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Cambio de coordenadas

List 2-3 fundamental differences between a geographic and a projected CRS.Describe the elements of each zone within Universal Trans Mercator (UTM) CRS and Geographic (WGS84) CRS.On the previous page, you explored the basic concept of a coordinate reference system. You looked at two different types of Coordinate Reference Systems:Geographic coordinate systems: coordinate systems that span the entire globe (e.g. latitude / longitude).Projected coordinate Systems: coordinate systems that are localized to minimize visual distortion in a particular region (e.g. Robinson, UTM, State Plane)On this page, you will learn about the differences between these CRSs in more detail.As you discussed in the previous lesson, each CRS is optimized to best represent the:shape and/orscale / distance and/orareaof features in a dataset. There is not a single CRS that does a great job at optimizing all three elements: shape, distance AND area. Some CRSs are optimized for shape, some are optimized for distance and some are optimized for area. Some CRSs are also optimized for particular regions - for instance the United States, or Europe.Intro to Geographic Coordinate Reference SystemsGeographic coordinate systems (which are often but not always in decimal degree units) are often optimal when you need to locate places on the Earth. Or when you need to create global maps. However, latitude and longitude locations are not located using uniform measurement units. Thus, geographic CRSs are not ideal for measuring distance. This is why other projected CRS have been developed. A geographic coordinate system locates latitude and longitude location using angles. Thus the spacing of each line of latitude moving north and south is not uniform. Source: ESRIThe Structure of a Geographic CRSA geographic CRS uses a grid that wraps around the entire globe. This means that each point on the globe is defined using the SAME coordinate system and the same units as defined within that particular geographic CRS. Geographic coordinate reference systems are best for global analysis however it is important to remember that distance is distorted using a geographic lat / long CRS.The geographic WGS84 lat/long CRS has an origin - (0,0) - located at the intersection of the Equator (0° latitude) and Prime Meridian (0° longitude) on the globe.You will review what data projected in a geographic CRS look like.import os from glob import glob import numpy as np import pandas as pd import matplotlib.pyplot as plt from matplotlib.ticker import ScalarFormatter import geopandas as gpd from shapely.geometry import Point import earthpy as et import seaborn as sns # Adjust plot font sizes sns.set(font_scale=1.5) sns.set_style("white") # Set working dir & get data data = et.data.get_data('spatial-vector-lidar') os.chdir(os.path.join(et.io.HOME, 'earth-analytics')) Global map in a geographic Coordinate Reference System. Data Note: The distance between the 2 degrees of longitude at the equator (0°) is ~ 69 miles. The distance between 2 degrees of longitude at 40°N (or S) is only 53 miles. This difference in actual distance relative to “distance” between the actual parallels and meridians demonstrates how distance calculations will be less accurate when using geographic CRSsProjected Coordinate Reference SystemsAs you learned above, geographic coordinate systems are ideal for creating global maps. However, they are prone to error when quantifying distance. In contrast, various spatial projections have evolved that can be used to more accurately capture distance, shape and/or area.What is a Spatial ProjectionSpatial projection refers to the mathematical calculations performed to flatten the 3D data onto a 2D plane (your computer screen or a paper map). Projecting data from a round surface onto a flat surface, results in visual modifications to the data when plotted on a map. Some areas are stretched and some are compressed. You can see this distortion when you look at a map of the entire globe.The mathematical calculations used in spatial projections are designed to optimize the relative size and shape of a particular region on the globe. The 3-dimensional globe must be transformed to create a flat 2-dimensional map. How that transformation or **projection** occurs changes the appearance of the final map and the relative size of objects in different parts of the map. Source: CA Furuti, progonos.com/furutiAbout UTMThe Universal Transverse Mercator (UTM) system is a commonly used projected coordinate reference system. UTM subdivides the globe into zones, numbered 0-60 (equivalent to longitude) and regions (north and south) Data Note: UTM zones are also defined using bands, lettered C-X (equivalent to latitude) however, the band designation is often dropped as it isn’t essential to specifying the location.While UTM zones span the entire globe, UTM uses a regional projection and associated coordinate system. The coordinate system grid for each zone is projected individually using the Mercator projection.The origin (0,0) for each UTM zone and associated region is located at the intersection of the equator and a location, 500,000 meters east of the central meridian of each zone. The origin location is placed outside of the boundary of the UTM zone, to avoid negative Easting numbers. The 0,0 origin of each UTM zone is located in the Bottom left hand corner (south west) of the zone - exactly 500,000 m EAST from the central meridian of the zone. Source: Penn State E-education The gridded UTM coordinate system across the globe. Source: NASA Earth ObservatoryUnderstand UTM CoordinatesCompare coordinates for one location, but saved in two different CRSs to better understand what this looks like. The coordinates for Boulder, Colorado in UTM are:UTM Zone 13N easting: 476,911.31m, northing: 4,429,455.35Remember that N denotes that it is in the Northern hemisphere on the Earth.Plot this coordinate on a map.boulder_df = np.array([[476911.31, 4429455.35]]) geometry = [Point(xy) for xy in boulder_df] boulder_loc = gpd.GeoDataFrame(geometry, columns=['geometry'], crs={'init': 'epsg:2957'}) /opt/conda/lib/python3.8/site-packages/pyproj/crs/crs.py:53: FutureWarning: '+init=:' syntax is deprecated. ':' is the preferred initialization method. When making the change, be mindful of axis order changes: return _prepare_from_string(" ".join(pjargs)) fig, ax = plt.subplots(figsize=(10, 10)) boulder_loc.plot(ax=ax) ax.set_title("Plot of Boulder, CO Location") # Turn off scientific notation plt.ticklabel_format(useOffset=False) plt.show() Plot of a single point that is provided for Boulder, Colorado in UTM units.# View crs boulder_loc.crs Name: NAD83(CSRS) / UTM zone 13N Axis Info [cartesian]: - E[east]: Easting (metre) - N[north]: Northing (metre) Area of Use: - name: Canada - 108°W to 102°W - bounds: (-108.0, 48.99, -102.0, 84.0) Coordinate Operation: - name: UTM zone 13N - method: Transverse Mercator Datum: NAD83 Canadian Spatial Reference System - Ellipsoid: GRS 1980 - Prime Meridian: Greenwich Note the projection of your data in UTM is EPSG code 2957If you spatially project your data into a geographic coordinate refence system, notice how your new coordinates are different - yet they still represent the same location.# Reproject the data to WGS84 boulder_df_geog = boulder_loc.to_crs(epsg=4326) boulder_df_geog.crs Name: WGS 84 Axis Info [ellipsoidal]: - Lat[north]: Geodetic latitude (degree) - Lon[east]: Geodetic longitude (degree) Area of Use: - name: World - bounds: (-180.0, -90.0, 180.0, 90.0) Datum: World Geodetic System 1984 - Ellipsoid: WGS 84 - Prime Meridian: Greenwich # View the coordinate values of the newly reprojected data. boulder_df_geog geometry0POINT (-105.27055 40.01498)Now you can plot your data on top of your world map which is also in a geographic CRS.fig, ax = plt.subplots(figsize=(10, 5)) worldBound.plot(cmap='Greys', ax=ax) ax.set(title="World map with Boulder, CO location Geographic WGS84 CRS", xlabel="X Coordinates (Decimal Degrees)", ylabel="Y Coordinates (Decimal Degrees)") boulder_df_geog.plot(ax=ax, markersize=52, color='springgreen') plt.show() Map showing the location of Boulder, CO. All layers are in geographic WGS84 CRS.Important TipsWhile sometimes UTM zones in the north vs south are specified using N and S respectively (e.g. UTM Zone 18N) other times you may see a letter as follows: Zone 18T, 730782m Easting, 4712631m Northing vs UTM Zone 18N, 730782m, 4712631m. Data Tip: The UTM system doesn’t apply to polar regions (>80°N or S). Universal Polar Stereographic (UPS) coordinate system is used in these area. This is where zones A, B and Y, Z are used if you were wondering why they weren’t in the UTM lettering system.The penn state e-education institute has a nice interactive tool that you can use to explore utm coordinate reference systems.View UTM Interactive toolDatumThe datum describes the vertical and horizontal reference point of the coordinate system. The vertical datum describes the relationship between a specific ellipsoid (the top of the earth’s surface) and the center of the earth. The datum also describes the origin (0,0) of a coordinate system.Frequently encountered datums:WGS84 – World Geodetic System (created in) 1984. The origin is the center of the earth.NAD27 & NAD83 – North American Datum 1927 and 1983, respectively. The origin for NAD 27 is Meades Ranch in Kansas.ED50 – European Datum 1950NOTE: All coordinate reference systems have a vertical and horizontal datum which defines a “0, 0” reference point. There are two models used to define the datum: ellipsoid (or spheroid): a mathematically representation of the shape of the earth. Visit Wikipedia’s article on the earth ellipsoid for more information and geoid: a model of the earth’s gravitatinal field which approximates the mean sea level across the entire earth. It is from this that elevation is measured. Visit Wikipedia’s geoid article for more information. You will not cover these concepts in this tutorial.Coordinate Reference System FormatsThere are numerous formats that are used to document a CRS. In the next tutorial you will discuss three of the commonly encountered formats including: Proj4, WKT (Well Known Text) and EPSG. CRS: epsg vs proj.4 Coordinate Reference Systems Aprende a convertir coordenadas geográficas a UTM y cartesianas fácilmente con fórmulas y ejemplos claros.Descubre cómo transformar coordenadas ECEF, UTM o polares a geodésicas usando pasos prácticos.Convertir coordenadas geográficas (latitud, longitud) a UTM.Transformar coordenadas cartesianas (X, Y, Z) a geodésicas (φ, λ, h).Calcular coordenadas polares a cartesianas en 3D.Convertir coordenadas ECEF a geodésicas usando el modelo WGS84.CiudadLatitud (°)Longitud (°)Zona UTMEasting (m)Northing (m)Ciudad de México19.4326-99.133214Q4482512141932Buenos Aires-34.6037-58.381621H5800006190000Madrid40.4168-3.703830T4410004475000Sydney-33.8688151.209356H3340006250000Tokio35.6895139.691754S3880003950000VariableDescripciónValor TípicoUnidadaSemieje mayor del elipsoide WGS846378137mfAplanamiento del elipsoide1/298.257223563adimensionale²Excentricidad al cuadrado0.00669437999014adimensionalφLatitud geodésicaVariablegrados o radianesλLongitud geodésicaVariablegrados o radianeshAltura sobre el elipsoideVariablemPara convertir latitud (φ), longitud (λ) y altura (h) a coordenadas cartesianas (X, Y, Z) en el sistema ECEF (Earth-Centered, Earth-Fixed), se utilizan las siguientes fórmulas:X = (N + h) × cos(φ) × cos(λ)Y = (N + h) × cos(φ) × sin(λ)Z = (N × (1 – e²) + h) × sin(φ)donde:N = Radio de curvatura en el primer vertical, calculado como a / sqrt(1 – e² × sin²(φ))a = Semieje mayor del elipsoide (WGS84: 6378137 m)e² = Excentricidad al cuadrado del elipsoide (WGS84: 0.00669437999014)φ = Latitud geodésica en radianesλ = Longitud geodésica en radianesh = Altura sobre el elipsoide en metrosEl proceso inverso es más complejo y se realiza mediante iteraciones o fórmulas aproximadas. Un método común es el algoritmo de Bowring:p = sqrt(X² + Y²)θ = atan2(Z × a, p × b)φ = atan2(Z + e′² × b × sin³(θ), p – e² × a × cos³(θ))λ = atan2(Y, X)N = a / sqrt(1 – e² × sin²(φ))h = p / cos(φ) – Ndonde:b = Semieje menor del elipsoide, b = a × (1 – f)e′² = Excentricidad segunda al cuadrado, e′² = (a² – b²) / b²atan2 = Función arcotangente de dos argumentos que devuelve el ángulo correctoEl sistema UTM divide la Tierra en zonas de 6° de longitud. La conversión utiliza las siguientes fórmulas simplificadas:k₀ = 0.9996 (factor de escala)λ₀ = longitud central de la zona UTMN = a / sqrt(1 – e² × sin²(φ))T = tan²(φ)C = e′² × cos²(φ)A = (λ – λ₀) × cos(φ)M = a × ((1 – e²/4 – 3e⁴/64 – 5e⁶/256) × φ – (3e²/8 + 3e⁴/32 + 45e⁶/1024) × sin(2φ) + (15e⁴/256 + 45e⁶/1024) × sin(4φ) – (35e⁶/3072) × sin(6φ))Las coordenadas UTM se calculan como:Easting = k₀ × N × (A + (1 – T + C) × A³/6 + (5 – 18T + T² + 72C – 58e′²) × A⁵/120) + 500000Northing = k₀ × (M + N × tan(φ) × (A²/2 + (5 – T + 9C + 4C²) × A⁴/24 + (61 – 58T + T² + 600C – 330e′²) × A⁶/720))Para hemisferio sur, se suma 10,000,000 m al Northing para evitar valores negativos.En 2D, dadas coordenadas polares (r, θ), la conversión a cartesianas (x, y) es:x = r × cos(θ)y = r × sin(θ)En 3D, con coordenadas esféricas (r, θ, φ):x = r × sin(φ) × cos(θ)y = r × sin(φ) × sin(θ)z = r × cos(φ)donde θ es el ángulo azimutal y φ el ángulo polar (colatitud).Suponga que desea convertir las coordenadas geográficas de la Ciudad de México (19.4326° N, -99.1332° O) a UTM.Latitud φ = 19.4326° → 0.339 radLongitud λ = -99.1332° → -1.730 radZona UTM: 14 (longitud central λ₀ = -99° → -1.727 rad)Calcule las variables necesarias:e² = 0.00669437999014a = 6378137 mN = a / sqrt(1 – e² × sin²(φ)) ≈ 6386976.165 mT = tan²(φ) ≈ tan²(0.339) ≈ 0.124C = e′² × cos²(φ), con e′² = e² / (1 – e²) ≈ 0.006739A = (λ – λ₀) × cos(φ) = (-1.730 + 1.727) × cos(0.339) ≈ -0.0029M calculado con la fórmula de meridianoAplicando las fórmulas para Easting y Northing:Easting ≈ 448251 mNorthing ≈ 2141932 mEstos valores coinciden con los datos tabulados para la Ciudad de México en UTM.Considere un punto con coordenadas ECEF:X = 1330711.0 mY = -4656582.0 mZ = 4138301.0 mObjetivo: obtener latitud (φ), longitud (λ) y altura (h) sobre el elipsoide WGS84.Calcule p = sqrt(X² + Y²) ≈ 4880510.5 mSemieje mayor a = 6378137 mSemieje menor b = a × (1 – f) = 6356752.3142 mExcentricidad segunda e′² = (a² – b²) / b² ≈ 0.0067390θ = atan2(Z × a, p × b) ≈ atan2(4138301 × 6378137, 4880510.5 × 6356752.3142) ≈ 0.713 radLatitud φ = atan2(Z + e′² × b × sin³(θ), p – e² × a × cos³(θ)) ≈ 0.710 rad ≈ 40.7°Longitud λ = atan2(Y, X) ≈ atan2(-4656582, 1330711) ≈ -1.292 rad ≈ -74.0°Radio de curvatura N = a / sqrt(1 – e² × sin²(φ)) ≈ 6388838 mAltura h = p / cos(φ) – N ≈ 100 mResultado: Latitud 40.7° N, Longitud 74.0° O, Altura 100 m.Datum y Sistemas de Referencia: La precisión en la conversión depende del datum utilizado (WGS84, NAD83, ED50, etc.).Proyecciones Cartográficas: UTM es una proyección conforme, pero existen otras como Lambert, Mercator, que requieren fórmulas específicas.Errores y Precisión: La conversión puede introducir errores por redondeo, modelo elipsoidal y altura geoidal.Software y Herramientas: Herramientas como PROJ, GDAL y librerías GIS implementan estas conversiones con alta precisión.Aplicaciones Prácticas: Navegación GPS, cartografía, ingeniería civil, y sistemas de posicionamiento requieren conversiones precisas y rápidas. En muchos estudios de diversas disciplinas es necesario georreferenciar la población de una especie, un accidente geográfico, un lugar de interés geológico o un yacimiento. Existen muchos tipos de coordenadas y en cada caso se suelen emplear unas u otras, por lo que a veces se hace difícil manejarlas si no estamos habituados a ellas.En esta página podrás realizar conversiones entre coordenadas geográficas, UTM y MGRS. Escribe los valores de las coordenadas y automáticamente obtendrás los restantes valores de otras coordenadas y además visualizarás su situación en un mapa. CoordenadaValor UTM MGRS G M S.s G M.m G.g When you are trying to choose a coordinate system for your map, are you sometimes confused by the options? What is the difference between a geographic coordinate system (GCS) and a projected coordinate system (PCS) anyways? Here’s the short answer: A GCS defines where the data is located on the earth’s surface. A PCS tells the data how to draw on a flat surface, like on a paper map or a computer screen. A GCS is round, and so records locations in angular units (usually degrees). A PCS is flat, so it records locations in linear units (usually meters). Where: Geographic Coordinate Systems You are part of a search and rescue team looking for an injured person in the Australian outback. The point location you have from her satellite phone is 134.577°E, 24.006°S. Where is she located? Both location A and B in the above image are correct. A is 134.577°E, 24.006°S in one GCS (Australian Geodetic Datum 1984) and B is the same coordinate location in another (WGS 1984). Without knowing which GCS the data is in, you don’t know if the hiker is on top of the plateau or if she has fallen off the cliff. A geographic coordinate system (GCS) is used to define locations on a model of the surface of the earth. The GCS uses a network of imaginary lines (longitude and latitude) to define locations. This network is called a graticule. So why isn’t knowing the latitude and longitude of a location good enough to know where it is? How can location A and location B in the Australia example both be correct? Well it turns out the earth isn’t a perfect sphere. It’s a lumpy, bumpy, and uneven rounded surface. There are high mountains and deep ocean trenches. Because the planet spins, the poles are a bit closer to the center of the earth than the equator is. But in order to draw a graticule, you need a model of the earth that is at least a regular spheroid, if not a perfect sphere. There are many different models of the earth’s surface, and therefore many different GCS! World Geodetic System 1984 (WGS 1984) is designed as a one-size-fits-all GCS, good for mapping global data. Australian Geodetic Datum 1984 is designed to fit the earth snugly around Australia, giving you good precision for this continent but poor accuracy anywhere else. The GCS is what ties your coordinate values to real locations on the earth. The coordinates 134.577°E, 24.006°S only tell you where a location is within a geographic coordinate system. You still need to know which GCS it is in before you know where it is on Earth. How: Projected Coordinate Systems Once your data knows where to draw, it needs to know how. The earth’s surface—and your GCS—are round, but your map—and your computer screen—are flat. That’s a problem. You can’t draw the round earth on a flat surface without deforming it. Imagine peeling an orange and trying to lay the peel flat on a table. You can get close, but only if you start tearing the peel apart. This is where map projections come in. They tell you how to distort the earth—how to tear and stretch that orange peel—so the parts that are most important to your map get the least distorted and are displayed best on the flat surface of the map. You’re perhaps already aware that there are many different map projections and that each displays the earth in a different way. Some are good for preserving areas on your map, others at preserving angles or distances. A projected coordinate system (PCS) is a GCS that has been flattened using a map projection. Your data must have a GCS before it knows where it is on earth. Projecting your data is optional, but projecting your map is not. Maps are flat, so your map must have a PCS in order to know how to draw. Next, let’s take a look at how these coordinate systems (geographic and projected alike) are put together. Coordinate System Construction In ArcGIS Pro, you can view the details of any coordinate system in the Map Properties window, on the Coordinate Systems tab. Click the green Details link. The image below shows the Details page for the Fuller (world) coordinate system: The first line tells you that it’s a Projected Coordinate System, as opposed to a GCS. A PCS, by definition, uses a Projection. The second line tells you that this PCS uses the Fuller projection, which was invented by Buckminster Fuller in 1954. WKID is a unique identifier number for the PCS, defined by its Authority. Coordinates in a PCS are recorded in a Linear Unit, often meters. False Easting, False Northing, and Option are parameters specific to the Fuller projection. Other projections have parameters like Central Meridian, Standard Parallel, and Latitude of Origin. You can often modify these parameters to center the PCS on a specific location. Below are two different PCS: Hawaii Albers Equal Area Conic and Canada Albers Equal Area Conic. They both use the same projection but different projection parameters. A PCS also contains a Geographic Coordinate System! In this case, it’s WGS 1984. Remember that a PCS is just a GCS that has been projected. Let’s look at the properties of the WGS 1984 geographic coordinate system: It has a WKID (and Authority) as well. Coordinates in a GCS are recorded in an Angular Unit, usually degrees. The Prime Meridian is an arbitrary line of longitude that is defined as 0°. It typically runs through Greenwich, England, but it doesn’t have to. The Datum defines which model is used to represent the earth’s surface and where that model is positioned relative to the surface. The Spheroid is the regular model of the irregular earth. It’s part of the datum. Semimajor Axis, Semiminor Axis, and Inverse Flattening define the size of the spheroid. But wait! Can’t we choose a GCS for our map instead of a PCS? I’ve made maps before that were in WGS 1984 and they drew just fine, didn’t they? Let’s try it out. In Map Properties, expand the Geographic Coordinate System list and choose any one. Click OK. Your map will look like this, regardless of which GCS you chose: Remember that it is impossible to draw the round earth on a flat surface without a projection. So when you tell ArcGIS to make a flat map with a GCS, it is forced to choose a projection! So it draws using a pseudo Plate Carrée projection. This is just latitude and longitude represented as a simple grid of squares. It is called pseudo because it is measured in angular units (degrees) rather than linear units (meters). This projection is easy to understand and easy to compute, but it also distorts all areas, angles, and distances, so it is senseless to use it for analysis and measurement. You should choose a different PCS. Summary: You can store your data in a GCS. But you can’t draw it on a flat map without a PCS. The GCS tells your data where to draw. The PCS tells the map how to stretch the GCS out flat. Which GCS you choose depends on where you are mapping. Which PCS you use depends on where you are mapping, but also the nature of your map—for example, should you distort area to preserve angles, or vice versa? Most of the time, you don’t need to choose a GCS. Your data was already stored in one and you should just stick with that. But often you do need to choose a PCS. Read the lesson Choose the Right Projection to learn how to pick the right one. There are plenty of other resources that help to explain coordinate systems in greater depth and in different ways. If you want to learn more, try some of these: You can also read these other articles that I have written about coordinate systems: Cloth globe image by Charles Preppernau. Free ArcGIS Pro Trial This site contains open, tutorials and course materials covering topics including data integration, GIS and data intensive science.Explore our 312 earth data science lessons that will help you learn how to work with data in the R and Python programming languages.Also be sure to check back often as we are posting a suite of new Python lessons and courses! 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You still need to know which GCS it is in before you know where it is on Earth. How: Projected Coordinate Systems Once your data knows where to draw, it needs to know how. The earth’s surface—and your GCS—are round, but your map—and your computer screen—are flat. That’s a problem. You can’t draw the round earth on a flat surface without deforming it. Imagine peeling an orange and trying to lay the peel flat on a table. You can get close, but only if you start tearing the peel apart. This is where map projections come in. They tell you how to distort the earth—how to tear and stretch that orange peel—so the parts that are most important to your map get the least distorted and are displayed best on the flat surface of the map. You’re perhaps already aware that there are many different map projections and that each displays the earth in a different way. Some are good for preserving areas on your map, others at preserving angles or distances. A projected coordinate system (PCS) is a GCS that has been flattened using a map projection. Your data must have a GCS before it knows where it is on earth. Projecting your data is optional, but projecting your map is not. Maps are flat, so your map must have a PCS in order to know how to draw. Next, let’s take a look at how these coordinate systems (geographic and projected alike) are put together. Coordinate System Construction In ArcGIS Pro, you can view the details of any coordinate system in the Map Properties window, on the Coordinate Systems tab. Click the green Details link. The image below shows the Details page for the Fuller (world) coordinate system: The first line tells you that it’s a Projected Coordinate System, as opposed to a GCS. A PCS, by definition, uses a Projection. The second line tells you that this PCS uses the Fuller projection, which was invented by Buckminster Fuller in 1954. WKID is a unique identifier number for the PCS, defined by its Authority. Coordinates in a PCS are recorded in a Linear Unit, often meters. False Easting, False Northing, and Option are parameters specific to the Fuller projection. Other projections have parameters like Central Meridian, Standard Parallel, and Latitude of Origin. You can often modify these parameters to center the PCS on a specific location. Below are two different PCS: Hawaii Albers Equal Area Conic and Canada Albers Equal Area Conic. They both use the same projection but different projection parameters. A PCS also contains a Geographic Coordinate System! In this case, it’s WGS 1984. Remember that a PCS is just a GCS that has been projected. Let’s look at the properties of the WGS 1984 geographic coordinate system: It has a WKID (and Authority) as well. Coordinates in a GCS are recorded in an Angular Unit, usually degrees. The Prime Meridian is an arbitrary line of longitude that is defined as 0°. It typically runs through Greenwich, England, but it doesn’t have to. The Datum defines which model is used to represent the earth’s surface and where that model is positioned relative to the surface. The Spheroid is the regular model of the irregular earth. It’s part of the datum. Semimajor Axis, Semiminor Axis, and Inverse Flattening define the size of the spheroid. But wait! Can’t we choose a GCS for our map instead of a PCS? I’ve made maps before that were in WGS 1984 and they drew just fine, didn’t they? Let’s try it out. In Map Properties, expand the Geographic Coordinate System list and choose any one. Click OK. Your map will look like this, regardless of which GCS you chose: Remember that it is impossible to draw the round earth on a flat surface without a projection. So when you tell ArcGIS to make a flat map with a GCS, it is forced to choose a projection! So it draws using a pseudo Plate Carrée projection. This is just latitude and longitude represented as a simple grid of squares. It is called pseudo because it is measured in angular units (degrees) rather than linear units (meters). This projection is easy to understand and easy to compute, but it also distorts all areas, angles, and distances, so it is senseless to use it for analysis and measurement. You should choose a different PCS. Summary: You can store your data in a GCS. But you can’t draw it on a flat map without a PCS. The GCS tells your data where to draw. The PCS tells the map how to stretch the GCS out flat. Which GCS you choose depends on where you are mapping. Which PCS you use depends on where you are mapping, but also the nature of your map—for example, should you distort area to preserve angles, or vice versa? Most of the time, you don’t need to choose a GCS. Your data was already stored in one and you should just stick with that. But often you do need to choose a PCS. Read the lesson Choose the Right Projection to learn how to pick the right one. There are plenty of other resources that help to explain coordinate systems in greater depth and in different ways. If you want to learn more, try some of these: You can also read these other articles that I have written about coordinate systems: Cloth globe image by Charles Preppernau. Free ArcGIS Pro Trial El sistema de coordenadas esféricas se utiliza habitualmente en física. Asigna tres números (conocidos como coordenadas) a cada punto del espacio euclídeo: distancia radial r, ángulo polar θ (θ) y ángulo acimutal φ (φ). El símbolo ρ (ρ) se utiliza a menudo en lugar de "r" En geometría, un sistema de coordenadas es un sistema de referencia que utiliza uno o más números (coordenadas) para determinar inequivocamente la posición de un punto u objeto geométrico.[1] El orden en que se escriben las coordenadas es significativo y a veces se las identifica por su posición en una tupla ordenada; también se las puede representar con letras, como por ejemplo «la coordenada-x». El estudio de los sistemas de coordenadas es el objeto de la geometría analítica, que permite formular problemas geométricos de forma "numérica".[2] Sistema de coordenadas cartesianas tridimensional En geometría, las coordenadas son valores numéricos que determinan la posición de un punto en un plano o en el espacio. En un plano euclídeo, la posición de un punto puede venir determinada por las distancias a dos líneas rectas (ejes de coordenadas) que se cruzan en un punto (origen) en ángulo recto; una de las coordenadas se llama ordenada y la otra abscisa. En el espacio euclídeo tridiomensional según el sistema de Descartes, la posición de un punto está determinada si se especifican las distancias a tres planos de coordenadas que se cruzan en un punto en ángulo recto entre sí. Sin embargo estas formas de especificar un punto no son las únicas posibles, las coordenadas polares en el plano o las coordenadas esféricas (donde el origen está en el centro de una serie de esferas) o las coordenadas cilíndricas en el espacio son otras formas que requieren especificar menos distancias y más ángulos de orientación. En geografía, las coordenadas se eligen como un sistema de coordenadas aproximadamente esférico: latitud, longitud y altura por encima de un nivel general conocido (como por ejemplo, el del océano). La latitud mide la ubicación norte-sur de un punto en relación con el ecuador, la longitud mide la ubicación este-oeste en relación con el meridiano de Greenwich, y la altura representa la elevación de un punto sobre un nivel de referencia, como el nivel del mar. Este sistema de coordenadas es esencial para la ubicación precisa en la superficie terrestre y se utiliza en cartografía, navegación, topografía y en tecnologías GNSS (Sistema Global de Navegación por Satélite), proporcionando una base sólida para la representación geoespacial y la geolocalización precisa de lugares en todo el mundo. El sistema de coordenadas más utilizado es el sistema de coordenadas rectangulares, también conocido como sistema de coordenadas cartesianas. Ese tipo de sistemas puede funcionar como un sistema de coordenadas único para todo un espacio euclídeo y los puntos y objetos situados dentro de él. Para lograr eso se requiere la noción de origen de coordenadas. Las coordenadas en el plano y en el espacio se pueden definir de un número ilimitado de formas diferentes. La resolución de numerosos problemas matemáticos o físicos implica elegir aquel sistema de coordenadas específico en el que el problema se resuelva más fácil o más conveniente en cada caso particular. En astronomía, las coordenadas celestes son un par ordenado de cantidades angulares (por ejemplo, ascensión recta y declinación), con las que se determina la posición de distintos puntos luminosos y de puntos auxiliares en la esfera celeste. En la práctica, se utilizan varios sistemas de coordenadas celestes. Cada uno de ellos es esencialmente un sistema de coordenadas esféricas (sin coordenadas radiales) con un plano fundamental y un origen elegidos apropiadamente. Dependiendo de la elección del plano fundamental, el sistema de coordenadas celestes se llama horizontal (plano del horizonte), ecuatorial (plano ecuatorial), eclíptico (plano de la eclíptica) o galáctico (plano galáctico). El concepto de sistemas de coordenadas aplica a espacios geométricos más complejos que el espacio euclídeo, por esa razón se requiere una definición formal de sistema de coordenadas que especifique la posición de puntos. Nótese que por ejemplo de acuerdo a la cosmología moderna la forma del espacio-tiempo es un espacio curvado por lo que en el universo no siempre sería posible usar coordenadas cartesianas. Dado un espacio geométrico o topológico E {\displaystyle {\mathcal {E}}} que tiene estructura de variedad diferenciable de dimensión n un sistema de coordenadas es una difeomorfismo: ϕ : E → A ⊂ R n {\displaystyle \phi :{\mathcal {E}}\to A\subset \mathbb {R} ^{n}} , donde A = ϕ [E] {\displaystyle A=\phi [{\mathcal {E}}]} es un conjunto abierto del espacio euclídeo n-dimensional. Es decir, para cada punto P ∈ E {\displaystyle P\in {\mathcal {E}}} tenemos las coordenadas ϕ (P) = (x 1 , … , x n) {\displaystyle \phi (P)=(x_{1},\dots ,x_{n})} , el conjunto de todas estas n-tuplas para el espacio E {\displaystyle {\mathcal {E}}} define un sistema de coordenadas local. Artículo principal: Recta real Es el conjunto de los números reales representado gráficamente por una recta en la que se pueden ubicar todos los números naturales, enteros, fraccionarios, decimales, etc.[3] Cada punto de la recta representa un número real, ya sea mediante una correspondencia biunívoca o mediante una aplicación biyectiva, usada para representar los números como puntos especialmente marcados, como por ejemplo los números enteros mediante una recta llamada recta graduada como la entera[3] de puntos ordenados y separados entre sí a la misma distancia. El punto que representa el cero (0 {\displaystyle 0}) es el punto de referencia principal del sistema de coordenadas, llamado punto de origen. Tomando en cuenta que cada uno de los puntos de la recta representa gráficamente un número real, a la derecha del punto origen O {\displaystyle O} se hallan todos los números reales positivos y a la izquierda todos los números reales negativos.[4] Para representar un número de la recta real se emplean las letras mayúsculas y sus coordenadas correspondientes, por ejemplo, los puntos A(5), B(3), C(-3), D(-5),etc. Recta real Artículo principal: Coordenadas cartesianas Coordenadas cartesianas Coordenadas cartesianas en el plano En un espacio euclídeo, un sistema de coordenadas cartesianas se define por dos o tres ejes ortogonales igualmente escalados, dependiendo de si es un sistema bidimensional o tridimensional (análogamente en R n {\displaystyle \scriptstyle \mathbb {R} ^{n}} se pueden definir sistemas n-dimensionales). El valor de cada una de las coordenadas de un punto (A) es igual a la proyección ortogonal del vector de posición de dicho punto (r A = OA {\displaystyle \mathbf {r} _{\text{A}}={\text{OA}}\,}) sobre un eje determinado: r A = OA = (x A , y A , z A) {\displaystyle \mathbf {r} _{\text{A}}={\text{OA}}= (x_{\text{A}},y_{\text{A}},z_{\text{A}})} Cada uno de los ejes está definido por un vector director y por el origen de coordenadas. Por ejemplo, el eje x está definido por el origen de coordenadas (O) y un vector (i {\displaystyle \mathbf {i} \,}) tal que: i = (1 , 0 , 0) {\displaystyle \mathbf {i} =(1,0,0)} , cuyo módulo es | i | = 1 {\displaystyle |\mathbf {i} |=1\,} . El valor de la coordenada x de un punto es igual a la proyección ortogonal del vector de posición de dicho punto sobre el eje x: x A = OA · i | OA | · | i | = OA | OA | · i {\displaystyle x_{\text{A}}={{\text{OA}}\cdot \mathbf {i} \over |{\text{OA}}||\cdot |\mathbf {i} |}={{\text{OA}} \over |{\text{OA}}|}\cdot \mathbf {i} } Artículo principal: Coordenadas polares Localización de un punto en coordenadas polares Las coordenadas polares son un sistema de coordenadas bidimensional en el que cada punto o posición del plano se determina mediante un ángulo y una distancia.[5] Se elige un punto como polo y se toma una semirrecta desde este punto como eje polar. Para un ángulo dado θ {\displaystyle \theta } , hay una única línea recta que pasa por el polo cuyo ángulo con el eje polar es θ {\displaystyle \theta } (medido en sentido contrario al de las agujas del reloj desde el eje hasta la línea). Entonces hay un único punto en esta línea cuya distancia con signo al origen es r para un número dado r. Para un par de coordenadas dado (r , θ) {\displaystyle (r,\theta)} hay un único punto, pero cualquier punto está representado por muchos pares de coordenadas. Por ejemplo, (r , θ) {\displaystyle (r,\theta)} , (r , θ + 2 π) {\displaystyle (r,\theta +2\pi)} y (− r , θ + π) {\displaystyle (-r,\theta +\pi)} son todas coordenadas polares para el mismo punto. El polo está representado por (0 , θ) {\displaystyle (0,\theta)} para cualquier valor de θ {\displaystyle \theta } . Artículo principal: Coordenadas log-polares Es un sistema de coordenadas donde un punto se identifica con dos números, uno para el logaritmo de la distancia a un cierto punto y otro para un ángulo. Las coordenadas logarítmicas están estrechamente conectadas con las coordenadas polares, que generalmente se usan para describir dominios en el plano con algún tipo de simetría rotacional. Artículo principal: Coordenadas cilíndricas Sistema de coordenadas cilíndricas Significado de las coordenadas cilíndricas El sistema de coordenadas cilíndricas C = { (ρ , φ , z) | ρ > 0 , 0