Geospatial Technologies for the Agricultural Sciences

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Outline

• What are the technologies?

• GPS details
  – Improving GPS accuracy/reducing error
  – GPS units

• Integration with GIS
  – GIS software packages, including freeware
  – Geospatial data & imagery

• Applications for agricultural field research
What is GPS?

Global Positioning Systems

- 24 satellites make up civilian GPS
- 6-7 satellites are visible from any spot on Earth
- 4 or more GPS satellites used to compute X, Y, and Z.
How GPS Works

- Need 4 or more satellites for accurate location!

Image credit: NOAA
GPS Accuracy

Accuracy primarily depends on:

1. Number of satellites used to calculate position

2. Strength of the signal of those satellites

3. Satellite position
   - Positional Dilution of Precision (PDOP)

4. Differential Correction Procedures
   - WAAS (can improve to 2-5m)
   - DGPS (can improve to 0.1-1m)

(Your GPS unit must be WAAS- or DGPS-compatible!)
What is GIS?

**Geographic Information Systems**

- Entry, editing, storage, query and retrieval, transformation, analysis, and display & printing of spatial data.

- GIS integrates spatial data from many sources, scales, and formats.

- **Key point:** All data in a GIS is *georeferenced*, i.e. located by means of geographical coordinates with respect to some reference system.
What is remote sensing?

- The capture of information about the Earth’s surface from a distance, usually an airplane or satellite.
Blue: soil, plants, roads, water
Green: vegetation type differences, roads
Red: vegetation type differences & man-made features
Near infrared: biomass, veg types, soil moisture
Middle infrared: moisture in veg and soils, rocks
Thermal infrared: vegetation stress, soil moisture, relative heat
Applications for Agricultural Field Research

- Precision agriculture includes the use of GPS, GIS, and remote sensing to manage practices in variable field conditions.

- Map, monitor, and manage:
  - Crop Production
    - Crop Pattern
    - Crop Yield (using NIR bands)
  - Irrigation
  - Moisture, Water stress (using Thermal bands)
  - Soil Management
    - Moisture (using Thermal bands)
    - Nutrients
  - Pests detection and monitoring
    - Spray applications

Image credits: http://www.gisrs.com/Agric.html
GPS Options for Field Research

- **Garmin w/ field notes**
  - Handheld GPS
  - Field notebook
  - **PROS**
    - Simple, light-weight, and inexpensive
  - **CONS**
    - Only gives GPS coordinates
    - Restricted to lower accuracy (2-15 m error)

- **Field PDA system**
  - PDA
  - GPS
  - Software
  - **PROS**
    - Collects data electronically
    - Uses custom programs and forms
    - Overlay GPS points on imagery in the field
    - Improved accuracy (up to 10 cm)
  - **CONS**
    - Expensive
    - Sometimes NOT user-friendly
    - Less light-weight
Handheld GPS Units

- Accuracy is usually 5-15m; can be as much as 50m due under heavy canopy, PDOP, etc.
- Cannot set PDOP threshold
- Some have WAAS differential correction to improve accuracy to 2-5m.
Guide to the Handheld Garmin models

- C – Color display
- S – Electronic compass and barometric altimeter
- X – Expandable memory, new SiRF chip

Garmin GPSmap 76 C
Garmin GPSmap 60 CSx
Garmin eTrex Vista Cx
Field PDA+GPS:

What You Need

- PDA:
- GPS (if needed):
- Software

ArcPad

Trimble TerraSync

Trimble GPS Pathfinder Office

GIIF
GPS for Agricultural Field Research

• What are your accuracy needs?
  – 2-15 m …handheld units are okay
  – <2 m …mapping-grade units are needed

• GPS good for mapping points, lines, and polygons of relatively small areas
  – Very large areas should be mapped/digitized using imagery in a GIS.

• How much data will you collect?
  – Points, lines, AND polygons?
  – Extensive field note taking?
GPS Standardization

• **Position Format**
  - How 3-D earth is mapped on a 2-D surface
  - Same thing as “projection”

• **Map Datum**
  - Mathematical model that fits the earth to an ellipsoid
GPS Standardization

• **Latitude/longitude is OK, but…**
  – Lat/long is not consistent across Earth.
  – Misinterpretation of the three different formats (degrees-minutes-seconds, degrees-decimal minutes, and decimal degrees) can cause error.
  – Rounding lat/long numbers can cause error.

• **Use UTM**
  – Numbers represent meters, so each integer is a meter.
  – Split into zones so there are never negative numbers

• **Most important thing is to be consistent and document what you do!**
Geospatial Data Examples

Counties

Rivers

Census data

Soil type

Roads

Habitat boundaries

GPS data
Geospatial Data Examples

- Satellite imagery
- Elevation
- Temperature
- Landcover/landuse
- Precipitation
- Aerial photography
- Digital USGS topo map
Free Geospatial Data for Calif.

- **California Spatial Information Library:**
  http://gis.ca.gov/data.epl

- **Cal GAP Project:**
  http://www.biogeog.ucsb.edu/projects/gap/gap_data2.html

- **CDF FRAP:**
  http://frap.cdf.ca.gov/infocenter.html

Includes geospatial data, such as political, cultural, and physical data.
Also includes some imagery!
Imagery

- **National Agriculture Imagery Program (NAIP)** – free!
  Annual true-color aerial photography for the entire state of CA (1m)
  Near-infrared flown but not yet available.

  Aerial photography of urban areas flown in 2002 (60cm) & in 2004 (1m) – not of entire state though!

- **NextMap California:** [http://www.intermap.com/corporate/california.cfm](http://www.intermap.com/corporate/california.cfm)
  Elevation and imagery of the entire state (1m)

- Satellite imagery? …can be very expensive.

- Fly your own aerial photography? …useful but can be expensive.
High Resolution Imagery

ADAR
NAIP photo
IKONOS
CIR photo
Quickbird
OrbView 3
SPOT
NextMap California IfSAR data
GIS Software:
Visualizing your geospatial data

Google Earth Plus
($20/yr)
Google Earth Pro
($400/yr)

Pros:
• Easily integrate your GPS data
• Add geospatial data
• Use Google’s huge database of imagery

Cons:
• Imagery might not be good for your site
• No spatial analyses
GIS Software: Make maps

Quantum GIS (QGIS) (free)

Pros:
- Add geospatial data
- Transfer your GPS points, after some setup
- Runs on PC and Mac

Cons:
- Sometimes finicky
- No spatial analyses
- Projection & datum must be the same
GIS Software: Analyzing your geospatial data

ArcGIS

Pros:
- Extremely powerful spatial analyses
- The sky is the limit!
- Projection on-the-fly

Cons:
- Steep learning curve for performing analyses
  - What to do?
  - Where to find the tool?
  - How to prepare the data?)
Spatial Analysis Example

You have GPS point samples
  – Water level
  – Nitrate

You can:
• Download NAIP imagery of your site,
• Plot your GPS points (with water level and nitrate as attributes),
• Interpolate contours of water level,
• Interpolate surface of nitrate concentration, and
• Make a map for distribution!
GIIF Workshops for UCCE

- **Introduction to GPS & GIS**
  - Wednesday, May 23
  - Wednesday, June 13

- **Intermediate/Advanced GIS**
  - Thursday, July 5th
  - Tuesday, July 24th
  - Tuesday, August 14th
  - Wednesday, September 5th

- Email Karin (karin@nature.berkeley.edu) to register!

- Visit [http://GIIF.cnr.berkeley.edu/RREA/](http://GIIF.cnr.berkeley.edu/RREA/) for more info!

Funded by Renewable Resources Extension Act (RREA)