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Floridan Aquifer Collaborative Engagement for Sustainability

A PARTICLE-TRACKING APPROACH TO ANALYZE THE AGE AND SOURCE COMPONENTS DURING TRANSIENT STREAM FLOW CONDITIONS

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USDA United States Department of Agriculture National Institute of Food and Agriculture

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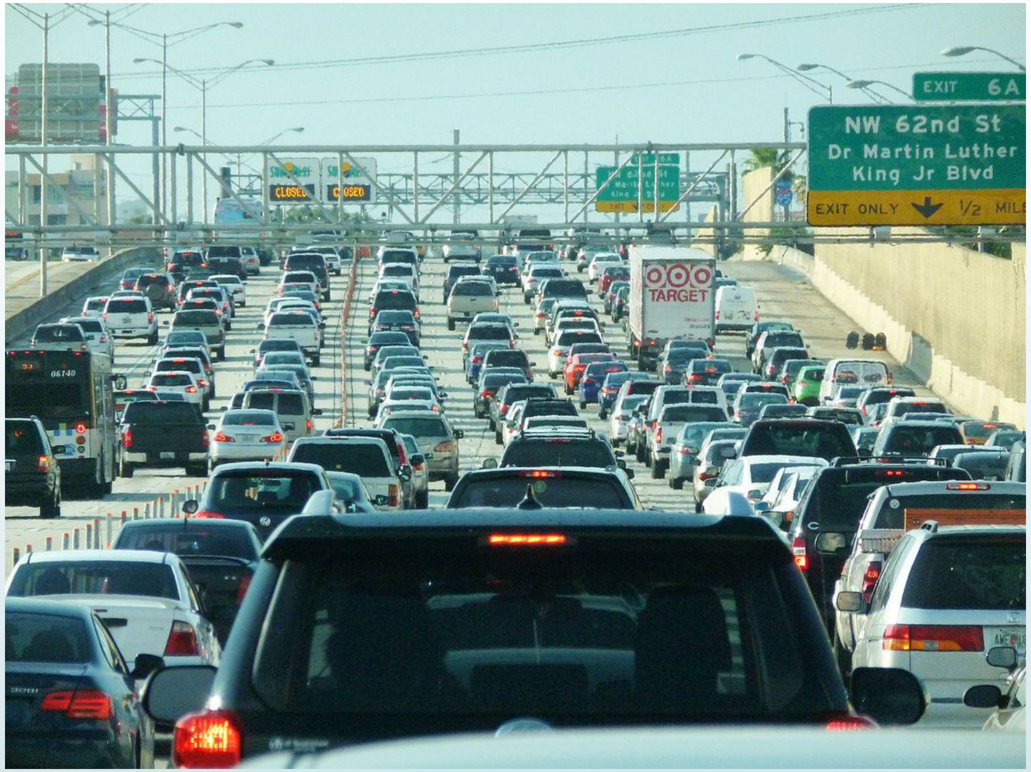
Age and source components ....



Different sources and different travel times

Travel times related to sources (distance) and speed

Same for stream flow

Mixture of water parcels that have converged along **different flow paths**

Water parcels have **different travel times and different sources**

Travel time distribution (TTD) varies with time

Insights from TTD's:

- **Time needed for contaminants to arrive (and time for biochemical reactions)**
- **Linking contaminants to historical land use practices**
- **Vulnerability**
- **TTD helps to characterize the flow system**

How to get a TTD?

Measurements

Can use isotopes (^{3}Tr, ^{3}He, ^{85}Kr,etc.), CFC's, etc.

Typically, we only get an average travel time

Interpretation based on simplified flow models …

Numerical models

Need a transport scheme to transport travel time of water parcels

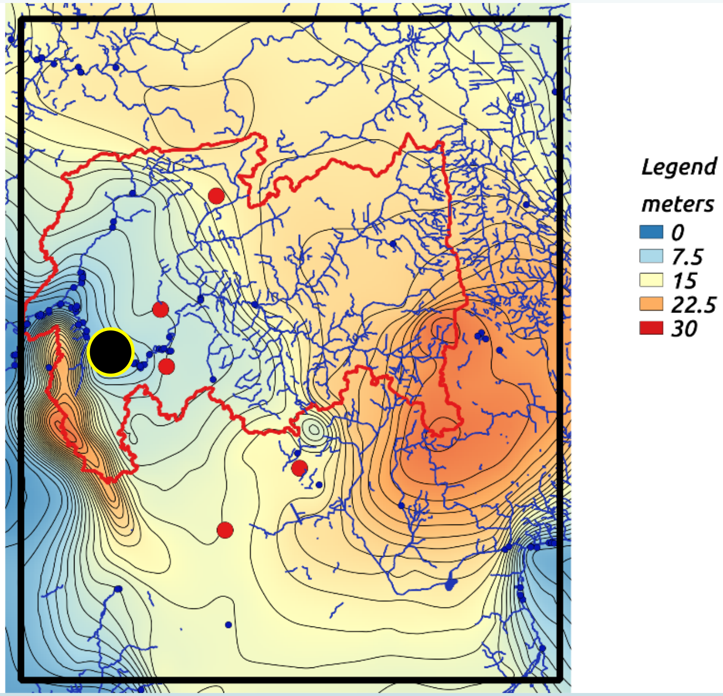
Advection-dispersion schemes / particle-tracking schemes

We use a particle tracking scheme

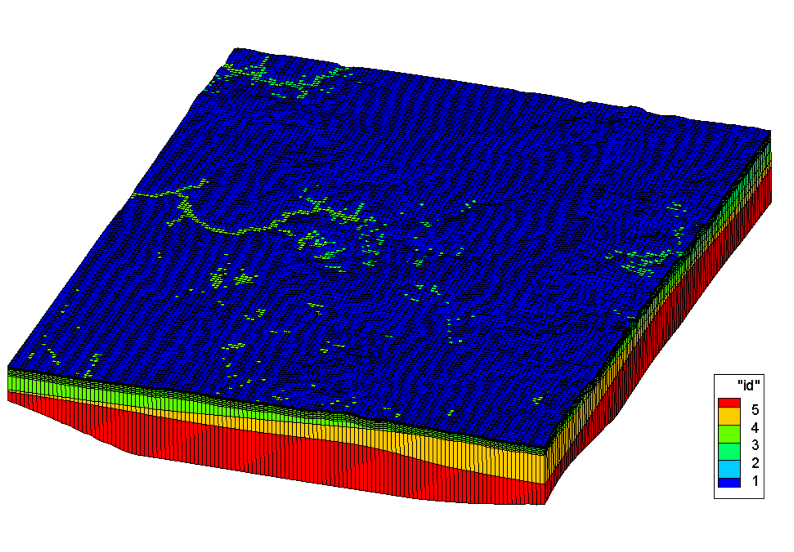
TTD in the Santa Fe River at Fort White

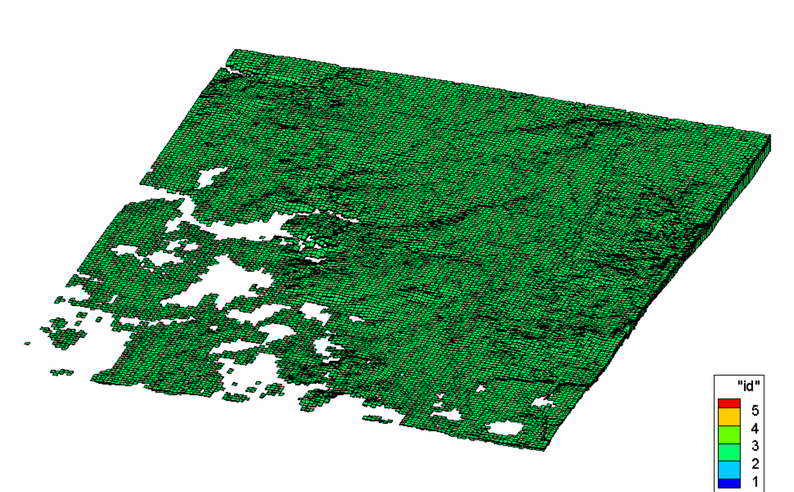
Particle-tracking requires a flow field

Flow field is simulated with a coupled surface-subsurface model (Disco)



DisCo model for Santa Fe River Basin





Layering is based on North Florida-Southeast Georgia regional groundwater model (NFSEG) built by SJRWMD & SRWMD.

Richards' equation for subsurface flow domain
Diffusive wave equation for overland domain

Penman-Monteith for atmospheric forcing

Need: land use map & weather data

NLDAS (North American Land Data Assimilation System**)**

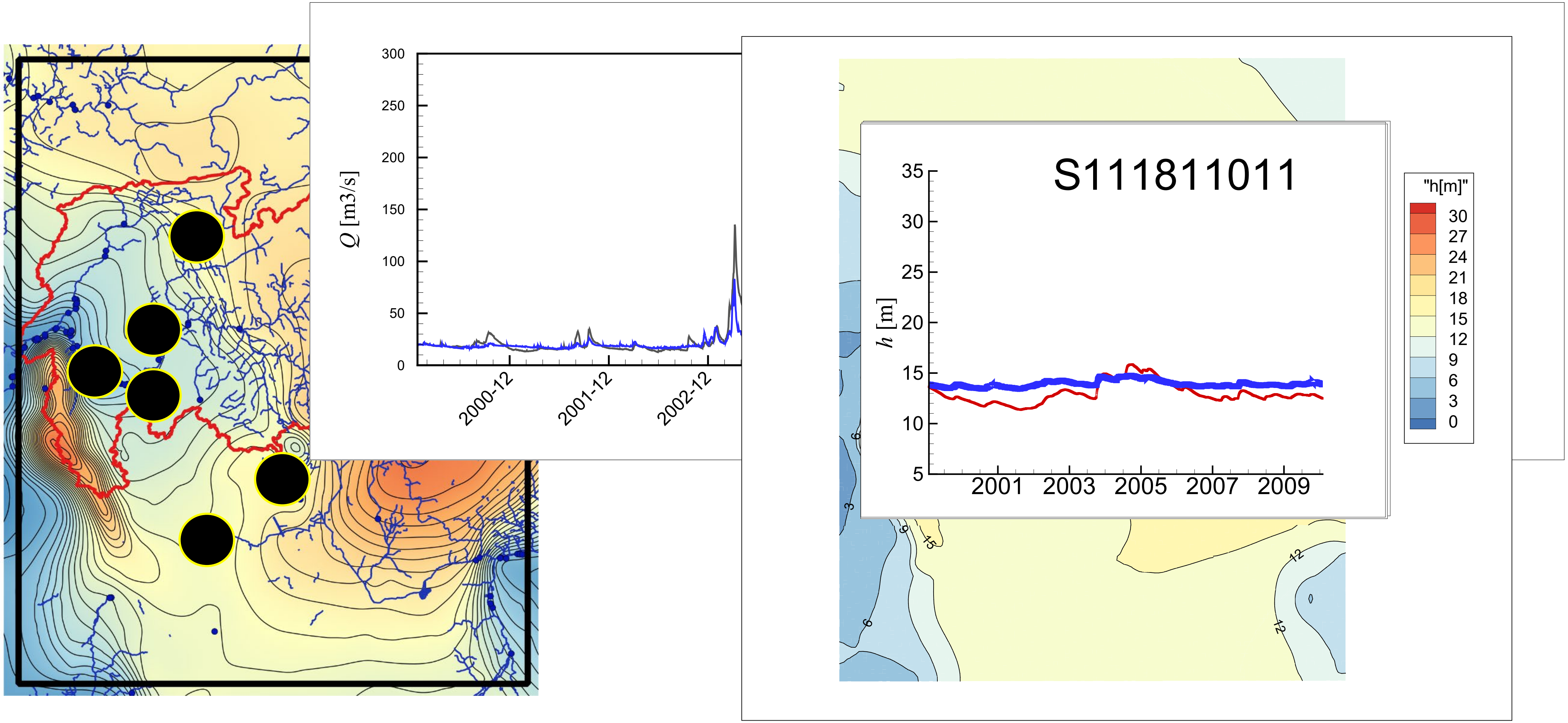
Transient and non-linear: computationally quite heavy …

Model uses 16 cores (parallelized with MPI)

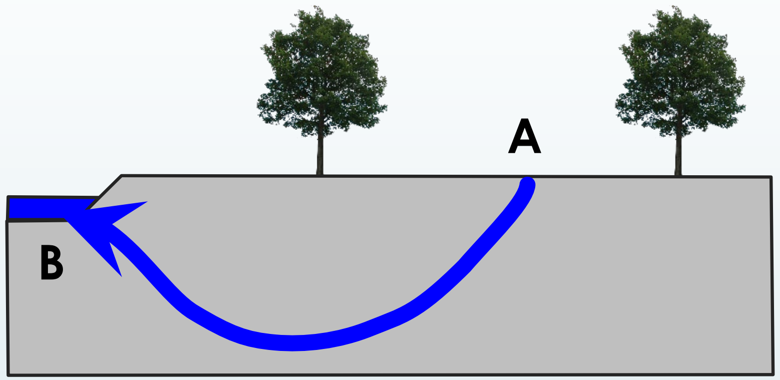
No automatic calibration

Particle-tracking scheme uses same amount of cores

Some results (flow)



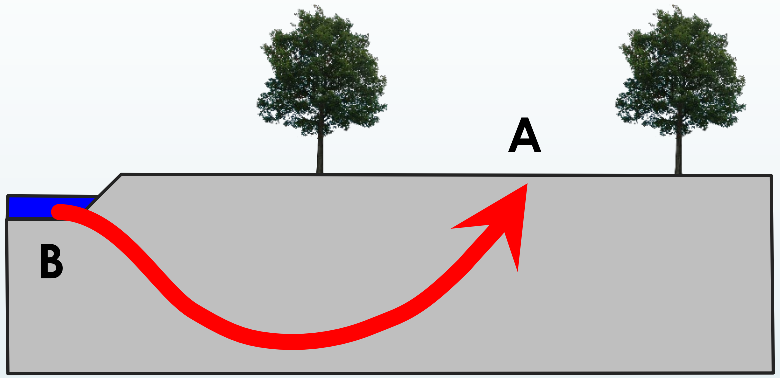
Forward versus backward particle-tracking
(change sign of velocity vectors)



$$\mathbf{v} = -\mathbf{v}$$

$$=>$$

$$t_{BA} = t_{AB}$$

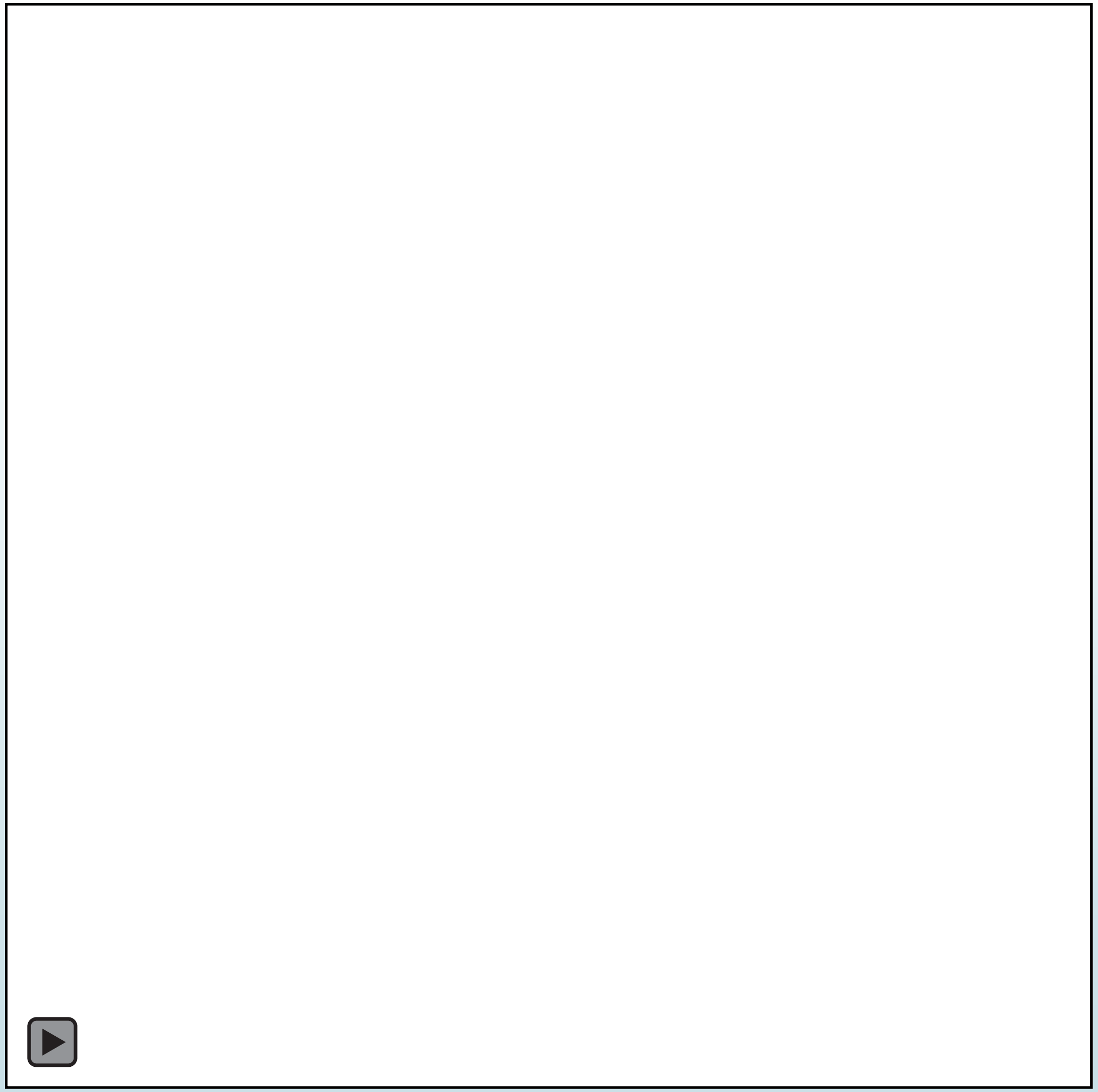


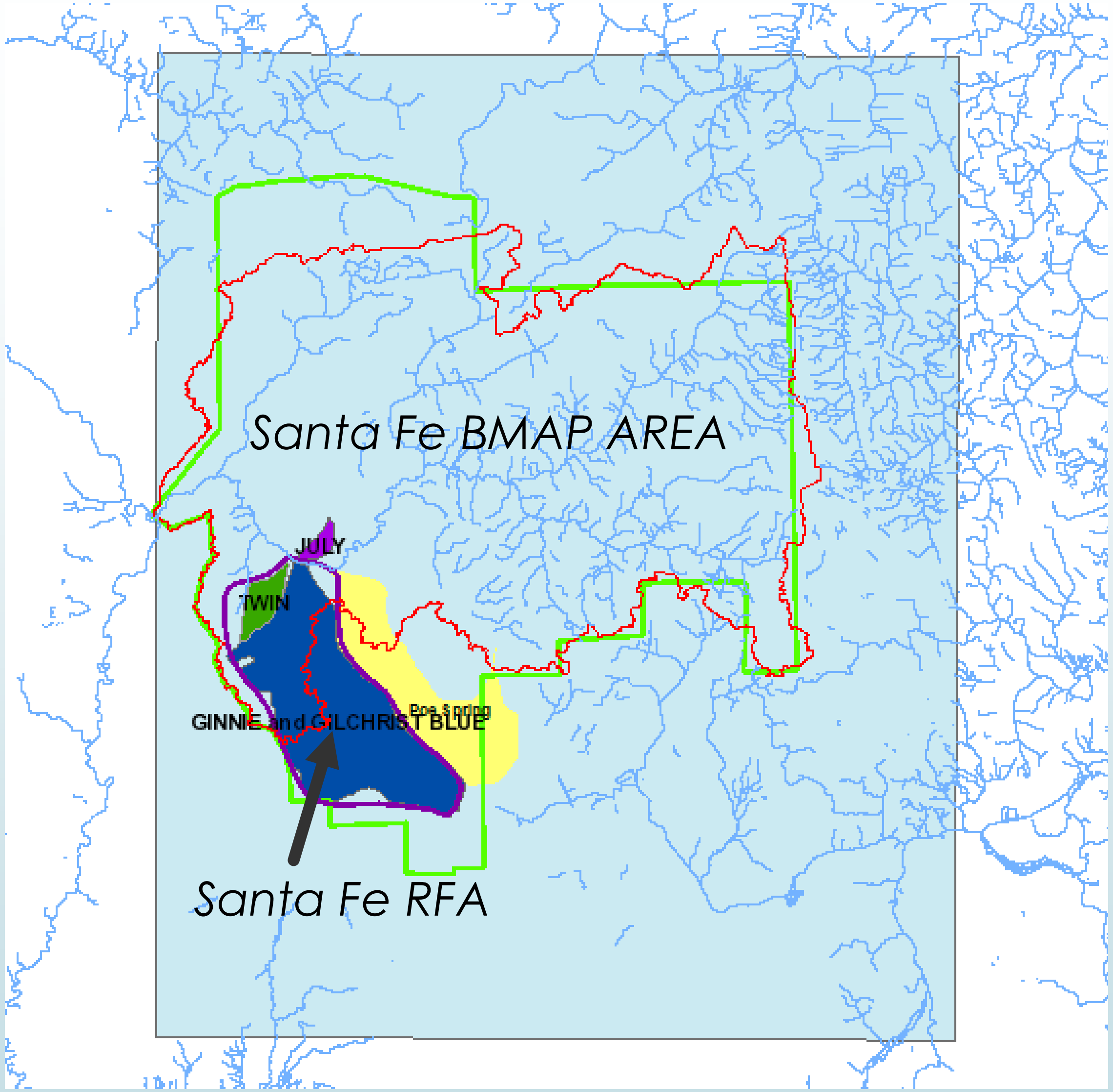
Advantage of backward-tracking:

All particles contribute to TTD
(drop them at location and time where TTD is desired

Short duration animation of backward particle tracking (surface flow)

Long duration animation of backward particle tracking (subsurface flow)





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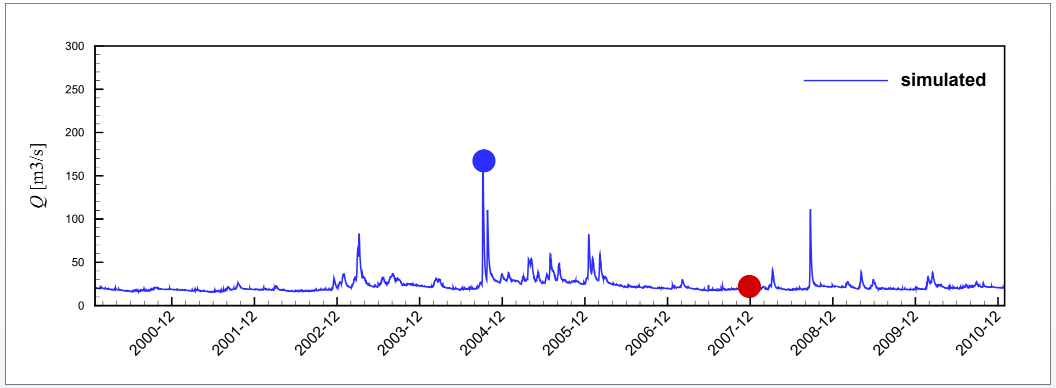
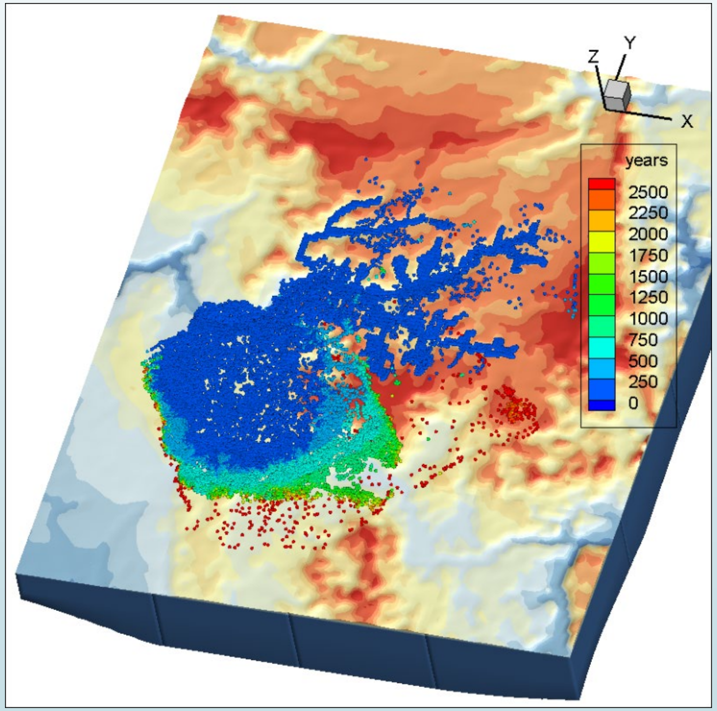
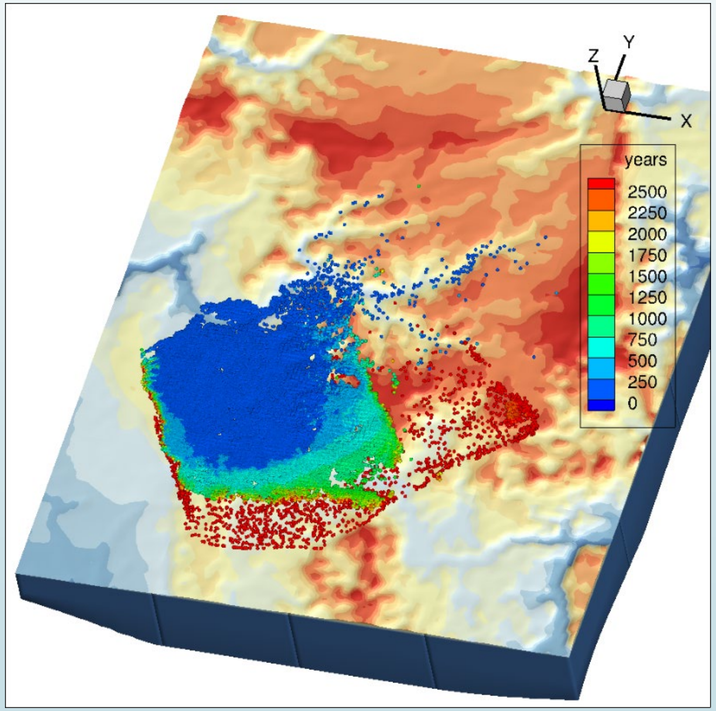
Back-tracking at high and low flow conditions







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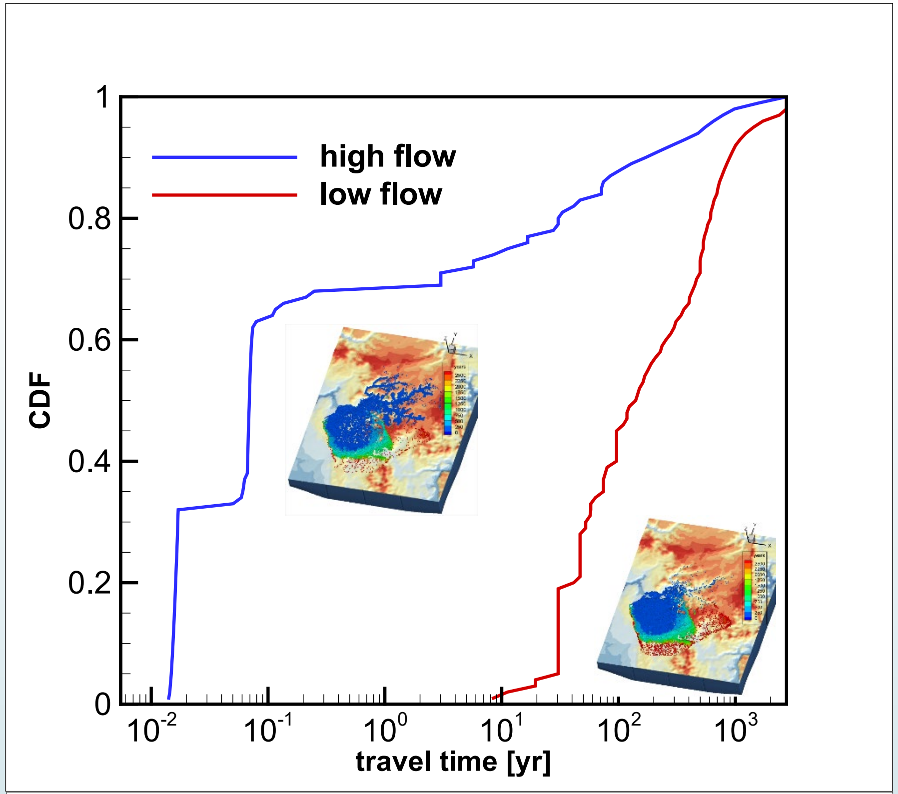
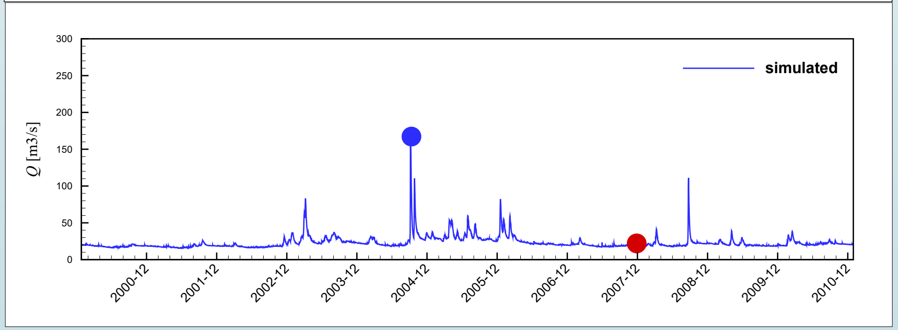
CDF of TTD



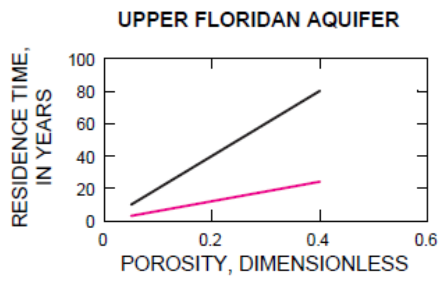


TTD closely related to source components:

High flow: More runoff from confined area
Fraction of young water is relatively high

Median age shifts from 50 days to about a 100 years

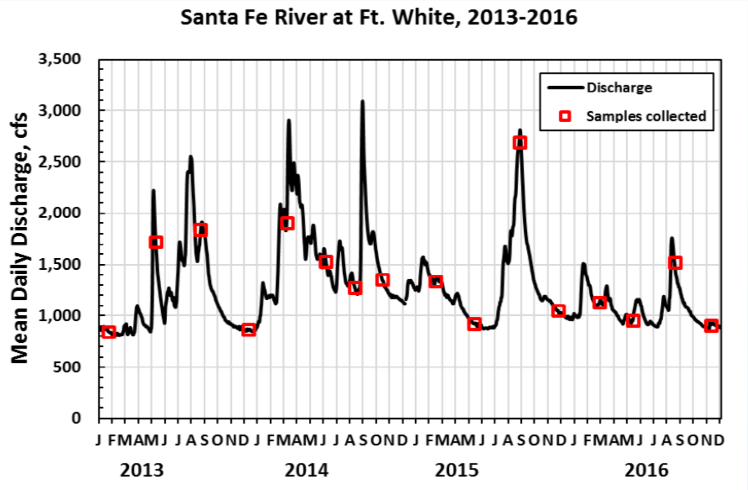
SPRING NAME	Tritium concen-tration, TU	CFC-11 Apparent age (PFM), yrs	CFC-113 Apparent age (PFM), yrs	CFC-11 Turnover time (EM), yrs	CFC-113 Turnover time (EM), yrs
SANTA FE RIVER SPRINGS					
GIL917971	3.3	16	10	22	13
Ginnie	5.2	16	14	16	21
Hornsby	5.8	25	24	43	110
July	5.4	Contam.	12	Contam.	15
Poe	5.1	27	22	64	81
Trail	4.5	22	13	32	19
Columbia	4.3	21	14	29	25
Ichetucknee Blue Hole	5.8	27	15	69	27

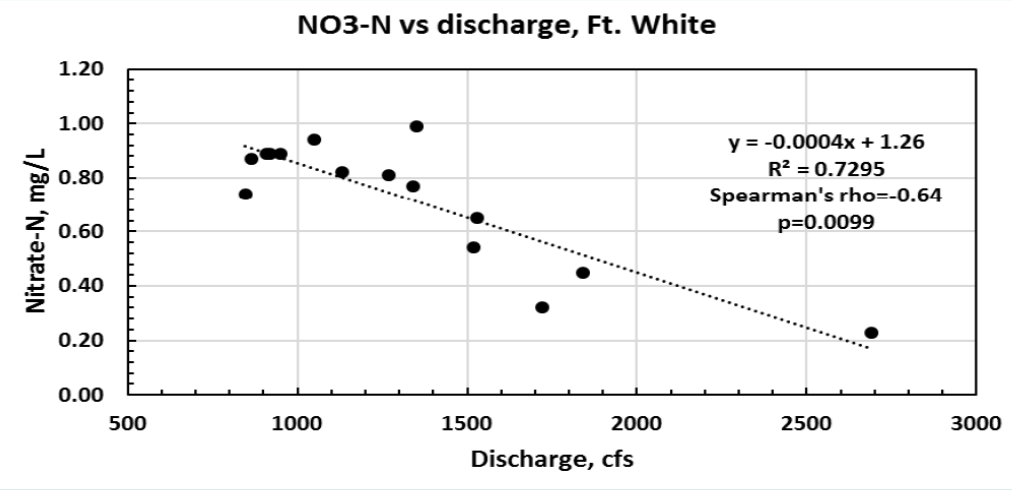


Sources and Chronology of nitrate contamination in spring waters, Suwannee River Basin, Florida, Katz et al., 1999, USGS.

Simulated TTD's in agreement with "what we know"

Taken from the Four-Year Progress Report (2013-2016) on the Implementation of BMAPS in Santa Fe Restoration Focus Area (DEP & FDACS, 2017):





Quote:

The decrease in nitrate-N concentrations at higher flows likely results from the dilution of elevated nitrate concentrations in groundwater and springs by low nitrate-N concentrations in upstream river water

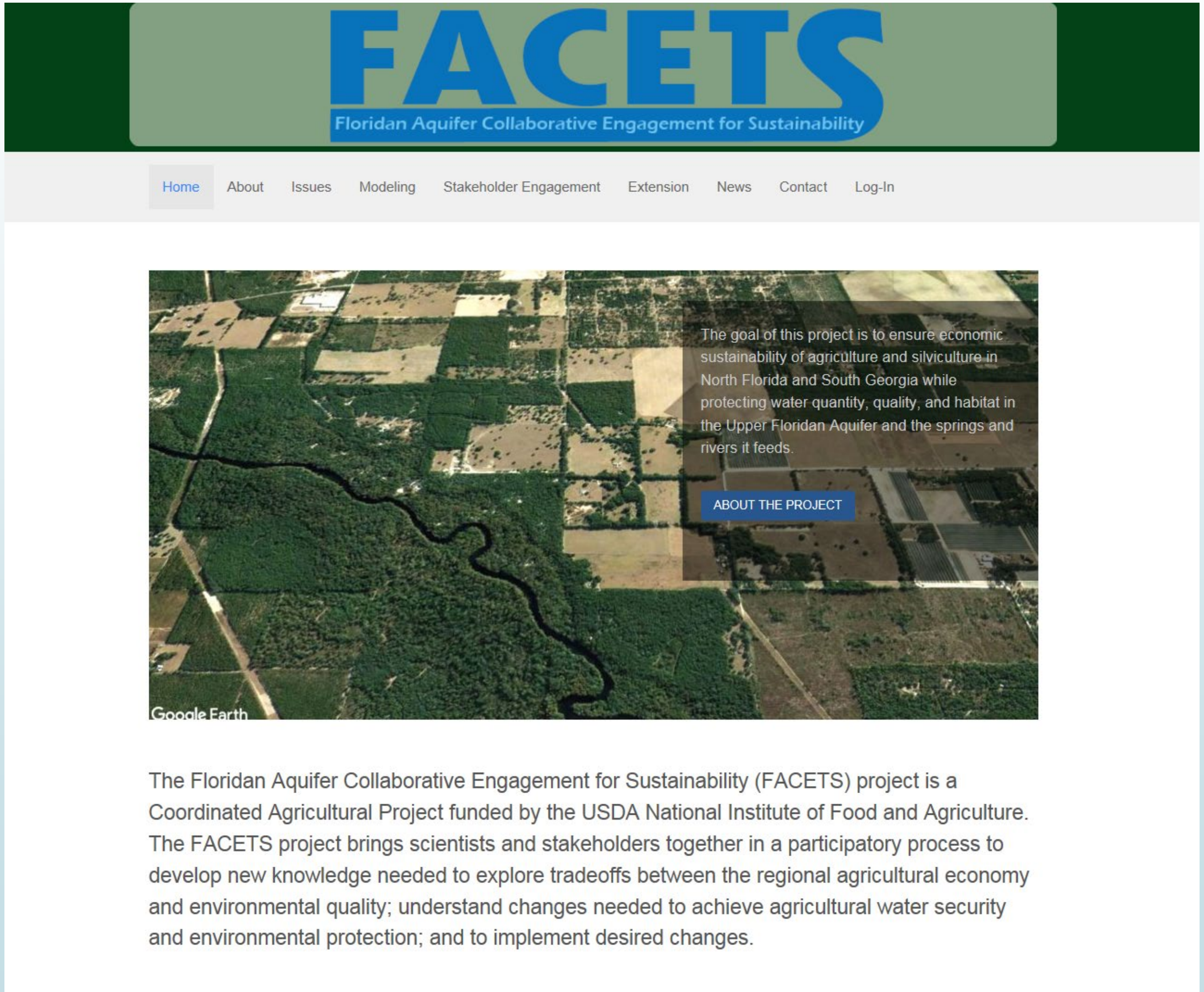
Also: EC measurements are higher during low flow

Summary and concluding remarks

- **During high flows the fraction of relatively young water increases**
- **Younger water during high flows reflects direct runoff from confined area**
- **TTD in Santa Fe River is highly transient**

- **Simulated TTD depends on underlying flow model (…)**
- **Simulated TTD's may be used to check underlying flow model**
- **Each particle-tracking simulation here only provides a TTD at a specific location and a specific time**
- **Alternatives for simulating transient TTD's are limited**
- **Similar experiments were carried out by Vibhava Srivastava using ParFlow** (Geologic, vegetative and climatic controls on coupled hydrologic processes in a complex river basin, Lessons learned from a fully integrated hydrologic model, PhD thesis, UF, 2013)

For more information: http://Floridanwater.org



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