From climate to crop: Conceptual and technical problems

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An important application of seasonal and long-term climate forecasting is the evaluation of impact on crop production. Numerous generic crop models having different complexity and data requirements are available, but their accuracy and practical utility is not always superior to that of empirical regression models. The choice of a more mechanistic or empirical approach depends on whether (1) extrapolation domains need to significantly exceed the range of available, historical scenarios; (2) effects of climate variation on the crop and cropping system are expected to be readily mitigated by technical adaptation, either in tactical (within-season) or strategic terms (long term); and (3) the modelling exercise is supposed to enable agronomic recommendations.

In the case of agricultural impact analyses for PROMISE climate scenarios in the Sahel, the targeted system is known for its high tactical responsiveness (e.g., sowing date and choice of photoperiod sensitive or insensitive variety). The main potential "client" is Agrhymet, a public institution doing regional, seasonal yield forecasts that serve to issue timely drought warnings, and that may in the future also enable technical recommendations to producers.

This particular case therefore requires a more generic, mechanistic crop model such as SARRAH, developed under PROMISE and calibrated, validated and evaluated for millet and groundnut in Senegal. Subsequent sensitivity analyses served to (1) evaluate minimum climatic data requirements for accurate water balance, crop duration and yield simulations, (2) determine the temporal and spatial resolution of rainfall data needed to realistically simulate soil water storage, and (3) evaluate simulated climate by comparing hindcasts with historical data. Evaporative demand (e.g., PET using Penman) and rainfall were found to be the foremost climate variables, sufficient to accurately simulate field water balance, crop growth and yield whenever water was limiting. On N-S transects that included humid areas, however, solar radiation was also needed to accurately simulate yield variations in the upper range. Crop duration was very sensitive to T, and for semi-arid areas, even information on diurnal T amplitudes were needed to avoid simulation errors. (Of course, radiation and T are also needed to calculate PET.) By contrast, CO2 levels were not considered because of uncertainties on their physiological impact and their probable offset by changes in solar radiation and T. Rainfall data need to be daily in order to accurately estimate runoff, evaporation, infiltration and drainage fractions. Consequently, rainfall bulked large pixels needs to be dis-aggregated using special models. Regarding tactical adjustments crop systems, the impact of climate variation on yield depended significantly on decision rules for sowing. This, in conjunction with the choice among crops having different phenology, made climate impact on crop yields highly dependent on intra-seasonal rainfall distribution, a fact that needs to be considered in any future application for semi-arid environments.

Friday I (Keynote talk)