2013 Monthly Highlights

NASA ENERGY AND WATER CYCLE STUDY

NEWS

NEWS Challenge:

Document and enable improved, observationally-based, predictions of water and energy cycle consequences of Earth system variability and change.

Program Manager: J. Entin (NASA-HQ)
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Flip-Flopping Rainfall During El Nino

Investigators: Scott Curtis (co-I under Robert Adler)

Science issue: A signal of monthly reversals of rainfall anomalies was found across the South Tropical Indian Ocean related to the El Nino/ Southern Oscillation (ENSO) in December-January-February.

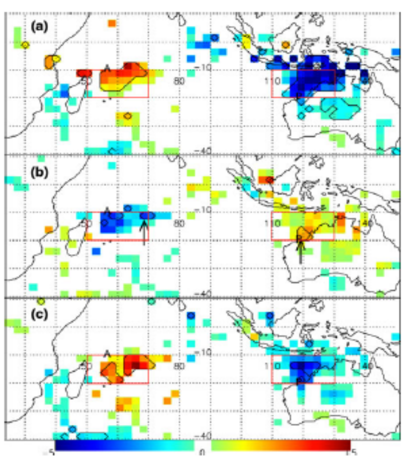
Approach: Global precipitation data was examined within 3-month ENSO seasons to identify the frequency of cases when the monthly anomalies were either consistent, or had a change of sign at the beginning, middle, or end of the season. One area of the globe stood out (See Figure).

Satellite-based data: GPCP Version 2.1

Models: None

Significance (with take away message): Predicting whether a future month will be wetter or drier than normal is an important scientific objective with many applications, including anticipating crop yields. Three-month seasonal forecasts are routinely made based on the state of ENSO, yet combining data into seasons can miss genuine ENSO relationships at the monthly scale. **What we have learned is that some long range precipitation forecasts can be improved to account for climate signals that evolve over an ENSO-season.** Finally, while most of the changes in rainfall and circulation examined here take place over the ocean (see Figure), the fact that Agalega Island and Port Hedland, Australia undergo significant changes in rainfall during El Niño versus La Niña austral summers demonstrates that the added monthly information has a societal benefit.

Figure with description in everyday terms:



Shown is the El Nino minus La Nina difference in precipitation for a) December, b) January, and c) February for only those grid boxes that flip-flopped (January anomaly was opposite in sign to December and February). Representative gauges (Algalega Island in the west and Port Hedland in the east) verified the results from GPCP. The reason for this pattern is related to the abrupt end of the ENSO-induced Indian Ocean Dipole in December forcing an atmospheric wave and sea surface temperature anomalies in the Southern Hemisphere in January and February.

***NEWS value added integration:**

Energy: Oceanic heat content related to ENSO.

Water: Changes in precipitation patterns

The Pacific warming associated with El Nino creates an atmosphere-ocean feedback mechanism in the Indian Ocean with consequence for monthly precipitation amounts

Publication: Curtis, S., 2012. ENSO induced monthly oscillations of precipitation: The unique case of the south tropical Indian Ocean in austral summer. *Climate Dynamics*, XX. YY-ZZ.

Date:04/04/12

Investigation of Earth radiation budget variability by cloud object

Seiji Kato[1] (PI), Kuan-Man Xu[1], Takmeng Wong[1], Patrick C. Taylor[1], Tristan S. L'Ecuyer[2]

[1]NASA Langley Research Center, [2] University of Wisconsin

Science issue:

How do active sensors improve cloud object properties?

- For example, can CALIPSO and CloudSat provide better low-level cloud height and cloud base?

Approach:

Collocate MODIS derived cloud properties (SSF) with CALIPSO and CloudSat derived cloud properties (CCCM)

NASA Data/Models:

- NEWS CCCM and CERES SSF data products.
- Cloud object data (derived using MODIS only)

Clear image with caption

Number of Deep convective, high-level cirrus cloud (CC), and low-level stratus cloud (SC) cloud objects in a month (Overlap with active sensor ground track)

March 2008	100-150 Km	150-300 Km	300 Km and up
Deep Conv.	763 (47)	791 (131)	457 (250)
SC 1	12321 (438)	3533 (512)	911 (557)
SC 2	8596 (331)	2683 (369)	829 (490)
SC 3	4118 (180)	1287 (262)	542 (328)
CC1	371 (14)	7 (0)	0 (n/a)
CC2	1592 (87)	190 (56)	14 (9)
CC3	4127 (181)	1637 (310)	504 (342)

Progress towards goals:

Used one month to test the algorithm to identify cloud objects. Extend the period to 4 years.

Significance (take away message):

Significant number of deep convective cloud objects, which is the largest cloud object, overlap with CALIPSO and CloudSat ground track

NEWS value added integration:

Publication:

Publication from our NEWS phase 1 project that discusses global mean radiation budget

Kato, S., N. G. Loeb, F. G. Rose, D. R. Doelling, D. A. Rutan, T. E. Caldwell, L. Yu, and R. A. Weller, 2012a: Surface irradiances consistent with CERES-derived top-of-atmosphere shortwave and longwave irradiances, *J. Climate*, in press.

Date submitted

Monthly highlight:

Using NEWS Water and Energy Cycle Products to Investigate Processes that Control Cloud Feedback

PI: Hui Su, Jet Propulsion Laboratory, California Institute of Technology

Science issue: Cloud simulations in climate models exhibit large discrepancies from observations. What is the dominant source of cloud errors?

Approach: Conditional sampling approach to examine cloud structures as functions of large-scale dynamic and thermodynamic environmental conditions and decompose cloud simulation errors into three components: the large-scale error, cloud parameterization error and co-variation error.

NASA Data/Models: CloudSat/CALIPSO observations of clouds structures, AIRS temperature and humidity profiles, AMSR-E sea surface temperature and water vapor path, ECMWF and NCEP reanalysis winds, CMIP5 models including NASA GISS models.

Progress towards goals:

- We found that cloud simulation errors are predominantly contributed by parameterization errors in 13 CMIP5 models.
- For the large-scale errors, the thermodynamic parameter errors (e.g., temperature and humidity structures) account for greater percentage of total errors than the dynamic parameter errors (e.g., winds).
- A manuscript by *Su et al.* is in press with *Journal of Geophysical Research.*

Significance (take away message):

- Future model improvements should focus on improving cloud parameterizations.

Clear image with caption *Su et al.* (2013, *JGR*)

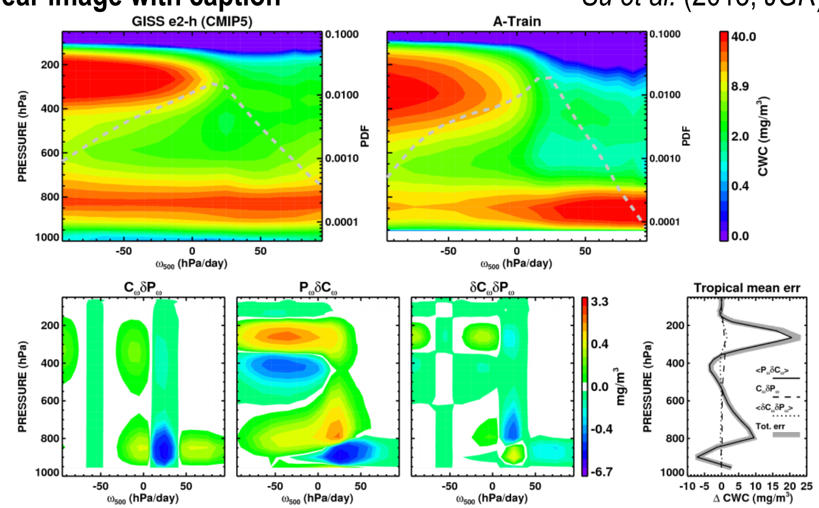


Figure 2: (top row) GISS e2-h simulated cloud water content sorted by ω_{500} , compared to CloudSat data. (bottom row) Three components of cloud errors as a function of ω_{500} and on the tropical averages.

NEWS value added integration:

- Integrated analysis that utilizes multiple satellite observations and model simulations to understand water and energy cycles
- Novel diagnostic framework for error analysis and process understanding
- Guidance to future climate model developments

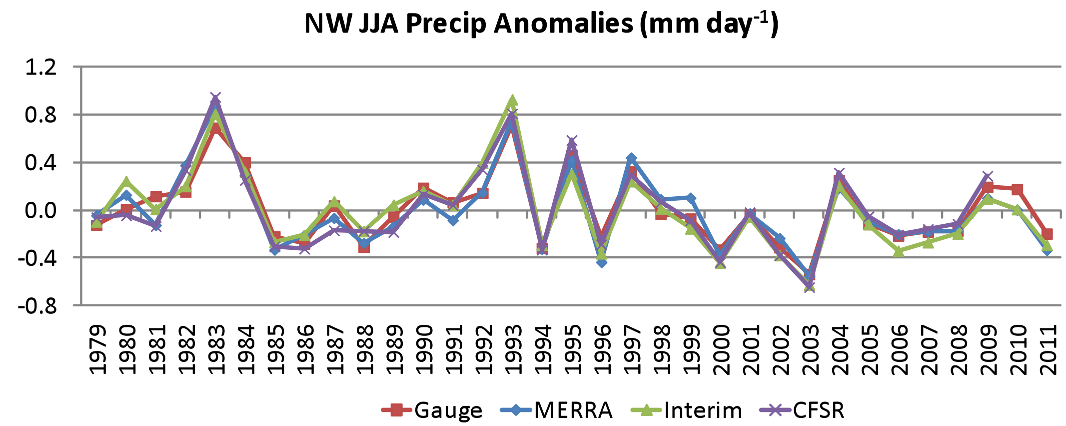
Publication:

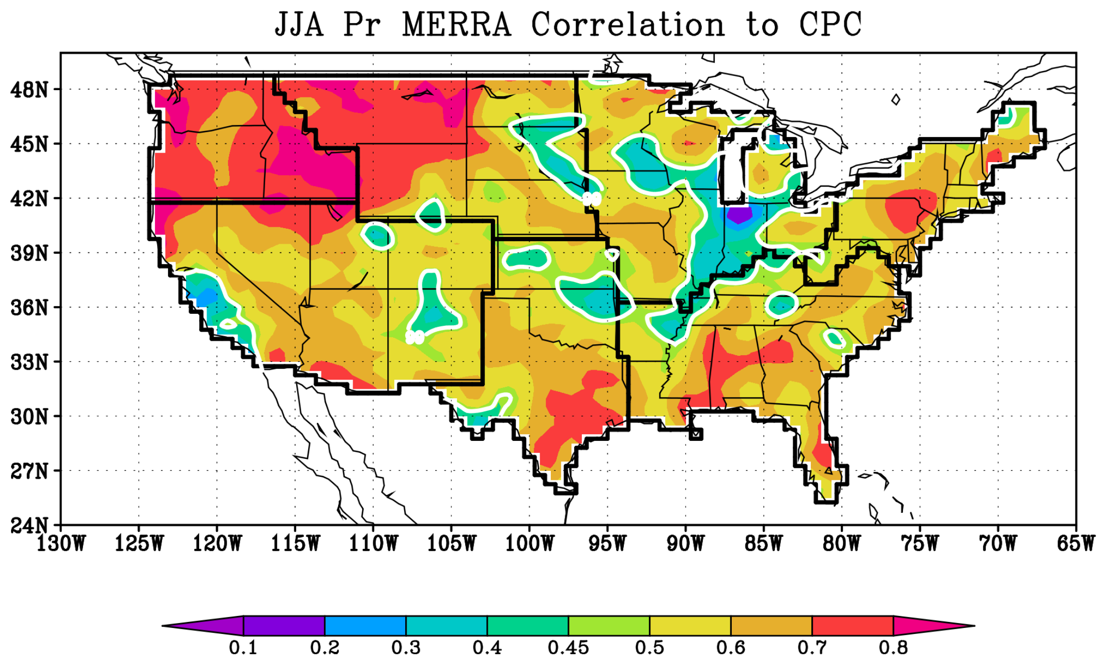
Su, H., J. H. Jiang, et al. (2013), Diagnosis of Regime-dependent Cloud Simulation Errors in CMIP5 Models Using "A-Train" Satellite Observations and Reanalysis Data, *J. Geophys. Res*, doi:2012JD018575, in press.

Date submitted: January 3, 2013

Monthly highlight:

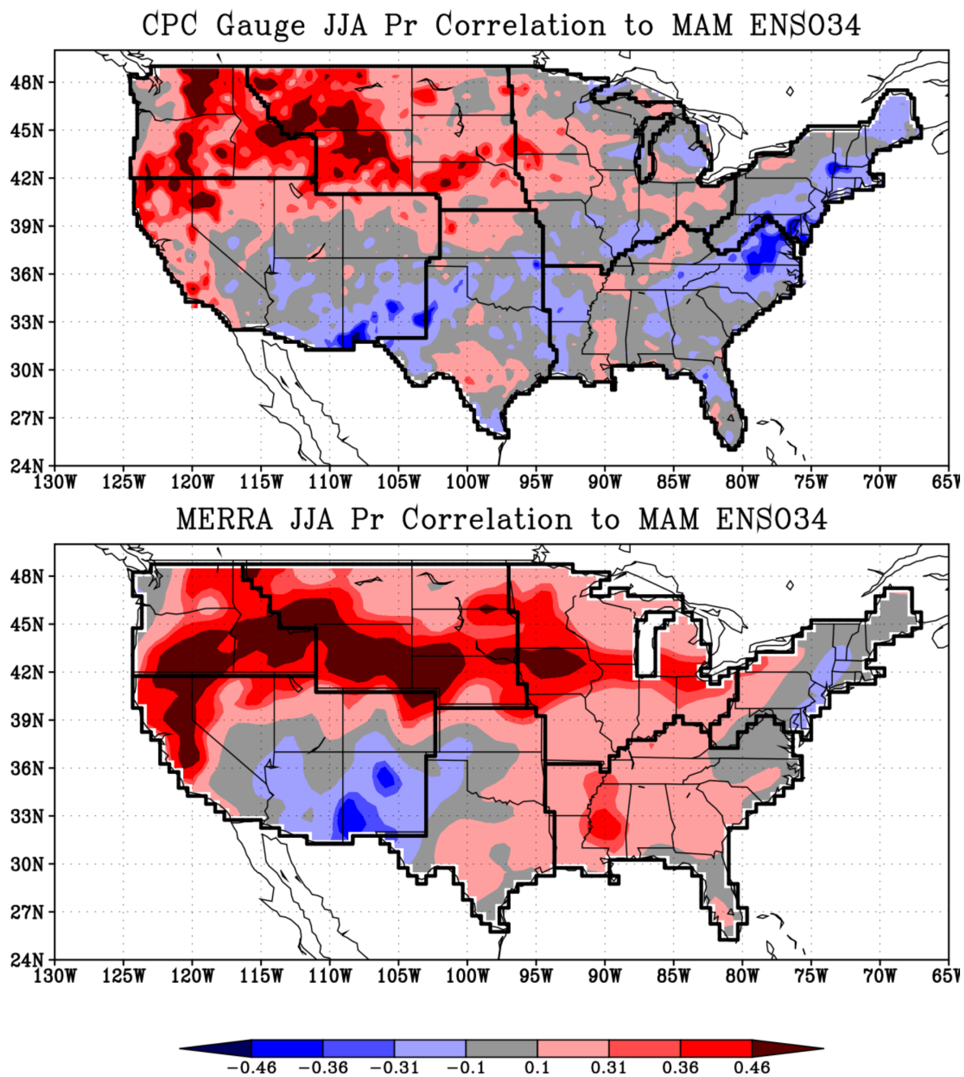
MERRA Summer Regional Precipitation





- MERRA has a high correlation to gauge observations in summer, especially the Northwest
- This also extends to other reanalyses and is also high in other regions of the US
- The Midwest US is a notable area of low correlation

Summertime Link to ENSO



- In correlating MERRA and gauge precipitation to ENSO (using Nino34), the NW shows high correlation
- MERRA's high correlation also extends to the MW and SE US, where observations disagree
- This likely means that local land and PBL processes and recycling are not represented well enough in MERRA (similar patterns can be seen in Interim and CFSR)

Investigation of Recycling Rate of Moisture in the Atmosphere From Observation and Model

PI: Xun Jiang (UH); Co-I: Yuk Yung (Caltech); Collaborator: Liming Li (UH)

Science issue: Better understand the hydrological cycle as a response to global warming. Quantitatively simulate the precipitation trend in order to predict the variation of precipitation in the future.

Data:

Precipitation: Special Sensor Microwave Imager (SSM/I) Version 6; Global Precipitation Climatology Project (GPCP) Version 2.1

Model:

NASA Goddard Institute for Space Studies (GISS) atmospheric general circulation model coupled to the HYbrid Coordinate Ocean Model (HYCOM)

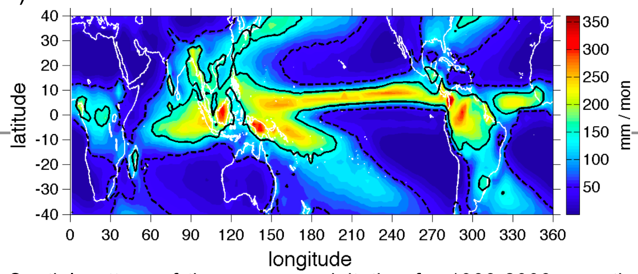


Figure 1: Spatial pattern of the mean precipitation for 1988-2008 over the tropical and subtropical region (40°S-40°N). We use the combined global data from the GPCP (V2.1) (land) and SSM/I (V6) (ocean). The 200 mm/mon and 50 mm/mon isopleths are shown by black solid lines and black dashed lines, respectively.

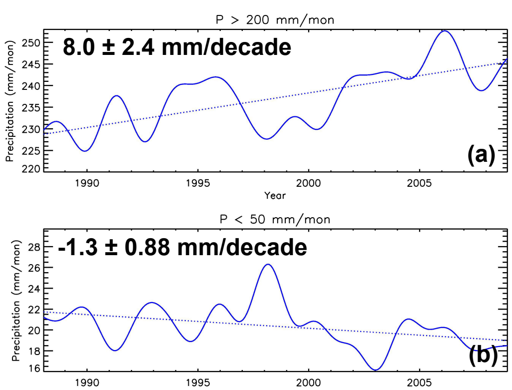


Figure 2: (a) Time series of precipitation (P) over the high-precipitation (P > 200 mm/mon) area. (b) Same as (a) except for low-precipitation (P < 50 mm/mon) area. El Nino Southern Oscillation (ENSO) signals have been removed from time series by a regression method based on the Niño3.4 index.

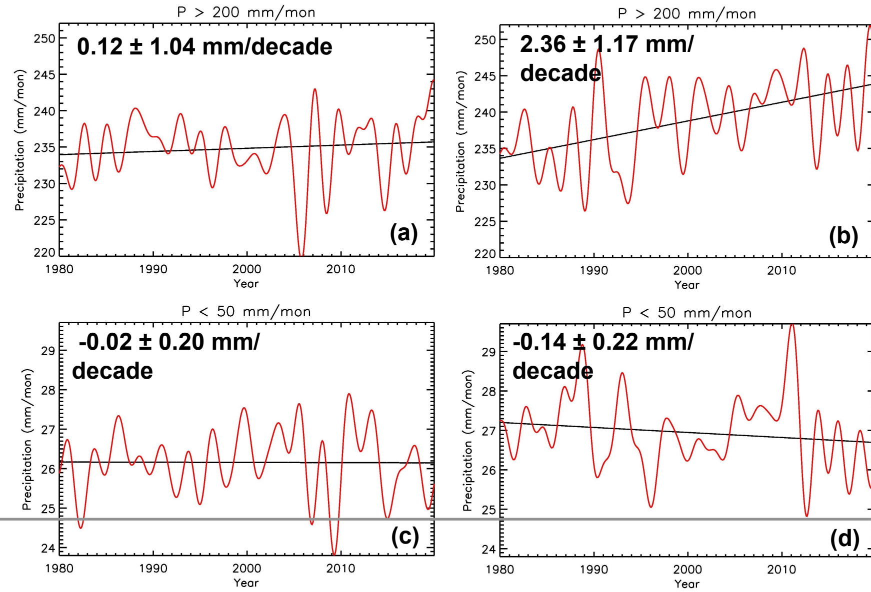


Figure 3: Time series for precipitation (P) from GISS-HYCOM. (a) P over high-precipitation area from the control run (greenhouse gas concentrations fixed). (b) P over high-precipitation area from the historic run (historic greenhouse gas concentrations included). (c) P over low precipitation area from the control run. (d) P over low precipitation area from the historic run.

Significance: GISS-HYCOM model captures the observed precipitation trends qualitatively. From the comparison between the historic and control runs, it suggests that the increasing greenhouse gas affects the temporal variation of precipitation, contributing to precipitation extremes.

NEWS value added integration:

This work was funded by NASA's Energy and Water Cycle Study program.

References:

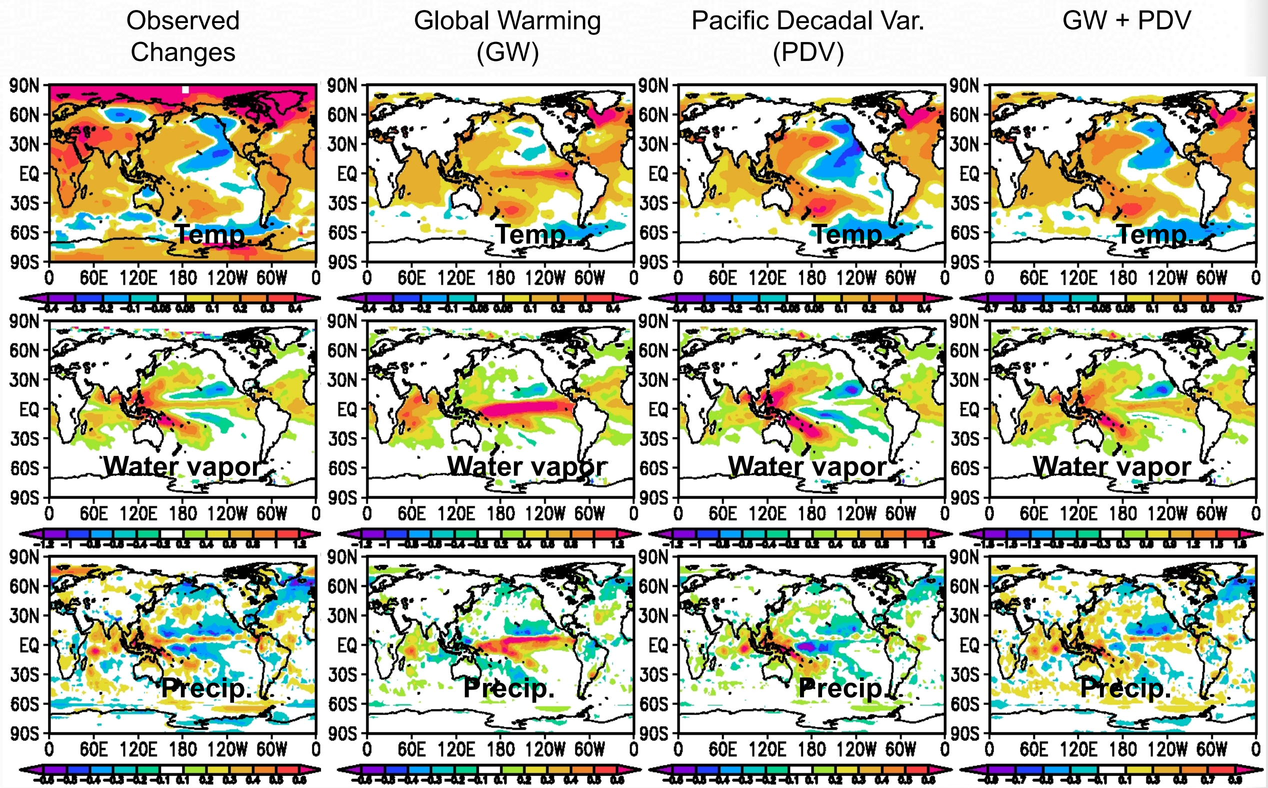
Trammell, J. H., X. Jiang, L. Li, M. Liang, J. Zhou, and Y. L. Yung, Investigation of Atmospheric Recycling Rate From Observation and Model, H13K-06, AGU 2012 Fall Meeting, San Francisco, CA, Dec 3-7, 2012.

Combination of Global Warming and PDV Drives Spatial Pattern of Precipitation Change

Robert Adler and Guojun Gu (University of Maryland)

<u>How is global warming affecting the pattern of precipitation change</u> (and temperature and water vapor) across the globe and are other climate processes involved? *Global observations of surface temperature, water vapor and precipitation and statistical techniques are used to <u>diagnose the relative impacts of long-term global warming (GW) and the inter-decadal Pacific Decadal Variability (PDV)</u>. The climate regime shift around 1998/1999, likely associated with PDV and its associated temperature changes in the Pacific, counteracts global warming and significantly affects the patterns of change.*

The first column in the figure shows the <u>observed trends</u> in the variables studied, while the second and third columns show <u>the estimated changes due to surface global warming and PDV SST changes</u>, respectively. The GW and PDV patterns are quite different over the Pacific, indicating compensating changes in some locations. A <u>weighted average of the GW and PDV signals</u> in the fourth column reproduces the observed patterns for all three variables.



The <u>results of this study</u> show that: 1) the <u>observed changes</u> in temperature, water vapor and precipitation over the last few decades are a result of <u>the combined impact of global warming and inter-decadal shifts in the Pacific Ocean.</u> 2) the <u>expected patterns of change due only to global warming</u> are given in the second column and should be what is expected from climate models simulating global warming processes.

Gu, G., and R. F. Adler, 2012: Interdedacal variability/long-term changes in global precipitation patterns during the past three decades: Global warming and/or Pacific Decadal Variability? *Climate Dynamics*, doi: 10.1007/s00382-012-1443-8.

Surface Evaporative Flux Discrepancies Identified with Land Surface Type

NASA ENERGY AND WATER CYCLE STUDY

Investigators: A. E. Lipton, P. Liang, C. Jiménez, C. Prigent, F. Aires, J. Galantowicz, J.-L Moncet, G. Uymin, W. Rossow

Science issue: There are large, systematic discrepancies between land surface model (LSM) evaporative latent heat fluxes (Qle) and satellite-derived products.

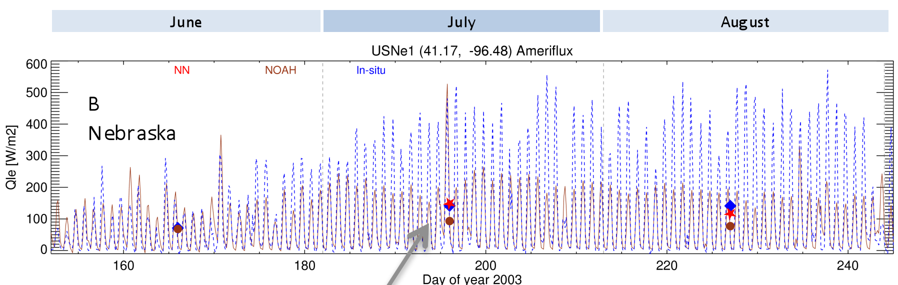
Approach: Use neural networks to estimate monthly-average Qle from satellite-derived parameters. The LSM and satellite Qle products are evaluated at sites where additional satellite and tower measurements are available, with a particular focus on anomalous discrepancies.

Satellite-based data: AMSR-E microwave emissivities, day-night difference in land surface temperature (from AMSR-E), downward solar and infrared fluxes from ISCCP cloud analysis, and MODIS visible and near-infrared surface reflectances from 2003.

Model: Global Land Data Assimilation System, Ver. 2 — NOAH

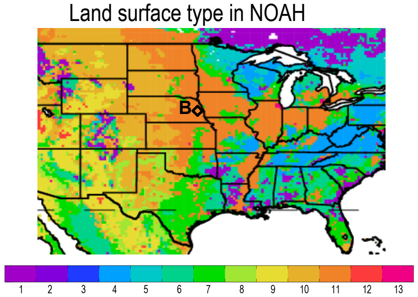
Significance: Existing estimates of evaporation over global land areas have large uncertainties.

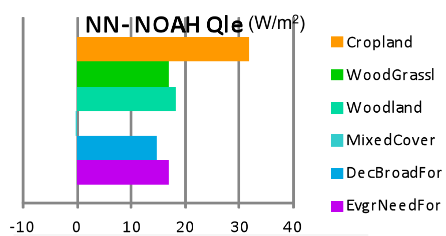
A large, persistent Qle discrepancy occurred over the North American Great Plains in summer. The largest differences are around the Nebraska, South Dakota, Iowa intersection and, in July, extending across the Dakotas. All of the satellite products support high Qle around the NE/SD/IA intersection, where the NOAH LSM's Qle is relatively low. The analysis is supported by data from Ameriflux tower sites. The NOAH Qle at these sites varies less than the other products from site-to-site and month-to-month. Comparing cropland to the surrounding land types (while excluding the arid grassland and scrubland areas to the west) the Qle is distinctly lower and NN−NOAH Qle discrepancies are distinctly higher for the areas classified as cropland in the LSM.



Monthly averages from satellite/neural network, NOAH LSM, flux tower

Land surface type in NOAH





Satellite/NN and NOAH LSM disagree most in cropland-classified areas

NEWS value added integration: These findings point to potential problems with elements of the LSM parameterization dependent on the cropland type in this summer environment. Other NEWS scientists are working on improving the ability of LSMs to depict and forecast surface fluxes. Improvements depend on improved use of satellite data in models, which in turn depends on understanding and minimizing discrepancies. Estimates of evaporative fluxes from LSMs are used by NEWS scientists to quantify interactions and changes in elements of the global water cycle.

2011 Publications from the research team:

Moncet, J.-L., P. Liang, A. E. Lipton, J. F. Galantowicz, and C. Prigent, 2011: Discrepancies between MODIS and ISCCP land surface temperature products analyzed with microwave measurements. J. Geophys. Res., 116, D21105.

Galantowicz, J. F., J.-L. Moncet, P. Liang, A. E. Lipton, G. Uymin, C. Prigent, and C. Grassotti, 2011: Subsurface emission effects in AMSR-E measurements: Implications for land surface microwave emissivity retrieval. J. Geophys. Res., 116, D17105.

J.-L. Moncet, P. Liang, J. F. Galantowicz, A. E. Lipton, G. Uymin, C. Prigent, and C. Grassotti, 2011: Land surface microwave emissivities derived from AMSR-E and MODIS measurements with advanced quality control. J. Geophys. Res., 116, D16104.