GIScience and Environmental Analysis

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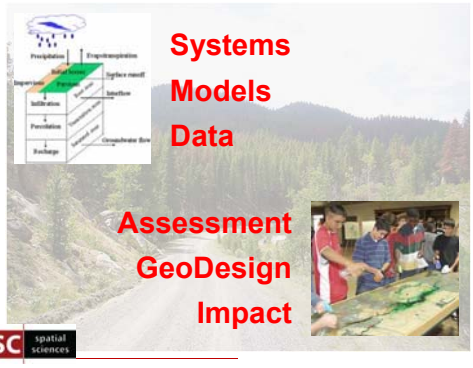
USC spatial sciences

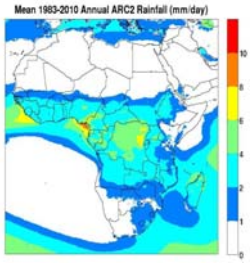
Outline

- Background
  - Climate
  - Topography
  - Soils & Geology
  - Land Use & Land Cover
  - People
- Enduring Challenges
  - Geospatial Semantics, Scale, & Time
- Sample Applications
  - Non-point Source Pollution
  - Melanoma Risk
- Final Thoughts

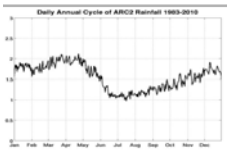
Background



Climate



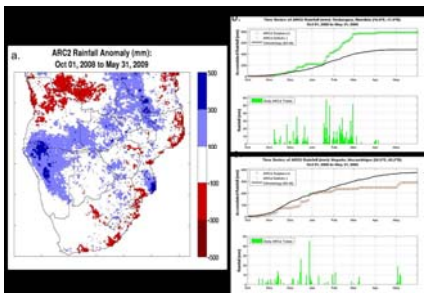
Spatial mean of annual ARC2 rainfall (mm/day) at a 0.1° resolution over Africa from 1983-2010



Annual cycle of ARC2 rainfall (mm/day) over Africa domain

NOAA NCEP CPC FEWS Africa DAILY ARC2 daily options – Columbia University

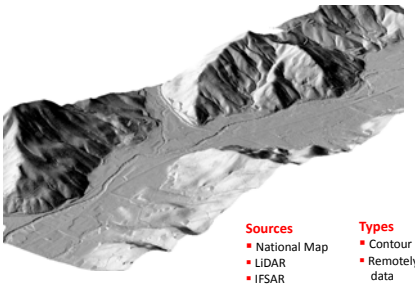
Climate Surfaces



Map of ARC2 total rainfall anomaly (mm), plus observed & cumulative ARC2 rainfall time series for Ondangwa, Nambia, & Maputo, Mozambique for southern Africa rainy season (10/1/08-5/31/09)

Source: Novella & Thiaw, n.d.

Topography

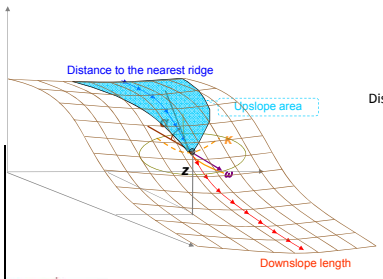


Sources
- National Map
- LiDAR
- IFSAR
- GPS

Types
- Contour and stream line data
- Remotely sensed elevation data
- Surface specific point elevation data

Picture: Courtesy of David Maune

Topographic attributes



Elevation (z)
Slope gradient (α)
Slope aspect (ω)
Curvatures (κ)
Distance to the nearest ridge
Downslope length
Upslope area

Slide: Courtesy of Bard Romstad

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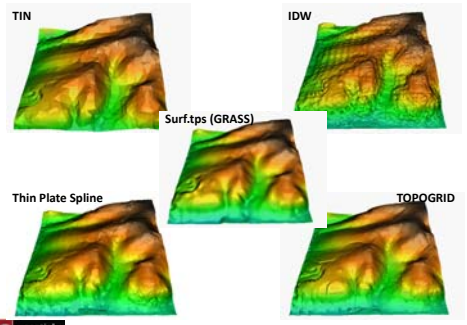
Sparse Data / Spatial Interpolation



Slide: Courtesy of Graeme Aggett

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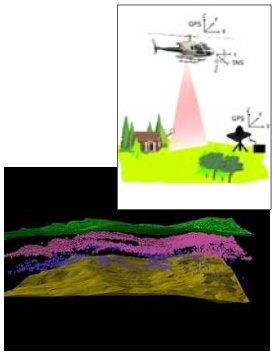
LiDAR / Spatial Filtering

- **LI**ght **D**etection **A**nd **R**anging
- Measures distance to, or other properties of a target by illuminating target with light, using pulses from a laser
- Three components
  - Airborne scanning laser rangefinder
  - Differential GPS
  - Internal Navigation System
- Generates millions of points at relatively low cost …



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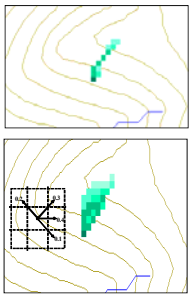
Pre-Processing Decisions

- Source and granularity of DEM used
- Presence and handling of spurious pits (interpolation)
- Choice of drainage enforcement option (if any)
- Choice of flow routing algorithm
- Dynamic character of key variables and processes
- **It is the topographic shape that matters most!**



Maps: Courtesy of David Tarboton

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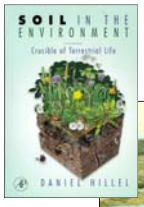
Geology / Soils



- Spatial granularity: Minimum mapping units
- Selection of attributes

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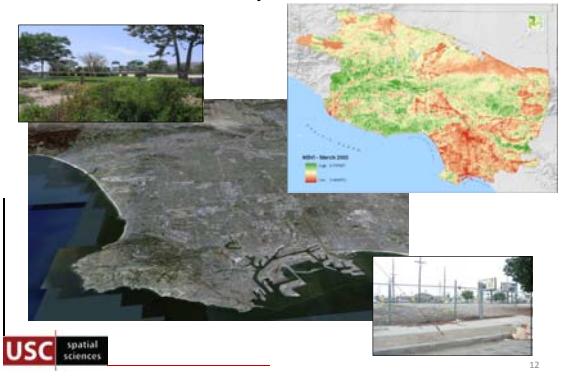
Land Use / Land Cover



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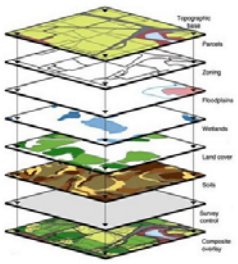
Mobile Elements: People & More

Catalina Island Fox, Photo: Courtesy of Tim Coonan

Mission Blue Butterfly, Photo: Courtesy of Travis Longcore

Poronui Lodge: Home Ranges for Stags

Enduring Challenges



Big Geo-Data

- Background
  - Geographic information science
  - Geospatial technologies
  - Web / Spatial 2.0
- Spatial literacy & spatial thinking
  - Fundamental concepts & linkages
- A spatially infused university
  - Teaching spatial science
  - Teaching spatial applications
  - Teaching spatial literacy
  - Workforce development
- Conclusions

80-20 Rule of Geospatial Semantics

- Background
  - Geographic information science
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A Paradigm Shift?

- Background
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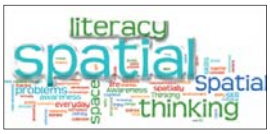

Scale and Complexity

Global		Cloud cover and CO2 levels control primary energy inputs to climate and weather patterns
Meso		Prevailing weather systems control long-term mean conditions; elevation-driven lapse rates control monthly climate; and geological substrate exerts control on soil chemistry
Topo		Surface morphology controls catchment hydrology; slope, aspect, horizon, and topographic shading control surface insolation
Micro		Vegetation canopy controls light, heat, and water for under-story plants; vegetation structure and plant physiognomy controls nutrient use
Nano		Soil microorganisms control nutrient recycling

(Slide: Courtesy of Michael Hutchinson)

Scale and Complexity (cont.)

- Strategies, processes, methods , ideas that work at one scale … may not work at other scales
- Possible examples …
  - Best Management Practices (to manage runoff and water quality)
  - Green Building Design (to support life)
  - Transit Oriented Development (to reduce congestion and vehicle emissions)
  - Smart Growth …

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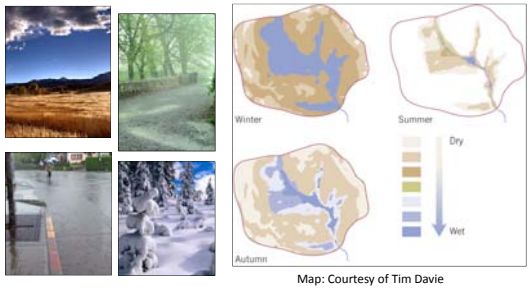
Space and Time



Map: Courtesy of Tim Davie

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Space and Time (cont.)

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Applications

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Melanoma Risk …

- Collaborative research with Myles Cockburn (Keck School of Medicine) and Zaria Tatalovich (NCI)
- One of most rapidly increasing cancers among white population in U.S.
- Studies consistently point to UV exposure as most important risk factor
- Individual sun exposure has proved difficult to quantify
- Initial research question …
  - How well can we model spatial variations in UV radiation given measurement network & interpolation techniques available (in 2005)?

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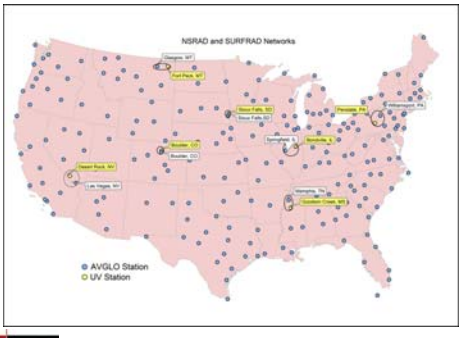
Measurement Network



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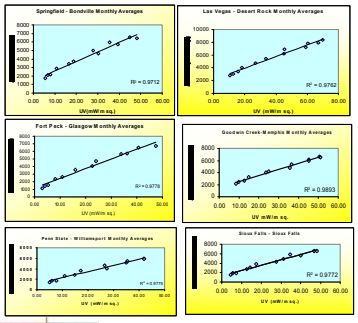
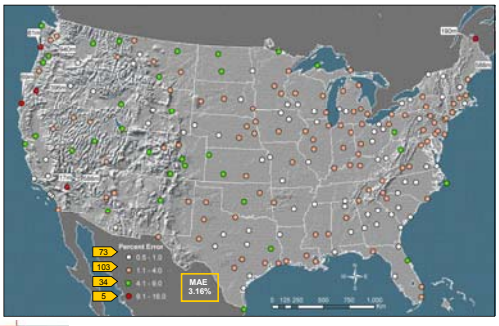
Radiation Data Correlations

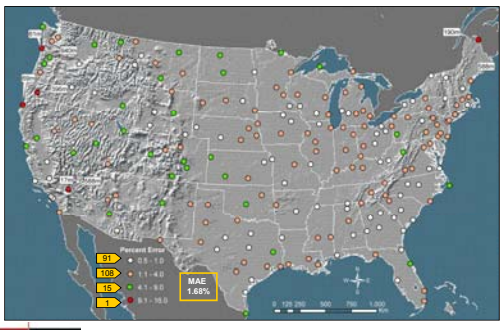


Springfield – Bondville, IL
Las Vegas – Desert Rock, NV
Boulder – Boulder, CO
Fort Peck – Glasgow, MT
Goldwin Creek – Memphis, TN
Penn State – Williamsport, PA
Sioux Falls – Sioux Falls, SD

Thiessen Error Map



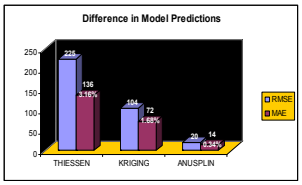
Kriging Error Map



Spline Error Map

Model Differences

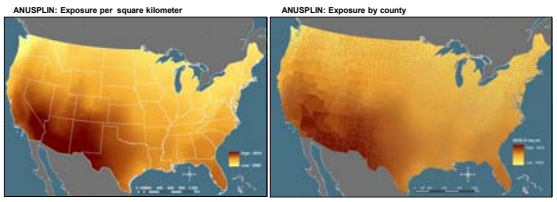
- Spline predictions 11 & 2.2 times better than Thiessen polygon & kriging predictions
- ANUSPLIN …
  - Smallest RMSE, MAE & VE
  - Highest R (observed / predicted)
  - Smallest R (observed / error)



	RMSE	MAE	VE	Correlation OBS/PRED	Correlation OBS/ERR
THIESSEN	225	136 (3.16%)	50906	0.90	0.40
KRIGING	104	72 (1.68%)	10885	0.98	0.31
ANUSPLIN	**20**	**14 (0.34%)**	**384**	**0.99**	**0.15**

ANUSPLIN UV Exposure Model

- **Used Arc/Info GRID tools to calculate zonal means**
- **Generated map of UV exposures by county**



Case Control Dataset

- Los Angeles County Cancer Surveillance Program
  - 820 melanoma cases among white, non-Hispanic residents < 65 years
  - Cases older than 65 yrs excluded to minimize recall bias of events occurring in young age
  - Controls included 877 individuals who lived nearby and that were matched to cases for ethnicity, age, and gender
- Structured interviews
  - Residential history from birth to time of interview recorded as county or country of residence (if outside USA)
  - Time spent at each residence reported in years
  - Time spent in outdoor activity (average number of days per year of outdoor activity during age periods 15-24, 24-44, >44 years of age)

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Statistical Analysis

- Second research question …
  - How is incidence of melanoma connected to place of residence and time spent outdoors?
- Conditional logistic regression used to estimate odds ratios for melanoma
  - Cumulative lifetime exposure: 4 classes (<150,000, 150-200,000, 200-250,000, >250,000 Wh/m^2)
  - Analysis of time spent in outdoor activity: 3 age-specific classes (15-24, 24-44, >45 yrs) because exposure at young age is important?
  - Self-reported time spent in outdoor activity: 4 classes (0-50, 51-100, 101-200, >200 days per year)
  - Examined 45+ yrs age group because younger adults have less chance for exposure & we controlled for matching variables of age, sex and socio-economic status

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Cumulative UV Exposure

Cumulative exposure (Wh/m^2)	Case-control	OR
< 150,000	118/143	1
150,000-200,000	160/174	1.62
200,000-250,000	168/201	2.64
> 250,000	215/191	6.01
p-Value		< 0.0001

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Average Annual UV Exposure

45+ years	Case-control	OR	*p*-Value
Average annual exposure 15-24 years			
< 4,043	92/122	1	
4,043-4,840	107/124	1.23	
> 250,000	215/191	1.74	0.0209 (0.0060)
Average annual exposure 25-44 years			
< 4,736	67/122	1	
4,736-5,080	121/116	1.91	
> 5,080	153/131	2.29	0.0002 (0.0001)
Average annual exposure 44+ years			
< 5,080	31/43	1	
> 5,080	310/326	1.20	0.48

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UV Adjusted Time Spent Outdoors

45+ years	Case-control	OR	*p*-Value
UV adjusted outdoor 15-24 years			
< 558,800	90/121	1	
558,800-1,042,671	123/124	1.33	
> 1,042,671	122/122	1.55	0.0955 (0.0333)
UV adjusted outdoors 25-44 years			
< 294,330	110/120	1	
294,330-645,333	125/125	1.91	
> 645,333	105/121	0.99	0.74 (0.61)
UV adjusted outdoor 44+ years			
< 299,720	123/121	1	
299,720-609,600	99/120	0.86	
> 609,600	116/127	0.91	0.74

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Environmental Applications

- Focus on terrestrial environments
- Focus on what is or what has been
- Most of the world has been ignored
  - Oceans – cover 70% of Earth's surface
  - Buildings – people spend 85% of their lives indoors & dense urban areas have more interior space than land area
- Not well aligned with everyday places & non-expert users
- Not connected to sketch & recording needs of design disciplines

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Questions …

Project for Public Spaces

Placemaking plans

City-wide strategic plans

Capacity building and cultural change

Placemaking 101

Lighter

Quicker

Cheaper

http://www.pps.org

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