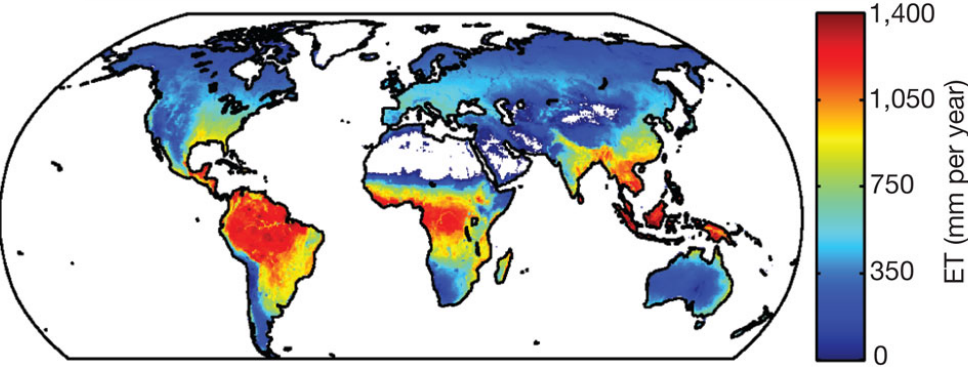
Recent Decline in the Global Land Evapotranspiration Trend Due to Limited Moisture Supply

Jung et al. (2010) Presented by Forrest M. Hoffman



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- Global land evapotranspiration (ET) returns about 60% of annual land precipitation to the atmosphere.
- Climate change is expected to intensify the hydrological cycle and to alter ET, but direct observational evidence of a positive trend in global ET is lacking.
- Jung et al. (2010) provide a data-driven estimate of global land ET from 1982–2008, compiled using FLUXNET, meteorological and remote-sensing observations, and a machine-learning algorithm (model tree ensemble or MTE).

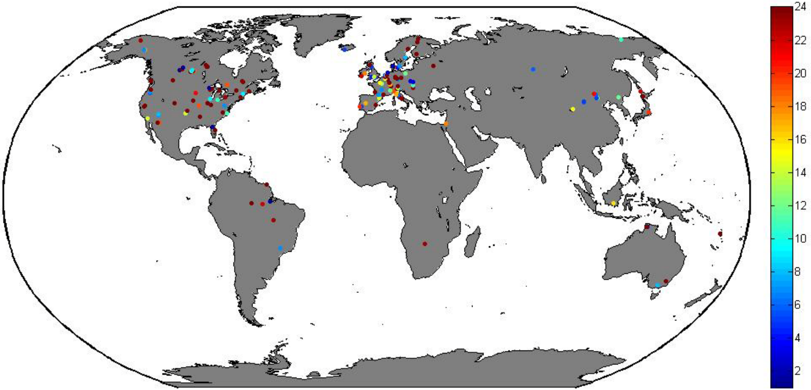

Figure S1: Jung et al. (2010) processed half-hourly eddy covariance data from **253 globally distributed flux towers** using standardized gap-filling and quality-control algorithms and a correction for incomplete energy closure. **4678 site-months from 198 towers** had all variables and passed quality controls.

- Annual global land ET for 1982–2008 is estimated to be $65 \pm 3 \times 10^3$ km^3 y^{-1}, with a spatial distribution as shown in (a).
- Consistent with another report and within model range from the Global Soil Wetness Project 2 (GSWP-2).
- Cross-validation at FLUXNET sites (b) and corroboration against independent ET estimates from 112 catchment water balances (c).
- Consistent with median model ensemble from simulations of 16 land-surface models participating in GSWP-2 (d).

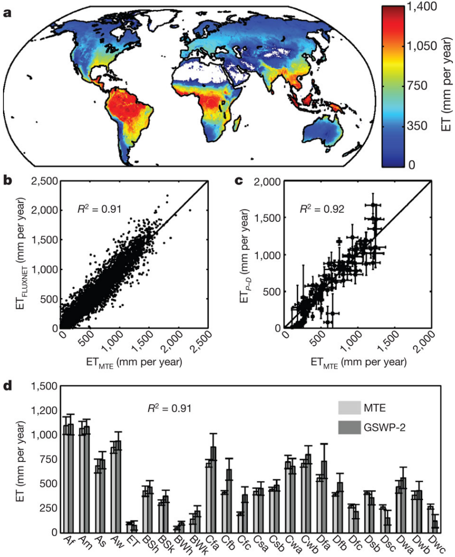

Figure 1: Validation of global land ET product from MTE.

- Rate of land ET increased by 7.1 ± 1.0 mm per year per decade for 1982–1997, consistent with expected ‘acceleration’ of hydrological cycle.
- Trend of rising ET disappears after last big El Niño in 1998, consistent with up to 9 LSMs.
- Trend becomes negative during 1998–2008 at -7.9 mm per year per decade.

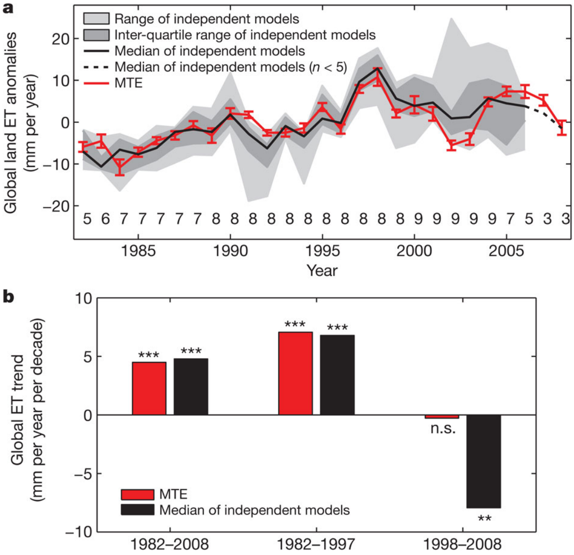

Figure 2: Global land-ET variability according to MTE and independent models. ***, significance of trends at 99% confidence interval; **, significance of trends at 95% confidence interval; n.s., not significant.

- Largest regional contributions to declining trend since 1998 originate from SH Africa and Australia.
- Largest trend declines occurred in regions in which **ET is limited by moisture**.
- Lower ET should feed back to the atmosphere and increase dryness in these regions.
- Recent decrease in relative humidity over Australia could be the result of declining ET.

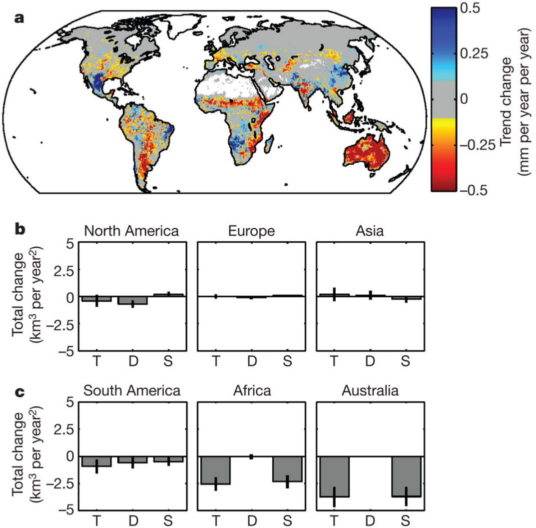

Figure 3: ET trend changes between 1982–1997 and 1998–2008. T, total area; D, demand-limited area; S, supply-limited area

- Could a soil moisture shortage be the reason for decline of ET trend since 1998?
- Significant soil moisture trends from TRMM (a), significant ET trends from MTE (b) and mean ET and soil-moisture anomalies of valid pixels of TRMM domain (c).
- Strong spatial consistency in estimated ET and soil-moisture trends suggests that decreasing soil moisture supply in SH is the main mechanism causing cessation of rising ET trend after 1998.

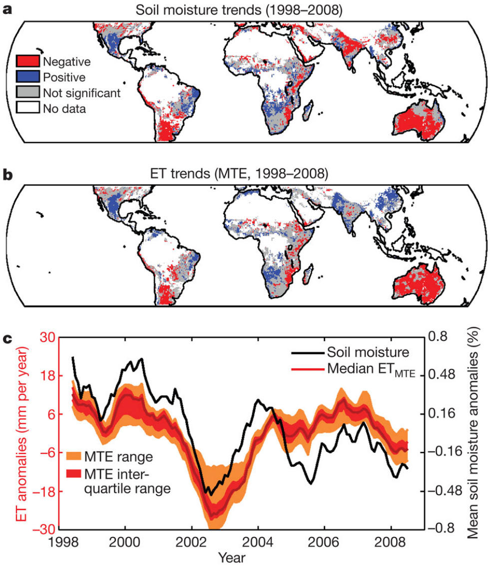

Figure 4: Soil-moisture and ET trends.

Other Mechanisms

- Other mechanisms that could be responsible for stabilization of global land ET "seem less important."
- These include:
  - stomata closure caused by increasing CO_2 concentrations,
  - land-use change, and
  - decreasing wind speed.

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- They cannot determine if transition is part of natural climate oscillation or a climate-change signal in which land-ET becomes progressively more supply-limited in the long term.
- The latter would imply a limit to the acceleration of the terrestrial hydrological cycle, and would suggest that it may have been reached.
- Consequences include decreasing terrestrial productivity and reduced C sink; preferential partitioning of energy fluxes at the land surface into sensible, rather than latent, heat flux and thus accelerating land-surface warming; and intensified regional land-atmosphere feedback.

References

Martin Jung, Markus Reichstein, Philippe Ciais, Sonia I. Seneviratne, Justin Sheffield, Michael L. Goulden, Gordon Bonan, Alessandro Cescatti, Jiquan Chen, Richard de Jeu, A. Johannes Dolman, Werner Eugster, Dieter Gerten, Damiano Gianelle, Nadine Gobron, Jens Heinke, John Kimball, Beverly E. Law, Leonardo Montagnani, Qiaozhen Mu, Brigitte Mueller, Keith Oleson, Dario Papale, Andrew D. Richardson, Olivier Roupsard, Steve Running, Enrico Tomelleri, Nicolas Viovy, Ulrich Weber, Christopher Williams, Eric Wood, Sönke Zaehle, and Ke Zhang. Recent decline in the global land evapotranspiration trend due to limited moisture supply. *Nature*, 467 (7318):951–954, October 2010. doi:10.1038/nature09396.

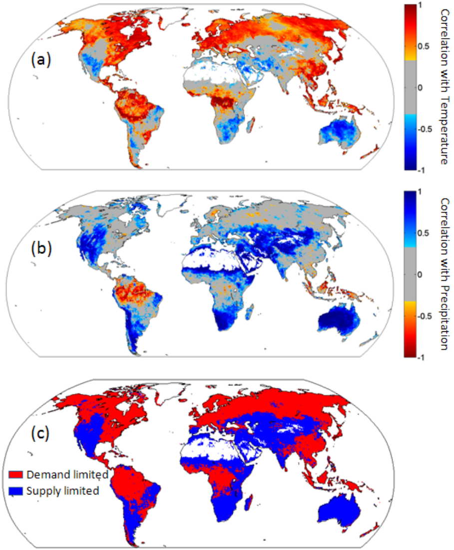

Figure S2: Inferred supply and demand limitation of ET.

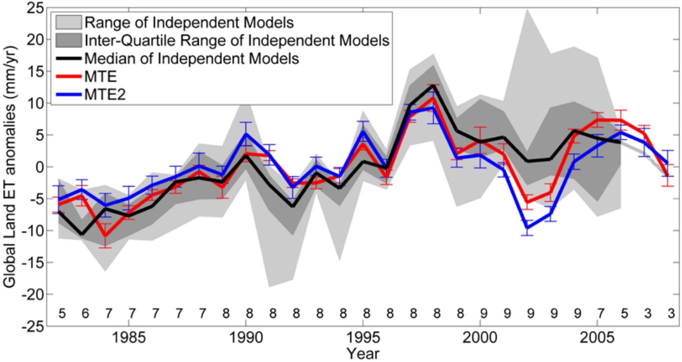

Figure S3: Global interannual variability of ET from MTE including vapour pressure deficit and radiation.

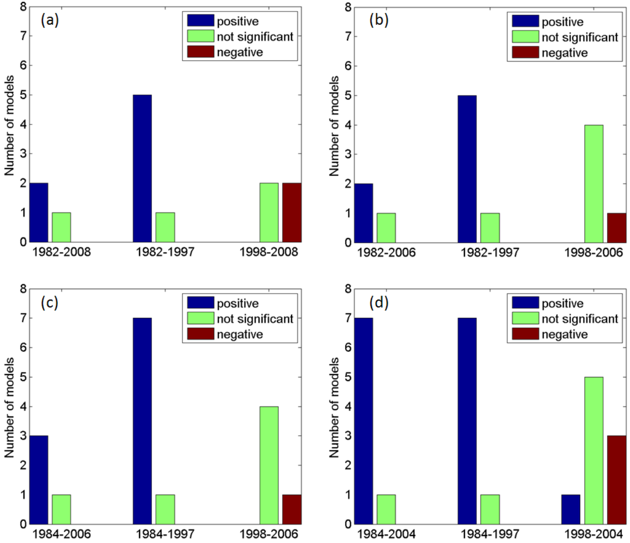

Figure S4: ET trend statistics of participating models.

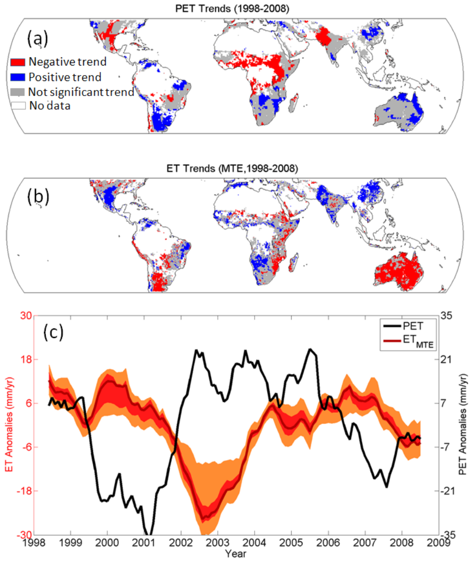

Figure S5: Trends in potential and actual evapotranspiration.

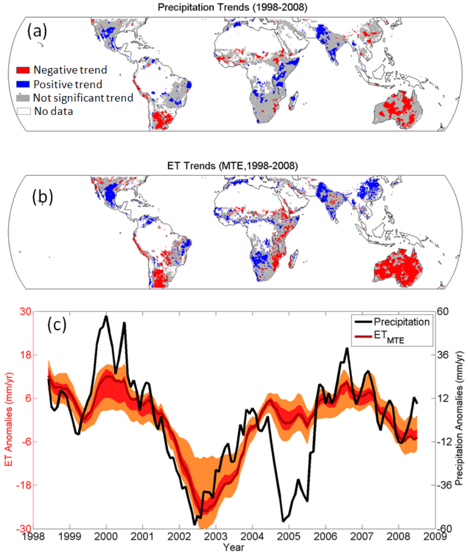

Figure S6: Trends in precipitation and evapotranspiration.