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
  - Defining Roughness Sectors
  - Assigning Airport/Non-airport Flags to Sectors
  - % Impervious and % Tree Canopy Implementation
- Future Work

Release Information

- AERSURFACE, v.20060
- Available on SCRAM beginning Tuesday, April 7, 2020
  - https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs#aersurface
  - Transmittal memo
  - Source code
  - Executables (32- and 64-bit, compiled with gfortran)
  - User's Guide
  - Spreadsheet to simulate application of impervious and tree canopy data

Status for Regulatory Use

- 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

Recommended Options

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

NLCD Data Sources for AERSURFACE

- **Multi-Resolution Land Characteristics (MRLC) Consortium**
  - The MRLC website should be the primary source for most recent NLCD products and documentation (https://www.mrlc.gov/)
  - GeoTIFFs compatible with AERSURFACE available via MRLC Viewer https://www.mrlc.gov/viewer/
  - Instructions posted on SCRAM at https://www3.epa.gov/ttn/scram/models/aermod/aersurface/NLCD_Sources_for_AERSURFACE_v20060.pdf

MRLC Inventory

Year	Data	Conterminous US	Alaska*	Hawaii	Puerto Rico
2001	Land Cover	✓	✓	✓	✓
	Impervious	✓	✓	✓	✓
	Canopy				
2006	Land Cover	✓			
	Impervious	✓			
	Canopy				
2011	Land Cover	✓	✓		
	Impervious	✓	✓		
	Canopy	✓	✓	✓	✓
2016	Land Cover	✓	✓		
	Impervious	✓	✓		
	Canopy	✓	✓	✓	✓

* *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**
  - 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/.
  - Converted from national ERDAS IMAGINE (IMG) files downloaded from MRLC website
  - 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
  - File boundaries overlap state boundaries to minimize issues at shared state boundaries

EPA FTP Server Inventory

Base Directory: ftp://newftp.epa.gov/aqmg/nlcd/	
Subdirectory	**Description**
1992/	1992 NLCD, partial/multi-state coverage
2001/	2001 NLCD, updated with 2016 NLCD release, partial/multi-state coverage
2001_2011ed/	2001 NLCD (2011 edition), single state and 3x3 degree coverage
2006/	2006 NLCD, updated with 2016 NLCD release, partial/multi-state coverage
2011/	2011 NLCD, updated with 2016 NLCD release, partial/multi-state coverage
2016/	2016 NLCD, partial/multi-state coverage
region_state_jpg/	JPEG image files illustrating coverage of partial/multi-state GeoTIFFs

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

PRIMARY and SECONDARY Met Sites

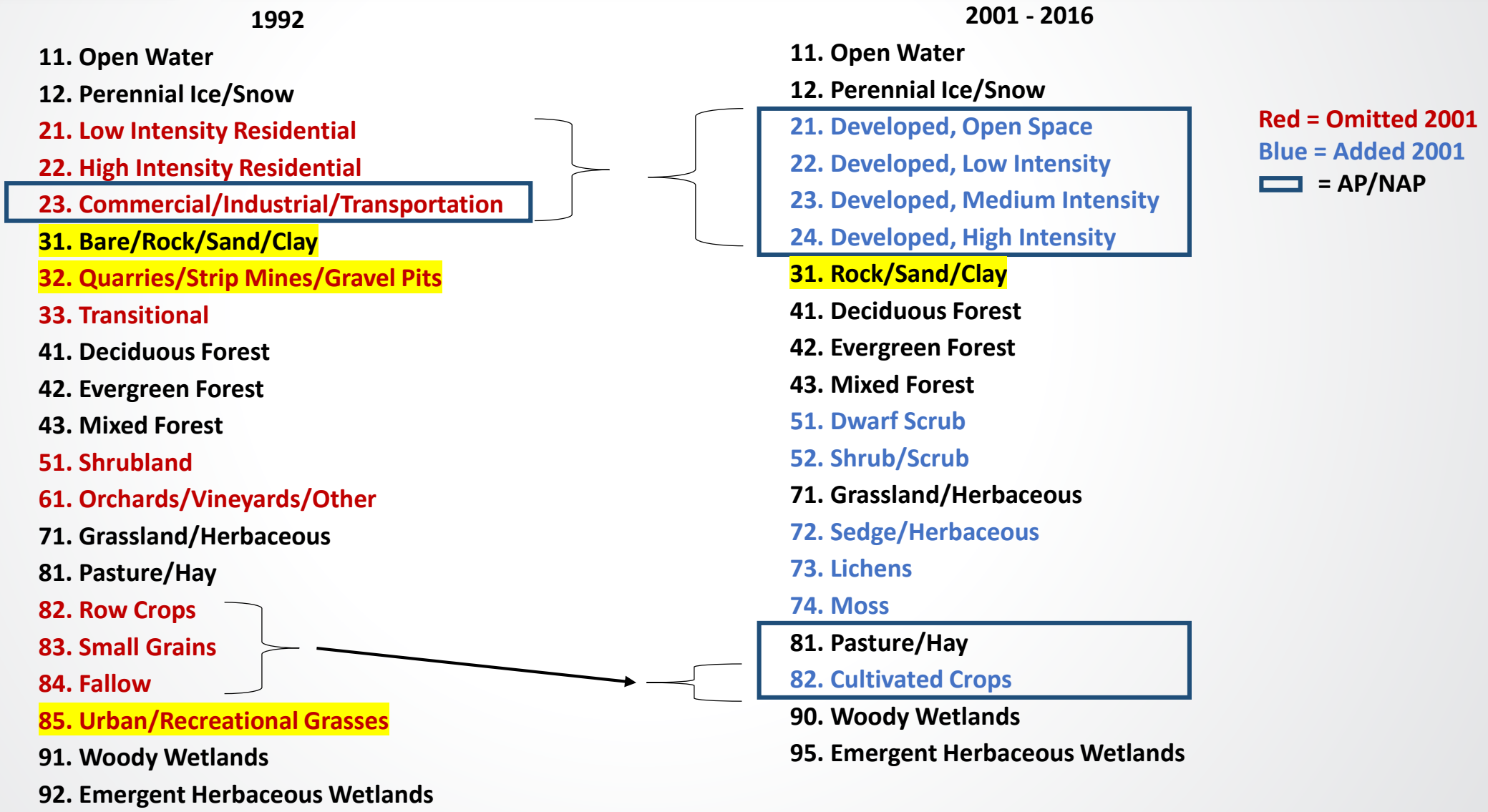
- AERMET requires two sets of surface characteristics when utilizing both surface meteorological data collected from a site-specific tower an NWS/FAA station (i.e., airport).
- Similar but different keywords in the AERMET control file identify the surface characteristics as either the PRIMARY or SECONDARY
- 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



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

Subdivision
Apartments
Metro area
Parking lot

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:

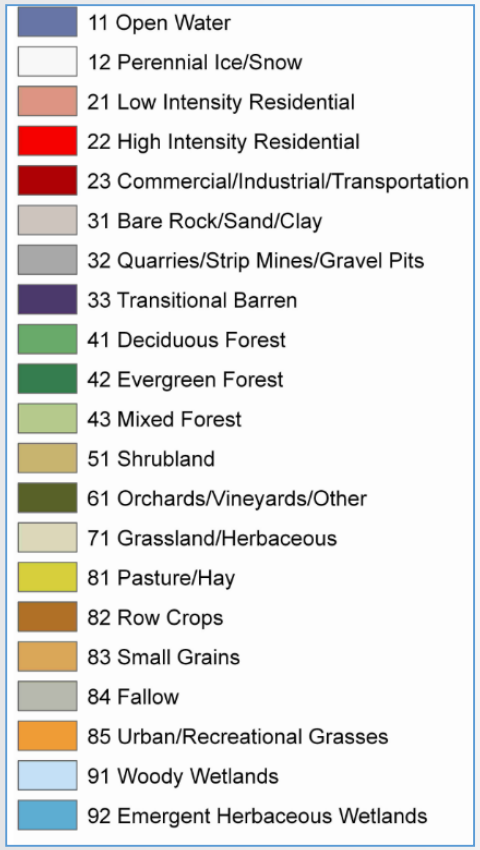
- Mix of constructed materials and vegetation.
- 50% to 79% impervious surfaces.
- Single-family housing units.

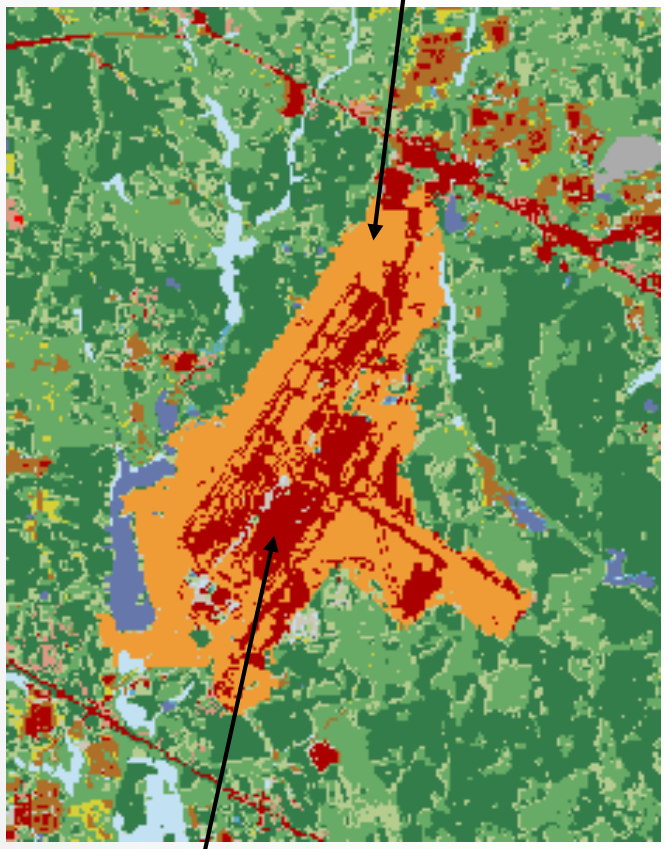
Developed, High Intensity :

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

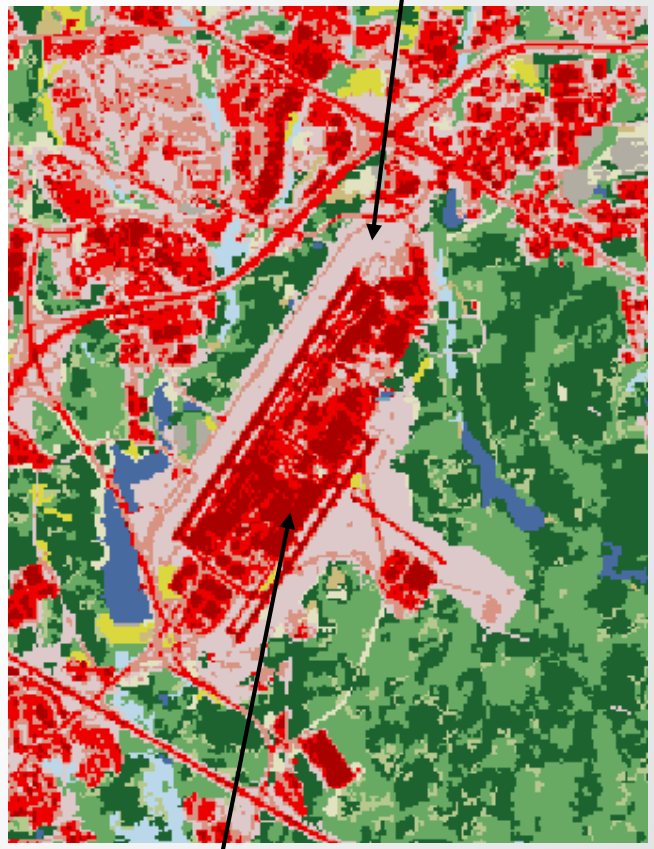
Challenges with Land Cover Changes

1992 - RDU



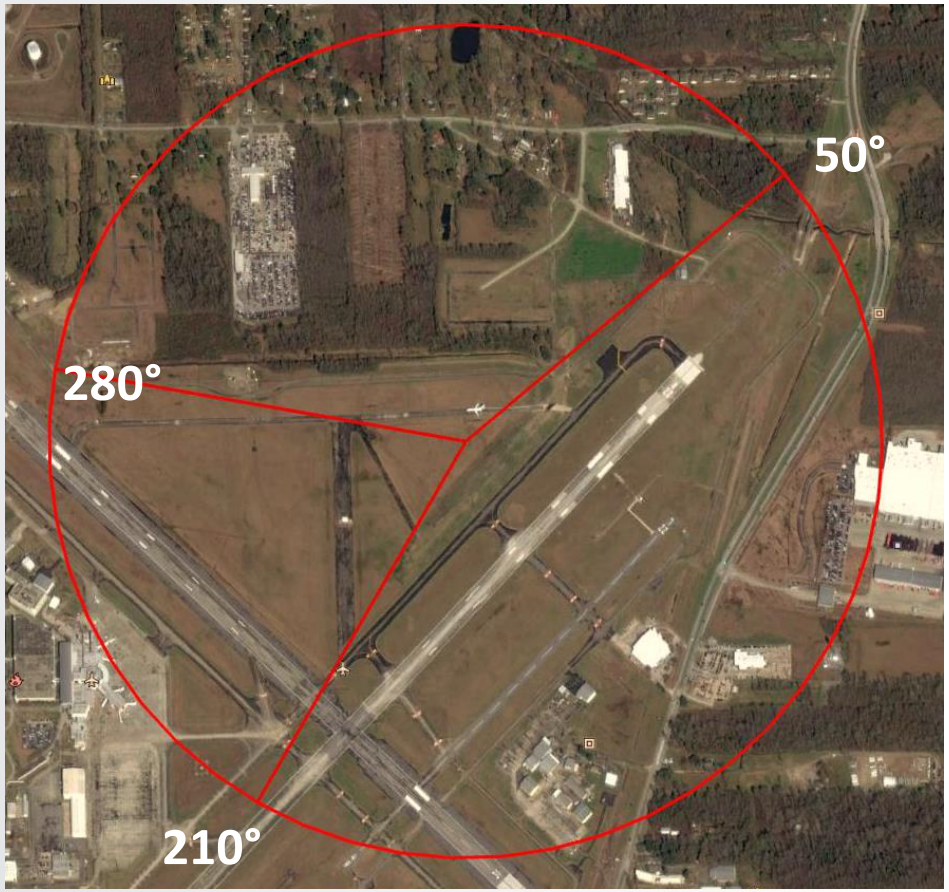


2011 - RDU

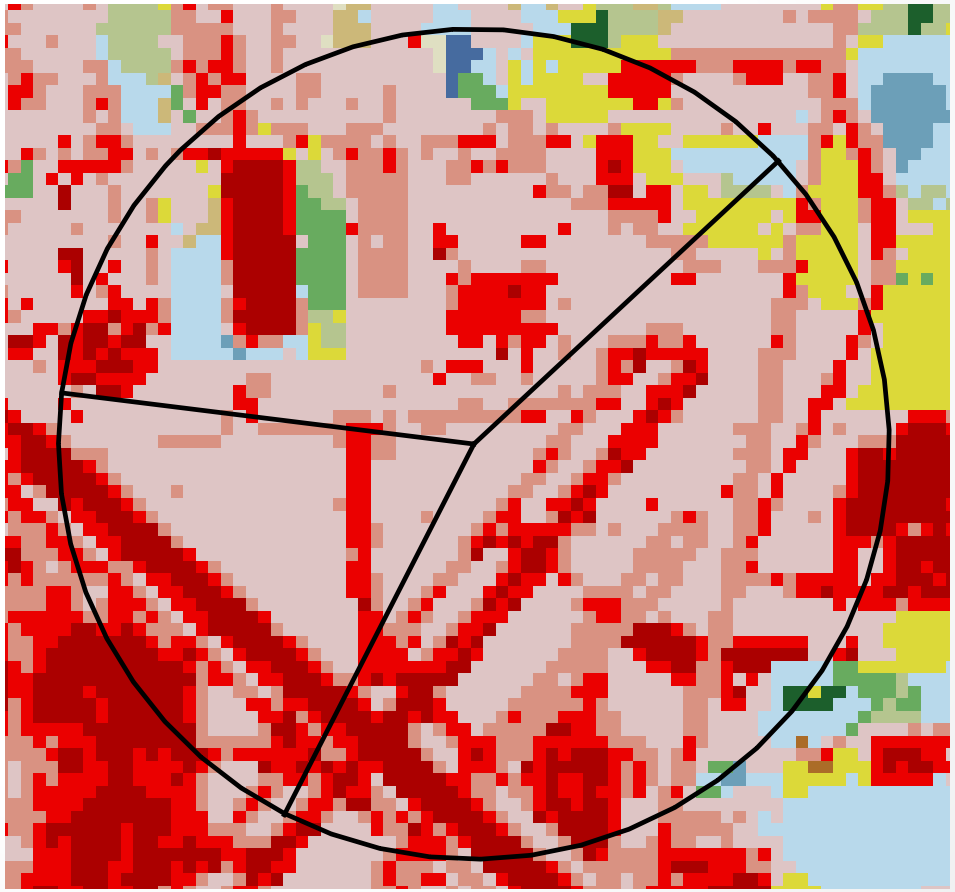


Defining Roughness Sectors - BTR

1/20/2016



NLCD 2016



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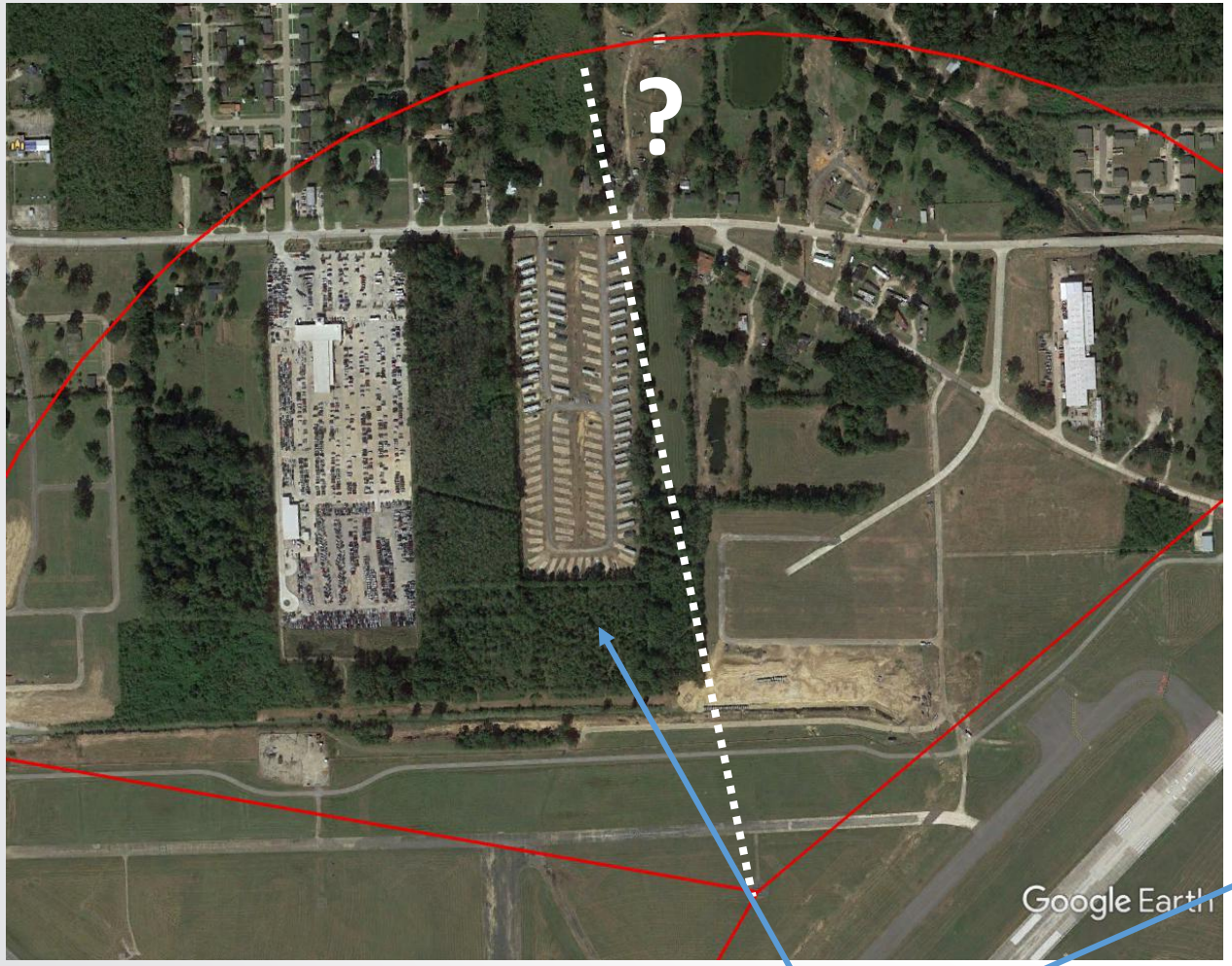
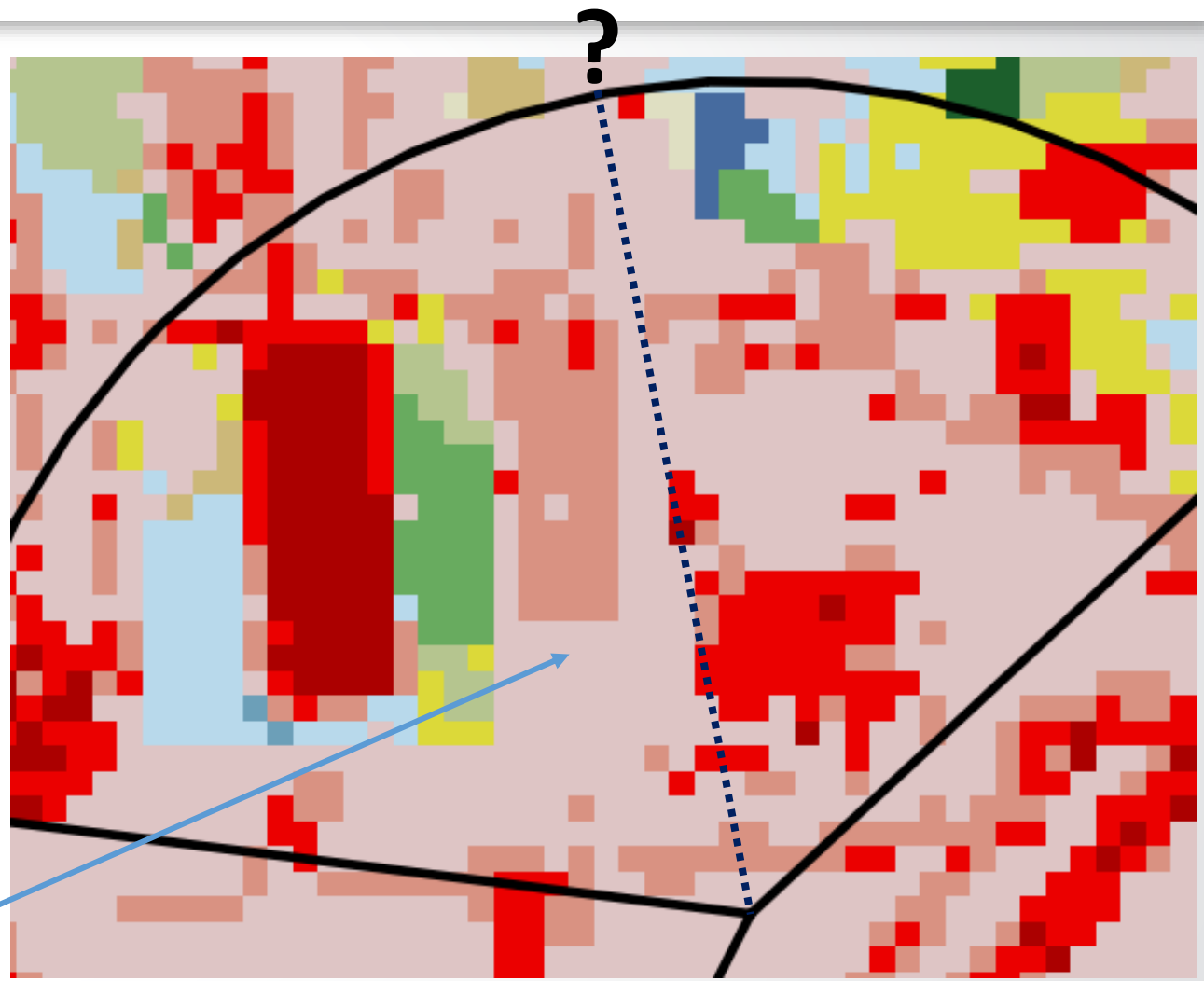
* Alaska only

Defining Roughness Sectors - BTR

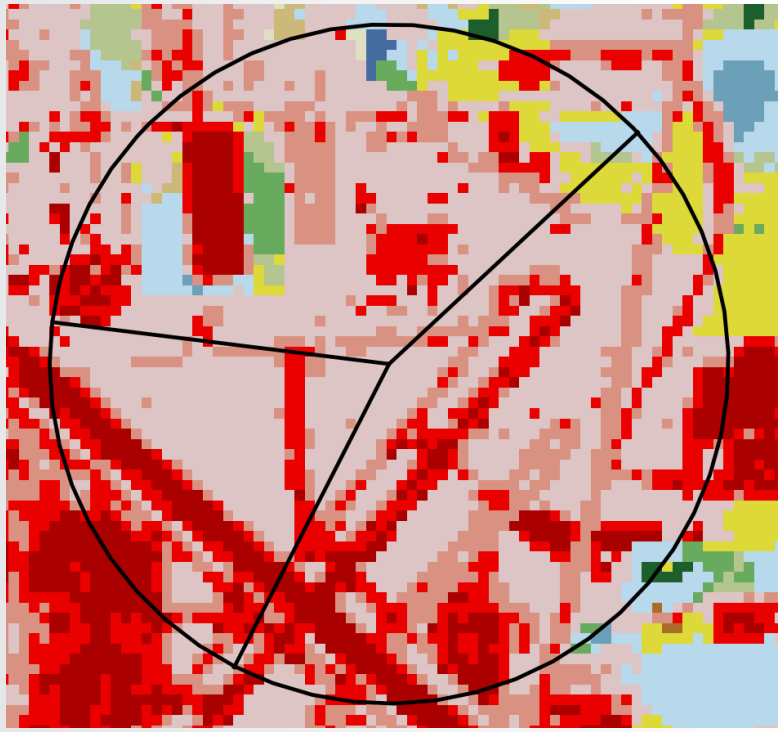




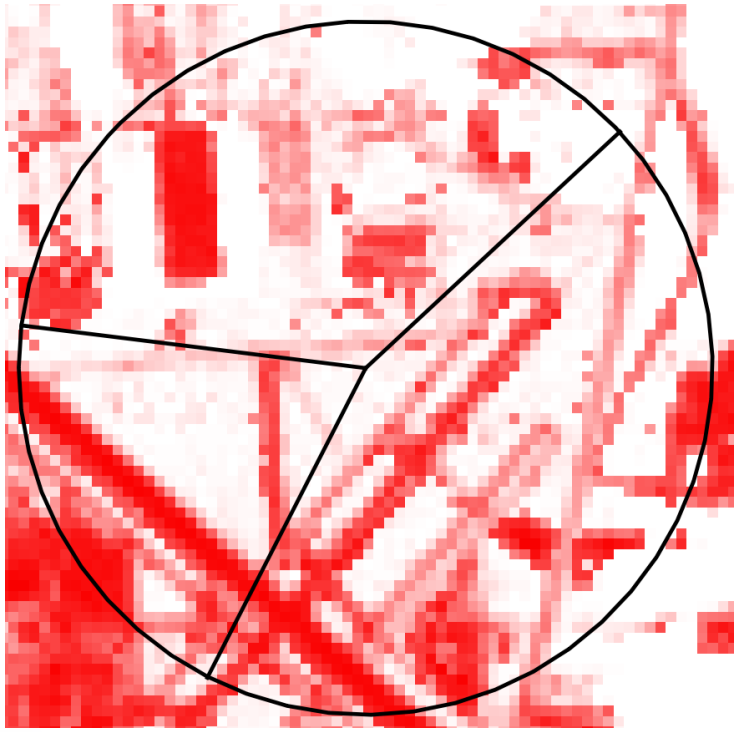
Developed – Open Space :: 7% Impervious :: 90% Tree Canopy

Defining Roughness Sectors - BTR

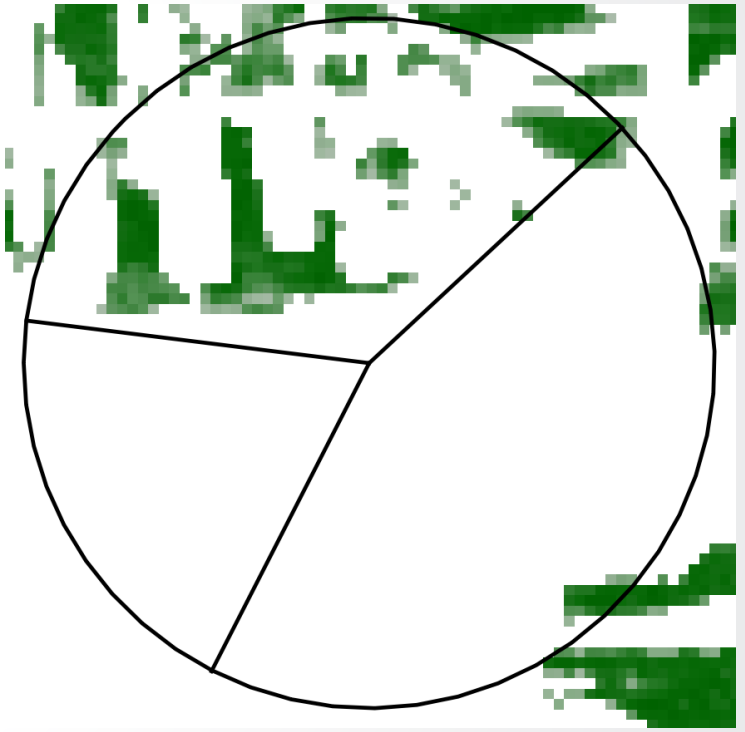
NLCD 2016



% 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)

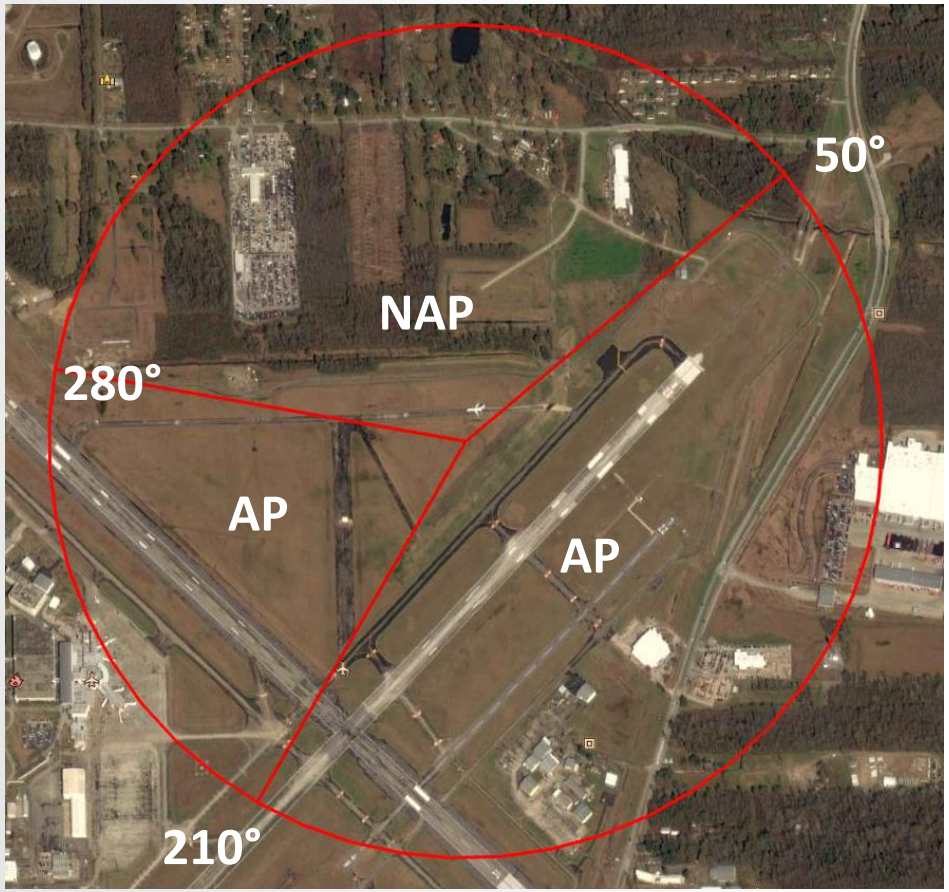
Land Use - Considerations	Characterization	Surface Roughness (m) by Season*				
		1	2	3	4	5
Developed – Open Space (21) Predominantly grass and impervious areas primarily paved areas	Airport	0.02	0.01	0.02	0.03	0.03
Developed – Open Space (21) Park with mix of trees, grass, and buildings, and/or residential area	Non-airport	.02	0.01	0.03	0.04	0.03
Developed – Low, Medium, High Intensity (22-24) Impervious areas are predominantly flat paved or unpaved surfaces (e.g. runways, parking lots, roads)	Airport	0.03-0.07	0.02-0.07	0.03-0.07	0.04-0.08	0.03-0.08
Developed – Low, Medium, High Intensity (22-24) Impervious areas substantial mix of buildings/structures and paved areas (e.g. airport terminal, commercial structures, residential)	Non-airport	0.07-0.70	0.05-0.70	0.09-0.70	0.1-0.70	0.09-0.70
Pasture/Hay (81) Pastures for grazing – short/low growing grasses	Airport	0.02	0.01	0.02	0.03	0.03
Pasture/Hay (81) Seed or hay crops	Non-airport	0.02	0.01	0.03	0.15	0.15
Cultivated Crops (82) Short crops	Airport	0.02	0.01	0.02	0.03	0.03
Cultivated Crops (82) Tall crops, vineyards, orchards	Non-airport	0.03	0.014	0.04	0.20	0.20

** 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*

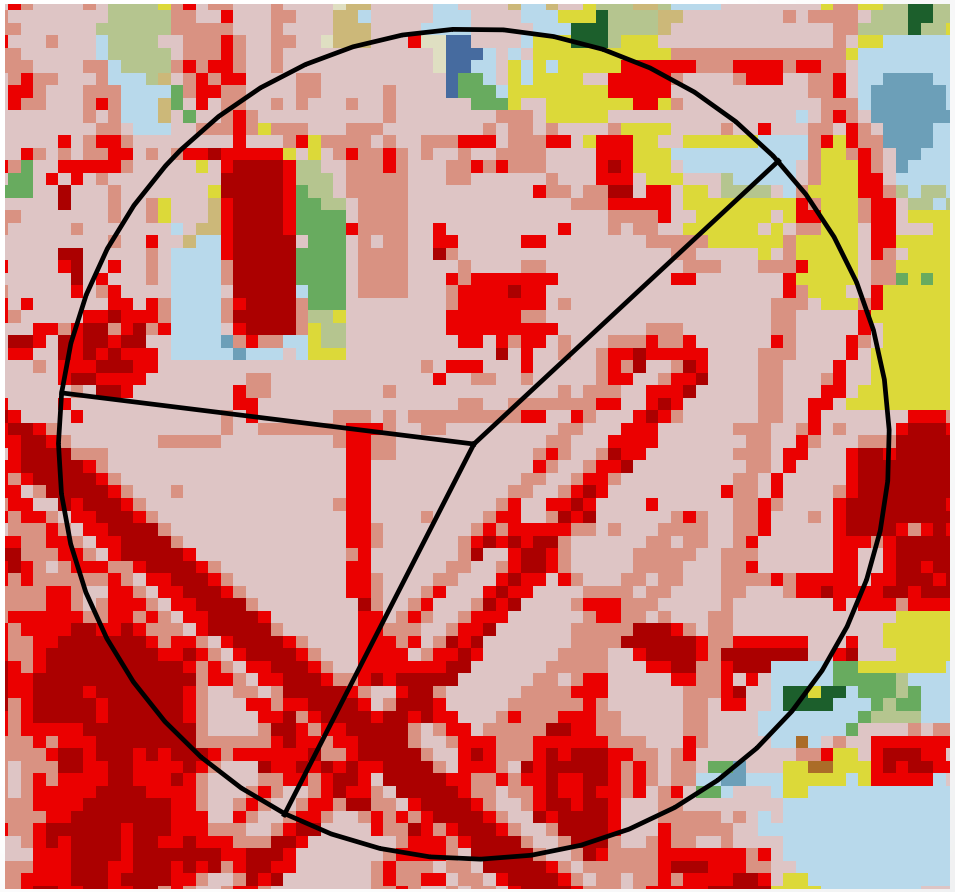
Developed Categories: Reported roughness values are only applied to Developed categories when % impervious and % tree canopy are excluded from processing.

Airport/Non-airport - BTR

1/20/2016



NLCD 2016



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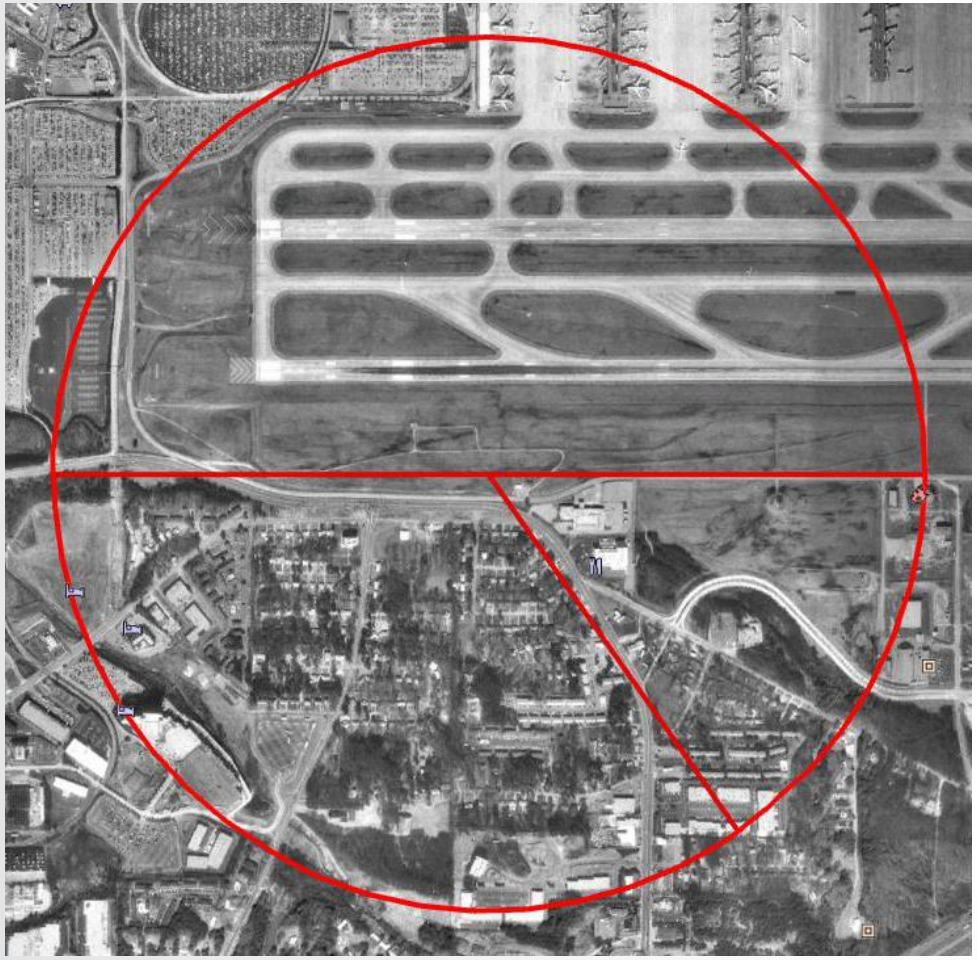
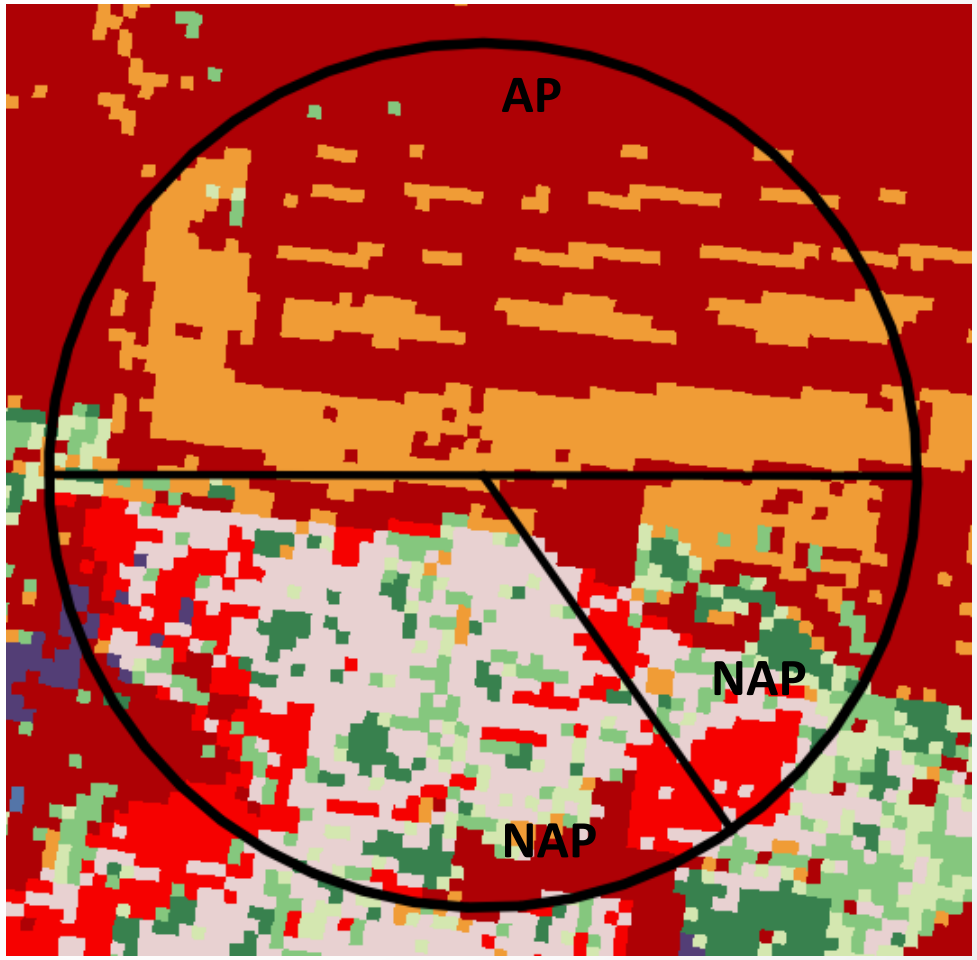
* Alaska only

ATL Sectors (1992)

Google Earth 2/26/1993



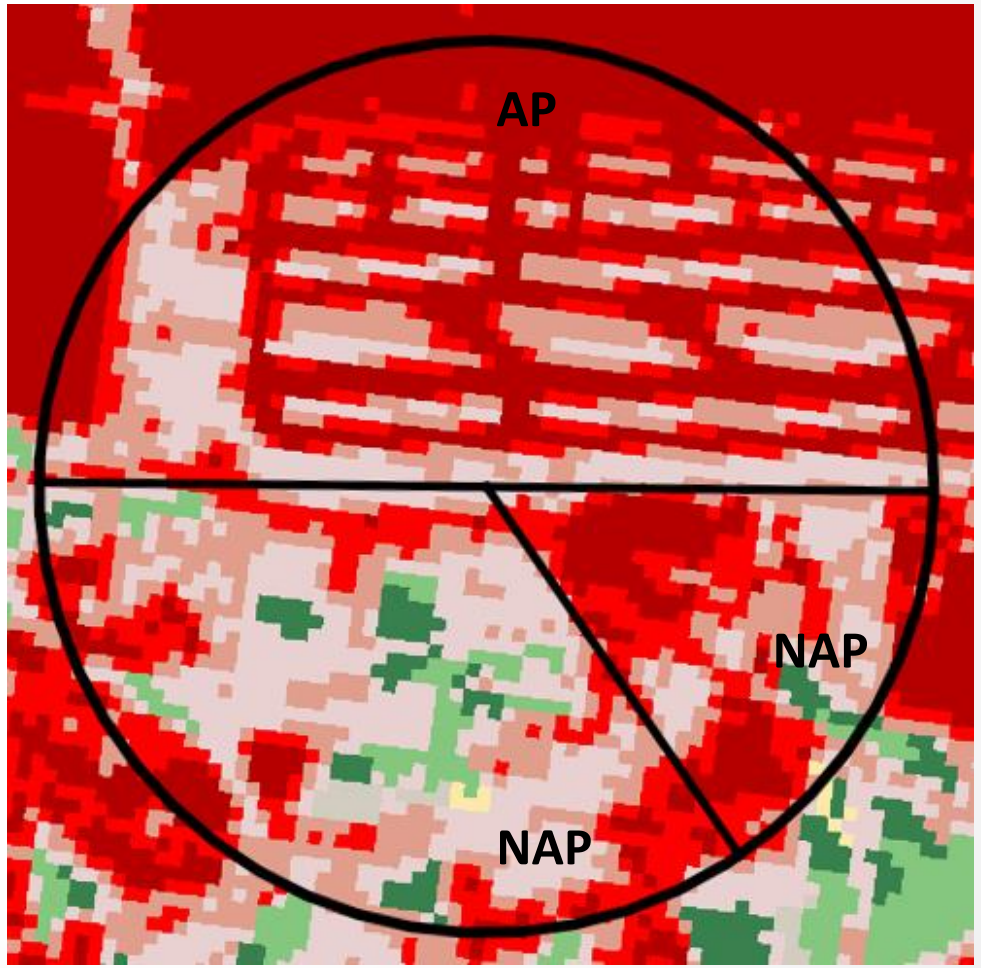
NLCD 1992 Land Cover



ATL Sectors (2001)

Google Earth 2/27/2002

NLCD 2001 Land Cover



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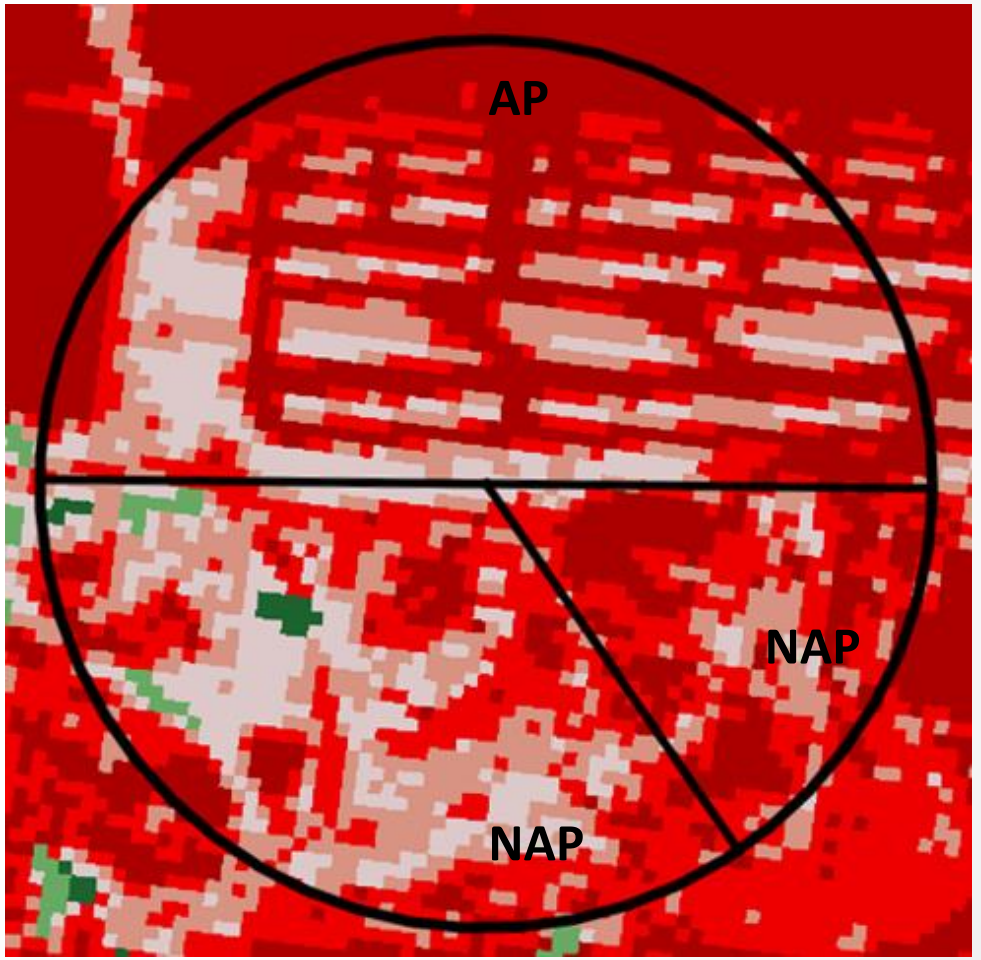
ATL Sectors (2011)

Google Earth 10/16/2011

NLCD 2011 Land Cover



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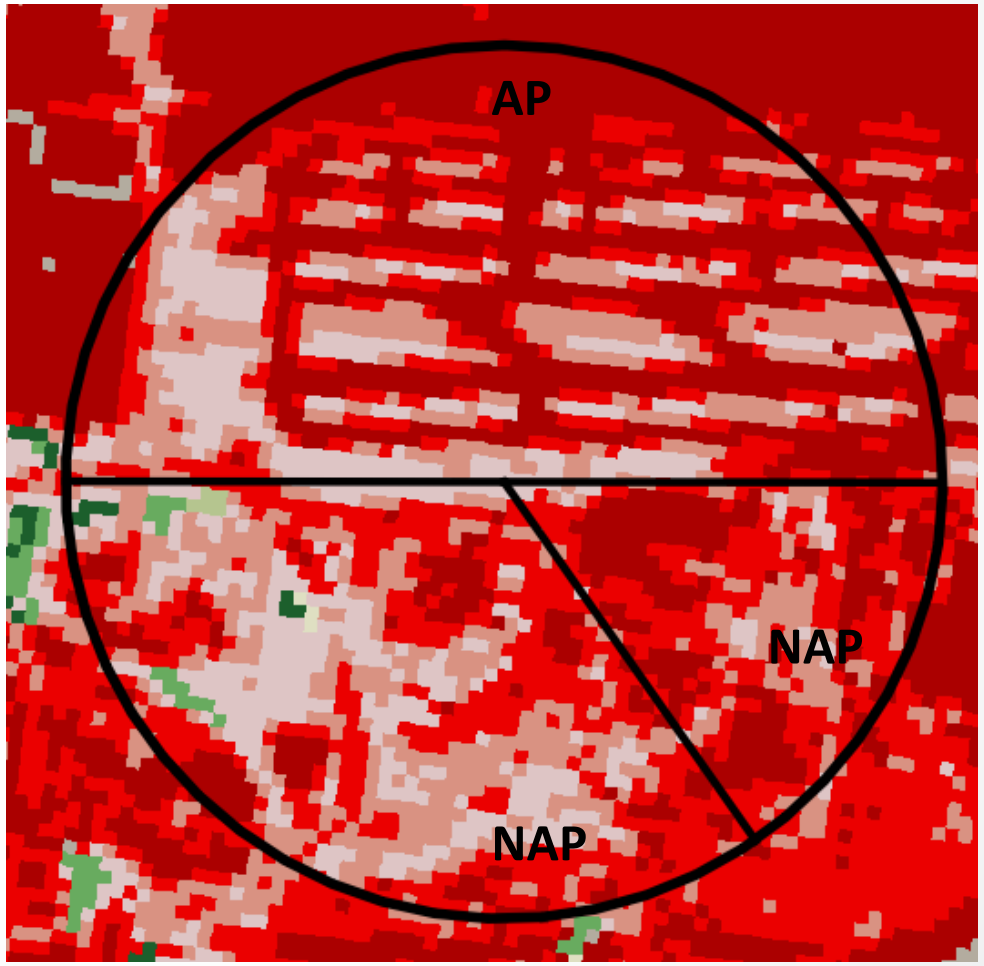
ATL Sectors (2016)

Google Earth 5/7/2016

NLCD 2016 Land Cover



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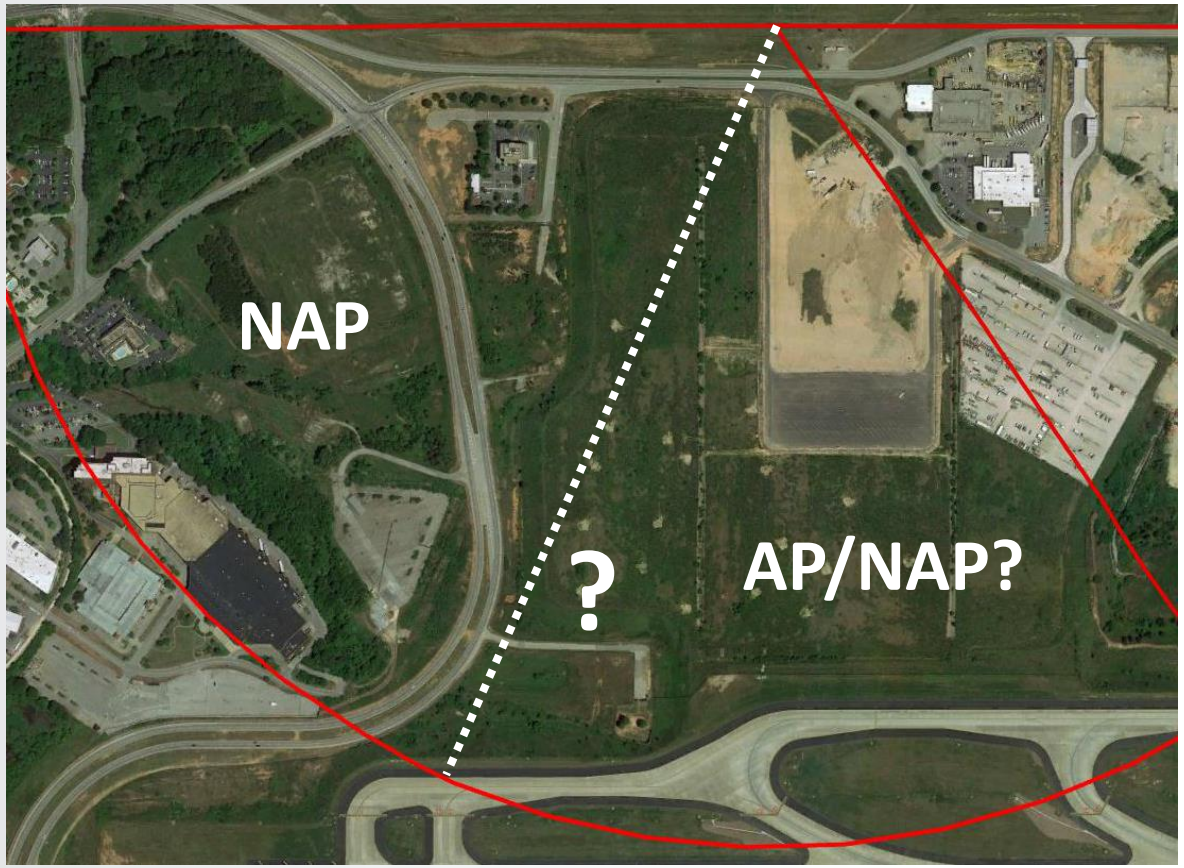
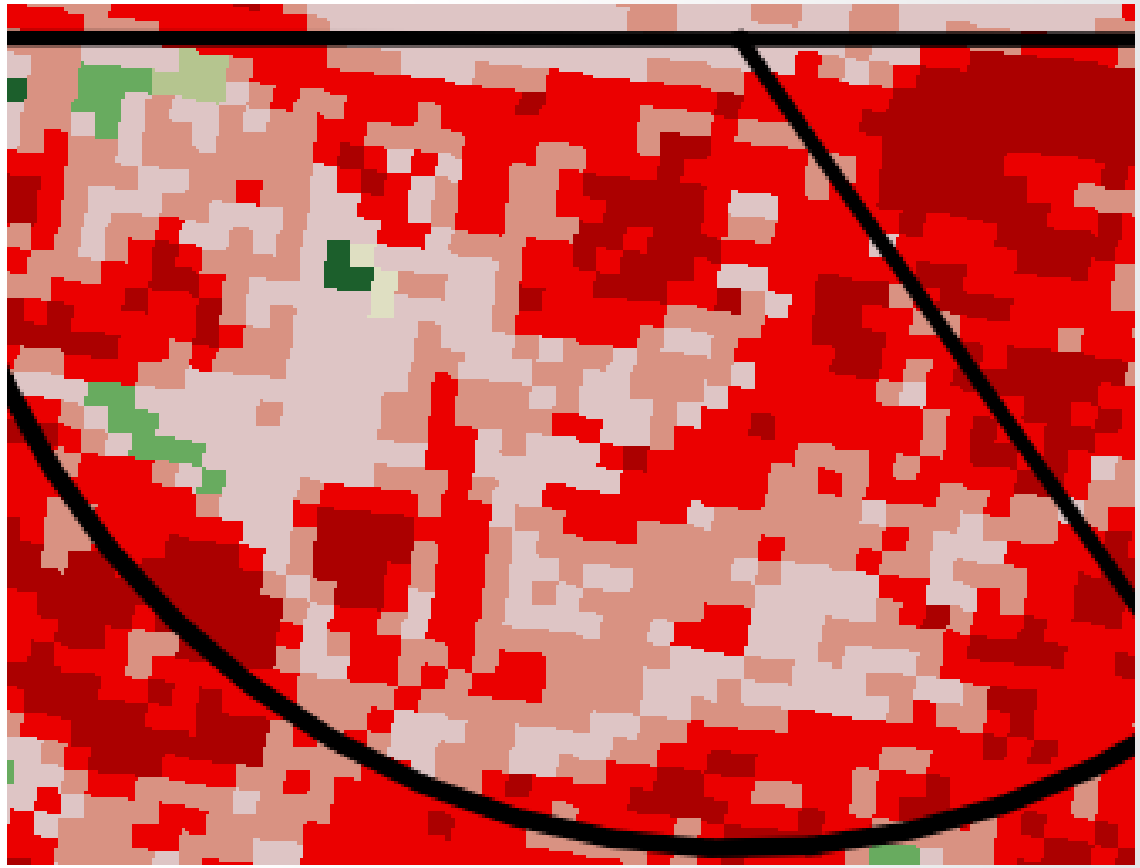
ATL Sectors (2016)

Google Earth 5/7/2016

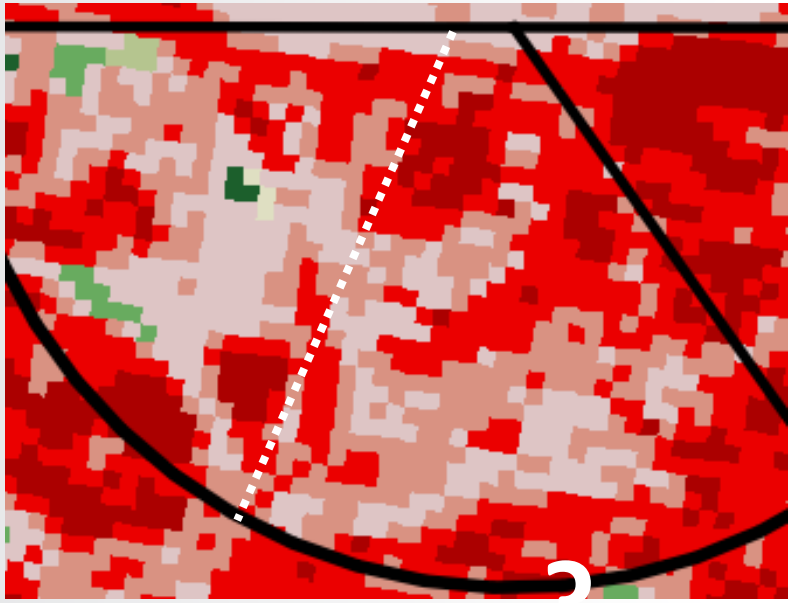


NLCD 2016 Land Cover

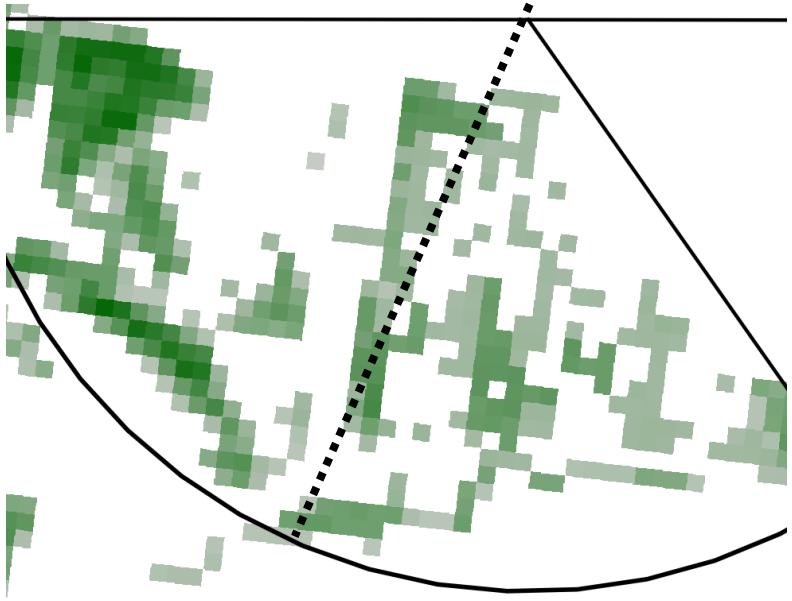


ATL Sectors (2016)

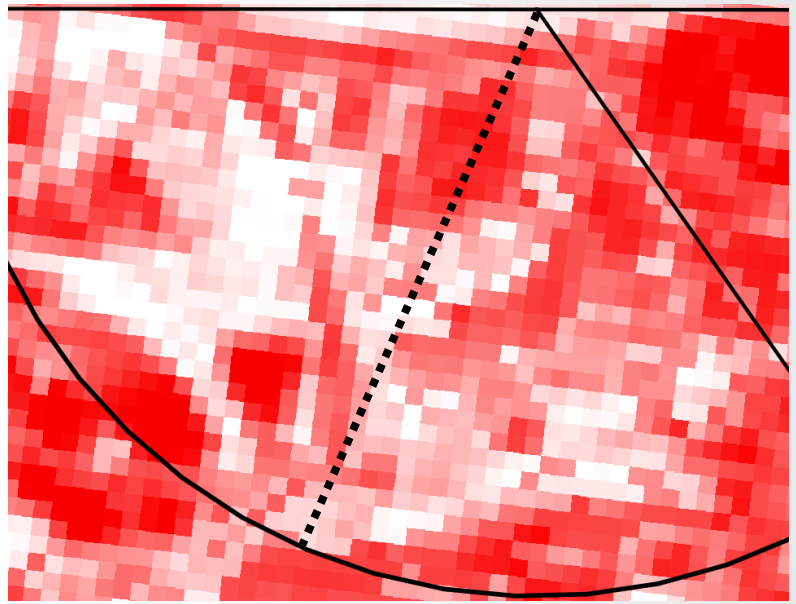
NLCD 2016 Land Cover



2016 % Tree Canopy



2016 % Impervious



% Impervious and % Tree Canopy Implementation

% Impervious and % Tree Canopy

Roughness for Developed categories (21-24) is computed based on the roughness values used from a mix of NLCD 1992 categories:

1992 Land Cover Category	Characterization	Weighting	Surface Roughness (m) by Season*				
			1	2	3	4	5
High Intensity Residential (22)	Airport	10% of Impervious	1.0	1.0	1.0	1.0	1.0
	Non-airport	90% of impervious					
Bare Rock/Sand/Clay (31)	Airport	90% of impervious	0.05	0.05	0.05	0.05	0.05
	Non-airport	10% of Impervious					
Mixed Forest (43)	---	% Canopy	0.90	0.80	1.10	1.30	1.30
Urban/Recreational Grasses (85)	---	1 – (% Impervious + % Canopy)	0.01	0.005	0.015	0.02	0.015

** 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)

[1] [2] [3] [4]

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

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)

[1] [2] [3] [4]

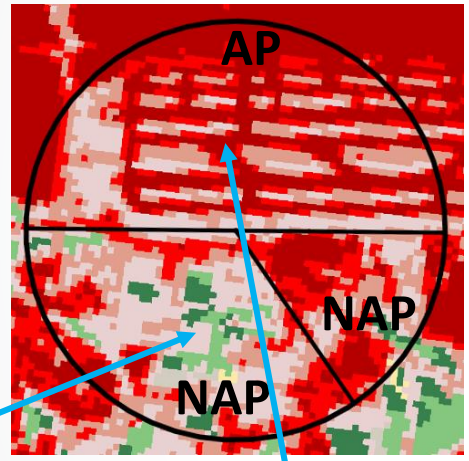
$$z_o = \exp(\ln(1.3) * 0.1 + 0.9 * \ln(1.0) * 0.6 + 0.1 * \ln(0.05) * 0.6 + \ln(0.02) * 0.3) = 0.27$$

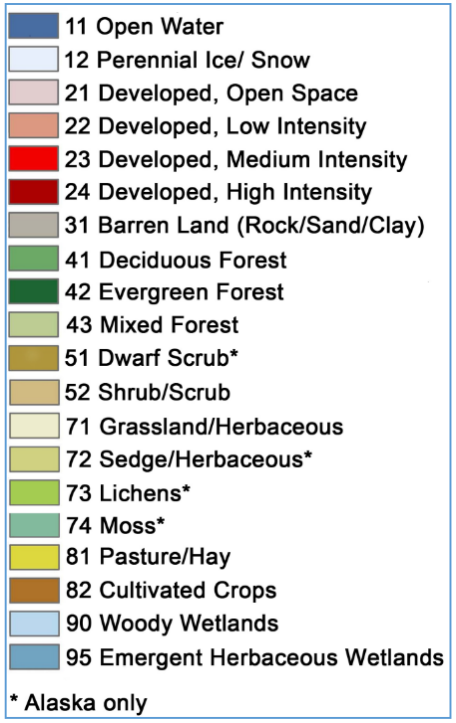
% Impervious and % Tree Canopy

ATL

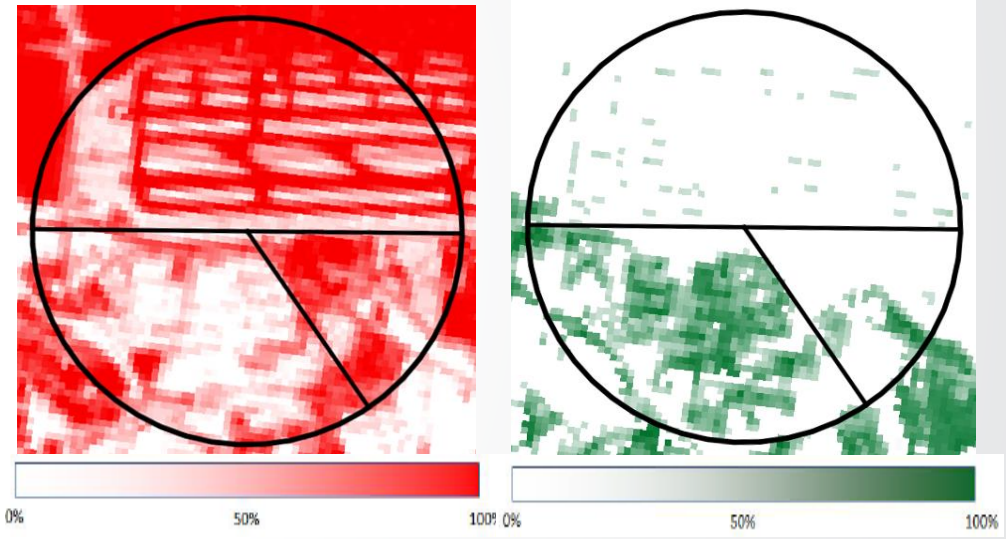
Google Earth
2/27/2002

NLCD 2001
Land Cover





NLCD 2001
% Impervious



NLCD 2001
% Canopy

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

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

% Impervious and % Tree Canopy

Developed, Open Space (30 x 30 m area) :: 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

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