Group 1: Oceans

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Paul Levine
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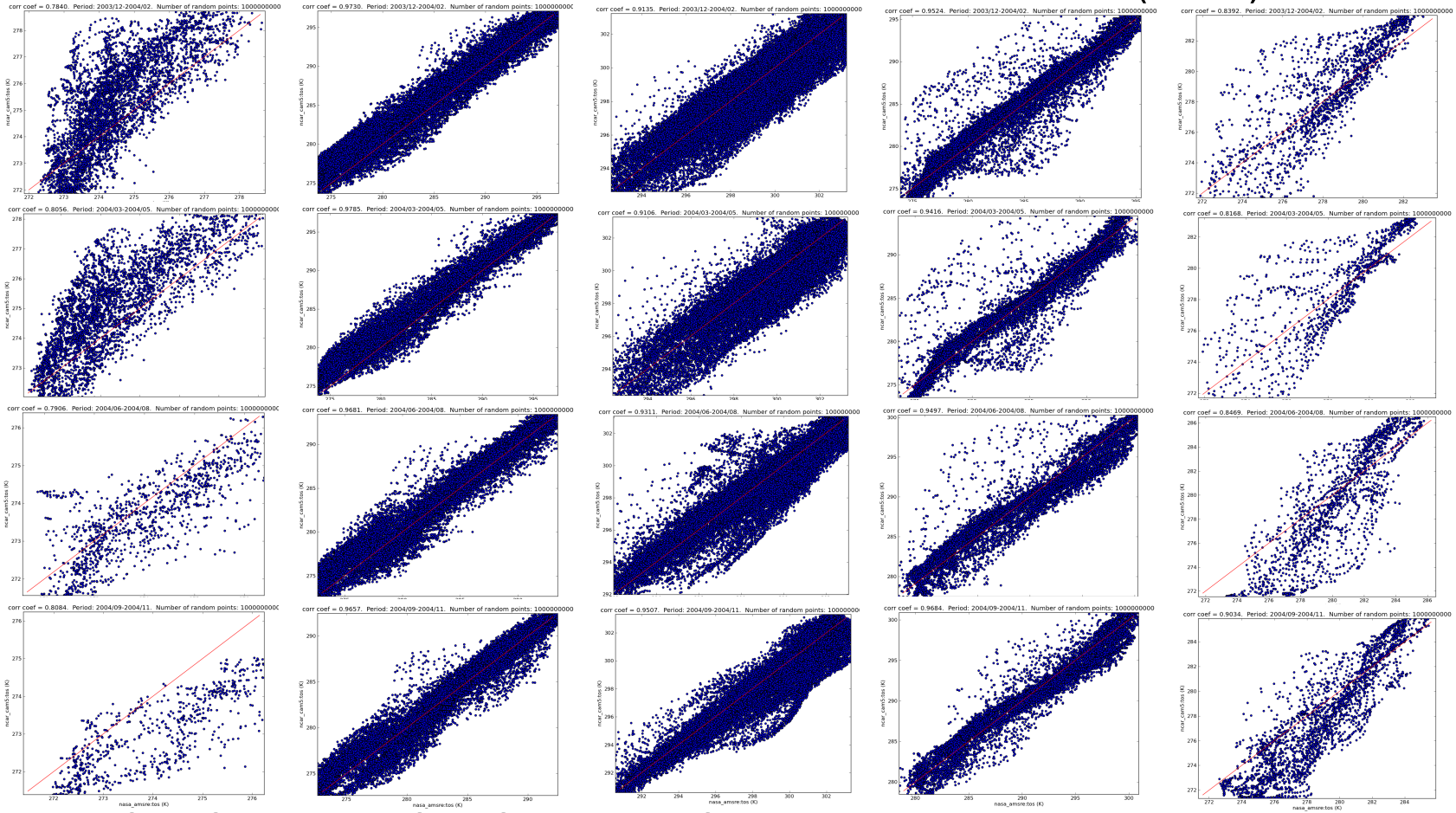
Question 1:

How is the seasonal cycle of SST observations related to model output?

Are there regional differences in agreement?

Scatter Plots of SST: AMSRE vs NCAR/CAM5 (2004)

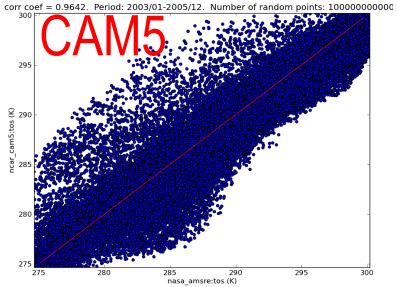


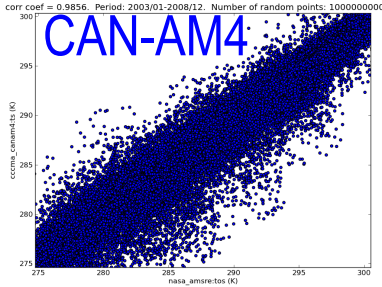
Scatter Plots of SST: AMSRE vs Models (2003–2008)

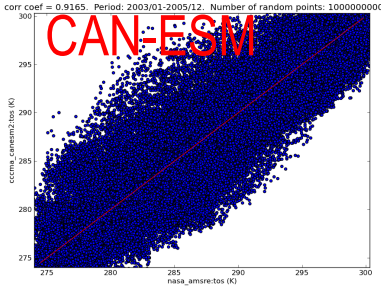
NH mid latitudes 30–60 N

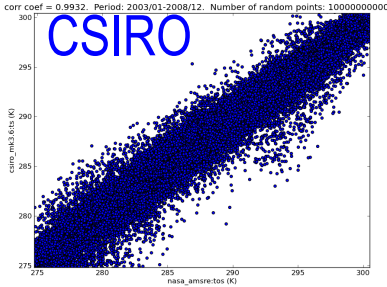
Blue denotes AMIP

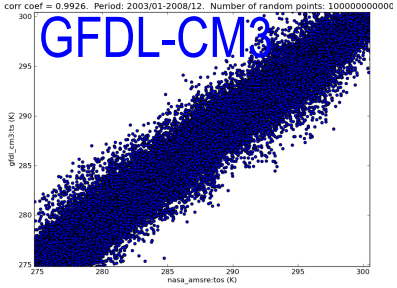
Red denotes historical run

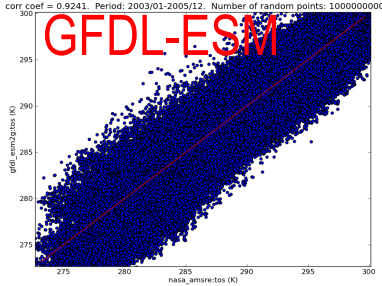


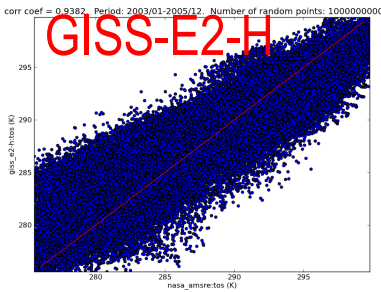


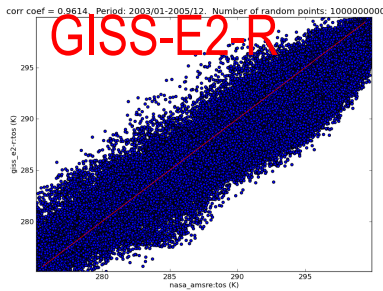


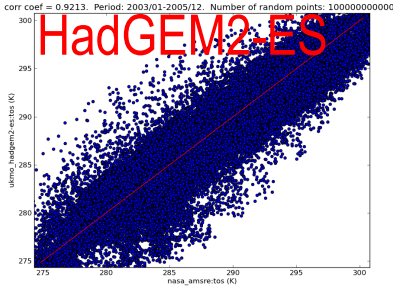


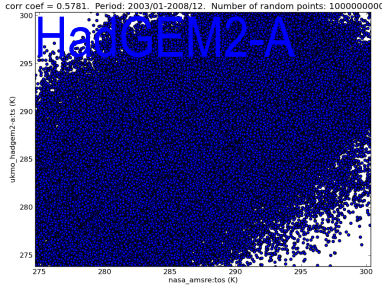


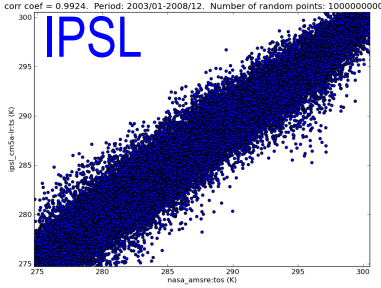


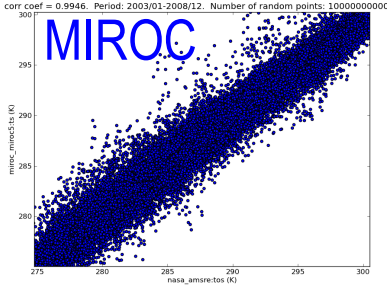










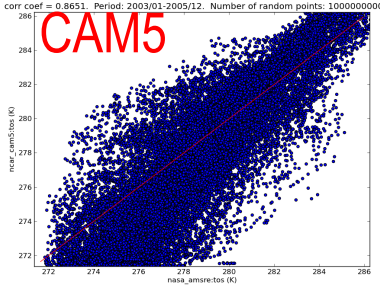


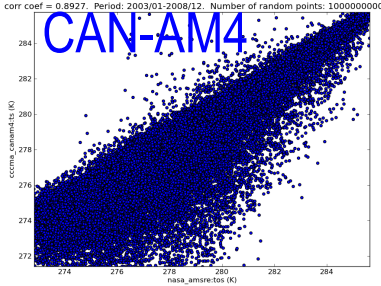
Scatter Plots of SST: AMSRE vs Models (2003–2008)

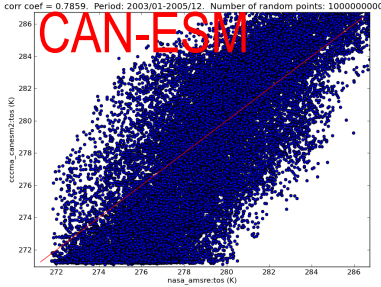
NH high latitudes 60–90 N

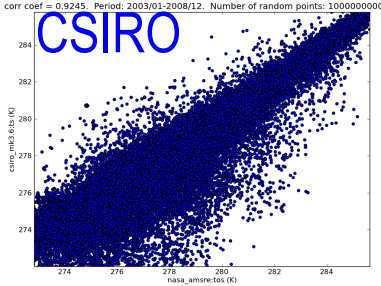
Blue denotes AMIP

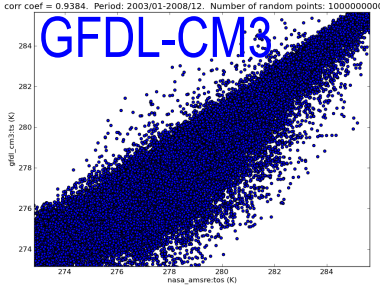
Red denotes historical run

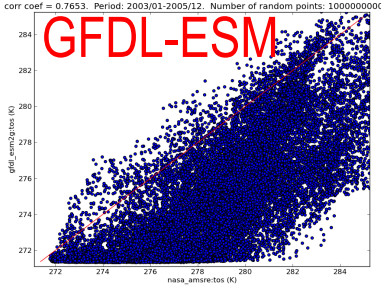


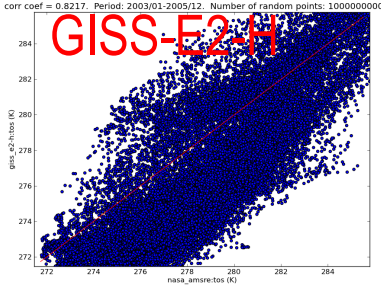


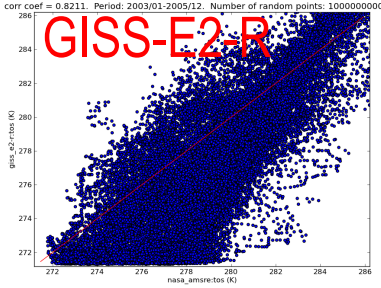


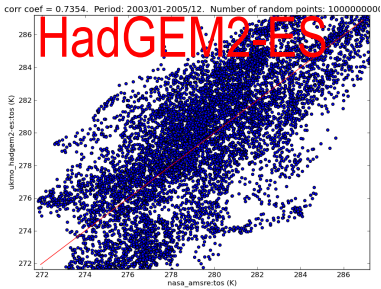


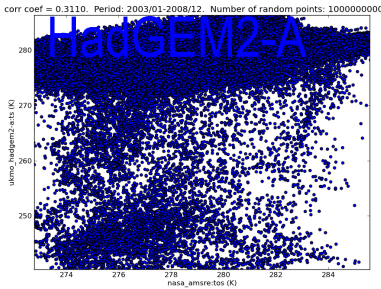


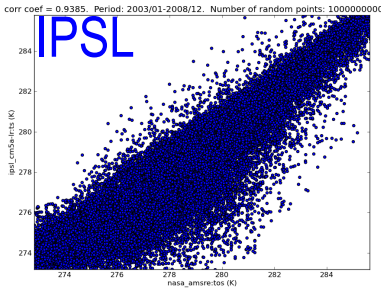


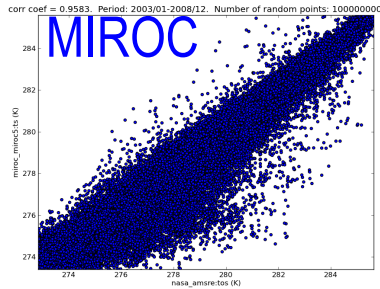




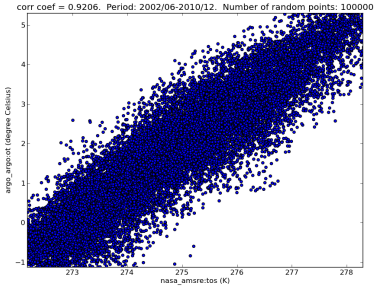


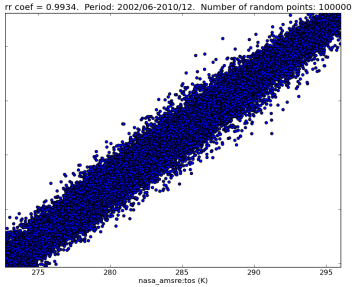


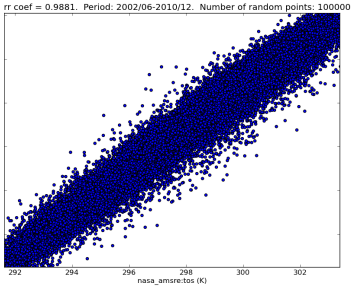


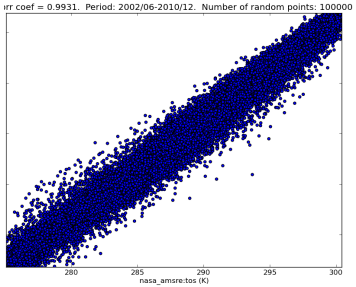


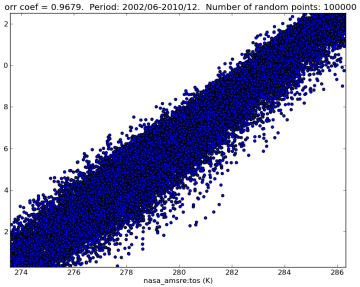
Scatter Plots of SST: AMSRE vs ARGO (2002–2010)

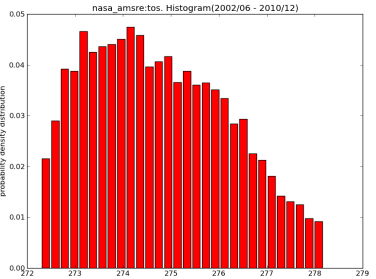


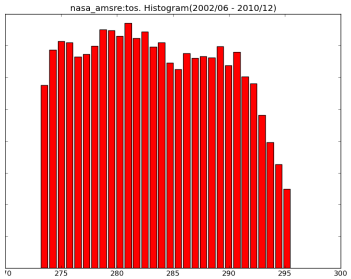


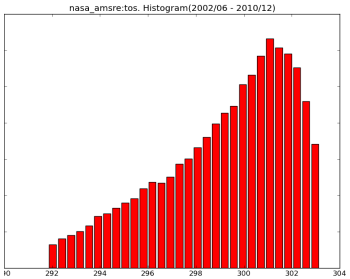


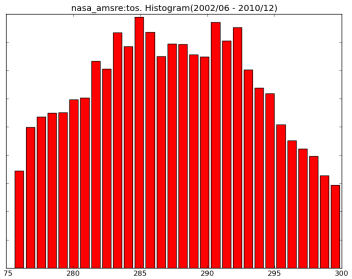


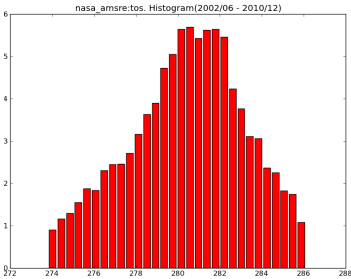


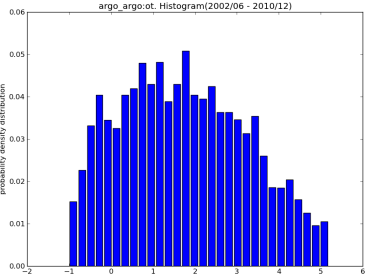


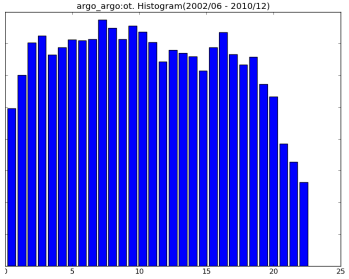


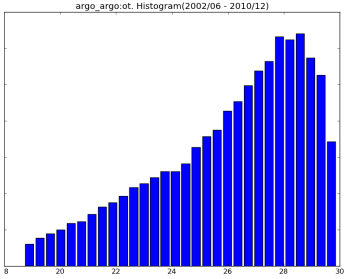


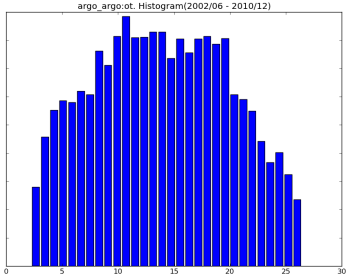


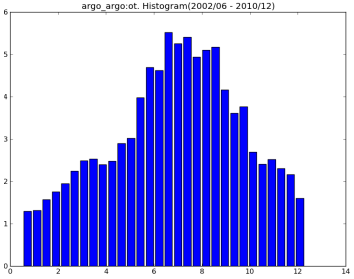












90S-60S | 60S-30S | 30S-30N | 30N-60N | 60N-90N

Question 2:

Besides the seasonality –

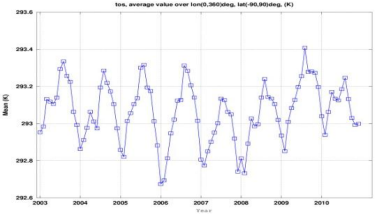
are there other features in the time series you observe?

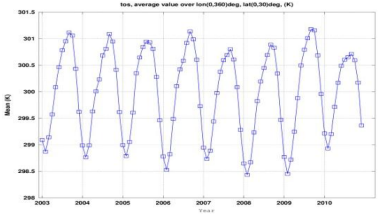
Global mean

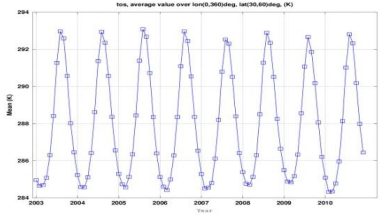
0 - ±30

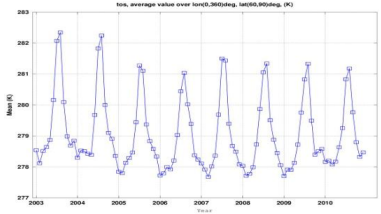
± 30 - ±60

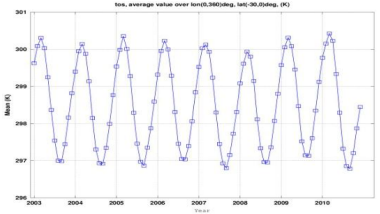
± 60 - ±90

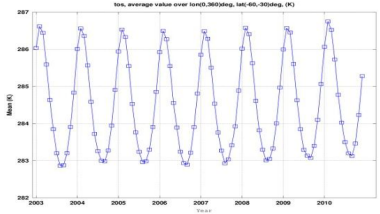


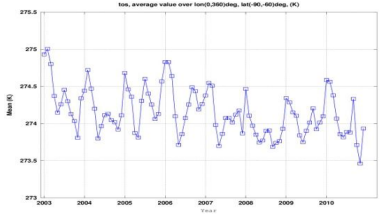




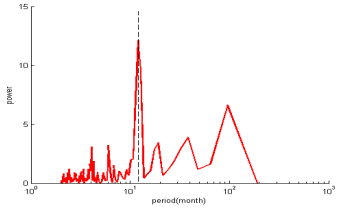


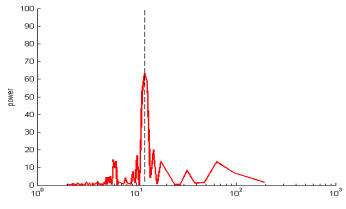


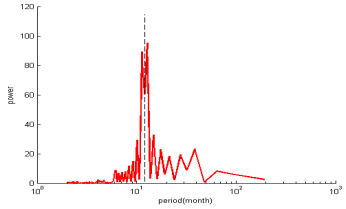


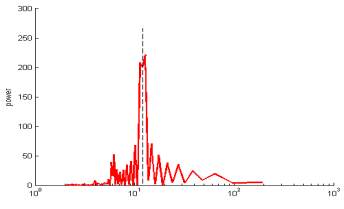


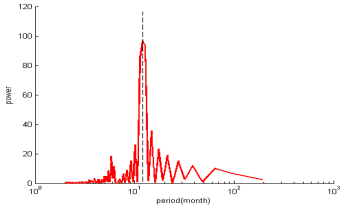
Time series FFT

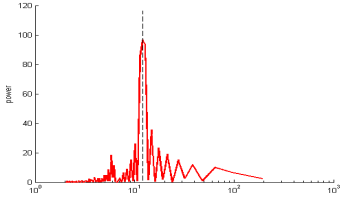


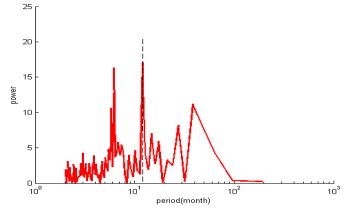








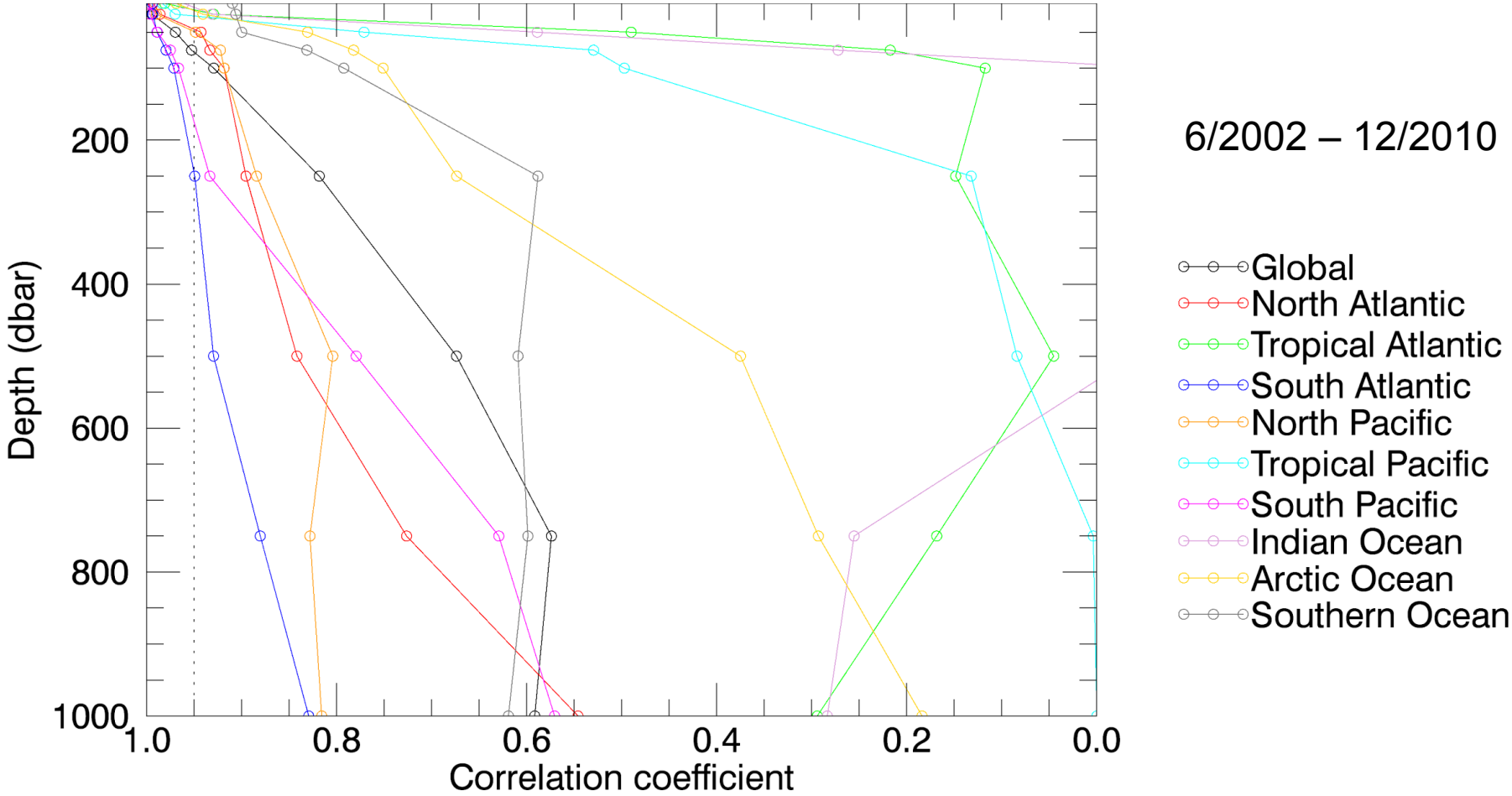




Question 3:

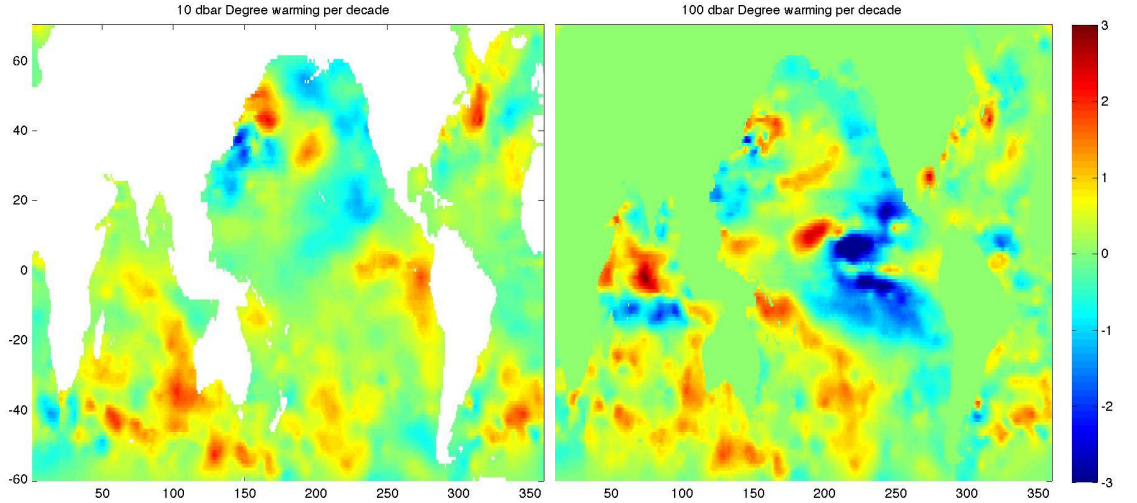
Can satellite SST (AMSR-E) be used to estimate *in situ* temperature measurements (ARGO)?
Where on earth, and to what depth?

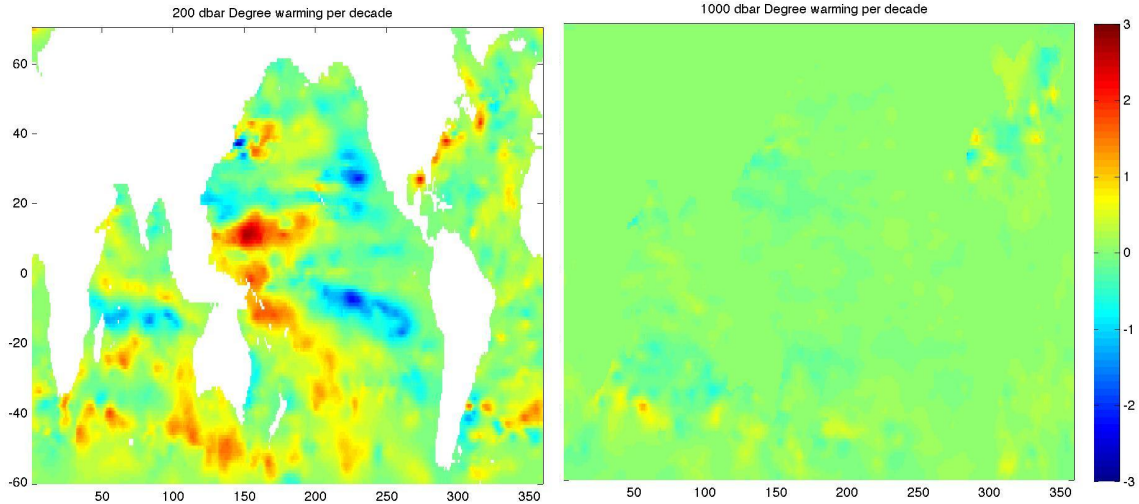
AMSR-E SST vs. ARGO Ocean Temperature



Question 4:

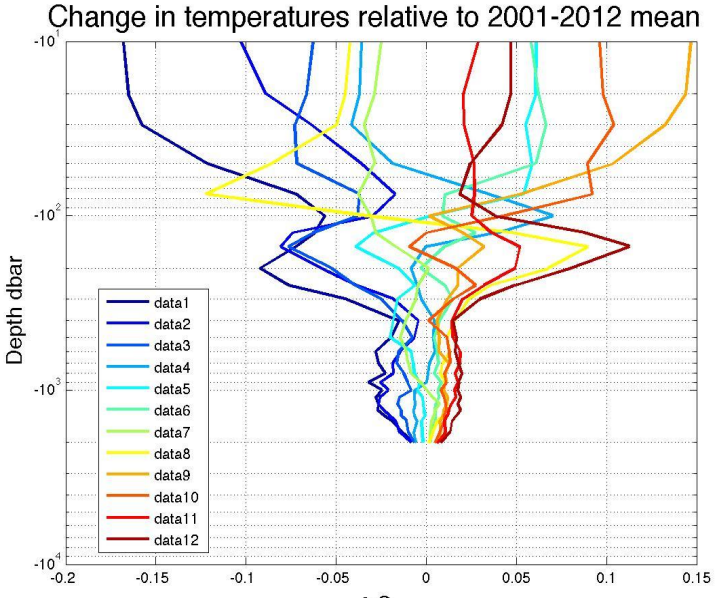
Where have there been increases in ocean temperature during the early 2000s?





Geographic trends in ocean warming vary with depth

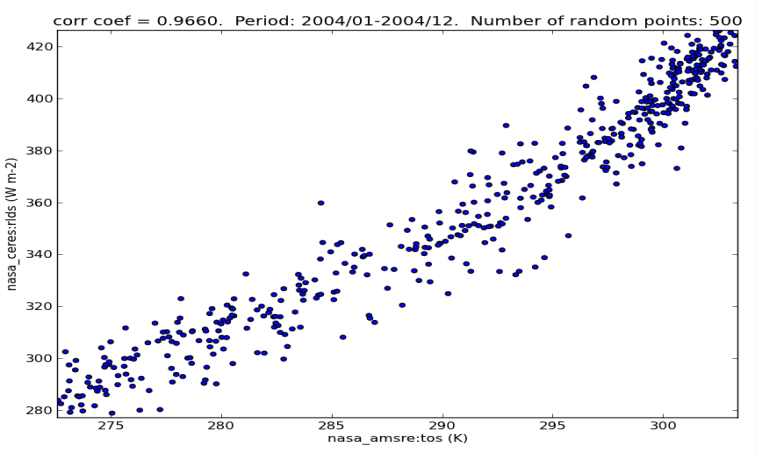
- Southern and Indian Oceans are warming whole way through
- West Pacific cools at 100dbar
- Inconsistent warming in Laborador Sea
- 100 dbar showed significant changes, but warming in some areas and cooling in others
- Consistent small amounts of warming at 1000 dbar



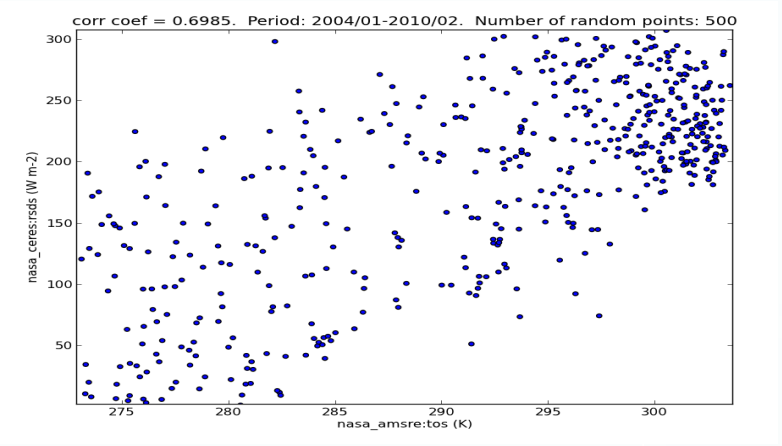
Question 5:

Are changes in sea surface temperature related to changes in the radiation reaching the surface?

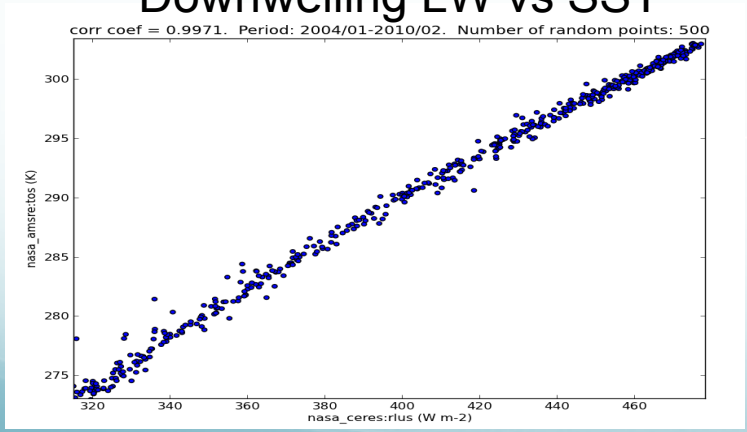
Radiation vs SST 2004-2010, Globally



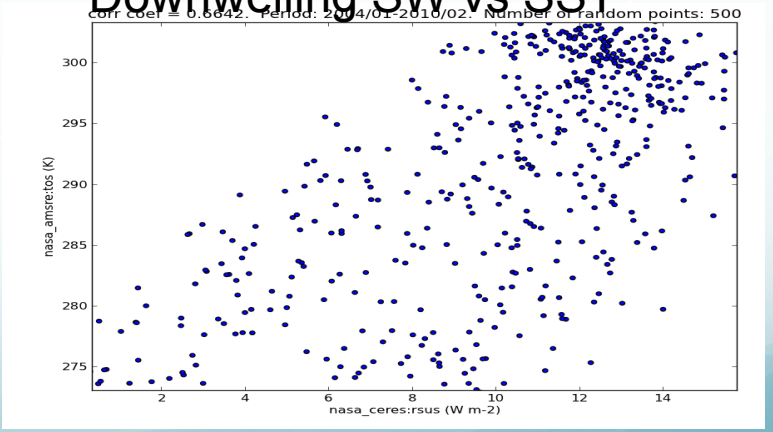
Downwelling LW vs SST



Downwelling SW vs SST

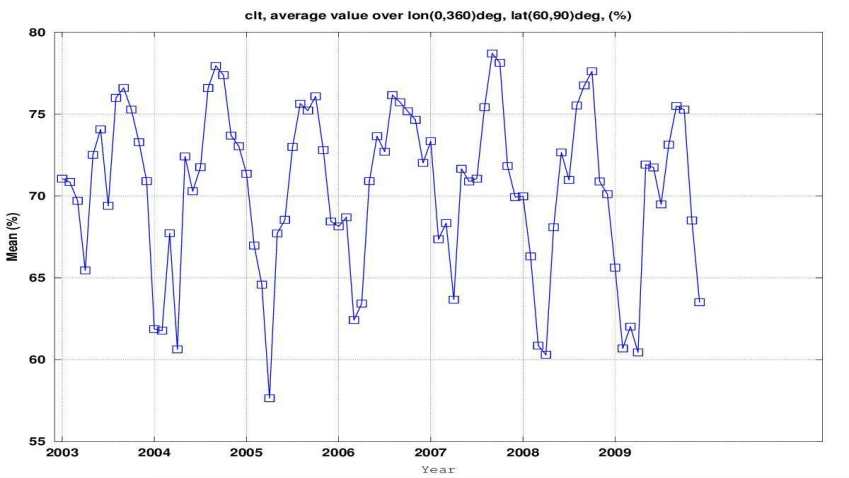


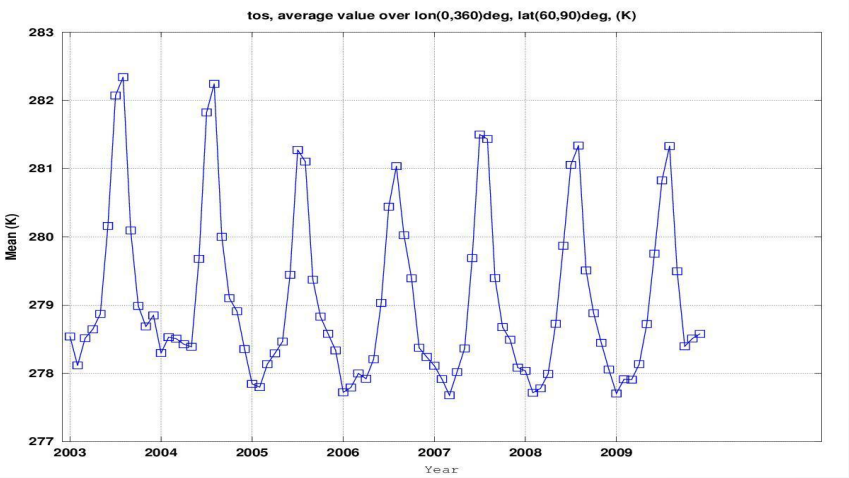
Upwelling LW vs SST



Upwelling SW vs SST

Radiation and cloud fraction effects on SST



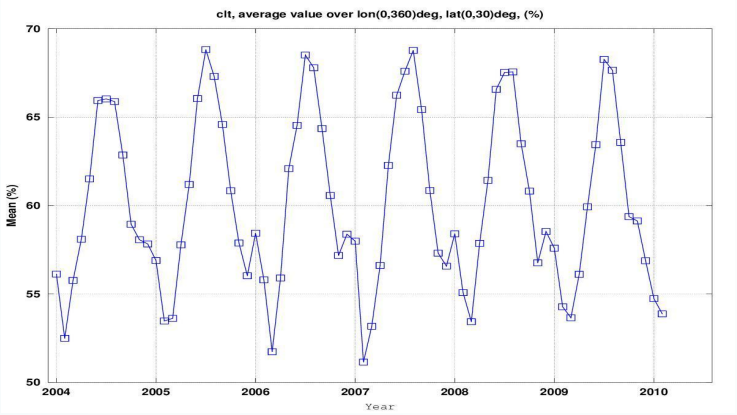


High Latitude(60-90) Cloud Fraction

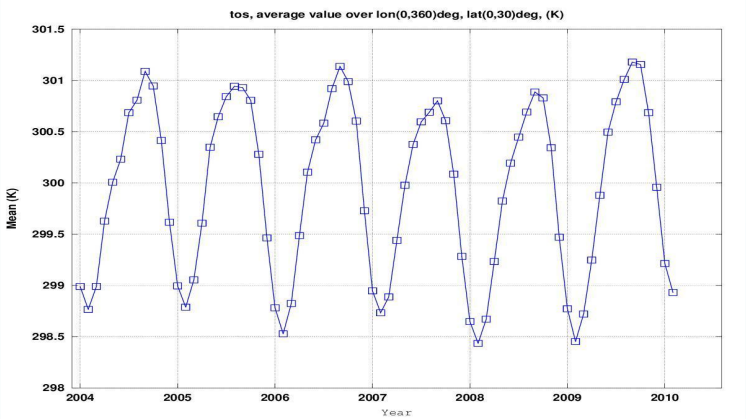
High Latitude (60-90)SST

- Cloud Fraction describes increase in SSTs in beginning of period (2004-2010) more than LW,SW upwelling or downwelling
- Increase in Cloud Fraction during ‘minimum’ annual time may increase

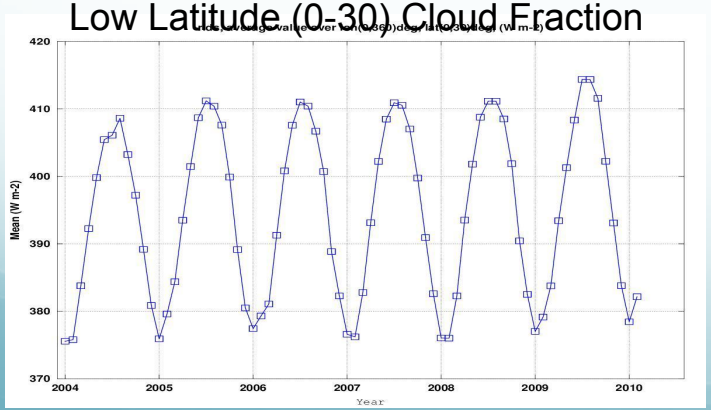
Radiation and cloud fraction effects on SST



Low Latitude (0-30) Cloud Fraction



Low Latitude (0-30)SST



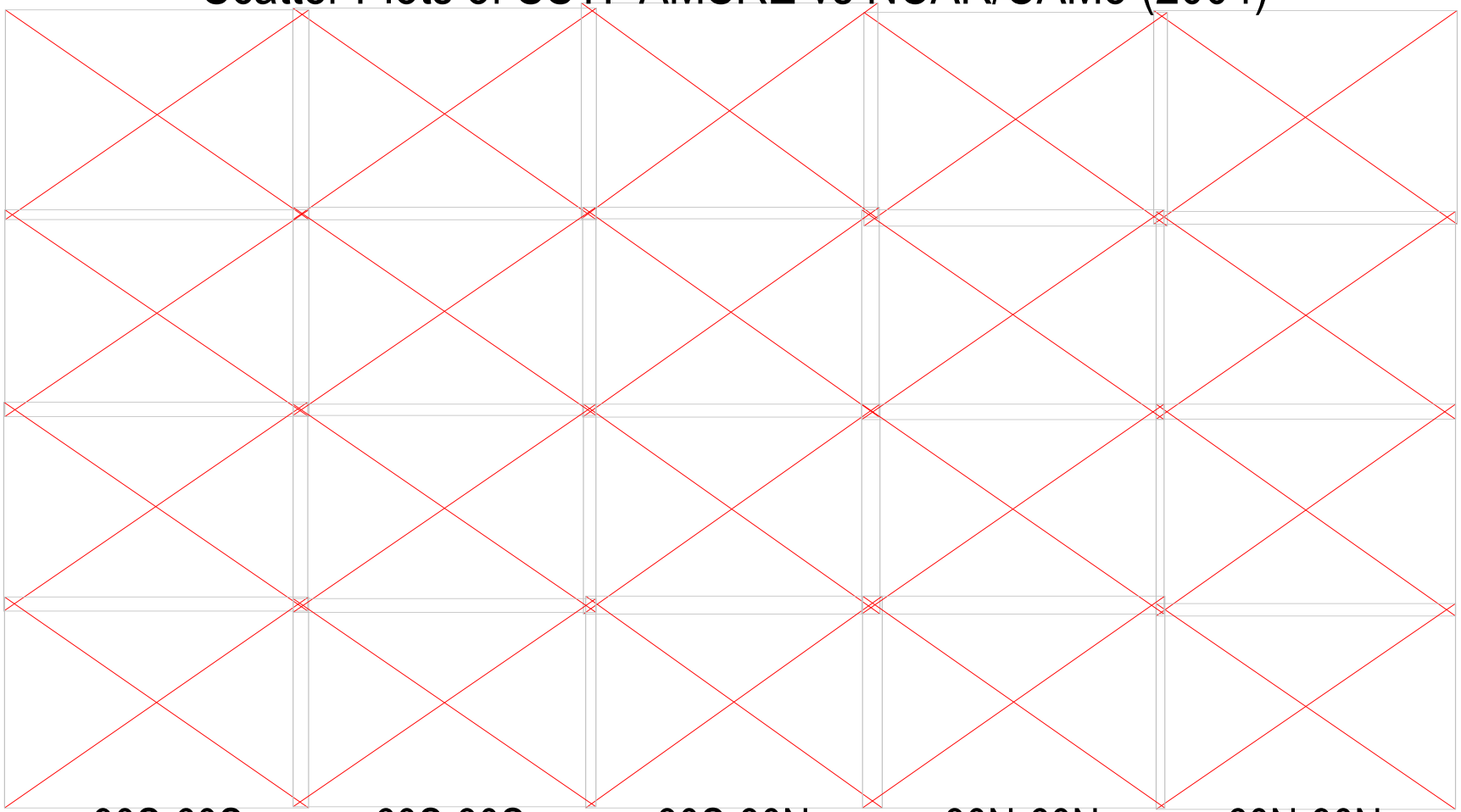
Low latitude (0-30) Downwelling LW

- Changes in SST not clearly correlated with cloud fraction or Radiation
- At end of period (2004-2010), higher Downwelling LW and high SST observed
- Low cloud fraction in 2006-2007, not much signal observed elsewhere

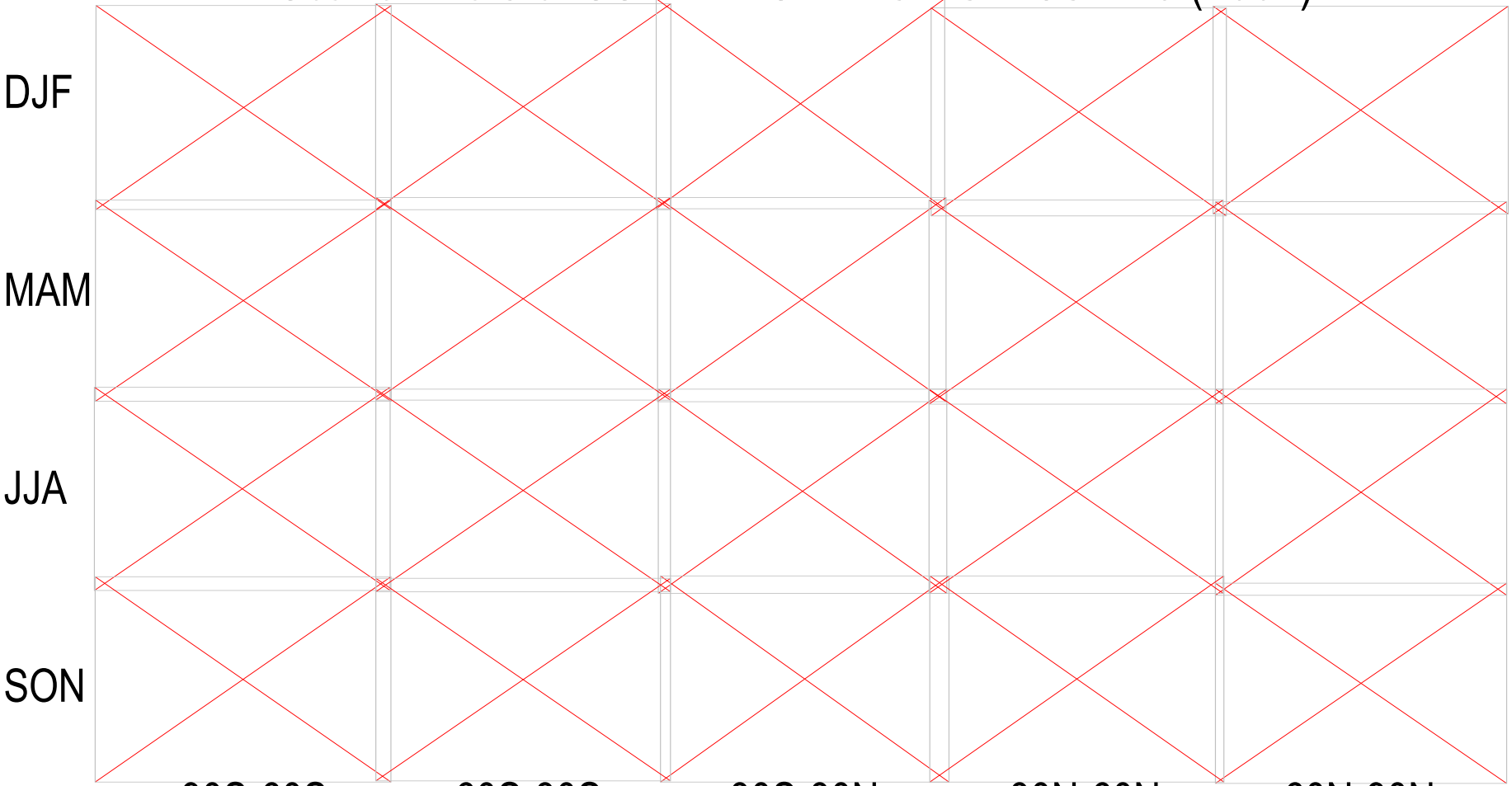
Conclusions:

1. Models best at mid-latitudes
2. Seasonal signals due to data availability
3. SST correlated to temperature at depth in some ocean basins
4. Warming in some parts of the ocean over the last decade
5. Longwave radiation is correlated to SST

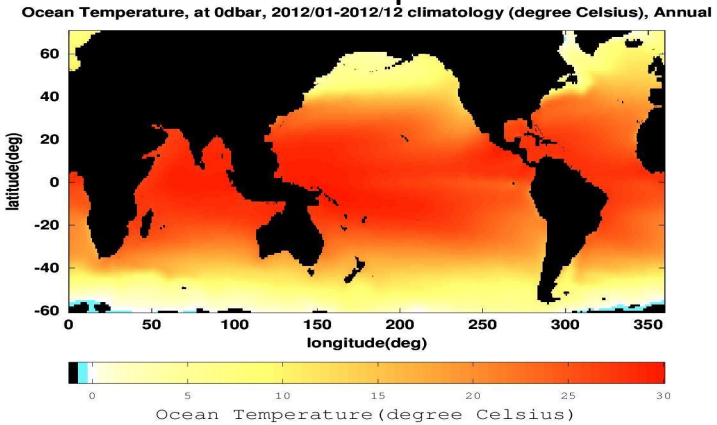
Scatter Plots of SST: AMSRE vs NCAR/CAM5 (2004)



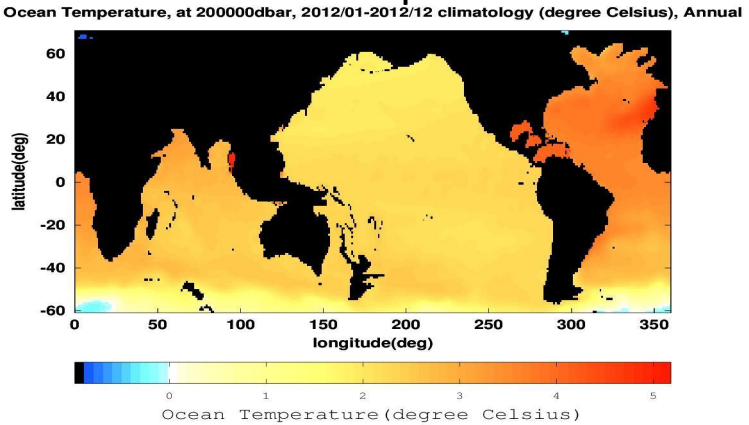
Scatter Plots of SST: AMSRE vs NCAR/CAM5 (2004)



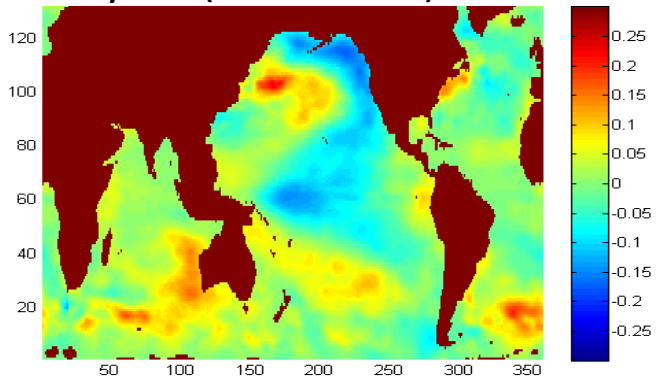
Surface temperature



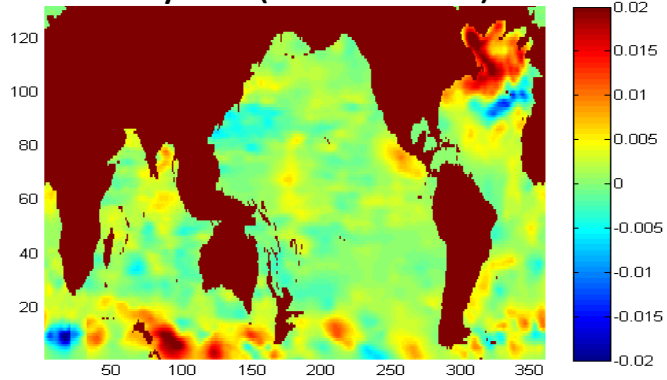
2000 m temperature



10-year (2003-2013) trend



10-year (2003-2013) trend



Student Group Research Presentation

Topic 2

Ja-Ho Koo, Cheng Li, and Rachel Scanza

2014 Summer School

JPL Center for Climate Sciences

Topic #2 (given on Tuesday)

- Topic: observed Variabilities of Clouds and Precipitation
- **Datasets: MODIS total cloud fraction, TRMM precipitation, AMSR-E sea surface temperature, CERES surface downwelling longwave and shortwave radiation**
- Geographic foci: global, tropics (15S-15N), subtropics (15-30S/N), mid-latitude (30-50S/N) and selected regions (ITCZ, northeast Pacific and southeast Pacific)
- Questions:
  - What are the spatial distributions of clouds and precipitation? Are their distributions related to underlying sea surface temperature? (2-D maps; zonal-mean plots; scatter plots; conditional sampling plots)
  - What are the seasonal and interannual variations of clouds and precipitation over the regional above? Are there detectable trends in each region? Are these temporal evolutions correlated with underlying sea surface temperature changes?
  - What are the radiative effects of clouds? How are the cloud radiative effects varying with time?
  - What is the histogram of precipitation? Are there detectable changes of precipitation histogram over the past decade?
- Contact Scientist: Dr. Hui Su (Hui.Su@jpl.nasa.gov)

$\Rightarrow$ **Our results quickly provided with 4 small chapters**

Q1. What are the spatial distributions (and regional characteristics) of clouds and precipitation? Are their distributions related to underlying sea surface temperature? (2-D maps; zonal-mean plots; scatter plots; conditional sampling plots)

1-1. Global mean pattern

- **1-1-1. Cloud fraction (CF) (MODIS)**
- **1-1-2. Precipitation (TRMM)**
- **1-1-3. Sea surface temperature (SST) (AMSR-E)**

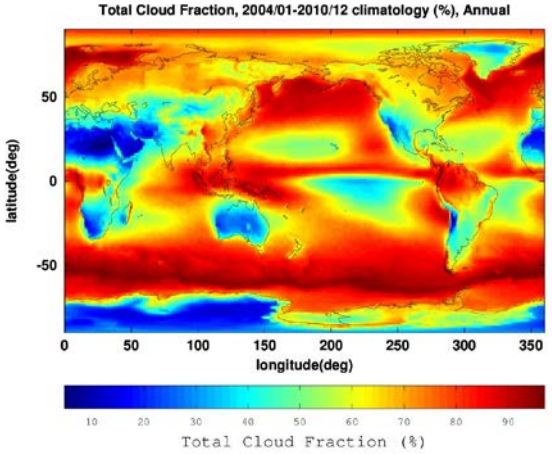
1-2. Relation of CF and precipitation to SST

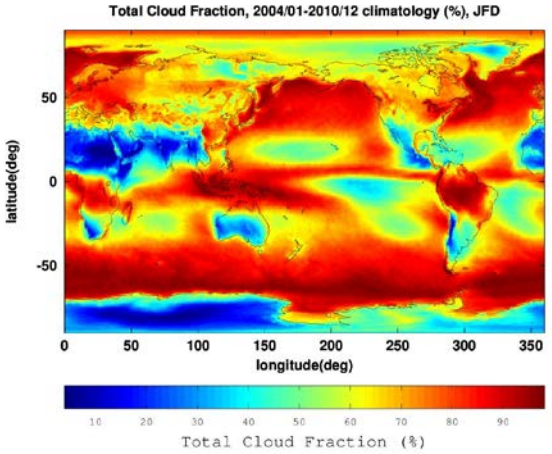
- **1-2-1. CF vs. SST**
- **1-2-2. Precipitation vs. SST**

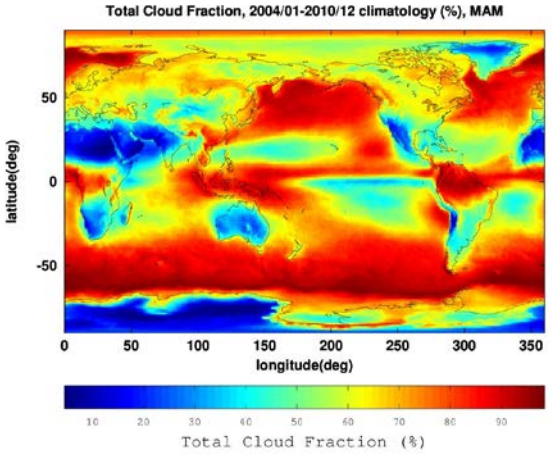
1-3. Relation of CF and precipitation to vertical wind

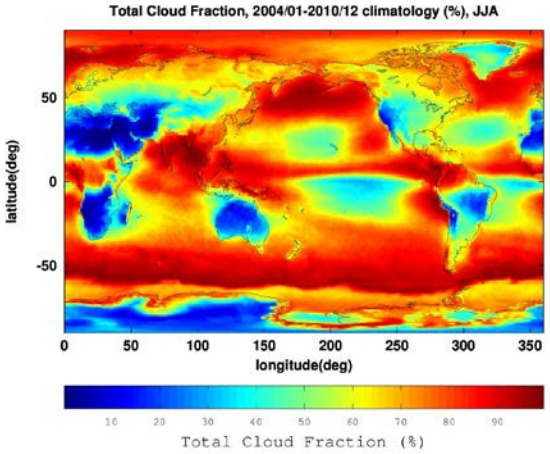
- **Compared to wind at 850 hpa and 300 hpa**

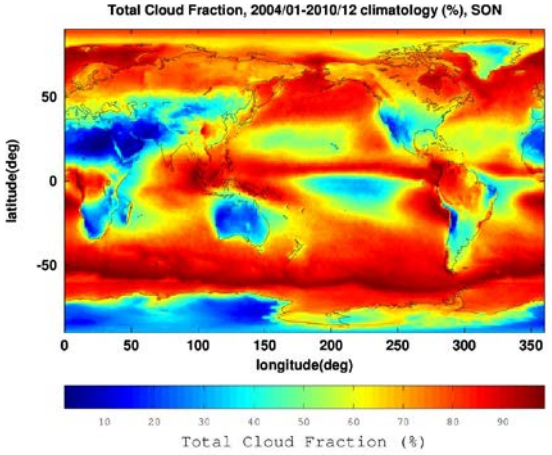
1-1-1. Cloud fraction (CF) (MODIS)



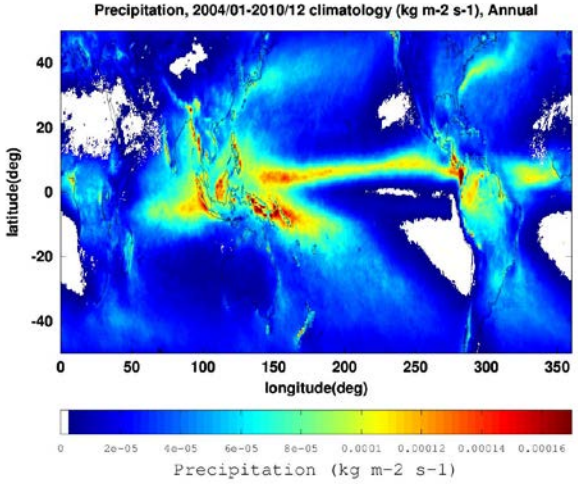


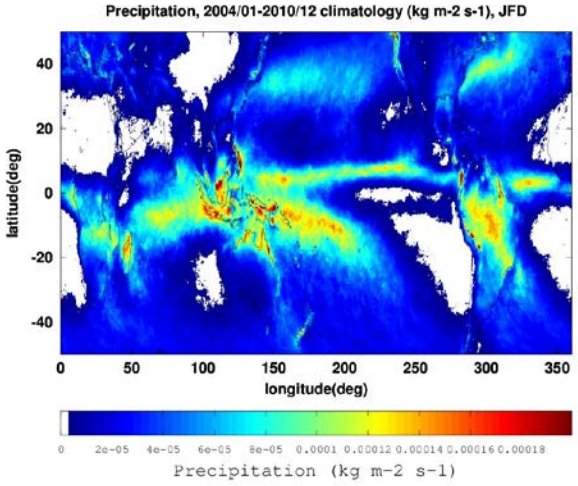


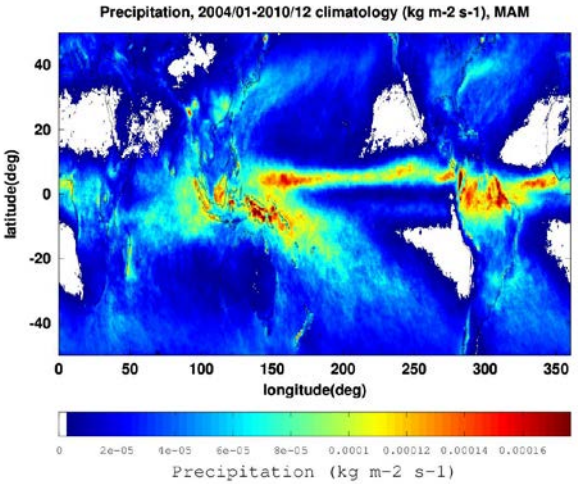


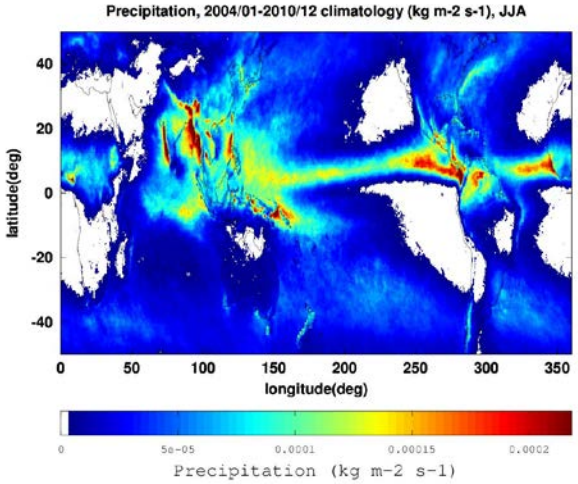


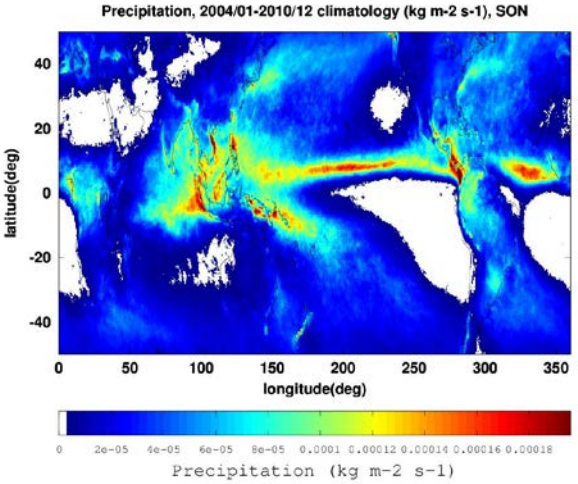
1-1-2. Precipitation (TRMM)



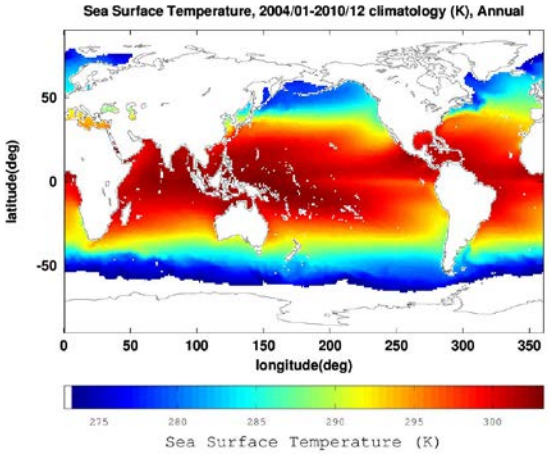


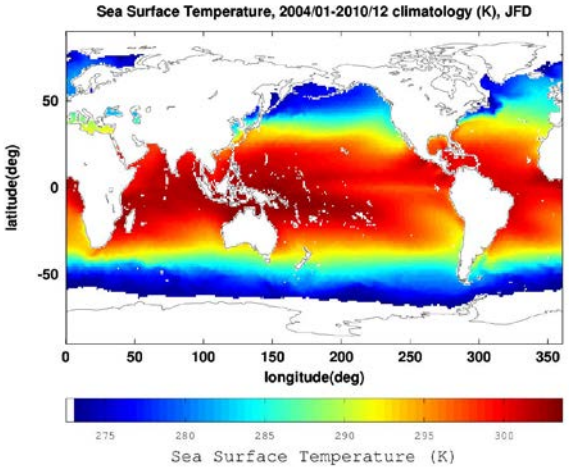


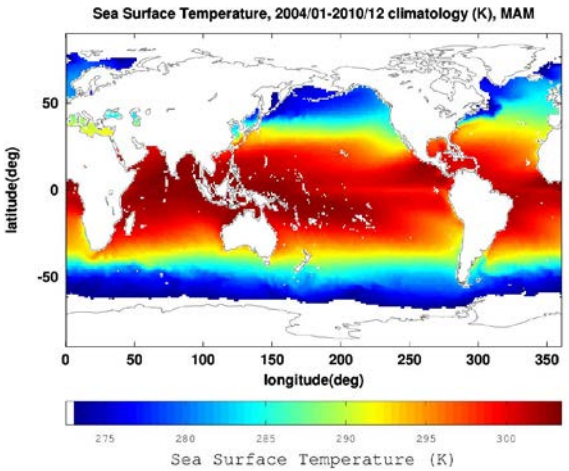


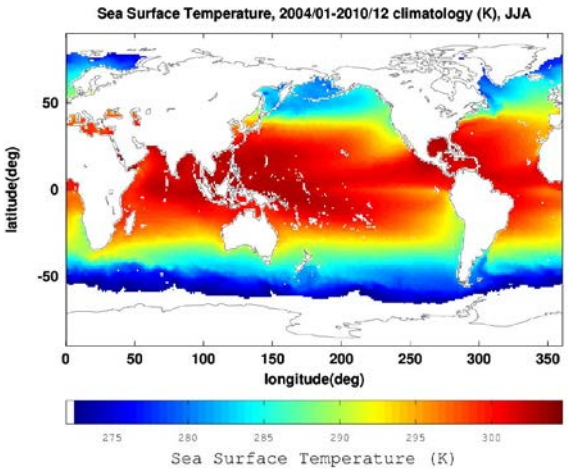


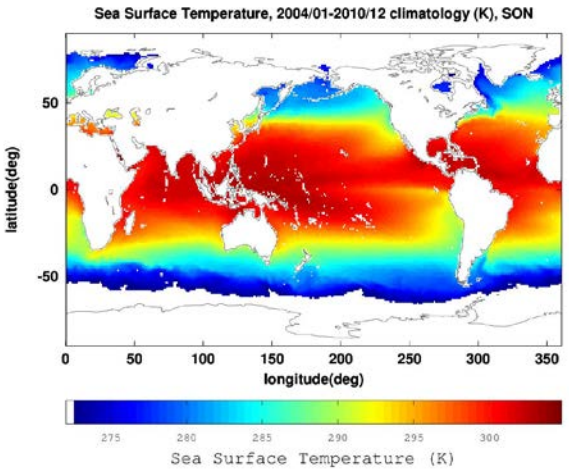
1-1-3. Sea surface temperature (SST) (AMSR-E)







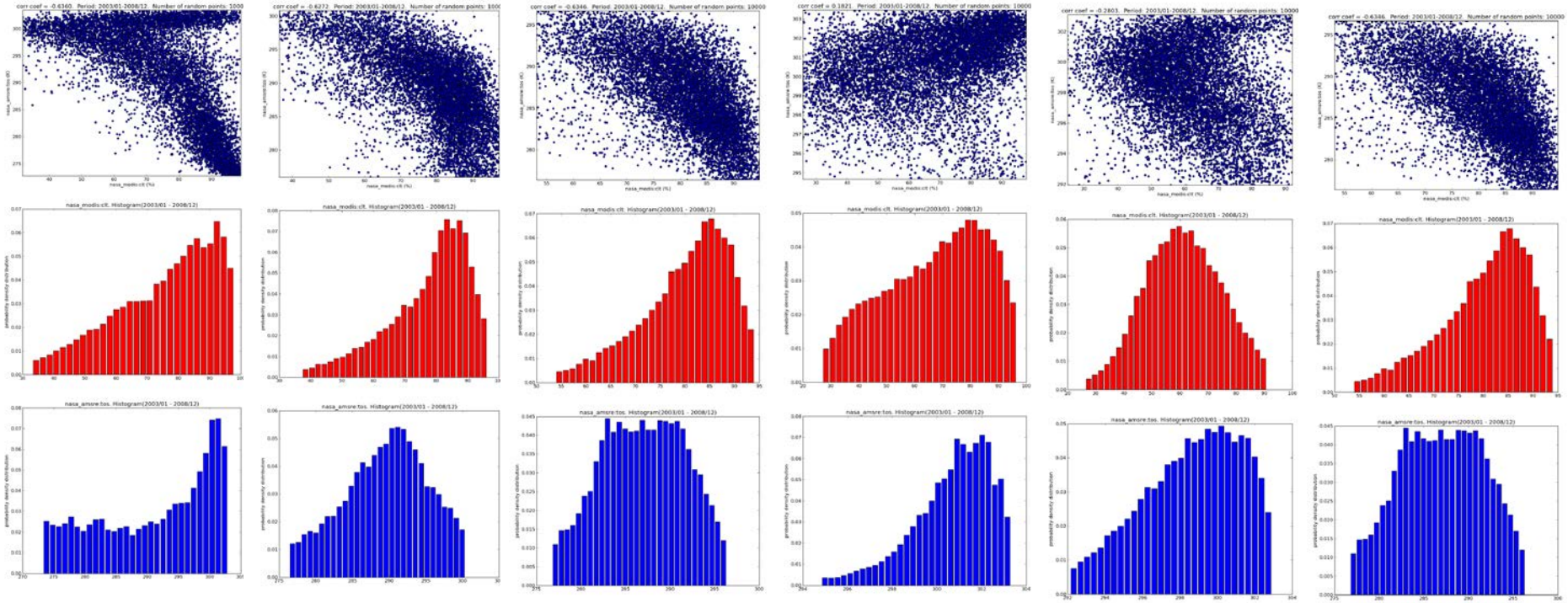




- First feeling: tropic seems a region that we need to focus on.

1-2-1. Correlation and histogram between MODIS CF and AMSR-E SST

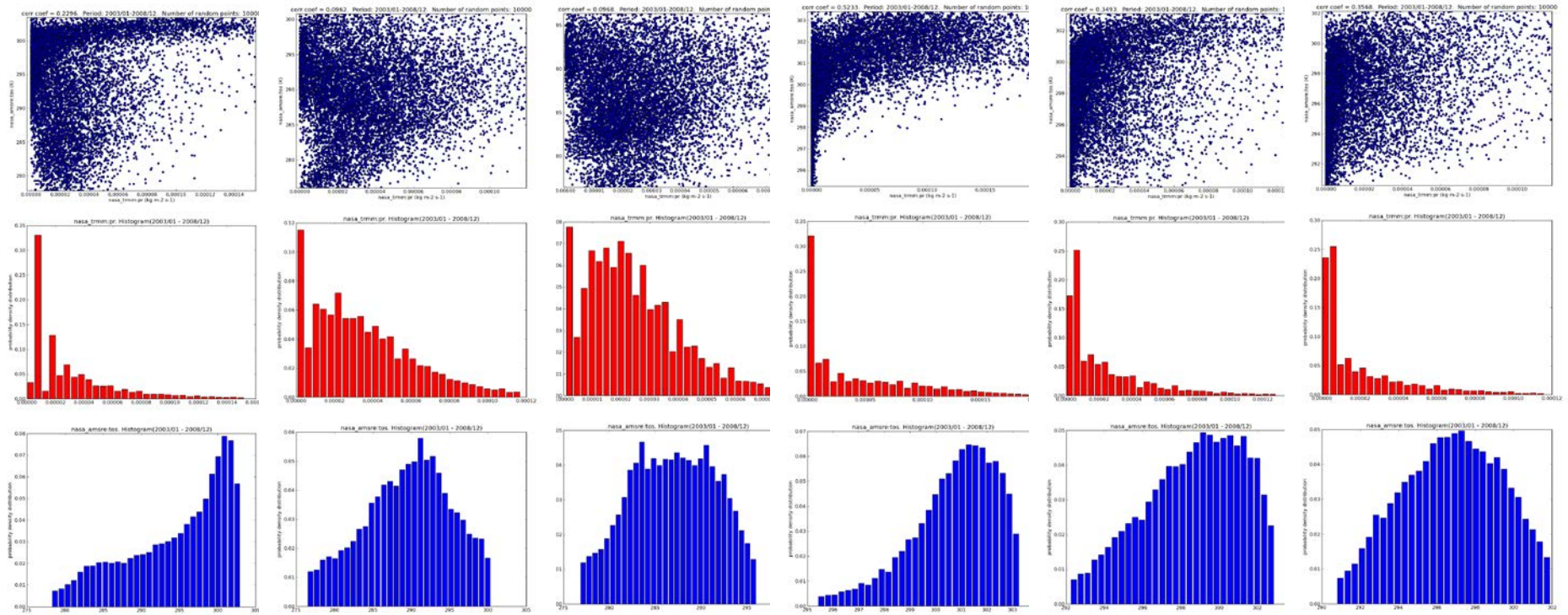
Global	Midlat (NH)	Midlat (SH)	Tropics	Subtropics (NH)	Subtropics (SH)



Finding 1: Regional difference of correlation with SST

1-2-2. Correlation and histogram between TRMM precipitation and AMSR-E SST

Global	Midlat (NH)	Midlat (SH)	Tropics	Subtropics (NH)	Subtropics (SH)

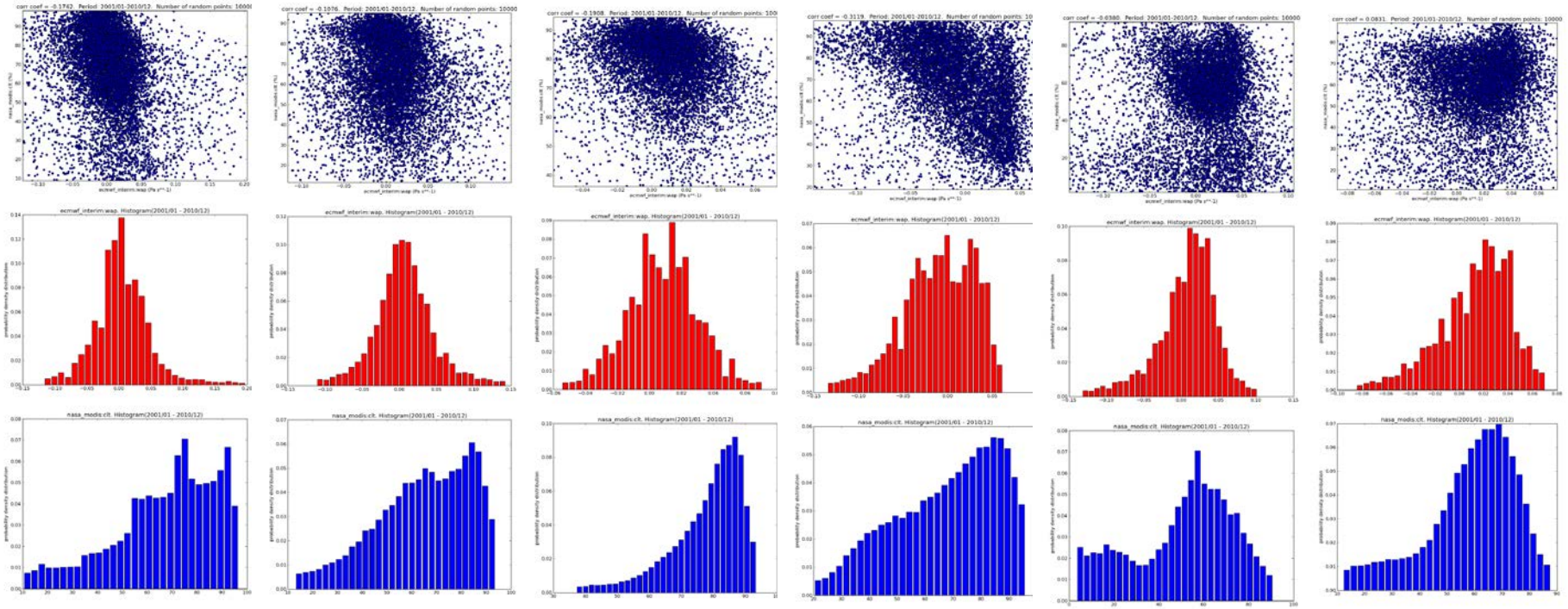


Finding 1: Regional difference of correlation with SST

Tropics: warm ocean surface – high CF and precipitation (opaque and rainy)
Others: warm ocean surface – less CF and precipitation (bright and clear)

1-3-1. Correlation and histogram between MODIS CF and ECWMF vertical wind at 850 hpa level (Pa/s)

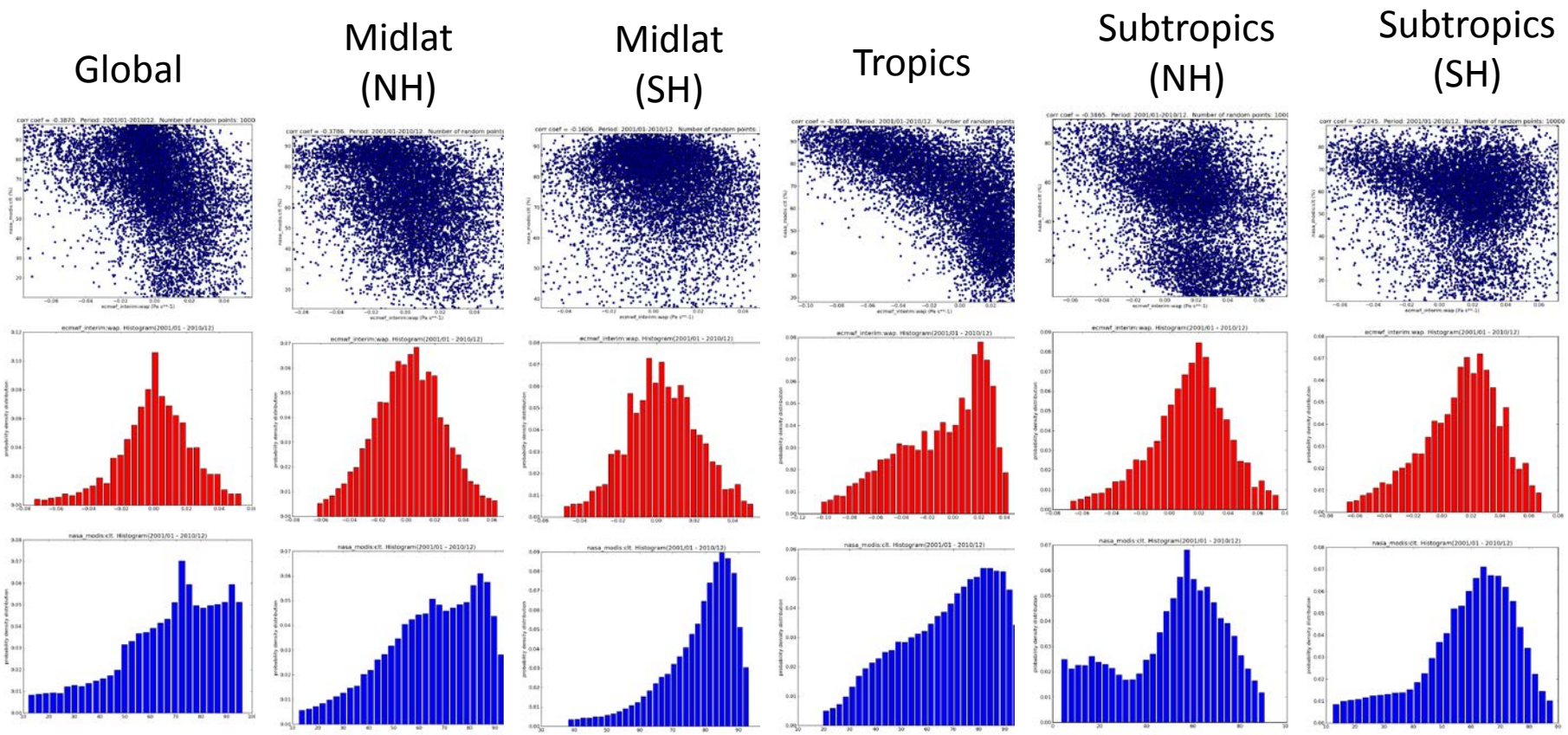
Global	Midlat (NH)	Midlat (SH)	Tropics	Subtropics (NH)	Subtropics (SH)



Vertical wind from ECMWF: Pa/s

- Positive value: downward subsidence
- Negative value : upward advection

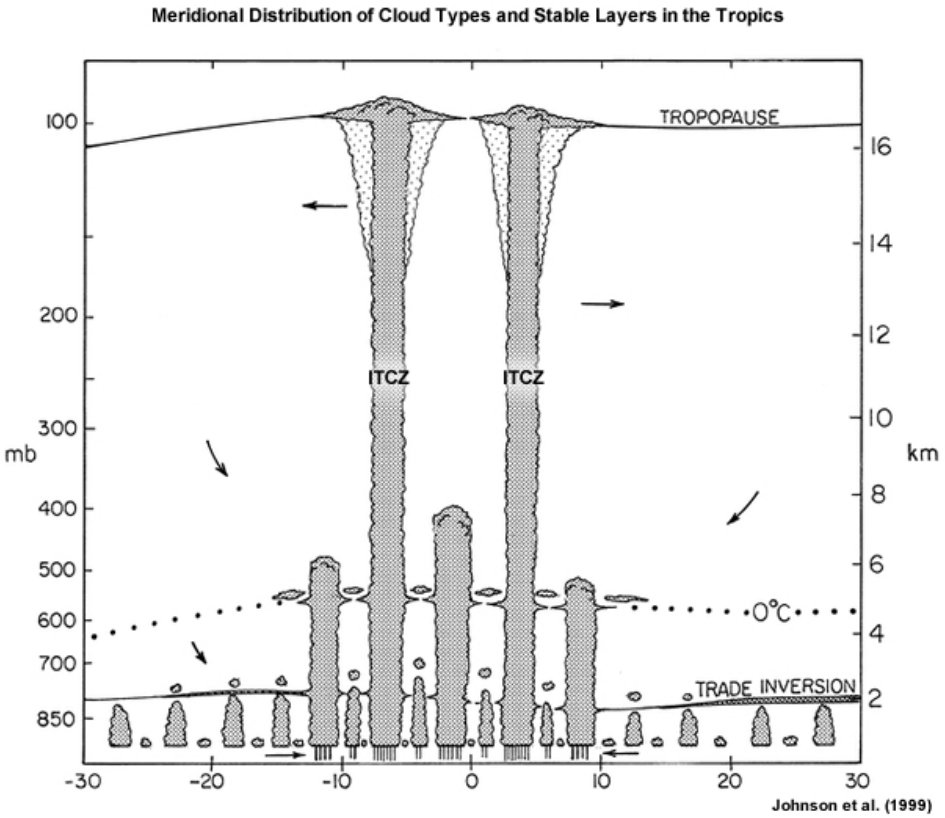
1-3-2. Correlation and histogram between MODIS CF and ECWMF vertical wind at 300 hpa level (Pa/s)



Finding 1: Regional difference of correlation with SST

Tropics: warm ocean surface – high CF and precipitation (evaporation)
- strong cloud formation in a deep convective condition (Cumulus)

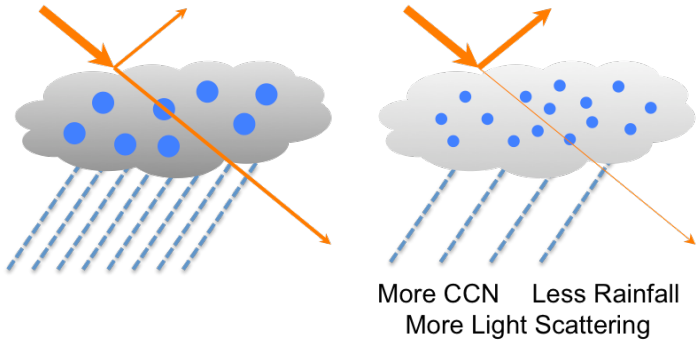
Others: warm ocean surface – less CF and precipitation (cloud indirect effect?)



Johnson et al. (J. Climate, 1999)

- Cloud formation in the convective condition of tropics

Cloud indirect effect



Q2. What are the radiative effects of clouds? How are the cloud radiative effects varying with time?

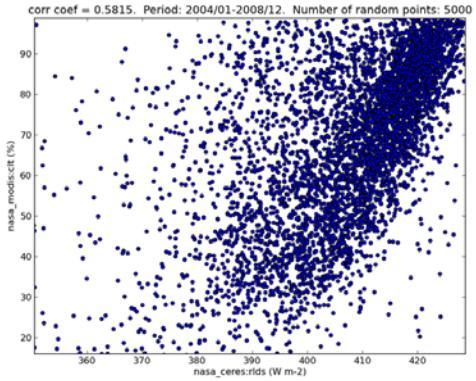
3-1. surface downwelling flux

3-2. surface upwelling flux

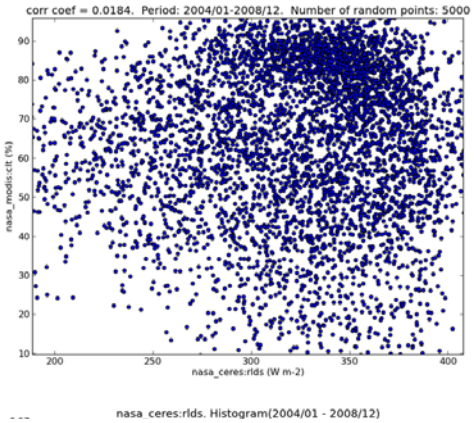
3-3. TOA SW/LW flux

3-1. surface downwelling flux

Surface downwelling flux (LW, W/m2)



Tropics



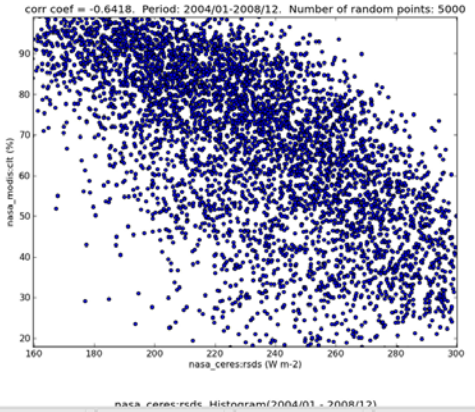
Mid-latitude (NH)

⇒ Cumulus: IR re-radiation

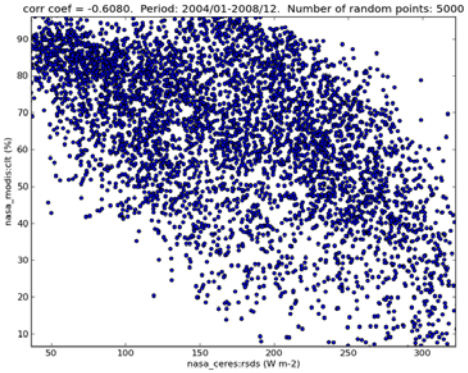
⇒ Stratus: IR absorption

High CF, Large LW ↓

Surface downwelling flux (SW, W/m2)



Tropics



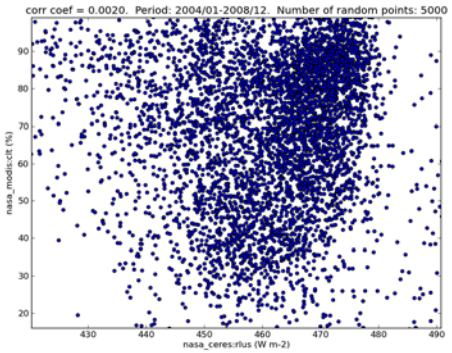
Mid-latitude (NH)

High CF, weak SW ↓

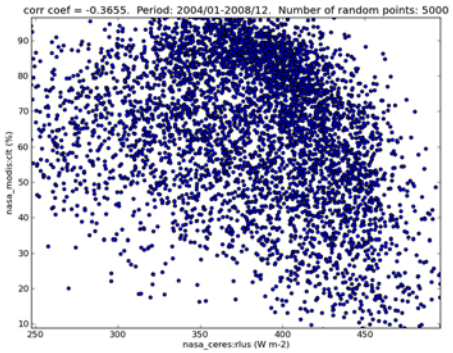
⇒ High scattering effect

Surface upwelling flux (LW, W/m2)

3-2. surface upwelling flux



Tropics



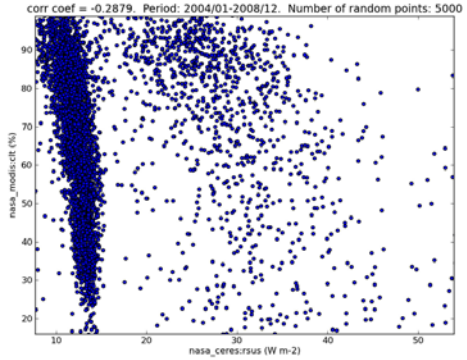
Mid-latitude (NH)

⇒ IR reradiation?

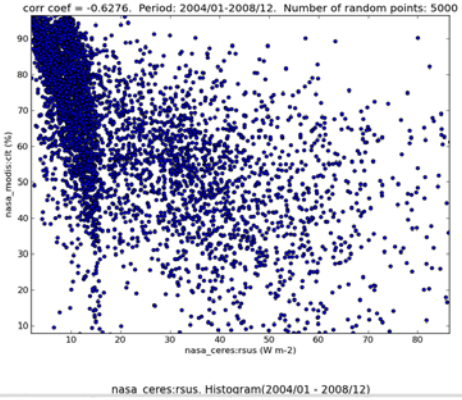
High CF, Large LW ↑

High CF, weak LW

Surface upwelling flux (SW, W/m2)



Tropics



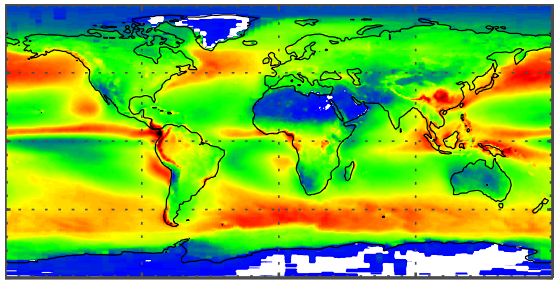
Mid-latitude (NH)

High CF, weak SW ↑

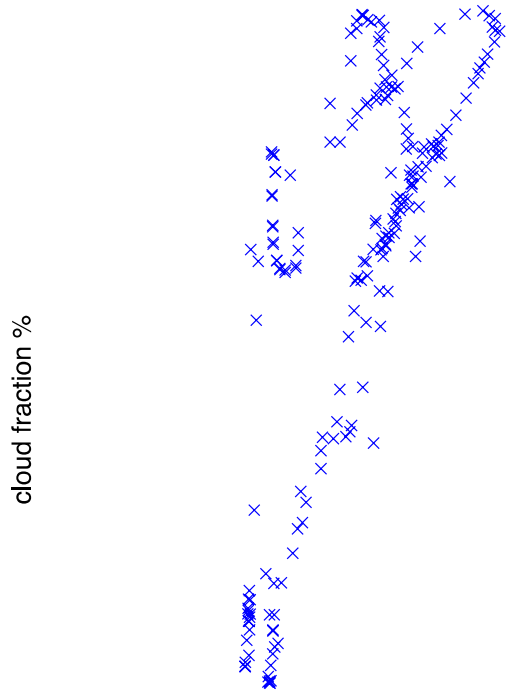
⇒ Lower incoming, lower reflection

SW cloud forcing at TOA vs MODIS cloud fraction 2004-2009

SW TOA cloud forcing



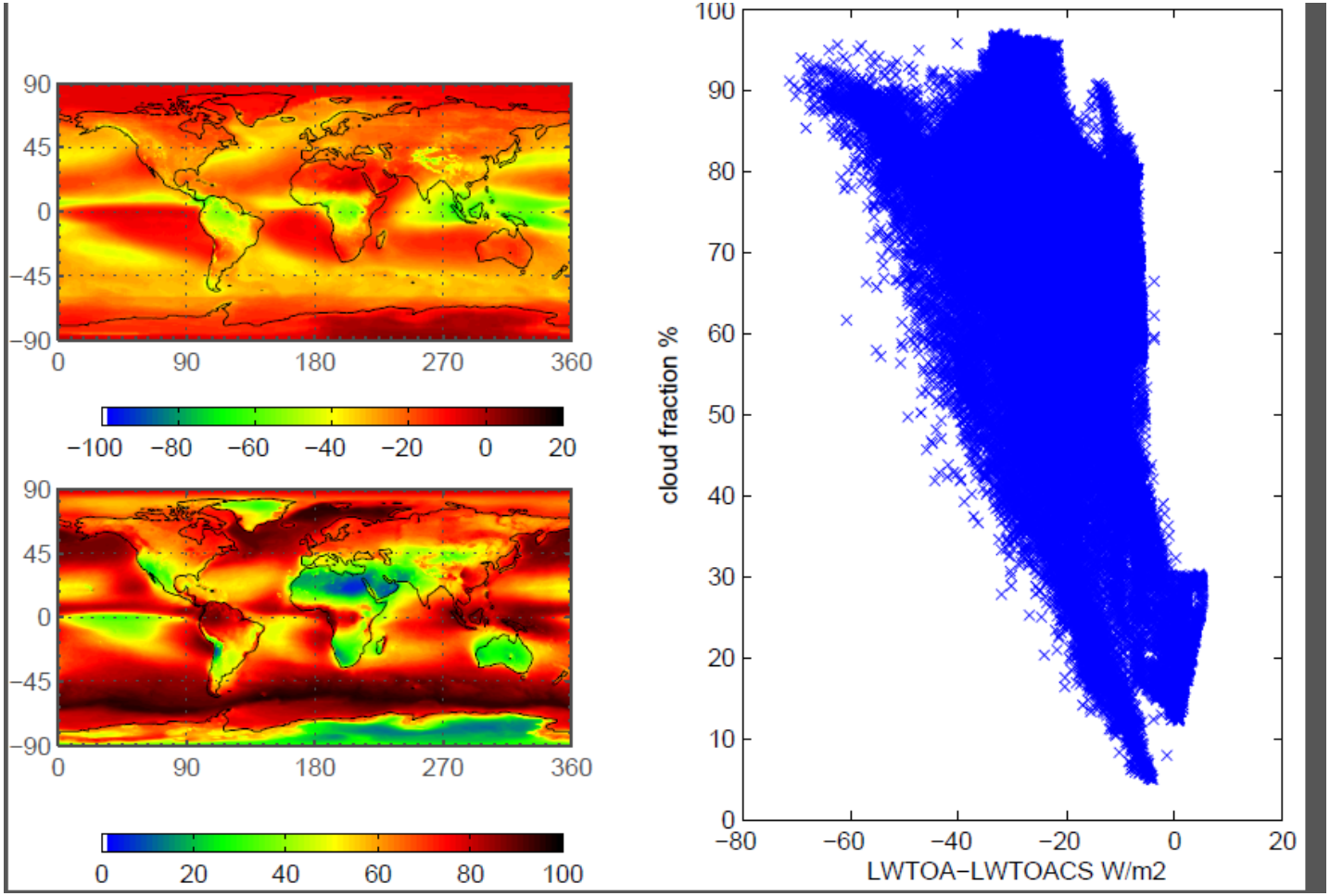
Cloud Fraction %



R = 0.716

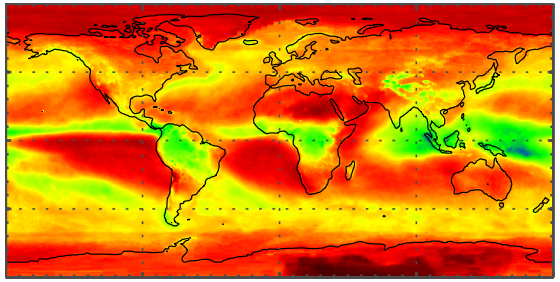
⇒ High reflection by the cloud

LW cloud forcing at TOA vs MODIS cloud fraction 2004-2009

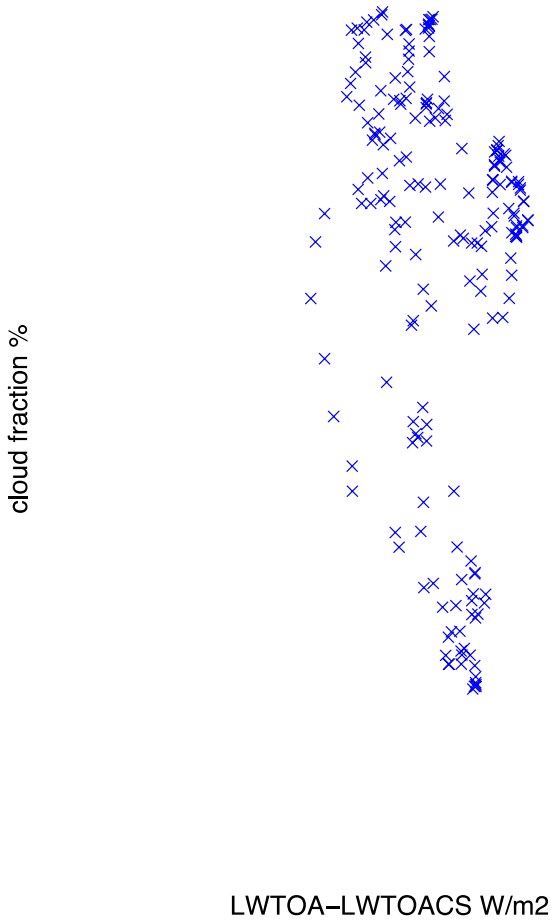


LW cloud forcing at TOA vs MODIS cloud fraction: 2004

LW tOA cloud forcing



Cloud Fraction %

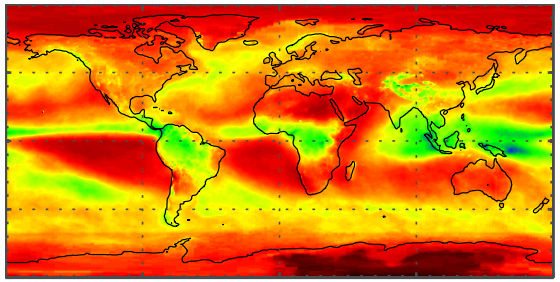


R = -0.492

⇒ Opaque by the cloud

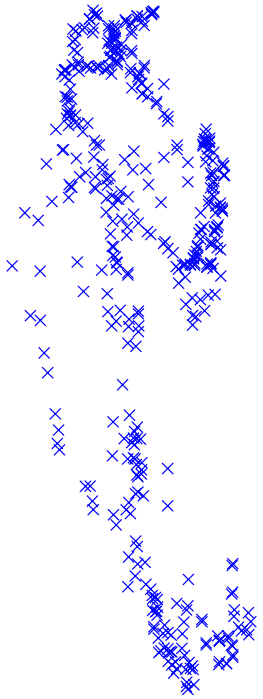
LW cloud forcing at TOA vs MODIS cloud fraction: 2005

LW tOA cloud forcing



Cloud Fraction %

cloud fraction %

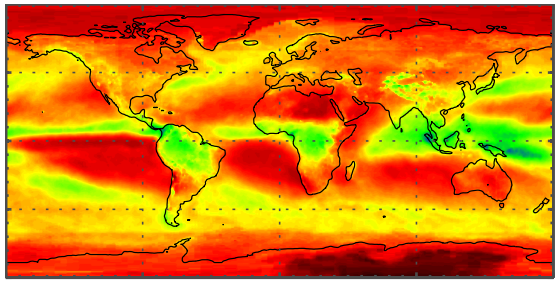


R = -0.544

LWTOA–LWTOACS W/m2

LW cloud forcing at TOA vs MODIS cloud fraction: 2006

LW tOA cloud forcing



R = -0.512

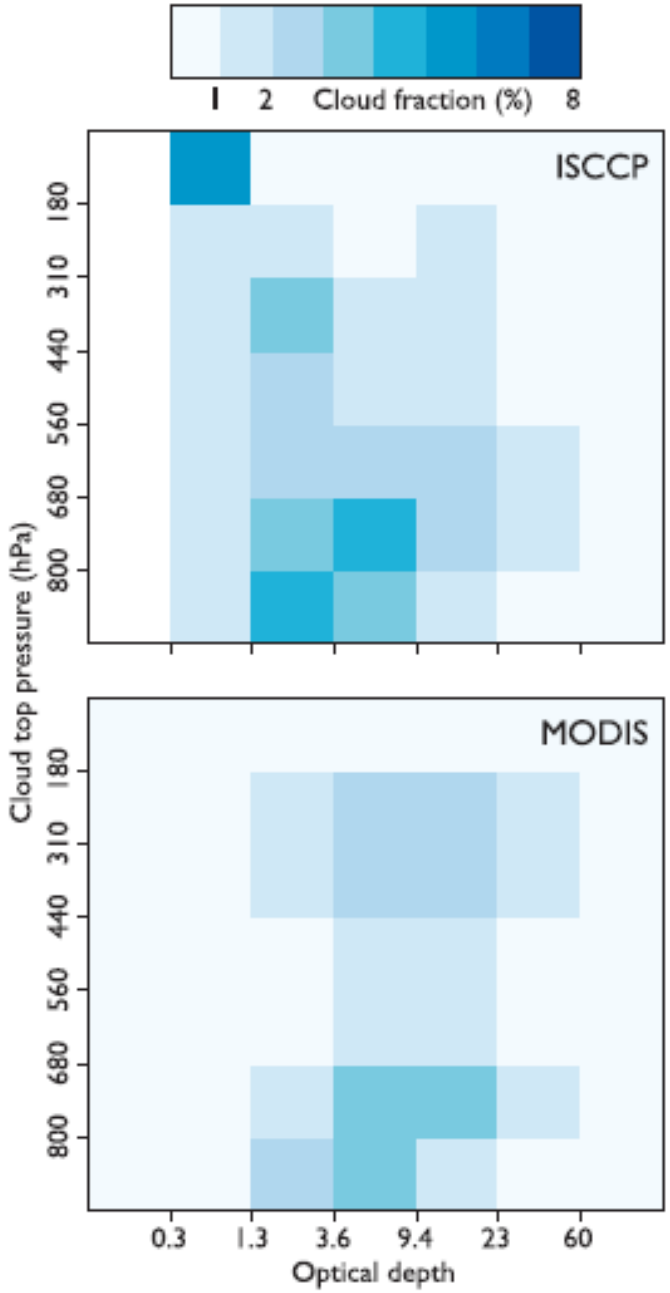
Cloud Fraction %

cloud fraction %

ACS W/m2

Which parameter is close to the best representative cloud information?

- Cloud fraction
- Cloud top height
- Cloud optical depth
- Cloud thickness ?



Pincus et al. (J. Climate 2014)

Q3. What are the seasonal and interannual variations of clouds and precipitation over the regional above? Are there detectable trends in each region? Are these temporal evolutions correlated with underlying sea surface temperature changes?

2-1. Time series of CF and precipitation

2-1-1. MODIS Cloud fraction

2-1-2. TRMM precipitation

2-1-3. AMSR-E SST

2-2. The comparison of annual/seasonal zonal mean (not shown all)

(1) annual

(2) winter (DJF)

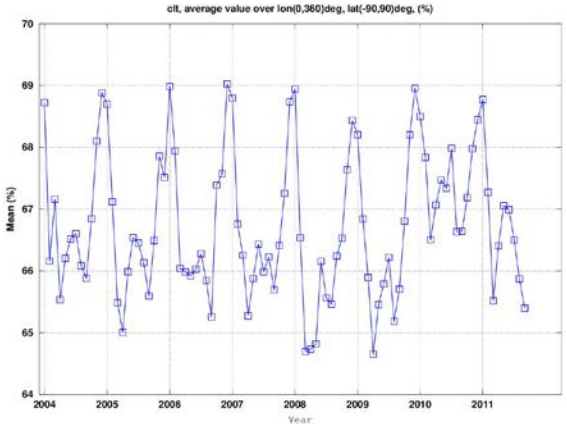
(3) spring (MAM)

(4) summer (JJA)

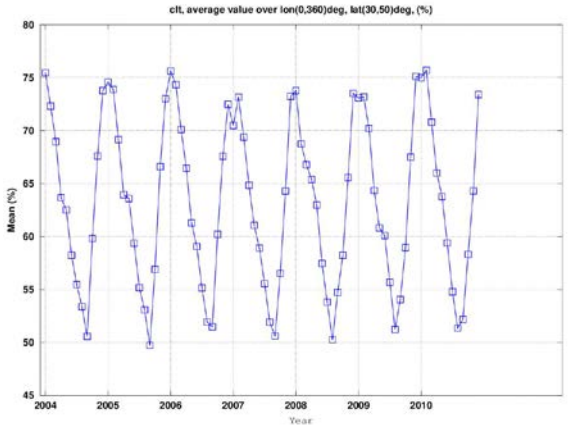
(5) Autumn (SON)

2-1-1. Time series, MODIS CF

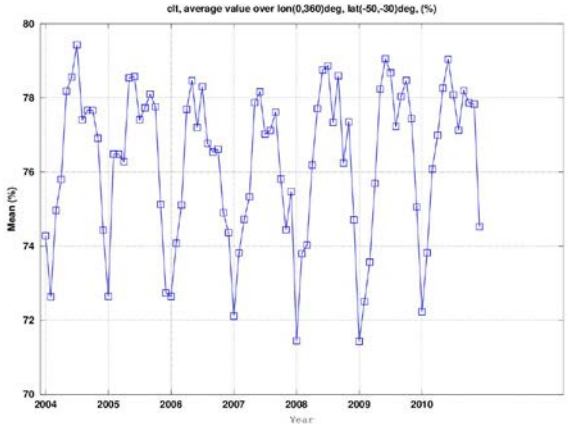
Global



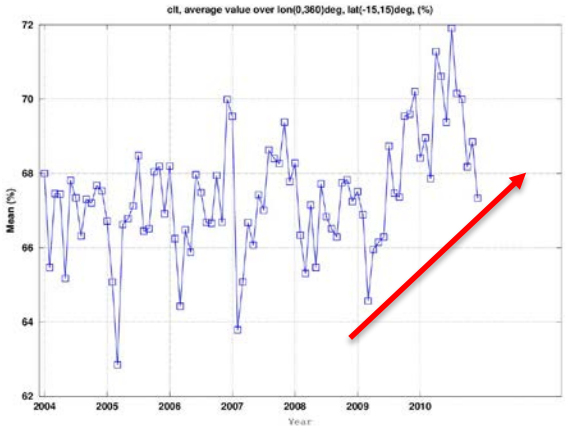
Midlat (NH)



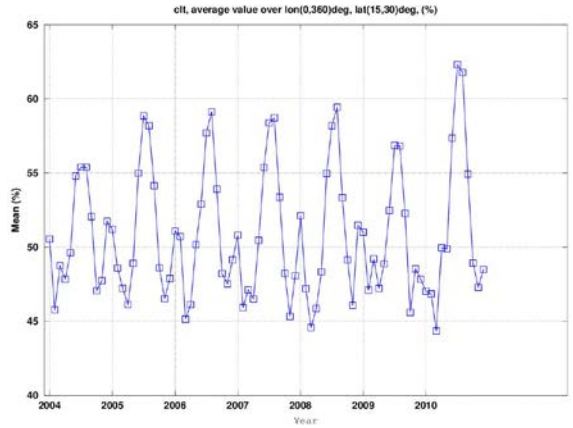
Midlat (SH)



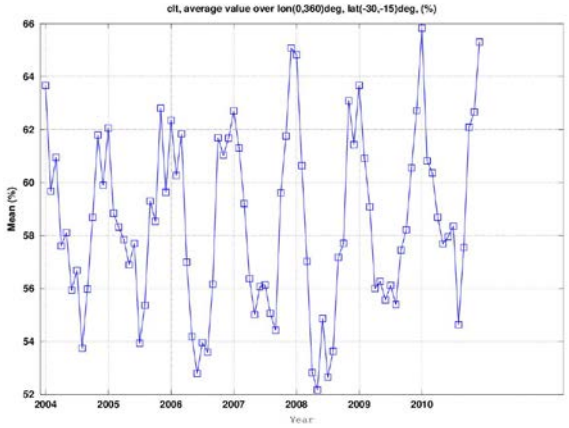
Tropics



Subtropics (NH)



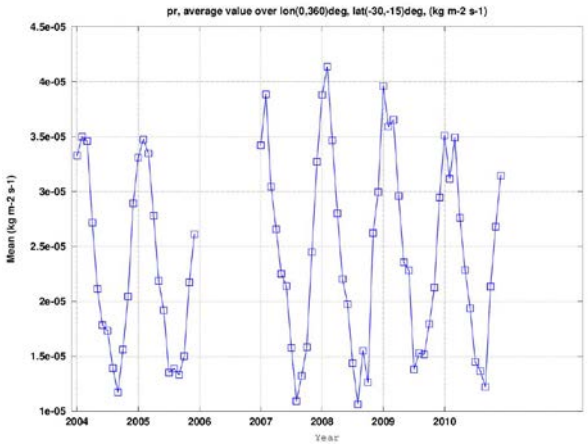
Subtropics (SH)



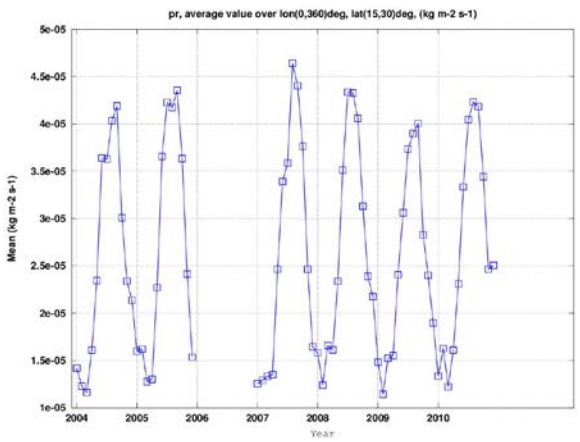
Finding 2: some particular trends in tropics?

2-1-2. Time series, TRMM Precipitation

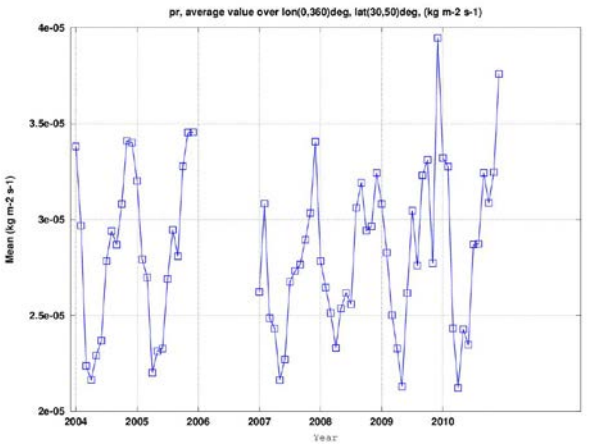
Global



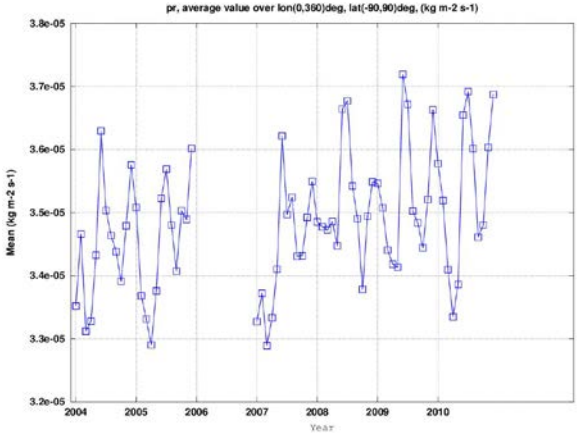
Midlat (NH)



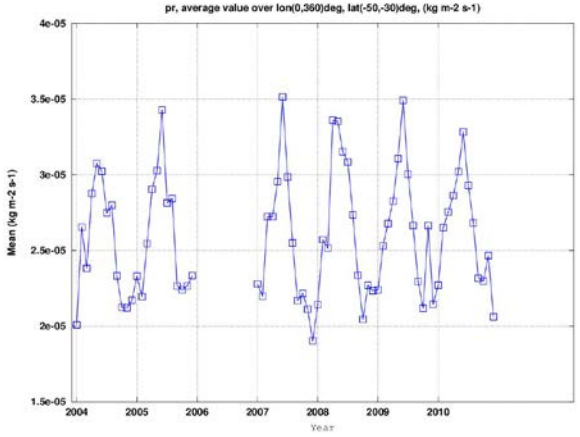
Midlat (SH)



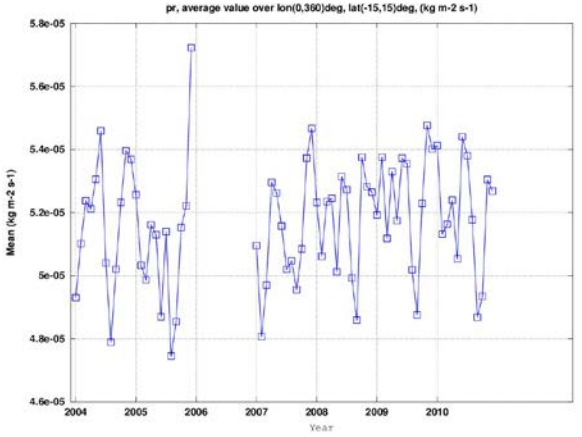
Tropics



Subtropics (NH)

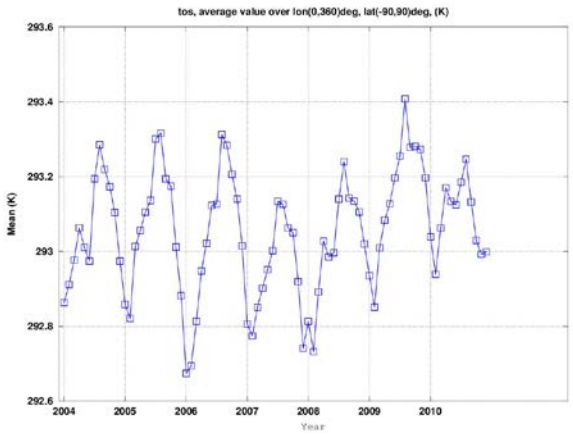


Subtropics (SH)

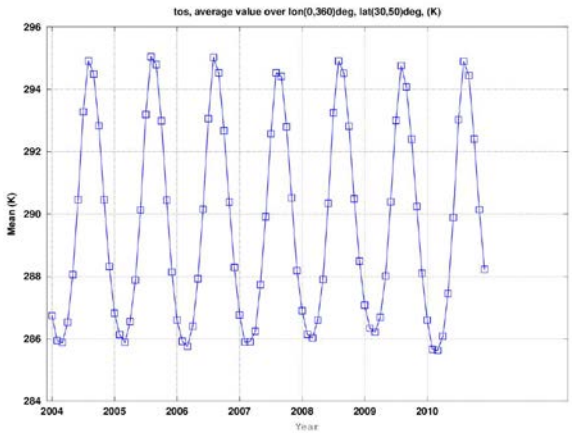


2-1-3. Time series, AMSR-E SST

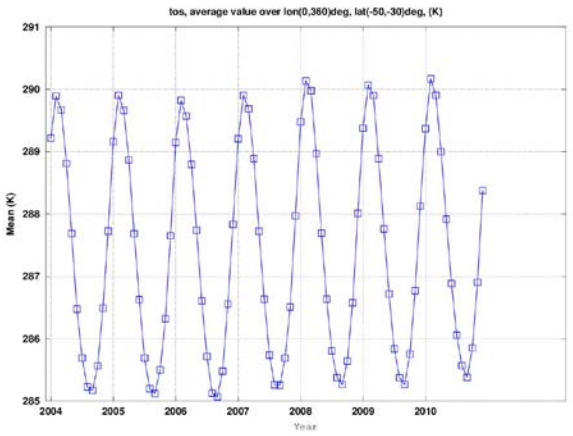
Global



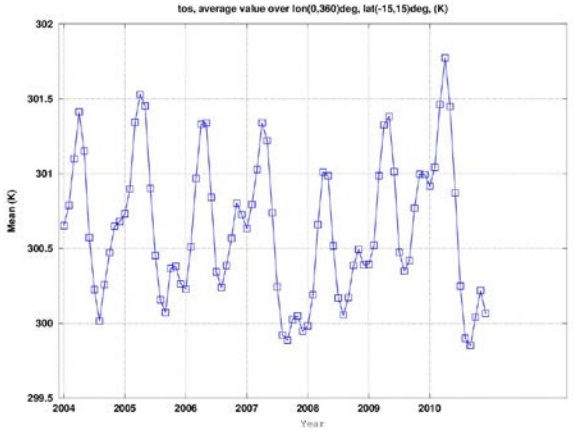
Midlat (NH)



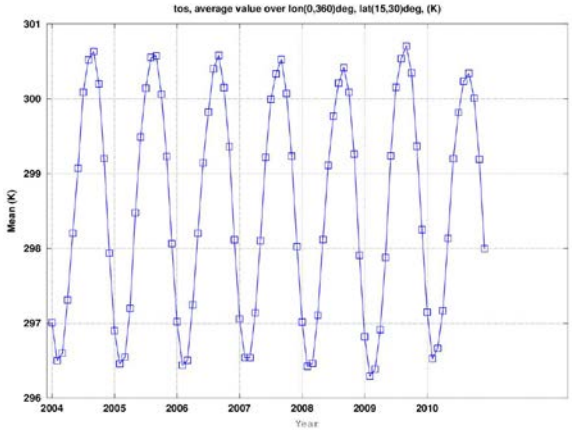
Midlat (SH)



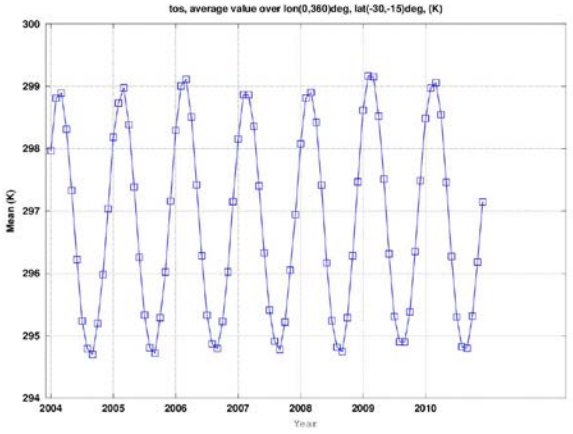
Tropics



Subtropics (NH)



Subtropics (SH)



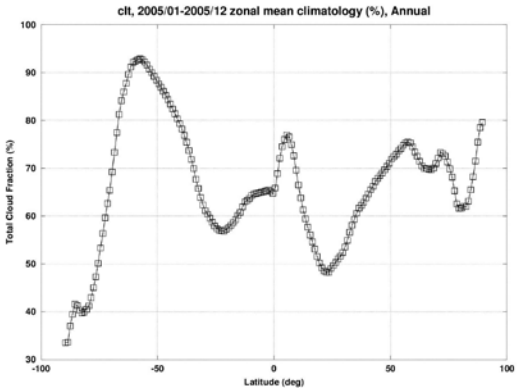
Finding 2: some particular trends in tropics?

- Only CF trend seems clear over the tropics

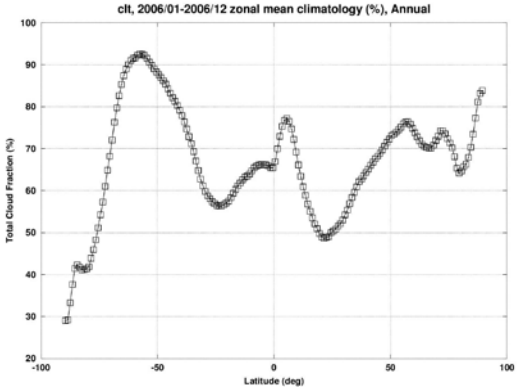
2-2. Zonal mean, MODIS CF and TRMM precipitation (just example)

1) annual mean

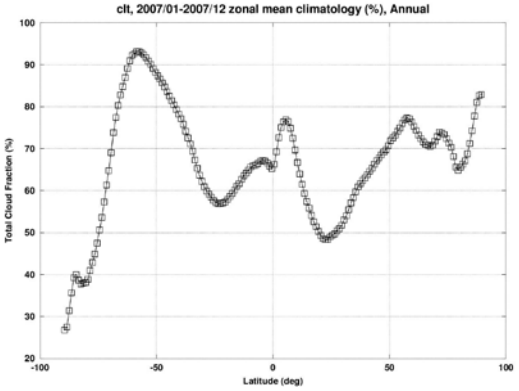
2005



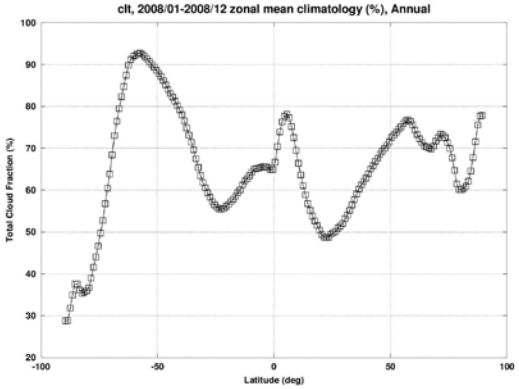
2006



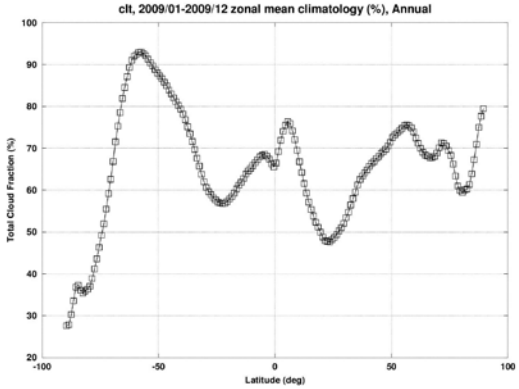
2007



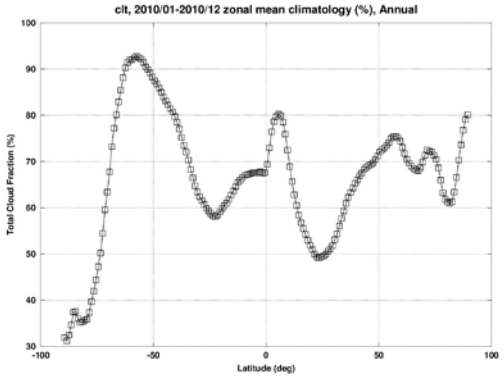
2008



2009

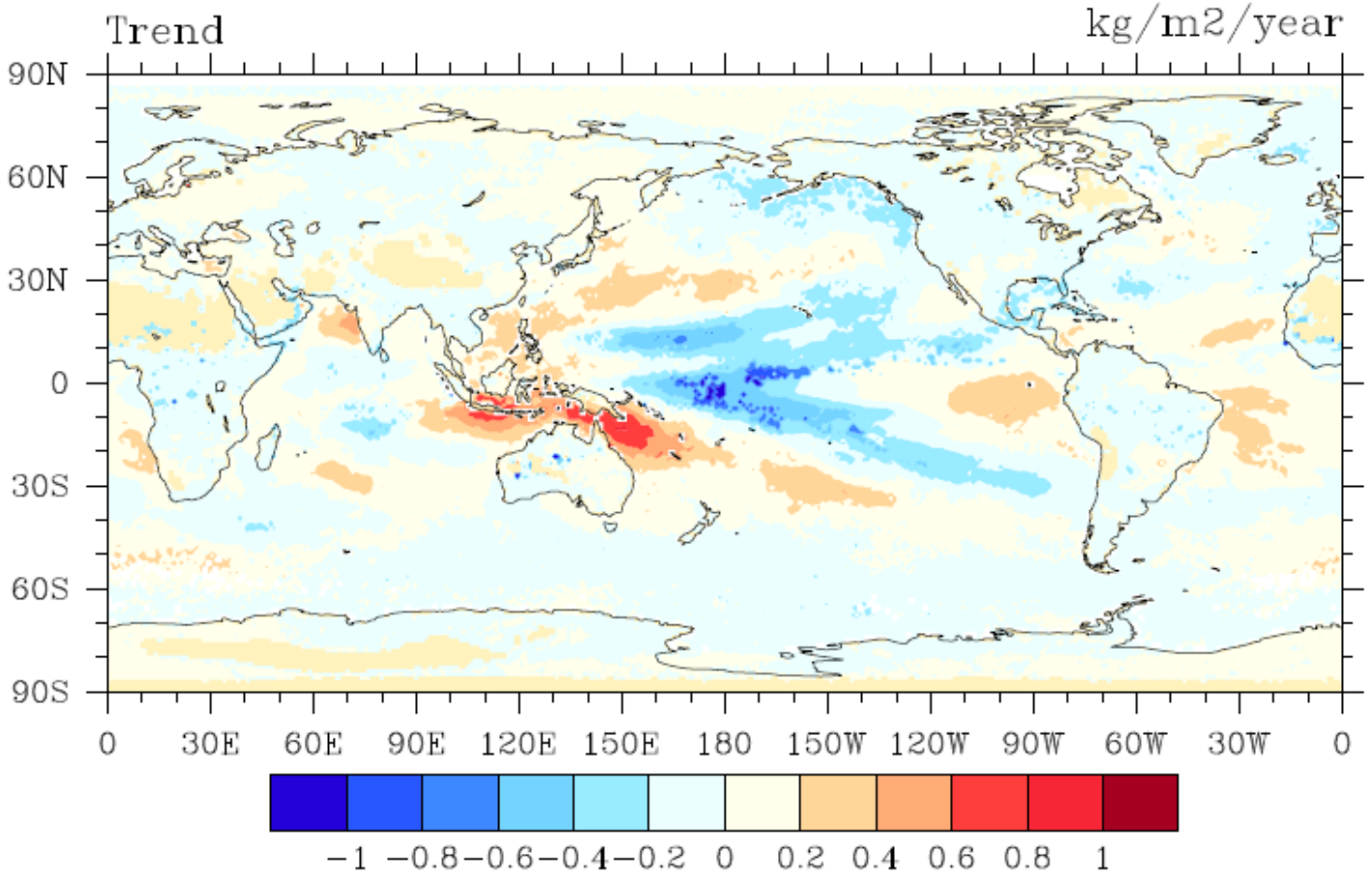


2010



- Hard to find an clear feature using zonal mean pattern

Trend of AIRS precipitable water (column integrated moisture) in the global scale

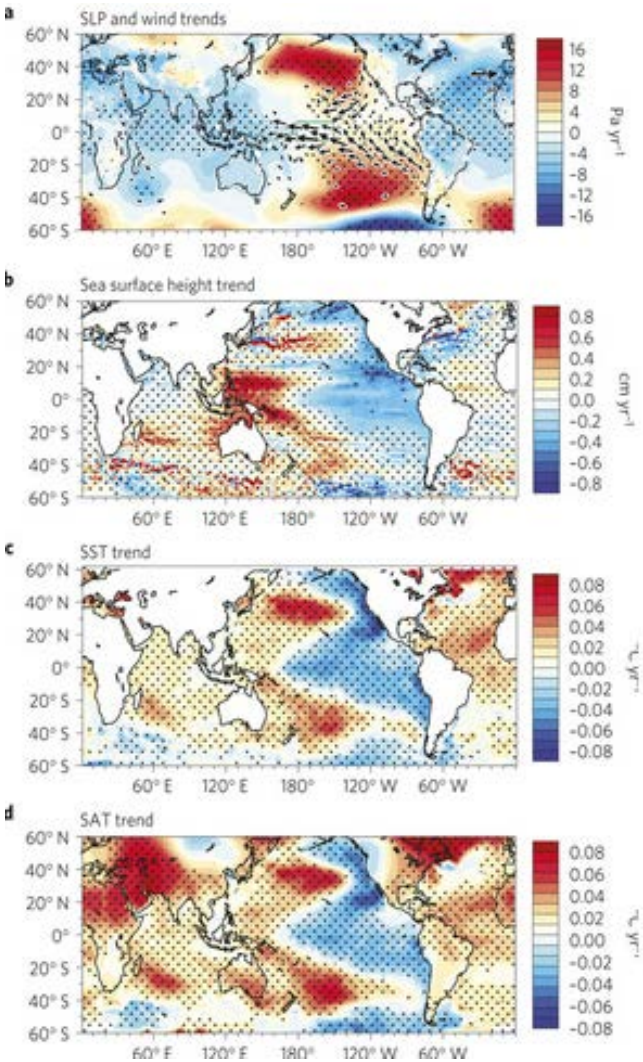


Finding 2: some particular trends in tropics?

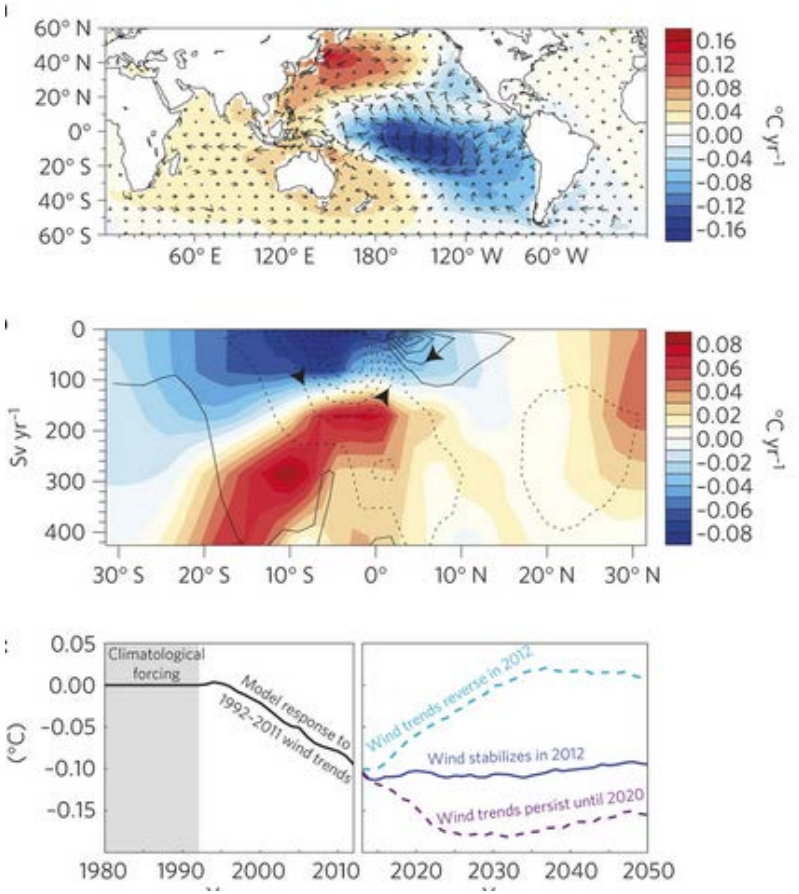
- Only CF trend seems clear over the tropics
- Zonal mean analysis may not be best way to see variation of the cloud and precipitation (affected by the tropospheric process strongly) – need other criteria?

Recent intensification of wind-driven circulation in the Pacific and the ongoing warming hiatus

Matthew H. England, Shayne McGregor, Paul Spence, Gerald A. Meehl, Axel Timmermann, Wenju Cai, Alex Sen Gupta, Michael J. McPhaden, Ariaan Purich & Agus Santoso



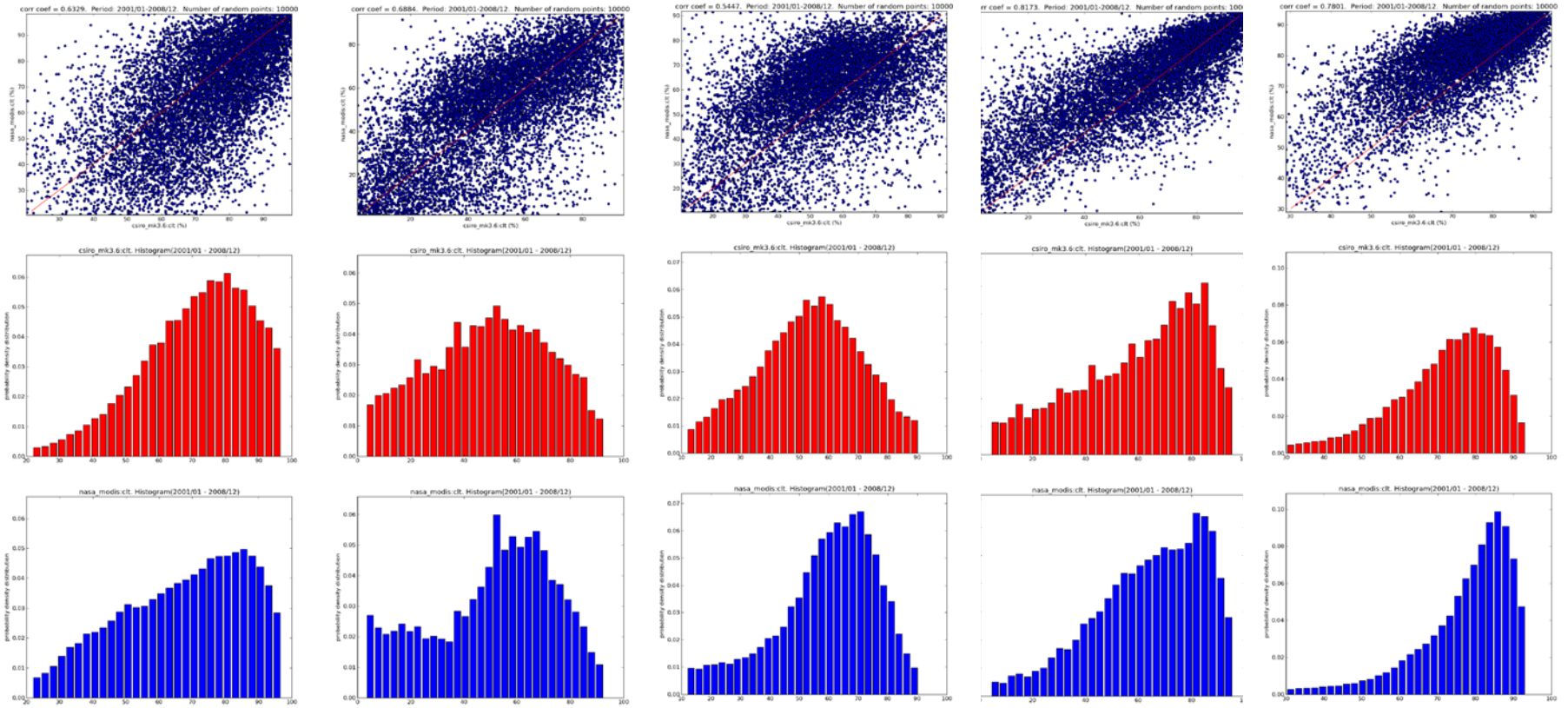
England et al.
(Nature climate change, 2014)



Optional discussion:

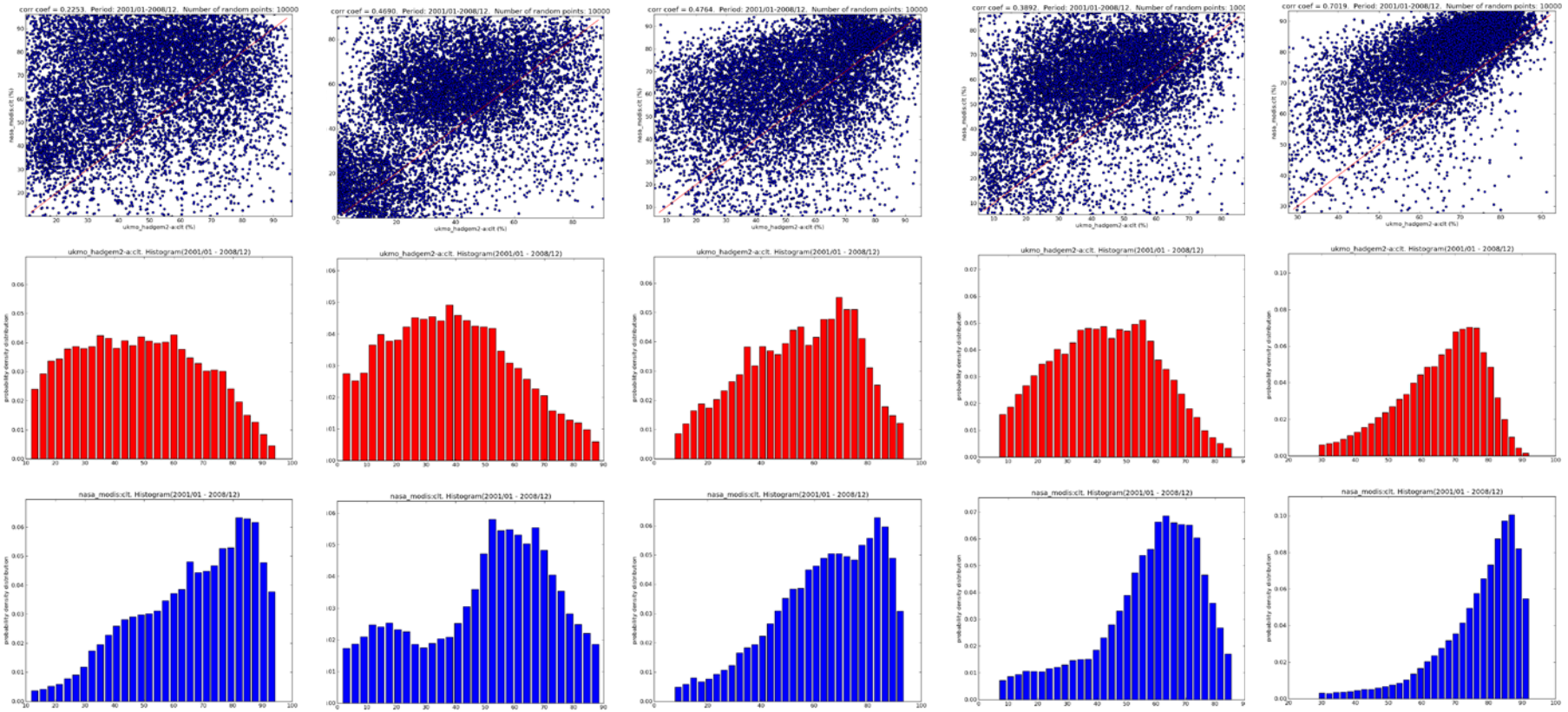
Inter-comparison of cloud fraction between model and observation

- MODIS CF vs. CSIRO CF



- Good correlation & consistent distribution in general.

- MODIS CF vs. UKMO CF



- Poor correlation comparing to previous one.

Evaluation of cloud and water vapor simulations in CMIP5 climate models using NASA "A-Train" satellite observations

Jonathan H. Jiang,[1] Hui Su,[1] Chengxing Zhai,[1] Vincent S. Perun,[1] Anthony Del Genio,[2] Larissa S. Nazarenko,[2] Leo J. Donner,[3] Larry Horowitz,[3] Charles Seman,[3] Jason Cole,[4] Andrew Gettelman,[5] Mark A. Ringer,[6] Leon Rotstayn,[7] Stephen Jeffrey,[8] Tongwen Wu,[9] Florent Brient,[10] Jean-Louis Dufresne,[10] Hideaki Kawai,[11] Tsuyoshi Koshiro,[11] Masahiro Watanabe,[12] Tristan S. LÉcuyer,[13] Evgeny M. Volodin,[14] Trond Iversen,[15] Helge Drange,[16] Michel D. S. Mesquita,[16] William G. Read,[17] Joe W. Waters,[17] Baijun Tian,[17] Joao Teixeira,[17] and Graeme L. Stephens[17]

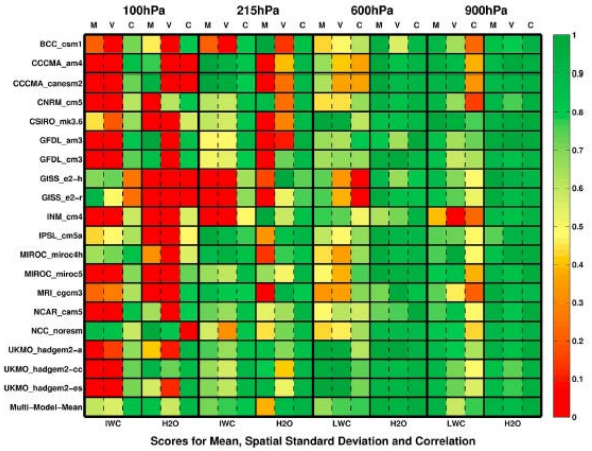
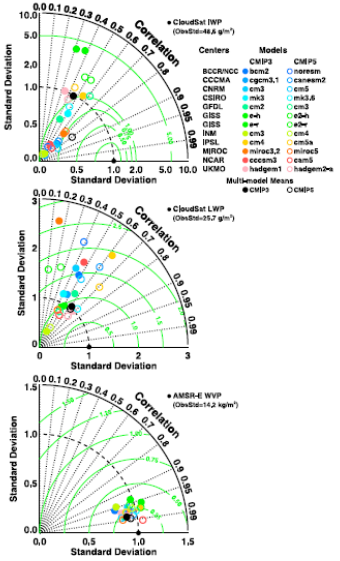


Figure 11. Color-coded summary of performance scores at 100, 215, 600, and 900 hPa. M: spatial mean performance scores G_m; V: spatial variance performance scores G_v; C: spatial correlation performance scores G_c.

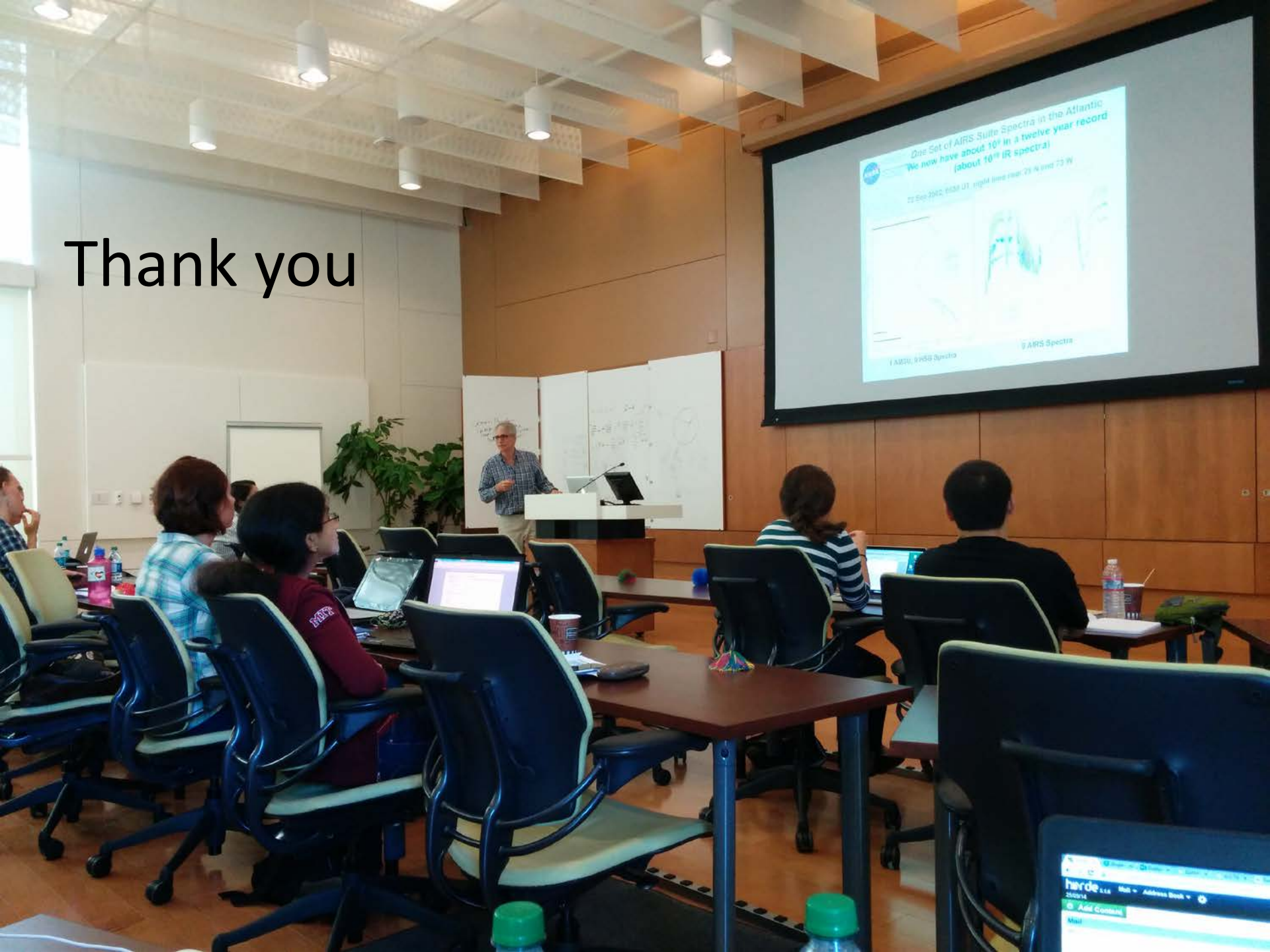
Jiang et al. (JGR, 2012) – Remenber Wednesday

Table 7. Overall Scores and Ranks for the CMIP5 Models at Individual Pressure Levels

	100 hPa		215 hPa		600 hPa		900 hPa	
CMIP5 Model	Score	Rank	Score	Rank	Score	Rank	Score	Rank
BCC csm1	0.37	7	0.50	12	0.65	10	0.73	10
CCCMA am4	0.27	12	0.67	7	0.70	8	0.84	3
CCCMA canesm2	0.28	11	0.64	8	0.69	9	0.82	5
CNRM cm5	0.34	8	0.67	7	0.71	7	0.72	11
CSIRO mk3.6	0.31	10	0.53	11	0.86	3	0.92	1
GFDL am3	0.44	4	0.49	13	0.76	5	0.86	2
GFDL cm3	0.40	5	0.58	10	0.80	4	0.79	7
GISS e2-h	0.28	11	0.42	14	0.57	12	0.81	6
GISS e2-r	0.27	12	0.33	15	0.63	11	0.81	6
INM cm4	0.19	14	0.49	13	0.71	7	0.56	13
IPSL cm5a	0.34	8	0.79	1	0.76	5	0.76	9
MIROC miroc4h	0.51	3	0.74	4	0.70	8	0.83	4
MIROC miroc5	0.24	13	0.70	6	0.75	6	0.79	7
MRI cgcm3	0.32	9	0.70	6	0.65	10	0.69	12
NCAR cam5	0.38	6	0.73	5	0.69	9	0.81	6
NCC noresm	0.69	1	0.62	9	0.70	8	0.79	7
UKMO hadgem2-a	0.38	6	0.78	2	0.91	1	0.84	3
UKMO hadgem2-cc	0.54	2	0.70	6	0.90	2	0.77	8
UKMO hadgem2-es	0.38	6	0.76	3	0.91	1	0.79	7
Multi-model mean	0.72	-	0.74	-	0.84	-	0.84	-



- Need to include more information?


Thank you
One Set of AIRS Suite Spectra in the Atlantic
We now have about 10⁸ in a twelve year record
(about 10¹⁰ IR spectra)
9 AIRS Spectra

Can Model Cloud Radiative Effects be Used to Constrain Climate Sensitivity?

Aditi, Octavia, Alex and Hailey

JPL Climate Science Summer School
September 26, 2014

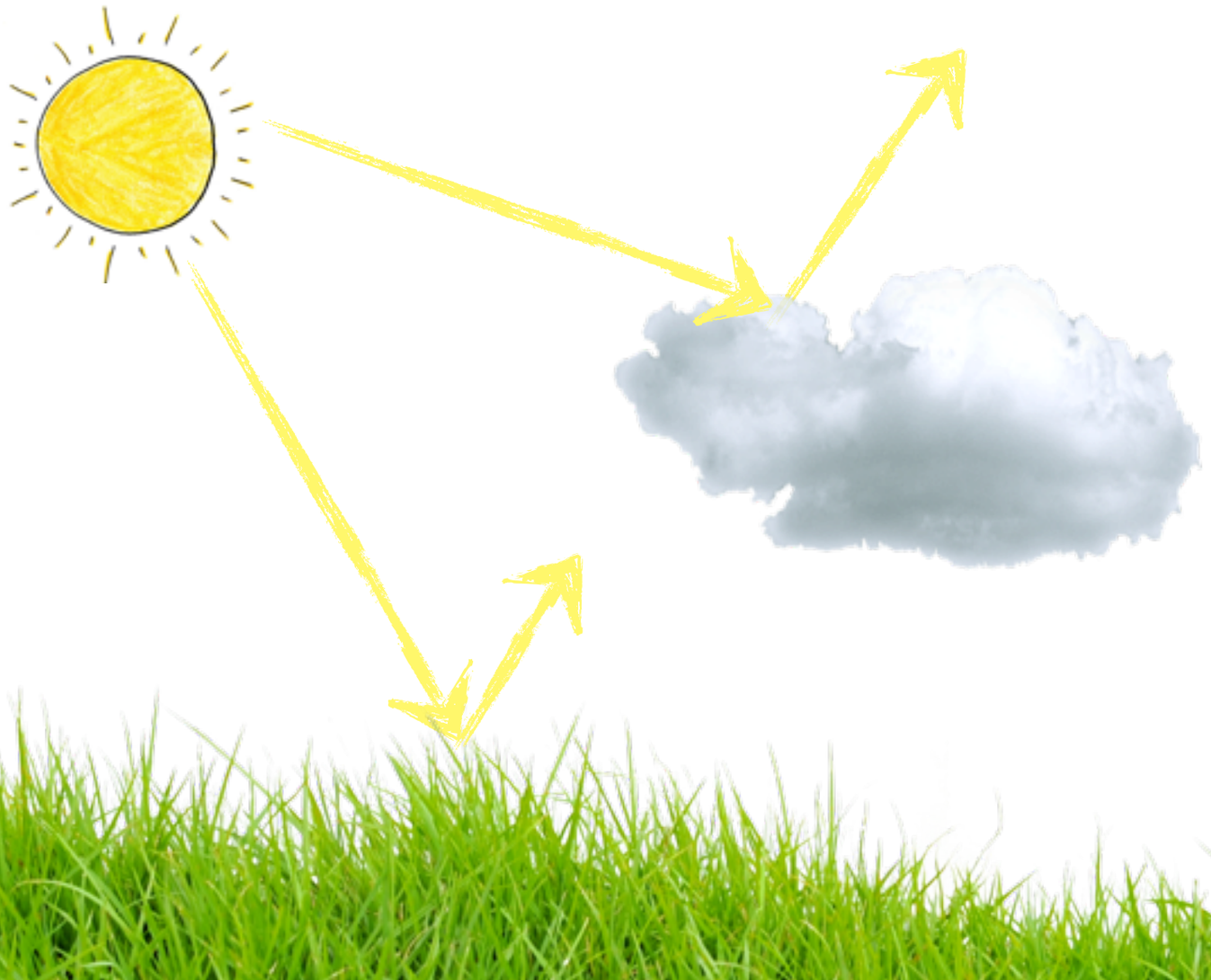
What is Cloud Radiative Effect?

- Impact of presence of clouds on SW and LW radiative fluxes

What is CRE?

- Impact of presence of clouds on SW and LW radiative fluxes

- Clouds relect SW radiation - cooling effect



What is CRE?

- Impact of presence of clouds on SW and LW radiative fluxes

- Clouds absorb/emit LW radiation - warming effect

How do you compute CRE?

- SW CRE = all-sky SW flux - clear-sky SW flux
- LW CRE = all-sky LW flux - clear-sky LW flux
- Net CRE = SW CRE + LW CRE
- We focus at the top of atmosphere

Our Analysis

- **Data:** 6 AMIP models and CERES TOA flux observations to compute SW, LW and net CRE

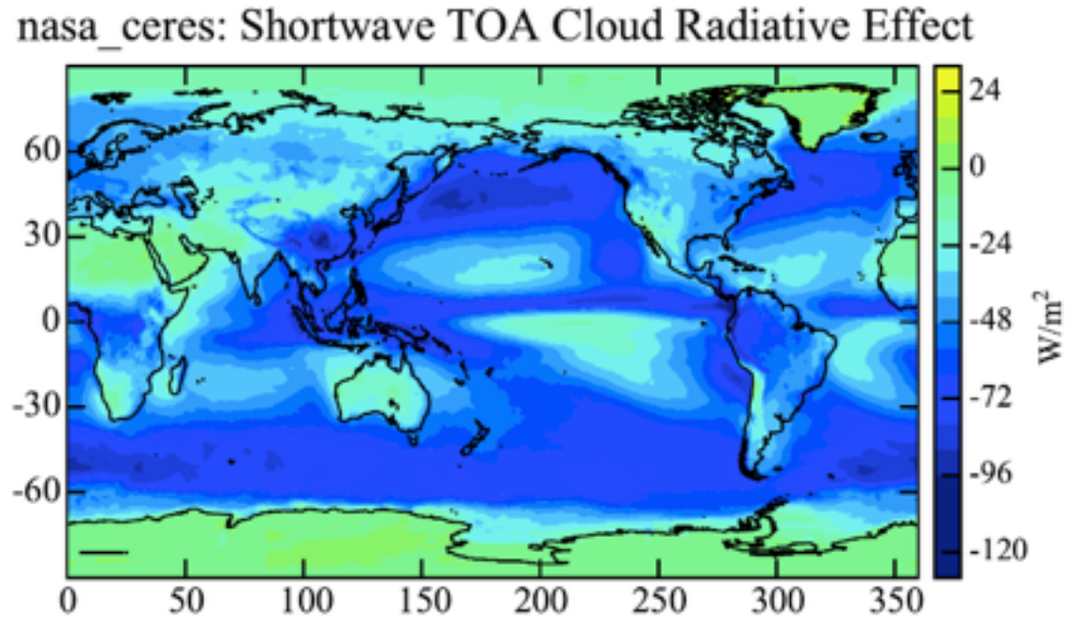
- Biases in model estimates of CRE in AMIP models

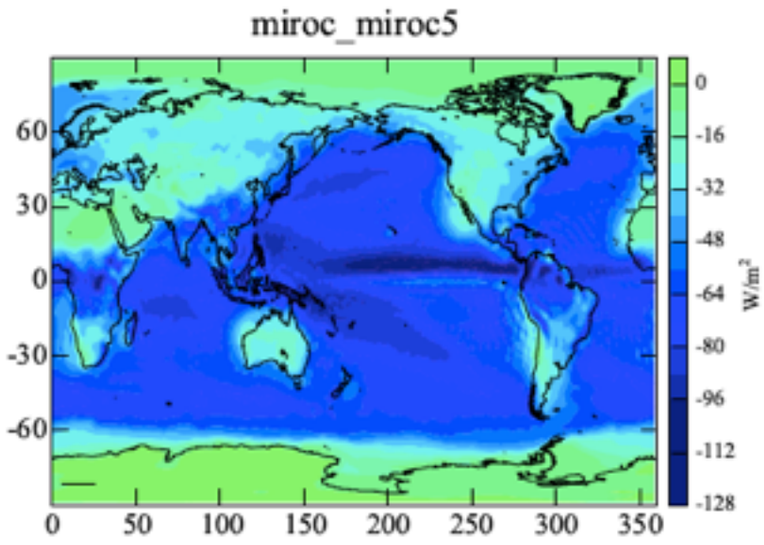
- Regression against climate sensitivity (constrain with CERES data)

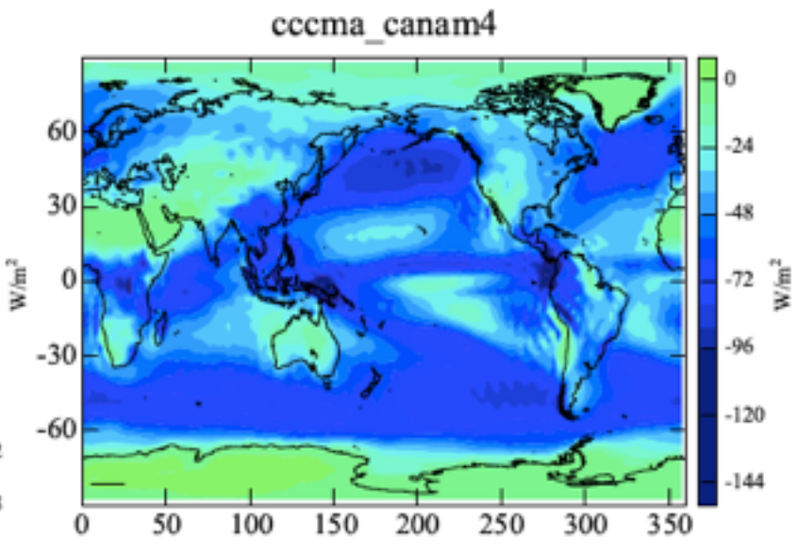
- Use model bias in cloud fraction and precipitation to see if they corroborate CRE results

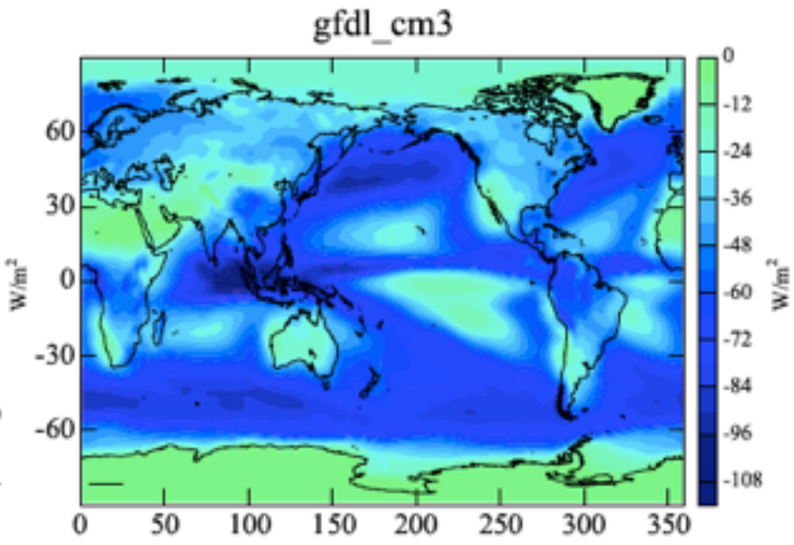
2003-2008 annual mean SW CRE at top-of-atmosphere

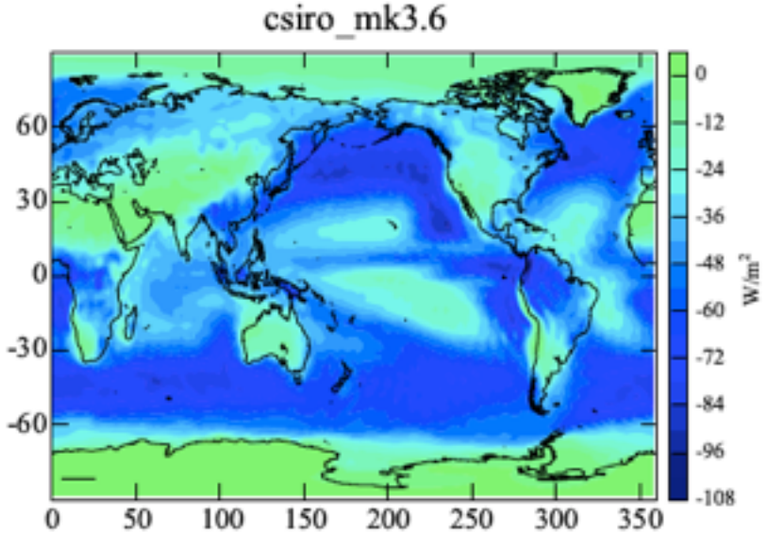
models sorted by climate sensitivity

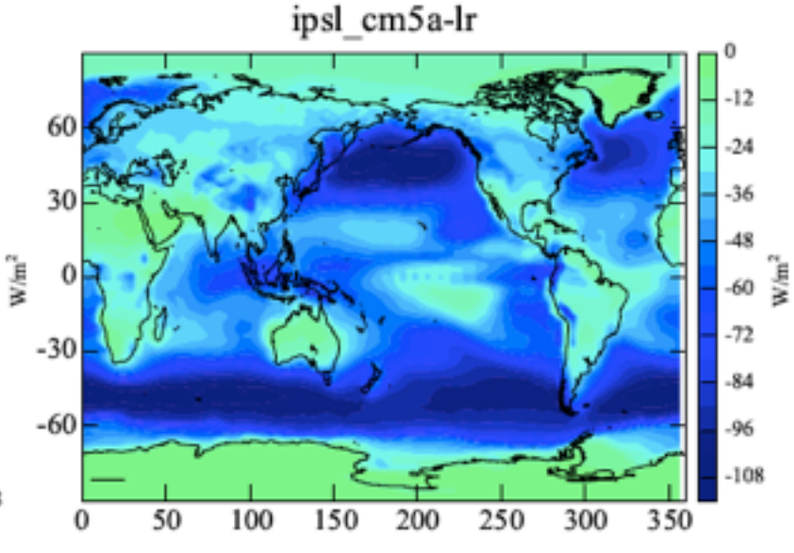


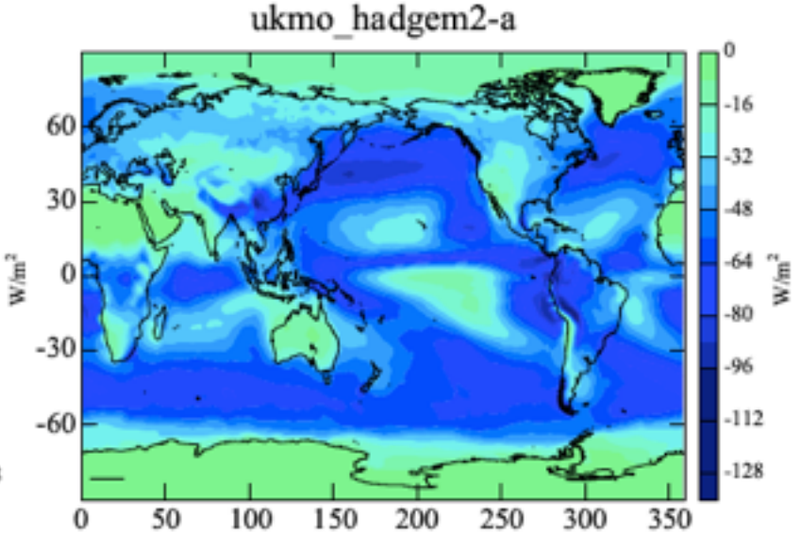






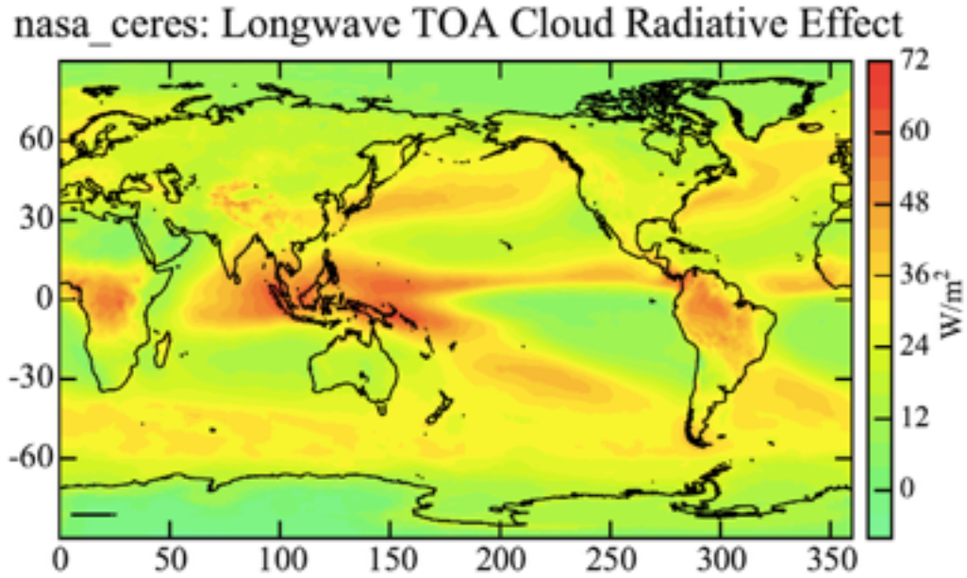


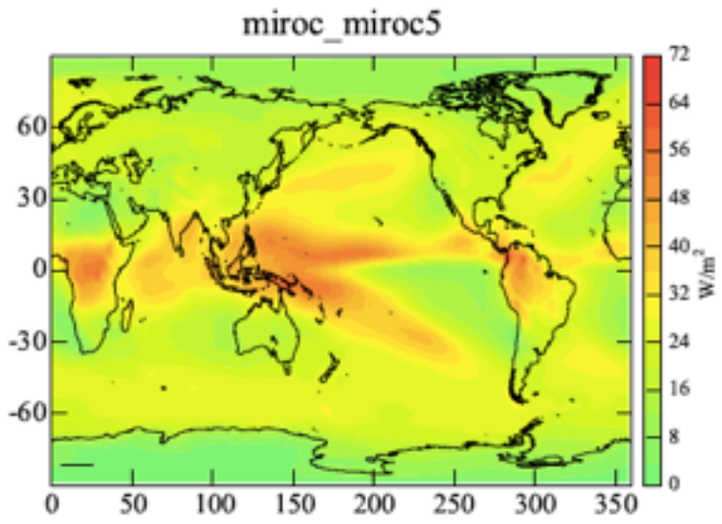


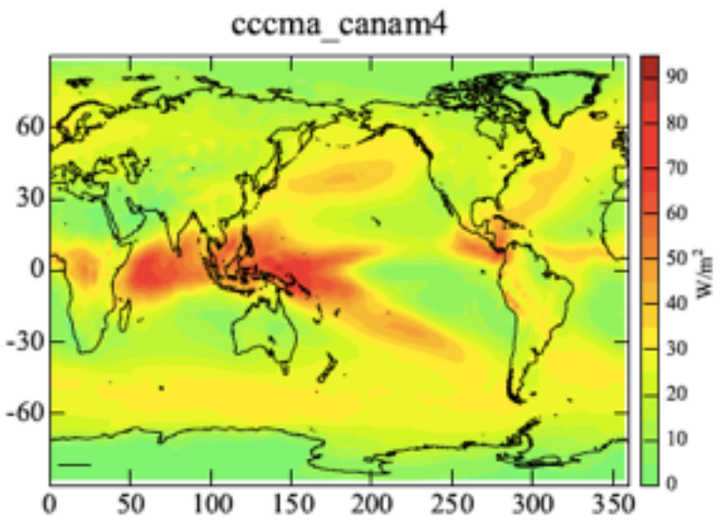


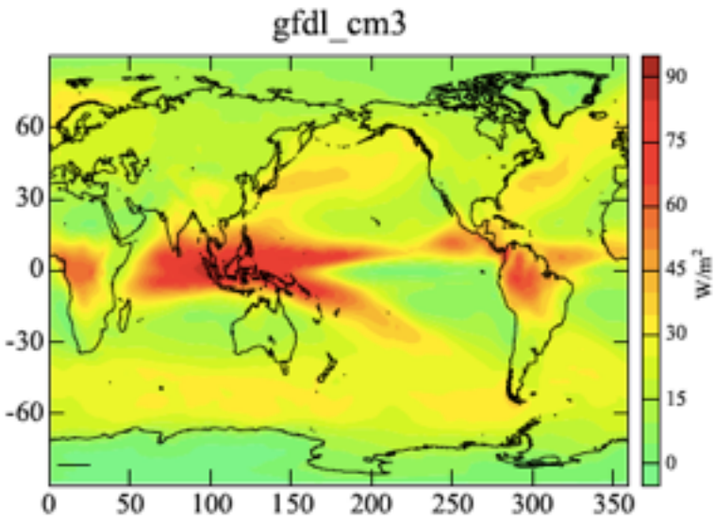
2003-2008 annual mean LW CRE at top-of-atmosphere

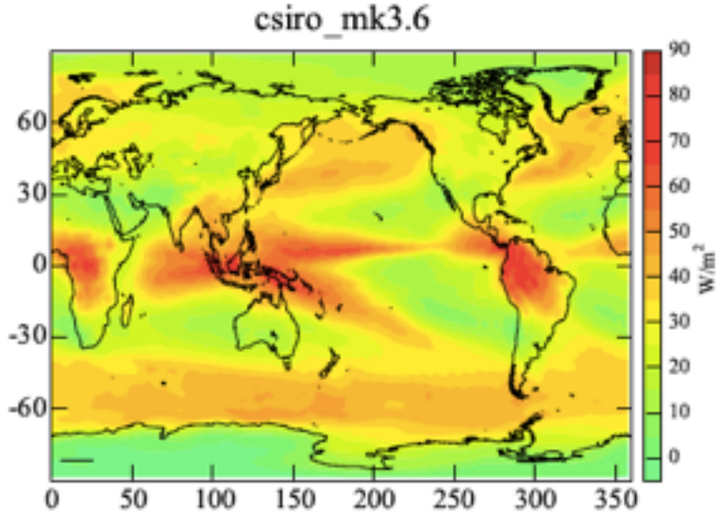
models sorted by climate sensitivity

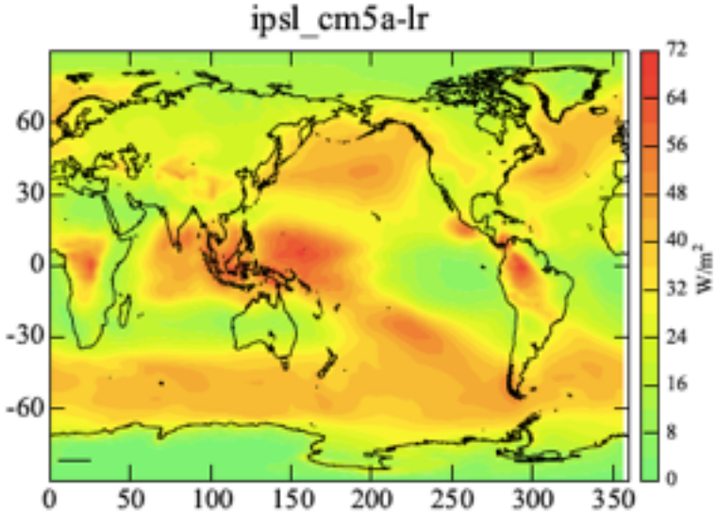


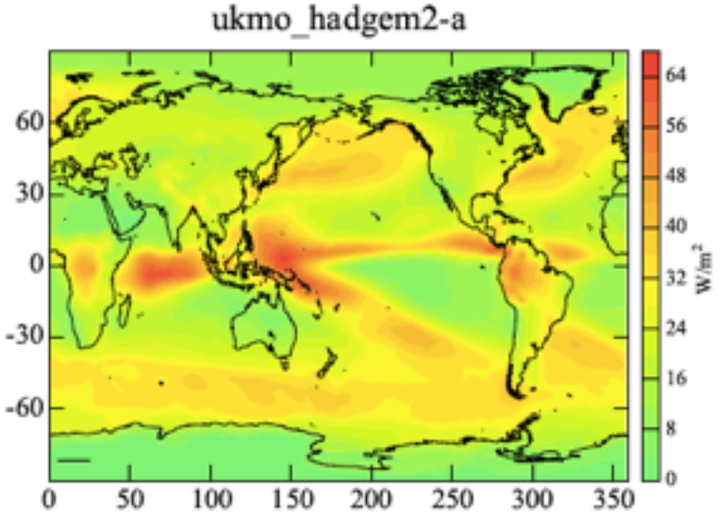






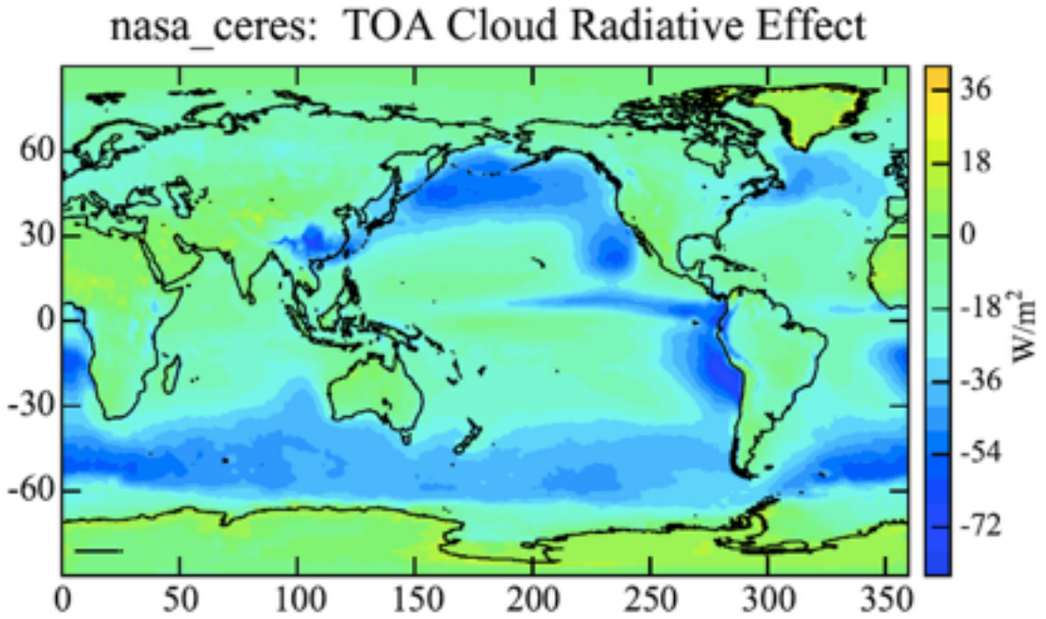


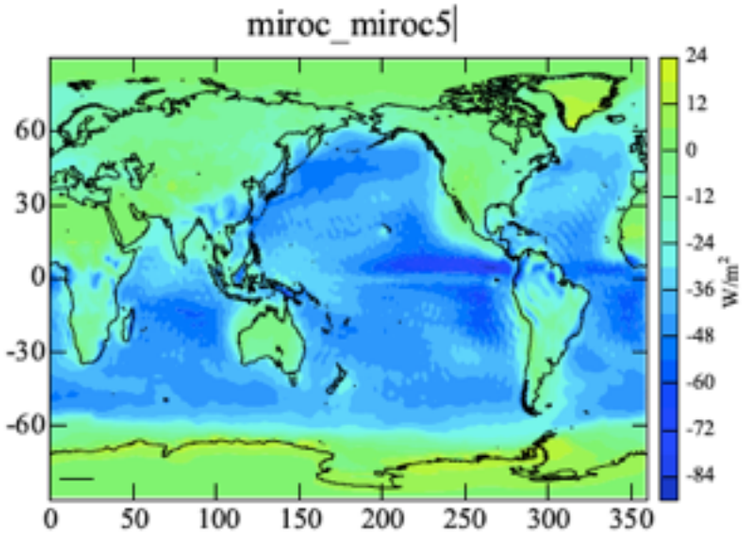


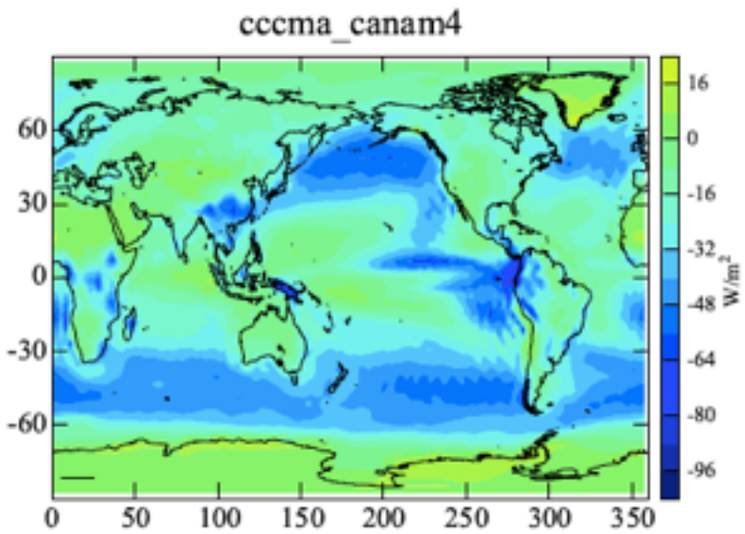


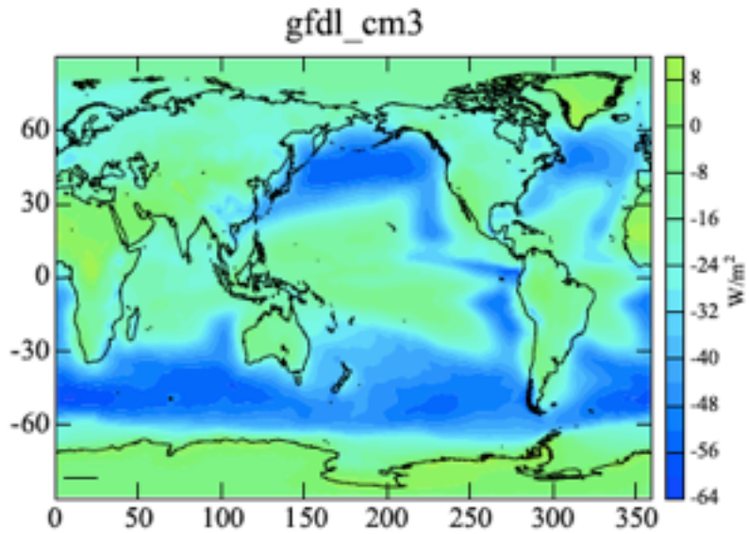
2003-2008 annual mean
Net CRE at top-of-atmosphere

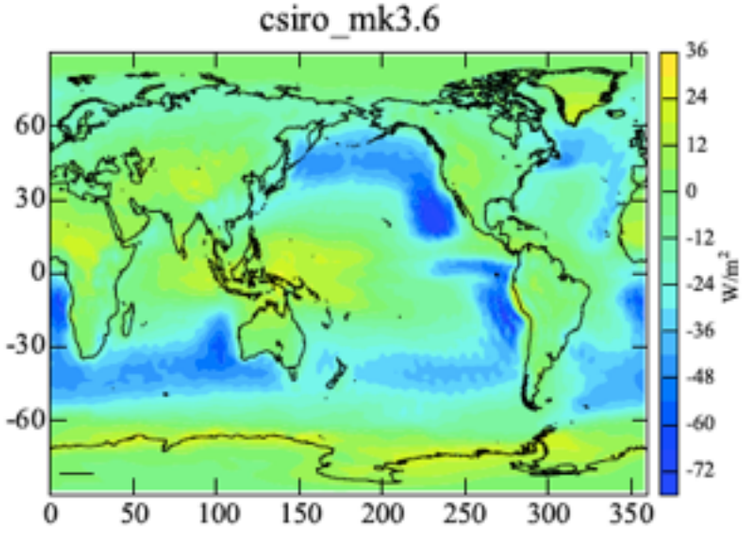
models sorted by climate sensitivity

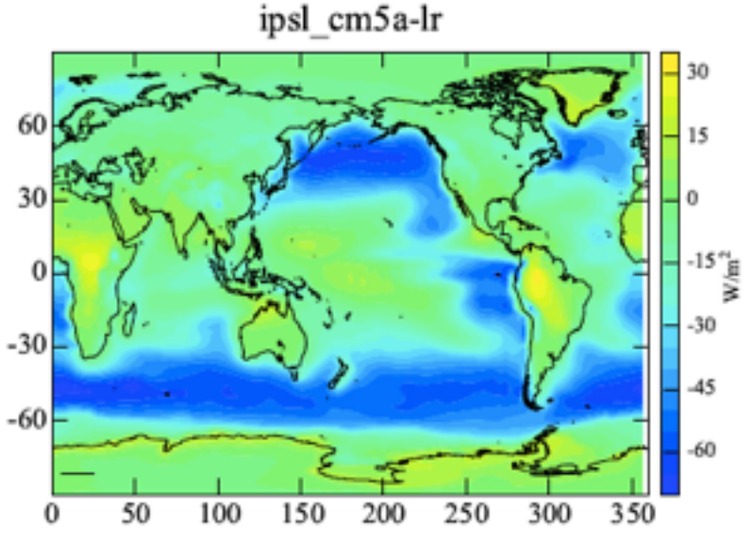


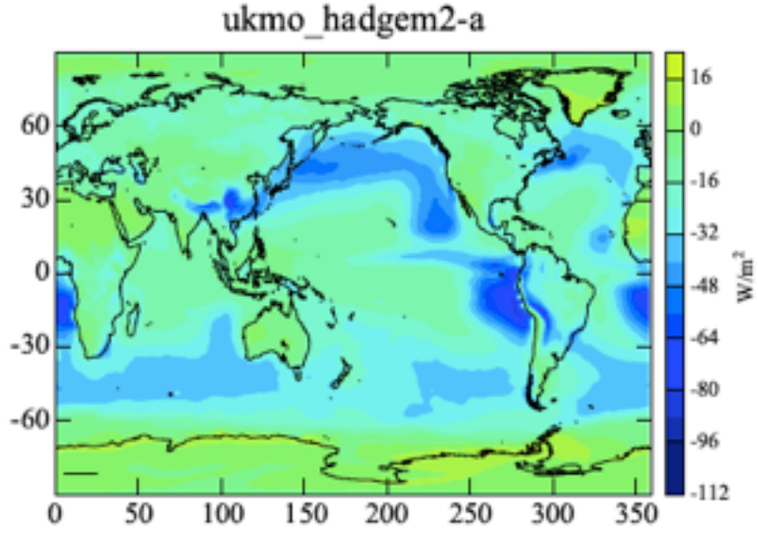




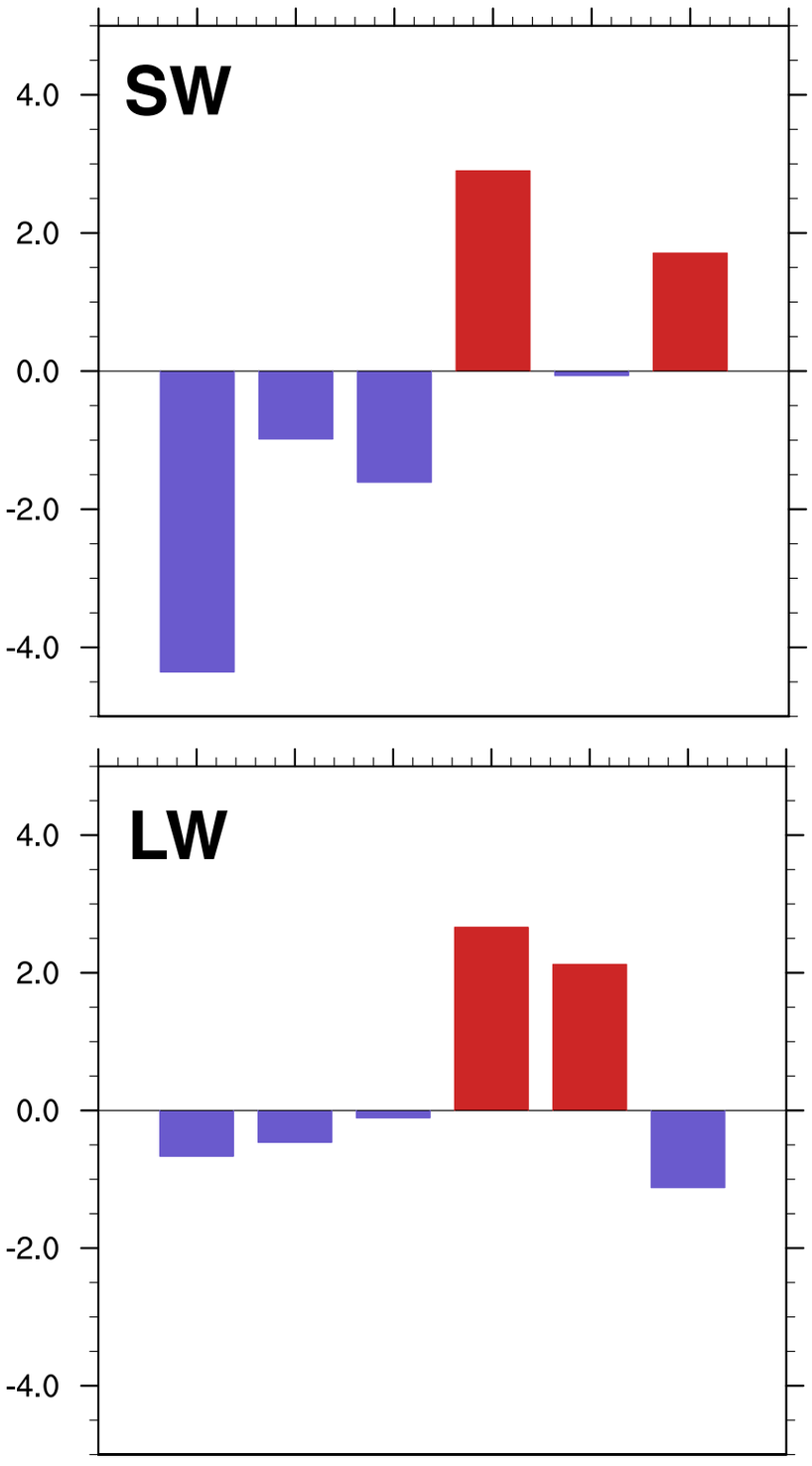


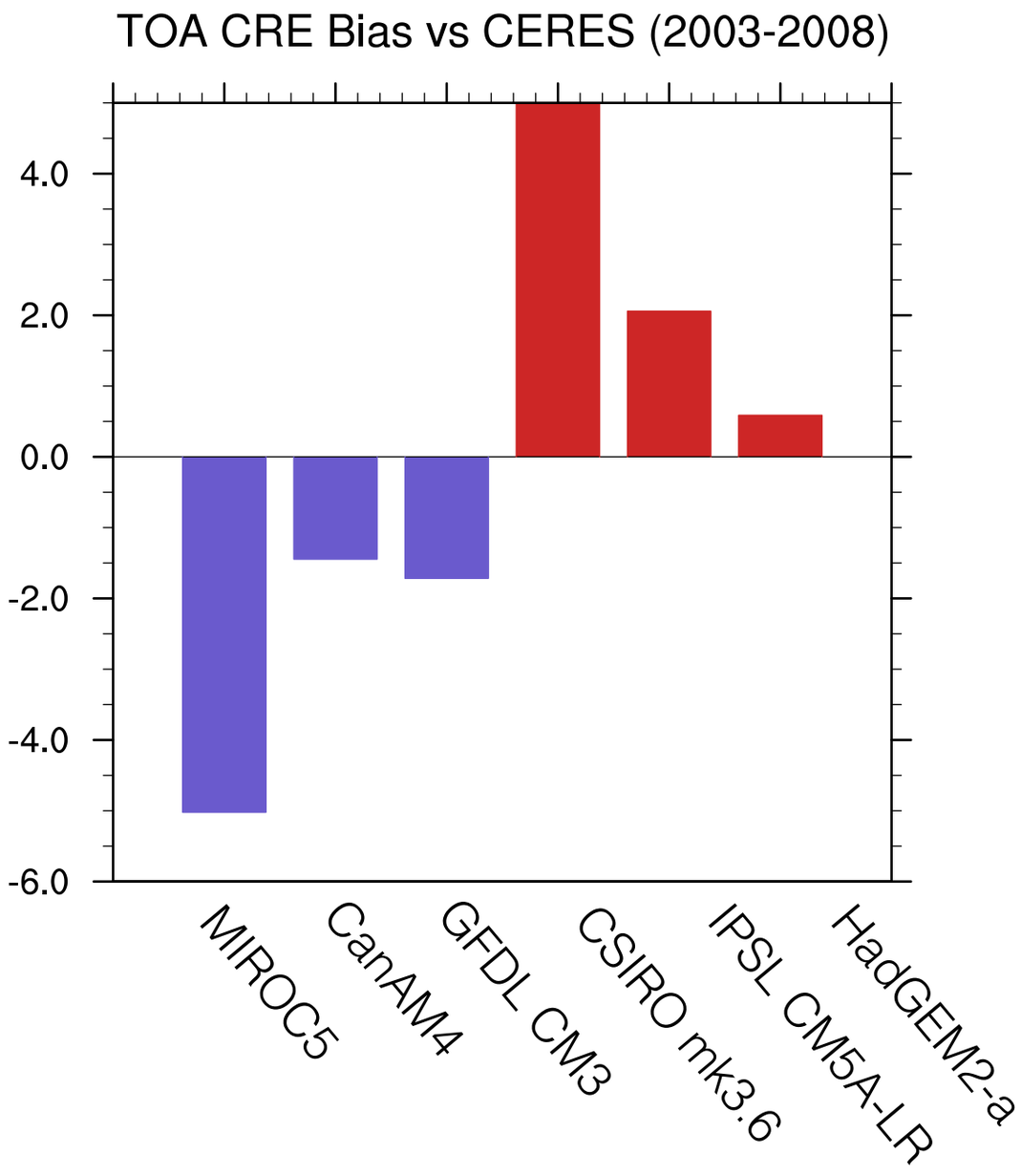




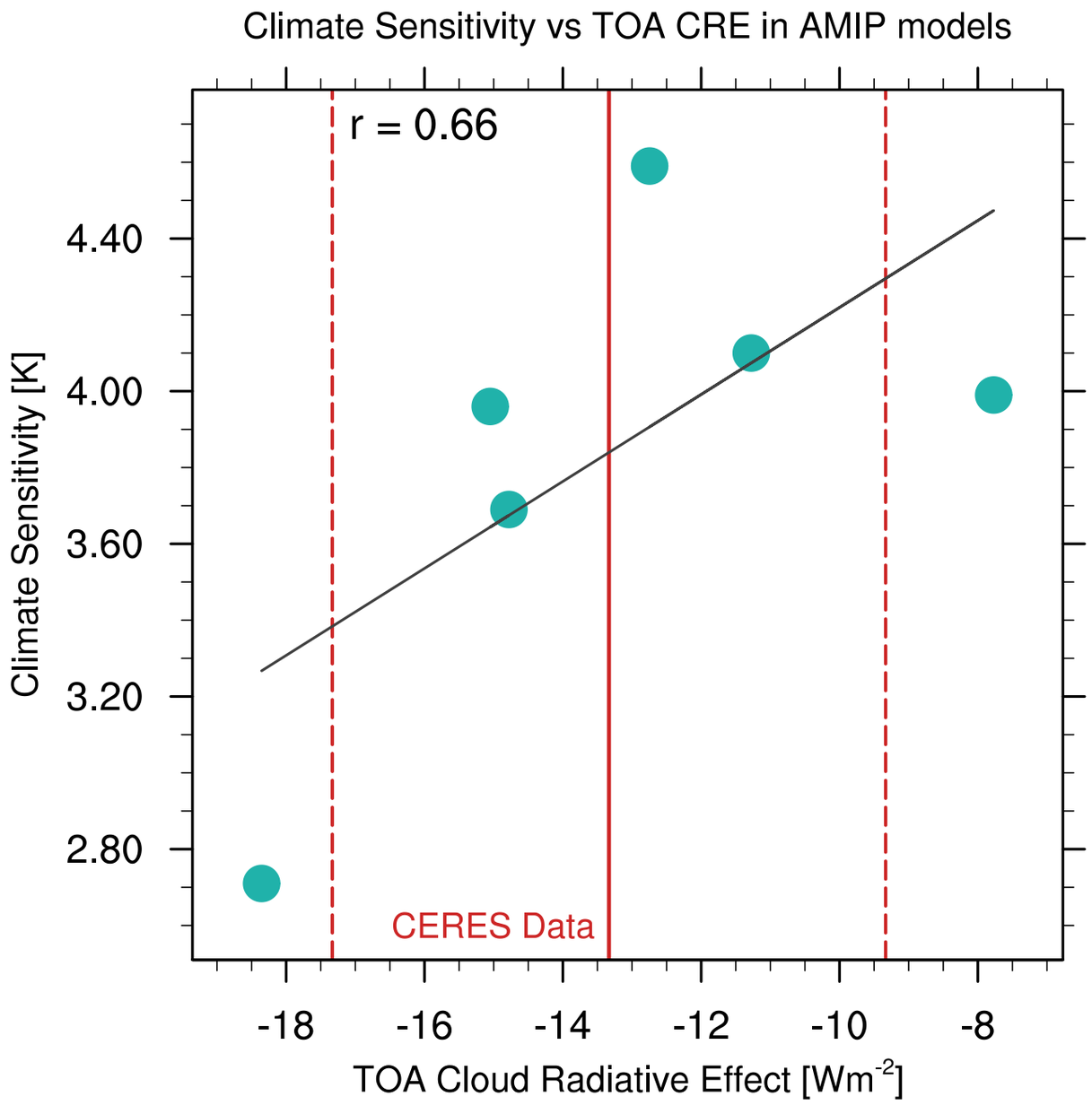


Bias in model estimates of CRE relative to CERES observations

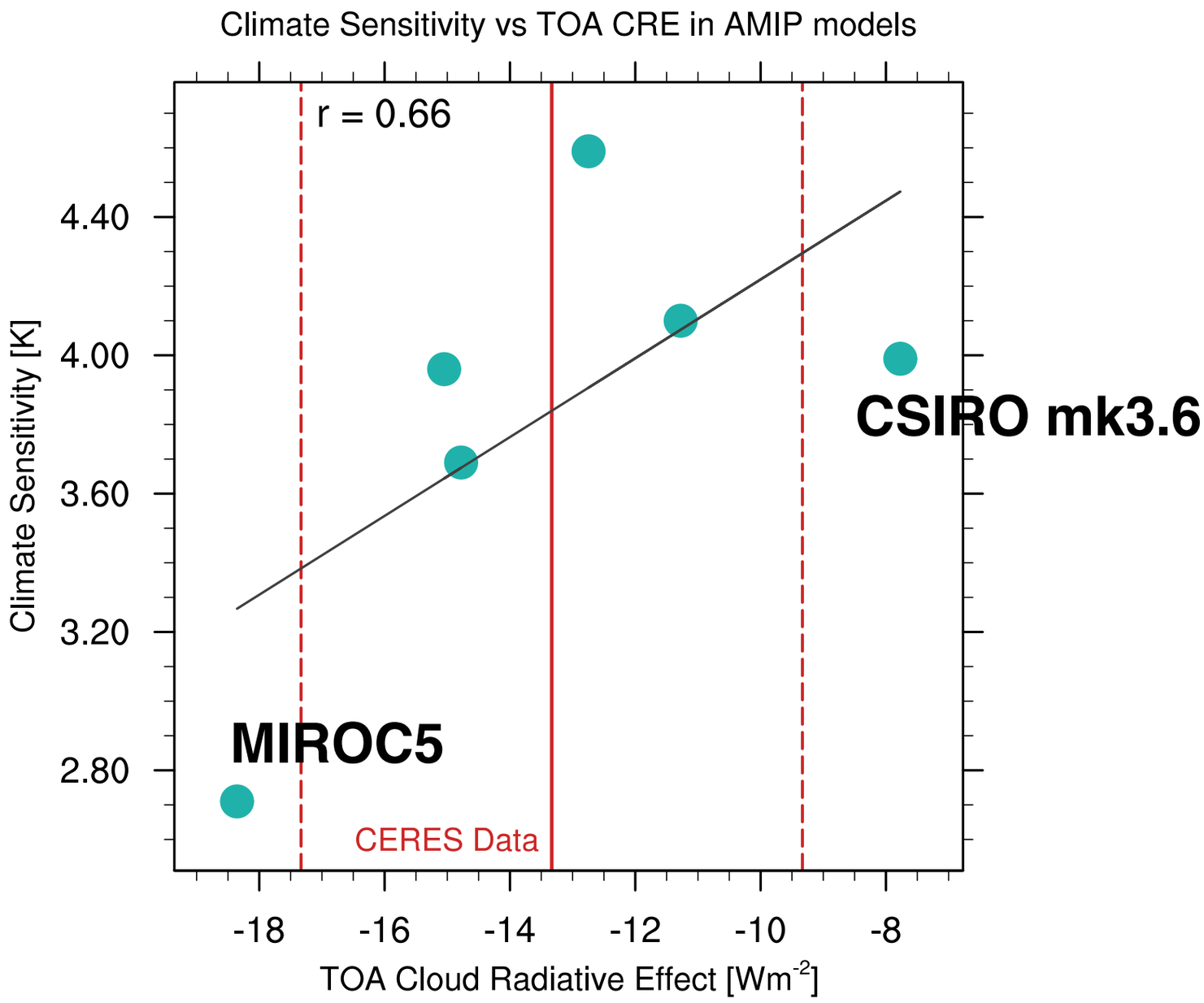




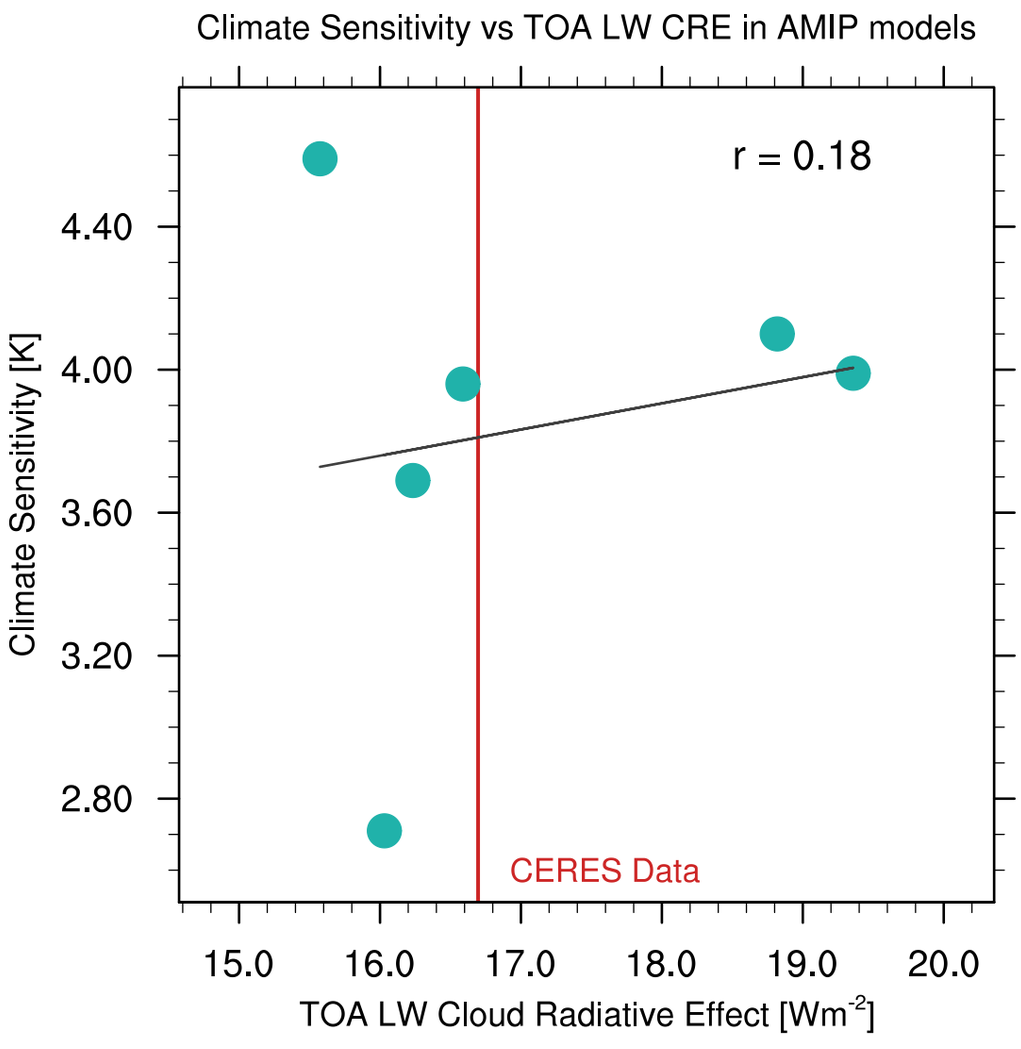
Relationship between model climate sensitivity and CRE

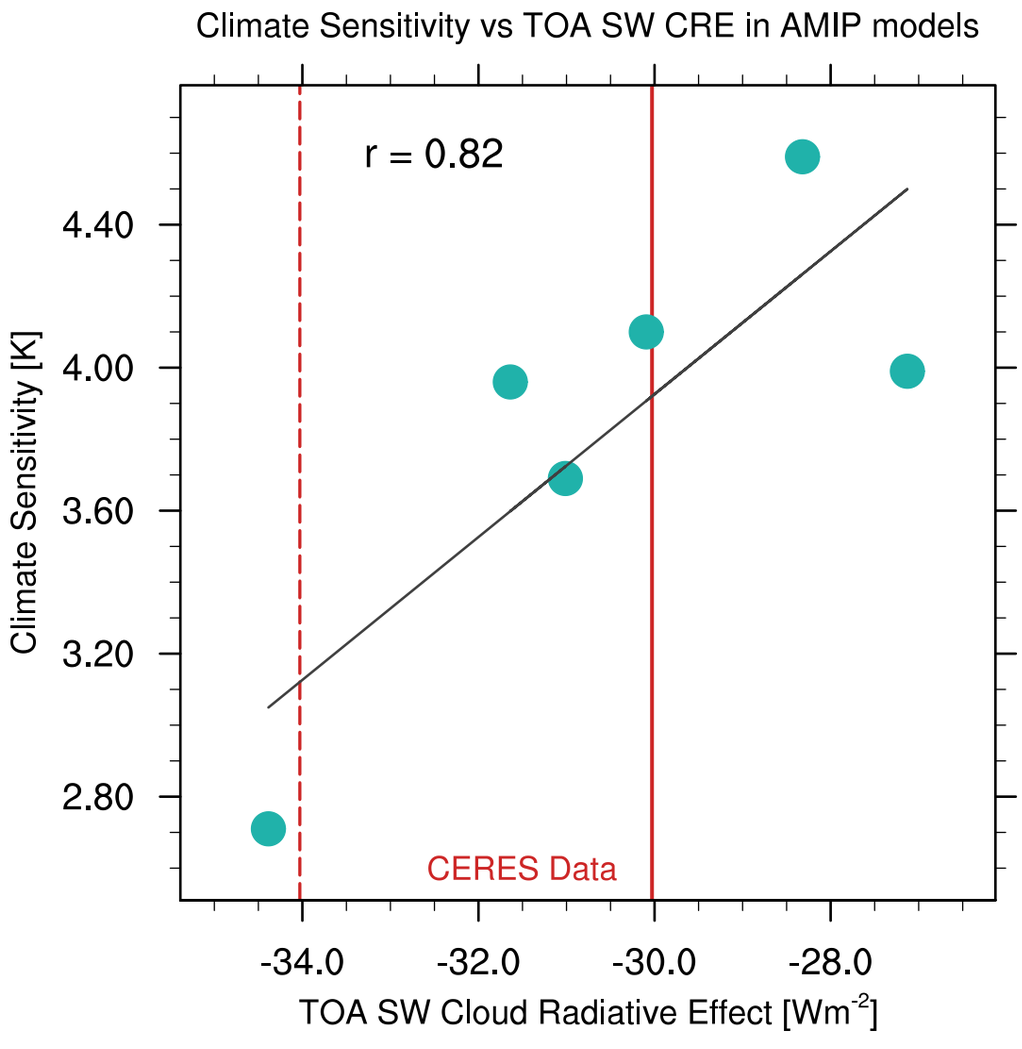


Relationship between model climate sensitivity and CRE

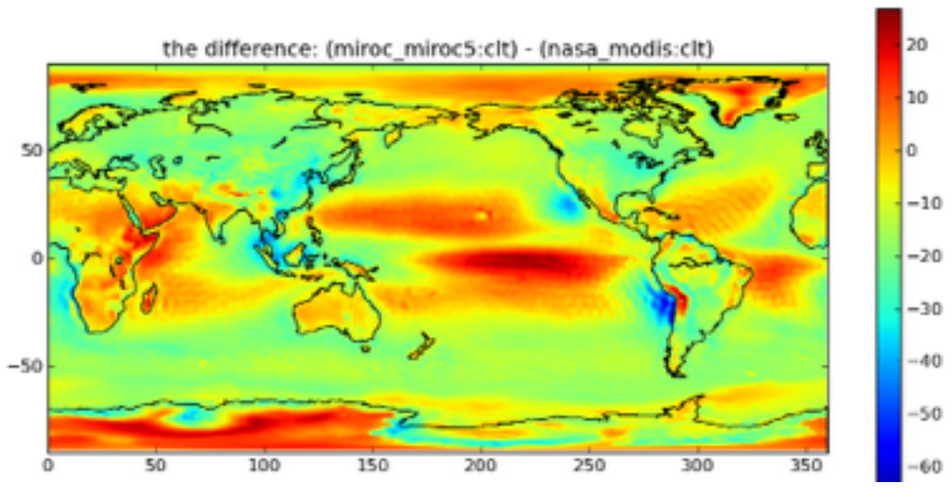


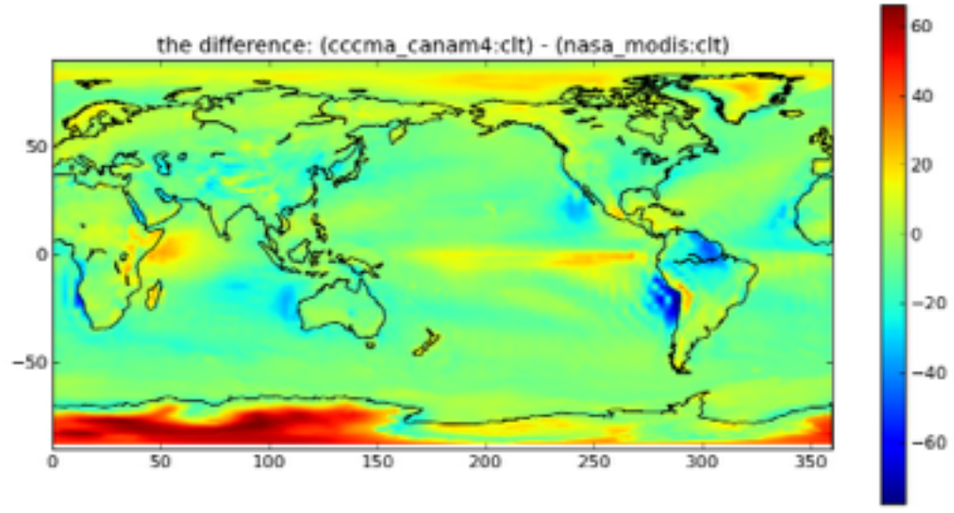
Relationship between model climate sensitivity and CRE

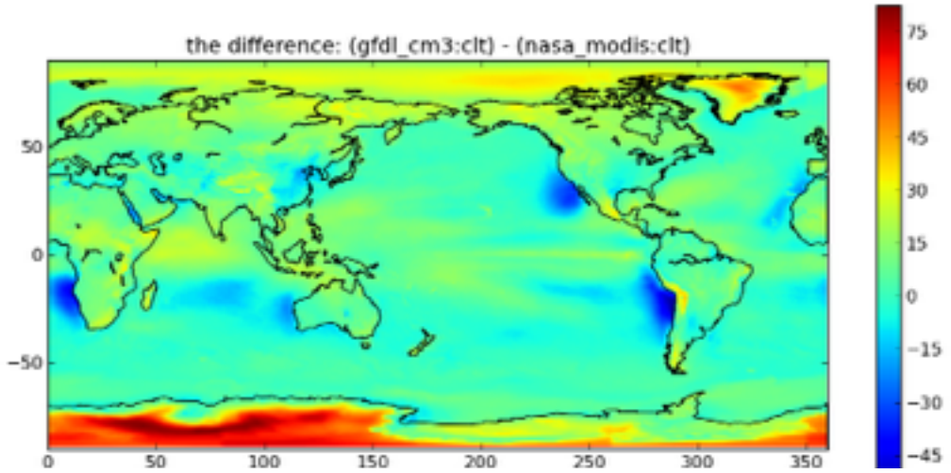


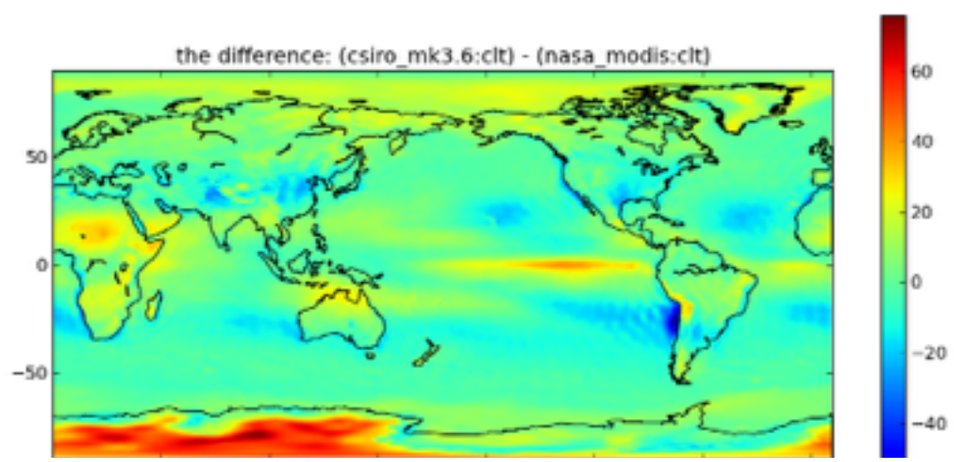


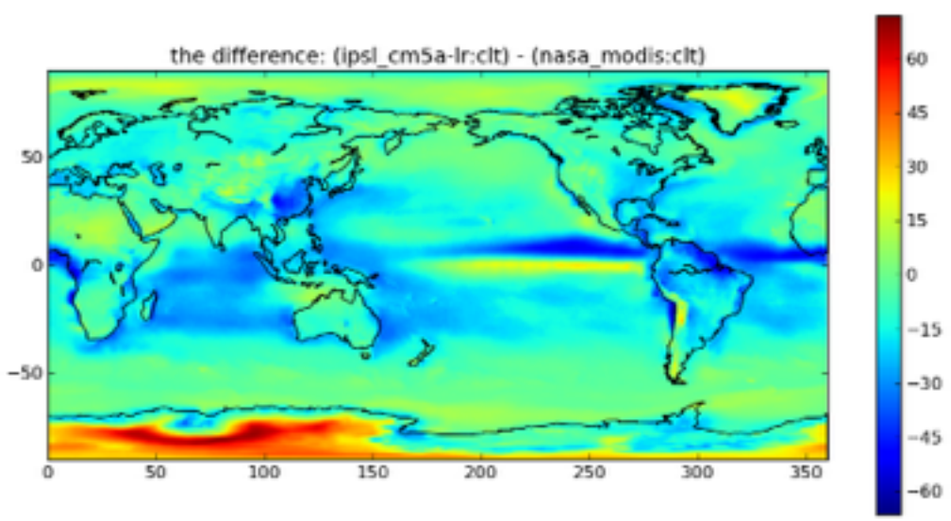
Is CRE Bias related to Clouds? We look at differences between model and MODIS total cloud fraction.

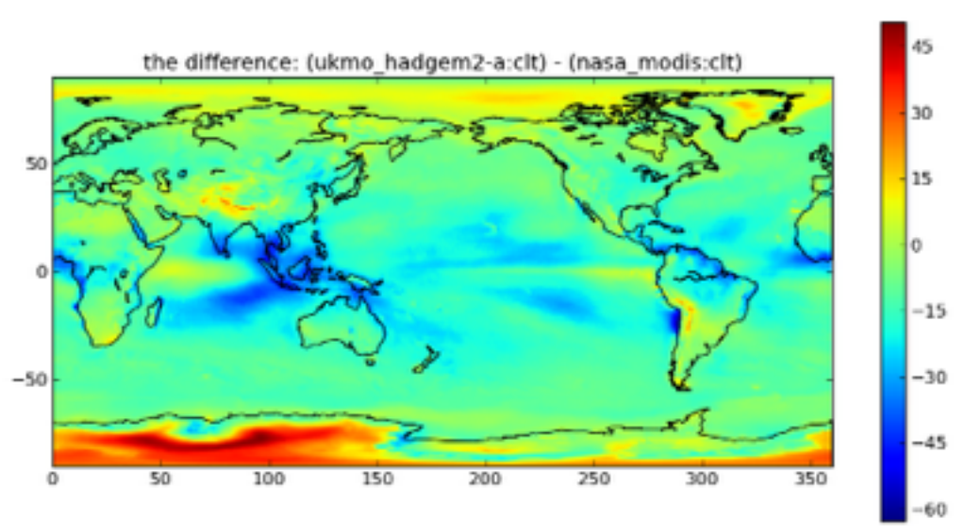




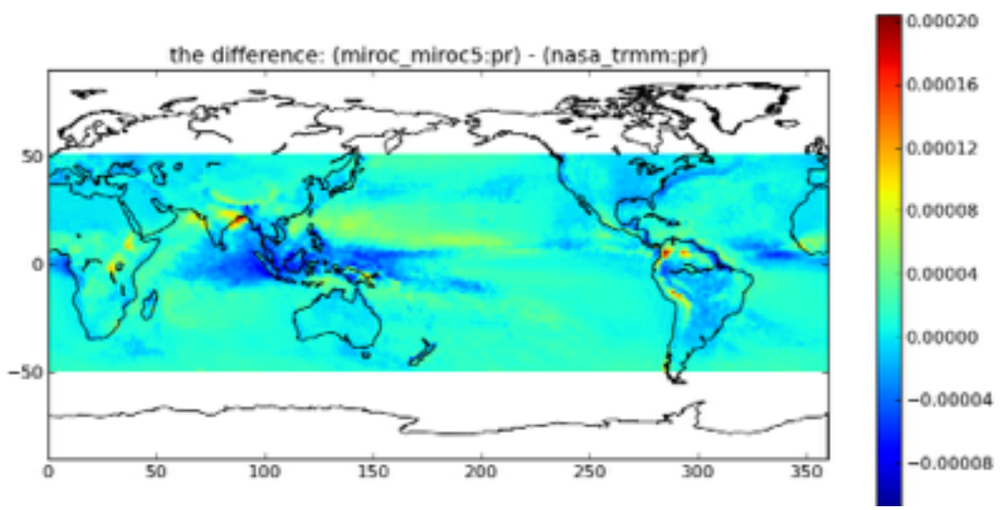


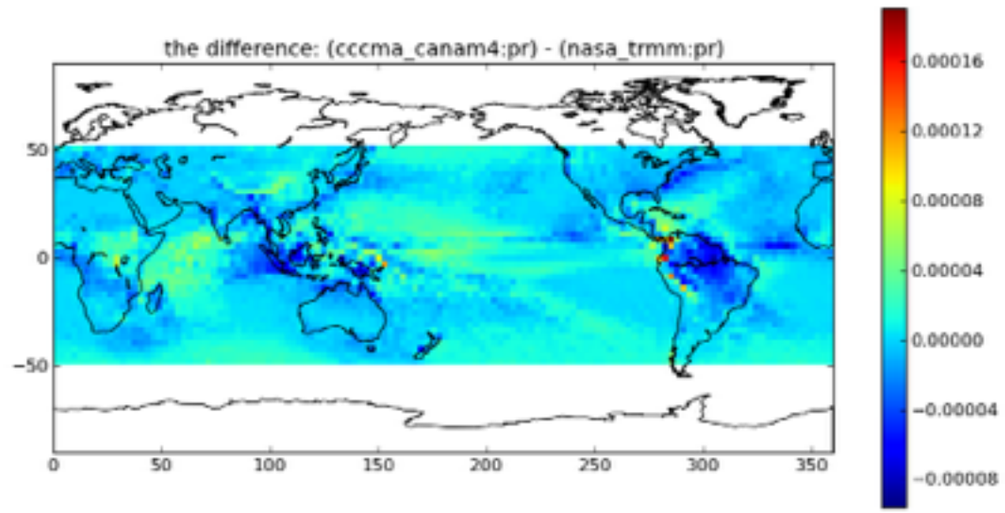


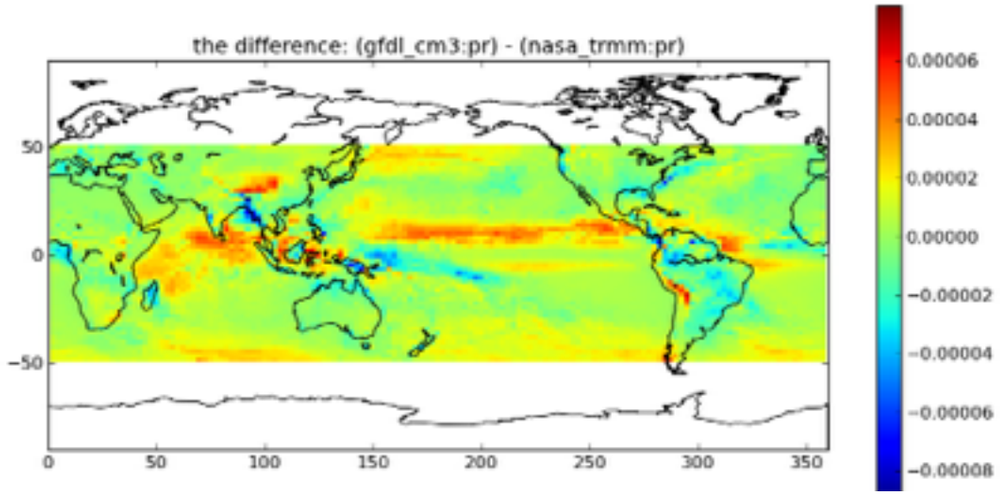


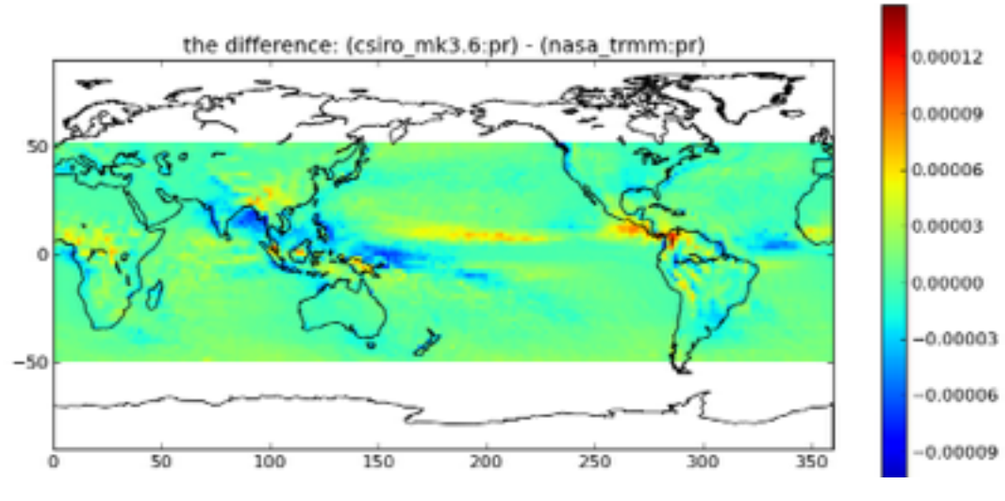


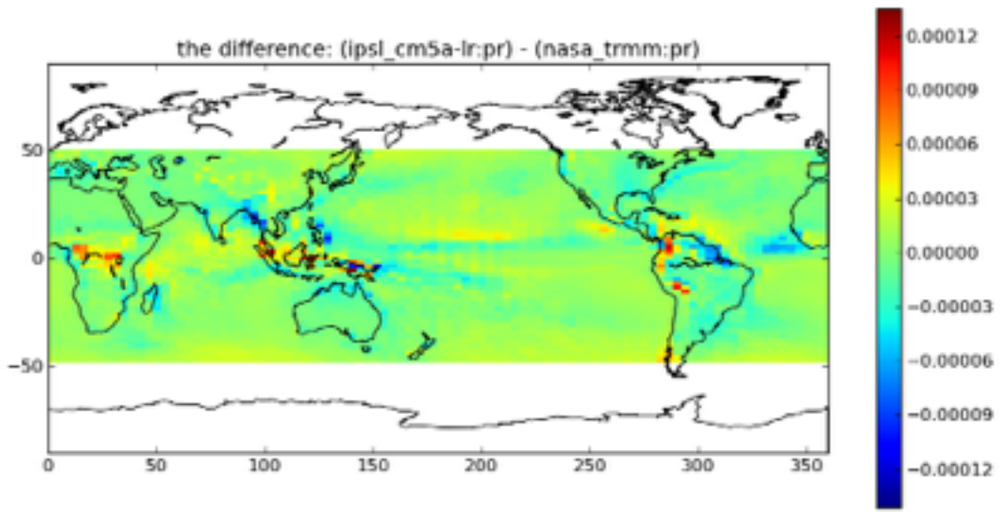
How about precipitation? Compare model estimates of precipitation flux to TRMM observations

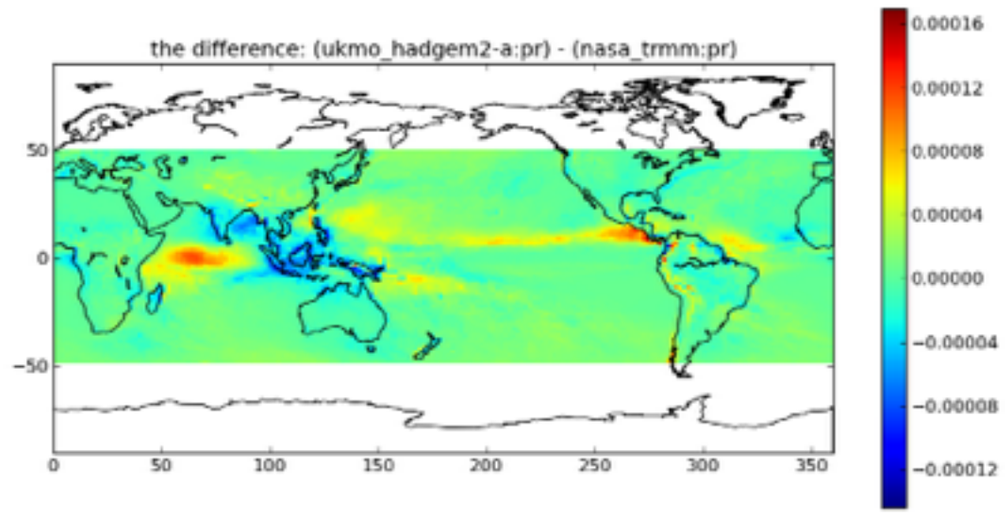












To summarize…

- (mostly SW) TOA CRE is correlated with model climate sensitivity

- Low sensitivity models have negative biases, high sensitivity models tend to have positive biases

- CERES observations don’t really constrain models, due to our crude treatment of CERES uncertainty

Caveats

- We only have 6 models
- unsure about climate sensitivity of UKMO model… with this small sample size, regressions will be very sensitive to that
- Our sample consists of mostly high sensitivity models. Not representative of full CMIP archive.
- unsure about error bars on CERES. We use 4W/m2 as a rough approximation for all flux quantities. How accurate is this?
- We only have 5 years of data. Too short to look at time variability

Vegetation Phenology and Climatic Controls

Topic #4

Andrea Thorstensen
Bruna Silveira
Chris Jones
Katie Pitts
Omid Mazdiyasni

Leaf Area Index

DATA PERIOD:

2002-09 to 2009-12

VARIABLES:

Leaf Area Index -> MODIS

Surface Downwelling

Shortwave Radiation -> CERES

Precipitation Flux -> TRMM

Air Temperature -> AIRS

REGIONS:

Australia: 39S – 11S

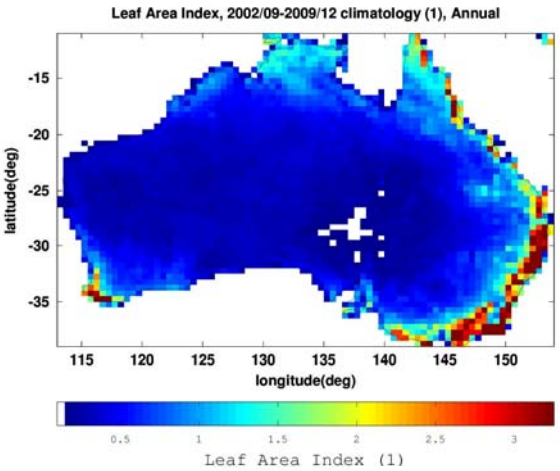
113E – 154W

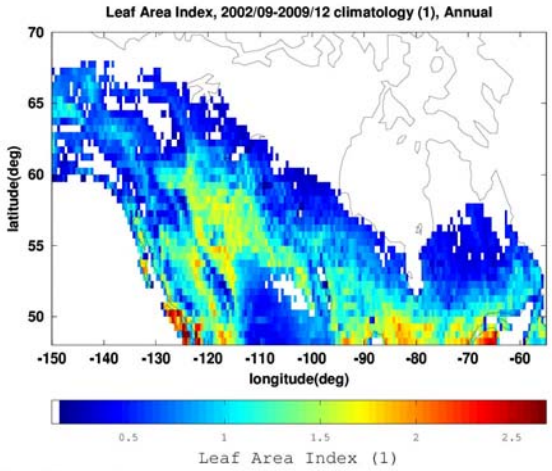
N. Forest: 48N – 70N

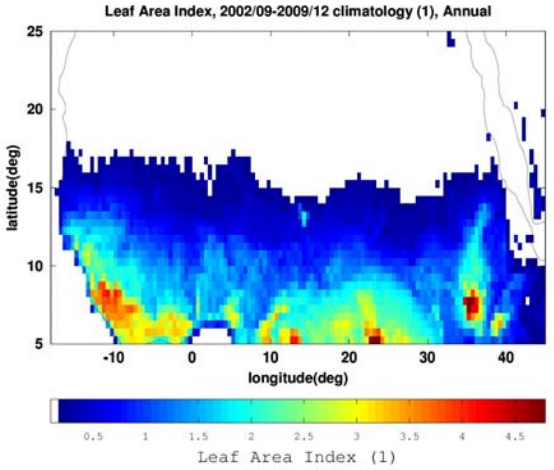
150W – 55W

Sahel: 5N – 25N

18W – 45E

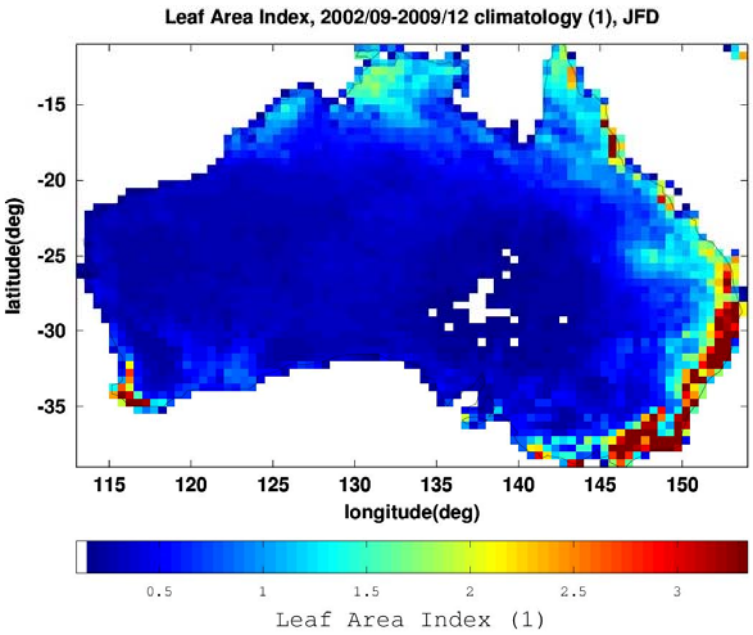




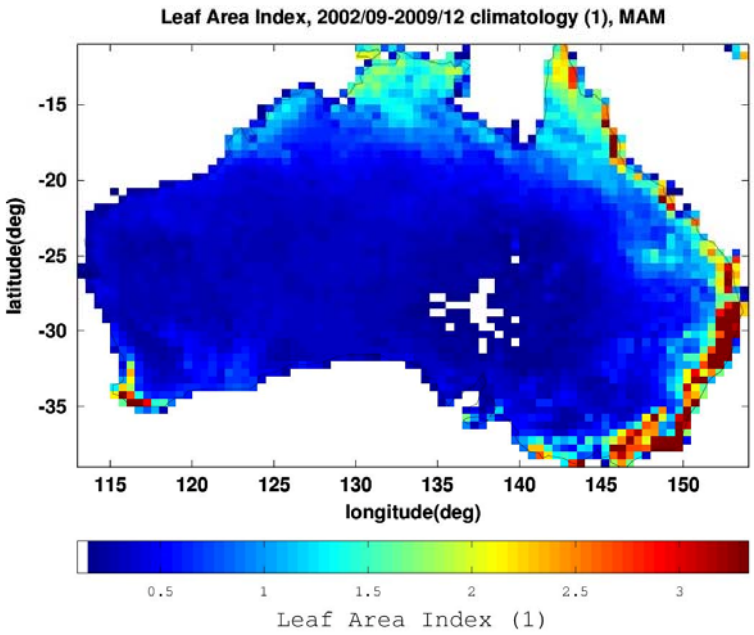


Australia

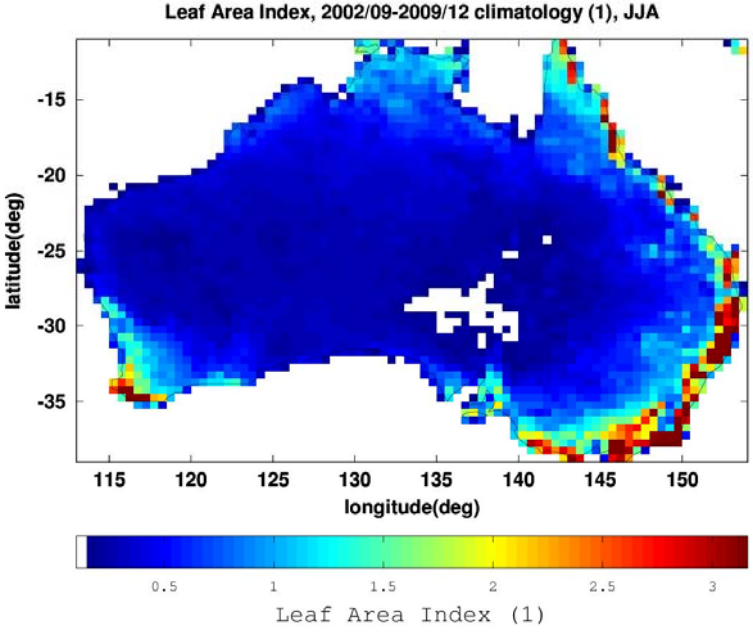
Winter



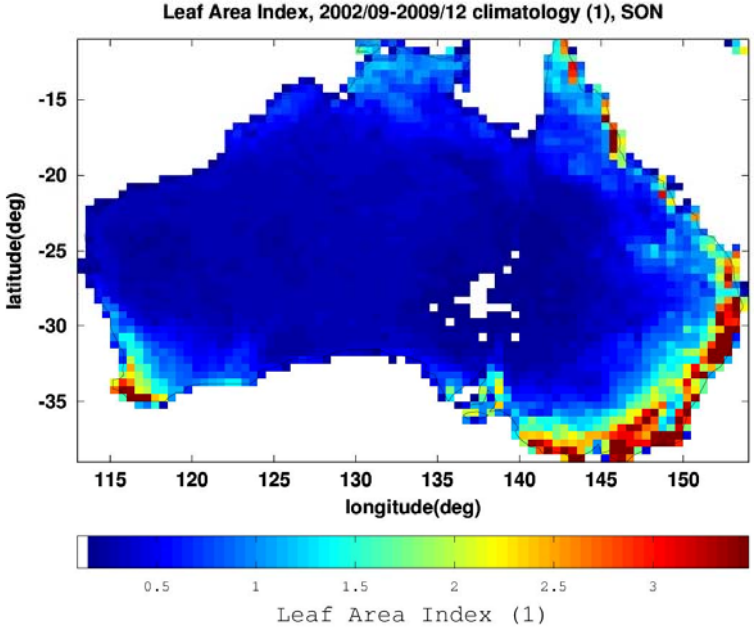
Spring



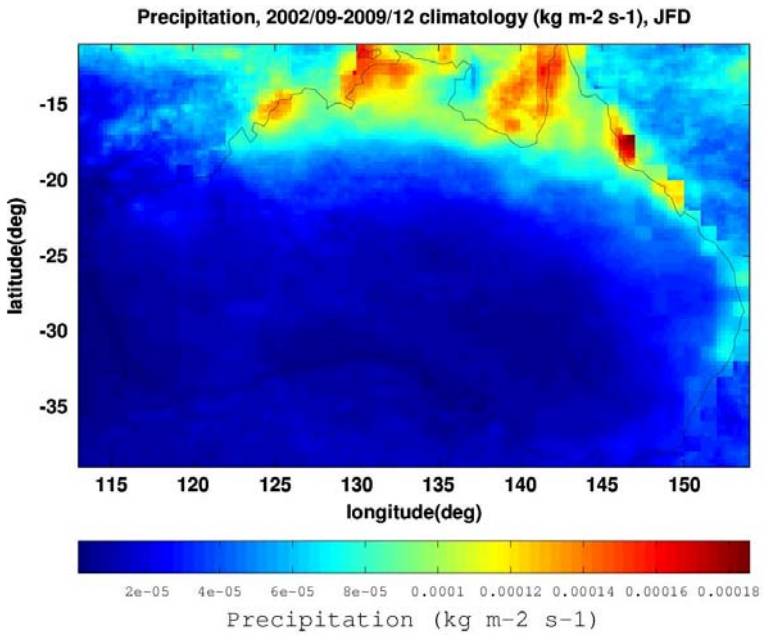
Summer



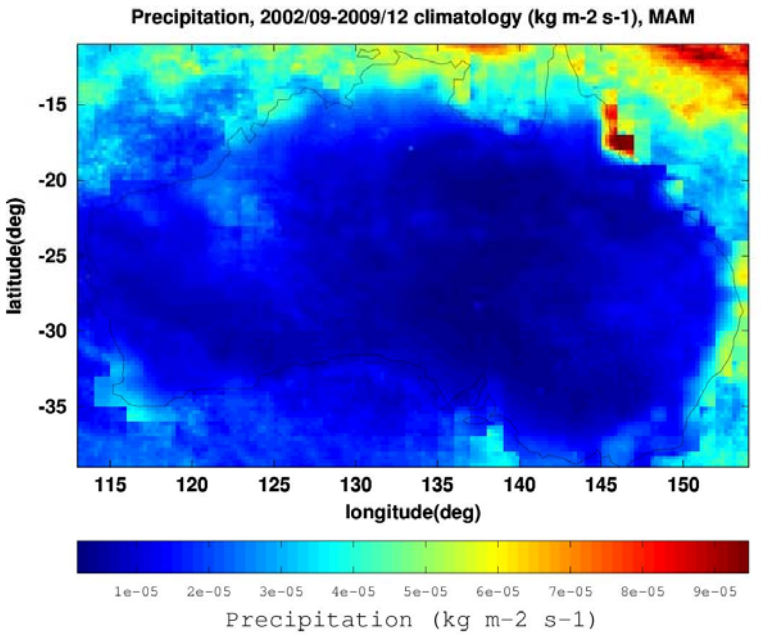
Fall



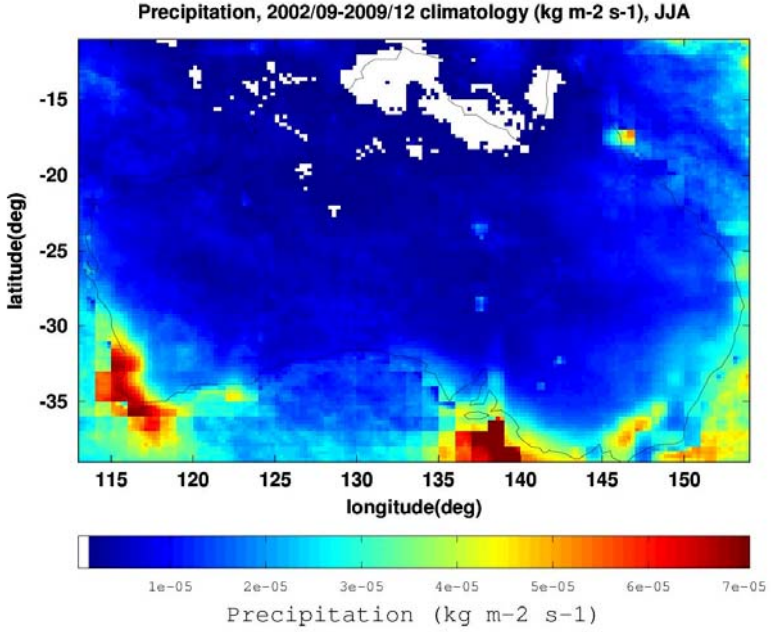
Winter



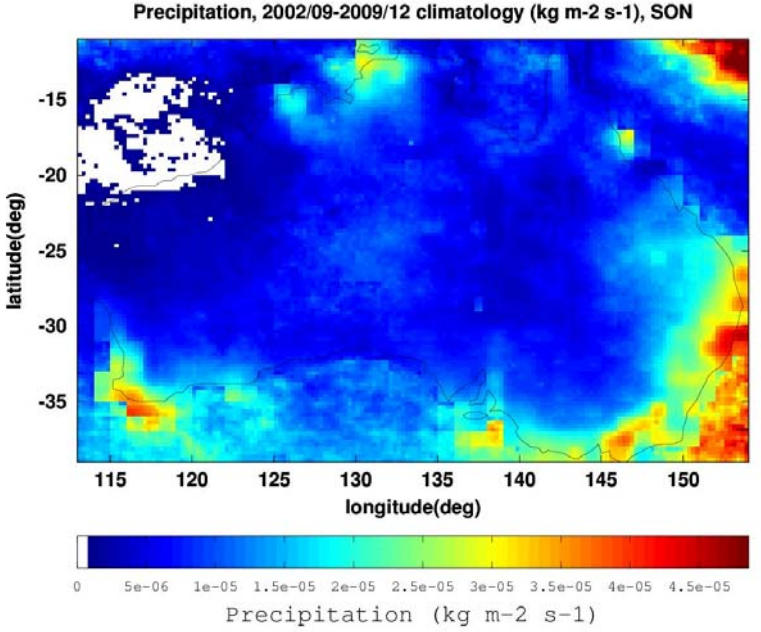
Spring



Summer



Fall

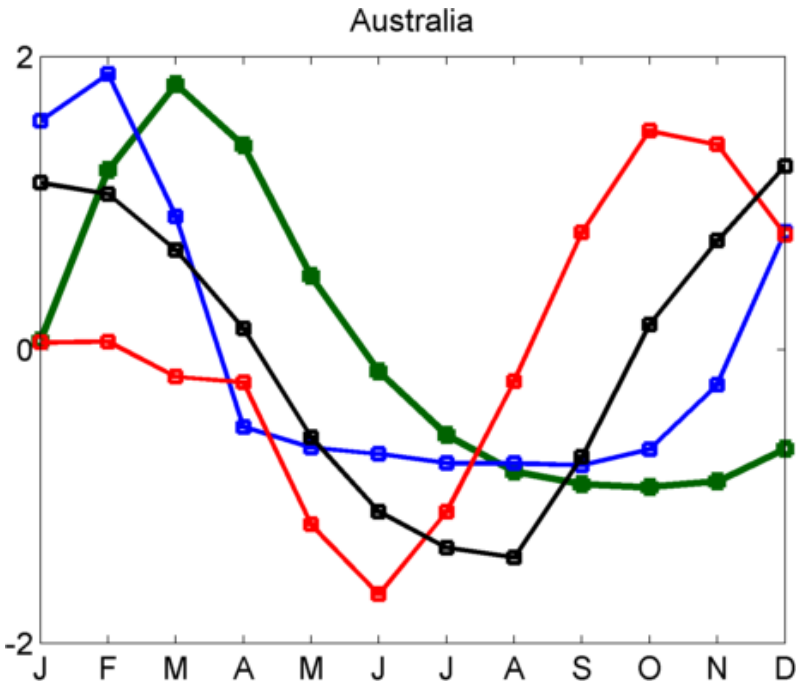


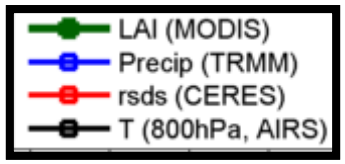
Australia:

water-limited

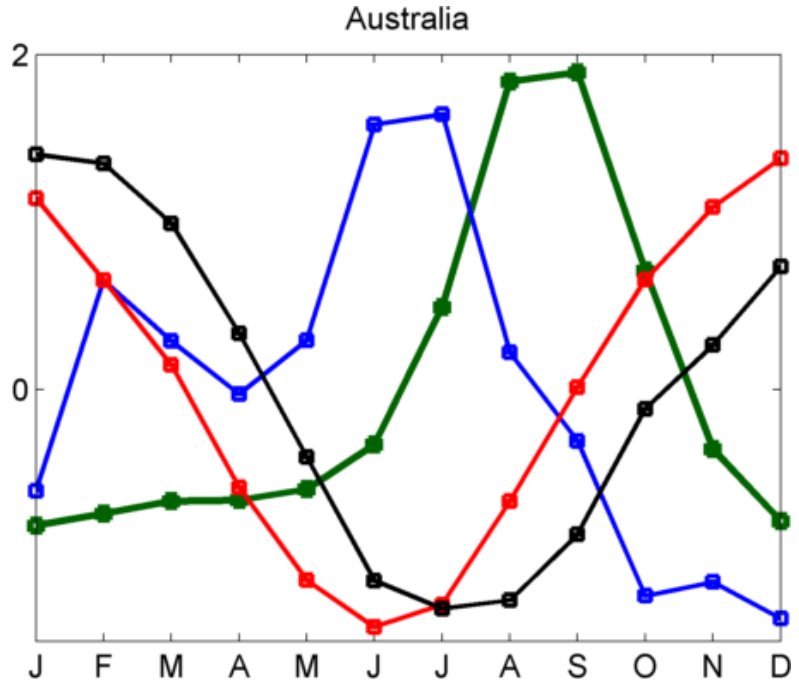
– Two rainy/vegetation seasons from different geographic areas

North



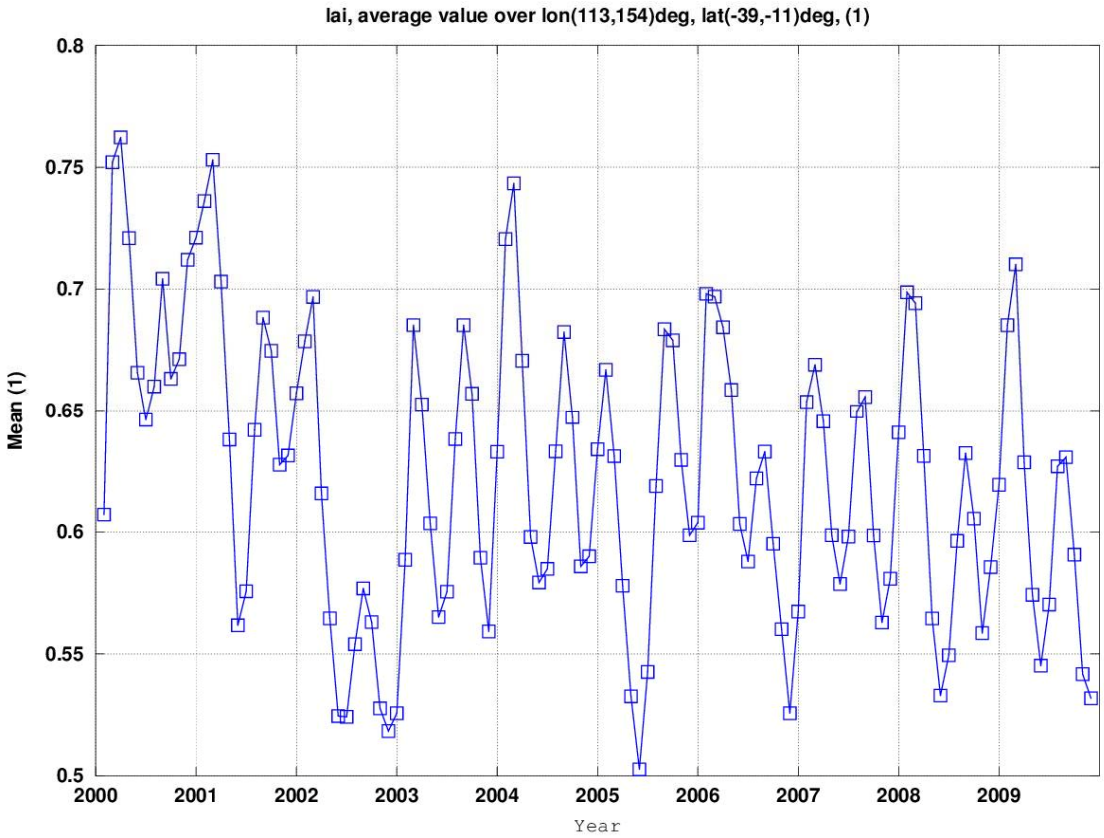


Southwest



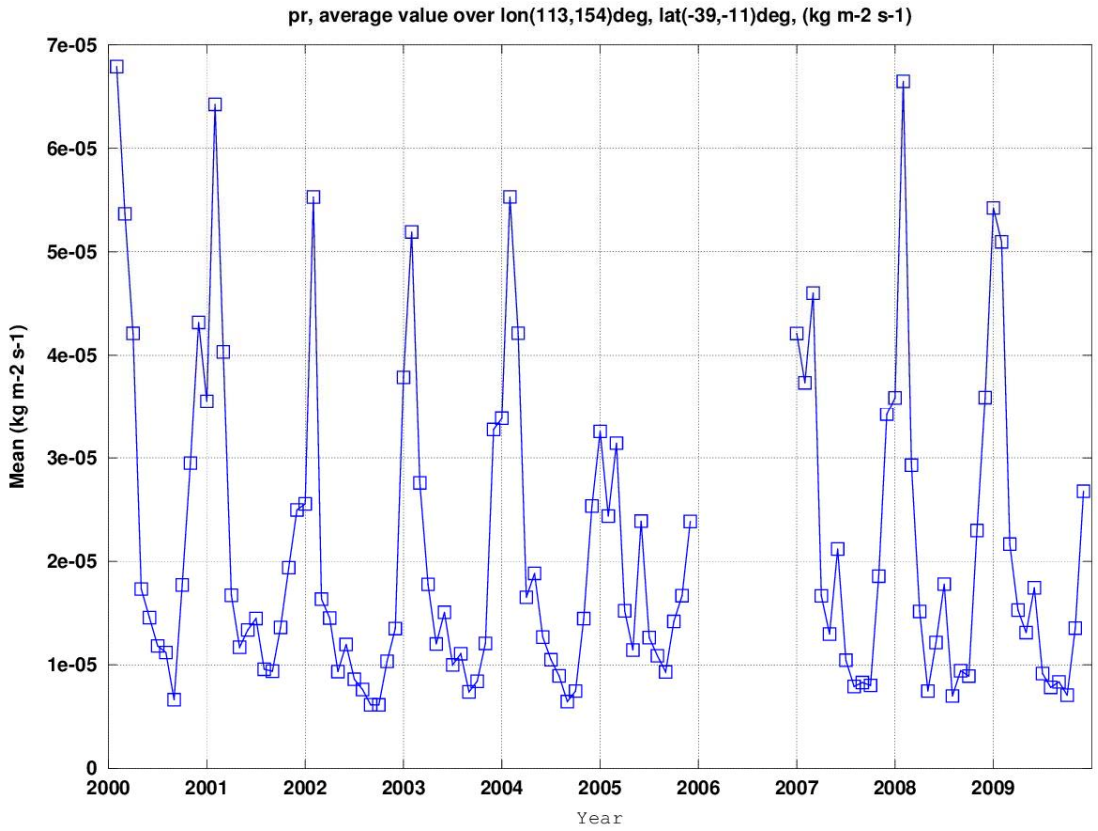
Australia – Leaf Area Index

- Mann-Kendall Trend Test – Trend
  - P Value: 0.0011 Significance Level: 0.05



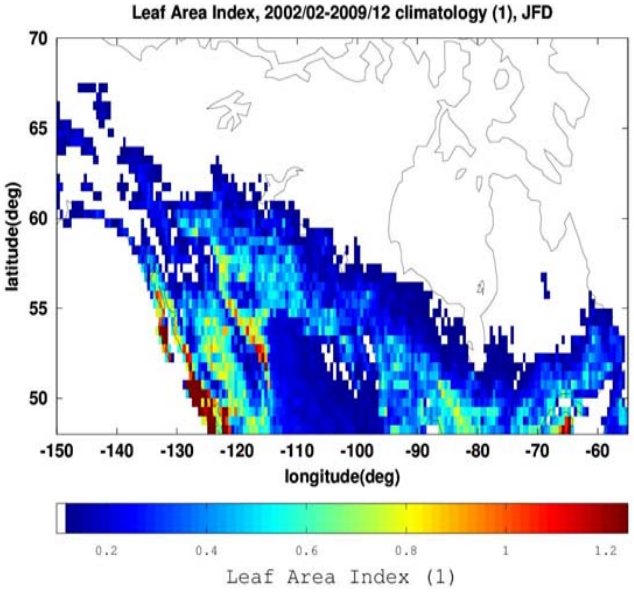
Australia – Precipitation Flux

- Mann-Kendall Trend Test – No Trend
  - P Value: 0.7433 Significance Level: 0.05

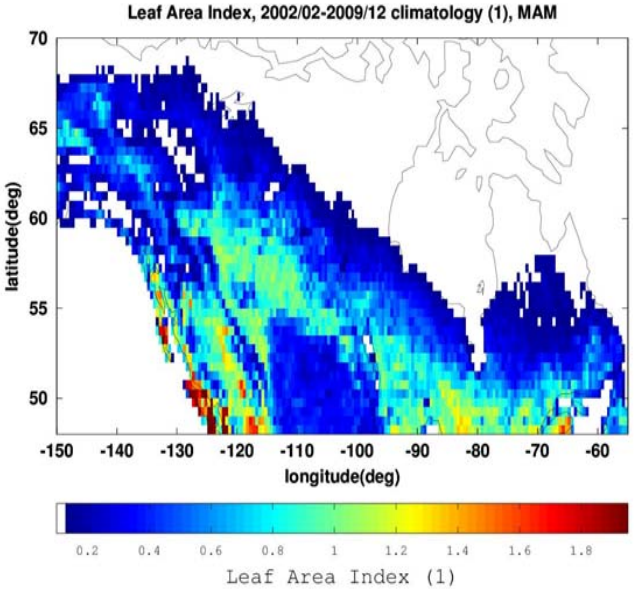


Northern Latitude Forests of North America

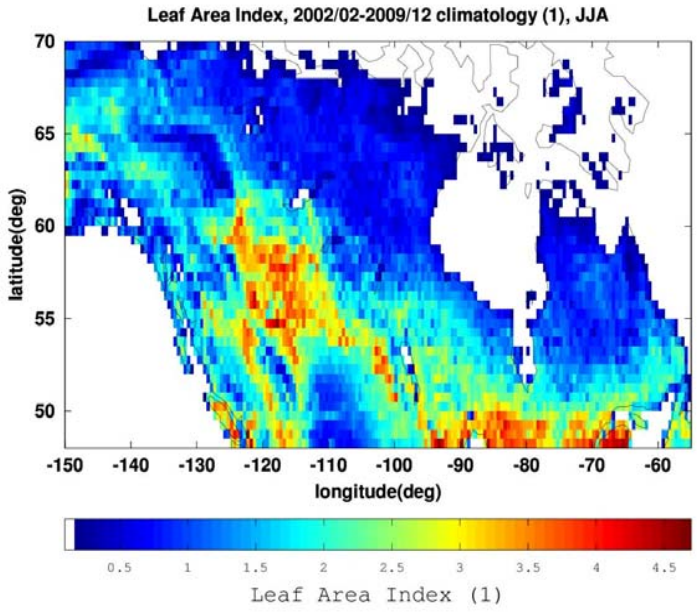
WINTER



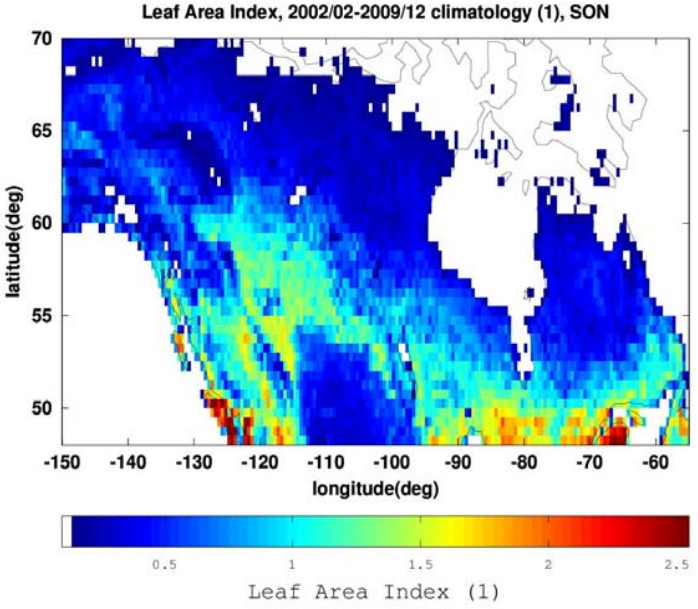
SPRING



SUMMER



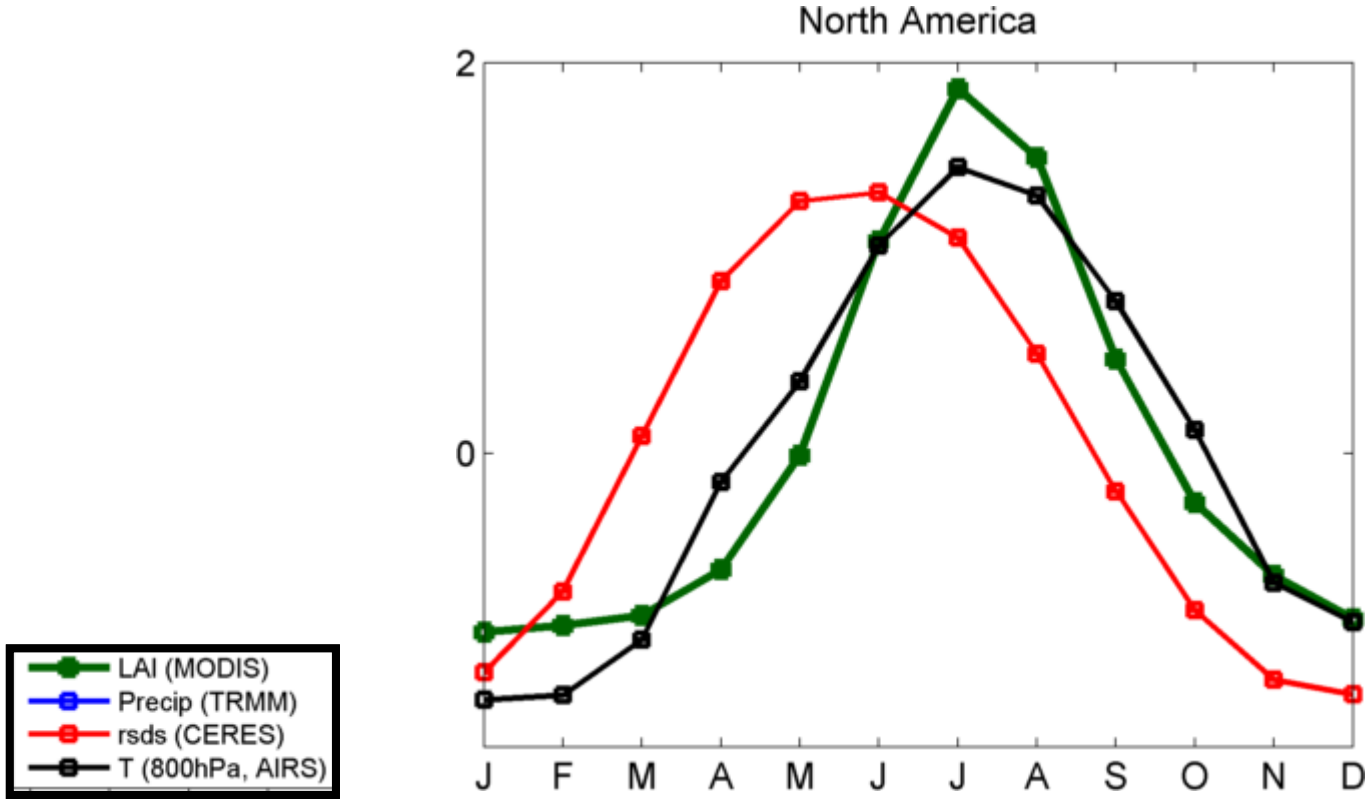
FALL



N. latitude NA forests:

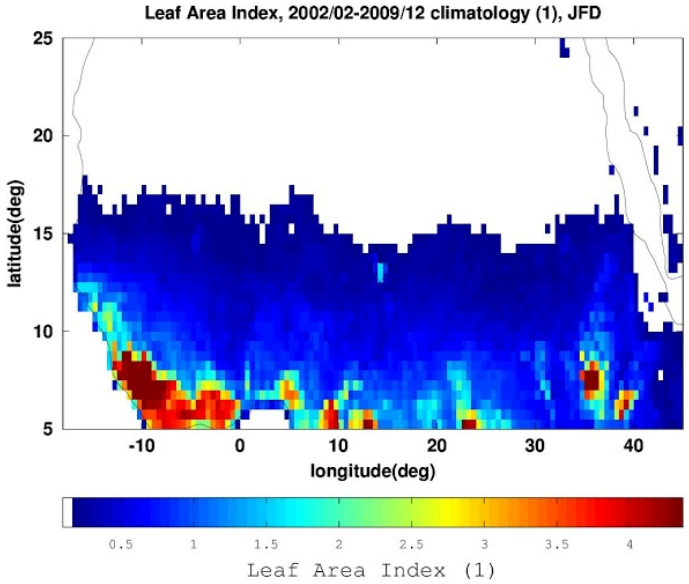
energy-limited

– TRMM precipitation only goes up to 50N



African Sahel

WINTER



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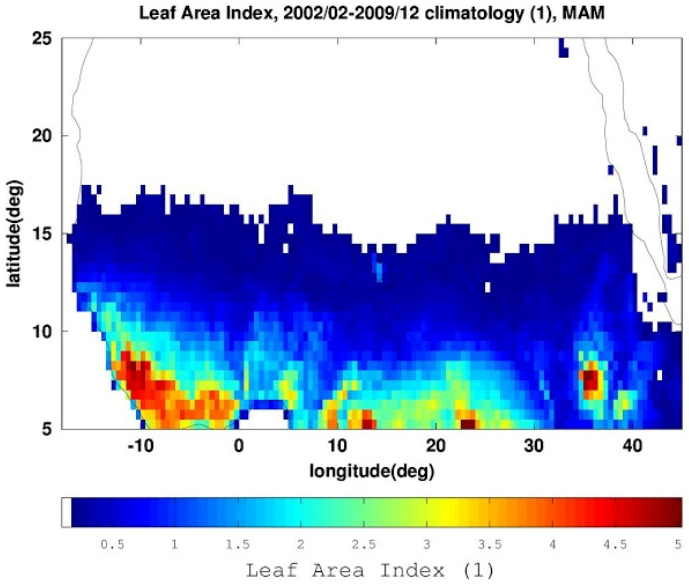
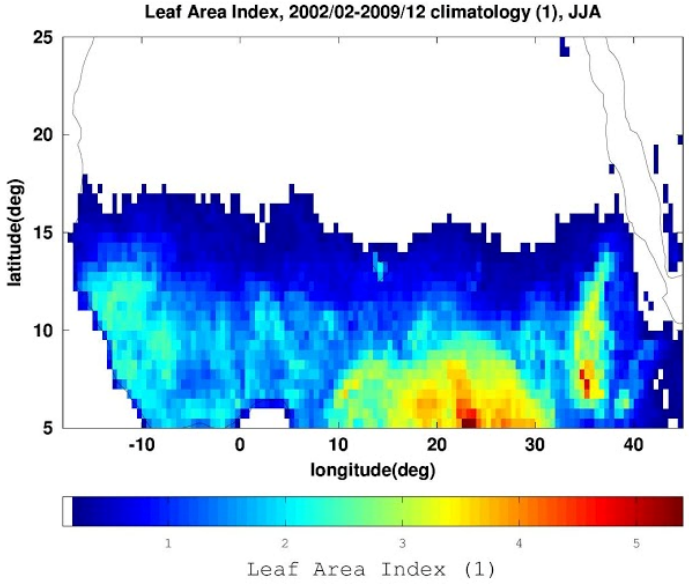
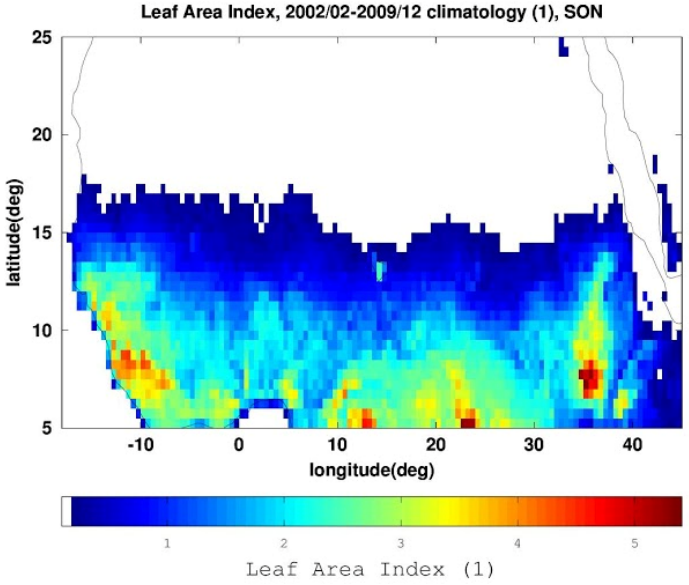


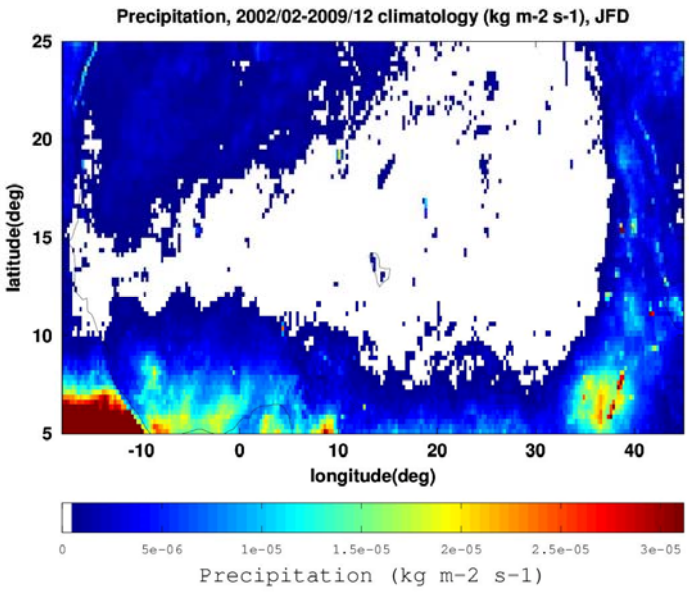
SUMMER



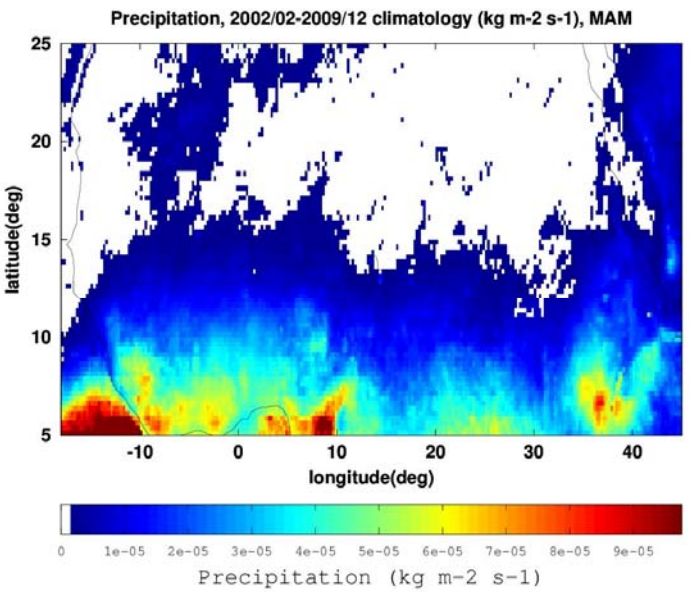
FALL



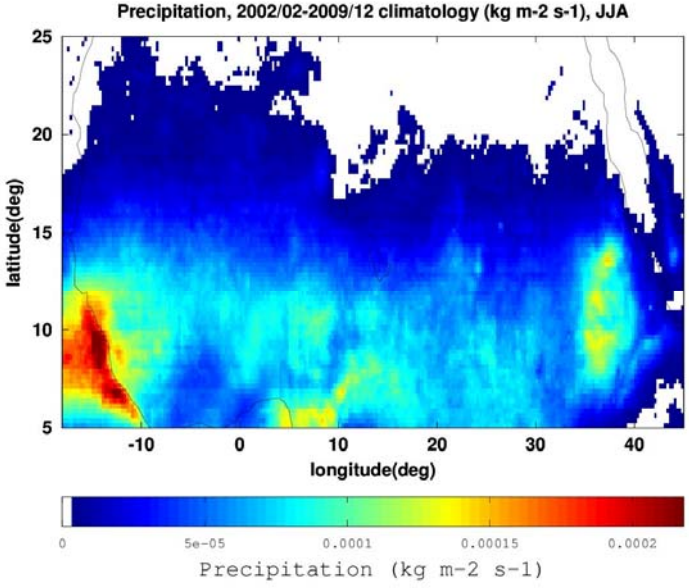
WINTER



SPRING



SUMMER



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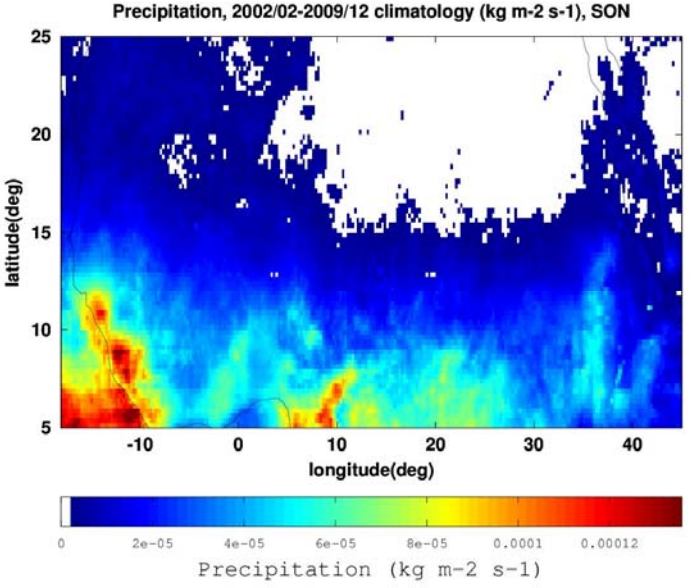
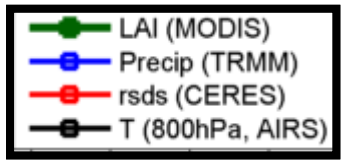
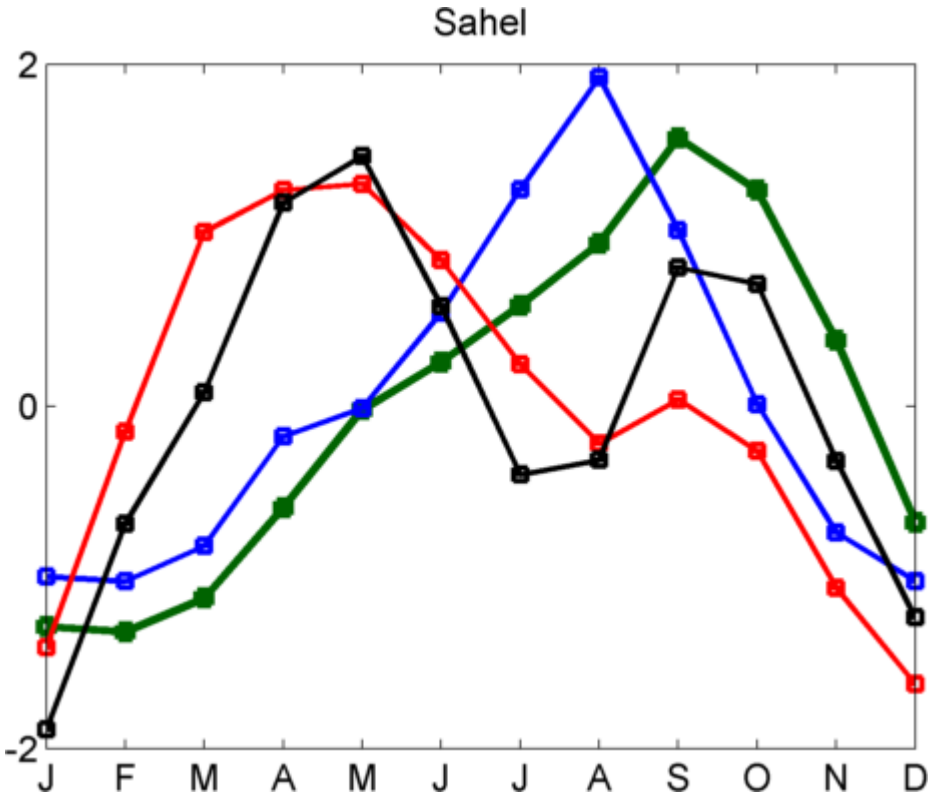


African Sahel:

water-limited

– Lag from peak precipitation to peak LAI





Conclusions

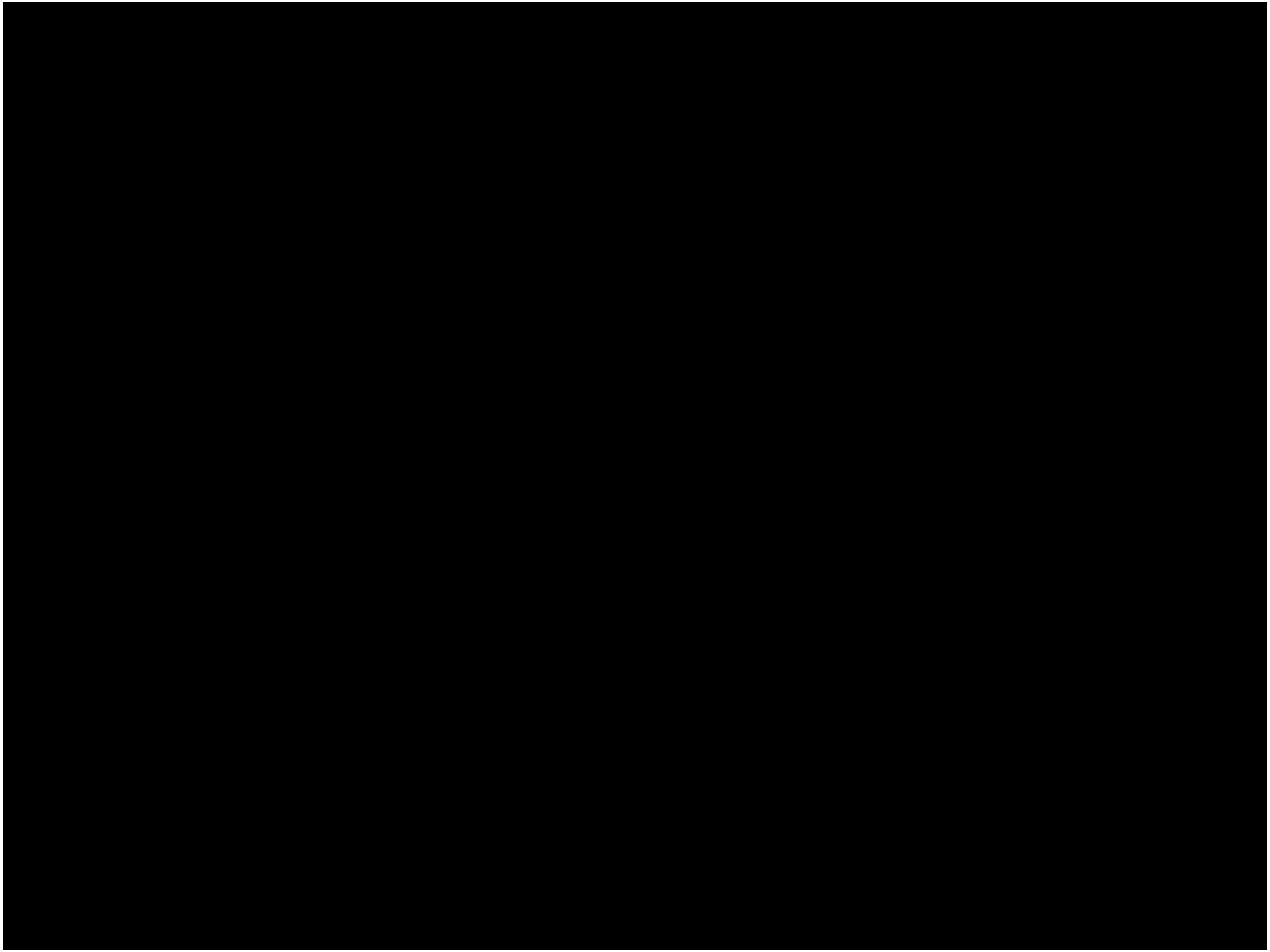
Australia: water-limited

N. latitude NA forests: energy-limited

African Sahel: water-limited

Future Work

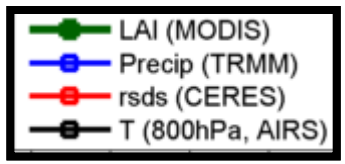
- Use AIRS surface temperature instead of 850 hPa
- Find a precipitation dataset for North America region

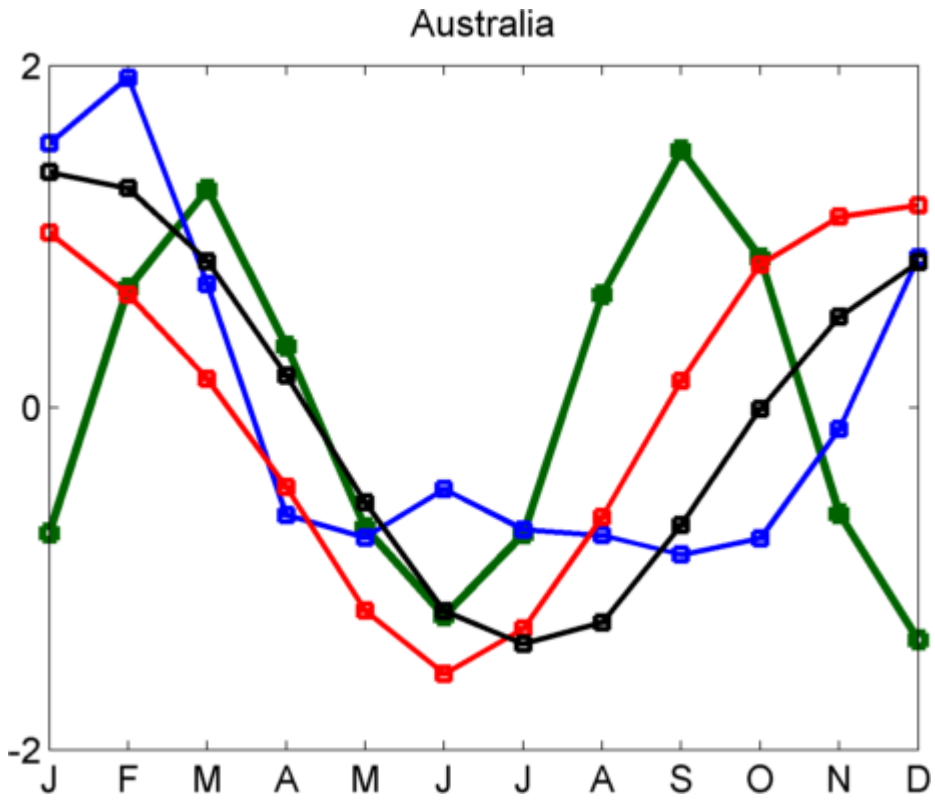


Australia:

water-limited

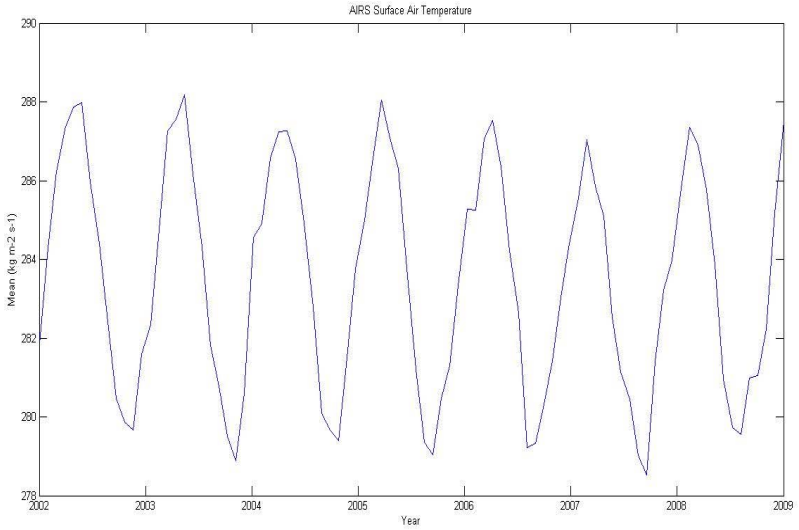
– Two rainy/vegetation seasons from different geographic areas

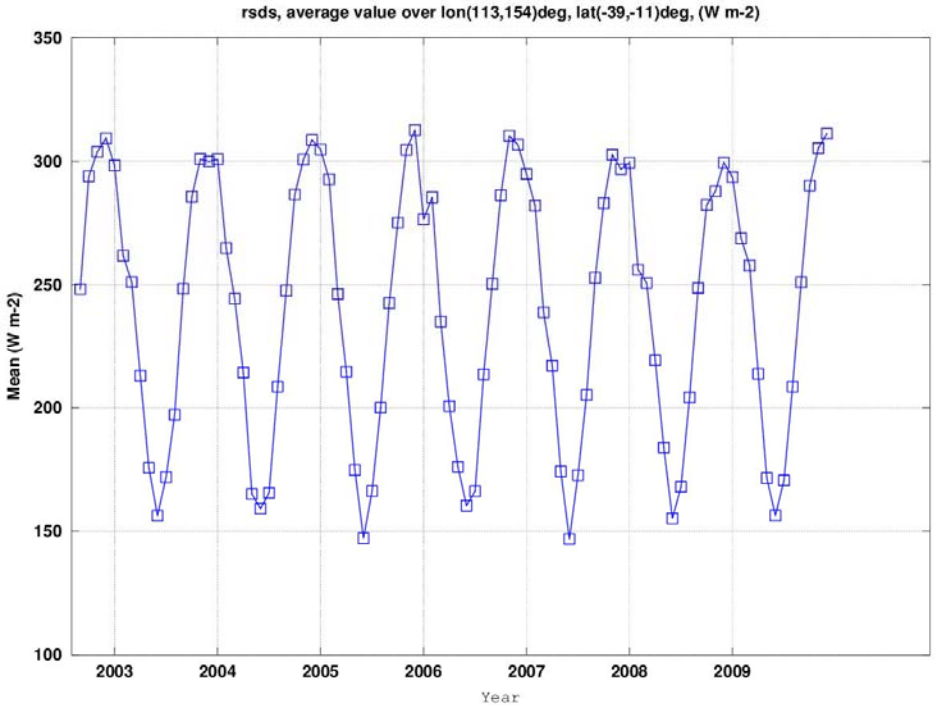




Australia – Air Temperature

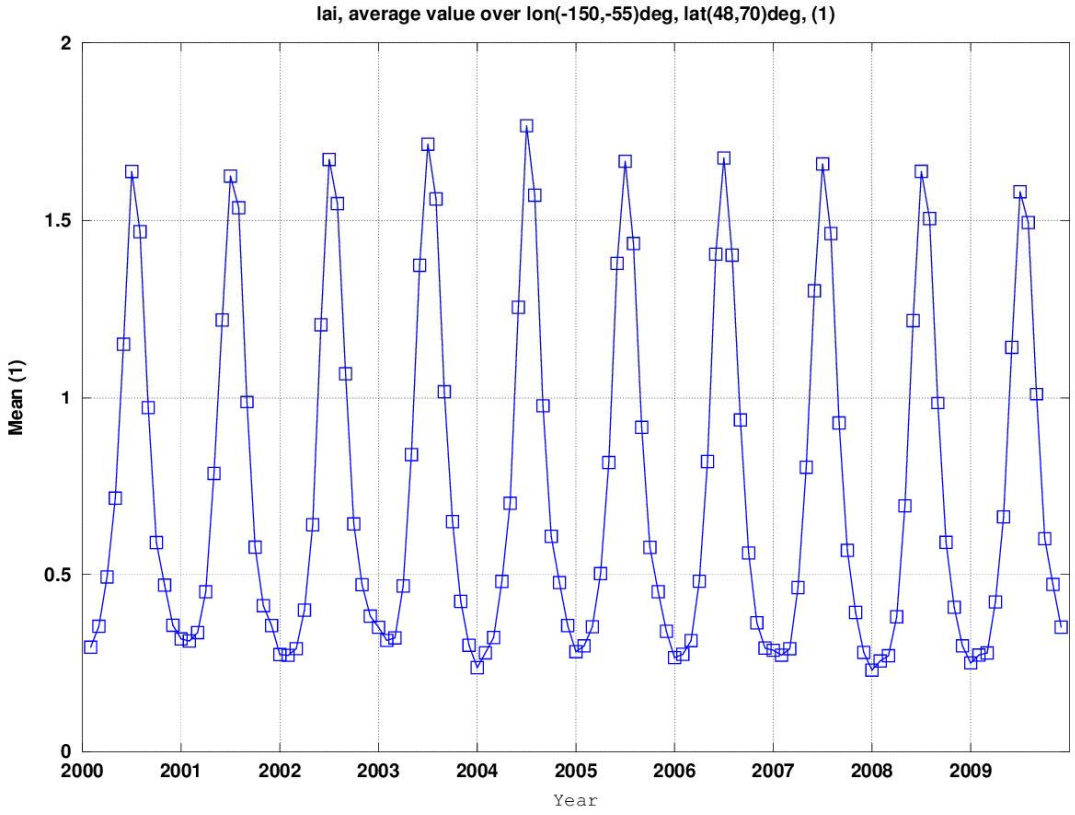
- Mann-Kendall Trend Test – No Trend
  - P Value: 0.1697 Significance Level: 0.05



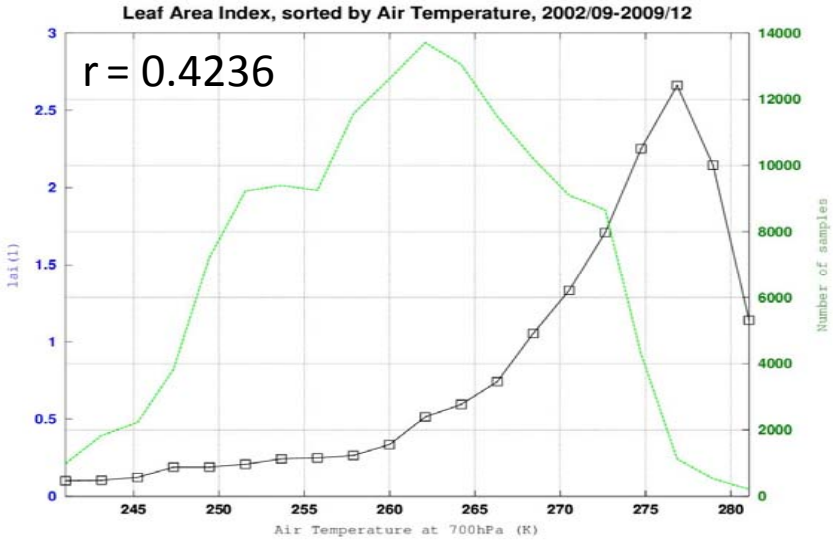


Canada – Leaf Area Index

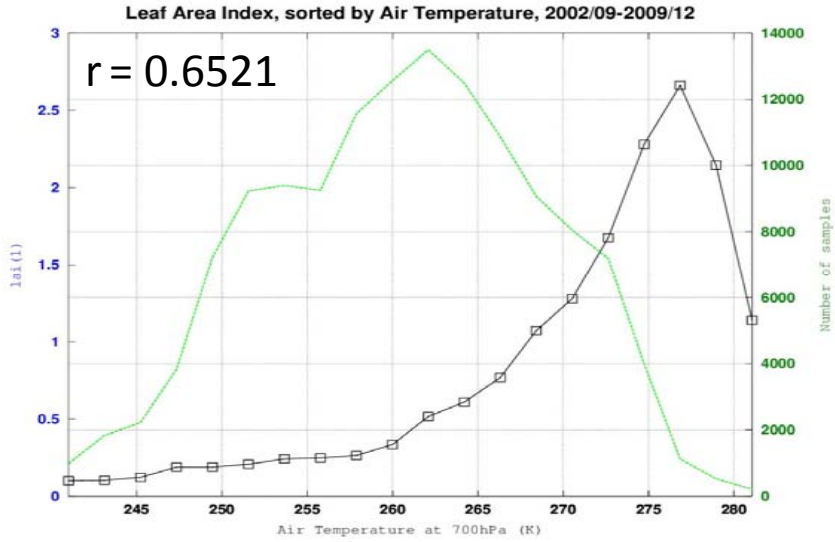
- Mann-Kendall Trend Test – No Trend
  - P Value: 0.5627 Significance Level: 0.05



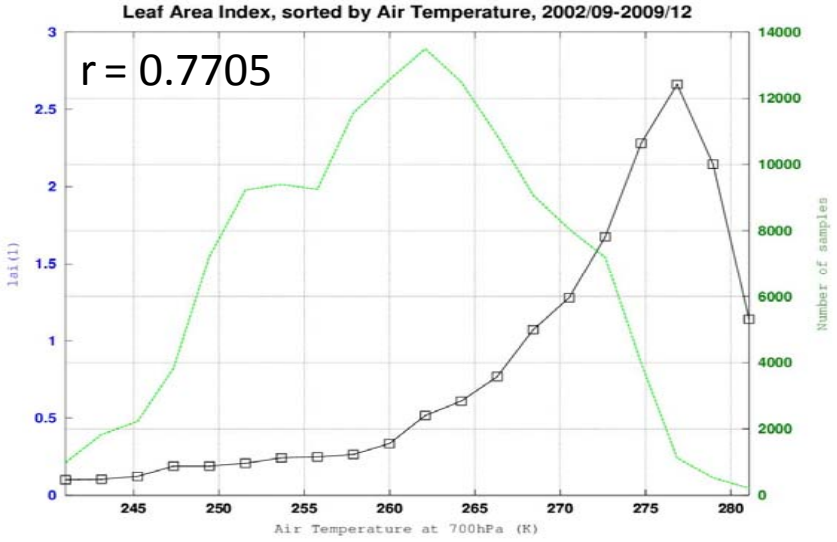
WINTER



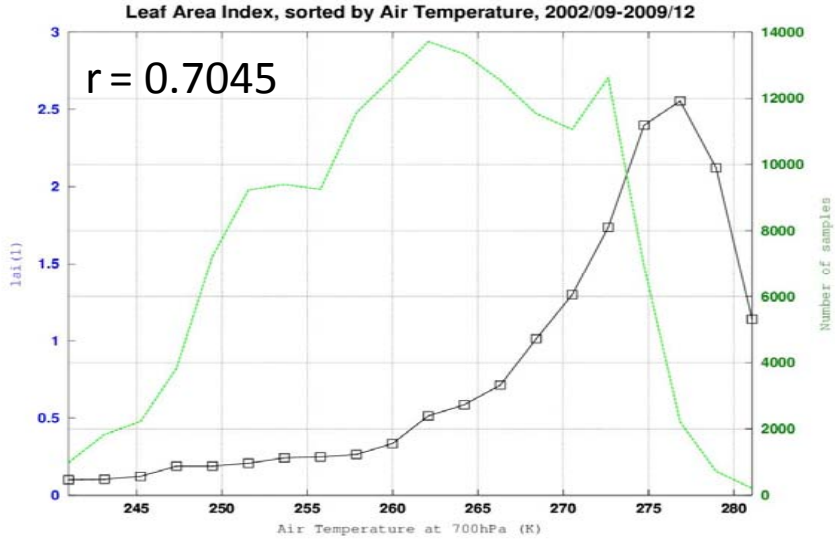
SPRING



SUMMER

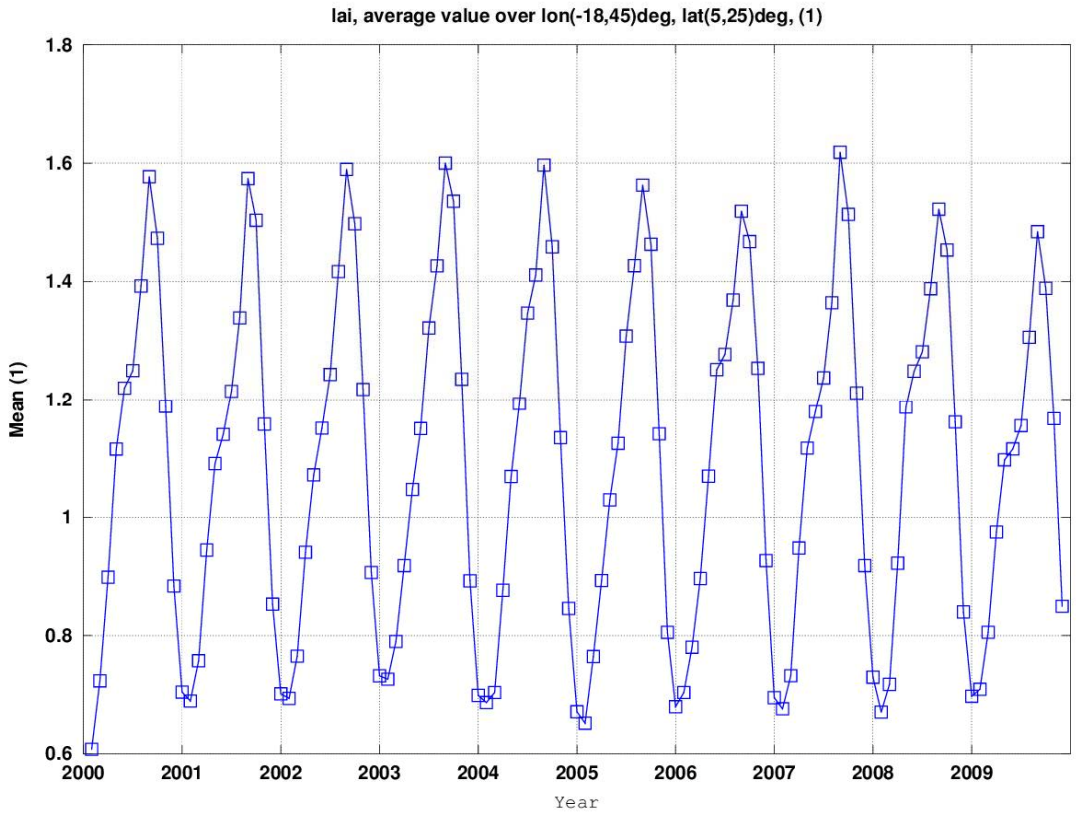


FALL



Africa – Leaf Area Index

- Mann-Kendall Trend Test – No Trend
  - P Value: 0.5973 Significance Level: 0.05

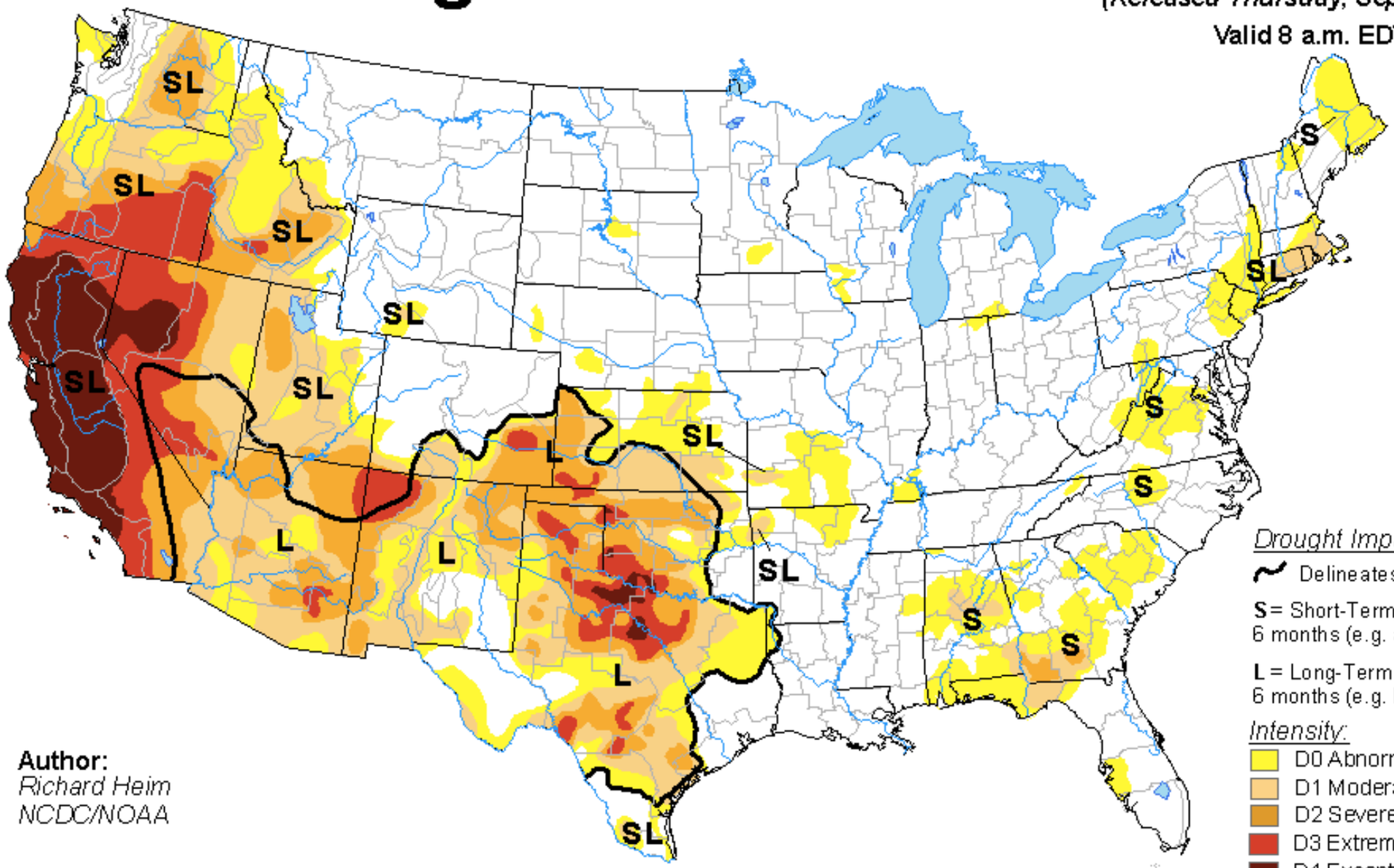


U.S. Drought Monitor

September 23, 2014

(Released Thursday, Sep. 25, 2014)

Valid 8 a.m. EDT



Author:
Richard Heim
NCDC/NOAA

Drought Impact Types:

~ Delineates dominant impacts

S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

USDA National Drought Mitigation Center

http://droughtmonitor.unl.edu/

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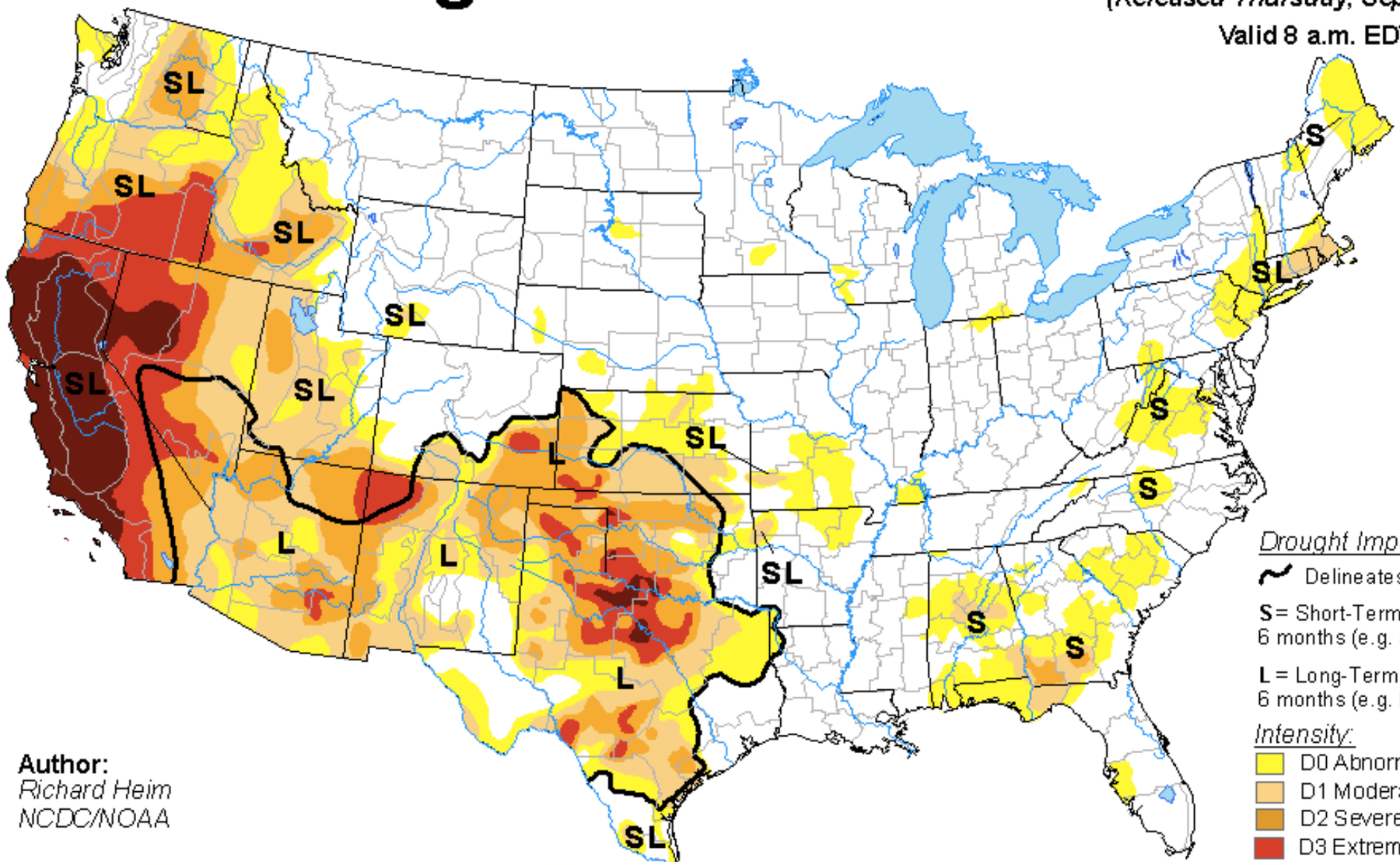

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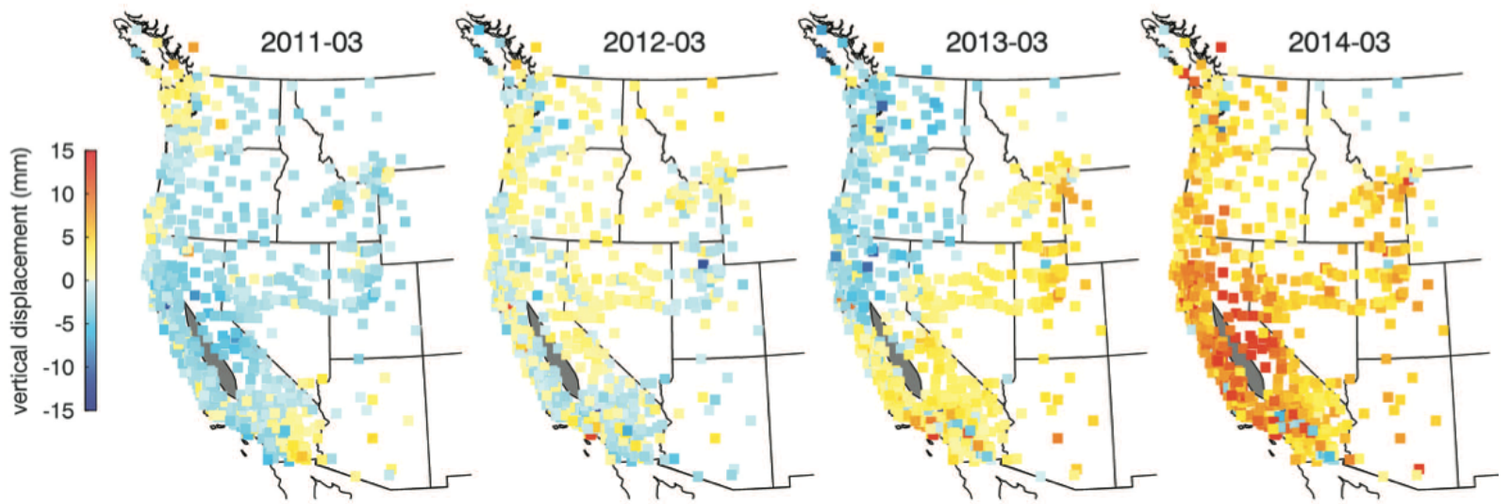
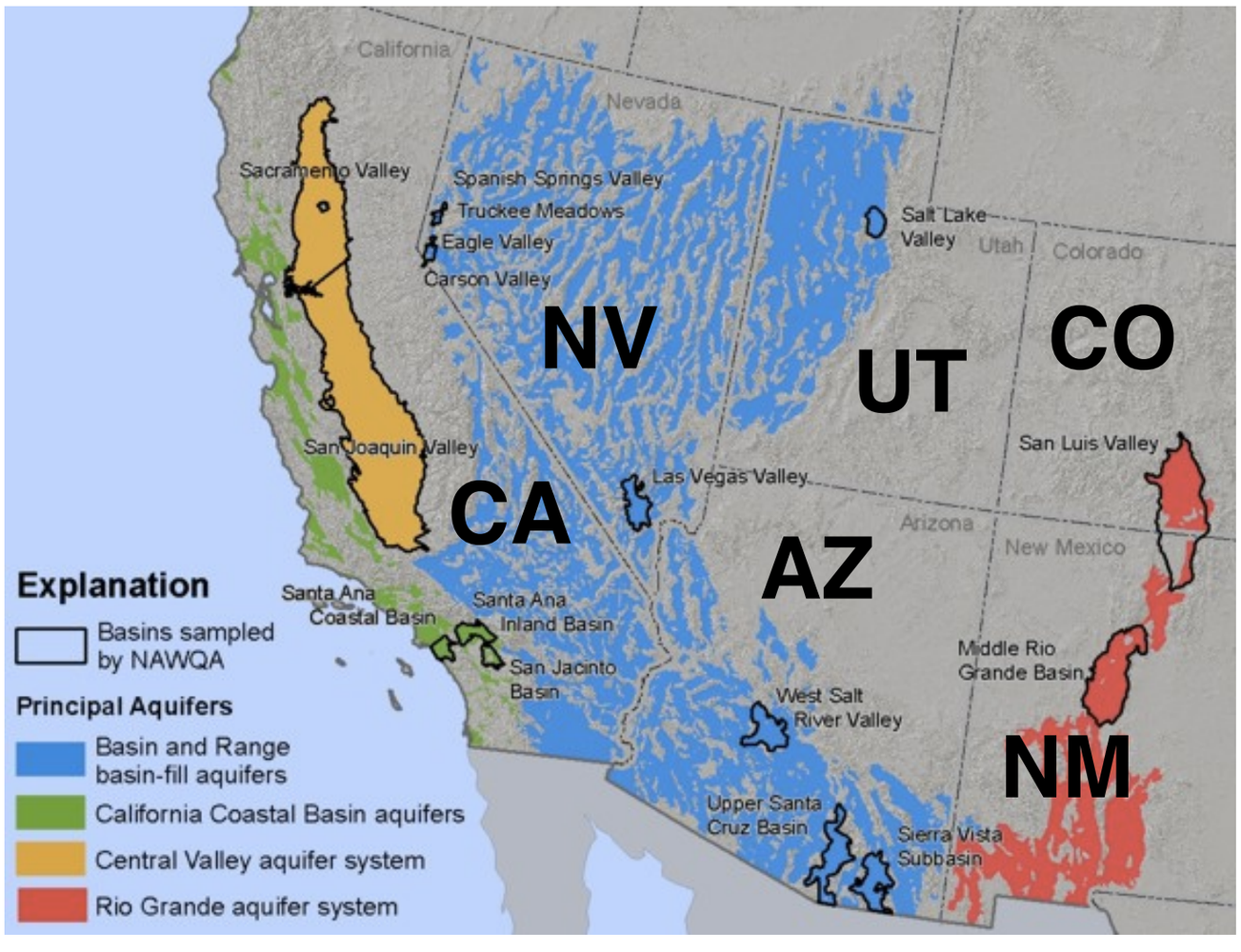
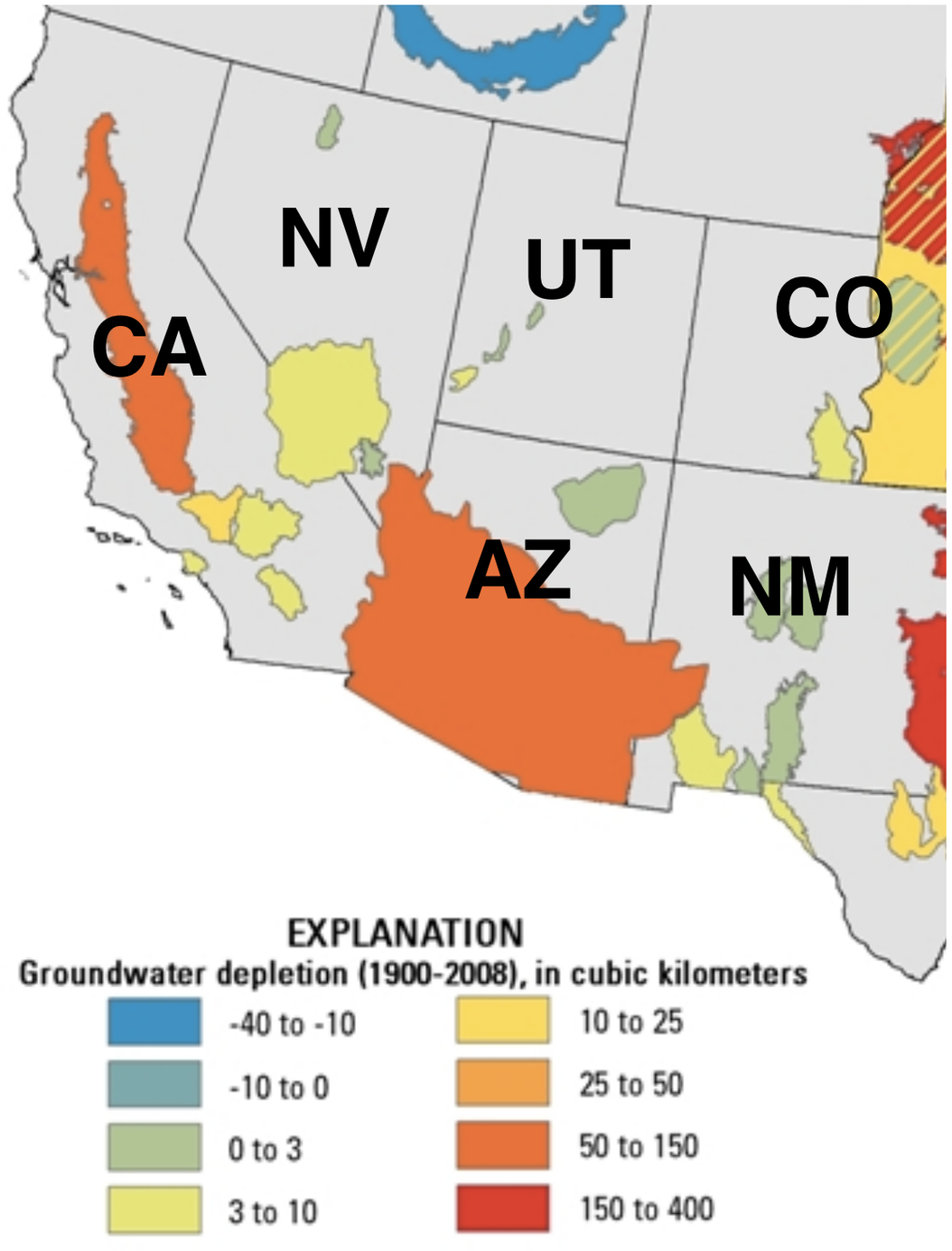


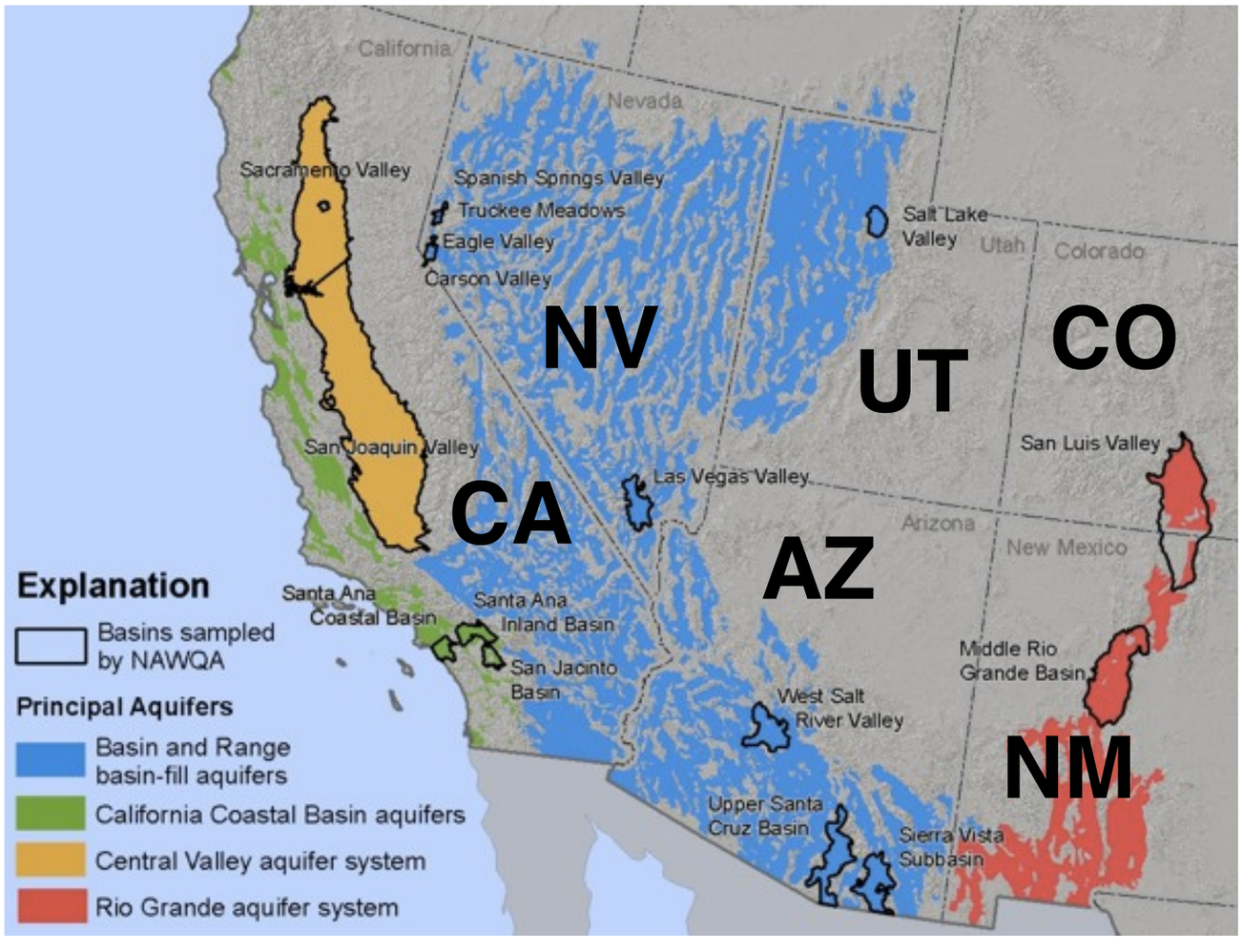
Fig. 2. Maps of vertical GPS displacements. Spatial distribution of displacements from the time series in Fig. 1, from 1 March 2011 through 2014. Uplift is indicated by yellow-red colors and subsidence by shades of blue. The gray region is where stations were excluded in the Central Valley of California.

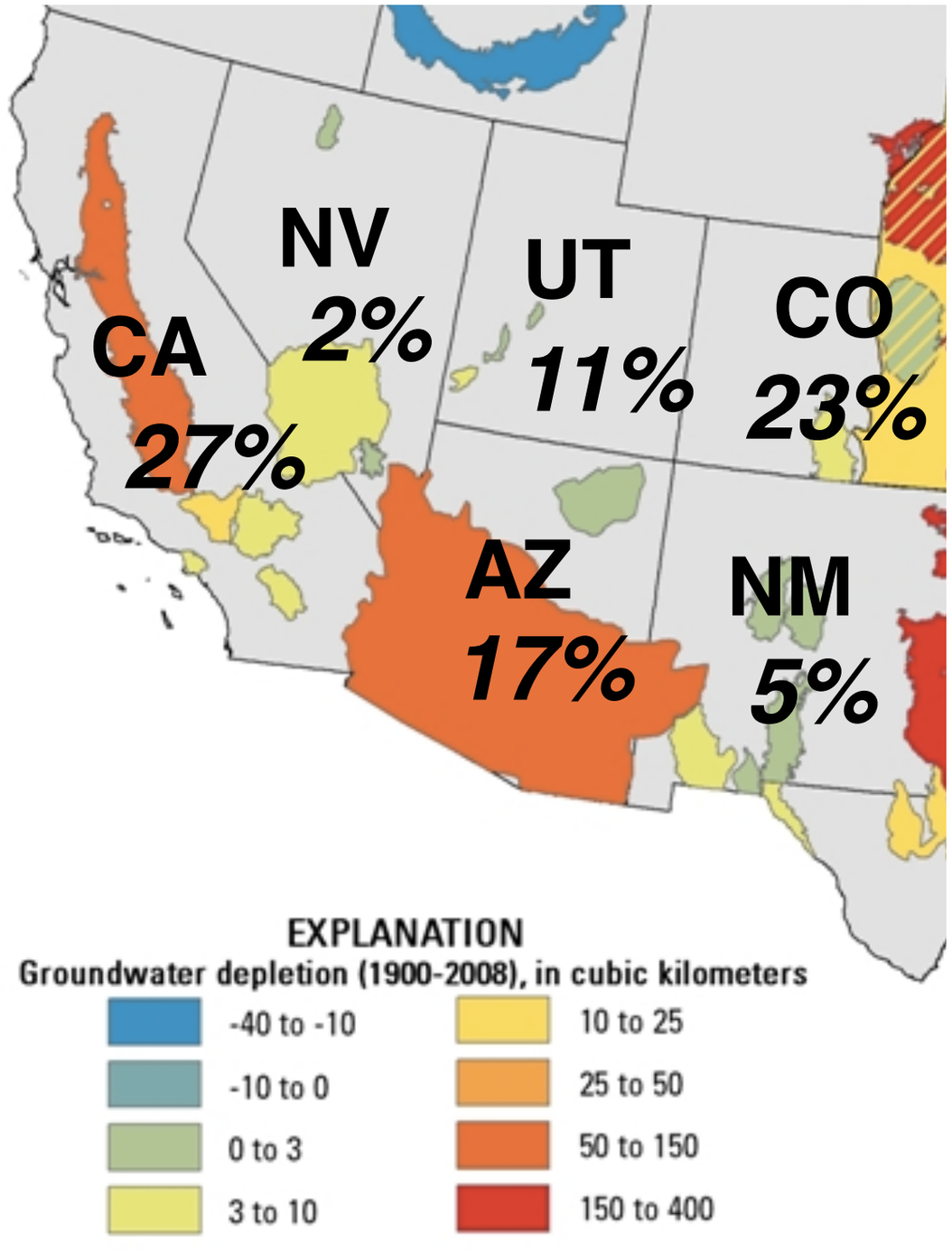
Water Availability and Stress in Southwest USA





Water Availability and Stress in Southwest USA

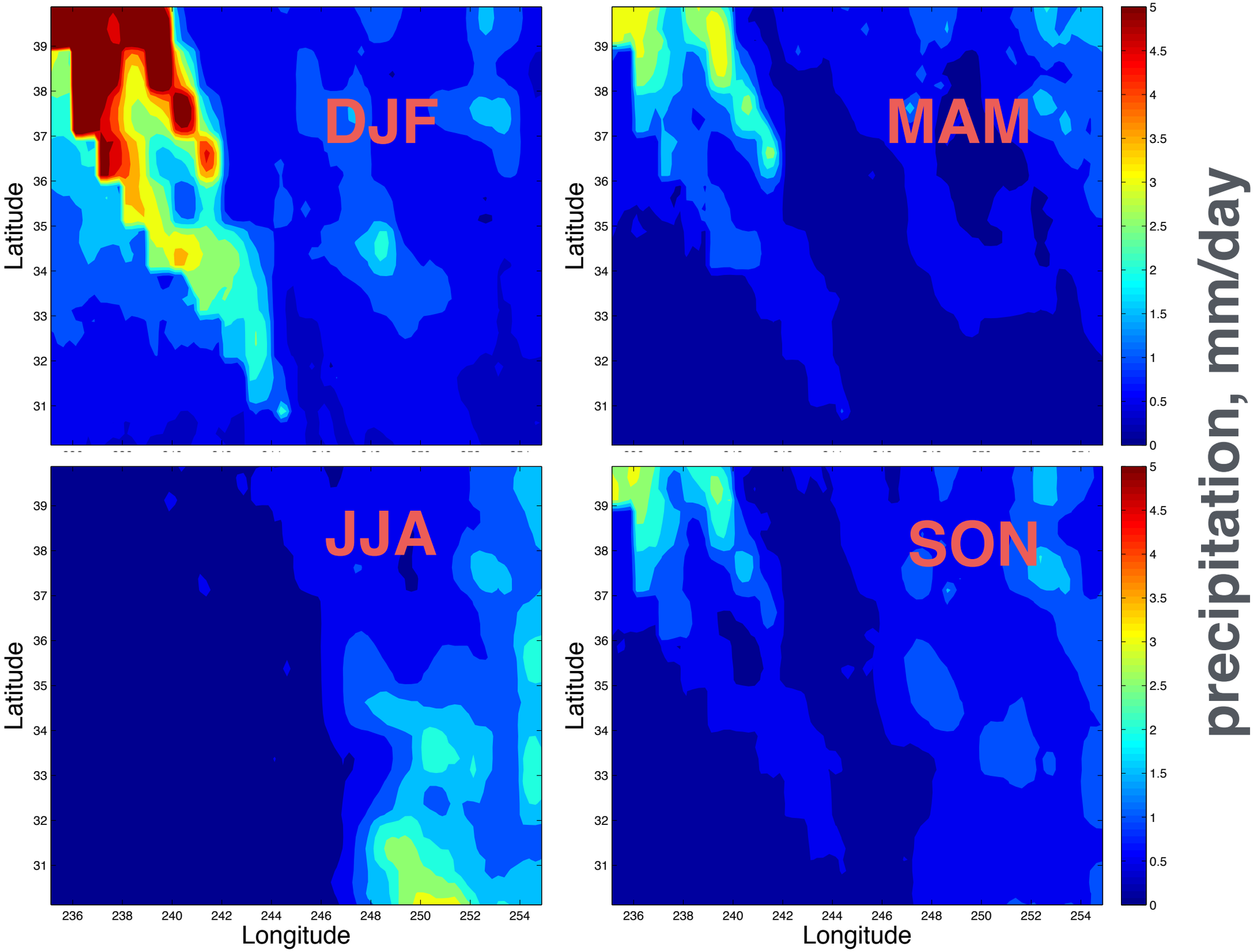




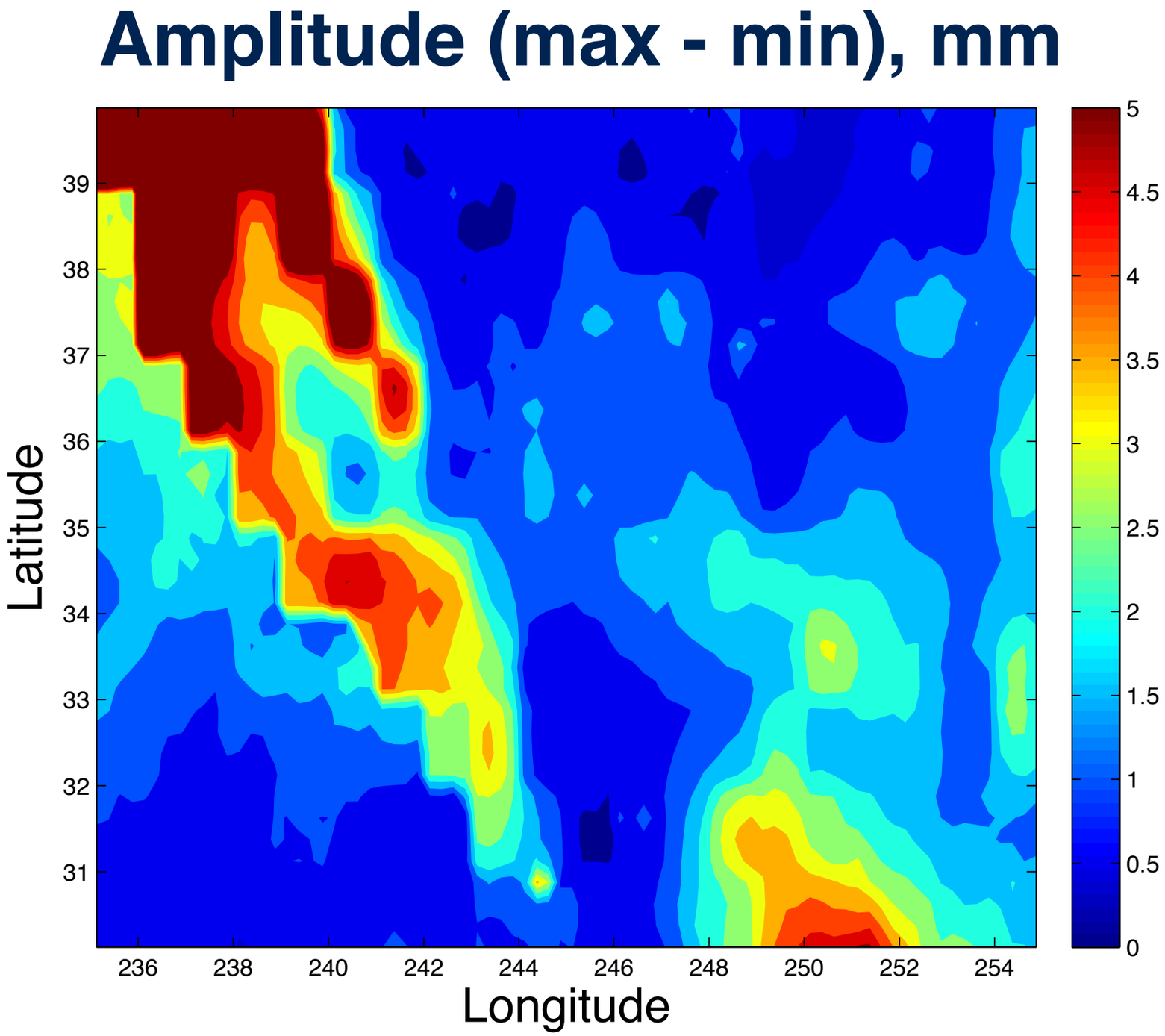
PLAN

- Precipitation from NASA/TRMM
- Soil Moisture from NASA/GRACE
- Short Wave Radiation from NASA CERES

Seasonal Precipitation

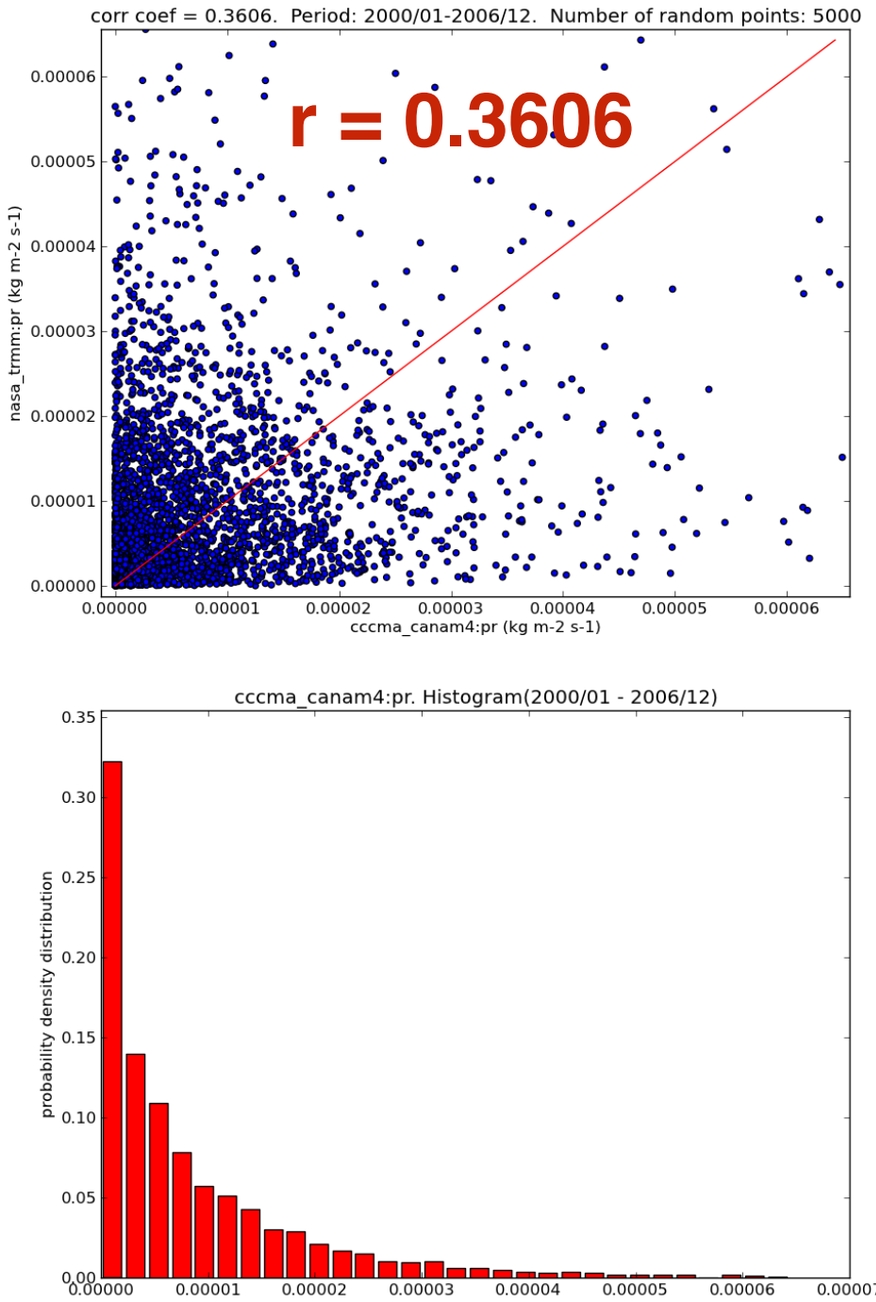


Precipitation Seasonality

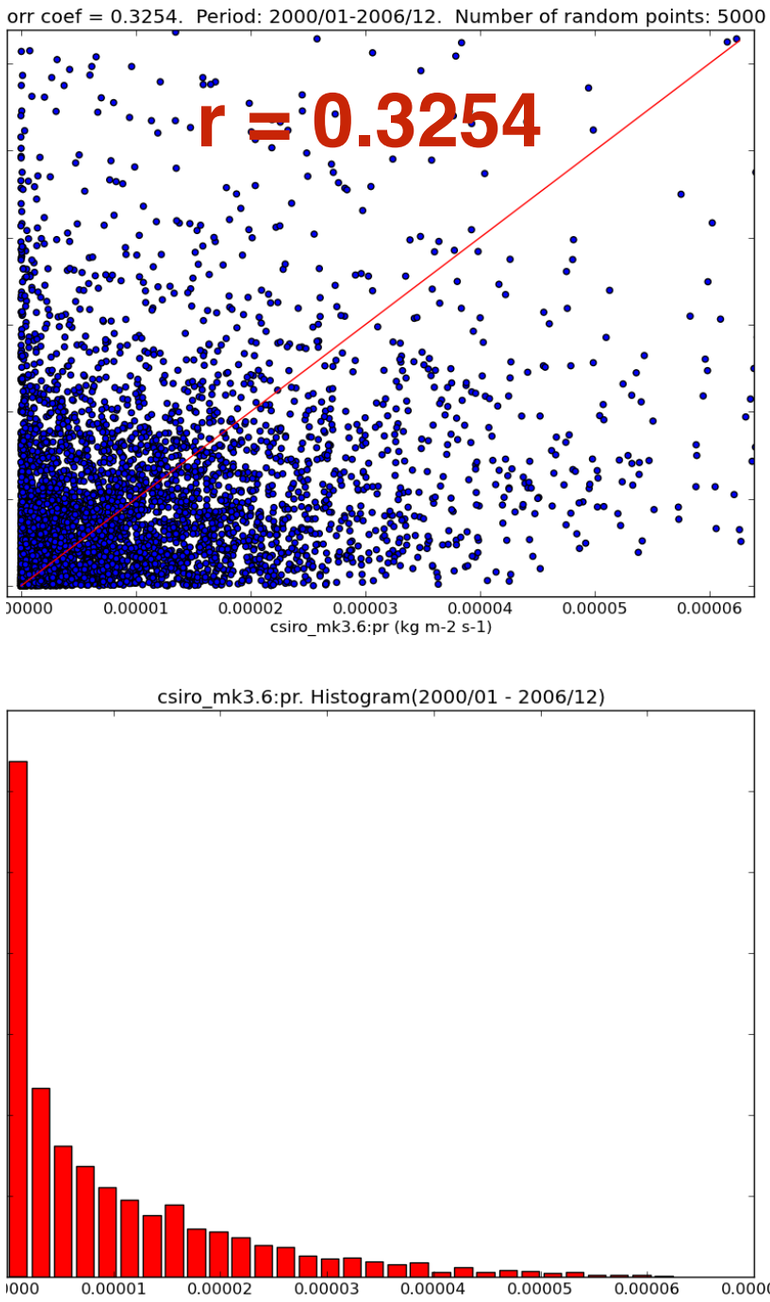


Quick look at model performance

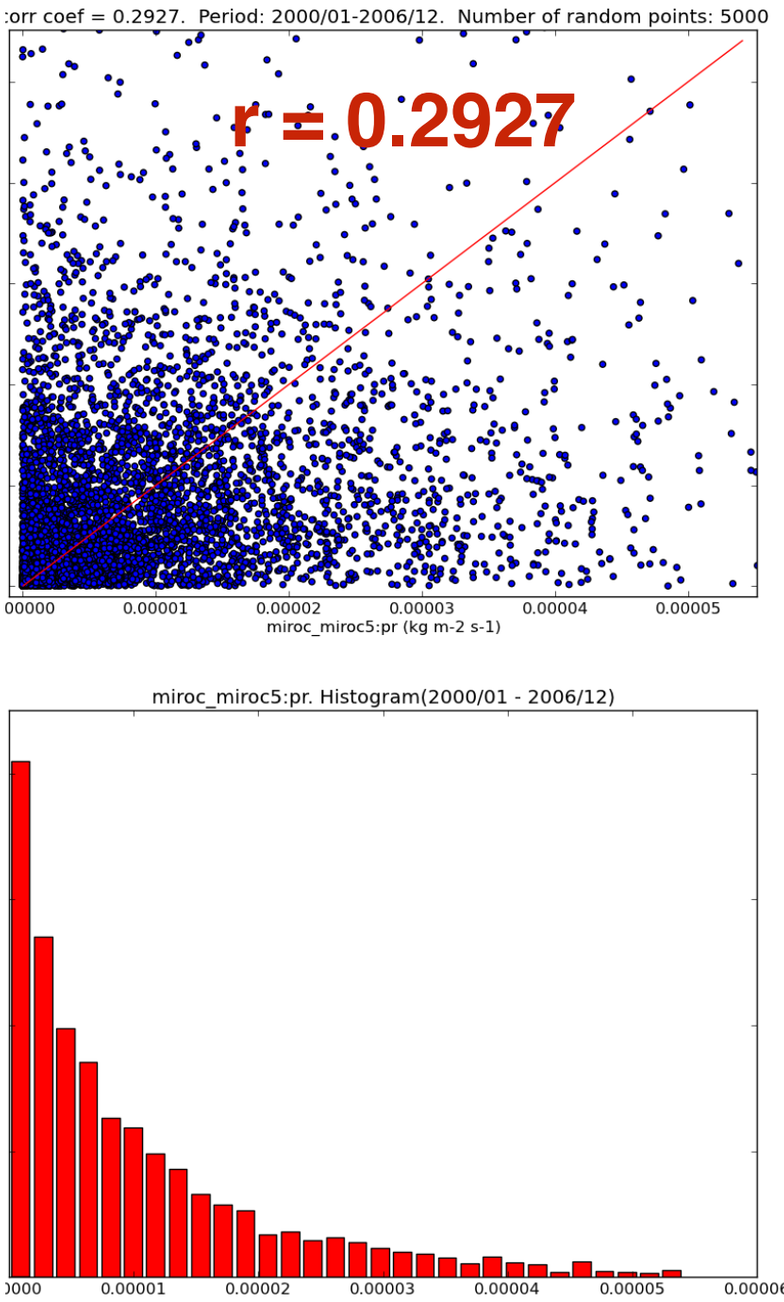
CCCMA/CANAM4



CSIRO/MK3.6



MIROC/MIROC5



Quick look at model performance

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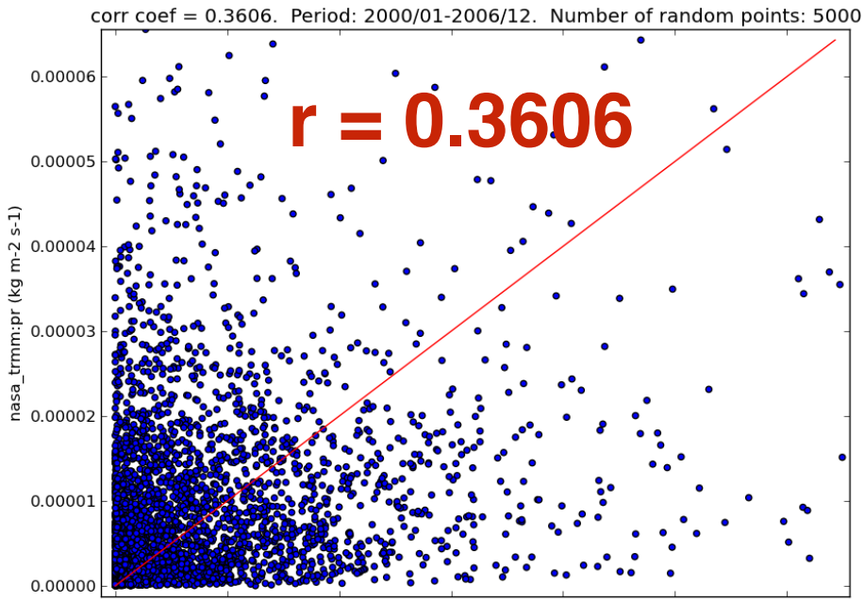

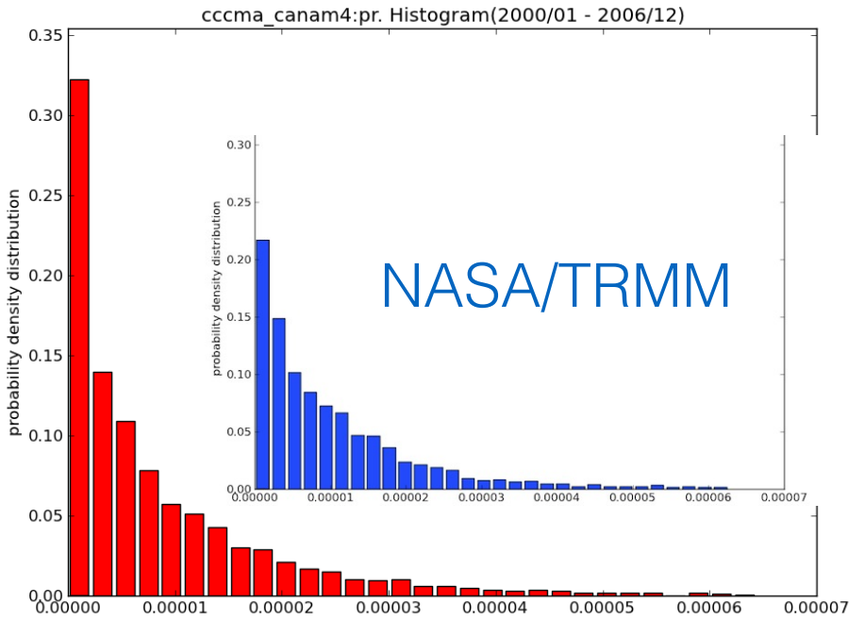

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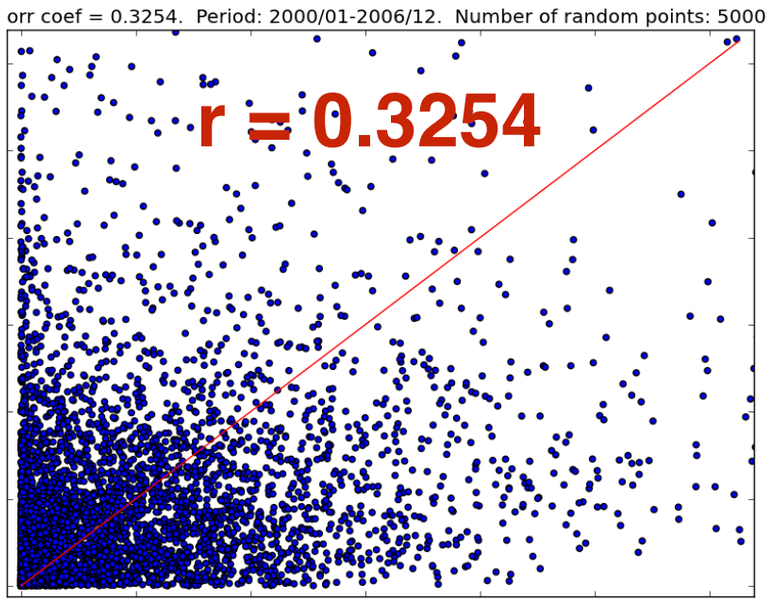

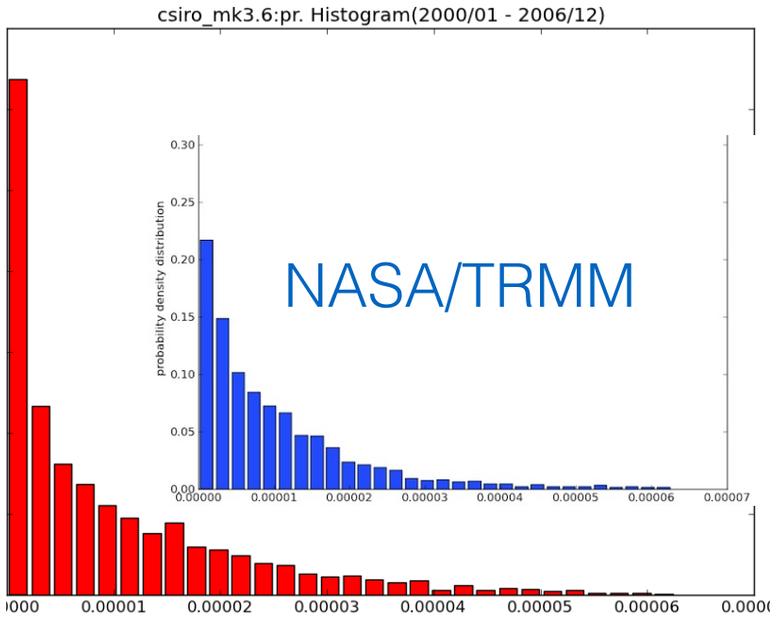

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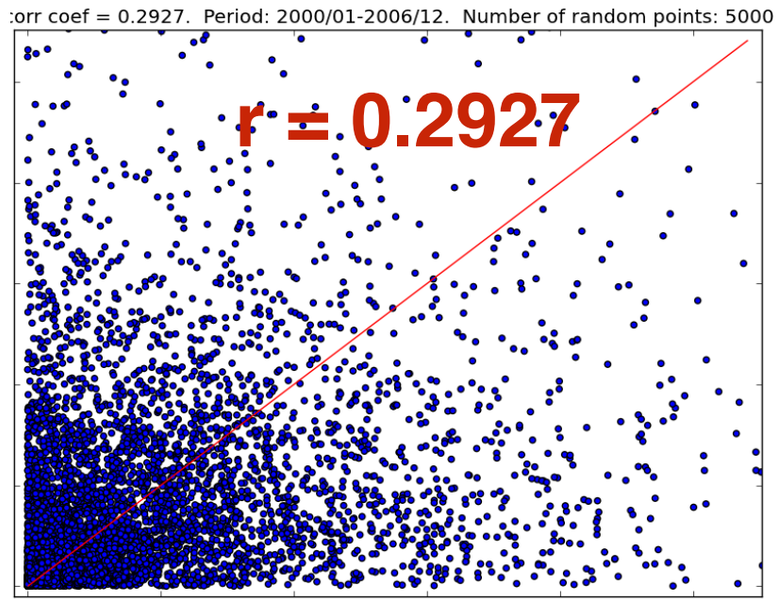
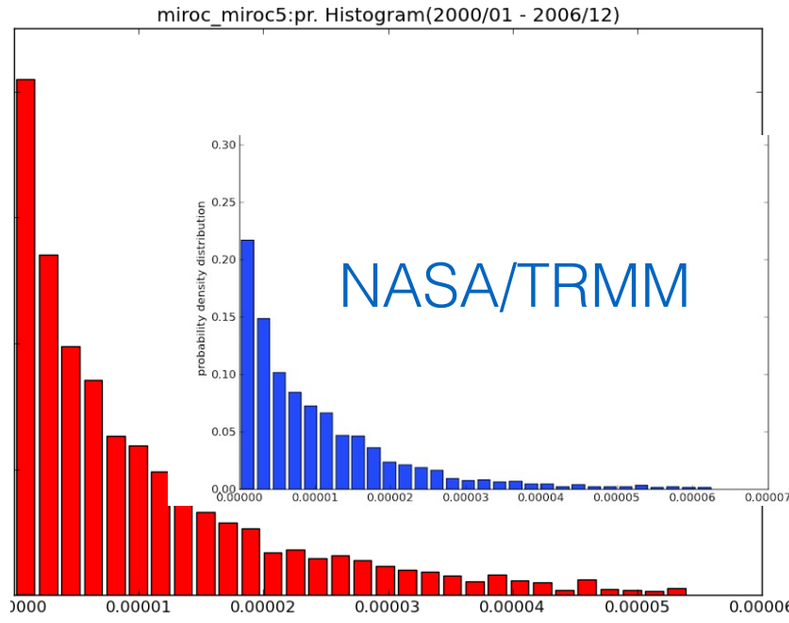
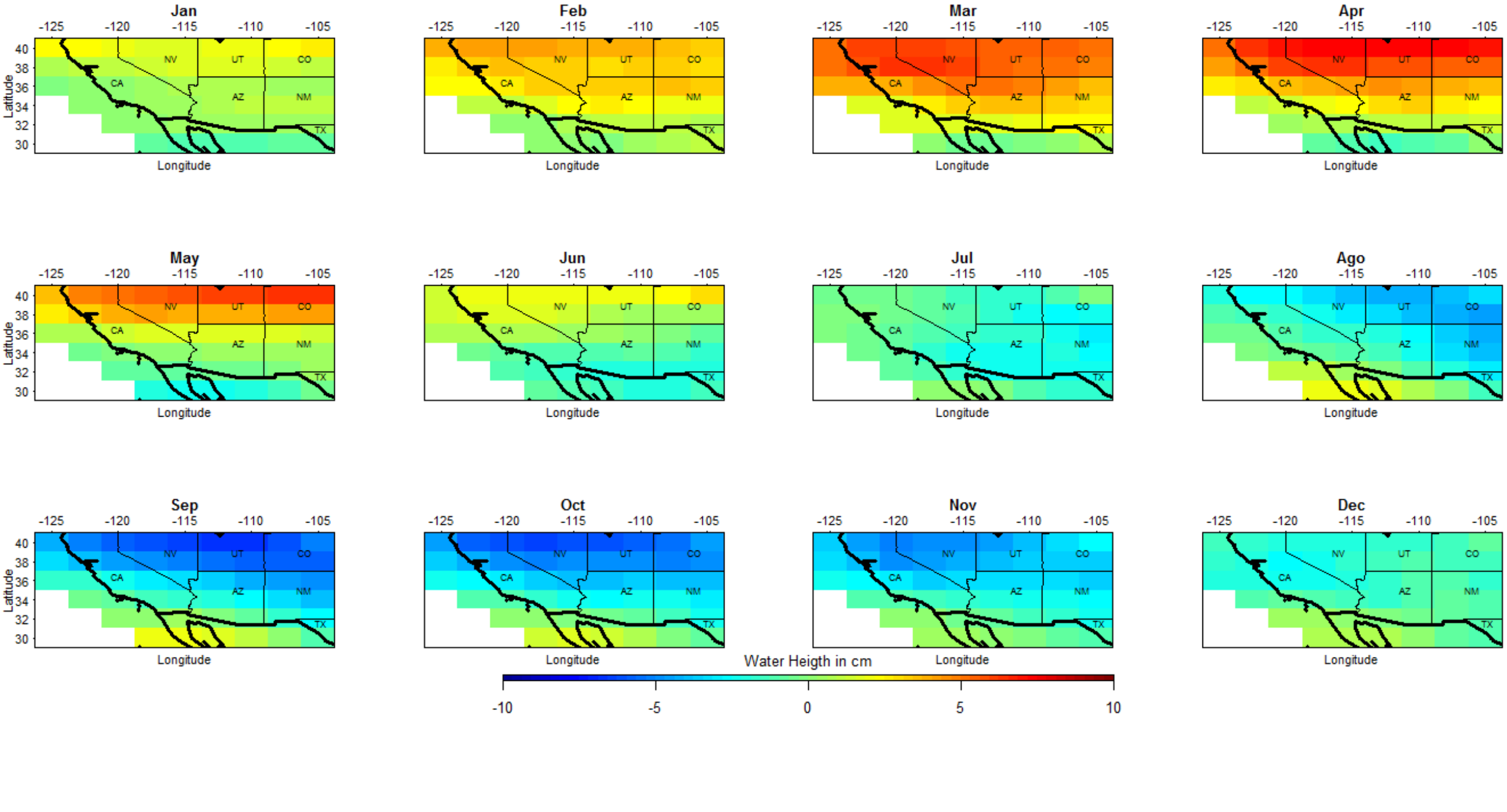
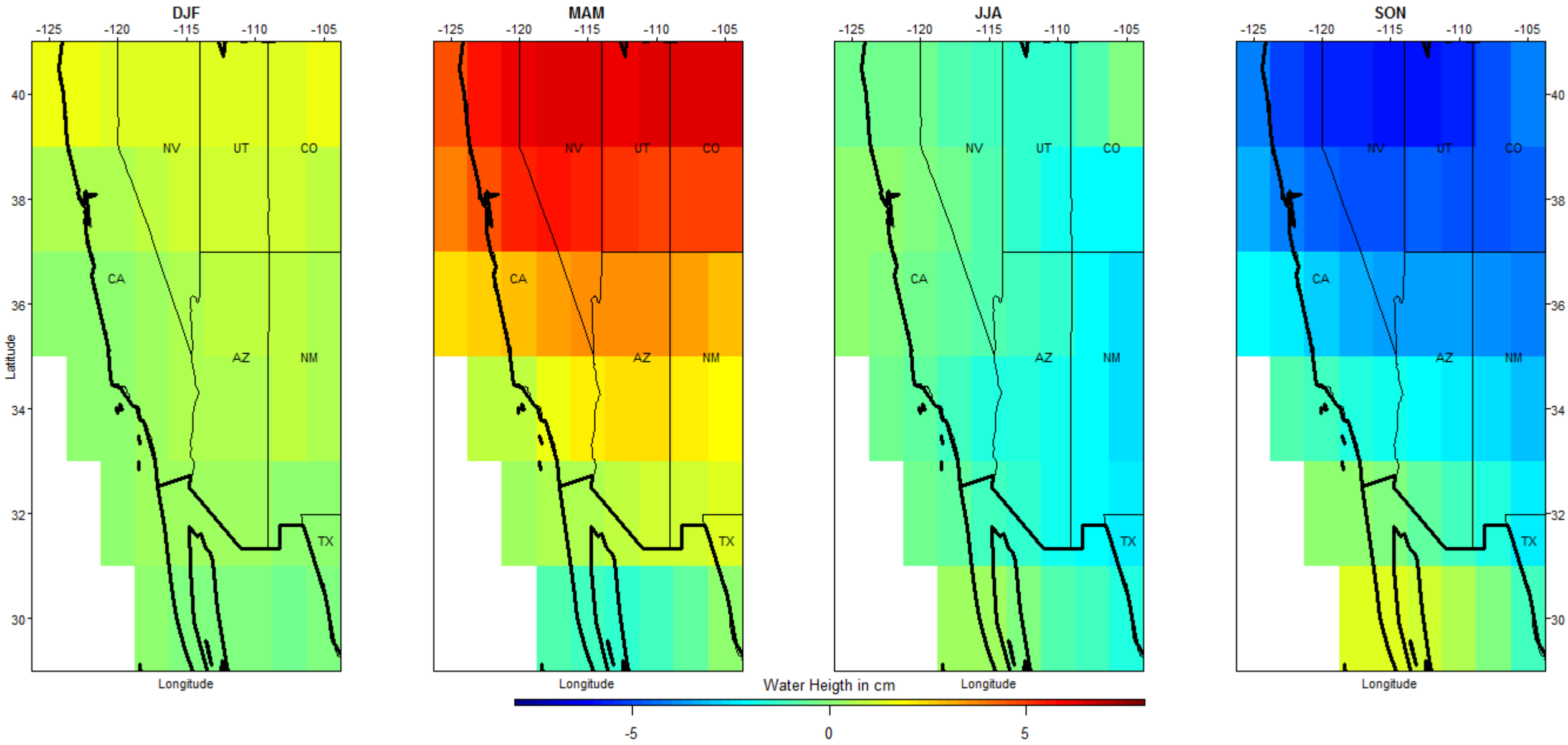




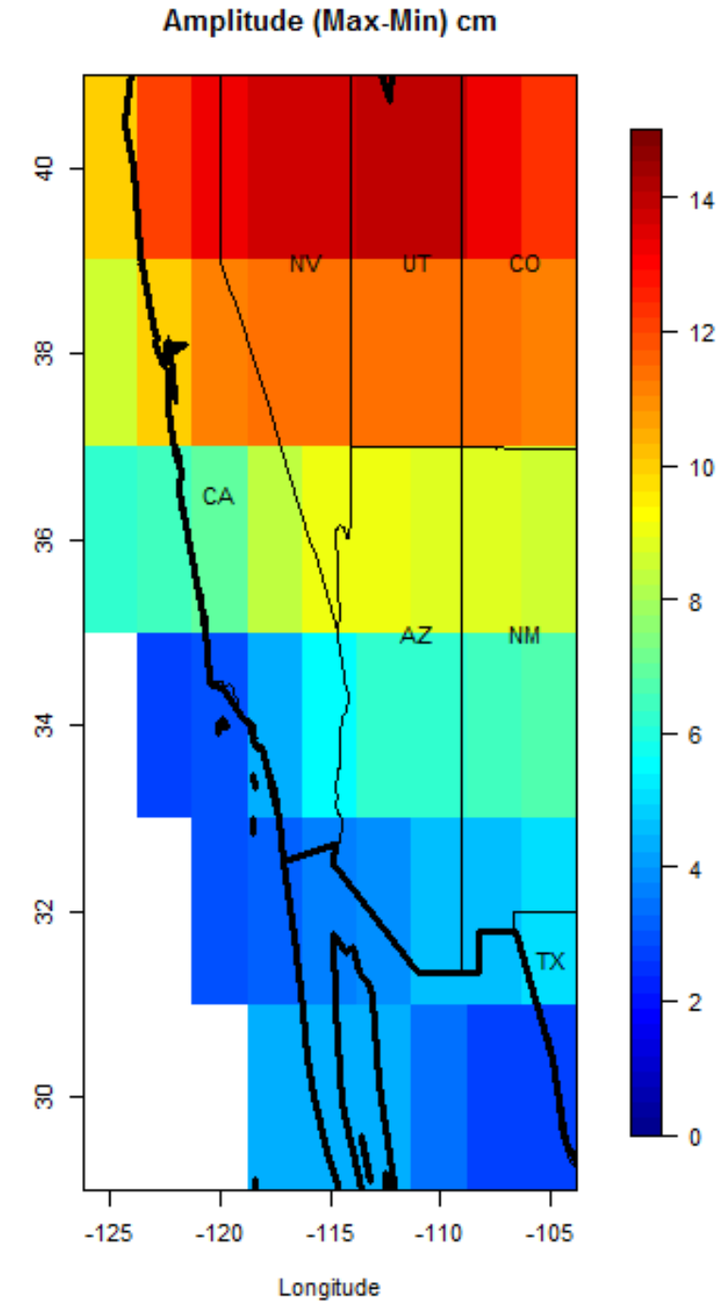
Soil Moisture

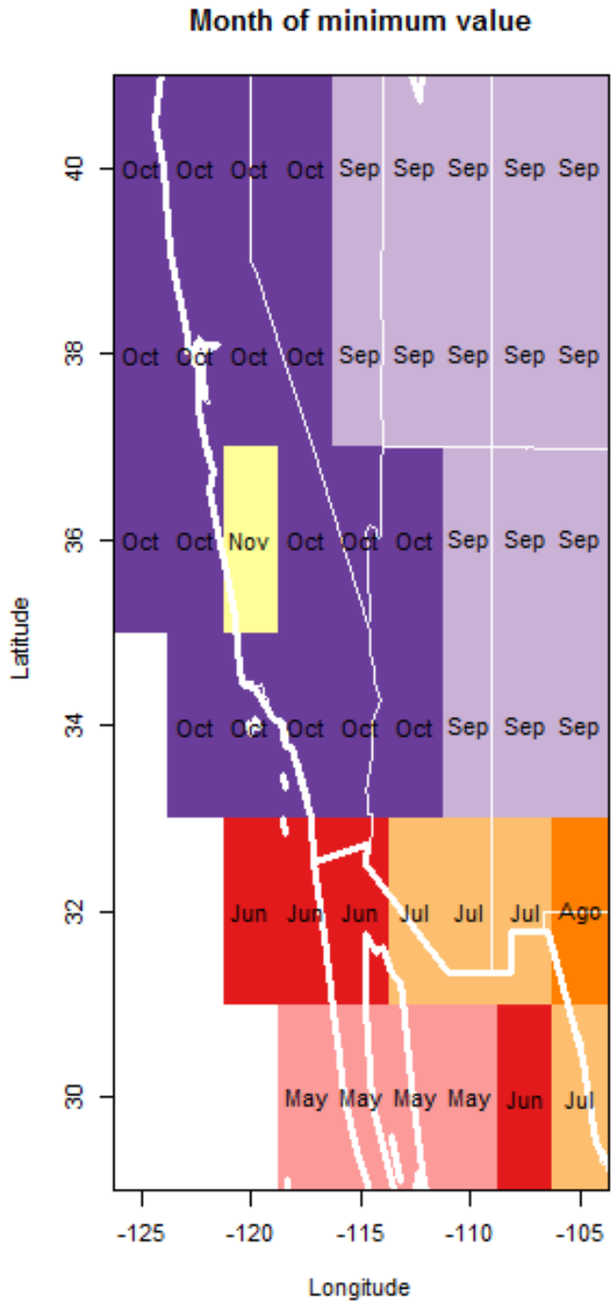


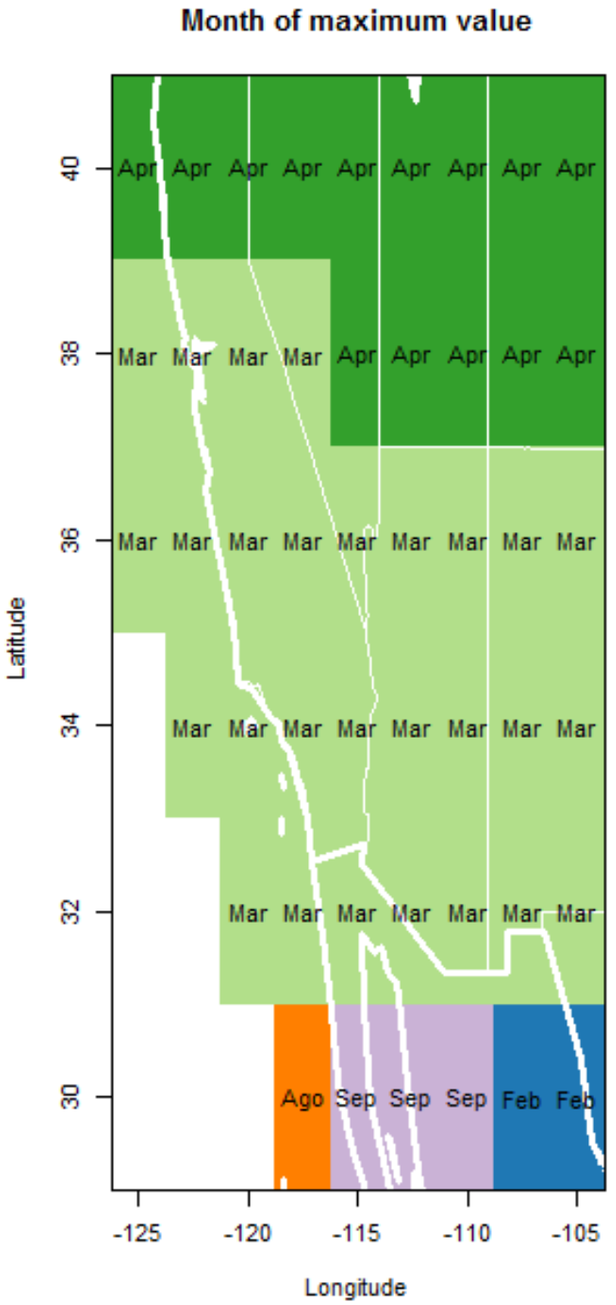
Seasonal Soil Moisture



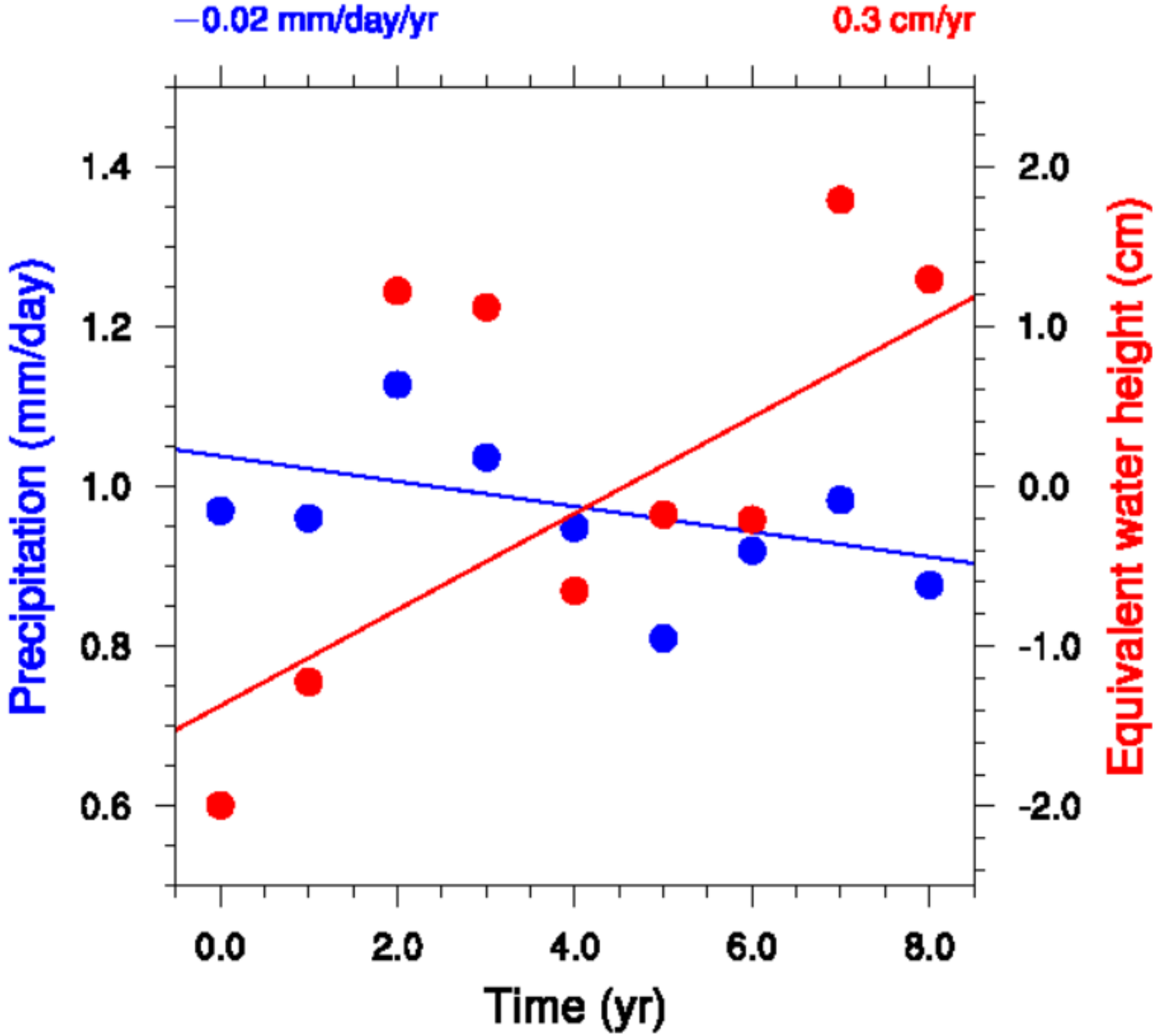
Soil Moisture Seasonality



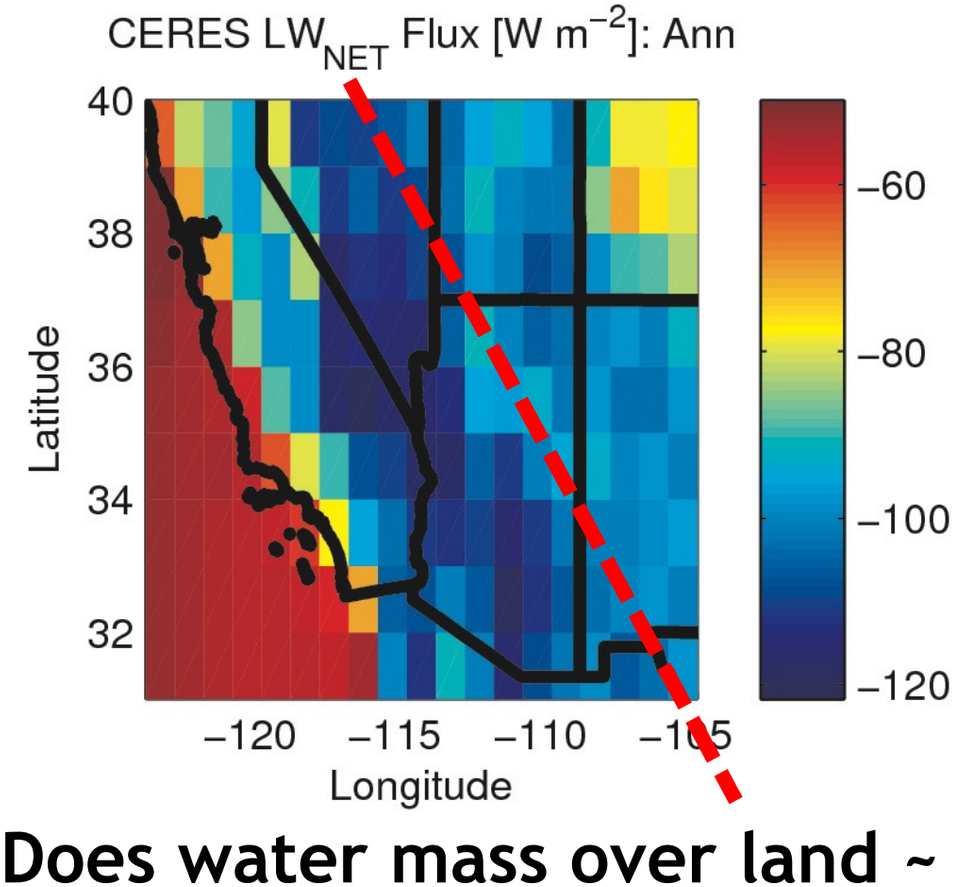


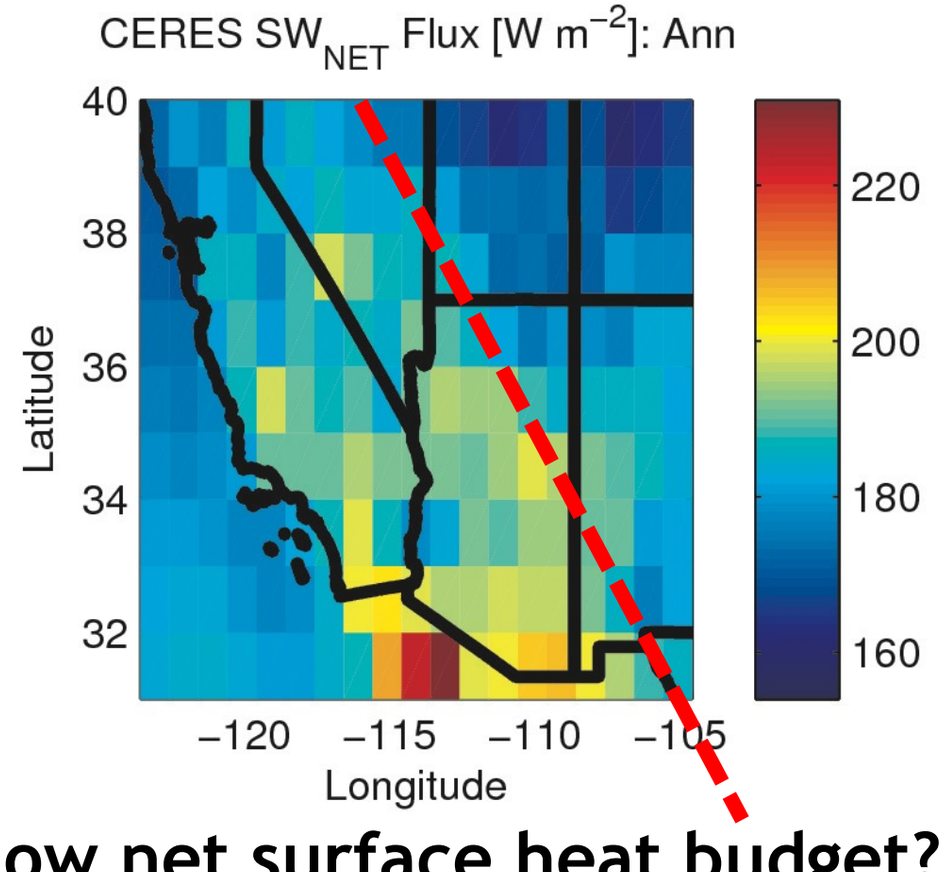


Southwest US water height increasing over "time"?



LW_{NET} distribution ≠ SW_{NET} distribution

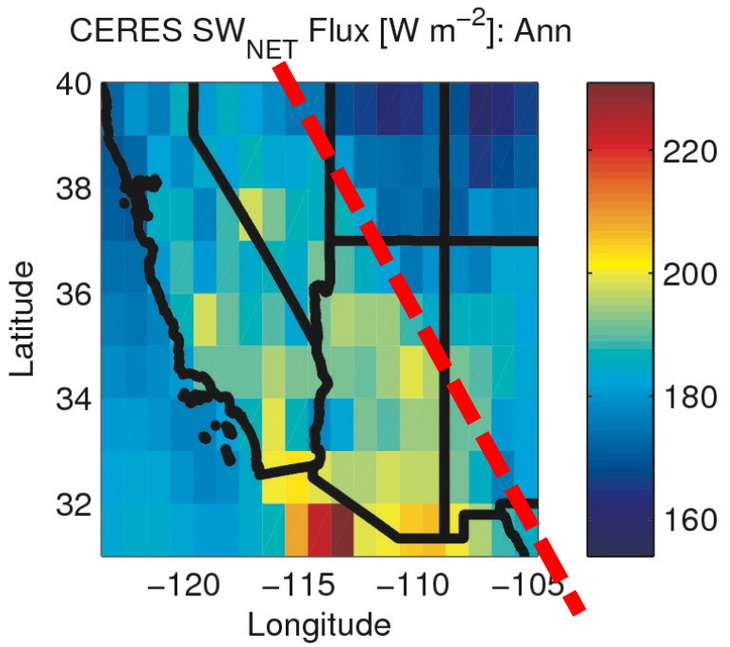


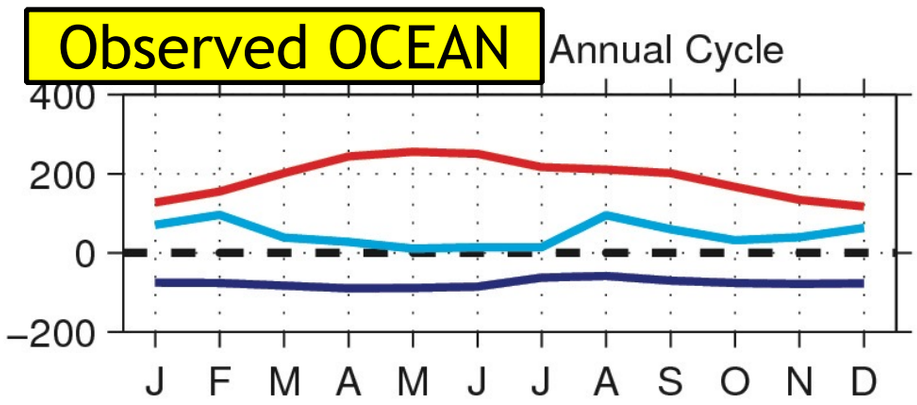


Does water mass over land ~ follow net surface heat budget?
Need turbulent heat fluxes…

Next step: isolate regions based on
different radiative fluxes;
characterize seasonal cycle

UKMO model vs. satellite observations: annual cycle of SW_{NET}, LW_{NET}, Precip, GRACE





SW_{NET} [W/m²]

LW_{NET} [W/m²]

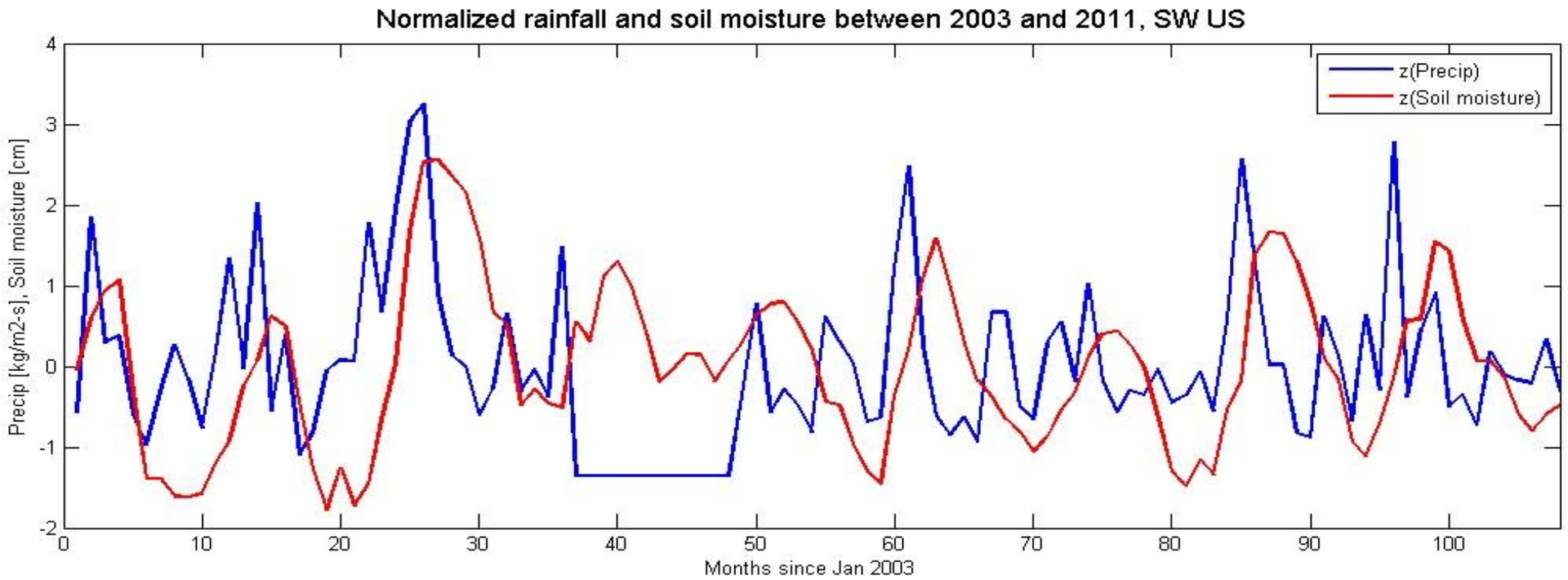
Scaled:

Precip *10^7 [flux]

GRACE water height*50 [cm]

>> Largest GRACE water height annual cycle: ROCKIES

How much variability in soil moisture can be explained by variability in precipitation between 2003 and 2011?



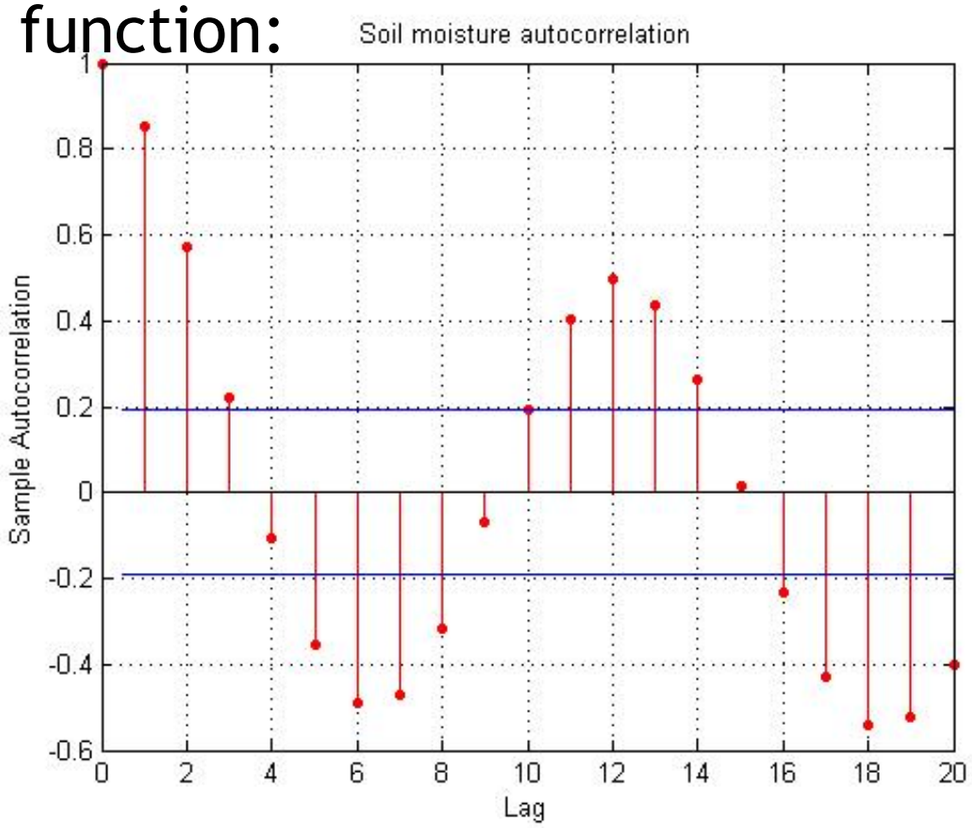
r^2 = 10 %

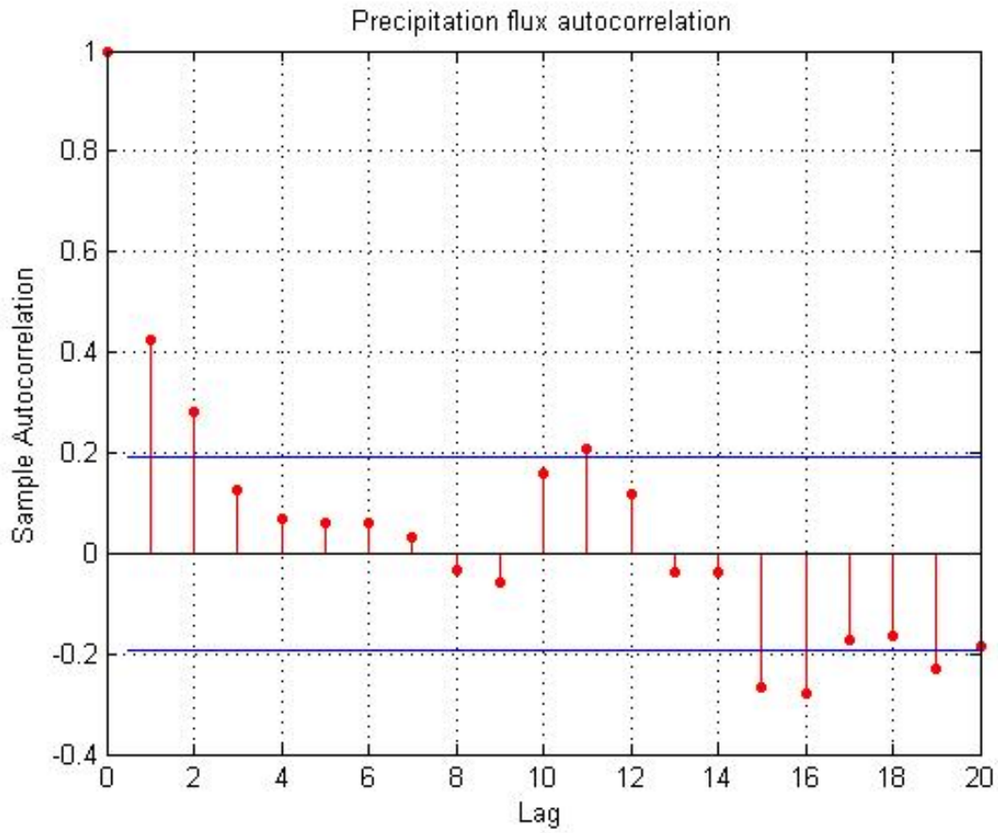
Instantaneous correlation is low but can we construct a predictive model from precipitation to soil moisture?

$$\frac{d(SMa)}{dt} = \alpha PR_a - \gamma SM_a$$

$$SM_a(t+1) = (1-\gamma\Delta t)SM_a(t) + PR_a(t)$$

Find gamma from an autocorrelation function:





Summary

- the observations confirm the existence of seasonality in precipitation and soil moisture
- the northern portion of the study area exhibits more pronounced seasonality
- soil moisture shows memory
- we found seasonal lag between precipitation and soil moisture (which could related to local geology)