The International Research Institute for Climate and Society

Climate Variability and Change over South America (and other places)

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Supervisor: Dr. Lisa Goddard

Outline

This presentation will describe research output from my time at IRI, where I am part of the Climate Program and, in particular, of the Near-Term Climate Change (NTCC) group.

Project:

Diagnosing Decadal-Scale Climate Variability in Current Generation Coupled Models for Informing Near-term Climate Change Impacts. NOAA CVP. Lead PI: L. Goddard.

1. Develop metrics and baselines for estimating the quality of decadal predictions

2. Determine the fidelity of the surface expression of oceanic decadal variability, and the associated climate teleconnections, in several state-of-the-art CGCMs

Develop metrics and baselines for estimating the quality of decadal predictions

Collaboration with US CLIVAR's Decadal Predictability Working Group

Clim Dyn
DOI 10.1007/s00382-012-1481-2

A verification framework for interannual-to-decadal predictions experiments

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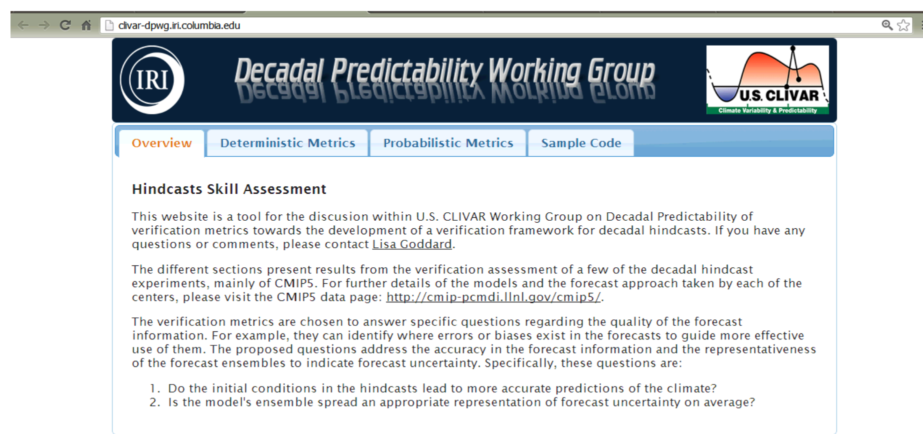
Abstract Decadal predictions have a high profile in the climate science community and beyond, yet very little is known about their skill. Nor is there any agreed protocol for estimating their skill. This paper proposes a sound and coordinated framework for verification of decadal hindcast experiments. The framework is illustrated for decadal hindcasts tailored to meet the requirements and specifications of CMIP5 (Coupled Model Intercomparison Project phase 5). The chosen metrics address key questions about the information content in initialized decadal hindcasts. These questions are: (1) Do the initial conditions in the hindcasts lead to more accurate predictions of the climate, compared to un-initialized climate change projections? and (2) Is the prediction model's ensemble spread an appropriate representation of forecast uncertainty on average? The first question is addressed through deterministic metrics that compare the initialized and uninitialized hindcasts. The second question is addressed through a probabilistic

Develop metrics and baselines for estimating the quality of decadal predictions

My roles in the activity:

- to program, test and document a set of deterministic and probabilistic metrics to evaluate the skill of the CMIP5 decadal hindcasts
- to search for adequate scales for temporal and spatial averaging
- to develop a website to share the hindcasts evaluation and the Matlab code I developed

Prototype:
http://iri.columbia.edu/~gonzalez/DPWG/



Final Version:
http://clivar-dpwg.iri.columbia.edu/

Develop metrics and baselines for estimating the quality of decadal predictions

The deterministic verification metrics face **Question 1**:

Do the initial conditions in the hindcasts lead to more accurate predictions of the climate?

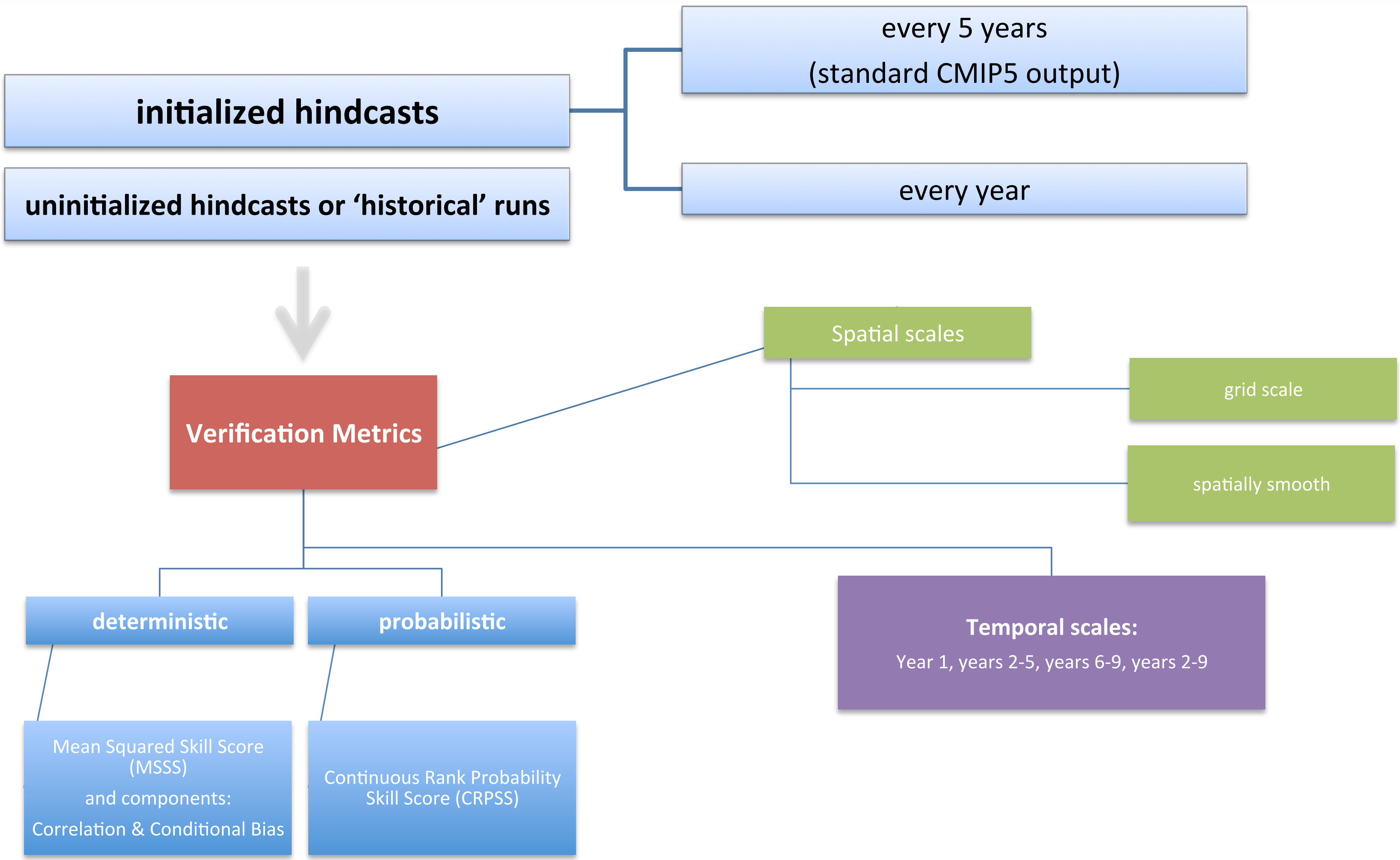
The probabilistic verification metrics face **Question 2**:

Is the model's ensemble spread an appropriate representation of forecast uncertainty on average?

and **Question 3**:

In the case that the forecast ensemble does offer information on overall forecast uncertainty, **Does the forecast-to-forecast variability of the ensemble spread carry meaningful information?**

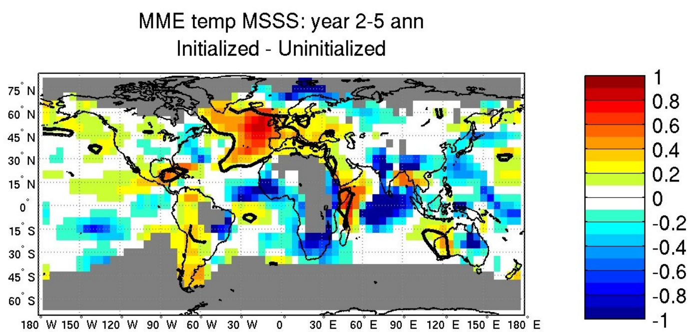
Develop metrics and baselines for estimating the quality of decadal predictions

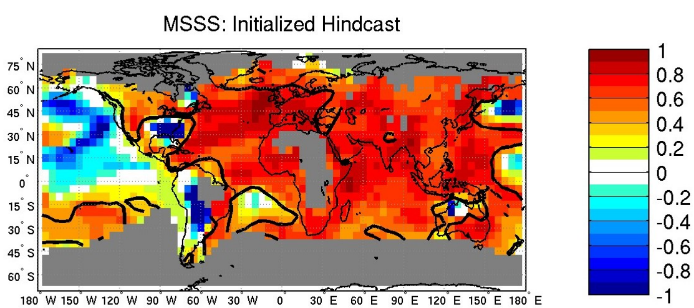


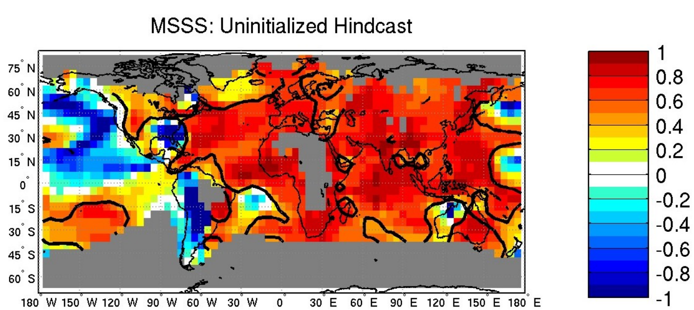
Develop metrics and baselines for estimating the quality of decadal predictions

Multi-model Ensemble Mean (12 models) – MSSS – years 2-5 – annual means

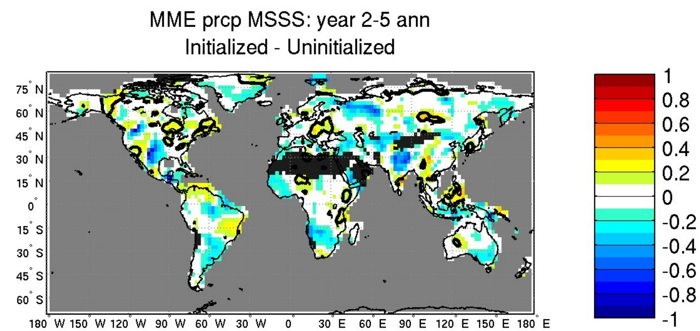
Temperature

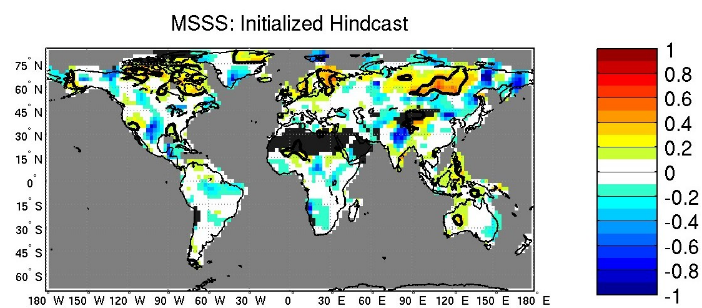


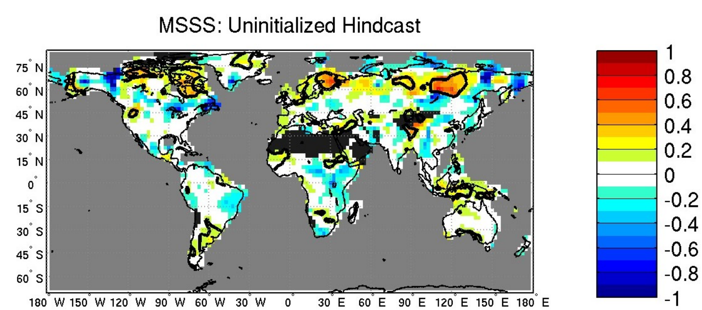




Precipitation





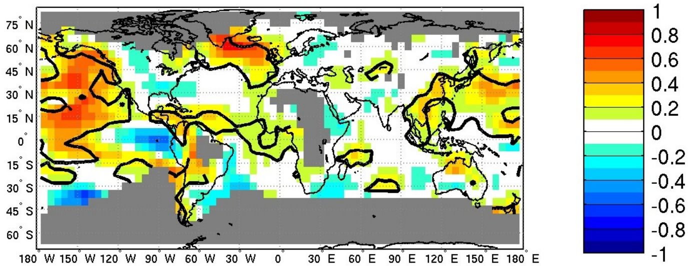


Develop metrics and baselines for estimating the quality of decadal predictions

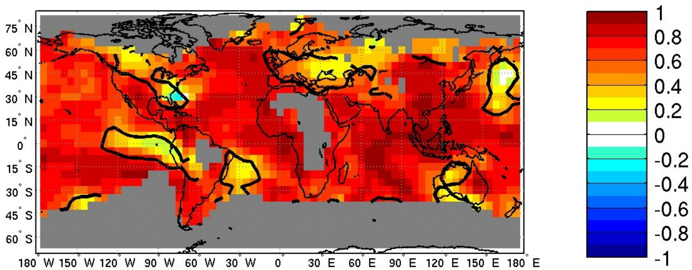
Multi-model Ensemble Mean (12 models) – Correlation – years 2-5 – annual means

Temperature

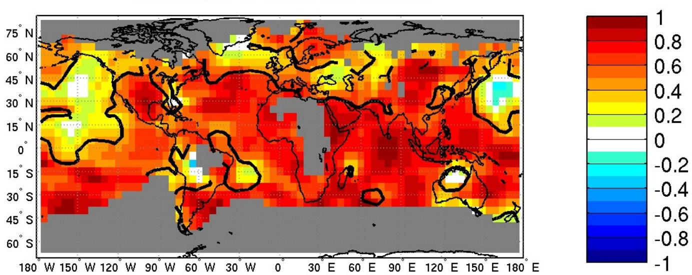
MME temp Correlation: year 1 ann
Initialized - Uninitialized



Correlation: Initialized Hindcast

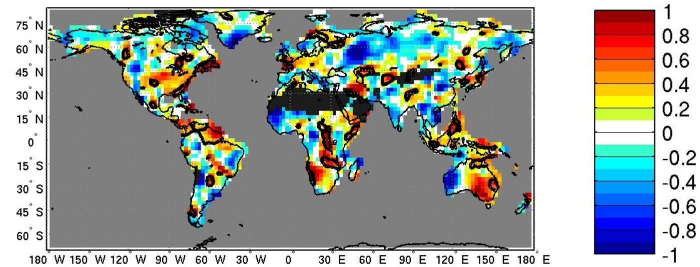


Correlation: Uninitialized Hindcast

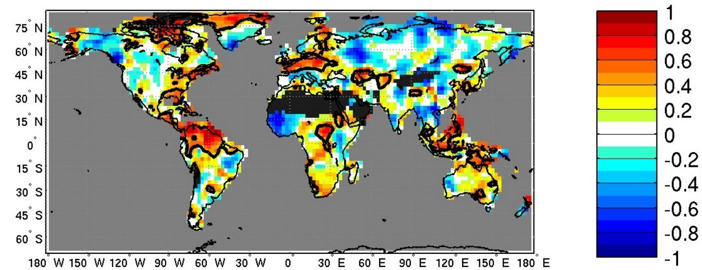


Precipitation

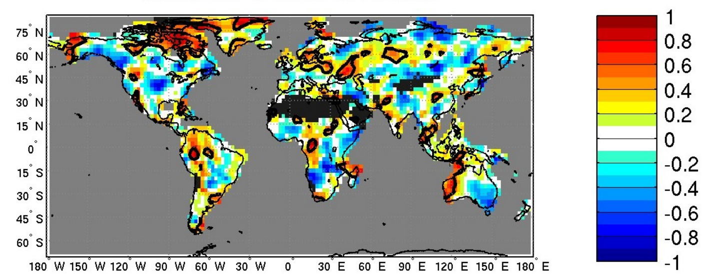
MME prcp Correlation: year 1 ann
Initialized - Uninitialized



Correlation: Initialized Hindcast



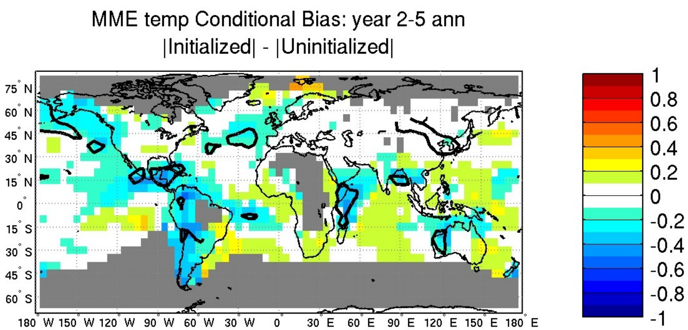
Correlation: Uninitialized Hindcast

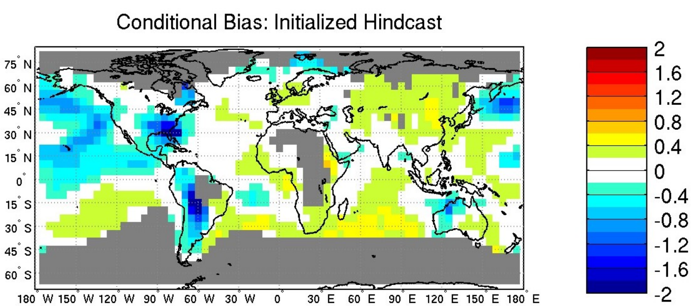


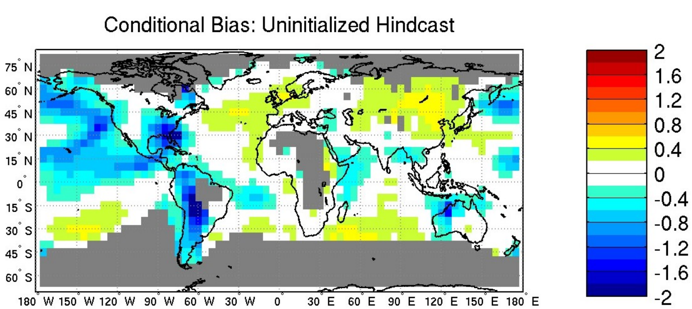
Develop metrics and baselines for estimating the quality of decadal predictions

MME (12 models) – Conditional Bias – years 2-5 – Spatially smooth - annual means

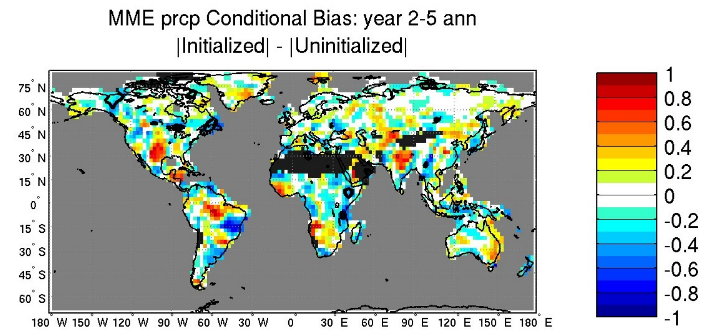
Temperature

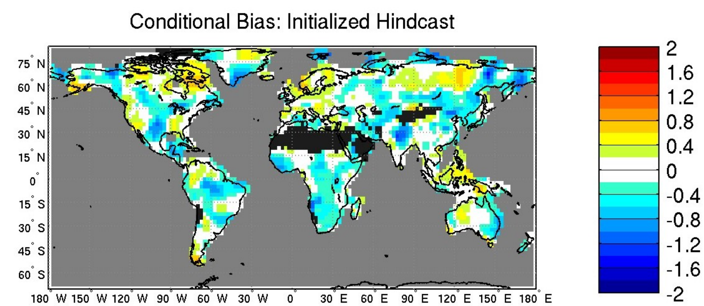


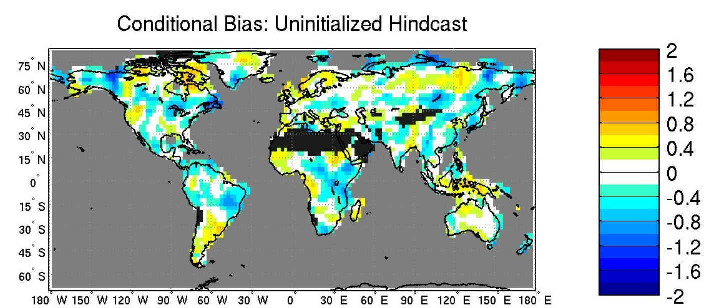




Precipitation



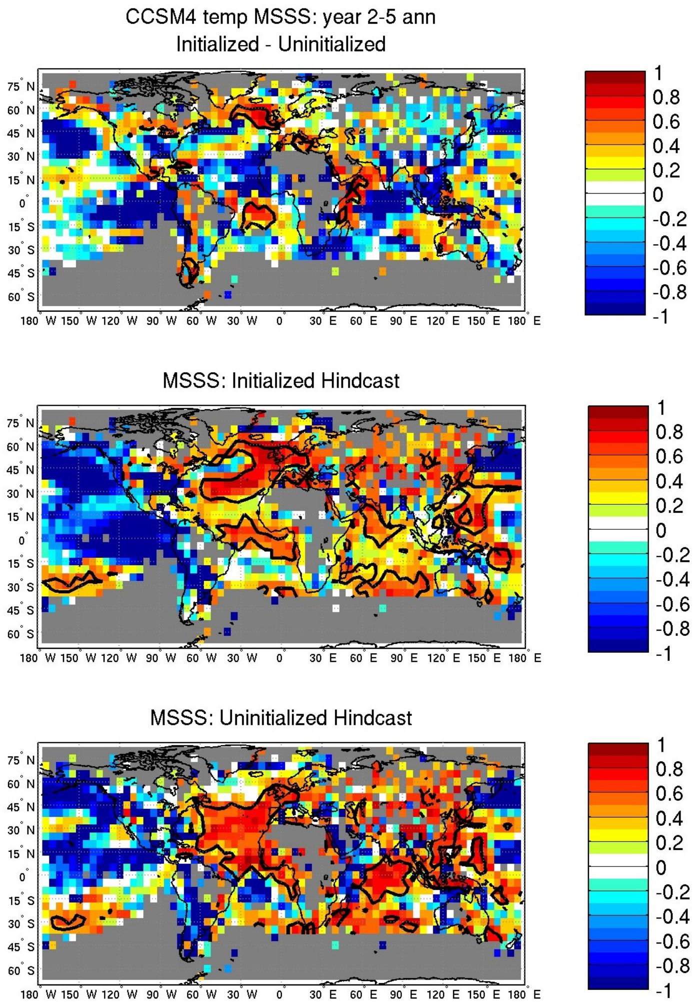




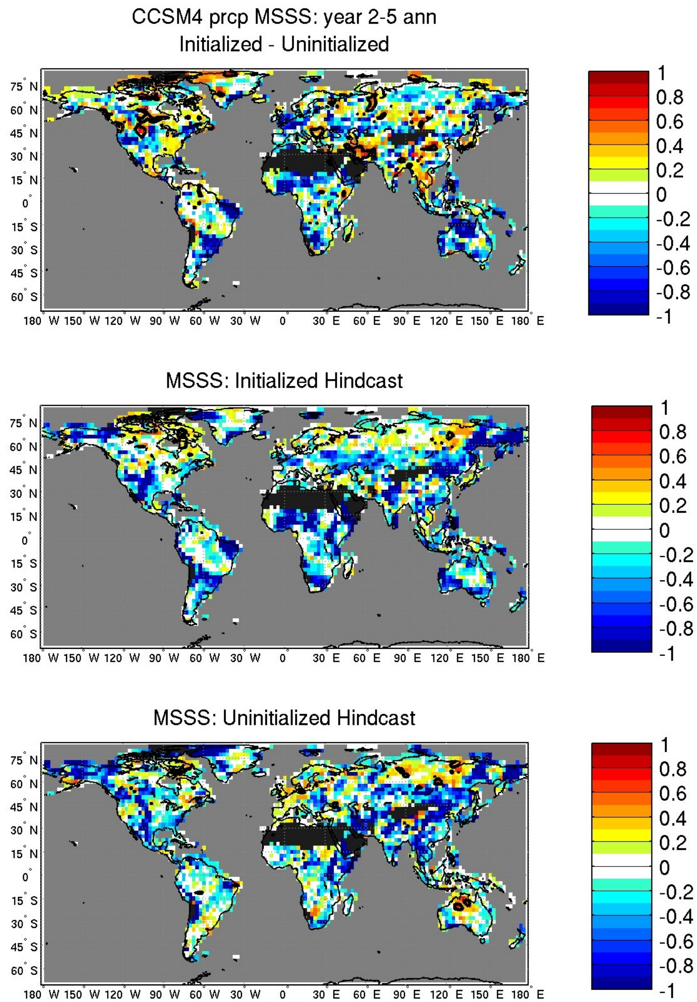
Develop metrics and baselines for estimating the quality of decadal predictions

CCSM4 – MSSS – years 2-5 – annual means

Temperature



Precipitation

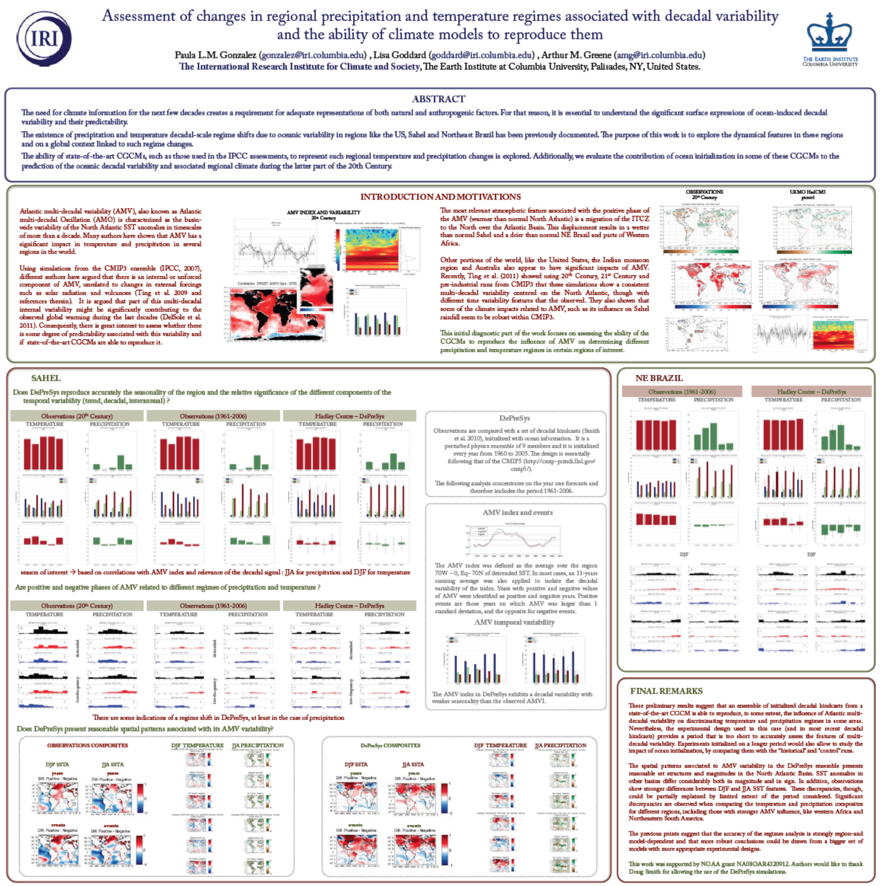


Determine the fidelity of the surface expression of oceanic decadal variability, and the associated climate teleconnections

2 Main presentations

WCRP Open Science Conference (2011)

"Assessment of changes in regional precipitation and temperature regimes associated with decadal variability and the ability of climate models to reproduce them"



37th NOAA Climate Diagnostics and Predictability Workshop (2012)

"Diagnosing decadal-scale climate variability in current generation coupled models"

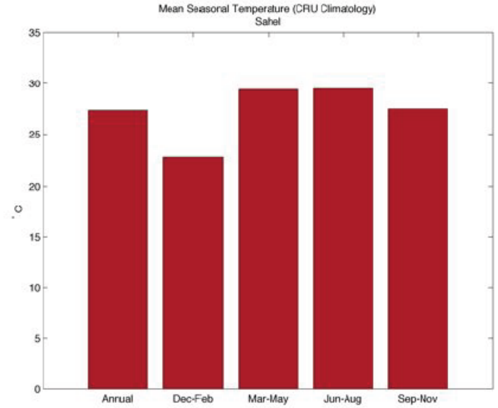
Observations (1961-2006)

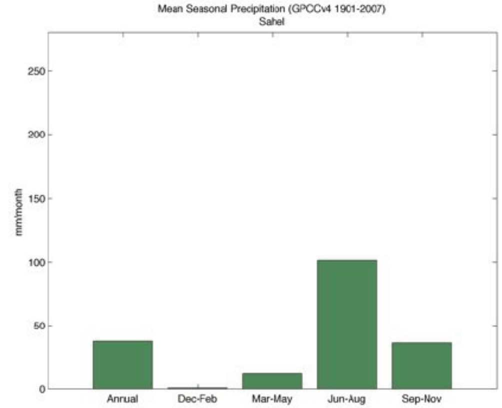
SAHEL

TEMPERATURE

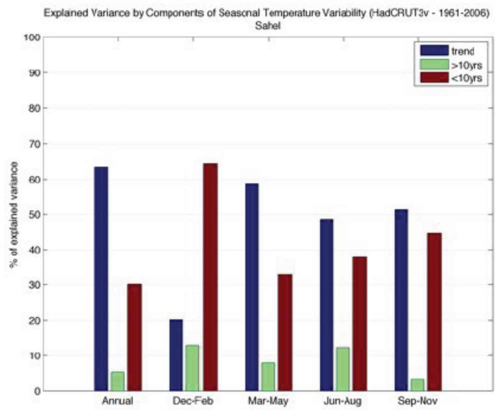
PRECIPITATION

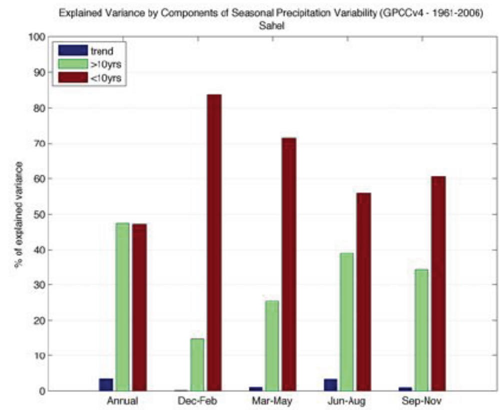
Seasonality



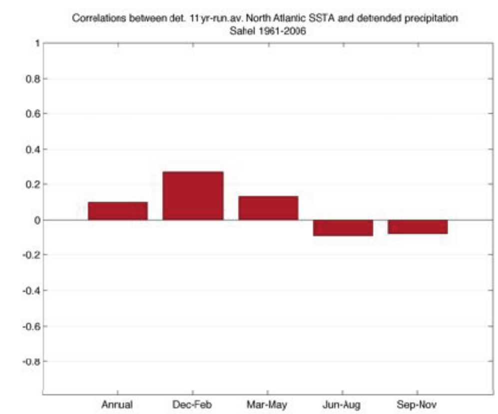


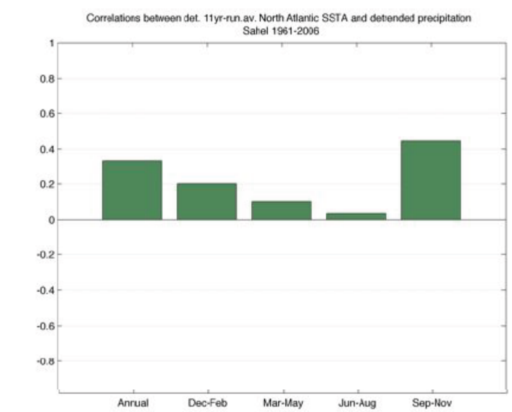
Time scales decomposition





AMV influence





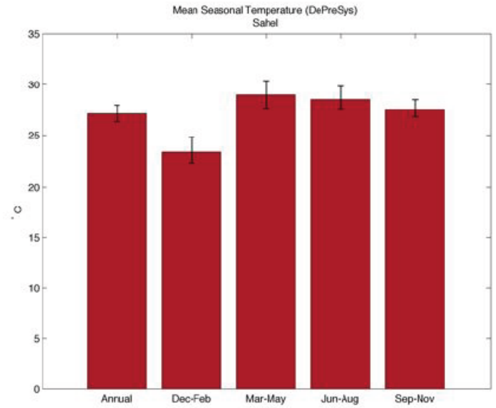
Hadley Centre – DePreSys

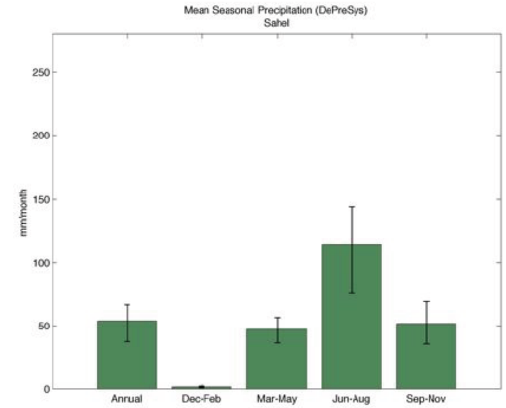
SAHEL

TEMPERATURE

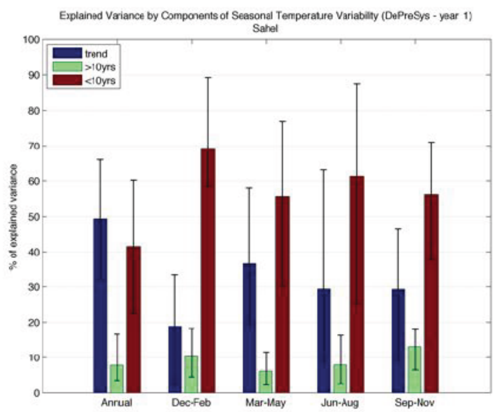
PRECIPITATION

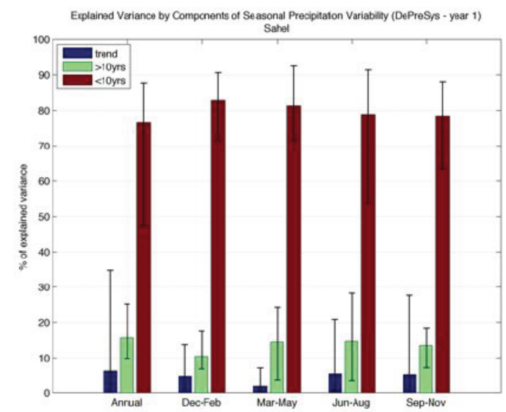
Seasonality



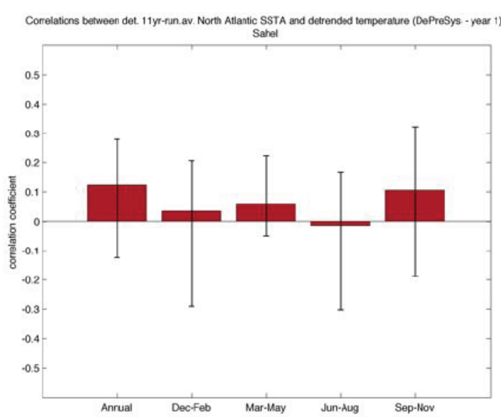


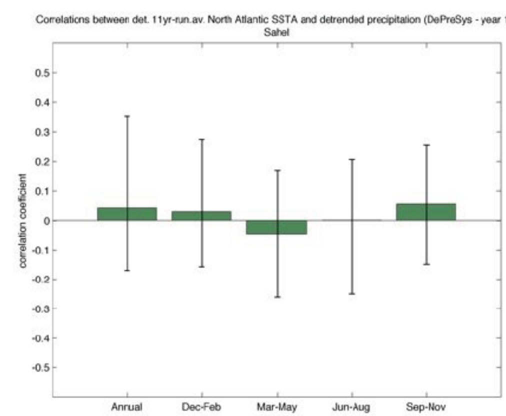
Time scales decomposition





AMV influence



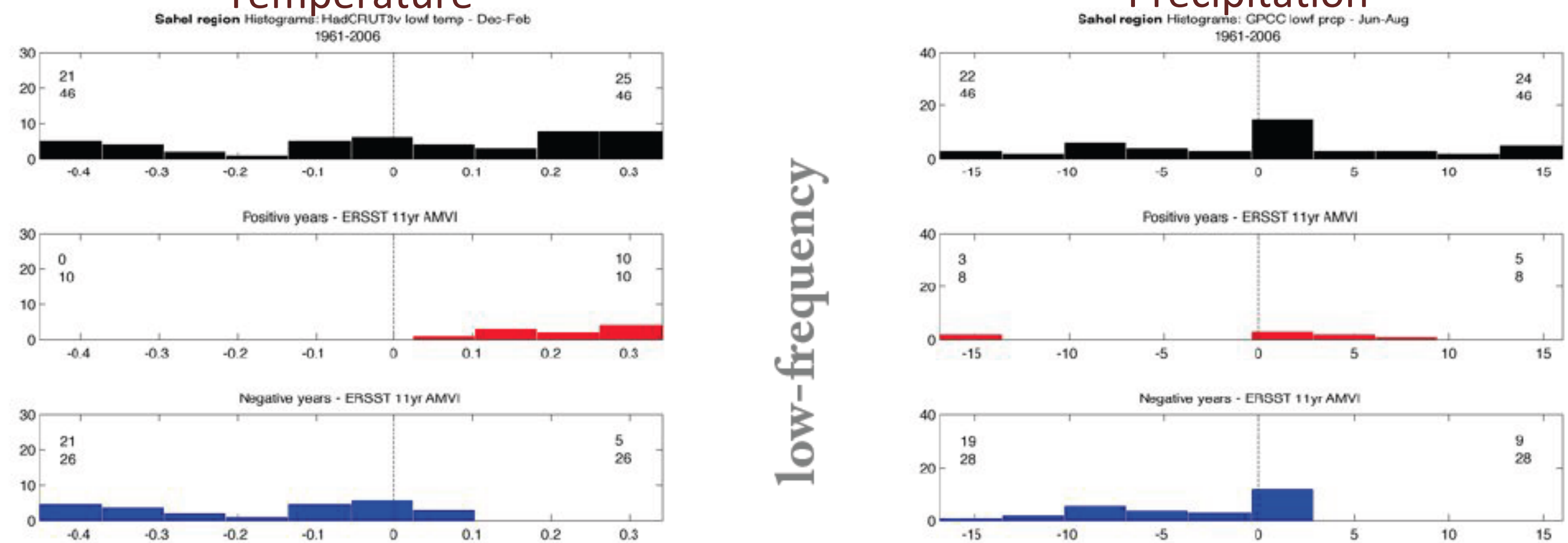


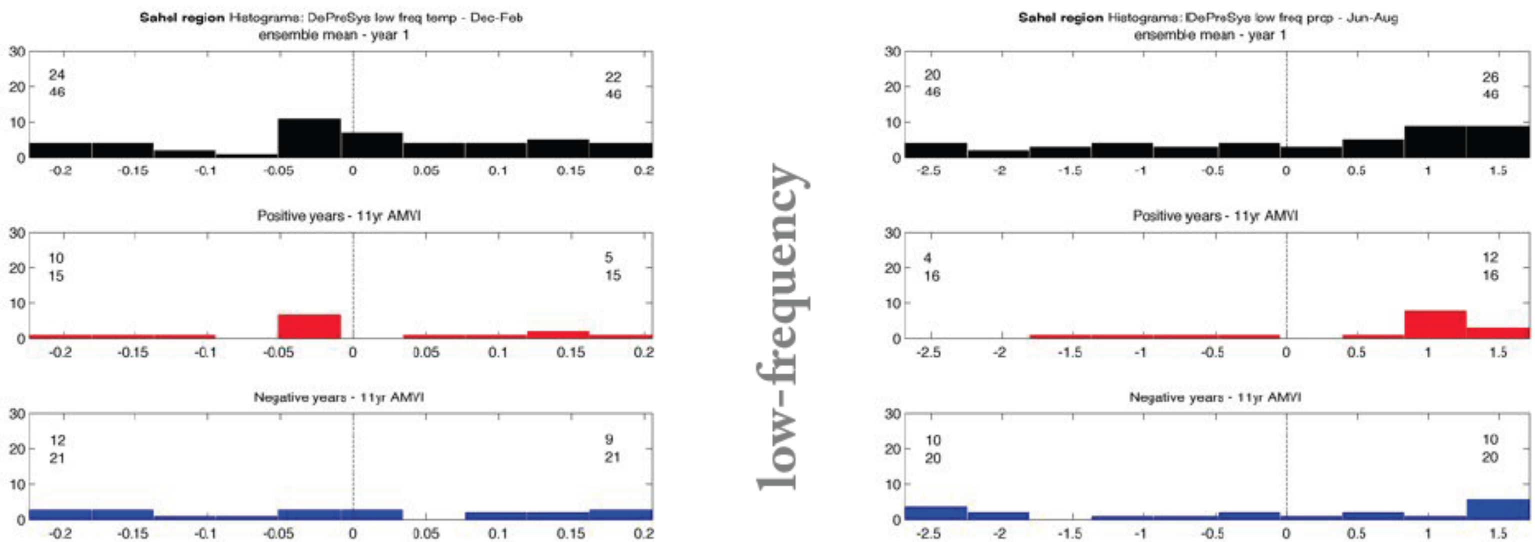
Determine the fidelity of the surface expression of oceanic decadal variability, and the associated climate teleconnections

Temperature

Precipitation

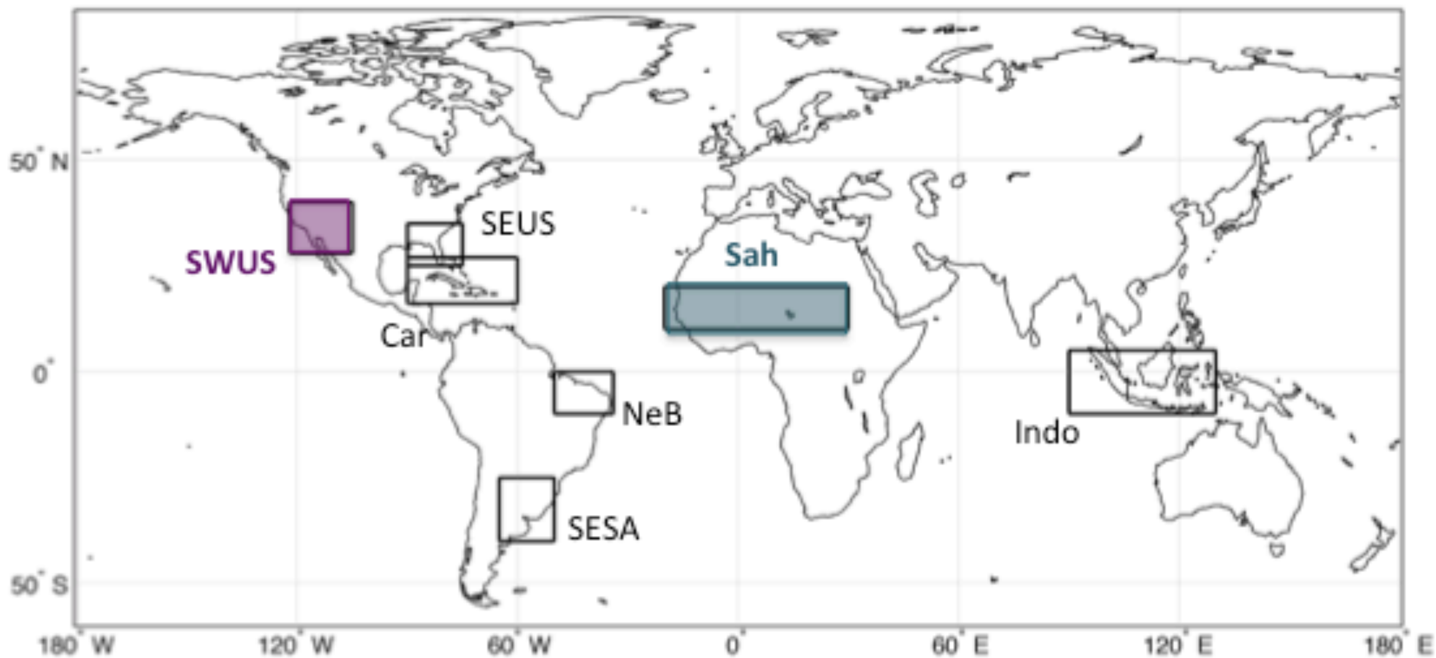
SAHEL Obs.

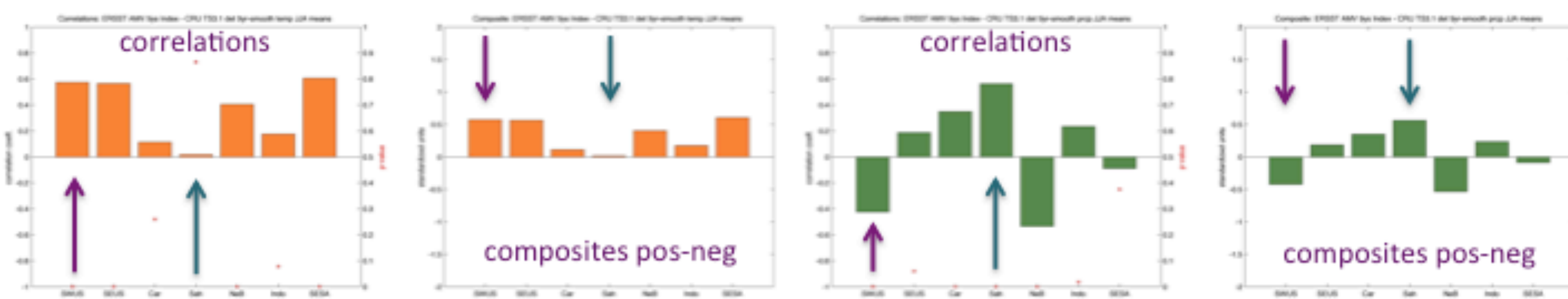




SAHEL DePreSys

Relationship between AMV and regional climate anomalies in CMIP5



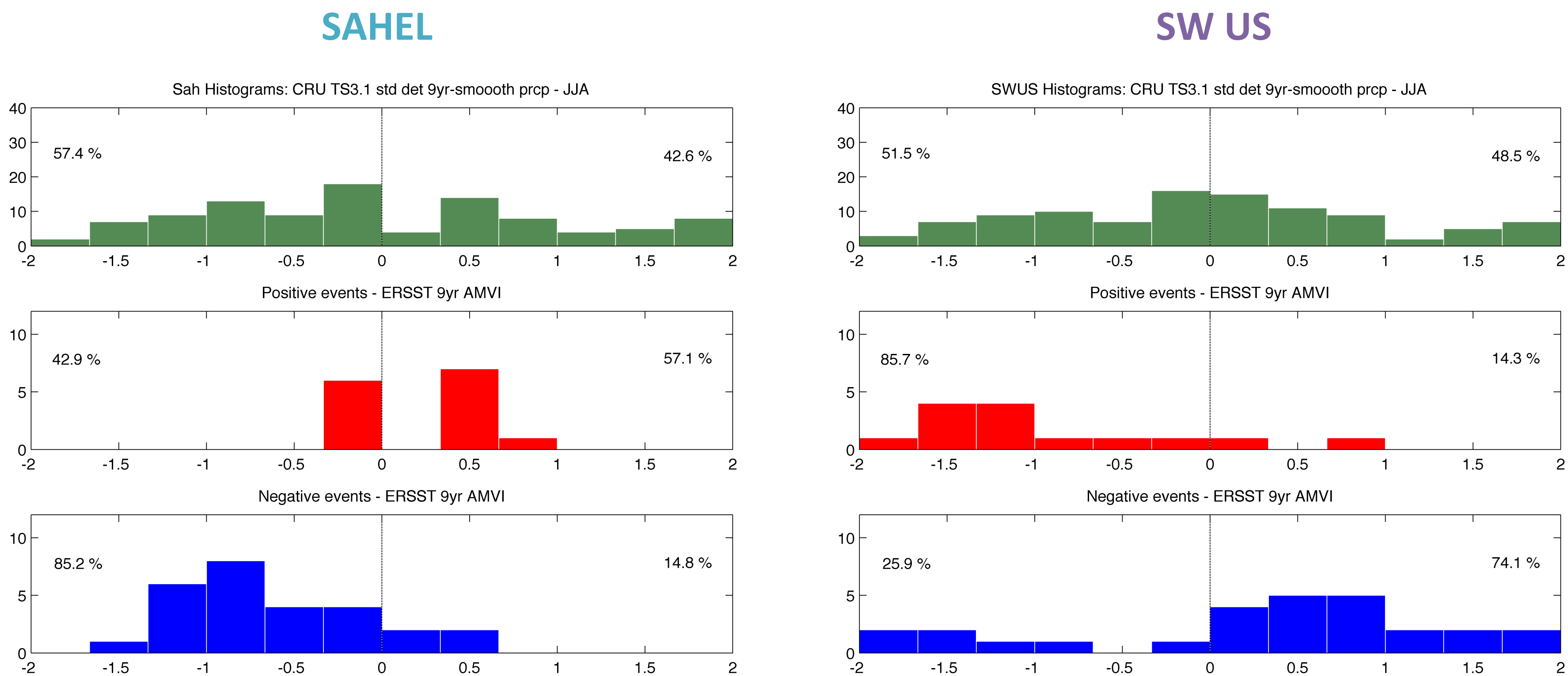


TEMPERATURE

PRECIPITATION

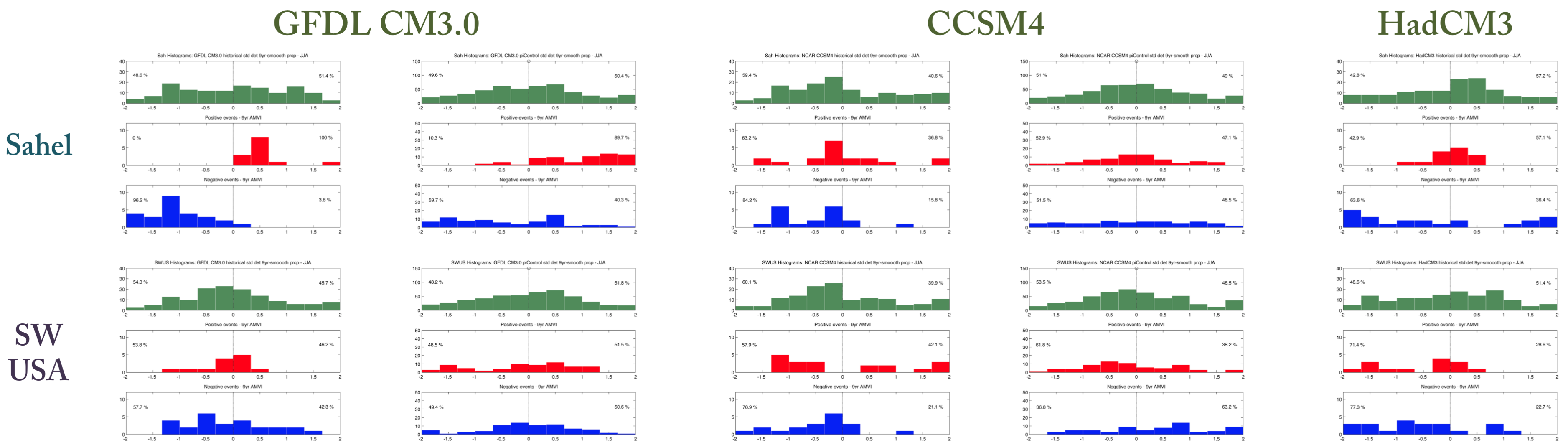
Relationship between AMV and regional climate anomalies in CMIP5

Example: Observations - precipitation – Sahel vs SW US



Relationship between AMV and regional climate anomalies in CMIP5

Example: historical/piControl - precipitation – Sahel vs SW US

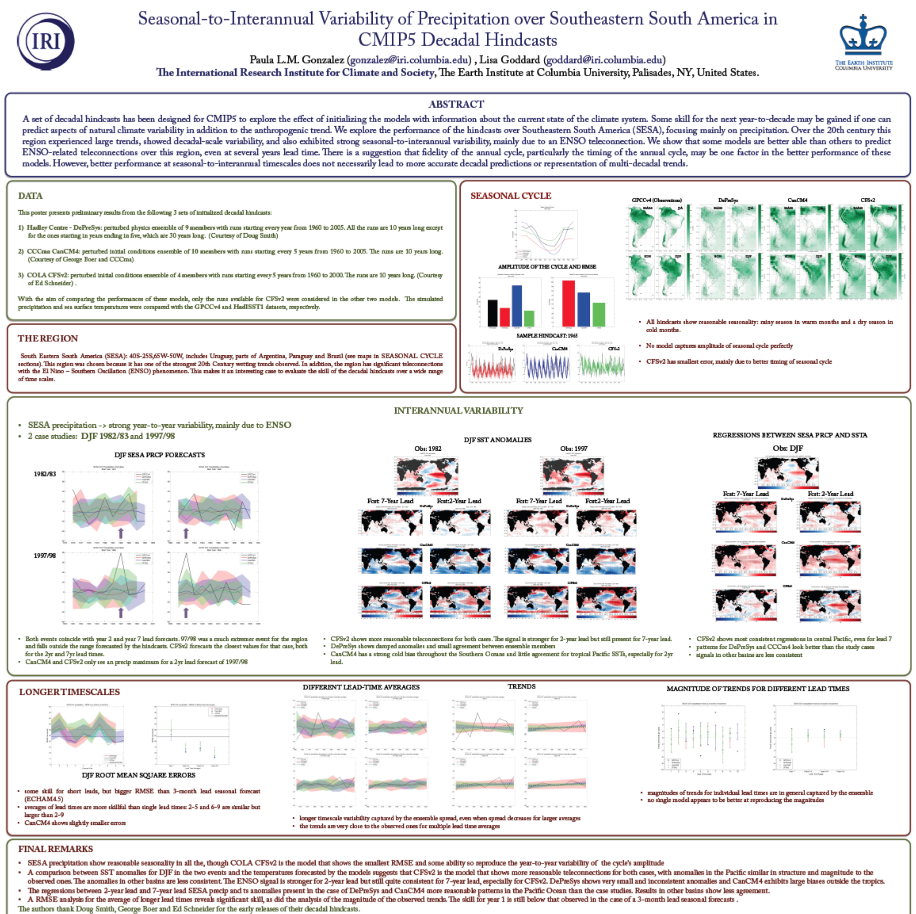


- The influence in the precipitation anomalies in some regions like Sahel seems more robust that in some others like SW USA.
- The discrimination is generally weaker in the piControl experiments.
- We are exploring whether the mluti-decadal variability in the Tropical Atlantic Ocean has more robust teleconnections with some of these regions.

Exploring seasonal-to-decadal predictability and teleconnections in CMIP5 decadal hindcasts

AGU Fall Meeting (2011)

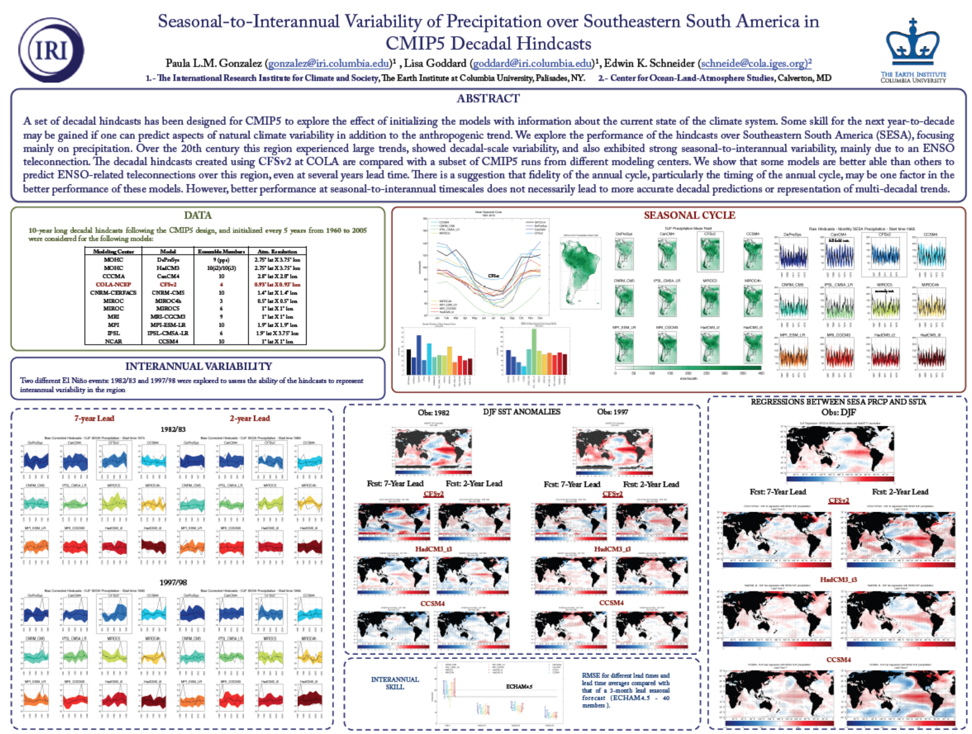
"Seasonal-to-interannual variability of precipitation over Southeastern South America en CMIP5 decadal hindcasts"



CFSv2 Evaluation Workshop (2012)

"Seasonal-to-interannual variability of precipitation over Southeastern South America en CMIP5 decadal hindcasts"

★ including 12 hindcasts

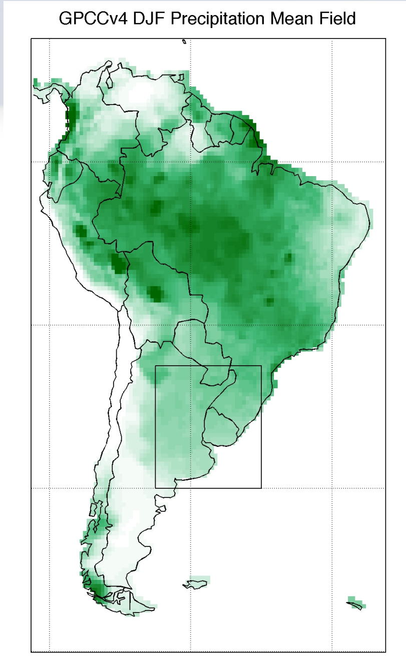


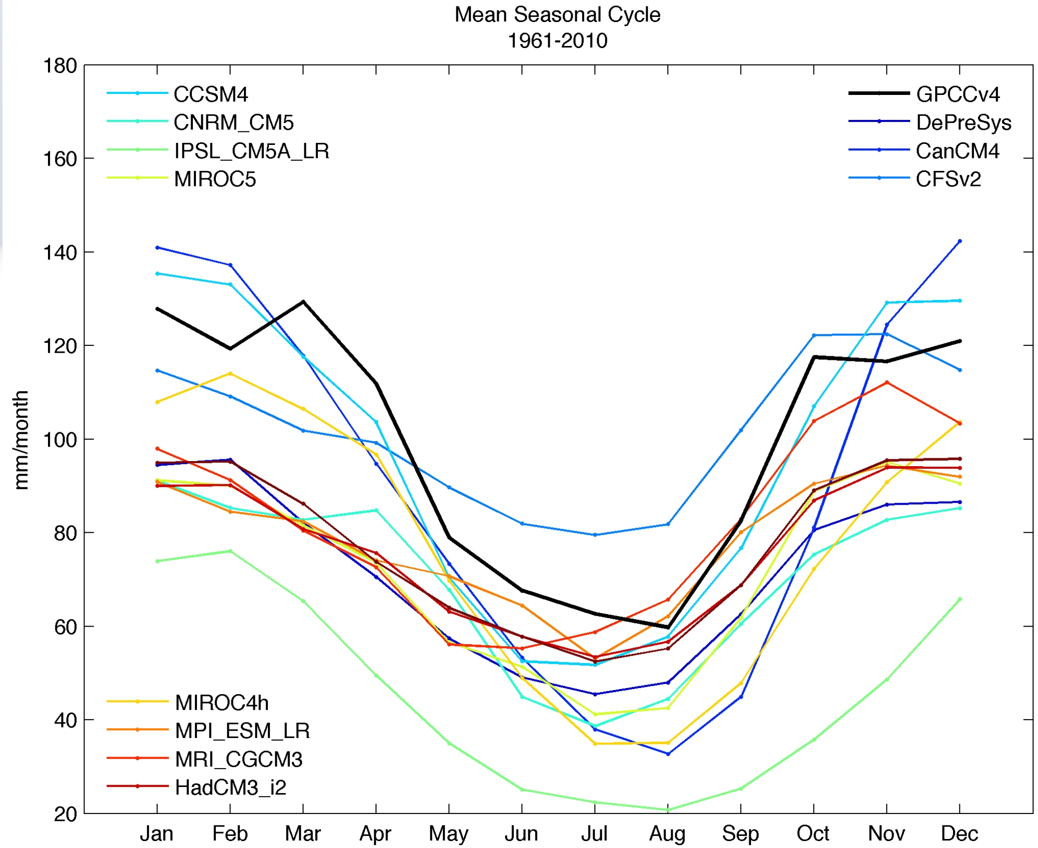
Updates of this work will be presented at :

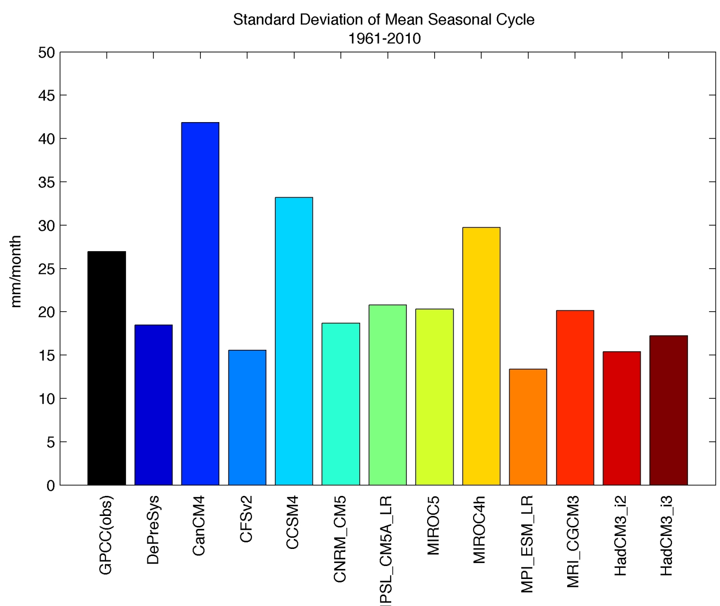
-International Workshop on seasonal to decadal prediction

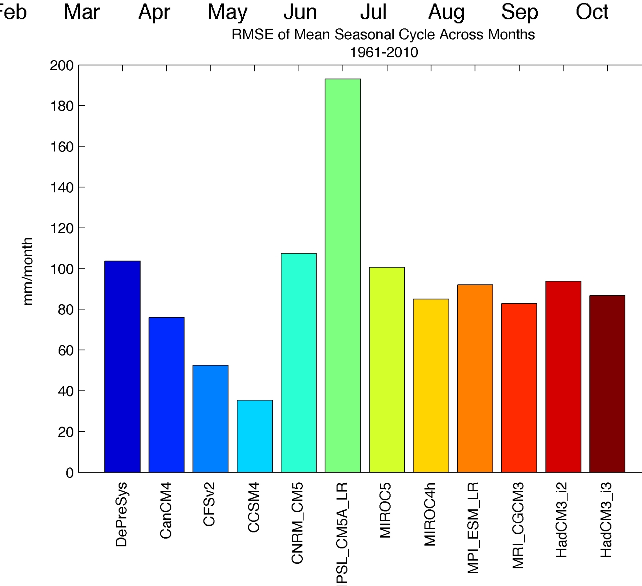
-DACA-13, Interannual to decadal climate variability and change

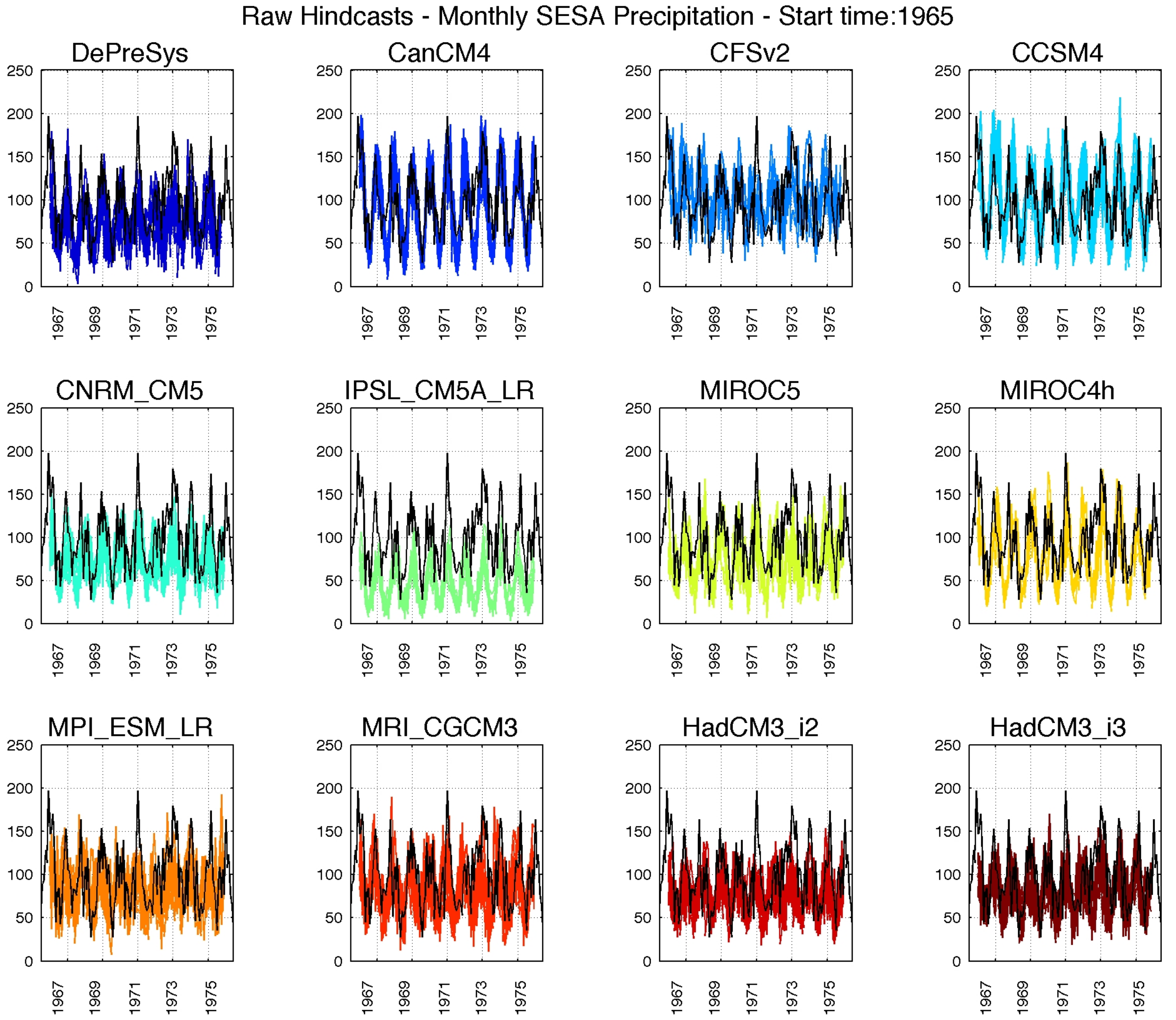
Seasonal cycle



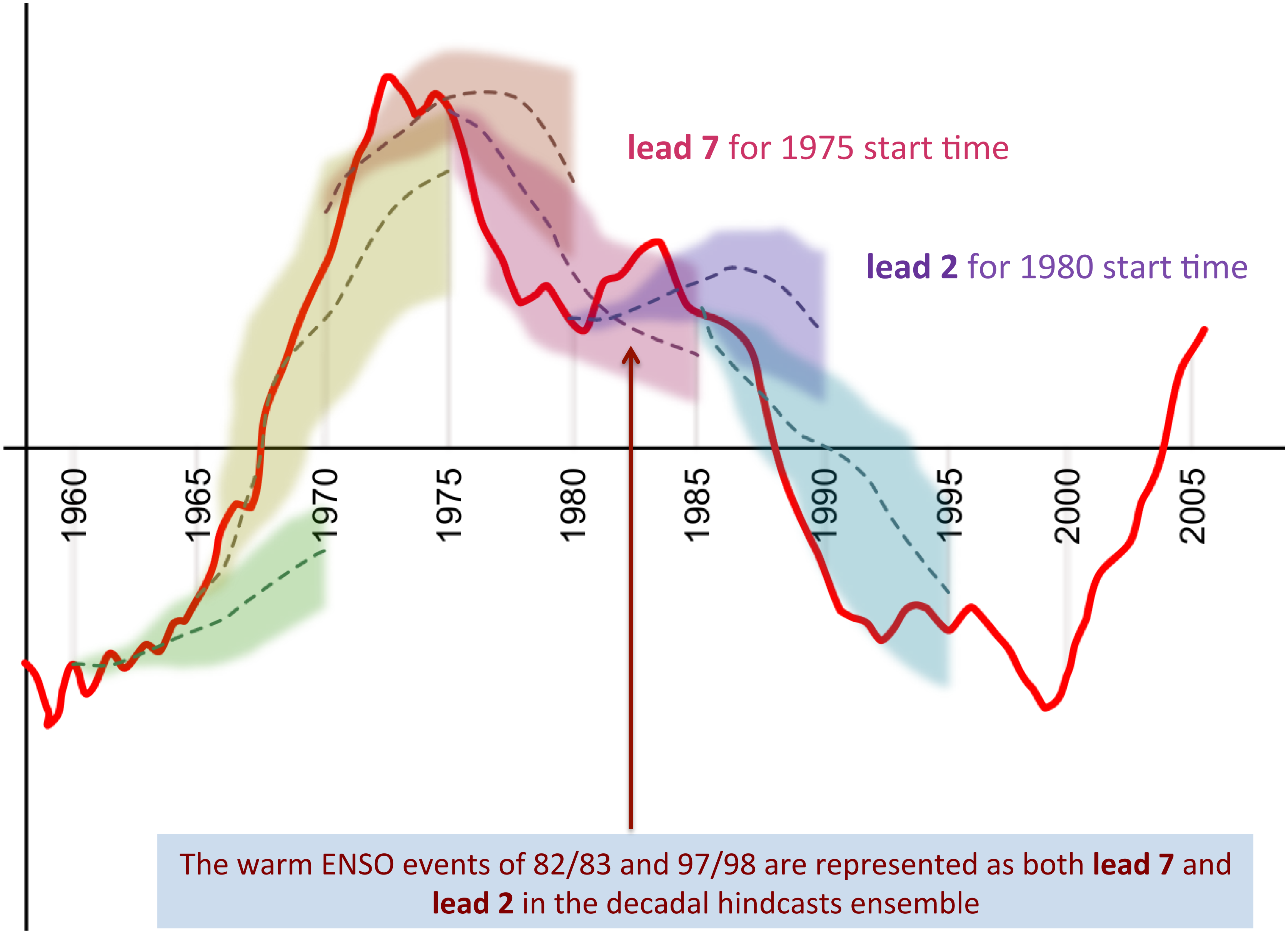







Raw Hindcasts - Monthly SESA Precipitation - Start time:1965
DePreSys
CanCM4
CFSv2
CCSM4
CNRM_CM5
IPSL_CM5A_LR
MIROC5
MIROC4h
MPI_ESM_LR
MRI_CGCM3
HadCM3_i2
HadCM3_i3
0
50
100
150
200
250
1967
1969
1971
1973
1975

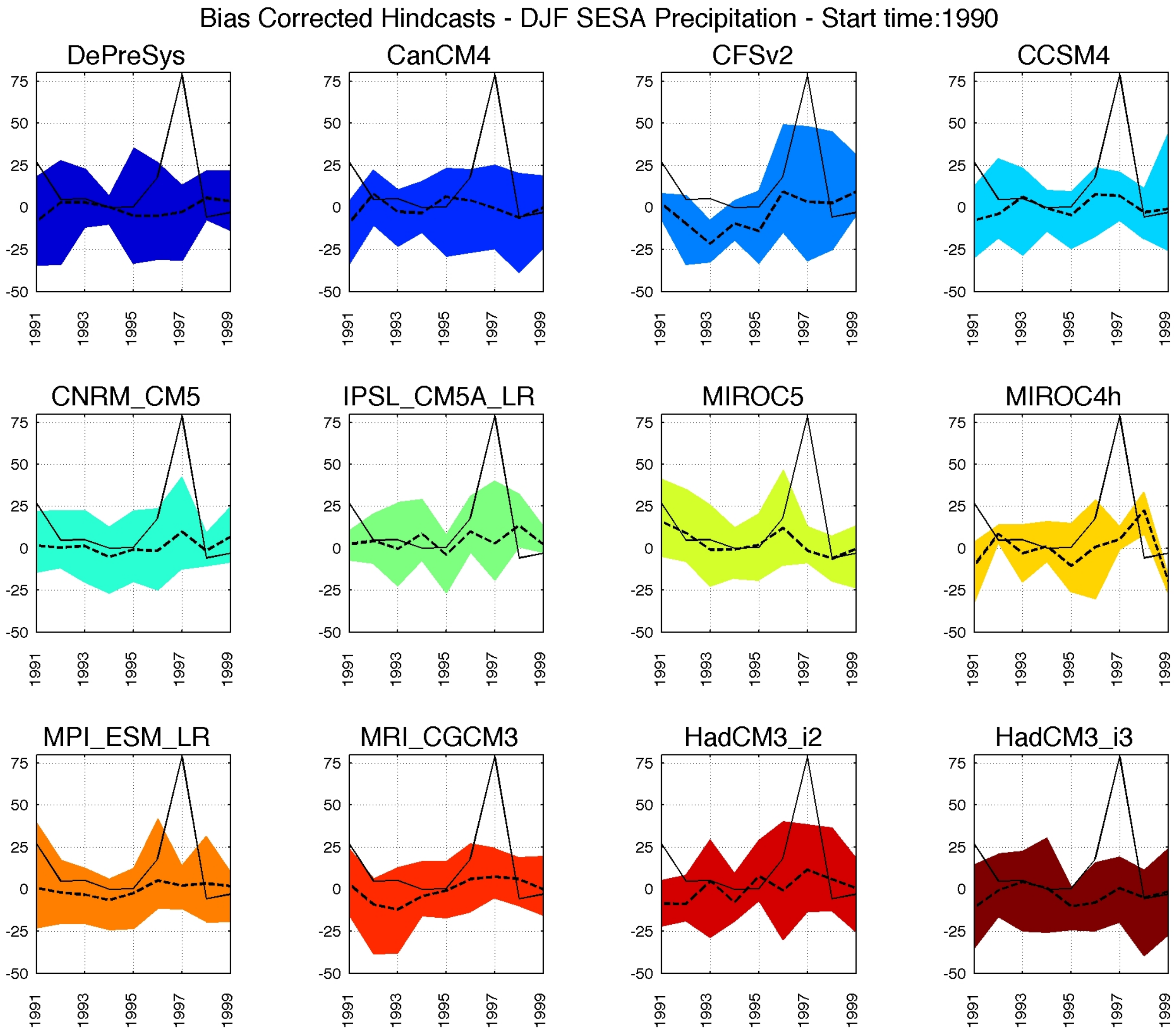
CMIP5 Decadal Hindcasts



The warm ENSO events of 82/83 and 97/98 are represented as both **lead 7** and **lead 2** in the decadal hindcasts ensemble

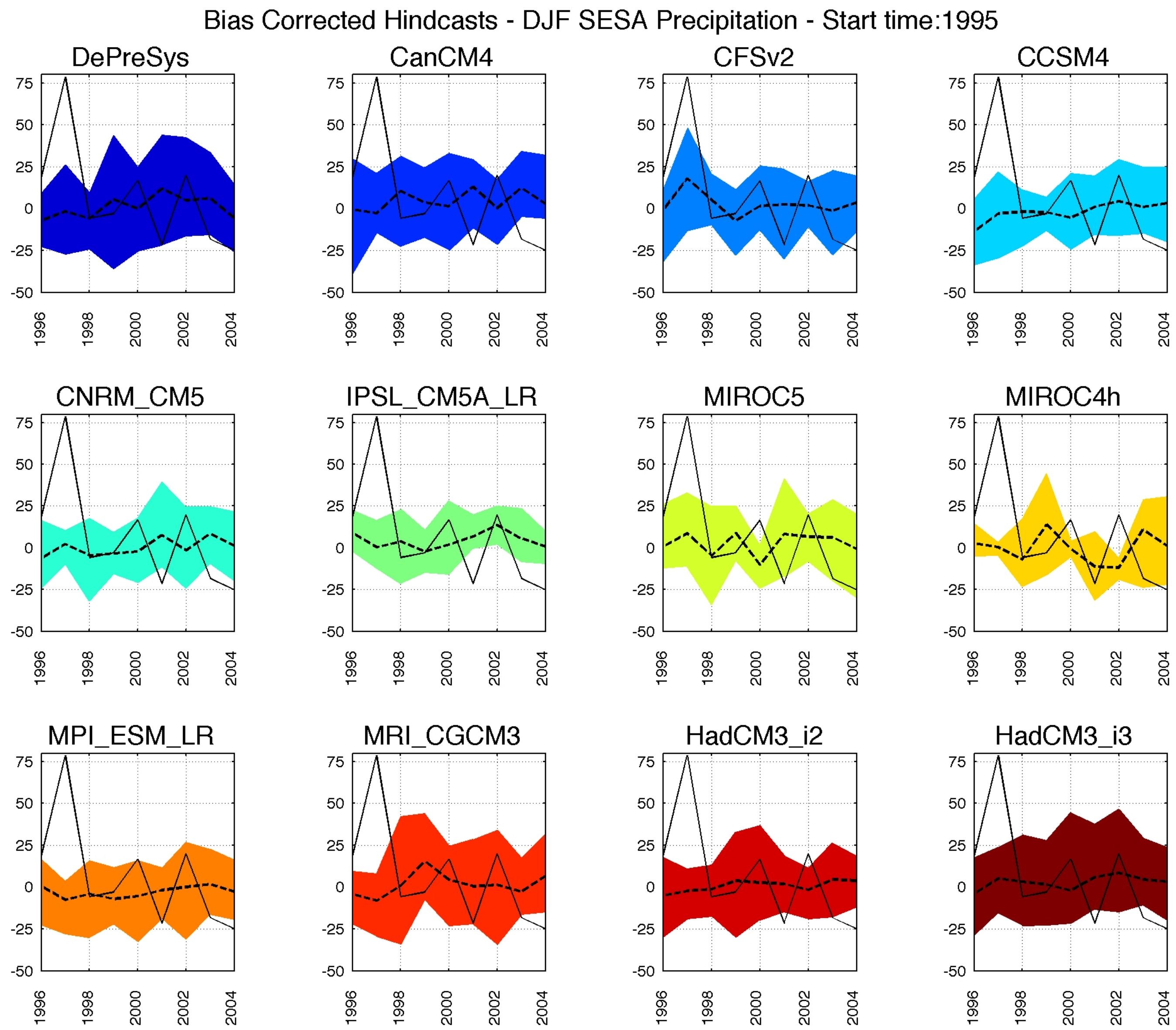
Exploring seasonal-to-decadal predictability and teleconnections in CMIP5 decadal hindcasts

El Nino 97/98
as **7-year lead**



Exploring seasonal-to-decadal predictability and teleconnections in CMIP5 decadal hindcasts

El Nino 97/98
as **2-year lead**

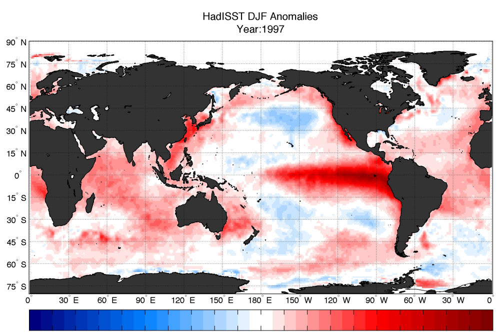


Fcst: 7-Year Lead

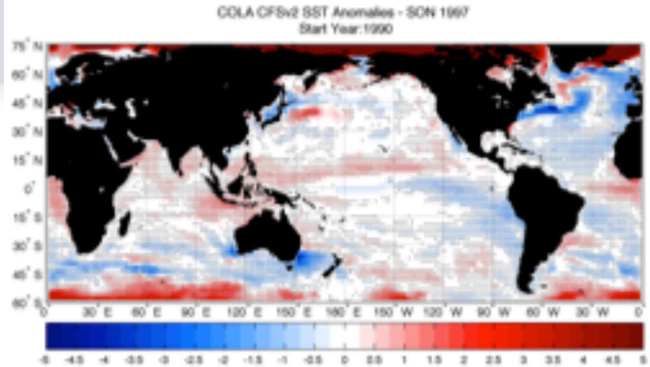
Fcst: 2-Year Lead

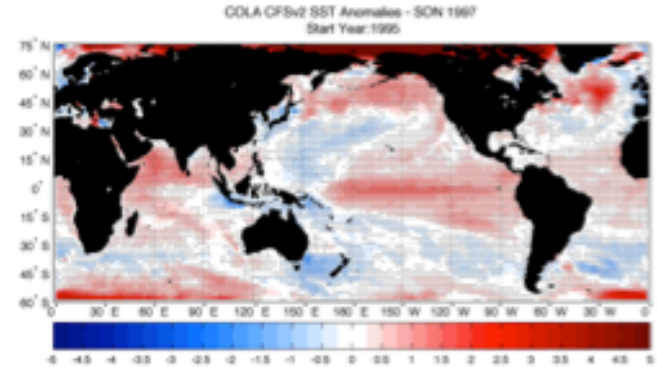
SST Anomalies

Obs: 97/98

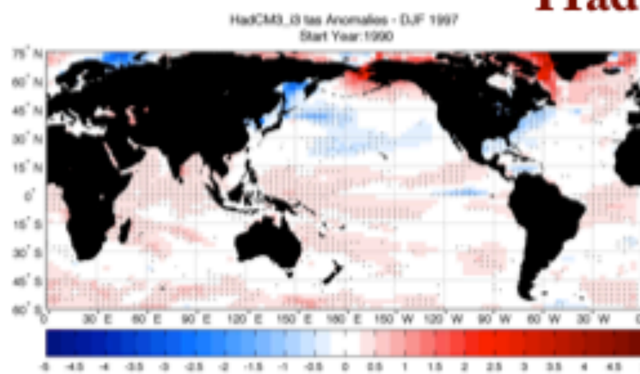


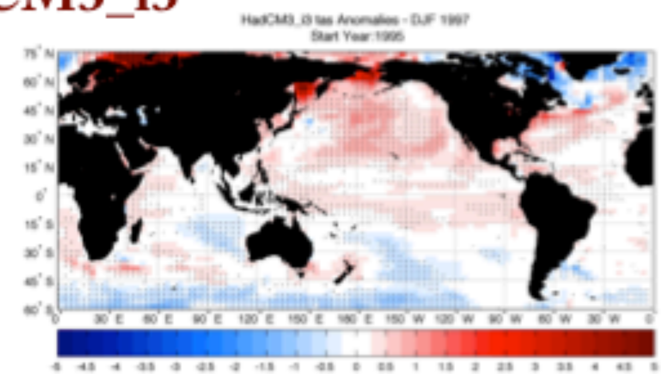
CFSv2



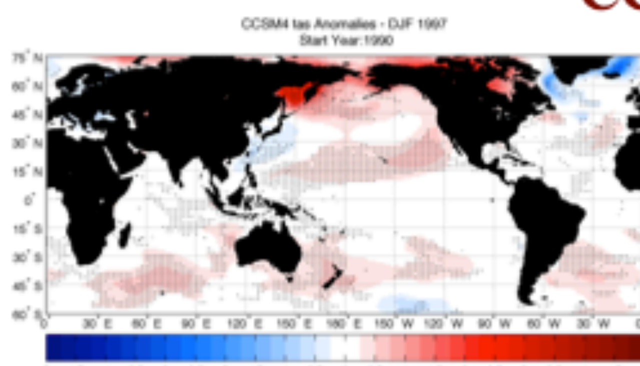


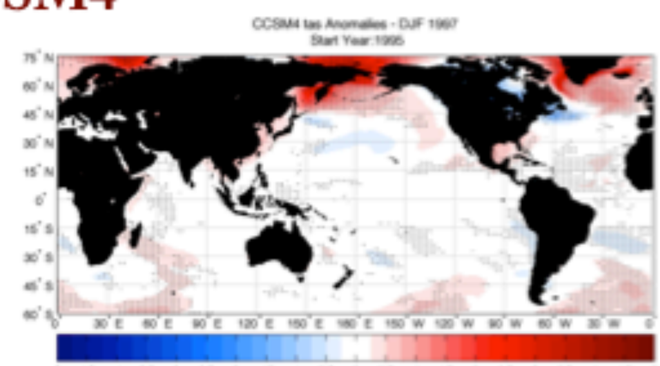
HadCM3_i3





CCSM4

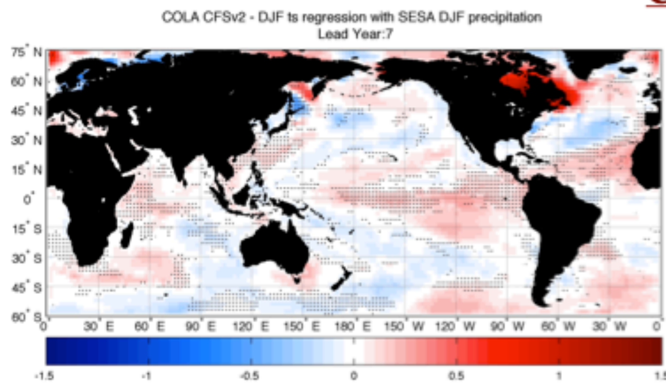


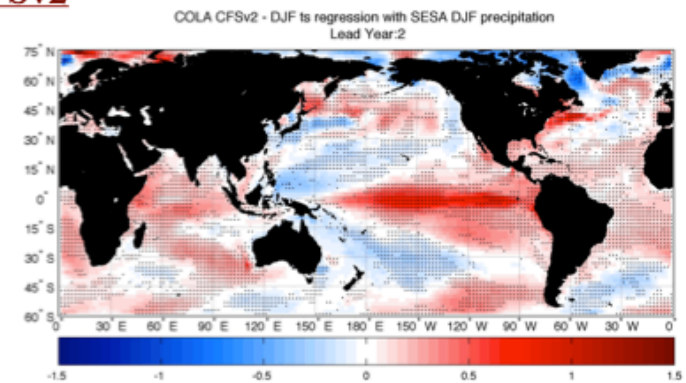


Regressions SESA precipitation vs SSTA

Fcst: 7-Year Lead	Fcst: 2-Year Lead

CFSv2





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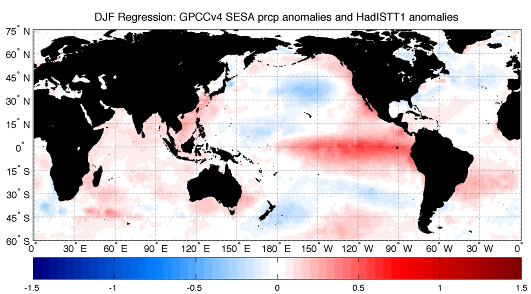
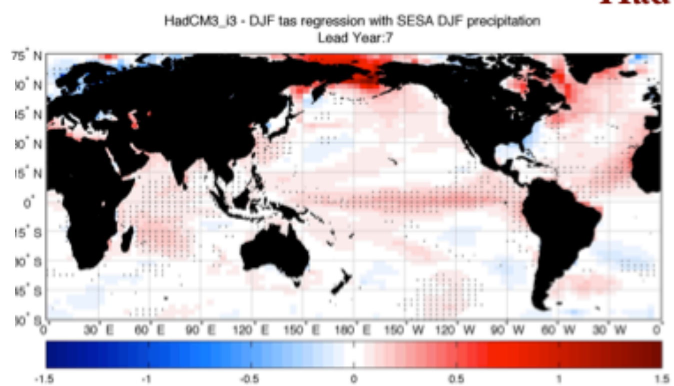
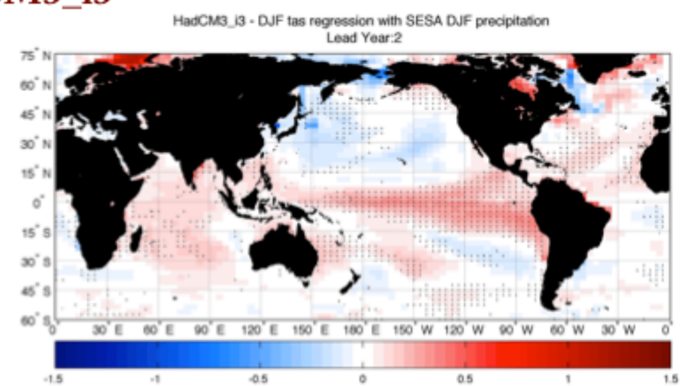
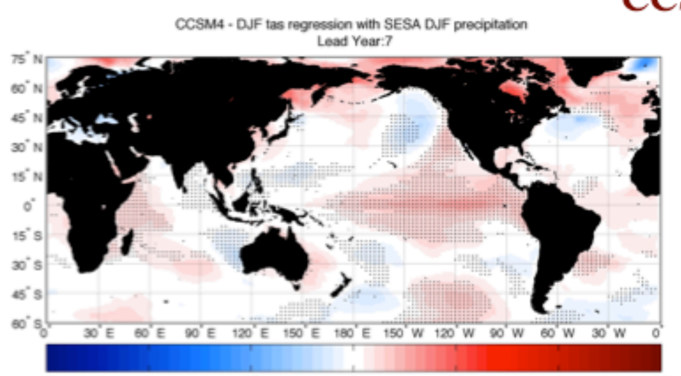


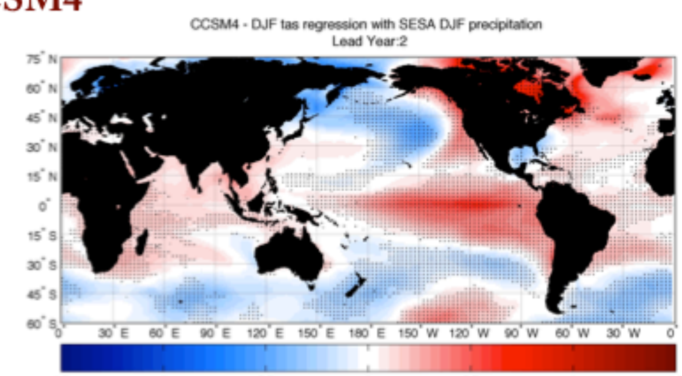
HadCM3_i3





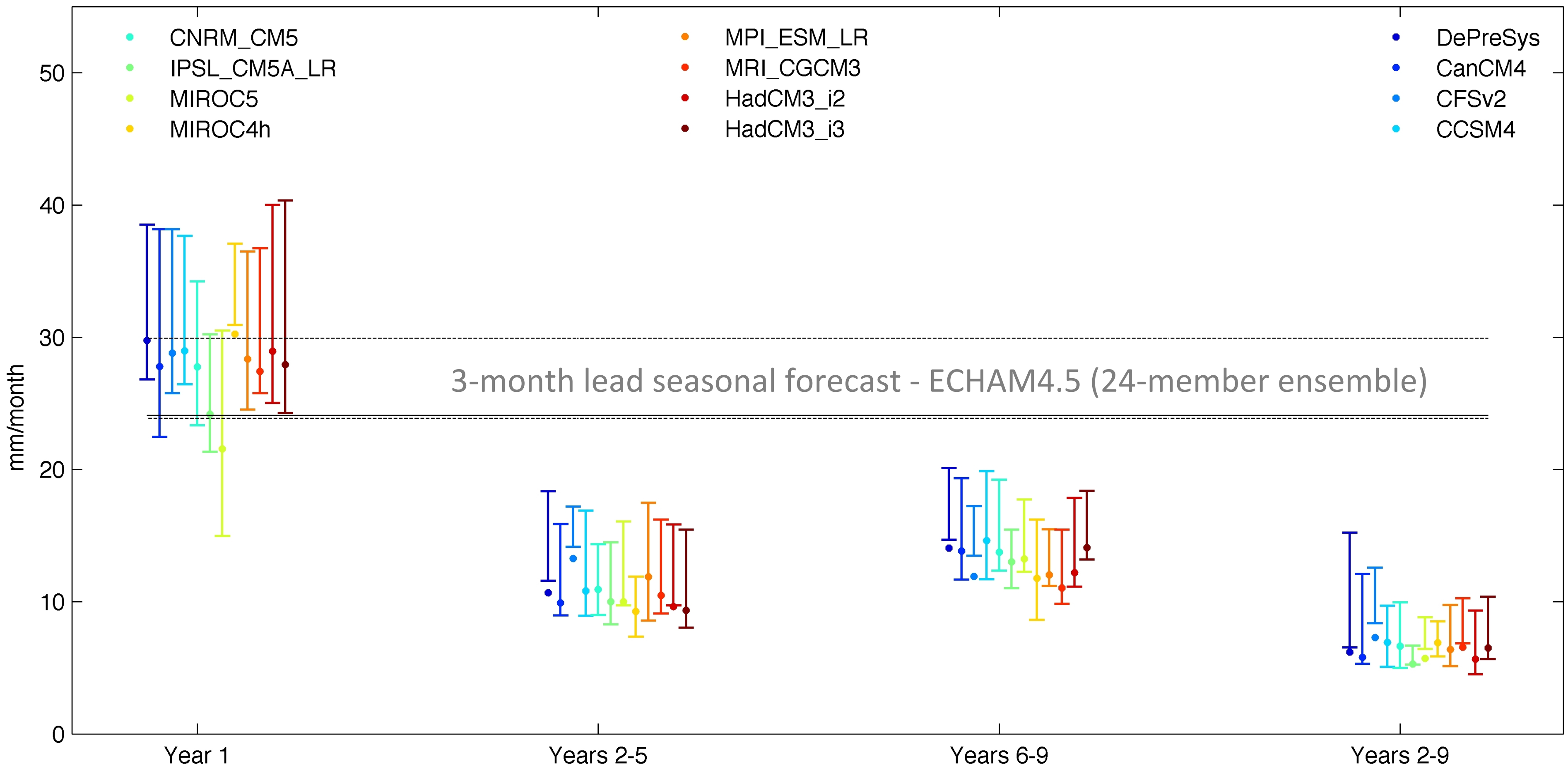
CCSM4





Exploring seasonal-to-decadal predictability and teleconnections in CMIP5 decadal hindcasts

SESA precipitation - Interannual-to-decadal skill (RMSE)



Development of multi-scale regional climate information

Projects:

Multi-scale Climate Information for Agricultural Planning in Southeastern South America for Coming Decades. NSF EaSM. PIs: Lisa Goddard, Walter Baethgen, Arthur Greene (IRI/Columbia University), Richard Seager (Lamont-Doherty Earth Observatory, ColumbiaUniversity).

Integration of Decadal Climate Predictions, Ecological Models and Human Decision-making Models to Support Climate-resilient Agriculture in the Argentine Pampas. NSF EaSM. Lead PI: Guillermo Podesta (Univ. of Miami).

A Framework for the Development of Multi-scale Regional Climate Information

Paula L.M. Gonzalez (gonzalez@iri.columbia.edu) , Lisa Goddard (goddard@iri.columbia.edu) , Arthur M. Greene (amg@iri.columbia.edu)
The International Research Institute for Climate and Society, The Earth Institute at Columbia University, Palisades, NY, United States.

AGU Fall Meeting 2010

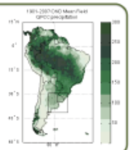
ABSTRACT

Climate information for the next few decades is required for both risk management and planning purposes. On this time horizon natural and anthropogenic factors can be equally important. We introduce here a strategy for the layering of information on different timescales – anthropogenically-forced climate change, natural low-frequency fluctuations and year-to-year variability – each with its associated uncertainty range. The approach involves the combination of dynamical and statistical projections, with specific methodologies being regionally tailored.

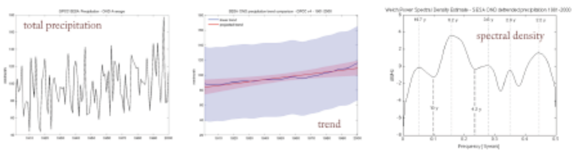
The example of South Eastern South America will be presented. Here, such information can play a crucial role in the development of land-use and water management policies. Approaches of varying complexity are considered in order to take advantage of observations, IPCC climate change projections and initialized decadal predictions, and to assess the uncertainties in these sources of information.

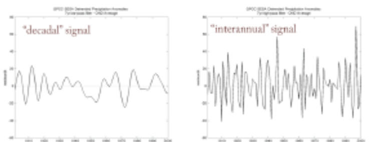
EXAMPLE: OND precipitation in South Eastern South America (SESA)

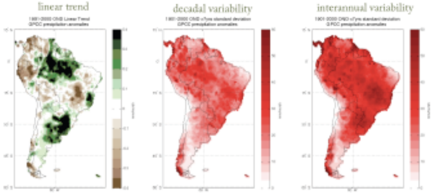
- **OND** was chosen for its strong coherent **variability and trend**, and for the importance of rainfall in that period to **regional agriculture**.
- The dataset chose was WMO's **GPCC** and some of the results might change slightly with different datasets.

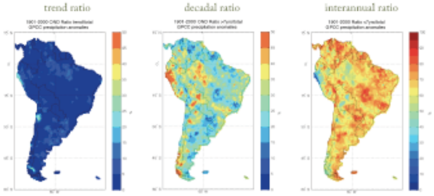


1) Understanding the past: 20th Century Variability And Change



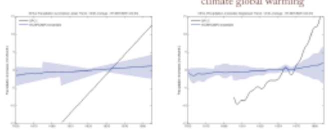






2) Looking towards the future

TREND



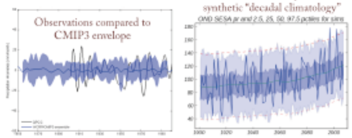
- The CMIP 3 coupled models used in the IPCC/AR4 highly **underestimate** the observed increase in SESA precipitation.
- To forecast short periods in the future, **linear trend extrapolation** may be a better estimate of the increase.
- If the time horizon is longer (i.e.: 50 years), the **regression** with the ensemble mean global temperature may be a better choice since it includes information from emission scenarios.

VARIABILITY

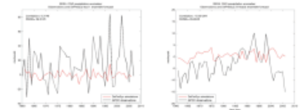
i) **"Decadal climatology"**: characterization of variability that represents likely magnitude and persistence of anomalies, by generating numerous synthetic realizations based on historical observations.

Observations outside range of possibilities according to WCRP/CMIP3

For periods in which deterministic forecasts have no skill, synthetic simulations provide useful information



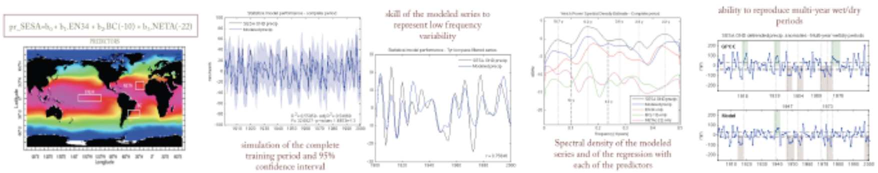
ii) **Dynamical predictions**: seasonal-to-interannual forecasts have skill during ENSO extremes, but not for decadal timescales in this model.



iii) **Statistical predictions:**

- an alternative to dynamical predictions, possibly merged with dynamical forecasts if predictors can be represented by the models.
- observational predictors with large (decadal) lags are particularly useful.

Example. Multiple linear regression model built with 3 : **EN 3.4 Index** (OND, yr 0); **Brazil current SSTa Index** (BC) [SON (t-10 yrs)] before and the **NE Tropical Atlantic SSTa index** (NETA) [SON (t-22 years)] . The model was trained using a moving 80-years window within 1901-2000.

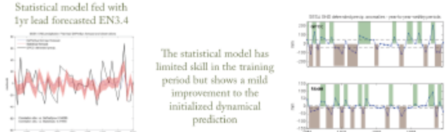


3) Putting it together

Combining: dynamical predictions (One year lead EN34) + statistical simulations + trend estimations

Statistical model fed with 1yr lead forecasted EN3.4

The statistical model has limited skill in the training period but shows a mild improvement to the initialized dynamical prediction

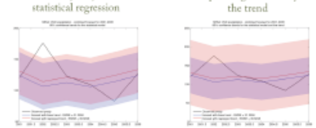


Validation of the statistical model forced by 1yr lead forecasted EN3.4

Independent forecasting period: 2001-2006

Uncertainty only for the statistical regression

Incorporating uncertainty in the trend



Conclusions

This framework (work in progress) needs information on all timescales, which is not always available from a single tool (i.e.: a dynamical model).

- Observed trends are not correctly represented in dynamical models;
- Statistical models can complement information from dynamical models;
- "decadal climatology" based on past observations is needed when there is no signal or skill in deterministic prediction tools.

Poster # T4-5

Multi-scale Climate Information for Agricultural Planning in Southeastern South America for Coming Decades

L. Goddard, W. Baethgen, A. Greene, R. Seager, P. Gonzalez, A.G. Munoz, A. Ines, C. Tebaldi, A. Ruane.

1. International Research Institute for Climate & Society. Earth Institute, Columbia University. Palisades. NY, USA. 2. Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA. 3. Climate Central, Princeton, NJ, USA. 4. GISS, NASA/Columbia University, New York, NY, USA.

NSF EaSM Pis Meeting 2012

Motivation

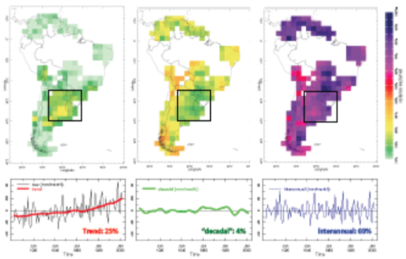
The agricultural frontier of SE South America has expanded over the past several decades due to large increases in regional precipitation. Are these increases likely to persist in the future, or are they part of decadal variability, or both?

Objective

To better understand the causes of climate variability and change in the region, and with that information, develop actionable climate information that can support agriculture planning for future decades.

Attribution: Decadal Variability versus Anthropogenic Change

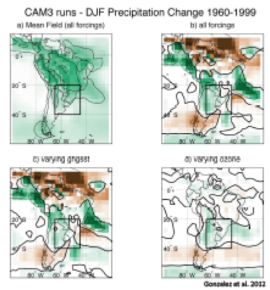
Observations: Time Scale Decomposition

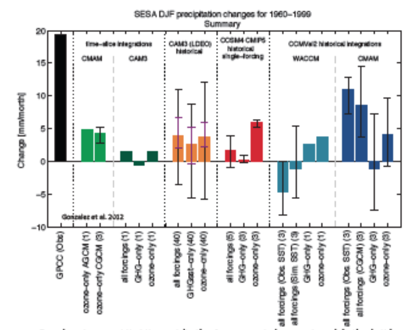


- Time-scales decomposition of South Eastern South America SONDJF precipitation
- Maproom: http://iridl.ldeo.columbia.edu/maproom/.Global/.Time_Scales/ [1]
- For this region, the trend is more important than the decadal variability

Models: O_3 versus GHG

- Ozone depletion is a significant driver of climate change in the Southern Hemisphere through its radiative and dynamical impacts[2,3]. It has contributed significantly to an increase in subtropical precipitation in the SH[4].
- The contribution of ozone to the wetting of SESA in the 1960-1999 period is explored in 6 sets of numerical simulations[5].

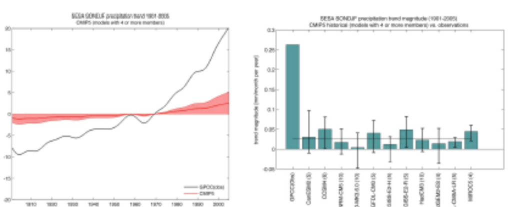




Experiments suggest that the contribution from ozone to increased precipitation in this region is comparable or larger than that from GHGs.

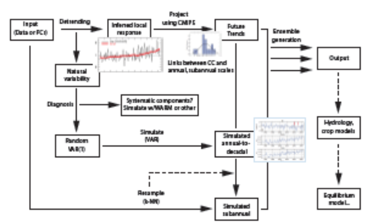
Future Climate Information

CMIP5 Models



- Coupled models are not able to capture the magnitude of the observed 20th Century trend, though they do better for the latter half of the century (i.e. GFDL CM3).
- The precipitation trend for this region should therefore be estimated through a different methodology. This will be informed by the attribution study.

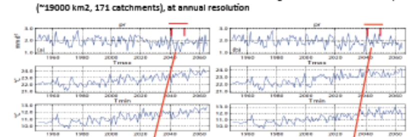
Layering Trend + Natural Variability



- A spatially-distributed observational record is decomposed into trend, annual-to-decadal and subannual components.
- Precipitation, Tmax, Tmin are modeled, in a multivariate framework
- Future regional trends may be informed by IPCC models; annual-to-decadal signal simulated with a first-order vector autoregressive (VAR)[6]

Stochastic Simulations

Distributions for both trend and decadal fluctuations: Example drawn from South Africa[6].
Two simulations are shown for the same catchment in a large watershed in Western Cape (~19000 km2, 171 catchments), at annual resolution

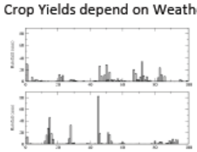


Decadal fluctuation at 5%-ile.
This doubles the drying due to trend

Decadal fluctuation at 95%-ile.
This completely compensates the drying due to trend

Weather Characteristics and Agriculture

Crop Yields depend on Weather Characteristics



Example: India –Wheat

1975
Total rainfall: 394mm
Simulated yield: 1059 kg/ha
Observed yield: 1360 kg/ha

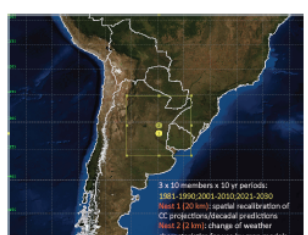
1991
Total rainfall 389mm
Simulated yield: 844 kg/ha
Observed yield: 901 kg/ha

- Daily characteristics are more important to yield than seasonal total[7]

- Downscaling will explore variations in transient weather characteristics related to variability (e.g. ENSO, AMO) and change.
- Perturbed physics ensemble. 10 members.

Time Scale / Info. Type	Climate Change (CC)	Decadal Climate Variability (DV)	Seasonal-to-Interannual (SI) Climate Characteristics	Weather Characteristics (Wx)
Baseline	Extrapolate Observed Trends	Decadal Climatology	Current Characteristics	Current Characteristics
Forecast	Recalibrated MME	Decadal Prediction + Unc.	Current Characteristics*	Hi-Resolution Downscaling

* Based on previous work (Coelho & Goddard, 2009), ENSO, which is the main contributor to SI variability over study region is not projected to change in future, so we assume Forecast SI = Current SI.



Summary

- Climate information for the coming decades must include realistic estimates, and associated uncertainties, for anthropogenic trends, interannual-to-decadal variability, and how those affect weather characteristics.
- Our approach includes dynamical model predictions, projections, and simulations, as well as assessment of past variability and change from observations, to create robust multi-scale climate information.
- The sensitivity of agricultural models to variability on different timescales will be tested.

References

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[2] Polvani, L.M. Polvani, D.W. Waugh, G.J.P. Correa and S.-W. Son, "Stratospheric ozone depletion: the main driver of 20th Century atmospheric circulation changes in the Southern Hemisphere, *J. Clim*, Vol 24, 795-812, 2011
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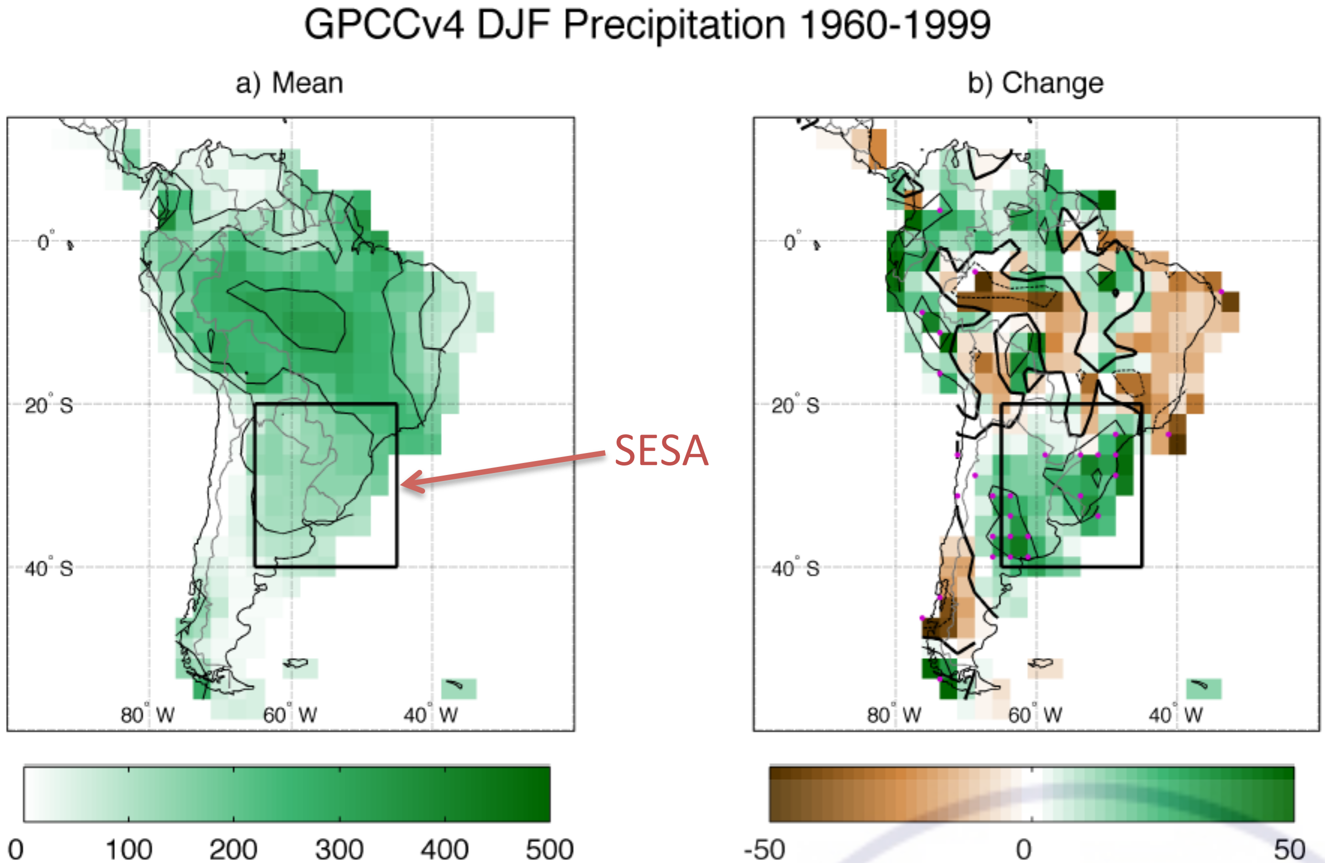
[5] Gonzalez, P.L.M., Polvani, L., Seager, R., Correa, G., "Impact of the 20th Century ozone depletion on increasing precipitation in South Eastern South America.", (In preparation), 2012
[6] Greene, A.M., Hellmuth, M., Lumsden, T., "Stochastic decadal climate simulations for the Berg and Breede Water Management Areas, Western Cape province, South Africa. *Water Resources Research*, Vol 48. W06504. 2012
[7] Challinor AJ, Wheeler TR, Slingo JM, Craufurd PQ, Grimes DIF, "Design and optimisation of a large-area process-based model for annual crops". Agricultural and Forest Meteorology 124, 99–120.
[8] Coelho, C.A.S. Goddard, L., "El Niño-induced Tropical Droughts in Climate Change Projections", *J. Clim.*, Vol. 22, 2009.

MOTIVATIONS

SESA has experienced a strong wetting trend over the complete 20th Century.



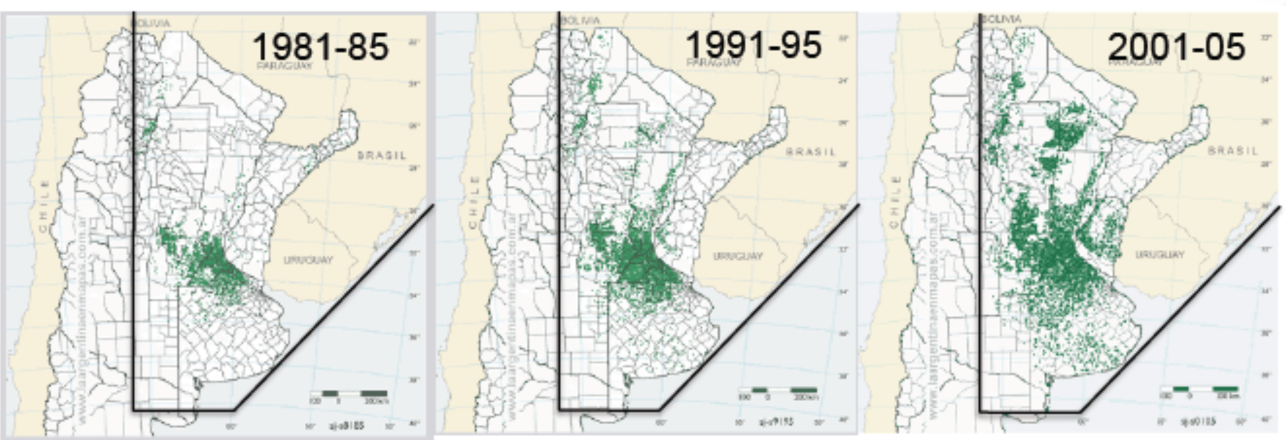
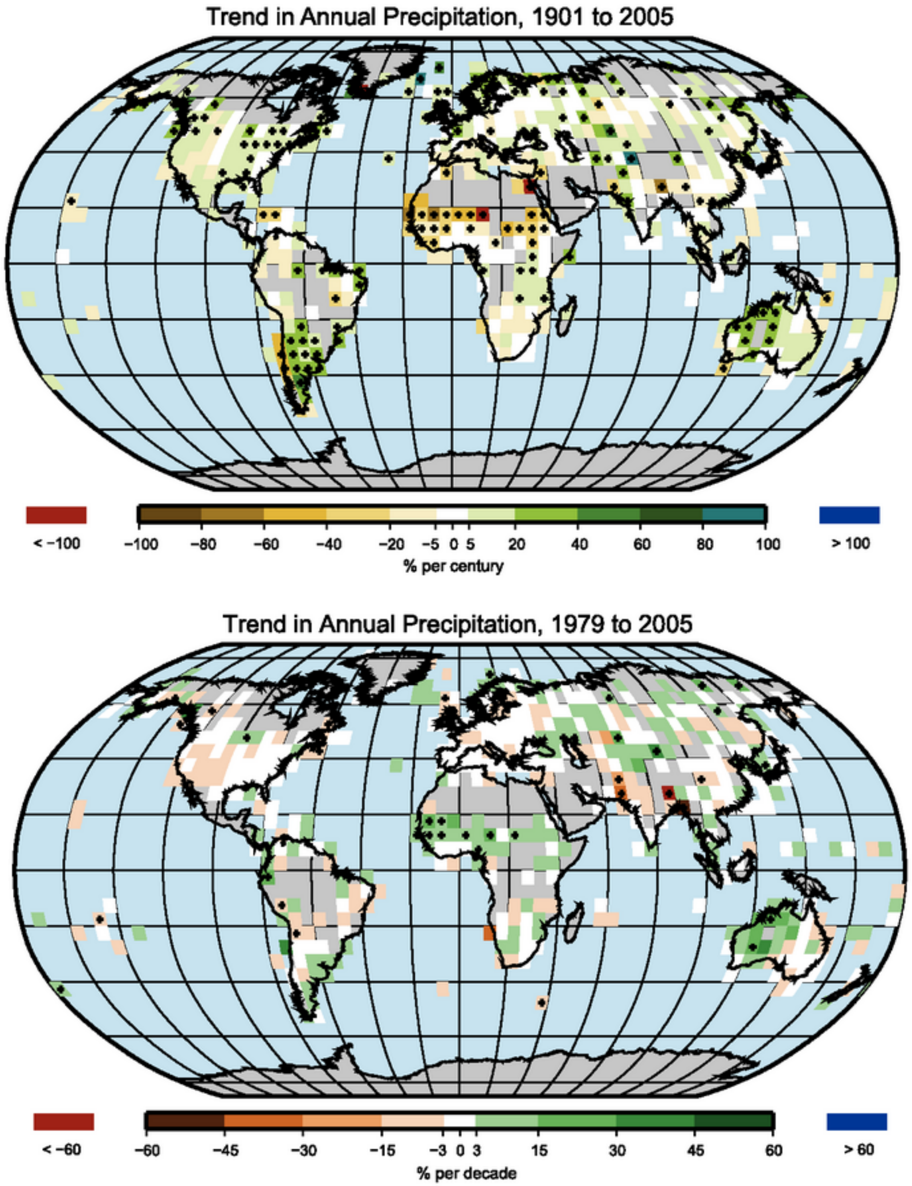


FIGURE 1. Changes in soybean cropping area over time for Argentina. One dot = 1000 ha. Lines delimit Southeastern South America region shown in Figure 2.

Over the last decades, the wetting has been followed by the expansion of the agricultural frontiers.

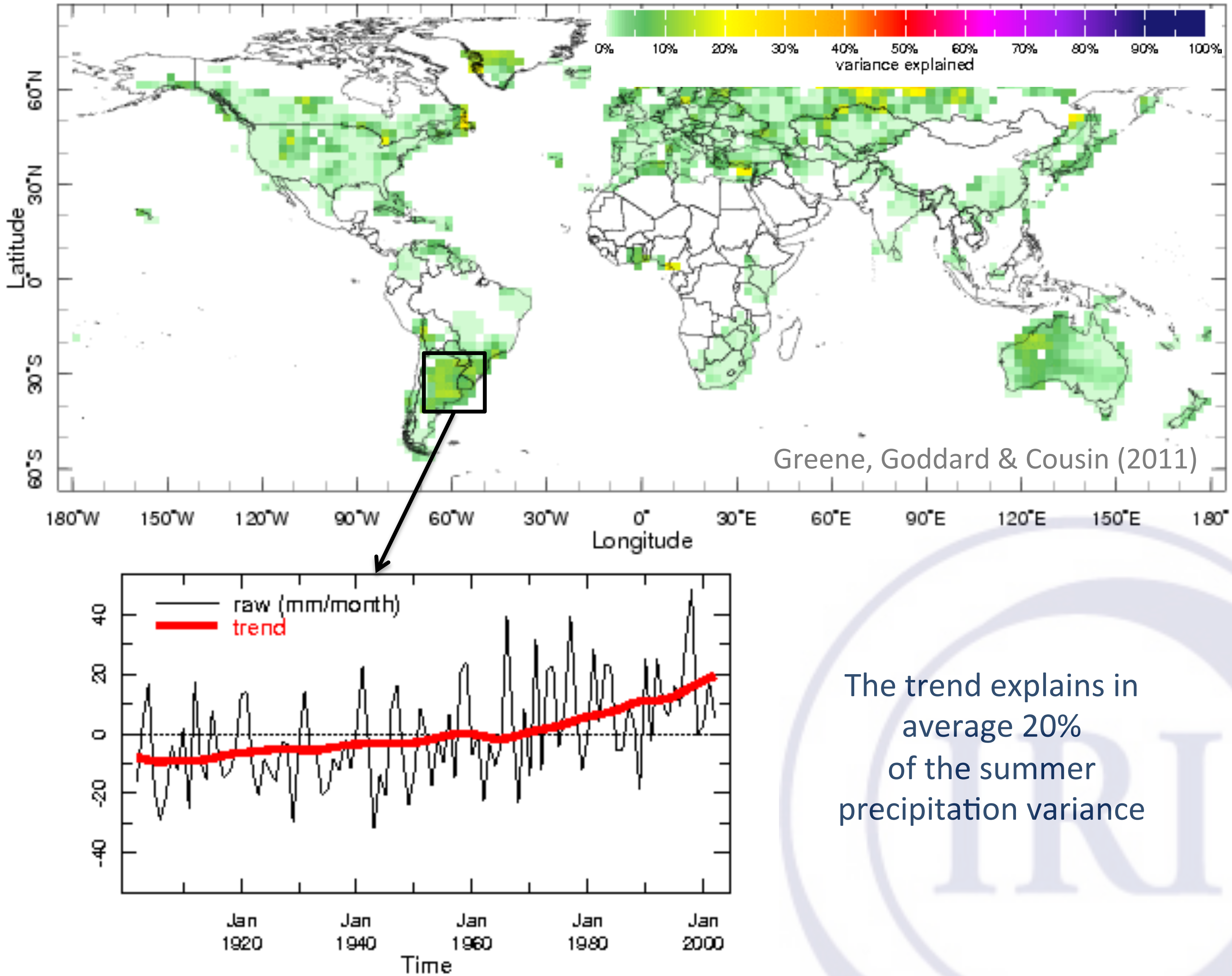
MOTIVATIONS



IPCC AR4

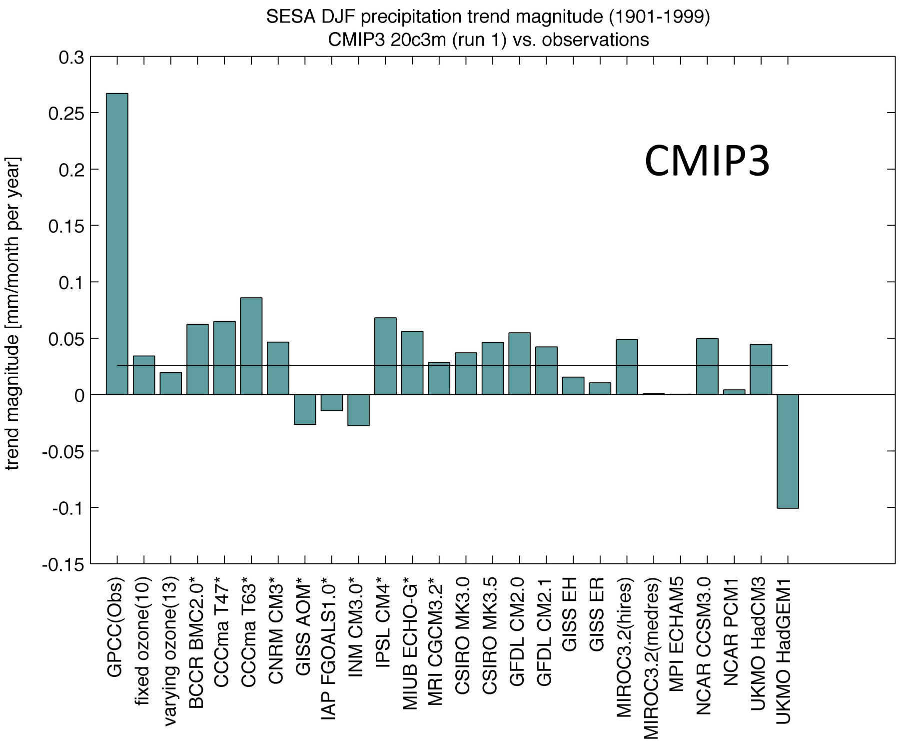
Figure 3.13. ***Trend of annual land precipitation amounts for 1901 to 2005 (top, % per century) and 1979 to 2005 (bottom, % per decade),*** *using the GHCN precipitation data set from NCDC. The percentage is based on the means for the 1961 to 1990 period. Areas in grey have insufficient data to produce reliable trends. The minimum number of years required to calculate a trend value is 66 for 1901 to 2005 and 18 for 1979 to 2005. An annual value is complete for a given year if all 12 monthly percentage anomaly values are present. Note the different colour bars and units in each plot. Trends significant at the 5% level are indicated by black + marks.*

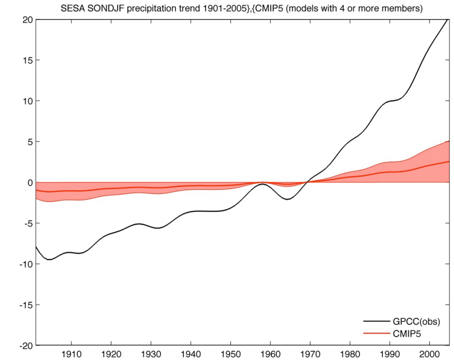
MOTIVATIONS

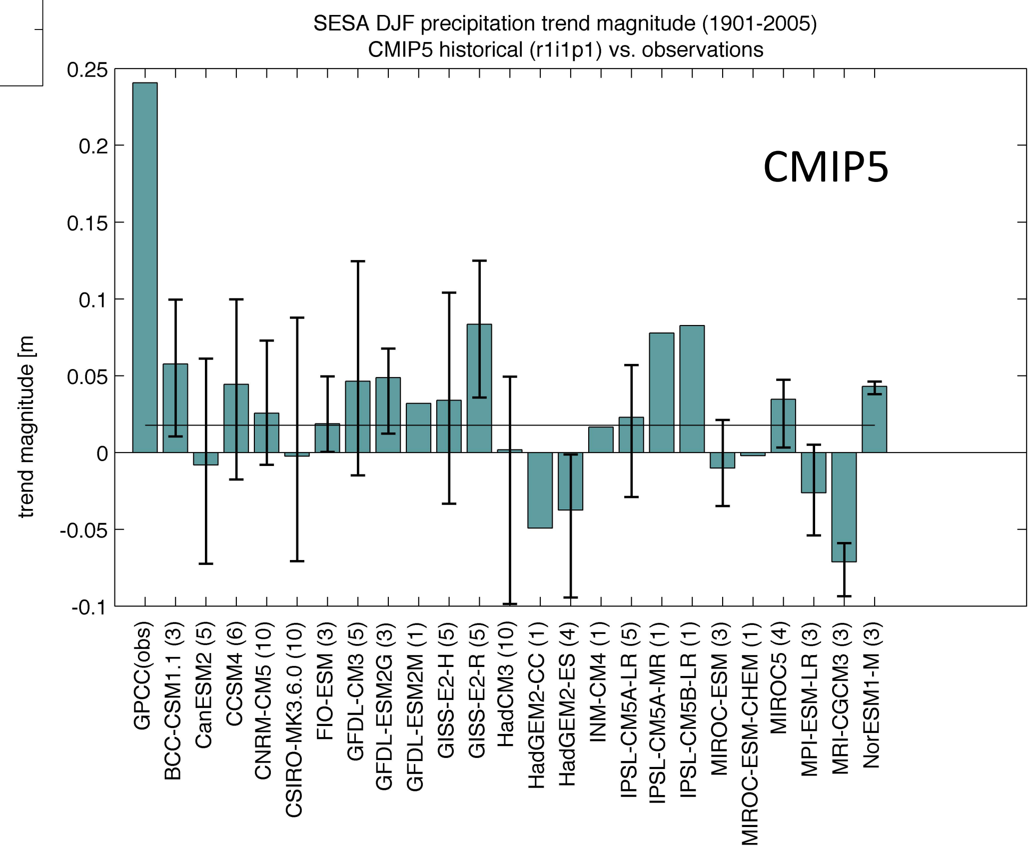


The trend explains in average 20% of the summer precipitation variance

MOTIVATIONS: CMIP3/CMIP5 – 20th Century

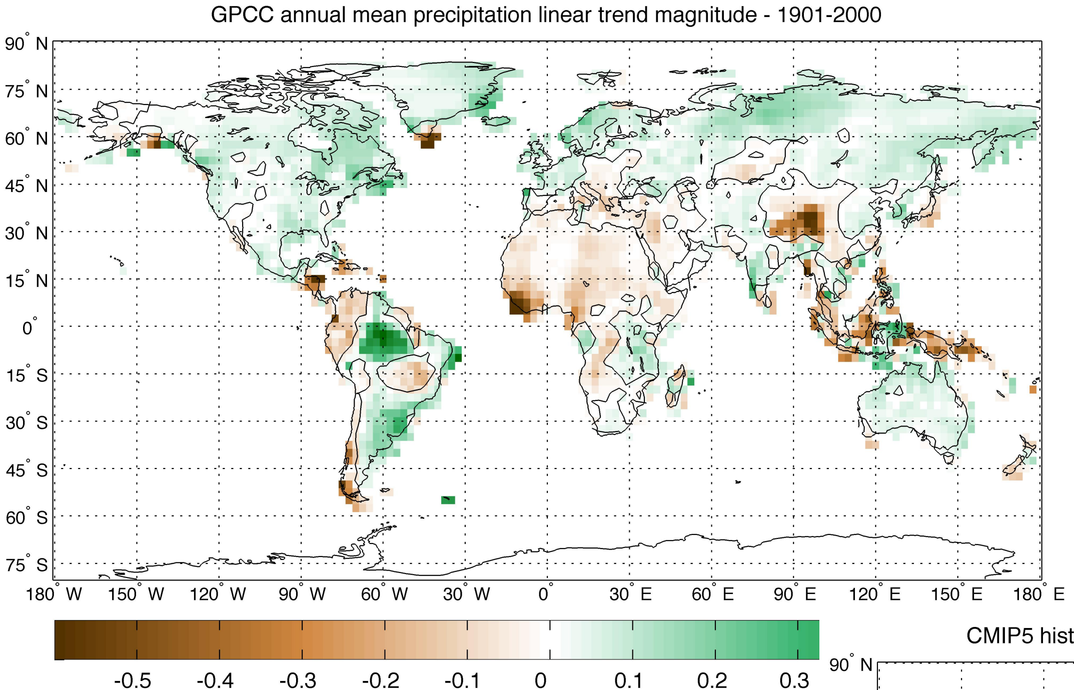




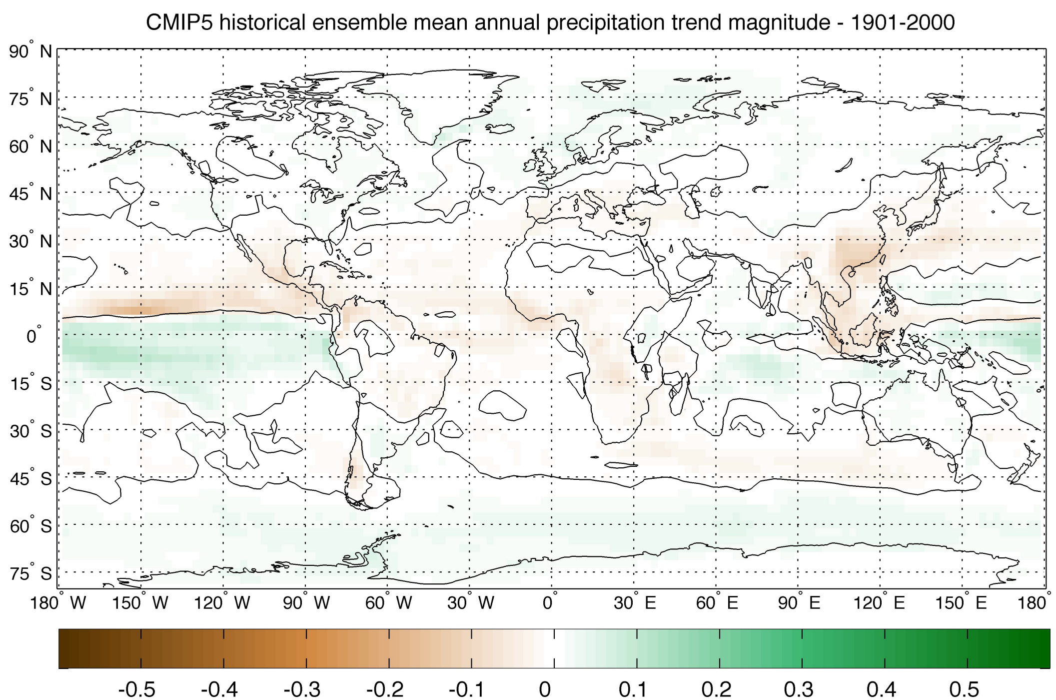


CMIP3 and CMIP5 models fail to reproduce the 20th Century wetting.

MOTIVATIONS: annual means – 20th Century



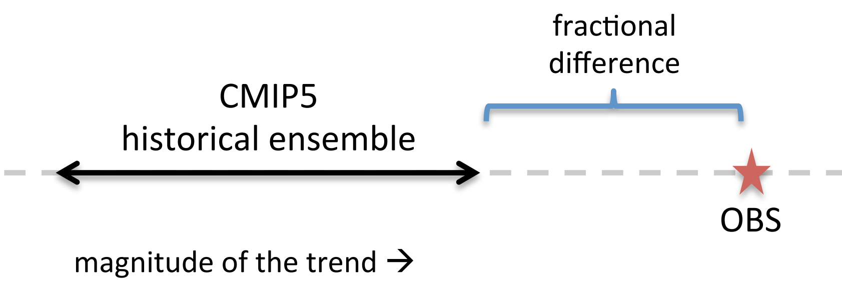
OBS

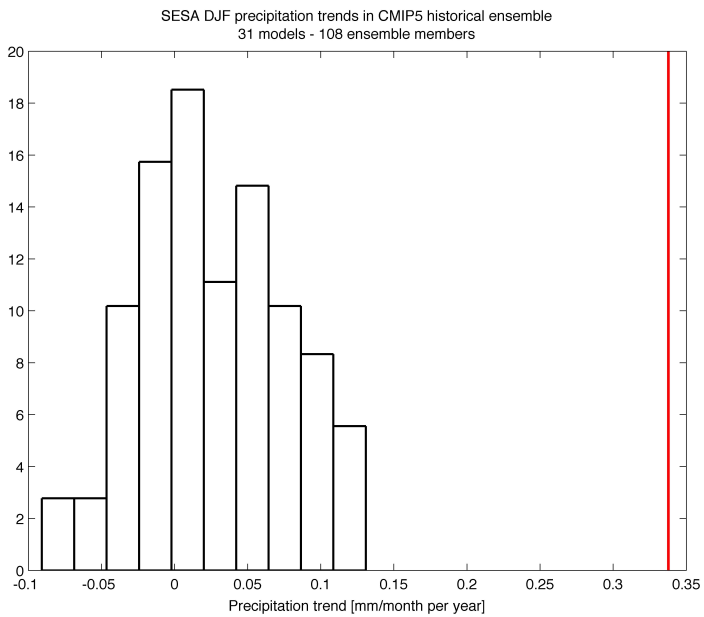


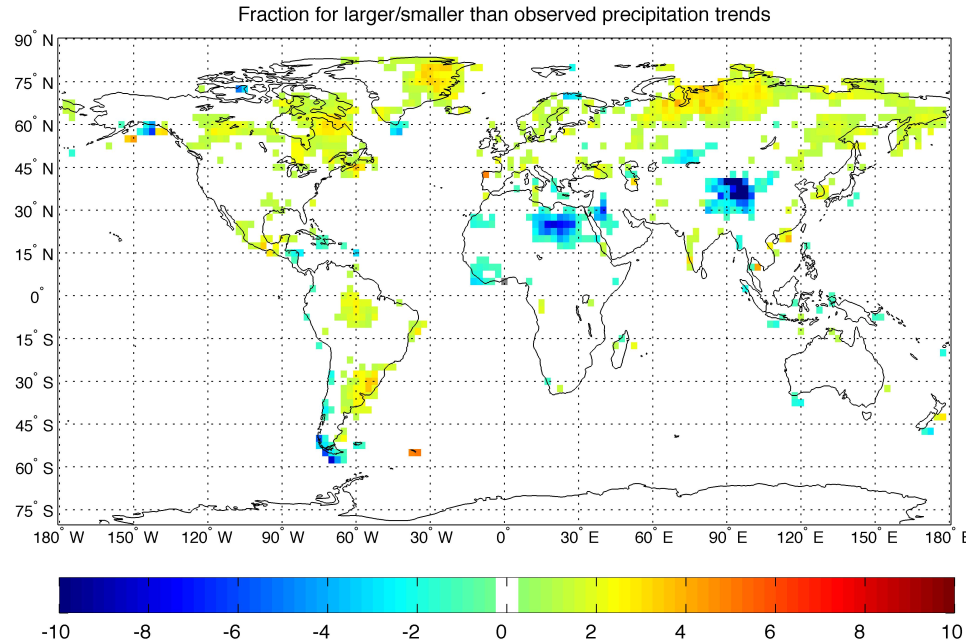
MME CMIP5

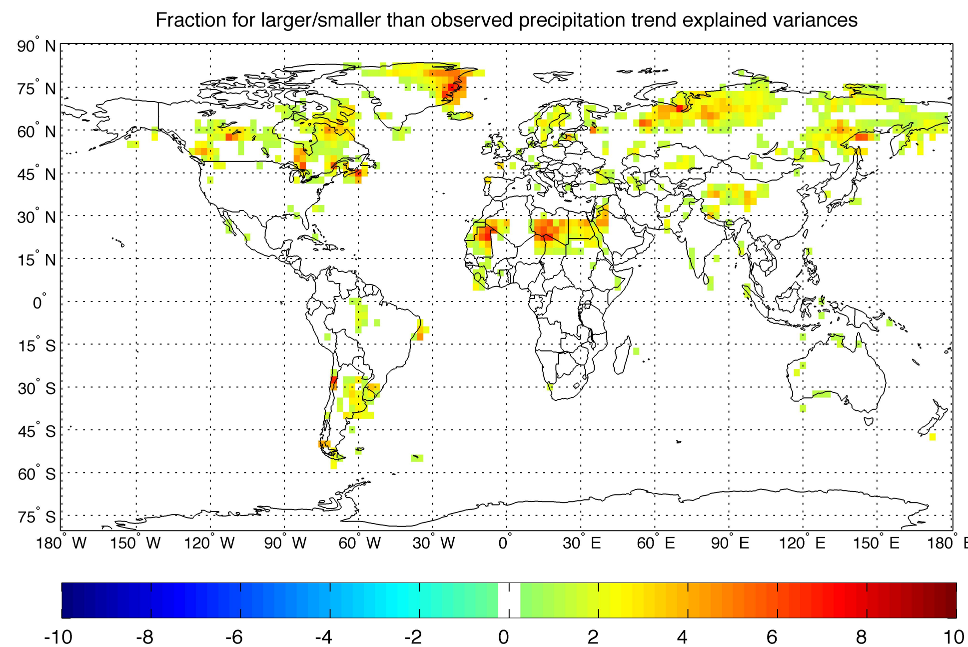
CMIP5 historical – annual mean precipitation – 20th Century

Comparing the magnitudes of the trend

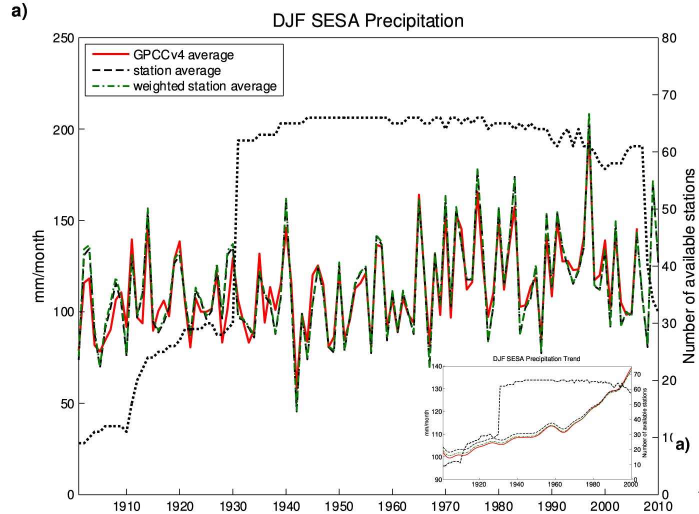








Comparing the % of variance explained by the trend



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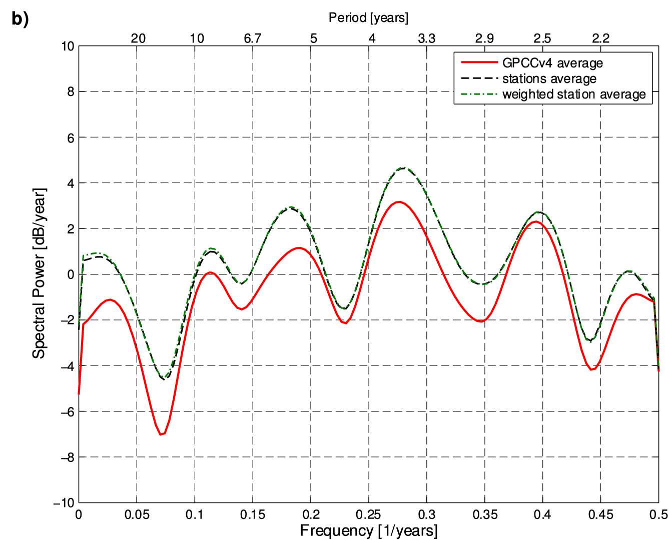
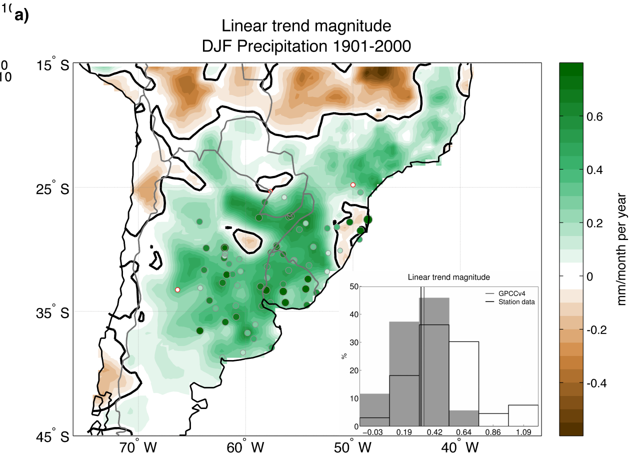
Royal Meteorological Society

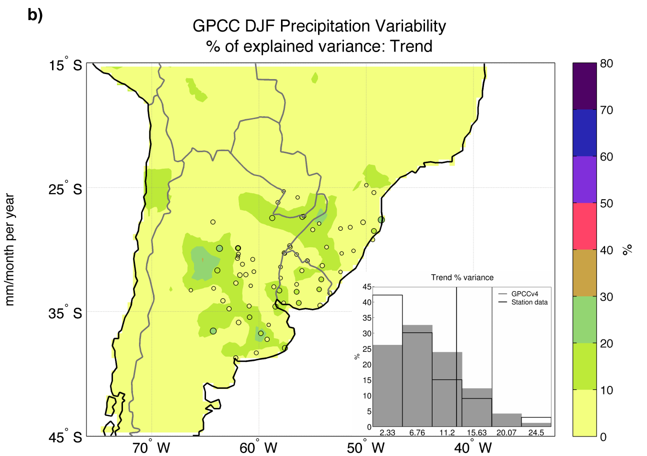
Short Communication

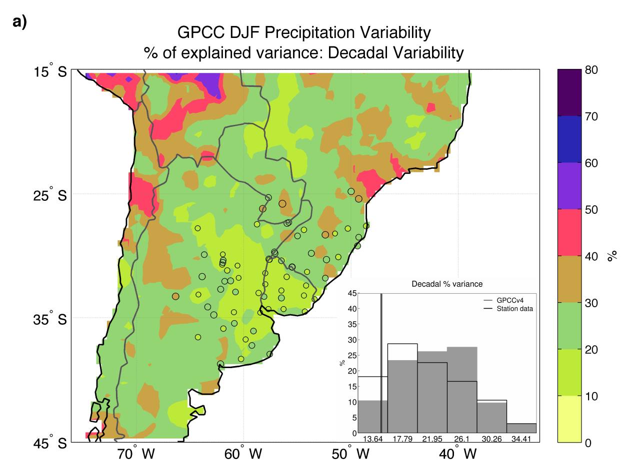
Twentieth-century summer precipitation in South Eastern South America: comparison of gridded and station data

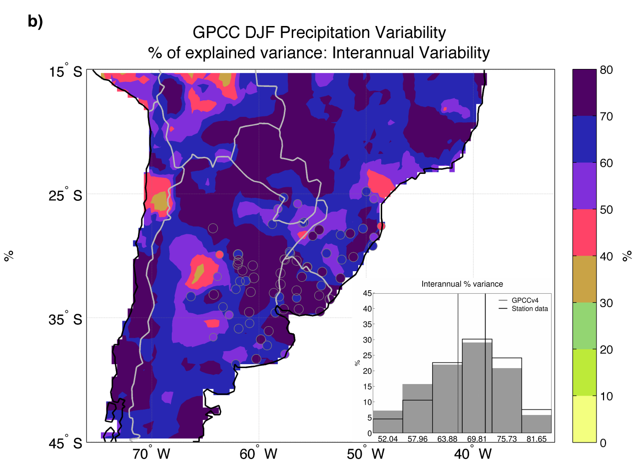
P. L. M. Gonzalez,* Lisa Goddard and Arthur M. Greene
International Research Institute for Climate and Society, Earth Institute, Columbia University, Palisades, NY, USA











Can we trust century-long gridded datasets over SESA?

Gonzalez PLM, Polvani LM, Seager R, Correa GJP (2012) ***Stratospheric ozone depletion: a key driver of recent precipitation trends in South Eastern South America***. Accepted in Climate Dynamics

MOTIVATIONS:
why ozone?

Ozone depletion has been shown to be one of the main drivers of climate change in the Southern Hemisphere (e.g. Polvani et al. 2011)

In particular, it has been linked to the observed wetting of the SH subtropics (Kang et al 2011)

Kang et al. 2011

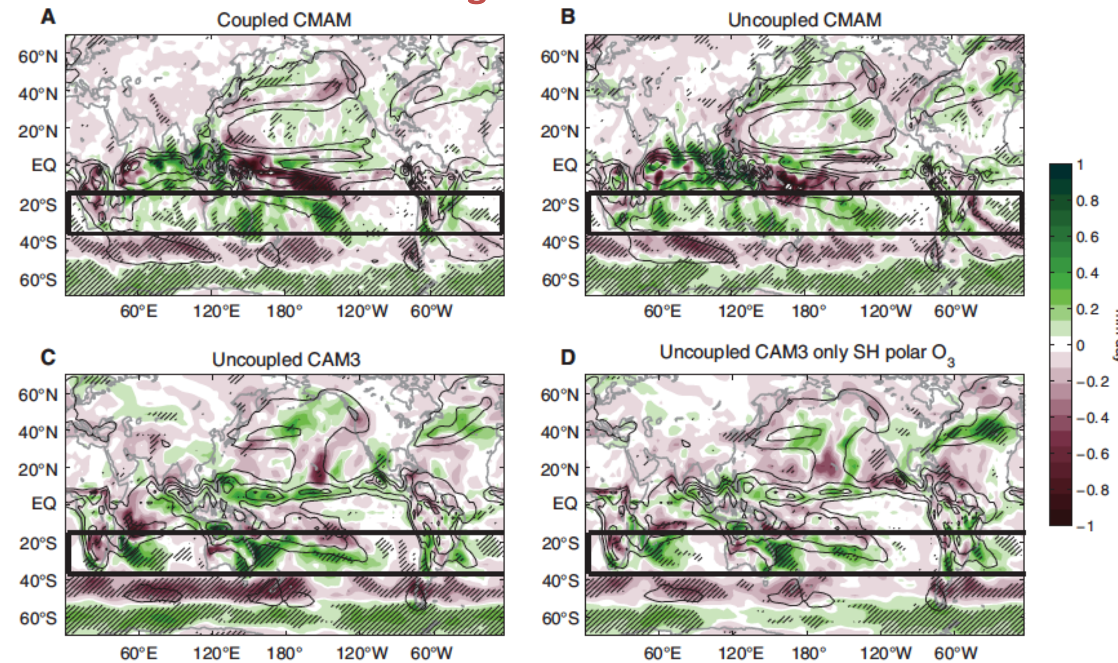
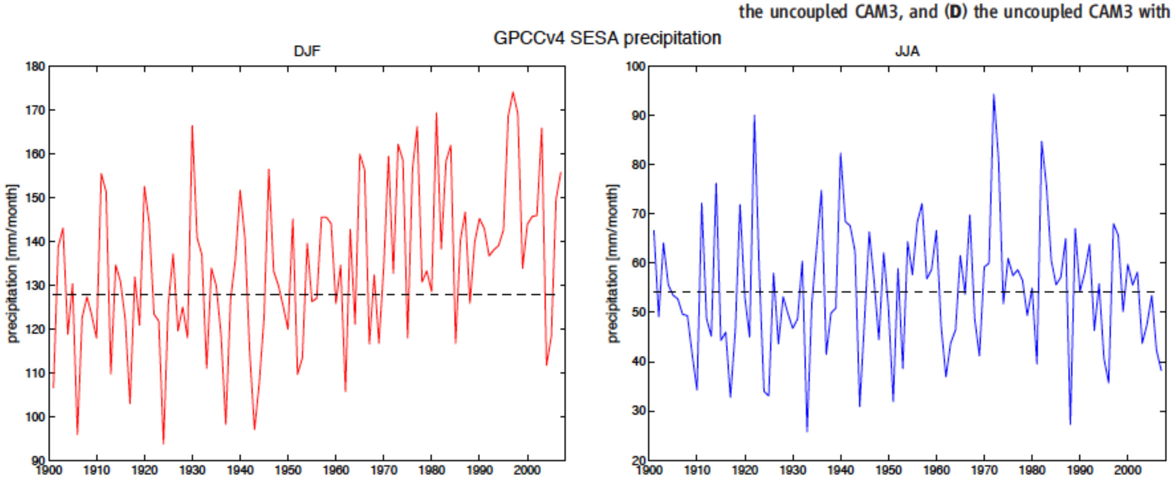
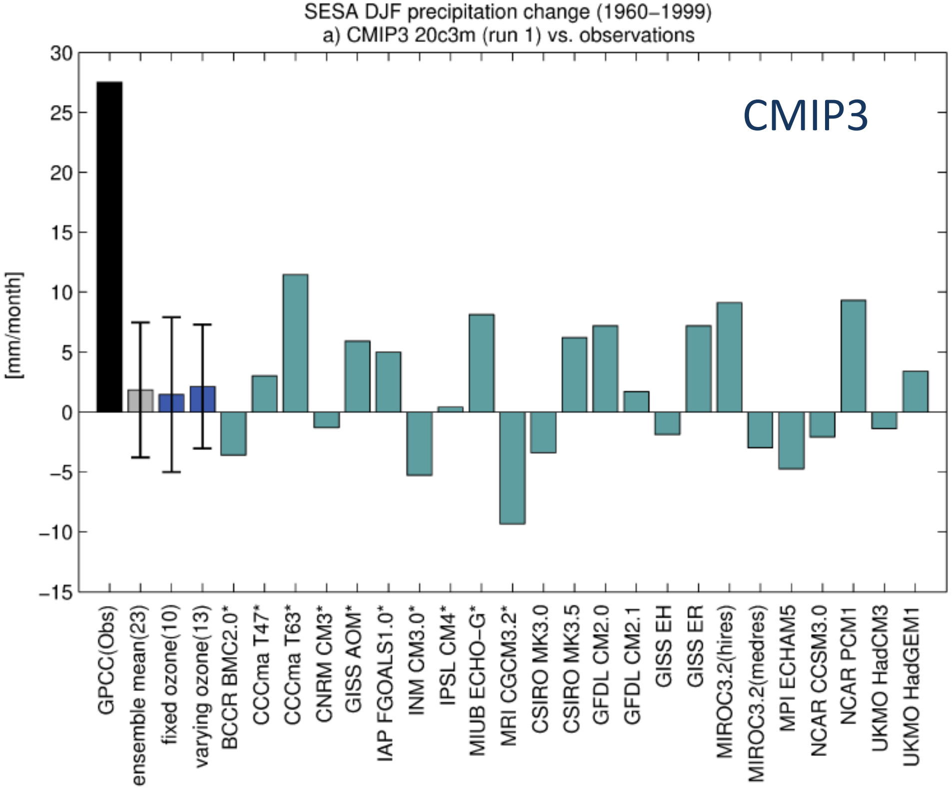


Fig. 2. Modeled precipitation change caused by the ozone hole. Shading shows austral summer precipitation difference (in mm day^{-1}) induced by ozone depletion in (**A**) the coupled CMAM, (**B**) the uncoupled CMAM, (**C**) the uncoupled CAM3, and (**D**) the uncoupled CAM3 with ozone depletion confined to 40°S to 90°S. Black contours show the mean precipitation in the respective reference integrations, with contour interval of 3 mm day^{-1}. Locations where the response is significant at the 95% confidence level are hatched.



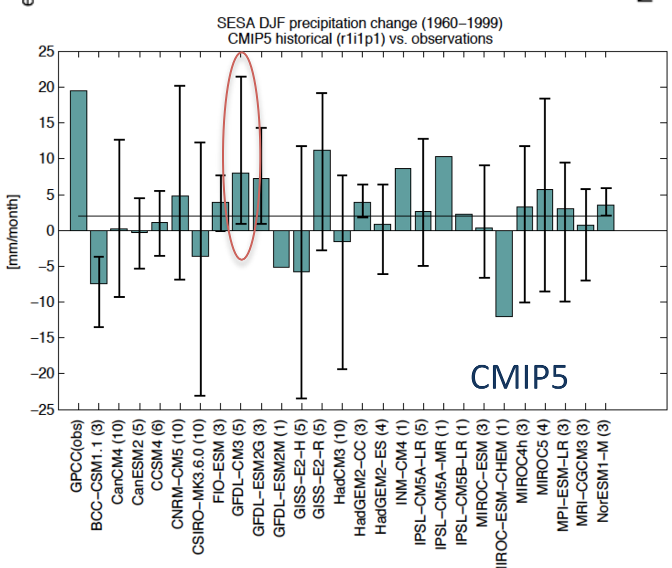
The fact that that the trend in SESA strengthens around 1960 and that this is only seen during summer could be evidences of the influence of ozone depletion.

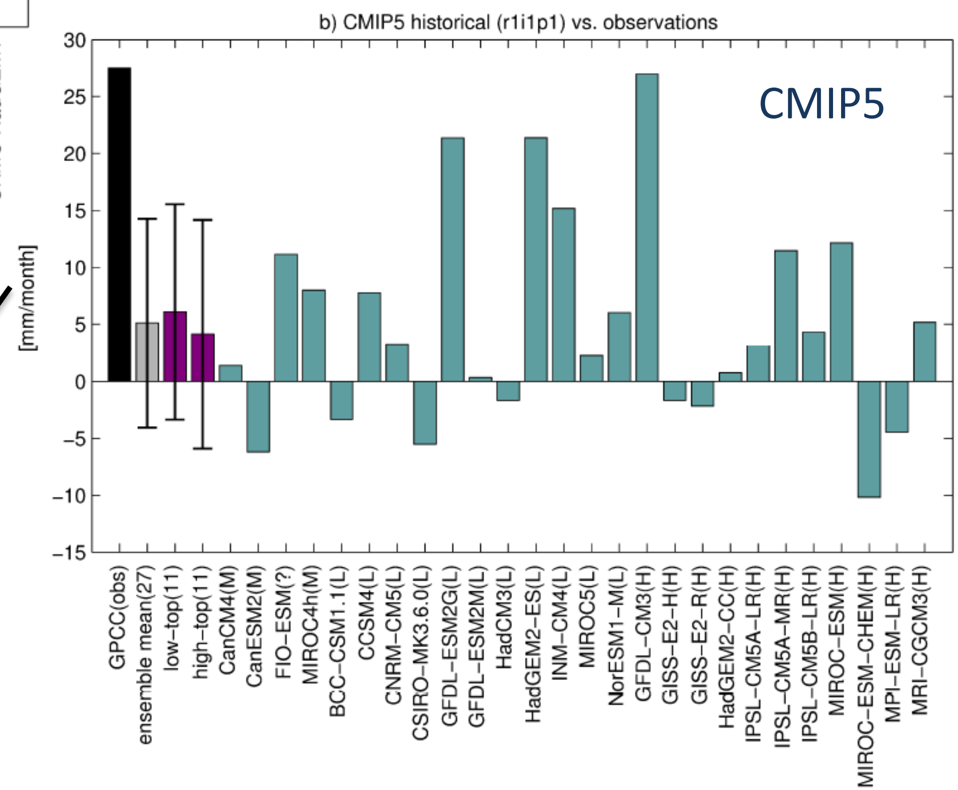
MOTIVATIONS: CMIP3/CMIP5 - 1960-1999



* Some CMIP5 models do better (e.g. GFDL CM3) but the spread is still very large.

* These ensembles provide inconsistent evidences of the influence of ozone depletion.





Impact of the 20th Century stratospheric ozone depletion on increasing precipitation in South Eastern South America

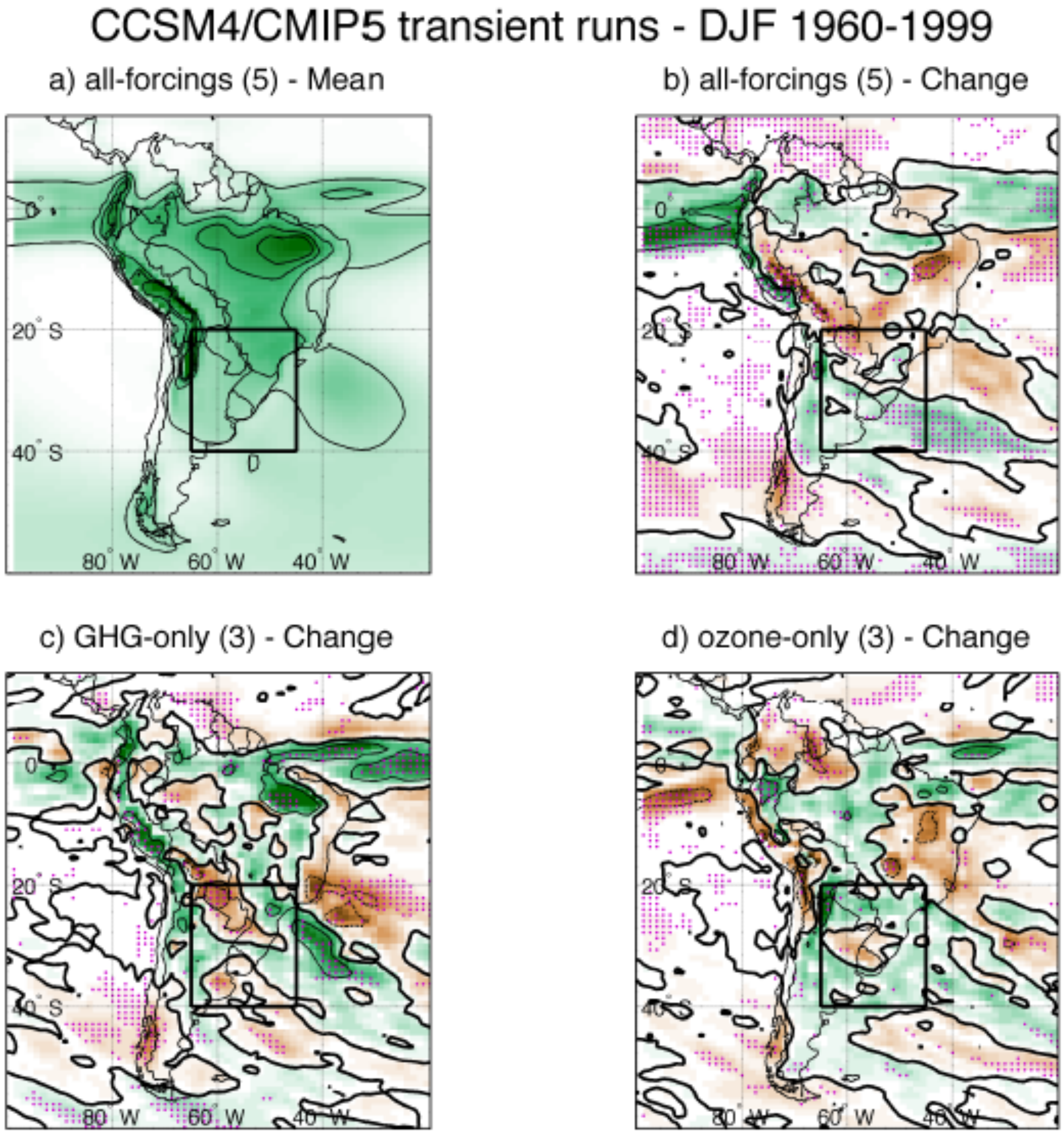
DESCRIPTION OF THE ENSEMBLE

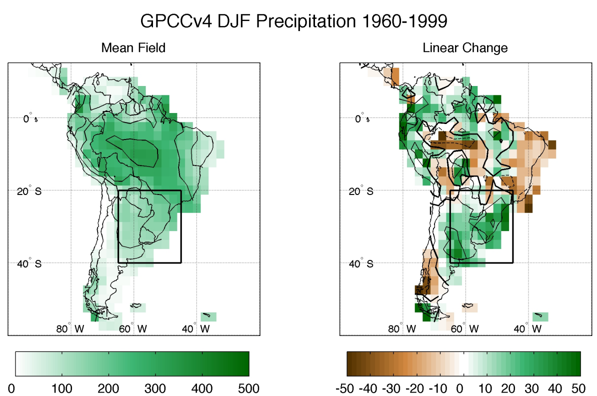
type	model	resolution	reference paper	# integration name	brief description
time-slice	CAM3	T42 L26 (low top)	Polvani et al. (2011a)	1 reference 1 all-forcings 1 GHG-only 1 ozone-only	50 years, steady forcings @ 1960 levels, SSTs from obs as reference, but all forcings at @ 2000 levels as reference, but GHGs & SSTs @ 2000 levels as reference, but O_3 @ 2000 levels
	CMAM	T63 L71 (high top)	Sigmond et al. (2010)	1 reference (CGCM) 3 ozone-only (CGCM) 1 reference (AGCM) 1 ozone-only (AGCM)	80 years, steady forcings @1979 levels, coupled model as CGCM reference, but O_3 @ 2005 levels as CGCM reference, atmosphere only (SSTs from reference) as AGCM reference, but O_3 @ 2005 levels
CAM3 transient	CAM3	T42 L26 (low top)	unpublished, but similar to Polvani et al. (2011a)	40 all-forcings 40 GHG-only 40 ozone-only	1950-2009, all forcings transient, SST from obs 1950-2009, only O_3 transient 1950-2009, only GHGs and SSTs transient
CCSM4/CMIP5 transient	CCSM4	$\sim 1^\circ$ L26 (low top)	Gent et al. (2011)	5 all-forcings 3 GHG-only 3 ozone-only	1850-2005, all forcings transient fixed 1850 forcings, but transient GHGs 1850-2005 fixed 1850 forcings, but transient O_3 1850-2005
CCMVal-2 transient	WACCM	$\sim 2^\circ$ L66 (high top)	Garcia et al. (2007)	3 all-forcings 1 GHG-only 1 ozone-only	1960-2100, all forcings transient, modeled SSTs (REF-B2) as REF-B2, but halogens @ 1960 levels (SCN-B2b) as REF-B2, but GHGs and SSTs @ 1960 levels (SCN-B2b)
	CMAM	T31 L71 (high top)	McLandress et al. (2010)	3 all-forcings 3 GHG-only 3 ozone-only	1960-2100, all forcings transient, coupled GCM (REF-B2) as REF-B2, but halogens @ 1960 levels (SCN-B2b) as REF-B2, but GHGs and SSts @ 1960 levels (SCN-B2c)

Table 1 Descriptions of the model output analyzed in this paper and the experimental design. In the fifth column, the name of each ensemble is preceeded by the number of integrations with identical forcings (i.e. the ensemble size).

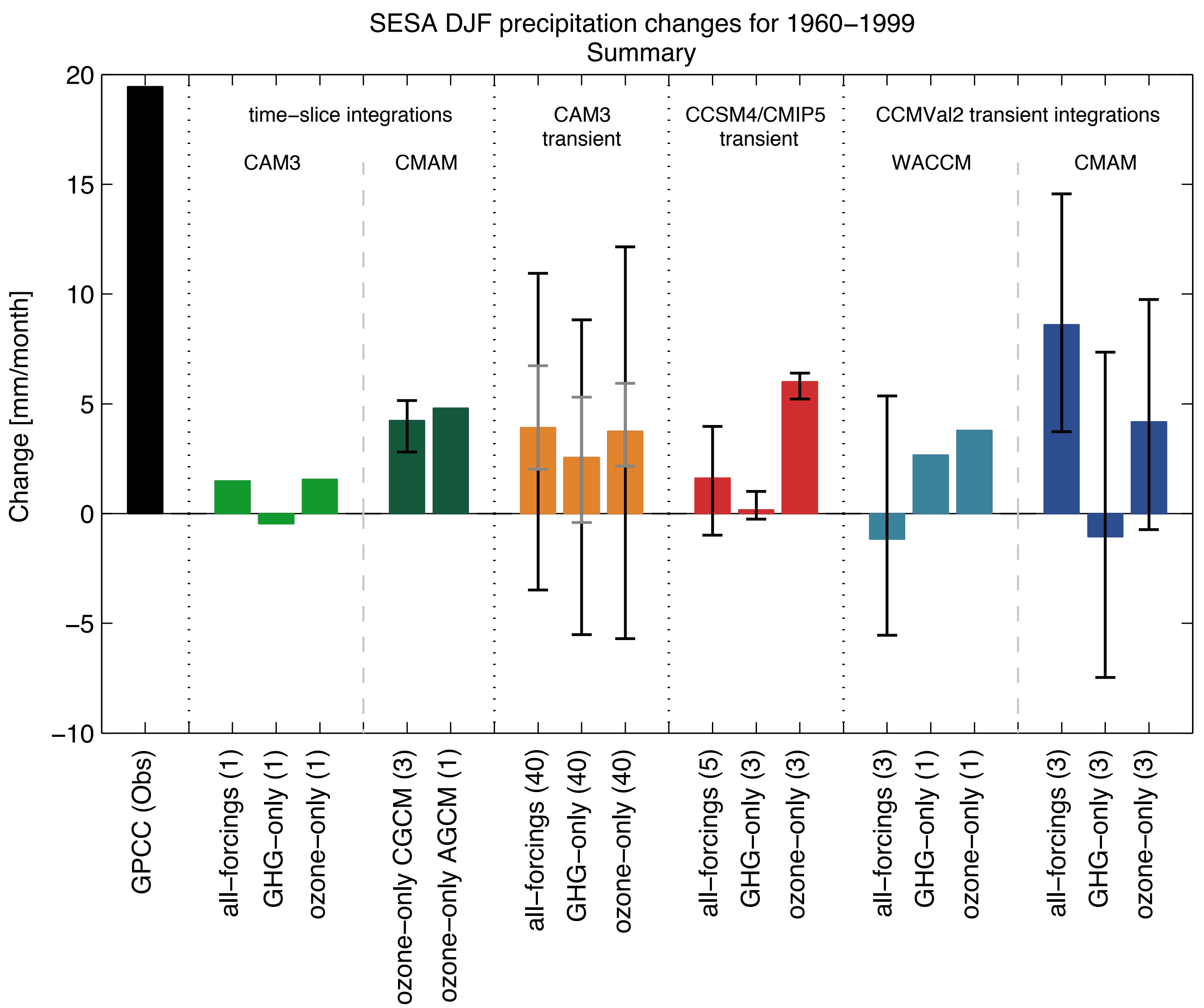
EXPERIMENTS: CCSM4/CMIP5 transient runs

CCSM4
(UCAR)
coupled (CAM4/POP2)
"1°" - L26
all-forcings (5m)
GHG-only (3m)
ozone-only (3m)
Gent et al. 2011



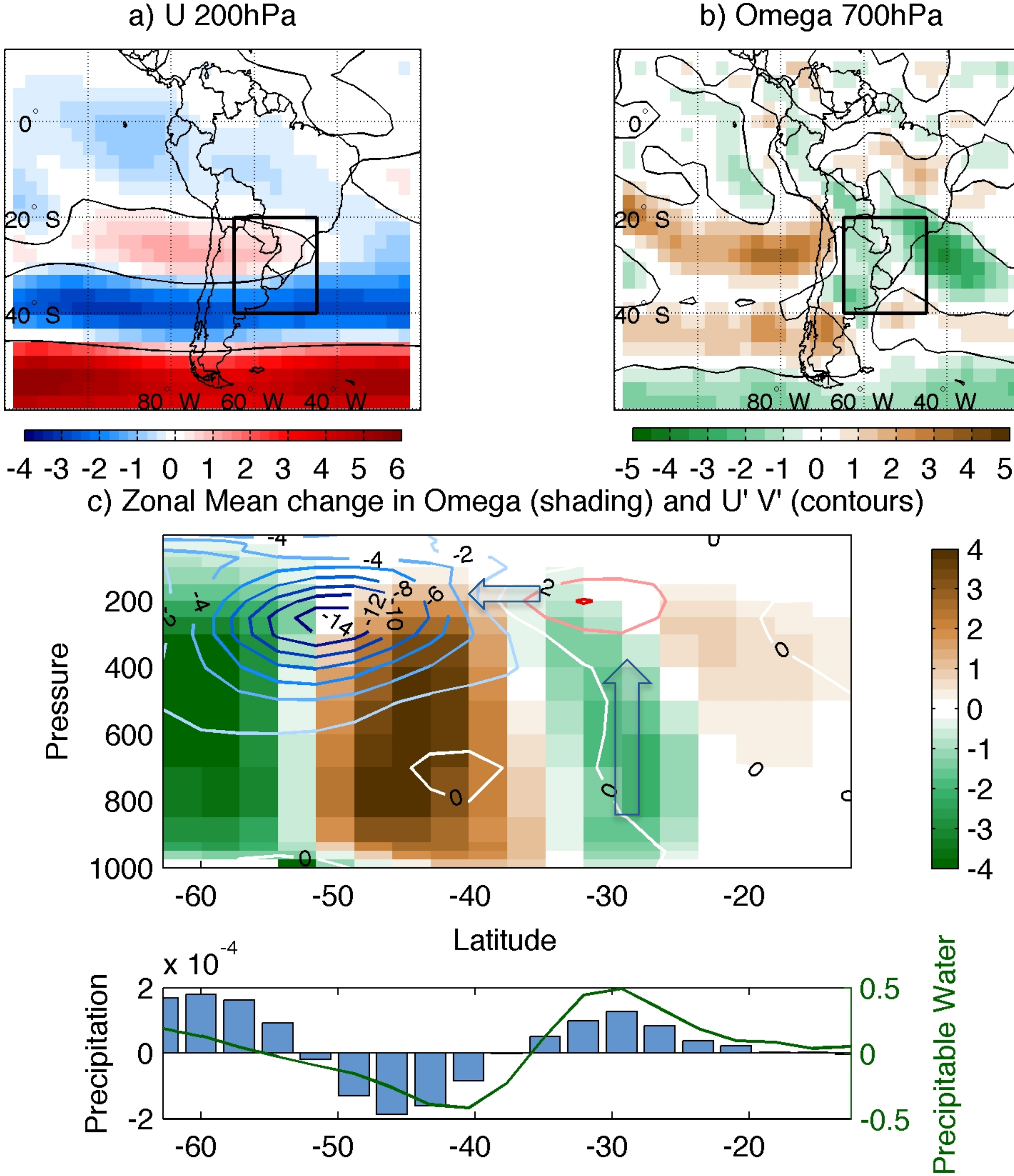


Impact of the 20th Century stratospheric ozone depletion on increasing precipitation in South Eastern South America

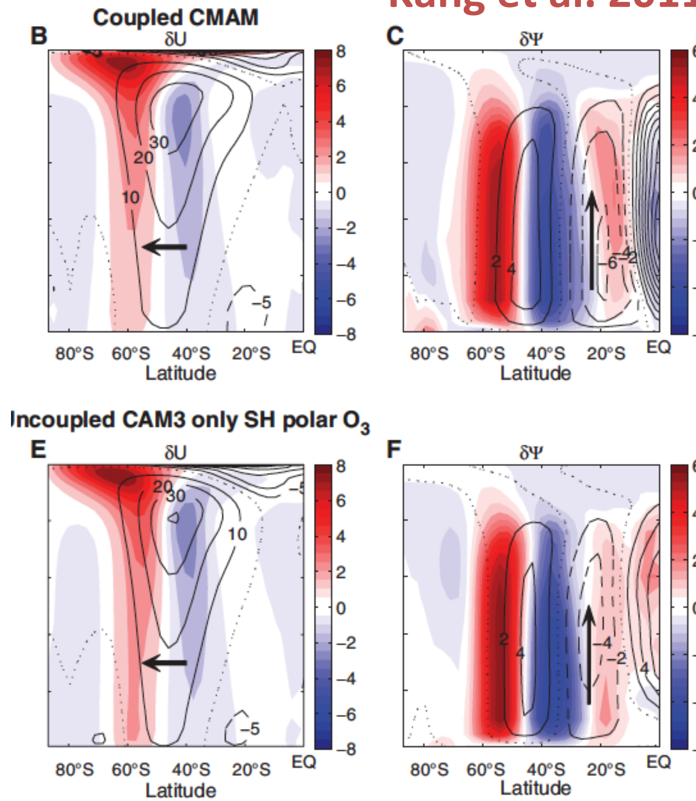


EXPERIMENTS: Dynamics of the simulated change

CAM3 LDEO ozone-only runs(40) - DJF Changes for 1960-1999



Kang et al. 2011



- poleward shift of extratropical jet
- upper level eddy momentum flux divergence (Eq flank)
- divergence balanced by southward upper tropospheric flow forcing upward motion
- increase in PW and precipitation

CONCLUDING REMARKS

- Throughout the analyzed experiments stratospheric ozone depletion caused a precipitation increase in SESA

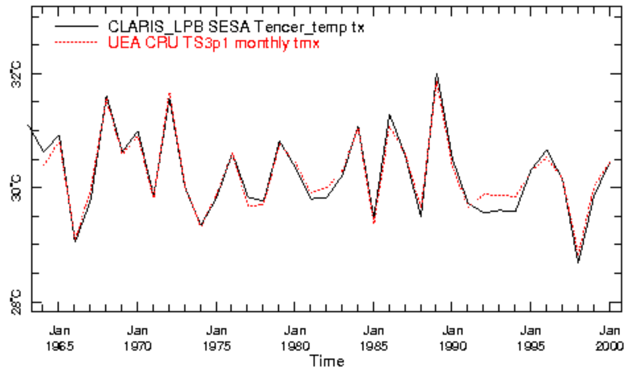
- In addition, the increase in GHGs causer smaller increases in precipitation or even a slight drying over SESA

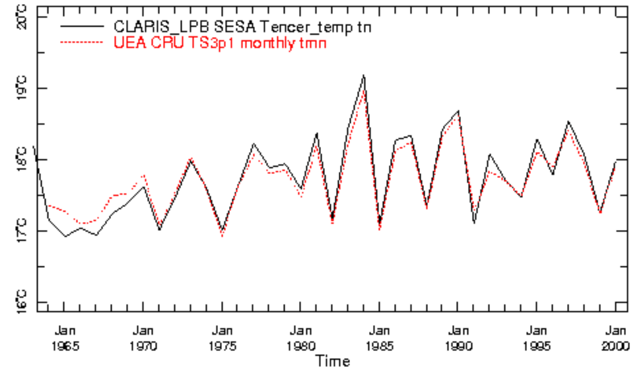
- All the models considered underestimate the precipitation trend over SESA, but so do the CMIP3 and CMIP5 ensembles …

- In the ozone-only experiment using **CAM3** (40 members), as shown by Kang et al. (2011), the radiative-driven changes in the stratosphere force the **extratropical jet** to **shift poleward**. The associated changes in the **eddy momentum fluxes** in the vicinity of South America generate an **upper level mass divergence** that is compensated with **upward motion** and **moisture convergence**, forcing increased precipitation in SESA.

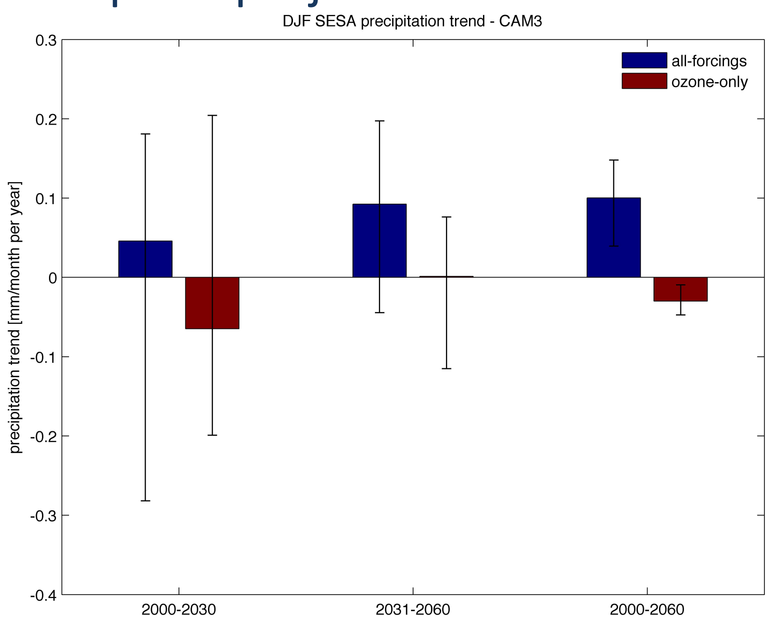
NEXT STEPS

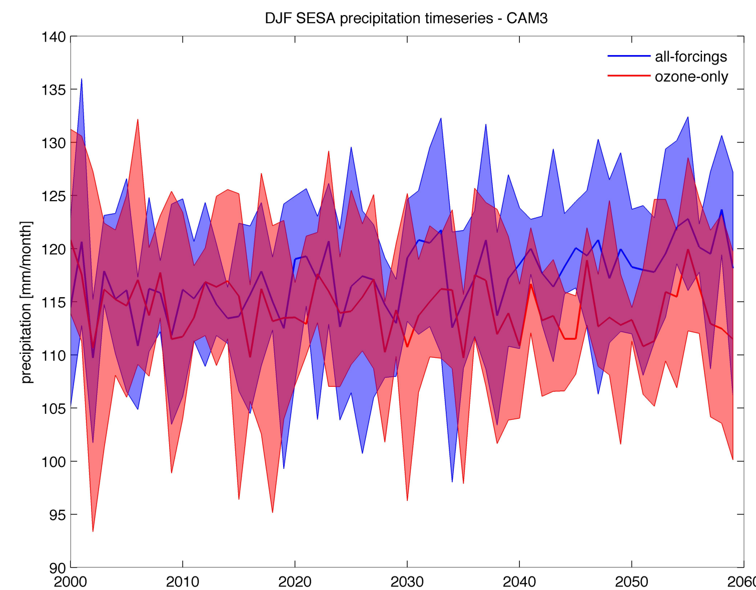
- Through the associated changes in cloudiness, this mechanism might also be important to explain changes in local temperature, especially DJF Tmin (not a lot of available model output …)





- Explore projections for future SESA change in "single-forcing" experiments





Other research for the SESA region

MOTIVATIONS

15 October 2010 SEAGER ET AL. 5517

Tropical Oceanic Causes of Interannual to Multidecadal Precipitation Variability in Southeast South America over the Past Century*

Richard Seager and Naomi Naik
Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York

Walter Baethgen and Andrew Robertson
International Research Institute for Climate and Society, Palisades, New York

Yochanan Kushnir and Jennifer Nakamura
Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York

Stephanie Jurburg
Columbia College, Columbia University, New York, New York

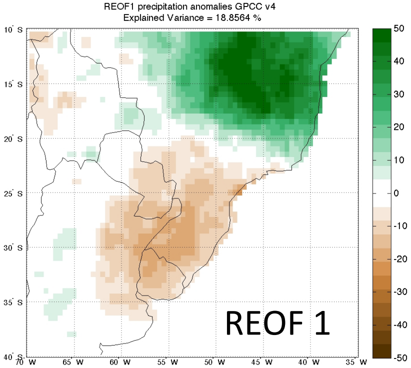
We are still exploring the mechanisms that might be responsible for SESA precipitation increases

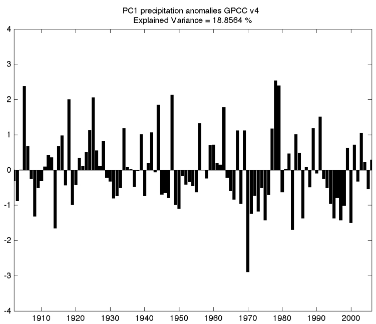
Clim Dyn
DOI 10.1007/s00382-011-1141-y

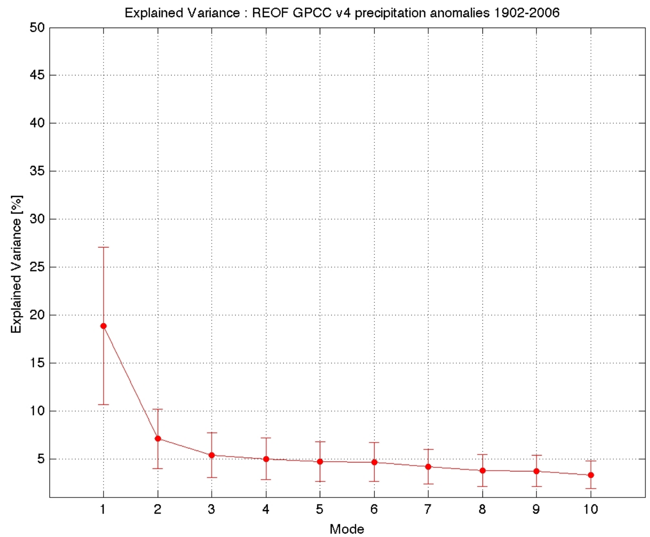
Summer precipitation variability over Southeastern South America in a global warming scenario

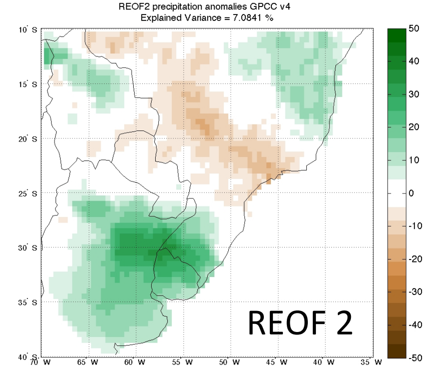
C. Junquas · C. Vera · L. Li · H. Le Treut

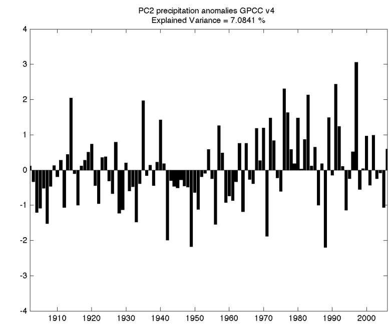
Rotated EOF DJF precipitation anomalies

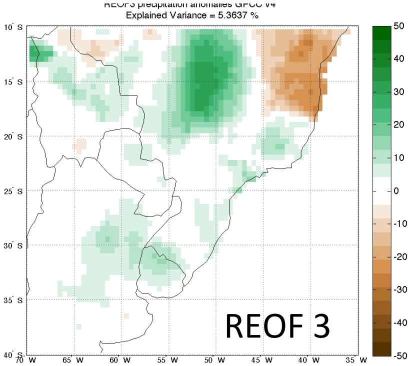


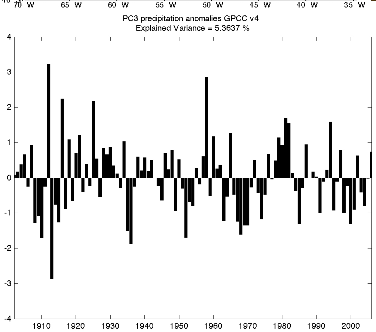


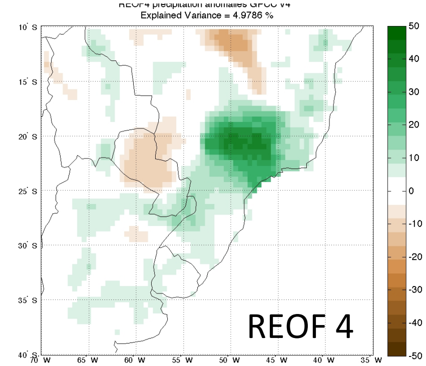


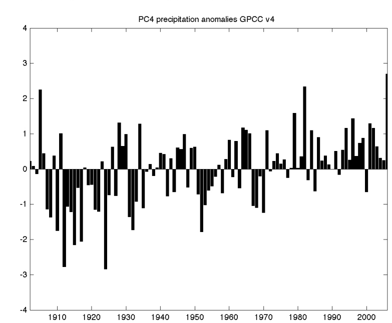




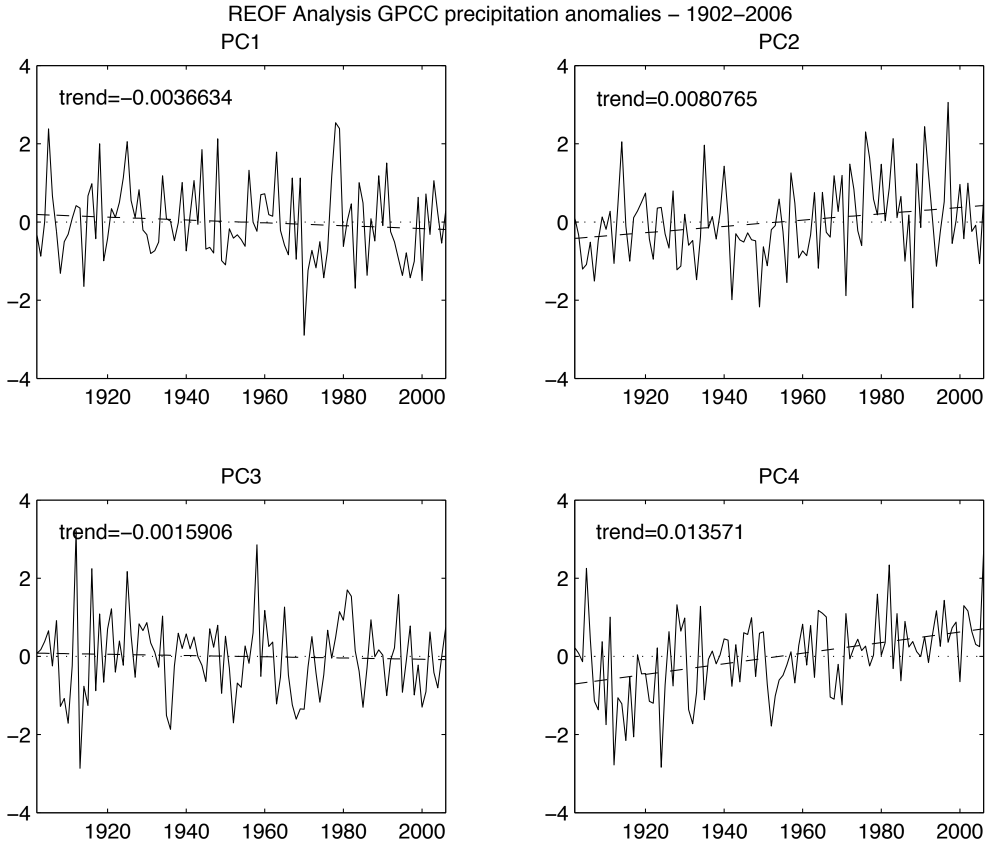


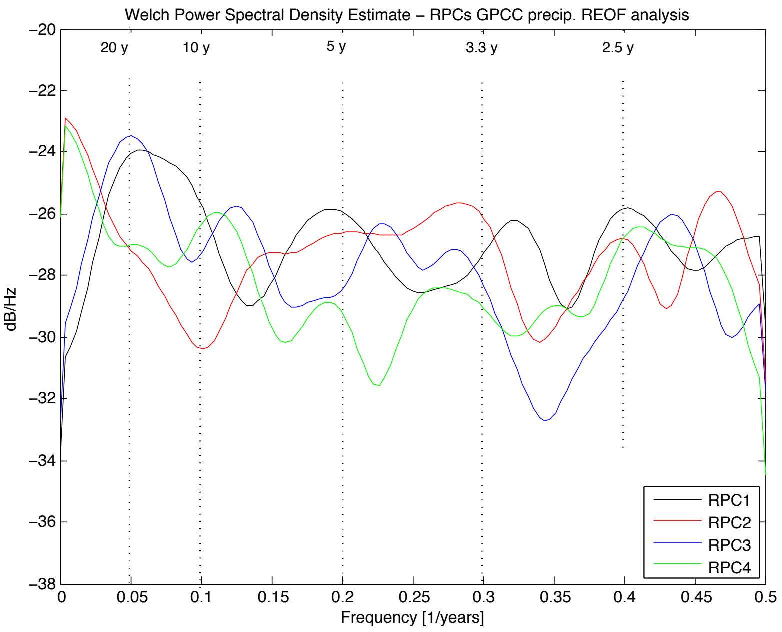




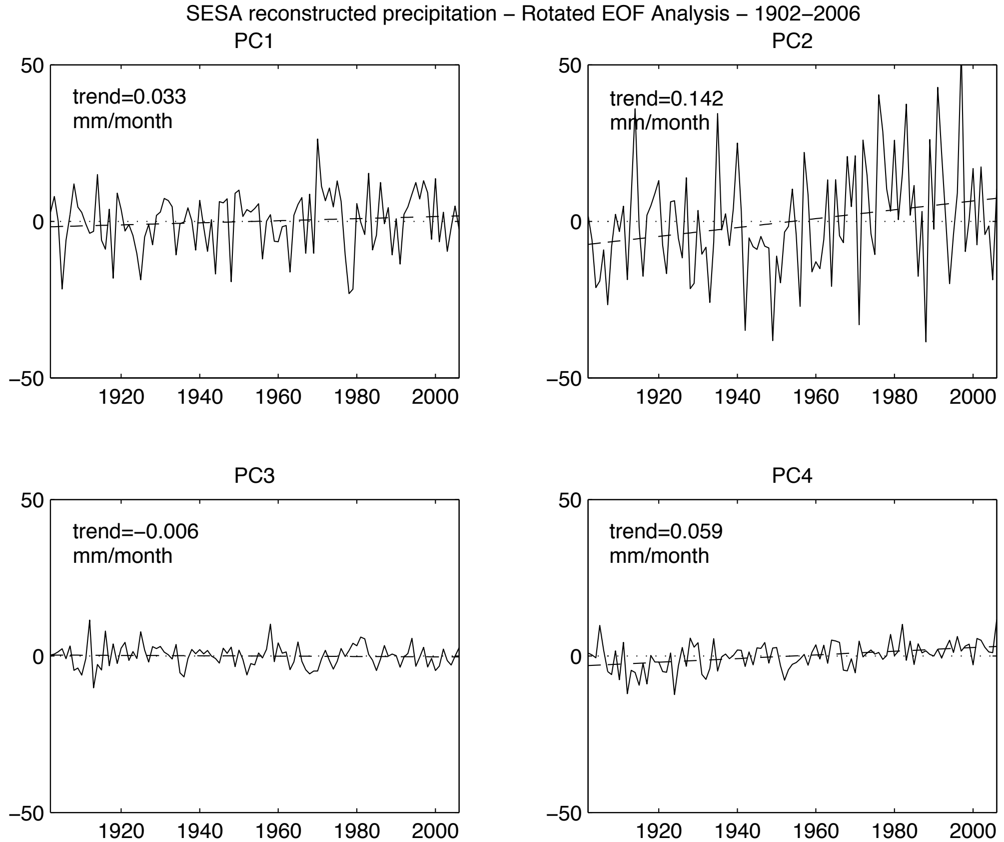


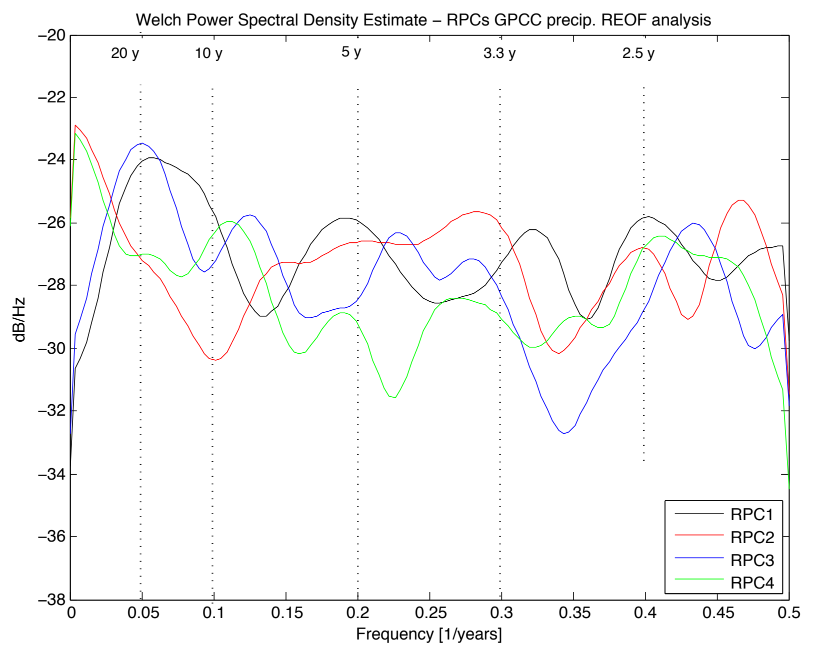
Temporal properties of PCs



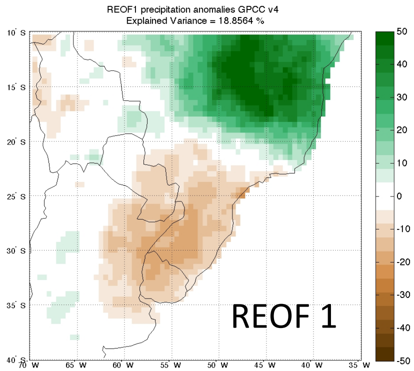


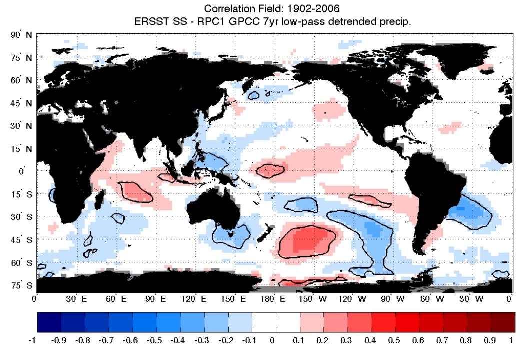
Temporal properties of SESA reconstructed precipitation

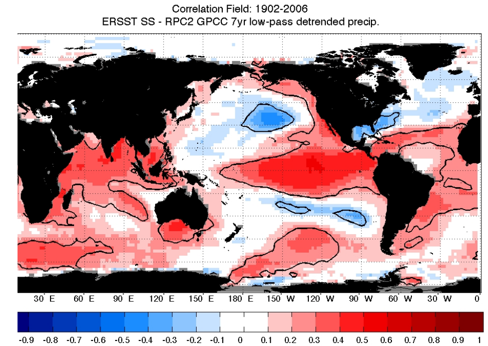


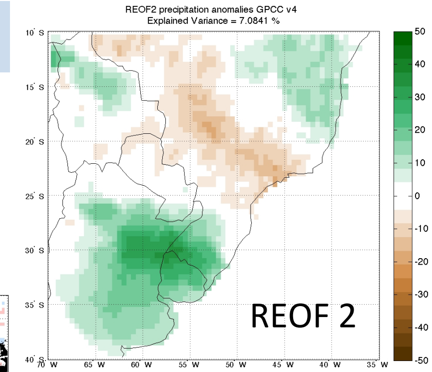


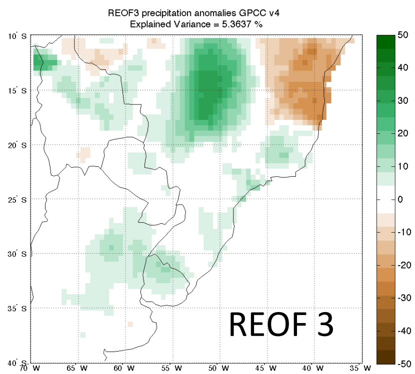
Correlation fields: PCs and SST anomalies

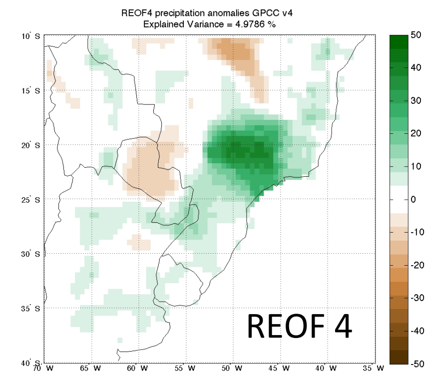


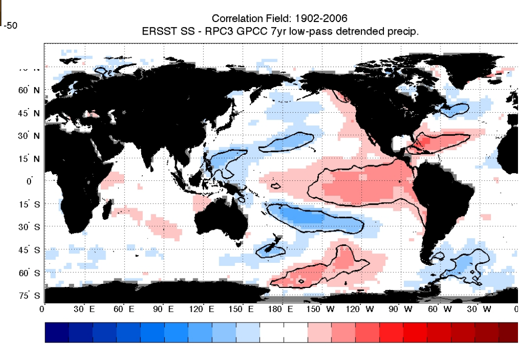


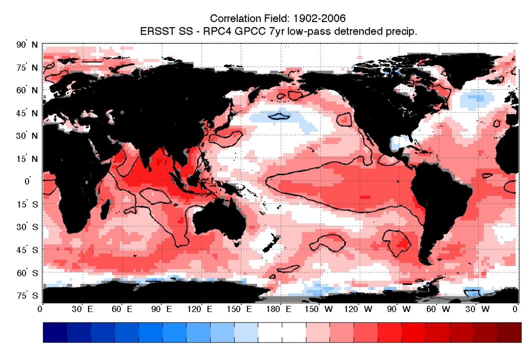




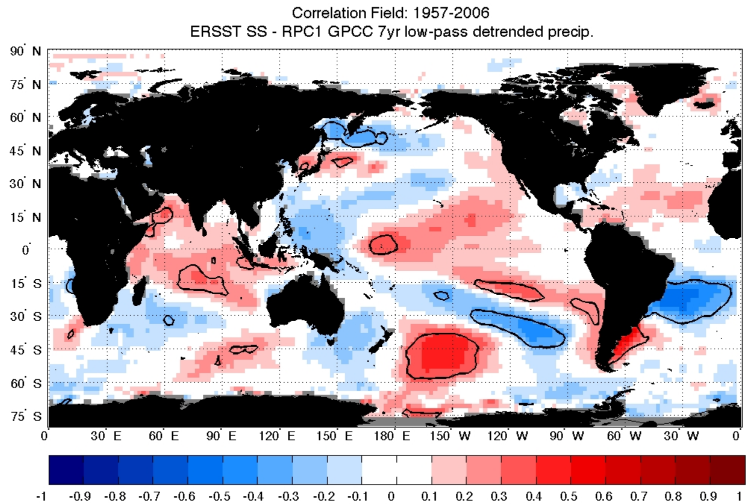


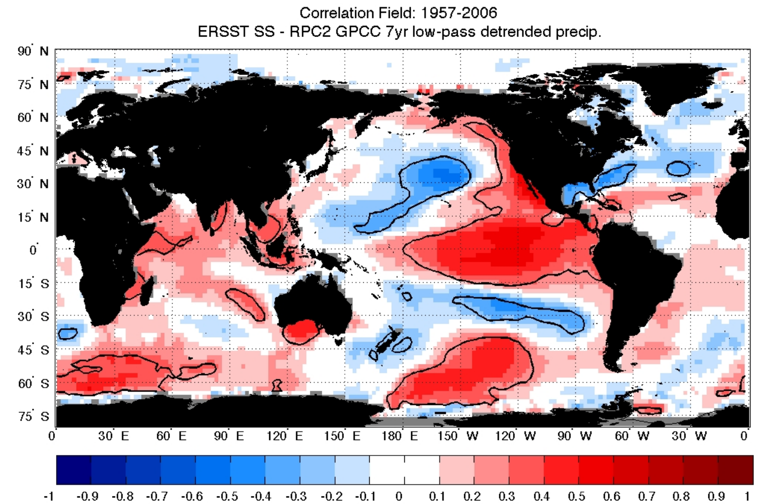


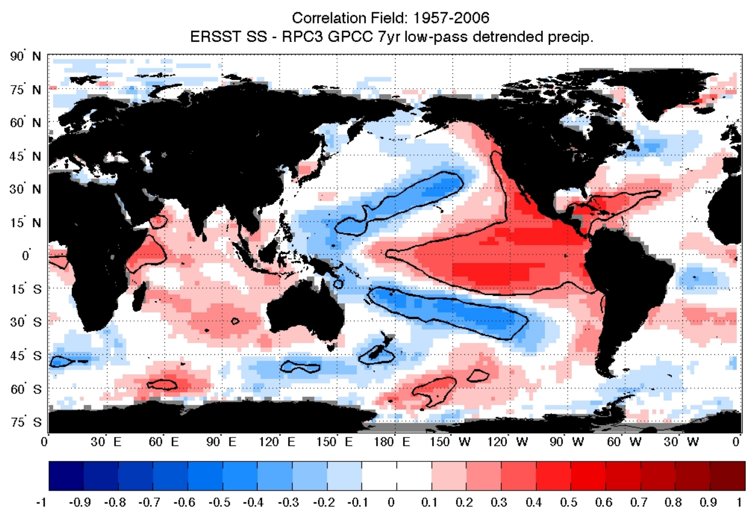


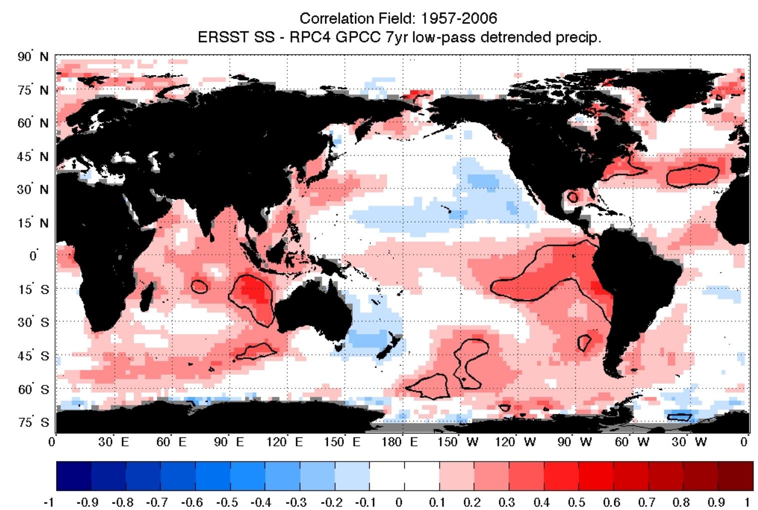


Correlation fields: PCs and SST anomalies
Seem more stable then EOFs for shorter period
1957-2006



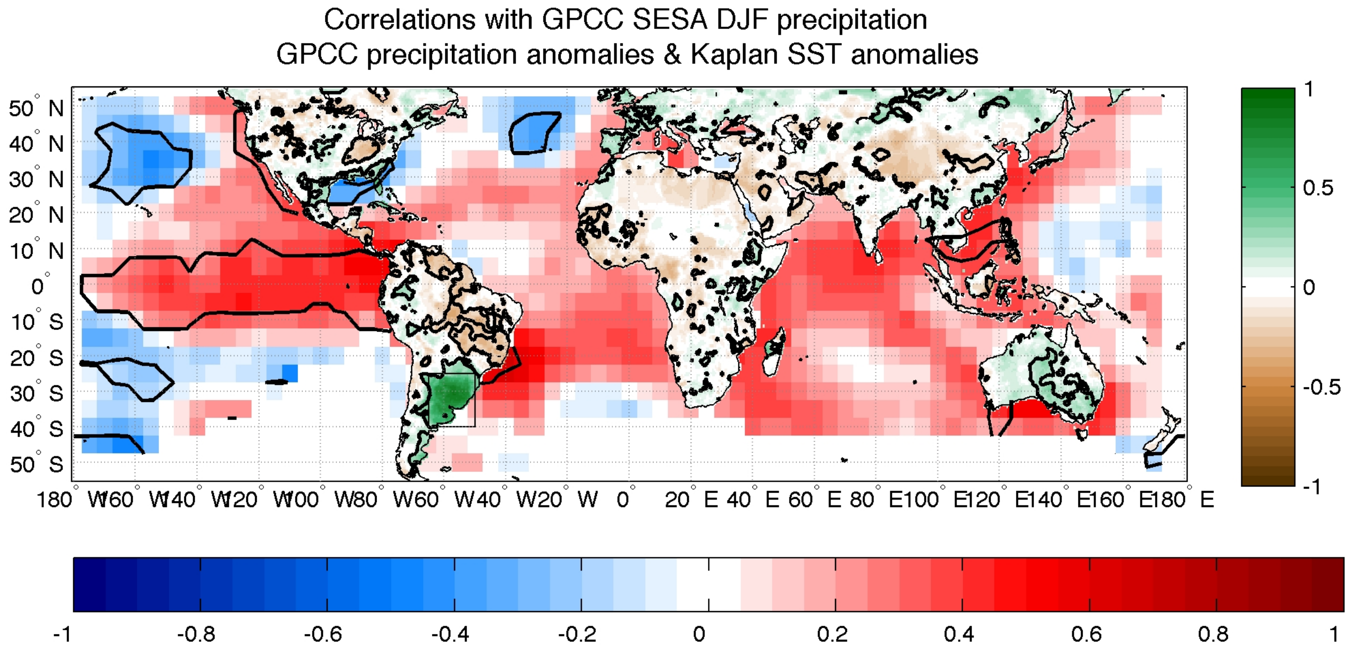


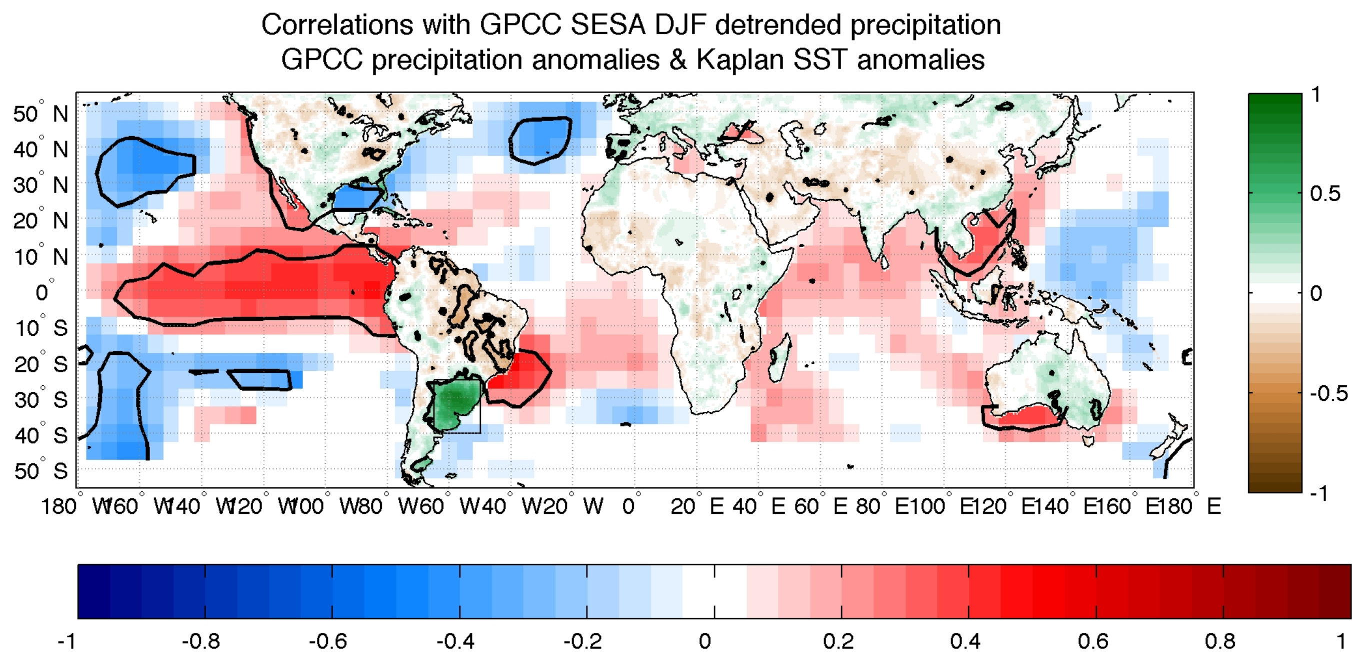




CORRELATIONS

SESA PRECIPITATION



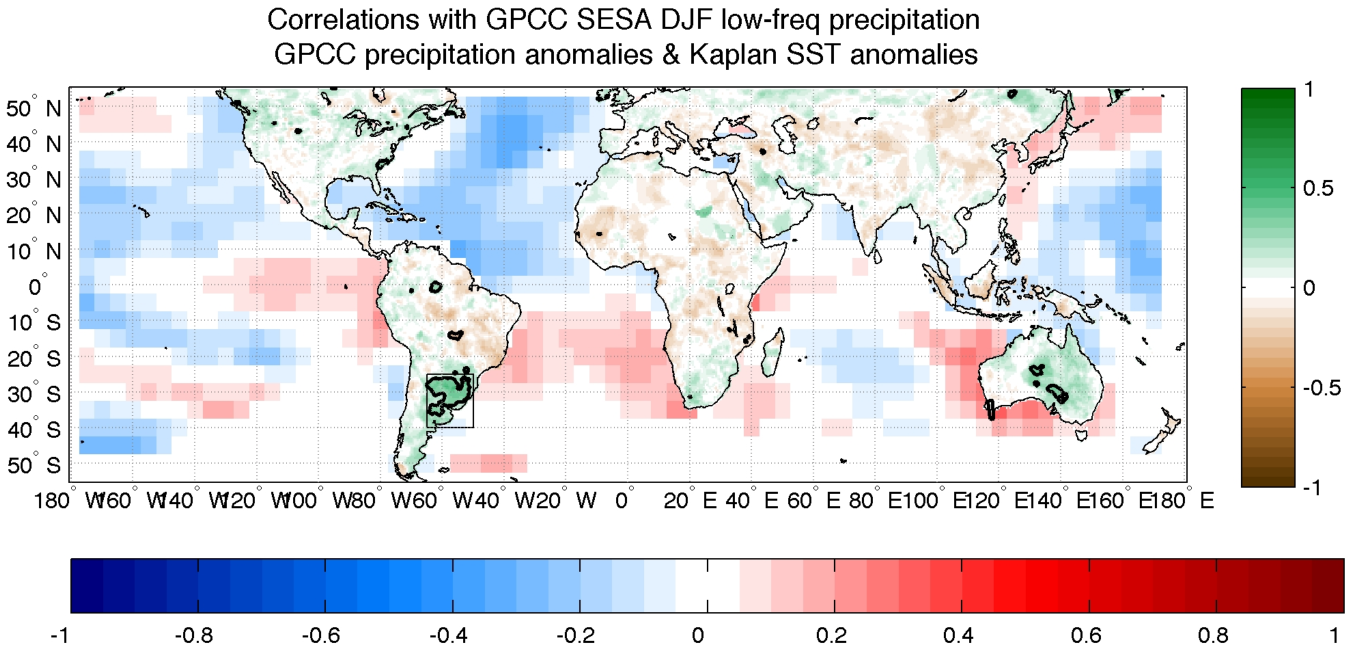


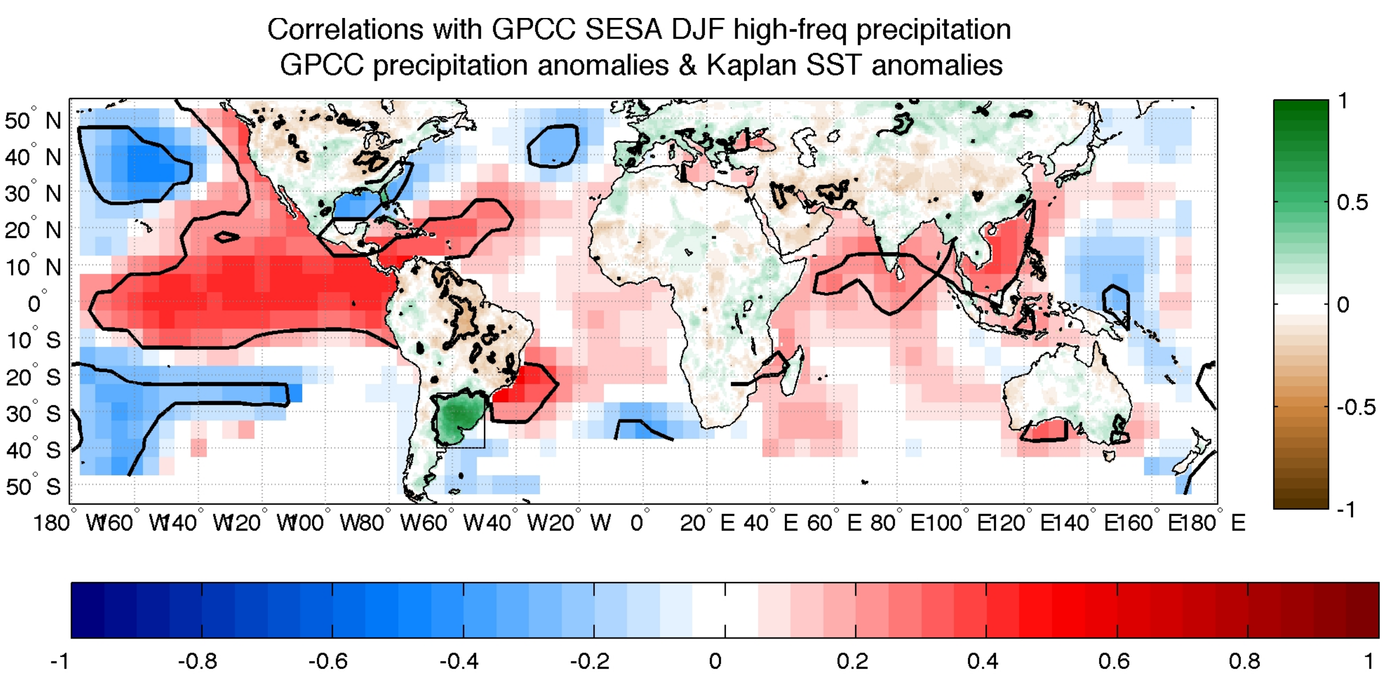
CORRELATIONS

SESA DETRENDED PRECIPITATION

CORRELATIONS

SESA "DECADAL" PRECIPITATION



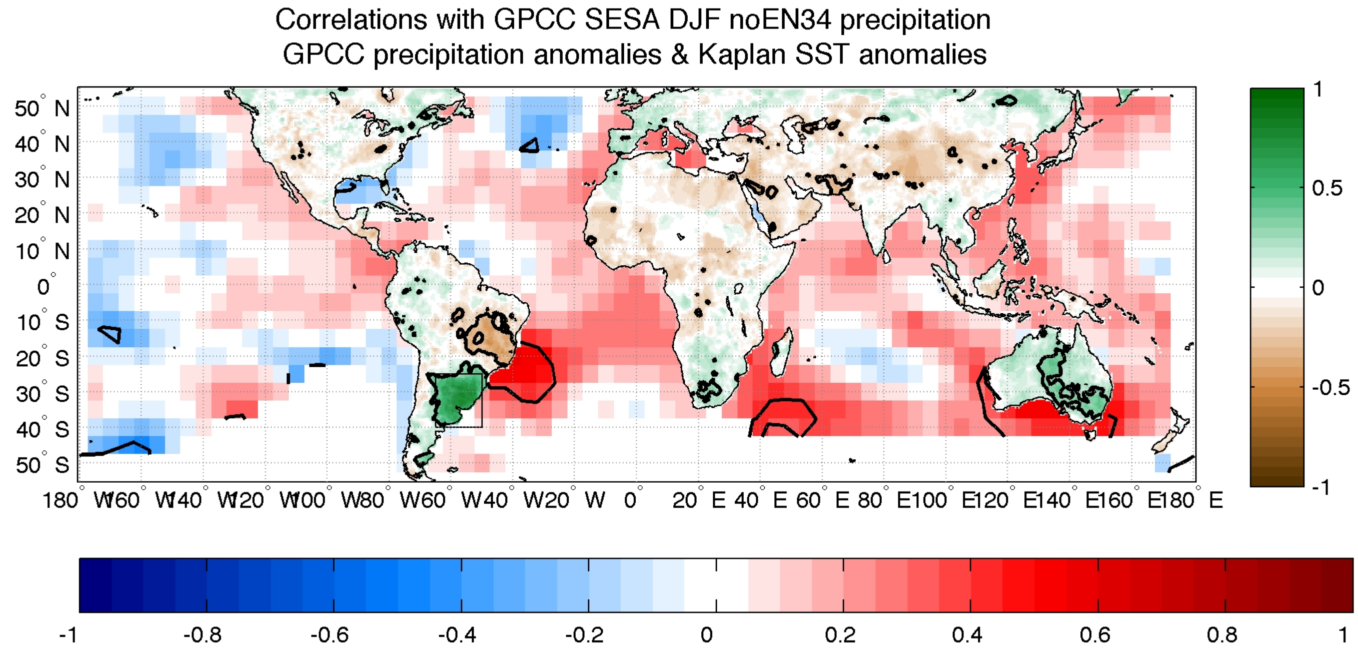


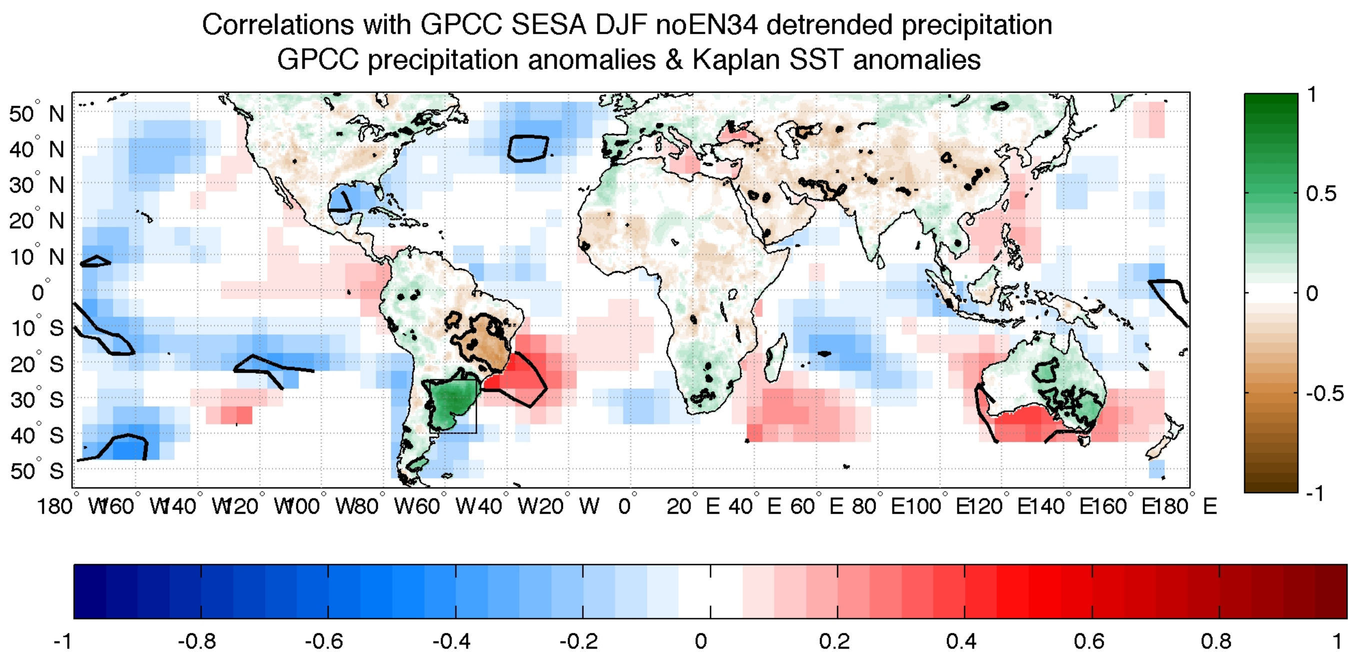
CORRELATIONS

SESA "INTERANNUAL" PRECIPITATION

CORRELATIONS

SESA PRECIPITATION after ENSO removal

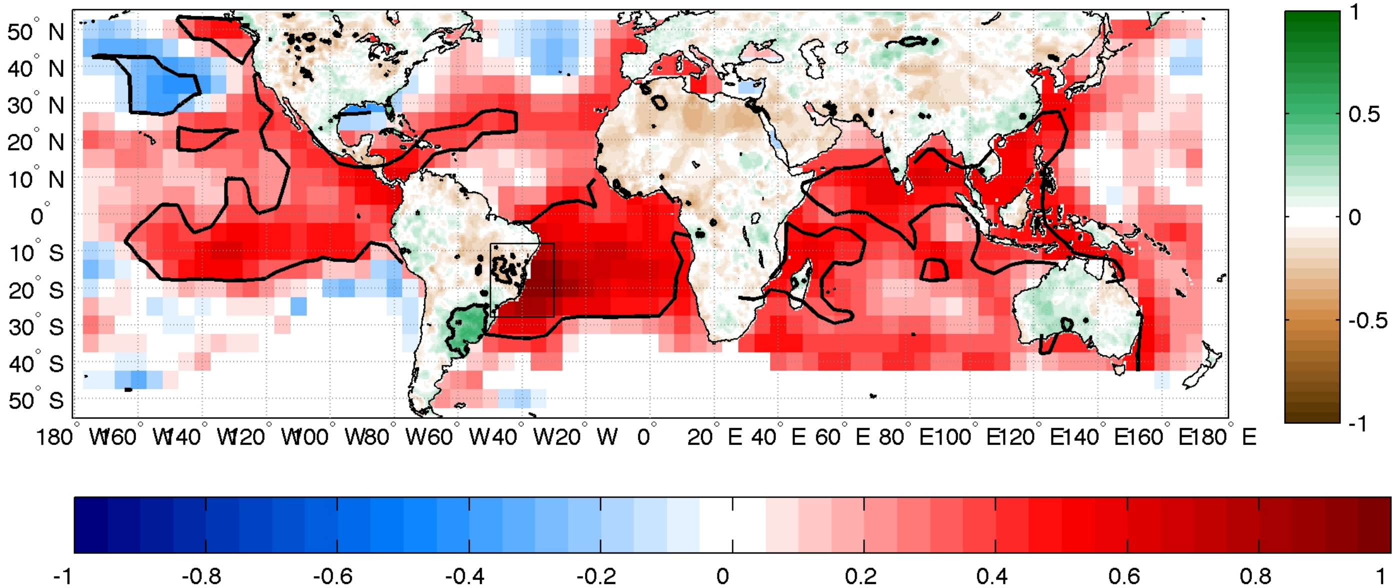




CORRELATIONS

SESA DETRENDED PRECIPITATION after ENSO removal

Correlations with BC Kaplan sstA
GPCC precipitation anomalies & Kaplan sst anomalies



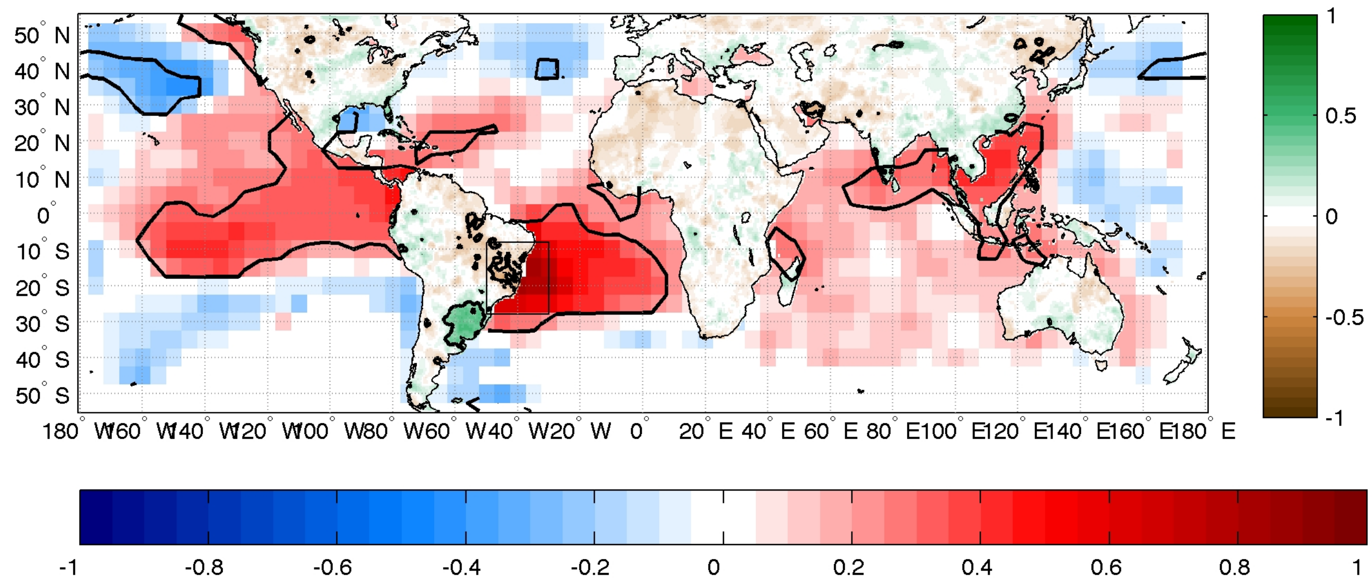
CORRELATIONS

BC SSTA

Correlations with Correlations with BC Kaplan detrended sstA
GPCC precipitation anomalies & Kaplan sst anomalies

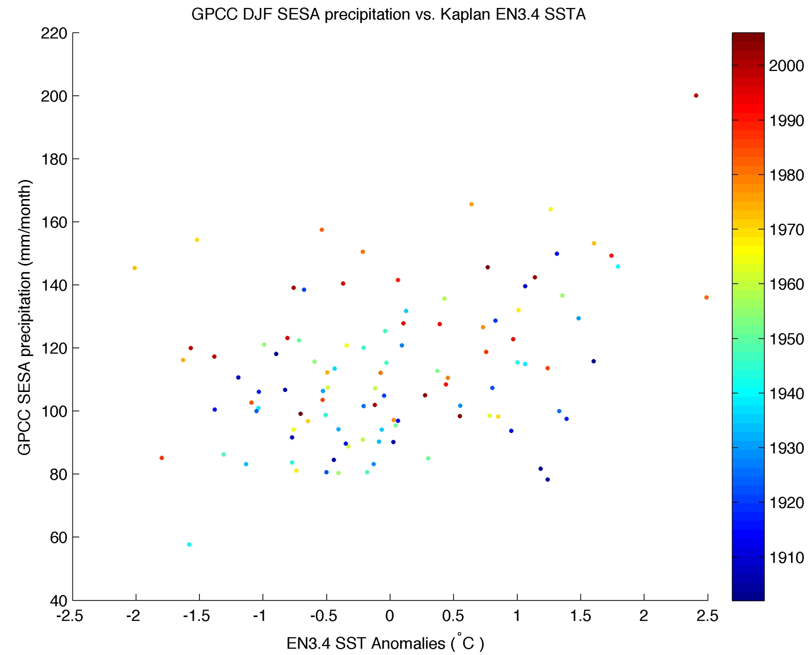
CORRELATIONS

BC detrended SSTA

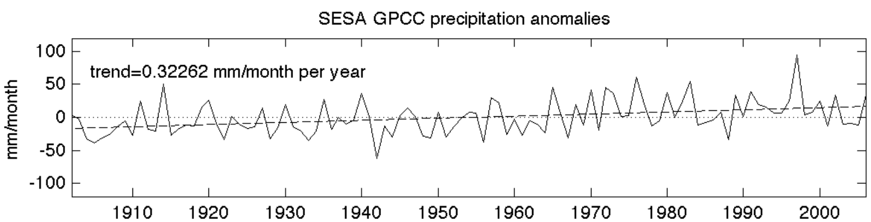


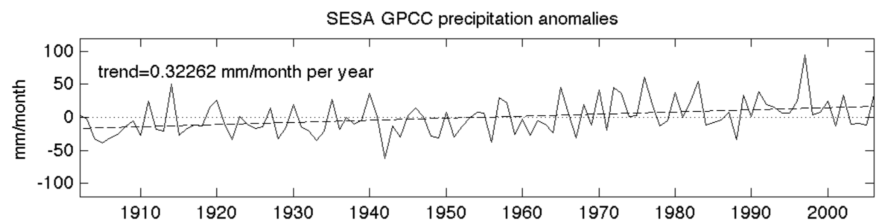
DJF PRECIPITATION LINEAR TREND

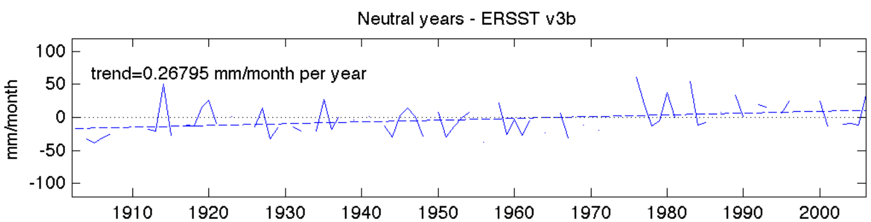
ENSO DISCRIMINATION ?

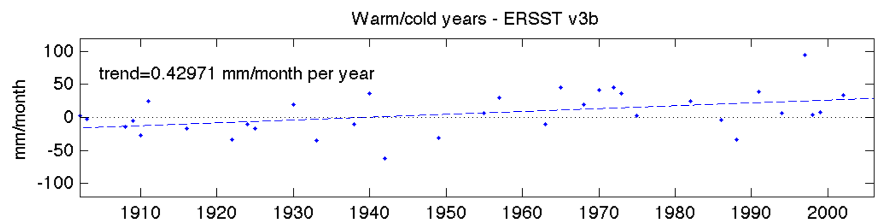


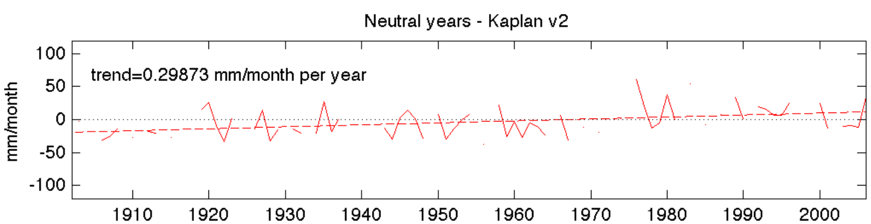
COLD/WARM ENSO years show twice the trend than NEUTRAL years

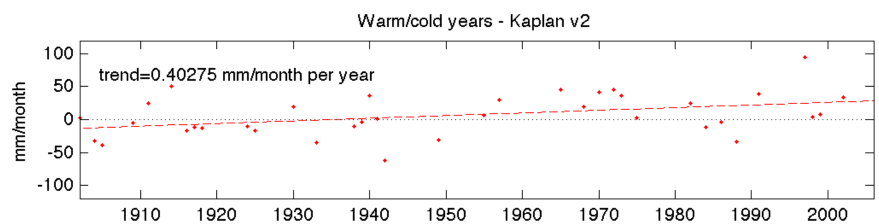












Thanks!
¡Muchas Gracias!

gonzalez@iri.columbia.edu