The Appalachian Water Tower:

The role of mountain catchments in regional water security

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Water cycle intensification

Climate catastrophes in the US 1980 - June 2012

- Meteorological events (storms)
- Hydrological events (flooding, landslides)
- Climatic events (temperature extremes, drought, forest fires)

*January - June 2012

Source: Manish Re, GeoRisk Research, NatCatSERVICE, August 2012 © DW

Air temperature (°C)

Water vapor pressure (kPa)
21st Century Precipitation & Aridity

Precipitation changes (%)

‘Moderate’ (RCP 4.5)

“High” (RCP 8.5)

Appalachian Mountains

Mountains as water towers – complex terrain & elevation

Important source of freshwater
• Potomac River provides Washington D.C. with 90% of its water;
• Ohio River upstream of Cincinnati provides water to 10 million people alone;

History of flooding & pollution
• Impacts to ecosystems, communities, economies
How sensitive are Appalachian Mountain ecosystems to change and what are implications of change for fresh water ecosystem services?

How vulnerable are Appalachian Mountain communities and what are implications of change for regional water security?

What role does Appalachian water play in the local, regional, & global economy?
Appalachian Freshwater Initiative

A few AFI projects...

Do-It-Yourself (DIY) Environmental Sensors
For STEM educators, community members, and researchers an inexpensive monitoring platform

AFI DIY Environmental Sensor Workshop (March 2018)

Region-wide climate & water data for researchers, educators, & decision makers (data development & workshops (upcoming))

Community & ecosystem vulnerability to floods & droughts
Appalachian Freshwater Initiative

Climate & water resources data for decision making

Appalachian region... and beyond

Dataset attributes

- Daily, 4-km (2.5 mile) gridded datasets
- **Climate:**
  - Precip., air temp., evaporation, wind speed/direction, humidity, radiation, aridity
- **Hydrology using VIC land surface model:**
  - Runoff & streamflow
  - Evapotranspiration
  - Storage (groundwater & soil moisture)
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Historic climate & water - 1950-2005

Future Scenarios (2006-2099):
• Based on Intergovernmental Panel on Climate Change (IPCC)

Future Scenarios (2006-2099):
- RCP4.5 (‘moderate’ scenario)
- RCP8.5 (‘high’ scenario)

17 different General Circulation Models (GCMs) (CMIP5 -Taylor et al. 2010)

• Use future climate to model future water resources availability throughout region
Quantifying the Appalachian Water Tower

Asking questions like “Where in the watershed is runoff available to downstream economies being generated?”

Relative Water Yield – Proportion of each grid to total water supply available downstream

\[ RW_i = \frac{q_i}{Q_{total}} \]

For example – Where is Pittsburgh’s Mon River water supply coming from?

Mountain grids in WV provide a larger proportion of Pittsburgh’s Mon River water supply
Quantifying the Appalachian Water Tower

and “What is the importance of each mountain cell for water used by downstream economies after accounting for water withdrawal along the way?”

Water Resource Contribution

\[ \frac{\text{Downstream}}{\text{Upstream}} = \frac{(\text{water supply}_i - \text{water use}_i)}{(\text{water supply}_i - \text{water use}_i)} \]

Gridded runoff

Gridded consumption
Quantifying the Appalachian Water Tower

**Water Resource Contribution** –

-1: lowland deficit which cannot be satisfied by upstream water

-1-0: lowland deficit which can be satisfied by upstream water

0-1: lowland surplus which can be satisfied by upstream water

≥ 1: lowland surplus

Water needed from other sources

Mountain water is essential to downstream users

Mountain water is not essential to downstream users

Lowland water surplus > mountain water

For example – What role does the WV proportion of the Mon. River watershed play in Pittsburgh’s water supply?

Vivirolo et al., 2017, *WRR*
Quantifying the Appalachian Water Tower

West Virginia: -0.9
-1-o: lowland deficit which can be satisfied by upstream water
Mountain water is essential to downstream users

Maryland: -9.5
≤ -1: lowland deficit which cannot be satisfied by upstream water
Water needed from other sources

On-going development:
- Grid scale WRC to identify specific
- Couple to economic production data & virtual water flows
- Decision support for restoration, conservation, & management
Implications for the Energy-Water Nexus

22,192,400 gal/day
or
33 Olympic pools

8.1 billion gal/year

Kearns, et al., In development