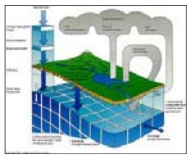
The Spatial Sciences: Connecting Society, Environment, and Health





John Wilson
University of Wisconsin-Milwaukee
18 November 2011

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Outline

- Interdisciplinary spatial science
  - The context
  - The need
- My own work
  - Modeling the spatial variability of UV radiation
  - Characterizing the relationship between UV exposure and melanoma risk
  - Modeling pollutant loadings and water quality impacts
- Future opportunities
  - GIS strengths and weaknesses
  - Geographic knowledge infrastructure
  - Collaborative spatial science

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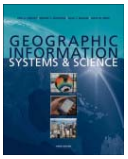
The context

- Systematic development of computational tools for handling spatial data began in 1960s
- Geographic information systems & software for image processing, pattern recognition & scientific visualization now in widespread use throughout academy
- Functions for manipulation, analysis, and modeling of spatial data available in standard statistical and mathematical packages
  - The ArcGIS toolbox has 750 such functions



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The need …

The development of relevant theory and concepts, and the cultivating of spatial intelligence through education, has lagged far behind … and it is clear that a wide gap exists between the power and accessibility of tools on the one hand and the ability of researchers, students, and the general public to make effective use of them on the other.

(Goodchild , Gober & Meyer, 2009)

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Melanoma risk …

- Collaborative research with Myles Cockburn (USC Keck School of Medicine) & 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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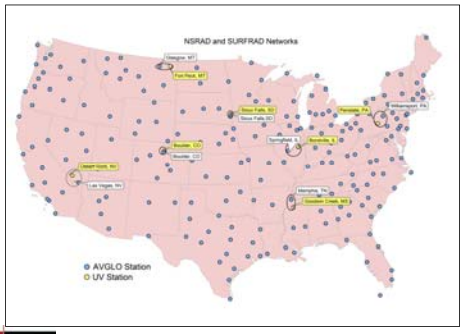
Measurement network



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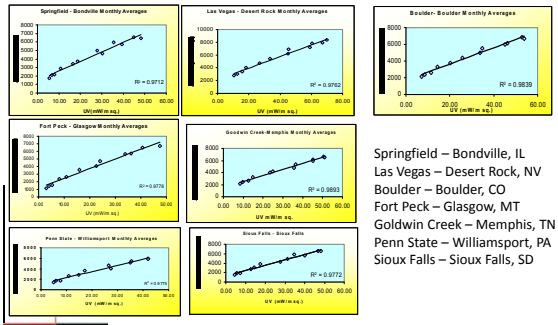
Radiation data correlations



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

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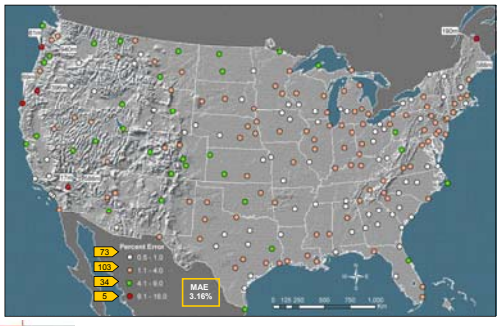
Thiessen polygon error map



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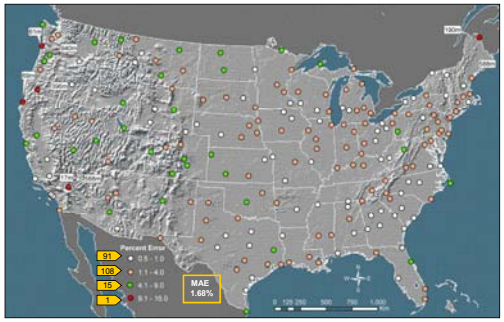
Kriging error map



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Spline error map

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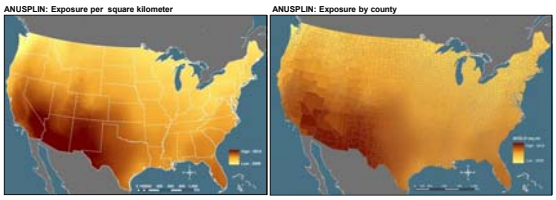
ANUSPLIN UV exposure maps

- Used ArcGIS GRID tools to calculate zonal means
- Generated map of UV exposures by county



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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 the 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 categorized using 4 classes (<150,000, 150-200,000, 200-250,000, >250,000 Wh/m^2)
  - Analysis of time spent in outdoor activity used 3 age-specific categories (15-24, 24-44, >45 yrs) because exposure at young age is thought to be important
  - Self-reported time spent in outdoor activity assigned to 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 and we controlled for matching variables of age, sex & socio-economic status

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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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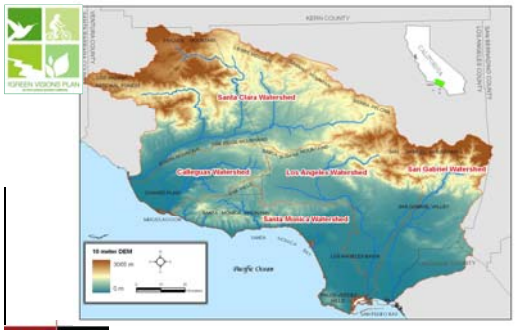
Green Visions Plan project



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Los Angeles Basin

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Green Visions Plan study area

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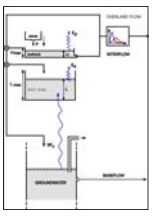
Hydrologic modeling component

- Collaborative work with Jingfen Sheng (ERM-Hong Kong)
- Gathered & organized MIKE BASIN model data
- Calibrated rainfall-runoff relationships
- Calibrated delivery & transport of contaminants
  - NO_3-N, NH_3-N
  - Total P
- Validated rainfall-runoff & water quality predictions
- Generated final results & tools



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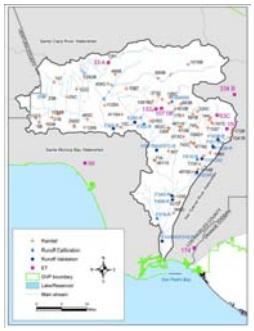
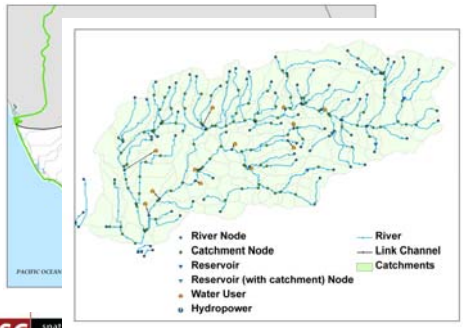
Spatial granularity – LA River

- Drains 2,002 km^2
- 1,783 unique stream segments (links) in NHD Plus
- 171 tributaries and sub-catchments used for MIKE BASIN model runs
- 11.7 km^2 (1,171 ha) minimum map unit

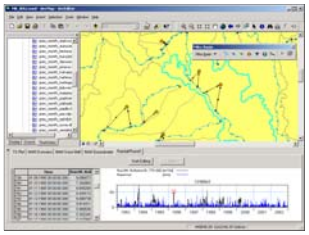


Subwatershed delineation

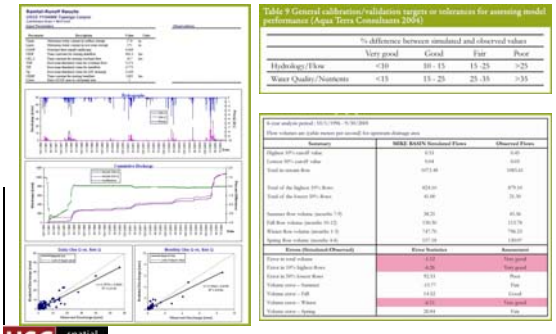


Rainfall-runoff analysis

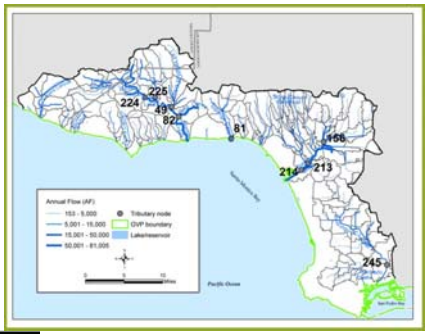
- Initial conditions
- Rainfall, potential evapotranspiration, & temperature time series
- Stream flow data for model calibration and validation



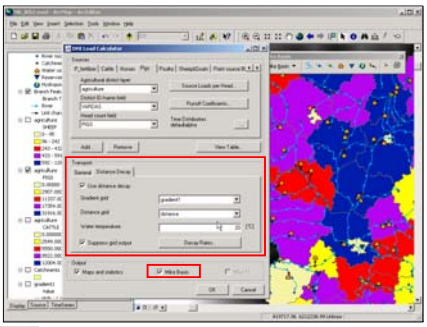
Rainfall-runoff results



Annual flows in map form



MIKE BASIN: WQ module



Contaminant sources

- Fertilizer Sources
  - Crop data
  - Fertilizer application rates
  - Distance decay factor (calibration)
- Livestock Sources
  - Very few
- Domestic Sources
  - Population estimates
  - Sewage treatment data
  - Distance decay factor (calibration)
- Point Sources
  - Five major NPDES

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Field observations

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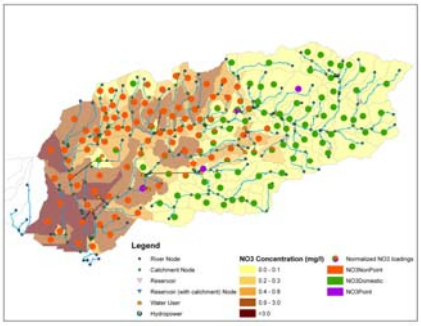
NO3-N predictions



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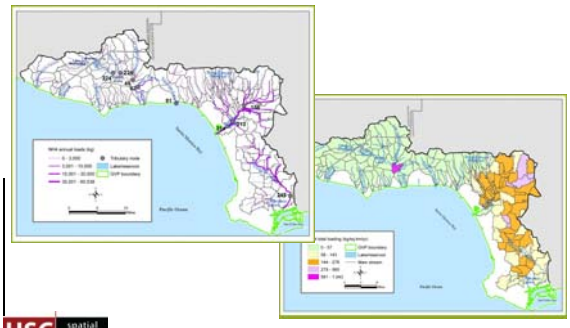
Annual NH4 loadings in map form



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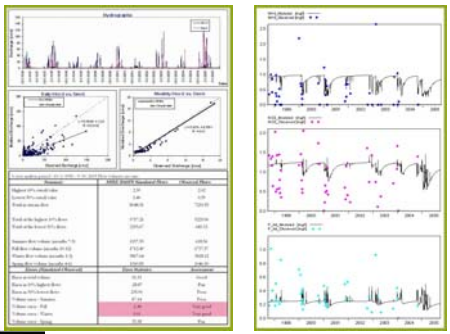
WQ results: Ballona Creek



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Green Visions Plan
Spatial Decision Support Tools
http://greenvisions.usc.edu/

GIS strengths & shortcomings

- Focus on terrestrial environments
  - Natural environments – forests, grasslands, etc.
  - Human environments & infrastructure – cities, roads, pipelines, crop and grazing lands
  - Environmental impacts – air & water pollution
- 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 much more interior space than land area

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Geographic knowledge infrastructure

- Contains knowledge describing natural and human environment on Earth
- Multiple components
  - Data
  - Data models that provide structure to the data
  - Models and analytic tools that show predictions or suitability
  - Geospatial workflows
  - Metadata, which describes the aforementioned components, and is key to sharing, discovery and access
- Web environments that make this knowledge more accessible and promote spatially integrated thinking

As we move from an industrial economy to an information economy, our reliance on physical infrastructure is being supplemented by reliance on a new type of infrastructure: geographic knowledge (Dangermond, 2010)

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Publication venues …

- *Geomorphology (2)*
- *Earthquake Spectra*
- *Journal of Insect Conservation*
- *GeoJournal*
- *Computers, Environment & Urban Systems*
- *International Journal of Geographical Information Science (3)*
- *Environmental Modeling & Software*
- *Natural Hazards*
- *International Journal of Health Geographics*
- *Social Science & Medicine*
- *Earth Surface Processes & Landforms*
- *Remote Sensing of Environment*
- *GIScience & Remote Sensing*
- *Hydrological Processes*

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