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Evaluating Validity of Bouchet-Morton Complementary Relationship at Regional Scale through Terrestrial Evapotranspiration derived using Remote Sensing Platform and Land Surface Models

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Evapotranspiration is one of the most important components of the terrestrial hydrological cycle, which depicts atmospheric water demand and accounts for loss of more than 60% land-surface precipitation globally. Decrease in potential/reference evapotranspiration (ET_p), despite significant increase in near-surface air temperature is reported at many locations across the world in the recent decades. This counter-intuitive phenomenon known as evaporation-paradox could be attributed to decrease in net solar radiation and/or wind speed and/or increase in terrestrial evapotranspiration (ET_a). Gaining insight into evaporation-paradox requires understanding complex interaction between land-plant-atmosphere systems. Bouchet–Morton complementary relationship (CR) hypothesizes that at regional scale there exists a feedback mechanism between ET_a and ET_p for homogeneous surfaces having low advection of heat and moisture. It postulates that increase in regional ET_a consumes energy thereby cooling and humidifying the overpassing air, which would result in reduction of regional ET_p. Similarly, available excess energy which is not used for evapotranspiration (due to decrease in regional ET_a) would result in an increase of regional ET_p through warming and drying of the atmosphere. Recent improvements in remote sensing technology provide scope to quantify ET_a and use it for evaluating validity of CR at regional scale to discern the possible cause for evaporation-paradox. If the CR is valid for a region, models could be developed to estimate regional ET_a using ET_p estimated using regional values of its predictor hydro-climate variables. Prior studies on Indian subcontinent found evidence of evaporation-paradox at various sites scattered widely in space. But there is lack of attempts to establish existence of the paradox at regional scale and discern possible cause(s) for the same. In this backdrop, research is envisaged to (i) form homogeneous ET_a and ET_p regions in India using a novel dynamic fuzzy clustering approach, (ii) investigate existence of evaporation-paradox in each of those regions, and (iii) identify validity of CR and discern possible cause(s) for the paradox, if evident. ET_a is typically estimated from eddy covariance flux towers, remote sensing techniques, or computed from land surface models which often suffer from limitations of scale and data. Uncertainty arising due to the use of (i) two different hydro-climate re-analysis datasets for ET_p estimation, and (ii) one remote sensing based and three land surface model derived ET_a products is assessed. The dynamic clustering approach yielded 18 homogeneous ET_p regions and 30 homogeneous ET_a regions in India. The role of CR on evaporation-paradox was evident in eight regions. The effect of vegetation and climate on CR is studied at regional scale using NDVI (normalized difference vegetation index). In addition, existence of CR hypotheses is verified in 405 major river basins of different sizes located in diverse climate regions across the globe using combination of several model derived and remotely sensed ET_a and ET_p datasets. This study is of significance, as evidence of the effect of location, vegetation and climate on CR at regional scale gives scope for developing region-specific models to arrive at ET_a estimates directly from ET_p which could be estimated/forecasted from hydro-climate variables.