

Introduction to Raster Data and other Geospatial Data Concepts

OILS 515 - Introduction to Spatial Data Management
Karl Benedict

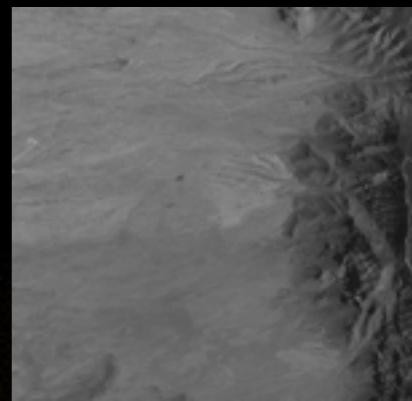
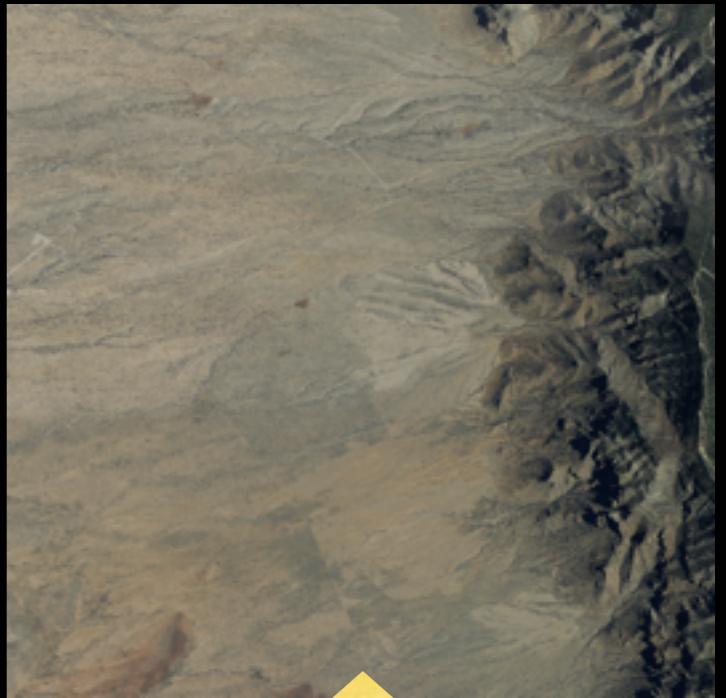


Raster Data

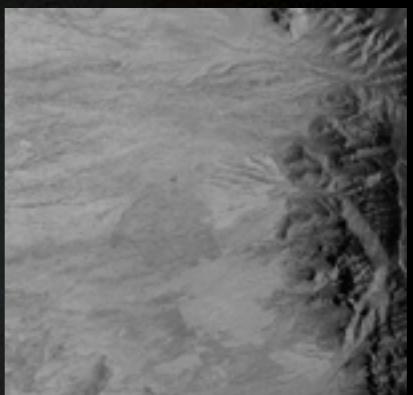


Spatial Data Types - Raster

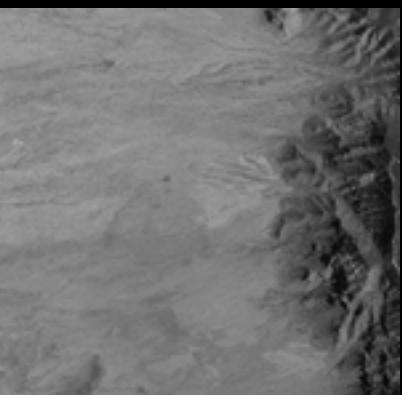
- Regularly gridded values
- Representing continuous values across space, for example
 - Elevation
 - Concentration or density
 - Reflectance (imagery)
- May be single or multiple “band” = value/pixel



Blue



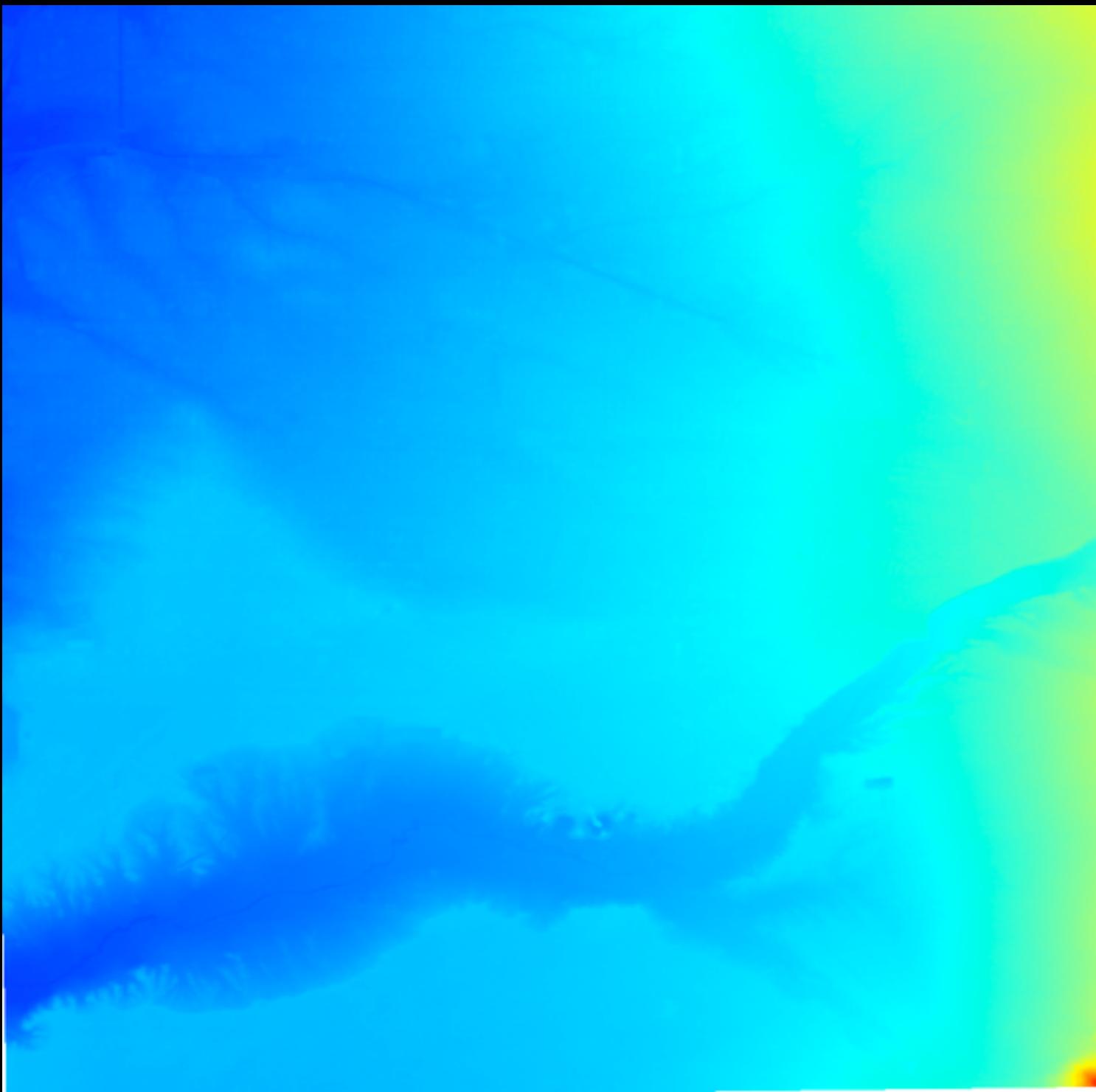
Red



Green

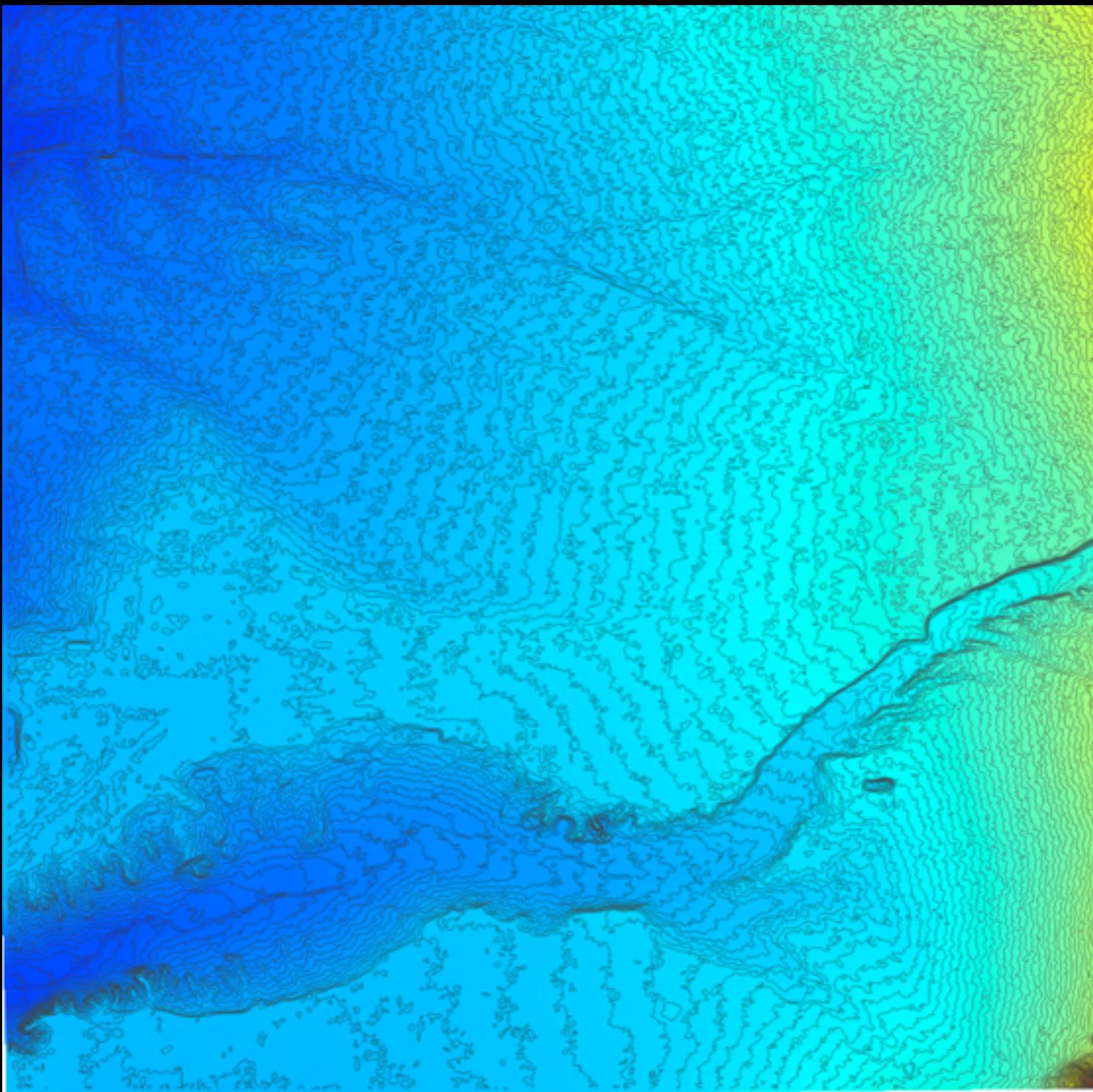
Sample image from Trinity Site SE, NAIP 2011 DOQQ ([metadata](#))
http://rgis.unm.edu/gstore/datasets/4dcba4c5-b3b0-451f-b4b8-97d83d3850d0/m_3310621_se_13_I_20110521.original.tif

Data Derived from Raster Data



Digital Elevation Model
for *Albuquerque East*
Topographic Quad
[\(download\)](#) [\(metadata\)](#)

Data Derived from Raster Data



Contour Lines based
upon the Digital
Elevation Model
for *Albuquerque East*
Topographic Quad

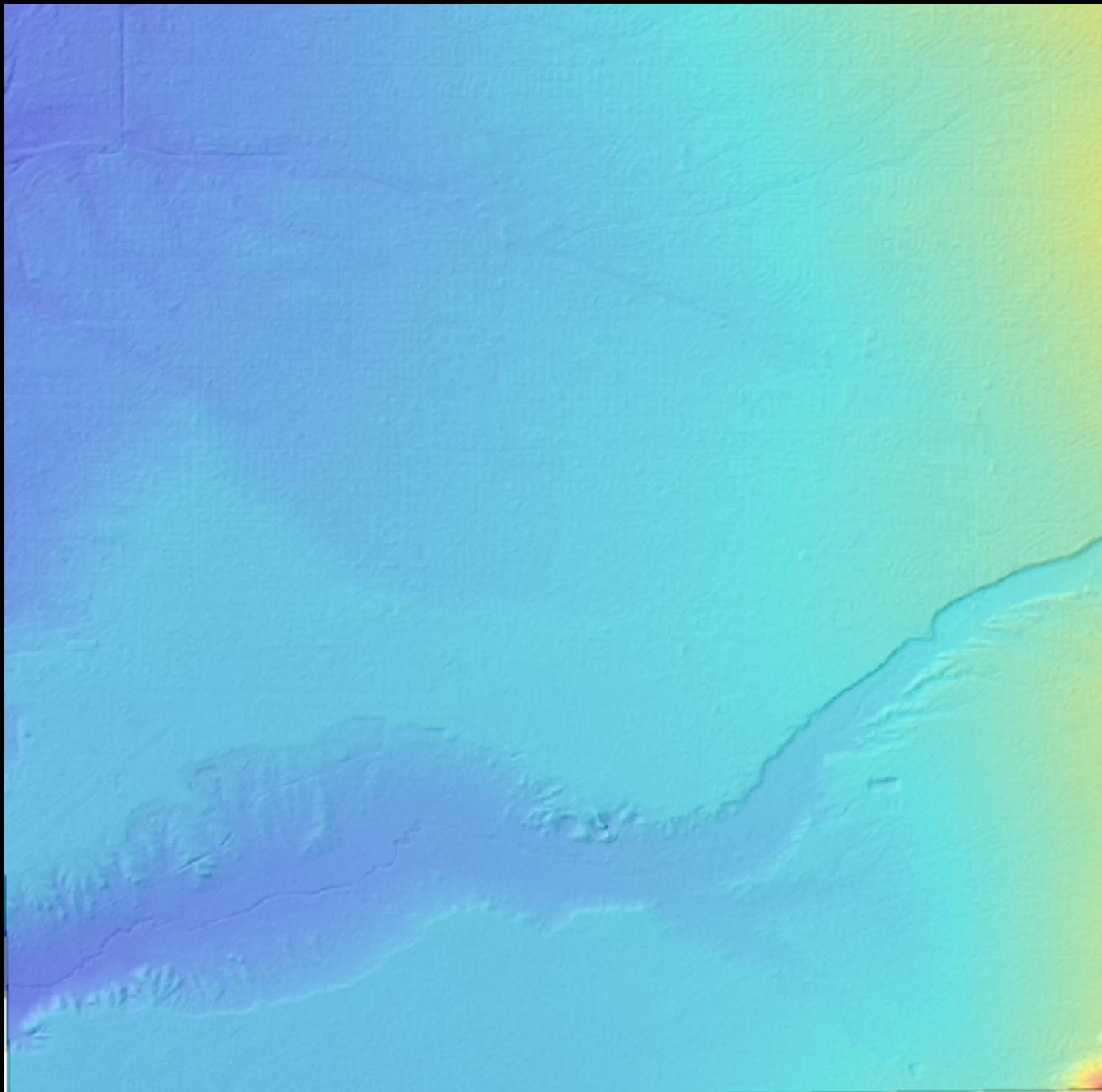
[\(download\)](#) [\(metadata\)](#)

Data Derived from Raster Data



Hillshade based upon
the Digital Elevation
Model
for Albuquerque East
Topographic Quad
([download](#)) ([metadata](#))

Data Derived from Raster Data



Hillshade based upon
the Digital Elevation
Model
*for Albuquerque East
Topographic Quad*
[\(download\)](#) [\(metadata\)](#)

Spatial Data Types - GeoDatabases

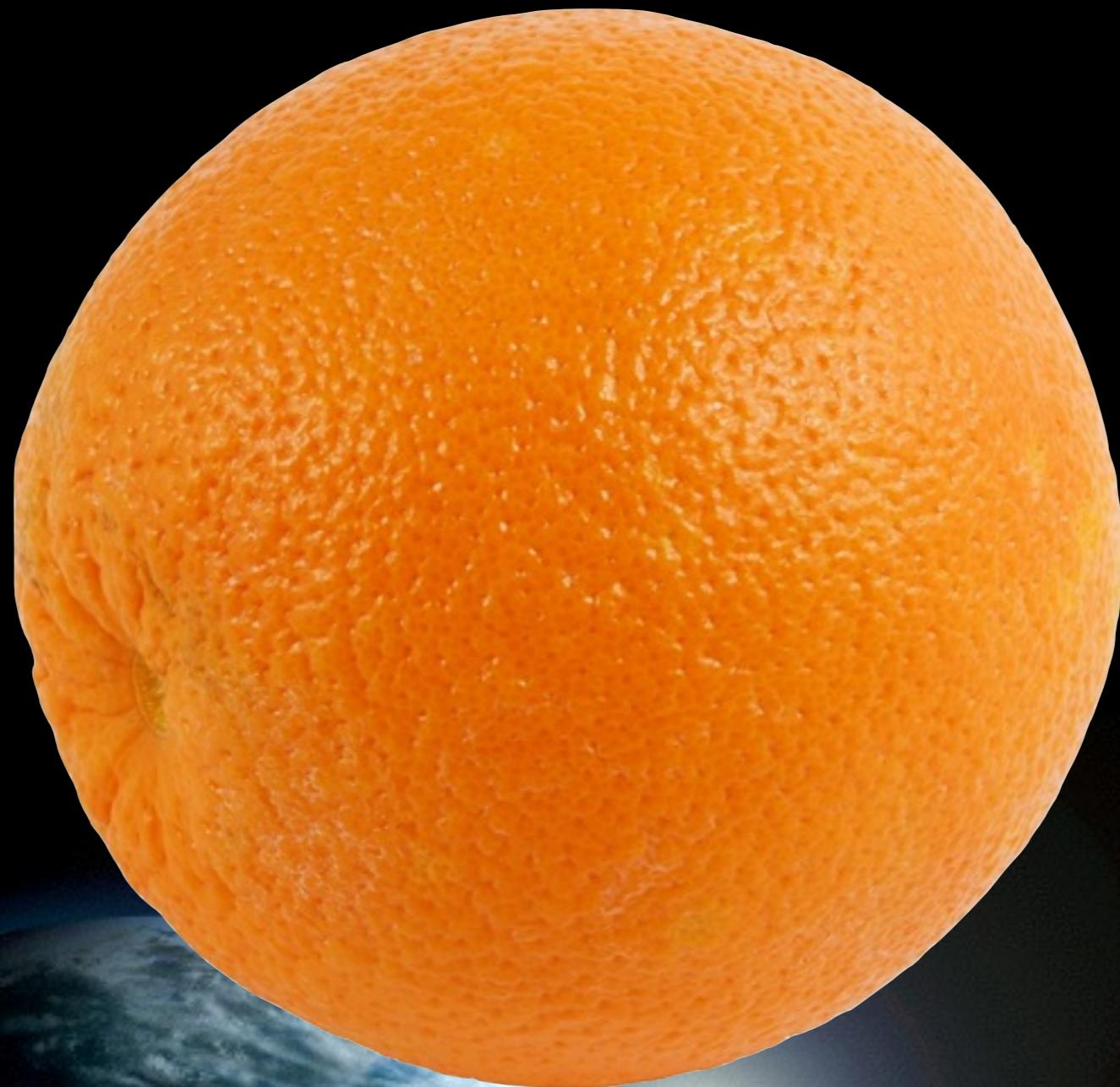
- Database model for storing geospatial data
- May contain *vector*, *raster* and *tabular* data
- May implement specialized analytic functions within the database



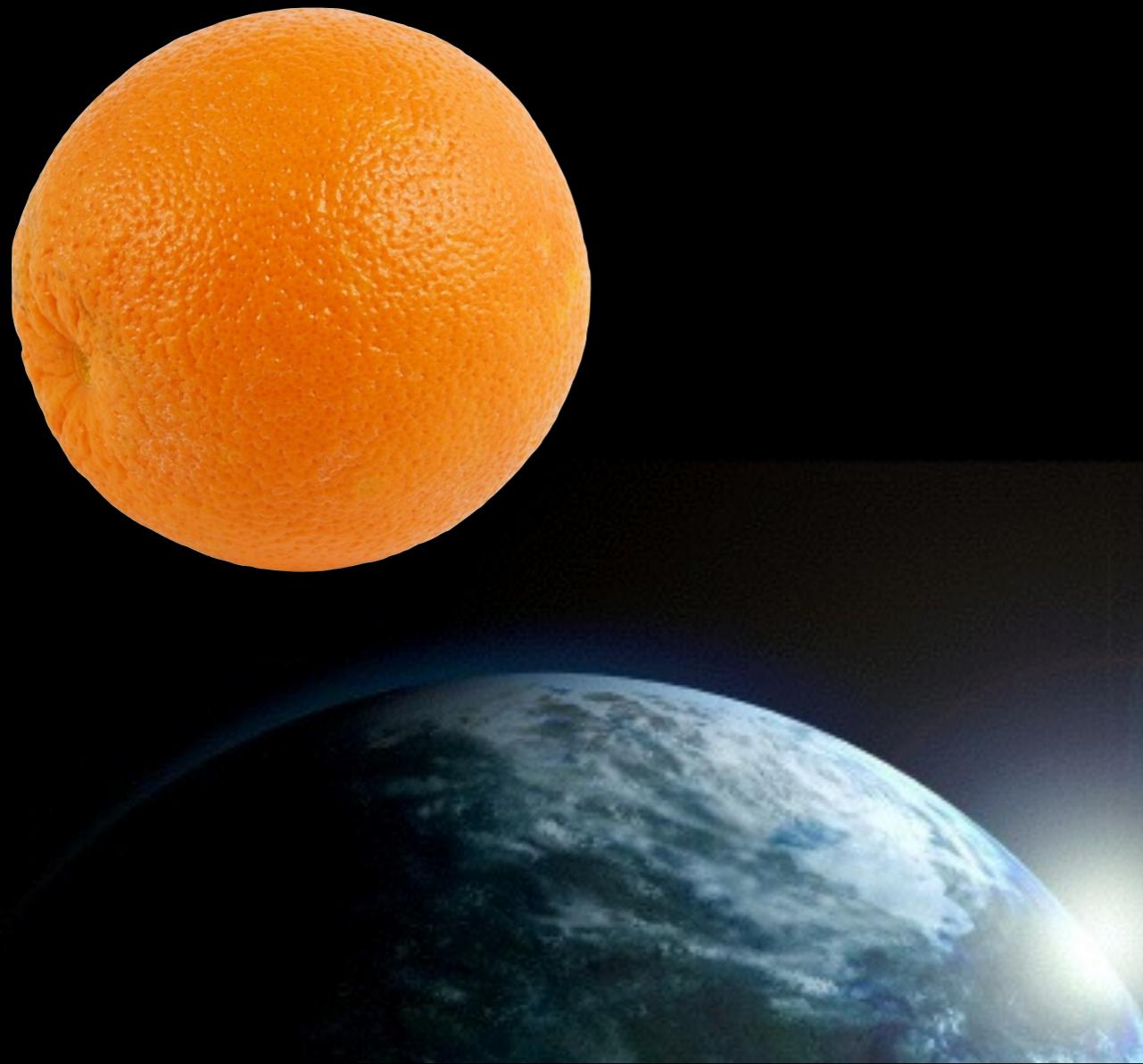
Representation of Coordinates



Flattening the Earth



Flattening the Earth

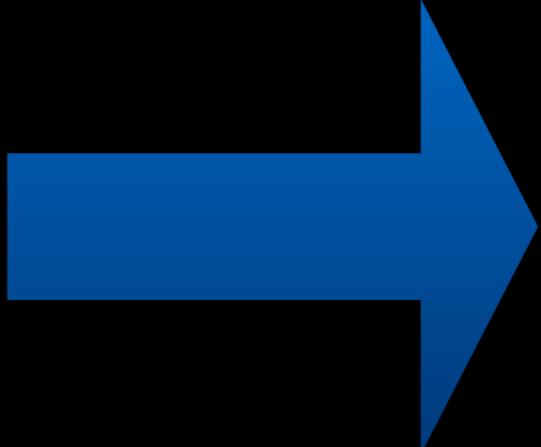


Flattening the Earth









Thanks to [XKCD](#)



WHAT YOUR FAVORITE
MAP PROJECTION
SAYS ABOUT YOU

MERCATOR

YOU'RE NOT A DEDICATED PERSON. YOU LOVE THE MERCATOR PROJECTION. YOU JUST WISH IT WEREN'T SQUARE. THE EARTH'S NOT A SQUARE, IT'S A OVAL. YOU LIKE CRISPS. TODAY IS GONNA BE A GOOD DAY.

ROBINSON

YOU HAVE A COMFORTABLE PAIR OF RUNNING SHOES THAT YOU WEAR EVERYWHERE. YOU LIKE COFFEE AND ENJOY THE SWEAT. YOU THINK THE ROBINSON IS THE BEST-LOOKING PROJECTION. HANOS DOWN.

WINKEL-TRIEPEL

NATIONAL GEOGRAPHIC ADOPTED THE WINKEL-TRIEPEL IN 1998, BUT YOU'VE BEEN A BIT TAN SINCE LONG BEFORE. "NAT GEO" SHOWED UP. YOU'RE WORRIED IT'S GOING TO GET OUT, AND ARE THINKING OF SETHING TO THE KITCHEN. YOU'VE GOT A PARTNIN DISH, WHICH A SIGHT SHAKED UP LIVING SHED WITH THIS. YOUR FAVORITE MOSHON, GOBLE, IS "TRENT".

GOODE-HOMOLOSINE

THEY SAY MAPPING THE EARTH ON A 2D SURFACE IS LIKE FLATTENING AN ORANGE PEEL, WHICH SEEMS ENOUGH. AND YOU LIKE DAY-SOUR CANDIES. YOU THINK WE MIGHT HAVE TO PARK PROBLEMS. I FIGGED OUT EXACT APPROPRIATE PEOPLE TO CHARGE, INSTEAD OF PLEASURES. YOU THINK AIRPLATES SHOULD SET OFF TOO MUCH FROM THE RESTAURANTS NEAR THE AIRPORTS, AND SERVE PART ON BOARD. YOU CHANGE YOUR OWN OIL, BUT BETTER WALKER, IF YOU REALLY NEED TO.

HOB-DYER

YOU WANT TO FIND CULTURAL HOMOPHONY, BUT YOU'VE HEARD BAD THINGS ABOUT GAY-PERS. YOU'RE CONFIDENT-ASSUE AND BUT DRUNK. YOU USE A POSITION-WEIGHTED SET OF GENDER-NEUTRAL FRIENDS AND THINK THAT'S WHAT THE WORLD NEEDS IS A REVOLUTION IN CONSCIOUSNESS.

PLATE-CARRÉE
(GOODE-HOMOLOSINE)

YOU THINK THIS ONE IS FINE. YOU LIKE HOW EASY IT IS TO LOCATE LATITUDE AND LONGITUDE. THE OTHER PROJECTIONS OVERCOMPLICATE THINGS. YOU WANT ME TO STOP TALKING ABOUT MAPS, SO I'LL GET BACK TO YOU.

A GLOBE!

YES, YOU'RE VERY CLEVER.

PEIRCE QUINCUNCIAL

YOU THINK THAT WHEN WE LOOK AT A MAP, THAT'S THE WAY WE SEE IT OURSELVES. AFTER YOU FIRST SAW ANGSTROM, YOU SAT SILENT IN THE THEATER FOR SIX HOURS. IT FORCED YOU OUT TO REALIZE THAT EVERYONE AROUND YOU HAS A SKILLION WAYS. THEY YOU AIN'T REALLY LOOKED AT YOUR HANDS.

WATERMAN-BUTTERFLY

ROBUST. YOU ALSO THE "WATERMAN" NAME. YOU SAW THE PEIRCE QUINCUNCIAL MAP — YOU HAVE A FRAMED REPRODUCTION AT HOME! UH... UHM, FORGET THESE QUESTIONS. ARE YOU DOING ANYTHING TONIGHT?

GALL-PETERS

I HATE YOU.



WHAT YOUR FAVORITE
MAP PROJECTION
SAYS ABOUT YOU

MERCATOR

YOU'RE NOT REALLY INTO MAPS.

ROBINSON

YOU HAVE A COMFORTABLE PAIR OF RUNNING SHOES THAT YOU WEAR EVERYWHERE. YOU LIKE COFFEE AND ENJOY THE BEATLES. YOU THINK THE ROBINSON IS THE BEST-LOOKING PROJECTION, HANDS DOWN.

VAN DER GRIJNEN

YOU'RE NOT A COMPLICATED PERSON. YOU LOVE THE MERCATOR PROJECTION; YOU JUST WISH IT WEREN'T SQUARE. THE EARTH'S NOT A SQUARE, IT'S A CIRCLE. YOU LIKE CIRCLES. TODAY IS GONNA BE A GOOD DAY!

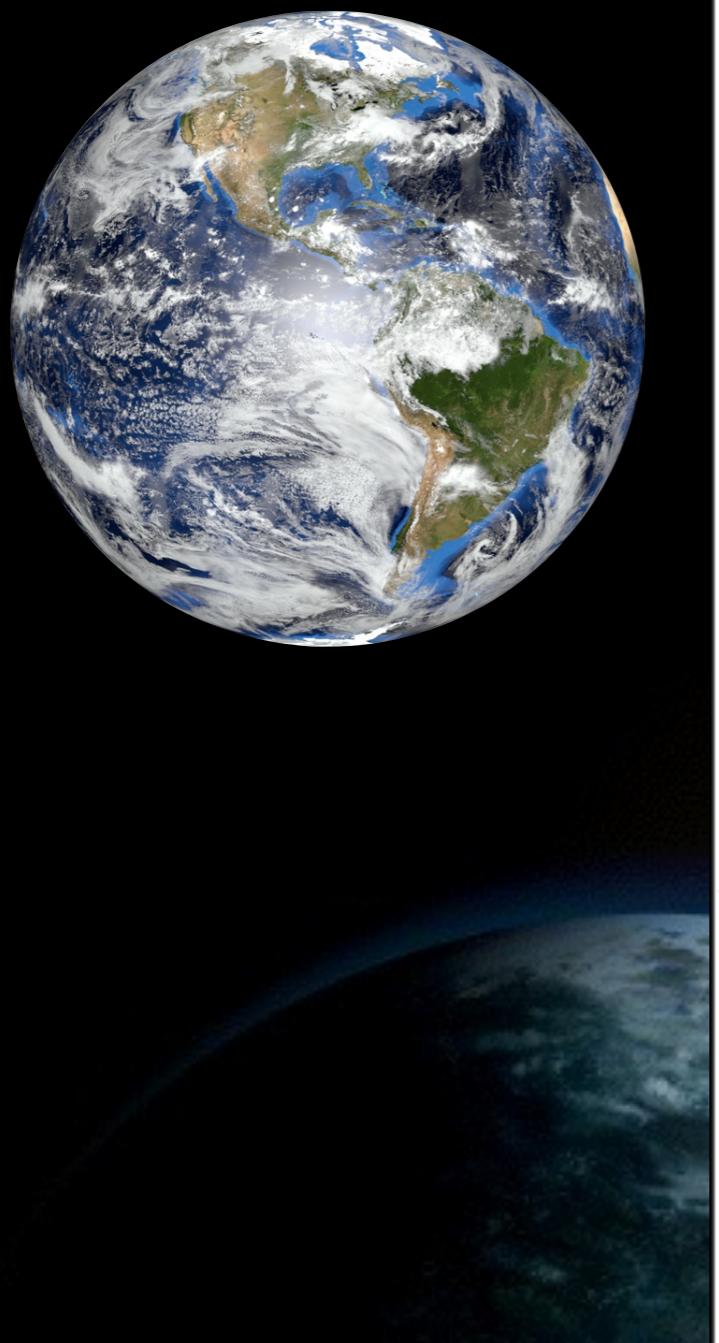
Dymaxion

YOU LIKE ISAAC ASIMOV, XML, AND SHOES WITH TOES. YOU THINK THE SEGWAY GOT A BAD RAP. YOU OWN 3D GOOGLES, WHICH YOU USE TO VIEW ROTATING MODELS OF BETTER 3D GOOGLES. YOU TYPE IN DVORAK.

WINKEL-TRIPEL

GOODE HOMOLOSINE

A comic strip titled "WHAT YOUR FAVORITE MAP PROJECTION SAYS ABOUT YOU" featuring six different map projections: Mercator, Robinson, Van der Grinten, Dymaxion, Winkel-Tripel, and Goode Homolosine. Each projection is shown as a solid black silhouette against a white background. The comic uses a combination of text and imagery to make broad personality statements based on the chosen map projection.



ENJOY THE BEERIES. YOU THINK THE ROBINSON IS THE BEST-LOOKING PROJECTION, HANDS DOWN.

GOOGLES, WHICH YOU USE TO VIEW ROTATING MODELS OF BETTER 3D GOOGLES. YOU TYPE IN DVORAK.

WINKEL-TRIPEL



NATIONAL GEOGRAPHIC ADOPTED THE WINKEL-TRIPEL IN 1998, BUT YOU'VE BEEN A W-T FAN SINCE LONG BEFORE "NAT GEO" SHOWED UP. YOU'RE WORRIED IT'S GETTING PLAYED OUT, AND ARE THINKING OF SWITCHING TO THE KAVRAYSKIY. YOU ONCE LEFT A PARTY IN DISGUST WHEN A GUEST SHOWED UP WEARING SHOES WITH TOES. YOUR FAVORITE MUSICAL GENRE IS "POST-".

HOBЫ-DYER



YOU WANT TO AVOID CULTURAL IMPERIALISM, BUT YOU'VE HEARD BAD THINGS ABOUT GALL-PETERS. YOU'RE CONFLICT-AVERSE AND BUY ORGANIC. YOU USE A RECENTLY-INVENTED SET OF GENDER-NEUTRAL PRONOUNS AND THINK THAT WHAT THE WORLD NEEDS IS A REVOLUTION IN CONSCIOUSNESS.

A GLOBE!

GOODE HOMOLOSIDINE



THEY SAY MAPPING THE EARTH ON A 2D SURFACE IS LIKE FLATTENING AN ORANGE PEEL, WHICH SEEMS EASY ENOUGH TO YOU. YOU LIKE EASY SOLUTIONS. YOU THINK WE WOULDN'T HAVE SO MANY PROBLEMS IF WE'D JUST ELECT *NORMAL* PEOPLE TO CONGRESS INSTEAD OF POLITICIANS. YOU THINK AIRLINES SHOULD JUST BUY FOOD FROM THE RESTAURANTS NEAR THE GATES AND SERVE THAT ON BOARD. YOU CHANGE YOUR CAR'S OIL, BUT SECRETLY WONDER IF YOU REALLY NEED TO.

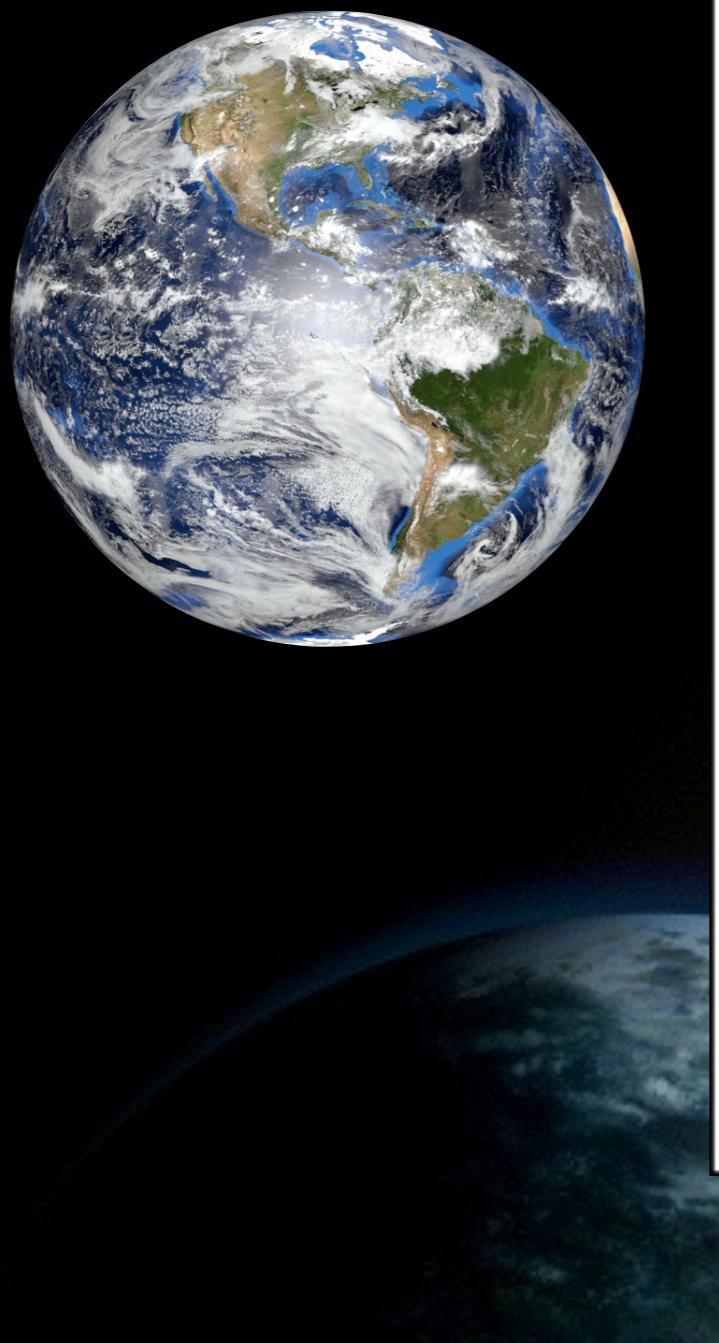
PLATE CARRÉE (EQUIRECTANGULAR)



YOU THINK THIS ONE IS FINE. YOU LIKE HOW X AND Y MAP TO LATITUDE AND LONGITUDE. THE OTHER PROJECTIONS OVERCOMPLICATE THINGS. YOU WANT ME TO STOP ASKING ABOUT MAPS SO YOU CAN ENJOY DINNER.

WATERMAN BUTTERFLY





USE A RECENTLY-INVENTED SET OF GENDER-NEUTRAL PRONOUNS AND THINK THAT WHAT THE WORLD NEEDS IS A REVOLUTION IN CONSCIOUSNESS.

A GLOBE!



YES, YOU'RE VERY CLEVER.

PEIRCE QUINCUNCIAL



YOU THINK THAT WHEN WE LOOK AT A MAP, WHAT WE REALLY SEE IS OURSELVES. AFTER YOU FIRST SAW INCEPTION, YOU SAT SILENT IN THE THEATER FOR SIX HOURS. IT FREAKS YOU OUT TO REALIZE THAT EVERYONE AROUND YOU HAS A SKELETON INSIDE THEM. YOU HAVE REALLY LOOKED AT YOUR HANDS.

TO STOP ASKING ABOUT MAPS SO YOU CAN ENJOY DINNER.

WATERMAN BUTTERFLY



REALLY? YOU KNOW THE WATERMAN? HAVE YOU SEEN THE 1909 CAHILL MAP IT'S BASED—... YOU HAVE A FRAMED REPRODUCTION AT HOME?! WHOA. ...LISTEN, FORGET THESE QUESTIONS. ARE YOU DOING ANYTHING TONIGHT?

GALL-PETERS



I HATE YOU.

What Is the Impact of Different Projections

- Coordinate values **ARE NOT** the same from one projection to another - even if they look similar
- Even Latitude and Longitude are not constant in the absence of a specific definition of the shape of the Earth
- *You Must Know the Projection (Coordinate Reference System) of your data*



Classification & Tradeoffs

- All map projections represent choices between different types of distortion
 - Area (equal area projections)
 - Direction and Shape (azimuthal, conformal)
 - Distance (equidistance)
- Geometric form upon which the Earth is projected
 - Cone
 - Cylinder
 - Plane



Resources for Identifying Spatial Reference Systems

- Some common systems for labeling systems
 - EPSG Codes (numeric codes that correspond with specific projection parameters)
 - ESRI References (.prj file model/ESRI WKT)
 - Proj4 Definitions (transformations defined using the Proj4 syntax)
 - WKT (OGC Well Known Text)
- Good resource for finding reference information
 - <http://spatialreference.org/>

Accuracy and Precision of Location Data

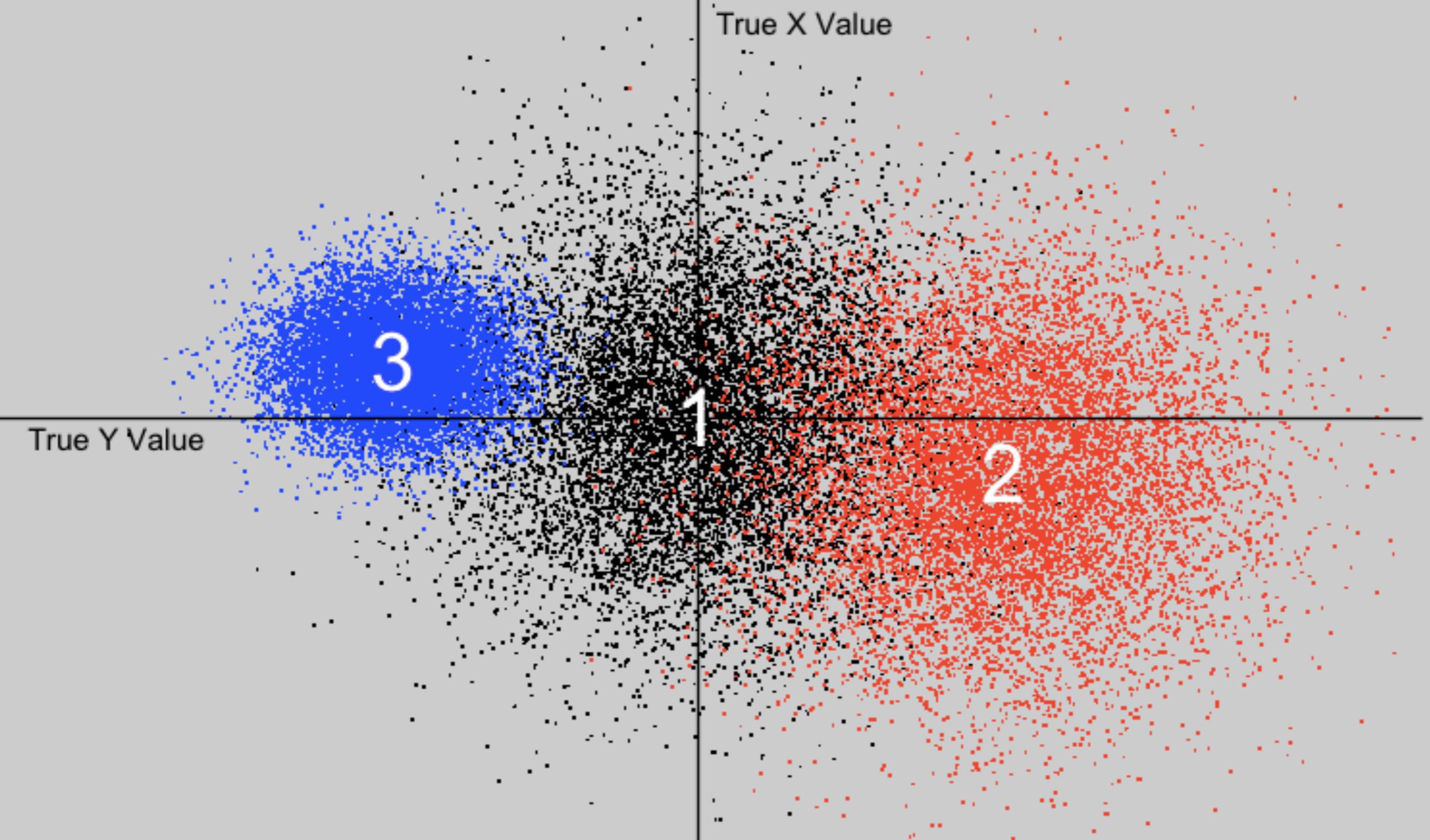


Definitions

- *Accuracy:* The closeness of a measured or computed value to its true value
- *Precision:* The closeness of repeated measurements of the same quantity to each other

Sokal and Rohlf (1995). *Biometry: The Principles and Practices of Statistics in Biological Research*. W. H. Freeman.
3rd edition. pg. 13





Relation with Spatial Data

How Does This Relate to Geographic Data

- Location is estimated using wide variety of methods, each with its own *known* or *unknown* accuracy and precision
 - Geocoding - estimation of geographic coordinates from street addresses
 - Satellite or aerial imagery
 - Total Stations/Laser Rangefinders
 - Global Positioning Systems

Sources of Bias in Spatial Data

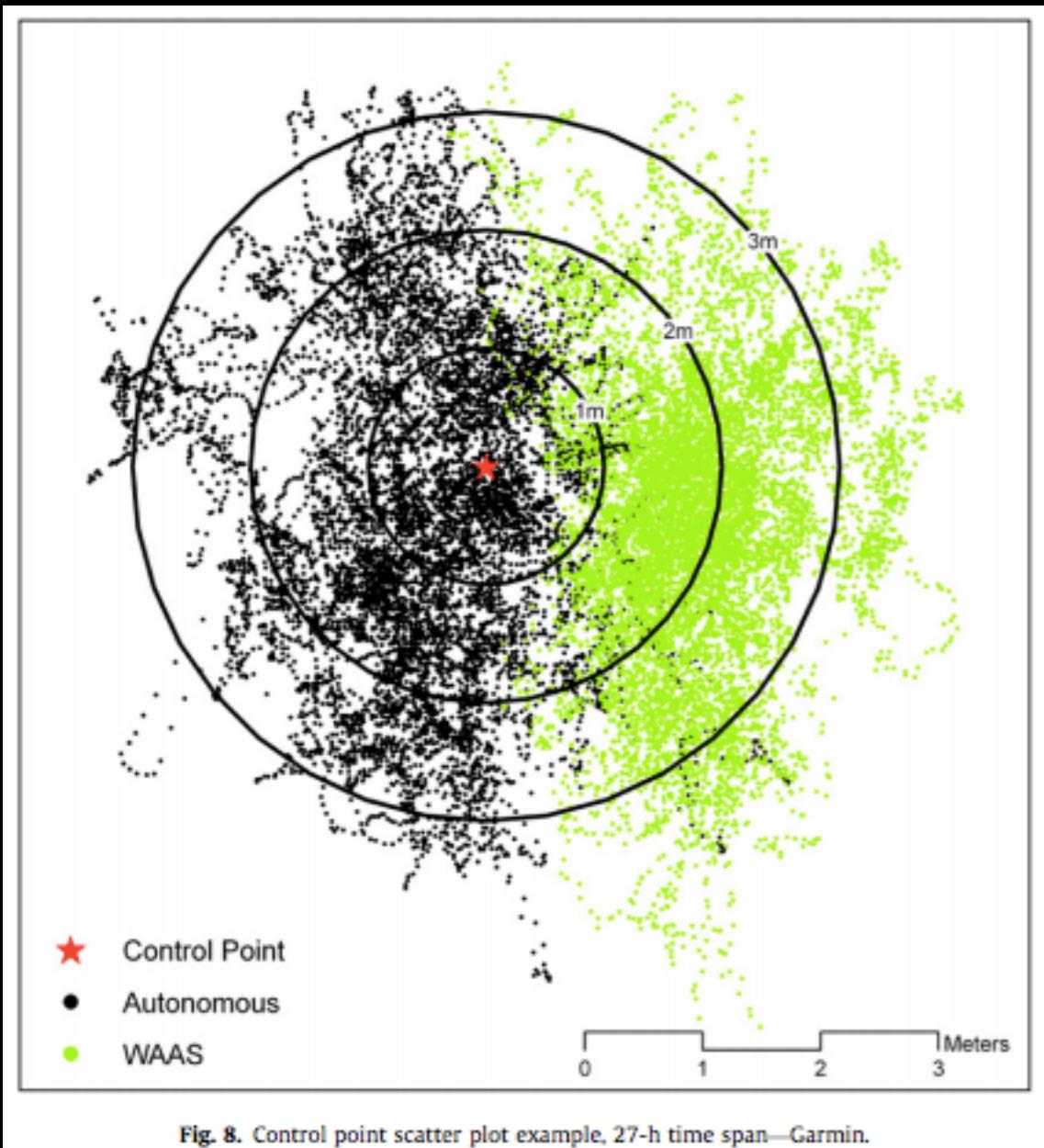
Systematic errors or misrepresentation of location or spatial relationships may be a product of *bias* in measurements, errors in representation of data, or explicit *choices* made in data storage and presentation

- Incorrect datum selection for spatial data
- Instrument mis-calibration
- Mis-located control point from which map points are derived
- A stretched measuring tape
- A strong electro-magnetic field
- Map projection characteristics
- Target map/data scale
- and many others ...

Map Projections - redux

- Map projections are *designed* with specific goals in mind:
 - Focus on particular world region
 - Retention of specific attributes: *direction*, *distance*, *area*
 - Defined in reference to preferred units
- There are an infinite number of potential map projection, each of which defines a mathematical transformation from a spherical coordinate system to a rectangular grid.

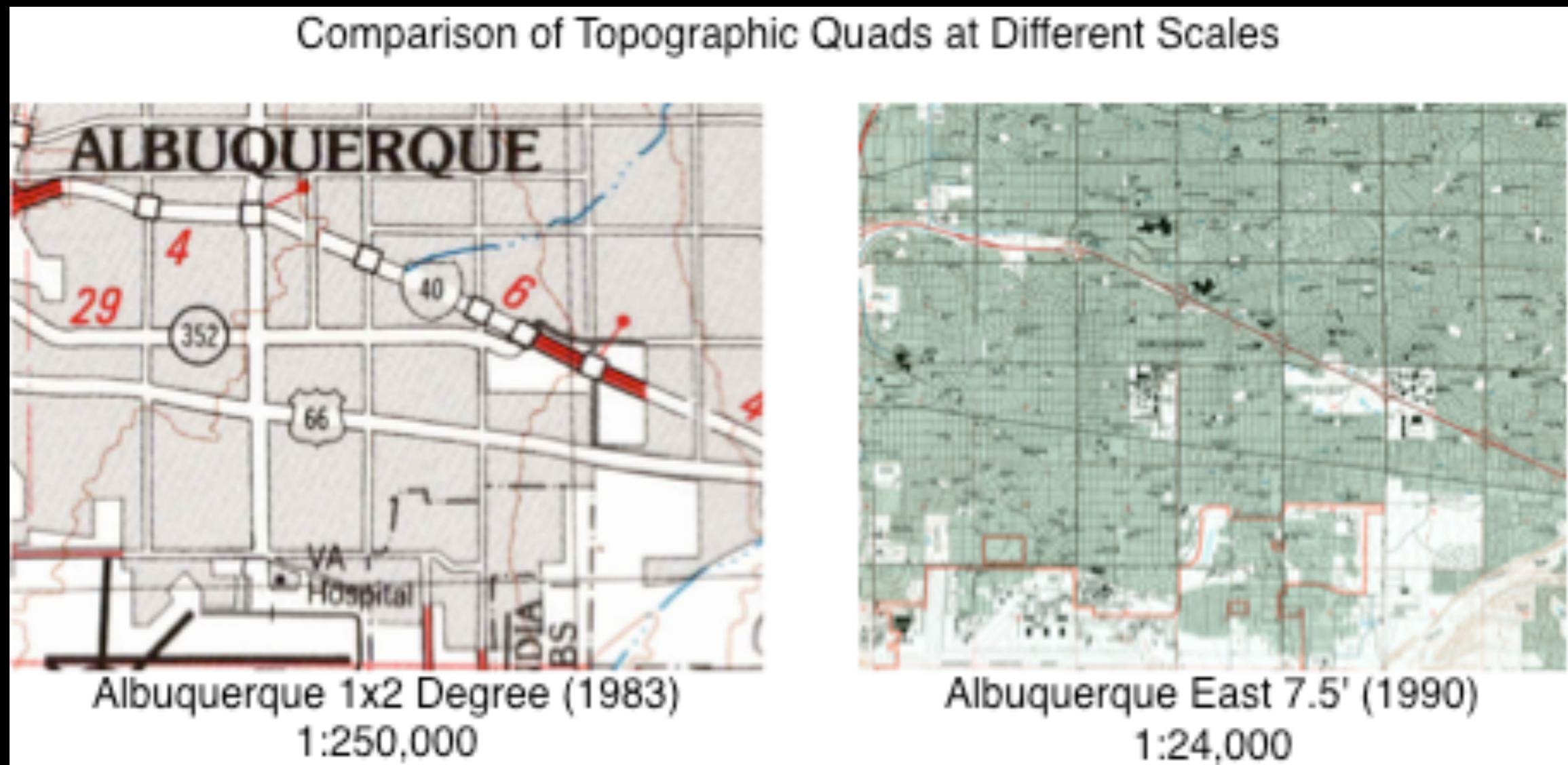
GPS Drift



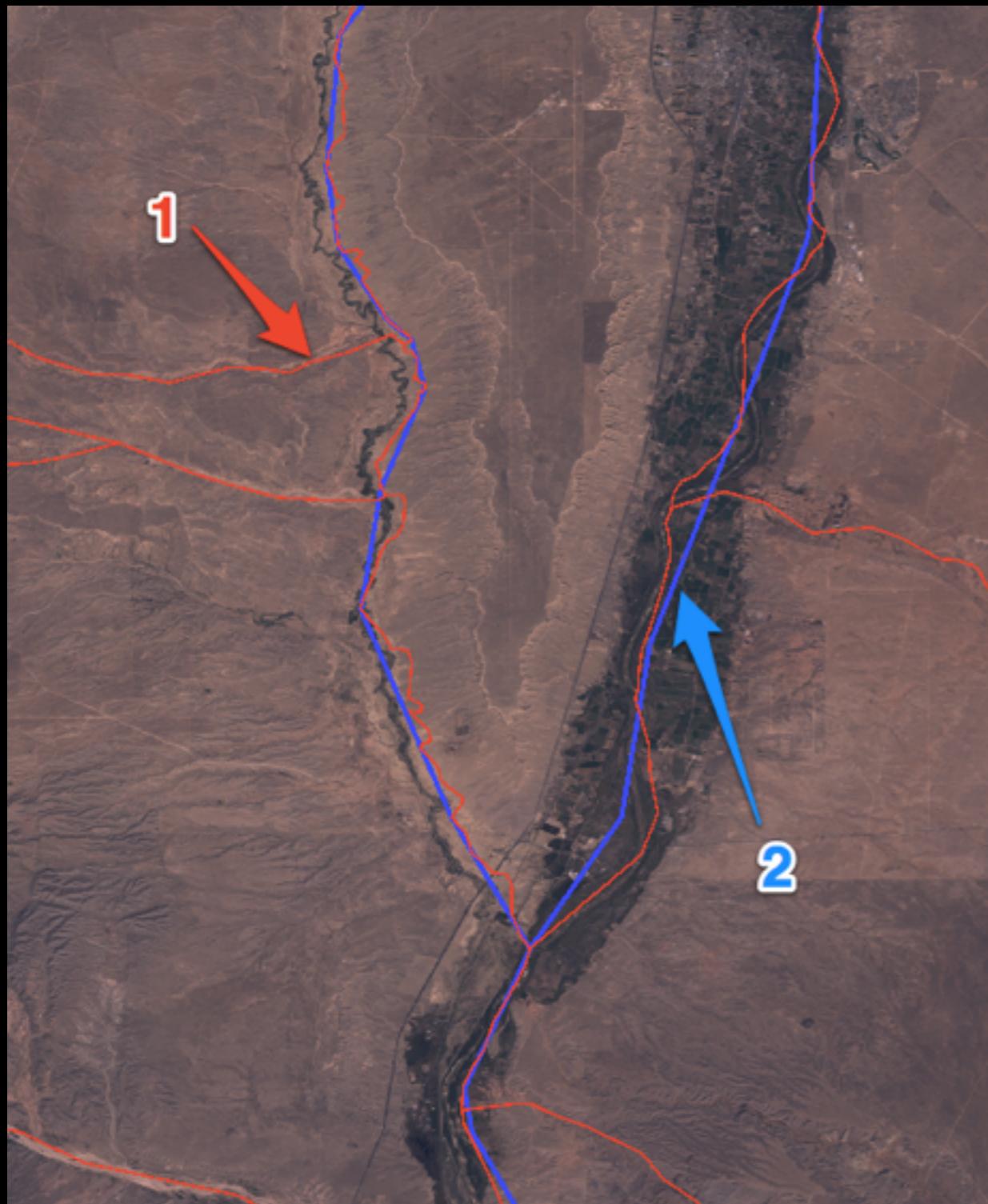
- 24-hour drift of an autonomous and WAAS GPS point scatter

From: Arnold and Zandbergen (2011). Positional Accuracy of the Wide Area Augmentation System in Consumer-Grade GPS Units. *Computers & Geosciences* 37. pp 883-892

Map Scale Comparisons



Map Scale Comparisons



- Comparison of two hydrography datasets
 - National Atlas: Hydrography ([download](#))
 - National Atlas: Streams and Water Bodies ([download](#))

Data Formats and Tools



Common Formats

- Tabular data: CSV, DBF, Excel
- Vector data: ESRI Shapefile, KML, GML
- Raster data: GeoTIFF, ECW (NetCDF, HDF)

There are many more, but these are some of the more frequently encountered formats



Tools - Geographic Information Systems

- Data creation and management
- Documentation
- Integration
- Visualization
- Analysis
- Programming
- Sharing/Publication

