Outline

- Background
- State-of-the-Art
  - Terrain Modeling
  - Hydrological Modeling
- Enduring Challenges
- Conclusions

Background (Terrain Modeling)

Terrain Modeling (2)

Scale / Processes / Regimes

The National Map

- A seamless, continually maintained, nationally consistent set of base geographic data
- Data steward partnerships
- Links the topographic map with underlying base geographic data
- Underpins Federal activities and those of other public and private organizations
- Consistent with NSDI principles

Source: Hutchinson (2000)
National Elevation Dataset (NED)

- Seamless national coverage of “best available” raster elevation data
  - Geographic “projection” with 1-arc-second (30-m) and 1/3-arc-second (10-m) grid spacing
  - Alaska: 2-arc-second grid spacing
  - Datum: NAD 83 horizontal; NAVD 88 vertical
  - Elevation units: decimal meters
  - Updated bi-monthly to incorporate new USGS DEM production
- The NED is the elevation layer of The National Map

Multi-Resolution NED

- 1 arc-second
- 1/3 arc-second

Elevation Derivatives (EDNA)

- Collaborative effort to create common topographically-derived data layers in systematic and consistent manner for U.S.
- Multi-layer data set (raster & vector)
- National Albers projection
- 30 m resolution

EDNA Stage 1 Layers

National Hydrography Dataset

- Rich cartographic feature content for making maps
- Stream addressing system for linking water-related information to the national drainage network
- Upstream/downstream modeling along the drainage network
- Infrastructure for maintenance and enhancement

Hydrologic Units

- 2-digit: 1st level = 22 regions
- 4-digit: 2nd level = 222 subregions
- 6-digit: 3rd level = 789 accounting
- 8-digit: 4th level = 2223 cataloging

- 10-digit: 5th level = ~22,000 watersheds
- 12-digit: 6th level = ~160,000 subwatersheds

new!
SRTM Datasets

- 11-day mission aboard Space Shuttle Endeavor in February 2000
- Collected interferometric SAR data for 80% of Earth’s land surface (60° N to 56° S latitude)
- JPL processed SAR data into DEMs
- Provides 1-arc-sec data over U.S. and 3-arc-sec (90-m) data other places

Slide Courtesy of Dean Gusch

Land Cover Effects

- SRTM data collected with a “first return” system, so measured elevations in forested and built-up areas often will not represent ground level elevations
- National Land Cover Dataset used to stratify assessment by land cover class to help characterize how surface features affect accuracy...

Slide Courtesy of John P. Wilson

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

Some Outstanding Issues ...

- 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!

Slide Courtesy of John P. Wilson

DEM Source and Data Type

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

Sources
- National Map
- LiDAR
- IFSAR
- GPS

Picture courtesy of David Maune

Surface Interpolation

TIN
- Surf.pts (GRASS)

IDW
- Thin Plate Spline

TOPOGRID
- Surf.tps (GRASS)

Slide Courtesy of Graeme Aggett
Drainage Enforcement

Slide Courtesy of Pete Steeves

Single vs. Multiple Flow Directions

Single Flow Direction Grid — A numerical representation of the flow direction field in which each cell takes on one of eight values depending on which of its eight neighboring cells is in the direction of steepest descent

Multiple Flow Direction Grid — A numerical representation of the flow direction field in which flow is partitioned between one or more or the eight neighboring cells such that proportions add up to one

Slide Courtesy of David Tarboton

SSURGO Soil Survey Data

Soil Sampling / Landscapes

Solum Depth Regression Tree

Predicted Solum Depth Map
Soil Water / Vegetation Links

Spruce Forest at Tree Line

Piercy Creek Clearcut
Tanoak replaces redwoods and douglas fir

Green Visions Project

Los Angeles Basin ...

GVP Watershed Modeling

- Determined quantities of contaminants entering stream network
- Simulated transport of contaminants in reservoirs, rivers, and groundwater
- Predicted water quality by stream catchment
- Used Danish Hydraulic Institute’s MIKE BASIN modeling tools

User Interface – WQ Module

MIKE BASIN

- Simulated time series of rainfall
- Performance of reservoirs and irrigation schemes
Model Implementation

- Prepare model and data
- Calibrate rainfall-runoff relationships
- Calibrate delivery and transport of contaminants
  - NO3-N, NH3-N
  - Total P
- Validate rainfall-runoff and water quality predictions

Subwatershed Delineation

Rainfall-Runoff Analysis

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

Monitoring Data

Rainfall-Runoff Results

Santa Monica Bay Flows
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

NO3-N Predictions

Santa Monica Bay Loads ...

Water Quality Results

Spatial Granularity – LA River

- Drains 2.002 km²
- 1,783 unique stream segments (links) in NHD Plus
- 171 tributaries and subcatchments used for MIKE BASIN model runs
- 11.7 km² (1,171 ha) minimum map unit

What is the Ultimate Goal?

Goal is to follow a drop of water from where it falls on the land, to the stream, and all the way to the ocean
**Enduring Challenges**

- Role of scale & landscape hierarchies
- Complex process feedbacks
  - Sensitivity of MIKE BASIN to model design decisions and inputs
- Dynamic character of key processes
  - Inclusion of cloud cover in solar radiation models
  - Quasi-dynamic topographic wetness index
- Role of measurement, calibration, validation, and uncertainty
  - Difficulty of handling scale mismatches and possibility that process regimes change with time

**Runoff Generation**

![Image of runoff generation](image)

**Preferred View ...**

- Saturated overland flow is dominant overland flow mechanism in humid, mid-latitude areas
- Variable source areas concept is most valid description of stormflow processes
- Infiltration excess overland flow occurs where infiltration capacity of a soil is low or rainfall rates are high

**The Immediate Challenge**

![Image of the immediate challenge](image)

**Final Thoughts**

- Need to rethink our research paradigms
  - Think of new ways to represent, measure and interpolate variables of interest, build and apply models, & inform decisions
- Geocomputation has major role to play here
  - Computing, modeling, sensor networks, etc.
- And with that, I will stop and take questions ...