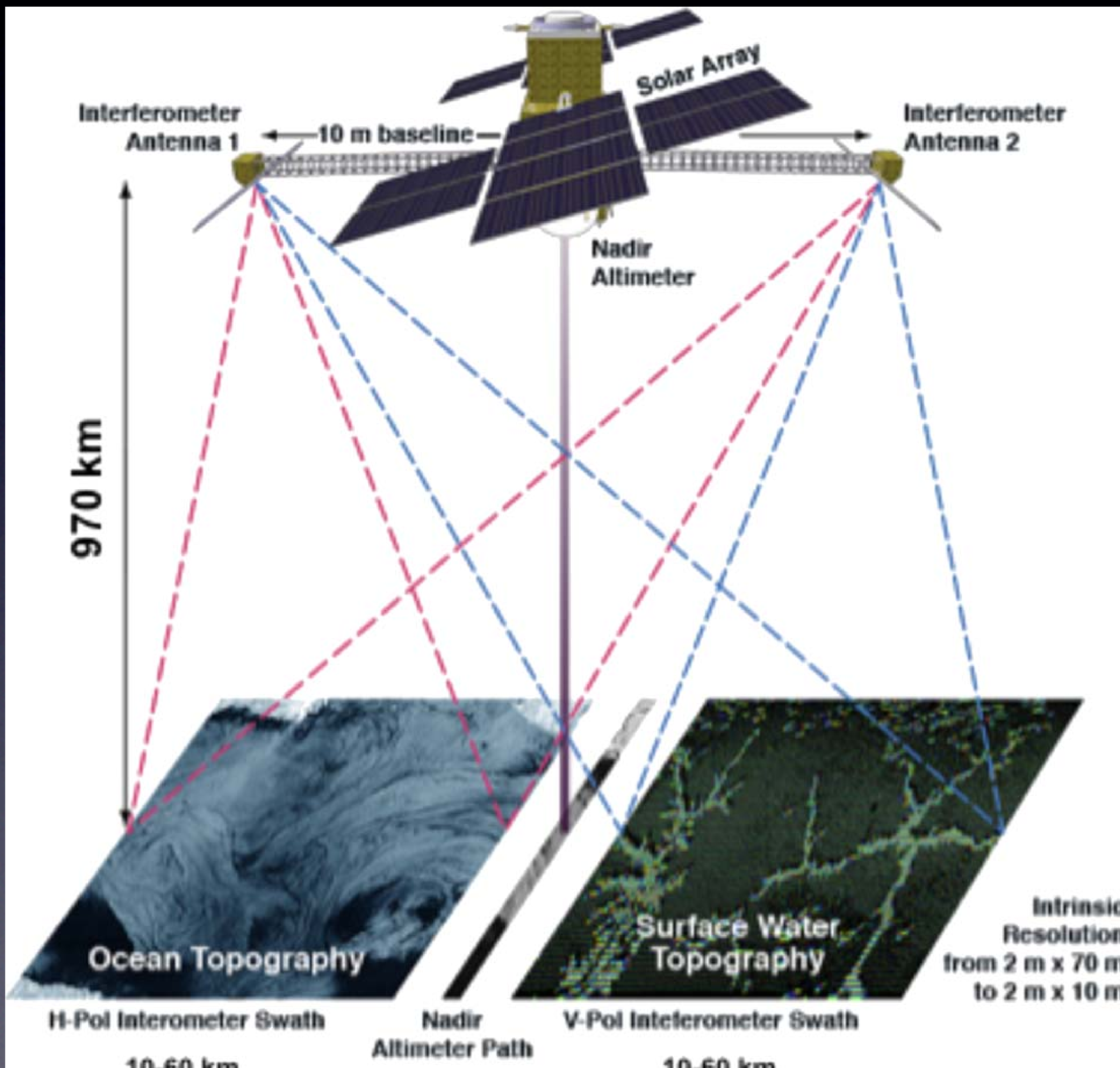
Estimating depth from SWOT measurements: A case study from the Rio Grande river



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Larry Smith
UCLA

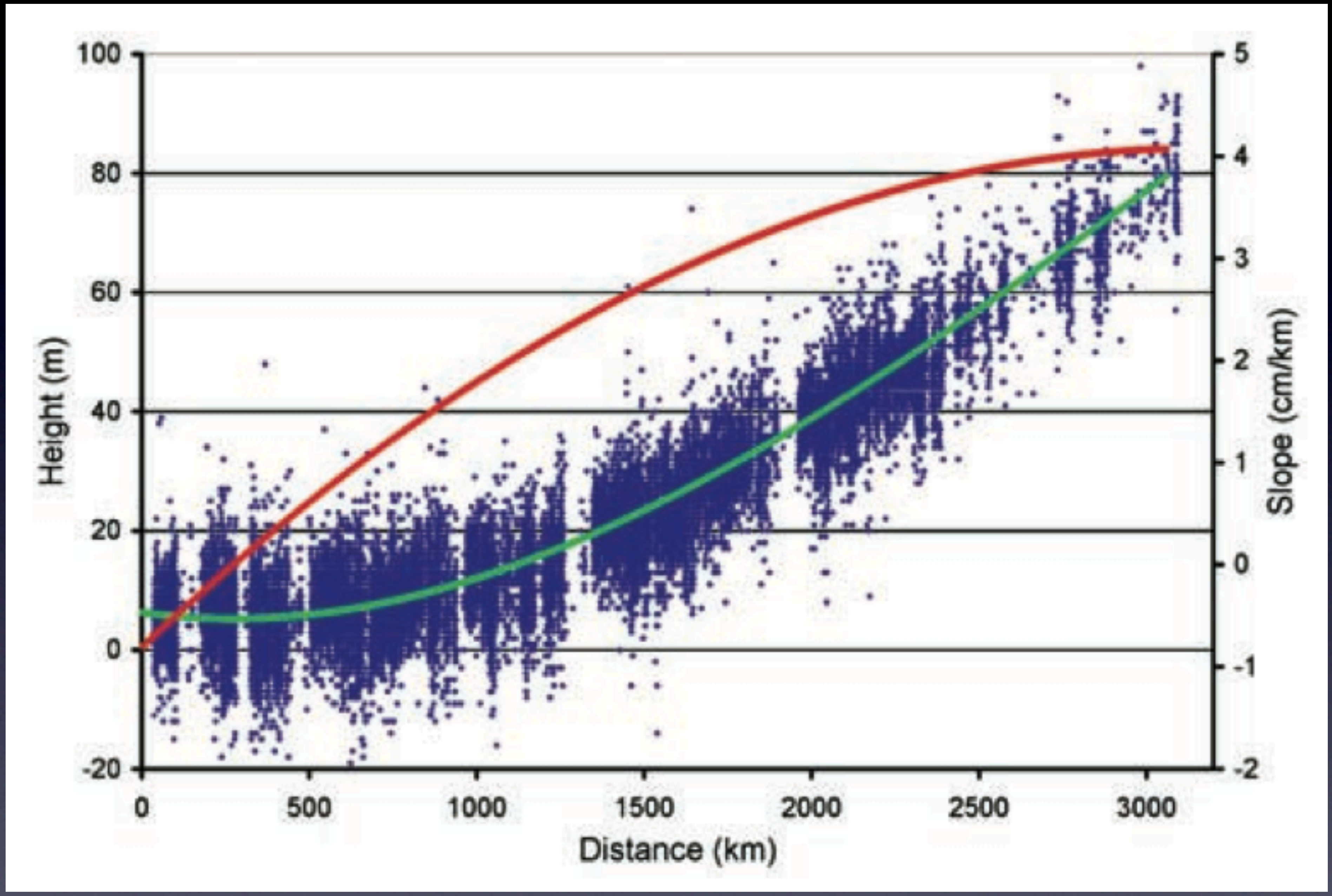
Lisbon Workshop
October 21, 2010

Funding: Physical Oceanography

Progress in estimating discharge

- LeFavour and Alsdorf, GRL, 2005
- Andreadis et al., GRL, 2007
- Durand et al., GRL, 2008
- Biancamaria et al., IEEE JSTARS, 2010
- Durand et al., IEEE JSTARS, 2010
- Biancamaria et al., RSE, 2010 (in press; Friday talk)
- Andreadis et al., in prep. (Friday talk)
- Clark et al., in prep. (See posters)
- Wilson et al., in prep. (See posters)
- Yoon et al., in prep. (See posters)
- Jasinski et al. (See posters)
- Carlo et al. (See posters)

Progress: Manning from space



$$Q = \frac{1}{n} w z^{5/3} \left(\frac{\partial h}{\partial x} \right)^{1/2}$$

Le Favour & Alsdorf, GRL, 2005

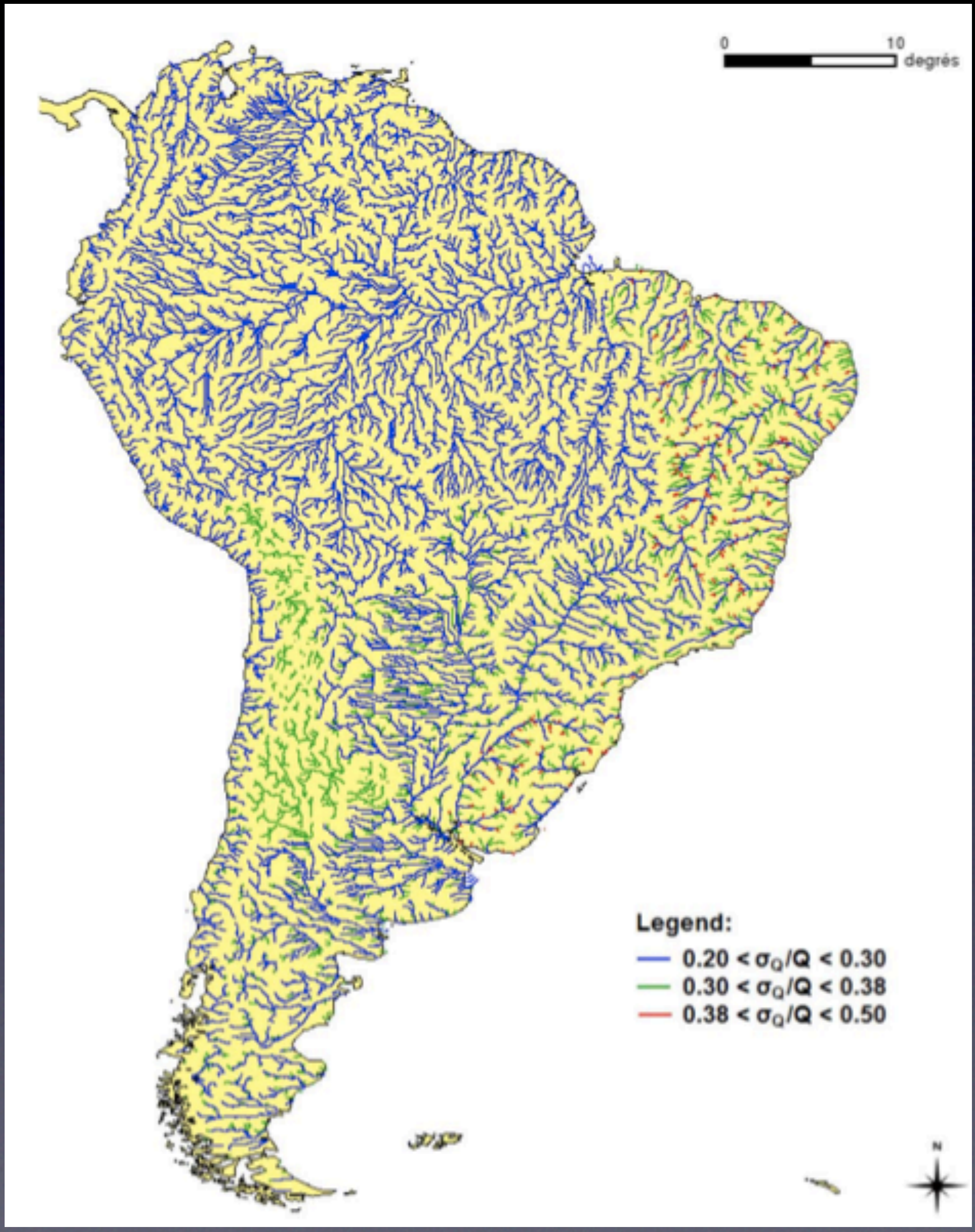
Progress: Effect of height errors

$$\left(\frac{\sigma_Q}{Q}\right)^2 = \eta^2 + \left(b\frac{\sigma_{H_{SWOT}}}{H_{SWOT}}\right)^2$$

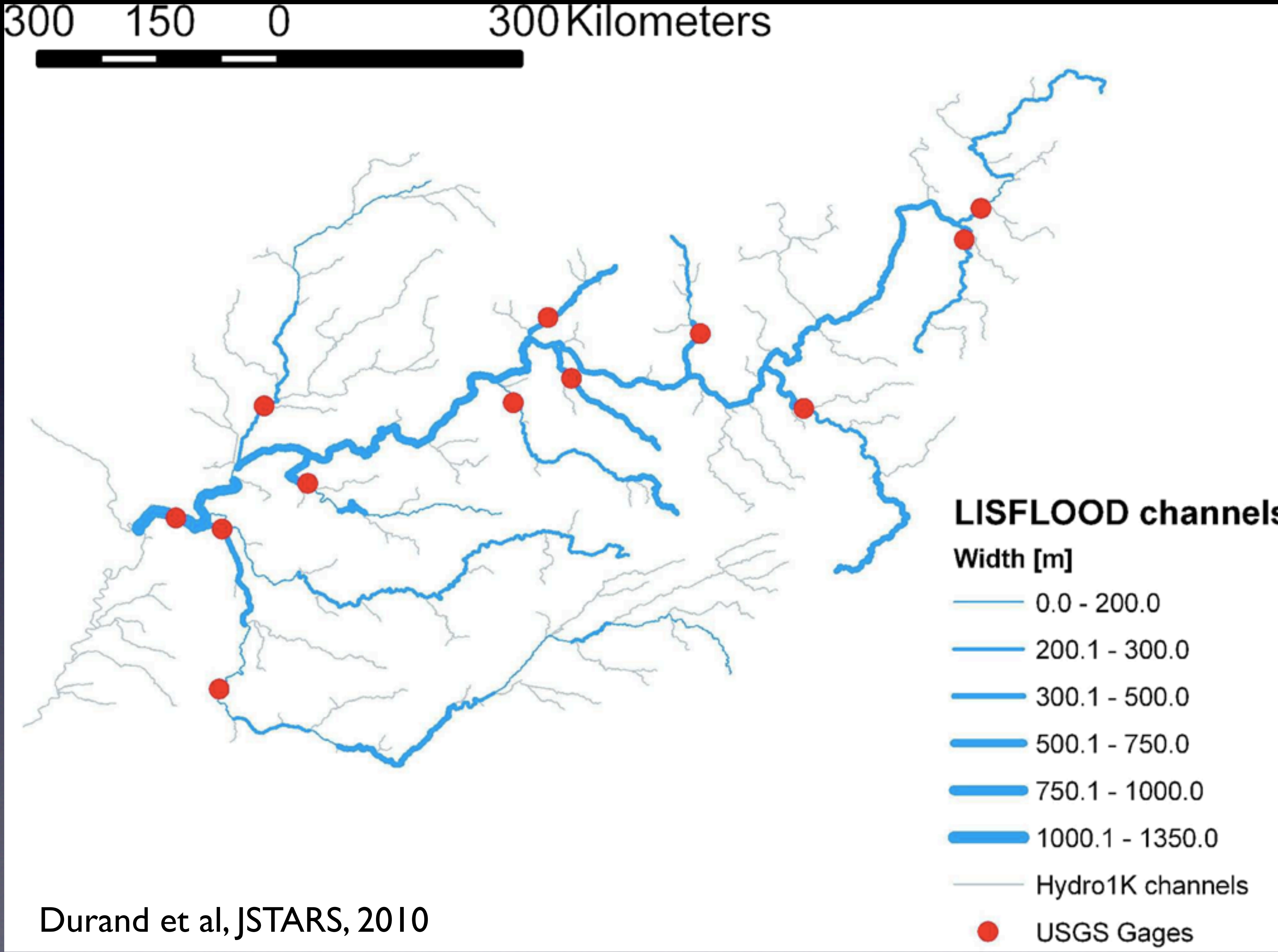
Height errors will not be a controlling factor in discharge estimates

Rivers deeper than ~1.5 m, uncertainty less than 25%

Biancamaria et al., JSTARS, 2010



Progress: Effect of depth errors

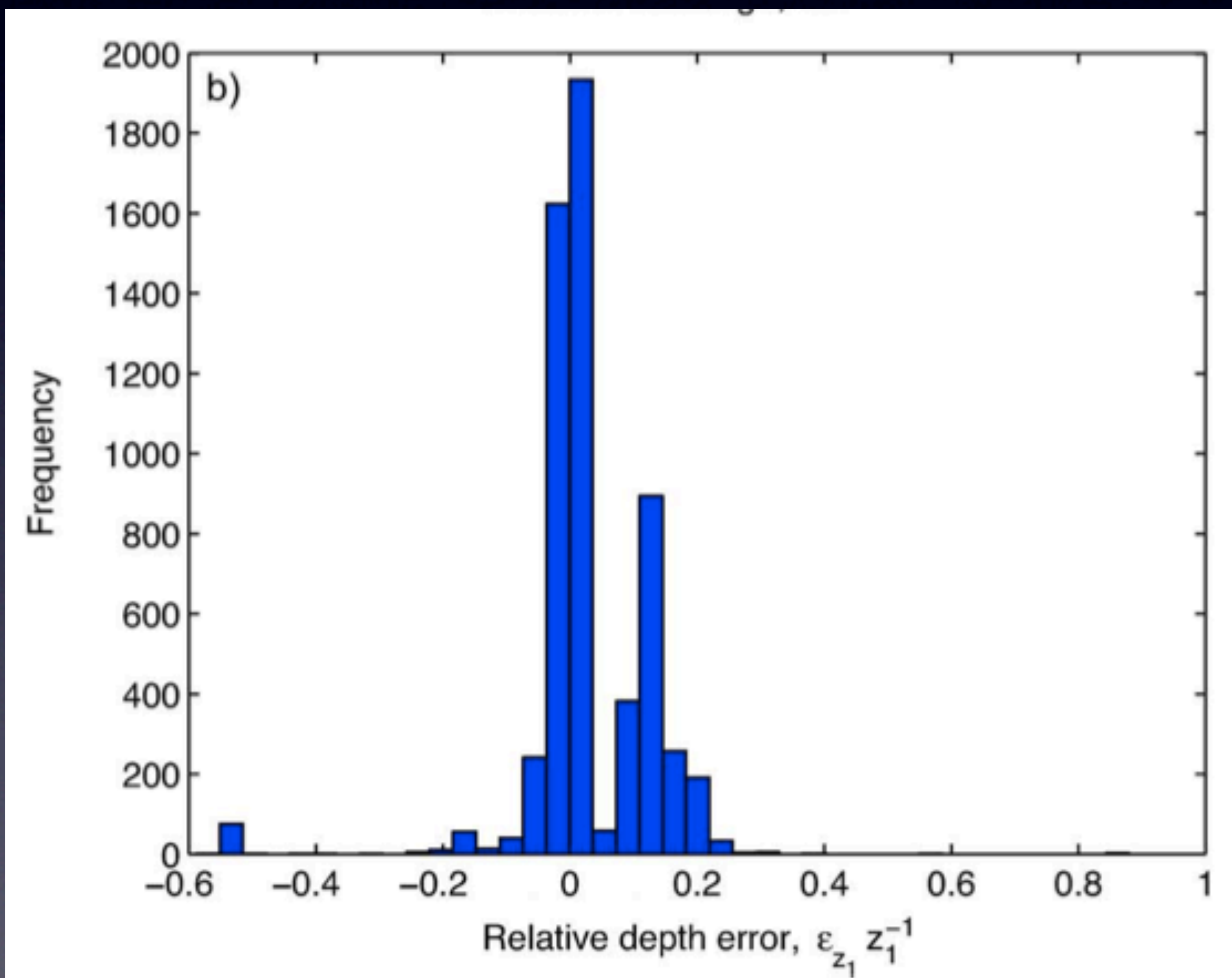


Durand et al, JSTARS, 2010

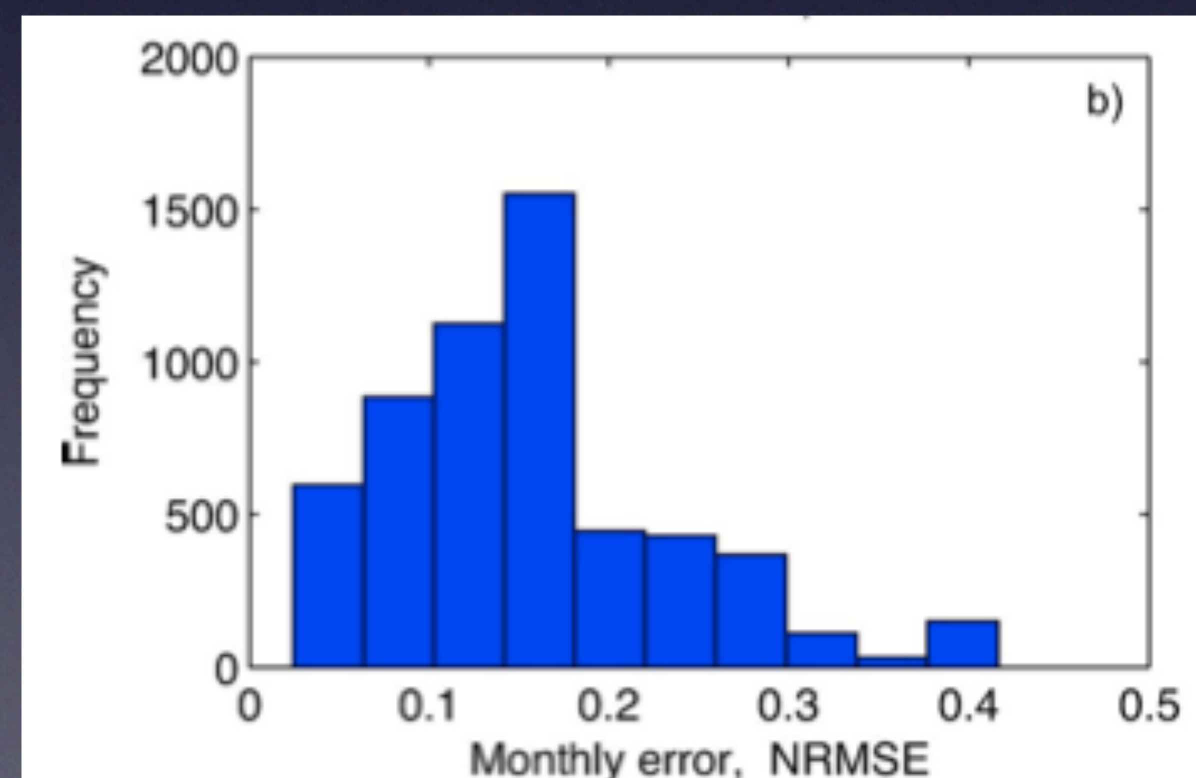
Progress: Effect of depth errors

Depth errors

Depth estimated by least-square continuity algorithm



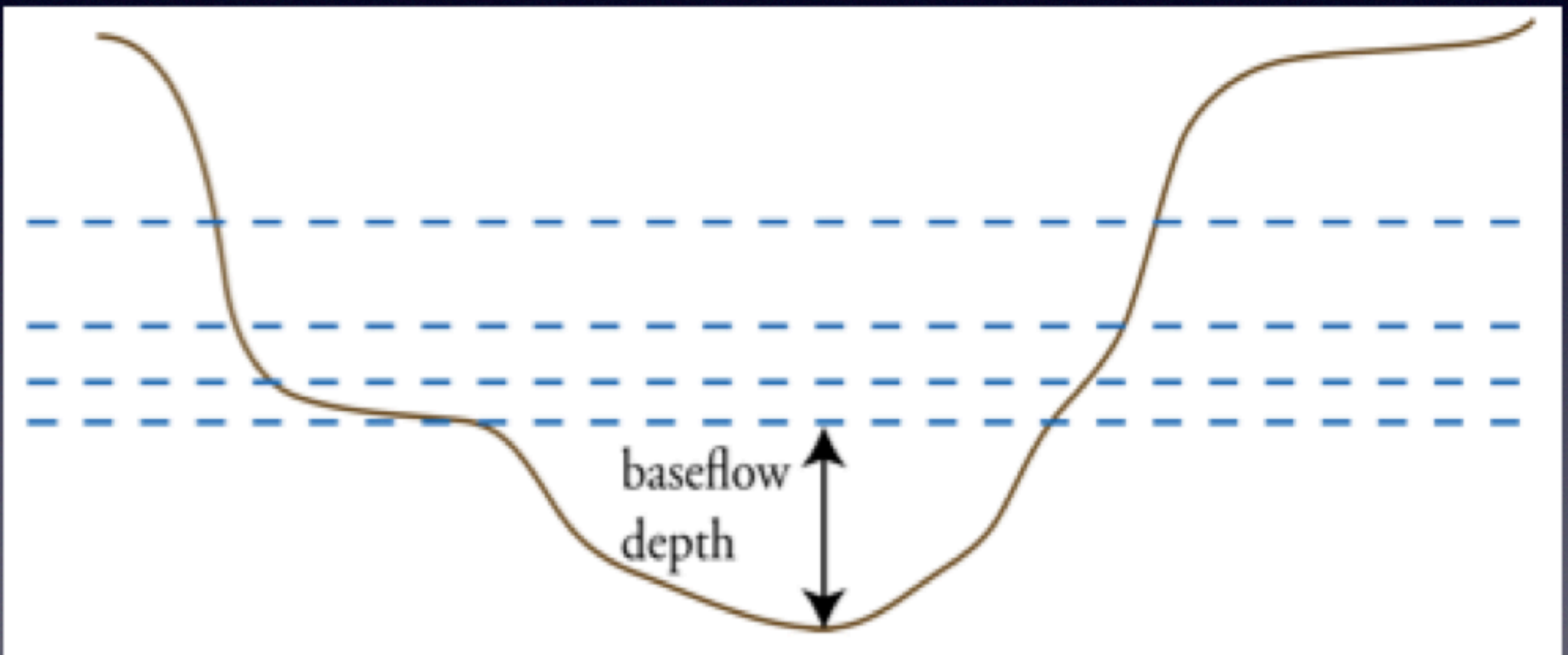
Includes errors due to SWOT height, baseflow depth, and temporal sampling



Durand et al, JSTARS, 2010

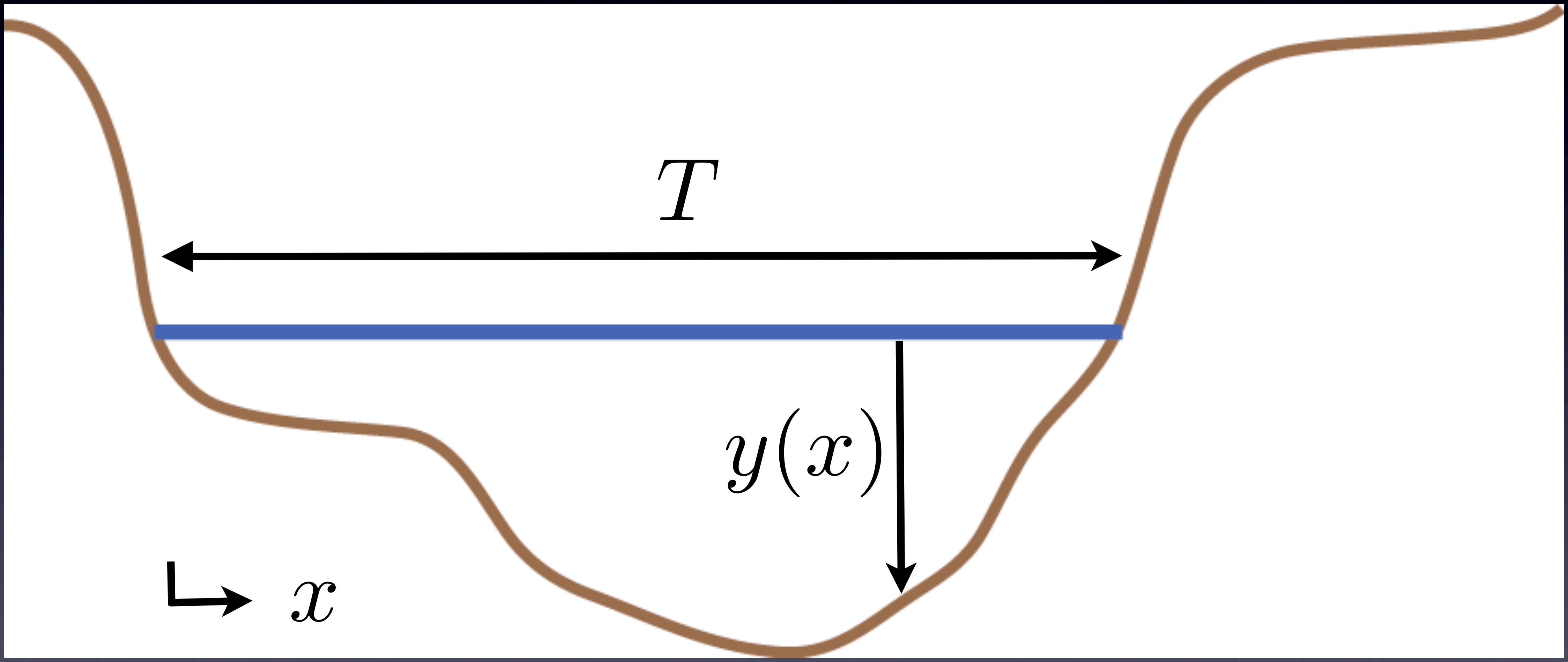
The depth problem: Another look

SWOT does not observe depth below
the lowest height measurement



Hydraulic depth: Definition

Goal: Estimate hydraulic depth from SWOT observations



$$D = A/T \qquad A = \int_{x_{min}}^{x_{max}} y(x)dx$$

A new project: Two approaches to depth

Hydraulic Geometry

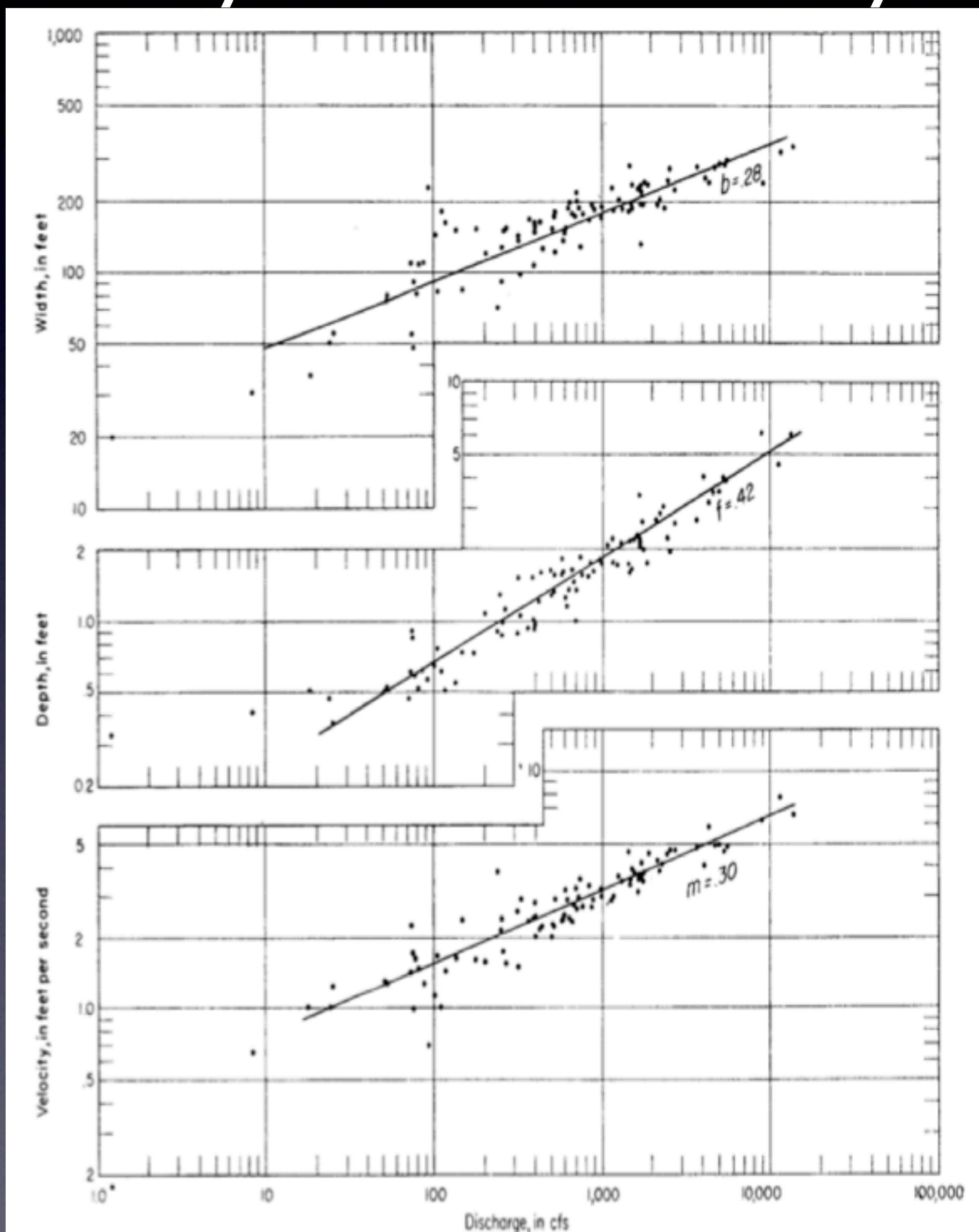
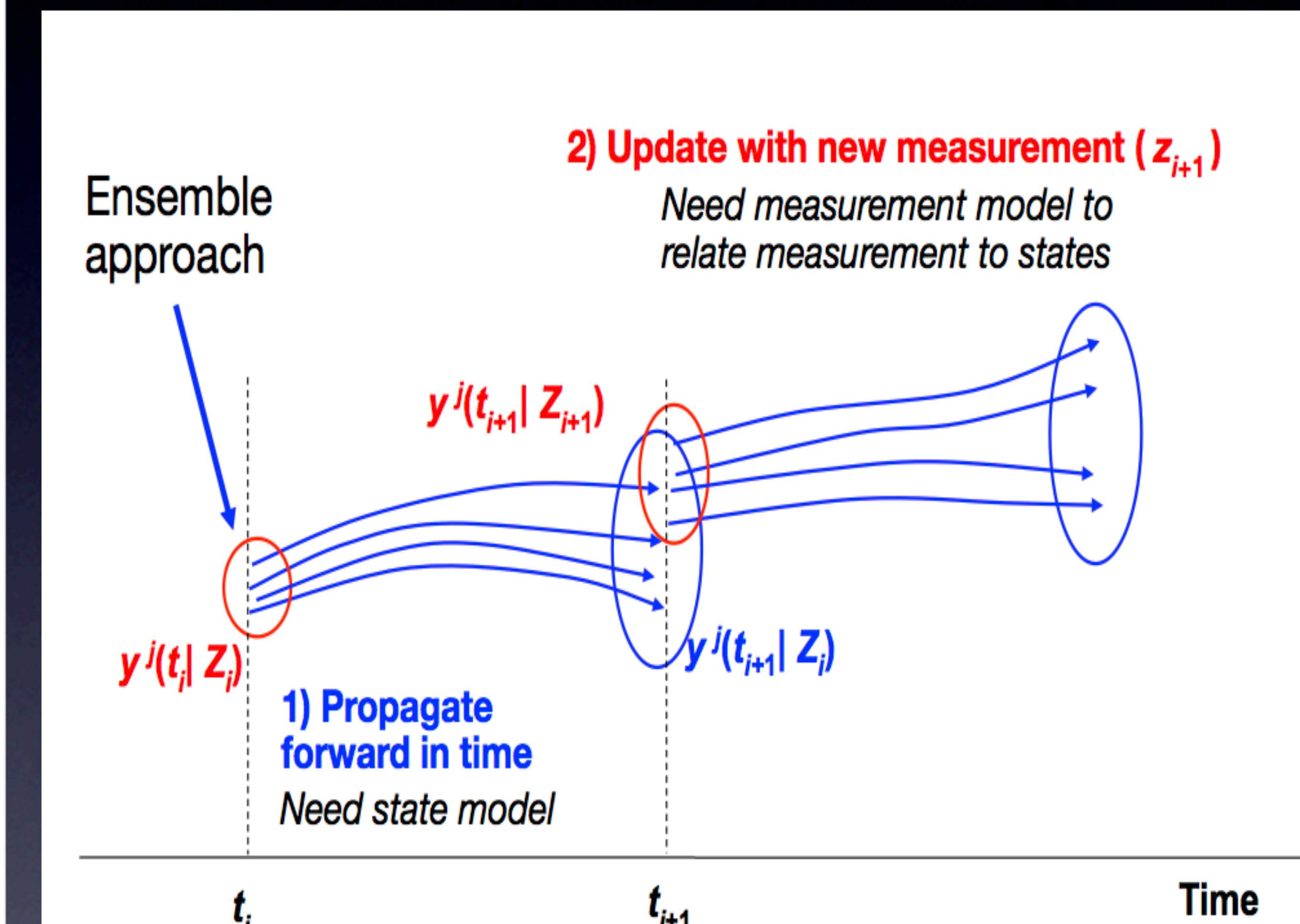


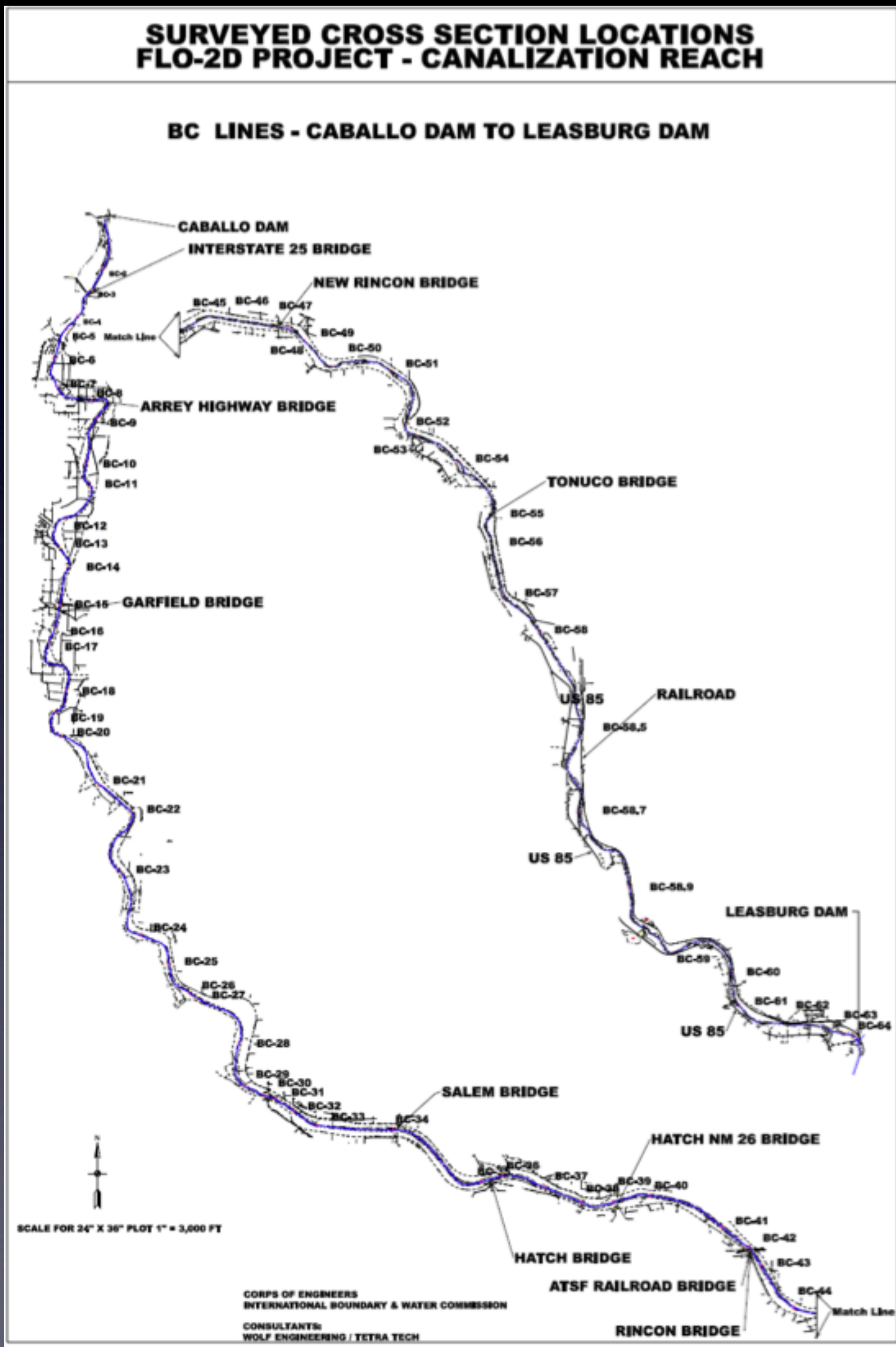
FIGURE 4, B.—Relation of width, depth, and velocity to discharge, Powder River at Locate, Mont.

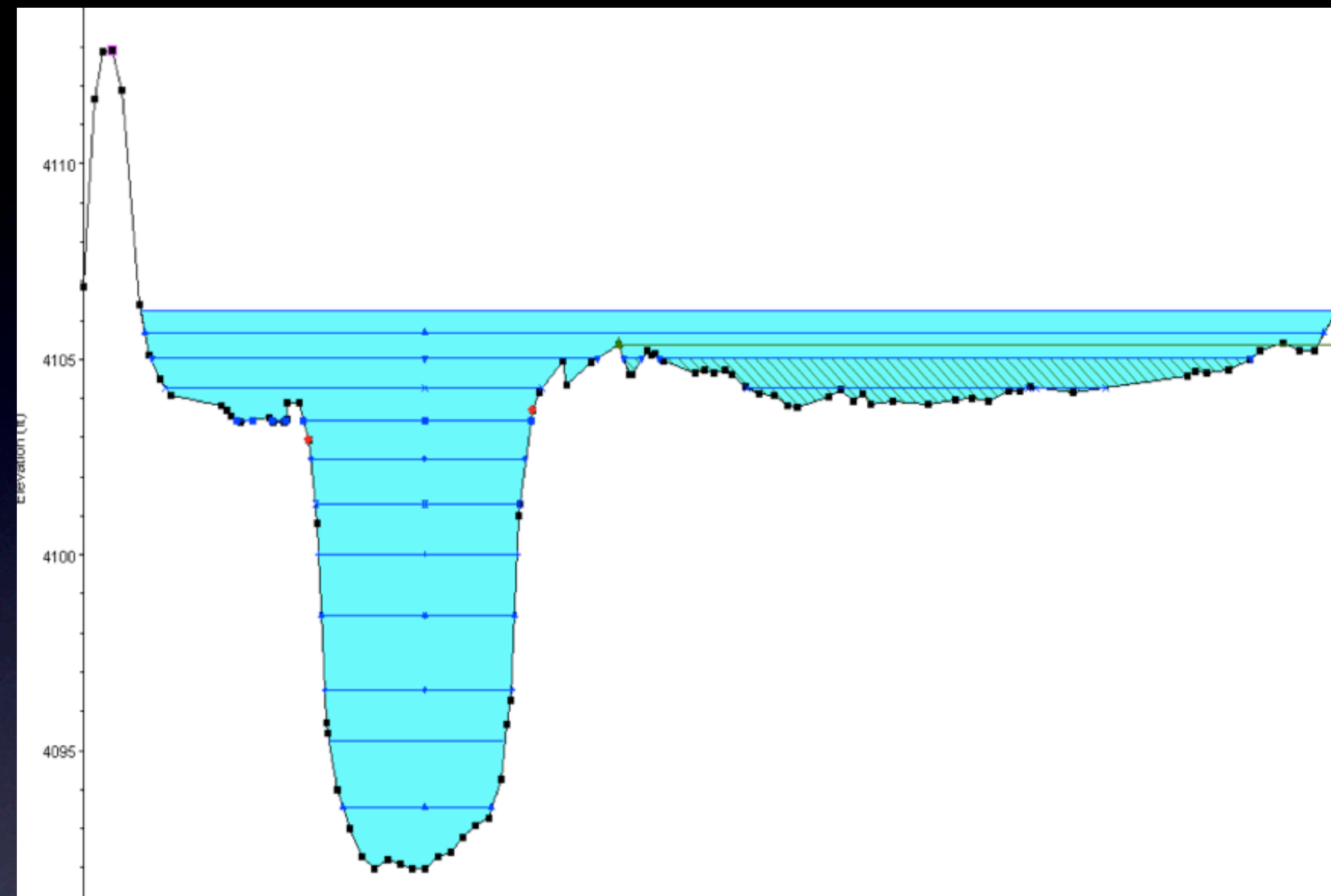
Data Assimilation

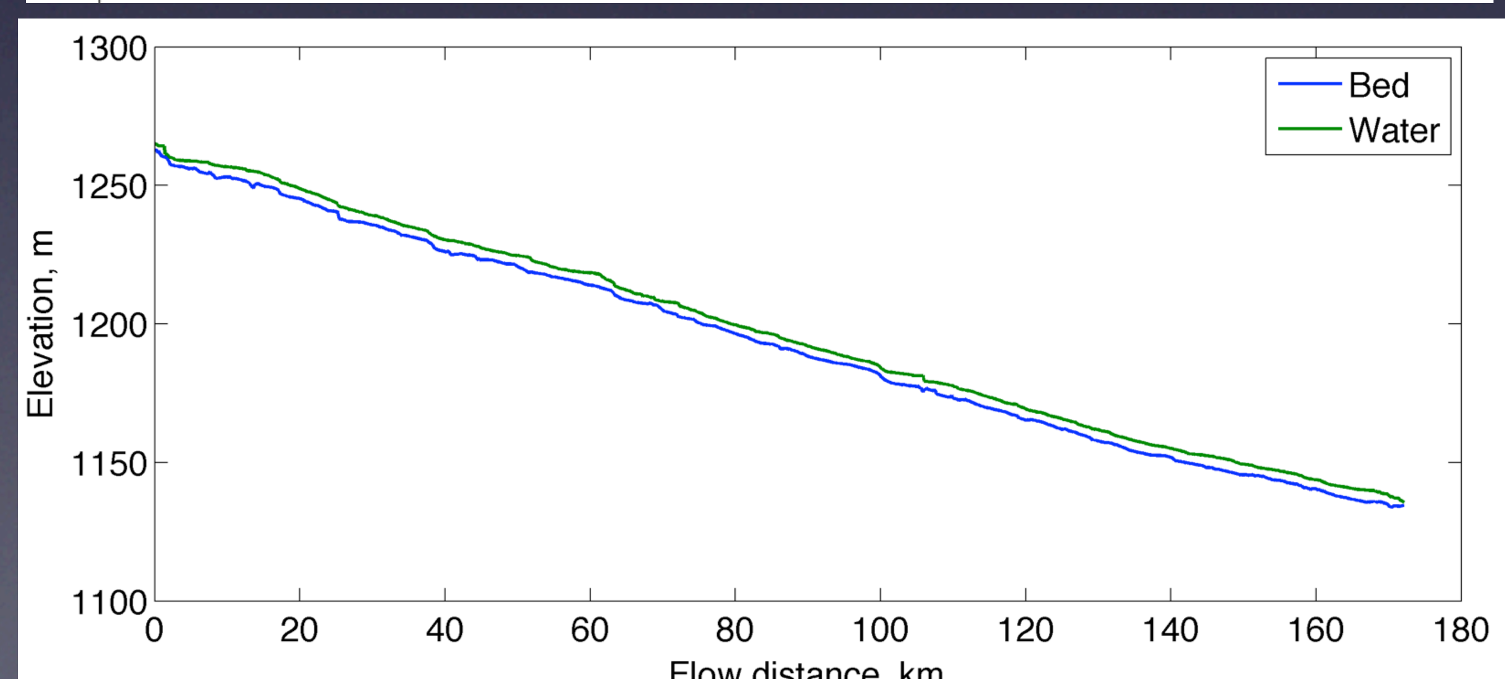


For more: See Larry Smith's talk tomorrow

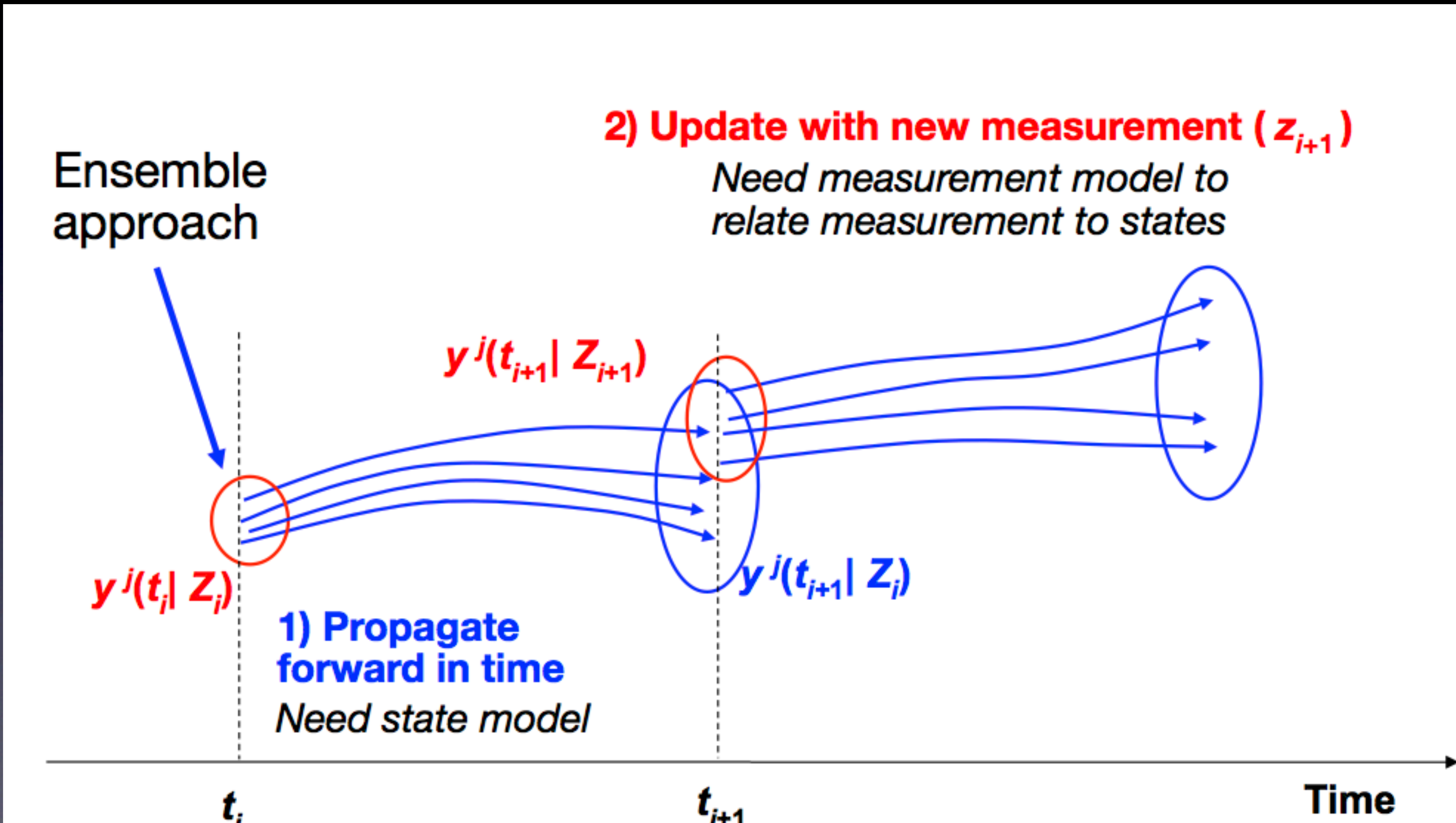
A new dataset: Rio Grande river



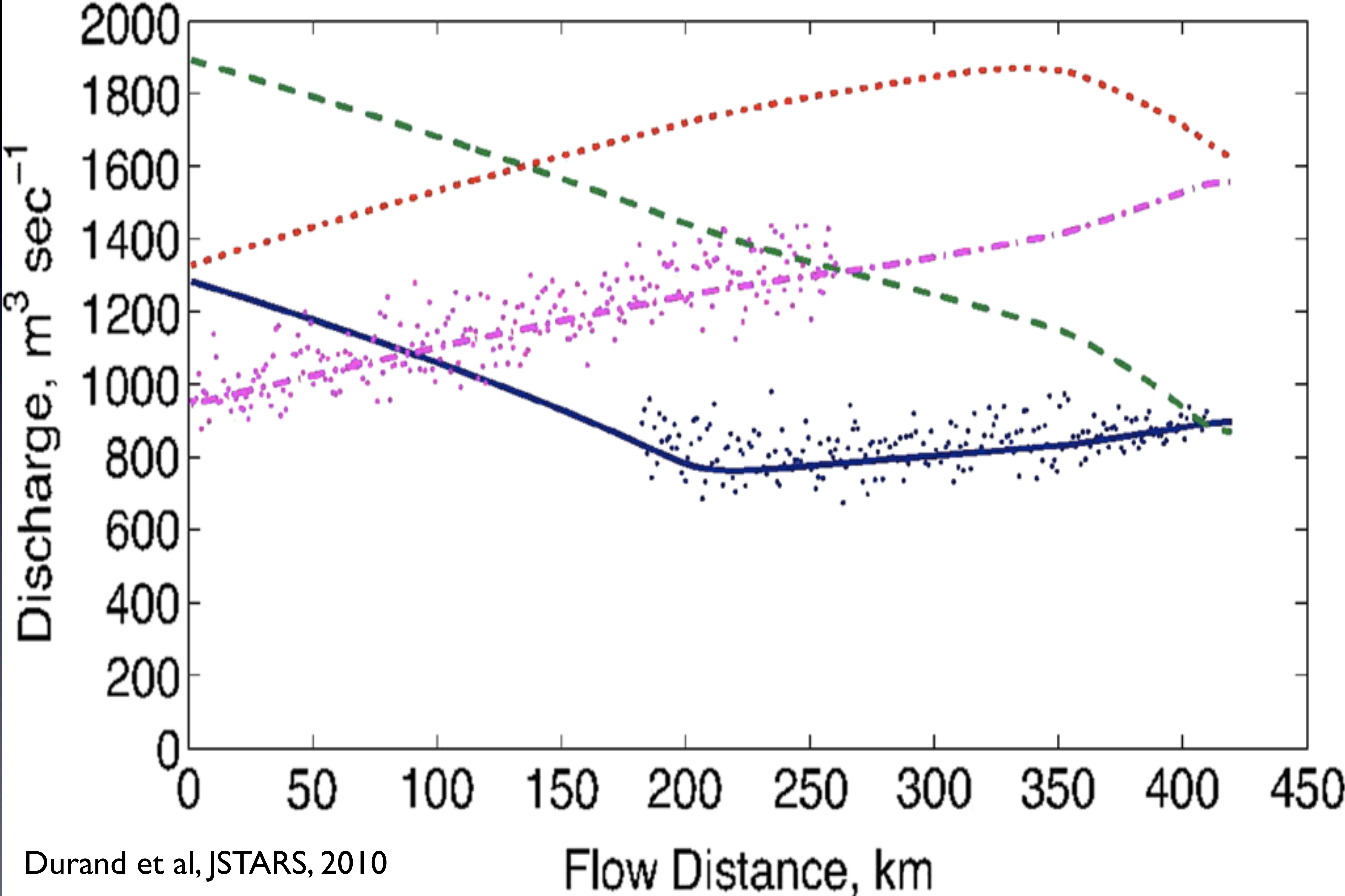




Data assimilation: Background

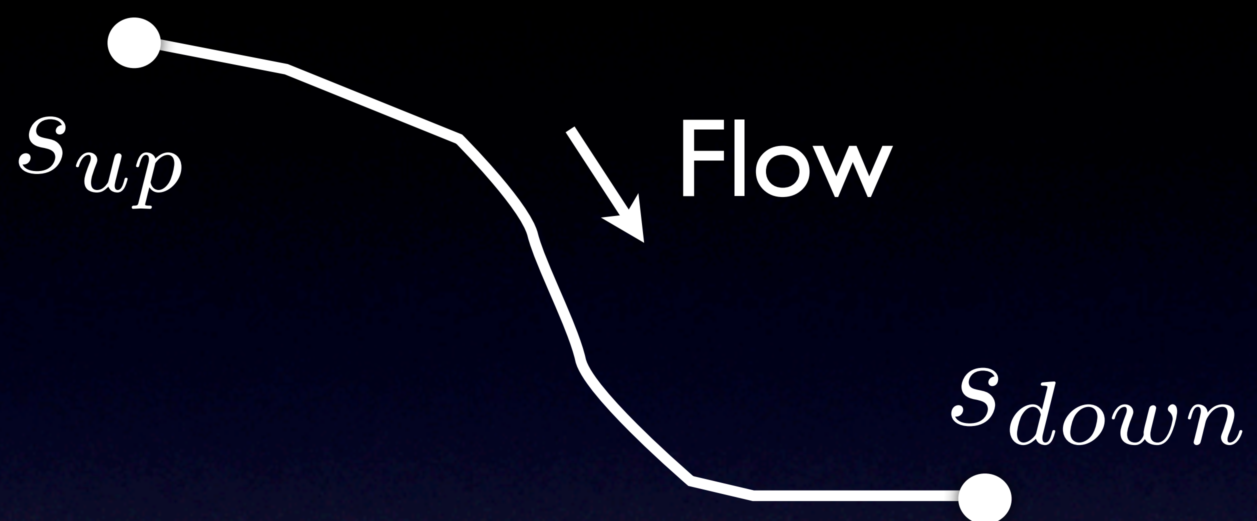


Trading time for space with SWOT

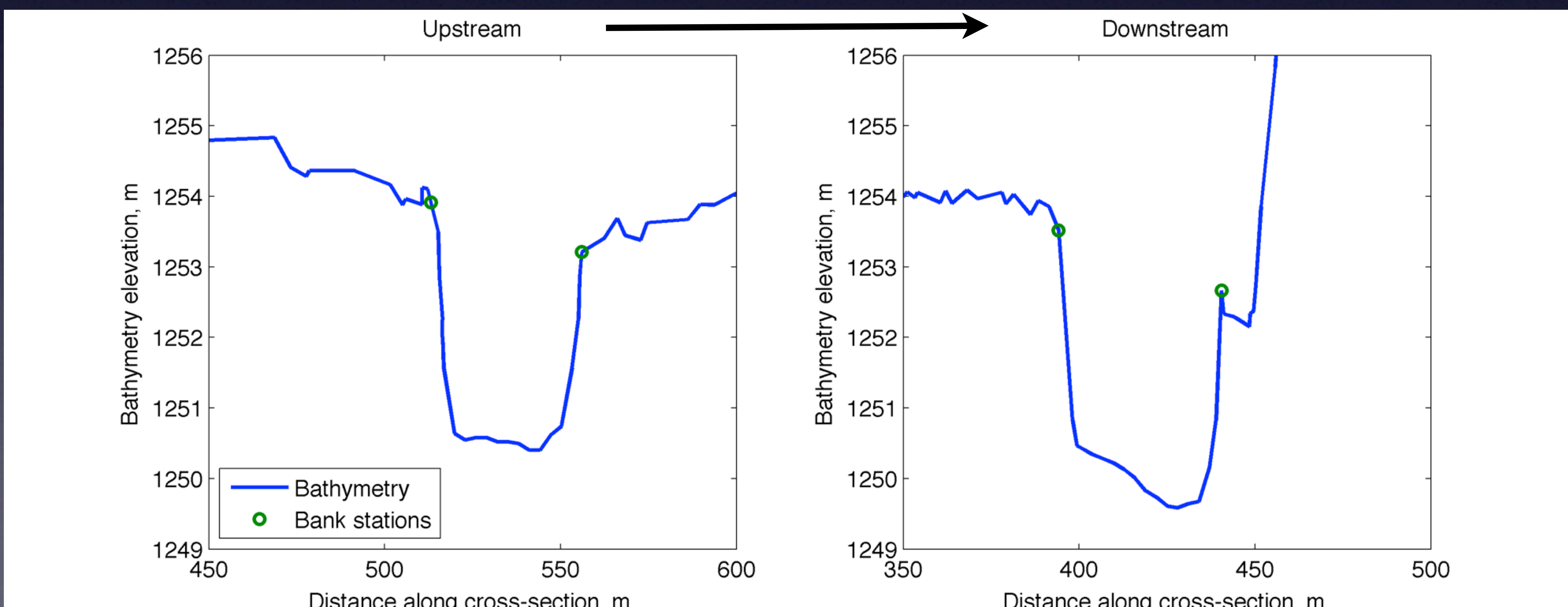


Durand et al, JSTARS, 2010

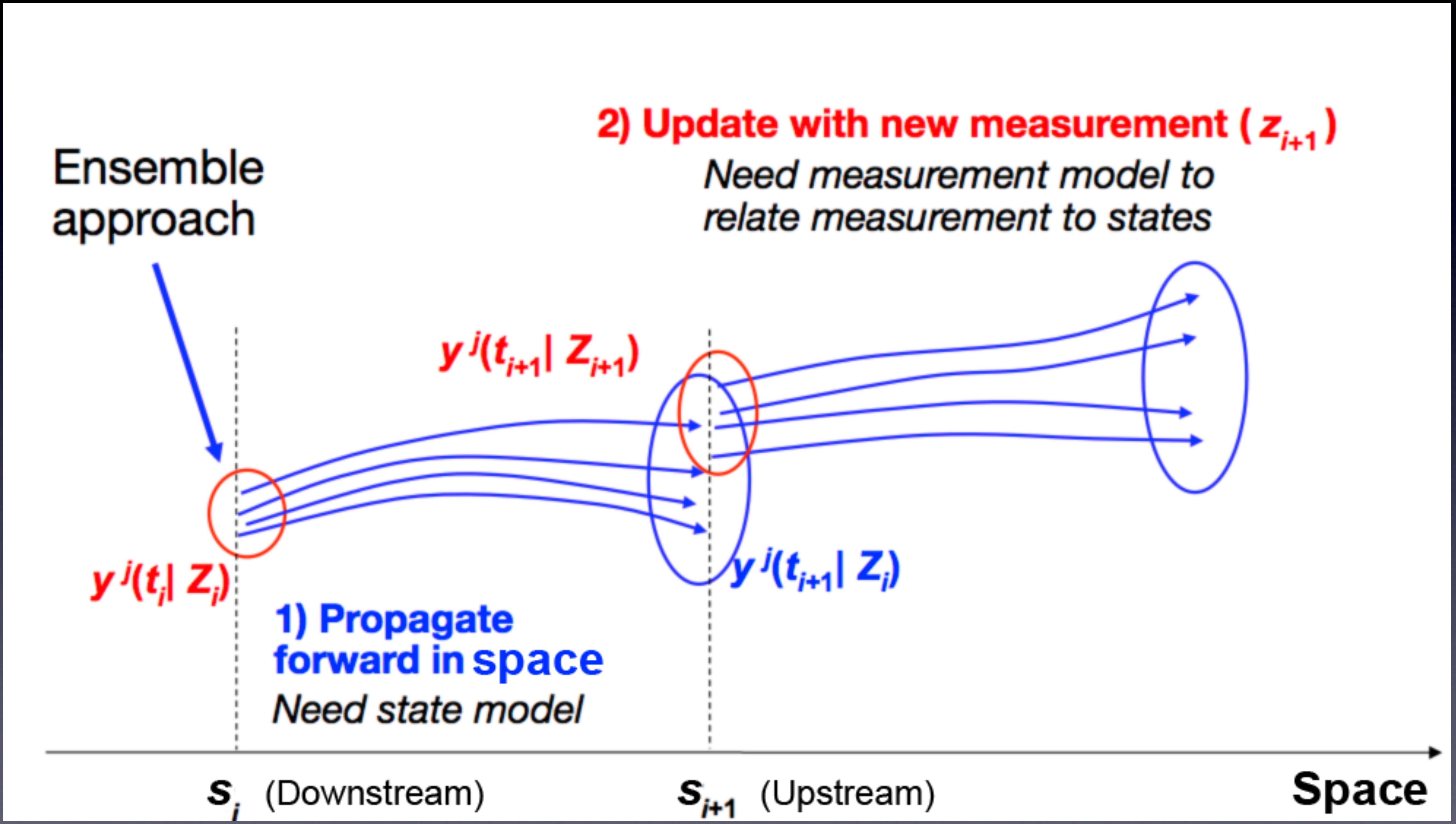
Hydraulics: Gradually-varied flow



$$\frac{\partial h}{\partial x} = \frac{S_0 - S_f}{1 - Fr^2} - S_0$$



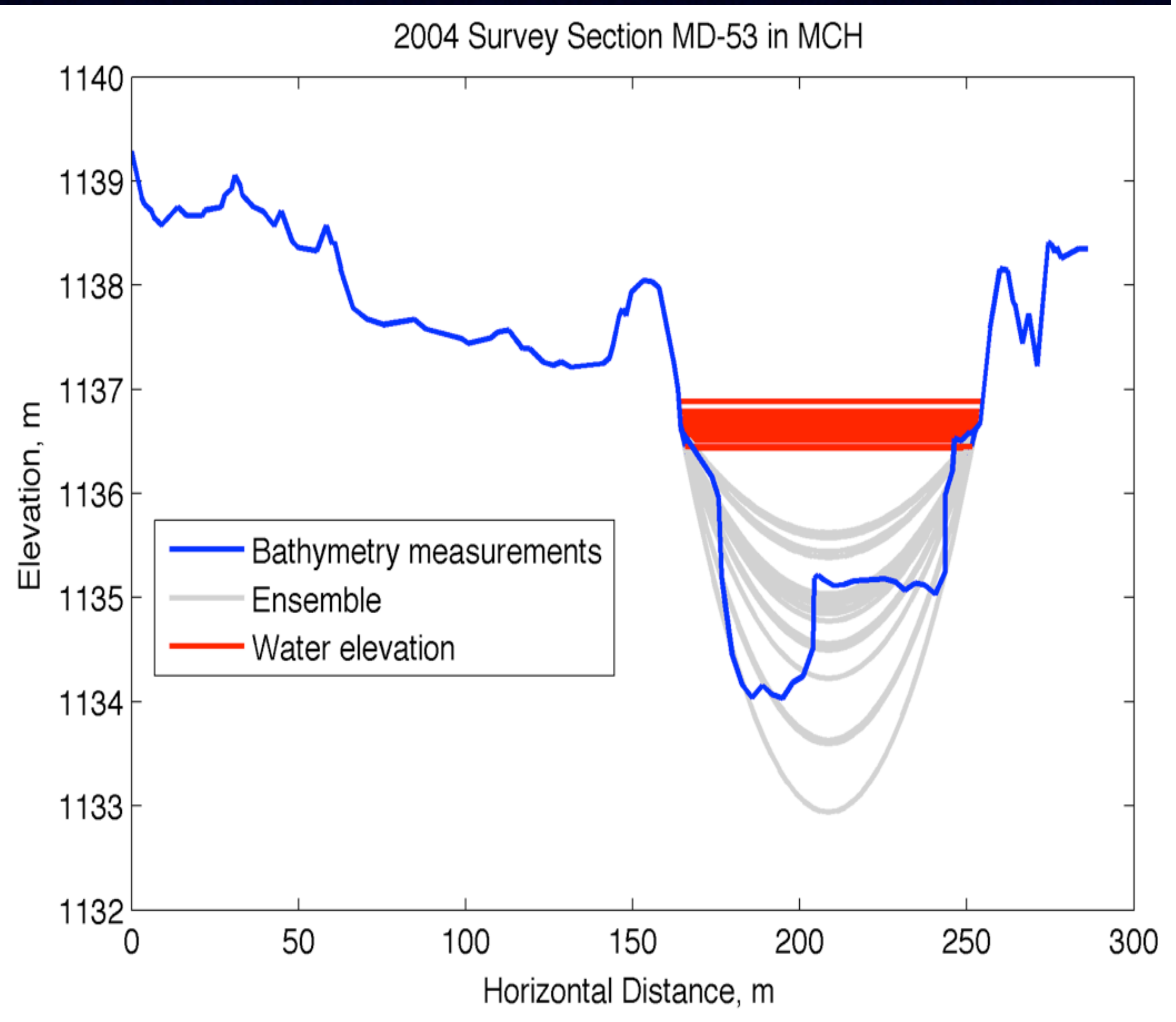
Spatial ensemble Kalman filter



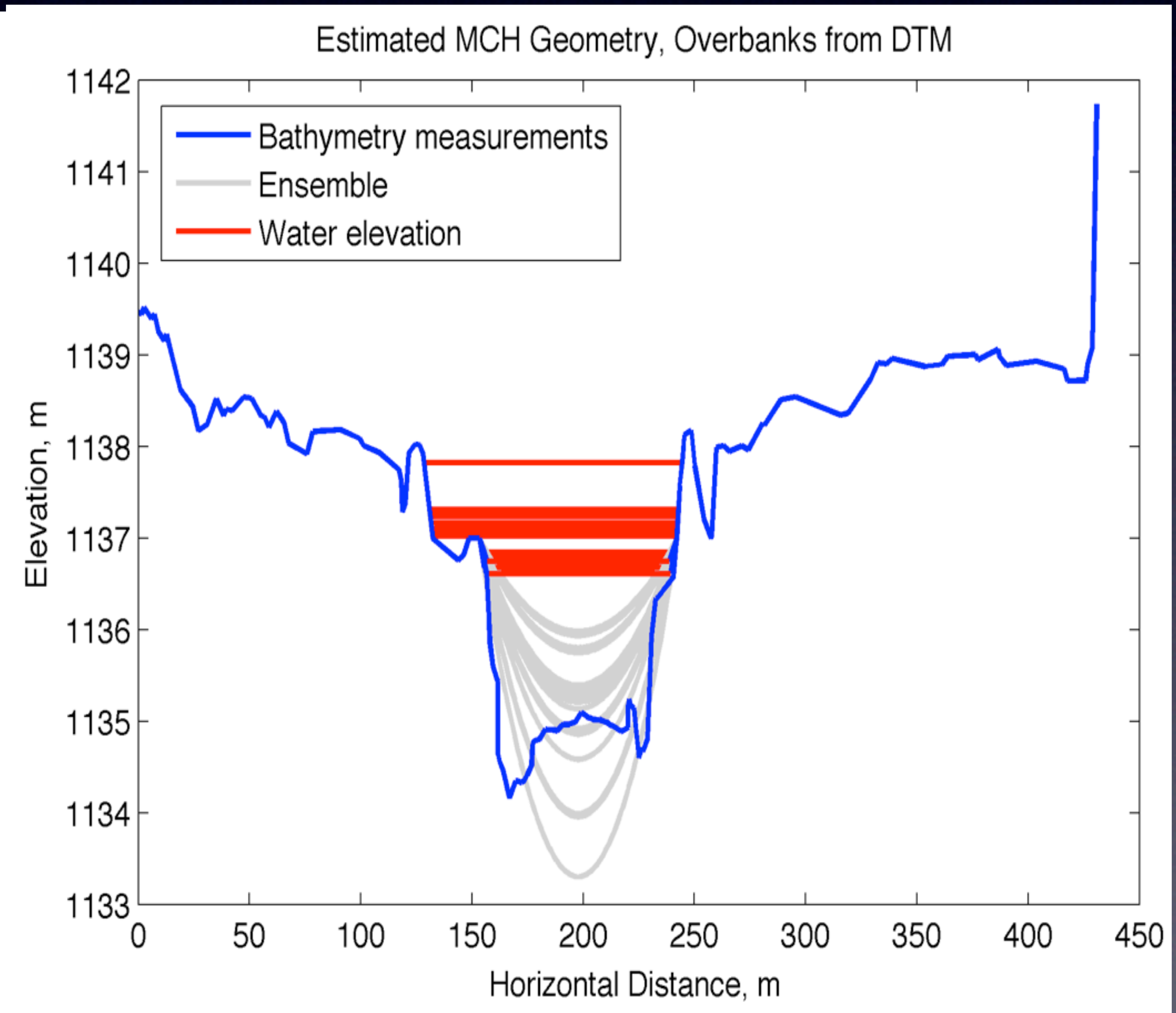
Parameterizing unseen bathymetry

Goal: Estimate the optimal minimum depth

Downstream

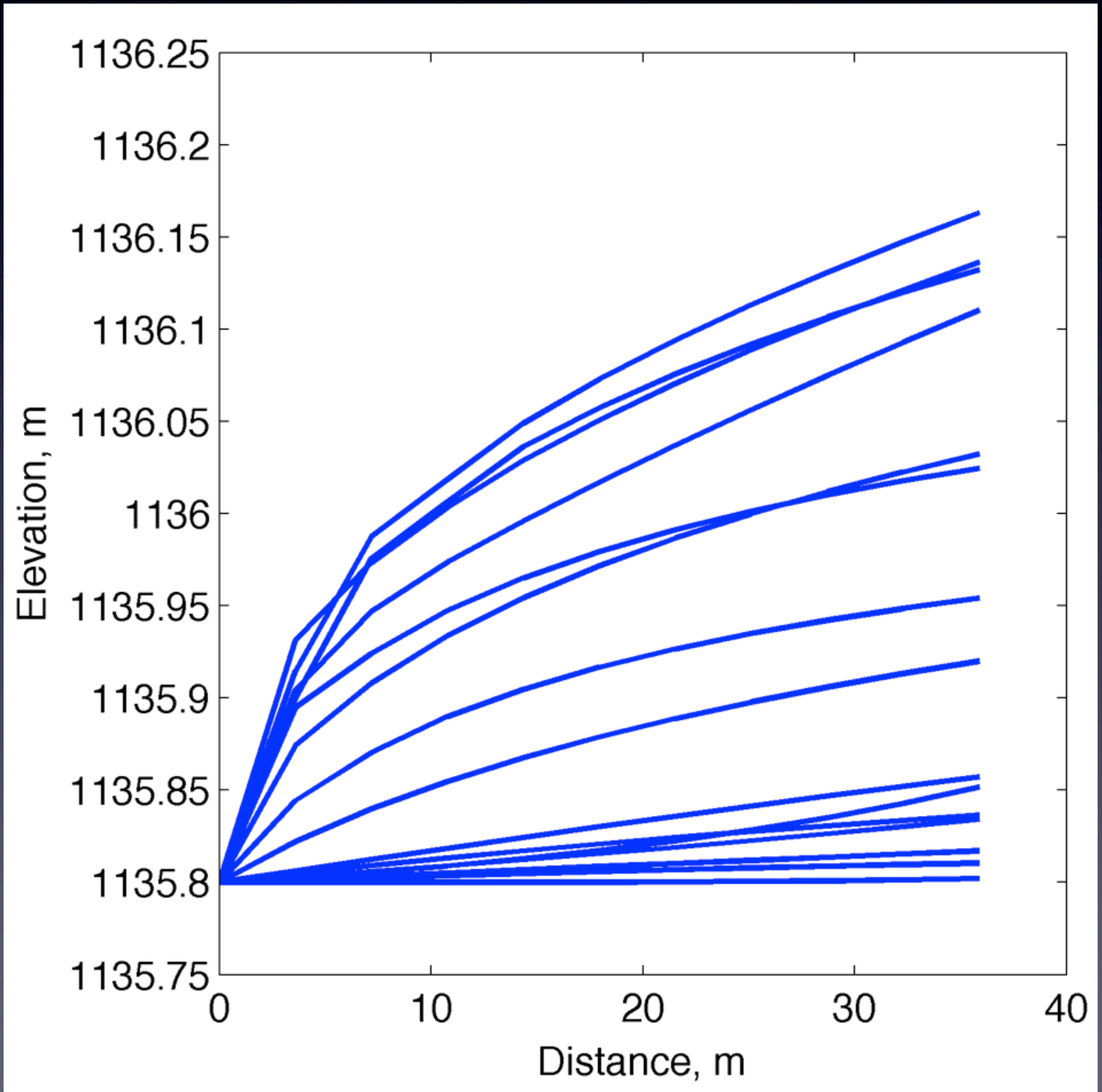


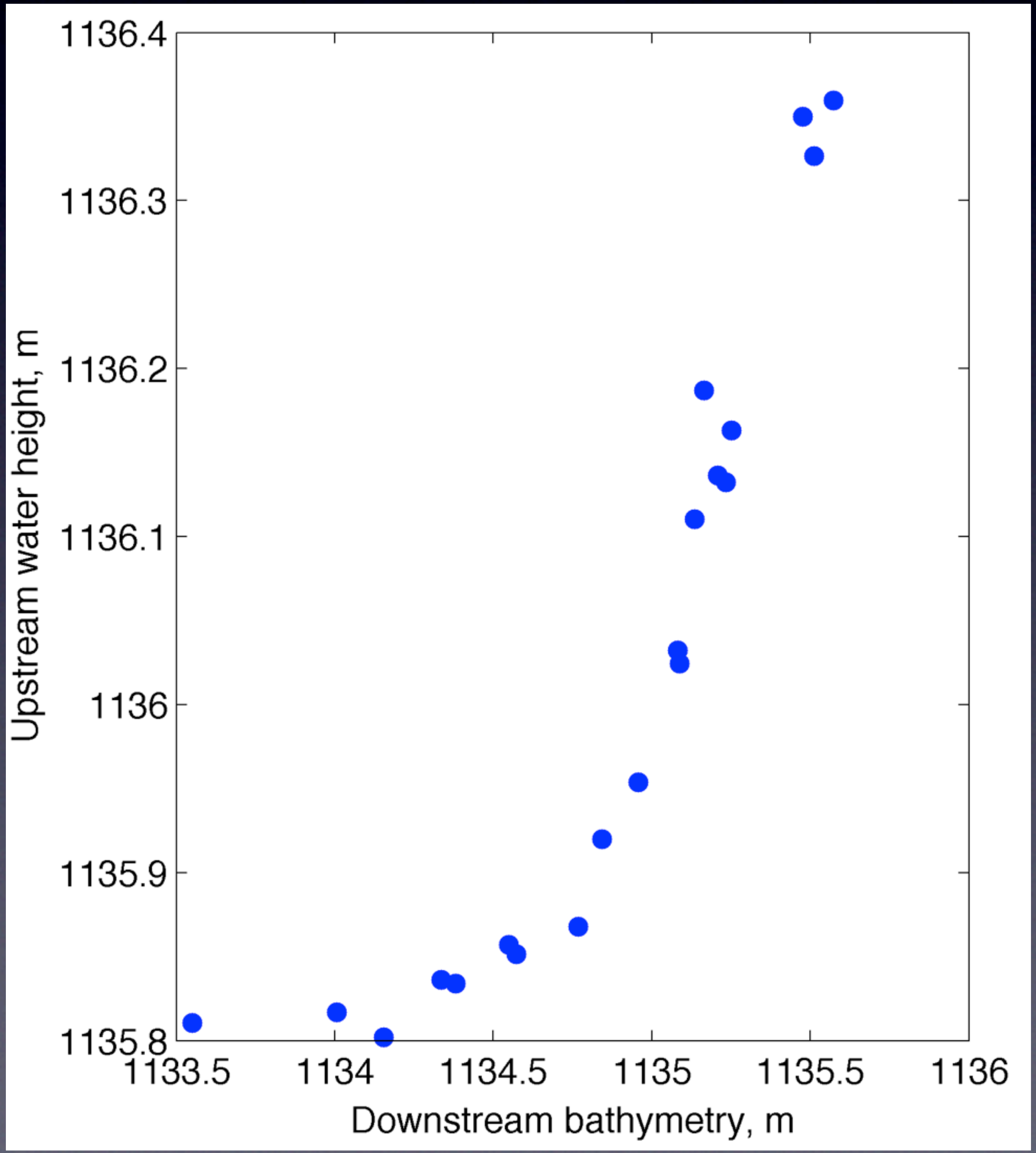
Upstream



Results at a single cross-section

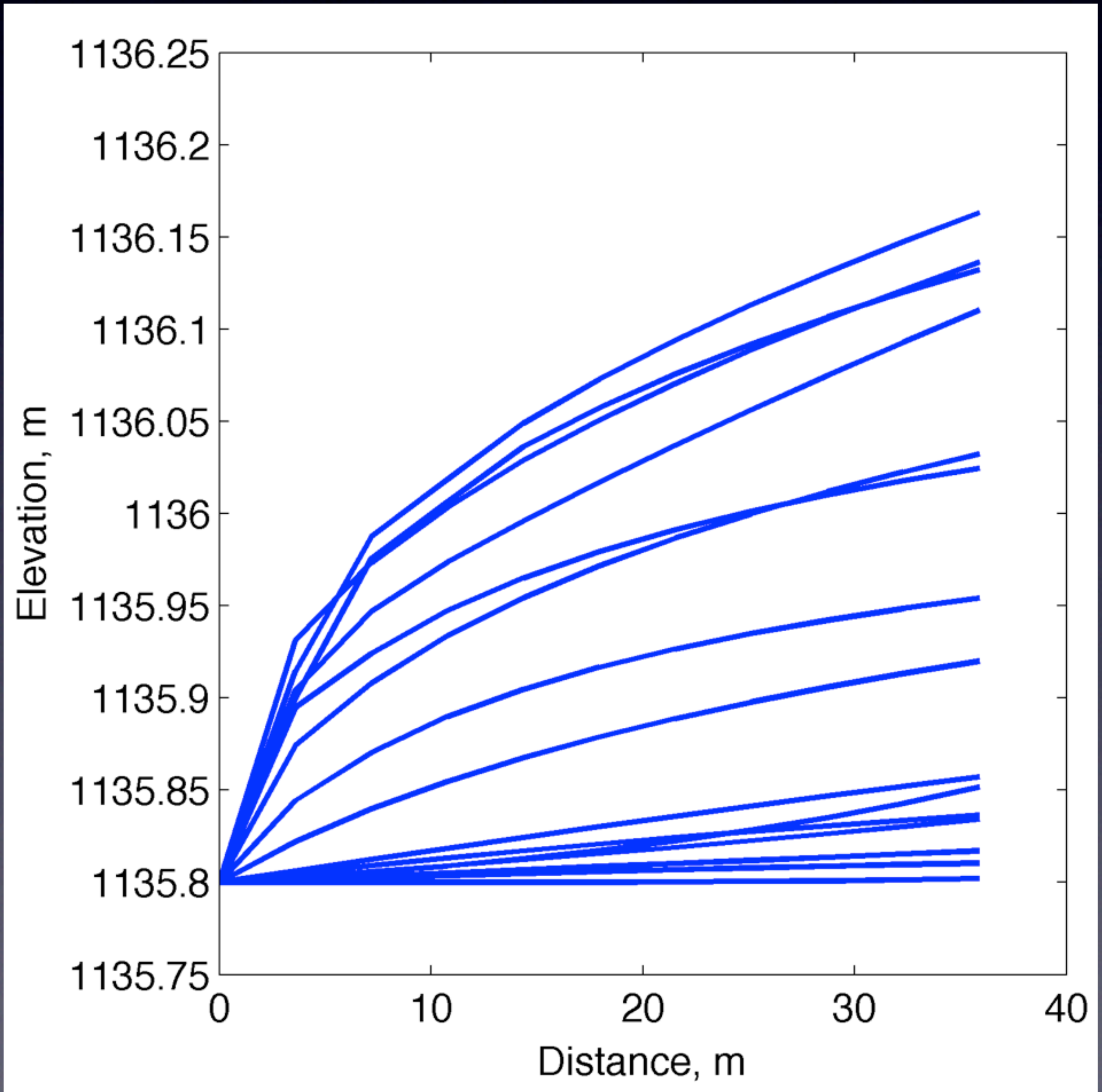
Downstream Upstream

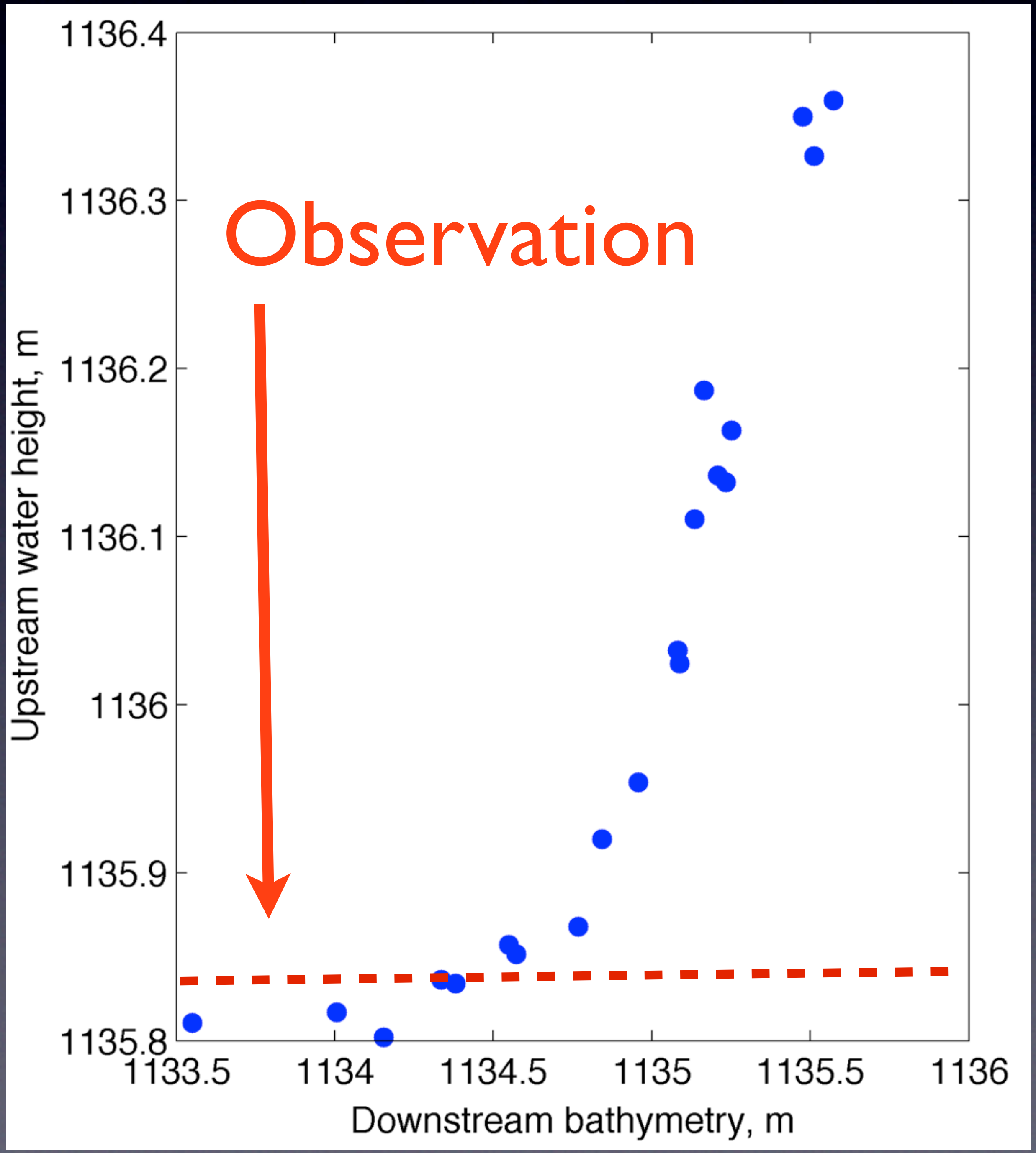




Results at a single cross-section

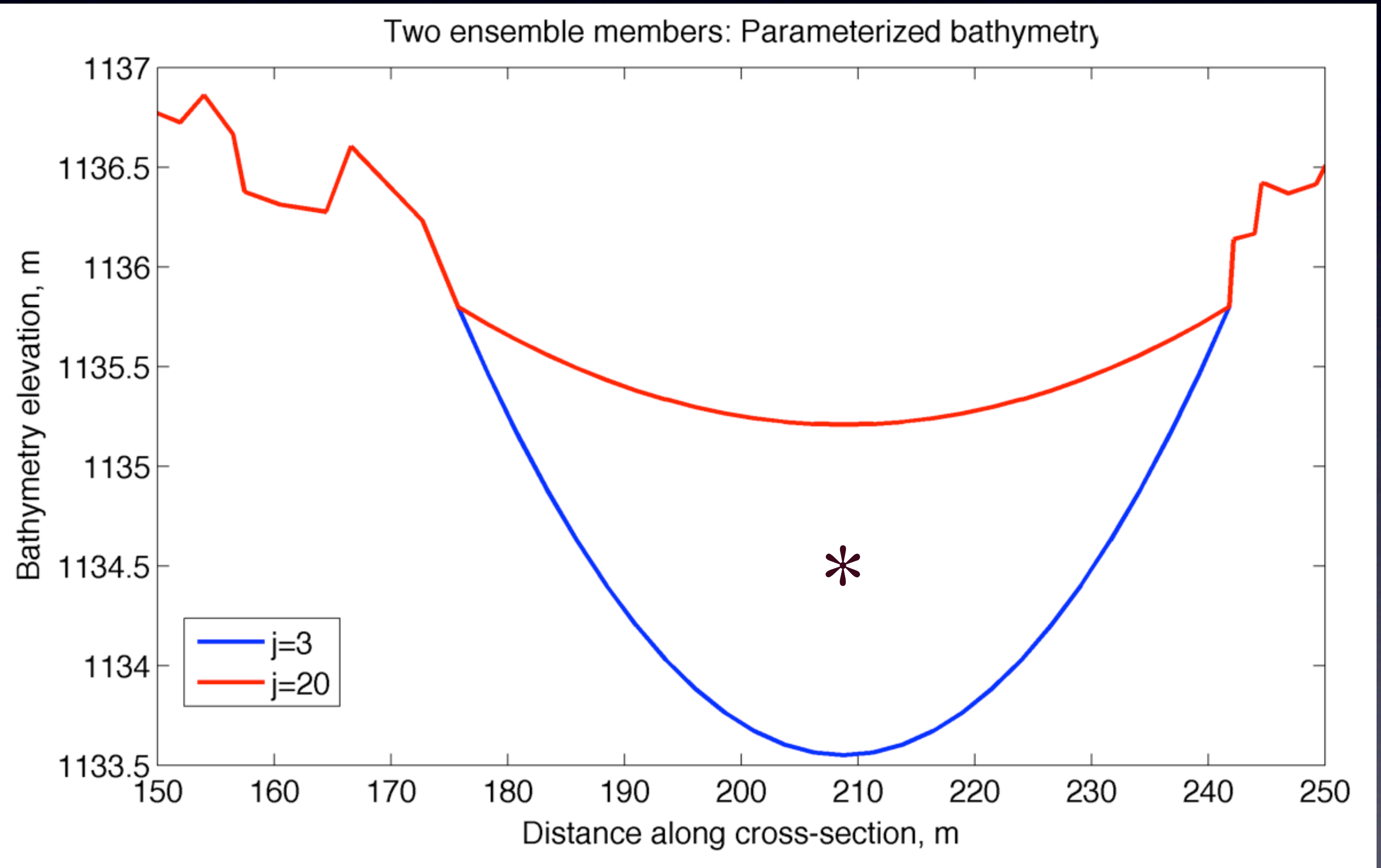
Downstream Upstream

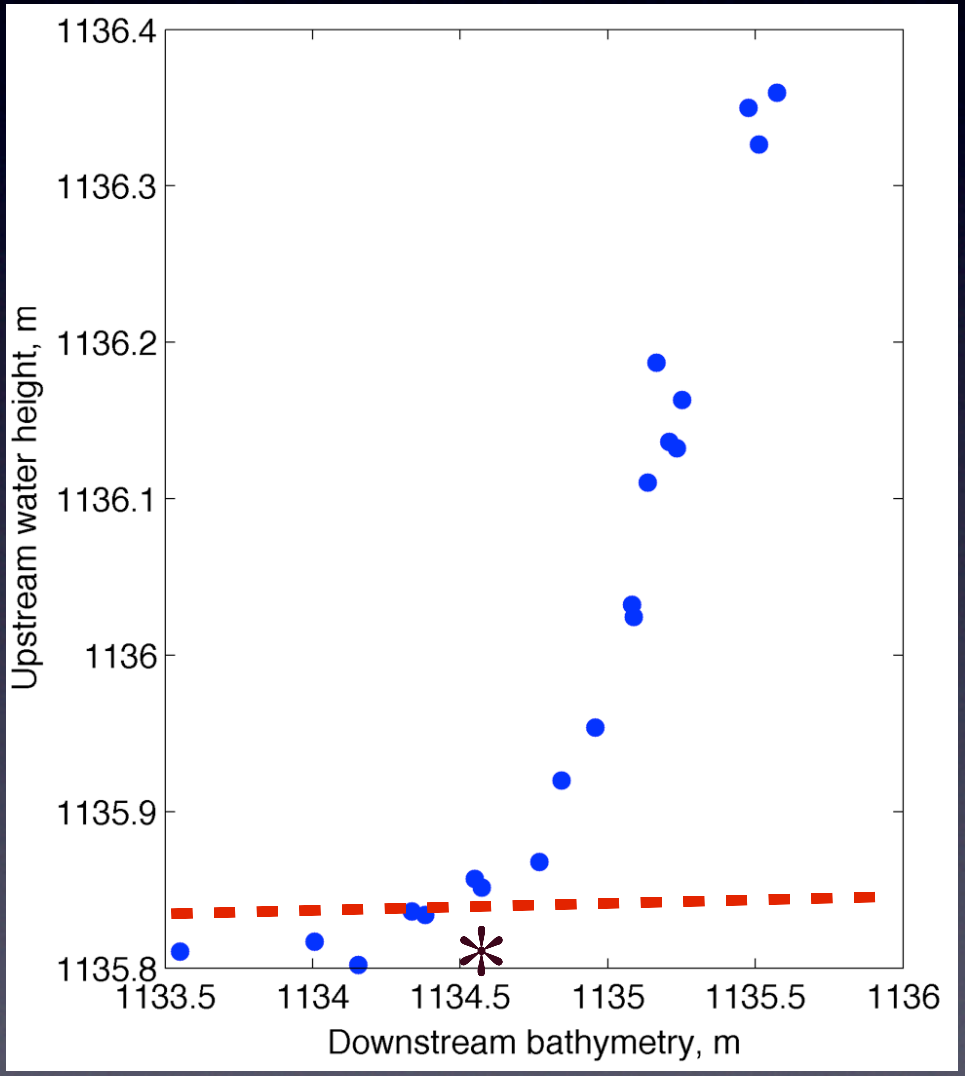




Hydraulic reasons for the correlation

Shallower bathymetry leads to lower height upstream

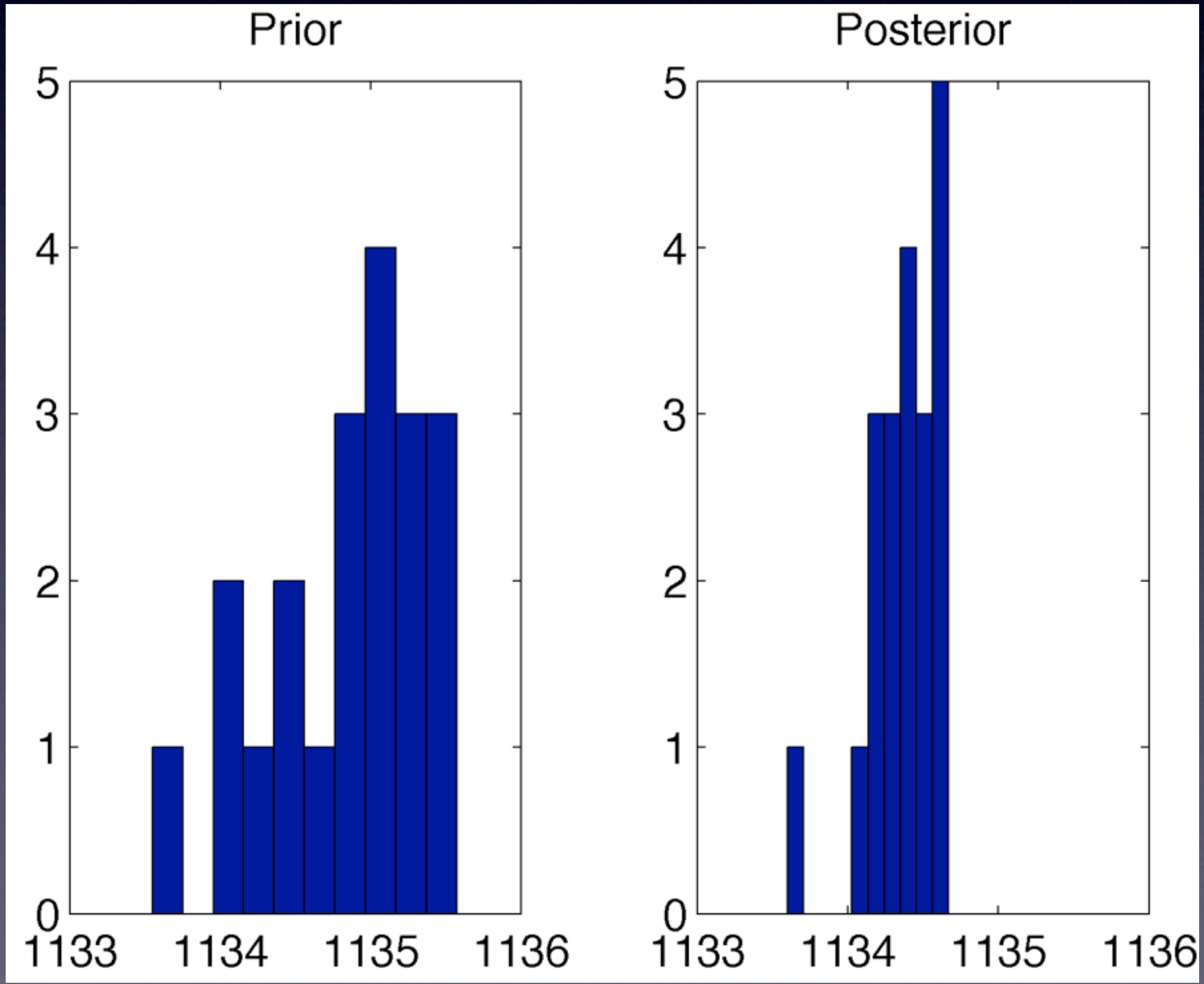


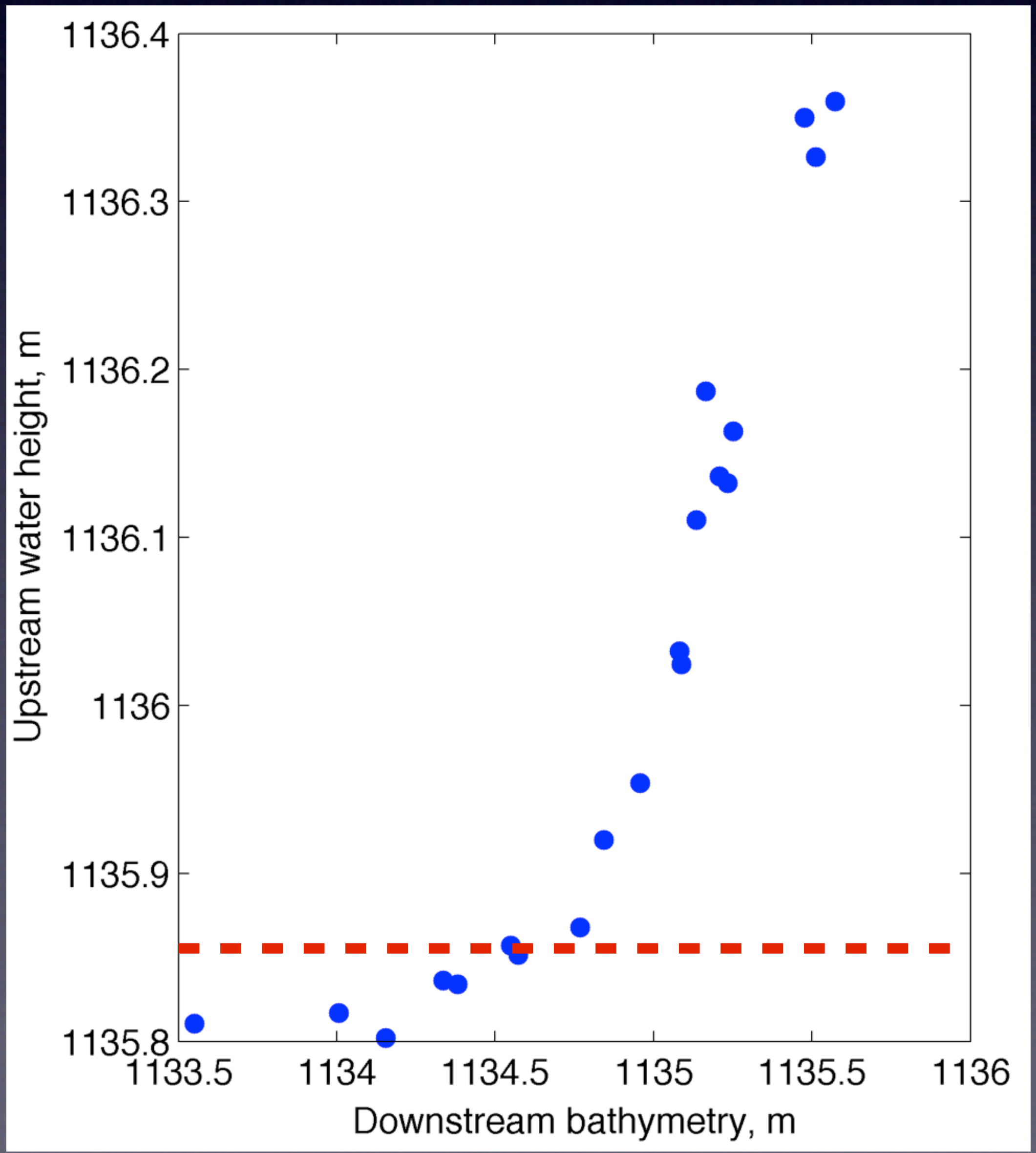


Estimating bathymetry from SWOT

Use the EnKF analysis equation:

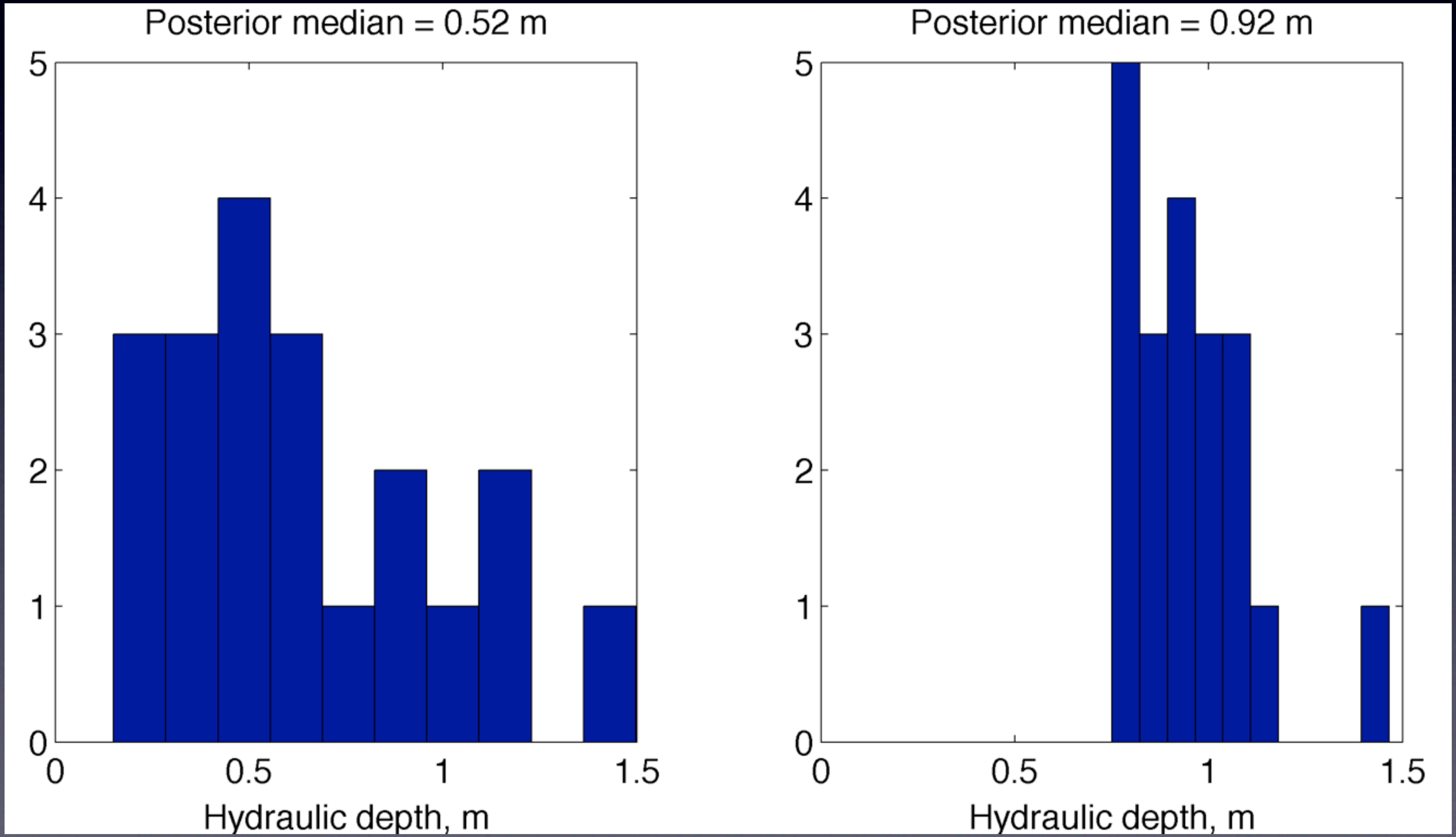
$$z_k^+ = z_k^- + C_{zh}\left(C_{hh} + C_v\right)^{-1}\left(h_{obs} - h_k^-\right)$$





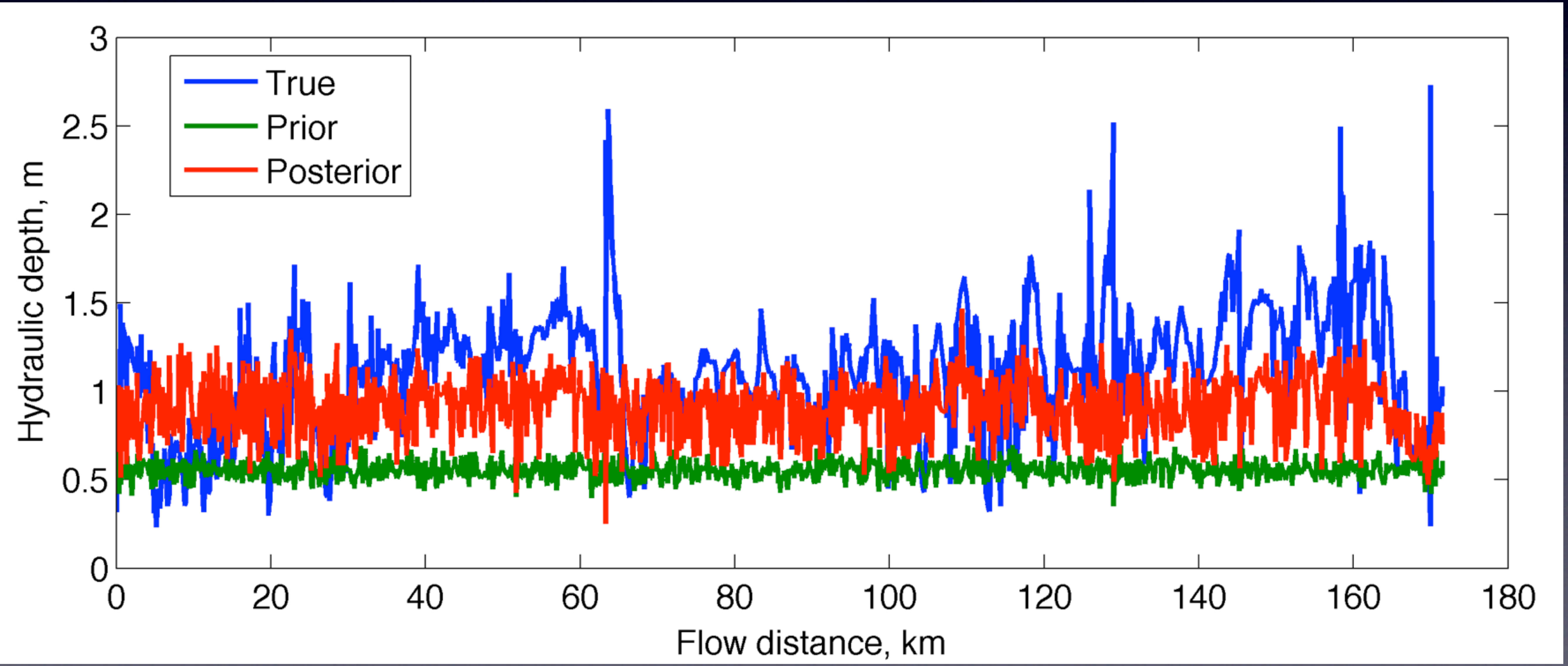
The correct hydraulic depth is obtained

True depth = 1.03 m



Rio Grande hydraulic depth

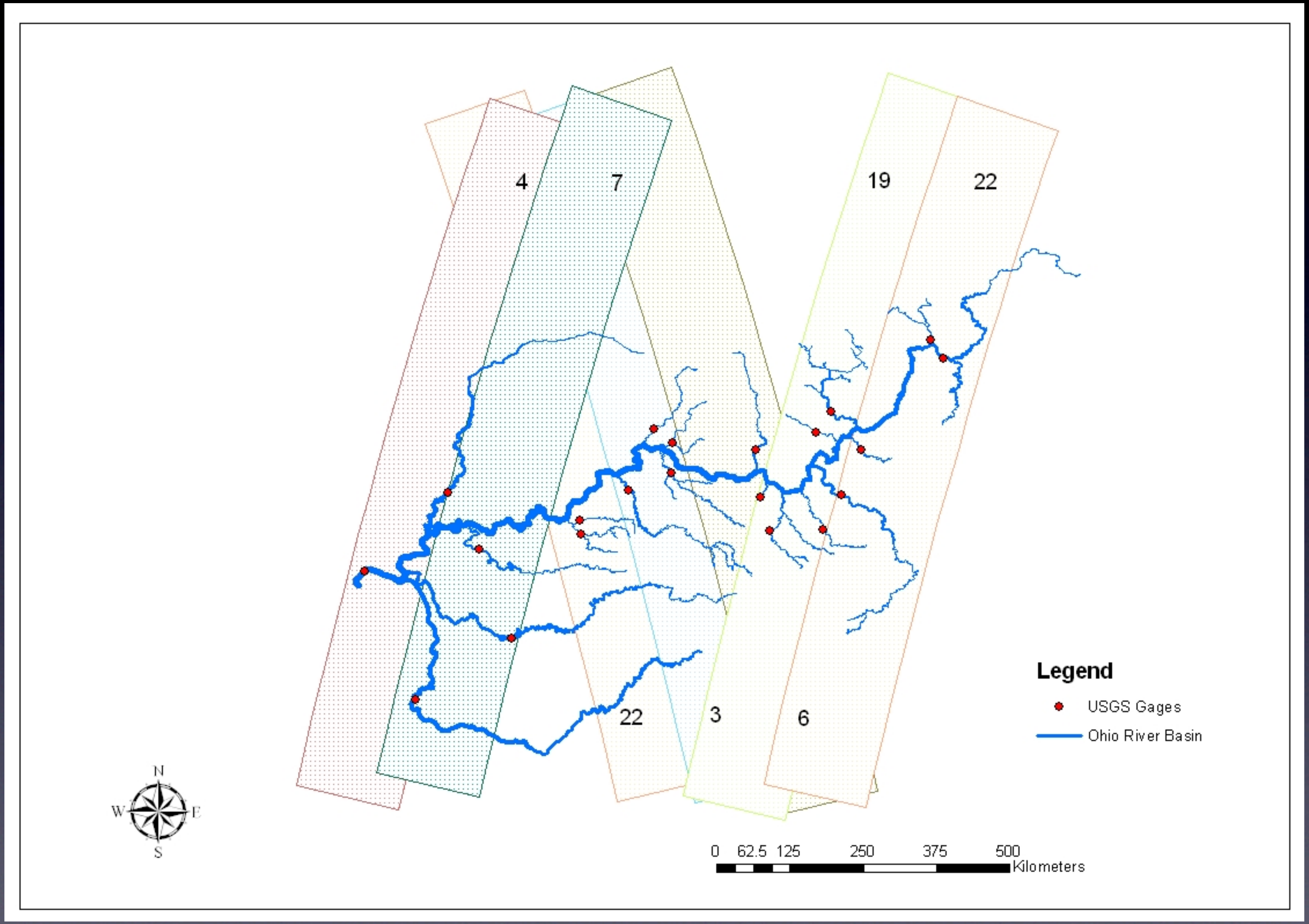
Bias Error
Prior: 58 cm
Posterior: 22 cm



Future and ongoing work

- Use spatial height sequence to update farther upstream
- Use sequence of height measurements (from high to low water) simultaneously to update bathymetry
- Sensitivity to measurement errors
- Application in 2-D (couple to instrument simulator)
- Introduce errors in discharge

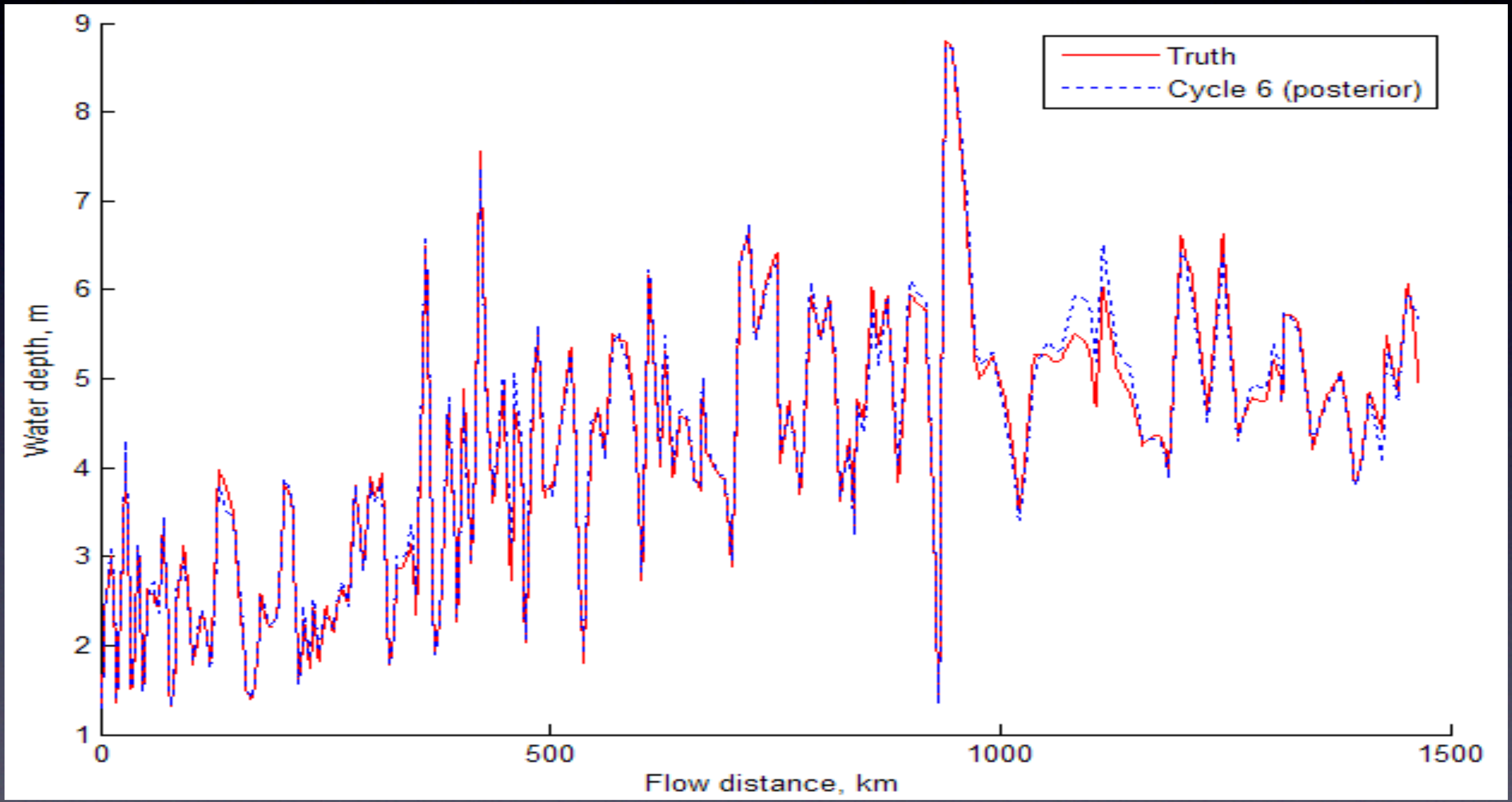
Another approach to depth



Courtesy: Yeosang Yoon, see posters

Estimating bathymetry and depth

Results from a combined state-parameter EnKF



Courtesy: Yeosang Yoon, see posters

Are there any questions?