Remote Sensing Seminar 2008

EUMETSAT

Monteponi,
Iglesias, Italy
21-27 Sep 2008

Consorzio per l'Università
del Sulcis Iglesiente

SSEC

Lectures in Monteponi
21 – 27 September 2008

Paul Menzel
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UW/CIMSS

Jochem Kerkmann
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EUMETSAT

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Schools on remote sensing have been held in

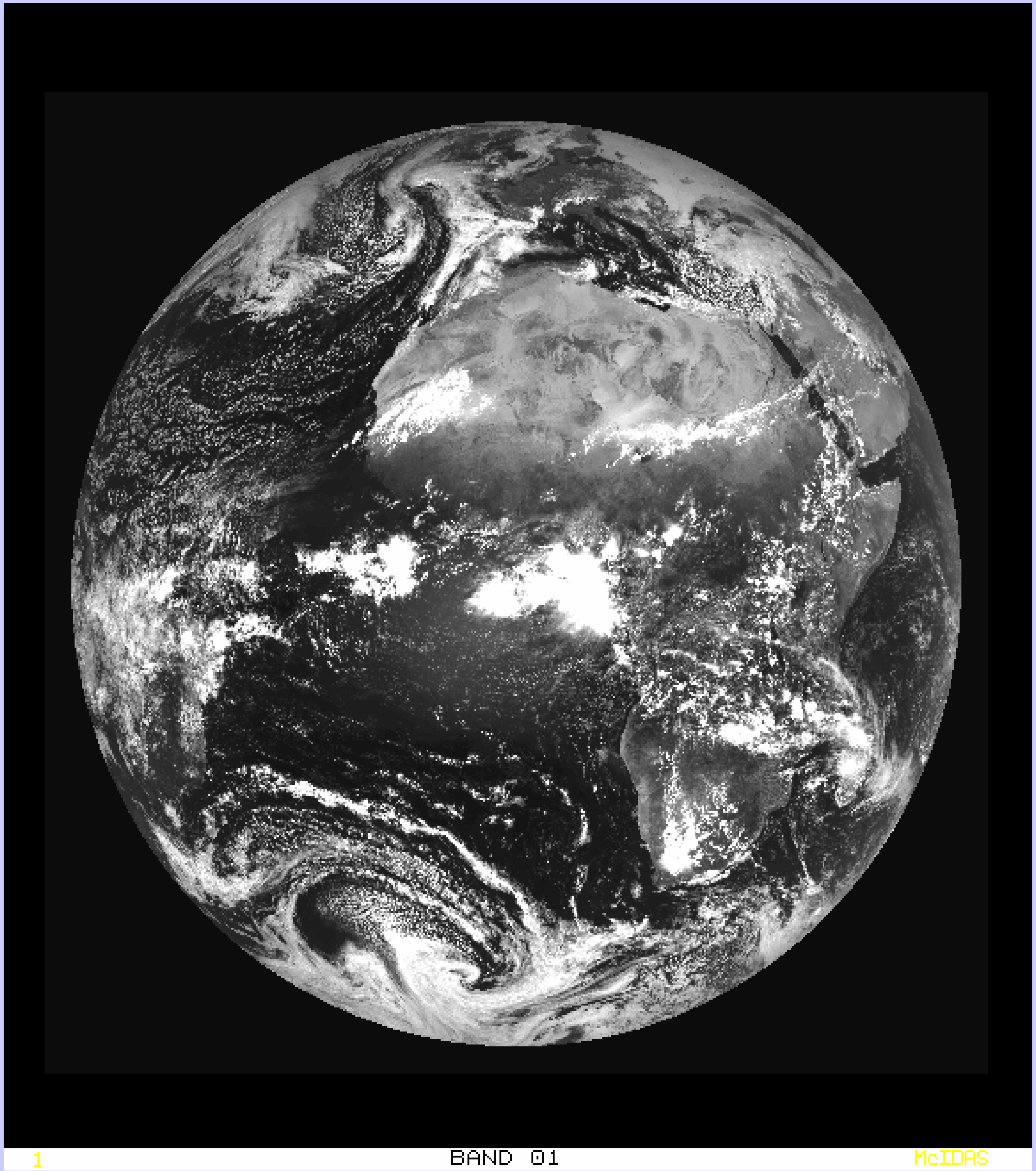
Bologna, Italy (Sep 01),
Rome, Italy (Jun 02),
Maratea, Italy (May 03),
Bertinoro, Italy (Jul 04),
Cape Town, South Africa (Apr 06),
Krakow, Poland (May 06),
Ostuni, Italy (Jun 06)
Benevento, Italy (Jun07)

Nominal Agenda

Su pm	*Ice breaker*	Introduction of students and teachers
Mo am	*Introduction*	Discussion of Agenda (All)
	Lecture 1	Radiative Transfer in the Earth Atmosphere (Menzel)
	Homework	
Mo pm	*Lab 1*	Lab on Planck Function and Intro to Hydra (Antonelli)
Tu am	*Lecture 2*	Spectral signatures from Earth's surface & atmosphere (Menzel)
Tu pm	*Lab 2*	Interrogating MODIS Data (Menzel)
We am	*Lecture 3a*	Investigations with leo and geo imagers (Antonelli)
	Lecture 3b	Tri-spectral window applications with SEVIRI (Kerkmann)
	Quiz 1	
We pm	*Lab 3*	AMSU and SEVIRI looking at clouds (Antonelli)
Th am	*Lecture 4*	Hyperspectral resolution (Antonelli)
Th pm	*Lab 4*	Exploring AIRS/IASI data (Antonelli)
Fr am	*Lab 5*	Student Projects
Fr pm	*Lab*	Student Presentations of their Investigations (All)
	Lecture 5	Visualization expectations with McIDAS-V (Roesli)
	Homework Review	
Sa am	*Lecture 6*	Summary (Menzel)
	Quiz 2	
	Concluding Ceremony	

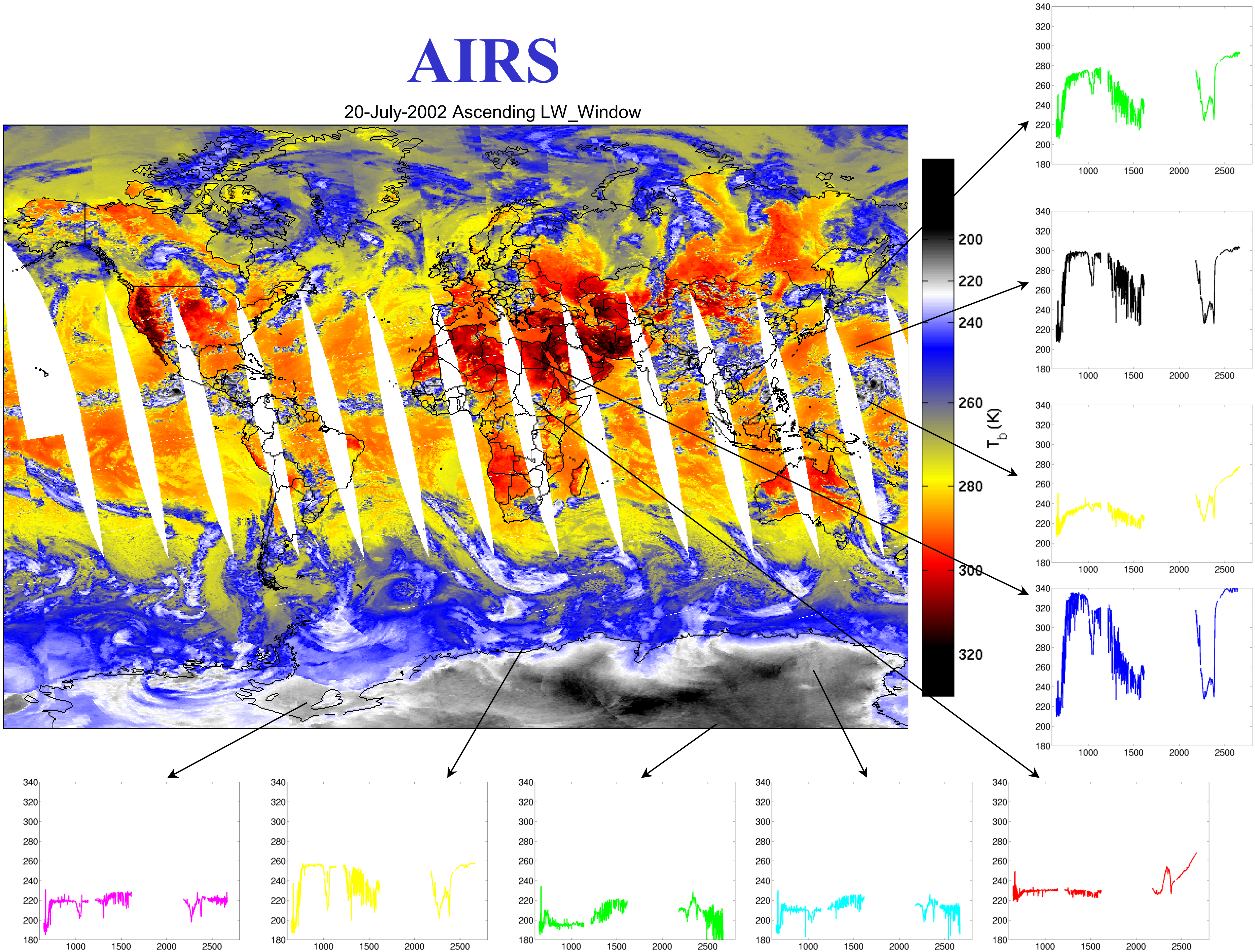
am sessions are from 9:00 am to 12:00 noon and pm sessions are from 1:30 pm to 5:30 pm


MODIS

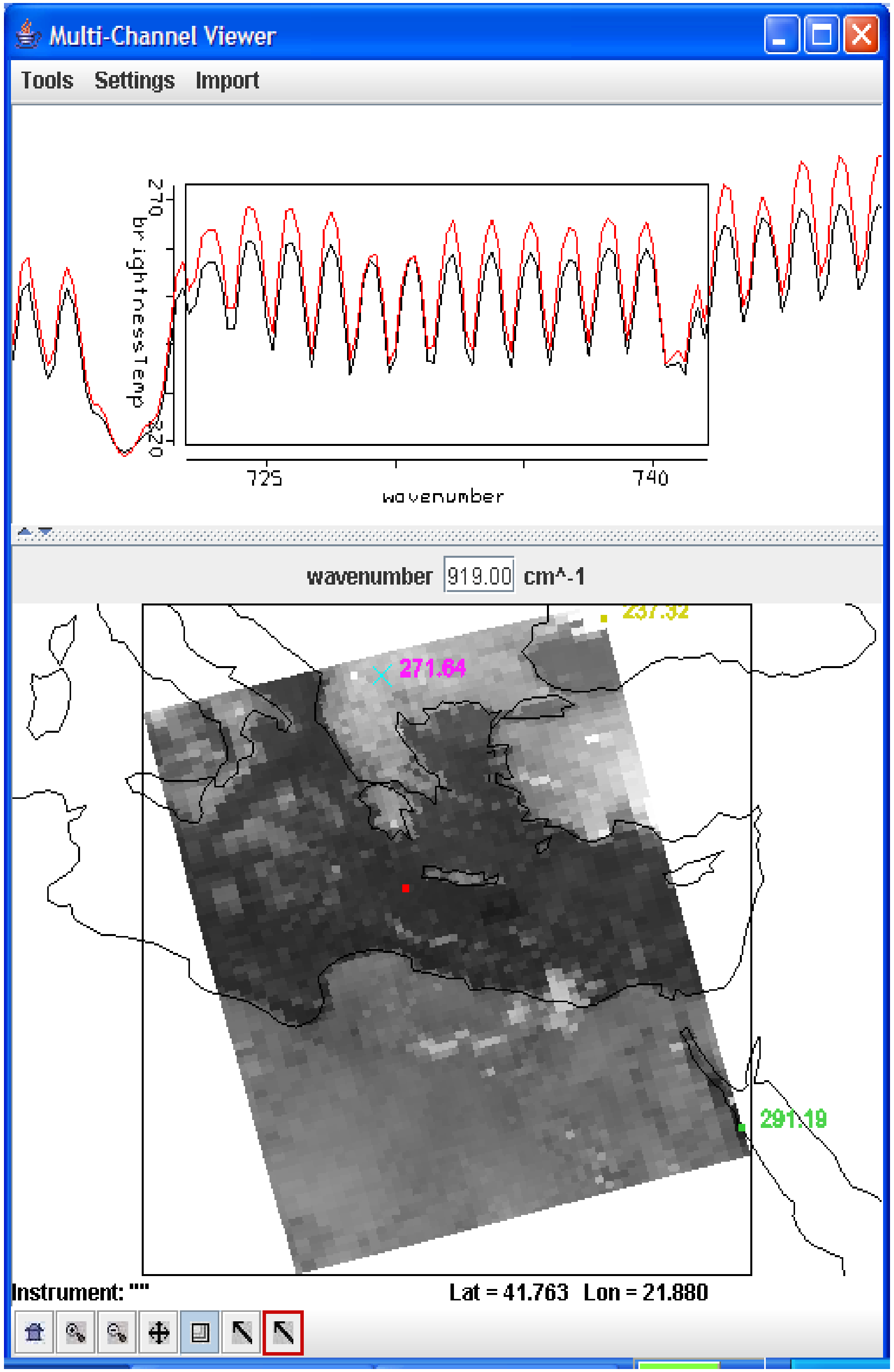


SEVIRI

HRV	Broadband
VIS0.6	0.635
VIS0.8	0.81
NIR1.6	1.64
IR3.9	3.90
WV6.2	6.25
WV7.3	7.35
IR8.7	8.70
IR9.7	9.66
IR10.8	10.80
IR12.0	12.00
IR13.4	13.40

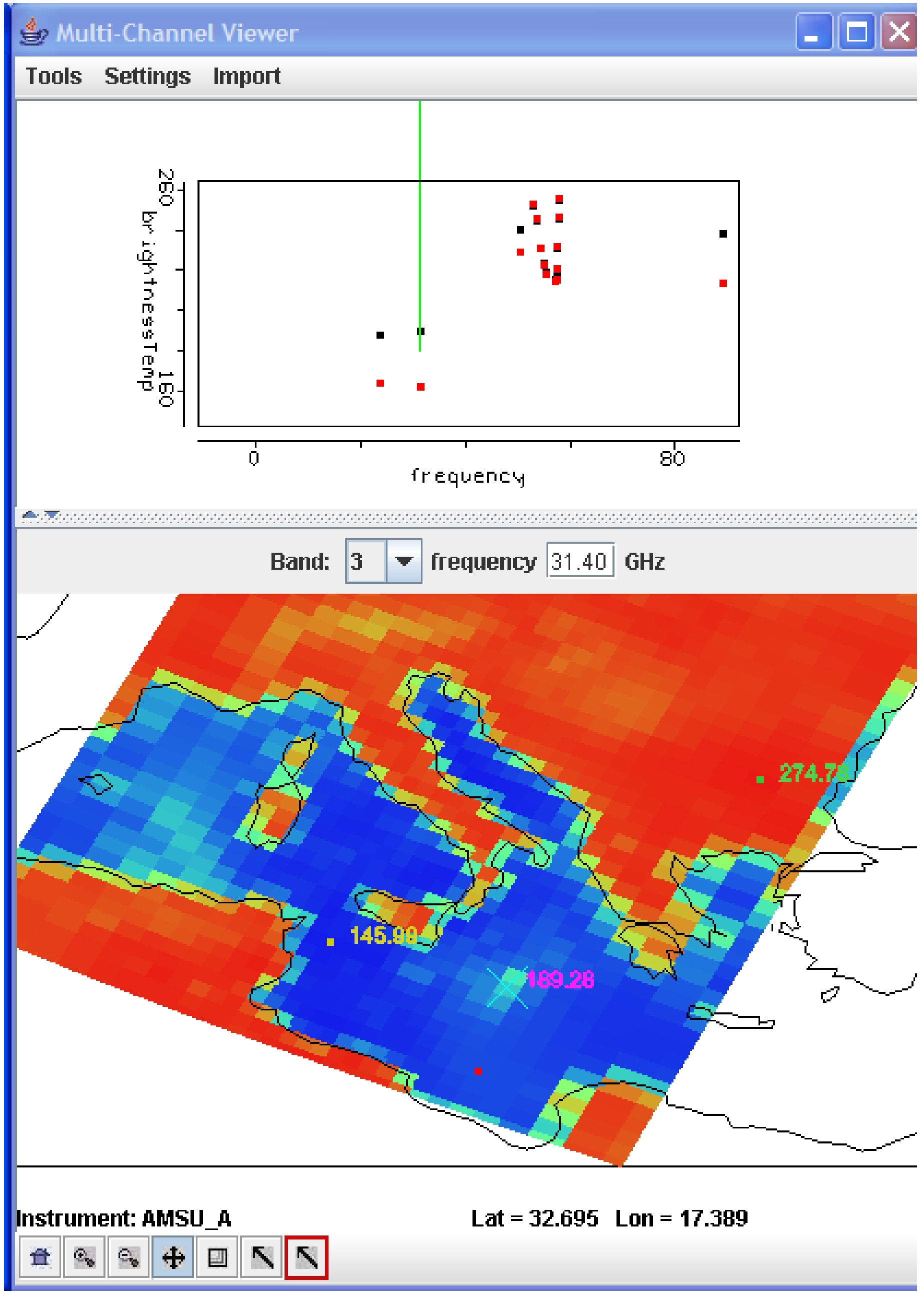

AIRS
20-July-2002 Ascending LW_Window
200
220
240
260
280
300
320
T_b (K)
340
320
300
280
260
240
220
200
180
1000
1500
2000
2500

IASI



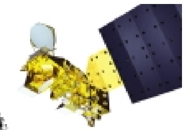
Multi-Channel Viewer
Tools Settings Import
270
brightnessTemp
220
725
740
wavenumber
wavenumber 919.00 cm^-1
237.32
271.64
291.19
Instrument: ""
Lat = 41.763 Lon = 21.880

AMSU


Multi-Channel Viewer
Tools Settings Import
260
brightnessTemp
160
0
80
frequency
Band: 3 frequency 31.40 GHz
274.7
145.98
189.28
Instrument: AMSU_A
Lat = 32.695 Lon = 17.389

HYperspectral viewer for Development of Research Applications - HYDRA

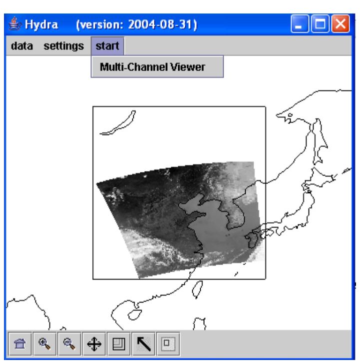
MSG,
GOES



MODIS,
AIRS, IASI,
AMSU,
CALIPSO

Freely available software
For researchers and educators
Computer platform independent
Extendable to more sensors and applications
Based in VisAD
(Visualization for Algorithm Development)
Uses Jython (Java implementation of Python)
runs on most machines
512MB main memory & 32MB graphics card suggested
on-going development effort

Rink et al, BAMS 2007



Developed at CIMSS by
Tom Rink
Tom Whittaker
Kevin Baggett

With guidance from
Paolo Antonelli
Liam Gumley
Paul Menzel
Allen Huang

CIMSS

http://www.ssec.wisc.edu/hydra/

Applications with Meteorological Satellites

ftp://ftp.ssec.wisc.edu/pub/menzel/

Using wavelengths

Planck's Law $B(\lambda,T) = c_1 / \lambda^5 / [e^{c_2/\lambda T} - 1]$ $(mW/m^2/ster/cm)$

where λ = wavelengths in cm

T = temperature of emitting surface (deg K)

c_1 = 1.191044 x 10-5 $(mW/m^2/ster/cm^{-4})$

c_2 = 1.438769 (cm deg K)

Wien's Law $dB(\lambda_{max},T) / d\lambda = 0$ where $\lambda(max) = .2897/T$

indicates peak of Planck function curve shifts to shorter wavelengths (greater wavenumbers) with temperature increase. Note $B(\lambda_{max},T) \sim T^5$.

Stefan-Boltzmann Law $E = \pi \int_o^\infty B(\lambda,T)\, d\lambda = \sigma T^4$, where σ = 5.67 x 10-8 W/m2/deg4.

states that irradiance of a black body (area under Planck curve) is proportional to T^4 .

Brightness Temperature

$$T = c_2 / [\lambda \ln(\frac{c_1}{\lambda^5 B_\lambda} + 1)]$$ is determined by inverting Planck function

In standard notation,

$$I_\lambda = \varepsilon_\lambda^{sfc} B_\lambda(T(p_s))\, \tau_\lambda(p_s) + \sum_p \varepsilon_\lambda(\Delta p)\, B_\lambda(T(p))\, \tau_\lambda(p)$$

The emissivity of an infinitesimal layer of the atmosphere at pressure p is equal to the absorptance (one minus the transmittance of the layer). Consequently,

$$\varepsilon_\lambda(\Delta p)\, \tau_\lambda(p) = [1 - \tau_\lambda(\Delta p)]\, \tau_\lambda(p)$$

Since transmittance is an exponential function of depth of absorbing constituent,

$$\tau_\lambda(\Delta p)\, \tau_\lambda(p) = \exp\left[- \int_p^{p+\Delta p} k_\lambda\, q\, g^{-1}\, dp\right] * \exp\left[- \int_o^{p} k_\lambda\, q\, g^{-1}\, dp\right] = \tau_\lambda(p + \Delta p)$$

Therefore

$$\varepsilon_\lambda(\Delta p)\, \tau_\lambda(p) = \tau_\lambda(p) - \tau_\lambda(p + \Delta p) = - \Delta\tau_\lambda(p) .$$

So we can write

$$I_\lambda = \varepsilon_\lambda^{sfc} B_\lambda(T(p_s))\, \tau_\lambda(p_s) - \sum_p B_\lambda(T(p))\, \Delta\tau_\lambda(p) .$$

which when written in integral form reads

$$I_\lambda = \varepsilon_\lambda^{sfc} B_\lambda(T(p_s))\, \tau_\lambda(p_s) - \int_o^{p_s} B_\lambda(T(p))\, [\, d\tau_\lambda(p) / dp \,]\, dp .$$

Welcome!