Atmosphere Algorithm Performance / Evaluation Report ATSK1

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Cloud Mask

- Overview of approach
- Methods of evaluation of approach
- Current activities

Channels used in cloud detection

Band	Wavelength (μm)	Used in Cloud Mask	
8	0.55	Y	thick clouds
13	0.68	Y	clouds
19	0.88	Y	low clouds
26	1.24	Y	snow, clouds, shadows
27	1.38	Y	Thin cirrus
28	1.64	Y	Snow, cloud
29	2.21	Y	Aerosols
30	3.7	Y	window
31	6.7	Y	high moisture
34	8.6	Y	mid moisture
35	10.8	Y	Window
36	12.0	Y	low moisture

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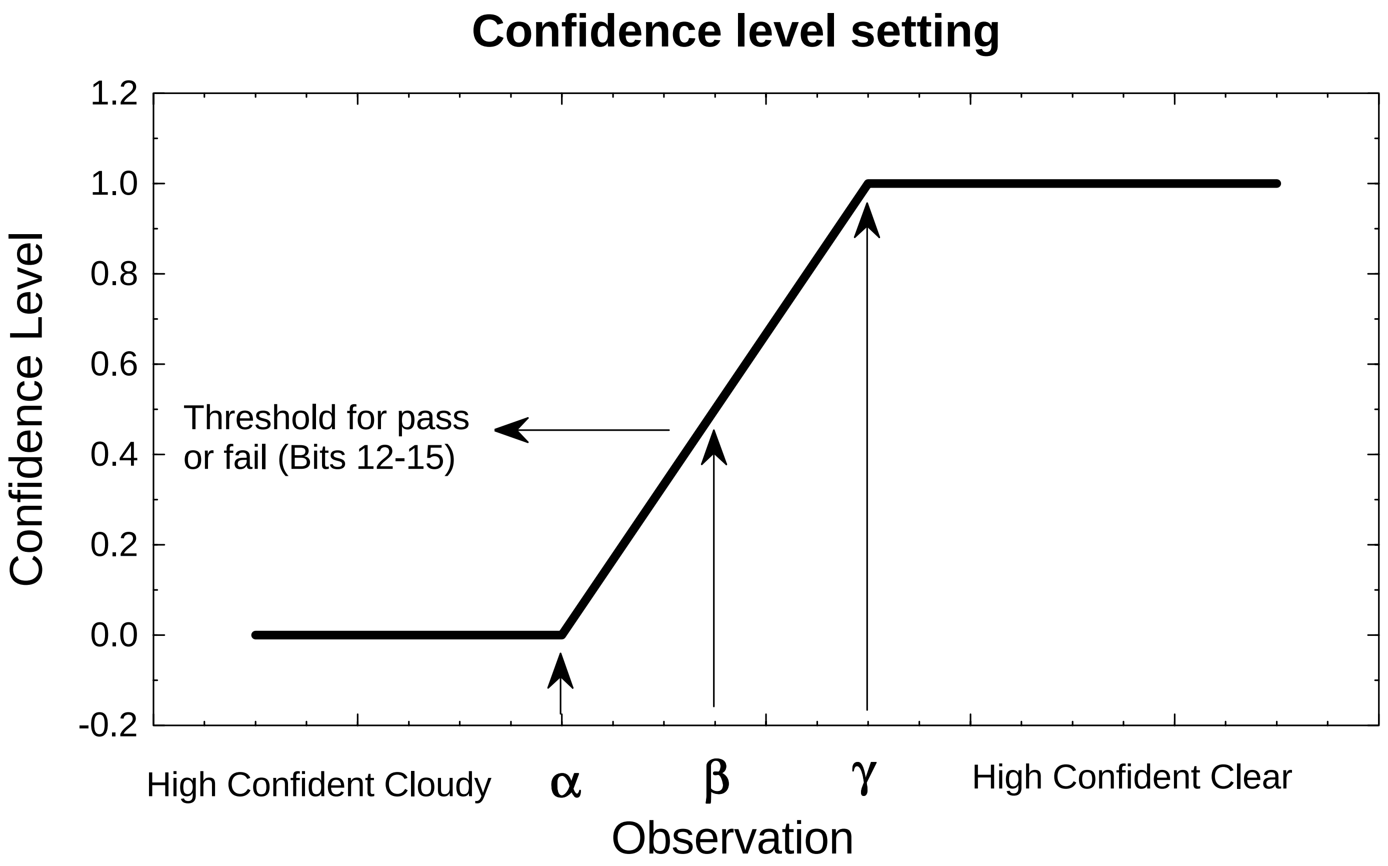
16 BIT GLI CLOUD MASK FILE SPECIFICATION		
BIT FIELD	**DESCRIPTION KEY**	**RESULT**
0-1	Unobstructed FOV Quality Flag	00 = cloudy 01 = uncertain 10 = probably clear 11 = high confidence clear
PROCESSING PATH FLAGS		
2	Day / Night Flag	0 = Night / 1 = Day
3	Sun glint Flag	0 = Yes / 1 = No
4	Snow / Ice Background Flag	0 = Yes/ 1 = No
5-6	Land / Water Flag	00 = Water 01 = Coastal 10 = Desert 11 = Land
ADDITIONAL FLAGS		
7	Non-cloud obstruction Flag (heavy aerosol)	0 = Yes / 1 = No
8	Thin Cirrus Detected (solar)	0 = Yes / 1 = No
9	Shadow Detected	0 = Yes / 1 = No
1-km CLOUD FLAGS		
10	Result from Group I tests	0 = Yes / 1 = No
11	Result from Group II tests	0 = Yes / 1 = No
12	Result from Group III tests	0 = Yes / 1 = No
13	Result from Group IV tests	0 = Yes / 1 = No
14	Result from Group V tests	0 = Yes / 1 = No
15	Spare	

A graphical depiction of three thresholds used in cloud screening



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Domains for Thresholds

1. daytime land surface,
2. daytime water,
3. nighttime land,
4. nighttime water,
5. daytime desert,
6. nighttime desert,
7. daytime snow covered regions, and
8. nighttime snow covered regions.

$$G_{j=1,5} = \min[F_i]$$

$$Q = \prod_{j=1,5} G_j$$

Bits 0 and 1

•Clear Q >0.99

•Probably clear Q>0.95

•Uncertain Q > 0.66

•Cloudy Q < 0.66

Group I (Simple IR threshold test)

BT_{11}

$BT_{6.7}$

Group II (Brightness temperature difference)

Tri-spectral test (BT_8 - BT_{11} and BT_{11}- BT_{12})

BT_{11}- $BT_{3.7}$

BT_{11}- $BT_{6.7}$

Group III (Solar reflectance tests)

$r_{0.87}$

$r_{.87}/r_{.66}$

Group IV (NIR thin cirrus)

$r_{1.38}$

Group V (IR thin cirrus)

BT_{11}- BT_{12}

BT_{12}- $BT_{3.7}$

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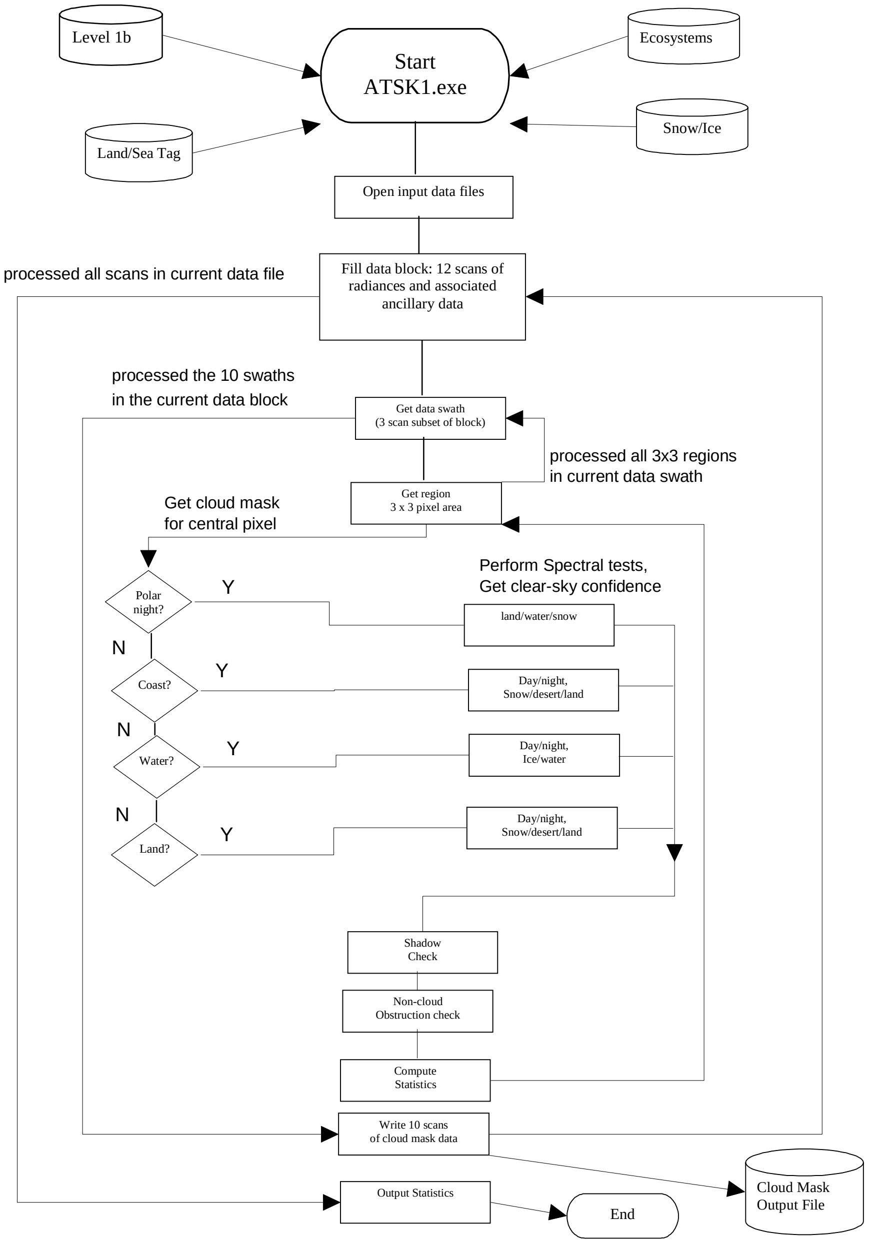
Flow Chart



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Data Set Examples

- PREVIOUS
  - MODIS Airborne Simulator (MAS) aircraft instrument flown on the NASA ER-2
  - AVHRR/HIRS
- MODIS FOCUSING NOW ON USING:
  - MODIS ("flat files" are generated)
  - GLI SIMULATOR

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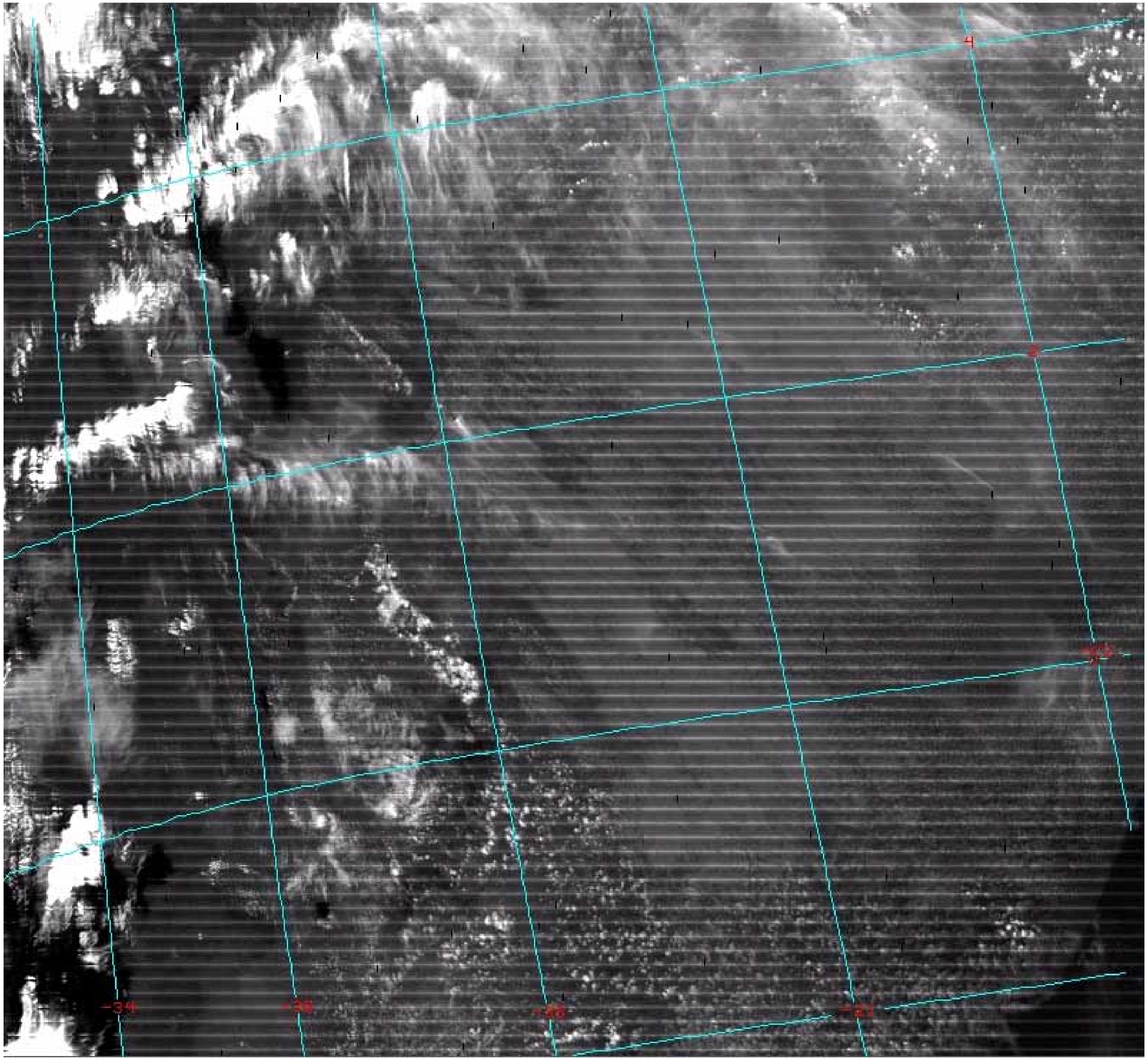
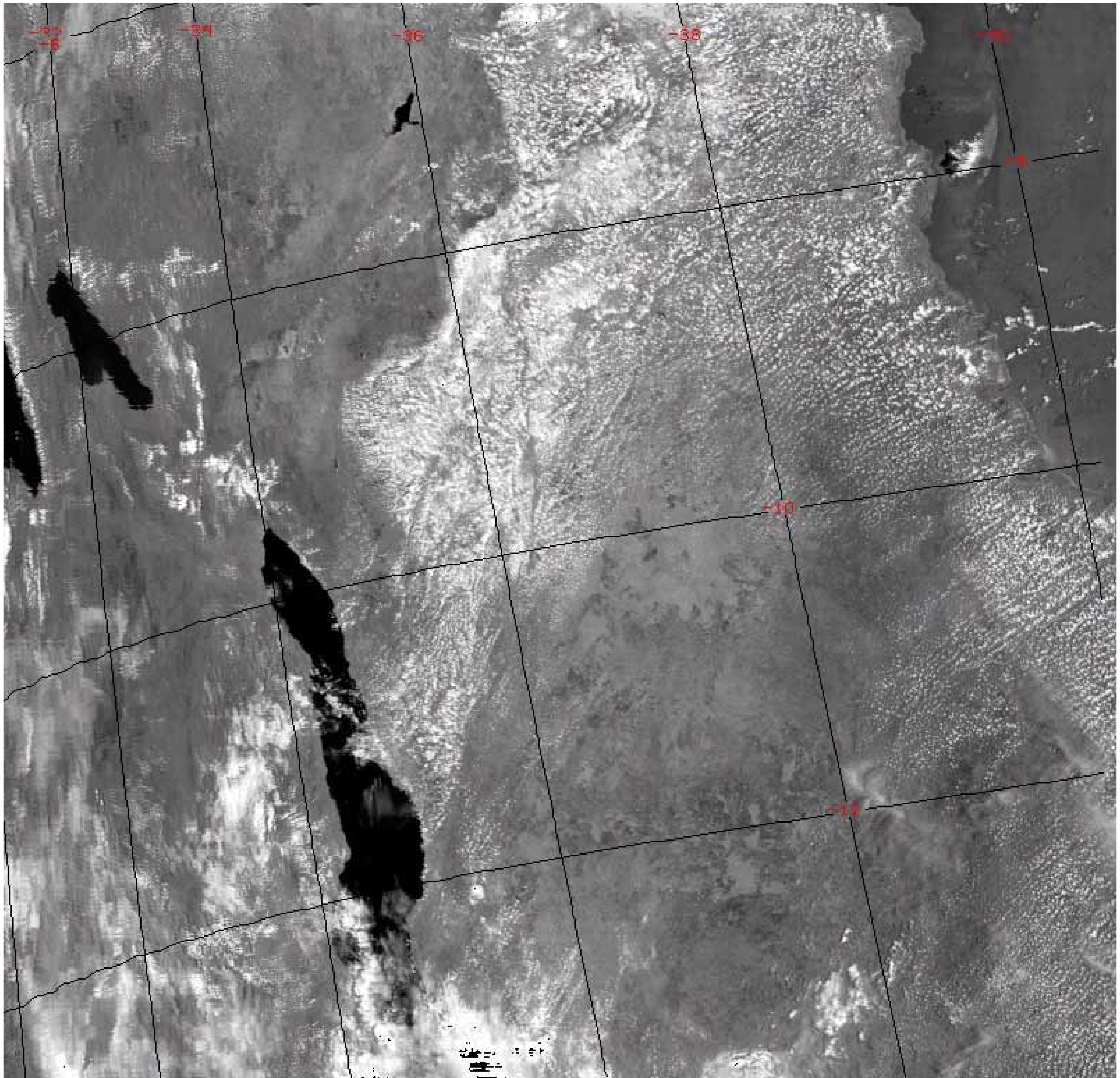
What have we learned from MODIS?

- Threshold Adjustments
  - Most thresholds were appropriate
  - 1.38 corrections for altitude and leakage
  - Desert scenes adjustments
- De-stripping data

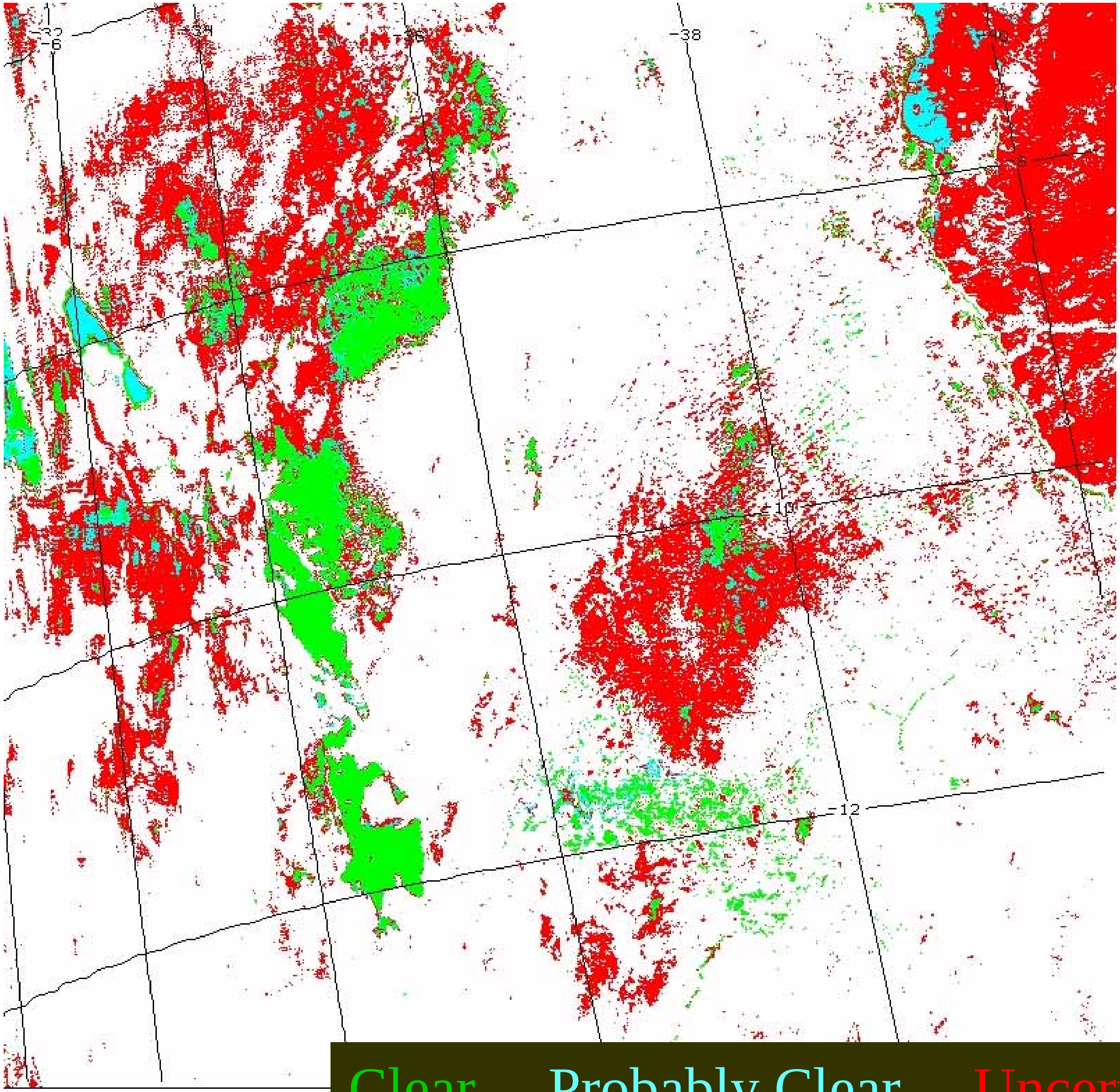
East African Rift Zone Region MODIS Band 26



Eastern South Africa MODIS Band 2

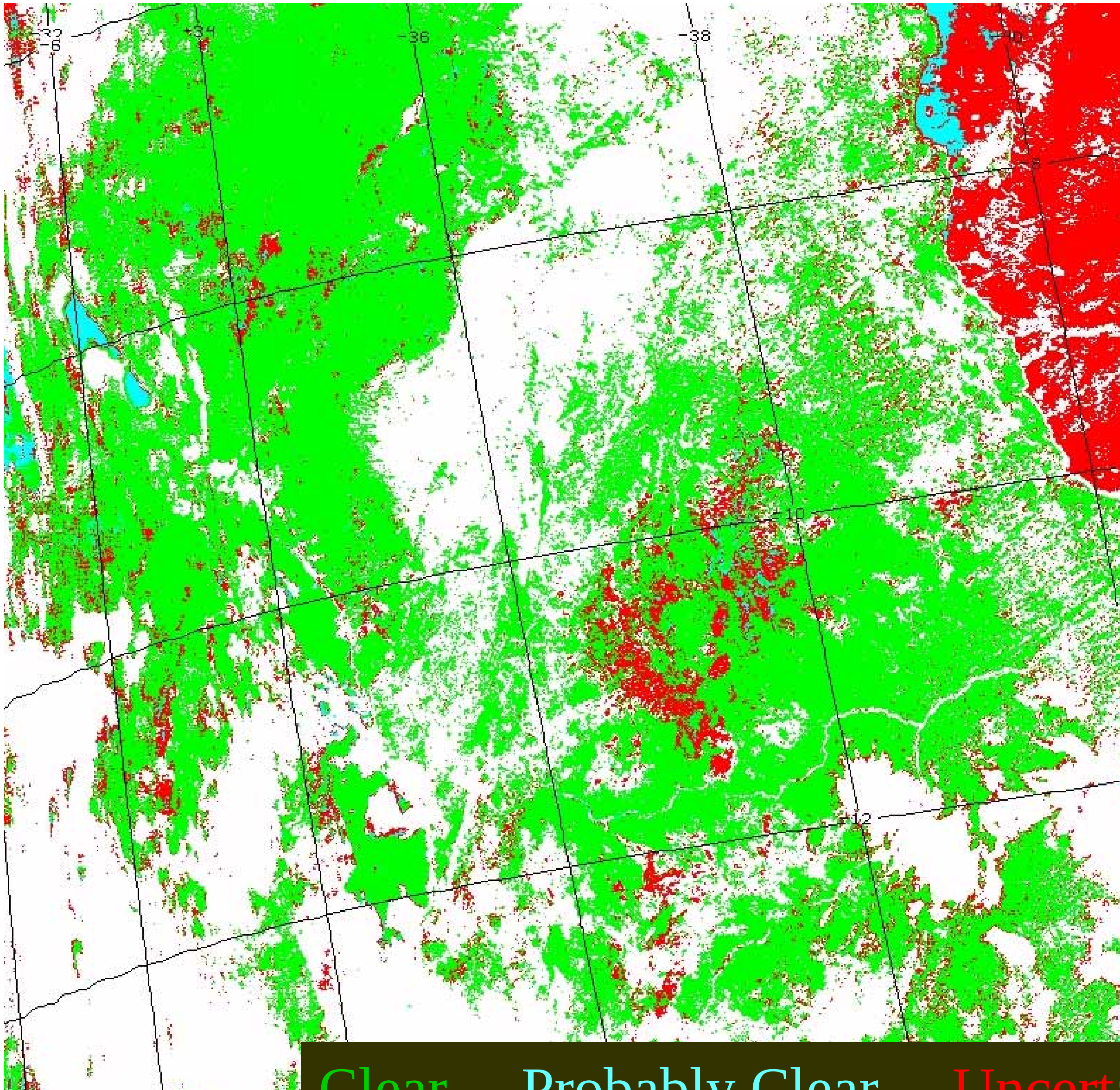


Eastern South Africa Original Cloud Mask

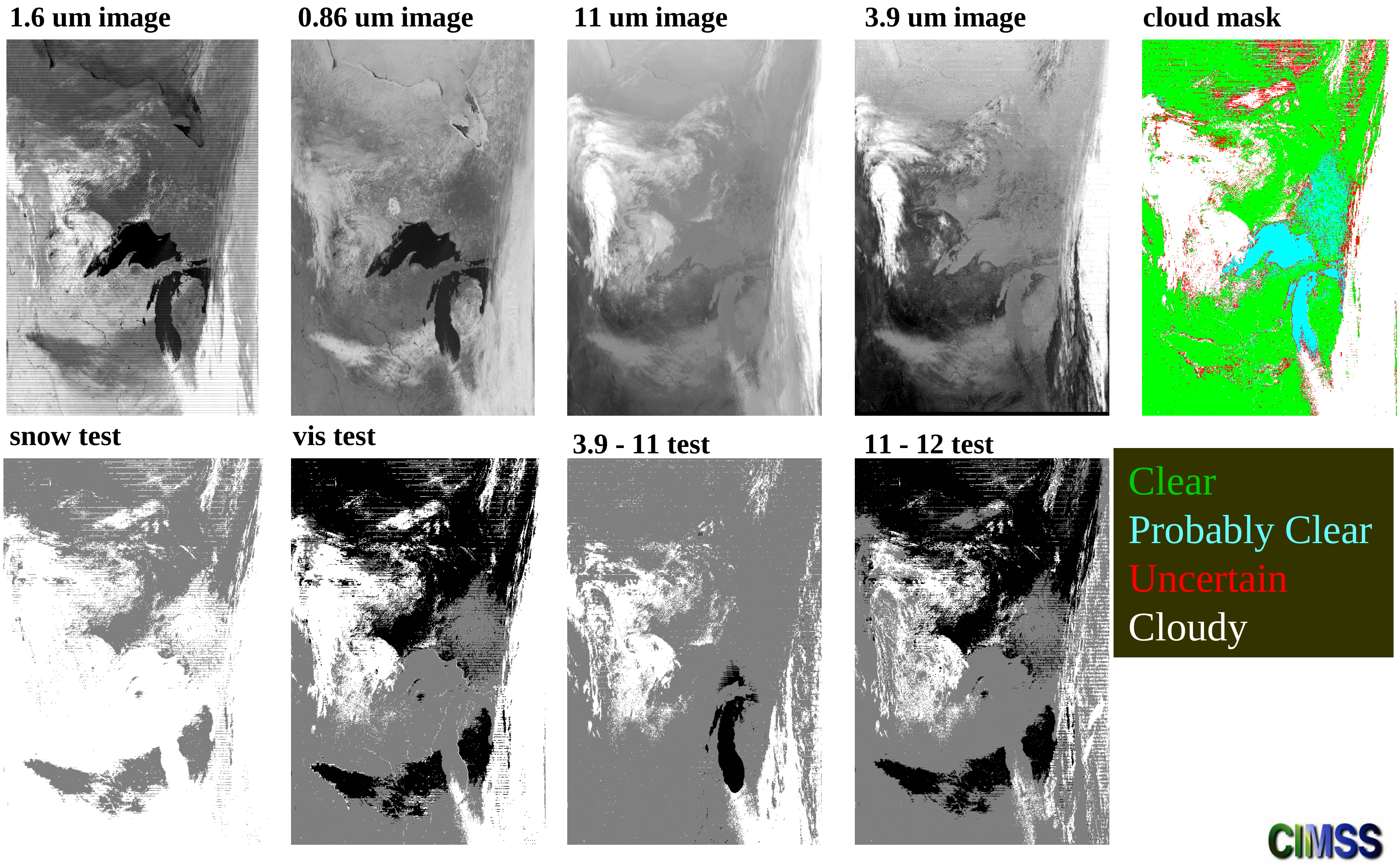


Clear Probably Clear Uncertain Cloudy

Eastern South Africa Improved Cloud Mask



Clear Probably Clear Uncertain Cloudy

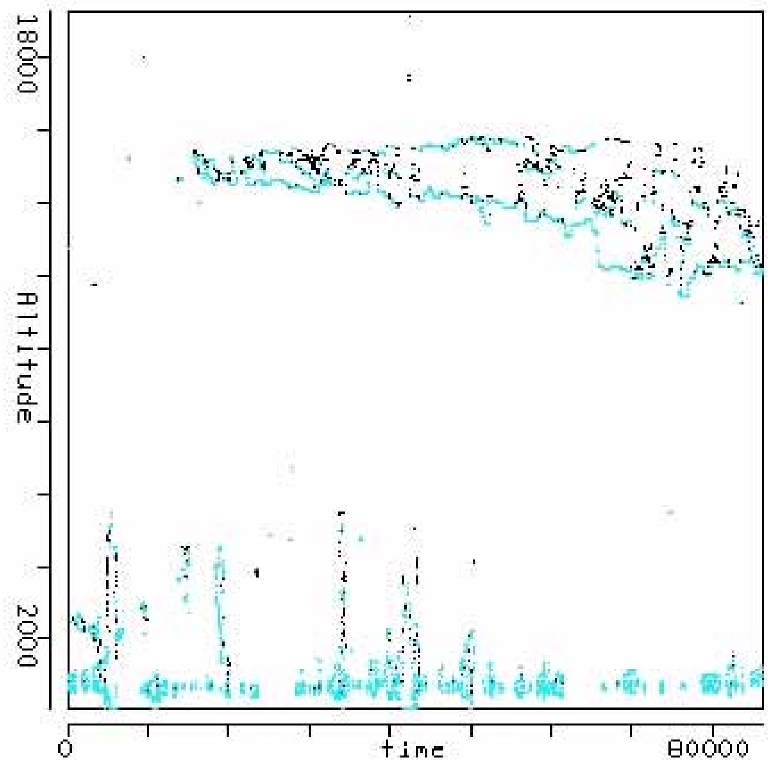


MODIS Cloud Mask (high confidence clear is green, confident is blue, uncertain is red, cloudy is white). Snow test determines which spectral tests / thresholds are used. Vis test is not used over snow-covered areas (shown as black). 3.9-11 µm test finds primarily low clouds. 11-12 µm test primarily finds high clouds.

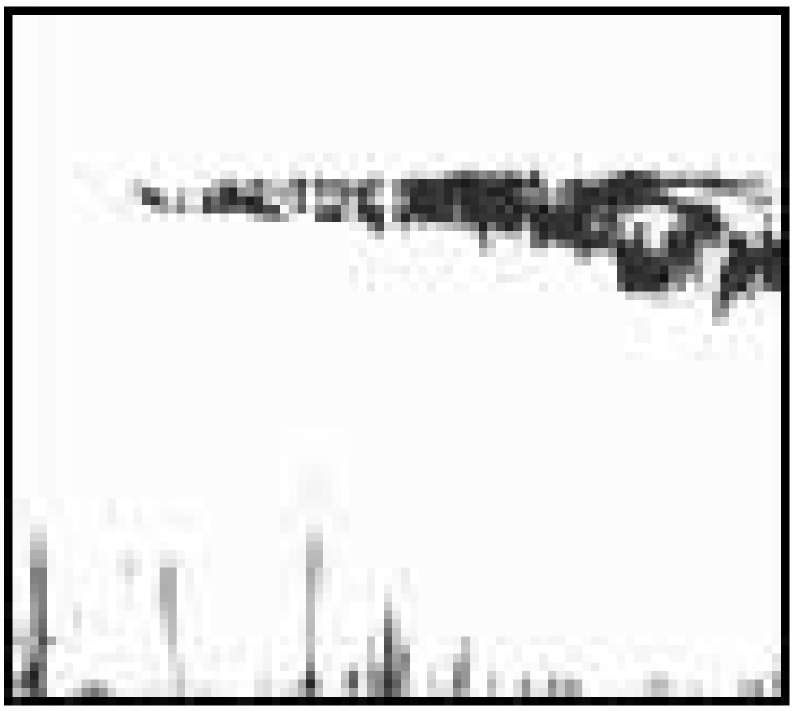
Cloud Mask Validation

- Image analysis
- Comparison with ground-based observations
- Comparison with aircraft observations
- Global distributions
- Comparison with other approaches

ARM Cloud Radar



Raw

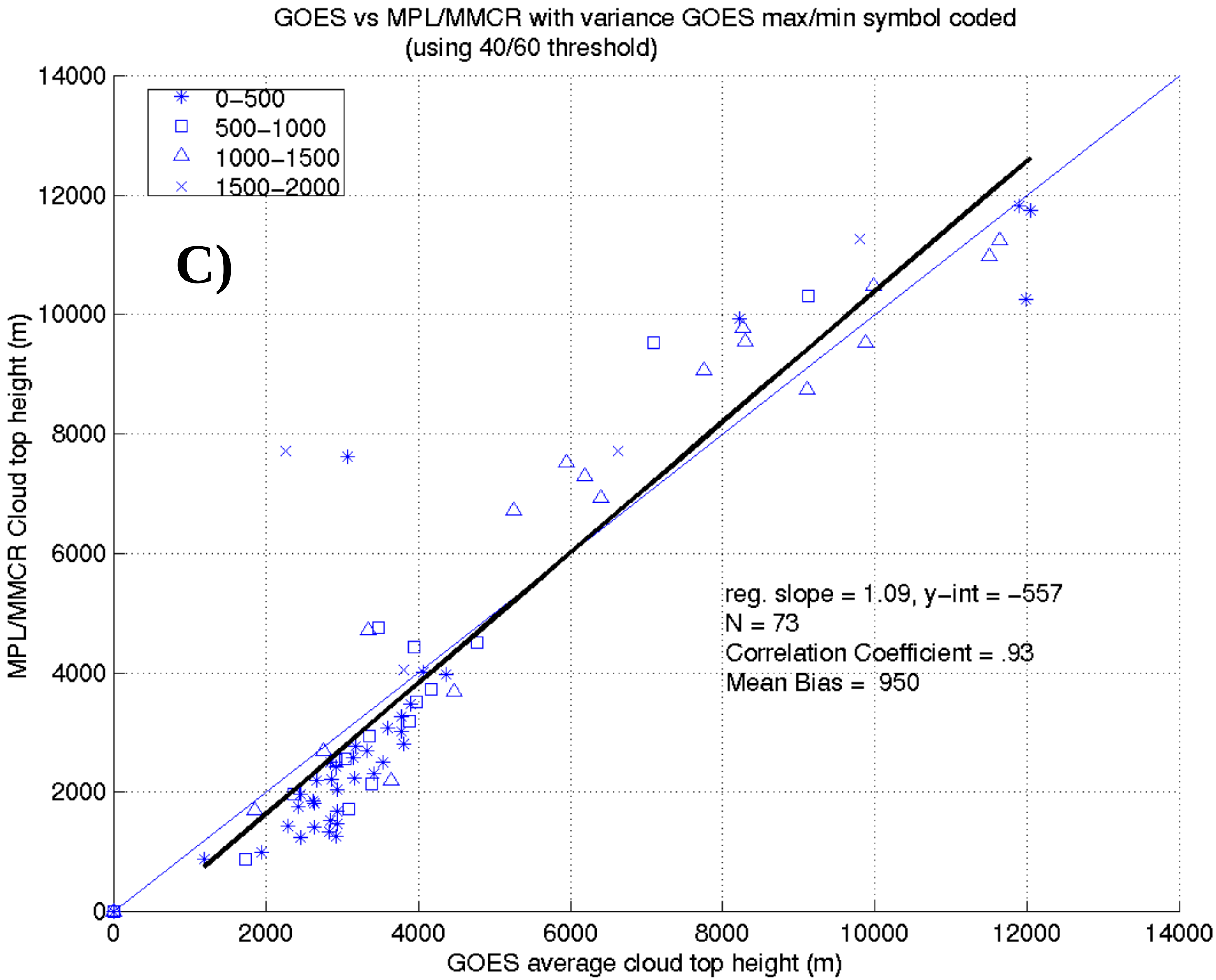


Binned

Composite of lidar/radar data

- Vertical observations binned into 250m vertical ‘slices’
- Time is binned into appropriate time (e.g. 10 second or 1 minute)
- In each “vertical slice”, time bin the frequency of cloud detected is determined
- A cloud is present if a threshold value is exceeded (e.g. 60% of any bin is cloudy)

Example application to GOES

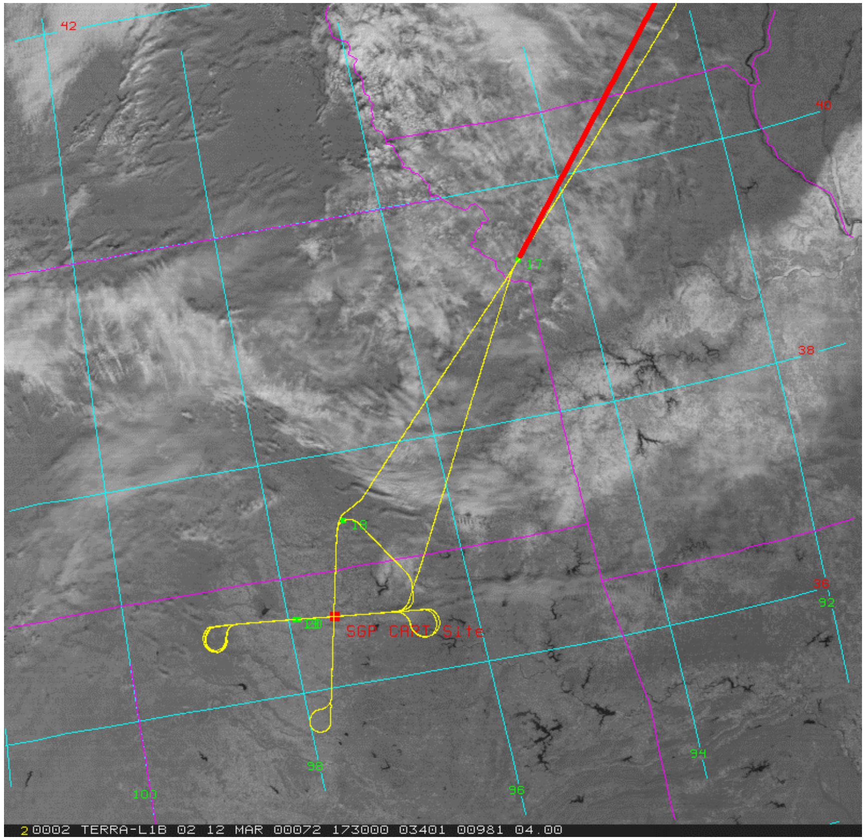


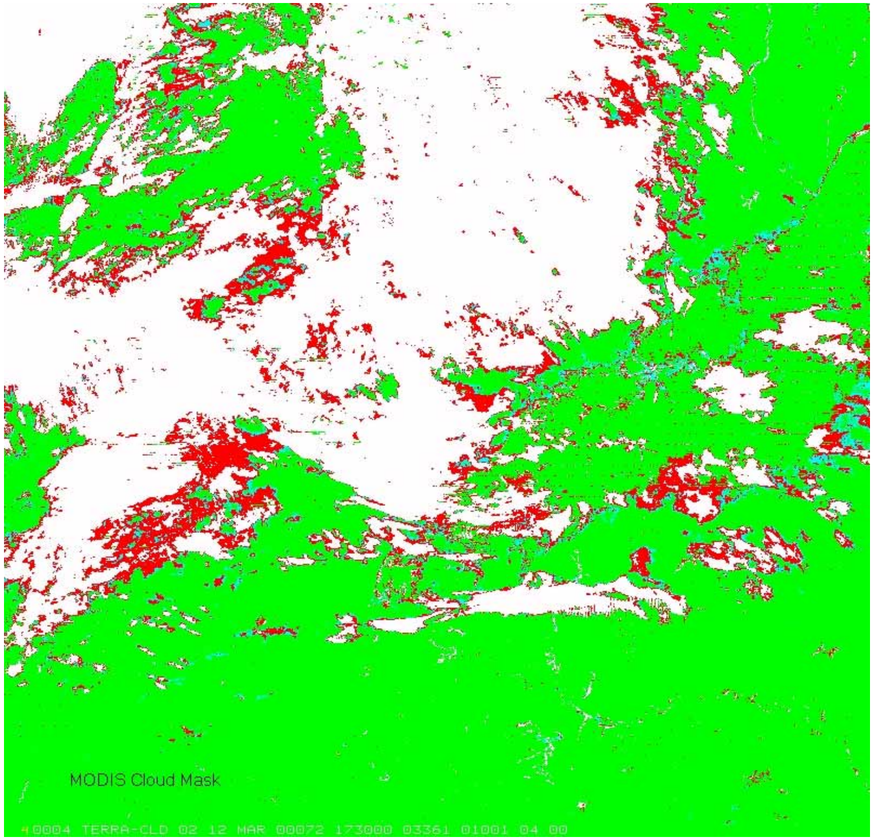
Cloud Mask Evaluation Cont.

- Comparisons with data collected during field experiments
  – WISC-T2000 (preliminary MODIS calibration)
  – SAFARI
  – Texas, spring 2001
- Time series comparison with radars/lidars over ARM sites

MODIS

Clear Probably Clear Uncertain Cloudy





ER-2 flight track on
MODIS 0.86 um image from 1710 UTC

Associated cloud mask

(ER-2) flew under the Terra on March 12, 2000 (WISC-T2000 Field Experiment)

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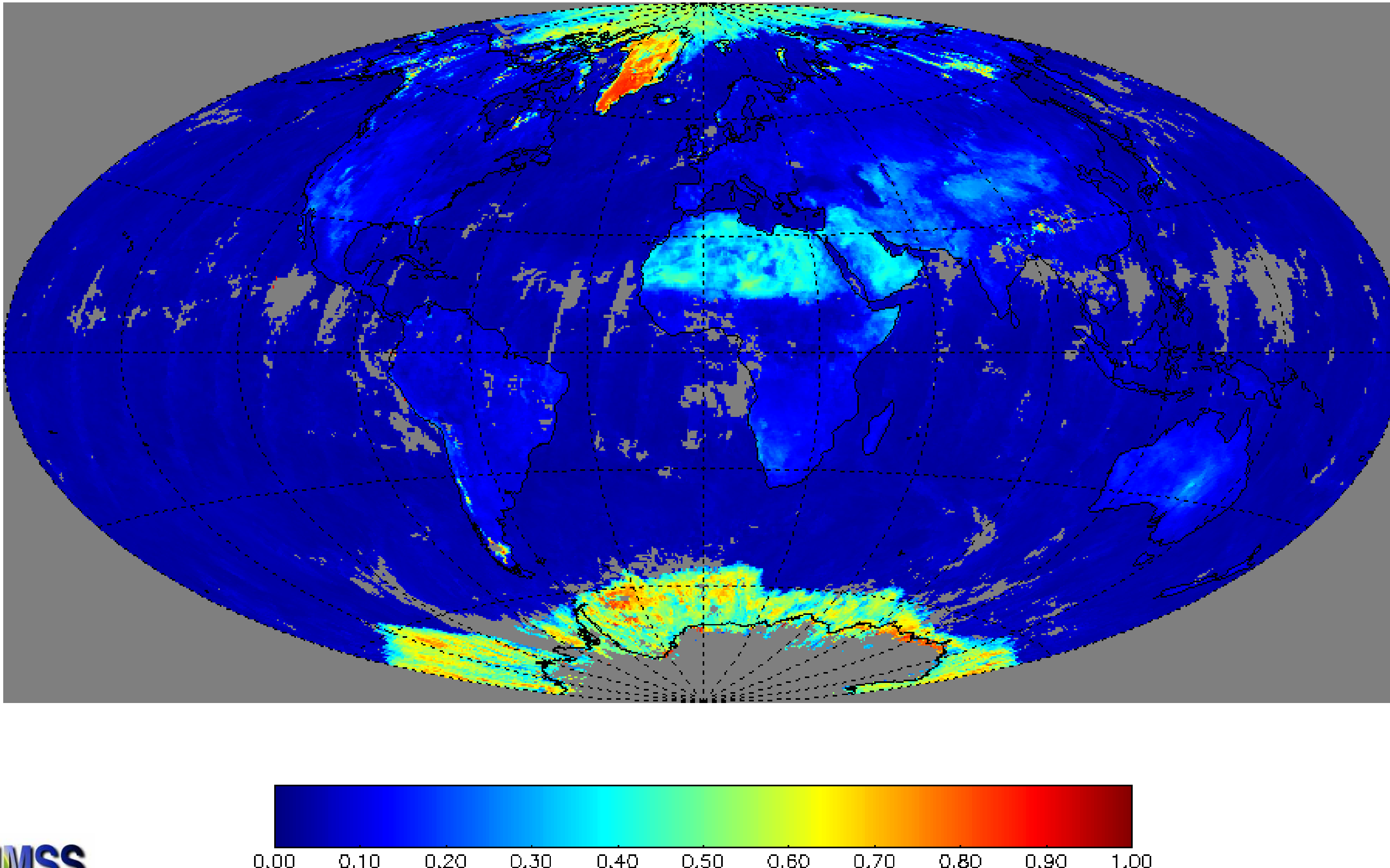
MODIS 2000/09/05-08 Band 1 (0.65 micron) Daytime Clearsky Reflectance
Parameter: Average, Units: Fraction

Clear sky composite - quality control



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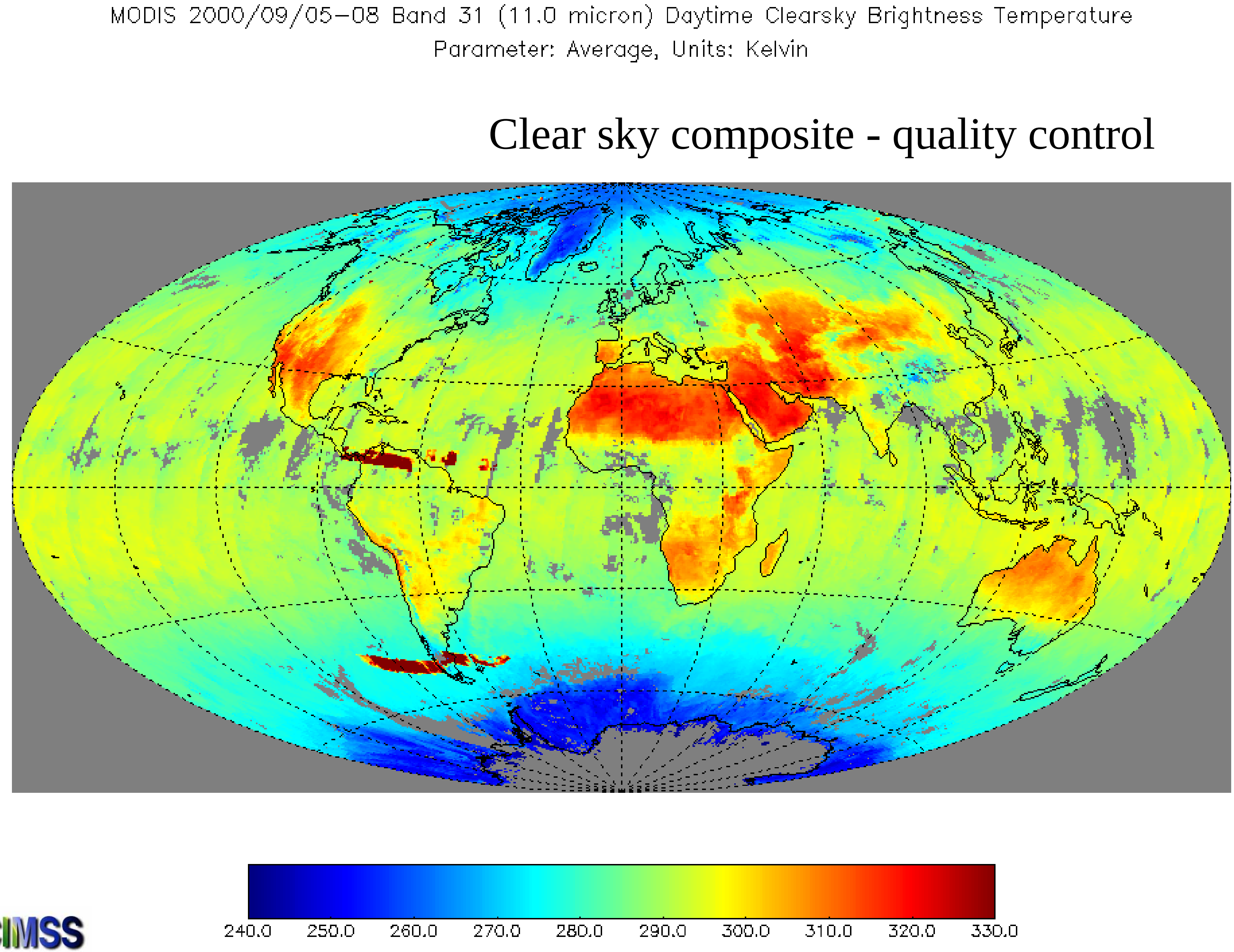
Clear sky composite - quality control



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Current Activities

- Use MODIS data to evaluate approach and prepare for GLI launch
  - use GLICNV to convert MODIS to GLI
    - having some problems with missing files
    - what will be final L1B format
  - test GLI with simulator flat files (on CD)
    - good approach
  - test GLI algorithms with MODIS generated flat files
    - adjusting direct broadcast to output flat files
- Update ATSK1 ATBD

GLI Thermodynamnic Phase Algorithm

- Combine use of straight *r* or *BT* threshold tests with fuzzy tests to create a Fuzzy System
- Define straight Threshold Tests First
  - BT11 < 243 K then ice
  - BT11 > 280 K then water (if no thin cirrus found)
  - Cloud Mask thin cirrus bit set, then ice
- Create Fuzzy Propositions in the form of:
  - If *w* is *Z* then *x* is *Y* for each phase type (ice, water or uncertain)

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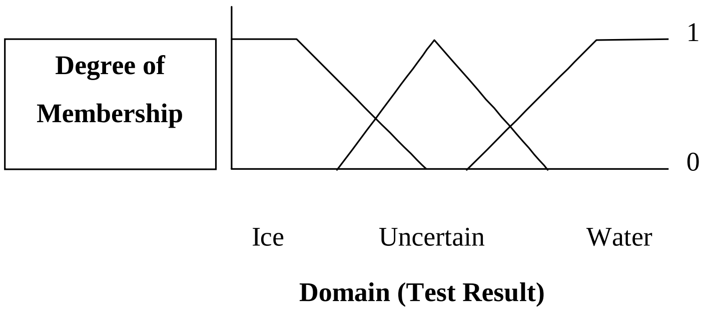
GLI Thermodynamnic Phase Algorithm (cont.)

- For example, a set of fuzzy rules for ice cloud:
  - If BT8-BT11 is large, then phase is ice
  - If BT11-BT12 is small, then phase is ice
  - If BT3.7-BT11 is small, then phase is ice
  - If *r*1.38/*r*.68 is large, then phase is ice
- Compute spectral test result degree of membership in a fuzzy truth phase set.



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GLI Thermodynamnic Phase Algorithm (cont.)

- Compute the intersections of the fuzzy sets by taking the minimum value of all spectral tests in a given phase type:

$$A \cap B = \min(\mu_a[x], \mu_b[y], \ldots)$$

- Here A and B are phase fuzzy sets (i.e., ice), and $\mu_a[x]$ and $\mu_b[y]$ are degree of membership values.

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GLI Thermodynamnic Phase Algorithm (cont.)

- Map the intersection values to an expected value of the solution fuzzy set (ice, water or uncertain). Centroid Defuzzification κ is:

$$\Re = \frac{\sum_{i=0}^{n} d_i \mu_A(d_i)}{\sum_{i=0}^{n} \mu_A(d_i)}$$

A is the solution region, $\mu(d_i)$ is the truth membership value for the domain point *i*.

- Represents a center of gravity value

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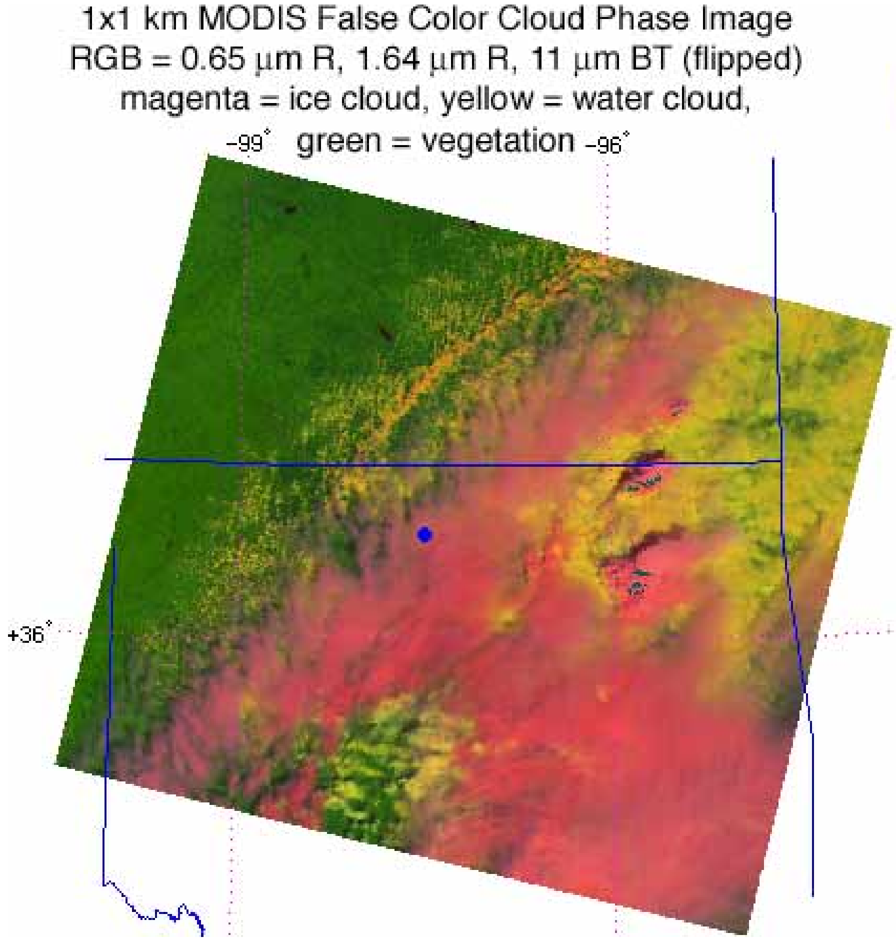
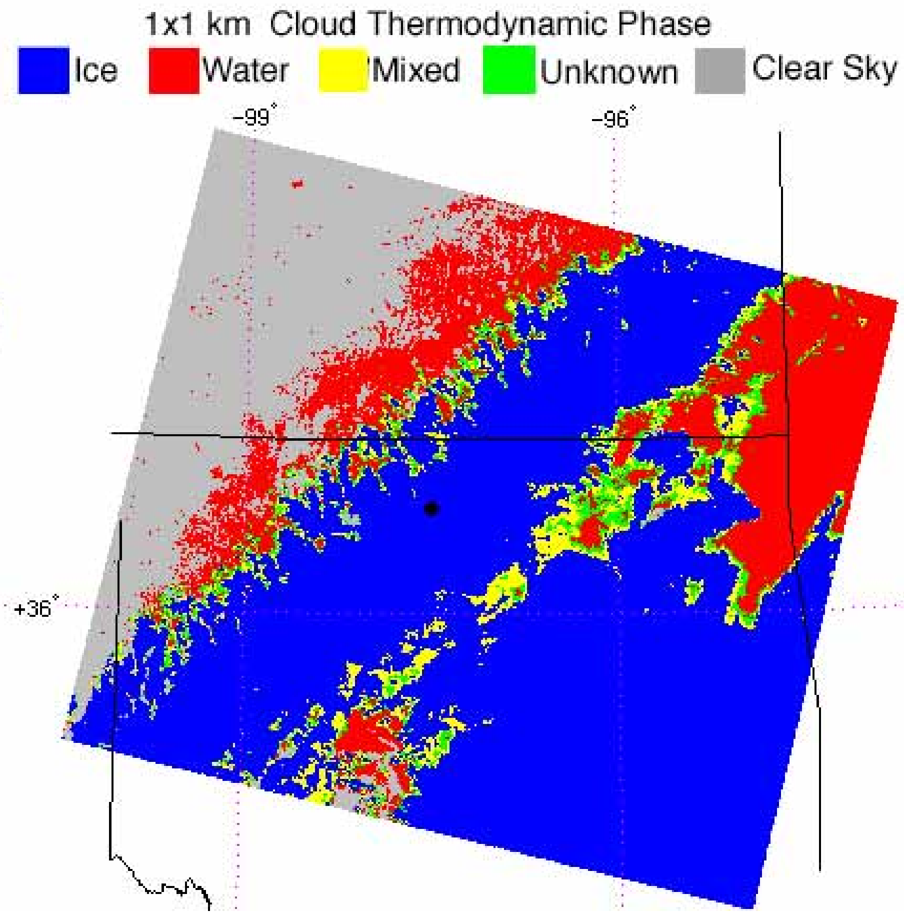
Current Activities (ATSK4)

- Use MODIS data to evaluate approach and prepare for GLI launch
  - test GLI with simulator flat files (on CD)
    - good approach
  - test GLI algorithms with MODIS generated flat files
    - adjusting direct broadcast to output flat files

MODIS Observations and Phase





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