A New State Plane Coordinate System for 2022

Federal Geodetic Control Subcommittee Meeting
Silver Spring, Maryland
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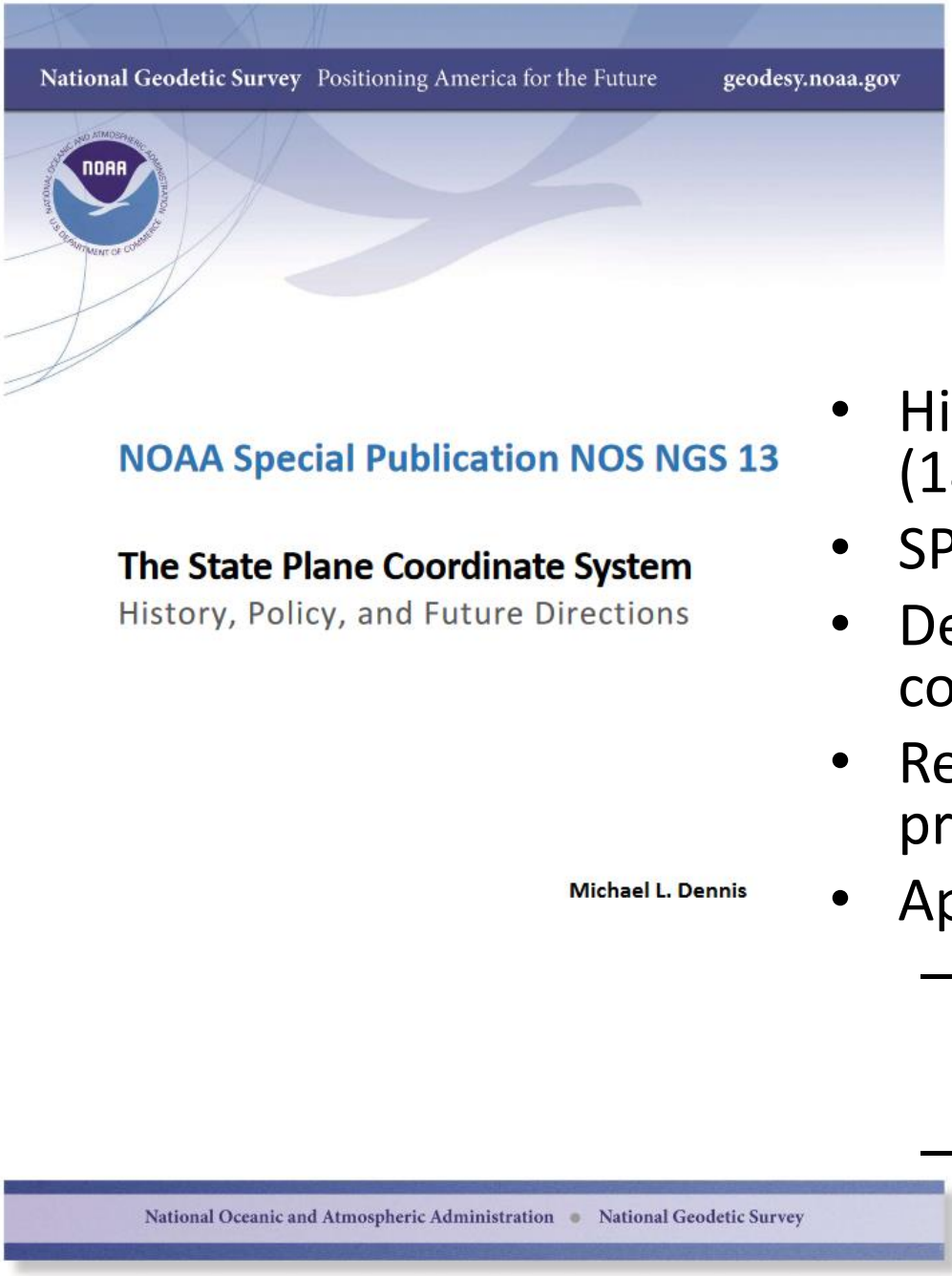
New State Plane Coordinate System

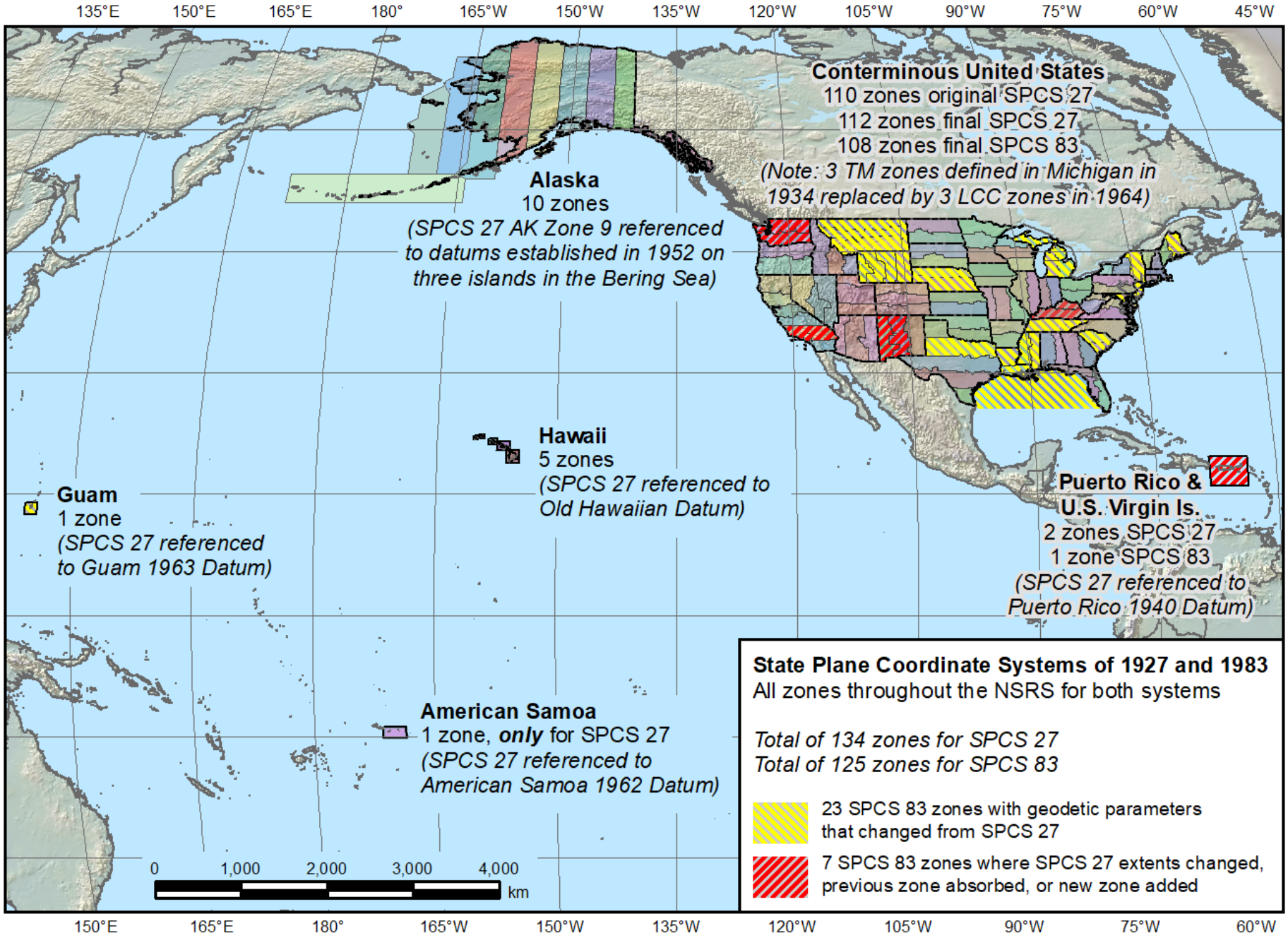
- ***State Plane Coordinate System of 2022 (SPCS2022)***
  - Referenced to new 2022 Terrestrial Reference Frames (TRFs)
  - Based on same reference ellipsoid (GRS 80)
  - Same 3 ***conformal*** projection types
    - Lambert Conformal Conic (LCC)
    - Transverse Mercator (TM)
    - Oblique Mercator (OM)
- NGS in process of specifying SPCS2022 characteristics
  - Draft policy and procedures for public comment
  - Federal Register Notice (FRN) on policy and procedures
  - New report on State Plane history, policy, and future
- **NOTE: SPCS2022 characteristics currently in review**
  - ***Approved version may differ from what is presented here***



SPCS Special Publication

- History of NGS projections (1853 to present)
- SPCS policies and legislation
- Departures from policy and convention
- Recent developments in projected coordinate systems
- Appendices
  - Defining parameters for ALL zones of ALL versions of SPCS, plus additional information
  - Status of SPCS 83 legislation and foot conversions

State Plane Coordinate Systems of 1927 (134 zones) and 1983 (125 zones)



Draft SPCS2022 Policy & Procedures

- Release for public comment period (FRN)
  - Deadline for comment: **July 31, 2018**
- Stakeholder input from states for their zones
  - DOTs, GIS offices, professional societies, universities
  - Deadlines:
    - **Dec 31, 2019 for requests and proposals**
    - **Dec 31, 2020 for submitted designs**
  - Consensus input ***REQUIRED***
- Federal agency input through FGCS
  - But input for specific zones is from state stakeholders
  - Can coordinate with state stakeholders

SPCS2022 characteristics *(draft)*

- Technical requirements
  - ***Linear distortion*** design criterion at topographic surface (*not* at ellipsoid surface)
    - Difference in distance between "ground" and "grid"
  - Use 1-parallel definition for LCC projections
- Other characteristics
  - Default designs (if no consensus stakeholder input)
  - "Layered" zones
  - Low-distortion projections (LDPs)
  - "Special purpose" zones

Linear distortion magnitudes

ppm = parts per million (mm/km)

- δ = **±20 ppm** = 2 cm/km = 0.1 ft/mile = 1 : 50,000
  Often used as "low distortion" design criterion (***at ground***)

- δ = **±50 ppm** = 5 cm/km = 0.3 ft/mile = 1 : 20,000
  Minimum design criterion for SPCS2022 designs by NGS (***at ground***)

- δ = **±100 ppm** = 10 cm/km = 0.5 ft/mile = 1 : 10,000
  "Nominal" maximum State Plane value (***on ellipsoid***)
  Can be much greater at topo surface

- δ = **±400 ppm** = 40 cm/km = 2.1 ft/mile = 1 : 2,500
  Maximum design criterion for SPCS2022 zones (***at ground***)
  Maximum UTM value (***on ellipsoid***)

This is distortion range (at ground) for zones designed by NGS, as proposed in SPCS2022 policy and procedures.

Default SPCS2022 designs *(draft)*

- Default needed in absence of stakeholder input
- Same projections and zones for most SPCS 83 zones
- Performance and coverage very similar to SPCS 83
- Characteristics that differ from SPCS 83:
  - Projection scale modified to minimize distortion at ground
  - Lambert Conformal Conic converted to one-parallel type
  - Most geodetic origins with arc-minutes evenly divisible by 3
  - A few zones with different projection & zone extents

SPCS 83
Arizona Central Zone
(Transverse Mercator)

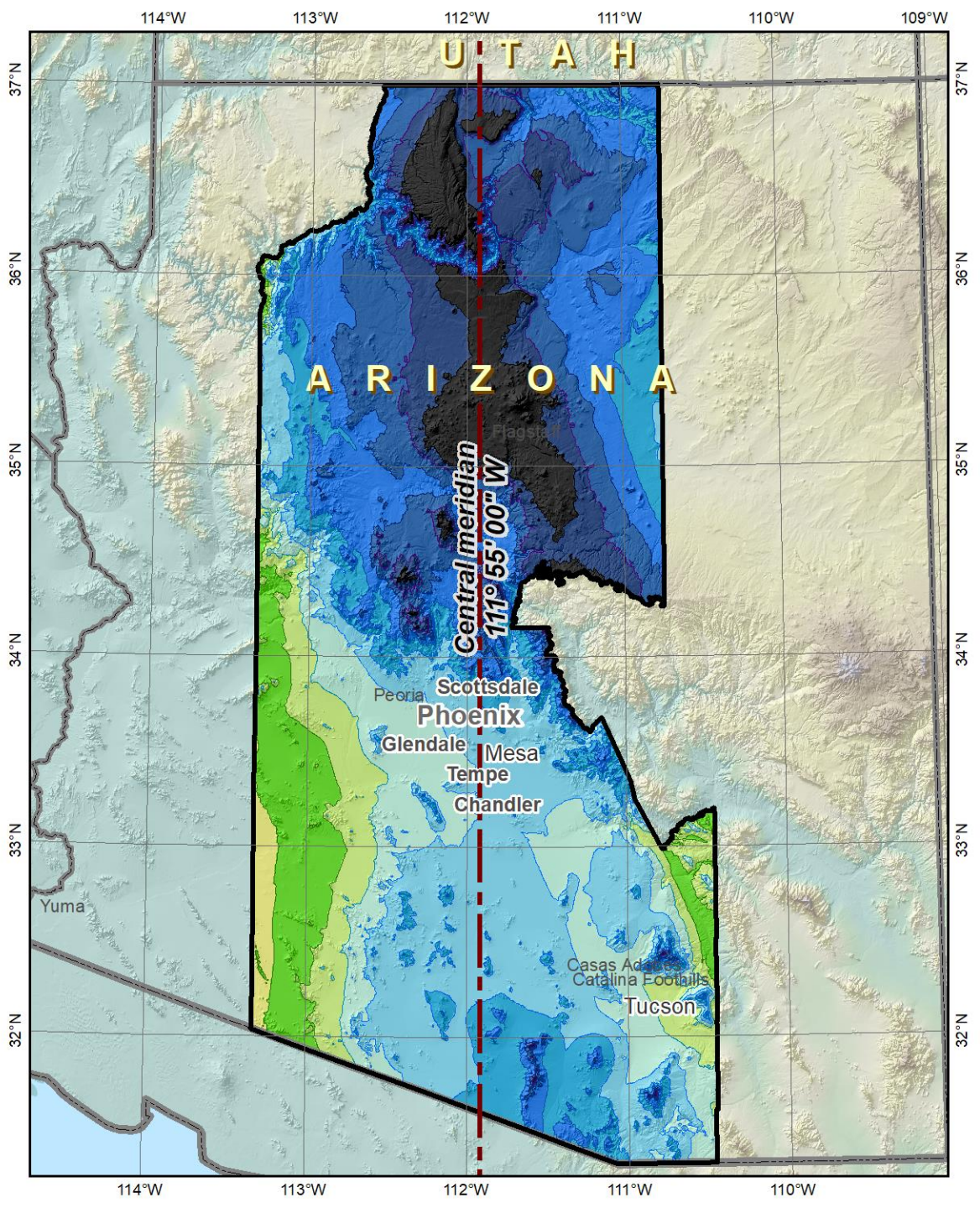
Height (m)	
Min	96
Max	3607
Mean	1177

SPCS 83 AZ C	
C.M.	111°55'W
Scale	0.9999
Distortion (ppm)	
Min	-660
Max	+102
Mean	-224

Linear distortion (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 50 100 150 200 km



SPCS2022 “default” Arizona Central Zone (Transverse Mercator)

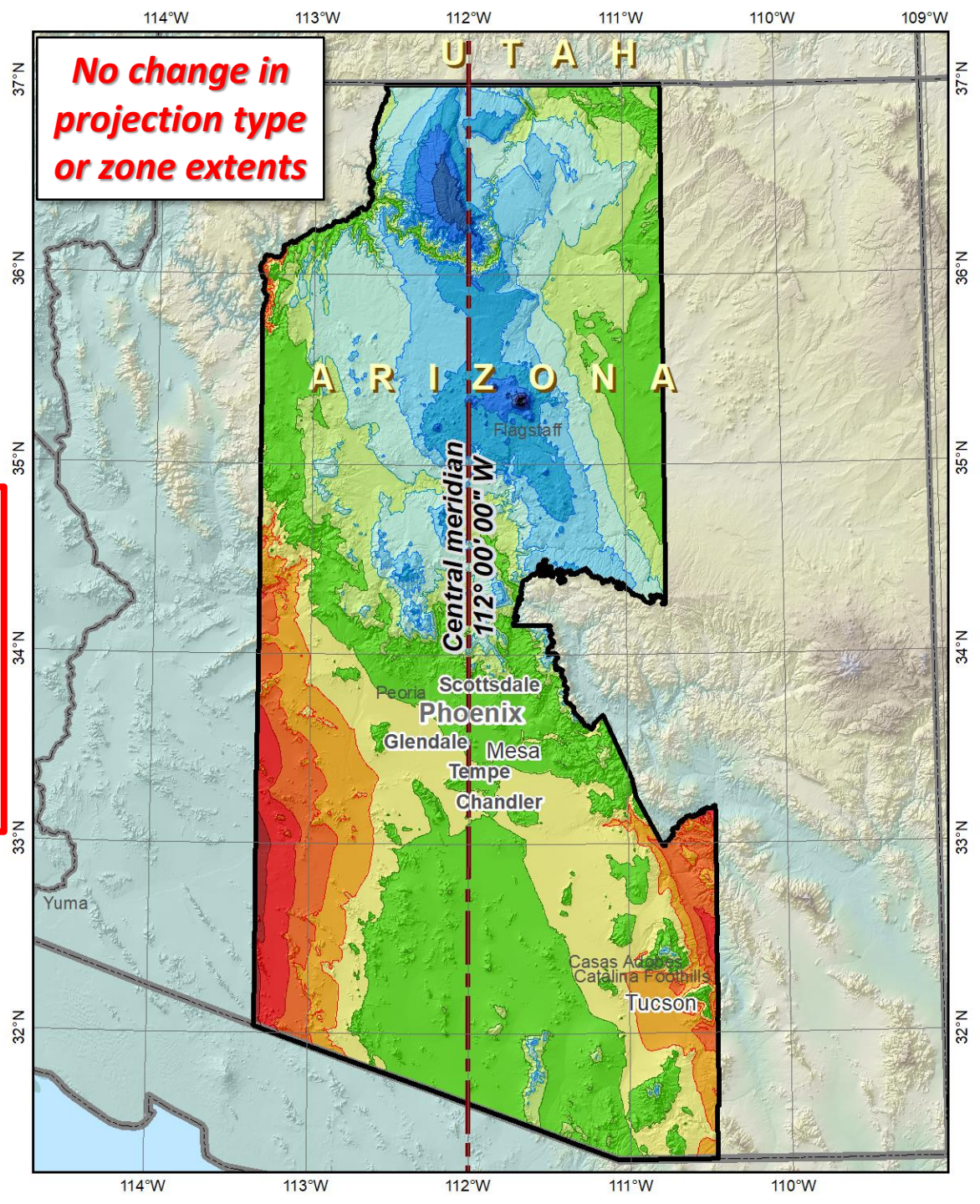
	Height (m)
Min	96
Max	3607
Mean	1177

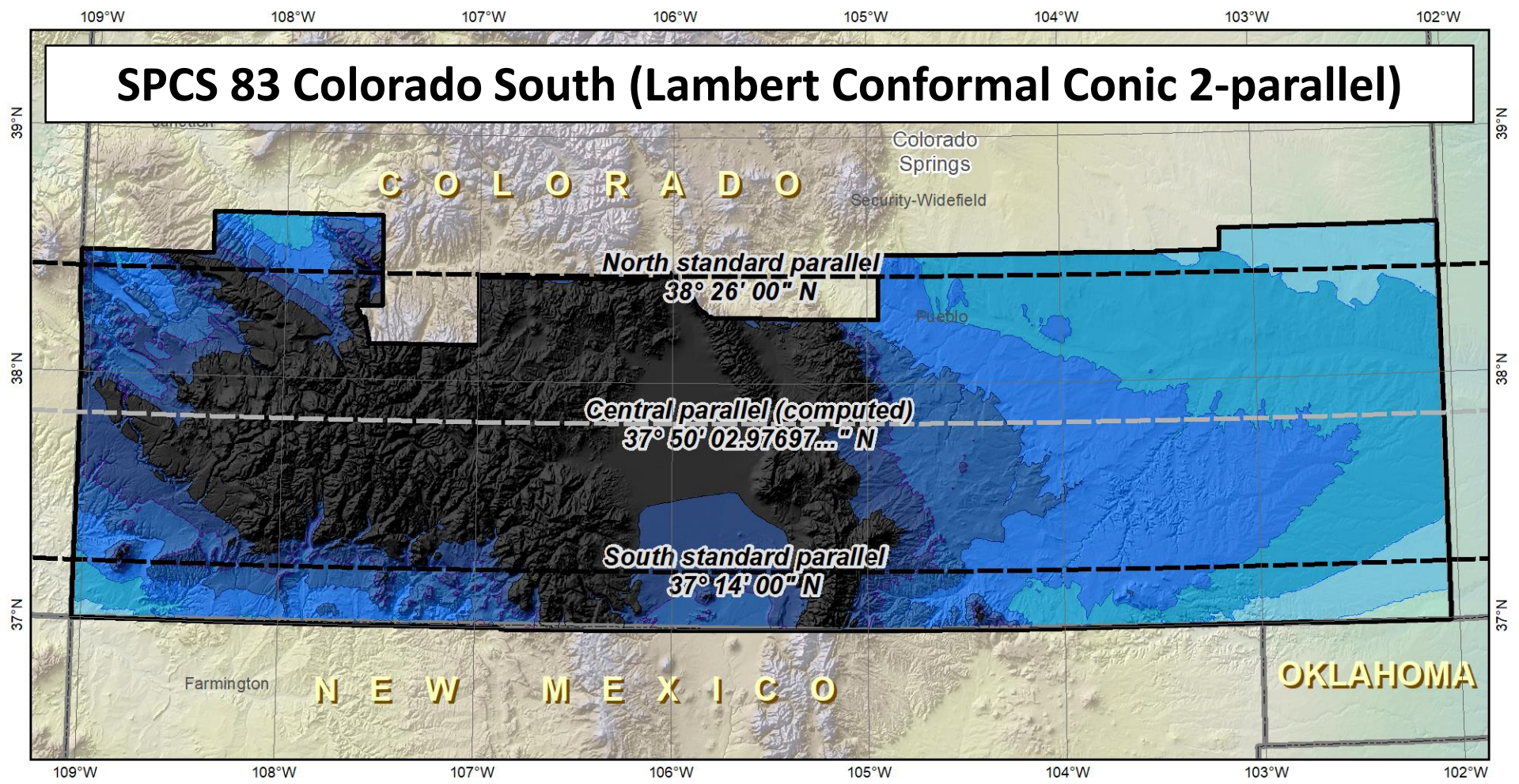
	SPCS 83 AZ C	SPCS2022
C.M.	111°55’W	112°W
Scale	0.9999	1.0001
	Distortion (ppm)	
Min	-660	-455
Max	+102	+277
Mean	-224	-24

Linear distortion (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 50 100 150 200 km



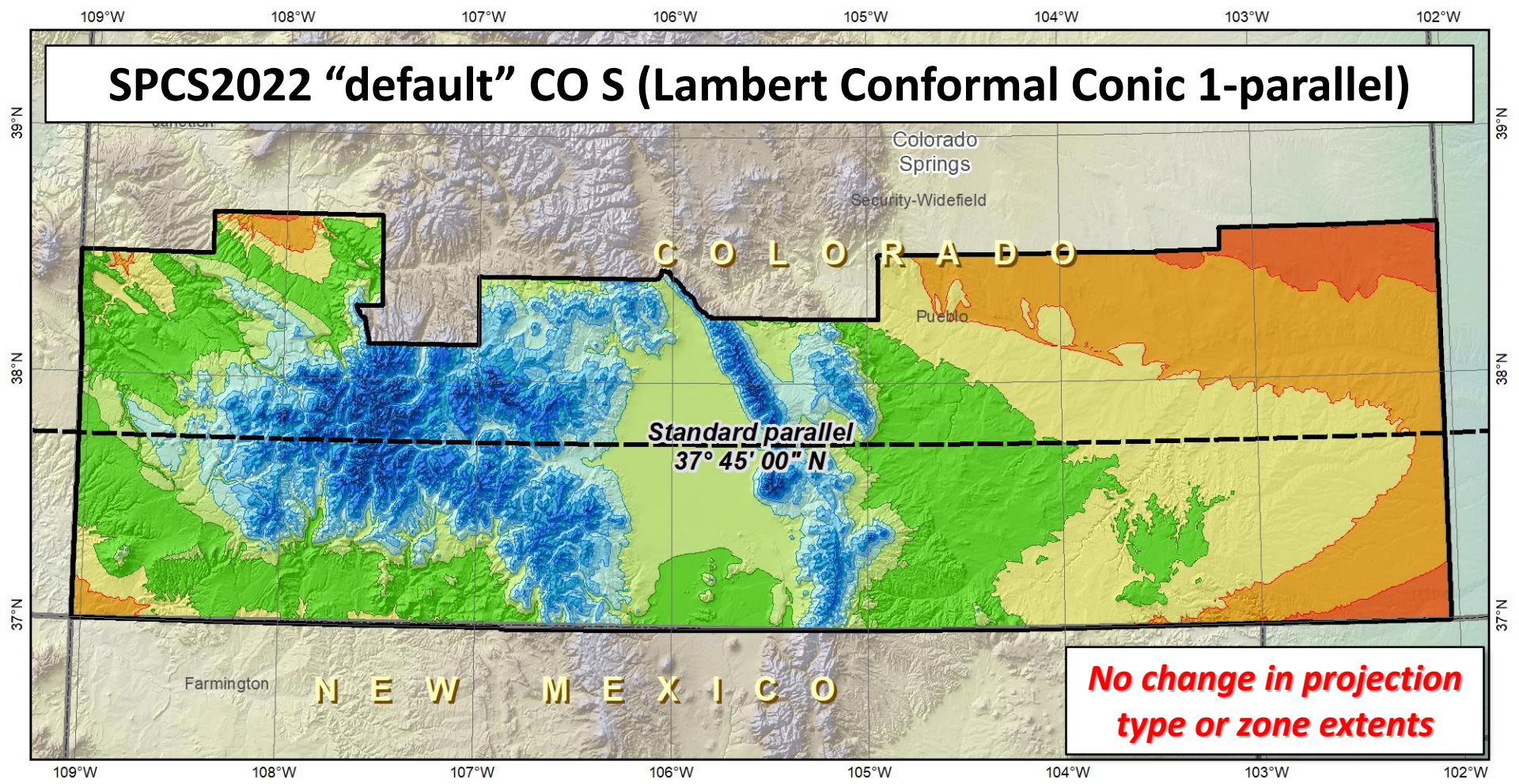


Linear distortion (parts per million)

< -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 50 100 150 200 km

	SPCS 83 CO S	
Central parallel	37°50’02.98…”N	
Cen parallel scale	0.9999453985…	
	Height (m)	Distortion (ppm)
Min	998	-697
Max	4106	-117
Mean	2091	-352



Linear distortion (parts per million)

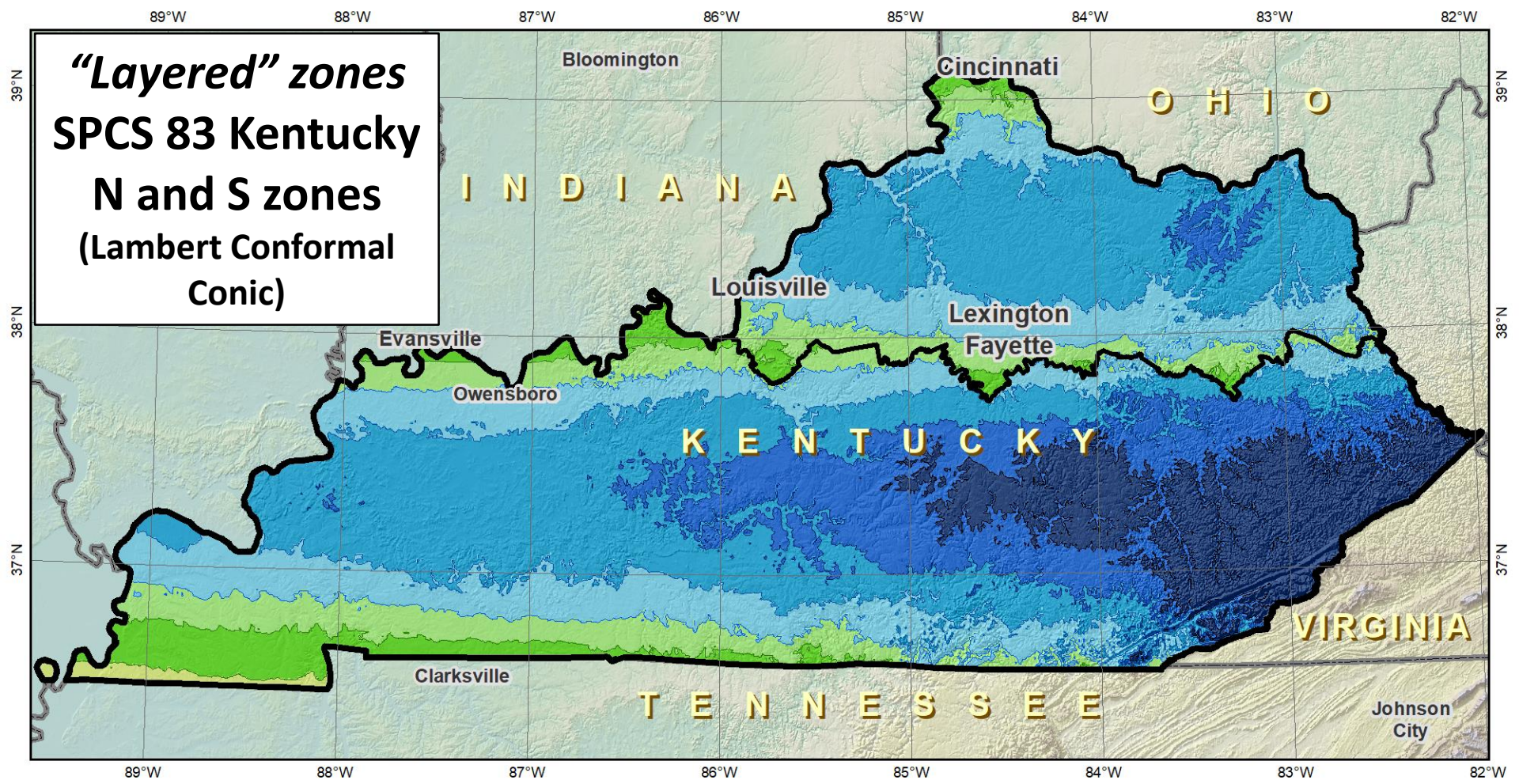
< -400	to -200	to +150
to -400	to -150	to +200
to -350	to -100	to +250
to -300	±50	to +300
to -250	to +100	> +300

0 50 100 150 200 km

	SPCS 83 CO S	SPCS2022
Central parallel	37°50’02.98…”N	37°45’N
Cen parallel scale	0.9999453985…	1.00028
	Height (m)	Distortion (ppm)
Min	998	-697	-360
Max	4106	-117	+209
Mean	2091	-352	-19

"Layered" zones *(draft)*

- Limitations
  - Max of ***TWO*** layers: Statewide and sub-zones
  - If two layers, one ***MUST*** be statewide
  - Minimum sub-zone dimension > 50 km
- States often want statewide ***and*** small zones
  - *Statewide:* Single geometry required for state GIS
  - *Sub-zones:* Lower distortion for surveying/engineering
- Accommodates state needs, but with restrictions
  - Prevent poor design choices for statewide zones
  - One already exists in SPCS 83…

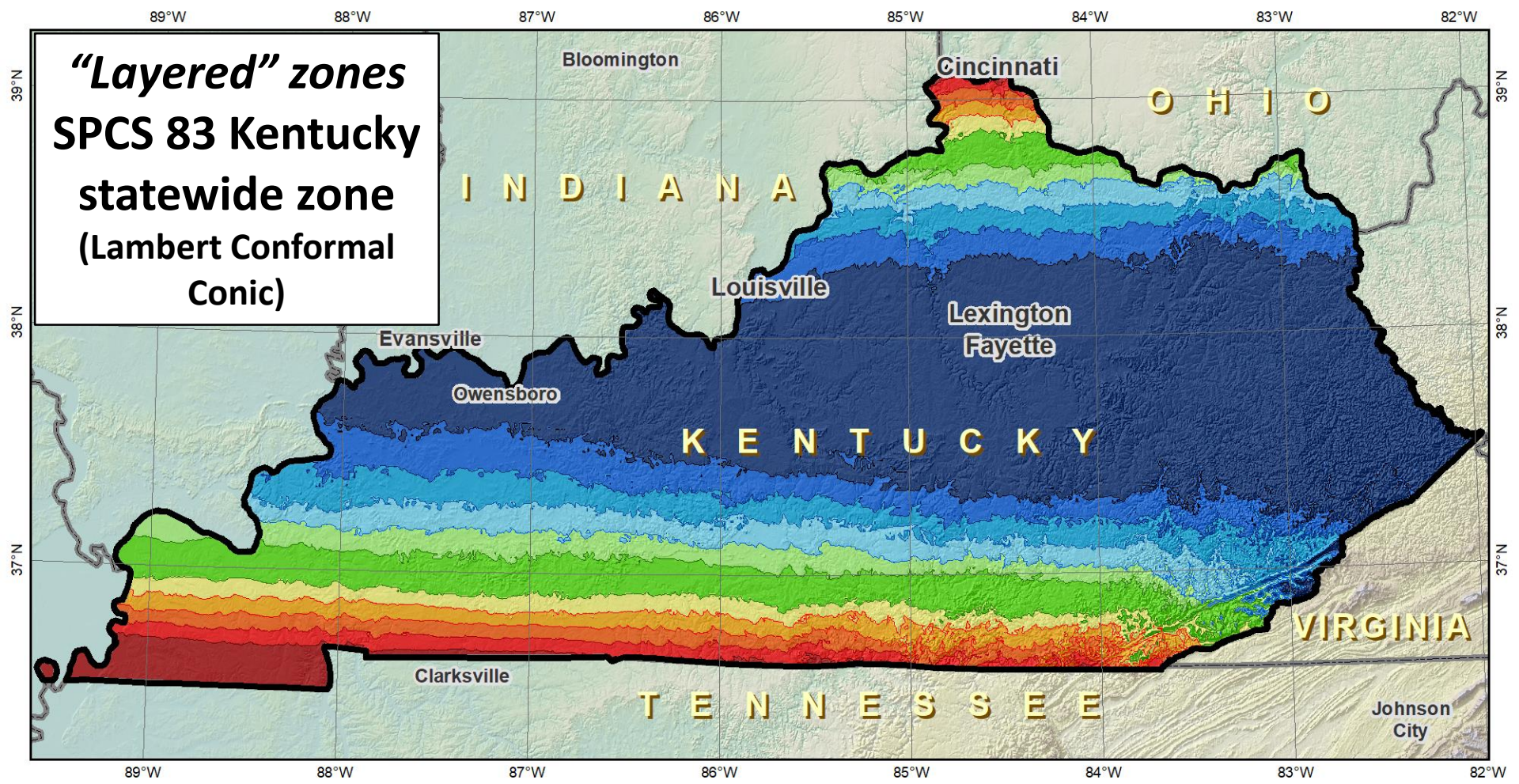


Linear distortion (parts per million)

<-100 ppm	+20 to +40
-80 to -100	+40 to +60
-60 to -80	+60 to +80
-40 to -60	+80 to +100
-20 to -40	>+100 ppm
±20 ppm	

0 50 100 150 200 km

	North	South
N parallel	38°58'N	37°56'N
S parallel	37°58'N	36°44'N
	Distortion (ppm)	
Min	-93	-211
Max	+17	+42
Mean	-56	-67



Linear distortion (parts per million)

<-100 ppm	+20 to +40
-80 to -100	+40 to +60
-60 to -80	+60 to +80
-40 to -60	+80 to +100
-20 to -40	>+100 ppm
±20 ppm	

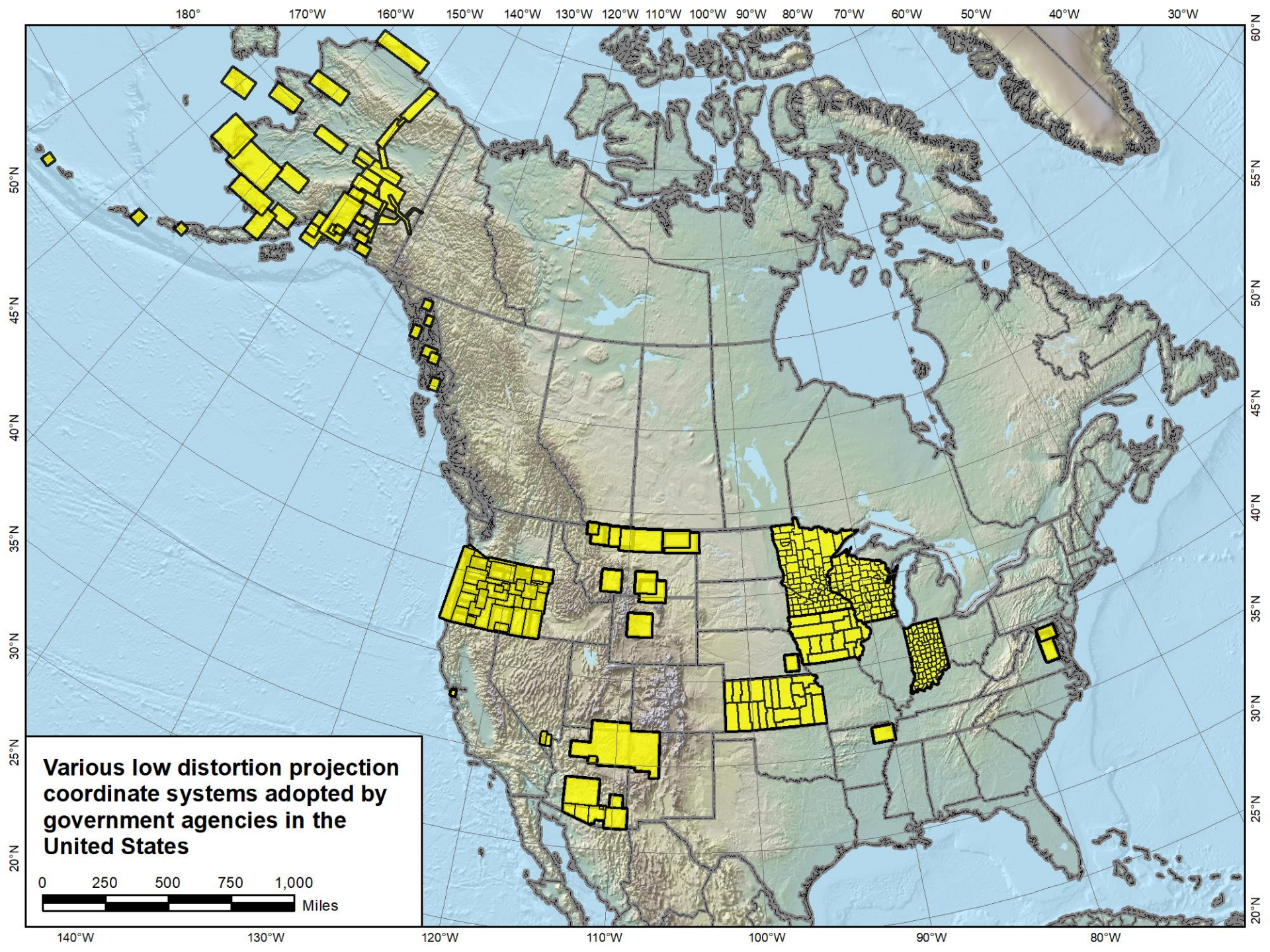
0 50 100 150 200 km

	North	South	Statewide
N parallel	38°58'N	37°56'N	38°40'N
S parallel	37°58'N	36°44'N	37°05'N
	Distortion (ppm)		
Min	-93	-211	-166
Max	+17	+42	+181
Mean	-56	-67	-58

Linear distortion design criteria *(draft)*

- NGS design of zones requested by stakeholders
  - Limited to zones with 50-400 ppm distortion criterion
    - **50 ppm** = 5 cm/km = 0.3 ft/mi = 1:20,000
    - **400 ppm** = 40 cm/km = 2.1 ft/mi = 1:2,500
- Design criterion < 50 ppm ("low distortion")
  - Min criterion **20 ppm** = 2 cm/km = 0.1 ft/mi = 1:50,000
  - Must be designed by others (not by NGS)
  - Proposed and final design reviewed by NGS

What is the current situation with "low distortion" projected coordinate systems?


180°
170°W
160°W
150°W
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W
50°W
40°W
30°W
60°N
55°N
50°N
45°N
40°N
35°N
30°N
25°N
20°N
140°W
130°W
120°W
110°W
100°W
90°W
80°W
Various low distortion projection coordinate systems adopted by government agencies in the United States
0
250
500
750
1,000
Miles

"Special purpose" zones

- For areas with inadequate SPCS zone coverage
  - Usually areas that are in more than one zone
- Categories:
  - Major urban areas (e.g., New York, Chicago, St. Louis)
  - Large Indian reservations (e.g., Navajo Nation)
  - Federal applications covering large areas (e.g., coastal mapping of Atlantic Coast; Grand Canyon)
- Permitted for metro areas in 1977 policy (but never used)
- Only in FRN, ***not*** in draft policy & procedures
  - Intent is to get input on concept first

SPCS2022 Summary

- Main characteristics
  - Designed with respect to "ground"
  - Default designs similar to existing State Plane
  - Can include a statewide zone plus a sub-zone layer
  - LDPs can be used but must be designed by others
- Stakeholder input on zones for their states
  - *REQUIRES* consensus input
- Federal agency input through FGCS
  - Can coordinate with states stakeholders
- **NGS webinars on March 8 and April 12 – register at:**

https://geodesy.noaa.gov/web/science_edu/webinar_series/Webinars.shtml

NOTE: SPCS2022 policy and procedures currently in review, not yet finalized