New Uses for Global Forecasts
FY 10 ECA Innovation Grant
- Final Report -

Executive Summary

In accordance with the goals of the Innovation Grant, World Bank staff undertook a study tour to Turkey to observe Turkey's innovative system to deliver farmer-focused weather alerts by cell phone. Staff then reviewed obstacles to implementation of similar systems in Central Asia and, in the Kyrgyz Republic, explored ways to overcome these barriers.

Staff have concluded that an adapted version of the Turkish program would be possible, economically beneficial and welcome in the Kyrgyz Republic.

MAIN FINDING

In May the team learned that in our pilot of this program in the Kyrgyz Republic, the forecasts although imperfect have been very useful. Jalal-Abad experienced a rainy and cold spring, and many farmers had difficulty identifying when to plant, or did not succeed in planting at all. ***But all farmers who were recipients of SMS weather messages under our pilot succeeded in planting their crops.***

Farmers not originally included in the pilot have asked to be added.

Farmers, as evidenced by a small pilot and field interviews in the Kyrgyz Republic, appreciate the value of the timely weather alerts. The currently available "for tomorrow" weather forecasts delivered to farmers mainly by the national TV is not fully satisfactory. It has very short time horizon. In rural areas these are aired after the evening TV news, which precludes the possibilities for advance work planning. Other channels of information are not usually available in rural areas: FM radios do not work, internet is beyond the reach, and newspapers are arriving, at best, several days after going out of press. This problem can be solved by using the longer-term global forecasts until the local longer-term modeling capacities are developed and then distributing these forecasts directly to the cell phones of the subscribed farmers.

Implementing this idea requires investments into training, equipment, and setup and running costs. Initially, these costs can be covered from donor-financed projects but in the longer-term the government should bear the costs if other alternative solutions are not found.

A new Food Security Project in Kyrgyz Republic might take this pilot up to a next level by financing training of Hydromet staff, advisory services and farmers, as well as procurement of mini meteorological stations, and other equipment for processing and distribution of the forecast information.

As for other sectors and other countries in Central Asia, the team does not know of any barriers that should prevent consideration of similar outreach.

Background

The regional priority on climate change adaptation highlights an adaptation mechanism that has emerged with broad support: upgrade and dissemination of spatially-resolved, accurate weather forecasts and robust mechanisms to place this information in the hands of farmers on a timely basis.

Weather information can facilitate the changeover away from climatology that is increasingly out of date. While experts make a heartfelt case for upcoming climate warming on the basis of human influence on the atmosphere, other experts make a plausible case for upcoming cooling in the near term driven by natural forcing such as solar effects. No one claims to understand all the first-order effects at work. No one claims to know what will happen locally to wind, precipitation and runoff, all of which are important to crop agriculture, livestock husbandry, and indeed to every sector. Following the food security crisis caused by adverse climate conditions and increased regional food prices in 2008-2009, rural poor in Central Asian countries, the Kyrgyz Republic and Tajikistan in particular, now face an income shock.

Weather forecasting could mitigate these effects in the future. With up-to-date forecasts, and with an understanding of the probabilistic nature of the information, farmers can make real time decisions and adapt their activities on a timely basis.

An example of possible gains is provided by the Government of Turkey. Turkey is pioneering a suite of farmer-focused weather services that could show the way for delivery of tailored services. Kastamonu Province in particular provides a key example and good practice. Kastamonu's provincial agricultural directorate tailors daily weather forecasts prepared by Turkey's national meteorological service so that the forecasts are tuned to Kastamonu's rural weather conditions and to the information needs of local farmers, such as its important subsector of orchard owners. To meet their particular information needs, frost alerts and information concerning weather-dependent pest infestations are dispatched by text messages (SMS) to farmers who have subscribed to this (free) service.

The objective of this Innovation Grant-funded activity was to bring ECA staff up to date on the emerging good practice in Turkey, providing an opportunity for staff working on the Central Asia portfolio to discuss with Turkish experts and colleagues how the model could be applied in Central Asia. A second phase of the activity would address the issue that, while Turkey generates its own high-resolution weather forecasts, the Bank's Central Asian clients do not. The activity therefore set out to identify practical options and methods to adapt the Turkish good practice by using publicly available forecasts from international sources.

Accordingly, a two-track activity was planned. First, a study tour to Turkey would set out the structure and outcome of a provincial weather warning service. Field trips to Kastamonu and Sivas would enable Bank staff to consider application of these ideas to several different agricultural systems. Second, staff would consider how to address the difference between forecasts available in Turkey and forecasts available in Central Asia. Central Asia does not have Turkey's weather forecasting capacity. On the other hand, there exist several global sources of forecasts. The applicability of such global forecasts to the purpose of providing weather alerts to farmers in Central Asia would be reviewed and tested in the field. This test would be a joint effort of the World Bank and the US Weather Service.

The Grant having been awarded in September 2009, the team undertook the study tour in November 2009 and studied applicability of its lessons in the Kyrgyz Republic from January to May.

Study Tour to Turkey – December 2009

Four World Bank staff, one Bank consultant and one staff from the US Weather Service participated in a study tour in Turkey to review early experiences in a pilot agricultural early warning service initiated in Kastamonu Province in spring 2008 by the Provincial Directorate of the Ministry for Agriculture and Rural Affairs (MARA). For two seasons (2008-2009) this service had advised farmers concerning the timing of pest management; in 2009 it had added warnings of frost risk.

Kastamonu

Kastamonu is an important agricultural district with special, though not exclusive, emphasis on fruit growing, a subsector particularly vulnerable to pests and to spring frosts. These two risks have been the focus of weather information services to agriculture provided by the provincial directorate of MARA (PDA) in the first two years of its agricultural early warning service (AEWS).

Integrated pest management (IPM) provided the first framework for PDA's weather services in Kastamonu. Use of IPM in Kastamonu integrates biological and chemical practices to control fruit tree pests and diseases, and MARA has developed manuals, safeguards and technical support documentation to support the fruit grower farmers/beneficiaries. Against this background, the principle underlying the weather warning service is that pests have a predictable life cycle if the warmth of their environment is taken into consideration. That is, they mature more quickly in warm weather, and the time of maturation can be predicted in terms of degree-days of their environment (where one day counts for as many degree-days as the day's average temperature exceeds the reference temperature).

On this principle, it is possible to time optimal pest interventions by observing pest emergence at a set of reference farms that are continuously monitored, and to select an optimal date for district-wide pesticide application based on daily temperatures in the microclimate of the affected area.

PDA's approach is as follows: PDA maintains close, routine interactions with orchards around the province, sampling the province's microclimates and crops. At fourteen reference farms, traps are deployed on trees to observe orchard pests as they emerge. On observation of a pest outbreak, the plant protection unit initializes the timing for the expected life cycle of the specific pest and undertakes continuing monitoring of the pest at the reference farms to calibrate these expectations. Meantime, at five weather stations that PDA maintains, sampling Kastamonu province's microclimates at a subset of the test farms, temperature is measured hourly, or more often if pre-set triggers are set off such that more frequent monitoring is called for. Figure 1 depicts one of these stations.

Figure 1. Weather stations are sited so as to monitor the microclimate of a typical orchard; as such, their siting does not correspond to WMO guidelines that would govern Turkey's basic weather monitoring network. The stations measure temperature, precipitation, wind, soil moisture, and leaf wetness, a different set of parameters from those measured at a basic weather station. PDA's current program does not draw on all these parameters, but further services to agriculture are possible and are envisioned

Drawing on monitoring at pest traps on the test farms together with temperature measurements at the weather stations, PDA keeps pace with pest life cycles, selecting the optimal timing for pesticide application optimally. PDA broadcasts this guidance on a wide scale, aiming to reach all affected farmers via mass media, village leaders, text messages, and other dissemination channels. Moreover, PDA follows up after its campaigns in order to identify farmers who were missed so that future campaigns will achieve 100 percent dissemination.

Results. The program has been a great success in its first two years. For example, since the program began in 2008, weather information has reduced the need for pesticide application to apple orchards from an average of six applications per year to three, bringing annual costs from 10 Turkish lira/tree/year to 7 lira – a saving equivalent to about USD 2.0 per tree, - according to one lead farmer. As there are about half a million commercial apple trees in the province, this single component of benefit alone could amount to averted losses of about a million USD/year, for an initiative whose startup capital cost (with O&M) was on the order of USD 40,000 for the two initial years. PDA's staff costs incremental to existing efforts appear to be modest although important.

Lessons learned from the IPM exercise that concern the weather element include the following:

> **Value of a good forecast.** PDA finds it very useful to draw on the forecasts produced by the national weather service, DMI, using them to drive software that models pest lifecycles. In this way, weather forecasts become pest development forecasts, supporting preparations for pesticide intervention. The national weather service forecasts do not pinpoint the climate of the orchards; systematic differences have been noted, perhaps because the farm microclimate is cooler than the urban settings of DMI's weather stations. Still, a strong sense of upcoming weather events is qualitatively very helpful, and the systematic errors are manageable.
>
> **Local microclimate monitoring is a necessary supplement** to forecasting in order to compensate for systematic errors and fine-tune pest lifecycle forecasts. The few degrees of systematic difference between forecasts and farm microclimates would cause a mistiming of interventions if the forecasts were used naively. It is for this reason that PDA maintains its network of five weather stations throughout Kastamonu. As Figure 1 showed above, the

locations selected for PDA's weather stations are different in principle from the sites that would be selected for stations compliant with WMO standards for the basic network.

Dissemination successfully draws on formal and informal networks. PDA's key messages are disseminated by leading farmers and village heads who are likely to broadcast and promote equitable distribution of information.

Frost risk alerts are a new service from PDA. Frost risk has been increasing in Kastamonu and has caused a drop in fruit production in Kastamonu in the past twenty years. The trend is not easy to categorize simply as warming or cooling. In some years, warm spring weather comes earlier than it does on average, initiating vulnerable growth of the trees and thus enhancing frost risk. But cold snaps bringing frost seem to occur later in spring than they formerly did, damaging growth. Overall apple production has been in decline as a result of rising frost risk. With this in mind, in 2009, PDA's AEWS program undertook frost risk warnings.

Figure 2. Alert sent automatically by modem/GSM module at orchard weather station. "FROM KASTA [ALARM] AIRT20CM -0.88c"

PDA's approach to frost warnings, like its approach to IPM, draws first of all on the high-resolution weather forecasts of the national weather service, DMI. DMI's forecasts of upcoming temperature flag anticipated levels of frost risk for various crops (damage may begin a few degrees above 0^0C depending on the crop). Again as above, PDA supplements the national forecasts with its own knowledge of the average difference between urban microclimates and those of rural orchards, the latter usually a degree or so colder. When PDA estimates, based on DMI's alerts and its own knowledge, that there exists a frost risk, it sends out an alert at 4 p.m. to all subscribing cell phones.

PDA's second layer of information is drawn from the five weather stations located on a subset of the reference farms, sampling a range of microclimates. These weather stations are programmed to dispatch alerts whenever an hourly temperature reading records a value below a pre-set level, e.g., 2^0C. See Figure 2.

Taken together with the earlier alert that frost risk was possible, and well as local knowledge that a temperature of 2^0C at 11 p.m. usually means frost before morning, these alerts have been fully effective in alerting farmers to times when frost risk mitigation measures must be undertaken. As noted above, the system has had neither a false alarm nor a missed event, and the lead time supplied has been adequate to enable mitigation measures to be undertaken.

A full evaluation of the pilot had not been undertaken yet at the time of the mission's visit to Kastamonu. However, to date no farmer who subscribed to the service had suffered a crop loss from frost, while anecdotally some neighbors who did not subscribe and did not attend to the warnings that they received informally did suffer crop losses.

As for the current scope of this effort, about 500 farmers can be reached by PDA directly on their cell phones. A multiplier exists in that the farmers notified then in turn notify their neighbors, but the magnitude of this multiplier could not be determined; it may be on the order of 50 in some situations, as where the village head is a subscriber, the only subscriber in a village.

Incremental cost of the IPM/frost alert system. The cost of the AEWS is not readily distinguished from the cost of PDA's existing services, such as the monitoring of reference farms. The clearly incremental element of the AEWS system is the network of weather stations (e.g., see Figure 1), with its associated telecommunications and the analysis software at PDA's district headquarters. A network of four stations, telecoms and software, with two years of maintenance and sparing, were procured for a total of USD 40,000 several years ago. Those four new stations, together with a single older station equipped with modem/landline, comprise the current five-station network.

In sum, the success of this alert program (avoidance of false alarms and missed events, and provision of adequate lead time) rests on three pillars: the forecasts and analyses delivered by DMI, PDA's knowledge of local microclimates and crops, and data from PDA's local weather monitoring stations.

The AEWS may take up new weather issues in the future: with an eye to further services, PDA collects and analyzes soil moisture and other data that is not used by the two current applications.

Sivas

The mission visited farms in Sivas, a region of eastern Turkey where livestock is important. This region does not yet have a project similar to that of Kastamonu although it does have access to the weather services of DMI. The visit to Sivas had two key outcomes: first, the example of Kastamonu was identified by a local project PIU as of considerable interest to this district, and it was rapidly concluded that the PIU would examine Kastamonu's findings. Second, the team had an opportunity to ask for the advice and opinion of agricultural farmers near Sivas concerning weather-related issues affecting their productivity. In the village visited, average farm area is ten ha/family. The area is rainfed rather than irrigated. Dairy cattle and a few sheep are supported. Farmers grow wheat, barley and fodder crops. Wheat production is about 2.5-3 tons/ha; barley is higher. The village has 84 households, who share 20-24 tractors.

The farmers from Basyayla village advised that their main source of weather forecast information is TV broadcasts which provide three days' forecast. The PDA also sends guidance on how to act on weather information, teaching agro-meteorology to farmers.

The farmers explained that recent climate trends are mixed. In recent years, the pattern of the past hundred years has changed. Spring frosts used to end before May 20 but recently have occurred as late as the 25th of May. In autumn, they arrive earlier than before. But at the same time, there seems to be less snow than before. If snow does not accumulate in winter, then spring snowmelt is less; further, wheat is unprotected from winter cold. It seems that winters are growing longer and that spring seedlings struggle. It seems that summer arrives later and that cold winds from the north are affecting the cucumbers and tomatoes. With respect to some of these phenomena, farmers were not certain whether phenomena were trends or cycles, with the exception of the late-occurring spring frosts which they are certain are anomalous with respect to the last hundred years. Because of these circumstances, accurate forecasts from DMI are more important now than before.

Forecasting is principally of importance for crops rather than livestock, but even so at sheep-shearing time producers check the forecasts, taking into consideration temperature and precipitation but also wind direction, for if the wind is from north then there is risk of disease among livestock (presumably because winds from the south would be moist, from the north dry[1]). Livestock producers also explained that in western Turkey though not in the east, heat forecasts in summer are of importance because livestock may need to shelter from the heat.

Exploring Adaptation of the Turkish Example to Central Asia

World Bank staff then reviewed the circumstances in Central Asia that would call for adaptation of the Turkish model.

Need for high-resolution national forecasts. Turkey undertakes high-resolution numerical weather modeling, with the result that forecasts over its national area are prepared daily at grid spacing of a few kilometers. Such models are not available in Central Asia.

- A medium-term alternative would be development of modeling capacity, which is certainly within reach even though resources are short. Many countries in Africa, most countries in Latin America, and every country in the Caucasus have undertaken such modeling successfully.

  This alternative is probably the best, but will take time and resources, and in the intervening few years, crops are damaged by weather and food security is becoming an issue.

- A short-term alternative would be use of the global models prepared and distributed daily by some capable national agencies. These models are publicly available but information on how to access them takes time to reach those who could benefit, the more so as the information is provided in national languages other than those of the users.

  It is not known whether global forecasts would be suited to local use. Global forecasts are prepared at low resolution, necessarily so considering the length of time required for high-resolution forecasting. The forecasting cycle from global observations to delivery of a global forecast, is less than 6 hours from end to end. In a follow-on step, national agencies build on the global forecasts, computing high-resolution national forecasts over national space that are forced to fit the global model outputs. Central Asian users would have only the low-resolution global forecasts available, while Turkish users have a national model available that forecasts with grid spacing of a few kilometers. Low resolution forecasts are particularly challenged to represent data-short mountain terrain, like that of Central Asia.

Institutions in Central Asia do not as yet disseminate public forecasts capturing benefits on the time frames made possible by new technology.

- One alternative to speed dissemination would be greater use of the web site of the national meteorological services, in direct imitation of Turkey. However, the absolute majority of farmers do not have access to the internet and hence some “disseminators” are needed to get the information down to farmers by other means.

[1] The veracity of this statement has not been verified.

- A complementary means of dissemination is via agricultural information outlets, also an aspect of the Turkish model.

An institution willing to absorb recurrent costs of the outreach is not yet identified.

The second phase of the activity therefore undertook an exploration focused on these issues: suitability of the available global forecasts, identification of a feasible institutional arrangement, and consideration of how to finance recurrent costs.

Suitability of the available global forecasts

The US Weather Service offered help to this initiative, donating the time of its staff and helping to clarify and simplify access to its global forecasts, which comprise the only freely available global ensemble forecast (that is, a global forecast with probabilistic information embedded in it). Bank staff received a briefing from US National Weather Service staff member Jordan Alpert concerning portals and analysis tools aimed to make these forecasts available (see Annex 1), and the team consultant undertook comparisons to find out whether the ensemble forecasts of precipitation in Bishkek are reasonably similar to what actually happens. See Figure 3 below.[2]

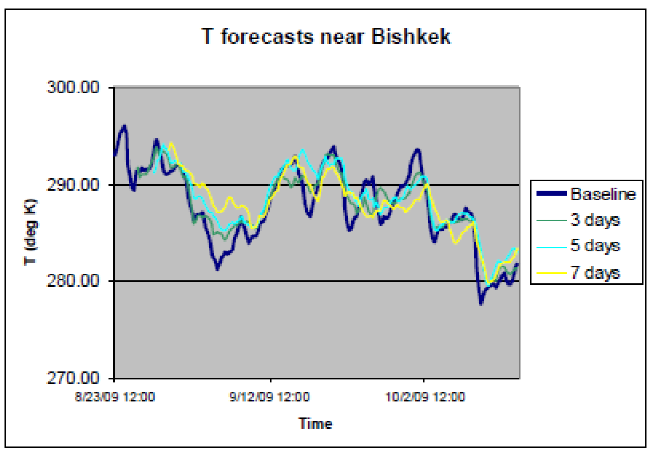
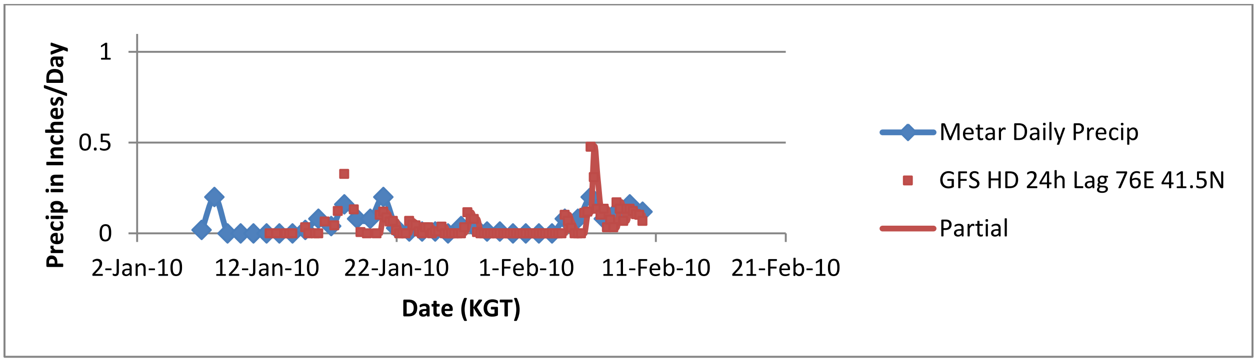


Figure 3. Comparison between temperature forecast by the US global ensemble forecast at a model gridpoint near Bishkek at lead time of 3, 5 and 7 days in advance versus the temperature calculated for that area when observations became available. The forecasts are often slightly off in timing, but qualitatively they do successfully highlight upcoming trends.

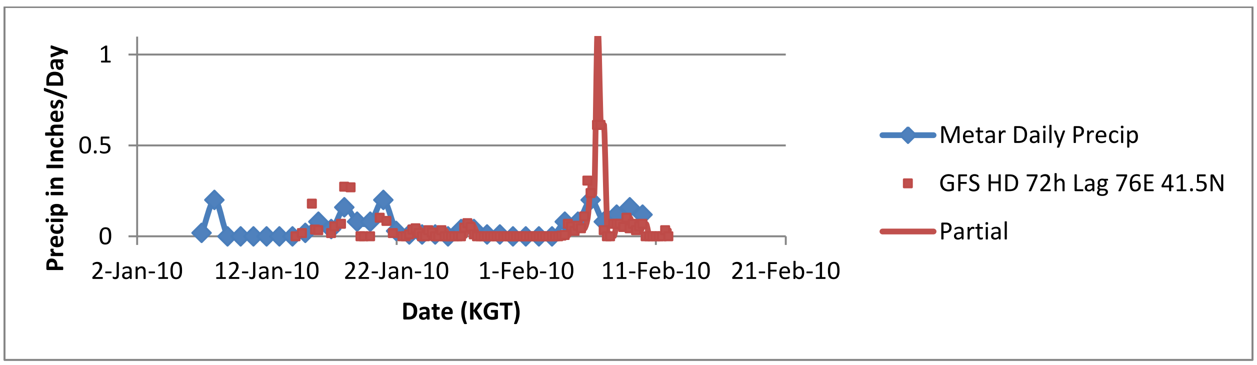
The US also prepares a deterministic forecast and makes it publicly available. Although a deterministic forecast by definition has no probabilistic information, it is a bit easier to analyze, and like the ensemble

[2] Further, Lucy Hancock and Jordan Alpert concurrently prepared a poster paper describing the comparison of the US global ensemble's Bishkek precipitation forecast to measurements, and presented it at a poster session of the American Geophysical Union in San Francisco, December 14, 2010. See Annex 2. Informal feedback from experts who viewed the presentation was that the verification methodology although novel is simple and reasonable, suited to its purpose, and that the verification is encouraging of such use of the global forecast databases.

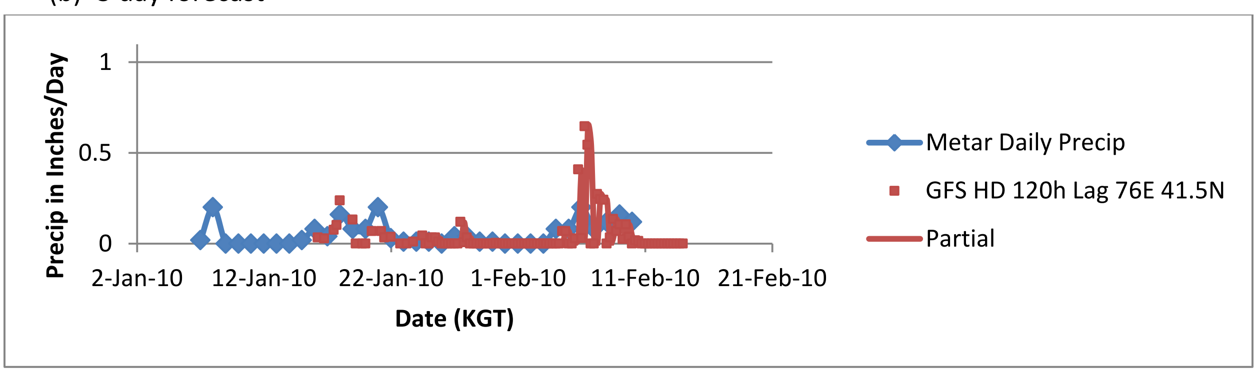
forecast it aims to assess a large number of variables of interest to agriculture that may be difficult to find elsewhere: soil moisture, cloudiness, wind speed and direction, humidity, and so on. The team consultant compared this forecast to available data, considering Naryn (see Figure 4) in January. The team consultant also prepared a workbook that somewhat simplifies the use of this data. See Annex 3.



(a) 1 day forecast

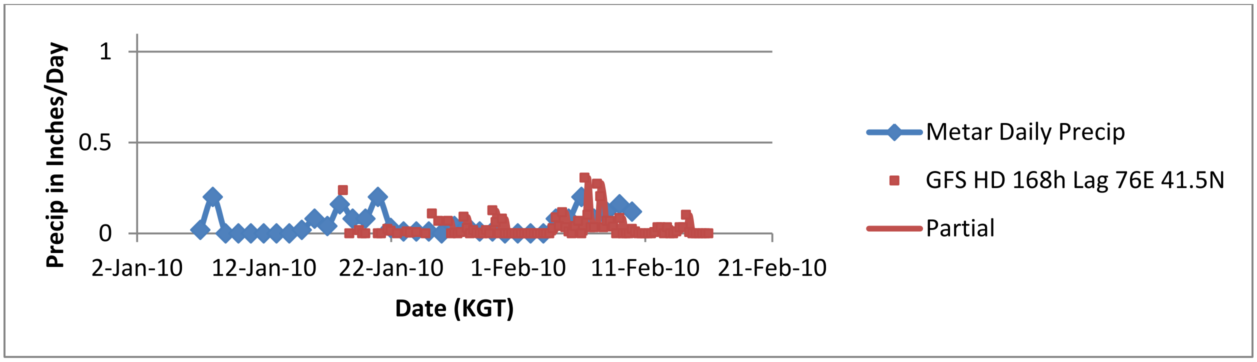


(b) 3 day forecast



(c) 5 day forecast

(d)



(e) 7 day forecast

Figure 4. Comparison between precipitation recorded in Naryn versus precipitation forecast in the US deterministic high resolution forecast, from January 11 to February 8, for forecast lead times from 1 day to 7 days. The forecasts time upcoming precipitation about right, plus or minus a half day or a day, although magnitude of precipitation is not forecast with such confidence. This would comprise highly useful guidance for agricultural decisions. Note that model success in Naryn in January does not necessarily assure success in other places and seasons. But as far as it goes, this is encouraging.

In order to extend the above comparisons, the team made arrangements to obtain local data (gathered by farmers and by the national Hydromet) in two locations during the spring planting season of 2010. The goal was to initiate verification of these data against global forecasts. Unfortunately this exchange was delayed by technical difficulties and is not complete, but when possible the comparison should be finalized. Adaptation of the Turkish experience would call for local users to undertake such comparisons over time to refine local experience in the difference between received forecasts and local weather which is highly variable given Kyrgyz topography.

Despite the team's heavy preparation in terms of the US global forecast, in fact the global forecast that has been used most thus far in this pilot is that of the Government of Norway, a deterministic forecast that is very easy to understand as presented on the Norwegian weather service's website, www.yr.no. See Annex 4. This forecast has not been verified but the team thinks that the US verification is relevant; the accuracy of the Norwegian deterministic forecast is likely to be somewhere near the accuracy of the US deterministic model considering that they are based on the same global data. Local forecasters should in any case review many models, because each has its strengths and weaknesses. The US forecasts will still provide an increment of information once they are absorbed, as they provide longer outlooks and more variables. But they cannot be characterized as easy to use.

Identification of a feasible institutional arrangement

As briefly noted above, the next challenge the team considered was how to replicate the functions of Turkey's national meteorological service and provincial agricultural directorate.

The best institutional arrangement answer depends on the type of alert considered, such as:

- Routine daily forecasts of a few key variables
    - Extending to a few days in which forecast skill is good
    - Or extending to five or seven days, a time frame in which forecast skill is weaker but still statistically better than blind guessing

- Alerts of precipitation accumulation, or temperature extremes, or of combinations such as high temperature and strong wind
- Forecasts made available on demand (a "pull" model)

In order to enable users to gain experience with the strengths and weaknesses of the forecasts over time, staff decided to begin with a scheduled routine delivery of a few key variables. In this way, a pilot network of farmers would learn over time how far to trust the forecasts.

Having selected this mode of alert, it was necessary to identify an institution able to staff a regular effort to interpret and pass on forecasts several times a week. The questions became:

- Who would be responsible for extracting the useful information from the global forecasts?
- Is the added value of a local high-resolution forecast important, and if so, who can take up this task?
- Who would maintain a running comparison between observation and forecasts in order to accumulate local experience in the differences?
- Who would select the key variables of most interest to local Kyrgyz farmers?
- Who would actually word the messages, and who would dispatch them?
- Who would monitor the value of the messages in order to improve their content and assure that dissemination reaches all farmers as in Turkey, rather than stop short at the best-connected farmers as would be far easier?

Local agricultural consultants may be able to undertake many of the listed tasks, but would not be able to take up local modeling and would need support and training in order to extract the full value of global forecasts.

To address these questions, in February and March 2010, the team undertook a sequence of meetings with Kyrgyz stakeholders. Those interviewed included management and key forecasting staff of the national meteorological service; rural advisory service consultant experts; and suppliers of cell phone services.

Hydromet. The Bank team met with representatives of the Hydromet Service of the Kyrgyz Republic to discuss the pilot and to receive their feedback and expression of interest. The Hydromet is strongly inclined to support the effort. It is able to interpret global forecasts and already has an effort underway to verify and compare not only those we had considered but several others (the Japanese model is of particular interest at the moment). The Hydromet has already come to the conclusion that it would be highly beneficial for it to take up local modeling as all countries of the Caucasus already do. Further it has the technical skills to maintain a running comparison between forecast and observations.

Its key constraints are (i) the need for thorough verification prior to operationalization of the effort; (ii) the need for training to enable staff to operationalize this effort; (iii) need for support to cover incremental costs. Because the success of the effort depends on its local nature, it calls for a very fine-grained knowledge of crops and microclimates to identify which variables are significant in each area. Crop agriculture has different requirements from livestock raising, and in each case, very local conditions are very important. Thus the incremental costs of a national effort would not be negligible.

The Hydromet made some clarifications concerning its mandate and circumstances. At present, the Hydromet provides its forecasts to regional authorities; their onward dissemination is the prerogative of those agencies. Its web site provides relatively long term forecasts compared to what is provided on television. In that the agency's incentive system punishes errors in forecasts disseminated, the Hydromet is signaled not to provide longer-term probabilistic forecasting even though longer-term probabilistic forecasts would be an improvement over guesswork. Therefore, the nature of the long-term probabilistic forecasting and its utility, despite the inevitable mistakes deriving from the very nature of the long-term forecasting, should be brought to the attention of the policy makers and government officials who drive the incentive system for the Hydromet.

Agricultural consultants. ***Chuy.*** The Bank team met with Mr. Jumabekov Joomart of the Chuy Rural Advisory Service to present a discussion of the Turkish experience and global forecasts that could enable a similar initiative in the Kyrygz Republic, discussing in particular the forecasts of Norway and the United States.

The team learned that at present farmers depend on the forecasts available on television, which are very short term ("tomorrow") and not provided at high resolution (one forecast for an oblast). Occasional weather alerts are also provided, such as a frost alert at a longer time horizon, but these are rare. Further weather information would be highly useful to agriculture. A number of examples: (i) Recently, the RAS in Chuy undertook an experiment with organic pest control, "biobugs" to protect orchard crops, that failed. The RAS considers in retrospect that a drop in temperature in the days that followed release of the biobugs likely killed them. This initiative otherwise had the potential to increase the value of the crop by 30-40 percent. Longer-term temperature forecasts would thus be useful. (ii) During the planting season, arrangements for sharing tractors would be facilitated by a better sense of expected precipitation. More broadly, at present the farmers can't guess at the optimal timing for fieldwork. (iii) Sugar beets sweeten as long as they are in the field prior to harvest, but an unexpected snowfall destroys the harvest left too long. (iv) The bean crop depends in part on the weather pattern when blossoms emerge. Productivity is higher if the blossoms emerge into cool weather; less if it is warm weather. This would require longer-range forecasts than the medium-range forecasts considered in this effort (three to ten days); still, as temperature is better forecast than precipitation, this information need should be borne in mind.

The Chuy RAS decided to undertake a pilot dissemination of weather forecasts based on the Norwegian deterministic global forecast, using cell phones and delivering forecasts delivered to the RAS farmer network. The Chuy RAS also agreed to share its results and findings with the activity team.

Jalal-Abad. The team met with Mr. Kachkynbaev Nadyrbek of the Jalal-Abad RAS and with staff of the RAS to present the initiative for their feedback. The team learned that the RAS had been thinking along the same lines, and indeed is experimenting with dissemination of the forecasts of the European Center for Medium-range Weather Forecasting, though using a "pull" model by which farmers who ask for the forecast are informed. Recently, the RAS had sought to have three-day forecasts from ECMWF's web page printed in the local paper for the use of all farmers. However, by the time the papers were printed the provided forecasts were already out of date. The team shared information concerning other global forecasts (Norway and US), each with its own advantages.

The RAS decided to undertake a pilot effort using cell phones to deliver forecasts on a regular basis to farmers. The RAS stated that it would be willing to collect and share feedback with the Bank team in order to support a later phase of farmer information.

Subsequently both RAS,and, particularly, Jala-Abad RAS, provided very positive feedbacks about acceptance of the idea by the farmers. It has been reported that farmers who received the 3-day forecasts through RAS were able better plan their spring planting activities. Some others have found it useful also for other occasions such as planning the wedding parties or other social events. Unfortunately, more systematic distribution of forecasts and collection of feedback data was disrupted due to April and June unrests in the country.

Financing of recurrent costs. The team discussed the financing of recurrent costs with the Hydromet and with agricultural advisory services. Cell phone service providers were not accessible for the meeting but it is expected that they will charge fees for the SMS distribution. The Hydromet, being underfinanced already, was not willing to take on extra costs associated with adopting new models, forecasting and distribution. Accordingly, during the period of this grant-financed pilot, the agricultural advisory services financed some insignificant recurrent costs associated with their participation in the pilot. The expansion of the coverage, as well as the fine-tuning, operating and maintenance of the model, requires, however, significantly more resources. At the initial stage, to promote the idea, a donor-funded project could finance these costs, but in the longer run the government may consider bearing the costs as part of its public service mandate. In Turkey, for example, financing for the SMS service was provided by the Provincial Governor's Office of Kastamonu once they understood the value of the initiative for the public of the province.

The final stage: progress/delay

Thus, by May 2010, the team had programs in place for two regions of the Kyrgyz Republic, piloting solutions to each issue and gathering experience in messaging effectiveness, data collection and verification of forecasts. The team looked toward a final mission at which it would be possible to summarize experience concerning farmer interest, on-the-ground data verification, and interest of stakeholders in later work. It was hoped that this would be an opportunity to identify further information needs and to frame requests to global forecast developers to improve support for global food security. Unfortunately the final mission could not take place as political events in the country have constrained travel and diverted somewhat the people's attention from atmospheric events to political heat.

In place of the planned final mission, the team has collected what final information it could.

(a) A final videoconference brought the chiefs of the two Rural Advisory Services together with Hydromet staff in Bishkek to discuss findings to date.
(b) The TTL in Bishkek undertook interviews with farmers filmed with available video cameras, in order to collect their feedback.
(c) Correspondence between the Hydromet, Rural Advisory Services and Bank staff attempted to identify solutions to small logistical and equipment problems.

Findings from these exchanges are encouraging although not definitive.

MAIN FINDING

Of greatest importance was the news that the forecasts although imperfect have been very useful. The Kyrgyz Republic experienced a late, rainy, and cold spring, and many farmers had difficulty identifying when to plant, or did not succeed in planting at all.

But all farmers who were recipients of the SMS weather messages succeeded in planting their crops.

The farmer networks have expanded in both regions, as farmers not originally included have asked to be added.

Of secondary importance are a series of logistical findings and lessons learned.

- The easy-to-use Norwegian forecast has been greatly helpful.
- Farmers are certainly finding the forecasts valuable; the RASs note that when their forecast messages are not on time, the farmers contact them to provide reminders.
- The agricultural consultants have designed and initiated regular programs of verification by which the farmers maintain records of the difference between forecasts and weather. This accumulating local experience covers wind, temperature and precipitation.
- The agricultural consultants are using consumer-grade mini-meteo stations qualitatively similar to those used by the Turkish province of Kastamonu. This information is potentially valuable and there seem to be no prohibitive difficulties with their use although it is inconvenient that no Russian-language or Kyrgyz-language user guides are available.

- The Hydromet supports the use of a higher-grade mini-meteo stations and notes that collection of such data could support national forecasting very usefully.

Conclusion

Staff have concluded that an adapted version of the Turkish program would be possible, economically beneficial and welcome in the Kyrgyz Republic.

As for other sectors and other countries in Central Asia, the team does not know of any barriers that should prevent consideration of similar outreach.

In sum, staff now understands the opportunities and challenges that this approach faces in the specific circumstances of an ECA country and that workable options exist to address the need for weather information through projects and programs in their countries.

The findings of this pilot study are being considered for inclusion into a new Food Security Project in the Kyrgyz Republic. The experience under this project, no doubt, will provide more insights into the gainful use of weather forecasts in the agricultural and rural development agenda.

Annex 1: US NOAA presentation

Annex 2: Hancock et al., AGU 2009 presentation.
Annex 3: Forecasting workbook for Jalal-Abad
Annex 4: Sample forecast from Norwegian web site