

Lecture on MODIS
Ben Kravitz
Tuesday, November 10, 2009

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This is a lecture on MODIS, which is part of the lecture on "Optical Properties of Aerosols and Clouds."

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MODIS stands for Moderate Resolution Imaging Spectrometer. It's an instrument that's on board both Aqua and Terra.

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Here are some specifications on MODIS. It's in a sun-synchronous near polar orbit, and it views the entire earth's surface every 1-2 days.

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Here are some of the details on what MODIS sees. It's a spectroradiometer which has 36 bands in the visible, near infrared, shortwave/mediumwave infrared, and the longwave infrared, covering 0.4-14.4 micron wavelengths. MODIS was designed as kind of a filler satellite to provide continuity of data from other sources. You'll notice by looking through the list of the primary uses, there isn't much here that you can't get from another source. For example, when viewing the land surface, we have LandsAT, which covers the earth at much, much higher resolution. However, there isn't another instrument up there that gets this much information all at once and as often. MODIS may only have 250m maximum resolution, but it provides that data very often.

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Here are some of the primary products of MODIS. I'm not going to read all of them to you, but I have a few things I wanted to highlight.

Leaf Area Index - This is the first global scale operational production of this field. It used to just be individual people going around their local areas and measuring.

Gross Primary Productivity - This is a measure of how many grams of carbon are taken up by vegetation per square meter per day.

Cloud measurements - Something new to MODIS is the 1.38 micron channel. This can measure sub-visible cirrus. (We'll talk more about that later on.)

Cloud optical thickness and cloud top pressure - Why is it good to know cloud top pressure? Good for assessing the general circulation, i.e. how high convection is lofting energy.

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I don't really see any point in going over the specifics of how the satellite works, since you've mostly seen all that stuff already in one form or another. Instead, I'm going to talk about what MODIS can do for us, i.e. what it can observe.

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Here are two sites where you can get a lot of cool images from MODIS. They're updated every day. And now I'm going to show you a few of them.

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Anyone know where this is?

Slide 10

Tibet. Why is Tibet important? Tibet is very sensitive to warming global temperatures. It's the source of a lot of irrigation and drinking water for China and India (mountain glaciers). The Tibetan Plateau is largely responsible for driving the Indian and Asian monsoonal system, so perturbations to Tibet can have a profound effect on the monsoon. Scientists want to monitor Tibet very closely, and this monitoring almost has to be done from space because the area is so remote that people can't easily set up observation stations.

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Where is this?

Slide 12

The Aral Sea in Central Asia. Why are people looking at this so carefully? Well, here's a picture of it in the winter....

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And here's the same place in the Summer. It's evaporating. This isn't good for anyone who lives nearby. It used to be a good source of fishing until it evaporated too much, making the water too salty for life.

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Where is this?

Slide 15

Brazil. Why is Brazil important? Brazil is the third largest emitter of CO₂ in the world. It's also one of the largest areas of deforestation in the world. Most of the deforested land is being used to grow sugarcane for biofuels.

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And here you can actually see some of what's going on. This is part of the Amazon that's been turned into farms.

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Okay, we know where this is. (The Great Lakes area, in case you don't.)

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Zooming in, we can actually see cities. That big area is Detroit, and there are smaller ones like Grand Rapids, Kalamazoo, etc. MODIS can be used to monitor large land changes.

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This is Greenland.

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Let's zoom into a part of Greenland. Why do we care about this? Greenland ice sheet melt is a big issue these days. So we need to have some way of observing this visually as well as the other ways we've talked about.

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Where is this?

Slide 22

South Central Russia. These little red dots are marked areas of interest. They're usually villages or some source of small fire. Sometimes you can see sheep herding if you look closely enough.

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MODIS can see typhoons. This is very useful for meteorologists trying to prepare their towns to evacuate in case a major typhoon is coming.

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Typhoons do approach major population centers.

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Taiwan gets hit by a lot of typhoons. There's actually a running joke that Taiwan exists to provide a typhoon buffer for mainland China. This was a category 4 when it made landfall on Taiwan. This one actually affected me, and I had to spend an extra day in Tokyo.

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Slide 28
Where is this?

Slide 29
New South Wales, Australia. Why is dust important? Dust really messes with the radiation budget. Dust both scatters and absorbs radiation. It screws up visibility. It affects clouds in various ways. Dust is really, really important to measure, and we just don't know enough about it. Dr. Miller has led several campaigns all over the world to measure dust.

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Where is this?

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West Africa. This is the Saharan dust plume. It happens in the spring/summer when the ground gets really, really hot. This creates convection which lofts the dust into the air where it can be transported by the wind. You can see that a lot of this dust will fall into the ocean. Dust is rich in minerals, which make good food for ocean biology. You can also see the Canary Islands making Karman vortices (which we've talked about previously in class).

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Saharan dust can travel across the entire Atlantic Ocean. I know someone who runs a LIDAR in Cuba, and he can measure Saharan Dust.

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Where is this?

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This is Central/Eastern Washington state. This is the result of something called dryland farming, which is used in very arid conditions. There's a lot of erosion in dryland farming (as you can see here).

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Where is this?

Slide 37

Mozambique (Southeast Africa). All of these red dots are individual fires that MODIS has located. Africa has the highest incidence of fire in the world, although I don't know if the Australian bushfires have caught up with that figure. Why is fire important? There are studies out there about the climate effects of soot. You've probably heard about how aerosols have a net cooling effect on the planet, and they've actually suppressed some of the effects of global warming. Well, that's true of aerosols in general, but soot actually results in warming. Also, soot can mix with other aerosols (like sulfur) and make dirty sulfur, which is much less reflective than sulfur on its own. Soot is a big radiative problem, so we need to know where it is.

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Where is this?

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These are the California wildfires. This was taken on September 1, 2009. You can see a LOT of smoke downwind of the fires.

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And this is what's left after the fires. You get these gigantic burn scars across the land. This is some serious land change. And MODIS is very good at detecting this. MODIS can see changes almost every day, which can be as useful as getting the detailed images that LandSAT would provide.

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Where is this? (Eastern China.) And what is this?

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This is haze produced by pollution. HUGE radiative effects.

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What's this?

Slide 45

This is Sarychev Volcano that erupted on June 12 of this year. This may be the largest eruption since Pinatubo (1991). For perspective, here's what the volcanic eruption looked like from the International Space

Station:

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Much more impressive looking.

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We can actually track what the volcanic cloud is doing.

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What do you think the wind is like on this day?

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How about now?

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Slide 51

Where is this? (Namibia.) What is it?

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These are hydrogen sulfide eruptions. What happens is biomass (of some type) sinks to the sea floor. The bacteria down there digest it and release hydrogen sulfide as a byproduct. This rises as a white cloud and turns the sea bright green. This is deadly for fish populations.

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You've seen these before. This is a phytoplankton bloom in the Bering Sea.

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Where is this? (The Yucatan.) What is going on here? (It's not phytoplankton.)

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This is sediment. The ground is eroding into the Gulf of Mexico and discoloring the water. Why is sediment important? Sediment contains a lot of minerals and other nutrients for, say, phytoplankton. Sediment is very important to biology.

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This is off the Aleutian islands. You can see all these lines in the picture. Well, MODIS is more or less a scatterometer, so the same effect that Dr. Wilkin talked about in one of his lectures can happen here too.

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Why do we care about clouds? According to the IPCC, clouds are the biggest source of uncertainty in the radiation budget. We do not know enough about

clouds, and we really need to.

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This slide illustrates something that was original to MODIS - the 1.38 micron band. This is a band that allows us to see sub-visible cirrus clouds.

What are sub-visible cirrus clouds? They're simply cirrus clouds that are just outside of the visible wavelengths. But as you can see from this picture, they have a **STRONG** impact on optical depth. Cirrus clouds are really important to the radiation budget. They're generally very thin, so they don't contribute a lot to warming, since they can't hold a lot of water. However, and you can see this if you go outside and just look at cirrus or if you look at this picture, they're very bright. Cirrus clouds can reflect a lot of solar radiation. This is very important to the radiation budget.

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Where is this?

Slide 60

Gulf of Mexico. These are called cloud streets. I think they're pretty.

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Where is this? (Pacific Ocean.) What's significant about this picture?

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Ship tracks. What's significant about ship tracks? They're evidence of the aerosol indirect effect, which says that if you take a cloud and put aerosols into it, you can brighten the cloud. The aerosol indirect effect is one of the most hotly debated items in radiation today. How big is it, how many clouds does it affect, does it matter, etc.

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This is a picture of clouds organizing themselves into convective cells of various shapes. We cannot reproduce this in a lab. We do not know why convection organizes into these shapes.

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Where is this? (Aleutian Islands.) What's going on here?

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These are gravity waves induced by air flowing over the islands. *Ask if they've heard of gravity waves.*

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This is a picture over China. Can you determine just with the naked eye which parts of this picture are snow/ice and which parts are cloud? I don't know about you, but I can't. MODIS can, because each of these will look different in different channels of MODIS. This is one of the advantages to having many channels on one instrument.

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Where is this?

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Black Sea (in Central Asia). Another example of differentiating clouds from snow/ice. Which leads us to....

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Slide 70
What's this?

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These are icebergs in the Atlantic Ocean. And, of course, we care about sea ice in all of its forms. This is a hot issue under climate change.

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Where is this? (The East Coast.)

Slide 73
This is a picture of snow and ice in New England. Now, in the visible channel it all looks white. But to MODIS...

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Here's the same image but falsely colored. MODIS can see which parts are snow and which parts are ice. Also, it can pick out clouds. I certainly didn't know those were clouds in some parts of this picture.

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Where is this?

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Hudson Bay. This is the ice breaking up in June. Figuring out how long sea ice stays is just as important as its extent, because this gives us an idea of sea ice thickness. Why do we care about sea ice thickness? *Explain.*

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And where is this?

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The Southern United States. *Point out the Mississippi River.* This is a picture of snow in the Southern U.S., but we can also see the Mississippi River outflow and a lot of other really important land features.

And that's it!