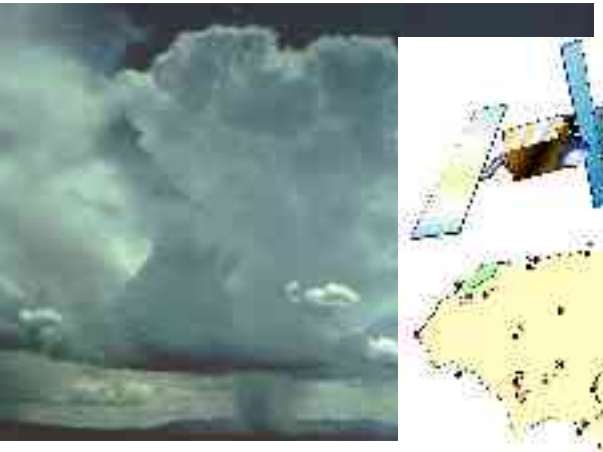
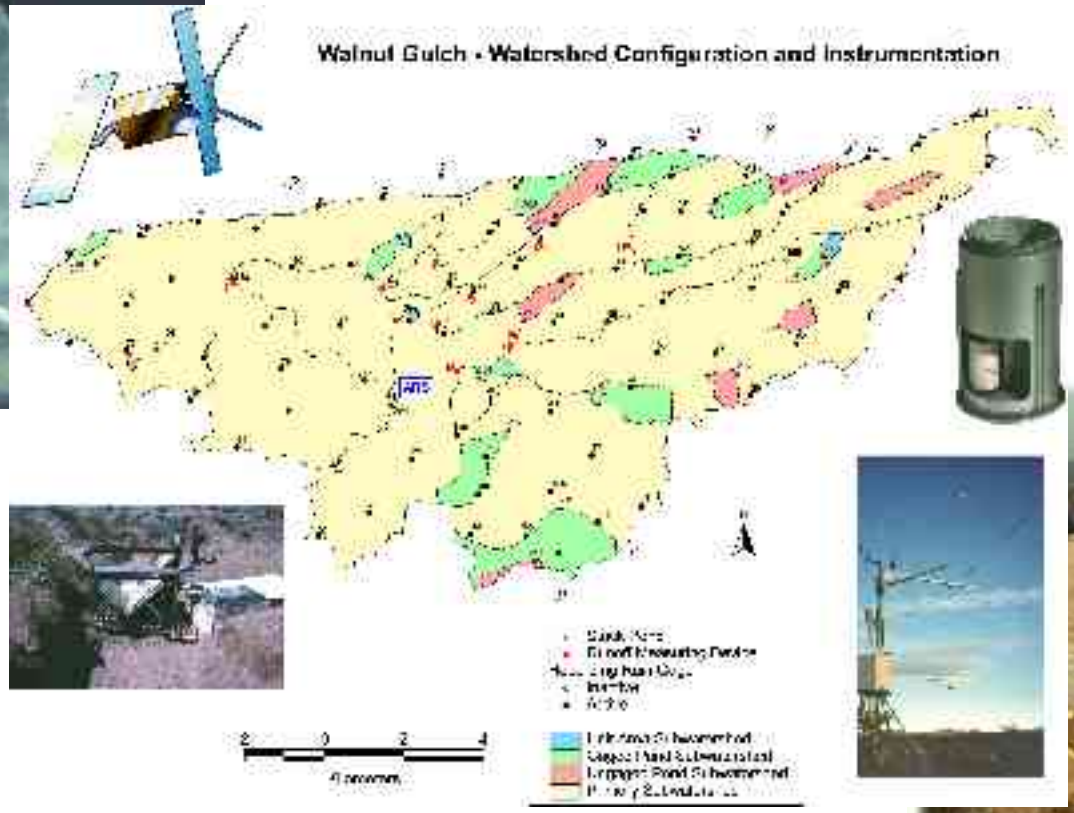
Selected Research from the WGEW and Challenges for the Future





This presentation contains unpublished data and should not be cited without author permission.

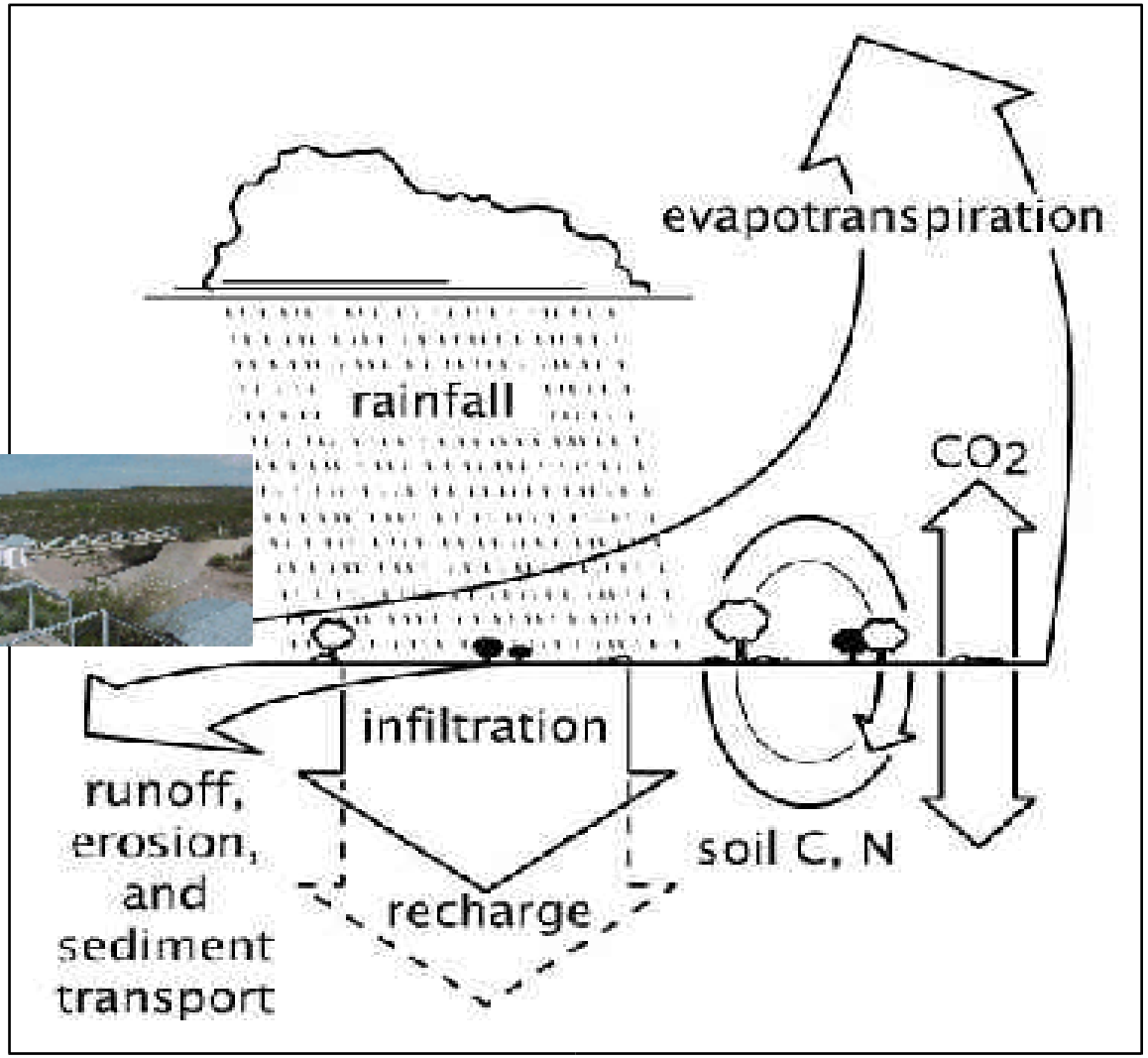
Results of Many, Many Groups and Individuals
Presented by David Goodrich
USDA- ARS, Tucson, Arizona

Background

- **Draw heavily from:**
  - **Renard, et al., 1993 - Agricultural impacts in an arid environment: Walnut Gulch case study. Hydrological Science & Technology 9(1-4):145-190.**
  - **Walnut Gulch Experimental Watershed Brochure (Keefer: http://www.tucson.ars.ag.gov/WGBrochure_2003_FinalDraft.pdf)**

- ***Thanks to all who preceeded us!!***

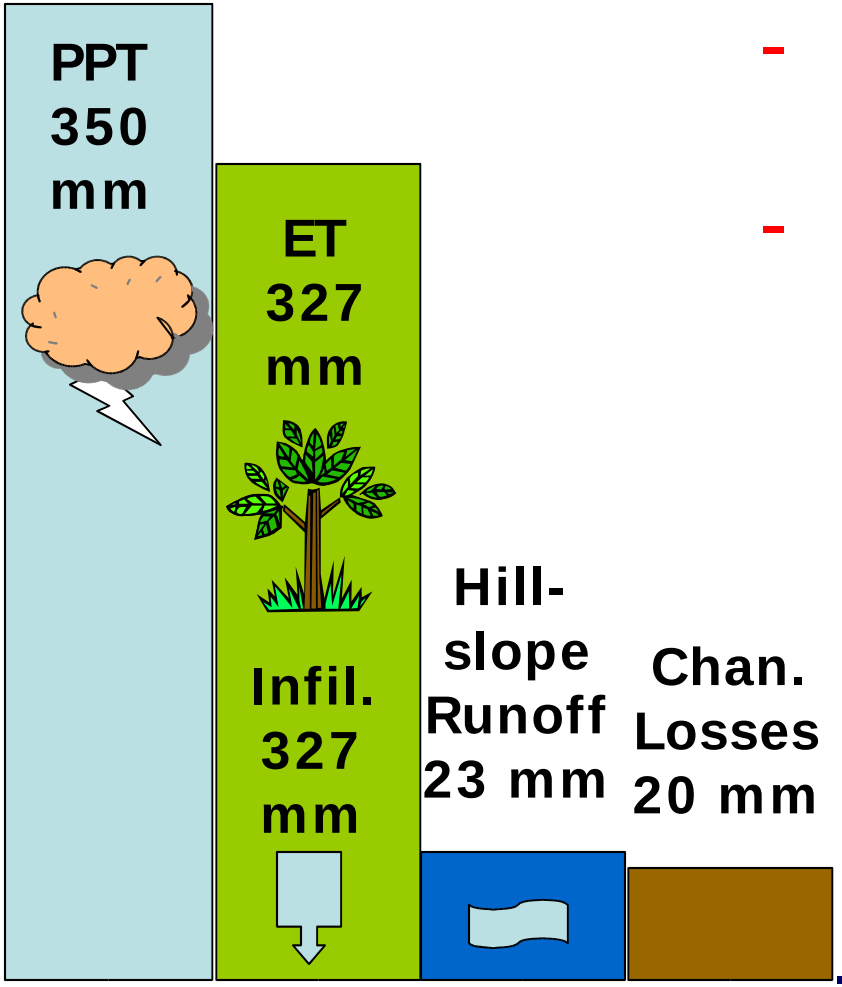
OVERVIEW



- Selected findings from WGEW
- Challenges
  - Hydro impacts of vegetation change
  - Rainfall estimation
  - Infiltration
- The future

SEMI- ARID RAINFALL - RUNOFF ISSUES

Walnut Gulch (148 sq. km)
Average Annual Water Balance



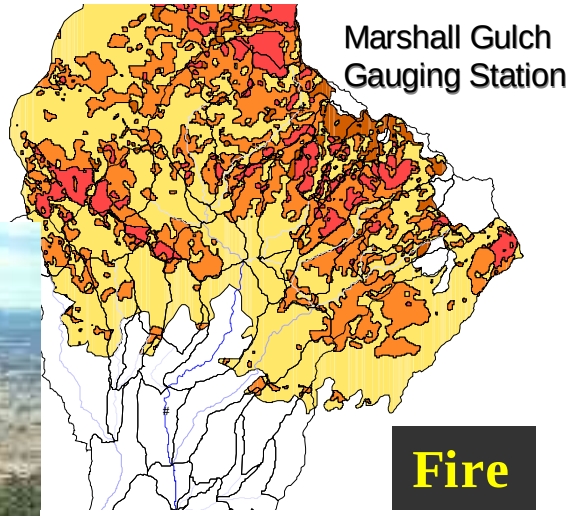
Runoff
2 mm = ~ 0.6% of rainfall

- Small Output/ Input (O/ I) ratio
- Large Noise/ Output (N/ O) ratio
  - Rain gauge measurement error ~ 3mm
  - Wind induced gauge errors ~ 5 to 15% of total rain depth (~ 15- 45 mm)
  - N/ O ratio increases as scale increases

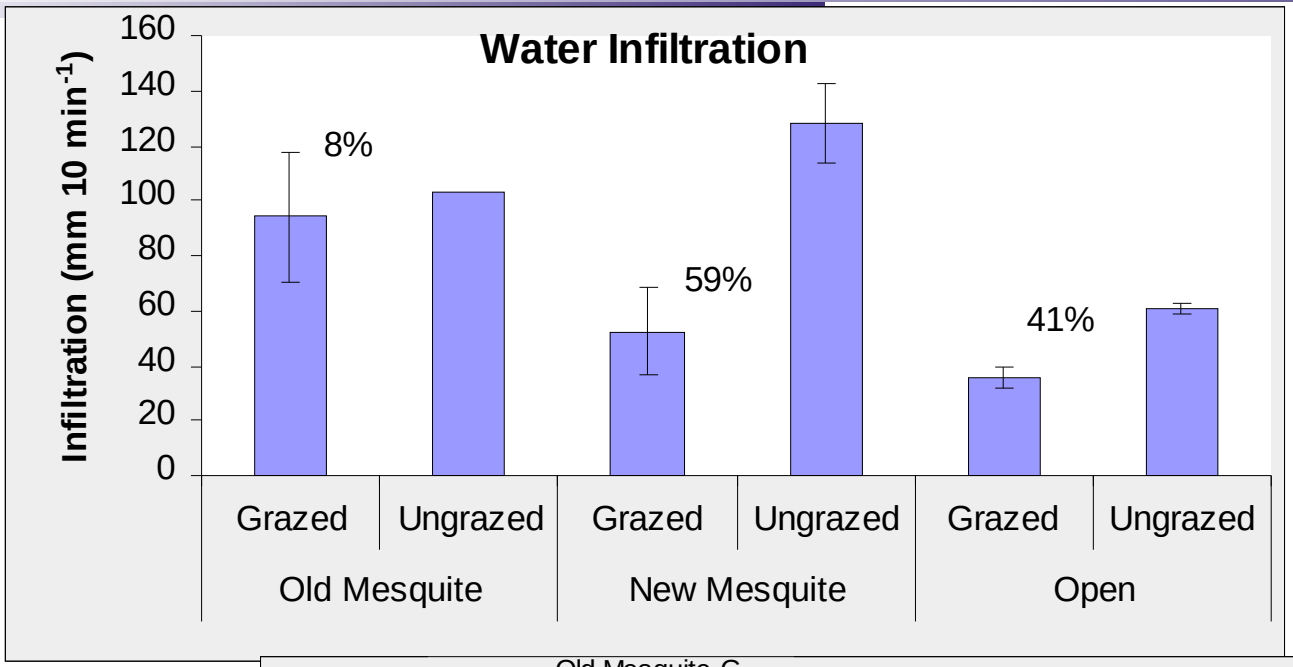
The Hydrologic Impacts of Land Cover Change at the Basin Scale (Range of Scales)

Drastic

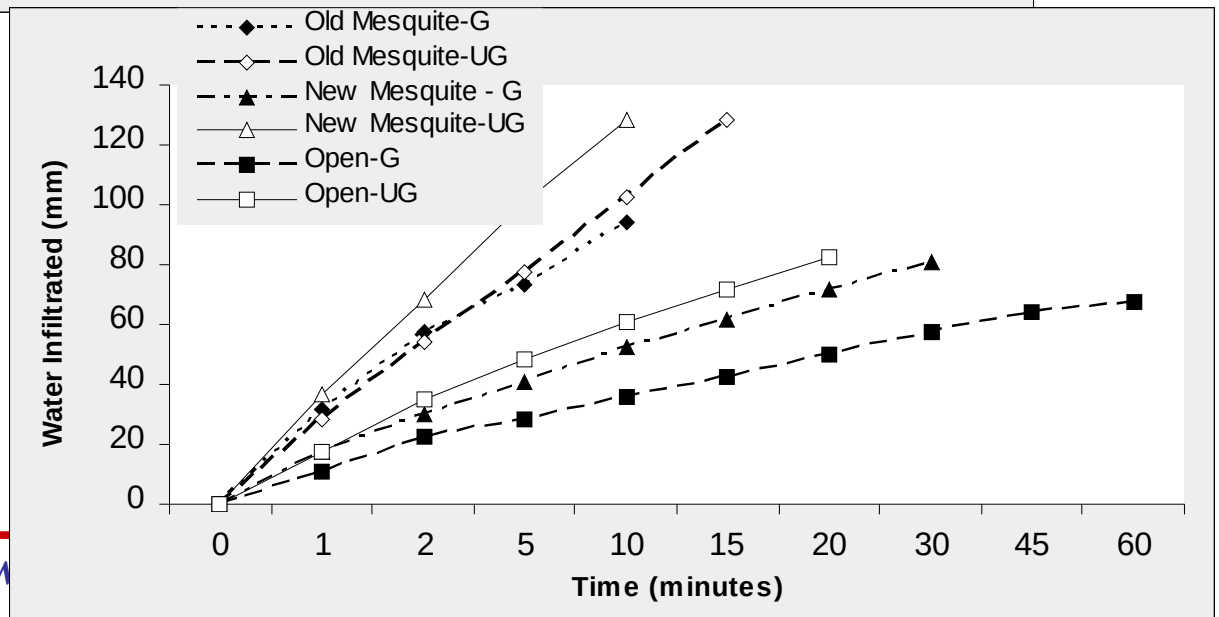
Subtle



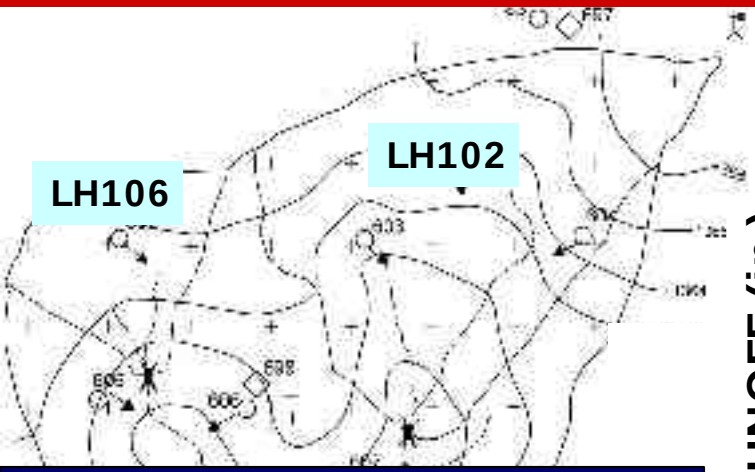
SINGLE RING INFILTRATION OBSERVATIONS



n = 3



PAIRED WATERSHED TREATMENTS

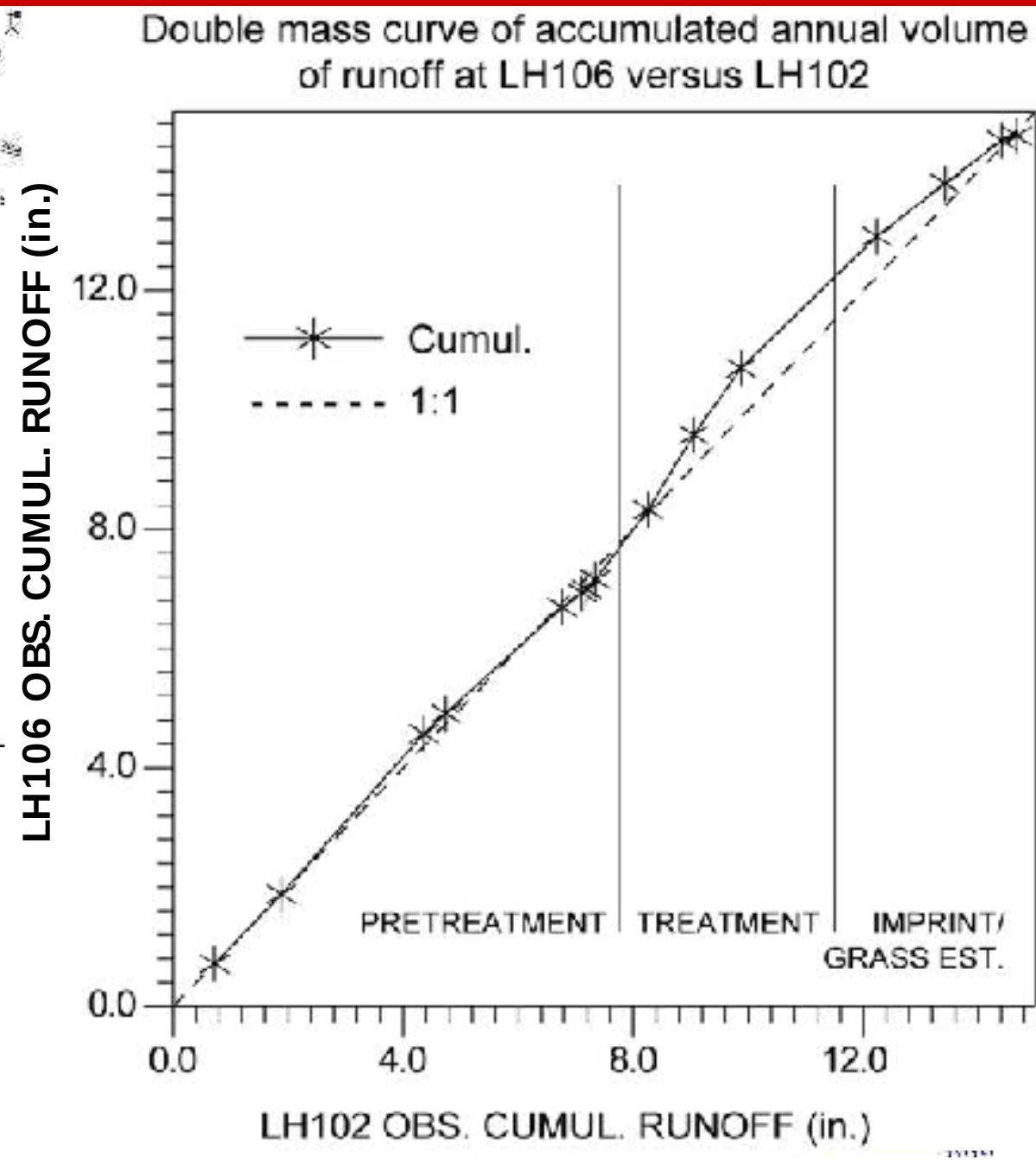


Feb. 1981:
- LH106 treated with herbicide to kill woody plants

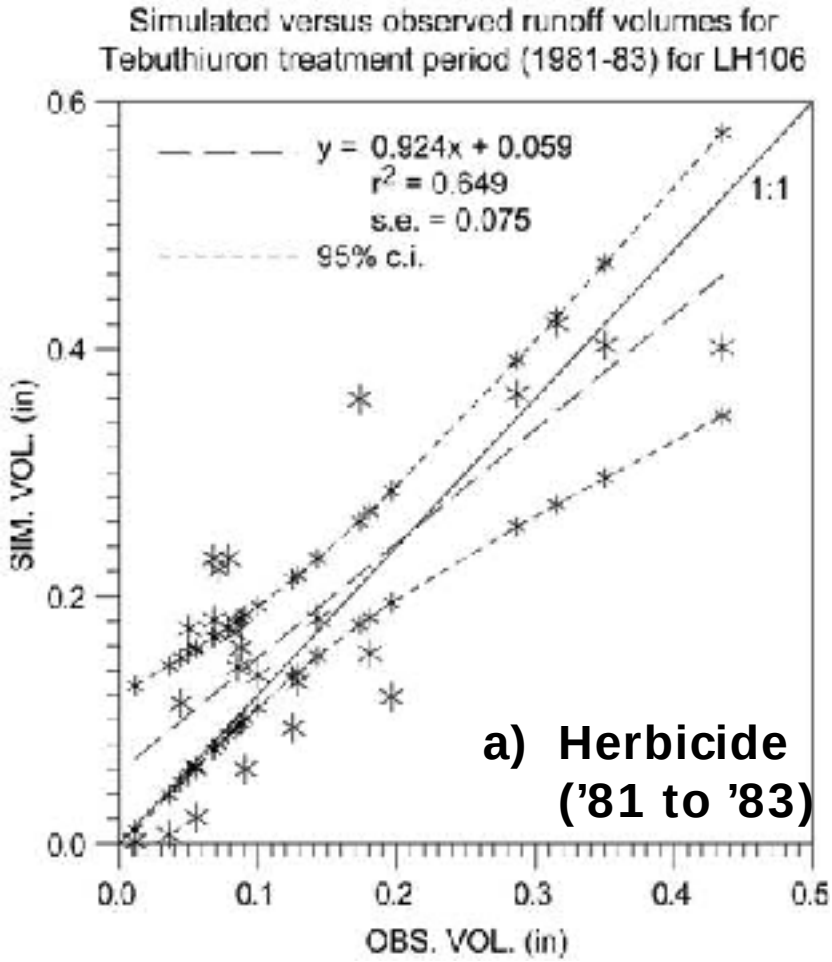
By 1984:
- LH106 Canopy cover = 12 %
- LH102 Canopy cover = 46%

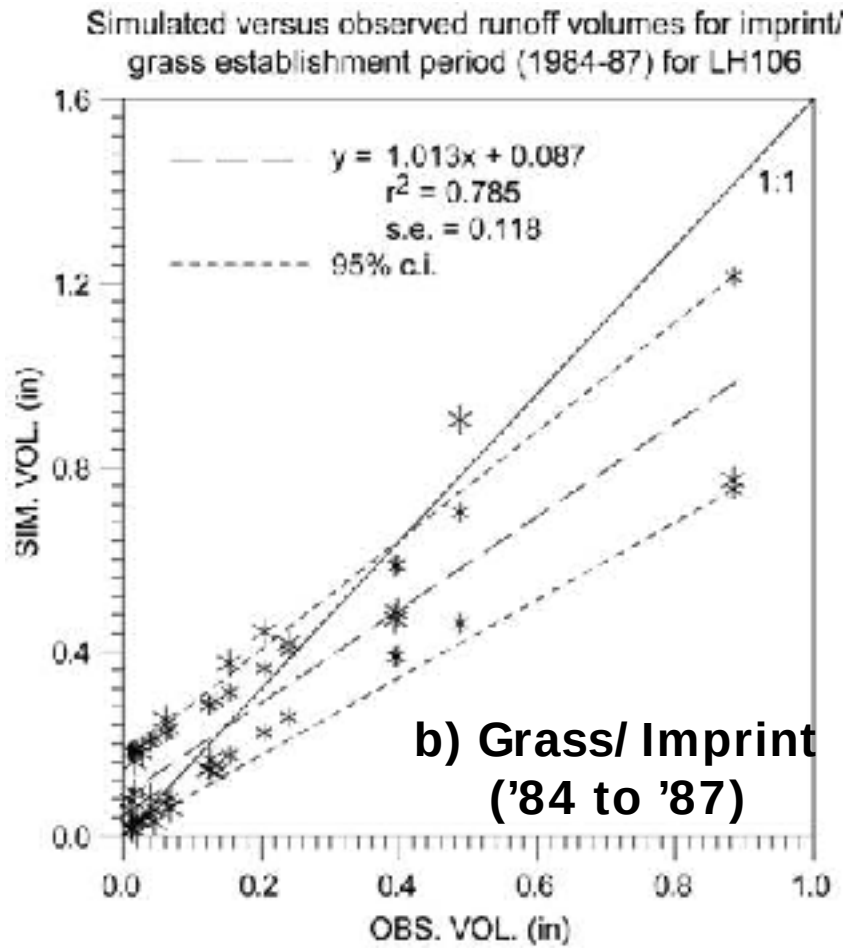
June 1984:
- Both LH102 & LH106 seeded with grass and forbs with land imprinter

Mid 1986:
- Imprints obliterated



Hydrologic Modeling to Detect Change

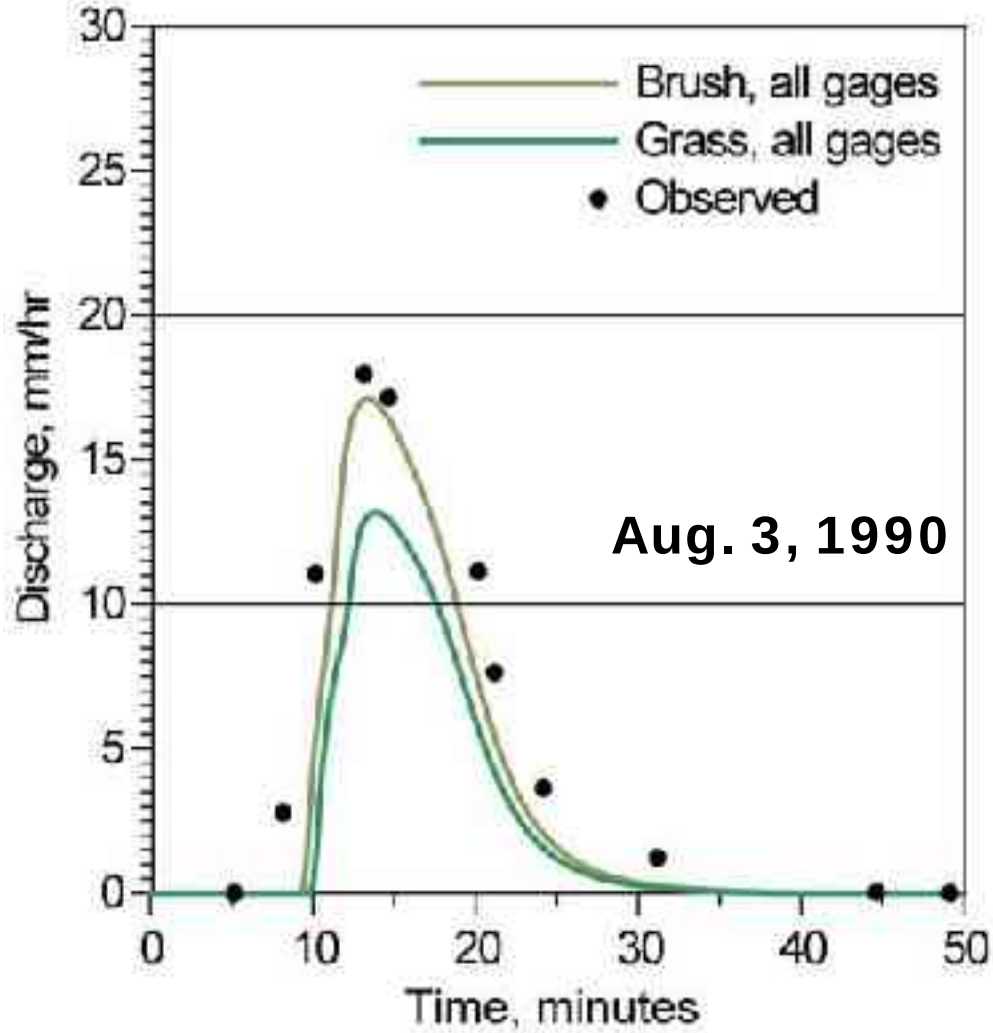


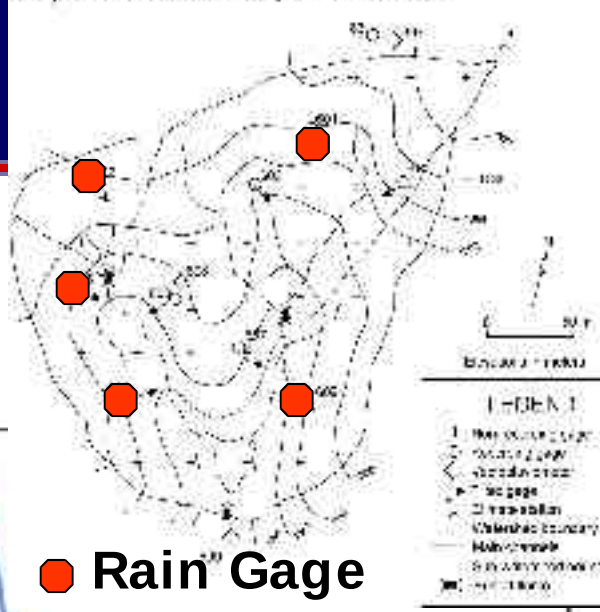


KINEROS calibrated/ validate to Pretreatment Condition ('73- '80) (for volumes, Nash- Sutcliffe Stat. Cal. = 0.92, and NS Val. = 0.93) and then run, using calibrated parameters on a) Herbicide and b) Grass/ imprint events

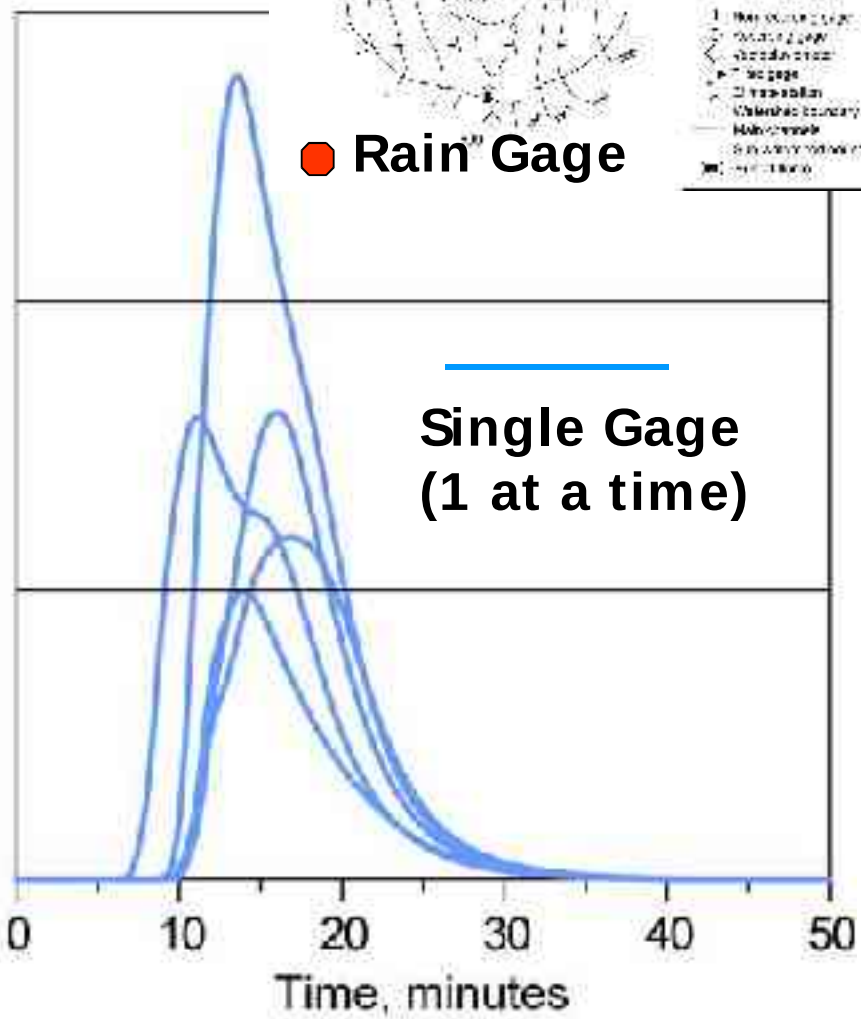
Uncertainty due to Rainfall Variability

Small scale spatial variability of rainfall (on the order of ~150 m)





Rain Gage



Challenge

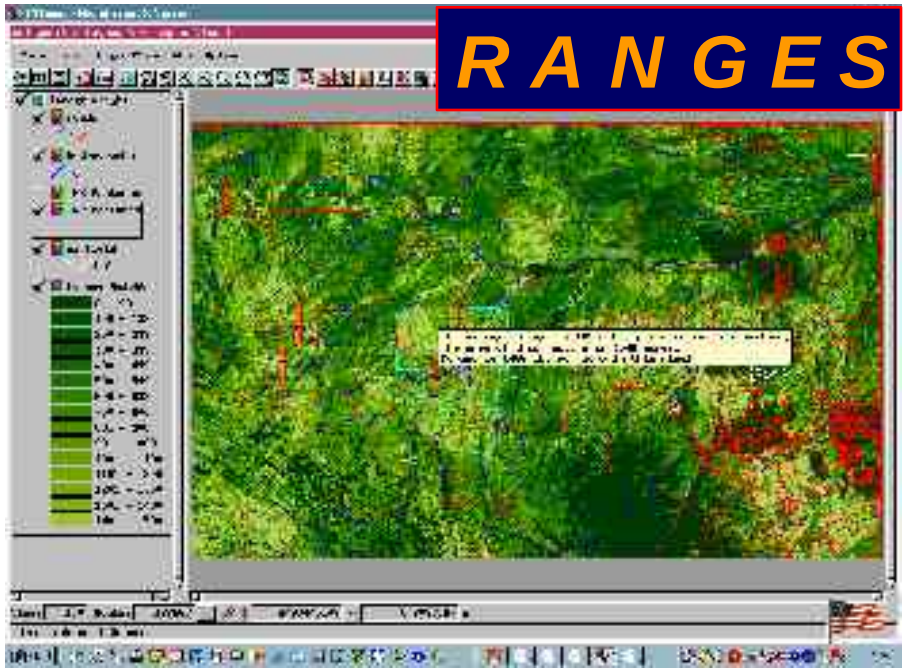
- At the point and small scale ***rainfall*** must be accurately measured to assess the hydrologic impacts of land cover change:
- It only gets worse as watershed size increases in arid in semiarid regions where runoff / rainfall ratios are small and runoff is our primary measure of basin response
  - Can we measure spatially distributed components of the water balance that are of much greater magnitude; e.g. ET, infiltration?
  - How might we improve spatially distributed estimates of infiltration parameters over large basins?
- Will radar- rainfall estimates improve our ability to estimate large- area areal rainfall outside of WG?

? QUESTION ?

Can "fast" responding Veg. be used as a distributed infiltration gauge in water- limited environments?

Point Measure Rain (Infil = Rain – Runoff)

Distributed Forage Weight Image (green or senescent)



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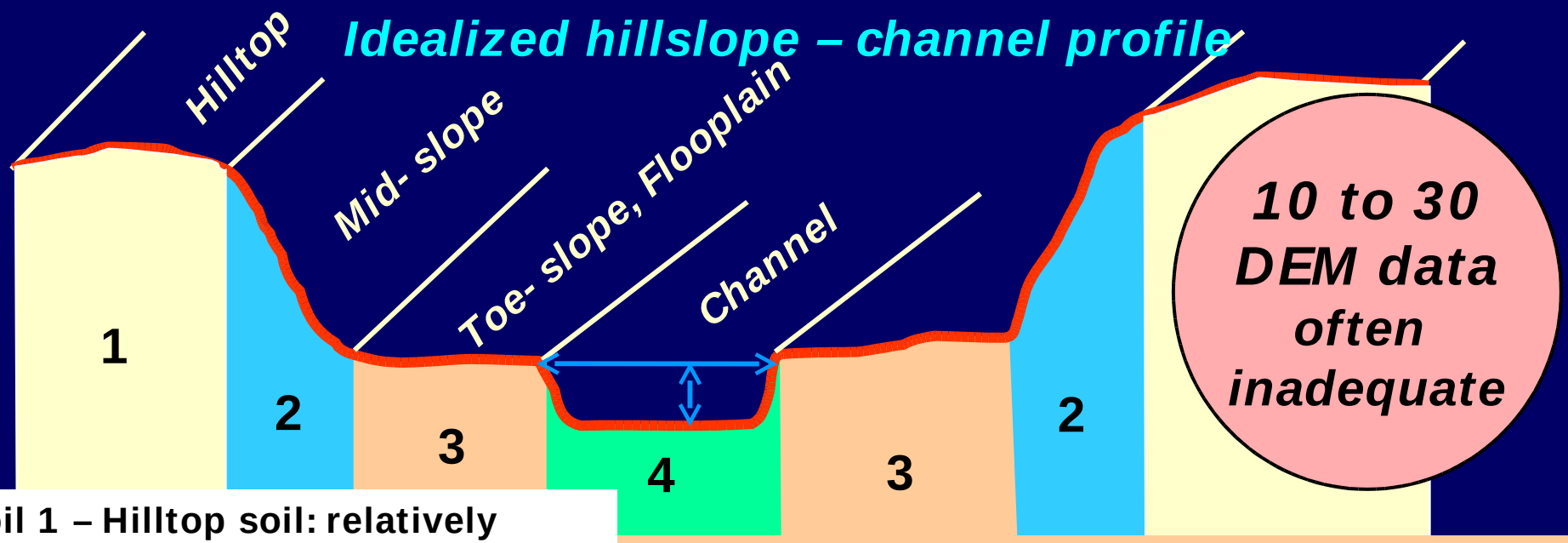
Combine Topo/ Soils to Improve Est. of Infil. Parameters

Goal - determine general soil classes with *texture information* based on:

- Geomorphic characteristics (Drainage Den., Sinuosity, Channel morphology)
- Position on landscape (Hilltop, hillslope, floodplain)
- Parent material (geology) and climatic history

GIS to extract channel geometry for hydrologic modeling and mobility

- channel width, depth, bank steepness



Soil 1 – Hilltop soil: relatively deep, shallow slopes, rocky

Soil 3–Floodplain soil: Deep, clay- rich, flat slope

Soil 2 – Transition soil: shallow, steep slopes

Soil 4–Channel (thalweg)–sandy, rocky

LIDAR Missions

NSF Center for Airborne Laser Mapping
Univ. of Florida

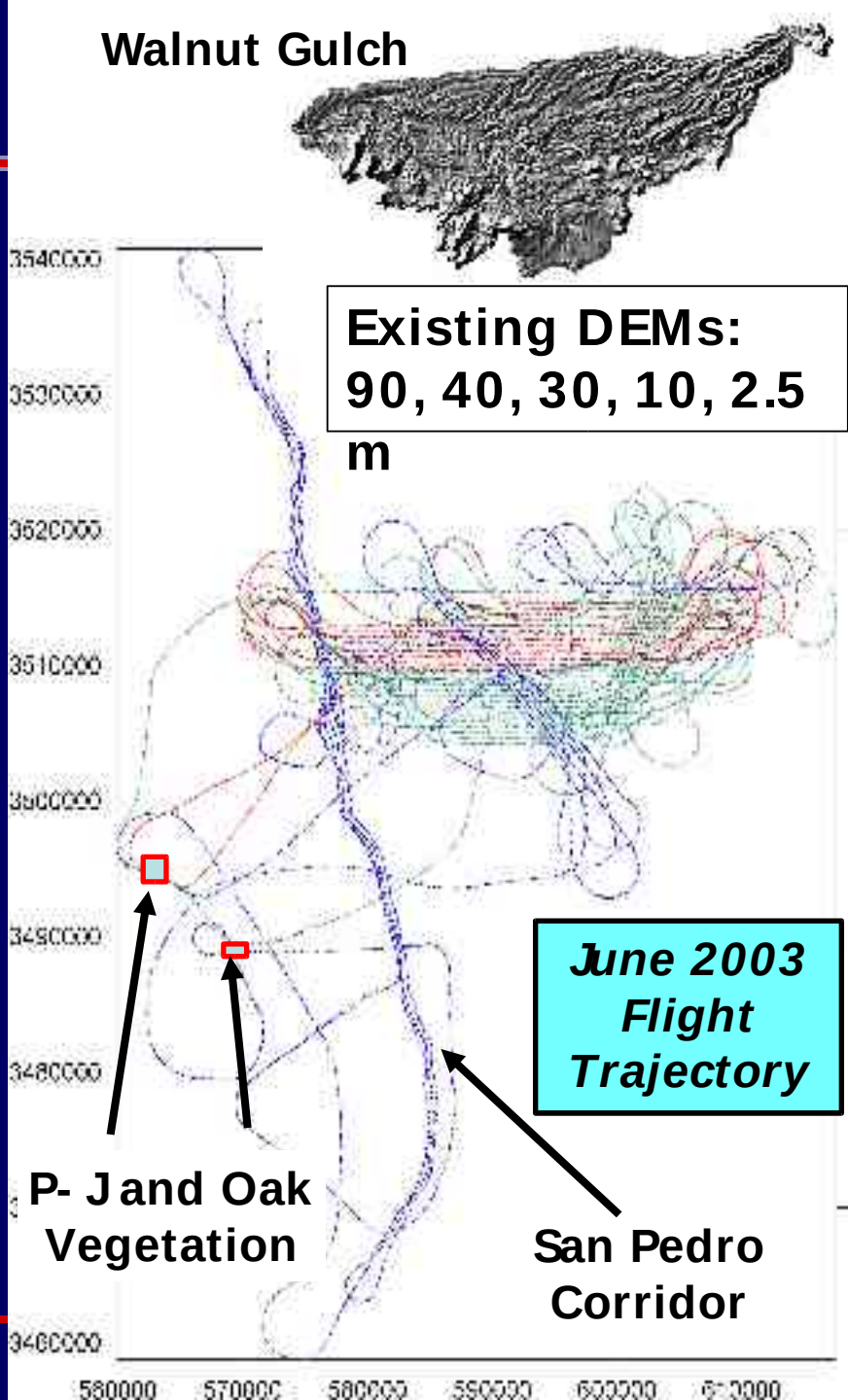
Two Missions (June, 2003 & 2004)

- Walnut Gulch & San Pedro Riparian Corridor

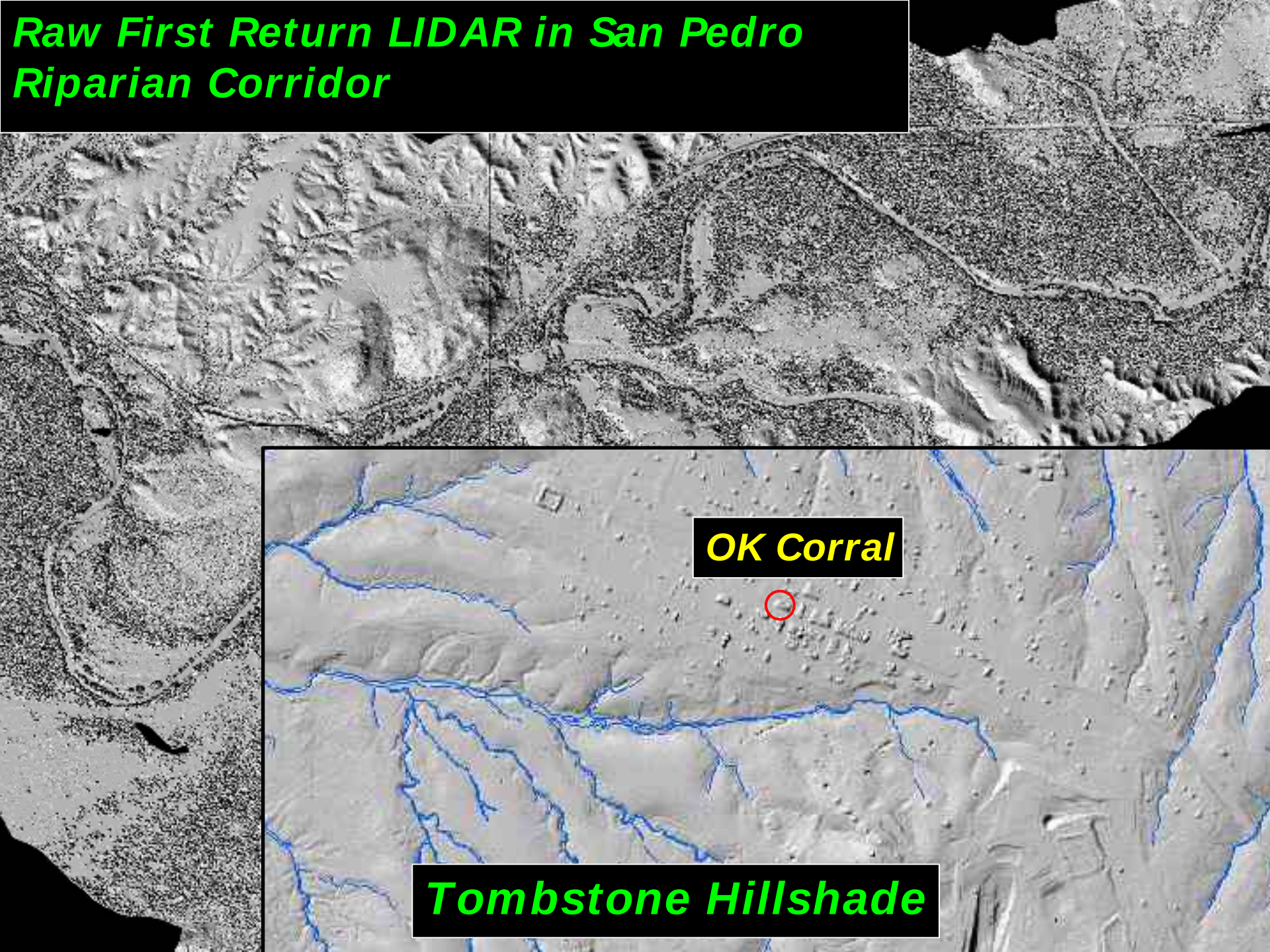
- Topography (second return)
  - 1 m post points
  - Absolute vertical accuracy ~ 10 cm
  - Point to point relative accuracy ~ 7cm

- Vegetation (first return)
  - Canopy height
  - Canopy shape / geometry

- Co- registered Color IR ~ 20 cm resolution



Raw First Return LIDAR in San Pedro Riparian Corridor



Soil & Texture - Test in Walnut Gulch

Step 1: ***Initialize Heuristic Model Based on Climate, Geology, Gen. Soils***

Step 2: ***Reduce Soil Information:*** **Re- classification based on texture similarity**

Step 3: ***Geomorphic Analysis***

- **Using 2.5 m IFSAR extract attributes (slope, etc) for the known soil polygons**
- **Perform regression to predict soil texture: %sand, %silt+ clay (fines)**

Results in WG: **High Corr. between soil texture vs geomorphic variables**

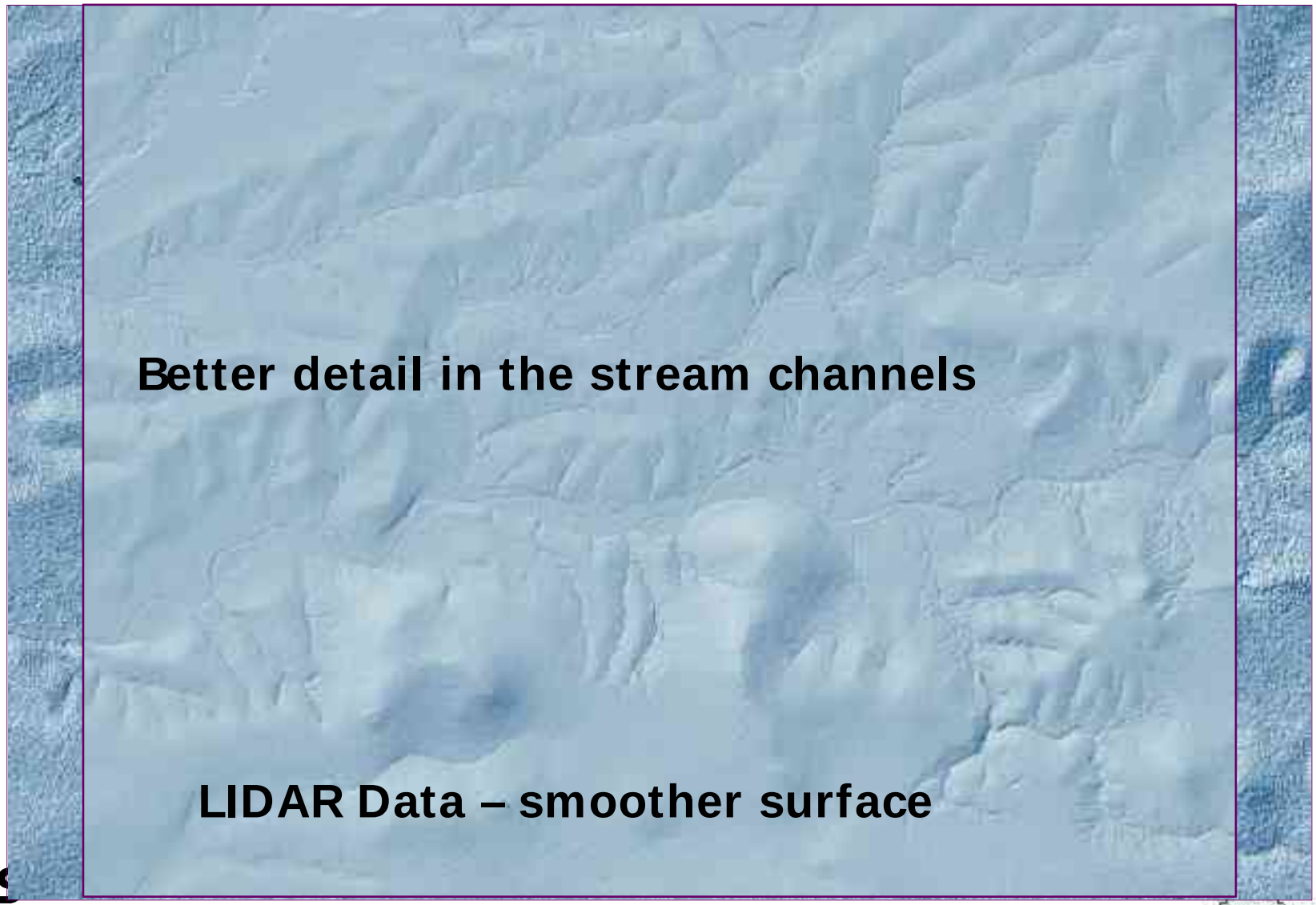
$$\text{Silt} + \text{clay} = 8.46(C) + 1500(Dd) - 0.041(S)$$

C = curvature, Dd = drainage density, S = slope

r^2 = 0.97, SExy = 0.163 ***ANOVA P- value = 0.002***

Improved Results with LIDAR ??

LIDAR


Better detail in the stream channels
LIDAR Data – smoother surface

Challenge

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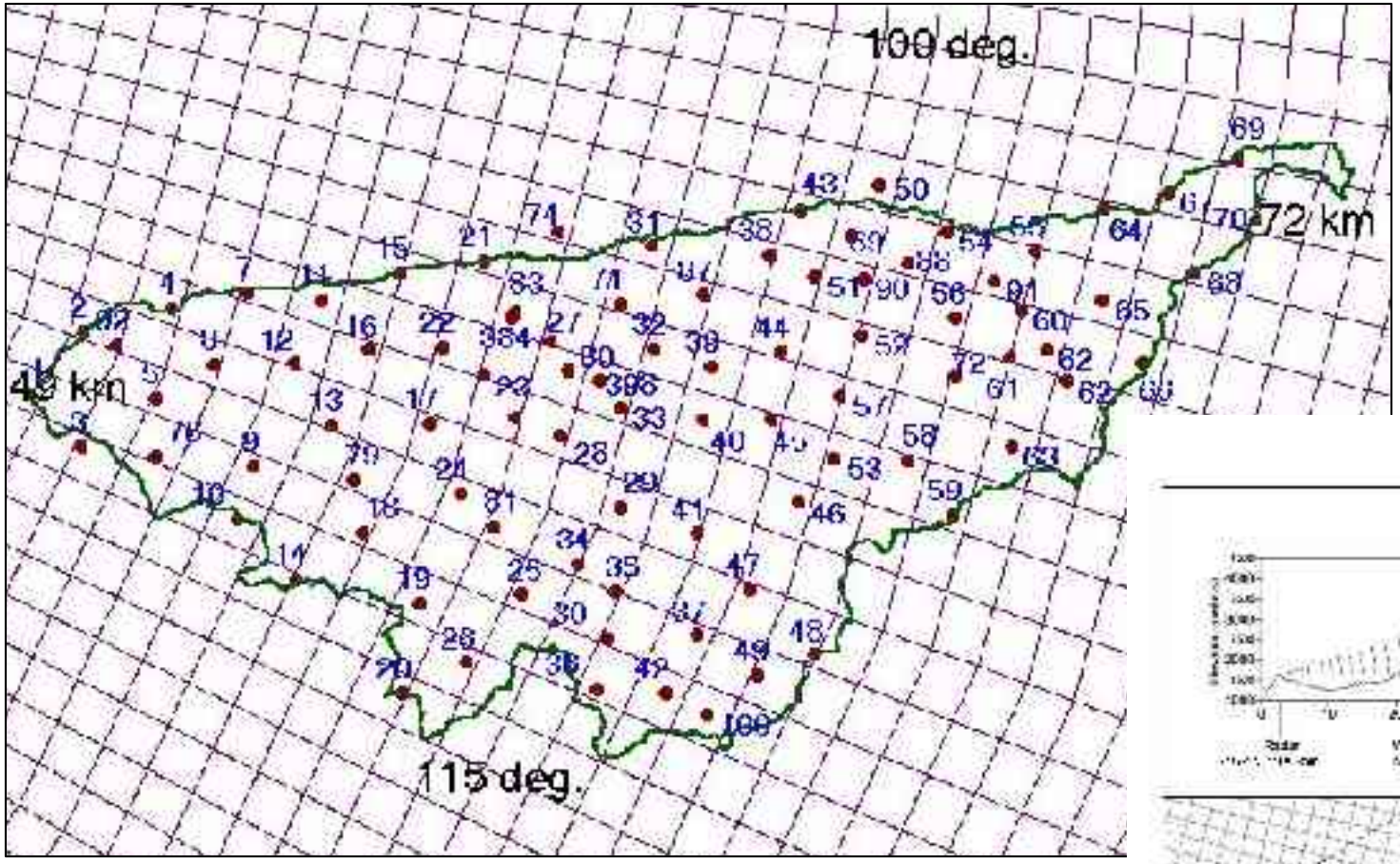
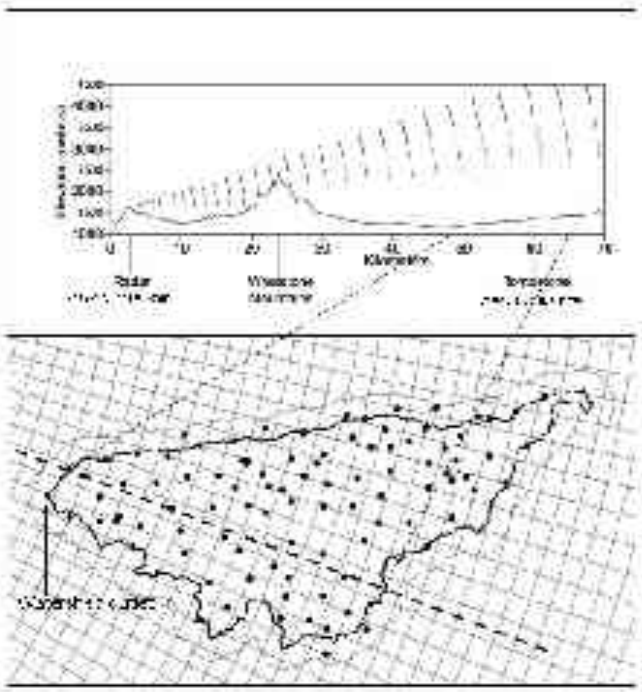
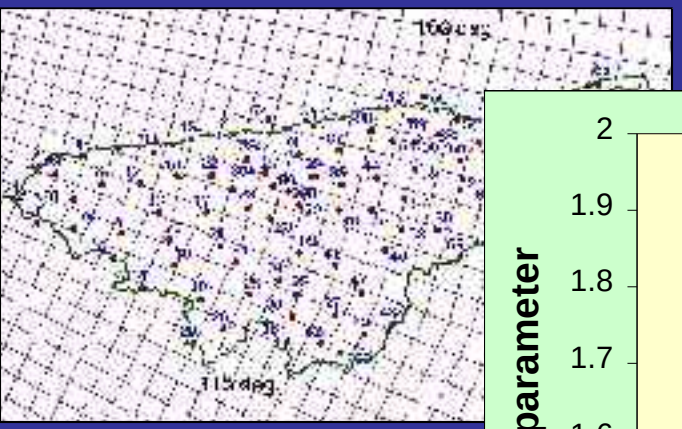
NEXRAD over WG

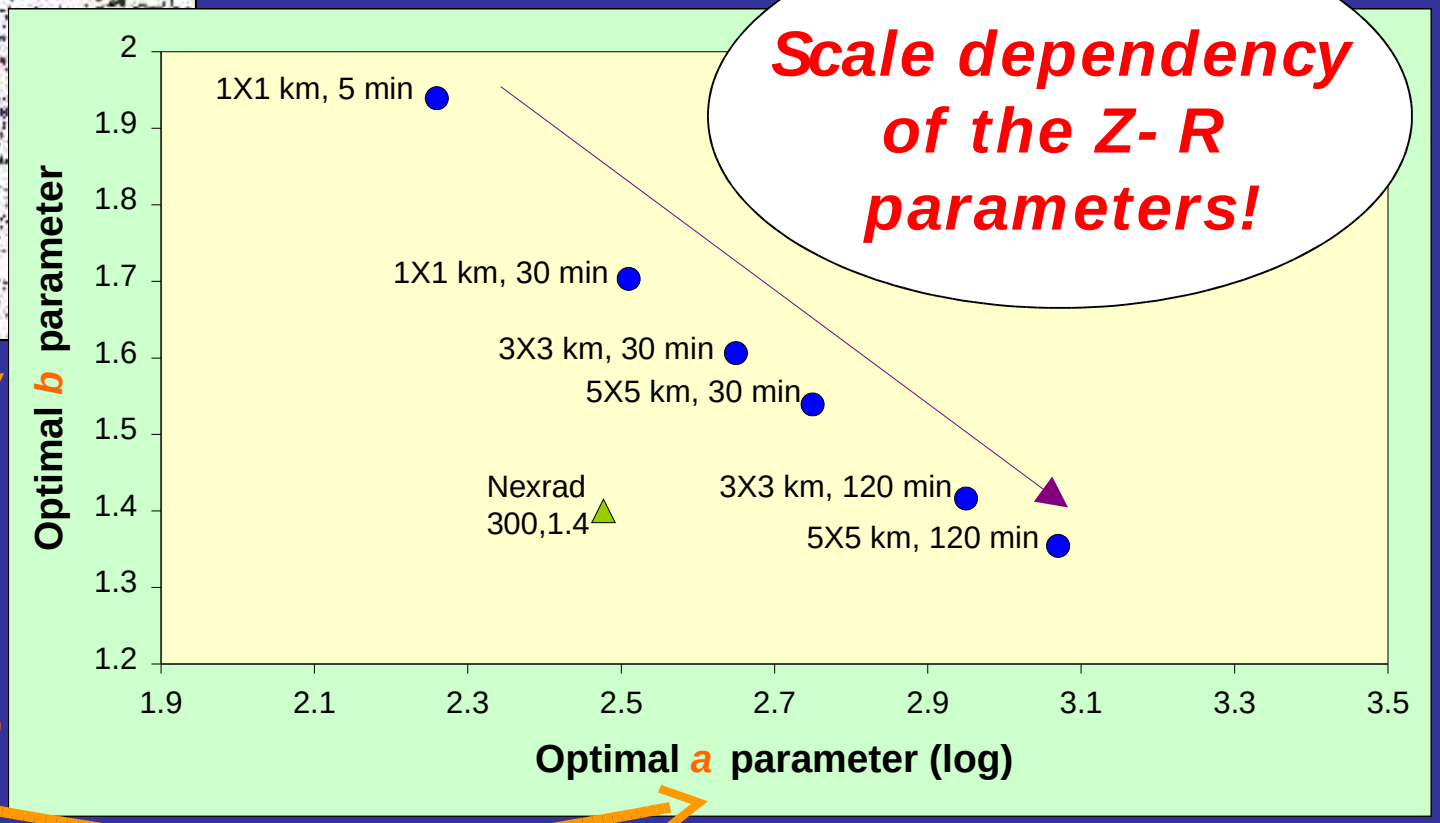




Rainfall estimation based on Nexrad data over W

Assuming the conventional NWS power- law relationship and the RMSE objective function, estimate the optimal Z- R parameters over 11 storms



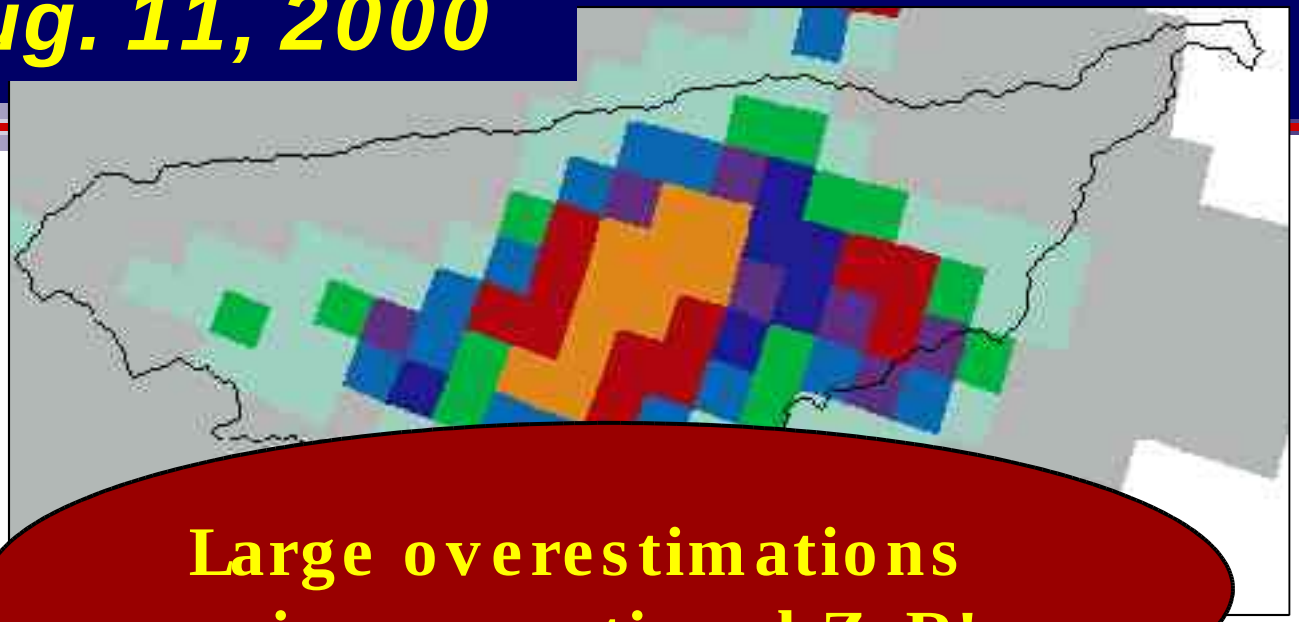


Scale dependency of the Z- R parameters!

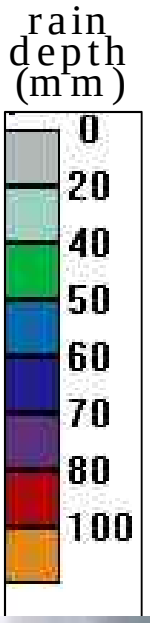
$$Z = a R^b$$

Storm: Aug. 11, 2000

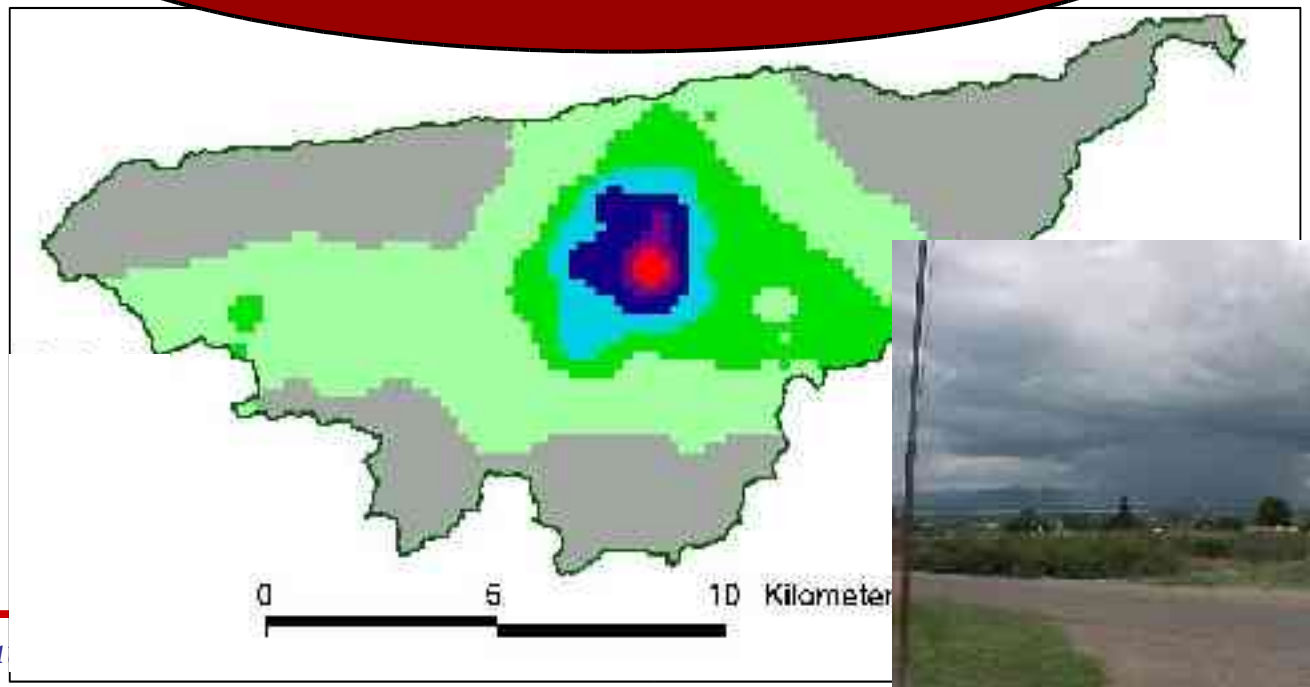
Radar based rainfall using operational Z-R



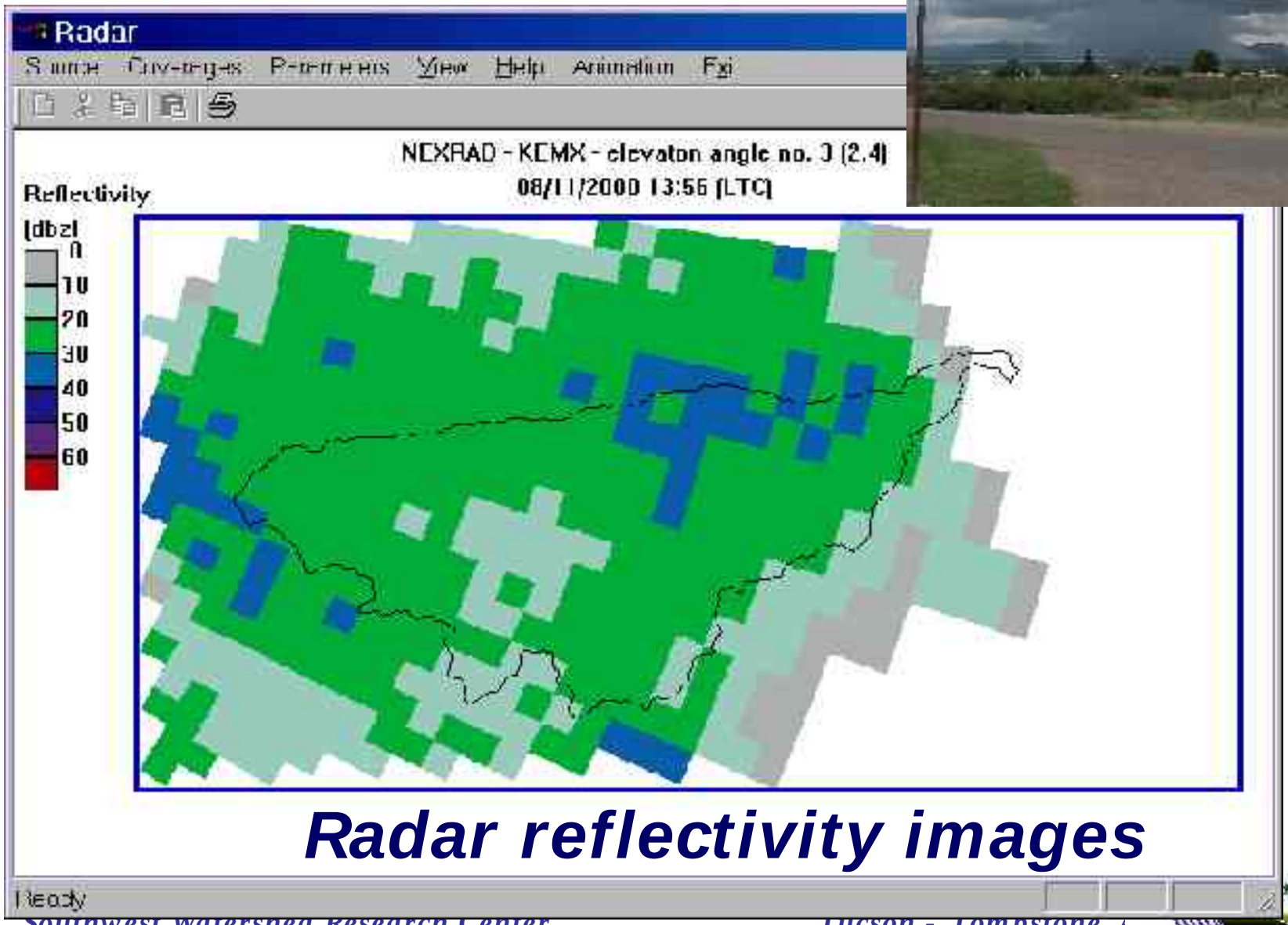
Large overestimations using operational Z-R!



Gage based rainfall



Storm: Aug. 11, 2000

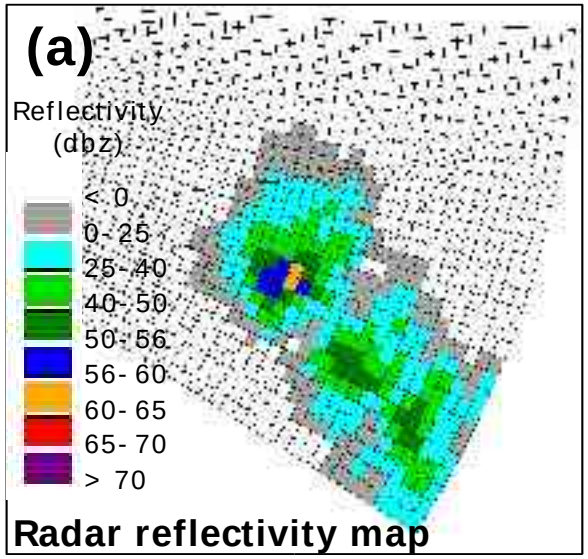


Radar reflectivity images

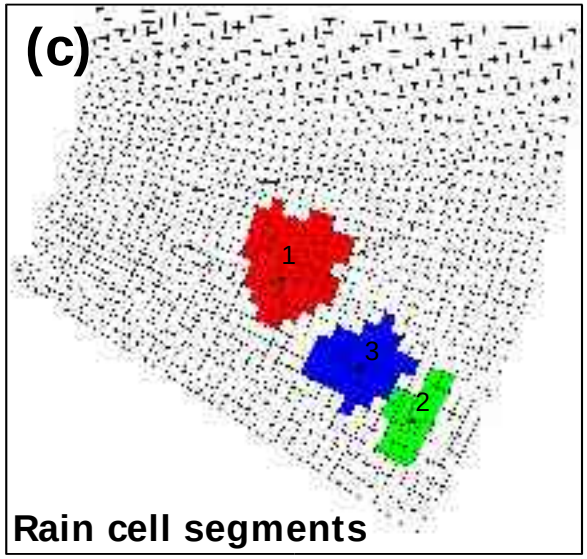
Conclusions - Challenges

- Precipitation estimation
  - NCAR high- res mobile radar campaign over WG
  - Pair pit raingages with standard gages at several locations
  - Interannual and interdecadal persistence of rainfall variability
- Changes in the Hydro Cycle with Vegetation Change – Multi-scale, interdisciplinary approaches and controlled experiments
- Combine vegetation patterns with topography and soil to further improve infiltration parameter estimates
- Total sediment estimates from large flumes
- Scaling of ephemeral channel recharge

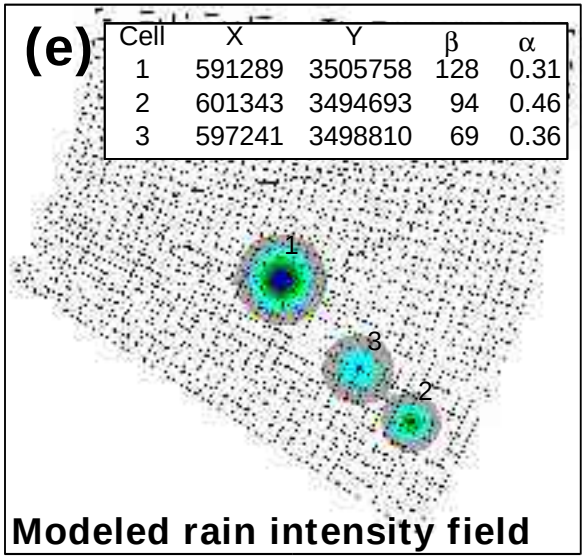
Radar- Rainfall Cell Modeling



Radar reflectivity map

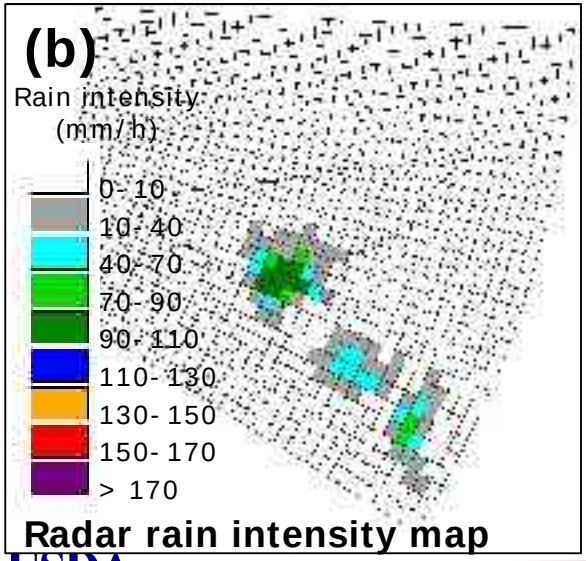


Rain cell segments

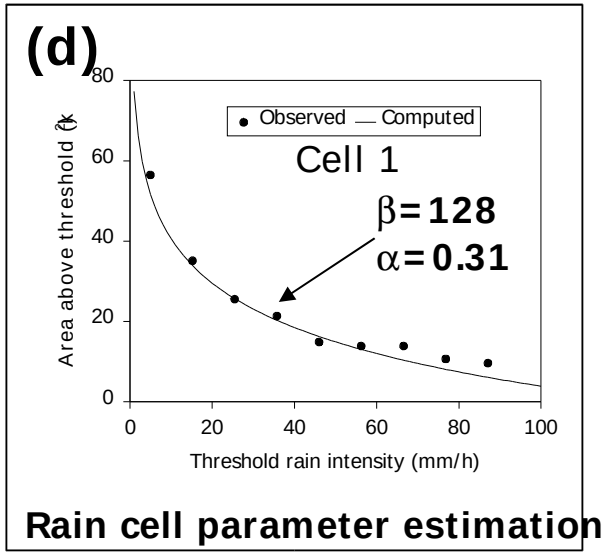


Cell	X	Y	β	α
1	591289	3505758	128	0.31
2	601343	3494693	94	0.46
3	597241	3498810	69	0.36

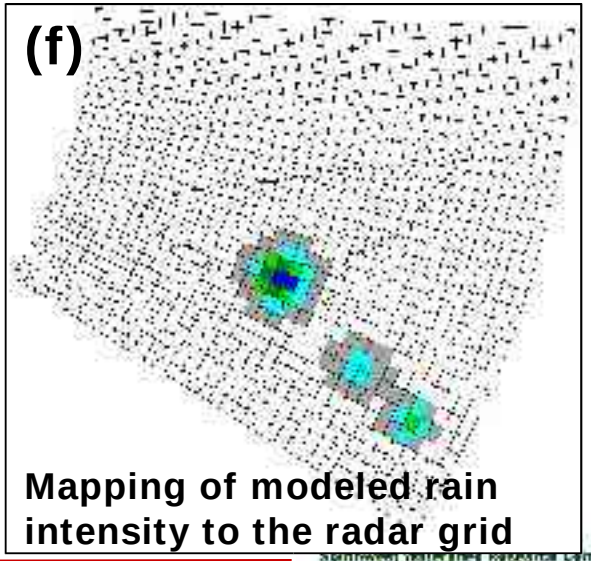
Modeled rain intensity field

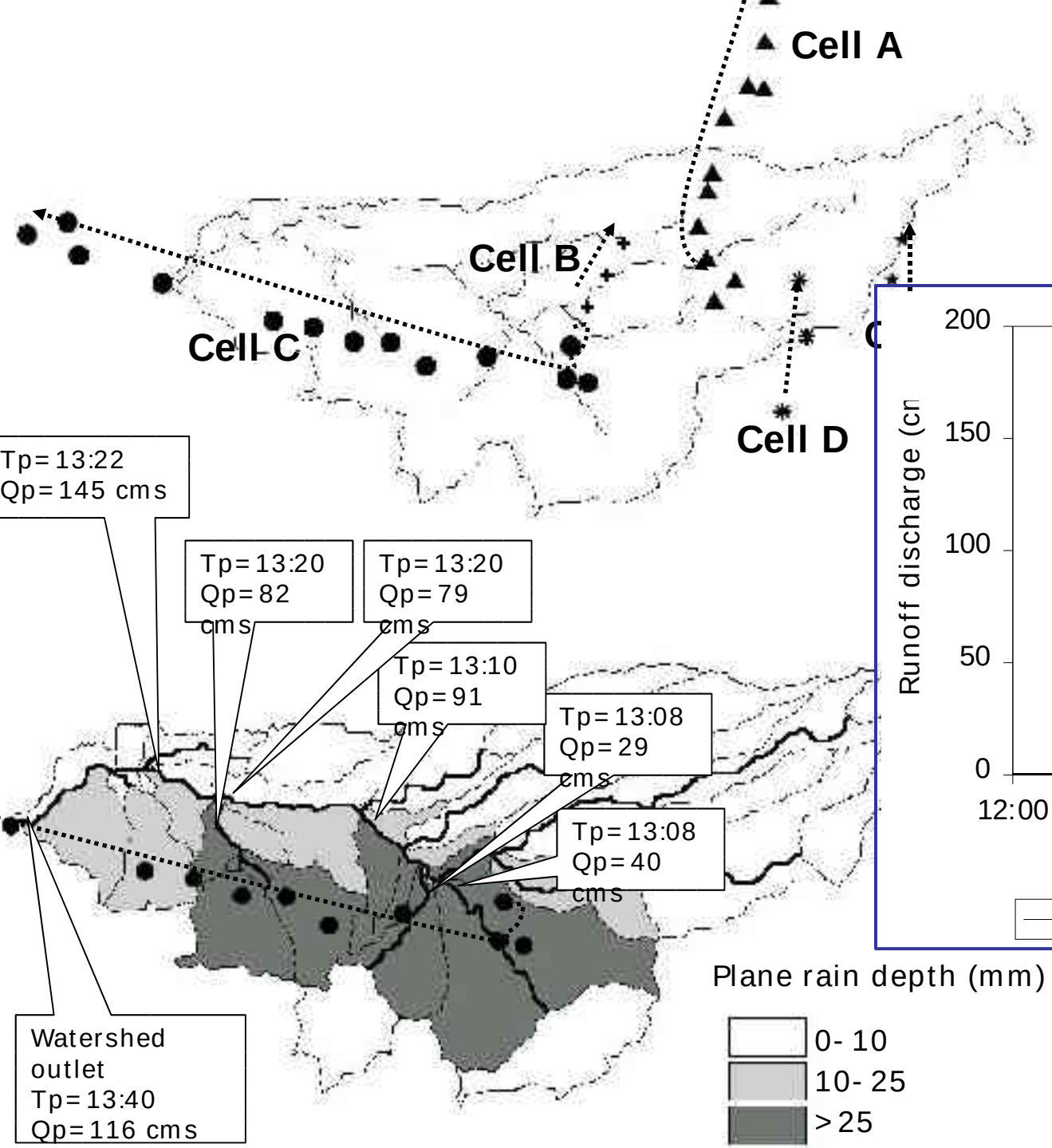
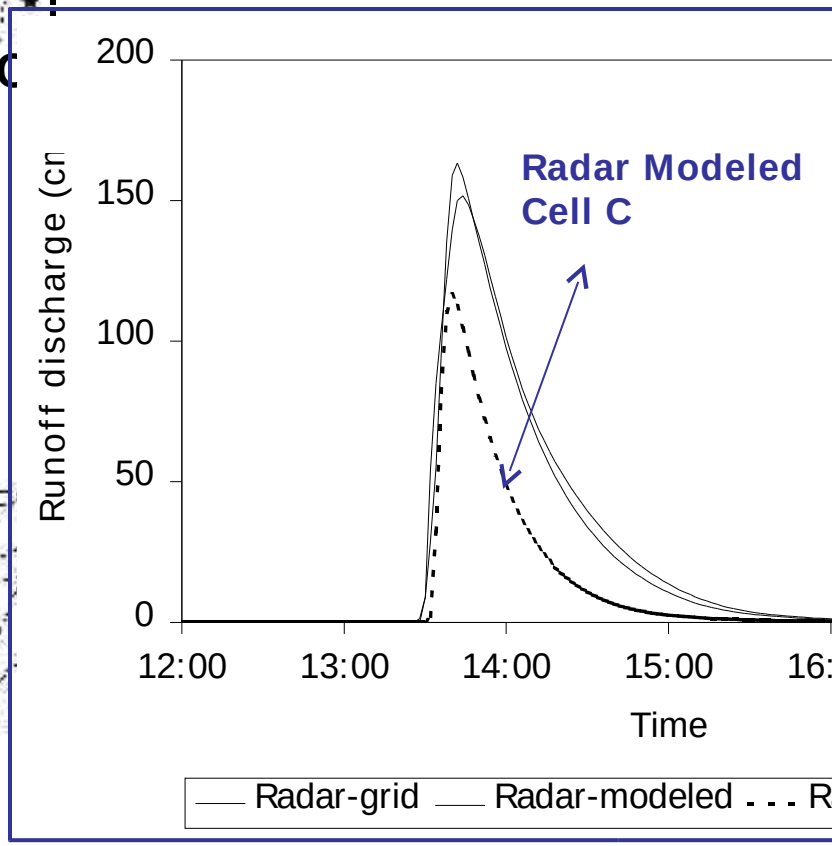


Radar rain intensity map



Rain cell parameter estimation



Mapping of modeled rain intensity to the radar grid

Rain Cell & Hydrograph Decomposition