# The Data Integration for Model Evaluation Web Site

## A One-Stop Shop for Model Evaluation

BY GEORGE TSELIOUDIS, WILLIAM B. ROSSOW, ANASTASIA N. GENTILCORE, AND JACK KATZFEY

Even though atmospheric models have improved greatly over the years, errors in their predictions often undermine the public's confidence in weather and climate forecasting. The first step in improving an atmospheric model is to evaluate the model results against observations of past weather and climate changes. If a model can accurately reproduce past weather or climate phenomena, we have more confidence that its predictions will be accurate.

The observations used in such model evaluations come from ground-based, airborne, or satellite instruments used in large observational campaigns. Even though most of those campaigns attempt to improve atmospheric models, only a small fraction of the collected data is actually used to evaluate and improve such models. This is primarily because of the differences between the datasets produced by observational programs and those needed or "wished for" by modelers for their evaluation studies. Observers produce data streams of parameters that are either retrieved or directly measured by their instruments at the time and space scales of their observational platforms. Modelers, on the other hand, require gridded data of those parameters that are directly calculated by the model at the space and time scales characteristic of their particular model grid.

The distinctive characteristics of the data collected by the different observational platforms introduce an additional problem. Field studies collect high-resolution samples at a few discrete locations, while satellites provide a top-down view at near-global coverage, but with relatively low space–time resolution. Testing and improving an atmospheric model requires both the detail of the field study data and the large-scale perspective of the satellite observations. Unfortunately, field experiment data banks rarely make available the satellite retrievals coincident with the time and place of the experiment. As a result, a modeler who wants to test an atmospheric model against all available information needs to search, extract, and manipulate data from a number of different sources.

The incompatibility between observational output and model evaluation needs became the source of great problems in the Global Energy and Water Experiment (GEWEX) Cloud System Study (GCSS). The study was conceived to improve the representation of clouds in climate and weather models by evaluating cloud system resolving models (CSRMs) using the observations collected by major field experiments. Five working groups were created to study the five major cloud types (stratocumulus, cirrus, midlatitude layered, convective, and polar). It was soon realized that the sparse and limited data collected by field studies were often insufficient for extensive model evaluations and that the immense resources of the coincident satellite observations were either underused or not used at all in those studies. Moreover, the results of a few field study evaluations needed more extensive statistics to generalize them.

Therefore, in its latest reorganization, GCSS decided to institute the Data Integration for Model Evaluation (DIME) activity. The main objective is to integrate "global" satellite and reanalysis datasets with field study datasets from ground-based and airplane observations to produce an inclusive and practical resource for model evaluation.

The first incarnation of the DIME Web site that is described in this paper attempts to collect in one lo-

**AFFILIATIONS:** TSELIOUDIS—NASA Goddard Institute for Space Studies and Columbia University Department of Applied Physics and Applied Mathematics, New York, New York; ROSSOW—NASA Goddard Institute for Space Studies, New York, New York; GENTILCORE—SGT Inc. at NASA Goddard Institute for Space Studies, New York, New York; KATZFEY—CSIRO, Melbourne, Australia
**CORRESPONDING AUTHOR:** George Tselioudis, NASA Goddard Institute for Space Studies, 2880 Broadway, New York, NY 10025
E-mail: gtselioudis@giss.nasa.gov
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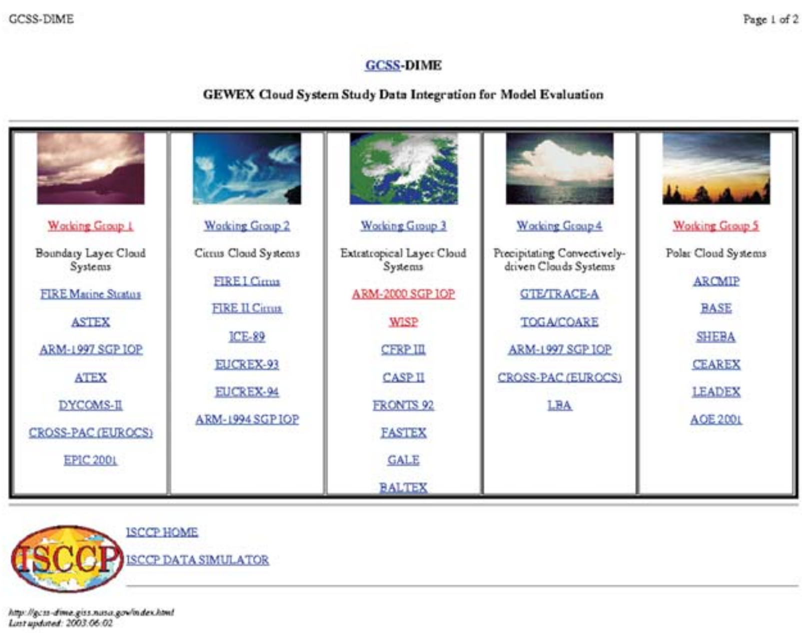



**FIG. 1. The DIME home page. It shows the list of field experiments that are included on the site for each of the five GCSS working groups. A click on a field experiment name brings the user to the DIME page for that experiment.**

cation all the tools and information that a modeler needs in order to run and evaluate an atmospheric model. This makes it easy for atmospheric modelers worldwide to test their models for a multitude of different atmospheric conditions. The Web-based dataset provides large-scale observations for the time and area of specific field experiments as well as links to the experiment datasets, usually at the field program Web sites. As a GCSS effort, DIME focuses on field experiments related to the study of clouds and radiation; however, climatological statistics for the same cloud types and climate regimes are also provided.

The DIME Web page at present includes around 30 field experiments, separated into the five cloud types. The datasets include both data to initialize model runs as well as data to evaluate the results. This overview of the available datasets presents a roadmap on how to initialize and run a model for a field study case and how to evaluate the model results against the wealth of available observations. We also give an example of one model evaluation result, using exclusively data from the DIME Web site.

**CONTENTS AND STRUCTURE.** Cloud types are useful classifiers of the field experiments (see Fig. 1) because they indicate distinct meteorological conditions, whether baroclinic storm systems or tropical waves. A modeler who wants to test a model's performance under certain meteorological conditions can choose a cloud type and field experiment that closely matches those conditions. In addition, through the DIME Web site any modeler can be involved in GCSS by running and testing a model for cases currently studied by the working groups (links to all working group Web sites are provided).

For each field experiment, the available datasets and software are provided, including model forcing datasets, large-scale observations, field study observations, statistical composites, and data simulator software (see example in Fig. 2 and Table 1).

*Model forcing datasets* can be used to initialize model runs for the region and time period of the field experiment. For all field experiments on the Web site, the standard forcing dataset consists of a subset of the National Centers for Environmental Prediction (NCEP) reanalysis atmospheric fields at 2.5° horizontal resolution, 17 vertical levels, and 6-h time resolution. A few field experiments include higher space and time resolution, and some of the ARM and Tropical Ocean Global Atmosphere Coupled Ocean–Atmosphere Response Experiment field experiment cases provide links to a variational analysis dataset (described by Zhang et al. in the November 2001 *Monthly Weather Review*) that can be used to initialize more accurately CSRM and single-column model simulations. Individual atmospheric parameters or the whole model forcing dataset can be downloaded via ftp from the DIME Web site.

The *large-scale observations* link mostly includes satellite retrievals of radiation, cloud, and precipitation properties, along with reanalysis data of meteorological conditions. The datasets usually cover 10°–30° of latitude by 20°–40° of longitude over a few days to a few months, depending on the extent of the experiment. The example in Fig. 3 illustrates some of the main large-scale datasets, including 3-hourly cloud-top pressure and cloud optical depth from the International Satellite Cloud Climatology Project (ISCCP), daily precipi-

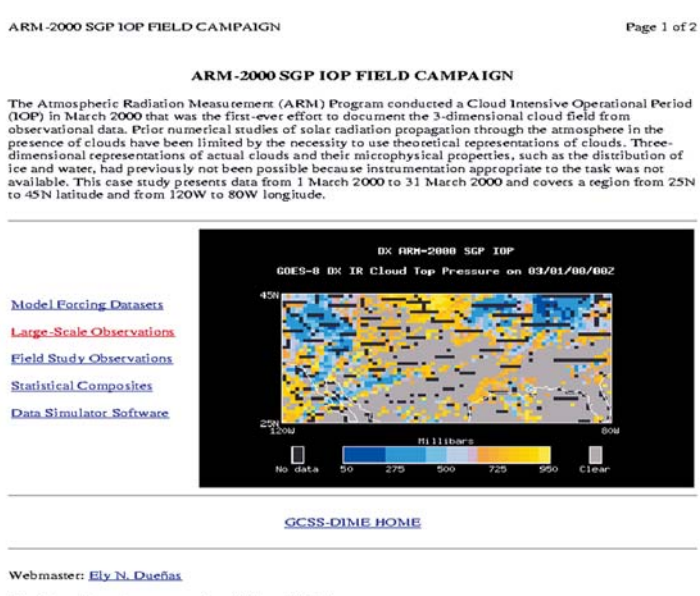
**Table 1. Summary of datasets and software packages provided in the DIME Web site for the ARM 2000 IOP.**

<table>
<tr><td>Model forcing datasets<br>• Limited area models<br>(NCEP/ECMWF reanalyses and regional model data assimilations)<br>• Single column models<br>(Variational analysis products)</td><td>Large scale observations<br>• Gridded data<br>– ISCCP D1/DX<br>– SSM/I<br>– TOVS<br>– GPCP<br>– NCEP/ECMWF reanalyses<br>– ISCCP radiative fluxes<br>• Point data<br>• Rawinsonde observations</td><td>Field study observations<br>• Links to the field study Web pages</td></tr>
<tr><td colspan="2">Statistical composites<br>• Climatological composites from ISCCP and other data sources</td><td>Data simulator software<br>• ISCCP simulator<br>• Convection collocator</td></tr>
</table>

tation from the Global Precipitation Climatology Project, 3-hourly radiative flux data from the ISCCP-derived climatology, and 6-hourly 500-mb vertical velocity from the NCEP reanalysis dataset. In addition, most field experiment cases on the DIME site include Special Sensor Microwave/Imager (SSM/I) retrievals of atmospheric water vapor, liquid water, and precipitation; TOVS atmospheric profiles of temperature and precipitable water; European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis meteorological data; and operational radiosonde profiles of temperature, humidity, and wind properties.

By selecting a launching location from a map (Fig. 4), the user can view or download the vertical profiles of temperature, relative humidity (RH), and wind, along with cloud boundary heights derived using the RH-based method described by Wang et al. in the *Journal of Climate* (September 2000). The large-scale observations can be used to test the performance of several components of a model simulation, ranging from the cloud and precipitation scheme to the radiative flux calculations and the atmospheric dynamics.

The Web site for the respective *field study observations* usually provides the full datasets that were collected by the different field experiment platforms. Such datasets include detailed information on fields like cloud microphysical properties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ARM-2000 SGP IOP FIELD CAMPAIGN

The Atmospheric Radiation Measurement (ARM) Program conducted a Cloud Intensive Operational Period (IOP) in March 2000 that was the first-ever effort to document the 3-dimensional cloud field from observational data. Prior numerical studies of solar radiation propagation through the atmosphere in the presence of clouds have been limited by the necessity to use theoretical representations of clouds. Three-dimensional representations of actual clouds and their microphysical properties, such as the distribution of ice and water, had previously not been possible because instrumentation appropriate to the task was not available. This case study presents data from 1 March 2000 to 31 March 2000 and covers a region from 25N to 45N latitude and from 120W to 80W longitude.

Model Forcing Datasets
Large-Scale Observations
Field Study Observations
Statistical Composites
Data Simulator Software



GCSS-DIME HOME

Webmaster: Ely N. Dueñas

*http://gcss-dime.giss.nasa.gov/arm-00/arm-00.html*

**Fig. 2. The DIME page for the Atmospheric Radiation Measurement (ARM) March 2000 Intensive Observations Period (IOP). It shows a list of the available datasets and software for that case. The list includes model forcing datasets, large-scale observations, field study observations, statistical composites, and data simulator software. An illustrative cloud-top pressure image from ISCCP data is also shown.**

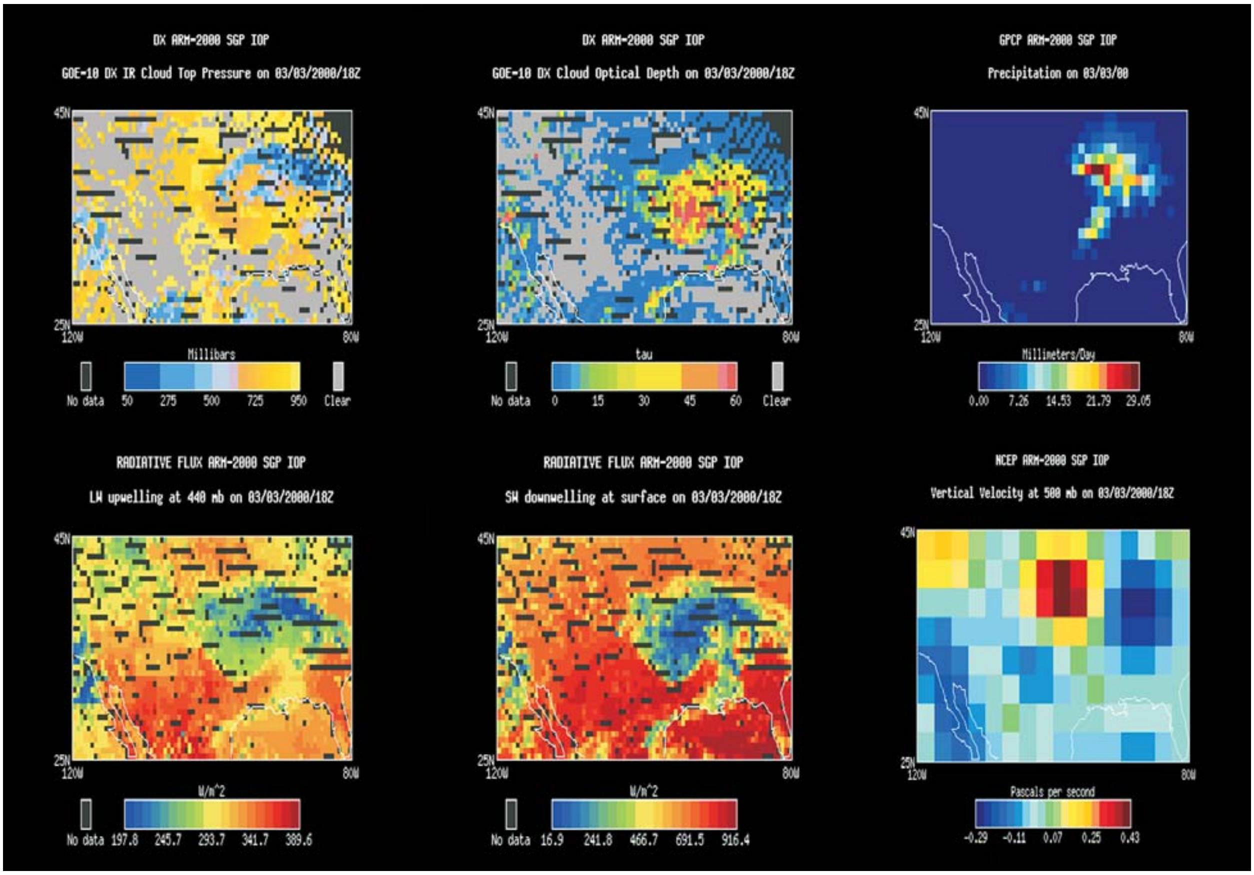


**FIG. 3. Illustration of some of the main large-scale datasets for one day during the March 2000 ARM IOP. It shows (clockwise from top left) cloud-top pressure and cloud optical depth from the ISCCP, precipitation from the Global Precipitation Climatology Project (GPCP), 500-mb vertical velocity from the NCEP reanalysis dataset, and shortwave downwelling flux at the surface and longwave upwelling flux at 440 mb from ISCCP-based radiative flux data.**

and water vapor vertical profiles that are not accurately retrieved or are not readily available in satellite datasets, and thus provide the smaller-scale details that are missing from global datasets. At the present time there is no attempt to merge field study and satellite observations in DIME. The plan is to test merging techniques for selected cases in the near future (e.g., Fig. 4).

The *statistical composites* put the field experiment cases in the context of regional climate. This part of the Web site is still under construction. So far, the only statistical composite is for the ARM-2000 Intensive Observing Period over the southern Great Plains. For March 2000, when the experiment took place, statistical distributions of cloud-top pressure and cloud optical thickness are derived from ISCCP observations for the field experiment location and for the whole central United States. In addition, for the field experiment location, a statistical composite of cloud-top height and vertical extent is derived from ARM radar retrievals. Those composites reveal the main cloud types over the experiment site in that month and the extent to which those types are representative of the cloud field in the region. In the near future, we intend to populate the Web site with statistical composites that will provide the climatological features of the cloud field for all the major climate regimes.

In the *data simulator software* we will archive software that manipulates model outputs to produce fields that can be directly compared to observational retrievals. At the moment, two software packages are archived. The ISCCP simulator uses as input typical cloud-related model output parameters, and produces cloud properties that can be quantitatively compared to those retrieved by ISCCP. The convection collocator scans ISCCP data and provides, for a given place and time, the nearest convective event and its

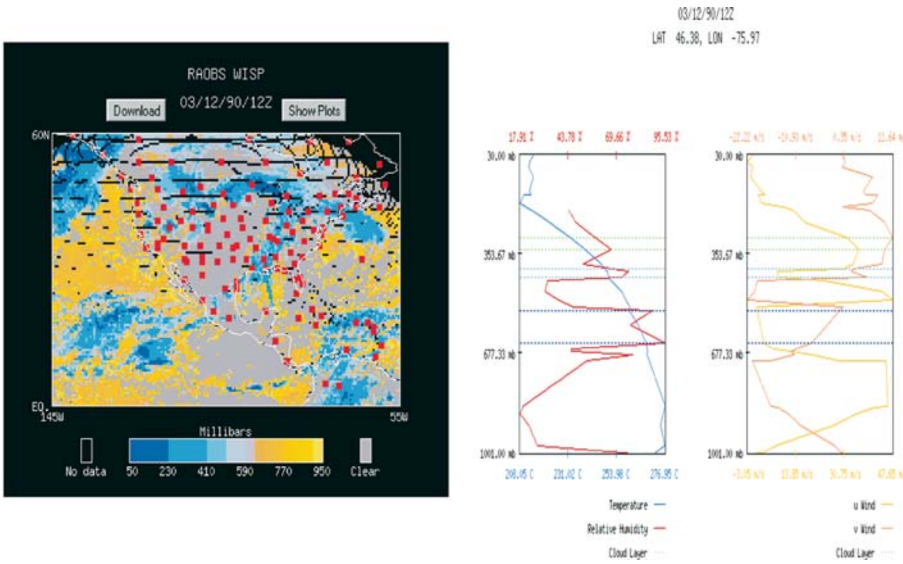


**Fig. 4. The left panel shows the launching locations of radiosondes (red squares) superimposed on ISCCP cloud-top pressure data for one time period during the Winter Icing and Storm Project (WISP) field experiment. By selecting one or more launching locations, the user can view or download the radiosonde vertical profiles of temperature, relative humidity, wind, and cloud boundaries for that location(s) as shown in the right panel of the figure.**

life history. It is hoped that in the near future we will archive on the site similar software packages that will make more meaningful comparisons of model output to retrievals by ground-based and airborne radar or by the newer generation of satellite instruments.

**DISCUSSION.** Data integration brings together data from disparate instruments to create a coherent description of observed physical processes. In model evaluation studies, this physical description makes it possible not only to identify the model parameters that are not correctly simulated, but also to attempt to explain the model simulation errors. In the model evaluation example for March 2000 in the central United States, using the datasets on the DIME Web site (Fig. 5), the Australian Division of Atmospheric Research Limited-Area Model (DARLAM) model (overall) produces optically thicker clouds near the center of the baroclinic storm. This problem was also found in a regional-model evaluation study of storm clouds over Australia by Ryan et al. (see the September 2000 *Monthly Weather Review*) and in a global model evaluation study of Northern Hemisphere midlatitude clouds (by Tselioudis and Jakob in the *Journal of Geophysical Research*, 2002). The too-large cloud optical depths of the model can be due to excessive cloud vertical extents, large cloud water contents, or incorrect simulation of cloud particle phase and size. The DIME Web site provides access to radiosonde and ARM radar data that help estimate the physical extent of the clouds, as well as aircraft data for the cloud water content and particle phase and size. These additional cloud properties, along with the description of the dynamical and thermodynamical conditions from the reanalysis datasets, make possible a detailed study of the physical mechanisms that may be responsible for the model cloud optical depth errors.

The DIME Web site is a work in progress and will remain so over the next few years. More recent field study cases will be added as the data become available. Finally, large-scale datasets from the new generation of satellite instruments will be added for the more recent field experiment cases. The improvement of the Web site, however, depends on the level of interest and the willingness of the observational and modeling communities to assist in this effort. The assistance can come in the form of model forcing or field study datasets or data-simulator software packages that can be included on or linked to the DIME Web site, thus making them more easily available to observers and modelers alike. The creation of an all-inclusive Web site for model evaluation studies is the ultimate objective of the GCSS DIME project.

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## FOR FURTHER READING

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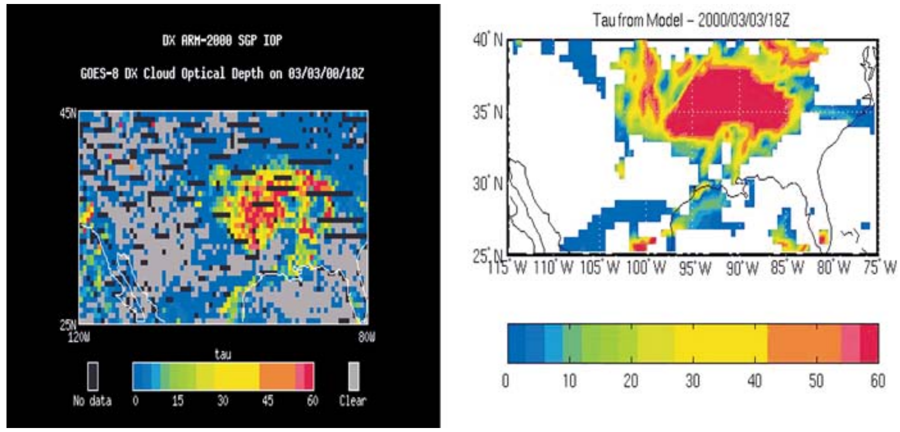


**Fig. 5. (Left panel) Cloud optical depth at 1800 GMT 3 March 2000 over the central United States from the ISCCP satellite retrievals. (Right panel) Cloud optical depth for the same time period from a simulation of March 2000 with the Australian DARLAM regional model. The model result comes from 12-h forecasts run every 6 h for the whole month, initialized with the NCEP reanalysis data stored in the model-forcing section of the DIME Web site. The model cloud optical depth is calculated using the ISCCP simulator software, making the model values, to a large extent, quantitatively comparable with the ISCCP retrievals.**

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