SPCS2022 in North Carolina

- New State Plane Coordinate System in 2022
  - Will replace SPCS 83
  - Referenced to new terrestrial reference frames
- Two conflicting desires for SPCS2022 coordinates:
  - Change coordinates as little as possible
    - Preserve systems based on SPCS 83 coordinates (sft)
    - E.g., parcel numbering system, FEMA flood mapping tiles
  - Change coordinates by large amount
    - Reduces confusion with SPCS 83 coordinates
    - Satisfies NGS policy on SPCS2022

SPCS2022 characteristics

- Characteristics pertinent to North Carolina:
  - Minimize distortion at **ground surface**
  - Lambert Conformal Conic: **1-parallel definition**
    - Central parallel defined to **nearest arc-minute**
    - Central parallel scale **≤ 6 decimal places**
  - Coordinates must change **≥ 10,000 m (~33,000 ft)**
  - Grid origins rounded to **nearest 1000 m**

SPCS2022 policy & procedures

- Policy and procedures still preliminary (draft)
  - Unlikely relevant characteristics will change
  - Would require **exceptions** for something different
  - NGS reluctant to grant exceptions
    - Other states may then also want exceptions
    - Makes overall system definitions more complex
- Possible solution:
  - Satisfy NGS requirements…
  - …but provide ***simple*** transformation to SPCS 83
    - Simpler if limit to translation and scale (with no rotation)
    - Accuracy goal is to get within ~1 ft of SPCS 83

Options for SPCS2022 in NC

1. Use existing SPCS 83 definition
   - Not really an option…
   - …but shows shift due to datum change only
2. Satisfy all NGS requirements
   - Will show 3 different ways to do this
3. Request 1 exception to NGS requirements
   - Grid origin to nearest 1 meter
4. Request 2 exceptions to NGS requirements
   - Same as #3 and…
   - …do ***not*** minimize distortion at ground surface

1. Use existing SPCS 83 definition

- Shifts due ***ONLY*** to datum change
- Can use translation alone to reduce coordinate differences with SPCS 83 to within ~0.4 ft
- This option cannot be used but shows smallest possible range in coordinate differences

Statistic	ΔNorth (ft)	ΔEast (ft)	ΔHorz (ft)
Minimum	2.7	-2.2	**3.3**
Maximum	3.0	-1.7	**3.6**
Range	*0.3*	*0.6*	***0.3***
Average	2.8	-1.9	**3.4**

2. Satisfy all NGS requirements

- Three alternatives:
  - **2a and 2b:**
    - Intentional very large coordinate shifts
    - Northings not equal to eastings:
    - Northings < 1 million feet most of state
    - Eastings > 2 million feet most of state
  - **2c:** Coordinate shifts smallest allowable (> 10,000 m)
- **2a:** Change central meridian from 79°W to 80°W
  - To balance positive/negative convergence angles
  - But this introduces ~½° rotation for coordinate conversion to SPCS 83
- **2b and 2c:** No change of central meridian

2. Satisfy all NGS requirements *(cont'd)*

2a. Move central meridian 1°W and use grid origins that give large coordinate change with N ≠ E in state

- Translation alone reduces max change to ~15,000 ft
- Also requires scale ***and*** rotation for max change ~1 ft (and differences may be larger than this)

Statistic	ΔNorth (ft)	ΔEast (ft)	ΔHorz (ft)
Minimum	95,728	1,574,383	**1,577,810**
Maximum	122,309	1,584,410	**1,588,559**
Range	*26,581*	*10,027*	***10,749***
Average	110,601	1,578,258	**1,582,140**

2. Satisfy all NGS requirements *(cont'd)*

2b. ***NO*** change in central meridian but use same grid origins as 2a

- Translation alone reduces max change to ~115 ft
- Also requires scale for max change of ~1 ft

Statistic	ΔNorth (ft)	ΔEast (ft)	ΔHorz (ft)
Minimum	110,217	1,280,708	**1,285,445**
Maximum	110,294	1,280,913	**1,285,650**
Range	*77*	*205*	***205***
Average	110,264	1,280,822	**1,285,560**

2. Satisfy all NGS requirements *(cont'd)*

2c. ***NO*** change in central meridian and smallest allowable coordinate change (> 10,000 m or ~32,800 ft)

- Translation alone reduces max change to ~115 ft
- Also requires scale for max change of ~1 ft

Statistic	ΔNorth (ft)	ΔEast (ft)	ΔHorz (ft)
Minimum	-1,331	33,991	**34,016**
Maximum	-1,255	34,196	**34,220**
Range	*77*	*205*	***204***
Average	-1,284	34,106	**34,130**

3. One exception to requirements

- **Exception:** Allow defining grid origins to nearest 1 m (rather than to nearest 1000 m)
- Within ~115 ft of SPC 83 (note difference is same as translation-only modification of options 2b and 2c)
- Requires scale to decrease max change to ~1 ft

Statistic	ΔNorth (ft)	ΔEast (ft)	ΔHorz (ft)
Minimum	-48.4	-112.9	**0.4**
Maximum	28.2	91.9	**113.9**
Range	*76.6*	*204.8*	***113.5***
Average	-1.5	1.5	**43.8**

4. Two exceptions to requirements

- **Exceptions:**
  1. Allow defining grid origins to nearest 1 m
  2. No attempt to minimize distortion at ground surface
- Within 2.2 ft of SPC 83 without any modification, ***but requires exception to important policy on distortion***

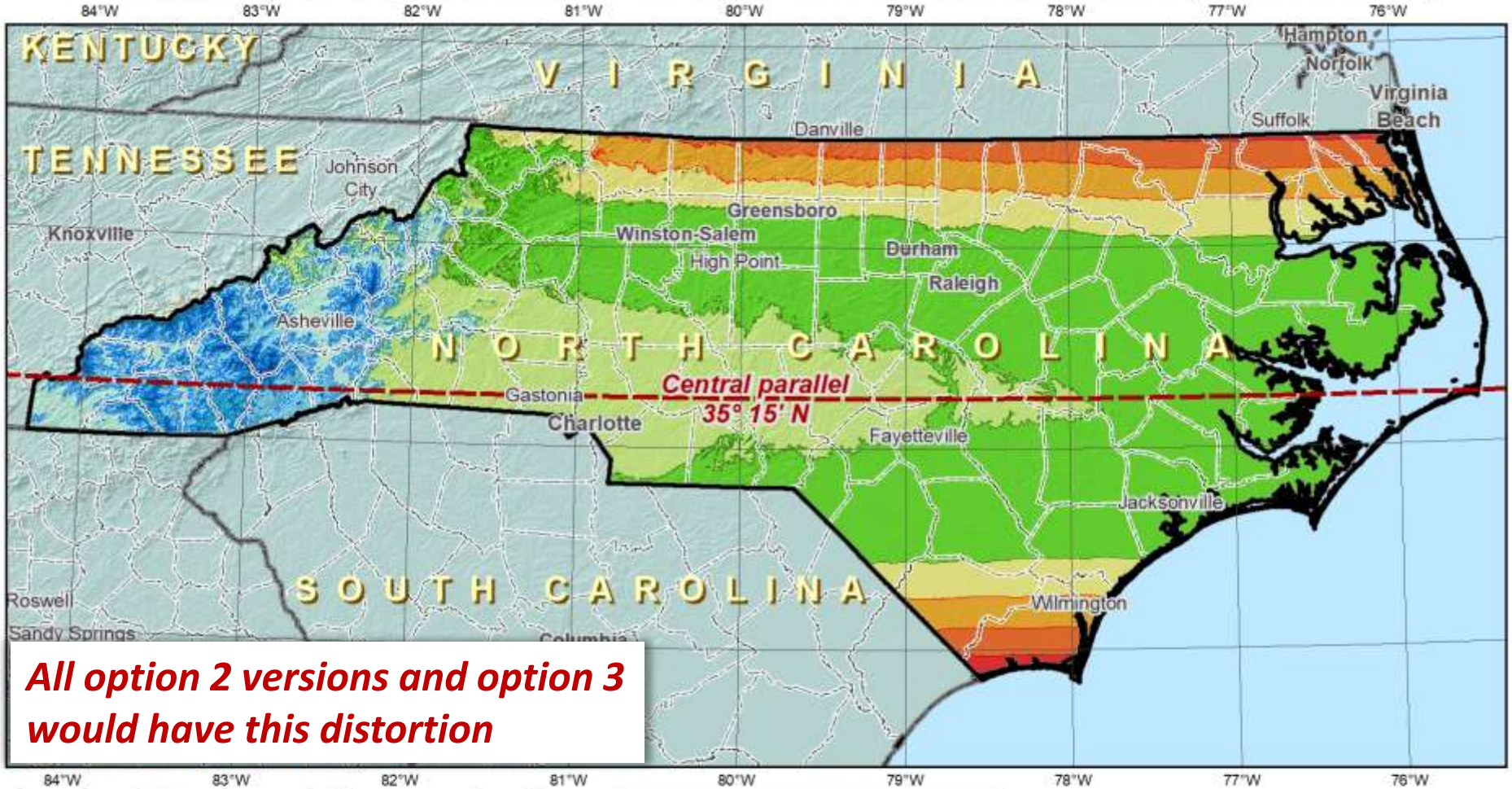
Statistic	ΔNorth (ft)	ΔEast (ft)	ΔHorz (ft)
Minimum	-2.2	-0.5	**0.0**
Maximum	0.3	1.9	**2.2**
Range	*2.4*	*2.4*	***2.2***
Average	-0.3	0.6	**0.8**

Distortion performance of options

- For linear distortion at ground surface
  - Options 2 and 3 have less distortion than SPCS 83
  - Option 4 performs about same as SPCS 83 (Option 1)
- This is a significant exception since intent of SPCS2022 is to ***minimize distortion at ground surface***
- Percentage of areas within ±100 ppm distortion (same as 1:10,000 or ±0.53 ft per mile):

Percentage of:	SPCS 83	Options 2 and 3	Option 4
Area of entire state	44%	76%	44%
All cities and towns	42%	78%	48%
Population	44%	90%	51%

Preliminary SPCS2022 default design: North Carolina Zone (alternative 1)



All option 2 versions and option 3 would have this distortion

Lambert Conformal Conic projection

North American Terrestrial Reference Frame of 2022

Central parallel: 35° 15' N

Cen parallel scale: 0.999 95 (exact)

Areas within ±100 ppm distortion (±0.53 ft per mile):

76% of entire zone

78% of all cities and towns

90% of population

Distortion values (ppm)

Entire zone:

Min = -341 Range = 597

Max = +256 Mean = -14

Cities:

Min = -222 Range = 469

Max = +246 Median = -32

Mean = -25

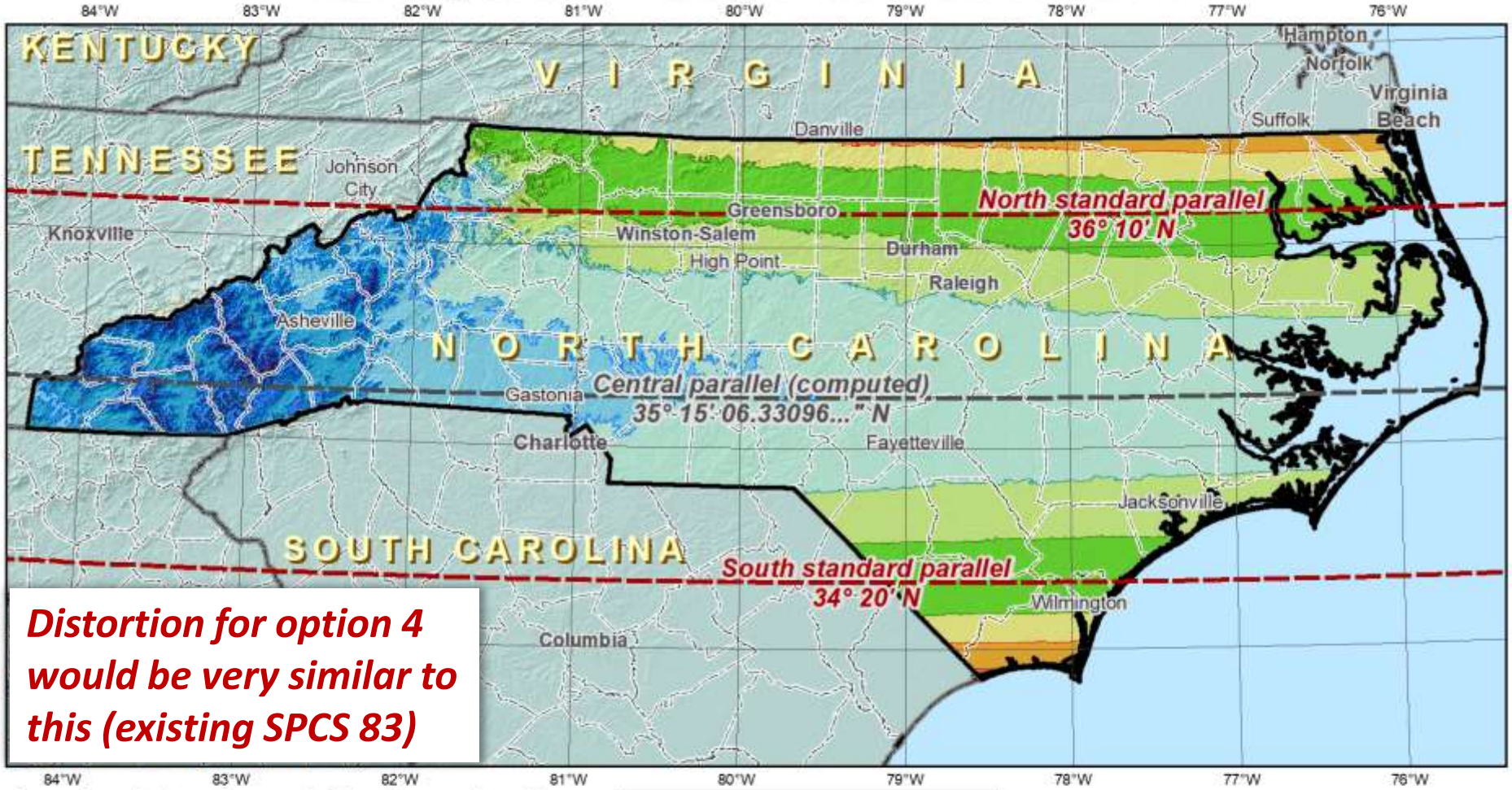
(weighted by population)

Linear distortion at topographic surface (parts per million)

< -400	to -200	to +150
to -400	to -150	to +200
to -350	to -100	to +250
to -300	±50	to +300
to -250	to +100	> +300

0 60 120 180 240 km

Existing SPCS 83 design: North Carolina Zone



Distortion for option 4 would be very similar to this (existing SPCS 83)

Lambert Conformal Conic projection

North American Datum of 1983

Central parallel: 35° 15' 06.3..." N

Cen parallel scale: 0.999 872 592...

Areas within ±100 ppm distortion (±0.53 ft per mile):

44% of entire zone

42% of all cities and towns

44% of population

Distortion values (ppm)

Entire zone:

Min = -418 Range = 597

Max = +179 Mean = -91

Cities:

Min = -300 Range = 469

Max = +169 Median = -109

Mean = -103

(weighted by population)

Linear distortion at topographic surface (parts per million)

< -400	to -200	to +150
to -400	to -150	to +200
to -350	to -100	to +250
to -300	±50	to +300
to -250	to +100	> +300

0 60 120 180 240 km

Projection parameters for options

- Same central parallel for all: **35º 15' N** (exact)
- Central parallel same as latitude of grid origin for all
- Central meridian **79ºW** for all (except **80ºW** for 2a)
- SPCS 83 parameters not shown (a 2-parallel definition with latitude of grid origin not same as central parallel)

Parameter	2a and 2b	2c	3	4
False northing (m)	200,000	166,000	166,391	166,394
False easting (m)	1,000,000	620,000	609,605	609,602
Cen parallel scale	0.99995	0.99995	0.99995	0.999873

Summary

- SPCS2022 coordinates in NC will differ from SPCS 83
- Differences < 10,000 m require exceptions to policy:
  - **No exceptions:** min differences of ~34,000 ft
  - **One minor exception:** differences within ~115 ft
  - **One minor + one major exception:** differences within ~2 ft
- Best solution may be a compromise:
  - Have no exceptions and use simple transformation
  - Option 2b with simple translation and scale (no rotation) could likely match SPCS 83 to within ~1 ft statewide
- Note that all definitions here are ***preliminary***
  - Final definitions may differ, even if one of the options here is selected