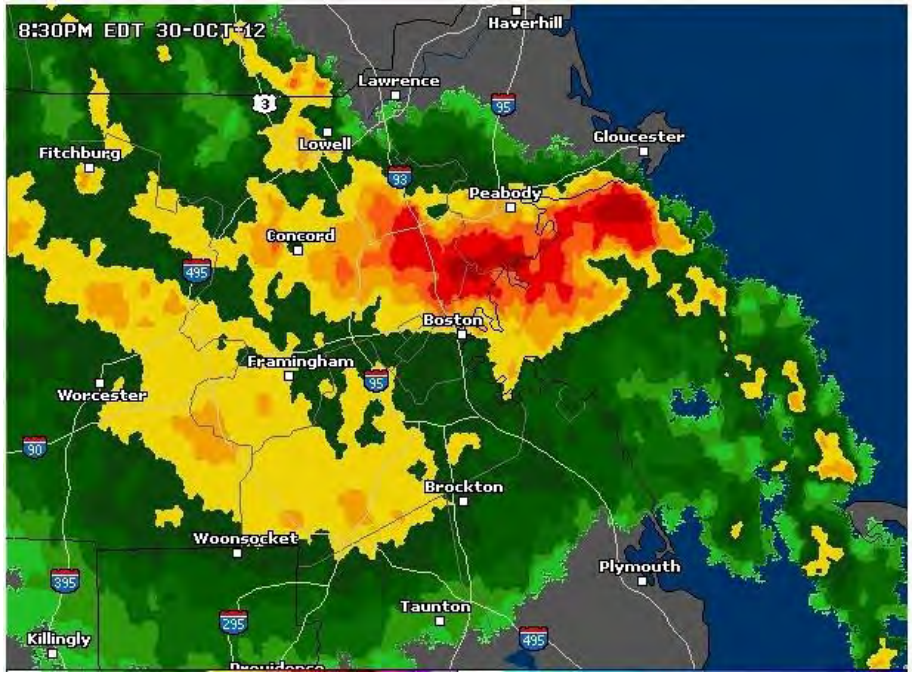
Rainfall Intensity can be estimated from Reflectivity

Marshall Palmer Equation

$Z=aR^b$

Z: rainfall intensity (mm/h)
R: reflectivity (mm^6/mm^3)
a, b: coefficients

Typical values:
a = 200
b = 1.6



- Rainfall calculated using Marshall Palmer Equation is called '**Unadjusted**' rainfall
- Unadjusted rainfall provides good estimate of relative rainfall, but absolute estimate can be inaccurate
- 'Unadjusted' Rainfall data is '**Adjusted**' using rain gauge data (various approaches available)

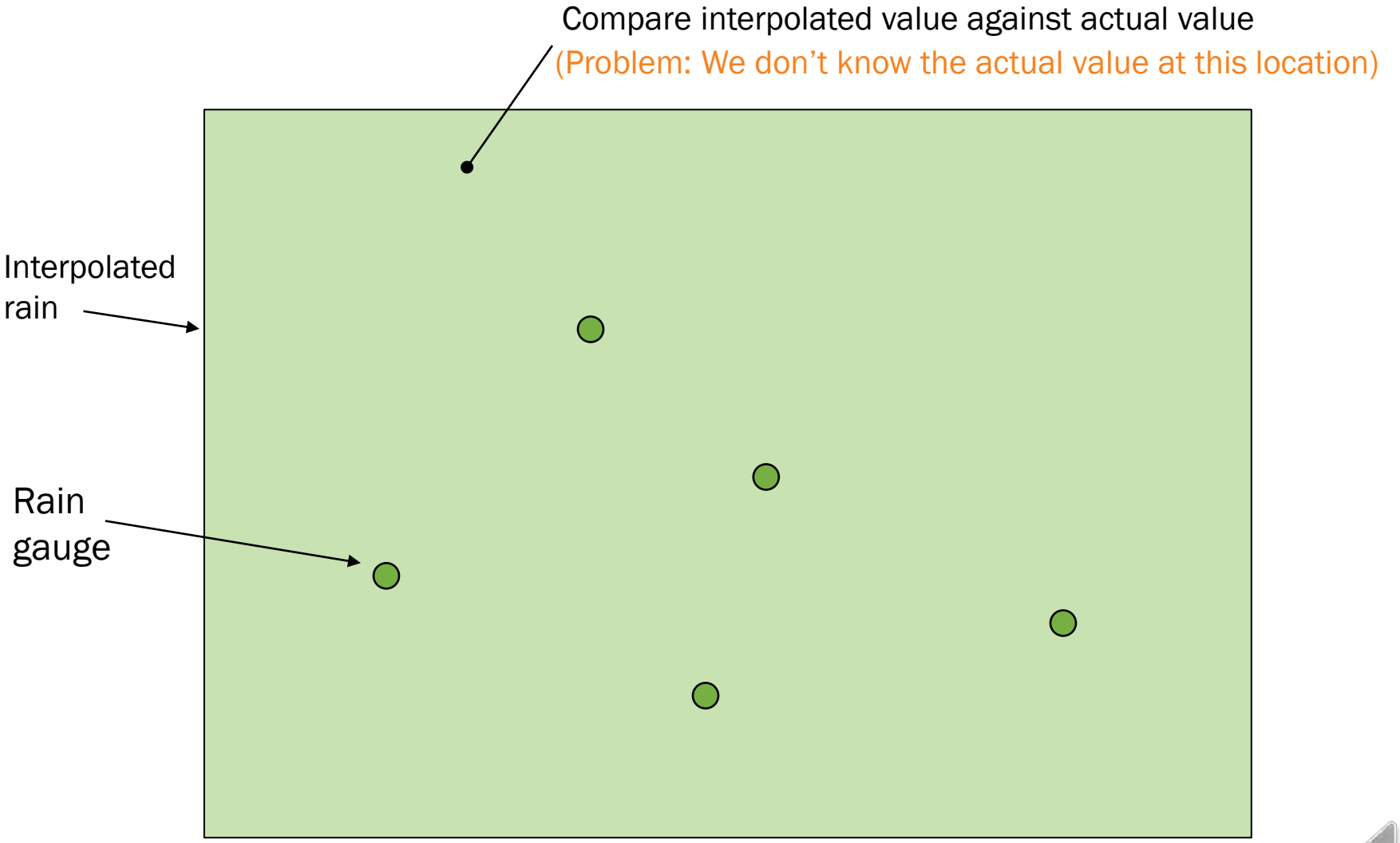
GARR Data combines the strengths of Radar and Ground-Based Rain Gauges

	Radar	Ground-Based Rain Gauges
Spatial Coverage	Excellent	Poor (point-based)
Accuracy of Rainfall Estimates	Poor	Excellent

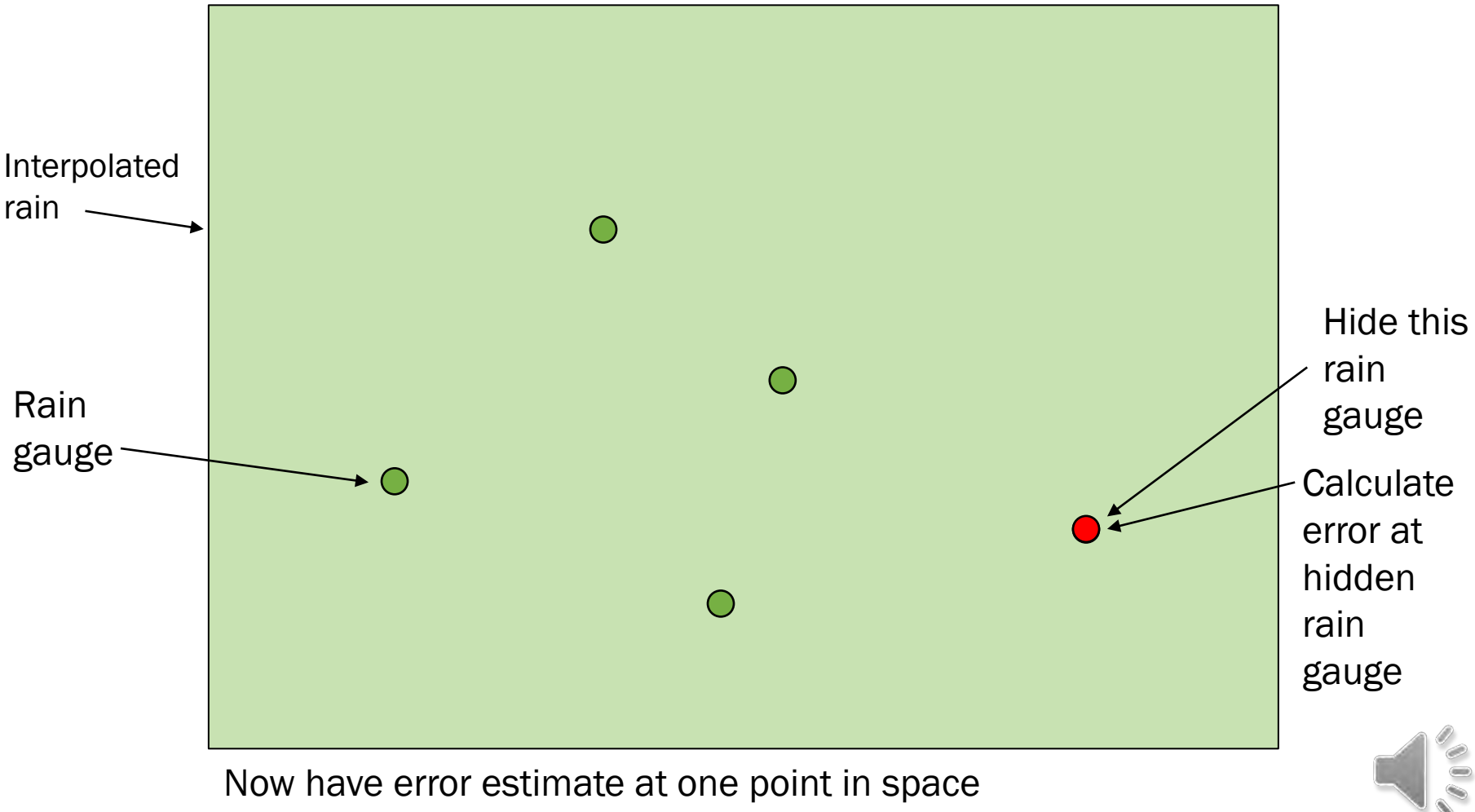
How Accurate are these Spatial Interpolation Methods?

- Nearest neighbor
- Inverse distance weighting
- Ordinary kriging
- Gauge adjusted radar rainfall

How to evaluate accuracy of interpolation methods?

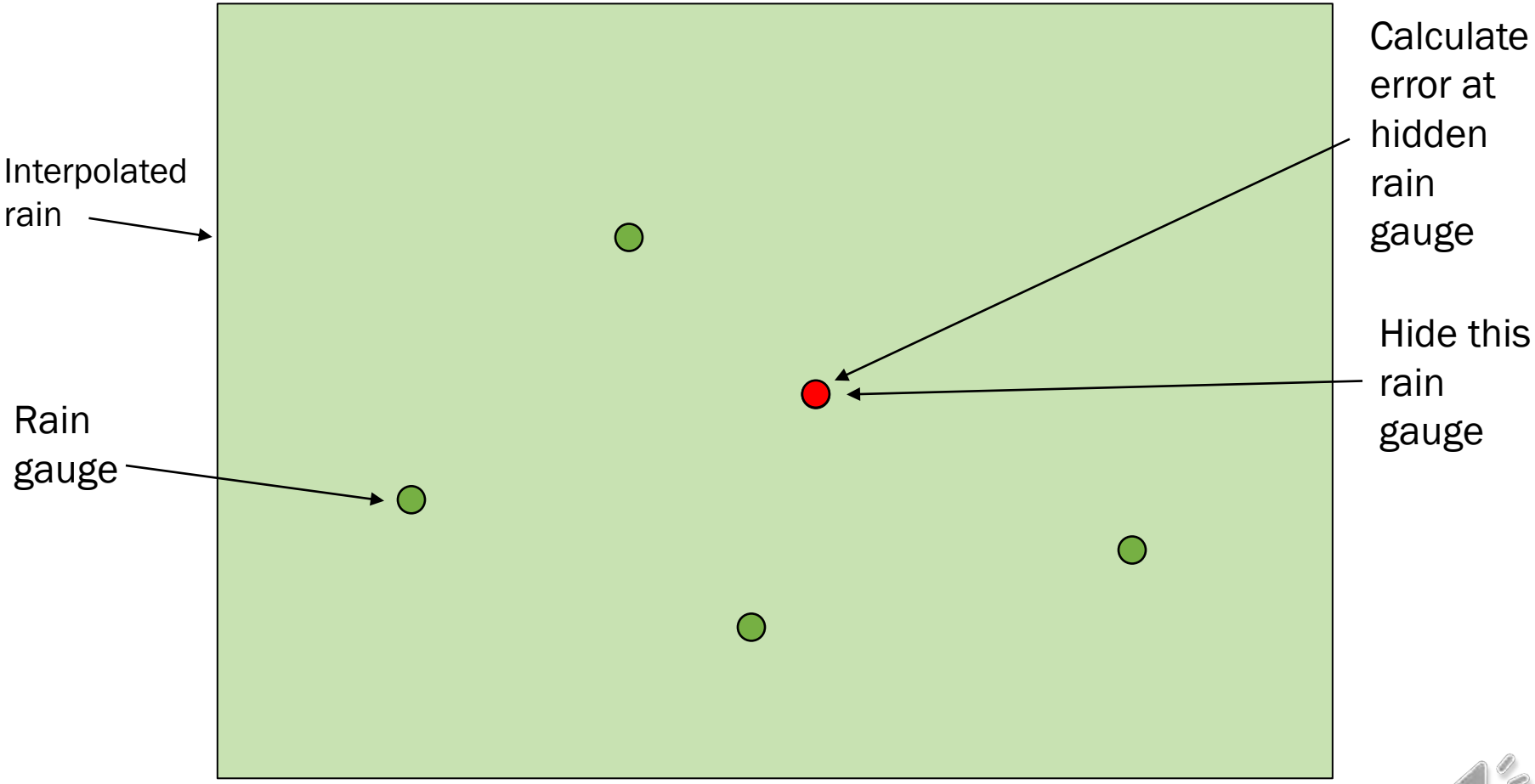


Leave-One-Out Cross-Validation



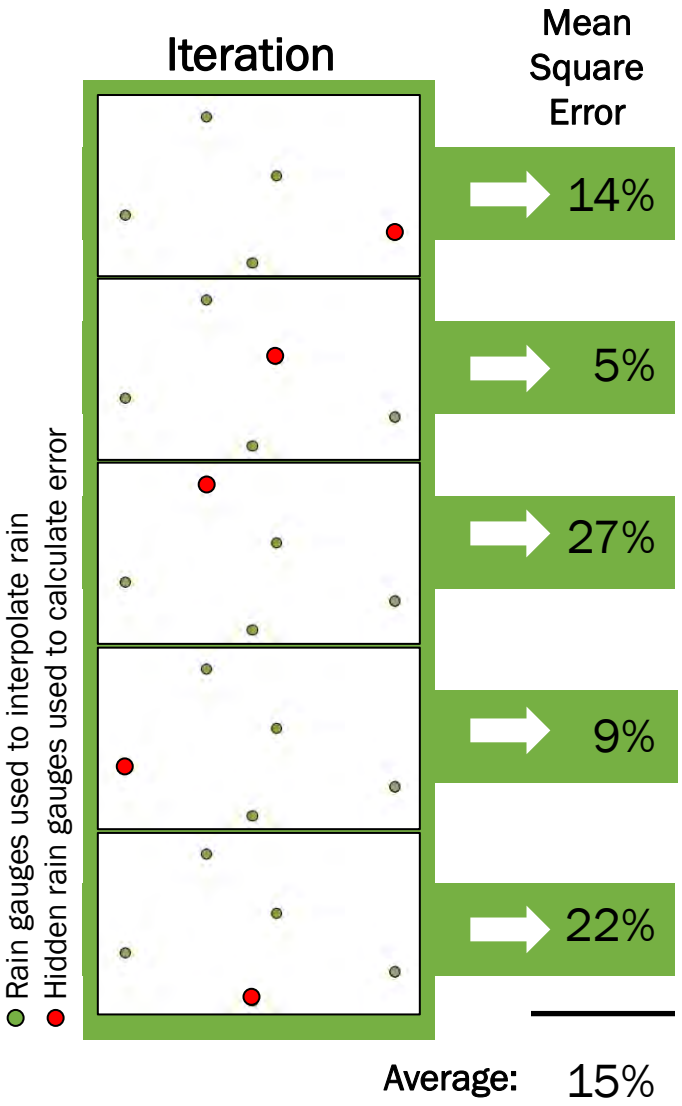
Now have error estimate at one point in space

Leave-One-Out Cross-Validation



Now have error estimate at two points in space

Leave-One-Out Cross-Validation



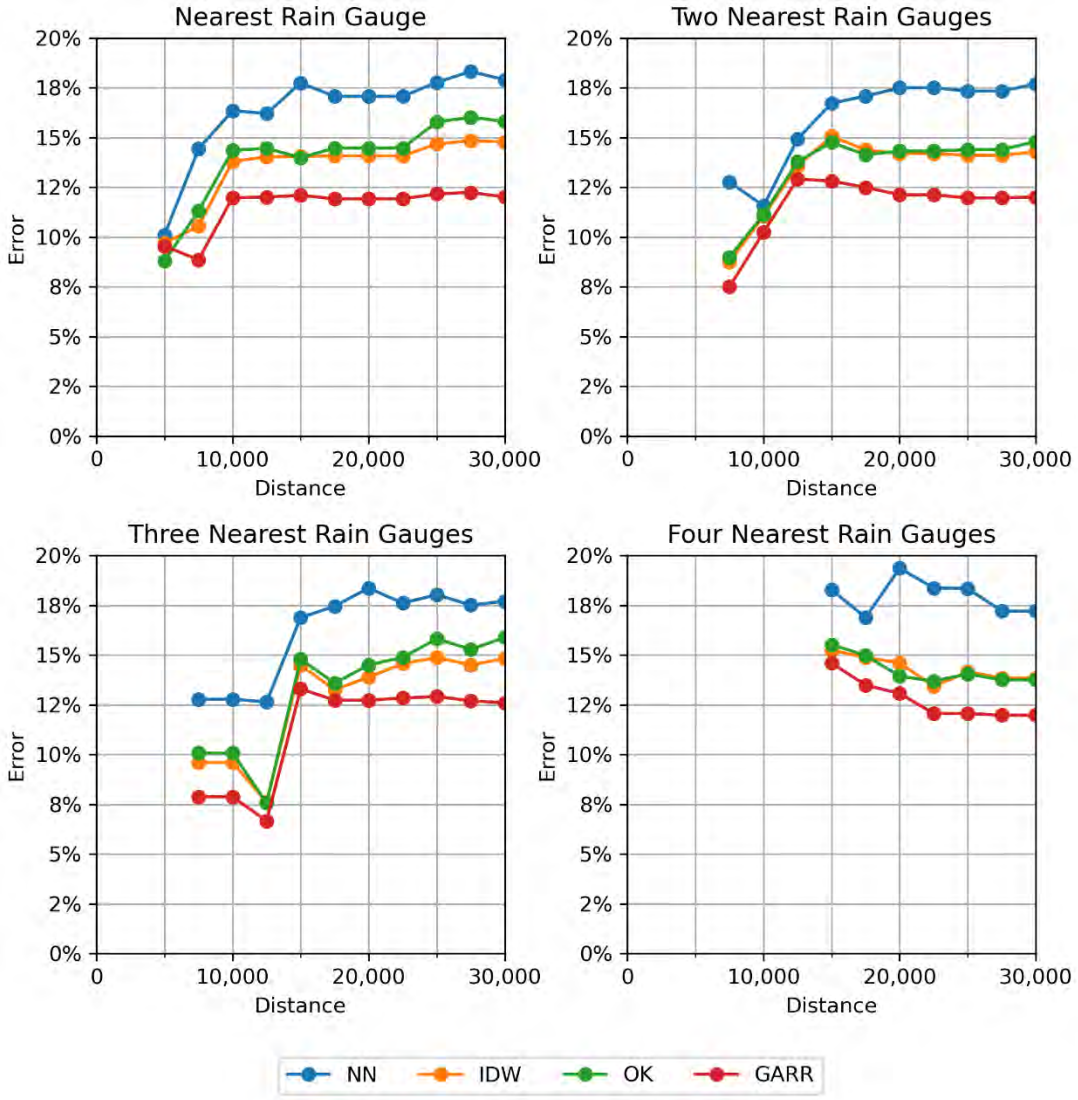
Accuracy of Rainfall Estimation Techniques

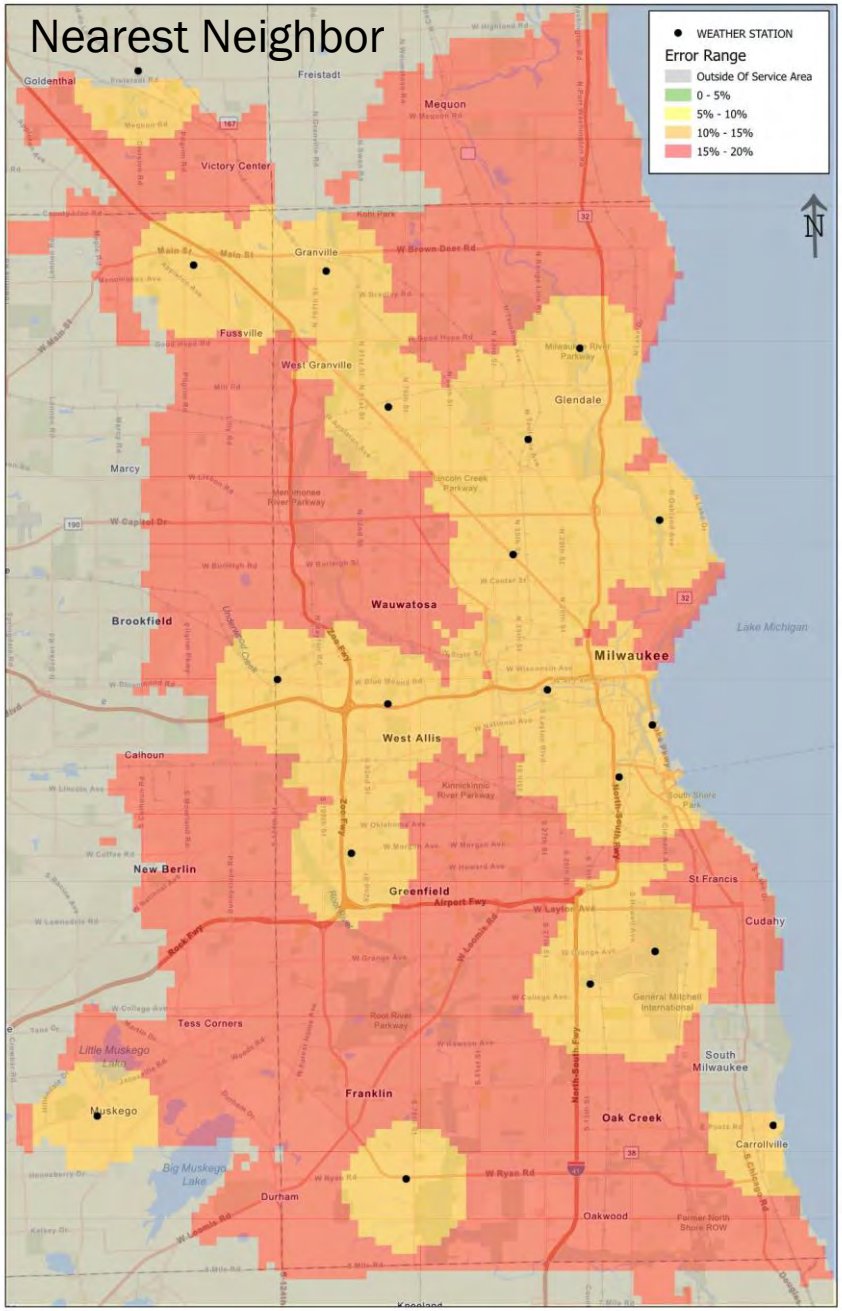
Table 5-1. Rainfall Estimation Results				
Rain Event ID	Error[1]			
	NN	IDW	OK	GARR
1	14.9%	13.9%	21.3%	11.8%
2	34.2%	25.0%	30.3%	16.7%
3	20.0%	19.1%	21.2%	15.9%
4	13.3%	10.3%	11.0%	9.2%
5	15.9%	12.6%	12.0%	11.6%
6	22.9%	20.0%	21.0%	13.8%
7	12.4%	10.8%	9.7%	10.0%
Average	19.1%	15.9%	18.1%	12.7%
Range	12.4%-34.2%	10.3%-25.0%	9.7%-30.3%	9.2%-16.7%

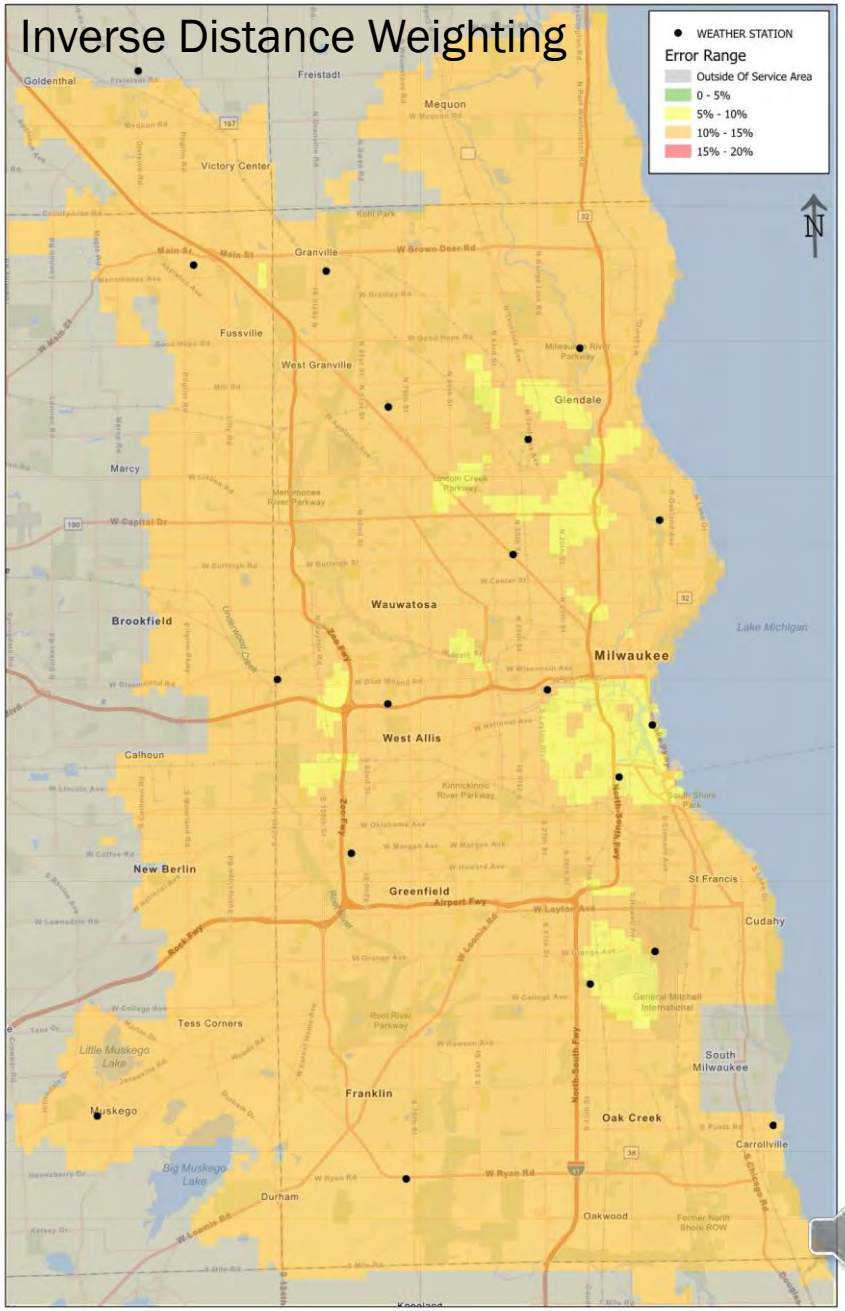
Notes:

1. *Average of the absolute errors from the leave-one-out cross validation.*

Relationships between Accuracy and Distance to Nearby Rain Gauges




Nearest Neighbor
WEATHER STATION
Error Range
Outside Of Service Area
0 - 5%
5% - 10%
10% - 15%
15% - 20%
N
Goldenthal
Freistadt
Mequon
Victory Center
Granville
Fussville
West Granville
Glendale
Marcy
Brookfield
Wauwatosa
Milwaukee
Lake Michigan
West Allis
Calhoun
New Berlin
Greenfield
St Francis
Cudahy
Tess Corners
Little Muskego Lake
Muskego
Franklin
South Milwaukee
Oak Creek
Carrollville
Big Muskego Lake
Durham
Oakwood


Inverse Distance Weighting
WEATHER STATION
Error Range
Outside Of Service Area
0 - 5%
5% - 10%
10% - 15%
15% - 20%
N
Goldenthal
Freistadt
Mequon
Victory Center
Granville
Fussville
West Granville
Glendale
Marcy
Brookfield
Wauwatosa
Milwaukee
Lake Michigan
West Allis
Calhoun
New Berlin
Greenfield
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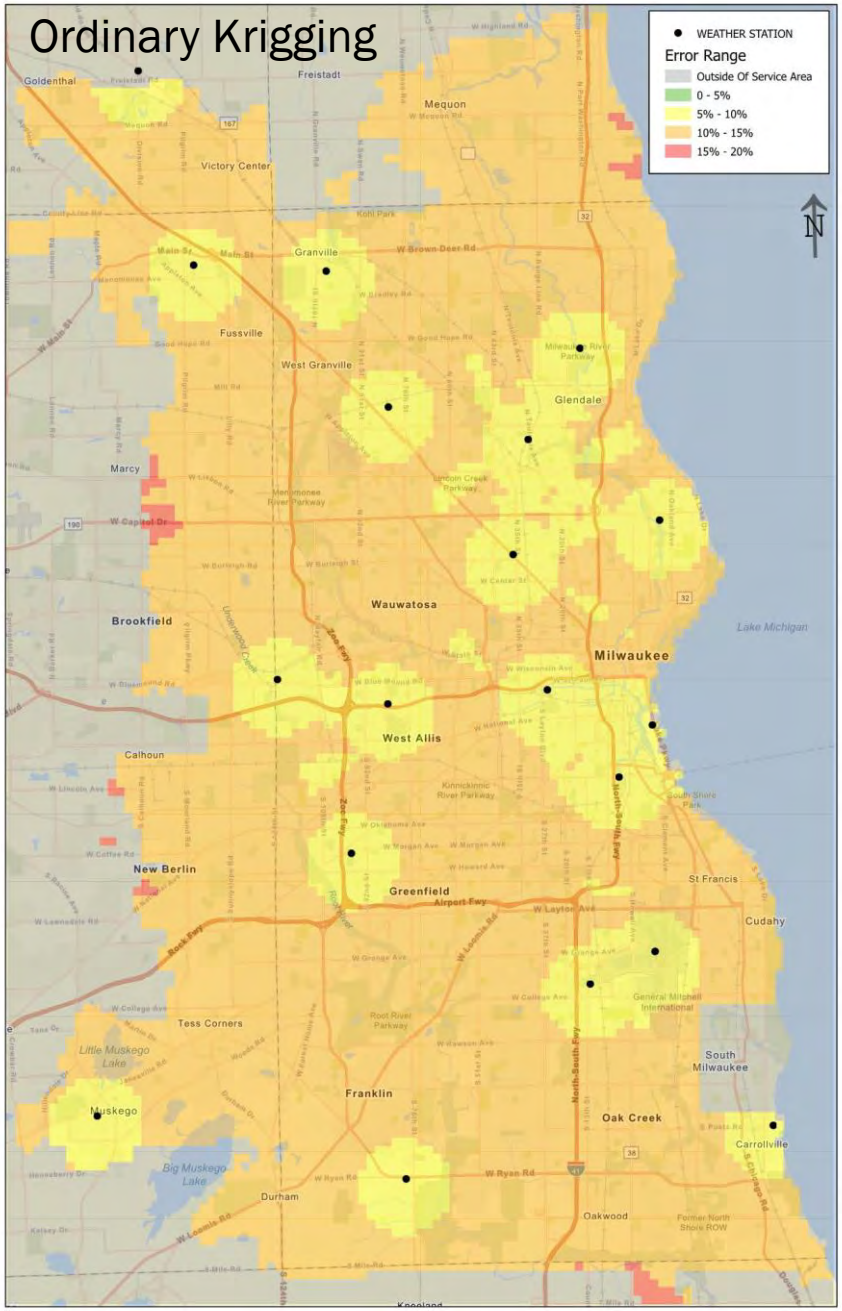
Ordinary Krigging
WEATHER STATION
Error Range
Outside Of Service Area
0 - 5%
5% - 10%
10% - 15%
15% - 20%
N
Goldenthal
Freistadt
Mequon
Victory Center
Granville
Fussville
West Granville
Glendale
Marcy
Brookfield
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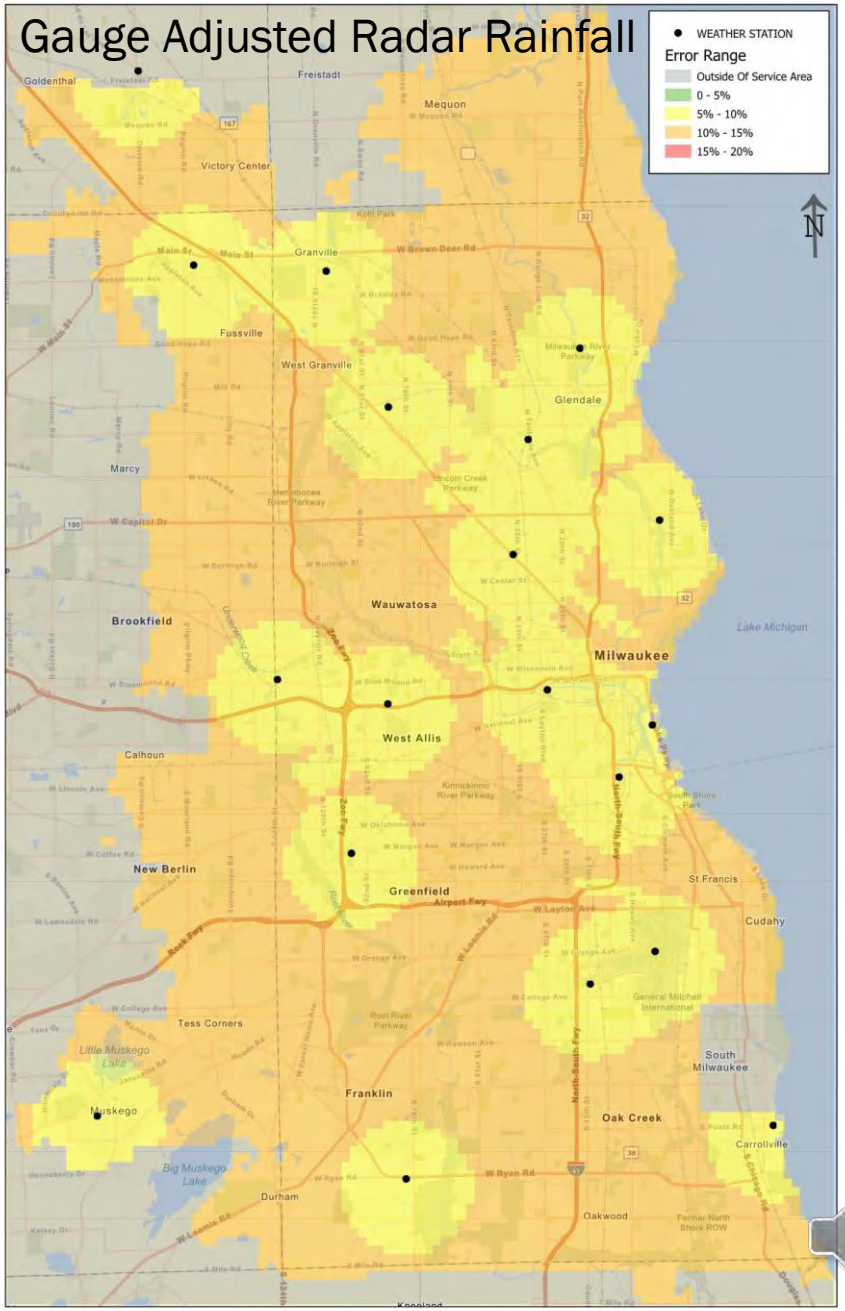
Gauge Adjusted Radar Rainfall
WEATHER STATION
Error Range
Outside Of Service Area
0 - 5%
5% - 10%
10% - 15%
15% - 20%
N
Goldenthal
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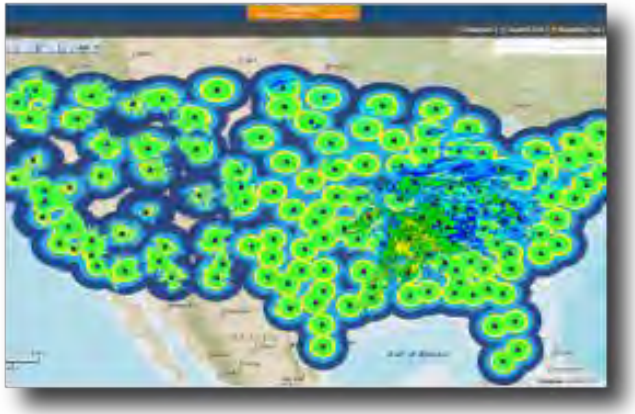
Oakwood

Level of Effort

Rainfall Estimation Technique	Approximate Time for Generate Hyetographs for Each Rainfall Event
Nearest Neighbor	1.5 minutes
Inverse Distance Weighting	1.5 minutes
Ordinary Kriging	5 hours
Gauge Adjusted Radar Rainfall	2 hours

How to get GARR data?

- Write Your Own Code with Python libraries
  - **Pyart** – Library for working with NEXRAD data
  - **wradlib** – Library for calibrating gauge rainfall and NEXRAD reflectivity data
  - **nexradaws** – Library for downloading NEXRAD data from Amazon web service



- Software
  - CALAMAR (RHEA SAS – KISTERS Group)
  - InfoWorks ICM (Innovyze)
  - PCSWMM (CHI)
- Service providers
  - Vieux and Associates
  - One Rain

Thank you.
Questions?

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