International Training Events and Educational Seminars on Satellite Remote Sensing

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Background and Motivation
Key Features
An example agenda
Course activities
Feedback
Considerations

Background

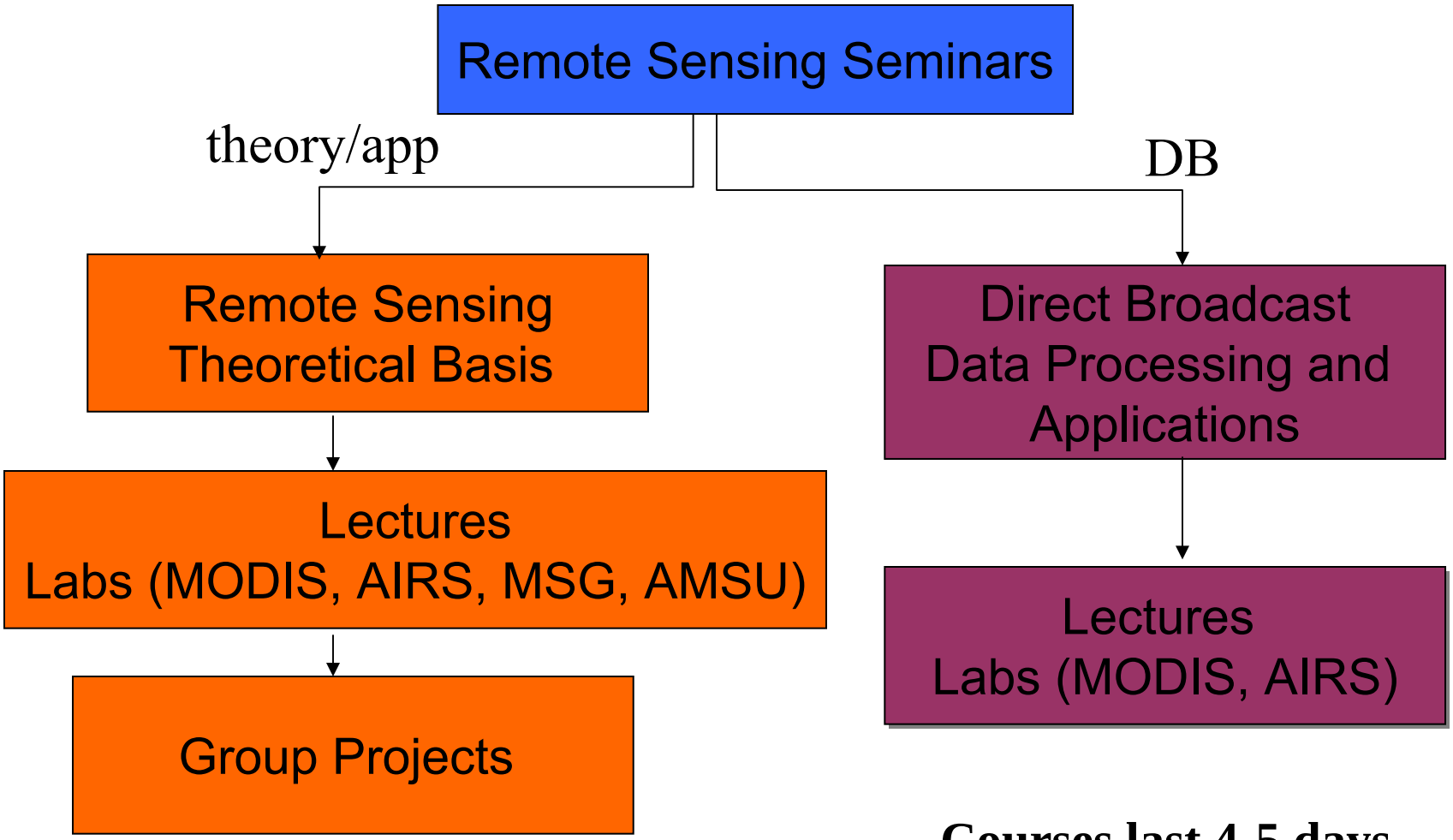
- SSEC/CIMSS has a long tradition of activities in education and outreach related to environmental remote sensing;
- Remote sensing seminars started in the 1980s when Bill Smith provided training to use his TOVS Processing Package
- In 2001, P. Menzel & P. Antonelli offered a ten day seminar and made the educational material, s/w, & EOS data, freely available to international students; these seminars are now offered annually;
- In 2006, L. Gumley & A. Huang added direct broadcast seminars on operational aspects of receiving and using EOS (later NPOESS) data
- To date, 22 courses have been offered in 14 different countries (Australia, Brazil, China, Costa Rica, Ethiopia, India, Italy, Norway, Poland, Russia, South Africa, Taiwan, Turkey, U.S.); ~ 600 students from 50 countries have attended
- Materials covered include (1) radiation & radiative transfer, (2) measurement characteristics, (3) multispectral investigations, (4) processing algorithms, and (5) data visualization tools & processing s/w.

Motivation

- Environmental awareness has increased; linkages to everyday aspects of life are more apparent; environmental issues are now recognized to require corrective actions;
- GEOSS has opened the door to accessible direct acquisition of environmental satellite data potentially to anyone in the world;
- Software has been developed and distributed that enables local generation of products for environmental monitoring;
- Demand for international training and cooperation in remote sensing keeps increasing, especially in countries desiring stronger scientific programs;
- CIMSS/SSEC efforts in outreach, training, and international collaboration are aimed at addressing these needs and responding to these issues.

Remote Sensing Seminars

2 versions



Courses last 7 days, 2 teachers, 2 tutors (selected from previous course participants)

Courses last 4-5 days with 4 or 5 teachers

Key Features

- Courses are tailored according to the needs of the hosting institutes and the participants; size is limited to about 10 participants per teacher (focus);
- Locations are selected avoiding large cities (when possible) in preference for smaller more isolated facilities;
  teachers and participants (when possible) share the same accommodations and much of their free time (connect);
- In addition to training the participants, there is an effort to elevate some of the students into tutors, and some of the tutors into teachers (train future trainers);
- Efforts are made to sustain some of the research projects started during the course into longer term collaborations (sustain collaborations);
- Emphasis is that remote sensing complemented by local knowledge is the most powerful tool of environmental stewardship (emphasize environmental theme)

Schools on remote sensing have been held in

Bologna, Italy (Sep 01)
Rome, Italy (Jun 02)
Maratea, Italy (May 03)
Nanjing, China (Jun 04)
Bertinoro, Italy (Aug 04)
San Jose, Costa Rica (Mar 05)
Andanes, Norway (Feb 06)
Cape Town, South Africa (Apr 06)
Krakow, Poland (May 06)
Ostuni, Italy (Jun 06)
Benevento, Italy (Jun 07)
Sao Paulo, Brazil (Nov 07)
Monteponi, Sardinia (Sep 08)
Istanbul, Turkey (Oct 08)

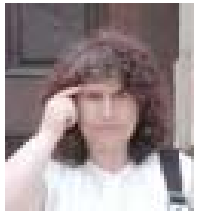
Some of the People

Also:
Vincenzo Levizzani
Maria Vasys
Leanne Avila
Jean Philips
Federica Rossi
Kevin Bagget

Instructors

Tutors

Hosts



Some of the Institutions

- EUMETSAT
- CNR Italy
- IPO
- WMO
- CIMSS/SSEC

Nominal Agenda

Su pm	*Welcome*	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)
	Ice breaker	
Tu am	*Lecture 2*	Spectral signatures from the Earth (Menzel)
Tu pm	*Lab 2*	Interrogating MODIS Data (Menzel)
We am	*Lecture 3*	Multispectral remote sensing (Antonelli)
		Tri-spectral window applications with SEVIRI (Prieto)
	Quiz 1	
We pm	*Lab 3*	AMSU and SEVIRI looking at clouds (Antonelli)
Th am	*Lecture 4*	Hyperspectral infrared resolution (Antonelli)
Th pm	*Lab 4*	Exploring AIRS/IASI data (Antonelli)
Fr am	*Lab 5*	Student Projects
Fr pm	*Lab*	Student Presentations of their Projects (All)
	Homework Review	
Sa am	*Lecture 5*	Summary (Menzel)
	Quiz 2	
	Concluding Ceremony	

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

Lectures

Applications with Meteorological Satellites is used as a resource text
It is available for free at *ftp://ftp.ssec.wisc.edu/pub/menzel/*

CHAPTER 1 - EVOLUTION OF SATELLITE METEOROLOGY
CHAPTER 2 - NATURE OF RADIATION *
CHAPTER 3 - ABSORPTION, EMISSION, REFLECTION, AND SCATTERING *
CHAPTER 4 - THE RADIATION BUDGET
CHAPTER 5 - THE RADIATIVE TRANSFER EQUATION (RTE) *
CHAPTER 6 - DETECTING CLOUDS *
CHAPTER 7 - SURFACE TEMPERATURE *
CHAPTER 8 - TECHNIQUES FOR DETERMINING ATMOSPHERIC PARAMETERS *
CHAPTER 9 - TECHNIQUES FOR DETERMINING ATMOSPHERIC MOTIONS
CHAPTER 10 - AN APPLICATION OF GEOSTATIONARY SATELLITE SOUNDING DATA
CHAPTER 11 - SATELLITE ORBITS
CHAPTER 12 - RADIOMETER DESIGN CONSIDERATIONS *
CHAPTER 13 - ESTABLISHING CLIMATE RECORDS FROM MULTISPECTRAL MODIS MEASUREMENTS
CHAPTER 14 - THE NEXT GENERATION OF SATELLITE SYSTEMS
CHAPTER 15 – INVESTIGATING LAND, OCEAN, AND ATMOSPHERE WITH MULTISPECTRAL MEASUREMENTS *

* indicates chapters covered

References, problems sets, and quizzes are included in the Appendices

Agenda includes material from Chapters 2, 3, 5, and 12

CHAPTER 2 - NATURE OF RADIATION

2.1	Remote Sensing of Radiation	2-1
2.2	Basic Units	2-1
2.3	Definitions of Radiation	2-2
2.5	Related Derivations	2-5

CHAPTER 3 - ABSORPTION, EMISSION, REFLECTION, AND SCATTERING

3.1	Absorption and Emission	3-1
3.2	Conservation of Energy	3-1
3.3	Planetary Albedo	3-2
3.4	Selective Absorption and Emission	3-2
3.7	Summary of Interactions between Radiation and Matter	3-6
3.8	Beer's Law and Schwarzchild's Equation	3-7
3.9	Atmospheric Scattering	3-9
3.10	The Solar Spectrum	3-11
3.11	Composition of the Earth's Atmosphere	3-11
3.12	Atmospheric Absorption and Emission of Solar Radiation	3-11
3.13	Atmospheric Absorption and Emission of Thermal Radiation	3-12
3.14	Atmospheric Absorption Bands in the IR Spectrum	3-13
3.15	Atmospheric Absorption Bands in the Microwave Spectrum	3-14
3.16	Remote Sensing Regions	3-14

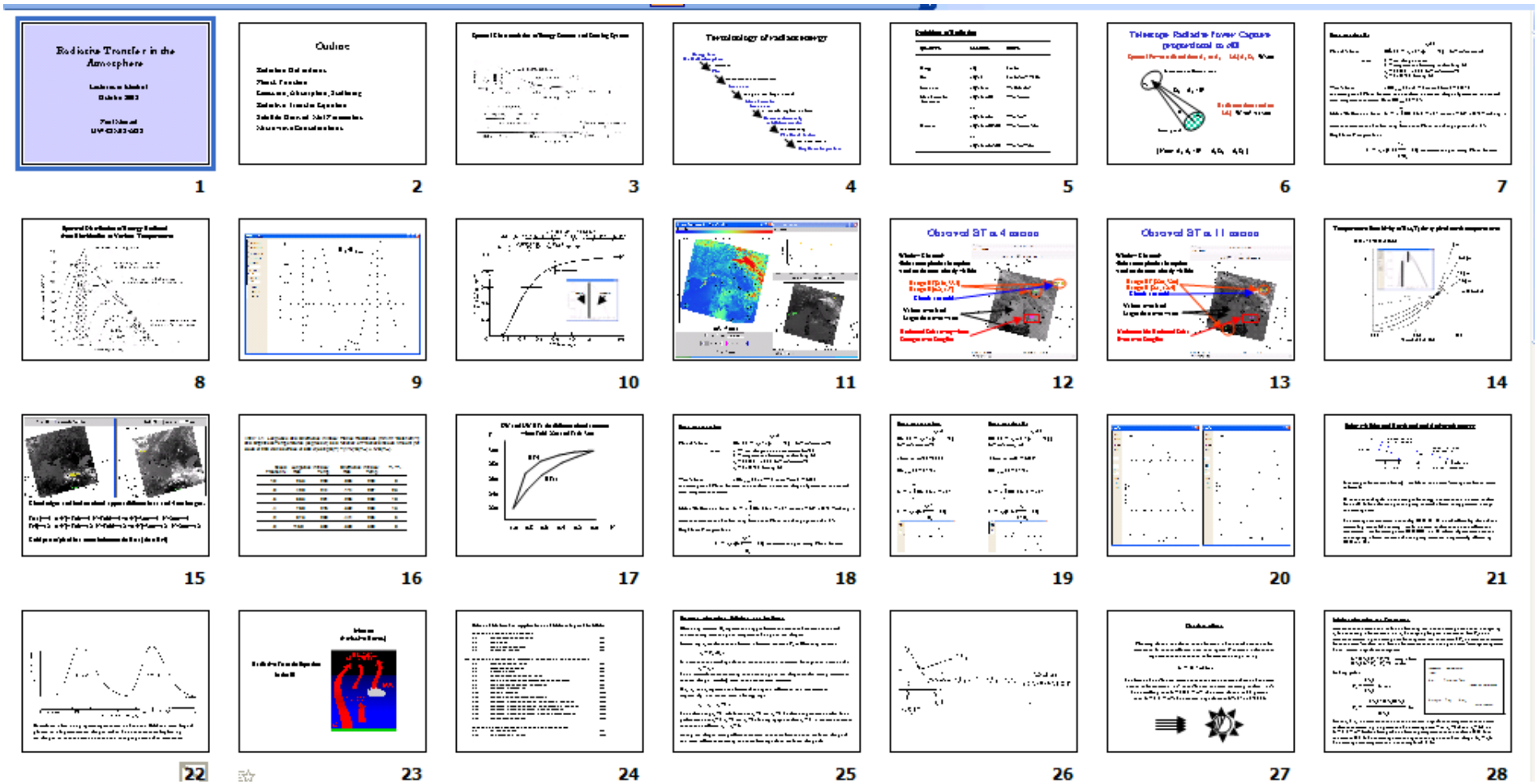
CHAPTER 5 - THE RADIATIVE TRANSFER EQUATION (RTE)

5.1	Derivation of RTE	5-1
5.10	Microwave Form of RTE	5-28

CHAPTER 12 - RADIOMETER DESIGN CONSIDERATIONS

12.3	Design Considerations	12-1

Lectures are given with powerpoint presentations



Material includes equations

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 $E = \pi \int_0^\infty B(\lambda,T)\, d\lambda = \sigma T^4$, 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

And some derivations,

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

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

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

Access to training materials

Power point lectures handed out before class to facilitate note taking

Web site of free textbook announced before course (*ftp://ftp.ssec.wisc.edu/pub/menzel/*)

CD of all materials distributed to class on last day of course

Email contact with instructors encouraged after course

Labs

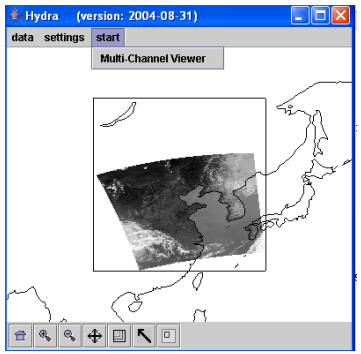
HYperspectral viewer for Development of Research Applications - HYDRA

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



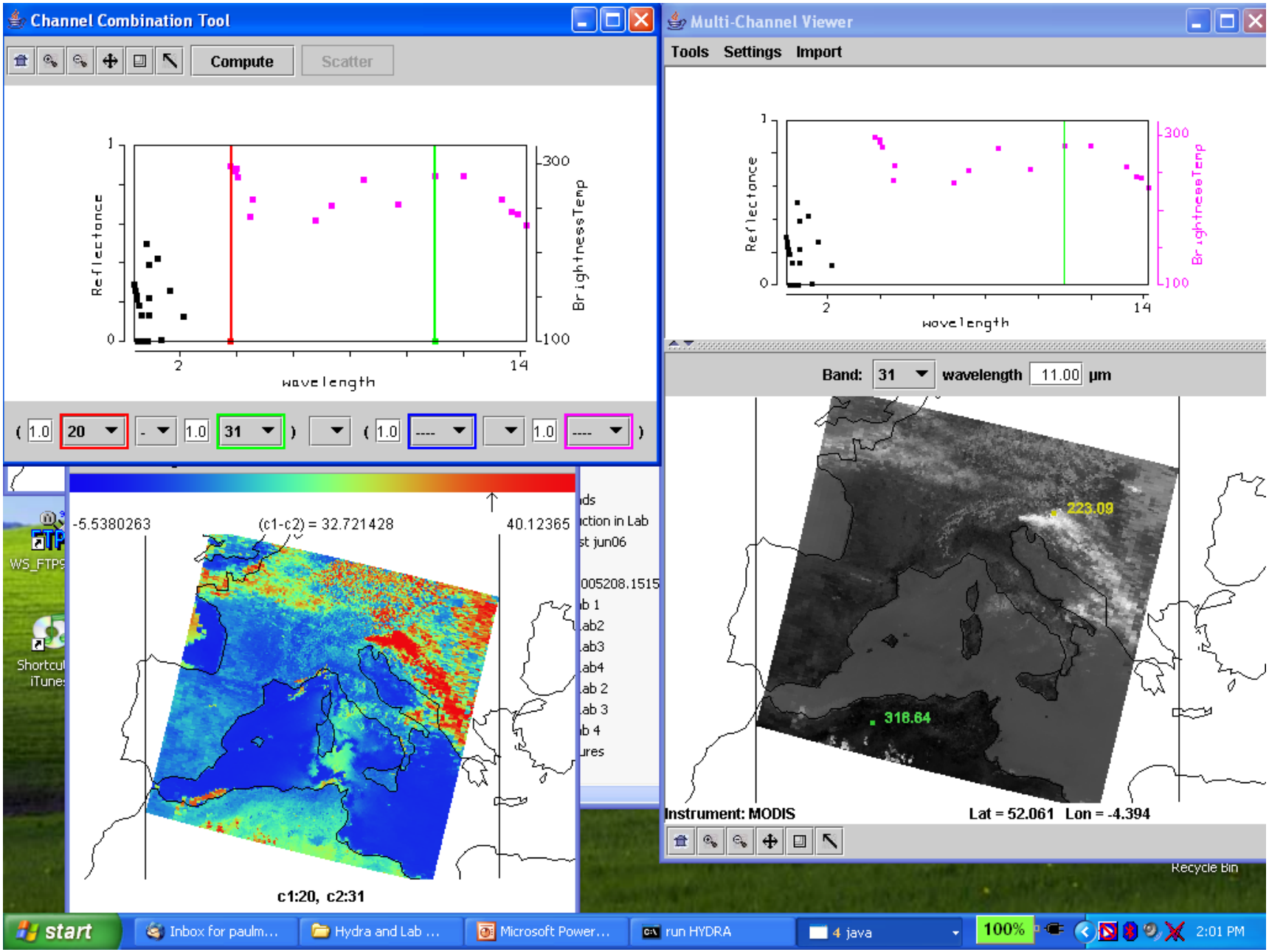
Developed at CIMSS by
Tom Rink
Tom Whittaker
Kevin Baggett

With guidance from
Paolo Antonelli
Liam Gumley
Paul Menzel
Allen Huang

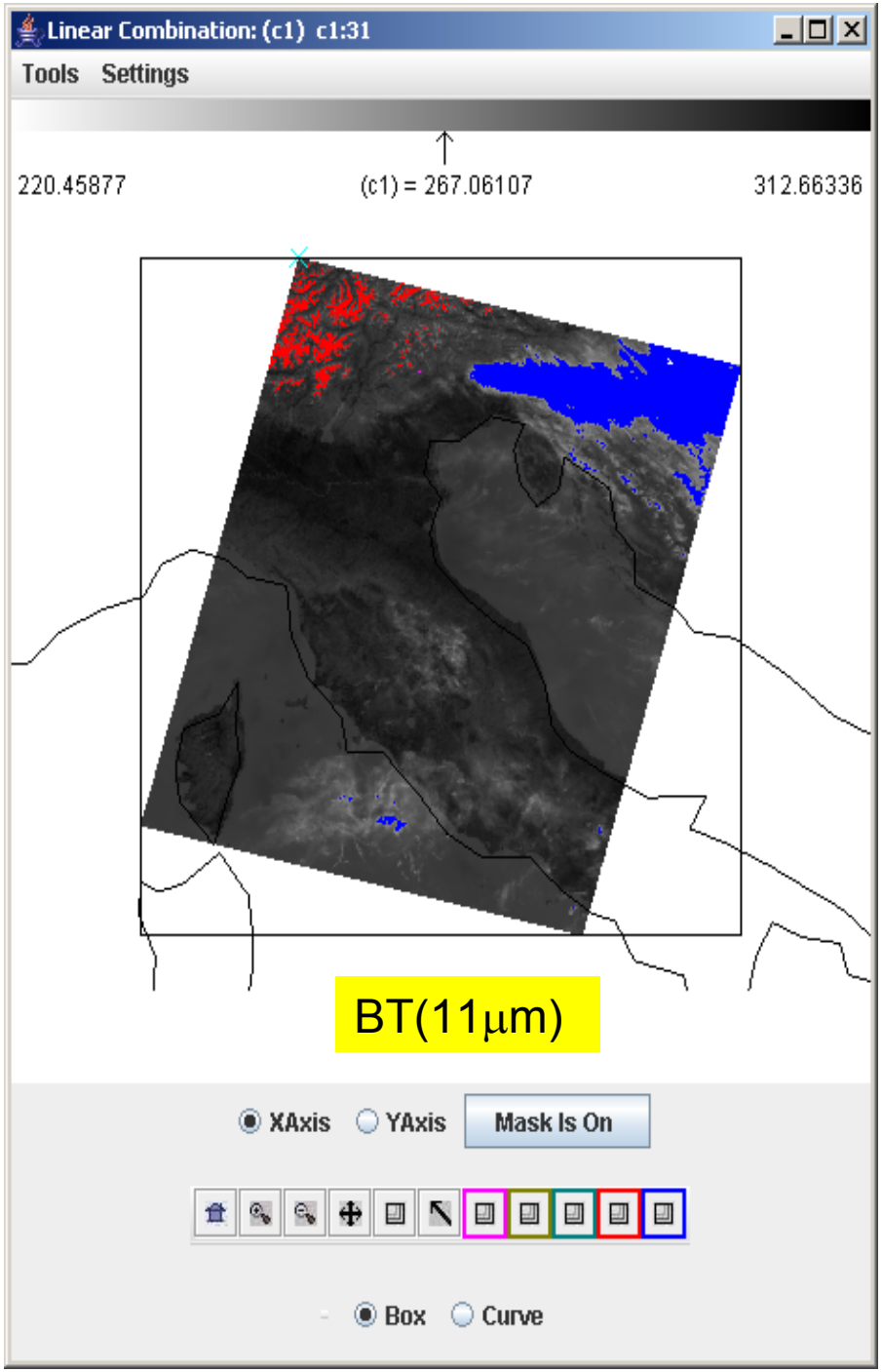
CIMSS

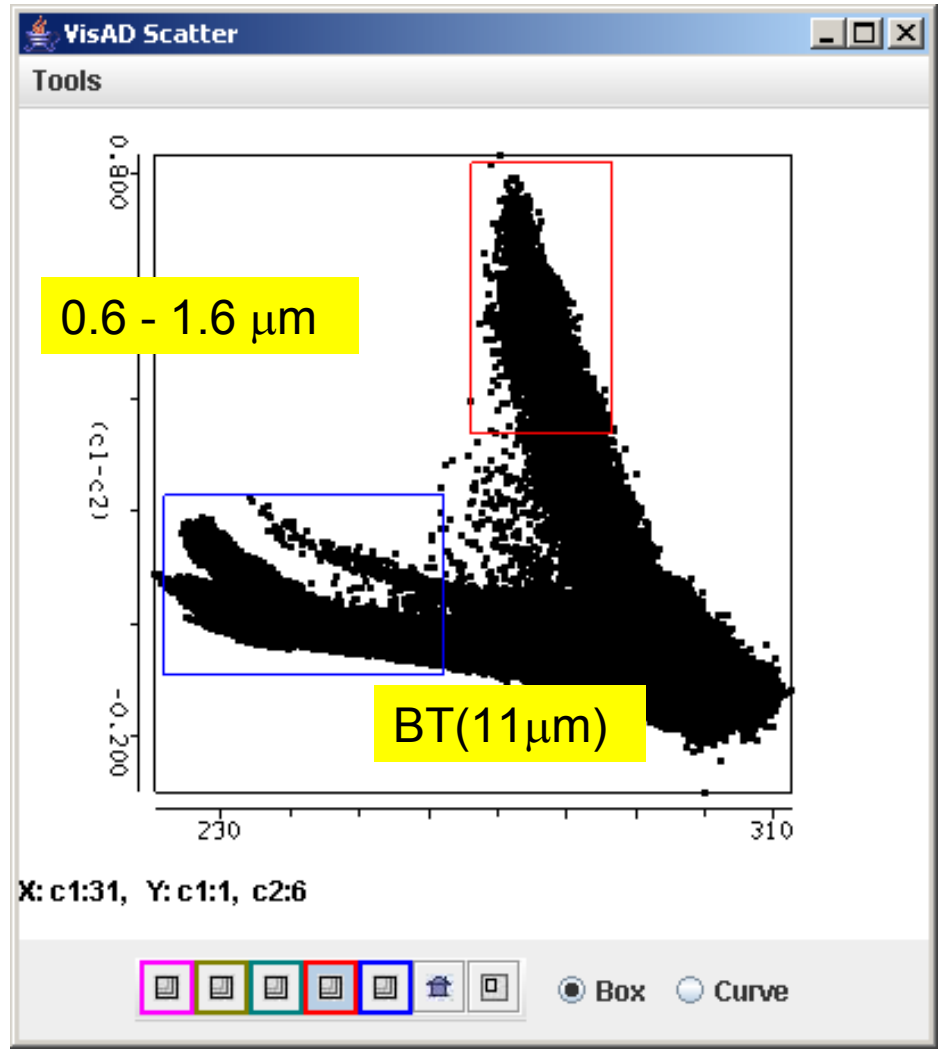
http://www.ssec.wisc.edu/hydra/

Viewing remote sensing data with HYDRA

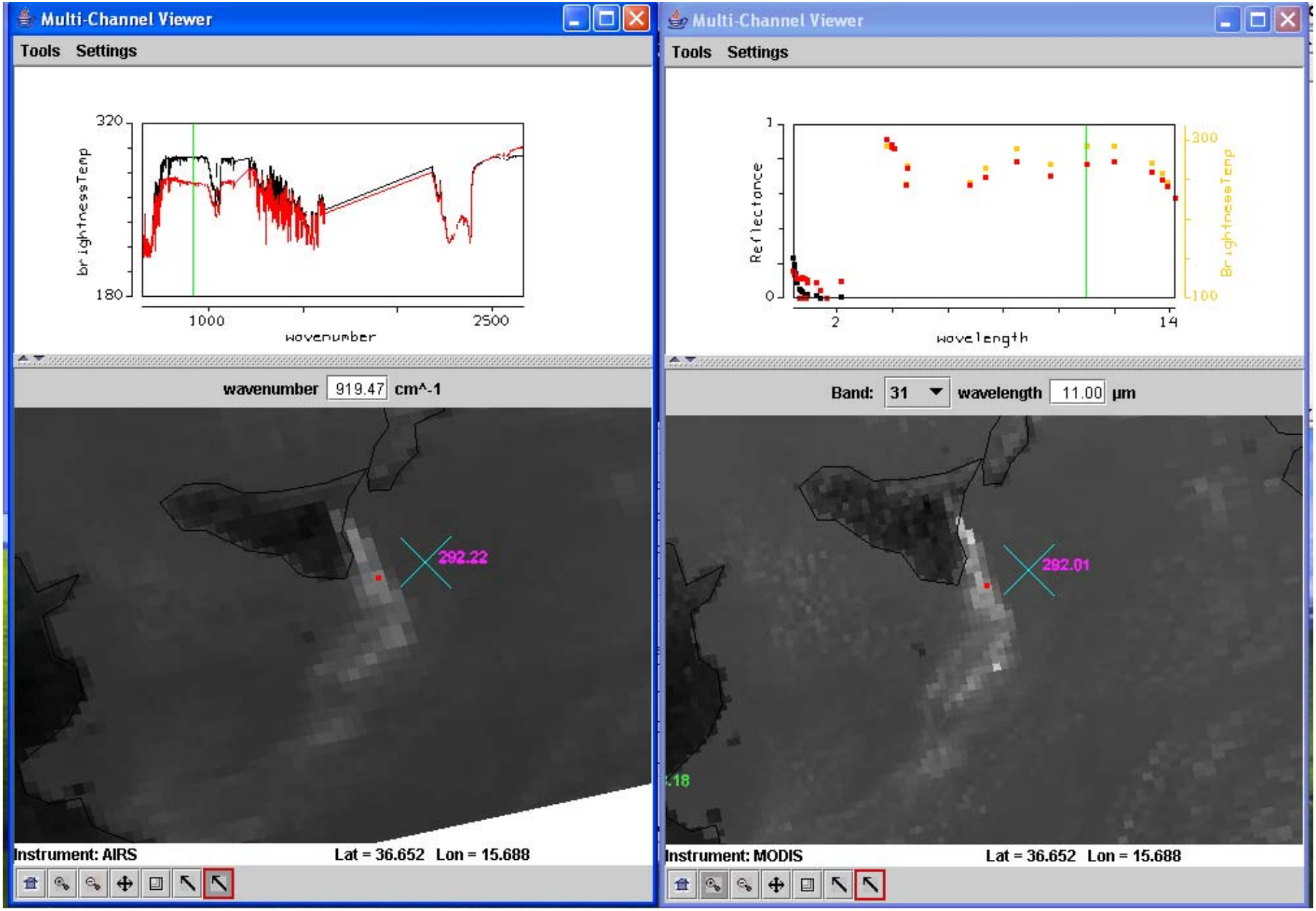


snow vs cloud detection



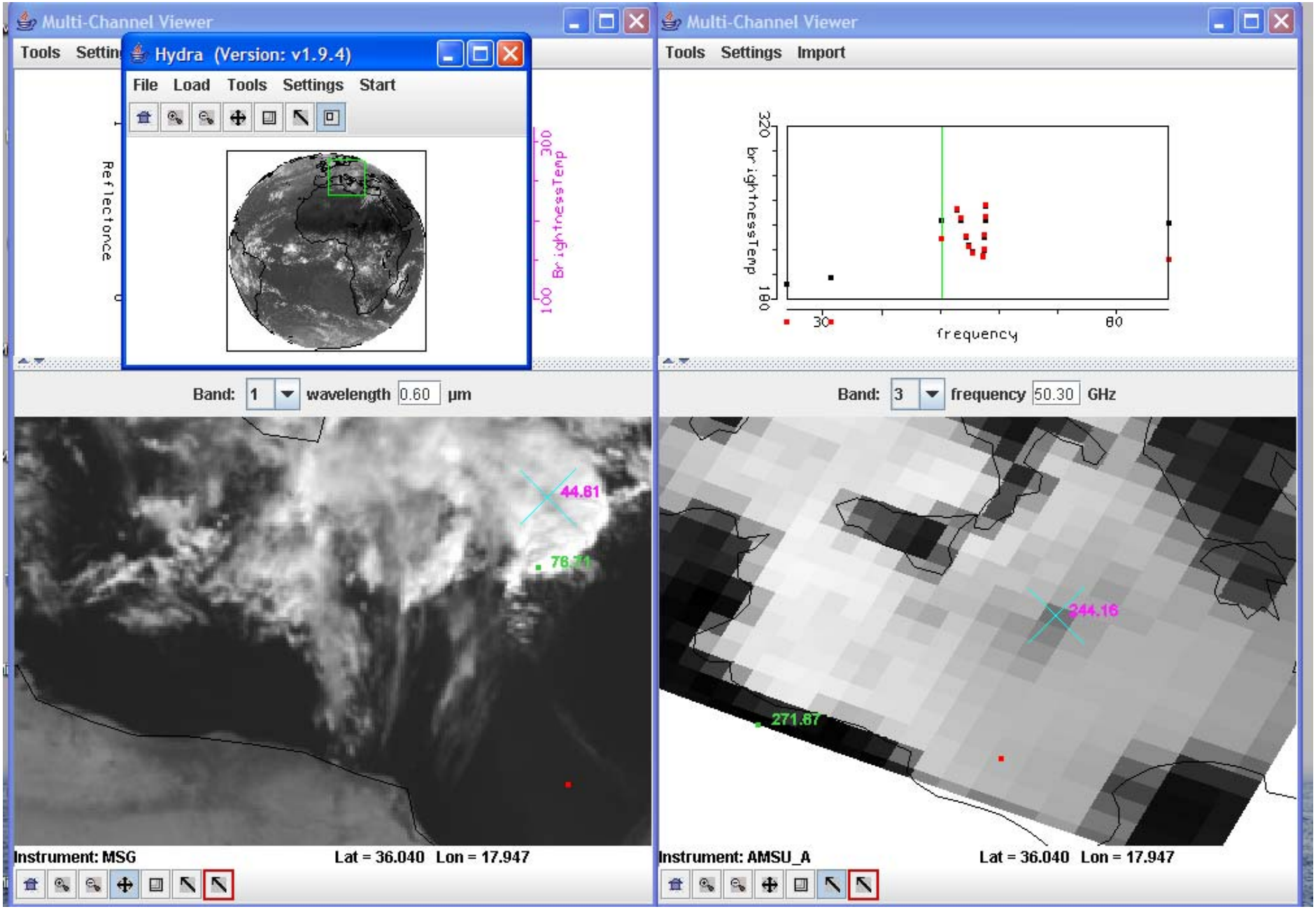


Francesca, Savka, and Vassil



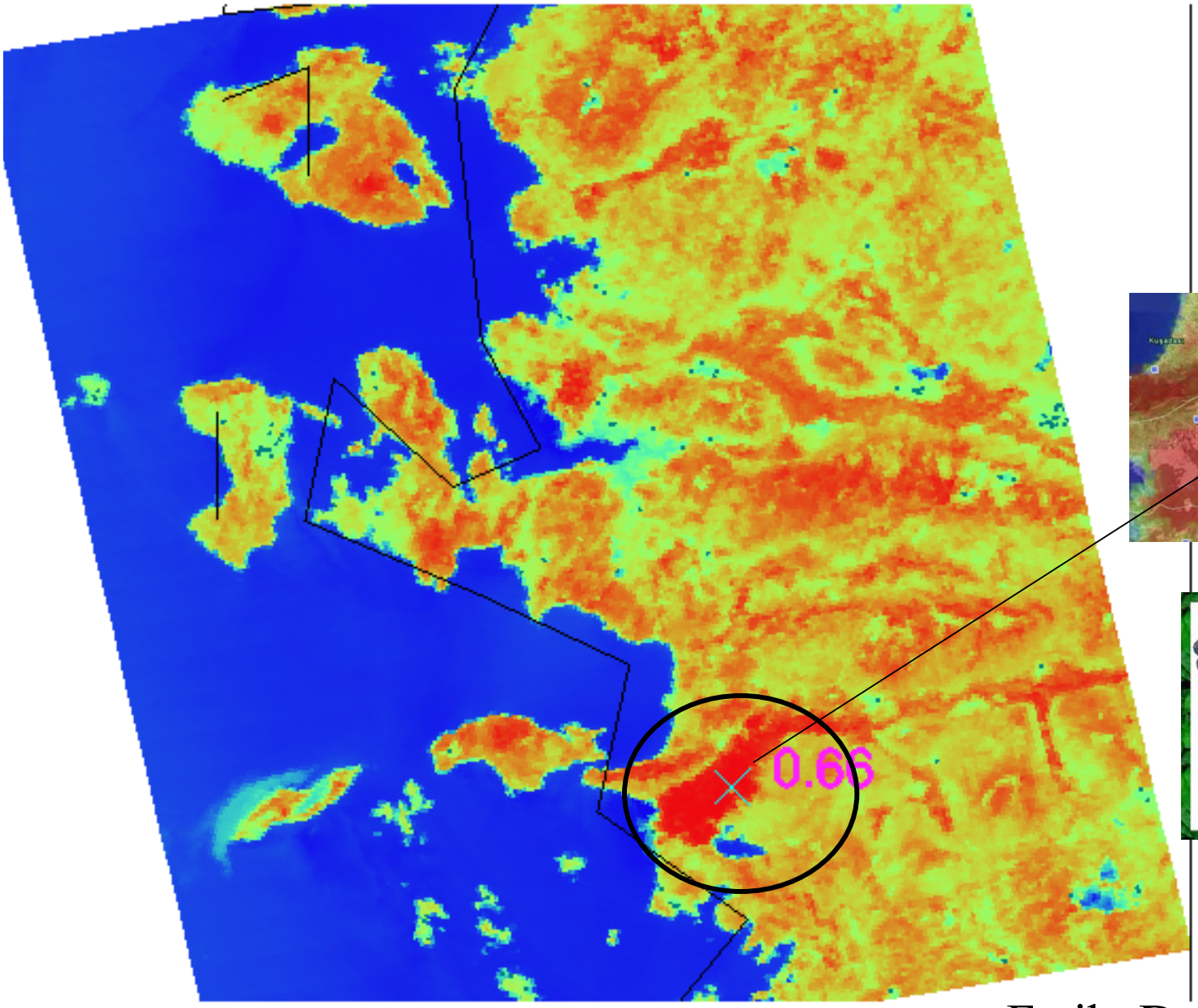
Colocated AIRS (left) & MODIS (right) spectra in & out of Etna ash

SEVIRI co-located with AMSU

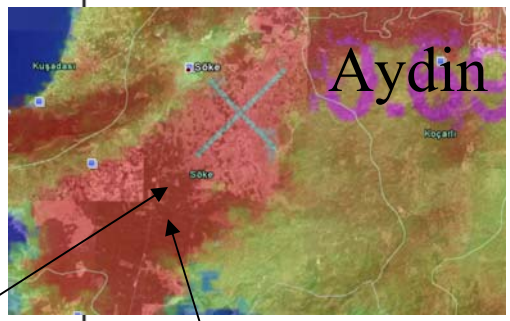


MODIS
sees Istanbul

Students use local knowledge to identify Turkish vineyards



MODIS
NDVI



Fatih, Denizhan, and Elif

Access to visualization tools and data

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

For MODIS data and quick browse images
http://rapidfire.sci.gsfc.nasa/realtime

For MODIS data orders
http://ladsweb.nascom.nasa.gov/

For AIRS data orders
http://daac.gsfc.nasa.gov/

Certificate of Participation

This is to certify that Alassane Nguirane sucessfully completed the ten day long *International Summer School on Applications with the Newest Multi-spectral Meteorological Satellites* that was taught in Benevento, Italy from 3 to 13 June 2007. The course included materials on

- Radiation and the Radiative Transfer Equation
- Spectral signatures from Earth's surface and atmosphere
- High resolution sounding using infrared high resolution spectral data
- Multi-spectral sensors for imaging
- Instrument Considerations and Cal/Val
- Evolving to the Future Global Observing System

Sixty hours of classroom work was split between lectures and laboratory exercises that emphasized investigation of high spatial resolution visible and infrared data (from MODIS and SEVIRI) and high spectral resolution infrared data (from AIRS and IASI). Homework assignments and classroom tests verified that good progress was made in learning and mastering the materials presented.

Benevento, 13 June 2007

Paul Menzel
Senior Scientist, Space Science and Engineering Center
Verner Suomi Professor, Atmospheric and Oceanic Sciences, University of Wisconsin

Paolo Antonelli
Scientist, Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin – Madison

A certificate of participation is given to students upon conclusion of the course

Feedback (1)

1. Do you feel that the programme met the expressed objectives? Please assess the extent to which the objectives were met:

Very well met	7	30%
Fully met	15	70%
Nearly met		
Not met		

2. Do you feel that the knowledge you have acquired has prepared you to contribute more effectively to the activities of your national Meteorological/Hydro meteorological Service or Institution ?

Yes	23	100%
No		

3. Estimate to what extent the programme will be relevant to the work you will be doing when you return to your home country/institution:

Very relevant	5	22%
Relevant	17	74%
Not relevant	1	4% (with a comment: not relevant now, though I hope will become relevant in future job)

4. Did you have any language difficulties?

Yes	3	14%
No	19	86%

5. In relation to your own educational background and experience, indicate the level at which the training activity was conducted:

Suitable	19	83%
Too high	3	13%
Too low	1	4%

Feedback (2)

1. Please give any comments you consider necessary and relevant to other aspects of the programme, such as handout-materials, the way the lectures were presented, etc.:

   - Materials and presentations were excellent!
   - Very good
   - One could choose not to print presentation slides that contained animation sequences and instead-print all necessary in a bit bigger sizes
   - No comments - good work
   - Sorry. I was really surprised how well was all done... No comments more
   - It was great that some aspects were highlighted among the many information that we have received. Maybe they should be highlighted more to understand them more clearly.
   - Groups of 3 people, not more
   - It was OK.
   - I suppose was a lot of new information in a very short time
   - More materials for lectures
   - A bit more time for the lectures, more and better computers
   - Handouts sometimes illegible and some slides missing (the printed form, I mean); other things – great
   - It was very well presented and prepared. Some handout materials were to small to write it
   - More materials for preparation to the homework and to the lectures
   - Too large range of knowledge in too less time of lectures. It could be better if such type of school could last longer (at least 7 or 8 days)

Feedback (3)

1. Have you any suggestions for improving the programme and arrangements for a similar, future activity?

Yes	3	3%	**would be great to have a training on IASI in the future ☺** the lectures could start earlier (e.g.8.30 am) and than they could be longer as well as time of labs could be longer
No	19	87%	

2. How would you rate the overall event?

Excellent	5	23%
Very successful	12	54%
Successful	5	23%
Fair		
Poor		

Non-academic aspects

3. Did you encounter any problems with regard to Travel and Accommodation Arrangements (Tickets – Payments – Accommodation – Transport …..)?

Yes	1	5%
No	21	95%

4. Any other comment....

– Very good organisation of the training course, high level of lectures and labs
– Always do arrange groups internationally – in such groups I observed the most powerful and fruitful discussions
– No.. but.. hope to participate in similar school in future. It's really great scientific and social experience
– Very good work
– Thank You all!
– Thank you for all of you (the organizers and the teachers) for having prepared tis school with a hard work. I think we had all learned a lot.
– The course was very fruitful, all lectures and tutors very helpful. Thank you.

Feedback: What in the course was really useful to you?

All the things I learned in Benevento are useful for me, but especially important for me was the fact that once more I rediscovered that the working the field of meteorology give me such pleasure that i can not get for many other work. this may seem strange to you but, because of the very low salaries in the universities in Bulgaria I had started to gave up on my science work and looking for other jobs. now behind working part time in a wind energy development company I am very determined and working on my PhD and trying to find a research position somewhere in Europe where I would be able to concentrate on my research. In short in Benevento I realized that for me is more important to work in the field of meteorology than to live in my own country. Behind this learning how to work with hydra anddiagnose different atmospheric and ground features and processes fromsatellite images will be very useful in my future work.I guess I do not need to mention that the contact with you and the other people I met in Benevento made me a very rich man!!! the beautiful communication between so many people from different countries, cultures and religions was something amazing and unforgettable, and even only because of this it is worth all the efforts of organizing such a course. Not to mention so many things that we had learned.

Considerations

- Face to face contact is important for initial courses
- Where possible longer term joint projects should be initiated (sometimes for MS at local university)
- Contact should be sustained using Visitview conferences periodically (monthly?) and a web site updated with examples of local utilization of new remote sensing tools and recent Q&A
- Web site with past teaching materials including ppts, labs, homeworks, quizzes helps future training by others (http://cimss.ssec.wisc.edu/rss/)
- Annual course in one venue sustains contacts

  (e.g. annual course in Italy sustains European connection)
- Follow on visit for a refresher course and progress check on local utilization should be considered
- Access to students from environmentally challenged locales has been facilitated by resources from satellite data providers (e.g. EUMETSAT)

Conclusion

International training events and educational seminars on satellite remote sensing have been a rewarding experience for both the students and the trainers