An Overview of the Global Drought Information System

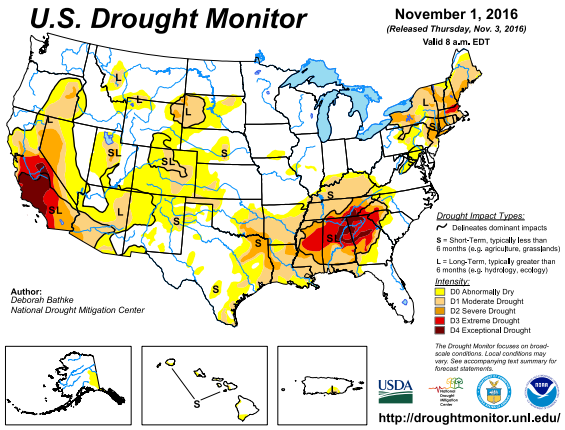
Siegfried Schubert (GMAO/NASA – emeritus)

DWD, SMUL, JRC and NOAA Collaboration Workshop

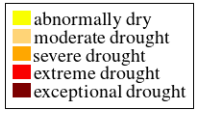
Sorting-out Drought!

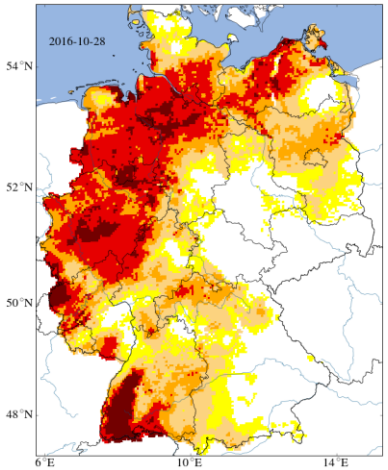
Pillnitz, Saxony, Germany

16 -18 Nov 2016



German Drought Monitor Upper 25cm soil moisture





Global Drought Information System

Siegfried Schubert (GMAO/NASA),

Doug Cripe (GEO), Mike Hayes (NDMC), Kingtse Mo (NOAA/CPC),
Will Pozzi,(GEO), Roger Pulwarty (NIDIS),

Sonia Seneviratne (ETH), Kerstin Stahl (Univ Freiburg),

Robert Stefanski (WMO), Ron Stewart (Univ Manitoba),

Juergen Vogt (JRC), Eric Wood (Princeton)

and the DIG Community

The WCRP Drought Interest Group (DIG)

(Founding members: D. Legler, S. Schubert, R. Stewart, H. Cattle, P. van Oevelen, V. Detemmerman, R. Lawford, R. Mechoso, C. Jakob, and A. Pirani)

The DIG was formed in 2008 as part of the WCRP Extremes crosscutting activity to *" identify and leverage current drought research activities within WCRP in order to assess the gaps in drought research and coordinate drought research at an international level with the goal of advancing the predictive understanding of extremes.* "

2011 workshop in Barcelona: "Drought Predictability and Prediction in a Changing Climate: Assessing Current Knowledge and Capabilities, User Requirements and Research Priorities, recommend developing a global drought information system (GDIS): (http://drought.wcrp-climate.org/workshop/ ICPO_161_WCRP_Report.pdf

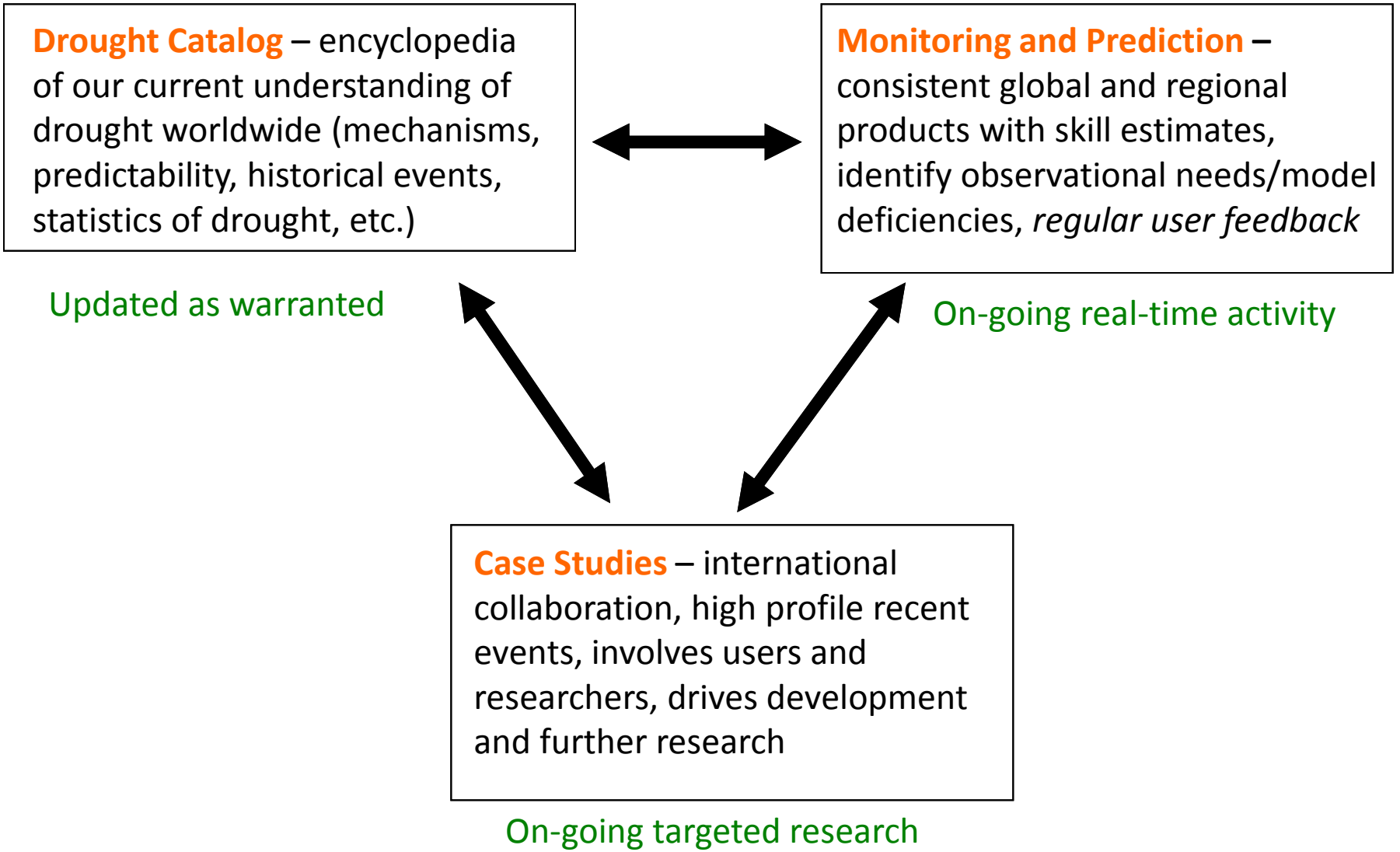
2012 workshop in Frascati: advance the Barcelona recommendations including the development of a Special Collection of JCLIM on drought world-wide: http://www.clivar.org/organization/extremes/resources/dig

2014 workshop in Pasadena: "International Global Drought Information System Workshop: Next Steps" focused on reviewing the GDIS special collection papers, and developing the necessary next steps required for moving forward with an experimental real time global drought monitoring and prediction system http://www.wcrp-climate.org/gdis-wkshp-2014-about

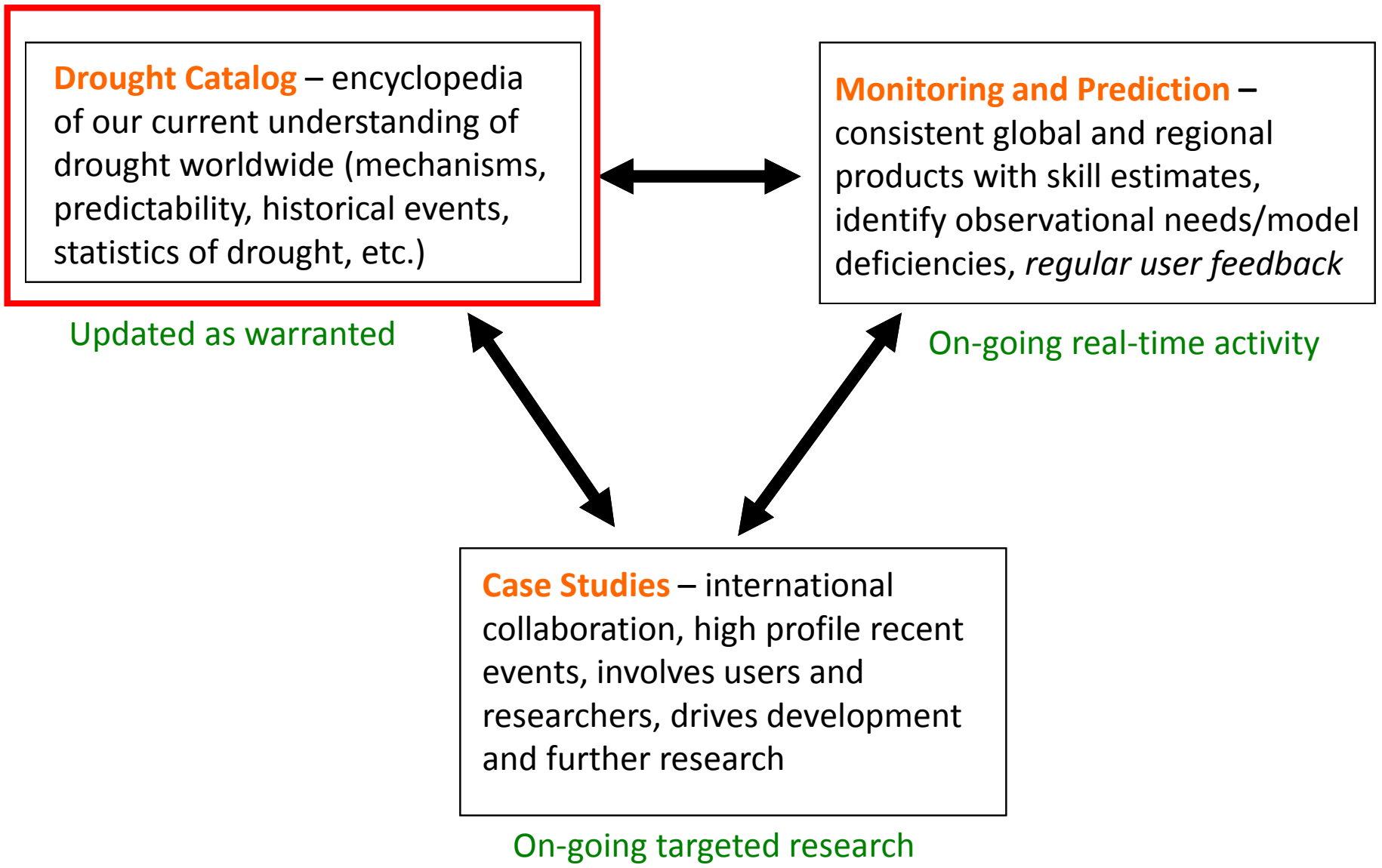
GDIS Goals

- Improve understanding of drought mechanisms and predictability world-wide
- Advance regional climate information and decision support within the GDIS framework
- Develop an implementation plan for advancing the real time GDIS (global monitoring and prediction)

GDIS Framework

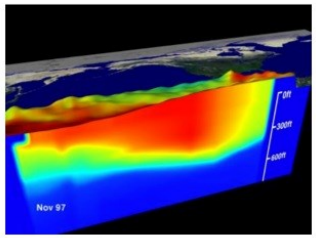


GDIS Framework



Large Scale Drivers of Drought

Pathways to Predictability

	SST anomalies	Global-Scale Atmospheric Changes	Regional Forcing and land feedbacks	Local Impacts, user needs
Key Phenomena, variables	ENSO, PDO, AMO, warm pool variability, Global Warming, etc	planetary waves, hydrological cycle, monsoons, Hadley Cell, Walker Circulation	precipitation, soil moisture, snow, low level jets, dust, vegetation, land/ atmosphere contrasts, changes in	soil moisture, stream flow, precipitation, ground water, lakes, reservoirs
				
Modeling Issues	Improvements in global coupled models, estimates of ocean variability and predictability, GHGs	Reduce uncertainties in atmos. response to SST, water cycle, atmos. variability and predictability	Reduce uncertainties in modeling land/ atmosphere interactions, predictability of weather "regimes", regional climate phenomena	Improved modeling of "downstream" impacts on land hydrology, higher resolution, downscaling

JCLIM Special Collection On Drought Worldwide

Collection Organizers: Ronald Stewart and Siegfried Schubert

Focus: Drought Characterization, Occurrence, Driving Mechanisms and Predictability Worldwide

Schubert, S., R. Stewart, H. Wang, M. Barlow, H. Berbery, W. Cai, M. Hoerling, K. Kanikicharla, R. Koster, B. Lyon, A. Mariotti, C. R. Mechoso, O. Müller, B. Rodriguez-Fonseca, R. Seager, S. Seneviratne, L. Zhang, T. Zhou., 2016: **Global Meteorological Drought: A Synthesis of Current Understanding with a Focus on SST Drivers of Precipitation Deficits**. *J. Climate*, **29**, 3989 – 4019, 2016.

Seager, Richard, Martin Hoerling, 2014: Atmosphere and Ocean Origins of **North American Droughts.** *J. Climate*, **27**, 4581–4606. doi: http://dx.doi.org/10.1175/JCLI-D-13-00329.1

Cai, Wenju, Ariaan Purich, Tim Cowan, Peter van Rensch, Evan Weller, 2014: Did Climate Change–Induced Rainfall Trends Contribute to the **Australian Millennium Drought**?. *J. Climate*, **27**, 3145–3168. doi: http://dx.doi.org/10.1175/JCLI-D-13-00322.1

Schubert, Siegfried D., Hailan Wang, Randal D. Koster, Max J. Suarez, Pavel Ya. Groisman, 2014: **Northern Eurasian Heat Waves and Droughts**. *J. Climate*, **27**, 3169–3207. doi: http://dx.doi.org/10.1175/JCLI-D-13-00360.1

Müller, O.V., E.H. Berbery , D. Alcaraz-Segura, M.B. Ek, 2014: Regional model simulations of the 2008 **drought in southern South America** using a consistent set of land surface properties. J. Climate, 27(17): 6754-6778. e-View doi: http://dx.doi.org/10.1175/JCLI-D-13-00463.1

Lyon, B., 2013: Seasonal **Drought in East Africa** and its Recent Increase During the March-May Long Rains, Under review.

Maria Belen Rodriguez-Fonseca, Elsa Mohino, C. Roberto Mechoso, Cyril Caminade, Marco Gaetani, J. Garcia-Serrano, Michela Biasutti, Edward K. Vizy, Kerry Cook, Yonkang Xue, Bernard Fontaine, Irene Polo, Teresa Losada, Juergen Bader, Francisco J. Doblas-Reyes, Lisa Goddard, Serge Janicot, A. Arribas, Leonard Druyan, William Lau, Andrew Colman, David P. Rowell, Fred Kucharski, and Aurore Voldoire, 2014: Climate Variability and Predictability of **West African Droughts**. Under Review.

Barlow, M., B. Zaitchik, S. Paz, E. Black, J. Evans, A. Hoell, 2013**:** **Drought in the Middle East and Southwest Asia**. J. Climate. Under review.

Zhang, L. and T. Zhou, 2014: **Droughts over East Asia**: A Review. J. Climate. Under review.

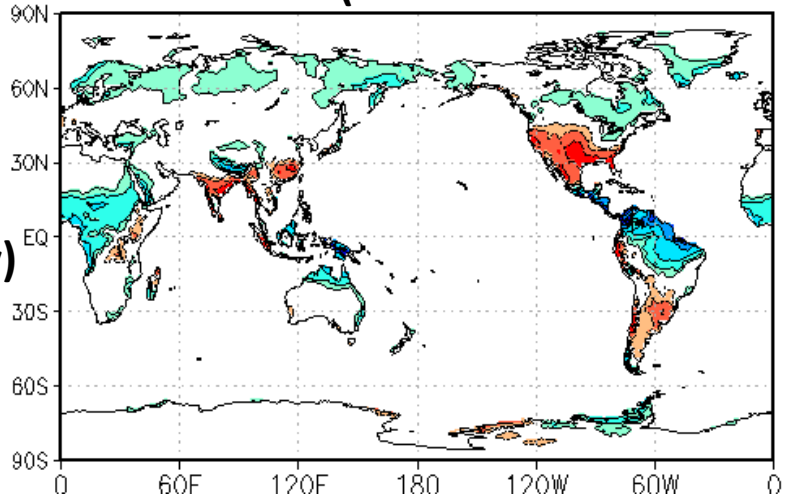
Krishna Kumar Kanikicharla, Ashwini Kulkarni, Sivanand Pai and Sumant Nigam, 2014: **Monsoon droughts in India**, J. Climate, under review.

Decadal Changes

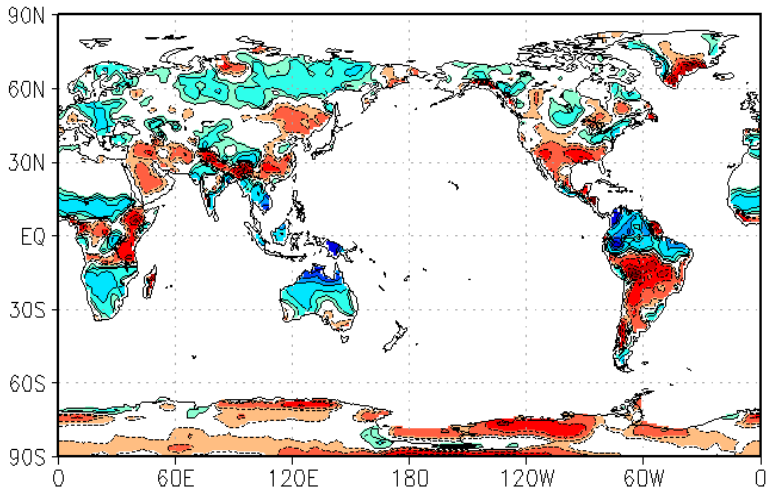
1998-2011 minus 1979-1993 (Annual Mean)

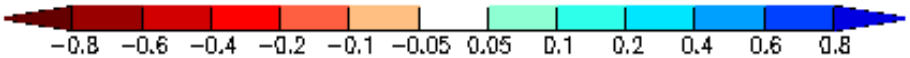
Precip (mm/day)

5-Model Mean (60 Ensemble Members)



GPCP

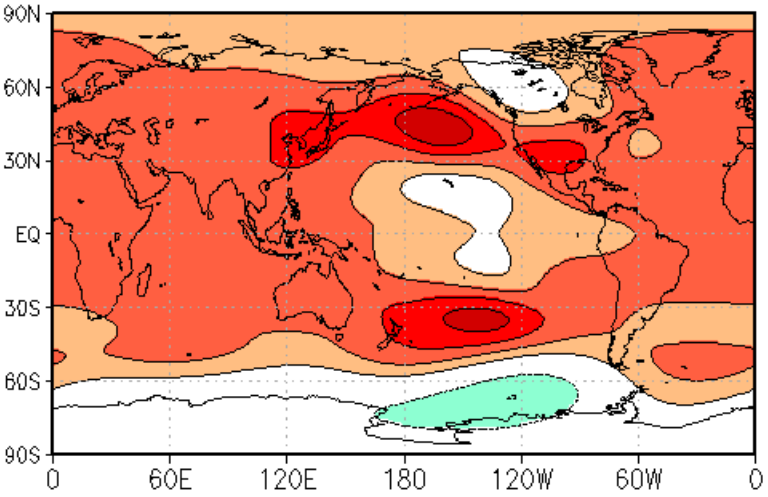




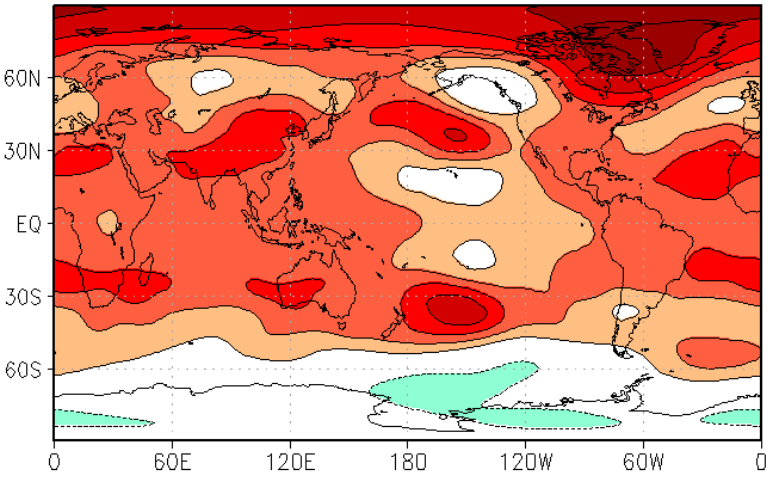
mm/day

200mb Z (m)

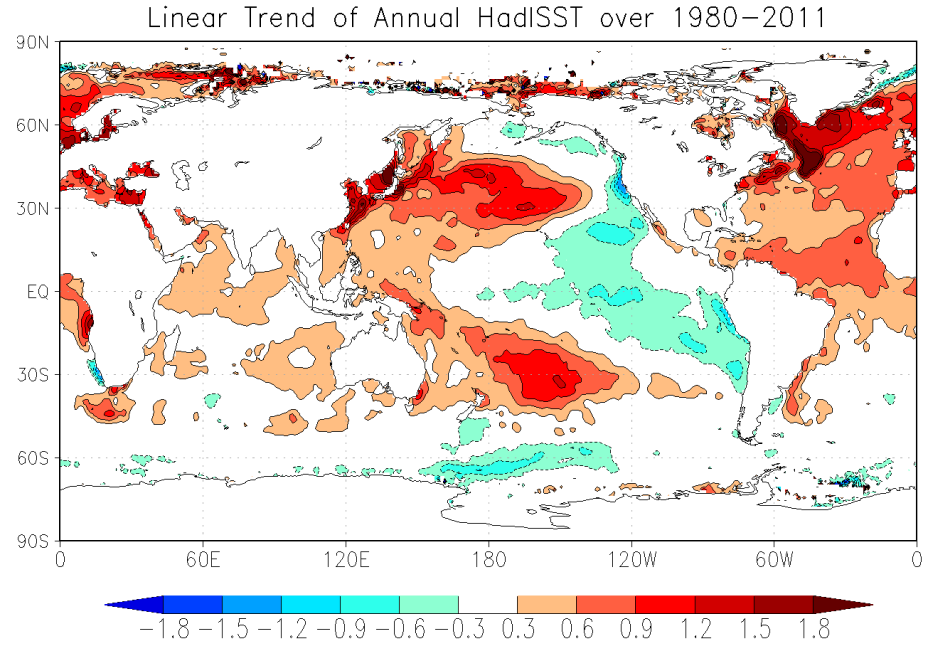
5-Model Mean (60 Ensemble Members)



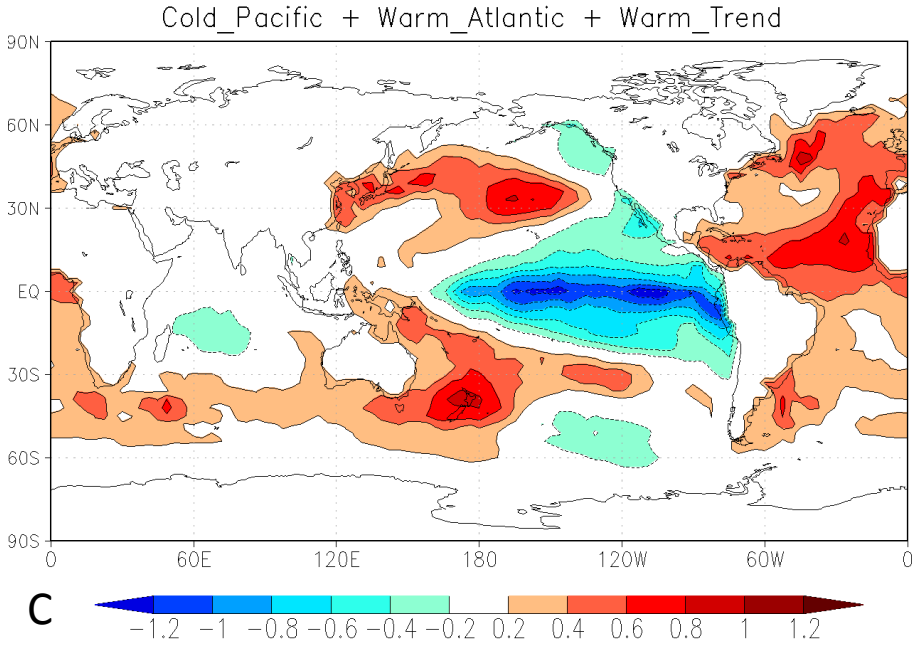
MERRA

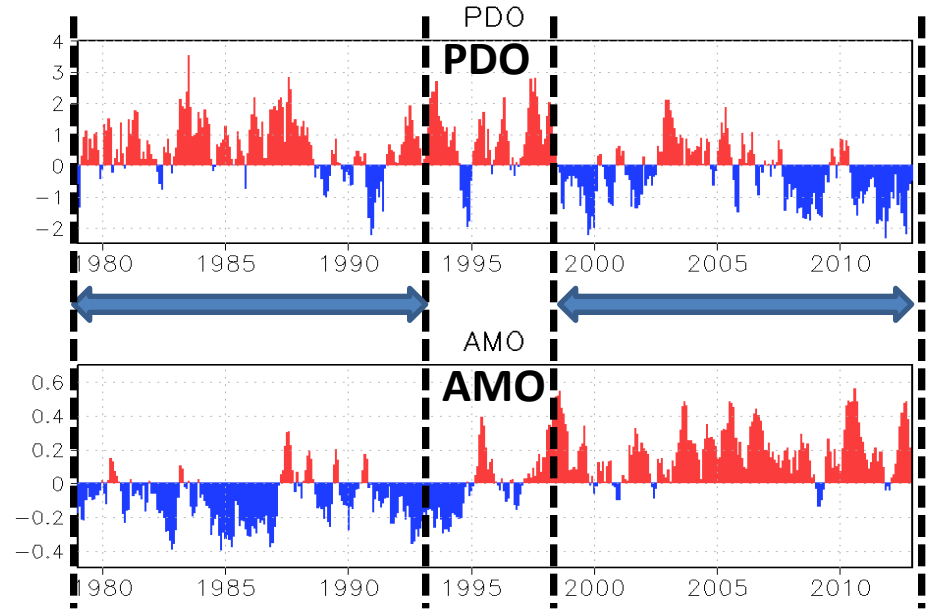


Observed Trend in SST (1980-2011)

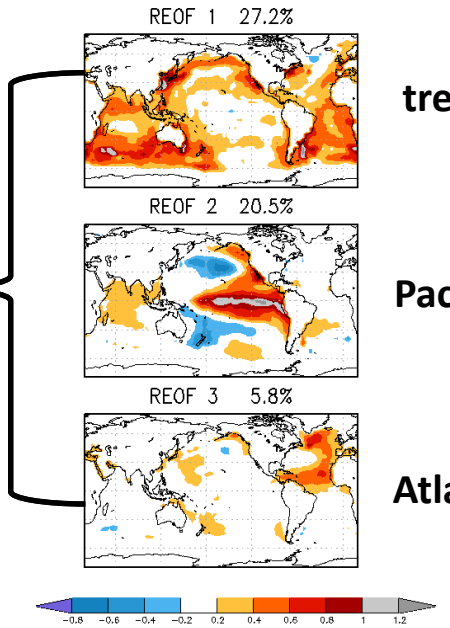


Idealized SST (ColdPac+WarmAtl+Warmtrend)

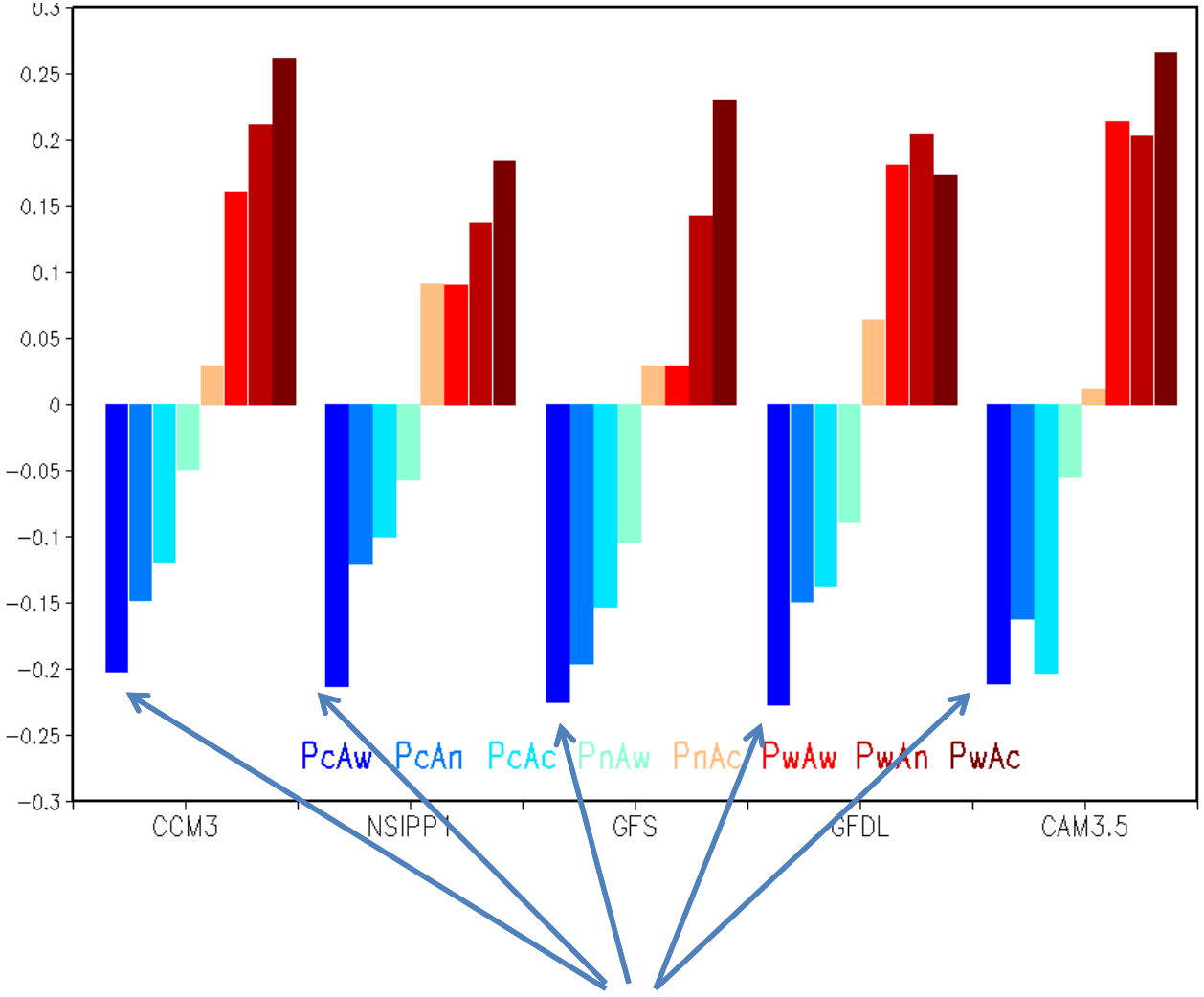




Above SST field is constructed from these three leading SST REOFs



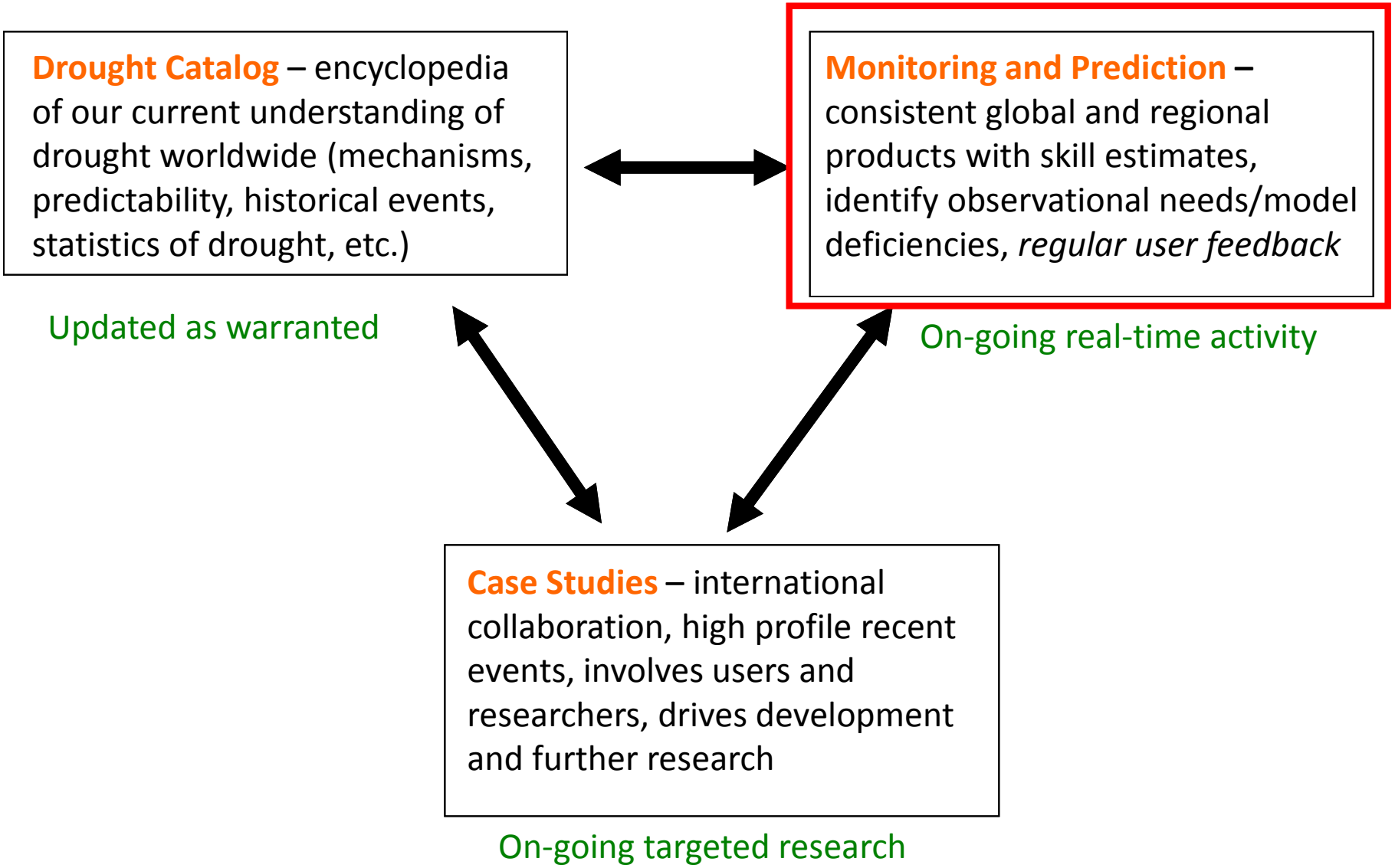
Example: US Precipitation Response to Idealized SST Patterns in 5 Different AGCMS



Models agree that largest precipitation deficits occur for cold Pacific and warm Atlantic

(Schubert et al. 2009)

GDIS Framework



Outcomes of Pasadena Meeting:

- *A comprehensive list of interested institutional partners for regional pilots and global providers*

- *Outline of a proposal for a limited duration demonstration of a global real time monitoring and prediction capability (with regional pilots)*

Schubert, Siegfried, Will Pozzi, Kingtse Mo, Eric F. Wood, Kerstin Stahl, Mike Hayes, Juergen Vogt, Sonia Seneviratne, Ron Stewart, Roger Pulwarty, and Robert Stefanski, 2015. **GDIS Workshop Report**. *NASA/TM–2015-104606*, Vol. **41**, 40 pp. Document (623 kB). Available at http://gmao.gsfc.nasa.gov/pubs/tm/ , Randal D. Koster, Editor.

-A comprehensive list of interested institutional partners for regional pilots

Interest in being global providers of drought information:

-NIDIS global drought portal (POC – R. Heim)
-UCLA (POC – D. Lettenmaier),
-Princeton (POC – E. Wood, J. Sheffield),
-NOAA/NCEP (POC – M. Ek),
-UC Irvine (POC - A. AghaKouchak)
-APCC (POC - J. Rhee),
-NOAA/NMME (POC - J. Huang),
-UK Met Office (POC – A. Maidens),
-ECMWF (POC – E. Dutra)

Interest in participating in regional pilots:

South America: Regional Climate Center for Western South America (RCC-WSA), POC – Will Pozzi; Local POC – Rodney Martinez, Regional Climate Center for Southern South America (RCC-SSA): POC – Hugo Berbery, Brazil: CPTEC

UNESCO-IHP: (Koen Verbist) POC - Justin Sheffield

Southeast European region - Drought Management Centre for South Eastern Europe (DMCSEE) in Southeastern Europe. coordinated with JRC EDO (contact Jürgen Vogt): POC - Gregor Gregoric.

China: China Meteorological Administration (CMA) - POCs - Yao Hui Li and Kingtse Mo

Southern Asian region: (India and Pakistan) - to be coordinated by WMO, POC- Bob Stefanski.

GEWEX RHPs - HYVIC - Hydrology of Lake Victoria Basin (POC- Frederick Semazzi), Australia-Pacific region: to be coordinated with Bureau of Meteorology through OzEWEX (GEWEX RHP) -- OzEWEX - Australian Energy and Water Exchanges Initiative. POC - Albert van Dijk, HyMeX - HYdrological cycle in the Mediterranean Experiment, POC - Annarita Mariotti, SASKRB - Saskatchewan River Basin. POCt – Howard Wheater

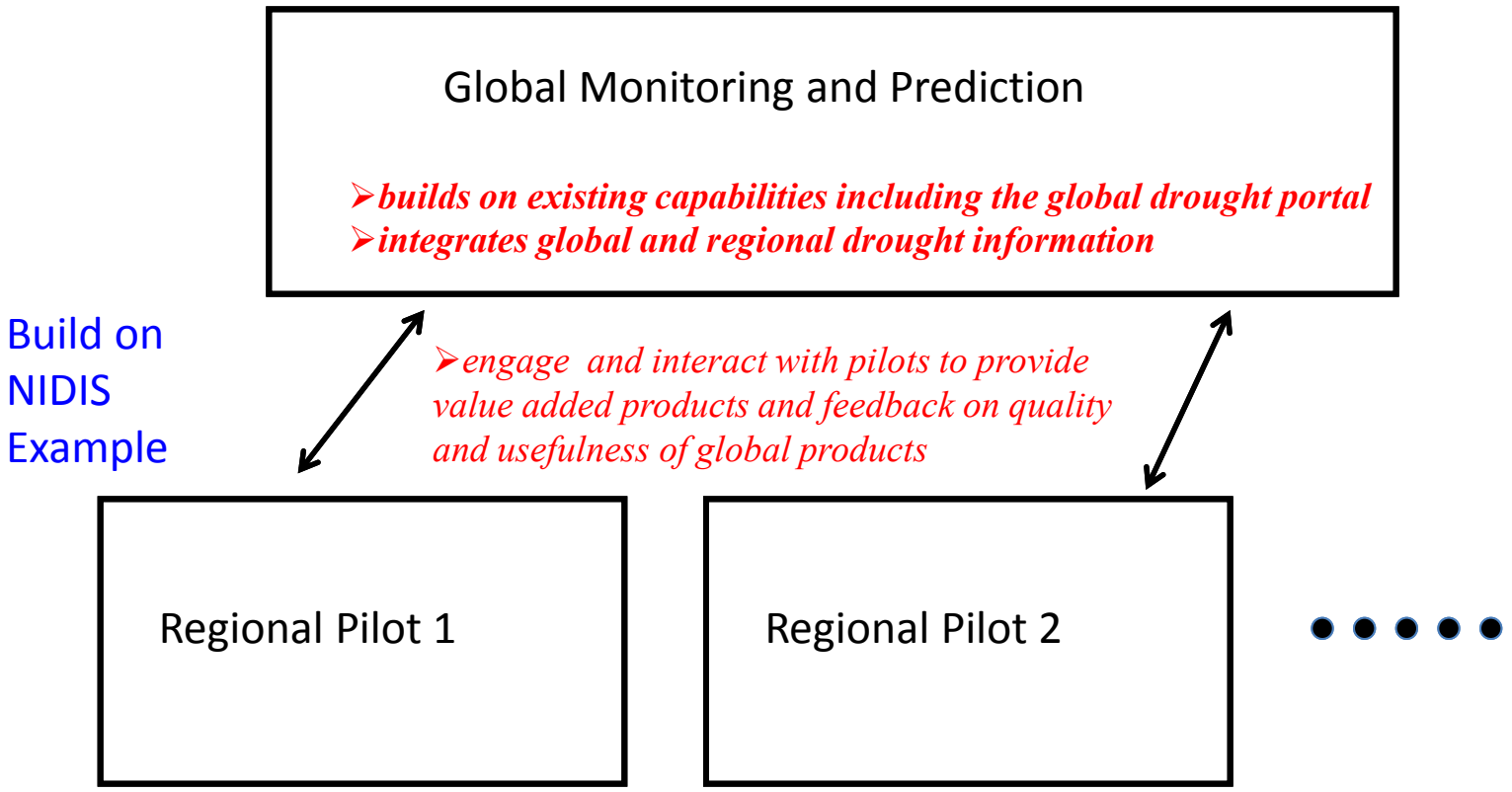
Earth2Observe: (Mediterranean, Ethiopia, Bangladesh, Colombia, Estonia, Australia/New Zealand), POC: Jaap Schellekens

AGRHYMET in Niger and ICPAC in Nairobi: POC Justin Sheffield

Middle East and Southwest Asia - Possible “interest area” – suggested by Matt Barlow

Develop a Global Real Time Monitoring and Prediction System

A limited Duration (2 year) Demonstration



➢*ensure synergy between the global and regional products and activities*

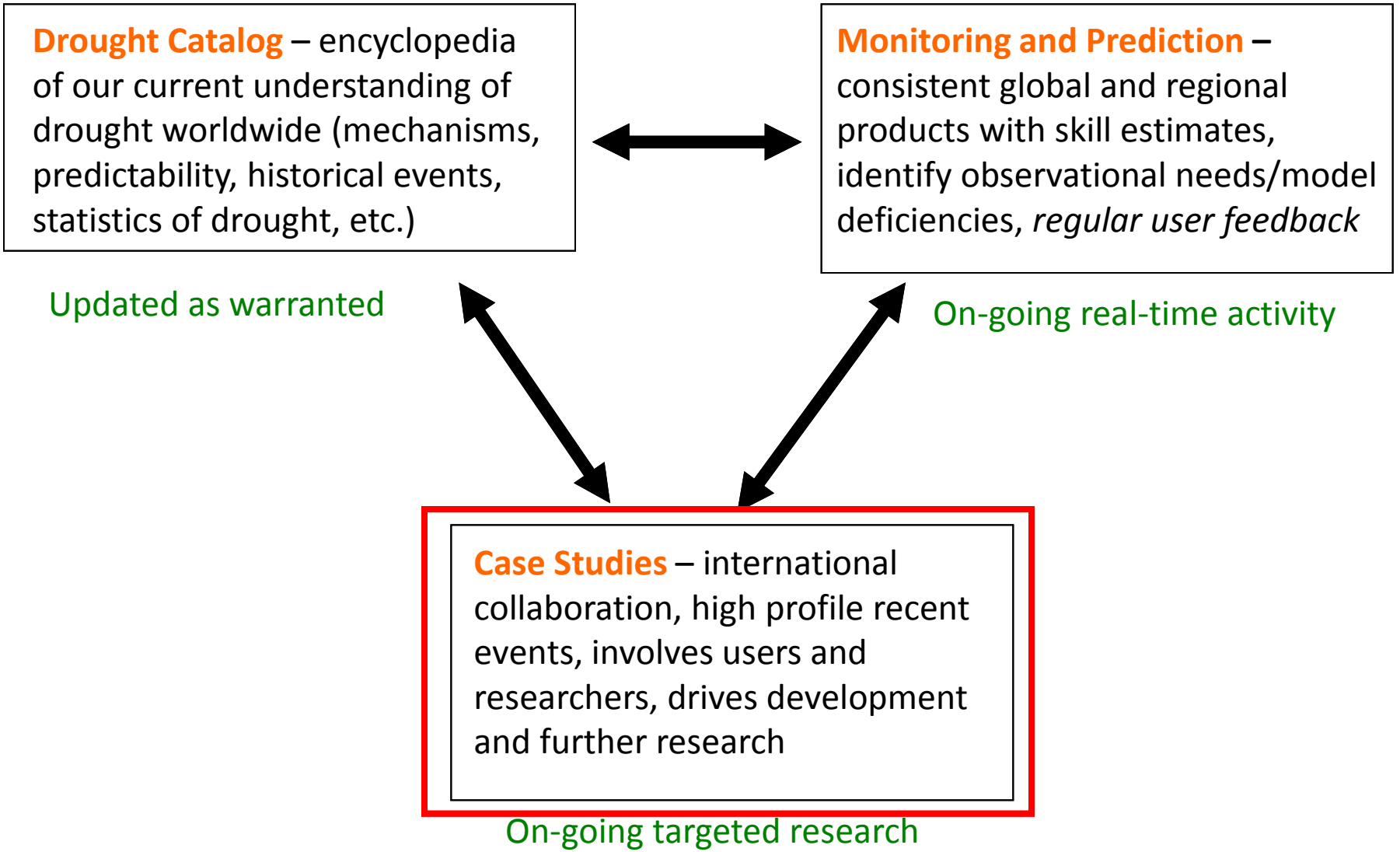
➢*identify gaps in the current drought monitoring and forecast system*

➢*gather data and information that can be used for drought related research*

Proposal for a Pilot program

- **A limited duration experimental real time global monitoring and prediction system with pilots playing a key role. Goals include**:
  - integrating global and regional drought information,
  - establishing mechanisms for real time dissemination and user interactions,
  - the joint development of products for regional applications, and
  - the establishment of partnerships for long-term drought-related activities including risk management.
    - **Equal partnerships with regions that have capacity for drought monitoring/prediction and**
    - **building working relationships for those with limited capacity.**
- **Specific actions include:**
  - producing a survey of data availability and establishing a protocol for data providers (a data survey form is on the web),
  - establishing protocols for the pilots and hosts and getting institutional commitments,
  - establishing formats and ways to communicate, and
  - establishing a list server for participants.

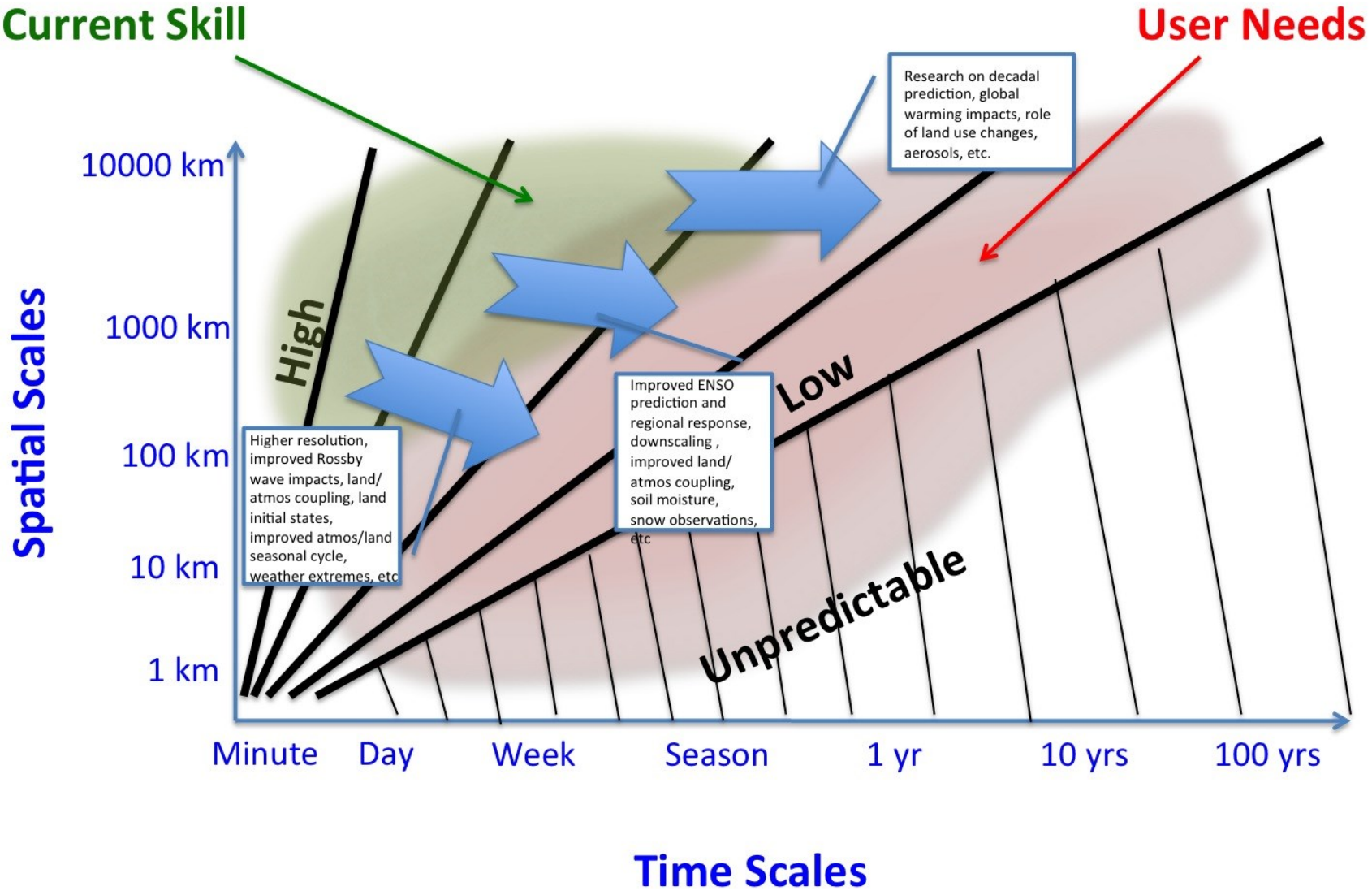
GDIS Framework



- **How can we coordinate/advance drought research internationally while at the same time engaging the user community to ensure relevance?**
  - Example in the US: The NOAA Drought Task Force in partnership with NIDIS

- **Key Science issues**:
  - What are the drivers of drought?
  - Intraseasonal, seasonal, decadal SST variability, climate change, unforced internal atmospheric variability, land feedbacks, …
  - Implications for observational needs
  - implications for predictability and forecast skill

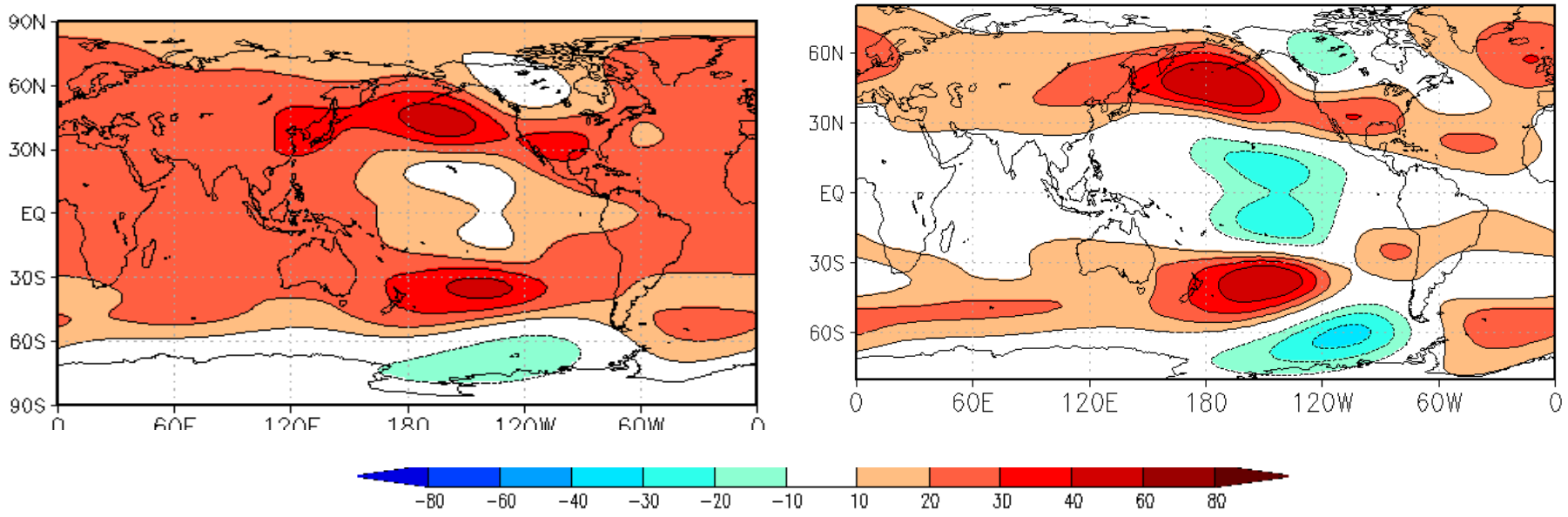
Predictability



Extra

Z200mb (1998-2011 minus 1979-1993)
(60-member ensemble mean GEOS-5, CCM3, GFS, CAM4 and ECHAM5)

z200mb response to idealized SST
(CCM3, GEOS-5, GFS, and GFDL)

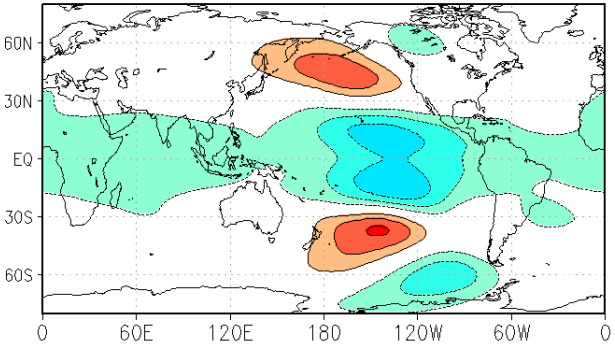


Schubert, S., D. Gutzler, H. Wang, A. Dai, T. Delworth, C. Deser, K. Findell, R. Fu, W. Higgins, M. Hoerling, B. Kirtman, R. Koster, A. Kumar, D. Legler, D. Lettenmaier, B. Lyon, V. Magana, K. Mo, S. Nigam, P. Pegion, A. Phillips, R. Pulwarty, D. Rind, A. Ruiz-Barradas, J. Schemm, R. Seager, R. Stewart, M. Suarez, J. Syktus, M. Ting, C. Wang, S. Weaver, N. Zeng, 2009: A USCLIVAR Project to Assess and Compare the Responses of Global Climate Models to Drought-Related SST Forcing Patterns: Overview and Results, J. Climate, 22, 5251–5272.

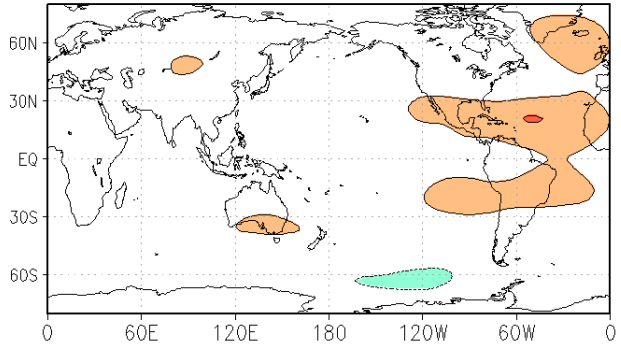
Components of z200mb Response to Idealized SST

(CCM3, GEOS-5, GFS, and GFDL)

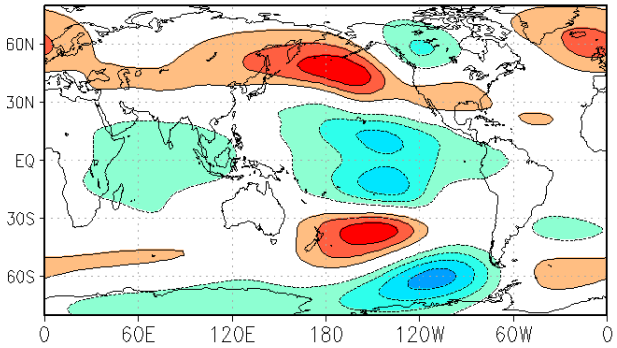
Cold Pacific



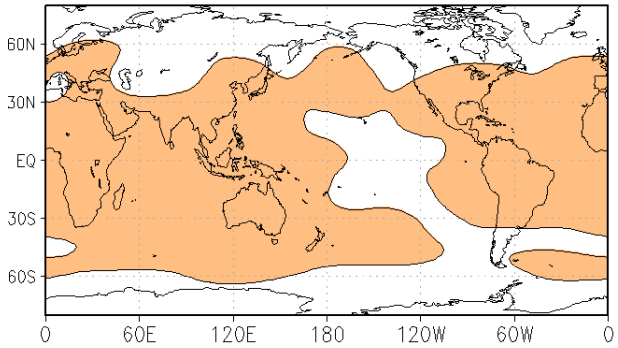
Warm Atlantic



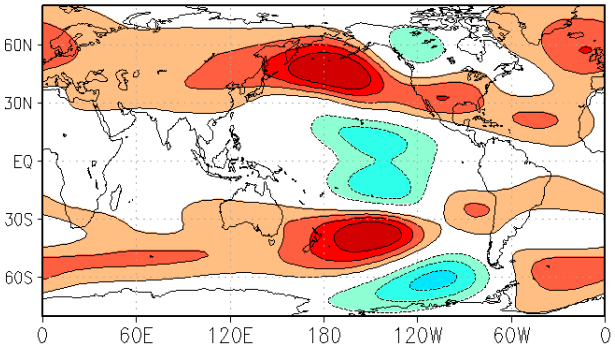
Cold Pacific+Warm Atlantic



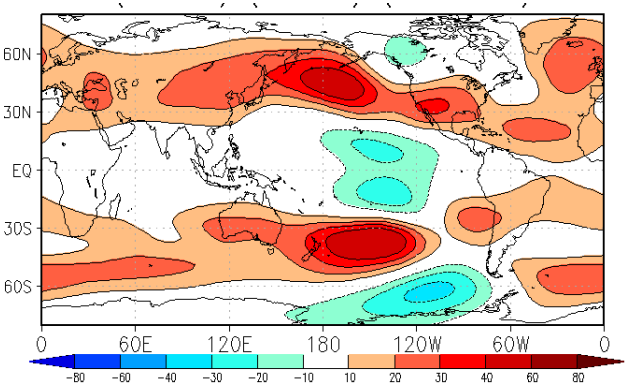
Warm Trend



Cold Pacific+Warm Atlantic + warm Trend

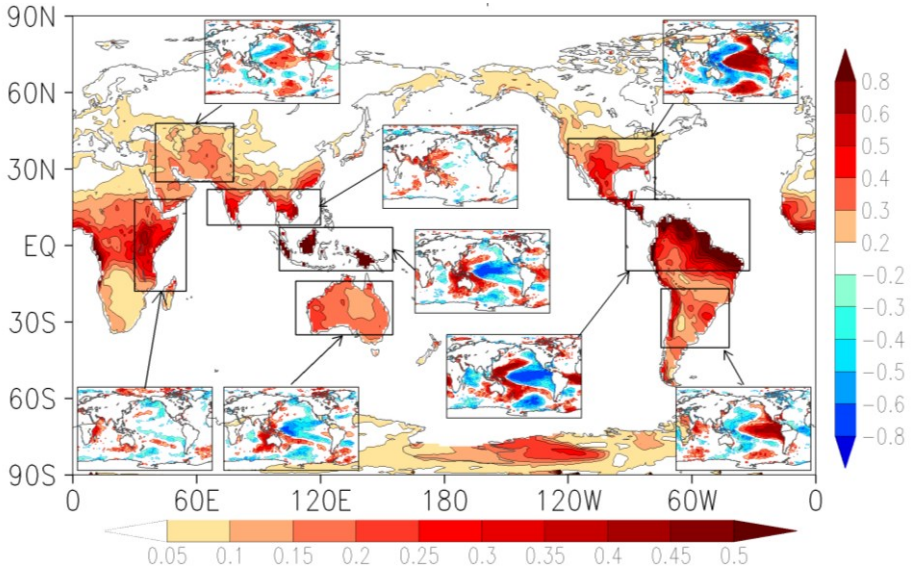


Sum of Components

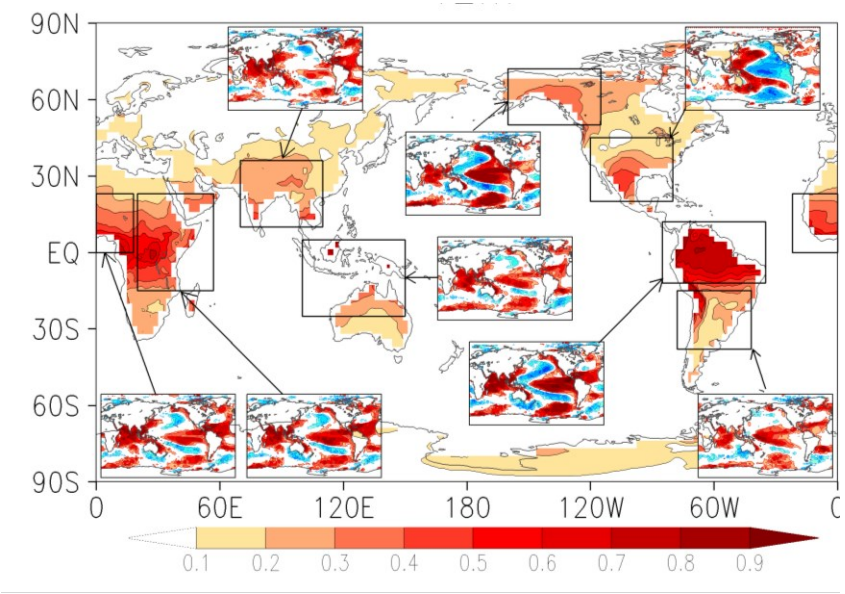


Fraction of “Forced” Variance on Interannual Time Scales and Link to SST

Precipitation



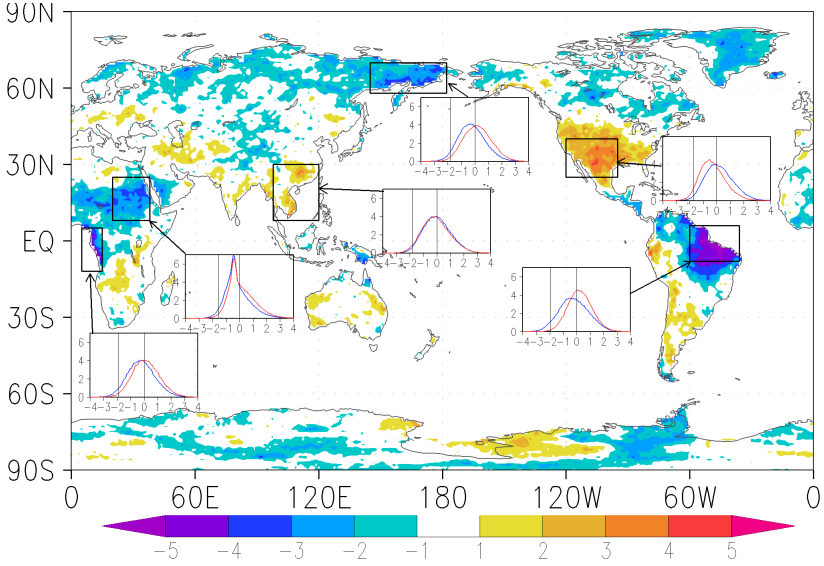
T2m



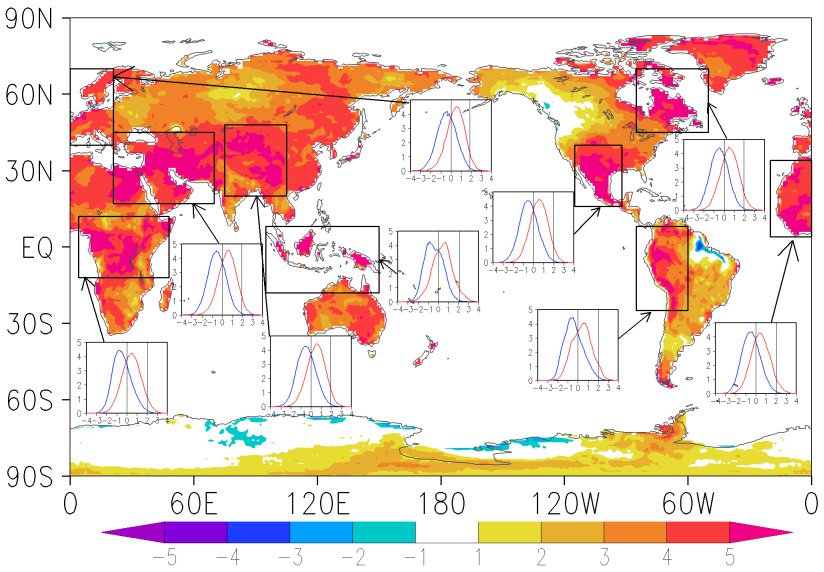
(Left) The background map shows the ratio of two variances: the variance of the ensemble mean time series of annual precipitation and the total variance of annual mean precipitation over all ensemble members (ratios are computed for each model separately and then averaged). Higher values of the ratio indicate a stronger impact of the prescribed SSTs on the precipitation time series. The small maps show the correlations between the ensemble mean annual fields (averaged over the boxed areas) with SST (correlations are computed for each model separately and then averaged). Results are based on 12 ensemble members for each of 5 models (GEOS-5, CCM3, CAM4, GFS, ECHAM5) using detrended values for the period 1979-2011. (Right) Same, but for 2m air temperature (note change in contour interval). The horizontal color bars are for the variance ratios, and the vertical color bars are for the correlations.

Changes in Extremes over the Period 1979-2011

Precipitation



T2m



The shift in probabilities of extremes between the two periods 1998-2011 and 1979-1993 defined as ($P(x_2>x_c)$ – $P(x_1>x_c)$)/$P(x>x_c)$, where x_2 refers to values during the recent period (1998-2011) and x_1 refers to values during the earlier period (1979-1993). The shift is normalized by $P(x>x_c)$, where x refers to values during the entire time period, and x_c is chosen so that $P(x>x_c)$ is 2.5%. The left panel shows results for precipitation and the right for 2m temperature; in the case of precipitation, the shift in probability actually refers to the left tail of the distribution (values less than x_c). The results are based on 12 ensemble members for each of 5 models (GEOS-5, CCM3, CAM4, GFS, ECHAM5). Each model's values are first normalized to have zero mean and unit variance. The inserts show the actual PDFs for the two periods (red is for the recent period and blue indicates the earlier period) for all grid points in the indicated boxes, land only). Vertical lines highlight the zero value and the value of x_c.