Specification of Requirements

Agricultural monitoring using satellite images

Contents:

1. Introduction ........................................................................................................................................ 1
2. Description of the analyses tasks ........................................................................................................ 1
3. Data processing..................................................................................................................................... 4
4. Data from DAA for Task 1 & 2) ........................................................................................................... 4
5. Webviewer .......................................................................................................................................... 4
6. Combined report.................................................................................................................................... 5
7. The customer’s minimum requirements ............................................................................................... 6

1. Introduction

The tender for “Agricultural monitoring using satellite images” consists of two analyses tasks. Task 1 is a monitoring task with the aim of detecting the timing of potential harvest-, tillage- and establishment of catch crops on all available fields nationwide in Denmark while task 2 is also a monitoring task but this task is specifically focused on detecting the timing of harvest of maize fields.

2. Description of the analyses tasks

Description of Task 1 - Crop Monitoring and establishment of catch crops

Deadline: October 1 2018 (Minimum requirement)

The Danish Agricultural Agency (DAA) wants to perform a nationwide monitoring task of Danish agricultural fields based on data from Sentinel-1, 2 and Landsat 7, 8 in the period of July-November, 2018. The national monitoring task (Task 1) is carried out because DAA wants to detect timing for harvesting, tillage and establishment of post-harvesting catch crops across the country. The project is a follow-up pilot project, with aim of further developing the project "Satellite Image Tasks for Agricultural Control 2017". DAA intend to use the results as a follow-up test on whether
Satellite monitoring still can contribute to a more efficient control of targeted catch crops in 2018. One way that the DAA will be evaluating the effect of this monitoring approach for catch crop control is to compare the findings from randomly selected catch crop controls with the catch crop controls selected from this project monitoring results. The expectation is that the monitoring approach will pinpoint more inadequate catch crops coverage than the randomly chosen control will. In addition to exploring and determining the potential of selecting controls based on satellite monitoring, another objective is to test how the agricultural industry responds to a direct letter of decision regarding the establishment of post-crops (no field visit). A subset of applicants who accumulates the highest risk of catch crop failure from the monitoring approach, will receive a consultation letter for a subsequent overall decision on the catch crop without field visit. This is done to test if it would be plausible to avoid some of the time-consuming catch crop field visits with letters. If the farmer disagrees with the decision in the letter, he may request a follow-up classic field visit as usual.

**Solution suggestions**

- **Subtask 1.1)**
  In the period from July 15 – September 15, The Danish fields are monitored for harvest using the available radar and optical data (Sentinel 1, 2 & Landsat 7, 8). On October 1, 2018, all the fields are delivered to DAA with a probability score for harvest and time interval for the potentially observed period for harvest date. A late harvest could indicate that there is a higher risk that the farmer does not manage to establish the catch crop in time.

- **Subtask 1.2)**
  In the period from July 15 – September 15, The Danish fields are monitored for tillage using the available radar and optical data (Sentinel 1, 2 & Landsat 7, 8). On October 1, 2018, all the fields are delivered to DAA with a probability for tillage and time interval for the potentially observed period for tillage date. A late tillage could indicate that there is a higher risk that the farmer does not manage to establish the catch crop in time.

- **Subtask 1.3)**
  In the period from September 1 – September 27 all Sentinel and Landsat-data across Denmark is gathered and all statistics e.g. mean/median NDVI or other vegetation indices that could indicate catch crop establishment per field is calculated. Based on the statistics the fields shall be divided into 3 categories: **NO vegetation, sparse vegetation & vegetation.** The subtask 1.3 results should be delivered consecutively to DAA and also delivered as a gathered delivery combined with the results from subtask 1.1 and subtask 1.2 on October 1, 2018.

**Table 1: Example of possible data columns in the data delivery on task 1. October 1.**

<table>
<thead>
<tr>
<th>Harvest Probability</th>
<th>Harvest Date 1</th>
<th>Harvest Date 2</th>
<th>Tillage Probability</th>
<th>Tillage Date 1</th>
<th>Tillage Date 2</th>
<th>Category</th>
<th>Mean NDVI</th>
<th>NDVI Date</th>
<th>NDVI Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 (number)</td>
<td>dd-mm-yyyy (Date)</td>
<td>dd-mm-yyyy (Date)</td>
<td>0-1 (number)</td>
<td>dd-mm-yyyy (Date)</td>
<td>dd-mm-yyyy (Date)</td>
<td><strong>NO vegetation, sparse vegetation &amp; vegetation</strong></td>
<td>From 1 to 1 (number)</td>
<td>dd-mm-yyyy (Date)</td>
<td>S2A,S2B,L7,L8 (text)</td>
</tr>
</tbody>
</table>
DAA is open for other project solutions for the task 1 than the setup listed above as long as the supplier deliver a purpose-fulfilling result at October 1 2018 (Minimum requirement) that is well documented and explained by the suppliers offer.

In the subtask 1.3 example above it is expected, that as a minimum, the NDVI statistics are delivered for the latest available cloud free image per parcel within the data collection period. However the supplier is free to suggest other approaches for identifying catch crops or the lack thereof e.g.:

- Multi temporal optical analysis
- Radar data / time series
- Other vegetation indices or more statistical measures that enhances differences in sparsely vegetated areas or in other typical catch crop conditions could be used instead.

Overall, the purpose of task 1 is to illuminate which fields that have catch crops established in the correct season. The abovementioned subtasks are therefore merely suggestions from DAA. A direct classification approach for catch crops could be another option. The classification approach could still be based on both Sentinel-1 and -2 data and using the farmers agricultural applications as training data. Instead of delivering separate results for farm events, the supplier could opt for delivering one combined classification result for catch crop along with a probability value.

All though the farmer applications only are provisional and there may be a certain amount of deviation, it might still be possible to obtain a confident/sufficient classification and timing of catch crop establishment/no catch crops establishments based on these applications in relation to the DAA success criteria of the project.

**Task 2) Harvest Detection - Maize (Minimum requirement)**
Deadline: November 12, 2018

DAA wants the monitoring task 2 to include the detection of harvest times on maize in the period from August 1 to November 12. The purpose of this “Task 2” is to determine whether the 8-week prohibition of using pesticides is respected after harvesting of the main crop.

By 2018, the control population is divided into 2, depending on whether the applicant has applied a grass catch crop in their maize fields or not. The part of the population where the applicants have applied grass catch crop is not allowed to receive their green support before January 2019, as the control for pesticides usage and the destruction deadline for maize crops must be completed first. The aim of this task is therefore to identify the harvest time for maize as accurately and quickly as possible. In this way, the monitoring can facilitate physical control to prioritize and schedule the field visits in a timely manner and determine whether the pesticide ban has been met or not as soon as possible.

In the period from August 1 – November 12, The Danish maize fields are monitored for harvest using the available radar and optical data (Sentinel 1, 2 & Landsat 7, 8).

The results should be delivered running or at least as three deliveries throughout the period of investigation. The last delivery must be delivered On November 12 2018. All the maize fields must be delivered to DAA with a probability score for harvest and time interval for the potentially observed period for harvest. The results must contain data as described in table 2
### Table 2: Data columns that the supplier must fill in task 2.

<table>
<thead>
<tr>
<th>Maize Harvest Probability</th>
<th>Maize Harvest Date 1</th>
<th>Maize Harvest Date 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 (number)</td>
<td>dd-mm-yyyy (Date)</td>
<td>dd-mm-yyyy (Date)</td>
</tr>
</tbody>
</table>

### 3. Data processing

It is preferred that the radar data used for both task 1 and task 2 is quality tested and processed using meteorological data, because DAA believe that soil moisture/ extreme wind of rainfall events may disturb the radar signal from crop surfaces. The quality testing and professional processing steps for the radar data, is deemed very important in order to ensure data consistency/comparability and reliable results. For the optical data, it is also preferable that the data is geo-referenced, cloud and shadow masked and atmospheric corrected, so that the data is best matched for analysis in the Danish summer/autumn conditions.

### 4. Data from DAA for Task 1 & 2)

**Field data/application data**

DAA will provide the supplier with all of the Danish rotational fields above 0.3 ha on July 1, 2018. The tenderer should have the capabilities to handle the field monitoring a national scale, but it can be specified by DAA, in collaboration with the supplier, which fields on the national scale that are preferred for the monitoring tasks onwards. In this process DAA will provide further information on locations place specific catch crops and on which fields targeted catch crops most likely may occur according to the farmers own applications.

**Ground truth data**

From the 2017 analysis, it was concluded that the availability of timely ground truth data is of great importance for the quality of the monitoring results for harvest, tillage and catch crops. This could help in the process of learning to interpret the radar and optical data better, thus better targeting the analysis. If necessary, DAA will assist in collecting harvest and tillage timings from rapid field visits near DAA regional offices. The data will be collected using tablets and the geo-tagged information will be registered to the existing field data shapefile and send to the supplier. If necessary DAA will provide the supplier with data from the physical control on targeted catch crops from 2017 along with the field data on the 1 July 2018.

DAA is pursuing the opportunity for a more direct connection to the farmers own generated ground truth data e.g. from tractor GPS logs/, farm books, crop yield data etc. Hence, if the supplier is able to collect or facilitate contacts for direct collection of ground truth data from the profession, then it will be considered beneficial in the evaluation.

### 5. Webviewer

Operational from August 1, 2018 (Minimum Requirement):

Results from all the satellite image analyses must be delivered on a SFTP as a shapefiles. In addition to these results, a webviewer portal with user management, which shows all satellite images used in task 1 and 2 along with the field parcel polygons, is required. The viewer portal should contain a feature that enables the user to search for individual fields, using a unique ID, farmer/ applicant id., which is supplied by DAA along with the field parcels. Relevant information on each field such as observed
harvest, observed tillage, and e.g. NDVI should be present in the viewer as well. S1, NDVI graphs or other relevant data for the data collection periods should be presented in the viewer.

The viewer must be accessible to DAA at August 1, 2018 the latest and subsequently satellite data must be made available on the portal, no later than 5 working days after the images are available from ESA. The viewer should include satellite images until November 12. The exhibited satellite images in the webviewer must spatially match the field parcel layer. The viewer must be available to The DAA for audit of the results for at least 2 years. All optical images must be available as NDVI, RGB and CIR versions. The webviewer platform shall include user management, which makes it possible to limit the user’s access to information in DAA. The satellite images must be presented in the highest possible spatial resolution and field colours should appear as natural as possible when zoomed in on a field level. It is expected that the viewer contain RGB, CIR and NDVI products as a minimum for each image used in the analysis. The visual appearance on field level is essential because it may serve as input in the decision making for the sending of letters.

The Webviewer functionalities above are considered as essential in order for the tenderer to deliver a operational webviewer that meets the minimum requirement August 1, 2018. Extra suggestions for functionalities that could lift the worth of the webviewer platform e.g. image export functions, image documentation tools, data graphs etc. are very welcome.

6. Combined report

December 14, 2018 (Minimum Requirement):

One combined report including description of the applied methods, an overview of the results and an evaluation of results/classification quality must be submitted to DAA no later than December 14, 2018. The report must be in a word or PDF format and it should at least contain the following chapters:

- Overview of available and used images and data
- Image processing
- Description of used software
- Detailed description of Harvest detection method
- Detailed description of Tillage detection method
- Detailed description of method for monitoring catch crops.
- (Optionally, detailed description of alternative catch crop method)
- Detailed description of method detection of maize-harvest
- Webviewer documentation/description
- Conclusion
- Recommendations
7. The customer's minimum requirements

By submitting a tender, the supplier must be able to meet the minimum requirements listed in this section. The customer has listed a list of minimum requirements (MR). The supplier should be aware if they cannot answer "yes" to a minimum requirement, then the customer will assess this a reservation causing the bid to be a non-compliant bid.

<table>
<thead>
<tr>
<th>MR</th>
<th>Supplier must deliver the results from task 1 no later than October 1 12:00</th>
<th>[To be filled by the Supplier with a yes or no]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR</td>
<td>Supplier must deliver the results from task 2 no later than November 12 12:00</td>
<td>[To be filled by the Supplier with a yes or no]</td>
</tr>
<tr>
<td>MR</td>
<td>Supplier must deliver an operational webviewer from August 1, 2018 containing the specifications described section 5</td>
<td>[To be filled by the Supplier with a yes or no]</td>
</tr>
<tr>
<td>MR</td>
<td>One combined report including description of the applied methods, an overview of the results and an evaluation of results/classification quality as described in section 6 must be submitted to DAA no later than December 14, 2018.</td>
<td>[To be filled by the Supplier with a yes or no]</td>
</tr>
<tr>
<td>MR</td>
<td>A timetable-draft for the complete process including a proposal for meeting structure must be handed in along with the bid. A physical start-up meeting in Copenhagen with the most relevant persons from both parties shall, as a minimum be included in the proposed meeting structure.</td>
<td>[To be filled by the Supplier with a yes or no]</td>
</tr>
<tr>
<td>MR</td>
<td>The supplier agrees to sign a confirmation certificate as enclosed in appendix 3 if a contract is awarded.</td>
<td>[To be filled by the Supplier with a yes or no]</td>
</tr>
</tbody>
</table>