

Assessing climate risk to improve farm business management

David A George¹, C Birch², D Buckley³, IJ Partridge¹ and JF Clewett⁴

¹ Department of Primary Industries and Fisheries, Queensland

² Faculty of Natural Resources, School of Agronomy and Horticulture, The University of Queensland

³ Faculty of Science and Agriculture, School of Agricultural and Veterinary Sciences, Charles Sturt University

⁴ Agroclim Australia, 64 Kuhls Road, Highfields, Queensland

David.George@dpi.qld.gov.au

Summary. Climate variability is a significant source of risk for farming businesses. Climate risk management involves assessing the impact of climate variability, applying structural change and making both strategic and tactical decisions to minimise the risk. This management is enhanced by improving the understanding of climatology and the potential application of seasonal climate forecasts to agriculture and natural resources. We argue that the extension of such climatological information plays a primary role in managing climate risk and can be delivered through workshops combined with user-friendly software.

Introduction

Variability in income is a fact of life for farm businesses, and much of it is directly associated with variability in climate. For example, climate affects the prices of agricultural produce in the local and global market place (Hammer et al. 1987; Stone 1993; White et al. 1999; White 2000). This paper will argue that presenting and discussing weather and climate information in an educational forum is a method that will help to survey and assess climate risk in order to reduce uncertainty and improve farm business management.

Climate uncertainty and risk in agriculture

Although climate variability affects all the factors influencing farm income, it is the impact on yield (production risk) that is most recognised by farm business managers (see Figure 1). Hardaker et al. (1997) define production risk as the risk that comes from the unpredictable nature of weather and uncertainty about the performance of crops or livestock. The relationship between climate and production risk is well recognised. For example, Hammer et al. (1996), McKeon et al. (2004) and Partridge (2000 and 2001) discuss the influence of rainfall on the yield of crops, the condition of native pastures and the amount of grass produced for livestock consumption. Mavi and Tupper (2004) also recognise that climate variability creates production risk through its impacts on resources, pests and diseases. Malcolm (1992) defines risk as the probability of something happening, while uncertainty covers all things that could happen which the decision-maker would not expect. Figure 1 shows the integration of multiple factors that explain climate in the context of uncertainty.

Climate risk management and the role of education

Risk management is the systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, treating and monitoring risk (Malcolm 1992). Climate risk management therefore assesses the possible impacts of climate variability on farm businesses, rural industries and the options available to mitigate the risk.

Malcolm (1992) and Krause (1994) describe how farming is a risky business, and how managing a risky business is about gathering relevant information, weighing it judiciously and acting accordingly. As improved knowledge about climate and skills in seasonal climate forecasting help in managing uncertainty in farming, the opportunity to learn about them has a pivotal role for all involved in rural production (Banks 2004).

The aim of this paper is to show that climate risk can be reduced through integration of understanding and systematic use of climate analysis into business decisions.

Climate variability issues relevant to business

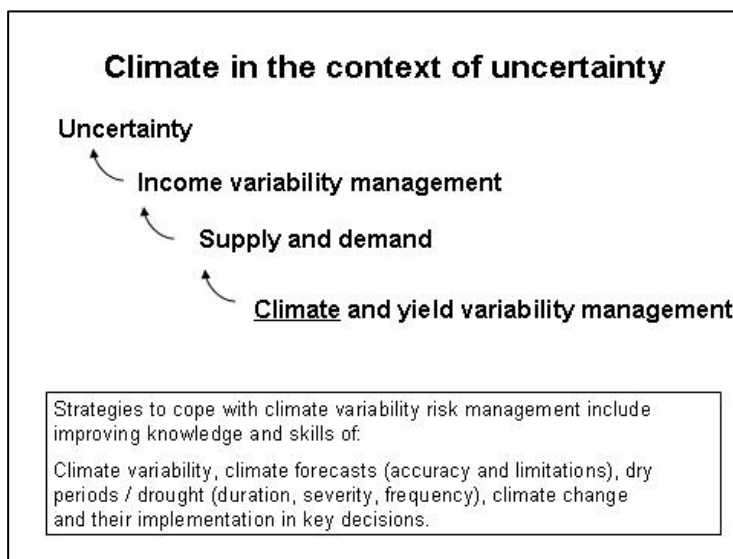
The climate in Australia is never 'normal', and examination of the rainfall of any location would demonstrate the extent of its variability (Lee and Gaffney 1986). The challenge to manage for times of higher or lower than average rainfall is not an easy one. However, analysing historical climatic data helps to provide a better understanding of the following issues:

- the degree of climate variability
- climate forecasts (accuracy and limitations)
- dry periods (duration, severity, frequency, forewarning)
- climate change.

A systematic process covering these aspects and developed from experience with farmer workshops is shown in Table 1. It shows a hierarchical process beginning with a review of historical

rainfall records for the participant's location and working through to critical decision points. It then covers tactical, strategic and structural farm planning aspects (George et al. 2000).

Figure 1. Conceptual map of climate in the context of uncertainty.



Some tools and process currently available to help manage climate risk

Tools to help manage climate variability through analyses of climatic data such as rainfall, streamflow and temperature include: Rainman Streamflow (Clewett 2002; Clewett et al. 2003), Whopper Cropper (Nelson et al. 2002) which assists in crop management decisions and DroughtPlan (Cobon and Clewett 1999) which assists with pasture and animal management decisions.

Clarkson et al. (2000) alluded to six requirements that are needed by farmers in order to manage climate variability. These include:

- awareness of climate variability
- understanding of climate and the causes of climate variability
- historical records for the location
- analytical tools to describe the variability
- forecasting tools to give advance warning of likely seasonal conditions
- application of forecasts to key decisions.

Many of these elements necessarily require the analysis of historical records. This can be an onerous and difficult task for managers of rural businesses. The ability of software to assist in the process of managing climate risk has been widely recognised (Nelson et al. 2002). A software program that allows analysis of climatic data for the key decision points in an agricultural system is especially valuable (Clewett 2002). White (2000) suggests that models and other decision support systems (DSS) have an important role in identifying those management strategies that are financially viable and exposed to minimum physical and financial risk, particularly in areas exposed to a variable climate. However, limitations of models and forecasts still need to be recognised (Robinson and Butler 2002).

The following key questions that software can help to raise and answer are not exhaustive, but may help to begin discussion about climate variability and better decisions. They include climate information for the key decisions in:

- cropping - what are the chances of getting sufficient rainfall over the next cropping season?
- livestock - when is the wet season likely to break and how much pasture will be produced over the growing season?; what will be the optimal stocking rate?
- irrigation - how many high flows could be expected in the local river this year?; what are the chances of getting heatwave conditions during the crop's flowering period?
- resource management - have heavy rainfall events become more frequent in recent years?; is it getting hotter with climate change at this location?

There is value in looking at the example of the chance of 300 mm of rain falling over the winter cropping season in central NSW (Figure 2). The climatological rainfall probabilities can be grouped according to the state of the Southern Oscillation Index (SOI) to produce separate probability

distributions. Rainfall of 300 mm should deliver a wheat yield of about 2200 kg/ha (assuming average farming conditions, no pests and diseases and yields commensurate with those calculated by the crop model Whopper Cropper (Nelson et al. 2002)). Over all the years, the chance of receiving 300 mm is 44%. However, if the SOI in the previous three months has been below -5 , there is only a 26% chance of 300 mm and a median rainfall of 193 mm. This equates to an expected yield of about 1600 kg/ha with a dollar return reduced by almost 30%.

Figure 2. Chance of receiving 300 mm of rainfall from June to November for the winter cropping period, based on March to May SOI, in Dubbo, NSW.

Chance of rainfall at DUBBO (COOREENA RD)				
Analysis of historical data (1875 to 2004) using average SOI: Mar to May Leadtime of 0 months				
The average SOI/rainfall relationship for this season is statistically significant because KW test is above 0.9, and Skill Score (14.3) is above 7.6 (p = 0.98). Chance result or real skill? Help				
Rainfall period: Jun to Nov	SOI below -5	SOI -5 to +5	SOI above +5	All years
% yrs with at least 478 mm	3	8	3	5
400 mm	6	19	9	13
350 mm	16	30	24	25
300 mm	26	49	50	44
250 mm	35	66	68	69
200 mm	48	79	82	73
138 mm	87	97	100	96
% yrs above median 274 mm	32	54	59	50
KS/KW probability tests	KS=0.995	KS=0.76	KS=0.63	KW=0.991
Significance level	**	Not significant	Not significant	
Years in historical record	31	63	34	128
Highest recorded (mm)	584	586	758	758
Lowest recorded (mm)	54	67	153	54
Median rainfall (mm)	193	289	299	274
Average rainfall (mm)	231	297	299	282

Source: Rainman software (Clewett et al. 2003)

Management options that could be considered knowing this probability shift arising from different SOI scenarios include: plant a different crop, plant a smaller area of wheat, reduce the seed rate and apply less fertiliser. Thus a better understanding of expected rainfall can be used to amend the crop management decisions, thereby reducing the risk of farming. However, education and training are needed so that the farmer fully understands probabilistic forecasts and their limitations. Details on the 'skilfulness' of forecasts are described in a companion paper (Clewett 2002).

A systematic way of developing knowledge and skills in managing climate variability is now described in terms of weather information, climate information and a theoretical basis to help deliver such information to agriculture.

Factors concerning weather 'contents' are:

- layers of the atmosphere
- differential heating of the earth by the sun
- atmospheric circulation to balance warm and cooler parts of the atmosphere
- behaviour of low and high pressure systems
- Australia's position in relation to the subtropical ridge of high pressure
- Coriolis effect resulting in south-east trade winds
- synoptic charts typical in summer and winter
- local conditions conducive to rain created by:
 - orographic uplift
 - convection
 - convergence
 - cold fronts
- regional effects of phenomena such as the Madden-Julian Oscillation, north-west cloud bands, upper level troughs and cut-off lows.

Up-to-date services and information via the Internet, satellite, radar and new developments such as 4–7-day forecasts can help in planning farm activities. Weather information generates short-term decisions such as those needed in hay-making, harvesting or shearing. Calculating how much hay to sell or store might be more influenced by the longer-term climate outlook.

Factors concerning climate 'contents' are:

- what conditions are needed for a good season?
- what are the chances of getting these conditions?
- what will be done if these conditions are not received?

- how may climate risk be minimised?

In order to answer these questions there should be an examination of the current and future climate and agricultural situation, including:

- identification of problems of climate and agriculture
- consideration of causes of these problems
- description of possible solutions to problems.

Actions to take include:

- identification of key issues and concerns
- examination of climate variability for a specific location
- consideration of effects of climate variability on production and returns
- understanding the forces that drive climate e.g. ocean temperatures, Walker Circulation
- use of forecast tools that explain much of the climate variability (e.g. ENSO, SSTs)
- examination of the current climate position (e.g. rainfall deciles for past 1, 3, 6, 12, and 24 months)
- assessment of the current outlook (for next 1, 3 and 10 days; 1, 3 and 12 months)

These actions, and the answering of other questions that may arise in the course of discussions and in reflection, will help to reduce climate uncertainty in terms of probabilities.

The high variability in Australia's climate is a challenge for agriculturalists (Munro and Lembitt 1997). Management requires better understanding of the causes and impacts of this variability and knowledge of the usefulness and limitations of seasonal forecasts. This flows to better management in soil-plant-animal-water systems. Climate change confounds this issue but makes the understanding of variability imperative (Nicholls 2003). Better understanding of climate variability will help management of climate change, and this will be helped by education and training in applied climatology.

Principles of adult learning relevant to the task of 'surveying climate and enterprise data' include:

- Application of action learning relevant to the ways farmers solve problems (Davey 1987; Kilpatrick 1997, 2000).
- Construction of knowledge, building from actual experiences to abstract concepts (Kolb 1984).
- Use of tables, graphs and animations to enhance different learning styles (Johnson and Johnson 1997).

Applied climate education helps improve knowledge and skills to better manage climate variability (George et al. 2000; Clewett et al 2000b; Sherrick et al. 2000) and ultimately climate change. Methodically surveying and assessing climate risk can reduce uncertainty and improve farm business management. Educational resources that address surveying and assessing climate risk to reduce uncertainty and improve farm business management include:

- introductory materials (Walker 1992; Krause 1994; Clewett et al. 2000a; Buckley 2000, 2002; Buckley and Horsley 2004)
- climate application courses that give elementary climate risk (Bayley and Brouwer 2000)
- courses that highlight climate risk (O'Sullivan and Paull 1994; Truscott and Egan 2002)
- courses that develop climate risk management strategies (George 2004)
- advanced texts also available (Hammer et al. 2000, Mavi and Tupper 2004).

Conclusion

Farm businesses suffer considerable risk from variability in income, much of which is a direct effect of climate variability. A major challenge for the future of Australian rural industries will be the ability to integrate climate variability, climate change and climate forecasts into the overall decision-making process. However, provision of more climate information does not ensure that it will be assimilated into management of agricultural production or natural resources; this requires more formal educational processes. A sequential way of surveying and assessing weather and climate information in educational forums is suggested as a method that will help to reduce uncertainty and improve farm business management.

References

- Banks R 2004, 'Rural decline and innovation: issues within issues; or what role for AFBM Journal', *Australian Farm Business Management Journal*, 1(1): 93-99.
- Bayley D and Brouwer D 2000, Weather and Climate in Farming, NSW Agriculture.
- Buckley D 2000, 'Forecasts help farmers to minimise losses', *Farming Ahead*, 105: 28-41.
- Buckley D 2002, 'Forecast accuracy limits on-farm use', *Farming Ahead*, 124: 34-46.

- Buckley D and Horsley P 2004, 'Climate risk for graziers', *Farming Ahead*, 144: 44-59.
- Clarkson NM, Abawi GY, Graham LB, Chiew FHS, James RA, Clewett JF, George DA and Berry. D 2000, Seasonal streamflow forecasts to improve management of water resources: Major issues and future directions in Australia, *Proceedings of the 26th National and 3rd International Hydrology and Water Resources Symposium of The Institution of Engineers, Australia*. 20-23 November 2000, Sheraton Perth Hotel, Perth, Australia. pp 653-658.
- Clewett JF, Cliffe N, Drosdowsky L, George DA, O'Sullivan D, Paull C, Partridge IJ and Saal R 2000a, Building knowledge and skills to use seasonal climate forecasts in property management planning, in: GL Hammer, N Nicholls and C Mitchell (eds), *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems - The Australian Experience*, Atmospheric and Oceanographic Sciences Library, Kluwer Academic, The Netherlands, Dordrecht, pp. 291-308.
- Clewett JF, Thompson PJM, George DA, Owens DT and Clarkson NM 2000b, Seasonal streamflow forecasts to improve management of water resources: Communicating results to improve knowledge and skills of clients in Australia, *Proceedings of the 26th National and 3rd International Hydrology and Water Resources Symposium of The Institution of Engineers, Australia*. 20-23 November 2000, Sheraton Perth Hotel, Perth, Australia, pp. 647-652.
- Clewett JF 2002, Seasonal climate forecasts and decision support systems for drought prone agriculture: A case study based on the development and application of Australian Rainman, *Coping against El Nino for Stabilising Rainfed Agriculture: Lessons from Asia and the Pacific*, ACIAR, Cebu, Philippines.
- Clewett JF, Clarkson NM, George DA, Ooi SH, Owens DT, Partridge IJ and Simpson GB 2003, *Rainman StreamFlow version 4.3: a comprehensive climate and streamflow analysis package on CD to assess seasonal forecasts and manage climate risk*, Q103040, Queensland Department of Primary Industries, Brisbane.
- Cobon DH and Clewett JF 1999, *DroughtPlan CD: A compilation of software packages, workshops, case studies and reports to assist management of climate variability in pastoral areas of northern Australia*, Queensland Department of Primary Industries, Brisbane.
- Davey PC 1987, The role of traditional and alternative extension methods in facilitating information transfer and client change, In: M. Littmann (ed), *Rural Extension in an Era of Change. Australasian Agricultural Extension Conference Proceedings*, Brisbane, pp. 661 - 668.
- George DA, Clewett JF, McBride J, Balasubramanian TN, Huda AKS, Geethalakshmi V, Selvaraju R and Mavi H 2000, Seasonal climate and weather forecasting - agricultural applications, in: JSP Yadav and JB Singh (eds), *Invited Paper presented at the International Conference on managing natural resources for sustainable agricultural production in the 21st century*, ICAR, 14 -18 Feb 2000, New Delhi.
- George DA 2004, *ClimEd, Managing Climate Risk - Participant Manual*, Department of Primary Industries and Fisheries, Queensland, AgForce Queensland and FarmBis (DAFF), Brisbane.
- Hammer GL, Woodruff DR and Robinson JB 1987, Effects of climatic variability and possible climatic change on reliability of wheat cropping - A modelling approach, *Agricultural and Forest Meteorology*, 41(1-2): 123-142.
- Hammer GL, Holzworth D and Stone R 1996, The value of skill in seasonal climate forecasting to wheat crop management in a region with high climate variability, *Australian Journal of Agricultural Research*, 47: 717-737.
- Hammer G L, Nicholls N, and Mitchell C 2000, (eds), *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems - the Australian Experience*, Kluwer Academic Publishers, Dordrecht.
- Hardaker JB, Huirne RBM and Anderson JR 1997, *Coping with risk in agriculture*, CAB International, Wallingford, UK, 274 pp.
- Johnson DW and Johnson FP 1997, *Joining Together: Group Theory and Group Skills*, Allyn and Bacon, Boston.
- Kilpatrick S 1997, *Effective delivery methodologies for education and training to rural Australia*, Centre for Research and Learning in Regional Australia, Australian National Training Authority: Launceston. p. 120.
- Kilpatrick S and Rosenblatt T 1998, Information versus training: Issues in farmer learning, *The Journal of Agricultural Education and Extension*, 5(1).
- Kilpatrick S 2000, Education and Training: Impacts on farm management practice, *The Journal of Agricultural Education and Extension*, 7(2): p. 105-116.
- Kolb D 1984, *Experiential learning, experience as the source of learning and development*, Prentice-Hall, New Jersey.
- Krause M 1994, *Risk management for agricultural and horticultural enterprises*, Adelaide Institute of TAFE, Adelaide.
- Lee DO and Gaffney DM 1986, *District rainfall deciles - Australian Meteorological Summary*, Bureau of Meteorology and AGPS, Canberra.
- Malcolm LR 1992, Farm risk management and decision-making, in: Trapnell LN and Fisher WW 1992, *Incorporating Risk into Decision Support and Farm Business Management Systems, National Workshop on Incorporating Risk into Decision Support and Farm Business Management Systems*, Victoria Department of Agriculture, Melbourne.
- Mavi HS and Tupper GT 2004, *Agrometeorology: principles and applications of climate studies in agriculture*, The Haworth Press, Inc., New York, 364 pp.

- McKeon GM Hall W, Henry B, Stone G and Watson I 2004, *Pasture degradation and recovery in Australia's rangelands: Learning from History*. Queensland Department of Natural Resources, Mines and Energy., Brisbane, Australia., 256 p.
- Munro RK and Lembit MJ 1997, Managing climate variability in the national interest: Need and objectives, in: RK Munro and LM Leslie (eds), *Climate Prediction for Agriculture and Resource Management*, Bureau of Resource Sciences, Canberra.
- Nelson RA, Holzworth DP, Hammer GL and Hayman PT 2002, Infusing the use of seasonal climate forecasting into crop management practice in North East Australia using discussion support software, *Agricultural Systems*, 74(3): 393-414.
- Nicholls N 2003, Climate change: are droughts becoming drier and more frequent? in: R. Stone and I.J. Partridge (eds), *Science for drought - Proceedings of the National Drought Forum*, Department of Primary Industries, Brisbane, pp. 1-7.
- O'Sullivan D and Paull C 1994, *Managing for Climate: understanding climate to improve risk management*, Queensland Department of Primary Industries, Brisbane.
- Partridge IJ 2000, *Managing grazing in the semi-arid woodlands: a graziers guide*, Queensland Department of Primary Industries, Brisbane.
- Partridge IJ 2001, *Will it rain? 3rd Edition. The effects of the Southern Oscillation and El Niño on Australia*, Queensland Department of Primary Industries, Brisbane.
- Robinson J and Butler DG 2002, An alternative method for assessing the value of the Southern Oscillation Index (SOI), including case studies of its value for crop management in the northern grainbelt of Australia, *Australian Journal of Agricultural Research*, 53: 423-428.
- Sherrick BJ, Sonka ST, Lamb PJ and Mazzocco MA 2000, Decision-maker expectations and the value of climate prediction information: conceptual considerations and preliminary evidence, *Meteorological Applications*, 7: 377-386.
- Stone R 1993, Assessment of Risk Associated With Climate Prediction In Management of Wheat In North Eastern Australia, *Proceedings 7th Australian Agronomy Conference*, Adelaide, 1993: 174-177.
- Truscott MA and Egan JP 2002, *Climate Risk Management Kit*, SARDI, Adelaide.
- Walker P 1992, *Managing for Drought*, NSW Department of Conservation and Land Management, Sydney.
- White BJ 2000, The importance of climate variability and seasonal forecasting to the Australian economy, in: GL Hammer, N Nicholls and C Mitchell (eds), *Applications of seasonal climate forecasting in agricultural and natural ecosystems*, Kluwer Academic Publishers, Dordrecht.
- White DH, Tupper GT and Mavi H 1999, *Agricultural climate research and services in Australia*, CV02/99, Land and Water Resources Research and Development Corporation, Canberra.

Table 1. A hierarchical theoretical framework for surveying and assessing climate risk for improving farm business management

Survey and assess climate information	Reason why important
1. View recent rainfall record	The up-to-date climate record is valuable as a learning tool on which to build from recent experience.
2. Examine the whole historical rainfall record	This provides a picture of the nature of variability in a location. It demonstrates the degree of variability of the climate as well as recent trends in that climatic record in the context of the whole historical period.
3. Assess the impact of ENSO and other forecasting tools	ENSO may be able to explain a considerable amount of variability for much of Australia. It is also helpful to know where and when ENSO is not useful as a forecast tool. ENSO's behaviour is unpredictable around autumn; however, once winter is established, ENSO's pattern will usually be set till the following autumn. Knowing where to look for updated SOI figures, SST's and the thermocline is of critical importance to knowing how and when ENSO establishes and dissipates.
4. Identify climate change trends	In response to the climate change debate, it is useful to examine if the climate is getting warmer or cooler, wetter or drier at specific locations, and then consider mechanisms driving this trend to help answer why it is so? And how can it be better managed?
5. Determine where the most accurate and reliable climate information can be accessed and which forecast system has most reliability	Knowing when a forecast is reliable is as valuable as knowing when there is not much reliability. New forecast systems being researched and developed need to be examined for specific locations and tested to see if there is spatial coherence. Current forecast systems used around Australia are SOI, SOI Phases, SST Phases.
6. Evaluate daily and weekly data	For planting decisions, or possible disease outbreak in particular, knowing the chances of getting x mm of rain in y days between date 1 and date 2 is useful information for management.
7. Consider the rainfall along with maximum and minimum temperature	In agriculture, and horticulture in particular, it is not just rainfall that is important but information such as dates of heat waves and critical frost periods. These may be managed if due warning is available.
8. Integrate climate data with enterprise information	Integrating climate information with enterprises is a tool to reduce risk.
9. Assess the impact of climate on soil – plant – animal – water systems (including pests, diseases, erosion, biota)	Climate is significant in agricultural systems; because it is beyond our 'control', it needs to be managed.
10. Characterise drought duration and frequency for your location	Dry periods of varying duration, severity and frequency have been a feature of Australia's climate. Characterising drought duration and frequency is recognised as being the most important climate skill required by producers.
11. Contrast seasonal climate patterns historically and recently	This issue raises serious questions: What is the recent climate trend and is it expected to persist? Do management practices need to change to allow for extremes of climate variability?
12. Determine critical periods or key decision points	Knowing more about climate variability and forecast provides producers with an edge that may help reach the goal of producing the right quality product at the lowest unit cost possible.
13. Evaluate climatic extremes of drought, flood, heat and cold stress, frost and wind	Knowing more about drought, flood, heat and cold stress, frost and wind and their forecast provides producers with an edge that may help reach the goal of producing the right quality product at the lowest unit cost possible.
14. Integrate climate information with business decisions	Integrating climate information with enterprises is a tool to reduce risk and help produce the right quality product at the lowest unit cost possible.
15. Manage climatic risk with structural (>5->10 years), strategic (>1-5 years) and tactical (1-10 days or season) decisions	Weather information is useful for tactical decisions, whereas climate information is useful for strategic and structural decision-making. The two are complementary.
16. Proceed to update weather and climate information, and decisions as a season unfolds	Updating data to have the most accurate and reliable climate information available is crucial in data analysis.

