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EXAMPLES OF CLIMATE APPLICATIONS OF TRMM DATA

Zhong Liu*[1], L. Chiu[1], W. Teng[2], G. Serafino, R. Yang[2]
GSFC Earth Sciences Data and Information Services Center
Distributed Active Archive Center
NASA/Goddard Space Flight Center, Greenbelt Maryland, USA 20771
[1] CEOSR, George Mason University, Fairfax, VA
[2] SSAI, Lanham, MD

1. INTRODUCTION

The Tropical Rainfall Measuring Mission (TRMM) is a joint U.S.-Japan satellite mission to monitor tropical and subtropical (40 S - 40 N) precipitation and to estimate its associated latent heating. The TRMM provides the first detailed and comprehensive dataset on the four dimensional distribution of rainfall and latent heating over vastly undersampled tropical and subtropical oceans and continents. The TRMM satellite was launched on November 27, 1997. Data from the TRMM are archived and distributed by the GSFC Earth Sciences Data and Information Services Center (GDISC).

To encourage the use of TRMM data, we prepared this poster to present several examples of using TRMM data sets in climate studies in the hope that these examples will help the users better understand the data and their applications. The poster includes: TRMM applications in 1) Geographic Information System (GIS); 2) Monsoon studies; 3) El Niño and La Niña study; 4) Weather forecasting; and 5) Rainfall assimilation in General Circulation Models.

2. TRMM PRODUCTS

The TRMM satellite flies at an altitude of 350 km with a period of 91.5 minutes. The TRMM satellite carries three rain-measuring instruments. NASA GSFC provided the TRMM Microwave Imager (TMI), the Visible Infrared Scanner (VIRS), and the observatory, and operates the TRMM satellite via the Tracking and Data Relay Satellite System (TDRSS). The National Space Development Agency (NASDA) of Japan provided the Precipitation Radar (PR), the first space-borne precipitation radar, and launched the TRMM observatory. Table 1 shows the instrument characteristics for the VIRS, TMI, and PR. Table 2 summarizes the TRMM standard products available at the Goddard DAAC. Level 1 products are the VIRS calibrated radiances, the TMI brightness temperatures, and the PR return power and reflectivity measurements. Level 2 products are derived geophysical parameters at the same resolution and location as those of the Level 1 source data. Level 3 products are the time-averaged parameters mapped onto a uniform space-time grid. All TRMM standard data can be searched and ordered through the GDISC by accessing the URL: http://lake.nascom.nasa.gov/data/dataset/TRMM. An evaluation of the sensor, algorithm performance and first major TRMM results appear in the Special Issue on the Tropical Rainfall Measuring Mission (TRMM), the combined publication of the Journal of Climate and Journal of Applied Meteorology (2000).

TRMM Instrument Characteristics

	Visible Infrared Scanner	TRMM Microwave Imager	Precipitation Radar
Frequency/Wavelength	0.63, 1.6, 3.75, 10.8, 12 um	10.65, 19.35, 37.0, 85.5 GHz dual polarization, 21.3 GHz vertical polarization	13.8 GHz horizontal polarization
Scanning Mode	Cross track	Conical	Cross track
Ground Resolution	2.1 km	Ranges from 5 km at 85.5 GHz to 45 km at 10.65 GHz	4.3 km at nadir
Swath Width	720 km	760 km	220 km

Table 1. TRMM instrument characteristics.

To validate the TRMM algorithms, field experiments including the Texas and Florida Underflight Experiments (TEFLUN A and B), the South China Sea Monsoon Experiment (SCSMEX), the Kwajalein Experiment (KWAJEX), and TRMM-LBA experiment in the Amazonia have bee conducted. The data can be obtained via the URL: http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/TRMM_FE/trmm_fe.shtml.

* *Corresponding author address*: Zhong Liu, GMU/DAAC, NASA/GSFC, Code 902, Greenbelt, MD 20771; Email: zliu@daac.gsfc.nasa.gov

	Visible Infrared Scanner	TRMM Microwave Imager	Precipitation Radar	Combined Products	Ground Validation (GV)
Level 1	Visible & IR radiances	Microwave brightness temperatures	Radar return power & reflectivity	NA	Cal. radar reflectivity at each GV site
Level 2	NA	TMI profile for CLW, prec. water, cloud ice, prec. ice, latent heat, & surface rain	PR surface cross-section & path attenuation, rain type, storm, & freezing height; PR profile for rain rate, reflec., attenuation, & rain top/bottom height	Rain rate, drop size dist. parameters, path integrated attenuation	Rain existence, rain map, rain type, 3-D reflectivity, rain gauge, disdrometer
Level 3	NA	TMI monthly rainfall, rain rate, rain frequency, & freezing height	PR monthly surface rain total, rain profile at 2, 4, 6, 10 & 15 km, fractional rain, storm height histogram, snow ice layer, surface rain rate, & path attenuation	Monthly surface rainfall, CLW, rain water, cloud ice, & grauples; combined instruments calibration, global gridded rainfall	Rain map, 3-D map

Table 2. TRMM products at GDISC.

3. APPLICATIONS

a. *Remote sensing information partner (RSIP)*

The purposes of the GDISC Remote Sensing Information Partner (RSIP) program are (1) to ensure that remote sensing data are widely disseminated to the end users, thus maximizing the usage of NASA data and technology and (2) state and local users receive their data and services directly from the RSIPs, thus easing the distribution load by GDISC. RSIPs receive remote sensing data and technology from GDISC, create value added products or services, and serve as local data storage and distribution centers. In serving their role, RSIPs provide better service to their user community and provide direct input to GDISC for further data and technology development [Chiu et al. 1999]. The Earth Data Analysis Center (EDAC) of the University of New Mexico is an early prototype RSIP. The product used in the poster, in GIS (ARC/INFO) format, is produced by GDISC [Pollack et al. 2000]. The conversion of the data into GIS compatible format facilitates TRMM data use by the traditionally GIS communities for monitoring and decision support, thus expanding the user base of TRMM data.

b. *Monsoon study*

Scientists at GSFC studied the 1998 devastating natural disaster over Yangtze River region in China [Lau et al. 1999]. They use TRMM Microwave Imager (TSDIS 2A12) and precipitation Radar (TSDIS 2A25) data, and in-situ observations from the South China Sea Monsoon Experiment (SCSMEX). The analyses reveal the dynamic and thermodynamic conditions associated with development of meso-scale convective system that gave rise to the Yangtze River flood in relation to the evolution of the South China Sea Monsoon (Figure 1).

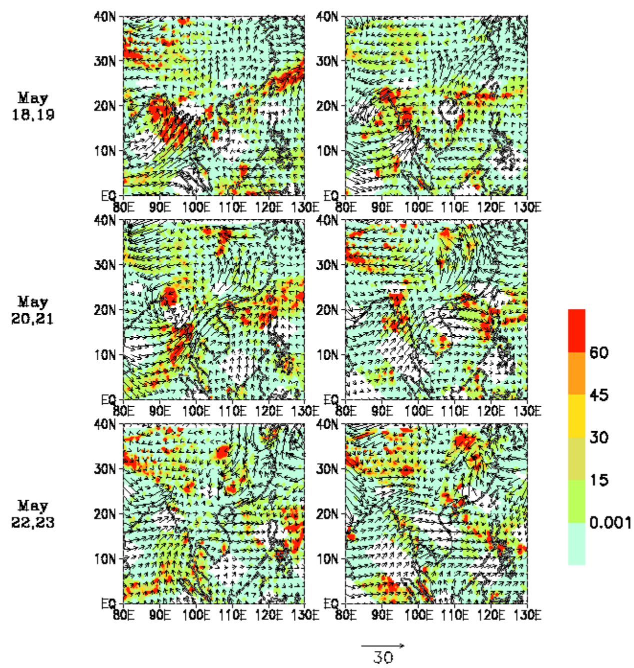

Figure 1. The figure shows the development of monsoon circulation along with the precipitation field. TRMM TMI rain rate (mm day^{-1}) (shaded area, see intensity scale) are plotted superimposed with 850mb wind (m s^{-1}, arrows) for the period of May 18 - May 23, 1998. It shows a monsoon depression (anti-clockwise strong wind) over the Bay of Bengal developed in May 18, and convection occurred east of China. With the southward shift of the convection, westerly winds associated with the Bay of Bengal depression developed feeding moisture into the South China Sea around 20 May, when the monsoon onset occurred.

c. *El Niño and La Niña Study*

TRMM product 3B43, the merged monthly 1 x 1 degree rain rate from TRMM, geosynchronous IR, SSM/I, and rain gauges, can be used for El Niño and La Niña studies. Figure 4 was derived from the 3B43 data set. It clearly shows the signatures of the El Niño and La Niña events between 1998 and 2000.

Scientists at GSFC explore the use of TRMM precipitation data in their numerical ocean model simulation [Murtugudde et al. 2000]. With TRMM precipitation data as an input, their model reproduces the real SST variations over the Indian Ocean, as well as over the eastern equatorial Pacific and the equatorial Atlantic Oceans, for the El Niño period of fall 1997 to spring 1998. TRMM data successfully document the interannual precipitation variation, coordinating the SST changes beneath the atmosphere (Figure 2).

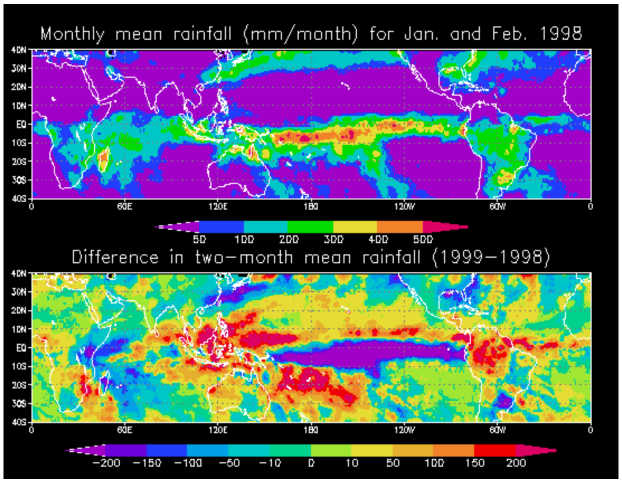

Figure 4. The panel is the two-month mean rainfall rate (mm/month) for January and February 1998 over the tropical and subtropical regions. Heavy rainfall appears over the South Pacific Convergence Zone (SPCZ), South Indian Ocean, and the South America.

d. *TRMM improves rainfall forecast*

One major accomplishment from the use of TRMM satellite data is the short-term rainfall forecast study carried out by researchers at the Florida State University [Simpson et al. 2000; Krishnamurti et al. 1999]. In their study, TRMM rainfall data and SSMI data are included into their multi-analysis process of numerical weather forecast model. Their results show that global as well as the regional forecast skills are higher with TRMM data than without TRMM data. Also, TRMM data are used as the validation data for deriving the statistical parameters of their multi-model super ensemble system. The resulted forecast correctly predicts the tracks of major hurricanes for 1999. The rainfall forecasting accuracy is dramatically increased. The scientists attributed this success to a combination of improved analyses available from the super-ensemble approach as well as the availability of accurate rainfall estimates over the tropics from the TRMM satellite.

e. TRMM improves rainfall data assimilation

Scientists at GSFC/NASA have successfully developed analysis techniques to bring TRMM rainfall observation into their global numerical model, called the Terra Goddard Earth Observation System (GEOS) data assimilation system (DAS). By assimilating the 6-hour averaged TMI surface rain and total precipitation water data into the Terra GEOS-DAS, they found that the primary hydrological fields, as well as key climate parameters, such as clouds and radiation, are improved significantly. The figures in the poster illustrate the performance that Terra GEOS-DAS had for the super-Typhoon Paka (December 10, 1997) assimilation.

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Special Issue on the Tropical Rainfall Measuring Mission (TRMM), combined publication of the December 2000 Journal of Climate and Part 1 of the December 2000 Journal of Applied Meteorology, American Meteorological Society, Boston, MA.

INFORMATION

All TRMM standard data can be searched and ordered via:
http://lake.nascom.nasa.gov/data/dataset/TRMM

For further details about TRMM, visit:
http://trmm.gsfc.nasa.gov

Questions and comments, please email to:
hydrology@daac.gsfc.nasa.gov