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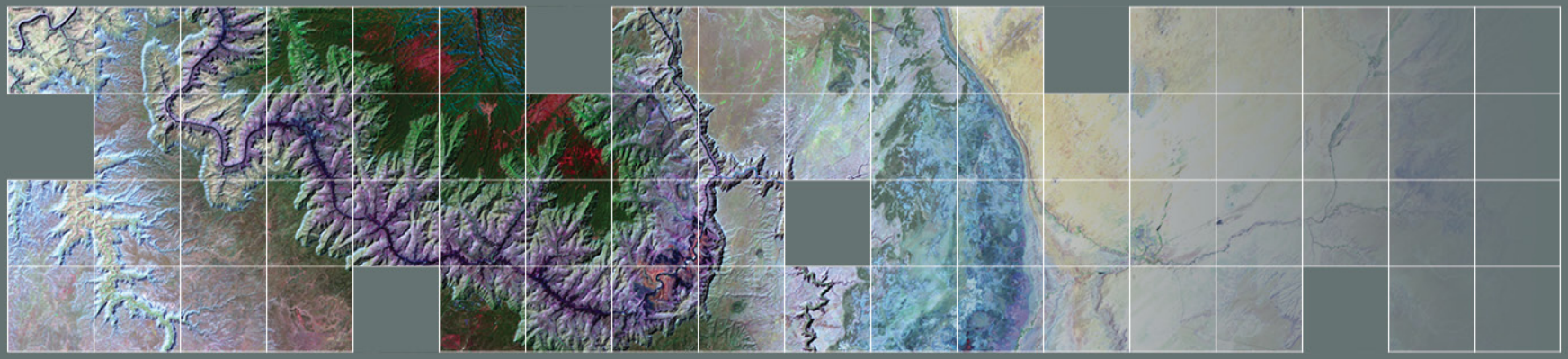
Climate and Land Use Change
Earth Resources Observation and Science (EROS) Center

New Frontiers in Seasonal Prediction in Africa

Chris C. Funk (USGS/UCSB Climate Hazards Group)



U.S. Department of the Interior
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FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

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CHG | Climate Hazards Group

Some important questions

- **Why** – because predicting and understanding drought in East Africa can save lives and livelihoods
- **Where** – Central/Eastern Kenya, Southern Ethiopia and Somalia
- **When** – the long/belg rainy season
- **How** – statistical forecasts based on Indo-Pacific SSTs or precipitation
- **Who** – Many friends and collaborators:
  Gideon Galu, Diriba Korecha, Gabriel Senay, Andrew Hoell, Shrad Shukla, Tsegaye Tadesse, Ben Zaitchik, Jim Verdin, Park Williams, Gary Eilerts, Greg Husak, Joel Michaelsen, Michael Marshall, Nigist Biru, Pete Peterson, Marty Landsfeld, Pete Robertson, Brent Roberts, Brant Liebmann, Marty Hoerling, …

Timeline

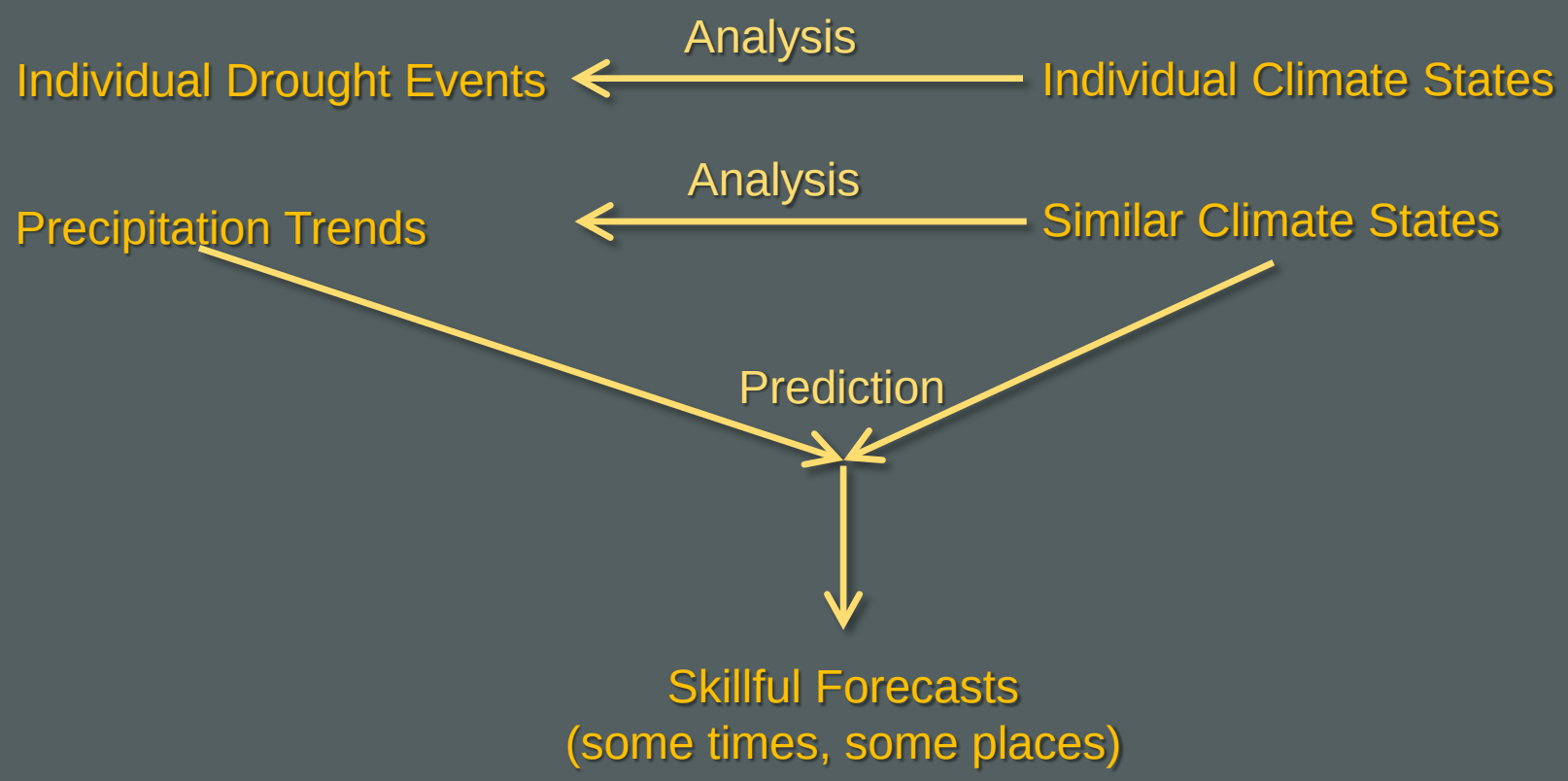
---- Prediction ---- ------ Explanation ------

- **2003 … Declines in ‘long cycle’ growing regions in Ethiopia identified**
- **2004 … Funk, Senay, Korecha analyze declines**
- **2009 … Cause of drought thought to be zonally overturning Rossby wave response to Indo-Pacific warming**
- **2011 … Williams links drought to stronger Walker circulation**
  - identifies stronger La Nina drought teleconnections
- **2012-2013 Lyon and Hoell identify connections to Pacific SSTs**
  - La Nina + stronger west Pacific gradient = more drought
- **2012-2014 Pacific gradient based long rains precipitation forecasts**
- **2014 – Integration of climate forecasts and land surface models**

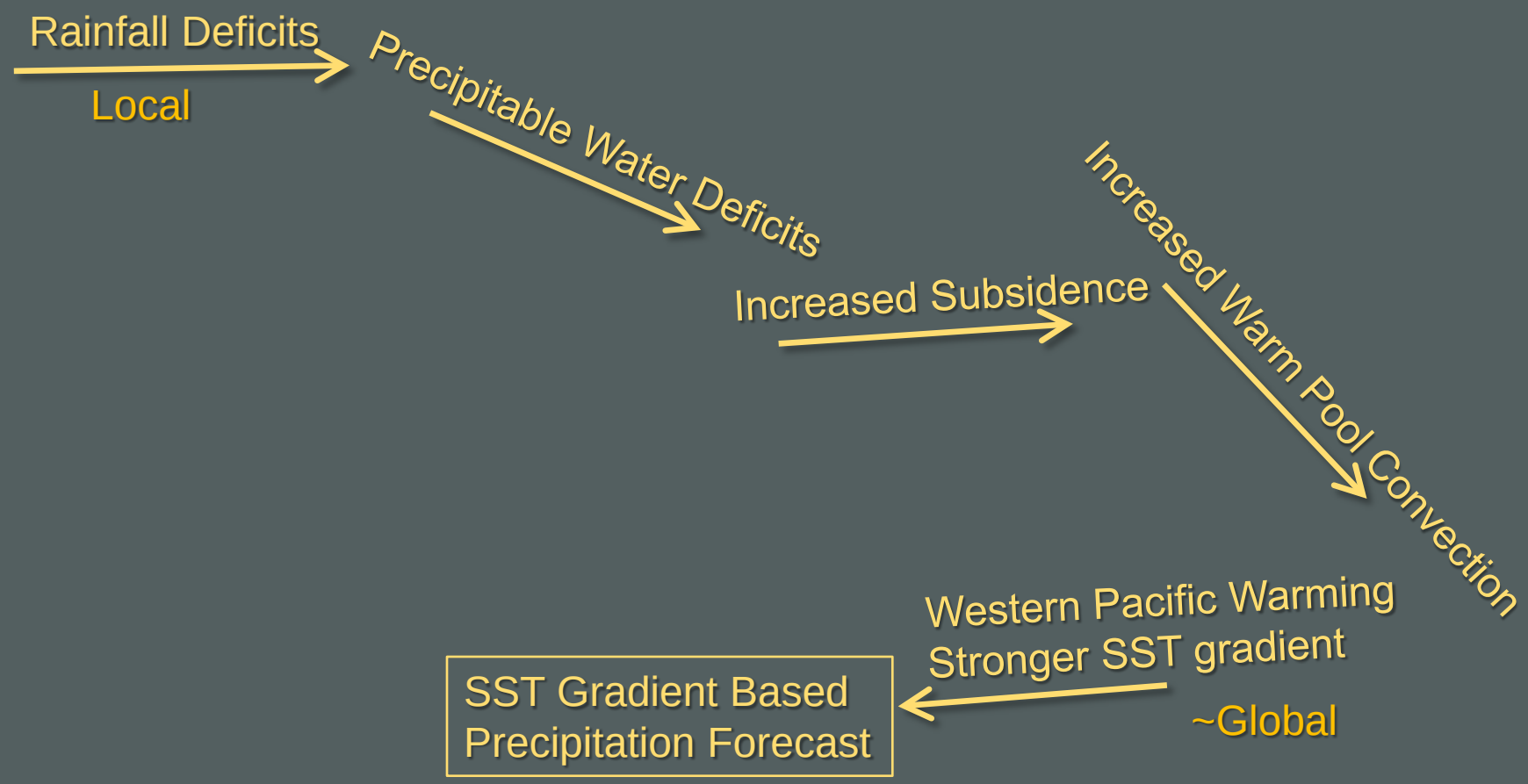
Overview

- Example – the 2014 April-May rains
- **Integrating forecasts and observations using land surface models**
- **Links to climate change**
  - Increasing the frequency of La Nina-like climate states
  - Increasing the predictability of long/belg season droughts?
- **Preliminary IDS results**

Playing Drought Detective informs Prediction



Example: April/May 2014 Rainfall Deficits



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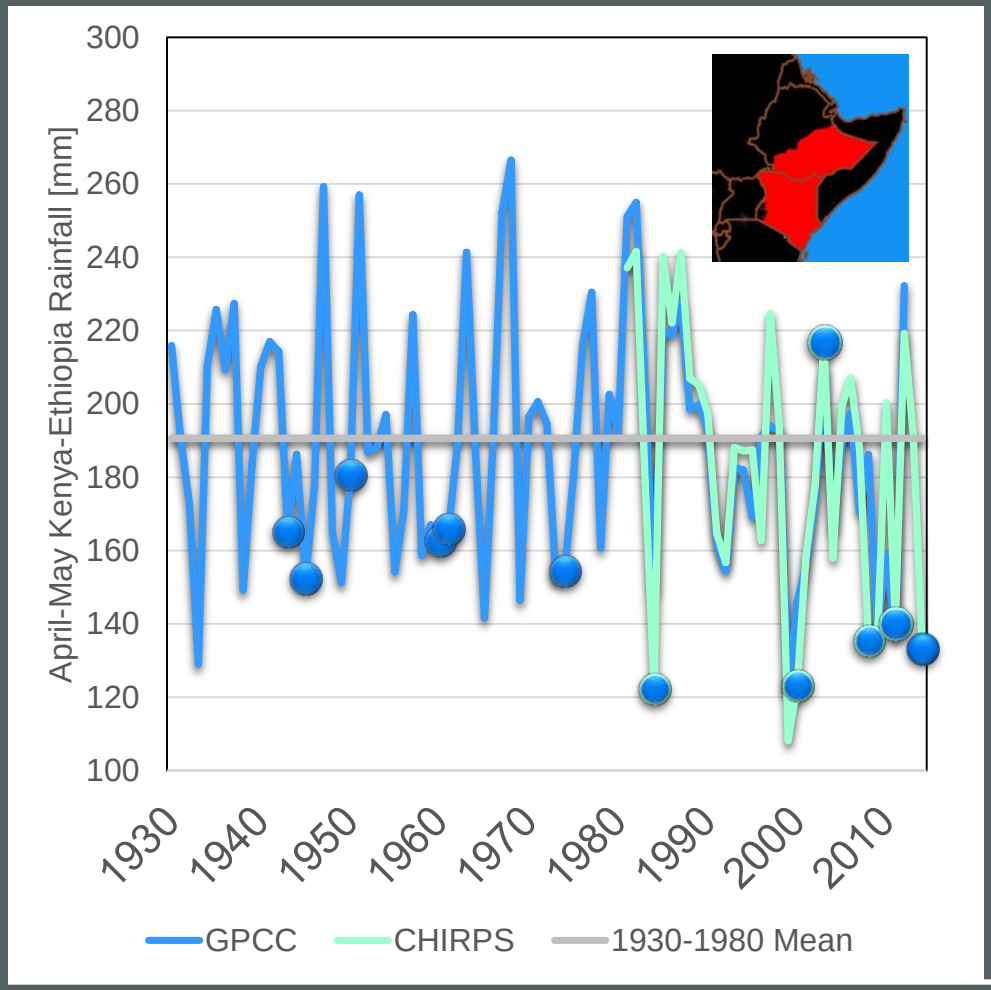
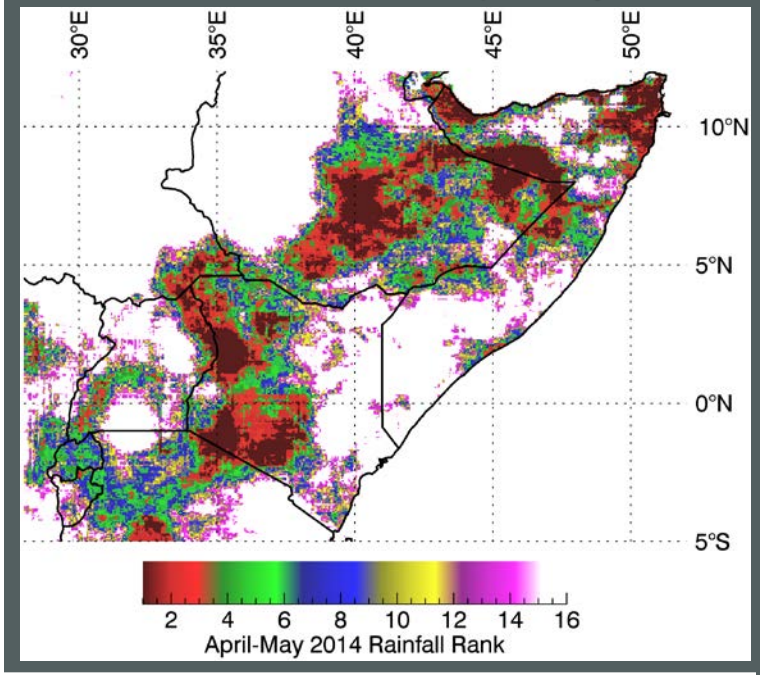
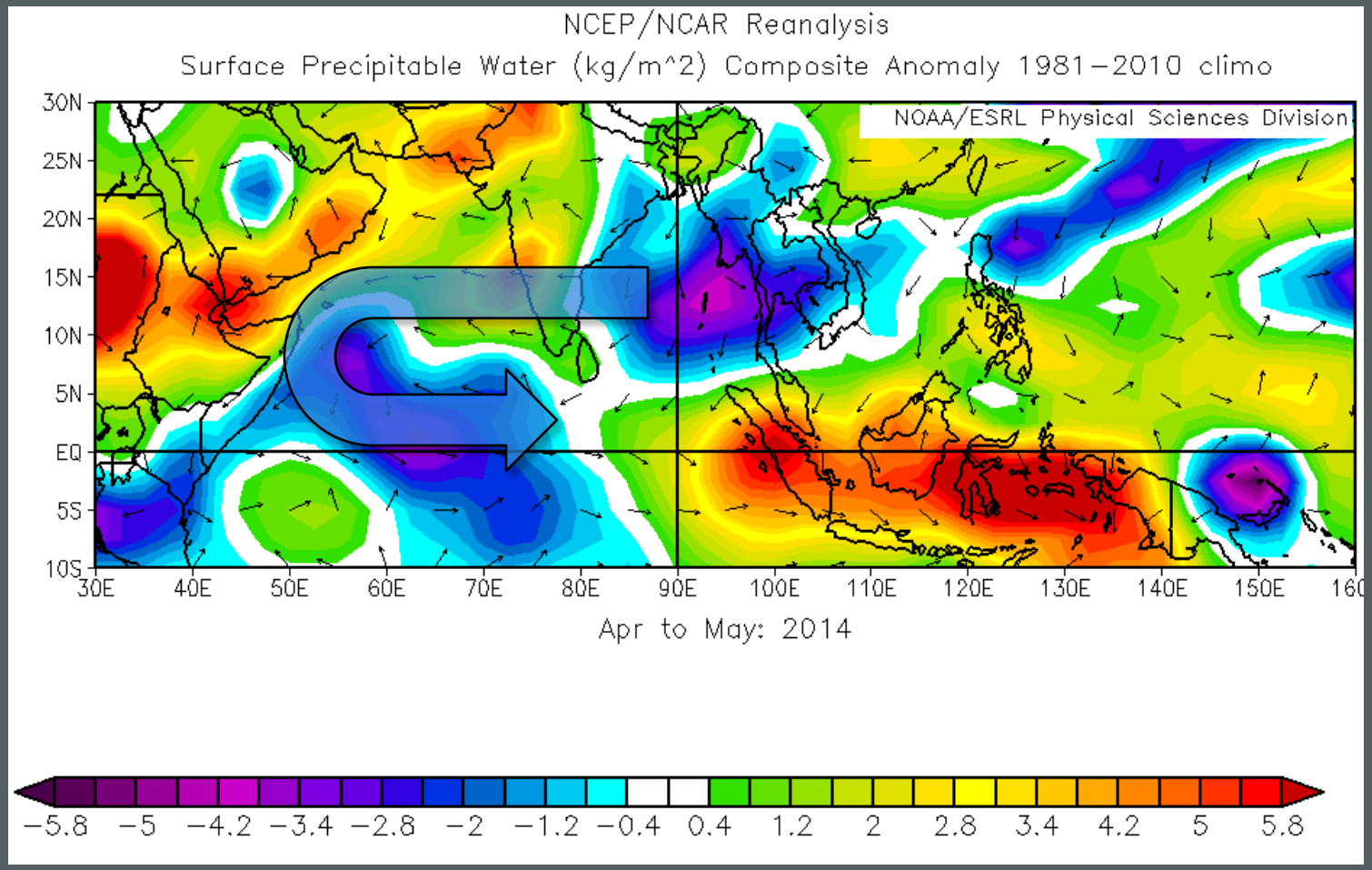


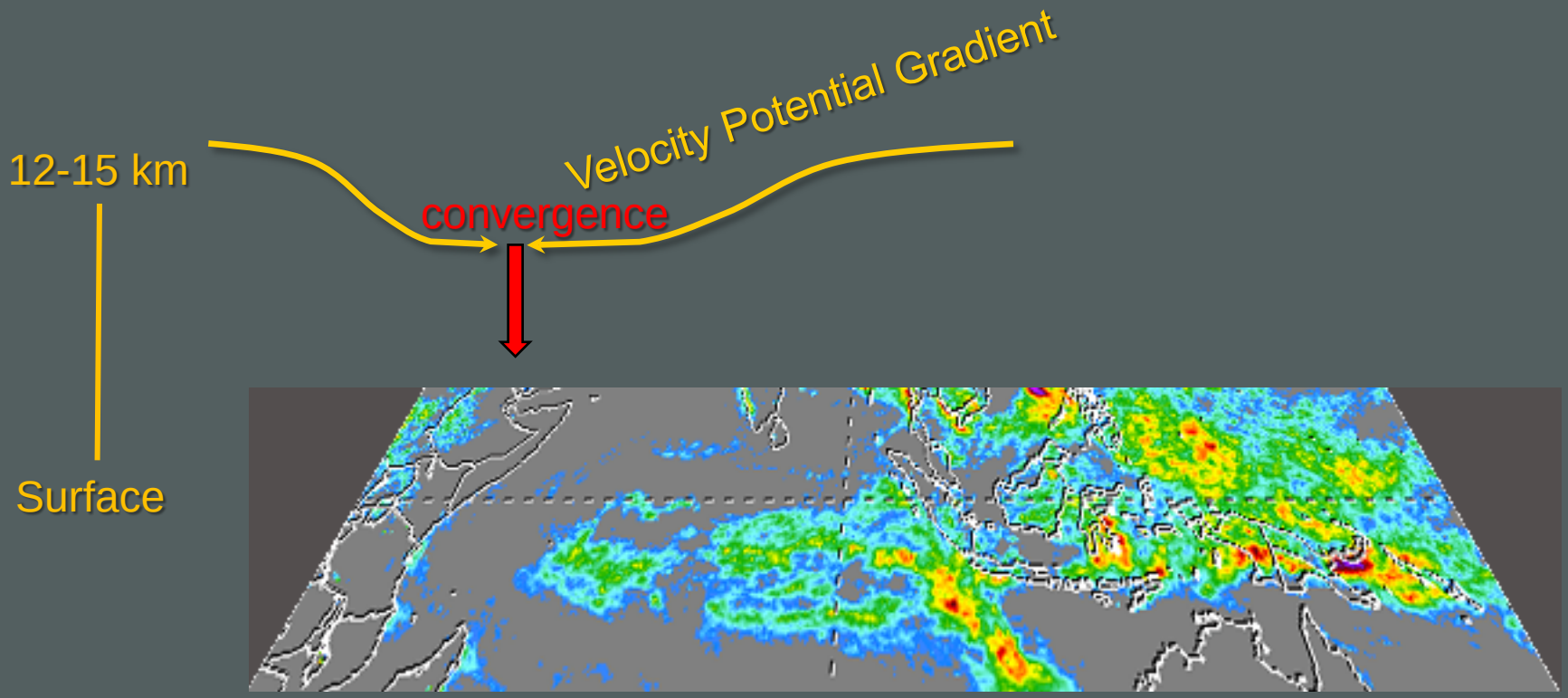
CHIRPS 1981-2014 April-May Ranks



April-May 2014 precipitable water anomalies

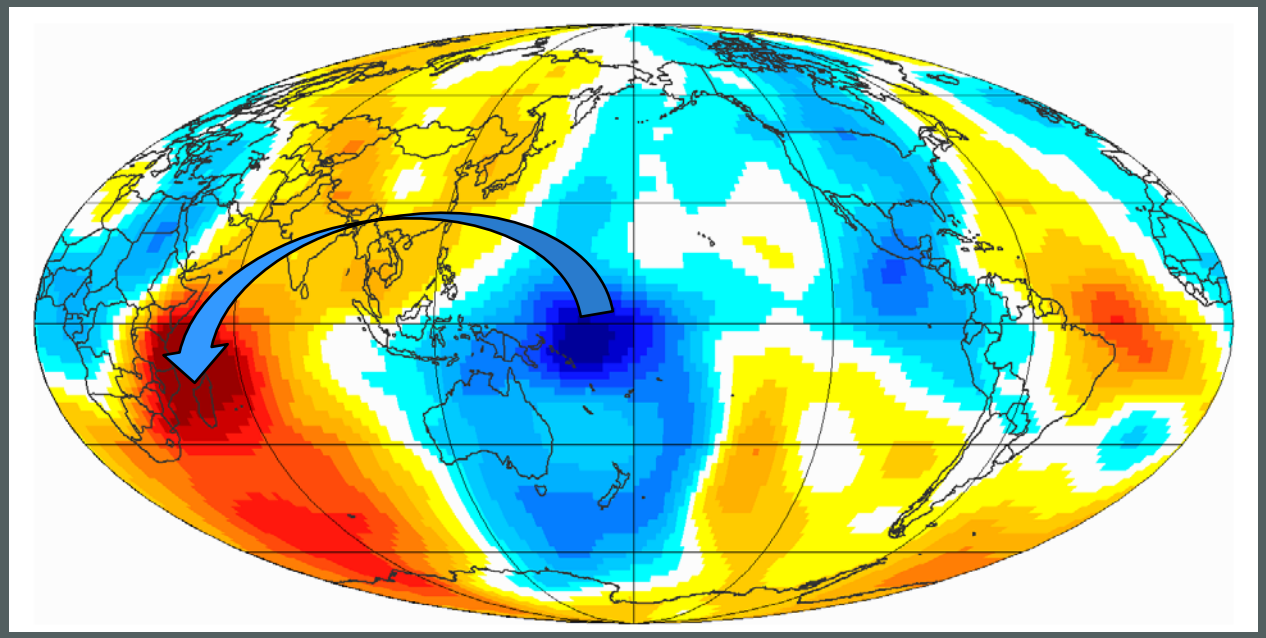


Why is East Africa dry?



TRMM rainfall data (http://trmm.gsfc.nasa.gov/)

Standardized April-May 2014 velocity potential anomalies



Standardized Anomalies

Based on a 1980-2010 baseline

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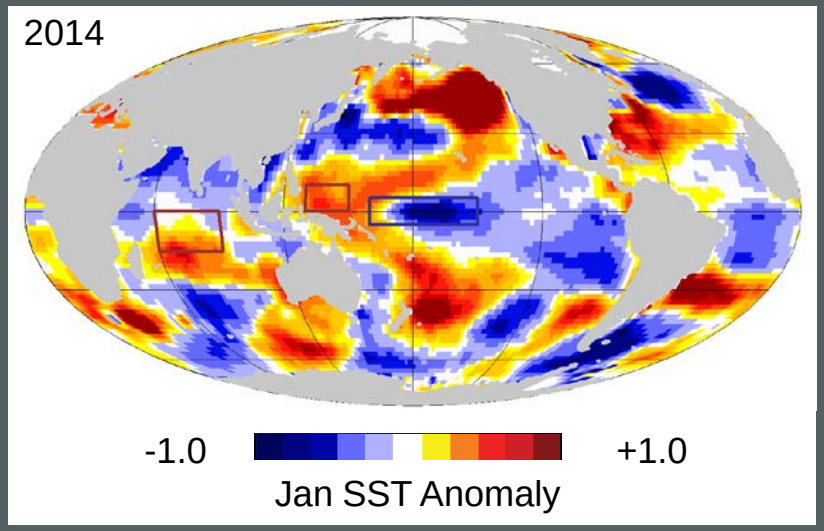
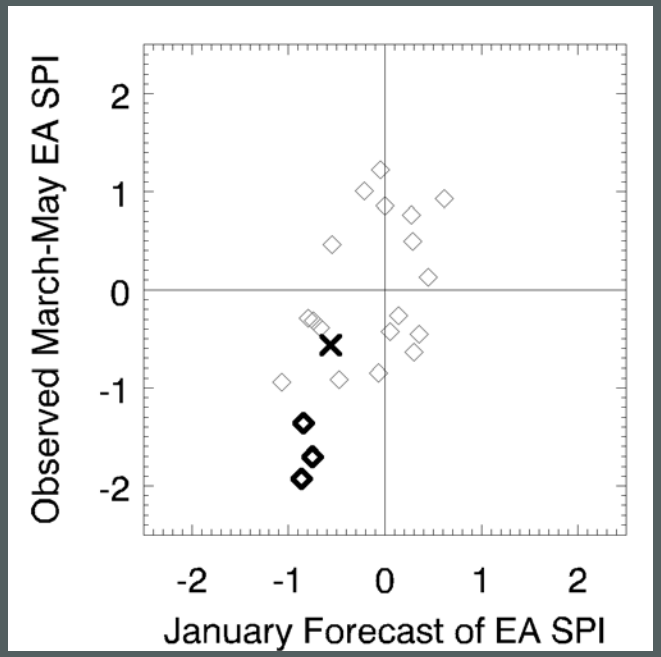
January 2014 SST and Forecast



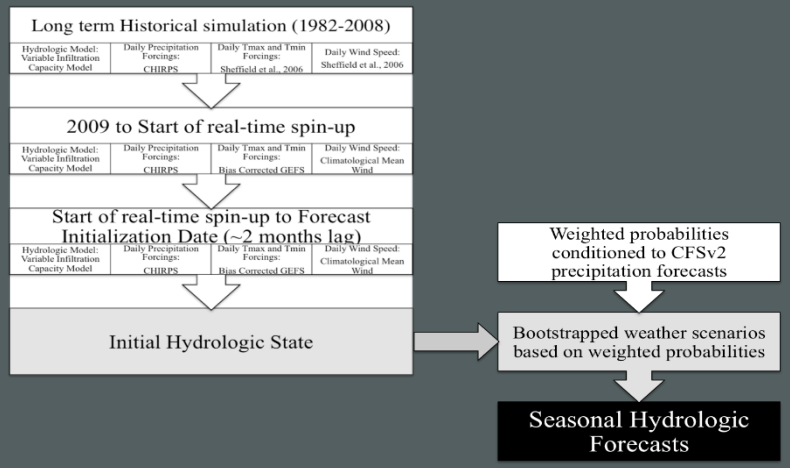


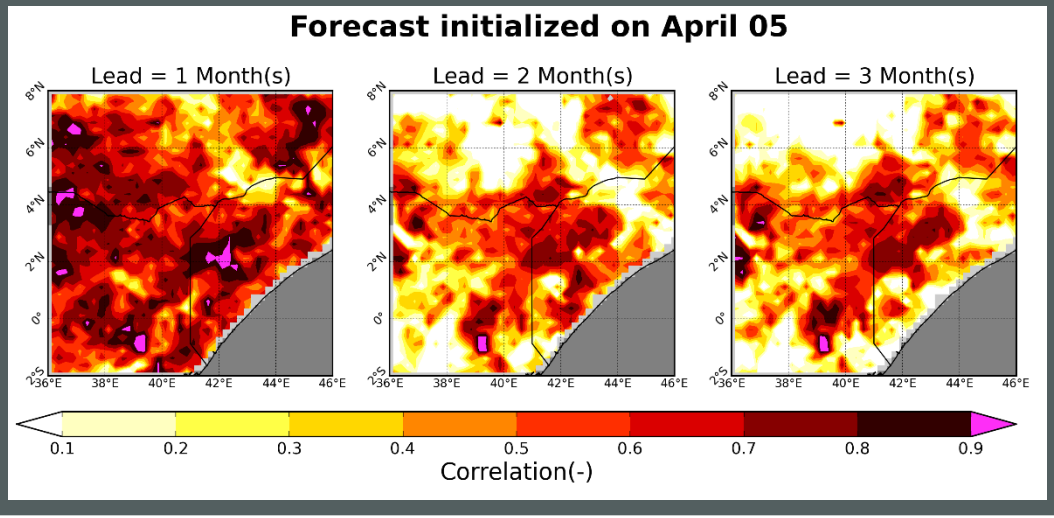
From Funk et al., 2014; HESSD

How we can use Pacific SST gradient information

- **Predict regional precipitation values or tercile probabilities (GHACOF forecasts)**
  - Regression
  - Constructed Analogs
  - Good pre-season approach
- **Assign probabilities to prior seasons based on similarity to current conditions**
  - Resample historical archives to drive land surface or crop models
  - Good mid-season approach

Combining forecasts with land surface models



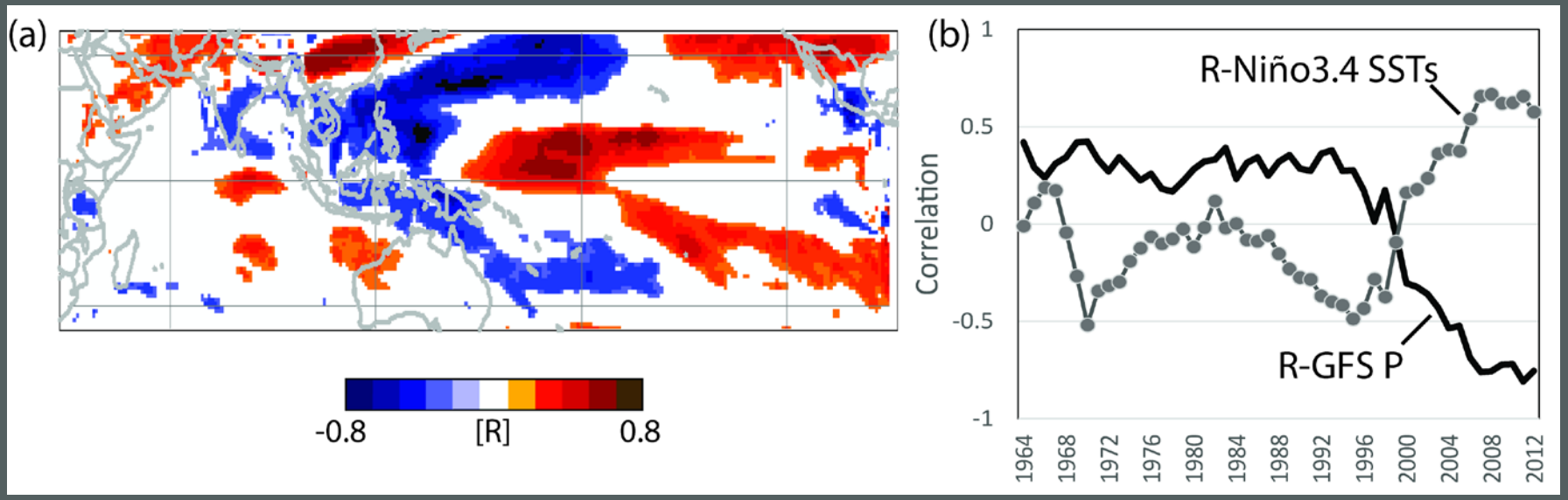


From Shukla et al., 2014; HESSD

Climate change provides new prediction opportunities-I

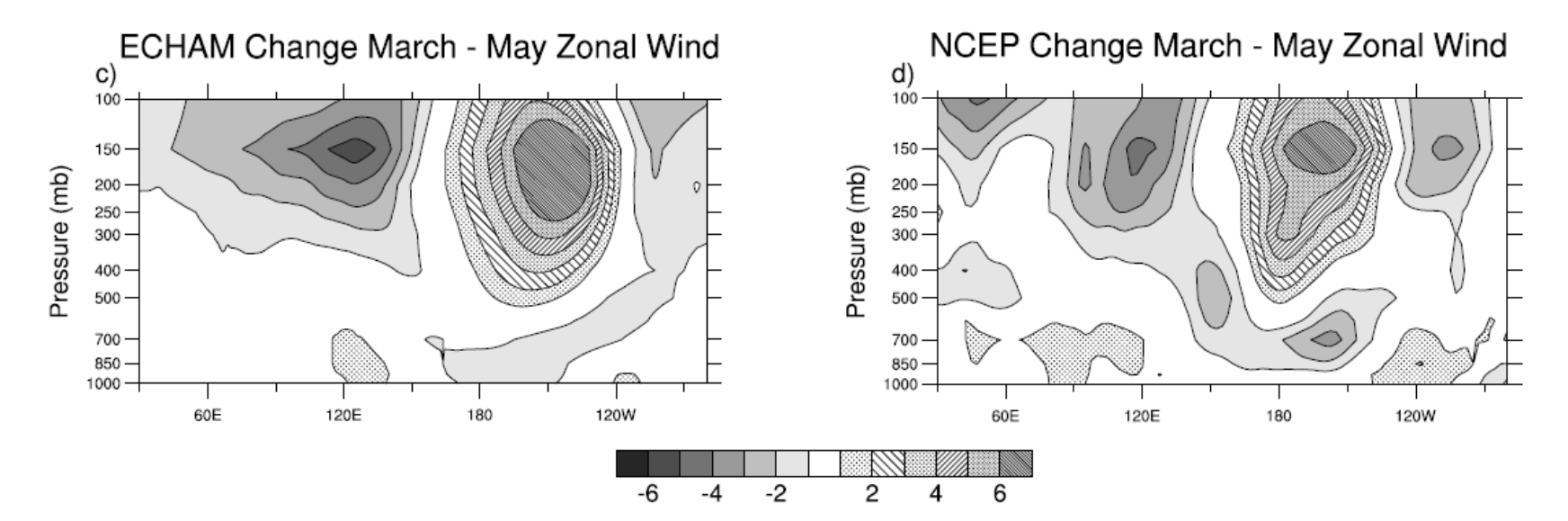
1993-2012 correlation with MAM EA Rainfall

15-year running correlations



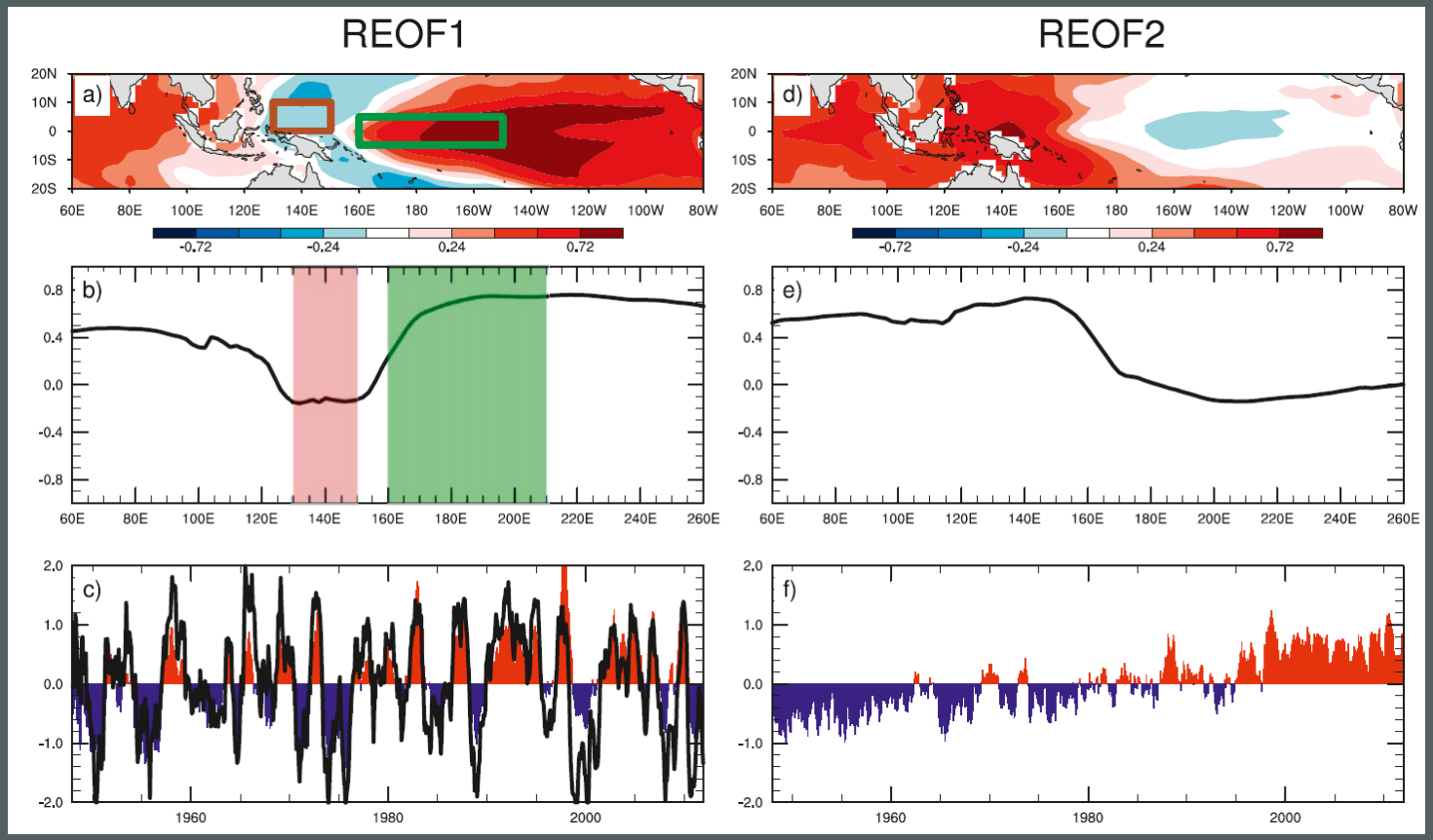
Funk et al. 2013; BAMS

Climate change provides new prediction opportunities-III
Stronger Walker Circulation



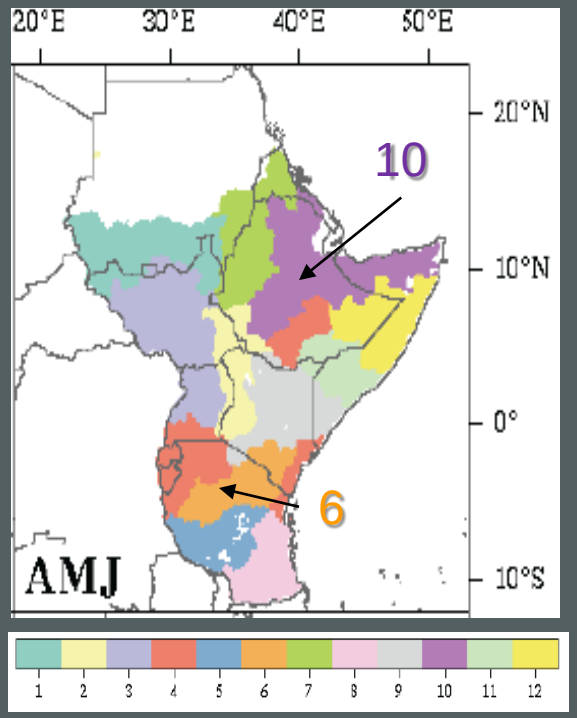
1979-2012 trends in equatorial zonal winds. From Liebmann et al. 2014.

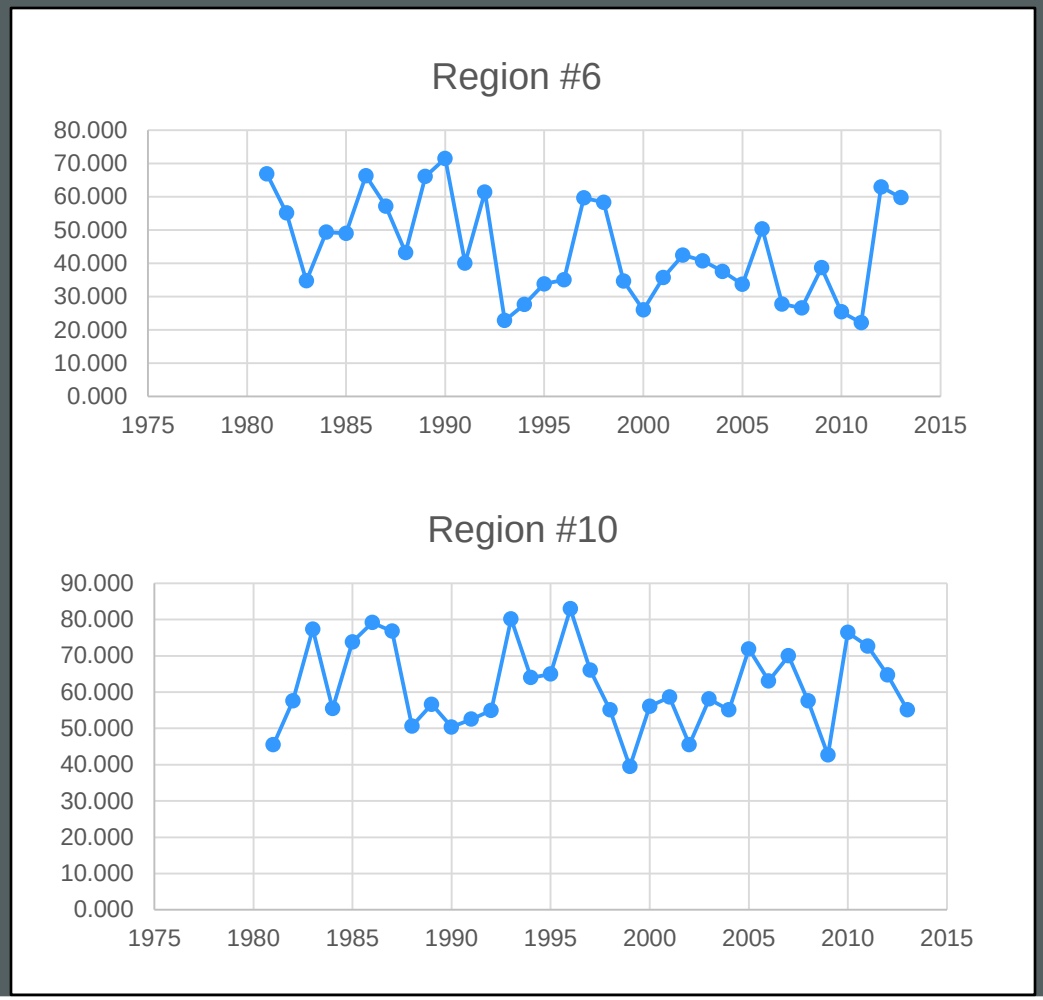
Climate change provides new prediction opportunities-IV
Stronger Pacific SST gradients



First and second tropical Pacific Empirical Orthogonal Functions. From Hoell and Funk, 2013.

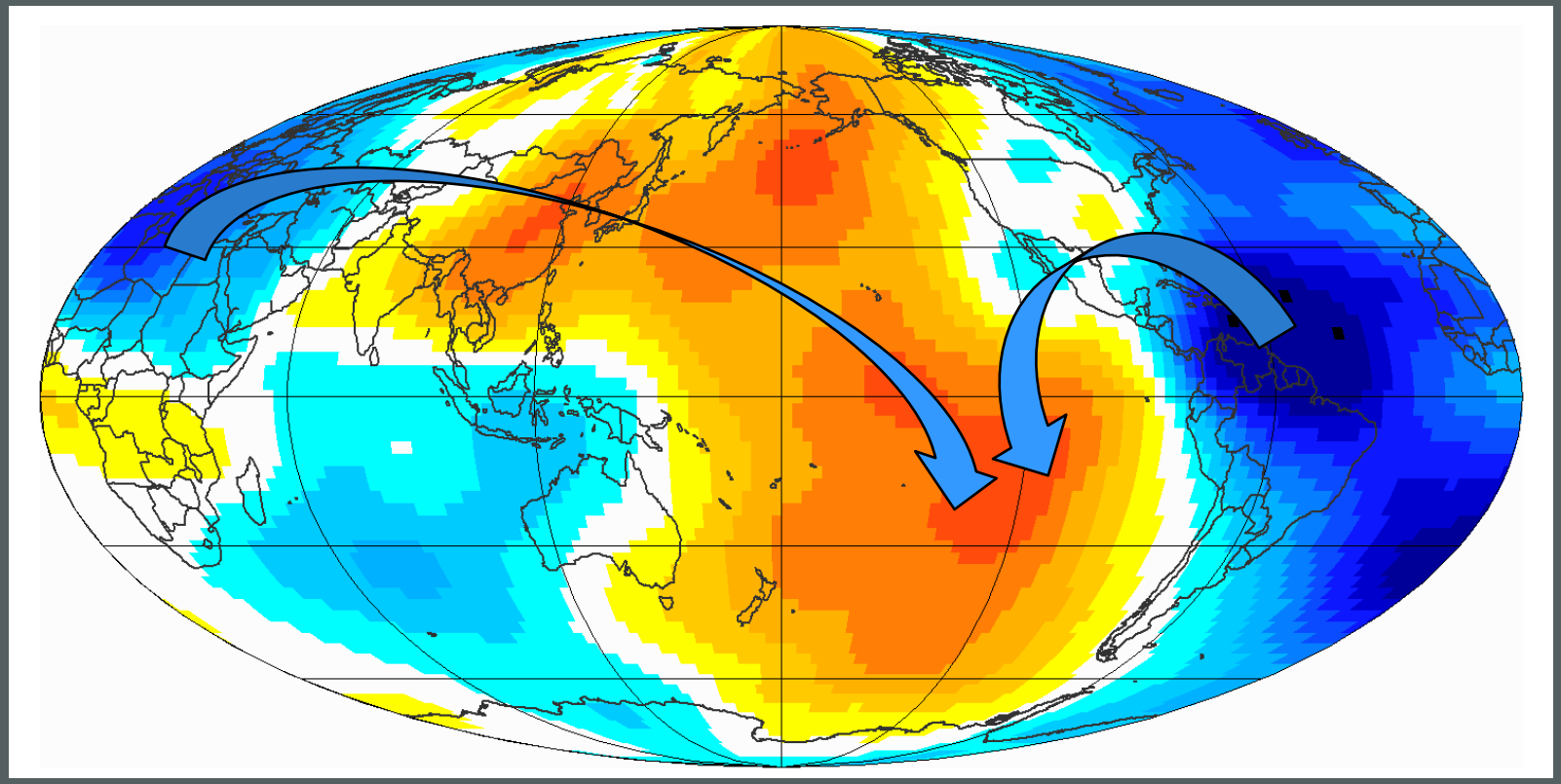
Preliminary Analysis – IDS regional AMJ Time series





Ward's hierarchical clustering
Results based on CHIRPS data
Analysis by Hamada Badr

1994-2013 correlation between AMJ velocity potential and Region 6 rainfall (Tanzania)



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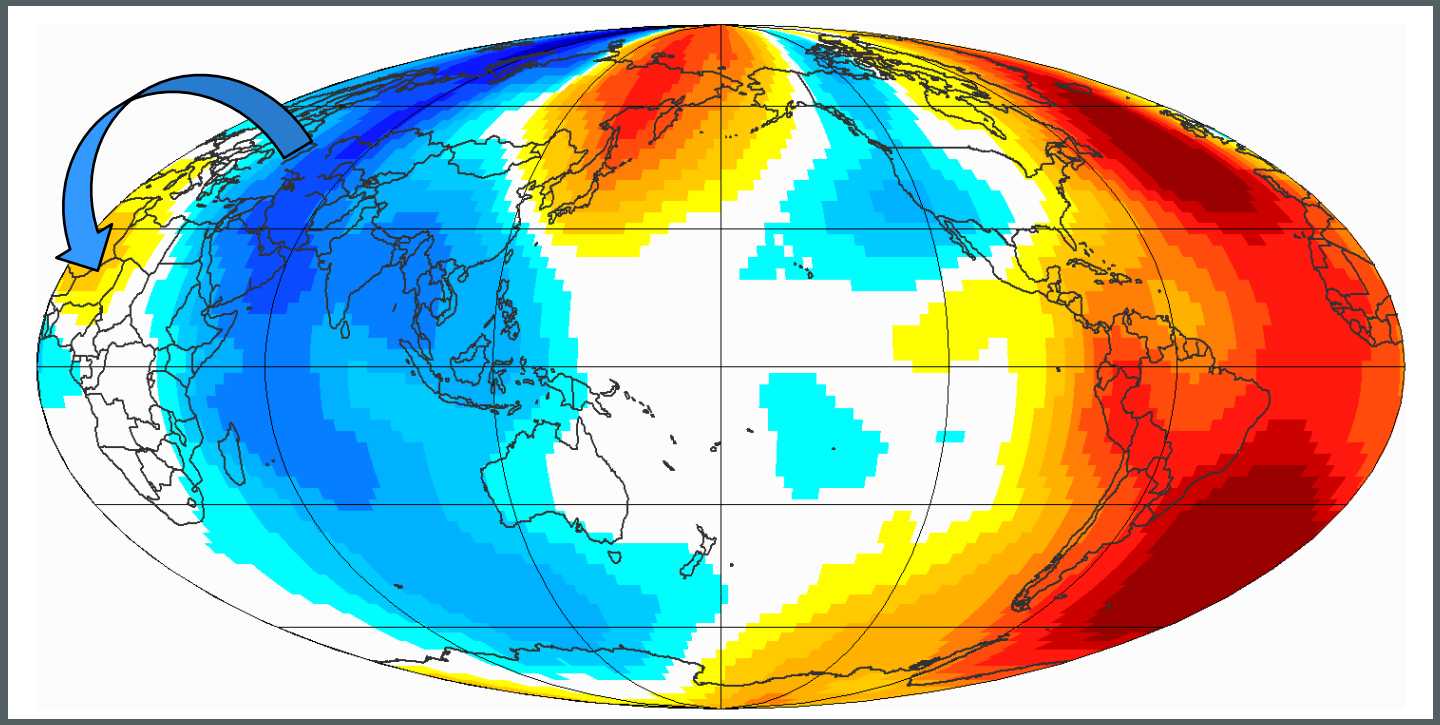
1994-2013 correlation between AMJ velocity potential and Region 10 rainfall (Ethiopia)



-.6 +.6

Correlation

Summary

- **Warming in the western Pacific has made parts of East Africa drier, but also more predictable**
  - Stronger La Nina/Central Pacific Teleconnection
- **SST gradients are the primary driver of this predictability**
- **New research is integrating monthly forecasts with land surface modeling**
- **Very preliminary analysis indicates other key drivers for other regions**
  - NASA IDS Project can explore!

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Publications – T H A N K S !!!

- Hoell, A. and C. Funk (2013): The ENSO-related West Pacific Sea Surface Temperature Gradient, Journal of Climate. Hoell, Andrew, Chris Funk, 2013: The ENSO-Related West Pacific Sea Surface Temperature Gradient. *J. Climate*, 26, 9545–9562.
  doi: http://dx.doi.org/10.1175/JCLI-D-12-00344.1
- Funk C., G. Husak, J. Michaelsen, S. Shukla, A. Hoell, B. Lyon, M. P. Hoerling, B. Liebmann, T. Zhang, J. Verdin, G. Galu, G. Eilerts, and J. Rowland, 2013: Attribution of 2012 and 2003-12 rainfall deficits in eastern Kenya and southern Somalia [in "Explaining Extreme Events of 2012 from a Climate Perspective"]. Bull. Amer. Meteor. Soc., 94, S45-S48. http://www.ametsoc.org/2012extremeeventsclimate.pdf
- Pricope, N. G., Husak, G., Lopez-Carr, D., Funk, C., & Michaelsen, J. (2013). The climate-population nexus in the East African Horn: Emerging degradation trends in rangeland and pastoral livelihood zones. Global Environmental Change, 23(6), 1525-1541.
  http://www.sciencedirect.com/science/article/pii/S0959378013001738
- Hoell A. and C. Funk (2013) Indo-Pacific Sea Surface Temperature Influences on Failed Consecutive Rainy Seasons over Eastern Africa, Climate Dynamics, *Clim. Dyn.*, DOI: 10.1007/s00382-013-1991-6. p1-16.
- Liebmann, B., Hoerling M., Funk C., Dole, R. M., Allured A., Pegion, P., Blade I., Eischeid, J.K, (2014) Understanding Eastern Africa Rainfall Variability and Change, Journal of Climate, In Press.
- Funk, C., Hoell, A., Shukla, S., Bladé, I., Liebmann, B., Roberts, J. B., and Husak, G. (2014). Predicting East African spring droughts using Pacific and Indian Ocean sea surface temperature indices. Hydrology and Earth System Sciences Discussions, 11(3), 3111-3136.
- Shukla, S., McNally, A., Husak, G., & Funk, C. (2014). A seasonal agricultural drought forecast system for food-insecure regions of East Africa. Hydrology and Earth System Sciences Discussions, 11(3), 3049-3081.
- Shukla S., Funk C. and Hoell A. (2014) Using constructed analogs to improve the skill of March-April-May precipitation forecasts in equatorial East Africa , Env. Res. Letters, In Press.