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The Dialog between Field Scientist and Watershed Modeler

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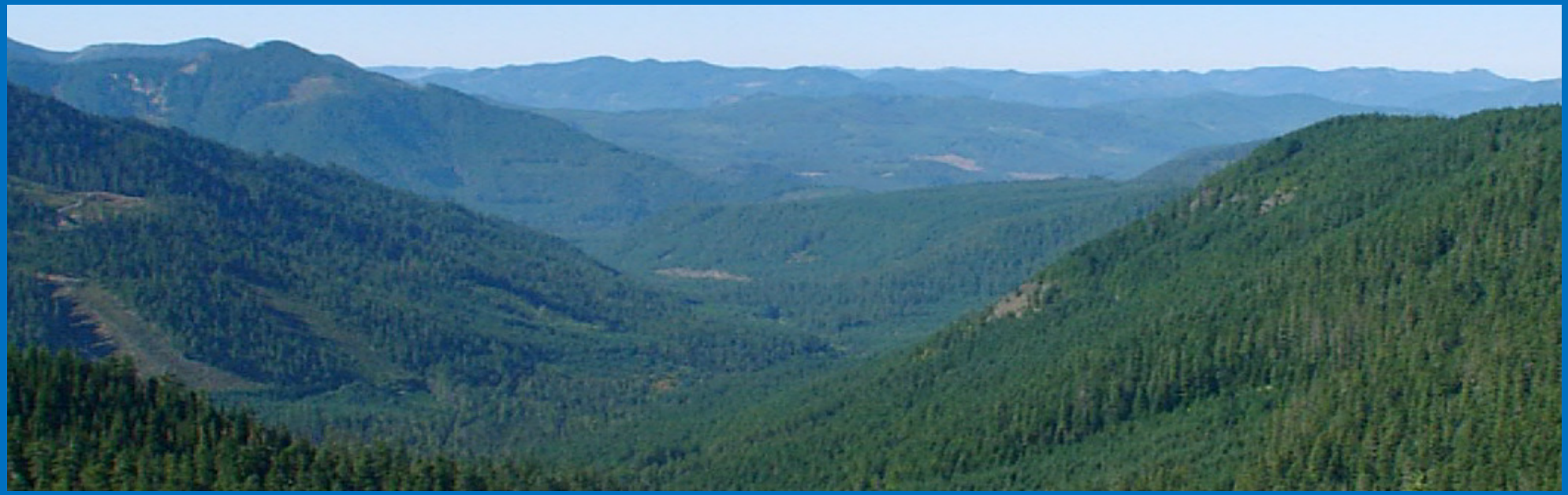
The dialog between field scientist and watershed modeler

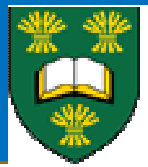


Jeff McDonnell

University of Saskatchewan, Oregon State University, University of Aberdeen

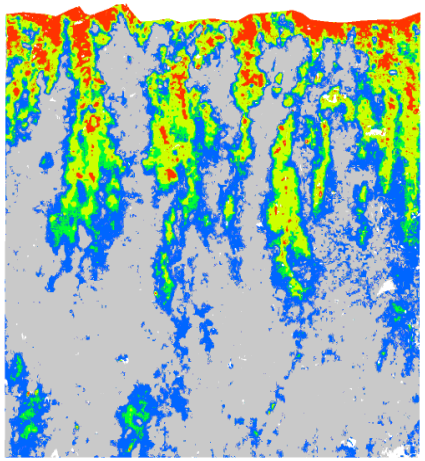
Jan Seibert

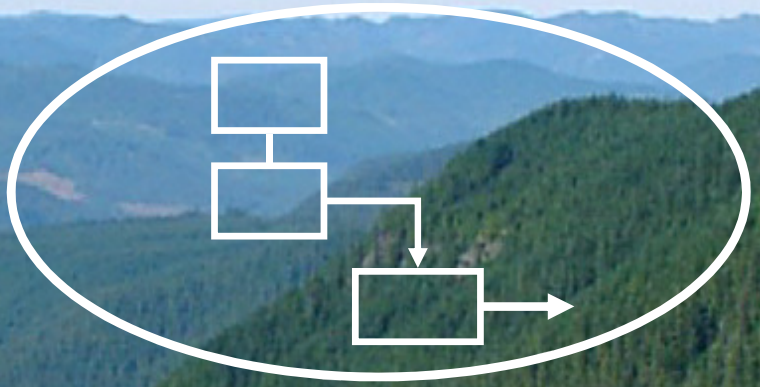
University of Zurich



UNIVERSITY OF SASKATCHEWAN

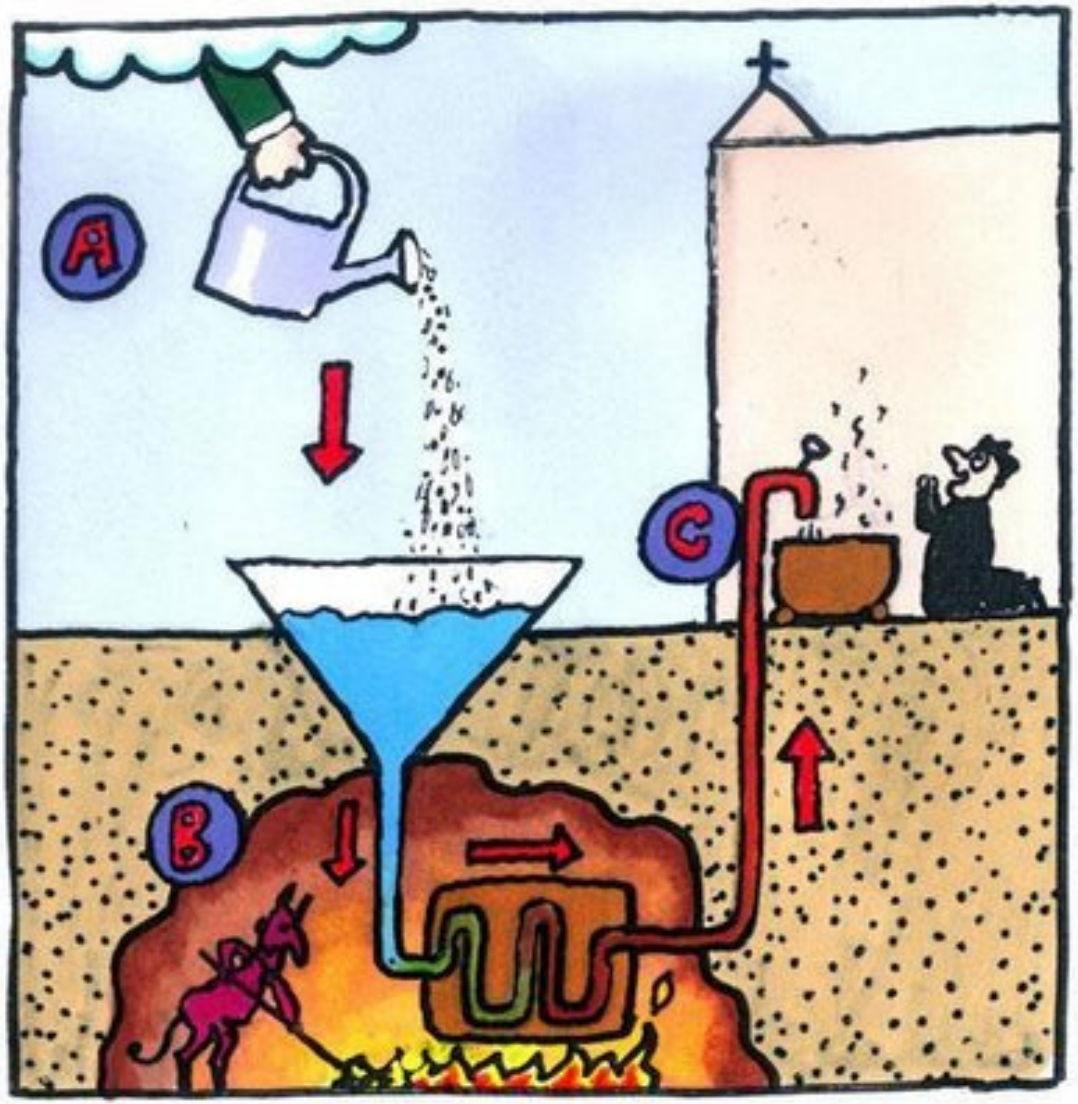
The dialog between field scientist and modeler





The dialog and model uncertainty:
Epistemic uncertainty

Dialog Btw Field Scientist and Modeler

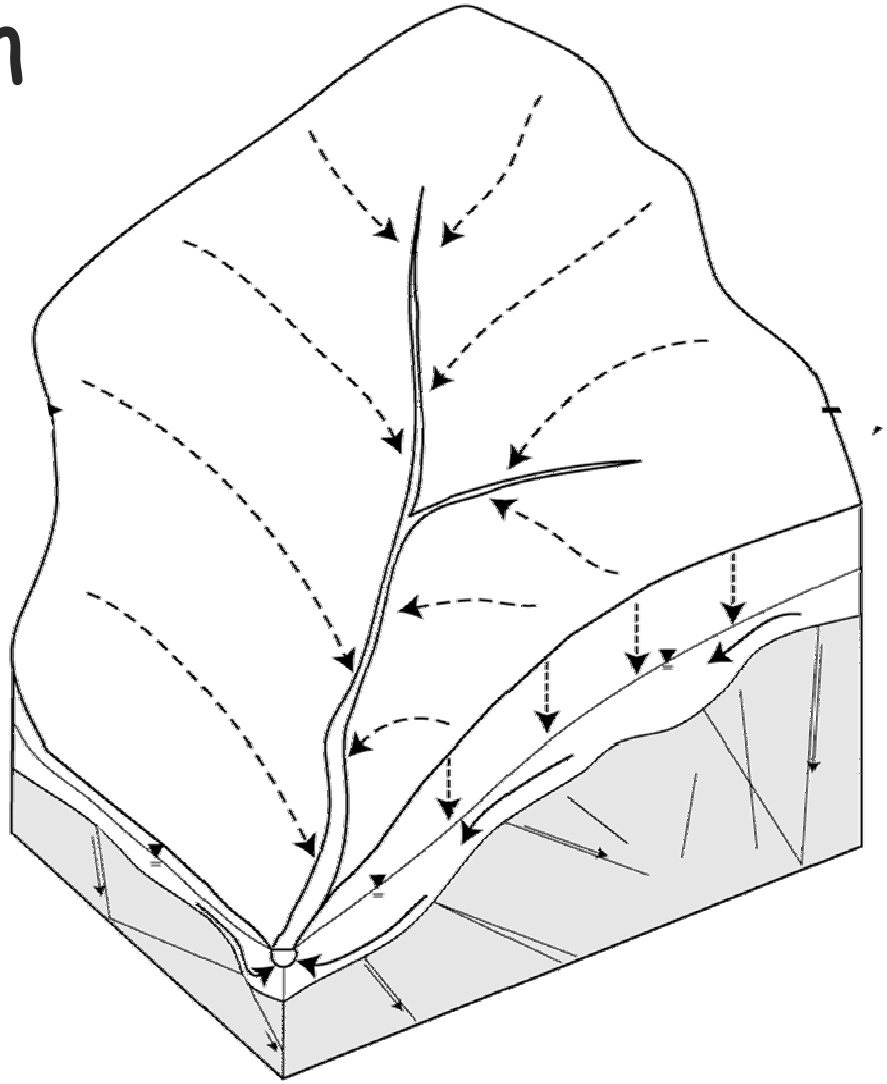


http://www.google.com/imgres?imgurl=http://2.bp.blogspot.com/_jW0fHcfb-L4/SNOaZoxuw3I/AAAAAAAAFy8/jgNkNp60-o

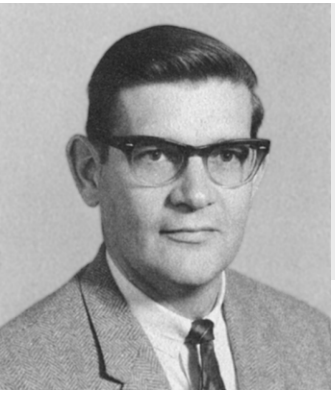
- Uncertainties that arise from lack of knowledge rather than random natural variability

Outline

- The dialog betweeen field scientist and modeler
  - Brief history
  - Recent work
- Future issues
  - Scaling as process realism



Brief history

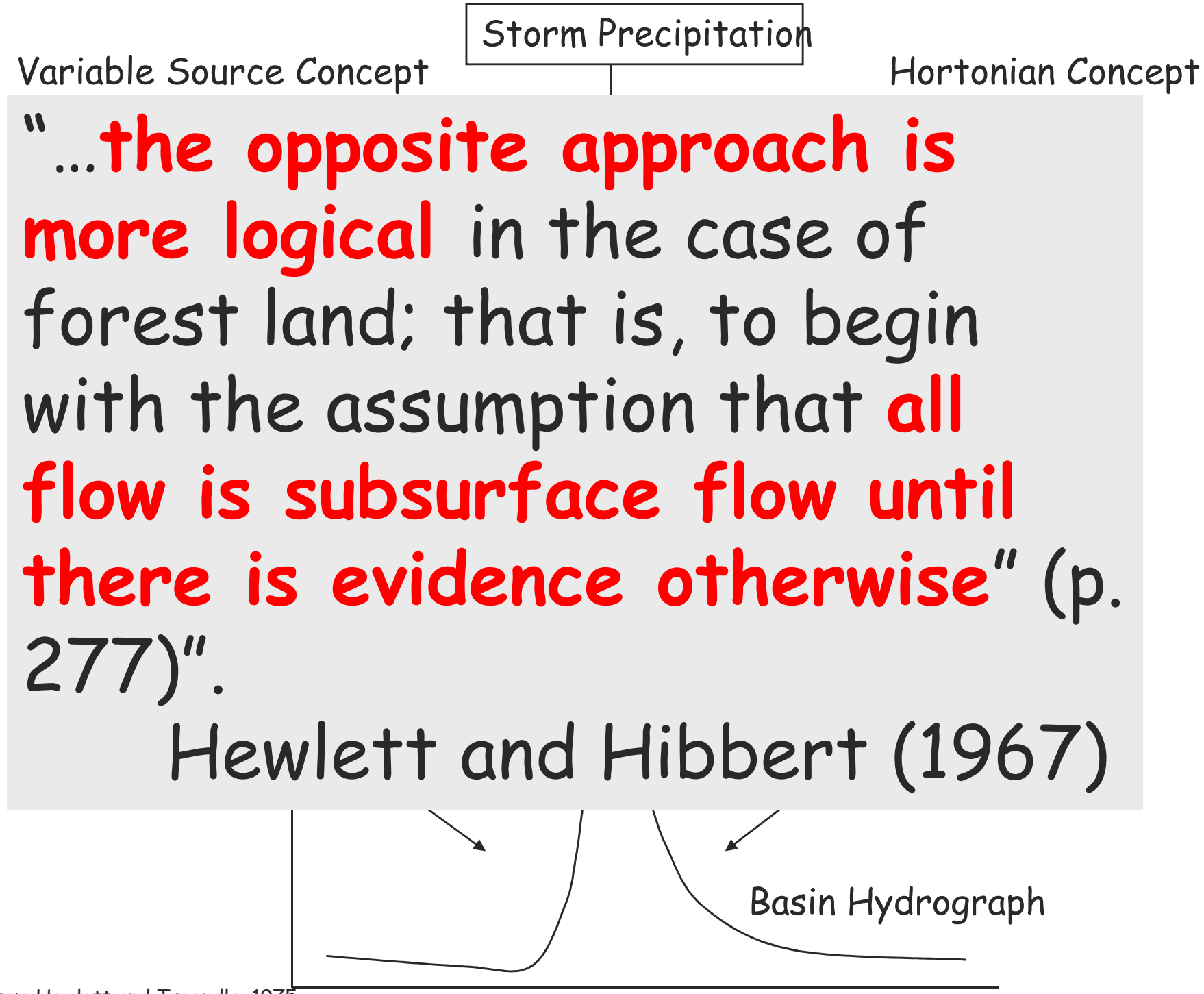


A meeting just like this ~40 years ago….

Dialog Btw Field Scientist and Modeler

"Accurate prediction of the headwater hydrograph implies adequate modeling of **sources, flowpaths and residence time** of water and solutes.

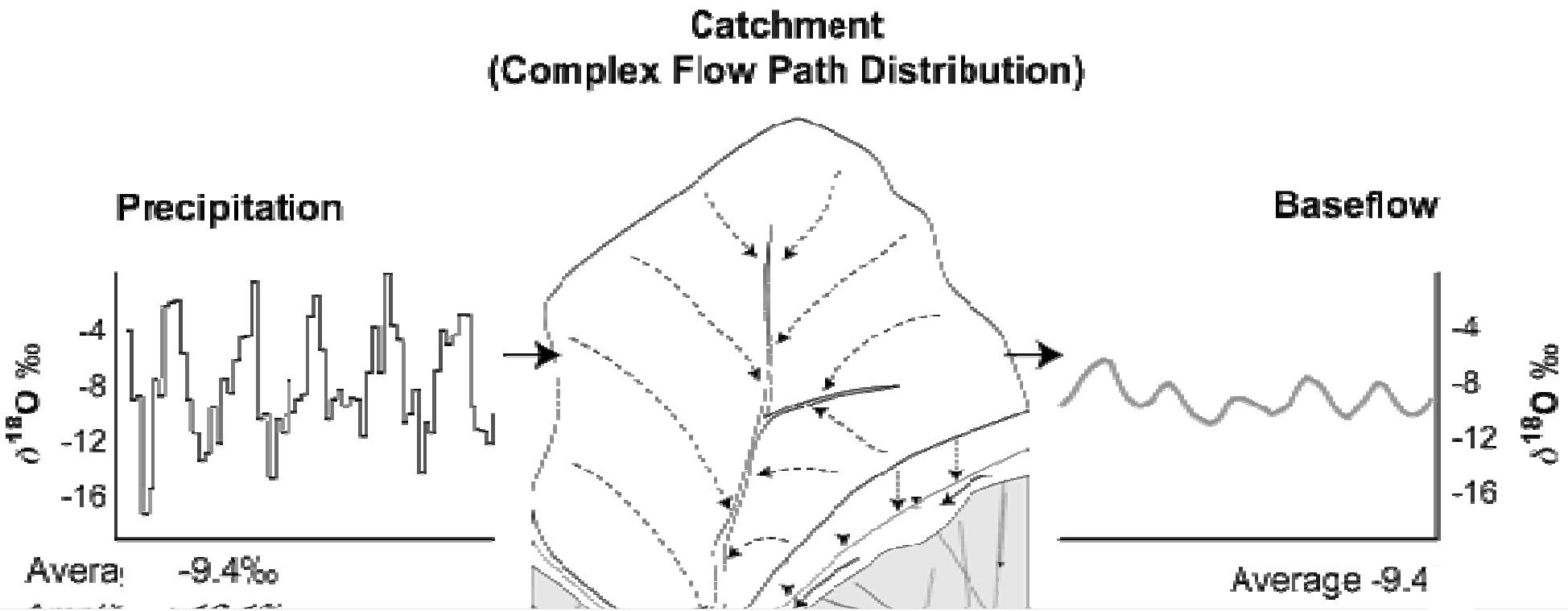
Hewlett and Troendle, 1975 ASCE



Re-drawn from Hewlett and Troendle, 1975

The next quantum leap

Dialog Btw Field Scientist and Modeler

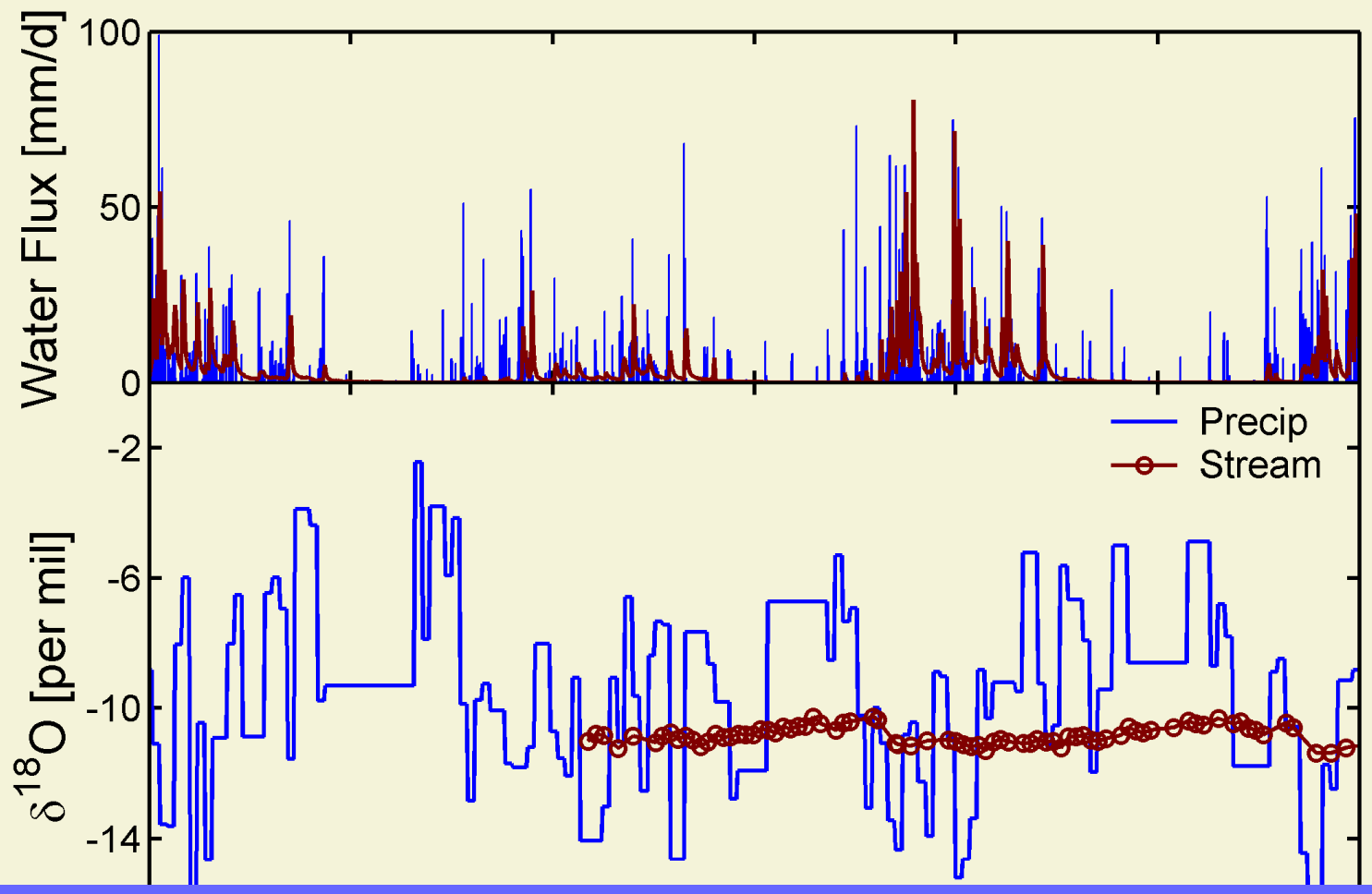


Mean transit time for water through catchments can be orders of magnitude longer than the timescale of hydrologic response

McDonnell et al., 2011 HP

An example

Dialog Btw Field Scientist and Modeler

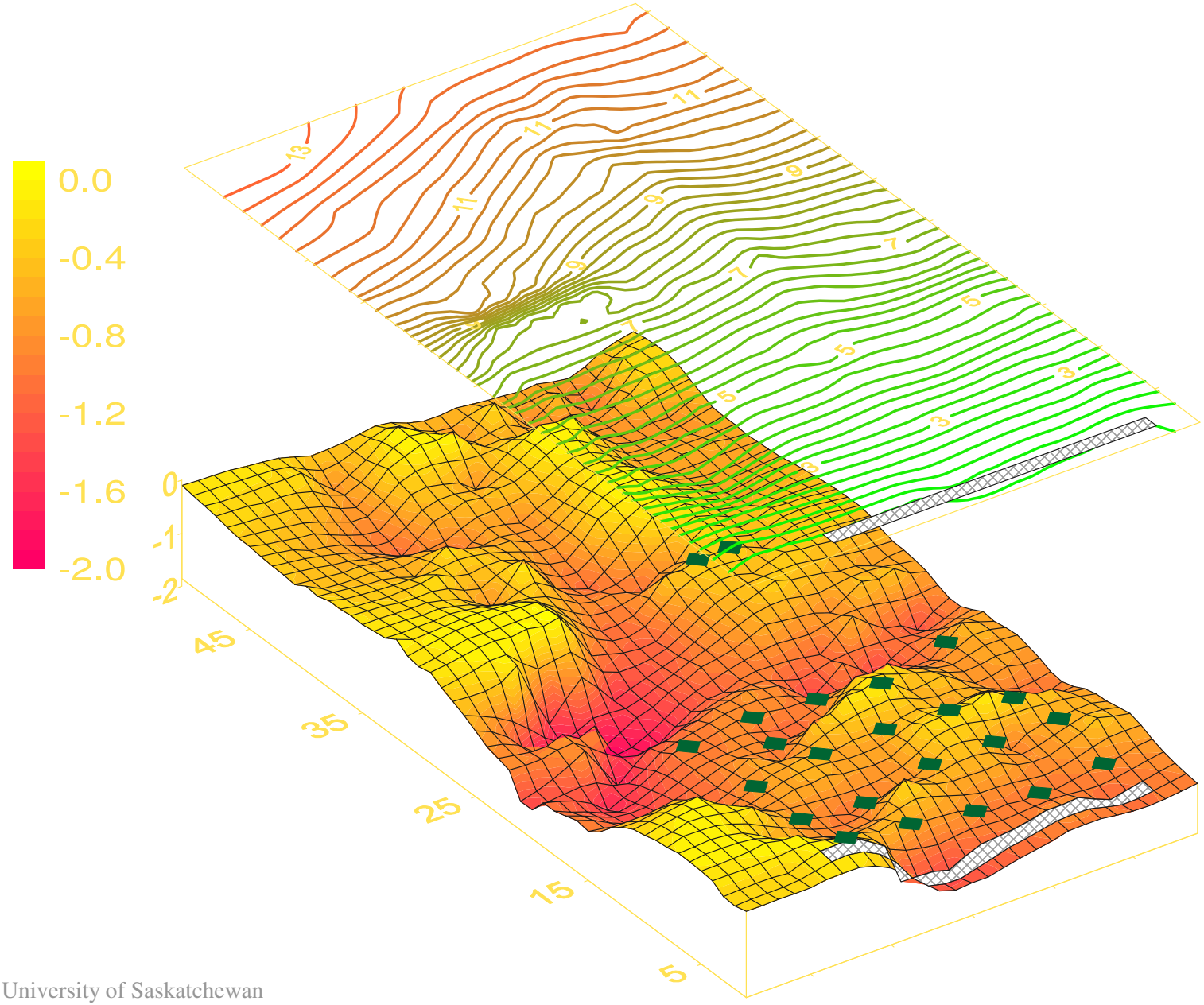


Hillslopes store water for months to years and then release it in minutes or hours to streams (Kirchner, 2003 HP)

The past 20 years:
Searching for mechanisms to explain this behavior

The importance of soil depth and subsurface topography

Dialog Btw Field Scientist and Modeler



Depth

Min 0.0 m

Max 1.86 m

Average 0.63 m

Volume

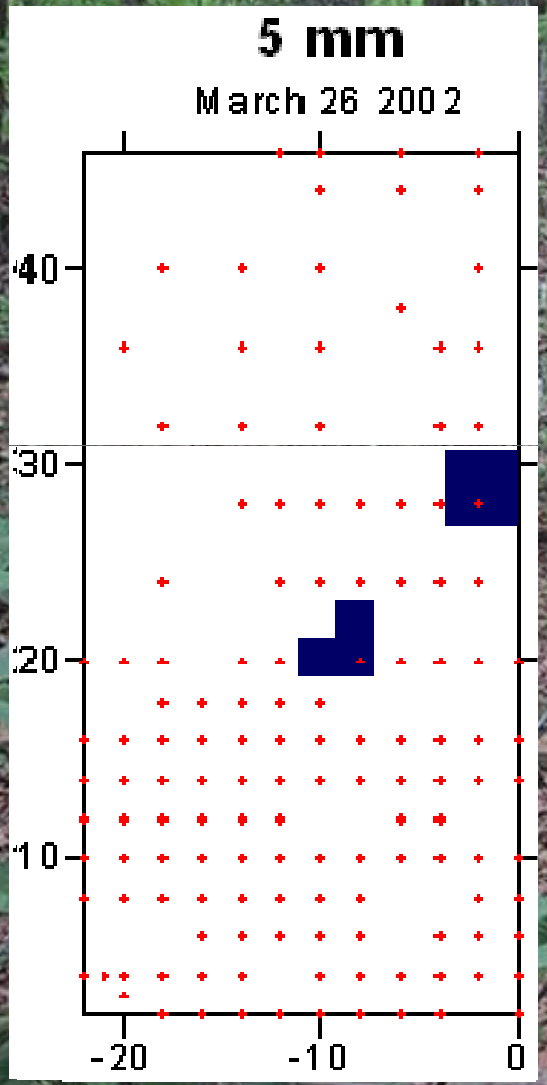
510 m^3 (θ 0.55)

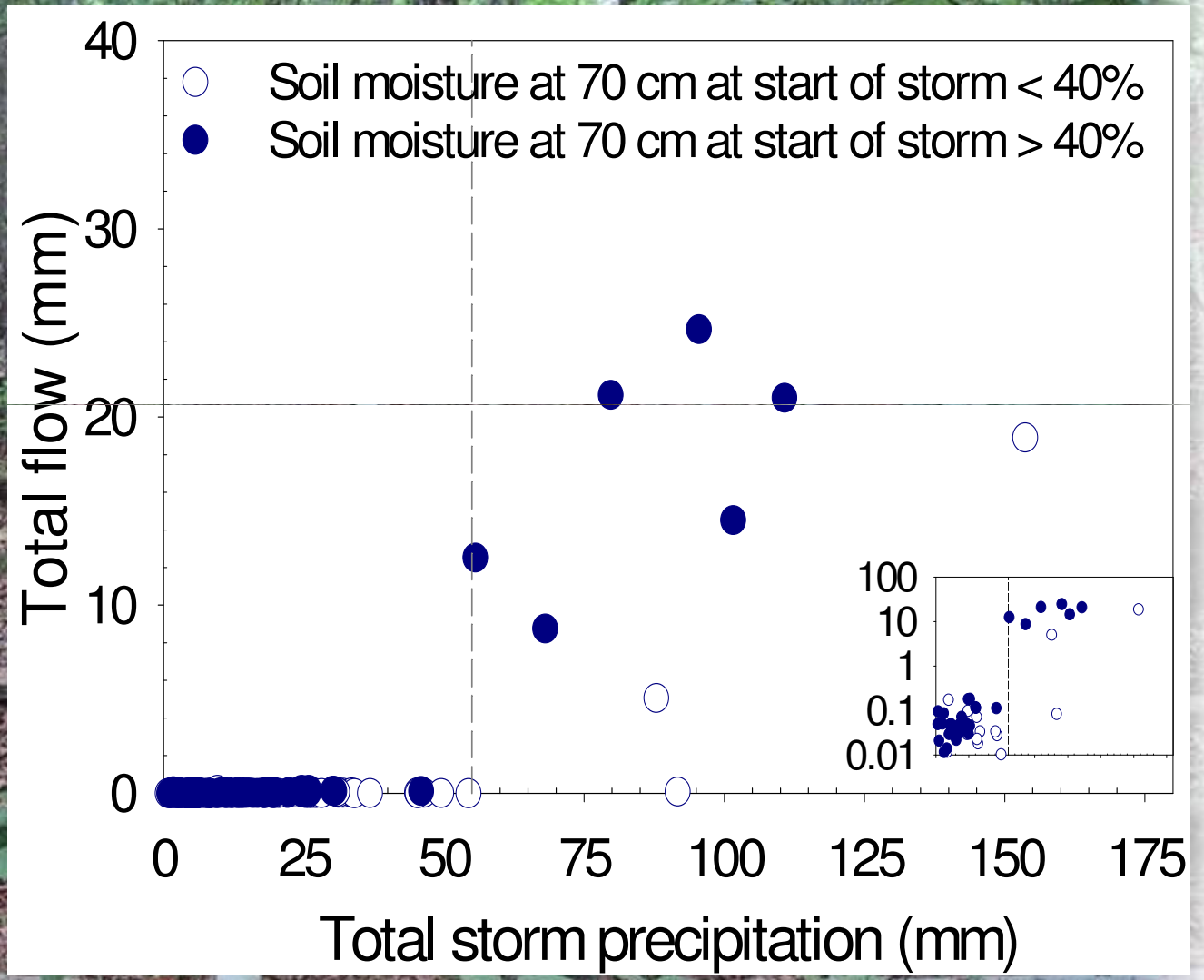
Scale

2 m gridscale

McDonnell et al., 1996 EOS

How is pre-event water mobilized?



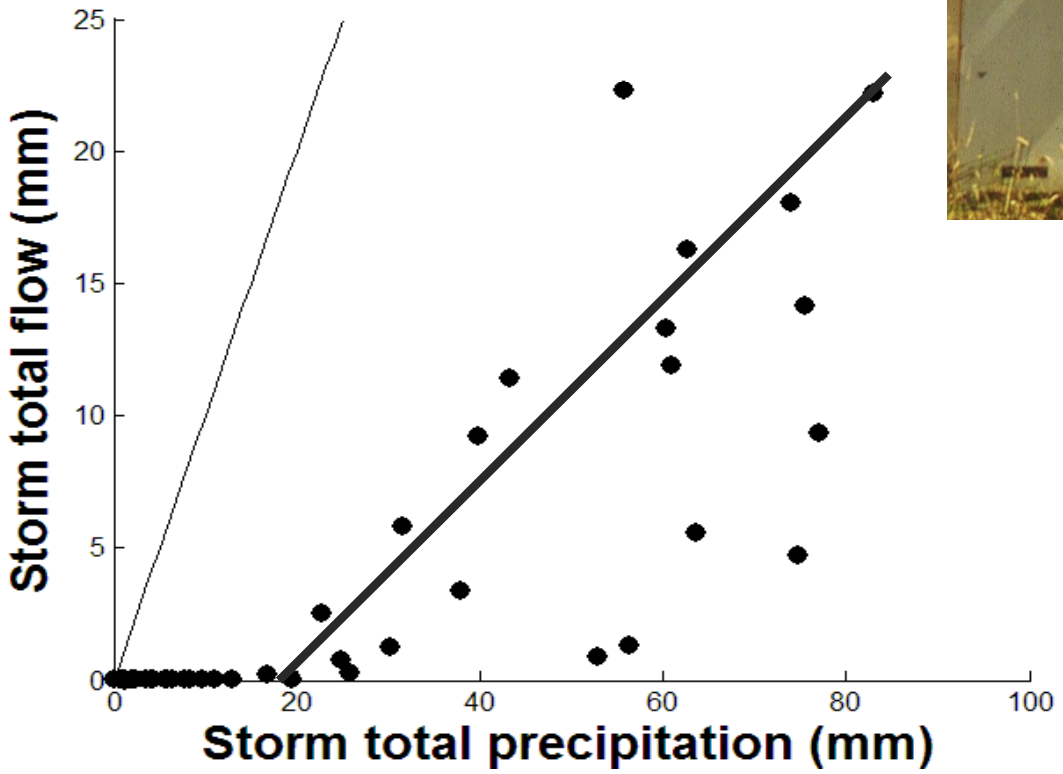


Tromp van Meerveld and McDonnell 2007 WRR

One extreme

Dialog Btw Field Scientist and Modeler

Maimai, NZ



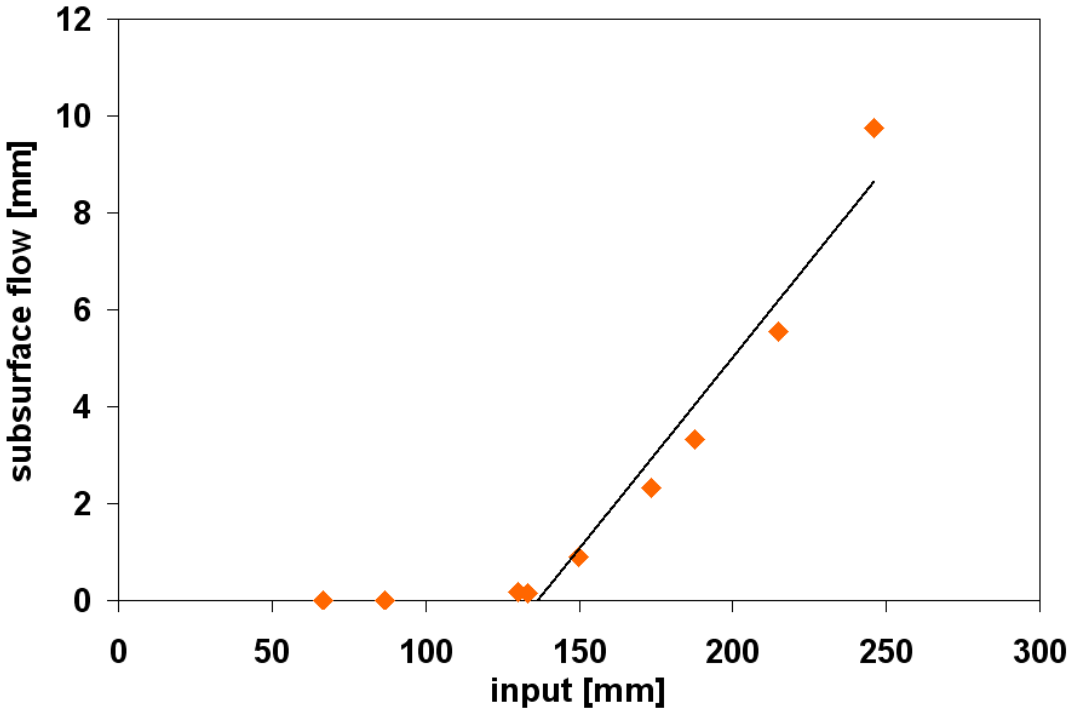
Graham and McDonnell., 2010 JoH

Another extreme

Dialog Btw Field Scientist and Modeler

Savannah River, South Carolina

- Slope 2.5 - 5°
- Depth to argillic layer
  - (mean: 0.97 m, cv: 21%)

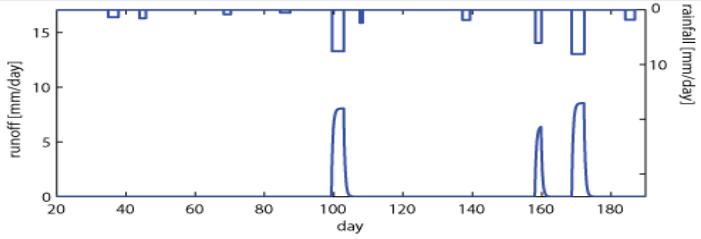


Hopp et al., in prep

Fill, spill, connectivity, threshold

Dialog Btw Field Scientist and Modeler

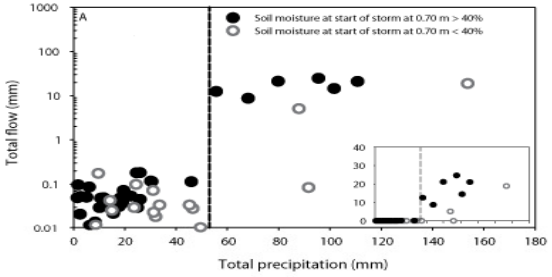
Filtering



Time series

Emergence

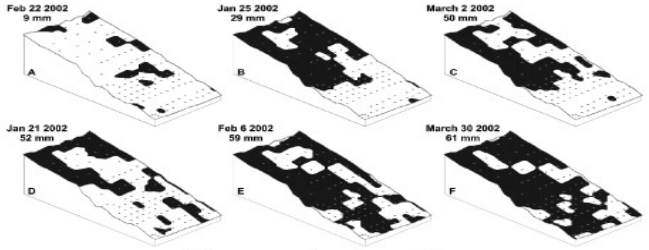
Threshold behavior



Rainfall-runoff relationship

Emergence

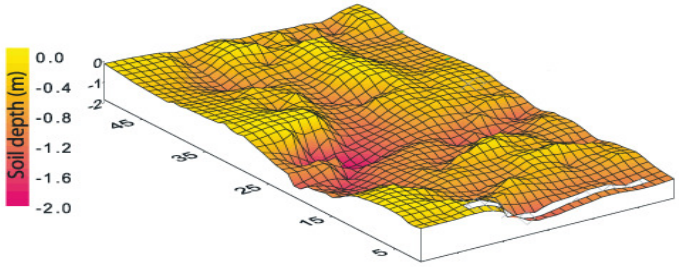
Connectivity



Zones of saturation

Emergence

Heterogeneity



Bedrock topography

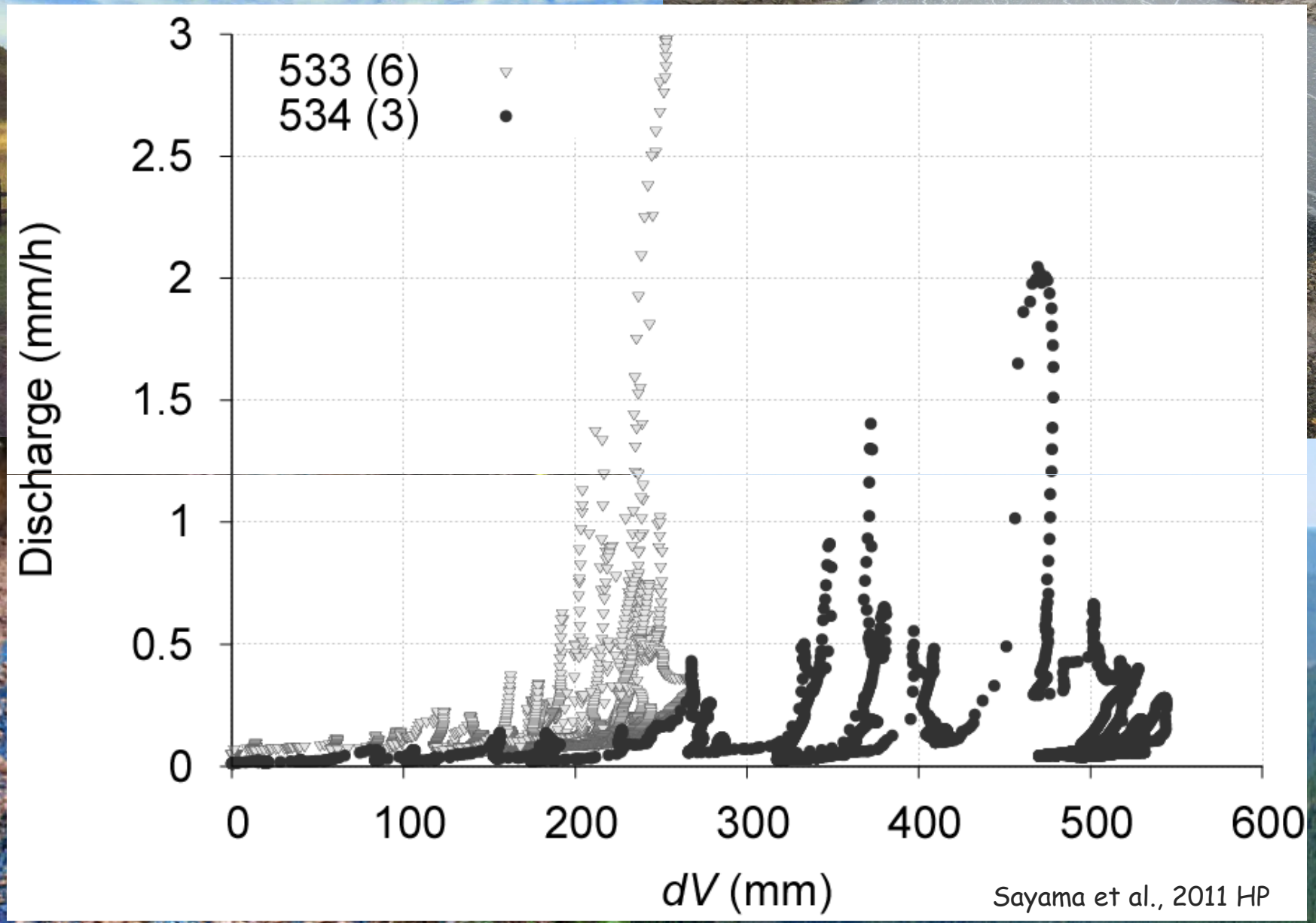
Black-box model

Continuum model

Slide prepared by Ciaran Harman

University of S

RO = P – Sd - Ic

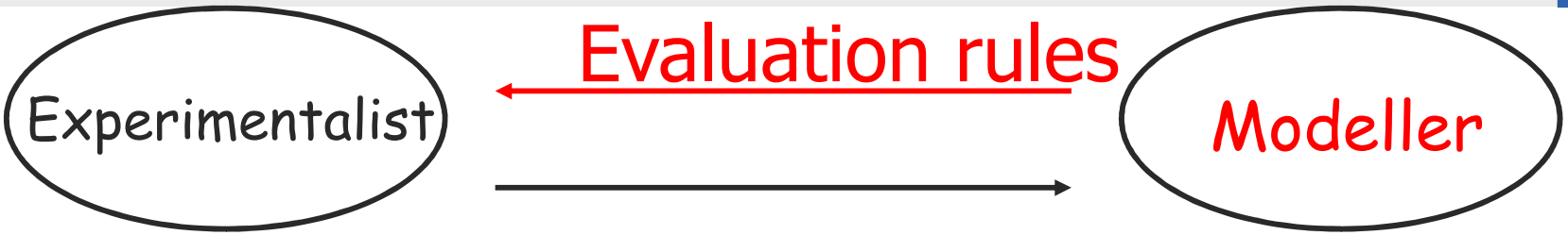


Sayama et al., 2011 HP

The dialog

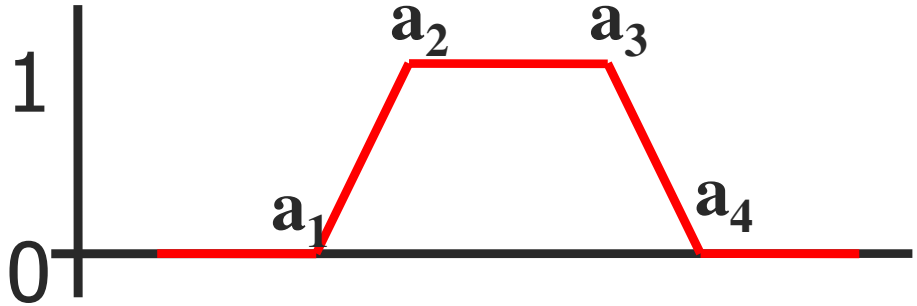
The soft data framework

Dialog Btw Field Scientist and Modeler



Values for evaluation rules (a_i)

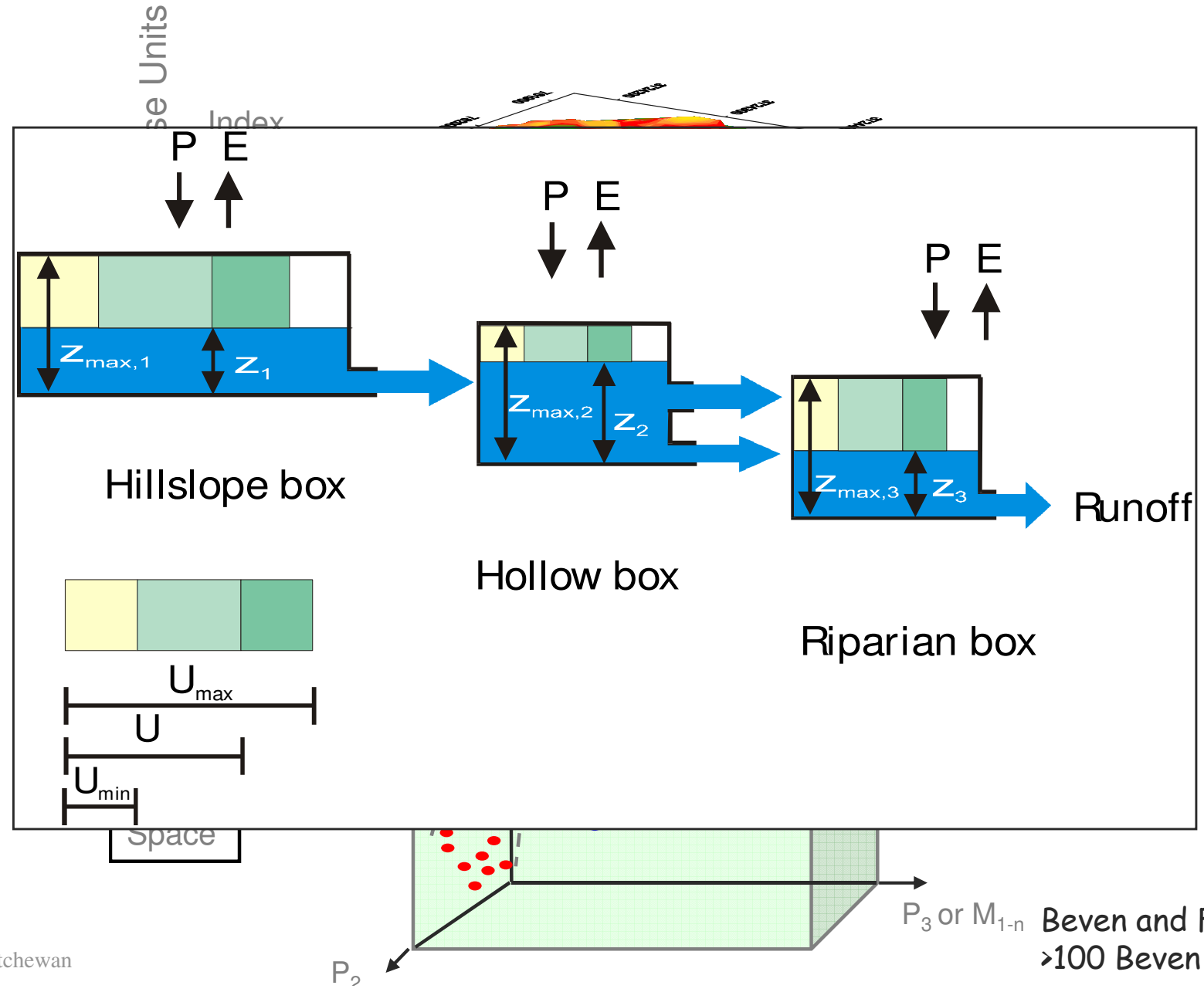
"Degree of acceptability"



Seibert and McDonnell (2002 WRR; ASCE JHE in review

And links to Keith Beven's "Landscape space to model space mapping"

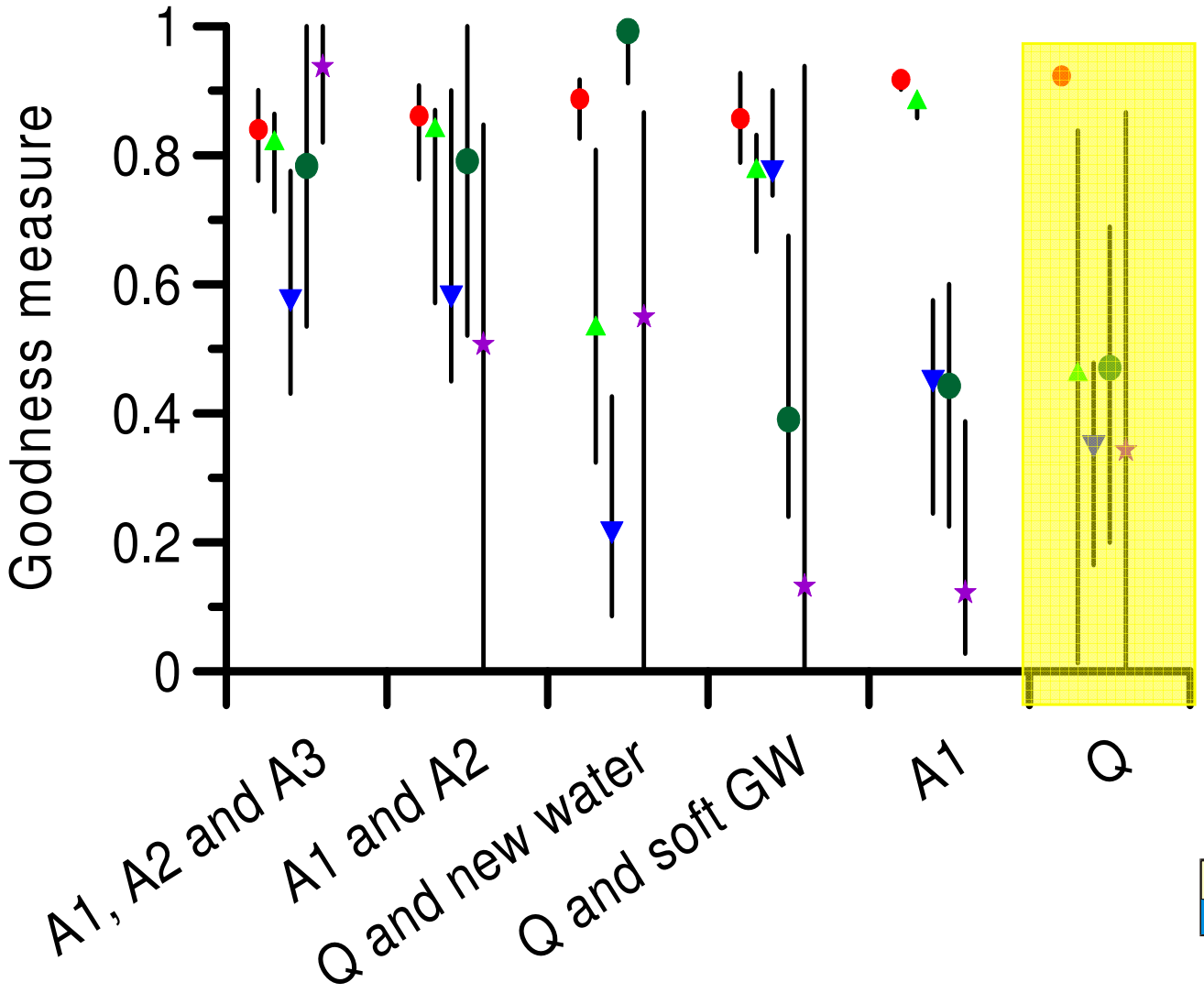
Dialog Btw Field Scientist and Modeler

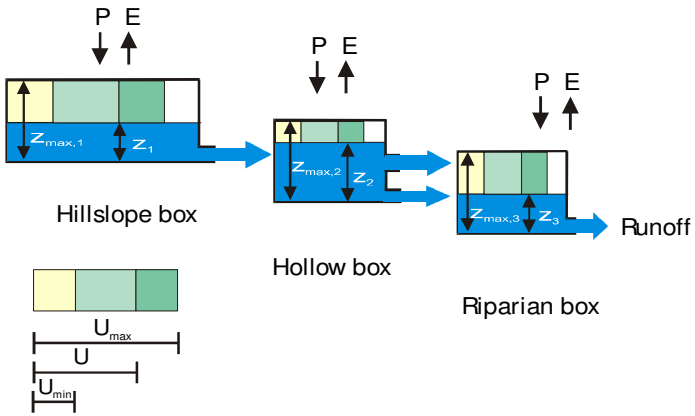


Beven and Freer, 2001 HP
>100 Beven papers since...

Use of soft data

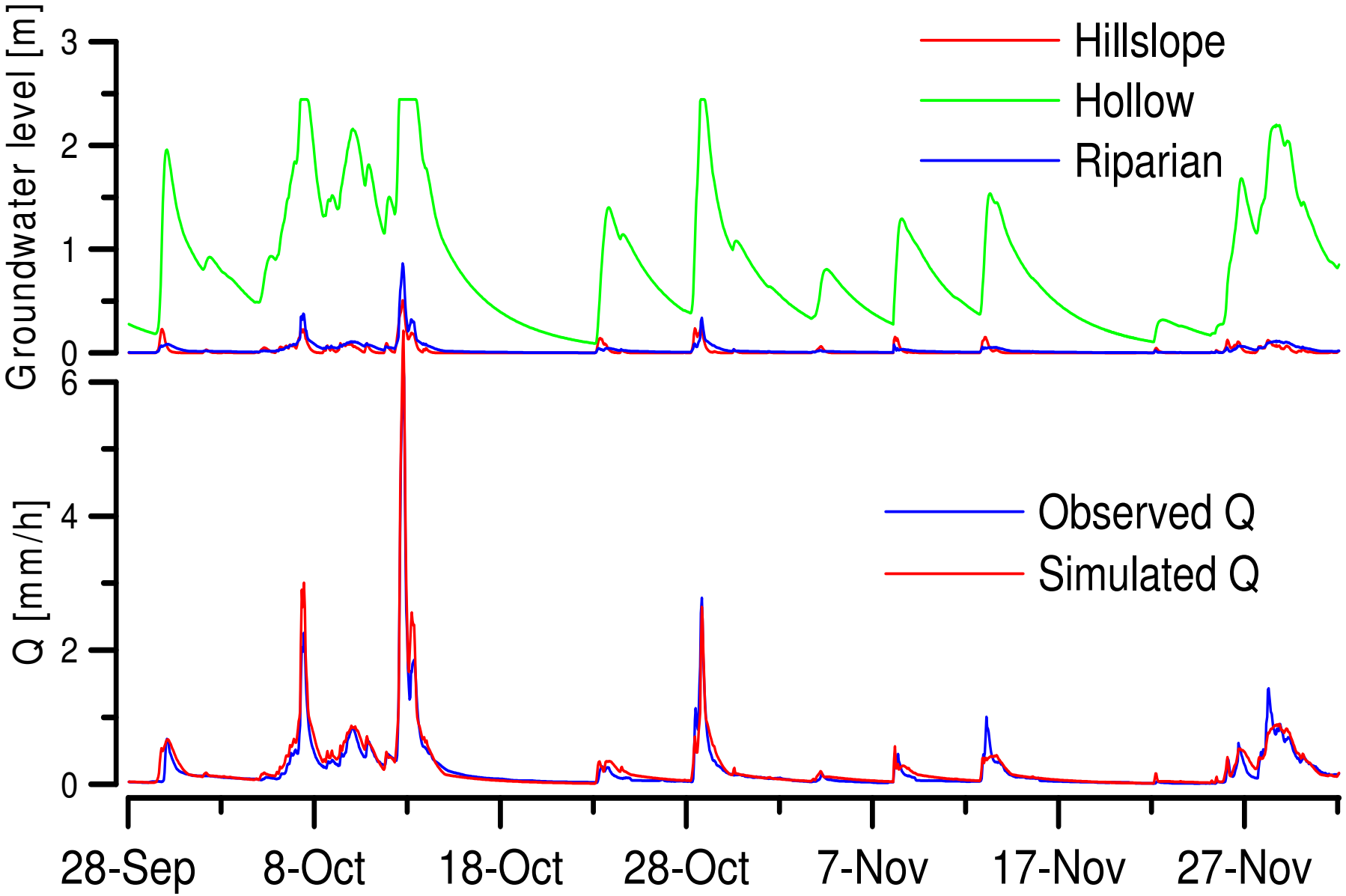
Dialog Btw Field Scientist and Modeler





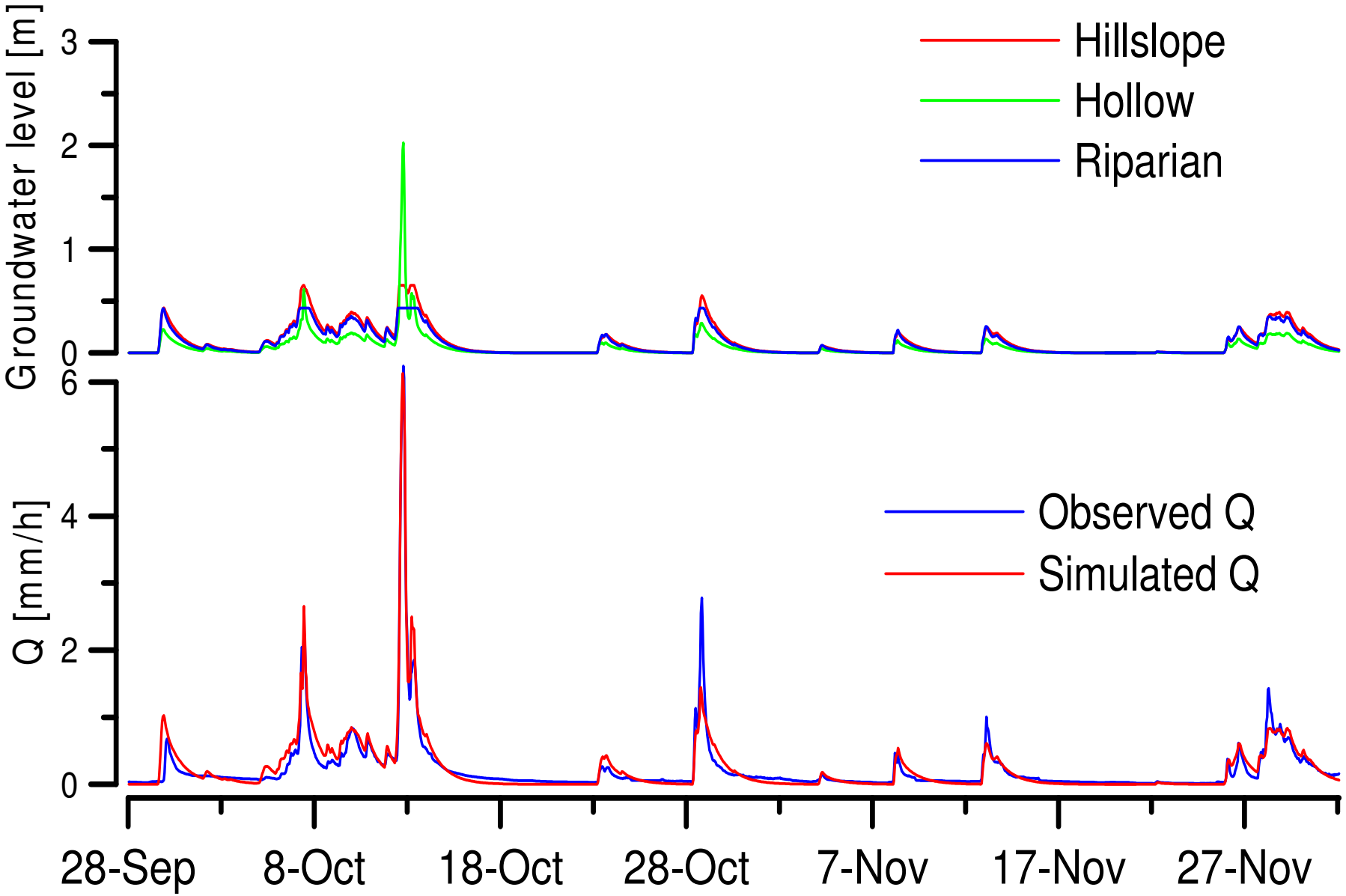
Model efficiency : 0.93

Dialog Btw Field Scientist and Modeler



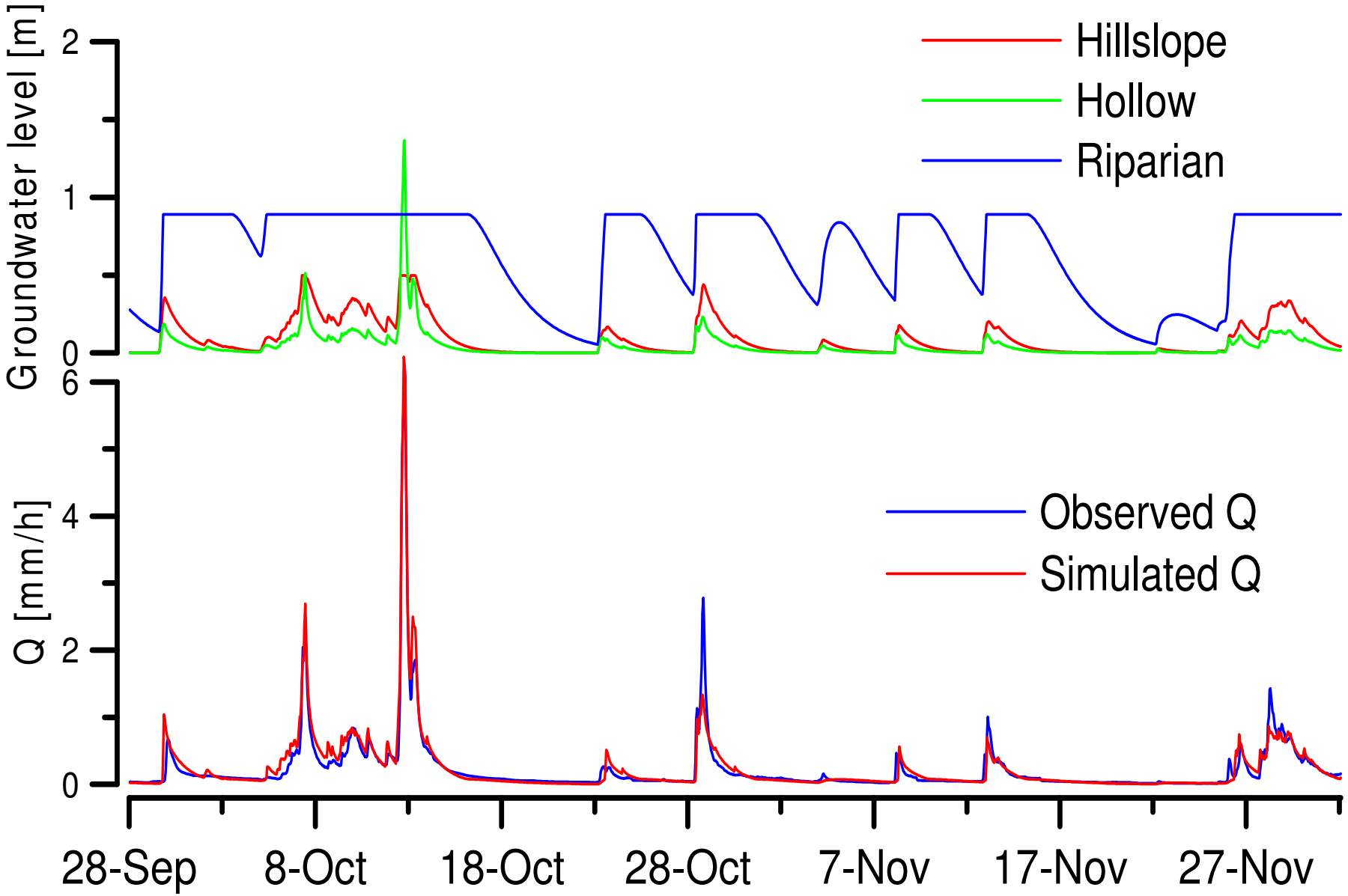
Model efficiency : 0.92

Dialog Btw Field Scientist and Modeler



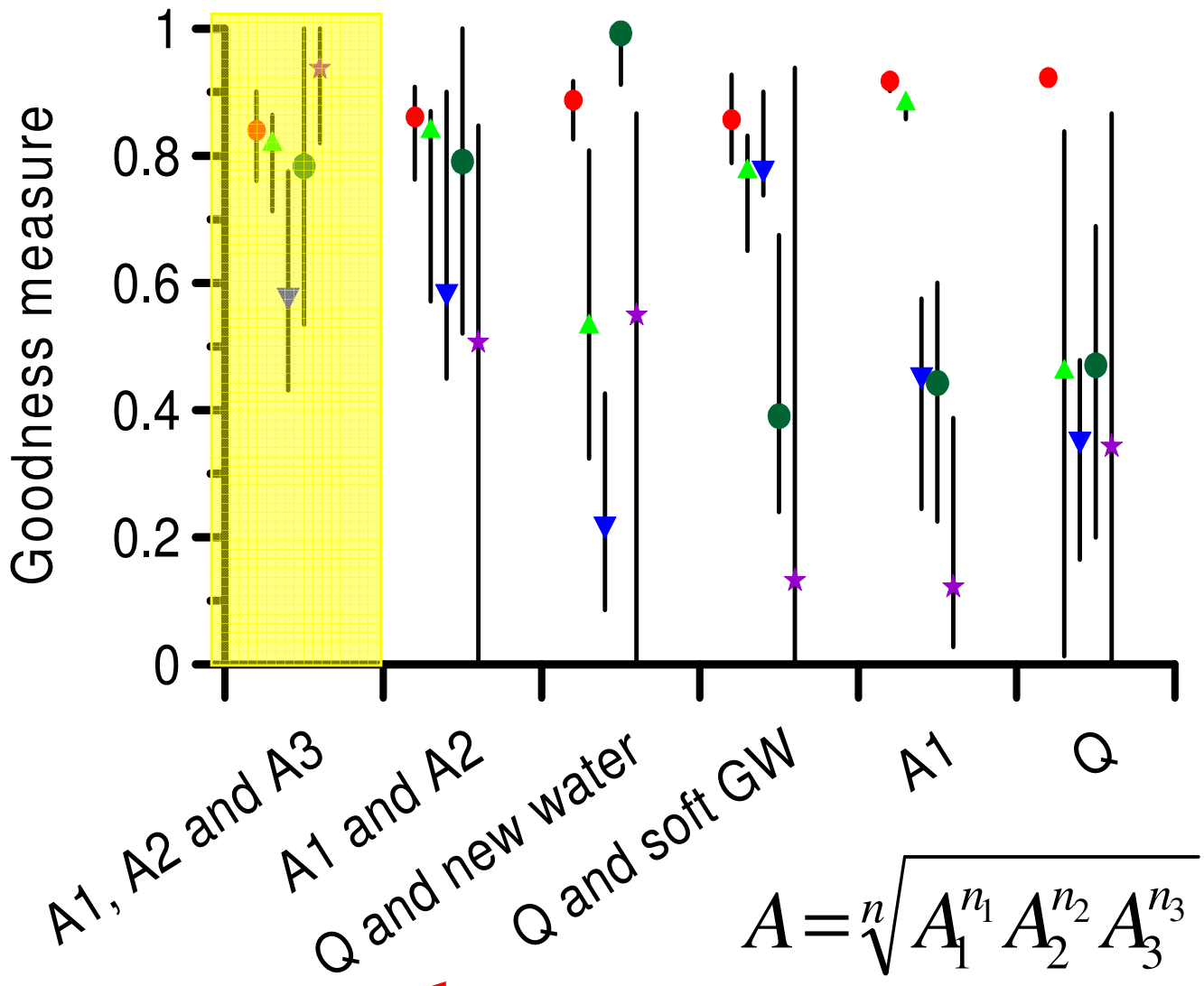
Model efficiency : 0.93

Dialog Btw Field Scientist and Modeler



Model performance

Dialog Btw Field Scientist and Modeler



- Runoff efficiency
- GW hard
- GW soft
- Parameter values
- New water

$$A = \sqrt[n]{A_1^{n_1} A_2^{n_2} A_3^{n_3}} \quad with\ n = n_1 + n_2 + n_3$$

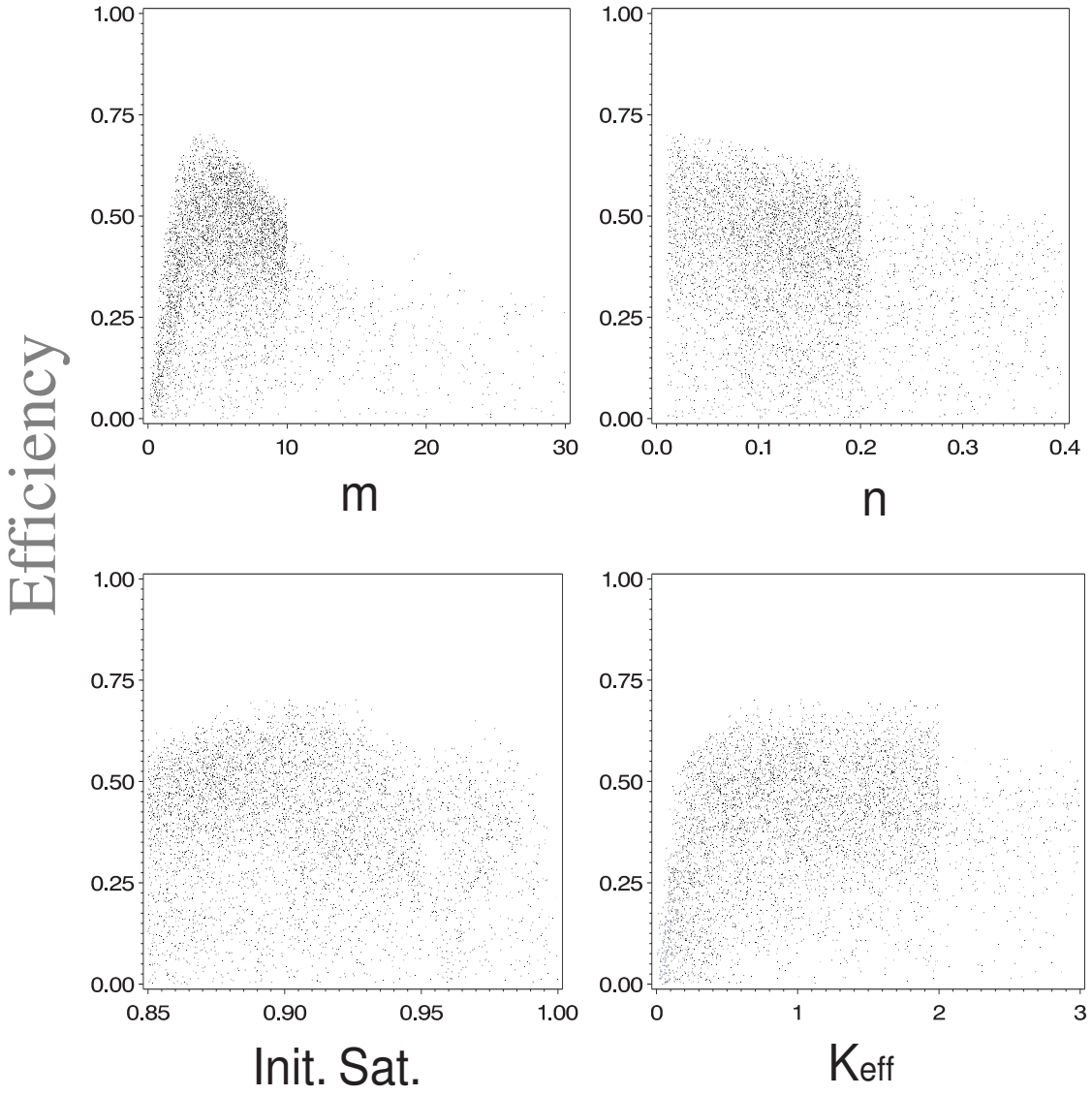
Increasing amount of soft data

Other examples

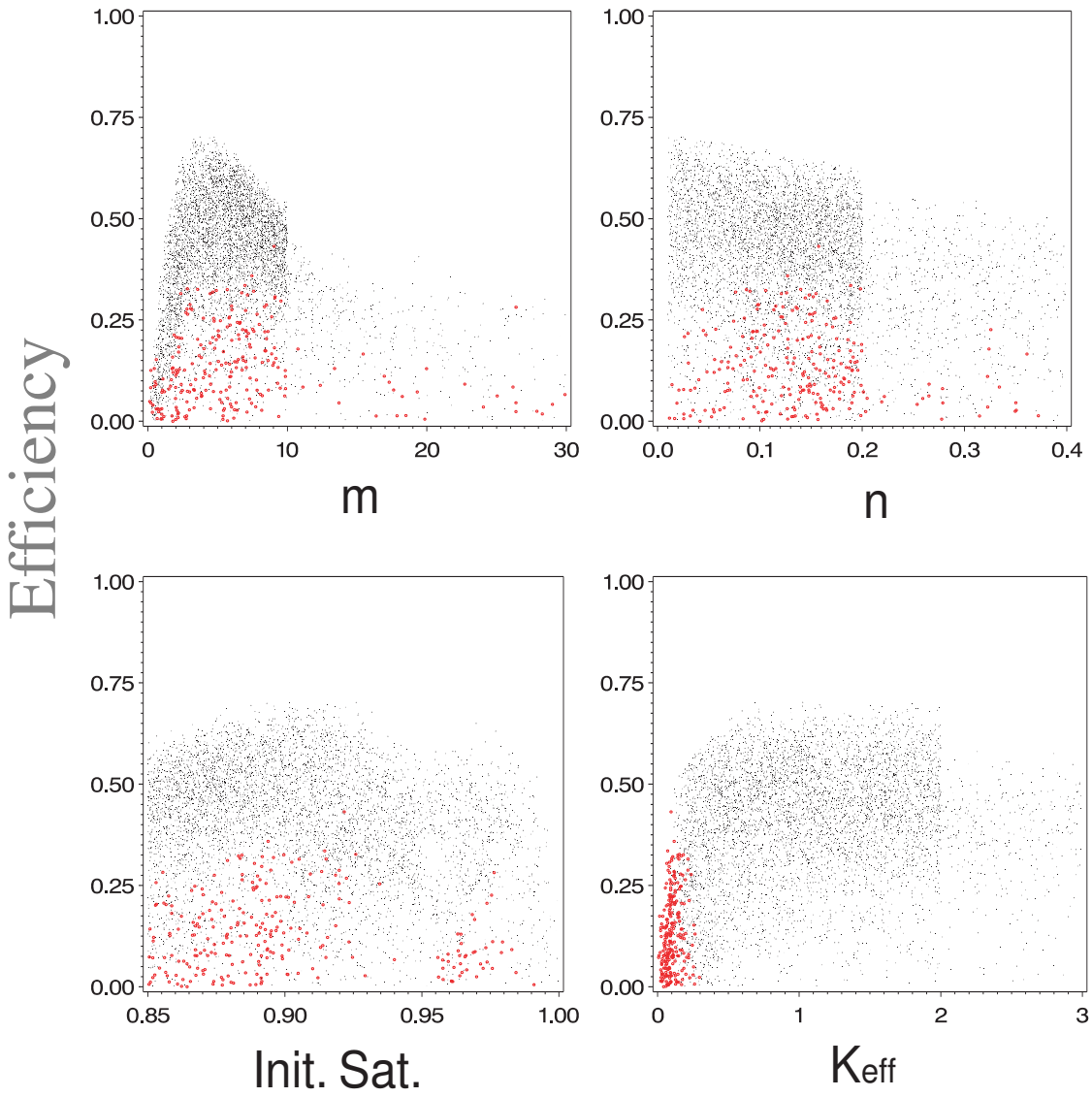
Soft data and *a posteriori* parameter rejection

Dialog Btw Field Scientist and Modeler

- A poorly gauged watershed in Chile
- An example of an additional criterion:
  - Percent new water in a storm hydrograph



- **Red dots** = % new water < 50
- **Black dots = % new water > 50**
- Identifies parameter sets that produce the "efficient" results for the wrong reasons

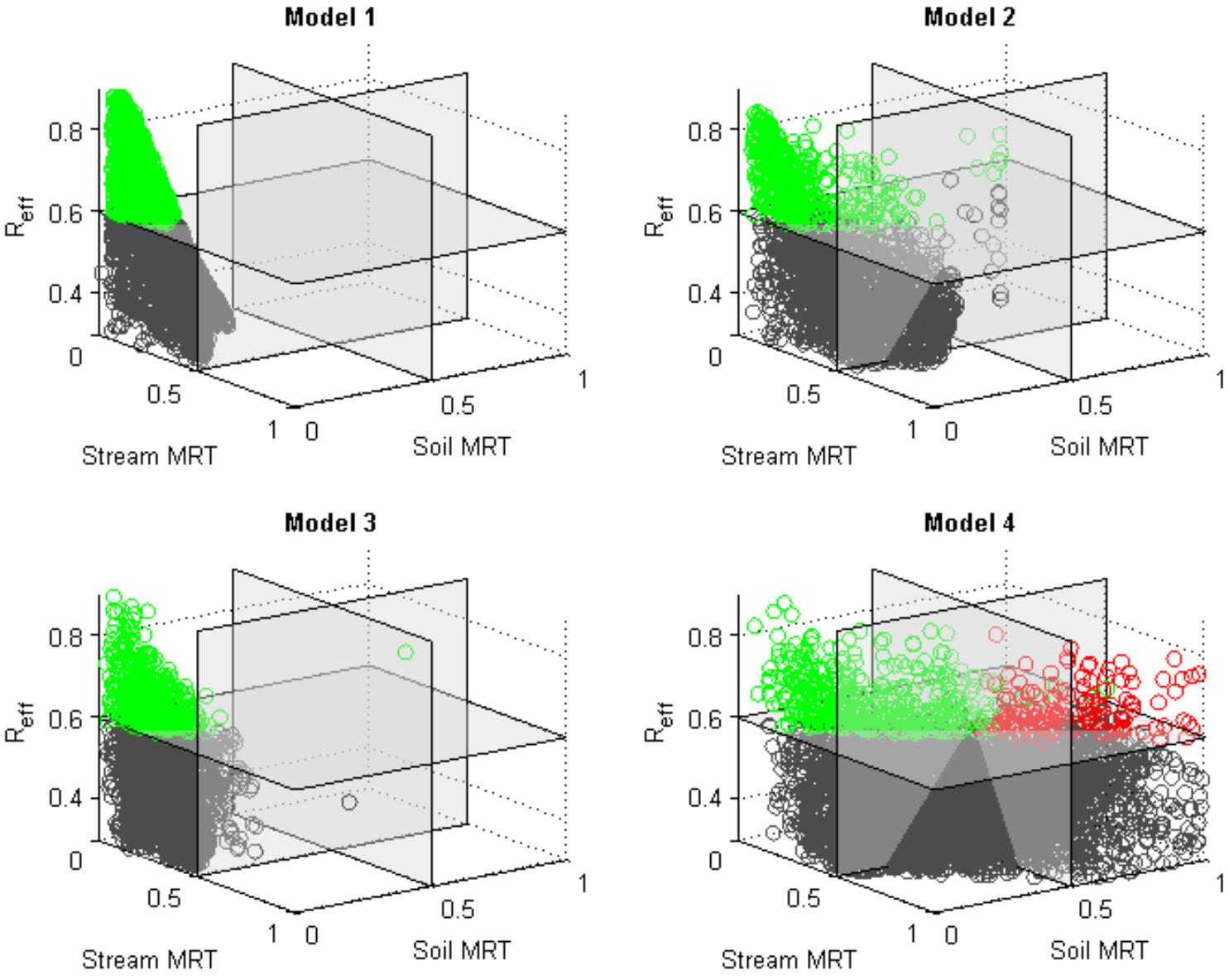


Vache et al., 2004 GRL

Other examples:

Soft data as orthogonal measures for model eval'n

Dialog Btw Field Scientist and Modeler



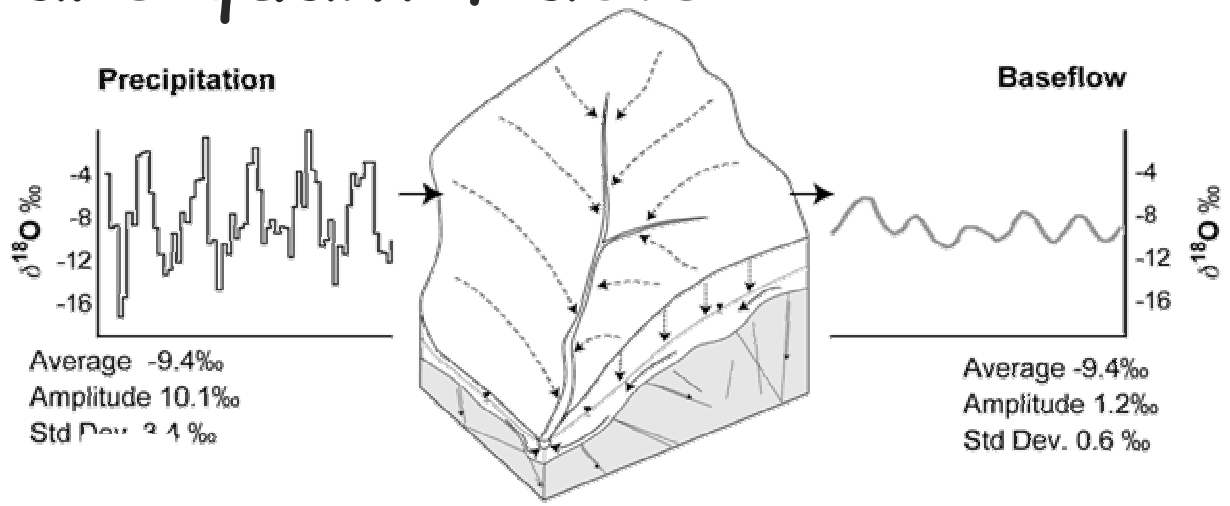
Vache and McDonnell, 2006 WRR

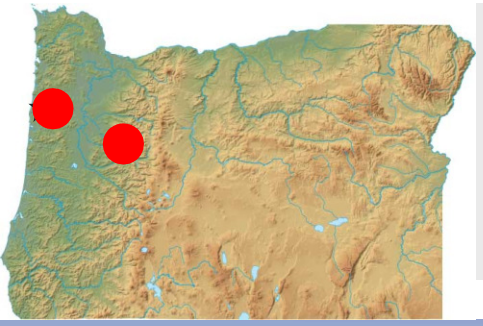
Looking forward

The dialog: *Looking forward*

Dialog Btw Field Scientist and Modeler

- Process realism as scaling realism
  - Scaling rules aggregate key process information
  - Residence time and storage make sense across all scales
  - Both are quantifiable



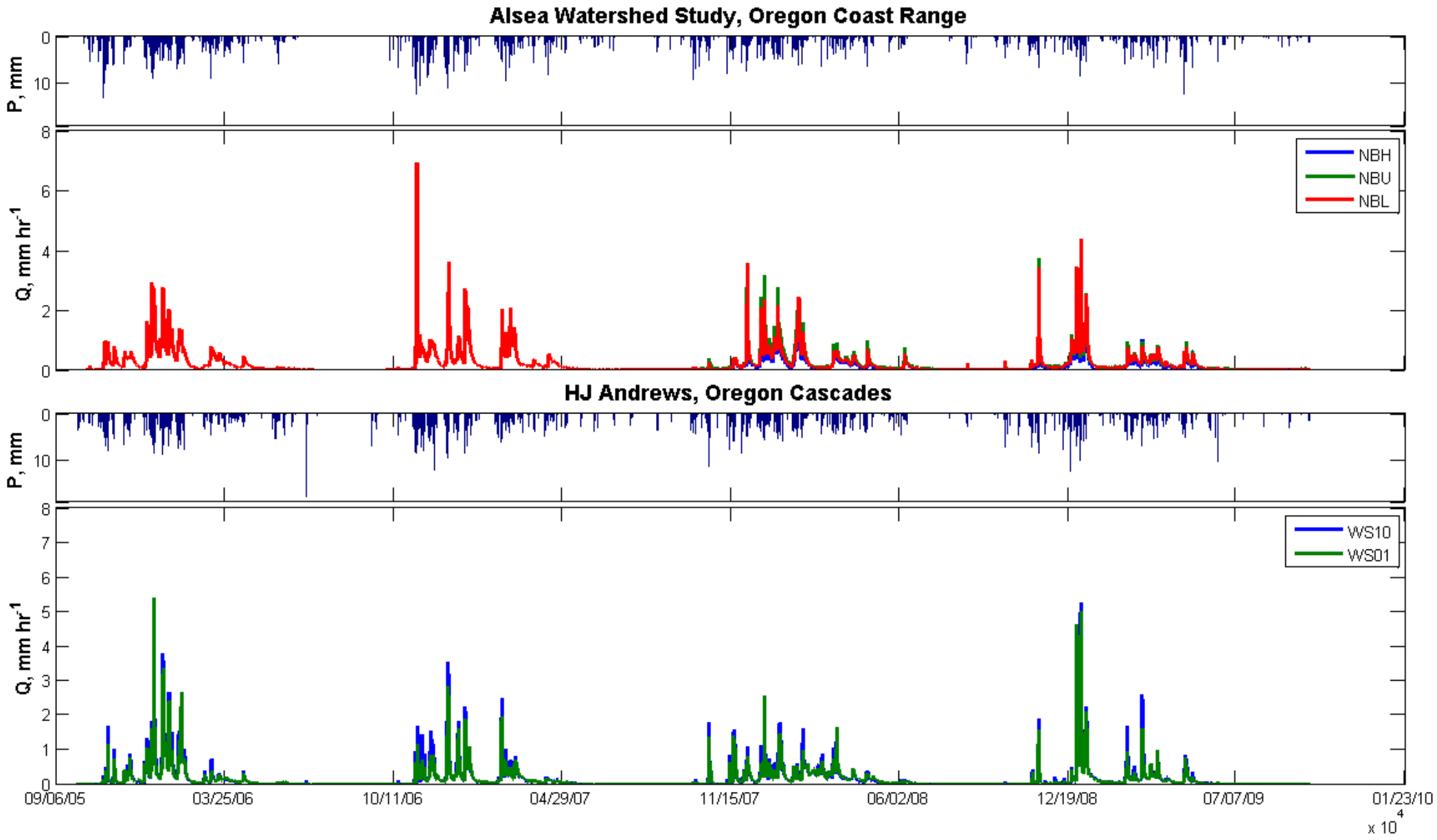


An example from Oregon

Dialog Btw Field Scientist and Modeler

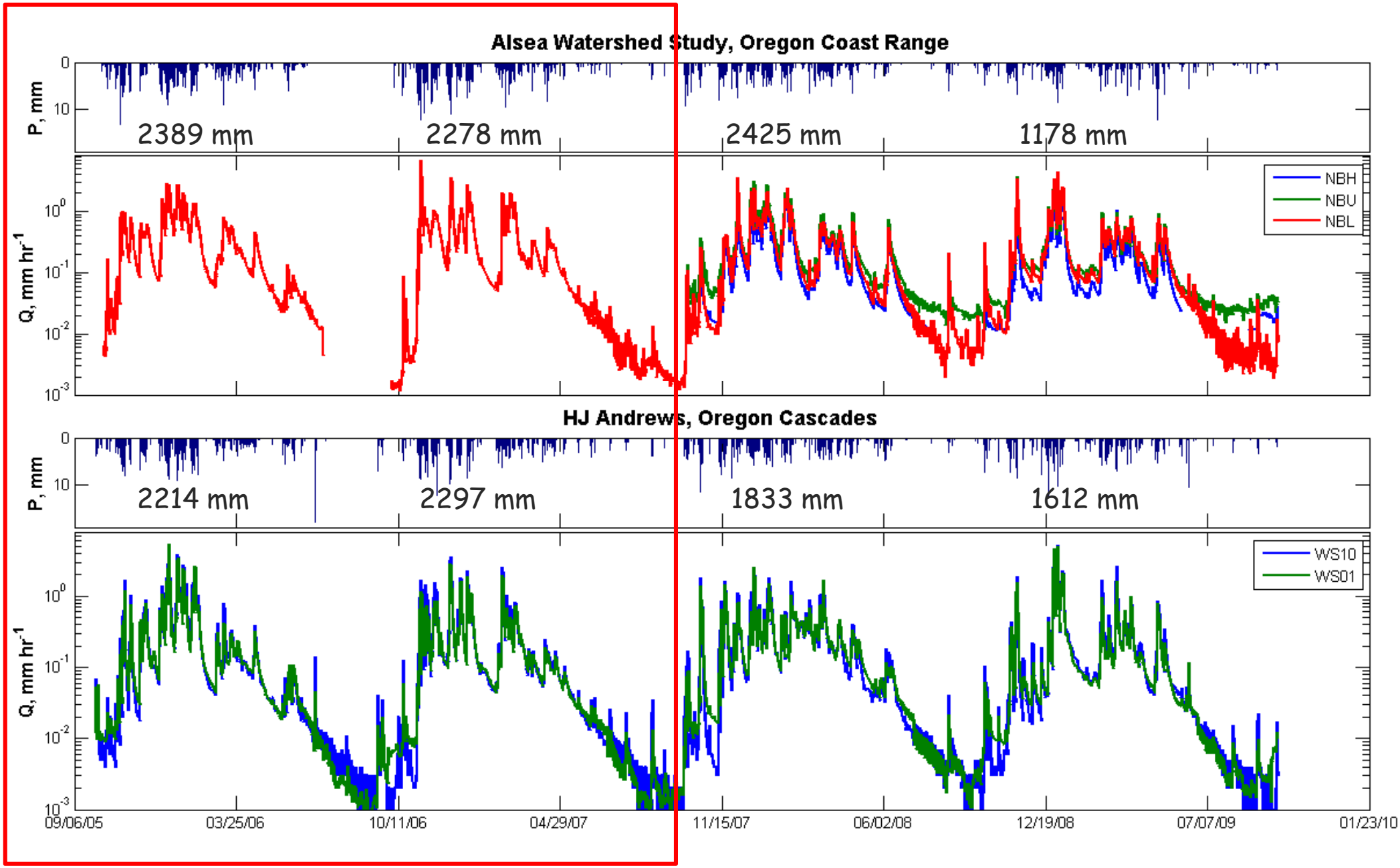
Rainfall-runoff for the two sites

Dialog Btw Field Scientist and Modeler



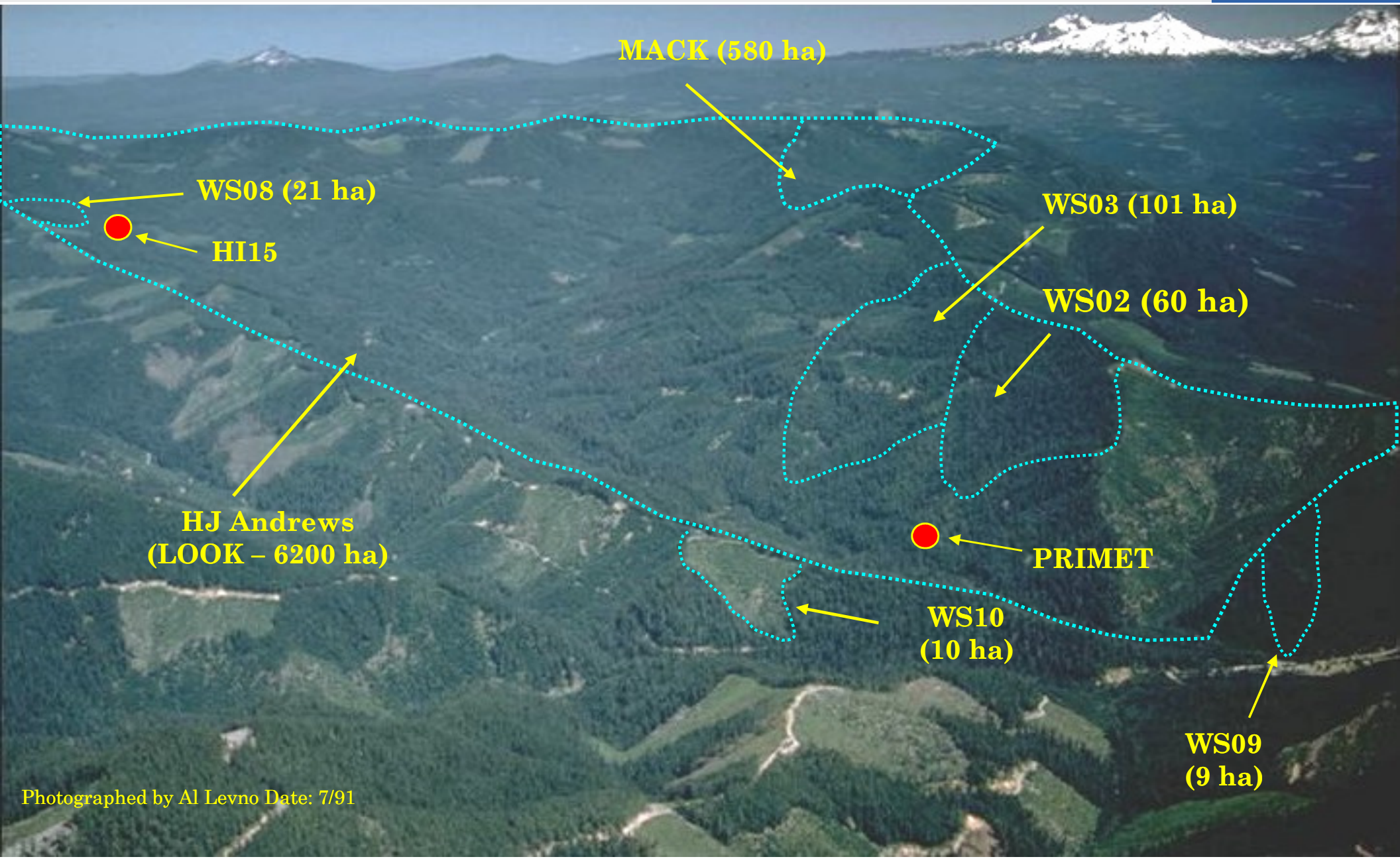
On a log scale

Dialog Btw Field Scientist and Modeler



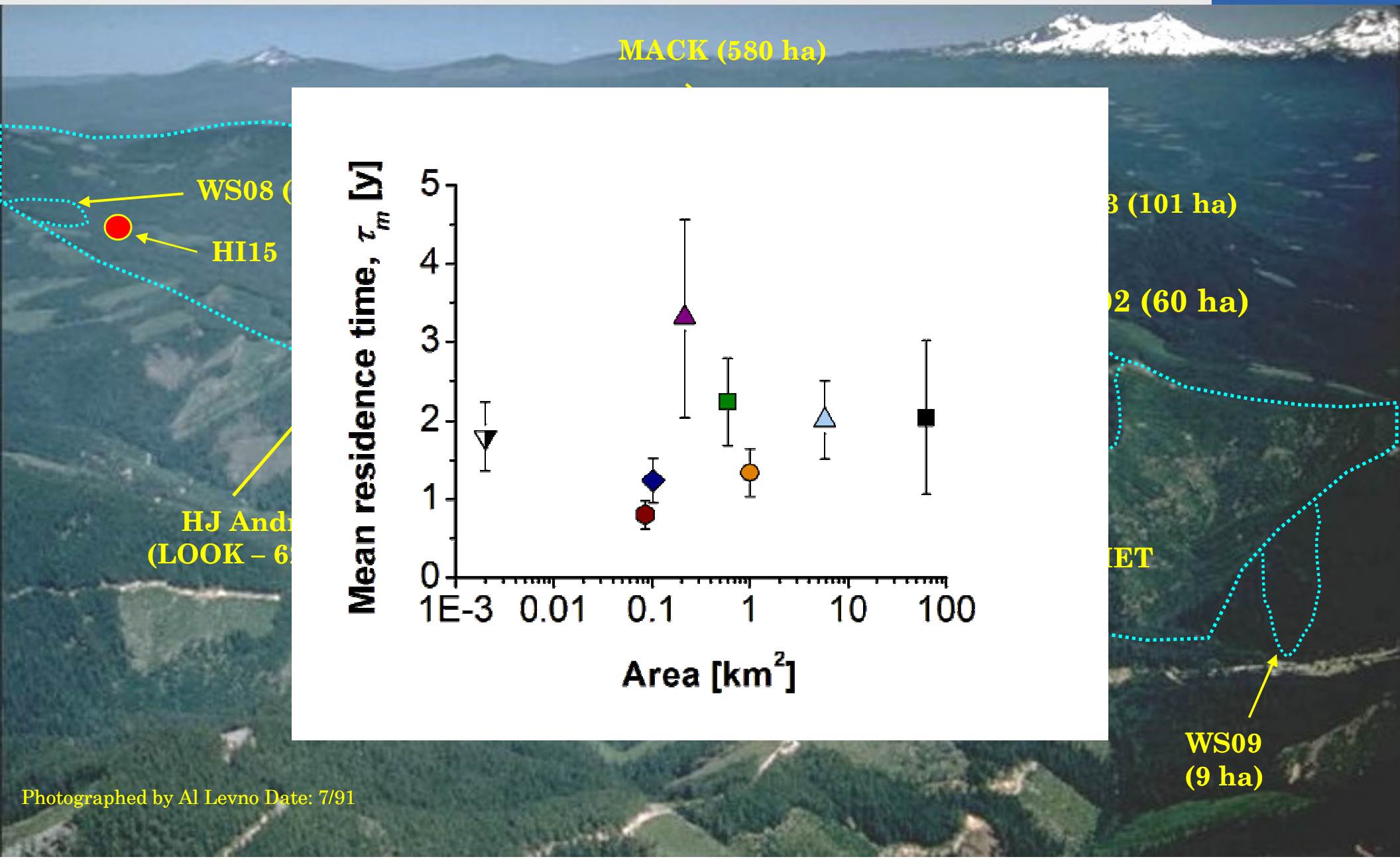
Exploring the scaling relations in low permeability rock

Dialog Btw Field Scientist and Modeler



…no relation to basin area, but…

Dialog Btw Field Scientist and Modeler

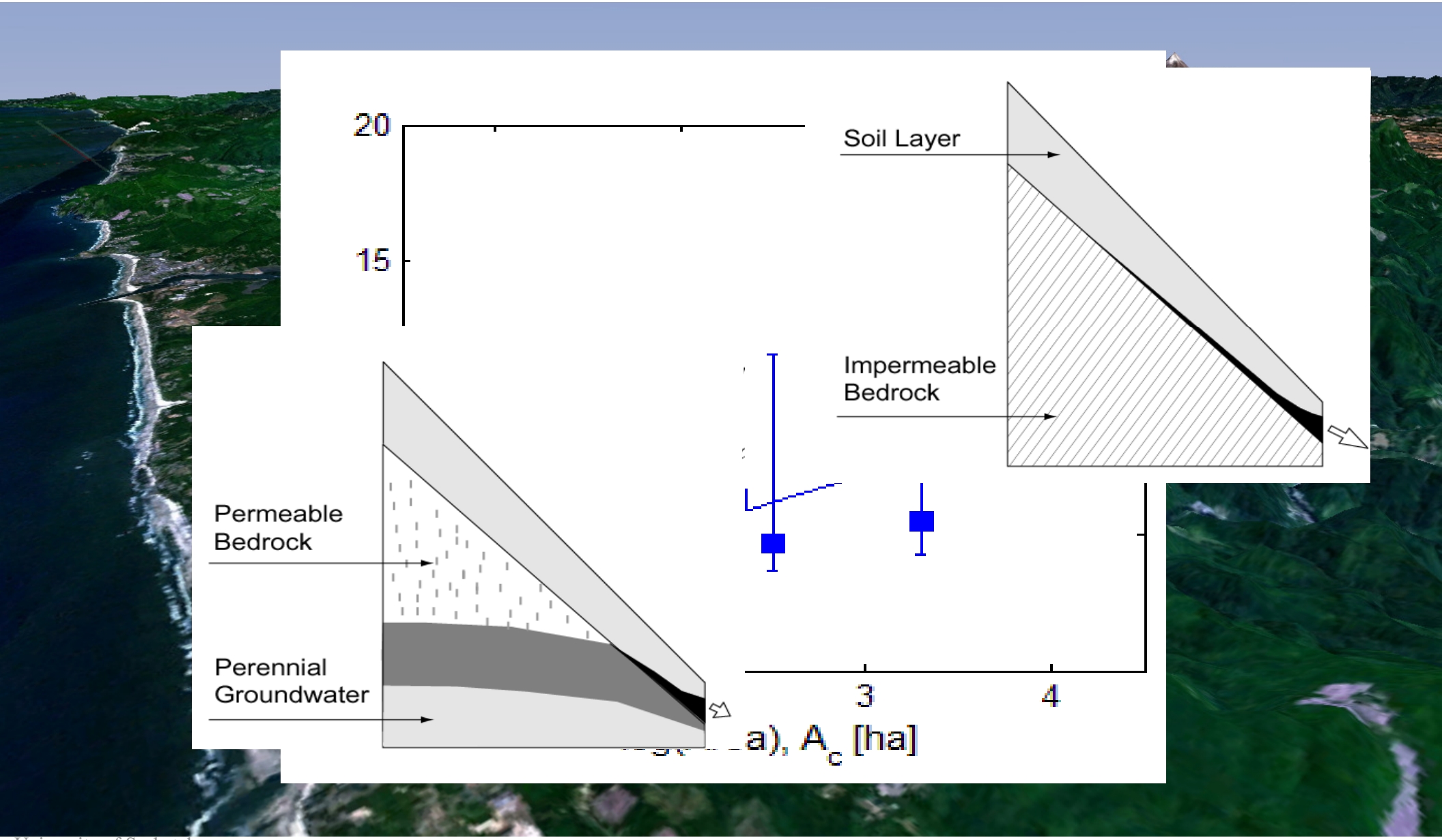


McGuire et al., 2005 WRR

Coast Range

The opposite scaling behavior!

Dialog Btw Field Scientist and Modeler

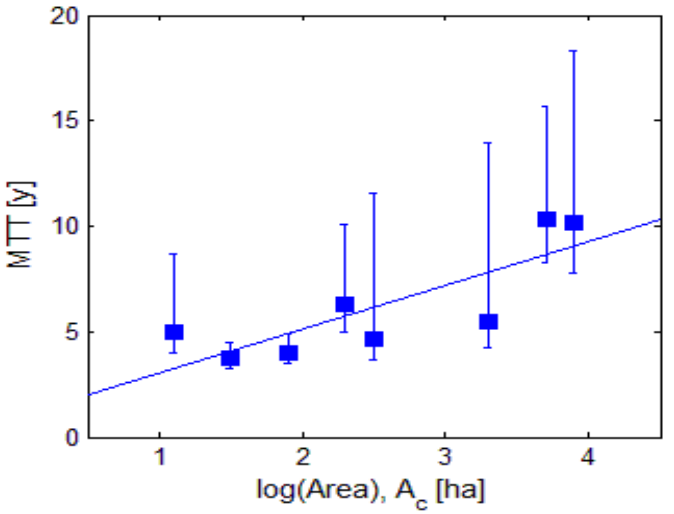


Hale and McDonnell, WRR in review

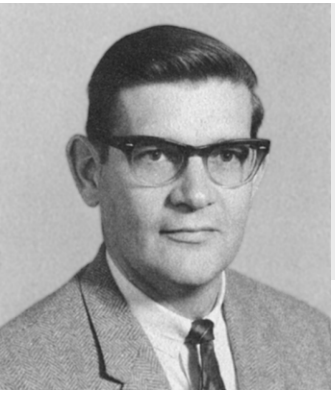
"Getting the right answers for the right reasons" Kirchner (2006 WRR)

Dialog Btw Field Scientist and Modeler

- Developing models that are minimally parameterized and therefore stand some chance of failing the tests that they are subjected to
- Experimentalists delivering orthogonal measures (but not all the gory details) that can be used for model testing



Wrap-up



Let's not let another 40 years go by….

Dialog Btw Field Scientist and Modeler

"Accurate prediction of the headwater hydrograph implies adequate modeling of **sources, flowpaths and residence time** of water and solutes.

Hewlett and Troendle, 1975 ASCE

http://www.google.ca/#hl=en&sclient=psy-ab&q=famiglietti+testimony+to+congress+water+&oq=famiglietti+testimony+to+congress+water+&gs_l=hp.3...4.8197.1.8536.29.28.0.0.0.3.141.2184.25j3.28.0.les%3B..0.0...1c.1.7hDjMpvMPWQ&pbx=1&bav=on.2,or.r_gc.r_pw.r_qf.&fp=a1243ebe7999b6eb&biw=1311&bih=625

Dialog Btw Field Scientist and Modeler

WRITTEN TESTIMONY OF

"**how can we manage water** for the benefit of mankind in nonstationary times **when we know so little about its various stores, flow pathways and residence times** even in a developed country like the United States?"

A H **TEM**

Chairman Hall, Ranking Member Johnson and other members of the committee: thank you for the opportunity to provide testimony on the National Integrated Drought Information System (NIDIS).

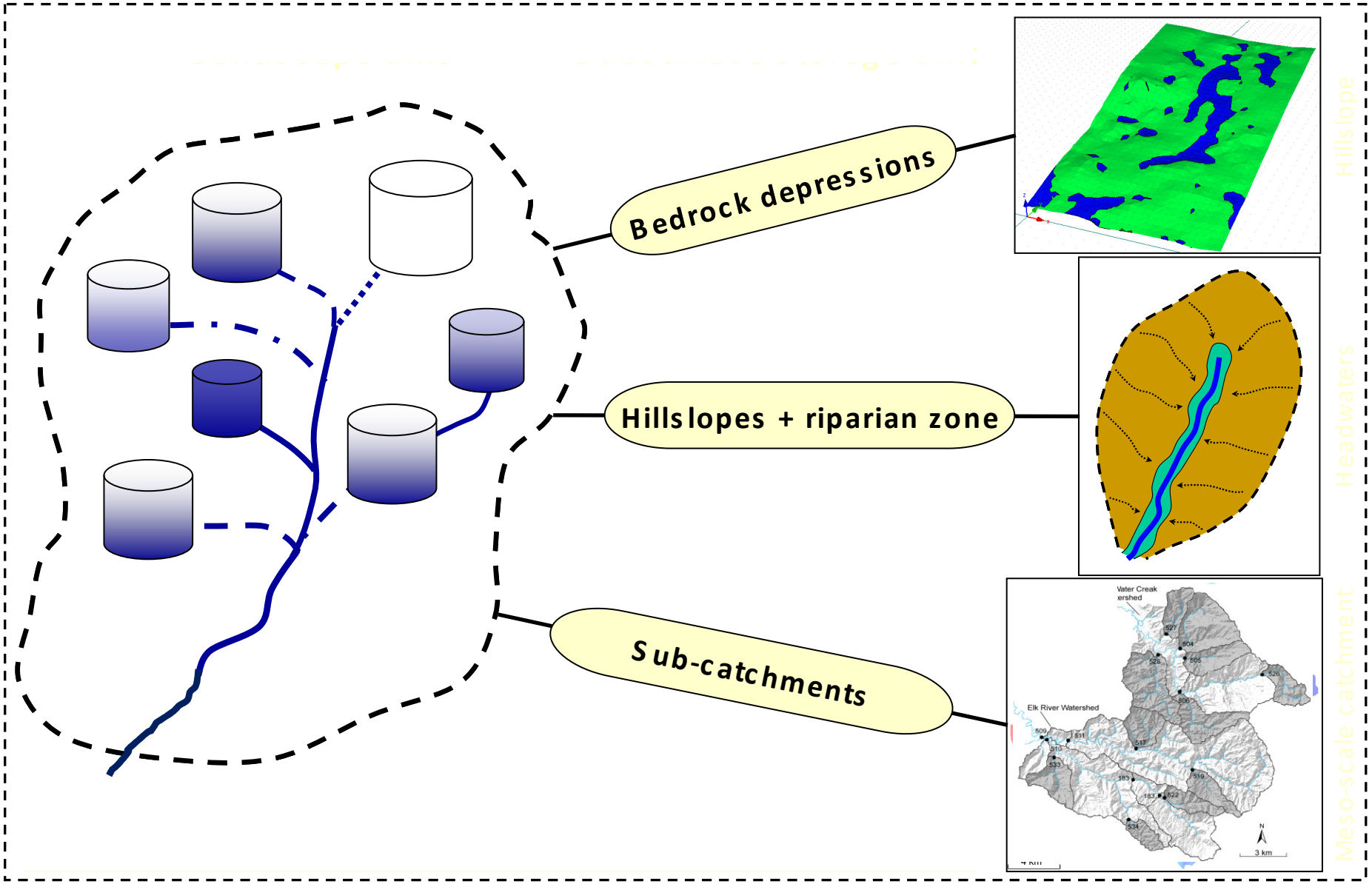
Summary I

- The dialog between FS and M is key for reducing epistemic error in the modeling process
- Precipitation-runoff data do not inform questions of sources, flowpaths and residence times
- TT of water through catchments can be orders of magnitude longer than the timescale of hydrologic response

A storage-based view of runoff

Fill, spill, connectivity, threshold

Dialog Btw Field Scientist and Modeler



Summary II

- Defining residence time scaling can lead to significant improvements in process realism
- Data availability is on the cusp of radical change
  - laser spectrometers!
- A binary classification of permeable vs poorly permeable could be a good start