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Foreign Commodity Production Forecasting

May 1980

THE INTEGRATED ANALYSIS PROCEDURE FOR IDENTIFICATION OF SPRING SMALL GRAINS AND BARLEY

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16. Abstract

This report describes how the Transition Year (TY) Classification and Mensuration Subsystem (CAMS) Detailed Analysis Procedures have been implemented in conjunction with techniques practiced by CAMS Operations (Ops) Verification personnel. This procedural approach, referred to as the "Integrated Procedure," was initially implemented in both the U.S. Northern Great Plains and in Canada by the CAMS Ops Verification personnel during the Transition Year. The procedure consists of three major functional activities: team labeling as described in the Detailed Analysis Procedures, a signature/label review process, and a segment proportion estimation evaluation. The latter function consisted, primarily, of trend analysis activities. These functions correspond to the TY CAMS operational activities of analyst labeling, quality assurance, and operational verification. Results show that the procedure can provide labeling accuracies which exceed those achieved operationally.

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PREFACE

The work which is the subject of this document was performed in support of the Earth Observations Division, Space and Life Sciences Directorate at the Lyndon B. Johnson Space Center, National Aeronautics and Space Administration. Under Contract NAS 9-15800, personnel of the Lockheed Engineering and Management Services Company, Inc., performed the tasks which contributed to the completion of this research.

The following scientists and other personnel assisted in compiling this report or providing technical inputs leading to the development of the procedure. J. M. Disler and W. F. Palmer of Lockheed Engineering and Management Services Company, Inc., provided technical inputs and consultation; L. C. Wade of the National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, reviewed the material for content and provided technical suggestions for improvement.

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1. INTRODUCTION

1.1 BACKGROUND

This report describes how the TY Cams Detailed Analysis Procedures[1] have been implemented in conjunction with techniques practiced by CAMS Operations (Ops) Verification personnel. This procedural approach, referred to as the "Integrated Procedure," was initially implemented by the CAMS Operations Verification personnel during the Transition Year. The procedure consists of three major functional activities: labeling as described in the Detailed Analysis Procedures, a signature/label review process and a segment proportion estimation evaluation. The latter function consisted, primarily, of trend analysis activities. These functions correspond to the TY CAMS operational activities of analyst labeling, quality assurance (QA) and operational verification, respectively.

The implementation of the Integrated Procedure included regionalized segment processing, with no specific time constraint for labeling an individual segment. Other elements included team labeling at the dot level and use of past years ground truth from blind sites and intensive test sites for labeling the current data. Additional important inputs into the segment processing were use of full frames, crop condition derived from the USDA weekly weather and crop reports and historical county crop proportion statistics where available.

It is important to recognize that the implementation approach for the three major functions and use of the various input data, including segment regionalization, varied depending upon data availability, the crop(s) of interest and the region involved.

1.2 DEVELOPMENT OF THE INTEGRATED PROCEDURE

1.2.1 OPS VERIFICATION IMPLEMENTATION

The Integrated Procedure was developed through an evolutionary process which began during LACIE Phase III with the implementation of the CAMS Operations

Verification Function. The verification function was initially used during the processing of U.S. Great Plains segments. The function was designed to monitor and evaluate the output, both labels and classification results, from the Classification and Mensuration Subsystem (CAMS).

The group performing this function consisted of senior LACIE analysts. The verification approach was to (1) re-analyze a large sample of the LACIE segments and (2) review grouped segments for signature labeling consistency. In addition, the verification group spent considerable time evaluating and applying information gained through the analysis of past years ground truth, current meteorological data and cropping practices. It was felt that senior analysts working as a team using this information would provide insight into effects from environmental conditions such as excessive rainfall or drought. Conditions such as these had contributed to mislabeling by operations analysts during the early phases of LACIE.

1.2.2 TREND ANALYSIS IMPLEMENTATION

During the latter part of Phase III and in the LACIE Transition Year, trend analysis techniques were included as an integral part of the detailed segment verifications. The result was a labeling-verification technique which integrated segment-level labeling, a signature-review process and trend analysis into a single procedure. The specific techniques employed for a procedural component (i.e., labeling, QA, etc.) varied as previously mentioned.

1.2.3 INTEGRATION OF LABELING, QA, AND VERIFICATION FUNCTIONS

An informal procedure which integrated the three operational functions (labeling, QA, and verification) was developed for use by the Operations Verification Group during the Transition Year processing of the U.S. Great Plains (USGP). This "Integrated Procedure" was developed to assist in the verification of analyst labeling. Qualitative evaluations of the results produced using this procedure indicated that improved labeling accuracy was possible.

1.2.4 INTEGRATED PROCEDURE TEST IN THE TY U.S. NORTHERN GREAT PLAINS

A limited test of the "Integrated Procedure" was conducted during the Transition Year using the USNGP blind sites.[2] A major objective of this test was to determine how well the "Direct Wheat/Barley Separation Procedure" would perform in an "integrated procedure" environment. A sub-objective was to test and evaluate the complete integrated procedure. In order to implement the procedure it was further developed to permit its operation with as few as two or three analysts performing joint labeling and discrepancy resolution.

The USNGP test resulted in improved spring small grains labeling accuracy. The improved accuracies have been attributed, primarily, to labeling using the integrated procedure approach.

1.2.5 INTEGRATED PROCEDURE TEST IN TY CANADA

Due to the improved labeling accuracy resulting from the USNGP experiment, along with the resource savings that would be realized using an integrated operations procedure, it was decided to process the TY Canadian test sites using the Integrated Procedure. The evaluation results from this experiment indicated good labeling accuracy for spring small grains.[5]

1.3 <u>MAXIMAL ANALYSIS LABELING PROCEDURE</u>

Various aspects of the Integrated Procedure are similar to the Accuracy Assessment experimental procedure referred to as the Maximal Analysis Labeling Procedure (MALP)[3]. Due to these similarities it has become necessary to describe their substantive differences. A comparison of the MALP and the Integrated Procedure is presented in Appendix A of this report.

2. ELEMENTS OF THE INTEGRATED PROCEDURE

The important procedural steps which occur during the three major functional activities (labeling, QA, verification) are described and specific examples of how Operations Verification personnel implemented the Detailed Analysis Procedures are given. Activities or functions incorporated into the Integrated Procedure which are documented in the Detailed Analysis Procedures are referenced. A functional flow depicting the generalized functions of the Integrated Procedure and their relation to TY CAMS Operations is shown in figure 1.

Descriptions and discussions regarding each of the three major functions in the Integrated Procedure are presented in sections 2.1, 2.2, and 2.3. Again it should be noted that procedural variations may be necessary where differences in regions, acquisition histories and ancillary data dictate different modes of analysis, signature reviewing and trend analyses. Variations of the generalized approach described in this document were utilized by the Ops Verification Group while processing the TY Canadian data and in performing the TY U.S. Northern Great Plains test.

2.1 STEP I — LABELING

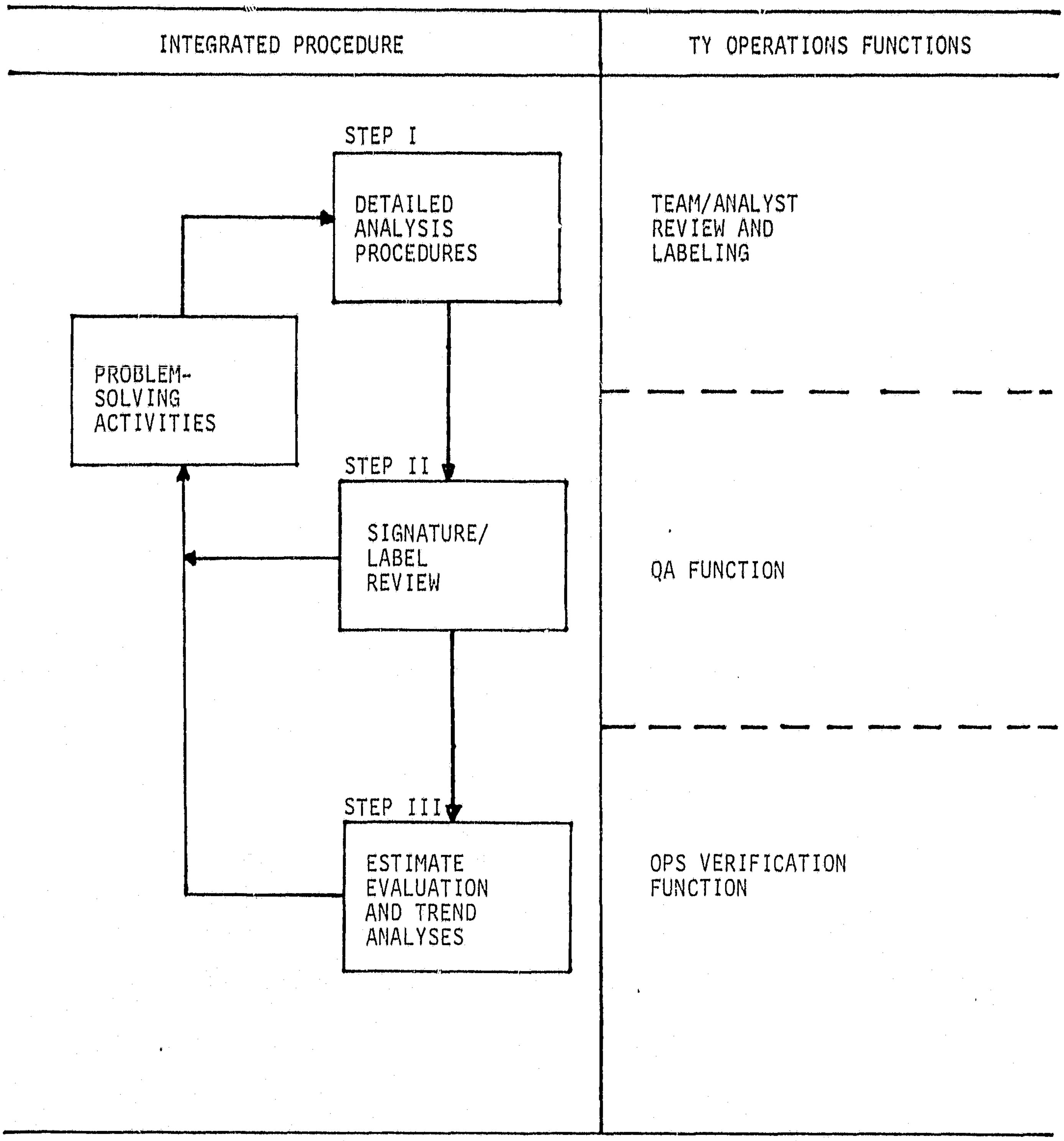
2.1.1 SEGMENT REGIONALIZATION

During the implementation of the Integrated Procedure segments were regionalized, primarily, by Refined Strata (RS) or Agrophysical Units (APU), although occasionally it became necessary to group certain segments using different criteria. An episodic event such as drought is an example of a condition which resulted in a variation of the regionalization scheme.

Segment regionalization was included in the procedure because it reduced the time required to label and verify signatures. Since similar-appearing segments were grouped for analysis the analyst start-up and preparatory times were reduced considerably. Analysis of grouped or regionalized segments also minimized the confusion that may have resulted from insufficient acquisitions. The analyst is more likely to recognize and correctly label signatures which have been "recently" viewed on similar or nearby segments.

Figure 1

INTEGRATED ANALYSIS PROCEDURE GENERALIZED FUNCTIONAL FLOW



2.1.2 LABELING INPUTS AND PREPARATORY TASKS

Many of the labeling procedures which are an integral part of the Integrated Procedure are documented in the TY CAMS Detailed Analysis Procedures. These procedures include the following analysis-related tasks:

- Area Familiarization (section 3.0)
- Team Interpretation (section 3.0)
- Use of Full Frames (sections 3.3 and 3.6, Part C)
- Historical Statistics Usage (sections 3.0 and 3.3, Part C)
- Evaluating Past Year's Segment Imagery (section 3.6, Part C)
- Spectral Aids Usage (section 6.3.3)
- Use of Map Data (section 2.4.1)

Additional tasks performed by the Ops Verification team while implementing the Integrated Procedure were:

- Evaluation of "Weekly Weather and Crop Reports"

  Optimal inputs into segment-level analysis could be best provided by agronomists and weather analysts. When this support was not available during the operational processing of segments, the analysts interpreted the agronomic and weather inputs as described in the Detailed Analysis Procedures.

- Studying Past Year's Ground Truth Data

2.1.3 LABELING APPROACH

Ops Verification personnel participated as a team not only in the general signature identification phase (Team Interpretation Task) but also in labeling each dot or field in the segment. This was accomplished through independent analyses by two analysts which concluded with joint resolution of label discrepancies. This particular labeling approach was important because many dots were border or edge and the "best" label could be determined only through team discussions.

2.1.4 SUMMARY OF INTEGRATED PROCEDURE DIFFERENCES FROM TY CAMS OPERATIONS

The major differences between the Ops Verification integrated analysis labeling approach and the CAMS Operations labeling approach implemented during TY can be summarized by restating the additional functions performed by the Ops Verification Group:

a. Regionalized segment processing

b. Team labeling at the pixel level with joint discrepancy resolution

c. Use of past years ground truth (this is in addition to the blind site segments documented in the Analyst Interpretation Keys, Volumes I and II)[4]

d. Removal of the processing time constraint on individual segments

e. Emphasis placed on usage of full frames for the replacement of 5 by 6 nm segment acquisitions not acquired (Operations processing time constraints often precluded adequate use of the full frame.)

2.2 <u>STEP II – SIGNATURE/LABEL REVIEW</u>

Following the labeling of all segments in a predefined region the segments were systematically reviewed by the team for consistency in signature labeling. This step was also important in recognizing those segments which were mislabeled due to incomplete acquisition histories. For example, this step may reveal that a missing key acquisition for a particular segment has resulted in small grains being confused with a non-small grain. By comparing the signatures within this segment to nearby segments which have "complete" acquisition histories the confusion may be recognized and rectified.

Early or late planted spring small grains omitted during Step I may also be detected through this multiple-segment review process. It should be noted that potential or actual confusion detected during this step can result in Step I being repeated and may involve the rework of more than one segment.

This function closely parallels the CAMS Operations Quality Assurance (QA) function described in the Detailed Analysis Procedures, section 1.0.

2.3 STEP III – TREND ANALYSES

Trend analyses or estimate evaluations were used to diagnose the potential for occurrence of labeling errors on an individual segment or groups of segments. One of the major objectives of this activity was to not only detect labeling errors but to explain all differences between the segments being evaluated and the reference data to which they were being compared. The reference data used for comparative studies included past year's ground truth and historical county crop proportion statistics.

Individual estimates were evaluated by comparing directly to the analyst estimates from previous years or to past year's ground truth proportions, if they were available. Multiple estimates were evaluated through trend analyses by grouping segments into well defined regions such as Refined Strata, CRD's or even entire states. In the case where segments within a CRD or a state were being evaluated the historical crop proportions were used as the comparison standard. Evaluations of multiple estimates within a Refined Strata consisted, primarily, of inspection for estimates which appeared to be outliers, either higher or lower than the majority of the remaining segments within the Refined Strata.

Descriptions of the trend analysis approaches are expanded in the following sections.

2.3.1 SINGLE-SEGMENT EVALUATION

Individual segments were evaluated by comparing to past year's analyst estimates or ground truth proportions and attempting to determine if normal year-to-year variability was exceeded by any segment. For example, if the proportion estimate dropped from 40 percent spring small grains to 20 percent the following year, this would be considered a significant change and warrant further investigation. Several plausible explanations are: (1) this is a wheat-fallow rotation area where the proportion of spring small grains may fluctuate from year to year, (2) the cropping practices have changed suddenly due to economic factors such as a major shift to another crop, or (3) labeling omission errors have occurred. If the latter was suspected, then the segment was re-analyzed with emphasis placed upon evaluating input data such as completeness of the reference imagery (AI keys, past ground truth, etc.), meteorological data, weekly crop reports, reports on economic factors affecting agricultural practices and completeness of the Landsat acquisitions.

If a significant increase in the proportion estimate had occurred and the only plausible explanation for the increase was analyst commission errors, then the labels/signatures were re-evaluated for non-small grains confusion. An example would be commission of alfalfa to the winter wheat category in eastern South Dakota. In this region, alfalfa appears similar to wheat and can easily be misidentified as small grains.

This technique also permits the detection of "new" signatures which have not been documented in the TY CAMS Detailed Analysis Procedures (including the AI keys). An example of undocumented signatures would be drought-affected small grains responses in a region where previous drought has not occurred since the collection of Landsat data has commenced.

2.3.2 REGIONAL TREND ANALYSES

2.3.2.1 Historical Crop Proportions

One method for flagging potential problems on a regional basis was to conduct a trend analysis using all segments in a CRD or state. Segment estimates, for example, for a CRD were compared to historical statistics (using one or more years historical data) in an attempt to detect a significant change in crop acreage. Individual segments were re-analyzed if large changes were detected. Frequently, the changes were not due to labeling errors but to occurrences such as sampling error or governmental inducements to increase or decrease acreage for a particular crop. Another common reason and perhaps the most prevalent reason for differences occurring between segment estimates and historical statistics was where predominately non-agricultural areas were sampled. In this case a segment with a small grain proportion estimate of 5 percent may have been located in an area where estimates averaged 30 percent per segment.

2.3.2.2 Refined Strata

Segment estimates within Refined Strata or even Agrophysical Units were evaluated for outliers. An outlier being an estimate significantly different from the remaining segments in the Refined Strata. This procedure is particularly useful in areas where reliable historical statistics are not available.

An example of this flagging technique is a 3 percent estimate in a Refined Strata where the segment estimates range from 15 to 40 percent. The explanation for this large of a difference could be mislabeling but it could also be due to the segment being largely non-agricultural.

2.3.2.3 Aggregated Area Estimates

The technique of comparing aggregated area estimates to state-level historical crop proportions was not employed in the TY Canadian processing or the U.S. Northern Great Plains test but it remains a viable trend analysis tool. This approach is extremely useful for detecting small labeling errors (0.5 to 3.0 percent) which have occurred on a large number of segments. Labeling errors of this magnitude are generally difficult to detect at the segment level, particularly, if the problem is confusion due to missing acquisitions.

If differences are noted, again the approach is to methodically review Step I in an attempt to explain the cause.

3. SUMMARY AND CONCLUSIONS

The Integrated Procedure was tested in both the U.S. Northern Great Plains and in Canada during the Transition Year and results show that the procedure can provide labeling accuracies which exceed those achieved operationally. The procedure combines the "TY CAMS Detailed Analysis Procedure" with techniques employed by the Operations Verification Group.

The Integrated Procedure has three basic functional components. These are the Team Labeling (Step I), Signature/Label Review (Step II), and Regional Trend Analyses (Step III).

Step I is the implementation of the "TY CAMS Detailed Analysis Procedure" (including team labeling), regionalized segment processing, use of past year's ground truth, and no specific time constraint for labeling an individual segment. Step II is essentially the same as the Operations Quality Assurance (QA) function whereby segments are evaluated for labeling consistency. Step III consists, primarily, of proportion estimate trend analyses that are designed to flag estimates which are outliers.

It should be noted that Step III (trend analyses) might conceivably introduce a bias into the segment estimation process but past experience has shown that the capability for flagging labeling errors outweighs any potential bias that may result from the trend analyses.

4. REFERENCES

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APPENDIX A

COMPARISON OF INTEGRATED PROCEDURE
AND THE MAXIMAL ANALYSIS LABELING PROCEDURE

APPENDIX A

COMPARISON OF INTEGRATED PROCEDURE AND THE MAXIMAL ANALYSIS LABELING PROCEDURE

The Maximal Analysis Labeling Procedure (MALP) and the Integrated Procedure both incorporate integral components of the Operational Detailed Analysis Procedures. Differences in the two procedures are in utilization, segment requirements, machine processing, and area estimation requirements.

Maximal Analysis Labeling Procedure

The MALP is an experiment designed to produce the most accurate crop labels possible from optimal segments selected using very stringent criteria. Accuracy Assessment has proposed using MALP for extension of error analysis to foreign indicator regions where ground observations are not available. Segment proportion estimates are not the emphasis of this procedure.

The current MALP processes integrates several labeling products (LIST, Badhwar , etc.) with independently derived analysts' labels into final consensus labeling decisions.

Agronomists and meteorologists provide technical support during the segment processing that would not normally be feasible in an operational environment.

Integrated Procedure

The integrated procedure is an operational procedure that was tested in both the U.S. Northern Great Plains and in Canada during the Transition Year. It is a combination of the "TY CAMS Detailed Analysis Procedure" and techniques employed by the Operations Verification Group. The objective is to provide labeling accuracies which support unbiased proportion estimation using Procedure 1.

An important technique is the regionalization of segments where segments with "complete" acquisition histories are used to aid in the identification of confused signatures on segments with incomplete Landsat coverage. Estimate evaluations (or Trend Analysis) are used to diagnose potential errors by evaluation of multiple estimates for outliers, either higher or lower than the majority of the segments within a Refined Strata. Past year's analyst estimates or ground truth proportions are evaluated to determine if normal year-to-year variability is exceeded by any segment. Segment estimates for a region are compared to historical statistics to detect significant changes in crop acreages. Aggregated area estimates are compared to state-level historical crop proportions for detection of omitted signatures which have occured on a large number of segments.

The integrated procedure uses independent and team labeling and, like MALP, has no specified time constraints. Consensus labeling is not a requirement.