Probabilistic links between meteorological and hydrological droughts from a threedimensional perspective

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1

Outline







An approach for linking meteorological and hydrological droughts



Propagation characteristics and probabilistic links



Conclusions (main findings)

Drought propagation in lower spaces



Reducing drought analysis into lower subspaces, e.g., analyzing the time series of drought indices for individual sites or area-averaged hydro-meteorological variables, or investigating the spatial pattern of drought for a specific time period.

Van Loon, A. F. (2015). Hydrological drought explained. Wiley Interdisciplinary Reviews: Water, 2(4), 359-392.



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- Pooling: meteorological droughts are combined into a prolonged hydrological drought
- Attenuation: meteorological droughts are attenuated in the stores
- Lagging: a lag occurs between meteorological, soil moisture, and hydrological drought
- Lengthening: droughts get longer moving from meteorological to soil moisture to hydrological drought

Query: Drought characterization includes duration, area, severity related issues and should be a spatiotemporal topic having the time-latitude-longitude dimensions. What is the propagation features in the three dimensions?

Study area and data



- Area: $79.5*10^4$ km²;
- Mean Temperature:4~14°C
- precipitation has significant seasonlity
- covering four climate zones(arid, semiarid, semihumidand humid zones) fromnorthwest to southeast

Spatial distribution of elevation (digital elevation model, DEM) and hydrometeorological stations in the Yellow River basin (YRB)

Input data for the variable infiltration capacity (VIC) model:

- daily meteorological variables from 101 national meteorological stations during 1961-2012
- daily streamflow from 10 hydrological stations during 1961-2012
- geographic information: elevation, land cover, and soil images



Grid-based hydrological variables were used for calculating SPEI and SRI.

Model setup:

- Time step: 24 hours
- Spatial resolution: 0.25°
- Calibration:1961-1990
- Validation: 1991-2012
- Evaluation coefficients: NSE, BIAS



Drought propagation in three dimensions



Drought identification in three dimensions



Grid points with SPEI/SRI values below -1 are classfied into different drought patches through a spatial clustering method

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A temporal connection is used to determine the link between drought patches in two adjacent months

Drought characteristics in three dimensions



Linking meteorological and hydrological drought events





Main steps:

Sorting meteorological and hydrological drought events
Judging the spatiotemporal overlaps between two drought types.
Integrating linked

meteorological and hydrological drought events and classifying their relationship

An example of paired drought events



New features of drought propagation

"Joint" effect:Several meteorological droughts collectively trigger one hydrological drought event



Decomposed" effect: One meteorological drought event induces several hydrological droughts in different regions in sequence



New features of drought propagation



Probabilsitic links between two drought types

The copula function was employed to establish the links between the characteristics (duration, area, and severity) of two drought types. Meanwhile, the predictive information of hydrological drought characteristics could be acquired through the conditional probabilistic distribution of a given meteorological drought characteristic



13

Probabilsitic links between two drought types

probability distributions of hydrological drought characteristics conditioned on meteorological drought

Evaluation on the stability of the conditional distribution model for hydrological drought prediction



Main findings

- In the three dimensions, the phenomena of lengthened duration, lagged response time, and attenuated drought severity are observed from meteorological to hydrological droughts, which is in accordance with previous studies. Besides, drought area is also attenuated during this process, especially in the arid southwest parts of YRB after 1998. The enlarged role of PET in meteorological drought development is one reason, where increased evaporative demand aggravates the meteorological dry circumstance, but does not necessarily cause a hydrological response.
- When using the copula based function to establish the links between the two drought types, the incorporation of typical mega-drought events with long persistence and wide spatial extent is more important for the stability of the constructed relationship comparing to the length of data sample.

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Thank You!

