TOVS

CONTENT

HISTORY of TOVS and TIROS-N series

- "**TOVS**" is an abbreviation used to identify a suite of three instruments that flew on board series of NOAA satellites, commencing with **TIROS-N**, in October, 1978. The series continued with **NOAA-6,7…** , and ended with **NOAA-14** launched in April 1995 and decommissioned in May, 2007. Sometimes this series is referred to as "**TIROS-N**" series. The **time coverage** of each of the **TIROS-N** series satellites can be found here.
- The original satellite names were **NOAA-A,C,E**... but were later renamed (numbered):

NOAA-	**A**	**C**	**E**	**F**	**G**	**H**	**D**	**I**	**J**
NOAA-	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**

Note, the letters **A-J** will appear in the file names.

- **TIROS** stands for "Television InfraRed Observation Satellite", whereas **TOVS** is the **T**IROS **O**perational **V**ertical **S**ounder. (See Acronyms)
- It is essential to think of TOVS as a suite of three instruments: **HIRS/2, MSU, and SSU**. Thus, TOVS can be considered as the predecessor of the **AIRS** mission flown on the NASA's **Aqua** satellite.
- **SSU** instrument was **not** flown on **NOAA-10** and **NOAA-12**.
- The **TIROS-N Guide from NOAA** is an excellent source of information on TOVS and other instrumentation flown on the **TIROS-N** series.
- The Advanced TIROS Operational Vertical Sounder (ATOVS) system was deployed when NOAA-15 (K) was launched in the Spring of 1998, replacing the aging TOVS suite of instruments.

PURPOSE

As the predecessor to AIRS, **TOVS** was the first suite of spaceborne instruments to provide measurements (infrared and microwave radiances) from which to retrieve global profiles of temperature and moisture, cloudiness, and outgoing longwave radiation (OLR).

Fundamental meteorological parameters such as atmospheric temperature, humidity, cloud properties and surface properties can be continuously measured by earth-orbiting satellites. By placing a satellite in a polar sun synchronous orbit, most of the entire planet can be sampled on a daily basis, excluding areas of orbital gores. However, with averaging of the data over five days and over a month almost

complete coverage on a 1 degree latitude by 1 degree longitude is available. This data provides a means to investigate long-term climate change and interannual variability of important meteorological quantities. It is also useful for studying local and/or periodic phenomena such as precipitation patterns, sea surface temperature anomalies (e.g., El Nino) and stratospheric warmings, to name a few.

PATHFINDER PROGRAM

TOVS was included in the joint (NASA–NOAA) Pathfinder program designed to produce quality satellite-derived climate datasets through analysis of NOAA operational satellite data by community consensus algorithms. In the case of TOVS, many types of algorithms existed, each with potential benefits and limitations. Consequently, it was decided to analyze TOVS data using a number of different methodologies, or **paths**. Three basic methodologies were identified and included in the TOVS Pathfinder dataset.

A physically based interactive retrieval methodology, called **Path A** or model dependent, produced full retrievals of temperature–moisture profiles as well as fields of other geophysical parameters derived from the data (Susskind, 1997). Aside from providing accurate first guess information, use of the interactive system also facilitated the ability to remove systematic errors between observed and computed radiances and improved the capability to handle effects of clouds on the radiances.

The second type of methodology, called **Path B** (model independent) retrievals, is also a physically based full retrieval system but uses a pattern recognition first guess (Chedin et al. 1985). This is an algorithm developed by Atmospheric Radiation Analysis group (ARA) at Laboratoire de Mtorologie Dynamique of the CNRS (France).

The last type of methodology, referred to as **Path C**, did not produce detailed retrievals but generated only coarse layer temperature climate indicators based on linear combinations of observed radiances in MSU channels (Goldberg and Fleming, 1995).

CURRENT SUPPORT

As of 2011, only the data from **Path A and B** are available from the GES DISC, in HDF4 format, under a limited support as legacy data.

Samples of retrievals are shown in the figures below. The data are a collection of daily, five day averages and monthly averages with coverage during the years 1985 - 1988 from the satellites NOAA-9 and NOAA-10.Data for 1989 from NOAA-10 and NOAA-11 was added by June of 1996.

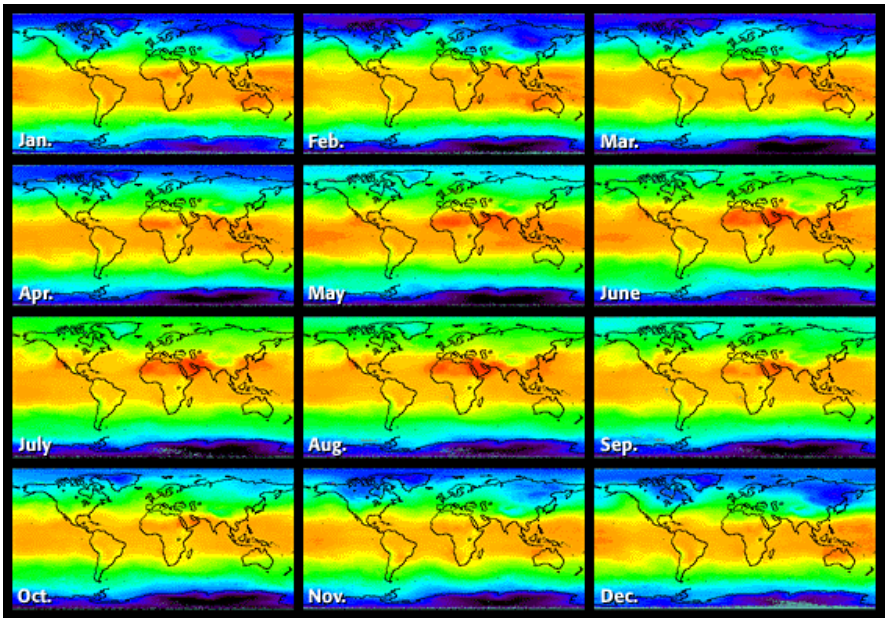
FAQ:

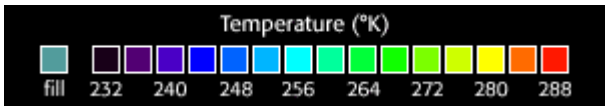
1. What do these data look like?
2. What can I do with these data?
3. What are the dataset parameters, temporal and spatial resolution and coverages?
4. What makes this dataset unique?
5. What kind of hardware and software do I need?
6. How can I get these data?

1.What do the data look like?

The monthly average temperature and water vapor amount for layers of the atmosphere are two of the eleven parameters of the data that can be used to study climate and climate changes.

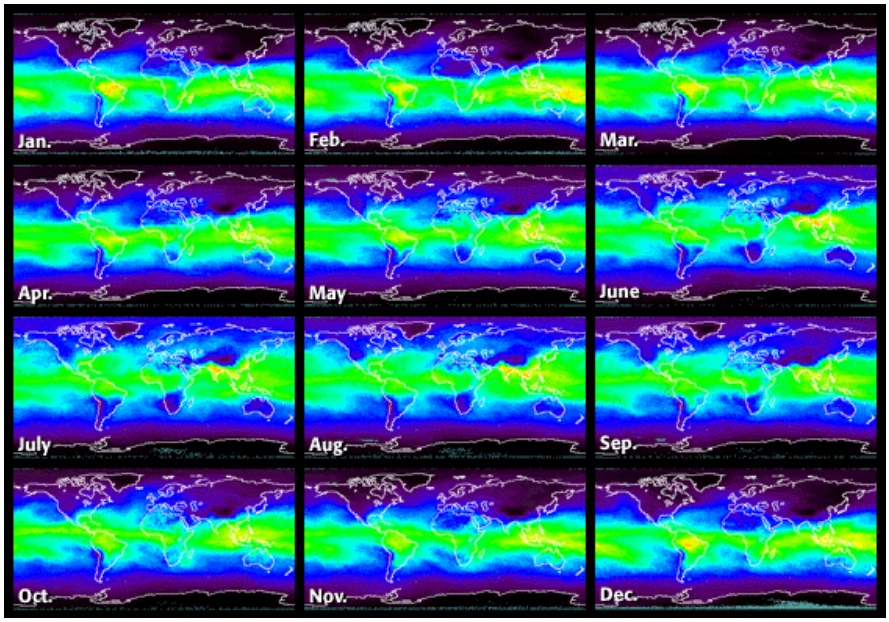
1.1 Monthly Temperature Averages

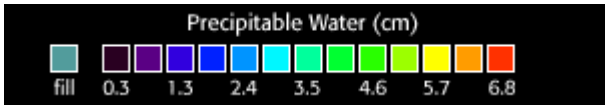




AVERAGE 1985 MONTHLY TEMPERATURES IN THE LAYER FROM SURFACE TO 500 MB, DERIVED FROM TOVS MEASUREMENTS TAKEN ABOARD THE NOAA-9 SPACECRAFT. In addition monthly average temperatures for the atmosphere between 500 to 300 mb, 300 to100 mb, and 100 to 30 mb are available.

1.2 Monthly Water Vapor Averages



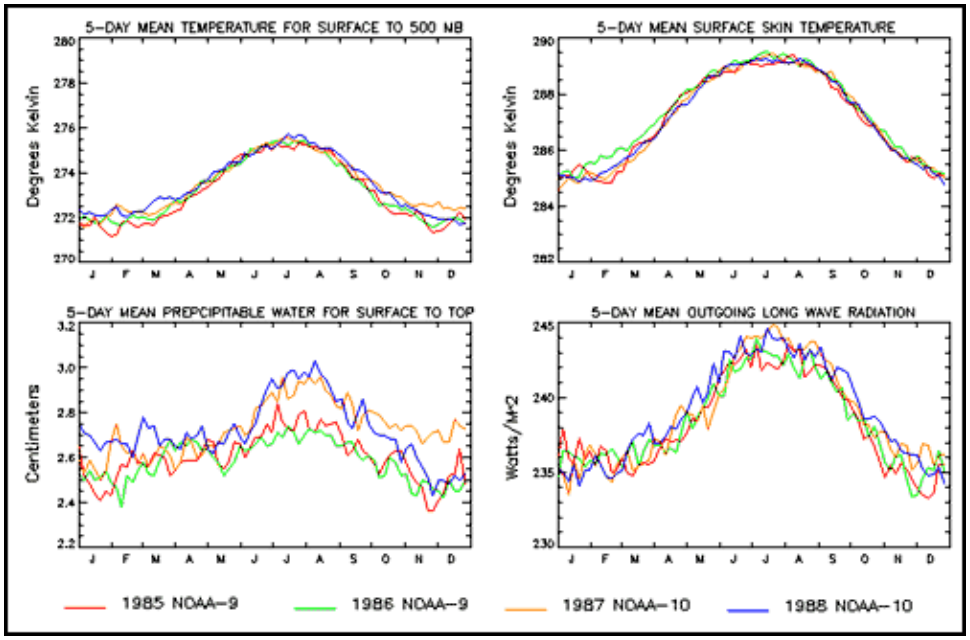


AVERAGE 1985 MONTHLY PRECIPITABLE WATER ABOVE THE SURFACE, DERIVED FROM TOVS MEASUREMENTS TAKEN ABOARD THE NOAA-9 SPACECRAFT. The precipitable water represents the vertically integrated water vapor from a particular pressure level (in this case, the surface) to the top of the atmosphere. In addition monthly averages of the precipitable water above 850 mb, 700 mb, 500 mb, 300 mb are also available.

2.What can I do with these data?

2.1 Measure Climatic Change

With a sufficiently long data record, climatic change may be discernible by averaging quantities such as temperature, moisture, and outgoing longwave radiation (OLR) over weekly or monthly periods and then using statistical techniques to isolate any possible trends in the data.



5-day means for temperature, surface skin temperature, precipitable water, and outgoing longwave radiation

2.2 ObserveEl Niño Phenomena

"El Niño" (Spanish for the Christ child) is the most important climate phenomenon known on a multi-year time scale. The name El Niño has been used by Peruvian fishermen for a long time to identify a phenomenon of warming of the ocean surface waters, often occurring at the end of the year and lasting for several months. Nine events have been recorded in the past forty years. The occurrence of El Nino can be correlated with changes in precipitation patterns throughout the tropical Pacific ocean including Australia, South America and even portions of North America. The "El Niño" event for1986-1987 can be seen in the TOVSdata by taking the difference in the sea surface temperaturefor the months of April in 1987 and 1988.

3.What are the dataset parameters, temporal and spatial resolution and coverages?

Full Data Set: Parameters, Temporal and Spatial Resolution and Coverage

A set for seventeen parameter groups containing basic statistics such as the mean, standard deviation, and number of samples for each parameter within every 1 degree grid box is also available. The atmospheric temperature is reported at more pressure levels than in the case of the subsetted dataset described above. In addition, the data is packaged in HDF (Hierarchical Data Format), resulting in files that are self-documenting and readable on a variety of diverse computer architectures.Each HDF file is about 30 MBytes in size and contains the data for all parameters as well as metadata and annotations describing the data and its characteristics.These data are also available as global 5-day or monthly averages, but unlike the smaller data set above, separate files have been created for the daytime and nighttime portions of the orbits. The subsetted data was derived from the full HDF data set.

Parameter	Parameter Group		Dimensions	Description
TEMP	TEMP_STD	TEMP_COUNT	360x180x12	Vertical temperature profile at 12 levels
CLTEMP	CLTEMP_STD	CLTEMP_COUNT	360x180x4	Mean temperatures for 4 coarse layers
PRWAT	PRWAT_STD	PRWAT_COUNT	360x180x5	Total precipitable water above 5 levels
TSURF	TSURF_STD	TSURF_COUNT	360x180	Surface skin temperature
FCLD	FCLD_STD	FCLD_COUNT	360x180	Effecitve total cloud fraction
FCLDP	FCLDP_STD	FCLDP_COUNT	360x180x7	Effective cloud fraction, 7 ISSCP layers
PCLD	PCLD_STD	PCLD_COUNT	360x180	Effective cloud top pressure
TCLD	TCLD_STD	TCLD_COUNT	360x180	Effective cloud top temperature
ZANGLE	ZANGLE_STD	ZANGLE_COUNT	360x180	Effective satellite zenith angle
TIME	TIME_STD	TIME_COUNT	360x180	Time of day
QFLAG	QFLAG_STD	QFLAG_COUNT	360x180	Quality flag
TOZ	TOZ_STD	TOZ_COUNT	360x180	Total ozone index
OLR	OLR_STD	OLR_COUNT	360x180	Outgoing longwave radiation
LCRF	LCRF_STD	LCRF_COUNT	360x180	Longwave cloud radiative forcing
PRECIP	PRECIP_STD	PRECIP_COUNT	360x180	Precipitation estimate
SPHUM	SPHUM_STD	SPHUM_COUNT	360x180x5	Specific humidity profile at 5 levels
PSURF	PSURF_STD	PSURF_COUNT	360x180	Model forecast surface pressure

4.What makes this dataset unique?

It provides full global coverage of surface thermal properties and the vertical distribution of temperature and moisture in the atmosphere on a daily basis. Thus it provides important information pertaining to the entire three dimensional structure of the atmosphere and its evolution with time.

Because this dataset has been generated with a single, fixed algorithm, and because considerable care has been taken to remove systematic biases, the data may potentially be used to detect long term climate change once a sufficiently long record of historical TOVS measurements has been processed.

The data set comes principally from satellite measurements but the results are also constrained to be dynamically consistent with a global circulation model (GCM), which provides an optimal measure of the state of the atmosphere for each 6-hour synoptic period.The system also uses in-situ measurements from radiosondes, ships and buoys to remove systematic biases in both the measured radiances and the derived temperature and moisture profiles (see Susskind et al., 1984).

5.What kind of hardware and software do I need?

The **Path A and B** data currently supported by GES DISC are in **HDF4** format, and are "externally" compressed. They need to first be "unzipped", before attempting to read the files with any HDF-compatible software package or tool. The utility "gzip" can do the unzipping. To open and read the uncompressed HDF file, various packages and tools can be used: IDL, MatLab, Fortran, HDFview, etc. (NASA does not endorse one commercial package over another.)

Command-line utilities from the HDF Group, like **ncdump** and **hdp**, can be used to quickly see the file content, and even dump out data in binary or ASCII (text) format. The **hdp** with the "dumpvd" option, makes it extremely easy to see TOVS data file annotation. E.g.:
>hdp dumpvd TOVS_5DAYS_AM_B940131.E940204_ND.HDF
will print on the monitor a detailed annotation for the dataset.

Desktop:
The HDF Group also provides a simple tool with java-based user interface, HDFView. This tool is very convenient to explore HDF files content, and produce simple graphic and image previews.

Fortran:
Simple Fortran routines, legacy from earlier years of TOVS support, can be found in this TAR archive. They, however, need to be compiled. Compiling guidance is provided in the README packaged with the fortran code in the TAR.

6.How can I get these data?

There are two basic ways to get TOVS Path-A and -B data from GES DISC: i) Anonymous FTP, and ii) Interactive search using Mirador.

- Anonymous FTP: **ftp://disc1.gsfc.nasa.gov/data/s4pa/tovs**

  The directory tree on the FTP server have the patterns:

  TOVSA [D,5,M] [NT,NF,NG,NH,ND] Or
  TOVSB [D,5,M] [NG,ND]

  Where:
  A,B - Path-A,B
  [D,5,M] - stands for Daily, 5-day (pentad), and Monthly

[NT,NF,NG,NH,ND] - which satellite, correspondingly: TIROS-N, NOAA-F,G,H,D

- Interactive, Mirador: **http://mirador.gsfc.nasa.gov**

References

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Glossary of Terms and Acronyms

- **AIRS:** Atmospheric InfraRed Sounder
- **Ascending Orbit (AM Orbit):** A polar orbit traversing from the south pole to the north pole.For the NOAA sun synchronous polar orbital satellites this orbit crosses the equator during daylight hours.
- **Descending Orbit (PM Orbit):** A polar orbit traversing from the north pole to the south pole.For the NOAA sun synchronous polar orbital satellites this orbit crosses the equator during nightime hours.
- **DAAC:** Distributed Active Archive Center, a repository for earth science data.
- **El Niño(Spanish for the Christ child)** This is the most important climate phenomenon known on a multi-year time scale. The name El Nio has been used by Peruvian fishermen for a long time to identify a phenomenon of warming of the ocean surface waters, often occurring at the end of the year and lasting for several months and which induces significant climactic change over the entire world.
- **FTP:** File Transport Protocol, a means of moving files over the Internet.
- **GCM:** Global Circulation Model, a time evolving simulation of the atmosphere using hydrodynamic equations that incorporates satellite measurements of the atmosphere with in-situ measurements to constrain the model.It can be used to interpolate between satellite and in-situ measurements or to predict future states of the atmosphere on a time scale of hours up to a few days.
- **HIRS/2:** High Resolution Infrared Radiation Sounder 2. The HIRS/2 instrument measures radiation emitted by the Earth- atmosphere system in 19 regions of the infrared spectrum between 3.7 and 15 microns. A visible channel is also available to measure the albedo of Earth's surface.

- **MSU:**The Microwave Sounding Unitinstrument is a four channel Dicke radiometer making passive microwave radiation measurements in four regions of the 50 GHz oxygen emission spectrum.
- **NOAA:** National Oceanic and Atmospheric Administration
- **In-situ Measurements:** Measurements of a phenomena at the spatial location where the phenomena is occurring such as by a radiosonde or a ship as opposed to remotely sensed data as by a satellite.
- **OLR:** Outgoing Longwave Radiation, energy radiated away from the atmosphere to space, integated over all frequencies in the earth's infrared spectrum (generally 2 to 20 microns)
- **Polar Orbit:** An orbit passing nearly over the poles.
- **Radiosonde:** A device carried by a weather balloon that measures atmospheric pressure, temperature, and moisture and transmits the measurements by radio to a ground station.There is a world wide network of radiosondes providing atmospheric measurementsup to 4 times daily.
- **Spatial Resolution:** the size of the smallest object recognizable using the detector.
- **Sun Synchronous:** An orbit that passes over the equator at the same local time each day.
- **SSU:** Stratospheric Sounding Unit, a three channel pressure modulated radiometer for sensing radiances emitted from the stratospheric part of the atmosphere.
- **TIROS**: Television InfraRed Observation Satellite
- **TOVS:** TIROS Operational Vertical Sounder, a suit of three instruments that measures upwelling radiation from the atmosphere from which surface properties, clouds, and the vertical structure of the atmosphere can be determined.