Making AERSURFACE "Hit the Mark"

Connecticut Department of
ENERGY &
ENVIRONMENTAL
PROTECTION

Making AERSURFACE "Hit the Mark"

A Geometric Approach to Classifying Sectors As Airport or Non-Airport

June 22, 2021

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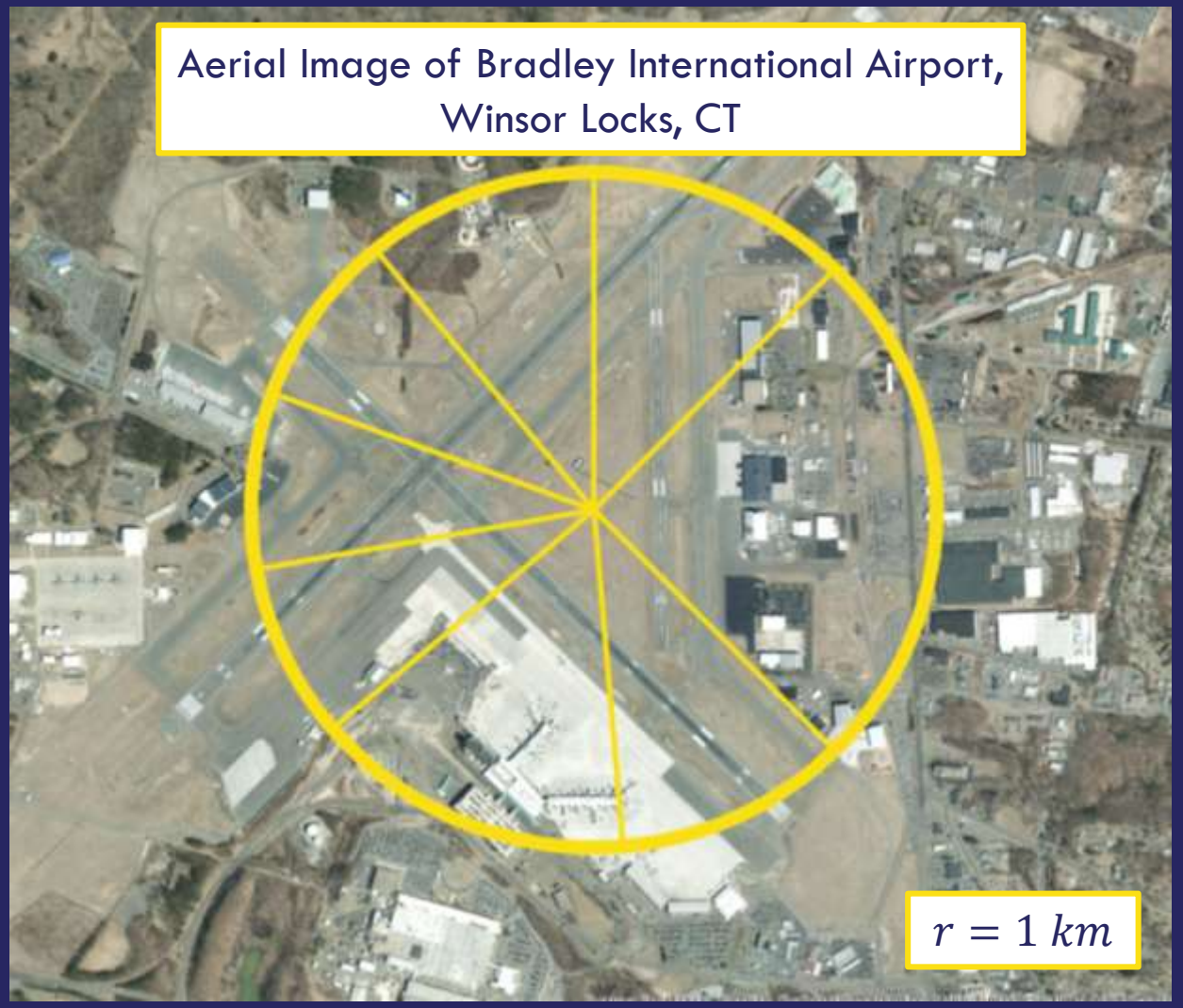
Connecticut Department of Energy & Environmental Department

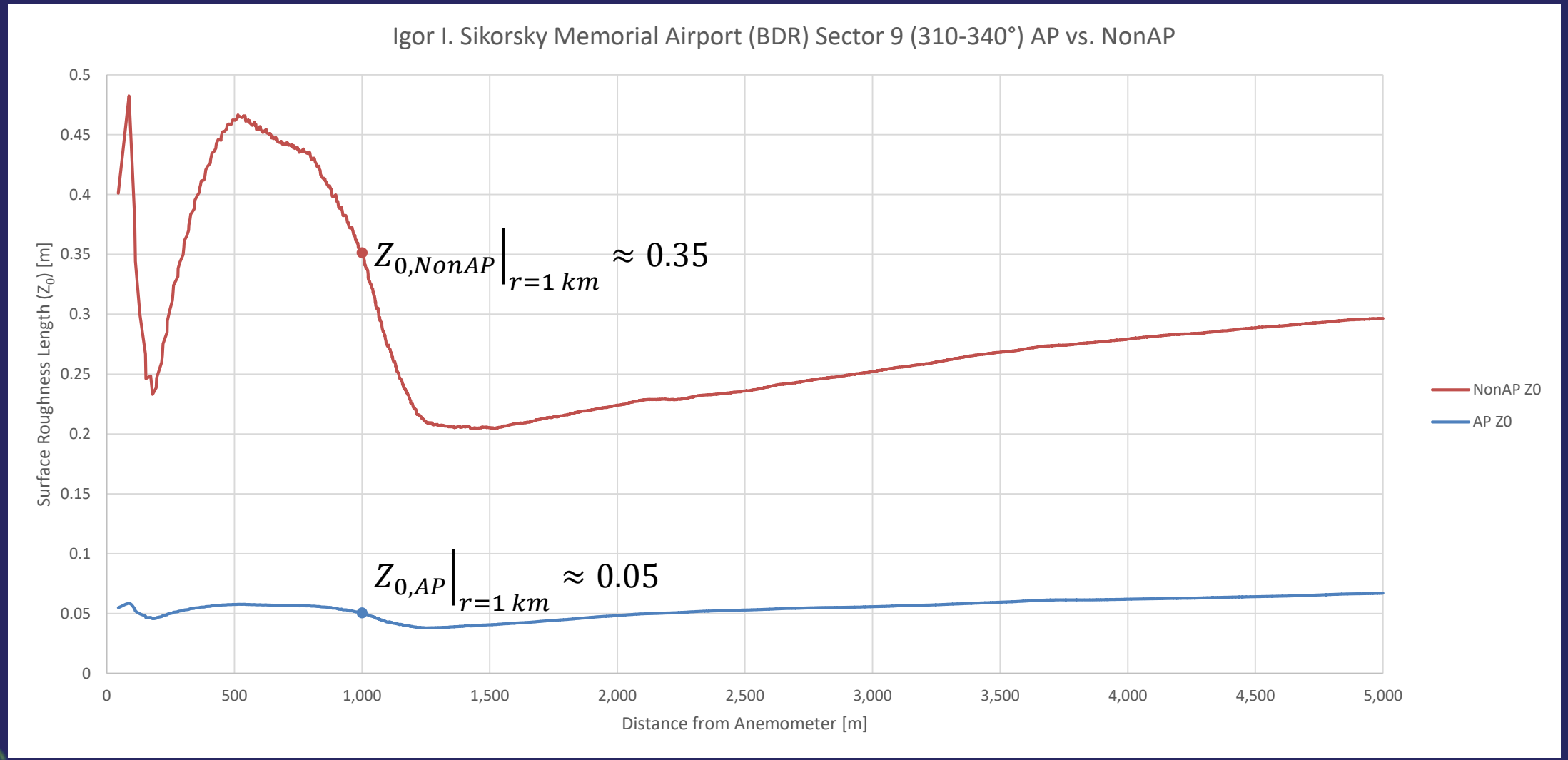
EPA Regional/State/Local Dispersion Modelers' Workshop

Methodology for Characterizing AERSURFACE Sectors

- Subjective Classifications of Airport and Non-Airport
- Necessity for a standard classification method



The Effect of Accurate Classification



Airport vs. Non-Airport Locations

- Discussed in Section 2.3.2 of the User's Guide

Airport

- "AERSURFACE assumes airports have lower roughness due to the presence of roads, runways, and other paved surfaces"

Non-Airport

- "… assumed to have higher roughness due to the presence of… buildings (i.e., lesser coverage of hard smooth surfaces at ground-level)."

- "A sector can be identified as airport or non-airport **independently** of whether the meteorological tower is physically located at an airport…"

How Should This Sector Be Classified?

- Apply definitions of Airport and Non-Airport
- What if there are both in a sector?

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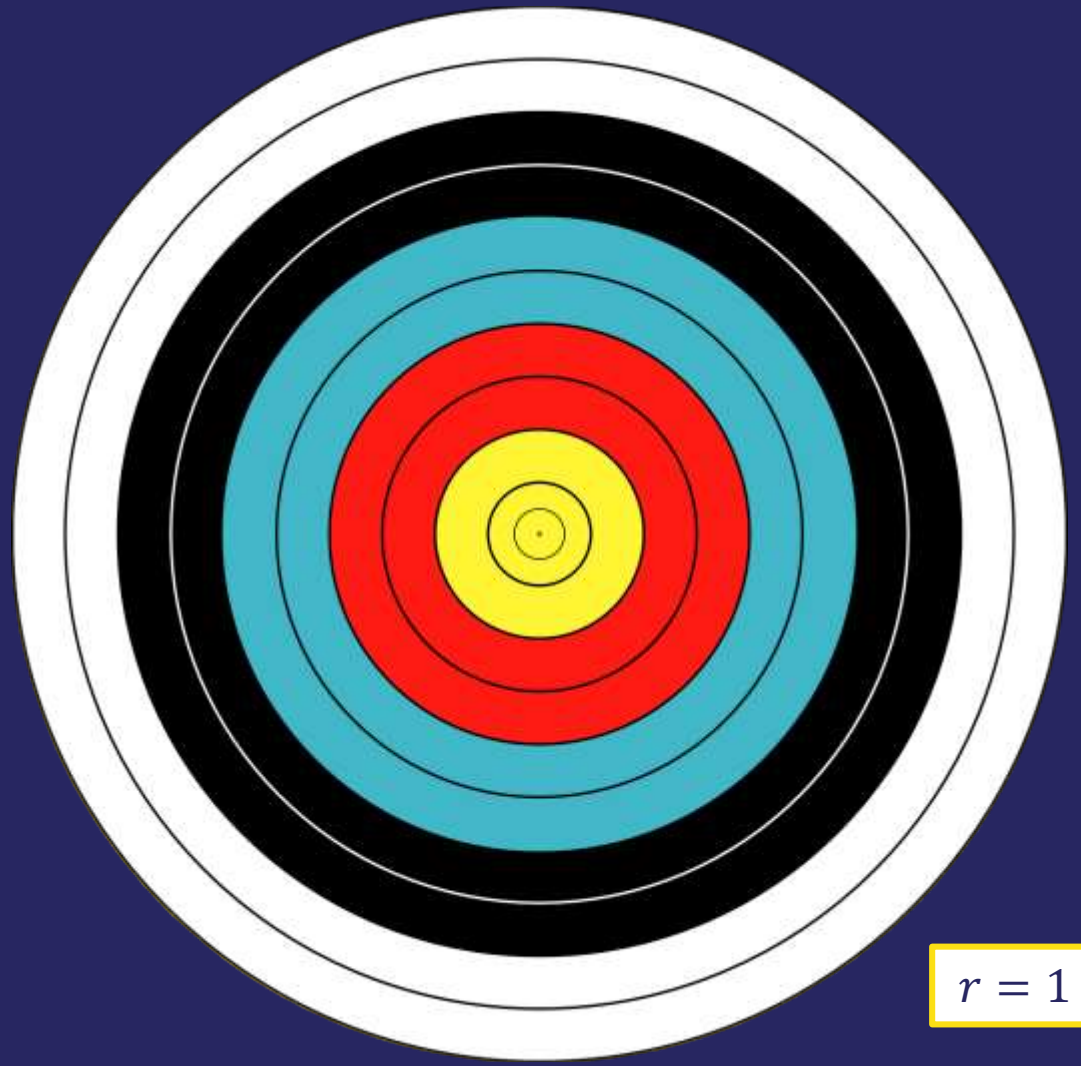
- What if there are both in a sector?
- Imagine an archery target overlaid on the airport



$r = 1\ km$

How Should This Sector Be Classified?

- Apply definitions of Airport and Non-Airport
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- Imagine an archery target overlaid on the airport

Mathematical Basis of Z0RAD

Equation 1 as found on page 2-17 of the User's Guide for AERSURFACE:

$$\overline{Z_0} = exp\left\{\frac{\sum_{i=1}^{n}\left[\frac{1}{{d_i}^p} * \ln(Z_{0_i})\right]}{\sum_{i=1}^{n}\frac{1}{{d_i}^p}}\right\}$$

- Where:
  - $\overline{Z_0}$: Inverse distance-weighted geometric mean of surface roughness length
  - Z_{0_i}: Surface Roughness Length for individual grid cell i
  - n: Total number of grid cells over which the geometric mean is computed
  - i: One of n grid cells
  - d_i: Distance between the center of the i^{th} grid cell and the meteorological tower
  - p: Weighting factor for distance. Set equal to 1.

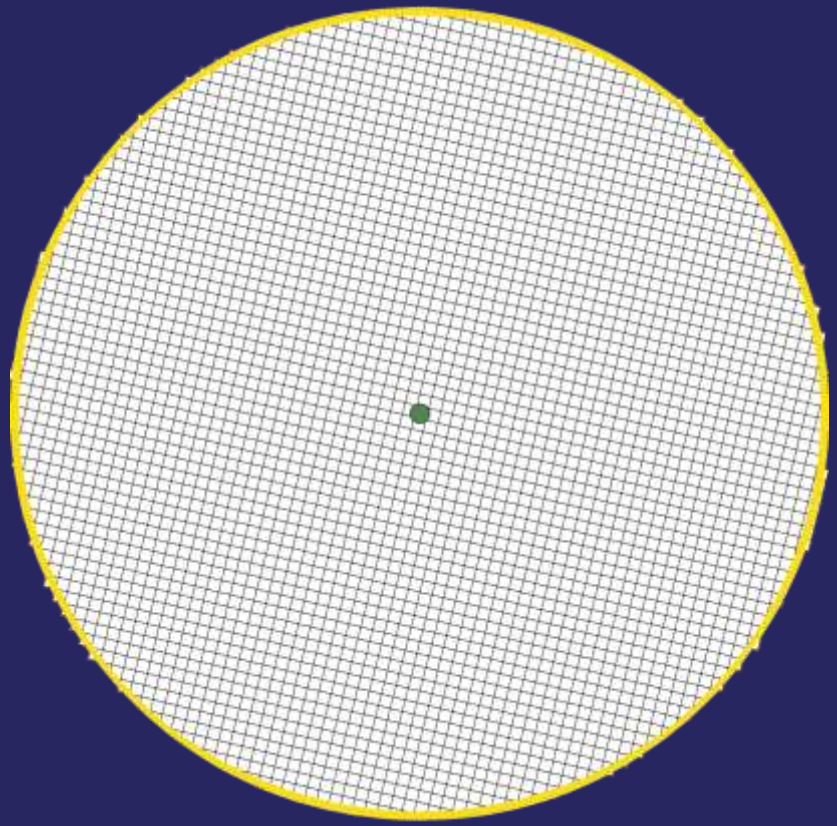
Evaluating the Summation Terms in Equation 1

- Because $p = 1, \frac{1}{d_i^p} = \frac{1}{d_i}$

$$\sum_{i=1}^{n} \frac{1}{d_i} = \frac{1}{d_1} + \frac{1}{d_2} + \cdots + \frac{1}{d_{n-1}} + \frac{1}{d_n}$$

Where

- $0 < d_i \leq ZORAD$



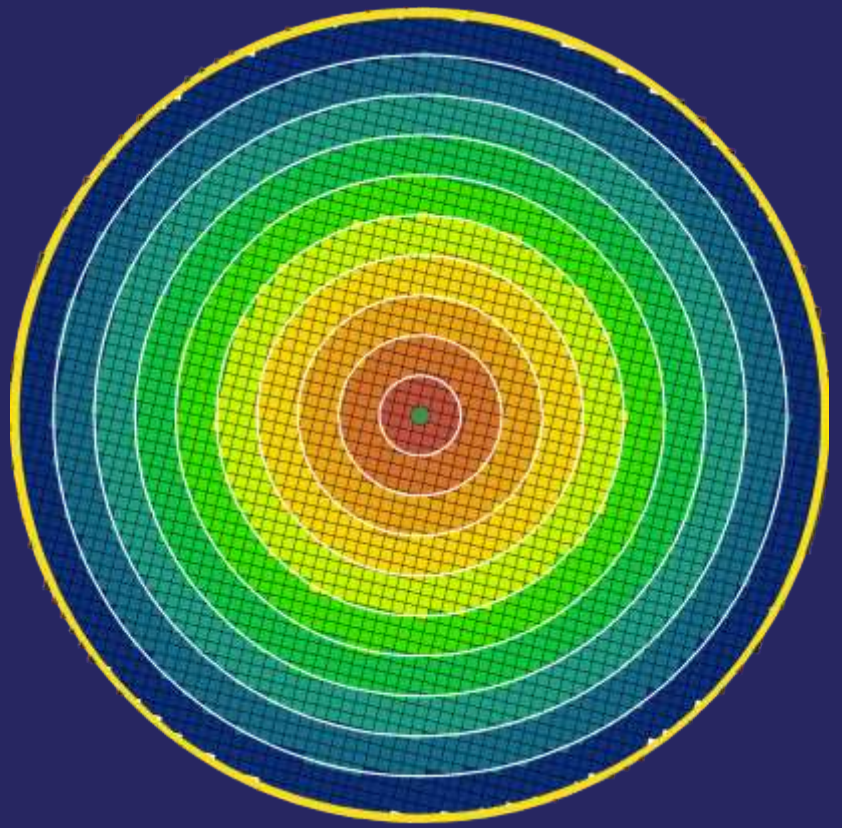
Let's separate $\sum_{i=1}^{n} \frac{1}{d_i}$ into evenly-spaced concentric rings of thickness t

$$\sum_{i=1}^{n} \frac{1}{d_i} = \left(\frac{1}{d_1} + \cdots + \frac{1}{d_j}\right) + \left(\frac{1}{d_k} + \cdots + \frac{1}{d_l}\right) + \cdots + \left(\frac{1}{d_m} + \cdots + \frac{1}{d_n}\right)$$

Where

- $0 < d_1, d_j \leq t$
- $t < d_k, d_l \leq 2t$
- $Z0RAD - t < d_m, d_n \leq Z0RAD$

$$\sum_{i=1}^{n} \frac{1}{d_i} = \sum_{i=1}^{j} \frac{1}{d_i} + \sum_{i=k}^{l} \frac{1}{d_i} + \cdots + \sum_{i=m}^{n} \frac{1}{d_i}$$



Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

37

Annular Ring
0 - 100 m
100 - 200 m
200 - 300 m
300 - 400 m
400 - 500 m
500 - 600 m
600 - 700 m
700 - 800 m
800 - 900 m
900 - 1,000 m

Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

103

Annular Ring
0 - 100 m
100 - 200 m
200 - 300 m
300 - 400 m
400 - 500 m
500 - 600 m
600 - 700 m
700 - 800 m
800 - 900 m
900 - 1,000 m

Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

173

Annular Ring
0 - 100 m
100 - 200 m
200 - 300 m
300 - 400 m
400 - 500 m
500 - 600 m
600 - 700 m
700 - 800 m
800 - 900 m
900 - 1,000 m

Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

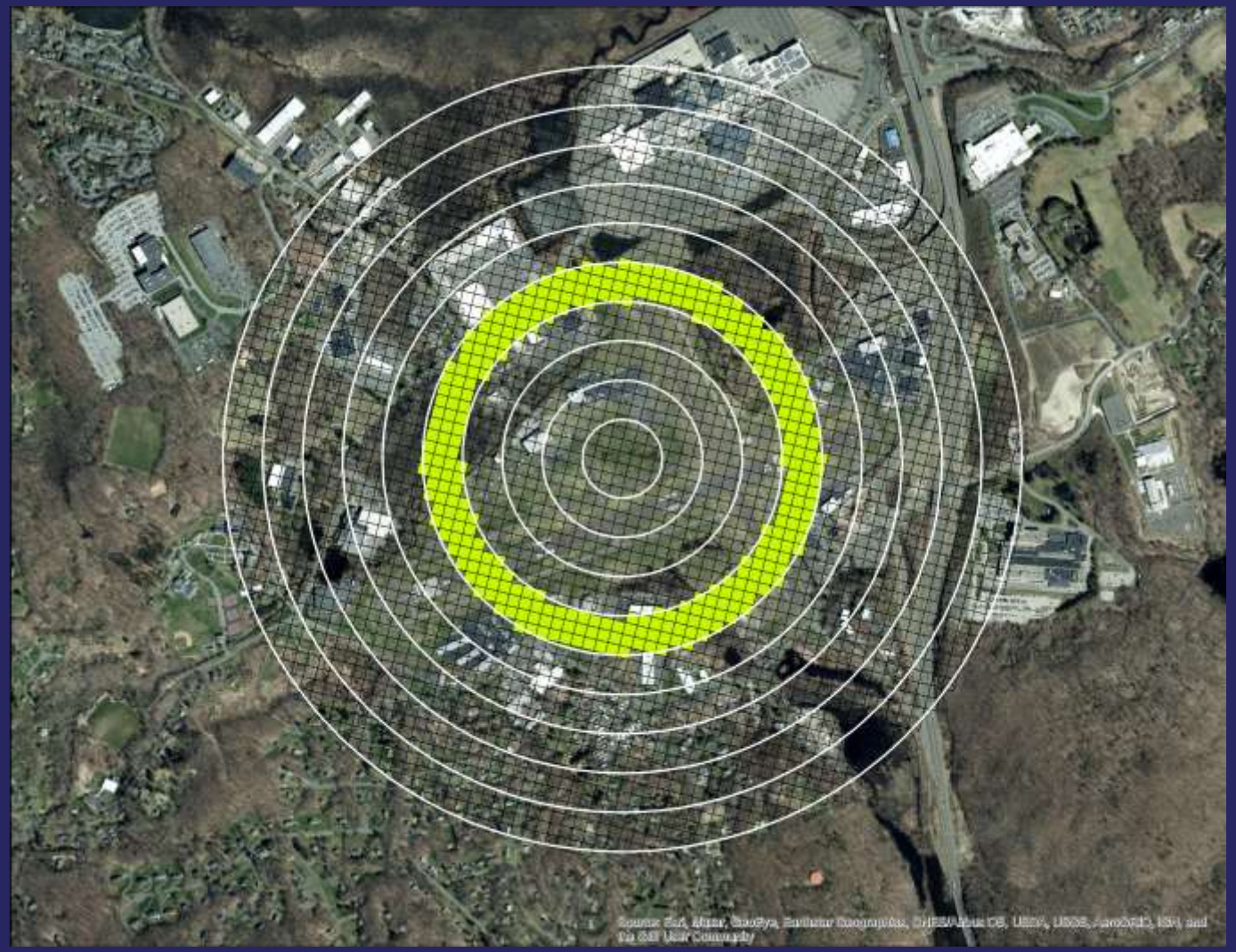
248

Annular Ring
0 - 100 m
100 - 200 m
200 - 300 m
300 - 400 m
400 - 500 m
500 - 600 m
600 - 700 m
700 - 800 m
800 - 900 m
900 - 1,000 m

Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

313



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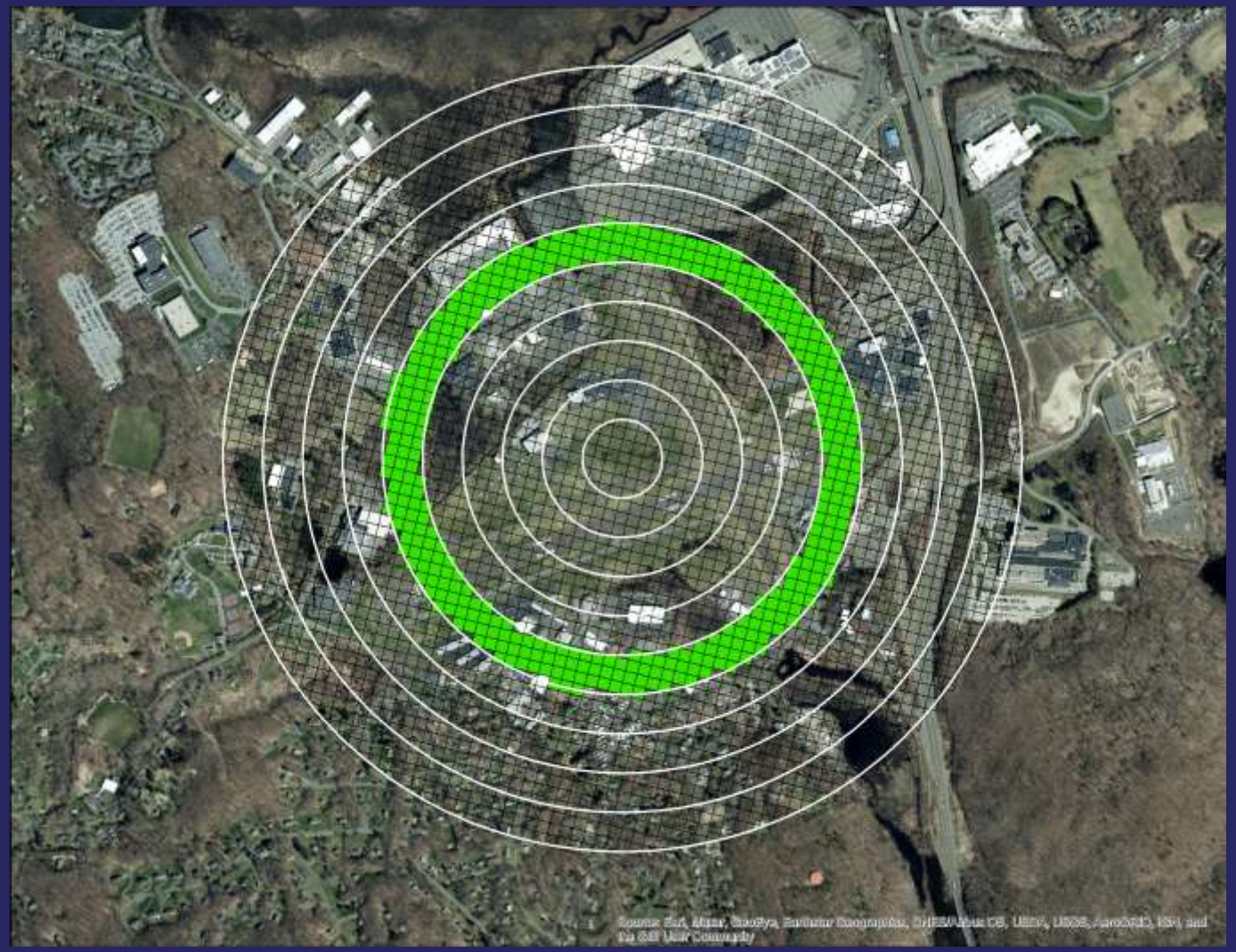
Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

381



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100 - 200 m
200 - 300 m
300 - 400 m
400 - 500 m
500 - 600 m
600 - 700 m
700 - 800 m
800 - 900 m
900 - 1,000 m

Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

460

Annular Ring
0 - 100 m
100 - 200 m
200 - 300 m
300 - 400 m
400 - 500 m
500 - 600 m
600 - 700 m
700 - 800 m
800 - 900 m
900 - 1,000 m

Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

517

Annular Ring
0 - 100 m
100 - 200 m
200 - 300 m
300 - 400 m
400 - 500 m
500 - 600 m
600 - 700 m
700 - 800 m
800 - 900 m
900 - 1,000 m

Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

596

Annular Ring
0 - 100 m
100 - 200 m
200 - 300 m
300 - 400 m
400 - 500 m
500 - 600 m
600 - 700 m
700 - 800 m
800 - 900 m
900 - 1,000 m

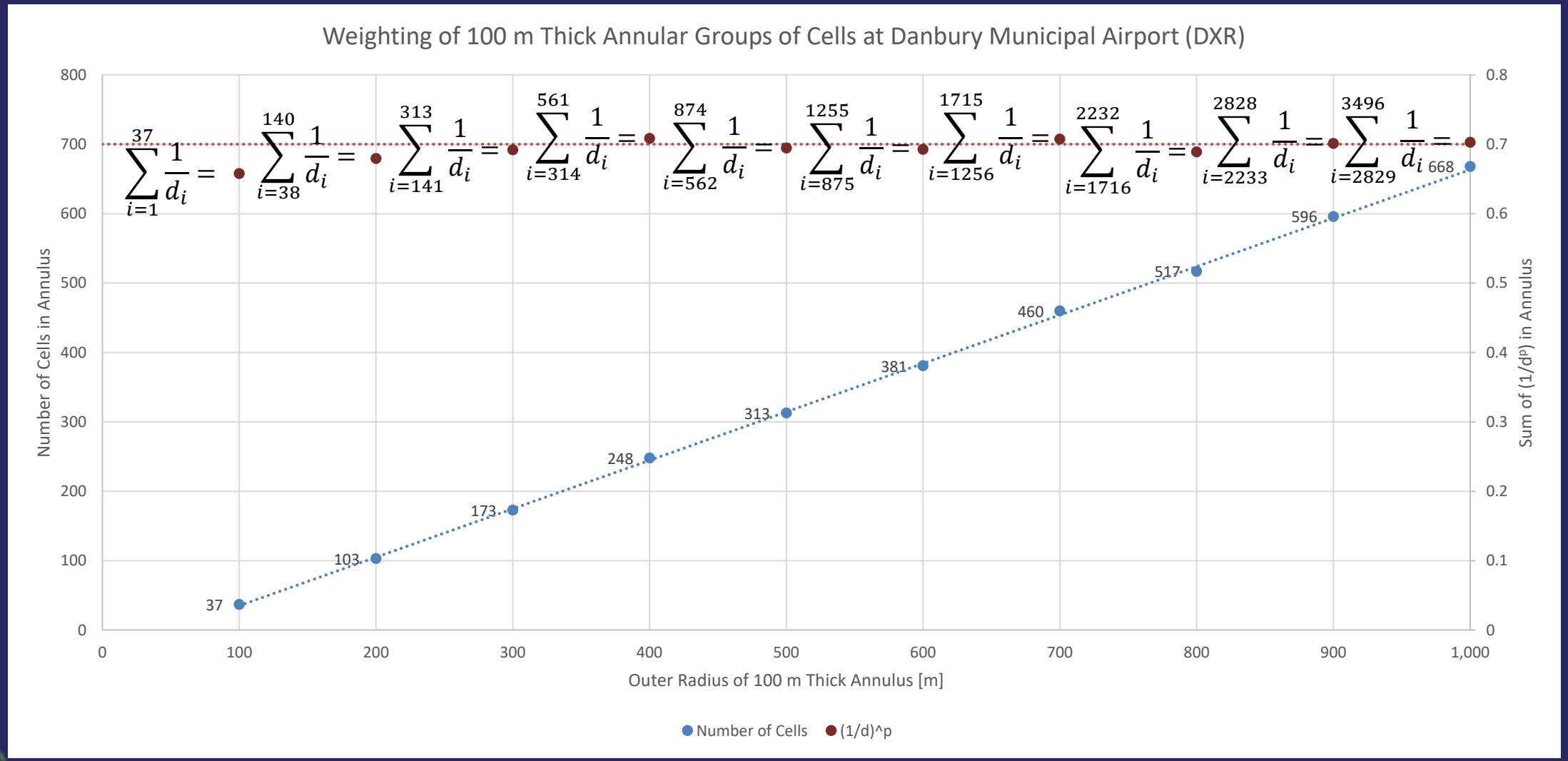
Visual Representation of Inverse Weighting

Number of Cells in Annular Ring:

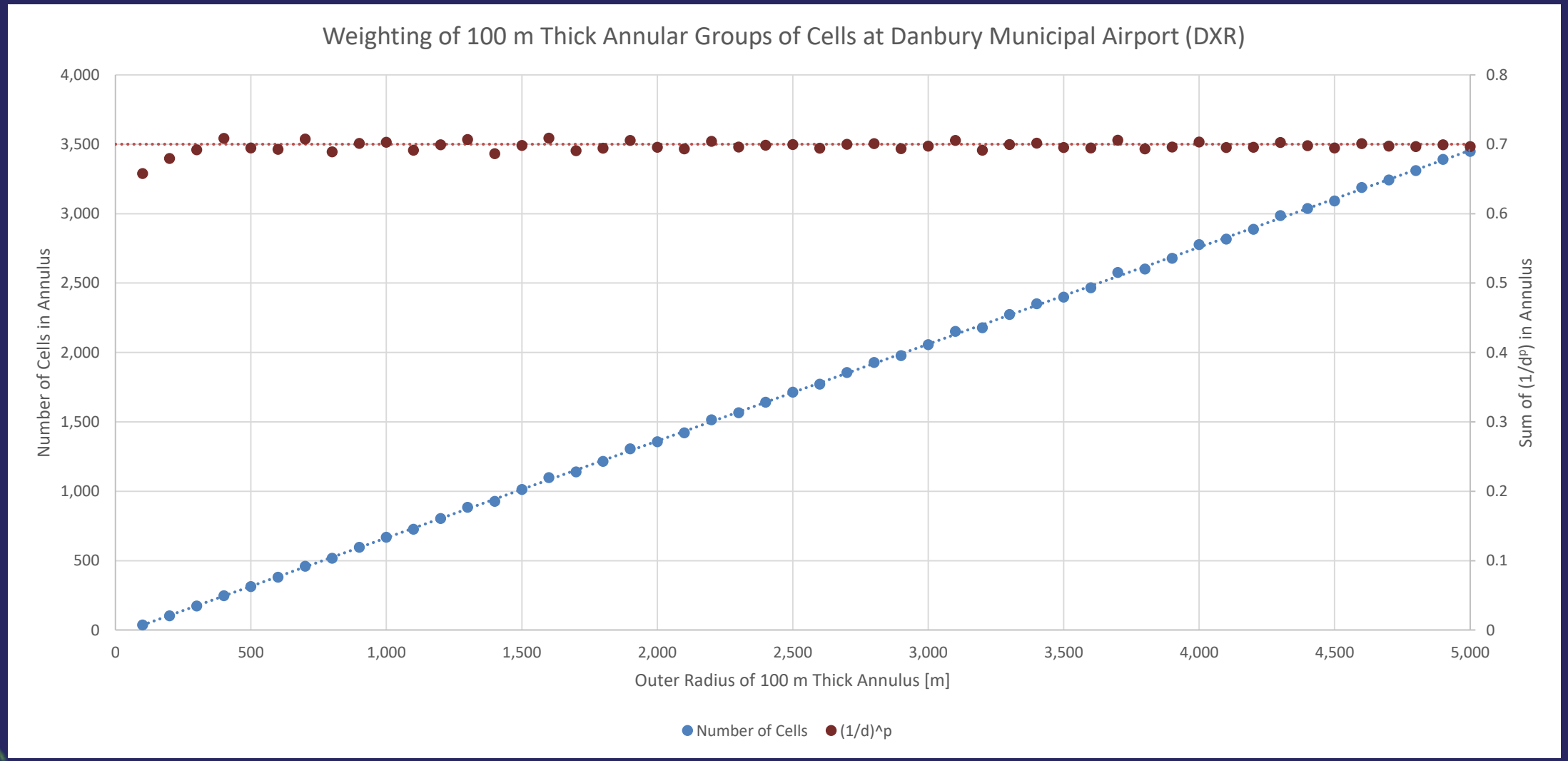
668

Annular Ring
0 - 100 m
100 - 200 m
200 - 300 m
300 - 400 m
400 - 500 m
500 - 600 m
600 - 700 m
700 - 800 m
800 - 900 m
900 - 1,000 m

Graphical Representation of Inverse Weighting



Graphical Representation of Inverse Weighting



Takeaways of the Annular Ring Approach

- If $p = 1$, proportionally sized groups of cells have EQUAL weight!
- Provides a quantitative, not subjective, method for classifying sectors

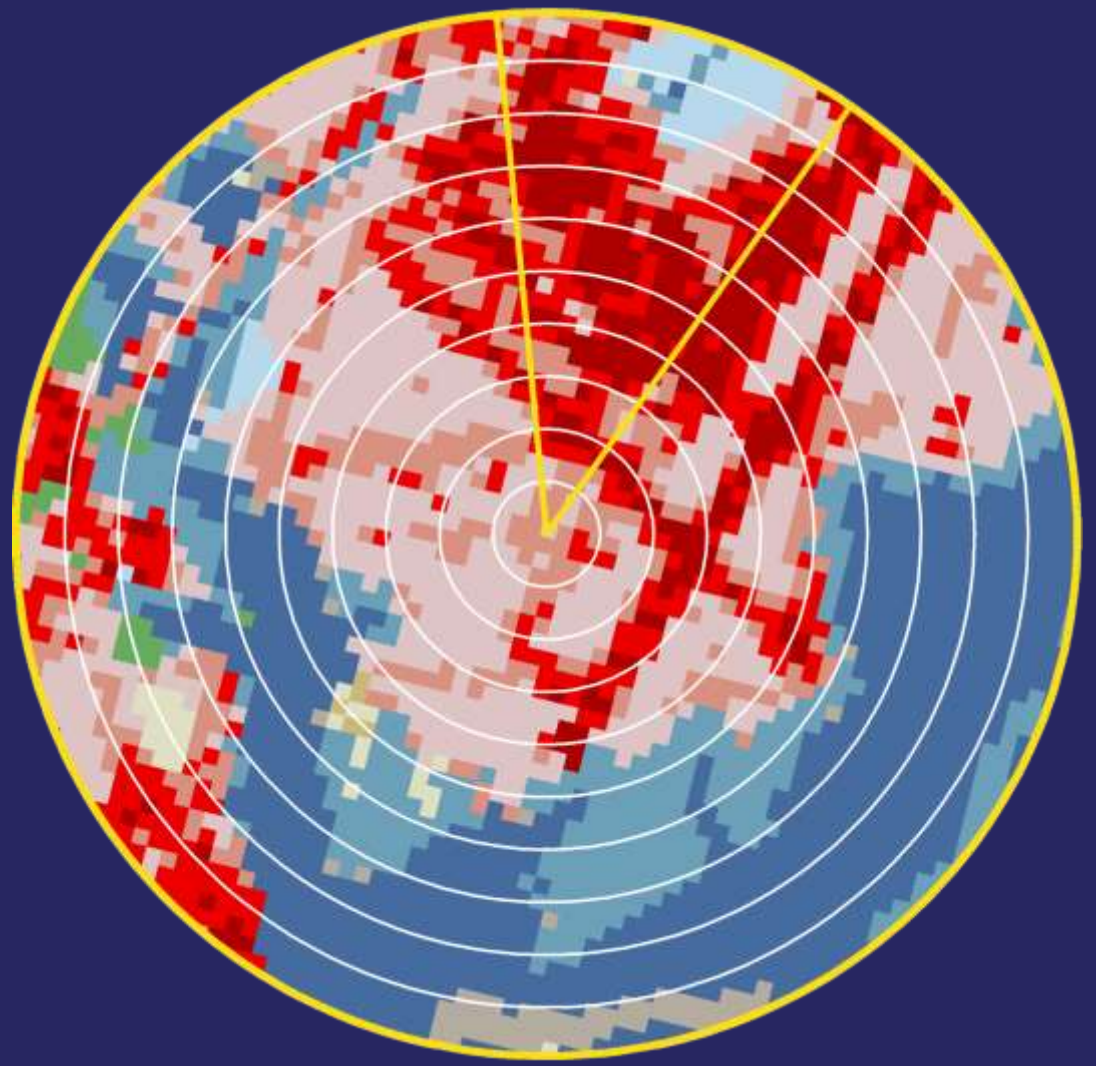
Sector Design Process

1) Draw sector lines to split area into sectors of similar land cover
2) Divide area into evenly-spaced concentric circles
3) How many rings are clearly comprised of roads? Of buildings?
   - If more rings in a sector are comprised of flat surfaces, i.e. roads, parking lots, etc., then characterize the sector as Airport
   - Otherwise, Non-Airport

Let's Designate a Sector!

- Example 1: Groton-New London Airport
  - Runway and parking lots before reaching the airport terminals and hangars
- Example 2: Windham Airport
  - Small amount of runway and a residential neighborhood
- Example 3: Bradley International Airport
  - Previous example of runway and buildings associated with airport operations

Example 1: Groton-New London Airport



NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
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$r = 1\ km$

Example 1: Groton-New London Airport

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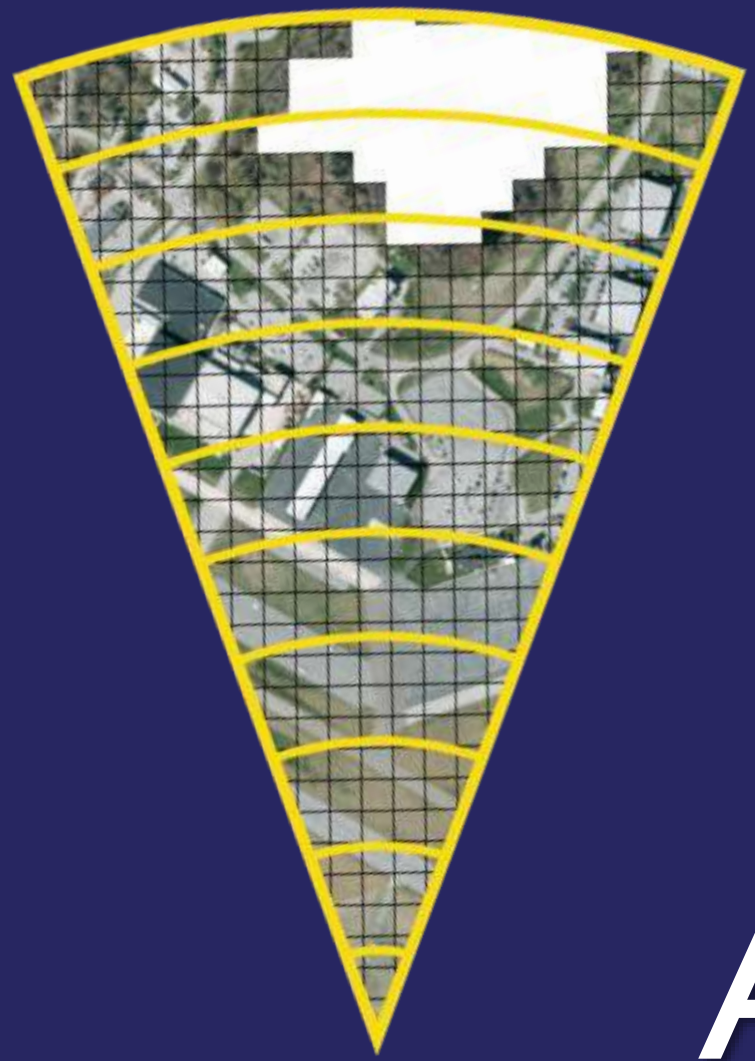

AP

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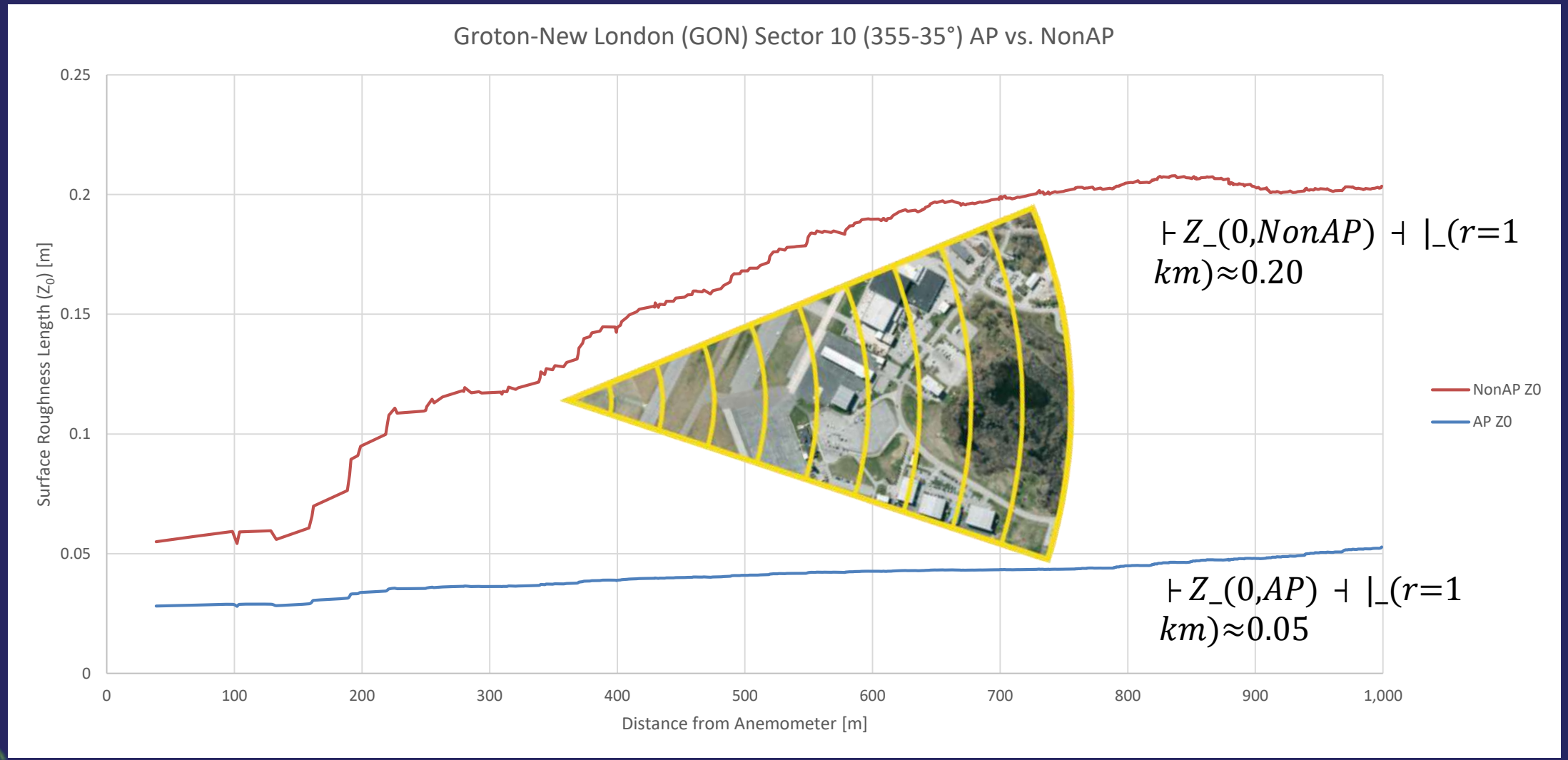

Example 2: Windham Airport

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$r = 1\ km$

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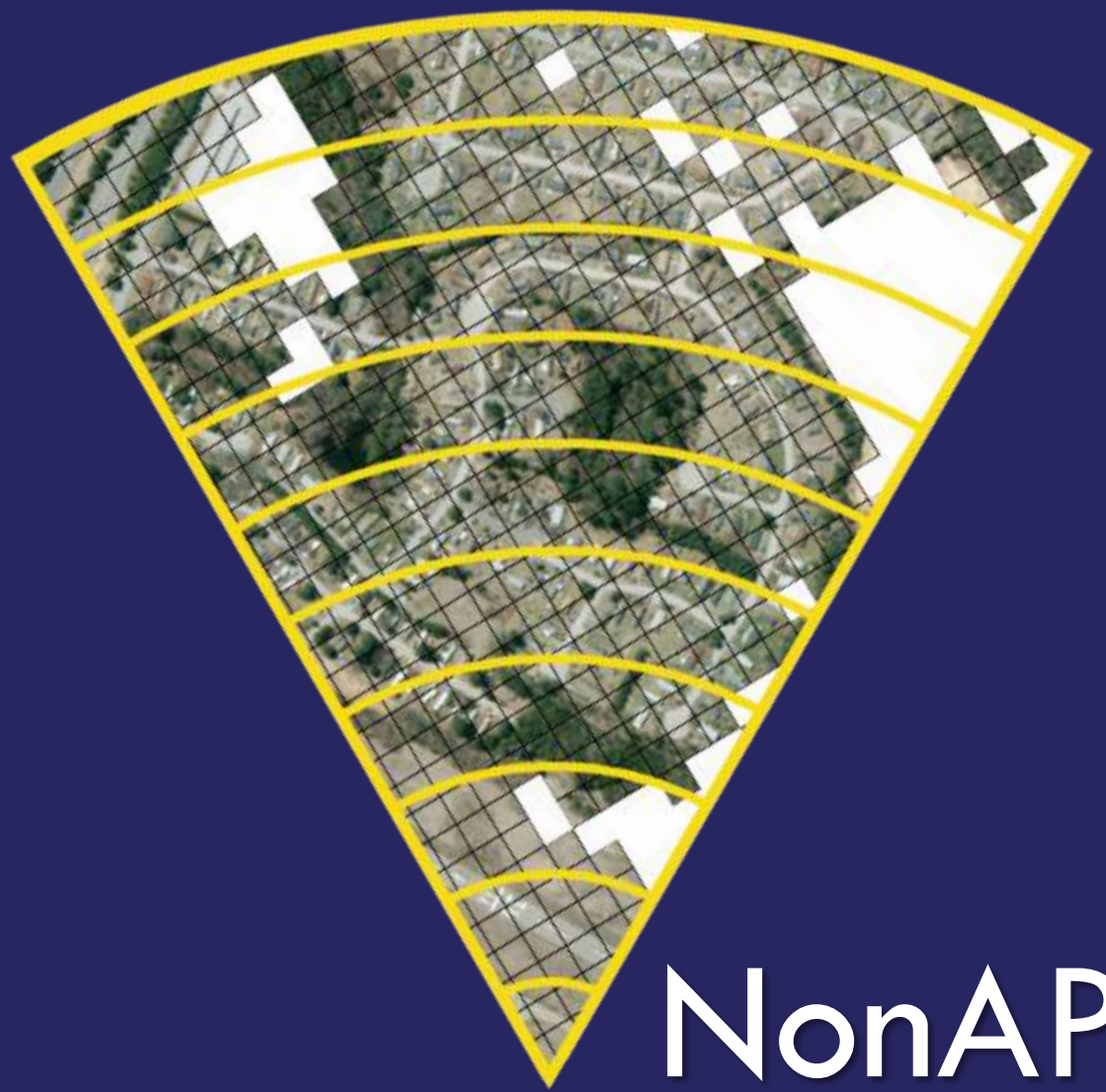
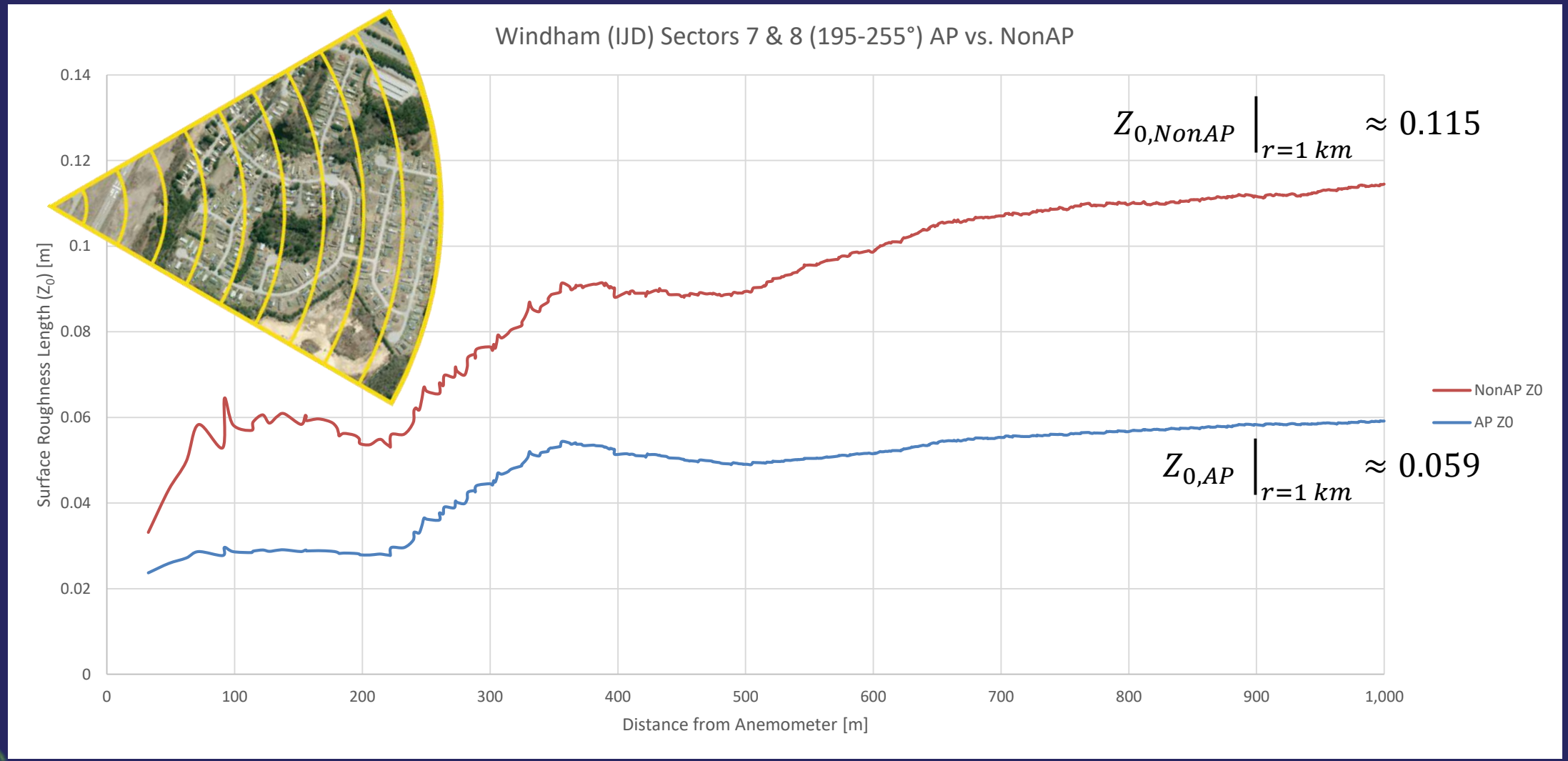


NonAP

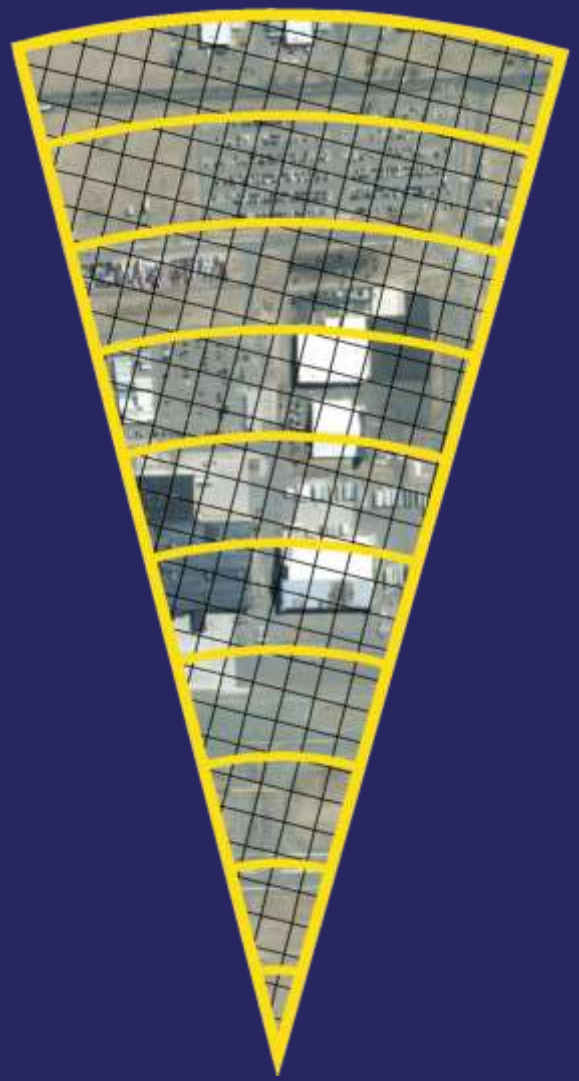
Example 2: Windham Airport



Returning to Bradley Sector 3

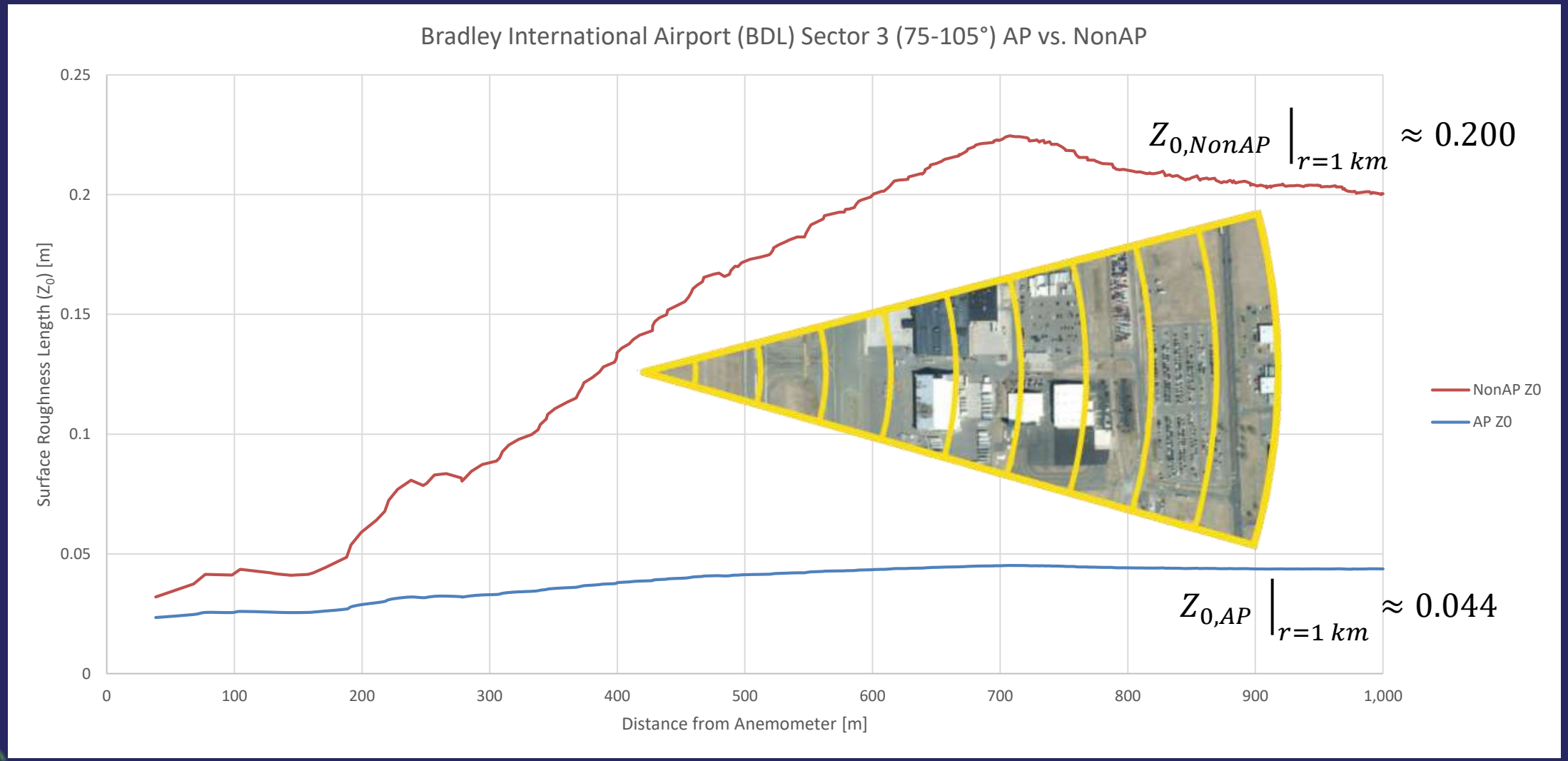
$r = 1\ km$

Returning to Bradley Sector 3



AP

Returning to Bradley Sector 3

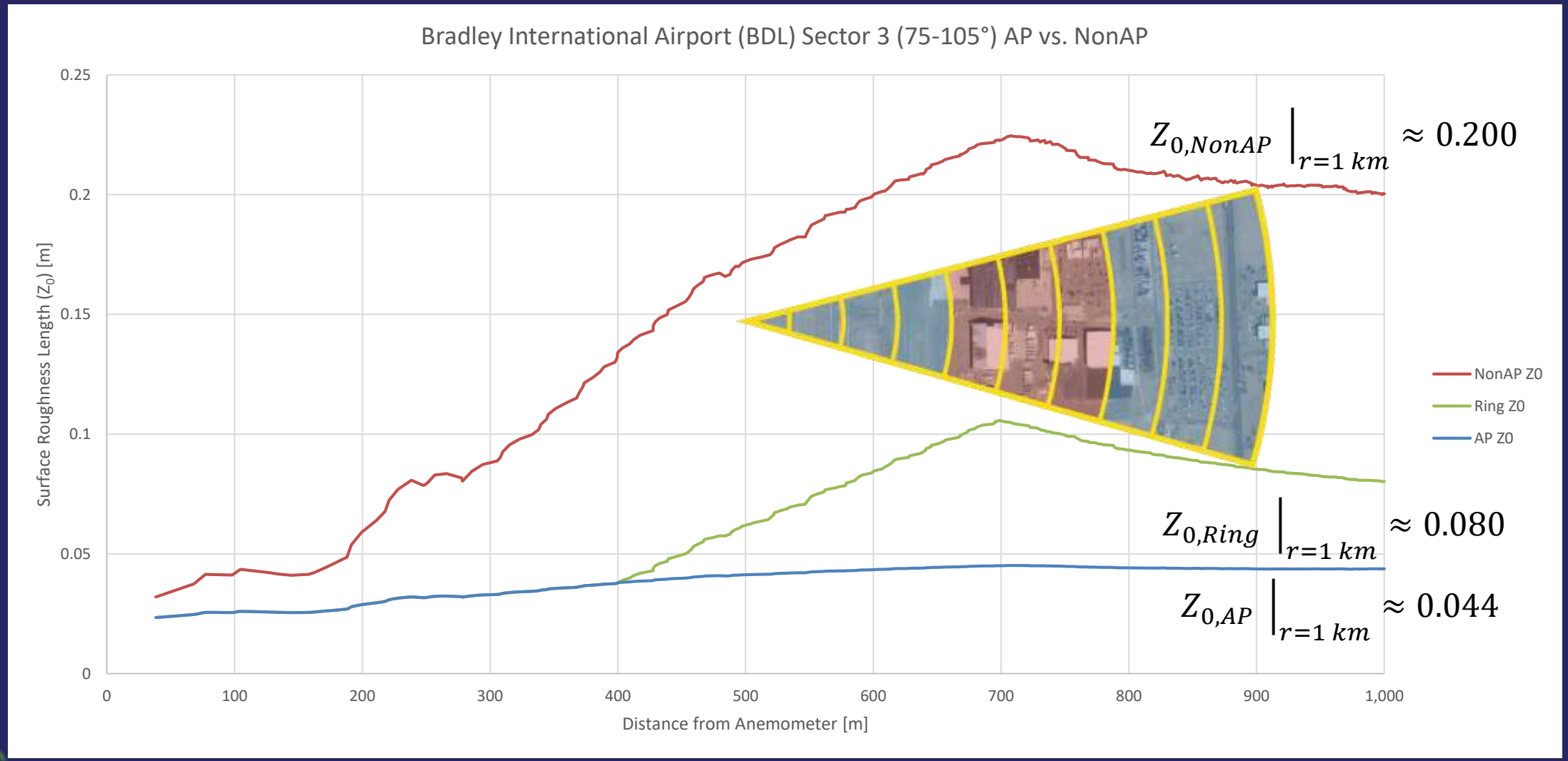


Is the Surface Roughness Being Accurately Captured?

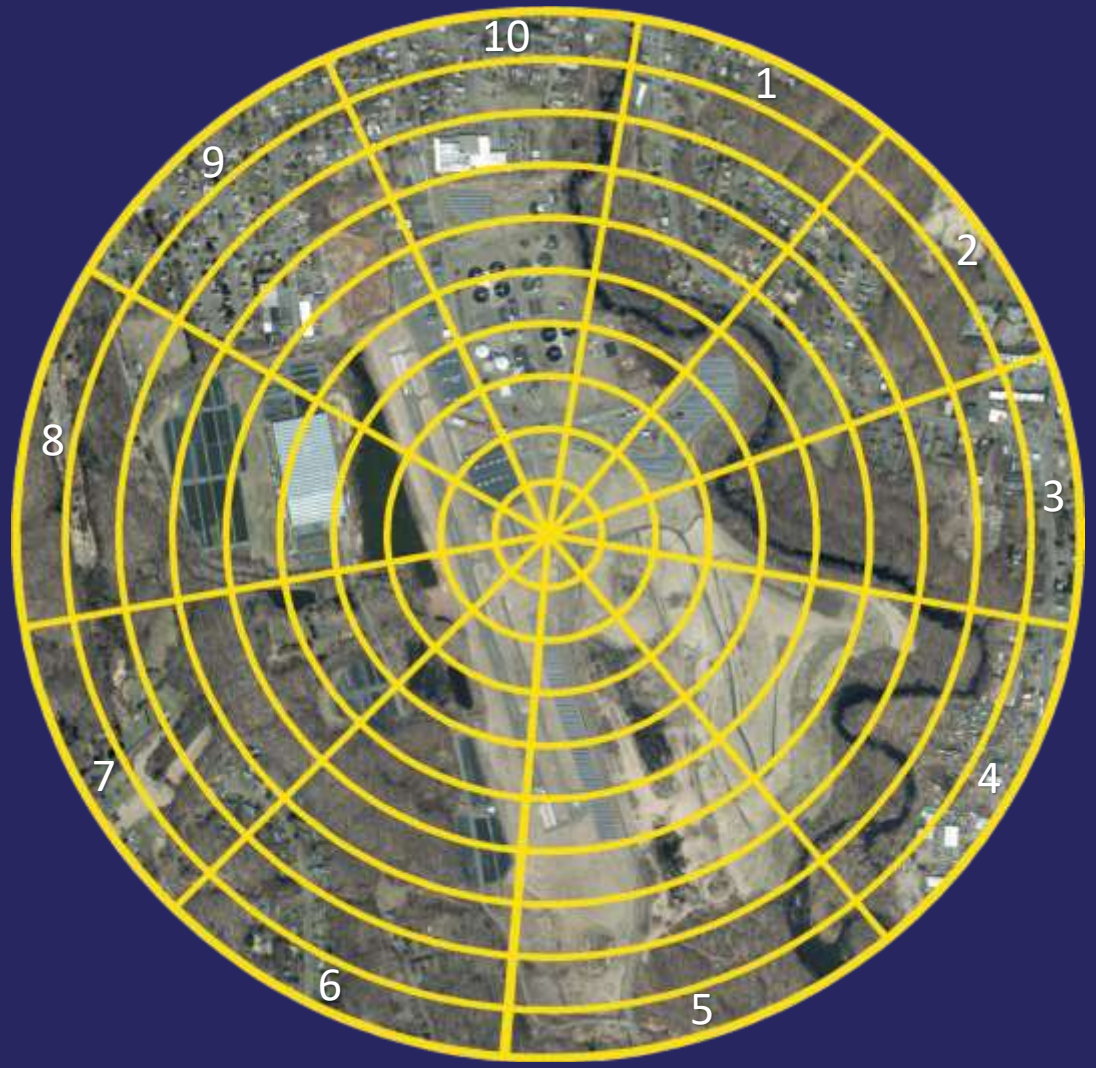
- Add ability to classify airport/non-airport cells within a sector

AP
AP
AP
NonAP
NonAP
NonAP
AP
AP
AP
AP

Returning to Bradley Sector 3



Full Airport Visualization of the Annular Ring Method



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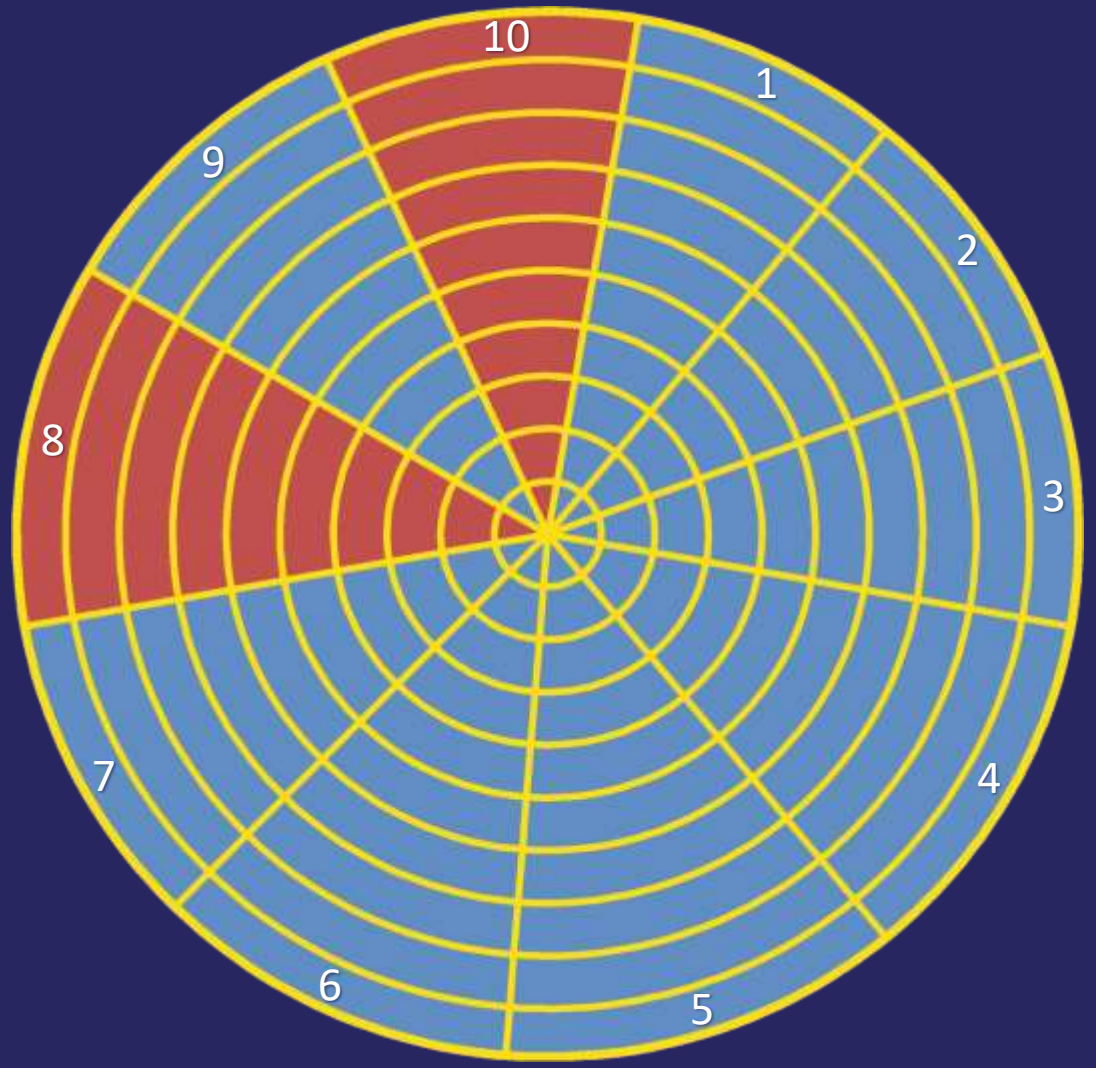

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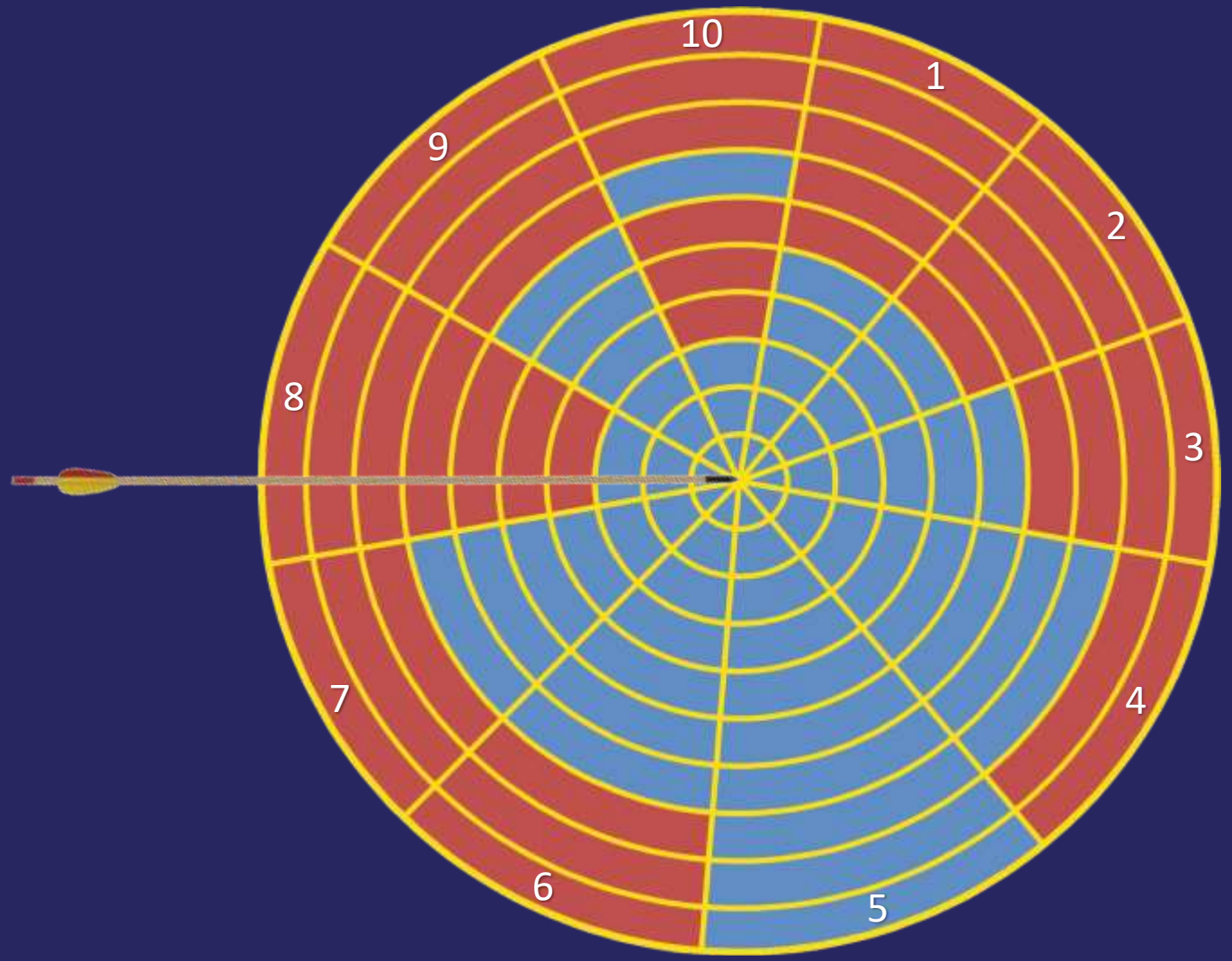

Sector	Full Sector Designation	Full Sector Z_0 [m]	Annular Ring Z_0 [m]	% Diff
1	AP	0.157	0.208	**28%**
2	AP	0.137	0.167	**20%**
3	AP	0.177	0.241	**31%**
4	AP	0.141	0.172	**20%**
5	AP	0.066	0.066	**0%**
6	AP	0.162	0.176	**8%**
7	AP	0.278	0.290	**4%**
8	NonAP	0.128	0.116	**10%**
9	AP	0.061	0.091	**40%**
10	NonAP	0.177	0.127	**33%**

$r = 1\ km$

Summary of Suggested Improvements

- Apply the annular ring method to classify sectors as AP or NonAP
  - Increase probability of consistent sectors between users
- Add the ability to characterize AP and NonAP rings within a sector
  - Increase accuracy of surface roughness length (Z_0) in a sector
- Change "Airport" and "Non-Airport" to less confusing terms
  - Road vs. Building
  - Structure vs. No Structure
  - Flat vs. Obstruction

Questions?

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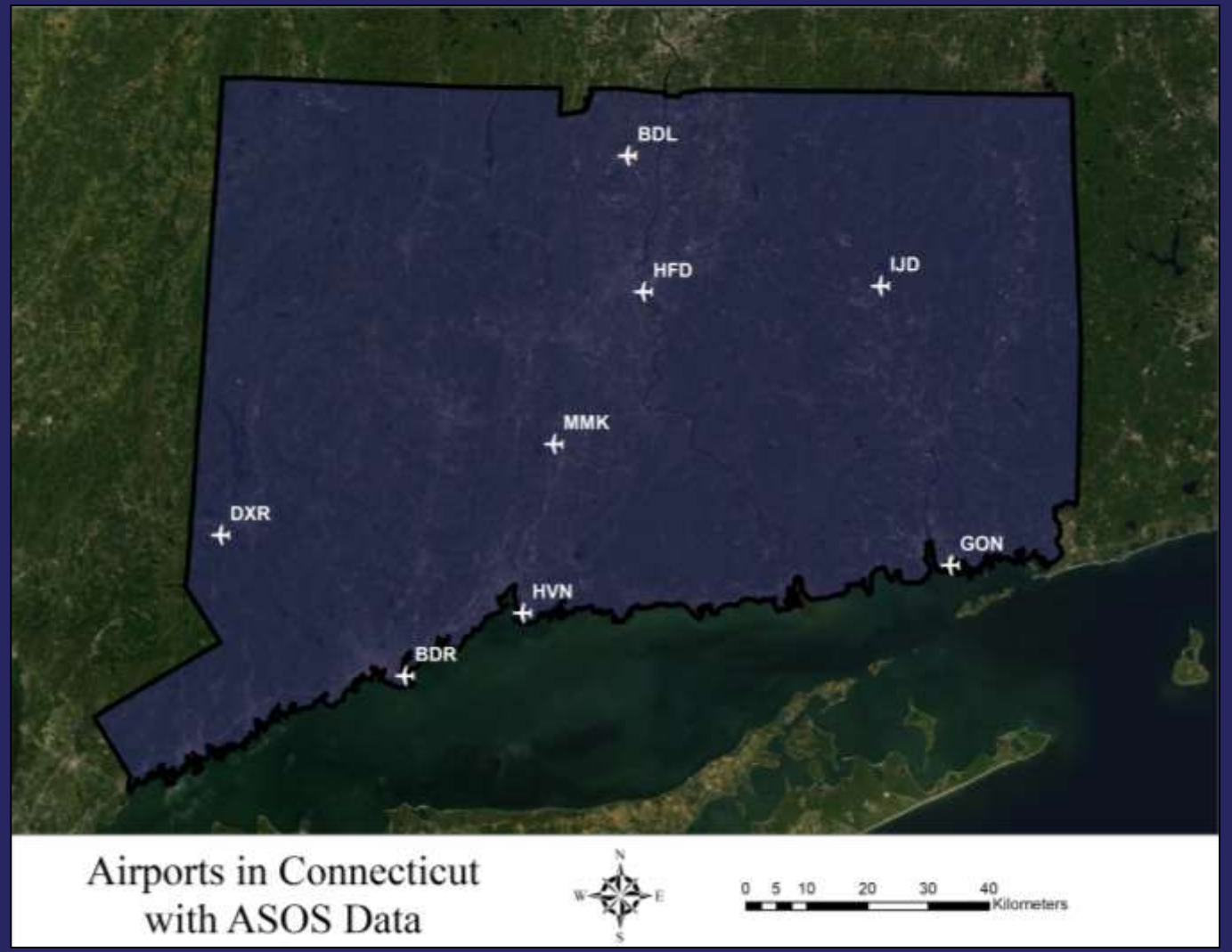
Background of Connecticut Airports

- Eight ASOS Airports
  - BDL: Bradley International
  - BDR: Sikorsky Memorial
  - DXR: Danbury Municipal
  - GON: Groton-New London
  - HFD: Hartford-Brainard
  - HVN: Tweed-New Haven
  - IJD: Windham
  - MMK: Meriden-Markham



AERSURFACE Inputs Used for Analysis

- NLCD 2016 Land Cover, Impervious, and Canopy Datasets
- Z0RAD
  - 5 km radius
- Z0EFF
  - $\text{IBL\_Factor} = \frac{60\,m}{anem\_ht\ [m]}$ (Wieringa suggested a 60 m "roughness blending height")
- Nonarid climate with average moisture
- Twelve (12) months split into five (5) seasons:
  - Winter w/ Snow: January February
  - Winter w/o Snow: March December
  - Spring: April May
  - Summer June July August
  - Fall: September October November

Bradley International Airport (BDL)

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

MMK

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Sector:

1

2

3

4

5

6

7

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10

11

Bradley International Airport (BDL)

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

MMK

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Sector:

1

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11

BDL Sector 1

Airport:

BDL

BDR

DXR

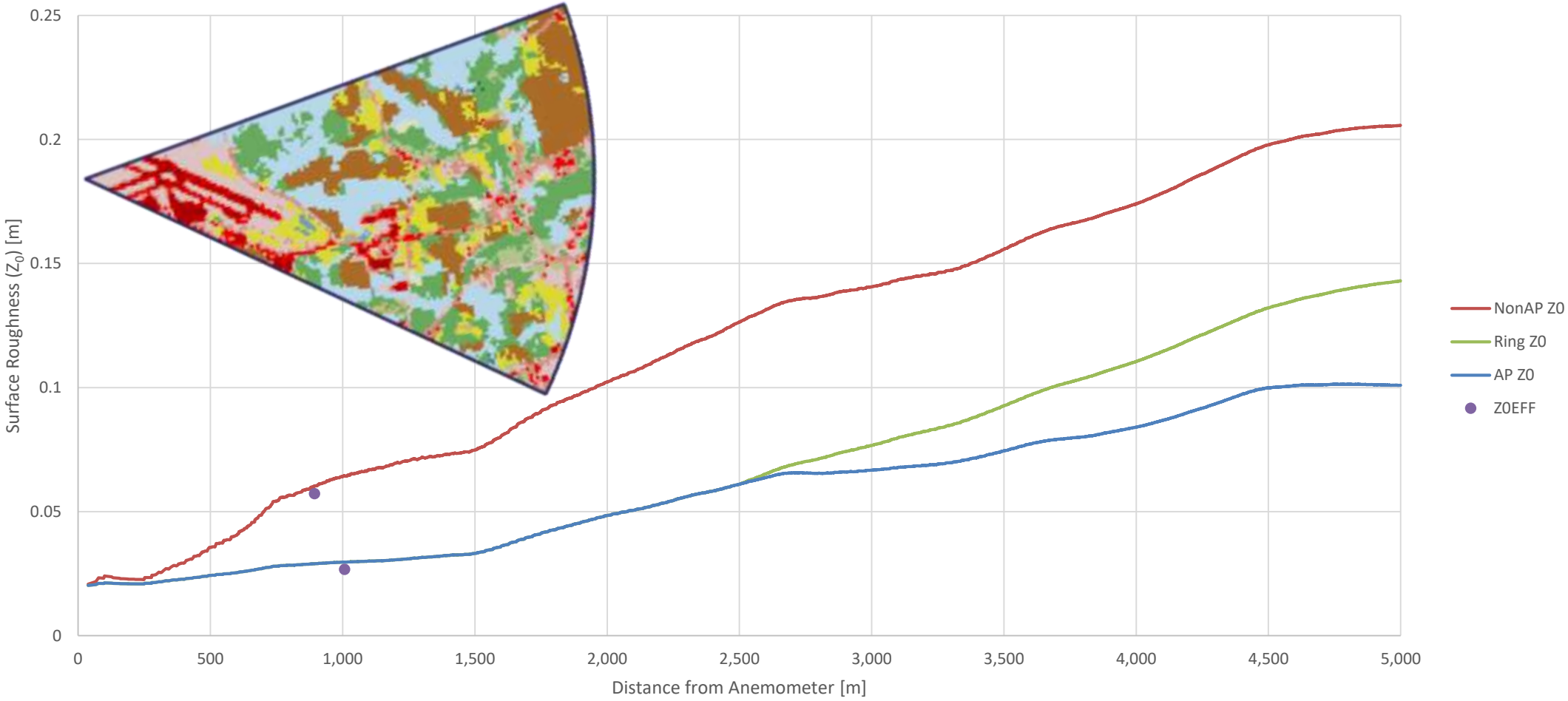
GON

HFD

HVN

IJD

MMK



Sector:

1

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11

BDL Sector 2

Airport:

BDL

BDR

DXR

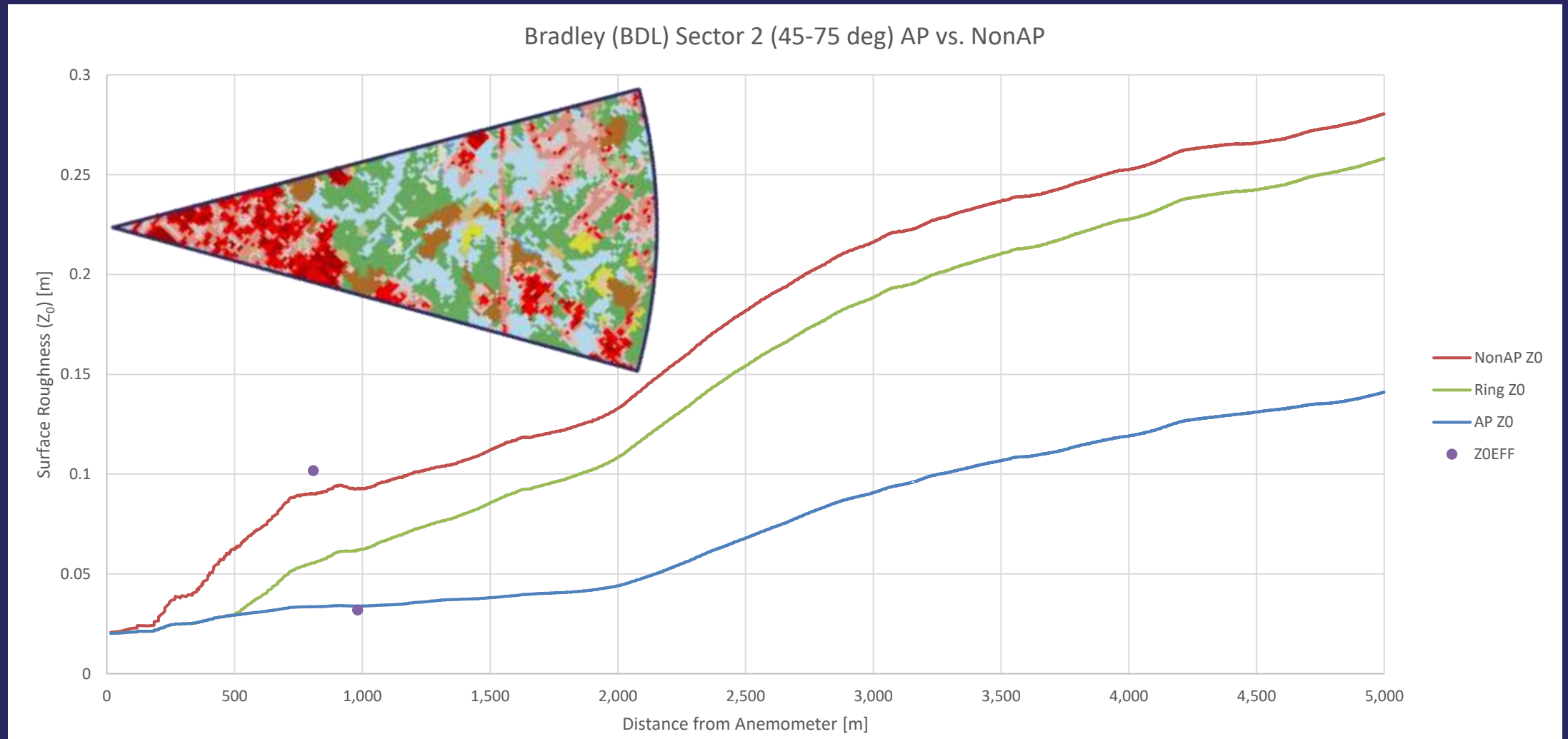
GON

HFD

HVN

IJD

MMK



Sector:

1

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11

Connecticut Department of Energy & Environmental Department

BDL Sector 3

Airport:

BDL

BDR

DXR

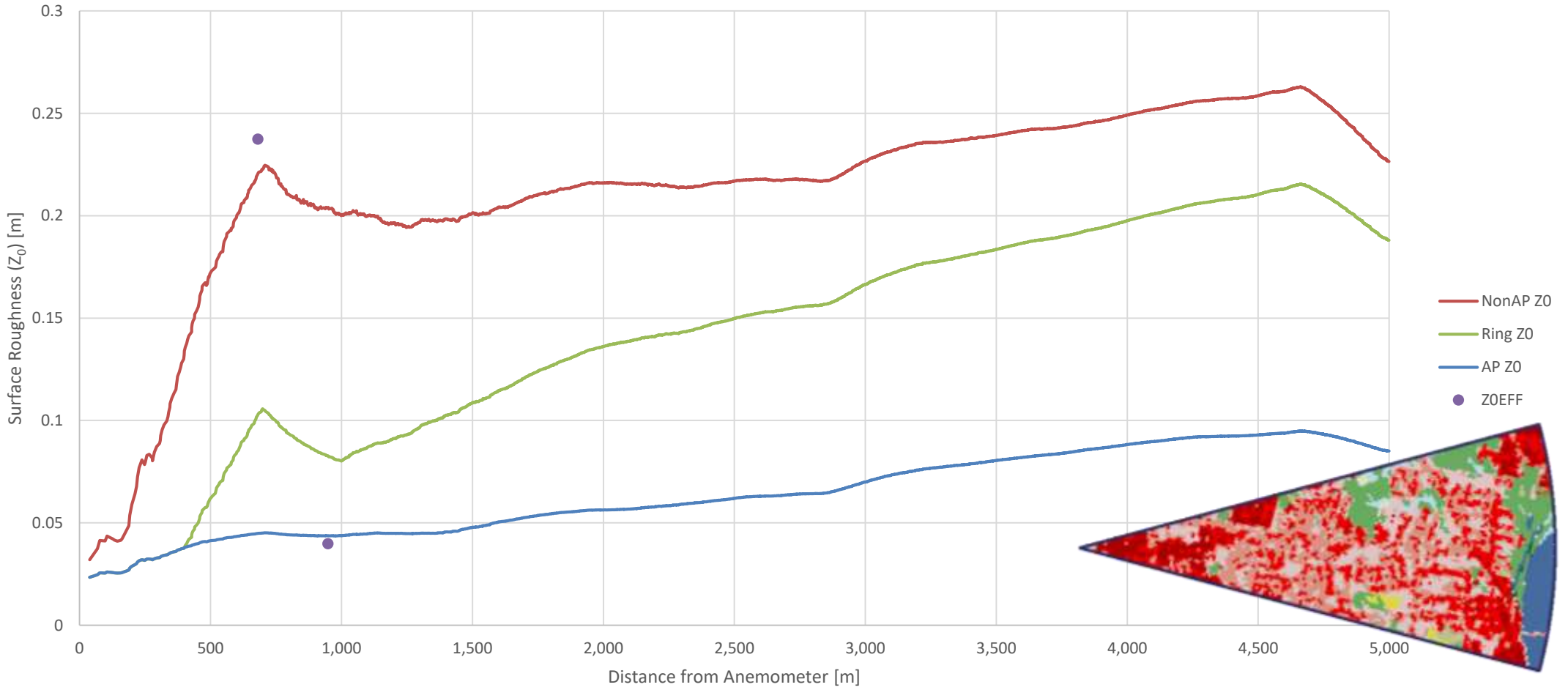
GON

HFD

HVN

IJD

MMK



Sector:

1

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11

Connecticut Department of Energy & Environmental Department

BDL Sector 4

Airport:

BDL

BDR

DXR

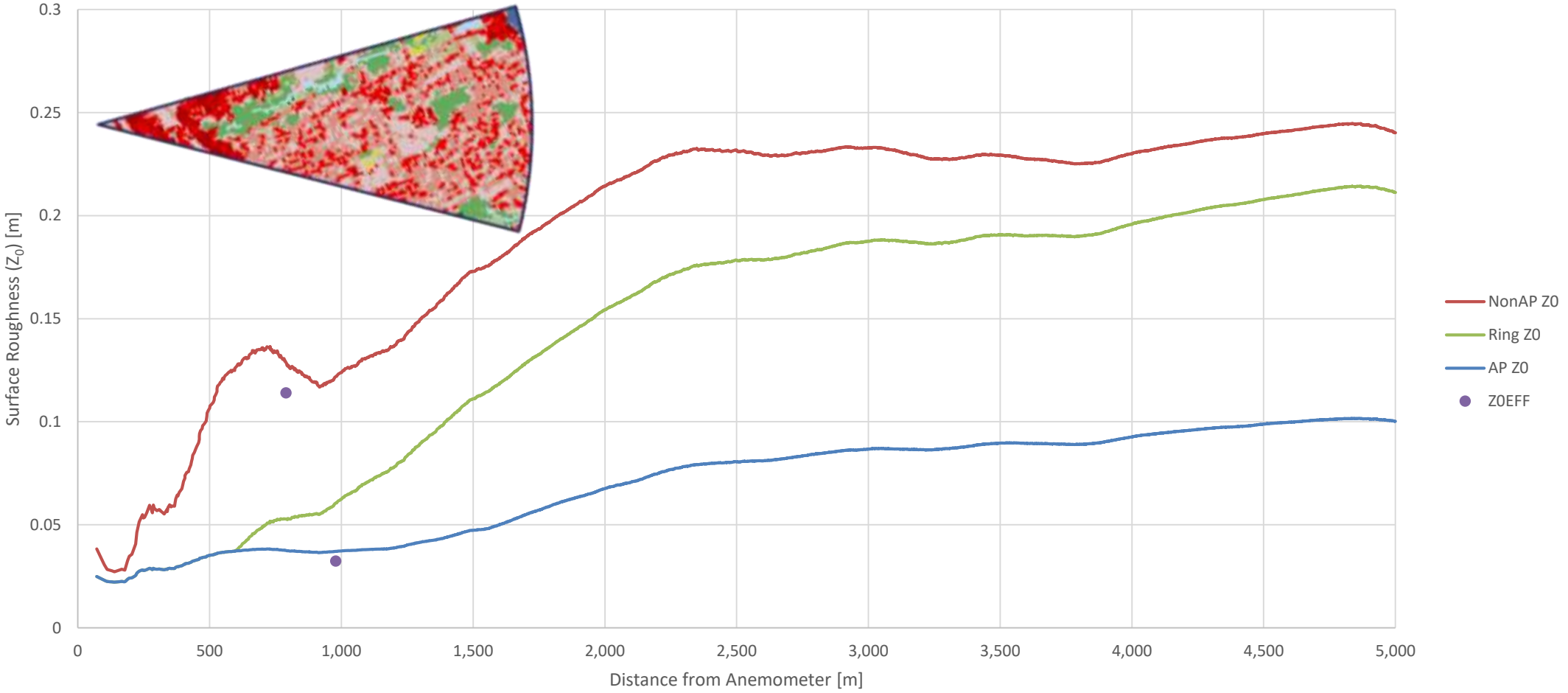
GON

HFD

HVN

IJD

MMK



Sector:

1

2

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9

10

11

BDL Sector 5

Airport:

BDL

BDR

DXR

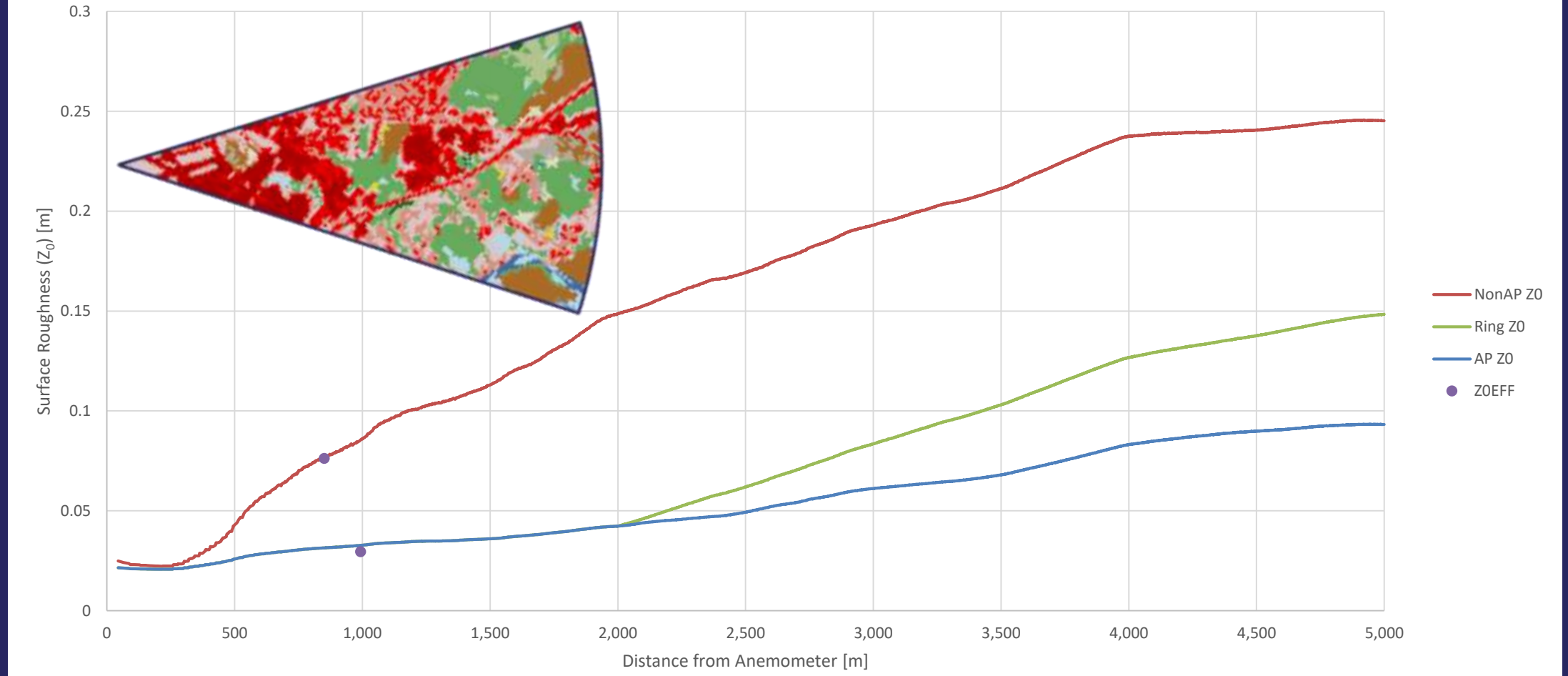
GON

HFD

HVN

IJD

MMK



Sector:

1

2

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Connecticut Department of Energy & Environmental Department

BDL Sector 6

Airport:

BDL

BDR

DXR

GON

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HVN

IJD

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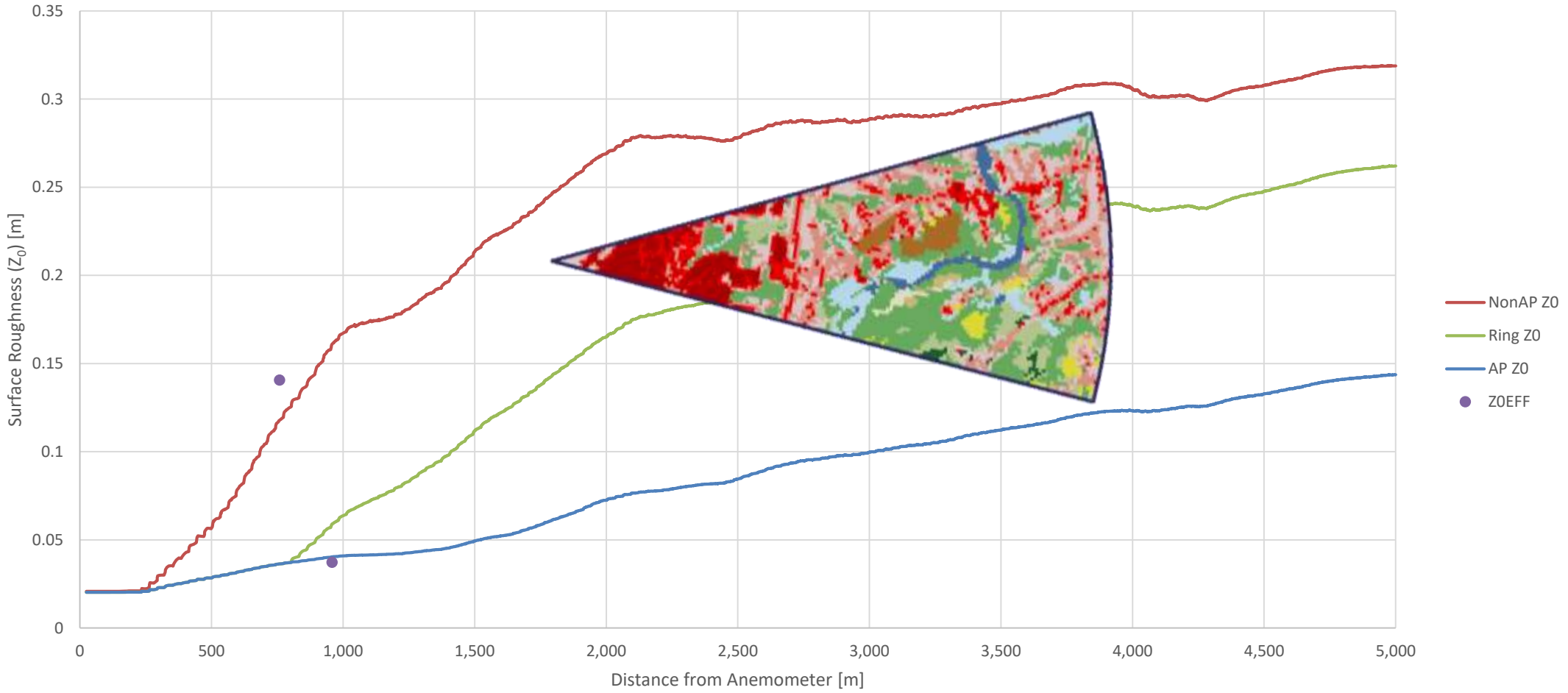

Sector:

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Connecticut Department of Energy & Environmental Department

BDL Sector 7

Airport:

BDL

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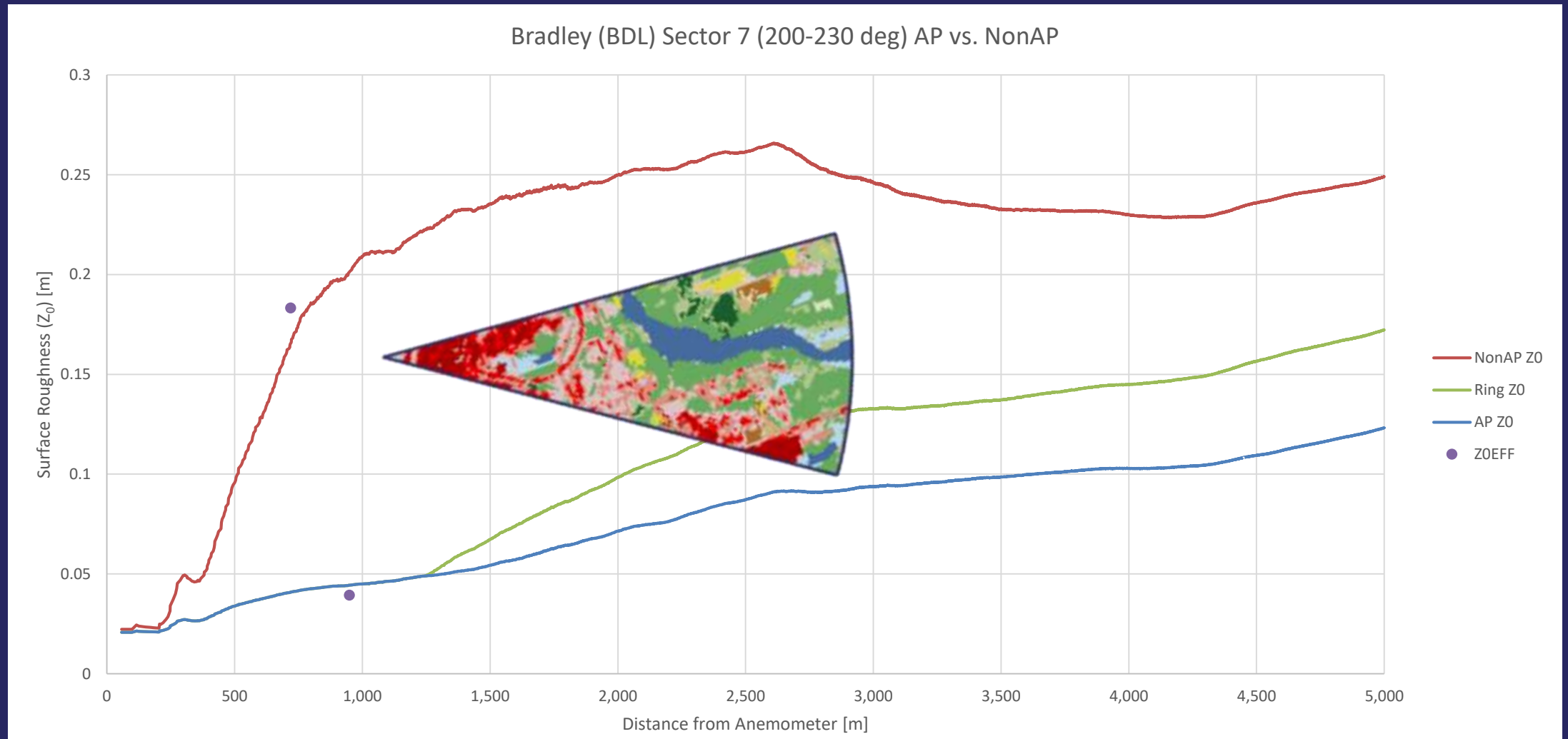

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Connecticut Department of Energy & Environmental Department

BDL Sector 8

Airport:

BDL

BDR

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HVN

IJD

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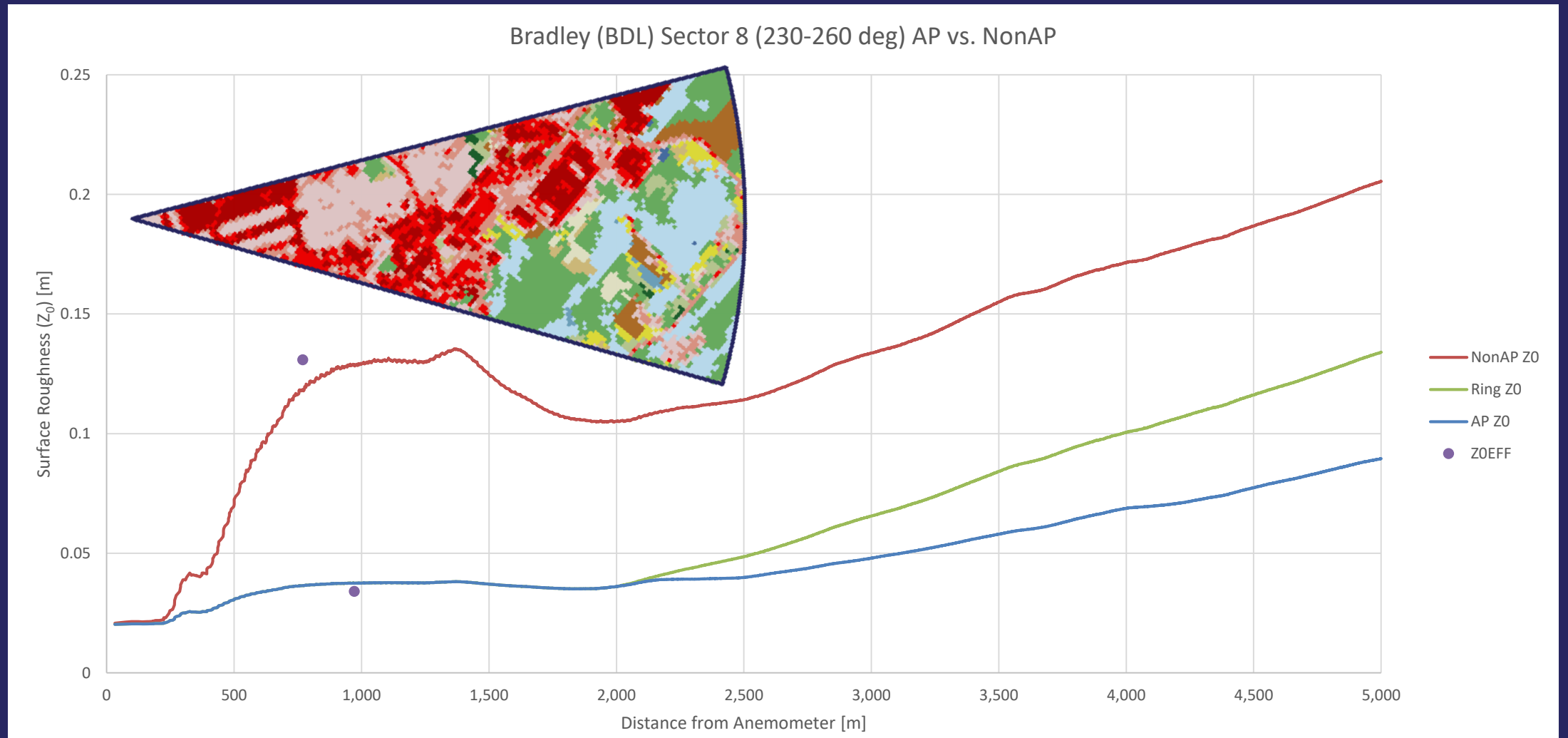

Sector:

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Connecticut Department of Energy & Environmental Department

BDL Sector 9

Airport:

BDL

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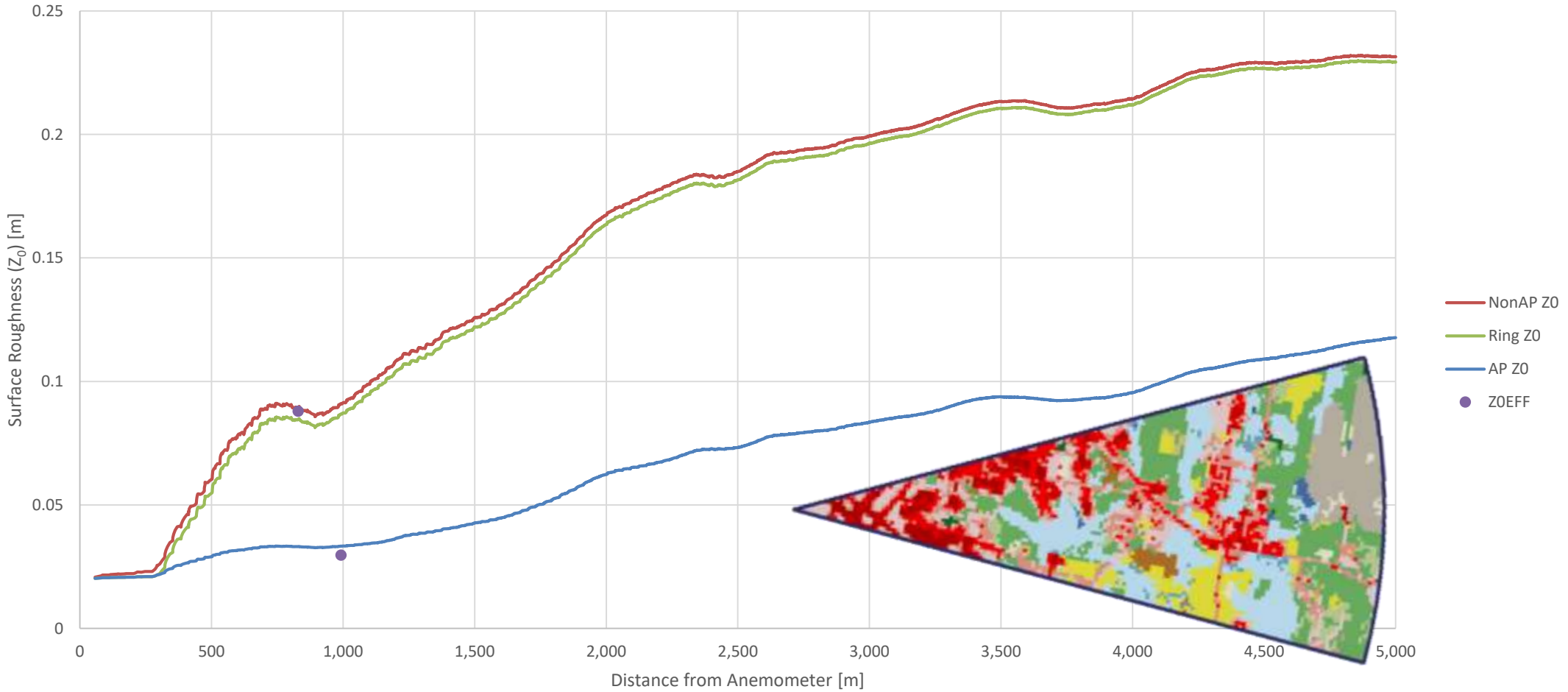
HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

BDL Sector 10

Airport:

BDL

BDR

DXR

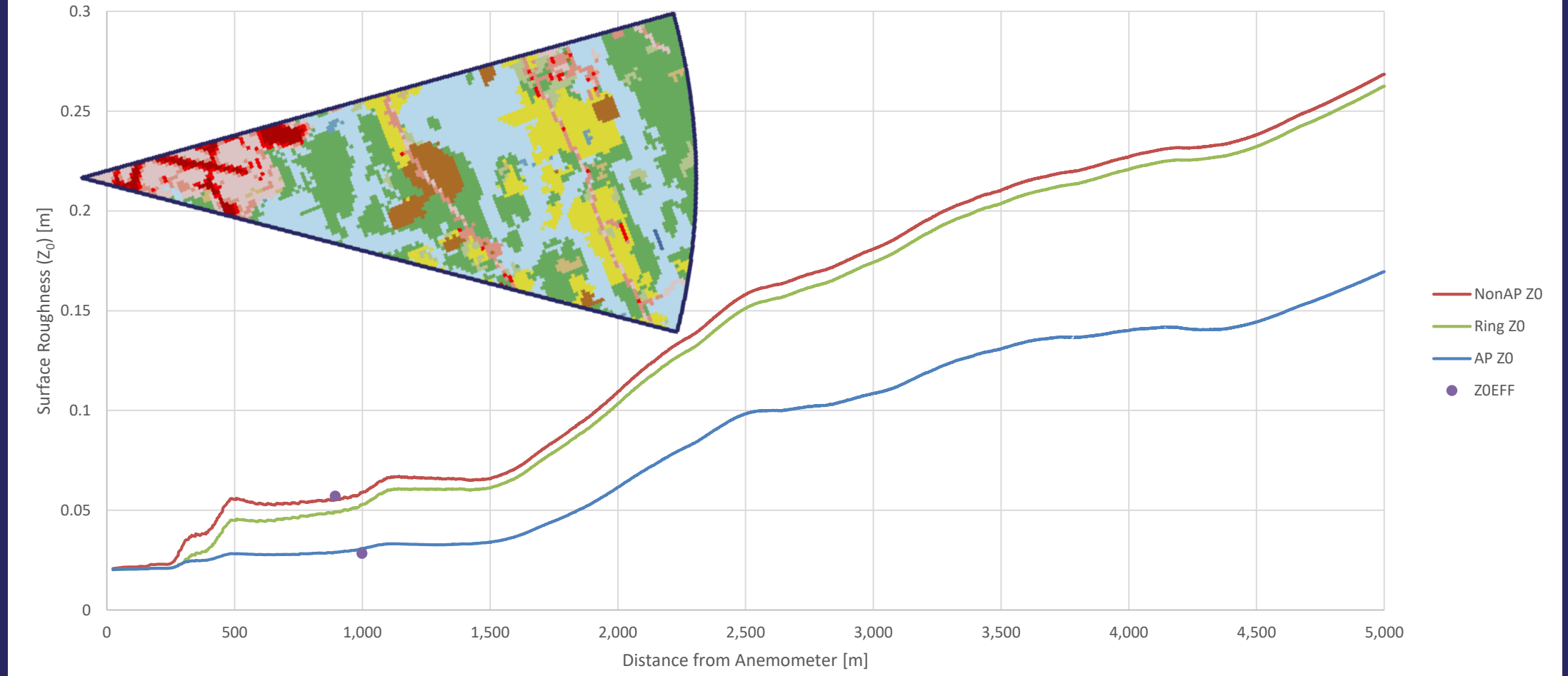
GON

HFD

HVN

IJD

MMK



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Connecticut Department of Energy & Environmental Department

BDL Sector 11

Airport:

BDL

BDR

DXR

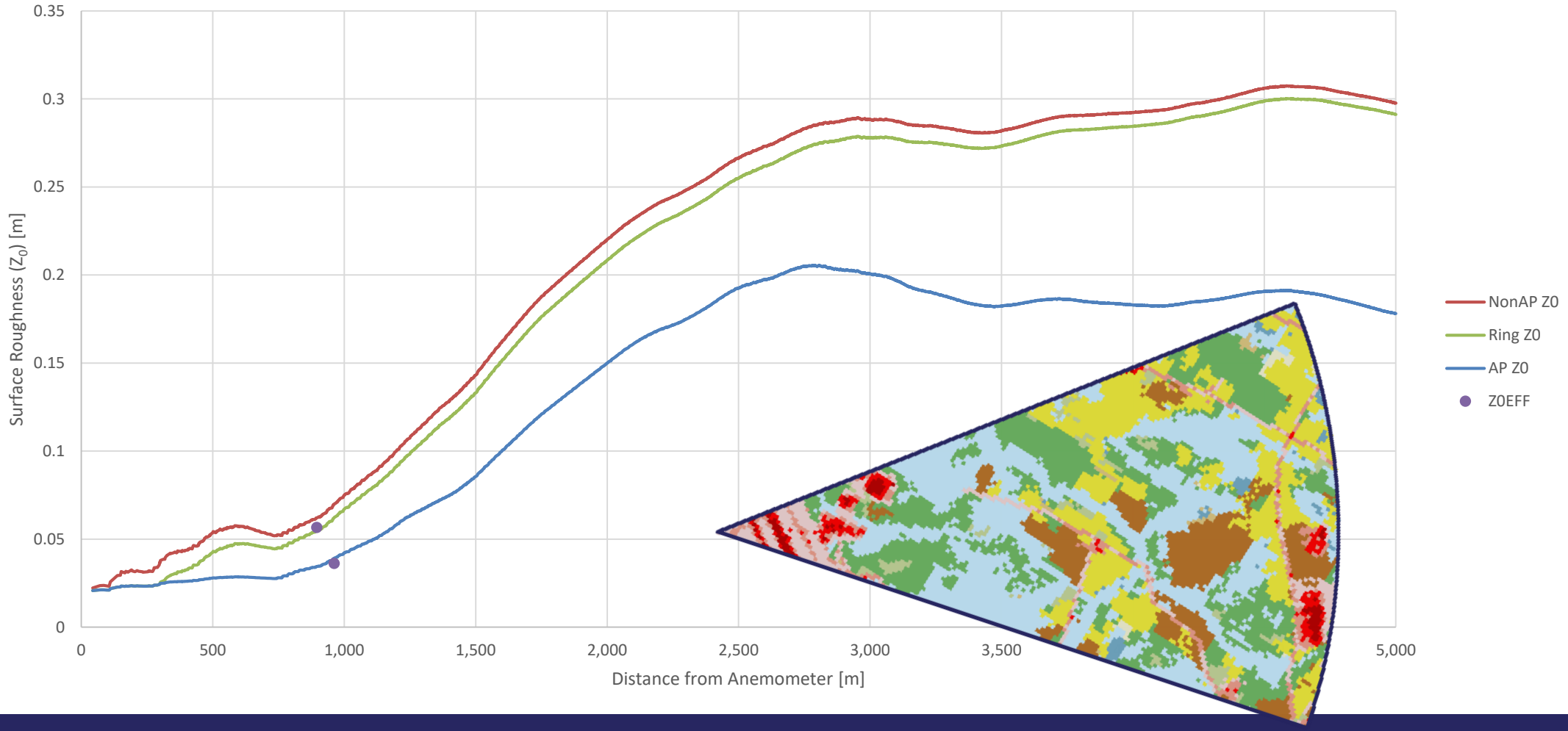
GON

HFD

HVN

IJD

MMK



Sector:

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11

Connecticut Department of Energy & Environmental Department

Igor I. Sikorsky Memorial Airport (BDR)

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

MMK

NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Igor I. Sikorsky Memorial Airport (BDR)

Airport:

BDL

BDR

DXR

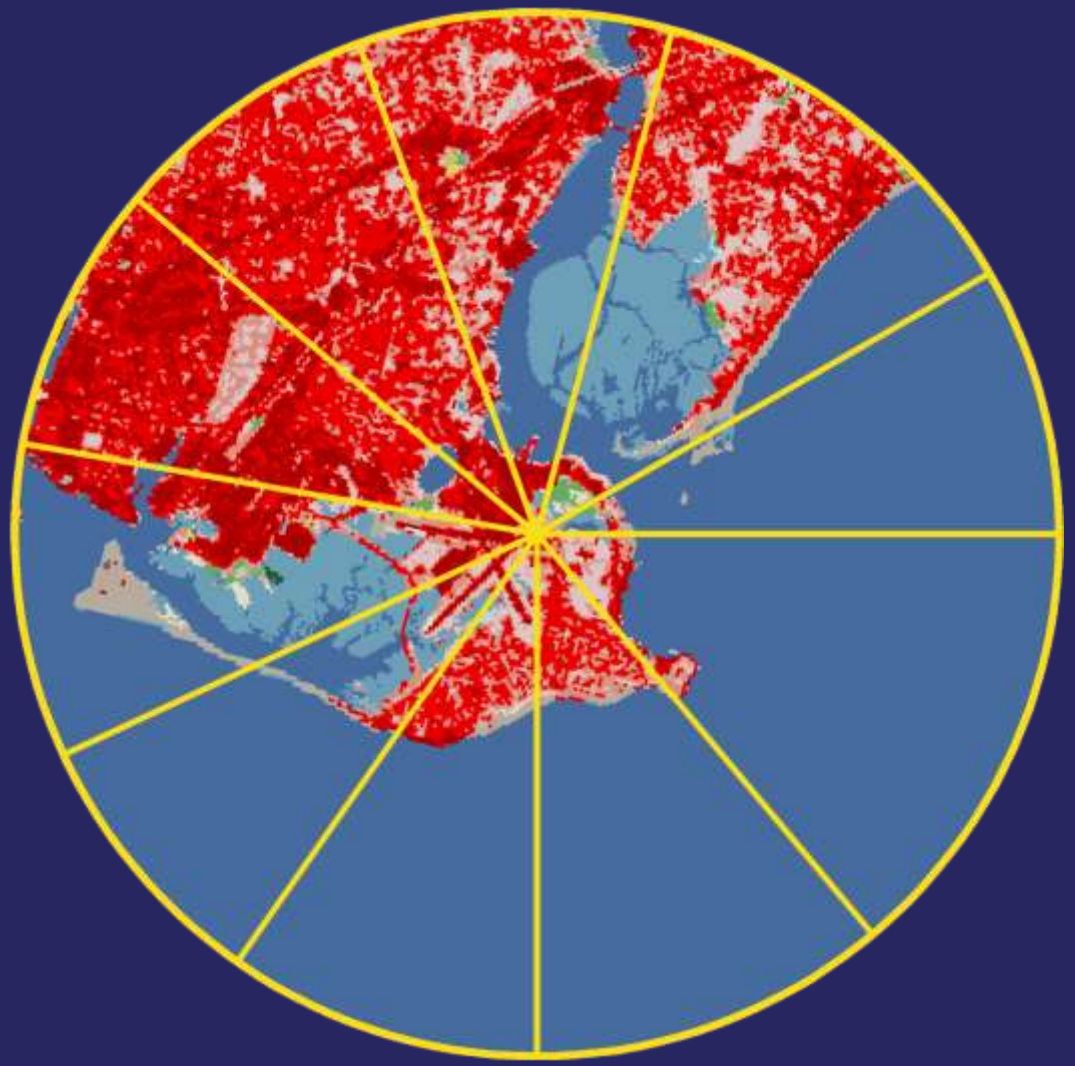
GON

HFD

HVN

IJD

MMK



NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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BDR Sector 1

Airport:

BDL

BDR

DXR

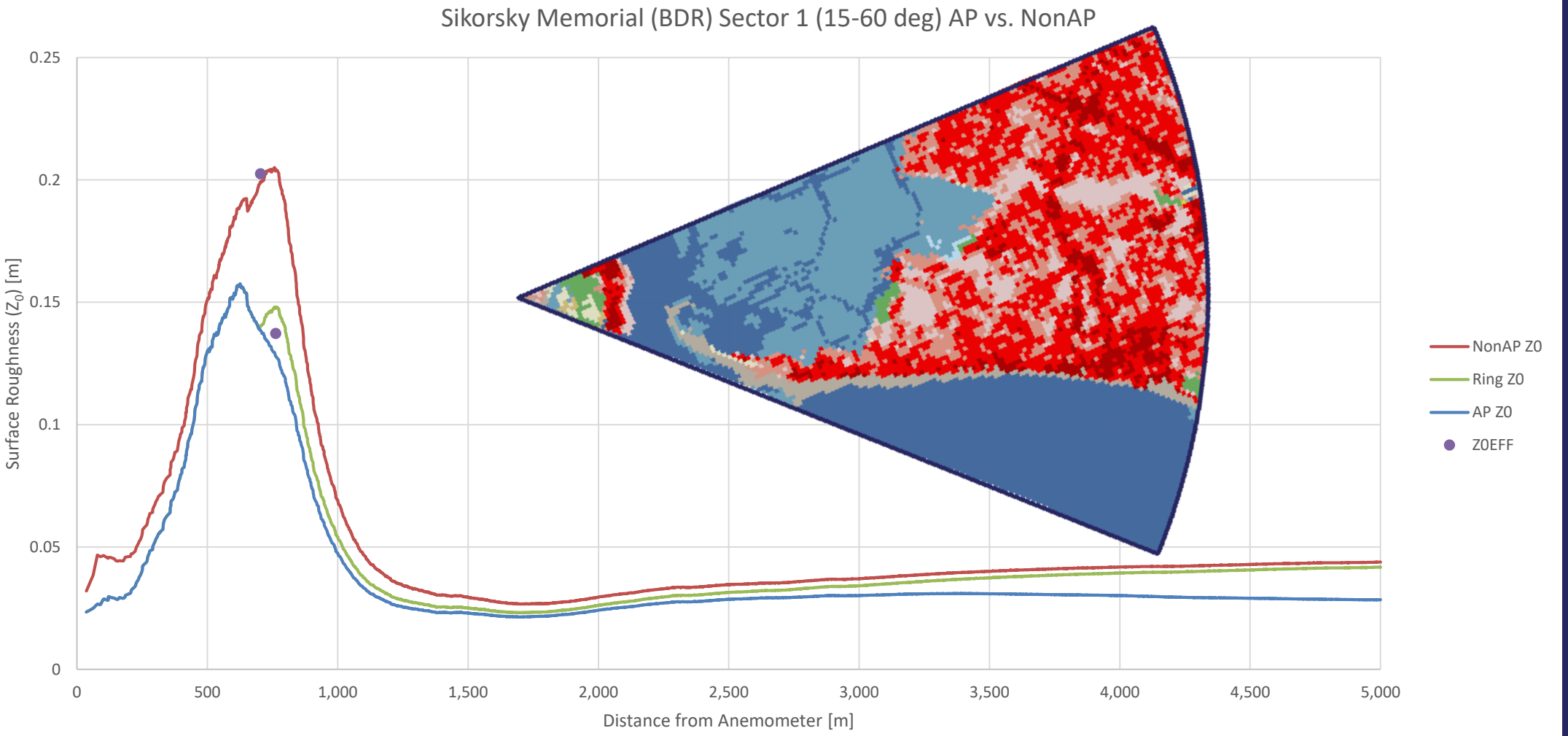
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

BDR Sector 2

Airport:

BDL

<u>BDR</u>

DXR

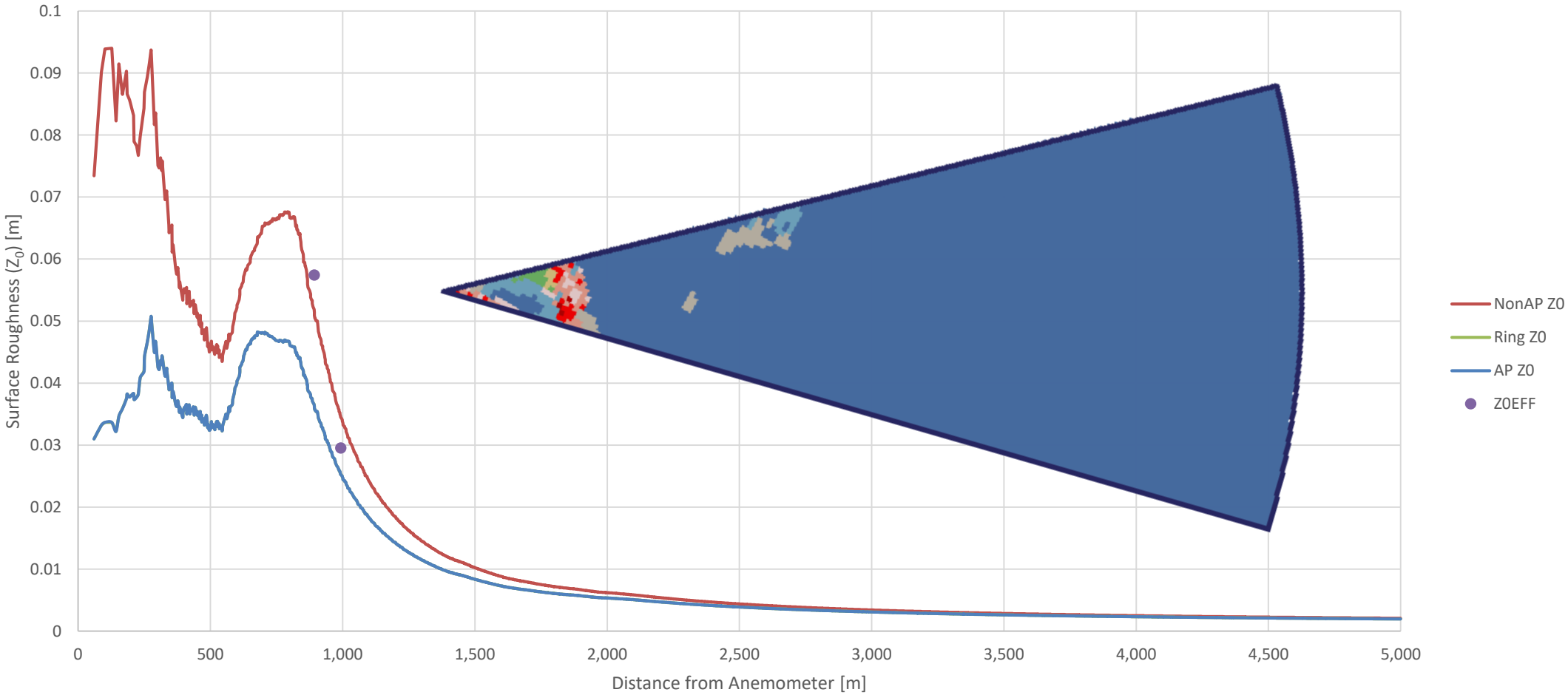
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

BDR Sector 3

Airport:

BDL

BDR

DXR

GON

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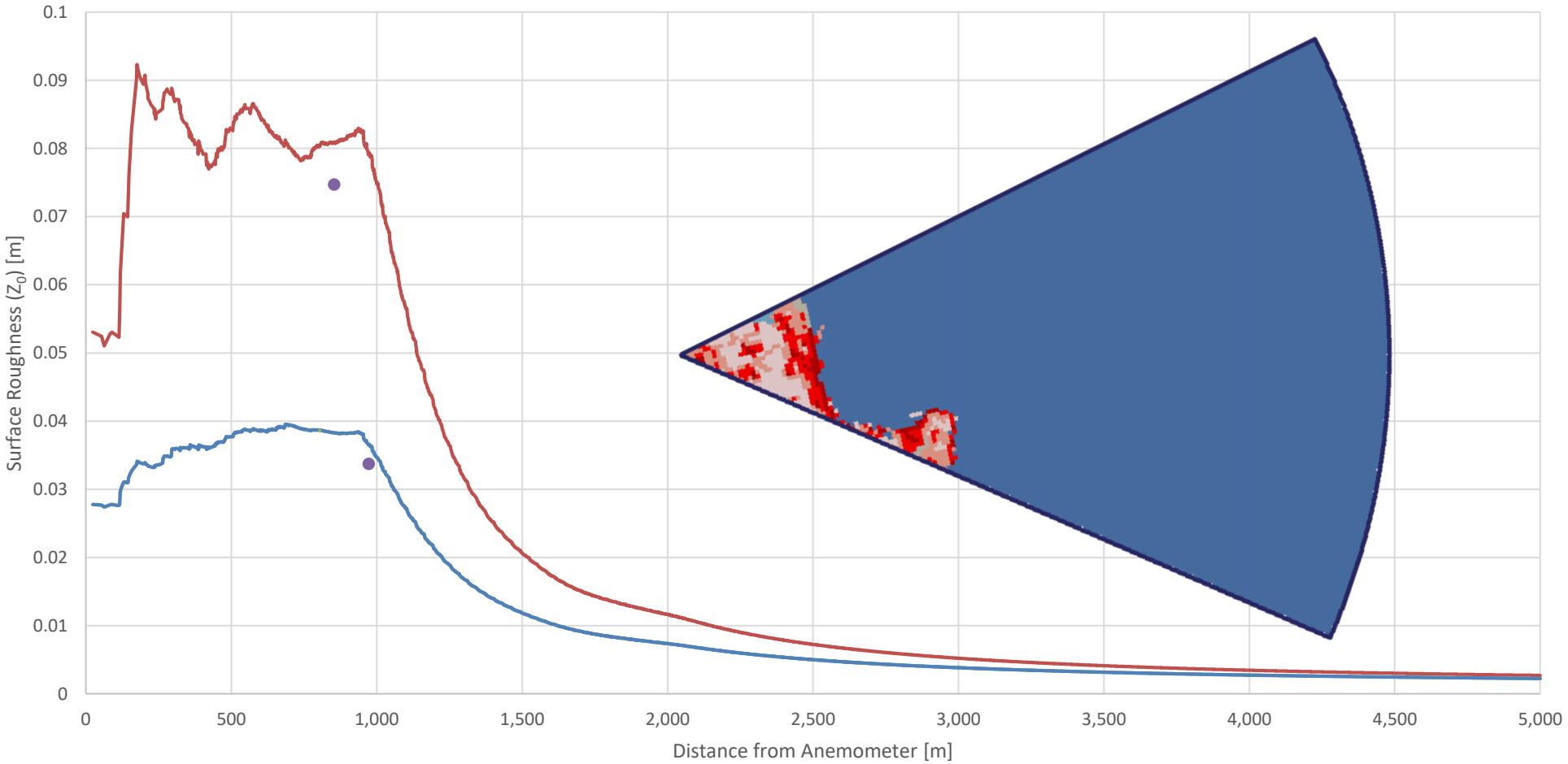
HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

BDR Sector 4

Airport:

BDL

BDR

DXR

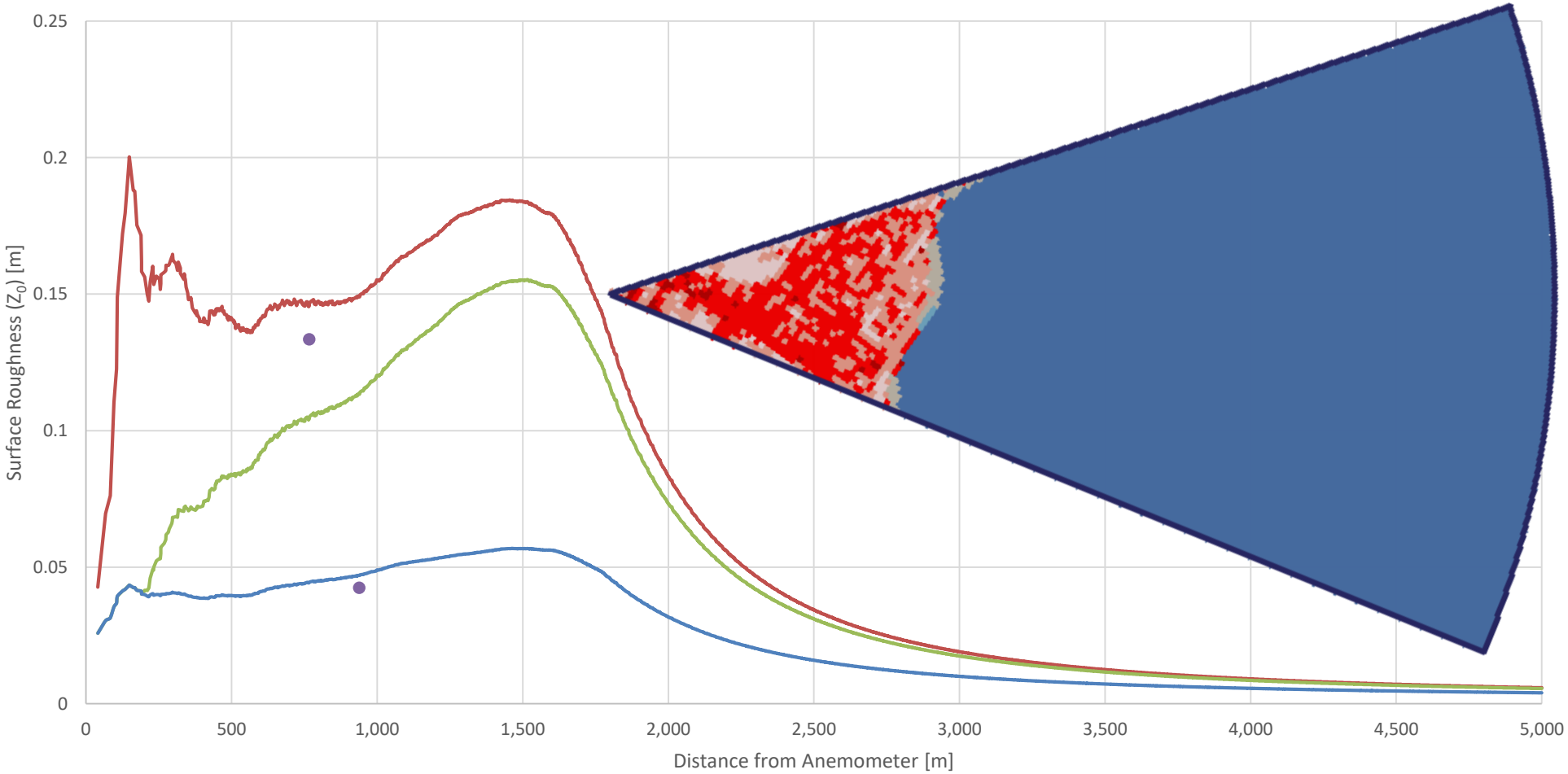
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

BDR Sector 5

Airport:

BDL

BDR

DXR

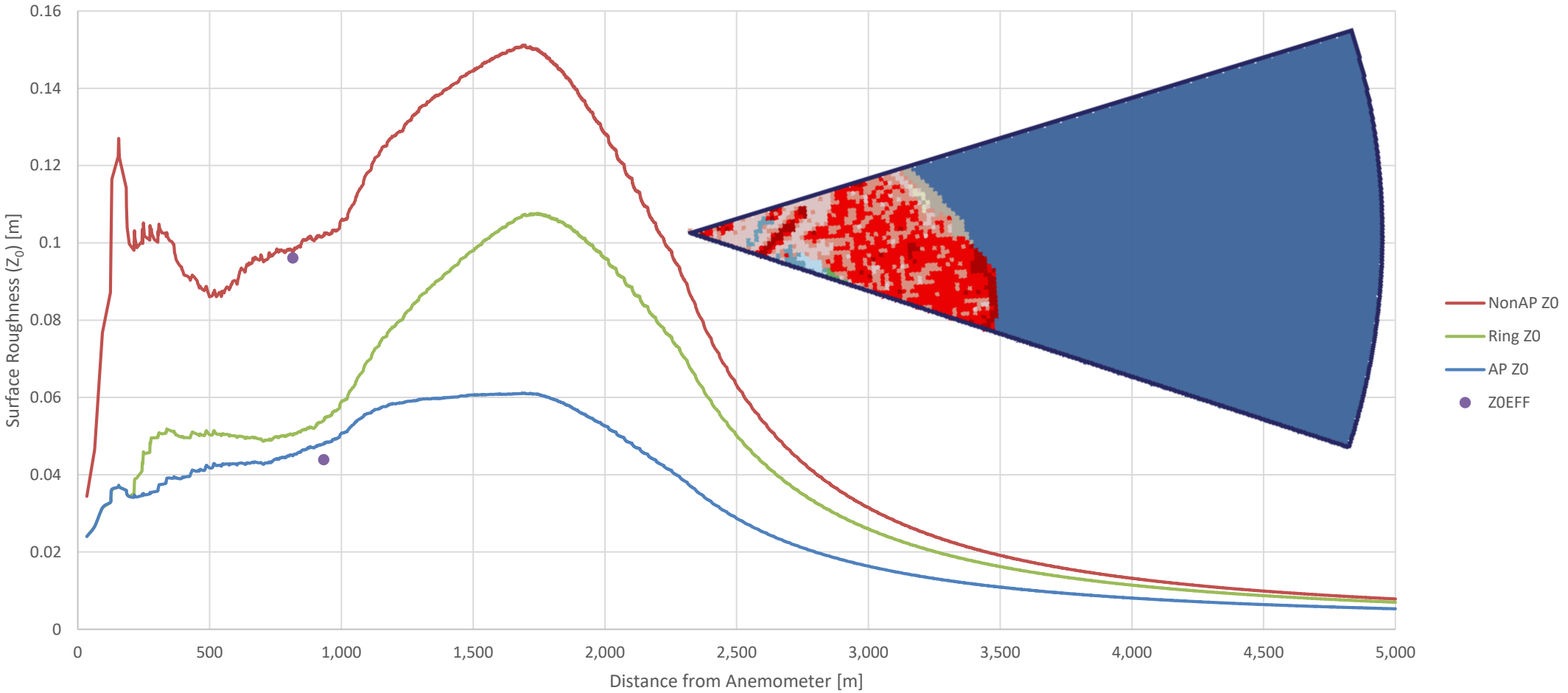
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

BDR Sector 6

Airport:

BDL

BDR

DXR

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HVN

IJD

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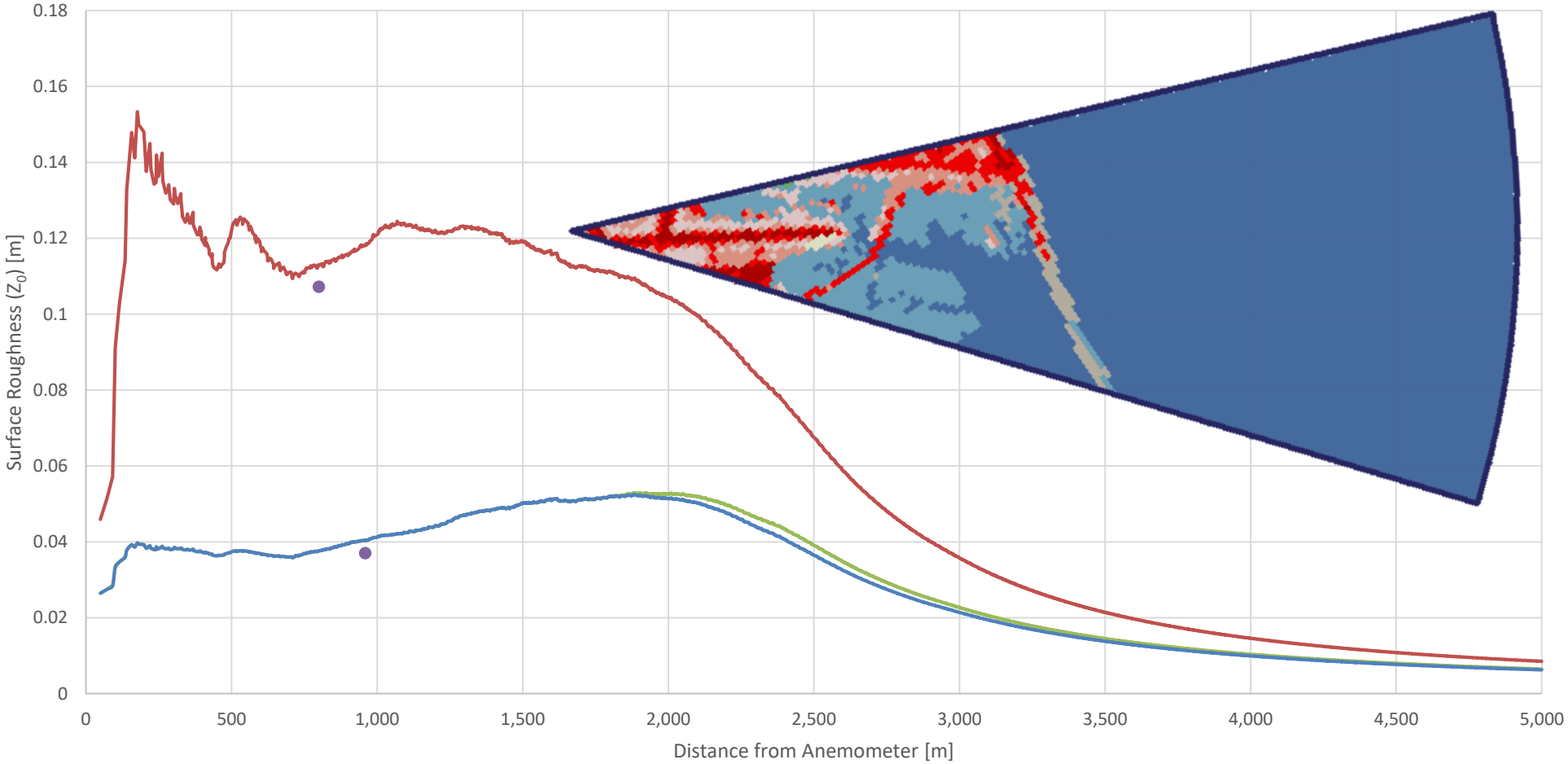

Sector:

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Connecticut Department of Energy & Environmental Department

BDR Sector 7

Airport:

BDL

BDR

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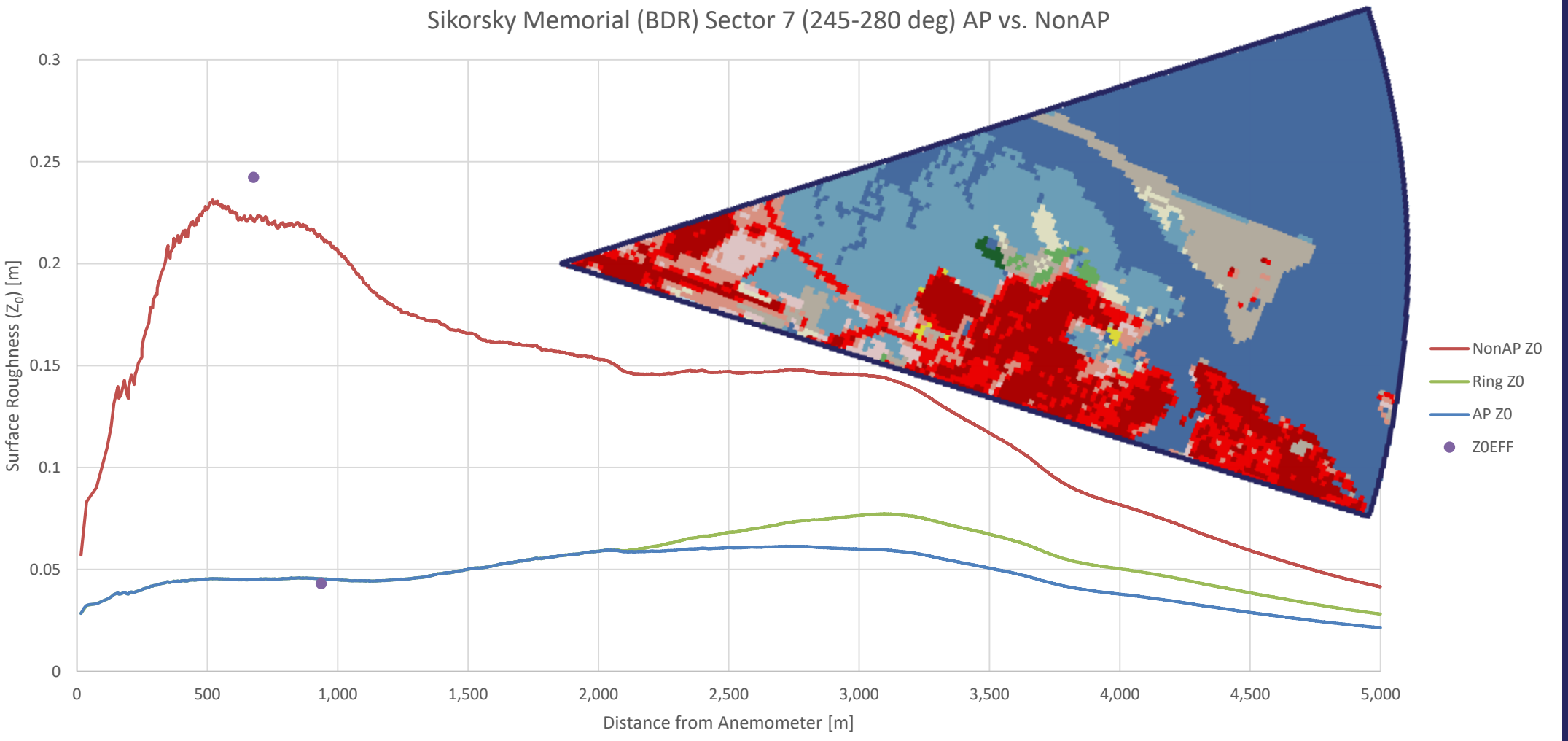
HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

BDR Sector 8

Airport:

BDL

BDR

DXR

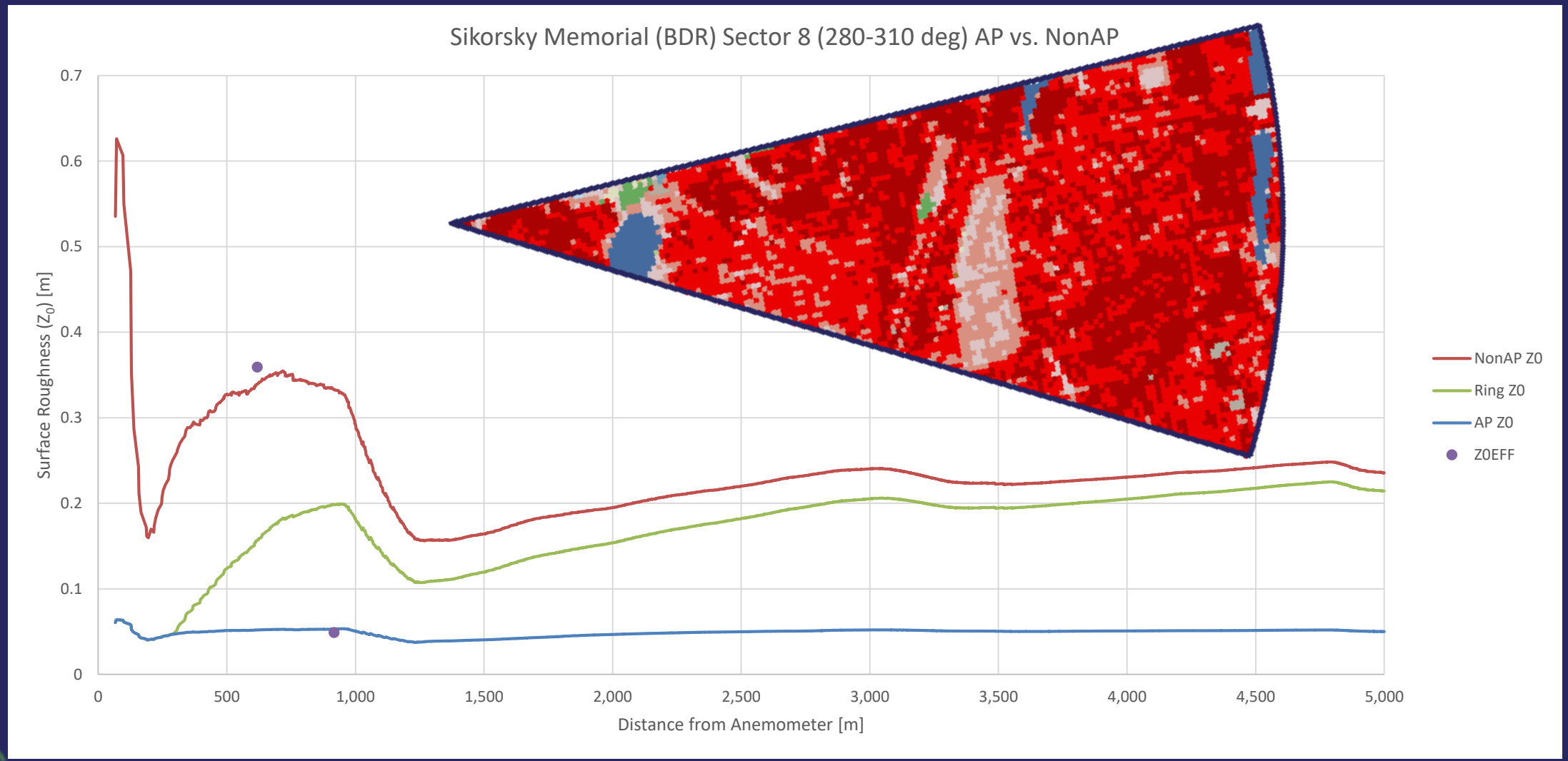
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

BDR Sector 9

Airport:

BDL

BDR

DXR

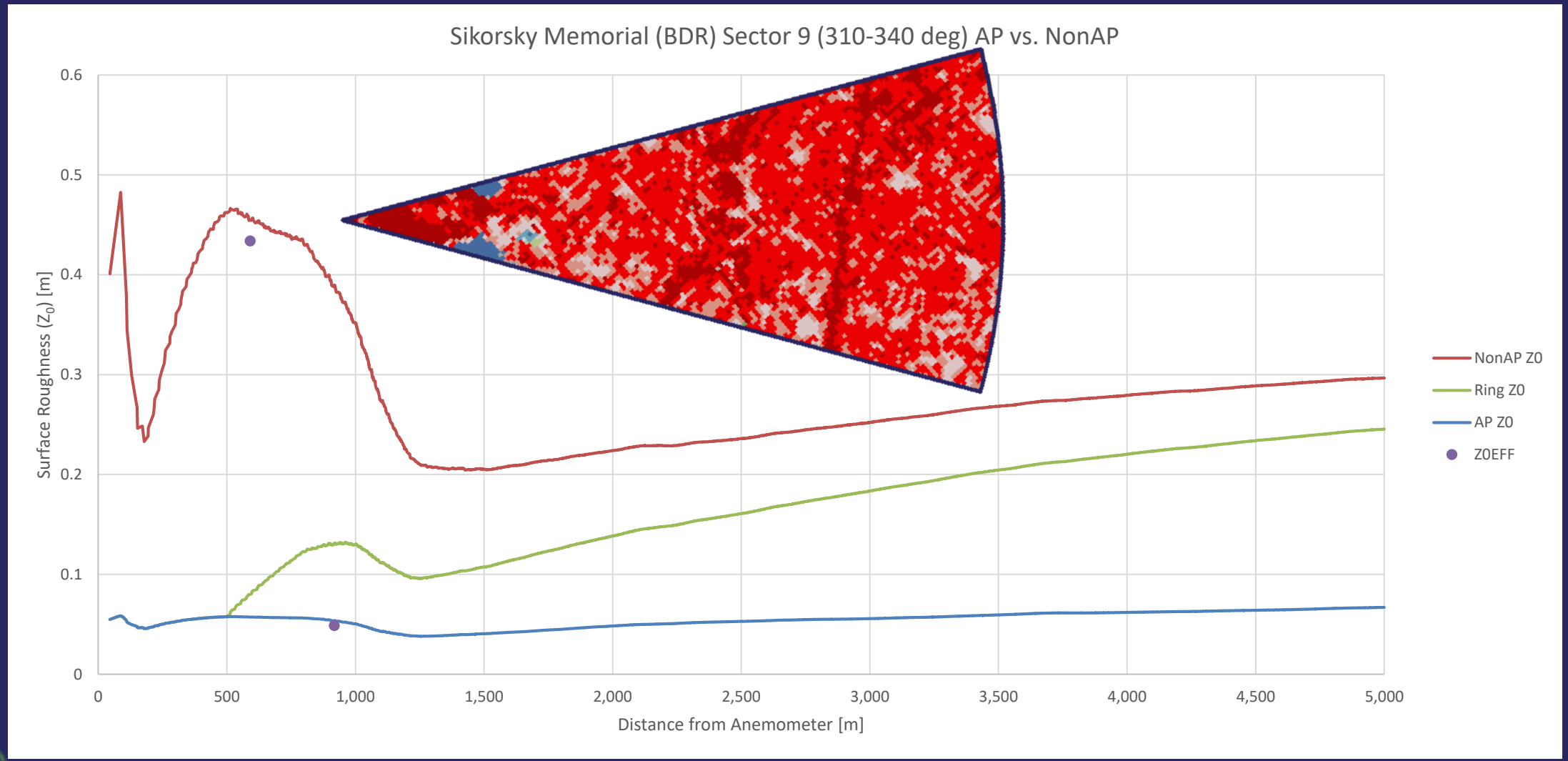
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

BDR Sector 10

Airport:

BDL

BDR

DXR

GON

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HVN

IJD

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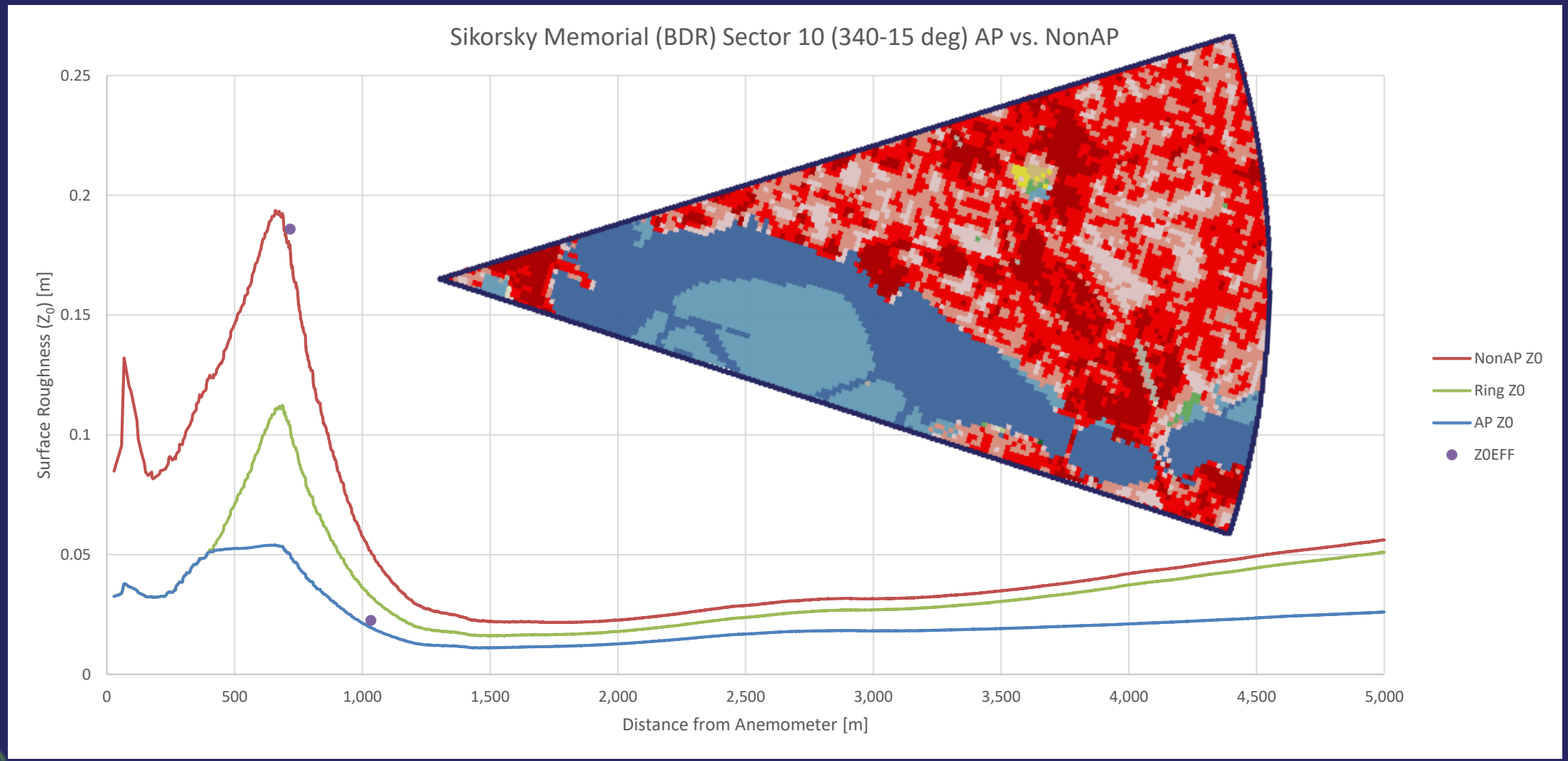

Sector:

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Connecticut Department of Energy & Environmental Department

Danbury Municipal Airport (DXR)

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

MMK

NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Danbury Municipal Airport (DXR)

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

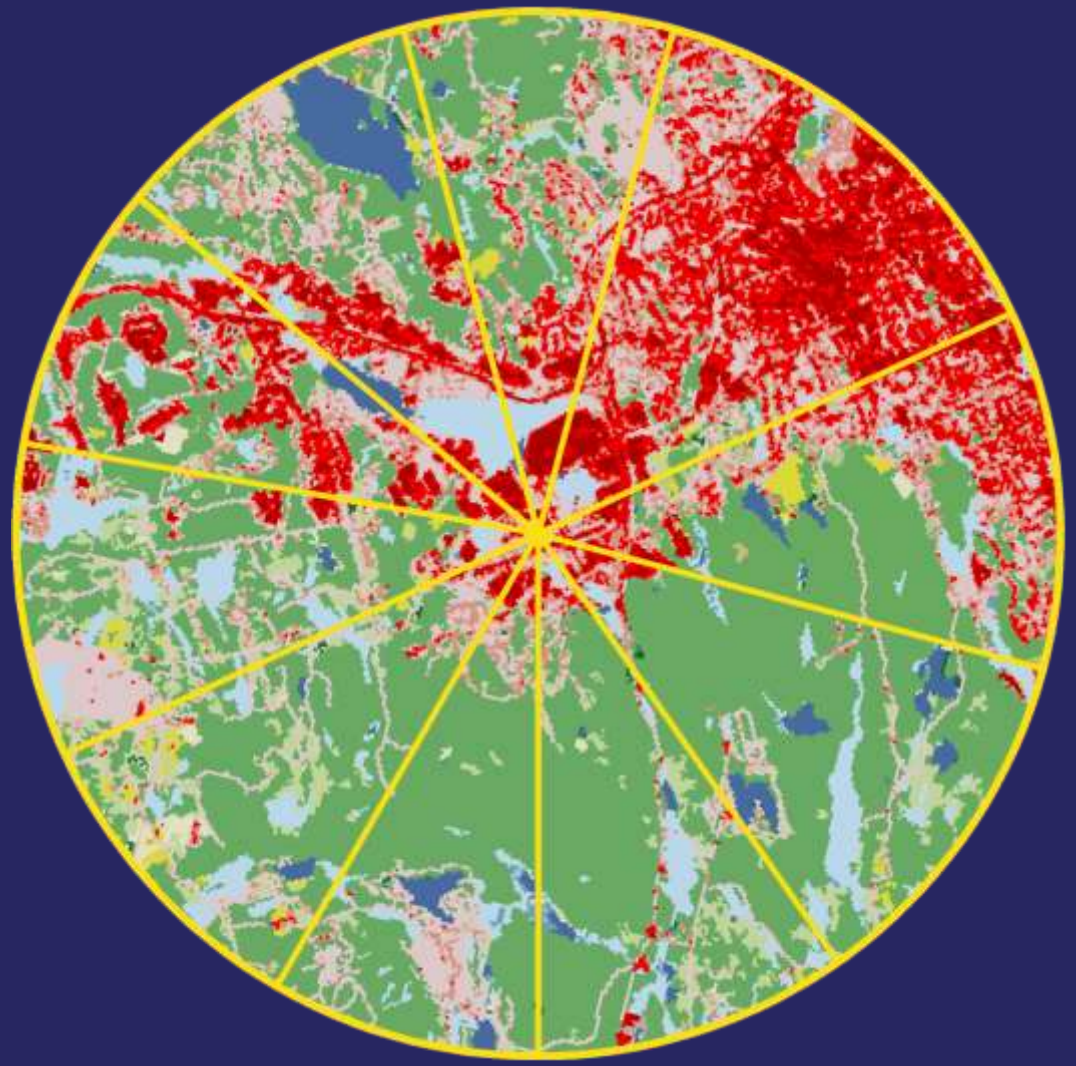
GON

HFD

HVN

IJD

MMK



NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 1

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

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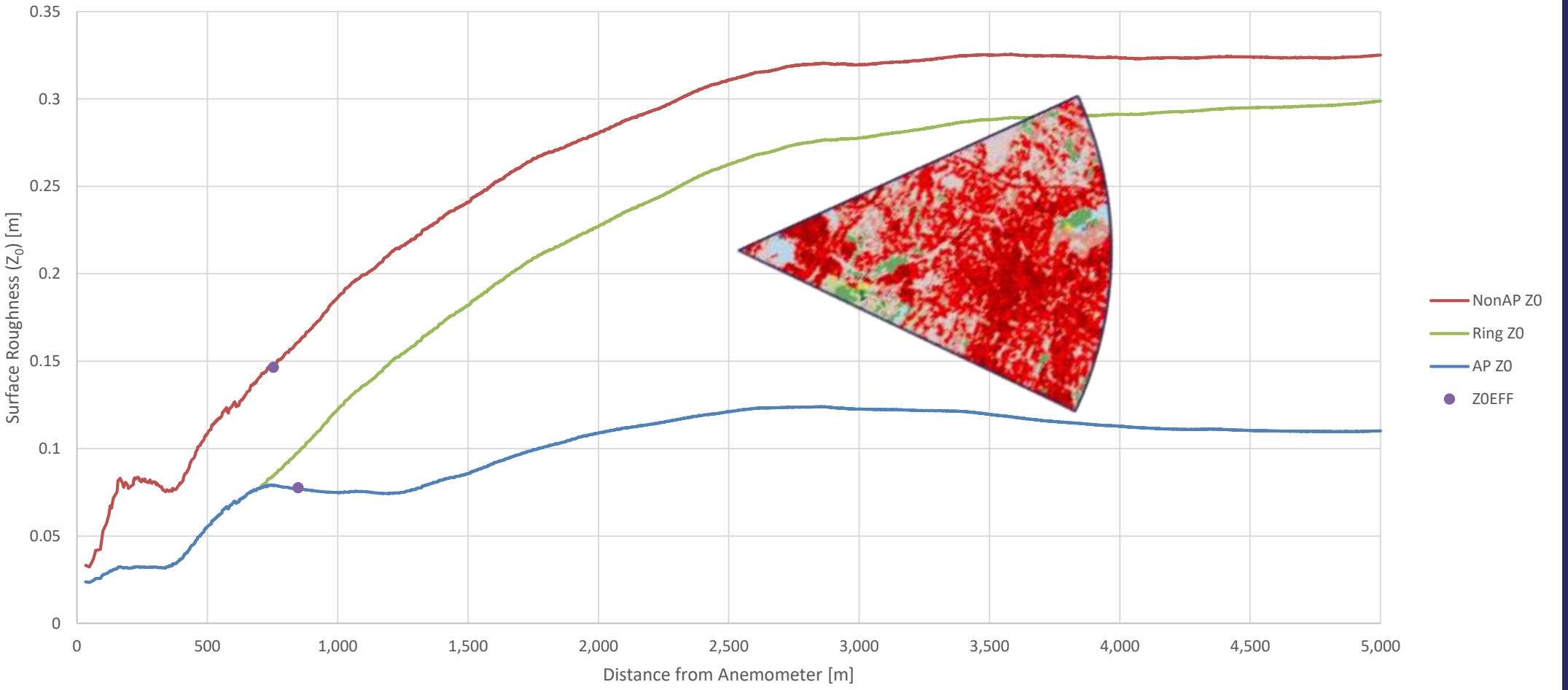

Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 2

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

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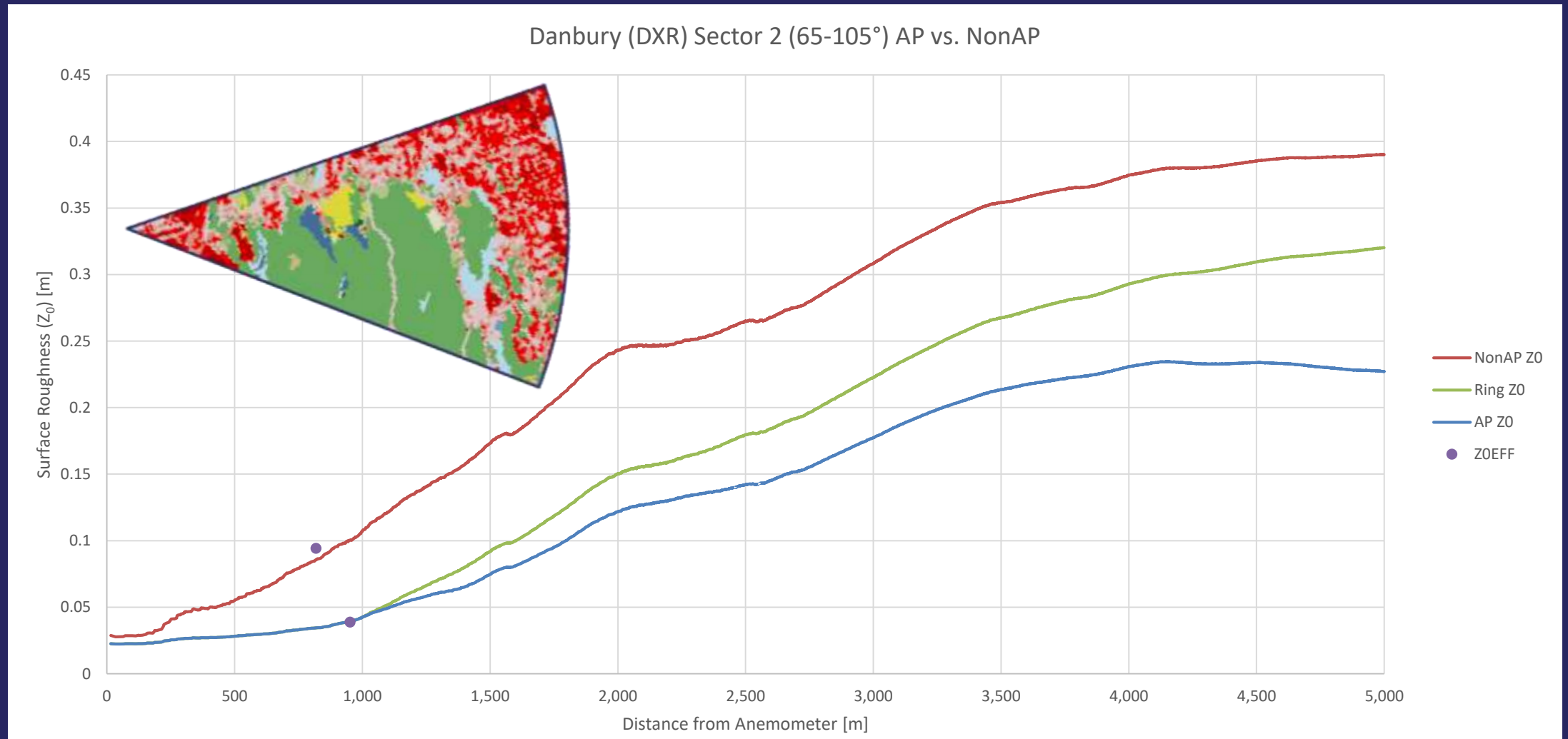
HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 3

DANBURY
CONNECTICUT

Airport:

BDL

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DXR

GON

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HVN

IJD

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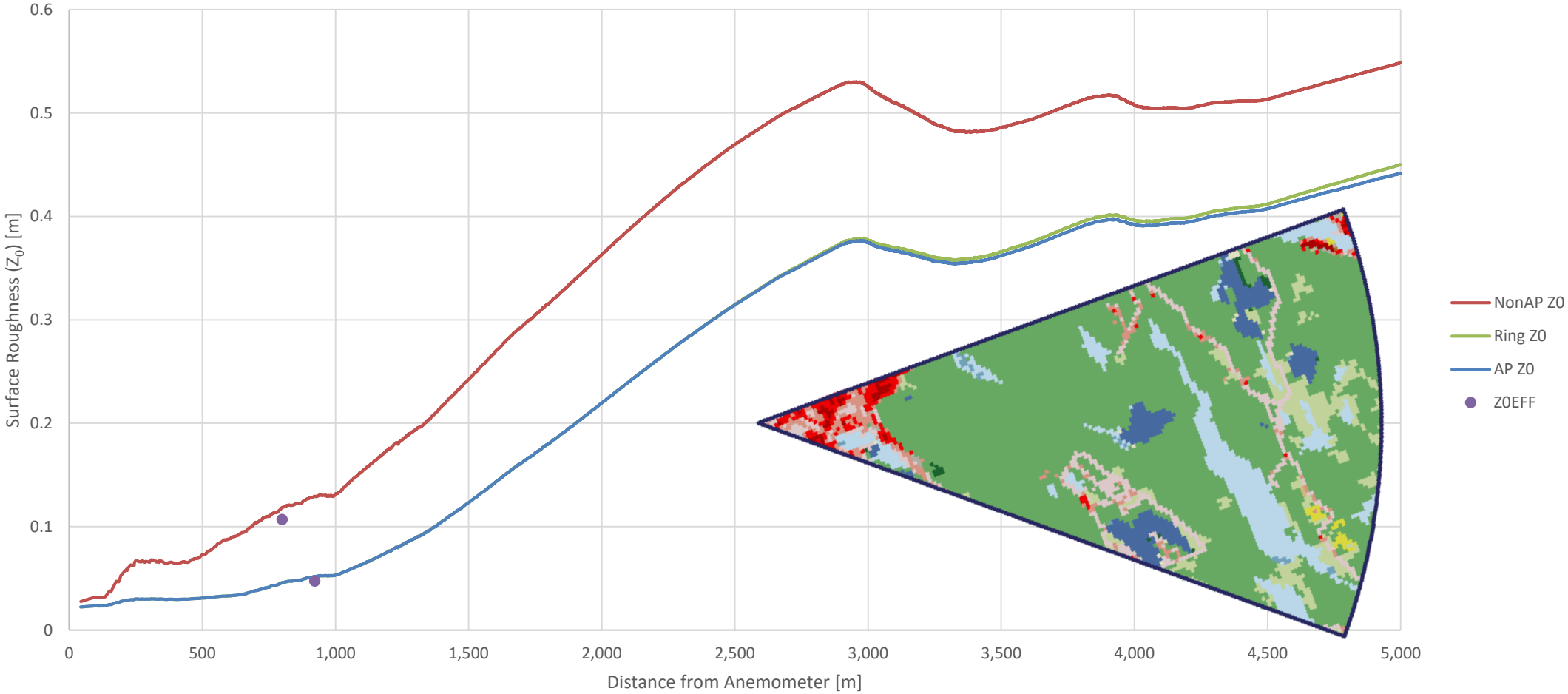

Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 4

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

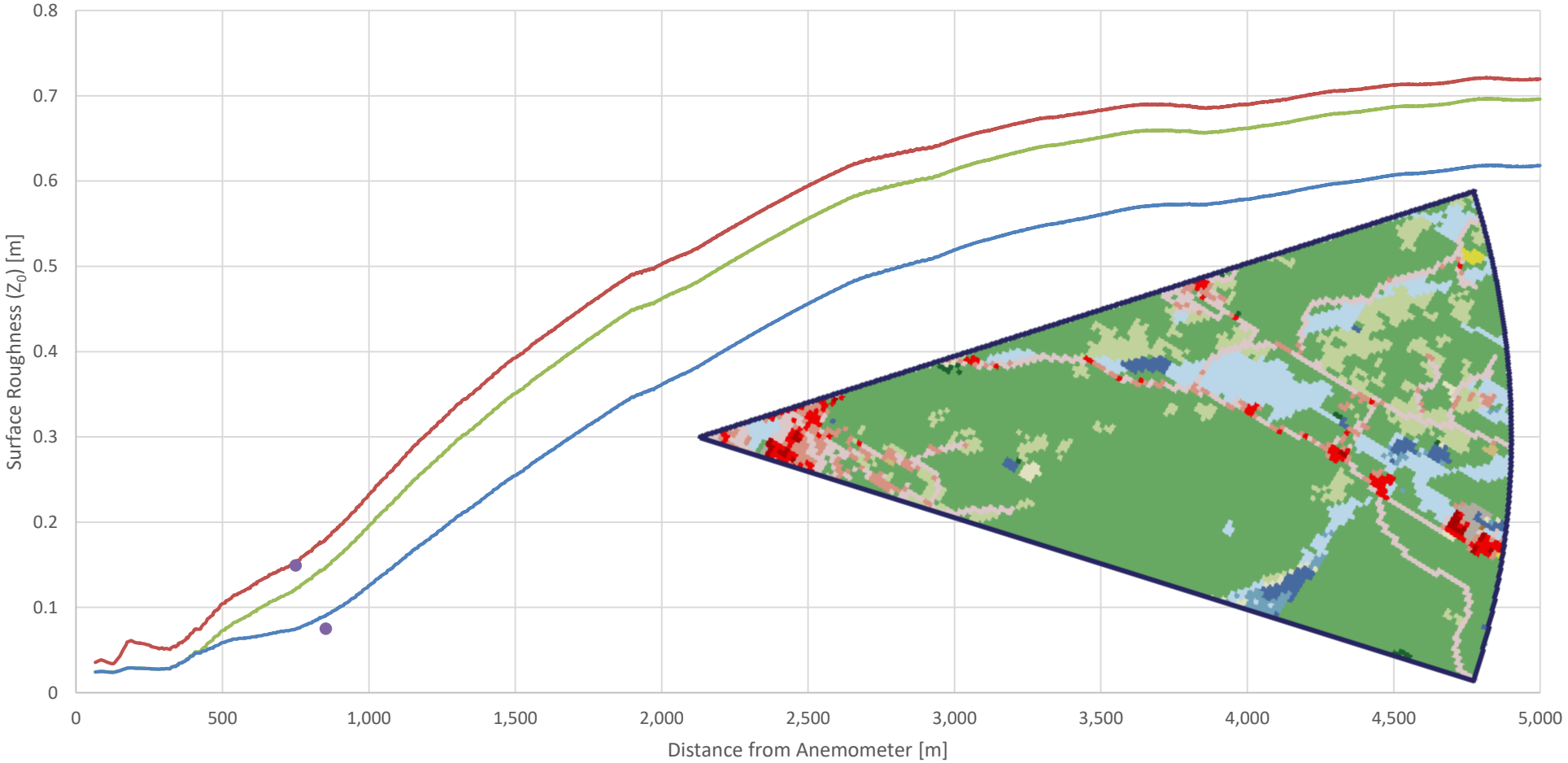
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 5

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

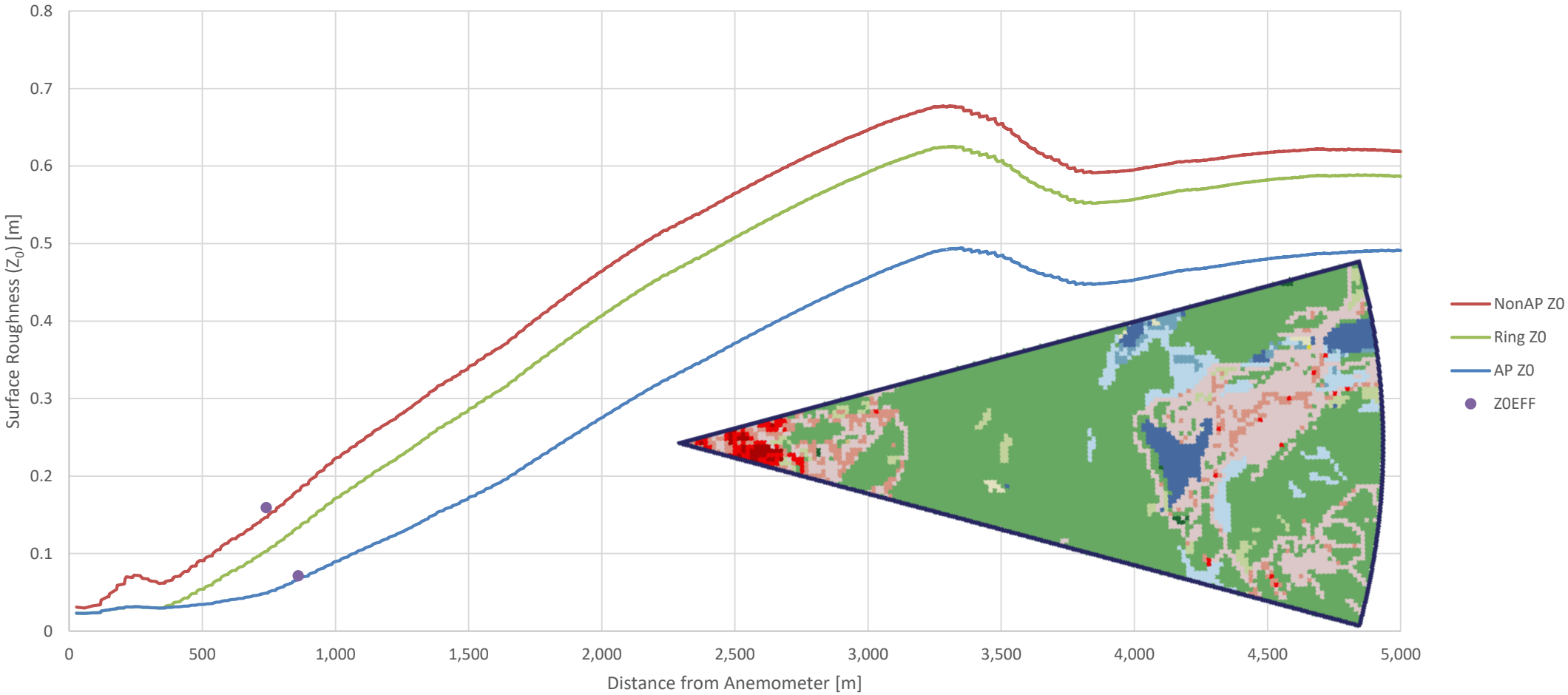
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 6

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

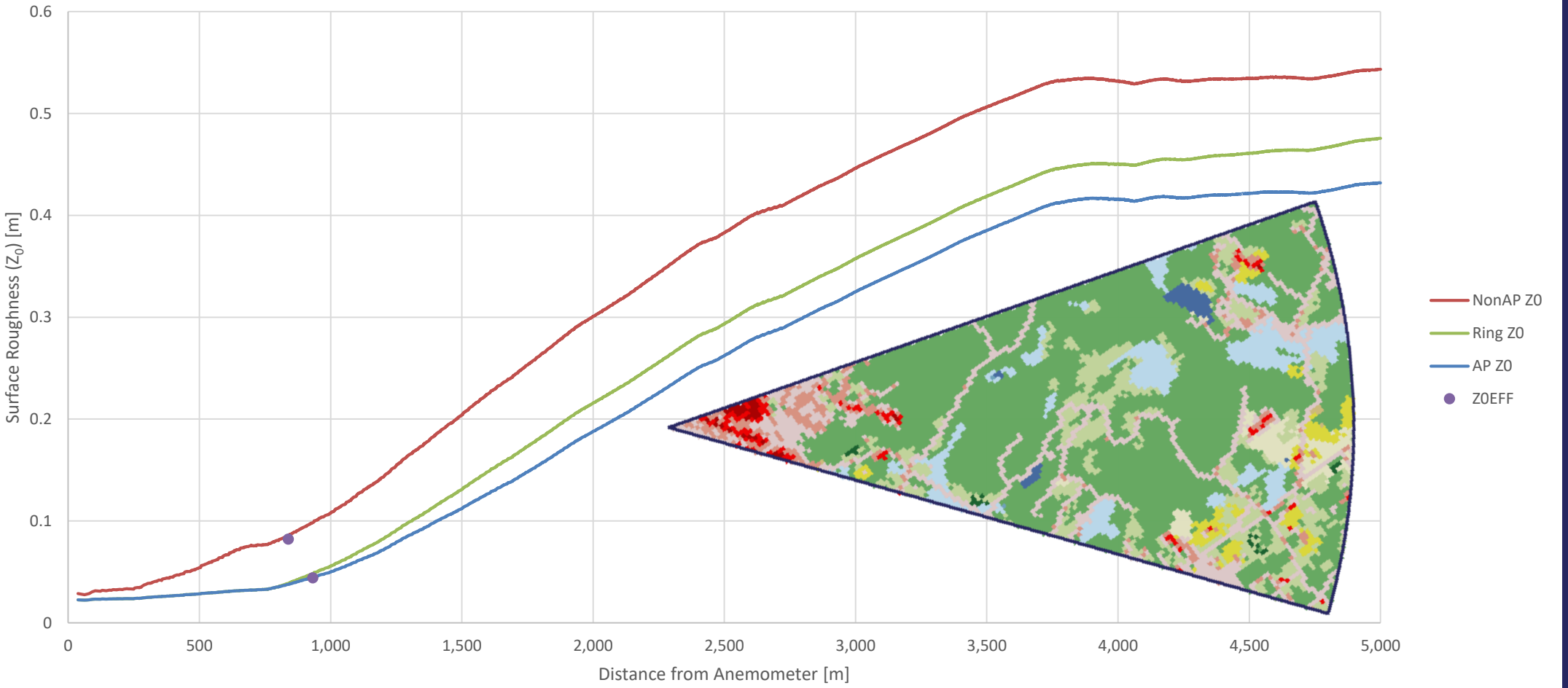
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 7

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

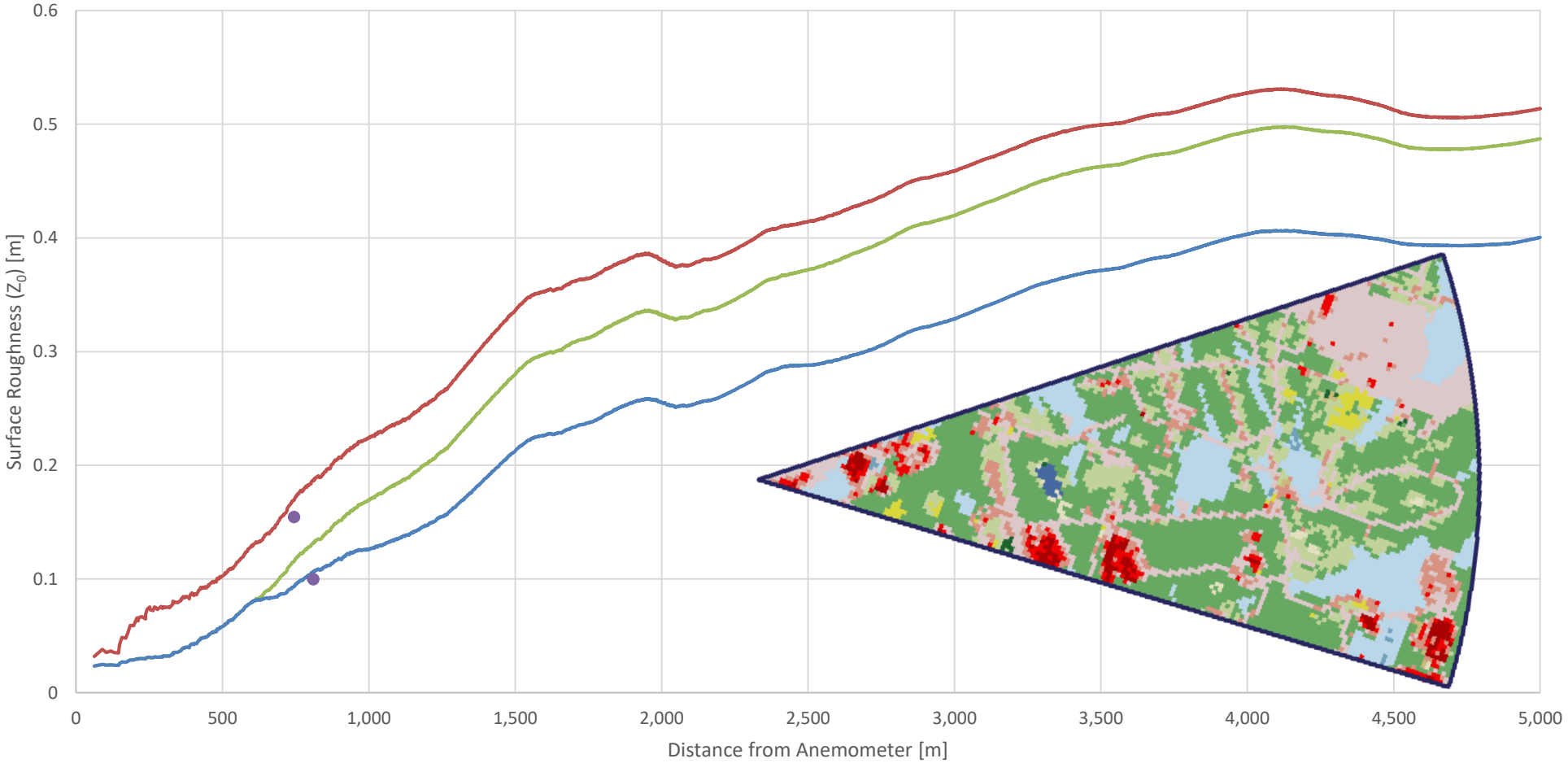
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 8

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

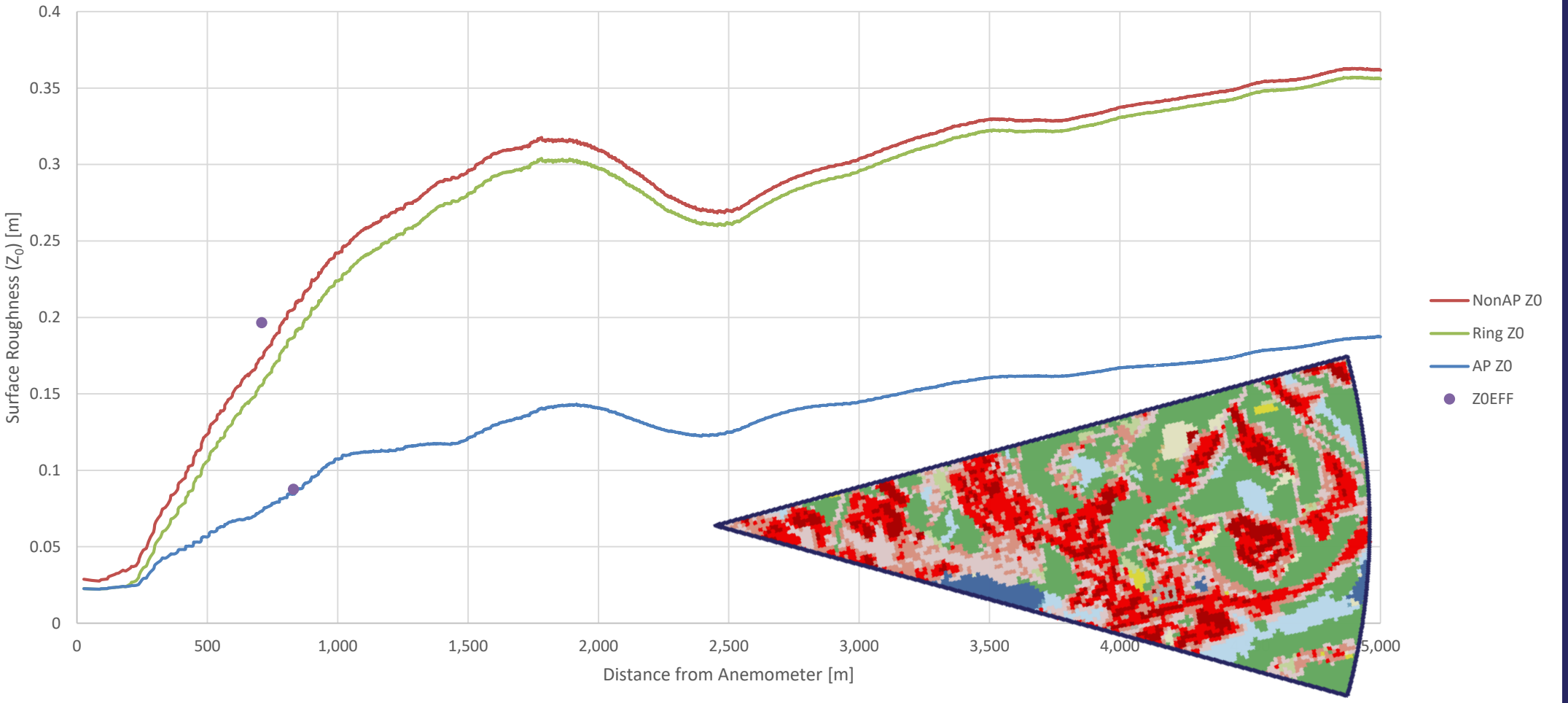
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 9

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

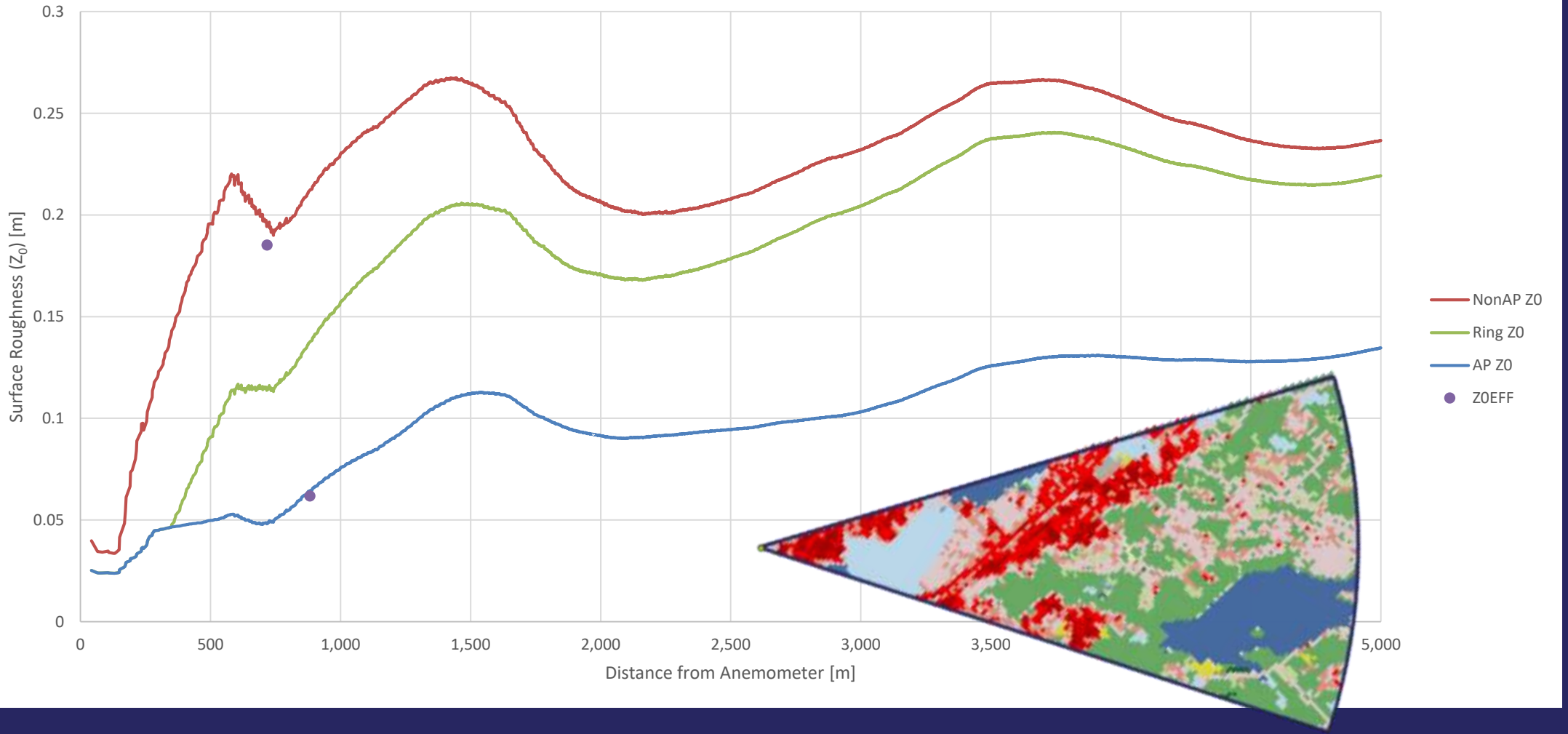
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

DXR Sector 10

DANBURY
CONNECTICUT

Airport:

BDL

BDR

DXR

GON

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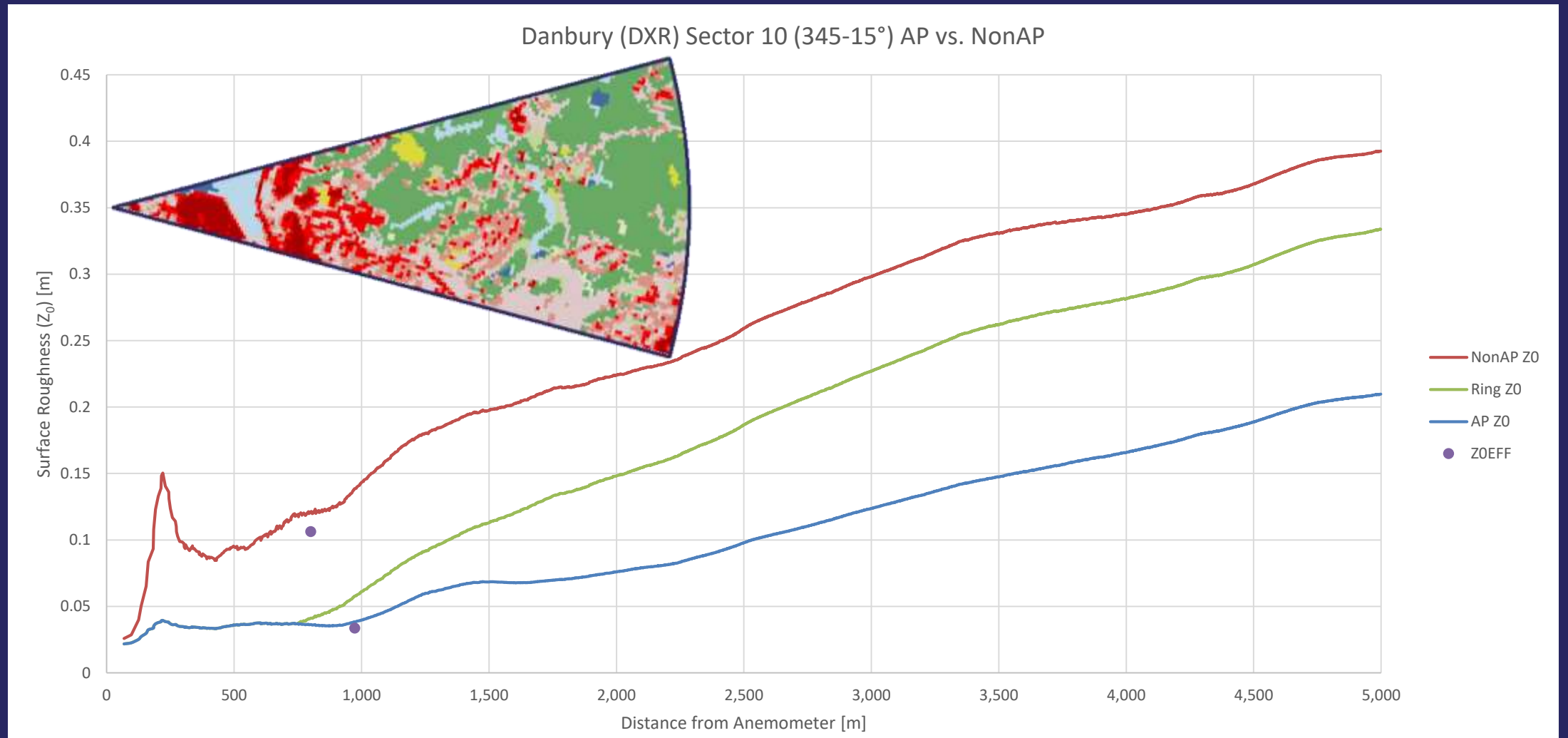
HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

Groton-New London Airport (GON)

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

MMK

NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Groton-New London Airport (GON)

Airport:

BDL

BDR

DXR

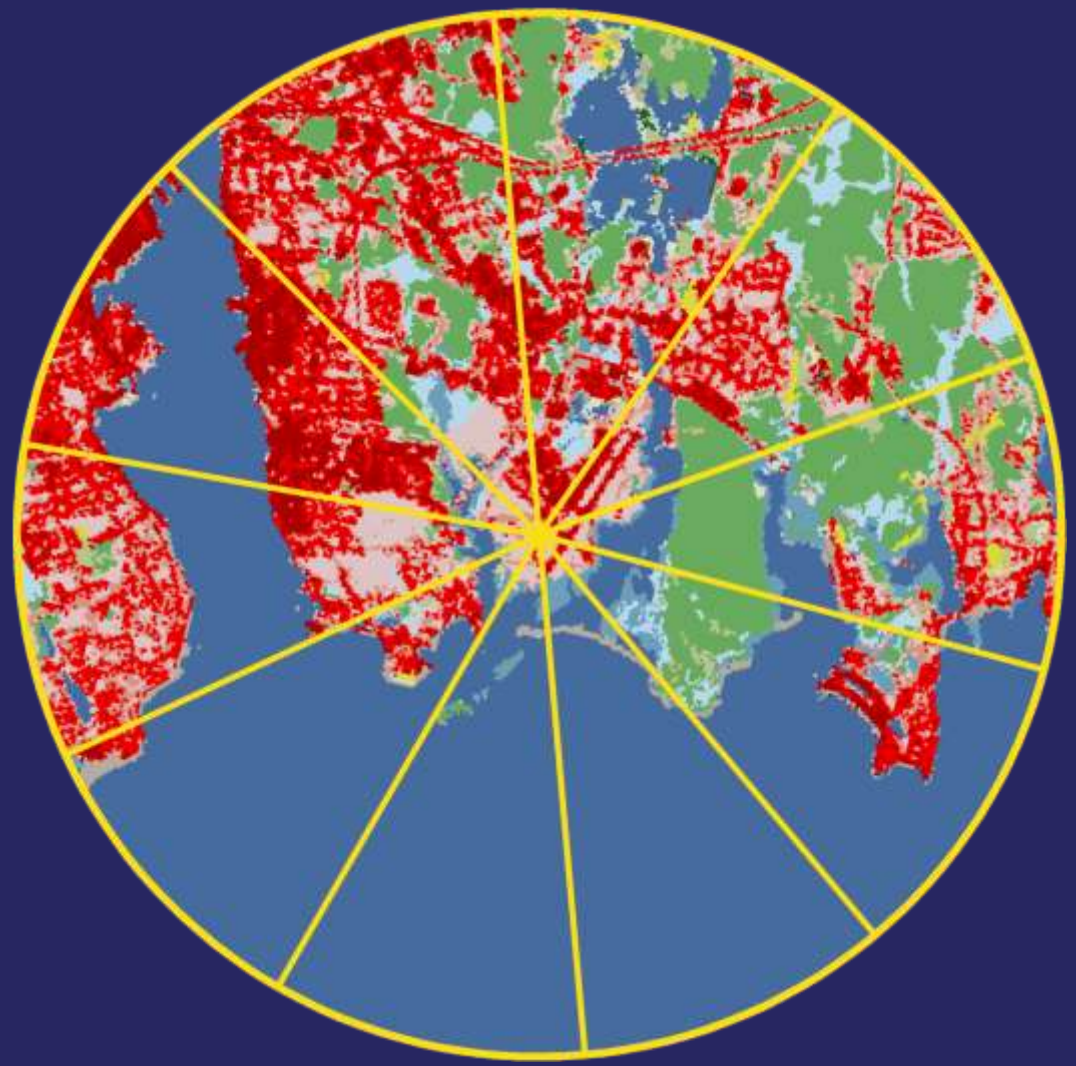
GON

HFD

HVN

IJD

MMK



NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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GON Sector 1

Airport:

BDL

BDR

DXR

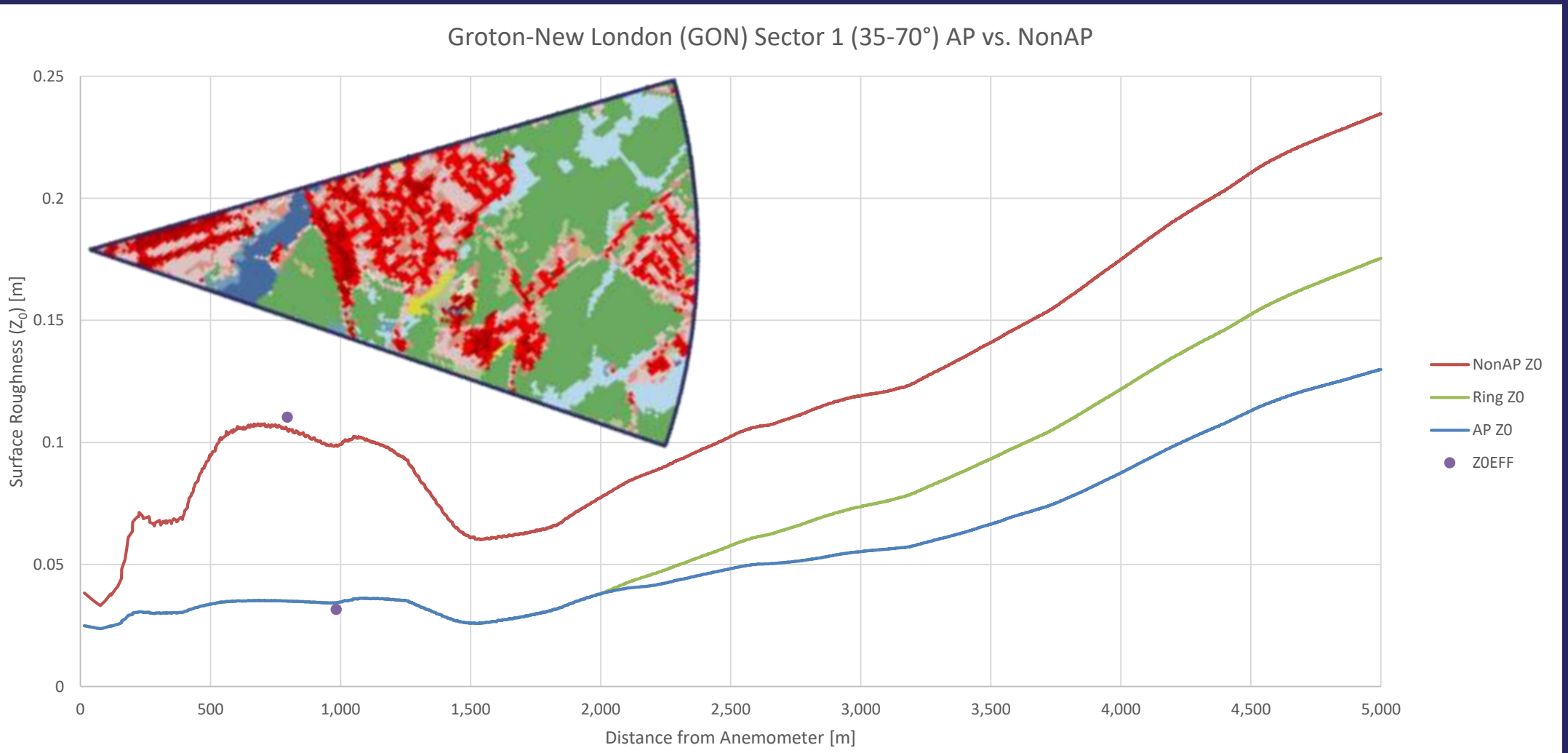
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

GON Sector 2

Airport:

BDL

BDR

DXR

<u>GON</u>

HFD

HVN

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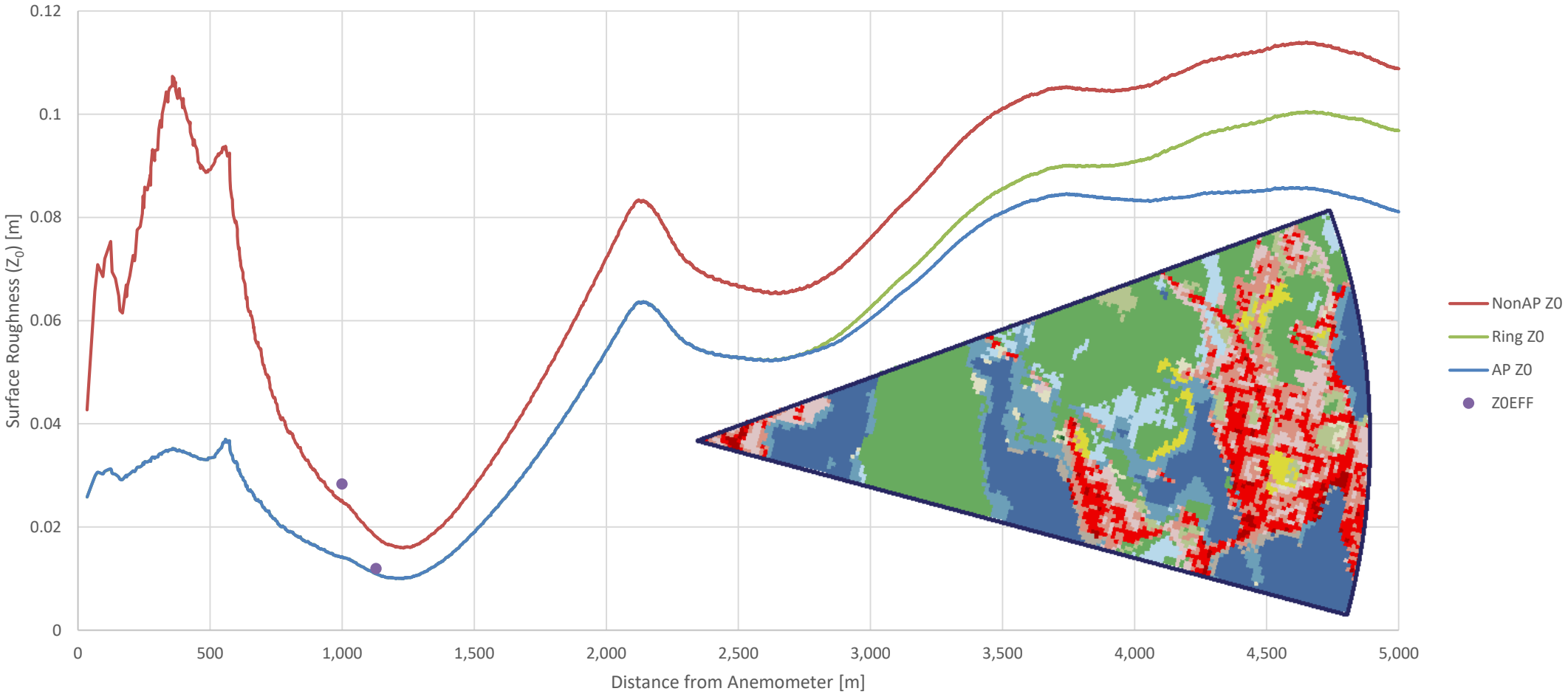
MMK



Sector:

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Connecticut Department of Energy & Environmental Department

GON Sector 3

Airport:

BDL

BDR

DXR

<u>GON</u>

HFD

HVN

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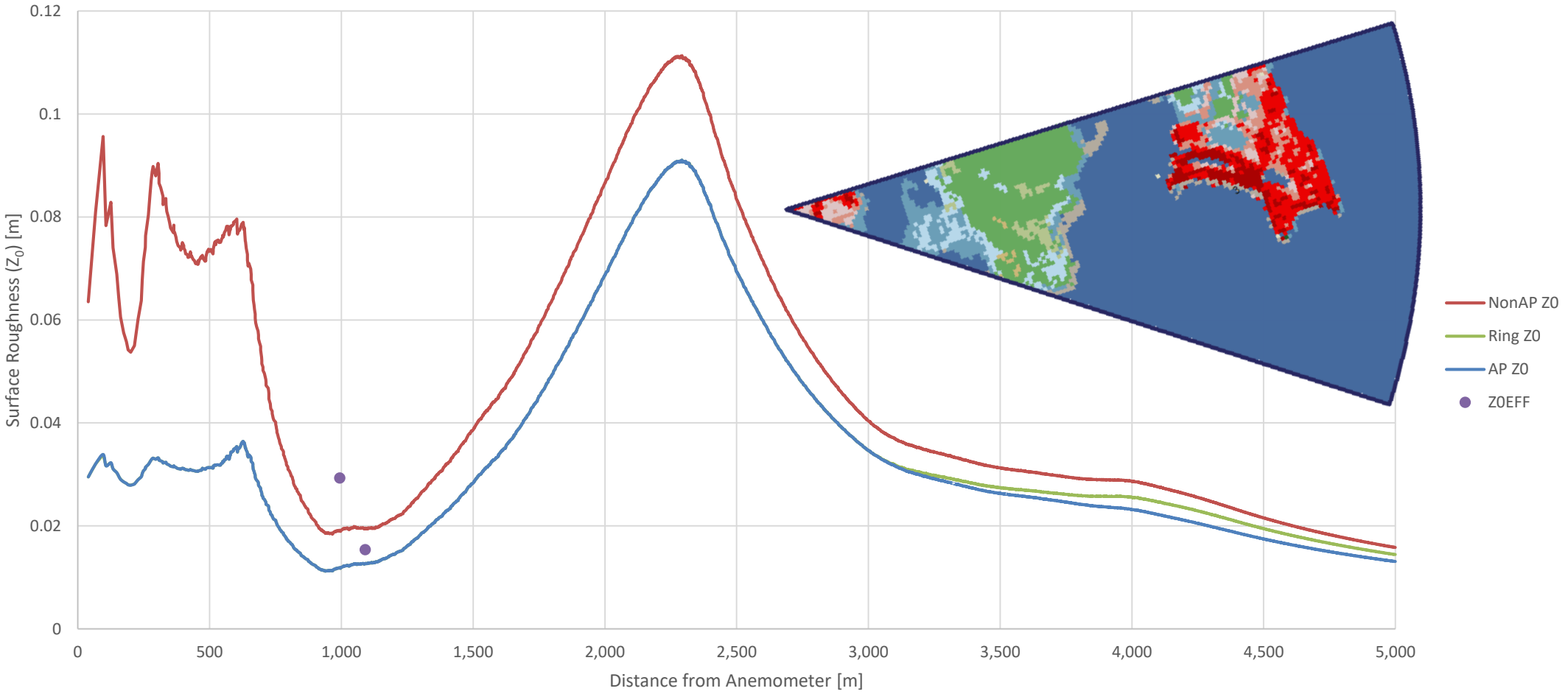

Sector:

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Connecticut Department of Energy & Environmental Department

GON Sector 4

Airport:

BDL

BDR

DXR

<u>GON</u>

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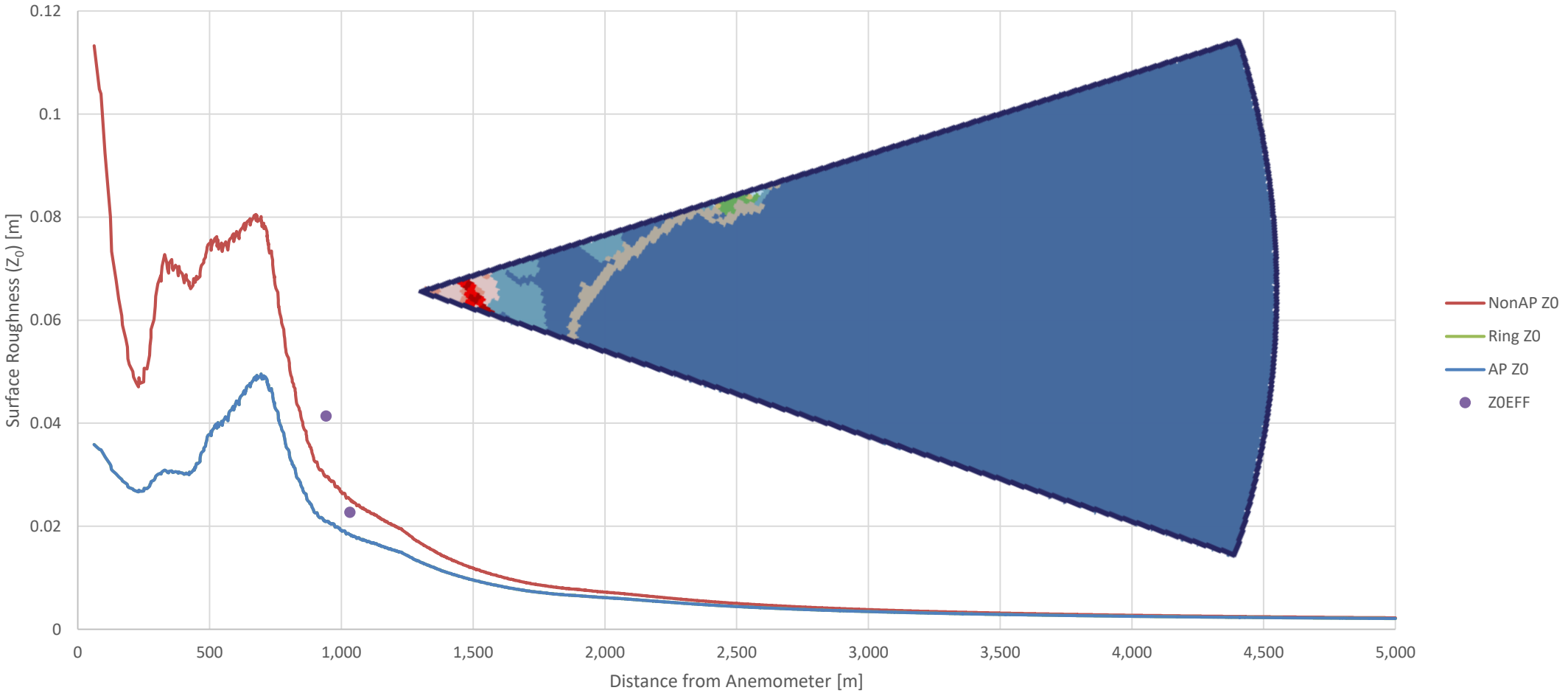

Sector:

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Connecticut Department of Energy & Environmental Department

GON Sector 5

Airport:

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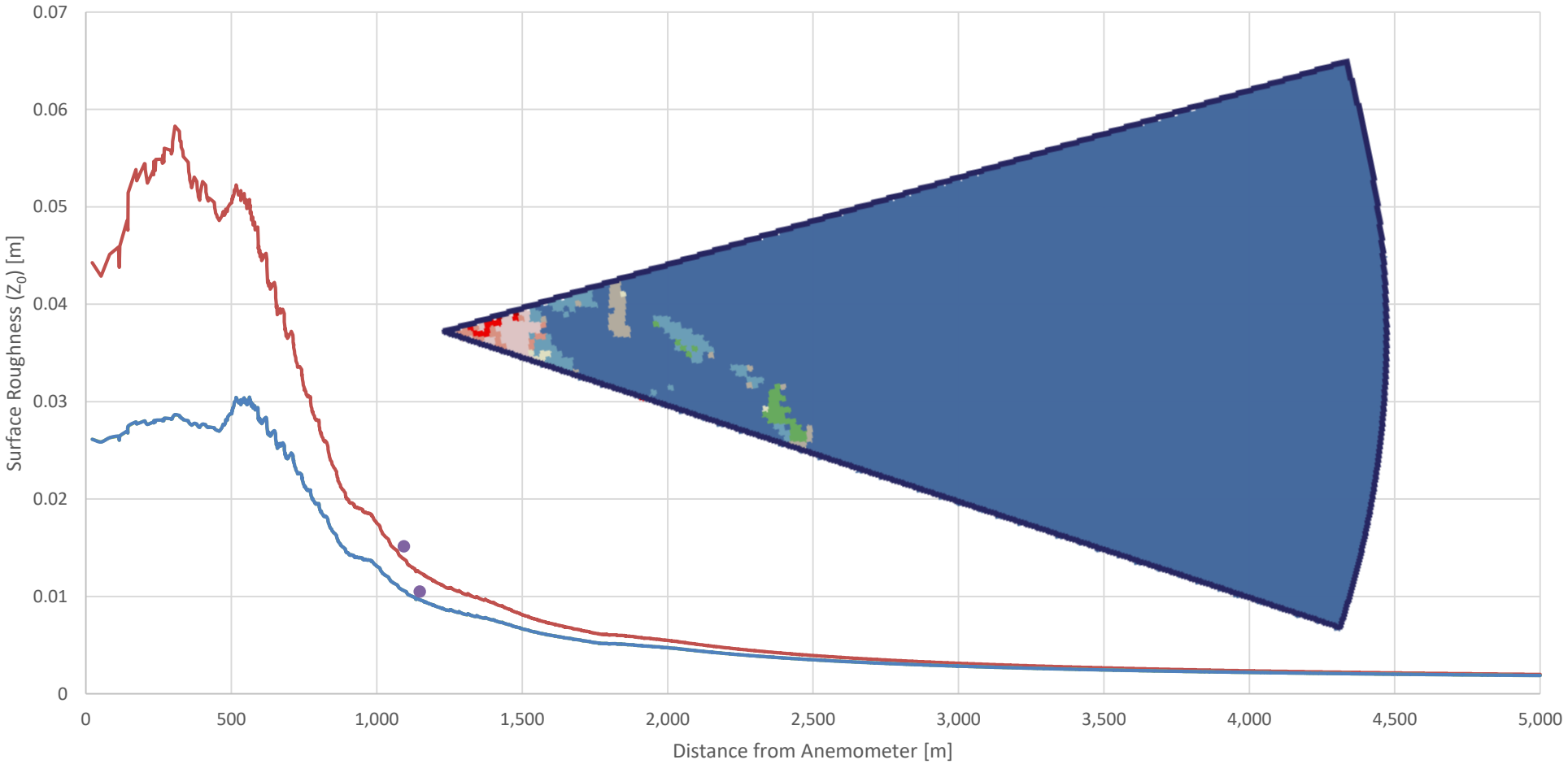

Sector:

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GON Sector 6

Airport:

BDL

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HVN

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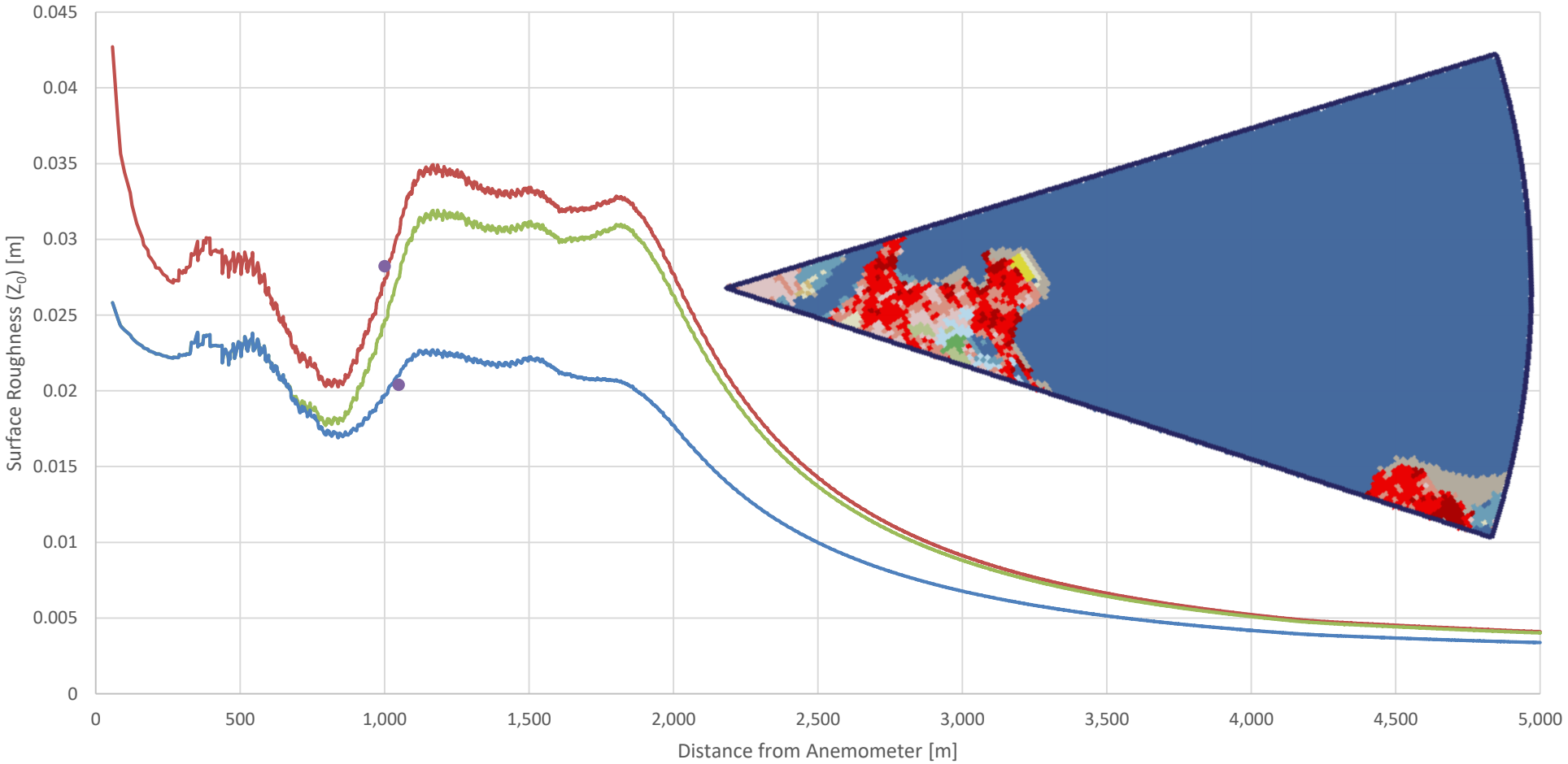

Sector:

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GON Sector 7

Airport:

BDL

BDR

DXR

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HVN

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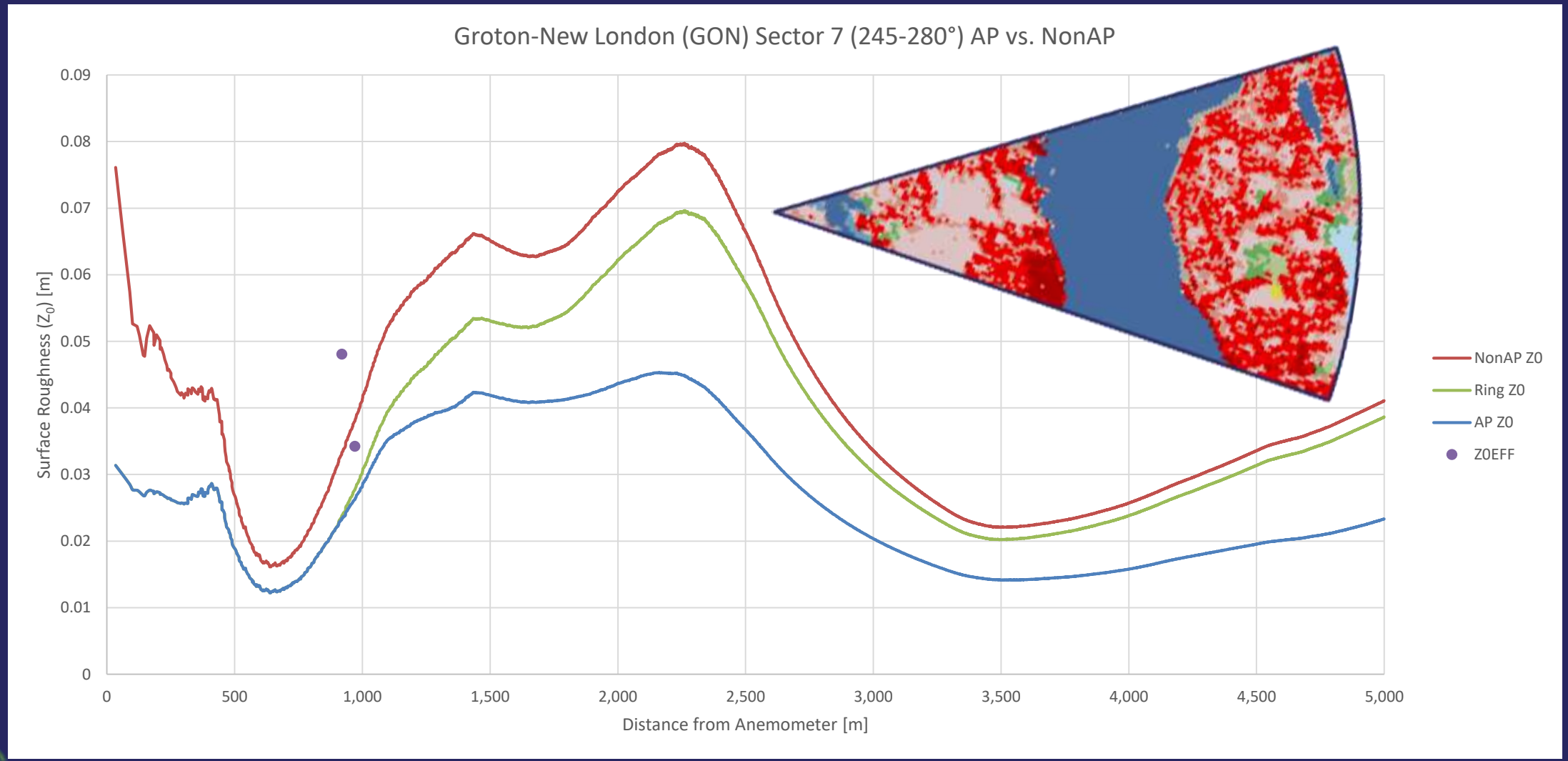
MMK



Sector:

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Connecticut Department of Energy & Environmental Department

GON Sector 8

Airport:

BDL

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HFD

HVN

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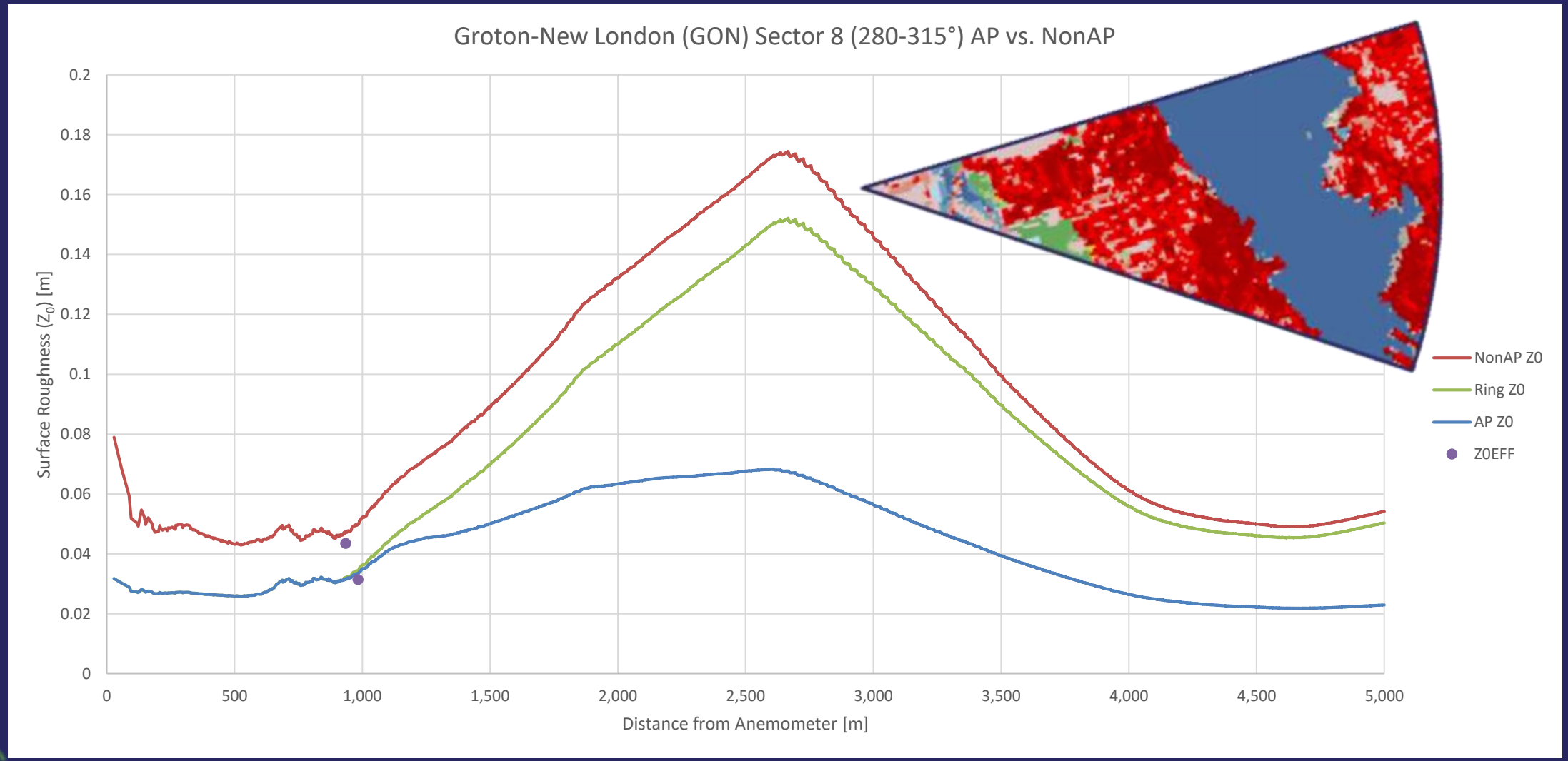

Sector:

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Connecticut Department of Energy & Environmental Department

GON Sector 9

Airport:

BDL

BDR

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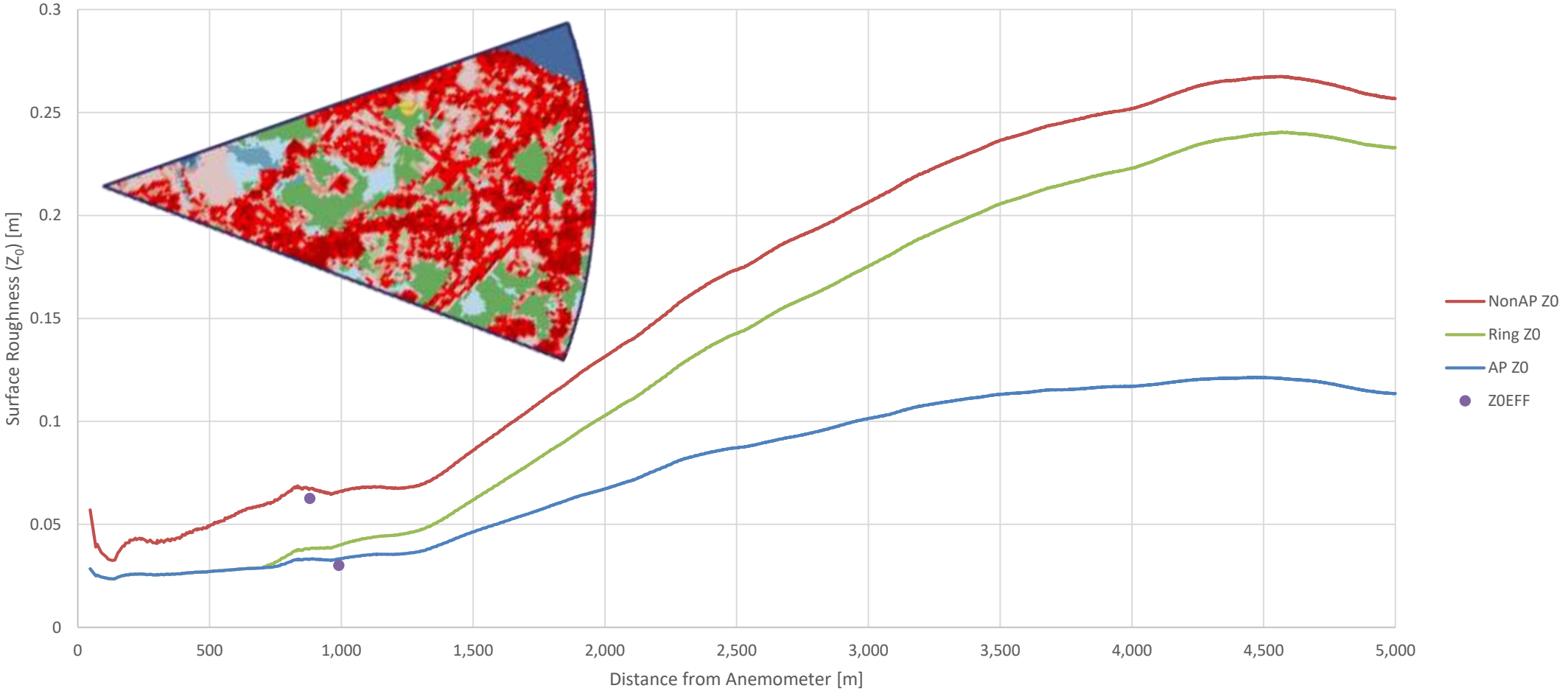
GON

HFD

HVN

IJD

MMK



Sector:

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GON Sector 10

Airport:

BDL

BDR

DXR

GON

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HVN

IJD

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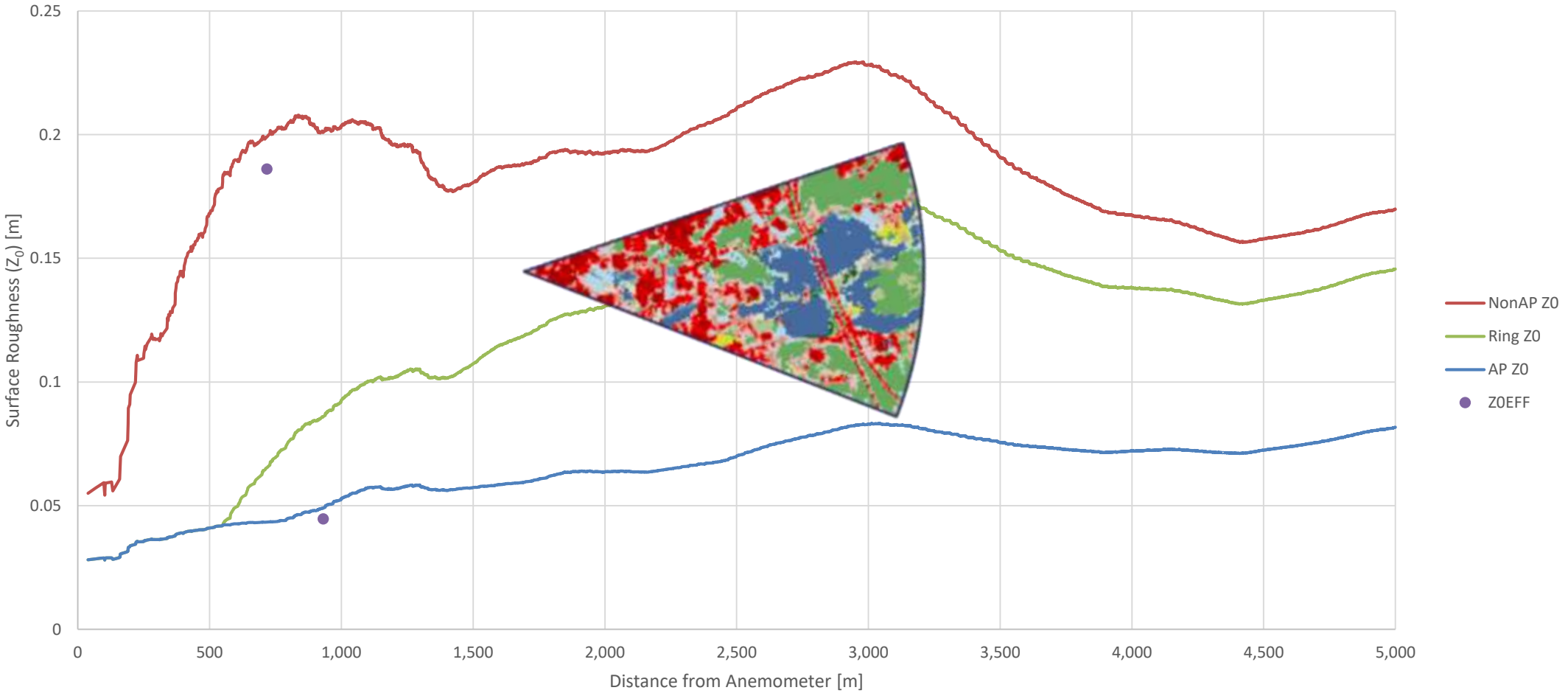

Sector:

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Connecticut Department of Energy & Environmental Department

Hartford-Brainard Airport (HFD)

HARTFORD JET CENTER

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

MMK

NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Connecticut Department of Energy & Environmental Department

Hartford-Brainard Airport (HFD)

HARTFORD JET CENTER

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

MMK

NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 1

HARTFORD JET CENTER

Airport:

BDL

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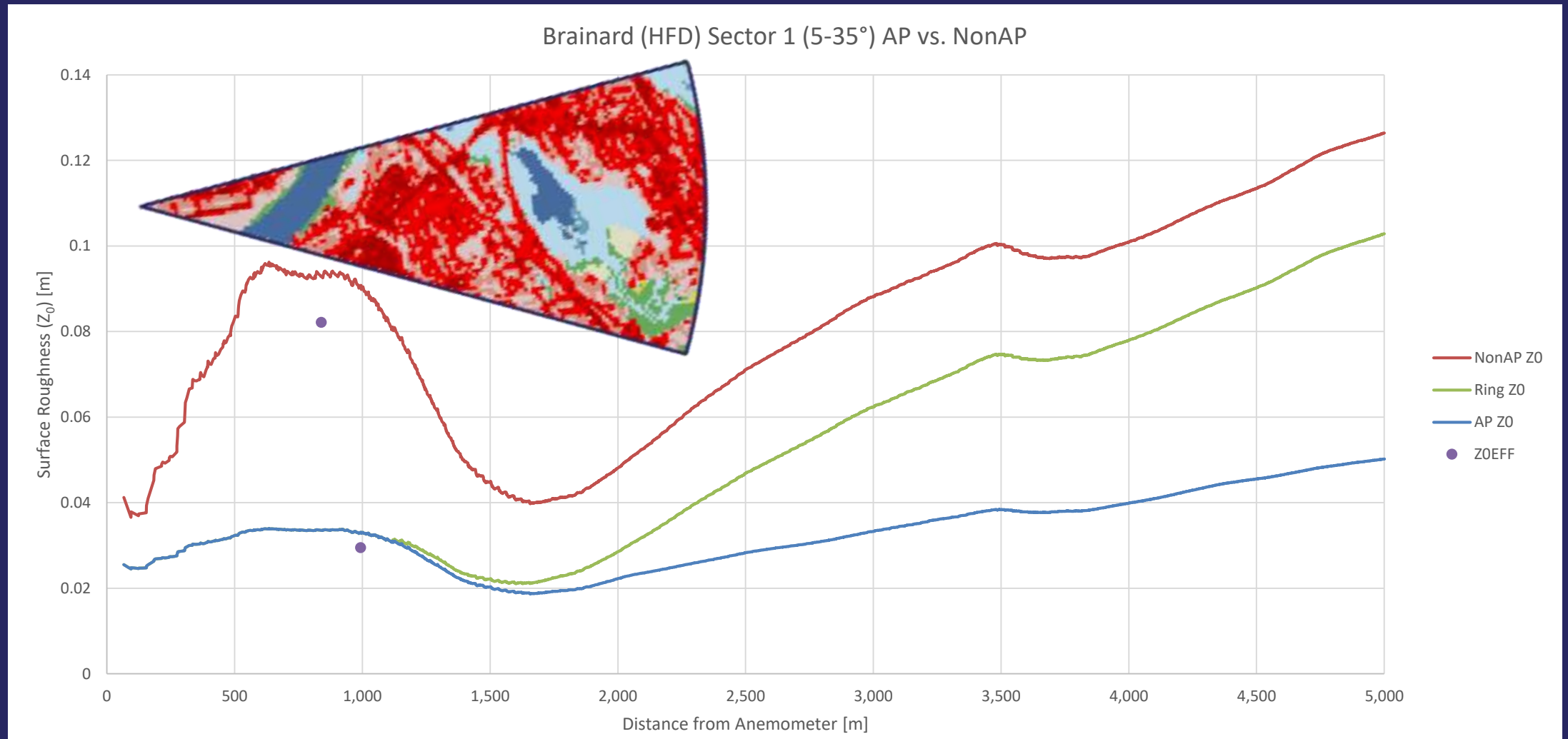

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 2

HARTFORD JET CENTER

Airport:

BDL

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HVN

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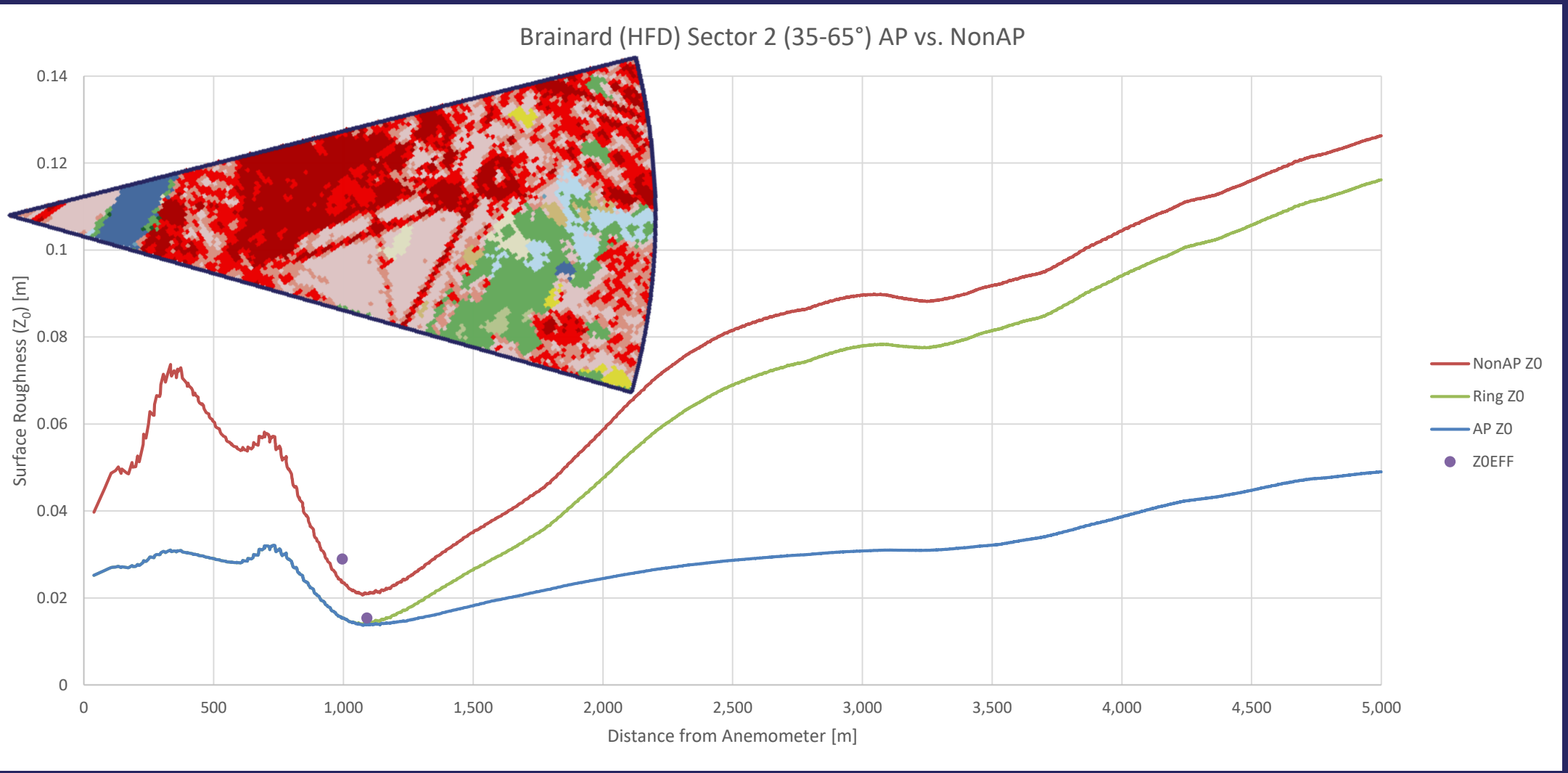

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 3

HARTFORD JET CENTER

Airport:

BDL

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HVN

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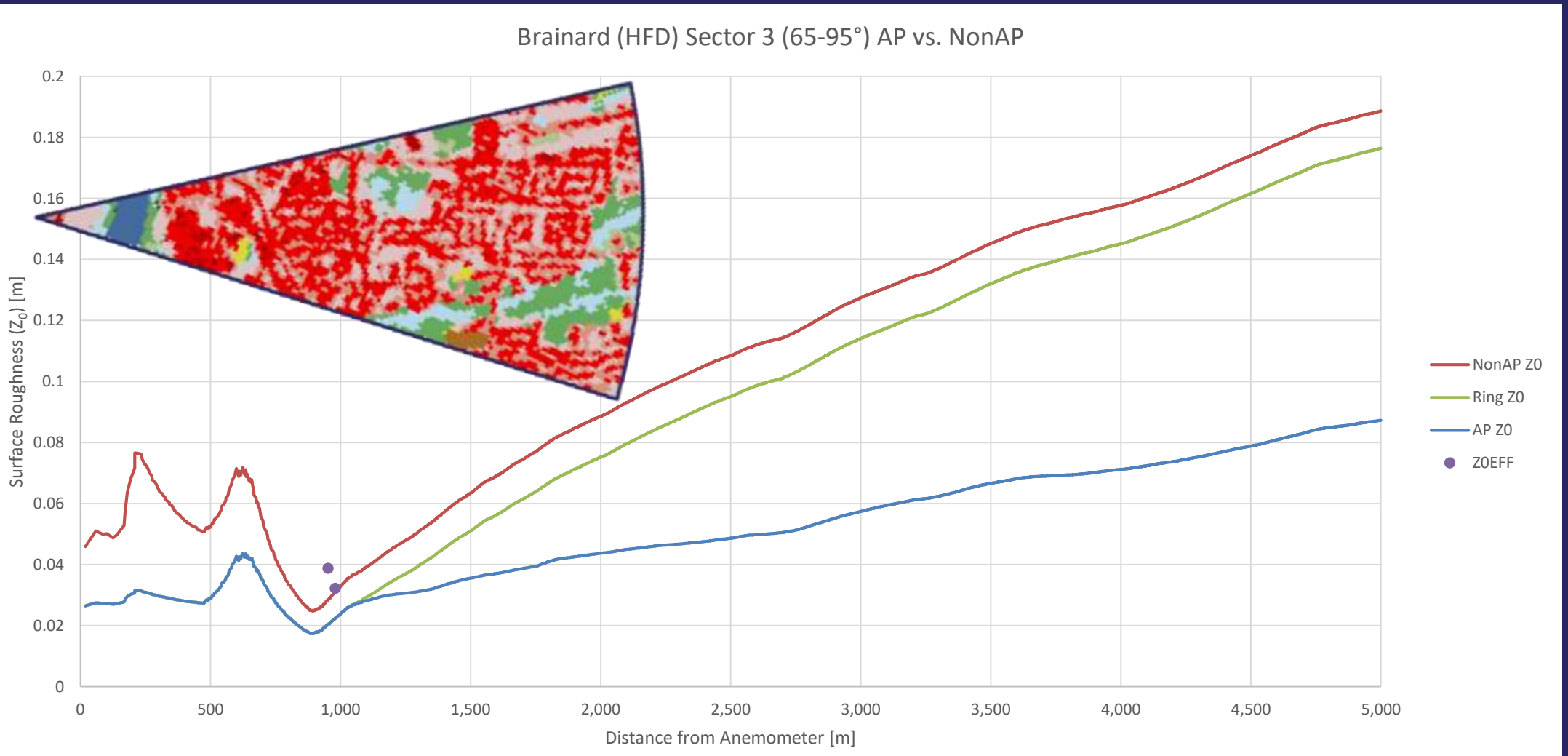

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 4

HARTFORD JET CENTER

Airport:

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HVN

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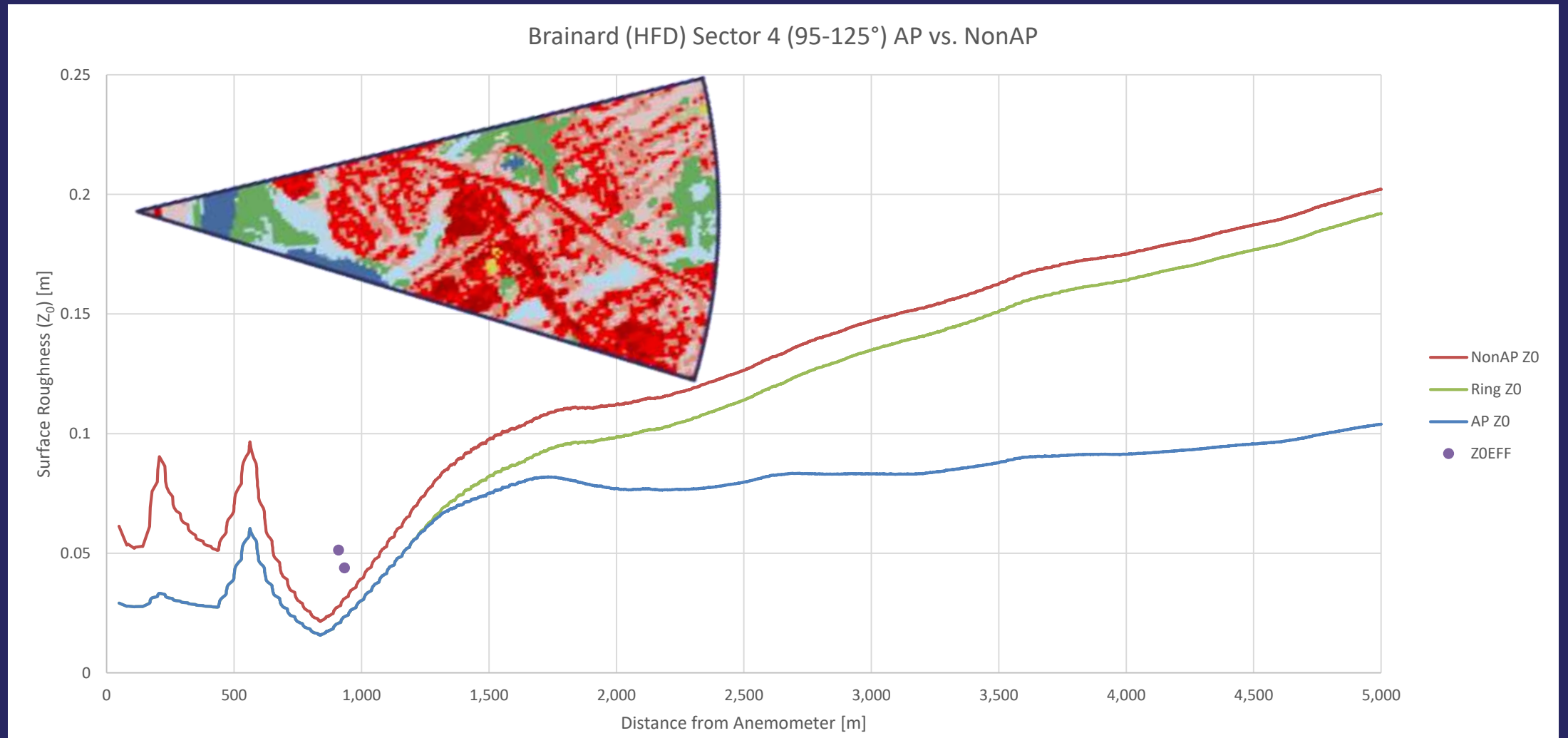

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 5

HARTFORD JET CENTER

Airport:

BDL

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GON

HFD

HVN

IJD

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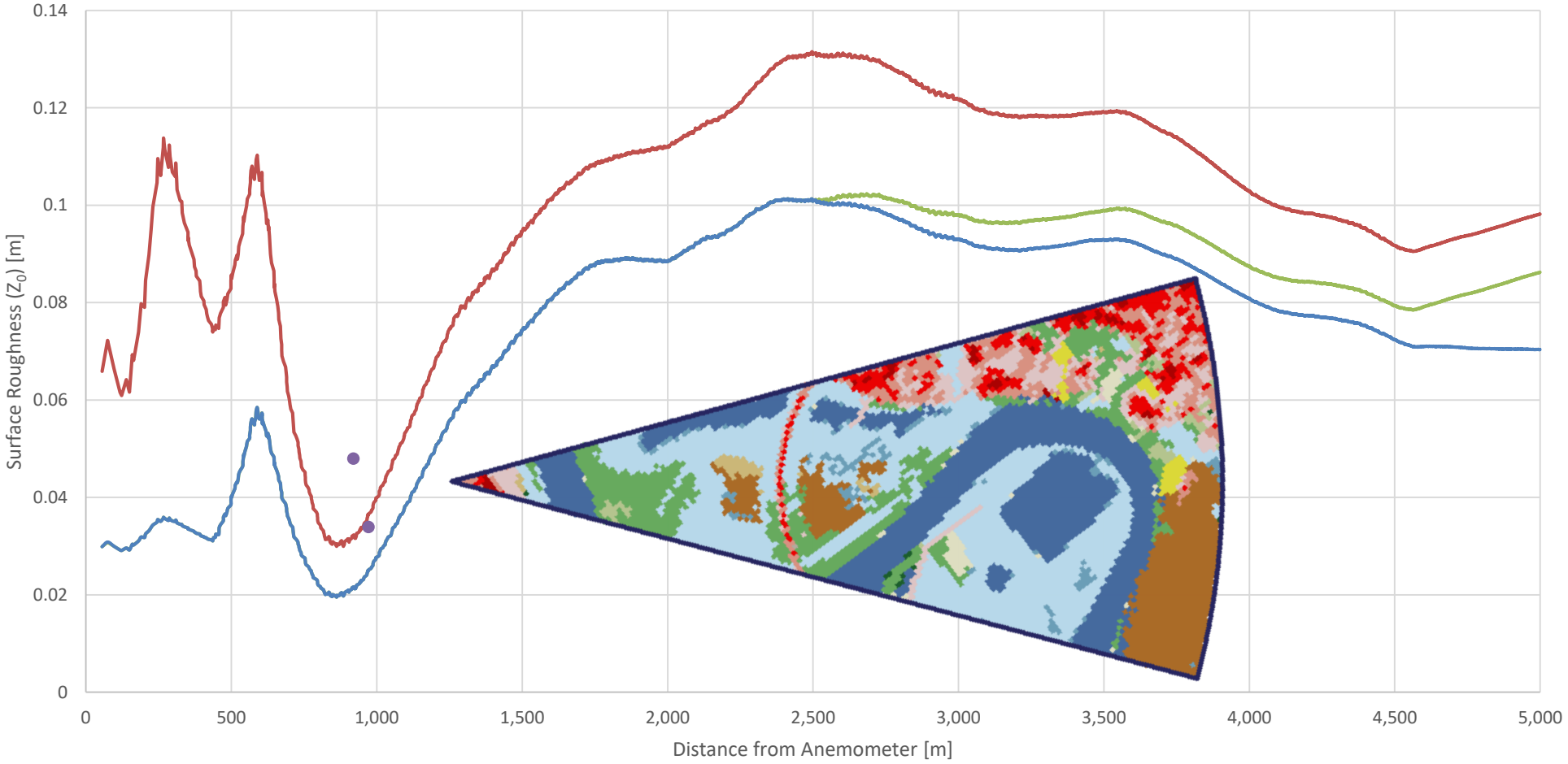

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 6

HARTFORD JET CENTER

Airport:

BDL

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HVN

IJD

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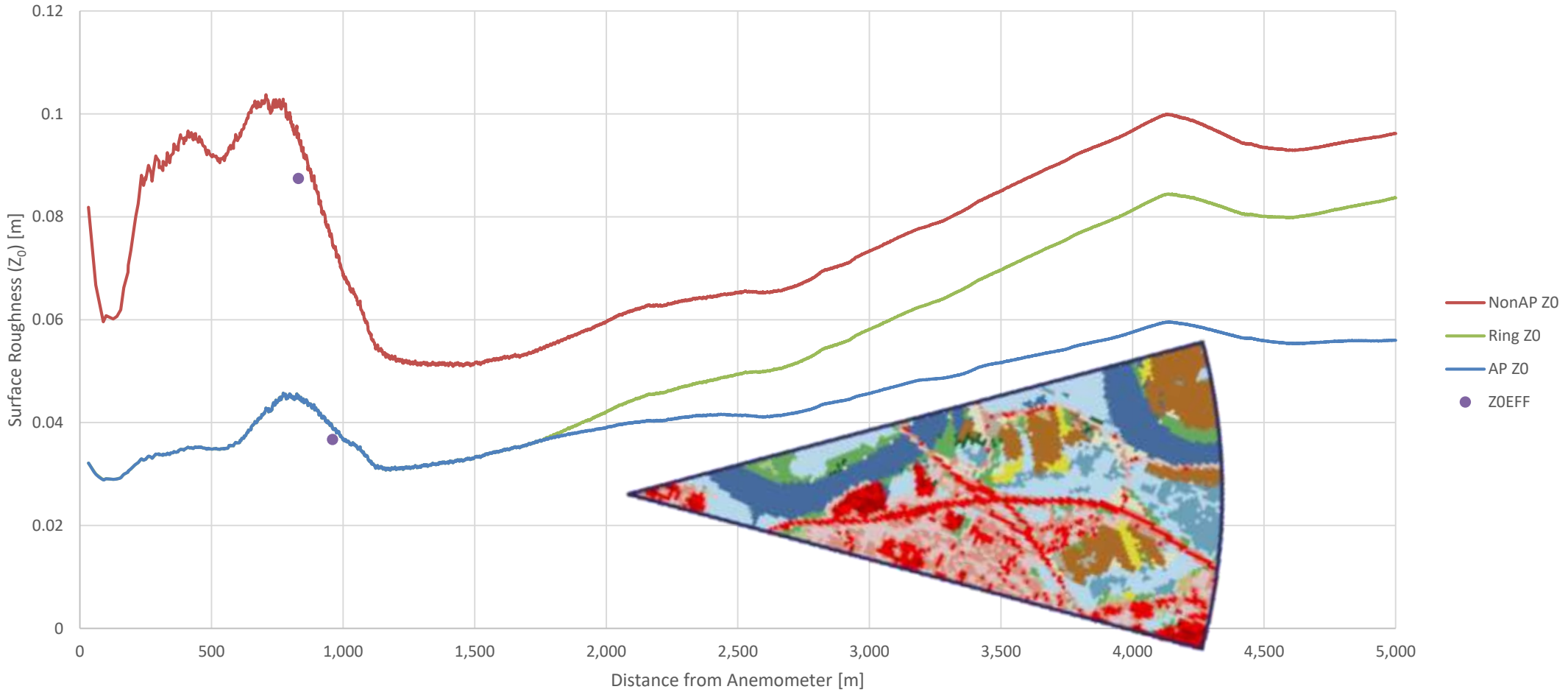

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 7

HARTFORD JET CENTER

Airport:

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HVN

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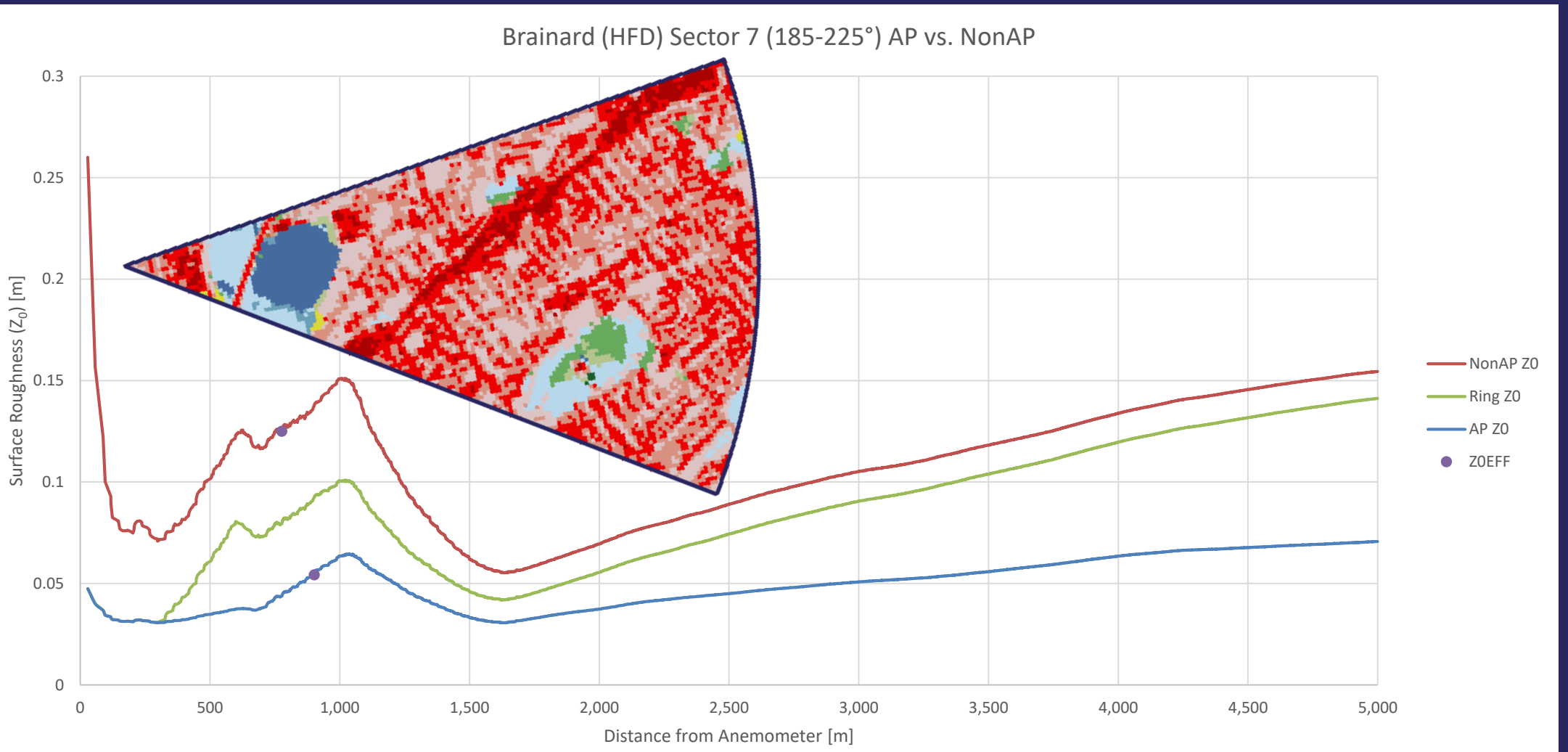

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 8

HARTFORD JET CENTER

Airport:

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HVN

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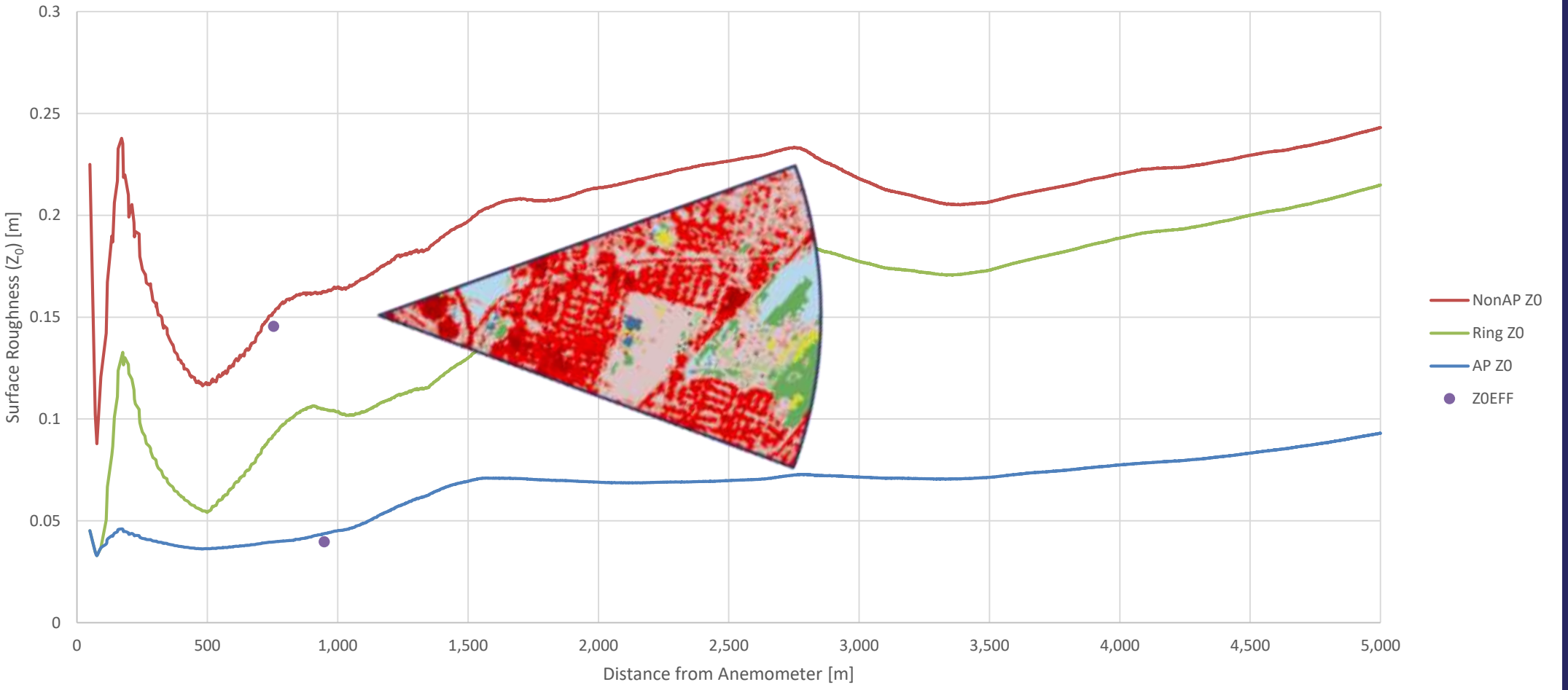

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 9

HARTFORD JET CENTER

Airport:

BDL

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HFD

HVN

IJD

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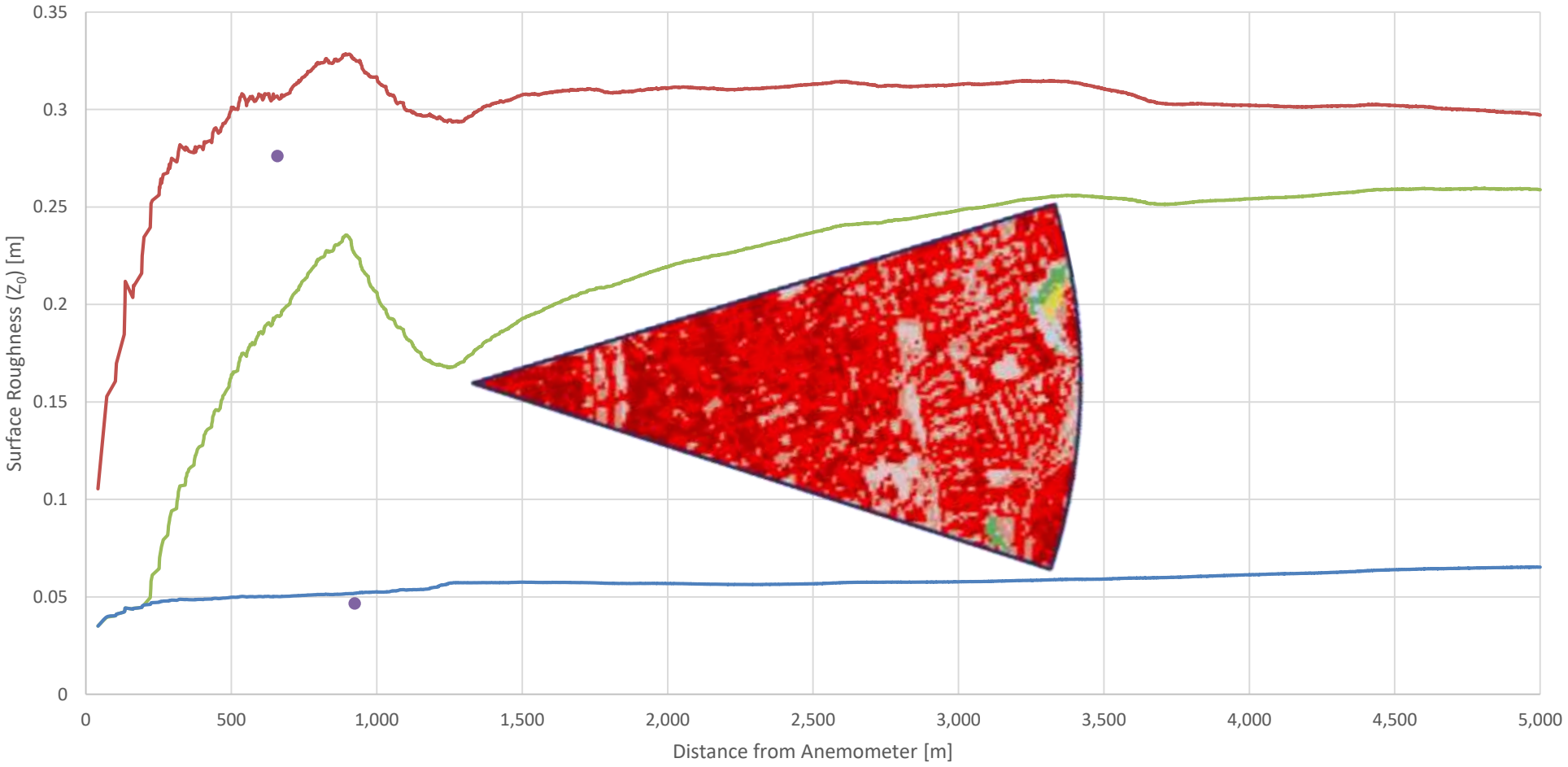

Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 10

HARTFORD JET CENTER

Airport:

BDL

BDR

DXR

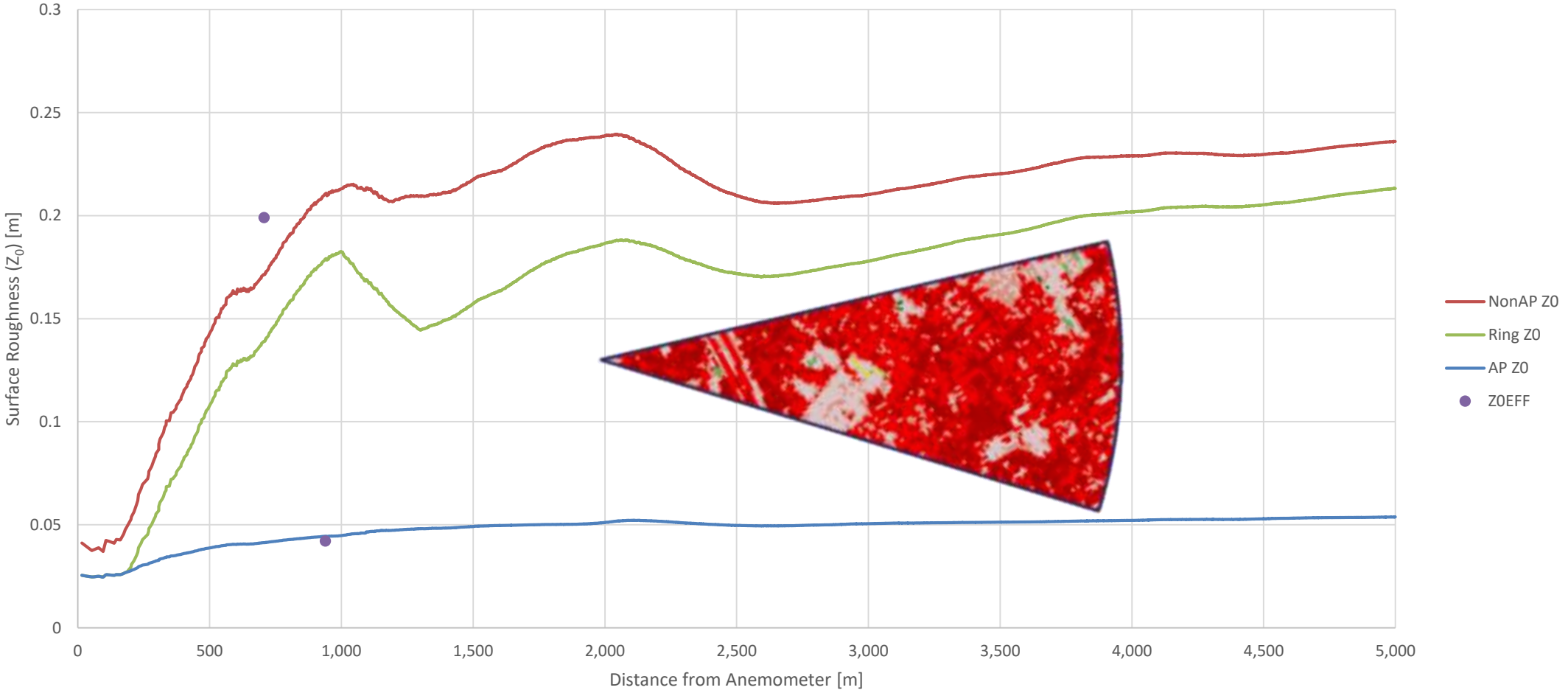
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

HFD Sector 11

HARTFORD JET CENTER

Airport:

BDL

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DXR

GON

HFD

HVN

IJD

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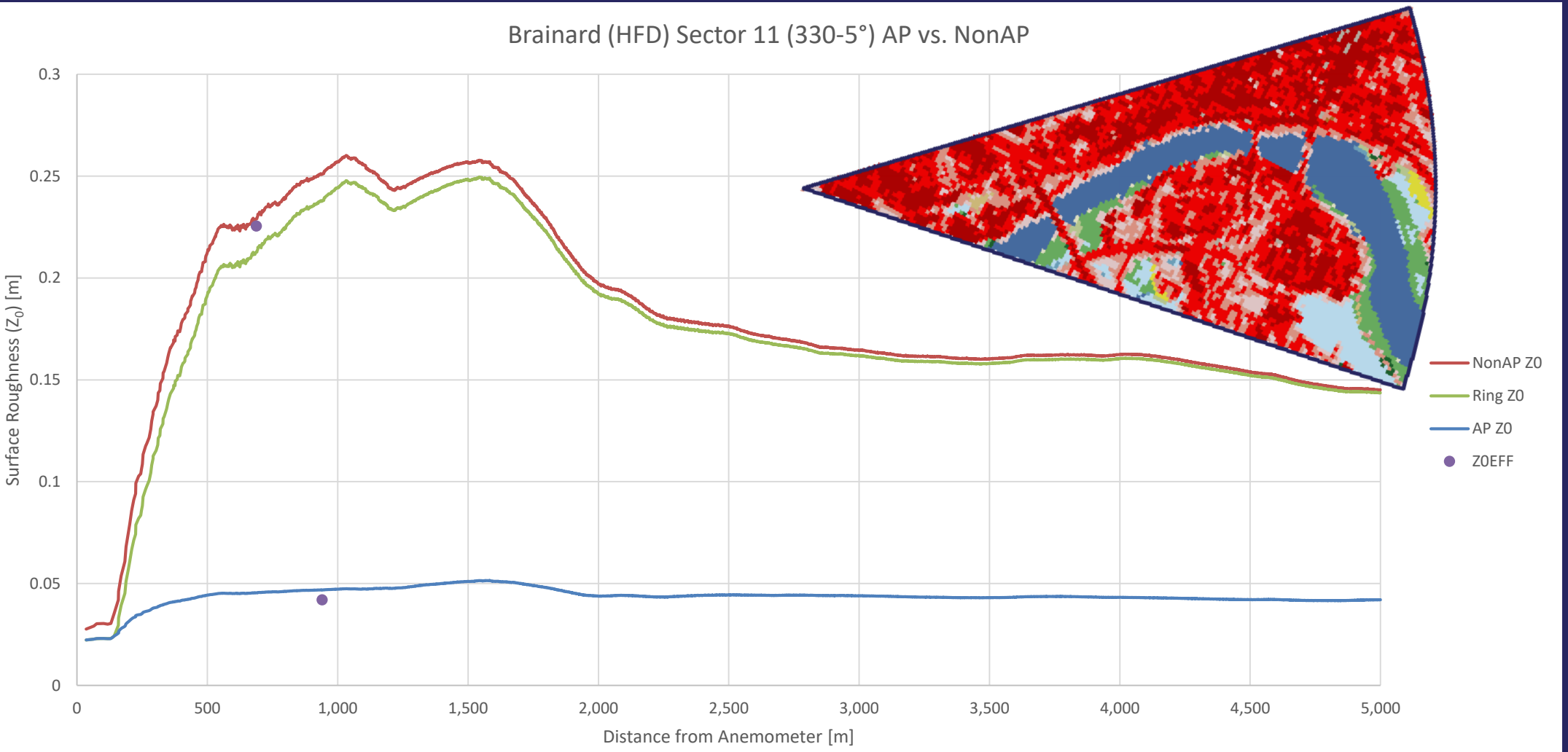

Sector:

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Connecticut Department of Energy & Environmental Department

Tweed-New Haven Airport (HVN)

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

MMK

NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Connecticut Department of Energy & Environmental Department

Tweed-New Haven Airport (HVN)

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

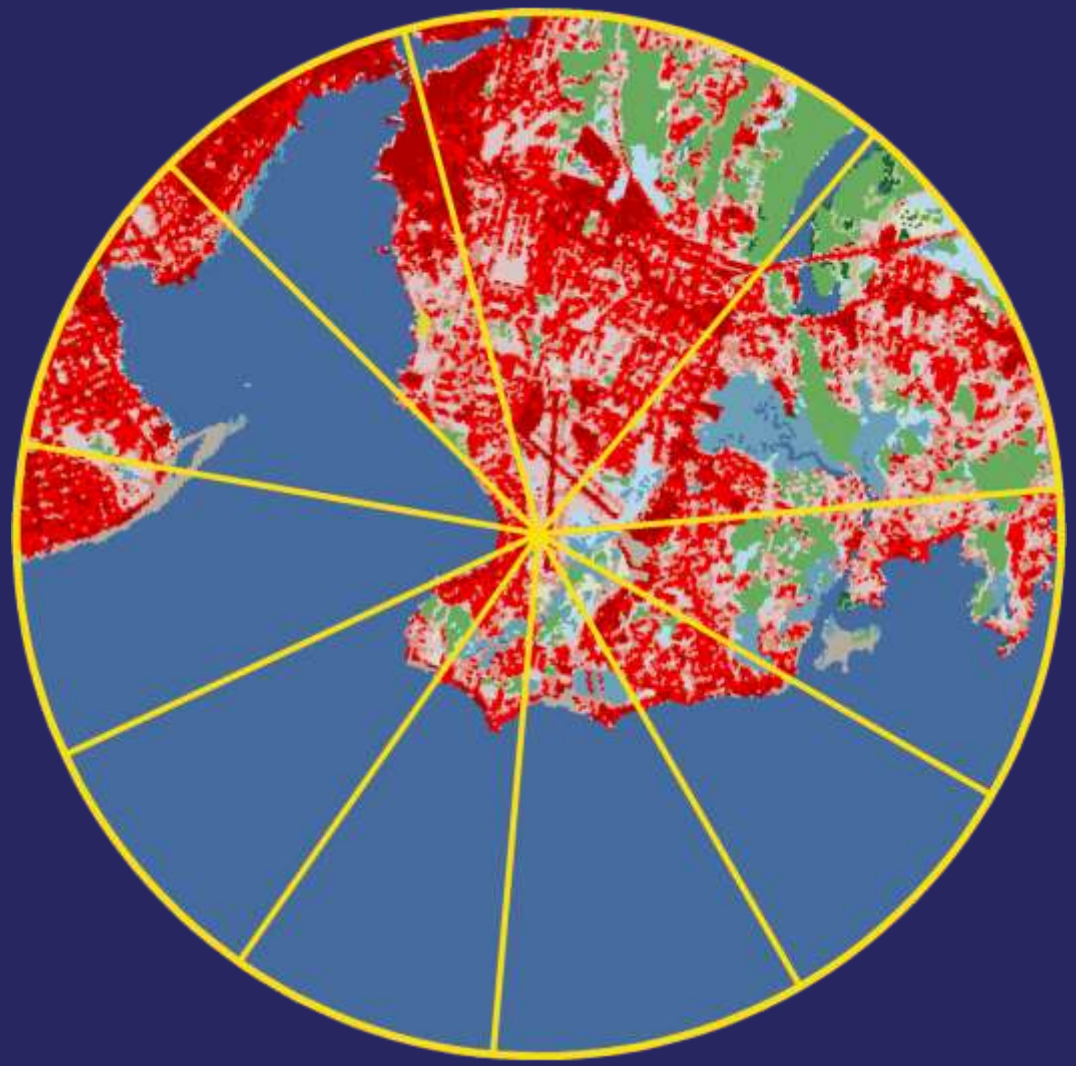
GON

HFD

HVN

IJD

MMK



NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 1

Airport:

BDL

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HFD

HVN

IJD

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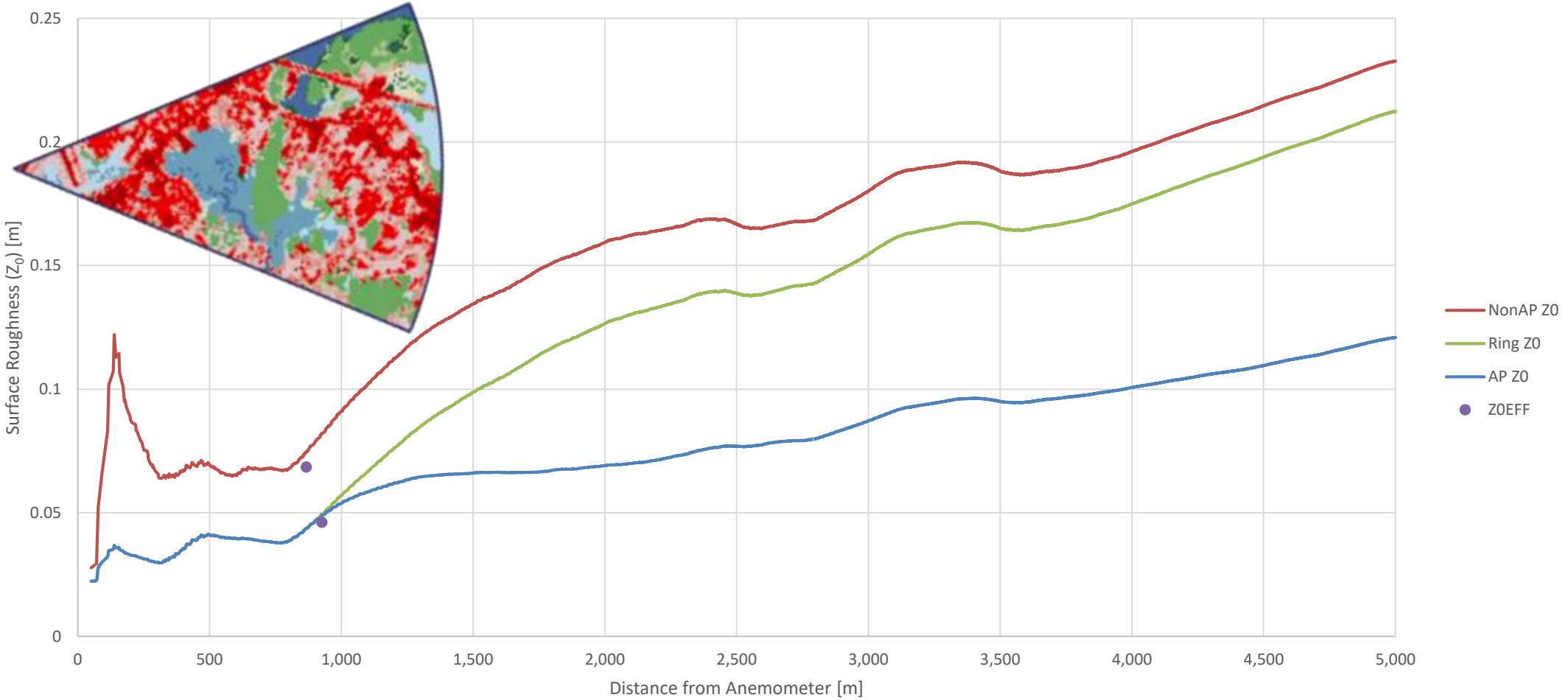

Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 2

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

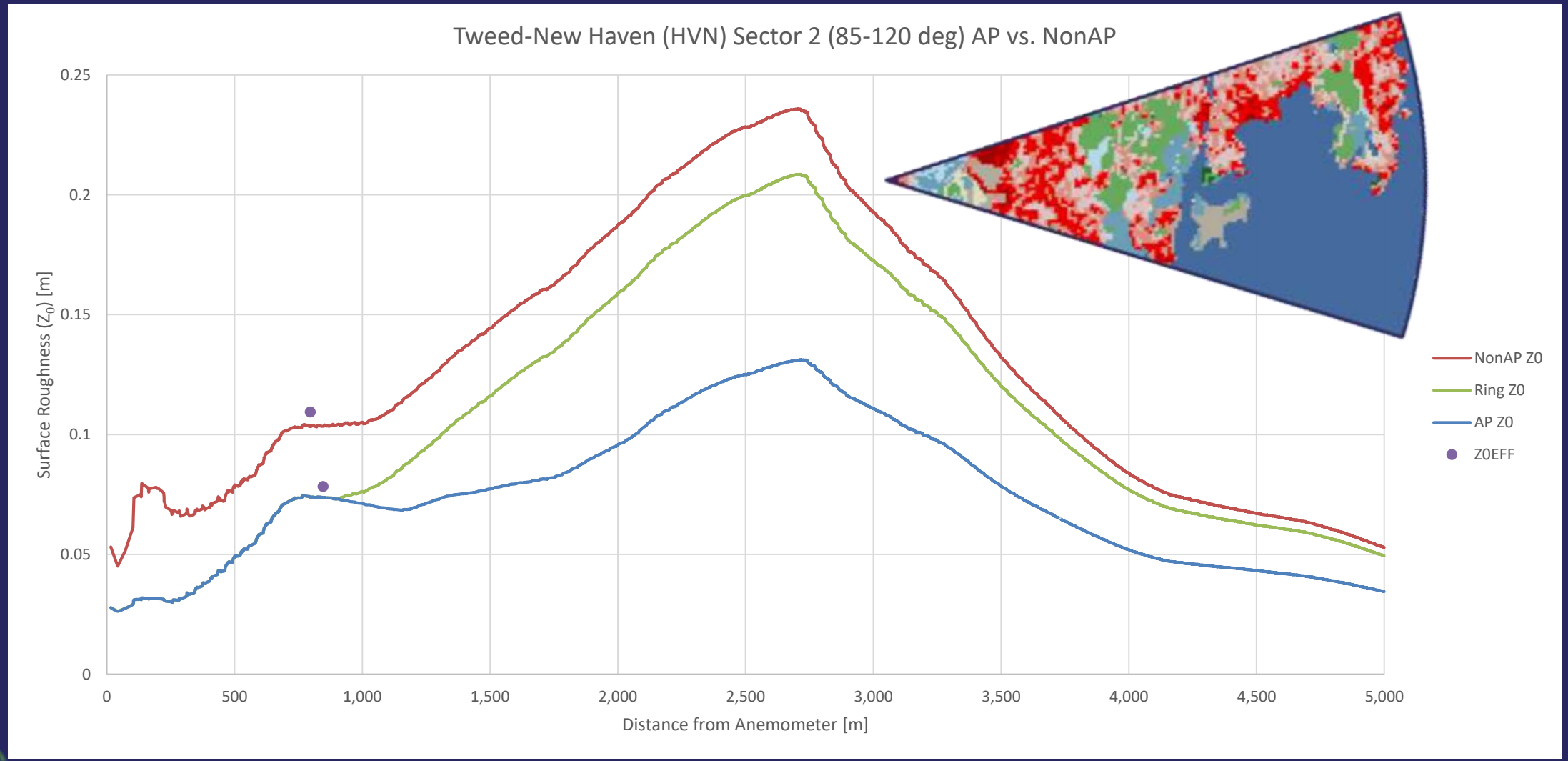
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 3

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

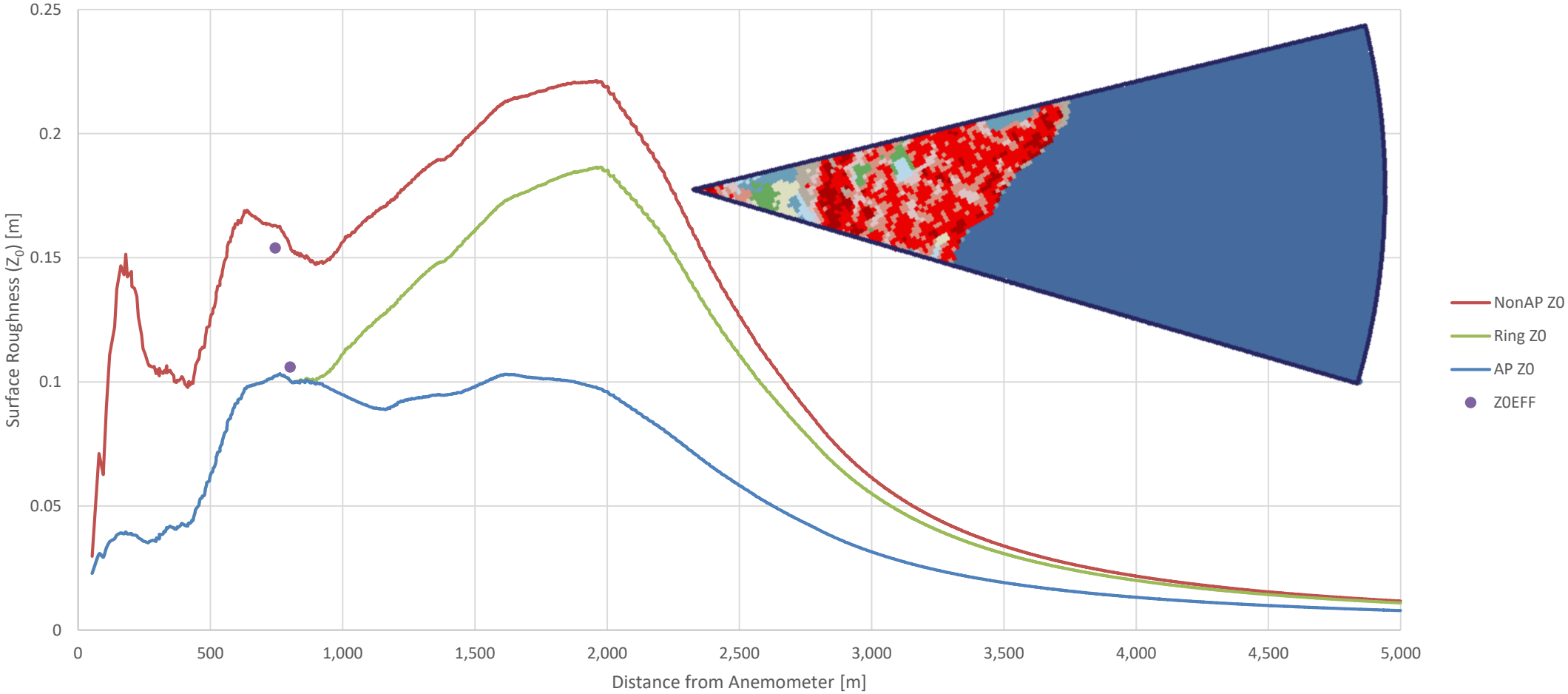
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 4

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

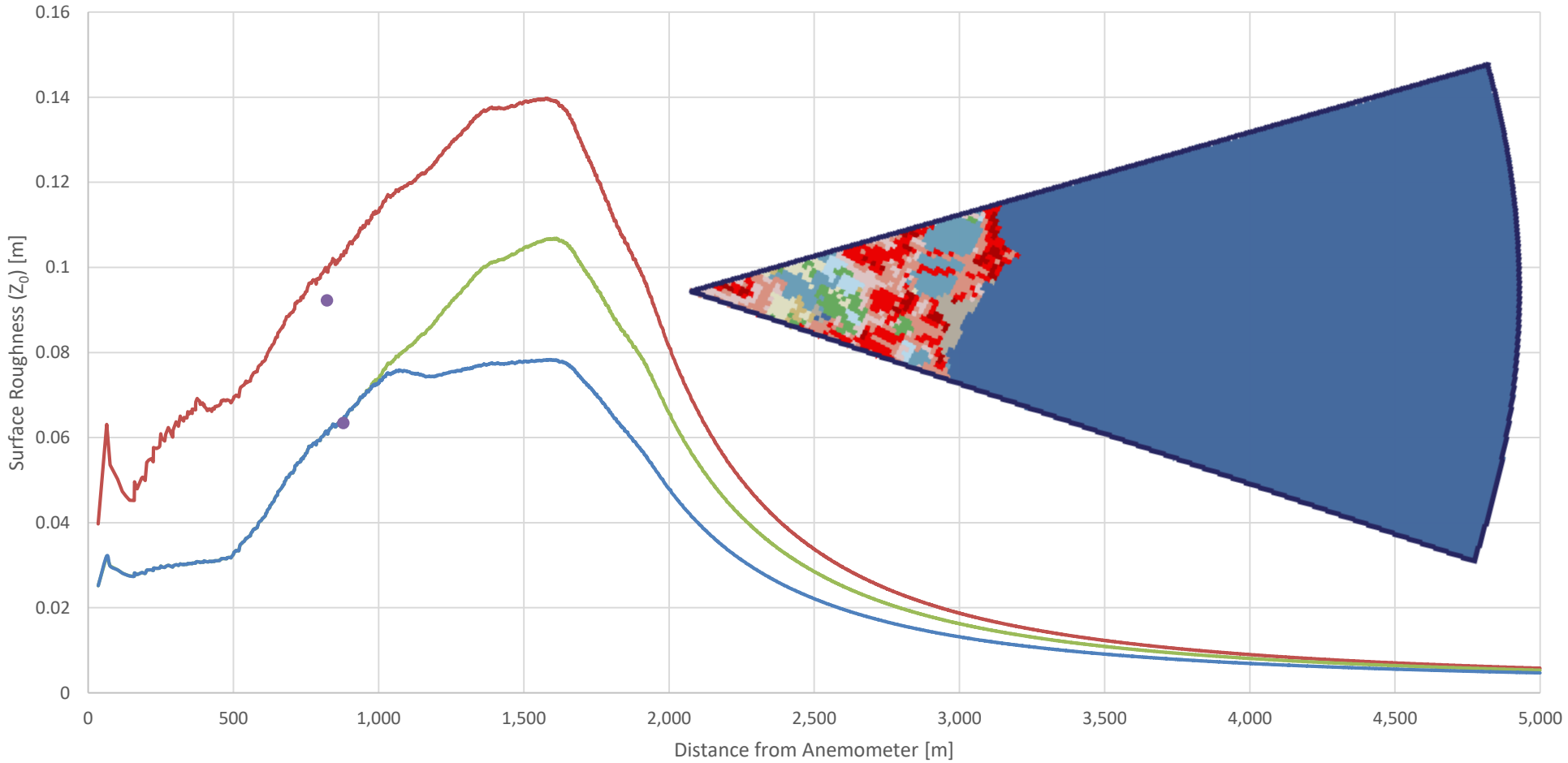
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 5

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

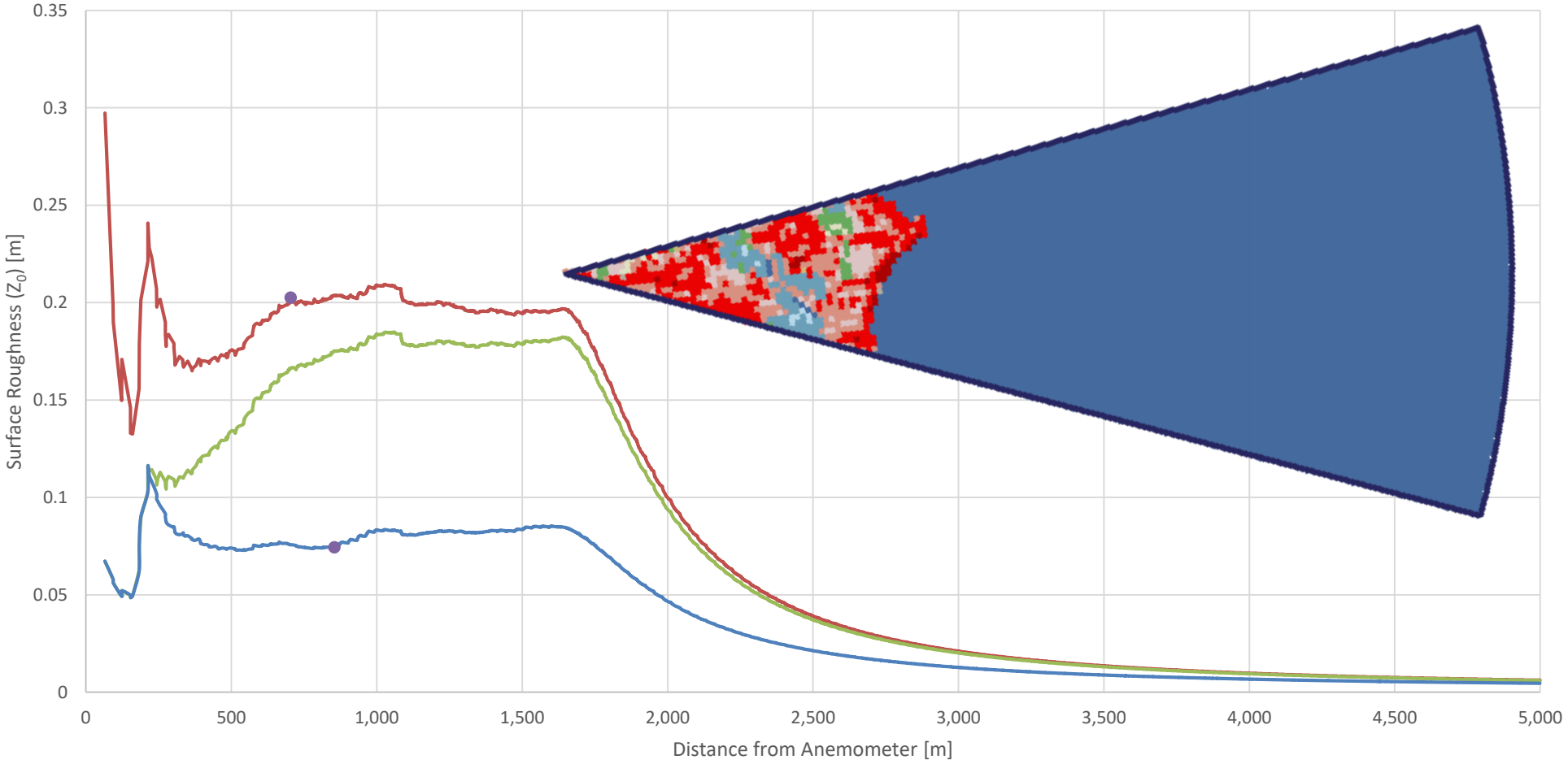
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 6

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

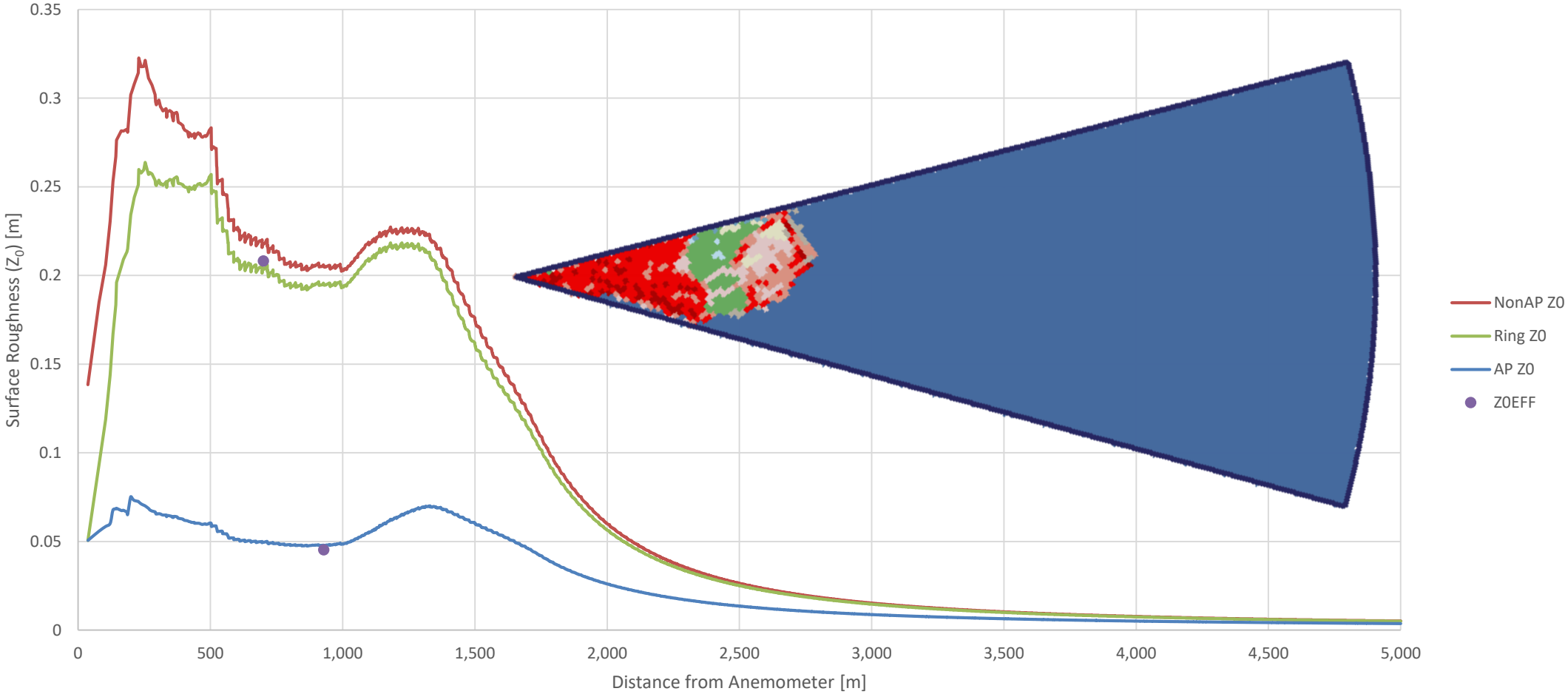
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 7

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

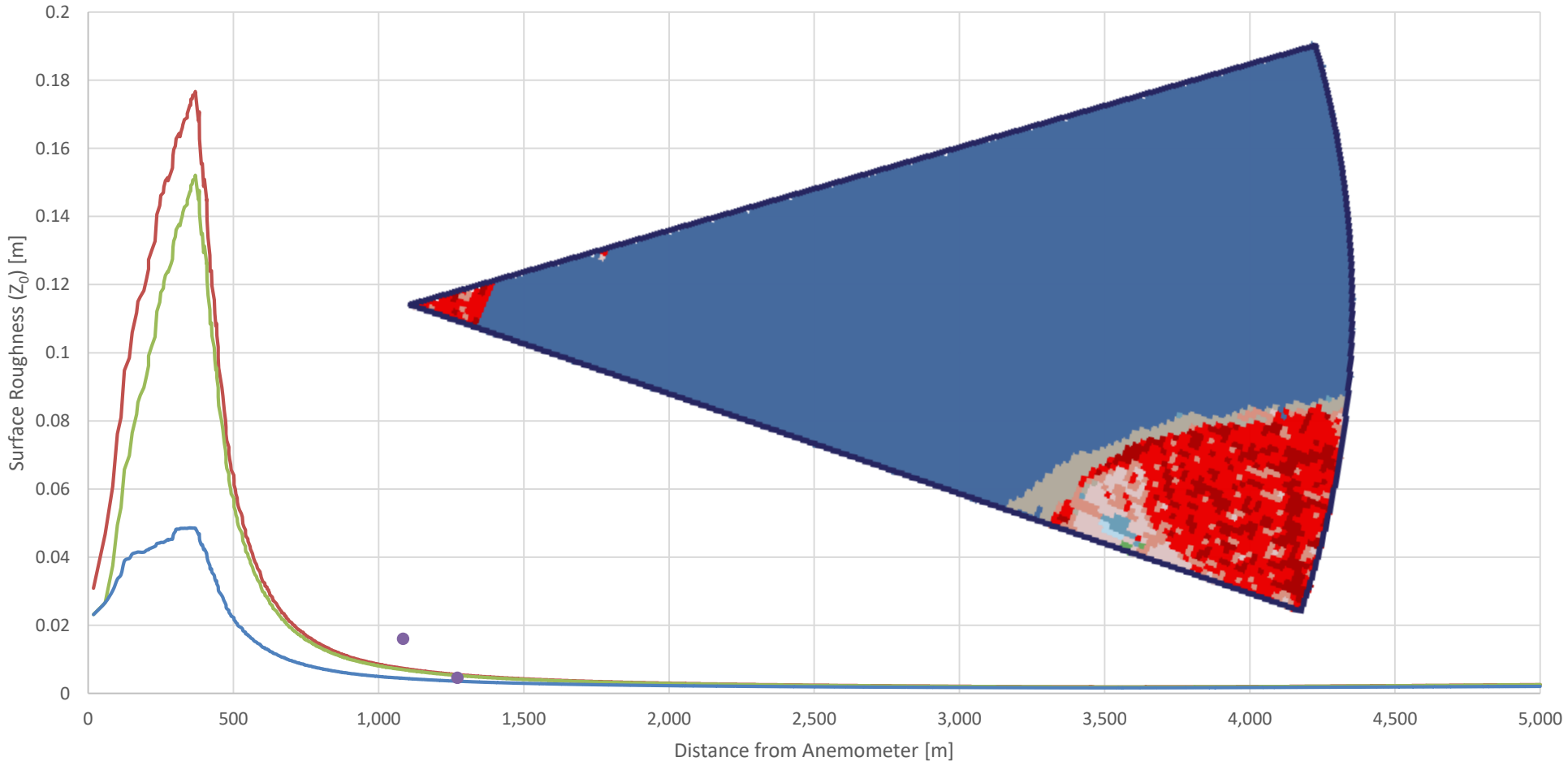
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 8

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

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DXR

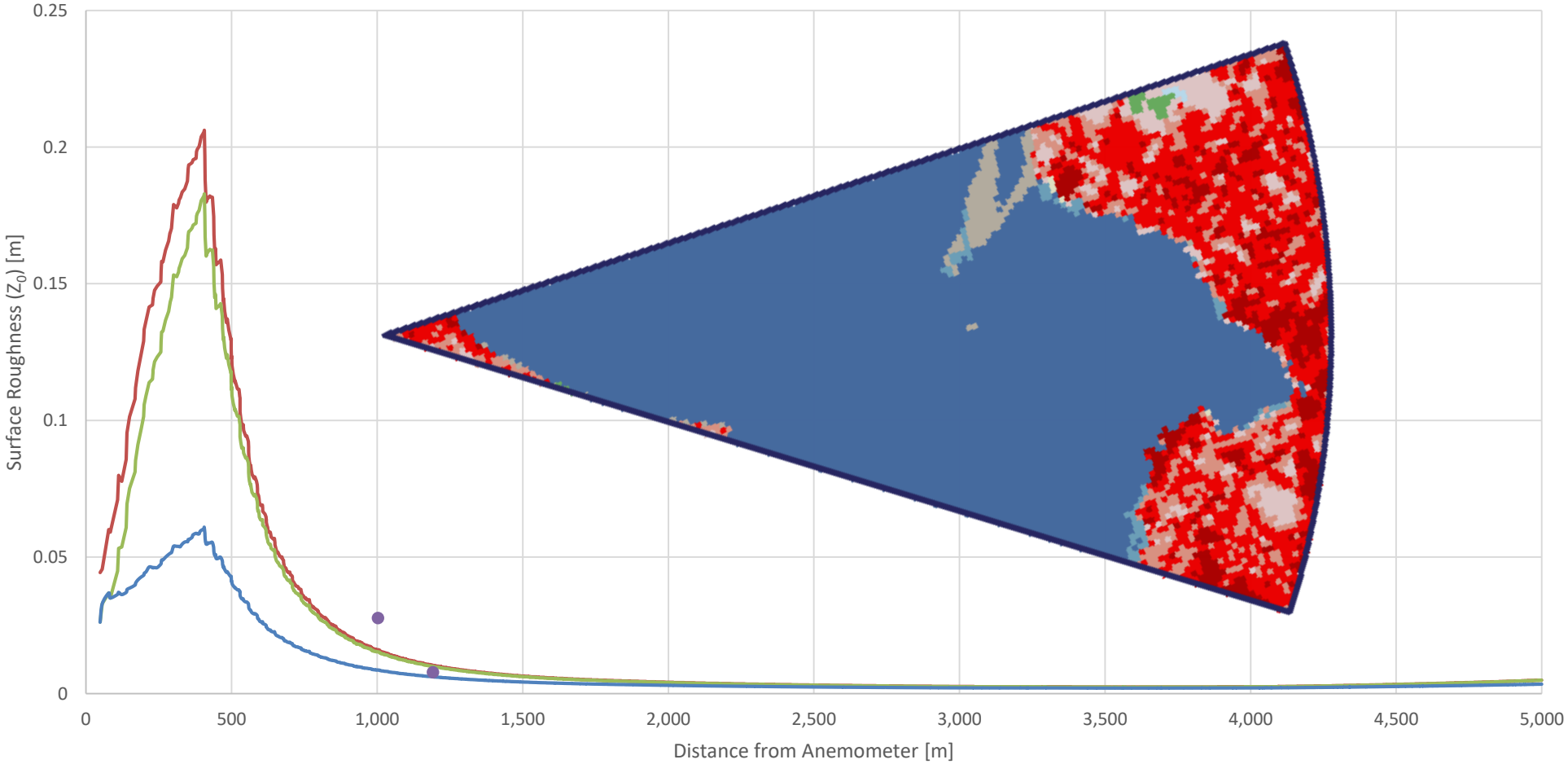
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 9

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

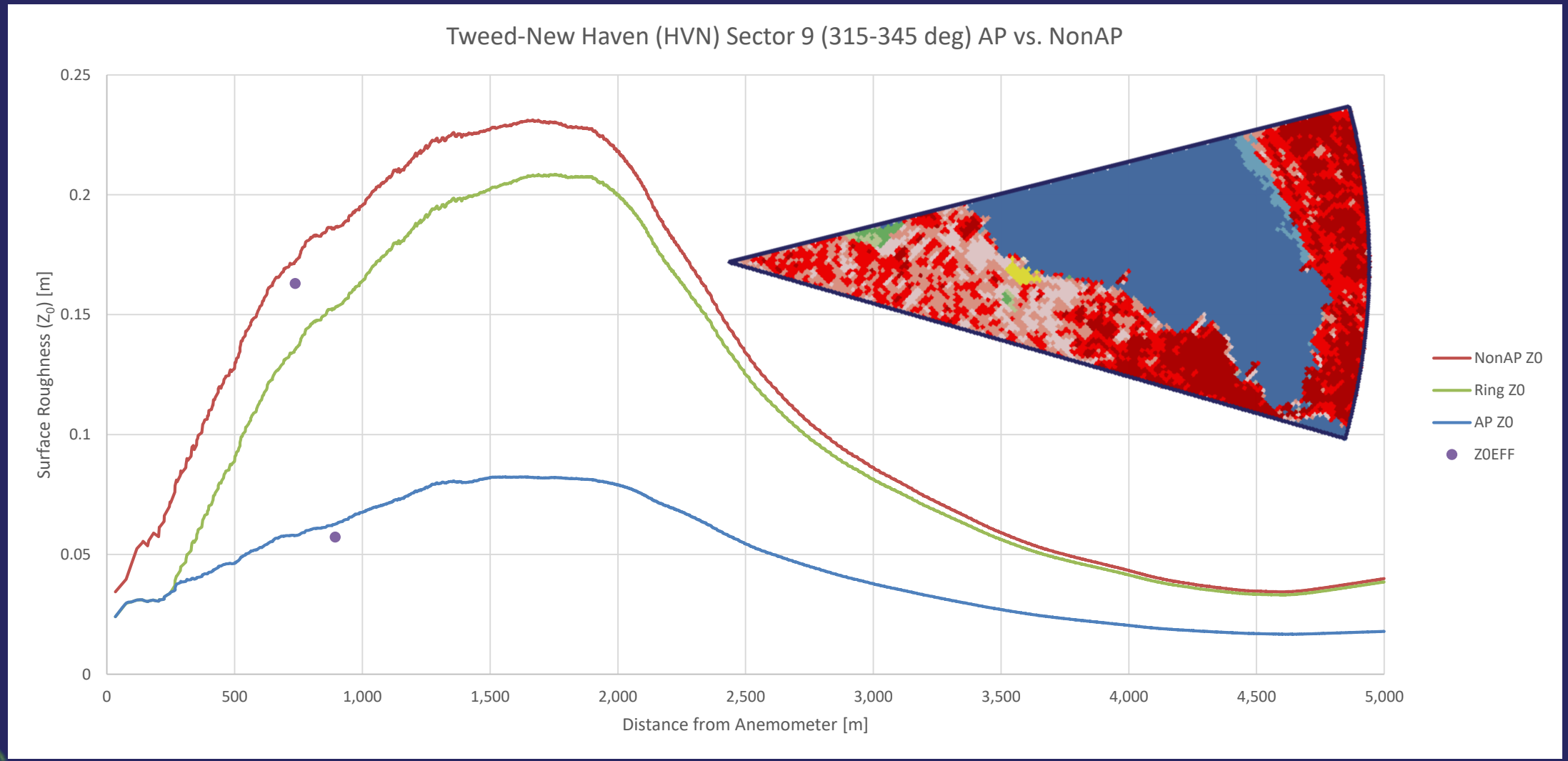
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

HVN Sector 10

tweed NEW HVN
Southern Connecticut's Airport

Airport:

BDL

BDR

DXR

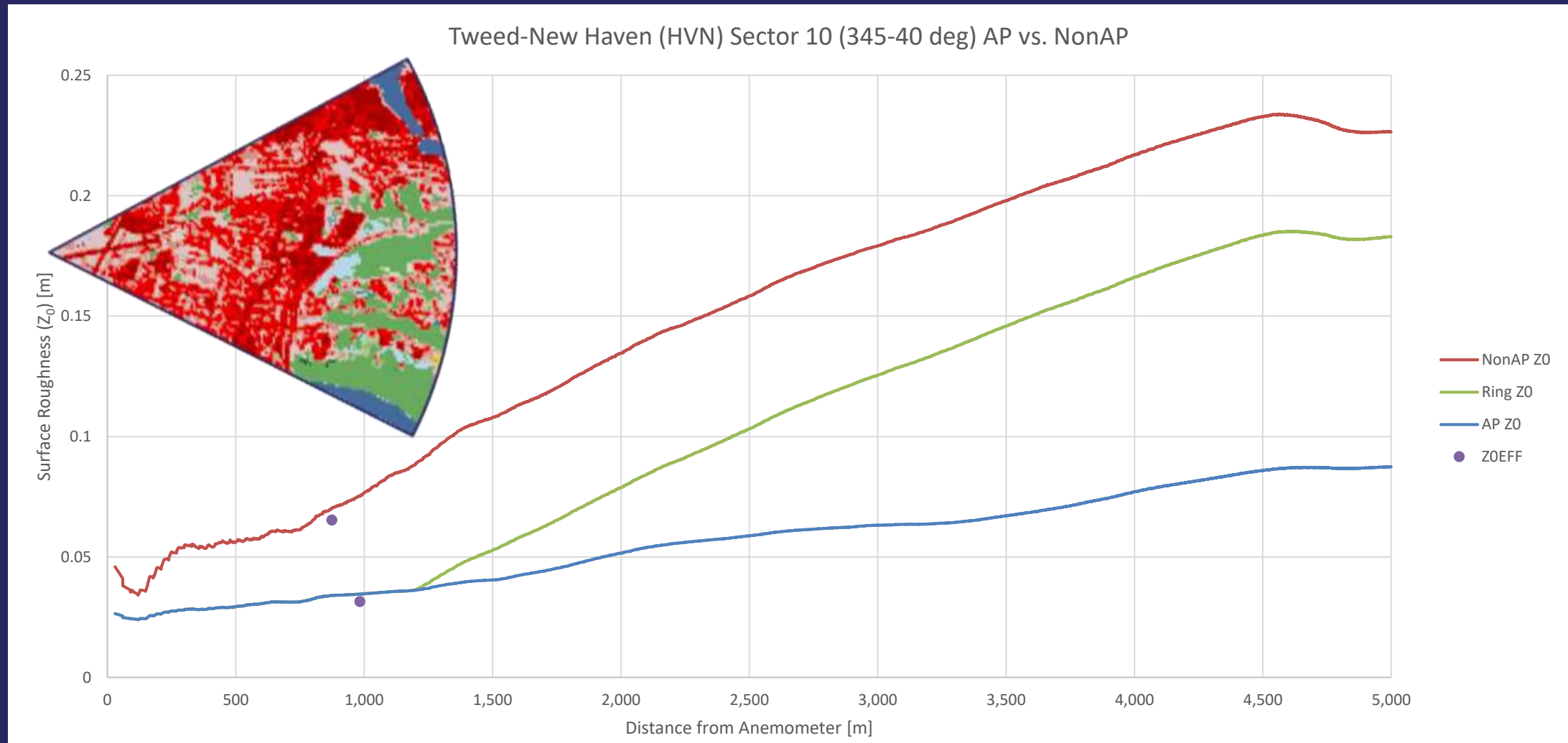
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

Windham Airport (IJD)

Airport:

BDL

BDR

DXR

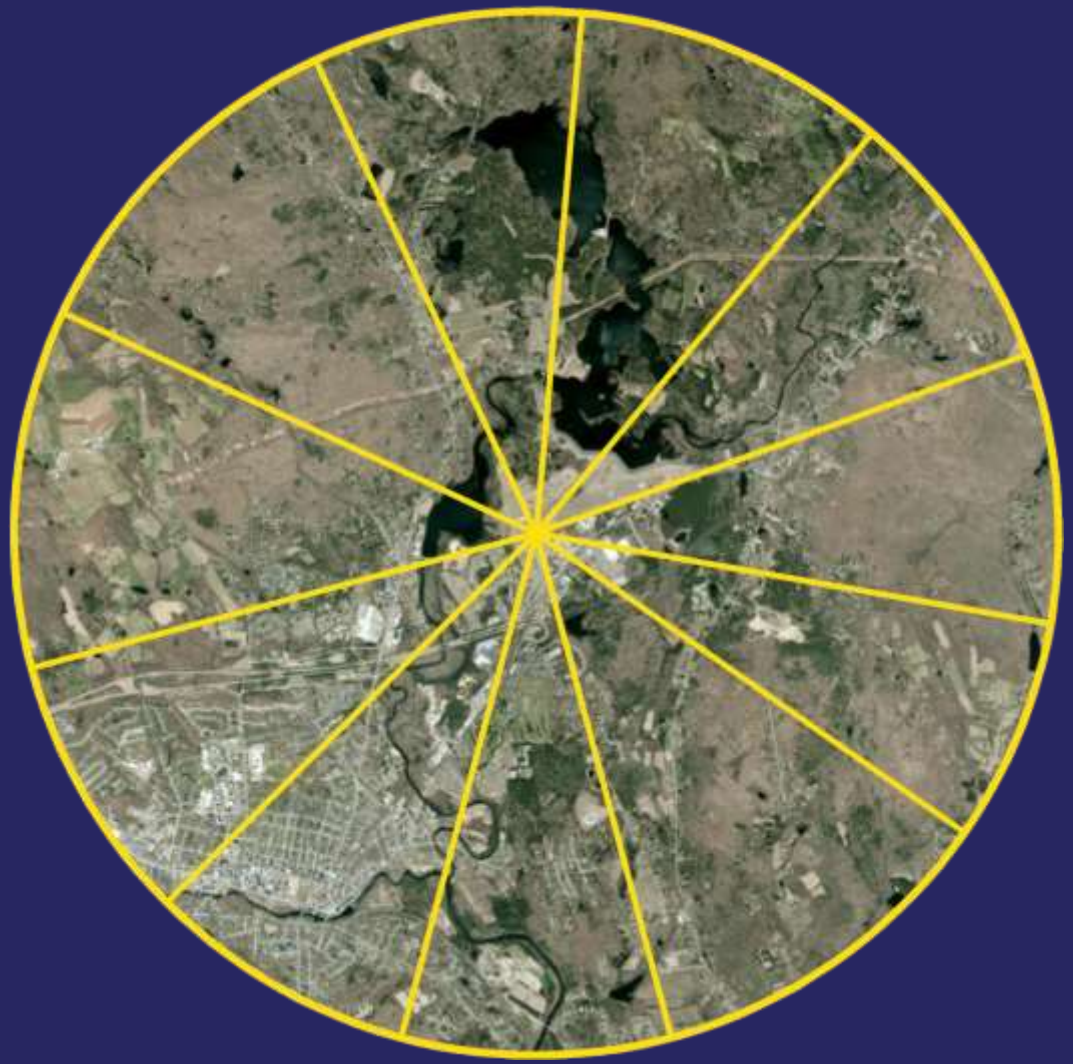
GON

HFD

HVN

IJD

MMK



NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
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- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
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- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Windham Airport (IJD)

Airport:

BDL

BDR

DXR

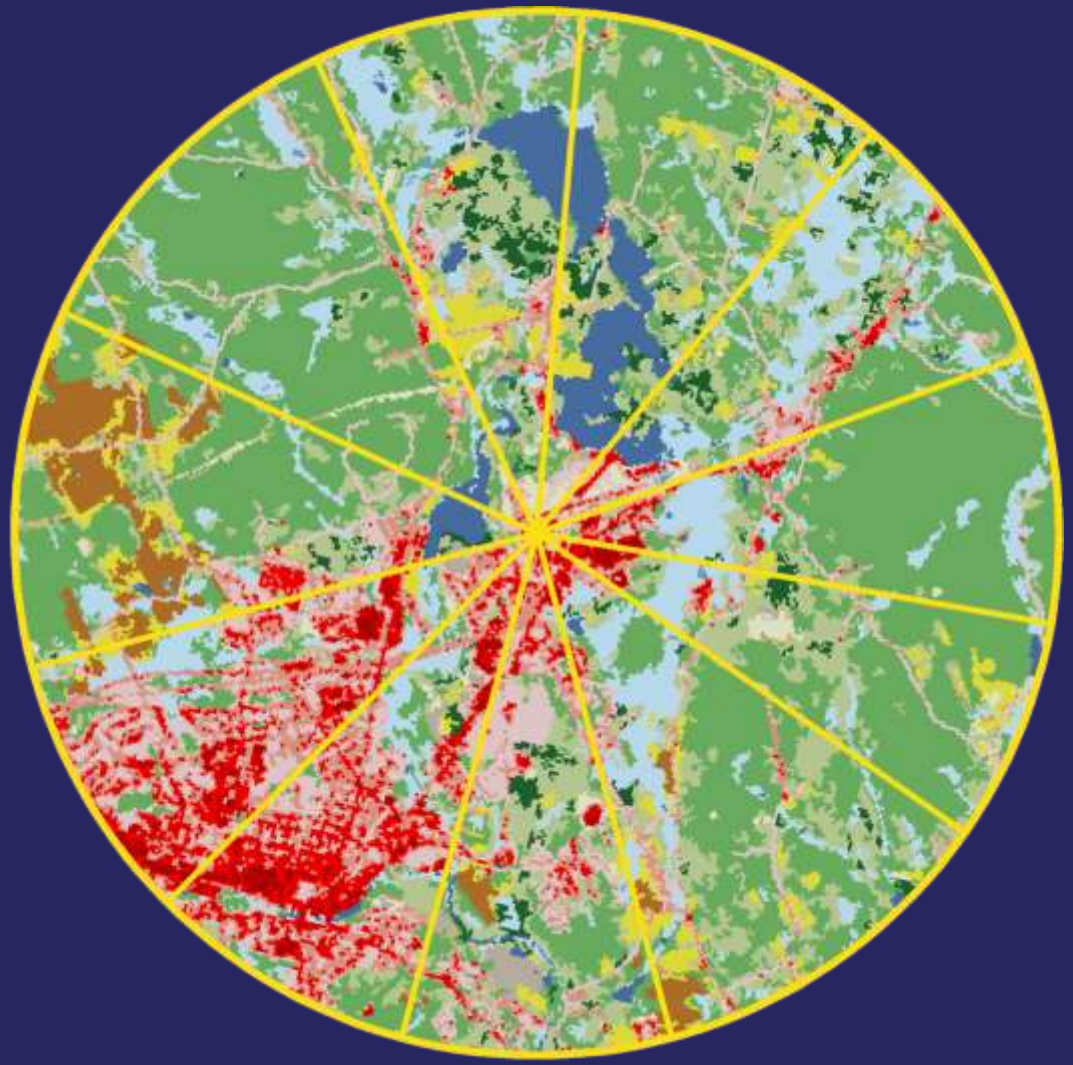
GON

HFD

HVN

IJD

MMK



NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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IJD Sector 1

Airport:

BDL

BDR

DXR

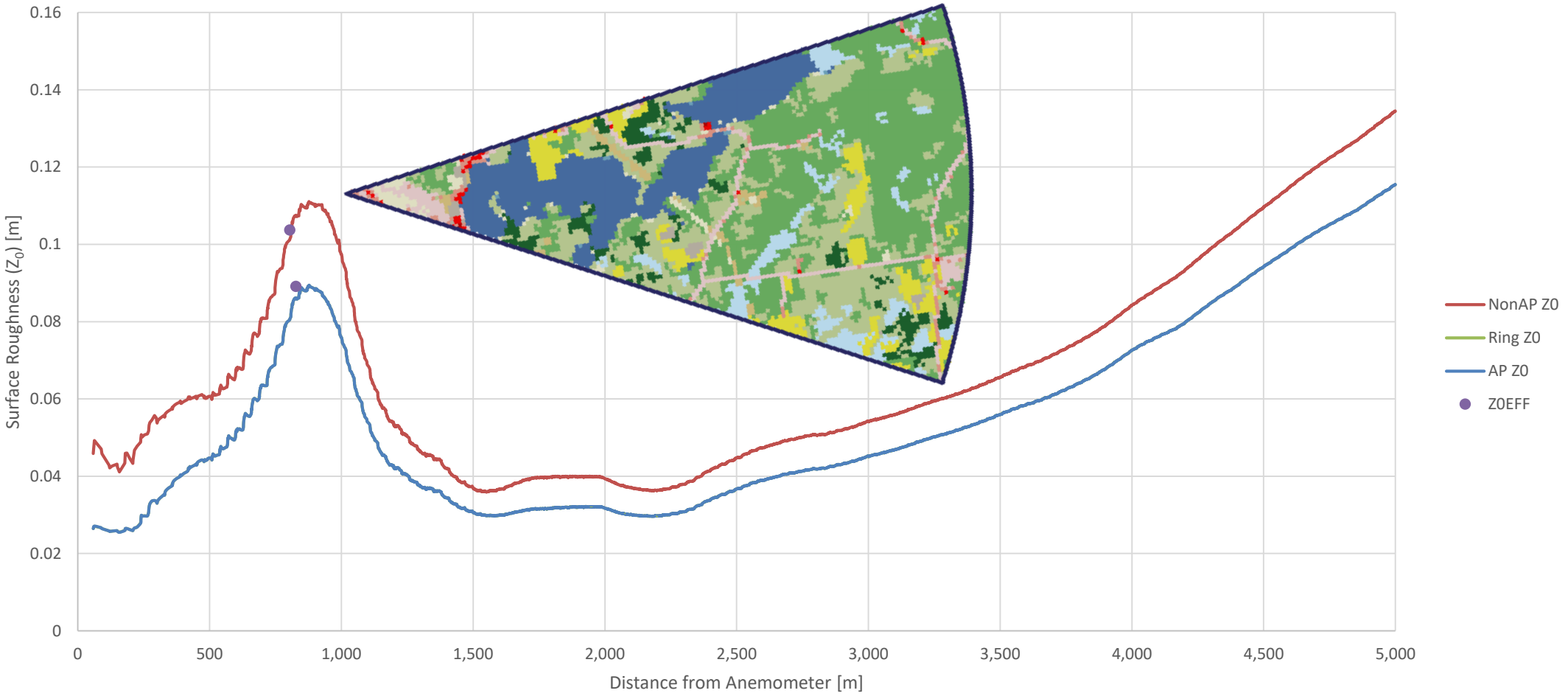
GON

HFD

HVN

IJD

MMK



Sector:

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IJD Sector 2

Airport:

BDL

BDR

DXR

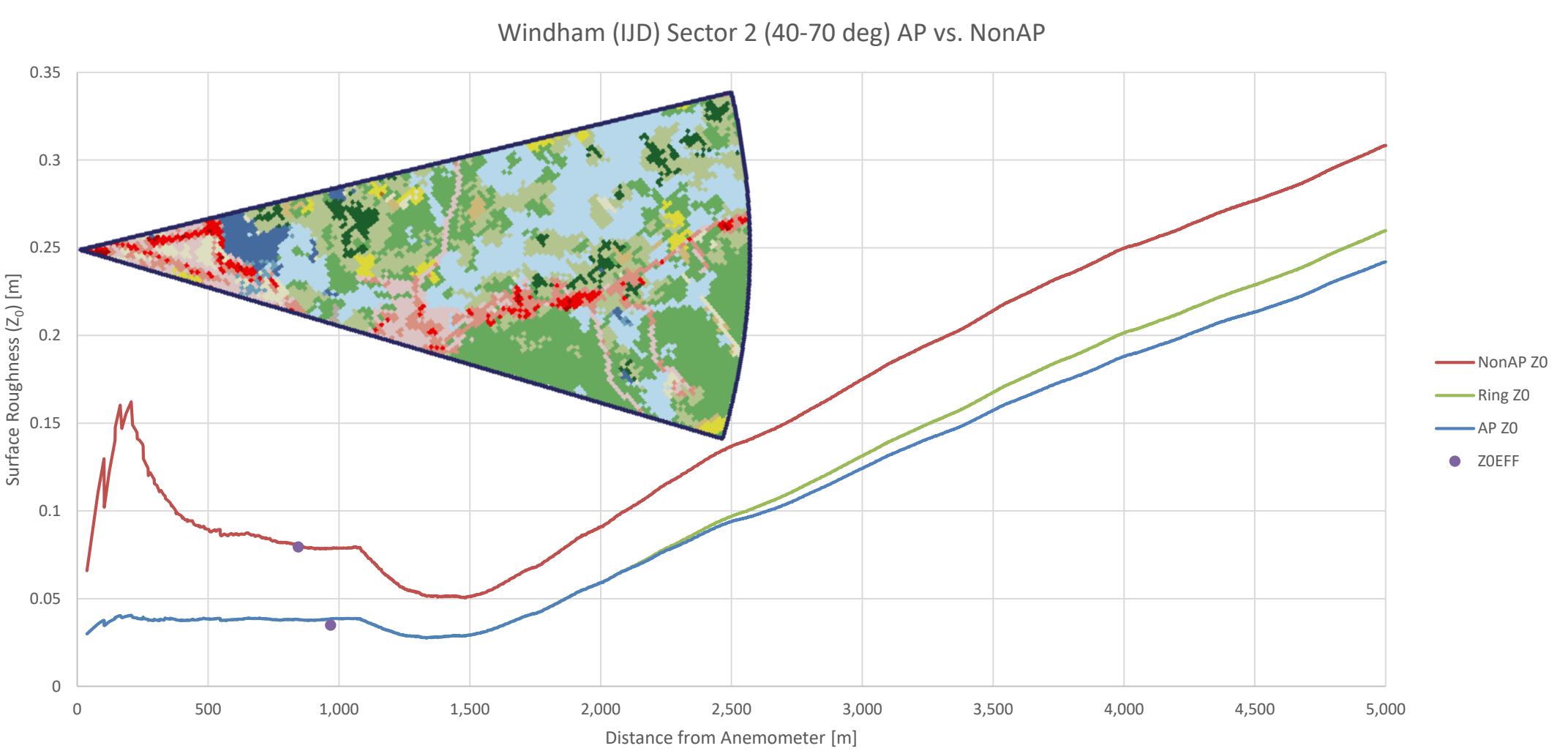
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

IJD Sector 3

Airport:

BDL

BDR

DXR

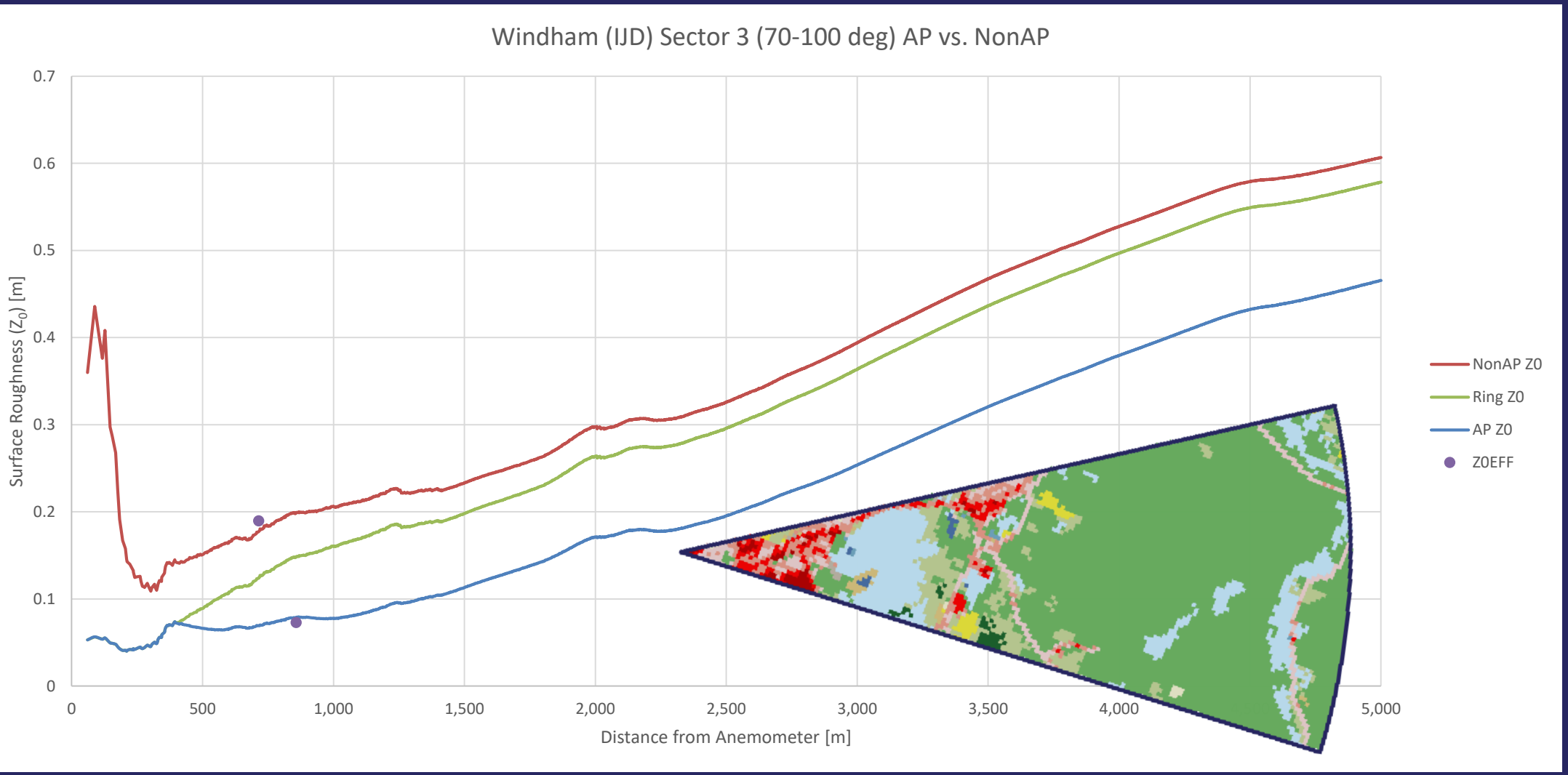
GON

HFD

HVN

<u>IJD</u>

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

IJD Sector 4

Airport:

BDL

BDR

DXR

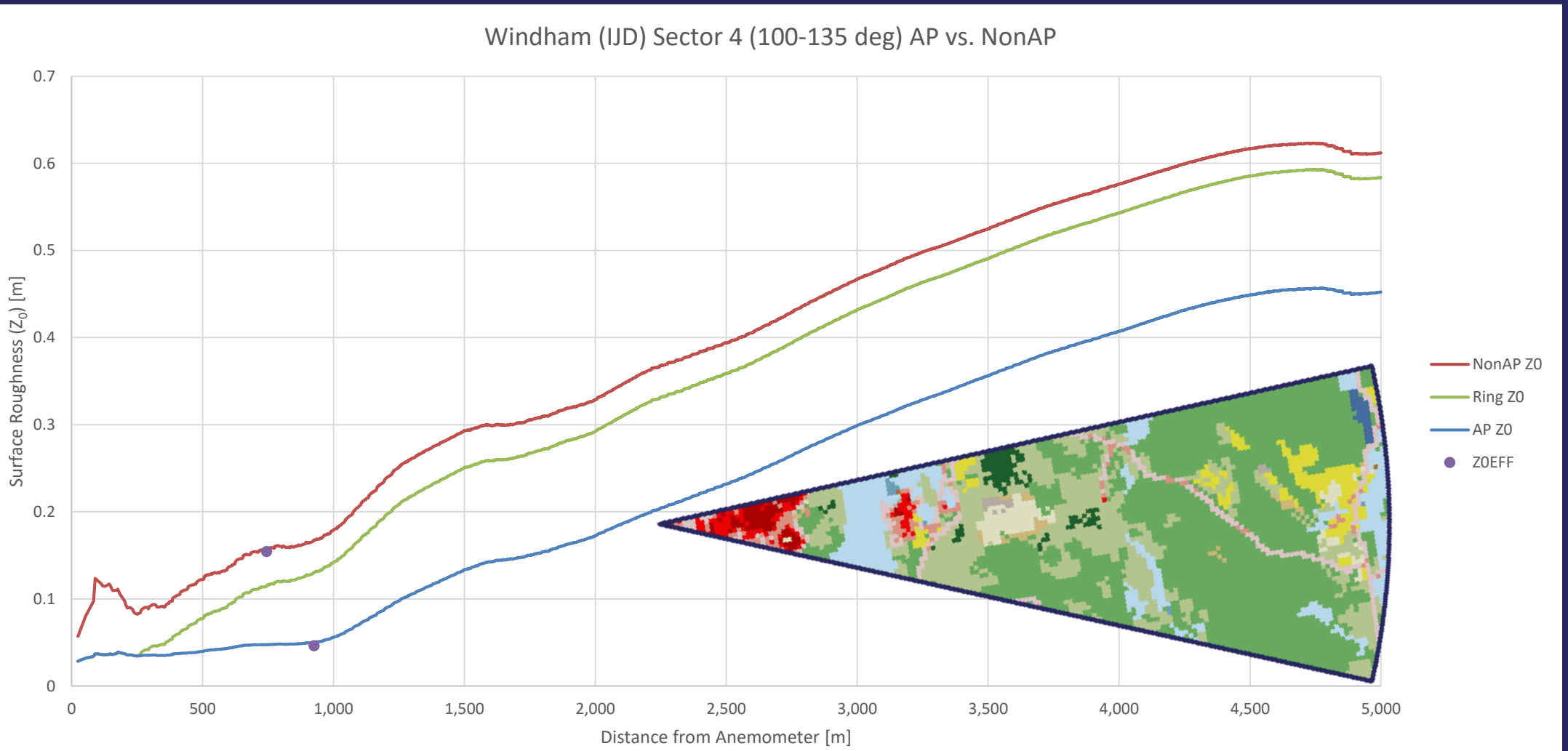
GON

HFD

HVN

IJD

MMK



Sector:

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IJD Sector 5

Airport:

BDL

BDR

DXR

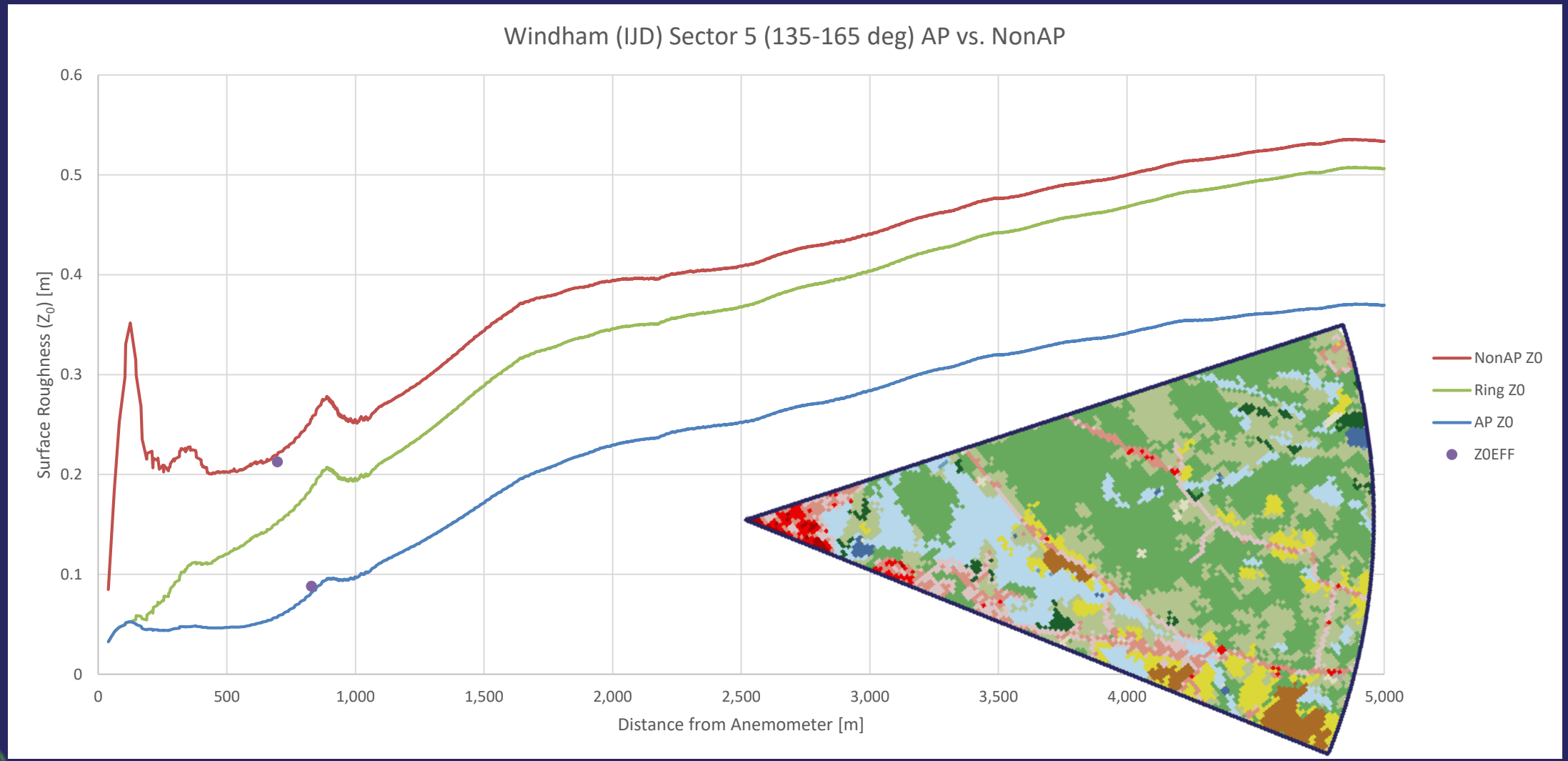
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

IJD Sector 6

Airport:

BDL

BDR

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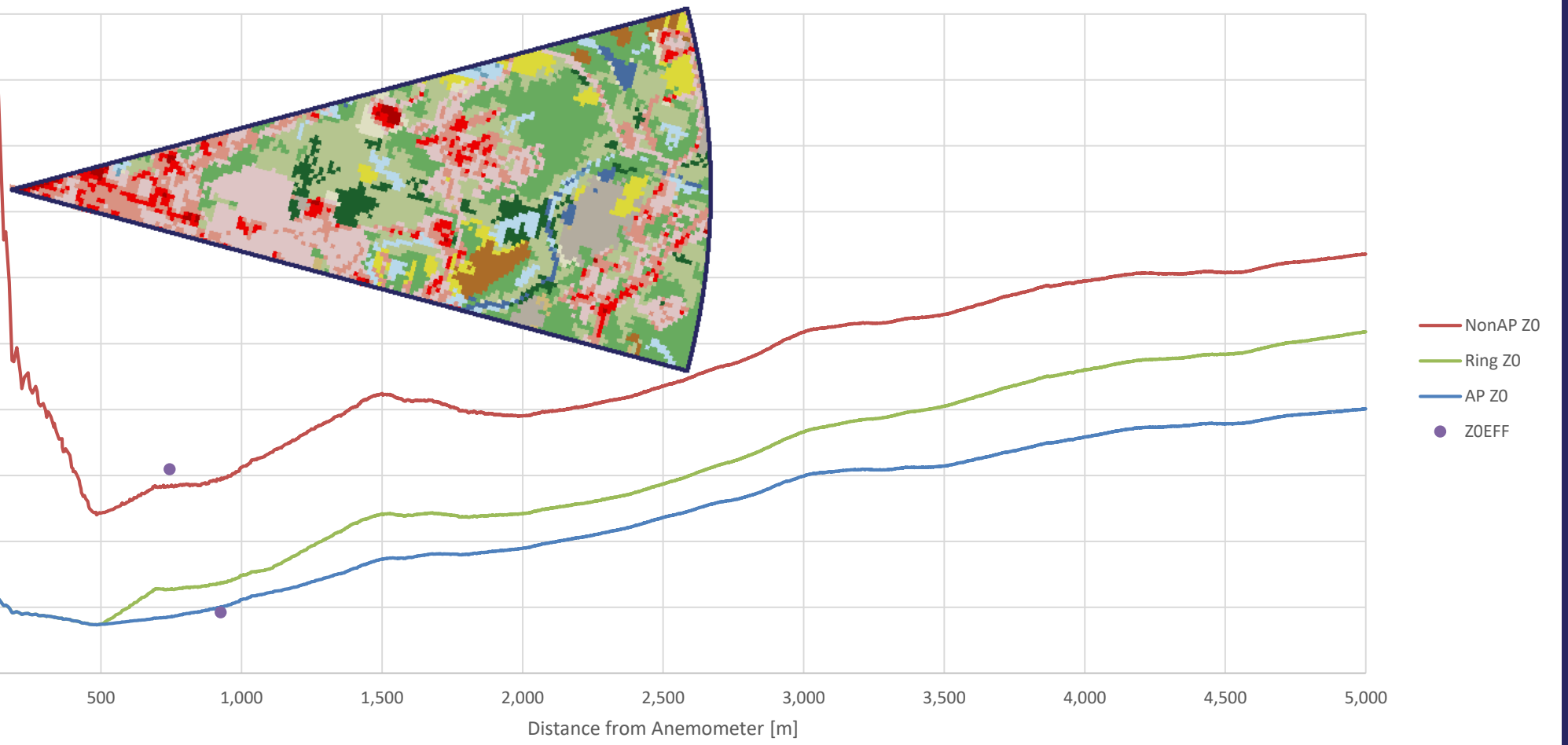
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

IJD Sector 7

Airport:

BDL

BDR

DXR

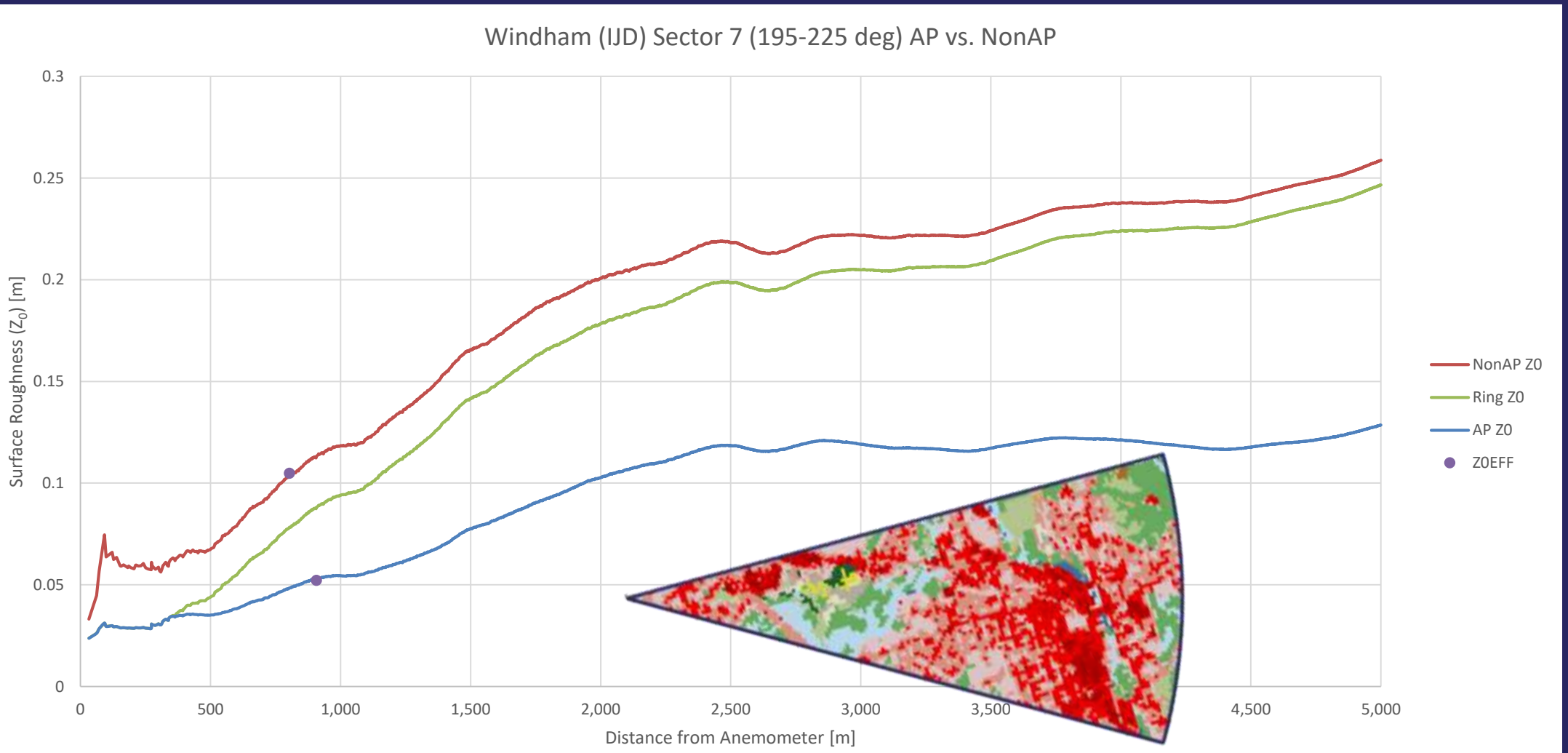
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

IJD Sector 8

Airport:

BDL

BDR

DXR

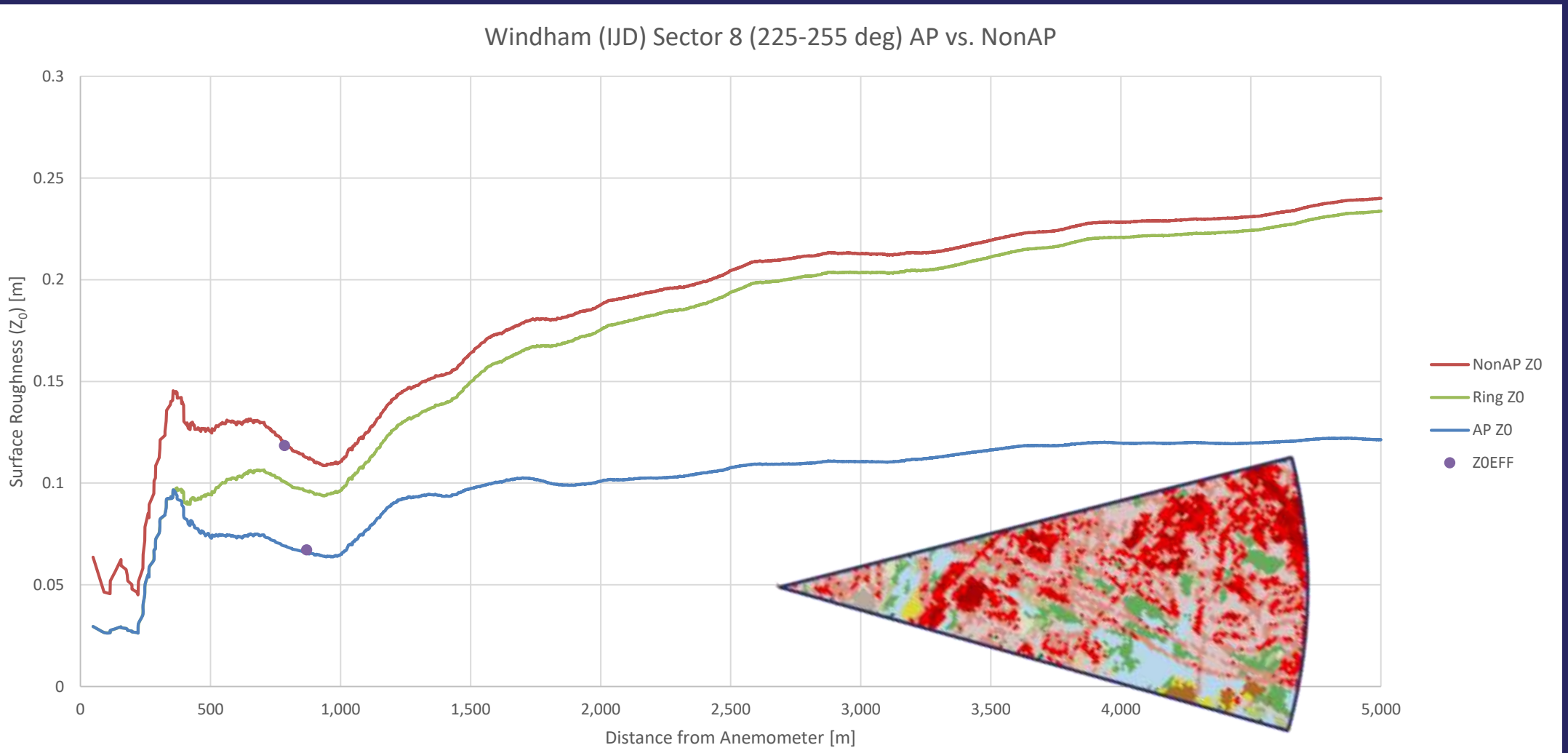
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

IJD Sector 9

Airport:

BDL

BDR

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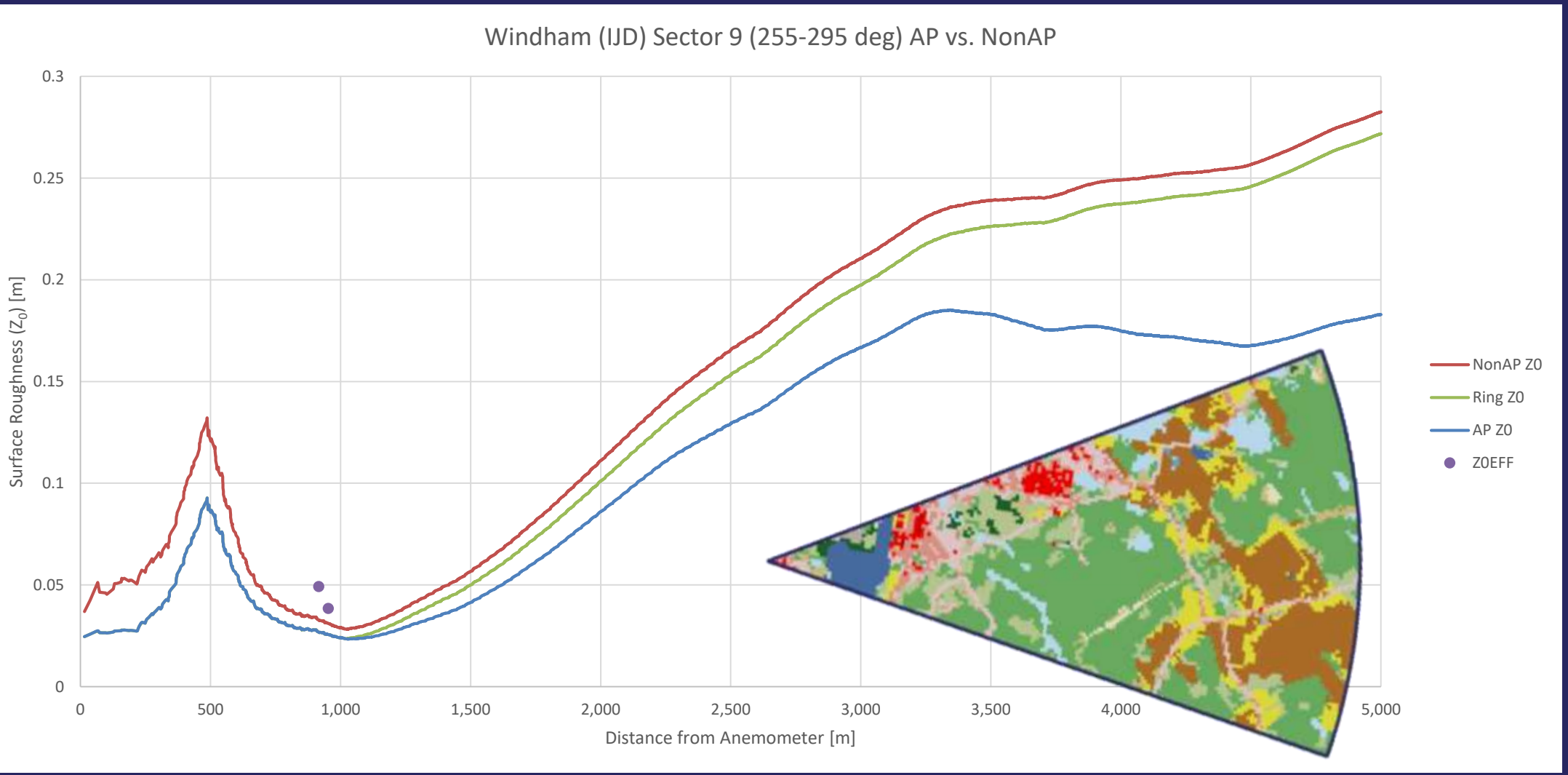
HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

IJD Sector 10

Airport:

BDL

BDR

DXR

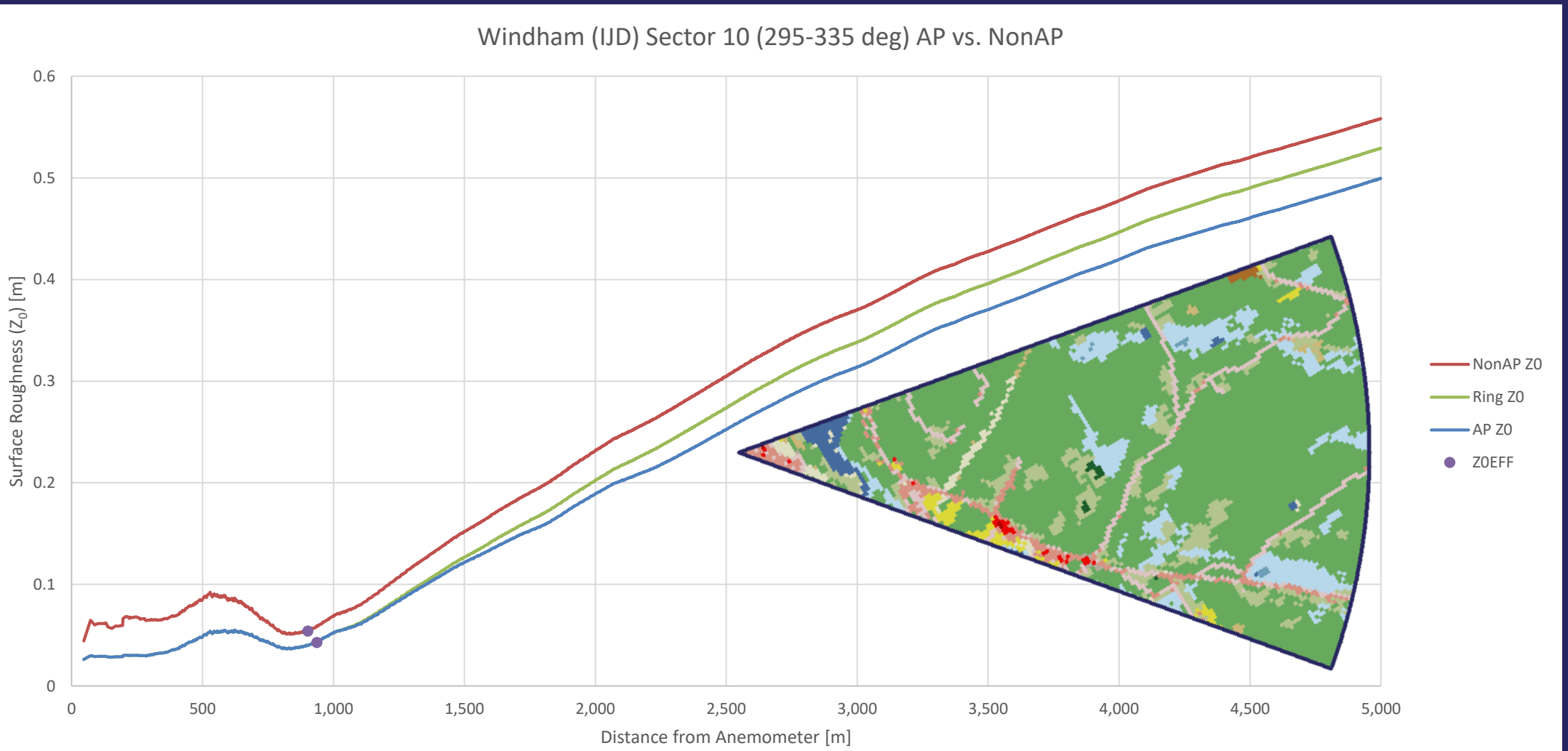
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

IJD Sector 11

Airport:

BDL

BDR

DXR

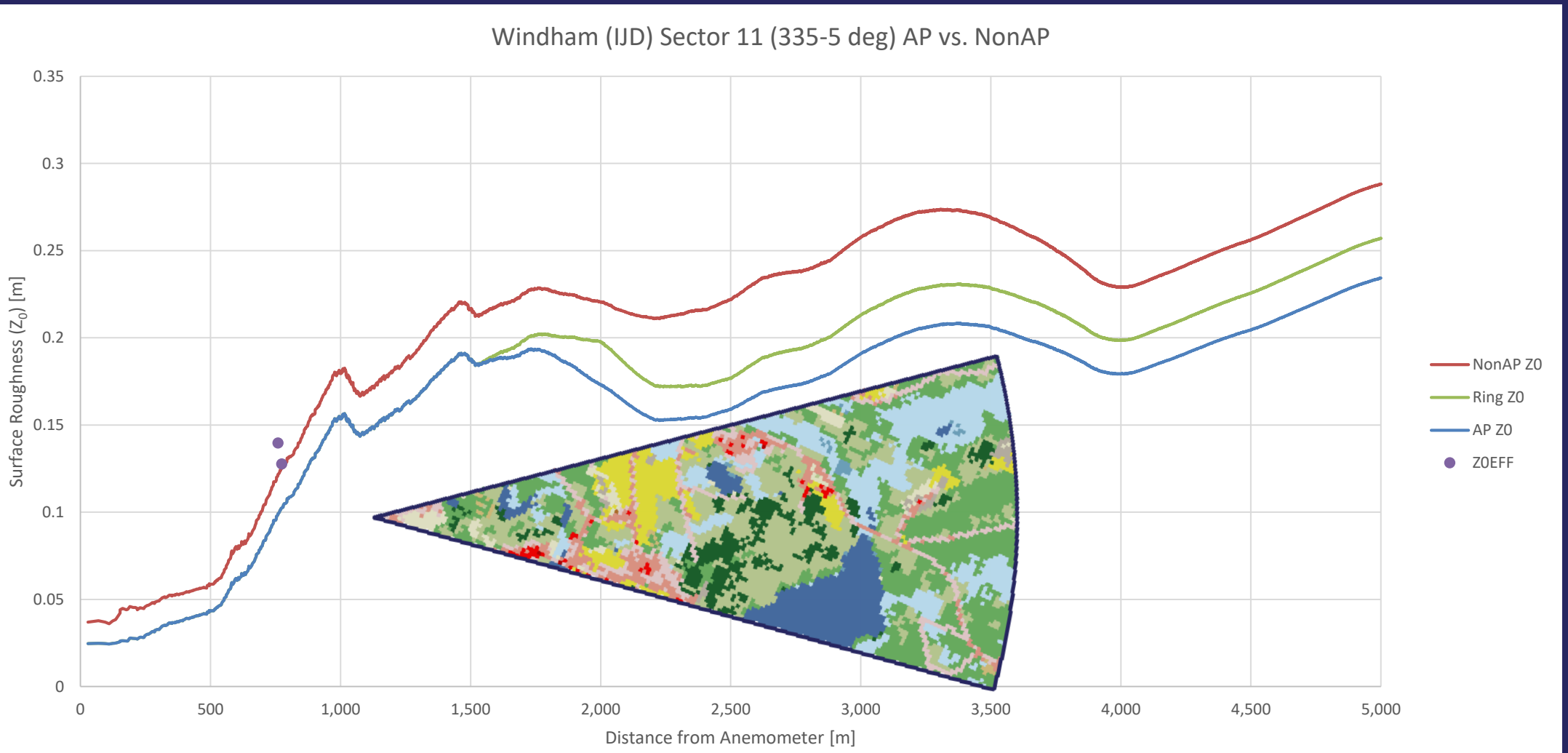
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

Meriden-Markham Airport (MMK)

Airport:

BDL

BDR

DXR

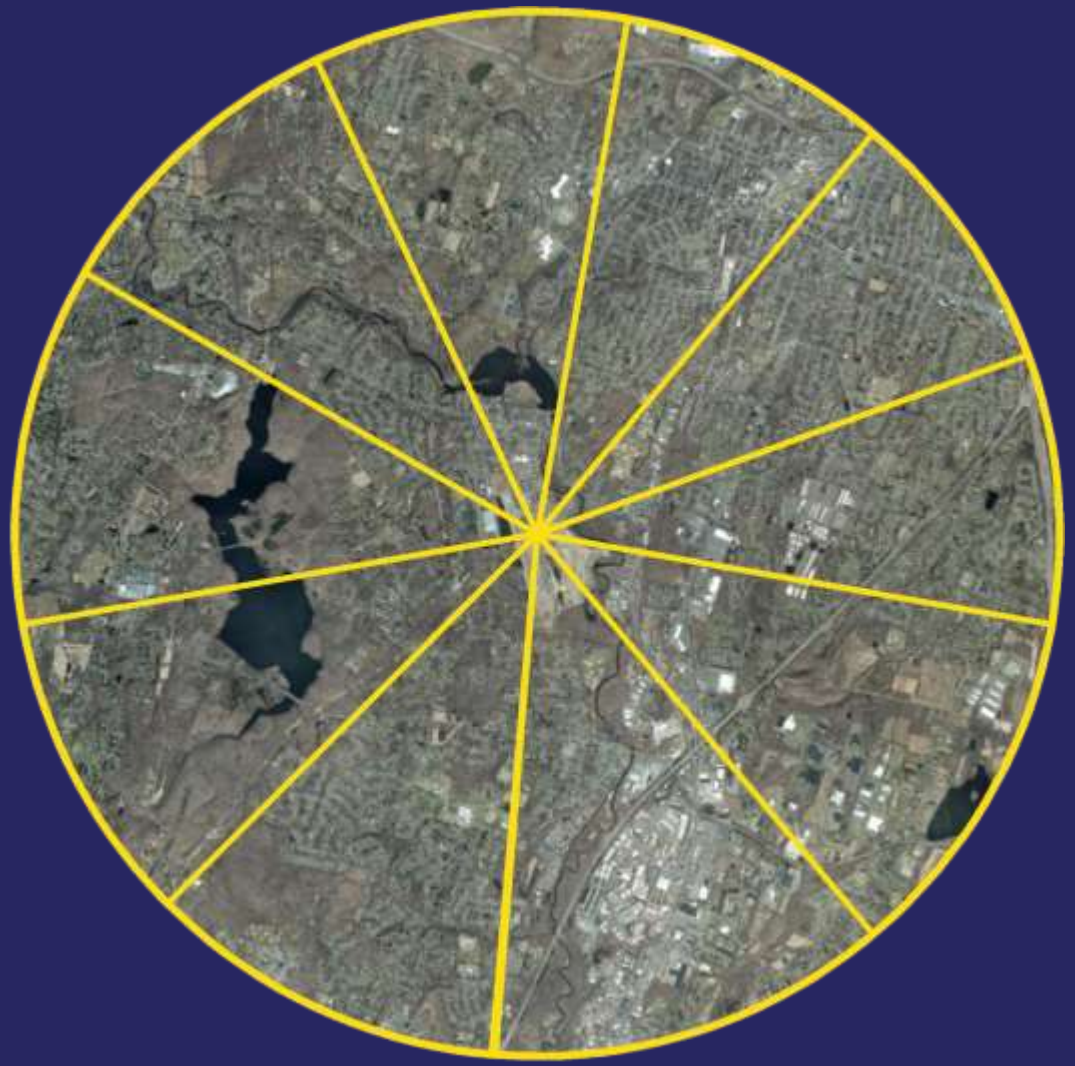
GON

HFD

HVN

IJD

MMK



NLCD 2016 CONUS Land Cover Legend

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- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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Meriden-Markham Airport (MMK)

Airport:

BDL

BDR

DXR

GON

HFD

HVN

IJD

MMK

NLCD 2016 CONUS Land Cover Legend

- Open Water (11)
- Perennial Ice/Snow/ (12)
- Developed, Open Space (21)
- Developed, Low Intensity (22)
- Developed, Medium Intensity (23)
- Developed, High Intensity (24)
- Barren Land (Rock/Sand/Clay) (31)
- Unconsolidated Shore (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Shrub/Scrub (52)
- Grasslands/Herbaceous (71)
- Pasture/Hay (81)
- Cultivated Crops (82)
- Woody Wetlands (90)
- Emergent Herbaceous Wetlands (95)

Sector:

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MMK Sector 1

Airport:

BDL

BDR

DXR

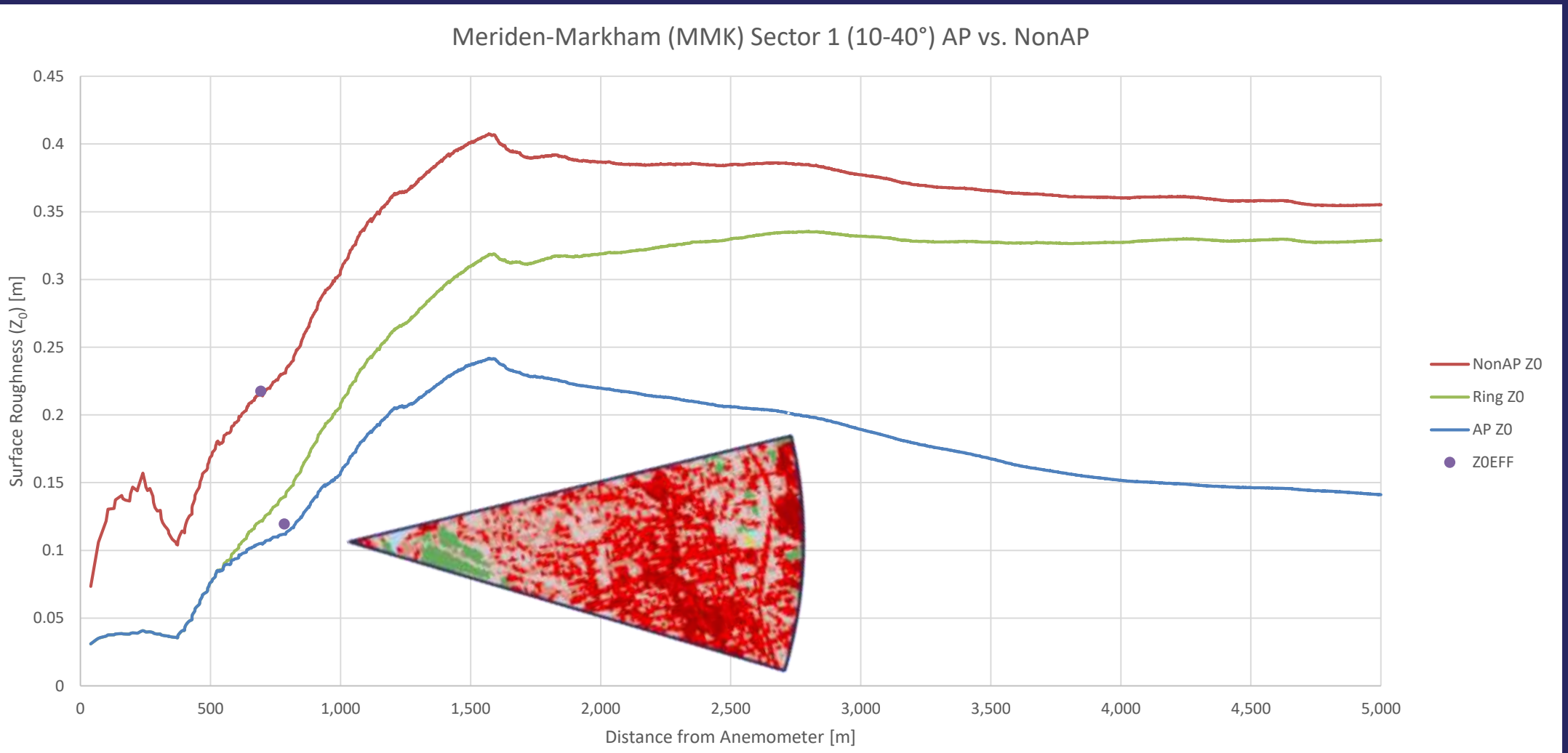
GON

HFD

HVN

IJD

MMK



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Connecticut Department of Energy & Environmental Department

MMK Sector 2

Airport:

BDL

BDR

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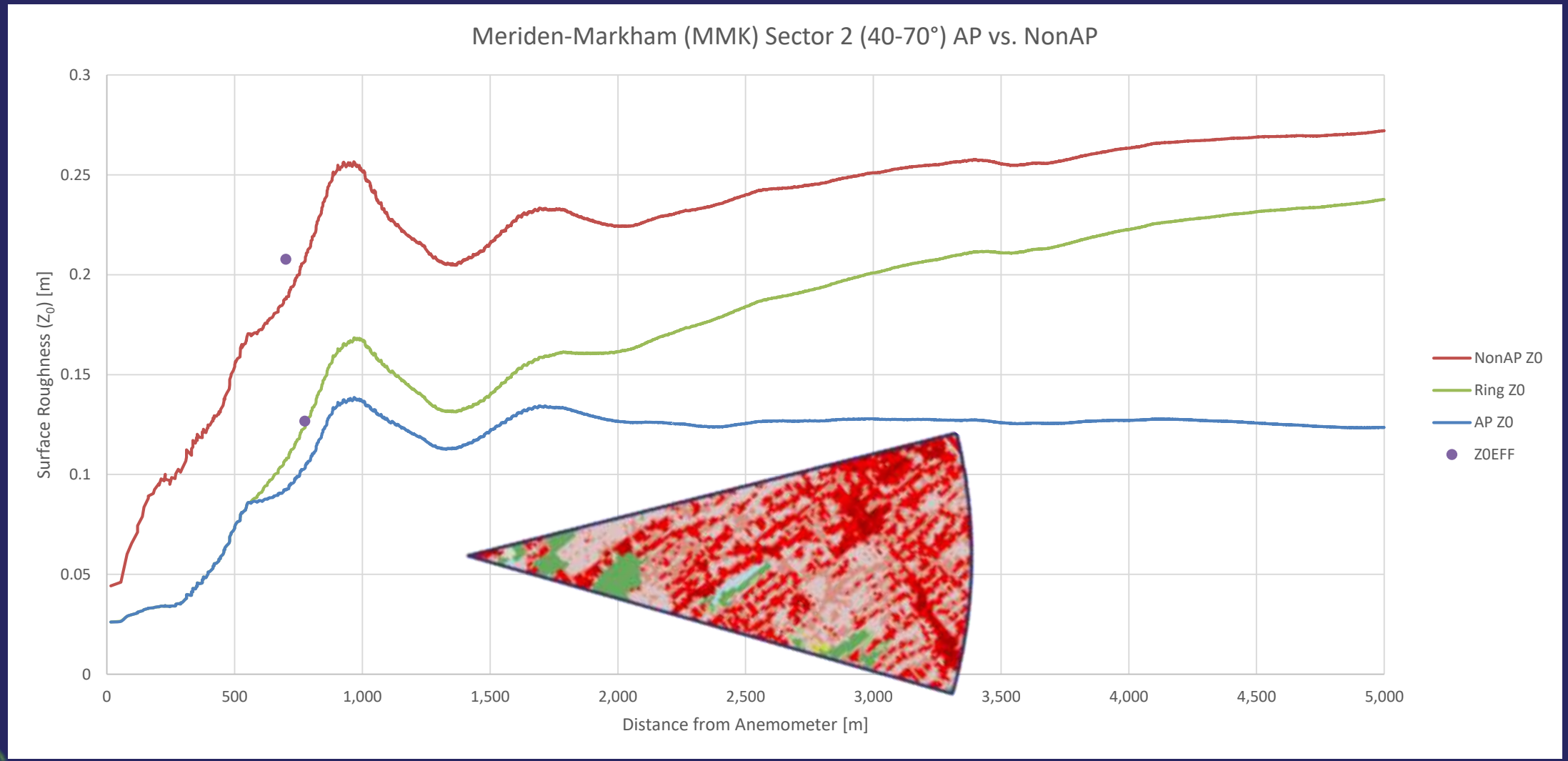
HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

MMK Sector 3

Airport:

BDL

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HVN

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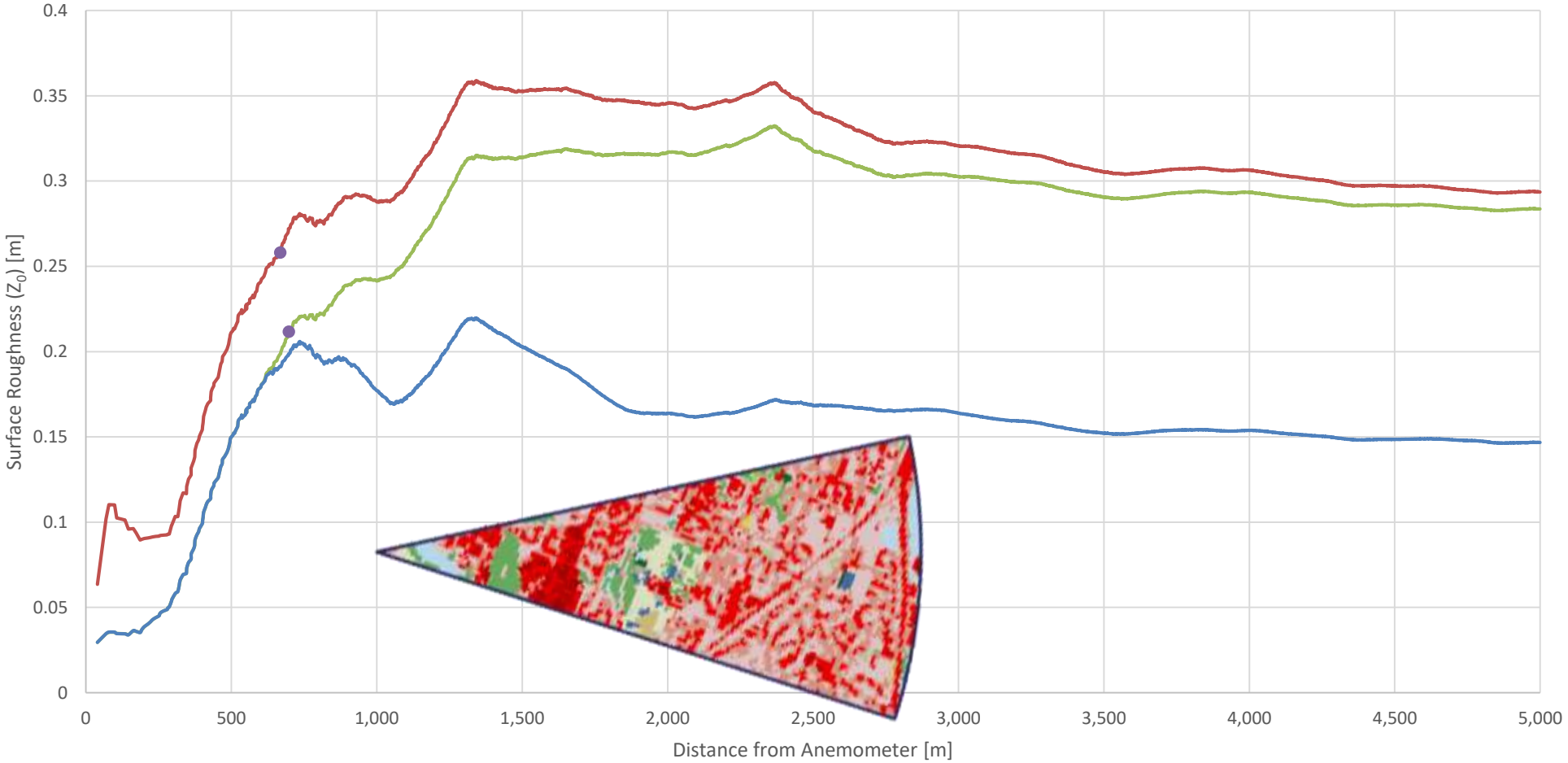
MMK



Sector:

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Connecticut Department of Energy & Environmental Department

MMK Sector 4

Airport:

BDL

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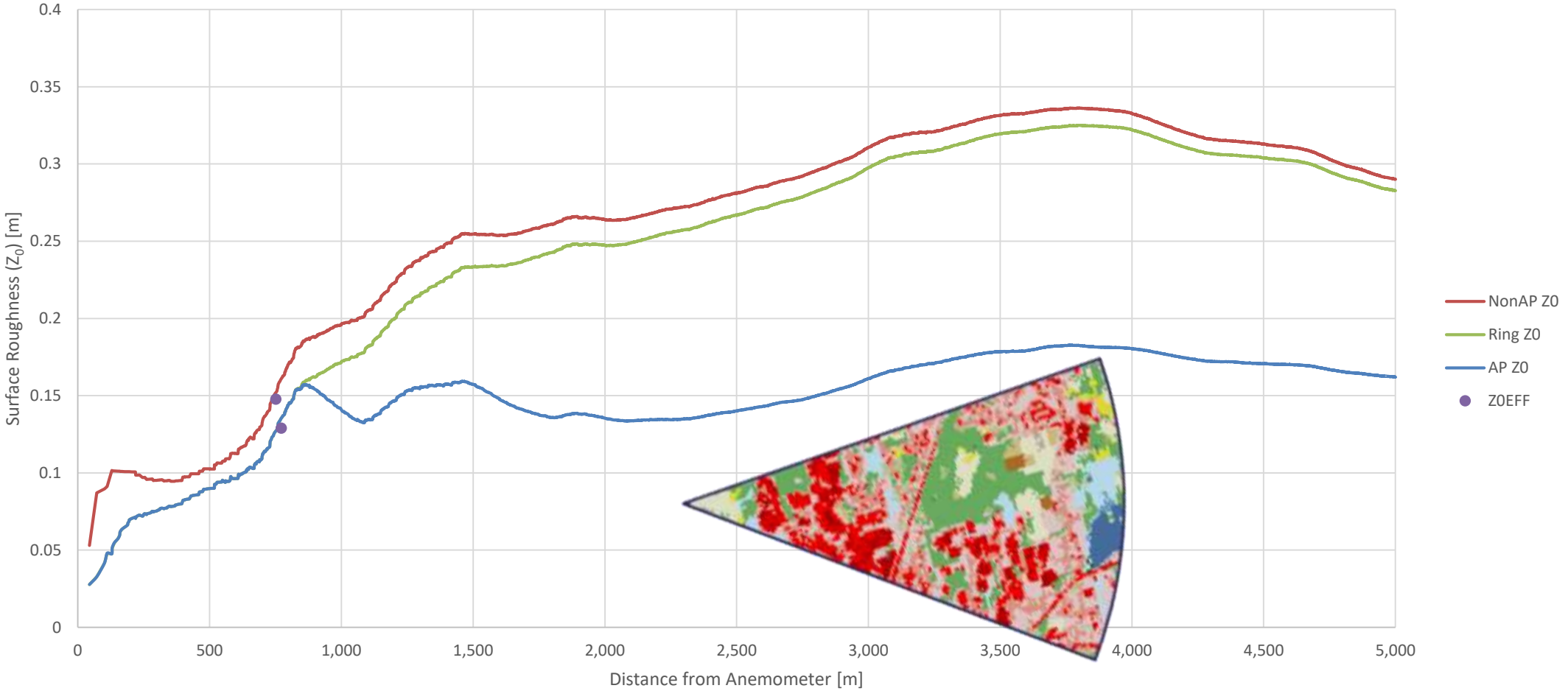
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

MMK Sector 5

Airport:

BDL

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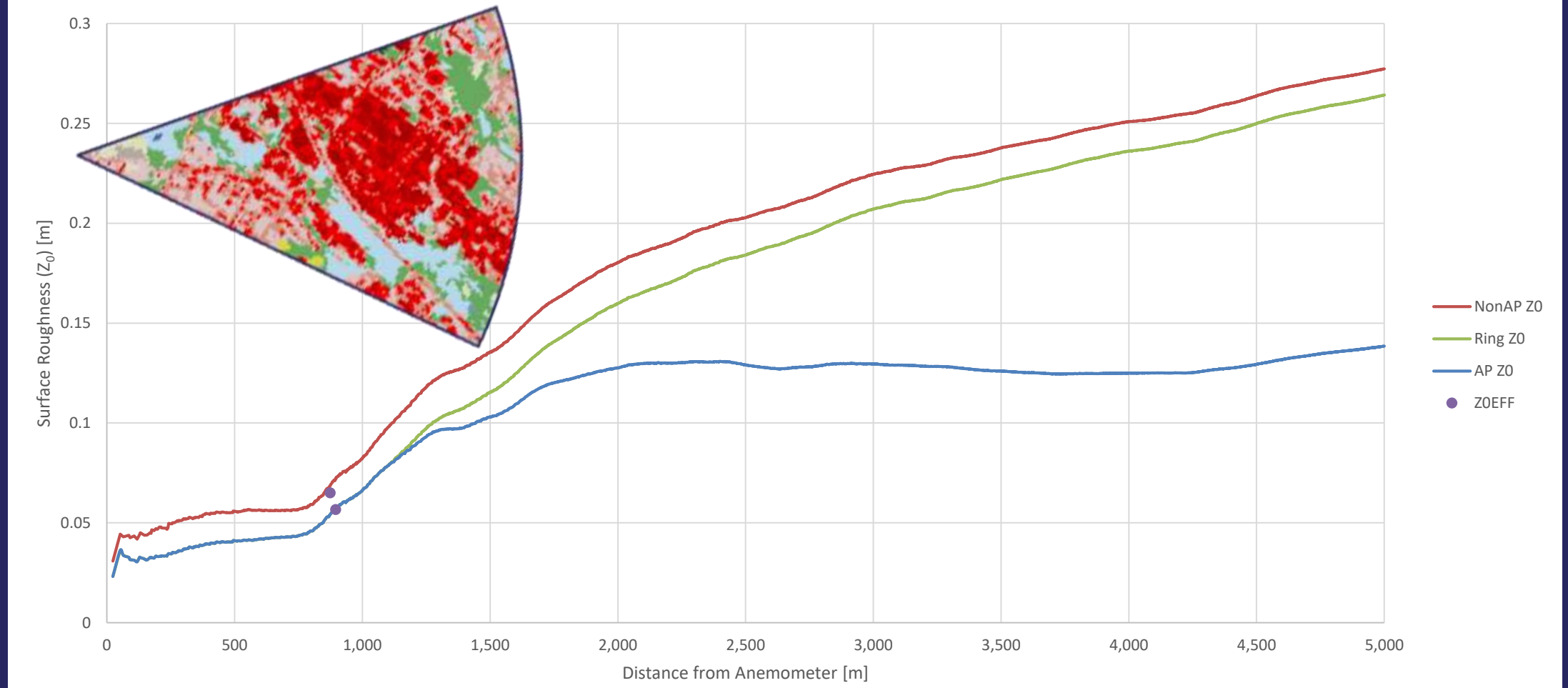
HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

MMK Sector 6

Airport:

BDL

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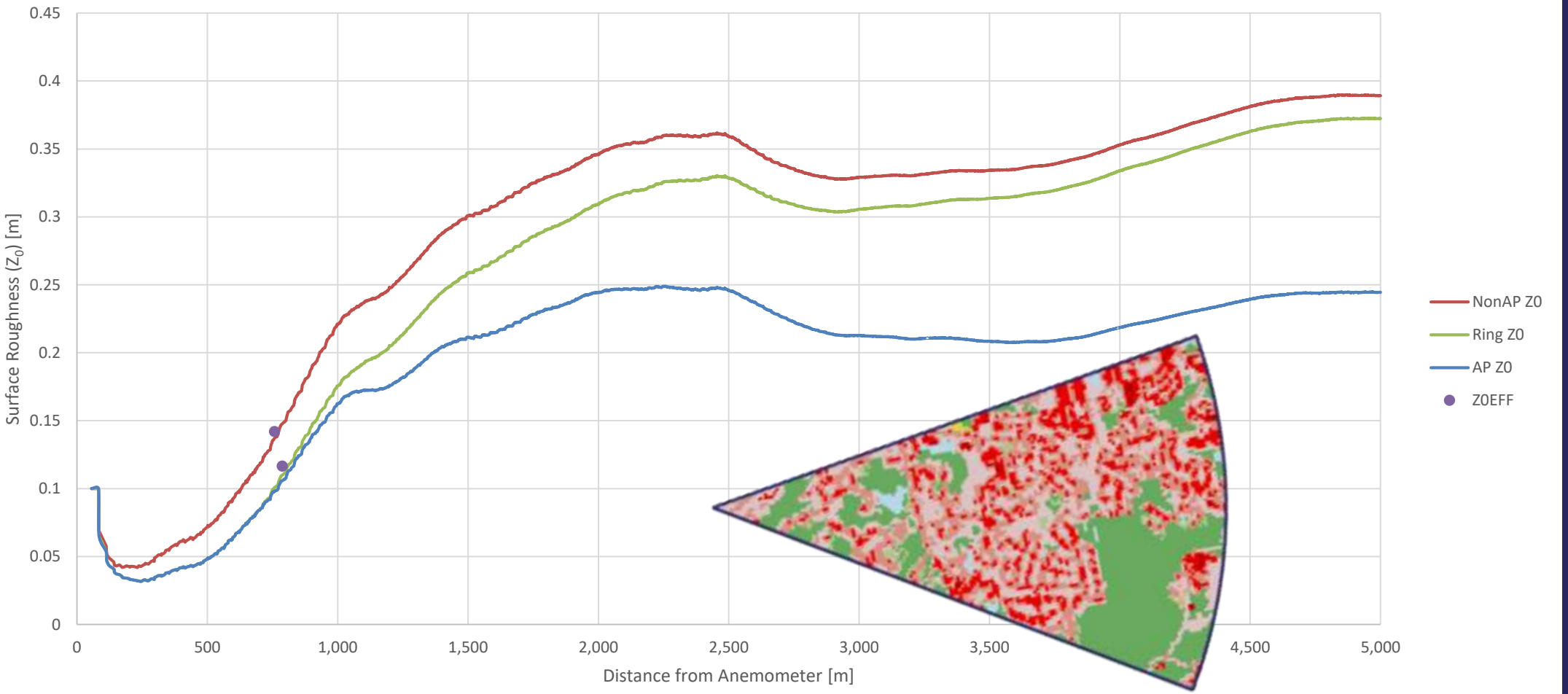

Sector:

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Connecticut Department of Energy & Environmental Department

MMK Sector 7

Airport:

BDL

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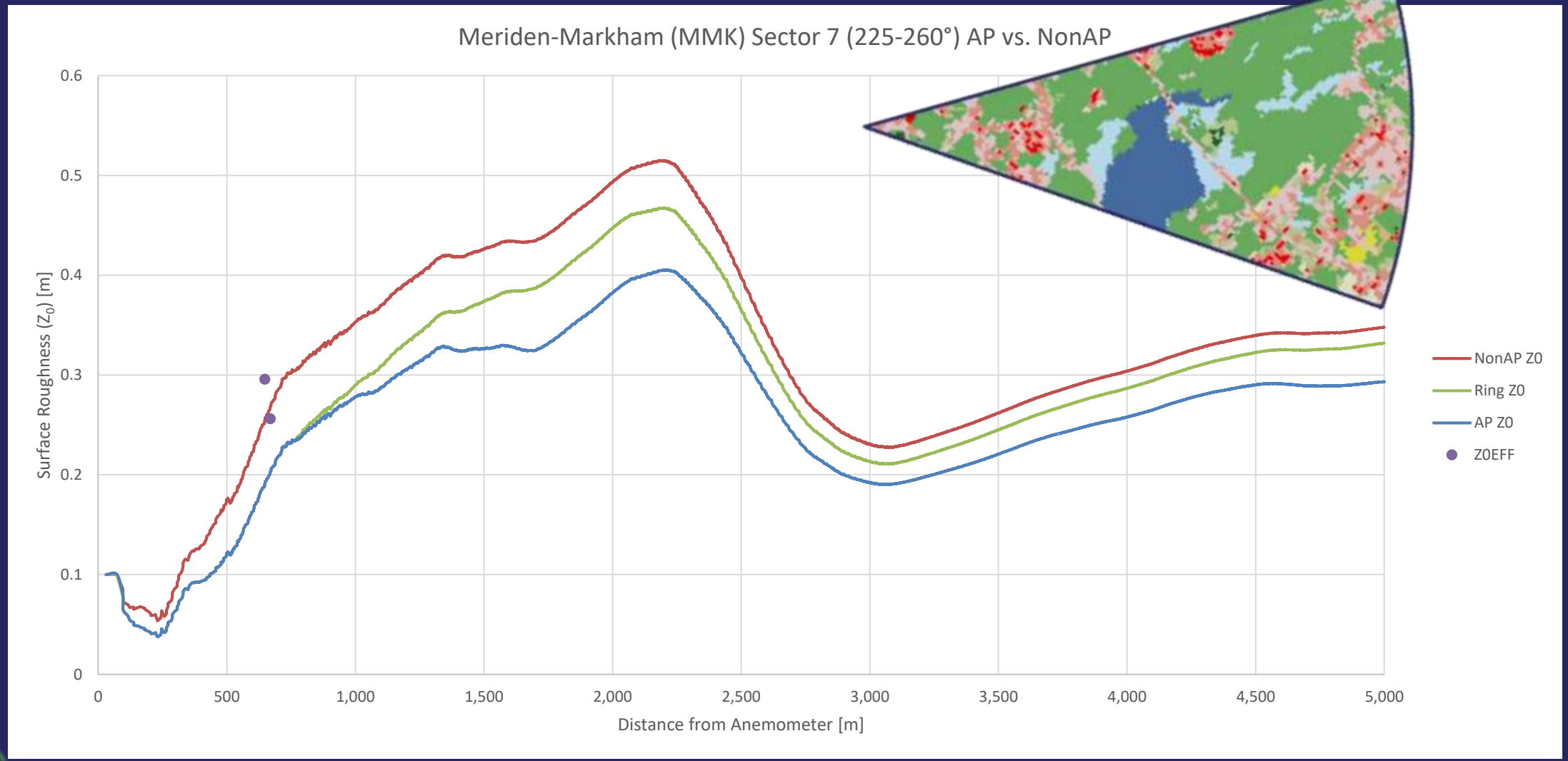

Sector:

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Connecticut Department of Energy & Environmental Department

MMK Sector 8

Airport:

BDL

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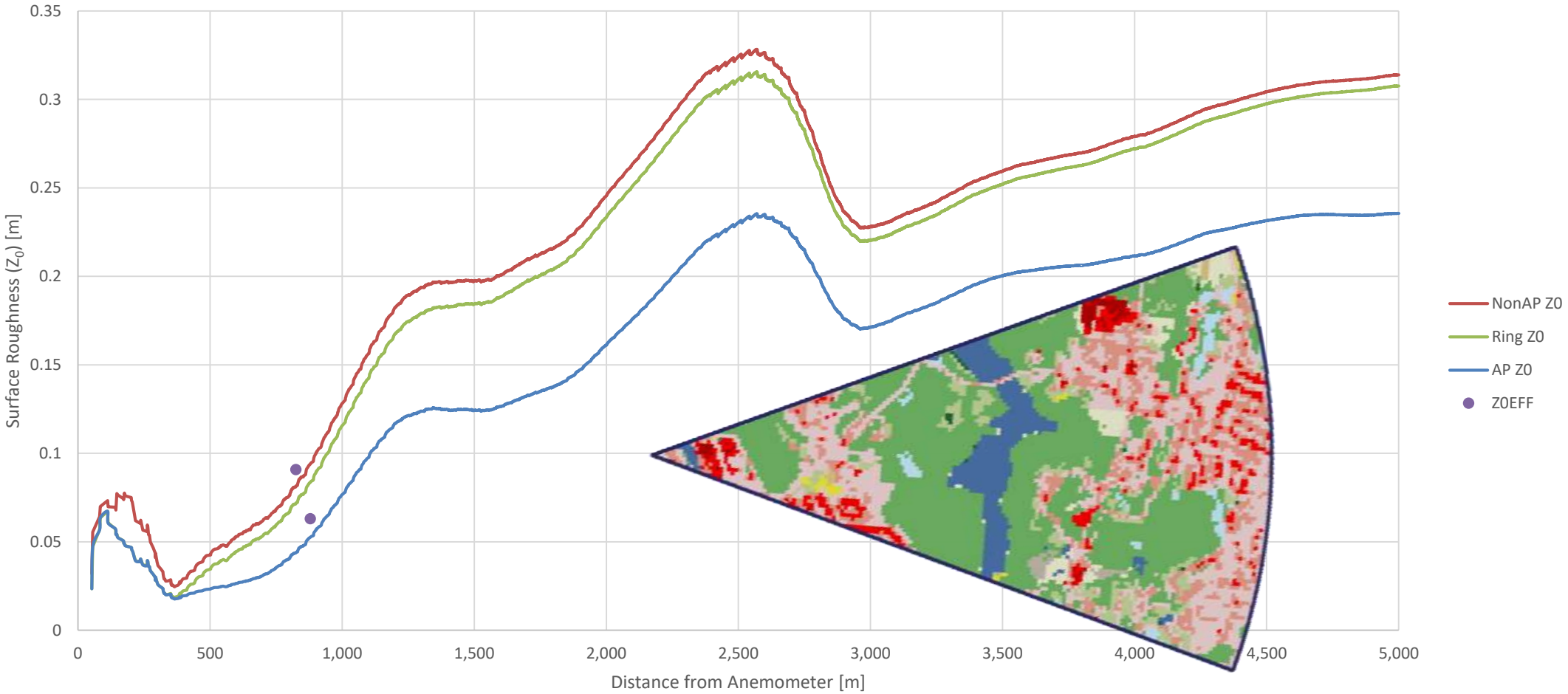
IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department

MMK Sector 9

Airport:

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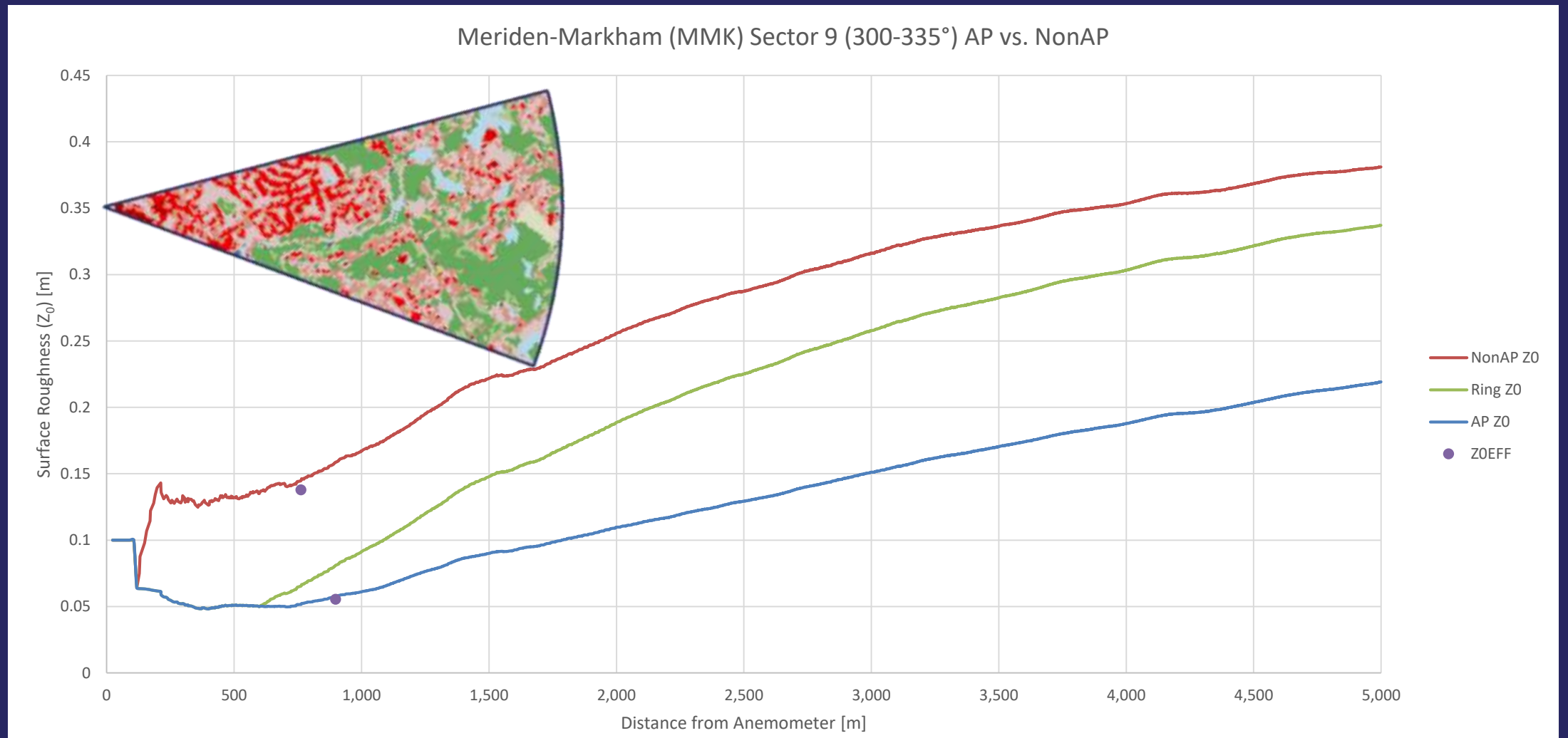
MMK



Sector:

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Connecticut Department of Energy & Environmental Department

MMK Sector 10

Airport:

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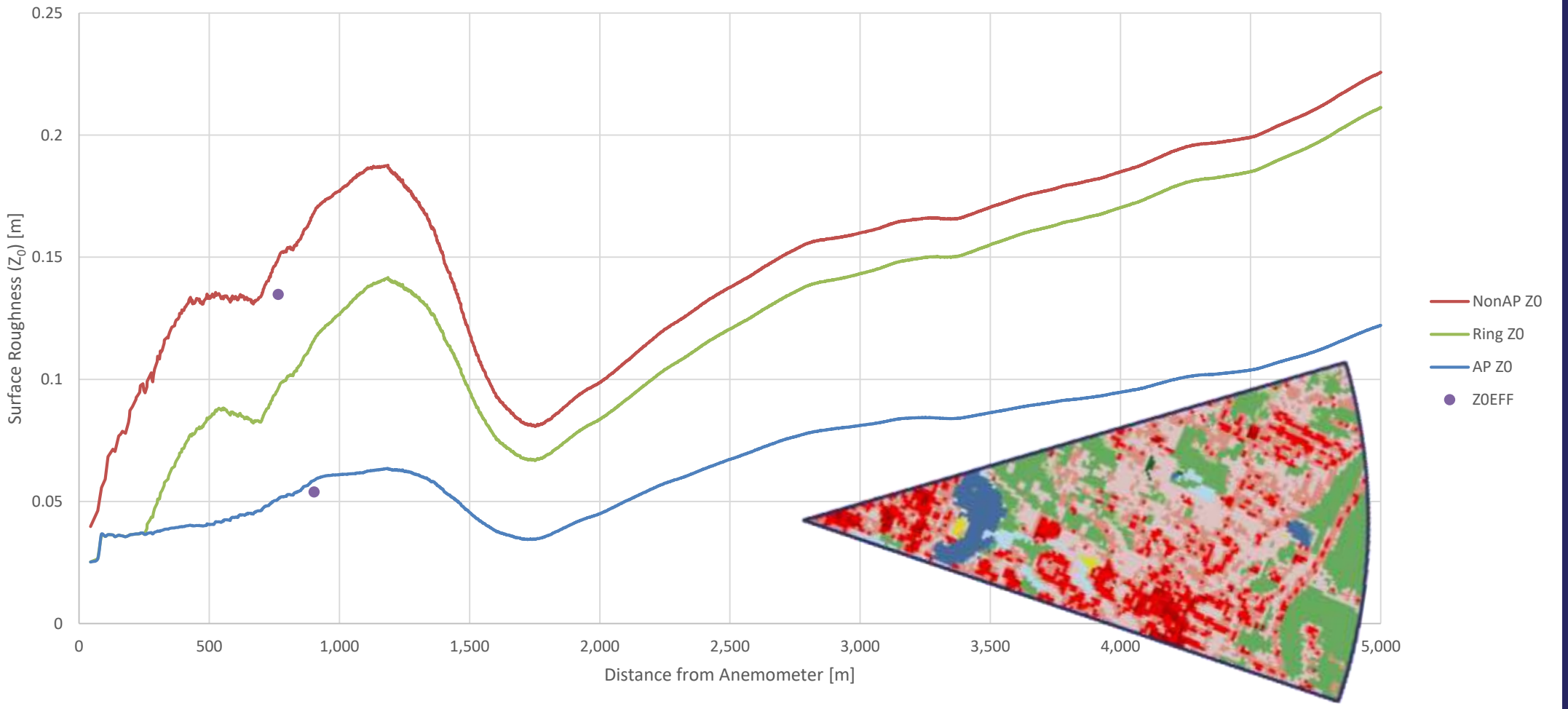
GON

HFD

HVN

IJD

MMK



Sector:

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Connecticut Department of Energy & Environmental Department