Agricultural Advisors as Climate Information Intermediaries: Exploring Differences in Capacity to Communicate Climate

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ABSTRACT

Although agricultural production faces chronic stress associated with extreme precipitation events, high temperatures, drought, and shifts in climate conditions, adoption of climate information into agricultural decision making has been relatively limited. Agricultural advisors have been shown to play important roles as information intermediaries between scientists and farmers, brokering, translating, and adding value to agronomic and economic information of use in agricultural management decision making. Yet little is known about the readiness of different types of agricultural advisors to use weather and climate information to help their clients manage risk under increasing climate uncertainty. More than 1700 agricultural advisors in four midwestern states (Nebraska, Indiana, Iowa, and Michigan) completed a web-based survey during the spring of 2012 about their use of weather and climate information, public or private sector employment, and roles as information intermediaries in three advising specializations: agronomic, conservation, and financial. Key findings reveal that advisors who specialize in providing agronomic information are positively inclined toward acting as weather and climate information intermediaries, based on influence and willingness to use climate information in providing many types of operational and tactical advice. Advisors who provide conservation advice appear to be considering weather and climate information when providing tactical and strategic land-use advice, but advisors who provide financial advice seem less inclined to act as climate information intermediaries. These findings highlight opportunities to increase the capacity of different types of advisors to enable them to be effective weather and climate information intermediaries.

1. Introduction

U.S. agriculture produces almost $330 billion annually in agricultural commodities and is vulnerable directly and indirectly to changing climate conditions and extreme weather events that impact crop and livestock productivity and pest and pathogen pressures (Harwood et al. 1999; Walthall et al. 2012; Pryor 2013; Melillo et al. 2014). The recently released U.S. National Climate Assessment points out that the success of farmers in managing climate risks depends upon their ability to continually adapt and innovate (Melillo et al. 2014), which in turn depends on access to knowledge and information (Moss et al. 2013). Increasing farmers' access to and use of climate information and forecasts is therefore needed to reduce their risk of economic losses, increase profits, and improve short- and long-term farm management decisions.

Seasonal climate projections (e.g., seasonal climate forecasts and climate model-based scenarios) show increasing potential for informing agricultural decisions, yet the actual adoption of climate information by farmers has been relatively limited (Zebiak and Cane 1987; Harrison 2005; Goddard et al. 2010; H. Meinke et al. 2008, personal communication; Lemos et al. 2012). Use of climate information is hindered by its high level

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of uncertainty, technical difficulty, and lack of clear application to on-farm decisions (Hollinger 1991; Lemos and Rood 2010; Mase and Prokopy 2014). Research has shown that boundary organizations and information intermediaries, who understand scientific information as well as users' information needs and decision contexts, play a critical role in increasing usability of technical information (Bessant and Rush 1995; Cash 2001; Lemos et al. 2012); however, the role that agricultural advisors play as intermediaries in fostering climate information use is relatively unexplored. Prior research in this area has largely focused on the U.S. Cooperative Extension Service, with less focus on the role of private sector advisors, for example (Buizer et al. 2010; Breuer et al. 2010; Mase and Prokopy 2014). New research suggests that a wide range of agricultural advisors may be potentially influential intermediaries and that a better understanding of agricultural advisor motivations, opportunities, and barriers faced in translating and communicating climate information is needed (Prokopy et al. 2013).

In this paper we explore the unique roles of an array of prevalent public and private agricultural advisors and examine their capacities to act as weather and climate information intermediaries. The orienting questions are 1) whether different types of agricultural advisors are equally likely to act as weather and climate information intermediaries and 2) which characteristics are associated with advisors' propensity to incorporate weather and climate information into the advice they provide to farmers.

2. Literature review

The agricultural sector is served by a diversity of advisors who specialize in making information and technological innovations accessible to farmers to guide their agronomic, conservation, and financial decisions. Historically, the first advisor group to play an intermediary role between agricultural scientific research and farmers was the Cooperative Extension Service, established as a partnership between state land-grant universities and the U.S. Department of Agriculture by the Smith–Lever Act of 1914 (USDA-NIFA 2013). Cooperative extension continues to actively serve in this role although exactly how much they directly influence farmers' decisions has been questioned (Samy et al. 2003; Prokopy et al. 2014, manuscript submitted to *Climatic Change*). Federal agencies such as the USDA's Natural Resource Conservation Service (NRCS) and Farm Services Agency (FSA) and local conservation districts (CDs) also act as advising organizations, providing technical support related to conservation, farm finances and farm policy and regulation (USDA-NRCS 2013). Over the past 20+ years, private sector consultants including agricultural retailers, certified crop consultants, and agricultural bankers have played increasingly important roles in farm decision support aimed at increasing yields, lowering production costs, improving crop quality, and managing risk (Wolf 1995, 1998; Briggeman et al. 2009; Keeney and Vorley 1998; ASA 2013, 2011).

Agricultural advisors are well positioned to act as climate information intermediaries and influence the use of climate science, as they help farmers identify information needs and recommend options for day-to-day decisions as well as future challenges and opportunities (Bessant and Rush 1995; Howells 2006; Lee and Cho 2005; Womack 2002; Lemos et al. 2012). The role of climate intermediary, though, demands organizational and individual investments in finding, understanding, translating, and communicating a variety of data and tools and identifying past, present, and future weather and climate conditions important for crop development. Lemos et al. (2012) suggest that use of climate information may vary depending upon how users perceive the information meeting their needs, how the information interacts with other types of information used, and the interaction between providers and users of the information. Thus, it is likely that agricultural advisors may differ in capacity and willingness to provide climate information as part of their professional duties (Just et al. 2003).

Agricultural advisors may express individually unique levels of capacity and willingness, as personal risk perceptions, beliefs, and typologies impact their decisions to adopt new technologies or information (March 1994; Venkatesh et al. 2003; Lemos et al. 2014). For example, age has been shown to be negatively associated with adoption of new technologies (Morris and Venkatesh 2000; Czaja et al. 2006; Prokopy et al. 2008), while educational attainment is positively associated with adoption of new technologies (Nelson and Phelps 1966; Prokopy et al. 2008). Personal experience with risk and perceptions of risk are also linked with an individual's intentions to take action to minimize risk (O'Connor et al. 2005; Horst et al. 2007; Weber 2006; Lemos et al. 2014). Little of the literature in this area has focused specifically on agricultural advisors (Mase and Prokopy 2014).

Advisors' decisions about investments in climate information may also be guided by fulfillment of their role, characterized by ''following the rules'' or social norms of their professional position (March 1994; Venkatesh et al. 2003). The advisor's sector, be it private (with the ability to extract monetary value from the information by charging a fee) or public (with no

TABLE 1. Survey population and recruitment.

	Total contacted	Returns (percent response)	Eligible participants
Certified crop advisors	~1610	434 (27%)	409
Agriculture retailers[a]	~1120	180 (16%)	167
University extension	369	141 (38%)	109
NRCS/local conservation districts[b]	1730	540 (31%)	422
USDA FSA	1599	462 (29%)	309
State Department of Agriculture/Department of Environment/Natural Resources[c]	298	134 (45%)	65
Agricultural bankers	~1160	280 (24%)	241
Total[d]	~7880	2171 (28%)	1722

[a] Category includes agricultural retailers, equipment dealers, and agricultural co-ops, which were reported separately in Prokopy et al. (2013).
[b] NRCS and local conservation districts were reported separately in Prokopy et al. (2013). The two groups were collected together and were indistinguishable from each other in one of the sample states; thus, we report these two groups as one.
[c] State Department of Agriculture and State Department of Environment and/or Natural Resources are reported together because of low sample sizes for each group individually.
[d] In this paper, we included only advisor groups for whom we could find and use sample frames in at least three of the four sample states, to avoid possible geographic biasing of the dataset.

direct associated fees) (Salin et al. 1998); the type of farmers served (Samy et al. 2003); the advisor's functional niche or specialization (Womack 2002); and institutional culture (Rayner et al. 2005; Lemos et al. 2014) may shape an advisor's role in such a way as to make investments in weather and climate information more or less ''mandatory.'' For example, according to Boehlje (1998), an advisor who charges a fee or is selling a product or service is more able to ''extract value or income'' from information, than one who does not charge a fee. Changes in the willingness of U.S. agribusinesses to use climate information over the past 20 years may be explained, in part, by the ability of the sector find monetary value in the information (Changnon 2004).

Similarly, organizational niches or specializations may play a role in how advice circulates through the agricultural system, with Wolf et al. (2001, p. 126) hypothesizing that ''the specific skills and capabilities. . .in which [intermediaries] choose to invest are important determinants of their functional role in information systems.'' Agricultural advising organizations may specialize in providing advice about short-term operational decisions, medium-term tactical decisions, or long-term strategic decisions. These different types of decisions have specific technical information needs, such as agronomic or marketing information that may or may not have interplay with climate information (Lemos et al. 2014) and particular climate and weather information that may or may not be available with adequate skill and timeliness (Meinke and Stone 2005; Hollinger 2009; Prokopy et al. 2013). In addition, depending on the type of decision being made, the success or outcome of using climate information may be known immediately or not until long after the decision maker has used the information, which also affects the potential value or payoff of using the information (Womack 2002). To date, the influence of intermediaries' role expectations on their climate information use has not been adequately examined. Frameworks linking professional roles and use of information may prove to be valuable to understanding this relationship.

3. Methods and approach to analysis

Approximately 7900 formal and informal agricultural advisors of corn (*Zea mays)* producers in four midwestern states (Nebraska, Iowa, Indiana, and Michigan) received invitations to participate in an online survey in the spring of 2012. We obtained e-mail lists of the universe of technical advisors and specialists in each state representing the USDA NRCS and state conservation districts, USDA FSA, state environmental and agricultural regulatory agencies, banks, agricultural retailers, certified crop advisors (CCAs), and the U.S. Cooperative Extension Service through organizations and agencies, professional or trade organizations, or their public websites. All of the listed advisors received an e-mail invitation to participate in the study, with a link to an online survey. Of the 7900 invited participants, 2171 responded to the survey, with response rates by group ranging from 45% to 16%, for an overall response rate of 28% [see Table 1 for response rates by categories used in this analysis; see Prokopy et al. (2013) for a complete listing of response rates from this survey].

Respondents who said they did not provide advice to corn farmers were not considered eligible for the survey, leaving a total of 1722 eligible completed surveys for analysis.

Participants received a survey instrument on weather, climate, and types of agricultural information provided to farmers, developed and pilot tested by a team of state climatologists, extension agronomists, and social scientists. The instrument was reviewed and accepted by the University Institutional Review Board (IRB) for human subjects. Survey items used in this paper are discussed in the next section and can be found in the appendix.

a. Variables

Independent variables in each model include the advisors' status as a public or private sector advisor, the advisor's advising niche, average client farm size, advisor age, advisor education, the degree to which advisors noticed unusual/variable weather across the Corn Belt, and the degree to which they thought changing weather patterns hurt farmers. We assigned respondents codes as public or private sector advisors, based on the organization with which they were associated, as listed in Table 1, and assigned advising niche(s) based on responses to the question ''What types of advice do you provide to corn producers? (check all that apply)'' with possible responses including agronomic, conservation practices, and financial types of advice (1 = yes, provides this advice, or 0 = no, does not provide this advice). We coded respondent-reported average client farm size as an ordinal variable with four categories based on distribution quartiles (coded as 0 = smallest number of acres through 3 = largest number of acres).

Respondents reported their highest level of education completed, and we created a dichotomous variable to separate those who had received a bachelor's degree or higher from those who had not, with choices ''some formal education less than high school, high school graduate/GED, some college, 2-year college or technical degree'' coded as education = 0 and ''4-year college degree or graduate degree'' coded as education = 1. Respondents reported age in years. Respondents indicated their level of agreement (1 = strongly disagree; 5 = strongly agree) with two statements (''In the past 5 years, I have noticed more variable/unusual weather across the Corn Belt'' and ''Changes in weather patterns are hurting the farmers I advise'') used as measures of experience with variable weather and weather patterns hurt farmers, respectively. Percentages of advisors agreeing (''agree'' or ''strongly agree'') with each statement are reported in the descriptive results while individual scores are used in the models.

Dependent variables for the models are 1) the degree to which advisors reported being influenced by climate information, 2) the degree to which they said they would like to use climate forecasts in the advice they provide, and 3) whether advisors reported incorporating weather and climate information into specific types of advice they give. We measured influence of climate information on a standardized four-point scale based on respondents' reported average influence (1 = no influence; 4 = strong influence) of four types of information that climatologists categorize as climate trends and climate data (as opposed to weather data): ''historical weather trends,'' ''weather data for the past 12 months,'' ''monthly or seasonal outlooks,'' and ''annual or longer term outlooks.'' The scale has a Cronbach alpha reliability score of 0.78. We measured willingness to use climate forecasts on a five-point agree–disagree scale (1 = strongly disagree; 5 = strongly agree) in response to the statement ''I would like to provide advice based on climate forecasts.'' Percentages of advisors agreeing (''agree'' or ''strongly agree'') with the statement are reported in the descriptive results while individual scores are used in the models.

We used 11 variables to measure incorporation of weather and climate information into advice on four different types of decisions: operational decisions, tactical purchasing decisions, tactical land-use decisions, and strategic land-use decisions (per Hollinger 2009). Operational decisions are made within days of carrying out the activity and are highly dependent on local weather conditions, such as plant/harvest dates, nitrogen application timing, and integrated pest management (IPM). Tactical decisions are made weeks to months in advance of carrying out the decisions. We separate tactical decisions into two subcategories: tactical purchase decisions, including seed purchase, fertilizer purchase, pesticide purchase, and crop insurance, and tactical land-use decisions, including crop rotation and field assignment, cover crops, and fall tillage decisions. Decisions about investments in adoption of conservation practices may be considered strategic land-use decisions, made months to years in advance of carrying out the decision. We asked respondents ''When you give advice to corn producers about the following decisions, do you consider historical weather trends and/or forecasts?'' for each decision listed above and coded their answers as 1 = ''yes'' and 0 = ''no, but I would'' or ''no.'' Respondents answering ''I don't give this advice'' were excluded from the analysis of the corresponding decision.

b. Analyses

Survey data were analyzed using StataCorp LP Stata software (version 12). We used descriptive analysis to explore differences among advisor groups with regard to

TABLE 2. Education level, age, and perceptions of weather patterns and information by advisor group. Here, n is the number of observations.

	Percent with 4-yr college or graduate degree	Avg age (std dev) n	Percent noticing more variable/unusual weather across Corn Belt	Percent agreeing that changes in weather patterns are hurting farmers
All advisors	77%	47 (11) n = 1497	73%	18%
Certified crop advisor	73%	48 (11) n = 367	76%	22%
Agricultural banker	88%	49 (11) n = 186	74%	12%
Agricultural retailer	62%	49 (12) n = 147	70%	10%
Extension	100%	49 (11) n = 98	74%	24%
NRCS/conservation district staff	79%	45 (12) n = 375	71%	18%
State agency/environmental agency	82%	45 (10) n = 60	71%	13%
FSA	69%	48 (10) n = 264	75%	19%

demographic characteristics, experience and beliefs related to climate variability and climate information, characteristics of advising role, use of climate information in advice, influence of climate information, and willingness to use climate information. We used regression models (multiple least squares, ordered logistic, and logistic) to understand which among the independent variables are related to the dependent variable and to explore the forms of these relationships with a focus on individual and role-based characteristics of advisors' and actions as a climate information intermediary. All analyses used listwise deletion to treat missing data.

4. Results

a. *The advisors*

The average age of respondents was 47, ranging by group from 45 (NRCS/conservation district staff and state agency staff) to 49 years (agricultural bankers, agricultural retailers, and extension educators). In terms of education, 77% of respondents had a 4-year college or graduate degree, ranging from 62% of agricultural retailers to 100% of extension educators (Table 2).

Past experience with weather patterns and information did not vary much across advisor groups. Overall, almost three-quarters (73%) of respondents had noticed more variable or unusual weather across the Corn Belt over the past 5 years, but fewer (only 18% overall) felt that changes in weather patterns were hurting farmers (Table 2).

The advisor groups were differentiated in their roles as information providers, based on sector, advising specialty, and size of farms served (Table 3). Of those included in this analysis, four advisor organizations were associated with the public sector and three were associated with the private sector. The organizations appeared to have carved out niches in the types of advice provided. Higher percentages of crop advisors and agricultural retailers said they provided agronomic (input purchase, crop management) advice than did advisors working for the NRCS, FSA, state agencies, or banks. Most advisors working for the NRCS and state agencies reported providing conservation advice. Extension advisors were unique in providing both agronomic advice (70% of respondents) and conservation advice (60% of respondents). As one would expect, financial advice was most often provided by agricultural bankers. Average client farm size also varied considerably between groups, with FSA reporting the smallest average client farm size and CCAs reporting the largest average client farm size. Public/private status and type of advice provided were correlated statistically with one another, although multicollinearity was not indicated.

TABLE 3. Advisor group sector, specialization, and client farm size.

	Public or private designation	Percent reporting agronomic specialization	Percent reporting conservation specialization	Percent reporting financial specialization	Avg client farm size in acres (std dev) n
Certified crop advisor	Private	97%	36%	17%	1546 (2207) n = 390
Agricultural banker	Private	9%	3%	100%	1253 (999) n = 216
Agricultural retailer	Private	75%	22%	18%	1244 (604) n = 153
Extension	Public	70%	60%	36%	891 (600) n = 93
NRCS/conservation district staff	Public	26%	98%	3%	912 (2006) n = 360
State agency/environmental agency	Public	27%	81%	2%	551 (497) n = 43
FSA	Public	5%	53%	39%	544 (364) n = 266

TABLE 4. Influence of climate information on advisors and their interest in providing advice based on climate forecasts.

	Avg influence of climate information (std dev, n) (1 = no influence; 2 = low influence; 3 = moderate influence; 4 = strong influence)	Percent who would like to provide climate information
CCA	2.53 (0.63, n = 379)	44%
Agricultural bank	2.50 (0.75, n = 201)	25%
Extension	2.57 (0.58, n = 99)	45%
FSA	1.99 (0.88, n = 262)	11%
NRCS/CD	2.49 (0.78, n = 377)	33%
Agricultural retail	2.61 (0.63, n = 144)	36%
State agency	2.27 (0.80, n = 55)	20%

b. *Influence of climate information*

On average, respondents across advisor groups rated climate information as "low" to "moderately" influential, with FSA advisors reporting being the least influenced by climate information (Table 4). Differences among advisors were associated with organizational as well as individual factors. Specializing in either agronomic information or conservation information was associated with higher levels of influence of climate information, as was advising larger size farms. On an individual level, advisors who had at least a 4-year college degree or experience with more variable or unusual weather across the Corn Belt were more influenced by climate information than those who did not (Table 5).

c. *Willingness to use climate forecasts in advice*

Advisors differed across groups as to whether they would like to provide advice based on climate forecasts. While 44% of CCAs and 45% of extension educators agreed that they would like to use climate forecasts in their advice, only 11% of FSA advisors agreed. Other groups fell in between (Table 4). Three individual characteristics were associated with increased willingness to use climate forecasts: having a 4-year college degree, experiencing increasingly variable weather, and seeing farmers hurt by recent weather patterns. Specialization in providing agronomic advice was also associated with increased willingness to use climate forecasts (Table 5).

d. *Incorporating weather and climate information into advice*

We found differences in incorporation of weather and climate information into advice, depending upon the type of advice given as well as the type of advisor (Table 6). Overall, incorporation of weather/climate information was most common when the advice related to timing of operations such as planting/harvesting, IPM practices, and N application. CCAs, agricultural retailers, and extension advisors reported most frequently that they incorporated weather and climate information into these decisions. Agricultural retailers and certified crop advisors were also more likely than extension, NRCS/CDs, FSA, or agricultural bankers to consider weather/climate information when providing advice about input purchases, such as seed and pesticide purchases. On the other hand, NRCS/CDs and state agencies reported with the highest frequencies that they considered weather/climate information when providing tactical land-use advice, including advice about use of cover crops and whether to till in the fall. Also, NRCS/conservation district advisors were more likely than CCAs, extension, FSA, and agricultural bankers to consider weather/climate information when providing strategic land-use advice (e.g., advice about adoption of conservation practices).

Advising specialization was related to use of weather and climate information when giving advice, and patterns in use emerged among different types of decision making (Table 7). For example, providing agronomic advice was associated with increased likelihood of

TABLE 5. The influence of climate information and willingness to use climate forecasts.

	Influence of climate information[a] (std error)	Like to use climate information in advice[b] (std error)
n	1227	1266
Private (vs public)	0.114 (0.063)	0.171 (0.155)
Financial advice	0.0162 (0.050)	0.064 (0.128)
Agronomic advice	0.181 (0.050)[c]	0.915 (0.128)[c]
Conservation advice	0.104 (0.053)[d]	0.135 (0.131)
Client farm size	0.073 (0.022)[c]	0.096 (0.055)
Education	0.224 (0.052)[c]	0.399 (0.129)[c]
Age	0.002 (0.002)	−0.003 (0.005)
Experienced variable weather	0.133 (0.027)[c]	0.322 (0.068)[c]
Saw farmers hurt	0.038 (0.027)	0.462 (0.072)[c]
Pseudo R2	0.090	0.060
Prob > F	$p < 0.01$	$p < 0.01$

[a] Models use regression.
[b] Models use ordered logistic regression.
[c] $p < 0.01$.
[d] $p < 0.05$.

TABLE 6. Percent of advisors who consider historical weather trends and/or forecasts when providing advice. Note that percentage is in relation to advisors who said they provide each type of advice (n). Respondents who said they do not provide each type of advice were omitted from the calculation.

	Operational decisions			Tactical purchasing decisions			Tactical land-use decisions			Strategic land-use decision
	IPM	Nitrogen timing	Plant harvest schedule	Seed purchase	Pesticide purchase	Crop insurance	Field assignment	Fall tillage	Cover crops	Conservation practices
	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
CCA	70% (338)	80% (354)	71% (321)	64% (332)	47% (312)	42% (172)	54% (337)	55% (305)	48% (263)	61% (275)
Agricultural retail	67% (102)	79% (110)	71% (107)	69% (106)	56% (107)	45% (53)	57% (101)	57% (78)	45% (78)	54% (74)
Extension	66% (79)	72% (75)	72% (75)	47% (53)	38% (70)	55% (52)	56% (72)	59% (77)	54% (80)	63% (81)
NRCS	60% (207)	69% (223)	63% (120)	34% (61)	42% (74)	31% (42)	52% (242)	66% (289)	65% (328)	77% (9366)
FSA	39% (51)	50% (44)	55% (69)	44% (43)	37% (43)	50% (149)	41% (51)	38% (76)	41% (97)	55% (175)
State agency	61% (23)	72% (32)	70% (23)	36% (11)	50% (12)	43% (7)	65% (20)	59% 33)	67% (33)	71% (45)
Agricultural banker	32% (66)	42% (66)	45% (89)	36% (74)	27% (77)	75% (177)	44% (63)	37% (70)	18% (55)	45% (94)

incorporating climate information into advice on every operational timing decision, while providing financial advice was associated with decreased likelihood of considering climate information for two out of three operational decisions. Providing agronomic advice was associated with increased likelihood of an advisor incorporating weather/climate information in tactical purchasing-related advice, except for advice about crop insurance. Providing either agronomic or conservation advice was associated with increased likelihood of using weather/climate information when providing tactical and strategic land-use advice, while in at least one case providing financial advice was associated with decreased likelihood of using weather/climate information to provide these types of advice.

Working in the public versus private sector was less related to incorporation of weather/climate information into advice, showing an association only with cover crop decision advice. Client farm size, too, was less important and was only associated with regard to fall tillage advice.

Individual characteristics such as education and age were positively associated with use of weather/climate information in advice on tactical and strategic land-use decisions. Experience with increasing weather variability was not associated with use of weather/climate information in any type of decision making, and experience with farmers being hurt by increased weather variability was only associated with use of weather/climate information in advice about crop field assignments and rotations (Table 7).

No relationships were evident in the use of climate information in providing advice about fertilizer use and agricultural drainage. They are not included in the table.

5. Discussion

We found that the advisor groups included in this study differed in their investments in climate information. Advisor groups were more or less likely to incorporate weather and climate information into advice, depending on whether the advice was related to operational, tactical purchasing, tactical land-use, or strategic land-use decisions. The groups differed in their interest in using climate forecasts and in how influenced they were by climate information.

Advising specialization or functional niche was particularly useful for understanding differences in use of climate information in different types of advice, influence of climate information, and willingness to use climate forecasts. These findings support Wolf et al.'s (2001) posit that an advisor's niche or specialization is connected to their investment in information and technology expertise. The findings also substantiate and refine Lemos et al.'s (2014, p. 1) findings that "at the individual and organizational levels, advisors who work in

TABLE 7. Advisors' consideration of weather and climate information when providing advice to corn producers. Note that models use logistic regression and the number is unstandardized regression coefficient.

	Operational decisions			Tactical purchasing decisions			Tactical land-use decisions			Strategic land-use decision
	IPM	Nitrogen application timing	Plant harvest schedule	Seed purchase	Pesticide purchase	Crop insurance	Field assignment	Fall tillage	Cover crops	Conservation practices
n	735	772	675	576	595	530	751	796	769	890
Private (vs public)	0.193 (0.239)	0.178 (0.243)	0.264 (0.233)	0.204 (0.255)	−0.002 (0.240)	0.456 (0.239)	−0.342 (0.220)	−0.250 (0.213)	−0.645 (0.224)*	−0.118 (0.217)
Financial advice	−0.457 (0.187)**	−0.401 (0.192)**	−0.241 (0.187)	0.087 (0.203)	−0.087 (0.192)	0.709 (0.205)*	−0.108 (0.180)	−0.249 (0.176)	−0.478 (0.185)**	−0.277 (0.172)
Agronomic advice	0.882 (0.206)*	0.794 (0.205)*	0.492 (0.205)**	1.171 (0.253)*	0.836 (0.243)*	−0.285 (0.213)	0.610 (0.193)*	0.257 (0.181)	0.569 (0.190)*	0.181 (0.176)
Conservation advice	0.403 (0.194)**	0.372 (0.200)	0.242 (0.192)	−0.118 (0.193)	−0.125 (0.187)	−0.035 (0.214)	−0.146 (0.178)	0.385 (0.179)**	0.46 (0.188)**	0.859 (0.182)*
Client farm size	−0.089 (0.085)	−0.007 (0.088)	−0.054 (0.091)	−0.035 (0.099)	−0.051 (0.093)	0.029 (0.098)	0.054 (0.080)	0.159 (0.077)**	−0.020 (0.077)	0.045 (0.076)
Education	0.056 (0.204)	0.042 (0.209)	0.215 (0.209)	0.035 (0.201)	−0.043 (0.211)	0.620 (0.233)	0.226 (0.187)*	0.369 (0.183)**	0.169 (0.189)	0.451 (0.184)**
Age	0.019 (0.007)	0.009 (0.007)	0.000 (0.008)	0.000 (0.008)	0.012 (0.008)	0.013 (0.009)	0.006 (0.007)	0.021 (0.007)*	0.019 (0.007)*	0.029 (0.007)*
Experienced variable weather	0.112 (0.104)	−0.043 (0.106)	0.018 (0.109)	−0.136 (0.114)	−0.063 (0.110)	0.035 (0.115)	−0.002 (0.095)	−0.021 (0.097)	0.008 (0.098)	0.068 (0.094)
Saw farmers hurt	−0.028 (0.103)	0.123 (0.107)	0.130 (0.108)	0.208 (0.115)	0.093 (0.106)	0.168 (0.121)	0.223 (0.096)**	0.170 (0.094)	−0.110 (0.095)	0.070 (0.092)
Pseudo R2	0.050	0.041	0.00	0.047	0.026	0.058	0.023	0.032	0.049	0.057
Prob > chi2	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.05$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$

* $p < 0.01$.
** $p < 0.05$.

supportive organizations. . .are more likely to provide climate information.'' Further, the size of clients' farms appeared to be related to influence of climate information, suggesting that investments may be partly driven by the advisors' clientele. More research is needed in this area. Whether an advisor worked in the public or private sector did not add much to our understanding of advisor investments in climate information (except for use of weather/climate information in advice about cover crops). This indicates that a simple public–private dichotomy is insufficient for understanding advisors' roles as information intermediaries and that more research is needed to understand the complex information-brokering relationships among public and private sector advising organizations.

While individual-level factors such as an advisor's education level and experience with variable weather were linked to the influence of climate information on their advice and their willingness to use climate forecasts, the role these factors played in determining whether they incorporated weather/climate information into specific advice was complicated. Individual-level factors were not associated with the use of climate information in advice related to operational or tactical purchasing decisions, which seemed to be driven exclusively by the specialized role of the advisor. Individual variables were important, though, in relation to the use of weather and climate information in advice about tactical and strategic land-use decisions. In other words, use of climate information in advice about tactical and strategic land-use decisions appears to vary among individuals based on their individual typologies and the roles they play as advisors, while use of climate information in advice about shorter-term decisions appears to be driven primarily by the specialized role of the advisor.

The emerging patterns provide some insight into factors underlying the current capacity of advisors to act as weather and climate information intermediaries. In the analysis, advisors who specialize in providing agronomic information appeared to be more positively inclined toward acting as weather and climate information intermediaries than advisors who did not provide agronomic advice. Advisors who provide conservation advice appeared to be considering weather and climate information when providing tactical and strategic land-use advice, although they were not necessarily more willing than others to use climate forecasts in advice.

The analysis provides evidence that advisors who provide financial advice may currently be less inclined than others to act as climate information intermediaries. Financial advisors may consider many on-farm decisions as existing outside of their advising realm and choose not to invest in related technical information such as climate outlooks. Tactical and strategic land-use decisions that are dependent upon financial resources, though, might benefit from an increase in investments in climate information by financial advisors.

6. Conclusions

In the context of increasing impacts of climate variability and change in agricultural systems, greater access to and use of climate information and forecasts has the potential to critically support farmers' efforts to manage and reduce risk, increase profits, and improve short- and long-term farm management decisions. The gap between climate science and the farmer is substantial, but agricultural advisors are trusted and credible sources of information and are well positioned to act as intermediaries to bridge the climate science information gap between scientists and farmers.

The systematic influence of advisors' niches on their investment in and use of information is a useful piece of information for those working to develop efficient and usable climate decision-support tools for agriculture. Agronomic advisors appear to have the capacity to act as weather and climate information intermediaries, particularly around operational and tactical purchasing decisions. Our findings highlight an opportunity and challenge to increase the capacity of financial advisors to be effective weather and climate information intermediaries. And we find that there is room for advisors who give conservation advice to focus more on weather/climate information than they currently do. Conservation advisors may need to increase their focus as climate information intermediaries as policy makers and researchers look to conservation practices to play a role in climate change adaptation.

Although our results add clarity to the picture of agricultural advisors as weather and climate information intermediaries, we note with caution that our models should not be used to infer causal relationships between the independent and dependent variables. Additional theoretical and empirical work is needed to address the gaps in understanding agricultural intermediaries' roles and their use of climate science in helping farmers prepare for and adapt to the risks and opportunities of a changing climate. This research leads to further questions about the interaction of advisor roles and their individual experiences and beliefs; the role of farmers' demands for information, access to information, and cost of advice; the effects of landscape characteristics such as soil and water resources on climate information investments; and the actual process advisors might go through in selecting and providing value-added information to farmers.

A better understanding of how agricultural advisors are influenced by climate and weather information, as well as how they use this information when providing advice to farmers, will allow scientists and educators to work more effectively with specific advisor groups. As advisors experience more variable weather, our research indicates that there may be more demand overall for high-quality weather and climate information. Enhancing advisors' roles as weather and climate information intermediaries will lead to more effective weather and climate information dissemination for use in agricultural risk management.

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APPENDIX

Questions (Q) Used in Analysis

Q1: What types of advice do you provide to corn producers (check all that apply)? Conservation practices, agronomic, and financial were three choices among a longer list.

Q2: In general, how much do the following types of weather information influence the advice you give to corn producers? (no influence, low influence, moderate influence, strong influence) (historical weather trends, weather data for the past 12 months, monthly or seasonal outlooks, annual or longer-term outlooks)

Q3: When you give advice to corn producers about the following decisions, do you consider historical weather trends and/or forecasts? (crop rotation/field assignment, seed purchase, seeding rate, fertilizer purchase, pesticide purchase, crop insurance, fall tillage, cover crops, IPM, timing of N application, planting/harvest schedule, investment in ag drainage, adoption of conservation practice not including drainage) (yes, no, no but I would, no I don't, don't give this advice)

Q4: Please indicate your level of agreement with the following statement: In the past 5 years, I have noticed more variable/unusual weather across the Corn Belt. (strongly disagree, disagree, uncertain, agree, strongly agree)

Q5: Please indicate your level of agreement with the following statement: Changes in weather patterns are hurting the farmers I advise. (strongly disagree, disagree, uncertain, agree, strongly agree)

Q6: Please indicate your level of agreement with the following statement: I would like to provide advice based on climate forecasts. (strongly disagree, disagree, uncertain, agree, strongly agree)

Q7: What is your highest level of education? (some formal education less than high school, high school graduate/GED, some college, 2-year college degree or technical degree, 4-year college degree, graduate degree)

Q8: Approximately, what is the average farm size of your clientele in acres?

Q9: What is your age (in years)?

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