Weather and Climate Tools for Food Shocks Modeling

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Climate Resources Vary by Time Horizon

Ruane et al., in prep.
AgMERRA: Historical Climate Dataset for Agricultural Model Applications

Ruane et al., 2013

AgMERRA features:

- Improved solar radiation (NASA/GEWEX SRB)
- Improved precipitation variability (MERRA-land)
- Fine spatial patterns of rainfall from satellites
- An adjustment to diurnal temperature range
- Relative humidity at Tmax

AgMERRA better captures rainfall distribution and actual sequence of extreme events

Avg of Tmax and Tmin Biases (°C)

Precipitation Correlation (r)

Threat score for 1, 25, and 50mm precipitation events (%)

3
Uncertainty in Agro-climatic Simulation

Access to high quality weather data is major limitation

Rain-fed Maize Season
1980-2010
9 Climate forcing datasets
12 Crop models

Standard deviation of seasonal $T'$ (°C)
Coefficient of variation for seasonal $P'$ (%)

Coefficient of variation for Simulated Rainfed Maize Yields (%)

Ruane et al., in preparation
Outputs from AgMIP GGCMI Phase 1

[Image of world maps showing standard deviation of temperature anomalies and coefficient of variation of precipitation anomalies]
• **Climate information continues to improve**
  - most notably in regions with poor in situ coverage and for extreme events.

• **Crop models can be run for retrospective analyses and forecast mode**

1980 … 2016 -6 months -60 days -15 days **Present** +15 days +60 days +6 months

**Retrospective Climate Analyses**

Climate Forcing Datasets for Agriculture

- Archived by Climate-System Historical Forecast Project (CHFP)
- Archived by Subseasonal to Seasonal Project (S2S)
- Archived by THORPEX Interactive Grand Global Ensemble (TIGGE)

**Examples:**
- NCEP/NCAR Reanalysis
- MERRA-2, ERA-Interim, CFSR
- AgMERRA, WFD-EI, DayMet, CHIRPS, IMERG
Models enable use of Latest Probabilistic Weather & Climate Forecasting

- **Climate information continues to improve**
  - most notably in regions with poor in situ coverage and for extreme events.

- **Crop models can be run for retrospective analyses and forecast mode and in hindcast mode to enable probabilistic decision-support**

1980 … 2016 -3 months -60 days -15 days Present +15 days +60 days +3 months
Example of Forecast Horizon Use (Early-season Perspective)

Ames, Iowa Temperature forecasts (May 1\textsuperscript{st} perspective)

Ames, Iowa Precipitation forecasts (May 1\textsuperscript{st} perspective)
Ames, Iowa Temperature forecasts (Iterative perspective)

Ames, Iowa Precipitation forecasts (Iterative perspective)

Example of Forecast Horizon Use (Iterative Perspective)

How best to inform and utilize big data approaches?
Analysis of different climate and soil datasets
Winter Wheat Yield using DSSAT

Soilgrids - CHIRPS

Soilgrids - NOAA Stage IV QPE

Soilgrids - Mesonet - Nearest Neighbor

Soilgrids - Mesonet - Inverse Distance Weighting

Soilgrids - Mesonet - Regression Kriging

STATSGO2 - CHIRPS

STATSGO2 - NOAA Stage IV QPE

STATSGO2 - Mesonet - Nearest Neighbor

STATSGO2 - Mesonet - Inverse Distance Weighting

STATSGO2 - Mesonet - Regression Kriging

Alderman, Ruane, et al. (in preparation)
Lead time skill improvement
Medford, Oklahoma, hindcast for 1997 winter wheat

Alderman, Ruane, et al. (in preparation)
Projections of Global Mean Temperature Change

• Scenarios of the future depend upon:
  – new technologies
  – technology sharing
  – population
  – volcanoes
  – emissions controls

• Range of projected average temperature increase due more to the path we take than model disagreement

IPCC, 2013
Earth’s climate is warming and changing
We can identify patterns

(a)

RCP 2.6
Change in average surface temperature (1986–2005 to 2081–2100)

RCP 8.5

(°C)

-2 -1.5 -1 -0.5 0 0.5 1 1.5 2 3 4 5 7 9 11
Near-term and tail-end risk scenarios

Diourbel, Senegal probabilistic projections to 2050s factor in mean changes and internal variability

(work done in collaboration with Arthur Greene and James Chryssanthacopoulos)

Tools available to generate 1000s of climatological years in order to examine risk of extreme events:

- Weather generators
- Climate emulators
- Large-ensemble ESM simulations
How would 1988 drought have been different if it were:

- Wetter
- Warmer

Ruane et al., in preparation
Additional Weather/Climate Products for Food Shock Analysis
Additional Weather/Climate Products

- Direct climate-based crop yield estimators

- Large number of climate indices:
  - Drought and heat wave indices
    - Hot/dry for plants
    - Hot/humid for humans and livestock
  - Be careful to distinguish between:
    - Meteorological drought (precipitation deficit)
    - Agricultural drought (soil moisture deficit)
    - Hydrologic drought (water resources deficit)

- Inland flooding planning can utilize hydrologic models
  - New advances in convection-permitting atmospheric models

- Coastal flooding planning can utilize tropical storm and surge models
  - Dramatic improvement in recent decades