Current status of SWOT data assimilation in hydrologic & hydrodynamic models

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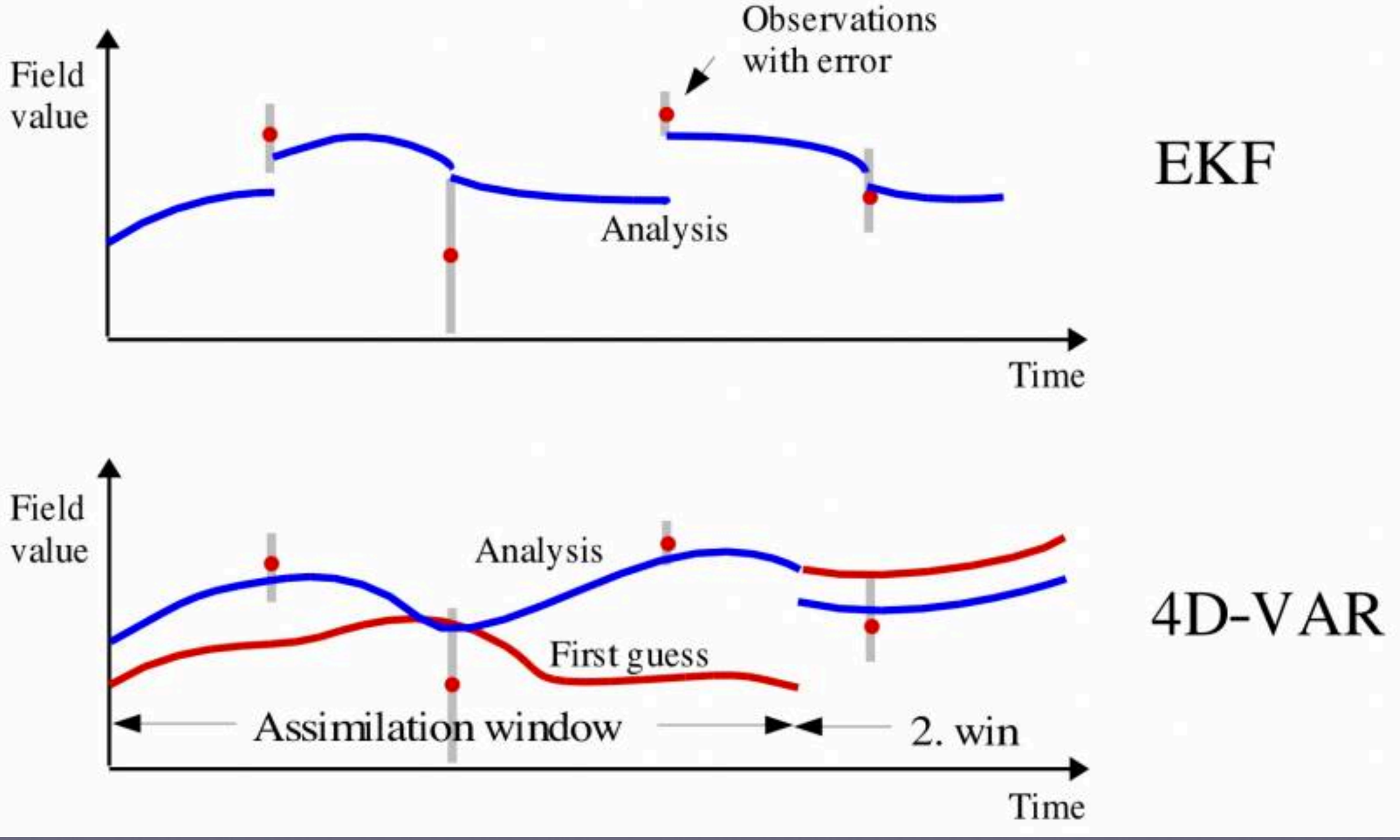
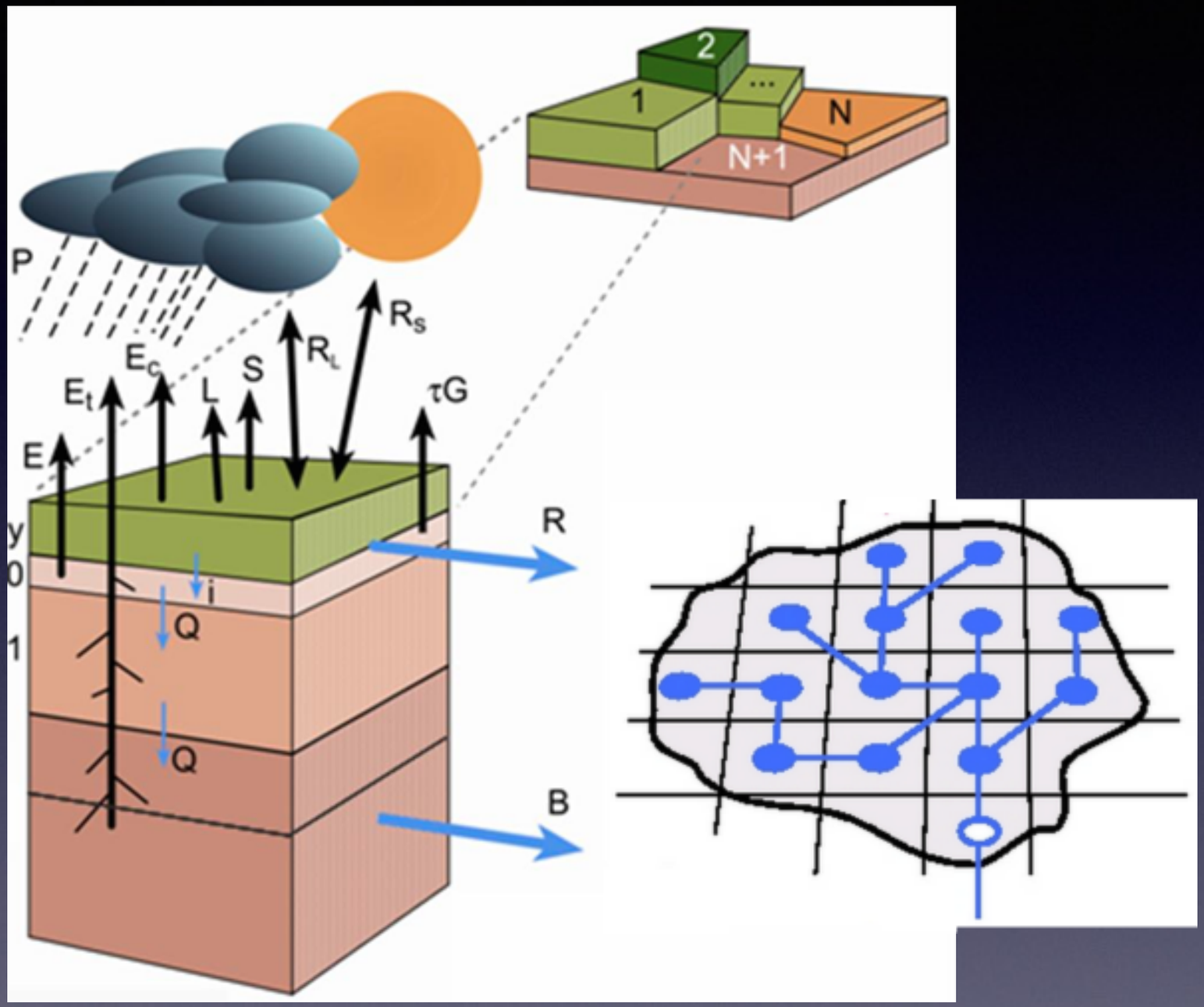
History of SWOT DA publications

Reference	DA/OI schemes	Model(s) + error	SWOT obs used + error	Corrected var./ Param.	Study domain
Andreadis et al. (2007)	EnKF	Hyrodynamic model + inflows errors	d (140km swath, 8-day/16-d/32-d orbit) + white noise	d	Ohio River (50km reach)
Durand et al. (2008)	EnKF	Hydrodynamic model + S_z and n errors	H (140km swath, 16-day orbit) + white noise	Z, S_z	Amazon River (240km reach)
Biancamaria et al. (2011)	LEnKF+ LEnKS	Hydrodynamic model + precip errors	d (140km swath, 22-day orbit) + white noise	d	Ob River (1120km)
Yoon et al. (2012)	EnKF+ LEnKS	Hydrodynamic model + precip errors/z errors/z spatial auto-correlation	H, S, w (140km swath, 22-day orbit) + white noise	Z, d	Ohio basin river system
Yoon et al. (2013)	LSTOK	Hydrodynamic model + bathymetry errors	d (140km swath, 22-d orbit) + white noise	d at times with no SWOT obs	Tennessee River (1050km)
Andreadis and Schumann (2014)	LEnTKF	Hydrodynamic model + sampling historical simulation	H, w, A_i (multi sat missions) + white noise	Initial condition to forecast model	Ohio River (500km reach)
Pedinotti et al. (2014)	EKF	Hydrologic model (0.5°×0.5° pixels) + n errors	d (140km swath, 22-d orbit) + white noise	n	Whole Niger basin
Paiva et al. (2015)	RK	Space-time Q covariance from diffusive wave approx. St-Venant eq	d, S, w, Q (140km swath, 22-day orbit) + white noise	Q at times with no SWOT obs	Ganges-Brahmaputra-Meghna river system in Bangladesh
Munier et al. (2015)	LEnKS + MPC	Hydrodynamic model & reservoir model + precip errors	d (120km swath, 21-d orbit) + white noise	d + optimized reservoir release	Upper Niger basin and Selingue reservoir

Data assimilation methods



The forward models…



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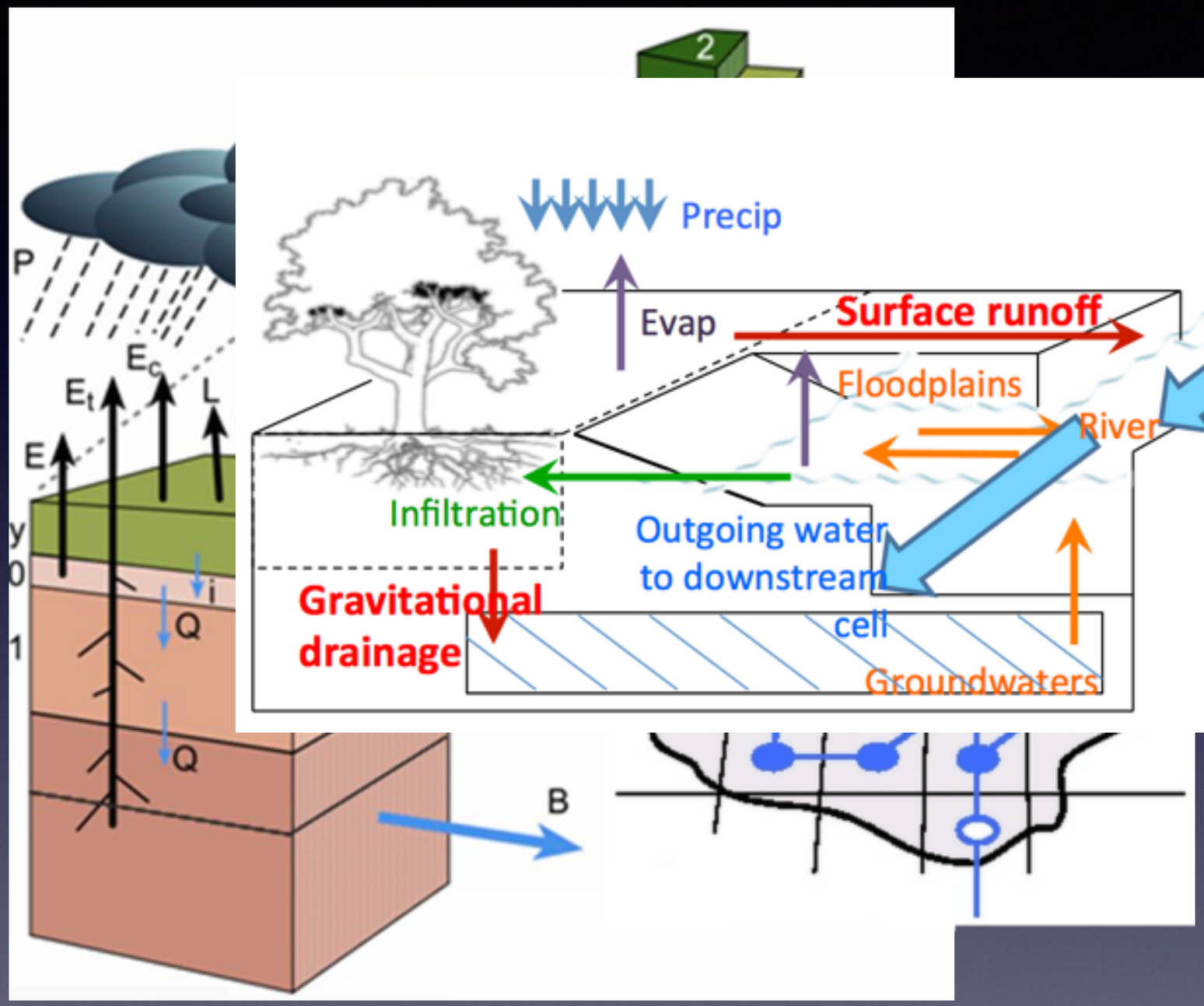

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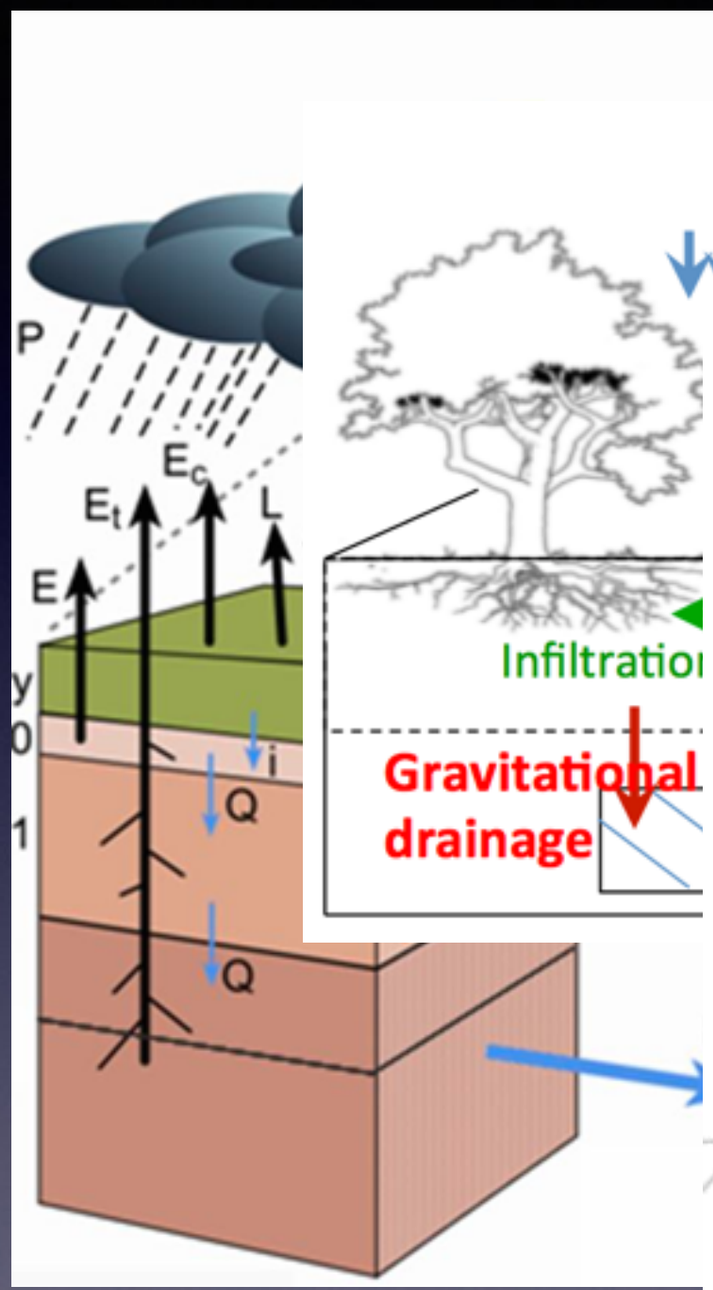

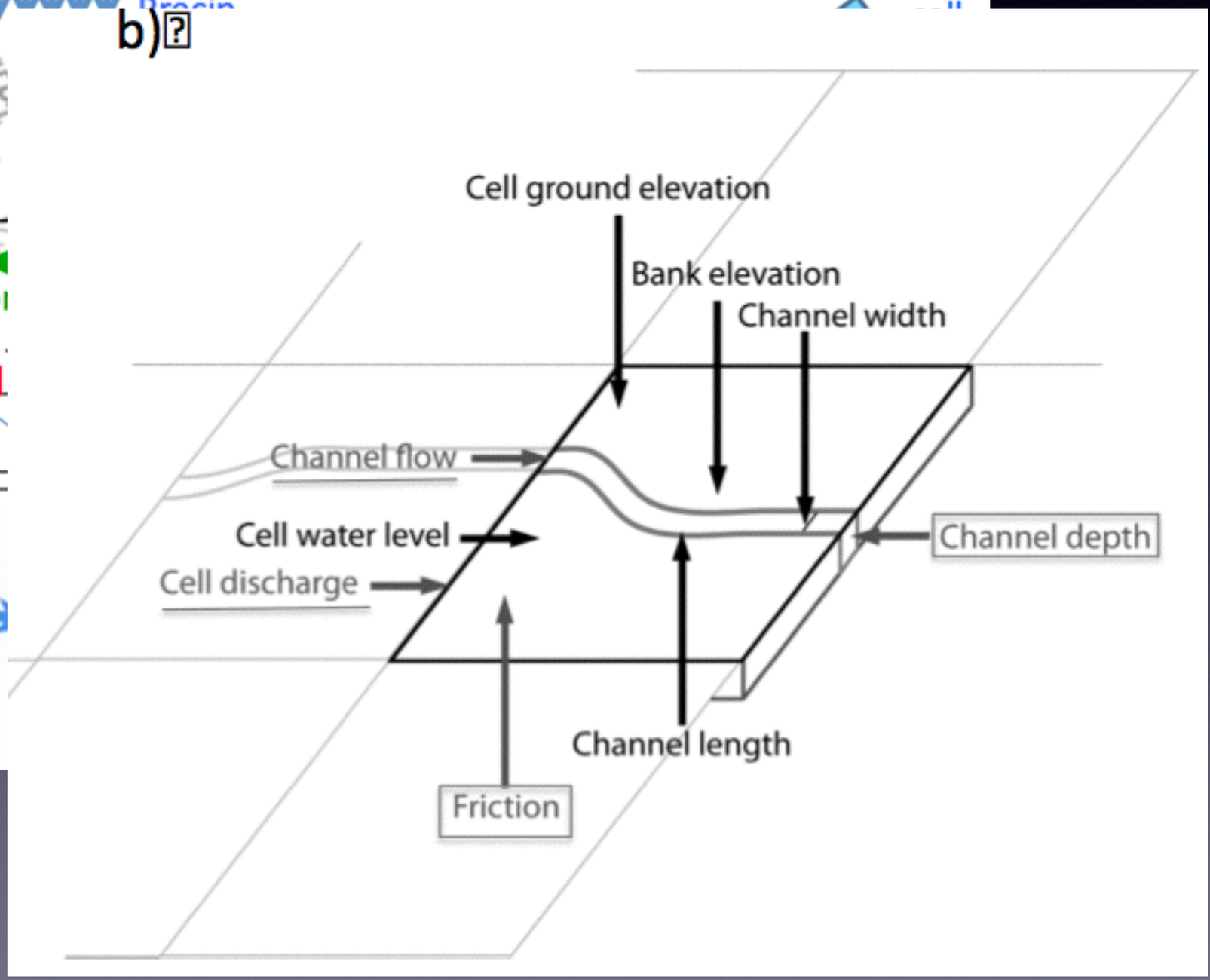

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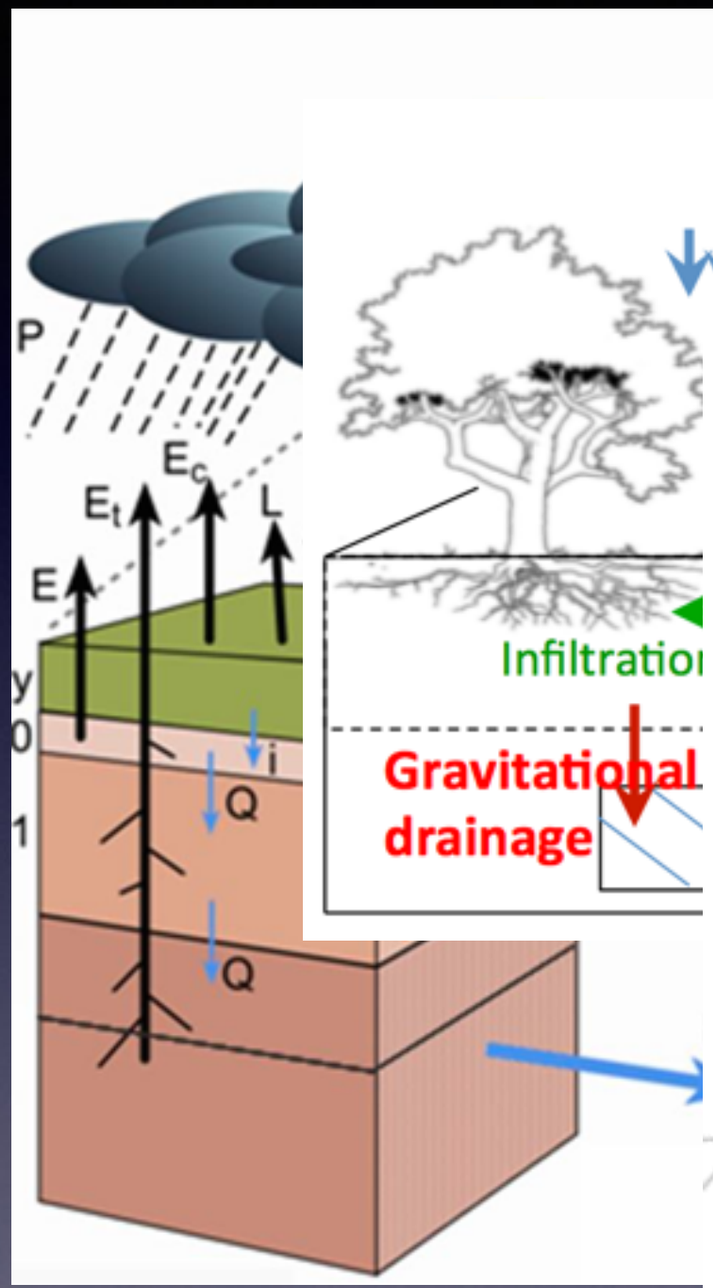

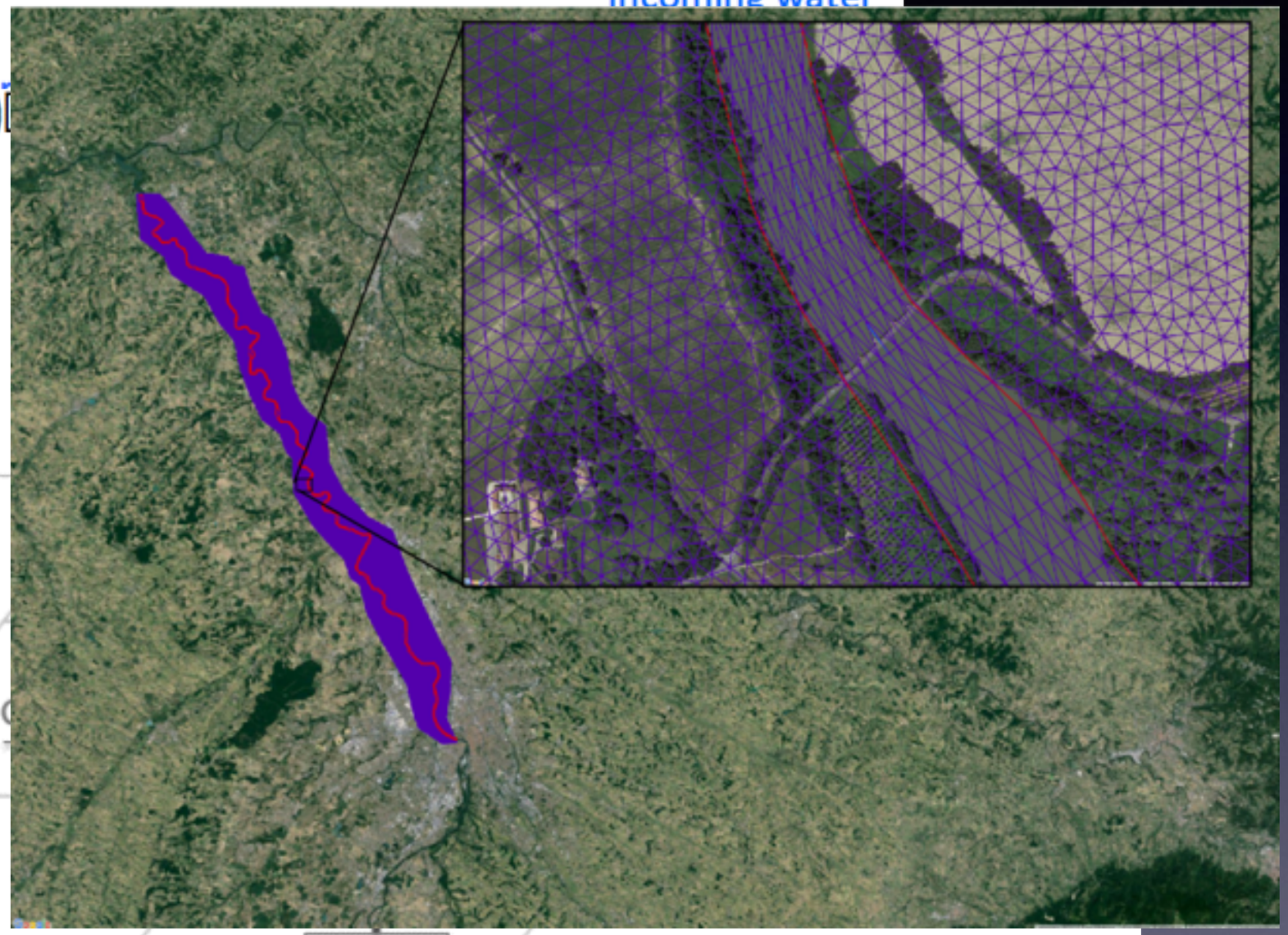

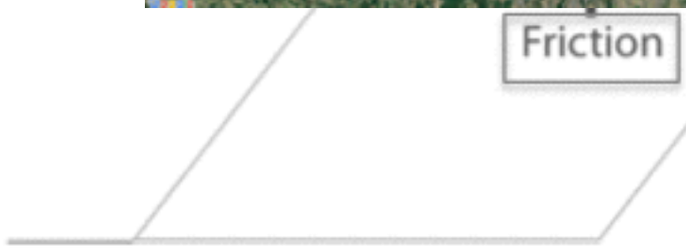

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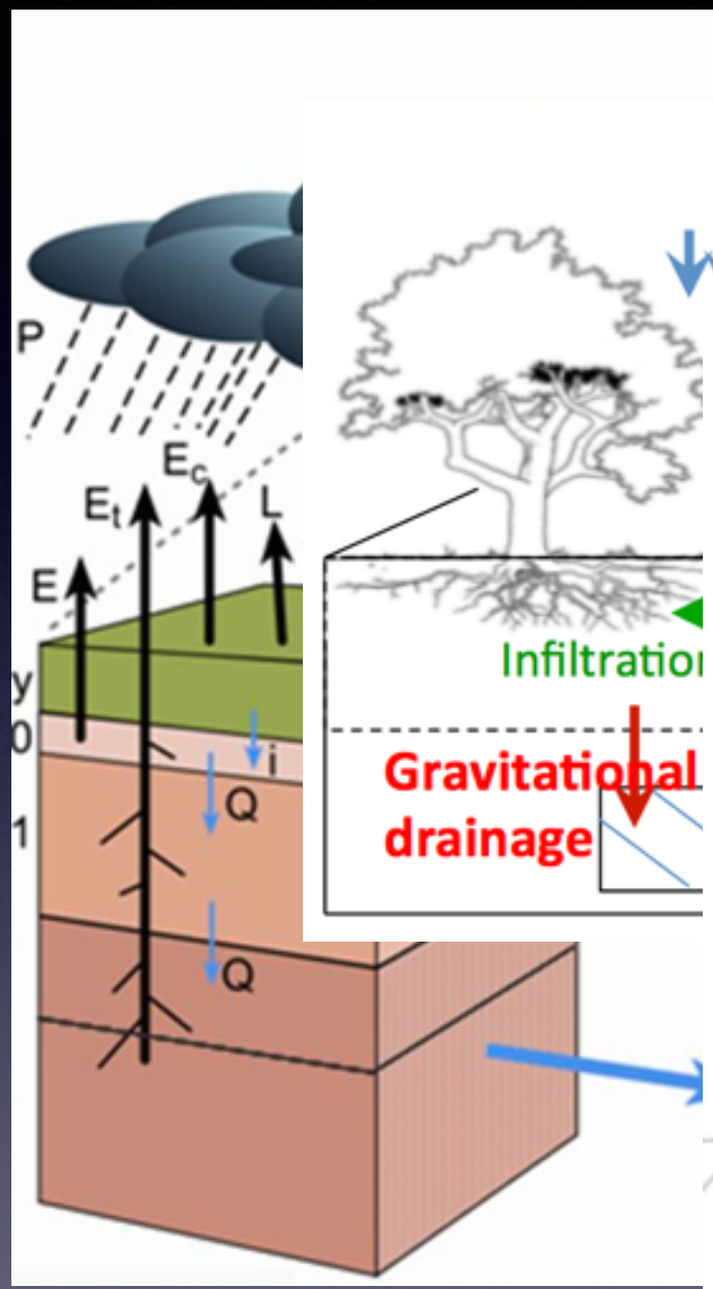
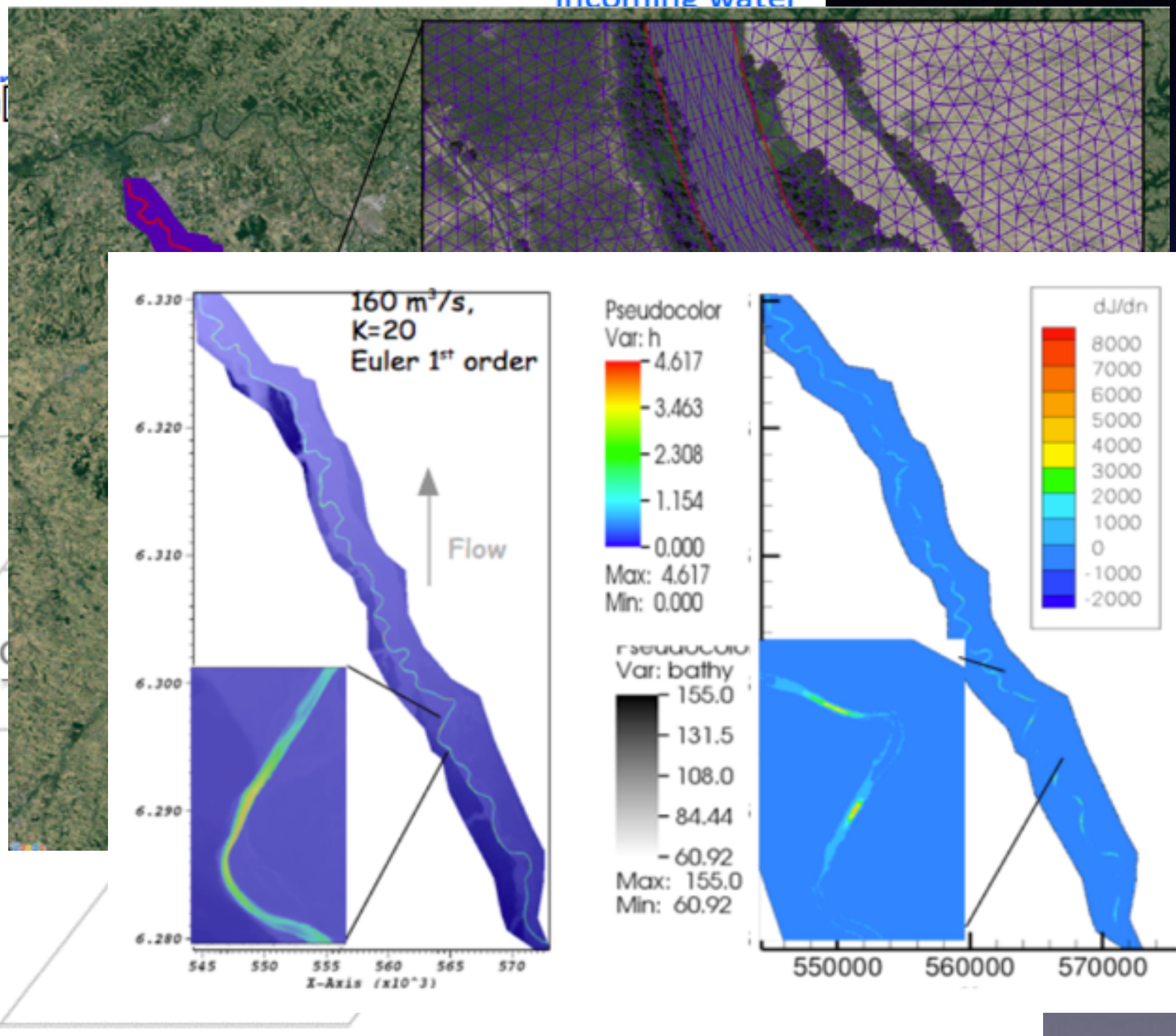
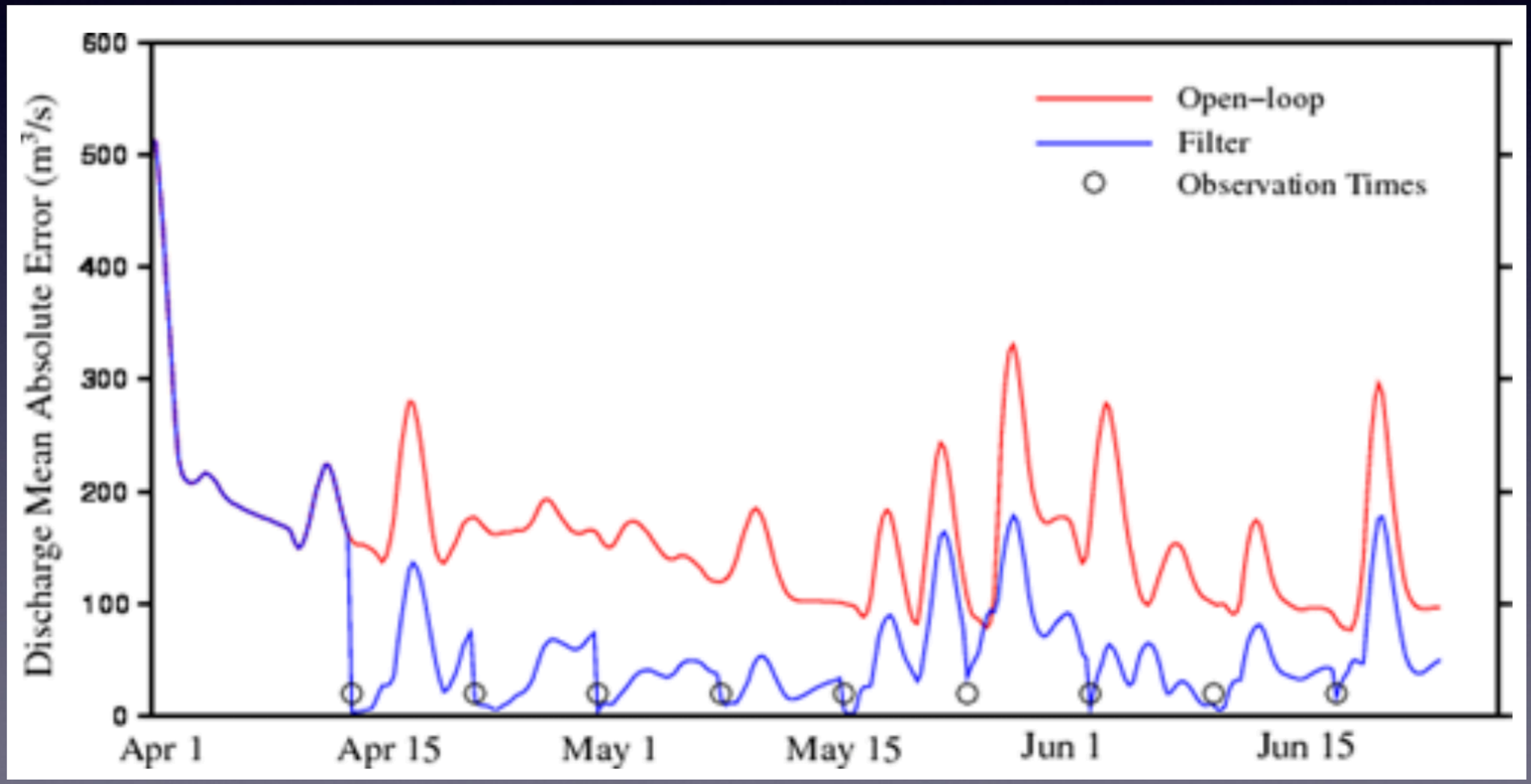




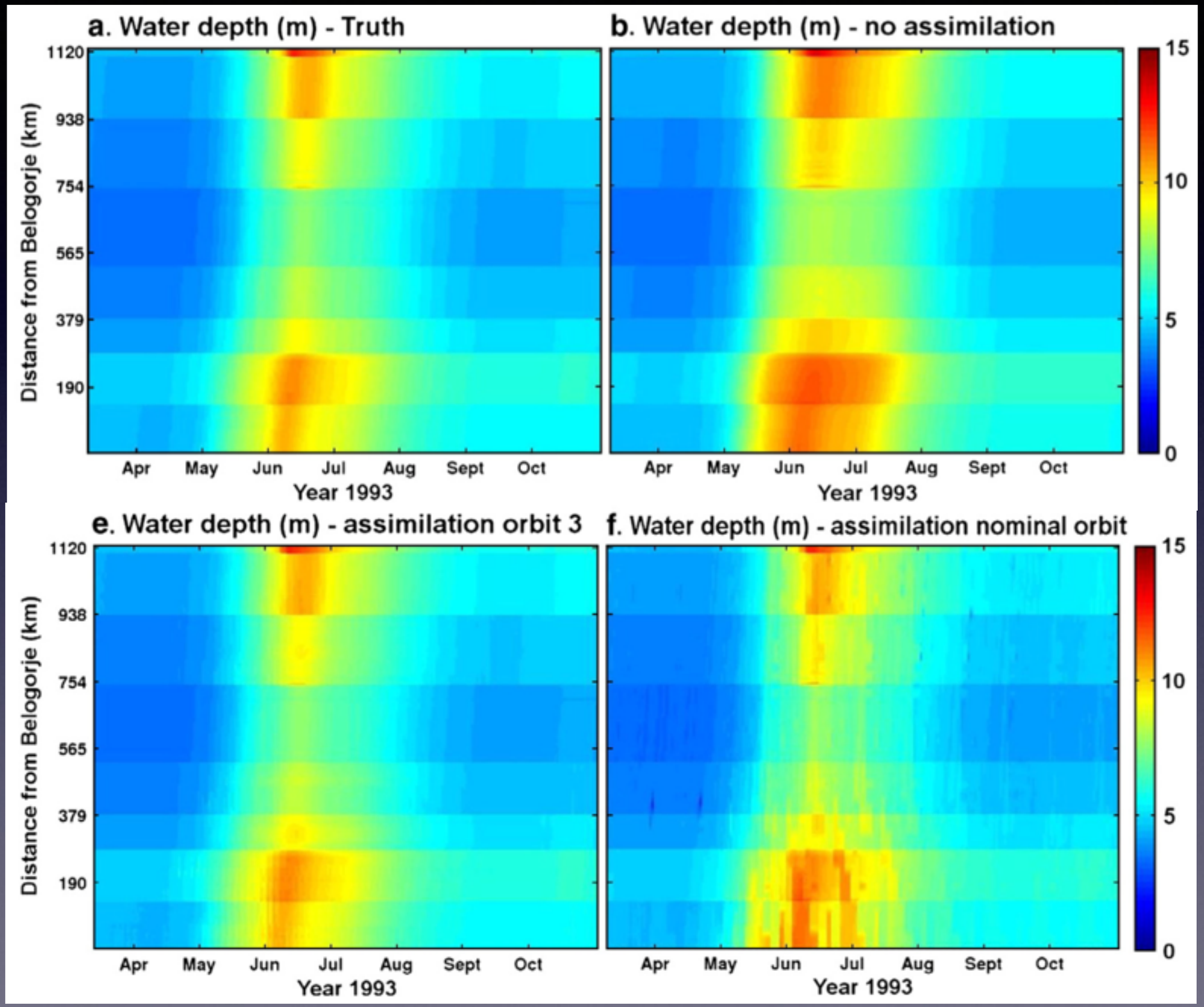
Estimating river discharge

- Assimilating water surface elevations with an EnKF



Andreadis et al. (2007)

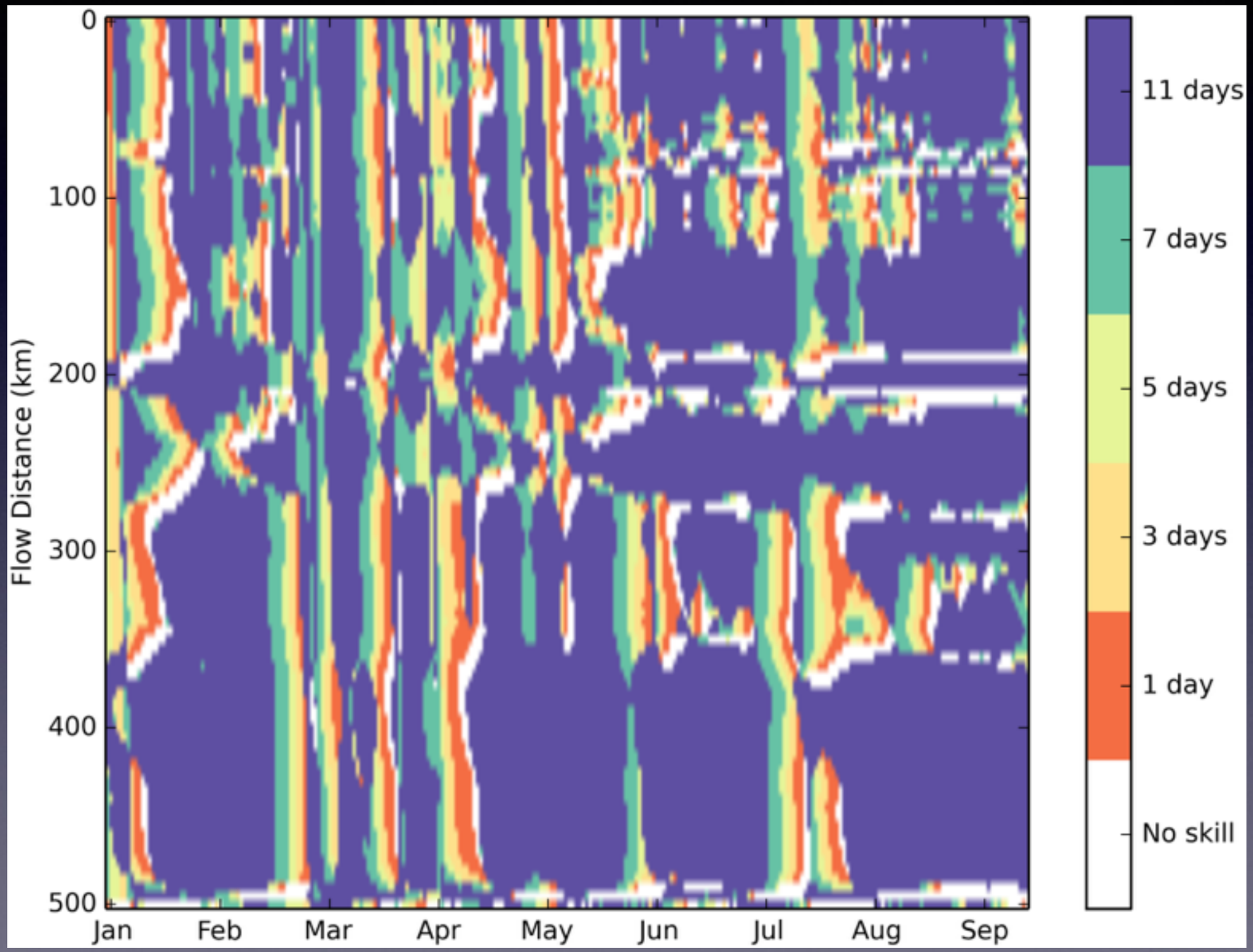
Estimating water depth



Biancamaria et al. (2011)

Persistence of assimilation impact

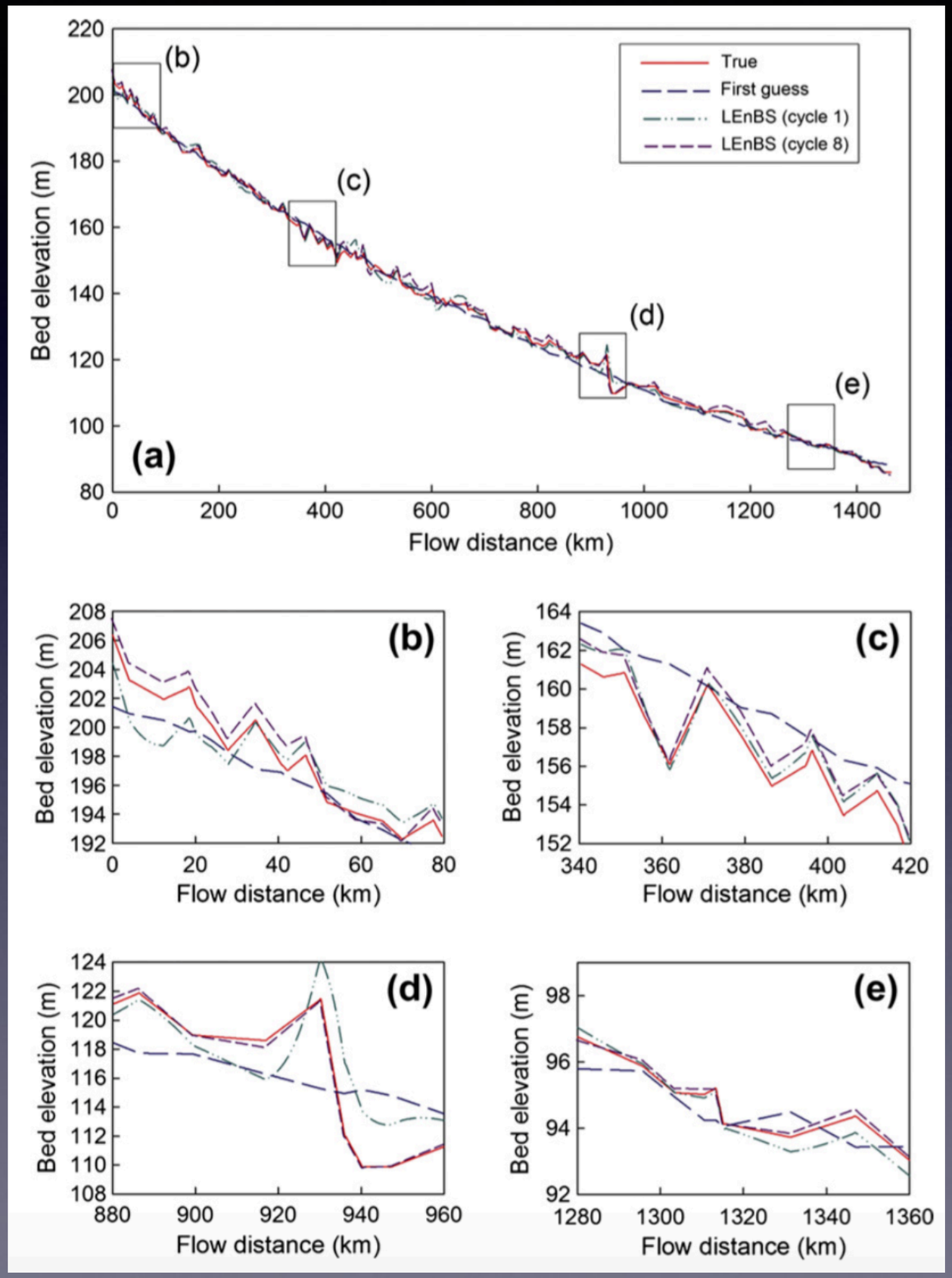
- Maximum number of days when error is reduced from SWOT assimilation



Andreadis & Schumann (2014)

Estimating bathymetry

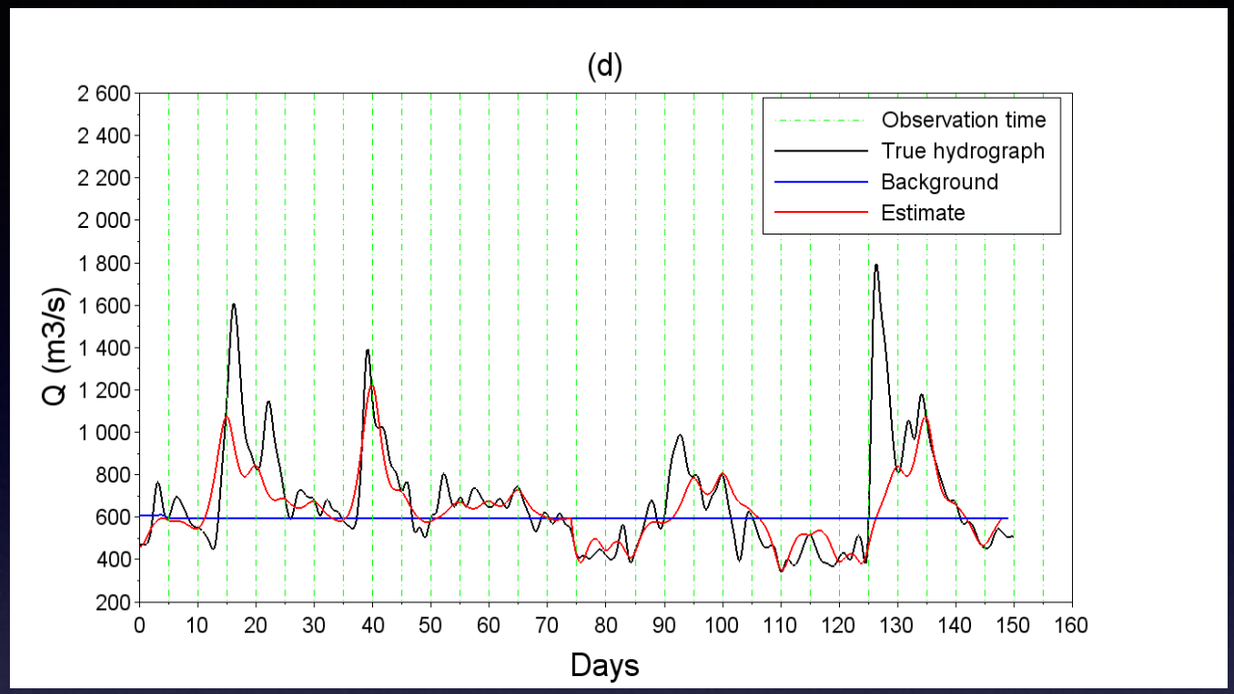
- Apart from depth and discharge other hydraulic variables can be estimated
- After a number of overpasses bathymetry can be estimated fairly accurately

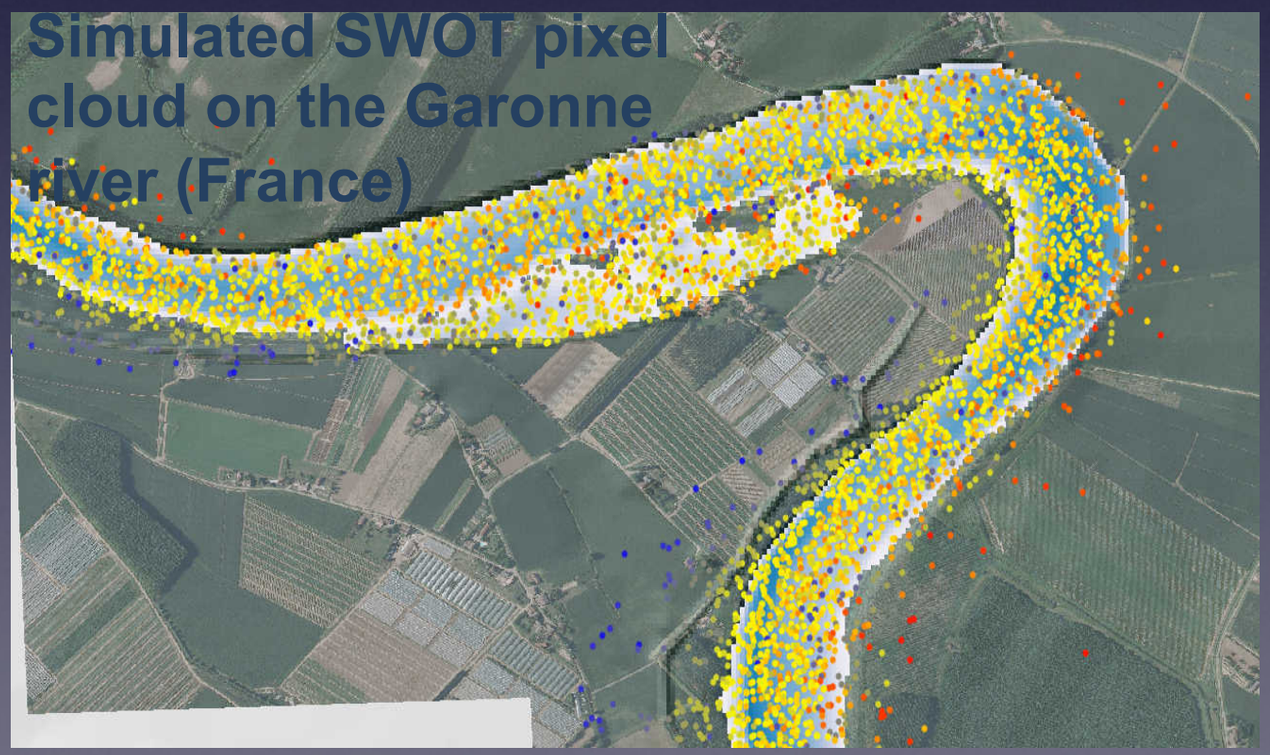


Yoon et al. (2012)

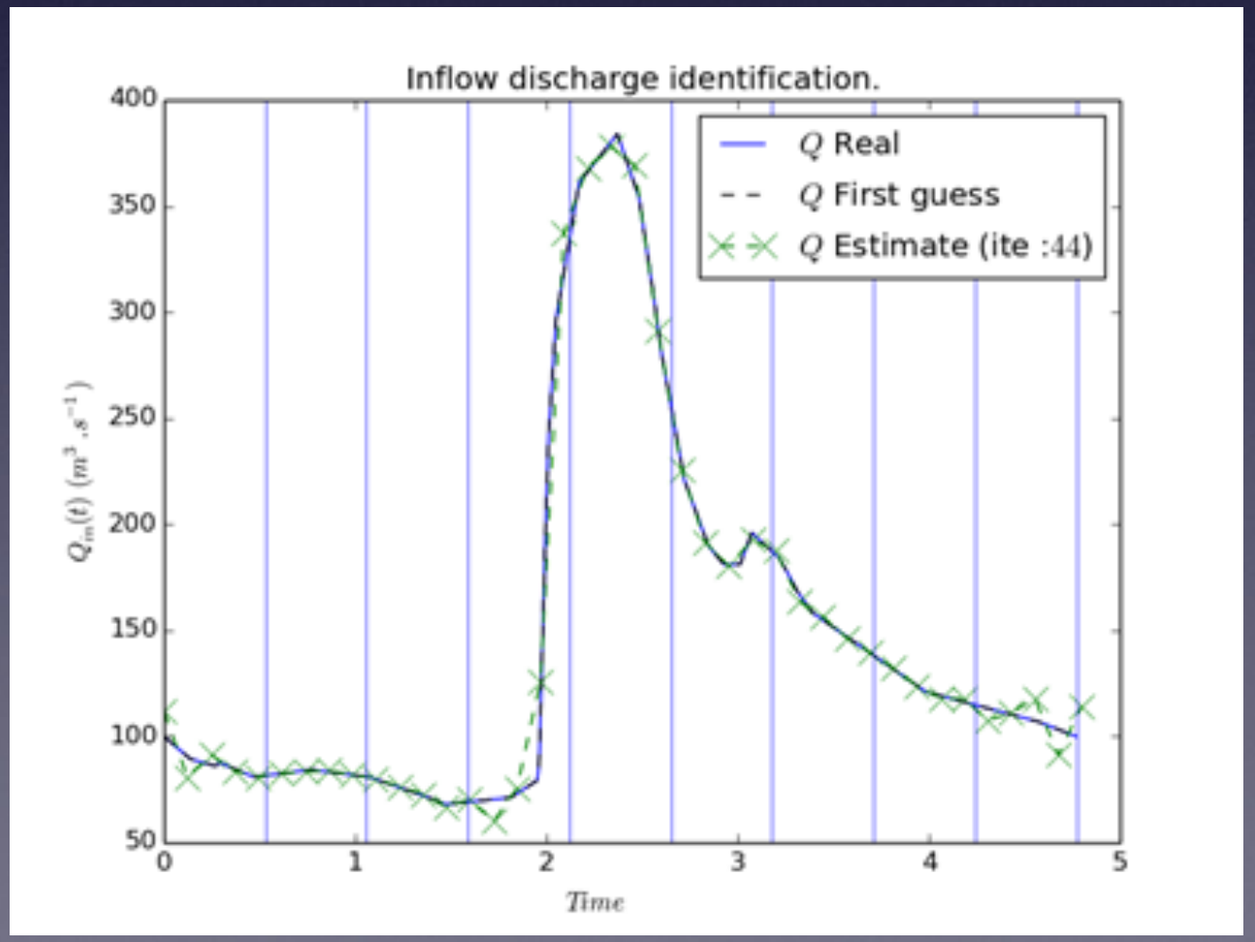
Discharge estimation with 4D-Var

- Test cases of Garonne & Xingu Rivers
- Estimating discharge as well as inflows



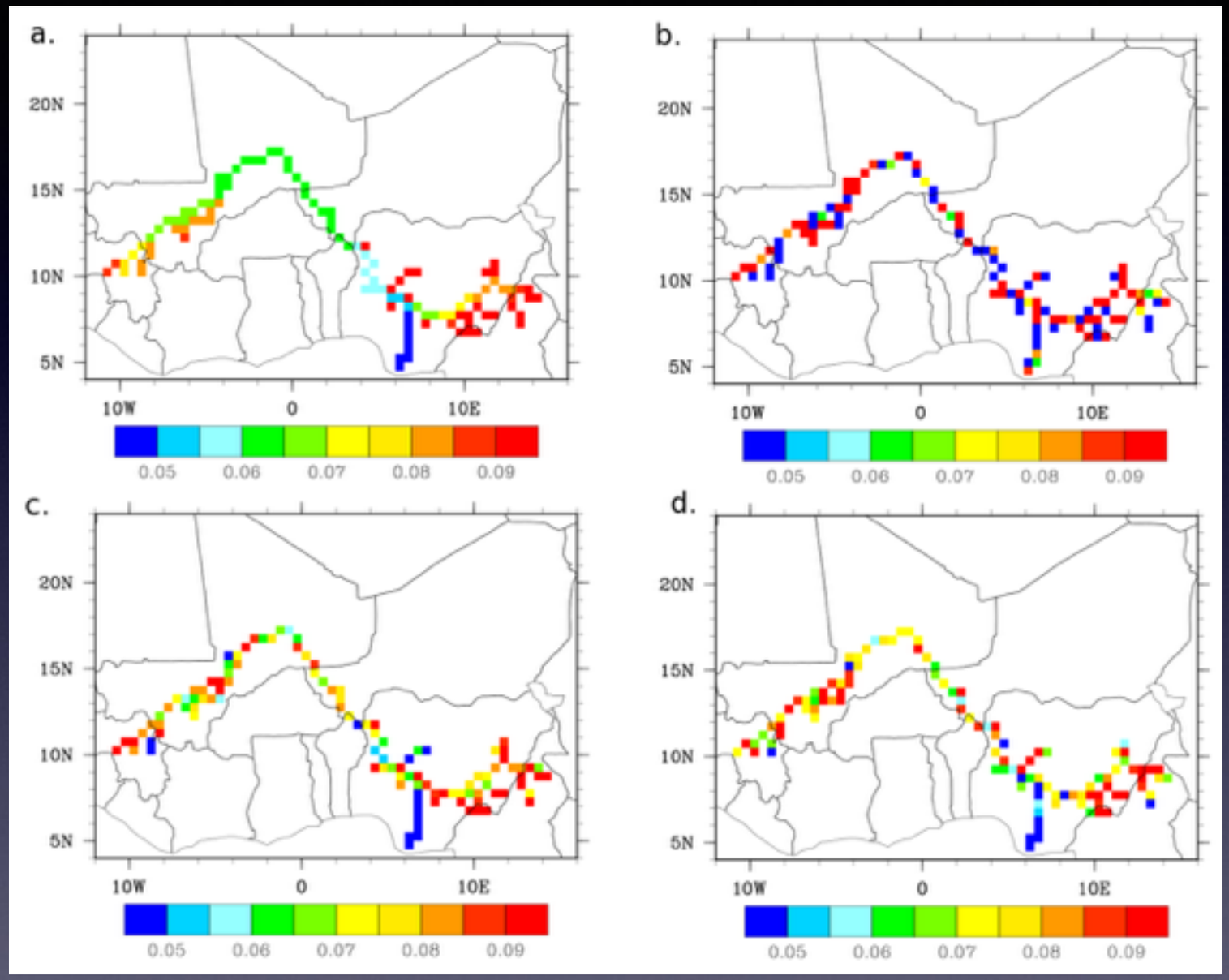


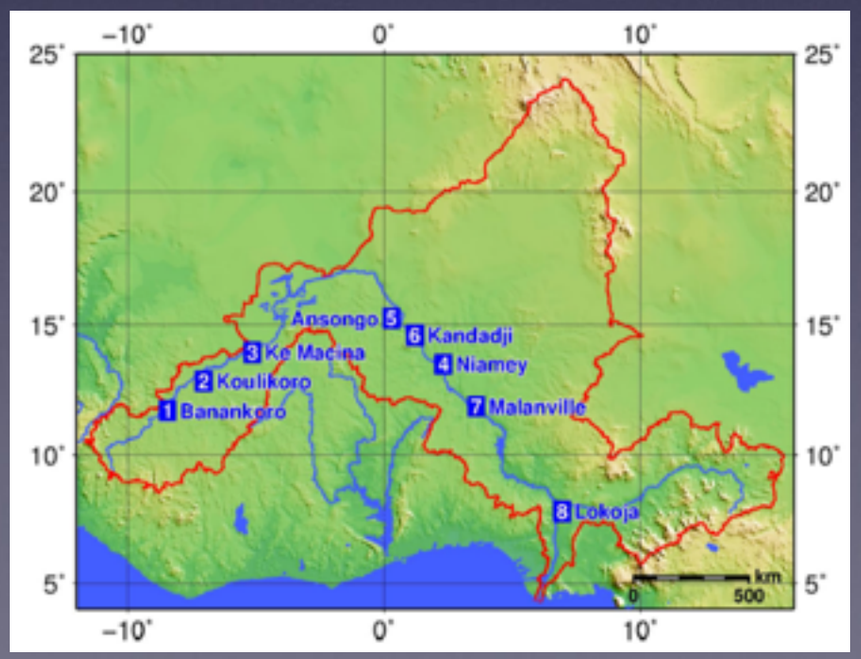
Brisset et al.; Houbenas et al.



Estimating flow friction

- Assimilating WSE with an EKF to estimate Manning's n
- Bias was reduced in friction, water levels as well as discharge



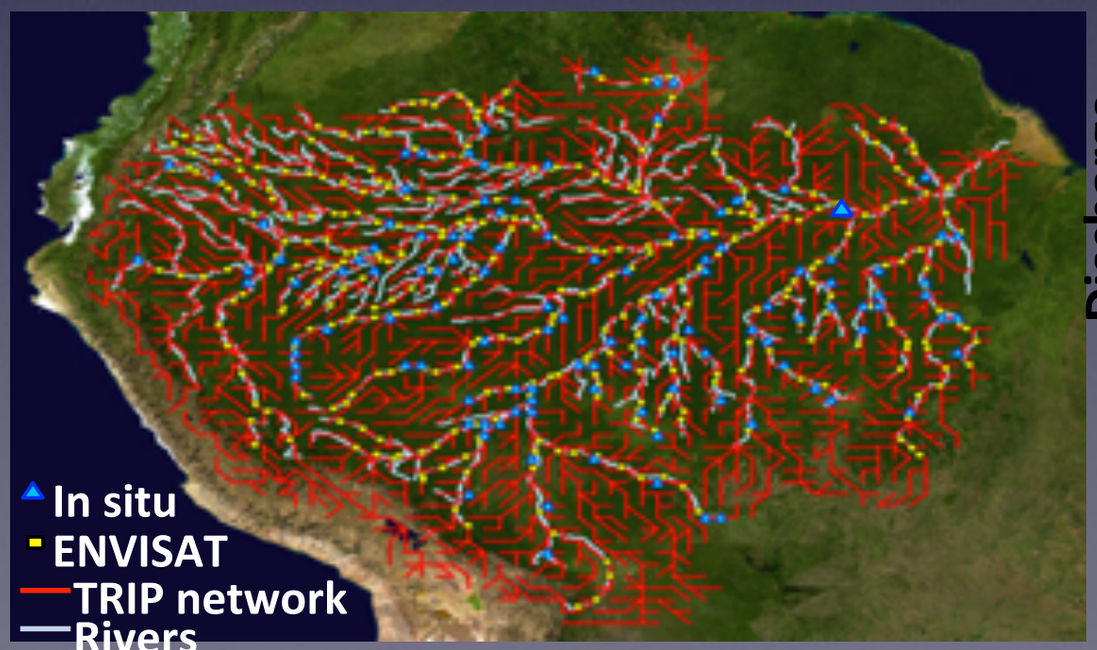


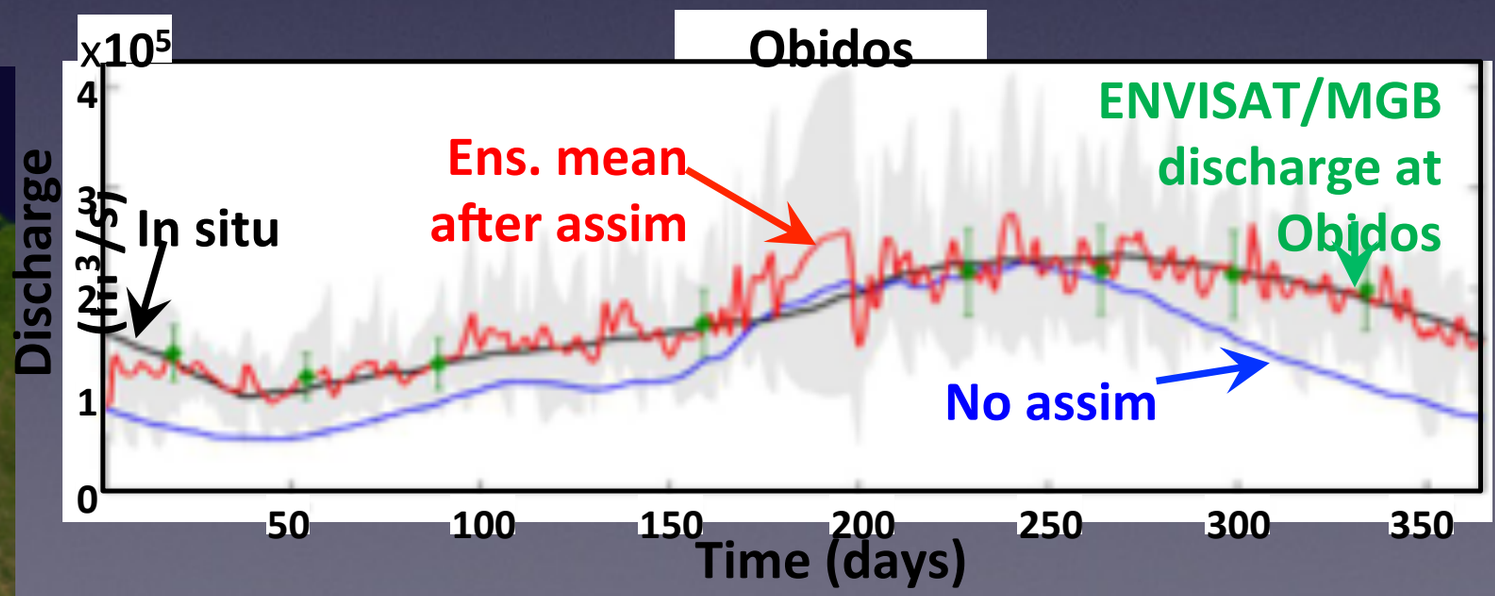
a. Truth
b. Open-loop
c. 1-day Assimilated
d. 3-day Assimilated

Pedinotti et al. (2014)

Assimilating altimetry observations

- Discharge derived from ENVISAT elevations and rating curve (Paris et al., 2016)
- EnKF used to correct river channel storage
- RMSE in river discharge reduced from 30% (w/o assimilation) to 13%

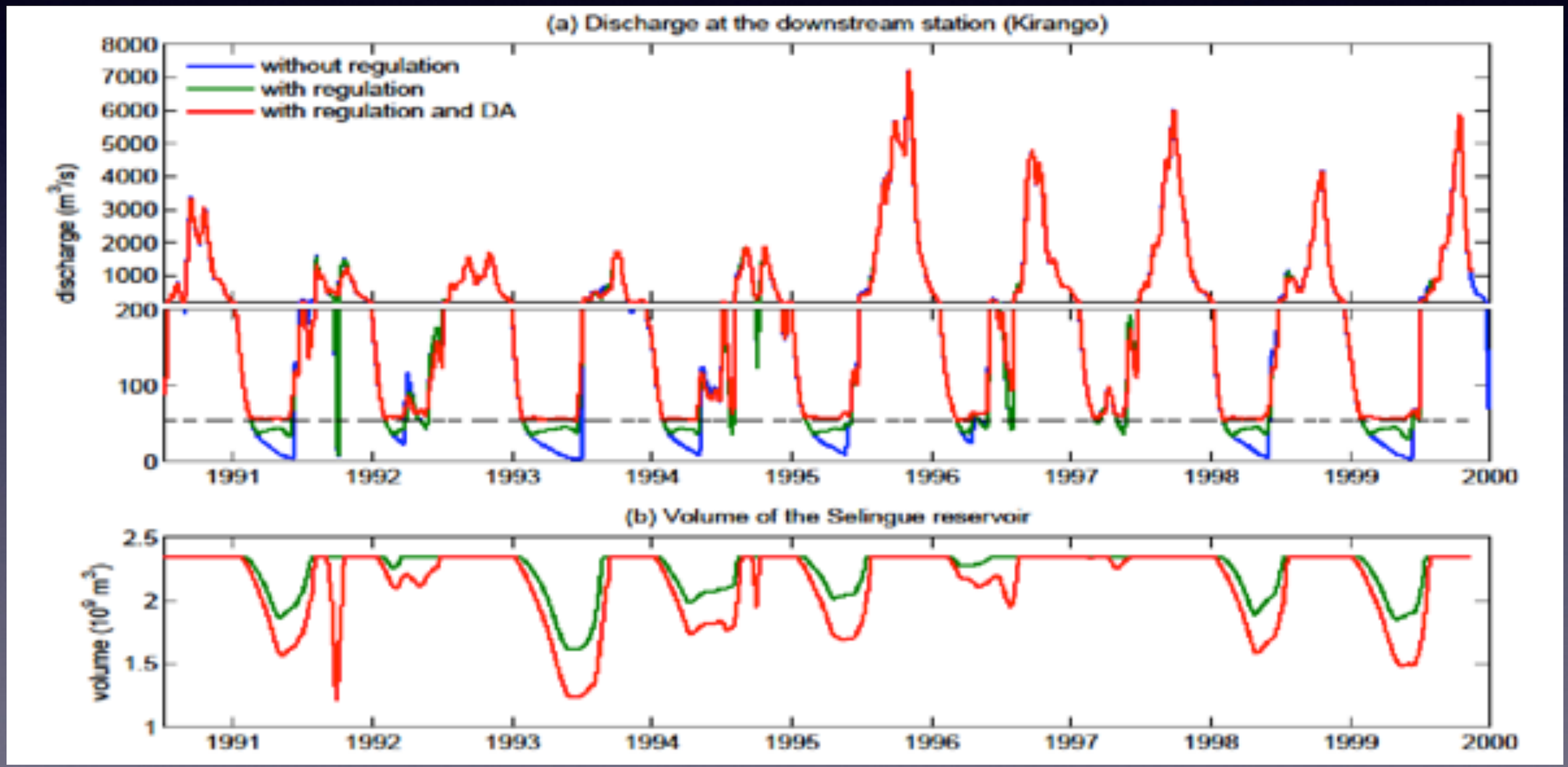




Emery et al. (in prep.)

Assimilation for operation water management

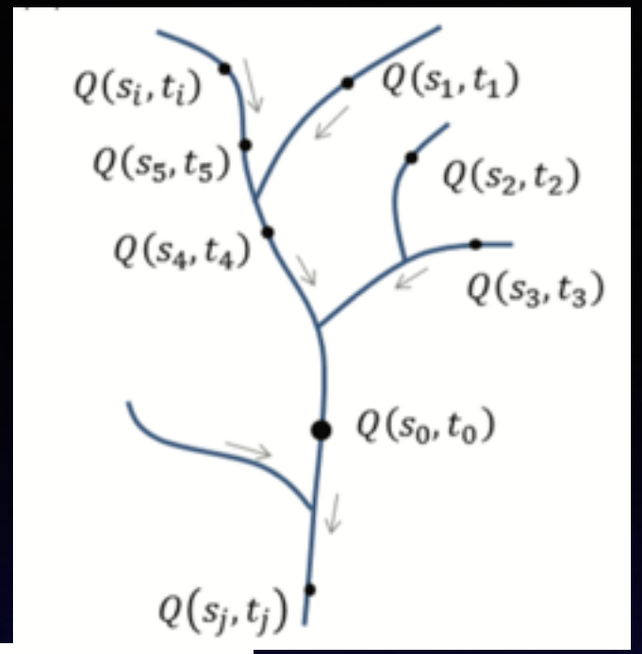
- Case study from Niger River that assimilated synthetic SWOT observations in order to maintain environmental minimum flows

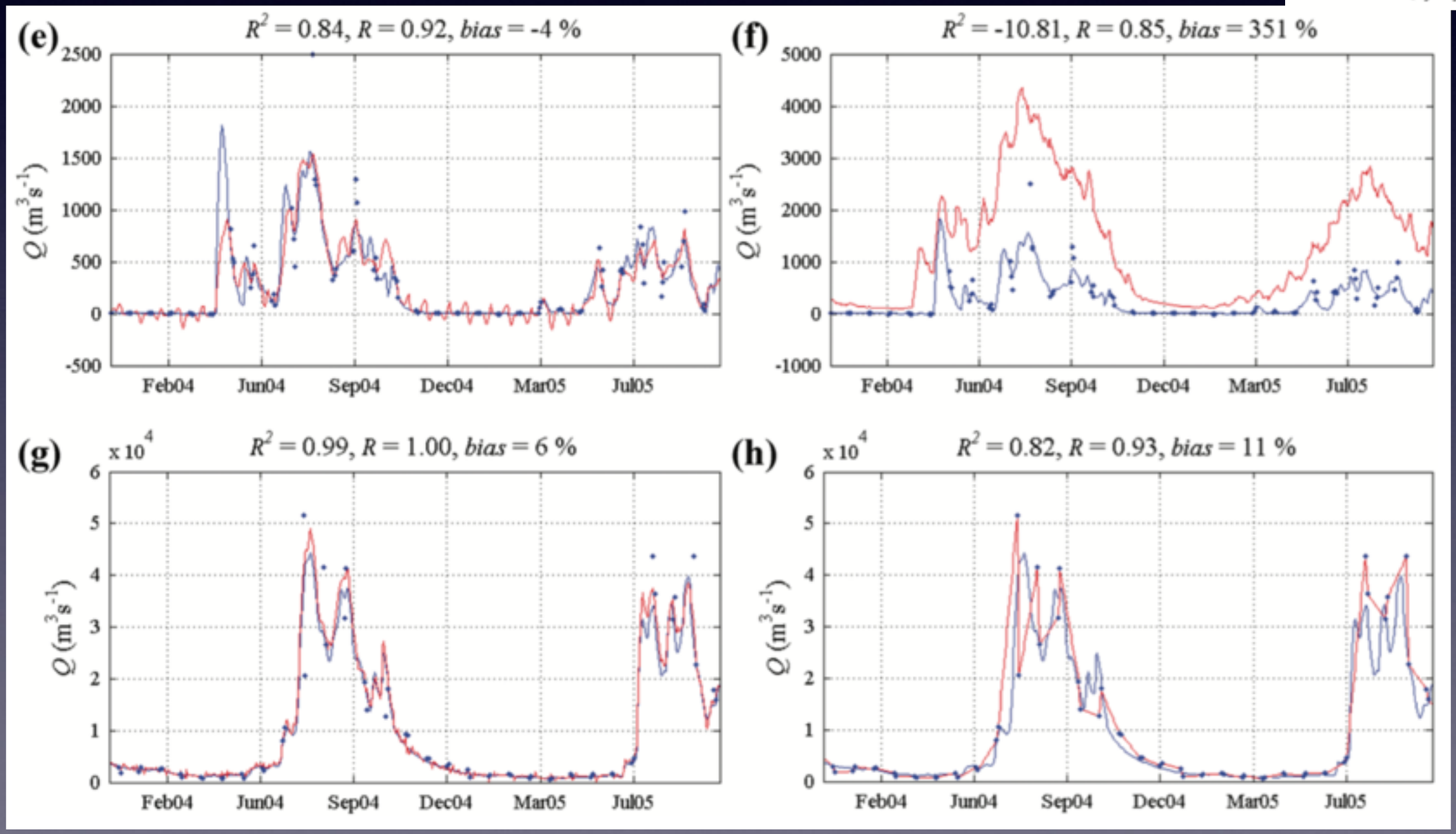


Munier et al. (2015)

Kriging of SWOT observations

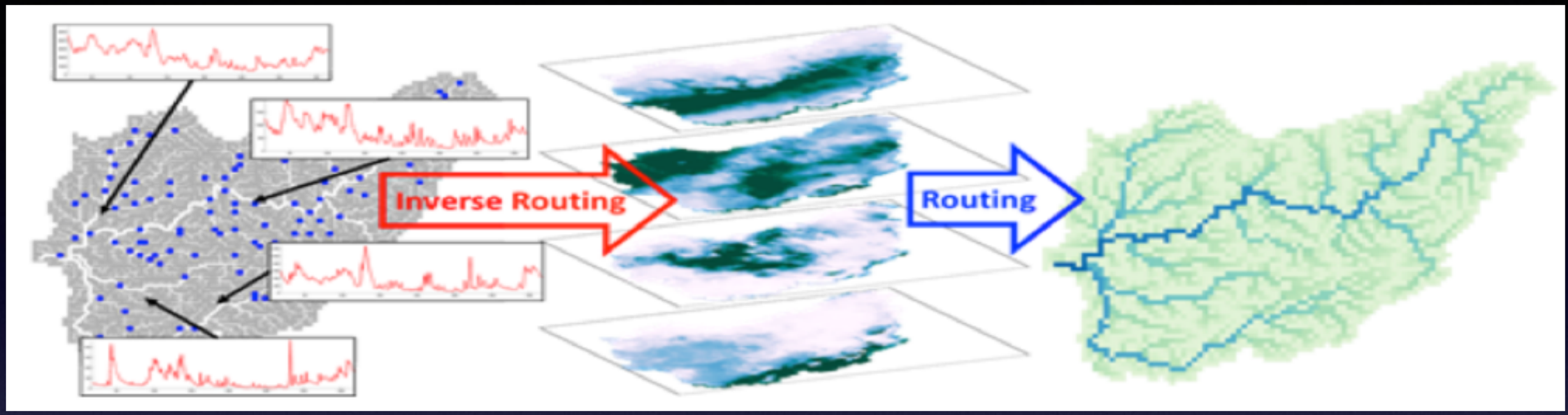
- Use covariance to interpolate discharge across river network
- Case study of Ganges-Brahmaputra showed good results



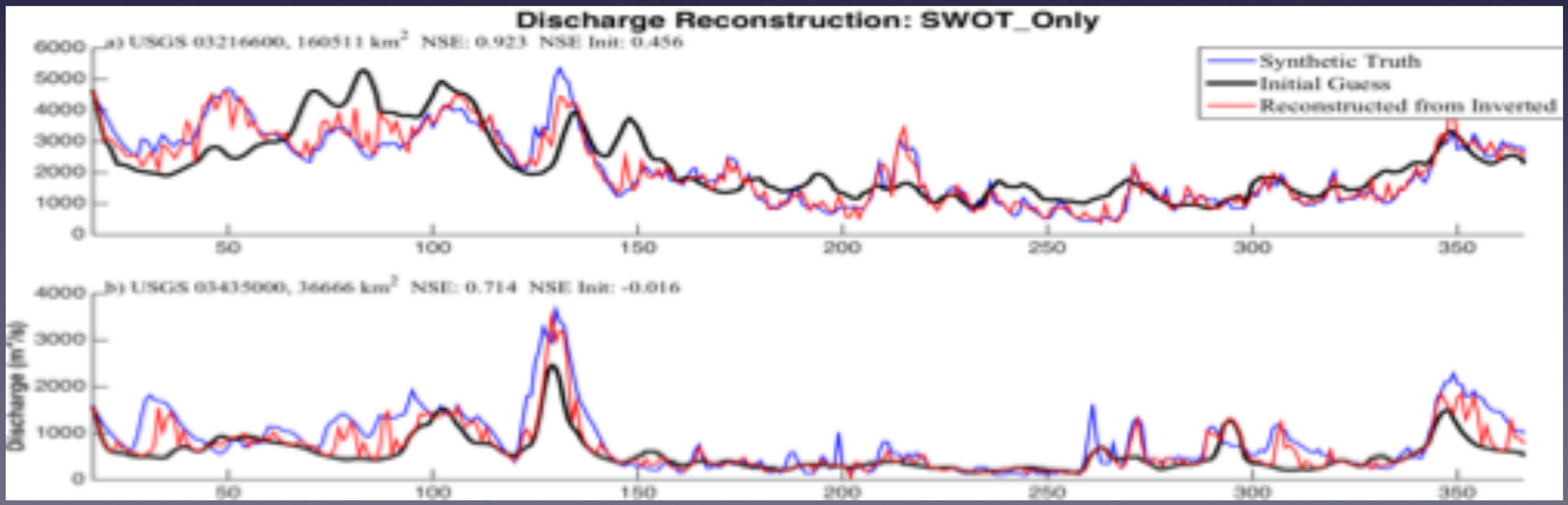


Paiva et al. (2015)

Inverse streamflow routing



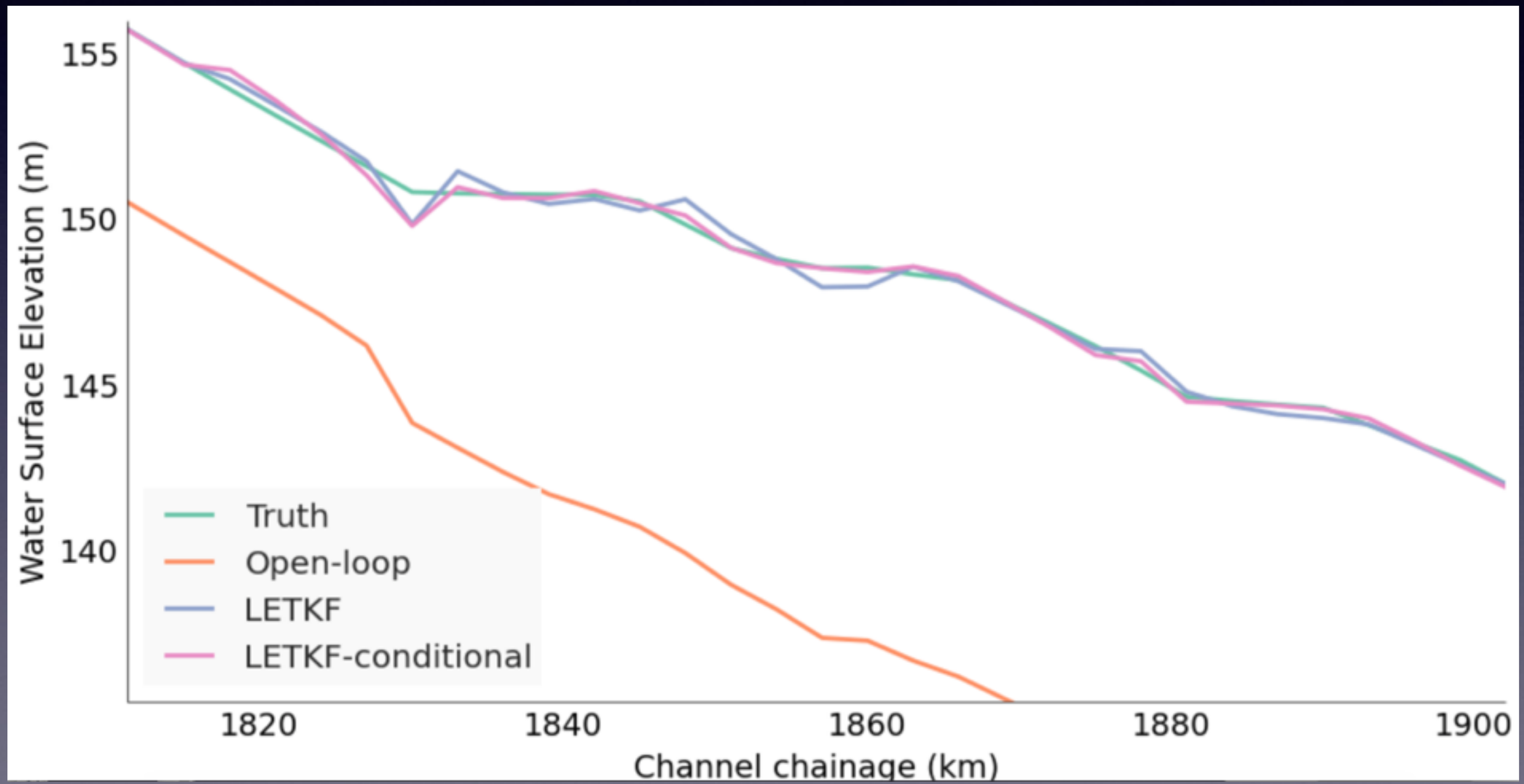
Discrete discharge estimates **Inverted runoff fields** **Complete discharge maps**



Fisher et al. (in prep.)

Data assimilation ≠ “black box”

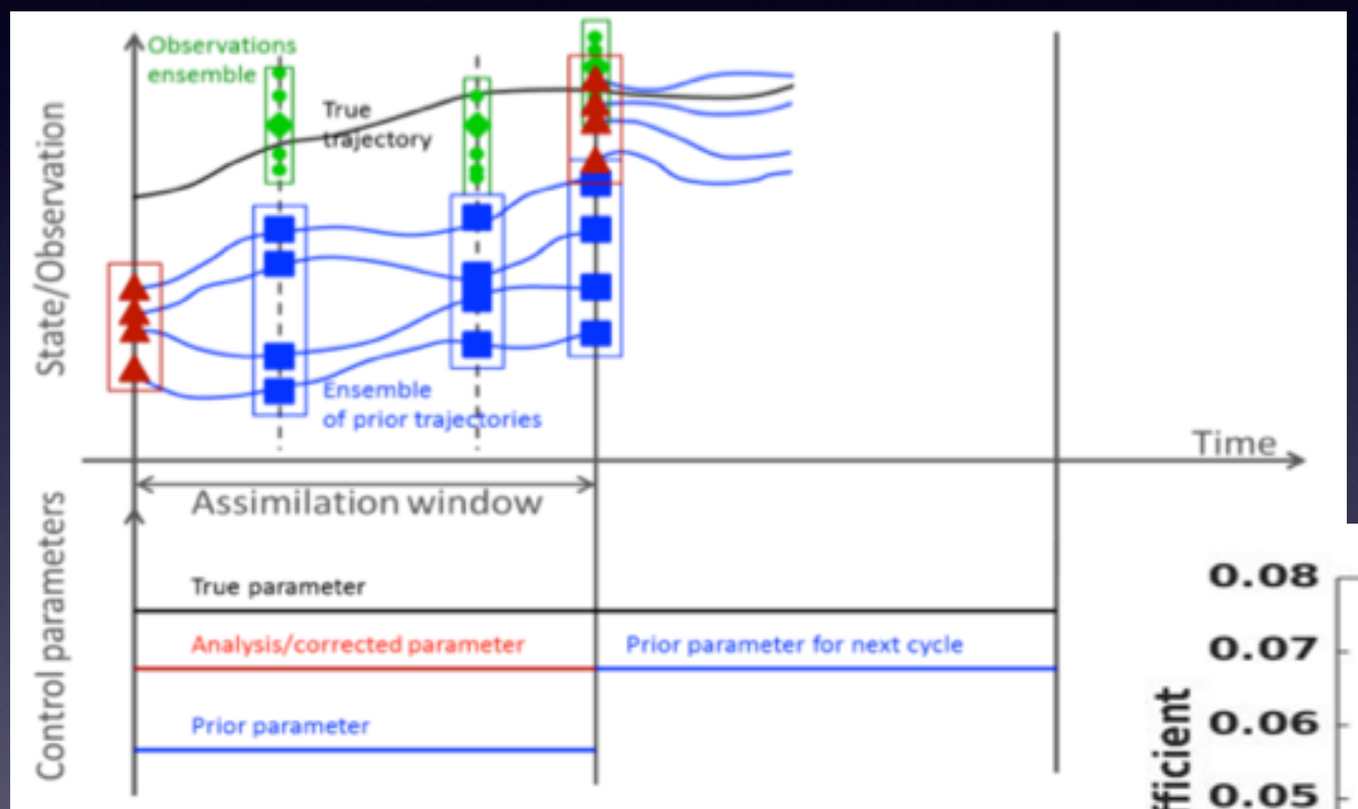
- Example of improved sampling of prior ensemble

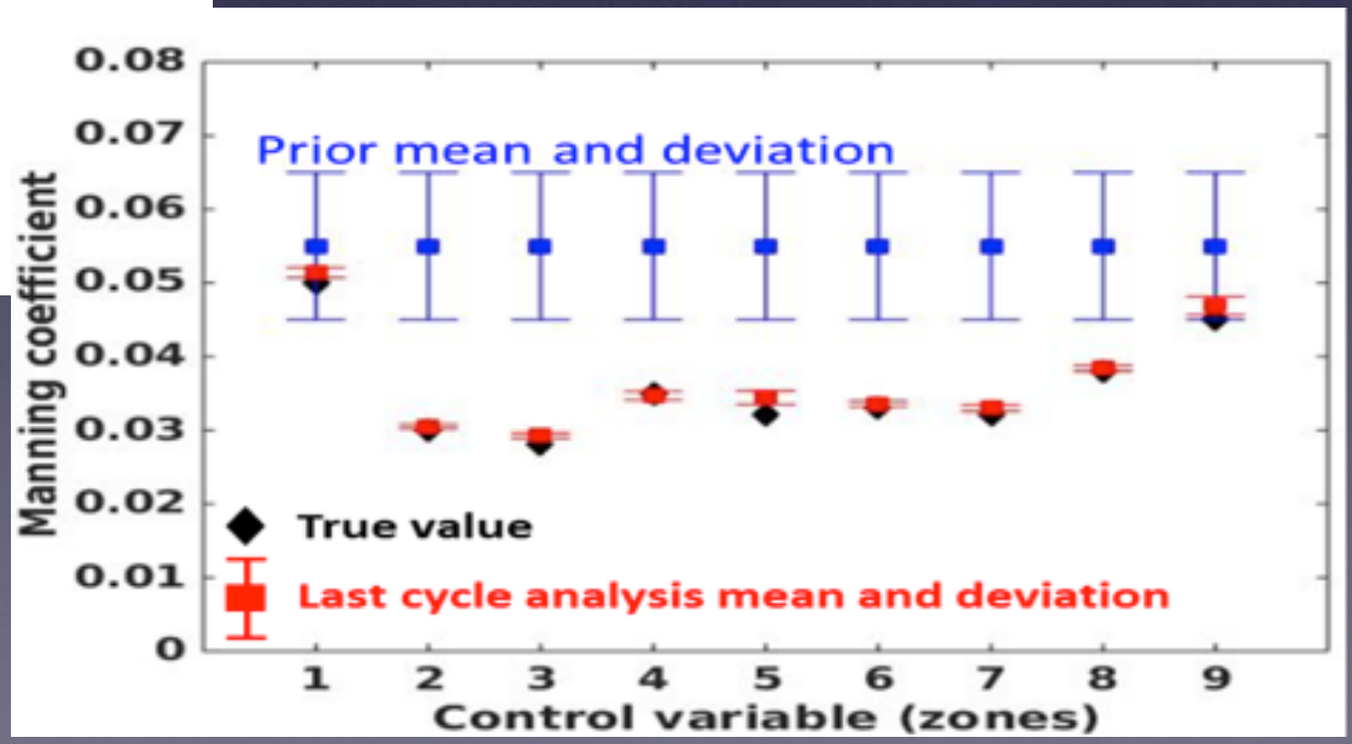


Andreadis et al. (in prep.)

Data assimilation ≠ “black box”

- Scaling to regional implementation with more realistic errors





Emery et al. (in prep.)

Challenges

- Inter-comparison of both assimilation algorithms and forward models
- More realistic SWOT observations and errors
- How can assimilation improve our models?
  - Identify structural errors
  - Calibrate model parameters
- Estimate discharge/water levels at unobserved locations
  - also indirectly observed variables
- Computationally efficient implementations over large areas (i.e. towards global assimilation)