

Data Visualization and Temporal-based Analysis of Groundwater Recharge

*An example study of an
experimental boreal catchment, Quebec, Canada*



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Visual Data Analytics, LLC

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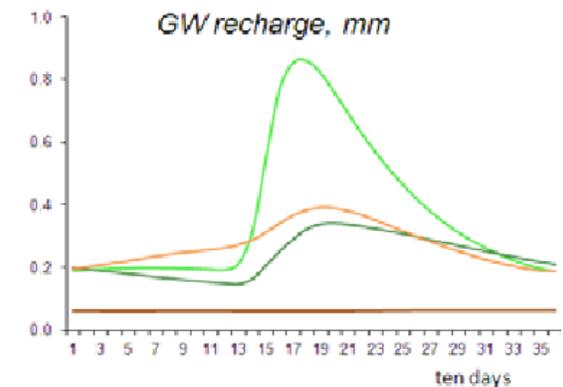
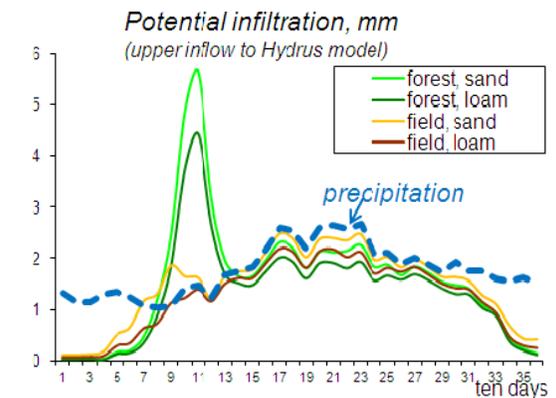
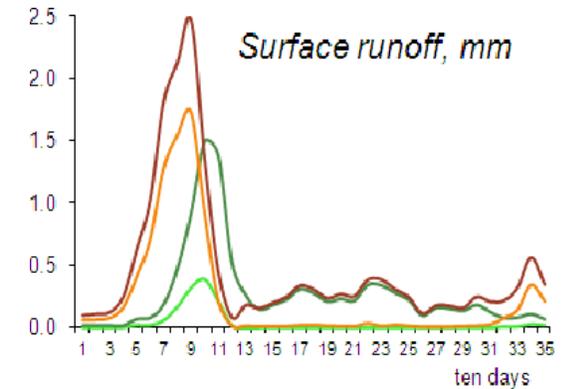
Data visualization

Traditional graphics

- Help notice the unexpected
- More information than tables

Raster-based graphic evolution

- Display data subtleties, interrelationships
- See multiple time-scales simultaneously
- New analysis techniques



Data for this talk

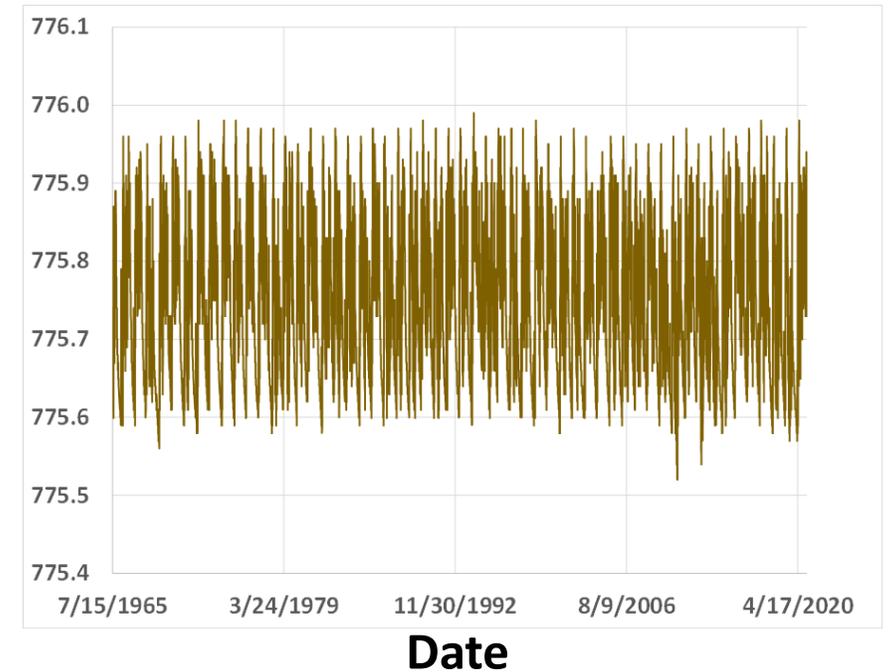
Boreal catchment data

Discharge	(m ³ /s)/day	Surface_Evap	(mm)/day
Head	(mASL)/day	Subsurface_Evap	(mm)/day
GW_Recharge	(mm)/day	Canopy	(mm)/day
Total_Precip	(mm)/day	Transpiration	(mm)/day
Infiltration	(mm)/day	Total_Evap	(mm)/day
Exfiltration	(mm)/day		

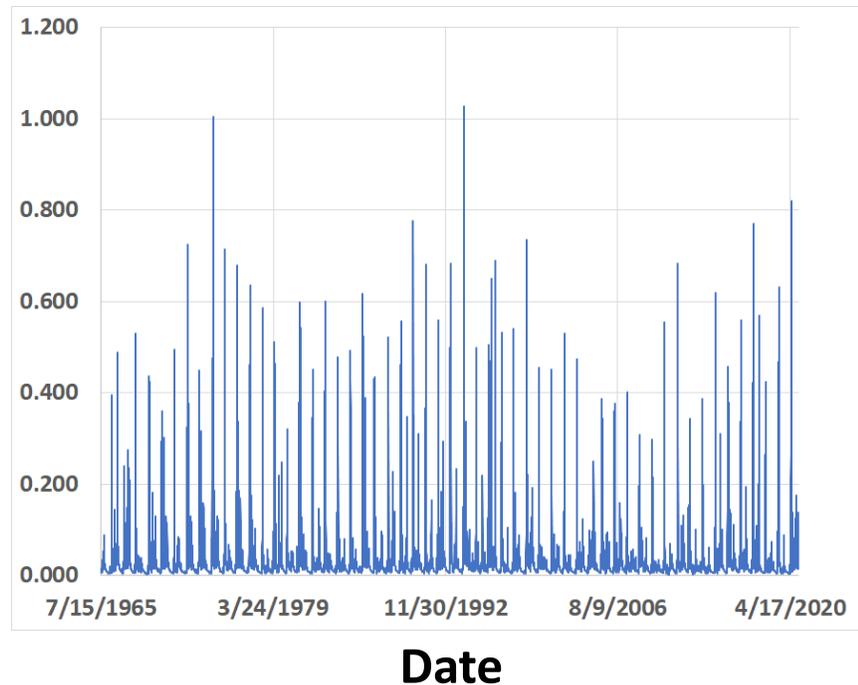
Line plots

- Limited
- Within, between comparisons difficult

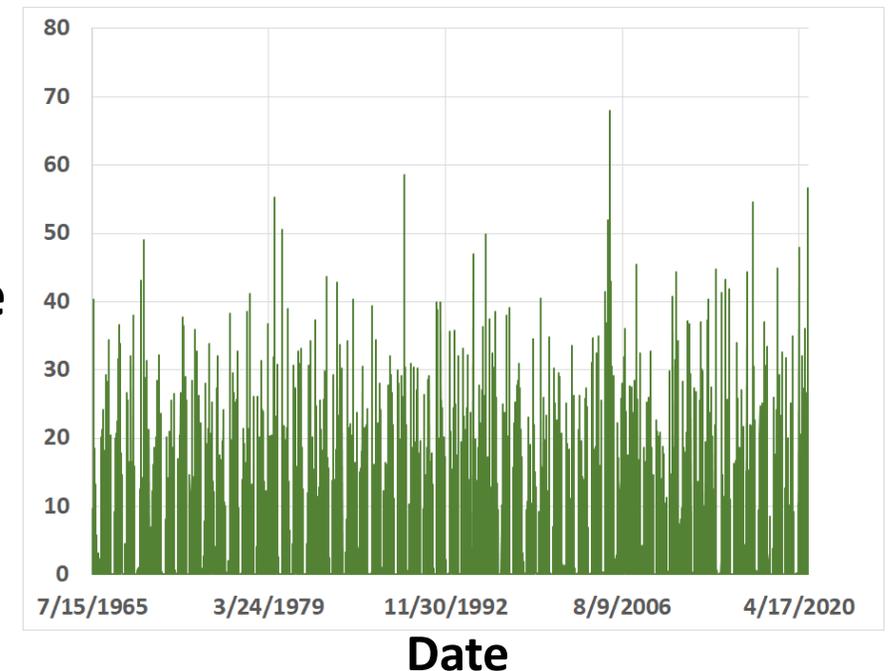
Head
mASL



Discharge
 m^3/s



GW
recharge
mm



Plot examination techniques

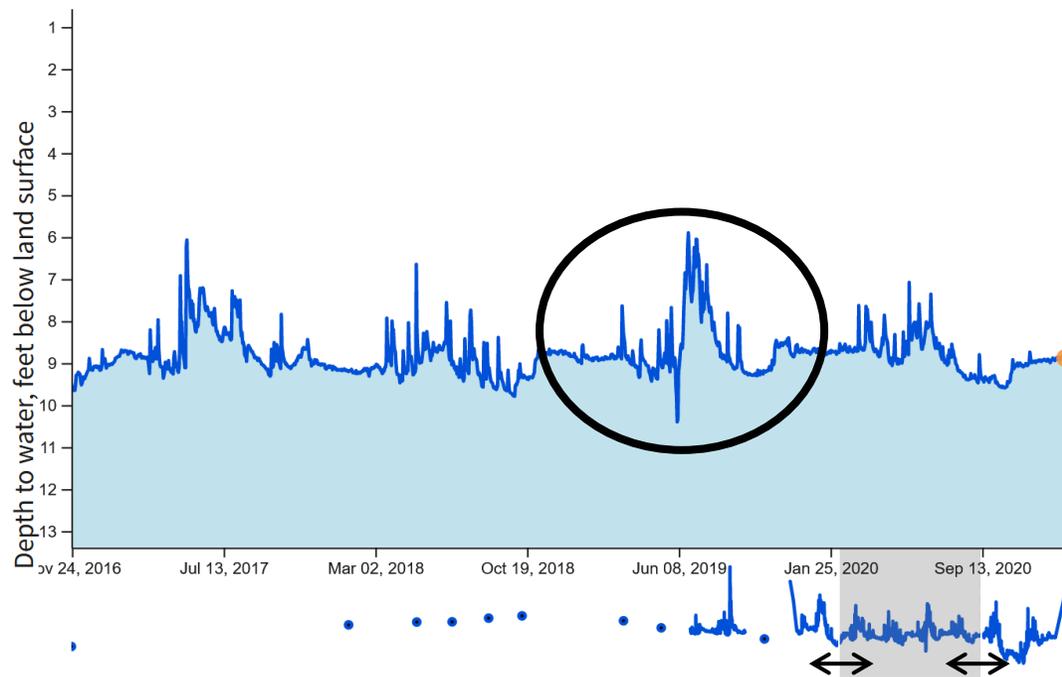
Adjust limits – groundwater graphs

LSP-124

Colorado Division of Water Resources

Water Levels, in feet below land surface

8.88 ft - 1/18/2021, 12:00:00 AM



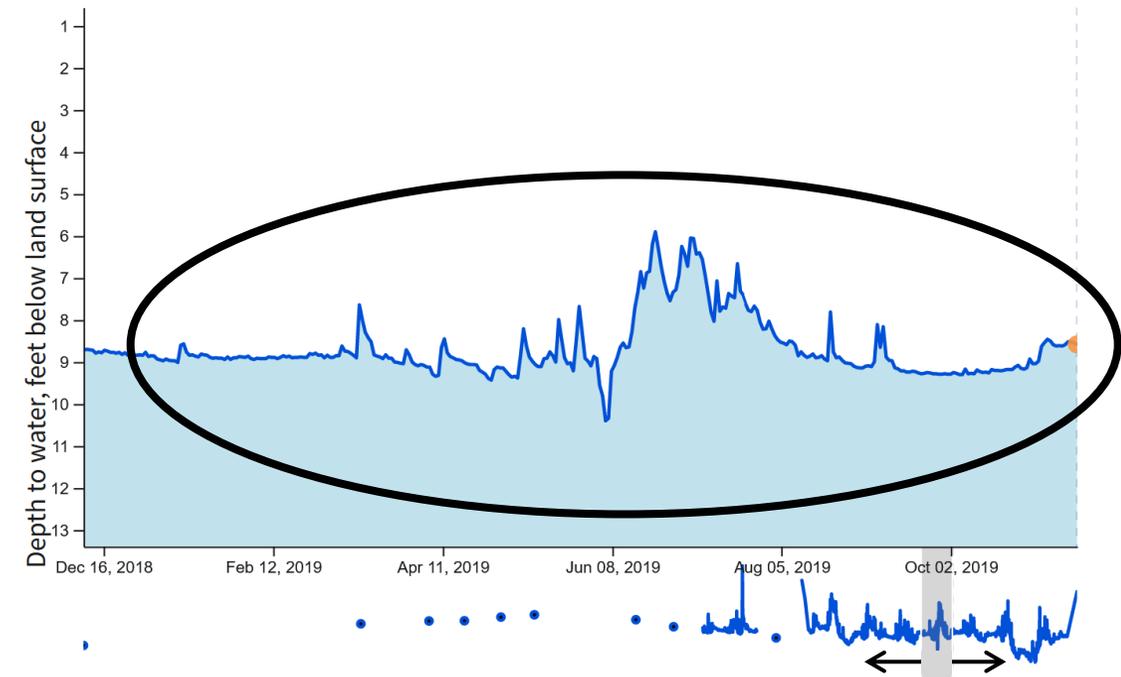
<https://cida.usgs.gov/ngwmn/provider/CODWR/site/11434/>

LSP-124

Colorado Division of Water Resources

Water Levels, in feet below land surface

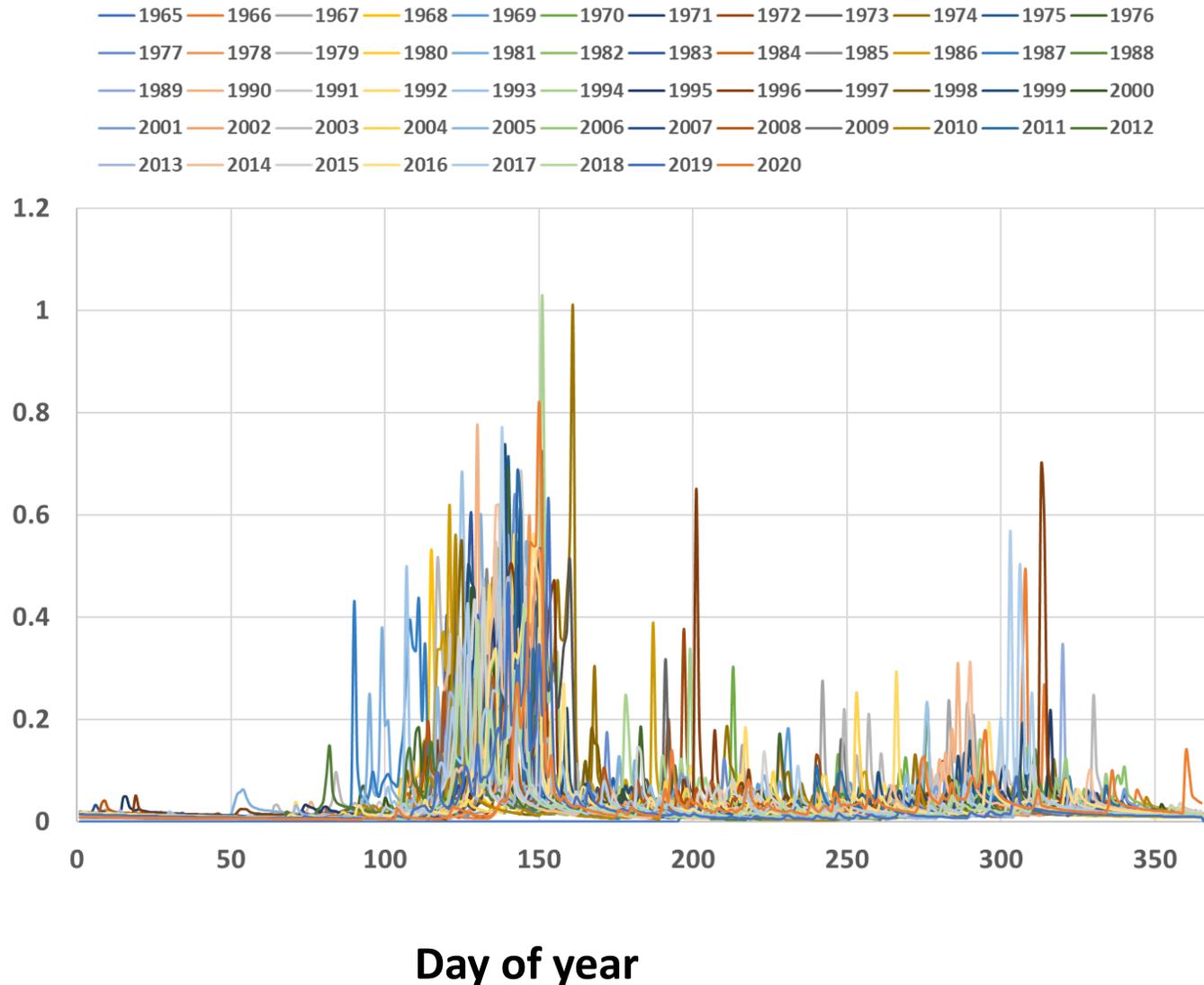
8.58 ft - 11/14/2019, 12:00:00 AM



Spaghetti line plots

- Lines within a single plane
- Comparisons difficult within and between years
- Best at showing extremes

Discharge
 m^3/s

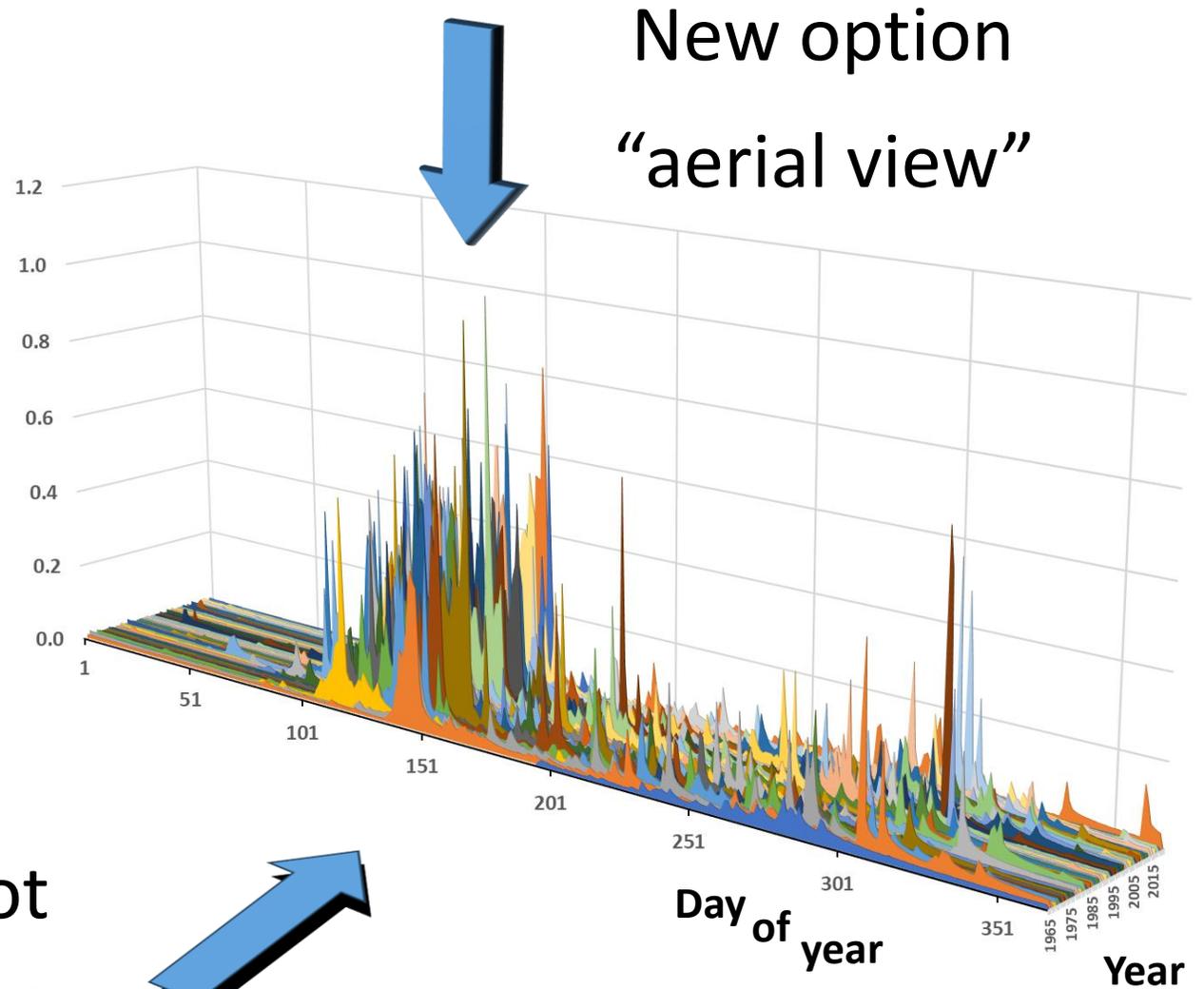


Different view

- Multiple stacked profiles
- Dual time scale
- Other views possible

Spaghetti plot
“ground view”

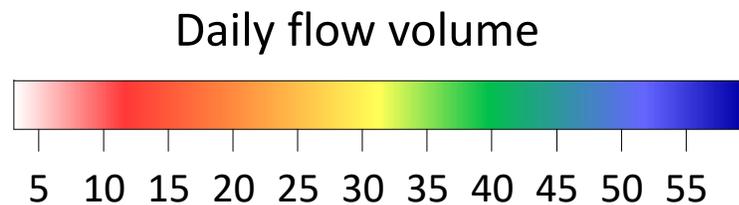
Discharge
(m³/s)



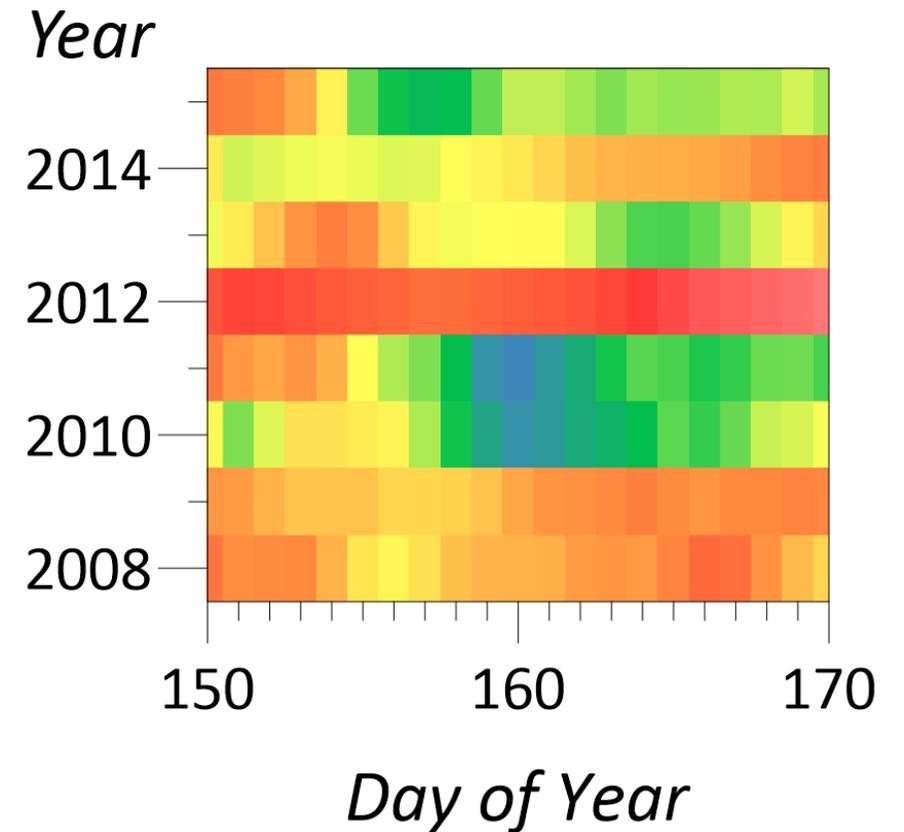
Raster time maps

Coordinates & attributes

- X** *Axis coordinate:* Day
- Y** *Axis coordinate:* Year
- Z** *Raster cell attribute:* Color



<https://colorbrewer2.org>

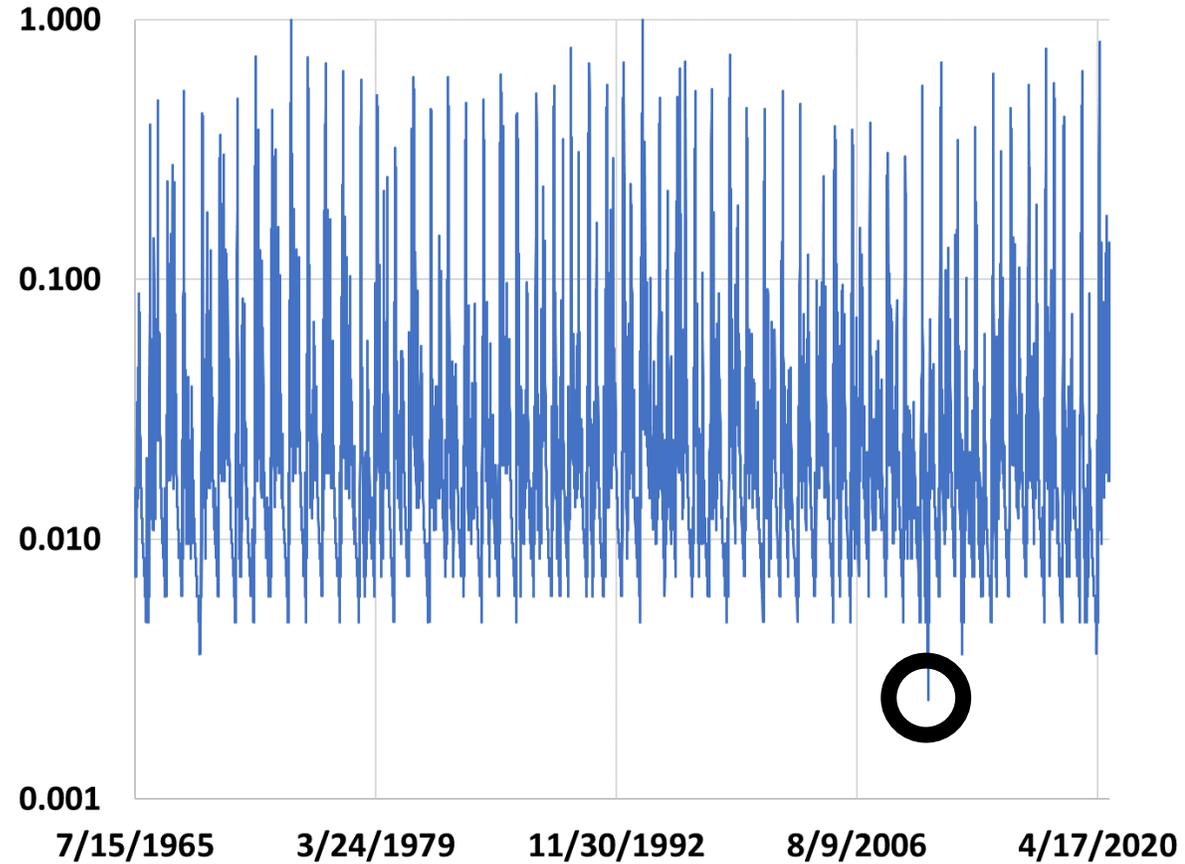
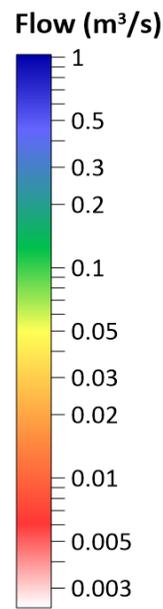
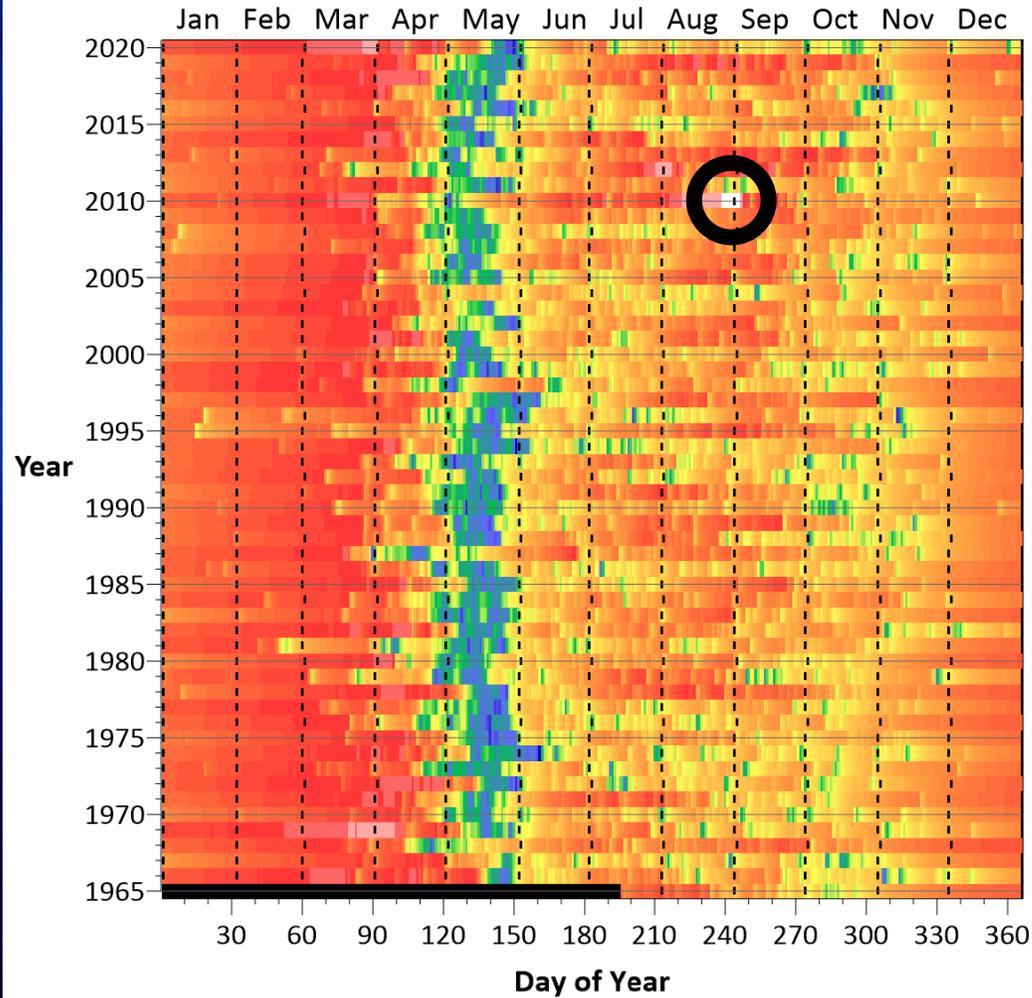


Only show:

- colorblind safe
- print friendly
- photocopy safe

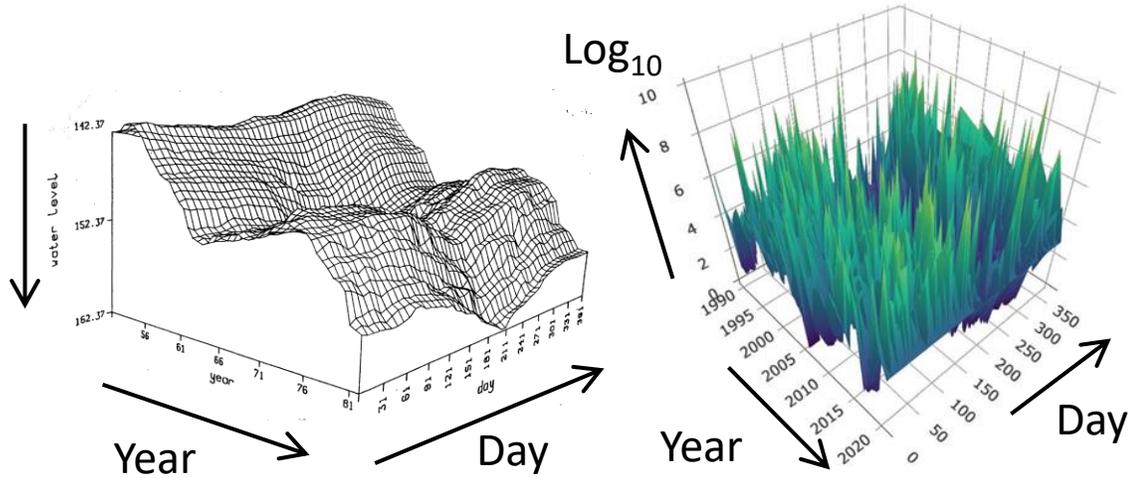
Raster hydrograph vs line hydrograph

Same dataset

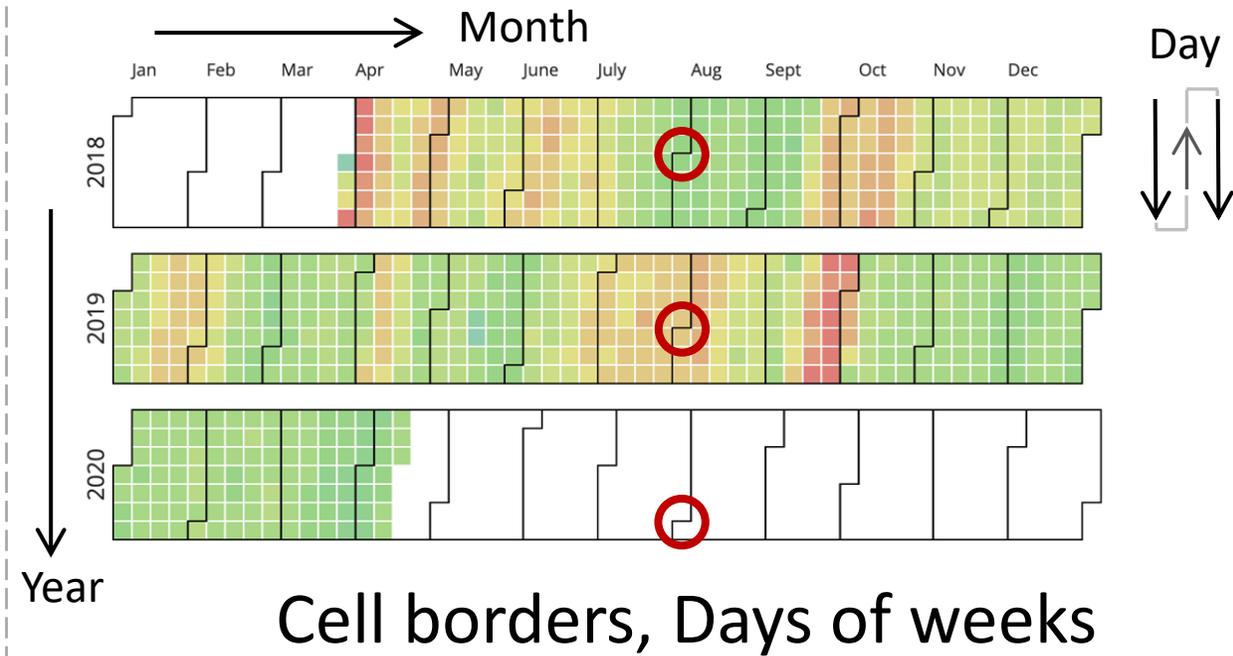
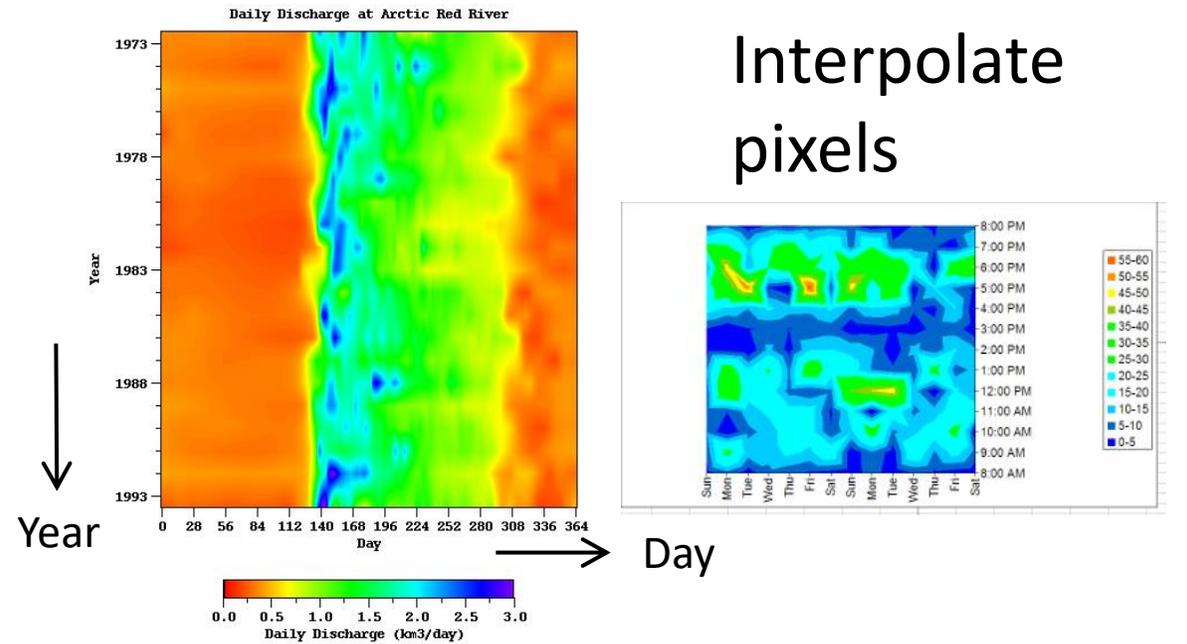
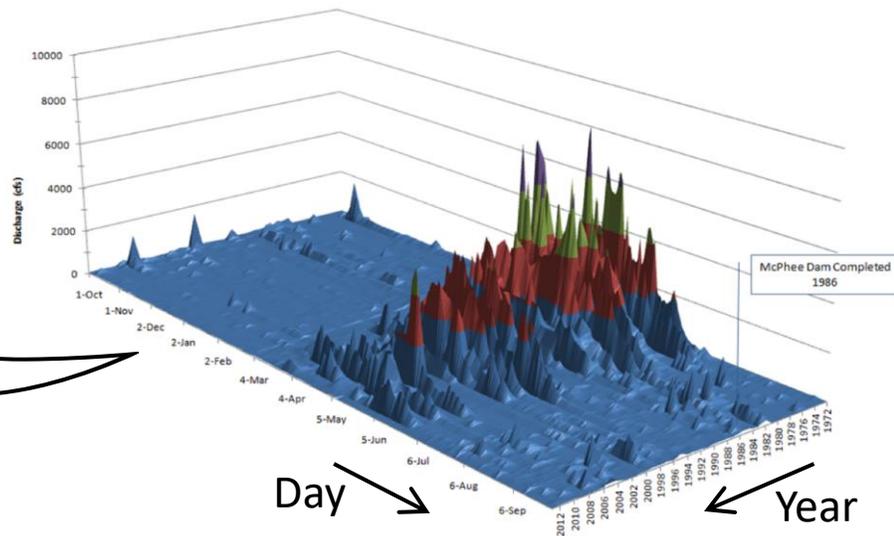


Practices to avoid

3D, perspective, scale



- 1 - Oct
- 1 - Nov
- 2 - Dec
- 2 - Jan
- 2 - Feb
- 4 - Mar
- 5 - May
- 5 - Jun
- 6 - Jul
- 6 - Aug
- 6 - Sep

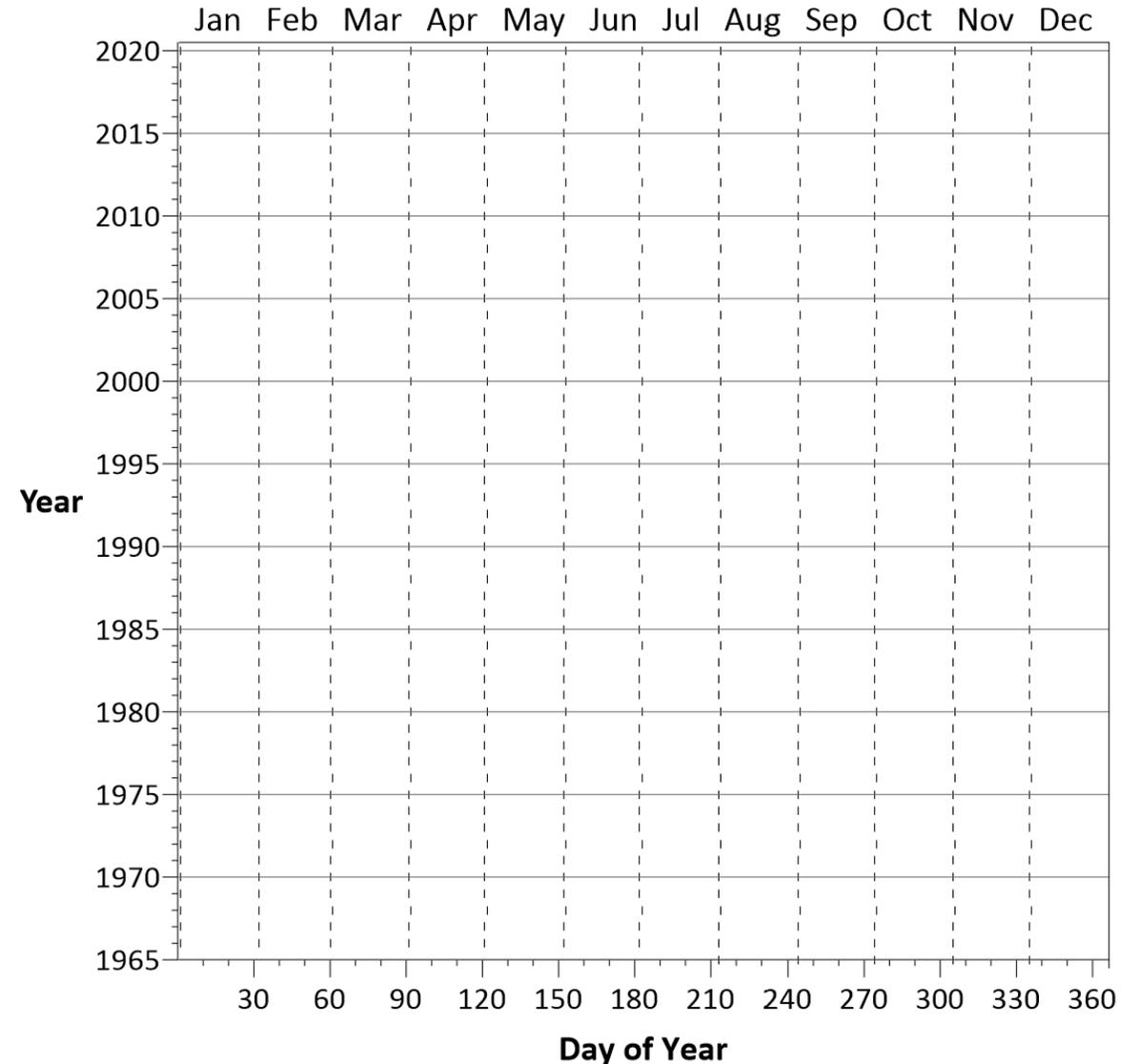
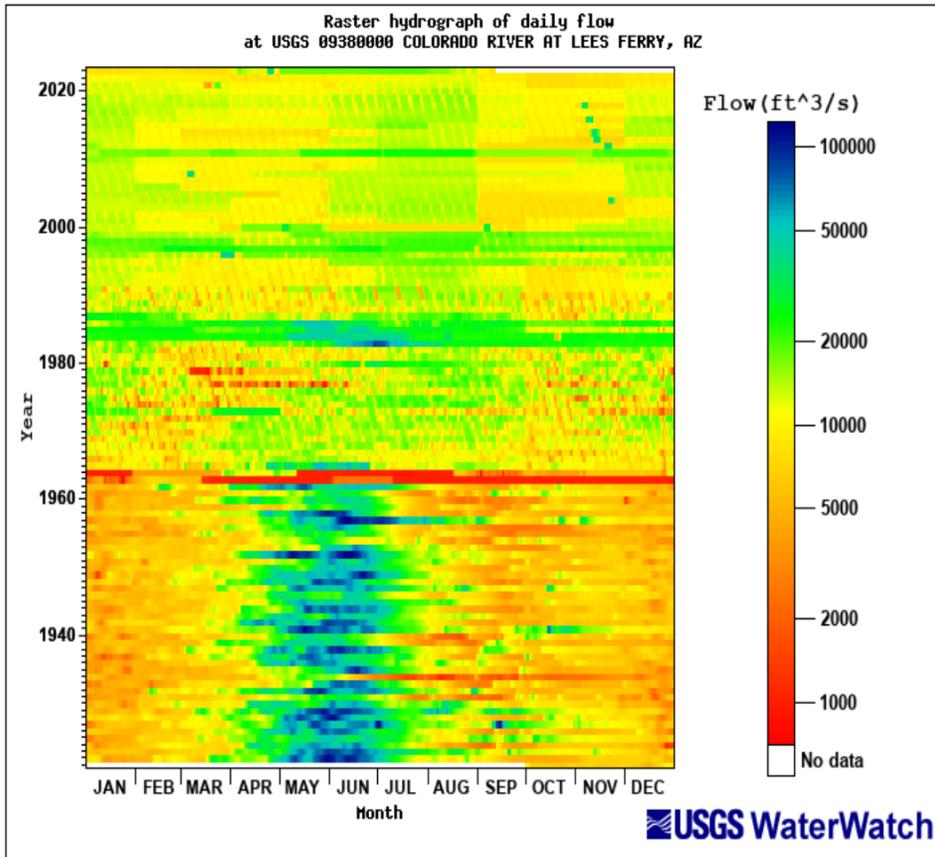


Standardization

Streamflow Raster-Hydrograph Builder *

(Warning: It may take several minutes to process)

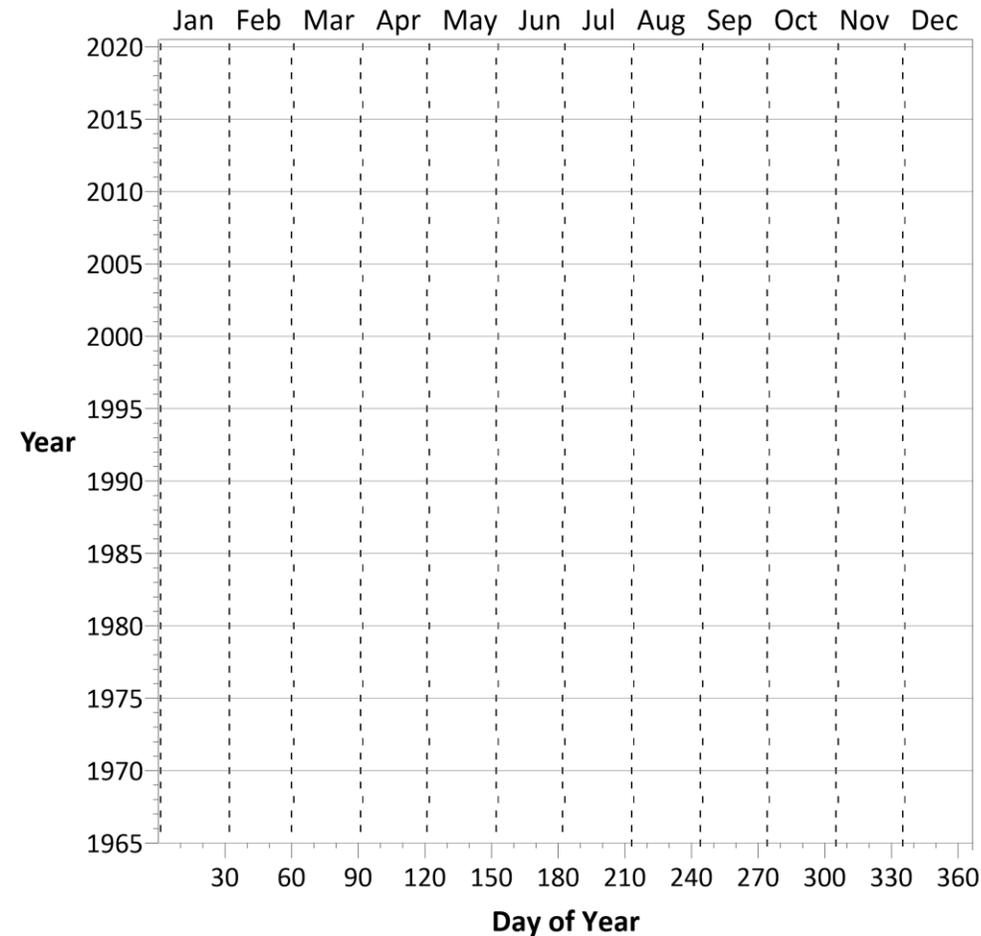
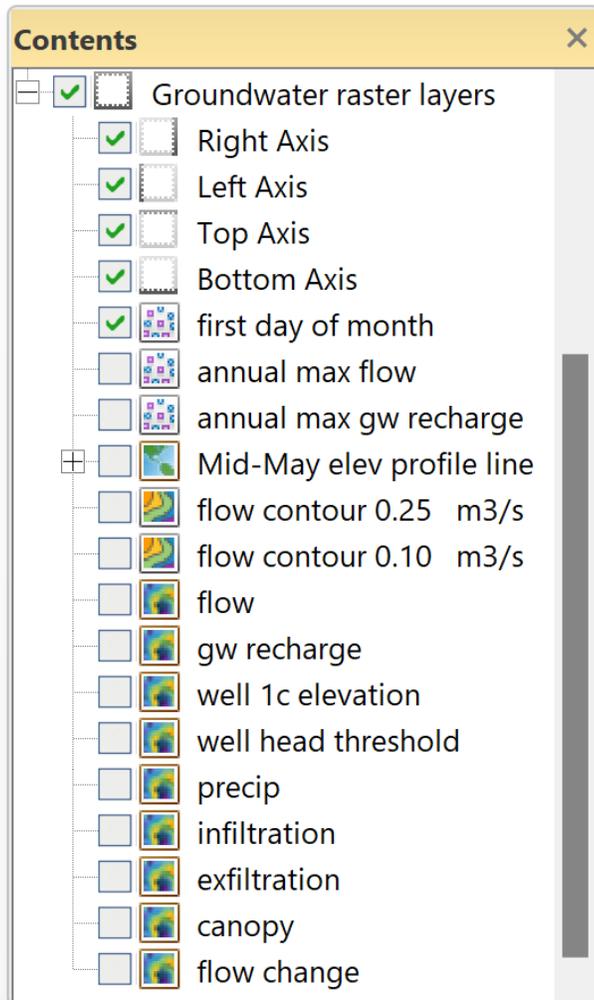
Site Data type Year type Begin year
End year Legend unit



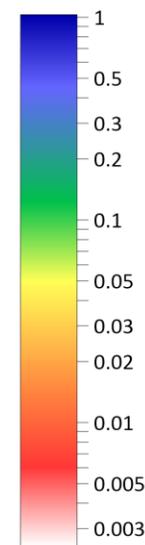
* Koehler, R.B., 2004. *Raster-based analysis and visualization of hydrologic time-series* (doctoral dissertation, Univ. of Ariz).

Geo-temporal Information System

GS Surfer demo

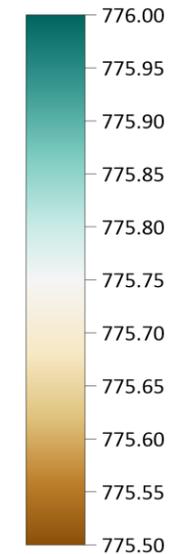


Flow (m³/s)



Missing

Head_7A_1C (mASL)



Recharge (mm/d)

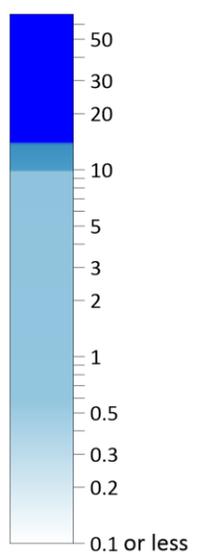


Image comparisons - slider

- Streamflow, Head (1 vs 2)
- Streamflow, GW Recharge (1 vs 3)
- Head, GW Recharge (2 vs 3)

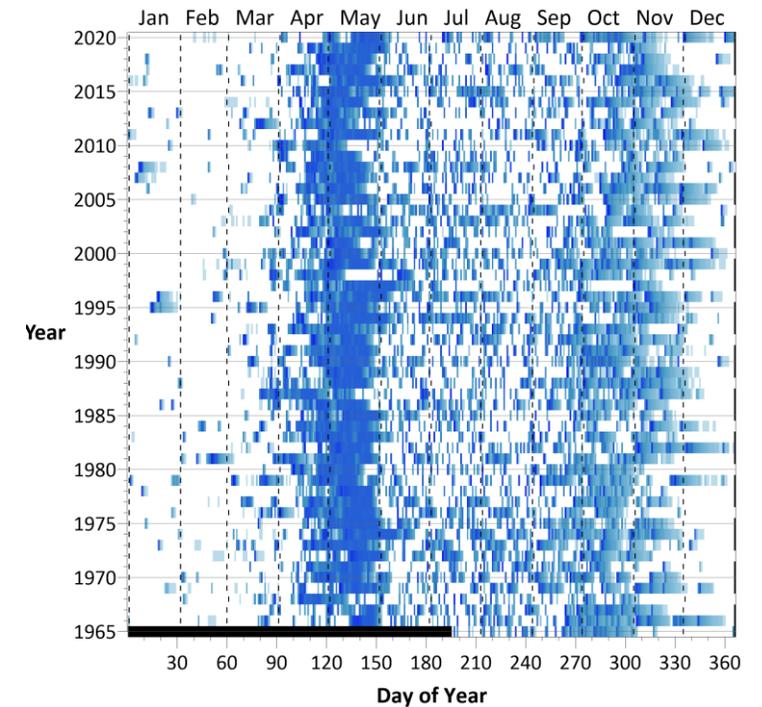
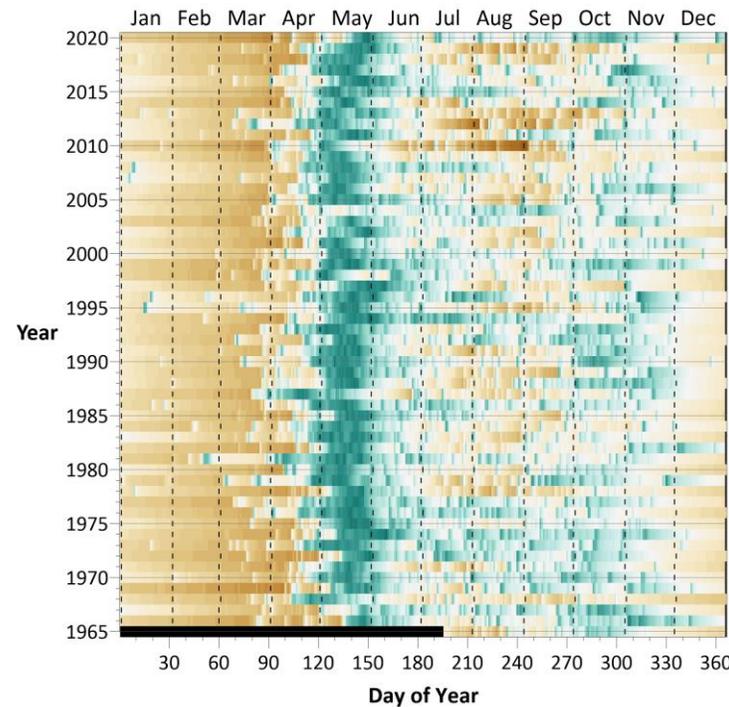
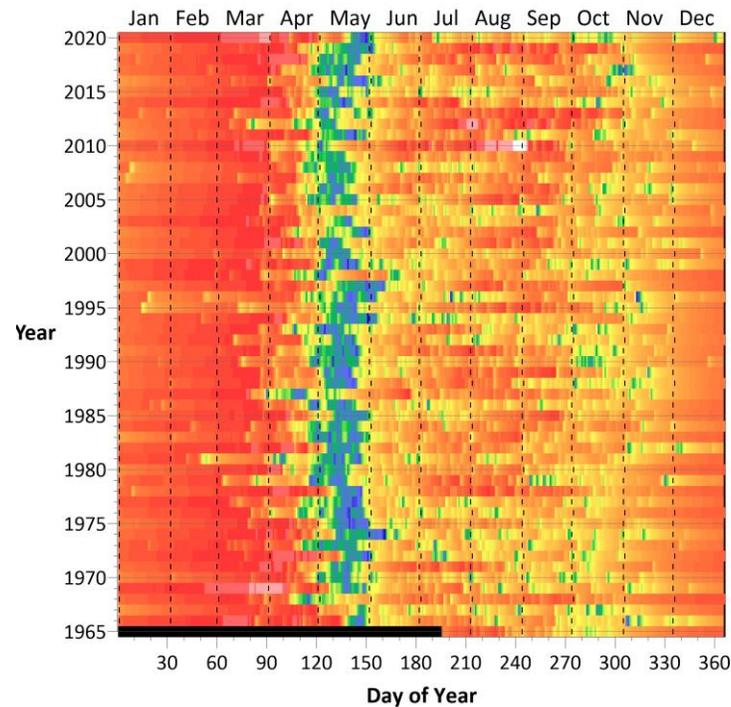
Image comparison slider

<https://sway.office.com/7eJdUkvts5E2DLSS?ref=Link>

1

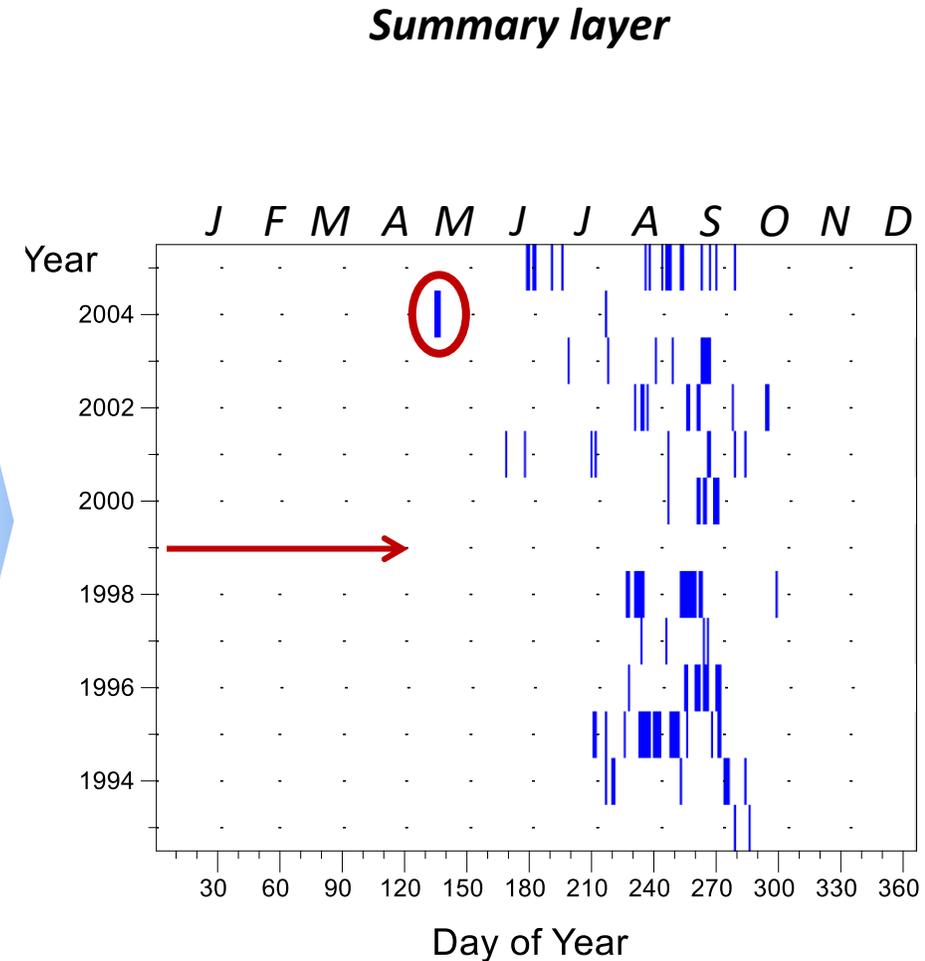
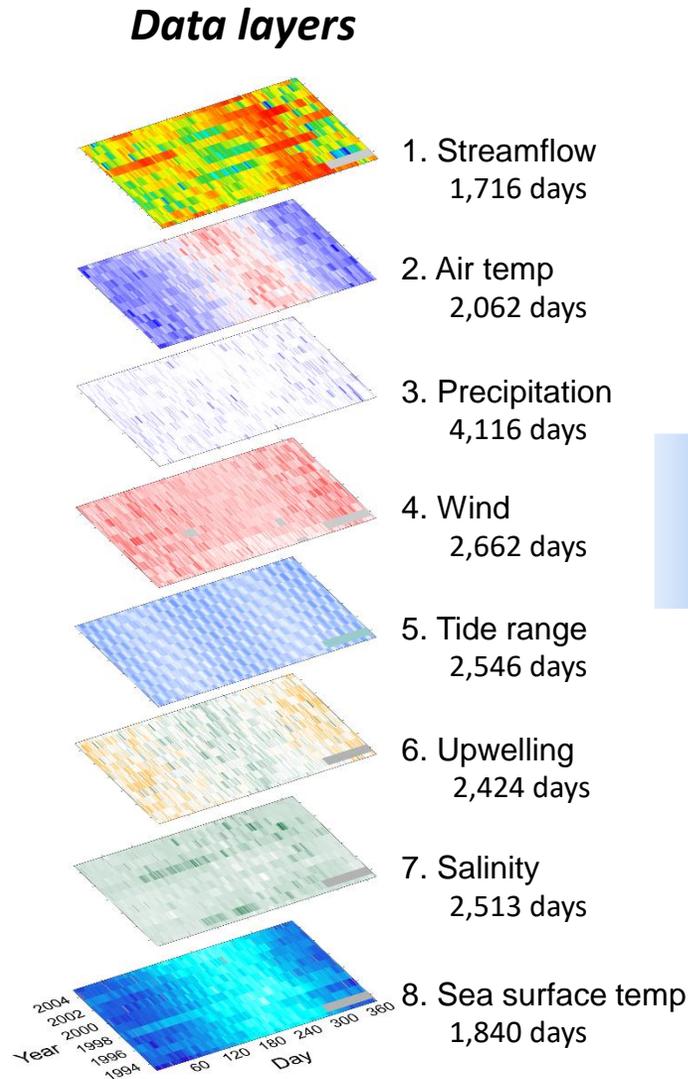
2

3



Workflow example - criteria analysis

1. Define criteria
Criterion for each layer
2. Apply binary filter
1 = meets
0 = does not meet
3. Grid math
Sum all filtered layers
4. Summary layer results
Show only days with 8 factors



Source
19,879 days

Results
126 days

Summary

- Status quo = limiting
- New data visualization = new options
- Standardization = new analysis techniques
 - Slider, criteria-threshold analysis
- New type of “GIS”

“The application of GIS is limited only by the imagination of those who use it.”

Jack Dangermond



Thank you!

Questions?



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