Atmosphere Algorithm Performance / Evaluation Report ATSK1

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Approach

Provide a confidence flag that indicates how certain we are that the pixel is clear

Restrictions

- Real time execution
- Computer storage
- Comprehension

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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

Data Sets used in Development

Data Set	Advantages	Disadvantages
AVHRR LAC	Similar spatial resolution; Readily available	5 Channels; No global coverage
AVHRR GAC	Global coverage; Readily available	5 Channels; 4 km footprint
Collocated HIRS/AVHRR	Many GLI-like channels; Collocation of smaller pixels within larger footprint	Large HIRS/2 FOV; Gaps between HIRS footprints
MAS (50 channels)	Most GLI like data set; High spatial resolution	No global coverage
MODIS	GLI like data set	

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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 = probably clear 10 = confident 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	

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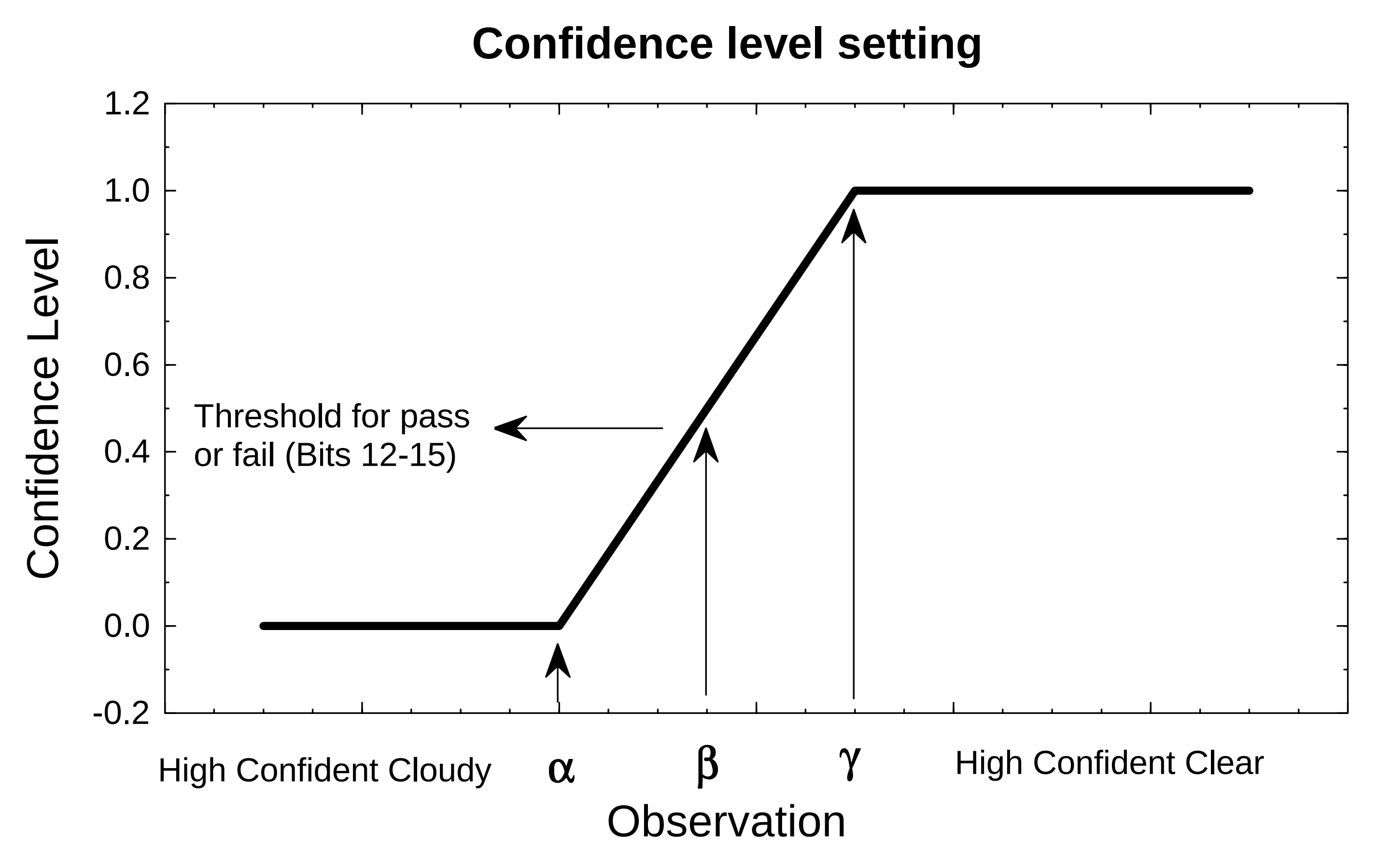
A graphical depiction of three thresholds used in cloud screening



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$$G_{j=1,4} = \min[F_i]$$

$$Q = \prod_{j=1,4} G_j$$

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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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.

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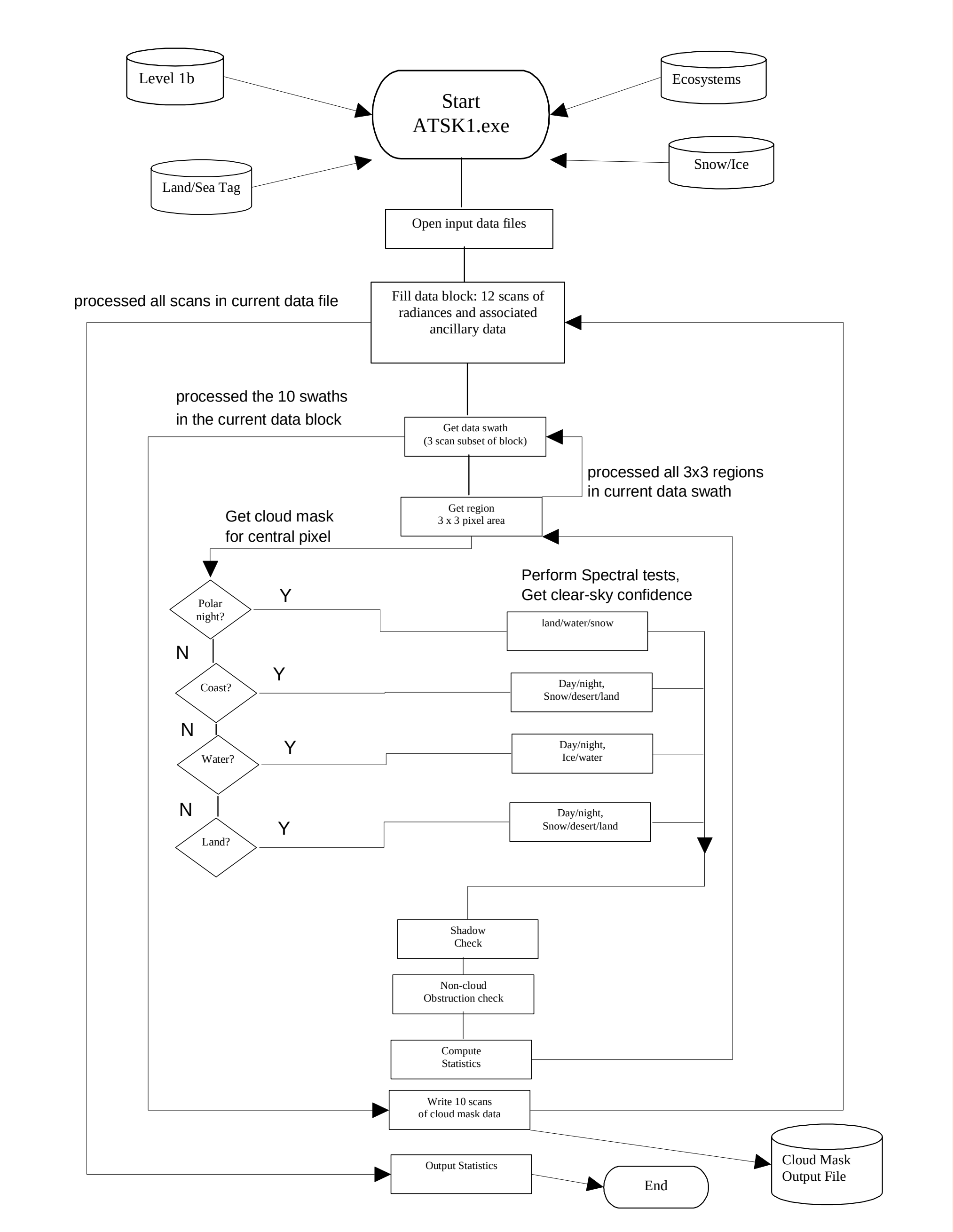
Flow Chart



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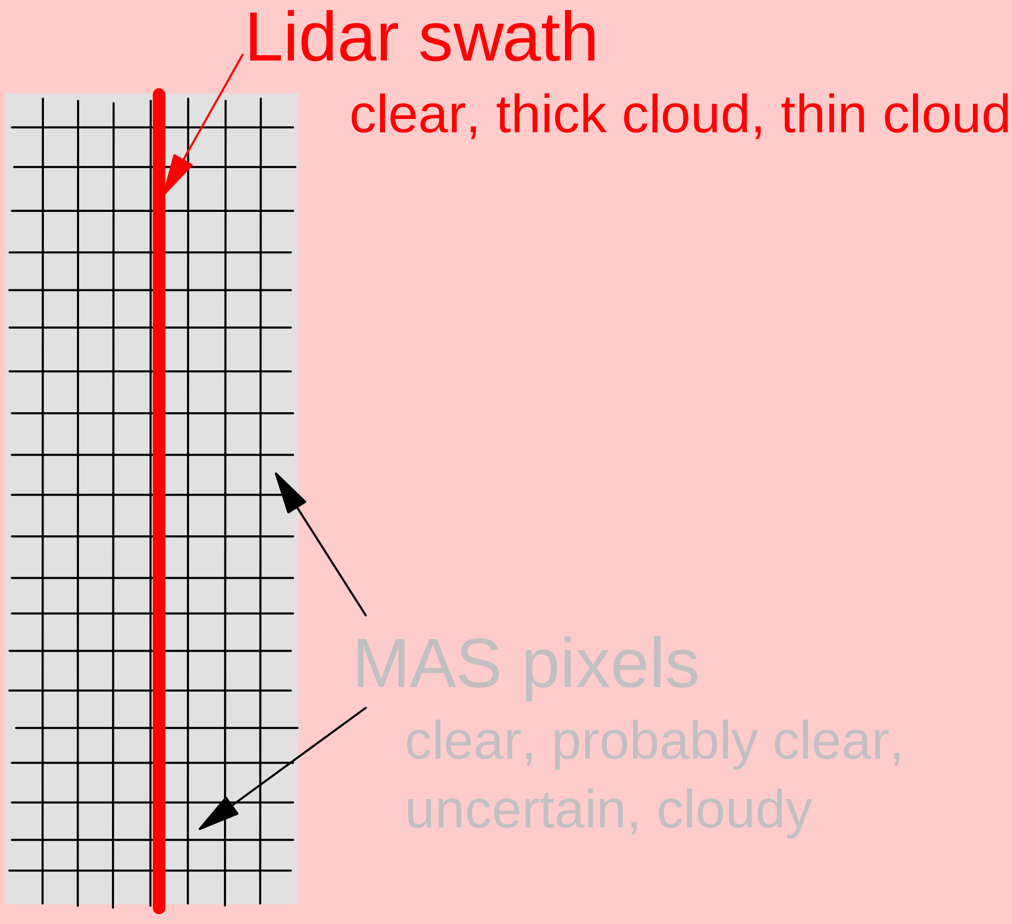
Examples

- MODIS Airborne Simulator
- AVHRR
- MODIS

Validation

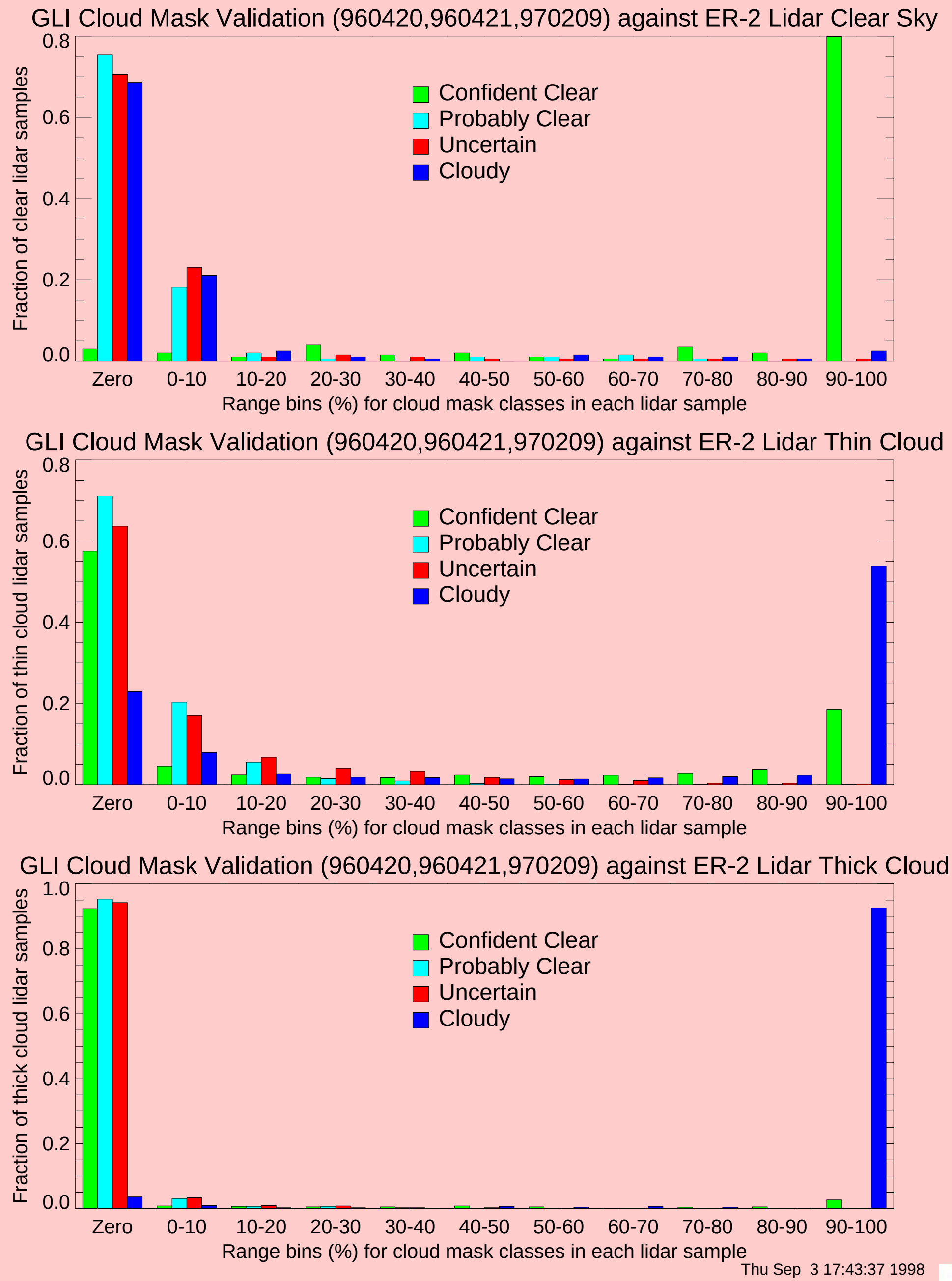
- Image analysis
- Comparison with ground-based obs.
- Comparison with lidar
- Global distributions
- Comparison with other approaches

Collocation of CLS and MAS



Comparison of GLI mask applied to MAS data and compared to CLS lidar observations.

Nearly all of the CLS labeled clear scenes are identified as high confident clear by the MAS cloud mask algorithm. Essentially all of the CLS labeled thick cloud scenes are labeled as cloudy by the MAS cloud mask. A majority of the thin cloud cases are labeled as either confident clear or cloudy by the MAS cloud mask algorithm.



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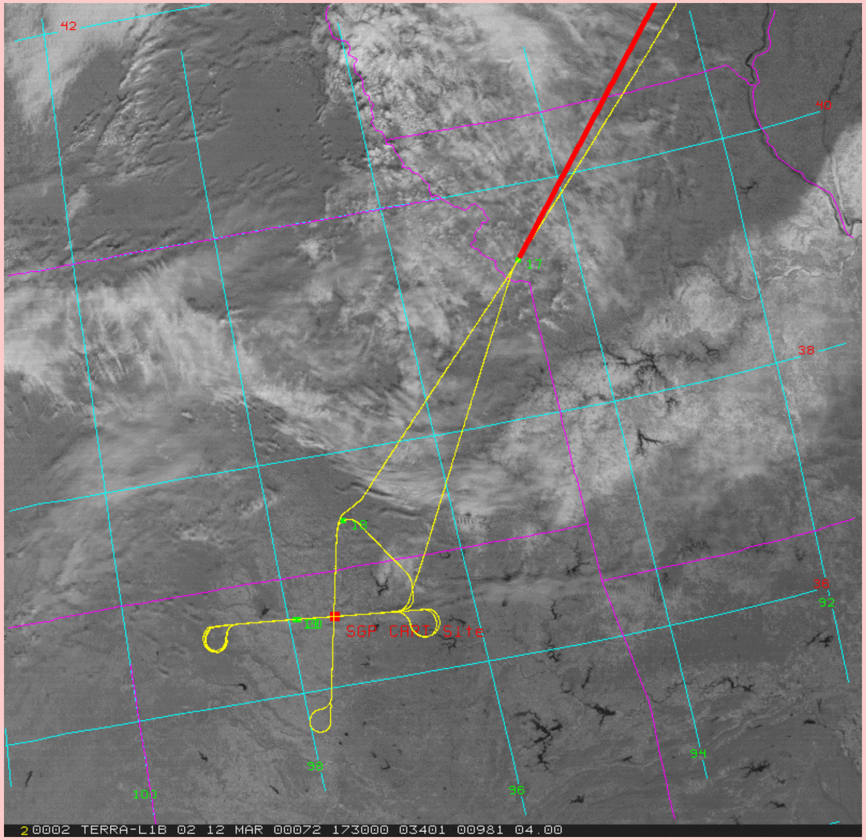
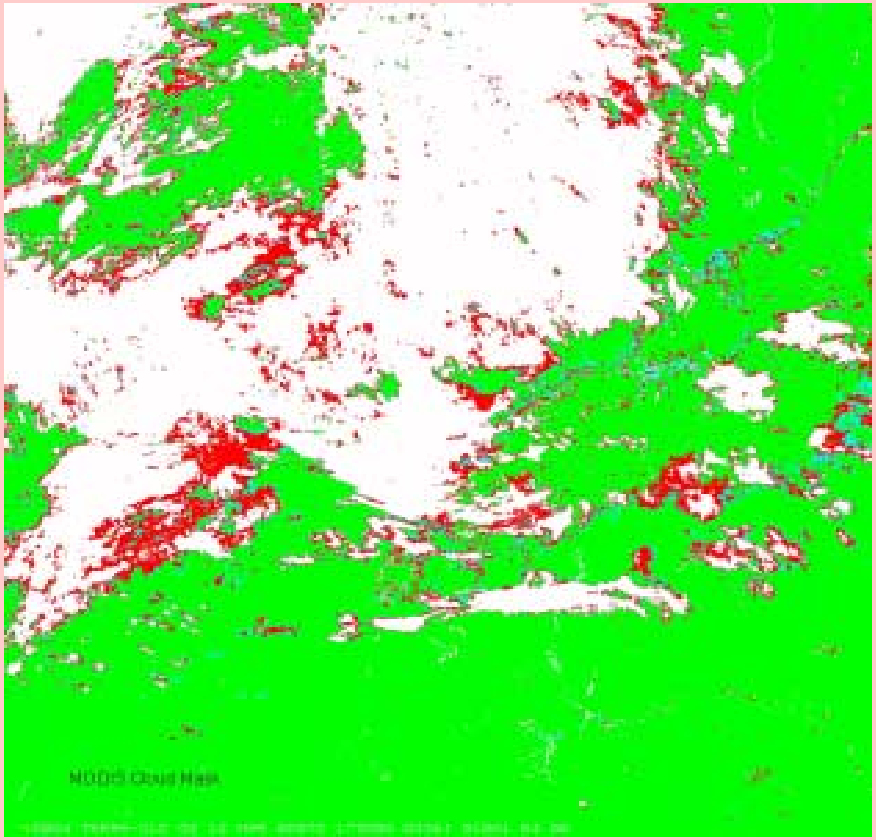


ER-2 flight track on
MODIS 0.86 um image from 1710 UTC



Associated cloud mask

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

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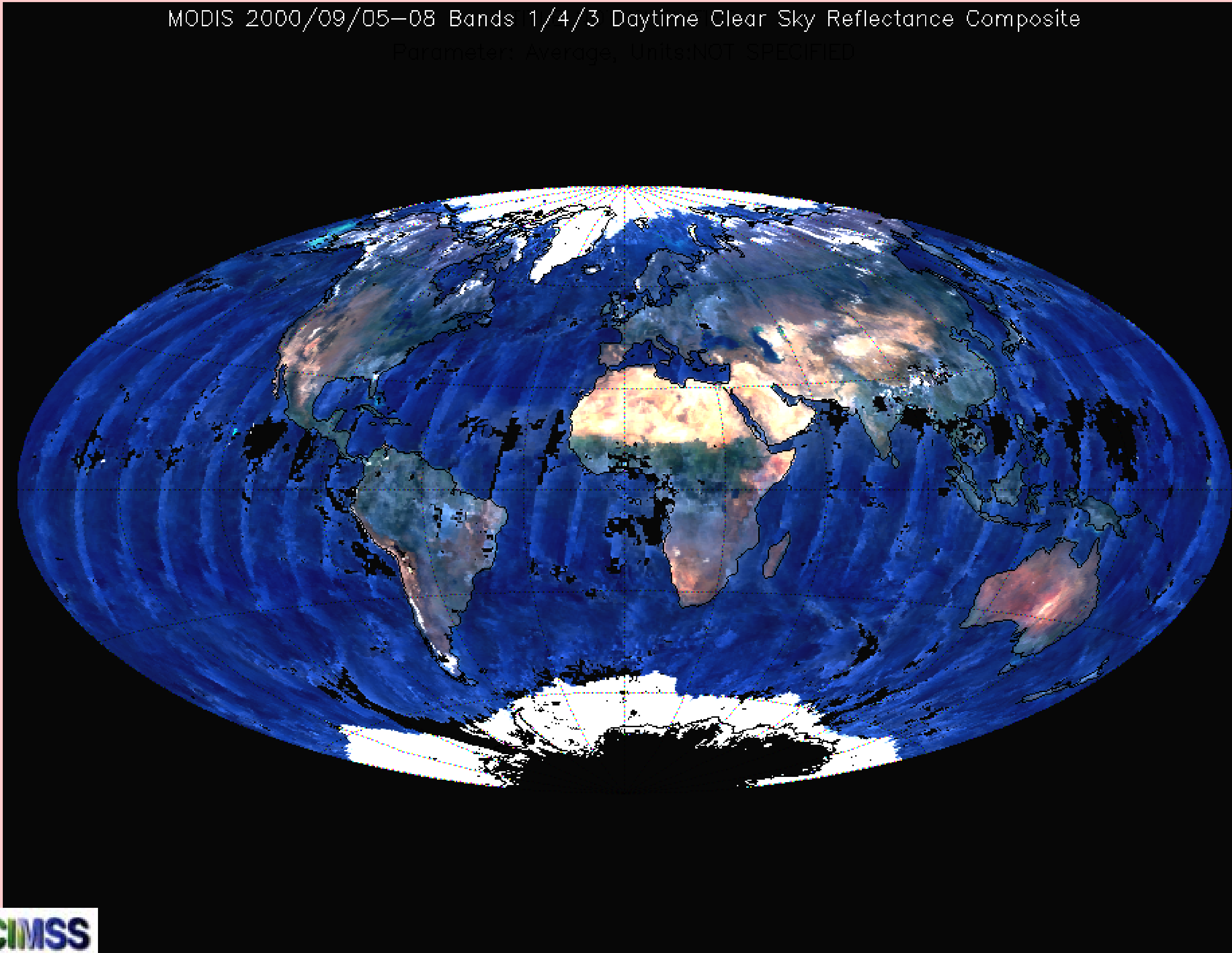
MODIS 2000/09/05–08 Bands 1/4/3 Daytime Clear Sky Reflectance Composite
Parameter: Average, Units:NOT SPECIFIED
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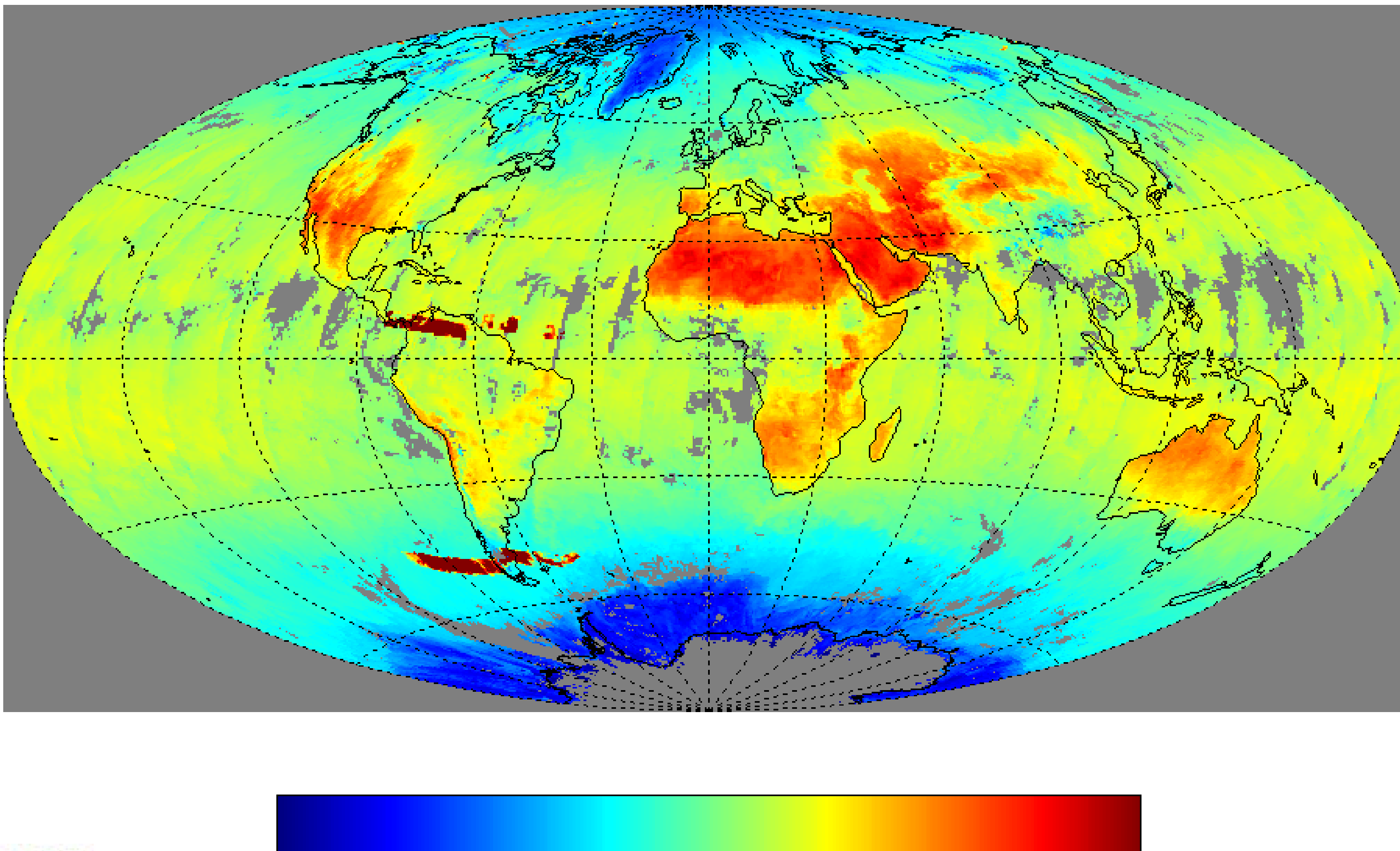
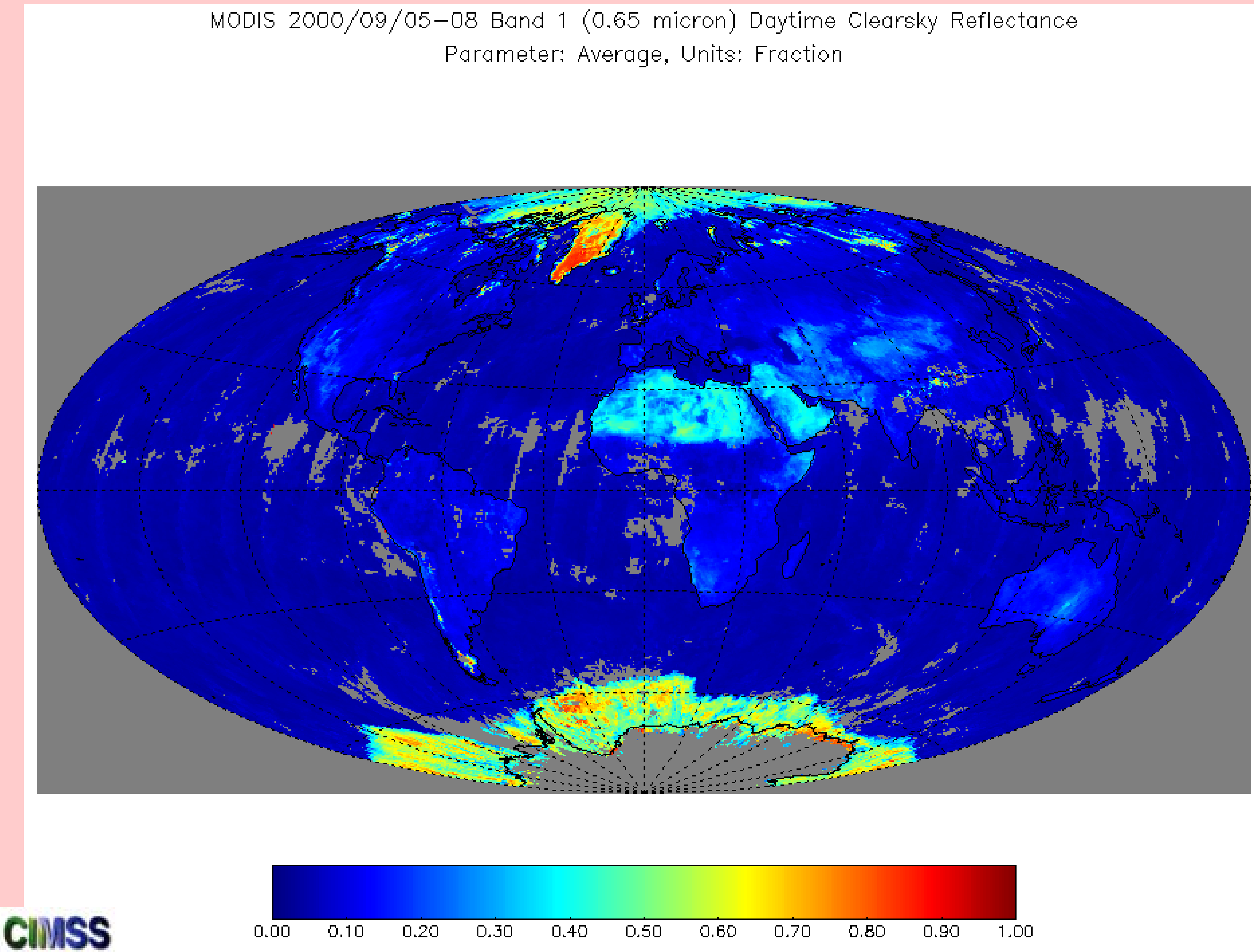
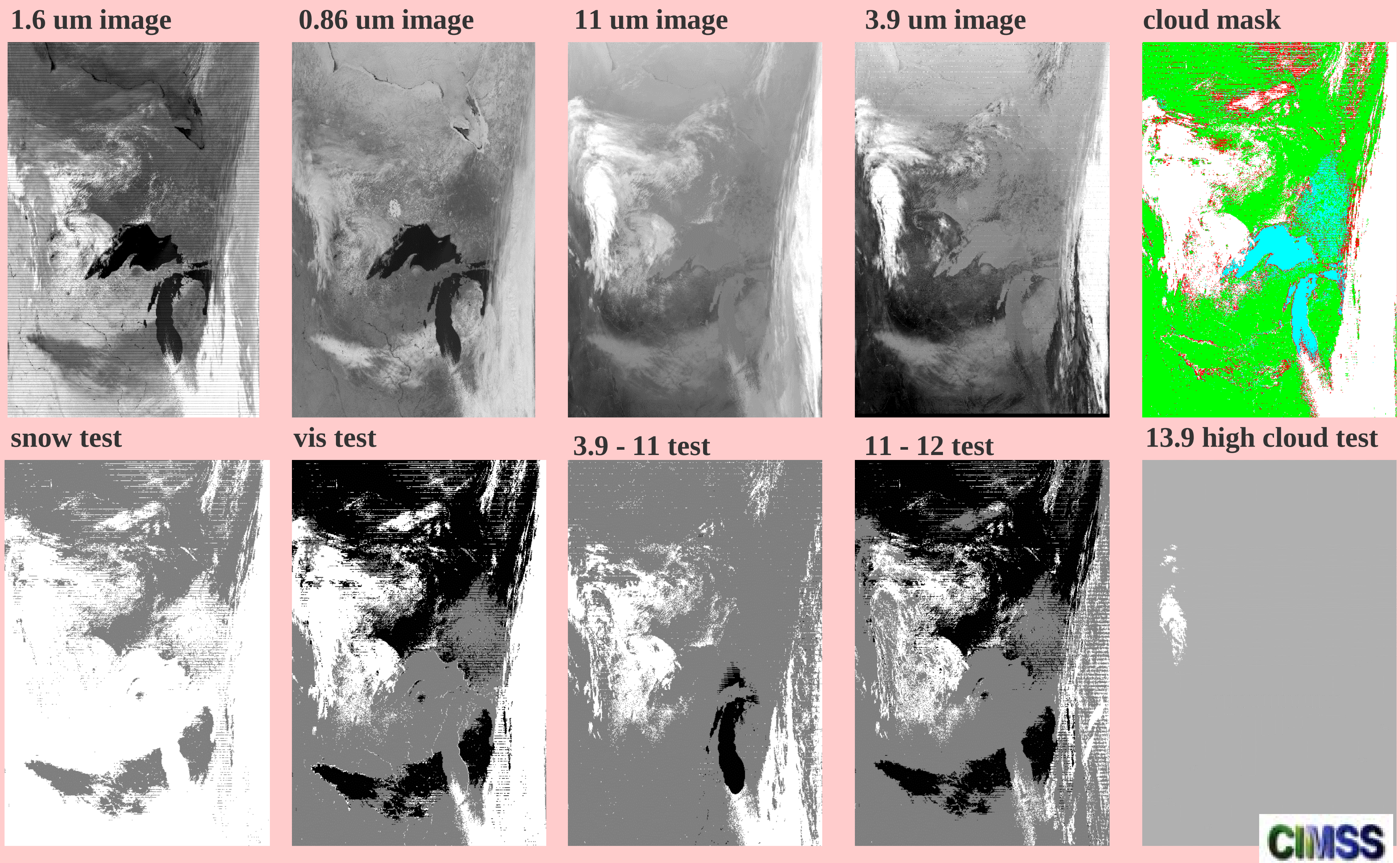
MODIS 2000/09/05–08 Band 31 (11.0 micron) Daytime Clearsky Brightness Temperature

Parameter: Average, Units: Kelvin




MODIS 2000/09/05–08 Band 1 (0.65 micron) Daytime Clearsky Reflectance
Parameter: Average, Units: Fraction
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00



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. 13.9 µm test is causing uncertainty in colder regions (should improve with stable calibration).

Investigations / Improvements pending from analysis of MODIS Cloud Mask Performance

1. Sun-glint regions
2. Warm cloud scenes in arid ecosystems
3. Antarctica
4. Low-level clouds on land at night
5. Snow/ice surfaces at night

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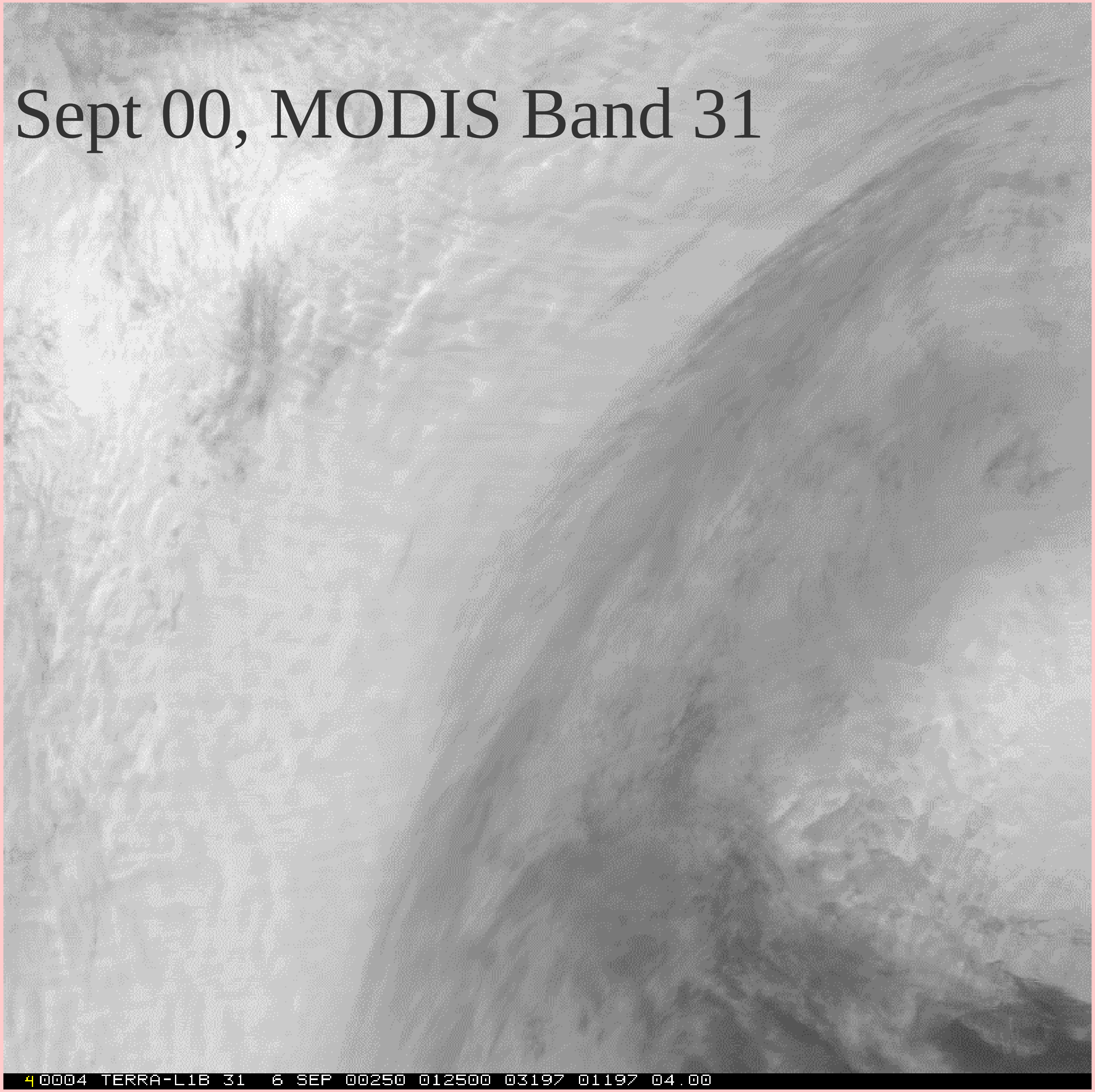
Antarctic, 6 Sept 00, MODIS Band 31



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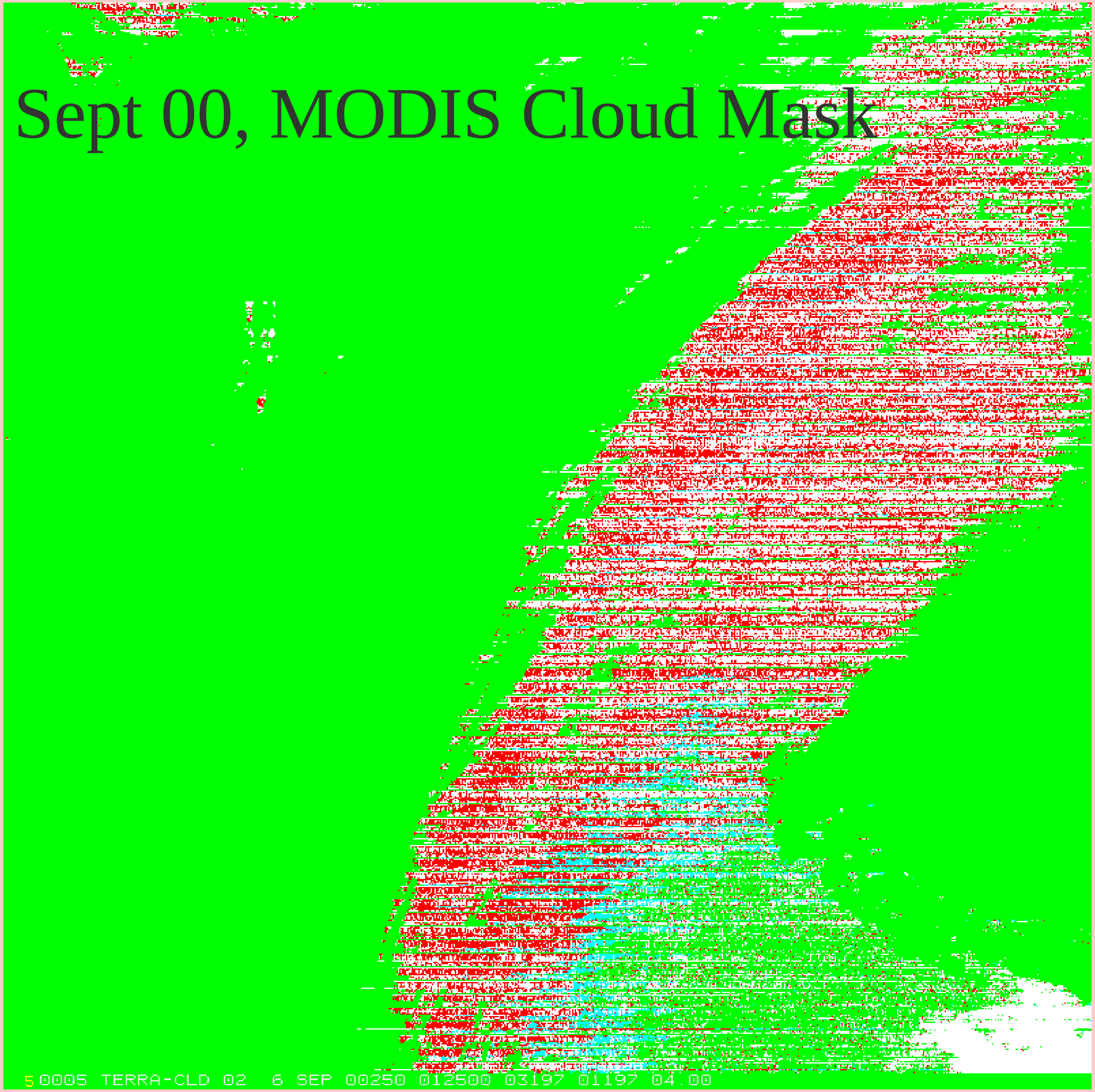
Antarctic, 6 Sept 00, MODIS Cloud Mask



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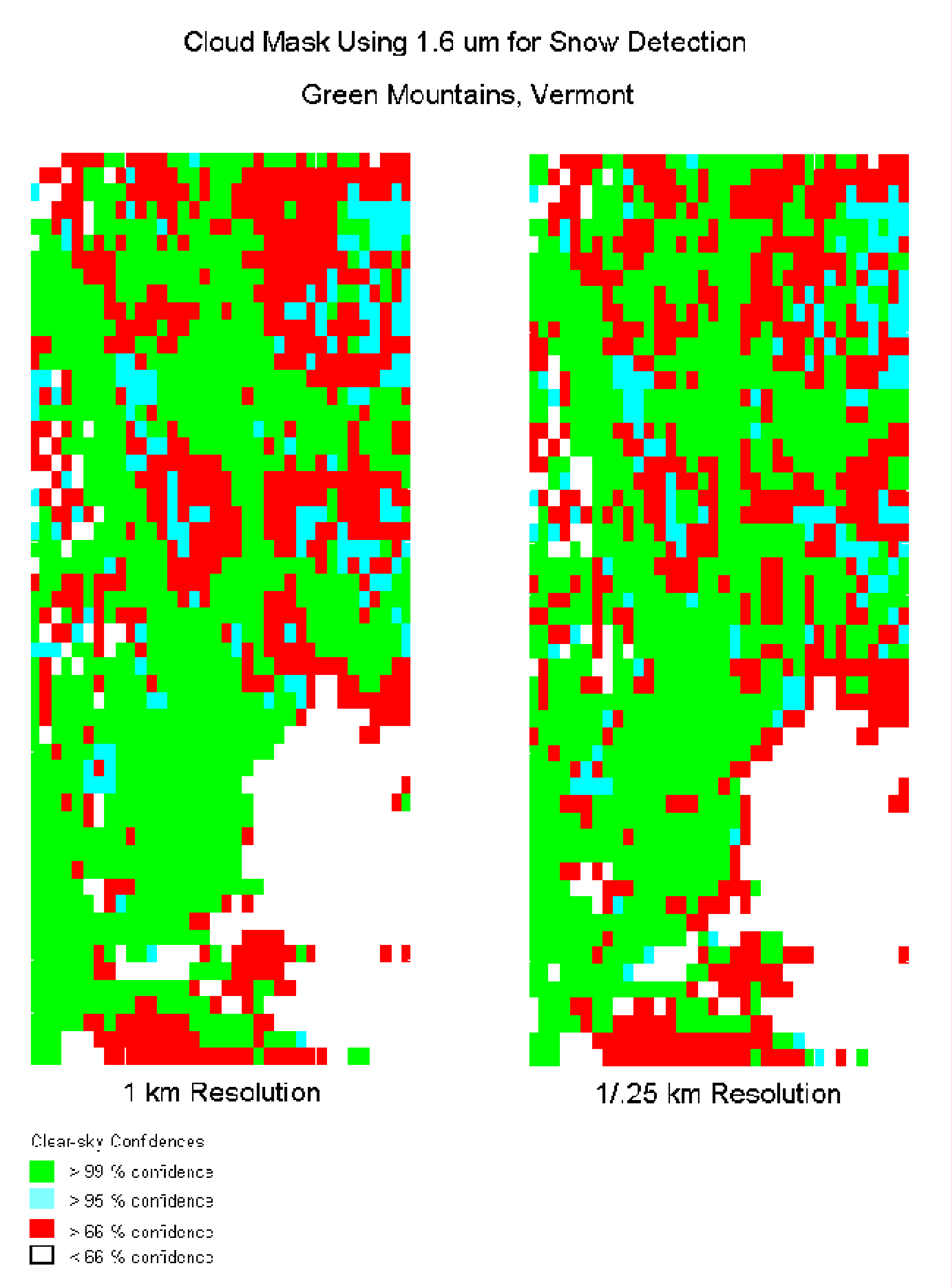
Cloud mask results using MAS 1 km and sub-sampled 1.6 µm channel.



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Use MODIS for GLI testing

- We've successfully off-loaded from tape, compiled, and run the MODIS to GLI conversion code (GLICNV).
- The documentation provided with the tape was very helpful.
- Some clarifications on GLICNV program :

- Do the files produced by the GLICNV program really like those which will be produced operationally?
- We need more documentation on units, scale factors, and offsets for radiance data in L1B files. These are not listed in files generated by GLICNV.
- It appears that one needs to read three L1B files in order to access all channels of GLI 1-km data. Is this true for operationally produced data?
- The geolocation data is recorded at reduced resolution in the L1B files. Will there be a separate "geolocation" file produced at 1-km resolution? If not, will NASDA provide an interpolation algorithm?

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UW-Madison Direct Broadcast Receiving Station

Use real-time MODIS data to develop and test GLI algorithms.

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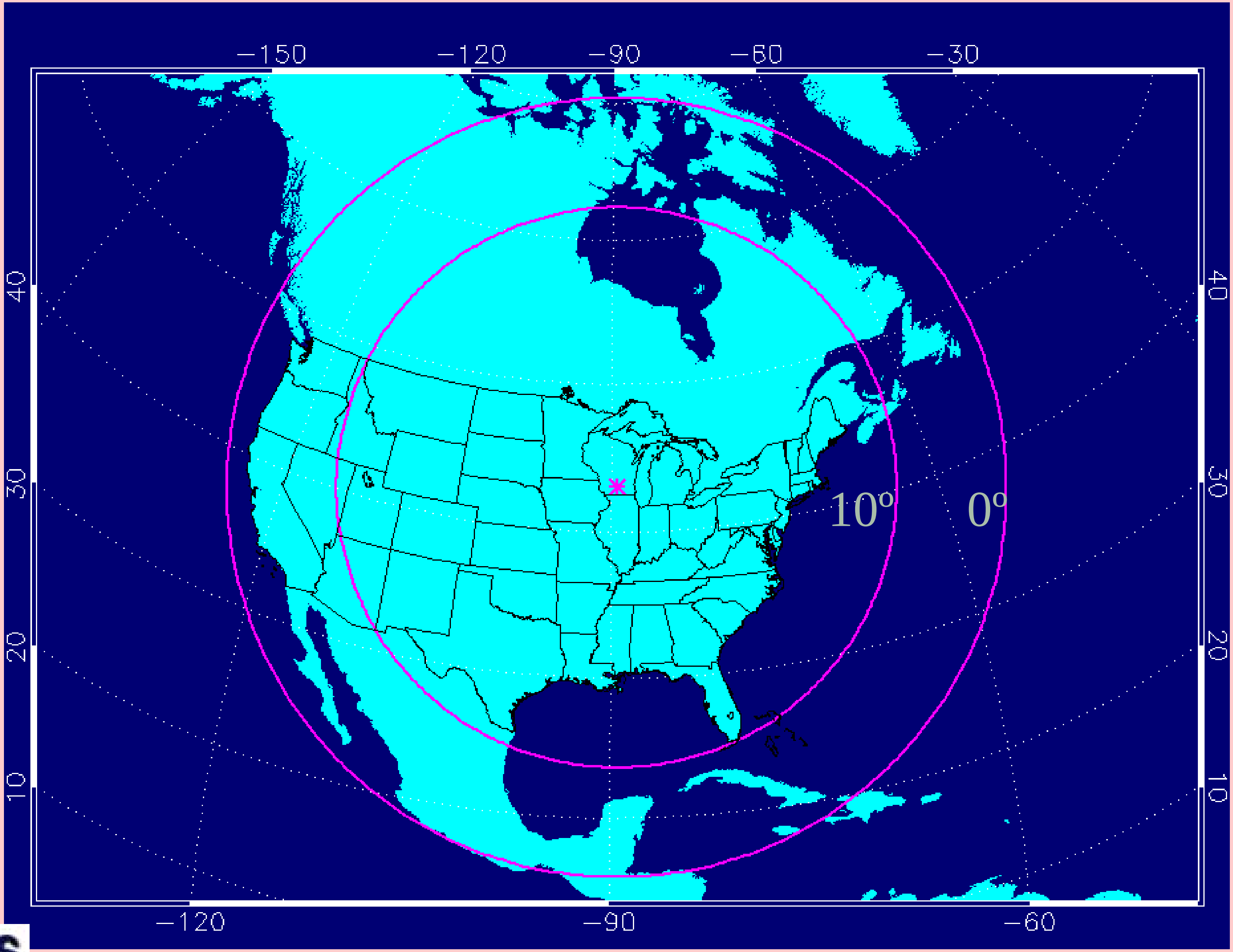
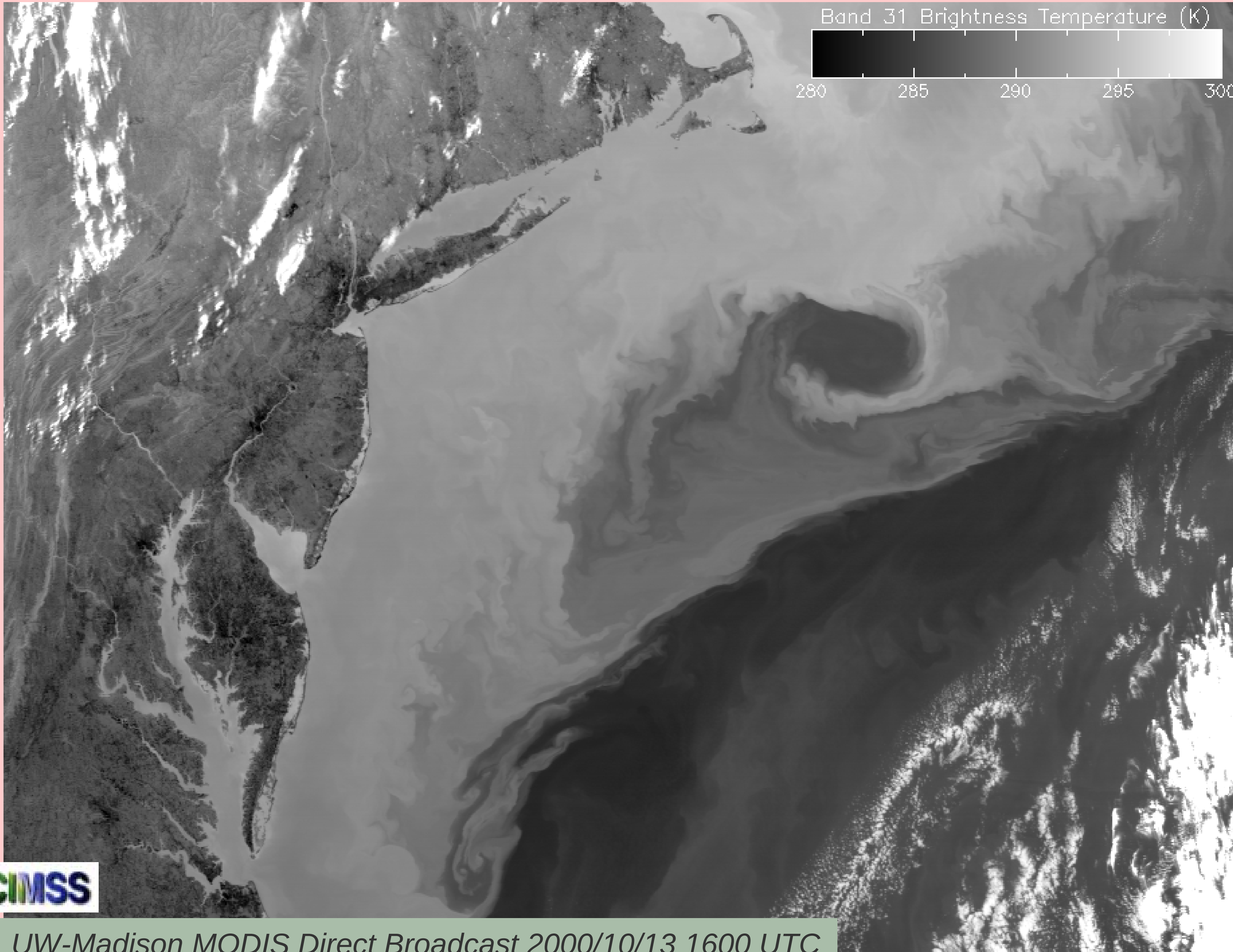
Direct Broadcast Coverage from SSEC





UW-Madison MODIS Direct Broadcast 2000/10/13 1600 UTC

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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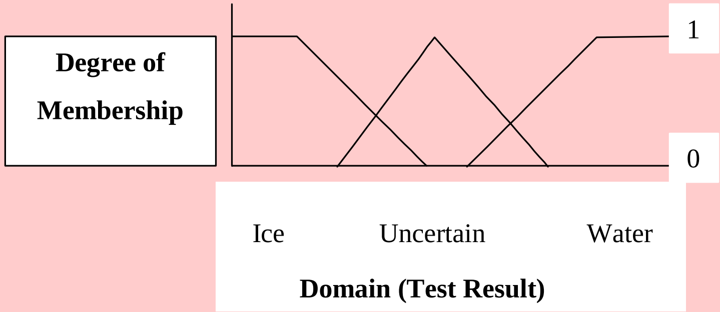
GLI Thermodynamnic Phase Algorithm (cont.)

- 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 (ie, ice), and $\mu_a[x]$ and $\mu_b[y]$ are degree of membership values.

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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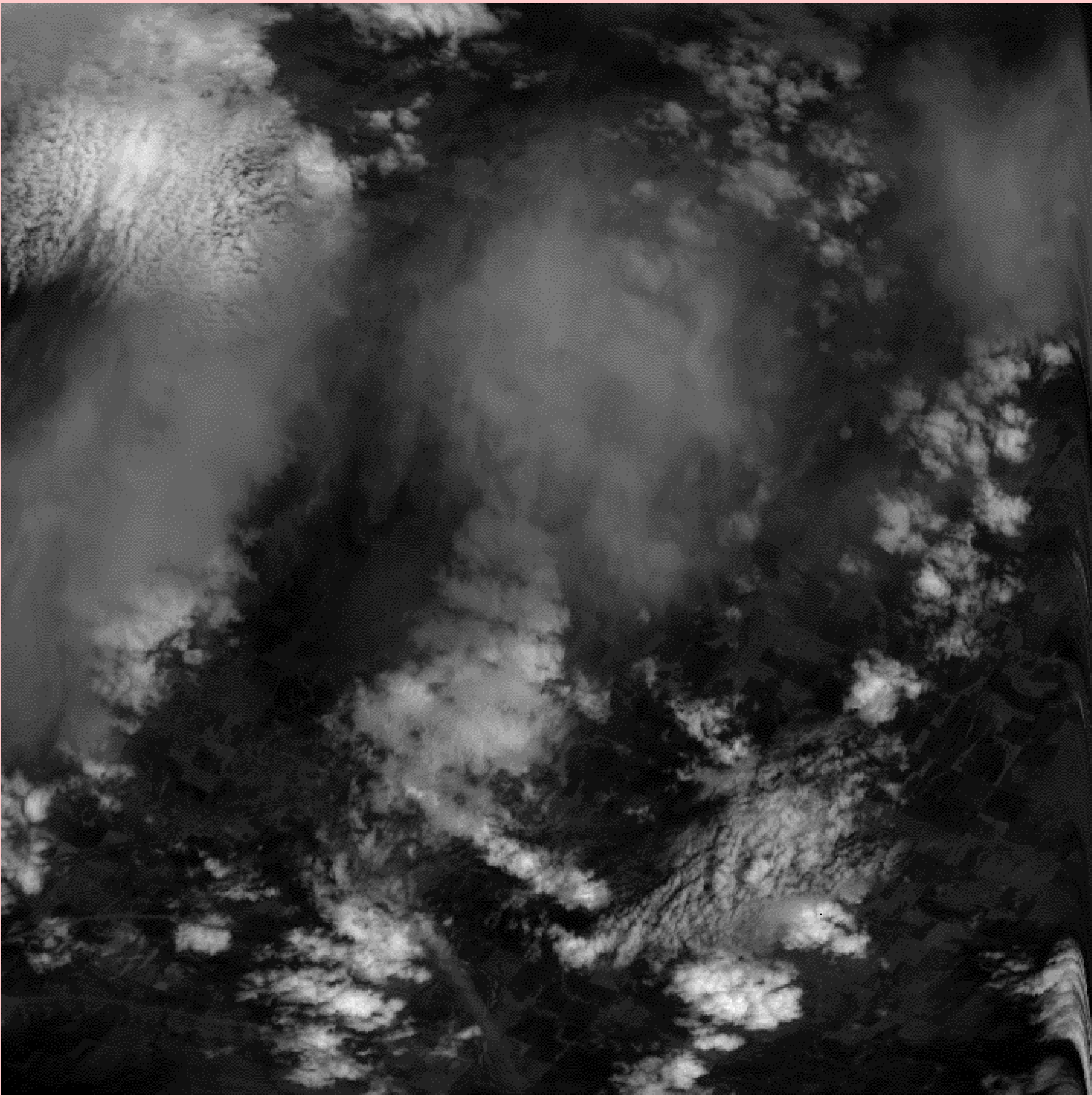

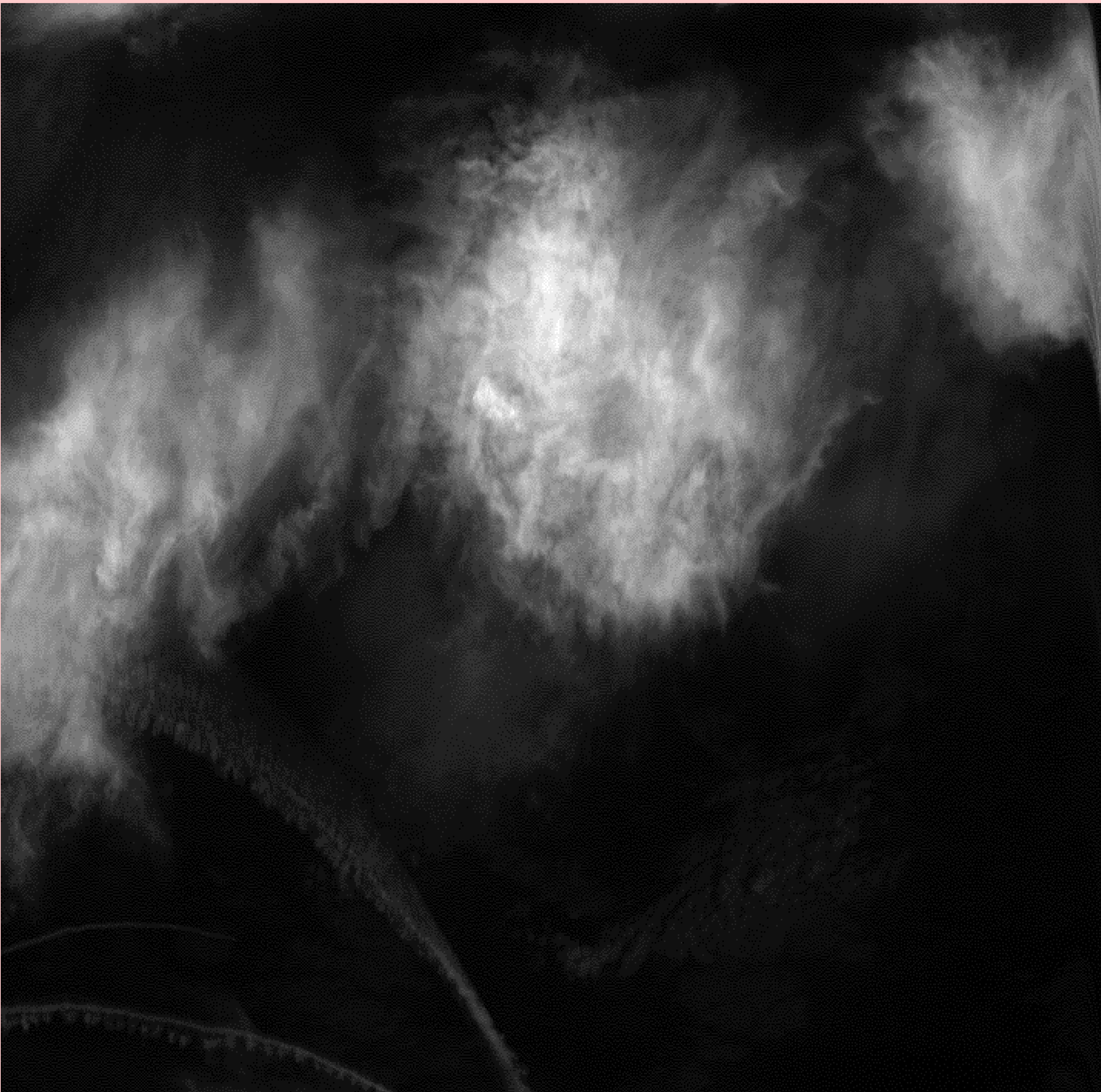

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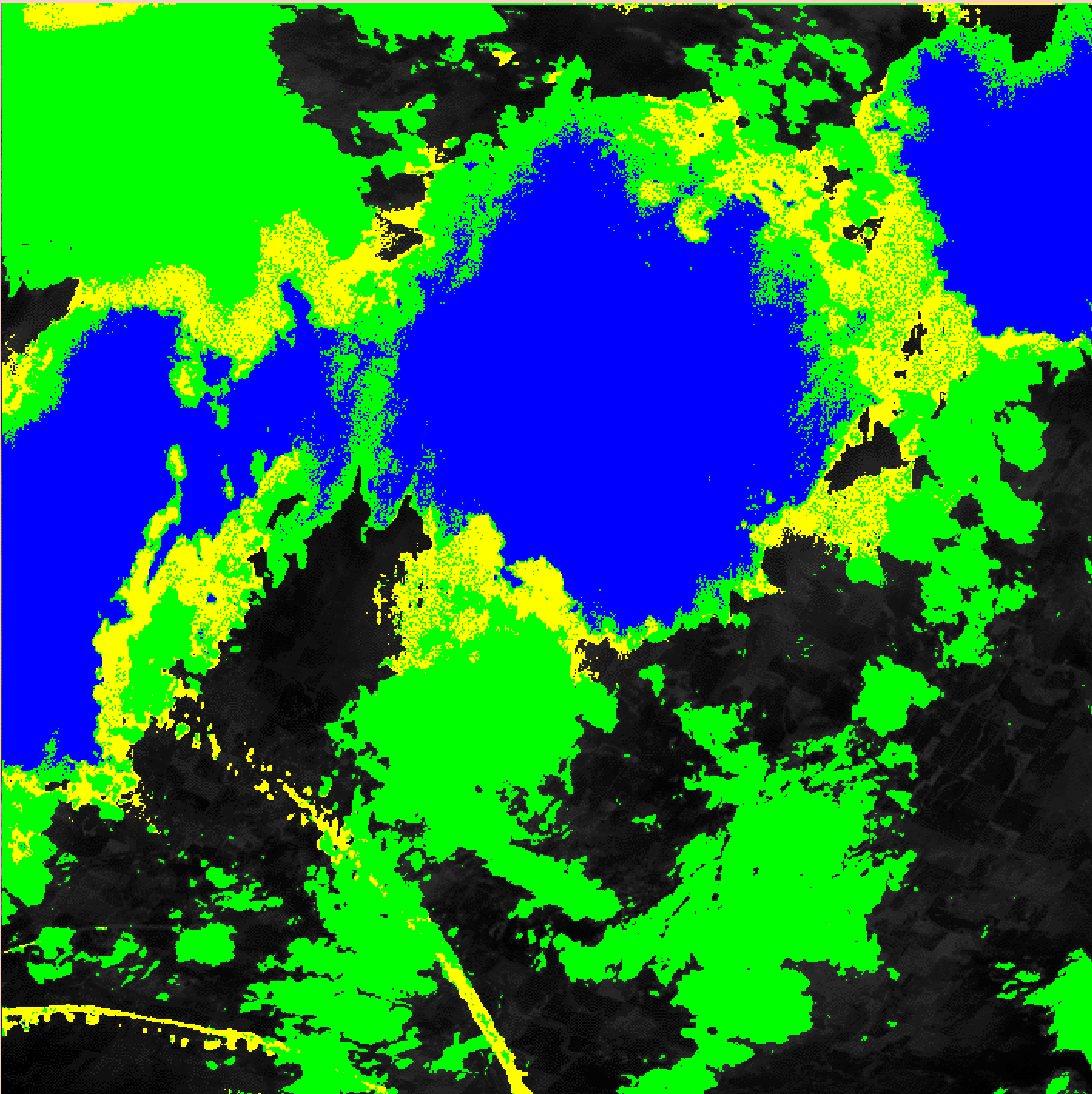
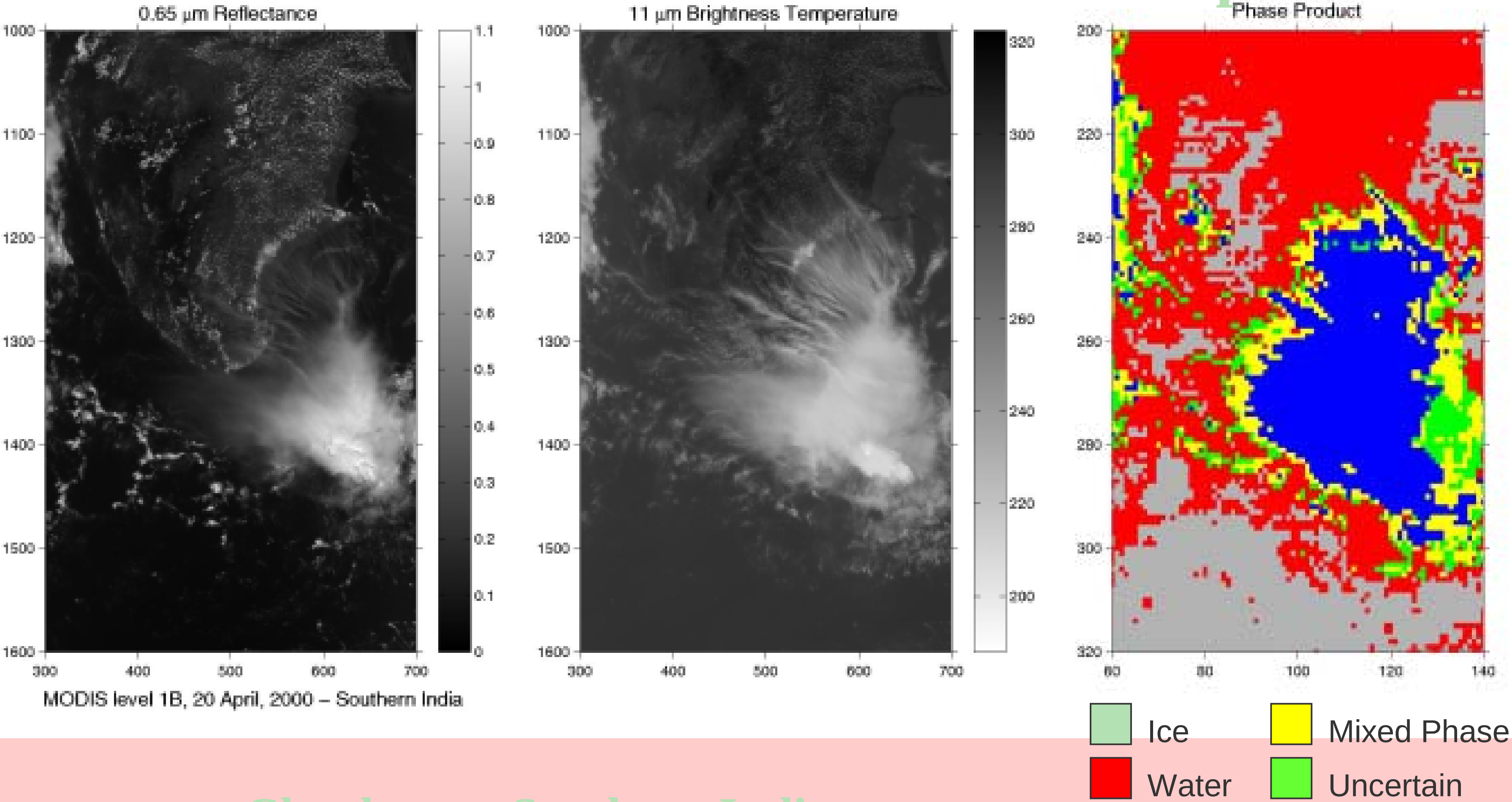


MODIS cloud thermodynamic phase

vis IRW phase



Clouds over Southern India
on 20 April 2000