Review of Agricultural management effects on mean and extreme temperature trends by Gormley-Gallagher et al for Earth System Dynamics Dec 28 2020

The authors' summary statement in the abstract is certainly an informative conclusion. They write

"Our results underline that agricultural management has complex and nonnegligible impacts on the local climate and highlights the need to account for land management in climate projections."

And further that

"It remains challenging to resolve this, however, because it is difficult to separate land management from other effects in GCMs – particularly natural climate variability (Cook et al., 2015)".

They summarize their paper with the text

"The goal of this study is thus to test the hypothesis that CESM version 1.2.2 overestimates warming trends in some regions because irrigation and CA are excluded. That is, warming rates are hypothesised to decline – showing signs of cooling, in irrigation- and CA-affected regions when climate models do account for a theoretical constant level of these land management practices. To realise this goal, the following three objectives were formulated: (1) Determine spatial warming rates using GCM simulations that account for irrigation and CA and inspect whether CESM overestimates warming trends; (2) Compare the observed rates of warming to the modelled rates of warming for irrigated and CA pixels, as well as nonirrigated and non-CA pixels; and (3) Estimate the impact of irrigation on the spatial average of the warming rates over time (1981-2010) for all land, selected regions, and irrigated and CA pixels."

However, the basis to quantify these impacts is flawed, or at least significantly muddled. First, model comparison studies are just model sensitivity studies. Without an assessment of model skill with the appropriate real world observed data, this is an incomplete (and potentially misleading) approach. The real world data needs to be on the spatial and temporal scale of the effect they are assessing (irrigation and conservation agriculture). The recent GRAINEX project quantified these scales [https://www.eol.ucar.edu/field_projects/grainex]. The model results should be compared against such data.

Indeed there are numerous regional, mesoscale and local studies that have assessed the role of irrigation and land management on weather and climate. The authors do not seem to be familiar with this research. Here are just a few

Adegoke, J.O., R.A. Pielke Sr., J. Eastman, R. Mahmood, and K.G. Hubbard, 2003: Impact of irrigation on midsummer surface fluxes and temperature under dry synoptic conditions: A regional atmospheric model study of the U.S. High Plains. Mon. Wea. Rev., 131, 556-564.

Betts RA. Implications of land ecosystem-atmosphere interactions for strategies for climate change adaptation and mitigation. Tellus B 2007, 59:602–615. doi:10.1111/j.1600-0889.2007.00284.x.

Boyaj et al, 2020: Increasing heavy rainfall events in south India due to changing land use and land cover. QJRMS https://doi.org/10.1002/qj.3826

Chen, C. J., C. C. Chen, M. H. Lo, J. Y. Juang, and C. M. Chang, 2020: Central Taiwan's hydroclimate in response to land use/cover change. *Env. Res. Lett.,* **15,** 034015

Douglas, E.M., D. Niyogi, S. Frolking, J.B. Yeluripati, R. A. Pielke Sr., N. Niyogi, C.J. Vörösmarty, and U.C. Mohanty, 2006: Changes in moisture and energy fluxes due to agricultural land use and irrigation in the Indian Monsoon Belt. Geophys. Res. Letts, 33, doi:10.1029/2006GL026550

He, Y., E. Lee, and J. S. Mankin, 2019: Seasonal tropospheric cooling in Northeast China associated with cropland expansion. Env. Res. Lett. 15, 034032.

Hossain, F., J. Arnold, E. Beighley, C. Brown, S. Burian, J. Chen, S. Madadgar, A. Mitra, D. Niyogi, R.A. Pielke Sr., V. Tidwell, and D. Wegner, 2015: Local-to-regional landscape drivers of extreme weather and climate: Implications for water infrastructure resilience. J. Hydrol. Eng., **10.1061/(ASCE)HE.1943-5584.0001210** , 02515002.

Marland, G., R.A. Pielke, Sr., M. Apps, R. Avissar, R.A. Betts, K.J. Davis, P.C. Frumhoff, S.T. Jackson, L. Joyce, P. Kauppi, J. Katzenberger, K.G. MacDicken, R. Neilson, J.O. Niles, D. dutta S. Niyogi, R.J. Norby, N. Pena, N. Sampson, and Y. Xue, 2003: The climatic impacts of land surface change and carbon management, and the implications for climate-change mitigation policy. Climate Policy, 3, 149-1

Pielke Sr., R.A., 2001: Influence of the spatial distribution of vegetation and soils on the prediction of cumulus convective rainfall. Rev. Geophys., 39, 151-177

Pielke Sr., R.A., R. Mahmood, and C. McAlpine, 2016: Land's complex role in climate change. Physics Today, 69(11), 40.

Ullah et al 2020: How Vegetation Spatially Alters the Response of Precipitation and Air Temperature? Evidence from Pakistan. Asian Journal of Atmospheric Environment 14(2):133 145

Woldemichael, A.T., F. Hossain, and R. A. Pielke Sr., 2014: Impacts of post-dam land-use/land-cover changes on modification of extreme precipitation in contrasting hydro-climate and terrain features. J. Hydrometeor., 15, 777–800, doi:10.1175/JHM-D-13-085.1

Zhang, T., R. Mahmood, X. Lin, and R.A. Pielke Sr.,2019: Irrigation impacts on minimum and maximum surface moist enthalpy in the Central Great Plains of the USA. Weather and Climate Extremes, 23, https://doi.org/10.1016/j.wace.2019.100197.

Unfortunately, the study does not have fine enough spatial resolution to realistically resolve these land use effects. As a result, the effects will likely be muted and quite possibly misrepresented. Even examining sub pixel (grid interval) model data is insufficient as local and mesoscale effects are missed.

As they report

"The period 1976-2010 was simulated with a horizontal pixel resolution of 0.9° latitude × 1.25° longitude."

This is much too coarse. Indeed since at least 4 grid increments are required to have some confidence that a feature is adequately resolved, their effective resolution is no finer than 3.6° latitude by 5° longitude.

Similarly, their observational analyses used to evaluate the model results are too coarse. They write

"For evaluation purposes, observational datasets for annual mean T2m with a spatial resolution of 0.5◦ × 0.5◦ for the same time period were obtained from the Climate Research Unit (CRU) (Harris et al., 2014). Annual mean TXx observational datasets were obtained from the daily Global Historical Climatology Network extremes data set (GHCNDEX) (Donat et al., 2013a) and the Hadley Centre extremes data set (HadEX2) (Donat et al., 2013b) with a spatial resolution of 2.5◦ × 2.5◦ "

And, as I mentioned above, even using sub-grid decomposition is significantly incomplete. They write

"To examine heterogeneous influences within grid cells, subgrid tiles that represent local physical, biogeochemical, and ecological characteristics – and therefore local (subgrid) influences of irrigation and CA – were evaluated against regional (grid-scale) influences. Up to 21 surface tiles may occur within one grid cell in CLM4, including glacier, wetland, lake, urban, bare soil and 16 PFTs."

While useful in a model sensitivity study, its lack of connection to real world data for locations where actual irrigation and conservation agriculture are occurring is a serious oversight.

In their recommendations they write

"The findings overall emphasise the need for a more in-depth evaluation of the sensitivity of future climate projections to irrigation and CA-induced temperature changes. A sensitivity analysis, using transient irrigation and CA extents, as well as additional land management techniques and climate models based on CMIP6 output, , is recommended."

I agree with the first sentence. The second sentence, however, is incomplete as a necessary condition. Real world testing of the skill of the models with respect to how land management affects the weather and climate is required. This must be completed using real world data that is on the appropriate space and time scales. This is not the case for this paper.

They also write

"This will support decision-making when planning land management strategies that combine resource use efficiency with climate change adaptation and mitigation, enabling sustainable intensification of land management to meet mitigation targets and future demand for food, fuel, fibre, and water."

The authors should be made aware that there are much more inclusive tools to assess sustainability. Sensitivity results from global models is, at best, a small part on the regional and local scales. Examples of such an approach are published in

Cross, M. S., et al. (2012). "The Adaptation for Conservation Targets (ACT) framework: a tool for incorporating climate change into natural resource management." Environmental Management 50(3): 341-351. DOI: 10.1007/s00267-012-9893-7

Hanamean, J.R. Jr., R.A. Pielke Sr., C.L. Castro, D.S. Ojima, B.C. Reed, and Z. Gao, 2003: Vegetation impacts on maximum and minimum temperatures in northeast Colorado. Meteorological Applications, 10, 203-215.

Hossain, F., E. Beighley, S. Burian, J. Chen, A. Mitra, D. Niyogi, R.A. Pielke Sr., and D. Wegner, 2017: Review approaches and recommendations for improving resilience of water management infrastructure: The case for large dams. J. Infrastructure Systems, 23, Issue 4, Dec. 2017, DOI: 10.1061/(ASCE)IS.1943-555X.0000370

Kittel, T.G.F., et al. (2011). "A vulnerability-based strategy for incorporating climate change in regional conservation planning: Framework and case study for the British Columbia Central Interior." BC Journal of Ecosystems and Management 12(1): 7-35. http://jem.forrex.org/index.php/jem/article/view/89.

Kittel, T.G.F. 2013. “The Vulnerability of Biodiversity to Rapid Climate Change.” Pp. 185-201 (Chapter 4.15), in: Vulnerability of Ecosystems to Climate, T.R. Seastedt and K. Suding (Eds.), Vol. 4 in: Climate Vulnerability: Understanding and Addressing Threats to Essential Resources, R.A. Pielke, Sr. (Editor-in-Chief). Elsevier Inc., Academic Press, Oxford. DOI: 10.1016/B978-0-12-384703-4.00437-8

Kling, M. M., Auer, S. L., Comer, P. J., Ackerly, D. D., & Hamilton, H. (2020). Multiple axes of ecological vulnerability to climate change. Global Change Biology, 26, 2798–2813

Ordonez, A., 2020. Points of view matter when assessing biodiversity vulnerability to environmental changes. *Global Change Biology*, *26*(5), pp.2734-2736.

Pielke Sr., R.A., R. Wilby, D. Niyogi, F. Hossain, K. Dairaku, J. Adegoke, G. Kallos, T. Seastedt, and K. Suding, 2012: Dealing with complexity and extreme events using a bottom-up, resource-based vulnerability perspective. Extreme Events and Natural Hazards: The Complexity Perspective Geophysical Monograph Series 196 © 2012. American Geophysical Union. All Rights Reserved. 10.1029/2011GM001086.

Romero-Lankao, P., et al. 2012: Vulnerability to temperature-related hazards: a meta-analysis and meta-knowledge approach. Glob. Environ. Change, http:// dx.doi.org/10.1016/j.gloenvcha.2012.04.002.

Stohlgren, T.J. and C.S. Jarnevich. 2009. Risk assessment of invasive species. In: M.N. Clout and P.A. Williams (eds.). Invasive Species Management: A Handbook of Principles and Techniques. New York: Oxford University Press. p. 19-35.

Thus, while I am pleased to see a study examining the effects of irrigation and conservation agriculture on climate, the study has significant shortcomings as summarized in this review.