Latest results from analyzing the NVAP-M global water data record

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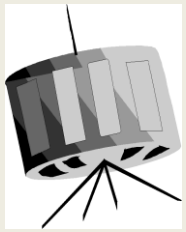


STC - METSAT

Science and Technology Corporation - Metsat Division, Fort Collins CO

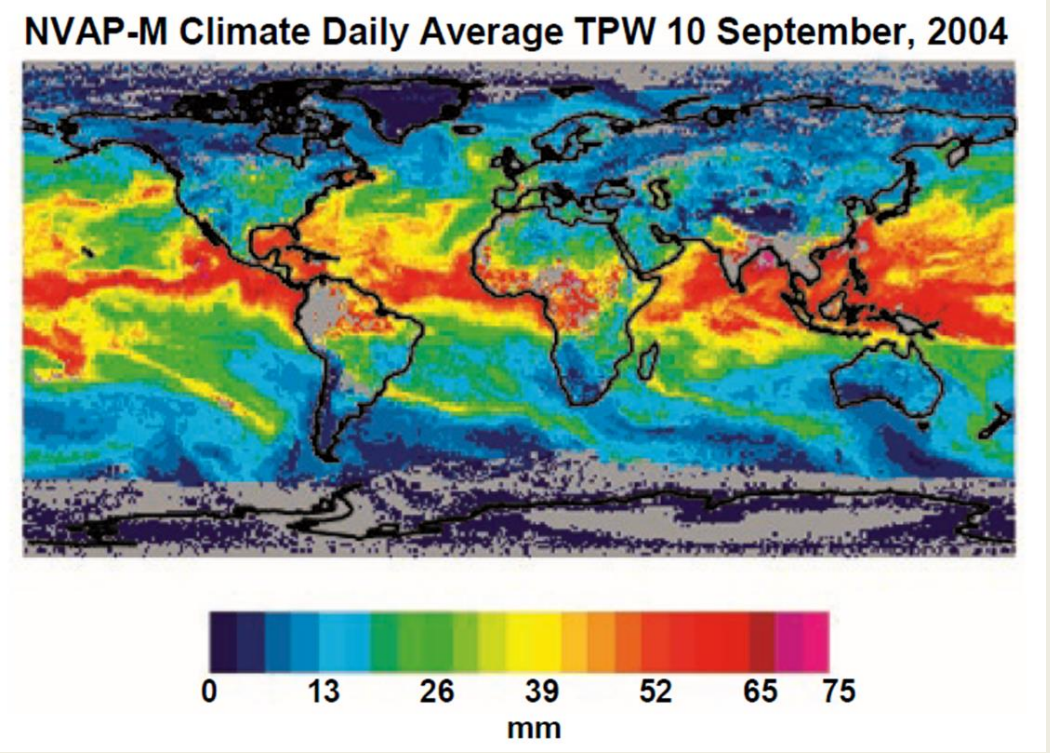
NVAP-M (NVAP (NASA Water Vapor Project) – MEaSUREs)

Produced under NASA MEaSUREs Program: Making Earth System Data Records for Use in Research Environments

NASA Water Vapor Project – MEaSUREs

- **Reanalysis**, **extension** (1988-2009) **and replacement** of the heritage NVAP (1988-2001) dataset
- **Global** (land and ocean) data designed for weather, climate and hydrology users
- Total (TPW) and layered (LPW) precipitable water
- **Removes time-dependent biases** caused by dataset and algorithm changes incurred during multi-phase processing.
  - Focus on **consistent data inputs and peer reviewed processing algorithms** through time.
- **Back-propagation of modern observations** through the entire data period.
  - Collaboration with AIRS water vapor project at NASA JPL. (E. Fetzer et al.)
- Highly model-independent
- **Available at NASA Langley Atmospheric Science Data Center (ASDC):** https://eosweb.larc.nasa.gov/project/nvap/nvap-m_table

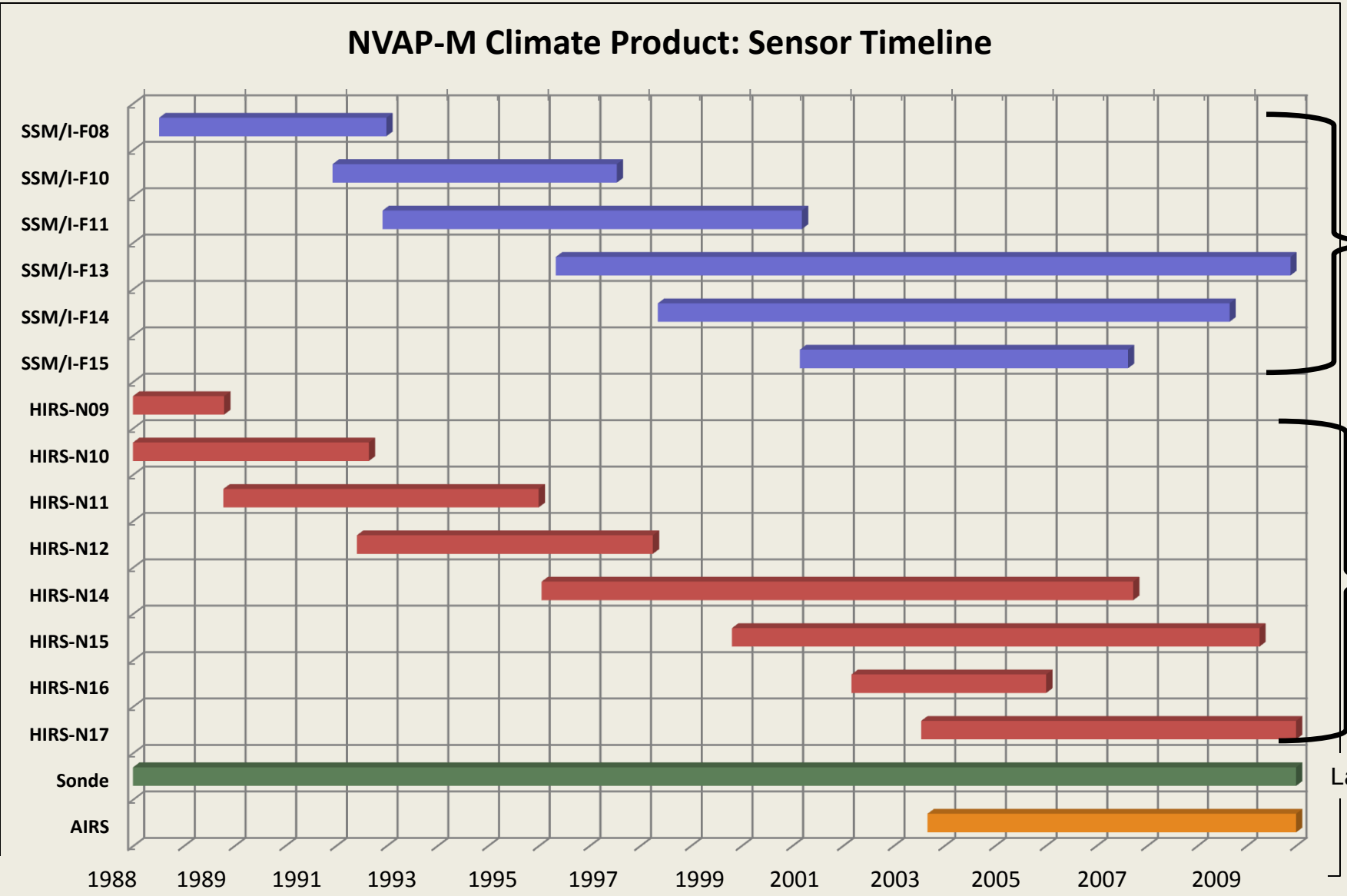
Similar in concept to GPCP, ISCCP, but with three products: Climate, Weather, Ocean.



Vonder Haar et al. 2012: Weather and climate analyses using improved global water vapor observations. *Geophys. Res. Lett.*, **39**, L15802. doi:10.1029/2012GL052094.

"NVAP-M" refers to the new NVAP-MEaSUREs data set. "Heritage NVAP" refers to the existing dataset described by Randel et al., 1996

As of April 2015: 309 orders, 135 users



HIRS portion of the product has provided the most challenges

NVAP-M: A Three-Tiered Product Approach

Heritage NVAP begun in early 1990's was "one size fits all" approach.

NVAP-Weather

Used for weather case studies on timescales of days to weeks

- SSM/I Level 1 C intercalibrated radiances
- HIRS cloud cleared radiances
- Radiosonde, GPS since 1997
- AIRS V5 Level 3 TPW and Layered PW

- Maximizes spatial and temporal coverage
- Not driven by reduction of time-dependent biases

- 4x daily
- ½ degree resolution
- TPW and layered precipitable water
  - surface to 700 hPa
  - 700 to 500 hPa
  - 500 to 300 hPa
  - < 300 hPa.

NVAP-Climate

Used for studies of climate change and interannual variability

- SSM/I Level 1 C intercalibrated radiances
- HIRS cloud cleared radiances, + AIRS since 2002
- Radiosonde

- Consistent inputs through time.
- Consistent, high quality retrievals.
- Less emphasis on spatial and temporal coverage

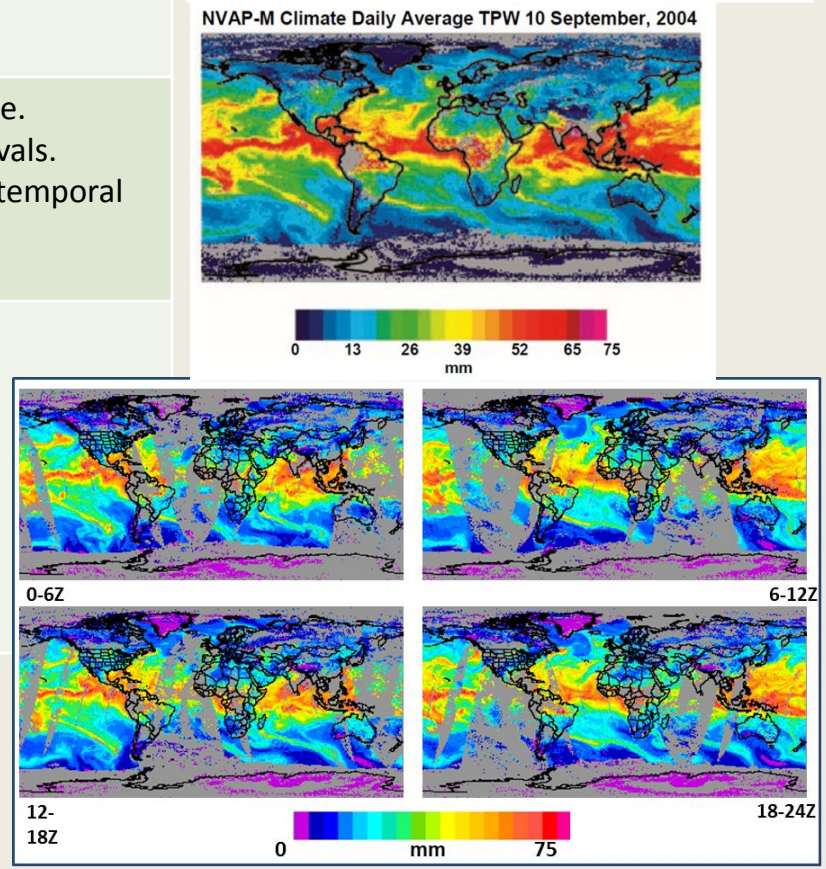
- Daily
- 1-degree resolution
- TPW
- layered precipitable water
  - surface to 700 hPa
  - 700 to 500 hPa
  - 500 to 300 hPa
  - < 300 hPa

NVAP-Ocean

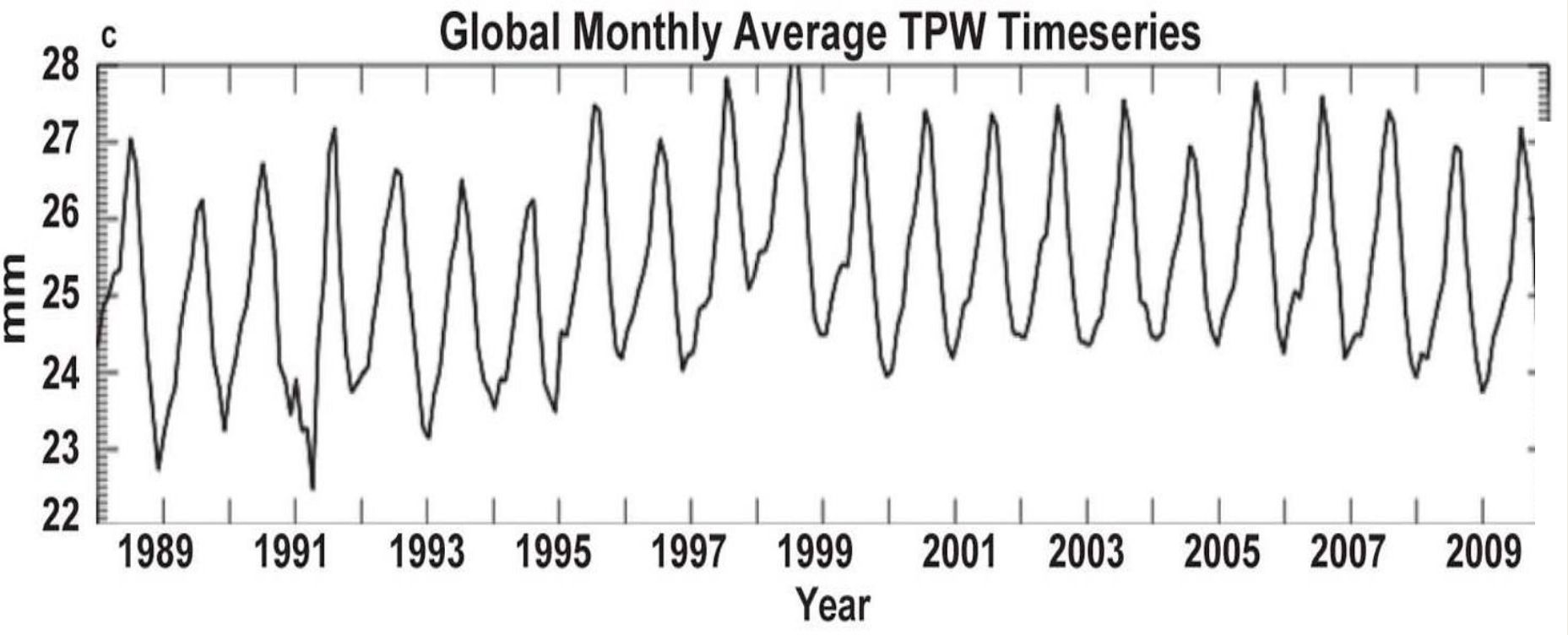
SSM/I-only. Level 1 C intercalibrated radiances (Berg and Sapiano, CSU)

Supplemental Fields

- Data source code (DSC) map, indicating the sources used in each grid box .

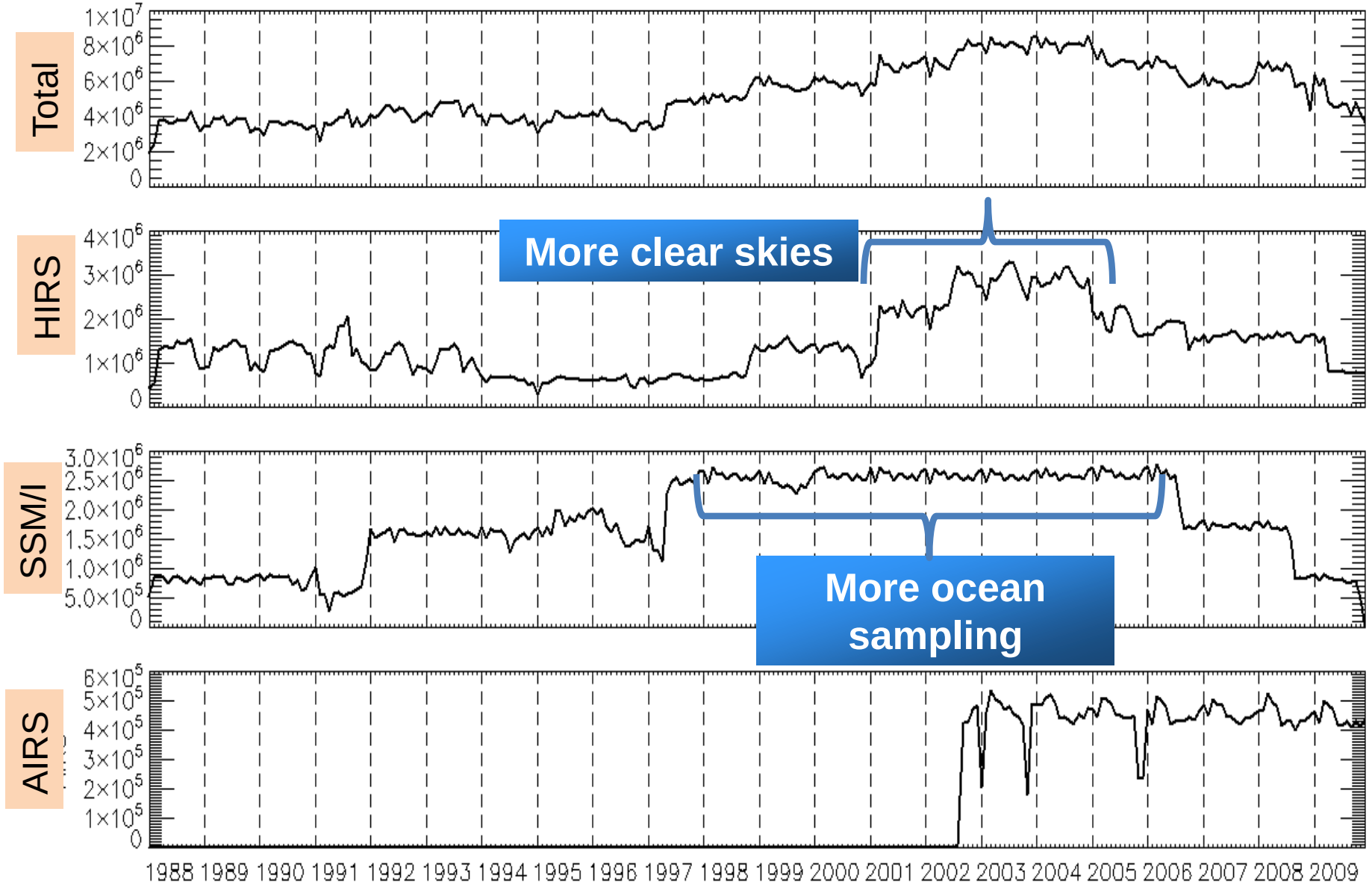


At this time
- due to time-varying sampling effects currently under study -
we can neither prove nor disprove a robust trend in the global water vapor data from the NVAP-M Climate data set (over land and ocean)



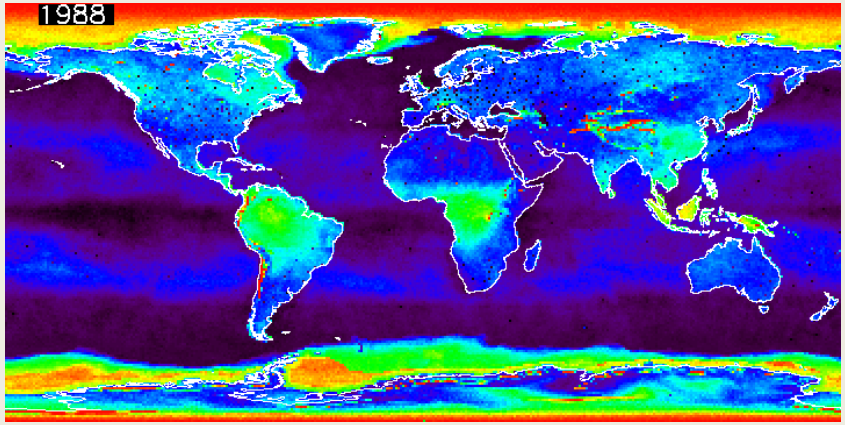
Science question: What is the trend error due to the time-varying mix of sensors sampling land/ocean, clear/cloudy?

Number of grid boxes in NVAP-M Climate using each data type

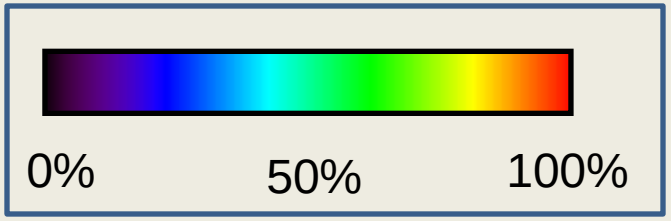


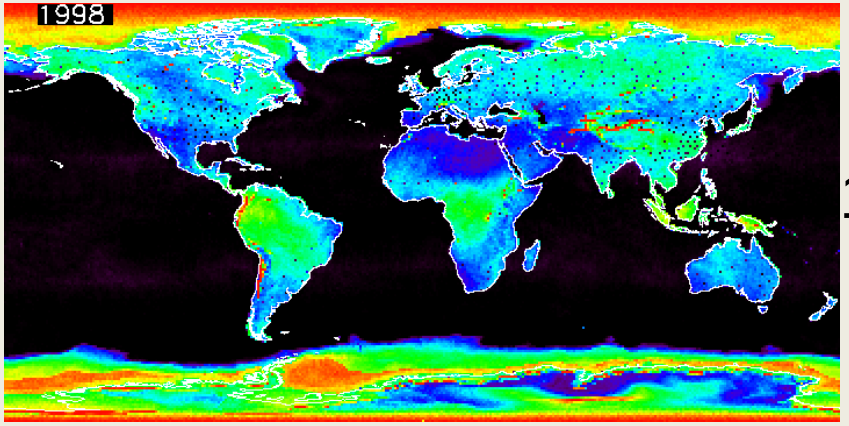
How do these changes affect trend results?

Percentage of Time Data Missing from NVAP-M Climate TPW

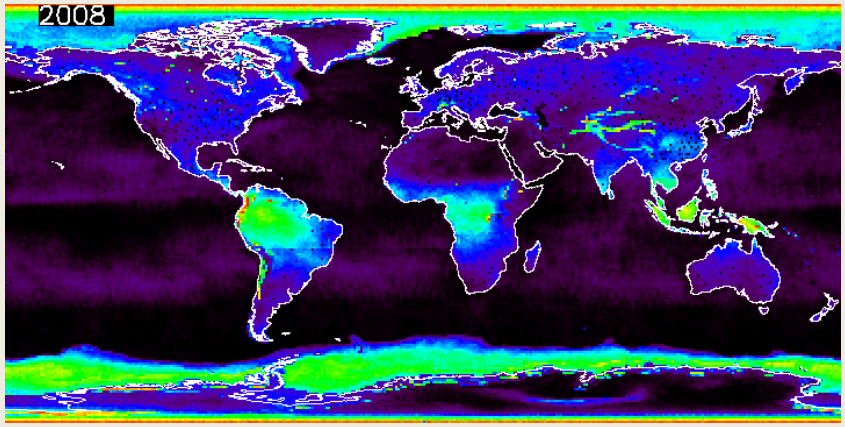


1988



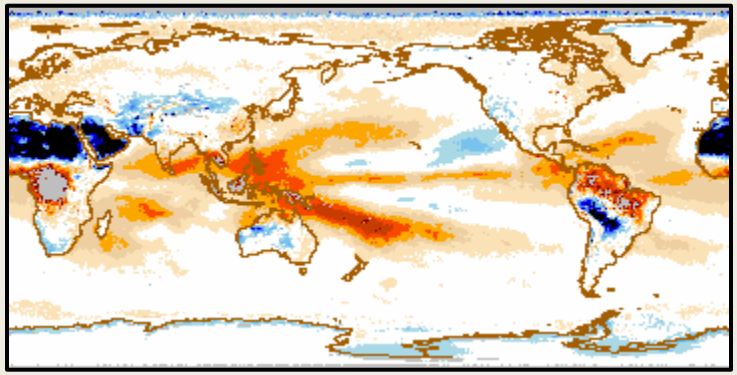


1998

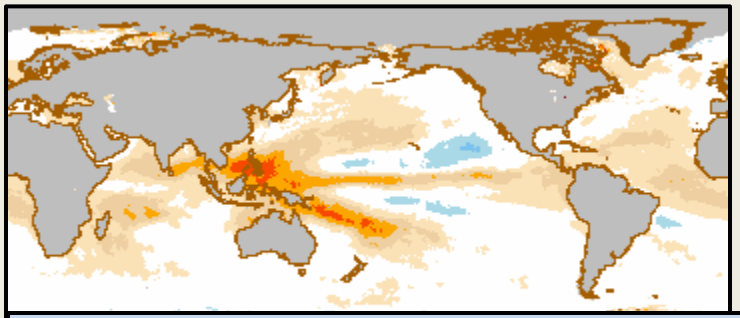


2008

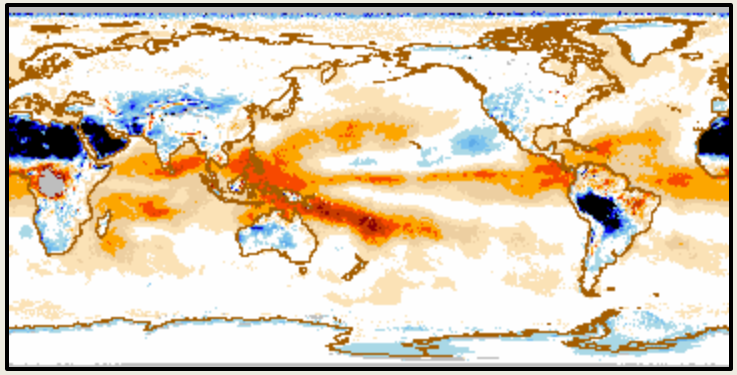
Data Witholding Experiments for 1988 – 2009 Trends



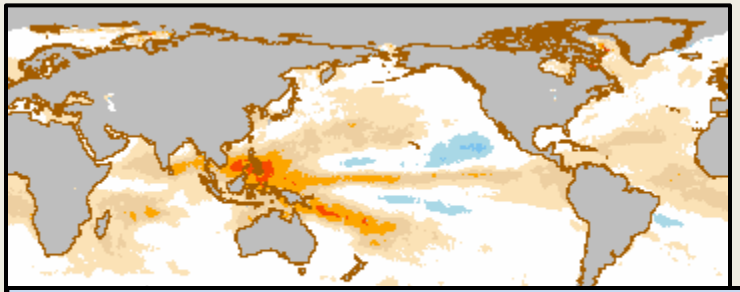
NVAP-M Climate as exists:
+ 0.51 mm / decade



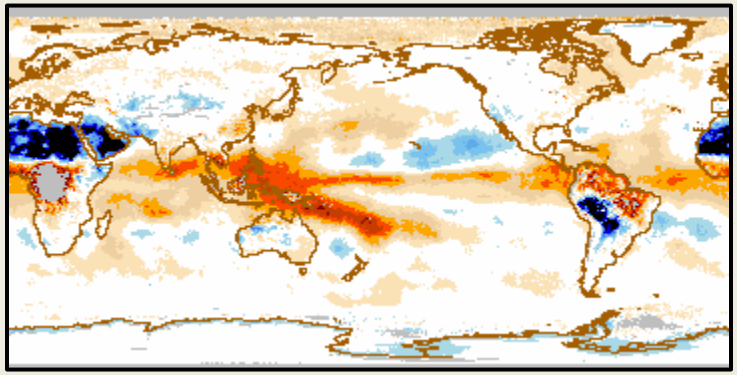
NVAP-Ocean as exists +0.53 mm / decade



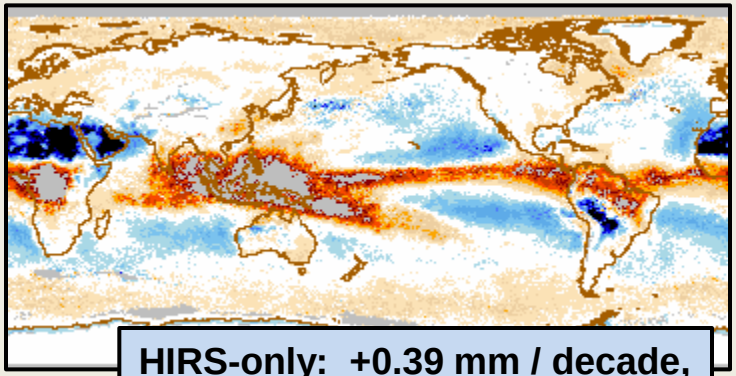
Two infrared, one SSM/I per day, no sondes
+ 0.45 mm / decade



NVAP-Ocean: One random SSM/I per day +0.51 mm / decade



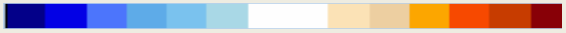
Two infrared, one SSM/I per day, No AIRS
+ 0.48 mm / decade



HIRS-only: +0.39 mm / decade, but trends more extreme over ocean

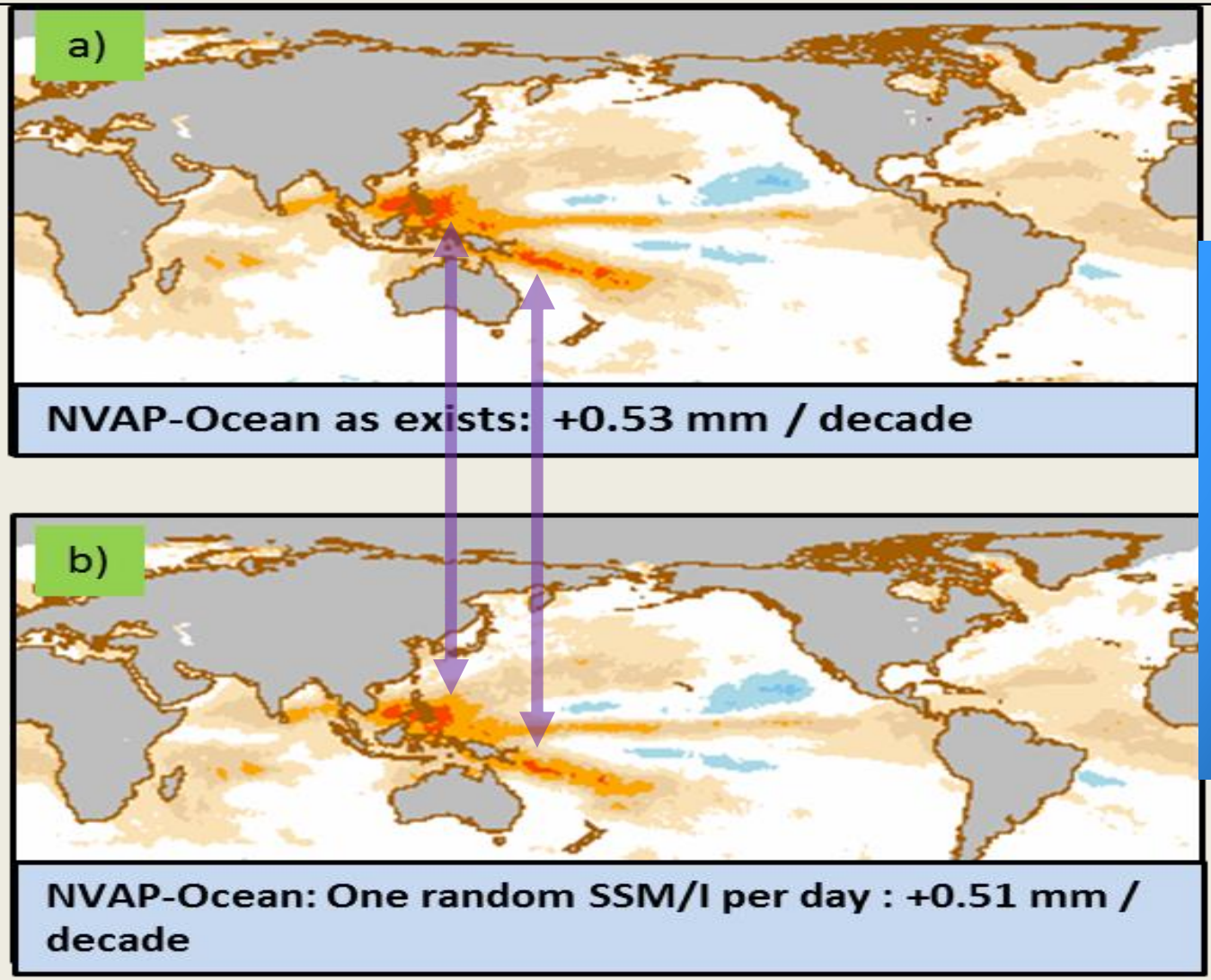
Insufficient data

-3.5



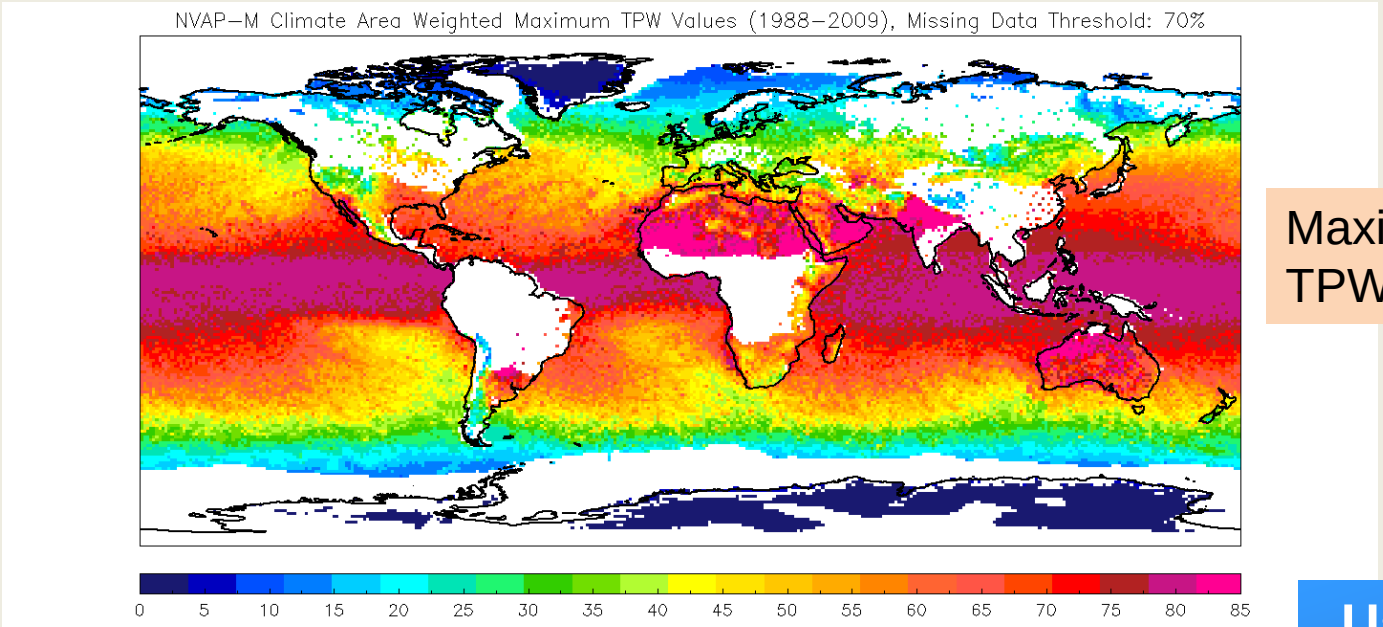
+3.5

(mm / decade)



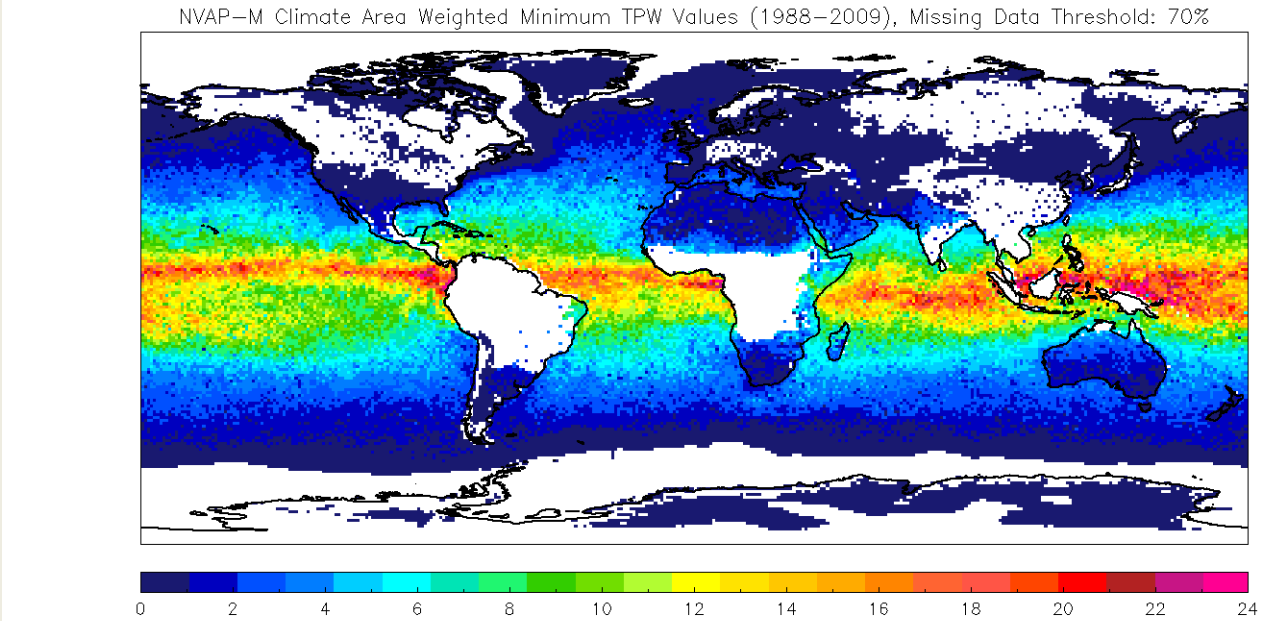
Appears like a stronger trend in the warm pool area when using > 1 SSM/I, perhaps due to more sampling of precipitating areas

Searching for Breakpoints Using Extreme Values



Maximum TPW (mm)

Useful to check for bad retrievals

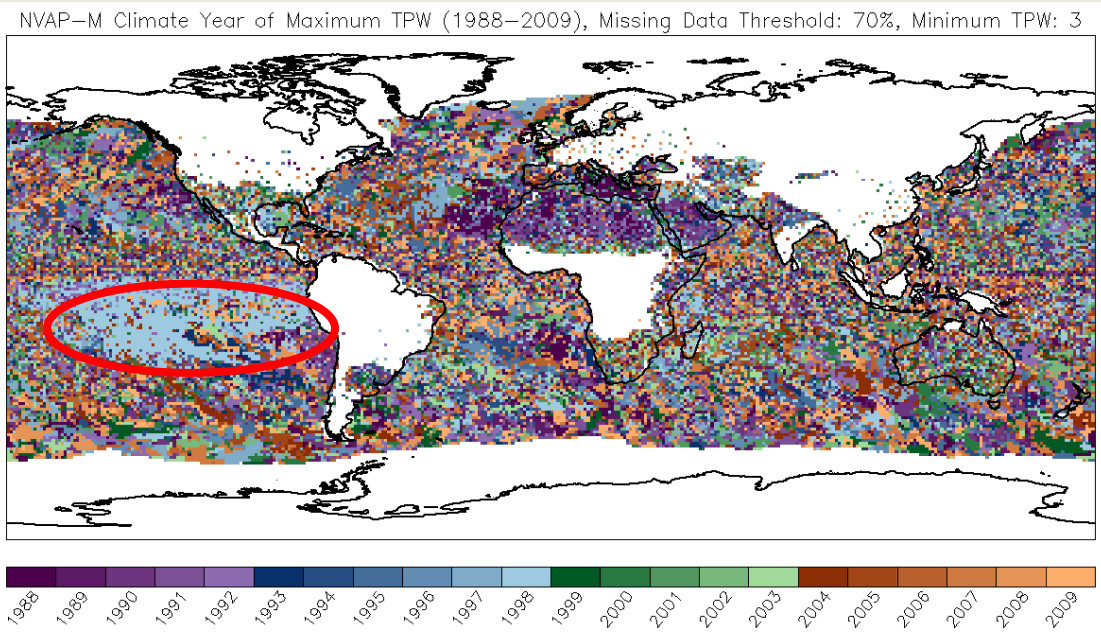


Minimum TPW (mm)

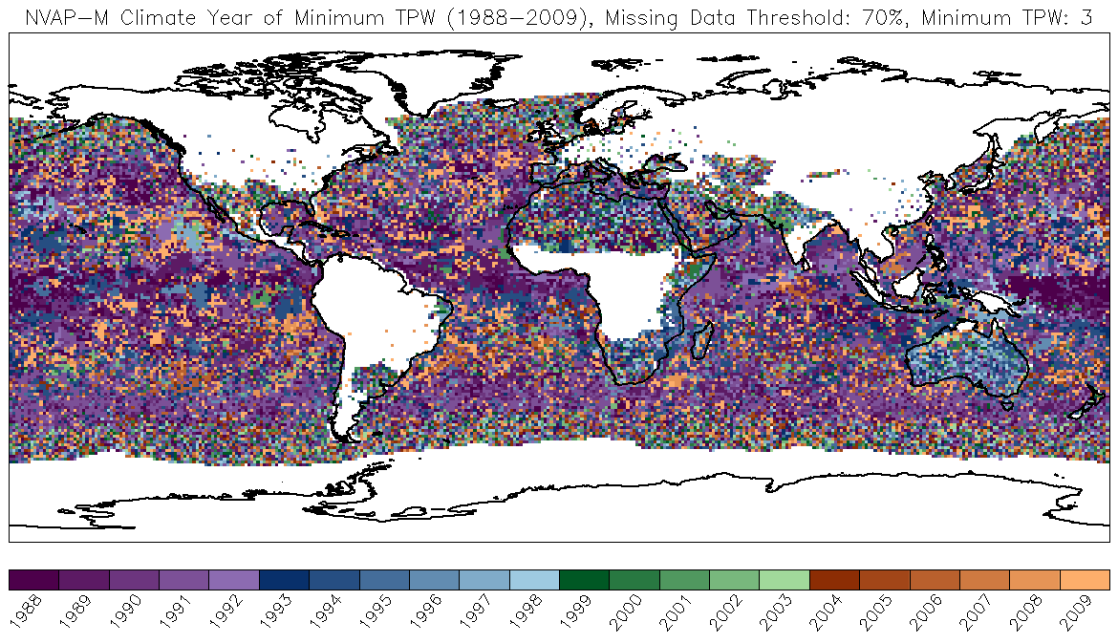
Calculated where < 30% of days in a year are missing

Year of Min / Max TPW

Mostly 1998

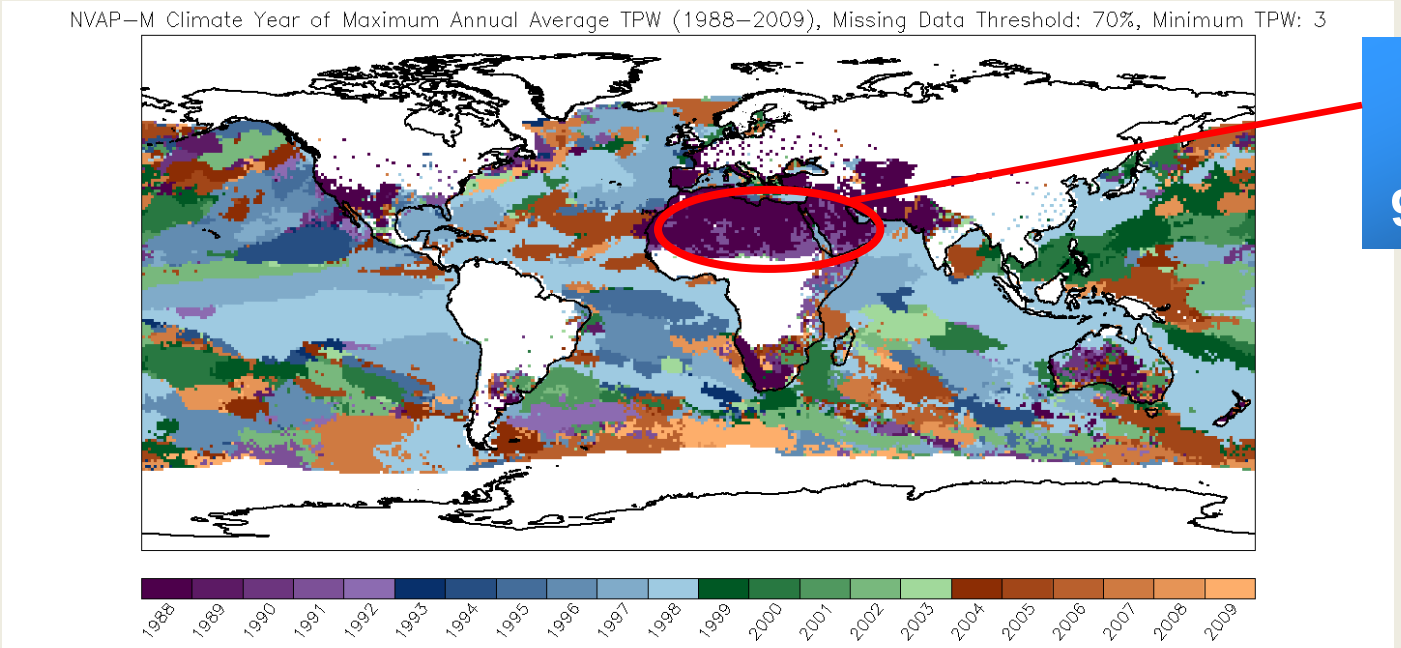


Maximum individual retrieval



Minimum individual retrieval

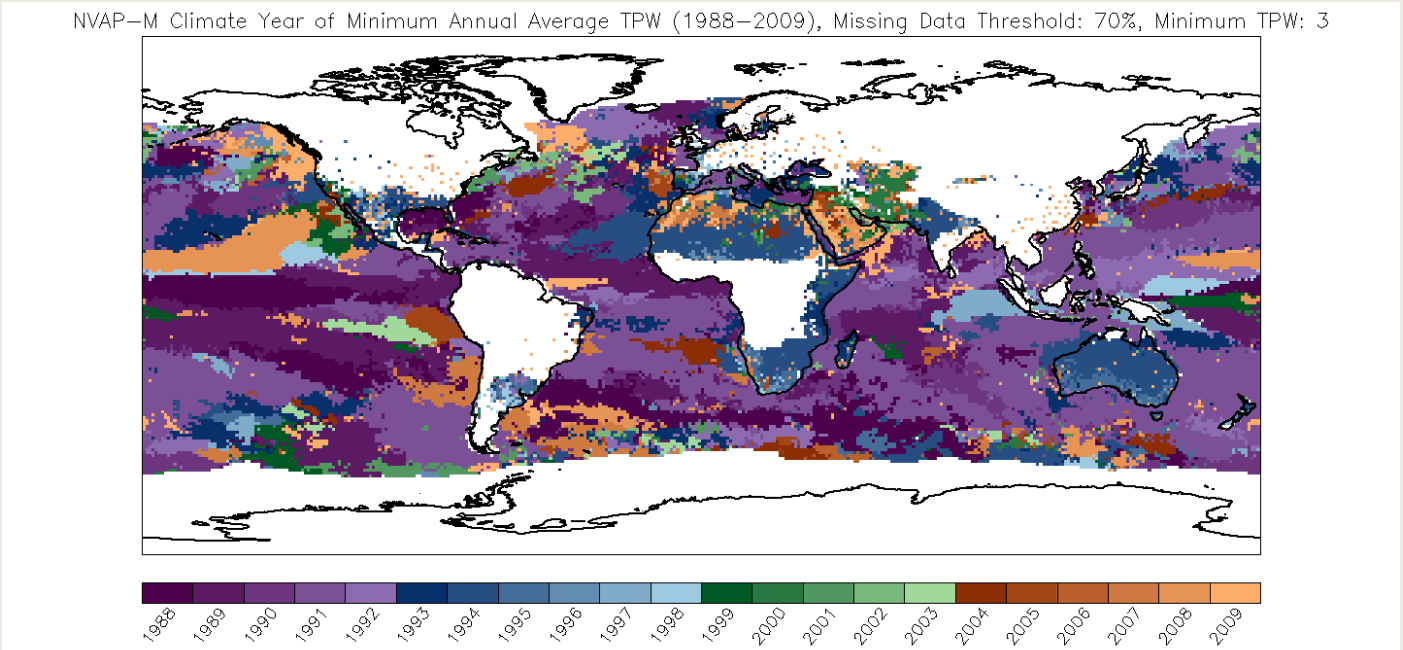
Calculated where < 30% of days in a year are missing



Possible high bias in NOAA-9/10 over Sahara

Year of Maximum <u>Annual Average</u> TPW

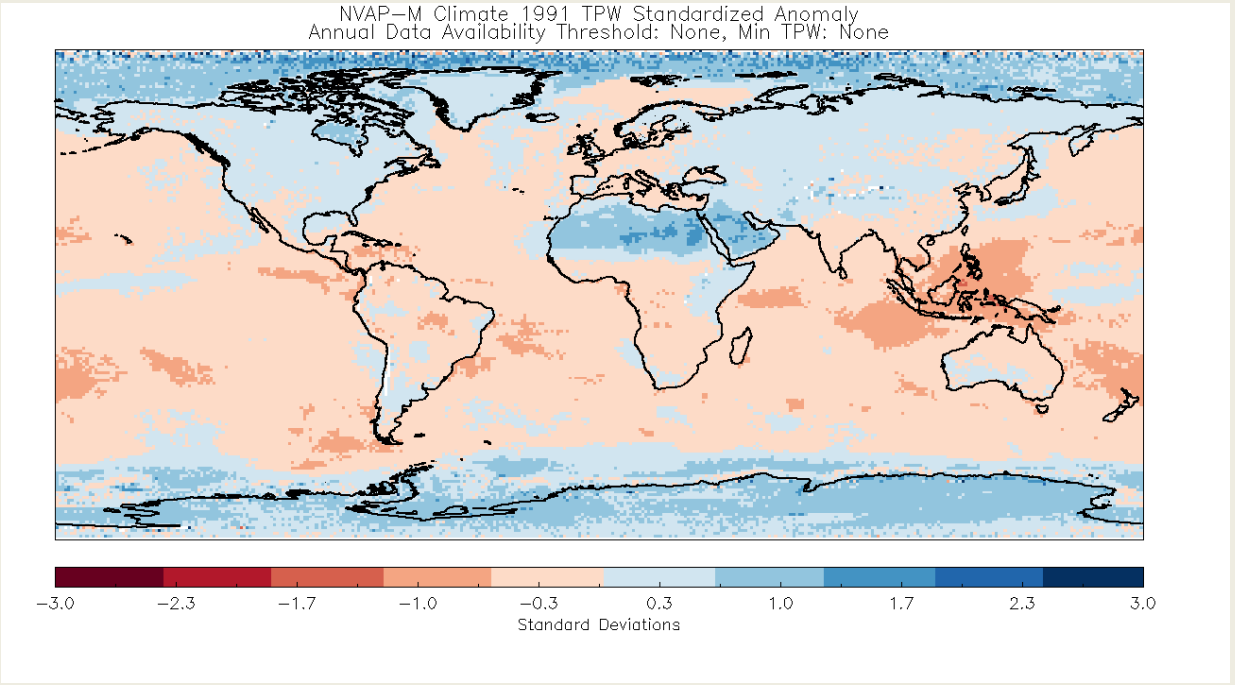
- 1998 very apparent in tropics due to strong El Nino



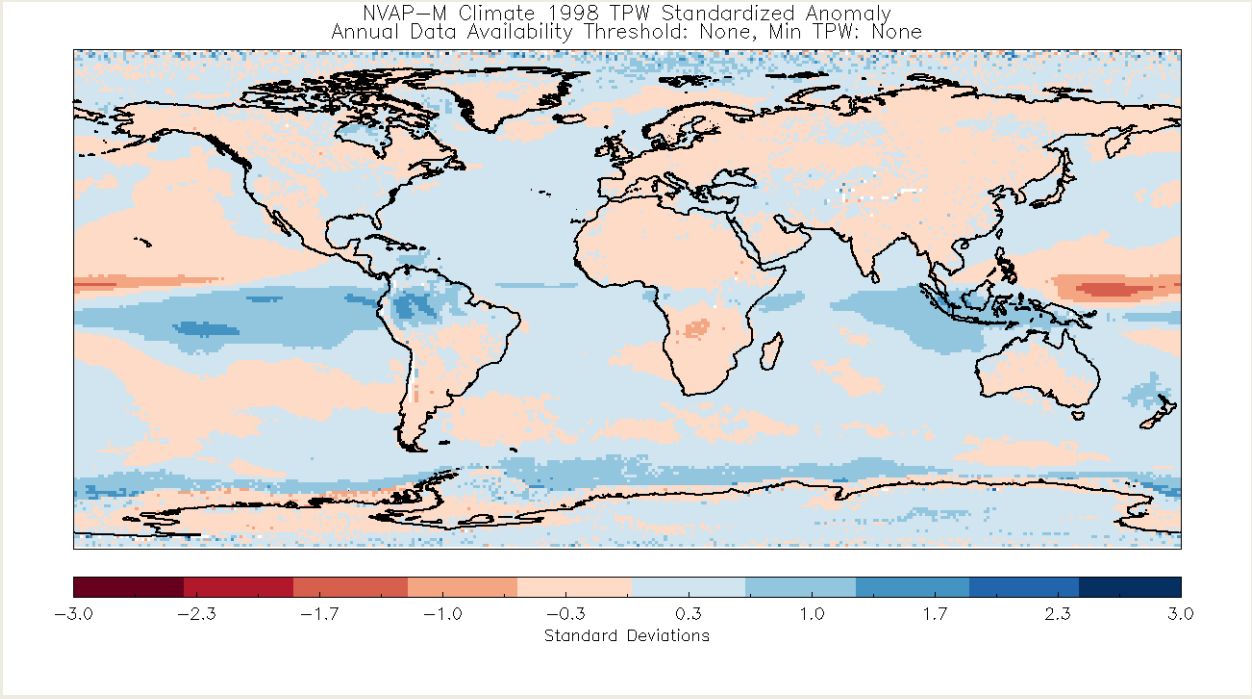
Year of Minimum <u>Annual Average</u> TPW

- Dominated by 1988 - 1992

Filtered by:
< 30% of days in a year missing



1991: Anomalous retrieved TCWV over Sahara



1998: Dominant effect of ENSO

G-VAP Report Section 3.1: Report on Overview of Sensors

J. M. Forsythe, E. R. Kursinski, A. Gambacorta and M. Schröder

Summary of major satellite instruments used for climate data records

Sensor	Type	Platform	Spatial	Number of channels	Intercalibration Level
SSM/I	Microwave Imager	Polar	40 km	7	High
AIRS	Infrared Hyperspectral Sounder	Polar	15 km	2378	High
IASI	Infrared Hyperspectral Sounder	Polar		8461	High
GPS-RO	Radio Occultation Limb Sounding	Middle earth orbit	~200 km along a ray	2	High
HIRS	Infrared Broadband Sounder	Polar	20 km	20	Medium
AMSU-B / MHS	Microwave Sounder	Polar	15 km at nadir	5	Medium
MODIS	Infrared Imager				Medium
MERIS	Infrared Imager	Polar	1 km	15	Medium
AMSR-E	Microwave Imager	Polar	12 km	12	High
TMI	Microwave Imager	Low inclination tropical orbit	10 km	9	High
TMR	Microwave Imager	Polar		3	Medium
SSM/T-2	Microwave Sounder	Polar	50 km	5	Low

Current Status:

- **No active NVAP-M project, working on best effort basis.**
- **Expect to propose reanalysis / extension to NASA when opportunity arises.**
- **Exploring using GPM as intercalibration for ATMS and DMSP via NOAA support.**
- **Primary research focus is to detect / understand breakpoints in time series, and to explore the effect of sampling changes (clear/cloudy, land/ocean) through time on TCWV trend results.**

Summary

- NVAP-MEaSUREs reprocesses, extends and replaces the original NVAP dataset.
- Data are available at the NASA Langley ASDC.
- Multisensor records of water vapor are challenging, but allow a global depiction of water vapor. The concept of creating different processing paths (Climate, Ocean, Weather) has proven useful for meeting the needs of diverse users.
- Changes in satellite sampling with time continue to hinder the ability to claim a significant robust global trend in TPW from NVAP-M.
- Current experiments in progress to examine the sensitivity of trends to different mixtures of input sensors.

Backup Slides

Journal Acronyms for Total Water Vapor in a Column (July 2013 search)

Acronym	AMS Journals	J. Geophy Res.
TPW	131	36
IPW	13	6
PWAT	23	10
IWV	33	67
TCWV	36	13
PWV	89	103
TWV	12	3
PWC	21	11
IPWV	4	1
PWAV	0	0
VIM	7	0
WVP	27	9
TPWV	2	0
WVPA	0	0
PRW	5	6
LPW (layered)	5	

At least 15 different acronyms

An Aside:

Can we agree on and recommend standardized terminology?

From AMS Glossary of Meteorology:
The total precipitable water is that contained in a column of unit cross section extending all of the way from the earth's surface to the "top" of the atmosphere. Mathematically, if $x(p)$ is the mixing ratio at the pressure level, p, then the precipitable water vapor, W, contained in a layer bounded by pressures p_1 and p_2 is given by

$$W = \frac{1}{g} \int_{p_1}^{p_2} x\,dp,$$