Development of agricultural decision supporting tools using gridded meteorological data embedded with weather forecast

Climate Change Adaptation Unit
Climate Change Division
Institute for Agro-Environmental Sciences, NARO, Japan
Hiroyuki Ohno (ohno@affrc.go.jp)

(December 5th, 2016)
Background

In the past few years, record heat waves and heavy rain have occurred throughout Japan, which have seriously affected agricultural produce in some areas.

In order to quickly grasp the degree and spread of weather damage, and to take measures to reduce them, we must always have the latest weather data that includes not only current and past data, but data of future predictions as well.

Therefore, NARO have constructed a 1-km grid daily meteorological data delivery system.
The Agro-Meteorological Grid Square Data System (AMGSDS)

The AMGSDS produces and serves daily agro-meteorological gridded data for Japan from 1980 to the current year. Observed, forecasted, and climatic normal data are linked seamlessly.
<table>
<thead>
<tr>
<th>Met. elements</th>
<th>Past</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean temperature</td>
<td>1980~</td>
<td>~26 days in the future</td>
</tr>
<tr>
<td>Maximum temperature</td>
<td>1980~</td>
<td>~26 days in the future</td>
</tr>
<tr>
<td>Minimum temperature</td>
<td>1980~</td>
<td>~26 days in the future</td>
</tr>
<tr>
<td>Precipitation</td>
<td>1980~</td>
<td>~26 days in the future</td>
</tr>
<tr>
<td>Sunshine duration</td>
<td>1980~</td>
<td>~9 days in the future</td>
</tr>
<tr>
<td>Global solar radiation</td>
<td>1980~</td>
<td>Under development</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>2008~</td>
<td>~9 days in the future</td>
</tr>
<tr>
<td>Wind speed</td>
<td>2008~</td>
<td>~9 days in the future</td>
</tr>
<tr>
<td>Atmospheric radiation</td>
<td>2008~</td>
<td>Under development</td>
</tr>
<tr>
<td>Snow depth</td>
<td>2008~</td>
<td>Under development</td>
</tr>
<tr>
<td>Snow water equivalent</td>
<td>2008~</td>
<td>Under development</td>
</tr>
<tr>
<td>Newly fallen snow water equivalent</td>
<td>2008~</td>
<td>Under development</td>
</tr>
</tbody>
</table>
Data source for the Past Data

1. The Automatic Meteorological Data Acquisition System (AMeDAS) by the Japan Meteorological Agency (JMA)
- 1,300 stations throughout Japan (approx. 1 / 20 km × 20 km)

- Meteorological Offices – 156 locations (Including special regional observation stations)
- 4-element observation stations – 686 locations (Rain / Temperature / Wind / Daylight time)
- 3-element observation stations – 87 locations (Including 8 temporary locations) (Rain / Temperature / Wind)
- Precipitation observation stations – 361 locations (Including 5 temporary locations)
- Snow depth observation stations – 312 locations

(Source: http://www.jma.go.jp/jma/kishou/know/amedas/kaisetsu.html)
Processing Algorithm for the Past Data

Observed values by locations

Normal values by locations

+ =

Gridded deviation from normal

Past data (Temperature)
Data sources for the forecast data

1. JMA’s Meso-Scale Model (MSM)
   - Regional model
   - Approx. 5 km grid
   - 1.5-day forecast

2. JMA’s Global Spectral Model (GSM)
   - Global model
   - Approx. 20 km grid
   - 9-day forecast

3. The Guidance for 1-month weather forecasts by JMA
   - Empirical forecast using 30 ensemble forecasts
   - Forecast for 156 points
   - 7-day mean anomaly
   - 4-week forecast

\[ Y = \alpha_i X_i + B + \sigma \]
\[ \alpha_i X_i + B = \tilde{Y} \]
Processing Algorithm for the Forecast Data

GMS data (20-km) → Re-gridding → 3\textsuperscript{ed} partition GSM data (1-km) + Past data (30-day average) = Forecast data (Temperature)

3\textsuperscript{ed} partition GSM data (30-day average) + Distribution of correction values
Accuracy of the AMDSDS data

Mean air temperature (°C)

Error of the past data by space interpolation

Error of the forecast data for 1-day forecast
Effect of the forecast

\[ e = \frac{(E_C - E_F)}{E_C} \times 100\% \]

- \( E_F \): error (R.M.S.E.) of mean air temperature of \( n \) days in the future
- \( E_C \): the error when the normal (30-year average) value is used as the forecast
Atmospheric radiation is compared with observed values at Tateno (Ibaraki, Tsukuba), while the others are with observations at Yawara (Ibaraki, Tsukubamirai).
Data Delivery Service

- A data delivery server is equipped.
- Arbitrary spatiotemporal subset can be delivered on demand.

AMGSDS

Grid Data Generator → Data Delivery Server

OPeNDAP
HTTP Get

User

MS-Excel Worksheet
Programing Language

GIS

Farming Support Solutions
Tools for decision making

(1) MS-Excel Application Worksheets

Set the latitude, longitude, and year

Crick the button to...

...acquire the data.

You also get normal year values.
The program acquires the data and fills in the array variables. You can create distribution figures or graphs based on the latest met. data.
Tools for decision making

(3) Farming Support Solutions

Supporting Contents under Developing
- Alerts for abnormally high/low temperature
- Alerts for disease infection
- Predicting crop development
- Suggesting quantity of fertilizer to reduce heat damage
- Suggesting suitable variety and farming period
- Suggesting harvesting date
- Suggesting date to apply insecticide / pesticide
Tools for decision making

(4) Web API Services

- Alerts for abnormally high/low temperature
- Alerts for disease infection
- Predicting crop development
- Suggesting quantity of fertilizer to reduce heat damage
- Suggesting suitable variety and farming period
- Suggesting harvesting date
- Suggesting date to apply insecticide / pesticide
Summary

We have constructed a 1-km grid daily meteorological data delivery system (AMGSDS).

AMGSDS has a nationwide areal data domain and a temporal domain from 1980 through the current year.

The Data have been updated with the latest monitoring and numerical forecasts and are seamlessly concatenated to those of climatic normal.

The advantage of the forecast can be recognized more than 30 days in accumulation of daily mean temperature, while it vanishes within 6 days in the daily comparison.

Users can retrieve an arbitrary spatiotemporal subset of data from AMGSDS via the Internet.

We are developing agricultural decision supporting tools using AMGSDS and applying four methodologies.