AERSURFACE
v.20060

Webinar
June 15, 2020

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U.S. EPA / OAQPS / Air Quality Modeling Group
Webinar Topics

• Basic Info (release info and materials, status, changes)
• EPA Recommendations
• Data Sources
• Meteorological Sites
• Special Topics
  o Defining Roughness Sectors
  o Assigning Airport/Non-airport Flags to Sectors
  o % Impervious and % Tree Canopy Implementation
• Future Work
• AERSURFACE, v.20060
• Available on SCRAM beginning Tuesday, April 7, 2020
    o [https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs#aersurface](https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs#aersurface)
    o Transmittal memo
    o Source code
    o Executables (32- and 64-bit, compiled with gfortran)
    o User’s Guide
    o Spreadsheet to simulate application of impervious and tree canopy data
• AERSURFACE v.20060 replaces v.13016 and v.19039_DRFT

• AERSURFACE is **not** part of the **regulatory** AERMOD system (AERMAP, AERMET, AERMOD)

• Section 8.4.2 of Appendix W to 40 CFR Part 51 recommends that users apply the latest version of AERSURFACE at the site of the meteorological tower to determine representative surface characteristics for input to AERMET, where applicable

• When data required by AERSURFACE are not available, EPA recommends that the techniques used by AERSURFACE are applied

• With the transition to more recent land cover products and a new version of AERSURFACE, EPA recognizes there might be applications where changes in land cover categories and ambiguity in their definitions affect AERSURFACE’s ability to appropriately assign reasonable surface characteristic values to an individual sector. When these situations arise, consult with reviewing agency and EPA Region.
Changes from AERSURFACE v.13016

- Path/keyword control file (similar to AERMOD)
- Command-line arguments for standard input/output files
- Keywords to process NLCD 1992, 2001, 2006, 2011, 2016 (GeoTIFF only)
  - USGS no longer providing/supporting NLCD 1992
  - EPA has archived 1992 NLCD GeoTIFF files for use with v.20060 (for historical purposes)
  - V.20060 will not process state-level “binary” 1992 NLCD files
- Supplement land cover with percent impervious and tree canopy, where available
- Characterize individual wind sectors as airport/non-airport
- Output appropriate AERMET keywords for PRIMARY or SECONDARY site
- Research grade method (ZOEFF) for determining surface roughness length
When used for a regulatory application, the EPA recommends the following:

• The default method for determining surface roughness length, ZORAD, based on the area within a 1 km radius of the meteorological tower.

• Supplement land cover with percent impervious and percent tree canopy data when both are available (do not recommend using one without the other)

• Land cover should only be supplemented with impervious and tree canopy data that are concurrent with the year and version of land cover data
• Multi-Resolution Land Characteristics (MRLC) Consortium

  o The MRLC website should be the primary source for most recent NLCD products and documentation (https://www.mrlc.gov/)

  o GeoTIFFs compatible with AERSURFACE available via MRLC Viewer https://www.mrlc.gov/viewer/

  o Instructions posted on SCRAM at https://www3.epa.gov/ttn/scram/models/aermod/aersurface/NLCD_Sources_for_AERSURFACE_v20060.pdf
## MRLC Inventory

<table>
<thead>
<tr>
<th>Year</th>
<th>Data</th>
<th>Conterminous US</th>
<th>Alaska*</th>
<th>Hawaii</th>
<th>Puerto Rico</th>
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<tr>
<td>2001</td>
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</tr>
<tr>
<td></td>
<td>Impervious</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
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<td>Canopy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>2006</td>
<td>Land Cover</td>
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<td></td>
</tr>
<tr>
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<td>Impervious</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canopy</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Land Cover</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td></td>
<td>Impervious</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canopy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2016</td>
<td>Land Cover</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Impervious</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canopy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

* Percent impervious and percent tree canopy data are available for only portions of Alaska and data types available do not overlap for all areas where available.
NLCD Data Sources for AERSURFACE

• EPA FTP Server
  
  o A secondary source for obtaining NLCD data files that are compatible with AERSURFACE is the EPA FTP server at ftp://newftp.epa.gov/Air/aqmg/nlcd/.

  o Converted from national ERDAS IMAGINE (IMG) files downloaded from MRLC website

  o US CONUS represented by 29 files, land area of files ranges from partial state (e.g., California) to full EPA Region (e.g., Region 1), based area extent. (Single GeoTIFF could be on the order of 1 GB.) Land cover zipped with canopy and impervious when available

  o File boundaries overlap state boundaries to minimize issues at shared state boundaries
## EPA FTP Server Inventory

**Base Directory:** [ftp://newftp.epa.gov/aqmg/nlcd/](ftp://newftp.epa.gov/aqmg/nlcd/)

<table>
<thead>
<tr>
<th>Subdirectory</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001/</td>
<td>2001 NLCD, updated with 2016 NLCD release, partial/multi-state coverage</td>
</tr>
<tr>
<td>2001_2011ed/</td>
<td>2001 NLCD (2011 edition), single state and 3x3 degree coverage</td>
</tr>
<tr>
<td>2006/</td>
<td>2006 NLCD, updated with 2016 NLCD release, partial/multi-state coverage</td>
</tr>
<tr>
<td>2011/</td>
<td>2011 NLCD, updated with 2016 NLCD release, partial/multi-state coverage</td>
</tr>
<tr>
<td>2016/</td>
<td>2016 NLCD, partial/multi-state coverage</td>
</tr>
<tr>
<td>region_state_jpg/</td>
<td>JPEG image files illustrating coverage of partial/multi-state GeoTIFFs</td>
</tr>
</tbody>
</table>
Reminder – Use Met Tower Location

• Per section 8.4.2 of Appendix W: *surface characteristics input to AERMET should be representative of the land cover in the vicinity of the meteorological data*, i.e., the location of the meteorological tower for measured data or the representative grid cell for prognostic data.

• When running AERSURFACE, input the coordinates of the meteorological tower

• **Should not** use AERSURFACE when using prognostic data
• AERMET requires two sets of surface characteristics when utilizing both surface meteorological data collected from a site-specific tower an NWS/FAA station (i.e., airport).

• Similar but different keywords in the AERMET control file identify the surface characteristics as either the PRIMARY or SECONDARY

• When both site-specific and NWS surface data are processed, the site-specific meteorological tower is the PRIMARY site and NWS tower is the SECONDARY site

• When only site-specific or only NWS surface data are processed with AERMET, the site processed is the PRIMARY site and only the keywords associated with the PRIMARY site should be used in AERMET
Defining Roughness Sectors
Defining Roughness Sectors

• Surface roughness length is calculated by AERSURFACE as an inverse distance-weighted geometric mean (land cover nearest tower has more influence)

• A common practice for defining roughness sectors when using AERSURFACE v.13016 was to use 12 individual 30-degree sectors starting at 0-degrees (i.e., 0-30, 30-60, 60-90, etc.) – may be sufficient for many sites

• To refine roughness, EPA recommends user-defined sectors based on changes in land cover and/or land use around the tower out to a 1 km radius

• Subjective process – use professional judgement – provide rationale

• Define areas that are somewhat homogeneous, when possible, based on land use/land cover

• Consider airport/non-airport assignments when defining sectors

• May need to initially define, then refine when designating as airport/non-airport based on land use/land cover
Changes in NLCD Categories

1992

11. Open Water
12. Perennial Ice/Snow
21. Low Intensity Residential
22. High Intensity Residential
23. Commercial/Industrial/Transportation
31. Bare/Rock/Sand/Clay
32. Quarries/Strip Mines/Gravel Pits
33. Transitional
41. Deciduous Forest
42. Evergreen Forest
43. Mixed Forest
51. Shrubland
61. Orchards/Vineyards/Other
71. Grassland/Herbaceous
81. Pasture/Hay
82. Row Crops
83. Small Grains
84. Fallow
85. Urban/Recreational Grasses
91. Woody Wetlands
92. Emergent Herbaceous Wetlands

2001 - 2016

11. Open Water
12. Perennial Ice/Snow
21. Developed, Open Space
22. Developed, Low Intensity
23. Developed, Medium Intensity
24. Developed, High Intensity
31. Rock/Sand/Clay
41. Deciduous Forest
42. Evergreen Forest
43. Mixed Forest
51. Dwarf Scrub
52. Shrub/Scrub
71. Grassland/Herbaceous
72. Sedge/Herbaceous
73. Lichens
74. Moss
81. Pasture/Hay
82. Cultivated Crops
83. Small Grains
84. Fallow
85. Urban/Recreational Grasses
91. Woody Wetlands
92. Emergent Herbaceous Wetlands
95. Emergent Herbaceous Wetlands

Red = Omitted 2001
Blue = Added 2001
= AP/NAP
Challenges with Land Cover Changes

1992

Low intensity Residential:
- 30% to 80% constructed materials.
- 20% to 70% vegetation.
- Single-family housing units.

High Intensity Residential:
- 80% to 100% constructed materials.
- < 20% vegetation.
- Apartment complexes and row houses.

Commercial/Industrial/Transportation:
- Areas of infrastructure (e.g. roads, railroads, etc.) and all highly developed areas not classified as High Intensity Residential

Nearly 100% lawn grasses or tree canopy
Scattered homes

2001-2016

Developed, Open Space:
- Mostly vegetation in form of lawn grasses.
- < 20% impervious surfaces.
- Large-lot single-family housing, parks, golf courses

Developed, Low Intensity:
- Mix of constructed materials and vegetation.
- 20% to 49% impervious surfaces.
- Single-family housing units.

Developed, Medium Intensity:
- Mix of constructed materials and vegetation.
- 50% to 79% impervious surfaces.
- Single-family housing units.

Developed, High Intensity:
- Highly developed, where people live or work
- 80% to 100% impervious surfaces.
- Apartment complexes, row houses, commercial/industrial

Subdivision
Apartments
Metro area
Parking lot
Challenges with Land Cover Changes

1992 - RDU

- Urban/Recreational Grasses
- Commercial/Industrial/Transportation

2011 - RDU

- Developed, Open Space
- Developed, High Intensity

Legend:
- 11 Open Water
- 12 Perennial Ice/Snow
- 21 Low Intensity Residential
- 22 High Intensity Residential
- 23 Commercial/Industrial/Transportation
- 31 Bare Rock/Sand/Clay
- 32 Quarries/Strip Mines/Gravel Pits
- 33 Transitional Barren
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Shrubland
- 61 Orchards/Vineyards/Other
- 71 Grassland/Herbaceous
- 81 Pasture/Hay
- 82 Row Crops
- 83 Small Grains
- 84 Fallow
- 85 Urban/Recreational Grasses
- 91 Woody Wetlands
- 92 Emergent Herbaceous Wetlands
- 11 Open Water
- 12 Perennial Ice/Snow
- 21 Developed, Open Space
- 22 Developed, Low Intensity
- 23 Developed, Medium Intensity
- 24 Developed, High Intensity
- 31 Barren Land (Rock/Sand/Clay)
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Dwarf Scrub*
- 52 Shrub/Scrub
- 71 Grassland/Herbaceous
- 72 Sedge/Herbaceous*
- 73 Lichens*
- 74 Moos*
- 81 Pasture/Hay
- 82 Cultivated Crops
- 90 Woody Wetlands
- 95 Emergent Herbaceous Wetlands

* Alaska only
Defining Roughness Sectors - BTR

1/20/2016

NLCD 2016

280° 50° 210°
Defining Roughness Sectors - BTR

Developed – Open Space :: 7% Impervious :: 90% Tree Canopy
Defining Roughness Sectors - BTR

NLCD 2016

% Impervious

% Tree Canopy
Airport vs Non-airport Sectors
Airport/Non-airport Sectors

- Characterize wind sectors individually as airport or non-airport

- Affects roughness lookup values for:
  - 1992 Comm/Trans/Industrial (23)
  - 2001-2016 Developed (21-24), Pasture Hay (81), and Cultivated Crops (82)

- Characterize based on land use within the sector rather than whether or not the met tower is physically located at an airport

- Important to judge what features in a sector would likely have substantial influence and their relative roughness (Airport = lower roughness table values, Non-airport = higher roughness)

- Met tower could be located with substantial area of short grass and runway near and around the tower, but one sector might include the terminal and may need to be considered non-airport to account for the higher roughness of the terminal
## Airport/Non-airport Sectors (2001-2016)

<table>
<thead>
<tr>
<th>Land Use - Considerations</th>
<th>Characterization</th>
<th>Surface Roughness (m) by Season*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed – Open Space (21)</td>
<td>Airport</td>
<td>0.02 0.01 0.02 0.03 0.03</td>
</tr>
<tr>
<td>Predominantly grass and impervious areas primarily paved areas</td>
<td>Non-airport</td>
<td>0.02 0.01 0.03 0.04 0.03</td>
</tr>
<tr>
<td>Developed – Open Space (21)</td>
<td>Airport</td>
<td>0.03-0.07 0.02-0.07 0.03-0.07 0.04-0.08 0.03-0.08</td>
</tr>
<tr>
<td>Park with mix of trees, grass, and buildings, and/or residential area</td>
<td>Non-airport</td>
<td>0.07-0.70 0.05-0.70 0.09-0.70 0.1-0.70 0.09-0.70</td>
</tr>
<tr>
<td>Developed – Low, Medium, High Intensity (22-24)</td>
<td>Airport</td>
<td>0.02 0.01 0.02 0.03 0.03</td>
</tr>
<tr>
<td>Impervious areas are predominantly flat paved or unpaved surfaces (e.g. runways, parking lots, roads)</td>
<td>Non-airport</td>
<td>0.02 0.01 0.03 0.15 0.15</td>
</tr>
<tr>
<td></td>
<td>Pasture/Hay (81)</td>
<td>Airport</td>
</tr>
<tr>
<td></td>
<td>Pastures for grazing – short/low growing grasses</td>
<td>Non-airport</td>
</tr>
<tr>
<td></td>
<td>Cultivated Crops (82)</td>
<td>Short crops</td>
</tr>
<tr>
<td></td>
<td>Tall crops, vineyards, orchards</td>
<td>Non-airport</td>
</tr>
</tbody>
</table>

* Seasons: 1 - Late autumn after frost and harvest; or winter with no snow; 2 - Winter with continuous snow on ground; 3 - Transitional spring with partial green coverage or short annuals; 4 - Midsummer with lush vegetation; 5 - Autumn with unharvested cropland

**Developed Categories:** Reported roughness values are only applied to Developed categories when % impervious and % tree canopy are excluded from processing.
Airport/Non-airport - BTR

1/20/2016

NLCD 2016
ATL Sectors (1992)

Google Earth 2/26/1993

NLCD 1992 Land Cover

- 11 Open Water
- 12 Perennial Ice/Snow
- 21 Low Intensity Residential
- 22 High Intensity Residential
- 23 Commercial/Industrial/Transportation
- 31 Bare Rock/Sand/Clay
- 32 Quarries/Strip Mines/Gravel Pits
- 33 Transitional Barren
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Shrubland
- 61 Orchards/Vineyards/Other
- 71 Grassland/Herbaceous
- 81 Pasture/Hay
- 82 Row Crops
- 83 Small Grains
- 84 Fallow
- 85 Urban/Recreational Grasses
- 91 Woody Wetlands
- 92 Emergent Herbaceous Wetlands
ATL Sectors (2011)

Google Earth 10/16/2011

NLCD 2011 Land Cover

Legend:
- 11 Open Water
- 12 Perennial Ice/ Snow
- 21 Developed, Open Space
- 22 Developed, Low Intensity
- 23 Developed, Medium Intensity
- 24 Developed, High Intensity
- 31 Barren Land (Rock/Sand/Clay)
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Dwarf Scrub*
- 52 Shrub/Scrub
- 71 Grassland/Herbaceous
- 72 Sedge/Herbaceous*
- 73 Lichens*
- 74 Moss*
- 81 Pasture/Hay
- 82 Cultivated Crops
- 90 Woody Wetlands
- 95 Emergent Herbaceous Wetlands

* Alaska only
ATL Sectors (2016)

Google Earth 5/7/2016

NLCD 2016 Land Cover

11 Open Water
12 Perennial Ice/ Snow
21 Developed, Open Space
22 Developed, Low Intensity
23 Developed, Medium Intensity
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73 Lichens*
74 Moss*
81 Pasture/Hay
82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands

* Alaska only
ATL Sectors (2016)

Google Earth 5/7/2016

NLCD 2016 Land Cover
ATL Sectors (2016)

NLCD 2016 Land Cover

2016 % Tree Canopy

2016 % Impervious
% Impervious and % Tree Canopy Implementation
Roughness for Developed categories (21-24) is computed based on the roughness values used from a mix of NLCD 1992 categories:

<table>
<thead>
<tr>
<th>1992 Land Cover Category</th>
<th>Characterization</th>
<th>Weighting</th>
<th>Surface Roughness (m) by Season*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>High Intensity Residential (22)</td>
<td>Airport</td>
<td>10% of Impervious</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Non-airport</td>
<td>90% of Impervious</td>
<td></td>
</tr>
<tr>
<td>Bare Rock/Sand/Clay (31)</td>
<td>Airport</td>
<td>90% of impervious</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>Non-airport</td>
<td>10% of Impervious</td>
<td></td>
</tr>
<tr>
<td>Mixed Forest (43)</td>
<td>---</td>
<td>% Canopy</td>
<td>0.90</td>
</tr>
<tr>
<td>Urban/Recreational Grasses (85)</td>
<td>---</td>
<td>1 – (% Impervious + % Canopy)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* Seasons: 1 - Late autumn after frost and harvest; or winter with no snow; 2 - Winter with continuous snow on ground; 3 - Transitional spring with partial green coverage or short annuals; 4 - Midsummer with lush vegetation; 5 - Autumn with unharvested cropland
% Impervious and % Tree Canopy

Modifications to Roughness for NLCD 2001-2016 Developed Categories when Supplemented with Impervious and Canopy Data

Ex. Developed-Medium Intensity: *Summer, 60% impervious, 10% canopy*

**Airport:** Computed based on the following combination of 1992 NLCD categories:
1. Mixed Forest (1.3) x %Canopy/100
2. 10%: 1992 High Intensity Residential (1.0) x %Impervious/100
3. 90%: Bare Rock/Sand/Clay (0.05) x %Impervious/100
4. Urban Recreational Grasses (0.02) x (1.0 – %Canopy/100 – %Impervious/100)

\[ z_o = \exp( \ln(1.3) * 0.1 + 0.1 * \ln(1.0) * 0.6 + 0.9 * \ln(0.05) * 0.6 + \ln(0.02) * 0.3 ) = 0.06 \]

**Non-airport:** Computed based on the following combination of 1992 NLCD categories:
1. Mixed Forest (1.3) x %Canopy/100
2. 90%: 1992 High Intensity Residential (1.0) x %Impervious/100
3. 10%: Bare Rock/Sand/Clay (0.05) x %Impervious/100
4. Urban Recreational Grasses (0.02) x (1.0 – %Canopy/100 – %Impervious/100)

\[ z_o = \exp( \ln(1.3) * 0.1 + 0.9 * \ln(1.0) * 0.6 + 0.1 * \ln(0.05) * 0.6 + \ln(0.02) * 0.3 ) = 0.27 \]
% Impervious and % Tree Canopy

Google Earth
2/27/2002

NLCD 2001 Land Cover

ATL

NLCD 2001 % Impervious

NLCD 2001 % Canopy

- Developed, Open Space (21)
  - 1% Impervious
  - 94% Tree Canopy

- Developed, High Intensity (24)
  - 100% Impervious
  - 0% Tree Canopy

Developed, Open Space (21)
1% Impervious
94% Tree Canopy

Developed, High Intensity (24)
100% Impervious
0% Tree Canopy

11 Open Water
12 Perennial Ice/ Snow
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51 Dwarf Scrub*
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71 Grassland/Herbaceous
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73 Lichens*
74 Moss*
81 Pasture/Hay
82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands

* Alaska only
### Developed, Open Space (30 x 30 m area) :: 1% Impervious :: 94% Canopy

<table>
<thead>
<tr>
<th>1992 NLCD Category</th>
<th>Description</th>
<th>ID</th>
<th>1992 NLCD Summer Zo (m)</th>
<th>Fraction Applied for Non-airport</th>
<th>Fraction Applied for Airport</th>
<th>Final Zo (m) Non-airport</th>
<th>Final Zo (m) Airport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Forest</td>
<td></td>
<td>43</td>
<td>1.30</td>
<td>1.00</td>
<td>1.00</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td>High Intensity Residential</td>
<td></td>
<td>22</td>
<td>1.00</td>
<td>0.90</td>
<td>0.10</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td>Bare Rock/Sand/Clay</td>
<td></td>
<td>31</td>
<td>0.05</td>
<td>0.10</td>
<td>0.90</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td>Urban/Recreational Grasses</td>
<td></td>
<td>85</td>
<td>0.02</td>
<td>1.00</td>
<td>1.00</td>
<td>1.05</td>
<td></td>
</tr>
</tbody>
</table>

Without Imp/Can: 0.03

### Developed, High Intensity :: 100% Impervious :: 0% Canopy

<table>
<thead>
<tr>
<th>1992 NLCD Category</th>
<th>Description</th>
<th>ID</th>
<th>1992 NLCD Summer Zo (m)</th>
<th>Fraction Applied for Non-airport</th>
<th>Fraction Applied for Airport</th>
<th>Final Zo (m) Non-airport</th>
<th>Final Zo (m) Airport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Forest</td>
<td></td>
<td>43</td>
<td>1.30</td>
<td>1.00</td>
<td>1.00</td>
<td>0.74</td>
<td>0.07</td>
</tr>
<tr>
<td>High Intensity Residential</td>
<td></td>
<td>22</td>
<td>1.00</td>
<td>0.90</td>
<td>0.10</td>
<td>0.74</td>
<td>0.07</td>
</tr>
<tr>
<td>Bare Rock/Sand/Clay</td>
<td></td>
<td>31</td>
<td>0.05</td>
<td>0.10</td>
<td>0.90</td>
<td>0.74</td>
<td>0.07</td>
</tr>
<tr>
<td>Urban/Recreational Grasses</td>
<td></td>
<td>85</td>
<td>0.02</td>
<td>1.00</td>
<td>1.00</td>
<td>0.74</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Without Imp/Can: 0.70
Future Work Needed

• Evaluation Methods

• Revive Gust Factor tool

• Consequence analysis (1992 vs 2016 NLCD) at selected NWS stations for array of source types and source characteristics to identify trends and analyze whether the trends agree with actual changes in land cover of nearly 2 decades

• Repeat/expand AERMET and AERMOD sensitivity analysis

• Development of GIS AERSURFACE equivalent