Draft AERSURFACE
v.19039_DRFT

Webinar

April 4, 2019

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

https://epawebconferencing.acms.com/daersurface/

Audio through web conference. Questions saved until the end. Will provide call-in.

Release Information

- Draft AERSURFACE, v.19039_DRFT
- Available on SCRAM beginning Friday, February 22, 2019
  - https://www.epa.gov/scram/draft-aersurface
  - Transmittal memo
  - Source code
  - Executables (32- and 64-bit, compiled with gfortran)
  - Complete User's Guide
  - Intercomparison input/output files (Appendix G of the User's Guide)
  - Spreadsheet to simulate application of impervious and tree canopy data

Changes from AERSURFACE v.13016

- Path/keyword control file (similar to AERMOD)
- Command-line arguments for standard input/output files
- Process NLCD 1992, 2001, 2006, and 2011 (GeoTIFF only)
  - ***USGS no longer providing NLCD 1992***
  - ***19039_DRFT will not process state-level "binary" 1992 NLCD files***
- Supplement land cover with percent impervious and tree canopy
- 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

Why a Draft Version?

Primarily due to uncertainty in derived surface roughness lengths

- Ambiguity in “Developed” categories 21-24, (NLCD 2001, 2006, 2011)
- No longer a category for Commercial/Industrial/Transportation
- 2001+: Developed, Open Space, Low Intensity, Medium Intensity, and High Intensity
- Uncertainty in assignment of roughness values to “Developed” categories
- Implementation of impervious and tree canopy to supplement “Developed”
- No longer a category for Urban/Recreational Grasses (areas between runways)
- Less delineation for crops (i.e., Row Crops, Small Grains, Fallow -> Cultivated Crops)

Feedback Requested

- Informal comment period through Monday, April 22, 2019
- Reference lookup tables for 2001 NLCD and later
- Implementation of the impervious and percent tree canopy data
- Implementation of research grade effective roughness method (ZOEFF)
- Methods for evaluating AERSURFACE (Databases?)
- Bug reports
- Guidance needs
- Documentation

Send feedback to:
tillerson.clint@epa.gov

Next Release

- Evaluate user feedback
- Apply revisions
- Hopeful to release final version prior to the 12th Modeling Conference tentatively scheduled for October 2019

Status for Regulatory Use

- AERSURFACE is **not** part of the regulatory AERMOD system.
- v.19039_DRFT is not a replacement for v.13016.
- There may be regulatory applications of AERMOD where an applicant wishes to use this draft version of AERSURFACE.
- Consult with the appropriate reviewing authority and the EPA Regional Office.
- AERSURFACE results should be closely inspected and considered.
- Written rationale for the results should be provided to the reviewing authority and the EPA Regional Office.

Recommended Options

When used for a regulatory application, the EPA recommends the following:

- The default method, ZORAD, for determining surface roughness length with a radius of 1 km.
- Supplement land cover with concurrent percent impervious and tree canopy data when available.
- If only impervious or tree canopy data are available, or neither is available, process land cover without impervious and canopy data.
- Land cover data should not be supplemented with impervious data only or canopy data only.

NLCD Data Sources

NLCD 1992 and State “binary” Files

Multi-Resolution Land Characteristics (MRLC) Consortium
no longer provides NLCD 1992 products
and no longer supports GeoTIFF files

NLCD 1992 State “binary” files can be downloaded from
EPA’s SCRAM website and processed with AERSURFACE v.130136

https://www.epa.gov/scram/interim-access-and-process-use-1992-nlcd-and-ned

(links to individual state files can be found at bottom of web page)

NLCD 2001, 2006, 2011

- NLCD 2001, 2006, and 2011 products as GeoTIFF files that can be input directly into AERSURFACE
  - USGS Science Base Catalogue at
    https://www.sciencebase.gov/catalog/item/4f70a43ce4b058caae3f8db3
  - USGS National Map at:
    https://viewer.nationalmap.gov/basic/
  - State-wide GeoTIFF files
  - 3 x 3-degree files GeoTIFF

NLCD 2016

2016 NLCD

Scheduled to be released this month (April 2019), per mrlc.gov.

When released, EPA will review.

If consistent with AERSURFACE, we anticipate the final AERSURFACE release will include capability to process 2016 data.

NLCD Inventory

Year	Data	Conterminous US	Alaska	Hawaii	Puerto Rico
1992*	Land Cover	✓			
2001	Land Cover	✓	✓	✓	✓
	Impervious	✓	✓	✓	✓
	Canopy	✓	✓	✓	✓
2006	Land Cover	✓			
	Impervious	✓			
	Canopy				
2011	Land Cover	✓	✓		
	Impervious	✓	✓ UG Correction		
	Canopy	✓			

* NLCD 1992 data are only available from the EPA SCRAM website as State binary files and can only be processed with AERSURFACE v.13016.

Running AERSURFACE

Sample Control File *(part 1)*

```
** Sample control file - for demonstration purposes only

CO STARTING
   TITLEONE  Sample AERSURFACE Control File
   TITLETWO  RDU - Met Tower, 2001 NLCD

** Using default options for OPTIONS keyword and parameters
   OPTIONS   PRIMARY  ZORAD

   DEBUGOPT  GRID  TIFF

   CENTERLL  35.892300   -78.781900   NAD83

   DATAFILE  NLCD2001  "RDU_2001_NLCD_LC.tif"
   DATAFILE  CNPY2001  "RDU_2001_NLCD_Can.tif"
   DATAFILE  MPRV2001  "RDU_2001_NLCD_Imp.tif"

** Use default 1 km radius
   ZORADIUS  1.0
```

Two Pathways:

- Control (CO)
- Output (OU)

Sample Control File *(part 2)*

```
   CLIMATE   AVERAGE  SNOW   NONARID

** Get monthly values for three sectors
** Vary AP/Non-AP sectors
   FREQ_SECT   MONTHLY    3  VARYAP

**         index  start    end
   SECTOR   1    30.00   60.00   NONAP
   SECTOR   2    60.00  225.00   AP
   SECTOR   3   225.00   30.00   NONAP

** Reassign months with continuous snow cover in January
   SEASON   WINTERNS   12 2 3
   SEASON   WINTERWS   1
   SEASON   SPRING     4 5
   SEASON   SUMMER     6 7 8
   SEASON   AUTUMN     9 10 11

   RUNORNOT  RUN
CO FINISHED

OU STARTING
   SFCCHAR    "rdu_2001_lc_can_imp_zorad_sfc.txt"
   NLCDGRID   "rdu_2001_lc_can_imp_zorad_lc_grid.txt"
   CNPYGRID   "rdu_2001_lc_can_imp_zorad_can_grid.txt"
   MPRVGRID   "rdu_2001_lc_can_imp_zorad_imp_grid.txt"
OU FINISHED
```

Sample Control File *(part 1)*

OPTIONS keyword is optional. Defaults to **PRIMARY** and **ZORAD** if omitted

```
** Sample control file - for demonstration purposes only

CO STARTING
   TITLEONE  Sample AERSURFACE Control File
   TITLETWO  RDU - Met Tower, 2001 NLCD

** Using default options for OPTIONS keyword and parameters
   OPTIONS   PRIMARY  ZORAD

   DEBUGOPT  GRID  TIFF

   CENTERLL  35.892300   -78.781900   NAD83

   DATAFILE  NLCD2001  "RDU_2001_NLCD_LC.tif"
   DATAFILE  CNPY2001  "RDU_2001_NLCD_Can.tif"
   DATAFILE  MPRV2001  "RDU_2001_NLCD_Imp.tif"

** Use default 1 km radius
   ZORADIUS  1.0
```

PRIMARY or SECONDARY
ZORAD or ZOEFF

EFFRAD and/or GRID and/or TIFF and/or ALL

NLCD1992
NLCD2001
NLCD2006
NLCD2011
MPRV2001
MPRV2006
MPRV2011
CNPY2001
CNPY2006
CNPY2011

ZORADIUS is optional and only applies to **ZORAD** option. Radius value will default to 1.0 km if **ZORADIUS** is omitted

DEBUGOPT is optional. No debug files will be created if omitted

Sample Control File *(part 2)*

```
   CLIMATE    AVERAGE   SNOW    NONARID

** Get monthly values for three sectors
** Vary AP/Non-AP sectors
   FREQ_SECT    MONTHLY     3  VARYAP

**          index   start     end
   SECTOR     1     30.00    60.00   NONAP
   SECTOR     2     60.00   225.00   AP
   SECTOR     3    225.00    30.00   NONAP

** Reassign months with continuous snow cover in January
   SEASON    WINTERNS    12 2 3
   SEASON    WINTERWS    1
   SEASON    SPRING      4 5
   SEASON    SUMMER      6 7 8
   SEASON    AUTUMN      9 10 11

   RUNORNOT   RUN
CO FINISHED

OU STARTING
   SFCCHAR     "rdu_2001_lc_can_imp_zorad_sfc.txt"
   NLCDGRID    "rdu_2001_lc_can_imp_zorad_lc_grid.txt"
   CNPYGRID    "rdu_2001_lc_can_imp_zorad_can_grid.txt"
   MPRVGRID    "rdu_2001_lc_can_imp_zorad_imp_grid.txt"
OU FINISHED
```

```
AVERAGE   SNOW     NONARID
WET       NOSNOW   ARID
DRY
```

CLIMATE keyword is optional. If omitted, defaults to **AVERAGE**, **NOSNOW**, and **NONARID**

```
AP
NONAP
VARYAP
```

Only applicable for **VARYAP** keyword

Only applicable when **FREQ_SECT** is **MONTHLY** or **ANNUAL**. For **SEASONAL** or if omitted, assignments default to:

```
WINTERNS 12   1   2
SPRING    3   4   5
SUMMER    6   7   8
AUTUMN    9   10  11
```

Output pathway is optional as are individual keywords. Default filenames will be used if pathway or keyword is omitted.

Run AERSURFACE at Command Prompt

- 4 options for entering command-line arguments when running AERSURFACE

```
C:\working_directory> "path-to-exe\aersurface"

C:\working_directory> "path-to-exe\aersurface"  "path/control_file"

C:\working_directory> "path-to-exe\aersurface"  "path/control_file"  "path/summary_file"

C:\working_directory> "path-to-exe\aersurface" "path/control_file"  "path/summary_file"  "path/log_file"
```

- AERSURFACE assumes control filename is "aersurface.inp" when control input file **is not** specified on command-line
- Summary and log output files are given default names when control file **is not** specified on command-line
- Summary and/or log output files are given control file base name when control file **is** specified on command-line and summary and/or log file **are not** specified

Output Files

Category	Type	OU Keyword	Default Filename	Description
Standard (auto-generated)	Summary	*Command-line*	*aersurface.out*	Replicates control file, errors and warnings, successful or unsuccessful completion.
	Log	*Command-line*	*aersurface.log*	Processing and datafile details (spatial resolution, georeference info, file organization, land cover category counts).
	Surface Values	SFCCHAR	*sfc_chars.out*	AERSURFACE derived surface values.
Debug (optional)	Effective Radius	EFFRAD	*effective_rad.txt*	Only applicable with ZOEFF option. Summary of calculated fetch by sector and month.
	TIFF Debug	NLCDTIFF MPRVTIFF CNPYTIFF	*lc_tif_dbg.txt* *imp_tif_dbg.txt* *can_tif_dbg.txt*	Record of TIFF tag and GeoKey values encoded in GeoTIFF file.
	GRID Files	NLCDGRID MPRVGRID CNPYGRID	*landcover.txt* *impervious.txt* *canopy.txt*	Grid of values extracted from GeoTIFF file with georeferencing information.

Challenges with Land Cover Changes

Challenges with Land Cover Changes

1992	2001 - 2011
11. Open Water	11. Open Water
12. Perennial Ice/Snow	12. Perennial Ice/Snow
21. Low Intensity Residential	21. Developed, Open Space
22. High Intensity Residential	22. Developed, Low Intensity
23. Commercial/Industrial/Transportation	23. Developed, Medium Intensity
31. Bare/Rock/Sand/Clay	24. Developed, High Intensity
32. Quarries/Strip Mines/Gravel Pits	31. Rock/Sand/Clay
33. Transitional	41. Deciduous Forest
41. Deciduous Forest	42. Evergreen Forest
42. Evergreen Forest	43. Mixed Forest
43. Mixed Forest	51. Dwarf Scrub
51. Shrubland	52. Shrub/Scrub
61. Orchards/Vineyards/Other	71. Grassland/Herbaceous
71. Grassland/Herbaceous	72. Sedge/Herbaceous
81. Pasture/Hay	73. Lichens
82. Row Crops	74. Moss
83. Small Grains	81. Pasture/Hay
84. Fallow	82. Cultivated Crops
85. Urban/Recreational Grasses	90. Woody Wetlands
91. Woody Wetlands	95. Emergent Herbaceous Wetlands
92. Emergent Herbaceous Wetlands	

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

2001-2011

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:

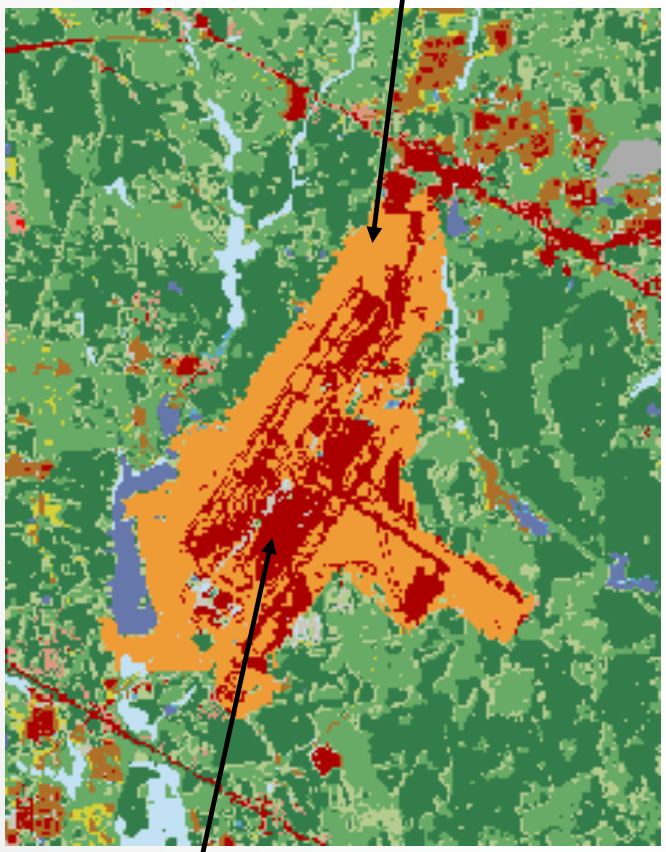
- Mix of constructed materials and vegetation.
- 50% to 79% impervious surfaces.
- Single-family housing units.

Developed, High Intensity :

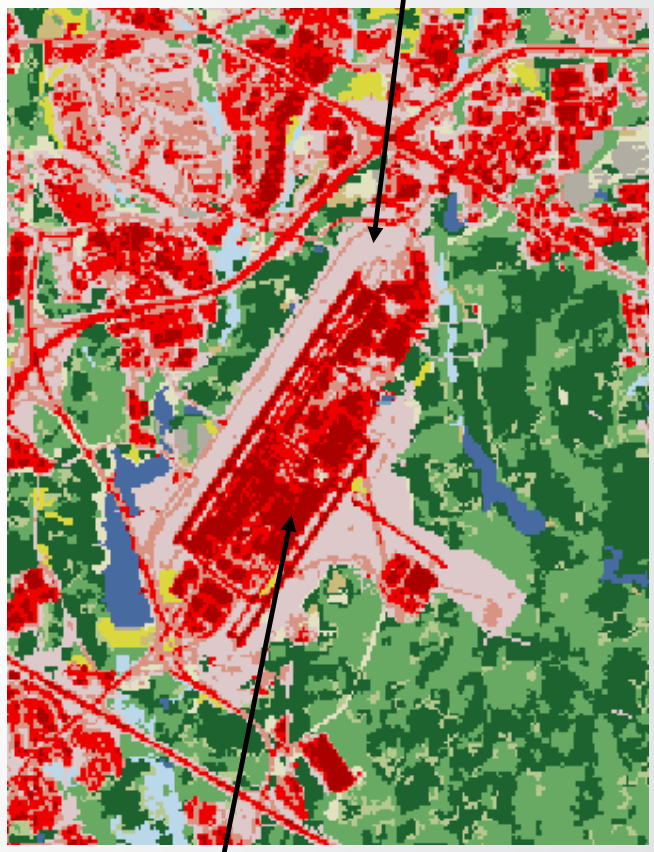
- Highly developed, where people live or work
- 80% to 100% impervious surfaces.
- Apartment complexes, row houses, **commercial/industrial**

Challenges with Land Cover Changes

1992 - RDU



2011 - RDU



Airport vs Non-airport Sectors

Airport/Non-airport Sectors

- Specify wind sectors individually as airport or non-airport
- Characterize based on land use within the sector rather than whether or not met tower is physically located at an airport
- Affects roughness lookup values for:
  - 1992 Comm/Trans/Industrial (23)
  - 2001-2011 Developed (21-24), Pasture Hay (81), and Cultivated Crops (82)
- Must use VARYAP secondary keyword with FREQ_SECT keyword
- Must specify individual sectors as AP or NONAP

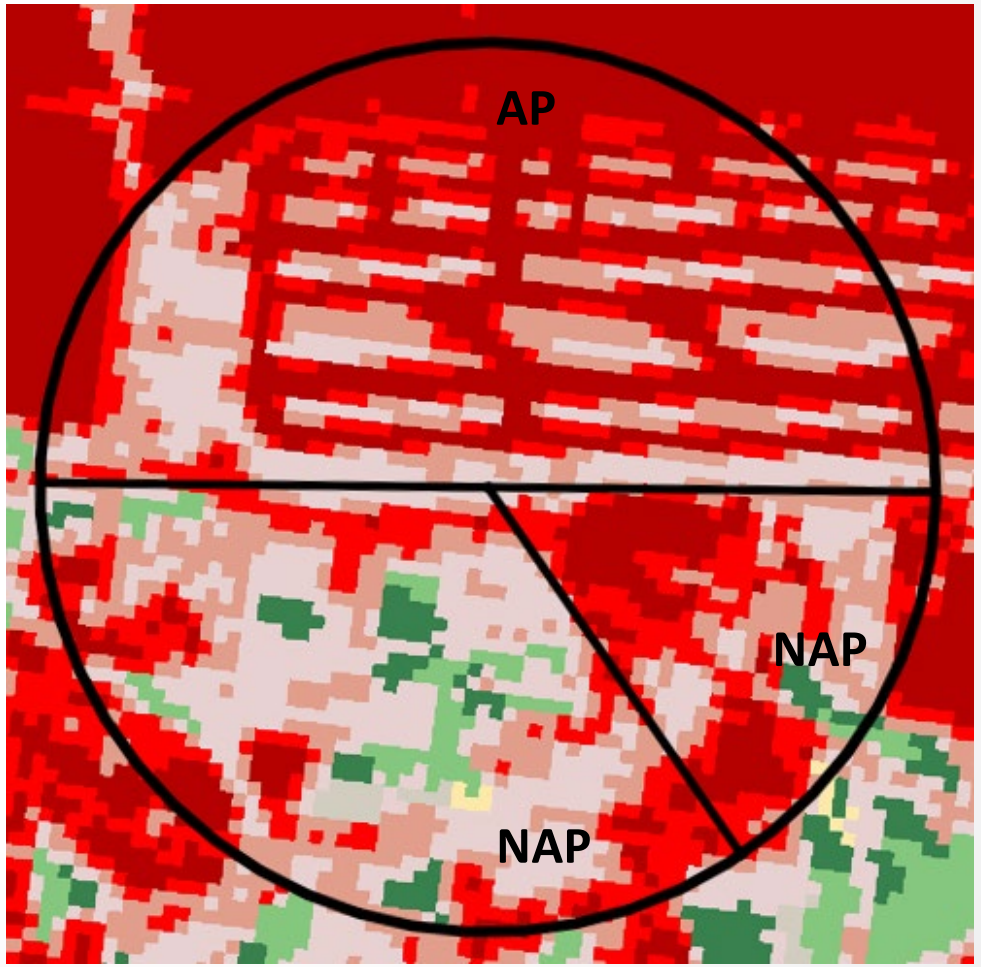
Airport/Non-airport Sectors (2001-2011)

Land Use - Considerations	Characterization
Developed – Open Space (21) Predominantly grass and impervious areas primarily paved areas	**Airport**
Developed – Open Space (21) Park and/or residential area	**Non-airport**
Developed – Low, Medium, High Intensity (22-24) Impervious areas are predominantly flat paved or unpaved surfaces (e.g. runways, parking lots, roads)	**Airport**
Developed – Low, Medium, High Intensity (22-24) Impervious areas are predominantly buildings/structures (e.g. airport terminal, commercial structures, residential)	**Non-airport**
Pasture/Hay (81) Pastures for grazing – short/low growing grasses	**Airport**
Pasture/Hay (81) Seed or hay crops	**Non-airport**
Cultivated Crops (82) Short crops	**Airport**
Cultivated Crops (82) Tall crops, vineyards, orchards	**Non-airport**

ATL Sectors (2001)

Google Earth 2/27/2002

NLCD 2001 Land Cover



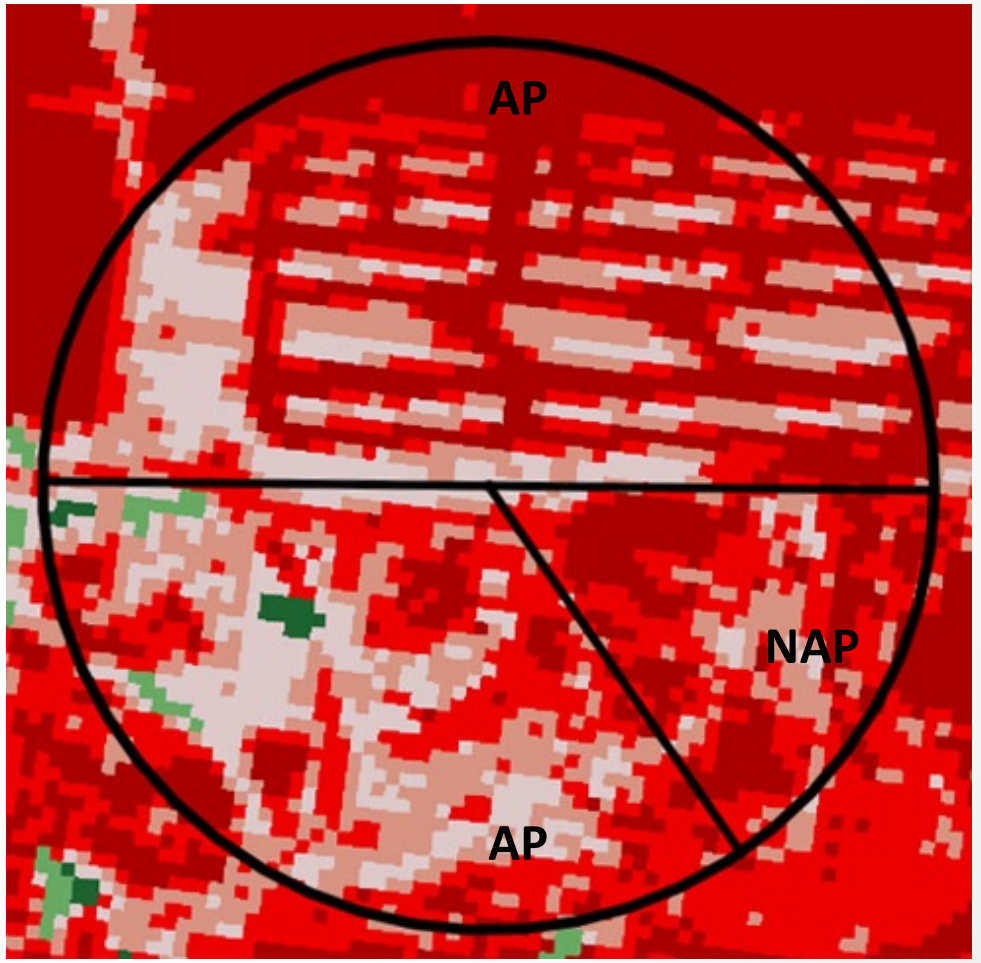
- 11 Open Water
- 12 Perennial Ice/ Snow
- 21 Developed, Open Space
- 22 Developed, Low Intensity
- 23 Developed, Medium Intensity
- 24 Developed, High Intensity
- 31 Barren Land (Rock/Sand/Clay)
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Dwarf Scrub*
- 52 Shrub/Scrub
- 71 Grassland/Herbaceous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

* Alaska only

ATL Sectors (2011)

Google Earth 10/16/2011

NLCD 2011 Land Cover



- 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

% Impervious and % Tree Canopy Implementation

% Impervious and % Tree Canopy

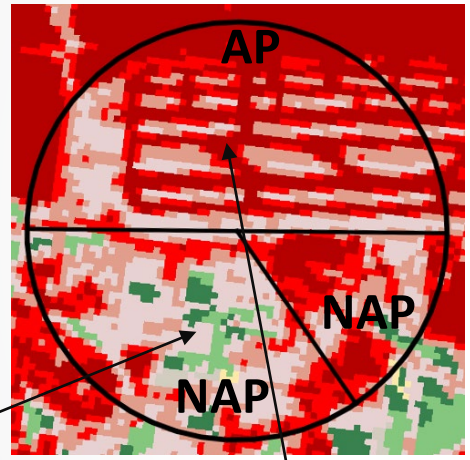
Google Earth
2/27/2002

NLCD 2001
Land Cover

ATL

NLCD 2001
% Impervious

NLCD 2001
% Canopy



- 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)
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- 74 Moss*
- 81 Pasture/Hay
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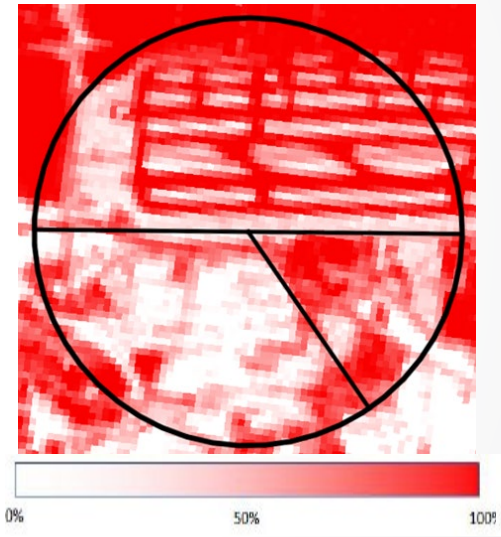
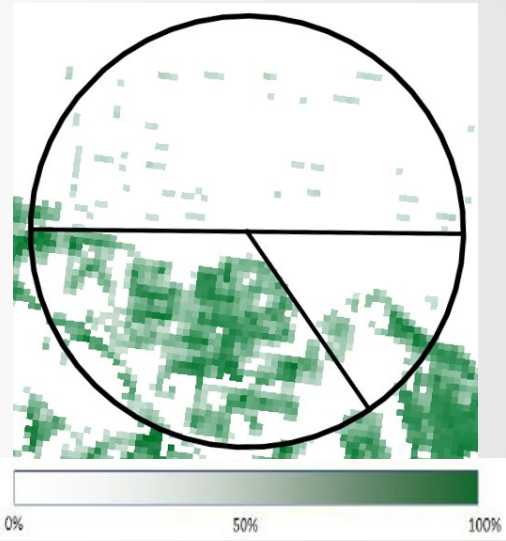
* Alaska only





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

- Developed, High Intensity
- 100% Impervious
- 0% Tree Canopy

% Impervious and % Tree Canopy

- Developed categories (21-24) are recategorized based on a mix of NLCD 1992 categories:
  - High Intensity Residential (22)
  - Bare Rock/Sand/Clay (31)
  - Mixed Forest (43)
  - Urban/Recreational Grasses (85)
- Airport: 90% of the impervious area is assumed Bare Rock/Sand/Clay, 10% assumed High Intensity Residential
- Non-airport: 90% impervious area is assumed High Intensity Residential, 10% assumed Bare Rock/Sand/Clay
- Mixed Forest is weighted by % canopy
- Urban/Recreational Grasses is weighted by percent that is neither impervious or canopy

% Impervious and % Tree Canopy

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

Land Cover Supplemented with Impervious and Canopy Data?

No → Use AERSURFACE Roughness Table

Yes ↓

Airport Sector?

No → Recategorize as Combination of:

- Mixed Forest (43) x %Canopy/100
- 90%: 1992 High Intensity Residential (22) x %Impervious/100
- 10%: Bare Rock/Sand/Clay (31) x %Impervious/100
- 1992 Urban Recreational Grasses (85) x (1.0 – %Canopy/100– %Impervious/100)

Ex. Developed-Medium Intensity (23): *summer, 60% impervious, 10% canopy*

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

Yes ↓

Recategorize as Combination of:

- Mixed Forest (43) x %Canopy/100
- 10%: 1992 High Intensity Residential (22) x %Impervious/100
- 90%: Bare Rock/Sand/Clay (31) x %Impervious/100
- 1992 Urban Recreational Grasses (85) x (1.0 – %Canopy/100– %Impervious/100)

Ex. Developed-Medium Intensity (23): *summer, 60% impervious, 10% canopy*

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

% Impervious and % Tree Canopy

Developed, Open Space :: 1% Impervious :: 94% Canopy

% Impervious	1
% Canopy	94

1992 NLCD Category Description	1992 NLCD Category ID	1992 NLCD Summer Zo (m)	Fraction Applied for Non-airport	Fraction Applied for Airport	Final Zo (m) Non-airport	Final Zo (m) Airport
Mixed Forest	43	1.30	1.00	1.00	1.05	1.02
High Intensity Residential	22	1.00	0.90	0.10		
Bare Rock/Sand/Clay	31	0.05	0.10	0.90		
Urban/Recreational Grasses	85	0.02	1.00	1.00		
				Without Imp/Can	0.03	0.03

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

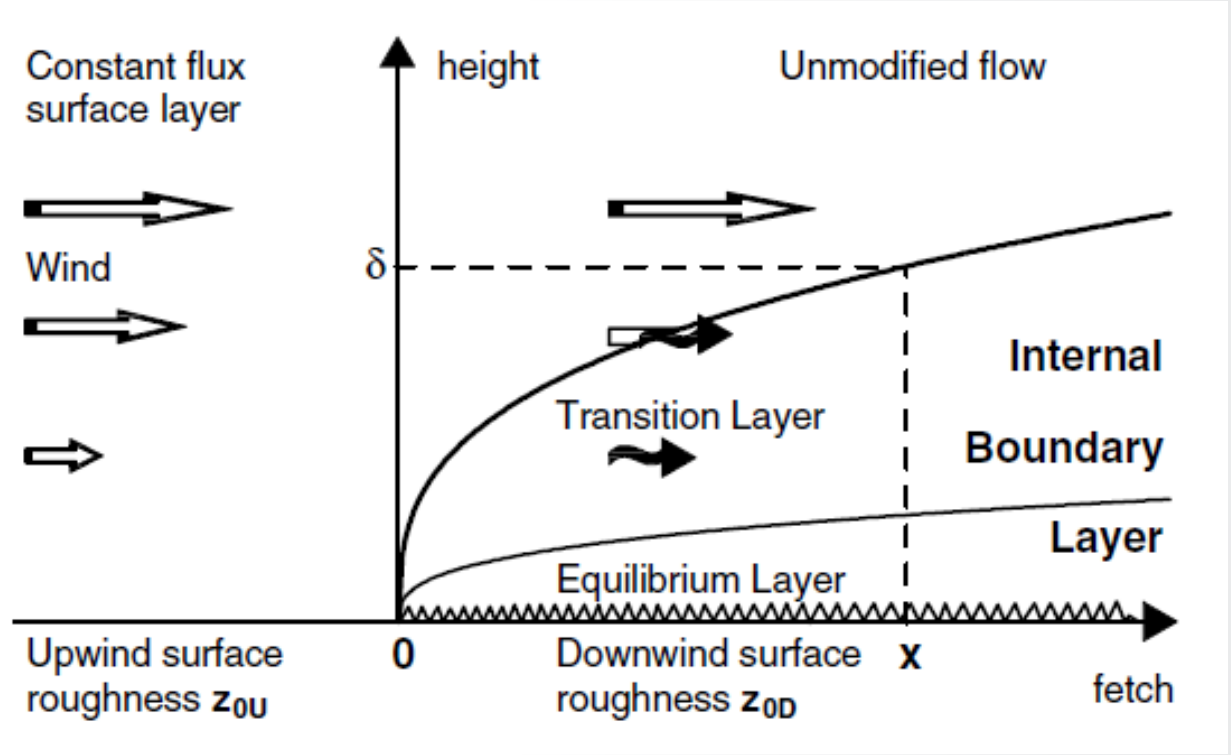
% Impervious	100
% Canopy	0

1992 NLCD Category Description	1992 NLCD Category ID	1992 NLCD Summer Zo (m)	Fraction Applied for Non-airport	Fraction Applied for Airport	Final Zo (m) Non-airport	Final Zo (m) Airport
Mixed Forest	43	1.30	1.00	1.00	0.74	0.07
High Intensity Residential	22	1.00	0.90	0.10		
Bare Rock/Sand/Clay	31	0.05	0.10	0.90		
Urban/Recreational Grasses	85	0.02	1.00	1.00		
				Without Imp/Can	0.70	0.08

Research Grade ZOEFF for Effective Roughness Length

ZOEFF Effective Roughness Method

Estimate roughness as a function of the growth of the internal boundary layer (IBL) as surface roughness elements are encountered by air flow toward the met tower.



Sergiy, A. S. and Tayler P. A. (2005). Internal Boundary Layers: I. Height Formulae for Neutral and Diabatic Flows. *Boundary-Layer Meteorology*, 115:1-25.

ZOEFF Option – Control File Sample

```
CO STARTING
   TITLEONE  Sample AERSURFACE Control File
   TITLETWO  RDU - Met Tower, 2001 NLCD

   OPTIONS   PRIMARY  ZOEFF

   DEBUGOPT  EFFRAD

   ANEM_HGT  10.1  6.0
   .
   .
   .
CO FINISHED

OU STARTING
   SFCCHAR   "RDU_2001_Sfc_Chars.txt"
   EFFRAD    "RDU_2001_Eff_Radius.txt"
OU FINISHED
```

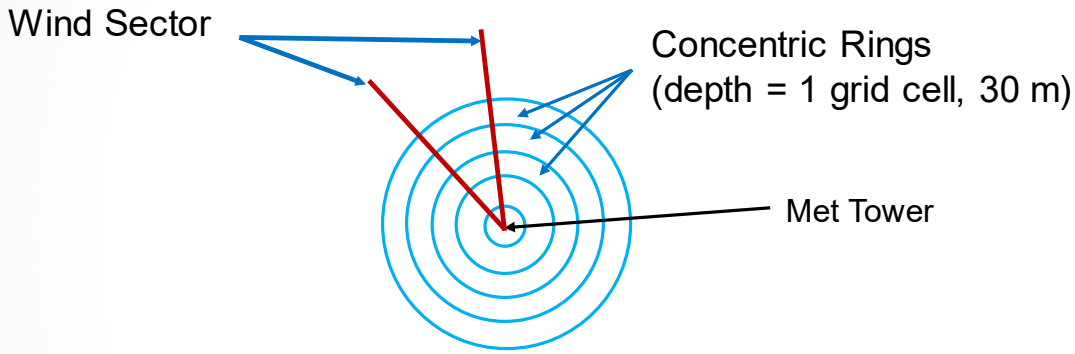
ANEM_HGT = Anemometer Height
Only applicable with the ZOEFF option.

IBL Factor, default = 6.0
Multiplied by anemometer height to get target IBL growth height

Anemometer height (m)

ZOEFF Option - Implementation

1. Construct concentric rings around the tower



2. Compute the “average” roughness for each ring segment within each wind sector *(inverse-distance weighted geometric mean)*
3. Iterative process to determine upwind distance (fetch) required to grow IBL to a target IBL height at tower (based on height of wind measurements) from cumulative growth increments across ring segments
4. Compute effective roughness length over derived fetch

Derived Fetch and Roughness - RDU

** Non-Airport Sector IDs: 1 3

Roughness (m) by Month and Sector **ZORAD**

(Roughness Fetch (m) = 1000.0)

Sector	Start Dir	Month 1	2	3	4	5	6	7	8	9	10	11	12
1	30.0	0.018	0.018	0.026	0.026	0.026	0.033	0.033	0.033	0.026	0.026	0.026	0.018
2	60.0	0.027	0.027	0.033	0.033	0.033	0.038	0.038	0.038	0.033	0.033	0.033	0.027
3	225.0	0.144	0.144	0.186	0.186	0.186	0.217	0.217	0.217	0.195	0.195	0.195	0.144

Roughness (m) by Month and Sector **ZOEFF**

Sector	Start Dir	Month 1	2	3	4	5	6	7	8	9	10	11	12
1	30.0	0.018	0.018	0.024	0.024	0.024	0.030	0.030	0.030	0.024	0.024	0.024	0.018
2	60.0	0.024	0.024	0.029	0.029	0.029	0.034	0.034	0.034	0.029	0.029	0.029	0.024
3	225.0	0.125	0.125	0.153	0.153	0.153	0.173	0.173	0.173	0.158	0.158	0.158	0.125

Roughness Fetch (m) by Month and Sector

Sector	Start Dir	Month 1	2	3	4	5	6	7	8	9	10	11	12
1	30.0	1069.5	1069.5	1023.2	1023.2	1023.2	991.0	991.0	991.0	1022.9	1022.9	1022.9	1069.5
2	60.0	1021.3	1021.3	993.6	993.6	993.6	973.3	973.3	973.3	993.5	993.5	993.5	1021.3
3	225.0	776.2	776.2	746.3	746.3	746.3	727.4	727.4	727.4	741.2	741.2	741.2	776.2

Average Roughness Fetch (m) = 923.3

Questions?

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