Cloud Mask Working Group

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- MODLAND: C. Schaaf
- SNOW MASK: G. Riggs
- CERES: B. Baum, R. Welch

Our approach to the MODIS Cloud Mask, is for each pixel to provide a confidence flag that indicates how certain we are that the pixel is clear.

Restrictions

- Real time execution
- Computer storage (5.25 g bytes per day)
- Comprehension

oud Mask Inputs

- Calibrated/navigated radiances
- Sun and viewing geometry
- Land/water map (1 km)
- Topography and ecosystem
- surface temperatures and atmosphe
  profiles
- clear sky composite maps
- snow/ice maps

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Why increase to 48 bits?

- Include results from individual tests
  - better interpretation of results
- Non-cloud obstruction bit
- A few spare bits
  - warm fuzzy feeling for operational algorithms

MODIS CLOUD MASK BIT STRUCTURE

48 bits (12/95)

Decision	1	1 mask determined, 0 no decision
Summary of all algorithms	2	unobstructed FOV (quality flag) 11 > 99% prob of clear 10 > 95% prob of clear 01 > 66% prob of clear 00 cloud
Processing path	1	Day or night processing (1 day, 0 night)
	1	Sunglint regime (1 no, 0 yes)
	1	snow/ice background (1 no, 0 yes)
	2	land/water background (11 land, 10 wetland, 01 coastal, 00 water)
Additional Information	1	Non-cloud obstruction (1 no, 0 yes)
	1	Thin cirrus detected (1 no, 0 yes)
	1	Shadow found (1 no, 0 yes)
Spares	2	
Results from cloud algorithms	1	IR threshold test did not find cloud
	1	CO2 high cloud test did not find high cloud
	1	6.7 micron test did not find high cloud
	1	1.88 micron test did not find high cloud
	1	3.7 - 12 micron test did not find high cloud
	1	Tri-spectral BTDIF tests did not find cloud
	1	3.7 - 11 micron test did not find cloud
	1	Visible reflectance test did not find cloud
	1	Reflectance ratio test did not find cloud
	1	.935/.87 reflectance test did not find cloud
	1	3.7-4.0 micron BT test did not find cloud
Additional tests	1	passed temporal consistency test
	1	passed spatial consistency test
Spares	6	
250m mask from	16	1 clear, 0 cloud for 16 FOVs in 1 km FOV visible tests

Development Data Sets

Global Collocated GAC AVHRR and HIRS

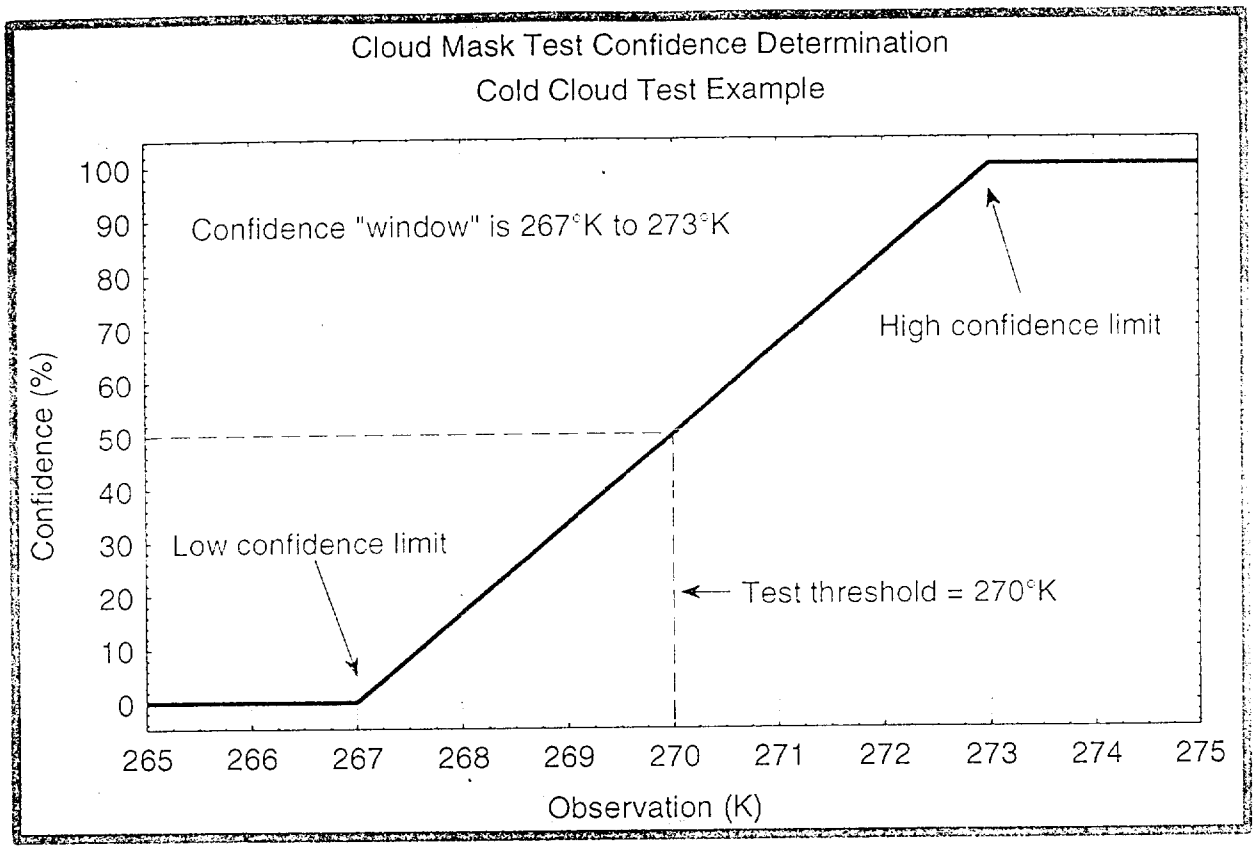
- Data good for developing IR test and global applications.

Regional LAC AVHRR

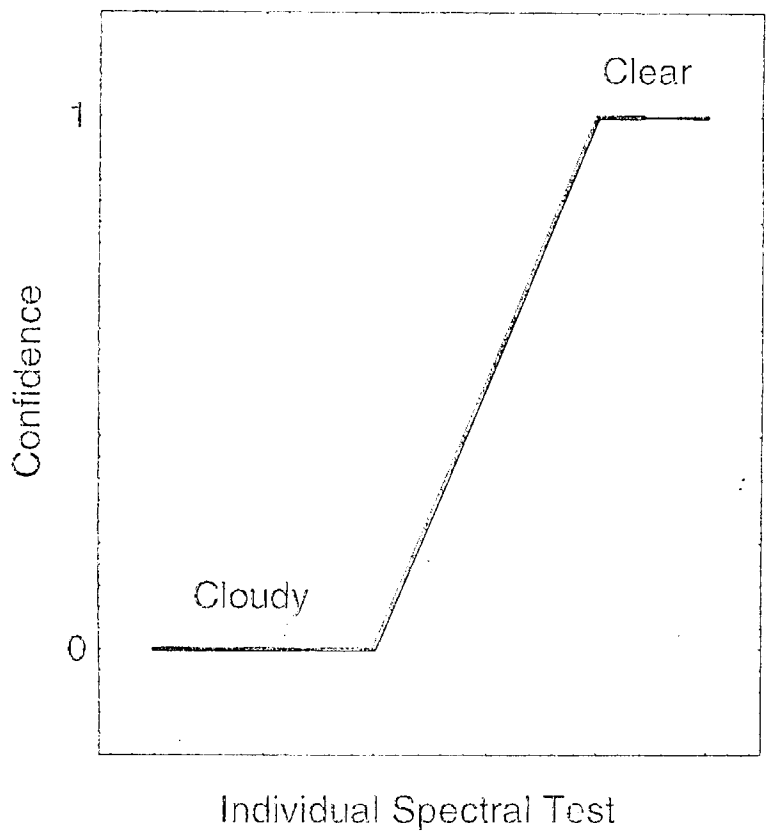
- Spatial resolution similar to MODIS.

Regional MAS Data

- 50 channels, 19 similar to MODIS. Variety of scenes from various field experiments.

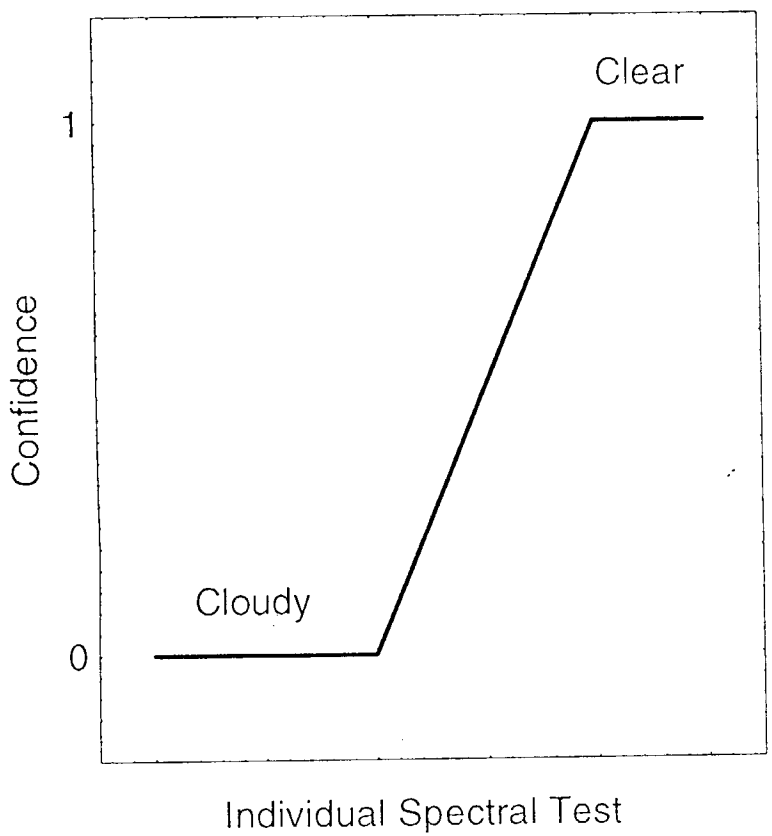

Cloud Mask Test Confidence Determination
Cold Cloud Test Example
Confidence "window" is 267°K to 273°K
High confidence limit
Low confidence limit
Test threshold = 270°K
Confidence (%)
100
90
80
70
60
50
40
30
20
10
0
265
266
267
268
269
270
271
272
273
274
275
Observation (K)

MAS Cloud Mask Confidence



- Confidence intervals are based on *closeness* to a threshold
- Confidence tests are combined to arrive at a **Quality Flag** (2 bits)

MAS Cloud Mask Confidence



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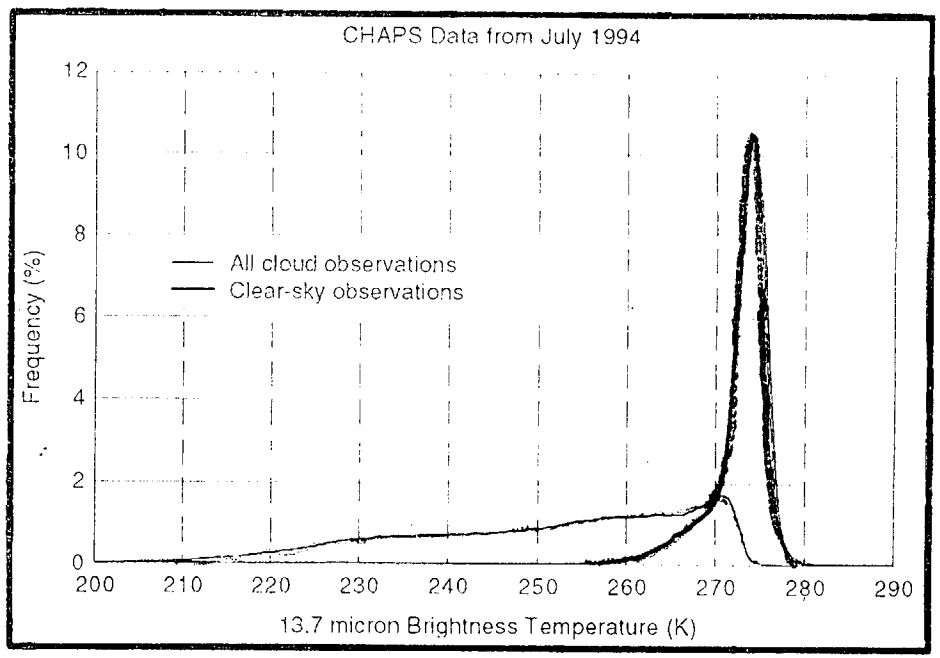
Cloud Mask Thresholds

- Previous Studies (ISCCP, APOLLO, CLAVR)
- Collocated AVHRR/HIRS
- MAS observations



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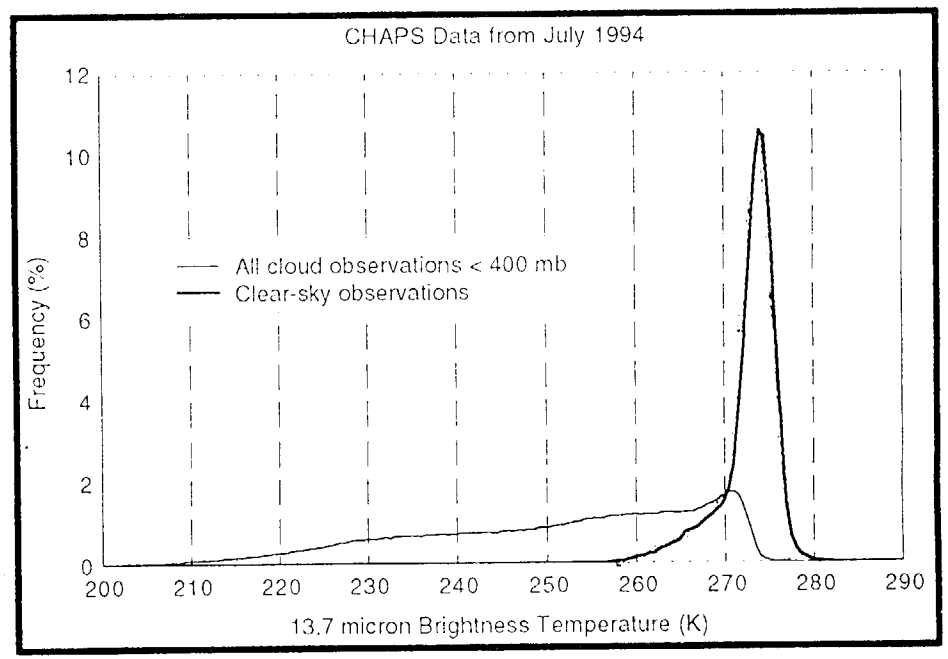
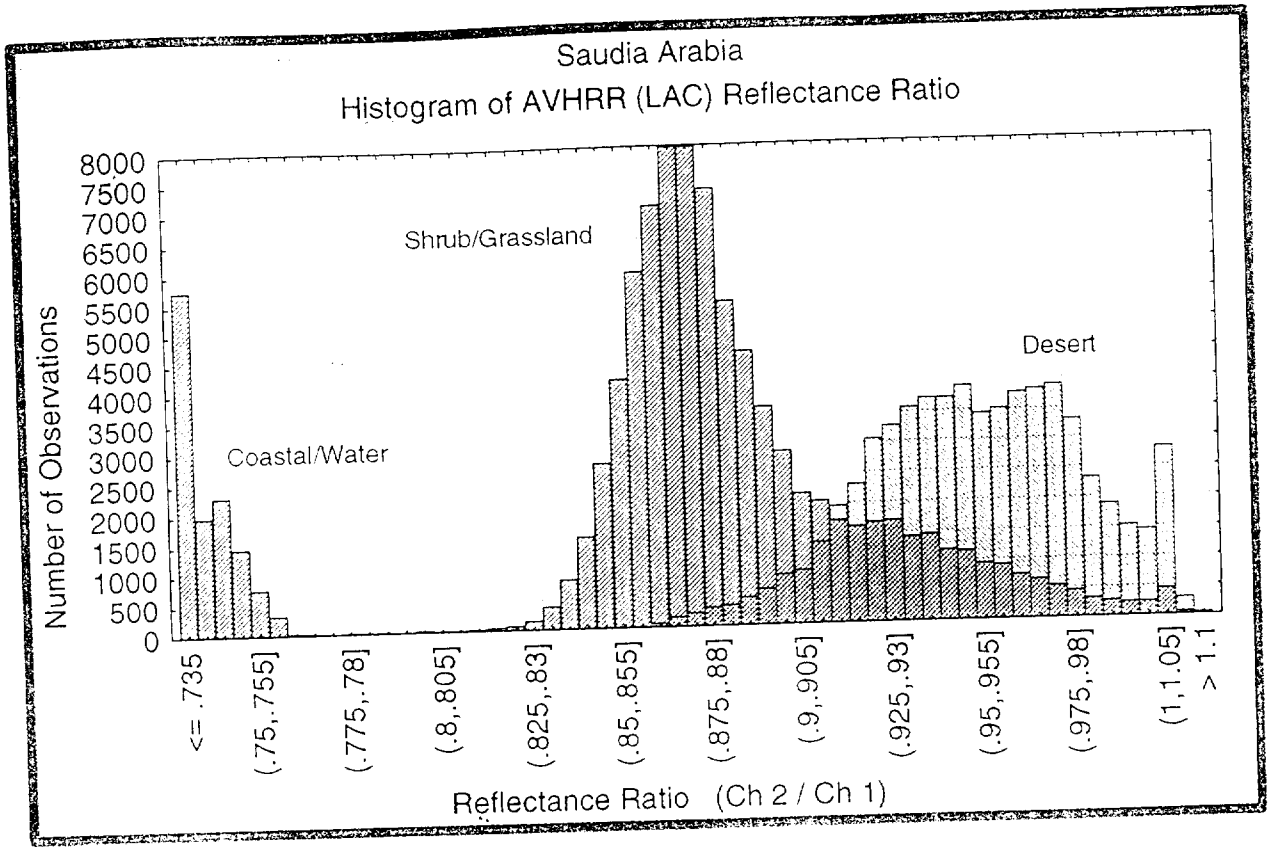
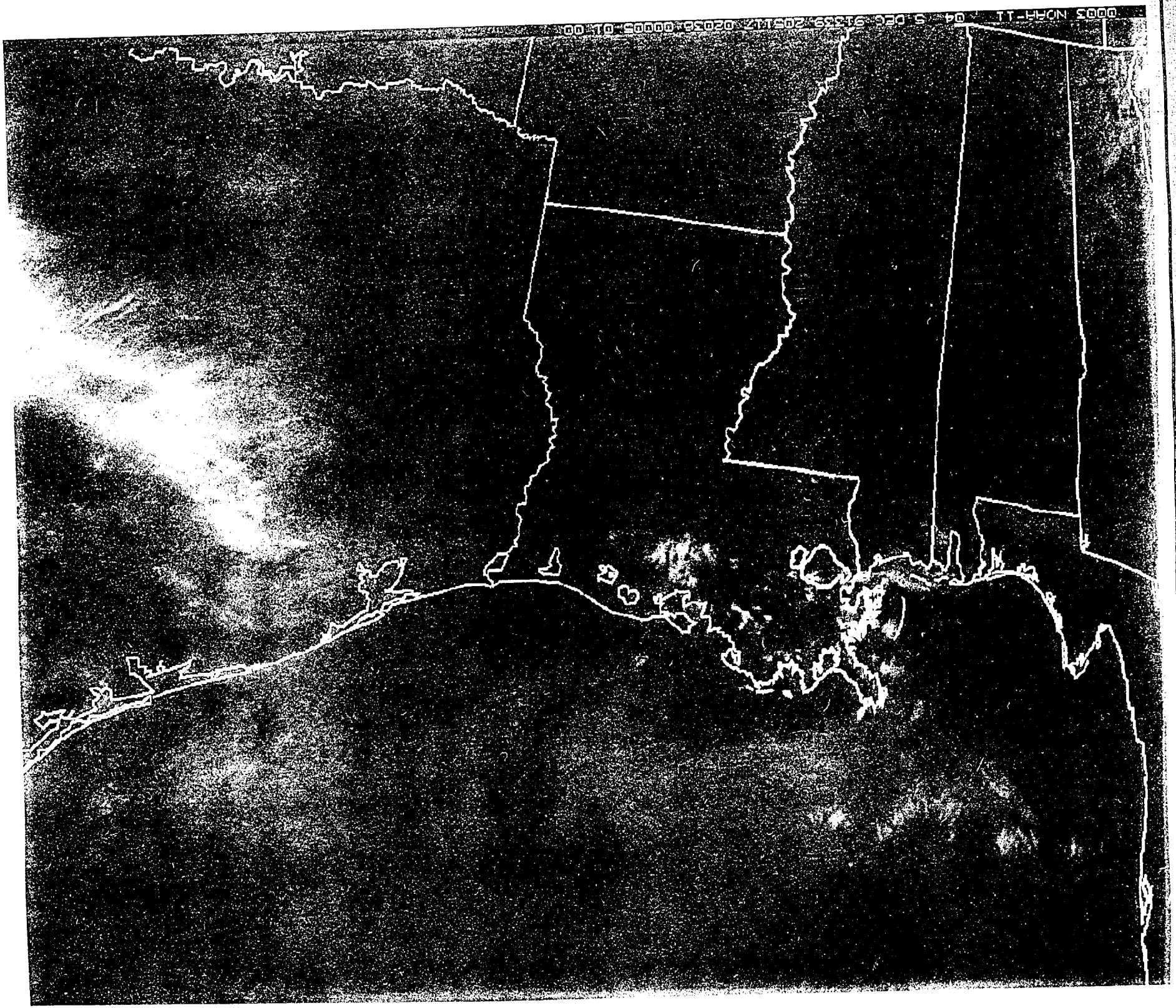


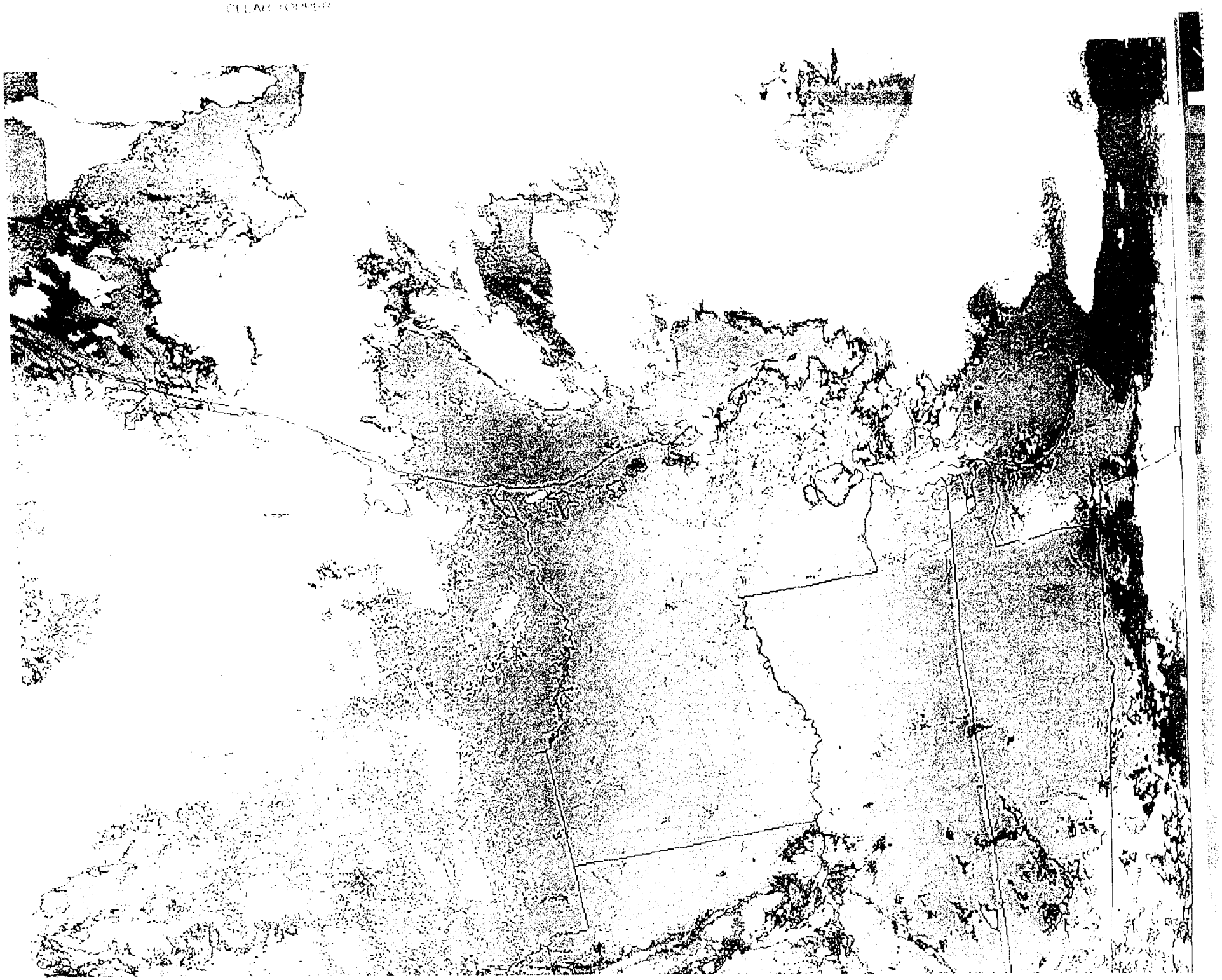

Saudia Arabia
Histogram of AVHRR (LAC) Reflectance Ratio
Number of Observations
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Shrub/Grassland
Desert
Coastal/Water
<= .735
(.75,.755]
(.775,.78]
(.8,.805]
(.825,.83]
(.85,.855]
(.875,.88]
(.9,.905]
(.925,.93]
(.95,.955]
(.975,.98]
(1,1.05]
> 1.1
Reflectance Ratio (Ch 2 / Ch 1)

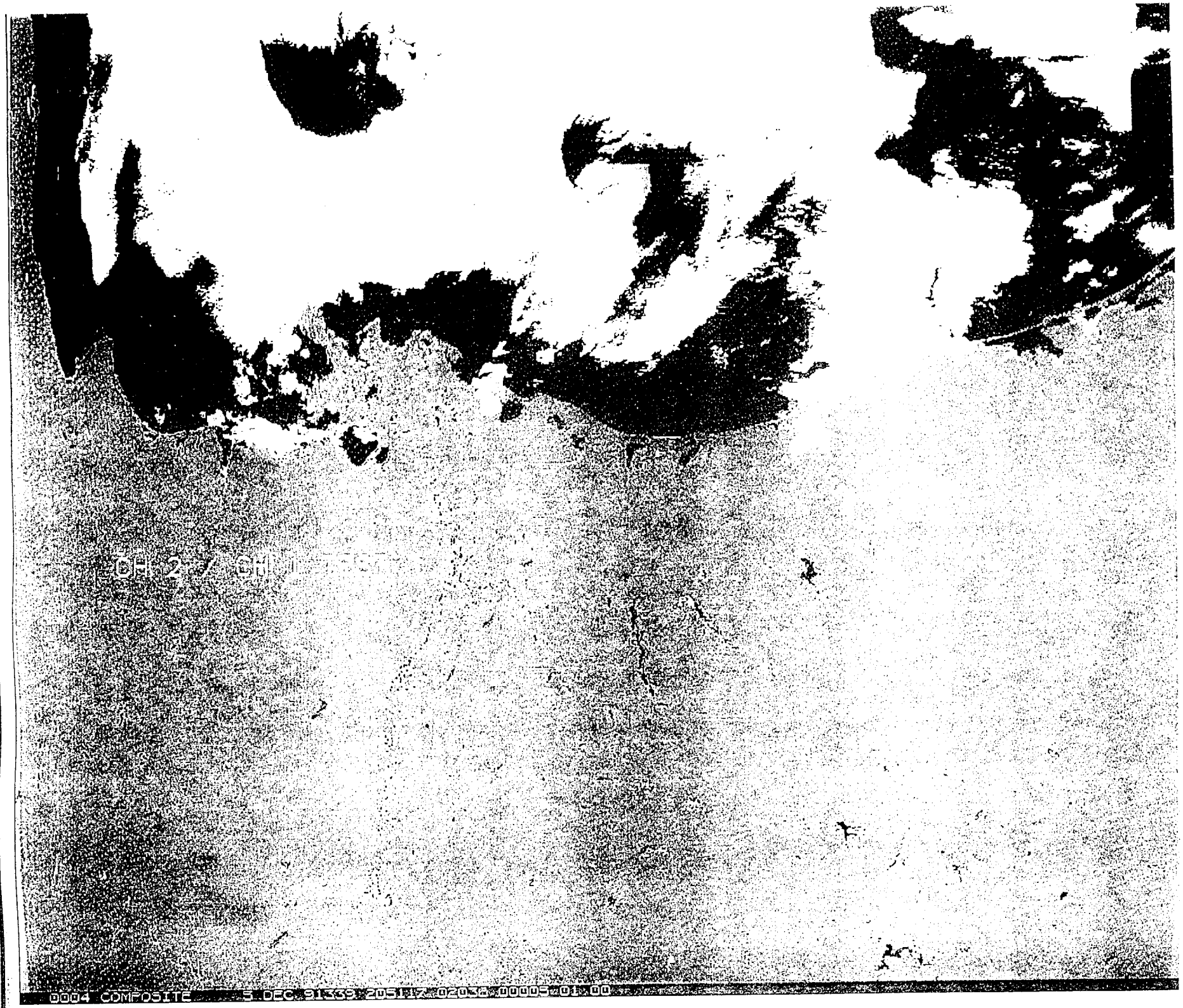
Final Quality Flag (2 bits)

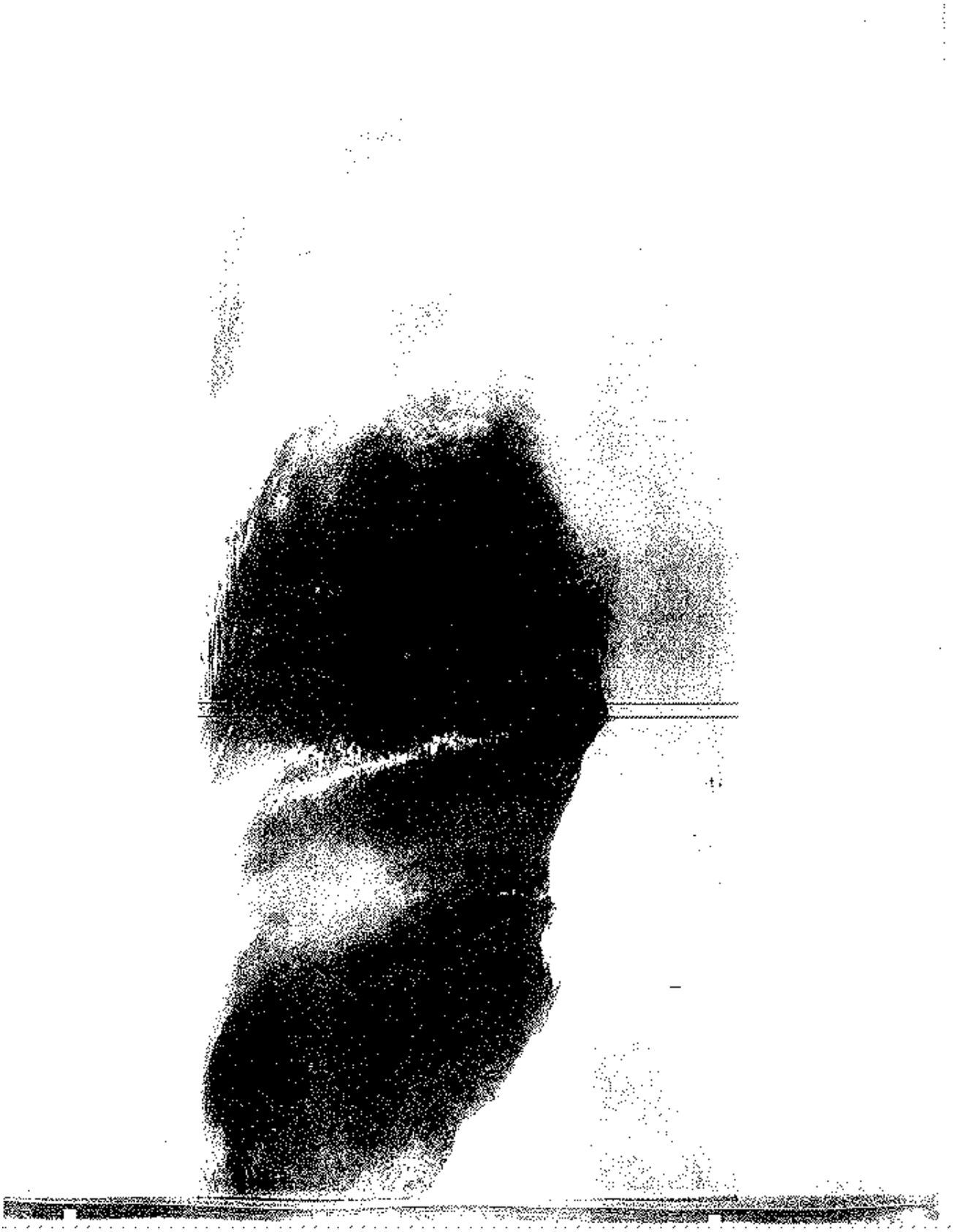
- How to combine *confidence levels* of individual tests?
  - Minimum of all tests
  - Maximum of all tests
  - Product of all tests
  - Combination (Group similar tests together)
    - "90% of the work to analyze 10% of the data"


0003 NOAA-11 04 5 DEC 91339 205117 02036 00005 01 00

C-LINE #62037
CLEAR / OPPER




CH 2 / CH 1
0004 COMPOSITE 5 DEC 91339 205117 02038 00005 01 00



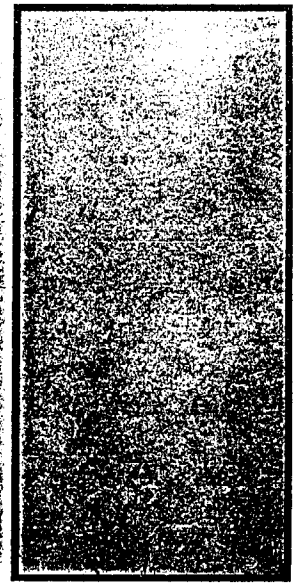
NORTH

Cloud Mask Low Latitude Test January 1995 MAS Gulf of Mexico Flight

MAS .66 micron

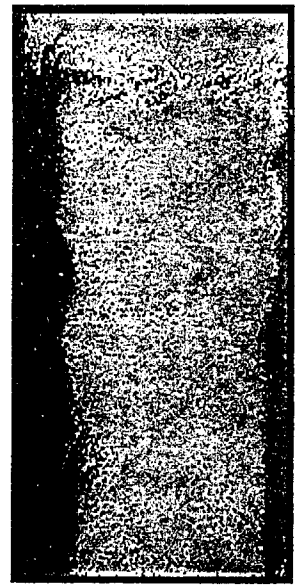
MAS .88 micron

MAS 1.88 micron



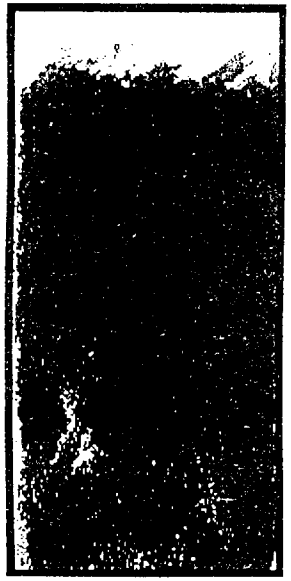
MAS 3.9 micron

MAS 11 micron



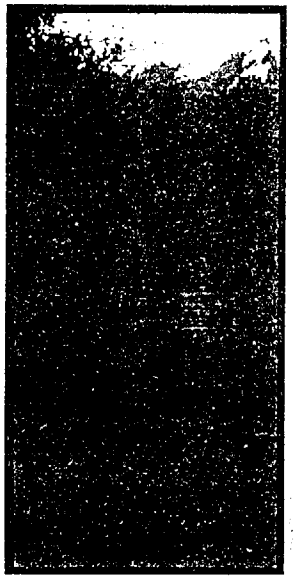
Spatial Variability

Observations

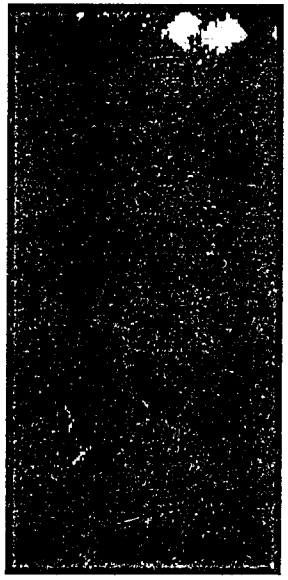


Vis. Reflectance

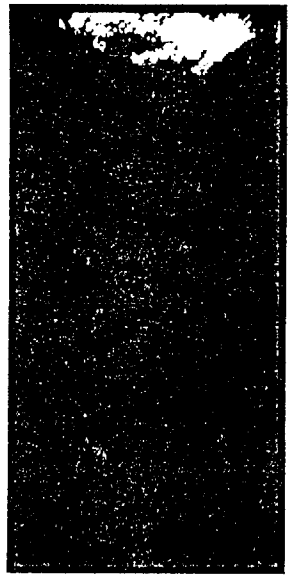
Visible Ratio



1.88 Thin Cirrus



SWIR BTD

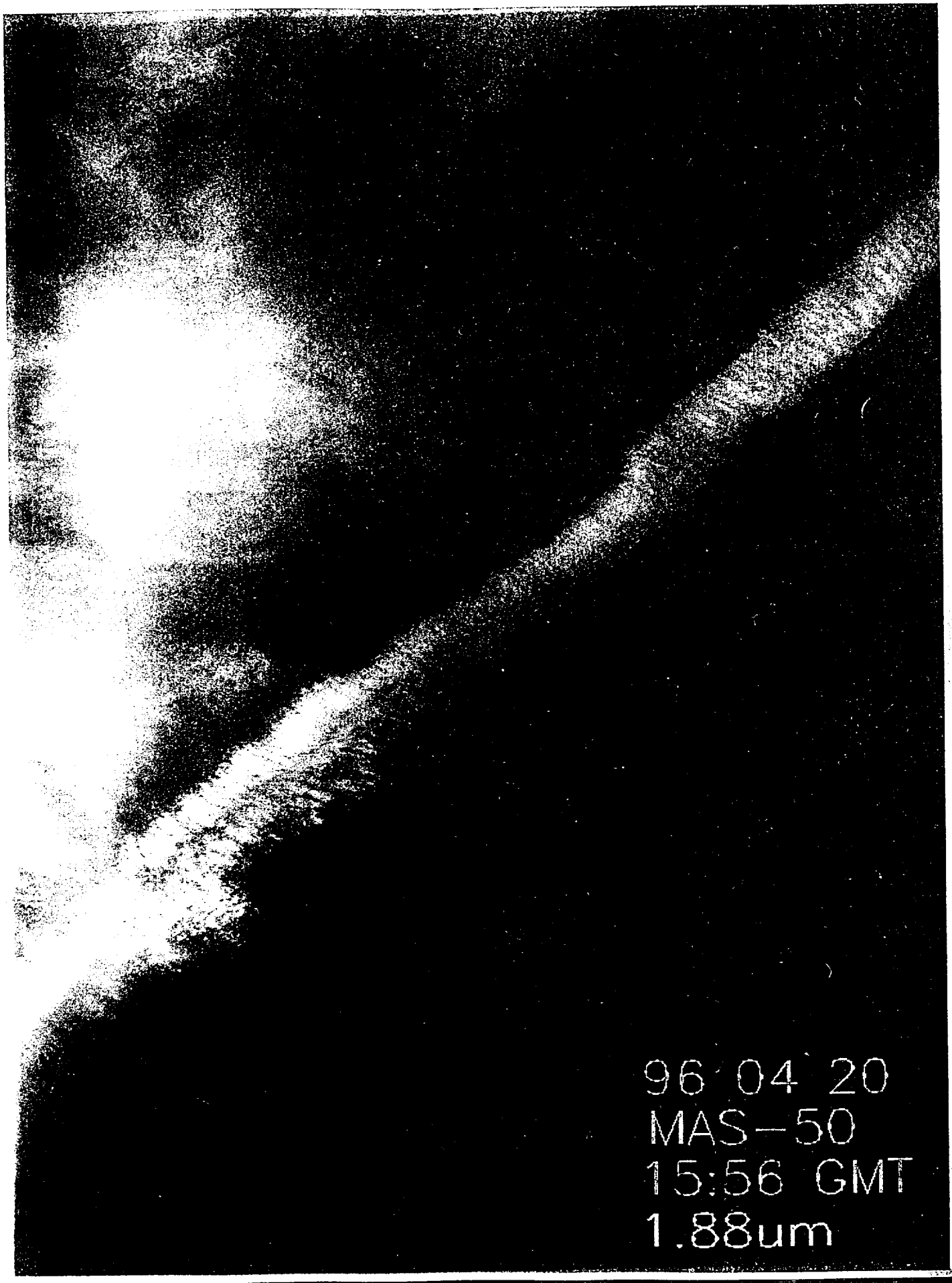


Cloud Mask Result

Individual Test Results

Result

UW/CIMSS


96 04 20
MAS-50
15:56 GMT
1.88um

Validation Approaches

- Image analysis
- Field experiments
  - Aircraft missions
  - Ground-based observations
- Global Statistics

Outstanding Problems

- ? Ecosystem Dependence
- ? Cloud Shadows
- ? Polar Cloud Detection
- ? What is "thin cirrus"
- ? Aerosol flagging
- ? Sun glint
- ? Infrared only techniques