

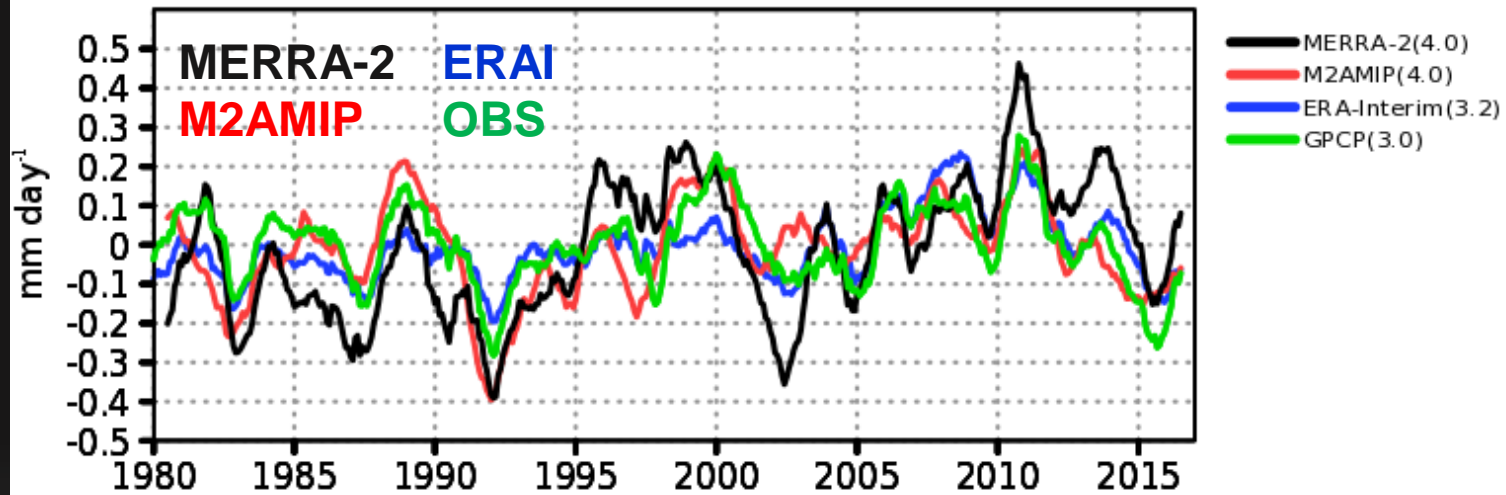


El Niño Coupled Tropical Land Surface Hydrologic Response

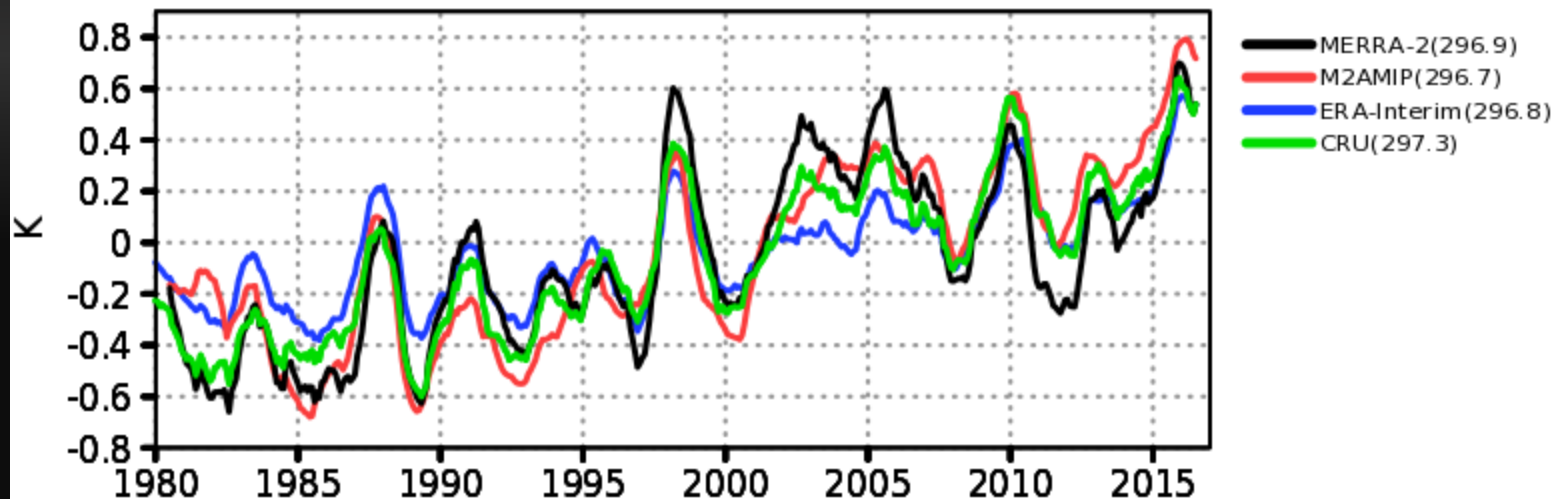
Michael G. Bosilovich (NASA GSFC), Franklin R. Robertson
(NASA MSFC) and Paul Stackhouse (NASA LaRC)

Tropical Land Precipitation and Temperature

Land(30) Monthly Anomaly Precipitation (mm day⁻¹)

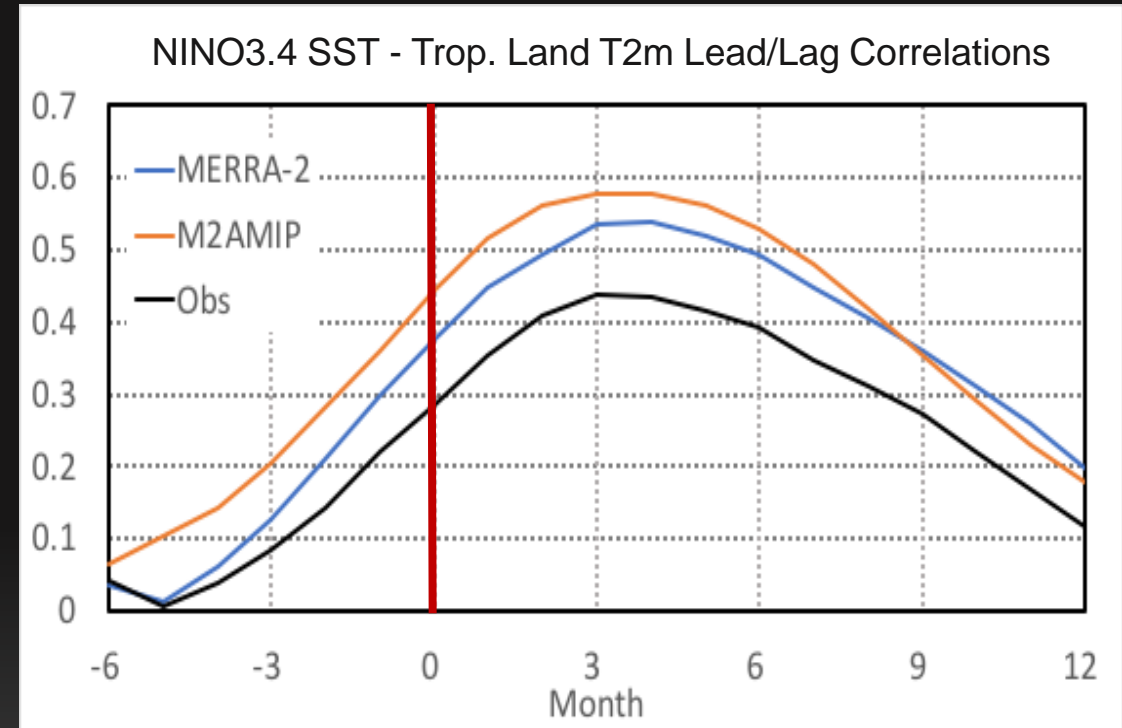
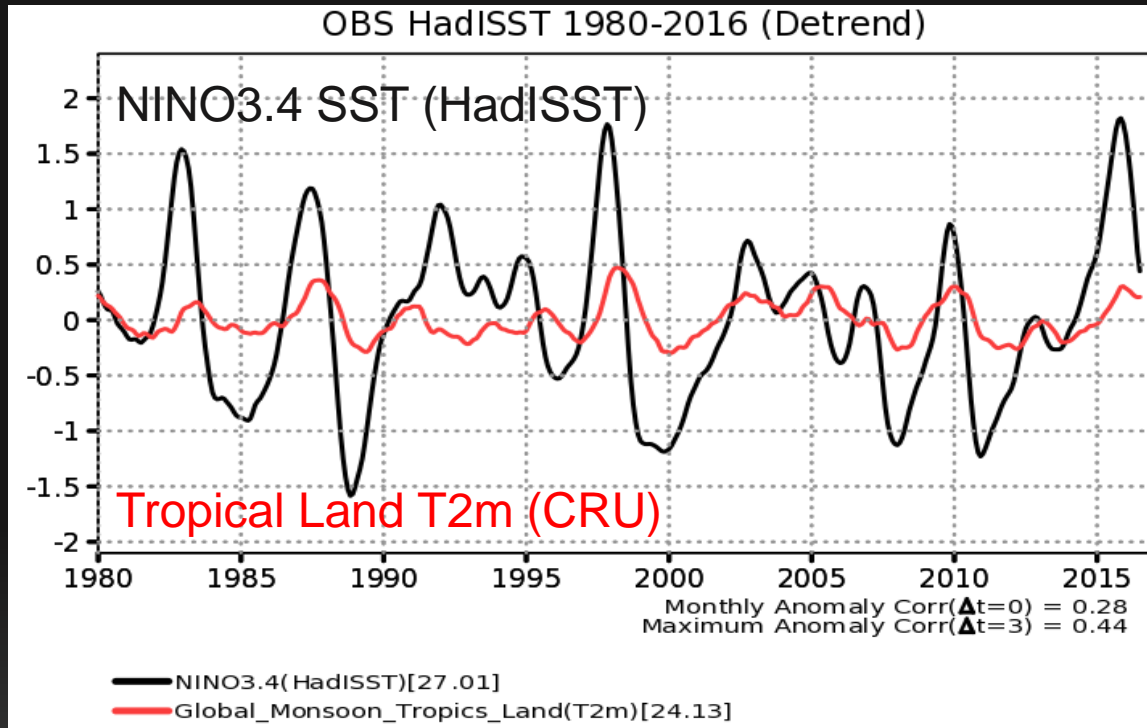


Land(30) Monthly Anomaly 2m Temp (K)



- Many regions around the world, especially in the tropics, show drought modes related to ENSO or SST in general (Schubert et al. 2016)
- El Niño leads to troposphere warming around the tropical belt (Chiang and Sobel, 2002)
- Warming oceans lead to warmer land owing to downwelling LW radiation in present day coupled models (Compo and Shardeshmukh 2009)
- AMIP Ensemble isolates the signal from SST forcing
- **Reanalyses assimilate obs** and so, should provide realistic large scale environment

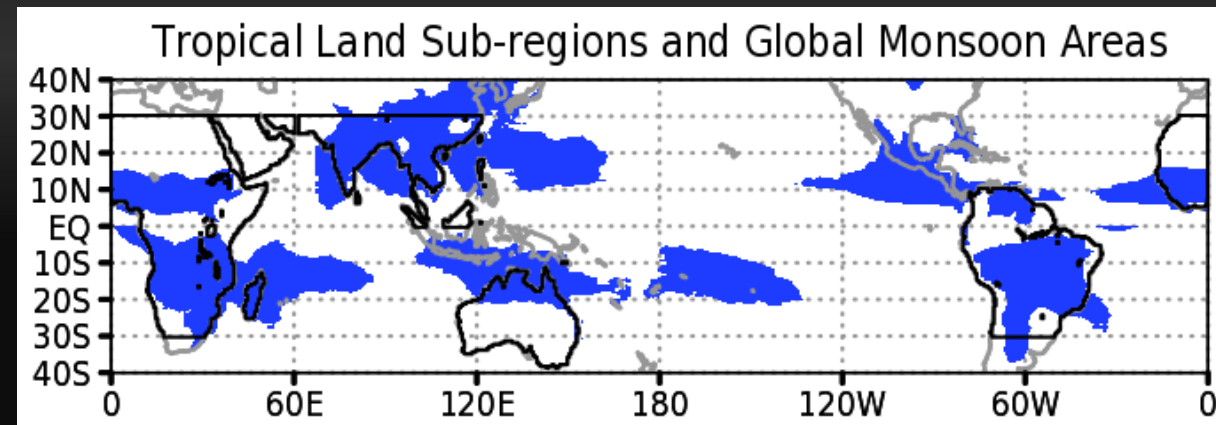
Motivation: Tropical Land Warming/Drought following El Niño



- The continental tropics warming/drought following El Niño is well observed (Chiang and Lintner 2005; Schubert et al. 2016)
- MERRA-2 and M2AMIP (ensemble) produce similar, but stronger, lead/lag correlations of the tropical land temperatures

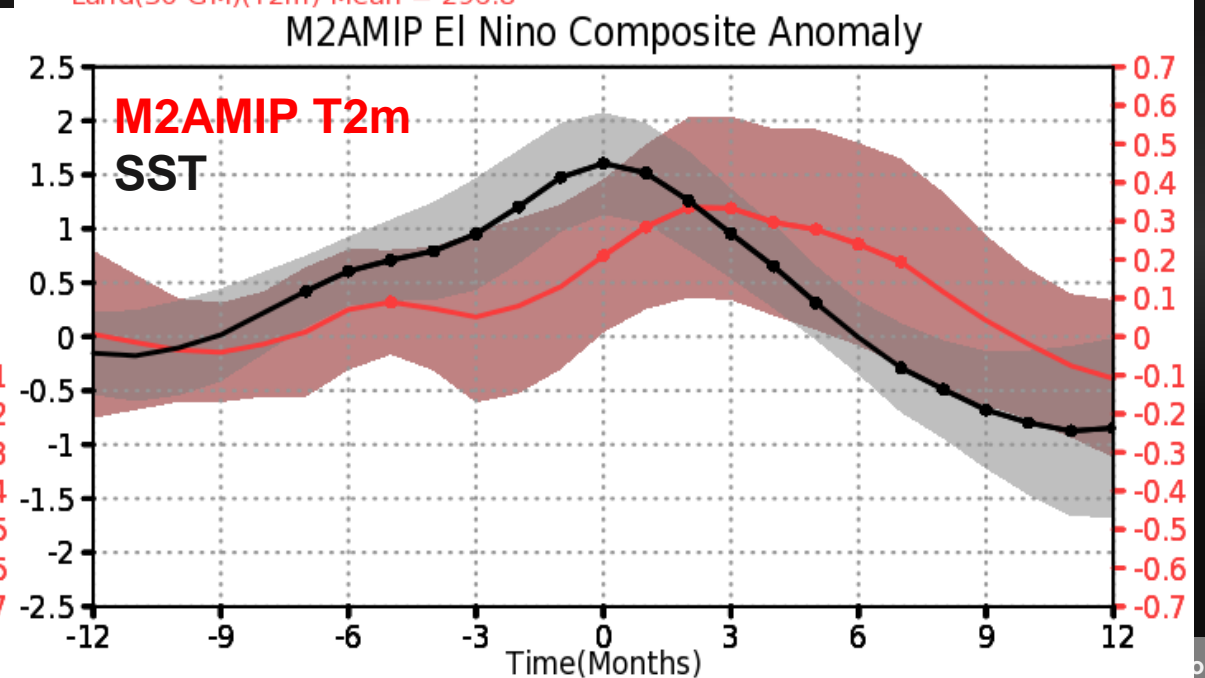
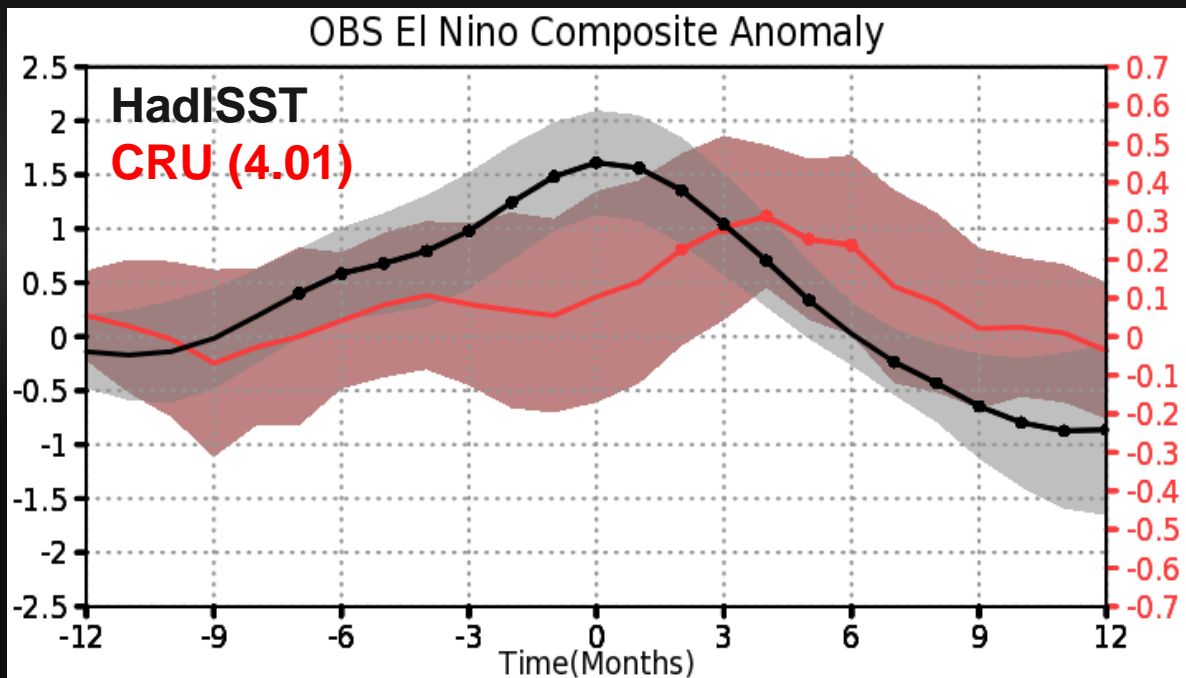
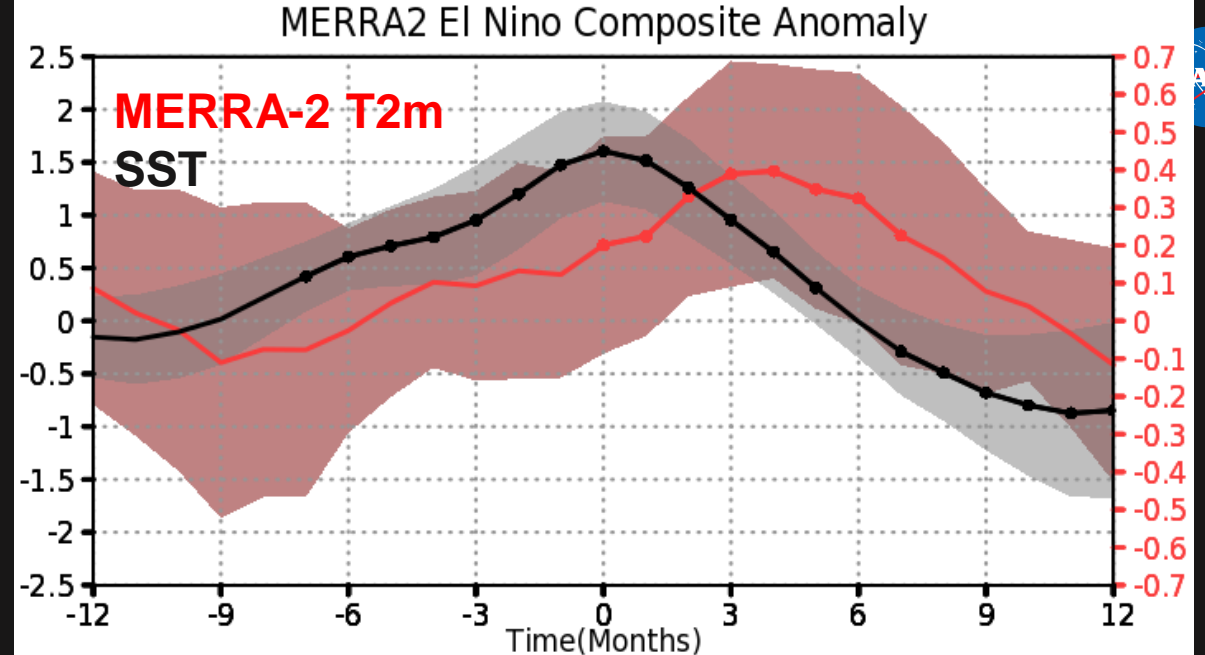
Data and Methods

- **MERRA-2**: Obs Corr Precip for Land Reichle et al (2017); Gelaro et al. (2017)
- **M2AMIP**: Uses the same model and climate forcing, including SST as MERRA-2. **10-member** ensemble mean. Collon et al. (2017)
- **Observations**: CRU (4.01 Harris et al. 2014), GPCP (v2.3), GEWEX Surface Radiation Budget (3.0 Zhang et al. 2009)
- **Composite El Niño**
 - **Deseasonalize and detrend** the anomaly time series
 - Find the peak surface temperature in the Niño34 region
 - Collect data for each of **8 peak NINO3.4** (+- 12 months) computing mean and st. dev.
- **Global Monsoon Region**: (e.g. Wang et al. 2012)



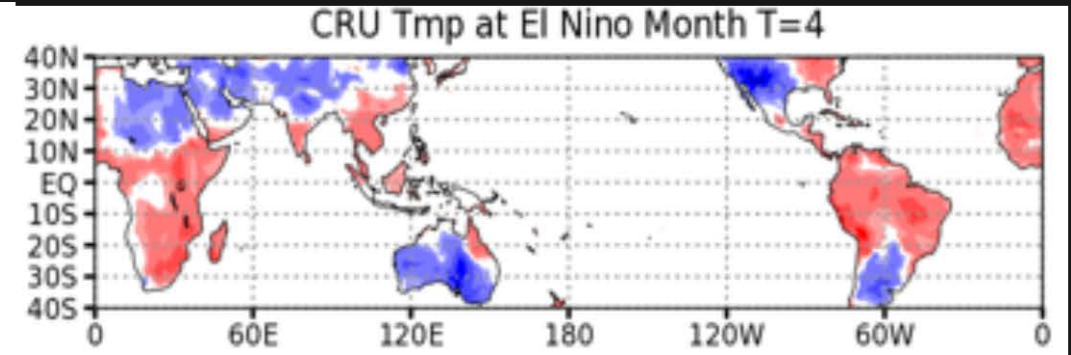
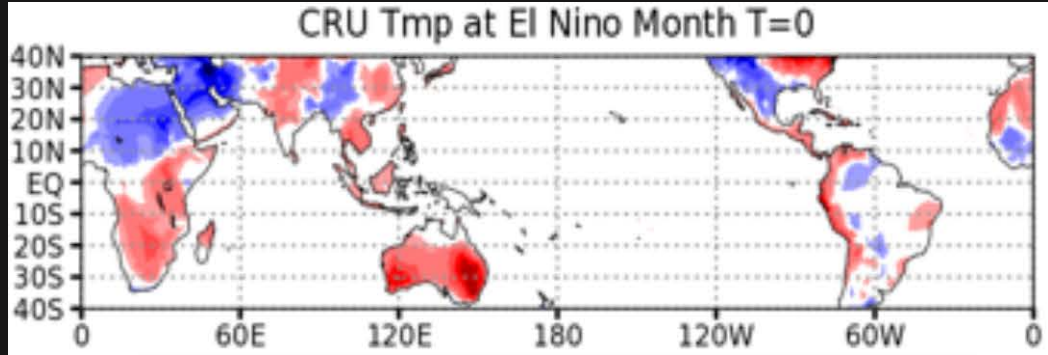
Tropics Temperature Composite El Niño

- MERRA-2: warms more than observed, a little earlier
- M2AMIP: Smoother; has early warming, but not as warm as M2
- Warm temps may persist longer

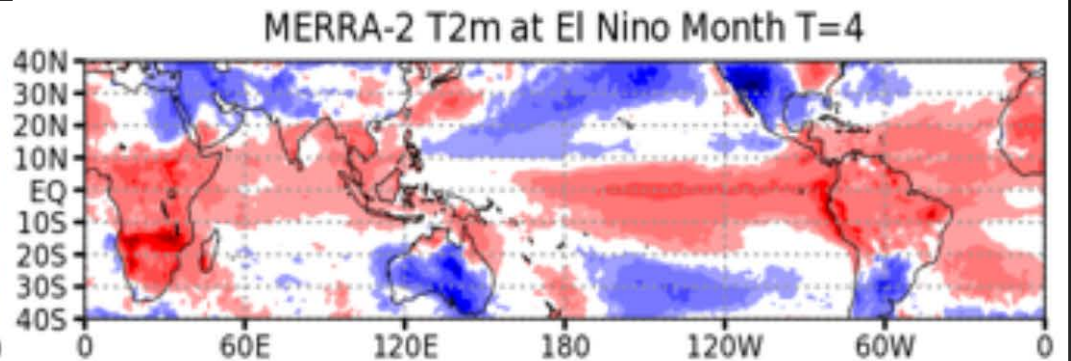
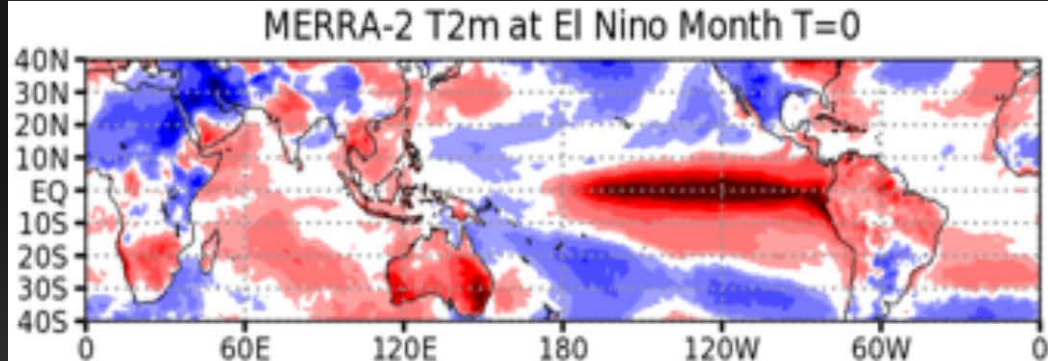


Composite of 2m Air Temperature

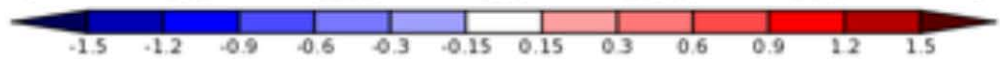
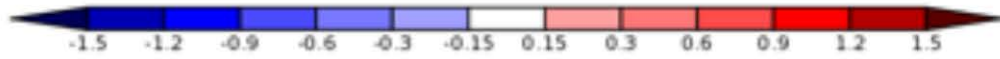
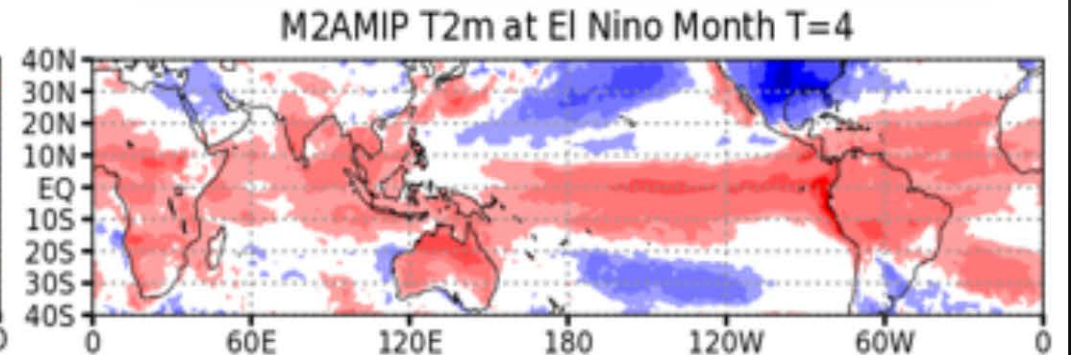
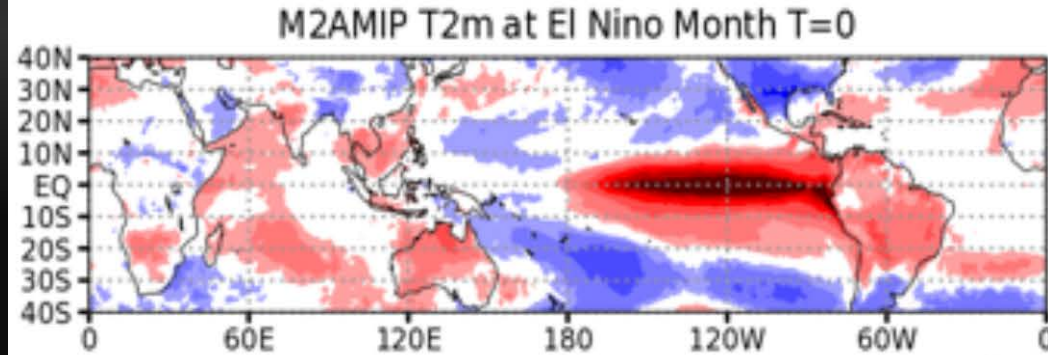
CRU



MERRA-2



M2AMIP



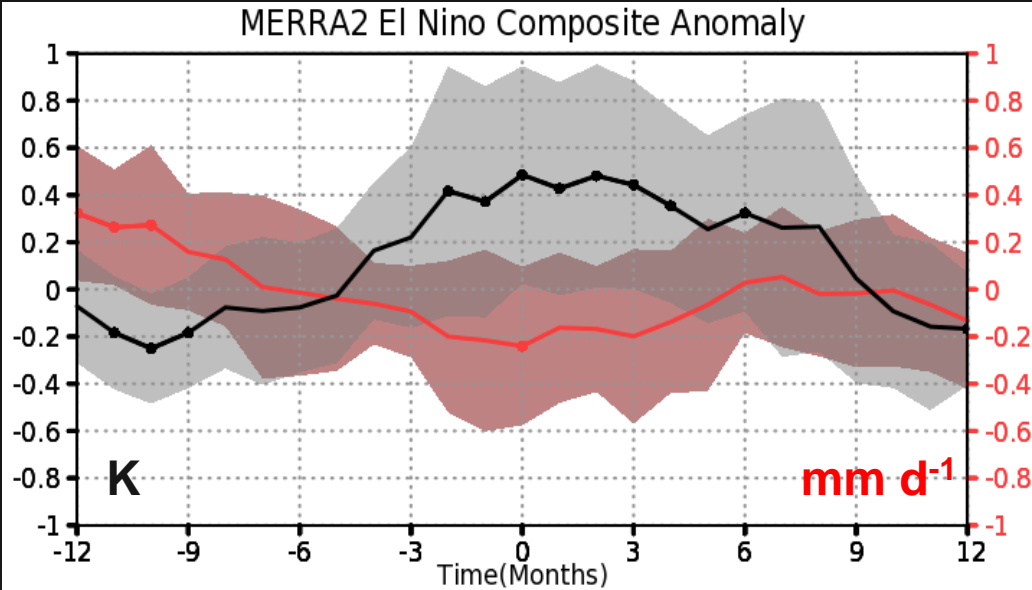
T=0

T=+4

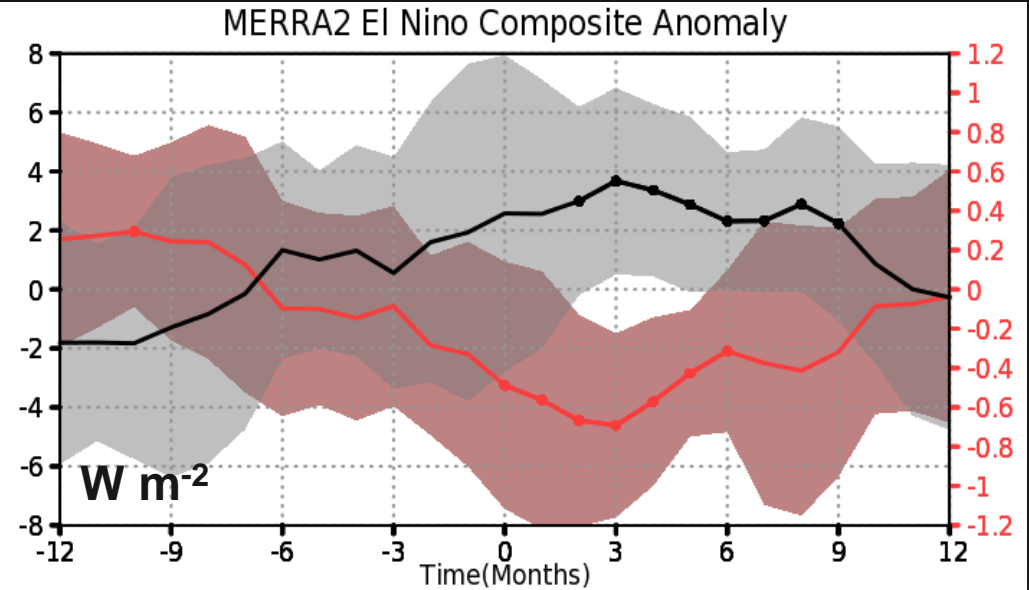
South America: MERRA-2

T2m
Prec

SWgCRE
LWgCRE



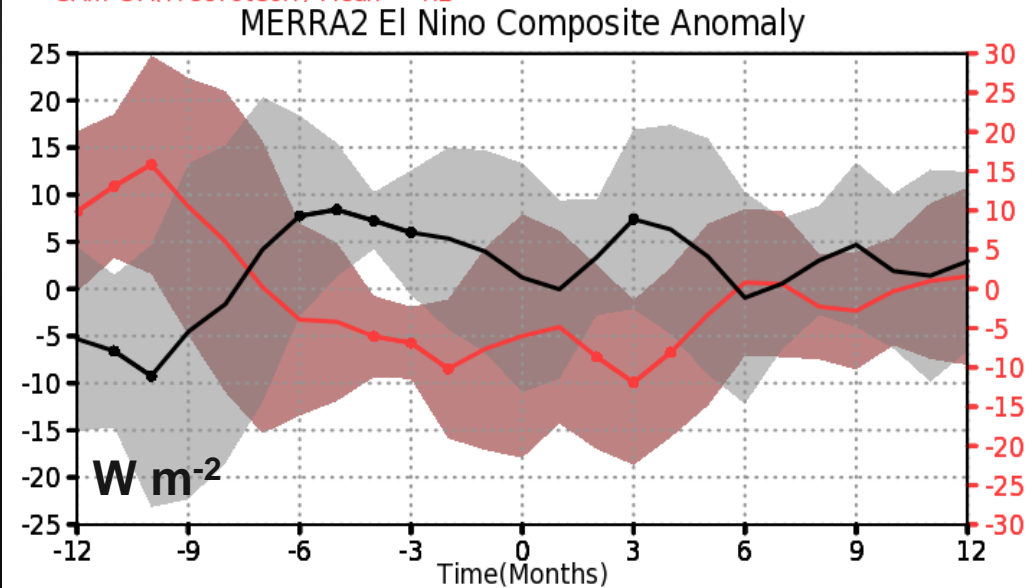
SAm-GM(T2m) Mean = 297.2
SAm-GM(PrecTotCorr) Mean = 4.2



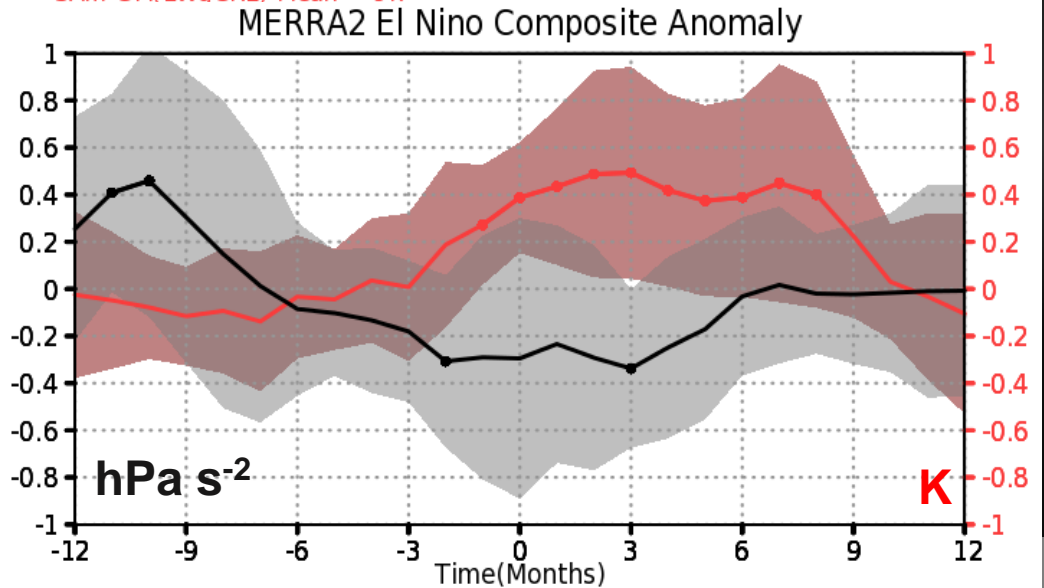
SAm-GM(SWgCRE) Mean = -55.8
SAm-GM(LWgCRE) Mean = 9.7

Conv.
CpT+Phi
Lqv

-Ω (500)
T(500)



SAm-GM(-(divCpT+divPhi)) Mean = -108.0
SAm-GM(-2.454e6*divqv) Mean = 42.2

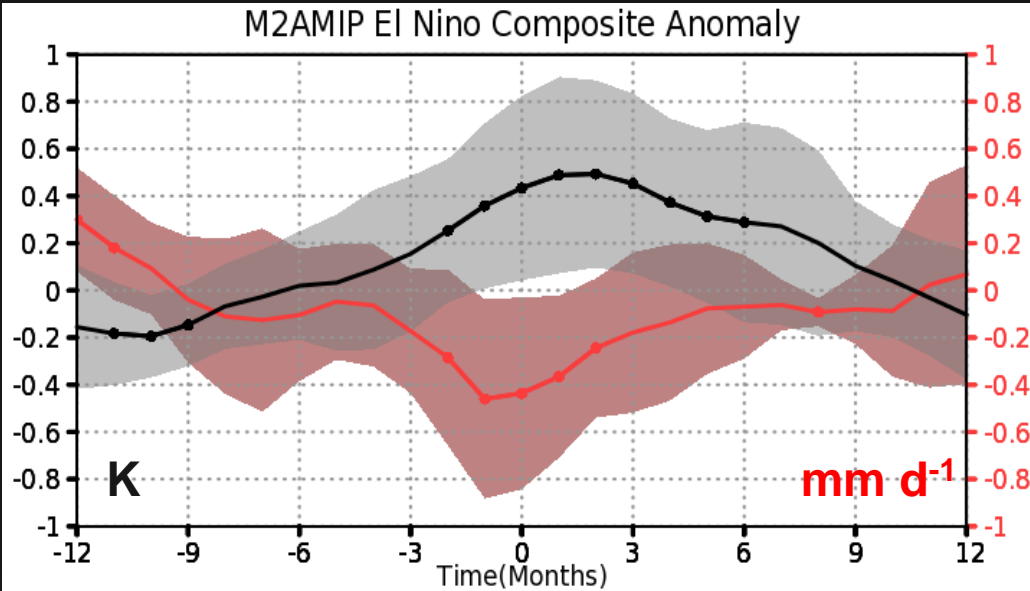


SAm-GM(-100*Omega500) Mean = 1.5
SAm-GM(T500) Mean = 267.3

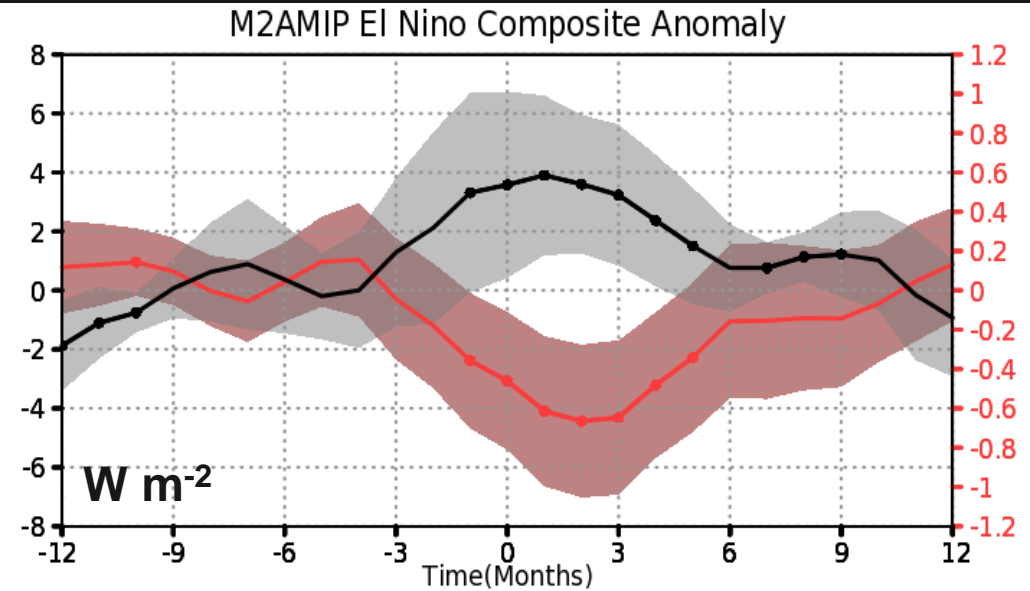
South America: M2AMIP

T2m
Prec

SWgCRE
LWgCRE



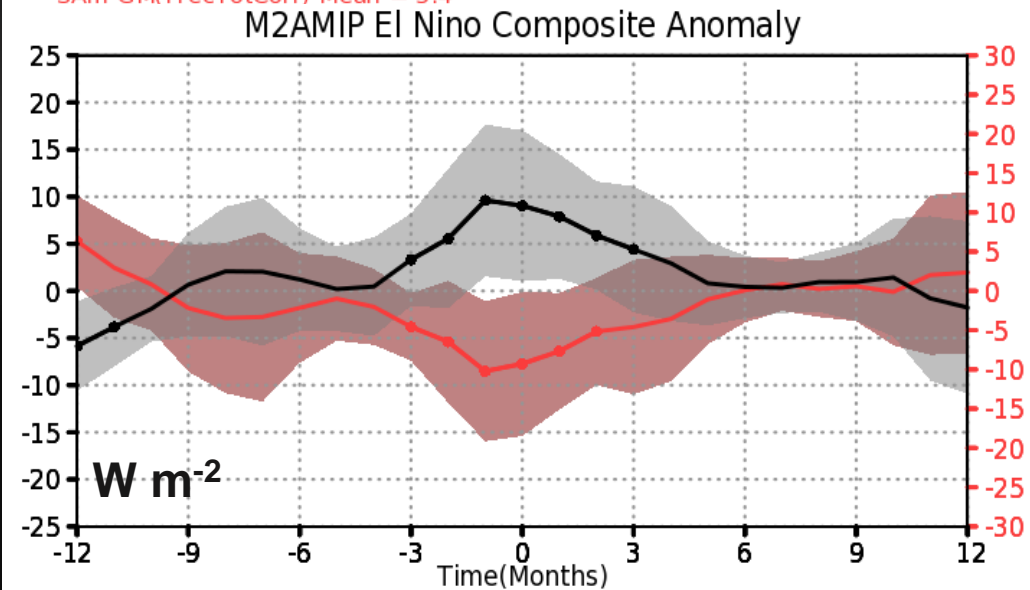
SAm-GM(T2m) Mean = 297.2
SAm-GM(PrecTotCorr) Mean = 5.4



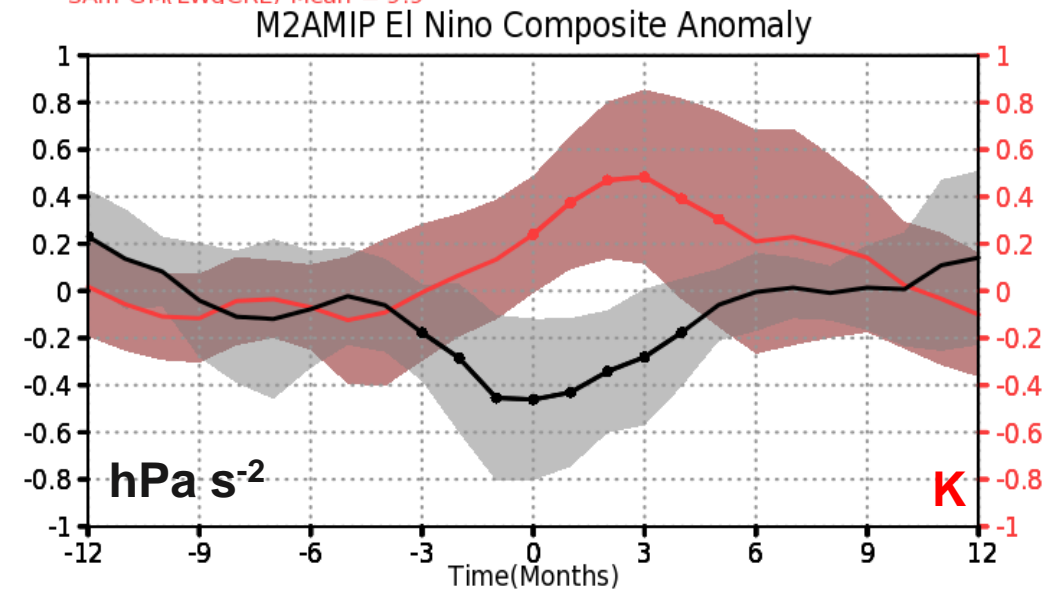
SAm-GM(SWgCRE) Mean = -56.9
SAm-GM(LWgCRE) Mean = 9.9

Conv.
DSE
Lqv

- Ω (500)
T(500)



SAm-GM(-(divCpT+divPhi)) Mean = -107.6
SAm-GM(-2.454e6*divqv) Mean = 56.4

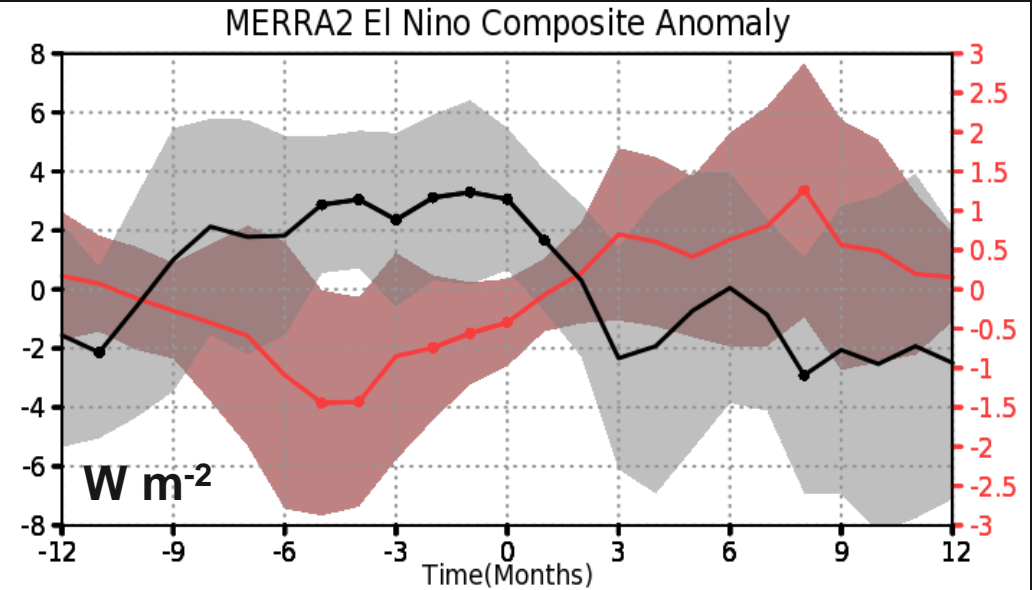
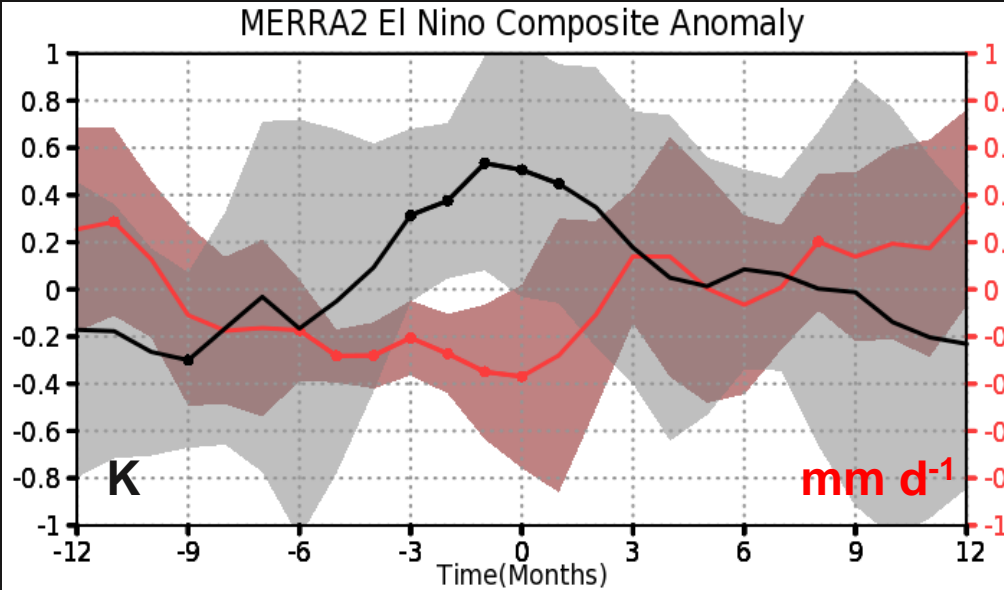


SAm-GM(-100*Omega500) Mean = 2.1
SAm-GM(T500) Mean = 267.5

Australia: MERRA-2

T2m
Prec

SWgCRE
LWgCRE

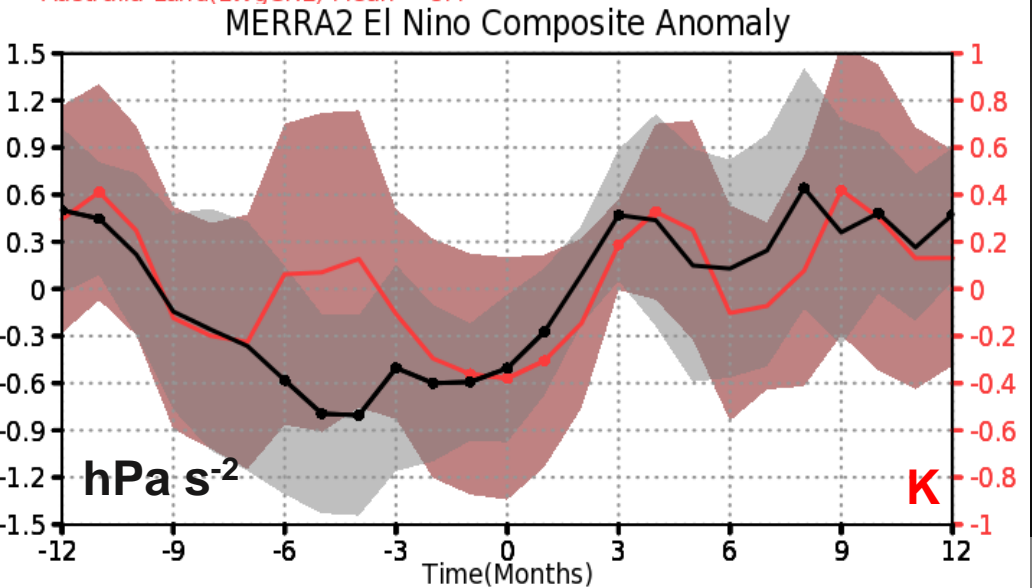
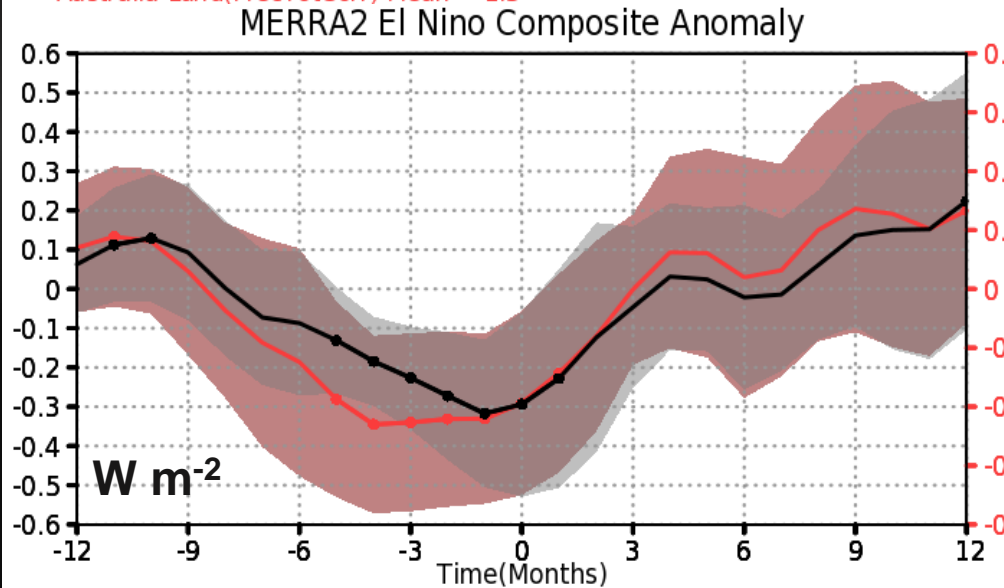


Australia-Land(T2m) Mean = 295.4
Australia-Land(PrecTotCorr) Mean = 1.3

Australia-Land(SWgCRE) Mean = -24.9
Australia-Land(LWgCRE) Mean = 8.4

LEvap
GwTop

$-\Omega(500)$
T(500)



Australia-Land(Evap) Mean = 1.2
Australia-Land(GwetTop) Mean = 0.3

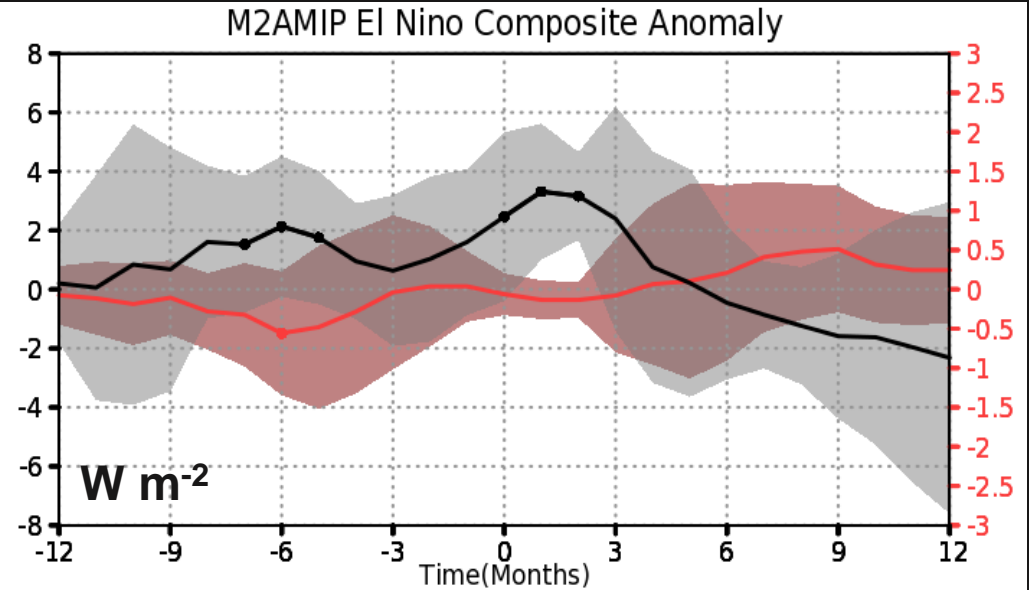
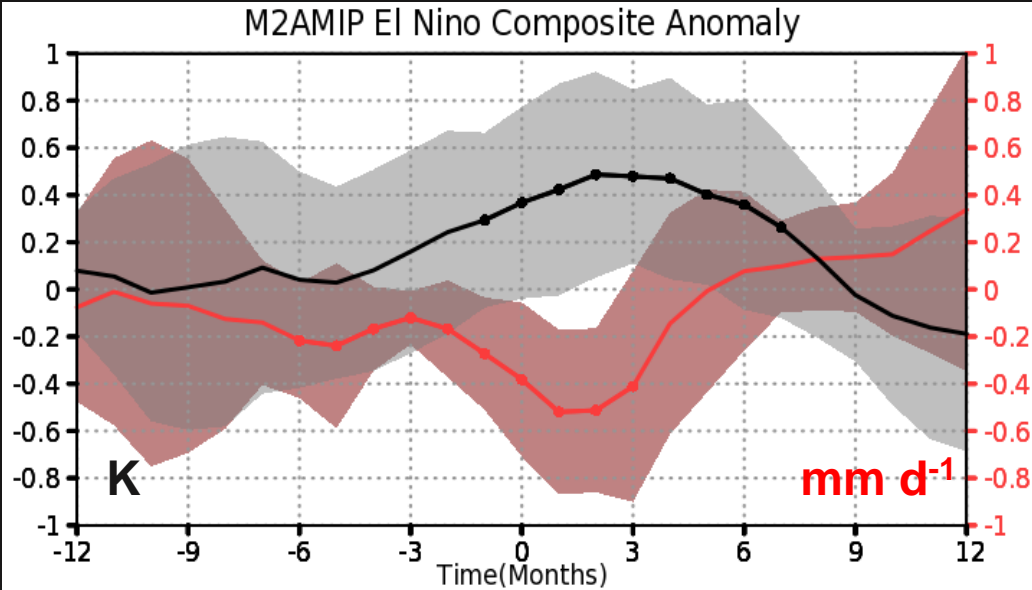
Australia-Land(-100*Omega500) Mean = -1.4
Australia-Land(T500) Mean = 263.3



Australia: M2AMIP

T2m
Prec

SWgCRE
LWgCRE

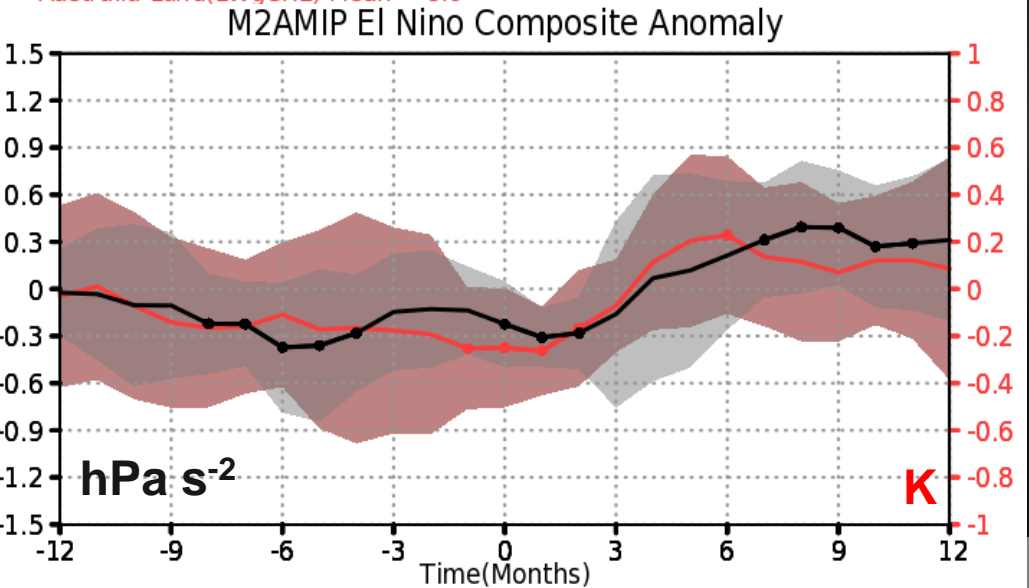
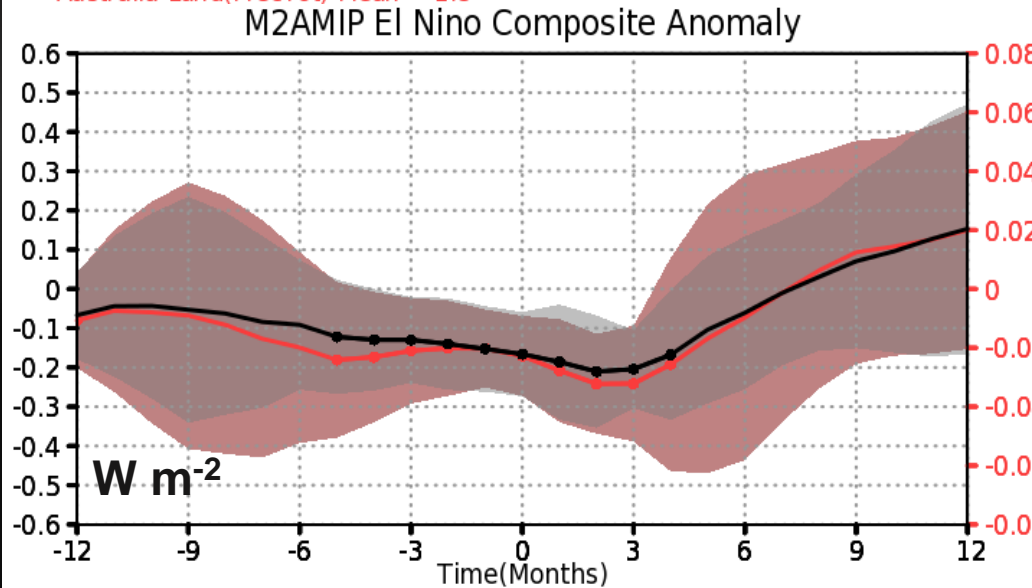


Australia-Land(T2m) Mean = 295.1
Australia-Land(PrecTot) Mean = 1.8

Australia-Land(SWgCRE) Mean = -26.0
Australia-Land(LWgCRE) Mean = 8.6

LEvap
GwTop

$-\Omega(500)$
T(500)



Australia-Land(Evap) Mean = 1.4
Australia-Land(GwetTop) Mean = 0.4

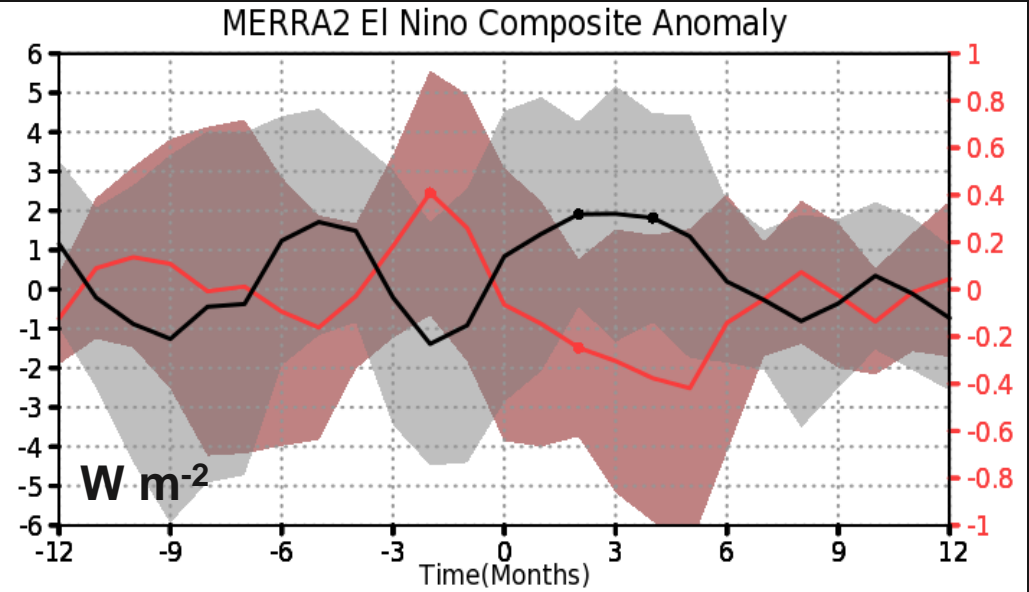
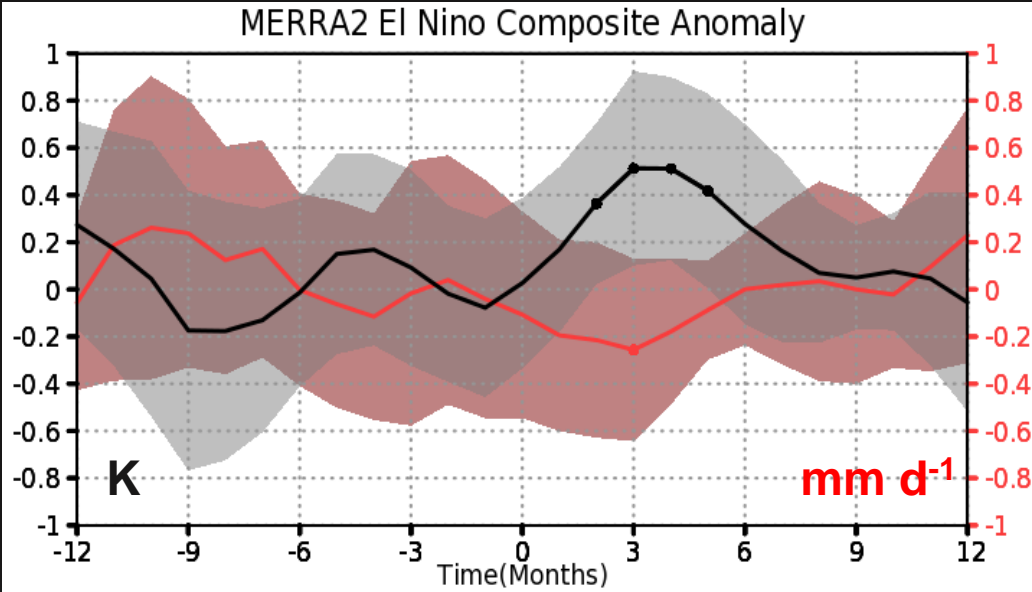
Australia-Land(-100*Omega500) Mean = -0.9
Australia-Land(T500) Mean = 264.0



Africa: MERRA-2

T2m
Prec

SWgCRE
LWgCRE

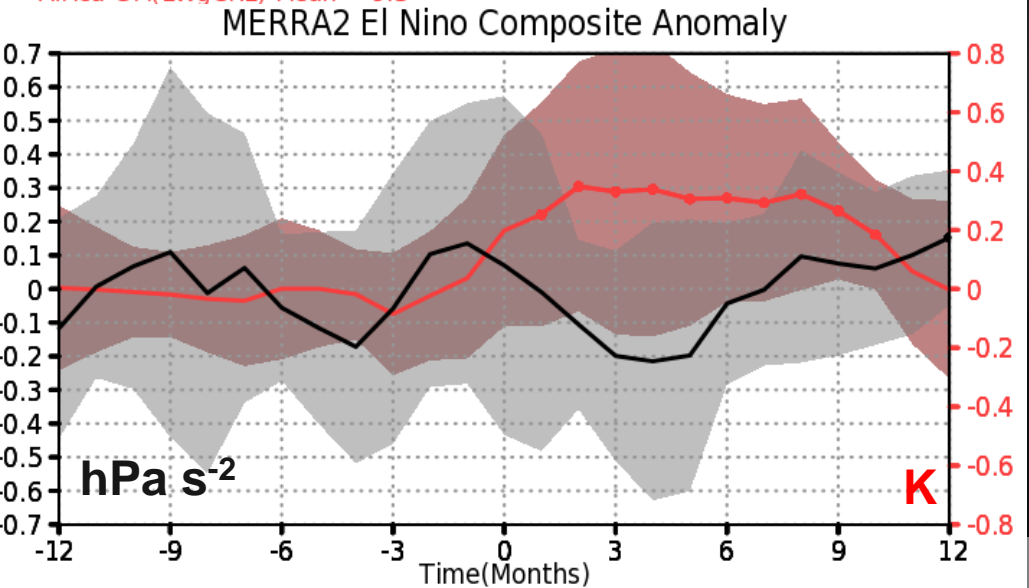
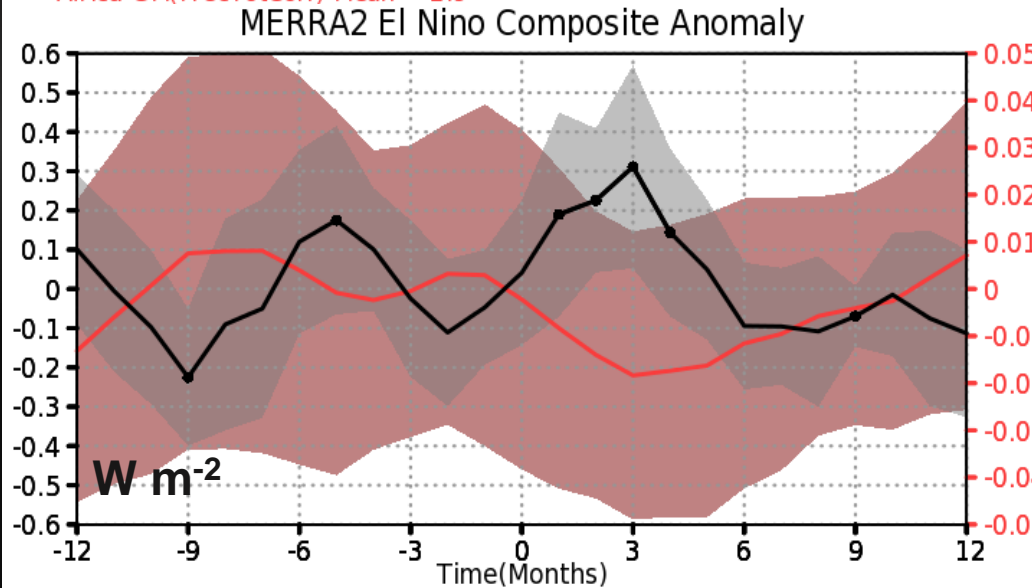


Africa-GM(T2m) Mean = 297.4
Africa-GM(PrecTotCorr) Mean = 2.9

Africa-GM(SWgCRE) Mean = -45.0
Africa-GM(LWgCRE) Mean = 9.3

SfcNet
GwTop

$-\omega(500)$
T(500)



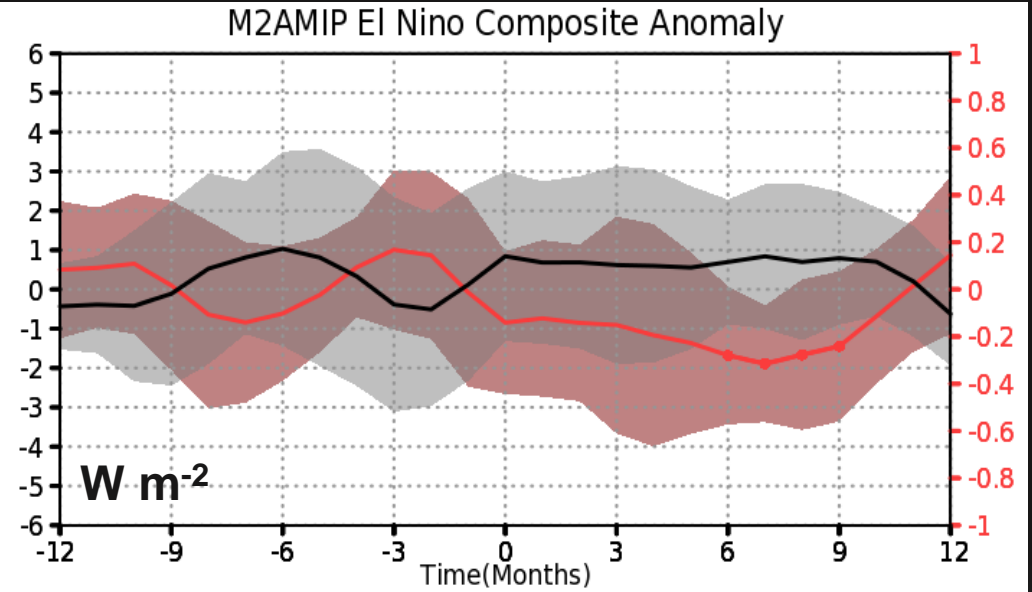
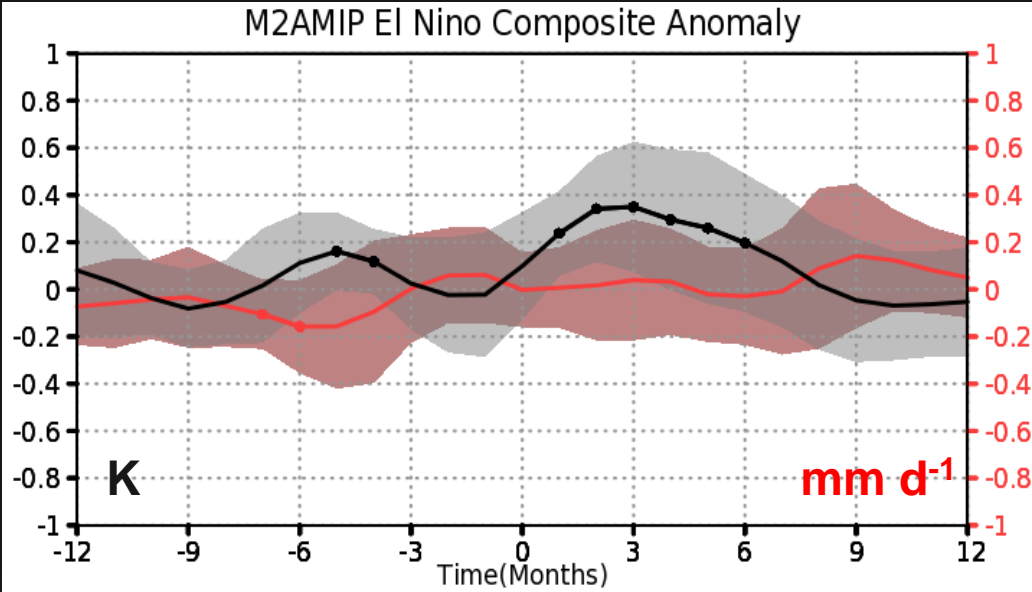
Africa-GM(SfcNet) Mean = 0.2
Africa-GM(GWetTop) Mean = 0.5

Africa-GM(-100*omega500) Mean = 0.7
Africa-GM(T500) Mean = 267.2

Africa: M2AMIP

T2m
Prec

SWgCRE
LWgCRE

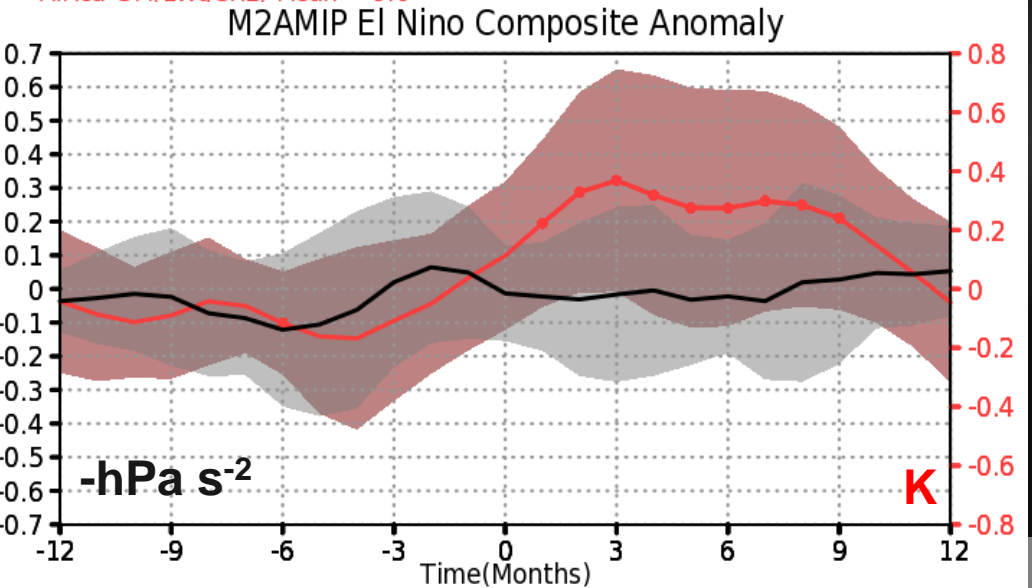
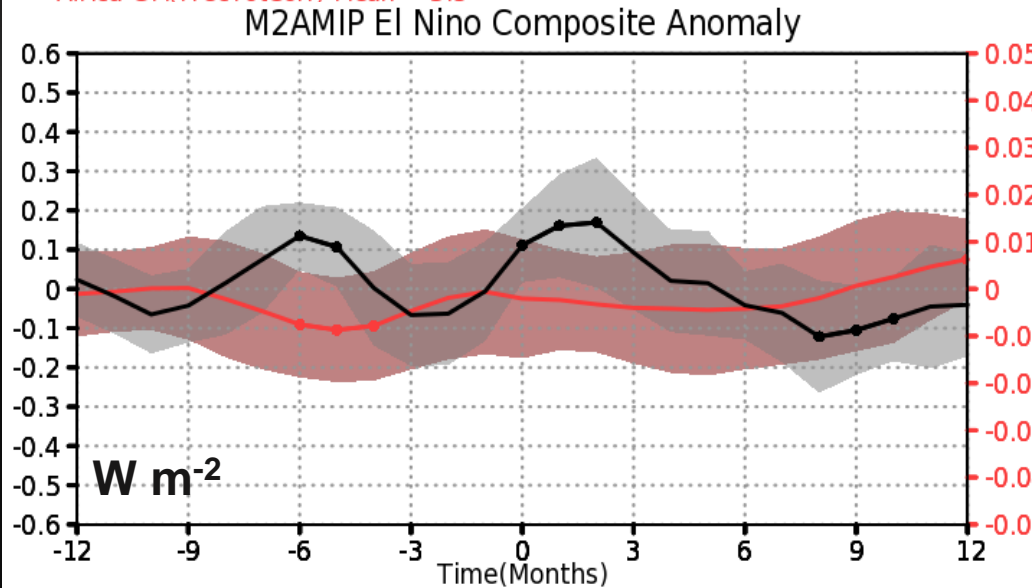


Africa-GM(T2m) Mean = 297.3
Africa-GM(PrecTotCorr) Mean = 3.5

Africa-GM(SWgCRE) Mean = -44.7
Africa-GM(LWgCRE) Mean = 9.6

SfcNet
GwTop

$-\omega(500)$
T(500)



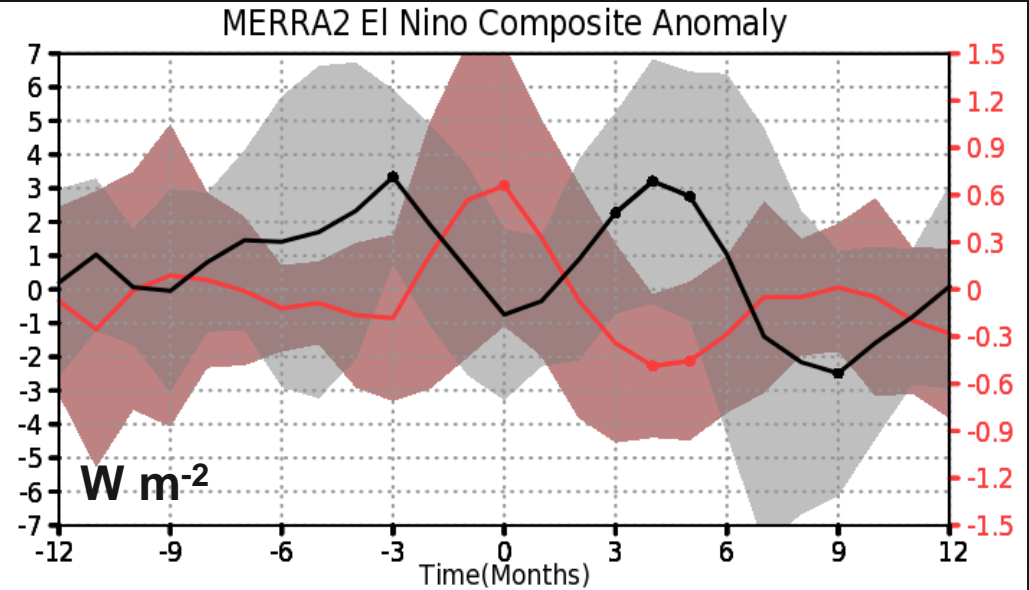
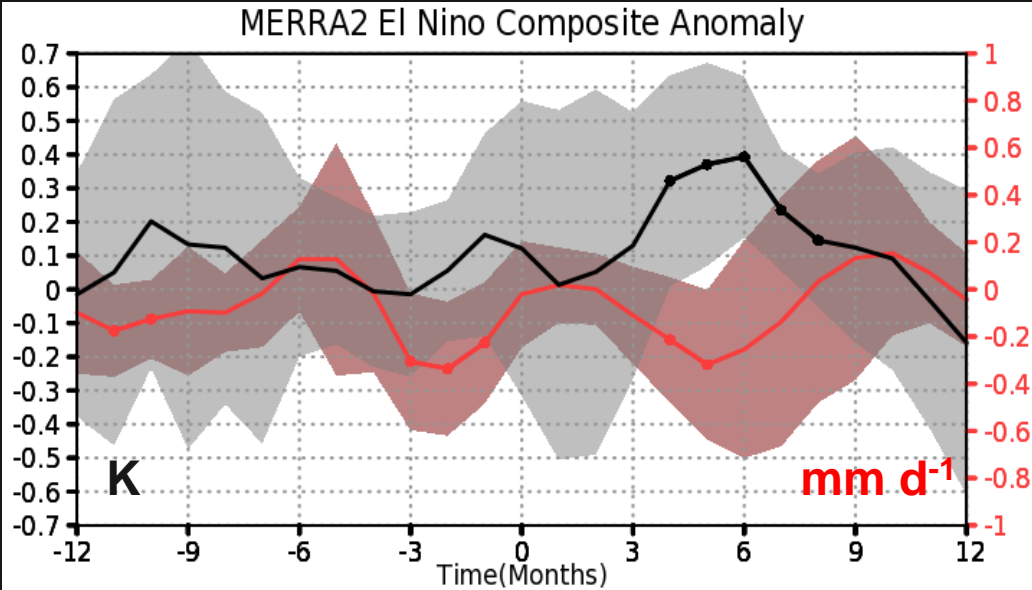
Africa-GM(SfcNet) Mean = 0.2
Africa-GM(GWetTop) Mean = 0.5

Africa-GM(-100*omega500) Mean = 1.0
Africa-GM(T500) Mean = 267.5

Tropical South Asia: MERRA-2

T2m
Prec

SWgCRE
LWgCRE

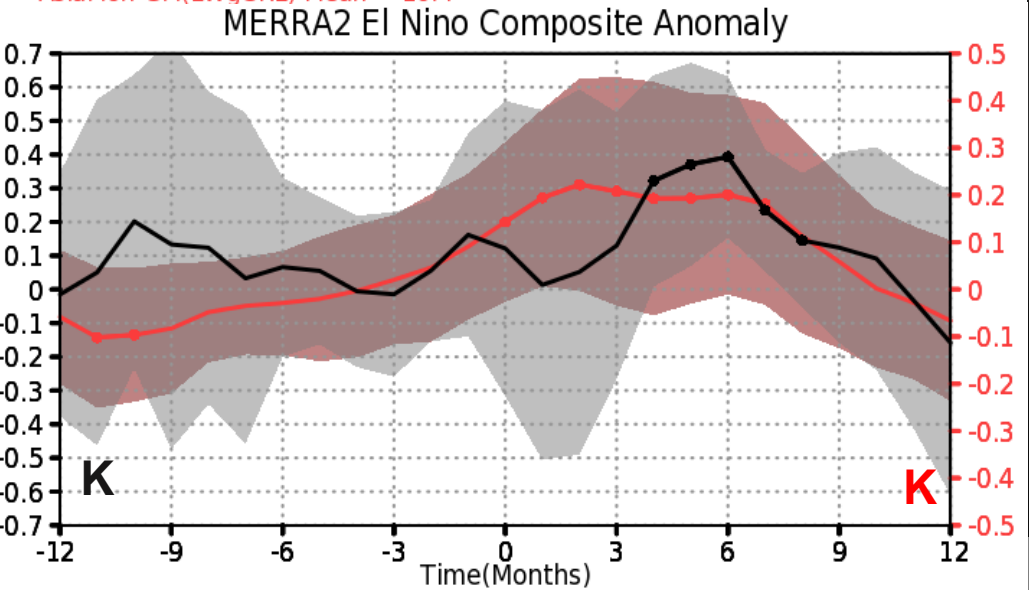
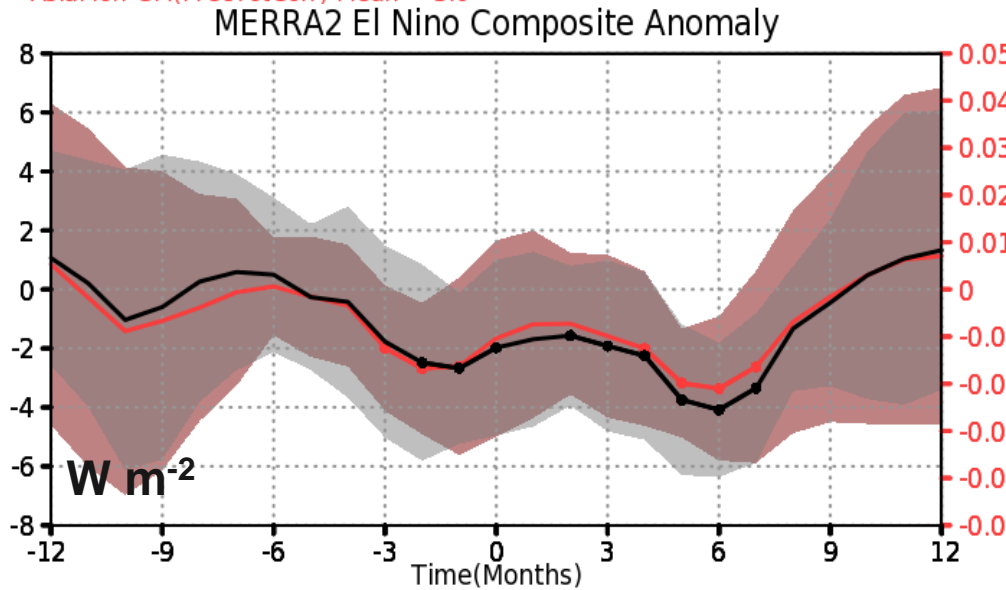


AsiaMon-GM(T2m) Mean = 294.6
AsiaMon-GM(PrecTotCorr) Mean = 3.0

AsiaMon-GM(SWgCRE) Mean = -47.4
AsiaMon-GM(LWgCRE) Mean = 10.4

LEvap
GwTop

T2m
Indian
Oc SST



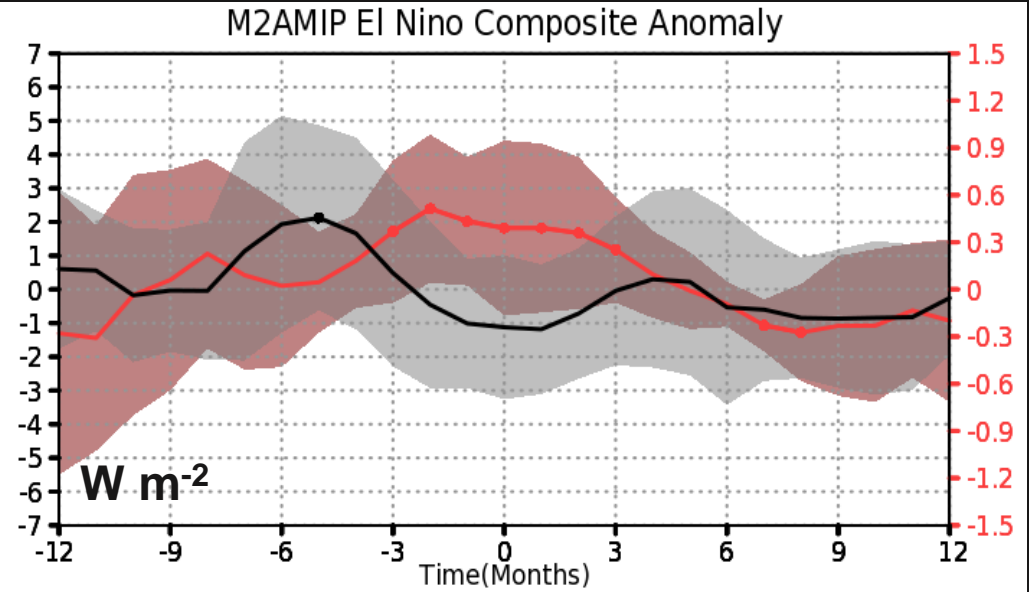
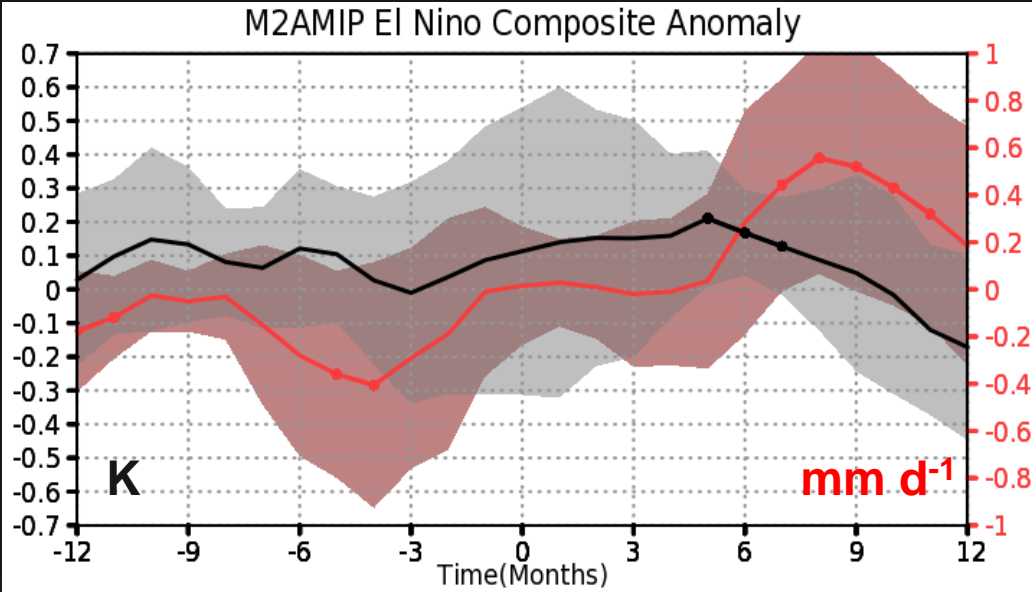
AsiaMon-GM(Eflux) Mean = 68.9
AsiaMon-GM(GWetTop) Mean = 0.6

AsiaMon-GM(T2m) Mean = 294.6
Indian Ocean(Ts) Mean = 299.9

Tropical South Asia: M2AMIP

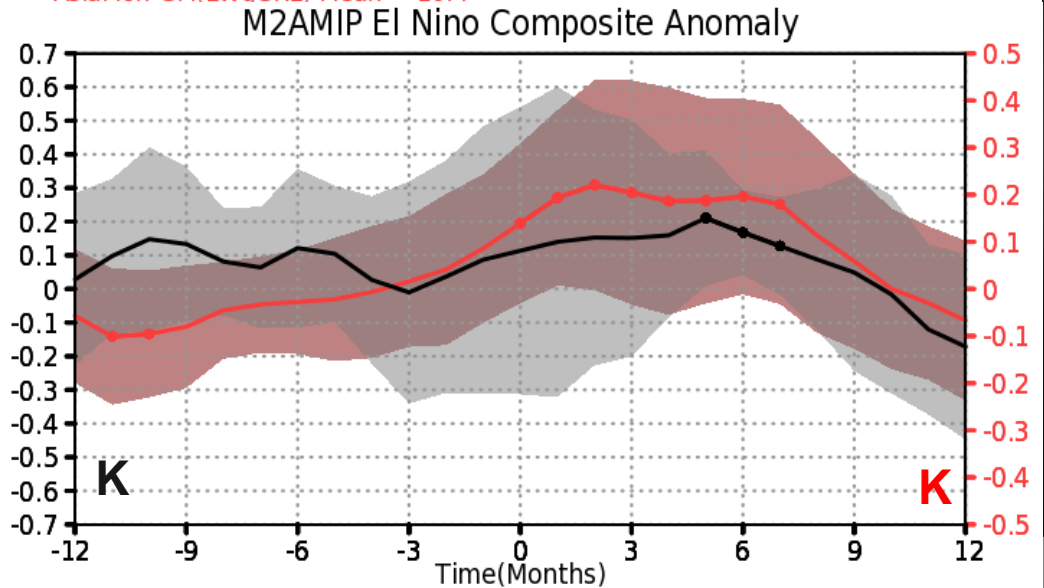
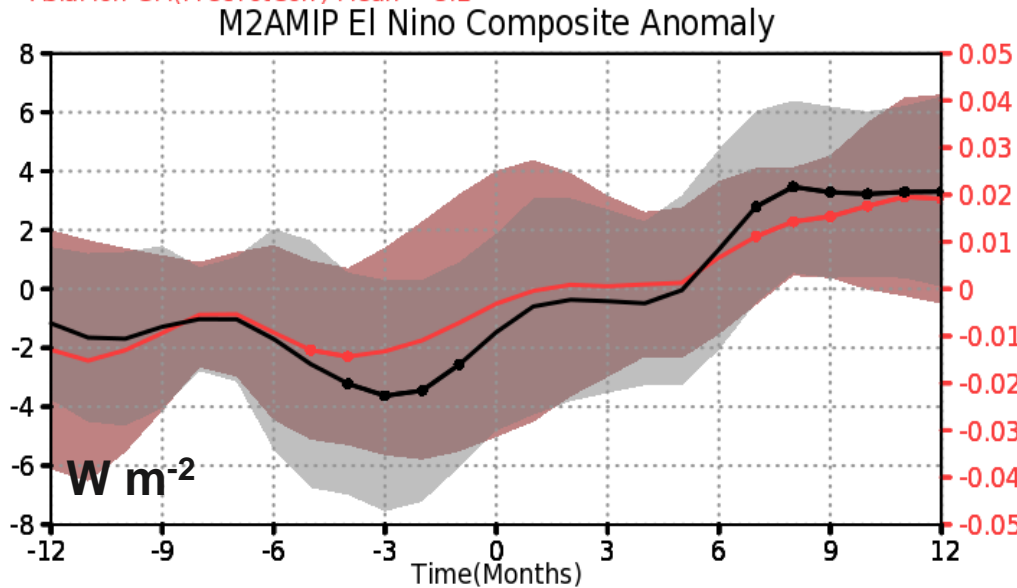
T2m
Prec

SWgCRE
LWgCRE



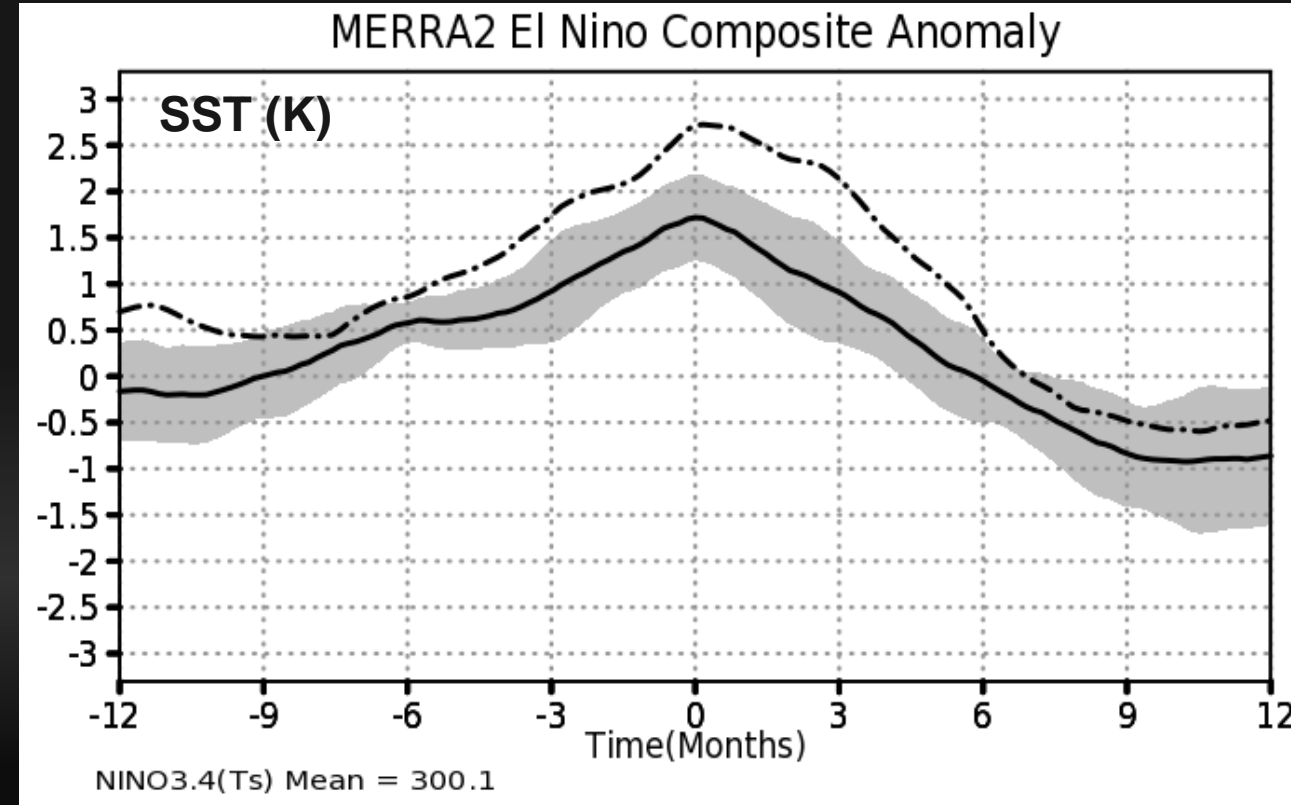
LEvap
GwTop

T2m
Indian
Oc SST



Examining Variations within the Composite

- Monthly means facilitated the comparison with the AMIP and global observed data
 - MERRA-2 hourly data reduced to **pentads** to examine higher frequency variability in the composite El Niño
- 8 El Niño events were composited over the 36 years of MERRA-2
 - 2015-16 El Niño was not included
 - One of the strongest events, will compare to the Pentad composite



2015-16 compared to Composite: Tropics Land

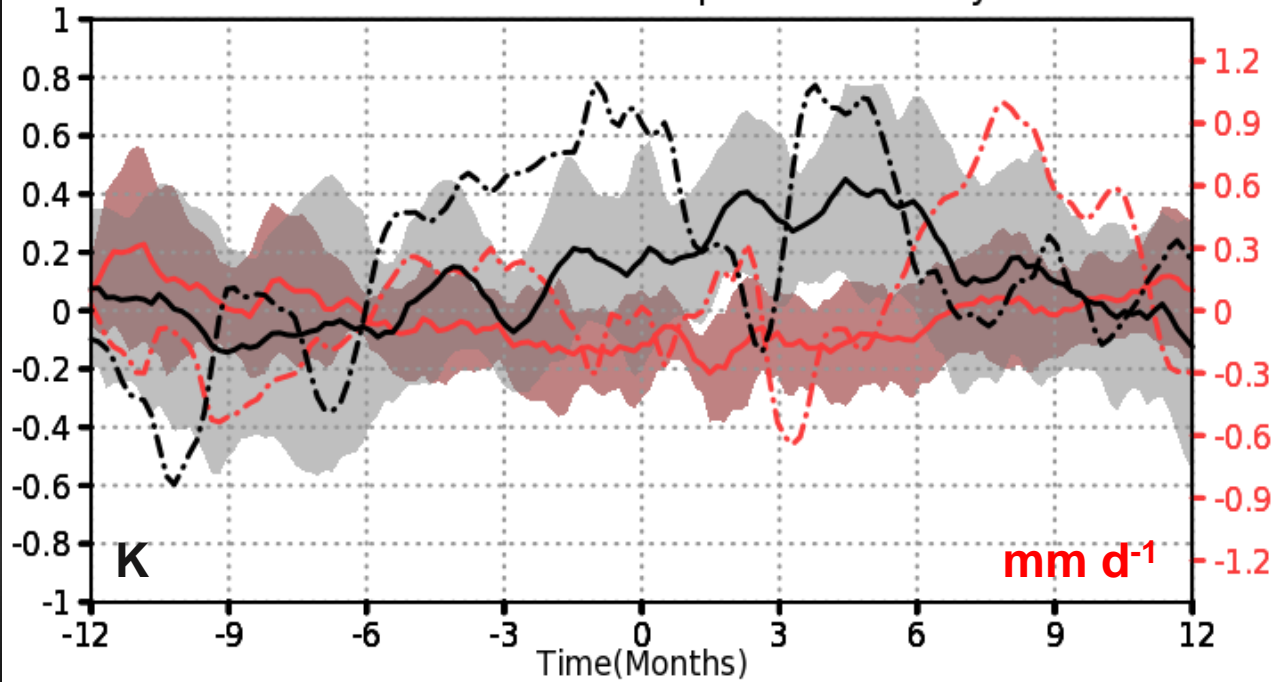
T2m

Prec

SWgCRE

LWgCRE

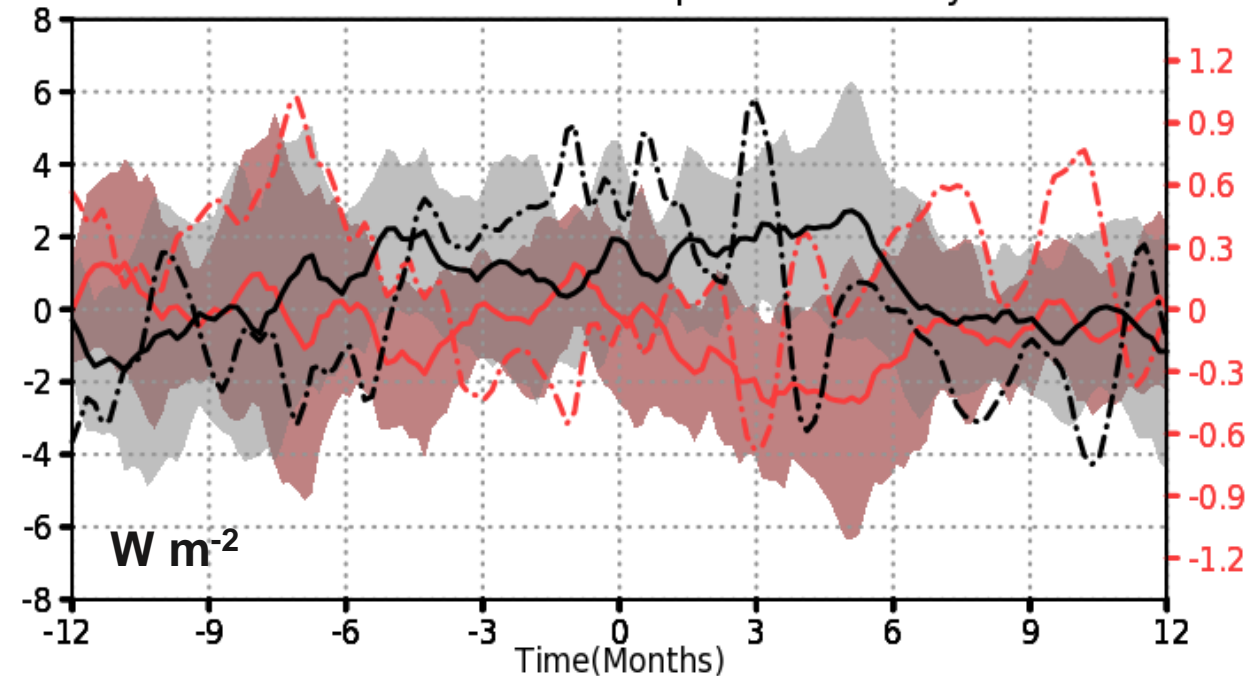
MERRA2 El Niño Composite Anomaly



Land(30-GM)(T2m) Mean = 296.8

Land(30-GM)(PrecTotCorr) Mean = 3.3

MERRA2 El Niño Composite Anomaly



Land(30-GM)(SWgCRE) Mean = -48.3

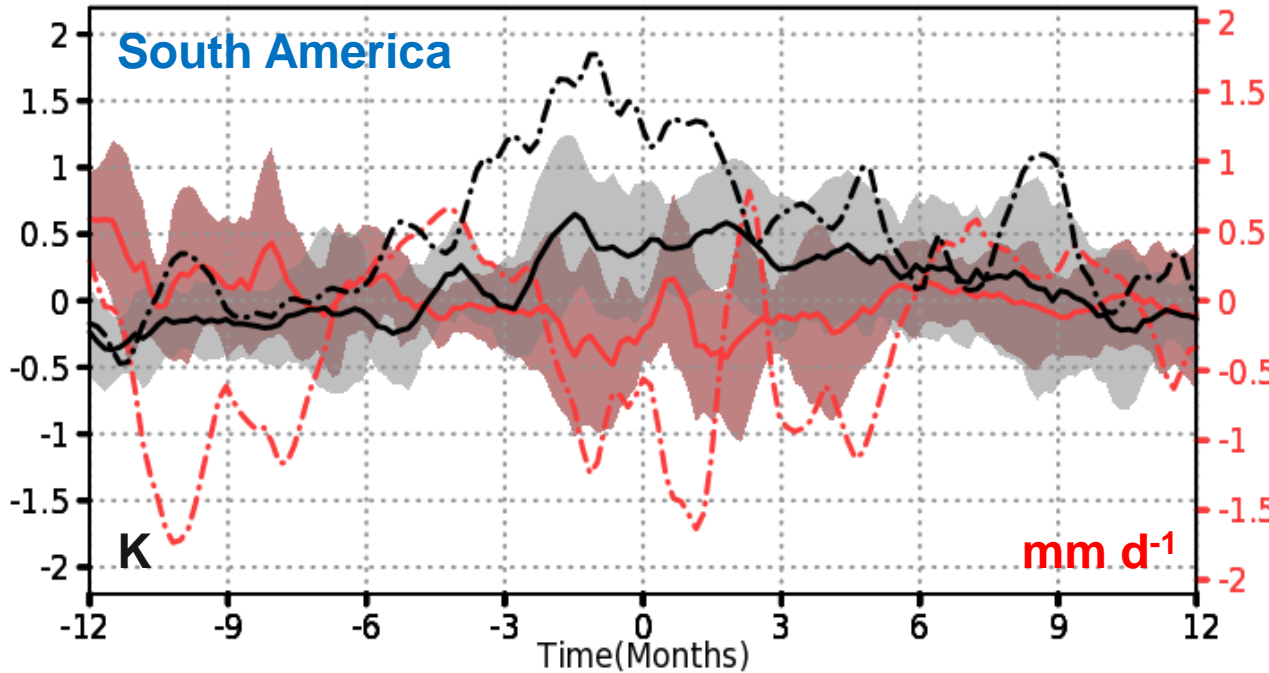
Land(30-GM)(LWgCRE) Mean = 9.6

With Precipitation above composite El Niño, 2m temperature is also warm, clouds (and the SWgCRE) appear as a strong driving force, in the first part of the composite

Regional Pentad Temperature and Precipitation

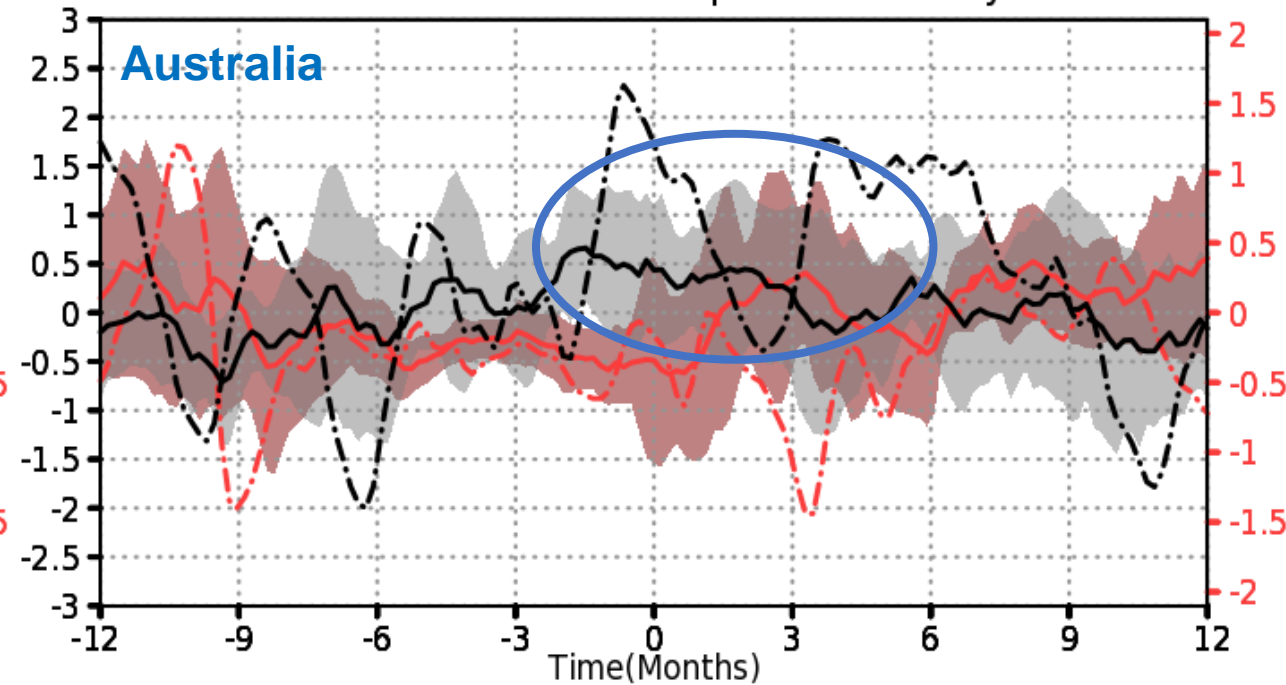
T2m **Prec**

MERRA2 El Nino Composite Anomaly



SAm-GM(T2m) Mean = 297.2
 SAm-GM(PrecTotCorr) Mean = 4.2

MERRA2 El Nino Composite Anomaly



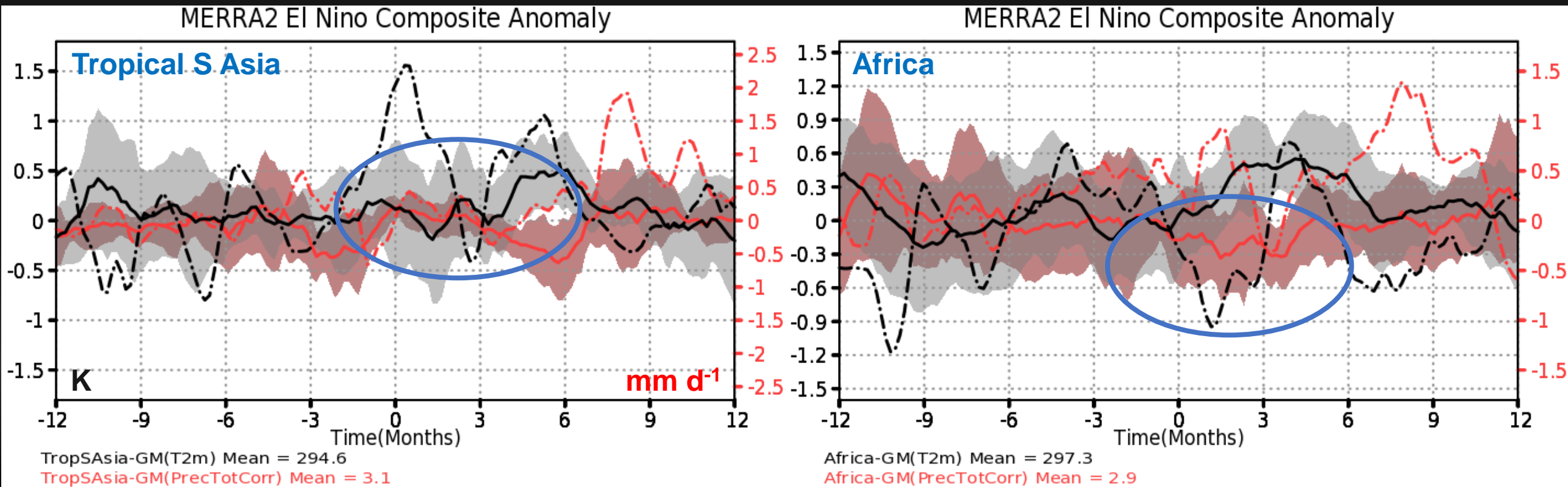
Australia-Land(T2m) Mean = 295.4
 Australia-Land(PrecTotCorr) Mean = 1.3

South America warm temperatures with precipitation reduction

Australia has reduced precipitation tracking composite, but temperatures much above composite

Regional Pentad Temperature and Precipitation

T2m Prec



Tropical South Asia has warm temps after Nino34 peak, precip not affected much
Africa experiences increased precipitation and decreased temperature

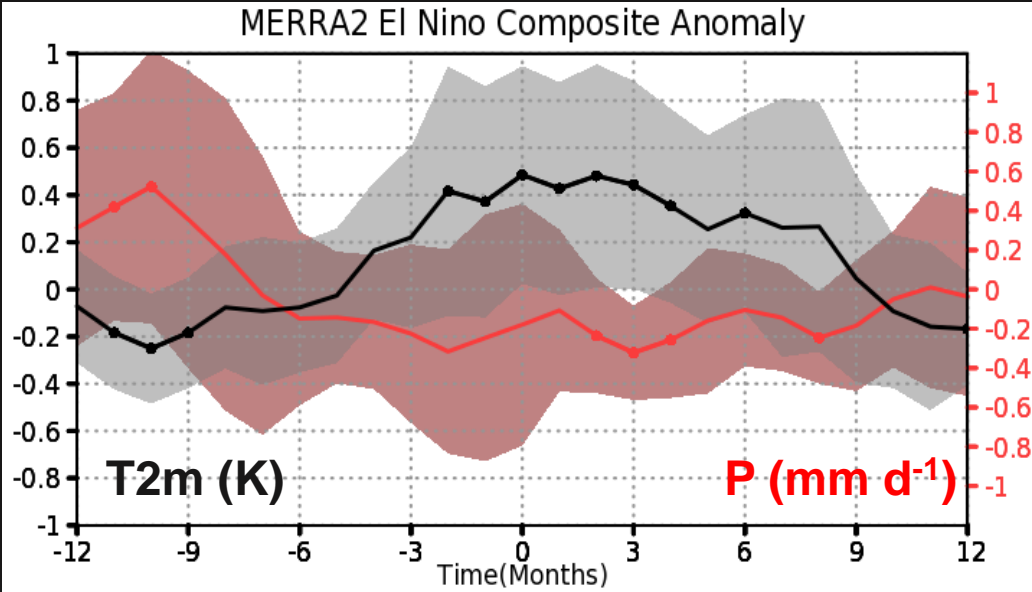
Summary

- MERRA-2 and M2AMIP **capture broad warming** over land following El Niño
- **Shortwave cloud radiative effect** is a dominant forcing process for the warming
 - More downward motion over the continents, clearer skies
 - Reduced precipitation and evaporation coincides **Needs more analysis**
 - Dynamical convergence (transport) is not a strong or consistent source of warming (Analysis Increments also are not a clear source of heat)
- M2AMIP has some regional issues, reducing its reliability (e.g. Australia)
- Each event is unique, yet some processes appear robust in composite El Niño
- MERRA-2 **simulated precipitation and 2m air temperature composites** reasonably reproduce observations at the regional scale, confidence in studying El Niño in general

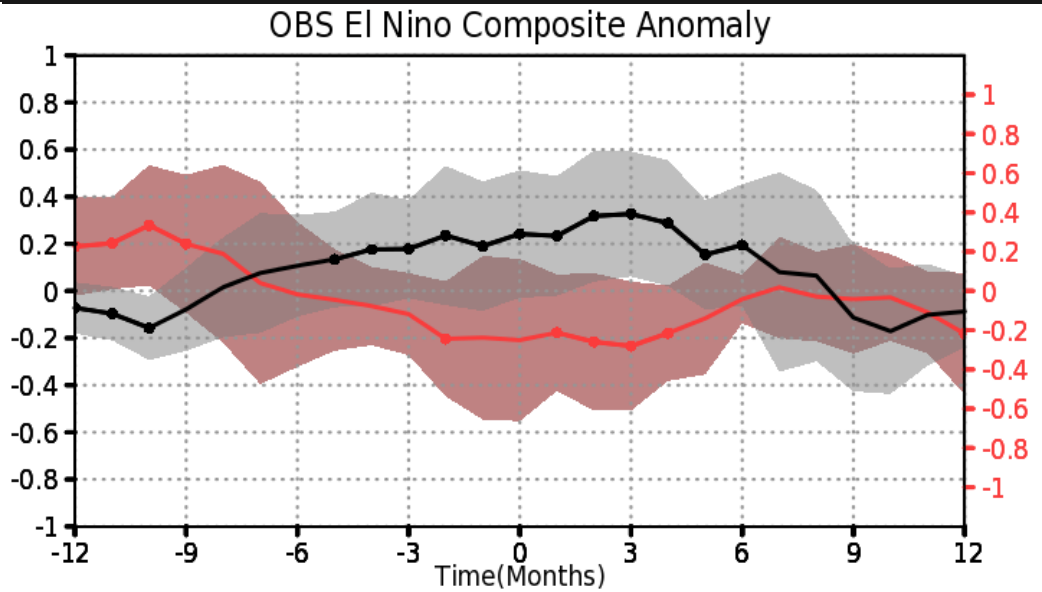
MERRA-2

OBS

South America

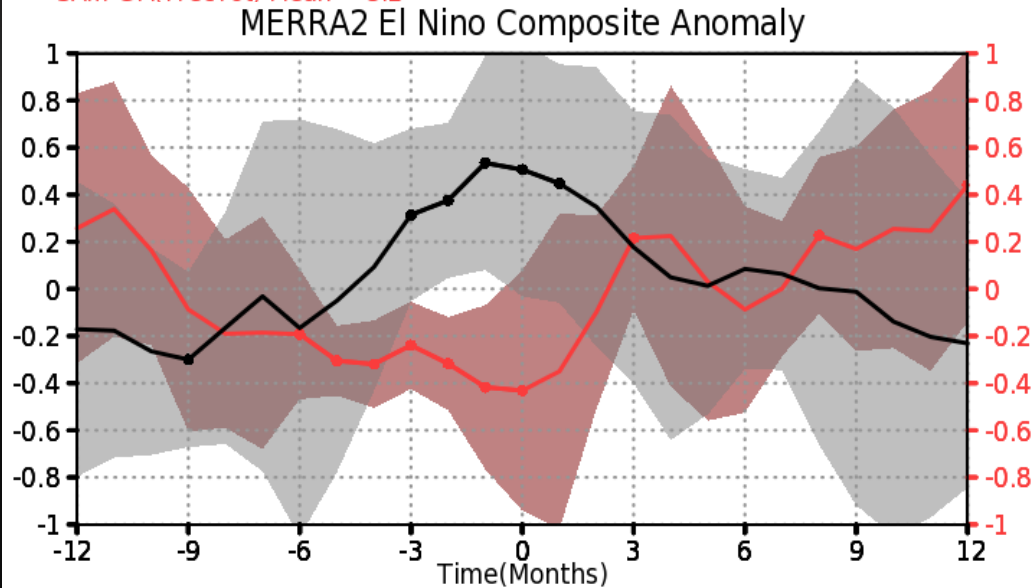


SAm-GM(T2m) Mean = 297.2
 SAm-GM(PrecTot) Mean = 5.2

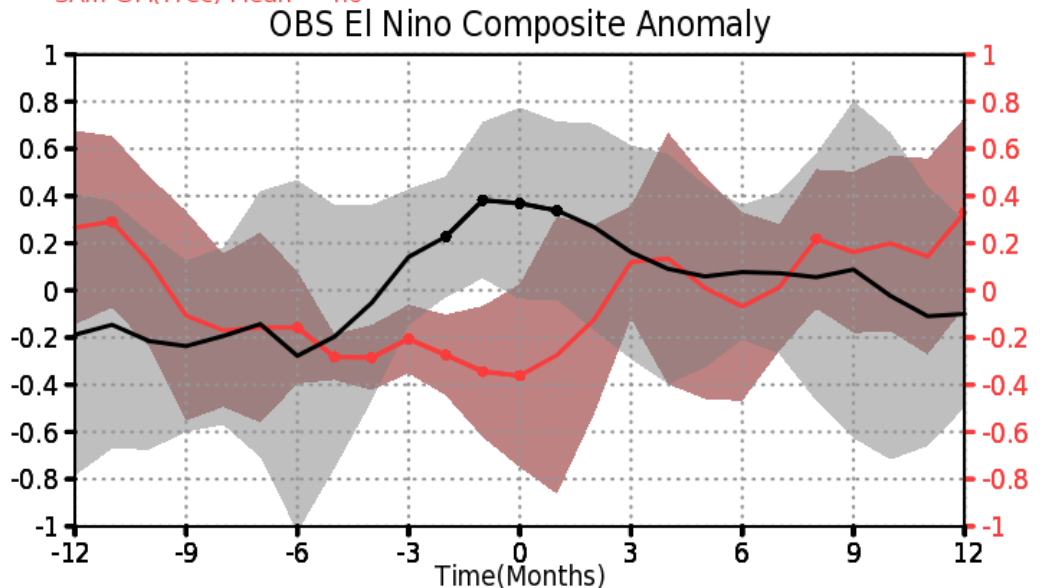


SAm-GM(T2m) Mean = 24.4
 SAm-GM(Prec) Mean = 4.6

Australia



Australia-Land(T2m) Mean = 295.4
 Australia-Land(PrecTot) Mean = 1.5

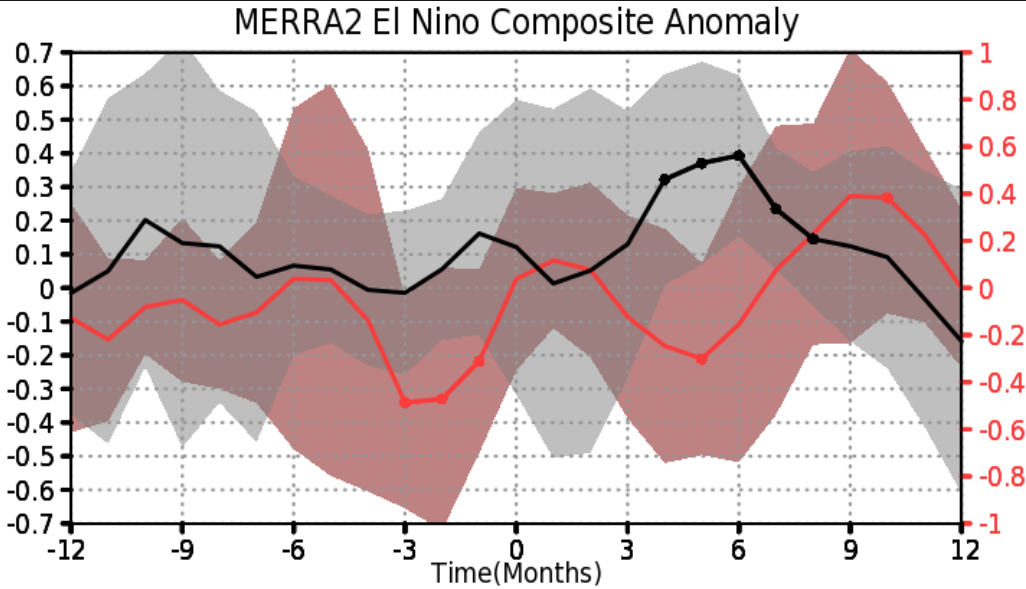


Australia-Land(T2m) Mean = 22.1
 Australia-Land(Prec) Mean = 1.3

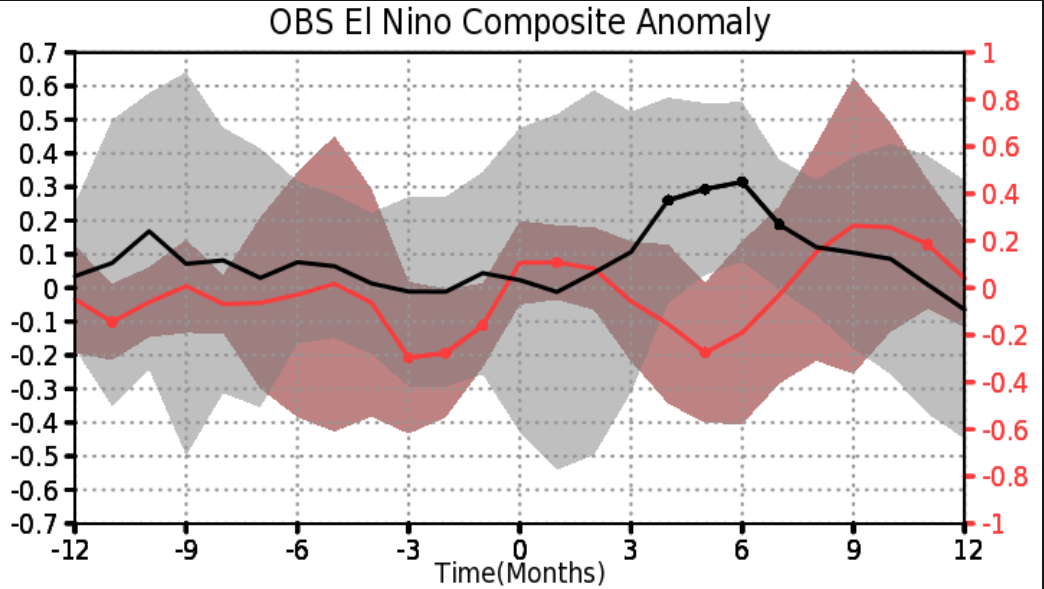
MERRA-2

OBS

Tropical
South
Asia

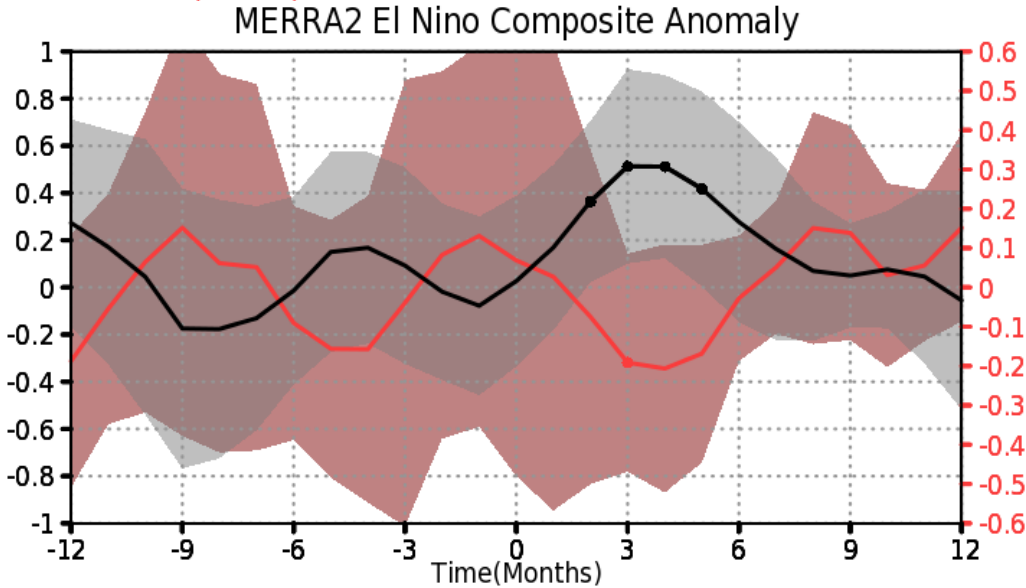


AsiaMon-GM(T2m) Mean = 294.6
 AsiaMon-GM(PrecTot) Mean = 5.3

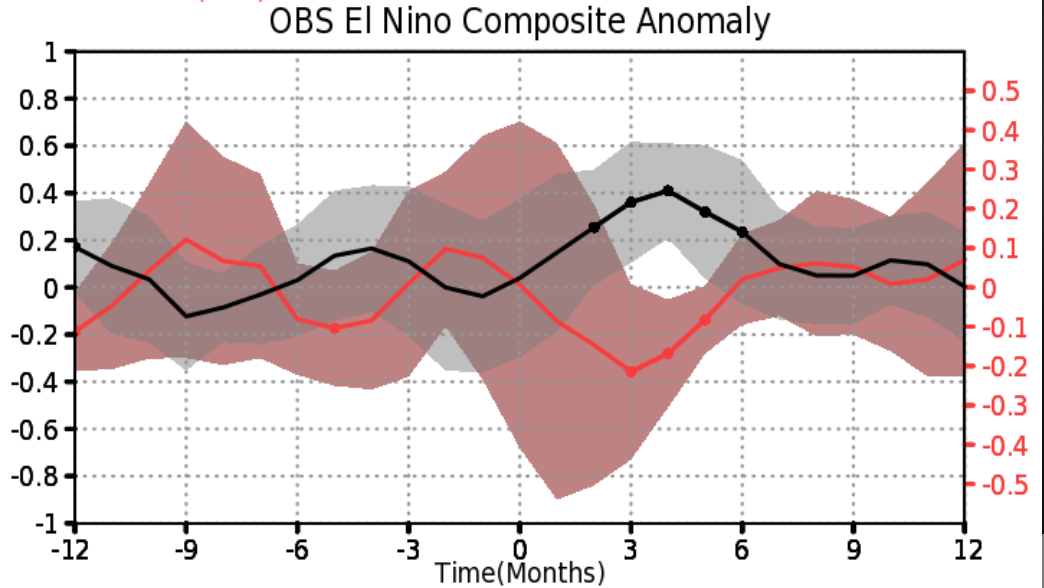


AsiaMon-GM(T2m) Mean = 21.6
 AsiaMon-GM(Prec) Mean = 3.9

Africa



Africa-GM(T2m) Mean = 297.4
 Africa-GM(PrecTot) Mean = 3.4



Africa-GM(T2m) Mean = 24.1
 Africa-GM(Prec) Mean = 2.8