EOS PM-1 Science Data Validation Workshop

Cloud and Radiation Products Panel

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Panel Charge

The Cloud and Radiation Products Validation Panel was charged to help maximize the value and cost-effectiveness of the PM-1 validation program by identifying additional validation requirements of the individual PM-1 instrument products, gaps in the validation plans between two or more PM-1 instrument teams, and by encouraging and facilitating coordination among the PM-1 Teams.

Cloud and Radiation Products

The cloud and radiation products to be produced by the relevant PM-1 instrument teams are:

CERES: Upward, downward, and net longwave and shortwave fluxes at the top of the atmosphere, in the atmosphere, and at the surface; cloud cover, cloud top height, cloud top temperature, visible optical thickness, 11-μm emissivity, liquid water path, and mean effective particle size.

MODIS: cloud cover, cloud top height, cloud top temperature, visible optical thickness, 11-μm emissivity, cloud liquid water path, and mean effective particle size for multiple cloud layers.

AIRS/AMSU/HSB: cloud cover, cloud top height, cloud top temperature, cloud liquid water path, and spectral longwave emissivity.

AMSR: cloud liquid water path.

Panel Recommendations

Validation is in essence an error analysis. Defining confidence bounds on error estimates is greatly complicated by the difficulty of specifying the true degrees of freedom in the validation data (for cloud/radiation products the horizontal scale of independence is 100's of km). Climate studies require validation of both the bias and random error components (accuracy and precision) under varying climate conditions. A fundamental premise of the clouds and radiation validation science community is that knowledge of the accuracy and precision of the satellite products will improve as longer time series of validation data become available. With this in mind, the panel identified four areas as critical for validating the PM-1 global cloud and radiation products:

1. Validation using long term intercomparisons of products retrieved from measurements made on PM-1 and measurements made at a growing number of surface sites;
2. Use of measurements from intensive field campaigns to provide physical process tests, characterize surface measurements and establish the validation linkage between individual satellite observations and measurements made at individual surface sites;
3. Intercomparison of products common to two or more PM-1 instrument teams;
4. Validation using new active and passive satellite remote sensing systems potentially available during the time frame of PM-1.

1. Validation using long term intercomparisons of products retrieved from measurements made on PM-1 and measurements made at a growing number of surface sites

The surface measurements of radiation, clouds, and aerosols in global networks are important because they provide an increasingly long series of samples needed for validating the satellite cloud and radiation retrieval algorithms and the satellite-inferred long-term trend of clouds and surface radiation budgets. These measurements include surface shortwave and longwave fluxes, shortwave sky radiances, surface temperature and humidity, and, in many cases, atmospheric temperature and humidity soundings and aerosols. A minimum of about 7 sites are required to cover major climatological regimes for measuring cloud properties, radiation fluxes, naturally produced aerosols and other atmospheric parameters. Surface radiation and aerosols require a minimum of 30 sites to cover varying anthropogenic aerosol emissions and surface variability.

The surface radiation and cloud/aerosol measurement networks important for PM-1 validation include: DOE's Atmospheric Radiation Measurement (ARM) sites, the Aerosol Robotic Network (AERONET), WCRP's Baseline Surface Radiation Network (BSRN) and Global Energy Balance Archive (GEBA), and NOAA's Surface Radiation (SURFRAD). NASA EOS is a major funding source for AERONET and contributes to BSRN and SURFRAD. In addition, FLUXNET, AMERIFLUX and other surface characterization sites with appropriate radiometric capability also provide useful data, some with NASA EOS funding support. CERES and other EOS teams also maintain other validation sites with very useful observations.

Recommendation: Increases in the number of sites, enhancements in the capabilities of existing sites, and operation of the sites to include all PM-1 satellite overpasses would greatly improve the validation of the cloud and radiation products. The lidar, cloud radar, shortwave and longwave radiometers at the 3 existing ARM sites provide an excellent basis for validation. Similar sites in climate regimes not represented would significantly enhance the validation capability. This could be at least partially accomplished by the judicious enhancement of several of AERONET sites to include the lidar, cloud radar and irradiance measurements. Additional surface sites are required, especially in subtropical, mid and high-latitude oceanic regimes. These additional sites may be added by inviting the involvement of the NOAA research ships and through international cooperation.

2. Use of measurements from intensive field campaigns to provide physical process tests, characterize surface measurements and establish the validation linkage between individual satellite observations and measurements made at individual surface sites

Measurements of cloud parameters, radiances, and fluxes in field experiments are indispensable for validation of PM-1 cloud and radiation products. These include surface and aircraft lidar and radar measurements of cloud height, water/ice content, and the vertical distribution of the extinction coefficient of shortwave radiation; surface and aircraft radiometric measurements of radiances and fluxes in both longwave and shortwave spectral regions; aircraft remote sensing of surface optical properties; and surface measurements of shortwave direct-beam flux and sky radiance.

There are several planned field experiments important to cloud and radiation validations prior to the launch of PM-1, which include: The First ISCCP Regional Experiment (FIRE) III Arctic Cloud Experiment, which will be conducted in May and June, 1998 over the Arctic Ocean 500 km north of Barrow, Alaska. The objective of this field campaign is to study stratus cloud formation and radiative fluxes in the Arctic region. The campaign is to

be collocated and concomitant with the Surface Heat Budget in the Arctic (SHEBA) experiment sponsored by NSF. Another planned field campaign is the GEWEX Asian Monsoon Experiment (GAME), which will be conducted starting in May 1998 in the South China Sea. The objective of this campaign is the study of monsoon dynamics and the related cloud system and heat budgets. There will be similar field experiments with cloud/radiation components that will benefit EOS PM-1 validation in the 2001-2005 time period. For example, the CRYSTAL tropical cirrus experiment, which is to study the microphysical, optical, and dynamical properties of anvil cirrus clouds in the western tropical Pacific, is planned for the summer of 2001. Both the FIRE III Arctic Cloud Experiment and the CRYSTAL experiment will have very close cooperation with the ARM sites located near both intensive study locations. In the case of CRYSTAL, current plans also call for deployment of a floating ARM site, NOAA's R.V. Ron Brown. The DOE ARM program has planned a continuing series of intensive field operation experiments related to clouds and radiation. These experiments will be located at the ARM sites. Indeed, MODIS and other EOS AM-1 teams plan a series of validation field experiments over the ARM site in Oklahoma that will likely continue into the PM-1 time period.

Recommendations: Field experiments are required to validate cloud profile information to be obtained by lidar, radar, and radiometers at the ARM and other sites which have these measurement capabilities. Additional airborne validation measurements would enhance the veracity of the measurements made at these surface sites. Future EOS/ARM field campaigns need to be planned to add to the validation data base.

3. Intercomparison of products common to two or more PM-1 instrument teams

As indicated in the clouds and radiation products list given above, there are many cloud parameters which are produced by one or more of the PM-1 instruments. Since all of the instruments are on the same spacecraft, spatial and temporal matching of the common products should be relatively straight forward.

Recommendations: The panel recommends that it is absolutely essential that the products from the various EOS teams be intercompared for the accuracy, consistency, spatial resolution, and temporal resolution. The investigations to be conducted should include statistics of discrepancy among the products from different teams, nature of the discrepancy, and sources of discrepancy for various temporal and spatial scales. The scales should include daily, monthly, seasonal, interannual, regional, zonal, climatic regimes, and global.

4. Validation using new active and passive satellite remote sensing systems potentially available during the time frame of PM-1.

The best global sampling of cloud top height, cloud overlap, physical thickness and ice water path (IWP)will come from new active and passive remote sensing technologies as part of the future ESSP and other international programs. Examples are improved measurements of cloud overlap using cloud lidar and radar, as well as improved measurements of ice cloud properties (IWP, effective single particle radius).

Recommendations: Comparisons of spatially and temporally coincident measurements made by these new satellite systems, with the appropriate PM-1 cloud and radiation products should be made to the greatest extent possible.