An Agriculture Module for CLM: CLM-AG

Arthur Gueneau, Adam Schlosser, Erwan Monier, Elodie Blanc,
Ken Strzepek and Xiang Gao

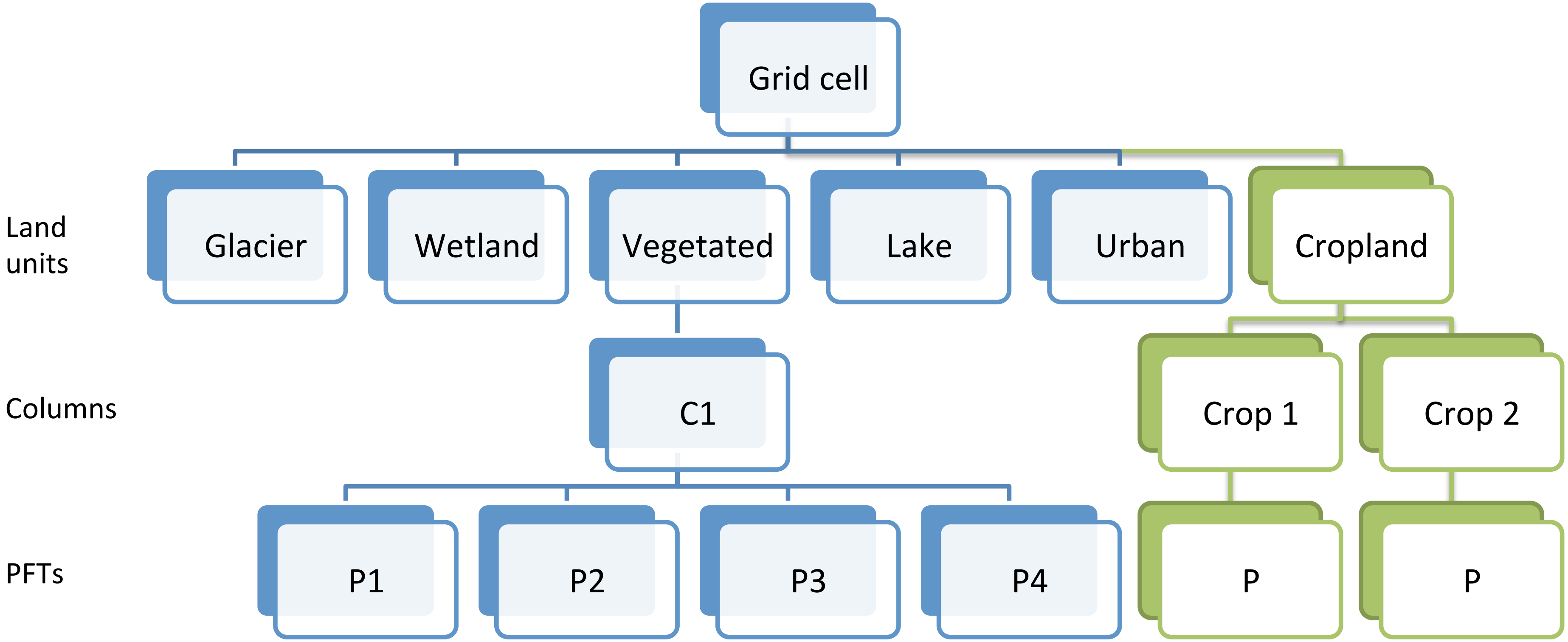
CCSM Land Model Working Group
February 20, 2013

MIT JOINT PROGRAM
SCIENCE POLICY
GLOBAL CHANGE

What is CLM-AG?

- CLM-AG is an agriculture module for the Community Land Model, which simulates crop growth and water stress.
- The AG module adds new plant functional types (PFTs) to the standard CLM framework while retaining the capabilities of CLM in terms of biogeophysical and hydrological processes.
- The agriculture module relies on the principles of two models:
  - ➢ The crop physiology and yield calculations are largely based on the AquaCrop model (Raes et al., 2009).
  - ➢ The irrigation demand and yield reduction routines are derived from CROPWAT (Smith, 1992).
- The output of CLM-AG are:
  - Water deficit (Irrigation demand to obtain maximum yield)
  - Potential attainable yield under rainfed and irrigated conditions

CLM-AG structure



CLM-AG crops

Crops validated	Crops under validation	Crops in development
Maize	Sunflower	Sugarcane
Spring wheat	Sugarbeet	Canola
Cotton	Sorghum	
Soybean	Potato	
Paddy rice[a]	Tomato	
Spring barley		

[a] Only irrigated paddy rice is simulated in CLM-AG, while all other crops are simulated for both rainfed and irrigated conditions.

CLM-AG crop physiology

Four distinct stages in the growing season:

1. ***Initial stage:***

   The seed is in the ground and the roots grow until the emergence of the plant.

2. ***Vegetative stage:***

   The plant grows and develops its leaves until it reaches full canopy cover.

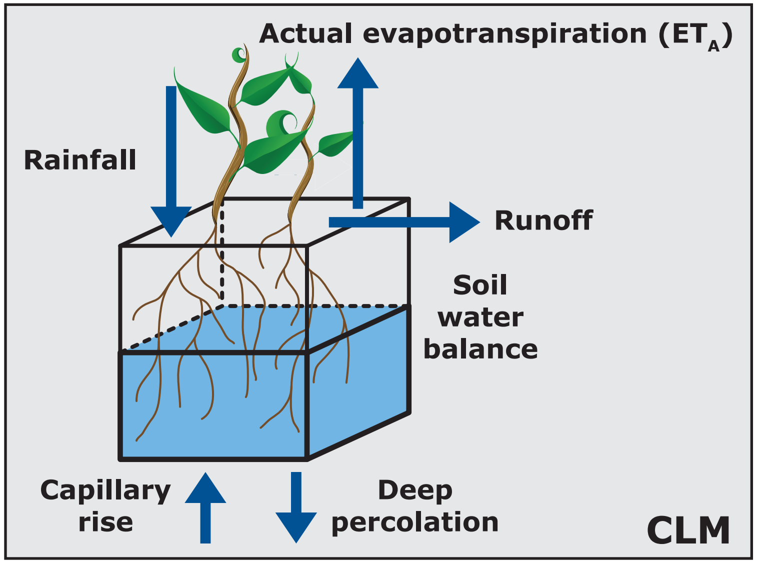
3. ***Yield formation:***

   The plant is at full canopy cover. This is when flowering happens and fruits begin to appear.

4. ***Senescence:***

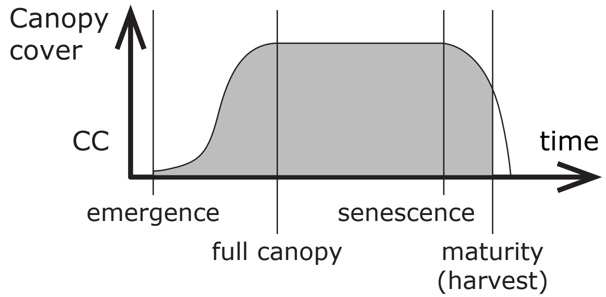
   The canopy cover diminishes as the plant ages and the fruits finish growing until they are harvested.

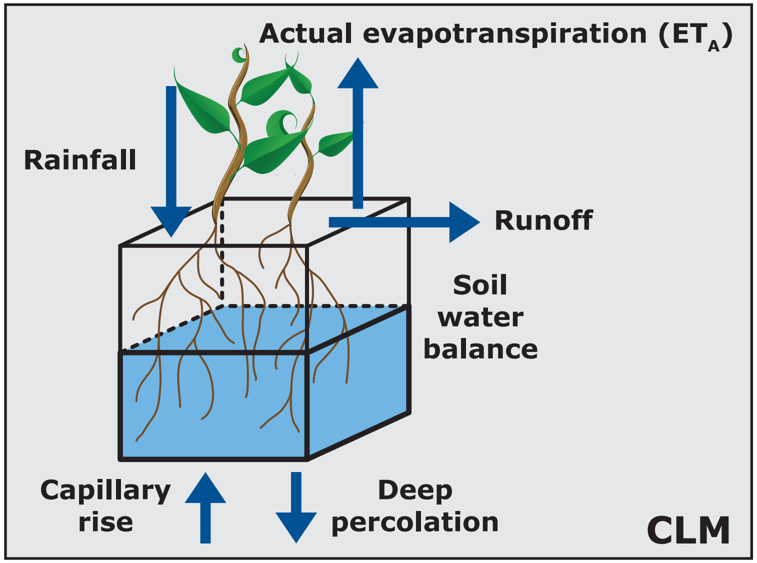
CLM-AG work flow



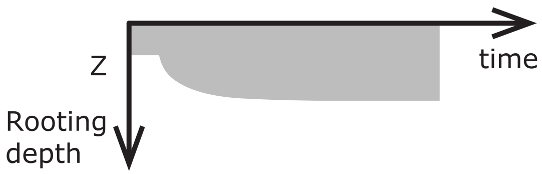
CLM-AG work flow

Canopy expansion

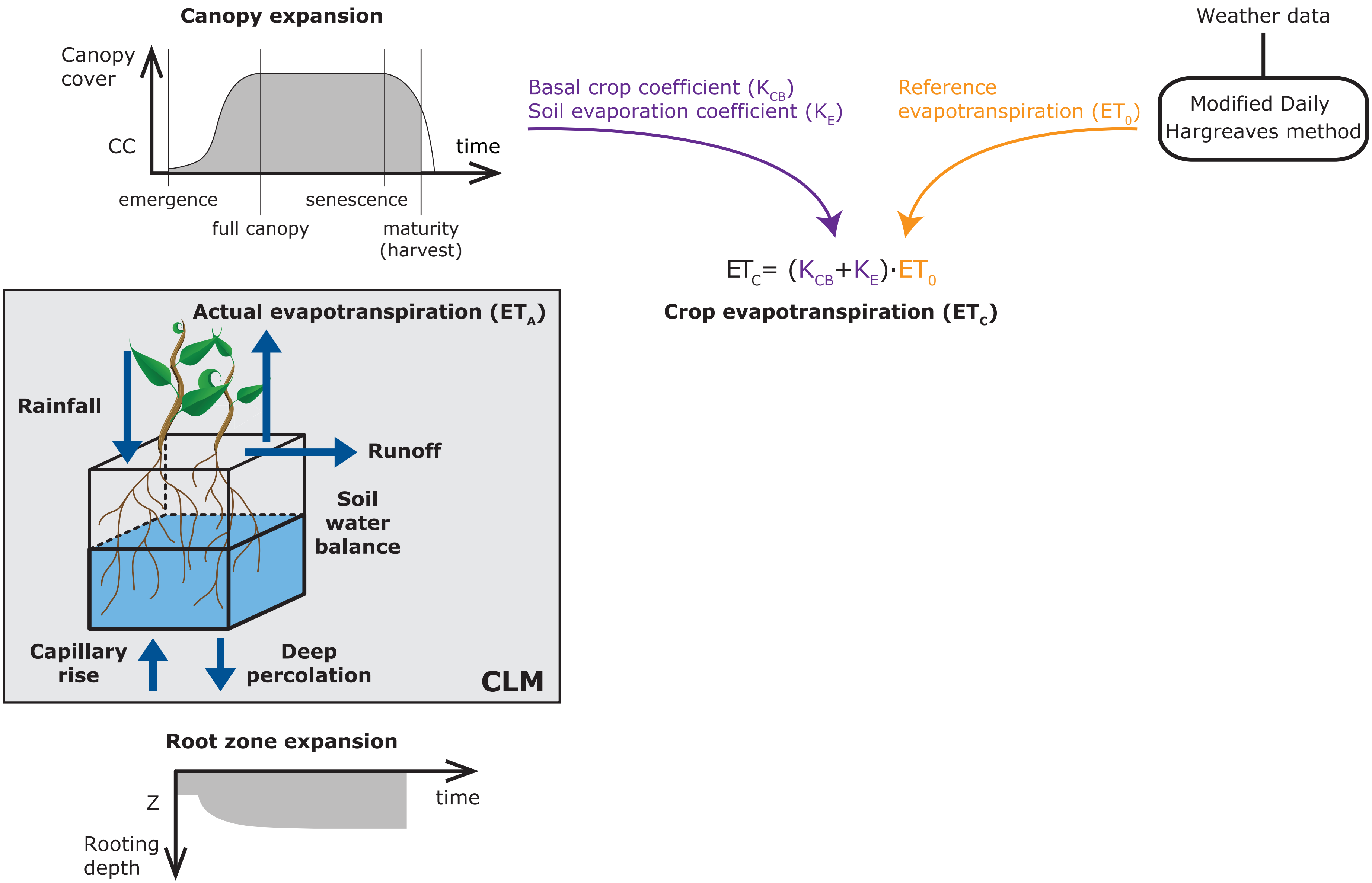




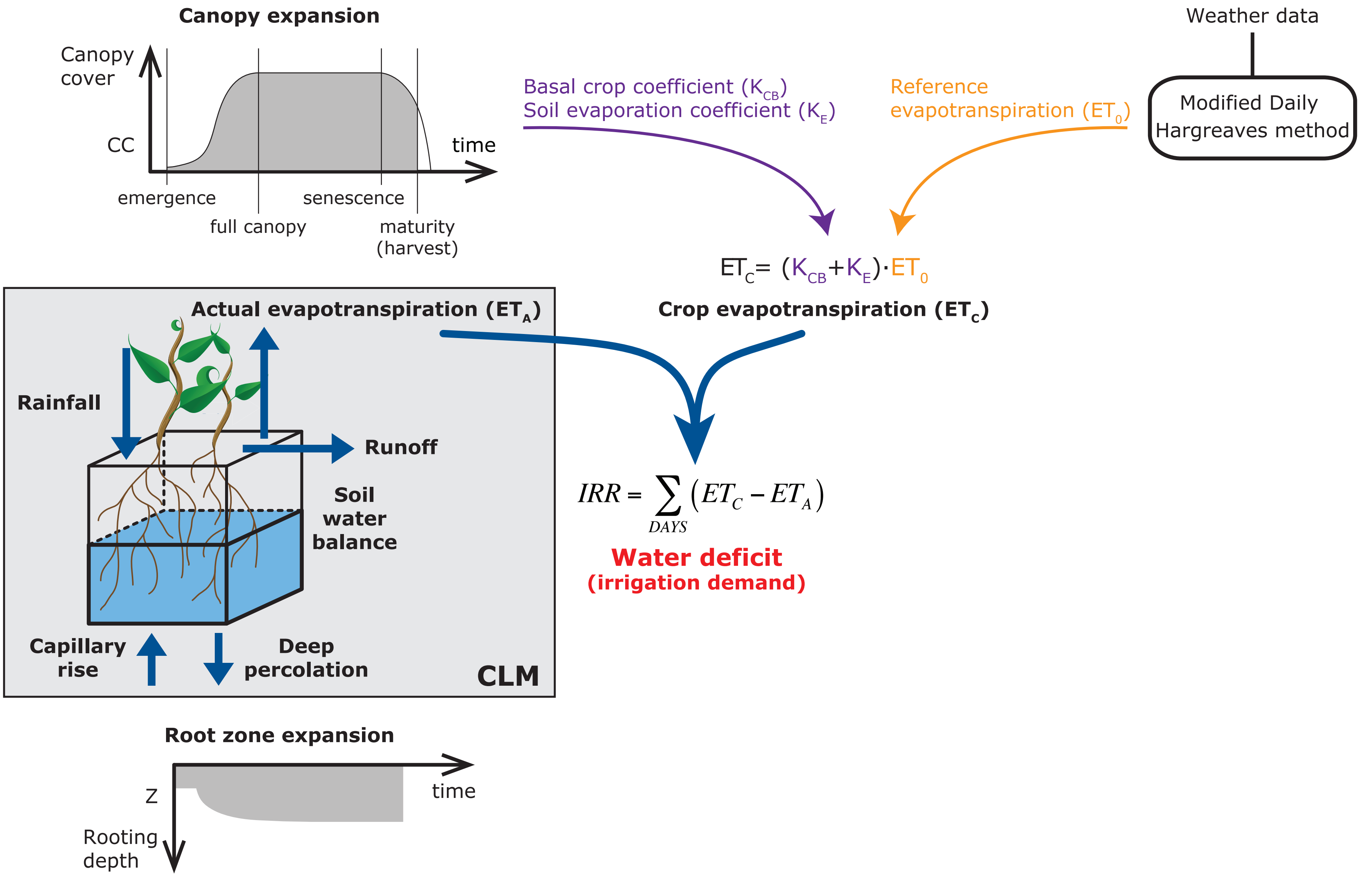
Root zone expansion



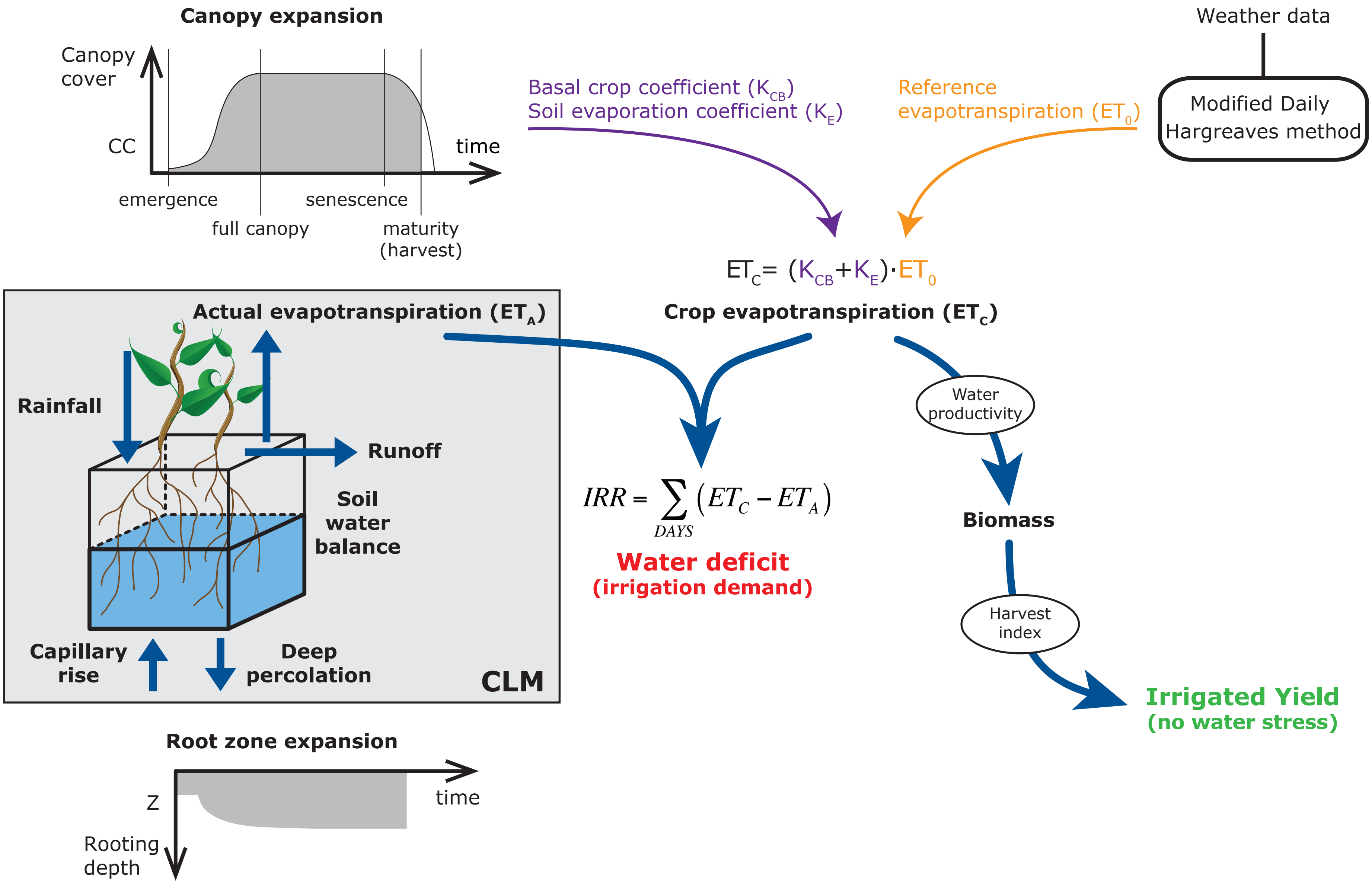
CLM-AG work flow



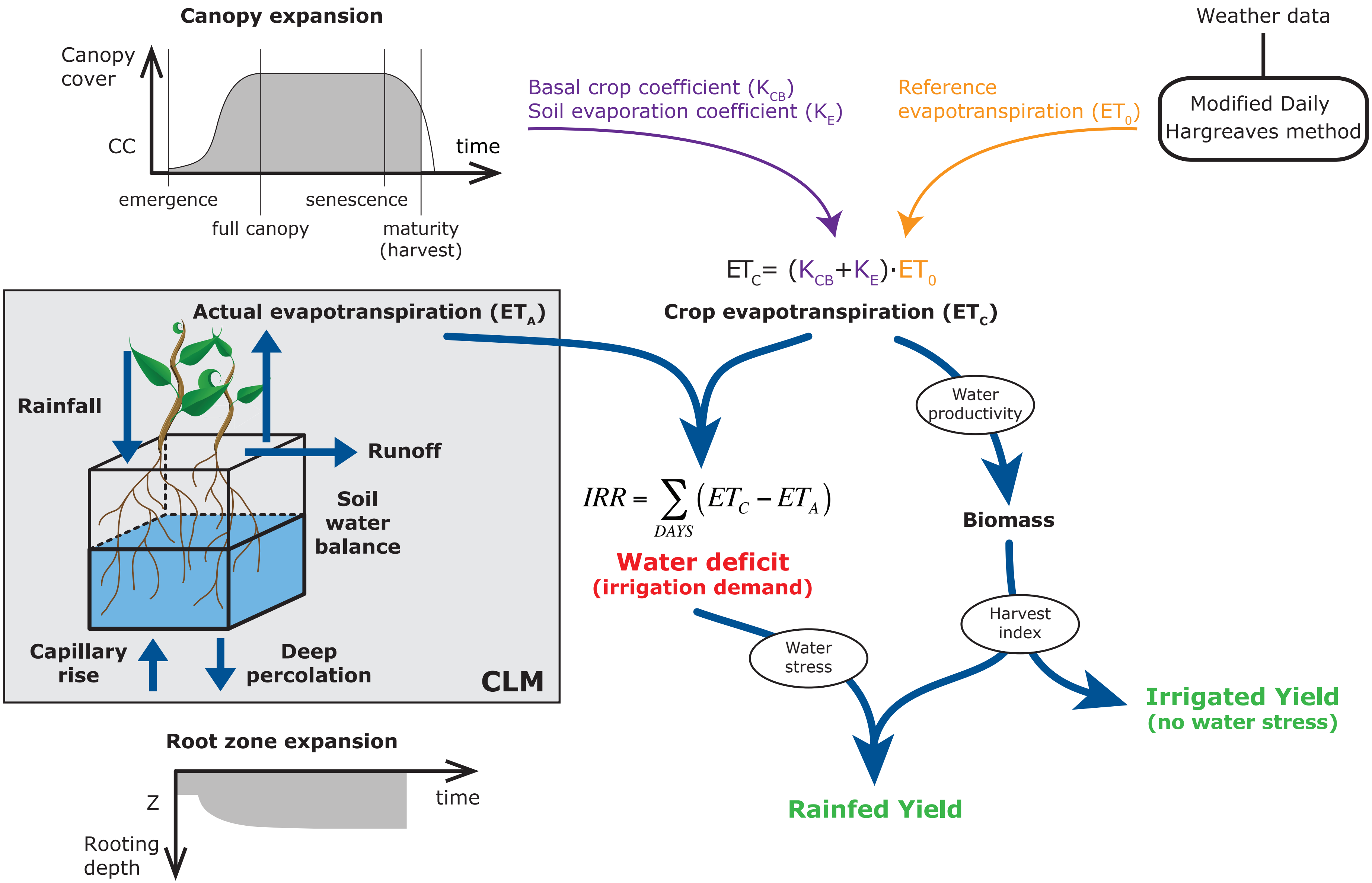
CLM-AG work flow



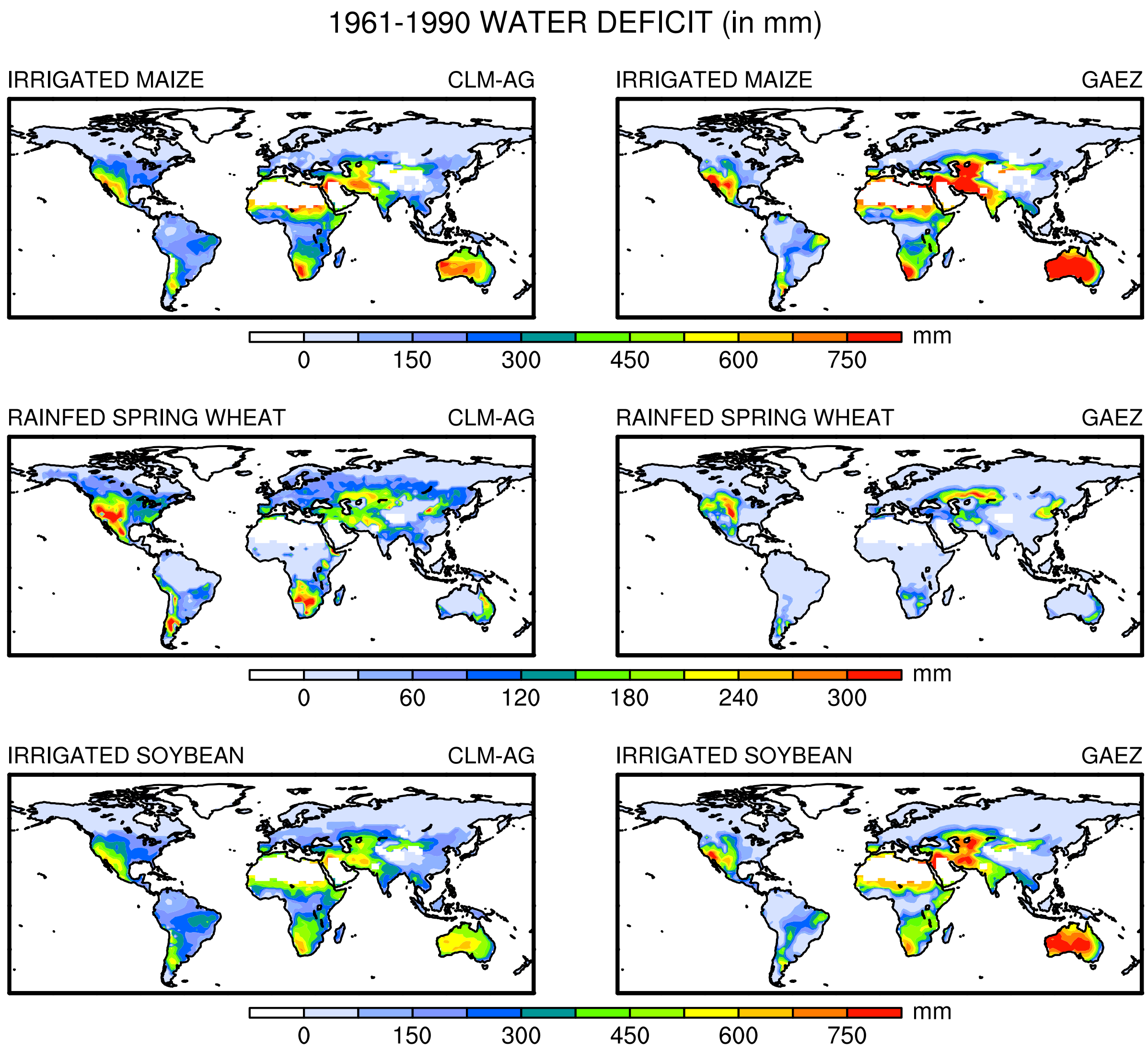
CLM-AG work flow



CLM-AG work flow

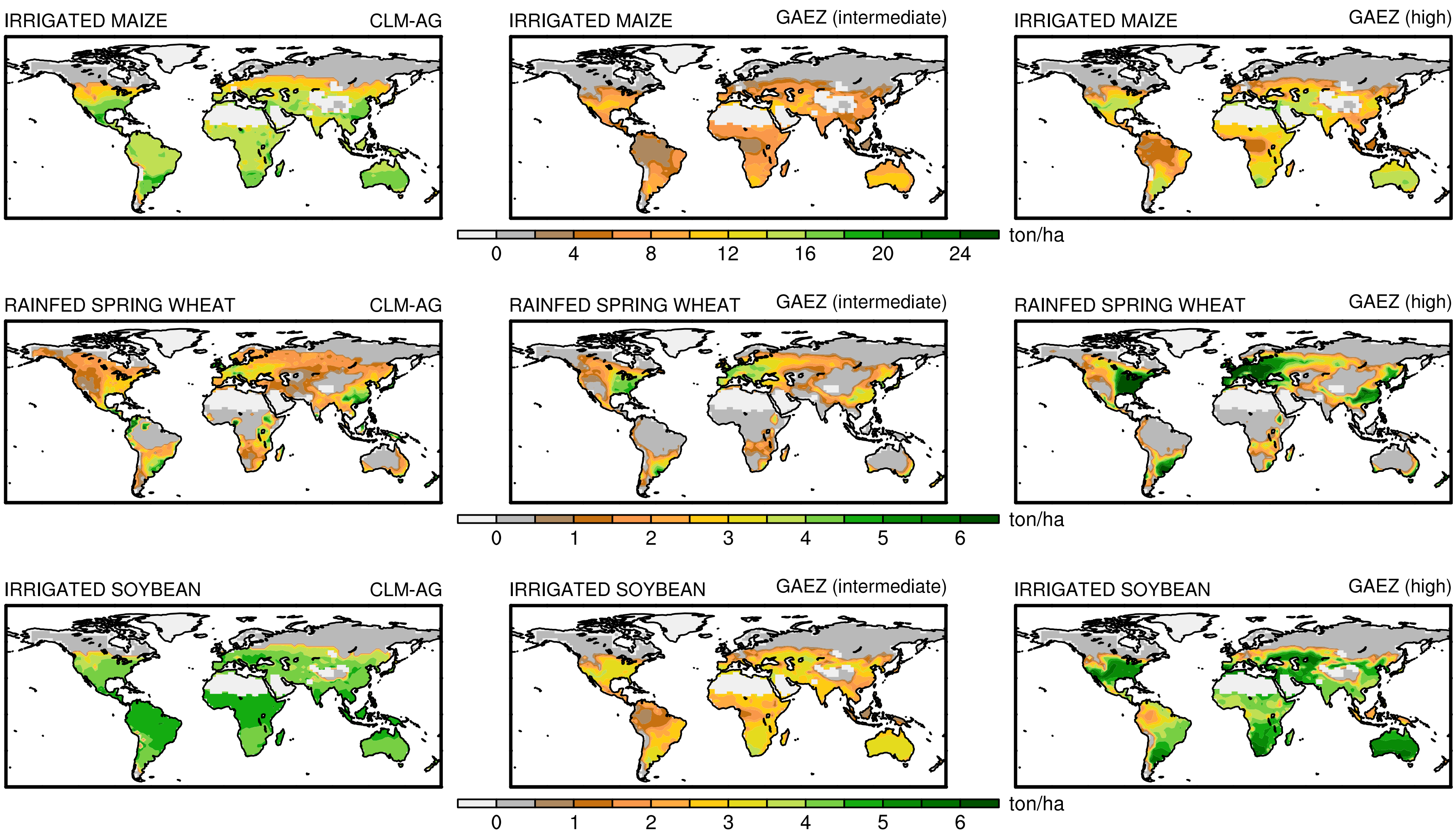


CLM-AG validation: water deficit

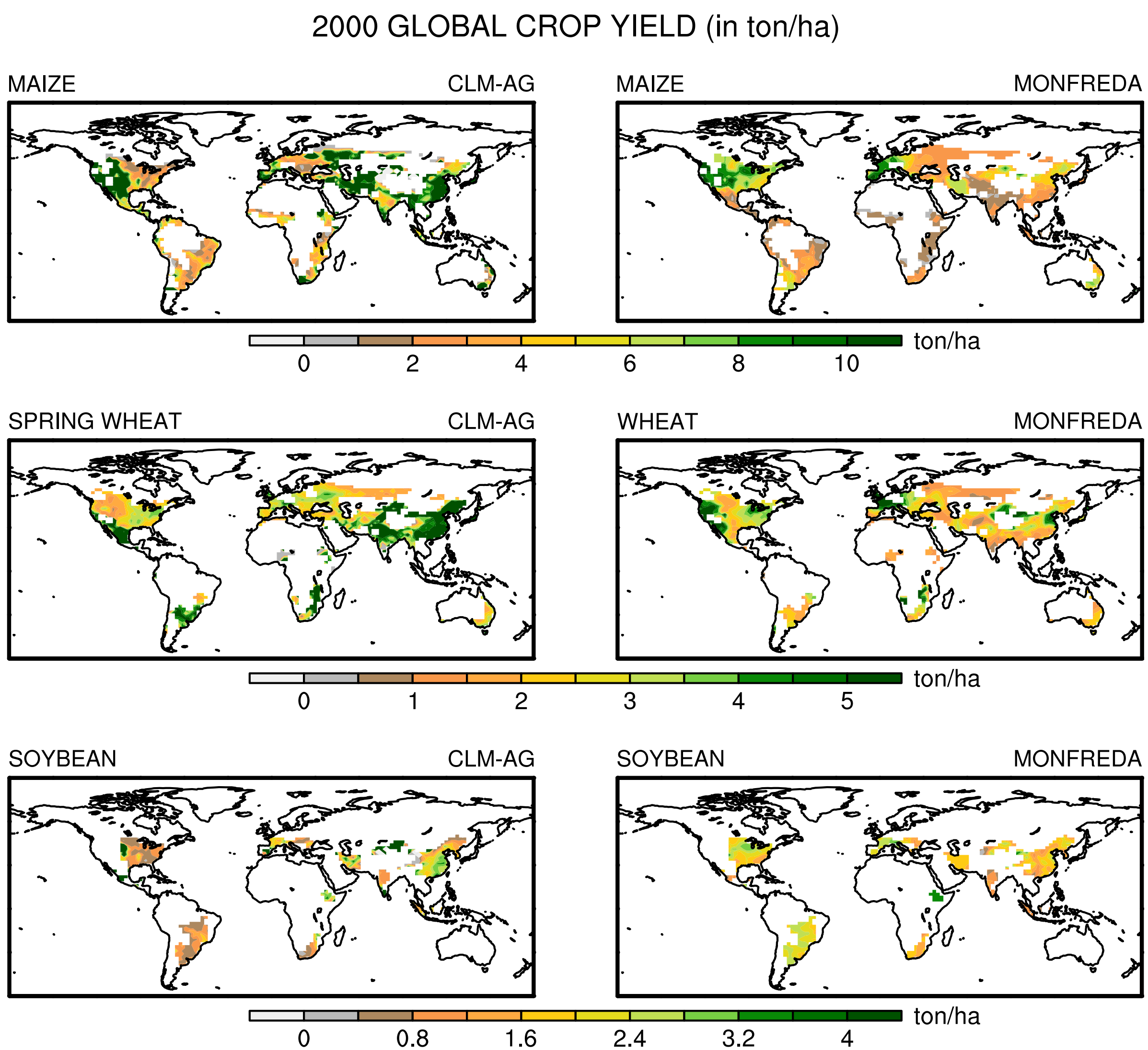


CLM-AG validation: potential yield

1961-1990 ATTAINABLE POTENTIAL YIELD (in ton/ha)



CLM-AG validation: actual yield



CLM-AG current limitations/future development

Current limitations:

- Carbon fertilization in post-processing (no impact on water deficit)
- No ozone damage, no nitrogen limitation
- No soil salinity or disease stresses
- Irrigated crops assume perfect irrigation

Future development:

- Carbon fertilization module interactive with plant physiology
- Coupling to the MIT Emissions Predictions and Policy Analysis (EPPA) model to determine the spatial distribution of cropland
- Coupling to the MIT Water Resource System (WRS) model that can predict water availability for irrigation needs
- Coupling to the MBL Terrestrial Ecosystem Model (TEM) to simulate ozone damage and nitrogen limitation

CLM-AG current publications

Publications:

A. Gueneau, C.A. Schlosser, E. Monier, E. Blanc, K.M. Strzepek and X. Gao, 2013: CLM-AG: An Agriculture Module for the Community Land Model, *Journal of Advances in Modeling Earth Systems,* under review.

E. Blanc, E. Monier, J. Reilly and A. Gueneau, 2013: Climate Change and Crop Productivity in the United States: an Uncertainty Analysis, *Climatic Change*, under review.