Hydrol. Earth Syst. Sci. Discuss., 9, C6419–C6422, 2013
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Hydrology and Earth System Sciences Discussions

Interactive comment on "Drought risk assessments of water resources systems under climate change: a case study in Southern Taiwan" *by* T. C. Yang et al.

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Received and published: 21 January 2013

General: The paper addresses an important and interesting topic: evaluating a number of drought indexes, using a case study in Taiwan of a watershed with a central reservoir that is used to provide water supply for agriculture (the majority), urban and industrial consumers. The reservoir input depends on climatic and meteorological variables, and the reservoir is operated according to rule curves. Three composite drought indexes that combine measures of reliability, resilience and vulnerability are tested: (1) Drought Risk Index (DRI), Sustainability Index (SUI) and MSUI (a Modified SUI).

The response of these indexes to four explanatory variables is tested (Figure 5): evapo-

ration, demand, reservoir storage capacity, inflow using historical and GCM forecasted data. The authors conclude (on the basis of requiring the index to respond monotonically to each of these explanatory variables) that DRI and MSUI meet this criterion.

I have inserted comments into the text, some of which may be repeated in this review.

Specific Comments

- The paper requires careful attention to issues of language. Some examples (skipping the 12 from the page numbers, for brevity): o Page 396, line 16: ". . . which makes a big challenge on water supply and allocation.." o Page 396, line 20: ". . . climate change causes that the atmospheric temperature and sea surface temperature increase." o Page 397, line 8: " may increase obviously in the future, which let Southern Taiwan have to face the possible water shortage and make a big challenge to the authorities of reservoir on water supply and allocation." o Page 397, line 13: ". . . which makes the wet and dry seasons obviously distinct in the area." o Page 403, lines 10-14: The term "discount" is not explained nor are the values of A1-B2 given. It can be assumed that these terms mean "reduction factor" of the value of the demand when the reservoir level is in certain zones. But: are these substantial reduction factors, which would be anticipatory and reduce the demands before a shortfall occurs? o And many more. - The authors state that: the Drought Risk index (DRI, Zongxue et al., 1998) and Sustainability Index (SUI, Loucks 1997) summarize/integrate three performance parameters of water management in a meaningful manner: reliability, resilience and vulnerability. They add the MSUI index (pages 12406-7) as a third index, and end up (page 12414, Section 5) recommending MSUI as the "best". - The authors want to capture "duration, number and severity" of droughts (page 12398), and set out to evaluate the "value" of the three indexes in characterizing these measures of the droughts, using four "explanatory variables": evaporation, demand, storage capacity, inflow (Figure 5). - Tsengwen watershed and reservoir are used as a case study: capacity 7,800 MCM, "the reservoir encloses" 481 km2 (is this the reservoir area or the watershed area?), precipitation 2740 mm/year. The demands are agriculture, industry, public supply (Figure 3, with

HESSD

9, C6419–C6422, 2013

agriculture being the greatly dominant demand). - It is stated that there are also considerations of flood control and hydropower (Section 2), but these do not appear at all in the rest of the paper (so why mention them?). - Total supply is 1,047 million tons (1,047 mcm‘ using tons is unusual). Is this the average demand or an actual average supply to meet the demands? Figure 5 shows the demands but the actual supply is now shown. - The paper uses units that are either not common or not internally consistent in the paper: tons of water; 10-day periods (Figures 3, 8, 12); monthly volumes (Figures 4, 9, 10, 11). This makes the reading difficult, as the reader must adjust to these different units in order to compare results. - 7 out of 24 GCMs were available, on a 25x25 km grid, but only A1B was used in the study, for daily precipitation: Markov chain using Richardson (1981) model, with many (8-9) PDFs, an autoregressive temperature generator, and a modified HBV model used for hydrology. Some results are shown for the 7 GCMs and for their ensemble (e.g., Fig. 10). - Daily inflows were routed through the reservoir with given water demands for domestic, industrial + agriculture, according to rule curves. The rule curves do not show any anticipatory ability or optimization. There are two operational zones on both sides of a "middle" curve, plus overflow and low limit lines. - Agriculture demands the vast majority of the supply with very large variability over the year (Fig. 3) between 5 mcm (and even 0) and 40 mcm per 10-day period. - The performance indexes: reliability, resilience and vulnerability are defined in section 3.4.1. - The composite indexes DRI, SUI and MSUI are defined in section 3.4.2. - The inflow "adjustment" in section 4.4 and especially 4.4.2 seem completely artificial, motivated to generate a desired result, justified only by the ratio of forecasted future precipitation relative to the historical value (page 12410). - MSUI is found/considered/recommended as the most appropriate (combined) index (Page 12414)

Evaluation of the methodology and the paper: - The justification for selecting MSUI as the most appropriate index is not fully convincing. Using a monotonic response of the index to explanatory variables must be justified (a) Why select these particular explanatory variables: evaporation, storage volume, demand, inflow? (b) Why, for

HESSD

9, C6419–C6422, 2013

example, not combine inflow and evaporation into "net water input to the reservoir"? They act in the same sense (Figure 5, for DRI and especially MSUI) namely more inflow and less evaporation (the reverse of the top graph) produce the same form of the response of the index? (c) Isn't it obvious that indexes that define drought must increase with demand and decrease with storage and inflow? - The reservoir is operated with fixed rule curves, i.e. there is no optimization that would/could be anticipatory and change the supply in view of forecasted future inflows and/or reservoir state. This task (of anticipating shortage) seems to be provided by the coefficients A1-B2 (page 12403), but there is no information that would explain how "clever" and "influential" these operational coefficients are. The drought indexes obviously depend on these coefficients and the supply is curtailed by them. But this does not appear in the results nor in the explanations. - This operation with fixed rule curves plus (unspecified) discount (reduction) factors is particularly deficient when one has a hydrological forecasting mechanism built into the system.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/9/C6419/2013/hessd-9-C6419-2013-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 12395, 2012.