Winter 2013 Geography 128

# Analytical and Computer Cartography

Professor Keith C. Clarke
With substantial help from
Kevin Mwenda

## The instructors

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## Class web site

http://www.geog.ucsb.edu/~kclarke/Geography128/Geog128.html
Plus Gauchospace for the labs


## Class goals

- (1) to create students who can skillfully and knowledgeably create high quality maps and graphics for other classwork, and for professional posters and presentations, both during and after their UCSB experience
- (2) to demonstrate that cartography consists of both theory (analytical cartography) and practise (computer cartography).

## What you will learn

- The cartographic side of Geographic Information Science
- What AC is, where it came from, and where its going
- Aspects of cartographic transformations
- Some extra details on 3D representation
- Several Open Source mapping packages
- How to build a map portfolio

## What I expect of you

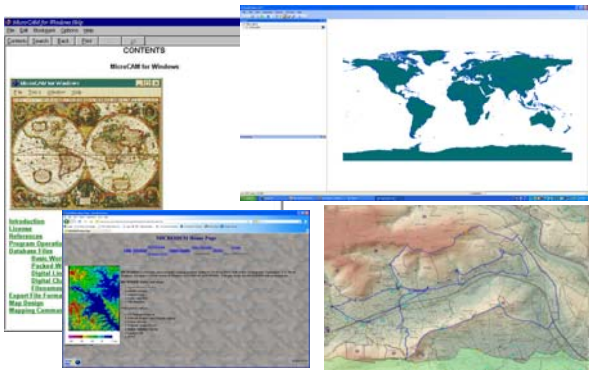
- Attend lecture and lab
- Do the assignments on time
- Use your web site to build a portfolio
- Look at any assigned readings
- Try it yourself first, then ask for help
- Study for the exams
- Learn and experiment

## The class

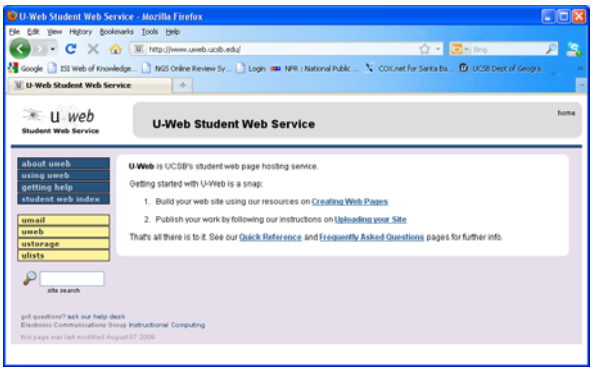
- Lectures 2x a week
- Labs once a week
- 5 labs, 2 weeks per lab
- Labs are far more self-help based than 176. Use your intelligence!
- Web site
- Gauchospace site

## The lab work

## Open source/Freeware



## Portfolio of maps




## The Class

- Taught as *Analytical Cartography* (Geog 482) at the University of Michigan by Waldo Tobler late 1960s on
- Topic of paper by Tobler in 1976, published the curriculum (more detailed than actual class!)
- Adopted by Keith Clarke at Hunter College in 1982, after taking the class at Michigan
- Led to *Analytical and Computer Cartography* 1990 textbook. 2 editions
- Moved the class to UCSB in 1996, taught in several other universities
- Many subsequent additions to the literature

## Geog 482

COURSE OUTLINE

*Analytical Cartography.* Geography 482. 3 credits. Prof. Waldo R. Tobler University of Michigan, Ann Arbor, Michigan 48109, U.S.A.

*Week I. Introduction.* Relation to mathematical geography, geodesy, photogrammetry, remote sensing. Replacement of map data storage by computer data storage. Technological change and the need for theoretical approach. Historical perspective.

*Week II. Computer Graphics.* Turing's theorem in relation to cartography. Output devices: lines, halftones, color. Sources of programs and algorithms. Dynamic cartography and computer movie making. Interactive graphics in cartography and geography.

*Week III. Geographical Matrices.* Triagonal, quadrilateral, hexagonal, and Escher types. Notation, neighborliness property, topological invariance. The varieties of geographical data: nominal, binary, scalar, complex, colored, N-valued, and infinite-valued matrices. Isomorphism to the surface of the earth.

*Week IV. Geographical Matrix Operators.* Functions of matrices: algebraic, logical, differentiable, invertible; linear, local, spatially invariant (translationally and rotationally). Parallel processing, windows, edge effects. Finite difference calculations.

*Week V. Response Functions.* Fourier and other orthogonal series. Operations in the frequency domain. Two-dimensional transforms.

*Week VI. Sampling and Resolution.* Fourier interpretations of aliasing, band limited functions, Nyquist limit, comb functions. The sampling theorem, random plane sampling, invisible distributions.

*Week VII. Quantization and Coding.* Analogue and digital processing. Quantization error, reduction of. Information theory: how many aerial photographs are there? Huffman coding, higher order statistics, spatial autocorrelation functions. Television and choropleth maps.

*Week VIII. Map Generalization.* Textual, acoustical, visual abstractions: smoothing and reconstruction, spread functions and inverses. Information loss. Point, line, network, binary to N-valued matrix generalization. Digital implementation, optical data processing. How the brain works: Limulus, frog, cat, human.

*Week IX. Pattern Recognition.* Preprocessing, enhancement, feature extraction; discrimination and classification (linear, Gaussian); signal-to-noise ratios; perceptrons.

*Week X. Generalized Spatial Partitionings.* Census tracts and the like, *ad nausium.* Point functions versus interval functions, a false dichotomy. Spatial resolution redefined. Generalized neighbors in a point set: epsilon neighborhood, $K^{th}$ surround, minimal triangulation, Gabriel contiguity, Thiessen polygons. Higher order neighbors. Interval sets associated with a point set; point sets associated with an interval set. Higher dimensional cases.

*Week XI. Generalized Geographical Operators.* Expansion of matrix operators to irregular point sets, to interval data, in such a manner as to include matrix as a special case. Generalized two-dimensional sampling theorem and reconstructions from sampled data.

*Week XII. Geographical Coding.* Information theoretical content of Latitude / Longitude, street address, ZIP code, telephone number, Public Land Survey, and the like.

Topological and metrical properties of place naming schemes. Gaussian coordinates. A variety of plane coordinate schemes. Formulae for working on sphere and ellipsoid.

*Week XIII. Geographical Code Conversions.* Complete-partial, redundant-optimal, invertible & non-invertible codes. Blum geometry and skeletal invariants. Point-point, point-interval, interval-interval conversions and their inverses. Polygonal and skeletal approaches; error measures. Street address, Latitude Longitude, and so forth.

*Week XIV. Map Projections.* The classical theory: Ptolemy, Mercator, Lambert, Euler, Gauss, Airy, Chebyshev, Tissot. Finite and differential measures of distortion. Applicability to "mental maps." Simplifying computations by using map projections. Some new ways of inventing projections. Computation of cartograms.

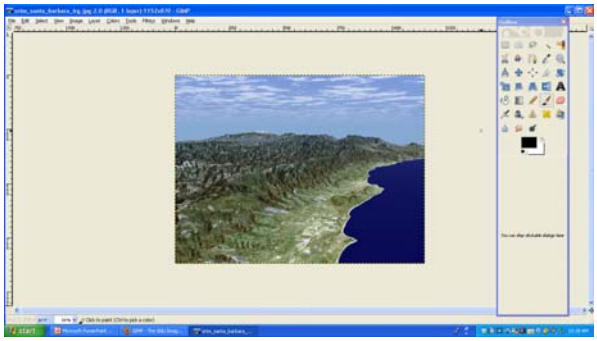
*Week XV. Geographical Information Systems.* Band width requirements; dollar requirements; hardware and software. Input schemes, manipulation algorithms, output schemes. Historical overview and examples: TIROS-ERTS, CATS-PJ-BATS, CLI-MLADS-DIME. Analytical approaches to using geographical data: optimization techniques, sensitivity testing, regionalization, spatial trend analysis, dynamic simulation, growth models, regional forecasting.


## Clarke *Analytical and Computer Cartography 2ed.*

- http://www.geog.ucsb.edu/~kclarke/AACC

## Generic Use Software: GIMP2.8

## Raster images

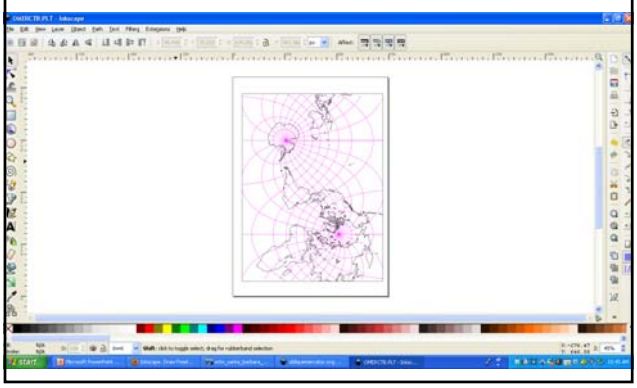


## GIMP features

- Layers
- Filters
- Crop and zoom
- Change resolution
- Paint and edit
- Import/Export
- Transparency
- Online manual

## Generic Use Software: InkScape


## Vector data



## Inkscape features

- Interactive editing
- Tools and effects
- Vector ingest
- Vector to raster transformation
- SVG
- Transparency
- Objects and layers

## Other useful software

- MICROCAM
- MicroDEM
- MapShaper
- MapWindow GIS
- Excel (or LibreOffice Calc)
- LandSerf
- Anything you choose!

## The assignments

- Create your own map projection
- Line generalization
- Terrain rendering
- Terrain analysis
- Your topic here!