Argonne NATIONAL LABORATORY

Climate driven planting date in the ACME Land Model

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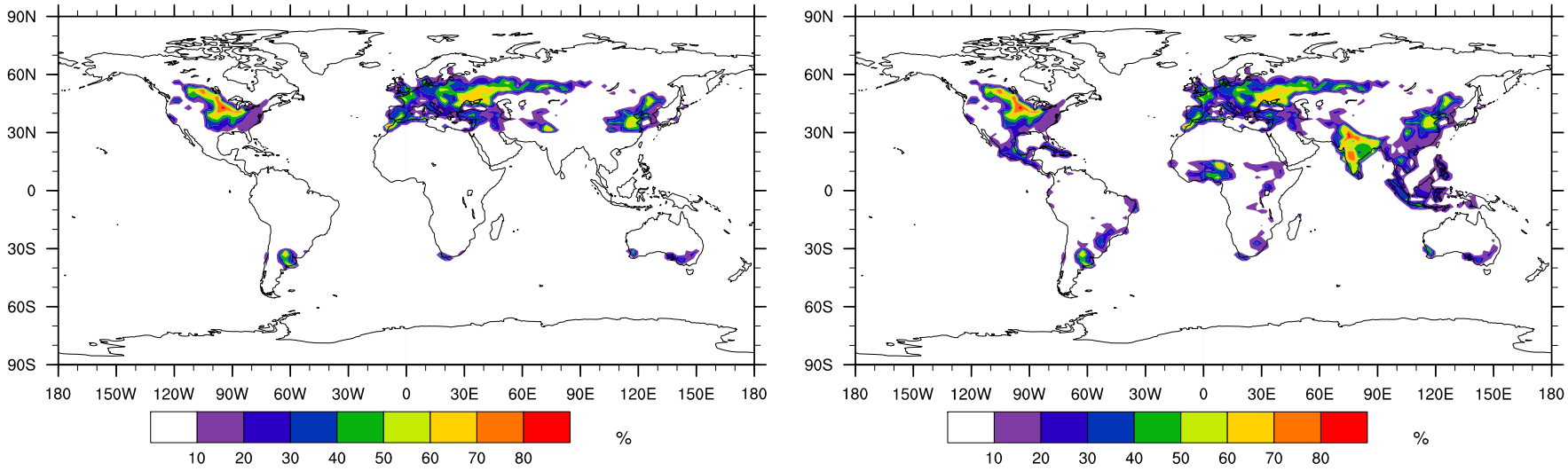
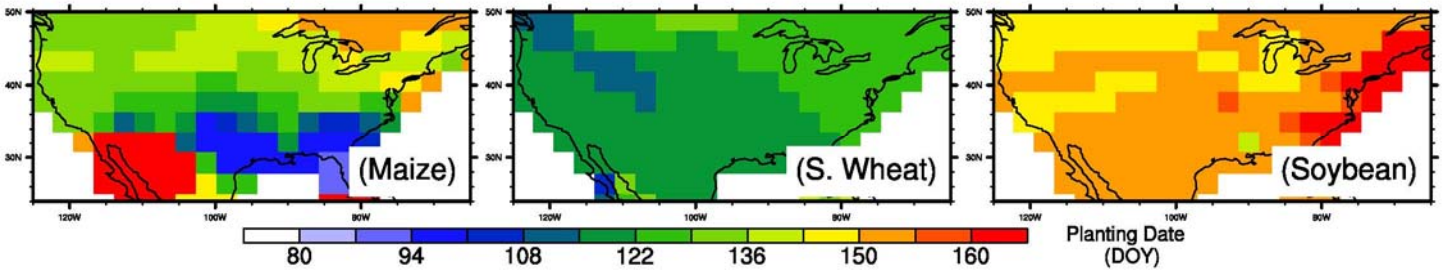
Where are crops grown?



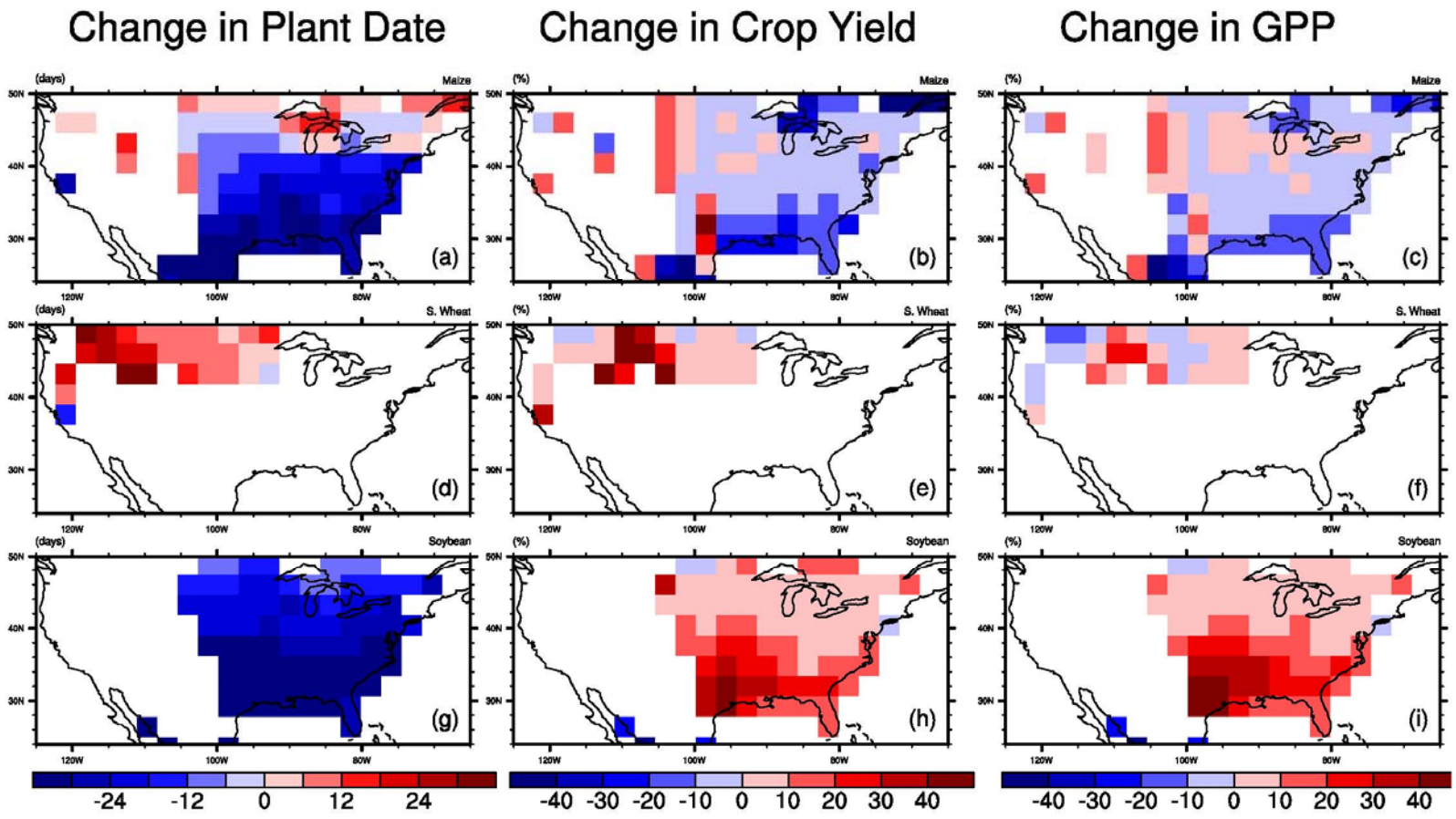
What we have done in the past

Fixed Plant Dates used in CLM - based on Crop Calendar Dataset (Sacks et al., 2010)



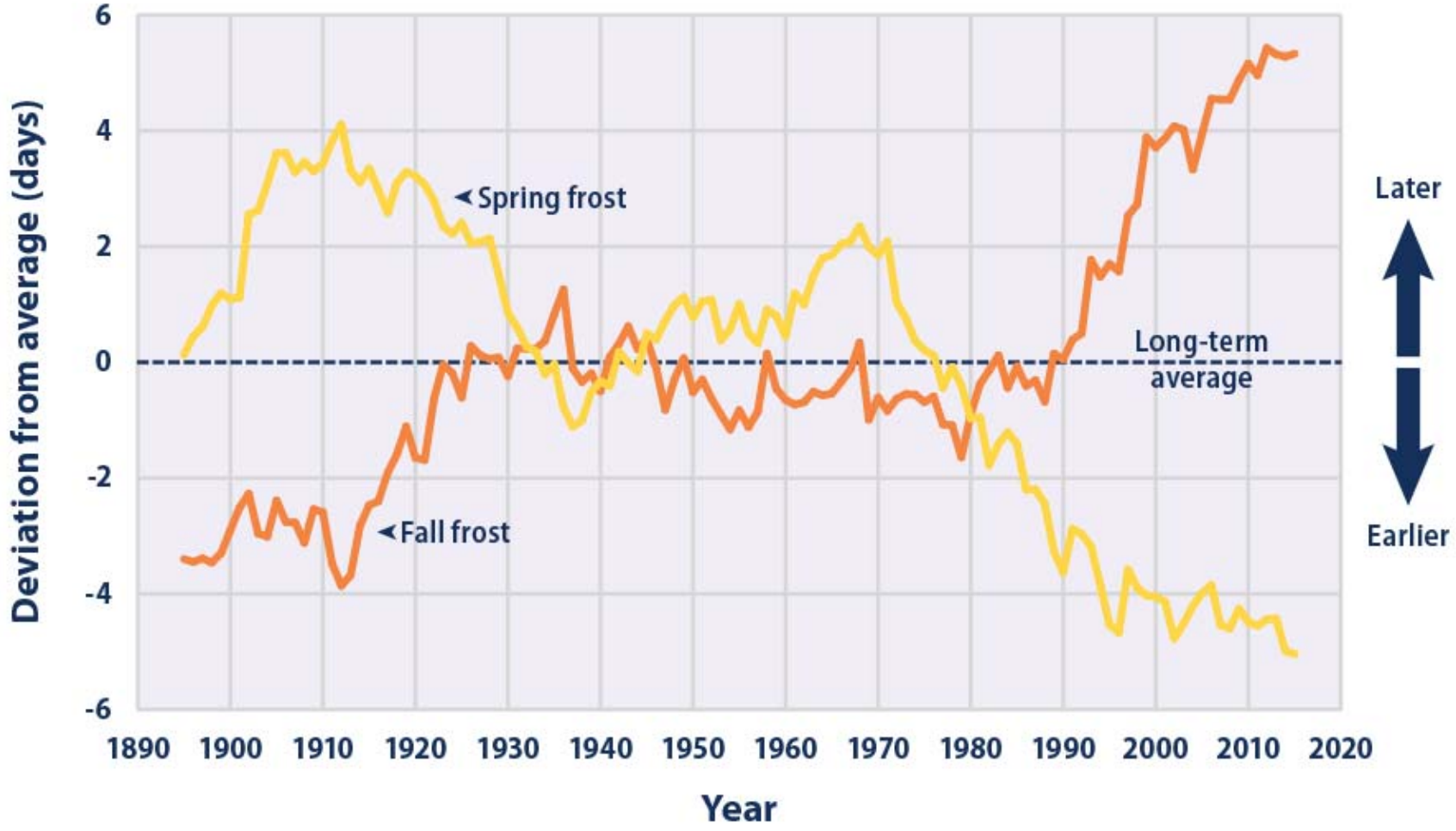
Site	Year	Crop Type	Observed Plant Date	Fixed Plant Date
Bondville, IL	2001	Corn	April 19	May 13
	2002	Soybean	June 2	May 28
	2003	Corn	April 16	May 13
	2004	Soybean	May 7	May 28
Mead, NE	2001	Corn	May 14	May 9
	2002	Soybean	May 20	June 1
	2003	Corn	May 13	May 9
	2004	Soybean	June 2	June 1

Crop productivity is sensitive to plant date



Drewniak et al., 2013

Changes in growing season

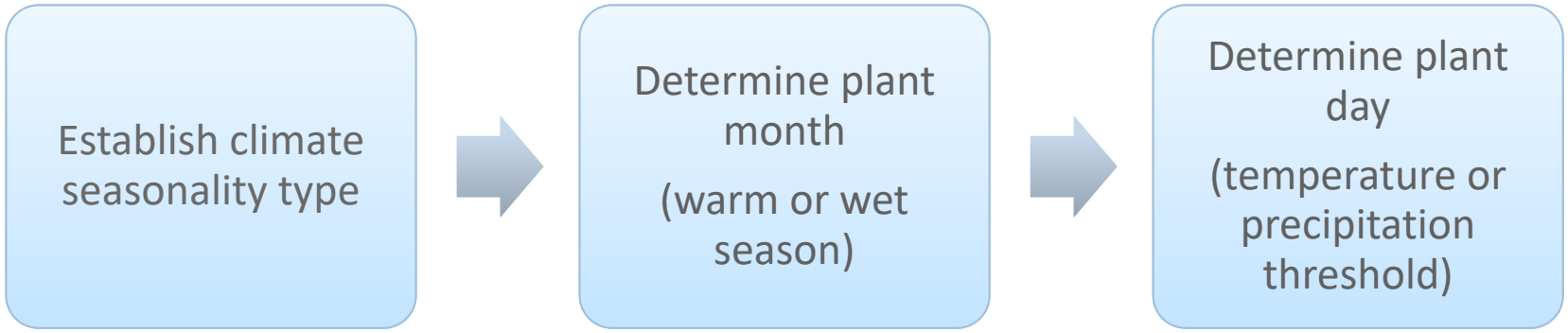


https://www.epa.gov/climate-indicators/climate-change-indicators-length-growing-season

Improved plant date will:

- Function globally
- Capture changes in crop management to adapt to climate change
- Easily accommodates changes in land use (i.e., new crops growing in a grid cell)
- Improve the timing of crop phenology and crop influences on carbon, nutrient, energy, and water cycles

Approach (Waha et al., 2012)



Seasonality determined by temperature and precipitation coefficients of variation (CV)

$$CV_j = \frac{\sigma_j}{\mu_j}$$

$$\sigma_j = \sqrt{\frac{1}{12-1} \times \sum_{m=1}^{12} \left(\overline{X}_{m,j} - \mu_j \right)^2}$$

$$\mu_j = \frac{1}{12} \times \sum_{m=1}^{12} \overline{X}_{m,j}$$

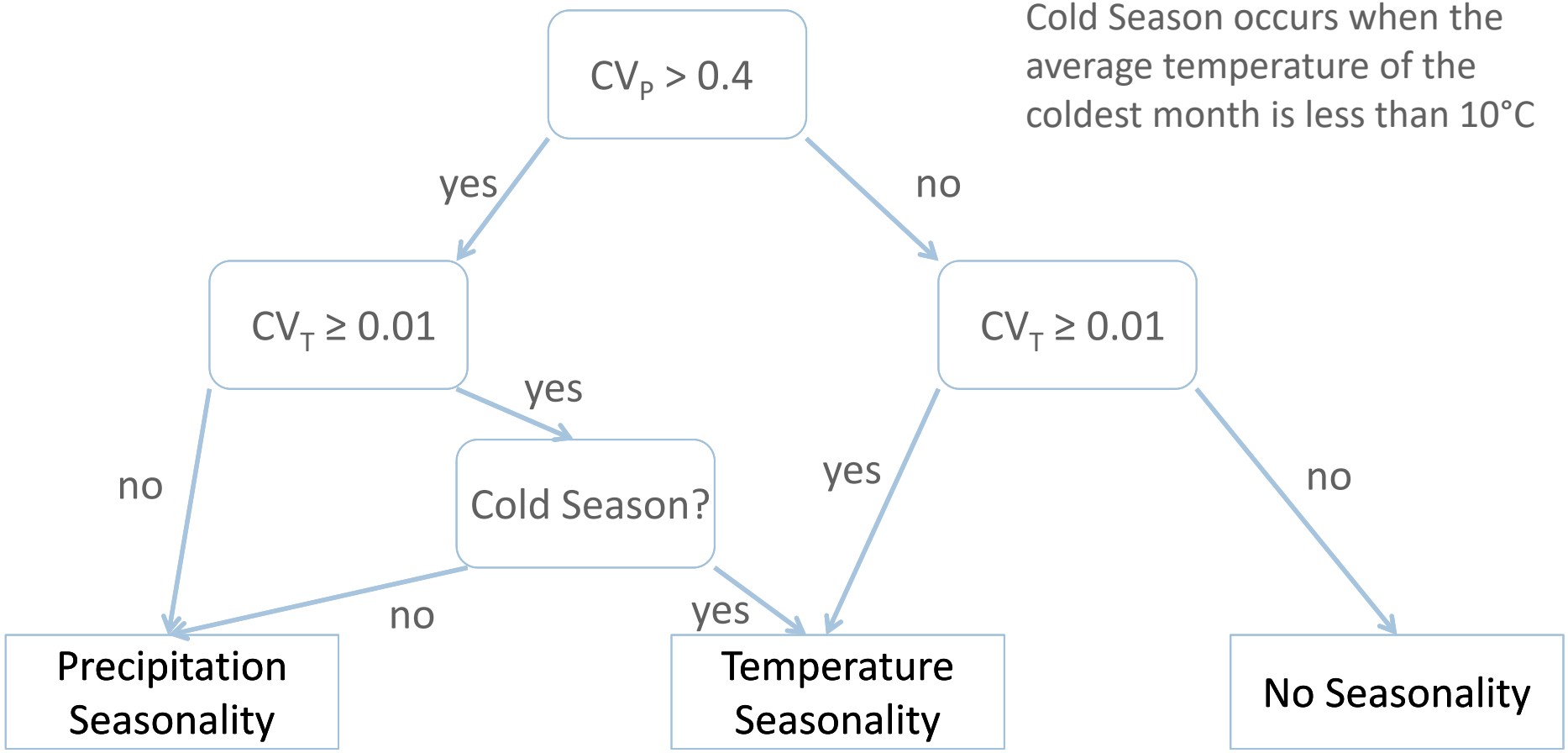
$$\overline{X}_{m,j} = \alpha \times X_{m.j} + (1-\alpha) \times \overline{X}_{m,j-1}$$

Weighting decrease (0.05)

Exponential weighted moving average

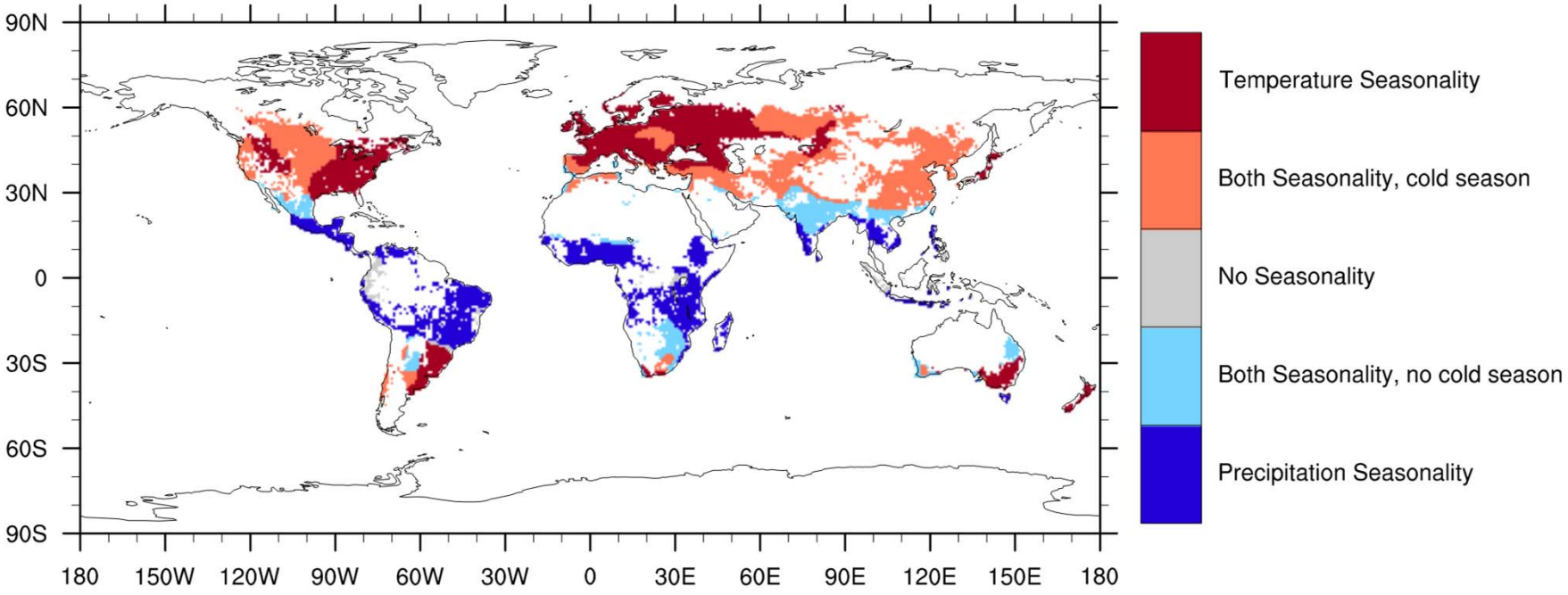
Waha et al, 2012

Seasonality decision tree (Waha et al., 2012)



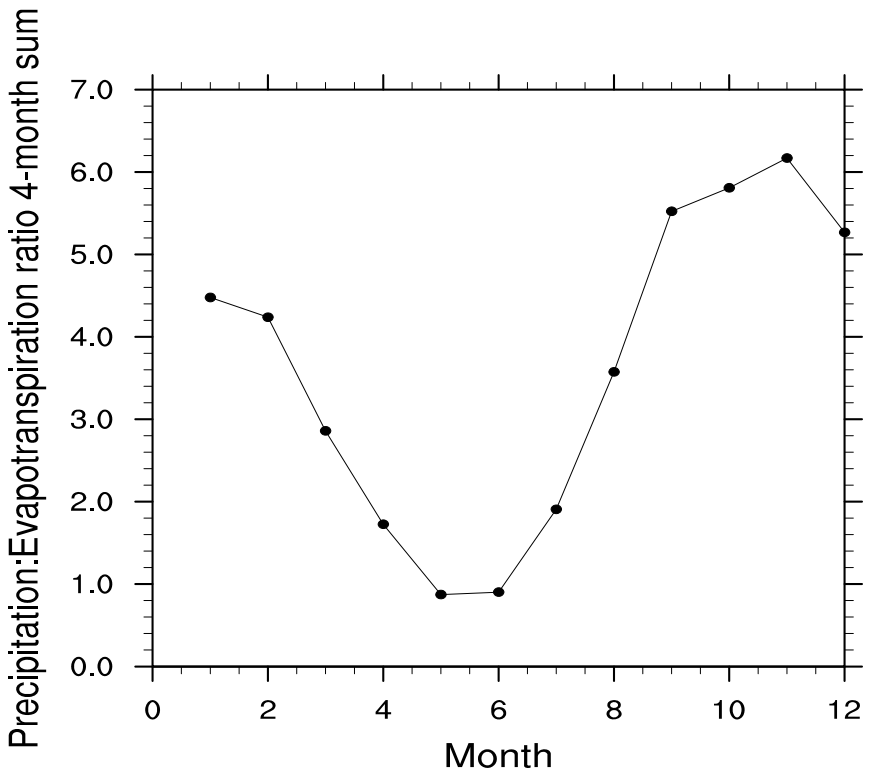
Cold Season occurs when the average temperature of the coldest month is less than 10°C

Map of seasonality



Precipitation Seasonality: Main Wet Season

- Largest 4-month sum of Precipitation:PET (potential evapotranspiration)
- Use Penman-Monteith method to determine PET
- Plant date is the first day of rain

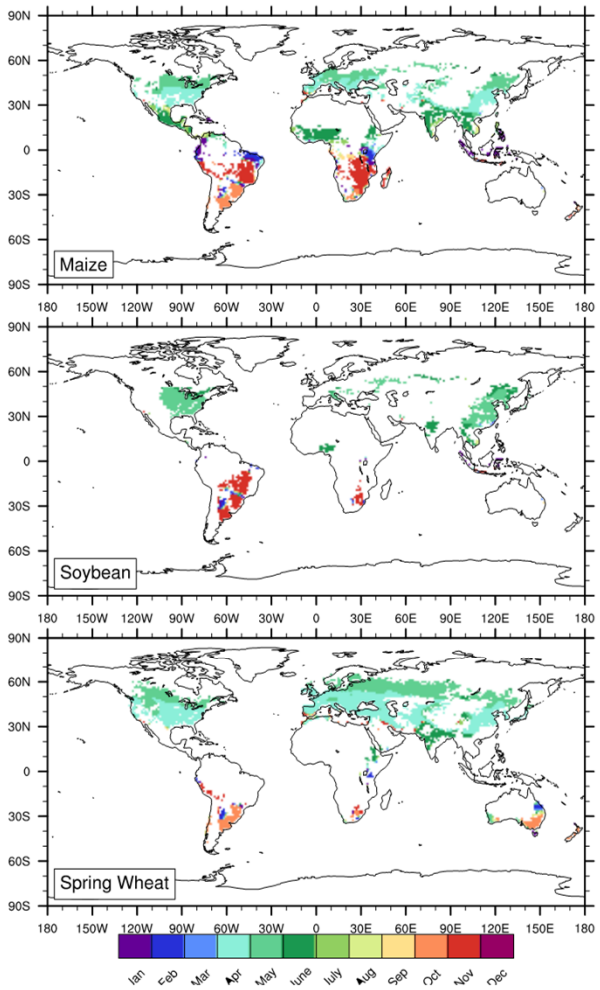


Temperature Seasonality: Main Warm Season

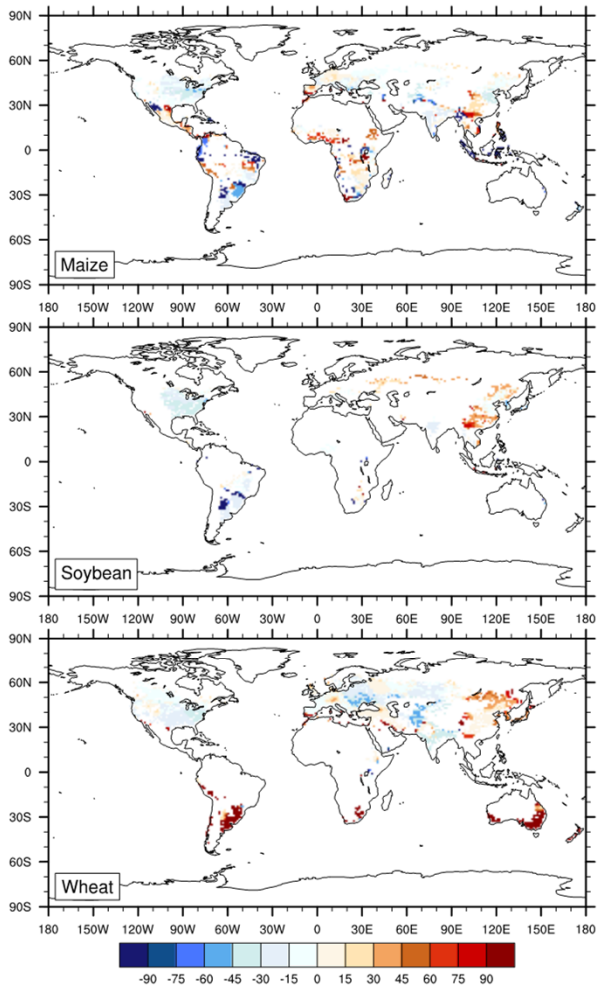
- Plant month is the first month with average T > threshold (crop dependent)
- Plant date is first day with 10-day average T and 10-day minimum T > threshold

Crop	Base Temperature (°C)	Temperature used in this study (°C) (from Waha et al., 2012)	Minimum temperature (°C)
Corn	8	14	6
Spring Wheat	0	5	0
Soybean	10	13	6
Rice	10	18	10

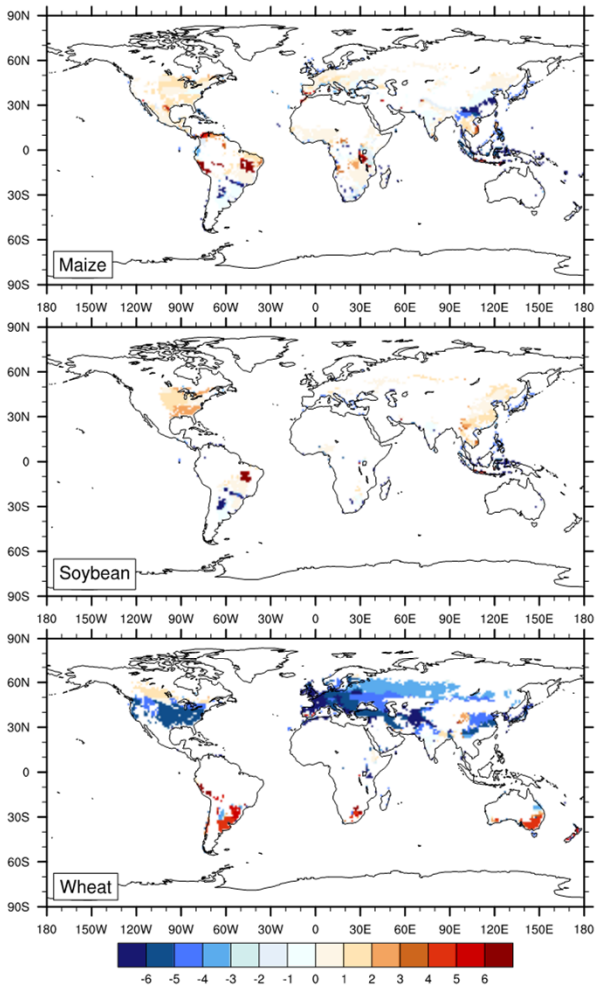
Planting Predictions



Plant month in ALM



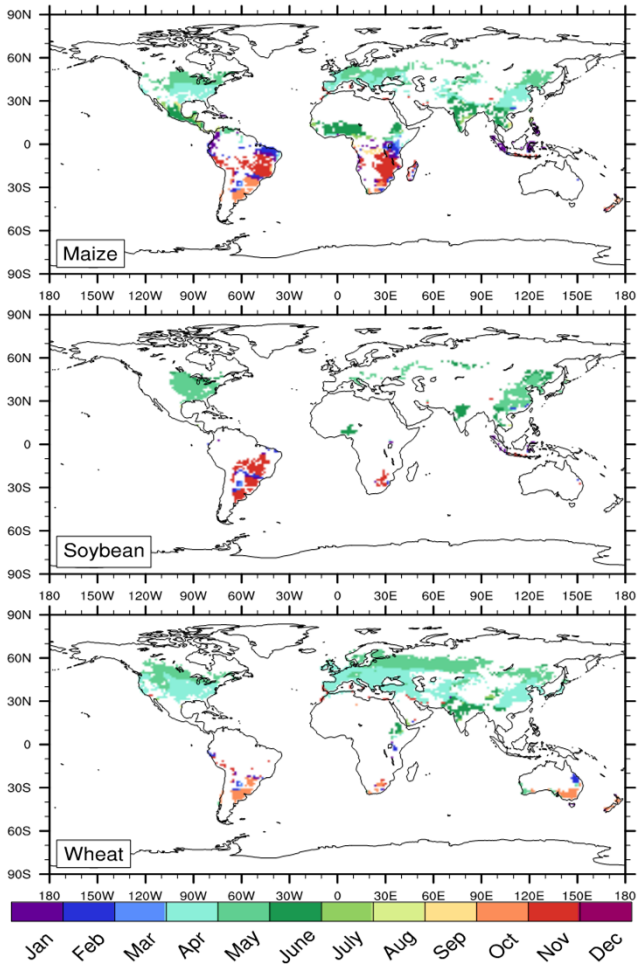
Difference in plant day:
ALM – Sacks et al. (2010)



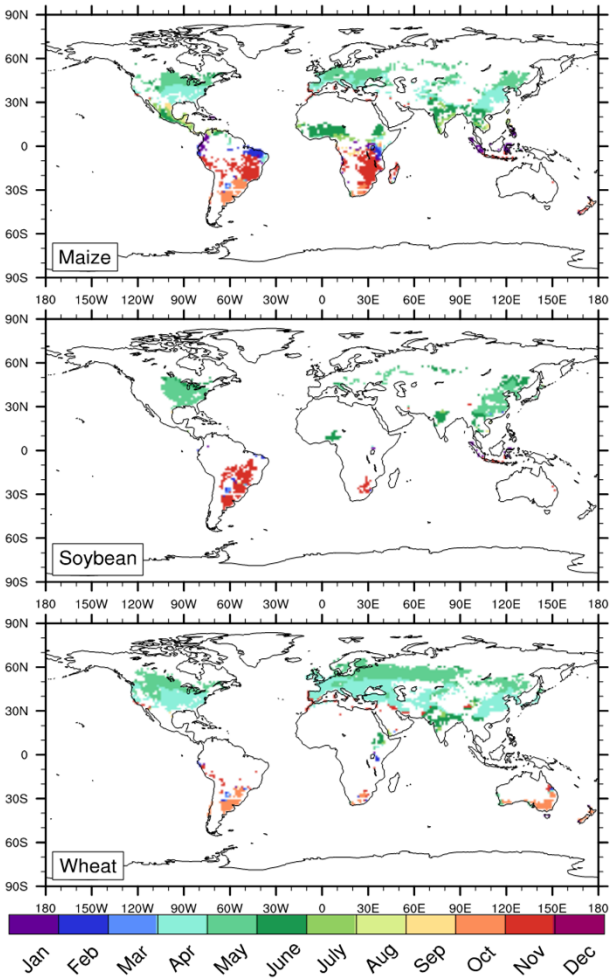
Difference in plant month:
ALM – Portmann et al. (2008)

Earliest and latest planting date don’t vary much

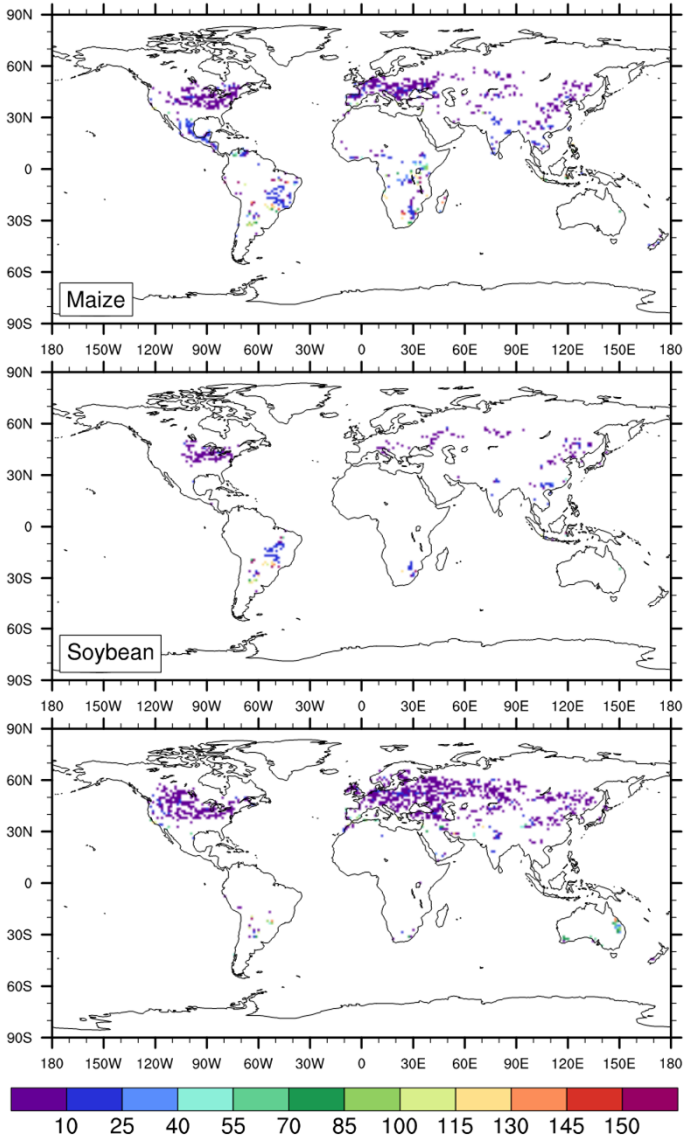
Earliest plant month



Latest plant month



But there is some variance



Standard deviation (days)

Summary

- The new plant date methodology in the ALM crop model predicts planting date based on climate metrics of temperature and precipitation.
- The scheme compares well with observations.
- The new plant date method can evolve with changes in local and regional climate and allows crops to be modeled globally.
- Adding new cropland to grid cells is a straightforward task because the method requires no additional inputs.
- The next steps for this work are to look at the response in yield and growing season from this new development and explore how future climate will influence changes in plant date.