On the meteorological drought propagation into the hydrological system in Central Italy

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Mediterranean droughts



Avanzi (Cima Research Foundation)



Hydrological drought and the basin water balance



ET -> modulated by bio-geophysical (i.e., vegetation), physical (i.e., radiation) and climate mechanisms (see Massari et al. 2022, HESS)

DS -> basin characteristics like lithology and soil, external groundwater carryover (see Bruno et al. 2022, AWR)

How catchments respond to multi-year drought periods?

Catchments show a runoff exacerbation not expected by the precipitation deficit that was not predicted by hydrological models





(1)

Evaporation enhancement during multi-year drought



Basins showing shift in the water balance are subjected to evaporation enhancment during periods of multi-year drought.



An experiment over 102 catchments across various hydro-climatological regimes in Italy



Resolving the water balance across Mediterranean with a LSM





10.1029/2010JD015140

Niu

et a

201

Central Italy (19 basins A<2000km²) No calibration



NOAH-MP 3.6 MODEL SETUP

- spatial resolution: 1 km
- study period: 2010-2021 (to be extended)
- land cover: PROBA-V 2015 from Copernicus Global Land service website
- **soil texture**: Harmonized World Soil Database
- runoff and groundwater: Biosphere-Atmosphere Transfer Scheme (BATS) runoff scheme (Yang and Dickinson, 1996 - <u>10.1)016/0921-8181(95)00041-0</u>)
- forcing: ERA-5



Drought in Tevere River - Central Italy



How do classical drought indices to monitor hydrological droughts work?



Standardized streamflow index suggests that 2017 is not really exceptional as SPEI suggests

Summer 2019-2020 mild droughts led to not expected hydrological droughts

SPEI12 suboptimal to represent the hydrological drought

Let's take a look at the Noah-MP water balance components



Runoff anomalies during prolonged mild droughts can be similar to single and severe dry years



How meteorological drought has been propagated in the hydrological system?



Intensification Attenuation





LAI anomalies



Noah-MP vs observations



Observed LAI anomalies smoother than the Noah-MP LAI anomalies (source of plant water probably deeper?). Test the new Noah-MP dynamic root water uptake with Dr. Guo-Yue Niu soon.

Take home message

- 1. Hydrological drought too complex to be correctly represented by classical drought indices across the Mediterranean region?
- 2. Noah-MP satisfactorily represents the hydrological drought across the Mediterranean
- 3. Drought propagation across Mediterranean basins depends on the interplay of basin storage and evaporation (can be different from basin to basin). Noah-MP not always optimal in simulating vegetation (this has implications for hydrological droughts)
- Prolonged mild meteorological droughts can be equally severe as single severe drought years





From Meteorological to hydrological Drought (Drought 2022 in Europe)



Figure 5: fAPAR anomaly - beginning of August 2022.

ERA5 data

Toreti et al. (2022, Drought in Europe August

What about vegetation activity?



Does vegetation use water from deeper soil/shallow groundwater? (ET and vegetation over-coupled with soil moisture)

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