Editorial

Understanding climate change and climate variability

The Intergovernmental Panel on Climate Change (IPCC) has defined the term climate variability and climate change as "*Climate variability* refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events." While "*Climate change* refers to a change in the state of the climate identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer". Although the above definitions are qualitative in nature and distinguishes climate change from climate variability, the following example may make it simpler to understand. Suppose we have long-term meteorological data (rainfall and temperature) for any location and If we plot the data on the EXCEL sheet considering year in the X-axis and rainfall/temperature in the Y-axis, then we will see the data are oscillating in the scatter diagram. Now if we add the trend line and also plot the mean climate (average of considered period), then we notice that data of each year are oscillating around mean and trend lines either on or above or below the mean climate or positioned on or above or below the trend line. These year to year changed values or oscillations are term as climate variability / noise, whereas in spite of climate variability or noise present in the data, there is clear cut either increasing or decreasing trends present in the data which is technically called as climate change signal or simply a climate change. In general, to get climate change information we must have long-term data which have year to year fluctuations or noise / variability and in spite of noise there exists a clear cut changing signal or trends which may either increasing or decreasing. Therefore, the climate variability is a short term change of the state of climatic condition while climate change is the indication of the change of the mean state of the climatic condition and normally assumed to be at least 30 years according to World Meteorological Organization (WMO).

Climate change impact studies

The common practices of the scientists to deal with implication of climate change on crop production are:

1. Collect the meteorological data particularly rainfall and temperature (daily maximum and minimum) or daily sunshine duration and collection some historical yield data and conclude that the weather has some influence on yield.

2. Some studies used to assess how crop production will change under future climate changed conditions using crop simulation models. To run crop simulation models, most of the studies are using the outputs from different RCPs of GCMs available in the CMIP5.

    The results provided by these studies are not accurate and contains huge uncertainties because all the crop models are running for local scale or site / point location and use the climatic information from the GCMs simulation. It is warned many times that till today GCMs horizontal resolution are still not adequate to represent local scale climatic conditions properly because GCMs have huge biases and uncertainty to simulate local scale. Therefore, quantifying crop production using erroneous future climate change information as inputs to the crop simulation models, produce some erroneous yield under climate change condition. To overcome these problems, we have to first evaluate GCMs on the local scales using conventional statistical measures and select the best performing GCMs or RCMs for their study domain. Then make multi-model ensemble (MME) using selected GCMs instead of all available GCMs from CMIP5. Plot time series of reference data (station data or IMD gridded data) and MME of best performing models and note the biases and uncertainty exhibits in the models simulation and adjust models simulation through adding in case of underestimation and subtract in case of over estimation as preliminary attempts. On the other hands, several sophisticated downscaling techniques have emerged recently to eliminate the model biases and uncertainty at local scale for using as reliable inputs to the impact models like crop simulation models or hydrological models at basin scales. The interpolation of coarser scale GCMs simulation using different techniques provides high resolution information but lags new process induced information at local climate because interpolation is simply mathematical manipulation. Why climate in point location

varies is not properly understood or captured by the interpolated values. Why the climate varies from station to station is manifested through their observed records. Therefore establishing local scale climate (station record) with GCMs or RCMs outputs are emerging as a practice and technically called as "downscaling".

Now-a-days downscaling the GCMs outputs using model outputs statistics (MOS) and prefect prognosis (PP) approaches is very popular. In the MOS methods, only observation and model outputs are used to train the downscaling model. But in the PP methods, in addition to observation and model outputs, the multi-variable predictors of reanalysis data are also considered to develop the downscaling model. In the PP based approaches, selection of suitable predictor(s) and suitable predictor domain is very crucial to obtain better downscaling product for crop simulation models. Many researchers used dynamical downscaling products namely PRECIS or MarkSim GCMs (weather generator tools). These are also not advisable because these products are neither evaluated with the local observed climate and nor corrected their biases and reduced their uncertainty at the local scales. Therefore, it is strongly recommended that before using outputs from any GCMs, the following actions have to be incorporated for their impact analysis studies:

Ø   Multi-level stakeholders should have high resolution downscaled climate change information beforehand to implement any adaptation and mitigation option towards combating climate change at local level

Ø   To adequately assess the impact of climate change on agricultural sector, crop specific process based crop simulation models must be run using local scale downscaling information as inputs instead of raw GCMs to produce future productivity scenarios over each homogeneous zones of India

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