Project Name: Sustained generations of upper tropospheric humidity Climate Data Records from multiple sensors with multi-agency cooperation

Project leader:
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Team composition:
John Bates, NOAA NESDIS National Climatic Data Center, Asheville, NC, USA
Stefan Buehler, Lulea University of Technology, Kiruna, Sweden
Shu-peng Ho, National Center for Atmospheric Research, Boulder, CO, USA
Viju John, Met Office Hadley Centre, Exeter, UK
Marc Schröder, Deutscher Wetterdienst, Satellite Based Climate Monitoring, Offenbach, Germany
Lei Shi, NOAA NESDIS National Climatic Data Center, Asheville, NC, USA
Brian Soden, University of Miami, Rosenstiel School of Marine & Atmospheric Science, Miami, FL, USA

Identification of satellite CDR capability

The upper tropospheric humidity (UTH) (also named as free tropospheric humidity (FTH)) is one of the Global Climate Observing System (GCOS) atmospheric Essential Climate Variables (ECVs). The datasets have been derived from the High Resolution Infrared Radiation Sounder (HIRS) since late 1978, from the Advanced Microwave Humidity Unit-B (AMSU-B) and the Microwave Humidity Sounder (MHS) since late 1998, and from Meteosat Visible and InfraRed Imager (MVIRI) and Spinning Enhanced Visible and InfraRed Imager (SEVIRI) since 1983. These satellite records have been improved by newly developed bias correction and improved homogenization procedures. Multiple sensors from different space agencies provide over three decades of daily data with near-global coverage.

For much of this period, there are multiple sensors in operation and this redundancy is critical to identify and correct for artifacts which arise from orbital drift and sensor calibration drift. Data sets from multiple sensors are complementary with varying strengths and weaknesses. For example, the infrared datasets cover longer time periods, starting from late 1978 for HIRS and from 1983 for Meteosat imagers, for long-term climate studies, however their clear-sky requirements for water vapor measurement can lead to dry biases for certain applications. The microwave sensors, on the other hand, affected by only ice clouds in upper troposphere, provide much better spatial coverage, however the data records are shorter, starting from late 1998. The UTH/FTH data from these three major sources complement each other in providing a full picture of the upper tropospheric water vapor. The good redundancy of these records from multiple sensors in recent years facilitates the examination of the homogeneity and stability of each satellite data record and to explain the differences among data records.

Justification of project

UTH plays a significant role in the radiative and hydrological feedback in the climate system. The dataset provides important information on the variability and change of large-scale atmospheric circulations. Studies have shown that UTH variations are closely associated with the

El Nino – Southern Oscillation and are closely correlated with major climate indices. UTH datasets also facilitated evaluation of climate model simulations. In recent years considerable work has been put into inter-satellite calibration to form homogenized time series from polar orbiting infrared and microwave sensors and from geostationary satellite sensors. Time series independently generated from each sensor and measurements from Global Positioning System (GPS) Radio Occultation (RO) provide means for inter-checking potential problems in certain time periods or certain areas in each sensor's dataset. Inter-comparison of data from different sensors can also lead to a better understanding of the differences. As this proposal is a coordinated activity among several government agencies and universities, we will exchange standards on software coding, metadata, and other data generation practices developed in each institution and strive to confirm to common standards.

Under the SCOPE-CM framework, the UTH project will follow SCOPE-CM's guidance on archiving satellite metadata, maintain appropriate data format for archived data, ensure accessibility, perform re-processing with improved inter-satellite calibration, and maintain sustained generation of UTH products for climate monitoring. The process aims at advancing maturity levels established by the SCOPE-CM Maturity Matrix Model.

Current and targeted maturity level

UTH datasets are derived from three groups of satellite sensors: HIRS, SSM-T2/AMSU-B/MHS, and MVIRI/SEVIRI. The following tables list the current maturity level for each dataset, where maturity levels are defined as in "Bates, J. J., and J. L. Privette (2012), A maturity model for assessing the completeness of climate data records, Eos Trans. AGU, 93(44), 441". In the tables, 1 represents minimum and 6 represents maximum maturity.

Current maturity level for HIRS upper tropospheric water vapor (UTWV, i.e., HIRS channel 12 brightness temperature; UTH is derived from UTWV):

Software Readiness	Metadata	Documentation	Product Validation	Public Access	Utility
3	2	1	2	3	5

Current maturity level for SSM-T2/AMSU-B/MHS UTH:

Software Readiness	Metadata	Documentation	Product Validation	Public Access	Utility
1	1	1	3	3	5

Current maturity level for METEOSAT MVIRI/SEVIRI FTH:

Software Readiness	Metadata	Documentation	Product Validation	Public Access	Utility
2	2	2	3	3	4

We propose that each of these datasets will reach the following maturity level at the completion of the project:

Targeted maturity level:

Software Readiness	Metadata	Documentation	Product Validation	Public Access	Utility
5	4	4	4	4	5

Expected results, challenges and potential contributions

Software Readiness: We will process HIRS, SSM/T-2, AMSU-B, MHS, and ATMS FCDR in an operational environment and ensure that the processing is stable and reproducible. It is expected that the METEOSAT FCDR will be provided by EUMETSAT. A fall back solution is an improved homogenization tool. Software will be developed for release of METEOSAT datasets with increased spatial and temporal resolution as well as coverage. In developing software we will strive to confirm to common program coding standards.
In cooperation with French partners, a geo-ring FTH demonstrator product will be developed which will cover the tropics and subtropics (within 45°N/S, all longitudes) and a short period in recent years. This activity contributes to the SCOPE-CM activity ICOG.

Metadata: The datasets will comply with netCDF CF format. We will consider following the same naming conventions where applicable and same gridding resolution where reasonable, thus products derived among different sensors can be easily analyzed and compared.

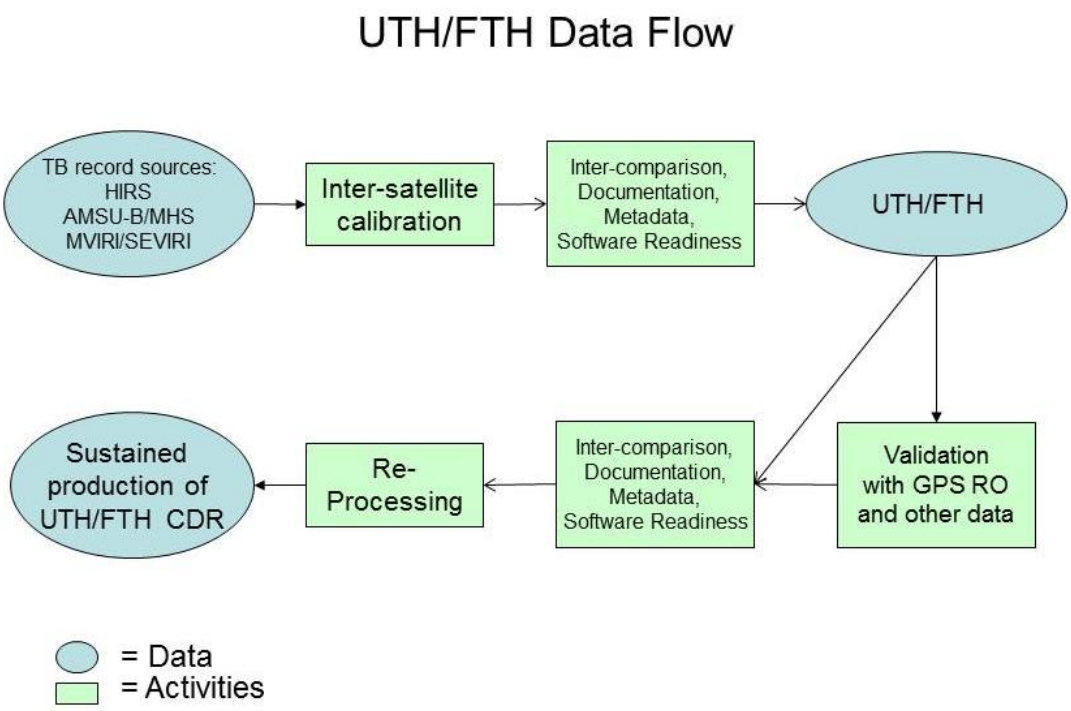
Documentation: We will complete C-ATBD for FCDR and TCDR products where applicable describing the correction procedures, for example, inter-satellite biases, scan-dependent biases, orbit drift correction. DOI numbers will be assigned to the products.

Product Validation: We will leverage efforts from our involvement with other programs such as the GEWEX Water Vapor Assessment and other projects. The UTH datasets will be validated using independent measurements including GPS RO data. UTH products as well as level 2 brightness temperatures among infrared and microwave observations and among polar-orbiting and geostationary data will be inter-compared. We will document the consistency and differences among UTH datasets.

Public Access: Data and source codes will be archived. We will follow perspective agency's policies in making data and source code publicly available. Where available, uncertainty estimates and known issues will be provided.

Utility: We will do comparisons with reanalyses and climate model simulations. Also, we will use the data for studies such as monsoon variability, MJO. Further analysis to enhance usability by climate modelers and elsewhere is planned. One of such activities is to assess the possibility to jointly contribute relevant UTH/FTH data sets for the Observations for Model Intercomparison Projects (obs4MIPs) project.

The following flowchart provides a schematic view of the data flow of the targeted UTH/FTH CDRs.



Expected project duration and tentative schedule

The duration for this proposal is expected to be 4-years (mid-2013 to mid-2017). Tentative schedule is provided in the following.

Year 1

- Please see the work plan for the first year.

Year 2

- Improve software coding to conform to common program coding standards.
- Coordinate metadata standards.
- Complete C-ATBD for both FCDR and TCDR products describing the correction procedures, for example, inter-satellite biases, scan-dependent biases, orbit drift correction.
- Adapt METEOSAT processing to new cloud mask and FCDR.
- Inter-compare both level 2 and UTH among several sensor sources.
- Validate UTH using independent measurements such as GPS RO data.
- Add capabilities in Cloud Feedback Model Intercomparison Project (CFMIP) Observation Simulator Package (COSP) for Tb to UTH conversion for all the sensors we are proposing.

Year 3

- Improve operational processing capability of UTH.

- Partly re-process UTH using up-to-date FCDRs.
- Document validation findings.
- Compare satellite derived UTH with climate model simulations.
- Use the data for studies such as monsoon variability and MJO.

Year 4

- Re-process full time series UTH using up-to-date FCDRs.
- Regularly process polar-orbiting UTH.
- Continue inter-comparison of UTH datasets from different sensors and other independent measurements.
- Submit papers for publications.
- Archive data and source codes. Data and sources codes are in version control.
- Follow perspective agency's policies in making data and source code publicly available.

Funding situation

John Bates and Lei Shi are funded by an NCDC internal operation fund. Viju John is funded by the Met Office Hadley Centre climate program and EUMETSAT CM SAF. Marc Schröder is funded by DWD and EUMETSAT CM SAF. Stefan Buehler is funded by internal University resources. Funding is needed to carry out the UTH evaluation using GPS RO data.

Needed and available processing capabilities

NCDC has an archive of HIRS level1b data from 1978 to present. Current computer capability is sufficient for HIRS UTH processing. Lulea University of Technology has all AMSU-B/MHS data and the computer capability for UTH processing. The university also currently offers gridded UTH data products for public download. DWD has an archive of METEOSAT SEVIRI level1.5 data. Current computer capability is sufficient for METEOSAT FTH processing. The FTH edition 1 data record will be released in February 2013, after close out and will be available free of charge at www.cmsaf.eu/wui.

Curriculum vitae

Curriculum vitae for the following key investigators are attached.

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Shu-peng Ho	NCAR	1-303-497-2132	spho@ucar.edu
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Dr. John J. Bates
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Education

Ph.D. Meteorology, 1986, University of Wisconsin, Madison

M.S. Meteorology, 1982, University of Wisconsin, Madison

B.S. Meteorology, 1976, Florida State University

Professional Societies and Awards

Board of Directors, American Geophysical Union, 2013-2014

Chairman, American Geophysical Union (AGU) Meetings Committee and Member AGU Council, 2010-2012

1998 Editors' Citation for Excellence in Refereeing, *Geophysical Research Letters* – "for thorough and efficient reviews of manuscripts on topics related to the measurement and climate implications of atmospheric water vapor"

Employment

Principal Scientist for Remote Sensing, National Climatic Data Center, NOAA/NESDIS, Asheville, NC, 5/2012-present

Supervisory Meteorologist, Chief Remote Sensing Applications Division, National Climatic Data Center, NOAA/NESDIS, Asheville, NC, 4/2002–4/2012

Reviewed Publications

Shi, L., and J. J. Bates, 2011: Three decades of intersatellite-calibrated High-Resolution Infrared Radiation Sounder upper tropospheric water vapor. *Journal of Geophysical Research*, **116**, D04108, doi:10.1029/2010JD014847.

Shi, L., J.J. Bates, and C. Cao, 2009: Scene radiance dependent intersatellite biases of HIRS longwave channels. *Journal of Atmospheric and Oceanic Technology,* 25(12), 2219–2229.

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Knapp, K., J.J. Bates, and B.R. Barkstrom, 2007: Scientific Data Stewardship Principles: Lessons learned from a satellite data rescue effort. *Bulletin of the American Meteorological Society,* 88(9), 1359–1361.

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EDUCATION:

University of Bremen	Physics	Ph.D. 1998
SUNY at Stony Brook	Physics	M.A. 1994
University of Tübingen	Physics	Vordiplom (comparable to B.S) 1993

EXPERIENCE:

Since September 2006:	Professor chair, Lulea University of Technology, Department of Space Science, Kiruna, Sweden
2005-2006:	Privatdozent (associate professor) University of Bremen
2001-2004:	Assistant professor (C2) University of Bremen
2000-2001:	Senior working group leader (BAT Ia) University of Bremen
1998-2000:	Working group leader (BAT IIa) University of Bremen

RELEVANT RESEARCH EFFORTS:

Prof. Buehler has more than 10 years of experience in the satellite remote sensing of water vapor, mainly from microwave sensors. His other research interests include the remote sensing of clouds and radiative transfer modeling. Recent water vapor research focused on the development of inter-satellite calibration of AMSU-B measurements, cloud clearing, comparison to other measurements (in particular radiosondes), and diurnal cycles. He has published over 60 peer-reviewed articles and according to Web of Science has a Hirsch index of 15 (researcher ID: A-4056-2009).

SELECTED PUBLICATIONS:

Buehler, S. A., M. Kuvatov, V. O. John, M. Milz, B. J. Soden, D. L. Jackson, and J. Notholt (2008), An Upper Tropospheric Humidity Data Set From Operational Satellite Microwave Data, J. Geophys. Res., 113, D14110, doi:10.1029/2007JD009314.

Buehler, S. A., M. Kuvatov, T. R. Sreerekha, V. O. John, B. Rydberg, P. Eriksson, and J. Notholt (2007), A cloud filtering method for microwave upper tropospheric humidity measurements, Atmos. Chem. Phys., 7(21), 5531–5542, doi:10.5194/acp-7-5531-2007.

Buehler, S. A., N. Courcoux, and V. O. John (2006), Radiative transfer calculations for a passive microwave satellite sensor: Comparing a fast model and a line-by-line model, J. Geophys. Res., 111, D20304, doi:10.1029/2005JD006552.

Buehler, S. A., M. Kuvatov, and V. O. John (2005), Scan asymmetries in AMSU-B data, Geophys. Res. Lett., 32, L24810, doi:10.1029/2005GL024747.

Buehler, S. A. and V. O. John (2005), A Simple Method to Relate Microwave Radiances to Upper Tropospheric Humidity, J. Geophys. Res., 110, D02110, doi:10.1029/2004JD005111.

Buehler, S. A., M. Kuvatov, V. O. John, U. Leiterer, and H. Dier (2004), Comparison of Microwave Satellite Humidity Data and Radiosonde Profiles: A Case Study, J. Geophys. Res., 109, D13103, doi:10.1029/2004JD004605.

SELECTED PROFESSIONAL SERVICE/ACTIVITIES:

2010:	Lead scientist of CloudIce ESA Earth Explorer mission proposal.
Since 2007:	Swedish delegate of COST Action ES0604 "Water Vapor in the Climate System".
Since 2008:	Editor for Atmospheric Chemistry and Physics (ACP) and Atmospheric Measurement Techniques (AMT).
2010:	Lead-organizer of COST WaVaCS final workshop, focus on science theme 1, water vapor time series and trends.

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EDUCATION:

Feng Chia University, Taichung, Taiwan, Computer Science, B.A., 1987
Rutgers-the State University of New Jersey, Meteorology, M.S, 1992
University of Wisconsin-Madison, Atmospheric Science, M.S., 1995
University of Wisconsin-Madison, Atmospheric Science, Ph. D., 1998

EXPERIENCE:

2008-current UCAR/COSMIC, NCAR/ACD, Project scientist II
2005-2008: UCAR/COSMIC, NCAR/ACD, Project scientist I
2002-2005: NCAR/ACD, Project scientist I
2001-2002: NCAR/ACD, Associate Scientist III
1998-2001: Analytical Service & Materials, Inc., in affiliation of NASA Langley Research Center, Hampton, VA, Research Scientist

RELEVANT RESEARCH EFFORTS:

Dr. Shu-peng Ho is currently a Research Scientist in the UCAR COSMIC program. He is an expert in satellite remote sensing. Dr. Shu-peng Ho has more than 12 years of experience in developing and testing retrieval algorithms and radiative transfer models for high spectral resolution instruments including AIRS, HIS, AMSR-E, and TES. Dr. Ho is a remote sensing expert and is a member of GEWEX water vapor assessment group, and a member of the Stratospheric Processes and their Role in Climate (SPARC). He is also a contributing author to the IPCC 5th assessment report. His recent works include the development of the combined AIRS, AMSU, and GPS RO retrieval algorithm for global temperature and water vapor profiles for data assimilation system. Dr. Ho published over 37 refereed journal papers. He is a regular reviewer for several remote sensing related Journals.

SELECTED PUBLICATIONS:

Ho, S.-P., and co-authors, Reproducibility of GPS Radio Occultation Data for Climate Monitoring: Profile-to-Profile Inter-comparison of CHAMP Climate Records 2002 to 2008 from Six Data Centers, *J. Geophy. Research.* VOL. 117, D18111, doi:10.1029/2012JD017665, 2012.

Ho, S.-P., Zhou X., Kuo Y.-H., Hunt D., Wang J.-H. Global Evaluation of Radiosonde Water Vapor Systematic Biases using GPS Radio Occultation from COSMIC and ECMWF Analysis. Remote Sensing. 2010; 2(5):1320-1330.

Ho, S.-P., Ying-Hwa Kuo ,William Schreiner, Xinjia Zhou, Using SI-traceable Global Positioning System Radio Occultation Measurements for Climate Monitoring [In "States of the Climate in 2009]. *Bul. Amer. Meteor. Sci.* 2010.

Ho, S.-P., M. Goldberg, Y.-H. Kuo, C.-Z Zou, W. Schreiner, Calibration of Temperature in the Lower Stratosphere from Microwave Measurements using COSMIC Radio Occultation Data: Preliminary Results, Terr. Atmos. Oceanic Sci., Vol. 20, doi: 10.3319/TAO.2007.12.06.01(F3C), 2009.

Ho, S.-P., W. He, and Y.-H. Kuo, Construction of consistent temperature records in the lower stratosphere using Global Positioning System radio occultation data and microwave sounding measurements, in New Horizons in Occultation Research, edited by A. K. Steiner et al., pp. 207–217, Springer, Berlin, doi:10.1007/978-3-642-00321-9_17, 2009.

Ho, S.-P., G. Kirchengast, S. Leroy, J. Wickert, A. J. Mannucci, A. K. Steiner, D. Hunt, W. Schreiner, S. Sokolovskiy, C. O. Ao, M. Borsche, A. von Engeln, U. Foelsche, S. Heise, B. Iijima, Y.-H. Kuo, R. Kursinski, B. Pirscher, M. Ringer, C. Rocken, and T. Schmidt,Estimating the Uncertainty of using GPS Radio Occultation Data for Climate Monitoring: Inter-comparison of CHAMP Refractivity Climate Records 2002-2006 from Different Data Centers, J. Geophys. Res., doi:10.1029/2009JD011969, 2009.

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EDUCATION:

University of Bremen, Germany	Physics	Ph.D.	2005
CUSAT, India	Atmospheric Sciences	M. Tech.	2000
CUSAT, India	Physics	M. Sc.	1998

EXPERIENCE:

Jan., 2008 – present	Scientist, Met Office, UK
Feb., 2006 – Dec. 2007	PDRA, RSMAS, Uni. of Miami, USA
Mar., 2001 – Jan. 2006	Scientific Researcher, Uni. of Bremen, Germany

RELEVANT RESEARCH EFFORTS:

Viju has more than 10 years of experience in the satellite remote sensing of temperature and water vapor from both infrared and microwave sensors. Recent research focused on the development of inter-satellite calibration of microwave humidity sounding measurements since 1993, development of upper tropospheric humidity dataset for climate studies, and evaluating climate models using observations.

SELECTED PUBLICATIONS:

Shi, Lei, Carl J. Schreck, and Viju O. John, 2013: An improved HIRS upper tropospheric water vapor dataset and its correlations with major climate indices, *Atmos. Chem. Phys. Discuss*., 33411-33442, doi:10.5194/acpd-12-33411-2012.

John, V. O., R. P. Allan, B. Bell, S. A. Buehler, and A. Kottayil (submitted 2013), Assessment of inter-calibration methods for satellite microwave humidity sounders, *J. Geophys. Res.*

Kottayil, A., V. O. John, and S. A. Buehler (in press 2013), Correcting diurnal cycle aliasing in satellite microwave humidity sounder measurements, *J. Geophys. Res.*, doi:10.1029/2012JD018545.

John, V. O., G. Holl, N. Atkinson, and S. A. Buehler (2013), Monitoring scan asymmetry of microwave humidity sounding channels using simultaneous all angle collocations (SAACs), *J. Geophys. Res.*, in press

John, V. O., G. Holl, S. A. Buehler, B. Candy, R. W. Saunders, and D. E. Parker (2012), Understanding inter-satellite biases of microwave humidity sounders using global simultaneous nadir overpasses, J. Geophys. Res., 117(D2), D02305, doi:10.1029/2011JD016349.

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John, V. O. and B. J. Soden (2007), Temperature and humidity biases in global climate models and their impact on climate feedbacks, Geophys. Res. Lett., 34, L18704, doi:10.1029/2007GL030429.

Marc Schröder

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EDUCATION:

Freie Universität Berlin, Berlin, Germany	Natural sciences	Ph.D.	2004
Carl von Ossietzky Universität Oldenburg, Germany	Physics	Diploma.	1999

EXPERIENCE:

Jul. 2007 – present	Scientist, DWD, Germany
May 2006 – June 2007	Consultant/Visiting Scientist at EUMETSAT, Darmstadt, Germany
Sept. 2004 – May 2006	Postdoc, FU Berlin, Berlin, Germany
April 2000 – August 2004	Research Assistant, FU Berlin, Berlin, Germany
Oct. 2002 – Dec. 2002	Research Assistant, University of Wisconsin, Madison, Wisconsin, USA

RELEVANT RESEARCH EFFORTS:

Marc Schröder is leading the CM SAF water vapour activities and is currently involved in the retrieval of global water vapour and temperature profiles from ATOVS observations, the retrieval of free tropospheric humidity from MVIRI/SEVIRI observations and the continuation and improvement of the Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite data (HOAPS), which - among others – include a total column water vapour product. Besides activities in geophysical space he is also working on the homogenisation of the METEOSAT time seris and is involved in the generation of a SSM/I FCDR.

SELECTED PUBLICATIONS:

B. Dürr, M. Schröder, R. Stöckli, and R. Posselt: HelioFTH: Combining cloud index principles and aggregated rating for cloud masking using infrared observations from geostationary satellites. Submitted to AMT, 2013.

Schröder, M., Jonas, M., Lindau, R., Schulz, J., and Fennig, K.: The CM SAF SSM/I-based total column water vapour climate data record: methods and evaluation against re-analyses and satellite, Atmos. Meas. Tech. Discuss., 5, 6423-6453, doi:10.5194/amtd-5-6423-2012, 2012.

Bennartz, Ralf and Marc Schröder. Convective activity over Africa and the tropical Atlantic inferred from 20 years of geostationary Meteosat infrared observations. Journal of Climate, Volume 25, Issue 1, 2012, pp.156-169.

Mieruch, Sebastian, Stefan Noël, Maximilian Reuter, Heinrich Bovensmann, John P. Burrows, Marc Schröder, Jörg Schulz, 2011: A New Method for the Comparison of Trend Data with an Application to Water Vapor. J. Climate, 24, 3124–3141. doi: 10.1175/2011JCLI3669.1

Mieruch, S., M. Schröder, S. Noel, J. Schulz, 2010: Comparison of monthly means of global total column water vapor retrieved from independent satellite observations. J. Geophys. Res., VOL. 115, D23310, doi:10.1029/2010JD013946, 2010.

SELECTED PROFESSIONAL SERVICE/ACTIVITIES:

Co-Chair for GEWEX Water Vapor Assessment,	2011-present
Coordinator for SCOPE-CM SSM/I pilot project	2008-2012
Member of the Post-EPS Mission Expert Team	2010-present
Member of the GRUAN Task Team 5	2010-present

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EDUCATION:

Florida State University	Meteorology	Ph.D. 1992
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EXPERIENCE:

Aug., 2003 – present	Meteorologist, NOAA National Climatic Data Center Asheville, NC, USA
Dec., 1993 – Aug. 2003	Staff Scientist, SeaSpace Corporation San Diego, CA, USA
Apr., 1992 – Nov. 1993	Post-doctoral Researcher, Scripps Institution of Oceanography, San Diego, CA, USA

RELEVANT RESEARCH EFFORTS:

Dr. Shi has more than 20 years of experience in the satellite remote sensing of temperature and water vapor from both infrared and microwave sensors. Recent research focused on the development of inter-satellite calibration of HIRS measurements since 1978, development of upper tropospheric water vapor dataset for climate studies, retrieval of global temperature and water vapor profiles from HIRS, and retrieval of temperature and humidity from AMSU-A and AMSU-B.

SELECTED PUBLICATIONS:

Shi, Lei, 2013: Intersatellite Differences of HIRS Longwave Channels Between NOAA-14 and NOAA-15 and Between NOAA-17 and METOP-A. *Geoscience and Remote Sensing, IEEE Transactions on*, **51,** 1414-1424.

Schreck, C. J., L. Shi, J. P. Kossin, and J. J. Bates, 2012: Identifying the MJO, Equatorial Waves, and Their Impacts Using 32 Years of HIRS Upper-Tropospheric Water Vapor. *J Climate*, **26,** 1418-1431.

Shi, Lei, Carl J. Schreck, and Viju O. John, 2012: An improved HIRS upper tropospheric water vapor dataset and its correlations with major climate indices, *Atmos. Chem. Phys. Discuss*., 33411-33442, doi:10.5194/acpd-12-33411-2012.

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Shi, Lei, and John J. Bates, 2011: Three decades of intersatellite-calibrated High-Resolution Infrared Radiation Sounder upper tropospheric water vapor. *J Geophys Res-Atmos*, **116**.

Shi, Lei, John J. Bates, and Changyong Cao, 2008a: Scene Radiance–Dependent Intersatellite Biases of HIRS Longwave Channels. *J Atmos Ocean Tech*, **25,** 2219-2229.

Shi, L., J. J. Bates, X. Li, S. M. Uppala, and G. Kelly, 2008b: Extending the satellite sounding archive back in time: the Vertical Temperature Profile Radiometer data. *J Appl Remote Sens*, **2**.

SELECTED PROFESSIONAL SERVICE/ACTIVITIES:

Co-Chair for GEWEX Water Vapor Assessment,	2011-present
Coordinator for SCOPE-CM UTH pilot project	2008-2012
Voting Member representing NOAA's climate goal in Low-Orbiting Satellite Requirement Working Group (LOW WG),	2007-2011
Team Lead for IJPS NOAA Archive and Access,	2003-2007

Brian J. Soden

EDUCATION:

June 1993	Ph. D. University of Chicago
March 1990	M.S. University of Chicago
May 1988	B.S. University of Miami

RESEARCH EXPERIENCE

8/04 -	Professor, Rosenstiel School for Marine and Atmospheric Science University of Miami, FL.
6/94 – 7/04	Physical Scientist, Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration, Princeton, NJ.
6/94 - 7/04	Lecturer with Rank of Associate Professor, Atmospheric and Oceanic Sciences Program, Princeton University.

RELEVANT RESEARCH EFFORTS:

Prof. Soden has more than 20 years of experience in the satellite remote sensing of water vapor and clouds, and their application for climate monitoring and model evaluation. He has been involved in the development of retreival algorithms, detection and correction of satellite orbital and calibration drifts, and the application of these data sets for climate change detection and attribution. He has published over 90 peer-reviewed articles and according to Google Scholar has an H-index of 42.

SELECT PROFESSIONAL ACTIVITIES:

Lead Author, Intergovernmental Panel on Climate Change (2007, 2013).
Chairman, GEWEX Water Vapor Project: GVaP (2001-2003).
Chairman, AMS Committee on Atmospheric Radiation (1998-2000).
Editor, Journal of Climate (2009-).

SELECT PUBLICATIONS:

Chung, E. S., and B. Soden, 2009: A satellite-based assemssment of upper tropospheric water vapor measurements during AFWEX. *J. Appl. Meteor. Climotol.*.

Gambacorta, A., C. Barnet, B. Soden, and L. Strow, 2008: An assessment of the tropical humidity-temperature covariance using AIRS, *Geophysical Research Letters,* **35**, L10814, doi:10.1029/2008GL033805.

Horvath, A. and B.J. Soden, 2008**:** Lagrangian diagnostics of tropical deep convection and its effect upon upper-tropospheric humidity, J*ournal of Climate*, **21**, 1013-1028.

Jackson, D. L., and B. J. Soden, 2007: Detection and correction of diurnal sampling bias in HIRS/2 brightness temperatures, *J. Atmos. Oceanic Technol.*, **24**, 1425-1438.

Soden, BJ, DL Jackson, V Ramaswamy, MD Schwarzkopf, and X. Huang, 2005: The radiative signature of upper tropospheric moistening, *Science,* **310**, 841-844.

Held, I.M. and B.J. Soden, 2000: Water vapor feedback and global warming. *Annu. Rev. Energy Env.,* **25**, 441-475.

Soden, B. J., and F. P. Bretherton, 1993: Upper tropospheric relative humidity from the GOES 6.7 μm channel: Method and climatology for July 1987. *J. Geophys. Res.*, **98**, 16,669-16,6888