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Satellite Merged Microwave Radiometer Datasets for Climate Studies

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Summary

This poster describes two microwave climate products available from Remote Sensing Systems. The Total Column Water Vapor (also called total precipitable water, TPW) and 10-meter Surface Wind Speed products are created using high-quality, consistently-processed microwave radiometer data. These climate products can be used for model comparison of global trends and the study of regional variations. The data are of high quality as each instrument has been intercalibrated on the brightness temperature level and a consistent processing algorithm has been used across instruments to bring uniformity to the data collection.

Climate Product Contents

Remote Sensing Systems has produced two important climate products from Microwave Radiometer Total Column Water Vapor (TPW) and 10-m Surface Wind Speed data.

The products are made from RSS Version-7 microwave radiometer data:

- all SSM/I (F8, F10, F11, F13, F14 and F15)
- SSMIS (F16, F17)
- AMSR-E
- WindSat
- No TMI data are used as it is not yet processed as V7

Each netCDF product file contains:

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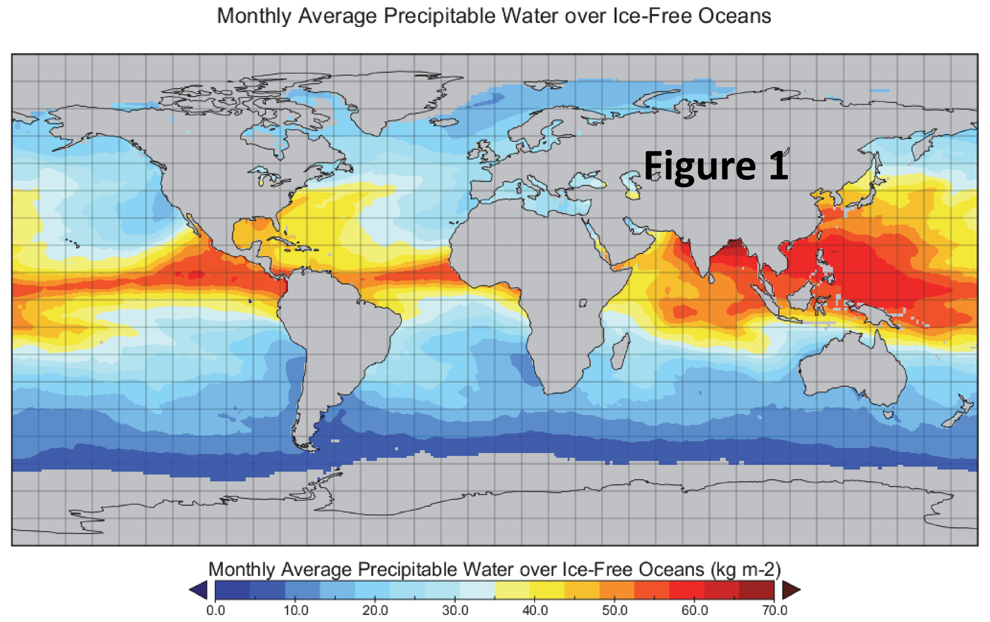
- Monthly mean values
- Monthly mean maps
- A set of 12 month climatology maps
- Monthly anomaly maps
- A global trend map
- A hovmöller (time-latitude) plot
- CF-compliant metadata

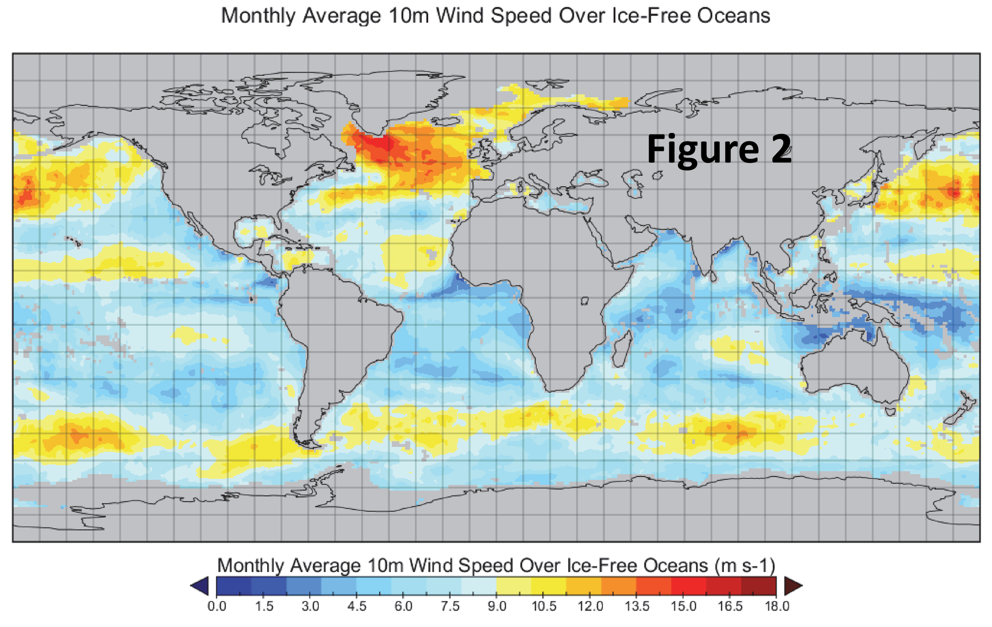
These climate products are available at ftp.remss.com/vapor/monthly_1deg/ and ftp.remss.com/wind/monthly_1deg/. Images can be viewed by visiting www.remss.com and selecting the vapor or wind category.

The data are also available from the NASA Global Hydrology Resource Center (GHRC) DAAC at ftp://ghrc.nsstc.nasa.gov/pub/tpw/data/ as individual month netCDF files

Both products are updated monthly around the middle of the month.

An example of the mean TPW (**Figure 1**) and Surface Wind Speed (**Figure 2**) for July 2012 is shown below. Since the data product is in netCDF format, a tool like Panoply can be used to easily display and access the data and metadata (http://www.giss.nasa.gov/tools/panoply).





Construction Methodology

Each climate product was constructed using a two-step process to have greater control over quality checks:

STEP 0: We start with carefully intercalibrated and uniformly processed microwave ocean retrievals.

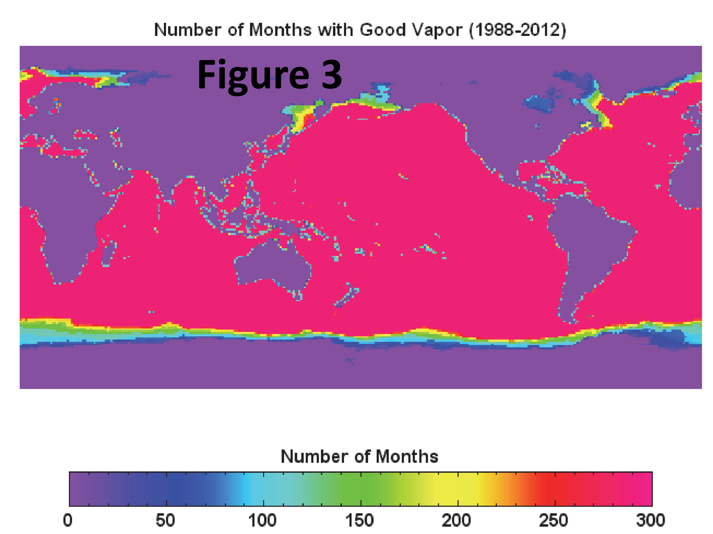
STEP 1: We create monthly, 1x1 deg maps for each satellite. These interim files contain: mean wind or vapor, number of obs, number of ice obs, and mean-day-of-month.

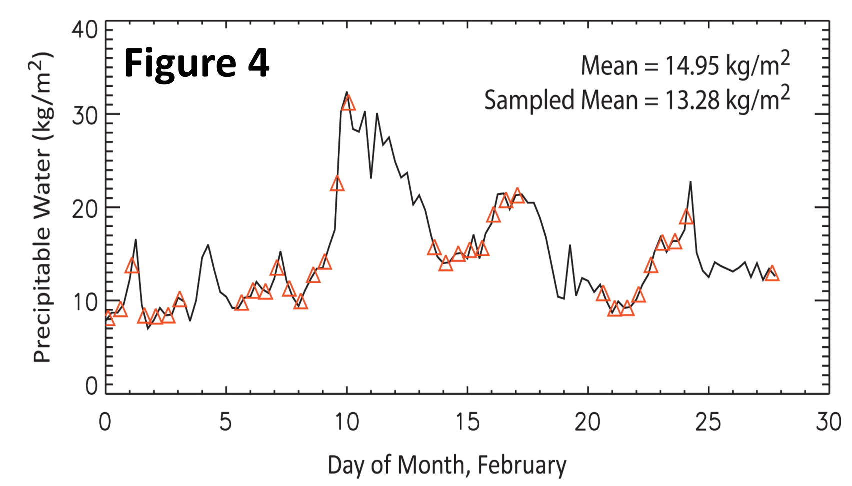
To address spatial and temporal sampling inadequacies, a mean value is calculated only if the following conditions are met: number of obs > 160 for the month (at least 15% of potential measurements per grid cell), number of ice obs <= 30 (less than 3% of possible data are affected by ice), and mean-day-of-month minus center of month (usually 15 or 15.5) < 6 days. A few satellite-months require an exception to the 3rd rule to avoid large data gaps in the time series: F08 for Jan 1988, F08 for Oct 1990, and F10 for Dec 1991.

Figure 3 shows an example of the number of months for a single SSMI satellite in the 1988 to 2012 time period. Note the change in ice coverage and variations in measurement near land boundaries. By setting a requirement of 160 observations per month per grid cell for each satellite we remove those cells with inadequate sampling.

The temporal check of the mean-day-of-month allows for removal of cells along the ice edge for which the ice is advancing or receding during the month. It also helps to address uneven sampling by a satellite. For instance, **Figure 4** shows an example of the sampling of water vapor by an SSMI instrument as plotted on NCEP water vapor for a grid cell located in the Pacific Ocean. Polar orbiting instruments have irregular measurement patterns for grid cells that introduce sampling error. Removal of poorly sampled cells helps to assure better product quality.

STEP 2: We use a simple approach to combine the individual instrument maps (drop-in-bucket method) to make the final merged product. We apply post-hoc corrections to AMSR-E and WindSat to account for small offsets due to time-of-measurement effects and variations in calibration datasets. We calculate a climatology for 1988 to 2007 that will be recalculated every 10 years (next recalculation in 2017). Anomaly values are determined using this climatology.





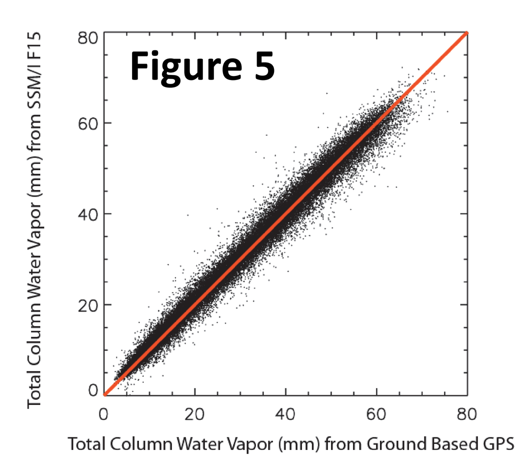
What Do We Mean By Climate Quality?

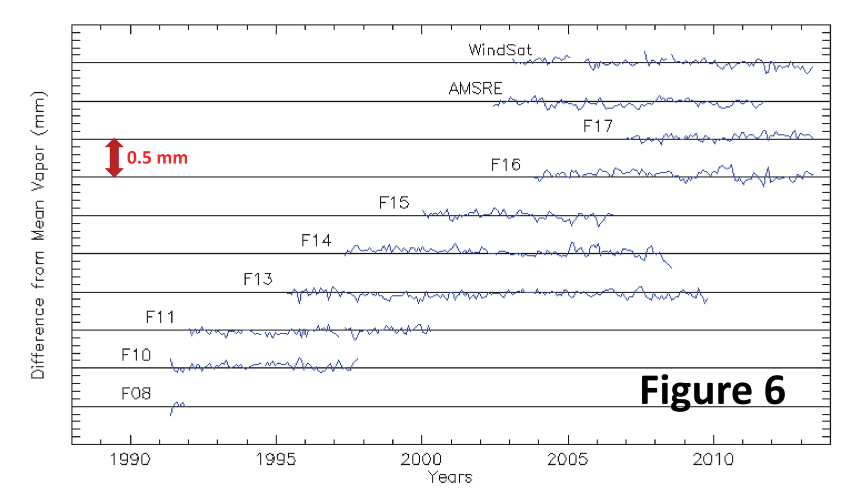
- All instruments have been intercalibrated on the brightness temperature level to within 0.2 K
- Data are processed using a consistent algorithm and approach (which we call Version-7)
- Differences in instrument design (channels, frequencies, footprint sizes) have been taken into account by using a complicated radiative transfer model
- The TPW and Surface Wind products have been created in a manner that reduces data alteration and sampling biases

There are a number of uncertainty sources in these merged products: spatial-temporal sampling errors, uncertainty in inter-satellite calibration, and systematic errors in the retrieval algorithm. Measurement noise is greatly reduced when calculating monthly averaged values.

Important steps are taken to assure high quality vapor and surface wind speed values for climate study. We monitor the accuracies of the input data (V7 ocean retrievals), as shown in **Figure 5**: check of the water vapor from F15 SSMI to GPS vapor values. **Figure 6** shows the inter-satellite differences for water vapor data that are merged into the product. Differences are less than 0.1 mm for all instruments.

On global monthly time scales, we estimate the uncertainty of both water vapor and wind speed to be about 2% (0.05mm and 0.1 m/s).





Global Trends, Model Comparisons, and Regional Patterns

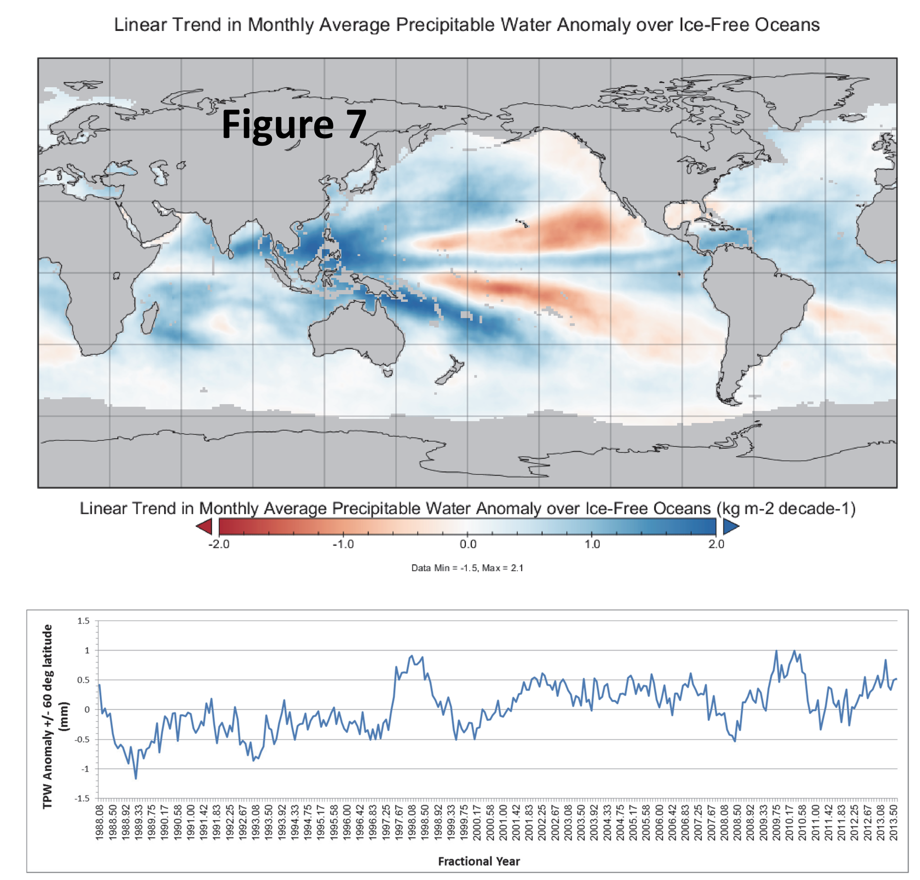
The Global Trend Maps are shown below: Water Vapor Trend Map (kg/m2 per decade) [**Figure 7**, left] and the Surface Wind Speed Trend Map (m/s per decade) [**Figure 8**, right]. A time series for each is shown below the trend maps. The trend patterns are fairly robust since the scale of the variability in the trend pattern is much larger than the global or tropical trends.

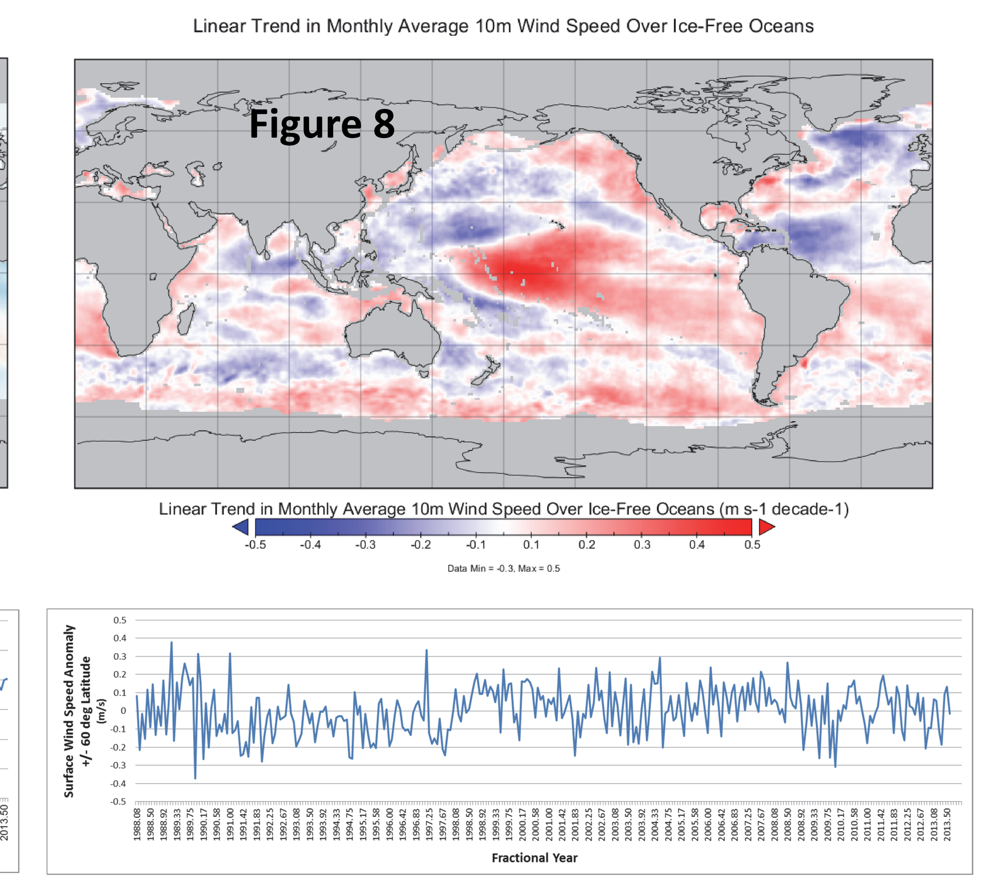
Further analyses are shown in the following posters:

Carl Mears [poster GC31B-1067] questions whether the trend patterns in these maps arise from anthropogenic changes in the Earth's climate or if they show decadal-scale interanual variability. Using 2 metrics, he assesses the significance of the trends in the map. He also compares the Water Vapor trend map to CMIP-5 historical runs and find few resemble the observations.

Lucrezia Ricciardulli [poster GC21A-0819] uses these data sets to study changes to the water cycle and compare results to CMIP-5 model output. Both posters will be available on the Remote Sensing Systems web site.

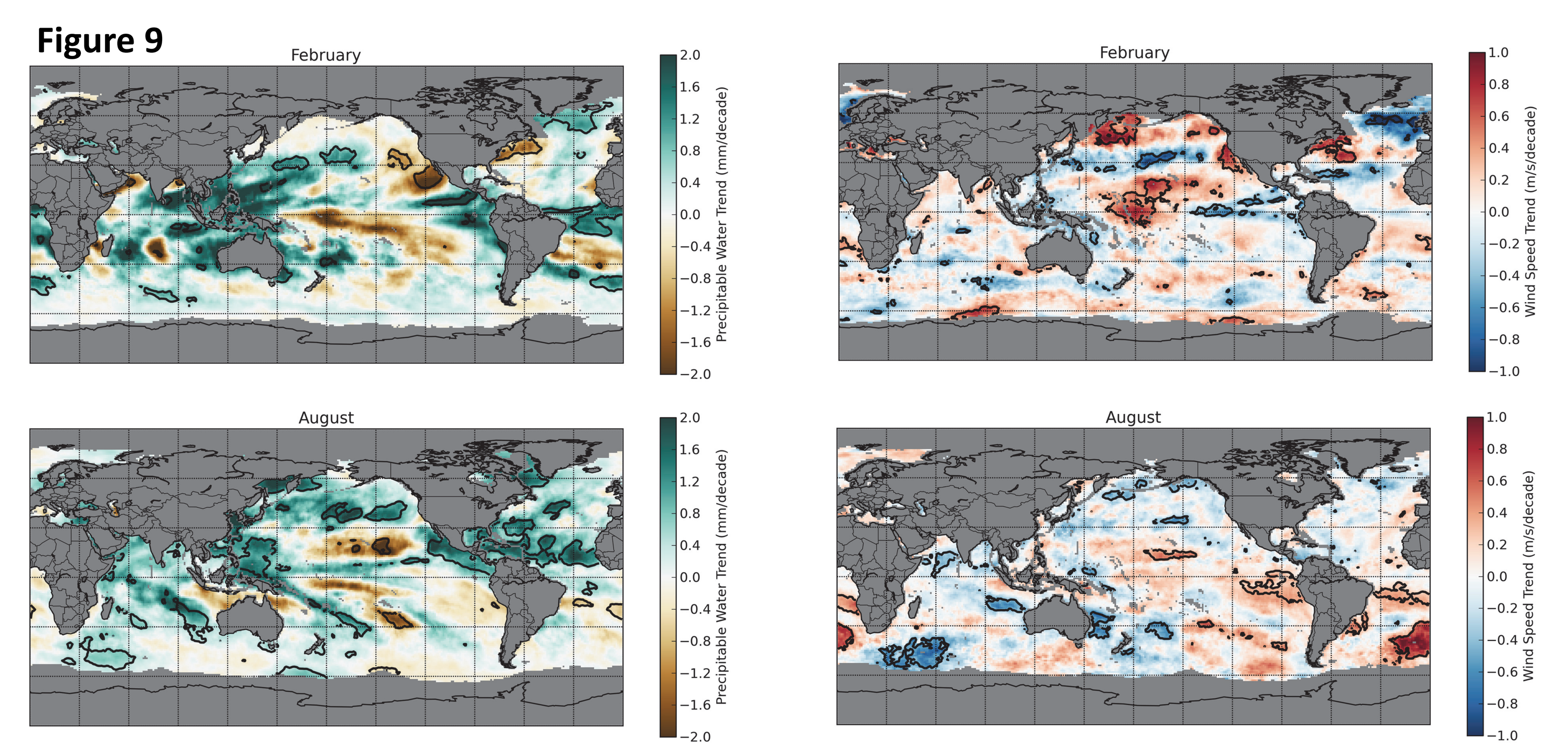
The linear trend maps are updated each year. For example, in Jan 2014, a new trend map will be available for 1988-2013.





These data products can also be used to study regional patterns. For example, we can look at the variability of different months to determine if there are temporal or spatial features in the data. We used the water vapor and wind products to calculate 25-year trend maps for each month. **Figure 9** shows water vapor (left) and wind speed (right) trend maps for 25 Februarys (top) and 25 Augusts (bottom). The heavy black contour lines enclose areas with statistically significant trends (at the 95% level).

We have started a study of regional patterns in these maps. For instance, the Gulf of Mexico demonstrates a drying trend in winter months and a moistening in summer months. This finding disagrees with NARR model results which shows a drying trend in this region for all months.



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