Workshop on Practical Applications of MODIS Data in Australia

Leeuwin Centre, Floreat WA
November 26-29, 2002

Liam Gumley
Space Science and Engineering Center
University of Wisconsin-Madison

Agenda: Day One

Introduction to MODIS

Survey of MODIS Spectral Bands

Coffee Break

Scanner Characteristics

Lunch: Catered at 12:30

Lab Session: MODIS Instrument Characteristics

Acknowledgements

NASA MODIS Science Team (GSFC),

NASA Earth Science Program (HQ),

University of Wisconsin-Madison,

- Space Science and Engineering Center

Curtin University of Technology,

- Department of Applied Physics
- Remote Sensing and Satellite Research Group

WASTAC,

Department of Land Administration,

Leeuwin Center for Earth Sensing Technologies,

Australian Meteorological and Oceanographic Society.

Slide Credits

University of Wisconsin-Madison: Paul Menzel, Steve Ackerman, Paolo Antonelli, Chris Moeller, Kathy Strabala, Bryan Baum.

MODIS Science Team: Michael King, Steve Platnick, Eric Vermote, Robert Wolfe, Bob Evans, Jacques Descloitres, Kurt Thome.

Other colleagues: Stefan Maier, Jackie Marsden, Simon Hook.

Terra

Launched: Dec. 18, 1999

10:30 am ascending

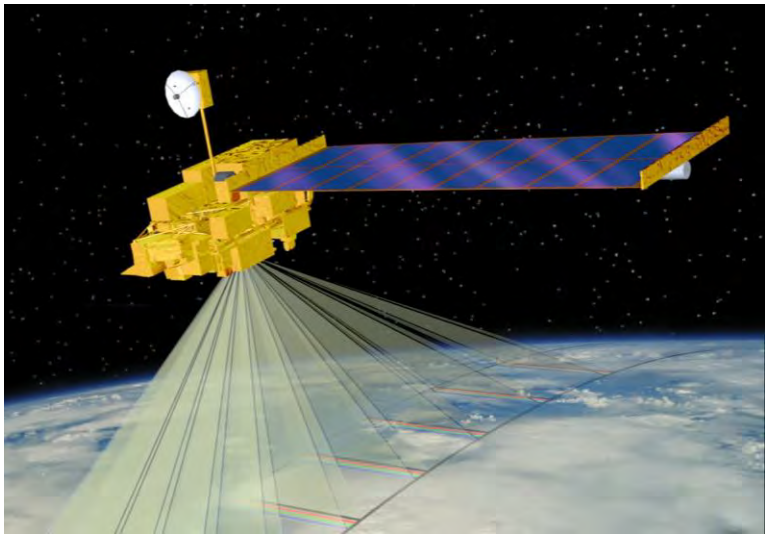
ASTER: Hi-res imager

CERES: Broadband scanner

MISR: Multi-view imager

MODIS: Multispectral imager

MOPITT: Limb sounder



Terra MODIS first light image, 24 Feb. 2000

Aqua

Launched: May 4, 2002

1:30 pm descending

AIRS: Infrared sounder

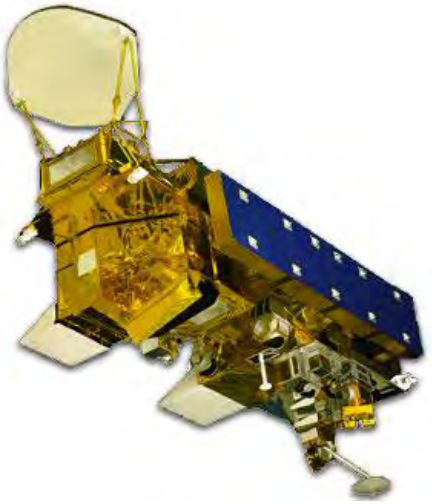
AMSR-E: Microwave scanner

AMSU: Microwave scanner

CERES: Broadband scanner

HSB: Microwave sounder

MODIS: Multispectral imager



Formation Flyers

Coordinated observations by multiple sensors
without the risk of one large platform

Morning Train (10:30 am)

- Terra (multidisciplinary)
- Landsat-7 (land)
- EO-1 (technology)
- SAC-C (GPS water vapor)
- NPP (EOS/NPOESS bridge)

Afternoon Train (1:30 pm)

- Aqua (multidisciplinary)
- Aura (chemistry)
- Cloudsat (cloud radar)
- CALIPSO (cloud lidar)
- Parasol (polarimetry)
- NOAA-16 (weather)

Moderate resolution imaging spectroradiometer (MODIS)

Heritage: AVHRR (land), SeaWIFS (ocean), HIRS (atmosphere)

Spectral coverage: 36 bands from 0.4 to 14.2 microns

Spatial resolution: 2 bands @ 250 m; 5 @ 500 m; 29 @ 1000 m

Major differences:

- More spectral bands (470 detectors)
- Multiple samples along track on each earth scan
- Higher spatial resolution
- On-orbit radiometric, spatial, and spectral calibration
- Improved radiometric accuracy and precision (12-bit)
- Improved geolocation accuracy
- Higher data rate requiring X-band direct broadcast

MODIS Specifications

Orbit: 705 km, 10:30 a.m. descending node (Terra) or 1:30 p.m. ascending node (Aqua), sun-synchronous, near-polar, circular

Scan Rate: 20.3 rpm

Swath Dimensions: 2330 km (cross track) by 10 km (along track)

Data Rate: 10.6 Mbps (peak daytime)

Quantization:12 bits

Spatial Resolution:
250 m (bands 1-2), 500 m (bands 3-7), 1000 m (bands 8-36)

MODIS Challenges

Multiple detectors:

- Detector differences are noticeable
- Dead or out-of-family detectors must be handled
- Multiple samples along track introduce bowtie distortion

Spectral information:

- Many interdependent bands
- How to utilize all the spectral information

Data rate:

- Orders of magnitude larger than heritage sensors

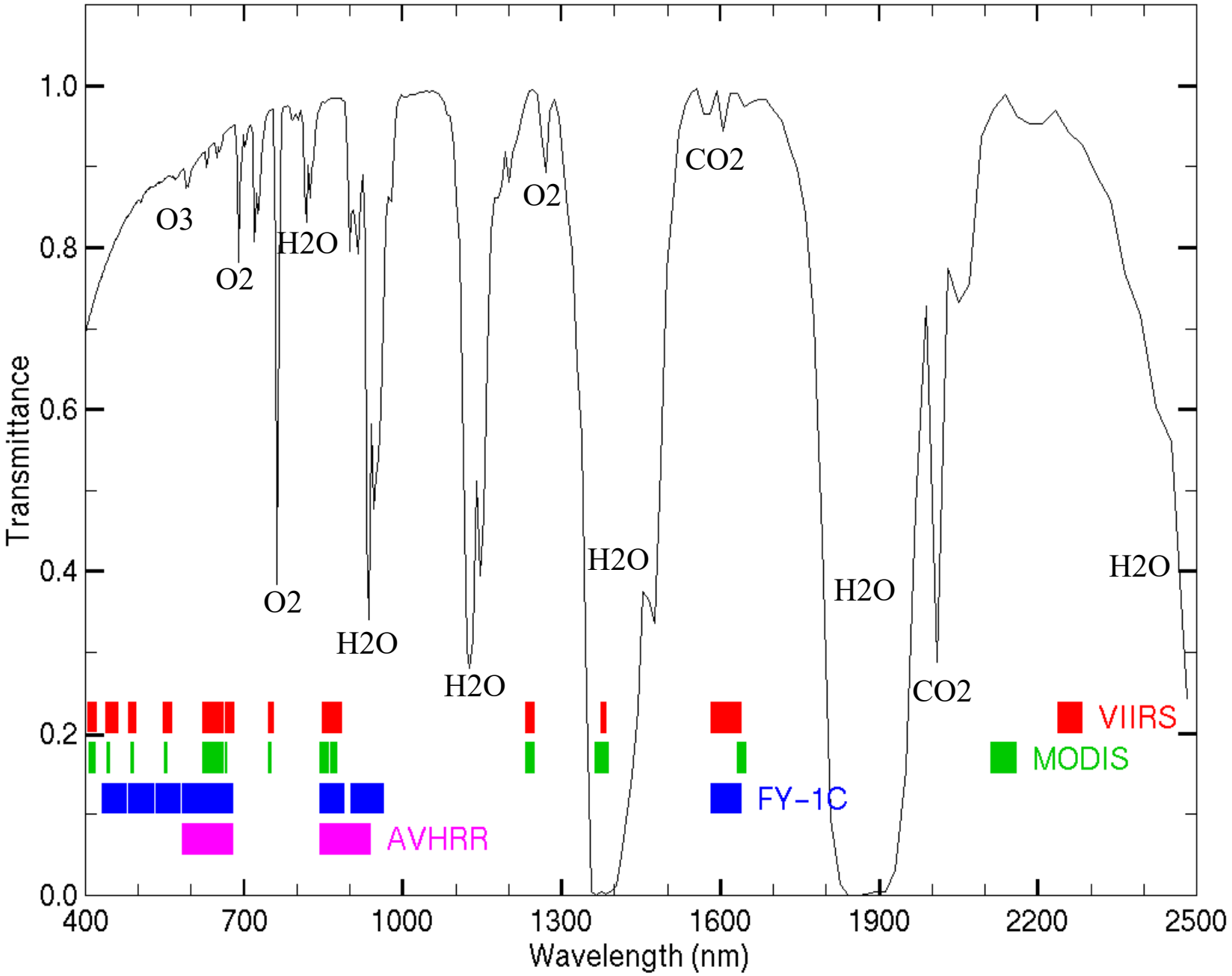
MODIS Reflective Band Specifications

Primary Use	Band	Bandwidth[1]	Spectral Radiance[2]	Required SNR[3]
Land/Cloud/Aerosols Boundaries	1	620 - 670	21.8	128
	2	841 - 876	24.7	201
Land/Cloud/Aerosols Properties	3	459 - 479	35.3	243
	4	545 - 565	29.0	228
	5	1230 - 1250	5.4	74
	6	1628 - 1652	7.3	275
	7	2105 - 2155	1.0	110
Ocean Color/ Phytoplankton/ Biogeochemistry	8	405 - 420	44.9	880
	9	438 - 448	41.9	838
	10	483 - 493	32.1	802
	11	526 - 536	27.9	754
	12	546 - 556	21.0	750
	13	662 - 672	9.5	910
	14	673 - 683	8.7	1087
	15	743 - 753	10.2	586
	16	862 - 877	6.2	516
Atmospheric Water Vapor	17	890 - 920	10.0	167
	18	931 - 941	3.6	57
	19	915 - 965	15.0	250

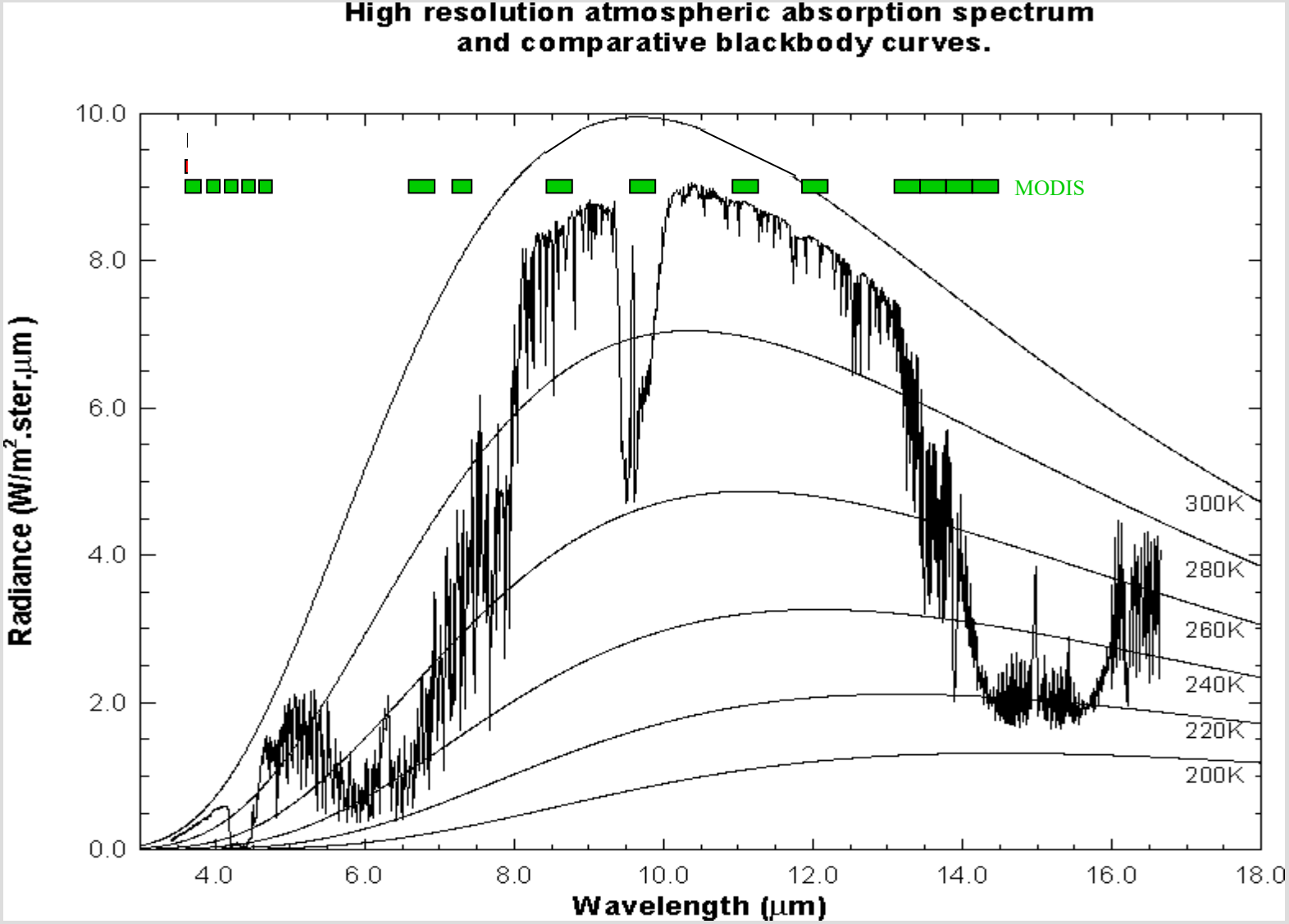
MODIS Emissive Band Specifications

Primary Atmospheric Application	Band	Bandwidth[1]	$T_{typical}$ (K)	Radiance[2] at $T_{typical}$	NEΔT (K) Specification	NEΔT (K) Predicted
Surface Temperature	20	3.660-3.840	300	0.45	0.05	0.05
	22	3.929-3.989	300	0.67	0.07	0.05
	23	4.020-4.080	300	0.79	0.07	0.05
Temperature profile	24	4.433-4.498	250	0.17	0.25	0.15
	25	4.482-4.549	275	0.59	0.25	0.10
Moisture profile	27	6.535-6.895	240	1.16	0.25	0.05
	28	7.175-7.475	250	2.18	0.25	0.05
	29	8.400-8.700	300	9.58	0.05	0.05
Ozone	30	9.580-9.880	250	3.69	0.25	0.05
Surface Temperature	31	10.780-11.280	300	9.55	0.05	0.05
	32	11.770-12.270	300	8.94	0.05	0.05
Temperature profile	33	13.185-13.485	260	4.52	0.25	0.15
	34	13.485-13.785	250	3.76	0.25	0.20
	35	13.785-14.085	240	3.11	0.25	0.25
	36	14.085-14.385	220	2.08	0.35	0.35

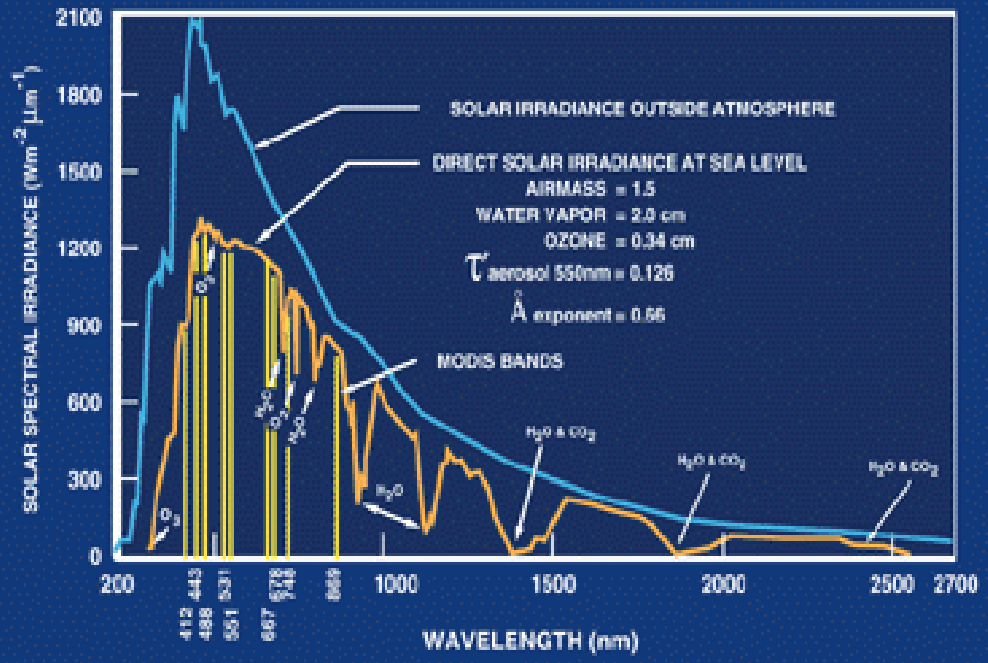
VIIRS, MODIS, FY-1C, AVHRR

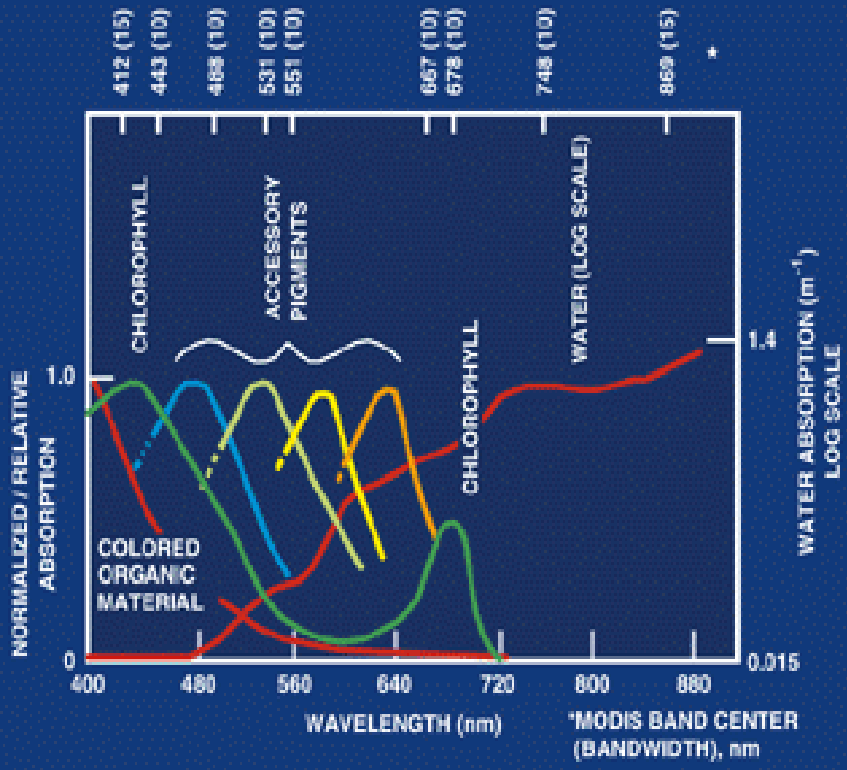


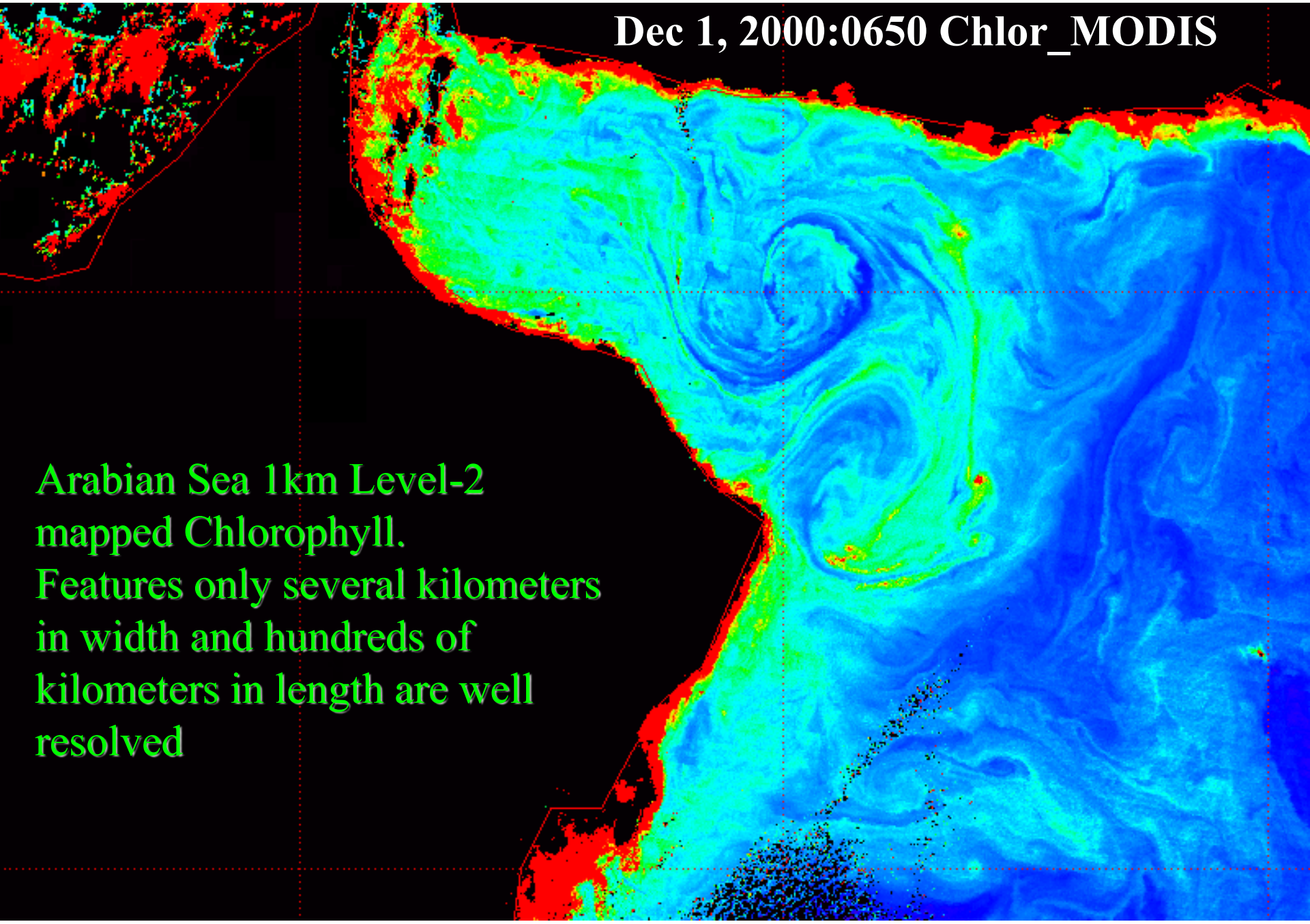
MODIS IR Spectral Bands



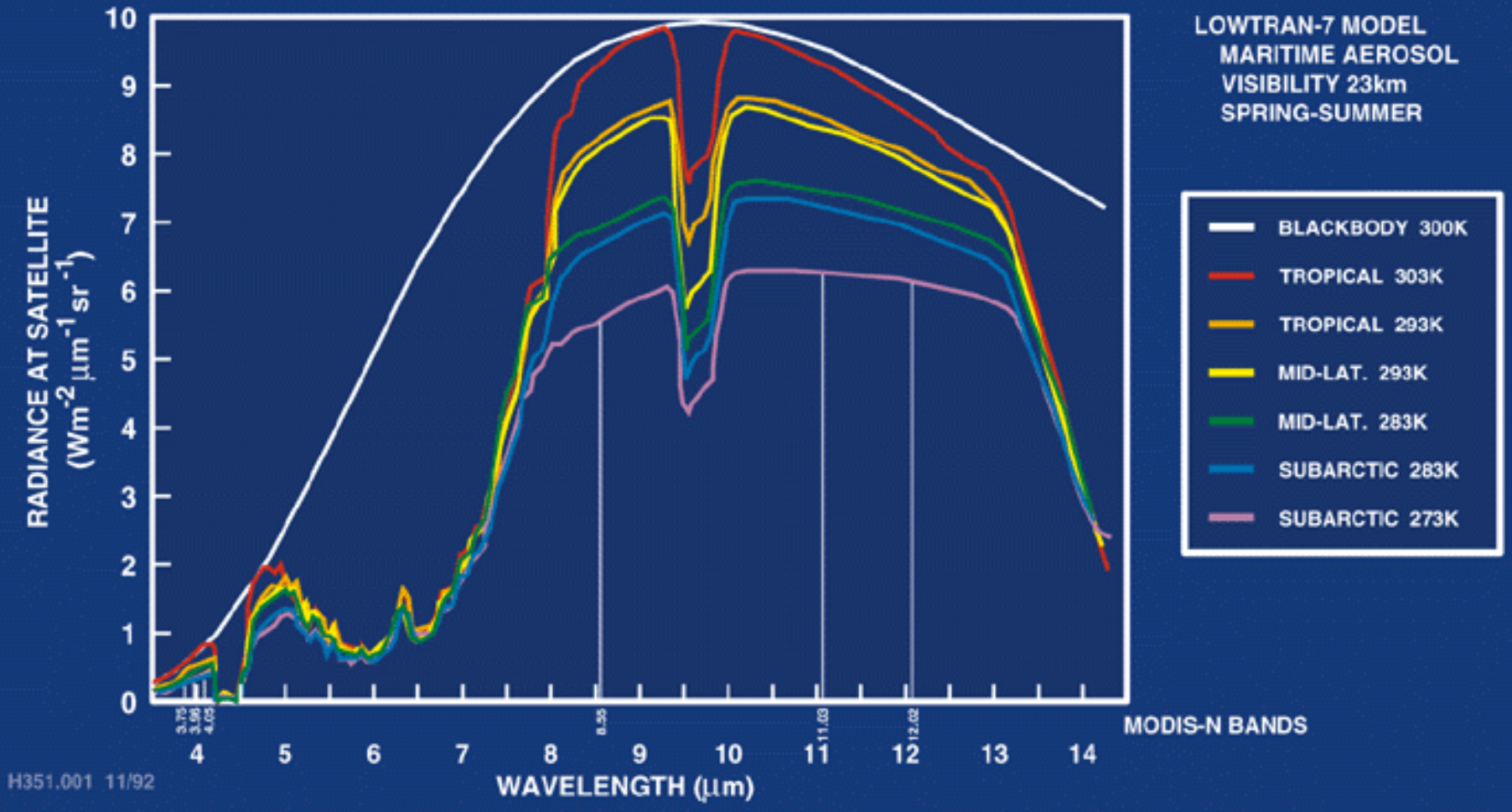
OCEAN-SOLAR RADIATION






Dec 1, 2000:0650 Chlor_MODIS
Arabian Sea 1km Level-2 mapped Chlorophyll.
Features only several kilometers in width and hundreds of kilometers in length are well resolved

MODIS SEA SURFACE TEMPERATURE



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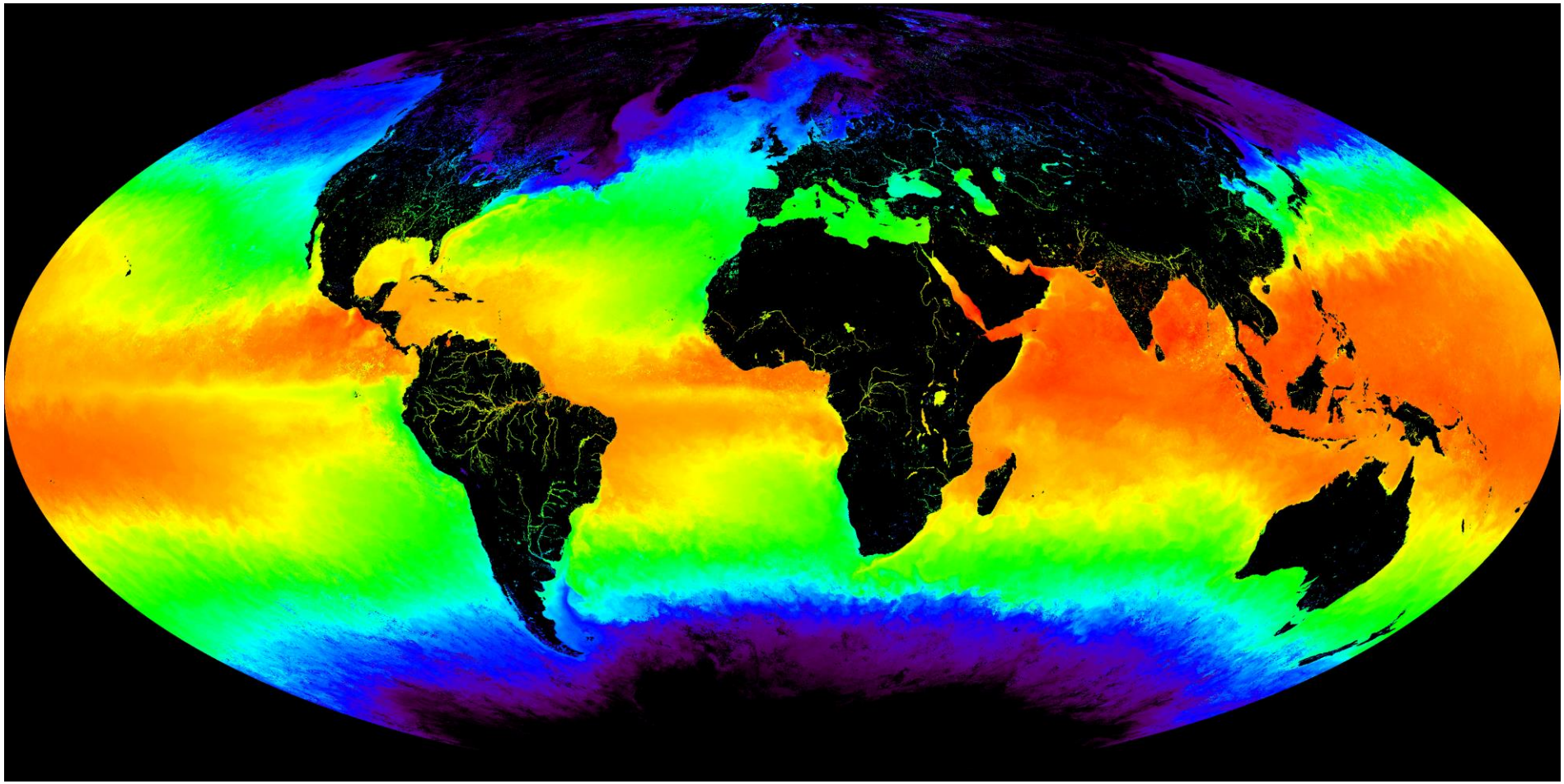
TERRA MODIS NIGHTTIME 4μm SST



-2 5 10 15 20 25 30 35

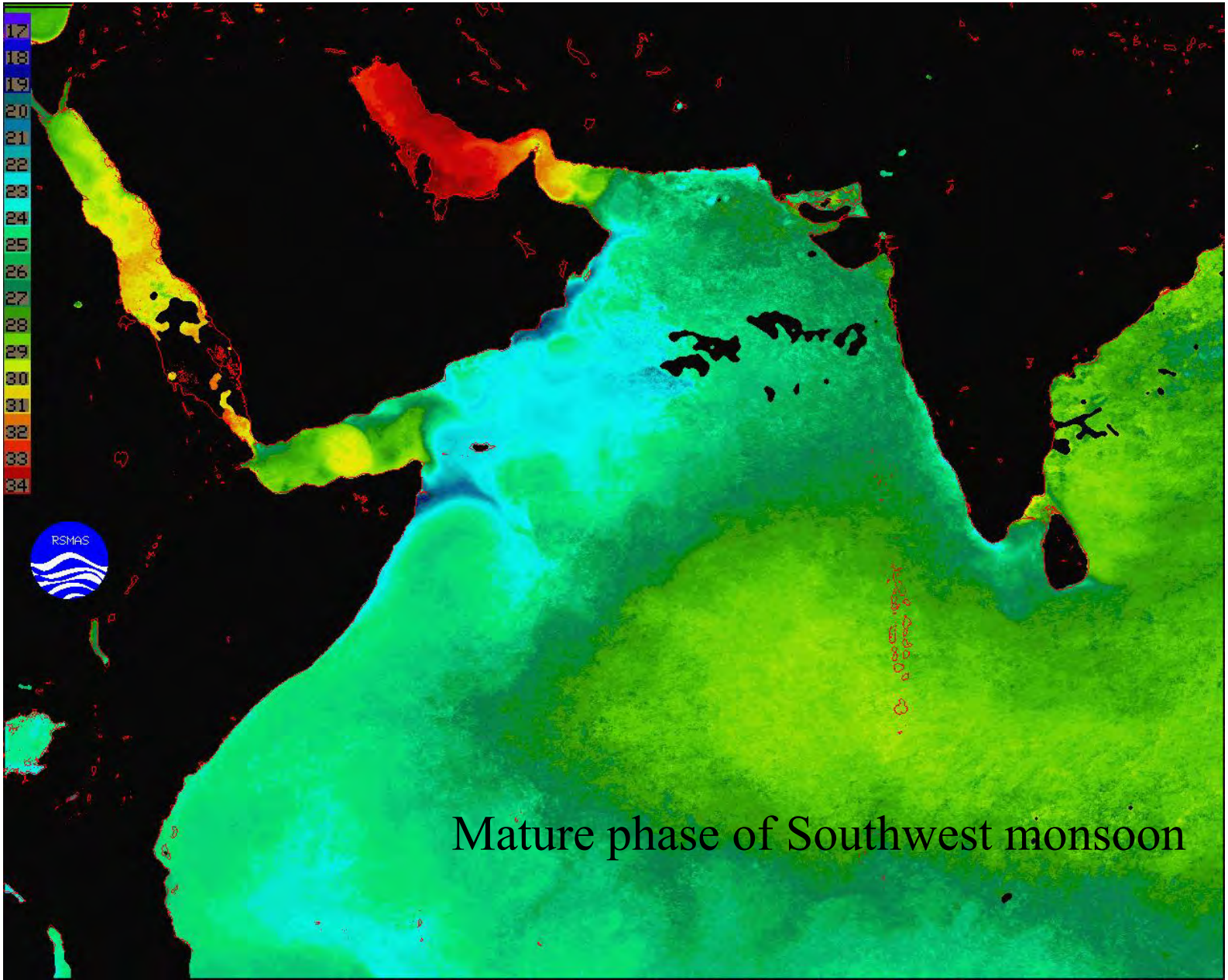
C°

MAY 2001

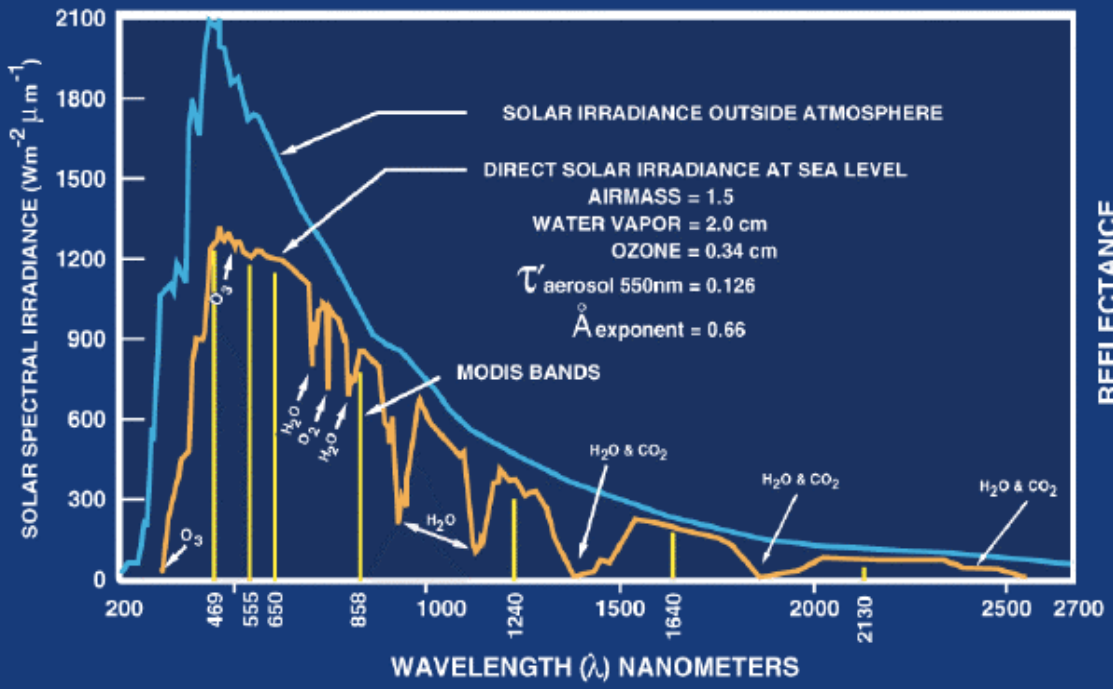
V 3.3.1

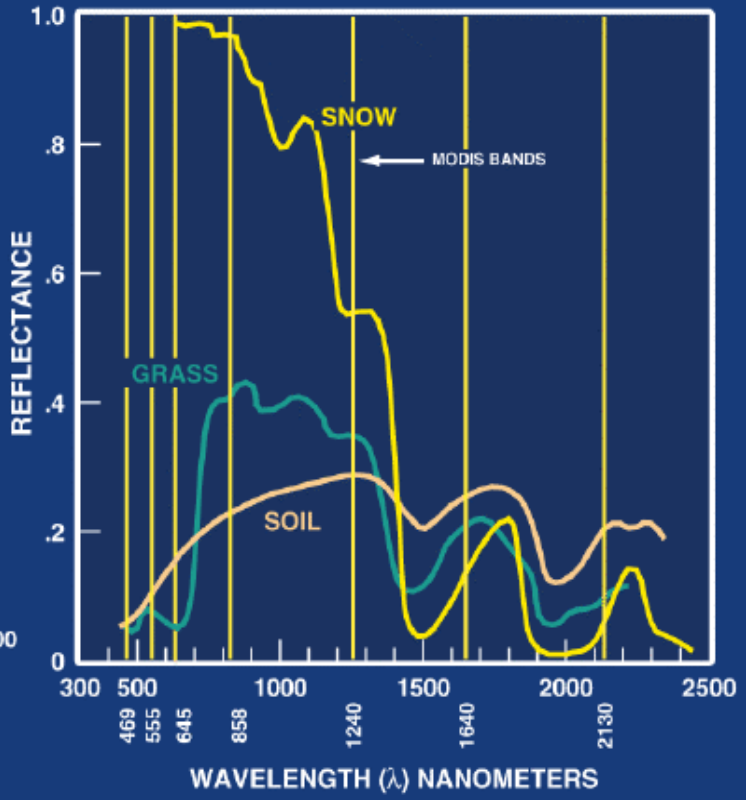
MODIS/OCEAN GROUP
GSFC, RSMAS

Arabian Sea Monthly Average SST Aug 2001

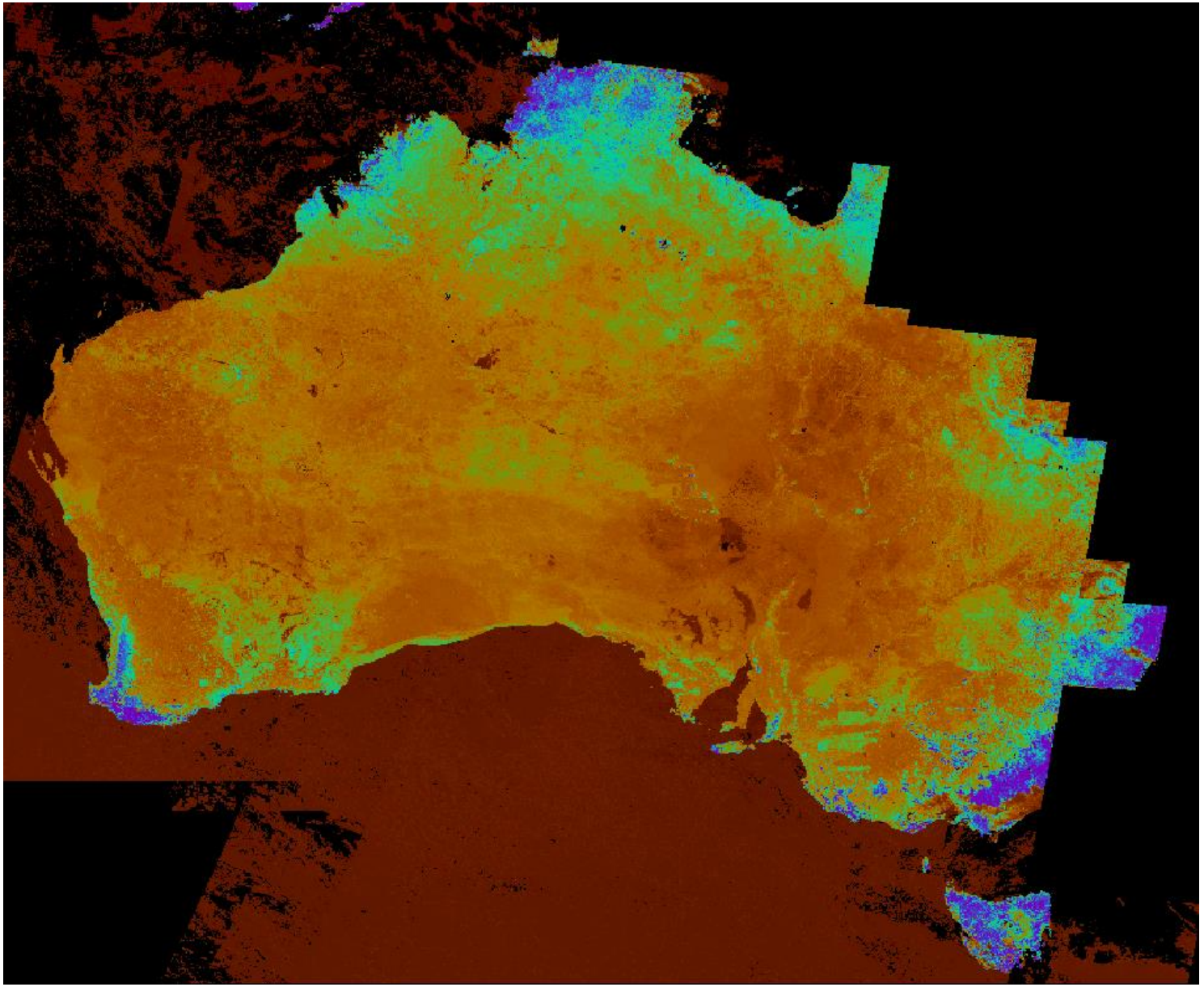


LAND-SOLAR RADIATION





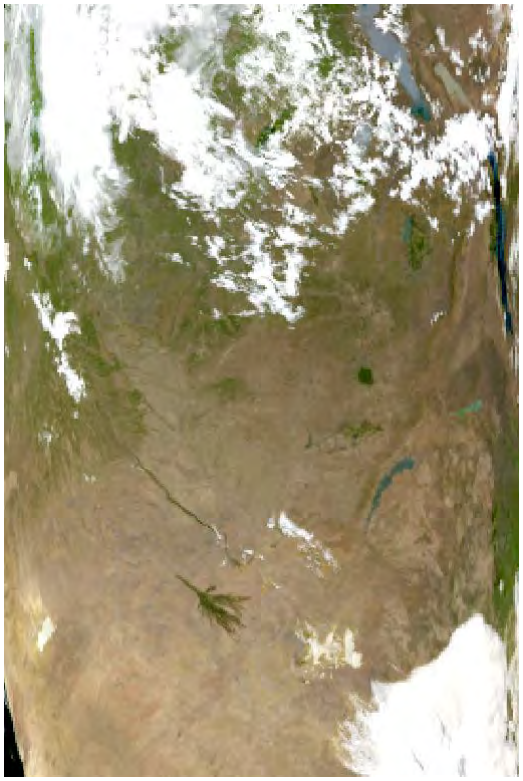
Terra MODIS NDVI composite 250 meter resolution



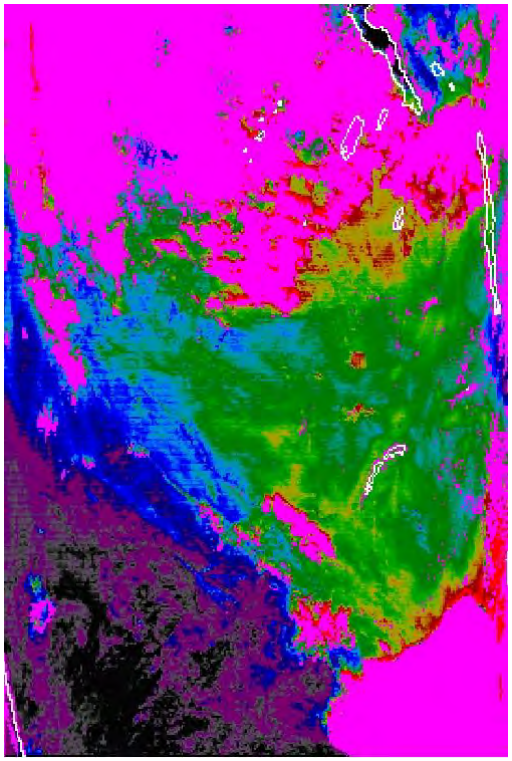
The surface reflectance algorithm uses internal 1km aerosol optical depth since collection 3 processing.

MODIS Granule over South Africa (Sept,13,2001, 8:45 to 8:50 GMT)

RGB no correction for aerosol effect

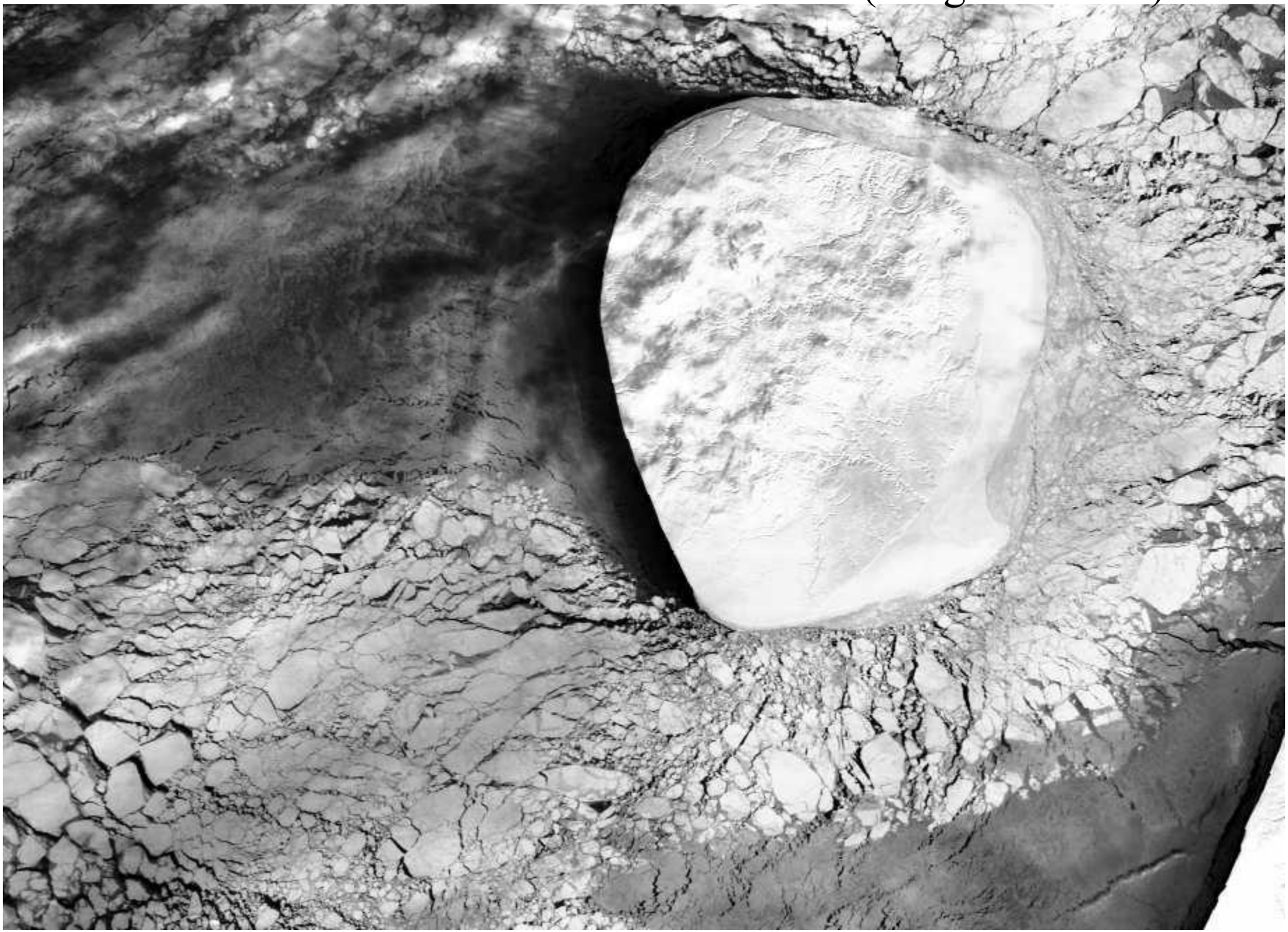


RGB surface reflectance (corrected for aerosol)

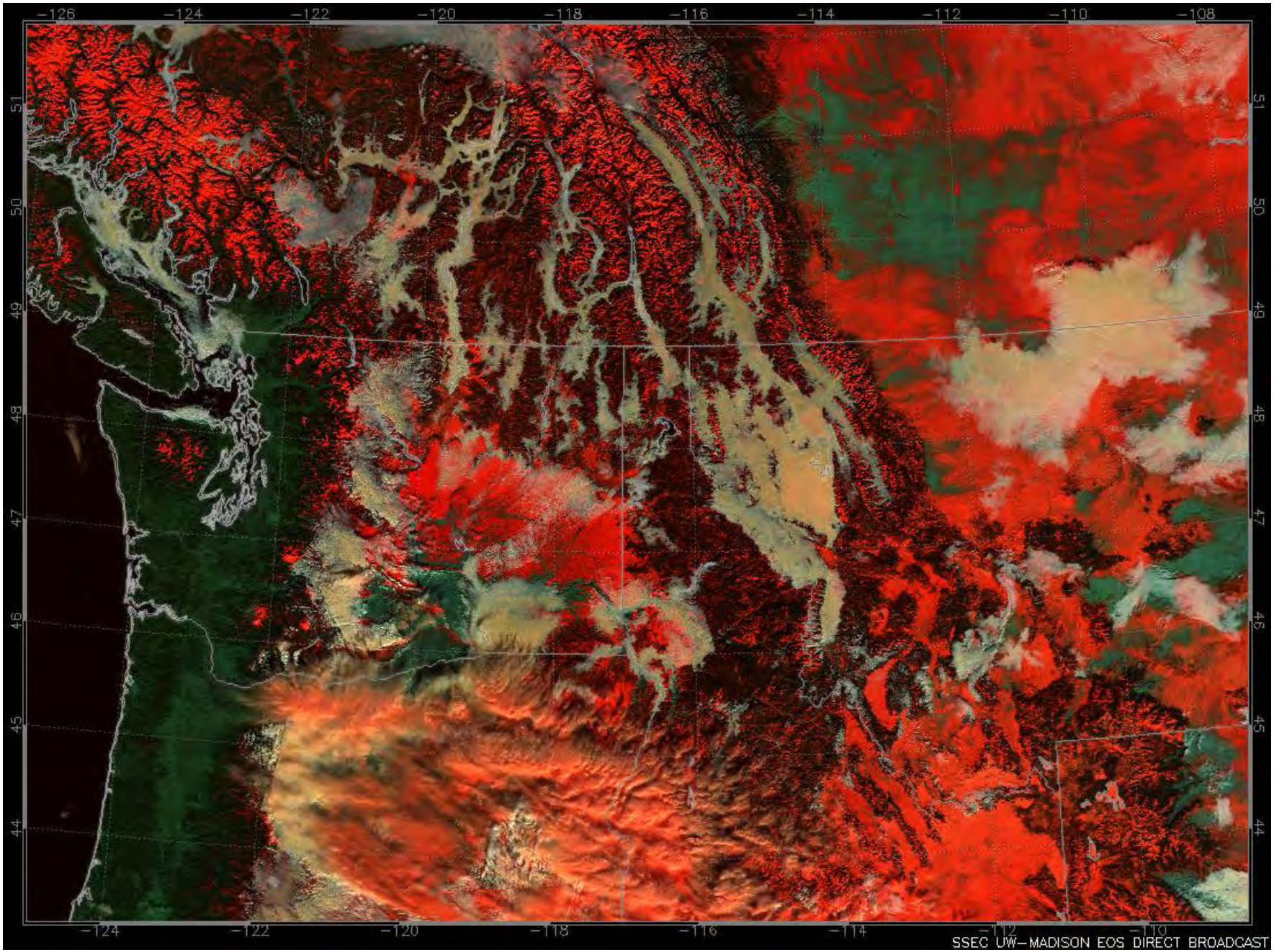


Corresponding aerosol optical thickness at 670nm (0 black, 1.0 and above red) linear rainbow scale. Clouds are in magenta, water bodies are outlined in white.

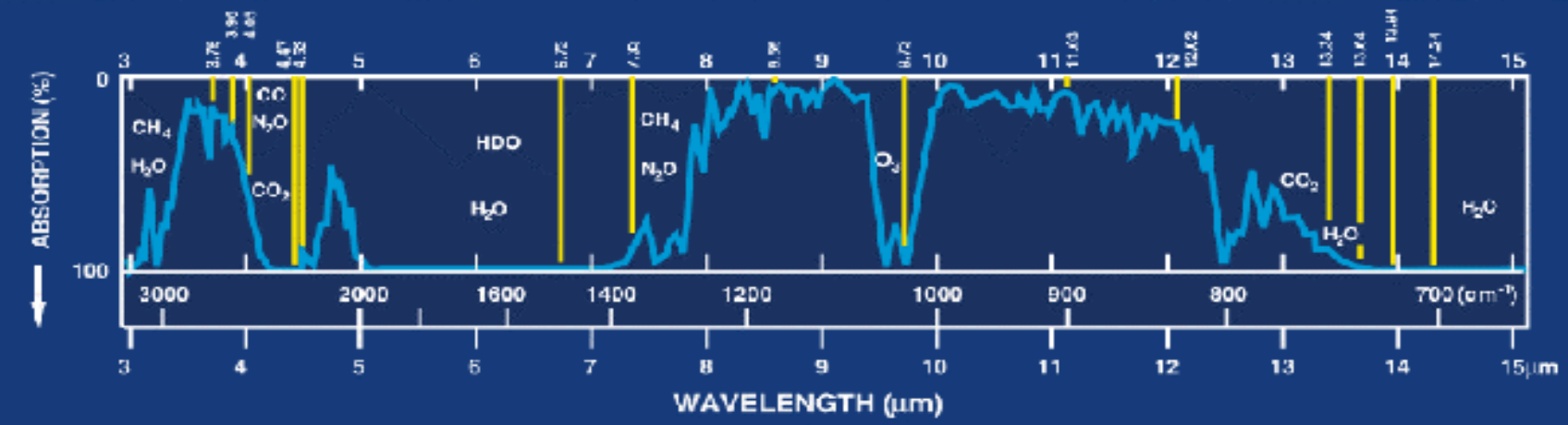
ScanEX 3/1/2001: Ice in the Barents Sea (Kolguev Island)

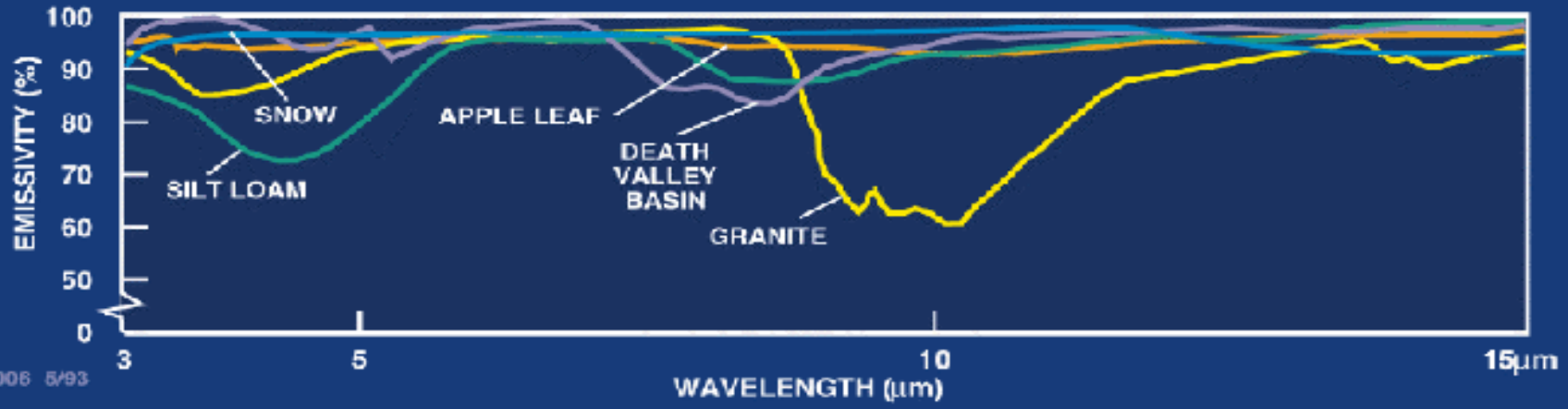


2001/01/26 1900: Northwest US, Snow and Fog



LAND - THERMAL RADIATION





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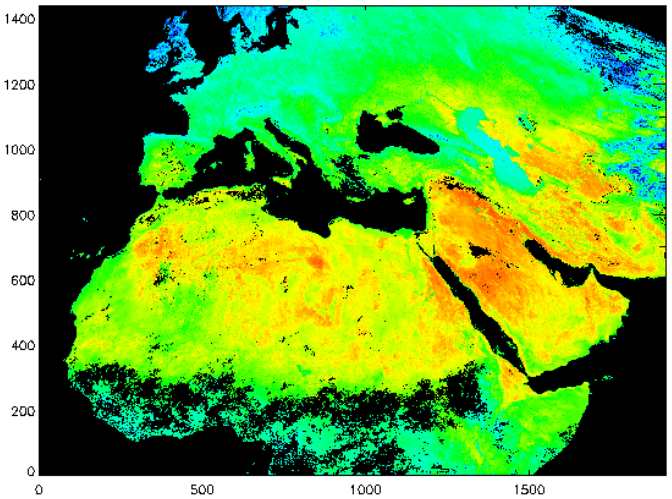
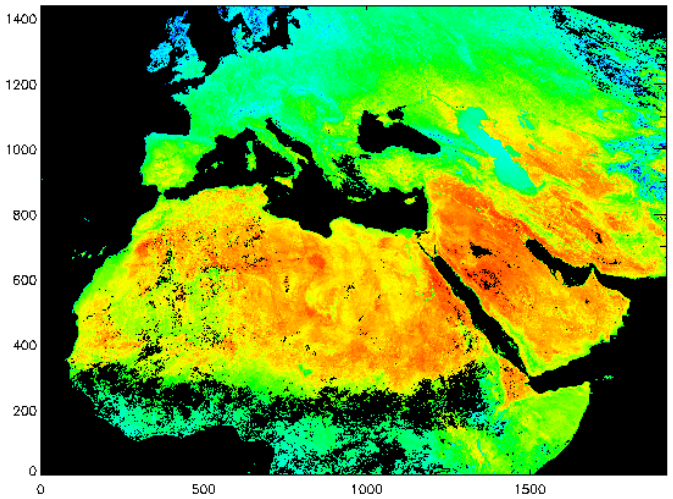
LSTs retrieved from Terra and Aqua MODIS data
on data days 176-177 and 185-190 (06/25-26 & 07/4-9)
to show spatial distribution of the diurnal variation

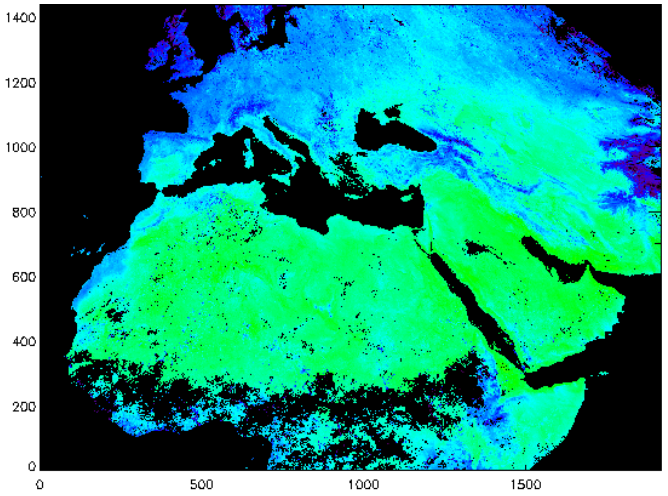
daytime Terra

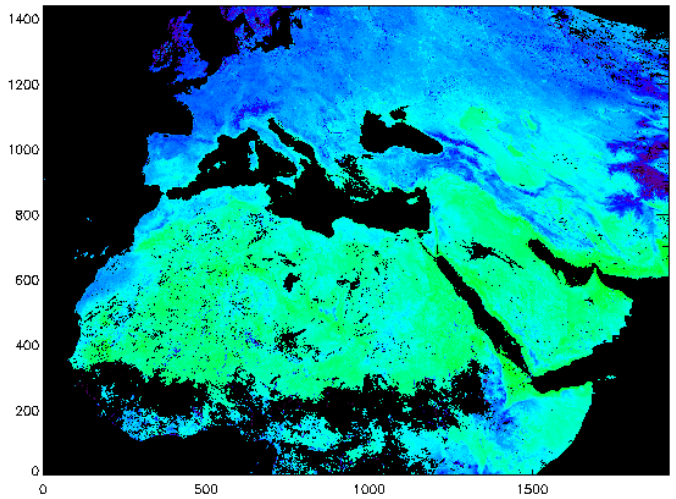




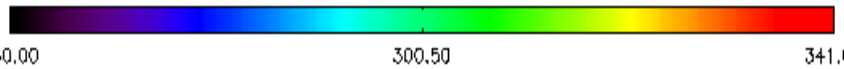
daytime Aqua

nighttime Terra





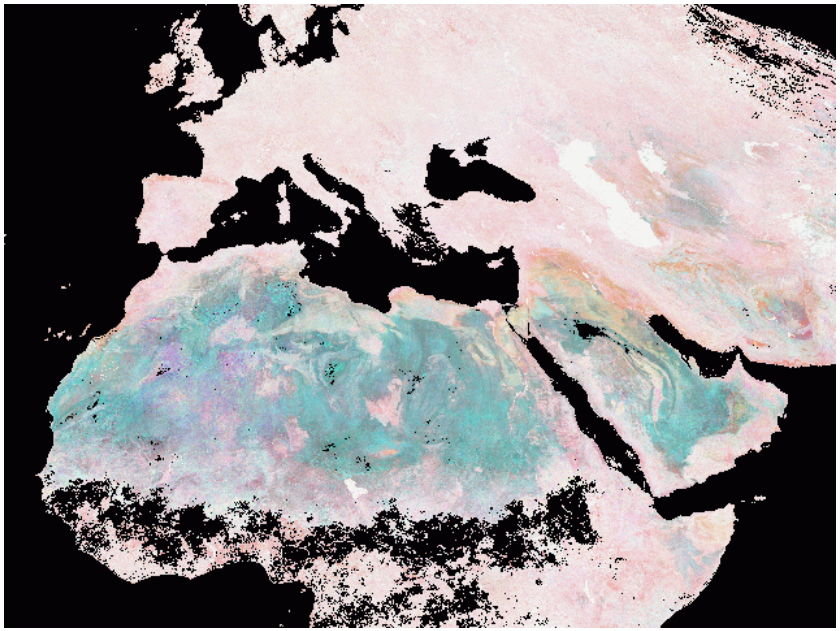
nighttime Aqua



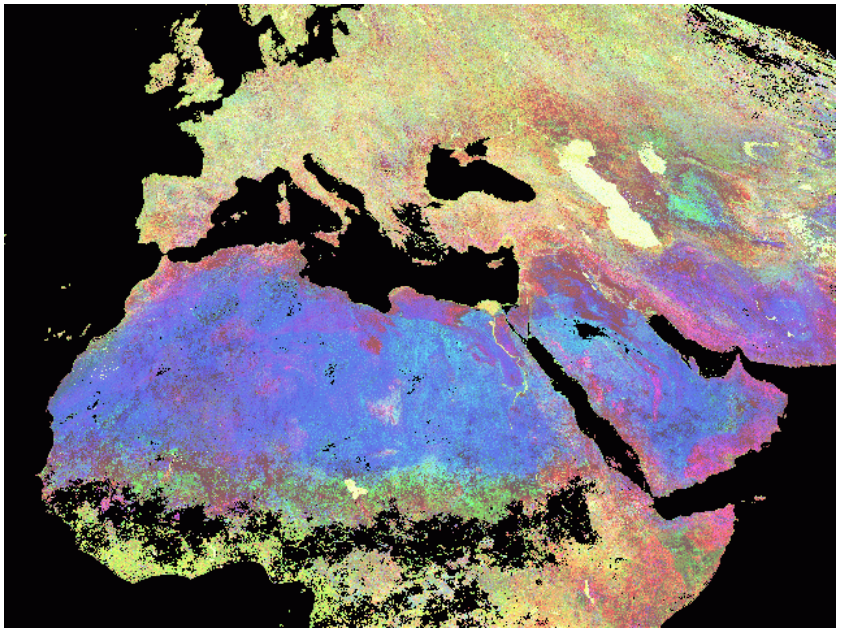
ICESS
Institute for Computational Earth System Science
University of California, Santa Barbara

Surface emissivities retrieved by Terra and Aqua MODIS

in data days 176-177 and 185-190 (06/25-26 & 07/4-9)



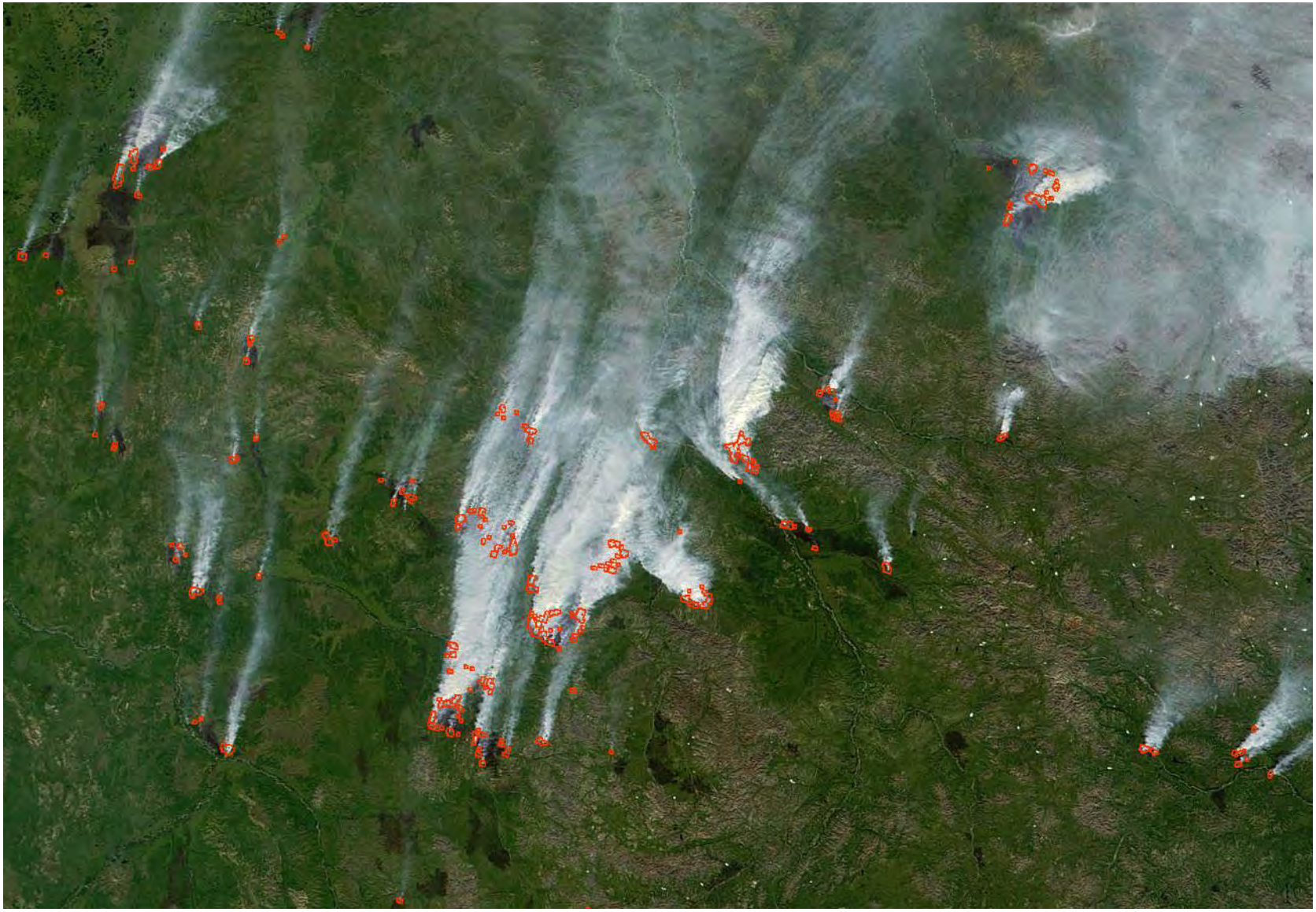
Color composite image with emissivities in bands 29, 22, and 20 as RGB components.



Color composite image with emissivities in bands 29, 31, and 32 enhanced by the equalization histogram method as RGB components.

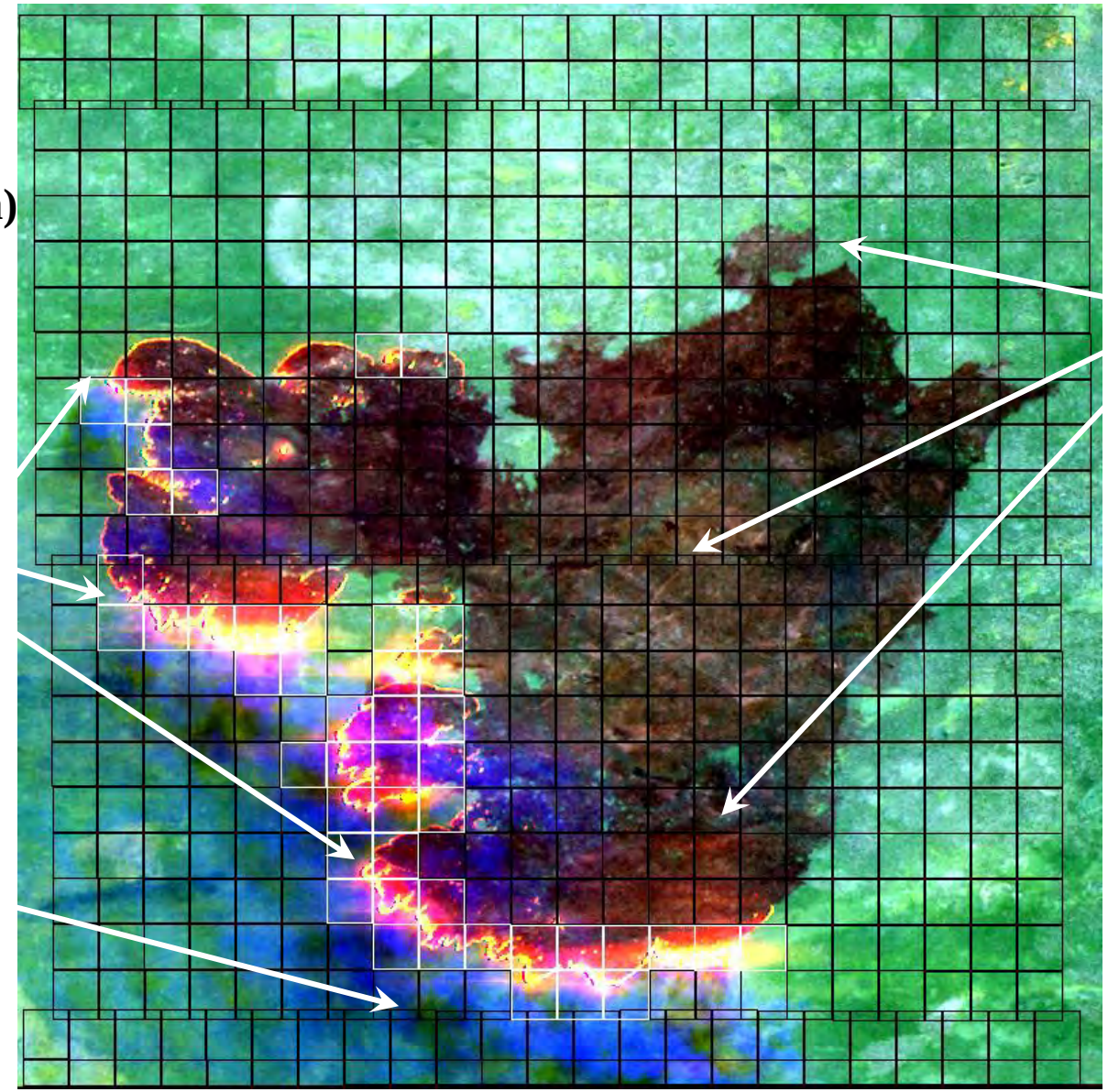
Example of Active Fire / Corrected Reflectance Product
Rodeo fire in Arizona (06/19/02)

Example of Active Fire / Corrected Reflectance Product
Siberia (05/22/01)



Active Fire Validation
Collocating ASTER and MODIS data

Aug 17 2001
09:08 UTC
18.8S 19.9 E
(NE Namibia)



White squares:
MODIS fire pixels

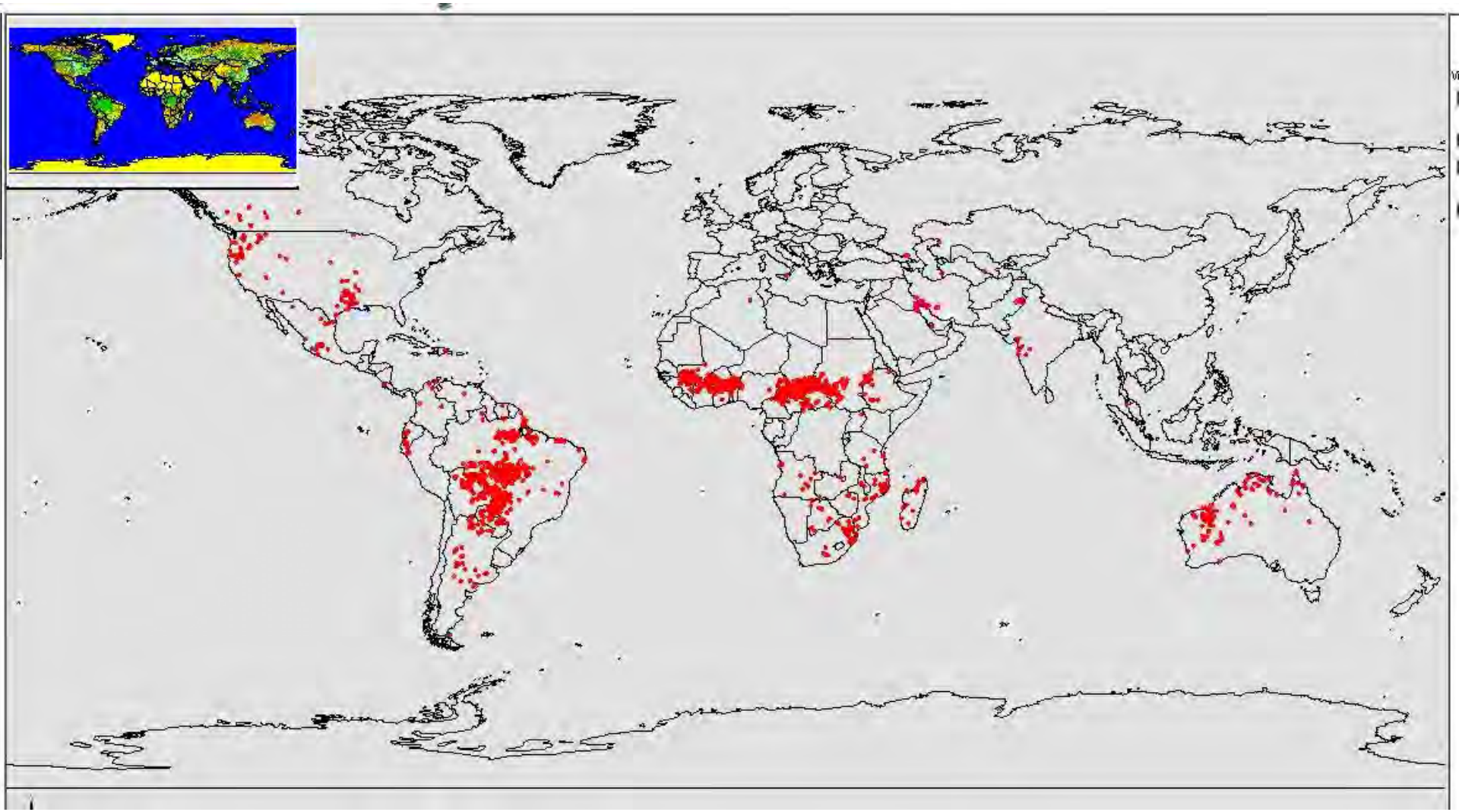
Burn scar

Fire fronts

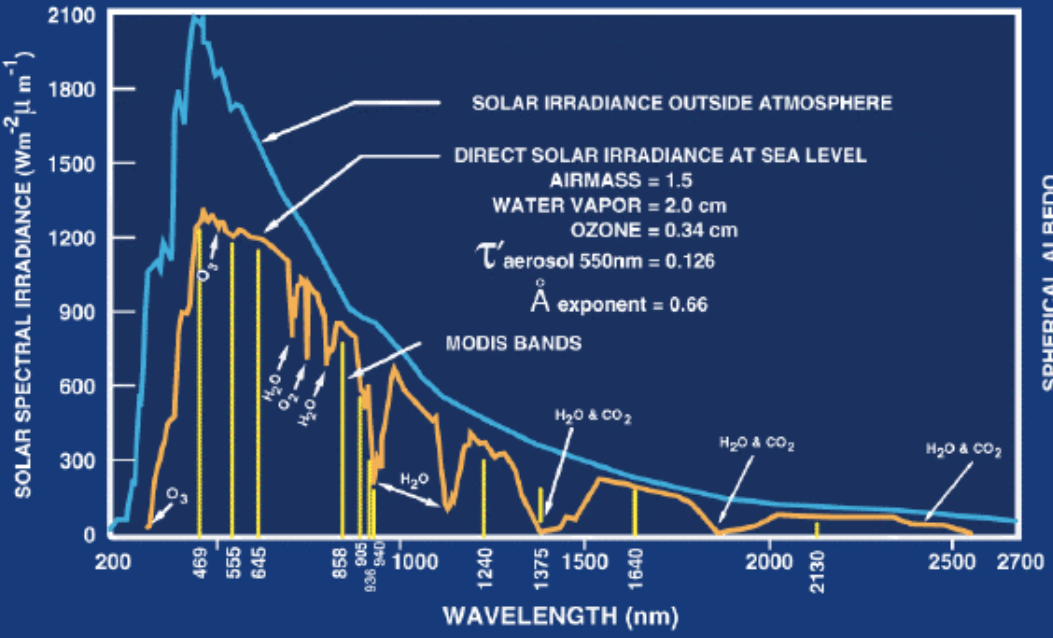
Smoke

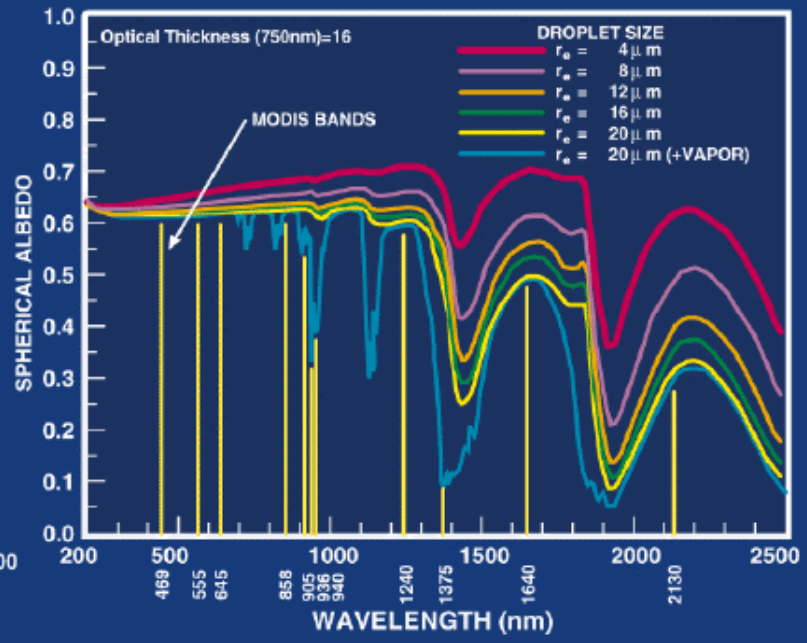
R: 2.16 µm
G: 1.65 µm
B: 0.56 µm

MODIS Global Fire Map Nov 20-22, 2002



ATMOSPHERE-SOLAR RADIATION

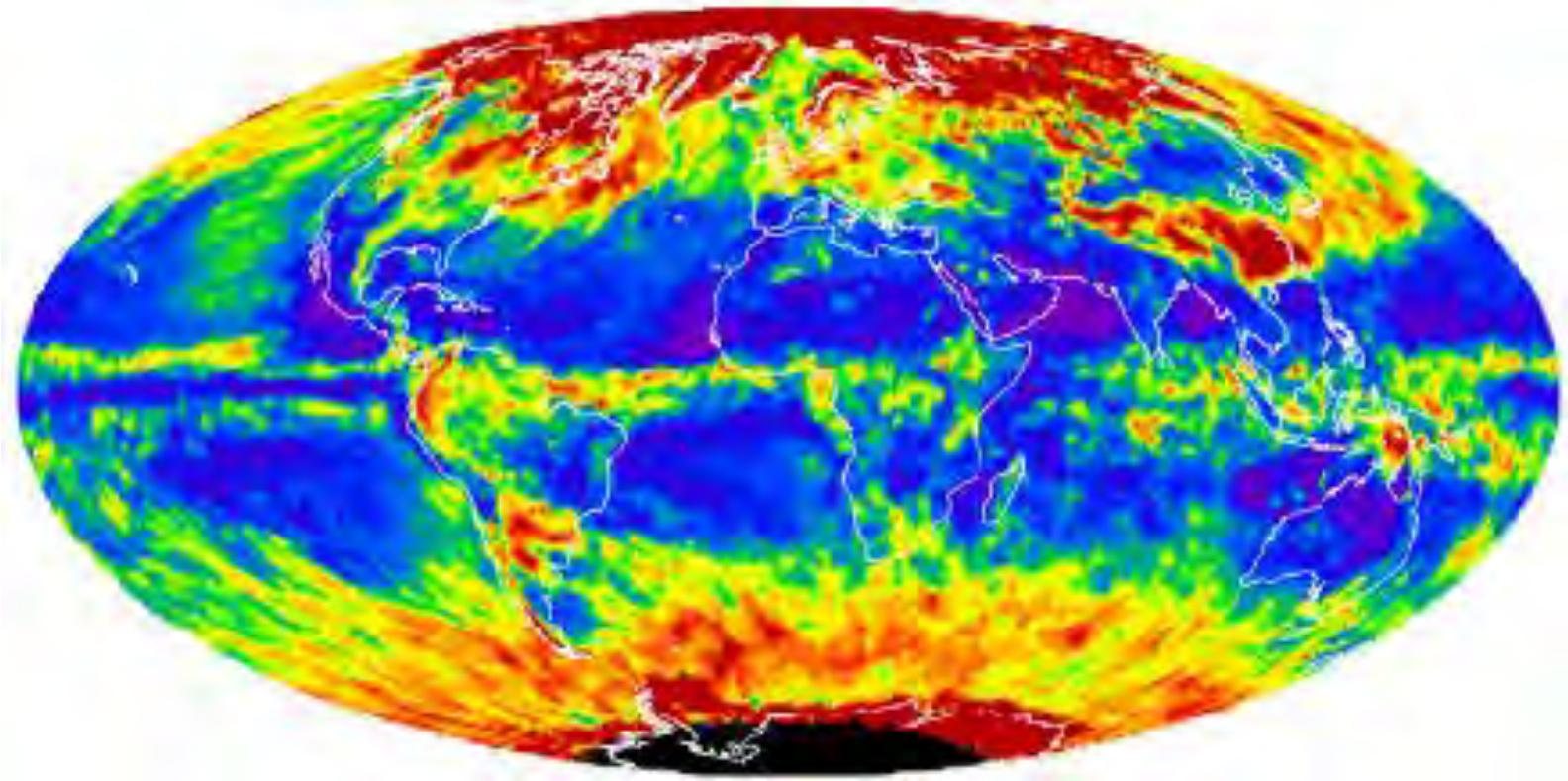




Cloud Optical Thickness

(M. D. King, S. Platnick, M. Gray, E. Moody, et al)

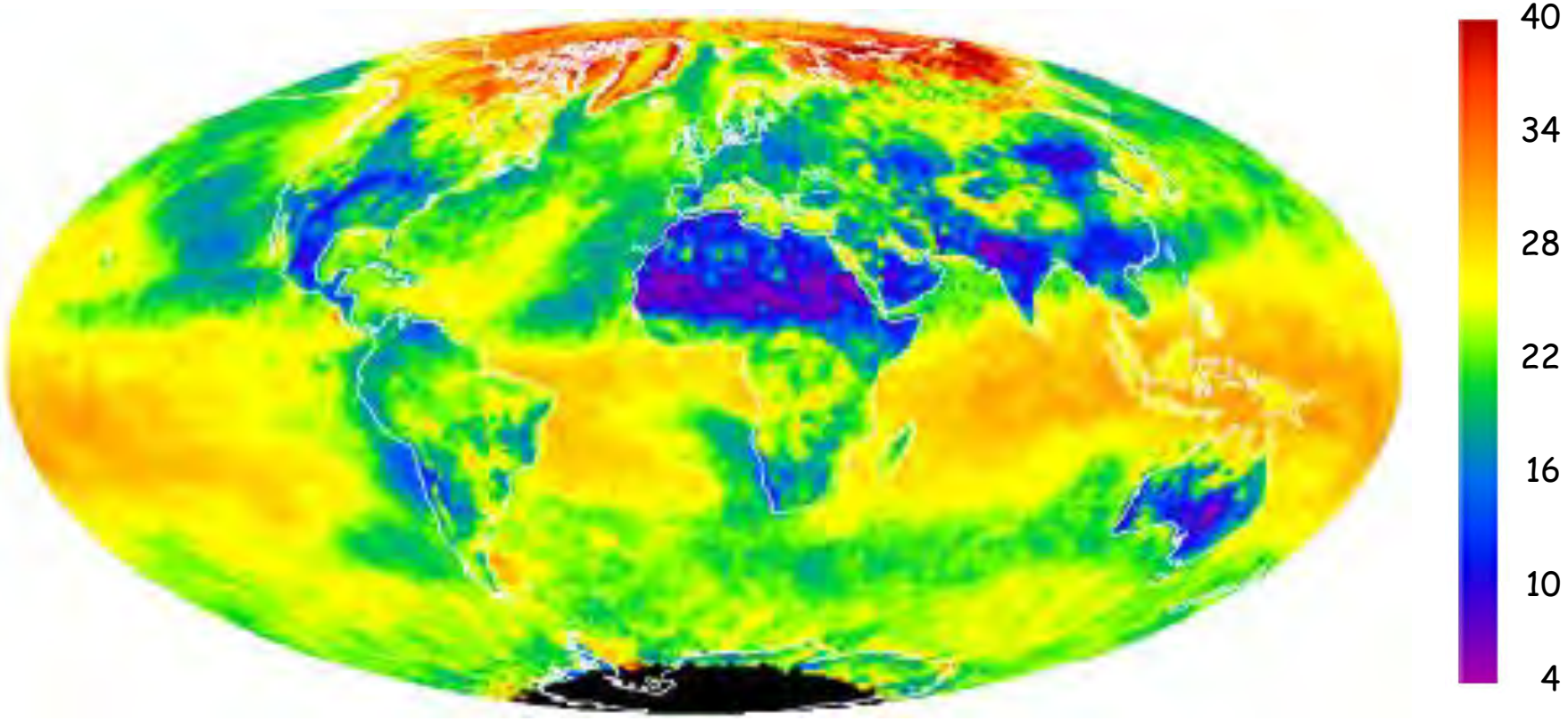
Level-3 Monthly
April 2001



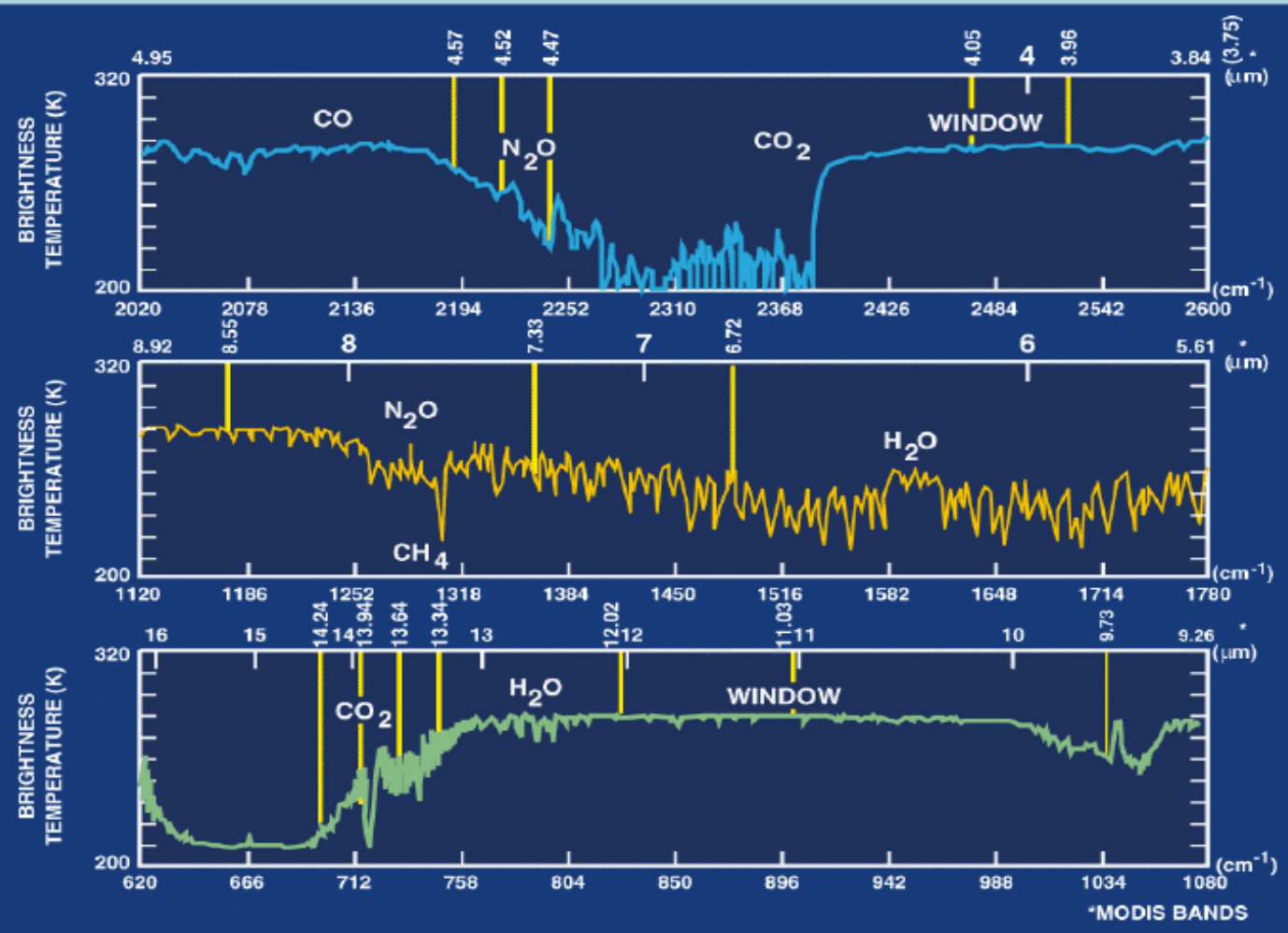
Cloud Effective Particle Radius

(M. D. King, S. Platnick, M. Gray, E. Moody, et al.)

Level-3 Monthly
April 2001



ATMOSPHERE - CLEAR SKY THERMAL EMISSION



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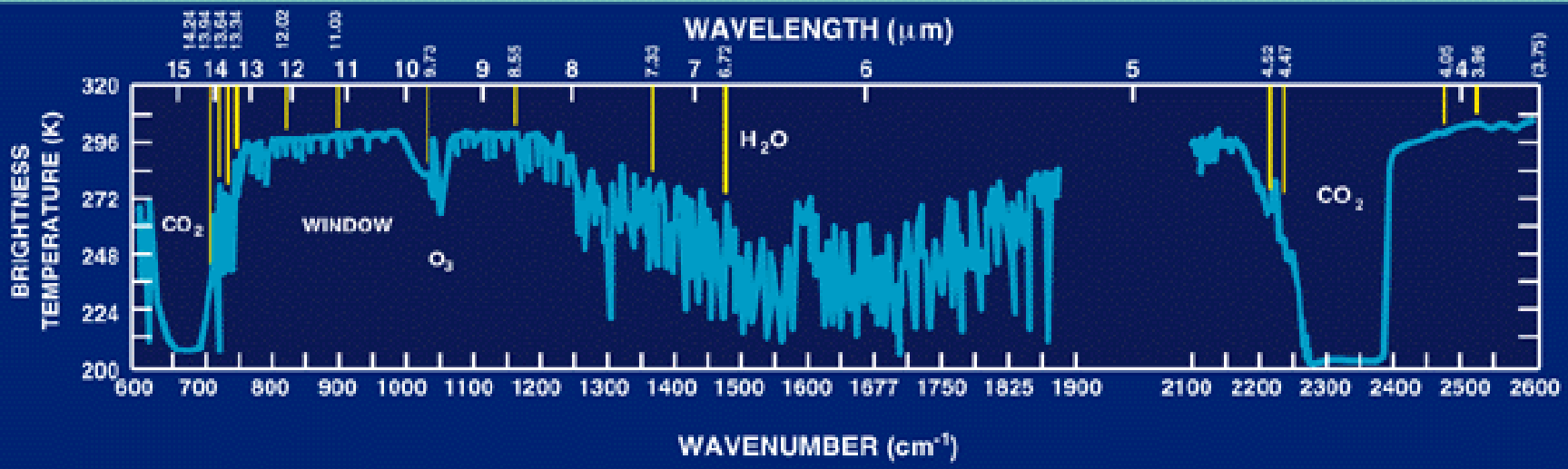
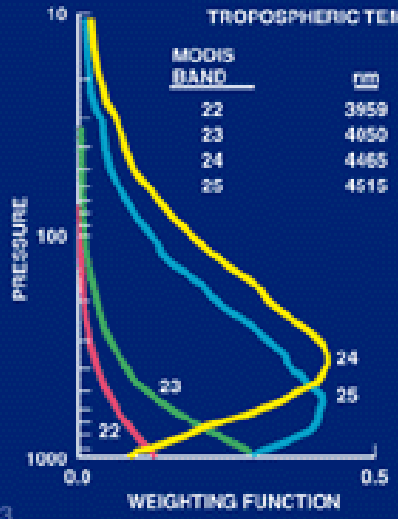
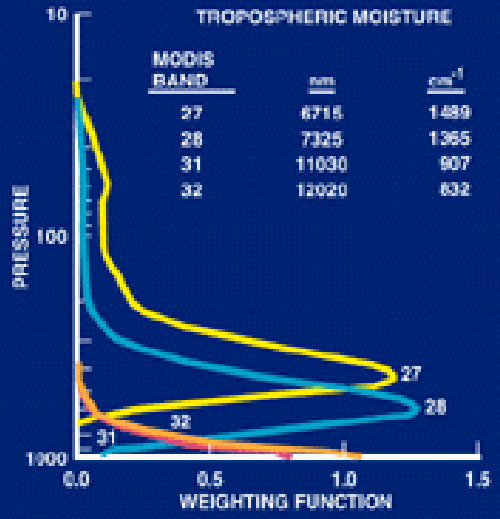
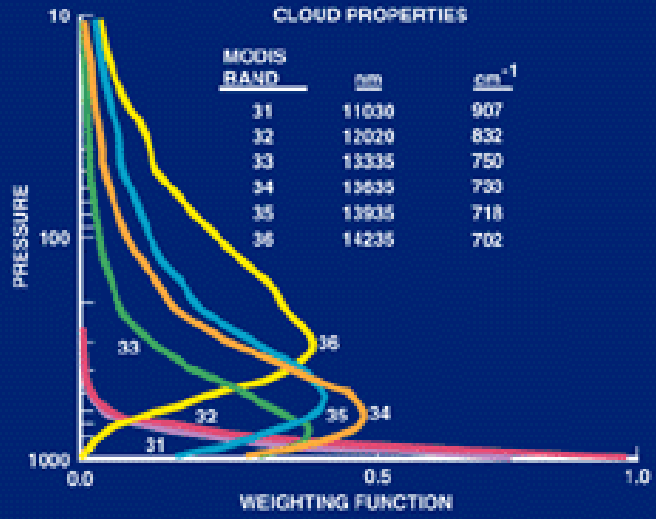
ATMOSPHERE - THERMAL RADIATION









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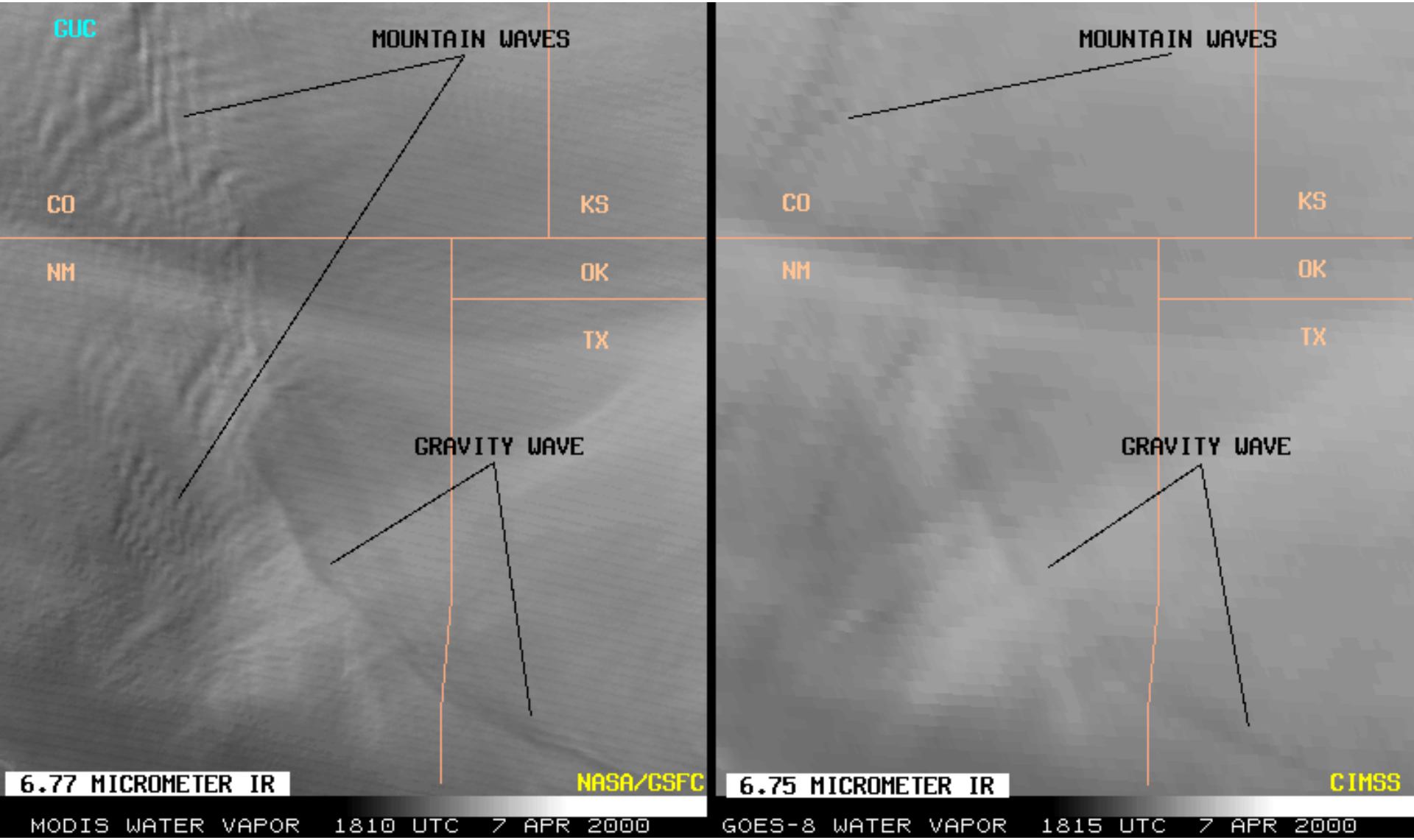
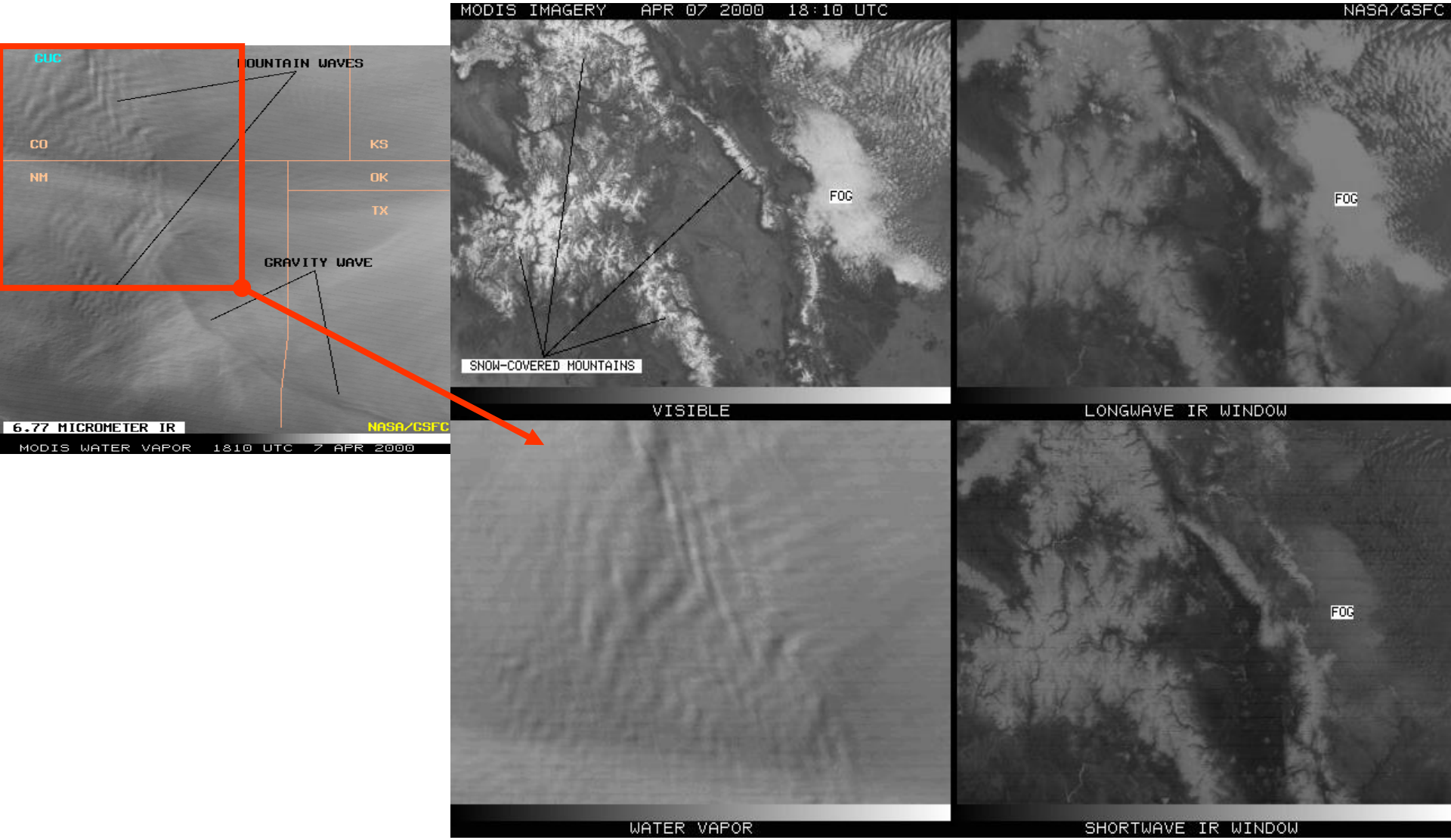
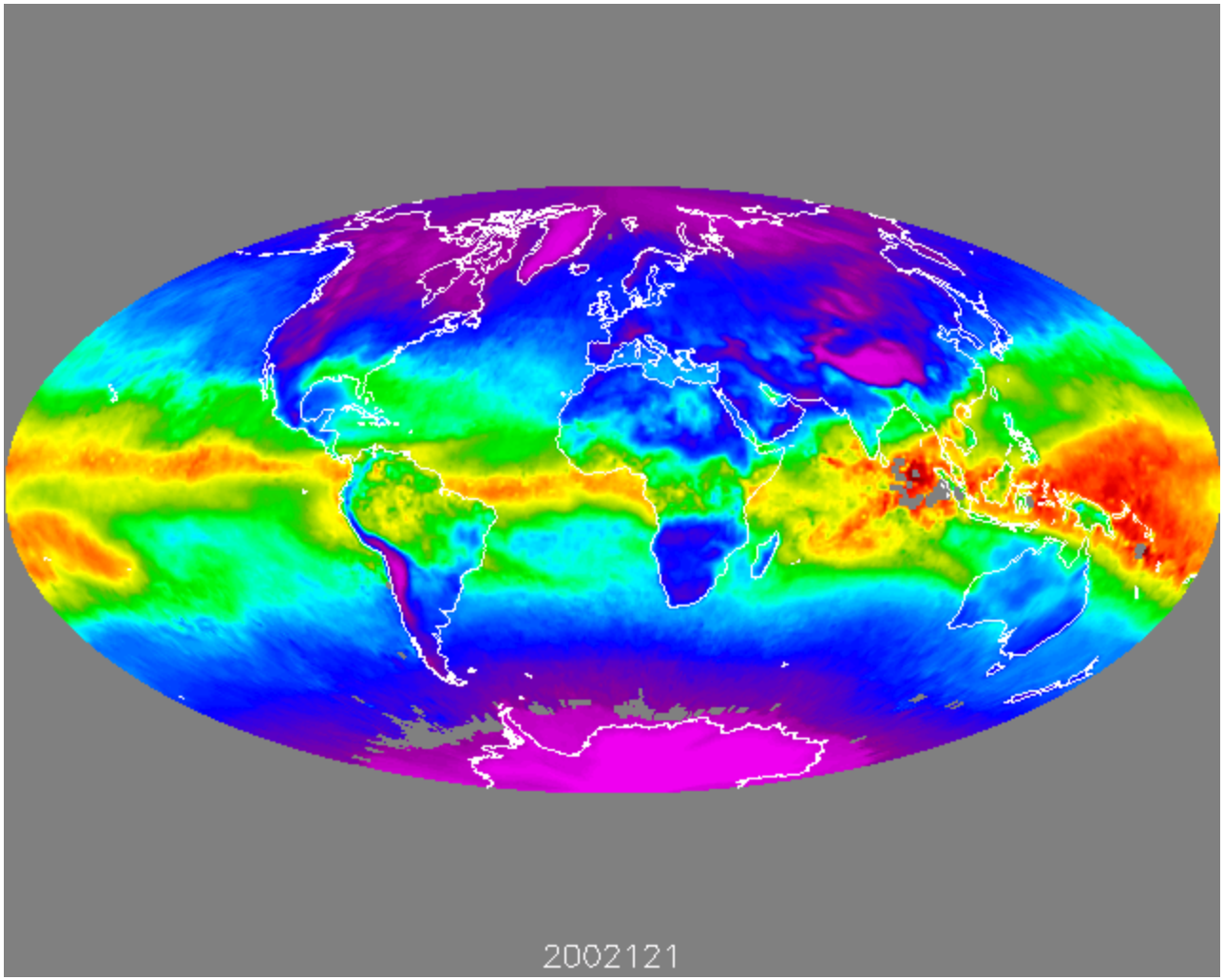
MODIS 1 km resolution reveals fine-scale structure



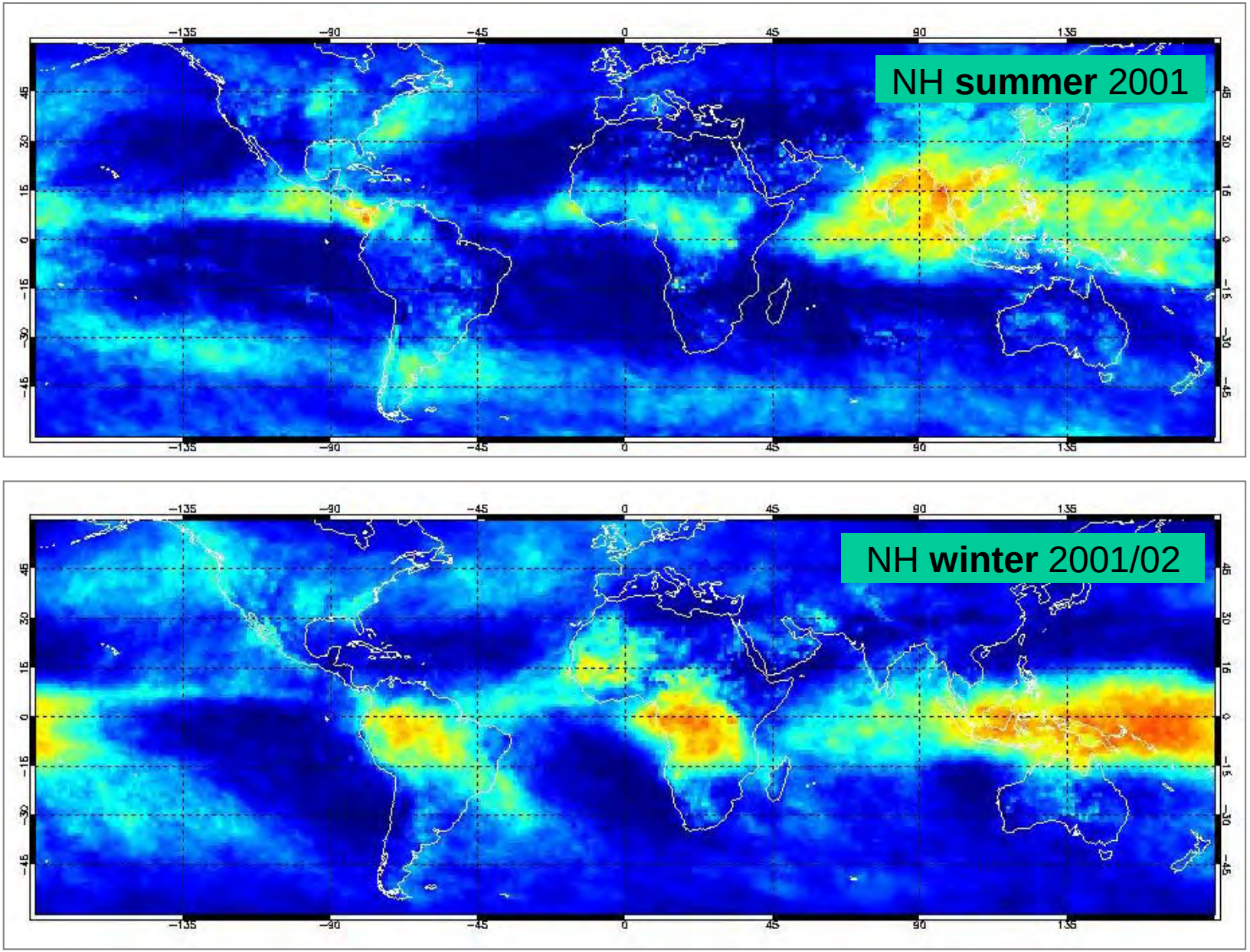
Four Panel Zoom of Cloud-Free Orographic Waves revealed in Water Vapor Imagery



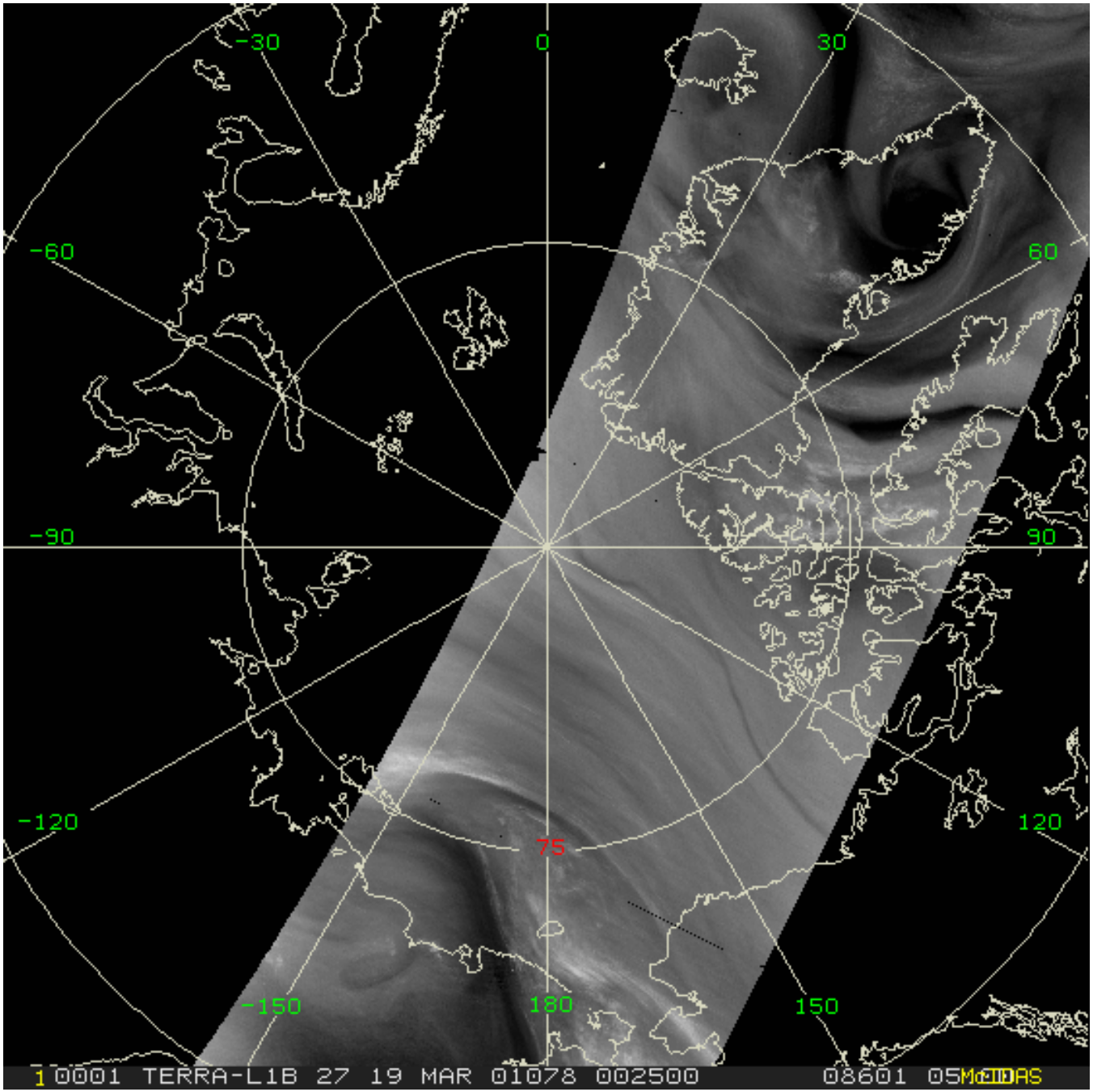
Terra MODIS global water vapor product



Sliding 8-day mean



Seasonal percentage high clouds (<400 mb) from Terra MODIS


-30
0
30
-60
60
-90
90
-120
120
75
-150
180
150
1 0001 TERRA-L1B 27 19 MAR 01078 002500 08601 05
MODIS

Winds from MODIS: An Arctic Example

Cloud-track winds (left) and water vapor winds (right) from MODIS for a case in the western Arctic. The wind vectors were derived from a sequence of three images, each separated by 100 minutes. They are plotted on the first 11 μm (left) and 6.7 μm (right) images in the sequence.