JSC-14557

LARGE AREA ★ CROP INVENTORY ★ EXPERIMENT

LACIE

79-10031

TM-79929

BRIEFING MATERIALS FOR TECHNICAL PRESENTATIONS

VOLUME B

THE LACIE SYMPOSIUM

OCTOBER 1978

(E79-10031) BRIEFING MATERIALS FOR TECHNICAL PRESENTATIONS, VOLUME B: THE LACIE SYMPOSIUM (NASA) 251 p HC A12/MF A01 CSCL 02C G3/43

N79-14480 THRU N79-14498 Unclas 00031

NASA

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston Texas 77058

LACIE CROP YEARS — AN ASSESSMENT OF CROP CONDITIONS

J. Hill, NOAA

NASA-S-78-16654

THE LACIE CROP YEARS 1974-77

AN ASSESSMENT OF CROP CONDITIONS IN 3 YEARS OF LACIE

NASA-S-78-16655

PURPOSE:

- DESCRIBE CONDITIONS UNDER WHICH PROJECT RESULTS WERE OBTAINED
- DEMONSTRATE THAT CONSIDERABLE INSIGHT INTO RELATIVE CROP CONDITION CAN BE DRAWN FROM METEOROLOGICAL AND LANDSAT DATA
- ILLUSTRATE THAT A WIDE VARIETY OF CROP GROWING CONDITIONS WERE ENCOUNTERED IN THE LACIE EXPERIENCE

SCOPE OF LACIE

- PHASE I – U.S. GREAT PLAINS
- PHASE II – U.S., CANADA, U.S.S.R. INDICATOR REGIONS
- PHASE III – U.S., U.S.S.R.

NASA-S-78-16656

DATA AVAILABLE FOR CROP CONDITION ASSESSMENT

- PRECIPITATION
- TEMPERATURE
  - AVERAGES FOR 7-, 10-, AND 30-DAY PERIODS
  - DEPARTURES FROM NORMAL
- DAILY EXTREMES
- SOIL MOISTURE AND PERCENT OF NORMAL
- CROP MOISTURE INDEX IN THE U.S.
- SNOW COVER BOUNDARIES
- LANDSAT DIGITAL DATA
- LANDSAT IMAGERY
  - 100- BY 100-MILE FULL FRAME
  - 5- BY 6-MILE SEGMENTS

NASA-S-78-16657

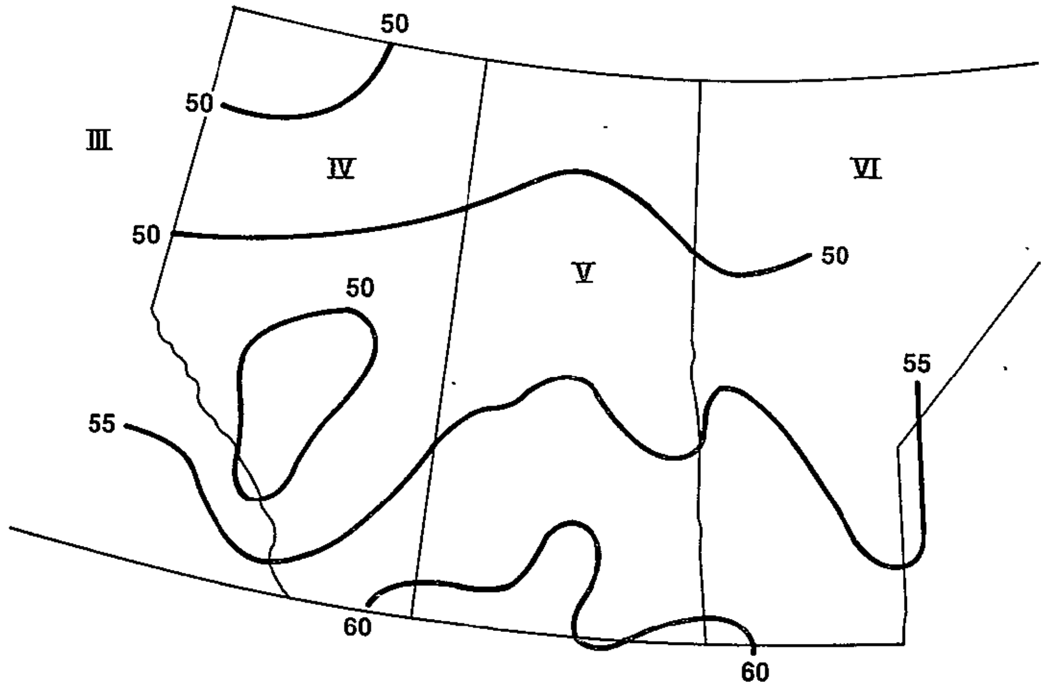
U.S. GREAT PLAINS

PRIMARY LACIE WEATHER-OBSERVING STATIONS

NASA-S-78-16658

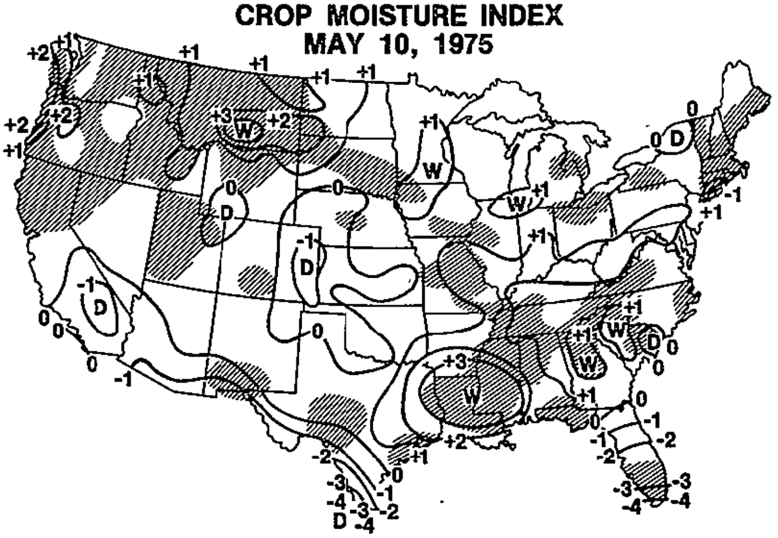
CANADIAN PRAIRIE PROVINCES

ACTUAL AVERAGE TEMPERATURES (°F)



NASA-S-78-16659

CROP MOISTURE INDEX
MAY 10, 1975



SHADED AREA INDICATES INCREASE OR NO CHANGE IN INDEX DURING WEEK

NASA-S-78-16660

LACIE PHASE I
1974-75
U.S. GREAT PLAINS

NASA-S-78-16661

U.S. WINTER WHEAT

- GOOD MOISTURE FOR ESTABLISHMENT
- WINTER TEMPERATURES NEAR NORMAL
- COOL SPRING LIMITED REGROWTH AFTER DORMANCY
- SPRING DRYNESS DEVELOPED FROM NEBRASKA TO THE TEXAS PANHANDLE
- HEAVY JUNE RAINFALL PRODUCED LOCAL FLOODING IN OKLAHOMA WHILE HAIL CAUSED ABOVE NORMAL LODGING IN TEXAS, KANSAS, AND OKLAHOMA
- DRYNESS MAY HAVE CAUSED UNUSUAL CROP PROGRESSION WHICH CHANGED ITS APPEARANCE FROM ANTICIPATED AND CONFUSED ANALYSTS. YIELD MODELS MAY ALSO HAVE BEEN CONFOUNDED

NASA-S-78-16662

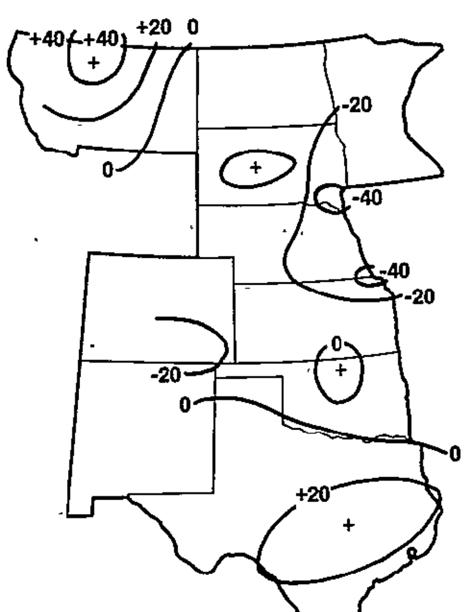
U.S. SPRING WHEAT

- SEEDING DELAYED 2 TO 3 WEEKS BY RAIN
- GOOD MOISTURE THROUGH JUNE IN NORTH DAKOTA AND MONTANA
- LOCAL FLOODING IN PORTIONS OF RED RIVER VALLEY DURING JULY
- VERY HIGH TEMPERATURES DURING JULY
- SIGNIFICANT MOISTURE STRESS DEVELOPED IN SOUTH DAKOTA

NASA-S-78-16663

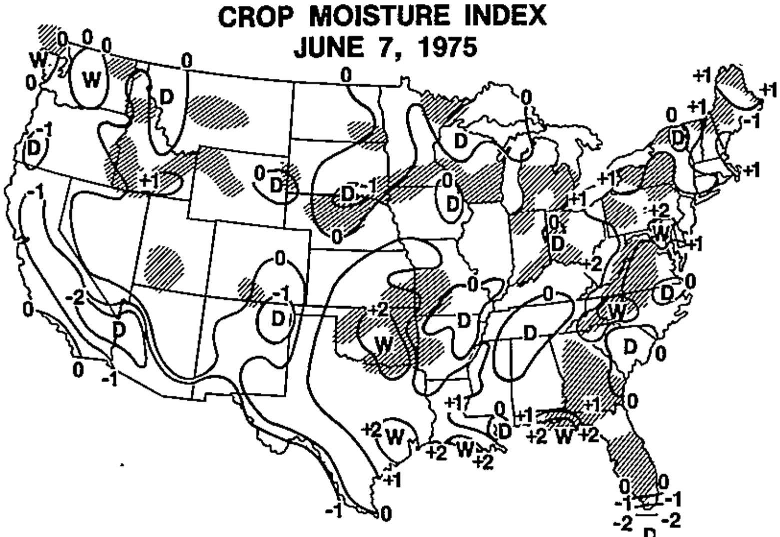
GREAT PLAINS CRD'S

1975 WINTER WHEAT PERCENT DEPARTURE FROM 5-YEAR AVERAGE YIELD (1970-74)



NASA-S-78-16664

CROP MOISTURE INDEX
JUNE 7, 1975

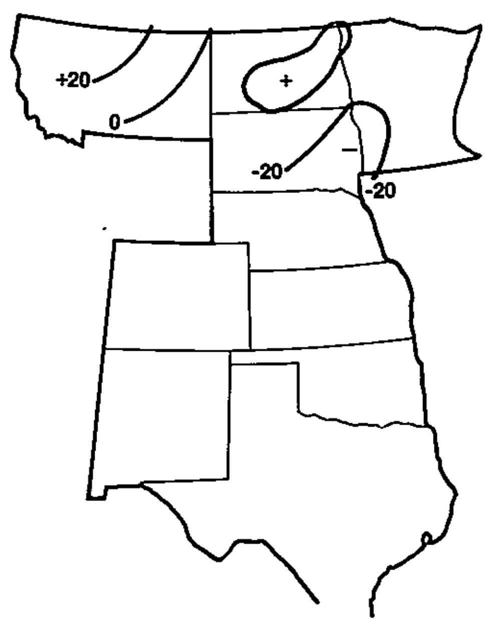


SHADED AREA INDICATES INCREASE OR NO CHANGE IN INDEX DURING WEEK

NASA-S-78-16665

GREAT PLAINS CRD'S

1975 SPRING WHEAT PERCENT DEPARTURE FROM 5-YEAR AVERAGE YIELD (1970-74)



NASA-S-78-16666

LACIE PHASE II

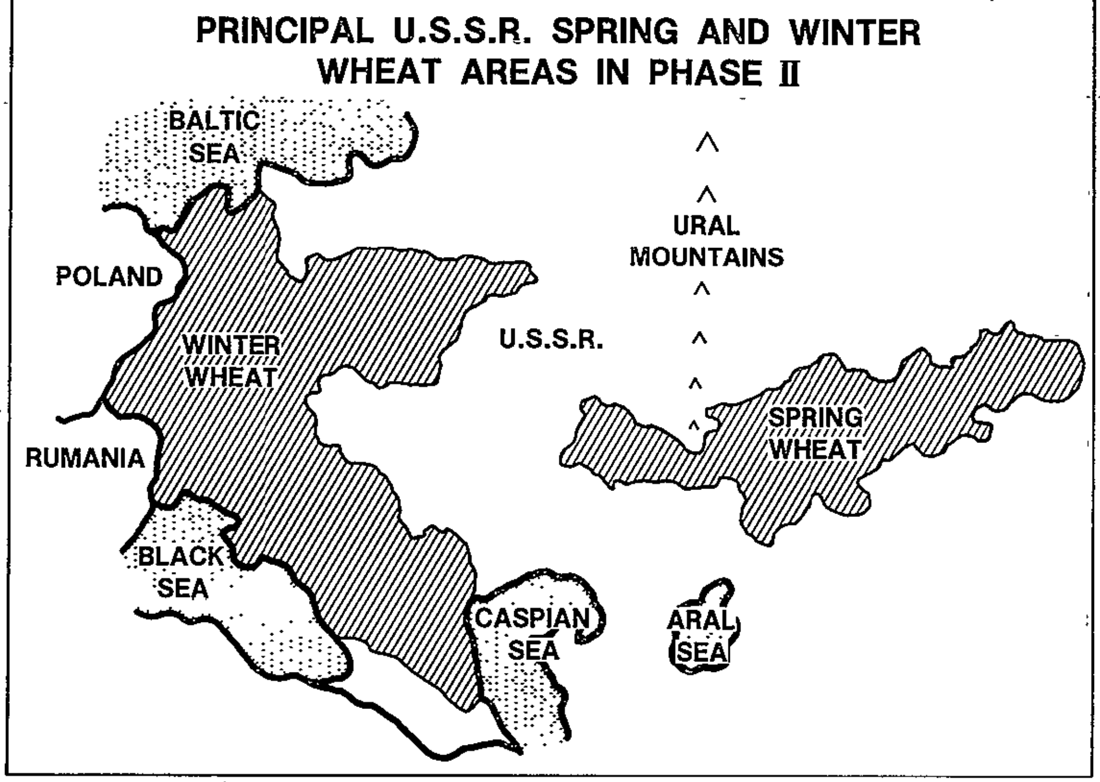
1975-76

NASA-S-78-16667

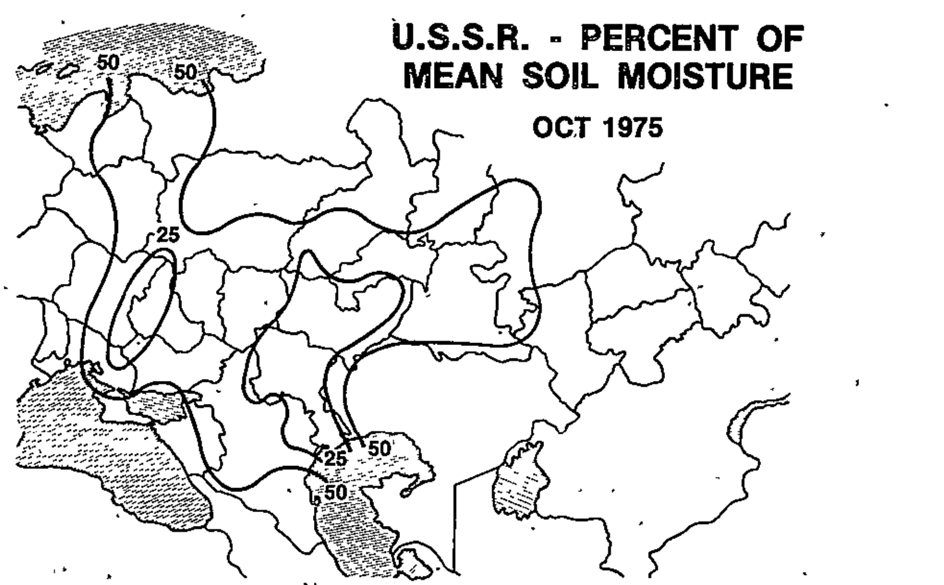
U.S.S.R. WINTER WHEAT INDICATOR REGION (83 PERCENT)

- DRY FALL WEATHER PRODUCED LIMITED MOISTURE AT ESTABLISHMENT
- IMPORTANT UKRAINE REGION HAD LESS THAN 25 PERCENT OF NORMAL SOIL MOISTURE IN OCTOBER
- WINTER PRECIPITATION WAS NEAR NORMAL; HOWEVER, SNOW COVER WAS MORE EXTENSIVE THAN USUAL
- WINTERKILL FROM COLD INJURY WAS LESS EXTENSIVE THAN USUAL
- GOOD SPRING RAINFALL OVERCAME SOIL MOISTURE DEFICITS AND PRODUCED NEAR-RECORD WHEAT YIELDS
- ANALYSTS MAY HAVE HAD DIFFICULTY IDENTIFYING WHEAT DURING THE FALL; HOWEVER, AFTER DORMANCY, THE APPEARANCE SHOULD HAVE BEEN VERY TYPICAL

NASA-S-78-16668



NASA-S078-16669



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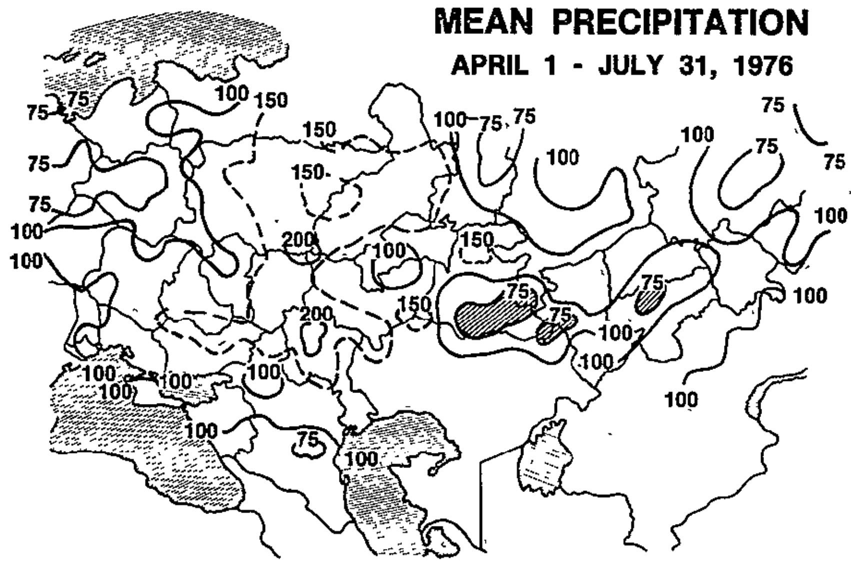
OF POOR QUALITY

NASA-S-78-16670

U.S.S.R. - PERCENT OF MEAN PRECIPITATION

APRIL 1 - JULY 31, 1976



NASA-S-78-16671

U.S.S.R. SPRING WHEAT INDICATOR REGION (37 PERCENT)

- UNLIKE WINTER WHEAT AREA, SPRING AND EARLY SUMMER RAINFALL WERE DEFICIENT IN SPRING WHEAT AREA
- MOISTURE STRESS EXISTED FROM ESTABLISHMENT THROUGH GRAIN FILLING
- SPRING WHEAT IN EUROPEAN U.S.S.R. RECEIVED BETTER RAIN THROUGHOUT THE ENTIRE GROWING SEASON
- AS A RESULT OF GOOD GROWING WEATHER IN THE EUROPEAN AREA, SOVIET SPRING WHEAT YIELDS AVERAGED A NEAR-RECORD 13 Q/ha FOR THE COUNTRY

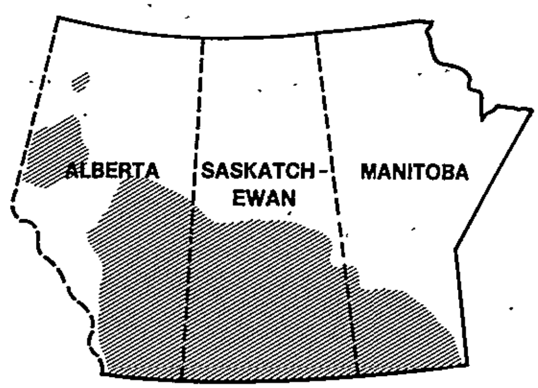
NASA-S-78-16672

CANADA

- AMPLE PRESEASON MOISTURE RESERVE
- DRY SPRING WEATHER ALLOWED TIMELY PLANTING
- JUNE RAINS ENCOURAGED GOOD GROWTH
- RAINFALL WAS ERRATIC DURING JULY AND EARLY AUGUST, BUT STORED MOISTURE APPARENTLY WAS ADEQUATE FOR HEADING AND GRAIN FILLING PERIOD
- WHEAT YIELDS WERE ABOVE AVERAGE IN ALL THREE PRAIRIE PROVINCES
- GOOD GROWING CONDITIONS SHOULD HAVE PROVIDED ANALYSTS WITH TYPICAL PROGRESSION OF WHEAT APPEARANCE
- UNDERAGE IN PREDICTED YIELD MAY BE DUE TO UNDERESTIMATE OF IMPORTANCE OF STORED MOISTURE AND EARLY-SEASON RAINFALL

NASA-S-78-16673

OUTLINE MAP OF THE PRAIRIE PROVINCES WITH MAJOR WHEAT AREA SHADED



NASA-S-78-16674

OFFICIAL 1976 CANADIAN YIELDS WITH COMPARISONS

PROVINCE	FINAL 1976, BU/ACRE	1975, BU/ACRE	AVERAGE 1965-74, BU/ACRE	LACIE YIELDS*, BU/ACRE
MANITOBA	27.2	25.2	25.3	23.2
SASKATCHEWAN	31.3	25.6	23.2	29.3
ALBERTA	32.7	29.9	26.1	25.1

*DERIVED FROM OFFICIAL CANADIAN ACREAGE REPORTS

NASA-S-78-16675

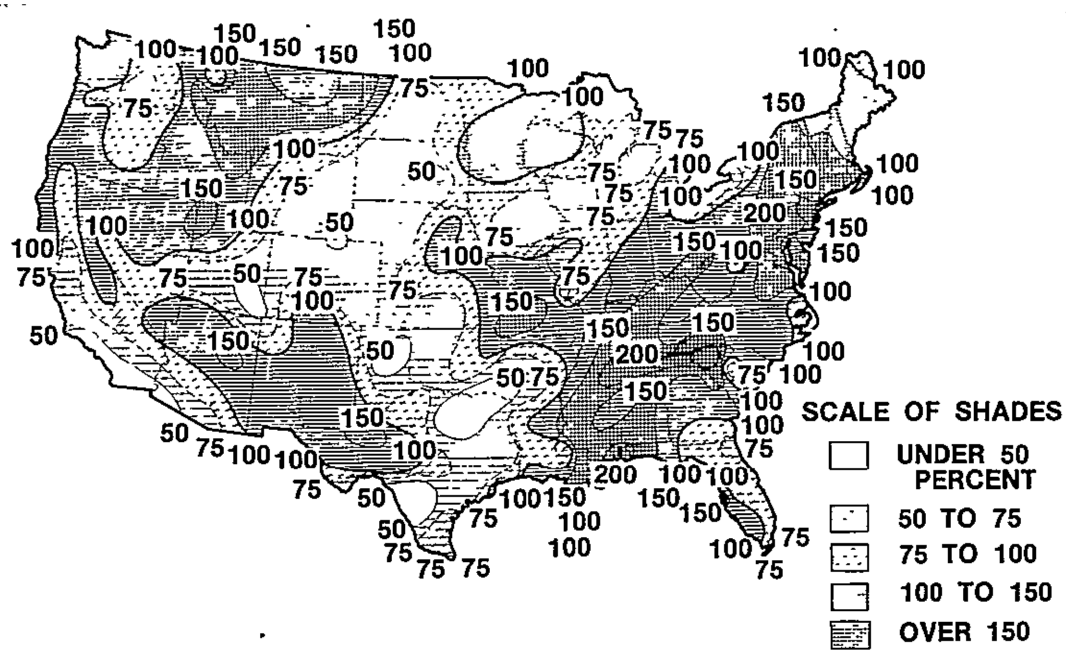
U.S. GREAT PLAINS WINTER WHEAT

- VERY DRY DURING ESTABLISHMENT
- DRY WINTER WITH LITTLE SNOW COVER ENCOURAGED WIND EROSION
- ABOVE-NORMAL WINTER TEMPERATURES AGGREVATED DRYNESS AND ENCOURAGED INSECT ACTIVITY
- WARM SPRING FORCED CROP DEVELOPMENT UNDER CONSIDERABLE MOISTURE STRESS
- APRIL RAINS BENEFITTED WHEAT IN OKLAHOMA, KANSAS, AND NORTHERN GREAT PLAINS
- LANDSAT IMAGERY VERIFIED DROUGHT IN PANHANDLE, KANSAS, AND COLORADO
- DRYNESS AND SUBSEQUENT RECOVERY OF WHEAT IN SOME AREAS PRODUCED UNCHARACTERISTIC APPEARANCE OF THE CROP

NASA-S-78-16676

PERCENTAGE OF NORMAL PRECIPITATION

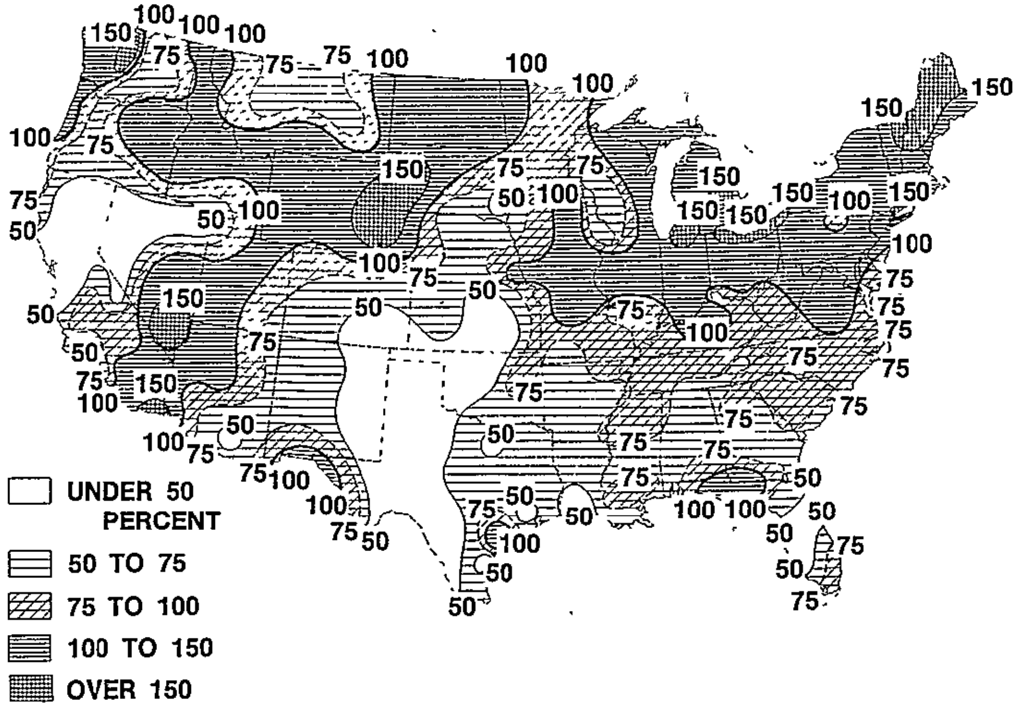
AUTUMN (SEPTEMBER-NOVEMBER 1975)



NASA-S-78-16677

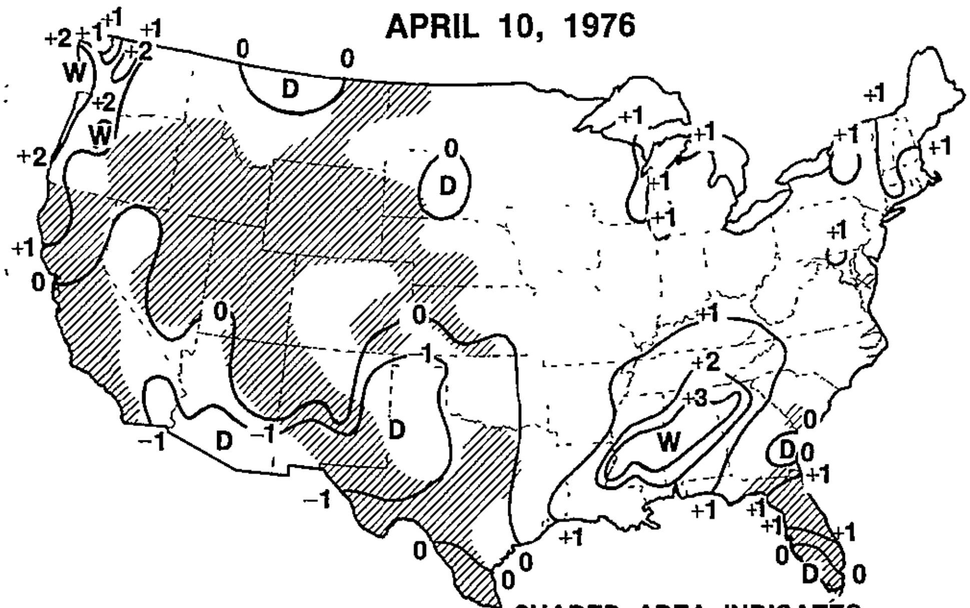
PERCENTAGE OF NORMAL PRECIPITATION

WINTER (DECEMBER 1975 - FEBRUARY 1976)



NASA-S-78-16678

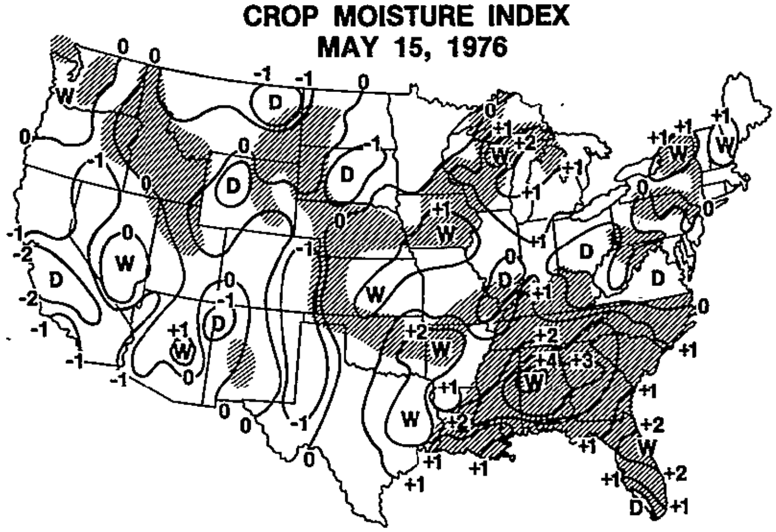
CROP MOISTURE INDEX
APRIL 10, 1976



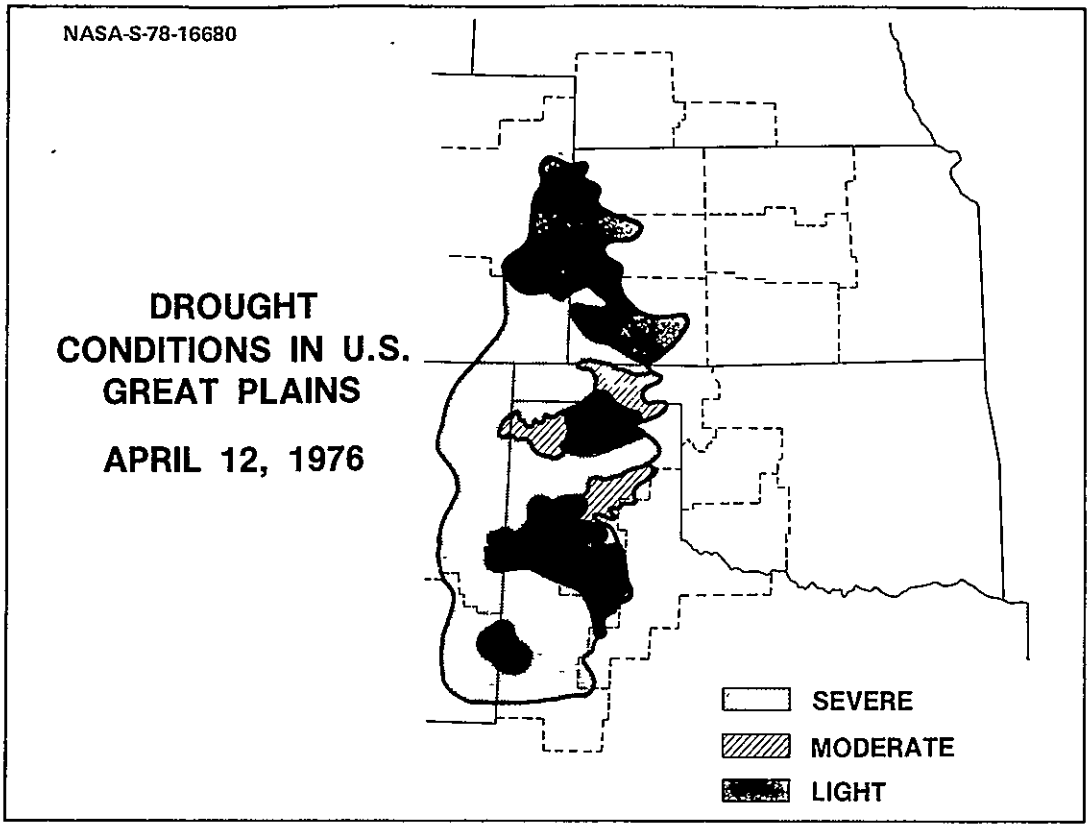
SHADED AREA INDICATES
INCREASE OR NO CHANGE
IN INDEX DURING WEEK

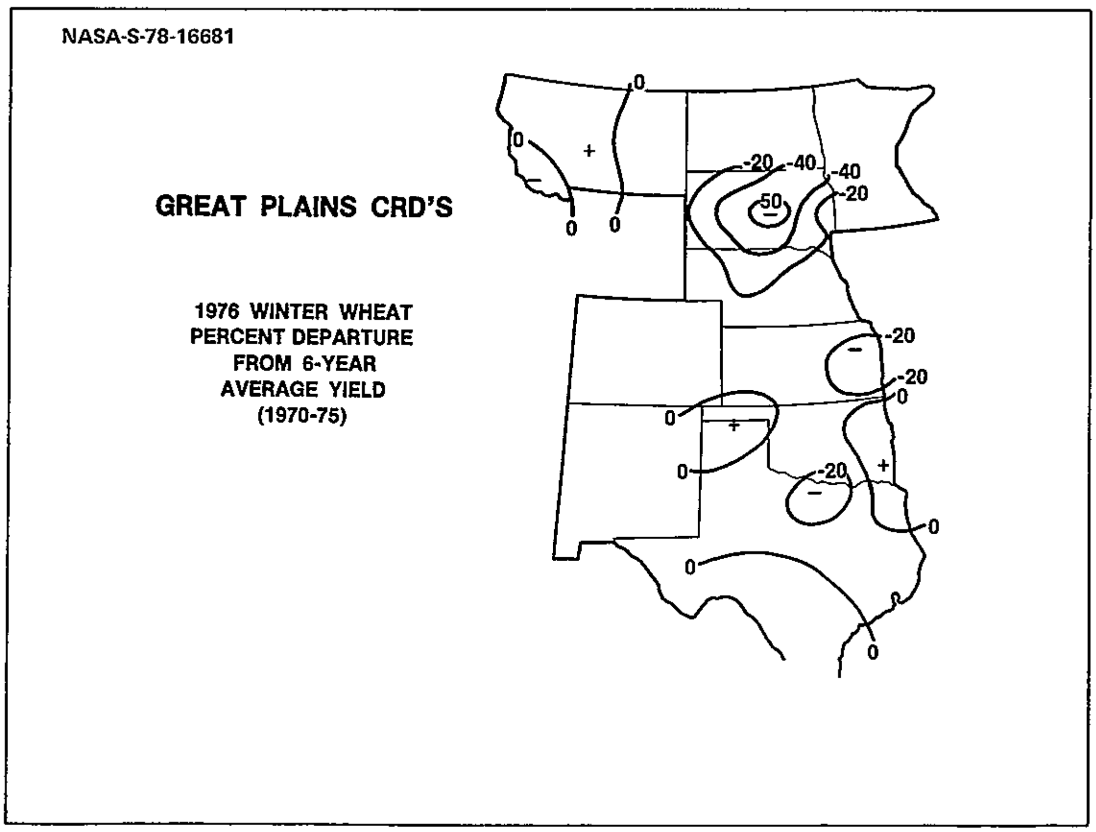
NASA-S-78-16679

CROP MOISTURE INDEX
MAY 15, 1976



SHADED AREA INDICATES INCREASE OR
NO CHANGE IN INDEX DURING WEEK


NASA-S-78-16680
DROUGHT
CONDITIONS IN U.S.
GREAT PLAINS
APRIL 12, 1976
SEVERE
MODERATE
LIGHT

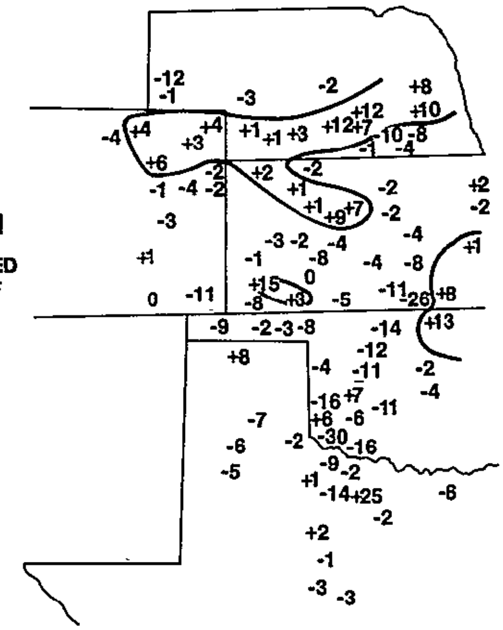

NASA-S-78-16681
GREAT PLAINS CRD'S
1976 WINTER WHEAT
PERCENT DEPARTURE
FROM 6-YEAR
AVERAGE YIELD
(1970-75)
0
+
-20
-40
-50
-20
0
-20
-20
0
-20
+
0
0
0

NASA-S-78-16682

PHASE II WINTER WHEAT REGION

DIFFERENCE BETWEEN ESTIMATED AND ACTUAL PROPORTIONS OF WHEAT IN LACIE 5-BY-6 NAUTICAL MILE SEGMENTS

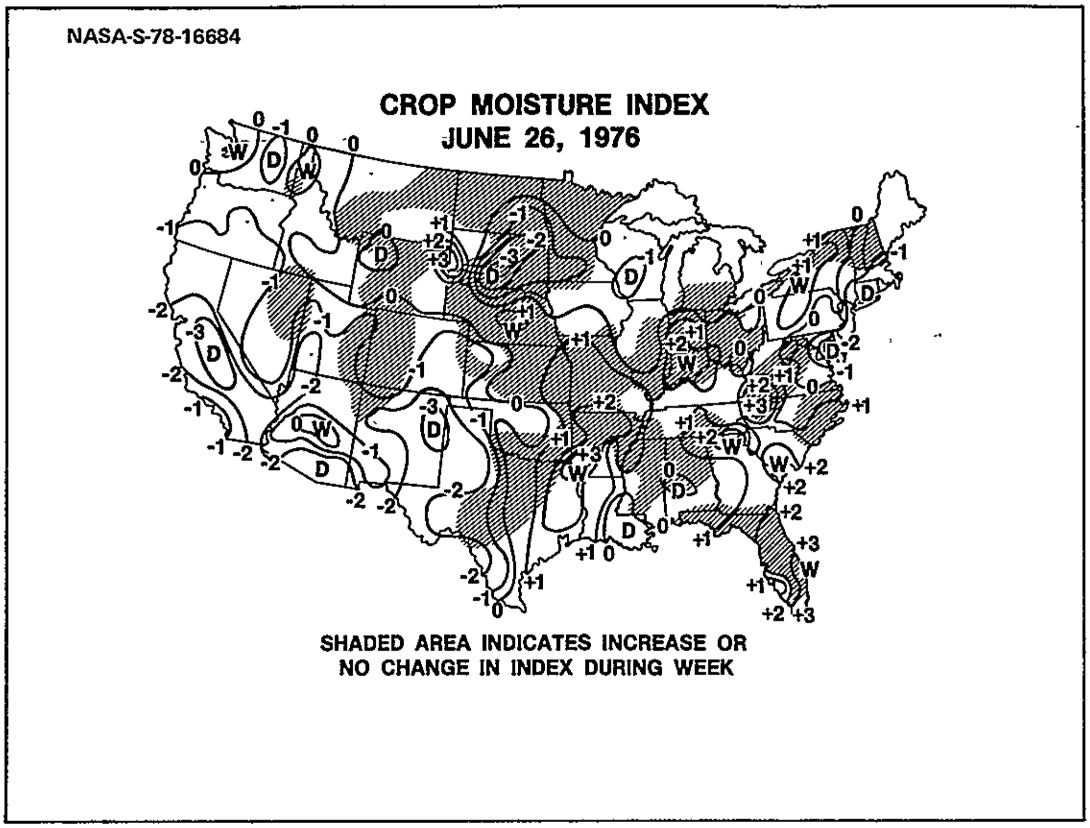
$(\hat{P} - P_{GT})$

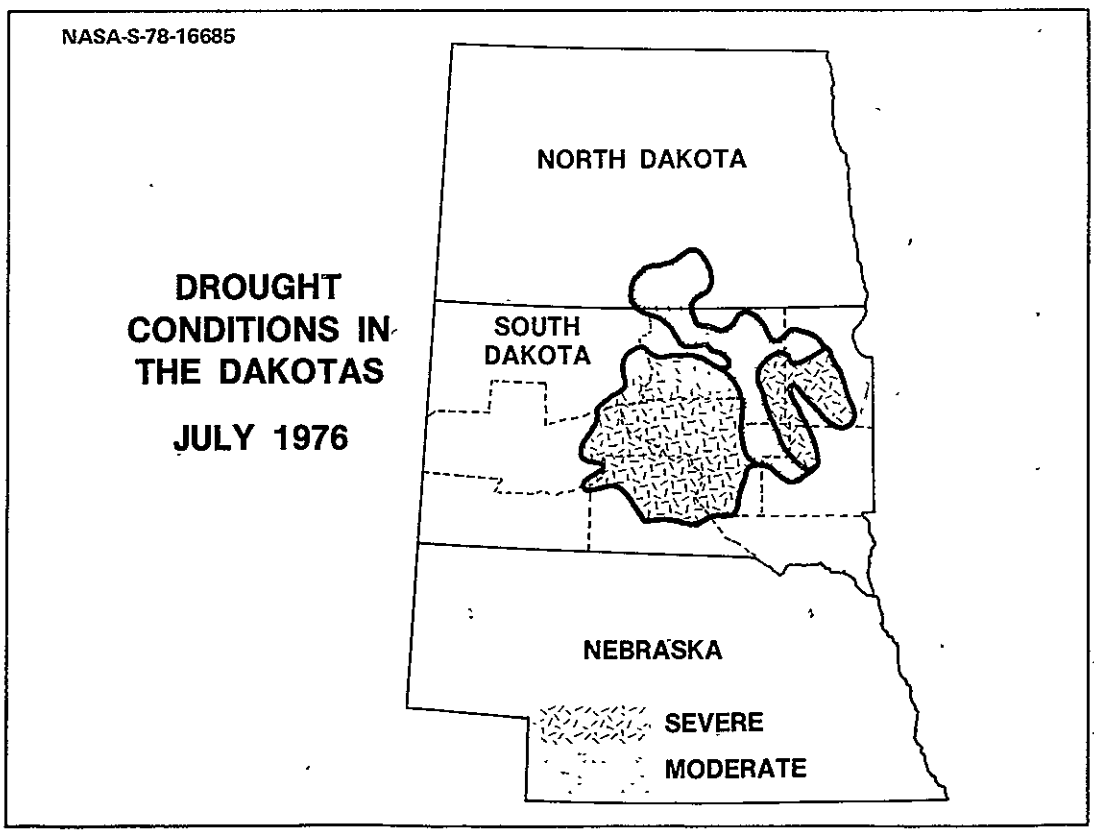


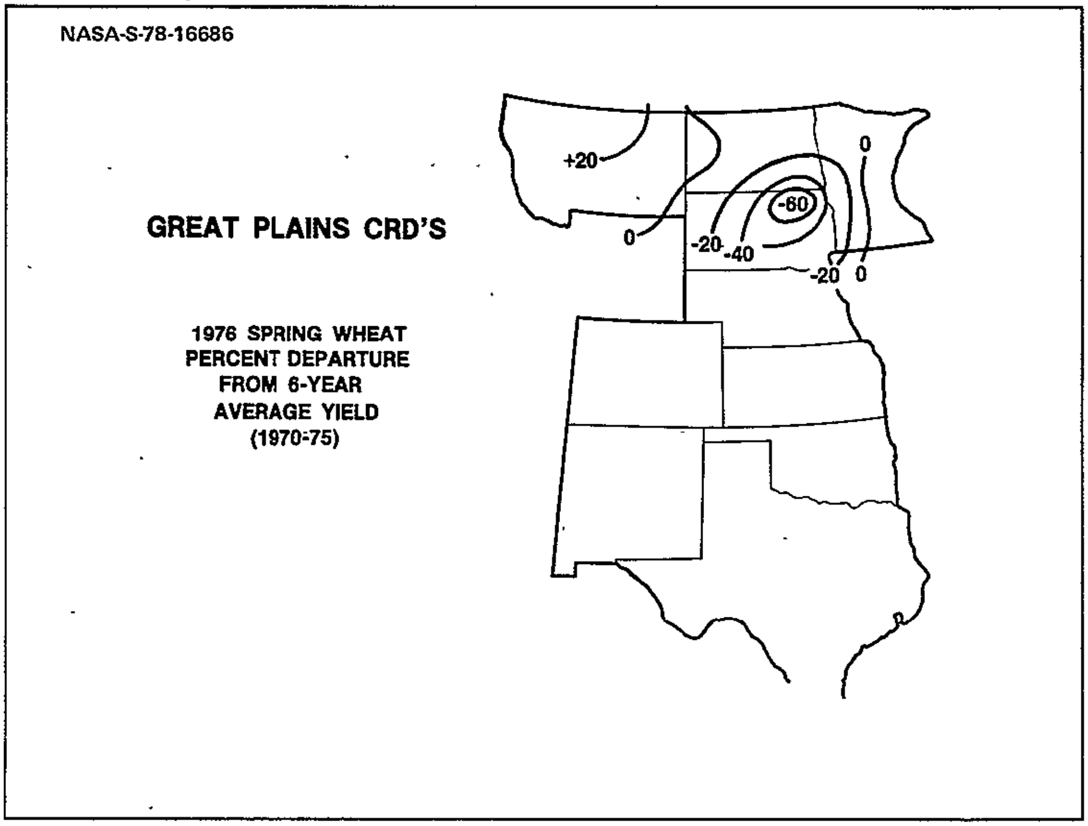
NASA-S-78-16683

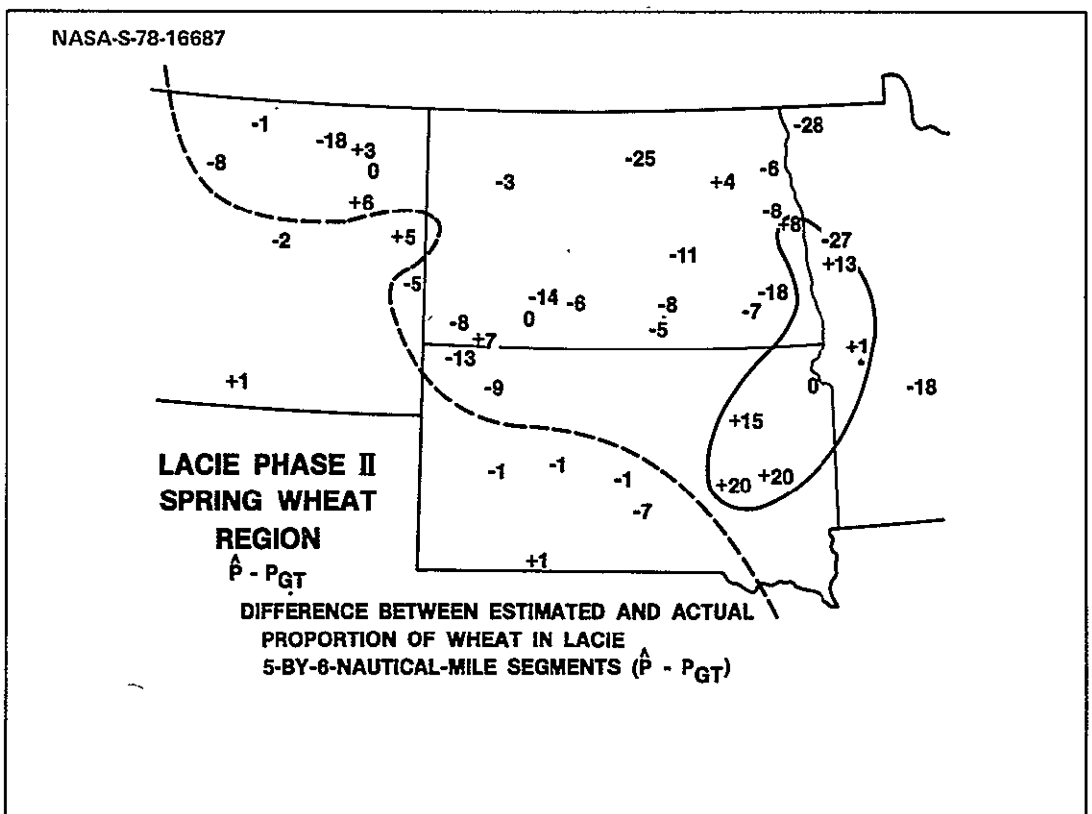
U.S. GREAT PLAINS SPRING WHEAT

- DRY WEATHER DURING PLANTING PERSISTED THROUGH ESTABLISHMENT
- RAINS IN MID-JUNE ALLEVIATED DRYNESS IN ALL AREAS EXCEPT EASTERN SOUTH DAKOTA AND SOUTHWESTERN MINNESOTA
- EXTREMELY SEVERE DROUGHT IN SOUTH DAKOTA CAUSED EXTENSIVE ABANDONMENT OF WHEAT AND 60 PERCENT REDUCTION IN YIELD
- LANDSAT IMAGERY CONFIRMED AND REFINED AREAL EXTENT OF SEVERE DROUGHT
- ANOMALIES IN CROP PROGRESSION AND APPEARANCE APPARENTLY CONFOUNDED ANALYSTS IN SOUTH DAKOTA


NASA-S-78-16684
CROP MOISTURE INDEX
JUNE 26, 1976
SHADED AREA INDICATES INCREASE OR
NO CHANGE IN INDEX DURING WEEK


NASA-S-78-16685
DROUGHT
CONDITIONS IN
THE DAKOTAS
JULY 1976
NORTH DAKOTA
SOUTH
DAKOTA
NEBRASKA
SEVERE
MODERATE


NASA-S-78-16686
GREAT PLAINS CRD'S
1976 SPRING WHEAT
PERCENT DEPARTURE
FROM 6-YEAR
AVERAGE YIELD
(1970-75)
+20
0
-60
-20
-40
-20
0
0


NASA-S-78-16687
LACIE PHASE II
SPRING WHEAT
REGION
$\hat{P} - P_{GT}$
DIFFERENCE BETWEEN ESTIMATED AND ACTUAL
PROPORTION OF WHEAT IN LACIE
5-BY-6-NAUTICAL-MILE SEGMENTS ($\hat{P} - P_{GT}$)
-1
-18
+3
-8
0
+6
-2
+5
-5
+1
-3
-25
+4
-6
-28
-8
+8
-27
+13
-11
-14
-6
0
-8
-5
-7
-18
-8
+7
-13
-9
+1
0
-18
+15
-1
-1
-1
-7
+20
+20
+1

NASA-S-78-16688

DEVELOPMENT OF DROUGHT MONITORING CAPABILITY USING LANDSAT

- UTILIZE THE LANDSAT DIGITAL DATA FROM FOUR SPECTRAL CHANNELS
- PRODUCE A RELATIVE ESTIMATE OF AGRICULTURAL RESPONSE TO MOISTURE SUPPLIES WHEN MEASURED AT PROPER PHENOLOGICAL STAGE

NASA-S-78-16689

LACIE PHASE III

1976-77

NASA-S-78-16690

U.S. GREAT PLAINS WINTER WHEAT

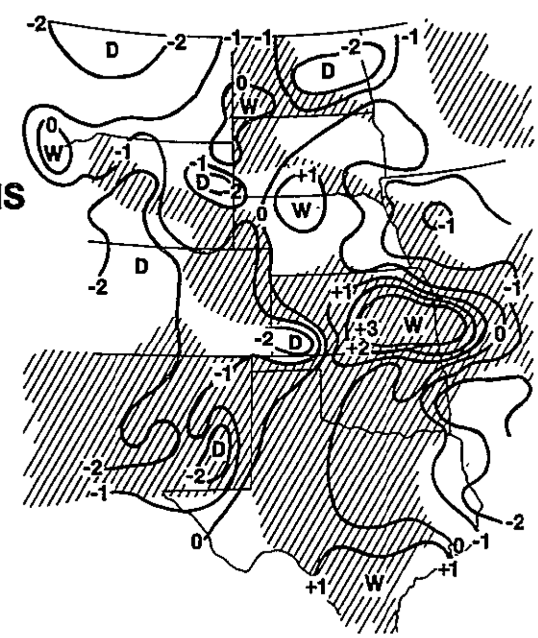
- DRY WEATHER AT PLANTING WAS FOLLOWED BY TIMELY RAINS
- EARLY COLD IN OCTOBER CAUSED DORMANCY BEFORE PLANTS WERE ABLE TO ACHIEVE THEIR USUAL DEGREE OF ESTABLISHMENT
- SNOW COVER WAS VARIABLE AND WINTERKILL OCCURRED IN PORTIONS OF KANSAS AND NEBRASKA
- EARLY WARM WEATHER AND TIMELY SPRING RAINS PRODUCED GOOD GROWTH AFTER DORMANCY IN ALL OF THE GREAT PLAINS EXCEPT COLORADO AND EXTREME SW KANSAS
- ABNORMALLY DRY WEATHER AFFECTED MONTANA DURING GRAIN-FILLING PERIOD
- IN DRY AREAS, ANALYSTS CONTINUED TO UNDERESTIMATE WHEAT AREA

NASA-S-78-16691

U.S. GREAT PLAINS

CLIMATIC DIVISIONS

JUNE 25, 1977



NASA-S-78-16692

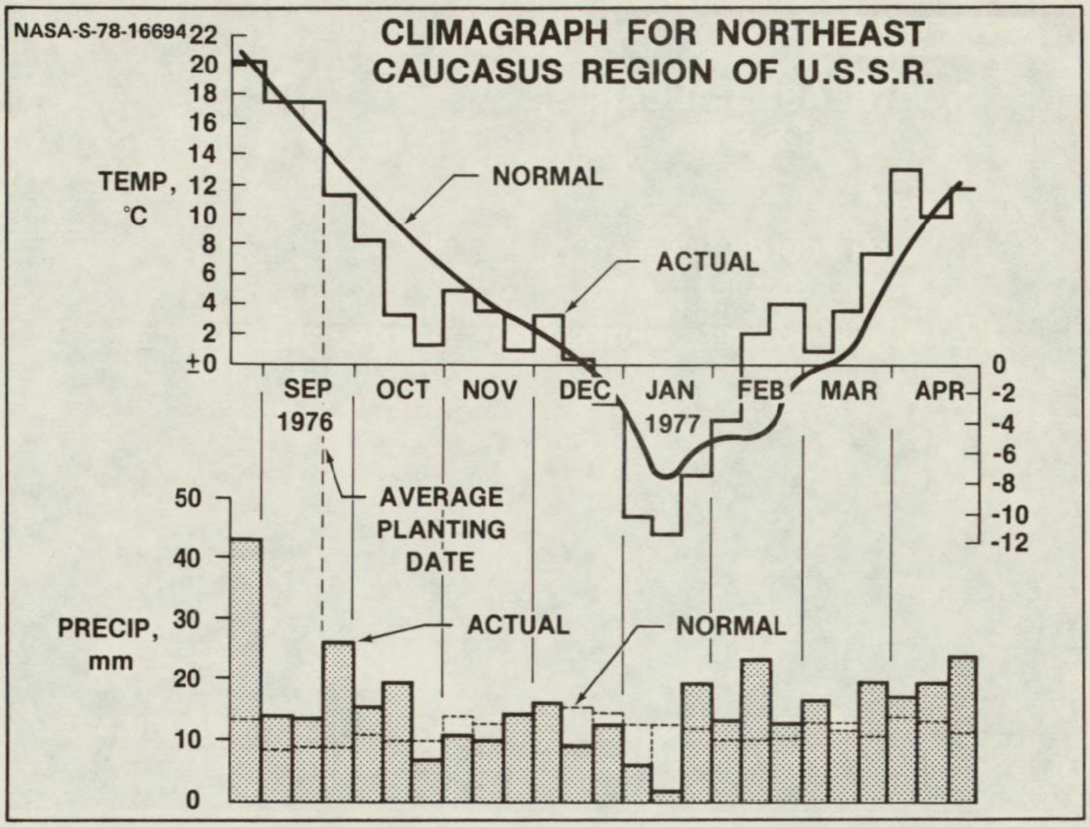
U.S. GREAT PLAINS SPRING WHEAT

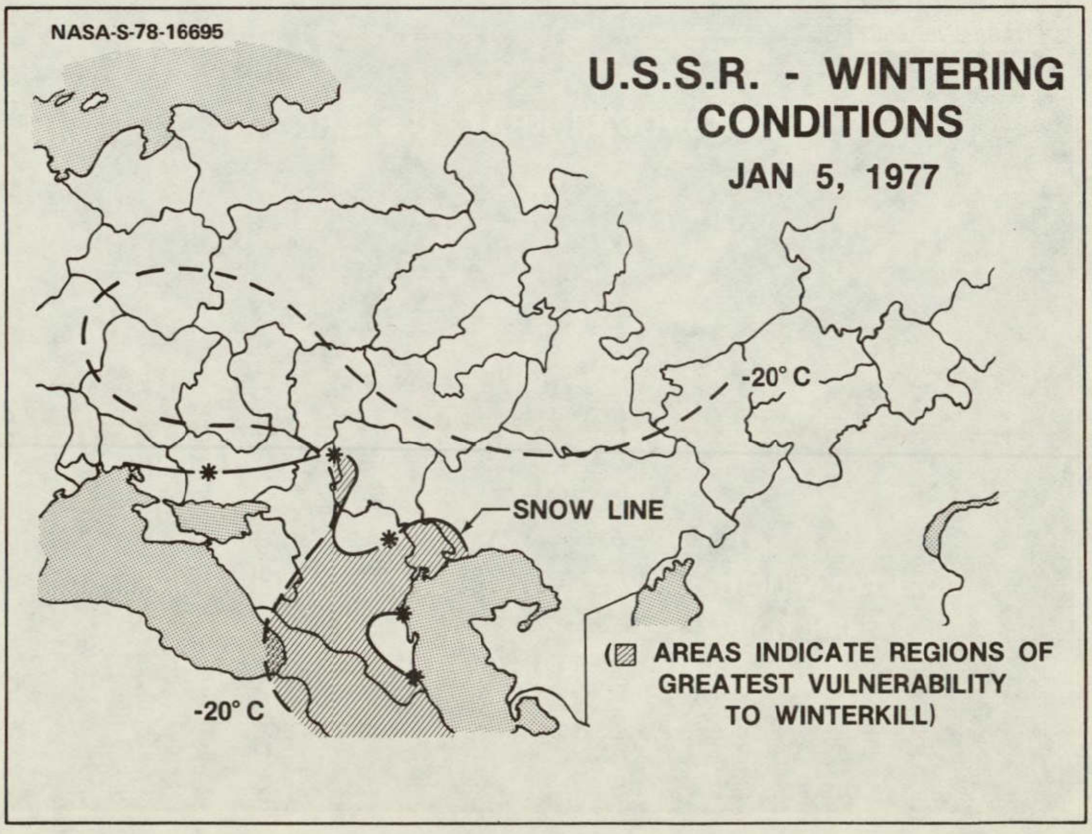
- ADEQUATE PRESEASON RAINFALL IMPROVED THE STORED MOISTURE FROM PREVIOUS SEASON'S LEVEL
- AFTER PLANTING, RAINFALL DEFICITS CAUSED SOIL MOISTURE TO BECOME SHORT IN MONTANA AND NORTH DAKOTA
- ANALYSIS OF LANDSAT DIGITAL DATA INDICATED DROUGHT STRESS PRESENT IN MONTANA

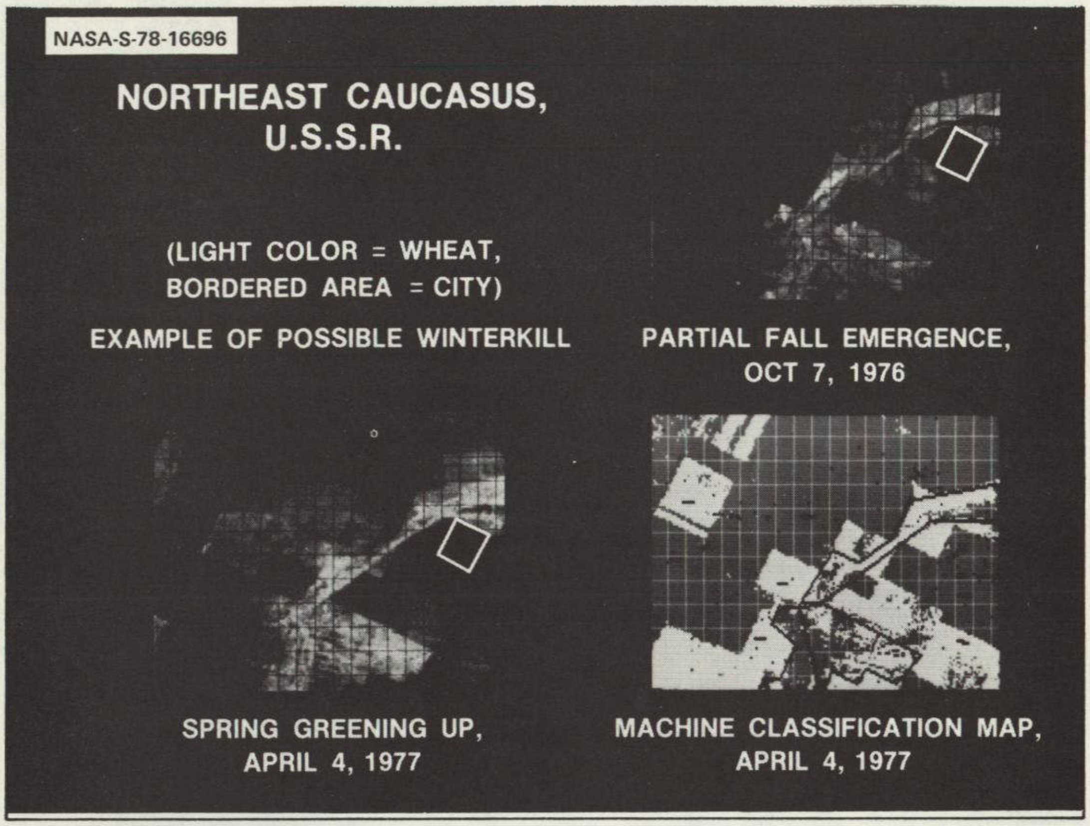
NASA-S-78-16693

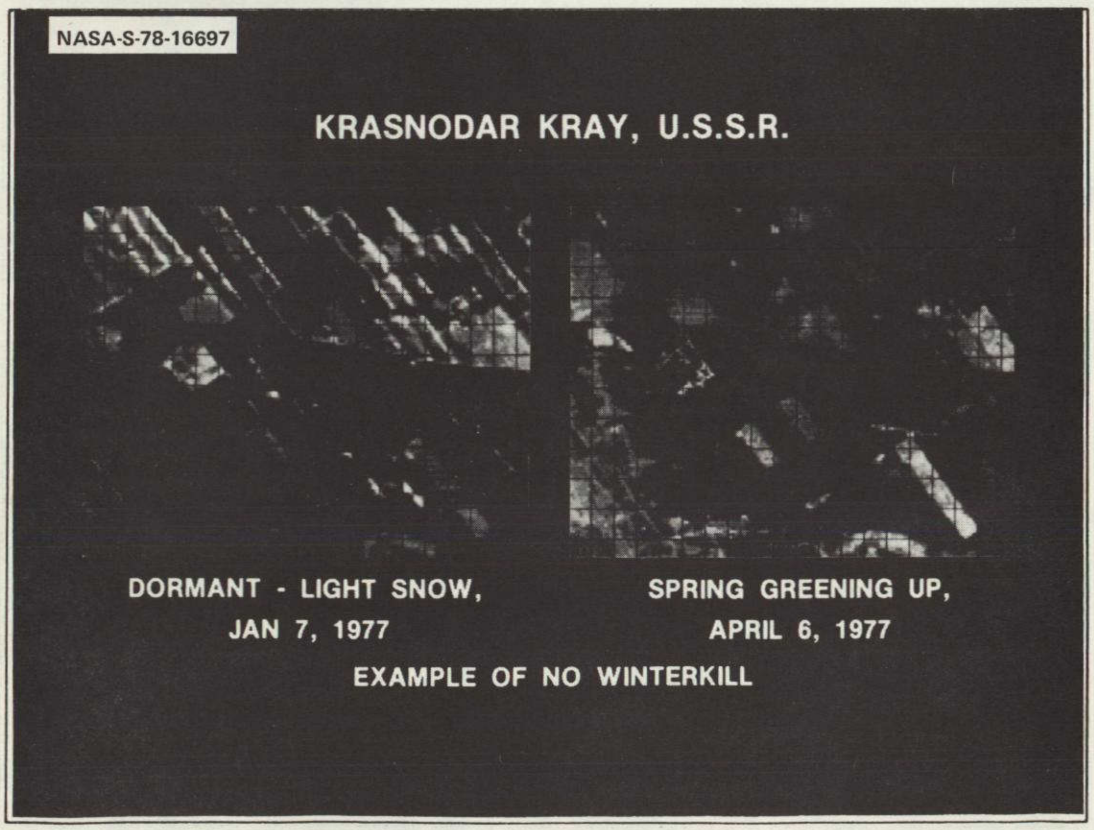
U.S.S.R. WINTER WHEAT

- FALL SEASON CHARACTERIZED BY AMPLE MOISTURE AND EARLY COLD
- POOR SNOW COVER AND COLD TEMPERATURES IN EARLY JANUARY WERE FAVORABLE FOR WINTERKILL IN SOUTHERN PORTIONS OF REGION
- EARLY WARM WEATHER AND ADEQUATE MOISTURE ENCOURAGED GOOD SPRING GROWTH
- NEAR-RECORD YIELDS IN RESPONSE TO IDEAL WEATHER AFTER DORMANCY
- OVERLY ADEQUATE RAINFALL PERSISTED INTO HARVEST PROMOTING DISEASE, LODGING, AND GENERALLY REDUCING GRAIN QUALITY


NASA-S-78-16694
CLIMAGRAPH FOR NORTHEAST CAUCASUS REGION OF U.S.S.R.
TEMP, °C
22
20
18
16
14
12
10
8
6
4
2
±0
NORMAL
ACTUAL
SEP 1976
OCT
NOV
DEC
JAN 1977
FEB
MAR
APR
0
-2
-4
-6
-8
-10
-12
AVERAGE PLANTING DATE
PRECIP, mm
50
40
30
20
10
0
ACTUAL
NORMAL


NASA-S-78-16695
U.S.S.R. - WINTERING CONDITIONS
JAN 5, 1977
-20° C
SNOW LINE
-20° C
(AREAS INDICATE REGIONS OF GREATEST VULNERABILITY TO WINTERKILL)

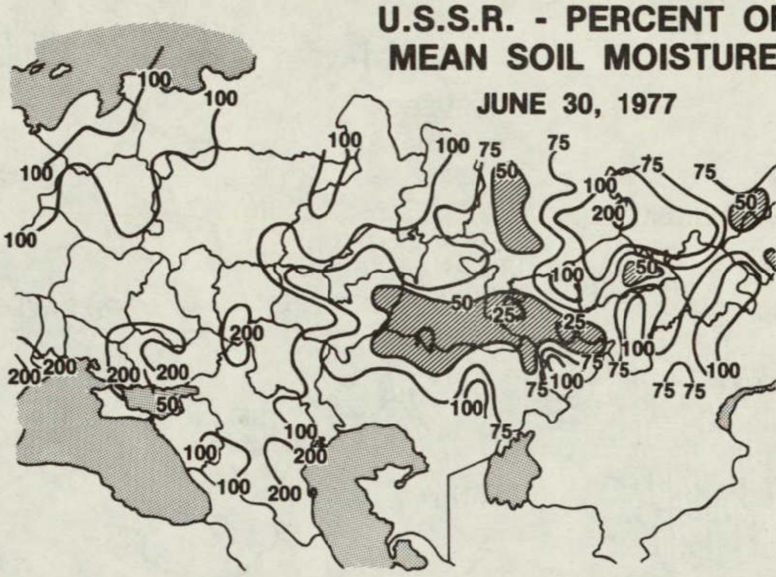

NASA-S-78-16696
NORTHEAST CAUCASUS, U.S.S.R.
(LIGHT COLOR = WHEAT, BORDERED AREA = CITY)
EXAMPLE OF POSSIBLE WINTERKILL
PARTIAL FALL EMERGENCE, OCT 7, 1976
SPRING GREENING UP, APRIL 4, 1977
MACHINE CLASSIFICATION MAP, APRIL 4, 1977


NASA-S-78-16697
KRASNODAR KRAY, U.S.S.R.
DORMANT - LIGHT SNOW, JAN 7, 1977
SPRING GREENING UP, APRIL 6, 1977
EXAMPLE OF NO WINTERKILL

NASA-S-78-16698

U.S.S.R. - PERCENT OF MEAN SOIL MOISTURE

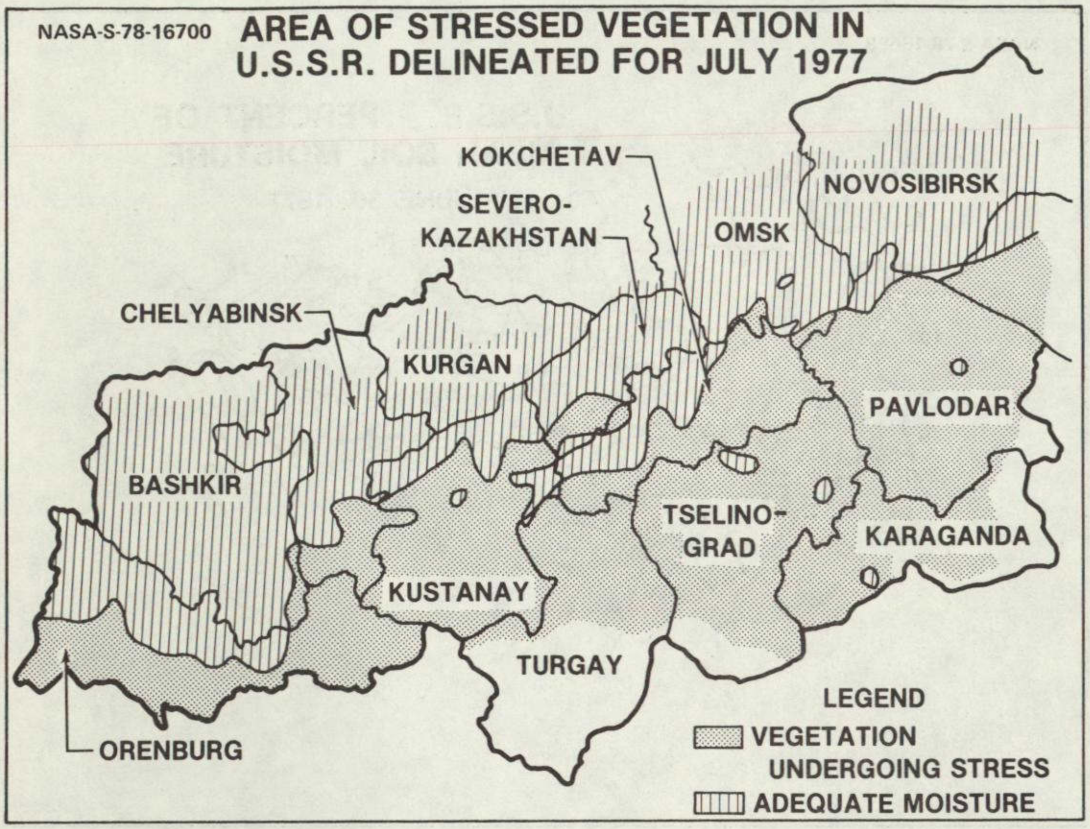
JUNE 30, 1977

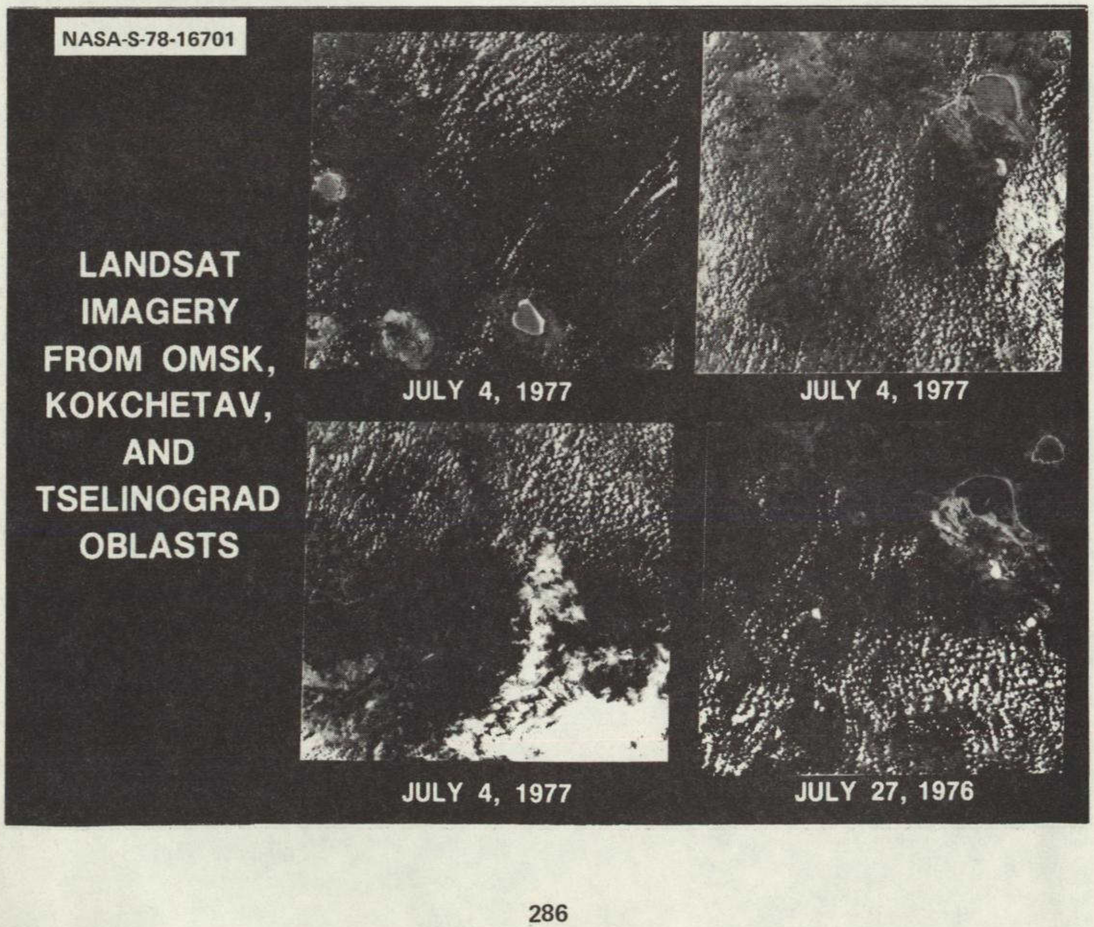


NASA-S-78-16699

U.S.S.R. SPRING WHEAT

- LIMITED RAINFALL PRODUCED LESS THAN NORMAL SOIL MOISTURE FROM THE MIDDLE VOLGA ACROSS THE SOUTHERN HALF OF THE SPRING WHEAT AREA
- LANDSAT DATA CONFIRMED CROPS WERE STRESSED BY SOIL MOISTURE SHORTAGE
- STRESSED WHEAT FAILED TO SHOW CHARACTERISTIC DEVELOPMENT AND MAY HAVE CAUSED ANALYSTS TO MISS MANY FIELDS
- AUGUST RAINFALL EXCEEDED NORMAL BUT WAS NOT TIMELY ENOUGH TO BENEFIT WHEAT. IT MAY ALSO HAVE PRODUCED PROBLEMS WITH QUALITY OF WHEAT


NASA-S-78-16700
AREA OF STRESSED VEGETATION IN U.S.S.R. DELINEATED FOR JULY 1977
KOKCHETAV
NOVOSIBIRSK
SEVERO-KAZAKHSTAN
OMSK
CHELYABINSK
KURGAN
PAVLODAR
BASHKIR
TSELINO-GRAD
KARAGANDA
KUSTANAY
TURGAY
ORENBURG
LEGEND
VEGETATION UNDERGOING STRESS
ADEQUATE MOISTURE


NASA-S-78-16701
LANDSAT IMAGERY FROM OMSK, KOKCHETAV, AND TSELINOGRAD OBLASTS
JULY 4, 1977
JULY 4, 1977
JULY 4, 1977
JULY 27, 1976

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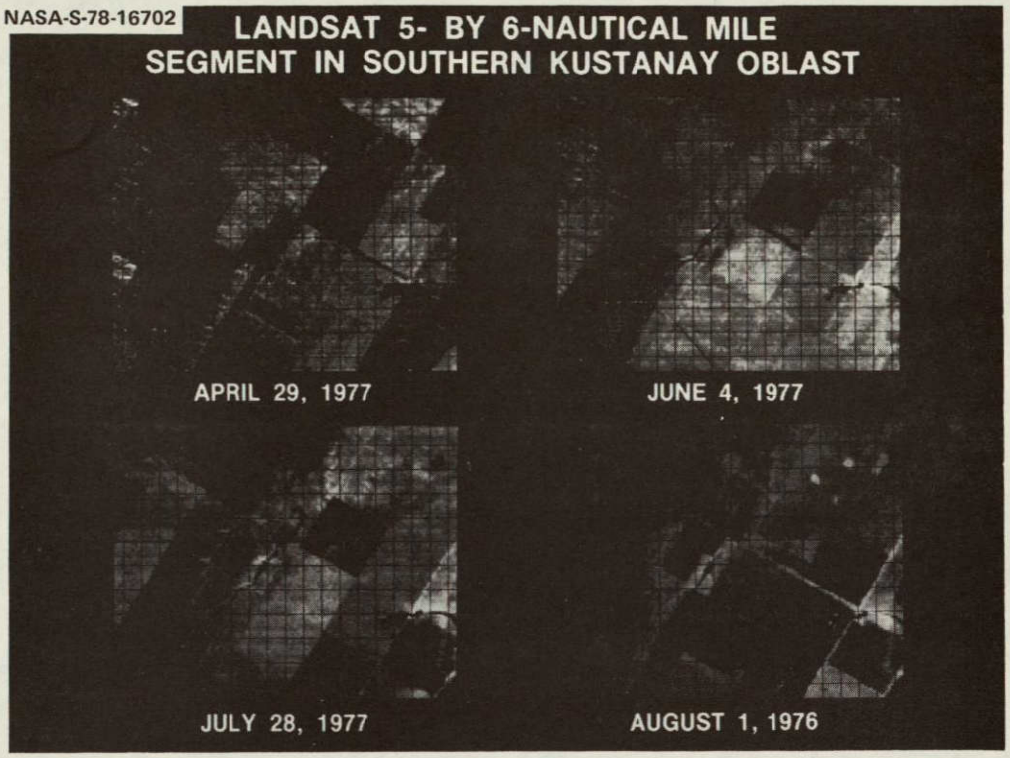

NASA-S-78-16704

SUMMARY

- LACIE ENCOUNTERED A WIDE VARIETY OF GROWING CONDITIONS DURING ITS THREE PHASES
- GLOBAL METEOROLOGICAL DATA ARE ADEQUATE TO GENERALLY DEFINE UNUSUAL GROWING CONDITIONS
- LANDSAT IMAGERY AND DIGITAL DATA ARE PROMISING SOURCES OF INFORMATION FOR ASSESSING RELATIVE CROP CONDITION, DEFINING AREAL EXTENT OF STRESSED CROPS, AND IDENTIFYING SPECIAL PROBLEMS

Material not available at presstime

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N79-14482

EXPERIMENT RESULTS SESSION

ACCURACY AND PERFORMANCE OF LACIE ESTIMATES

G. Houston, JSC

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NASA-S-78-17016

ACCURACY AND PERFORMANCE CHARACTERISTICS OF LACIE AREA ESTIMATES

NASA-S-78-17017

OUTLINE

SUMMARY

BY PHASE

- SCOPE
- 90/90 EVALUATION
- RELATIVE CONTRIBUTION OF AREA AND YIELD ERRORS
- AREA ERROR SOURCE ANALYSES
  - LACIE EST VS SRS (ESCS) EST AT STATE AND REGIONAL LEVELS
  - LACIE EST VS GROUND OBSERVED EST AT SEGMENT LEVEL

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NASA-S-78-17018

SUMMARY

- PRODUCTION ESTIMATOR FOR WINTER WHEAT REGIONS (U.S., U.S.S.R.) SUPPORTED 90/90 ACCURACY GOAL FOR ALL THREE PHASES — — 1-1/2 TO 2 MONTHS BEFORE HARVEST
  - ONE PROBLEM — PHASE II UNDERESTIMATION OF OKLAHOMA WW AREA DUE TO EPISODIC CONDITIONS
  - OVERALL TENDENCY TO UNDERESTIMATE WW AREA BUT DID NOT AFFECT ACCURACY GOAL

NASA-S-78-17019

SUMMARY (CONT)

- PRODUCTION ESTIMATOR FOR SPRING WHEAT DID NOT SUPPORT ACCURACY GOAL IN U.S. AND CANADA; SUPPORT INDICATED FOR U.S.S.R.
  - NEGATIVE BIAS INDICATED FOR SPRING WHEAT AREA ESTIMATOR IN U.S. AND CANADA
  - SIGNIFICANT IMPROVEMENT REALIZED IN PHASE III IN U.S. WHEN P1 INTRODUCED
  - UNDERESTIMATION OF AREA NOT OBSERVED IN U.S.S.R.; IF ANYTHING, TENDENCY TO OVERESTIMATE
  - CANNOT RELIABLY SEPARATE SPRING WHEAT FROM OTHER SPRING GRAINS; IN PARTICULAR, SPRING BARLEY

NASA-S-78-17020

SUMMARY (CONC)

- TEN-YEAR TESTS OF YIELD MODELS INDICATED ACCURACY GOAL SUPPORTED EXCEPT IN YEARS WHEN AGRICULTURAL AND METEOROLOGICAL CONDITIONS DIFFERED SIGNIFICANTLY FROM HISTORICAL DATA BASE

NASA-S-78-17021

PHASE I

- SCOPE
  - WHEAT AREA ESTIMATION IN USGP YARDSTICK REGION
  - YIELD AND PRODUCTION FEASIBILITY STUDIES
- 90/90 EVALUATION – AREA ESTIMATOR EVALUATED AT NATIONAL LEVEL
  - USSGP WINTER WHEAT – SUPPORTED ACCURACY GOAL
  - USNGP TOTAL WHEAT – DID NOT SUPPORT 90/90
    – ESTIMATED RELATIVE BIAS OF -30.2 PERCENT
  - USGP TOTAL WHEAT – DID NOT SUPPORT 90/90
    – ESTIMATED RELATIVE BIAS OF -10.7 PERCENT

NASA-S-78-17022

PHASE I (CONT)

- AREA ERROR SOURCE ANALYSIS
  - COMPARISONS WITH USDA/SRS ESTIMATES (RELEASED DEC 1975)

	AREA, ACRES		DEVIATION, PERCENT		TEST STATISTIC
	USDA/SRS	LACIE	CV	RD	
SOUTHERN GREAT PLAINS	$29\,830 \times 10^3$	$29\,779 \times 10^3$	7.0	-0.2	-0.03
NORTHERN GREAT PLAINS	21 035	16 156	9.7	-30.2	-3.11*
U.S. GREAT PLAINS	50 865	45 935	5.7	-10.7	1.88*

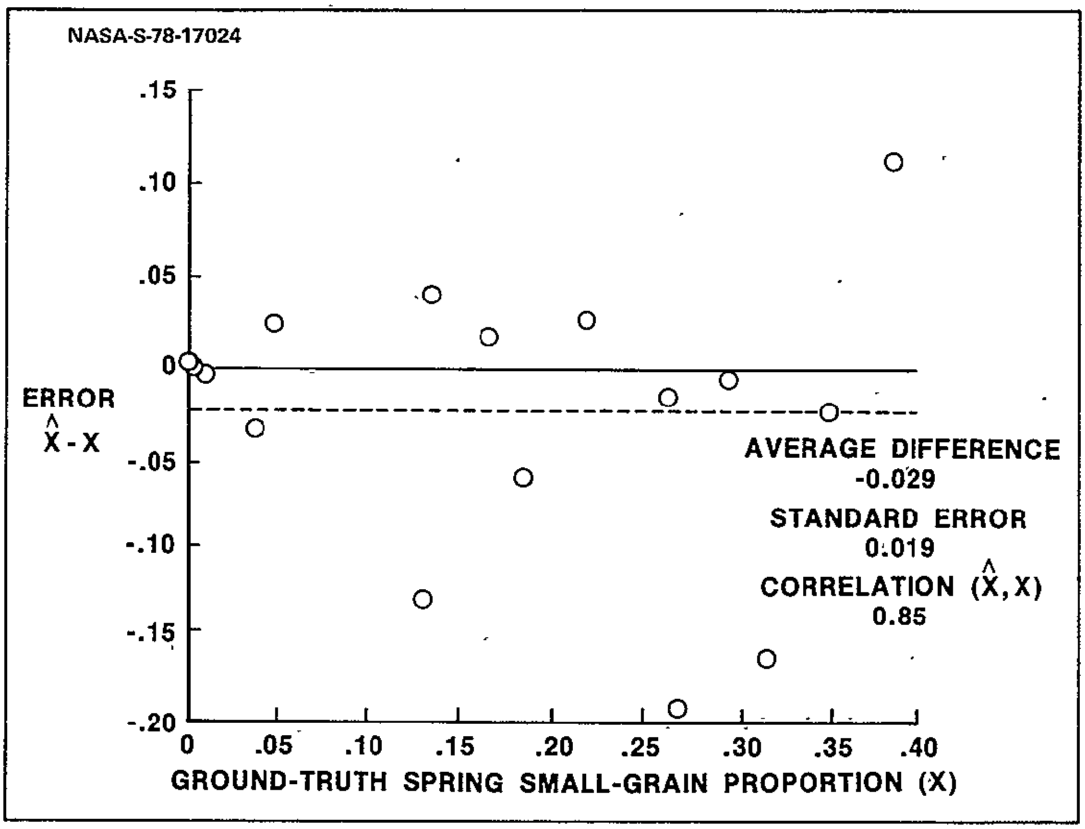
*INDICATES ESTIMATES ARE SIGNIFICANTLY DIFFERENT

– NEGATIVE BIAS INDICATED FOR NORTHERN GREAT PLAINS DUE MAINLY TO UNDERESTIMATION IN NORTH DAKOTA (RD = -74.5 PERCENT)

NASA-S-78-17023

PHASE I (CONT)

- AREA ERROR SOURCE ANALYSES (CONT)
  - LACIE SEGMENT ESTIMATES VS GROUND OBSERVED ESTIMATES
    - 20 BLIND SITES IN NORTH DAKOTA – 16 WORKED BY CAMS
    - SPRING SMALL-GRAIN PROPORTION COMPARISONS INDICATED TENDENCY TO UNDERESTIMATE BUT NOT SIGNIFICANT
    - COMPARISON OF GROUND OBSERVED PROPORTIONS WITH CORRESPONDING SRS COUNTY PROPORTIONS INDICATED SAMPLING TO BE THE MAJOR PROBLEM – GROUND OBSERVED PROPORTIONS WERE 38 PERCENT BELOW CORRESPONDING SRS COUNTY PROPORTIONS



NASA-S-78-17025

PHASE I (CONT)

SUMMARY

- ADDED 20 SEGMENTS TO NORTH DAKOTA TO ALLEVIATE SAMPLING PROBLEM
- MOVED SEGMENTS IN NON-AG AREAS TO AG AREAS
- INCREASED NO. OF BLIND SITES FOR PHASE II TO FURTHER UNDERSTAND CLASSIFICATION PROBLEMS
- CONTINUED TO USE HISTORIC WHEAT-TO-SMALL GRAINS RATIOS FOR WHEAT AREA ESTIMATION

NASA-S-78-17026

PHASE II

- SCOPE – AREA, YIELD, AND PRODUCTION ESTIMATION
  - USGP YARDSTICK REGION
  - CANADA
  - TWO INDICATOR REGIONS IN U.S.S.R.
- 90/90 EVALUATION – FOR U.S., PRODUCTION ESTIMATOR EVALUATED AT USGP LEVEL
  - WINTER WHEAT REGION – SUPPORTED ACCURACY GOAL
  - SPRING WHEAT REGION – DID NOT SUPPORT ACCURACY GOAL
    – ESTIMATED RELATIVE BIAS OF -22.3 PERCENT
  - USGP TOTAL WHEAT – DID NOT SUPPORT ACCURACY GOAL
    – ESTIMATED RELATIVE BIAS OF -12.3 PERCENT

NASA-S-78-17027

PHASE II (CONT)

- RELATIVE CONTRIBUTIONS OF AREA AND YIELD ERRORS TO BIAS OF PRODUCTION ESTIMATE

		RD (PERCENT)	
REGION	TOTAL RD, PERCENT	LACIE ACREAGES x SRS YIELDS	LACIE YIELDS x SRS ACREAGES
WINTER WHEAT	-7.2	-7.6	-1.1
SPRING WHEAT	-22.3	-29.1	+6.3
TOTAL WHEAT	-12.3	-14.9	+1.5

- INDICATES PRODUCTION UNDERESTIMATION DUE PRIMARILY TO AREA UNDERESTIMATION

NASA-S-78-17028

PHASE II (CONT)

AREA ERROR SOURCE ANALYSES

- COMPARISONS WITH USDA/SRS
  - WINTER WHEAT AREA

	AREA, ACRES		DEVIATION, PERCENT		TEST STATISTIC
	USDA/SRS	LACIE	CV	RD	
SOUTHERN GREAT PLAINS	27 450 x 10^3	25 833 x 10^3	5	-6.3	-1.26
U.S. GREAT PLAINS	31,500	29 364	5	-7.3	-1.46

- — INDICATES TENDENCY TO UNDERESTIMATE BUT NOT SIGNIFICANT
- — UNDERESTIMATION TENDENCY DUE MAINLY TO UNDERESTIMATION IN OKLAHOMA (RD = -47.9 PERCENT)

NASA-S-78-17029

PHASE II (CONT)

- COMPARISONS WITH USDA/SRS (CONT)
  - SPRING WHEAT AREA

	AREA, ACRES		DEVIATION, PERCENT		TEST STATISTIC
	USDA/SRS	LACIE	CV	RD	
SPRING WHEAT STATES	15 413 x 10^3	12 054 x 10^3	7	-27.9	-3.99*
MIXED WHEAT STATES	4 355	3 595	12	-21.1	-1.76*
USNGP	19 768	15 649	6	-26.3	-4.38*

*INDICATES ESTIMATES ARE SIGNIFICANTLY DIFFERENT

- — SIGNIFICANT UNDERESTIMATION INDICATED FOR SPRING WHEAT REGION
- — SOUTH DAKOTA ONLY STATE WHERE UNDERESTIMATION WAS NOT OBSERVED (RD = 2.8 PERCENT)

NASA-S-78-17030

PHASE II (CONT)

- COMPARISONS WITH USDA/SRS (CONT)
  - TOTAL WHEAT AREA

	AREA, ACRES		DEVIATION, PERCENT		TEST STATISTIC
	USDA/SRS	LACIE	CV	RD	
USSGP WINTER	27 450 x 10^3	25 833 x 10^3	5	-6.3	-1.26
USNGP TOTAL	23 818	19 180	5	-24.2	-4.84*
USGP	51 268	45 013	4	-13.9	-3.48*

*INDICATES ESTIMATES ARE SIGNIFICANTLY DIFFERENT

– SIGNIFICANT UNDERESTIMATION FOR TOTAL WHEAT DUE MAINLY TO SIGNIFICANT UNDERESTIMATION OF SPRING WHEAT AREA

NASA-S-78-17031

PHASE II (CONT)

- LACIE SEGMENT ESTIMATES VS GROUND OBSERVED SEGMENT ESTIMATES
  - BIAS DUE TO CLASSIFICATION — WEIGHTED ANALYSIS

WINTER WHEAT	n/N	RB, PERCENT	CV, PERCENT	TEST STATISTIC
USSGP	103/233	-15.0	5.1	-2.94*
USSGP (EXCLUDING OKLAHOMA)	83/193	-6.0	5.4	-1.11

*INDICATES SIGNIFICANT UNDERESTIMATION DUE TO CLASSIFICATION MAINLY DUE TO PROBLEMS IN OKLAHOMA

NASA-S-78-17032

PHASE II (CONT)

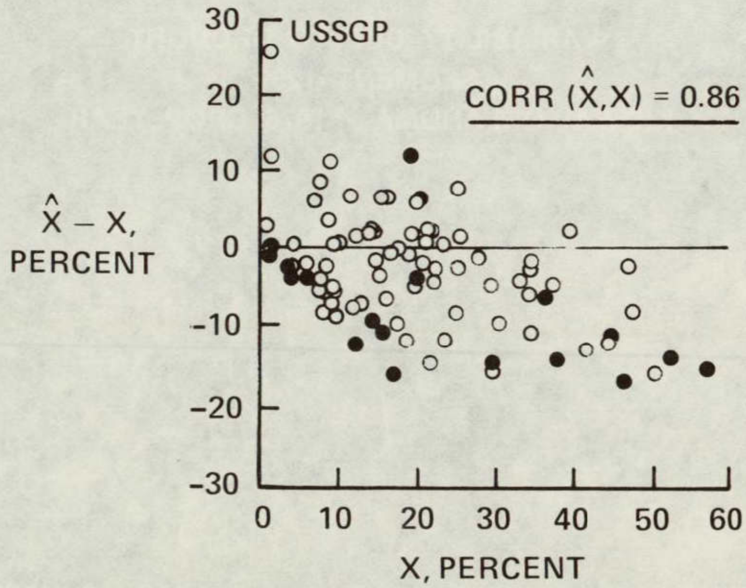
- BIAS DUE TO CLASSIFICATION -- UNWEIGHTED ANALYSIS

WINTER WHEAT	n	$\bar{D}$	$S_{\bar{D}}$	t
USSGP	105	-1.9	0.8	-2.5*
USSGP (EXCLUDING OKLAHOMA)	85	-.8	0.8	-1.1

*SIGNIFICANT UNDERESTIMATION DUE MAINLY TO OKLAHOMA PROBLEMS

NASA-S-78-17033

PHASE II (CONT)



SOLID DOTS REPRESENT OKLAHOMA SITES

NASA-S-78-17034

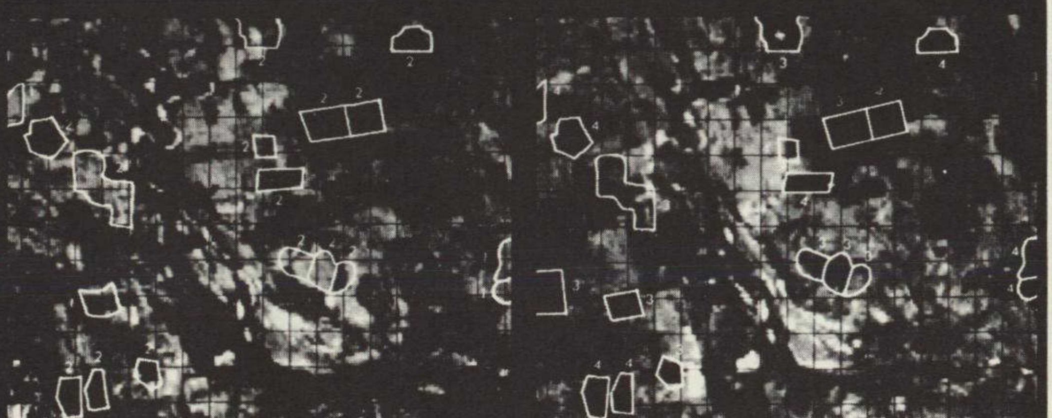
PHASE II (CONT)

- OKLAHOMA PROBLEM INVESTIGATION
  - INDICATED WHEAT MISLABELED AS OTHER DUE TO THIN STANDS CAUSED BY
    - DROUGHT
    - WINTERKILL
    - GREEN BUGS
    - CATTLE GRAZING
    - LATE PLANTING
  - EXAMPLE – SEGMENT 1232 –
    - KIOWA COUNTY, SOUTHWEST OKLAHOMA
    - $\hat{x}$ = 29.7 PERCENT x = 35.9 PERCENT
    - DISPARITY IN SIGNATURES DUE TO DROUGHT AND CATTLE GRAZING

NASA-S-78-16069

WHEAT SIGNATURE

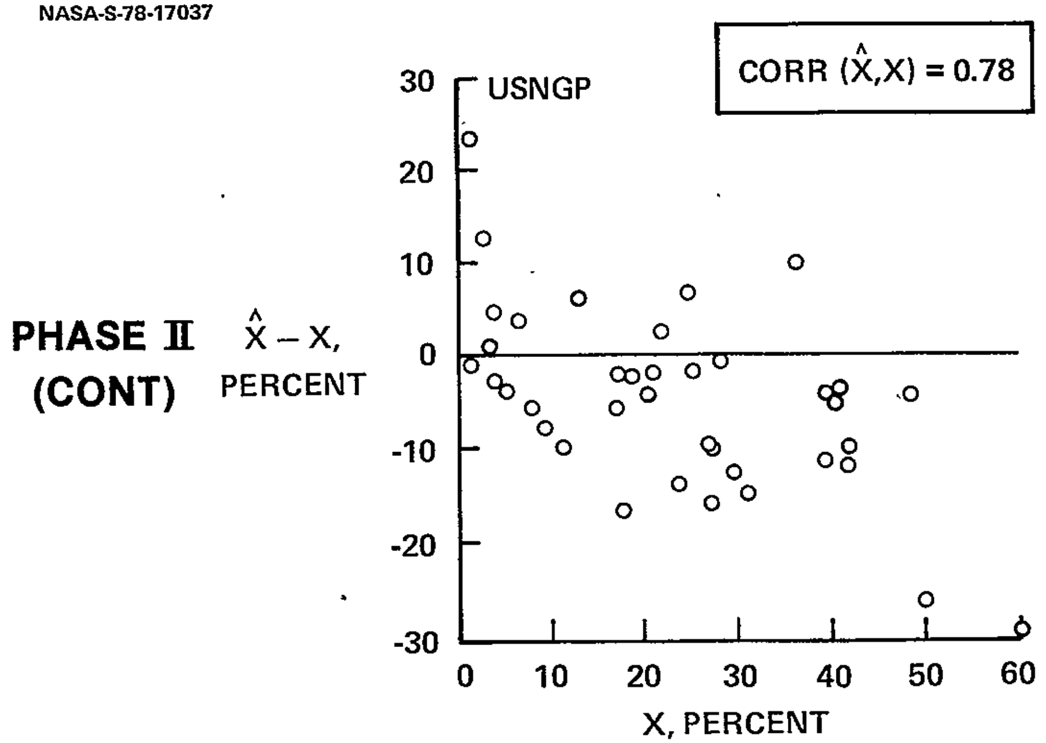
VARIABILITY DUE TO DROUGHT
SEGMENT 1232
KIOWA, OKLAHOMA - 1976 CROP YEAR



NOVEMBER 24, 1975   APRIL 16, 1976

NUMBER INDICATES BIO-WINDOW

NASA-S-78-17037



NASA-S-78-17038

PHASE II (CONT)

- RELATIVE CONTRIBUTIONS OF SMALL-GRAIN CLASSIFICATION AND WHEAT TO SMALL-GRAIN RATIO ERRORS

	n	BIAS	MEAN SQUARED ERROR
TOTAL	37	-5.2	104.5
LACIE RATIO x GROUND OBS SG, PERCENT		-3.1	25.7
GROUND OBS RATIO x LACIE SG, PERCENT		-2.2	78.6

  - INDICATES VARIABILITY PRIMARILY DUE TO ERRORS IN CLASSIFICATION OF SPRING SMALL GRAINS
  - WHEAT TO SMALL-GRAIN RATIO ERRORS INTRODUCED MORE BIAS THAN SMALL-GRAIN CLASSIFICATION ERRORS

NASA-S-78-17039

PHASE II (CONT)

SUMMARY

- DEVELOPED ECONOMETRIC MODELS FOR FORECASTING WHEAT-TO-SMALL GRAINS RATIOS TO REDUCE BIAS
- INTRODUCED PROCEDURE I IN ORDER TO INCREASE CLASSIFICATION PRECISION
- REVISED SAMPLE STRATEGY IN U.S. TO ACHIEVE 2.3 PERCENT SAMPLE ERROR AND ALLOW FOR SOME BIAS
- EXPANDED BLIND SITE PROGRAM FOR MORE DETAILED CLASSIFICATION ERROR ANALYSES

NASA-S-78-17040

PHASE III

- SCOPE – AREA, YIELD, AND PRODUCTION ESTIMATION
  - USGP YARDSTICK REGION
  - U.S.S.R.
- 90/90 EVALUATION
  - WINTER WHEAT REGION – SUPPORTED ACCURACY GOAL
  - SPRING WHEAT REGION – DID NOT SUPPORT ACCURACY GOAL
    – ESTIMATED RELATIVE BIAS OF -25.7 PERCENT
  - USGP TOTAL WHEAT – SUPPORTED ACCURACY GOAL
    – ESTIMATED RELATIVE BIAS OF -10.0 PERCENT

NASA-S-78-17042

PHASE III (CONT)

- RELATIVE CONTRIBUTION OF AREA AND YIELD ERRORS
  - TO BIAS OF PRODUCTION ESTIMATE

	TOTAL RD, PERCENT	RD (PERCENT) LACIE ACREAGES x SRS YIELDS	LACIE YIELDS x SRS ACREAGES
WINTER WHEAT	-3.4	+4.9	-8.9
SPRING WHEAT	-25.7	-12.3	-15.5
TOTAL WHEAT	-10.0	-.2	-10.9

— INDICATES PRODUCTION UNDERESTIMATION DUE PRIMARILY TO YIELD UNDERESTIMATION

NASA-S-78-17041

PHASE III (CONT)

- AREA ERROR SOURCE ANALYSES
  - COMPARISONS WITH USDA/SRS
    WINTER WHEAT REGION

	AREA, ACRES USDA/SRS	LACIE	PERCENT CV	RD	TEST STAT-ISTIC
SOUTHERN GREAT PLAINS	$28\ 800 \times 10^3$	$29\ 537 \times 10^3$	3.4	2.5	0.74
U.S. GREAT PLAINS	32 280	33 820	3.2	4.6	1.44

— INDICATES TENDENCY TO OVERESTIMATE BUT NOT SIGNIFICANT

NASA-S-78-17043

PHASE III (CONT)

- AREA ERROR SOURCE ANALYSES
  - COMPARISONS WITH USDA/SRS

    SPRING WHEAT REGION

	AREA, ACRES		PERCENT		TEST STAT-ISTIC
	USDA/SRS	LACIE	CV	RD	
SPRING WHEAT STATES	$12\,372 \times 10^3$	$11\,527 \times 10^3$	4.0	-7.3	-1.8*
MIXED WHEAT STATES	4 596	4 110	7.0	-11.8	-1.7*
USNGP	16 968	15 637	3.5	-8.5	-2.4*

*INDICATES SIGNIFICANT UNDERESTIMATION OF SPRING WHEAT AREA

– SIGNIFICANT IMPROVEMENT OVER PHASE II (RD = -26.3 PERCENT)

NASA-S-78-17044

PHASE III (CONT)

- COMPARISONS WITH USDA/SRS (CONT)

  TOTAL WHEAT

	AREA, ACRES		PERCENT		TEST STAT-ISTIC
	USDA/SRS	LACIE	CV	RD	
USSGP WINTER	$28\,800 \times 10^3$	$29\,537 \times 10^3$	3.4	2.5	0.7
USNGP TOTAL	20 448	19 921	7.6	-2.6	-.3
USGP	49 248	49 458	2.4	.4	.2

- INDICATES ESTIMATES NOT SIGNIFICANTLY DIFFERENT FOR TOTAL WHEAT AREA

NASA-S-78-17045

PHASE III (CONT)

- LACIE SEGMENT ESTIMATES VS GROUND OBSERVED SEGMENT ESTIMATES
  - BIAS DUE TO CLASSIFICATION – WEIGHTED ANALYSIS

WINTER WHEAT	n/N	RB, PERCENT	CV, PERCENT	TEST STATISTIC
USSGP	75/240	-10.3	4.5	-2.3*
USGP	92/298	-9.5	4.2	-2.3*

*INDICATES NEGATIVE BIAS DUE TO CLASSIFICATION OF WINTER WHEAT

NASA-S-78-17046

PHASE III (CONT)

- BIAS DUE TO CLASSIFICATION – UNWEIGHTED ANALYSIS

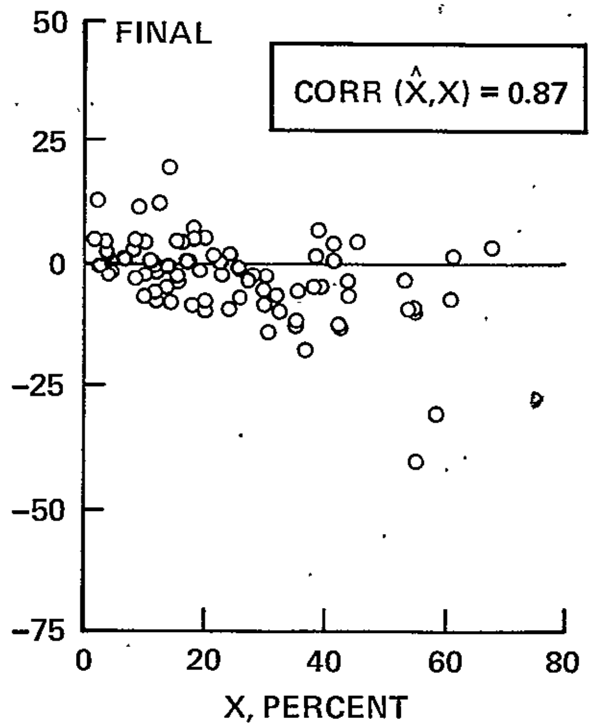
WINTER WHEAT

	n	$\bar{D}$	$S_{\bar{D}}$	t
USSGP	75	-2.9	1.0	-2.8*
USGP	92	-2.4	.8	-2.8*

*INDICATES NEGATIVE BIAS

NASA-S-78-17047

PHASE III (CONT)



NASA-S-78-17048

PHASE III (CONT)

- LACIE SEGMENT ESTIMATES VS GROUND OBSERVED SEGMENT ESTIMATES
  - BIAS DUE TO CLASSIFICATION – WEIGHTED ANALYSIS

SPRING WHEAT	n/N	RB, PERCENT	CV, PERCENT	TEST STATISTIC
USNGP	53/178	-22.9	6.9	-3.3*

*INDICATES NEGATIVE BIAS DUE TO CLASSIFICATION OF SPRING WHEAT

NASA-S-78-17049

PHASE III (CONT)

- BIAS DUE TO CLASSIFICATION – UNWEIGHTED ANALYSIS (CONT)

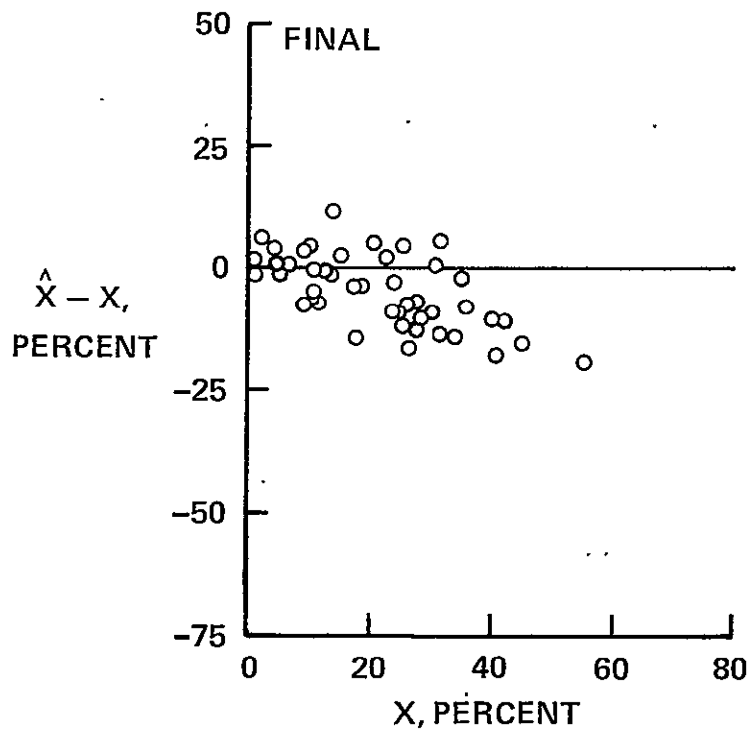
SPRING WHEAT

	n	$\bar{D}$	$S_{\bar{D}}$	t
USNGP	53	-3.6	1.0	-3.5*

– INDICATES SIGNIFICANT UNDERESTIMATION OF SPRING WHEAT PROPORTIONS

NASA-S-78-17050

PHASE III (CONT)



NASA-S-78-17051

PHASE III (CONT)

- RELATIVE CONTRIBUTIONS OF CLASSIFICATION AND WHEAT TO SMALL-GRAIN RATIO ERRORS
  - SPRING WHEAT REGION OF NORTH DAKOTA AND MINNESOTA SPRING WHEAT PROPORTIONS

	n	$\bar{D}$	$S_{\bar{D}}$	t
SPRING WHEAT STATES	33	-3.8	1.1	-3.5*

*INDICATES SIGNIFICANT UNDERESTIMATION

CONTRIBUTIONS OF CLASSIFICATION AND RATIOING ERRORS

NASA-S-78-17052

PHASE III LABEL ERROR CAUSES

PERCENT OF TOTAL PIXELS LABELED

CAUSE OF ERROR	ND (18)		MN (6)		MT (10)		CO (6)		OK (11)	
	OM	COM	OM	COM	OM	COM	OM	COM	OM	COM
• ABNORMAL SIGNATURES	4.4	0.5	2.6	0.3	1.4	0.9	2.8	–	3.3	1.4
• BOUNDARIES	3.2	.7	4.0	1.1	1.0	.6	2.3	0.8	2.2	.8
• LACK OF ACQUISITION	1.5	1.0	–	–	.5	–	–	–	3.0	–
TOTAL ERRORS ERRORS OF OMISSION	11.2	–	9.1	–	4.8	–	6.0	–	9.9	–
TOTAL ERRORS OF COMMISSION	–	3.0	–	2.6	–	2.1	–	.8	–	5.5

NASA S 78-16398

PHASE III OMISSION LABELING ERROR EXAMPLES

GRANT COUNTY, MINNESOTA

HEADING — JUNE 23, 1977
SW — RED
NW — GREEN

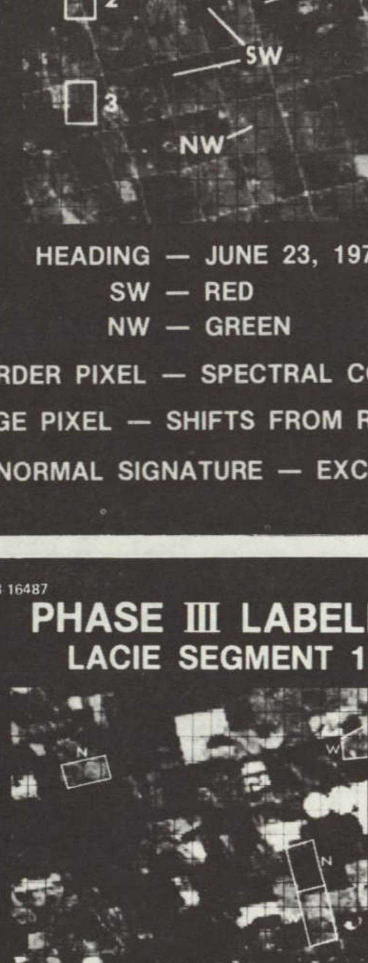
TURNING — JULY 29, 1977
SW — GREEN
NW — RED

1. BORDER PIXEL — SPECTRAL CONFUSION OF SW AND SUNFLOWERS
2. EDGE PIXEL — SHIFTS FROM ROAD (HEADING) TO SW (TURNING)
3. ABNORMAL SIGNATURE — EXCESS WATER RETARDED SW DEVELOPMENT

NASA S 78-16487

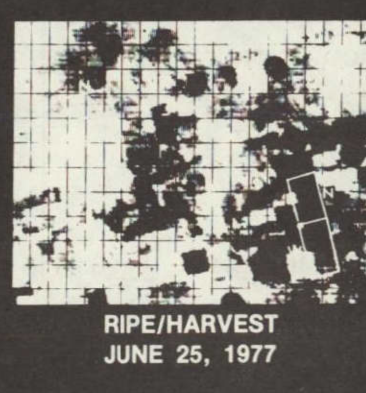
PHASE III LABELING ERROR EXAMPLE

LACIE SEGMENT 1021, SHERMAN, KANSAS



PLANTED/EMERGENT
NOV 21, 1976

INADEQUATE
MULTITEMPORAL
ACQUISITIONS



RIPE/HARVEST
JUNE 25, 1977

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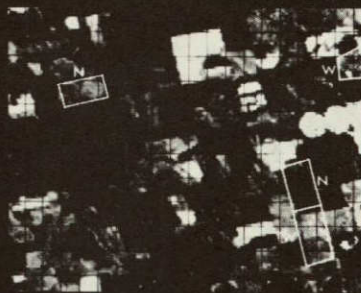
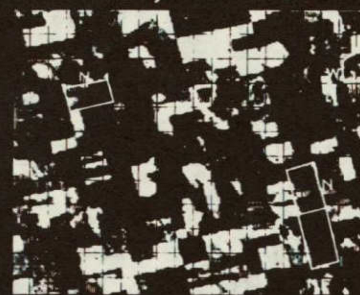
NASA S 78 16488

PHASE III LABELING ERROR EXAMPLE (CONT)

LACIE SEGMENT 1021, SHERMAN, KANSAS

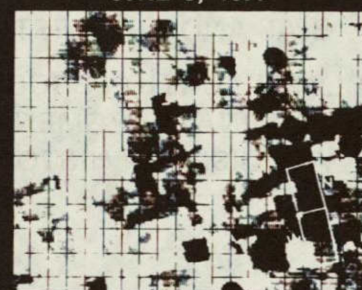


PLANTING/EMERGENCE
NOV 21, 1976



TILLERING/HEADING
JUNE 8, 1977

ADEQUATE
MULTITEMPORAL
ACQUISITIONS



RIPE/HARVEST
JUNE 25, 1977

NASA-S-78-17053

PHASE III (CONT)

RELATIVE CONTRIBUTIONS OF SAMPLING AND CLASSIFICATION ERRORS TO VARIABILITY OF AREA ESTIMATE

CROP	AREA CV, PERCENT	CLASSIFICATION CV, PERCENT	SAMPLING CV, PERCENT
WINTER WHEAT			
USGP--7	3.2	2.0	2.5
SPRING WHEAT			
USNGP	3.5	2.3	2.8
TOTAL WHEAT			
USGP	2.4	1.5	1.9

NASA-S-78-17054

PHASE III (CONT)

SUMMARY

- PHASE III GOAL FOR 2.3 PERCENT SAMPLE ERROR WAS ACHIEVED
- PROCEDURE I LED TO INCREASED PRECISION PARTICULARLY IN SPRING WHEAT AREA
- RESULTING INCREASED PRECISION ALLOWED SOME BIAS AND AREA ESTIMATOR SUPPORTED 90/90
- CLASSIFICATION PROCEDURES WERE MODIFIED TO ELIMINATE SEGMENT ESTIMATES BASED ON POOR ACQUISITION HISTORIES

NASA-S-78-17055

ACCURACY AND PERFORMANCE CHARACTERISTICS OF LACIE YIELD MODELS

NASA-S-78-17056

EVALUATION OF YIELD MODELS

- OBJECTIVE
  - MINIMIZE CONTRIBUTIONS FROM YIELD TO ERRORS IN THE LACIE PRODUCTION ESTIMATES THROUGH AN ORDERLY DEVELOPMENT OF YIELD TECHNOLOGY
- APPROACH
  - IDENTIFY AND EVALUATE THE ERROR SOURCES IN OPERATIONAL YIELD MODELS FOR PURPOSES OF MODEL IMPROVEMENT
    - MODIFY EXISTING MODELS
    - IMPLEMENT ALTERNATIVE MODEL FORMS
- REQUIREMENTS
  - EVALUATE ABILITY OF MODELS TO PROVIDE YIELD ESTIMATES THAT SUPPORT THE 90/90 CRITERION
  - DETERMINE MODEL SENSITIVITY TO CONDITIONS CAUSING IMPORTANT DEPARTURES FROM EXPECTED YIELDS

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NASA-S-78-17057

LACIE YIELD MODELS

- MODEL IS AN AREA SPECIFIC POLYNOMIAL BASED ON MULTIPLE LINEAR REGRESSION

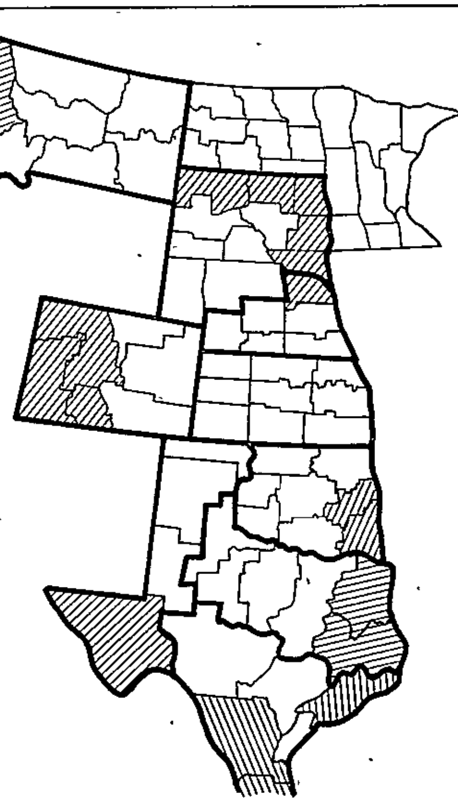
$$Y = \beta X + \epsilon$$

- INDEPENDENT VARIABLES ARE FUNCTIONS OF MONTHLY AVERAGES OF AIR TEMPERATURE AND PRECIPITATION
- TREND (TECHNOLOGICAL CHANGE) IS MODELED AS A PIECE WISE LINEAR FUNCTION OF YEAR
- PREDICTION ERROR IS CALCULATED IN THE STANDARD STATISTICAL MANNER

$$(\text{PREDICTION ERROR})^2 = S^2 \left[1 + X_K^1 (X^1 X)^{-1} X_K\right]$$

NASA-S-78-17058

U.S. GREAT PLAINS WINTER WHEAT MODELS



NASA-S-78-17063

YIELD MODELS
DEVELOPED AND TESTED

COUNTRY	NO. OF MODELS	TYPE OF TEST	SUPPORT 90/90
ARGENTINA	5	HISTORICAL	NO
AUSTRALIA	5	HISTORICAL	YES
BRAZIL	1	HISTORICAL	NO
CANADA	16	HISTORICAL/ OPERATIONS	YES
INDIA	1	HISTORICAL	YES
U.S.S.R.	44 (21 WW/23 SW)	HISTORICAL/ OPERATIONS	YES
U.S.	15 (10 WW/5 SW)	HISTORICAL/ OPERATIONS	YES

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PHASE I (CROP YEAR 1975) EVALUATION

- HISTORICAL TEST
  - MODELS WERE TESTED AT BOTH THE CRD AND STATE LEVELS
  - THE MODELS DID NOT SUPPORT THE 90/90 CRITERION FOR THE ENTIRE U.S. GREAT PLAINS
  - THE WEATHER RESPONSE OF THE MODELS WAS JUDGED INADEQUATE FOR 10 OF 12 MODELS

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TEN-YEAR BOOTSTRAP TEST (1965-74) FOR U.S. PHASE I BY MODEL REGION

MODEL	CROP	MEAN ERROR, BU/ACRE	RMSE, BU/ACRE	SUPPORT 90/90
MONTANA	SW	-0.4	2.40	YES
NORTH DAKOTA	SW	+2.3	4.55	NO
RED RIVER	SW	+2.6	4.69	YES
SOUTH DAKOTA	SW	-0.0	2.24	YES
MONTANA	WW	-0.7	3.71	YES
BADLANDS	WW	-1.9	5.30	YES
NEBRASKA	WW	-2.2	4.42	YES
COLORADO	WW	-0.3	4.33	YES
KANSAS	WW	+2.1	7.19	NO
OKLAHOMA	WW	+1.7	3.41	YES
PANHANDLE	WW	+0.4	3.29	YES
TEXAS LOW PLAINS	WW	-1.4	3.08	YES
TOTAL	SW	+2.0	3.51	
TOTAL	WW	+0.5	3.51	
TOTAL	W	+1.0	2.77	

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PHASE II (CROP YEAR 1976) EVALUATION

- OPERATIONAL TEST
  - MODEL PERFORMANCE VERY GOOD OVERALL
  - SEVERE DROUGHT IN SOUTH DAKOTA NOT ADEQUATELY REFLECTED IN MODEL ESTIMATES

NASA-S-78-17067

ELEVEN-YEAR BOOTSTRAP TEST (1965-75) FOR U.S. PHASE II BY MODEL REGION

MODEL	CROP	MEAN ERROR, BU/ACRE	RMSE, BU/ACRE	SUPPORT 90/90
MONTANA	SW	-0.7	2.16	YES
NORTH DAKOTA	SW	+2.5*	3.42	YES
RED RIVER	SW	+2.0	3.96	YES
SOUTH DAKOTA	SW	+0.3	2.45	YES
MONTANA	WW	-1.0	3.37	YES
BADLANDS	WW	-1.6	5.00	YES
NEBRASKA	WW	-2.7*	4.23	YES
COLORADO	WW	+.5	4.55	YES
KANSAS	WW	+.3	3.72	YES
OKLAHOMA	WW	-1.6*	3.00	YES
PANHANDLE	WW	-1.1	3.23	YES
TEXAS LOW PLAINS	WW	-.2	2.59	YES
TOTAL	SW	+1.6	2.70	
TOTAL	WW	-0.7	1.80	
TOTAL	W	+0.1	1.68	

*MODELS WITH SIGNIFICANT BIAS

NASA-S-78-17068

PHASE II
(CROP YEAR 1976) EVALUATION

- OPERATIONAL TEST
  - MODEL PERFORMANCE VERY GOOD OVERALL
  - SEVERE DROUGHT IN SOUTH DAKOTA NOT ADEQUATELY REFLECTED IN MODEL ESTIMATES

NASA-S-78-17069

PHASE II (1976 CROP YEAR) RESULTS FROM OPERATIONAL MODELS

AREA	CROP	SRS, BU/ACRE	REL DIF (a)	LACIE, BU/ACRE	ERROR, BU/ACRE	REL DIF (b)
MONTANA	SW	29.4	25	27.1	-2.3	-8.5
N. DAKOTA	SW	24.7	-14	27.0	+2 3	8.5
MINNESOTA	SW	32.4	-9	30.3	-2.1	-6.9
S. DAKOTA	SW	10.9	-55	17.2	+6.3	36.6
MONTANA	WW	32 0	5	29.9	-2.1	-7.0
S. DAKOTA	WW	18.0	-44	31.6	+13.6	43.0
NEBRASKA	WW	32.0	-7	32.7	-0.7	2.1
COLORADO	WW	21.5	-16	19.6	-1 9	-9.7
KANSAS	WW	30.0	-6	31.0	+1.0	3.2
OKLAHOMA	WW	24 0	0	22.6	-1.4	-6.2
TEXAS	WW	22.0	9	18.7	-3.3	-17.6
USGP	SW	25.3		26.2	+0.9	3.4
USGP	WW	27.0		27.0	-0.0	0.0
USGP	TW	26.4		26.7	+0.3	1.1

a RELATIVE DIFFERENCE = $\frac{\text{SRS - TREND}}{\text{TREND}}$ x 100 PERCENT

b RELATIVE DIFFERENCE = $\frac{\text{LACIE - SRS}}{\text{LACIE}}$ x 100 PERCENT

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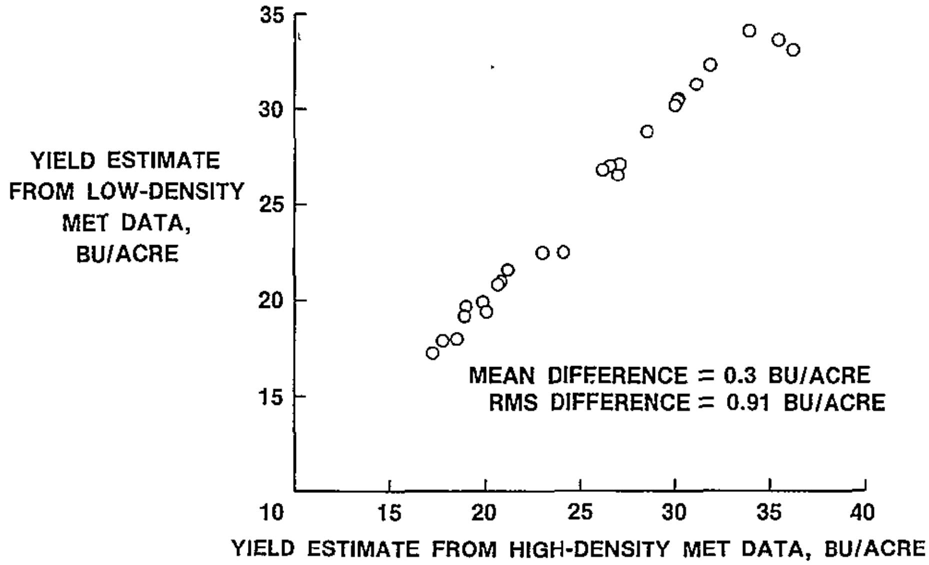
PHASE III (CROP YEAR 1977) EVALUATION

- MODEL REVISIONS
  - MODELS WERE REVISED TO REMOTE BIAS DUE TO OVERLAP OF MODELED REGIONS
  - MODELS WERE IMPLEMENTED FOR MINNESOTA AND SOUTH CENTRAL TEXAS
- HISTORICAL TEST
  - REVISION OF EVALUATION METHODOLOGY TO REMOVE EFFECTS OF HINDSIGHT KNOWLEDGE OF TREND
  - EVALUATION OF THE EFFECTS OF OPERATION ESTIMATION OF METEOROLOGICAL INPUTS ON MODEL PERFORMANCE
  - MODELS SUPPORTED THE 90/90 CRITERION
  - WEATHER RESPONSE LESS THAN DESIRED
  - TENDENCY TO OVERESTIMATE TREND (SPRING WHEAT)
  - PREHARVEST ESTIMATES SHOW PREDICTIVE ABILITY

NASA-S-78-17071

COMPARISON OF YIELD ESTIMATES RESULTING FROM HIGH- AND LOW-DENSITY INPUT METEOROLOGICAL DATA FOR CROP YEARS 1976 AND 1977 FOR EACH U.S. MODEL



NASA-S-78-17072

10-YEAR BOOTSTRAP TEST FOR U.S. PHASE III MODELS WITH CONTINUED TREND

	TOTAL WHEAT		SPRING WHEAT		WINTER WHEAT	
YEAR	SRS BU/ACRE	MODEL ERROR	SRS BU/ACRE	MODEL ERROR	SRS BU/ACRE	MODEL ERROR
1967	21.6	+0.9	22.9	+0.3	21.0	+1.1
1968	26.0	-1.4	26.1	-1.9	25.9	-1.2
1969	28.4	+1.0	28.4	+2.2	28.4	+.5
1970	28.2	-1.6	23.5	-1.0	30.4	-1.9
1971	30.8	-2.9	30.6	-1.7	30.9	-3.7
1972	29.3	-.2	28.5	+2.2	29.7	-1.5
1973	30.8	-.2	27.7	+.2	32.4	-.3
1974	23.8	+4.6	20.8	+6.6	25.5	+3.4
1975	26.8	+.5	25.7	+.8	27.4	+.3
1976	26.4	+.7	25.3	+2.0	27.1	+.1
MEAN ERROR	+0.1 BU/ACRE		+1.0 BU/ACRE		-0.4 BU/ACRE	
RMSE	1.90 BU/ACRE		2.56 BU/ACRE		1.84 BU/ACRE	

NASA-S-78-17073

CONTINGENCY TABLE OF MODEL ERROR AND DEVIATION OF ACTUAL YIELD FROM TREND FOR ALL SPRING WHEAT MODELS

PERCENT SRS DEVIATION FROM TREND

PERCENT MODEL ERROR	<− 20	− 20 TO − 10	+ 10 TO + 10	+ 10 TO + 20	> + 20	
<− 20						MODEL UNDERESTIMATED
− 20 TO − 10	1		2		2	
− 10 TO + 10	2	8	18	3	1	$\chi^2 = 33.79$, d.f. = 16
+ 10 TO + 20	4	2	2			
>+ 20	4	1				MODEL OVERESTIMATED
	YIELD BELOW TREND			YIELD ABOVE TREND		

NASA-S-78-17074

- SIGNIFICANT (1-PERCENT LEVEL) OVERESTIMATION OF BELOW NORMAL YIELDS AND UNDERESTIMATION OF ABOVE NORMAL YIELDS
- MODELED TREND APPEARS TO BE AN OVERESTIMATE OF THE ACTUAL TREND
- TENDENCY TOWARD A POSITIVE BIAS FOR THE AGGREGATED SPRING WHEAT REGION DUE IN PART TO TREND ERRORS

NASA-S-78-17075

RESULTS OF 10 YEAR BOOTSTRAP TEST FOR PHASE III KANSAS WINTER WHEAT YIELD MODEL BY TRUNCATION

CCEA TRUNCATION

YEAR	SRS	TREND	FEB	MAR	MAY	JUNE
1967	20.0	23.4	22.4	20 8	22.4	20.6
1968	26.0	24.5	23.3	22.3	24.0	24.4
1969	31.0	25.1	26.8	30.1	30 7	31.7
1970	33 0	26.9	26.9	29.1	29.3	30.0
1971	34.5	28.8	28.7	27.7	28.6	28.9
1972	33.5	30.7	29 9	28.6	29.6	29.6
1973	37.0	31.2	32.7	35.0	34.6	35.9
1974	27.5	32.1	33.4	33.6	32.2	32.8
1975	29.0	31.5	31 3	32.0	32.3	31.9
1976	30.0	31.2	29.0	29.2	30.2	30.3
MEAN ERROR		-1.4	-1.7	-1.3	-.8	-.5
RMSE		4.54	4.17	3.89	3.35	3.11

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PHASE III (CROP YEAR 1977) EVALUATION

- OPERATIONAL TEST
  - MODEL PERFORMANCE POOR COMPARED TO BOTH HISTORICAL TESTS AND 1976 RESULTS

NASA-S-78-17077

PHASE III (1977 CROP YEAR) RESULTS FROM OPERATIONAL MODELS

AREA	CROP	SRS, BU/ACRE	REL DIF (a)	LACIE, BU/ACRE	ERROR, BU/ACRE	REL DIF (b)
MONTANA	SW	22.0	-6	18.0	-4.0	-22.2
N. DAKOTA	SW	24.9	-14	23.1	-1.8	-7.8
MINNESOTA	SW	39.9	12	32.0	-7.9	-24.7
S. DAKOTA	SW	23.5	-2	20.8	-2.7	-13.0
MONTANA	WW	29.0	-5	26.5	-2.5	-9.4
S. DAKOTA	WW	25.0	-22	27.1	+2.1	7.7
NEBRASKA	WW	35.0	1	32.0	-3.0	-9.4
COLORADO	WW	22.0	-14	22.5	+0.5	2.2
KANSAS	WW	28.5	-11	28.8	+0.3	.1
OKLAHOMA	WW	27.0	13	20.0	-7.0	-35.0
TEXAS	WW	25.0	24	20.3	-4.7	-23.2

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PHASE III (1977 CROP YEAR) RESULTS FROM OPERATIONAL MODELS (CONT)

AREA	CROP	SRS, BU/ACRE	REL DIF (a)	LACIE, BU/ACRE	ERROR, BU/ACRE	REL DIF (b)
USGP	SW	27.1		23.4	-3.7	-15.8
USGP	WW	27.7		25.6	-2.1	-8.2
USGP	TW	27.5		24.9	-2.6	-10.4

a RELATIVE DIFFERENCE = $\frac{\text{SRS - TREND}}{\text{TREND}}$ x 100 PERCENT

b RELATIVE DIFFERENCE = $\frac{\text{LACIE - SRS}}{\text{LACIE}}$ x 100 PERCENT

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PHASE III (1977 CROP YEAR) COMPARISON OF LACIE AND FAS/U.S.S.R. YIELD ESTIMATES

MONTH OF ESTIMATE	SPRING WHEAT		
	FAS/U.S.S.R. ESTIMATE, ql/ha	LACIE ESTIMATE, ql/ha	REL DIF, PERCENT
APR			
MAY			
JUNE			
JULY			
AUG	11.0	9.0	-22.2
SEPT	9.7	9.0	-7.8
OCT	9.7	8.8	-10.2
FINAL	9.7	8.8	-10.2

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PHASE III (1977 CROP YEAR) COMPARISON OF LACIE AND FAS/U.S.S.R. YIELD ESTIMATES

MONTH OF ESTIMATE	WINTER WHEAT		
	FAS/U.S.S.R. ESTIMATE, ql/ha	LACIE ESTIMATE, ql/ha	REL DIF, PERCENT
APR		24.3	
MAY		24.1	
JUNE		25.6	
JULY		25.9	
AUG	27.0	25.5	-5.9
SEPT	28.8	25.6	-5.5
OCT	28.8	25.6	-5.5
FINAL	28.8	25.6	-5.5

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PHASE III (1977 CROP YEAR) COMPARISON OF LACIE AND FAS/U.S.S.R. YIELD ESTIMATES

MONTH OF ESTIMATE	TOTAL WHEAT		
	FAS/U.S.S.R. ESTIMATE, ql/ha	LACIE ESTIMATE, ql/ha	REL DIF, PERCENT
APR			
MAY			
JUNE			
JULY			
AUG	16.0	15.2	-5.3
SEPT	16.1	14.7	-9.5
OCT	16.1	14.5	-11.0
FINAL	16.1	14.5	-11.0

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LACIE YIELD MODELS

SUMMARY

- LACIE YIELD ESTIMATES HAVE SHOWN SIGNIFICANT SKILL BOTH AT HARVEST AND PRIOR TO THE END OF SEASON
- WITH EXPERIENCE, THE QUALITY OF ESTIMATES OBTAINED FROM LARGE-AREA REGRESSION MODELS WAS STEADILY IMPROVED
- POTENTIAL WEAKNESSES IN THE LACIE YIELD MODELS WERE IDENTIFIED AS POINTS OF DEPARTURE FOR FUTURE RESEARCH
  - SPECIFICATION OF TREND
  - SIZE OF AREA MODELED
  - SPATIAL DENSITY OF INPUT METEOROLOGICAL DATA
  - UTILIZATION OF CROP CALENDARS

N79-14484

ACCURACY AND PERFORMANCE OF LACIE CROP DEVELOPMENT MODELS

S. Woolley, Lockheed/JSC

NASA-S-78-16523

ACCURACY AND PERFORMANCE CHARACTERISTICS OF LACIE CROP DEVELOPMENT MODELS

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ACCURACY OF LACIE CROP DEVELOPMENT MODELS

- PURPOSE AND DESCRIPTION OF CROP CALENDAR MODEL
- ASSESSMENT PROCEDURES
- RESULTS
- AREAS IDENTIFIED FOR MODEL IMPROVEMENT

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ACCURACY AND PERFORMANCE CHARACTERISTICS OF LACIE CROP DEVELOPMENT MODELS

PURPOSE OF CROP CALENDAR MODELS

- TO PROVIDE AN ESTIMATE OF THE STAGE OF DEVELOPMENT TO
  - THE ANALYST INTERPRETERS
  - THE ADVANCED YIELD MODELS

DESCRIPTION OF INITIAL MODEL

- MODELS AVAILABLE
  - HEAT UNIT
  - PHOTOTHERMAL UNIT
  - ROBERTSON TRIQUADRATIC
    - INPUTS: DAILY MAX AND MIN AIR TEMPERATURES AND DAY LENGTH
    - OUTPUT: A DAILY INCREMENT OF DEVELOPMENT THROUGH 6 PHYSIOLOGICAL STAGES OF GROWTH

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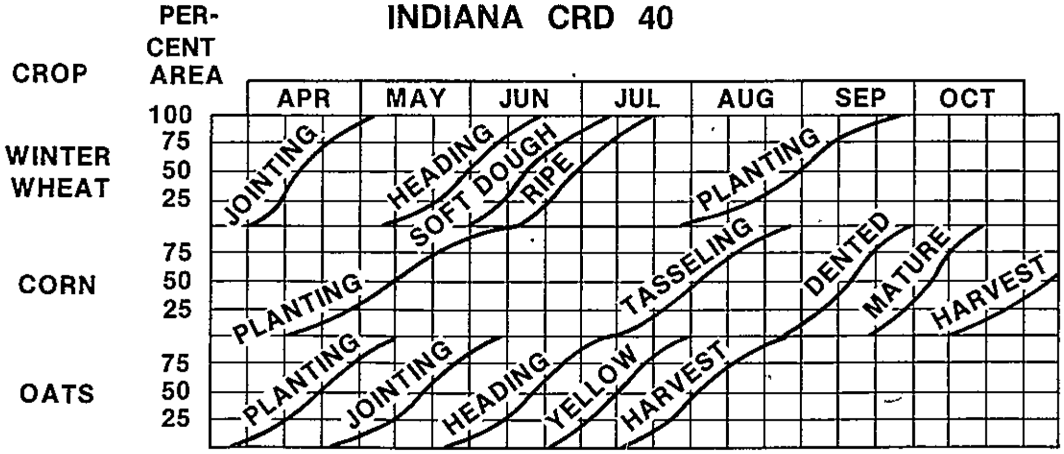
CROP CALENDARS

PERCENT OF AREA IN DEVELOPMENT STAGE BY SPECIFIED DATE FOR INDIANA CRD 40



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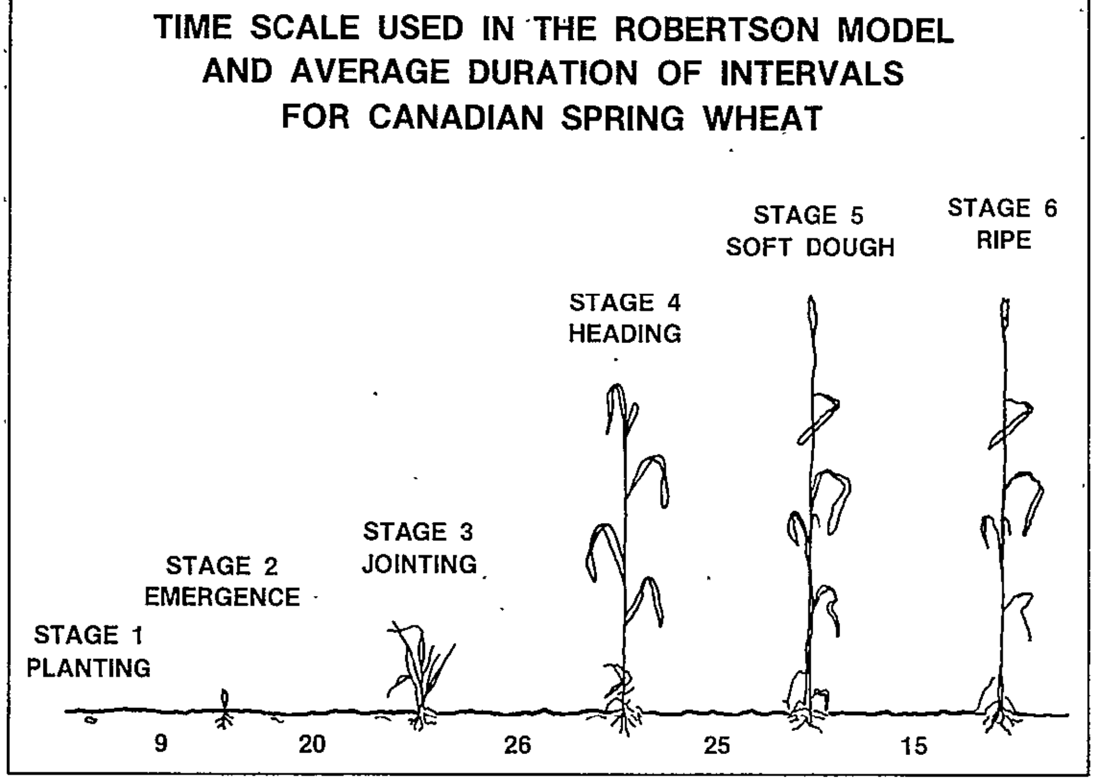

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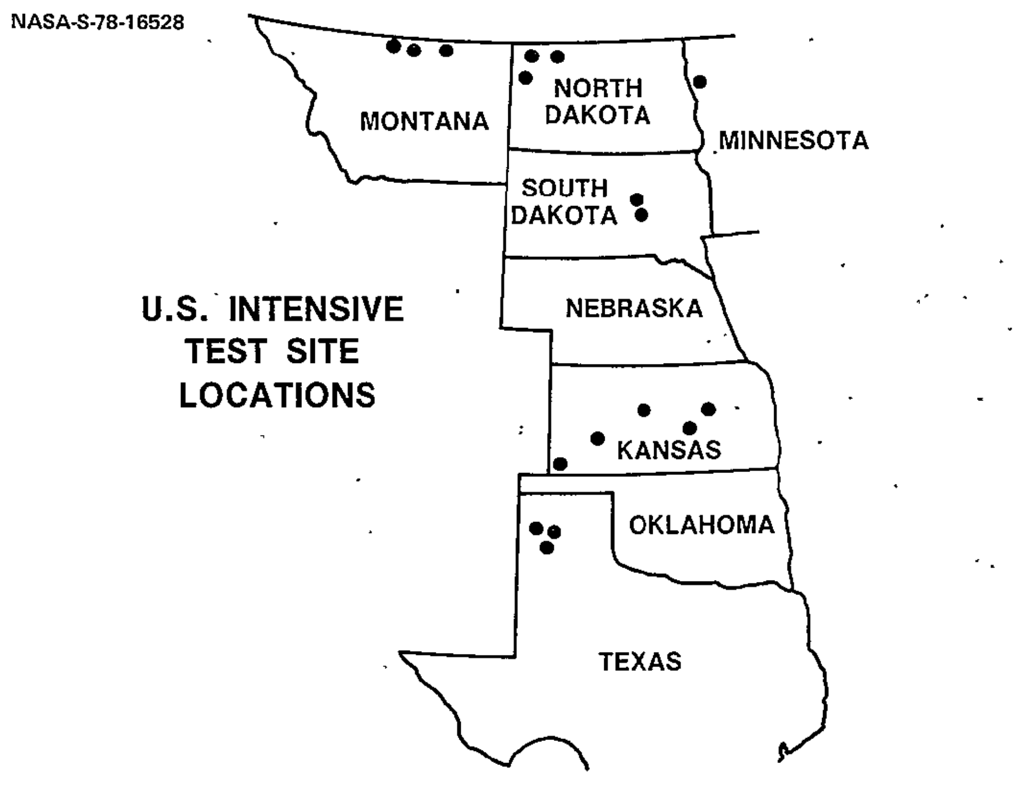

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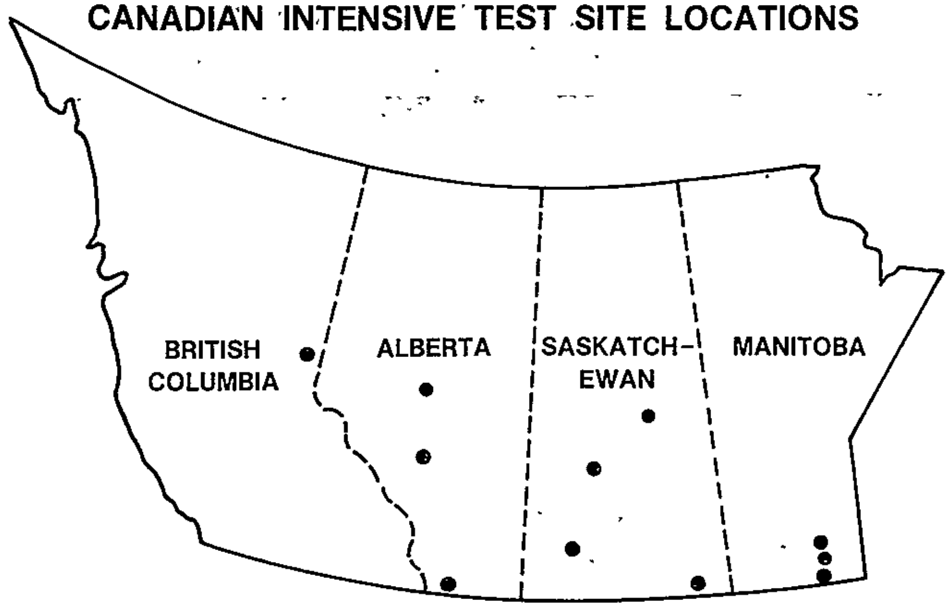
CANADIAN INTENSIVE TEST SITE LOCATIONS



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GROUND TRUTH PERIODIC OBSERVATION

LAND USE CODES	GROWTH STAGES
100–SPRING WHEAT	01–NOT PLANTED
200–BARLEY	02–PLANTED, NO EMERGENCE
300–OATS	03–EMERGENCE
400–WINTER WHEAT	04–TILLERING, PREBOOT, PREBUD
500–GRASSES/PASTURE	05–BOOTED OR BUDDED
600–OTHER CROPS	06–BEGINNING TO HEAD OR FLOWER
601–RAPESEED	07–FULLY HEADED OR FLOWERED
602–RYE	08–BEGINNING TO RIPEN
604–FLAX	09–RIPE MATURE
607–CORN	10–HARVESTED
617–SOYBEANS	11–DOES NOT APPLY
618–COTTON	
700–SUMMER FALLOW	
900–UNKNOWN CROPS	

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FIELD NO.	LAND USE CODE	GROWTH STAGE (CIRCLE ONE)
107	404	01 02 03 04 05 06 (07) 08 09 10 11
129	700	01 02 03 04 05 06 07 08 09 10 (11)
104	404	01 02 03 04 05 06 (07) 08 09 10 11
124	404	01 02 03 04 05 06 (07) 08 09 10 11

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ROBERTSON BMTS AND OBSERVED ITS WHEAT PHENOLOGICAL STAGES

ROBERTSON STAGE	BMTS	ITS	DESCRIPTION
PLANTED	1.0	01	PLANTED
		02	PLANTED, NO EMERGENCE
EMERGENGE	2.0	03	EMERGENCE
JOINTING	3.0	04	TILLERING, PREBOOTING, PREBUDDING
	3.5	05	BOOTED OR BUDDED
HEADING	4.0	06	BEGINNING TO HEAD OR FLOWER
	4.5	07	FULLY HEADED OR FLOWERED
SOFT DOUGH	5.0	08	BEGINNING TO RIPEN
RIPENING	6.0	09	RIPE TO MATURE

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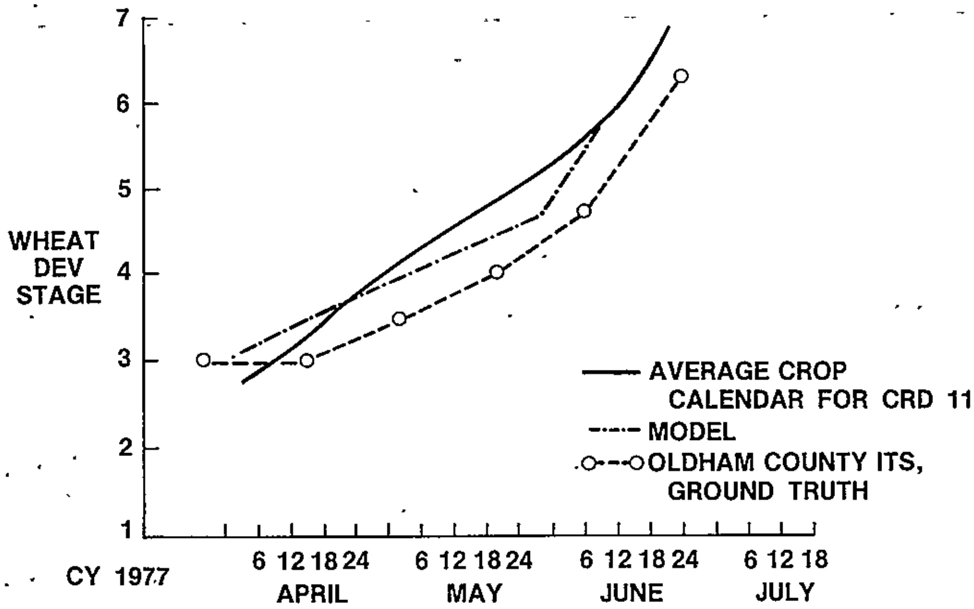
OLDHAM COUNTY, TEXAS, WINTER WHEAT



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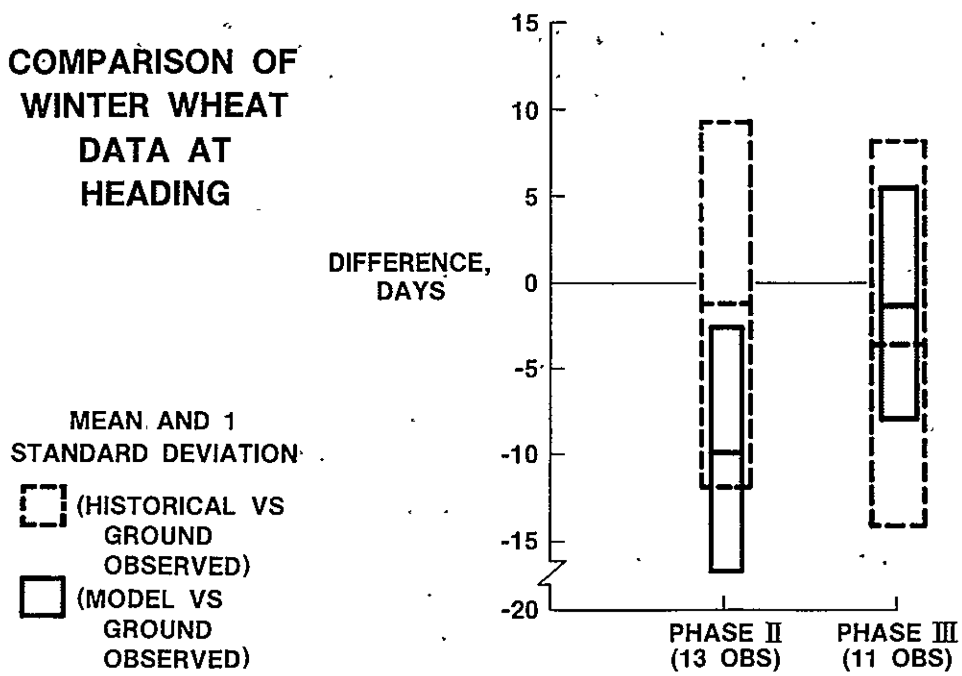
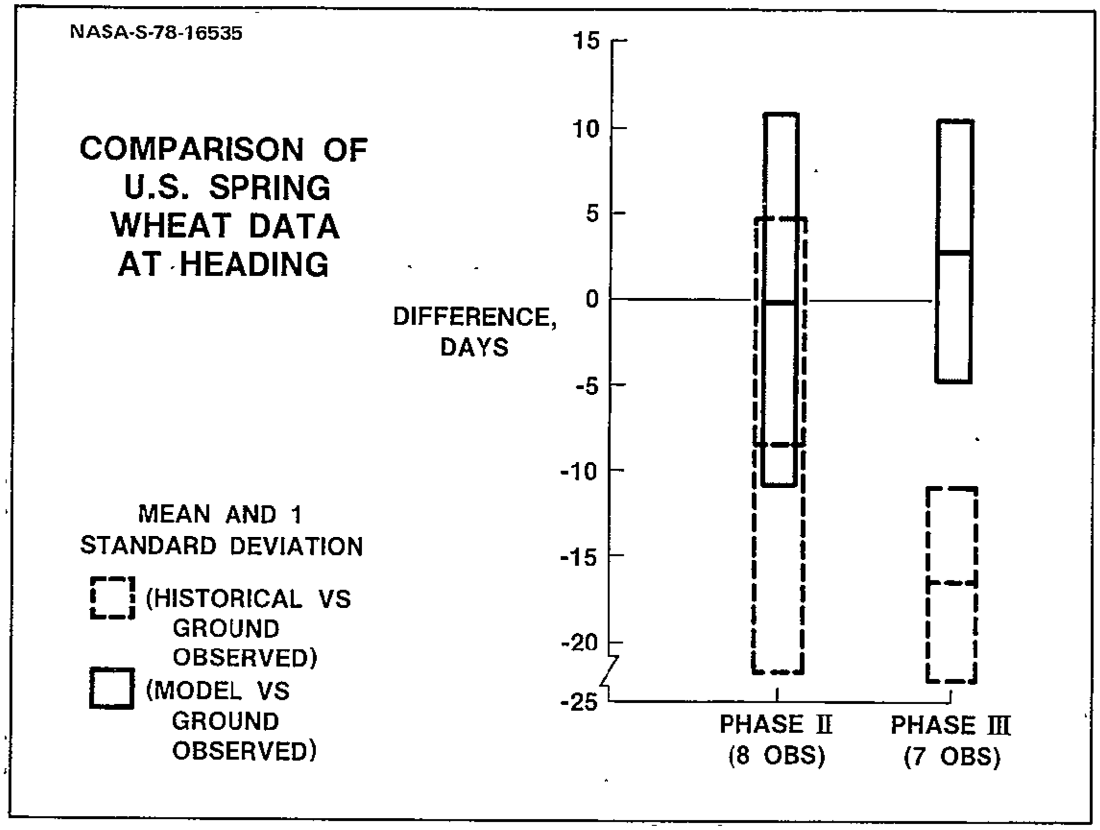
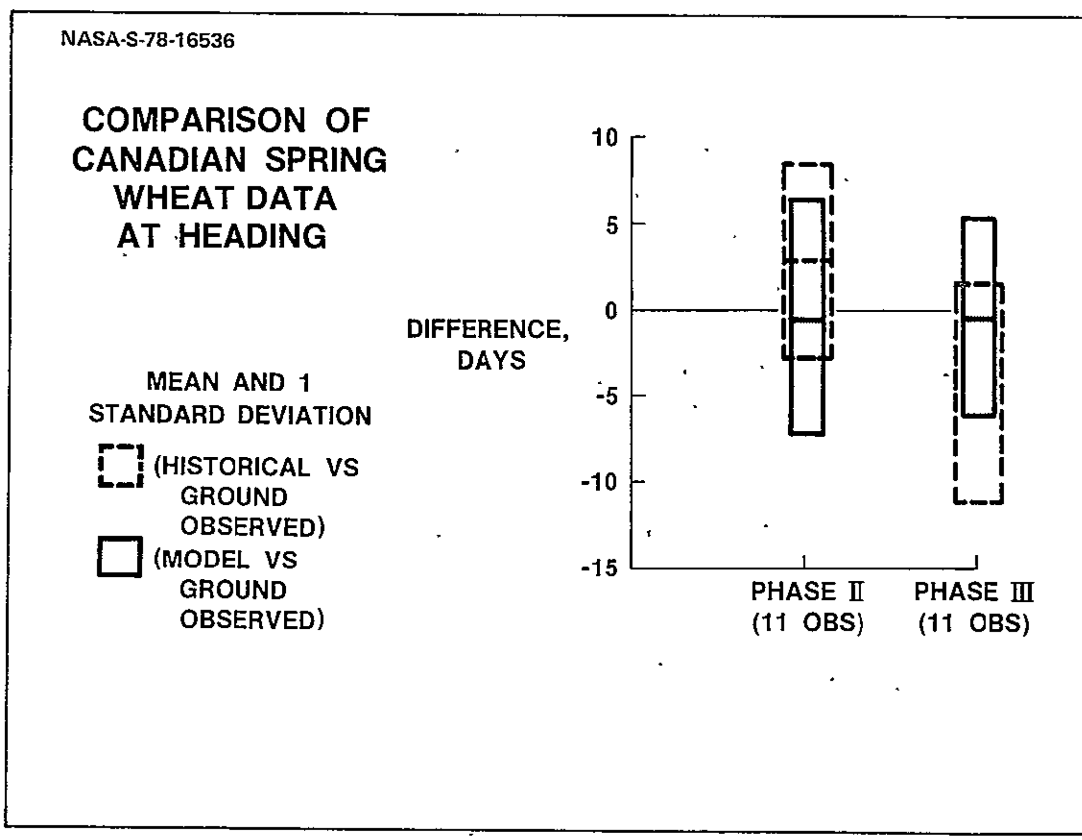
COMPARISON OF WINTER WHEAT DATA AT HEADING

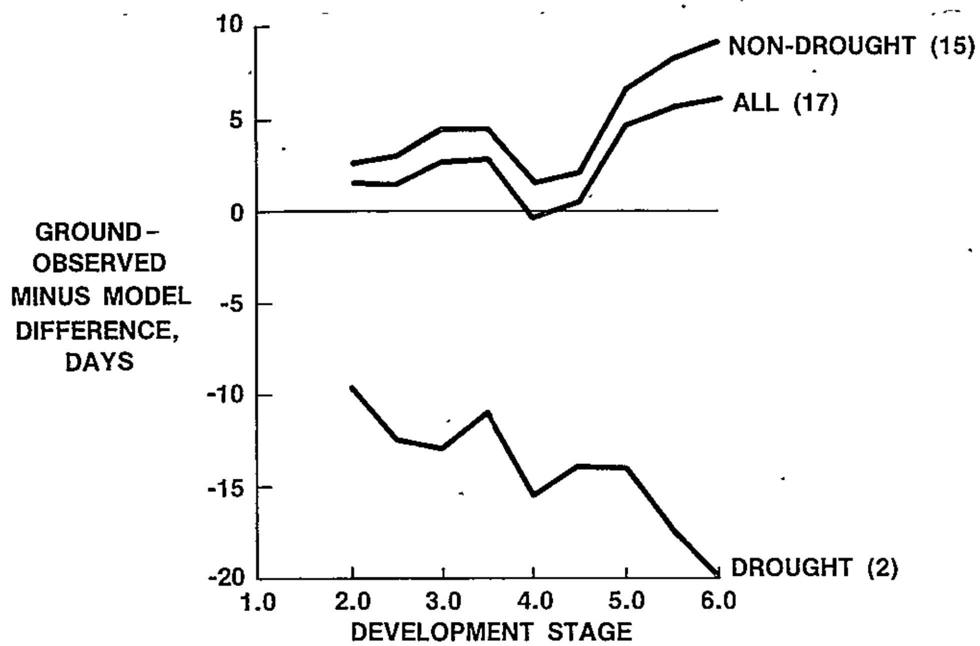



NASA-S-78-16535
COMPARISON OF U.S. SPRING WHEAT DATA AT HEADING
DIFFERENCE, DAYS
15
10
5
0
-5
-10
-15
-20
-25
MEAN AND 1 STANDARD DEVIATION
(HISTORICAL VS GROUND OBSERVED)
(MODEL VS GROUND OBSERVED)
PHASE II (8 OBS)
PHASE III (7 OBS)


NASA-S-78-16536
COMPARISON OF CANADIAN SPRING WHEAT DATA AT HEADING
DIFFERENCE, DAYS
10
5
0
-5
-10
-15
MEAN AND 1 STANDARD DEVIATION
(HISTORICAL VS GROUND OBSERVED)
(MODEL VS GROUND OBSERVED)
PHASE II (11 OBS)
PHASE III (11 OBS)

NASA-S-78-16537

PHASE II SPRING WHEAT CROP CALENDAR ERROR



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SUMMARY

- MODEL TENDED TO PREDICT WINTER WHEAT HEADING LATER IN THE YEAR THAN THAT OBSERVED
- IN PHASE III, INCREASED ACCURACY IN WINTER WHEAT ESTIMATES WAS APPARENTLY OBTAINED BY USING SCALAR MULTIPLIER'S
- DEVELOPMENT BETWEEN HEADING AND SOFT DOUGH WAS PREDICTED TO BE MORE RAPID THAN THAT OBSERVED
- BIASES TENDED TO PROPAGATE FROM INITIAL SPRING ERRORS
- OVERALL, MODEL ESTIMATES PROVIDED MORE ACCURATE INFORMATION THAN WAS AVAILABLE FROM HISTORICAL AVERAGES
- MODEL PROVIDED MORE ACCURATE ESTIMATES FOR THE CANADIAN SPRING WHEAT REGION

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AREAS IN NEED OF FURTHER IMPROVEMENT OR DEVELOPMENT

- DEFINITION OF USER ACCURACY REQUIREMENTS
- EVALUATION METHODOLOGY
- REFINEMENTS OF MODELS
  - ACCOUNTING FOR DROUGHT EFFECTS
  - VARIETY EFFECTS
  - STARTER MODELS
  - DORMANCY
- OBJECTIVE METHODS FOR INCLUSION OF LANDSAT DATA

EXPERIMENT RESULTS SESSION

ECONOMIC EVALUATION: CONCEPTS, SELECTED STUDIES, SYSTEM COST, AND A PROPOSED PROGRAM

F. Osterhoudt, USDA

NASA-S-78-17083

ECONOMIC EVALUATION: CONCEPTS, SELECTED STUDIES, SYSTEM COSTS, AND A PROPOSED PROGRAM

NASA-S-78-17084

- OVERALL QUESTION:
  - SHOULD THE USDA INCORPORATE OPERATIONAL EARTH SATELLITE DATA GATHERING TECHNOLOGY INTO ITS GLOBAL CROP INFORMATION SYSTEM?
- TECHNICAL QUESTIONS:
  - CAN GLOBAL CROP ESTIMATES BE MADE USING SATELLITES?
  - HOW GOOD ARE THE CROP ESTIMATES?
  - WHAT TECHNOLOGY NEEDS TO BE IMPROVED?
- ECONOMIC QUESTION:
  - WILL THERE BE SUFFICIENT BENEFITS TO JUSTIFY A COST-EFFECTIVE IMPLEMENTATION?

NASA-S-78-17085

BENEFITS DERIVED FROM DECISIONS

- INFORMATION HAS VALUE ONLY AS IT FACILITATES BETTER DECISIONS
- DECISIONS AFFECTED BY CROP INFORMATION
  - BUYING
  - SELLING
  - INVESTING
  - SETTING GOVERNMENT ECONOMIC PROGRAMS
  - HUMAN LIFE
- DECISIONS ARE BETTER BECAUSE OF
  - INCREASED ACCURACY
  - IMPROVED TIMELINESS
  - MORE CERTAINTY

NASA-S-78-17086

DECISIONS AFFECTED BY CROP INFORMATION

- WITHIN THE MARKET PLACE
  - DOMESTIC OR INTERNATIONAL GRAIN TRADE
  - U.S. PRODUCERS AND CONSUMERS
  - FOREIGN PRODUCERS AND CONSUMERS
- OUTSIDE THE MARKET PLACE
  - MAKING GOVERNMENT POLICY
  - ADMINISTERING GOVERNMENT PROGRAMS
  - AGREEMENTS WITH OTHER NATIONS

NASA-S-78-17087

MORE THAN CROP INFORMATION NEEDED

- EXAMPLE: GOVERNMENT POLICY DECISION NEEDS INCLUDE
  - CROP INFORMATION
  - STATE OF THE ECONOMY
  - MONEY SUPPLY
  - TRADE POLICIES
  - PENDING LEGISLATION

NASA-S-78-17088

PROPERTIES OF CROP PRODUCTION DATA

- ACCURACY IS BASIC
- ACCURACY IS CONDITIONED BY
  - WHEN AVAILABLE IN CROP SEASON
  - FRESHNESS OF DATA
  - GEOGRAPHIC LOCATION
  - GEOGRAPHIC DETAIL
  - COMPREHENSIVENESS
  - CONTINUITY
  - RELIABILITY
  - PERCEIVED OBJECTIVITY

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GLOBAL MODELING APPROACHES

- SIMULATIONS, ECONOMETRIC MODELING
  - BENEFITS DERIVE FROM EFFECTS OF INFORMATION ON RELEVANT SECTORS OF THE ECONOMY
  - CONSUMER AND PRODUCER SURPLUS
  - HYAMI-PETERSON; ECON, INC
- DECISION ANALYSIS, DECISION THEORY
  - ESTIMATE IMPACT OF INFORMATION ON DECISION PROCESS, THEN ASSIGN VALUE TO THAT IMPACT
  - USUALLY USED FOR VALUE TO INDIVIDUAL FIRM BUT HAS BEEN USED FOR AGGREGATE VALUE
  - MARSCHAK, HOWARD, AGNEW

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USER GROUP APPROACHES

- PRAGMATIC
- EFFECTS ANALYZED GROUP-BY-GROUP, WITH AGGREGATION EFFORT SECONDARY
- QUANTITATIVE MODELING USED WHEN POSSIBLE AND APPROPRIATE
- QUALITATIVE ASSESSMENTS, EXPERT OPINION, AND LESS FORMAL QUANTITATIVE ESTIMATES ACCEPTED
- USER SURVEYS SOMETIMES INCORPORATED BUT LIMITED BY MYOPIA OF RESPONDENTS
- PANEL ON METHODOLOGY FOR STATISTICAL PRIORITIES
- HOOS, DUNCAN, SHARP

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MILLER'S INTEGRATED METHODOLOGY

- EXPHASIS ON EMPIRICAL ESTIMATION OF INFORMATION MODELS AND DECISION MODELS
- FRAMEWORK FOR MARKET USERS AND NONMARKET USERS.
- VALUE OF EVOLVING TECHNOLOGY CONSIDERED

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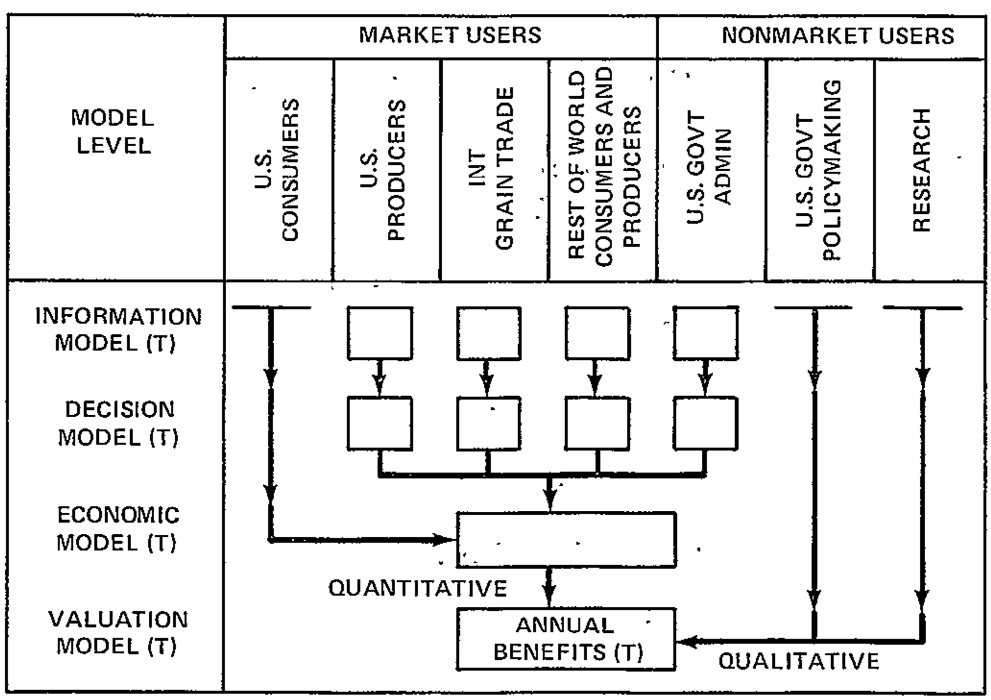
POSSIBLE CROSS-SECTIONAL BENEFITS OF INFORMATION



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OVERALL PROBLEMS

- NO GENERALLY ACCEPTED METHODOLOGY
- MYTHOLOGY OF METHODOLOGY:
  - BECAUSE A METHOD IS NEEDED, A METHOD IS READILY AVAILABLE
- BASIC RESEARCH NEEDS TO BE DONE
  - EXAMPLE: RELATIONSHIPS BETWEEN INFORMATION, DECISIONS, AND MARKET STRUCTURE

NASA-S-78-17094

MEASURING INFORMATION QUALITY

- QUALITIES OF INFORMATION
  - OBJECTIVITY
  - ACCURACY
  - RELIABILITY
  - CONTINUITY
  - COMPREHENSIVENESS
  - GEOGRAPHIC DETAIL
  - TIMELINESS
  - ADEQUACY
  - RELEVANCE
  - BELIEVABILITY
- QUANTIFICATION IS DIFFICULT
- IMPROVEMENTS ARE REAL

NASA-S-78-17095

OTHER PROBLEMS

- PERFORMANCE LEVELS OF EVOLVING TECHNOLOGY ARE UNKNOWN
- POLITICAL OR ECONOMIC CONDITIONS INFLUENCE
  - INFORMATION REQUIREMENTS
  - VALUE
  - DISTRIBUTION OF BENEFITS
- EMPIRICAL LINKAGE OF PRODUCTION CHANGES, SUPPLY, AND PRICE ARE NOT KNOWN
- ECONOMIC MODELS MEASURE CHANGES IN EFFICIENCY, NOT MARKET STRUCTURE OR INCOME DISTRIBUTION

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ECON STUDIES

- KEY ASSUMPTIONS
  - PERFORMANCE OF AT-HARVEST CROP ESTIMATES IS WITHIN 10 PERCENT OF TRUE PRODUCTION 9 YEARS OUT OF 10 – THE LACIE 90/90 EXPERIMENT CRITERION
  - U.S. OPERATES IN A PERFECTLY COMPETITIVE INTERNATIONAL MARKET
- BENEFITS TO U.S. ANNUALLY FROM IMPROVED FOREIGN ESTIMATES
  - FOR ALL MAJOR CROPS – $300 MILLION
  - FOR WHEAT ALONE – $240 MILLION

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ECON MODEL

- STOCHASTIC DYNAMIC DECISION MODEL
  - RESTS ON PERFECT COMPETITION AND IMPERFECT FORESIGHT
  - USES DYNAMIC PROGRAMING TO MAXIMIZE PRODUCER AND CONSUMER SURPLUS
  - GLOBAL CROP PRODUCTION, CONSUMPTION ARE TREATED AS PROCESSES
  - ESTIMATES OF SUPPLY IN U.S. AND REST OF WORLD ARE RESULTANT STATE VARIABLES
- VALUE OF IMPROVED INFORMATION
  - DIFFERENCE IN CONSUMER/PRODUCER SURPLUS OBTAINED UNDER ALTERNATIVE INFORMATION SYSTEMS

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ECON RESULTS

- PRINCIPAL BENEFIT TO U.S. IS FROM SELLING LARGER QUANTITIES TO REST OF WORLD IN MONTHS OF HIGHER PRICES
- ACTIVITY IS INVENTORY ADJUSTMENT, LIKE HYAMI-PETERSON
  - INVENTORIES IN U.S. INCREASE, INVENTORIES IN REST OF WORLD DECREASE, TOTAL INVENTORIES DECREASE
  - TOTAL ANNUAL U.S. EXPORTS REMAIN THE SAME
  - TOTAL EXPORT REVENUES INCREASE
- TRADE BENEFITS TRICKLE DOWN EVENTUALLY TO PRODUCERS AND CONSUMERS
- ADDITIONAL BENEFITS
  - TO U.S. FROM ADJUSTMENT IN PRODUCTION (SMALL)
  - TO REST OF WORLD FROM DECREASED INVENTORY COSTS (10-PERCENT U.S. BENEFITS)

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FUTURES GROUP STUDY

- PURPOSE
  - USEFULNESS OF IMPROVED FOREIGN WHEAT INFORMATION TO USDA
- METHOD
  - INTERVIEWED DEPARTMENT OFFICIALS
  - RESPONDENTS WERE PROGRAM MANAGERS, ANALYSTS, AND MANAGER/ANALYSTS

NASA-S-78-17100

FUTURES GROUP RESULTS

- PRINCIPAL USES OF IMPROVED FOREIGN CROP INFORMATION
  - MANAGEMENT OF EXPORT PROGRAMS
  - BILATERAL AGREEMENTS
  - INTERNATIONAL WHEAT RESERVES OR EMBARGOES
- MARKET DISRUPTIONS INCREASE NEED FOR GOOD CROP INFORMATION
- IF NO PROGRAMS, NO INFORMATION NEEDED FOR ADMINISTRATIVE PURPOSES
- ANTICIPATED NEED FOR MORE ACCURATE AND TIMELY INFORMATION

NASA-S-78-17101

FUTURES GROUP RESULTS (CONT)

- IMPROVED GOVERNMENT DECISIONS COME FROM IMPROVED INFORMATION ON
  - CROPS
    - PRODUCTION, FOREIGN AND DOMESTIC
    - PRICES
    - GRAIN CARRYOVER
    - LIVESTOCK NUMBERS AND FEED USE
  - GOVERNMENT FACTORS
    - STATE OF THE ECONOMY
    - TRADE POLICIES
    - PENDING LEGISLATION
  - OTHER
    - AVAILABILITY OF FOREIGN EXCHANGE
    - FOREIGN ATTITUDES AND ACTIONS
    - TRANSPORTATION PROBLEMS

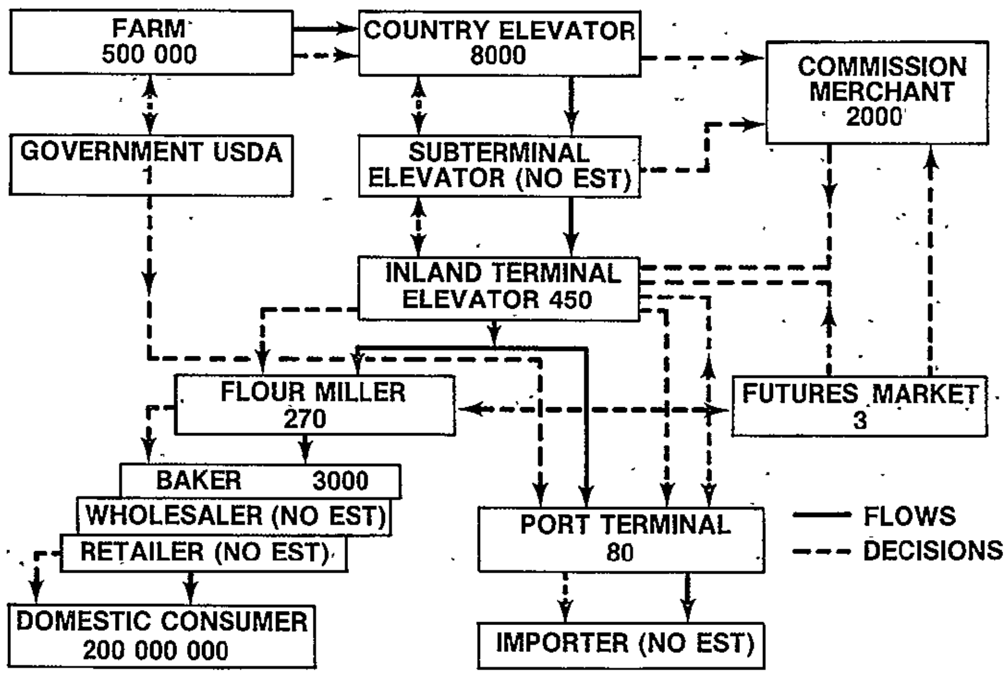
NASA-S-78-17102

OVERVIEW OF U.S. WHEAT INDUSTRY

- CONDUCTED BY ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE OF USDA
- PROVIDES BACKGROUND REGARDING USE OF CROP INFORMATION
- TRACES PHYSICAL FLOWS AND DECISION FLOWS
- TWO KEY LOCATIONS FOR WHEAT PRICE INFORMATION
  - LARGE INTEGRATED EXPORT FIRMS
  - TERMINAL MARKETS
- AVAILABILITY AND TIMELINESS OF WHEAT INFORMATION IS CRITICAL

NASA-S-78-17103

MAJOR WHEAT FLOW BY SECTOR, FLOW OF MERCHANDISING DECISIONS, AND NUMBER OF PARTICIPANT LOCATIONS BY SECTOR



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OILSEEDS AND PRODUCTS PROGRAM EVALUATION

- FOREIGN AGRICULTURAL SERVICE OF USDA EVALUATED THEIR OILSEEDS AND PRODUCTS PROGRAM IN 1976
- NOT RELATED TO LACIE
- NOT LIMITED TO CROP PRODUCTION INFORMATION
- HAS IMPLICATIONS FOR WHEAT INFORMATION
- MAIL SURVEYED SUBSCRIBERS
  - PRIVATE TRADE
  - EXECUTIVES OF FIRMS
  - MEDIA, FARM AND TRADE ASSOCIATIONS, EDUCATIONAL INSTITUTIONS
- TWO MAJOR FINDINGS
  - CROP PRODUCTION INFORMATION WAS THE TOP PRIORITY INFORMATION REQUIREMENT IDENTIFIED BY SUBSCRIBERS
  - MOST-CRITICIZED ATTRIBUTE OF FAS INFORMATION WAS TIMELINESS

NASA-S-78-17105

COST PERSPECTIVE

- KEY QUESTION: WILL THE BENEFITS OF A CROP INFORMATION SYSTEM RESTING ON LACIE-DEVELOPED TECHNOLOGY OUTWEIGH THE COST SUFFICIENTLY TO WARRANT FURTHER INVESTIGATION?
- TWO SETS OF COSTS ESTIMATED
- PRESENT SYSTEM ASSEMBLES, WEIGHS, DISSEMINATES INFORMATION DEVELOPED AND PAID FOR BY OTHERS
- PROPOSED SYSTEM WOULD BE A NEW SOURCE OF INFORMATION
- COST ESTIMATES ARE NOT DIRECTLY COMPARABLE
- SIMULTANEOUS COMPARISON OF PRODUCT QUALITY AND ASSOCIATED BENEFITS MUST BE MADE
- COMPLETE ANALYSIS OF USES AND BENEFITS HAS NOT BEEN MADE

NASA-S-78-17106

COST OF SATELLITE-BASED SYSTEMS

- PROJECTED SYSTEMS PRODUCE REPETITIVE AREA, YIELD, AND PRODUCTION FORECASTS THROUGHOUT THE SEASON
- COST PROJECTIONS ARE FOR SINGLE-CROP SYSTEM OR ALTERNATIVE MULTICROP SYSTEM; EACH INCLUDES MAJOR PRODUCING COUNTRIES OF THE WORLD; EITHER COULD PROVIDE PERIODIC UPDATES FOR AREAS OF CURRENT CRITICAL INTEREST
- PROJECTIONS MADE WITH COST RELATIONSHIP/DEPENDENCY COMPUTER MODEL
- COSTS OF THE 3 YEARS OF LACIE RESEARCH AND DEVELOPMENT ARE NOT INCLUDED
- COSTS ASSOCIATED WITH APPLICATION, DEVELOPMENT, AND TEST PHASES FOLLOWING LACIE ARE INCLUDED
- COSTS OF COLLECTION AND GROUND PROCESSING SYSTEMS ARE INCLUDED ONLY AS AN ANNUAL PAYMENT FOR LANDSAT PRODUCTS
- NOTE THAT OTHER SYSTEMS COULD BE DESIGNED – WITH DIFFERENCES IN COST, PRODUCTS, AND ASSOCIATED BENEFITS

NASA-S-78-17107

COST OF PRESENT SYSTEM

- PRESENT USDA FOREIGN CROP INFORMATION SYSTEM COVERS ABOUT 110 COUNTRIES. IN ADDITION TO REPORTING ON CROP PRODUCTION, IT ALSO REPORTS ON TRADE, STOCKS, CONSUMPTION, POLICIES, AND PRICES
- PRINCIPAL SOURCE OF FOREIGN CROP INFORMATION IN USDA IS THE 98 AGRICULTURAL ATTACHES AND ASSISTANT ATTACHES
- RESPONSIBILITY FOR ESTIMATION OF FOREIGN CROPS LIES WITH FOREIGN AGRICULTURAL SERVICE (FAS), EXCEPT FOR THE U.S.S.R. AND THE PEOPLE'S REPUBLIC OF CHINA, WHICH ARE DONE MOSTLY BY ECONOMICS DIVISIONS OF ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE (ESCS)

NASA-S-78-17108

PROPOSED PROGRAM OF ECONOMIC EVALUATION

- DEVELOPED BY INTERAGENCY ECONOMIC EVALUATION PLANNING TEAM
- APPROACH IS PRAGMATIC AND ORIENTED TOWARD INFORMATION USERS AND USES PROVEN ECONOMIC METHODOLOGY WHEREVER POSSIBLE
- FIVE TASKS SPECIFIED WITH FOLLOWING OBJECTIVES:
  - APPRAISE THE USEFULNESS OF IMPROVED WHEAT INFORMATION TO MAJOR USER GROUPS
  - MODIFY AVAILABLE MODELS TO ESTIMATE THE EXPECTED VALUE OF IMPROVED WHEAT PRODUCTION ESTIMATES
  - ASSESS THE IMPACT OF DIFFERENT LEVELS OF PUBLIC FOREIGN CROP INFORMATION ON STRUCTURE OF GRAIN TRADE
  - ANALYZE THE IMPACT OF EVOLVING REMOTE-SENSING TECHNOLOGY ON THE QUALITY OF WHEAT PRODUCTION INFORMATION
  - UPDATE COST PROJECTIONS

NASA-S-78-17109

SUMMARY

- SATELLITE-ASSISTED CROP FORECAST SYSTEM
  - A NEW SOURCE OF INFORMATION
  - INVESTMENT OF $9 TO $30 MILLION CUMULATIVE OVER 10-YEAR PERIOD
  - ANNUAL OPERATING COSTS OF $4 TO $9 MILLION
  - ONLY ESTIMATE AVAILABLE OF TOTAL BENEFITS TO U.S. FROM SATELLITE-BASED WHEAT ESTIMATES (BY ECON) IS $240 MILLION ANNUALLY
- PRESENT USDA SYSTEM
  - ESSENTIALLY A CROP INTELLIGENCE SYSTEM
  - COVERS ABOUT 110 COUNTRIES
  - IN ADDITION TO CROP REPORTING, INCLUDES INFORMATION ON STOCKS, TRADE, CONSUMPTION, POLICY, AND PRICES
  - TOTAL SYSTEM COSTS ABOUT $20 MILLION ANNUALLY

NASA-S-78-17110

SUMMARY (CONT)

- PRINCIPAL USES BY USDA OF IMPROVED FOREIGN CROP INFORMATION
  - MANAGEMENT OF EXPORT PROGRAMS
  - EXPORT POLICY DECISIONS
  - SHORT WHEAT SUPPLY WOULD INCREASE THE IMPORTANCE OF IMPROVED INFORMATION
- OILSEEDS AND PRODUCTS STUDY SHOWS
  - CROP PRODUCTION INFORMATION TOP FUTURE INFORMATION NEED FROM FAS PROGRAM
  - LACK OF TIMELINESS WAS CRITICIZED MOST

SUPPORTING RESEARCH AND TECHNOLOGY (SRT) SESSION

SUPPORTING RESEARCH, A FOCUSED APPROACH TO RESEARCH AND DEVELOPMENT

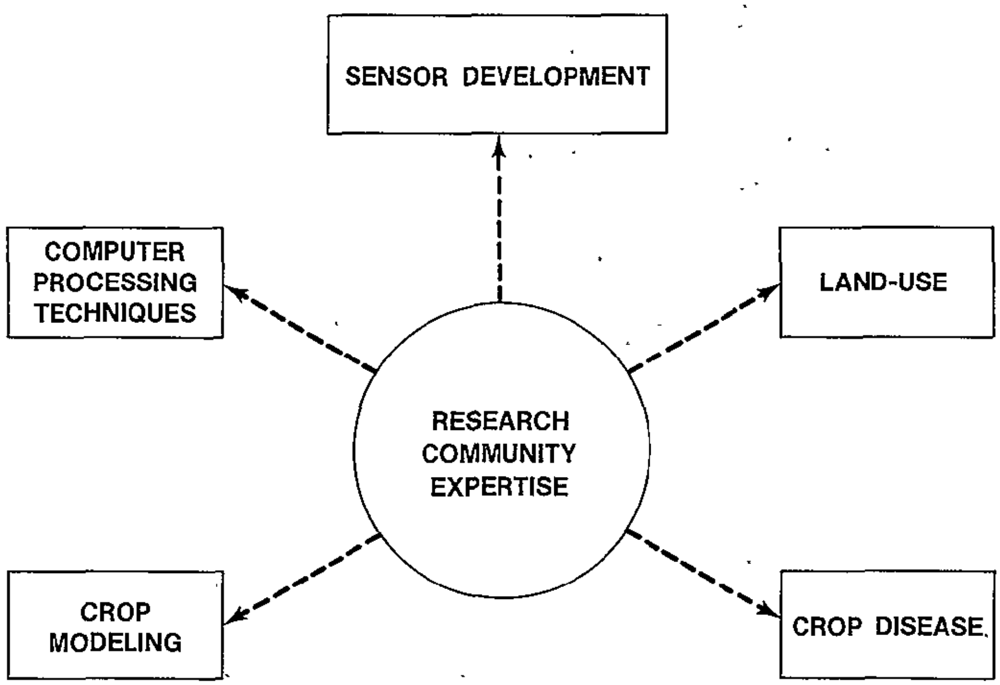
J. Erickson, JSC

NASA-S-78-16018

LACIE
SUPPORTING RESEARCH PROGRAM
"A FOCUSED APPROACH"

NASA-S-78-16006

PRE-LACIE AGRICULTURAL REMOTE-SENSING RESEARCH



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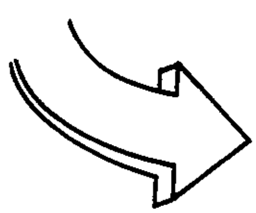
LACIE GOAL

- TO RESEARCH, DEVELOP, APPLY, TEST, AND UPGRADE TECHNOLOGY TO ESTIMATE WHEAT PRODUCTION WORLDWIDE WITH IMPROVED ACCURACY AND TIMELINESS OVER CURRENT GLOBAL ESTIMATES

NASA-S-78-16012

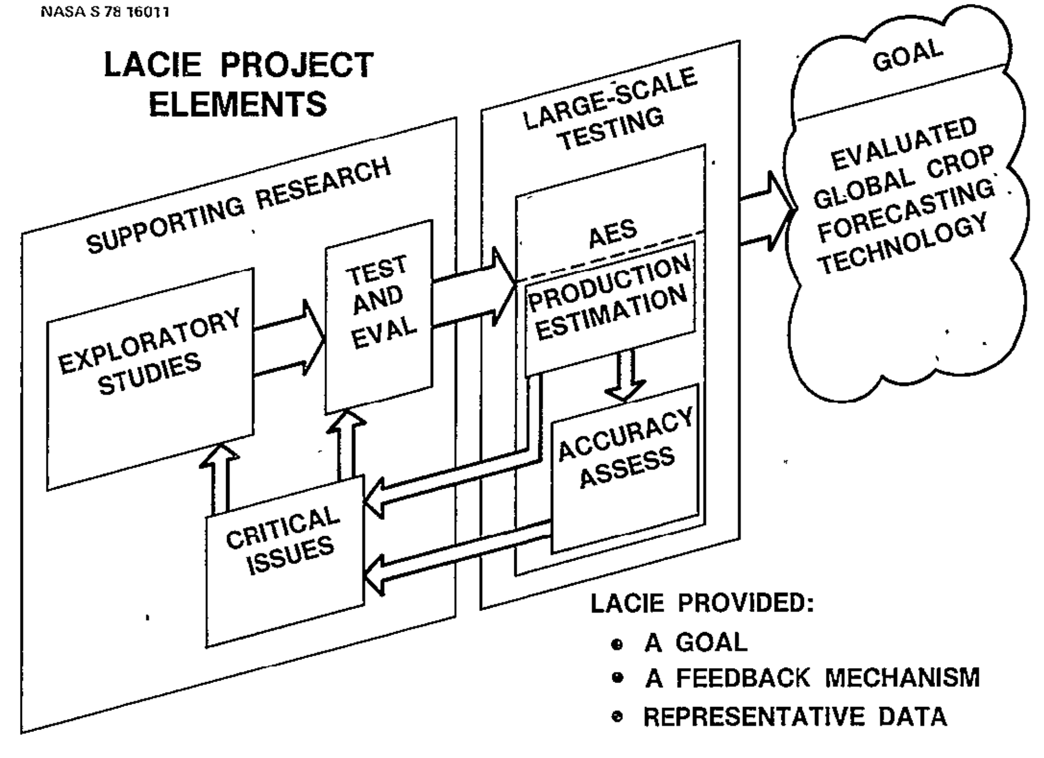
FUNCTION OF SUPPORTING RESEARCH IN LACIE

- LACIE WAS A RESEARCH, DEVELOPMENT, TEST, AND EVALUATION PROJECT
- LACIE PROJECT ELEMENTS INCLUDED:
  - APPLICATIONS EVALUATION SYSTEMS
  - SUPPORTING RESEARCH



SUPPORTING RESEARCH FUNCTION
"DEVELOPMENT AND IMPROVEMENT OF TECHNOLOGY"

NASA S 78 16011



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WHAT WE LEARNED

- LACIE LARGE-SCALE TESTING DEFINED KEY RESEARCH ISSUES
- INTERMEDIATE-SCALE TESTING QUALIFIED ALTERNATE RESEARCH APPROACHES BEFORE INTEGRATION INTO LACIE EVALUATIONS
- SUPPORTING RESEARCH PROVIDED A TECHNOLOGY BASE FOR LACIE AND PROVIDED NEEDED IMPROVEMENTS
- REPRESENTATIVE DATA SETS WERE ESSENTIAL FOR SUPPORTING RESEARCH AND LACIE EVALUATIONS

NASA-S-78-16020

LARGE-SCALE TESTING/APPLICATIONS EVALUATION SYSTEM (AES) CONTRIBUTIONS TO RESEARCH

- DEMONSTRATED SOME POTENTIAL KEY RESEARCH ISSUES WERE NOT PROBLEM AREAS
- IDENTIFIED KEY RESEARCH ISSUES FOR EXPLORATORY STUDIES
- ACQUISITION OF REPRESENTATIVE DATA IS NOW A VALUABLE RESOURCE

NASA-S-78-16025

WHAT WE LEARNED

- LACIE LARGE-SCALE TESTING DEFINED KEY RESEARCH ISSUES
- INTERMEDIATE-SCALE TESTING QUALIFIED ALTERNATE RESEARCH APPROACHES BEFORE INTEGRATION INTO LACIE EVALUATIONS
- SUPPORTING RESEARCH PROVIDED A TECHNOLOGY BASE FOR LACIE AND PROVIDED NEEDED IMPROVEMENTS
- REPRESENTATIVE DATA SETS WERE ESSENTIAL FOR SUPPORTING RESEARCH AND LACIE EVALUATIONS

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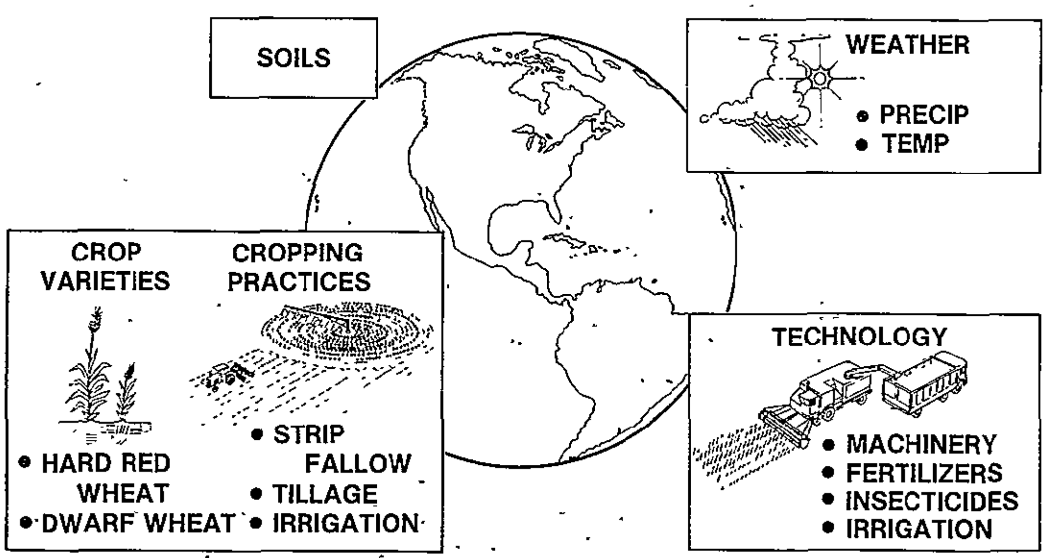
INTERMEDIATE-SCALE TESTING QUALIFICATION OF ALTERNATE RESEARCH APPROACHES

- DUE TO THE WIDE NATURAL VARIABILITY IN GLOBAL AGRICULTURE, ALTERNATE RESEARCH APPROACHES COULD NOT BE QUALIFIED WITHOUT INTERMEDIATE-SCALE TESTING
- ALTERNATE RESEARCH APPROACHES ALSO REQUIRED ADDITIONAL DEVELOPMENT AND INTERMEDIATE-SCALE TESTING IN ORDER TO ESTABLISH THEIR VALIDITY IN HIGH-THROUGHPUT FORM

NASA-S-78-16007

GLOBAL FORECASTING MUST DEAL WITH A WIDE RANGE OF HIGHLY-VARIABLE CONDITIONS



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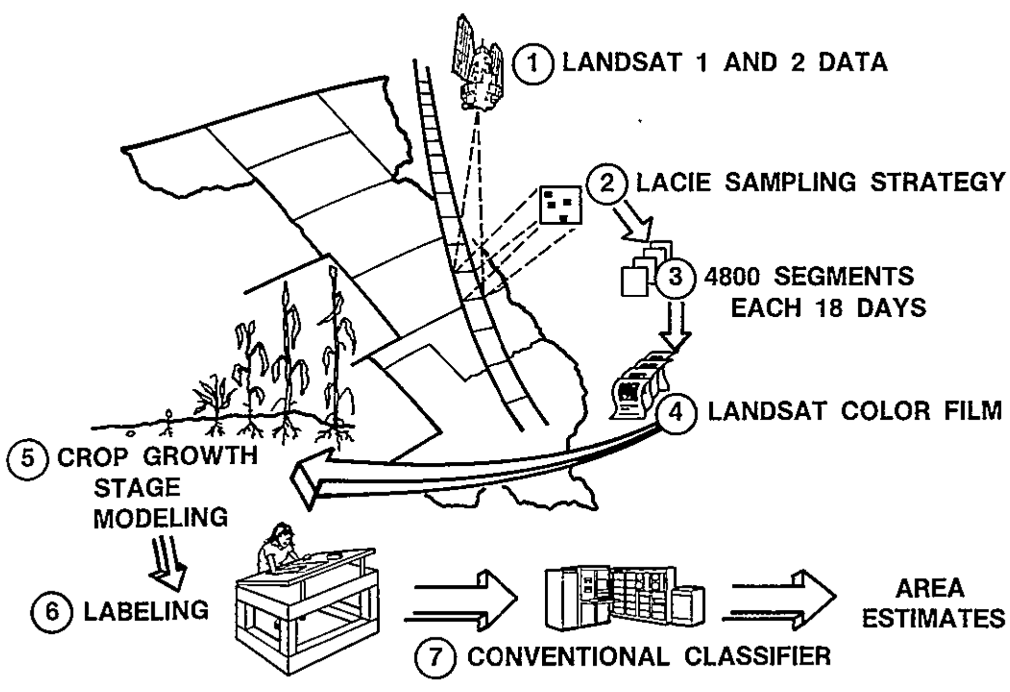
WHAT WE LEARNED

- LACIE LARGE-SCALE TESTING DEFINED KEY RESEARCH ISSUES
- INTERMEDIATE-SCALE TESTING QUALIFIED ALTERNATE RESEARCH APPROACHES BEFORE INTEGRATION INTO LACIE EVALUATIONS
- SUPPORTING RESEARCH PROVIDED A TECHNOLOGY BASE FOR LACIE AND PROVIDED NEEDED IMPROVEMENTS
- REPRESENTATIVE DATA SETS WERE ESSENTIAL FOR SUPPORTING RESEARCH AND LACIE EVALUATIONS

NASA S 78-16009

SUMMARY OF 1974 LACIE TECHNOLOGY BASE



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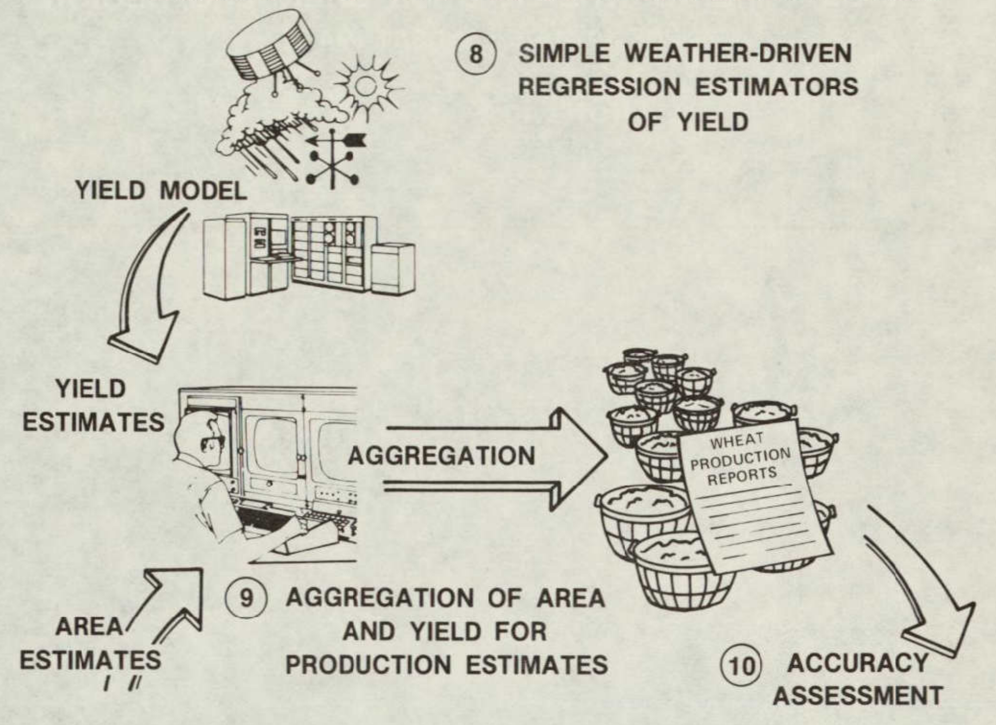
SUMMARY OF 1974 LACIE TECHNOLOGY BASE



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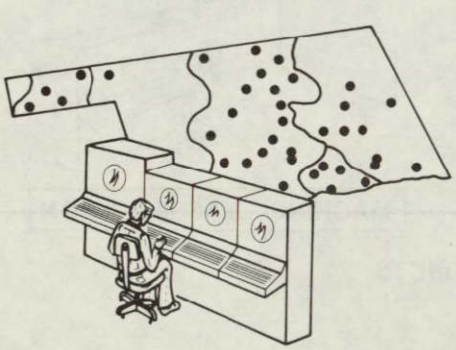
LACIE DEVELOPMENTS SAMPLING AND AGGREGATION



- USE OF LANDSAT FOR EXCLUSION OF NONCROPLAND
- IMPROVEMENTS TO AGGREGATION
  - ERROR STATISTICS
- NATURAL SAMPLE STRATEGY
- ADVANCED SAMPLE STRATEGY

▭ IMPLEMENTED IN LACIE

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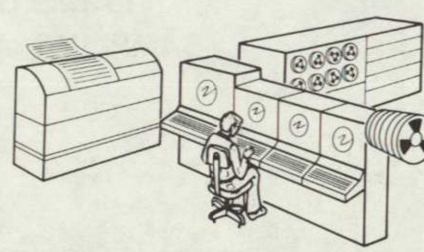
U.S.S.R. SPRING WHEAT, ORSK-ORENBERG REGION

JUNE 19, 1975 LANDSAT IMAGE

NASA-S-78-16015

LACIE DEVELOPMENTS
AREA ESTIMATION

ANALYST LABELING



MACHINE CLASSIFICATION

- IMPROVEMENTS TO FILM PRODUCTS
- IMPROVEMENTS TO LABELING
- REVISED APPROACH TO LABELING
- NEW LANDSAT CLASSIFICATION PROCESS
- PROCEDURE TO SEPARATE WHEAT FROM OTHER SMALL GRAINS
- MAJOR IMPROVEMENTS IN MACHINE LANDSAT ANALYSES

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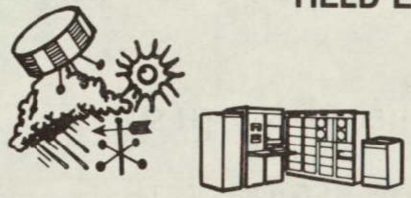
LACIE DEVELOPMENTS
YIELD ESTIMATION



- IMPROVEMENTS TO BASIC YIELD REGRESSION MODELS
  - ERROR STSTISTICS
  - IMPROVED TESTING
- 2ND-GENERATION PHYSIOLOGICALLY MOTIVATED YIELD REGRESSION MODELS
- NEW YIELD MODEL FORM - LAW OF MINIMUM

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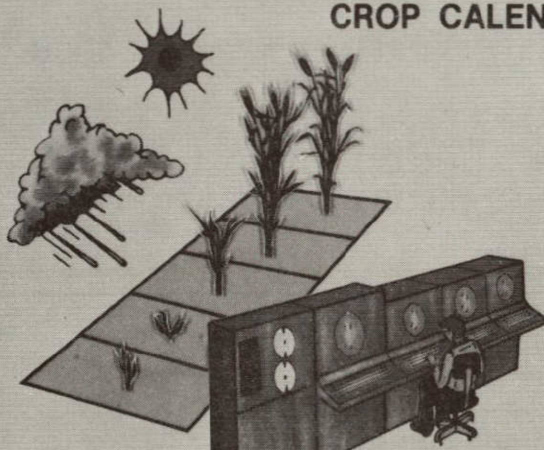
LACIE DEVELOPMENTS
CROP CALENDARS



- WINTER WHEAT MODEL
- SPRING WHEAT STARTER MODEL

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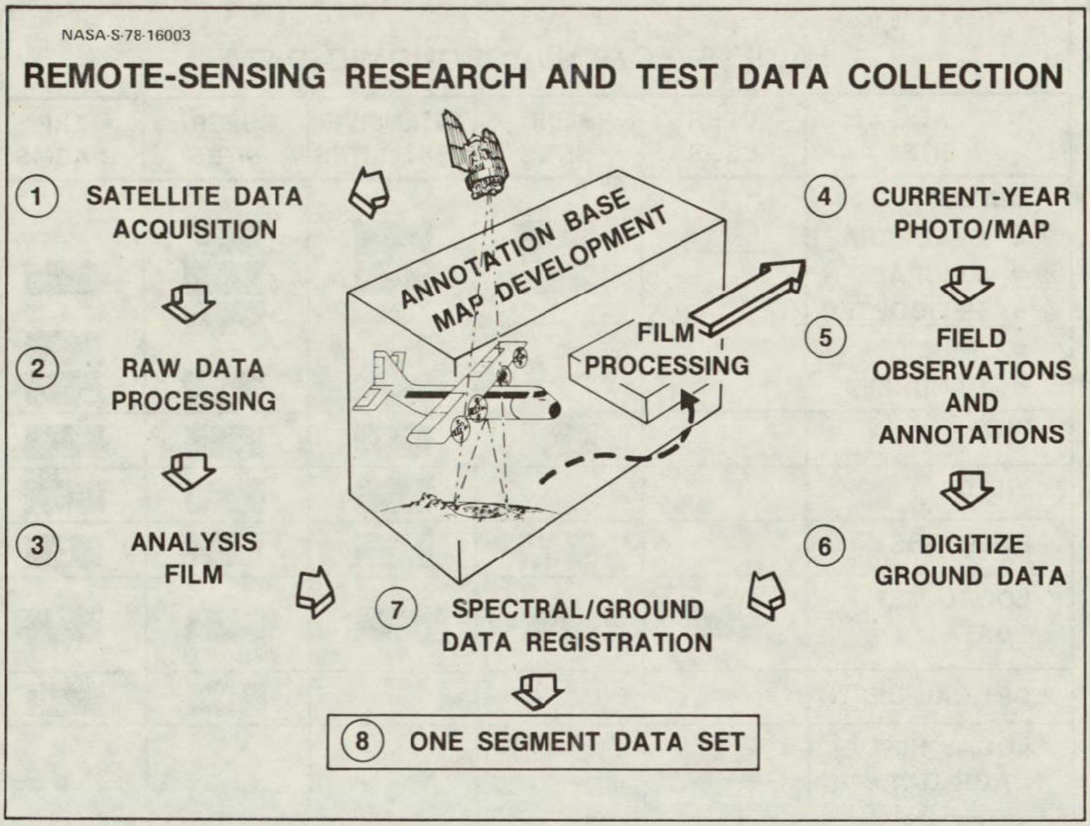
MAJOR KEY RESEARCH ISSUES REMAINING

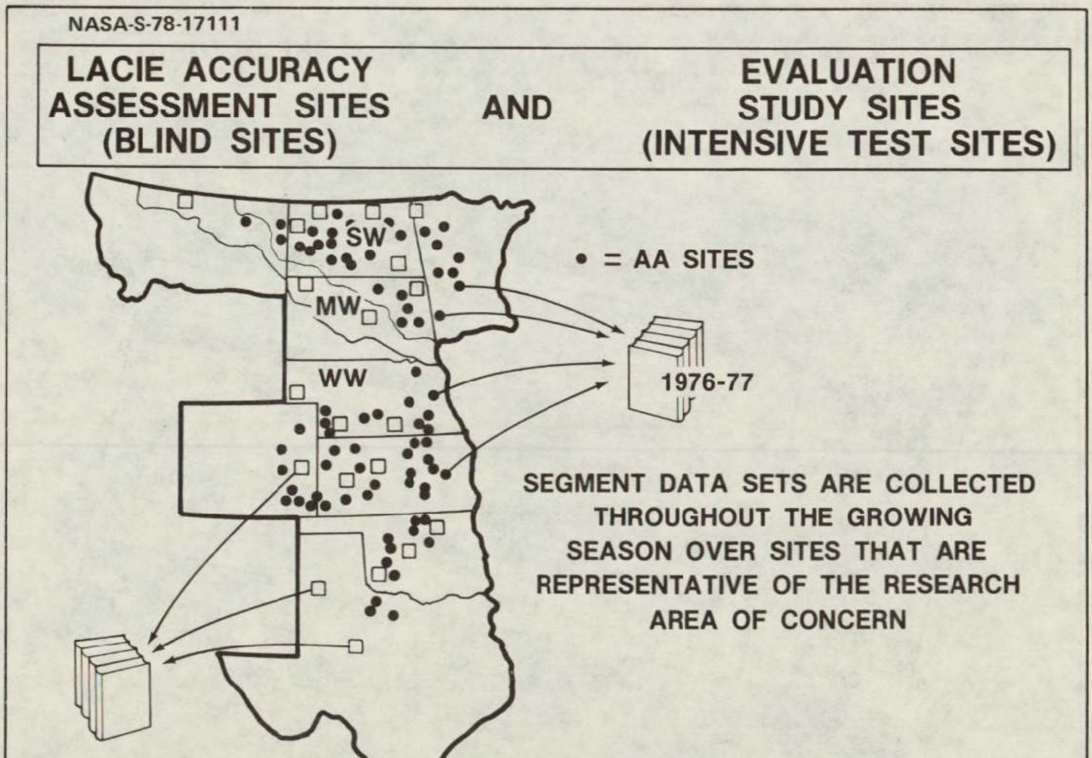
- AREA ESTIMATION
  - LANDSAT ANALYSIS IN REGIONS WITH SMALL OR NARROW FIELDS
  - WHEAT FROM LANDSAT IN REGIONS WITH OTHER SMALL GRAINS
- YIELD ESTIMATION
  - TRACKING MAJOR DEPARTURES FROM YIELD TREND
  - YIELD MODELS IN AREAS WHERE HISTORICAL DATA ARE DEFICIENT

NASA-S-78-16026

WHAT WE LEARNED

- LACIE LARGE-SCALE TESTING DEFINED KEY RESEARCH ISSUES
- INTERMEDIATE-SCALE TESTING QUALIFIED ALTERNATE RESEARCH APPROACHES BEFORE INTEGRATION INTO LACIE EVALUATIONS
- SUPPORTING RESEARCH PROVIDED A TECHNOLOGY BASE FOR LACIE AND PROVIDED NEEDED IMPROVEMENTS
- REPRESENTATIVE DATA SETS WERE ESSENTIAL FOR SUPPORTING RESEARCH AND LACIE EVALUATIONS


NASA-S-78-16003
REMOTE-SENSING RESEARCH AND TEST DATA COLLECTION
1 SATELLITE DATA ACQUISITION
2 RAW DATA PROCESSING
3 ANALYSIS FILM
ANNOTATION BASE MAP DEVELOPMENT
FILM PROCESSING
4 CURRENT-YEAR PHOTO/MAP
5 FIELD OBSERVATIONS AND ANNOTATIONS
6 DIGITIZE GROUND DATA
7 SPECTRAL/GROUND DATA REGISTRATION
8 ONE SEGMENT DATA SET


NASA-S-78-17111
LACIE ACCURACY ASSESSMENT SITES (BLIND SITES) AND EVALUATION STUDY SITES (INTENSIVE TEST SITES)
SW
MW
WW
• = AA SITES
1976-77
SEGMENT DATA SETS ARE COLLECTED THROUGHOUT THE GROWING SEASON OVER SITES THAT ARE REPRESENTATIVE OF THE RESEARCH AREA OF CONCERN
□ = ITS'S

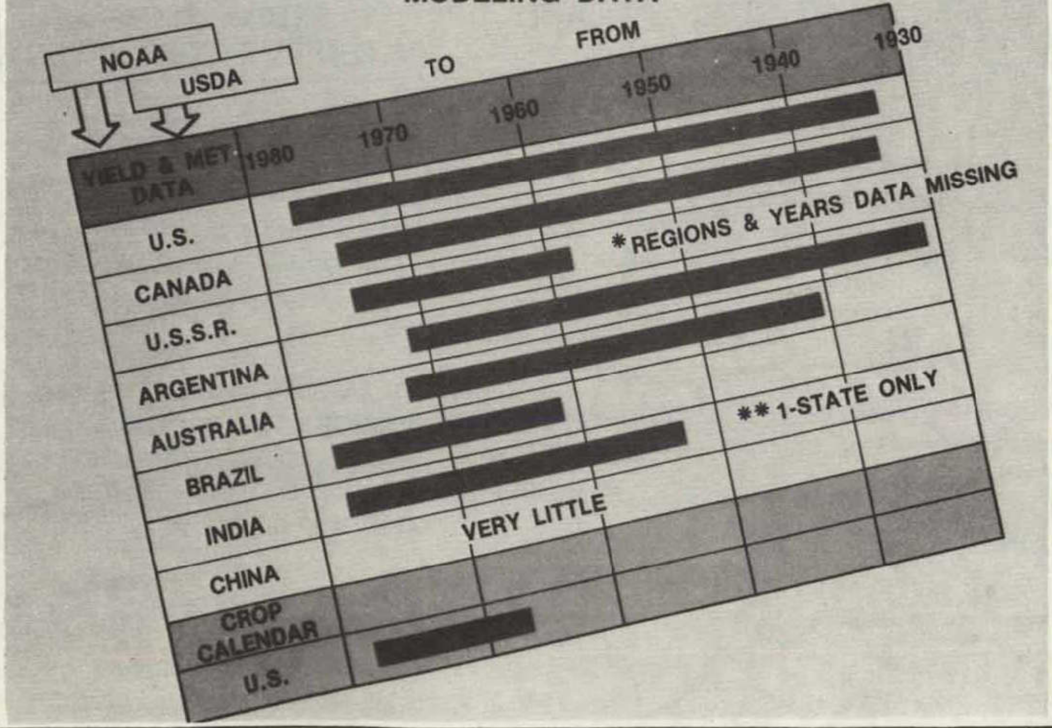
NASA-S-78-16004

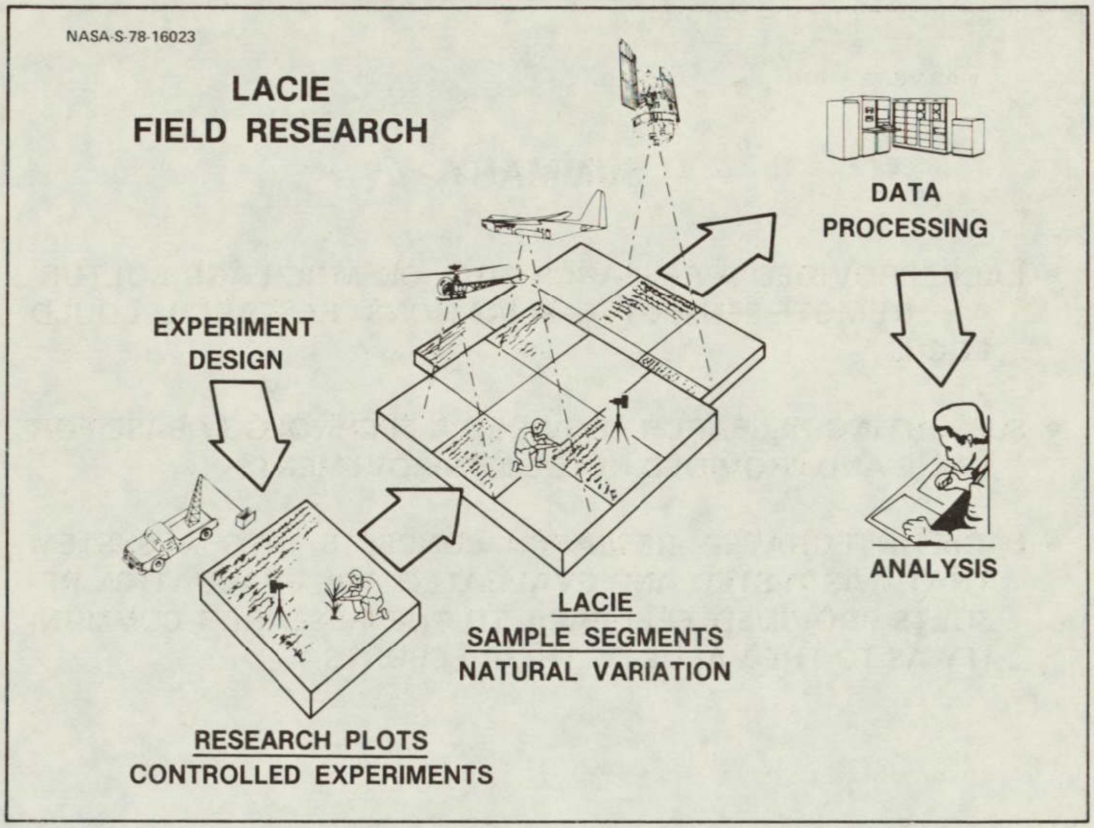
LACIE SPECTRAL/AGRONOMIC DATA

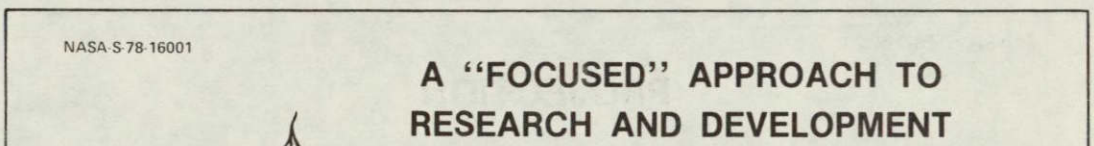
ACQ SITES	OPER SEGS	BLIND SITES	INTENSIVE TEST SITES	SUPER-SITES	EXP FARMS
IMAGERY					
• SPACECRAFT	■	■	■	■	
• AIRCRAFT		■	■	■	■
• HELICOPTER				■	
• TRUCK					■
• HANDHELD				■	■
CROP ID'S		■	■	■	■
YIELD			■	■	■
FIELD OBS		S	E	C	C
LOCAL MET DATA	■	■	■	■	■
OPTICAL DEPTH				■	■
LOCAL HIST AGR DATA	■				

NASA-S-78-16005

LACIE HISTORICAL METEOROLOGICAL/AGRICULTURAL MODELING DATA




NASA-S-78-16023
LACIE
FIELD RESEARCH
DATA
PROCESSING
EXPERIMENT
DESIGN
ANALYSIS
LACIE
SAMPLE SEGMENTS
NATURAL VARIATION
RESEARCH PLOTS
CONTROLLED EXPERIMENTS


NASA-S-78-16001
A "FOCUSED" APPROACH TO
RESEARCH AND DEVELOPMENT
SRT COMMUNITY
RESEARCH
EXPERTISE
FOCUSED ON
CRITICAL ISSUES OF
LACIE COMPONENTS
YIELD
SAMPLING
PRODUCTION
AREA
LACIE

NASA-S-78-16019

SUMMARY

- LACIE PROVIDED A RESEARCH GOAL ON WHICH AGRICULTURAL REMOTE-SENSING APPLICATIONS RESEARCH COULD FOCUS
- SUPPORTING RESEARCH PROVIDED A TECHNOLOGY BASE FOR LACIE AND PROVIDED NEEDED IMPROVEMENTS
- LACIE INTEGRATED RESEARCH CONCEPTS INTO A SYSTEM THAT WAS TESTED AND EVALUATED. THE EVALUATION RESULTS PROVIDED FEEDBACK TO THE RESEARCH COMMUNITY AS TO THE VALUE OF THEIR EFFORTS

NASA-S-78-16021

PROJECTION

(FROM SUPPORTING RESEARCH VIEWPOINT)

- TO USE THE CURRENT TECHNOLOGY FOR WHEAT INVENTORY WHERE USEFUL
- TO IMPROVE THE WHEAT INVENTORY CAPABILITY BY ADDRESSING KEY ISSUES
  - DIRECT WHEAT IDENTIFICATION
  - MORE PHYSIOLOGICALLY BASED YIELD MODELS
  - BETTER CROP STAGE MODELS
  - SMALL-FIELDS METHODS
  - EARLY-SEASON ESTIMATION OF AREA
  - TESTS OVER OTHER SIGNIFICANT REGIONS
- TO INITIATE EXPERIMENTS IN OTHER CROPS

N79-14487

SUPPORTING RESEARCH AND TECHNOLOGY (SRT) SESSION

METHODS FOR SEGMENT WHEAT AREA ESTIMATION

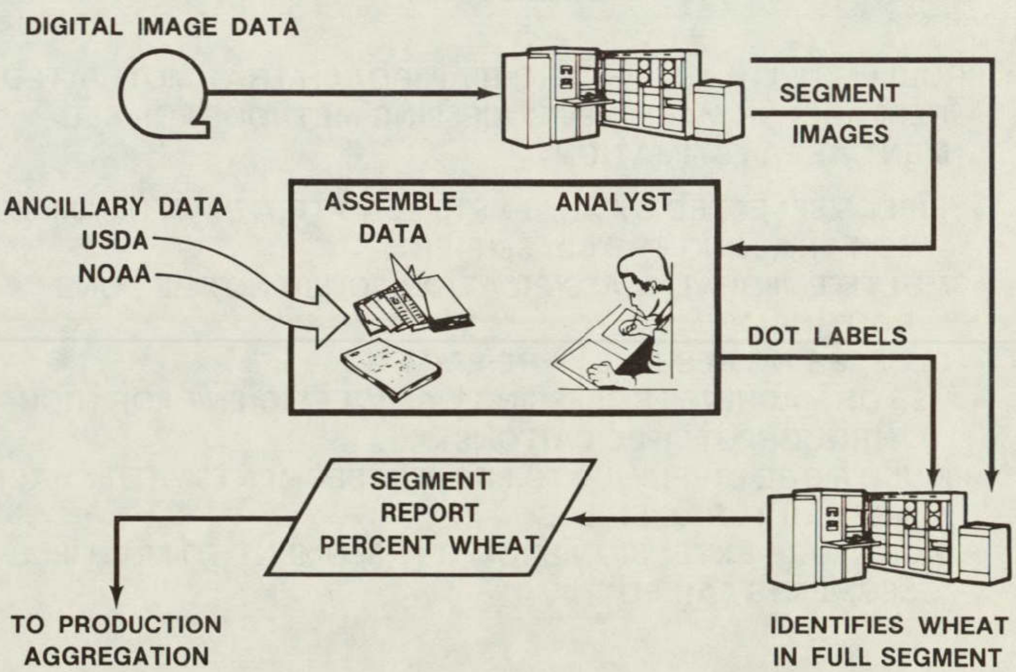
R. Heydorn, JSC

NASA-S-78-17112

METHODS FOR SEGMENT WHEAT AREA ESTIMATION

NASA-S-78-17113

ANALYSIS STEPS IN PHASES I AND II OF LACIE



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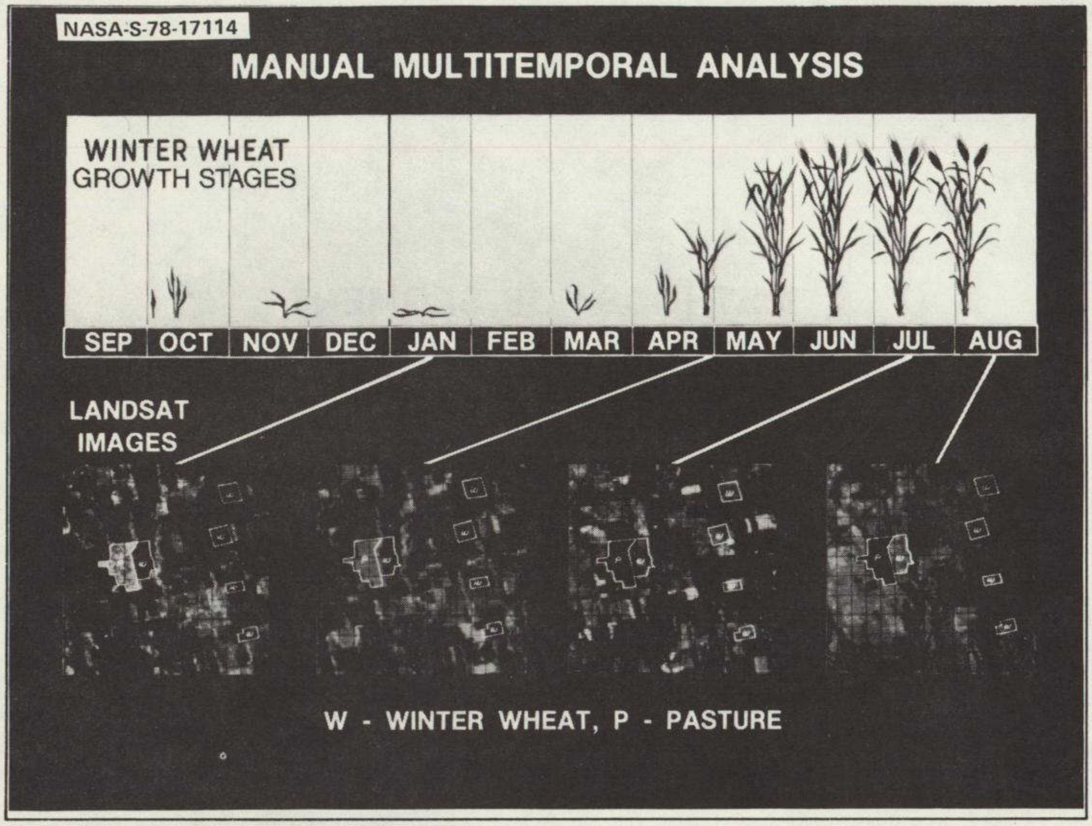


NASA-S-78-17115

OVERVIEW

- PROBLEMS WITH THE PHASE I, II APPROACH THAT MOTIVATED RESEARCH IN MACHINE-PROCESSING METHODS FOR SEGMENT AREA ESTIMATION
  - FIELDS SELECTED BY ANALYSTS LEAD TO A BIASED SAMPLE FOR TRAINING THE CLASSIFIER
  - MULTITEMPORAL CLASSIFICATION COULD NOT BE DONE ROUTINELY
  - CLUSTERING RESULTS WERE ERRATIC
  - USE OF MACHINE PROCESSING WAS INEFFICIENT FOR HIGH-THROUGHPUT APPLICAITONS
  - MUCH MORE DIFFICULT TO PROCESS SEGMENTS WITH SMALL AGRICULTURAL FIELDS
  - SIGNATURE EXTENSION FROM ONE SEGMENT TO MULTIPLE SEGMENTS FAILED

NASA-S-78-17116

OVERVIEW (CONT)

- IN PHASE III, THE APPROACH FOR OBTAINING SEGMENT AREA ESTIMATES WAS REDESIGNED. NEW DESIGN CALLED PROCEDURE 1
- RESEARCH RESULTS THAT WERE IMPLEMENTED IN THE PROCEDURE 1 DESIGN
  - DATA TRANSFORMATIONS FOR NUMERICAL DISPLAYS
  - SPECTRAL CLUSTERING
  - TWO-STAGE STRATIFIED AREAL PROPORTION ESTIMATION

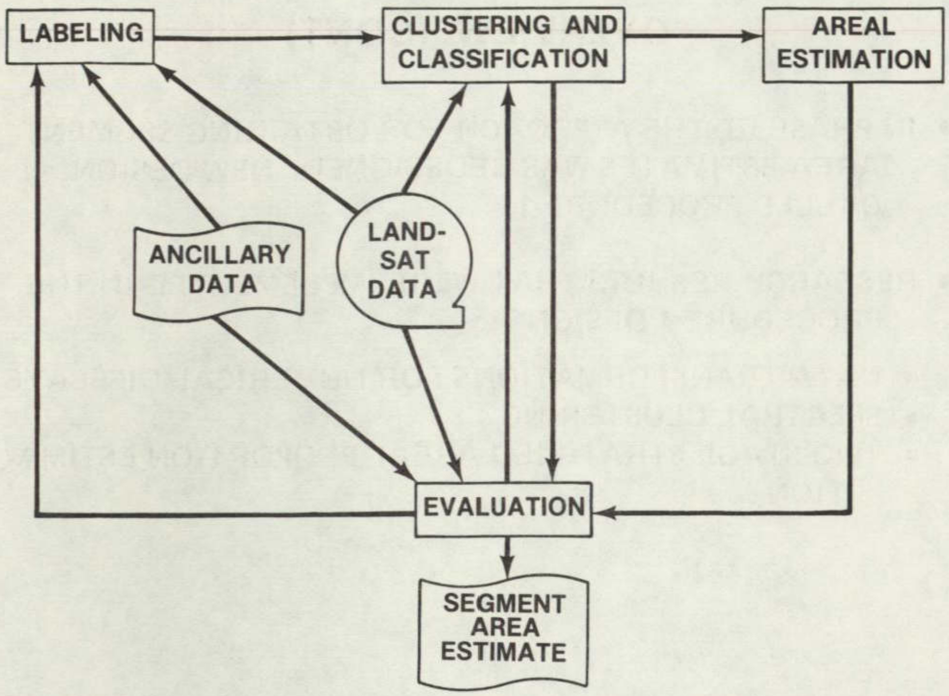
NASA-S-78-17117

OVERVIEW (CONT)

- ADDITIONAL RESEARCH STUDIES FOR FUTURE REMOTE-SENSING INVENTORY APPLICATIONS
  - EVALUATION OF (UNBIASED) PROPORTION ESTIMATION METHODS
  - DEVELOPMENT OF SPATIAL/SPECTRAL CLUSTERING ALGORITHMS
  - STUDIES INTO SIGNATURE EXTENSION METHODS BASED ON SAMPLING CONCEPTS

NASA-S-78-17118

PROCESSING FLOW IN PROCEDURE 1



NASA-S-78-17119

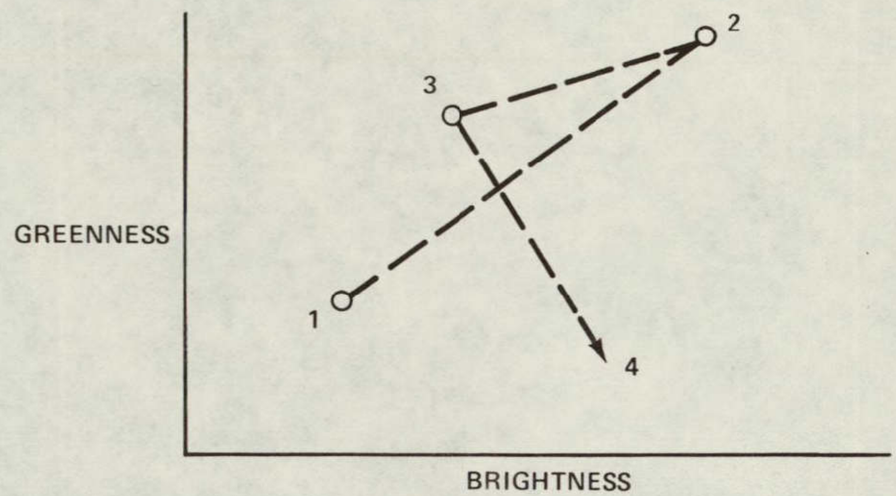
RESEARCH CONTRIBUTIONS TO THE DESIGN OF PROCEDURE 1

- LABELING
  - PROCEDURE 1 PROVIDES THE ANALYST WITH NUMERICAL LABELING AID DISPLAYS
    – TRAJECTORY PLOTS
      - ALLOWS THE ANALYST TO COMPARE MULTITEMPORAL PATTERNS OF A DOT

    – SCATTER PLOT
      - PROVIDES INFORMATION ON THE CONSISTENCY OF LABELING DECISIONS
  - DISPLAYS BASED ON A "FEATURE EXTRACTION" TRANSFORMATION THAT RELATES LANDSAT VARIABLES TO CROP DEVELOPMENT AND BACKGROUND VARIABLES (ERIM)
    – BRIGHTNESS VARIABLE IS RELATED TO SOIL COLOR
    – GREENNESS VARIABLE IS RELATED TO THE VEGETATIVE DEVELOPMENT OF A CANOPY

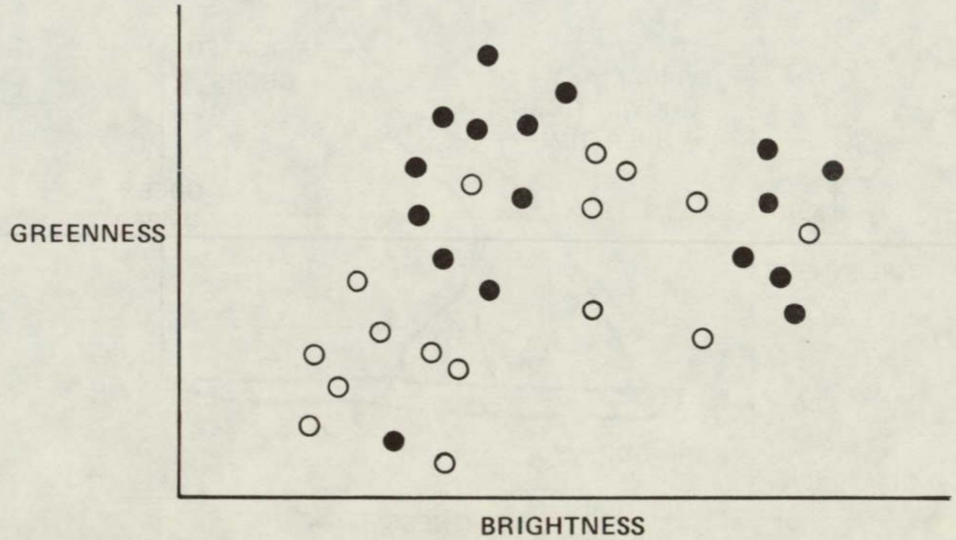
NASA-S-78-17120

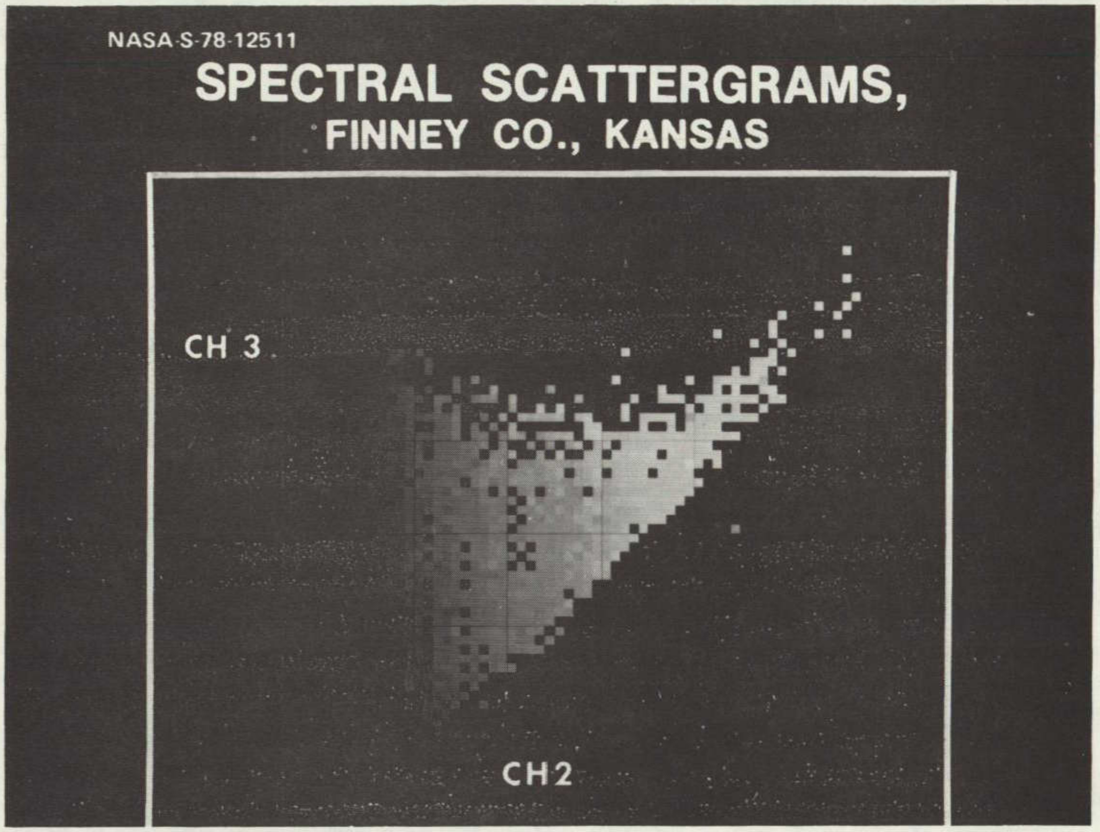
ANALYST AID - TRAJECTORY PLOT

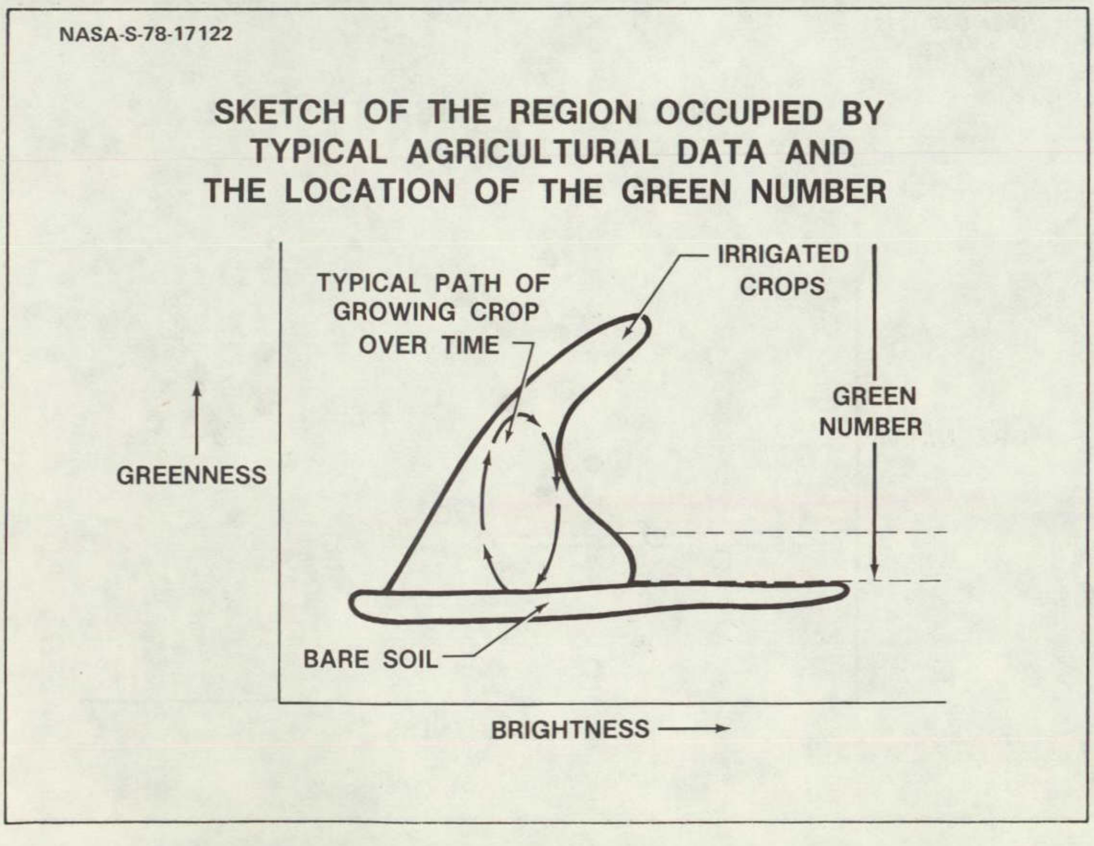


NASA-S-78-17121

ANALYST AID - SCATTER PLOT




NASA-S-78-12511
SPECTRAL SCATTERGRAMS,
FINNEY CO., KANSAS
CH 3
CH2


NASA-S-78-17122
SKETCH OF THE REGION OCCUPIED BY
TYPICAL AGRICULTURAL DATA AND
THE LOCATION OF THE GREEN NUMBER
IRRIGATED
CROPS
TYPICAL PATH OF
GROWING CROP
OVER TIME
GREEN
NUMBER
GREENNESS
BARE SOIL
BRIGHTNESS

NASA-S-78-17123

KAUTH LANDSAT AGRICULTURAL MATRIX

$$\begin{array}{ll} \text{BRIGHTNESS} & = \\ \text{GREENNESS} & = \\ \text{YELLOWNESS} & = \\ \text{NONE SUCH} & = \end{array} \begin{bmatrix} 0.43258 & 0.63248 & 0.58572 & 0.26414 \\ -.28972 & -.56199 & .59953 & .49070 \\ -.82418 & .53290 & -.05018 & .18502 \\ .22286 & .01249 & -.54311 & .80945 \end{bmatrix} \begin{bmatrix} CH1 \\ CH2 \\ CH3 \\ CH4 \end{bmatrix}$$

BRIGHTNESS	SUM OF CHANNELS
GREENNESS	IR MINUS VISIBLE
YELLOWNESS	RED MINUS GREEN
NONE SUCH	CH 4 - CH 3

(THE MATRIX IS ORTHOGONAL)

NASA-S-78-17124

RESEARCH CONTRIBUTIONS TO THE DESIGN OF PROCEDURE 1 (CONT)

CLUSTERING

- CLUSTERING IS USED IN PROCEDURE 1 TO "AUTOMATICALLY" GROUP THE LANDSAT DATA INTO SPECTRAL SUBCLASSES
  - SUBCLASS LABELS ASSIGNED FROM TYPE 1 DOTS
  - MEANS AND COVARIANCE MATRIX ESTIMATES REQUIRED FOR CLASSIFICATION ARE DERIVED FROM THE SUBCLASSES
- IN THE EARLY LACIE CLUSTERING ALGORITHMS AT JSC REQUIRED MULTIPLE MANUAL ITERATIONS AND WERE NOT SUITABLE FOR BATCH PROCESSING

NASA-S-78-17125

RESEARCH CONTRIBUTIONS TO THE DESIGN OF PROCEDURE 1 (CONT)

CLUSTERING

- RESEARCH TEAM OF NASA, LEC, AND U OF HOUSTON MEMBERS FORMED TO IMPROVE THE ISOCLS ALGORITHM
  - APPLIED CORRECTION FOR VARIATION IN SUN ANGLE TO IMPROVE MULTITEMPORAL CLUSTERING
  - INCREASED THE LIMIT ON THE NUMBER OF CLUSTERS FROM 20 TO 60
  - ADDED THE CAPABILITY TO START CLUSTERING AROUND "SEED" VECTORS
  - IMPROVE GENERAL LOGIC DESIGN

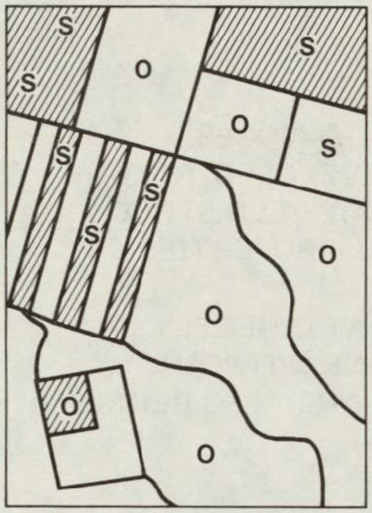
NASA-S-78-17126

RESEARCH CONTRIBUTIONS TO THE DESIGN OF PROCEDURE 1 (CONT)

- ACREAGE PROPORTION ESTIMATION
  - ACREAGE ESTIMATES BASED ON A TABULATION OF CLASSIFICATION RESULTS WILL IN GENERAL BE BIASED
    - BIAS RELATED TO CLASSIFICATION ERRORS OF OMISSION AND COMMISSION
  - IN PROCEDURE 1, CLASSIFICATION IS TREATED AS A STRATIFICATION OF THE SEGMENT INTO SMALL GRAINS AND NON-SMALL-GRAINS
    - SECOND SAMPLING (TYPE 2 DOTS)USED TO CORRECT BIAS
    - METHOD IS UNBIASED PROVIDED ANALYST LABELING IS ERROR-FREE
    - INCREASES THE EFFICIENCY (REDUCES THE VARIANCE) OF A MANUAL ESTIMATE BASED ON TYPE 2 DOTS

NASA-S-78-17127

STRATIFIED AREAL ESTIMATE IN PROCEDURE 1



CLASSIFIED LACIE SEGMENT

- AREA CLASSIFIED AS SMALL GRAINS. TOTAL NO. OF PIXELS = N_1
- AREA CLASSIFIED AS NON-SMALL-GRAINS. TOTAL NO. OF PIXELS = N_2

S - TYPE 2 DOT LABELED SMALL GRAINS

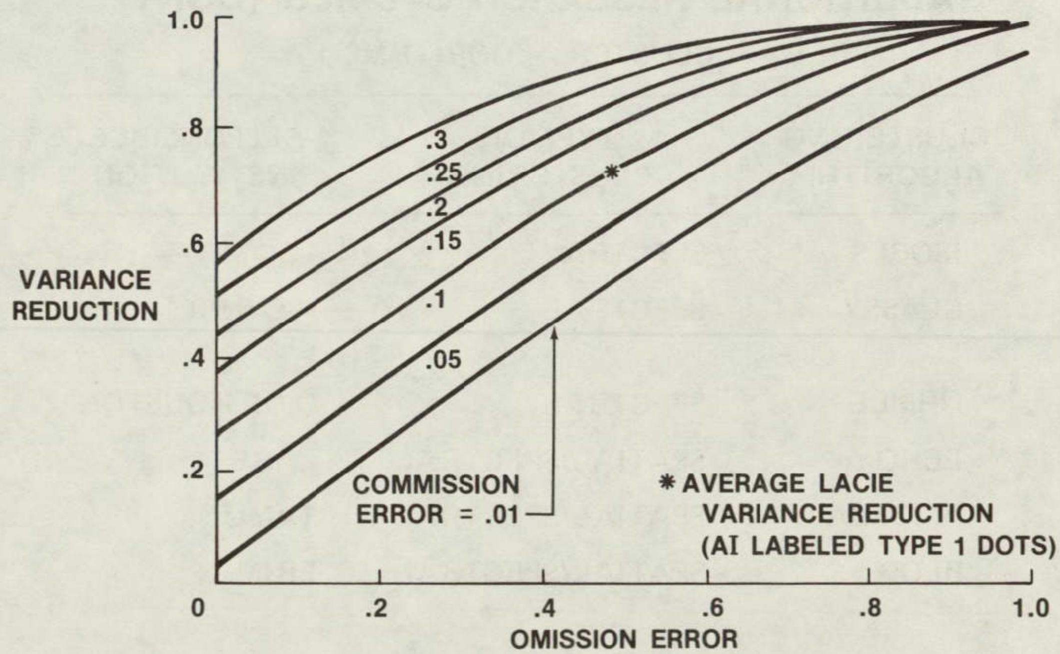
O - TYPE 2 DOT LABELED NON-SMALL-GRAINS

AREA PROPORTION ESTIMATE

$$P = \frac{6}{7}\frac{N_1}{N_1 + N_2} + \frac{1}{6}\frac{N_2}{N_1 + N_2}$$

NASA-S-78-17128

VARIANCE REDUCTION



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ADDITIONAL RESEARCH STUDIES

CLUSTERING

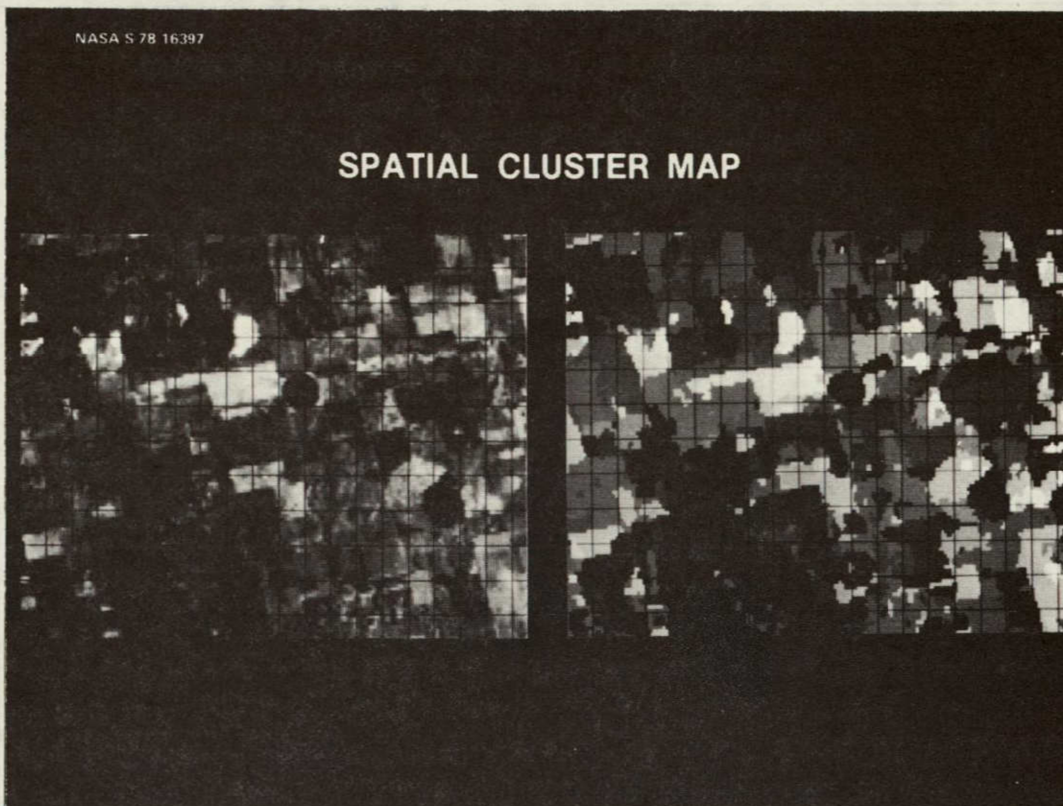
- AS A POSSIBLE IMPROVEMENT TO ISOCLS, ALGORITHMS ARE BEING DEVELOPED THAT USE SPATIAL (AGRICULTURAL FIELD STRUCTURE) AS WELL AS SPECTRAL PROPERTIES
- CLUSTERING ALGORITHMS THAT DIRECTLY ESTIMATE CROP PROPORTIONS (WITHOUT FURTHER CLASSIFICATION) ARE ALSO BEING DEVELOPED

NASA-S-78-17130

ADDITIONAL RESEARCH STUDIES (CONT)

CLUSTER ALGORITHMS

CLUSTERING ALGORITHM	TYPE OF CLUSTERING	RESPONSIBLE INSTITUTION
ISOCLS	SPECTRAL	LEC
CLASSY	SPECTRAL	JSC (NRC) LEC
UHMLE	SPECTRAL	U OF HOUSTON
ECHO	SPATIAL/SPECTRAL	LARS
AMOEBA	SPATIAL/SPECTRAL	TAMU
BLOB	SPATIAL/SPECTRAL	ERIM



NASA-S-78-17131

PROPORTION ESTIMATION METHODS

METHOD	DESCRIPTION	RESPONSIBLE INSTITUTION
• INVERTING THE CONFUSION MATRIX	ESTIMATE THE OMISSION/ COMMISSION ERROR MATRIX AND USE IT TO CORRECT FOR BIAS	UNIV OF TEX/ DALLAS
• MAXIMUM-LIKELIHOOD ESTIMATE OF PROPORTION	ASSUME NORMAL COMPONENT DENSITIES AND MAXIMIZE THE LIKELIHOOD OF THE MIXTURE DISTRIBUTION W.R.T. MIXING PROPORTIONS	UNIV OF TEX/ DALLAS
• METHODS OF MOMENTS	ESTIMATE THE PROPORTION OF COMPONENT MOMENTS IN THE MIXTURE MOMENTS	TEXAS A&M UNIV

NASA-S-78-17132

PROPORTION ESTIMATION METHODS (CONT)

METHOD	DESCRIPTION	RESPONSIBLE INSTITUTION
• CDF MIXTURE METHOD	ESTIMATE THE PROPORTION OF COMPONENT MARGINAL CUMULATIVE DISTRIBUTION FUNCTIONS (CDF) IN THE MIXTURE MARGINAL CDF'S	UNIV OF TEX/ DALLAS
• BIN METHOD	SAME AS ABOVE EXCEPT DENSITY HISTOGRAMS USE IN PLACE OF CDF'S	LEC
• POSTERIOR PROBABILITY	TREAT CLASSIFICATION AS SMALL-GRAINS/NON-SMALL-GRAINS STRATIFICATION AND ESTIMATE SMALL-GRAINS PROPORTION FROM A STRATIFIED RANDOM SAMPLE	JSC

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ADDITIONAL RESEARCH STUDIES (CONT)

PROPORTION ESTIMATION METHODS

- SMALL-SCALE EVALUATIONS SHOWED THAT THESE PROPORTION ESTIMATION METHODS DID NOT OFFER SIGNIFICANT IMPROVEMENT OVER STRAIGHT CLASSIFICATION APPROACHES
- SOME INDICATION OF POTENTIAL BENEFIT OFFERED BY SOME OF THE METHODS (E.G., BIN METHOD) IN MULTITEMPORAL APPLICATIONS
  - SOMEWHAT LESS SENSITIVE TO REGISTRATION ERRORS

NASA-S-78-17136

ADDITIONAL RESEARCH STUDIES (CONT)

SIGNATURE EXTENSION (CONT)

- MAJOR STEPS IN THE THIRD APPROACH (CONT)
  - FROM ALL SEGMENTS IN A GIVEN STRATUM, PICK THE SMALLEST SUBSET THAT CONTAINS SAMPLES FROM ALL THE MAJOR CROP SUBCLASSES. THESE ARE THE TRAINING SEGMENTS (ERIM, IBM)
  - LABEL EACH TRAINING SEGMENT (AS IS DONE, E.G., IN PROCEDURE 1)
  - CLASSIFY OR OTHERWISE APPLY PROPORTION ESTIMATION METHODS TO EACH RECOGNITION SEGMENT (ERIM, IBM, LEC)
  - ESTIMATE CROP AREA IN THE STRATUM (ERIM, IBM)

NASA-S-78-17137

RECOMMENDATIONS FOR FURTHER RESEARCH

- NEED TO DEVELOP IMPROVED MACHINE-PROCESSING TECHNIQUES THAT
  - ACCOUNT FOR ANALYST LABELING ERROR
    - EXAMPLE: CLUSTER LABELING BASED ON MAJORITY RULE LOGIC
  - OR USE ONLY ANALYST RESPONSES THAT HAVE A HIGH LIKELIHOOD OF BEING ERROR-FREE
    - EXAMPLE: ANALYST NOT REQUIRED TO MAKE A LABELING DECISION BUT ONLY TO ANSWER QUESTIONS RELATED TO SCENE FEATURES (CF LIST)

NASA-S-78-17138

RECOMMENDATIONS FOR FURTHER RESEARCH (CONT)

- NEED IMPROVEMENTS IN MACHINE-PROCESSING EFFICIENCY (AS MEASURED BY THE AMOUNT OF MANUAL OPERATIONS REQUIRED), AT A GIVEN LEVEL OF ACCURACY
  - DEVELOP BETTER DISCRIMINATION/PROPORTION ESTIMATION METHODS
    - WHAT ARE THE BEST ACQUISITION TIMES TO DISCRIMINATE A GIVEN CROP TYPE?
    - WOULD THE INCLUSION OF ADDITIONAL VARIABLES (BESIDES SPECTRAL) IN THE MACHINE METHODS SIGNIFICANTLY IMPROVE RESULTS?
      - SPATIAL
      - ANCILLARY
      - PREVIOUS-YEAR DATA
  - DEVELOP A SIGNATURE EXTENSION APPROACH

SUPPORTING RESEARCH AND TECHNOLOGY (SRT) SESSION

MANUAL IDENTIFICATION OF CROP TYPES

C. Hay, University of California at Berkeley

NASA-S-78-17139

SR&T EFFORTS IN MANUAL IDENTIFICATION OF CROP TYPE FROM LANDSAT DATA

NASA-S-78-17140

SUMMARY

- MANUAL CROP IDENTIFICATION NEEDED IN LIEU OF GROUND DATA IN FOREIGN AGRICULTURAL INVENTORY SYSTEM
- PHASE I AND PHASE II EXPERIENCE INDICATED MANUAL MEASUREMENT ERROR OUTSIDE PERFORMANCE TOLERANCE RANGE IN SPRING WHEAT REGIONS
- DEVELOPMENT OF IMPROVED MANUAL PROCEDURES DEPENDENT ON AN ADEQUATE UNDERSTANDING OF THE MANUAL ANALYSIS PROCESS
  - FEATURE DETECTION AND CHARACTERISTICS DETERMINATION WITH LANDSAT DATA
  - FEATURE INTERPRETATION AND EVALUATION WITH LANDSAT, A PRIORI, AND ANCILLARY DATA

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NASA-S-78-17141

SUMMARY (CONT)

- SPECIFIC ANALYST INTERPRETATION PROBLEMS
  - VERY DIFFICULT TO PICK A GOOD SAMPLE OF TRAINING FIELDS IN MULTITEMPORAL CLASSIFICATION ATTEMPTS
  - ABNORMAL SITUATIONS (E.G., DROUGHT, SMALL FIELDS, ETC) SIGNIFICANTLY INCREASE ANALYST LABELING ERROR AND VARIABILITY AMONG ANALYSTS
  - LANDSAT AND ANCILLARY DATA NOT ALWAYS ADEQUATE
    - DISTORTION IN CIR IMAGERY MAKES DETECTION OF CROP DEVELOPMENT PATTERNS DIFFICULT
    - ERRORS IN CROP CALENDAR MODEL PREDICTIONS CAUSE THE ANALYST TO MISLABEL
    - INTERPRETATION OF PIXELS ON OR NEAR FIELD BOUNDARIES IS A VERY ERROR PRONE PROCESS ESPECIALLY WHEN REGISTRATION ERRORS ARE LARGE

NASA-S-78-17142

SUMMARY (CONT)

- SPECIFIC RESEARCH DONE TO AID ANALYST LABELING PROBLEMS
  - NEW LANDSAT DATA PRODUCTS WERE DEVELOPED FOR BETTER FEATURE DETECTION AND CHARACTERISTIC DETERMINATION
  - CROP SPECTRAL SEPARABILITY STUDIES UNDERTAKEN TO INCREASE UNDERSTANDING
  - SEMIAUTOMATIC LABELING PROCEDURES BASED ON STATISTICAL DISCRIMINANT ANALYSIS OF QUESTION AND ANSWER RESPONSE DATA WERE DEVELOPED TO INCREASE CONSISTENCY AND ACCURACY OF LABELS
  - INTERPRETATION KEYS WERE COMPILED AS A BASIC TRAINING TOOL TO DECREASE VARIABILITY AMONG ANALYSTS

NASA-S-78-17143

HISTORY OF MANUAL ANALYSIS IN LACIE

- PHASE I AND PHASE II

  "FIELDS PROCEDURE"

  - SELECTION OF REPRESENTATIVE SPECTRAL CLASSES
  - CROP TYPE LABELING (IDENTIFICATION) OF SELECTED CLASSES

- PHASE III

  PROCEDURE 1

  - CROP TYPE LABELING OF RANDOMLY SELECTED PIXELS (DOTS)

NASA-S-78-17144

CROP IDENTIFICATION ANALYSIS PROCESS

- ANALYSIS COMPONENTS
  - FEATURES OF INTEREST: CROPPED FIELDS
  - FEATURE DETECTION AND CHARACTERISTICS DETERMINATION
    - DISCRIMINATION OF UNIQUE FEATURE BASED ON LANDSAT SPATIAL, SPECTRAL, AND TEMPORAL CHARACTERISTICS
  - FEATURE INTERPRETATION AND EVALUATION
    - ASSIGNMENT OF A NAME OR LABEL (E.G., WHEAT, NONWHEAT) TO A DETECTED FEATURE BASED ON EVALUATION OF LANDSAT, A PRIORI, AND ANCILLARY DATA

NASA-S-78-17145

PROBLEMS ENCOUNTERED IN MANUAL ANALYSIS

- PHASE I AND PHASE II EXPERIENCE INDICATED THAT AVERAGE ANALYST INTERPRETATION ERROR WAS OUTSIDE PERFORMANCE TOLERANCE LIMITS IN SPRING WHEAT AREAS

NASA-S-78-17146

PROBLEMS ENCOUNTERED IN MANUAL ANALYSIS (CONT)

- PROBLEMS IN DETECTION AND CHARACTERISTICS DETERMINATION
  - DISTORTED REPRESENTATION OF LANDSAT DATA
  - INADEQUATE TEMPORAL SAMPLE
    - MISSING OR POORLY TIMED ACQUISITIONS
  - FEATURE BELOW RESOLUTION LIMIT
    - SMALL-FIELDS PROBLEM
  - MISREGISTERED AND BOUNDARY PIXELS
  - "ABNORMAL" CROP DEVELOPMENT
    - EXTREME SHIFTS IN TEMPORAL-SPECTRAL PATTERNS CAUSING UNUSUAL OVERLAP BETWEEN CROPS

NASA-S-78-17147

PROBLEMS ENCOUNTERED IN MANUAL ANALYSIS (CONT)

- PROBLEMS IN DATA INTERPRETATION AND EVALUATION
  - A PRIORI KNOWLEDGE INSUFFICIENT
    - VARIABILITY IN EXPECTED CROP TEMPORAL-SPECTRAL PATTERNS NOT WELL KNOWN
    - CROP TYPE TEMPORAL-SPECTRAL SEPARABILITY INFORMATION INADEQUATE
    - VARIABILITY BETWEEN ANALYSTS BACKGROUND AND EXPERIENCE

NASA-S-78-17148

PROBLEMS ENCOUNTERED IN MANUAL ANALYSIS (CONT)

- PROBLEMS IN DATA INTERPRETATION AND EVALUATION
  - ANCILLARY DATA INSUFFICIENT
    - NO YEAR SPECIFIC ADJUSTED CROP CALENDAR FOR CROPS OTHER THAN WHEAT
    - MINIMALLY ACCEPTABLE PERFORMANCE OF ADJUSTABLE WHEAT CROP CALENDAR MODEL
    - INCOMPLETE CROPPING PRACTICE INFORMATION
    - LIMITED USE OF HISTORICAL AGRICULTURAL STATISTICS
    - INADEQUATE RECENT EPISODAL EVENTS DATA
    - INSUFFICIENT LABELING OPTIONS AND/OR GUIDELINES
  - MISREGISTERED AND BOUNDARY PIXELS

NASA-S-78-17149

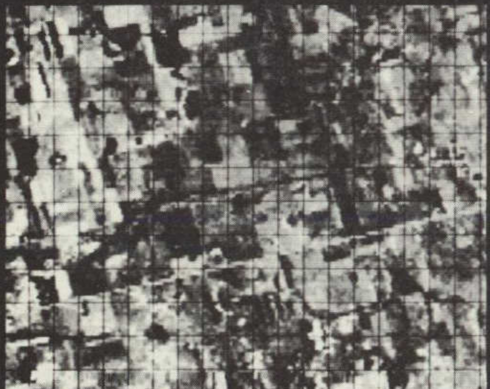
MAJOR RESEARCH EFFORTS TO IMPROVE ANALYST LABELS

- LANDSAT DATA PRODUCTS IMPROVED AND EXPANDED
  - IMAGE PRODUCTS DEVELOPED
    - UNDISTORTED SPECTRAL IMAGE PRODUCTS
      - PRODUCT 3 OR KRAUS PRODUCT
  - ISOPERCEPTIBLE CHROMATICITY IMAGE STUDY

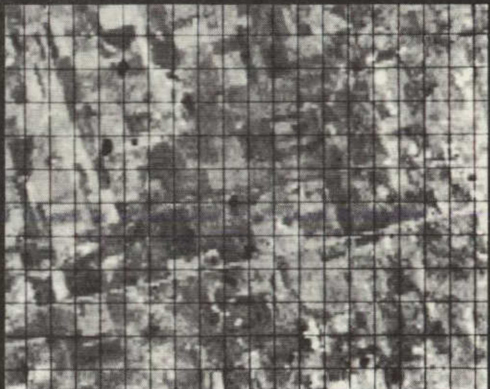
NASA-S-78-17150

EXAMPLE OF STANDARD IMAGE PRODUCT 1 AND PRODUCT 3 FOR SEGMENT 1640 - MAY 20, 1977

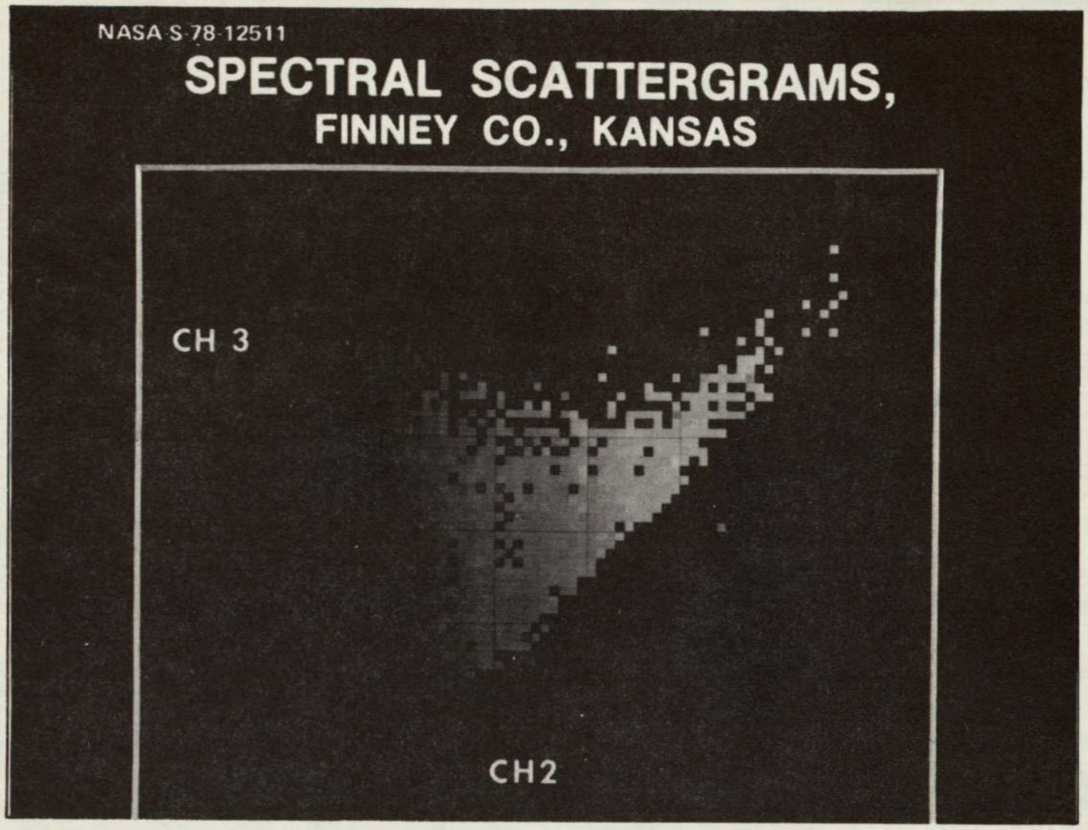
IMAGE PRODUCTS



PRODUCT 1



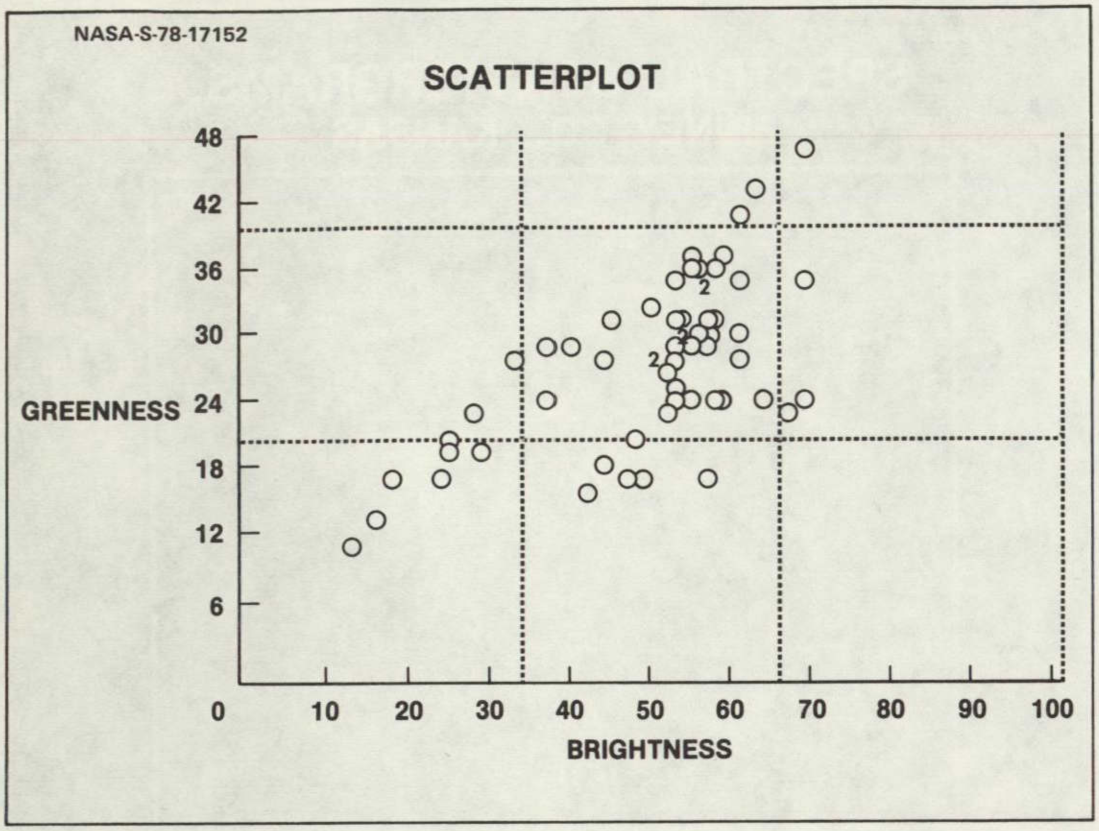
PRODUCT 3

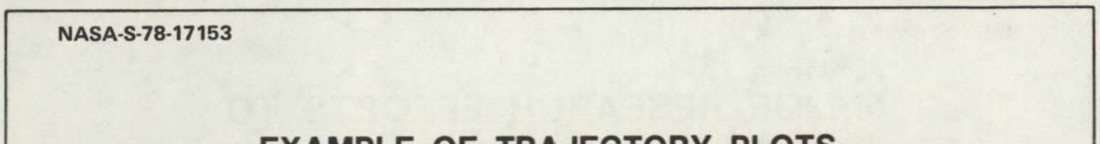


NASA-S-78-17151

MAJOR RESEARCH EFFORTS TO IMPROVE ANALYST LABELS

- LANDSAT DATA PRODUCTS IMPROVED AND EXPANDED
  - NUMERIC AND GRAPHIC PRODUCTS DEVELOPED
    - AFFINE TRANSFORMATION FIRST APPLIED TO LANDSAT DATA
    - SCATTERGRAMS: GREEN NUMBER VS BRIGHTNESS FOR EACH ACQUISITION
    - TRAJECTORY PLOTS: GREEN NUMBER VS BRIGHTNESS FOR EACH SAMPLE PIXEL
    - NUMERIC LIST: GREEN NUMBER AND BRIGHTNESS FOR EACH SAMPLE PIXEL


NASA-S-78-17152
SCATTERPLOT
GREENNESS
48
42
36
30
24
18
12
6
0
10
20
30
40
50
60
70
80
90
100
BRIGHTNESS


NASA-S-78-17153
EXAMPLE OF TRAJECTORY PLOTS
70 43 62 62 119
80 12 30 20 6
GREEN NUMBER
30
15
0
.50 .. 70.. 90 ..110
BRIGHTNESS
SPRING WHEAT
40 83 77 73 98
40 35 30 31 11
GREEN NUMBER
30
15
0
50 .. 70 ..90..110
BRIGHTNESS
NONWHEAT

NASA-S-78-17156

MAJOR RESEARCH EFFORTS TO IMPROVE ANALYST LABELS (CONT)

A PRIORI STRATIFICATION OF UNLABELED CLUSTERS

- DELTA FUNCTION STRATIFICATION PROCEDURE
  - POTENTIAL BENEFITS
    - DECREASE ANALYST LABELING EFFORT
    - INCREASE OVERALL SEGMENT PROCESSING EFFICIENCY
  - INPUT DATA
    - VEGETATION INDICATOR (MSS 7/MSS 5 RATIO) OF CLUSTER MEANS
  - A PRIORI STRATIFICATION CRITERION (ACQUISITION SET DEPENDENT) USING VEGETATION INDICATOR

NASA-S-78-17157

MAJOR RESEARCH EFFORTS TO IMPROVE ANALYST LABELS (CONT)

LABEL IDENTIFICATION BY STATISTICAL TABULATION (LIST)

- PURPOSE OF LIST IS TO
  - CONTROL BIAS DUE TO LABELING ERROR
  - DEVELOP A RESEARCH INSIGHT INTO VARIABLES THAT ARE MOST INFORMATIVE IN THE DOT LABELING PROCESS
- LIST IS A QUESTION AND ANSWER APPROACH TO ANALYST INTERPRETATION
  - ANALYST REQUIRED TO SELECT AMONG A SET OF ANSWERS TO SPECIFIC QUESTIONS
  - THESE RESPONSE VARIABLES ARE WEIGHTED
  - WEIGHTED RESPONSES ARE SUMMED TO
    - GIVE A WHEAT/NONWHEAT DECISION FOR EACH DOT
    - GIVE AN ESTIMATE OF RELIABILITY OF THE DECISION
  - INPUT DATA
    - LANDSAT SPECTRAL VALUES
    - SPATIAL INFORMATION FROM ANALYST ANALYSIS
    - ANCILLARY DATA VALUES

NASA-S-78-17158

MAJOR RESEARCH EFFORTS TO IMPROVE ANALYST LABELS (CONT)

- FROM ANALYST RESPONSES
  - SPATIAL INFORMATION
    - PIXEL IN NONAGRICULTURAL AREA?
    - MISREGISTERED?
    - ON A BOUNDARY?
    - NOT REPRESENTATIVE?
  - TEMPORAL-SPECTRAL
    - QUALITY OF VEGETATION CANOPY BY ACQUISITION

NASA-S-78-17159

MAJOR RESEARCH EFFORTS TO IMPROVE ANALYST LABELS (CONT)

- AUTOMATICALLY EXTRACTED DATA
  - EXPECTED WINTER AND SPRING WHEAT BIOSTAGES BY ACQUISITION
  - GREEN NUMBER OF PIXEL
  - BRIGHTNESS NUMBER OF PIXEL
  - WINTER AND SPRING WHEAT PRINCIPAL COMPONENT GREENNESS STATISTIC
- AUTOMATICALLY EVALUATED INFORMATION
  - GREEN NUMBER IN SMALL GRAINS RANGE?
  - VEGETATION INDICATION FOR PIXEL VALID FOR ACQUISITION SPECIFIC BIOSTAGE OF WHEAT?
  - PIXEL FOLLOWS SMALL GRAINS VEGETATION CANOPY DEVELOPMENT PATTERN?

NASA-S-78-17160

MAJOR RESEARCH EFFORTS TO IMPROVE ANALYST LABELS (CONT)

- LIST: TEST RESULTS

  (4 TRAINING AND 4 TEST SEGMENTS EACH SITE)

  - WINTER SMALL GRAINS SITES
    - ANALYST
      - 18-PERCENT OMISSION ERROR
      - 13-PERCENT COMMISSION ERROR
    - LIST
      - 17-PERCENT OMISSION ERROR
      - 15-PERCENT COMMISSION ERROR
  - SPRING SMALL GRAINS SITES
    - ANALYST
      - 50-PERCENT OMISSION ERROR
      - 29-PERCENT COMMISSION ERROR
    - LIST
      - 53-PERCENT OMISSION ERROR
      - 39-PERCENT COMMISSION ERROR

NASA-S-78-17161

CONCLUSIONS

- MULTIPLE DISPLAY FORMATS NEEDED FOR MOST EFFICIENT AND EFFECTIVE ANALYSIS OF LANDSAT DATA
  - IMAGE FORMAT FOR OPTIMUM SPATIAL INFORMATION EXTRACTION
  - NUMERIC AND GRAPHIC FORMAT FOR OPTIMUM TEMPORAL-SPECTRAL INFORMATION EXTRACTION
- TEMPORAL SAMPLING RATE (ACQUISITION HISTORY) MOST SIGNIFICANTLY AFFECTS LABELING ACCURACIES
- QUALITY AND QUANTITY OF A PRIORI KNOWLEDGE AND ANCILLARY DATA DIRECTLY AND SIGNIFICANTLY AFFECT LABELING ACCURACIES
- PROCEDURAL MODIFICATIONS CAN HELP STANDARDIZE QUALITY OF PIXEL LABELS
  - LIST
  - A PRIORI STRATIFICATION OF UNLABELED CLUSTERS

NASA-S-78-17162

OPEN ISSUES

- BETTER YEAR SPECIFIC ADJUSTABLE CROP CALENDAR MODELS FOR ALL CROPS
- DEVELOPMENT OF SPECTRAL CROP CALENDAR CONCEPT AND MODELS
- ADDITIONAL CROP TYPE TEMPORAL-SPECTRAL SEPARABILITY INFORMATION
- ADDITIONAL INFORMATION ON CROP TYPE TEMPORAL-SPECTRAL PATTERN VARIABILITY IN "NORMAL" AND "ABNORMAL" SITUATIONS
- REFINEMENT OF WITHIN-SEGMENT MEASUREMENT AND SAMPLING PROCEDURES
- REFINEMENT AND DEVELOPMENT OF BETTER DATA DISPLAY PRODUCTS

NASA-S-78-17163

DELTA FUNCTION STRATIFICATION PROCEDURE (DFS)

- CLUSTER SEGMENT (MULTITEMPORAL DATA)
- ASSIGN CLUSTERS TO SMALL GRAINS PROBABILITY STRATA
  - ORDER CLUSTERS ACCORDING TO 7/5 RATIO OF CLUSTER MEANS ON REFERENCE DATE
  - ANALYSE 7/5 TEMPORAL PATTERN WITHIN EACH CLUSTER TO DETERMINE STRATA ASSIGNMENT (USE 2 x B7/B5 = 1.1 AS SOIL LINE FOR GREEN VEGETATION MATTER)
- APPLY P-1 BIAS CORRECTION PROCEDURE TO STRATA TO PRODUCE SEGMENT ESTIMATE

NASA-S-78-17164

EXAMPLE OF CLUSTERS STRATA ASSIGNMENT

SEGMENT 1041

STRATUM	CLUSTER NO.	2 x B7/B5 RATIO ON ACQUISITION DATES (ROBERTSON BIOSTAGES)		
		MAY 15, 1976* (3.5 TO 4.0)	JUNE 2, 1976 (4.5 TO 5.0)	JULY 8, 1976 (7.0 +)
MA	38	3.17	1.36	1.23
HA	55	2.49	2.07	.86
HA	15	1.89	1.93	.97
HB	44	1.87	.89	.98
MB	10	1.42	1.75	1.39
LA	4	1.00	.85	.86
LB	40	.97	1.19	2.24

* REFERENCE DATE

NASA-S-78-17165

EXAMPLE OF CLUSTERS STRATA ASSIGNMENT (CONT)

HA = (>1.10, >1.10, <1.10)

HB = (>1.10, <1.10, <1.10)

MA = (>1.50, >1.10, > 1.10)

MB = (>1.10 & <1.50, >1.10, >1.10)

LA = (<1.10, <1.10, <1.10)

LB = (<1.10, ANYWHERE, >1.10)

NASA-S-78-17166

SUMMARY OF RESULTS FOR DFS

(AT HARVEST)

- NO SIGNIFICANT DIFFERENCE BETWEEN TRUE W/SG ESTIMATES AND DFS ESTIMATES
- NO SIGNIFICANT DIFFERENCE BETWEEN FIELDS PROCEDURE (WITH OR WITHOUT BIAS CORRECTION) W/SG ESTIMATES AND DFS ESTIMATES
- SIGNIFICANT INTERPRETATION TIME REDUCTION OVER FIELDS PROCEDURE WITH DFS
- SOME TIME REDUCTION OVER P-1 WITH DFS
- STRATIFICATION PROCEDURE CAN BE AUTOMATED

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SUPPORTING RESEARCH AND TECHNOLOGY (SRT) SESSION

STATUS OF YIELD ESTIMATION TECHNOLOGY – A REVIEW OF SECOND-GENERATION MODEL DEVELOPMENT

R. Stuff, JSC

NASA–S-78-17167

STATUS OF YIELD ESTIMATION TECHNOLOGY: A REVIEW OF SECOND-GENERATION MODEL DEVELOPMENT AND EVALUATION

NASA-S-78-17168

OUTLINE

- INTRODUCTION AND BACKGROUND
- OBJECTIVES
- APPROACH
- RESULTS
- CONCLUSIONS
- RECOMMENDATIONS

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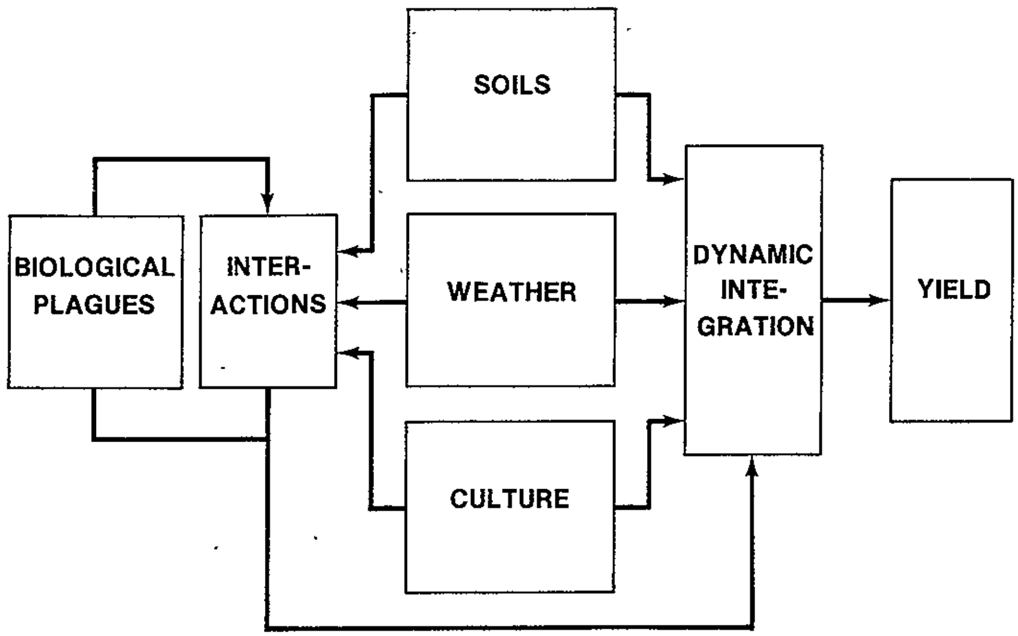
FIRST SUBDIVISION OF YIELD FACTORS



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LACIE BASELINE YIELD MODELS

- NO COMPREHENSIVE ASSESSMENTS OF AGROMETEOROLOGICAL YIELD MODEL CAPABILITIES PRIOR TO LACIE
- MULTIPLE REGRESSION MODELING* APPROACH SELECTED FOR APPLICATIONS EVALUATION ON THE BASIS OF RELATIVE EXPERIENCE AND EXPEDIENCY
- PERFORMANCE OF THE MULTIPLE REGRESSION MODELS ASSUMED AS BASELINE FOR EVALUATING ALTERNATIVES

*CLASSIFIED AS A FIRST-GENERATION MODEL – CORRELATION BASED CAUSE-EFFECT RELATIONSHIPS INFERRED DIRECTLY FROM TRADITIONAL HISTORICAL SURVEY DATA AGGREGATED FOR SPECIFIC AREAS

NASA-S-78-17171

MODEL FORM

$\hat{Y}$ = CONSTANT + TREND + WEATHER EFFECTS

CONSTANT = THE BASE YIELD CHARACTERISTIC OF A REGION IN THE ABSENCE OF TECHNOLOGICAL ENHANCEMENT

TREND = THE COMBINED EFFECT OF THE TECHNOLOGICAL IMPROVEMENTS ON YIELD – EXPRESSED AS A FUNCTION OF THE CHRONOLOGICAL YEAR

WEATHER EFFECTS = THE COMPONENT OF YIELD VARIATION ATTRIBUTABLE TO FLUCTUATIONS ABOUT THE LONG-TERM AVERAGE WEATHER IN A CROP REGION

BASED ON PREMISE THAT THERE IS A LEVEL OF YIELD GENERALLY DETERMINED BY LOCAL TECHNOLOGY AND SOIL CAPABILITY WITH YEAR-TO-YEAR FLUCTUATIONS ABOUT THAT LEVEL DUE TO WEATHER VARIATION

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GENERAL LIMITATIONS OF THE LACIE BASELINE YIELD MODELS

- NOT EXTENDABLE TO DIFFERENT OR ALTERNATIVE GEOGRAPHIC AREAS
- NUMBER OF VARIABLES (RESPONSIVENESS) CONSTRAINED BY LENGTHS OF HISTORICAL DATA RECORDS
- UNCERTAINTIES ASSOCIATED WITH THE USE OF SURROGATE VARIABLES
- DAMPING OF POTENTIAL RESPONSE AMPLITUDES DUE TO INFORMATION LOSS IN AREA-TIME DATA AVERAGING
  - EFFECTS OF LOCAL SHORT-DURATION WEATHER PHENOMENA
  - EFFECTS OF CROP CALENDAR SHIFTS
  - EFFECTS OF SOIL USAGE CHANGES

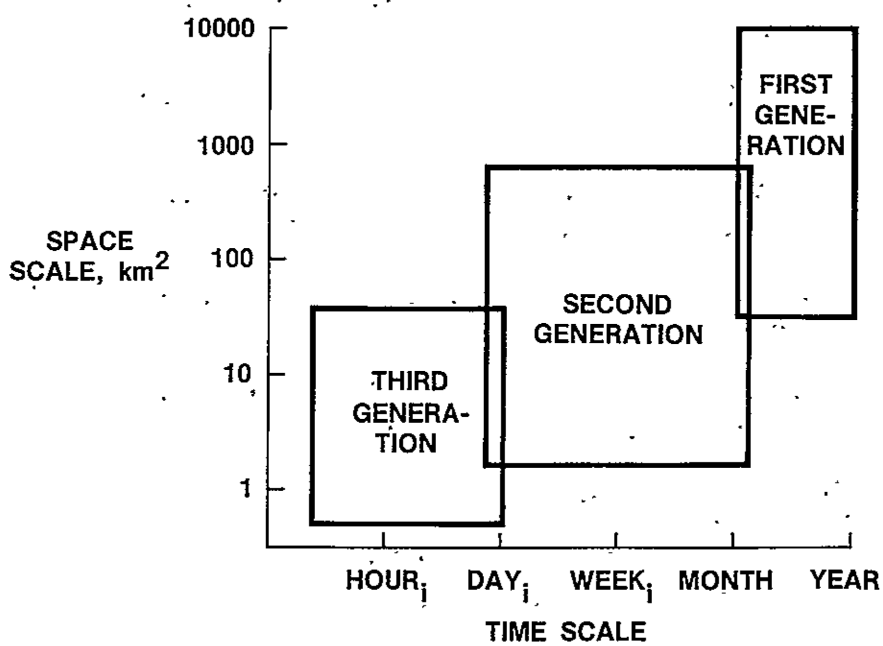
NASA-S-78-17173

OBJECTIVES OF SECOND-GENERATION YIELD MODELS

- CONTAIN A BASIS FOR EXTENSION TO ANY GEOGRAPHICAL AREA
- INCREASED FLEXIBILITY AND CAPABILITY TO UTILIZE ADDITIONAL INFORMATION SOURCES SUCH AS:
  - SATELLITE DATA
  - SOIL SURVEYS
  - SOIL MOISTURE MODELS
  - NITROGEN USE MODELS
  - PEST MODELS
  - CROP CALENDAR MODELS
- INCREASED RESPONSIVENESS TO EXTREME WEATHER CONDITIONS THROUGH RELATIONSHIPS THAT ARE REALISTIC TO A DAILY-FIELD LEVEL OF DETAIL

NASA-S-78-17174

RELATIONSHIP OF YIELD MODEL TYPES TO INPUT/OUTPUT SCALES



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INITIAL APPROACH AND BASIC RATIONALE

- IDENTIFY EXISTING AGROMETEOROLOGICAL MODELS THAT COULD POTENTIALLY SATISFY THE SECOND-GENERATION OBJECTIVES AND ESTIMATE THEIR PERFORMANCE RELATIVE TO THE LACIE BASELINE MODELS

GREATER YIELD ESTIMATION ACCURACY MAY BE NECESSARY TO MEET LACIE GOALS AND BELIEVED POSSIBLE WITH MINIMAL ADAPTATION OF THE BAIER OR HAUN MODELS WITH EXISTING DATA

- CARRY OUT RESEARCH NECESSARY TO UNDERSTAND THE APPLICABILITY OF MULTISPECTRAL OBSERVATIONS FOR ESTIMATING CROP YIELDS

IT WAS HYPOTHESIZED THAT LANDSAT DATA PRESENT A MEANS OF IMPROVING YIELD ESTIMATION SINCE THE INTEGRATED EFFECTS OF MORE YIELD FACTORS ARE POTENTIALLY OBSERVABLE AT ANY DESIRED LOCATION

NASA-S-78-17176

PROGRAM SUMMARY

PHASE	RESEARCH	COMPARATIVE EVALUATION
I	• SPECTRAL-YIELD THEORY • SPECTRAL-YIELD FIELD RESEARCH • LANDSAT-LAI-YIELD	• BAIER MODEL • HAUN MODEL
II	• SPECTRAL-YIELD FIELD RESEARCH • LANDSAT-LAI-YIELD • FEYERHERM MODEL	• EARTHSAT MODEL
III	• CCEA II MODEL • CATE-LIEBIG MODEL • USDA/SEA (SUBMODELS) • LANDSAT-LAI-YIELD	• FEYERHERM MODEL

NASA-S-78-17177

COMPARATIVE TEST AND EVALUATION CRITERIA

- WILCOXON PAIRED RANK TEST TO VERIFY GREATER ACCURACY THAN THE BASELINE MODELS IN THE USGP YARDSTICK REGION
- UNBIAS AND SIMILARITY OF MEAN SQUARE ERRORS FOR TEST PREDICTIONS OVER INDEPENDENT AREAS
- ANALYTICAL AND SENSITIVITY ANALYSES TO IDENTIFY AGRONOMIC REASONABLENESS, STRENGTHS, AND WEAKNESSES OF MODEL COMPONENTS (SOIL MOISTURE, ERROR PROPAGATION, PREHARVEST ESTIMATORS, ETC.)

NASA-S-78-17178

BAIER SPRING WHEAT MODEL

- YIELD = F(DAILY MAX TEMP) x F(DAILY MIN TEMP) x
  F(ACTUAL EVAPOTRANS/POTENTIAL EVAPOTRANS)
- SUBMODELS – PHENOLOGY
  – SOIL MOISTURE
- DATA BASE – EXPERIMENTAL PLOTS THROUGHOUT CANADA
- EVALUATION APPROACH
  - TEST RUN FOR VARIETY TRIAL DATA FROM USGP EXPERIMENTAL STATIONS
  - RECALIBRATE FOR WINTER WHEAT
- EVALUATION RESULTS
  - MODEL PREDICTED ERRATIC AND UNREALISTIC YIELDS
  - NO STABLE CALIBRATION FOUND FOR WINTER WHEAT

NASA-S-78-17179

HAUN SPRING WHEAT MODEL

- YIELD = EXP [$\alpha_0 + \alpha_1$ (GROWTH INDEX) + α_2 (PRESEASON PRECIP)
  + α_3 (GROWTH INDEX SQUARED) + α_4 (PRESEASON PRECIP SQUARED)
  + α_5 (GROWTH INDEX x PRESEASON PRECIP)]
- SUBMODELS – GROWTH INDEX
  – SOIL MOISTURE
- DATA BASE FOR α_1 – SAMPLE OF COUNTIES

  DATA BASE GROWTH INDEX – EXPERIMENTAL PLOTS
- EVALUATION APPROACH
  - ASSESS PERFORMANCE WITH TEST RUNS ON INDEPENDENT DATA
- EVALUATION RESULTS
  - NEW DATA BASE REQUIRED FOR WINTER WHEAT

NASA-S-78-17180

EARTHSAT SPRING WHEAT MODEL

- YIELD = $\alpha_0 + \alpha_1$(YEAR) + α_2 (1 – ACTUAL EVAPOTRANS/ POTENTIAL EVAPOTRANS)
- SUBMODELS – GRID CELL WEATHER FROM METEOROLOGICAL SATELLITES
  – PHENOLOGY
  – SOIL MOISTURE
- DATA BASE FOR FITTING YIELD EQUATION = 1950 TO 1972 FOR 3 NORTH DAKOTA COUNTIES
- EVALUATION PROCEDURE
  - USE AREA UNITS (COUNTIES, DISTRICTS, AND STATES) AS REPETITIONS TO COMPARE MODEL PREDICTIONS FOR 1975 WITH INDEPENDENT TREND ESTIMATES
  - TESTS METEOROLOGICAL SUBMODEL

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EARTHSAT SPRING WHEAT MODEL (CONT)

- EVALUATION RESULTS
  - MODEL PREDICTIONS WERE LESS ACCURATE THAN TREND PROJECTIONS
  - APPARENT MODEL BIAS WITH EXTENSION TO DIFFERENT AREAS
  - LOW DEGREE OF ASSOCIATION BETWEEN VARIATION IN ACTUAL AND PREDICTED YIELDS
- CONCLUSIONS
  - CRITICAL VARIABLES MISSING IN MODEL
  - ADDITIONAL RESEARCH ON ESTIMATING PRECIPITATION FROM SATELLITES NEEDED

NASA-S-78-17182

STATISTICS FOR COMPARING 1975 SPRING WHEAT YIELDS (USDA) AND PREDICTIONS BY EARTHSAT AND TIME SERIES MODELS

		AREA STRATA		
	STATISTIC	COUNTY	DISTRICT	STATE
EARTHSAT MODEL	CORRELATION COEFFICIENT	0.27	0.45	0.45
	REGRESSION COEFF (SLOPE)	.08	.15	.21
	MEAN DIFFERENCE	2.0	2.1	.8
	RMS ERROR	7.0	5.8	4.3
TIME SERIES MODEL	CORRELATION COEFFICIENT	0.75	0.90	0.94
	REGRESSION COEFF (SLOPE)	.55	.74	.85
	MEAN DIFFERENCE	3.1	3.4	3.2
	RMS ERROR	5.6	4.3	3.6
COMPARISON	RMSE MODEL / RMSE TIME SERIES	1.57	1.77	1.38

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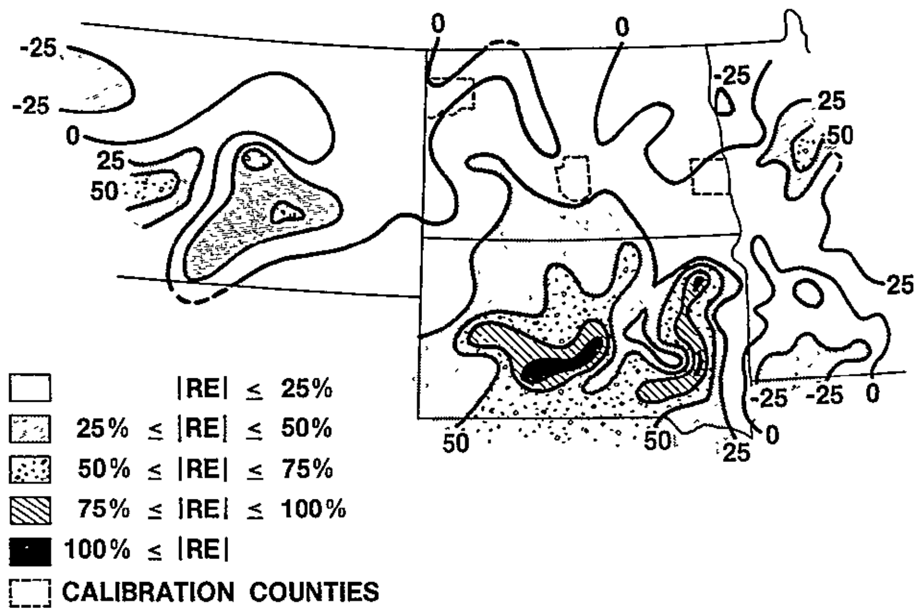
RELATIVE ERRORS (RE) FOR THE EARTHSAT MODEL PREDICTIONS OF 1975 SPRING WHEAT YIELDS



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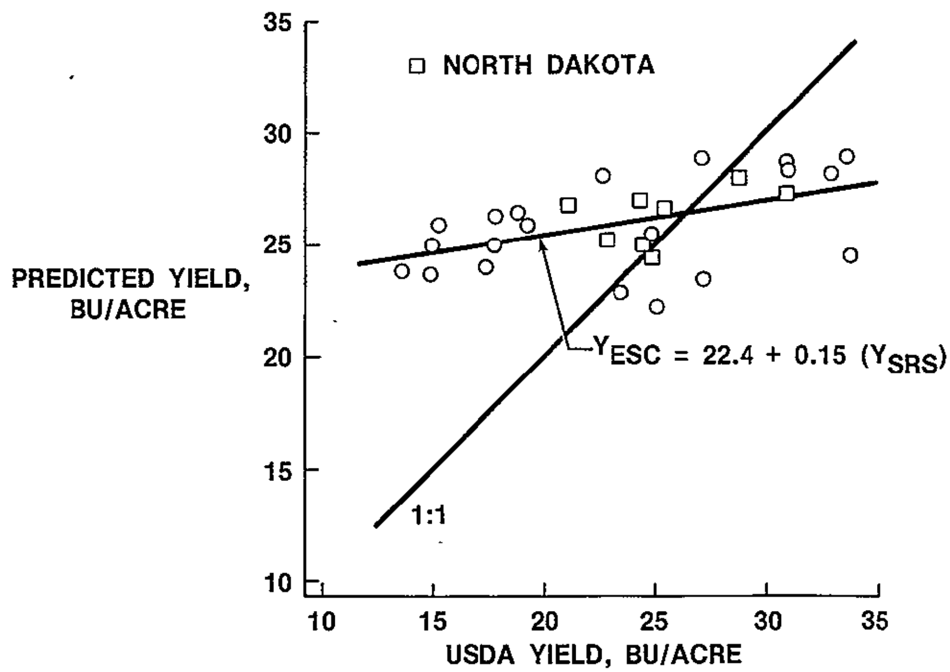
COMPARISON OF USDA AND PREDICTED 1975 DISTRICT YIELDS BY THE EARTHSAT MODEL



NASA-S-78-17185

FEYERHERM SPRING AND WINTER WHEAT YIELD MODELS

- $YIELD_{SW} = \alpha_0 + 0.5 \left[\sum_{i=1}^{3} (\text{AREA WT}_i \times \text{VARIETY}) \left(\sum_{j=1}^{12} \alpha_j \text{ WX VARIABLE } j + \alpha_i \text{ NITROGEN} \right) \right]$

  SUBMODELS – PHENOLOGY
  – SOIL MOISTURE

- DATA BASE FOR α_0 AND CULTURAL PRACTICE i = 4 TO 10 YEARS OF REGIONAL HISTORICAL DATA

  DATA BASE FOR α_j = VARIETY TRIAL PLOTS

- EVALUATION PROCEDURE
  - COMPARE ACCURACY TO BASELINE MODELS FOR 10 YEARS OF USGP TEST PREDICTIONS
  - ANALYZE MODEL PREDICTIONS OVER DIFFERENT AREAS

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FEYERHERM SPRING AND WINTER WHEAT YIELD MODELS (CONT)

- EVALUATION RESULTS
  - ACCURACY OF PREDICTIONS FOR USGP SPRING WHEAT EQUIVALENT TO LACIE BASELINE MODELS
  - ACCURACY OF PREDICTIONS FOR USGP WINTER WHEAT LESS THAN LACIE BASELINE MODELS
  - PREDICTIONS FOR "FOREIGN" AREAS ARE UNBIASED BUT VARIANCE APPEARS LARGER
- CONCLUSIONS
  - INADEQUATE SOILS, SOIL MOISTURE, CROP CALENDAR, AND DISEASE INFORMATION IN DATA BASE
  - CONCEPT OF MODEL EXTENSION TO DIFFERENT AREAS SUPPORTED

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RESULTS OF THE 10-YEAR (1967-76) COMPARATIVE TEST OF THE FEYERHERM AND LACIE PHASE III YIELD MODELS*

SPRING WHEAT	LACIE PHASE III**		FEYERHERM***	
PSEUDOZONE	BIAS	RMSE	BIAS	RMSE
MONTANA	-0.6	2.2	-0.1	2.6
NORTH DAKOTA	-1.2	2.9	-.1	2.5
RED RIVER	-1.4	4.0	.9	2.7
MINNESOTA	-.6	3.8	2.6	5.6
SOUTH DAKOTA	-.8	3.0	.9	5.0
TOTAL	-1.0	2.6	0.4	2.1

WILCOXON STATISTIC =-0.05

* MODEL PREDICTIONS RELATIVE TO USDA REPORTED YIELDS
** BASED ON COOPERATIVE MET STATION NETWORK
*** BASED ON SYNOPTIC MET STATION NETWORK

NASA-S-78-17188

RESULTS OF THE 10-YEAR (1967-76) COMPARATIVE TEST OF THE FEYERHERM AND LACIE PHASE III YIELD MODELS *

WINTER WHEAT	LACIE PHASE III**		FEYERHERM***	
PSEUDOZONE	BIAS	RMSE	BIAS	RMSE
MONTANA	-0.3	2.7	-0.1	2.2
BADLANDS	-.1	4.6	2.0	4.6
NEBRASKA	.2	2.9	2.2	4.5
COLORADO	-.8	3.4	1.6	4.6
KANSAS	-.3	3.4	.9	3.5
OKLAHOMA	.1	2.2	-1.0	2.2
OK-TX PAN-HANDLE	-.5	2.7	-.8	3.6
TEXAS	-.5	2.8	-1.3	2.2
TOTAL	-0.1	1.9	0.6	2.4

WILCOXON STATISTIC = -1.78

* MODEL PREDICTIONS RELATIVE TO USDA REPORTED YIELDS
** BASED ON COOPERATIVE MET STATION NETWORK
*** BASED ON SYNOPTIC MET STATION NETWORK

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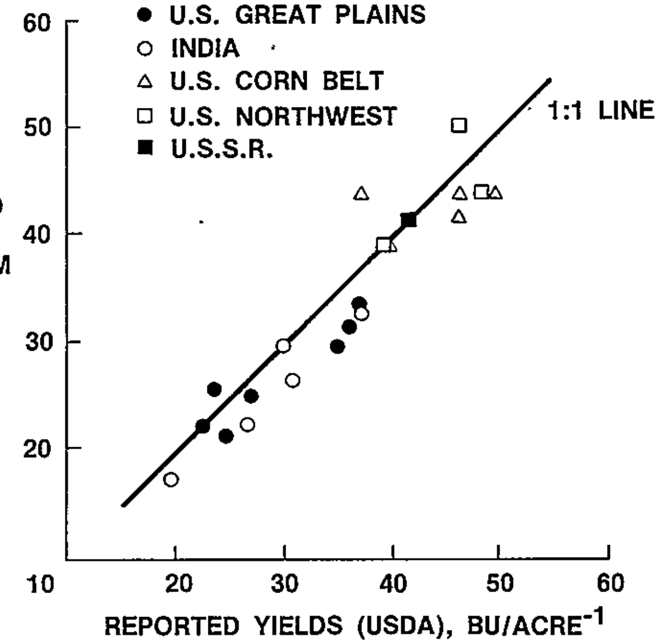
COMPARISON OF MEAN PREDICTED AND REPORTED WINTER WHEAT YIELDS FOR STRATA USED TO TEST THE FEYERHERM MODEL



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PRELIMINARY TESTS ON FEYERHERM WINTER WHEAT MODEL

REGION		BIAS, BU/ACRE	RMSE, BU/ACRE
U.S. GREAT PLAINS,	7 STATES x 10 YR	0.6	2.4
U.S. CORN BELT,	5 STATES, 12 YR	.8	4.4
U.S. NORTHWEST	3 STATES, 12 YR	1.0	4.5
U.S.S.R.	1 OBLAST, 10 YR	-.6	3.4

NASA-S-78-17191

CCEA II NORTH DAKOTA PROTOTYPE MODEL

- YIELD = $\alpha_0 + \alpha_1$(YEAR) + F(YEAR) + $\sum \alpha_i$ (WX VARIABLE)$_i$
- SUBMODELS – PHENOLOGY
  – SOIL MOISTURE
- DATA BASE – HISTORICAL RECORDS FOR NORTH DAKOTA CROP DISTRICTS
- RESEARCH RESULTS – SMALLER ERRORS WERE OBTAINED FOR "PROBLEM" YEARS FOR THE LACIE NORTH DAKOTA MODEL

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CATE-LIEBIG EXPLORATORY SPRING WHEAT MODEL

- YIELD = α_0 + 0.4 (NITROGEN · WATER UPTAKE) + α_1(TEMPERATURE)
- SUBMODELS – PHENOLOGY
  – WATER BALANCE
  – SOIL NITROGEN
- DATA BASE – CROP DISTRICTS USED TO ESTIMATE α_0 AND CULTURAL PRACTICES FOR THE FEYERHERM SPRING WHEAT MODEL
- RESEARCH RESULTS – PREDICTION ACCURACIES EQUIVALENT TO FEYERHERM AND LACIE MODELS CONSIDERED OF PRACTICAL SIGNIFICANCE FOR MODEL BUILDING

NASA-S-78-17193

RESULTS OF THE 10-YEAR (1967-76) COMPARATIVE TEST OF THE CATE-LIEBIG EXPLORATORY AND LACIE PHASE III YIELD MODELS *

SPRING WHEAT	LACIE PHASE III**		CATE-LIEBIG***	
PSEUDOZONE	BIAS	RMSE	BIAS	RMSE
MONTANA	-0.6	2.2	0.8	3.4
NORTH DAKOTA	-1.2	2.9	.1	1.4
RED RIVER	-1.4	4.0	-.8	3.2
MINNESOTA	-.6	3.8	-1.3	5.8
SOUTH DAKOTA	-.8	3.0	.8	4.1
TOTAL	-1.0	2.6	0.0	1.3

WILCOXON STATISTIC = -1.17

* MODEL PREDICTIONS RELATIVE TO USDA REPORTED YIELDS

** BASED ON COOPERATIVE MET STATION NETWORK

*** BASED ON SYNOPTIC MET STATION NETWORK

NASA-S-78-17194

USDA/SEA WINTER WHEAT MODEL CONCEPT

- YIELD = (HEADS PER ACRE) x (KERNELS PER HEAD) x (WEIGHT PER KERNEL)
- SUBMODELS – PHENOLOGY
  - – SOIL MOISTURE
  - – WINTER SURVIVAL
  - – TILLERING
  - – KERNEL SET
  - – KERNEL WEIGHT
  - – LANDSAT
- DATA BASE – RESEARCH PLOTS AND COMMERCIAL FIELDS
- STATUS – DATA COLLECTION INITIATED

NASA-S-78-17195

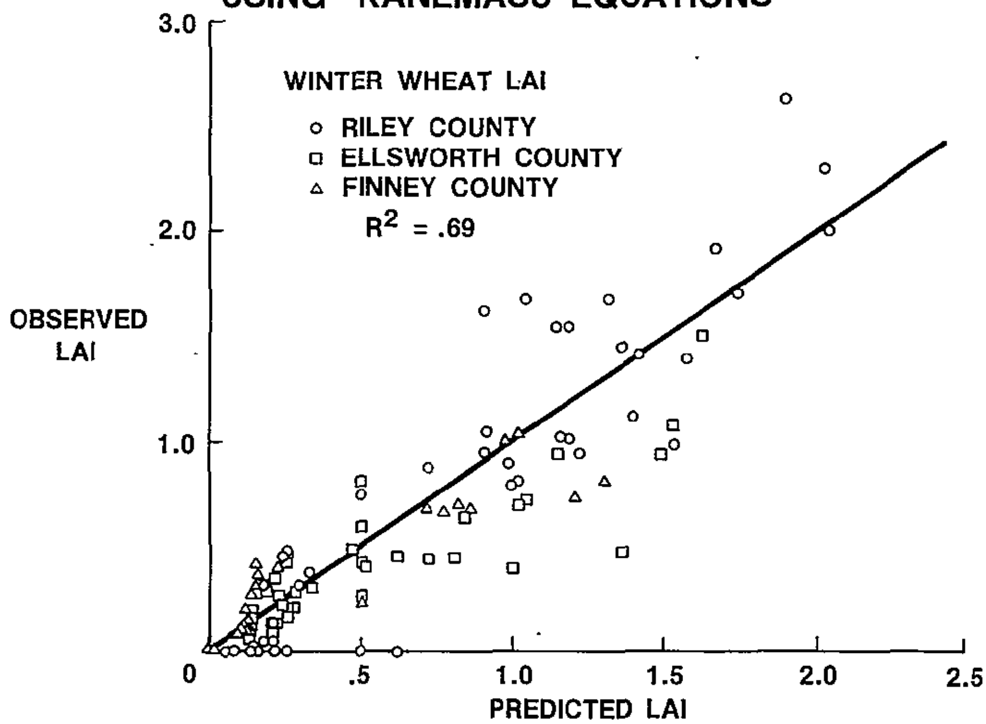
KANEMASU WINTER WHEAT PROTOTYPE MODELS

- YIELD = α_0 [(ACTUAL/POTENTIAL TRANS$_1$)$^{\alpha_1}$ (ACTUAL/POTENTIAL TRANS$_2$)$^{\alpha_2}$ (ACTUAL/POTENTIAL TRANS$_3$)$^{\alpha_3}$]

  YIELD = 0.74 [α_1(CARBON EXC RATE) + α_2 (LEAF AREA INDEX + CARBON EXC RATE + Σ CARBON EXC RATE)]
- SUBMODELS – PHENOLOGY
  - SOIL MOISTURE
  - DRY MATTER ACCUMULATION
  - LANDSAT LEAF AREA INDEX
- DATA BASE – EXPERIMENTAL PLOTS AND LACIE INTENSIVE TEST SITE FIELDS
- RESEARCH RESULTS – INDICATION OF SIGNIFICANT ABILITY TO ESTIMATE LEAF AREA AND FIELD YIELDS WITH THE TRANSPIRATION MODEL

NASA-S-78-17196

COMPARISON OF OBSERVED VERSUS PREDICTED LAI USING KANEMASU EQUATIONS



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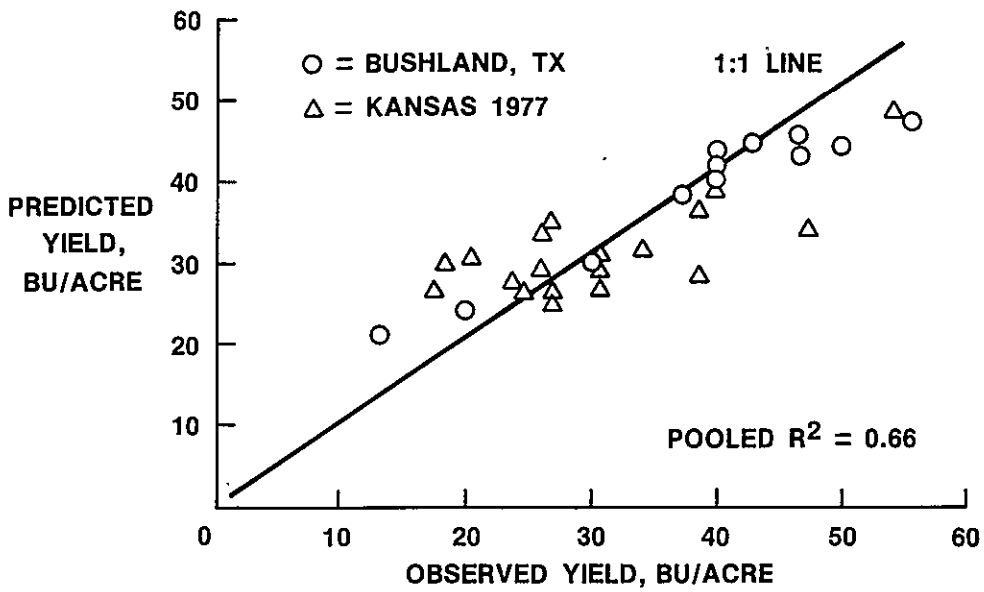
COMPARISON OF OBSERVED FIELD YIELDS WITH INDEPENDENT PREDICTIONS BY THE KANEMASU TRANSPIRATION MODEL



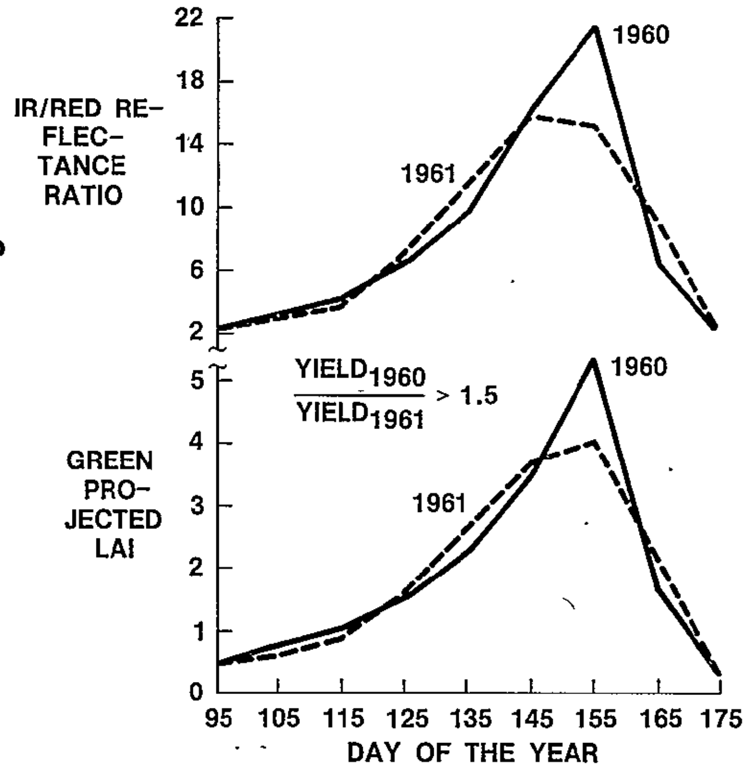
NASA-S-78-17198

ERIM SPECTRAL-YIELD SIMULATION MODEL

- YIELD = F(GREEN LEAF AREA DURATION)
- SUBMODELS — CROP GROWTH SIMULATION
  — BIDIRECTIONAL REFLECTANCE
- RESEARCH RESULTS — THEORETICAL YIELD DIFFERENCES THAT CAN BE DETERMINED BY CANOPY REFLECTANCES IN THE LANDSAT BANDS

NASA-S-78-17199

SIMULATED CROP AND SPECTRAL VALUES USING ERIM GROWTH AND VEGETATION REFLECTANCE MODELS



NASA-S-78-17200

OTHER SPECTRAL-YIELD STUDIES

- YIELD – SPECTRAL CORRELATION ANALYSES
- DATA BASE – LACIE INTENSIVE TEST SITE AND FIELD MEASUREMENT OBSERVATIONS
- RESULTS – SIGNIFICANT LANDSAT-YIELD CORRELATIONS THAT ARE CROP CALENDAR DEPENDENT
  – INDICATIONS OF CROP FEATURES IN ADDITION TO GREEN LEAF AREA "VIEWED" BY LANDSAT

NASA-S-78-17201

LANDSAT* - CROP DATA CORRELATION COEFFICIENTS

SAMPLE	NO. FIELDS	PLANT HEIGHT	GROUND COVER	YIELD DETRACTANT	ESTIMATED YIELD
A	30	0.28	0.26	-0.13	0.45
B	23	.45	.77	.02	.75
C	23	.25	.70	.16	.73
COMB	76	.54	.77	.02	.62

CORRELATION BETWEEN GROUND COVER AND YIELD (COMB) = 0.30

* KAUTH GREEN NUMBER

NASA-S-78-17202

CONCLUSIONS

- IMPROVED "YARDSTICK REGION" ACCURACY NOT DEMONSTRATED BY SECOND-GENERATION MODELS
  - DEVELOPMENT OF SECOND-GENERATION MODELS INCOMPLETE
  - IMPROVED DATA BASES NEEDED TO DEVELOP SECOND-GENERATION MODELS
- CONCEPT OF EXTENDING BASIC MODEL TO AREAS WITH SPARSE DATA RECORDS SUPPORTED
- COMPARATIVE EVALUATION CRITERIA DEVELOPED
- YIELD INFORMATION CONTENT IN LANDSAT DATA DEMONSTRATED AND CONCEPT OF COMBINED SPECTRAL-METEOROLOGICAL MODEL DEVELOPED

NASA-S-78-17203

RECOMMENDATIONS

- ESTIMATE OPTIMUM AREA REPRESENTATION/ SAMPLING FOR THE APPLICATION OF PARTICULAR YIELD MODELS
- DESIGN EXPERIMENTS TO DEVELOP JOINT AGROMETEOROLOGICAL-SPECTRAL YIELD MODELS
- COMPILE COMPREHENSIVE DATA BASES CONTAINING SOIL FERTILITY, SOIL MOISTURE, CROP CALENDAR, INSECT & DISEASE DAMAGE, SPECTRAL REFLECTANCE & RADIANCE, OBSERVATIONS
- IMPROVE SUBMODELS FOR ESTIMATING YEAR-TO-YEAR CHANGES IN CULTURAL PRACTICES, CROP PLANTING, AND BIOLOGICAL INFESTATIONS
- INVESTIGATE ADDITIONAL TIME SERIES PROCEDURES AS BASELINES FOR COMPARING MODELS AND POTENTIAL INPUT TO EARLY-SEASON YIELD ESTIMATION

SUPPORTING RESEARCH AND TECHNOLOGY (SRT) SESSION

PREDICTION OF WHEAT PHENOLOGICAL DEVELOPMENT — A STATE-OF-THE-ART REVIEW

M. Seeley, Lockheed/JSC

NASA-S-78-17204

PREDICTION OF WHEAT PHENOLOGICAL DEVELOPMENT

A STATE-OF-THE-ART REVIEW

NASA-S-78-17205

PREDICTION OF WHEAT PHENOLOGICAL DEVELOPMENT A STATE-OF-THE-ART REVIEW

- INTRODUCTION
- THE CONCEPT OF CROP PHENOLOGY
  - GROWTH
  - DEVELOPMENT
  - ASSUMPTION INVOLVED IN PHENOLOGICAL MODELS
- APPROACHES TO MODELING CROP PHENOLOGY
  - ROBERTSON'S MODEL
    - – THE NEED FOR A STARTER MODEL
    - – THE NEED FOR A DORMANCY MODEL
  - RE-DERIVED ROBERTSON MODELS
- LACIE CONTRIBUTIONS TO MODELING
- FUTURE TASKS

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INTRODUCTION

- THE OBJECTIVES OF THIS PAPER ARE TO DESCRIBE THE SUPPORTING RESEARCH IN CROP DEVELOPMENT MODELING (CROP CALENDARS) AND, MORE SPECIFICALLY, TO DISCUSS SOME OF THE RELATIVE MERITS AND SHORT-COMINGS OF VARIOUS MODELS FOR THE DEVELOPMENT OF WHEAT (TRITICUM AESTIVUM L.) WHICH EVOLVED FROM LACIE
- THE REQUIREMENTS FOR A WHEAT CROP CALENDAR AND ITS USES IN LACIE OPERATIONS HAVE BEEN DOCUMENTED IN PAPERS BY WHITEHEAD, WOOLLEY, AND ROGERS

NASA-S-78-17207

THE CONCEPT OF CROP PHENOLOGY

- CROP PHENOLOGY IS THE STUDY OF THE EXPRESSION OF GENOTYPIC x ENVIRONMENTAL INTERACTIONS EVIDENCED BY CHANGES IN PLANT CHARACTERISTICS DURING ITS LIFE CYCLE
- PHENOTYPIC CHARACTERISTICS ARE MANIFESTATIONS OF BOTH GROWTH AND DEVELOPMENT. HOWEVER, THESE TWO PROCESSES ARE FREQUENTLY CONFUSED
- GROWTH REFERENCES AN INCREASE IN PLANT SIZE (ROOTS, SHOOTS, STEMS, LEAVES, ETC.). THIS IS CELL DIVISION TO A PHYSIOLOGIST
- DEVELOPMENT IS THE SEQUENCE OF LIFE CYCLE EVENTS (INCLUDING GROWTH) WHICH LEAD TO CHANGES IN TISSUE STRUCTURE AND/OR FUNCTION. THIS COVERS CELL DIVISION, DIFFERENTIATION, AND SENESCENCE

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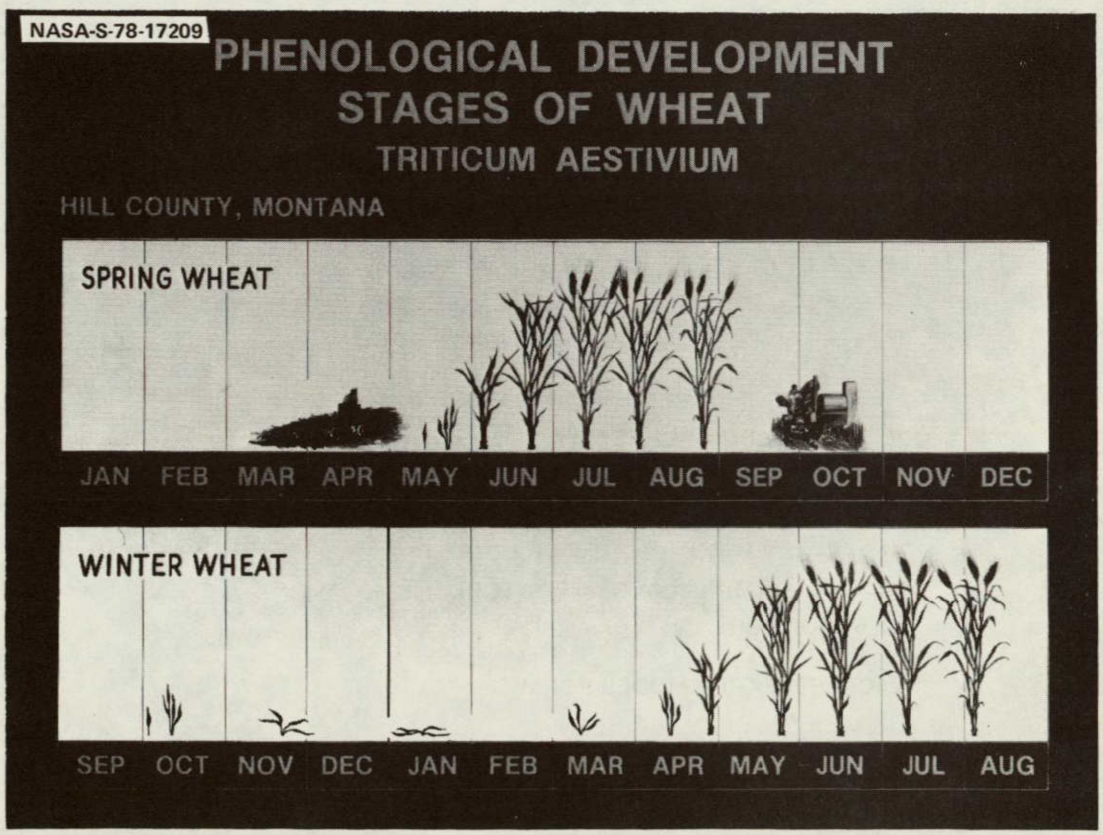
TYPES OF PLANT DEVELOPMENT

- THERE IS SOME DISAGREEMENT AMONG AGRICULTURAL SCIENTISTS CONCERNING THE CONCEPT OF PLANT DEVELOPMENT. THREE VARIANT CATEGORIES OF DEVELOPMENT CAN BE DESCRIBED
  - THE <u>POTENTIAL</u> RATE OF DEVELOPMENT IS DETERMINED GENETICALLY AND CAN ONLY BE ACHIEVED UNDER CONTROLLED OPTIMUM CONDITIONS
  - THE <u>ACTUAL</u> RATE OF DEVELOPMENT IS THE RESULT OF A SYSTEM OF GENOTYPIC x CLIMATIC x NUTRITIONAL INTERACTIONS WHICH OCCUR AT THE BIOCHEMICAL LEVEL IN NATURAL ENVIRONMENTS
  - THE <u>OBSERVED</u> RATE OF DEVELOPMENT DEPENDS ON THE DEGREE TO WHICH A CROP EXPRESSES CHANGES IN TISSUE STRUCTURE OR FUNCTION AND THE FREQUENCY AND ACCURACY OF OBSERVATIONS OF SUCH CHANGES



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SOME IMPORTANT ASSUMPTIONS ABOUT WHEAT DEVELOPMENT MADE IN LACIE CROP CALENDAR RESEARCH

- PHENOTYPIC CHARACTERISTICS OF WHEAT EXPRESS THE DEVELOPMENTAL PROCESS WELL AND ARE EASILY OBSERVED
- WHEAT IS RELATIVELY STABLE PHENOTYPICALLY
- THE DEVELOPMENT OF WHEAT CAN BE MODELED WITH READILY AVAILABLE CLIMATIC DATA
- THE SPATIAL VARIABILITY IN THE OCCURRENCE OF SPECIFIC STAGES IS RELATIVELY UNIFORM OVER YEARS

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APPROACHES TO MODELING WHEAT PHENOLOGICAL DEVELOPMENT

R = CONSTANT	STANDARD NORMAL CROP CALENDAR
R = F (GDD)	COOPER, KINCER, NUTTONSON, OTHERS
R = F (T, DL)	NUTTONSON, ASANA, OTHERS
R = F (Tx, Tn, DL)	ROBERTSON, FRIEND
*R = F (Tx, Tn, DL, M)	BAKER, TRENCHARD

R = RATE OF DEVELOPMENT/DAY
GDD = GROWING DEGREE DAYS
T = DAILY MEAN TEMPERATURE
DL = DAY LENGTH
Tx = DAILY MAXIMUM TEMPERATURE
Tn = DAILY MINIMUM TEMPERATURE
M = MOISTURE

*LACIE RESEARCH MODEL FORM

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PROBLEM 1

THE NEED FOR A STARTER MODEL TO INITIALIZE THE BMTS USED IN LACIE

STARTING THE BMTS WITH NORMAL PLANTING DATES RESULTED IN ERRORS (COMMONLY 10 OR MORE DAYS) DUE TO THE DIFFERENCES BETWEEN NORMAL AND ACTUAL PLANTING DATES

STARTER MODEL DEVELOPMENT IN LACIE

LACIE PHASE I

1. HAUN (CLEMSON) DEVELOPED A SPRING WHEAT STARTER MODEL USING TEMPERATURES, ESTIMATED SOIL MOISTURE, AND PRECIPITATION. TESTS OF THIS MODEL IN NORTH DAKOTA CRD'S SHOWED AN RMSE OF 11.4 DAYS

LACIE PHASE II

2. FEYERHERM (KSU) RELATED TEMPERATURE ACCUMULATIONS TO PLANTING DATES FOR SPRING WHEAT. PRELIMINARY TESTS IN NORTH DAKOTA SHOW AN RMSE OF 6 5 DAYS
3. STUFF (NASA/JSC) AND PHINNEY (LEC/SSD) USED TEMPERATURE, PRECIPITATION, AND NORMAL PLANTING DATES TO ESTIMATE PLANTING OF SPRING WHEAT. PRELIMINARY TESTS IN NORTH DAKOTA SHOW AN RMSE OF 6.5 DAYS

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PROBLEM 1, (CONT)

LACIE PHASE II AND TY

4 LYTLE ET AL (CCEA) DEVELOPED A STARTER MODEL FOR SPRING WHEAT USING TEMPERATURE, PRECIPITATION, TRENDS IN PLANTING, AND THE DIFFERENCES BETWEEN PRECIPITATION AND POTENTIAL EVAPOTRANSPIRATION (THORNTHWAITE). PRELIMINARY TESTS IN NORTH DAKOTA SHOW AN S.E.E. = 4.5 DAYS
5. DEVELOPMENT PLANNING AND RESEARCH ASSOCIATES, INC., ARE CURRENTLY DEVELOPING A STARTER MODEL FOR WINTER WHEAT USING NORMAL PLANTING DATES, SOIL TRAFFICABILITY (SOIL MOISTURE), AND FARMER BEHAVORIAL CONCEPTS TO DATE, THERE ARE NO TEST RESULTS ON THIS MODEL

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PROBLEM 1

ACCURACY OF SPRING WHEAT CROP CALENDAR WITH FEYERHERM STARTER MODEL

- COMPARISON OF LACIE ACC WITH OBSERVED STAGES OF DEVELOPMENT IN SPRING WHEAT INTENSIVE TEST SITES PHASE III (U.S. AND CANADA)

OBSERVED (ACC)	JOINTING	HEADING	SOFT DOUGH	RIPE
MEAN BIAS (DAYS)	3.7	1.6	7.8	5.6
STANDARD ERROR (DAYS)	7.2	6.8	9.9	11.7

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PROBLEM 2

WITHOUT CORRECTIONS FOR THE DORMANCY PERIOD IN WINTER WHEAT, THE PERFORMANCE OF THE BMTS WAS POOR (PHASE I)

ADJUSTMENTS FOR DORMANCY IN THE LACIE WINTER WHEAT CROP CALENDARS

LACIE PHASE II

1. BASKETT ET AL (LEC/SSD) ADJUSTED THE BMTS BY DEFINING THRESHOLD LEVELS IN THE DAILY INCREMENT OF DEVELOPMENT (DID). THIS MODEL WAS USED OPERATIONALLY IN PHASE II; HOWEVER, IT STILL SHOWED ERRORS OF UP TO 20 DAYS FOR THE EMERGENCE TO HEADING PERIOD

2. FEYERHERM (KSU) CORRECTED FOR THE DORMANCY PERIOD BY ADJUSTING THE BMTS INTERVAL FOR EMERGENCE TO HEADING USING ANNUAL PRECIPITATION AND JANUARY TEMPERATURE. THIS METHOD HAS BEEN USED IN OPERATIONS SINCE PHASE III. WHEN TESTED ON AN INDEPENDENT PHENOLOGICAL DATA SET, THIS METHOD SHOWS ERRORS IN ESTIMATING THE EMERGENCE TO HEADING PERIOD OF 15 TO 20 DAYS

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PROBLEM 2 (CONT)
LACIE PHASE III AND TY

3. BAKER (FORT LEWIS COLLEGE) ADJUSTED THE WINTER WHEAT MODEL FOR DORMANCY BY USING A DAILY MEAN TEMPERATURE BASE AS THE CRITICAL VALUE FOR STOPPING THE EARLY GROWTH PERIOD (0° C) AND RESTARTING IN THE SPRING. (4.5°C) TO DATE, THIS MODEL SHOWS RMSE TERMS OF 18 OR MORE DAYS FOR THE E–J PERIOD WHEN TESTED IN U.S. WINTER WHEAT AREAS

4. TRENCHARD (LEC/SSD) ADJUSTED THE BMTS FOR THE EMERGENCE TO JOINTING PERIOD IN WINTER WHEAT BY RE-DERIVING COEFFICIENTS FOR THIS PERIOD USING A USDA-SRS PHENOLOGICAL DATA BASE FOR 23 CRD's. THE S.E.E. ASSOCIATED WITH THE E–J PERIOD IN THE NEW MODEL WAS 11.5 DAYS. TO DATE, NO INDEPENDENT TEST HAS BEEN MADE

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WINTER WHEAT CROP CALENDARS
ERRORS IN DAYS GIVEN THE OBSERVED STAGE AND STARTING DATE OF EACH BIOPHASE

STAGE	2	3	4	5	6
ORIGINAL					
BIAS	6.78	16.97	-8.46	-1.77	6.71
RMSE	9.32	20.45	9.66	6.03	7.72
RE-DERIVED					
BIAS	12.07	6.25	0.51	0.61	0.19
RMSE	13.38	11.58	4.77	4.31	3.84
NEW (RDCC)					
BIAS		-1.47	0.62	-0.08	-0.25
RMSE		10.06	5.04	4.23	3.54
NO. OBS	46	32	71	83	48

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WINTER WHEAT CROP CALENDARS

ERROR IN DAYS WHEN RUN FROM THE OBSERVED PLANTING DATE

STAGE	2	3	4	5	6
ORIGINAL					
BIAS	6.78	20.00	0.57	-1.19	7.15
RMSE	9.32	24.73	8.20	7.00	11.40
RE-DERIVED					
BIAS		28.57	24.50	24.40	22.53
RMSE		35.92	33.60	28.67	27.71
NEW (RDCC)					
BIAS		1.66	2.26	2.18	0.49
RMSE		17.57	12.83	11.18	11.74
NO. OBS	46	94	102	103	55

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RE-DERIVATION OF THE ROBERTSON MODEL FOR WINTER WHEAT

- TRENCHARD (LEC/SSD) RE-DERIVED THE ROBERTSON TRIQUADRATIC EQUATIONS FOR EACH BIOSTAGE, USING USDA-SRS WINTER WHEAT PHENOLOGICAL DATA FROM SEVEN STATES. RESULTS OF THIS WORK ARE ENCOURAGING, BUT THERE IS A LACK OF INDEPENDENT PHENOLOGICAL DATA WITH WHICH TO TEST THIS MODEL

- TRENCHARD USED THE SAME PHENOLOGICAL DATA SET TO DERIVE A NEW BMTS FOR WINTER WHEAT IN WHICH PRECIPITATION (RDCC) IS SUBSTITUTED FOR DAY LENGTH. THIS MODEL FORM FIT THE DATA FROM WHICH IT WAS DEVELOPED QUITE WELL AND WILL BE FURTHER TESTED

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LACIE CONTRIBUTIONS TO MODELING THE PHENOLOGICAL DEVELOPMENT OF WHEAT

- TESTING OF THE ROBERTSON BIOMETEOROLOGICAL TIME SCALE ON DIFFERENT TYPES OF WHEAT, AND IN DIFFERENT AGRICULTURAL REGIONS OF THE WORLD AND ASSESSING THE LIMITS TO THE EXTRAPOLATION OF THIS MODEL
- STARTER MODELS FOR INITIALIZING THE BMTS FOR SPRING WHEAT
- IMPROVEMENT OF THE ROBERTSON EQUATIONS FOR WINTER WHEAT DEVELOPMENT AND, MORE SPECIFICALLY, AN ACCOUNTING OF THE DORMANCY PERIOD

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RECOMMENDED FUTURE TASKS

- ASSESS THE NOISE LEVEL IN THE USDA-SRS PHENOLOGICAL DATA ACCORDING TO THE ROBERTSON DEVELOPMENT SCALE
- OBTAIN ADDITIONAL PHENOLOGICAL DATA FROM PUBLIC INSTITUTIONS AND/OR PRIVATE INDUSTRY THROUGH THE SUPPORTING RESEARCH AND TECHNOLOGY PROGRAM
- TEST THE RE-DERIVED FORMS OF THE ROBERTSON EQUATIONS, INCLUDING THOSE WITH A MOISTURE VARIABLE
- TRY THE CATE-LIEBIG LAW OF THE MINIMUM TECHNIQUE IN MODELING PHENOLOGICAL DEVELOPMENT
- ASSESS THE USE OF MSS DATA IN BOTH DEVELOPING AND CALIBRATING CROP CALENDAR MODELS

NASA-S-78-17224

SUMMARY HIGHLIGHTS FROM THE STATE-OF-THE-ART REVIEW PAPER ON WHEAT PHENOLOGICAL MODELS

- CROP DEVELOPMENT MODELS (CROP CALENDARS) HAVE TRADITIONALLY BEEN BASED ON OBSERVED CHARACTERISTICS OF THE PLANT LIFE CYCLE (CROP PHENOLOGY)
- OF THE FUNCTIONAL FORMS AVAILABLE, THE ROBERTSON BIOMETEOROLOGICAL TIME SCALE (BMTS) FOR ESTIMATING THE DEVELOPMENT OF SPRING WHEAT WAS USED IN LACIE BECAUSE IT USED A SIMPLE PHENOLOGICAL SCALE AND IT CONSIDERED CURVILINEAR EFFECTS OF TEMPERATURE AND DAY LENGTH
- STARTER MODELS DEVELOPED TO INITIALIZE THE SPRING WHEAT CROP CALENDAR IMPROVED ESTIMATES OF THE FIRST BIOPHASE (E-J) BY 40 TO 50 PERCENT
- WINTER WHEAT DORMANCY MODELS, REQUIRED TO ADJUST THE ORIGINAL SPRING WHEAT BMTS, IMPROVED ESTIMATION OF THE EARLY STAGES IN WINTER WHEAT BY 50 PERCENT
- IN ORDER TO FURTHER ADVANCE THE STATE OF WHEAT PHENOLOGICAL MODELS, MUCH MORE FIELD DATA ARE NEEDED TO TEST RESEARCH MODELS SUCH AS THE TRENCHARD CROP CALENDAR WHICH USES TEMPERATURE AND MOISTURE INPUTS

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RESOURCES ALLOCATED FOR LACIE CROP CALENDAR DEVELOPMENT

RESEARCH RESPONSIBILITY	FUNDING
• CONTRACTS	
• BAKER (FORT LEWIS, COLORADO)	$ 25 000
• FEYERHERM (KSU)	$ 40 000
• DPRA (MANHATTAN, KANSAS)	$ 60 000*
• IN-HOUSE (JSC)	$100 000

*CONTRACT RESEARCH STILL IN PROGRESS

N79-1449

SUPPORTING RESEARCH AND TECHNOLOGY (SRT) SESSION

NEW DEVELOPMENTS IN SAMPLING AND AGGREGATION FOR REMOTELY SENSED SURVEYS

A. Feiveson, JSC

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NEW DEVELOPMENTS IN SAMPLING AND AGGREGATION

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NEW DEVELOPMENTS IN SAMPLING AND AGGREGATION*

- NEW STRATIFICATION PROCEDURES BASED ON
  - CLIMATE/SOILS/AG DIST. (NATURAL SAMPLING STRATEGY)
  - FULL-FRAME CRUDE ESTIMATES OF SMALL GRAINS CONTENT
- NEW AGGREGATION PROCEDURES BASED ON
  - REGRESSION
  - MULTIYEAR DATA
  - DOWNWEIGHTING OF QUESTIONABLE SEGMENT ESTIMATES

*AGGREGATION: THE PROCESS OF OBTAINING AN ESTIMATE OF CROP ACREAGE OR PRODUCTION OVER A LARGE AREA FROM MEASUREMENTS ON BASIC SAMPLING UNITS WITHIN THAT AREA

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NASA-S-78-17228

STRATIFICATION

OBJECTIVE:

TO DIVIDE A COUNTRY INTO STRATA SUCH THAT A GIVEN ACCURACY GOAL FOR NATIONAL WHEAT PRODUCTION (BASED ON STRATIFIED SAMPLING) CAN BE MET WITH MINIMUM COST (i.e., SAMPLE SIZE)

SOURCES OF DATA AVAILABLE FOR STRATIFICATION

- HISTORICAL WHEAT DATA FOR POLITICAL SUBDIVISIONS*
- CLIMATIC DATA**
- SOILS MAPS**
- TOPOGRAPHIC MAPS**
- LANDSAT DATA FROM PREVIOUS YEARS
  - AG/NON-AG*
  - SMALL GRAINS***

*USED IN LACIE FIRST-GENERATION STRATIFICATION
**USED IN "NATURAL SAMPLING STRATEGY"
***PROPOSED BY THE UNIVERSITY OF CALIFORNIA

NASA-S-78-17229

THREE LEVELS OF STRATIFICATION TECHNOLOGY

I LACIE FIRST-GENERATION STRATEGY

- STRATA CONSISTED OF AG AREA WITHIN POLITICAL SUBDIVISIONS

(+) • STRATIFICATION EFFICIENCY GOOD IN COUNTRIES SUCH AS U.S. WHERE ADEQUATE AND RELIABLE HISTORICAL DATA WERE AVAILABLE

(+) • HISTORICAL DATA FOR POLITICAL SUBDIVISIONS WAS A CONVENIENT BASIS ON WHICH TO ALLOCATE SAMPLES

(-) • STRATA IN OTHER COUNTRIES SUCH AS U.S.S.R. WERE TOO LARGE AND NONHOMOGENEOUS AND HENCE NOT EFFICIENT

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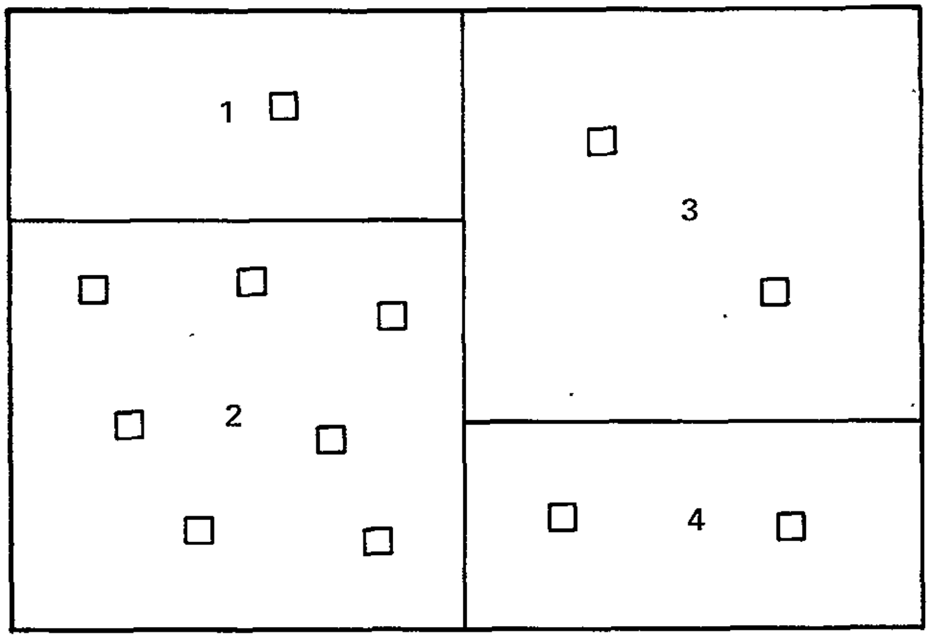
LACIE FIRST-GENERATION SAMPLING STRATEGY



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THREE LEVELS OF STRATIFICATION TECHNOLOGY (CONT)

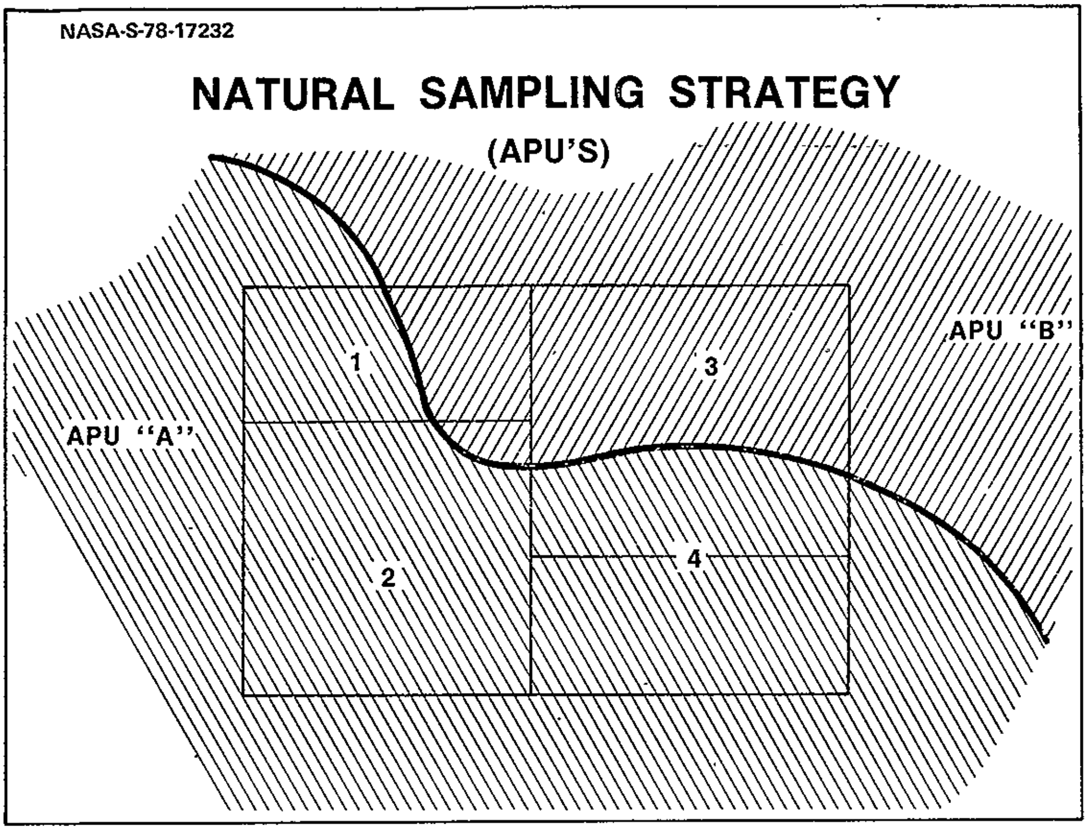
II. NATURAL SAMPLING STRATEGY

- DIVIDE COUNTRY INTO APU'S (AGROPHYSICAL UNITS) BASED ON CLIMATE, TOPOGRAPHY, SOILS, AND AG
- INTERSECT APU'S WITH STRATA FROM FIRST-GENERATION STRATEGY TO FORM "REFINED STRATA"

(+) • PROVIDES MORE HOMOGENEOUS STRATA IN COUNTRIES WITHOUT ADEQUATE HISTORICAL DATA

(+) • COULD REDUCE BIAS CAUSED BY UNEQUAL INCIDENCE OF CLOUD COVER

(-) • MORE DIFFICULT TO DECIDE ON ALLOCATION OF SAMPLES TO STRATA SINCE HISTORICAL DATA NOT AVAILABLE AT STRATUM LEVEL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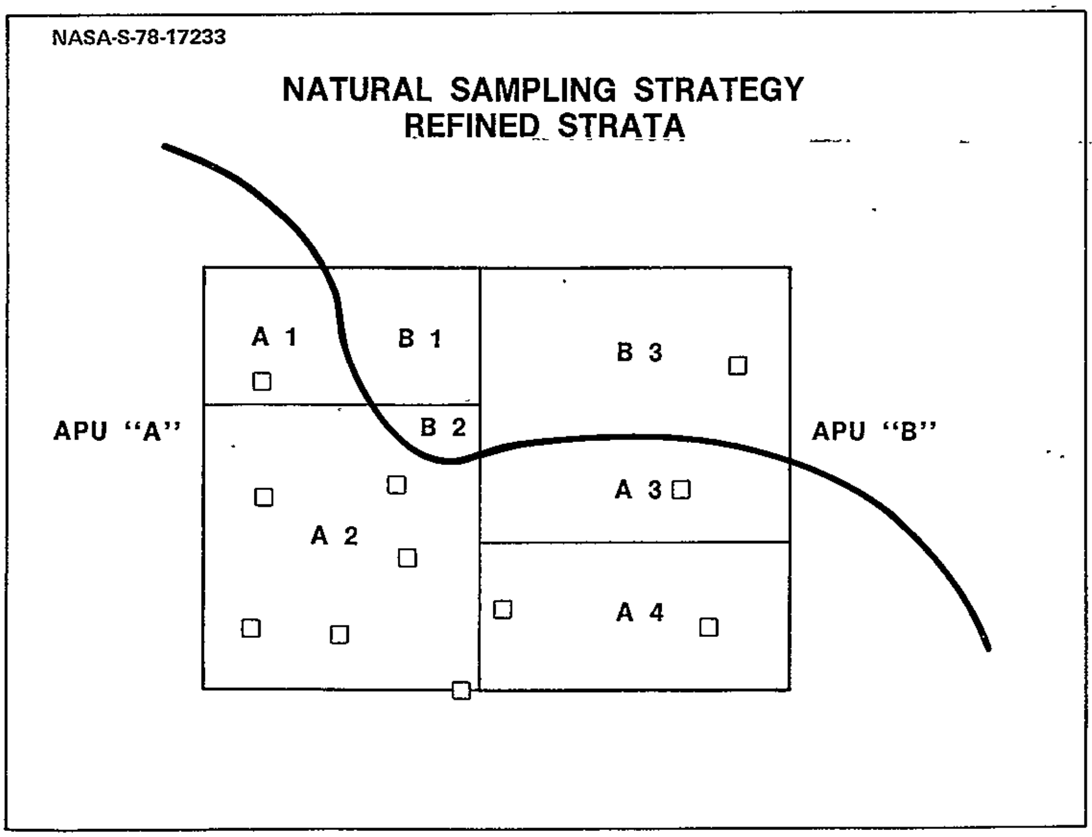
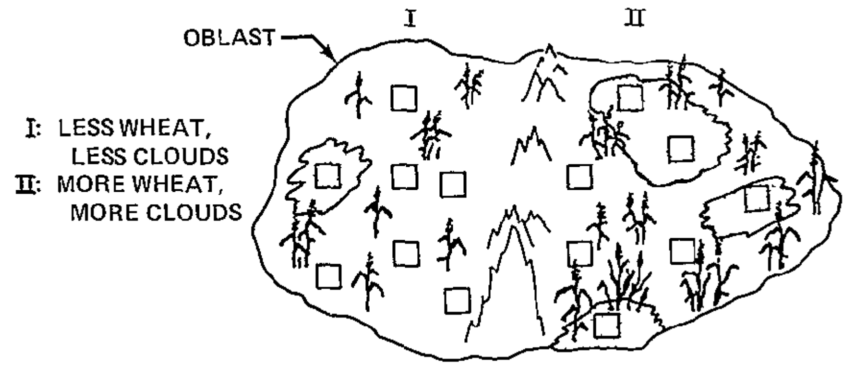
NATURAL SAMPLING STRATEGY
(APU'S)
1
3
APU "B"
APU "A"
4
2


NASA-S-78-17233
NATURAL SAMPLING STRATEGY
REFINED STRATA
A 1
B 1
B 3
APU "A"
B 2
APU "B"
A 3
A 2
A 4

NASA-S-78-17234

HOW THE NSS CAN ELIMINATE CLOUD-COVER BIAS



□ – SAMPLE SEGMENT   – SAMPLE SEGMENT OBSCURED

LACIE: $\hat{Y} = \frac{N}{n} \sum_{i=1}^{n} y_i$ (BIASED)   NSS: $\hat{Y} = \frac{N_1}{n_1} \sum_{i \in I} y_i + \frac{N_2}{n_2} \sum_{i \in II} y_i$ (UNBIASED)

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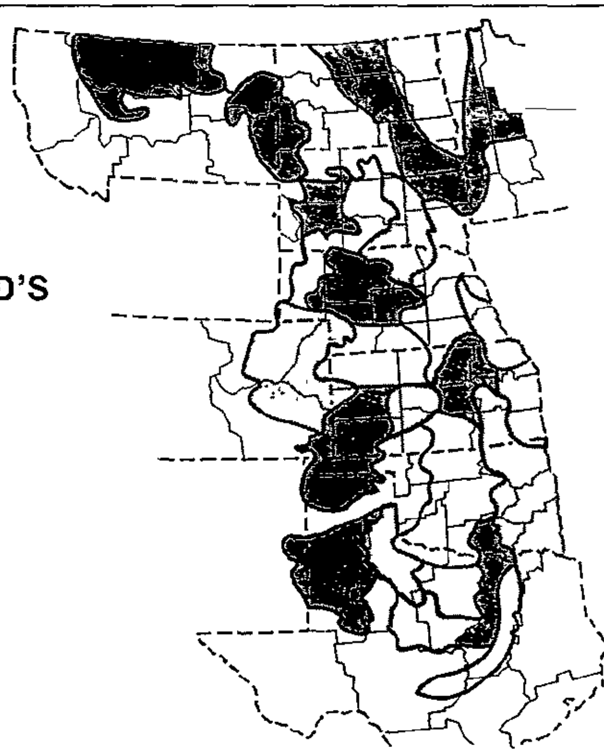
GREAT PLAINS CRD'S AND APU'S



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NATURAL SAMPLING STRATEGY TEST

- TEST FEASIBILITY OF NATURAL STRATIFICATION TECHNIQUES IN USGP AND U.S.S.R.
  - EVALUATE BETWEEN-STRATUM VARIANCE FOR "REFINED STRATA" FOR 6 STATES – COMPARE WITH CRD's
  - PERFORM ALLOCATION AND AGGREGATION FOR SELECTED STATES AND OBLASTS

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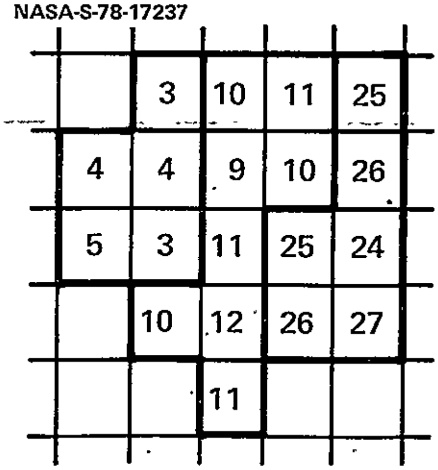
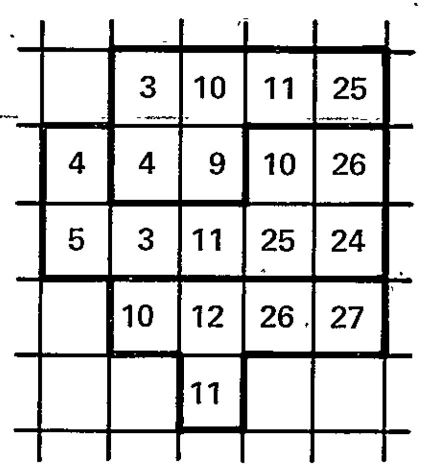


HOMOGENEOUS STRATA
MEANS: 3.8, 10.5, 25.5
HIGH BSS

NEEDS FEWER SEGMENTS TO ESTIMATE TOTAL



NONHOMOGENEOUS STRATA
MEANS: 10.3, 13.5, 17.2
LOW BSS

NEEDS MORE SAMPLES TO ESTIMATE TOTAL

NASA-S-78-17238

NATURAL SAMPLING STRATEGY TEST RESULTS

A. RELATIVE DIFFERENCE* IN BETWEEN-STRATA VARIANCE, APU vs CRD

STATE	AG DENSITY	WHEAT DENSITY	WHEAT YIELD
TEXAS	0.7469	0.6346	-0.1690
OKLAHOMA	.1649	.1231	.2059
KANSAS	5.2776	.0293	.9139
NEBRASKA	.1515	.2182	1.2616
S. DAKOTA	.1560	.1819	-.0975
MINNESOTA	-.9643	.2253	-.4574

* [BSS(APU) – BSS(CRD)] /BSS(CRD) – BASED ON COUNTY STATISTICS

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NATURAL SAMPLING STRATEGY TEST RESULTS (CONT)

B. AGGREGATIONS IN U.S.S.R./U.S.

REGION	NO. SEGMENTS (NSS)	NO. SEGMENTS (OLD)	CV PRODUCTION (NSS)	CV PRODUCTION (OLD)
KANSAS	76	108	9.1	6.6
KURGAN (U.S.S.R.)	6	12	28.6	22.7
KUSTANAY (U.S.S.R.)	48	52	38.2	38.8
TSELINOGRAD (U.S.S.R.)	17	28	39.3	39.5

NASA-S-78-17240

THREE LEVELS OF STRATIFICATION TECHNOLOGY (CONC)

III. TWO-PHASE PPES STRATA (U. OF CAL.)

- EXAMINE MOST RECENT IMAGERY ON A FULL-FRAME BASIS TO OBTAIN CRUDE WHEAT PROPORTION ESTIMATE
- USE ABOVE INFORMATION TO FURTHER REFINE STRATA, IF NECESSARY
- ALLOCATE CURRENT-YEAR SEGMENTS USING ABOVE INFORMATION
- (+?) IF CRUDE ESTIMATES HAVE A REASONABLE CORRELATION WITH ACTUAL WHEAT ON THE GROUND, A MORE EFFICIENT SAMPLING DESIGN CAN BE CONSTRUCTED

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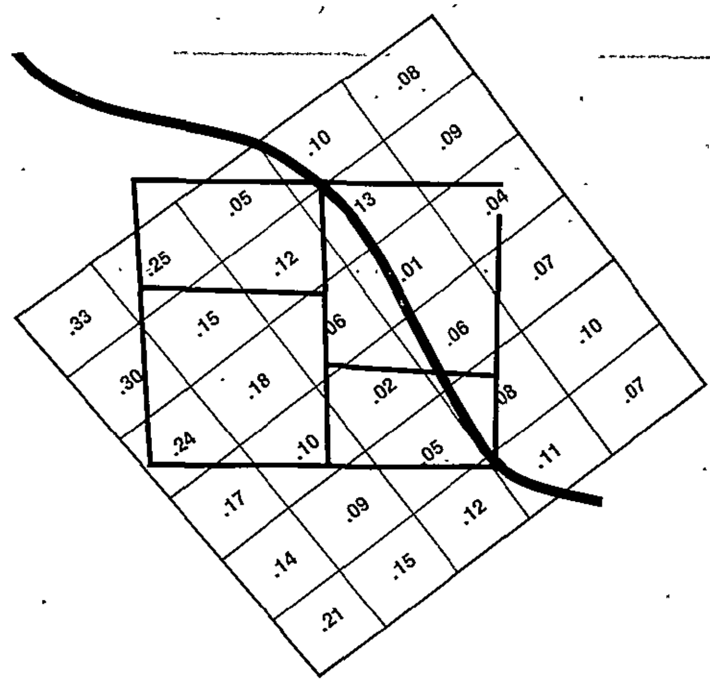

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PRELIMINARY TEST OF VIABILITY OF FULL-FRAME ESTIMATES

- COMPUTE CORRELATION BETWEEN "CRUDE" WHEAT PROPORTION ESTIMATES MADE FROM FULL-FRAME IMAGERY AND ESTIMATES MADE BY INTENSIVE EXAMINATION OF DETAILED IMAGERY FOR A SAMPLE OF SEGMENTS IN SOME CRD's IN KANSAS

RESULTS:

LOCATION	NO. SEGMENTS	CORRELATION
SW CRD	16	0.82
CENTRAL CRD	16	-.05
CENTRAL CRD*	14	.79

*DIFFERENT DATE

NASA-S-78-17243

AGGREGATION

OBJECTIVE: TO COMBINE SEGMENT-LEVEL WHEAT ACREAGE ESTIMATES WITH AVAILABLE YIELD AND ANCILLARY INFORMATION SO AS TO PRODUCE THE MOST ACCURATE ESTIMATE POSSIBLE FOR A COUNTRY'S WHEAT PRODUCTION

SOURCES OF DATA AVAILABLE FOR AGGREGATION

- CURRENT-YEAR SEGMENT WHEAT AREA ESTIMATES*
- OTHER YEARS' SEGMENT WHEAT AREA ESTIMATES**
- INDICATORS OF SEGMENT ACCURACY (BIOPHASES USED, CAMS RATING, ETC.)***
- FULL-FRAME IMAGERY****
- CURRENT-YEAR YIELD ESTIMATES*
- HISTORICAL YIELD AND WHEAT ACREAGE DATA*

*USED IN LACIE FIRST-GENERATION AGGREGATION TECHNOLOGY

**PROPOSED FOR MULTIYEAR ESTIMATION BY H. O. HARTLEY

***PROPOSED FOR WEIGHTED AGGREGATION

****PROPOSED FOR REGRESSION ESTIMATION (UCB)

NASA-S-78-17244

FOUR TYPES OF AGGREGATION TECHNOLOGY

I. LACIE FIRST GENERATION

- FOR STRATA WITH SEGMENTS, USE "DIRECT EXPANSION"
- "GROUP III RATIO" FOR STRATA WITHOUT SEGMENTS
- MULTIPLY BY YIELD AND SUM

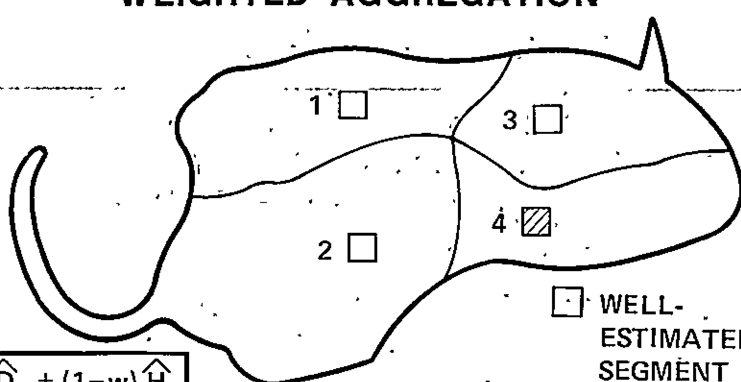
II. WEIGHTED AGGREGATION

- ALLOW FOR DIFFERENCES IN RELIABILITY OF SEGMENT-LEVEL ESTIMATES BY DOWNWEIGHTING THOSE THOUGHT TO BE POORLY ESTIMATED
- REPLACE STRATUM ESTIMATE BY WEIGHTED AVERAGE BETWEEN "DIRECT" AND "GROUP III" ESTIMATES

(+) • PREVENTS "WILD" ACREAGE ESTIMATES CAUSED BY POORLY ESTIMATED SEGMENTS PLAYING TOO LARGE A ROLE IN THE AGGREGATION PROCESS

NASA-S-78-17245

WEIGHTED AGGREGATION



WELL-ESTIMATED SEGMENT

POORLY ESTIMATED SEGMENT

$$\widehat{A}_4 = w\widehat{D}_4 + (1-w)\widehat{H}_4$$

$\widehat{D}_4$ = DIRECT ESTIMATE FOR COUNTY 4

$\widehat{H}_4$ = "HISTORICAL RATIO ESTIMATE" $= \left(\dfrac{W_4}{W_1 + W_2 + W_3}\right)\left(\widehat{A}_1 + \widehat{A}_2 + \widehat{A}_3\right)$

W_I = HISTORICAL WHEAT IN I-TH COUNTY

w = WEIGHT

NASA-S-78-17246

PRELIMINARY TEST OF WEIGHTED AGGREGATION (WHEAT ACREAGE)

- WEIGHTED AGGREGATION FOR COLORADO (PHASE III) WAS PERFORMED USING A FUNCTION OF BIOPHASE COMBINATION TO DETERMINE WEIGHTS

RESULTS:

LACIE		WEIGHTED		USDA
ESTIMATE*	S.E.**	ESTIMATE*	S.E.	ESTIMATE*
2718	318	2205	271	2360

*THOUSANDS OF ACRES
**STANDARD ERROR

NASA-S-78-17247

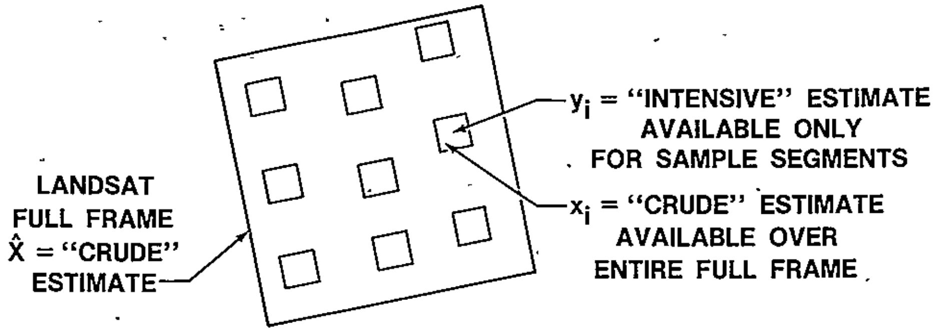
FOUR TYPES OF AGGREGATION TECHNOLOGY (CONT)

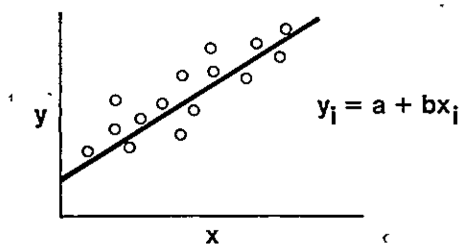
III. REGRESSION

- CONSTRUCT CRUDE FULL-FRAME ESTIMATES OF WHEAT PROPORTION
- USE STANDARD SEGMENTS (INTENSIVE ANALYSIS) TO CORRECT FULL-FRAME ESTIMATES VIA REGRESSION
- (+) IF CRUDE ESTIMATES HAVE REASONABLE CORRELATION WITH WHEAT ON THE GROUND, A MORE EFFICIENT LARGE-AREA ESTIMATE CAN BE MADE

NASA-S-78-17248

REGRESSION ESTIMATION





REGRESSION ESTIMATOR

$\hat{Y} = a + b\hat{X}$

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FOUR TYPES OF AGGREGATION TECHNOLOGY (CONC)

IV. MULTIYEAR ESTIMATION

- USE PREVIOUS YEARS' DATA TO IMPROVE THIS YEARS' ESTIMATE WHEN DATA ARE MISSING OR OF POOR QUALITY

(+)
- IF THE WHEAT ACREAGE IN A LACIE SEGMENT IS FAIRLY STABLE OVER YEARS, PREVIOUS YEARS' ESTIMATES CAN BE USED TO OBTAIN MORE ACCURATE ESTIMATES FOR CURRENT YEAR

C-3

NASA-S-78-17250

MULTIYEAR ACREAGE ESTIMATION MODEL

$A_{HTS} = \alpha_T + (\delta\beta)_H + C_{HS} + E_{HTS}$

A_{HTS} = WHEAT ACREAGE FOR S-TH SEGMENT IN H-TH STRATUM FOR YEAR T

α_T = YEAR EFFECT (FOR ALL STRATA, SEGMENTS)

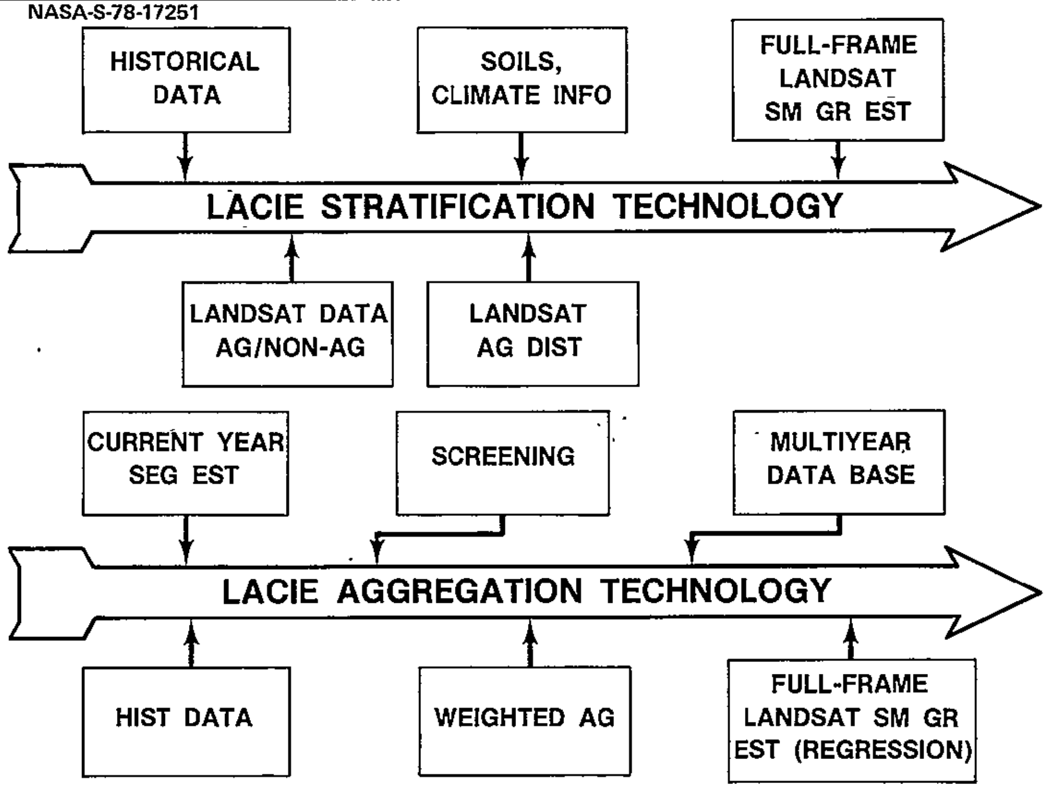
$(\delta\beta)H$ = DIFFERENTIAL STRATUM EFFECT

C_{HS} = RANDOM SEGMENT EFFECT (<u>OVER ALL YEARS</u>)

E_{HTS} = ERROR TERM = 2 COMPONENTS: CLASSIFICATION + LACK OF FIT

- USE CURRENT-YEAR SEGMENTS TO ESTIMATE α_T WHERE T = CURRENT YEAR
- USE SEGMENTS FROM ALL YEARS TO ESTIMATE $(\delta\beta)_H$
- SUM OVER S TO GET ACREAGE ESTIMATE FOR STRATUM H IN YEAR T

NASA-S-78-17251



SUPPORTING RESEARCH AND TECHNOLOGY (SRT) SESSION

COLLECTION AND ANALYSIS OF FIELD MEASUREMENT DATA

M. Bauer, Purdue University

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USDA APPLICATION TEST SYSTEM (ATS) SESSION

TECHNOLOGY TRANSFER: CONCEPTS, USER REQUIREMENTS, AND THEIR PRACTICAL APPLICATION
J. Murphy, USDA

NASA-S-78-17252

USER REQUIREMENTS AND A PRACTICAL APPLICATION OF TECHNOLOGY

- USDA OBJECTIVES
- ROLE OF USER REQUIREMENTS
- ATS CONCEPTUAL FRAMEWORK
- PRACTICAL ATTRIBUTES OF THE ATS APPROACH
- PRESENT STATUS OF THE ATS

NASA-S-78-17253

USDA OBJECTIVES

- PARTICIPATE IN THE LACIE EXPERIMENT
- TRAIN A MULTIDISCIPLINE TEAM IN THE TECHNOLOGY
- EVALUATE THE TECHNIQUES USED TO ESTIMATE WHEAT PRODUCTION
- PLAY A LEAD ROLE IN COST-BENEFIT STUDIES
- FORMULATE A COST-EFFECTIVE DESIGN FOR TECHNOLOGY TRANSFER

NASA-S-78-17254

INTRODUCTION TO USDA REQUIREMENTS

- BASIC PREMISE
  - THE END USER AND HIS NEEDS MUST BE PARAMOUNT IN R&D PLANNING
  - THE USER MUST ASSUME RESPONSIBILITY FOR REAL-WORLD TESTING AND EVALUATION OF TECHNOLOGY
- TWO BASIC APPROACHES TO REQUIREMENT DEFINITION
  - WORK STATION COLLECTION AND ANALYSIS
  - DECISION UNIT STATEMENT OF INFORMATION REQUIREMENTS

NASA-S-78-17255

ROLE OF USDA REQUIREMENTS IN REMOTE SENSING

- USDA REMOTE-SENSING USER REQUIREMENTS TASK FORCE
  - 1973-76
- LARGE AREA CROP INVENTORY EXPERIMENT REQUIREMENT
  - 1975
- USDA SECRETARY INITIATIVES
  - 1977

NASA-S-78-17256

CHANGING NEEDS MUST BE REFLECTED IN REQUIREMENTS

- USER INFORMATION NEEDS ARE CONSTANTLY CHANGING RELATIVE TO
  - FARM PROGRAMS
  - INTERNATIONAL ECONOMICS
  - FOREIGN POLICY
- ADEQUATE DEFINITION IS DIFFICULT IN A DYNAMIC PROGRAM AND ECONOMIC ENVIRONMENT
  - LEAD TIME FOR MANAGEMENT EVALUATION OF NEW TECHNOLOGY
  - DIFFICULTY IN INTRODUCING NEW TECHNIQUES INTO A MAIN-LINE OPERATION
- REQUIREMENT UPDATES ARE MANDATORY TO PROVIDE GUIDELINES FOR OPTIMAL EXPENDITURE OF R&D MONIES

NASA-S-78-17257

TECHNOLOGY TRANSFER

- FACT: A "CLOSED-LOOP INFORMATION SYSTEM" APPROACH IS ESSENTIAL TO A CLEAR DEFINITION OF RESPONSIBILITIES AND CONTROL MECHANISMS BETWEEN USER AND THE R&D COMMUNITY
- IMPETUS TO APPLY NEW TECHNOLOGY MAY ORIGINATE FROM
  - A USER ORGANIZATION
  - THE RESEARCH AND DEVELOPMENT COMMUNITY
- KEYSTONE IS USER TEST AND EVALUATION TO DETERMINE
  - PERFORMANCE AGAINST REQUIREMENTS
  - CONSTRAINTS TO IMPLEMENTATION
  - MODIFICATIONS NEEDED
  - LONG-TERM RESEARCH REQUIRED
- SUPPORTING ELEMENTS NECESSARY TO SUCCESS
  - STAFF EXCHANGES
  - COST CONTROL AND STANDARDIZATION

NASA-S-78-17258

RESEARCH AND DEVELOPMENT REALITIES

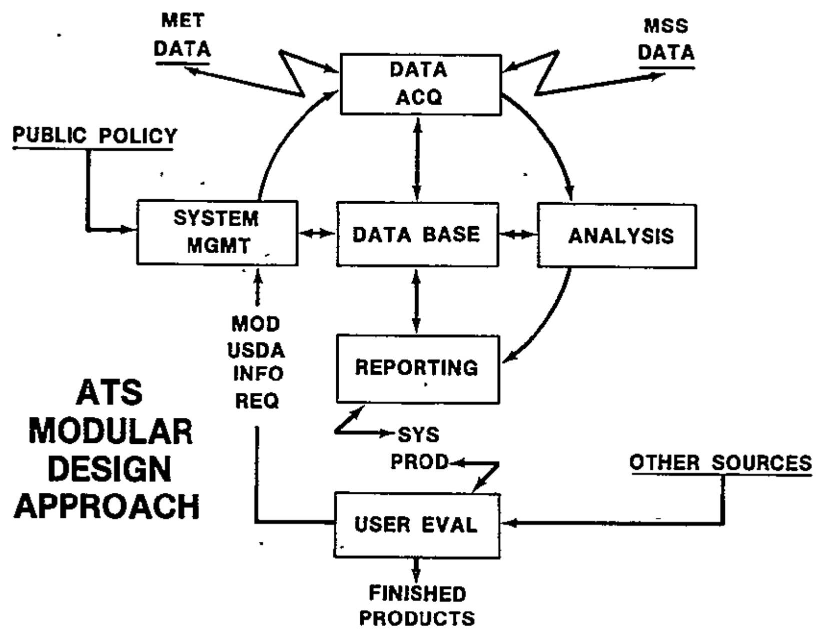
- "REAL WORLD" REALITIES DICTATE THAT RESEARCH IS A CONTINUUM ALONG WHICH:
  - HYPOTHESES ARE FORMULATED
  - DATA ARE GATHERED AND ANALYZED
  - RESULTS ARE TESTED AGAINST ORIGINAL HYPOTHESES AND
  - HYPOTHESES ARE ACCEPTED, REJECTED, OR MODIFIED
- ECONOMIC REALITIES DICTATE A DECISION POINT IN THE RESEARCH CONTINUUM AT WHICH DEVELOPMENT COMMENCES VIA:
  - A PILOT TEST OR
  - A PROTOTYPE ELEMENT AND/OR
  - A UNIT OR SYSTEM TEST
- DEVELOPMENT ACTIVITY TRIGGERS APPLICATION OF THE TECHNOLOGY IN AN OPERATIONAL MODE:
  - AGAINST DEFINED USER NEEDS AND/OR
  - PREDICATED ON THE URGENCY OF USER NEEDS OR PRE-DETERMINED PERFORMANCE CRITERIA

NASA-S-78-17259

ATS SYSTEM LIFE CONSIDERATIONS

- BACKGROUND
  - DECISION MADE TO APPLY TECHNOLOGY EARLY 1976
  - A ONE-FOR-ONE TRANSFER OF TECHNOLOGY COULD NOT BE DEFENDED
  - RAPID TECHNOLOGY ADVANCES THAT WOULD CHANGE DESIGN WERE ANTICIPATED
  - DECISION MADE TO PROCEED WITH CLASSICAL SYSTEMS APPROACH
- KNOWN CONSTRAINTS
  - COST/PERFORMANCE – MEASURABLE INDEX MUST BE SHOWN
  - CHANGING USER DEMANDS
  - CHANGING TECHNOLOGY

NASA-S-78-17260



ATS MODULAR DESIGN APPROACH

NASA-S-78-17261

ATS IMPLEMENTATION APPROACH

- STRATEGY
  - MODULAR APPROACH USING MINICOMPUTERS WITH EACH ADDITIONAL MODULE (HARDWARE) BEING ASSESSED ON ITS OWN MERIT
  - A CONTINUING EFFORT KEYED TO FUND LEVELS AND DEMONSTRATED PERFORMANCE WOULD UPGRADE CAPABILITY OVER TIME
- TECHNICAL REQUIREMENTS
  - COMMODITY DATA SECURITY
  - MAN-MACHINE INTERACTION
  - DEPENDABILITY
- PRACTICAL ATTRIBUTES TO BE EVALUATED
  - FLEXIBILITY TO MEET CHANGING NEEDS
  - STANDARDIZATION OF HARDWARE/SOFTWARE/PROCEDURES
  - COMMON DATA BASE SUPPORTING MULTIPLE REQUIREMENTS
  - COST MANAGEMENT

NASA-S-78-17262

PRESENT STATUS OF THE ATS
1978

TECHNOLOGY TRANSFERRED

- SAMPLING STRATEGY
- YIELD MODELS (SOIL MOISTURE BUDGET)
- SPECTRAL ANALYSIS PROCEDURES
- VEGETATIVE INDEXES
- 30 TRAINED USDA PROFESSIONALS

ATS SYSTEM COMPONENTS

- ANALYSIS HARDWARE AND SOFTWARE
- COLOR GRAPHIC TERMINALS
- OPERATING PROCEDURES

ATS CAPABILITY

- APPLICATION TEST OF SPRING WHEAT PRODUCTION IN U.S.S.R.
- VALIDATE CONDITION ASSESSMENT IN MONTANA AND NORTH DAKOTA SPRING WHEAT AREA
- VALIDATE AREAS OF MOISTURE STRESS IN U.S.S.R. SPRING WHEAT

NASA-S-78-17263

PRESENT STATUS OF THE ATS (CONT)
1979

TECHNOLOGY TRANSFERRED

- FULL-FRAME DATA HANDLING TECHNIQUES
- UPDATED LACIE TECHNIQUES FOR WHEAT, CORN, AND SOYBEANS

ATS SYSTEM COMPONENTS

- DATA ACQUISITION HARDWARE AND SOFTWARE
- LINK BETWEEN ACQUISITION AND ANALYSIS COMPONENTS
- PROCURE DATA BASE COMPONENT

ATS CAPABILITY

AT THE DISCRETION OF USDA MANAGEMENT:

- CONDITION ASSESSMENT
- PRODUCTION IMPACTS
- AVAILABLE YIELD MODELS
- GEOGRAPHIC DATA BASES

NASA-S-78-17264

SUMMARY

- USER REQUIREMENTS AND A CONCEPT FOR PRACTICAL APPLICATION OF NEW TECHNOLOGY ARE DIFFICULT TO SYNCHRONIZE IN AN ECONOMICAL MANNER
- USDA DEVELOPMENT OF USER REQUIREMENTS HAS FOLLOWED TRADITIONAL LINES
  - DATA FLOWS THROUGH ORGANIZATIONS
  - DECISION UNIT DEFINITION OF INFORMATION NEEDS
- TECHNOLOGY TRANSFER AS A CONCEPT IS NOT A "TURNKEY" APPROACH

NASA-S-78-17265

SUMMARY (CONT)

- USDA DESIGN APPROACH BUILDS ON CONSTRUCTION OF A DATA BASE SHARED BY OTHER COMPONENTS OF A "CLOSED-LOOP" PROCESSING SYSTEM
- USDA DESIGN CAN ACCOMMODATE CHANGING TECHNOLOGY AND USER REQUIREMENTS IN A COST-EFFECTIVE MANNER
- USDA APPLICATION OF LACIE-LIKE TECHNOLOGY IS
  - PREDICATED ON AN UNDERSTANDING OF THE "REAL WORLD" ENVIRONMENT OF AN OPERATIONAL AGENCY AND
  - DRAWS ITS STRENGTHS ON PROVEN EXPERIENCES IN OPERATIONS AND SYSTEMS ANALYSIS THEORY

N79-14493

USDA APPLICATION TEST SYSTEM (ATS) SESSION

THE APPLICATION TEST SYSTEM: AN APPROACH FOR TECHNOLOGY TRANSFER

F. David, USDA

NASA-S-78-17266

THE APPLICATION TEST SYSTEM: AN APPROACH TO TECHNOLOGY TRANSFER

NASA-S-78-17267

PURPOSE

TO PRESENT THE TECHNOLOGY TRANSFER EXPERIENCE BETWEEN THE LACIE AND THE ATS HIGHLIGHTING THE APPROACH, ACHIEVEMENTS, AND LESSONS LEARNED

NASA-S-78-17268

ATS RELATIONSHIP TO LACIE

THE ATS HAS BEEN IMPLEMENTED TO TEST AND EVALUATE LACIE AND LACIE-LIKE INPUTS, TECHNOLOGY, AND TECHNIQUES IN AN APPLICATION ENVIRONMENT TO ASSESS FUTURE OPERATIONAL FEASIBILITY WITHIN THE USDA ENVIRONMENT

KEY POINTS

- ATS IS AN INTERMEDIATE USER OF TECHNOLOGY, NOT AN END USER
- ATS WILL TEST AND EVALUATE LACIE AND LACIE-LIKE TECHNOLOGY/TECHNIQUES
- USDA MANAGEMENT WILL MAKE FINAL DECISION TO TRANSFER TECHNOLOGY TO AN OPERATIONAL ENVIRONMENT

NASA-S-78-17269

OVERVIEW OF PRESENTATION

- CONCEPT AND APPROACH
- IMPLEMENTATION OF APPROACH
- ACHIEVEMENTS
- SHORTCOMINGS
- LESSONS LEARNED

NASA-S-78-17270

CONCEPT AND APPROACH

- USER REQUIREMENTS
  - IDEALLY SHOULD HAVE EXISTED BEFORE LACIE
    - LACIE (IDEALLY) WOULD THEN DESIGN, IMPLEMENT, TEST SYSTEM
    - USDA TRANSFERS MIRROR-IMAGE SYSTEM
  - IN REALITY, USER REQUIREMENTS DID NOT EXIST
    - LACIE INITIATED R&D WITHOUT IN-DEPTH REQUIREMENTS
    - HAD TO USE AVAILABLE COMPUTER SYSTEM(S)
- TECHNOLOGY TRANSFER BY USDA CONSTRAINED BY
  - LIMITED USDA RESOURCES
  - IMPLEMENTATION OF THE "BEST" OF LACIE
  - REJECTION OF LABOR-INTENSIVE PROCEDURES

NASA-S-78-17271

CONCEPT AND APPROACH (CONT)

- TECHNOLOGY TRANSFER IMPLEMENTATION HAD TO BE MODULAR
  - SINGLE, VERY LARGE INVESTMENT DECISION NOT REASONABLE – VIEWED AS HIGH RISK BY USDA
  - INSTEAD, A SERIES OF RELATIVELY SMALL INVESTMENT DECISIONS IS BEING/WILL BE MADE
  - HENCE, MINICOMPUTER APPROACH FOR INCREMENTAL INCREASE IN CAPABILITY
  - PRESENT ATS CONFIGURATION REPRESENTS FIRST INCREMENT
- FUNCTIONAL CAPABILITIES TRANSFER NECESSARY
  - NOT A MIRROR-IMAGE TRANSFER
  - TECHNOLOGY STILL EVOLVING
  - USDA MUST INVEST IN MINICOMPUTER HARDWARE/ EXECUTIVE SOFTWARE/APPLICATION SOFTWARE
  - CLASSIC SYSTEMS APPROACH NECESSARY, USING IT AS A "ROADMAP"

NASA-S-78-17272

IMPLEMENTATION OF APPROACH

- DEDICATE A CADRE OF PERSONNEL TO TRANSFER TECHNOLOGY
  - USDA/NASA STAFFED
  - MOSTLY ADP PERSONNEL AT FIRST (FOR ADP PROCUREMENTS)
  - AUGMENTED BY CROP ANALYSTS LATER
- COORDINATE WITH LACIE
  - ADP AND CROP ANALYST TRAINING
  - GAIN EXPERIENCE FROM LACIE
  - SELECT CANDIDATE TECHNOLOGY
  - STAFF THE FUNCTIONAL DESIGN
    - LACIE FOR TECHNOLOGY
    - USDA MANAGEMENT FOR RESOURCES

NASA-S-78-17273

IMPLEMENTATION OF APPROACH (CONT)

- APPLY MIX OF IN-HOUSE CAPABILITIES/CONTRACTOR AUGMENTATION
  - INITIALLY
    - IN-HOUSE PERSONNEL FOR FUNCTIONAL SPECIFICATIONS AND PRACTICAL APPLICATION ASSESSMENT
    - CONTRACT SUPPORT FOR DETAILED DESIGN, TECHNICAL IMPLEMENTATION WITH USDA PARTICIPATION
    - RFP'S AND WINNING PROPOSALS REPRESENT SINGLE BEST SOURCE OF ADP TECHNOLOGY TRANSFERRED
  - LATER
    - USDA ASSUMES GREATER RESPONSIBILITY FOR DETAILED DESIGN, TECHNICAL IMPLEMENTATION
  - IN ALL CASES, USDA RESPONSIBLE FOR
    - SYSTEM OPERATION
    - OUTPUT PRODUCTS AND THEIR ASSESSMENT

NASA-S-78-17274

1978 ACHIEVEMENTS

- TECHNOLOGY TRANSFERRED
  - SAMPLING STRATEGY
  - YIELD MODELS
  - SPECTRAL ANALYSIS PROCEDURES
  - VEGETATIVE INDEXES
  - 30 TRAINED USDA PROFESSIONALS
- ATS IMPLEMENTED
  - ANALYSIS HARDWARE AND SOFTWARE
  - OPERATIONAL PROCEDURES
- ATS CAPABILITY FOR 1978
  - PRODUCTION INVENTORY TEST OF A KEY AREA OF U.S.S.R. SPRING WHEAT
  - MONITOR CONDITION ASSESSMENT IN MONTANA AND NORTH DAKOTA SPRING WHEAT AREAS
  - MONITOR AREAS OF MOISTURE STRESS IN U.S.S.R. SPRING WHEAT AREA

NASA-S-78-17275

SHORTCOMINGS

- USDA USER REQUIREMENTS NOT AVAILABLE SOON ENOUGH
- EFFICIENT MECHANISM FOR TECHNOLOGY TRANSFER WAS NOT FULLY "PROCEDURALIZED"

NASA-S-78-17276

LESSONS LEARNED

- USER REQUIREMENTS AND PRACTICAL APPLICATION OF NEW TECHNOLOGY DIFFICULT TO SYNCHRONIZE
- TECHNOLOGY TRANSFER IS NOT ALWAYS AMENABLE TO A "TURNKEY" APPROACH
- USDA APPLICATION OF LACIE-LIKE TECHNOLOGY
  - DEPENDENT ON TRAINED AND EXPERIENCED PERSONNEL
  - UNDERSTANDING OF NEEDS OF USDA OPERATIONAL UNITS
- UNDERSTANDING OF TECHNOLOGY BY USDA TOP MANAGEMENT CRITICAL IN EVEN THOSE CASES WHERE NEW AVAILABLE TECHNOLOGY IS KNOWN AT THE LACIE LEVEL TO BE VALID

NASA-S-78-17277

FUTURE PLANS - 1979

- TECHNOLOGY TO BE TRANSFERRED
  - FULL-FRAME DATA-HANDLING TECHNIQUES
  - UPDATE LACIE TECHNIQUES FOR WHEAT, CORN, SOYBEANS
- "END-TO-END" SYSTEM
  - ANALYSIS COMPONENT
  - ACQUISITION COMPONENT INSTALLATION
  - DATA BASE COMPONENT PROCUREMENT
- ADDED ATS CAPABILITIES (AT USDA MANAGEMENT'S DISCRETION)
  - CONDITION ASSESSMENT
  - PRODUCTION IMPACTS

NASA-S-78-17278

CHRONOLOGY OF EVENTS

DATE	EVENT	LACIE SYMPOSIUM PAPER
APR 1975	USDA USER REQUIREMENTS	USER REQUIREMENTS AND A PRACTICAL APPLICATION OF TECHNOLOGY
FEB 1976	MANAGEMENT PLAN	TECHNOLOGY TRANSFER TO USER ATS
		FUNCTIONAL DEFINITION AND A DESIGN OF A USDA SYSTEM
APR 1976	DESIGN STUDY INITIATED	DATA BASE DESIGN FOR A WORLDWIDE MULTICROP INFORMATION SYSTEM
AUG 1976	DESIGN CDR	A MODEL FOR COST PROJECTIONS OF APPLICATIONS SYSTEM

NASA-S-78-17279

CHRONOLOGY OF EVENTS (CONT)

DATE	EVENT	LACIE SYMPOSIUM PAPER
JUN 1977	ATS CONTRACT AWARD	THE APPLICATION TEST SYSTEM: TECHNICAL APPROACH AND SYSTEM DESIGN
OCT 1977	ATS USE INITIATED	THE APPLICATION TEST SYSTEM: EXPERIENCE TO DATE AND FUTURE PLANS
DEC 1977	SYSTEM CAPABILITIES EXPANSION	

N79-14494

USDA APPLICATION TEST SYSTEM (ATS) SESSION

FUNCTIONAL DEFINITION AND DESIGN OF A USDA SYSTEM

S. Evans, USDA

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NASA-S-78-16540

FUNCTIONAL DEFINITION AND DESIGN OF A USDA SYSTEM

NASA-S-78-16541

CONTENTS OF PAPER

- REPRESENTS A DESIGN BASED ON TECHNOLOGY AND REQUIREMENTS AS OF JUNE 1976
- WRITTEN IN A MIXTURE OF TENSES
- WAS USED AS A BASIS FOR THE PRESENT ATS BUT NOT MEANT AS A "BLUEPRINT" FOR FURTHER EXPANSION OF THE PRESENT SYSTEM

NASA-S-78-16542

BACKGROUND

- LACIE WAS INVESTIGATING THE USE OF REMOTE-SENSING TECHNOLOGY
- A SYSTEM WAS NEEDED TO BE RESPONSIVE TO USDA REQUIREMENTS
- USER ADVANCED SYSTEM GROUP WAS FORMED TO EXPLOIT LACIE TECHNOLOGY
- TECHNOLOGY ADVISORY GROUP (TAG) WAS FORMED TO EXPEDITE TECHNOLOGY TRANSFER

NASA-S-78-16543

CONSTRAINTS

- AVAILABLE MANPOWER WOULD BE 60 PERSONS
- PERSONNEL WOULD NOT LIKELY BE FAMILIAR WITH ADP TECHNIQUES OR TERMINOLOGY
- 7-DAY TURNAROUND
- SECURITY PRECAUTIONS FOR SAFE-GUARDING CROP ESTIMATE DATA
- SOFTWARE TO BE WRITTEN IN HIGH-LEVEL LANGUAGES

NASA-S-78-16544

CONCEPTS

- UTILIZE "TEAM APPROACH"
- UTILIZE STANDARD "OFF-THE-SHELF" HARDWARE AND SOFTWARE
- TUTORIAL SOFTWARE FOR ANALYST'S USE
- SYSTEM WOULD BE OPERATED THROUGH THE DATA BASE FROM MODULAR COMPONENTS

NASA-S-78-16545

OBJECTIVES

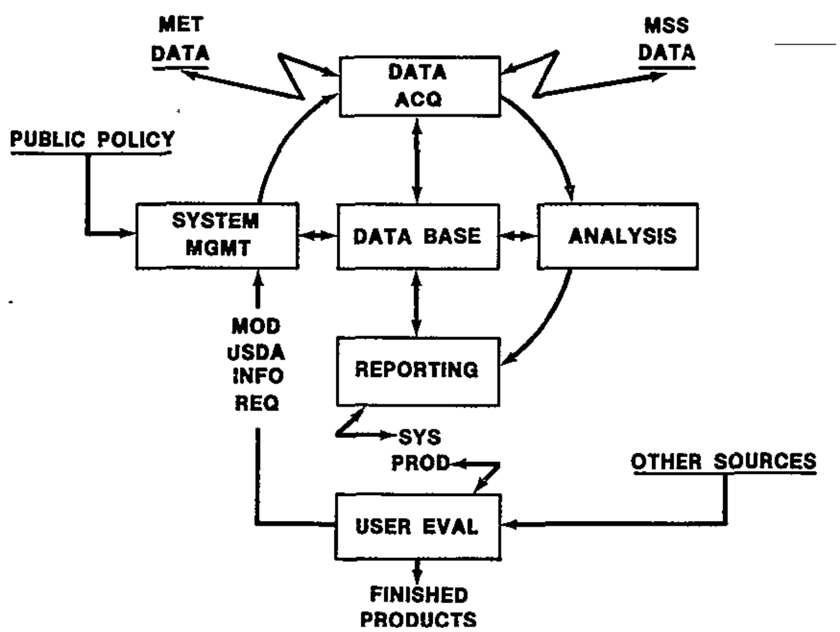
- VALIDATE AND ASSIST IN OPTIMIZATION OF LACIE TECHNOLOGY
- TRANSFER OPTIMIZED TECHNOLOGY
- TRAIN USDA ANALYSTS IN LACIE TECHNIQUES
- APPLY LACIE EXPERIENCE TO ASSESS POTENTIAL OF OTHER FEASIBLE PROJECTS
- ACHIEVE DETAILED SYSTEM GOALS:
  - TIMELINESS
  - ACCURACY
  - OBJECTIVITY
  - CONTINUITY

NASA-S-78-16546

GENERAL DESIGN APPROACH

- CLASSICAL DESIGN MECHANISMS
  - IDENTIFY USDA REQUIREMENTS
  - ASSESS REMOTE-SENSING CONTRIBUTION
  - EVALUATE EXISTING PROCESSING PROCEDURES
  - CREATE DESIGN THAT MEETS REQUIREMENTS

NASA-S-78-16547



NASA-S-78-16548

DATA PROCESSING SYSTEM (DPS)

- DPS PROVIDES
  - DATA BASE STORAGE AND PROCESSING CAPABILITY
  - CROP ANALYSIS DISPLAYS AND PROCESSING
  - REPORT GENERATION
  - END USER INTERFACE
- COMPUTERS AND PERIPHERAL DEVICES
  - STANDARD PRODUCT
  - SMALL TO MEDIUM
  - MODULAR
- OPERATING SYSTEMS AND SUPPORT SOFTWARE
  - STANDARD PRODUCT
  - STANDARD "HOOKS"
  - PROVIDE INTERACTIVE INTERFACE

NASA-S-78-16549

DPS COMPONENT CONFIGURATION

- HOST COMPUTERS
  - HIST DATA
  - EVAL DATA
  - REPORT DATA
- DATA BASE COMPUTER
  - YIELD ANALYSIS
  - AGGREGATION
  - REPORTING
- ACQUISITION COMPUTER
  - MSS DATA
  - MET DATA
- ANALYST COMPUTERS (3)
  - ANALYST STATIONS (3 x 3)

NASA-S-78-16550

SIMULATION

- REQUIRED TO SUPPORT ECONOMIC ANALYSIS
- IBM MCC FUNCTIONAL MODEL USED
- SIMULATION DONE CONCURRENT WITH DESIGN EFFORT
- SYSTEM PERFORMANCE AND THROUGHPUT WAS SIMULATED IN TERMS OF:
  - I/0 ACTIVITY AGAINST DATA FILES
  - "BOTTLENECKS"
  - EVALUATION OF SPECIAL-PURPOSE EQUIPMENT
  - TIME REQUIRED TO PROCESS A GIVEN DATA CYCLE
  - TIME REQUIRED TO PROCESS A PRIORITY EVENT

NASA-S-78-16551

SIMULATION RESULTS AND CONCLUSIONS

- VERIFICATION OF SAMPLE SEGMENT PROCESSING TIME
- FEASIBILITY OF A MINICOMPUTER-BASED DESIGN

N79-14495

USDA APPLICATION TEST SYSTEM (ATS) SESSION

ATS – TECHNICAL APPROACH AND SYSTEM DESIGN

R. Hurst, USDA

NASA-S-78-17280

THE APPLICATION TEST SYSTEM TECHNICAL APPROACH AND SYSTEM DESIGN

NASA-S-78-17281

OBJECTIVES

- PRESENT THE DESIGN OF THE ATS COMPUTER SYSTEM WITH REGARD TO:
  - ESTABLISHMENT OF REQUIREMENTS
  - PERFORMANCE SPECIFICATIONS
  - PROCUREMENT ACTIVITIES
- DESCRIBE MAJOR HARDWARE AND SOFTWARE COMPONENTS
- DESCRIBE SYSTEM UTILIZATION
- PRESENT CURRENT AND PLANNED AUGMENTATION

NASA-S-78-17282

BACKGROUNDS TO EVENTUAL ATS DESIGN

- USDA USER REQUIREMENTS – FALL 1975
- JOINT FORD AEROSPACE/USDA DESIGN/ SPECIFICATION STUDY – SUMMER 1976
- MITRE CORPORATION INDUSTRY STUDY – FALL 1976
- LACIE EXPERIENCE – 1975 TO PRESENT
- DESIGNER INNOVATION

NASA-S-78-17283

IMPLEMENTATION CONSTRAINTS/REQUIREMENTS

- SYSTEM HARDWARE AND SOFTWARE MUST BE STANDARD VENDOR-SUPPORTED PRODUCT TO ENSURE SYSTEM RELIABILITY
- OPERATING SYSTEM MUST NOT BE MODIFIED
- MODULAR COMPONENTS (RESPONSIVE TO DYNAMIC OPERATIONAL SYSTEM REQUIREMENTS)
- HIGHER LEVEL LANGUAGES USED FOR APPLICATIONS SOFTWARE
- CODASYL DATA BASE MANAGEMENT SYSTEM MUST BE PROVIDED
- QUERY PACKAGE MUST BE PROVIDED
- MUST BE STAND-ALONE SYSTEM BUT HAVE CAPABILITY OF INTERFACING WITH A DATA ACQUISITION COMPUTER SYSTEM AND A DATA BASE COMPUTER SYSTEM
- MUST SUPPORT 5 ANALYST STATIONS

NASA-S-78-17284

TIMING SPECIFICATIONS

- MAXIMUM-LIKELIHOOD CLASSIFICATION
  - CLASSIFY 4-CHANNEL 117 x 196-PIXEL IMAGE IN LESS THAN 10 SEC
  - CLASSIFY 6-CHANNEL 512 x 512-PIXEL IMAGE IN LESS THAN 1 MIN
- CLUSTERING
  - CLUSTER 4-CHANNEL 117 x 196-PIXEL IMAGE WITH 30 CLUSTERS IN LESS THAN 30 SEC

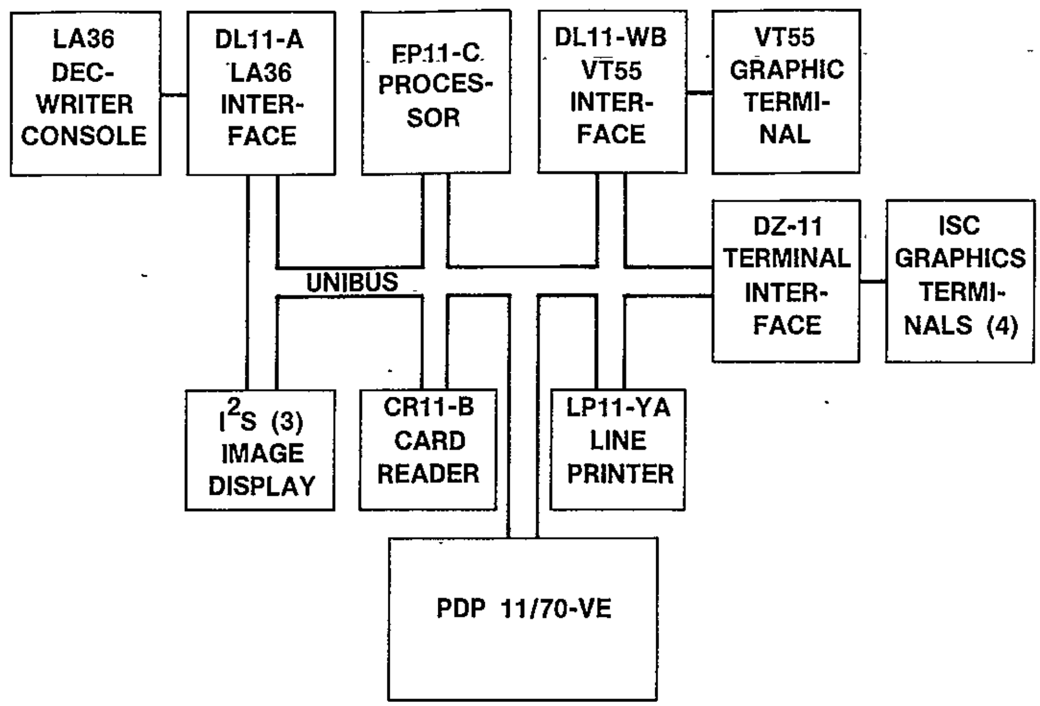
NASA-S-78-17285

COMPETITIVE PROCUREMENT

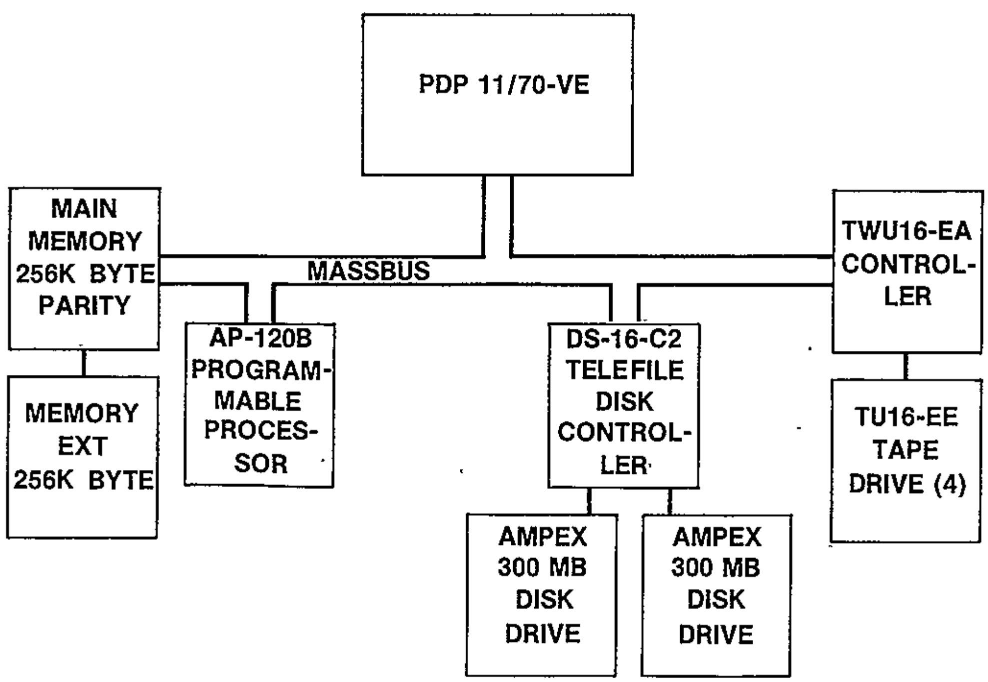
- ESTABLISHED PROCUREMENT TEAM
  - USDA, NASA PERSONNEL WROTE RFP USING SUBSET OF CRITERIA, DESIGN, REQUIREMENTS DESCRIBED PREVIOUSLY (JAN 1977)
  - USDA, NASA EVALUATED VENDOR PROPOSALS
  - AWARDED CONTRACT TO FORD (JUNE 1977)
- SYSTEM DELIVERED (OCT 1977)

NASA-S-78-17286

ATS CONFIGURATION

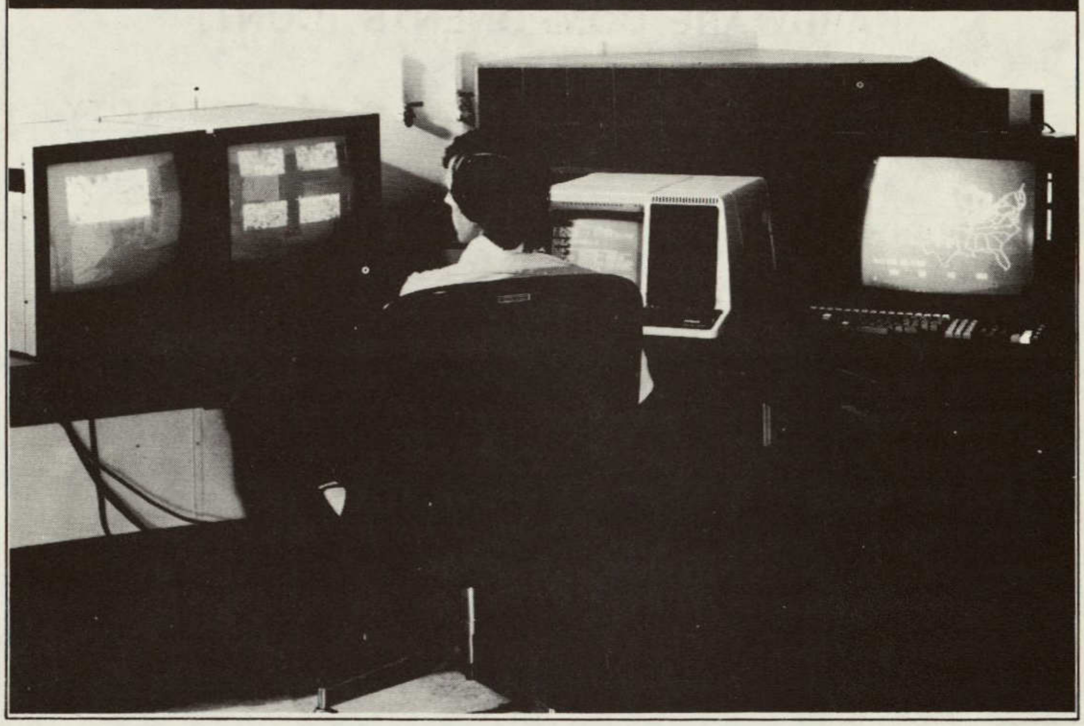


NASA-S-78-17287



NASA-S-78-12519

ANALYST STATION



NASA-S-78-17288

APPLICATION TEST SYSTEM HARDWARE COMPONENTS

ITEM	MODEL	QUANTITY
	MAINFRAME	
CPU	DEC PDP 11-70-VE	1
MAIN MEMORY	DEC 512K BYTES	–
PROGRAMMABLE PROCESSOR	FLOATING POINT SYSTEMS, INC., AP120B	1
	ANALYST CONSOLE/STATION	
IMAGE DISPLAY	I^2S MODEL 70E	1
ALPHA/GRAPHICS DISPLAY	DEC VT55	1
DISPLAY HARDCOPY	DEC VT55	1

NASA-S-78-17289

APPLICATION TEST SYSTEM HARDWARE COMPONENTS (CONT)

ITEM	MODEL	QUANTITY
	PERIPHERALS	
DISK DRIVES	AMPEX 9300, 300 MEGABYTES EACH	2
TAPE DRIVES	DEC DUAL DENSITY, 45 IPS	4
CARD READER	DEC 600 CPM	1
OPERATOR CONSOLE	DEC LA36	1
LINE PRINTER	DEC LP11A, 600 LPM	1
CHANNELS	MASSBUS, UNIBUS	—
COLOR ALPHA/GRAPHICS TERMINALS	ISC 8051	4

NASA-S-78-17290

APPLICATION TEST SYSTEM SOFTWARE COMPONENTS

ITEM	MODEL
OS	DEC IAS
ANALYST STATION SOFTWARE	FORD AEROSPACE IMDACS I^2S APPLICATIONS SOFTWARE
FORTRAN COMPILER	DEC FORTRAN-IV PLUS
COBOL COMPILER	DEC 1974 ANSI COBOL
SORT/MERGE	DEC UTILITY
TEXT EDITOR	DEC EDI, INTERACTIVE TEXT EDITOR
ASSEMBLER, SIMULATOR	FLOATING POINT SYSTEMS, INC
DBMS	CULLINANE CORP IDMS (CODASYL BASED)
QUERY	CARS 3
STATISTICAL PACKAGE	TEXAS A&M MATHPAC

N79-14496

USDA APPLICATION TEST SYSTEM (ATS) SESSION

DATA BASE DESIGN FOR A WORLDWIDE MULTICROP INFORMATION SYSTEM

G. Driggers, USDA

PAGE 506 INTENTIONALLY !

NASA-S-78-17293

DATA BASE DESIGN FOR A WORLDWIDE MULTICROP INFORMATION SYSTEM

NASA-S-78-17294

PURPOSE

TO PRESENT AN OVERVIEW OF THE DATA BASE DESIGN FOR THE USDA APPLICATION TEST SYSTEM

- BACKGROUND
- DATA CATEGORIES
- DESIGN
- EXPERIENCE TO DATE

NASA-S-78-17295

BACKGROUND

- DATA BASE OBJECTIVES
  - SUPPORT REMOTE-SENSING APPLICATIONS
    - LARGE DATA VOLUMES
    - COMPLEX RELATIONSHIPS – GEOGRAPHIC, CROP
  - SERVE VARIED USERS
    - ANALYST
    - END USER
    - MANAGEMENT
  - BUILD ON LACIE EXPERIENCE
    - LACIE/ERIPS – IMAGES, FIELDS, RESULTS
    - DATA LOGISTICS, INTERFACES

NASA-S-78-17296

BACKGROUND (CONT)

- DATA MANAGEMENT REQUIREMENTS
  - MINIMUM REDUNDANCY
  - CONSISTENCY
  - FLEXIBILITY
  - ACCESS – APPLICATIONS, QUERY
  - INTEGRITY
  - SECURITY

NASA-S-78-17297

DATA CATEGORIES

- GEOGRAPHIC UNITS
  - GEOGRAPHIC HIERARCHY
    - COUNTRY, REGION, ZONE, STRATUM, SUBSTRATUM
  - METEOROLOGICAL STATION
    - WMO, OTHER
  - AGROPHYSICAL UNIT, REFINED STRATUM
    - SIMILAR SOILS, CLIMATE, TOPOGRAPHY
  - GRID CELL
    - FULL CELL – APPROX 25 x 25 N MI
    - QUADRANT
    - STRATUM, APU – COLLECTIONS OF QUADRANTS

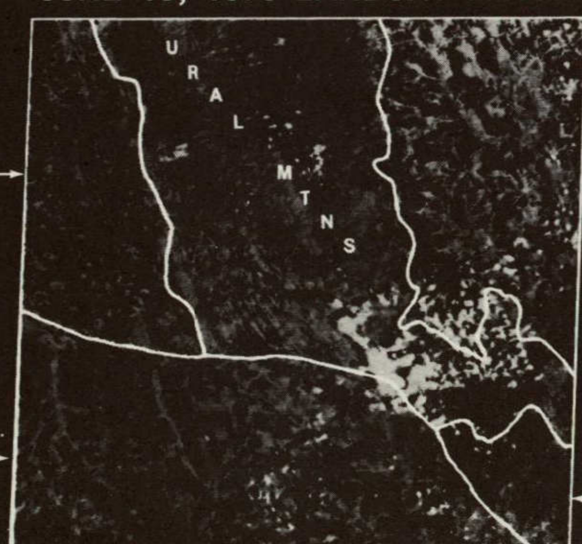
NASA-S-78-12580

U.S.S.R. SPRING WHEAT, ORSK-ORENBERG REGION

JUNE 19, 1975 LANDSAT IMAGE

APU 13→

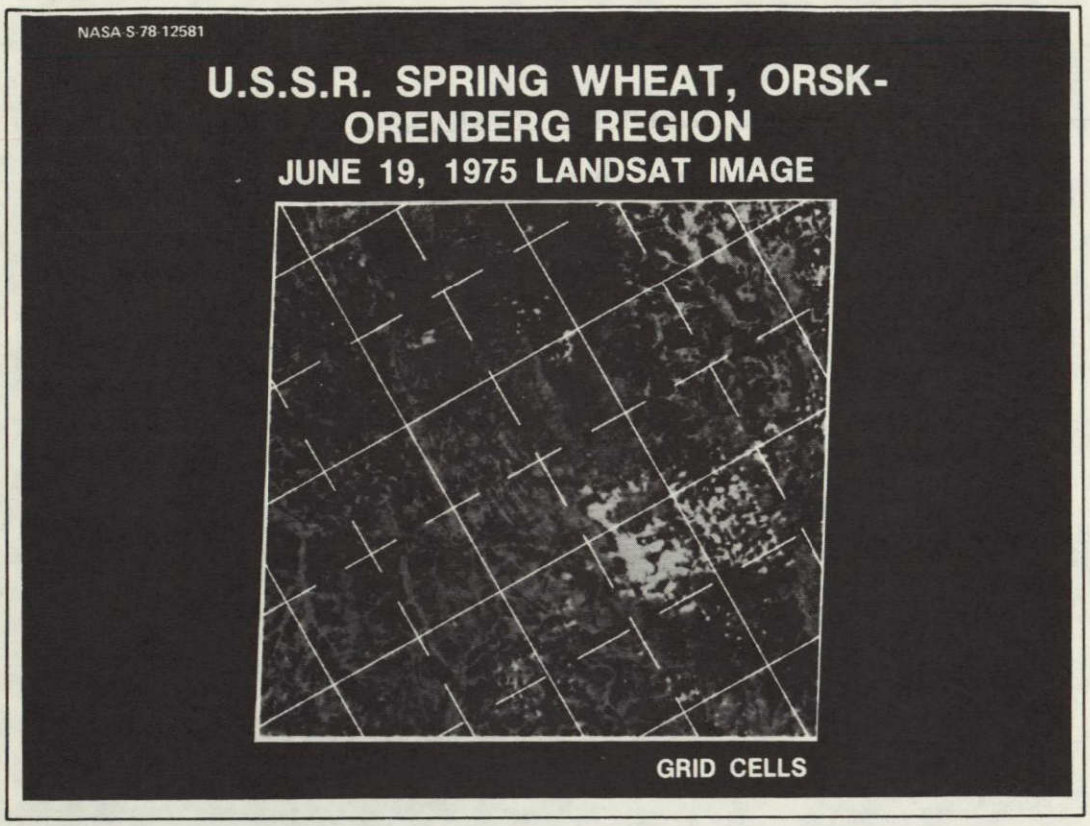
←APU 10

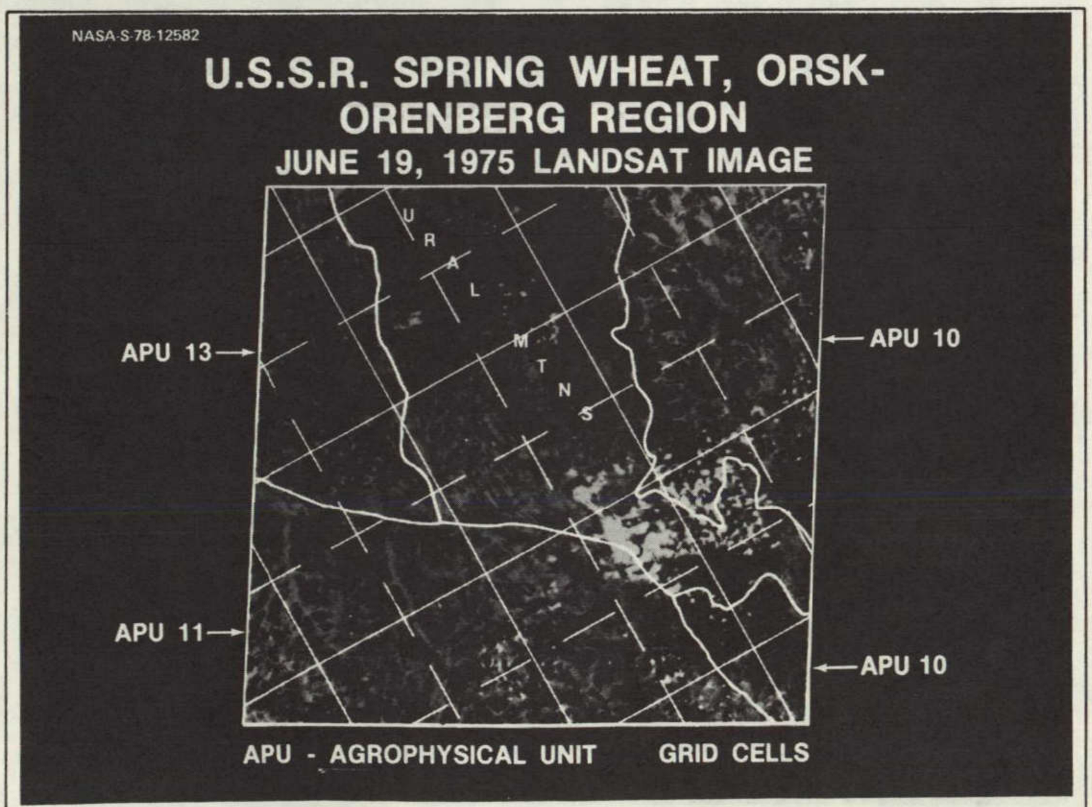


APU 11→

←APU 10

APU - AGROPHYSICAL UNIT


NASA-S-78-12581
U.S.S.R. SPRING WHEAT, ORSK-ORENBERG REGION
JUNE 19, 1975 LANDSAT IMAGE
GRID CELLS


NASA-S-78-12582
U.S.S.R. SPRING WHEAT, ORSK-ORENBERG REGION
JUNE 19, 1975 LANDSAT IMAGE
U R A L M T N S
APU 13
APU 10
APU 11
APU 10
APU - AGROPHYSICAL UNIT
GRID CELLS

NASA-S-78-17300

DATA CATEGORIES (CONT)

- METEOROLOGICAL DATA
  - STATION – DAILY, MONTHLY
  - GRID CELL – DAILY, MONTHLY
- AGRONOMIC DATA
  - SOILS
  - CROPPING PRACTICES
- CROP ASSESSMENT REPORTS
  - ATS, CAS
- HISTORICAL DATA
  - USDA DATA – AREA, YIELD, PRODUCTION
  - METEOROLOGICAL
- STATUS DATA

NASA-S-78-17301

DATA BASE DESIGN

- CONFIGURATION
  - HARDWARE
    - – PDP 11-70, 512K BYTES MAIN STORAGE
    - – DISK STORAGE
      - TELEFILE CONTROLLER
      - TWO AMPEX DISK DRIVES WITH 300-MB PACKS
    - – TAPE DRIVES (4)
  - SOFTWARE – IDMS, FMS, QUERY
- DESIGN APPROACH
  - RECORD TYPES
  - STRUCTURE
  - SCHEMA DESIGN
  - STORAGE ALLOCATION

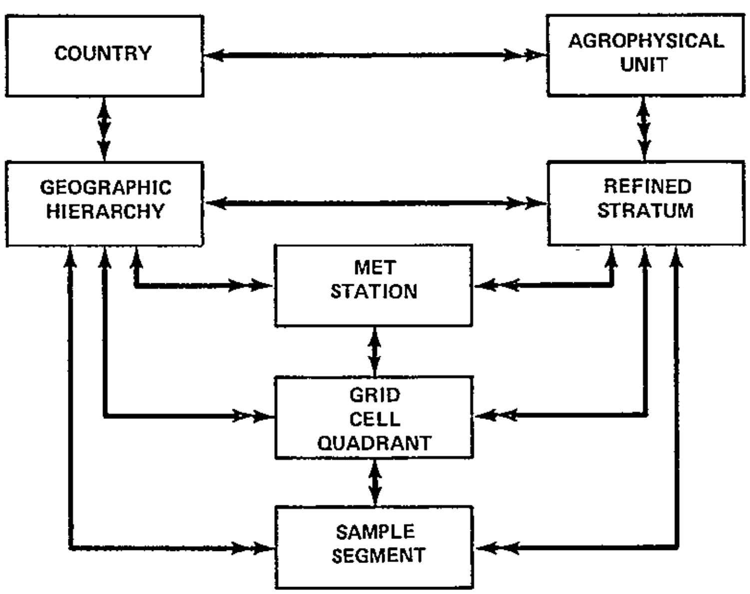
NASA-S-78-17302

IDMS-11 SUMMARY

- CULLINANE PRODUCT
- CODASYL DATA BASE TASK GROUP REPORT
- HIERARCHICAL, NETWORK STRUCTURES
- DDL, DML
- SCHEMA
  - DATA ELEMENTS
  - RECORDS
  - AREAS, FILES
  - DATA RELATIONSHIPS
- SUBSCHEMA
  - USER INTERFACE
  - PRIVACY FACILITIES
- JOURNAL
- QUERY
  - PROGRAMER-ORIENTED
  - LIMITED CAPABILITY

NASA-S-78-17303

DATA STRUCTURE-GEOGRAPHIC UNITS



NASA-S-78-17304

DATA VOLUME (MILLIONS OF BYTES)

	5.5 ACQ/SS	7.0 ACQ/SS
• IMAGERY, CLASSIFICATION DATA	245	310
• ANCILLARY DATA	35	35
• SOFTWARE, WORKING STORAGE	50	50
TOTAL	330	395

REQUIRED DISK CAPACITY (MILLIONS OF BYTES)

	ASSUMED DISK LOAD FACTORS		
	60 PERCENT	70 PERCENT	80 PERCENT
• AVERAGE 5.5 ACQUISITIONS	550	470	415
• AVERAGE 7.0 ACQUISITIONS	660	565	495

NASA-S-78-17305

ASSUMPTIONS

- 266 SAMPLE SEGMENTS
- LANDSAT-2 FORMAT (4 BANDS, 117 LINES OF 196 PIXELS)
- 350 METEOROLOGICAL STATIONS
- 3450 GRID CELLS (FULL, QUADRANT)

NASA-S-78-17306

EXPERIENCE TO DATE

- PLANNED PHASES
  - 1978 – QUERY, GRID CELLS
  - 1979 – EXTENDED DATA TYPES
- INITIAL PHASE
  - STATUS
  - PROBLEMS
    - – QUERY
    - – OVERHEAD
  - ASSESSMENT

NASA-S-78-17307

IMPLEMENTATION STATUS

- CROP GEOGRAPHY
  - * COUNTRY
  - * CROP
  - * GEOGRAPHIC HIERARCHY
  - * APU
  - * REFINED STRATUM
  - * SAMPLE SEGMENT
- GRID CELL
  - * FULL GRID CELL
  - * GRID-CELL QUADRANT
  - * SOILS—GRID CELL
  - * SOILS—GENERAL
  - DAILY MET DATA
  - AGRONOMIC DATA
- MET DATA
  - * MET STATION
  - * CLIMATIC CROP REGION
  - * DAILY MET DATA
  - HISTORICAL MET
  - MONTHLY SUMMARY
  - YIELD REPORTS
  - STATUS—MET
- SUPPORT
  - * EVALUATED SEGMENTS
  - * CROP ASSESSMENT REPORTS
  - * HISTORICAL CROP DATA
- CLASSIFICATION
  - SEGMENT ACQUISITION
  - IMAGES
  - FIELDS
  - DOTS
  - CLASS MAPS
  - MASKS
  - STATUS—IMAGERY

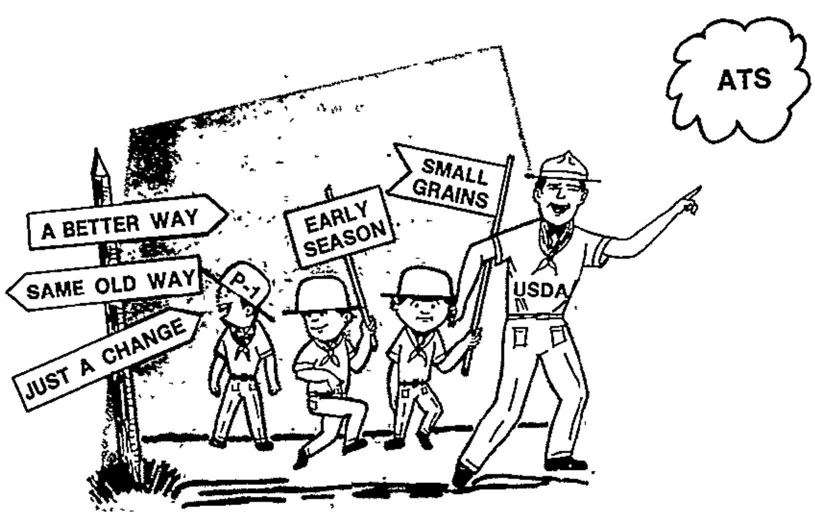
USDA APPLICATION TEST SYSTEM (ATS) SESSION

ATS – EXPERIENCE TO DATE AND FUTURE PLANS
G. May, USDA

NASA-S-78-17308

THE ATS EXPERIENCE TO DATE, CURRENT AND FUTURE PLANS

NASA-S-78-17309



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NASA-S-78-17310

PURPOSE OF PRESENTATION

DISCUSS THE DATA ANALYSIS COMPONENT AND HOW THE DATA ARE BEING APPLIED TO PROBLEMS IN AGRICULTURE

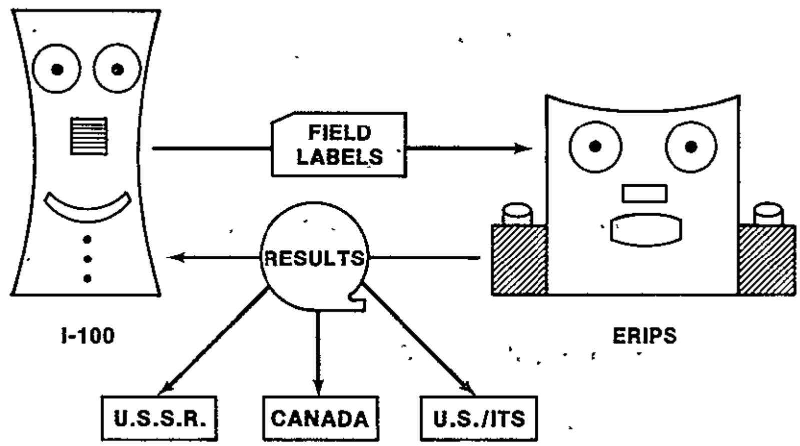
NASA-S-78-17311

THREE-PART PRESENTATION

- ANALYST EXPERIENCE TO DATE
- CURRENT WORK
- FUTURE PLANS

NASA-S-78-17313

I-100 HYBRID SYSTEM



NASA-S-78-17312

DISADVANTAGES/PROBLEMS

- INTERFACING/LOGISTICS
- TIME DELAYS
- REQUIRED MINIMUM OF TWO SESSIONS TO PROCESS A SEGMENT
- STATUS AND TRACKING

NASA-S-78-17314

ADVANTAGES

- ON-LINE SPECTRAL AIDS
- ON-LINE RELABELING CAPABILITY
- OVERLAY CAPABILITY
- INTERACTIVE MODE

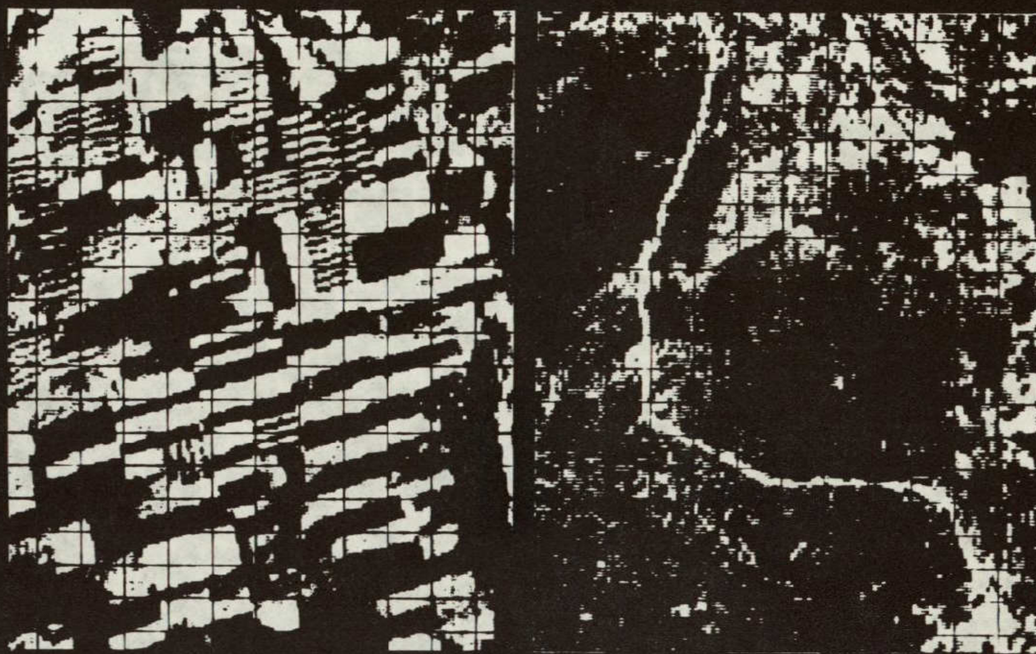
NASA-S-78-17315

VARIED CONDITIONS THROUGHOUT STUDY AREA

- CULTURAL PRACTICES
- WEATHER CONDITIONS
- FARMING METHODS
- CROP TYPES

NASA-S-78-12520

EXAMPLE OF VARIED CONDITIONS



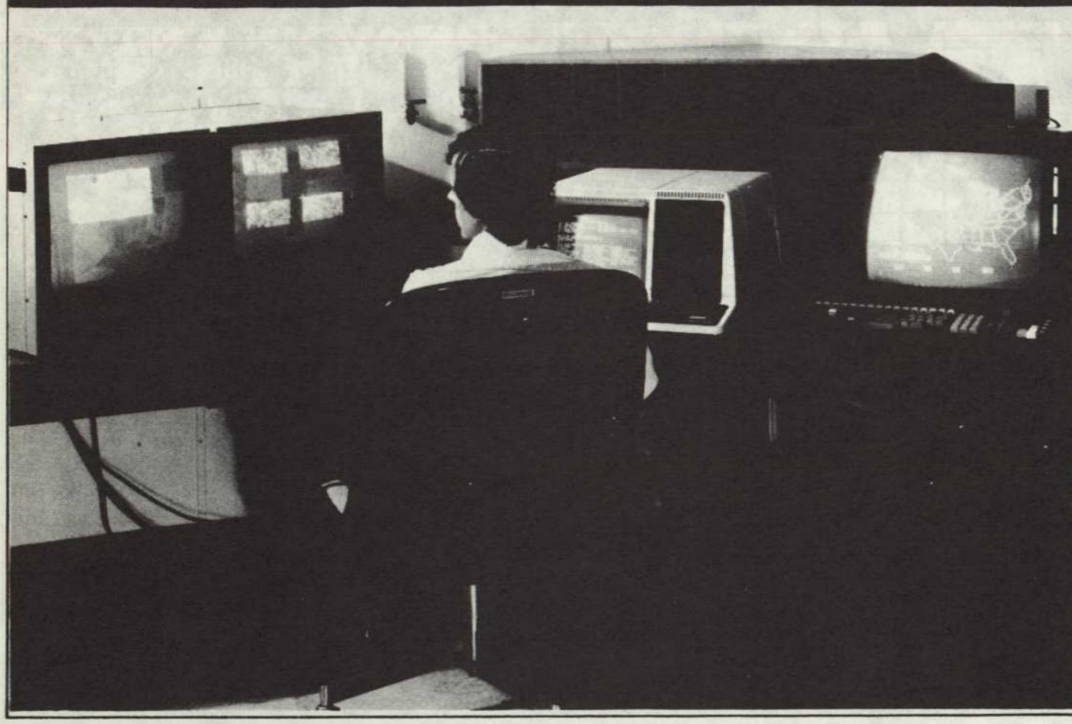
NASA-S-78-17316

SUMMARY OF I-100 HYBRID EFFORT

- HARDWARE, SOFTWARE PROBLEMS IDENTIFIED AND CORRECTED
- IDENTIFICATION OF IMPROVEMENTS THAT UPGRADED SYSTEM
- USDA ANALYSTS GAINED EXPERIENCE IN PROCESSING AND ANALYZING SEGMENTS ON INTERACTIVE SYSTEM
- EXPERIENCE GAINED WAS INCORPORATED INTO THE DESIGN AND IMPLEMENTATION OF THE USDA APPLICATION TEST SYSTEM

NASA-S-78-12519

ANALYST STATION



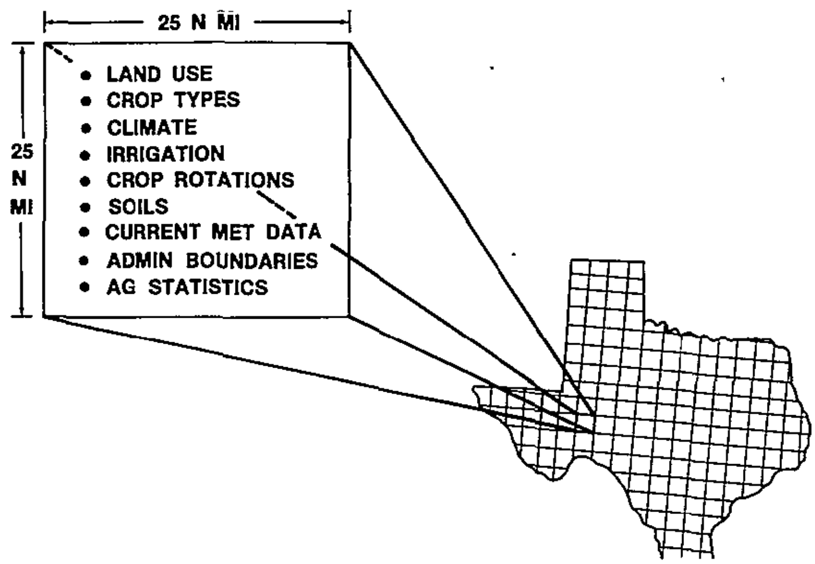
NASA-S-78-17317

CURRENT PLANS

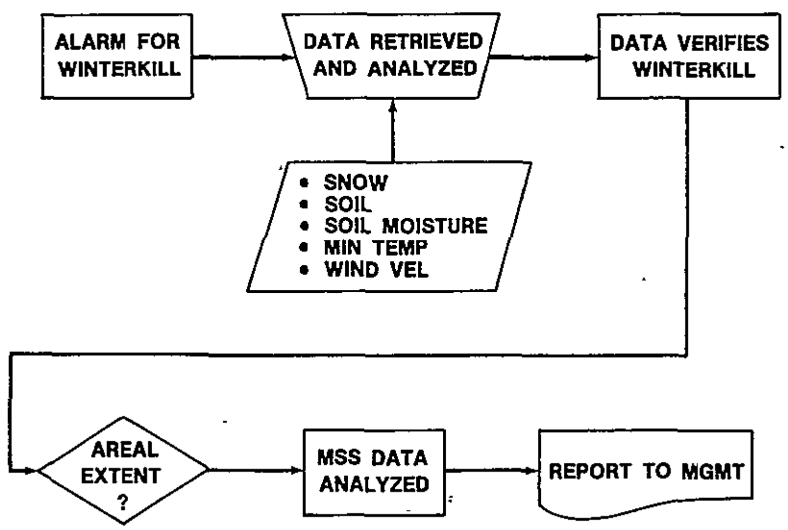
- DEVELOP AN EARLY WARNING SYSTEM FOR SPRING AND WINTER WHEAT
- THE PURPOSE OF THIS SYSTEM IS TO DETECT AND ASSESS, AS EARLY AS POSSIBLE, CROP CONDITIONS THAT MAY AFFECT PRODUCTION AND QUALITY OF WHEAT

NASA-S-78-17320

GRIDDED DATA BASE COMPOSITION



NASA-S-78-17321



NASA-S-78-17322

CROP CONDITION ASSESSMENT

- DETERMINATION OF THE HEALTH OR VIGOR OF WHEAT
- COMPARISON/EVALUATION OF CURRENT YEAR DATA TO HISTORICAL DATA

NASA-S-78-17323

DATA USED FOR ASSESSMENT

- GREEN NUMBERS
- LANDSAT IMAGERY
- CROP BIOSTAGE
- METEOROLOGICAL
- SOIL MOISTURE (WHERE AVAILABLE)

NASA-S-78-17324

IMPLEMENTED FROM LACIE

- VERSATILE SOIL MOISTURE BUDGET
- CROP CALENDAR MODEL
- CCEA AND KSU YIELD MODELS
- CLIMATIC ALARMS FOR WHEAT
- PROCESSING PROCEDURES
  - P-1 (PHASE III)
  - DESIGNATED CROP (PHASE II)
  - TRAINING FIELDS (PHASE I)

NASA-S-78-17325

FUTURE PLANS

MID-1980'S

- DEVELOP AN EARLY WARNING SYSTEM FOR
  - BARLEY
  - RYE
  - CORN
  - SOYBEANS
  - SUNFLOWERS
  - COTTON
  - SORGHUM
  - PEANUTS
  - RICE

NASA-S-78-17326

SUMMARY

- ATS CHARTERED TO APPLY LATEST REMOTE-SENSING TECHNOLOGY TO PROBLEMS IN AGRICULTURE
- PLANS ARE TO TEST AND IMPLEMENT LATEST TECHNOLOGY IN STORAGE, RETRIEVAL, ANALYSIS, AND APPLICATION OF REMOTELY SENSED METEOROLOGICAL AND AGRICULTURAL DATA TO SUPPORT AN EARLY WARNING SYSTEM

USDA APPLICATION TEST SYSTEM (ATS) SESSION

RESOURCE MODELING: A REALITY FOR PROGRAM COST ANALYSIS
L. Fouts, USDA

NASA-S-78-16742

INTRODUCTION

- QUESTION OF MONETARY RESOURCES
- LACIE OBJECTIVE
- OFFICE OF MANAGEMENT AND BUDGET
- SENIOR USDA MANAGEMENT

NASA-S-78-16743

BACKGROUND

- ALTERNATE DESIGNS
- MULTIPLE LOCATIONS
- VARYING WORKLOADS/PHASE IN
  - PROJECTED PROCUREMENTS
  - FACILITY SPACE
  - MANPOWER RESOURCES
- MULTIYEAR PROJECTIONS
- ALTERNATIVE DECISION FACTORS WITHIN EACH MAJOR COST AREA

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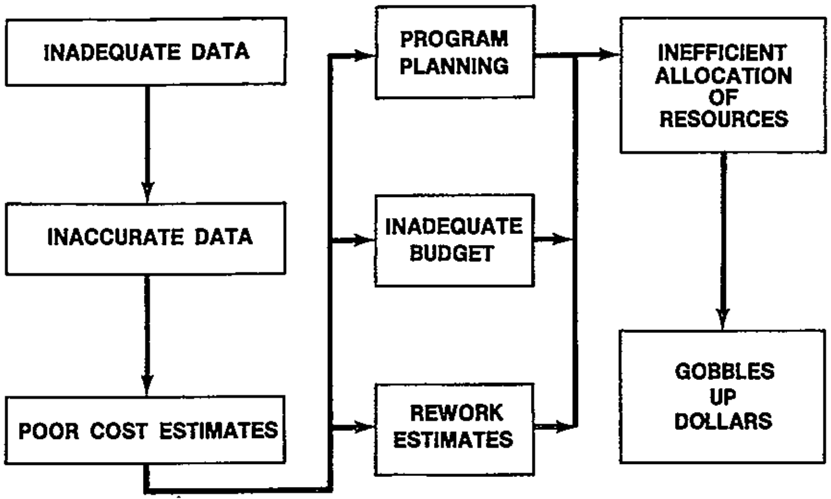
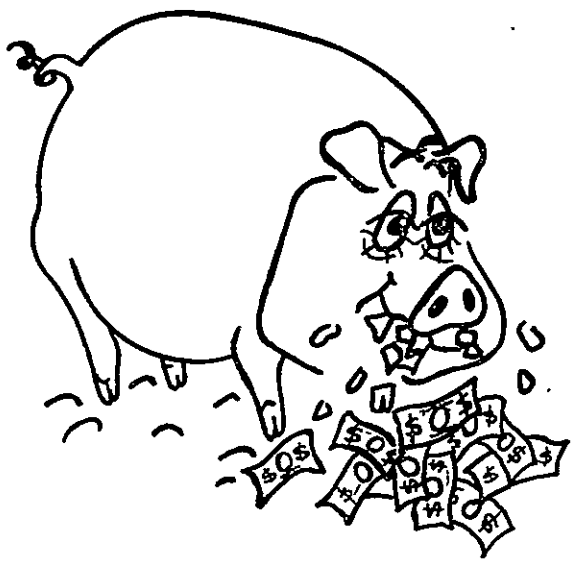
NASA-S-78-16744

DEVELOPMENT OF COSTING DATA



NASA-S-78-16745



POOR COST ESTIMATES = RESOURCE HOG

NASA-S-78-16746

PURPOSE

- USED TO ASSESS AND INFLUENCE THE DESIGN AND DEVELOPMENT ASPECTS OF THE USDA ADVANCED SYSTEM
- PROVIDE MANAGEMENT WITH A TOOL THAT CAN INCREASE THE COMPETENCE OF MANAGEMENT DECISIONS
- GUIDE MANAGEMENT IN DECISION ON SCHEDULING EQUIPMENT PROCUREMENT
- USED TO ASSESS AND INFLUENCE FUTURE MANPOWER AND BUDGET PLANNING
- RESPOND TO BUDGET AND COST "WHAT IF" SITUATIONS IN A MINIMUM AMOUNT OF TIME

NASA-S-78-16747

APPROACH TO MODELING

- IDENTIFY MAJOR COST ELEMENTS
- CATEGORIZE COST ELEMENTS

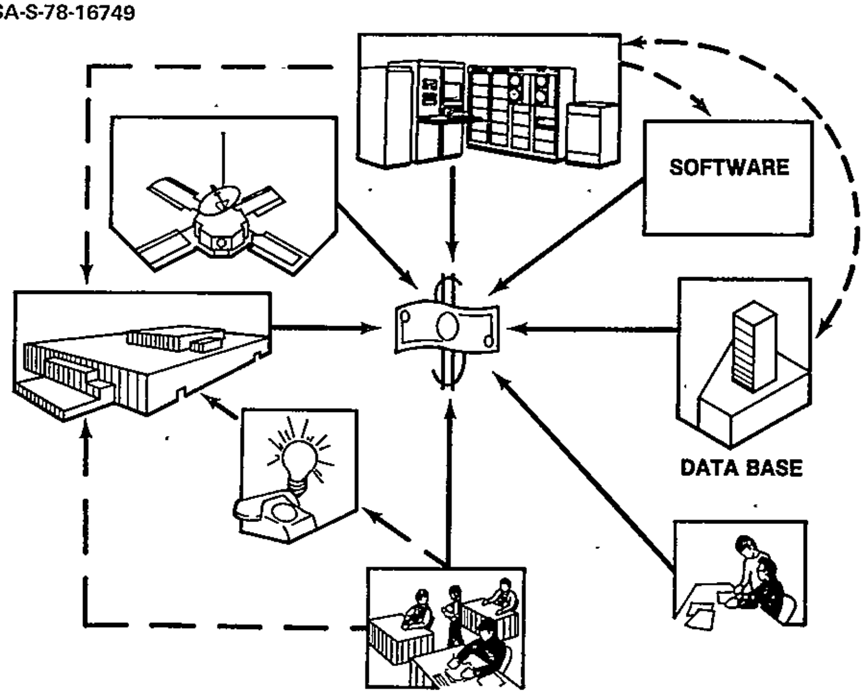
  INVESTMENT
  OPERATIONS
- ESTABLISH INTERDEPENDENT RELATIONSHIPS
- DETERMINE DETAIL COMPONENTS OF EACH ELEMENT
- OUTPUT FORMATS

NASA-S-78-16748

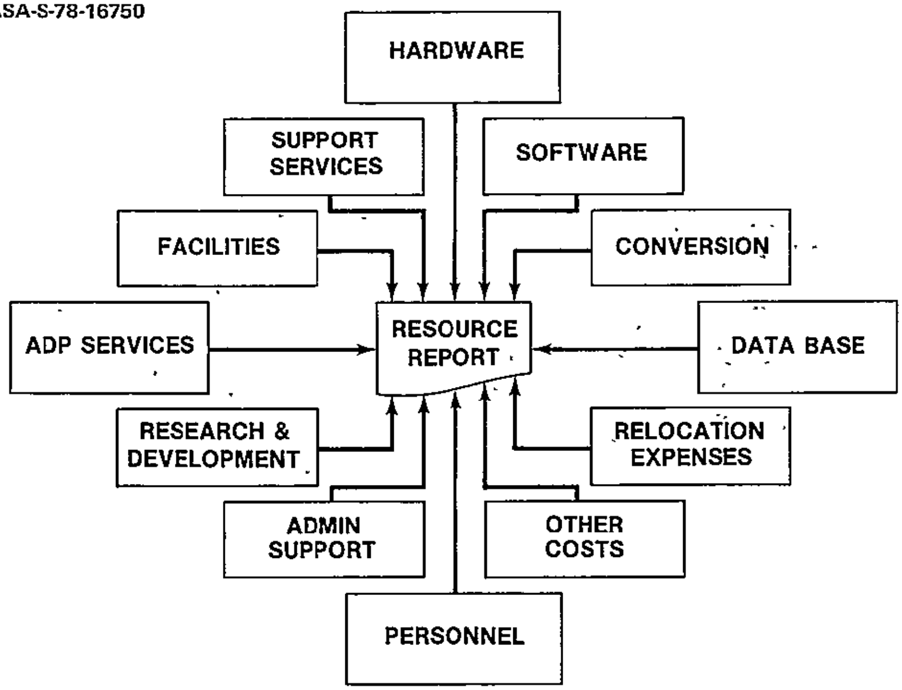
GENERAL ASSUMPTIONS AND GUIDELINES

- PROSECTIONS SPAN OF 10 YEARS
- PROCURING AND LAUNCHING OF SATELLITE COSTS ARE NOT INCLUDED. COST OF DIGITAL IMAGE DATA PRODUCT IS INCLUDED
- CURRENT GSA FACILITY LEASE RATES ARE USED FOR EACH POTENTIAL LOCATION
- USDA/FAS BUDGETING POLICIES WERE FOLLOWED IN RESOURCE CALCULATIONS
- PERSONNEL SALARIES PROJECTED BASED ON ACTUAL AND PROJECTED POSITIONS
- FORTRAN WAS THE COMPUTER LANGUAGE USED
- CONCEPT OF MODULAR PROGRAMMING WAS APPLIED
- DEVELOPED AND OPERATES ON A MINICOMPUTER

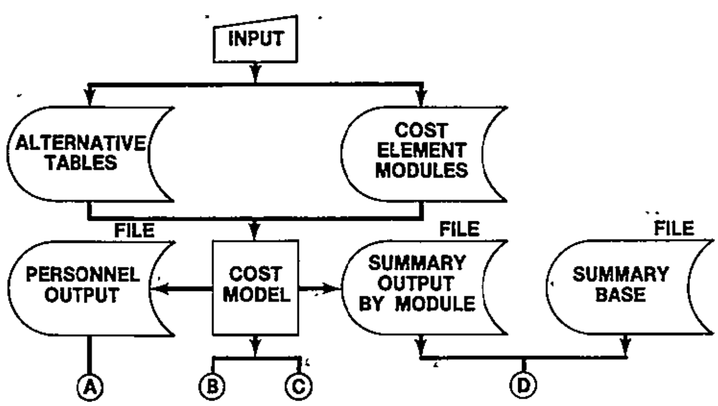
NASA-S-78-16749



NASA-S-78-16750



NASA-S-78-16751



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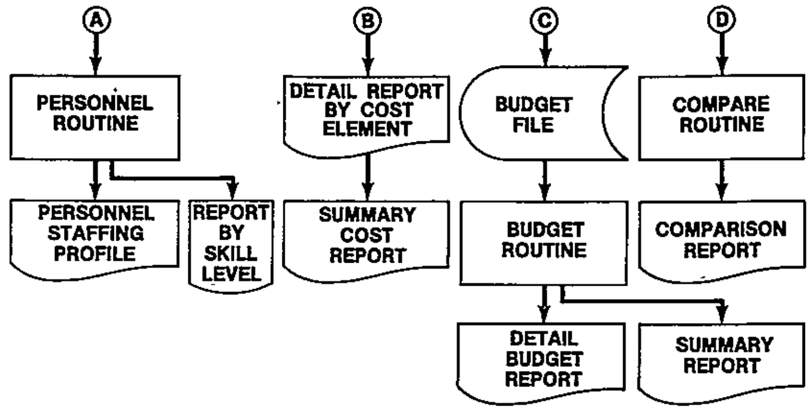

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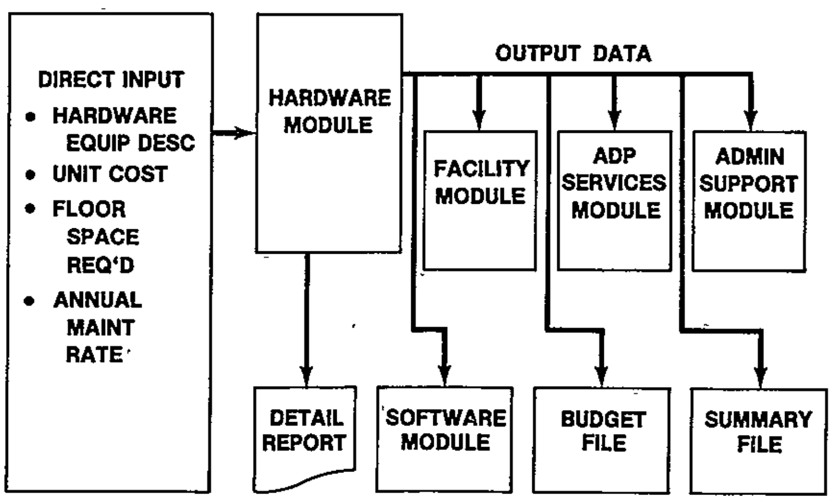

NASA-S-78-16754

DETAILED REPORT - HARDWARE

NAME	QTY	PRICE	CURRENT	FY 2	→ FY 10
DISK CONTROLLER	15	9.1	9.1	9.1	9.1
DISK UNITS	34	15.0	139.6	139.6	30.0
MAG TAPE CONTROLLER	14	12.5	12.5	12.5	12.5
MAG TAPE DRIVE	25	14.0	28.0	28.0	14.0
GRAPHIC TERM/COPIER	12	7.5	7.5	7.5	0.0
CARD RDR/PUNCH	5	15.0	15.0	15.0	15.0
CARD READER	8	5.6	0.0	0.0	0.0
LINE PRINTER - 1200LP	1	31.5	31.5	0.0	0.0
*****SUBTOTAL*****			-19.2	[illegible]	0.0
TOTAL HARDWARE			[illegible]	0.0	712.6
PRESENT VALUE			727.0	727.2	302.1

NASA-S-78-16755

INVESTMENT AND OPERATIONAL COST SUMMARY

INVESTMENT COSTS	CURRENT	FY 2	FY 3	→ FY 10	TOTAL	P.V.
HARDWARE	700.0	800.0	1778.6	712.6	18996.3	12244.3
SOFTWARE	326.6	440.0	846.2	263.7	7432.4	4993.7
OPERATIONAL COSTS						
PERSONNEL	1167.6	1591.1	2169.0	5072.3		19512.4
ADMINISTRATIVE	383.7	-108.7	639.8	1262.4		4782.9
TOTAL	[illegible]	[illegible]	5290.4	5784.8	8681.9	
PV	[illegible]	1818.1	4369.8	4148.8		40739.0
GRAND TOTAL			6476.2	10340.9		
TOTAL P.V.		3121.8	7001.4	4596.5		

NASA-S-78-16756

DETAIL BUDGET PROJECTION REPORT

		CURRENT	FY 2	FY 3 → FY 10	
25 0	ADMIN SUPPORT	150.0	150.0	150.0 →	150.0
2551	SITE PREPARATION	0.0	25.0	75.0 →	0.0
↓					
25	TOTAL OTHER SERVICES	474.2	655.5	626.6 →	527.3
↓					
26	TOTAL SUPPLIES	[illegible]	[illegible]	7.0 →	2.9
↓					
31	TOTAL EQUIPMENT	111.1	521.7	159.2 →	0.0

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NASA-S-78-16757

BUDGET PROJECTION SUMMARY REPORT

TOTAL	CURRENT	FY 2	FY 3 →	FY 10	TOTAL
11 – PERSONNEL COMPENSATION	136.4	179.5	253.6 →	436.5	3512.5
12 – PERSONNEL BENEFITS	32.3	23.3	44.6 →	45.8	440.7
21 – TRAVEL AND TRANSPORTATION OF PERSONS	25.0	27.5	30.0 →	15.0	279.0
22 – TRANSPORTATION OF THINGS		3.5	10.0 →	[illegible]	40.0
23 – RENTS, COMMUNI[illegible]	[illegible]	[illegible]	34.1 →	53.7	561.0
25 – OTHER [illegible]	474.2	655.5	626.6 →	527.3	6120.7
26 – SUPPLIES	4.3	8.4	7.0 →	2.9	67.1
31 – EQUIPMENT	111.1	521.7	159.2 →	0.0	2753.9
GRAND TOTAL	816.7	1446.1	1165.1 →	1081.2	13774.9

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NASA-S-78-16758

PERSONNEL STAFFING PROFILE REPORT

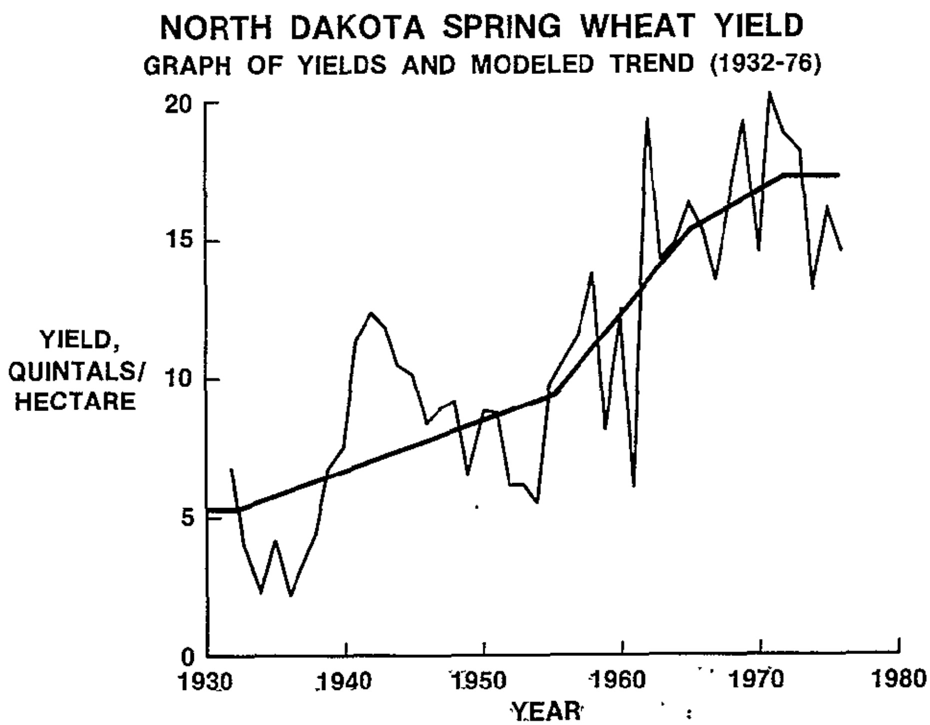
NAME	POSITION	GRADE	CURRENT	FY 2 ⟶ FY 10
PUBLIC, JOHN Q	PROJ MGR	301 15-1	38.0	40.7 ⟶ 52.4
SMITH, MARY	EXEC SEC	318 06-1	11.1	11.9 ⟶ 15.3
↓				
STOLES, RICHARD	AG ECON	110 14-3	32.8	35.1 ⟶ 45.2
↓				
2 (VACANT)	AG STAT R/ST	1529 09-1	0.0	0.0 ⟶ 19.4
↓				
2 (VACANT)	AG STAT [illegible]	[illegible]	0.0	32.6 ⟶ 42.0
2 (VACANT)	[illegible]	[illegible]1	0.0	0.0 ⟶ 19.4
2 (VACANT)	[illegible]RONOMIST	11 09-1	0.0	0.0 ⟶ 18.1
2 (VACANT)	AGRONOMIST	471 09-1	0.0	0.0 ⟶ 20.8
2 (VACANT)	AG ECON C/S	110 09-1	0.0	0.0 ⟶ 19.5

DATA GENERATED FOR EXAMPLES ONLY

MODEL UTILIZATION

- FLEXIBLE, EFFICIENT, AND EFFECTIVE MANAGEMENT TOOL
- COST ANALYSIS
  - INITIAL COST ANALYSIS FOR OMB – 1976
  - UPDATED COST ANALYSIS FOR OMB – 1977
  - FINAL COST ANALYSIS FOR OMB – 1978
- ADP IMPACTS
  - OMB – ADP BUDGET PROJECTION – FY77, 78, 79
  - CONFIGURATION COST COMPARISONS
- BUDGET USE
  - FY78 ADP PART OF BUDGET
  - FY79, FY80 ENTIRE BUDGET IN ZBB DECISION PACKAGES
- MANPOWER PLANNING
  - EFFECTS OF NEW POSITIONS
  - CURRENT STAFFING PROFILE
- RESPONDS QUICKLY TO MANAGEMENT REQUESTS FOR INFORMATION

NASA-S-78-17059



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POTENTIAL WEAKNESSES

- LACK OF SENSITIVITY TO WEATHER CONDITIONS PRODUCING LARGE DEPARTURES FROM EXPECTED YIELDS
- INCORRECT PARAMETERIZATION OF TECHNOLOGICAL CHANGE
- LACK SUFFICIENT SPATIAL RESOLUTION IN DEFINITION OF MODELED REGIONS
- LACK OF SPATIAL AND TEMPORAL RESOLUTION IN METEOROLOGICAL INPUT DATA

NASA-S-78-17061

YIELD MODELS
EVALUATION METHODOLOGY

- THROUGH HISTORICAL TESTS
  - TEST FOR SUPPORT OF 90/90 CRITERION
  - EVALUATE MODEL RESPONSE TO EXTREME WEATHER CONDITIONS
  - DETERMINE PREHARVEST PREDICTIVE ABILITY OF MODELS
  - MONITOR IMPACT OF SIGNIFICANT CHANGES IN TECHNOLOGY
  - EVALUATE ABILITY TO ESTIMATE PREDICTION ERRORS
- EMPHASIS HAS BEEN ON THE U.S. GREAT PLAINS AS A YARDSTICK TO EVALUATE FOREIGN CAPABILITIES
- THROUGH OPERATIONAL TESTS
  - EVALUATE THE METEOROLOGICAL DATA HANDLING CAPABILITIES
  - TEST THE "TRUE" PREDICTIVE ABILITIES OF THE LACIE YIELD MODELS

NASA-S-78-17062

YIELD MODELS
90/90 CRITERION TEST

- PROBABILITY $(|\hat{P}-P| \leq 0.1P) \geq 0.9$
- IT CAN BE SHOWN THAT THE 90/90 CRITERION WITH BOTH ACREAGE AND YIELD ERRORS IS EQUIVALENT TO A 90/93 CRITERION FOR A PRODUCTION ESTIMATE WITH ONLY YIELD ERRORS
- PROBABILITY $(|\hat{P}_{*}-P| \leq .0707\,P) \geq 0.9$