Using downscaled climate products to enhance decision-making in US agriculture: current applications and future needs

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Workshop on Impact Relevance and Usability of High Resolution Climate Modeling and Datasets

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Talk outline

• Introduction to the USDA Climate Hubs
• Scale of this talk: Farmer decision-making (not regional modeling or policy)
• Farmers’ beliefs and attitudes toward climate
• Why US farmers don’t use climate forecasts
• How climate may affect decision making for
  – Corn
  – Beef cattle
  – Almonds
• Summary and recommendations
The USDA Regional Climate Hubs

In early 2014, USDA created seven Regional Climate Hubs to serve the whole US, plus three Sub Hubs to focus on unique issues and locations.

The California Sub Hub works closely with the main Southwest Hub in Las Cruces, NM.

The Hubs are **boundary organizations** to bridge the gap between **climate researchers** and the information needs of **farmers, ranchers, and foresters**.
Scale of this talk: Farmer decision-making

Not large-scale, long-term agricultural impacts modeling...

Not policymaking of any kind...

Not public infrastructure planning...

...rather, what producers do on their land, day to day and year to year.
Many US farmers are skeptical about climate change...

Results from a 2010-2011 survey of 162 farmers in Yolo County, California. (Niles et al., 2013)
...and are not highly concerned about climate change impacts...

Results from a 2010-2011 survey of 162 farmers in Yolo County, California. (Niles et al., 2013)

Fig. 1. Average level of concern for local climate change impacts. Farmers’ responses to the question, “How concerned are you about the following climate-related risks and the future impact they may have on your farming operations during your career?” Responses are ranked on a four point scale ranging from very concerned to not concerned.
...in part because farmers are used to coping with climate variability.

*Niles et al., 2013: Seventy-six percent of farmers stated confidence in their ability to adapt to climate change compared with only 8% of farmers stating pessimism for their adaptive potential:*

- “I have other more important things that affect my business or my family that I want to spend time on.”
- “I think that with the years of experience in farming that we have, I think we know how to deal with problems. I think farmers in general are fairly adaptable.”
- “I’ll have to react to [climate change] and adapt to it. But that’s been my business. In agriculture you’re dealing with the weather.”
Farmers care more about near-term weather than climate forecasts.
Agriculture is profoundly affected by weather (averages & extremes)

Causes of **insured crop losses** in California: (A) indemnity; (B) natural disasters, 1980-2007. Data: USDA Risk Management Agency. (Lobell et al., 2011)
So why aren’t US farmers interested in using climate predictions?

- Current tools and models are not widely used, as they may not be meeting farmers’ needs (Mase & Prokopy, 2013).
- Average annual temperatures are not usually the most important variable (Baldocchi & Wong, 2007). Finer temporal resolution is needed.
- Key metrics may differ with crop, but the most generally useful metrics may be: thresholds at the upper and lower tails of probability distributions, and timing of certain temperature or rainfall regimes (Baldocchi & Wong, 2007).
Example 1: Corn

- Corn is the most valuable US crop ($67 billion in 2012).
- US corn is about 80% rainfed, 20% irrigated.
- Corn, an annual crop, usually requires management decisions on the time scale of less than one year.
- “Corn farming... is very sensitive to drought and low soil moisture. Decisions made on the time scales of weeks to seasons rely on short-term and seasonal forecasts of the soil moisture, which have become invaluable tools to help farmers decide on irrigation needs during drought conditions.”

Decisions for which corn farmers use weather and trend forecasts

- Weather forecasts are not useful to corn producers
- Historical weather trends are not useful to corn producers
- Plan fuel purchases
- Better plan input purchases
- Improve marketing strategies
- Improve irrigation planning
- Allocate field assignments and crop rotations
- Select or modify insurance products
- Increase profitability
- Plan harvest
- Plan tillage timing/strategy
- Tailor hybrid selection
- Reduce risk of economic losses
- Plan planting

Q. Corn producers can use historical weather and/or trend forecasts to... (Please check all that apply)

How might climate change affect corn production in the US?

- Temperatures above 86°F decrease corn yields. The more time spent above 86°, the lower the yield (Lobell et al., 2013).
- The 86°C threshold will be exceeded more frequently as global temperatures increase.
- So what’s a corn farmer to do? Right now, probably nothing. There’s no way to protect corn in the field from a heat wave (though irrigation can help a little). In the long term, new heat-tolerant varieties may be needed.
Example 2: Beef cattle

• Beef producers in California are struggling due to the drought, now in its 4th year, that has devastated forage production on rangelands.

• “When will it end?” Should a struggling rancher keep buying supplemental feed, take out more loans, or just give up and sell the whole herd?

• Unfortunately, climate models could not predict the drought’s onset and duration. Models disagree on whether similar droughts will become more common in the future.
Counties compensated in 2015 under the USDA's Livestock Forage Program.
# California ranchers’ drought strategies

<table>
<thead>
<tr>
<th>Drought Management Practices</th>
<th>% (n = 490)</th>
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<tbody>
<tr>
<td><strong>Proactive</strong></td>
<td></td>
</tr>
<tr>
<td>Employ conservative stocking rates</td>
<td>34</td>
</tr>
<tr>
<td>Incorporate pasture rest into grazing system</td>
<td>23</td>
</tr>
<tr>
<td>Incorporate both cow-calf and stockers for flexibility</td>
<td>21</td>
</tr>
<tr>
<td>Grass bank/Stockpile forage</td>
<td>12</td>
</tr>
<tr>
<td><strong>Use 1-3 month weather predictions to adjust stocking</strong></td>
<td>11</td>
</tr>
<tr>
<td>Add other livestock types for flexibility</td>
<td>3</td>
</tr>
<tr>
<td><strong>Reactive</strong></td>
<td></td>
</tr>
<tr>
<td>Reduce herd size</td>
<td>70</td>
</tr>
<tr>
<td>Purchase feed</td>
<td>69</td>
</tr>
<tr>
<td>Apply for government assistance programs</td>
<td>39</td>
</tr>
<tr>
<td>Wean early</td>
<td>39</td>
</tr>
<tr>
<td>Rent additional pasture</td>
<td>26</td>
</tr>
<tr>
<td>Move livestock to another location</td>
<td>24</td>
</tr>
<tr>
<td>Earn off-ranch income</td>
<td>23</td>
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<tr>
<td>Sell retained yearlings</td>
<td>22</td>
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<tr>
<td>Place livestock in a feedlot</td>
<td>8</td>
</tr>
<tr>
<td>Allow livestock condition to decline</td>
<td>7</td>
</tr>
<tr>
<td>Add alternative on-ranch enterprise</td>
<td>4</td>
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</tbody>
</table>

Results from a summer 2011 survey of California ranchers. (Roche, 2014)
Example 3: Almonds

- Almonds are California’s **most valuable** crop: $6 billion per year, which is 80% of the world’s supply.
- Almond orchards require **major investment** in irrigation and harvesting equipment.
- For good yields, most almond cultivars require about **400 chill-hours** (hours below 45°F).
- Almond trees take 3-5 years to mature and have a **25-30 year** productive lifespan, which may expose them to a **different climate** in the future.
Some of an almond farmer’s decisions

Climate effects on almond production

- The clearest climate risk for almonds is a decrease in chill-hours. Much modeling effort has been devoted to this issue (e.g., Luedeling et al., 2009), but changes have not been made on the ground.
- Other key parameters (such as frost risk, timing of spring rainfall, and hours favorable for bee activity) have not yet been modeled, but can be.
- Future water availability is a concern because perennials “lock in” water demand – they can’t be fallowed or replaced. But almond farmers irrigate with groundwater and with delivered surface water, adding a complex policy aspect.
Answers to the assigned questions

1) What phenomena are most important for assessing impacts and informing decisions in agriculture?

2) What are the potential ways in which higher resolution products may or may not enhance agricultural capability?

3) What more is needed to improve the credibility, impact relevance, and usability of potential future high resolution datasets?
1. What phenomena are most important for assessing impacts and informing decisions in agriculture?

• This very much depends on crop and location.
• *Most consistently relevant*: extreme events such as heat waves, severe freezes, and floods.
• *Sometimes relevant*:
  – Timing and/or amount of precipitation.
  – Time spent below (chill-hours) or above (GDD) a given temperature.
• *Often not relevant*: Minor increments in annual (or seasonal) temperatures.
2. What are the potential ways in which higher resolution products may or may not enhance agricultural capability?

- Low resolution is not the primary reason that farmers do not use climate data. Rather...
- Farmers tend to make decisions on time scales at which climate forecasts are not relevant or not available (days, months, a year or two).
- Where resolution is an obstacle, often temporal resolution is more important (e.g., to predict freezes, chill-hours, GDDs).
- Better spatial resolution will be crucial for a few crops in particular locations (e.g., Napa vineyards)
2. How enhance ag capability? (cont’d)

• To **directly** benefit individual farmers, high-resolution climate data **must help farmers improve the daily decisions they are already making** - for example, what **varieties** to plant; what **irrigation equipment** to install; whether to buy **disaster insurance**.

• The **indirect benefits of** high-resolution climate data are also important (via large-scale analyses; policymaking; and infrastructure planning (**slide 4**), but these benefits are left to others to discuss.
3. What more is needed to improve credibility, impact relevance, and usability of high resolution datasets?

- Evaluate climate information needs for particular crops and users (Mase and Prokopy, 2015). *We will soon do this for almond growers in California.*

- Focus on end users other than farmers:
  - Extension agents / crop advisors
  - Crop insurance representatives
  - Plant breeders
  - Input providers (e.g. fertilizer and seed dealers)

- Offer climate forecasts in same venues and formats as weather products that are already frequently used.
Recommendations and conclusions

• Lack of a participatory approach to climate forecasting has limited the usefulness of climate forecasts to decision makers in the agriculture sector.

• However, even if climate forecasts are carefully tailored, they may never be a primary concern for some farmers. Other factors may dominate, such as government policies and market dynamics.

• Farmers are used to weather variability, and many assume “consistency eventually pays off” rather than constantly adjusting strategies (Mase & Prokopy, 2013).

• To adopt bolder (rather than no-regrets) adaptation strategies, farmers will need concrete information on the costs and benefits of doing so (GAO, 2014).


Thank you! Questions?

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