A three-dimensional integrated hydrologic model of the Chesapeake Bay Watershed using High Performance Computing

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I. Study area and goals

- Goal is to quantify groundwater stores and fluxes within the Chesapeake Bay Watershed.
- We used a 3D integrated, distributed hydrologic model at high resolution.

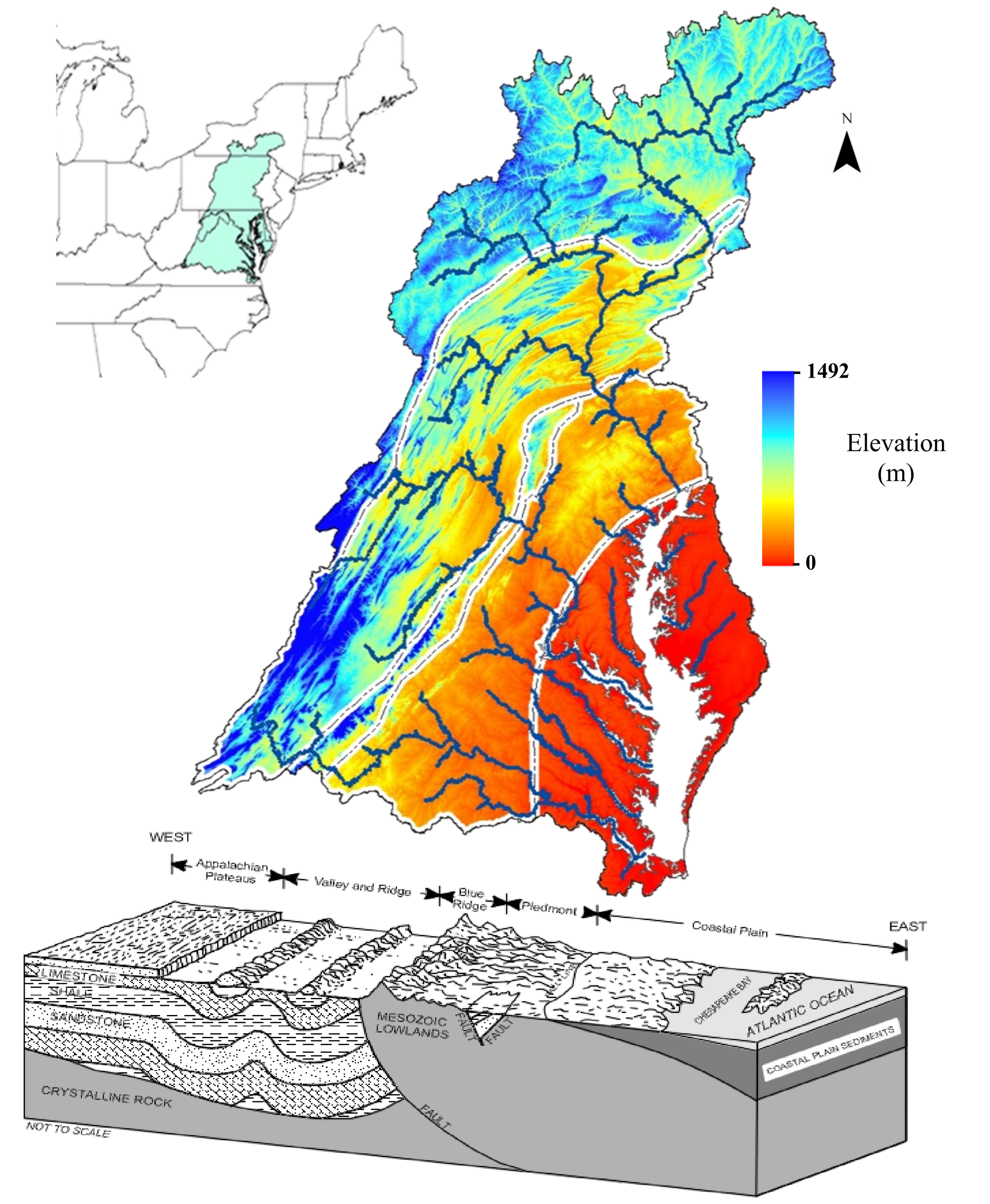

Figure 1. Chesapeake Bay watershed : location, land surface elevation and physiographic provinces[1, 2]

- Study area : 164,000 km^2 watershed
  - Five physiographic provinces
  - Population :16 million

II. Model design and inputs

- Area : 374,976 km^2
- Depth : 500 m
- $\Delta x = \Delta y = 2000$ m
- $\Delta z = 5$m

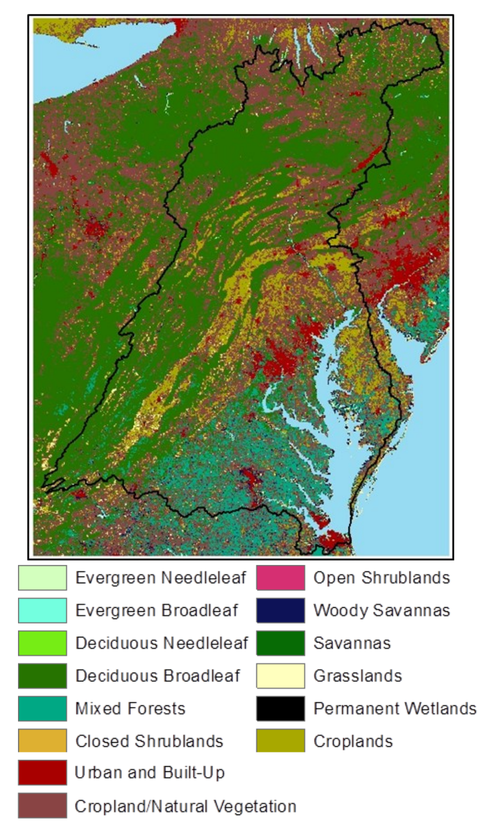

Figure 2. Land cover map

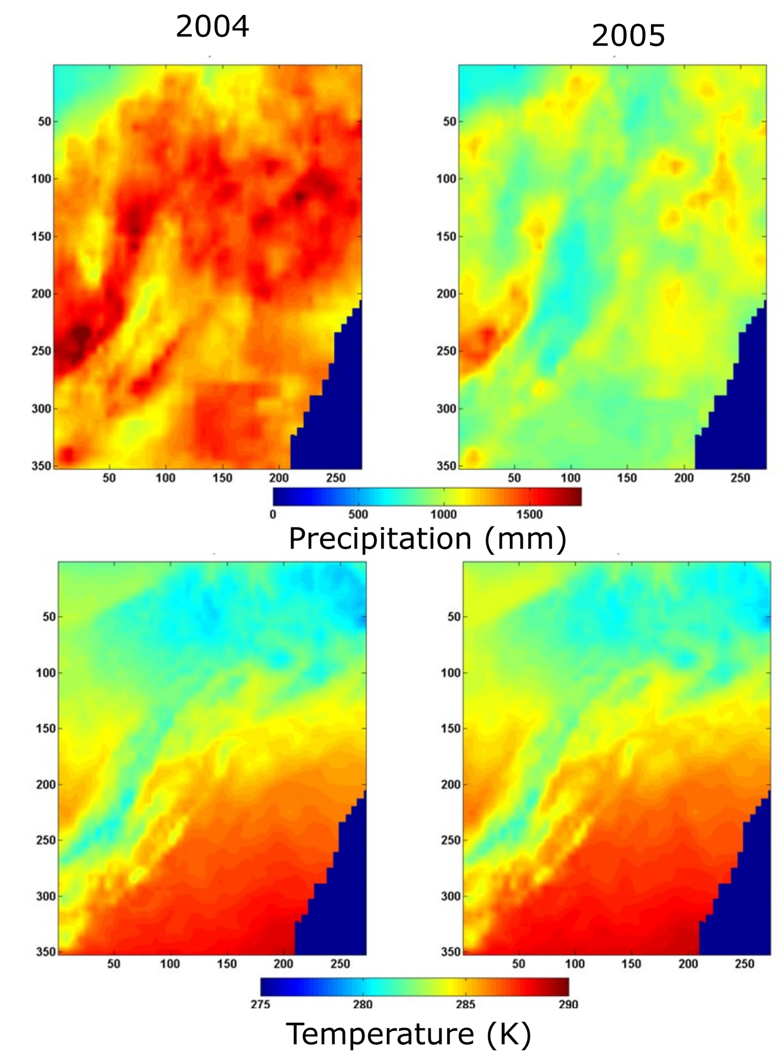

Figure 3. Cumulative precipitation (mm) and average temperature (K)

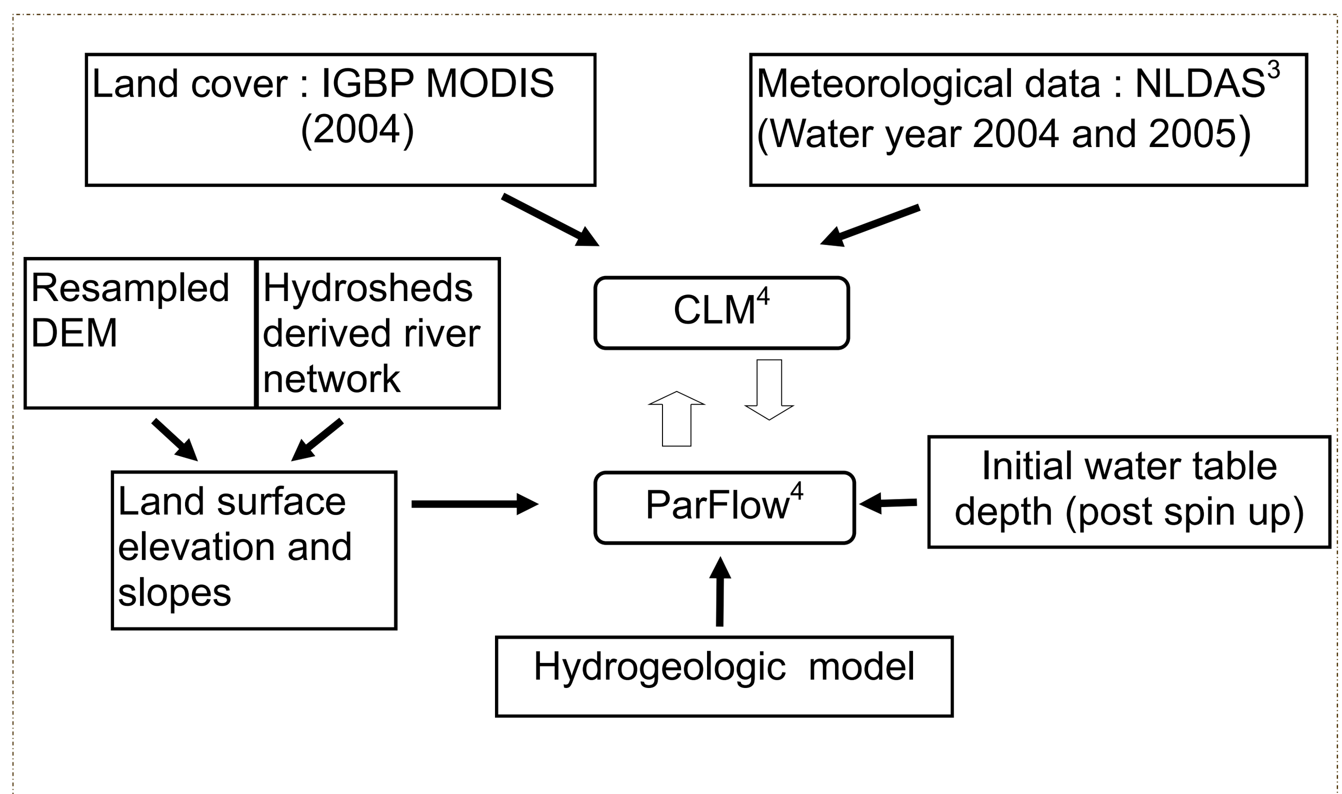

Figure 4. Model[3] and inputs

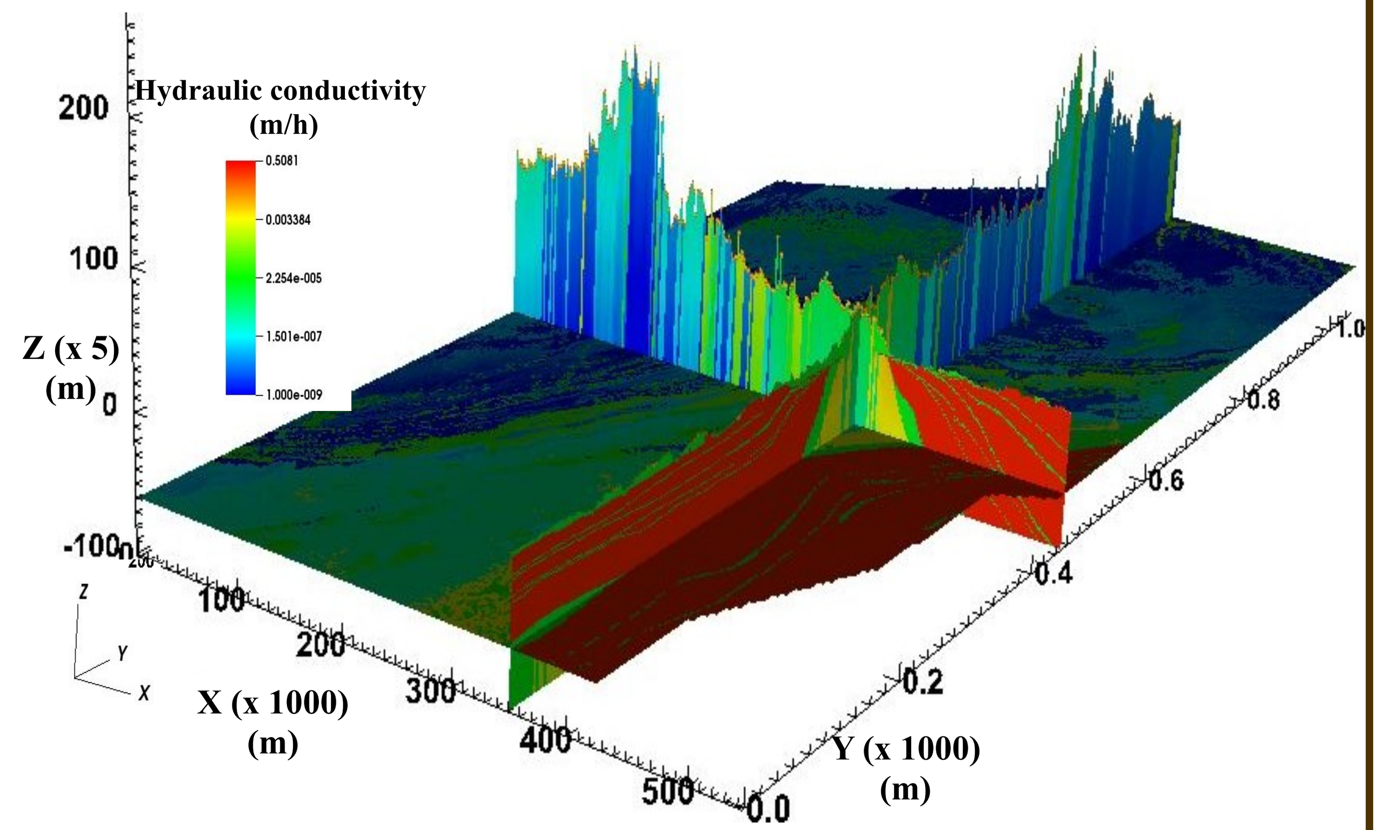

Figure 4. Model hydraulic conductivity field[5]

III. Results

(1) Spatial variability in model outputs is consistent with topography, hydrogeologic setting, land cover and meteorological input.

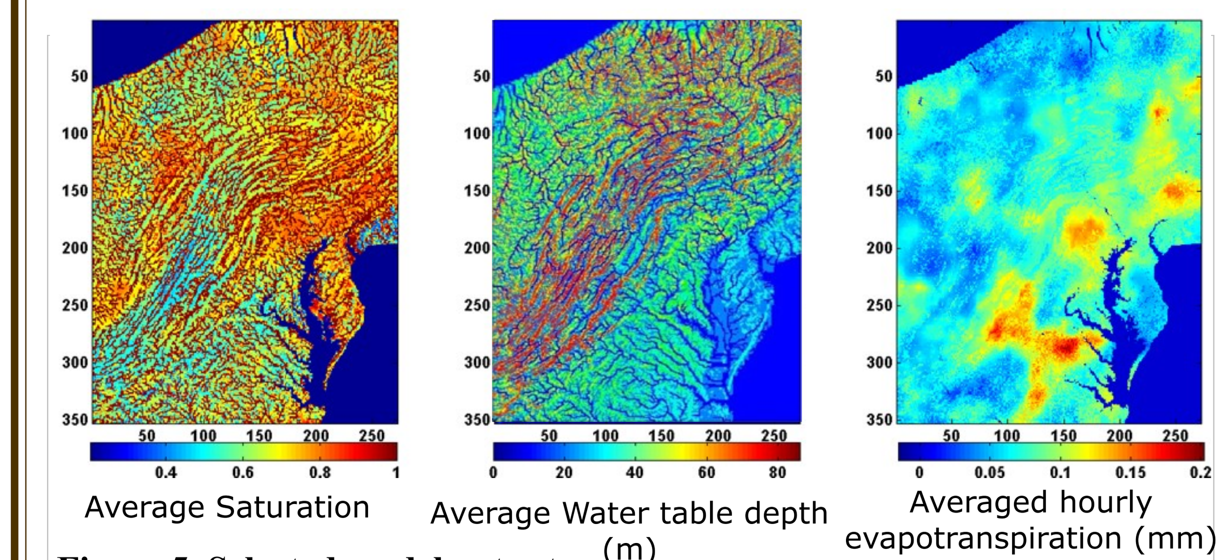

Figure 5. Selected model outputs

(2) Model depicts inter-annual variability in water fluxes with notably higher values in the year 2004 due to the occurrence of main rainfall events during that summer.

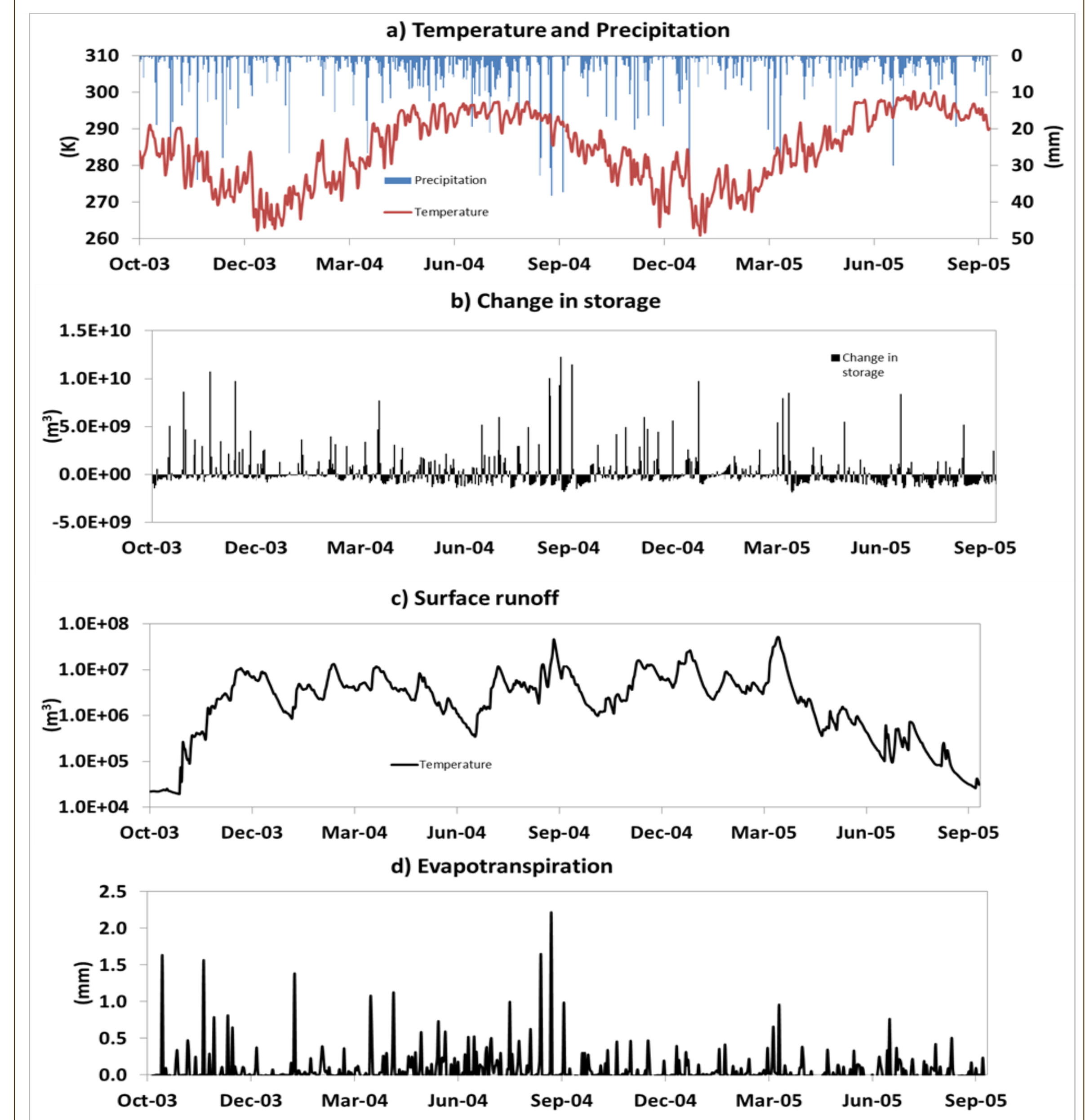

Figure 6. Basin averaged water fluxes

Year	Temp.	Precip.	Evap.		Surface runoff	Groundwater discharge	Groundwater recharge
	(C)	(mm)	(mm)	(%)	(m^3/day)	(m^3/day)	(m^3/day)
2004	14.1	1325	776	58.6	4.33E+06	9.67E+07	1.07E+08
2005	14.6	973	337	34.5	4.75E+06	1.02E+08	9.25E+07

(3) Groundwater stores vary significantly between the Coastal Plain and other provinces. Stores are mainly dictated by topography in provinces underlain by consolidated rocks. Groundwater in these provinces is mostly (60 to 75%) stored within 100m of the land surface. On the edge of the Coastal Plain province, almost all groundwater is stored within the top 100 m.

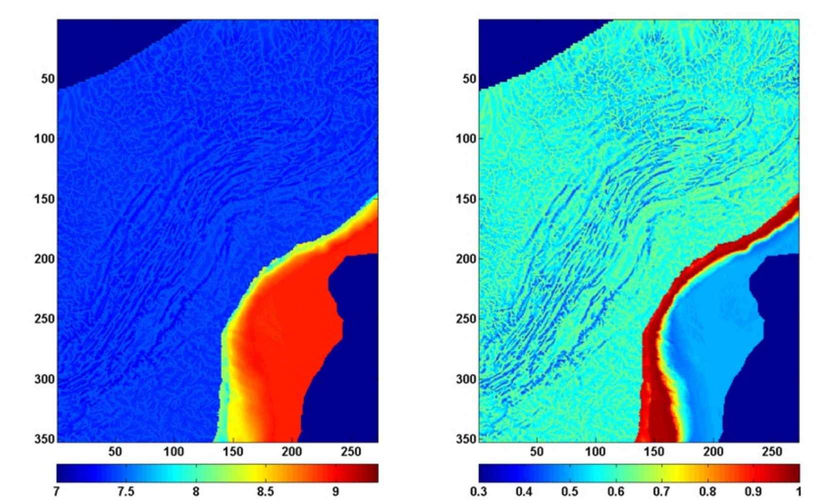

Figure 7. Groundwater storage (left panel) and groundwater storage in top 100 m of subsurface medium (right panel)

(4) Spatial patterns of seasonal groundwater storage changes appear to be mainly driven by climate.

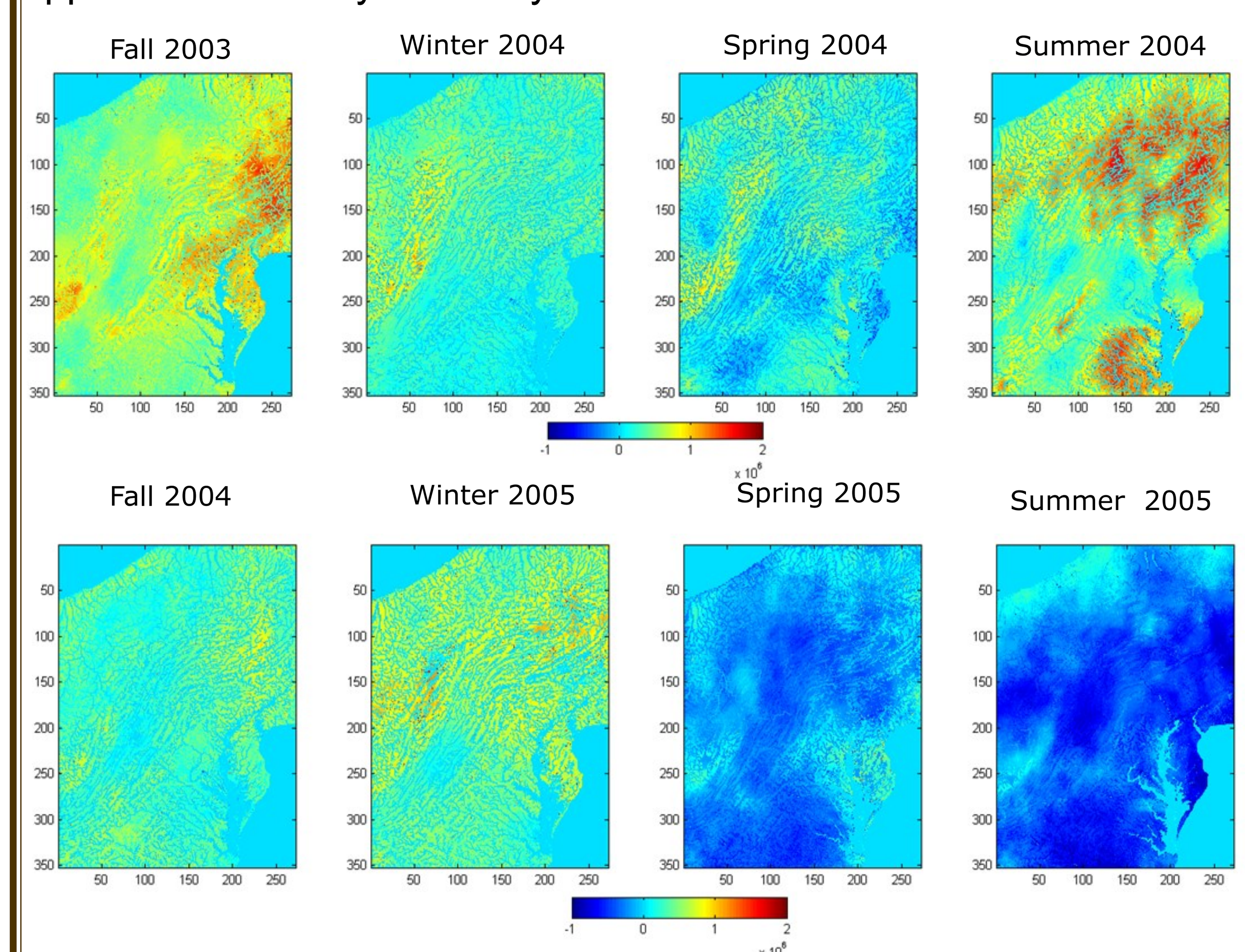

Figure 8. Seasonal groundwater storage changes (m^3)

(5) Similar groundwater recharge and discharge rates are observed for different physiographic provinces.

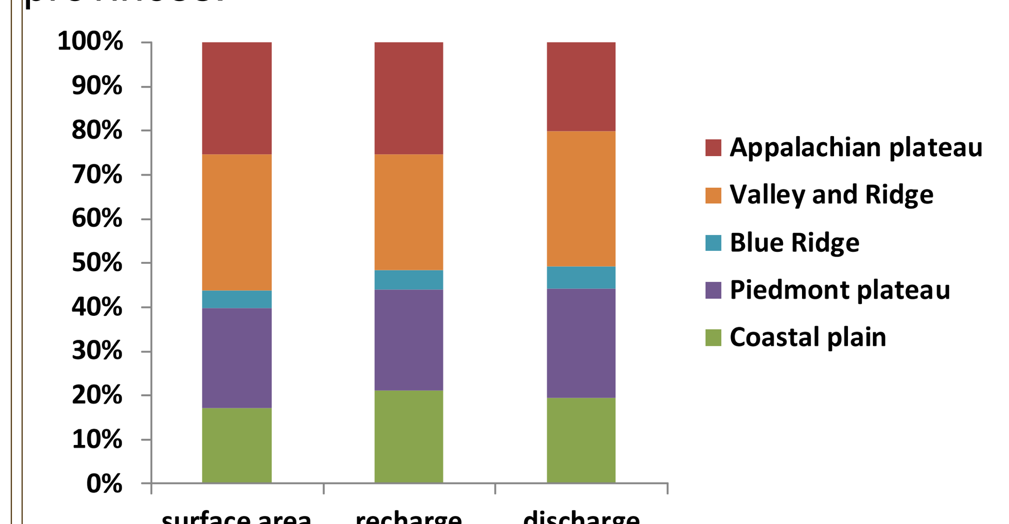

Figure 9. Percentage of groundwater recharge and discharge by physiographic province

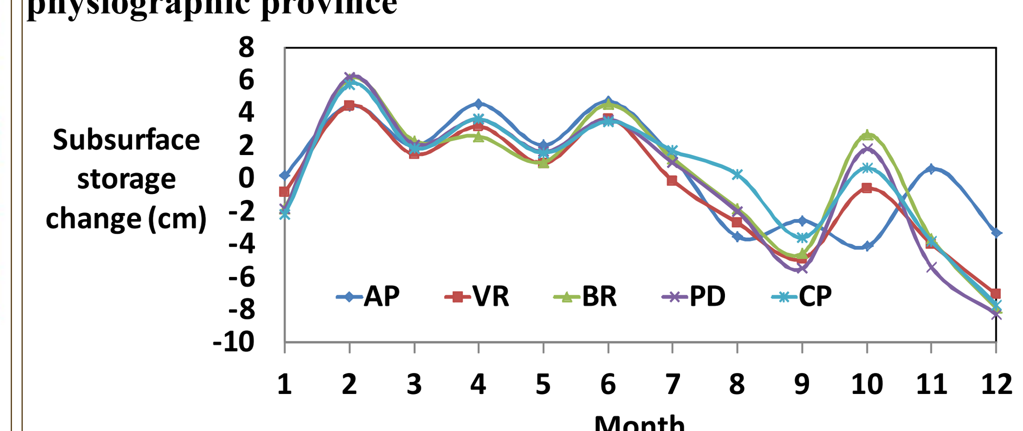

Figure 10. Averaged monthly groundwater storage changes (cm)

References

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