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The International Satellite Cloud Climatology Project H-Series Climate Data Record Product

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Abstract

This paper describes the new global long-term, International Satellite Cloud Climatology Project (ISCCP) H-Series climate data record (CDR). The H-Series data contains a suite of level 2 and level 3 products for monitoring the distribution and variation of cloud and surface properties to better understand the effects of clouds on climate, the radiation budget, and the global hydrologic cycle. This product is currently available for public use and is derived from both geostationary and polar orbiting satellite imaging radiometers with common visible and infrared (IR) channels. The H-Series data spans from July 1983 to Dec 2009 with plans for continued production to extend the record to the present with regular updates. The H-series data are the longest combined geostationary and polar orbiter satellite based CDR of cloud properties. Access to the data is provided in network Common Data Form (netCDF) and archived by NOAA's National Centers for Environmental Information (NCEI) under the satellite Climate Data Record Program (https://doi.org/10.7289/V5QZ281S). The basic characteristics, history, and evolution of the dataset are presented herein with particular emphasis on and discussion of product changes between the H-Series and the widely used predecessor D-Series product which also spans from July 1983 through December 2009. Key refinements included in the ISCCP H-Series CDR are based on improved quality control measures, modified ancillary inputs, higher spatial resolution input and output products, calibration refinements, and updated documentation and metadata to bring the H-Series product into compliance with existing standards for climate data records.

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1. Introduction

The International Satellite and Cloud Climatology Project (ISCCP) was established in 1982. Its intent was to produce a global, reduced resolution, calibrated infrared and visible radiance dataset with basic information on surface and atmospheric radiative properties and to derive global cloud characteristics from satellite data (Schiffer and Rossow, 1983). Today, ISCCP is the longest running international satellite-based global environmental data project. It delivers a 30+ year record of global cloud and surface radiative properties obtained from radiance images from the complementary geostationary and polar orbiting satellites. As a mark of the dataset's value, it has been cited in more than 15,000 articles with Rossow and Schiffer (1999), receiving over 1800 citations (Fig.1). This achievement can be attributed to the precedent set by the World Climate Research Program which aided ISCCP in establishing international collaborations to obtain, process, distribute, and archive data from U.S. and non-U.S. operated geostationary and polar imaging satellites. The collection of ISCCP applications and analyses demonstrate that ISCCP has made a significant contribution to advancing climate science and assessment.

However, the widely used ISCCP D-Series product has not been updated beyond December of 2009. In 2008, a large data stewardship effort by the National Climatic Data Center (now known as NCEI) led to the rescue of ISCCP B1 data with 10 km and 3 hourly spatial and temporal resolution (Knapp, 2008). This effort ultimately set the stage for ISCCP B1U (uniformly formatted B1) data to be input to ISCCP processing. The ISCCP algorithm and analysis has gradually matured based on new research results (Rossow, and Schiffer, 1991, 1999) and has been revised again with funding from the NASA MEASURES program and the NOAA Climate Data Record program exploiting more recent research results. More importantly the products have also evolved to use higher resolution and improved input data products and to transition the processing to an operational environment at NOAA.

In this paper, the updated ISCCP H-Series product is described with specific emphasis on the changes in the algorithm and products going from D- (Rossow and Schiffer, 1999) to H-Series (ISCCP C-ATBD, 2017) products. The sections below provide a description of the newly developed H-Series collection, comparison with its predecessor D-Series product, data access, caveats, and plans for future development under the stewardship of NOAA's National Centers of Environmental Information (NCEI).

2. ISCCP H-Series Processing

The primary instruments that serve as inputs to the ISCCP analysis are the imaging radiometers on operational weather satellites. These include the Advanced Very High Resolution Radiometer (AVHRR) on the polar orbiting satellites and a variety of imagers that fly onboard the geostationary satellites. ISCCP handles these data using five data processing streams (see Figure 2). These streams are labeled by the originating satellites:

- GMS: Japanese Geostationary Meteorological Satellite with a subsatellite longitude of ~140°E
- INS: Indian ocean sector coverage with a subsatellite at ~63°E
- MET: European and African sector coverage with a subsatellite longitude of ~0°
- GOE: Eastern United States and South American coverage with a subsatellite longitude of 75°W
- GOW: Pacific Ocean and Western United States coverage with a subsatellite longitude of 135°W

Two additional streams represent the Polar Orbiter (PO) data:

- NOA: Afternoon polar orbiting satellite stream
- NOM: Morning polar orbiting satellite stream

The combination of the geostationary and polar orbiting satellites allows ISCCP to establish an intercalibration procedure whereby radiances from imagers onboard the geostationary satellites are normalized to the low earth orbit AVHRR radiances from the afternoon polar orbiter satellite series. In this approach, NOAA-9 acts as the absolute reference through 2009 (Rossow and Ferrier, 2015). NOAA-18 now performs this function for 2010 and beyond. Although most of the imaging radiometers make measurements of radiation emitted from earth at multiple spectral wavelengths, the H-Series ISCCP analysis uses only the visible (VIS ≈ 0.65µm wavelength) and infrared (IR ≈ 10.5 µm wavelength) "window" channels to derive cloud and surface properties. In previous versions of the ISCCP, data products have relied on B3 data with 3-hour and 30 km temporal and spatial resolution (Rossow and Schiffer, 1985). The primary geostationary input to ISCCP H-Series is B1U data which has 3-hour and ~10 km temporal and spatial resolutions. ISCCP ancillary products have also undergone modifications. Table 1, shows the details of D- to H-Series changes. In general, the updated input and ancillary data products yield a more consistent record for the reprocessing of higher resolution cloud products.

3. ISCCP H-Series Cloud Detection

The ISCCP H-series cloud detection algorithm and retrievals are generally minor revisions of the D-Series algorithm and retrievals in four steps. First, tests of the space and time variations of the observed radiances at several scales are used to estimate cloud-free radiances. Results of the space-time tests are used in conjunction with the ancillary products to obtain a global composite of clear sky radiances for each image pixel location and time. Second, cloudy conditions are diagnosed when IR or VIS observed satellite radiances sufficiently deviate from estimated values using various combinations of VIS and IR thresholds (Rossow and Garder 1993a,b, Rossow et al. 1993). Third, the properties of the surface are retrieved from the clear-sky radiances with the help of ancillary data describing the properties of the atmosphere. Lastly, the properties of clouds are retrieved from the cloudy-sky radiances using the retrieved surface properties and the ancillary atmospheric data (Rossow and Schiffer 1991, 1999).

Differences in the D- and H-Series cloud detection algorithm include the following modifications: (1) added a new radiance space contrast test inside regions of land-water mixtures, (2) updated surface type categories for algorithm tests to improve cloud tests in rough topography, (3) revised daytime cloud detection over snow and ice by eliminating 3.7 µm tests since this channel is not available for all AVHRR datasets over the whole period of record and implemented simpler test for reversed VIS radiance contrast situations to improve homogeneity of record, (4) improved summertime polar cloud detection by reducing VIS thresholds over snow and ice, and (5) improved wintertime polar cloud detection by changing marginally cloudy to clear and marginally clear to cloudy. Otherwise, the current H-Version

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(v01r00) of the ISCCP cloud detection algorithm is the same as the D-Version which is a modification of the C-Version. Hence, all publications regarding the first two versions of ISCCP products are also relevant to the H-Series algorithm.

Likewise the differences in the D- and H-Series surface and cloud retrievals are generally small changes in the assumptions in the radiative transfer calculations that they are based on. The most notable changes are listed in the next Section.

4. ISCCP H-Series Products

4.1. H-Series Products

The ISCCP D-Series algorithm relied on ISCCP Stage B3 data with spatial and temporal resolutions of 30 km and 3 hours for geostationary satellites. Thus, the highest resolution D-Series data produced was the 30-km 3-hourly product for individual satellites known as DX. Downstream level 3 products included D1 (global and 3 hourly) and D2 (monthly mean) products on an equal area grid with a spatial interval of 280 km (2.5 degree equivalent). In comparison, the ISCCP H-Series products rely on ~10 km and 3 hourly B1U data and polar orbiter data sampled to ~10 km intervals. The Level 2 products are HXS and HXG and Level 3 products are HGS, HGG, HGH, and HGM. The products have the following descriptions:

- **HXS** (**H**-Series pi**X**el-level by **S**atellite) provides pixel level results of cloud and surface properties retrieved or used in the retrieval for each individual satellite image in nearly the original projection for geostationary satellites and for groupings of orbit swaths for polar orbiter data in six midlatitude (ascending and descending swaths in 120° longitude sectors) and two polar sectors. HXS is like the old DX product.
- **HXG** (**H**-Series pi**X**el-level **G**lobal) is a global merger of the information from HXS common to all satellites and is mapped and provided every 3 hrs on a 0.10-degree equal angle grid (~240 files per month).
- **HGS** (**H**-SERIES **G**ridded by **S**atellite) reduces the HXS Product to the 1-degree-equal angle grid with additional statistical and cloud type information, and combines these

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results with the information from the ancillary data products prior to the global merger. HGS is like the old DS (which was never released).

- **HGG** (**H**-Series **G**ridded **G**lobal) is the global merger of the HGS products from all available satellites, where overlapping coverage is resolved in favor of the satellite with the best viewing geometry with a preference for geostationary results at lower latitudes and polar orbiter results in the polar regions. The time interval is 3 hr and the map grid is 1-degree-equal area grid. The HGG product is the H-Series analog to the D1 product and should be regarded as the main ISCCP Cloud Product.
- **HGH** (**H**igh-resolution **G**lobal **H**ourly) is the monthly 1 degree-equal area gridded average of the HGG product at each of the eight three hourly times-of-day (00Z, 03Z, 06Z, etc.) used in the ISCCP algorithm. This product is like the old D2 product.
- **HGM** (**H**igh-resolution **G**lobal **M**onthly) is the average of the eight HGH products for each month. This product is like the old D3 product.

All H-Series products, except HXS, are formatted in netCDF-4. Other differences in the D- and H-Series products include (1) revisions in the COUNTS-to-physical conversion tables to remove special values for underflow and overflow (2) increased uncertainty estimate information (3) missing observations are filled in the global, 3-hrly product (HGG) instead of the monthly product (the HXG product is also filled). A subset of the HGG, HGH, and HGM products are also available in a CF-compliant equal angle format known as ISCCP Basic. This product has fewer variables and a total volume of 305 GB.

Other changes between the D-Series and H-Series products include the following:

- **Radiance Calibrations from D-Version to H-Version:** (1) Anchor for VIS calibration extended to combined results for NOAA-9 (through 2009) and NOAA-18 (post 2009), spanning the whole record. (2) Overall IR calibration adjusted for small gain error in AVHRR calibrations compared to MODIS for all AVHRRs on NOAA-15 et seq (Cao and Heidinger, 2002). (3) Geostationary normalization procedure changed to use all of the radiance data directly instead of a small number of special samples – manual procedures eliminated (similar to that used by Inamdar and Knapp, 2015).

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- **VIS and IR Radiance Models from D-Version to H-Version:** (1) Replaced ocean VIS reflectance model with more accurate version that includes a better glint treatment. (2) Calculated instrument-specific ozone absorption coefficients. (3) Added water vapor above 300 mb level in atmospheric ancillary data. (4) Added treatment of stratospheric and tropospheric aerosol scattering and absorption. (5) Improved surface temperature retrieval by accounting for variations of surface IR emissivity by surface type. (6) Introduced more explicit atmospheric and cloud vertical structures for cloud retrievals. (7) Changed specified liquid cloud droplet effective radius from 10 µm everywhere to 13 and 15 µm over land and ocean, respectively. (8) Changed cloud top temperature value separating ice and liquid phase clouds from 260 K to 253 K. (9) Updated ice cloud scattering phase function to empirically-based model from satellite polarimetry observations and revised specified ice particle effective radius from 30 µm for all clouds to 20 and 34 µm for clouds with TAU < 3.55 and TAU ≥ 3.55, respectively. (10) Corrected placement of thin clouds from just above the tropopause to at the tropopause. (11) Added treatment of cloud top location when surface temperature inversions are present. (12) Updated solar ephemeris.

4.2. Product Variables

Beginning with the original C-Series product, ISCCP has delivered an extensive set of product variables. The cloud properties include (but are not limited to) the following:

- Cloud Amount
- Cloud Top Temperature, TC (in Kelvins)
- Cloud Top Pressure, PC (in mb)
- Cloud Optical Thickness, TAU (unitless)
- Cloud Water Path, CWP (in g/m^2)
- Cloud Phase
- Cloud Type

Surface properties include:

- Surface Temperature, TS (in Kelvins)
- Surface Reflectance, RS (unitless)

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Separate procedures are used to produce these data under daytime versus nighttime conditions (the nighttime procedure is applied day and night). In the H-Series Basic product introduced in Section 4.1 these variables are converted to their physical units. For a more detailed list of all ISCCP variables, please refer to the ISCCP Climate-Algorithm Theoretical Basis Document.

5. Basic Characterization of the ISSCP H-Series Monthly Cloud Amount

Given the higher resolution of the input data used to produce the H-Series products, the H-Series data yields improved geospatial results that will particularly enhance the capabilities for long-term regional scale evaluations of cloud characteristics and variations. Some impacts of the higher resolution input products are illustrated in Figure 3 showing the January 2009 monthly mean ISCCP Global Cloud Fraction (%) differences between H and D series (a) the H-Series HGM product at 1° (b) and the D-Series D2 product at 2.5° (c). As shown in (a) the differences between the products are greatest in the polar and coastal regions where for the case of January 2009 the H-Series product has a slightly lower cloud fraction (cf. 65.46% (H) and 66.29% (D)). On average, the differences between the H-and D-Versions of the ISCCP products are similar in magnitude. Differences are present due to the higher resolution input (B1U) data that impacts the assessment of clear/cloudy scenes (which increases the number of scenes with no or total cloud cover), enhanced efforts to gather and/or limit undesirable data from processing/production via QC, and changes in the analysis procedure described in Section 2.

In addition to the monthly H- and D-Series comparison provided in Figure 3, which gives users a monthly snapshot of the H- and D- series CF differences, Figure 4 provides the comparison of ISCCP H- and D-Series monthly mean cloud fraction (%) for July 1983 through Dec. 2009 for a) global, b) land, and c) water. The global mean differences are on average ~0.21% which demonstrates that the H-Series product generally captures a slightly higher cloud fraction compared to D-Series data. However, H- and D- differences follow a seasonal pattern whereby months from November through April on average show that H-Series CF is slightly lower than the D-Series product and during May-October, H-Series data CF is slightly higher than the D-

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Series product: this difference is due mainly to the impact of the algorithm changes over the polar regions, more significantly over Antarctica. As displayed in Figure 4 b) and c) the monthly mean land cloud fraction for both H- and D- is generally less than the CF reported for water. The land CF also reflects a higher percentage of the global mean differences (0.16%) compared to water (-0.06%). Other components of the comparison between H- and D- data reveal that the inclusion of MACv1 for the treatment of stratospheric and tropospheric aerosols, which were not included in the D-Series product, has a considerable impact on the cloud fraction particularly during periods that experience a volcanic eruption. This is shown by the spike in CF in the summer of 1991 due to the Mount Pinatubo eruption in June of 1991.

6. Product Caveats

There are some caveats that users should be aware of that primarily involve the absence of some data in the initial release of the product.

The following is a list of issues and caveats users should know.

- General notes:
    - **Calibration D to H** - ISCCP H series calibration follows the method and process of the ISCCP D series. Any calibration issues present in ISCCP D will also be present here. Any analysis of long-term trends in cloud cover addressed using the D-Series data should be considered in any evaluation of the H-Series assessment.
    - **Spatio-temporal series analysis** - ISCCP H series cloud algorithm is mostly unchanged. The examination of the geographic distributions of average ISCCP cloud amounts continues to show artifacts in association with large changes in the average value of satellite zenith angle (Rossow and Garder, 1993b).
    - **Satellite coverage** - The ISCCP product is limited by the input geostationary datasets. These have gaps in coverage that are large (seen in the Geostationary Quilt) and small. The larger gaps are caused by satellite outages, or gaps in the geostationary ring. The smaller gaps can be up to a week in length and occur more often in the early years.
- Specific issues:

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- MET-3 1995 - Many files are missing visible channel.
- GMS-3 1986 - Many images in Feb-Apr are missing visible channels.
- The afternoon Polar Orbiter data (NOM) has a 2-year gap from 2000-2002 for the NOAA-15 to NOAA-17 transition. We have the data and just received status for the AVHRR instrument for this period. This will be resolved in future reprocessing.
- Cloud top pressure errors over Pacific for May 1994 (and possibly other months). This is caused by large view zenith angles in glint regions.

7. Product Access, Availability, and Future Development

ISCCP H-Series data are available for July 1983 - December 2009 with plans for updates beginning in September 2017 that will extend the record back to 1982 and forward to 2015. The record will be operationally maintained with annual updates beginning in 2018. The NOAA Climate Data Record of the ISCCP H-Series product, Version v01r00 is archived and distributed by NCEI's satellite Climate Data Record Program. The ISCCP H-Series products are maintained by and available from NOAA. The full set of ISCCP CDR products, as well as the ancillary data, are available through the Hierarchical Data Storage System (HDSS) Archive System (HDS) at http://has.ncdc.noaa.gov . The processing code and the Climate Algorithm Theoretical Basis Document (C-ATBD), which more fully outlines ISCCP H-Series production, can be accessed from https://www.ncdc.noaa.gov/cdr/atmospheric/cloud-properties-isccp. The ISCCP H-Series Basic CDR product can be downloaded via FTP or from the NCEI THREDDS data server (https://doi.org/10.7289/V5QZ281S). Users are also requested to register at https://www.ncdc.noaa.gov/isccp.

The future development of the ISCCP H-Series products includes the following options ƒ in order of priority:

- Setting up the ISCCP system to process the newer geostationary and polar orbiter imagers (e.g., Himawari-8 and GOE S-R) to extend the data record through the present with operational plans for annual updates.

- Improvements to satellite calibration particularly to increase the calibration consistency between adjacent geostationary satellites.
- Continued efforts for backfilling missing data to develop a more complete record.

8. Conclusions

ISCCP H-Series data is now a component of NOAA's suite of Climate Data Records and will be operationally produced and updated by NOAA NCEI. Research users are encouraged to use the ISCCP products described herein to investigate cloud processes in weather and climate. The ISCCP Basic product is suitable for software applications that allow for ease in viewing and handling netcdf files (i.e., Weather Climate Toolkit, Panoply, ToolsUI, etc.). Future improvements and versions will be driven by user requirements.

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10. References

Armstrong, R. L., & Brodzik, M. J. (2005). Northern Hemisphere EASE-Grid weekly snow cover and sea ice extent version 3. *National Snow and Ice Data Center, Boulder, CO, digital media.[Available online at http://nsidc. org/data/nsidc-0046. html.]*.

Brown, R. D., & Robinson, D. A. (2011). Northern Hemisphere spring snow cover variability and change over 1922–2010 including an assessment of uncertainty. *The Cryosphere*, *5*(1), 219-229.

Cao, Changyong, and Andrew K. Heidinger. "Inter-comparison of the longwave infrared channels of MODIS and AVHRR/NOAA-16 using simultaneous nadir observations at orbit intersections." *Earth Observing Systems VII*. Vol. 4814. 2002.

Chesters, D, A. Neuendorffer, 1991: Comparison between TOMS, TOVS, and DOBSON observations: Satellite and surface views of total column ozone. Palaeogeography Palaeoclimatology, 90, 61-67.

Inamdar, A. K. and K. R. Knapp, 2015: Intercomparison of Independent Calibration Techniques Applied to the Visible Channel of the ISCCP B1 Data. J. Atmos. Oceanic Technol., 32, 1225–1240. doi: http://dx.doi.org/10.1175/JTECH-D-14-00040.1

Kinne, S., O'Donnel, D., Stier, P., Kloster, S., Zhang, K., Schmidt, H., ... & Stevens, B. (2013). MAC-v1: A new global aerosol climatology for climate studies. *Journal of Advances in Modeling Earth Systems*, *5*(4), 704-740.

Knapp, K. R., 2008: Scientific data stewardship of International Satellite Cloud Climatology Project B1 global geostationary observations. *Journal of Applied Remote Sensing*, 2, 023548, doi:10.1117/1.3043461.

Kroon, M., J.F. de Haan, J.P. Veefkind, L. Froidevaux, R. Wang, R. Kivi and J.J. Hakkarainen, 2011: Validation of operational ozone profiles from the Ozone Monitoring Instrument. J. Geophys. Res., 116, D18305, doi:10.1029/2010JD015100.

Liu, X., P.K. Bhartia, K. Chance, L. Froidevaux, R.J.D. Spurr and T.P. Kurosu, 2010: Validation of Ozone Monitoring Instrument ozone profiles and stratospheric ozone columns with Microwave Limb Sounder measurements. Atmos. Phys. Chem., 10(5), 2539-2549, doi:10.5194/acp-10-2539-2010.

Loveland, T. R., Reed, B. C., Brown, J. F., Ohlen, D. O., Zhu, Z., Yang, L. W. M. J., & Merchant, J. W. (2000). Development of a global land cover characteristics database and IGBP DISCover from 1 km AVHRR data. *International Journal of Remote Sensing*, *21*(6-7), 1303-1330.

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Matthews, E. (1983). Global vegetation and land use: New high-resolution data bases for climate studies. *Journal of climate and applied meteorology*, *22*(3), 474-487.

Neuendorffer, A.C., 1996: Ozone monitoring with TIROS-N operation vertical sounders. J. Geophys. Res., 101, D13, 18807-18828.

Rossow, W.B., and R.A. Schiffer, 1991: ISCCP cloud data products. *Bull. Amer. Meteorol. Soc.*, **71**, 2-20.

Rossow, W.B., and J. Ferrier, 2015: Evaluation of long-term calibrations of the AVHRR visible radiances. J. Atmos. Ocean. Technol., **32**, no. 4, 744-766, doi:10.1175/JTECH-D-14-00134.1.

Rossow, W.B., and R.A. Schiffer, 1999: Advances in understanding clouds from ISCCP. Bull. Amer. Meteorol. Soc., **80**, 2261-2288, doi:10.1175/1520-0477(1999)080<2261:AIUCFI>2.0.CO;2.

Rossow, W. R.: Climate Data Record Program (CDRP): Climate Algorithm Theoretical Basis Document (C-ATBD) International Satellite Cloud Climatology Project (ISCCP) H-Series , CDRP-ATBD-0872, Asheville, Northl Carolina, USA, 179 pp., 2017.

Rossow, W.B., and L.C. Garder, 1993a: Validation of ISCCP cloud detections. *J. Climate*, **6**, 2370-2393, doi:10.1175/1520-0442(1993)006<2370:VOICD>2.0.CO;2.

Rossow, W.B., and L.C. Garder, 1993b: Validation of ISCCP cloud detections. J. Climate, **6**, 2370-2393, doi:10.1175/1520-0442(1993)006<2370:VOICD>2.0.CO;2.

Rossow, W.B., A.W. Walker, and L.C. Garder, 1993: Comparison of ISCCP and other cloud amounts. *J. Climate*, **6**, 2394-2418, doi:10.1175/1520-0442(1993)006<2394:COIAOC>2.0.CO;2.

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Schiffer, R.A., and W.B. Rossow, 1983: The International Satellite Cloud Climatology Project (ISCCP): The first project of the World Climate Research Programme. *Bull. Amer. Meteorol. Soc.*, **64**, 779-784.

Schiffer, R.A., and W.B. Rossow, 1985: ISCCP global radiance data set: A new resource for climate research. *Bull. Amer. Meteorol. Soc.*, **66**, 1498-1505, doi:10.1175/1520-0477(1985)066<1498:IGRDSA>2.0.CO;2.

Shi, L., Matthews, J. L., Ho, S. P., Yang, Q., & Bates, J. J. (2016). Algorithm development of temperature and humidity profile retrievals for long-term HIRS observations. *Remote Sensing*, *8*(4), 280.

Stolarski, R.S., R. Bloomfield, R.D. McPeters and J.R. Herman, 1991: Total ozone trends deduced from Nimbus 7 TOMS data. Geophys. Res. Lett., 18, 1015-1018.

Yan, S-K., S. Zhou and A.J. Miller, 2006: SMOBA: A 3-dimensional daily ozone analysis using SBUV/2 & TOVS measurements (http://www.cpc.noaa.gov/products/stratosphere/SMOBA/smoba_doc.shtml)

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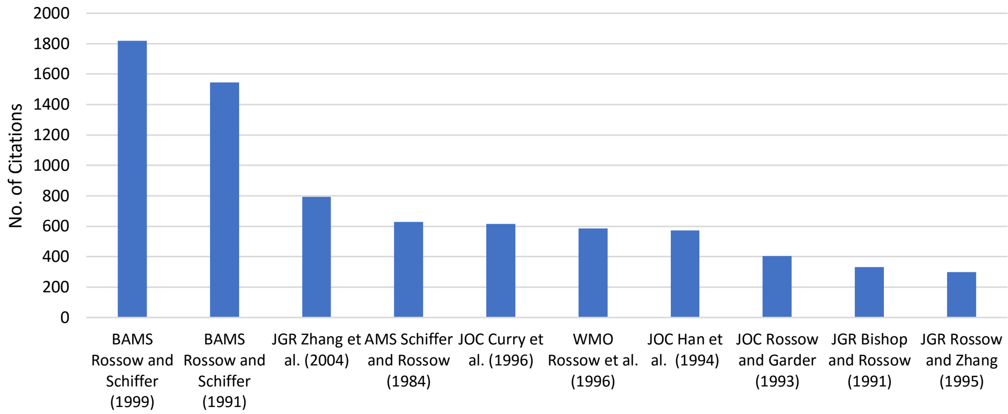

Figure 1. ISCCP ten most cited papers that have contributed to the dataset's more than citations. The number of citations given here is based on Google Analytics.

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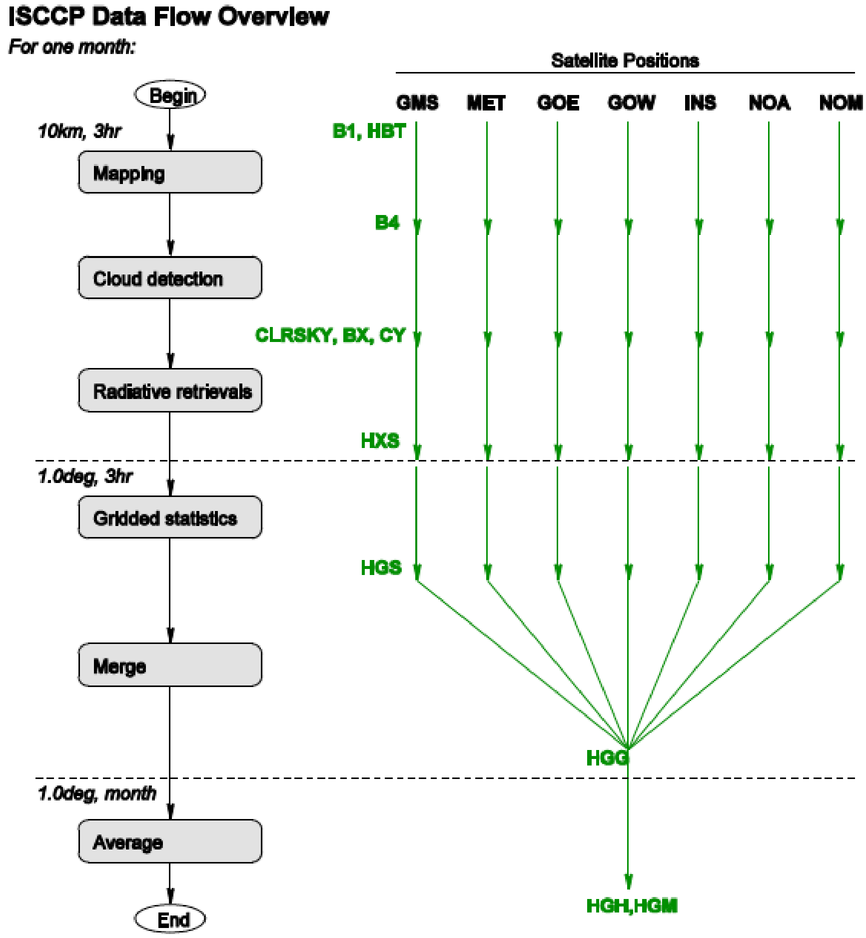

Figure 2. ISCCP Production data flow overview with satellite processing streams defined for 5 geostationary data streams (GMS at 140°E, MET at 0°, GOE at 75°W, GOW at 135°W and INS at ~63°E). Left side of image, shows important steps in ISCCP H-Series data processing that feed into the various products for HXS, HGS, HGG, HGH, and HGM.

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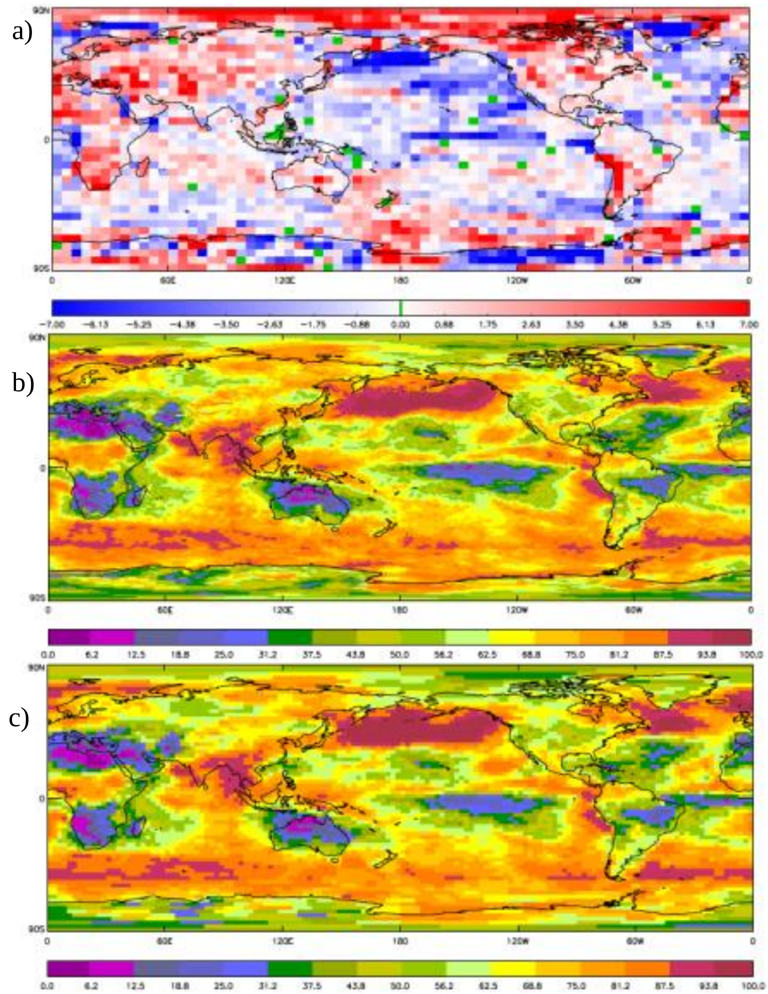

Figure 3. January 2009 ISCCP Global Cloud Amount % for a) differences between H and D series, b) H-Series HGM product at 1° and c) D-Series D2 product at 2.5°. As shown, in a) the differences between the products are greatest in the polar and coastal regions where for this case the H-Series product has a slightly higher cloud fraction. In general, the distributions of cloud amount have good agreement.

Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2017-73
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Discussion started: 9 August 2017

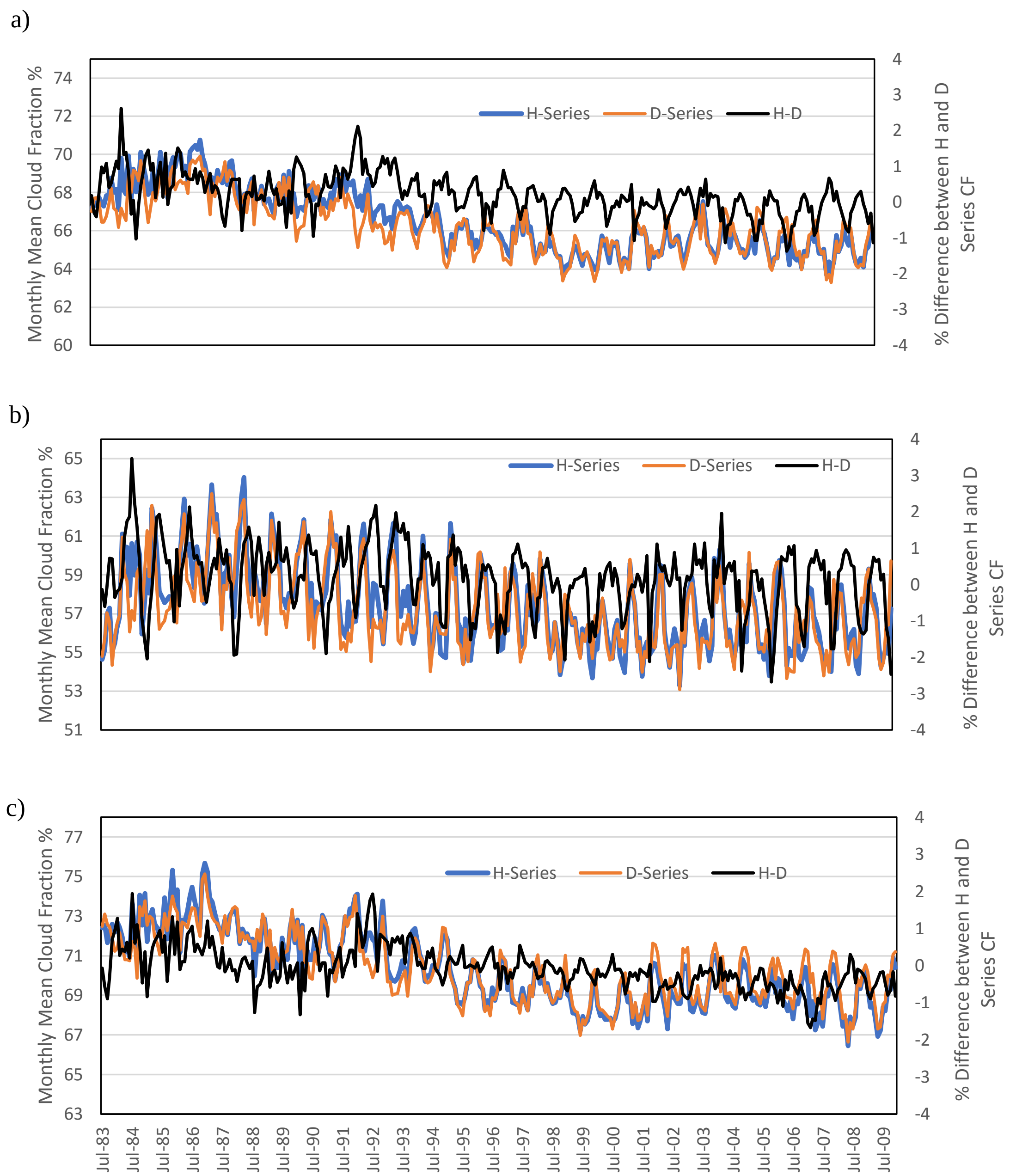

Figure 4. Comparison ISCCP H- (blue) and D-Series (orange) and differences between H- and D- (black) monthly mean cloud fraction (%) for July 1983 through Dec. 2009 for a) global b) land, and c) water.

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List of Tables and Captions

	Version	Product	Description	Product Reference	Product Resolution
Atmospheric Profiles	H	nnHIRS	Neural Network Analysis of High-resolution Infrared Radiometer Sounder (HIRS) and Stratospheric Water and Ozone Satellite Homogenized data	Shi *et al.* 2016	3-hourly global 1°equivalent equal-area grid
	D	TOVS	Atmosphere and surface data including temperature structure, water, and ozone abundances obtained from the TIROS Operational Vertical Sounding (TOVS) Product and supplemented by two climatologies		Daily 280 km equivalent equal-area grid
AEROSOL	H	MACv.1	Merges surface based aerosol emission data from AERONET and satellite products from MODIS and MISR, with the median results from an ensemble of emission-transport models.	Kinne *et al.* 2013	Monthly 1° equivalent equal-area grid
	D	n/a			
OZONE abundance	H	TOMS, TOVS, SMOBA, OMI	Daily variations of the global distribution of total column ozone abundance from a combination of satellite based instruments. Data is reported at 16 vertical levels.	Stolarski et al. 1981, Kroon et al. 2011, Chesters et al. 1991, Neuendorffer et al. 1996, Yan et al. 2006	daily 1° equivalent equal-area grid
	D	TOVS	The main data set used to produce a daily, global description of the ozone, temperature and humidity distributions is that obtained from the analysis of data from the TIROS Operational Vertical Sounder (TOVS) System. Data is reported at 10 vertical levels.	ISCCP Science Team doi: 10.5067/ISCCP/TOVS_NAT	Daily 280 km equivalent equal-area grid
SNOW/ICE cover fraction	H		Northern Hemisphere EASE-Grid Weekly Snow Cover and Sea Ice Extent (Version3), NOAA NSIDC IMS Daily Northern Hemisphere Snow and Ice Analysis, OSI-SAF Global Sea Ice Concentration Reprocessing Dataset, GLIMS permanent glacier cover product	Brown and Robinson 2011, Amstrong *et al.* 2005	daily 0.25° equivalent equal-area grid
	D		Averages of snow and sea ice fractional coverage deduced from ship/shore station reports and satellite visible, infrared, and microwave imagery data	ISCCP Science Team (1999)	112 km equal area grid, 5-days, global
SURFACETYPE	H		USGS EROS GTOPO30 product reconciled with the USGS Global Land 1-KM AVHRR Project land-water mask		Fixed 0.25° equivalent equal-area grid
	D		CIA summary of what was known		
TOPO	H		MODIS IGBP surface type classification	Loveland *et al.* 2009	Fixed 0.10° equivalent equal-area grid

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	D		**Global Vegetation Types, 1971-1982 (Matthews)** A global digital data base of vegetation was compiled at 1 degree latitude by 1 degree longitude resolution, drawing on approximately 100 published sources.	Matthews, 1983 doi:10.3334/ORNLDAAC/419	Fixed 1.0°

Table 1: List of H-Series and D-Series ancillary data products including in producing ISCCP Cloud and Surface Products.