El Niño Coupled Tropical Land Surface Hydrologic Response

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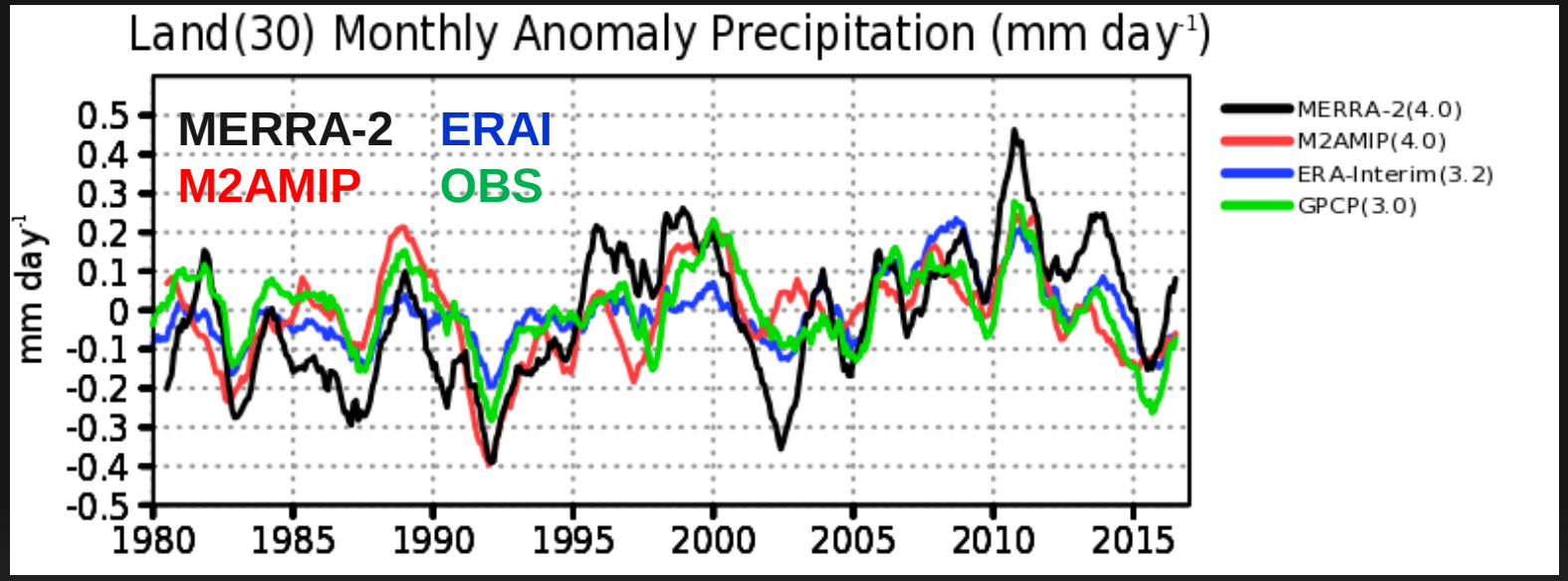
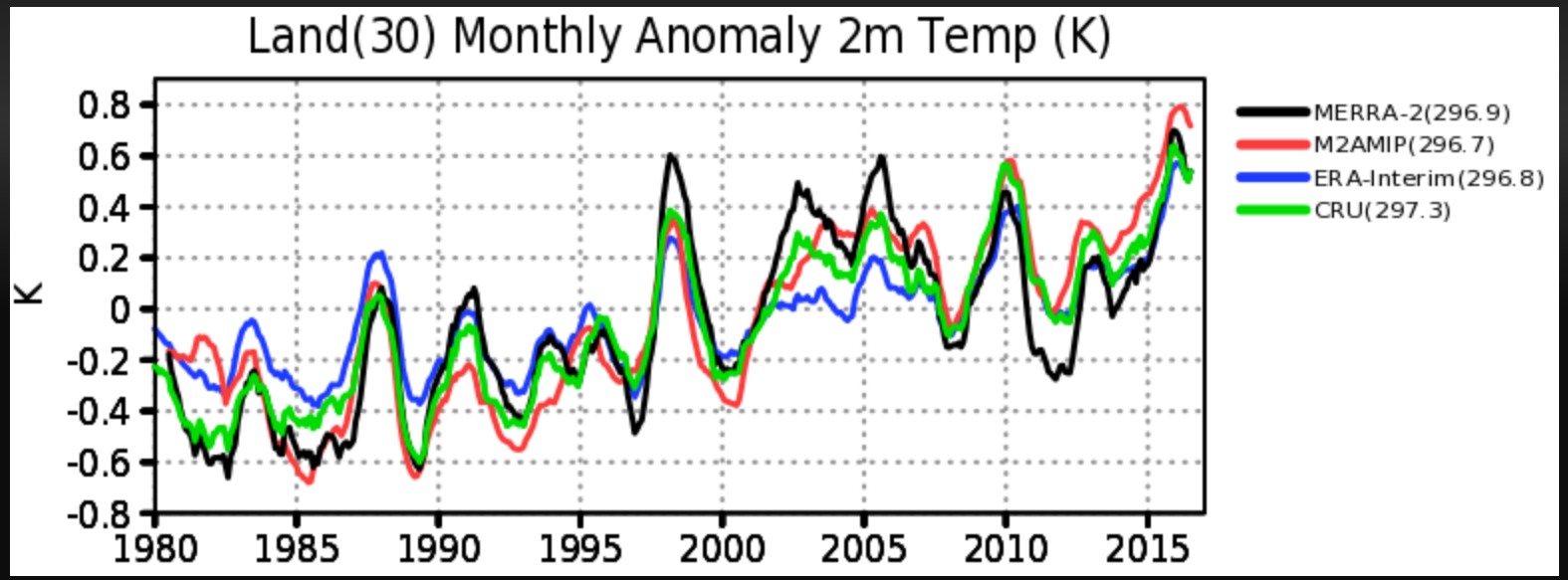
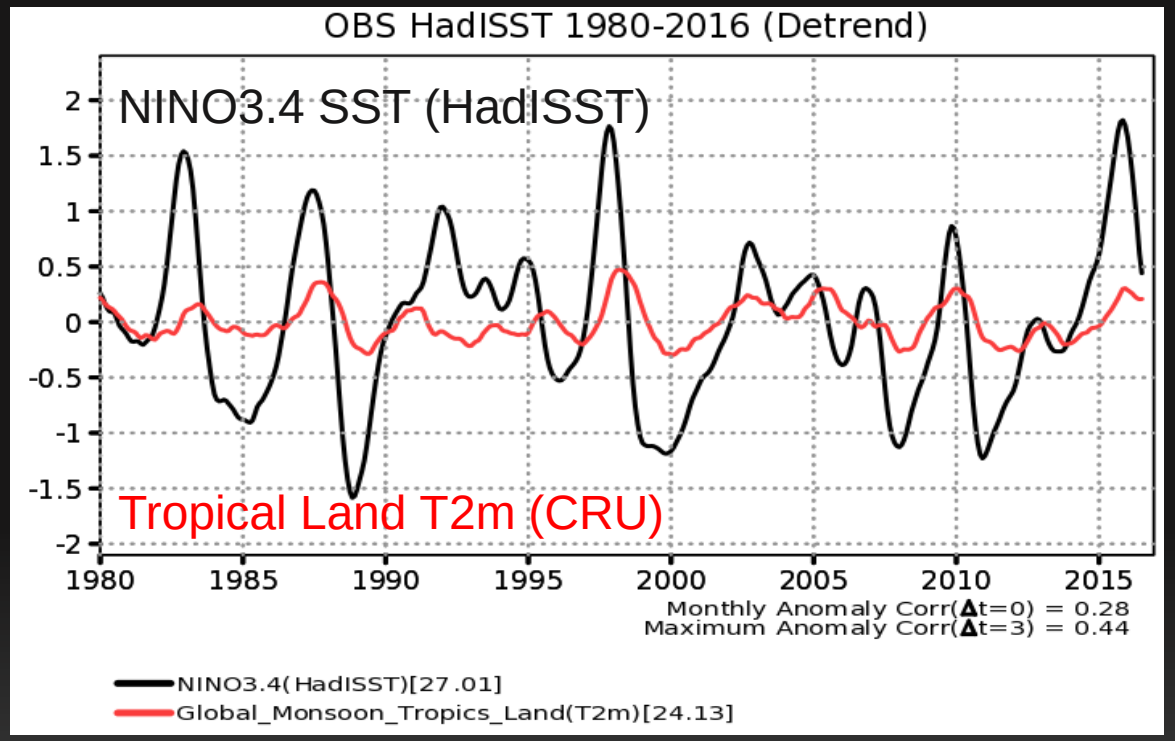
Tropical Land Precipitation and Temperature

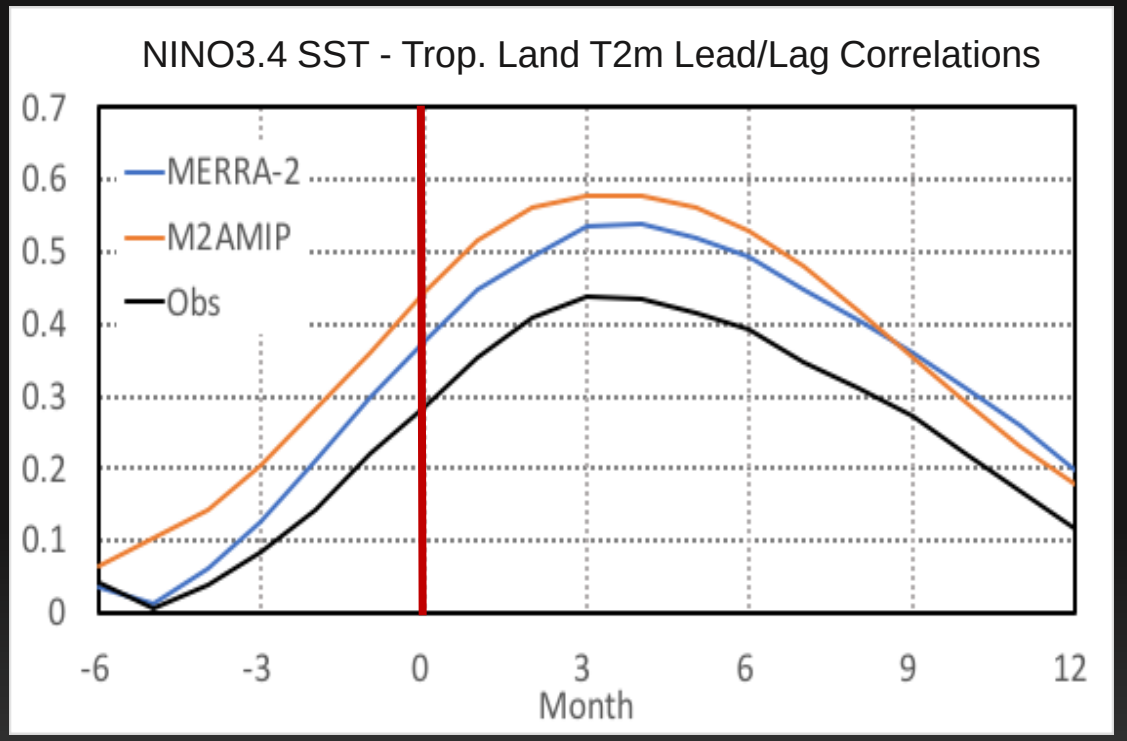




- Many regions around the world, especially in the tropics, show drought modes related to ENSO or SST in general (Schubert et al. 2016)
- El Niño leads to troposphere warming around the tropical belt (Chiang and Sobel, 2002)
- Warming oceans lead to warmer land owing to downwelling LW radiation in present 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



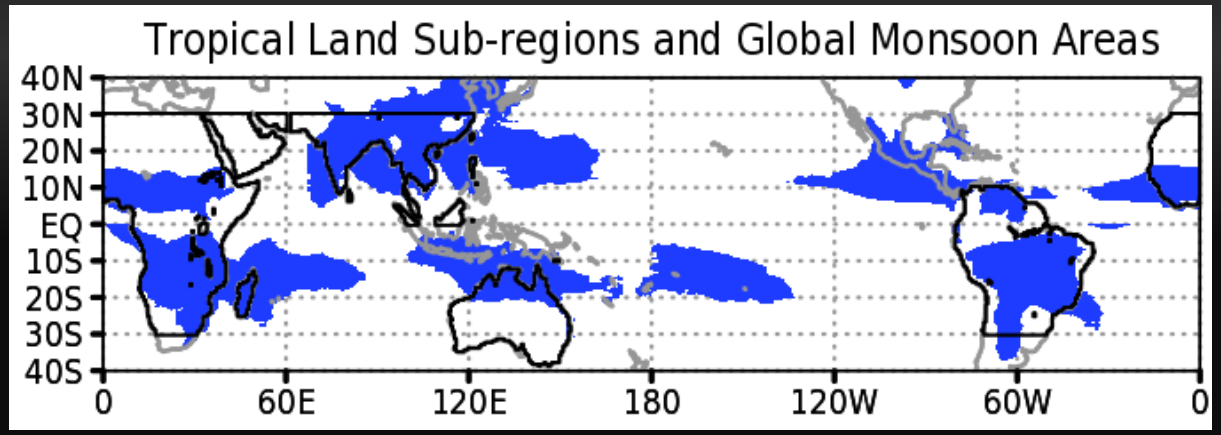


- The continental tropics warming/drought following El Niño is well observed (Chiang and Lintner 2005; Schubert et al. 2016)
- MERRA-2 and M2AMIP (ensemble) produce similar, but stronger, lead/lag correlations of the tropical land temperatures

Data and Methods

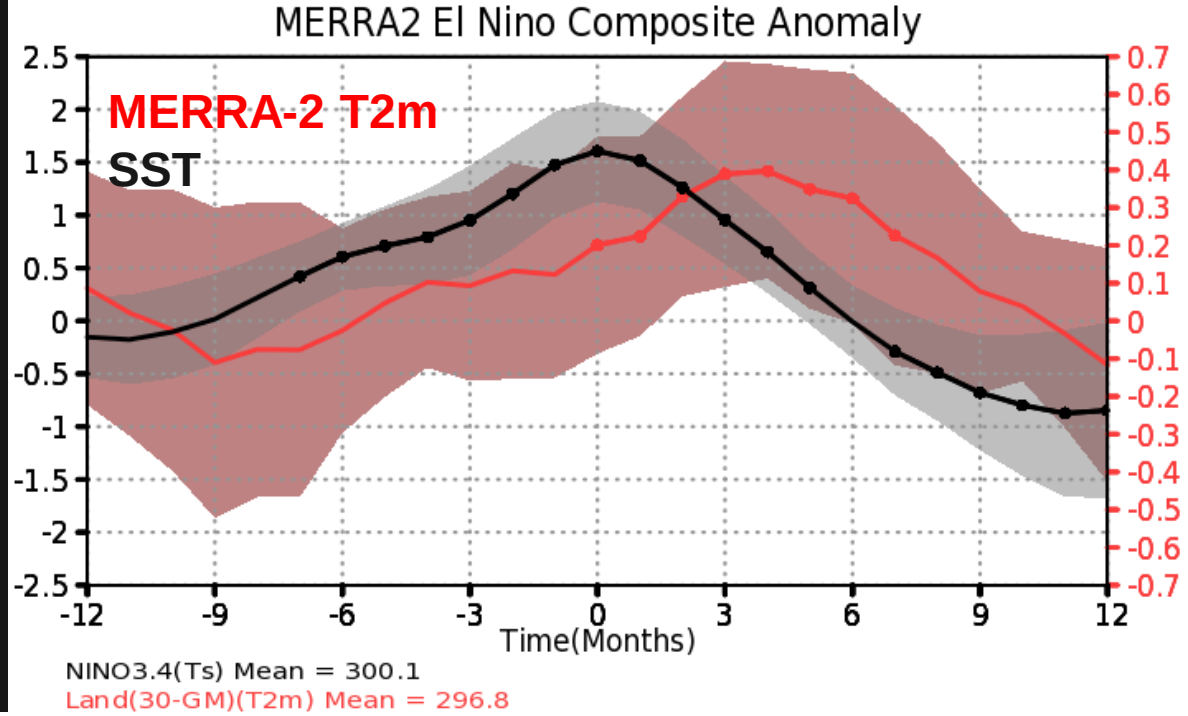
- MERRA-2: Obs Corr Precip for Land Reichle et al (2017); Gelaro et al. (2017)
- M2AMIP: Uses the same model and climate forcing, including SST as MERRA-2. **10-member** ensemble mean. Collow et al. (2017)
- Observations: CRU (4.01 Harris et al. 2014), GPCP (v2.3), GEWEX Surface Radiation Budget (3.0 Zhang et al. 2009)

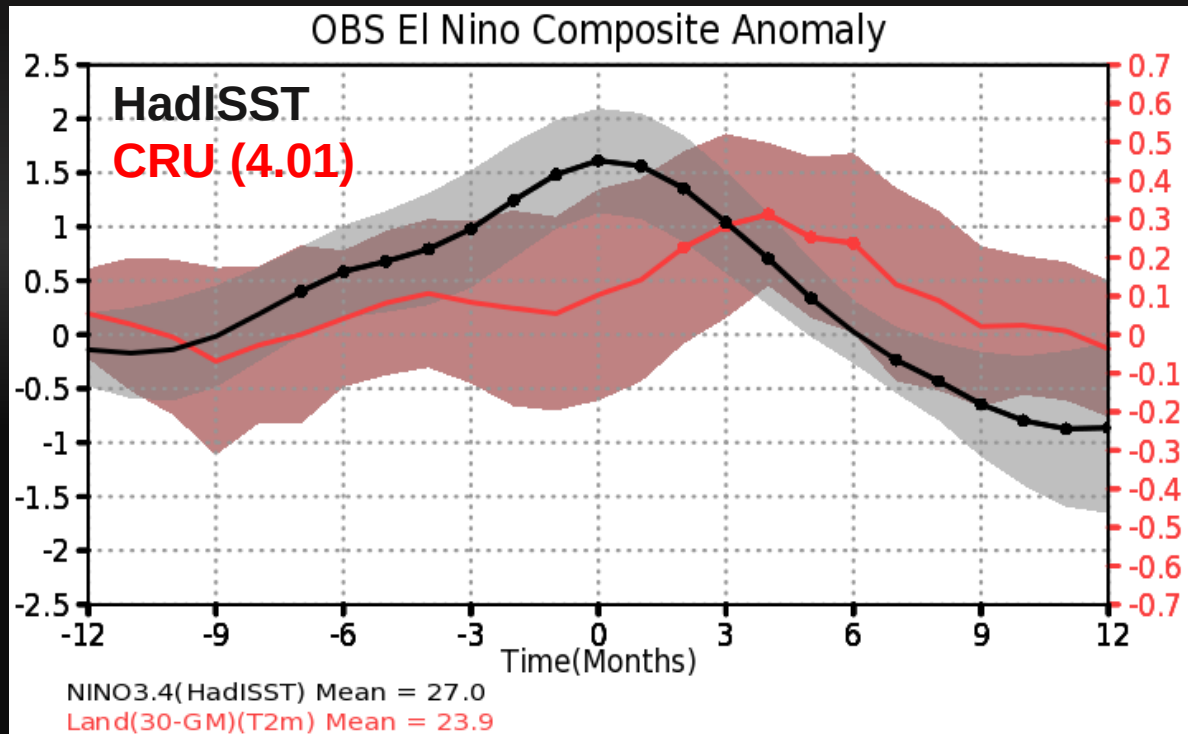
- **Composite** El Niño
  - Deseasonalize and detrend the anomaly time series
  - Find the peak surface temperature in the Niño34 region
  - Collect data for each of **8 peak NINO3.4** (+-12 months) computing mean and st. dev.
- Global Monsoon Region: (e.g. Wang et al. 2012)

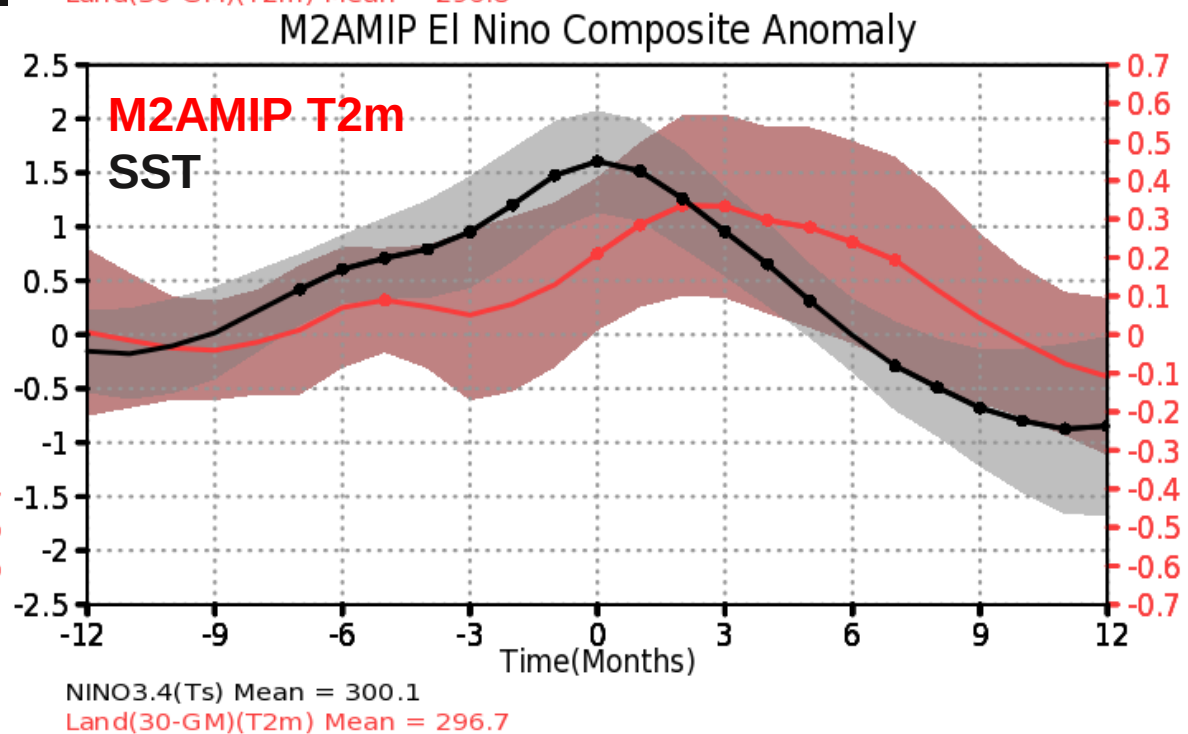


Tropics Temperature Composite El Niño

- 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





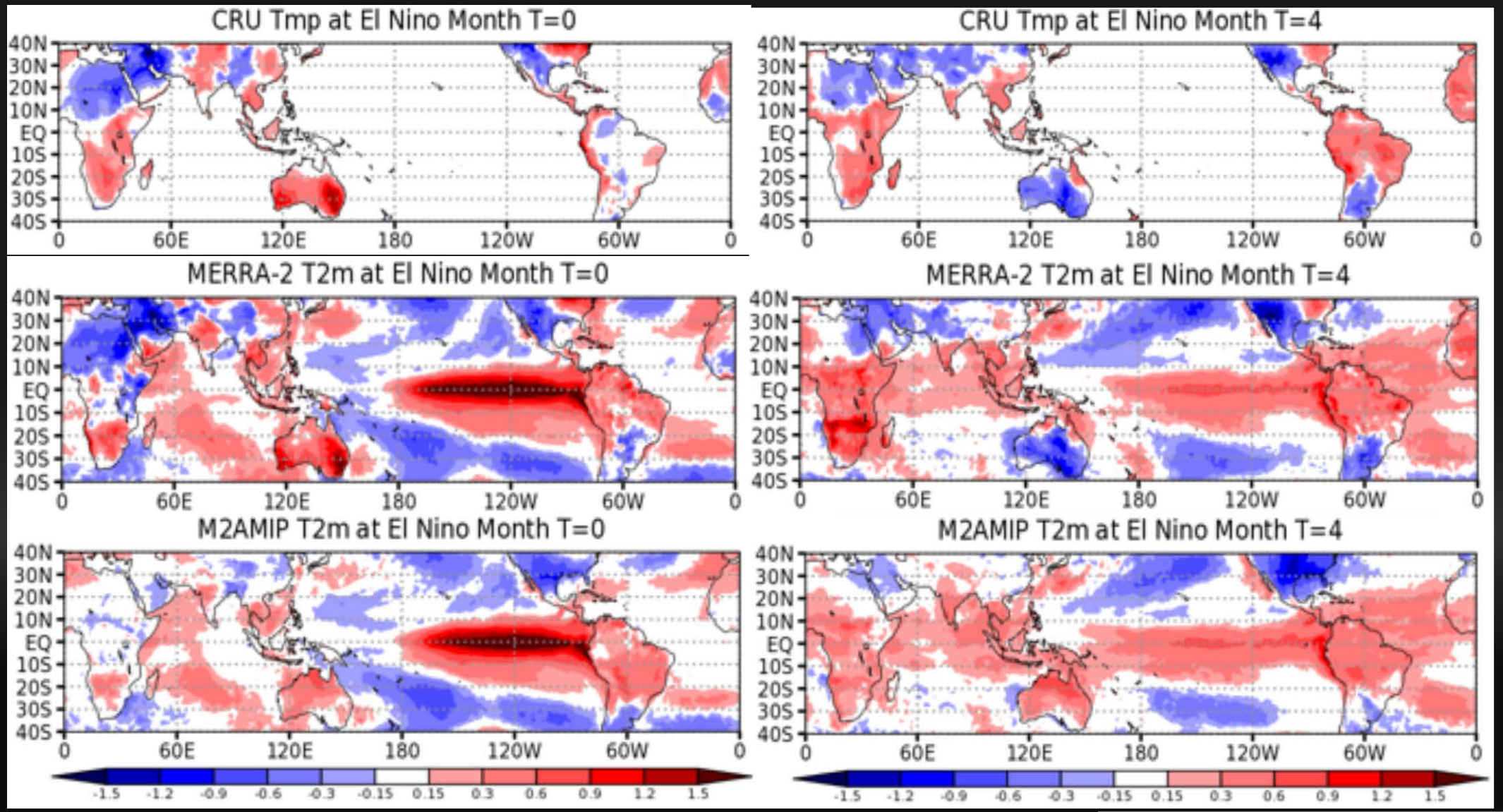


Composite of 2m Air Temperature

CRU

MERRA-2

M2AMIP

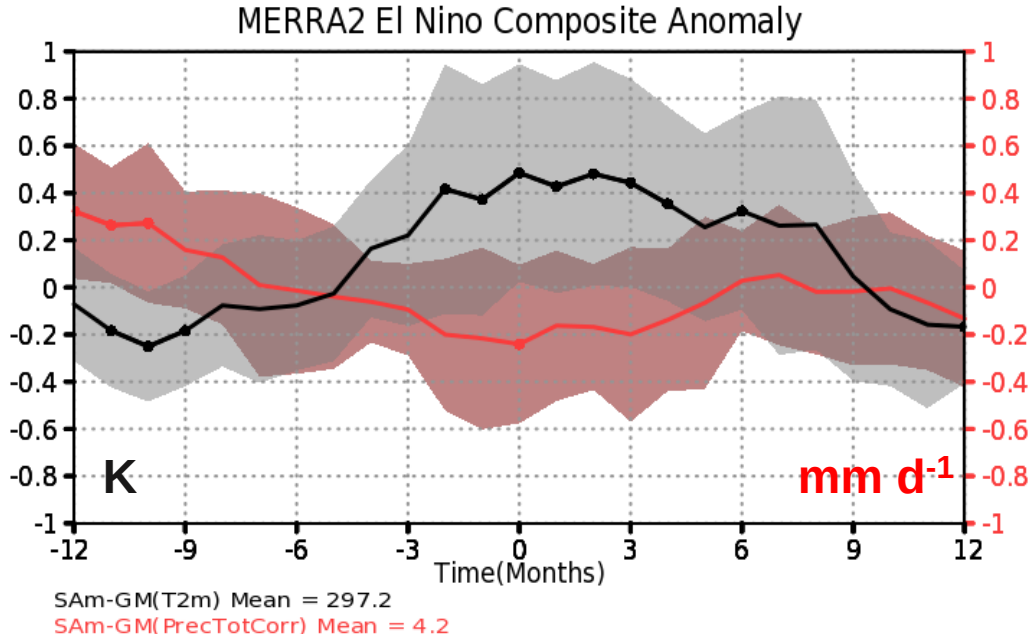


T=0

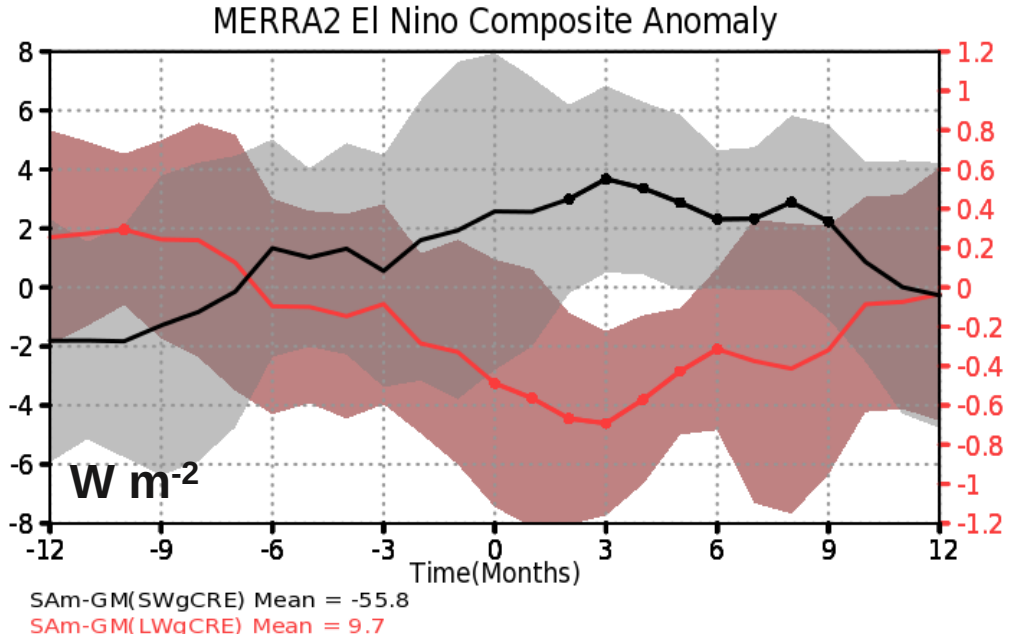
T=+4

South America: MERRA-2

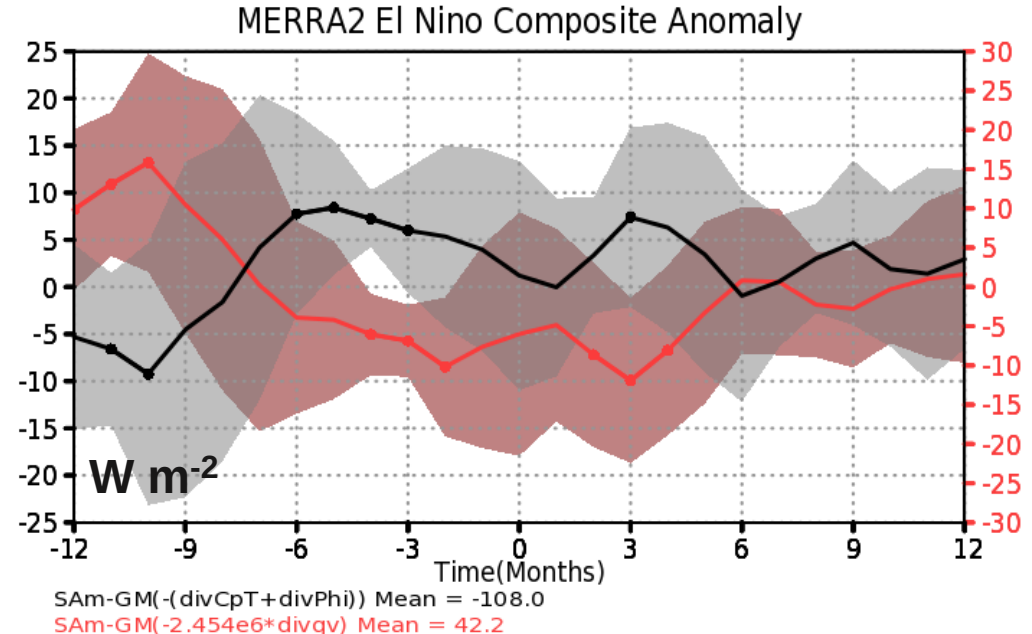
T2m
Prec



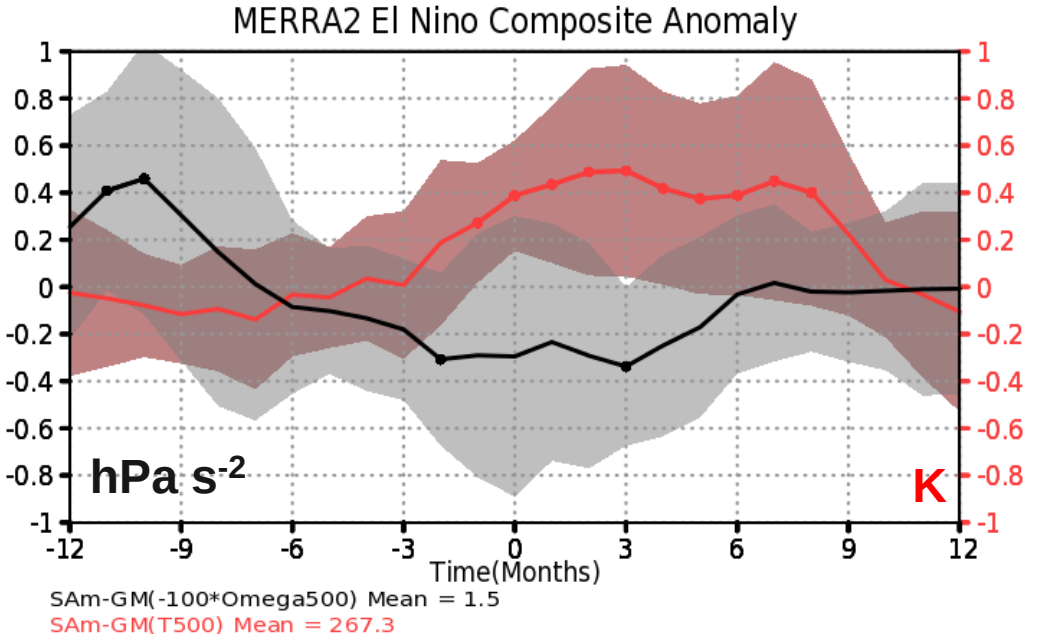
SWgCRE
LWgCRE



Conv.
CpT+Phi
Lqv

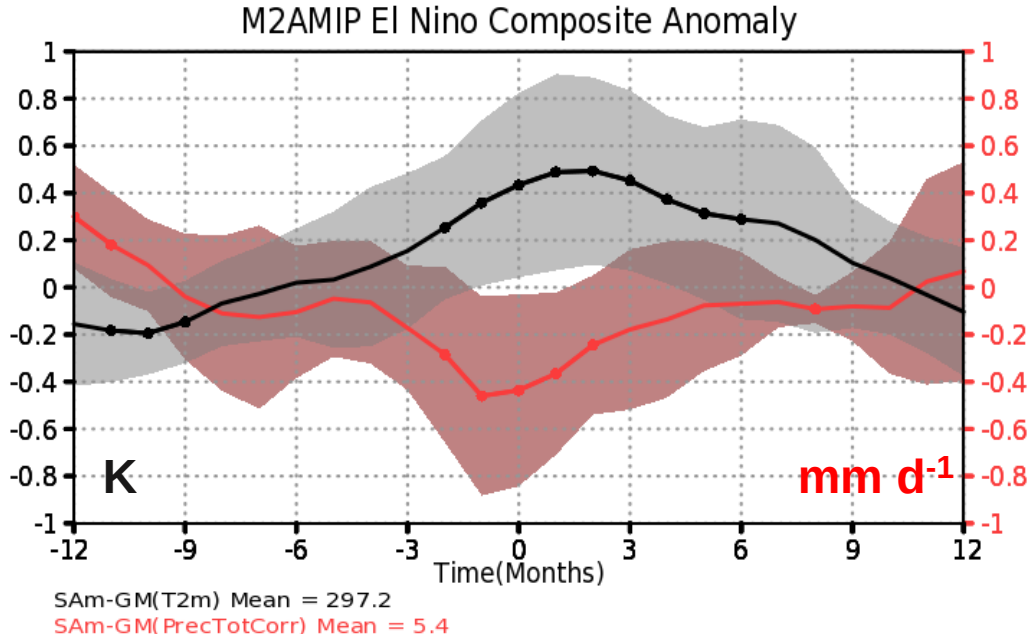


-ω (500)
T(500)

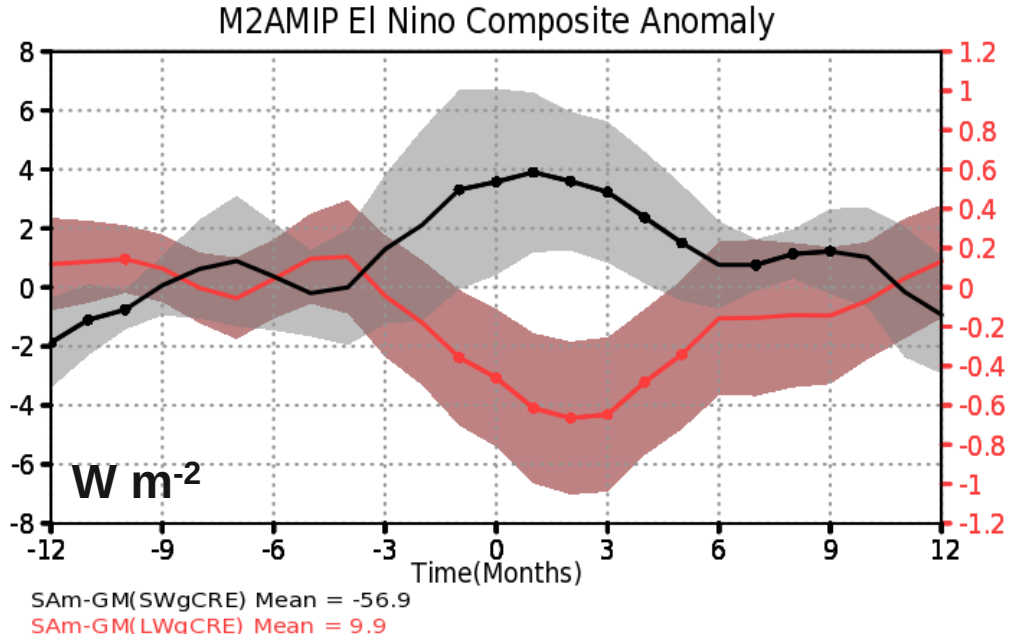


South America: M2AMIP

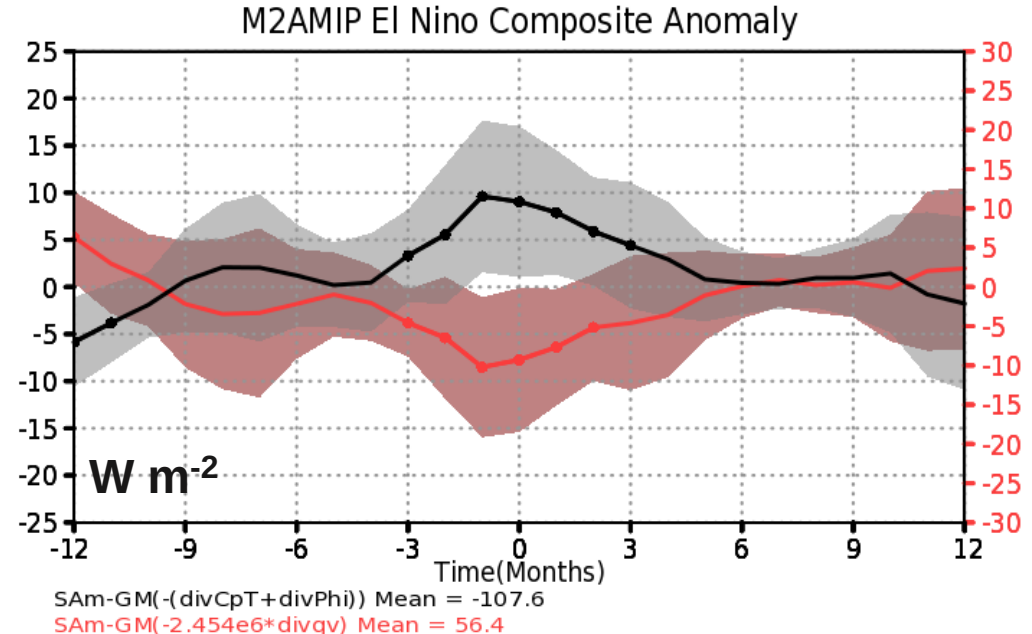
T2m
Prec



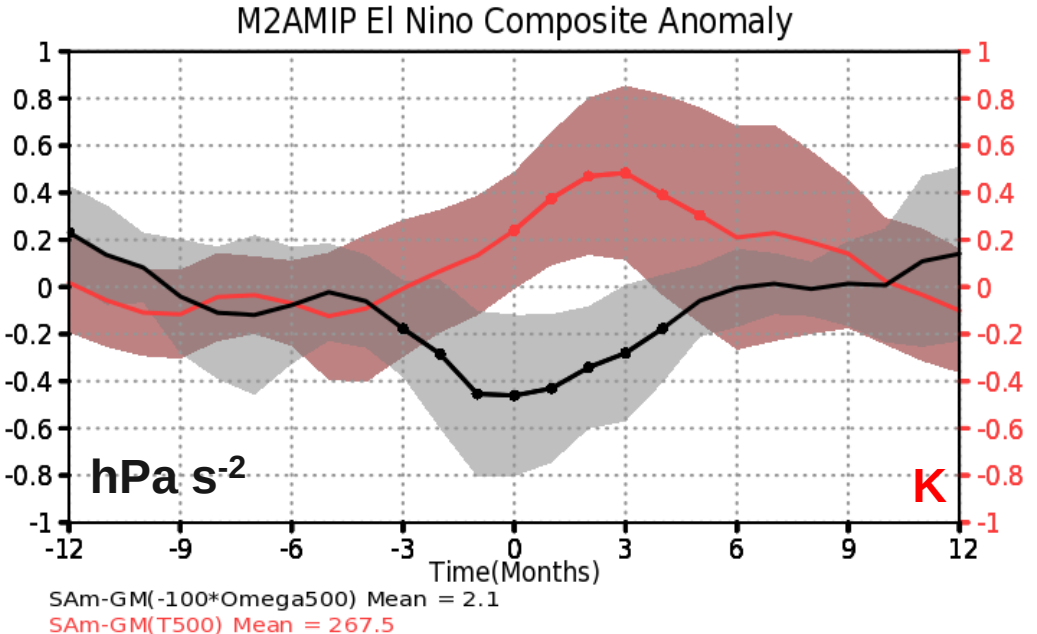
SWgCRE
LWgCRE



Conv.
DSE
Lqv

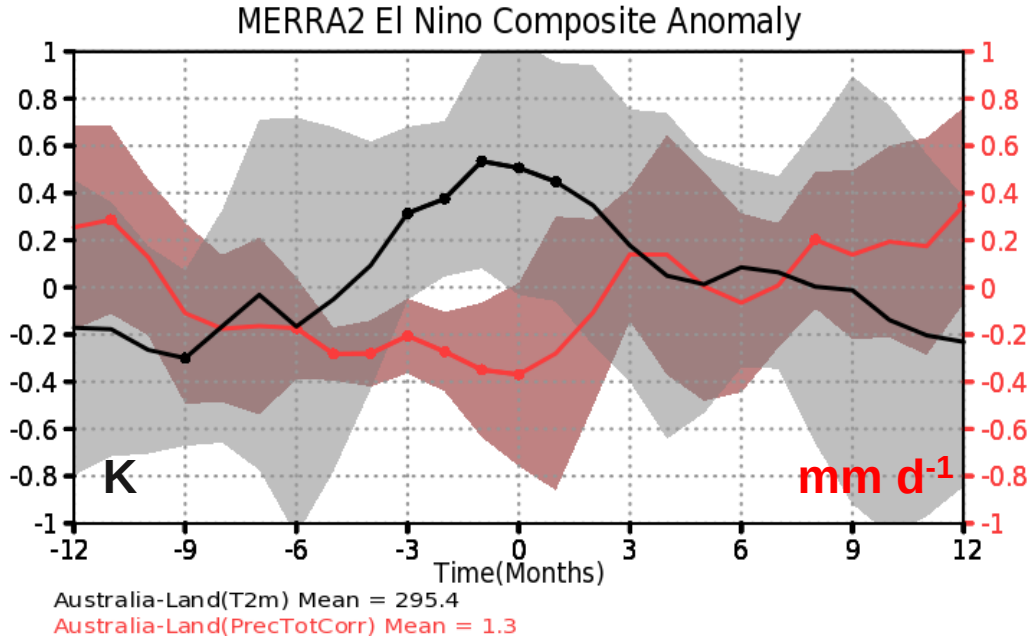


−ω(500)
T(500)

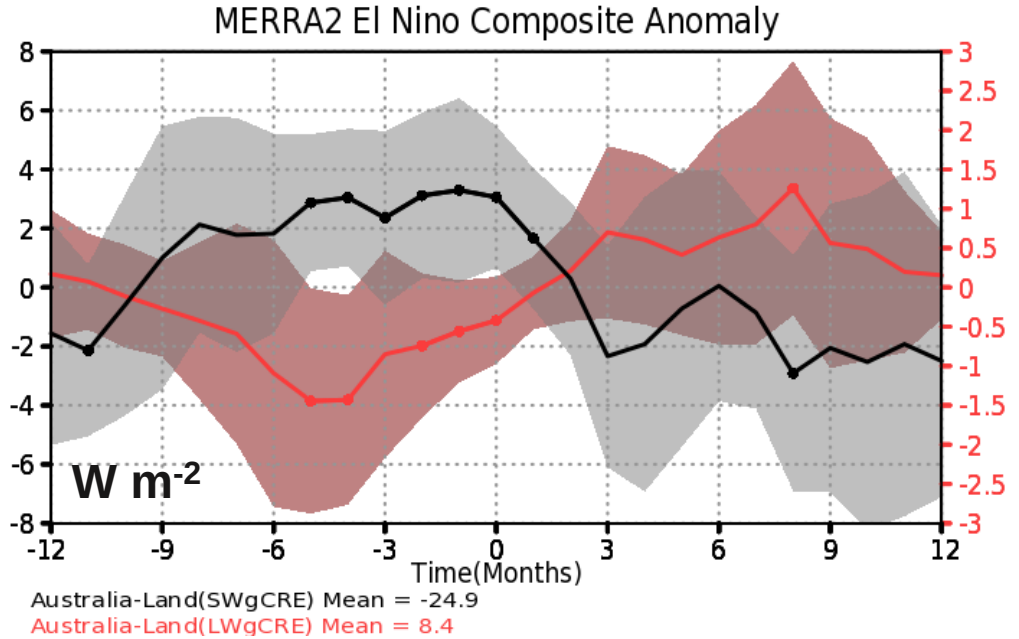


Australia: MERRA-2

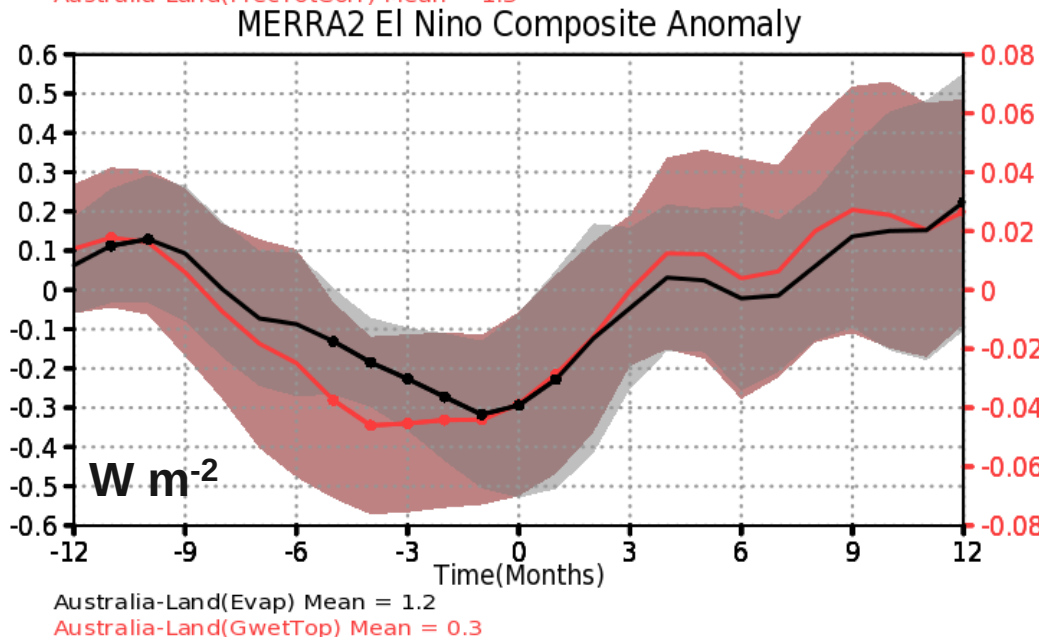
T2m
Prec



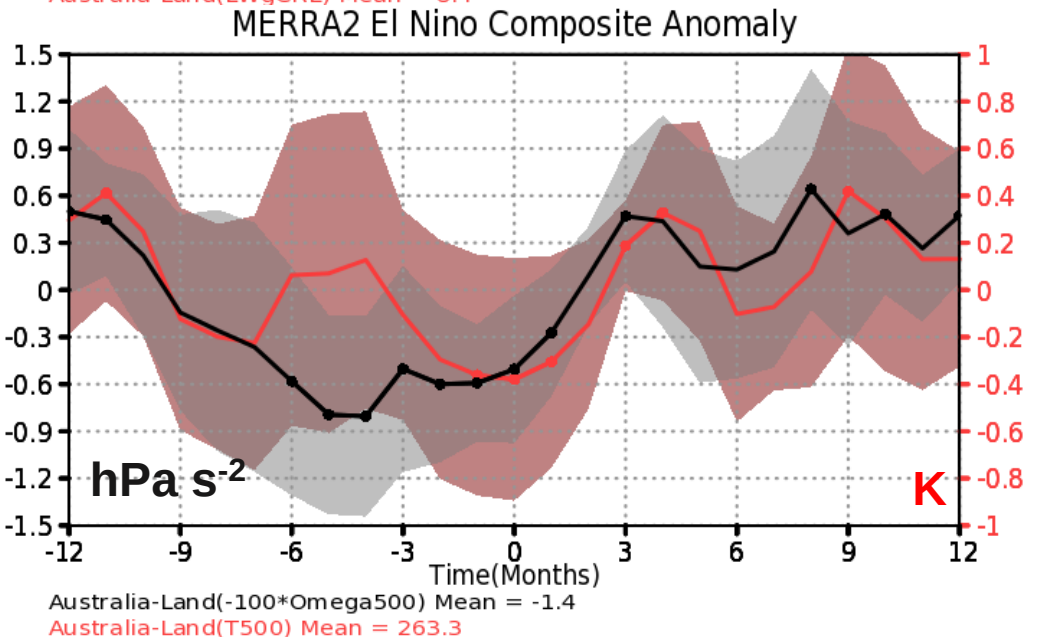
SWgCRE
LWgCRE



LEvap
GwTop

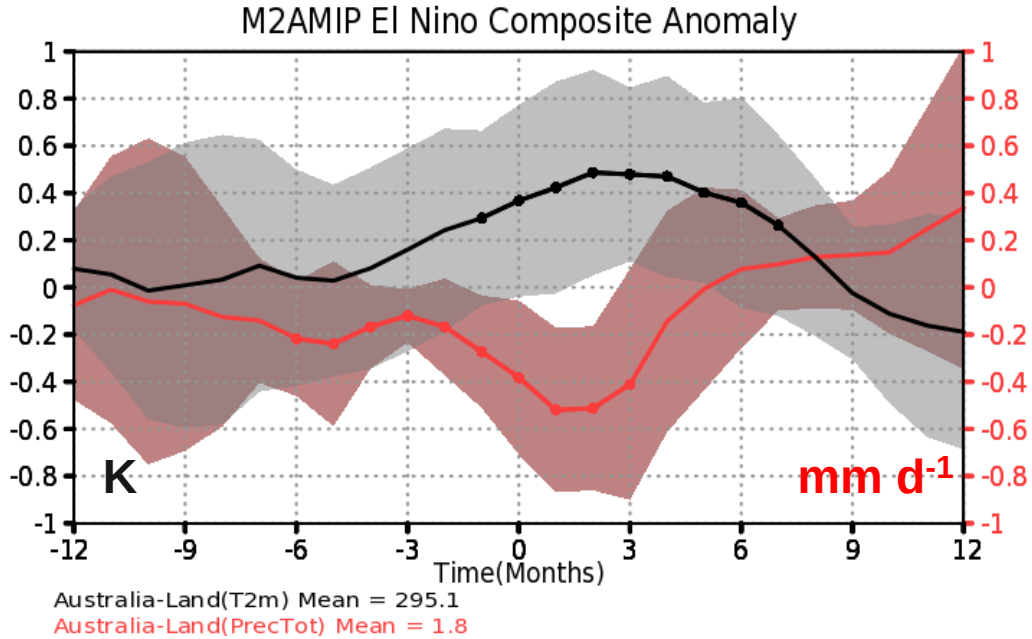


-ω(500)
T(500)

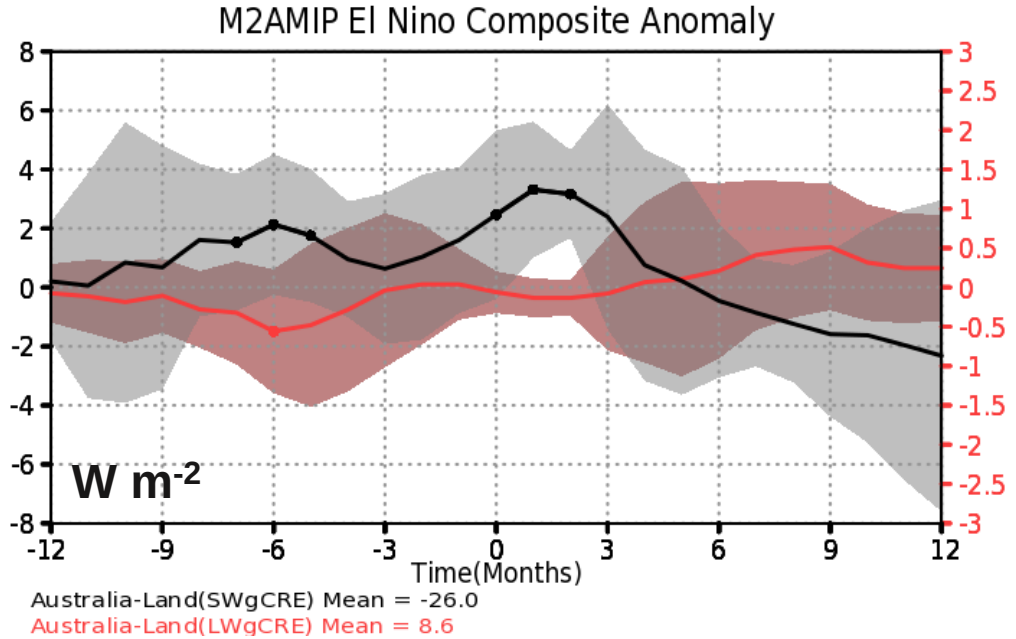


Australia: M2AMIP

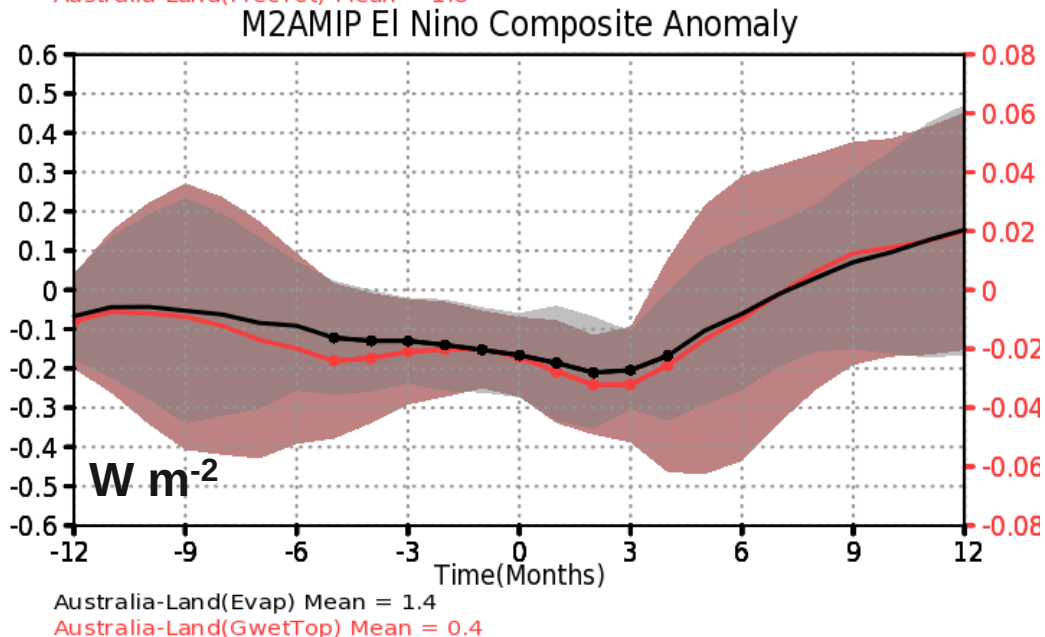
T2m
Prec



SWgCRE
LWgCRE



LEvap
GwTop



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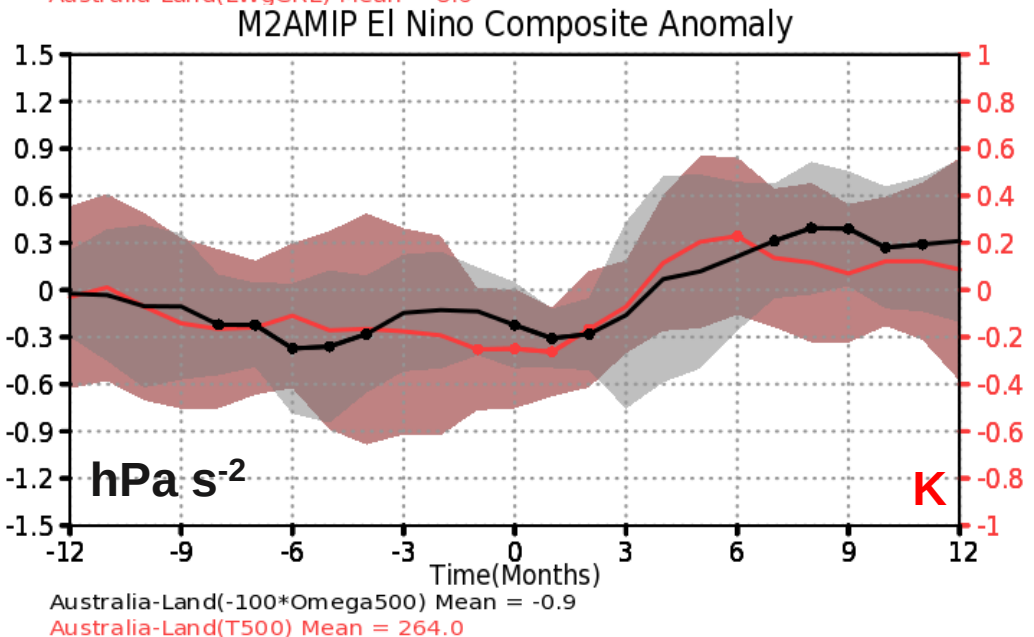
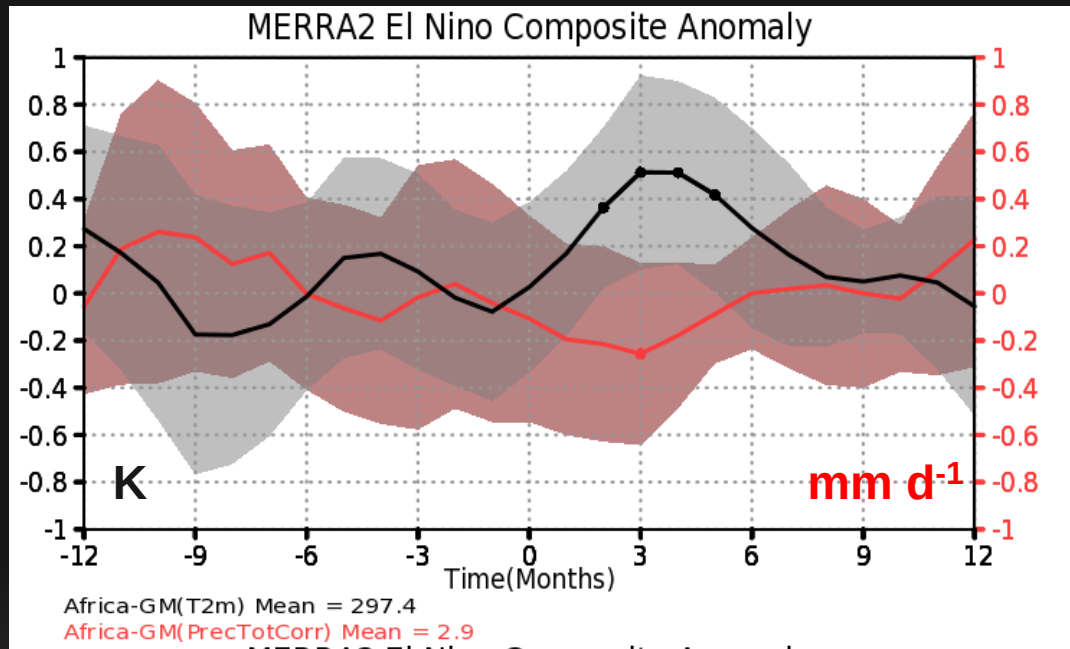
T(500)

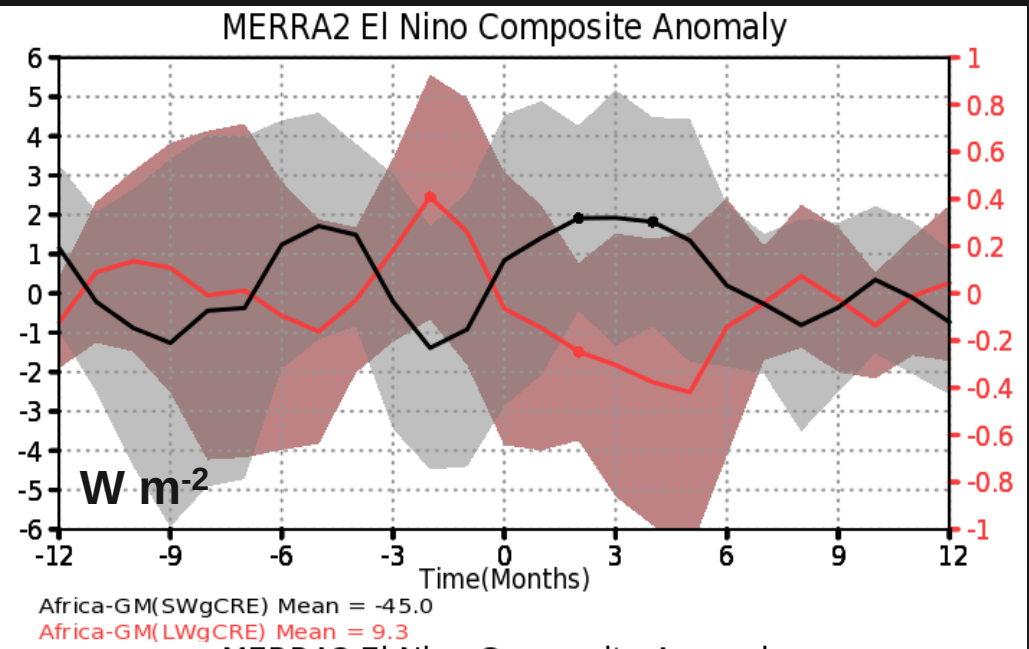


Africa: MERRA-2

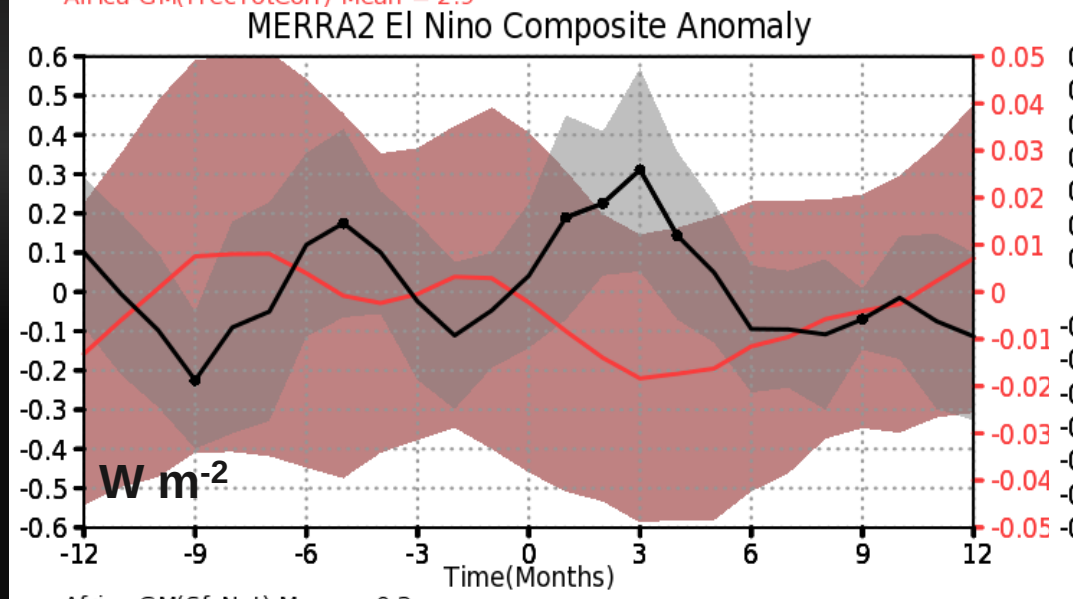
T2m
Prec



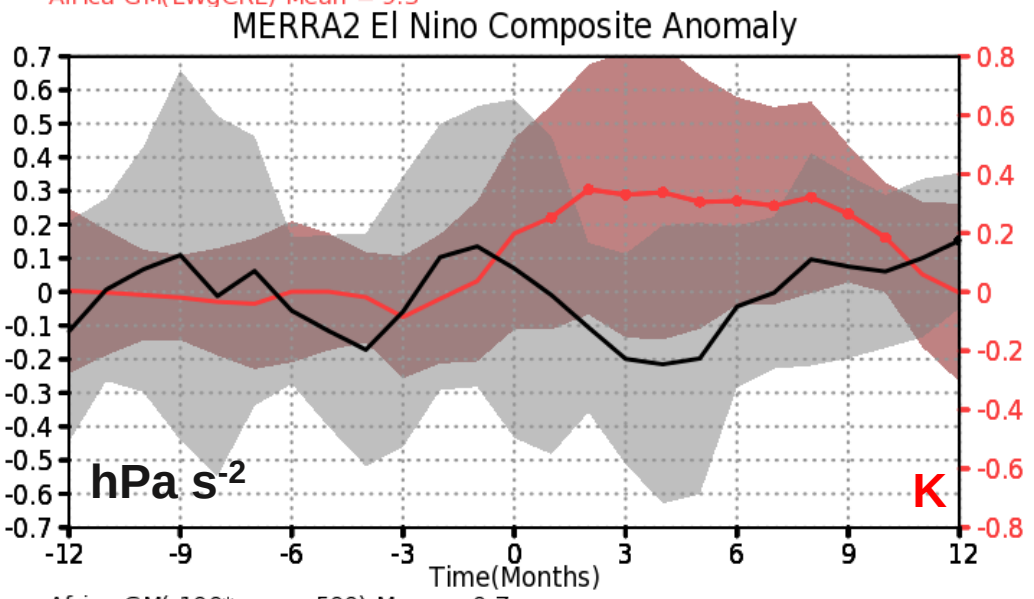
SWgCRE
LWgCRE



SfcNet
GwTop

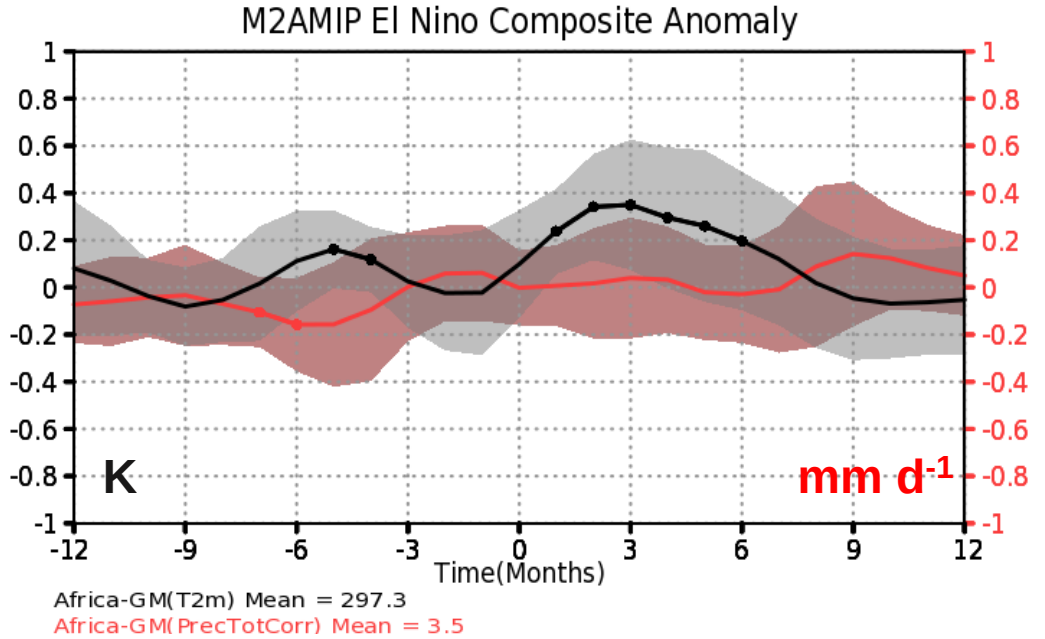


-ω(500)
T(500)

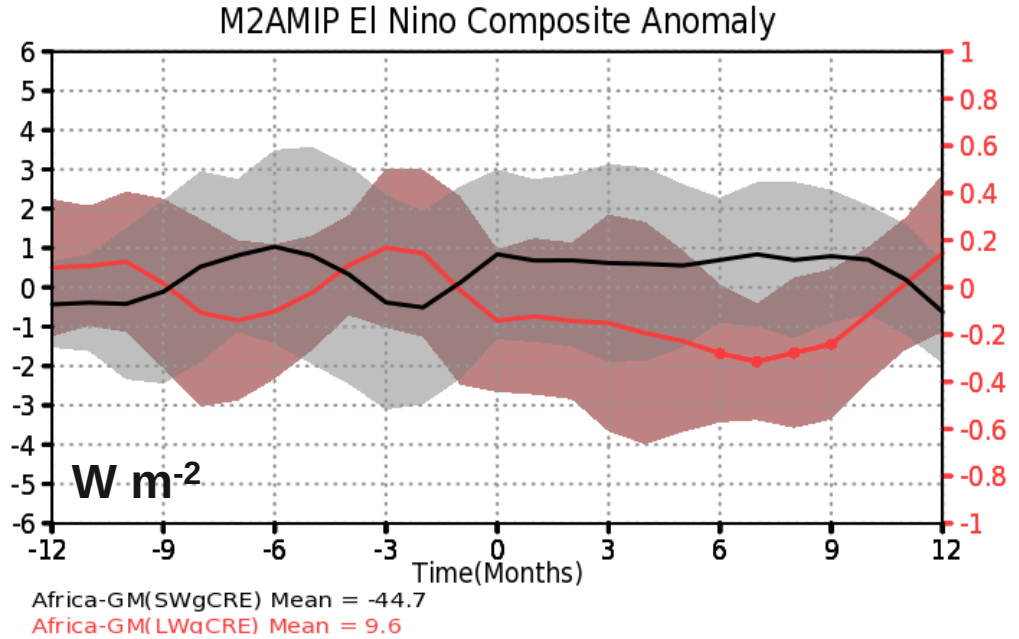


Africa: M2AMIP

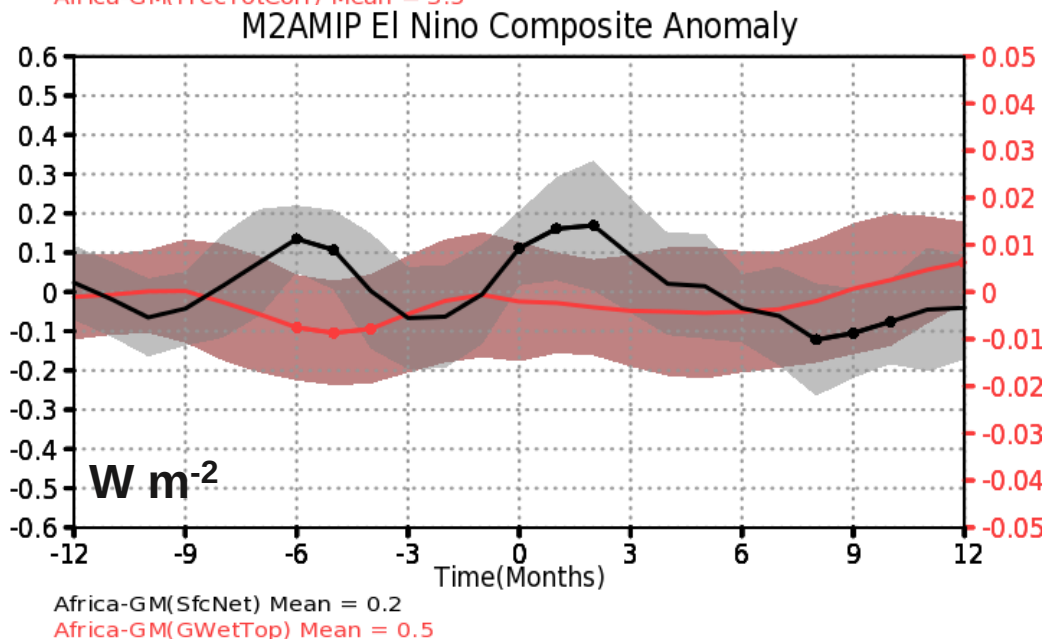
T2m
Prec



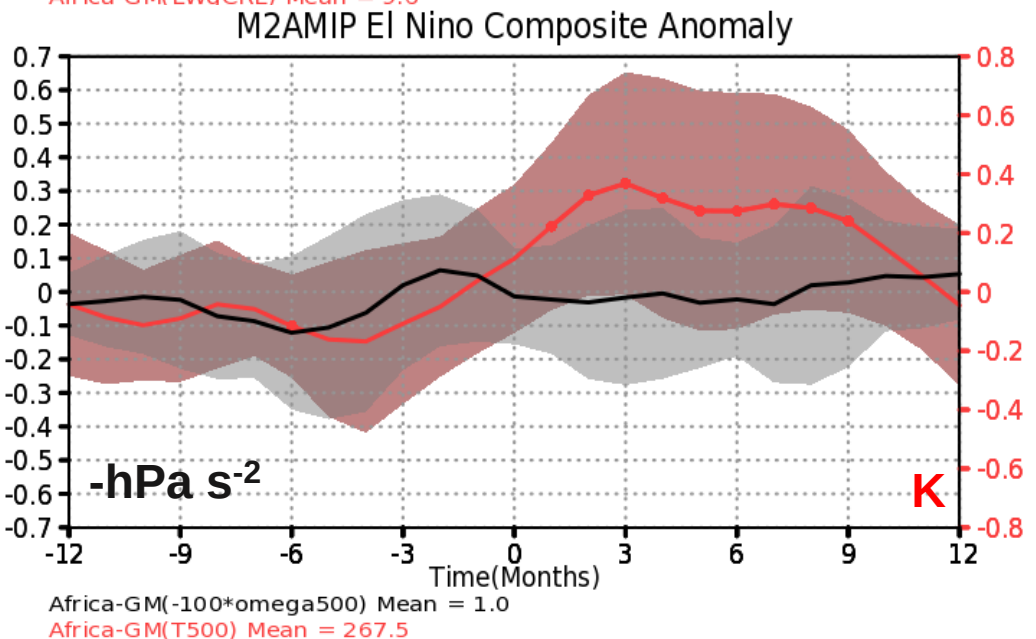
SWgCRE
LWgCRE



SfcNet
GwTop

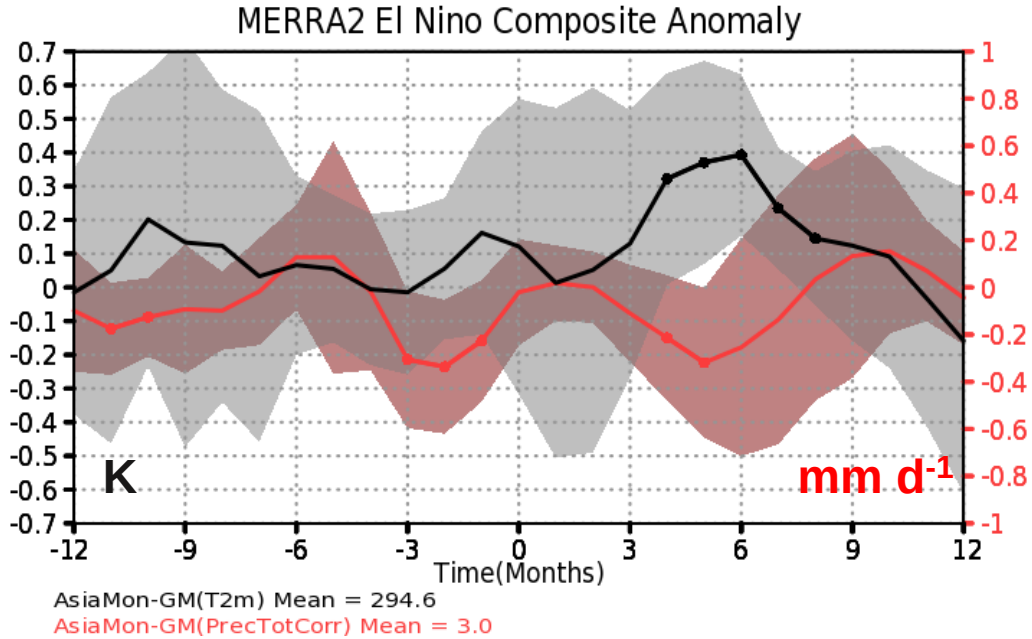


-ω(500)
T(500)

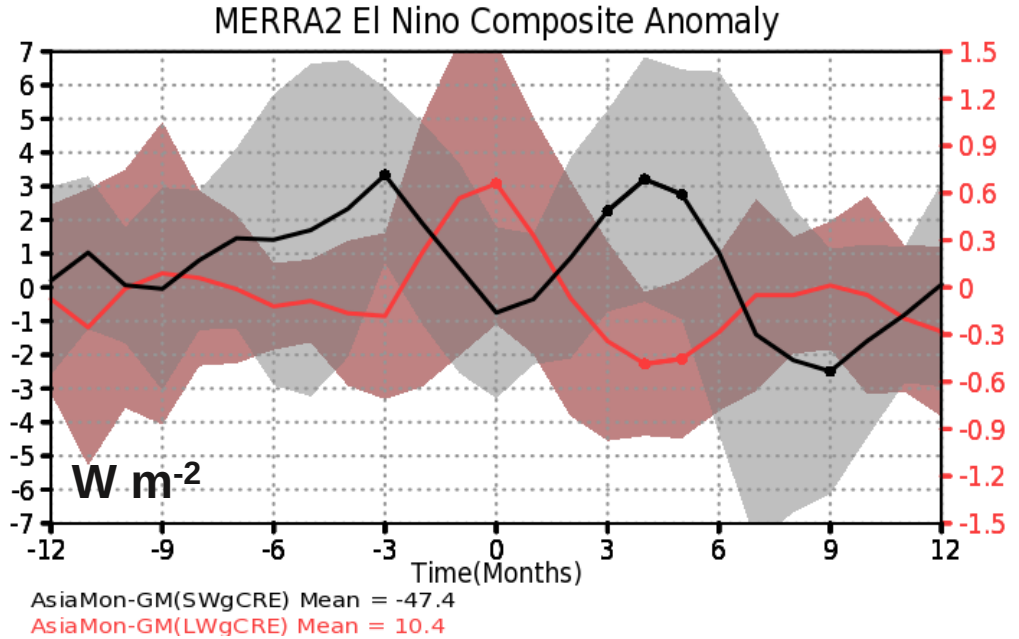


Tropical South Asia: MERRA-2

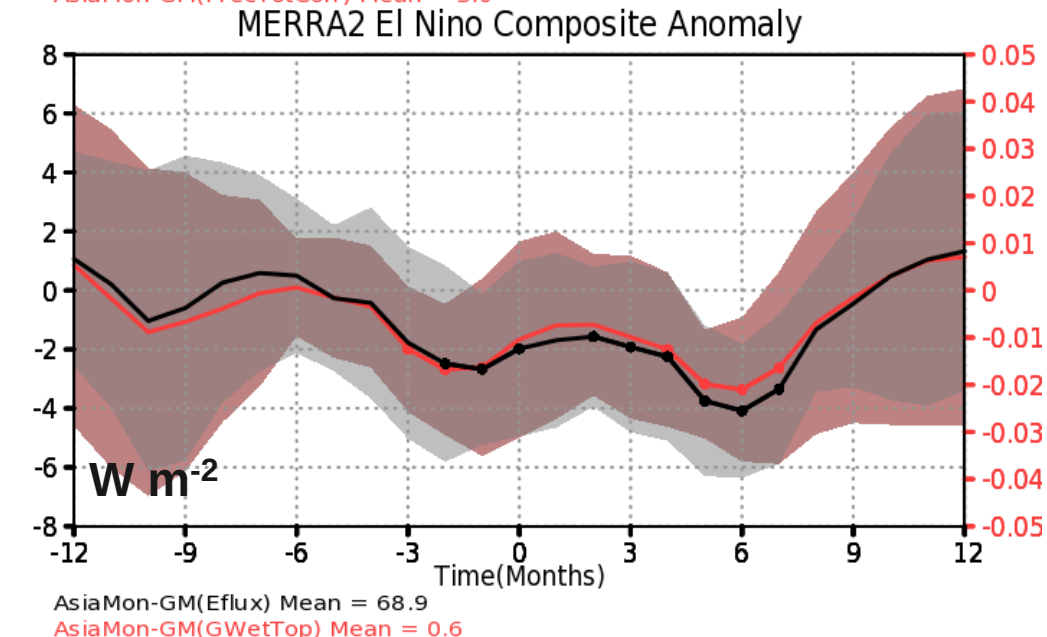
T2m
Prec



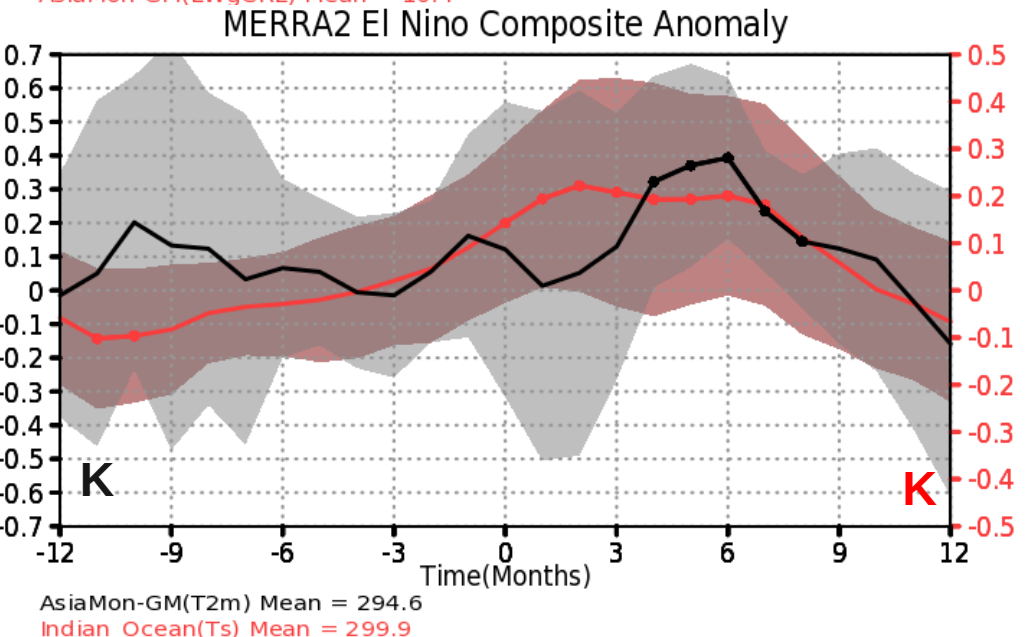
SWgCRE
LWgCRE



LEvap
GwTop

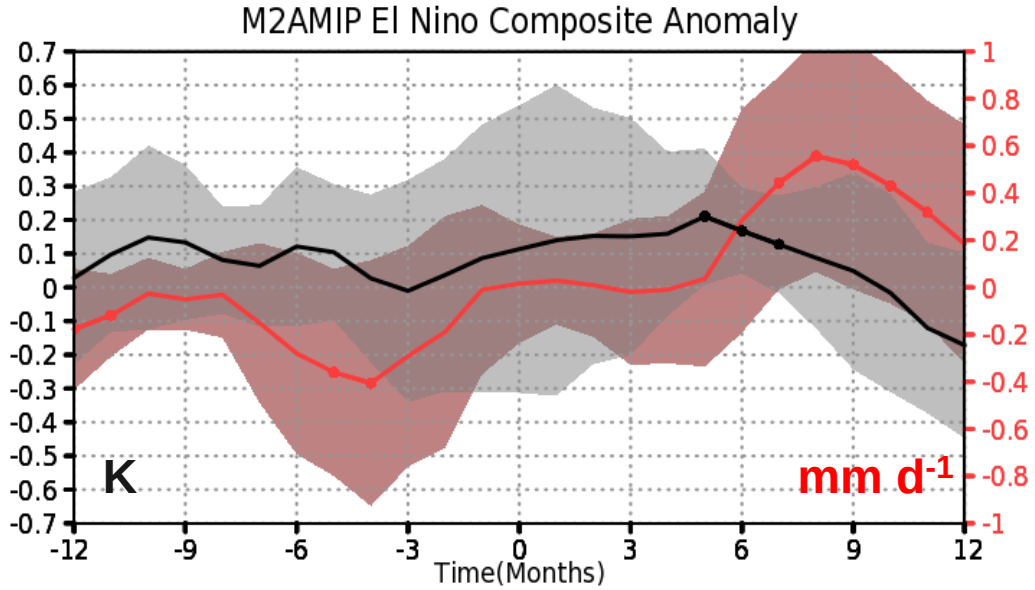


T2m
Indian
Oc SST



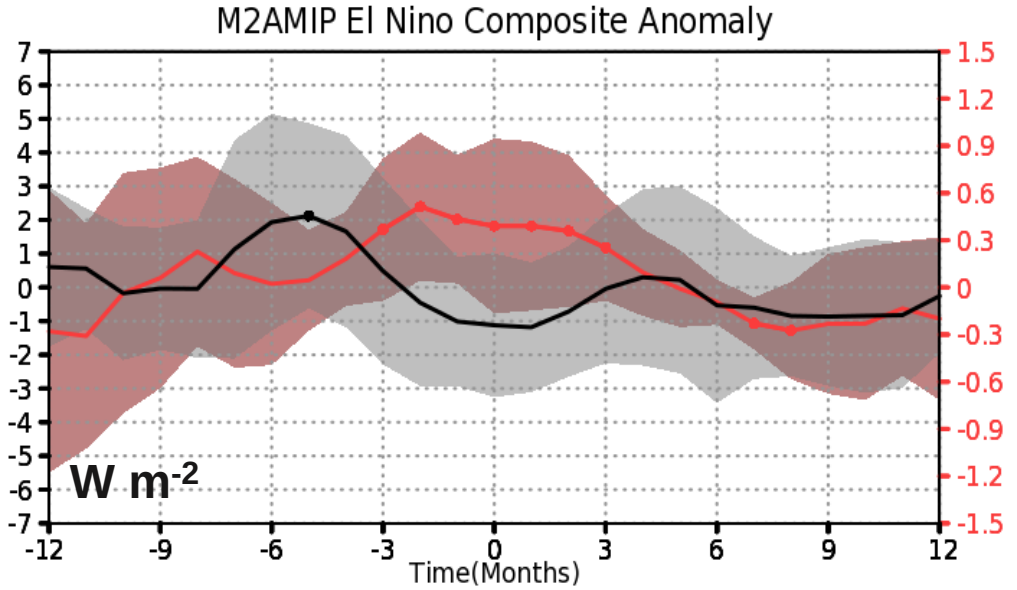
Tropical South Asia: M2AMIP

T2m
Prec



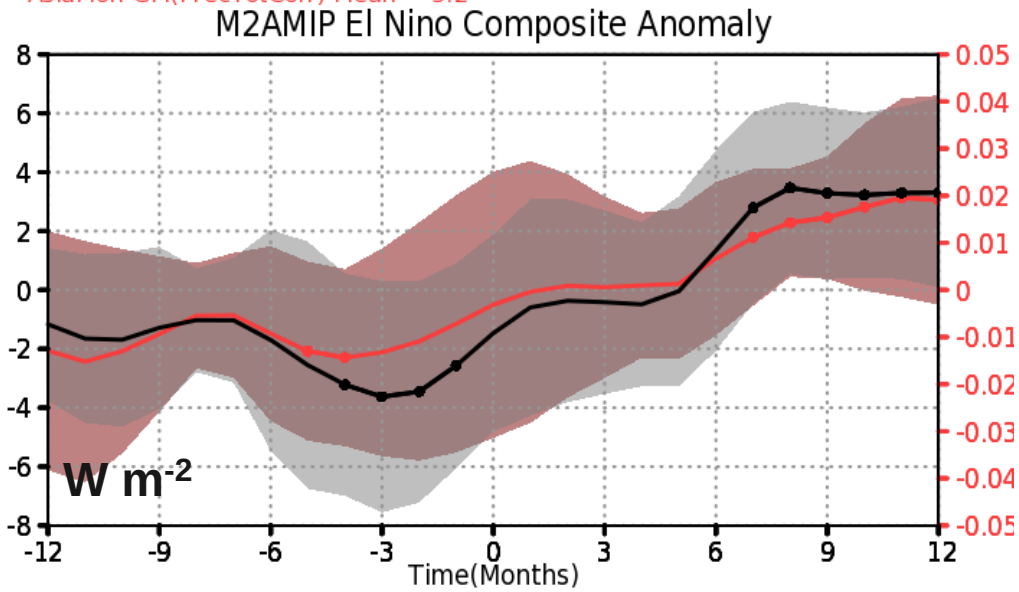
AsiaMon-GM(T2m) Mean = 294.7
AsiaMon-GM(PrecTotCorr) Mean = 5.2

SWgCRE
LWgCRE



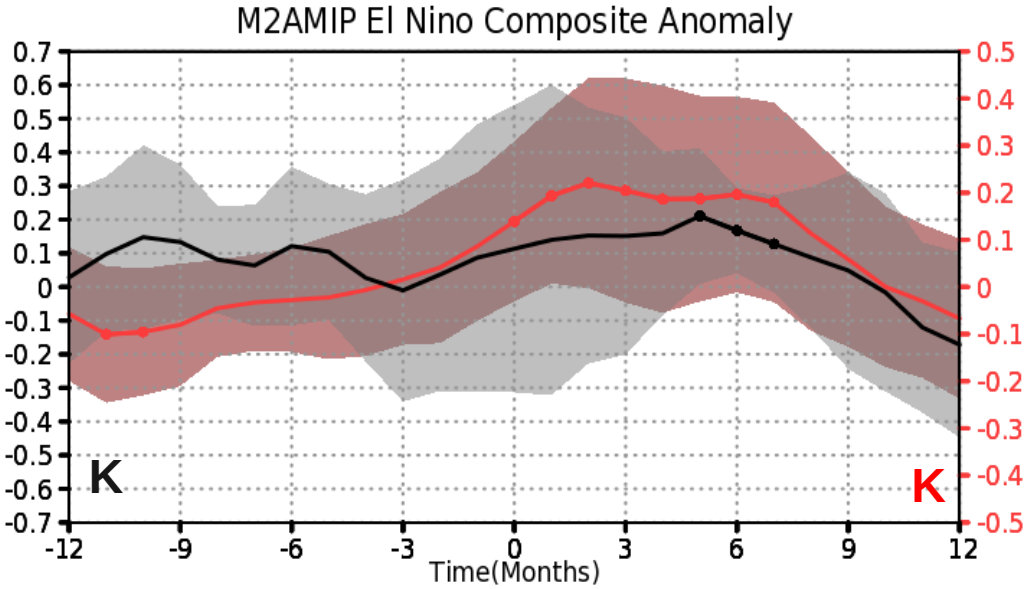
AsiaMon-GM(SWgCRE) Mean = -45.4
AsiaMon-GM(LWgCRE) Mean = 10.4

LEvap
GwTop



AsiaMon-GM(Eflux) Mean = 77.9
AsiaMon-GM(GWetTop) Mean = 0.6

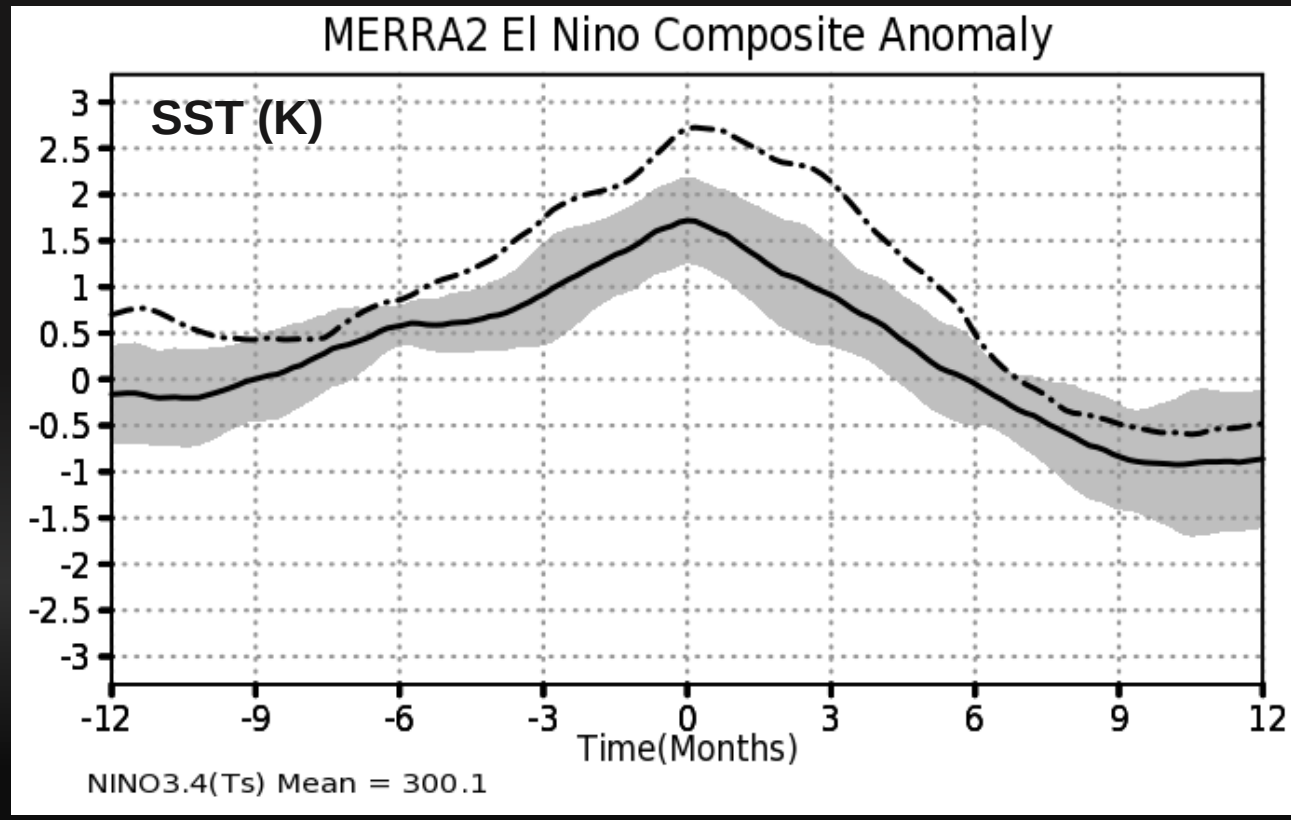
T2m
Indian
Oc SST



AsiaMon-GM(T2m) Mean = 294.7
Indian Ocean(Ts) Mean = 299.9

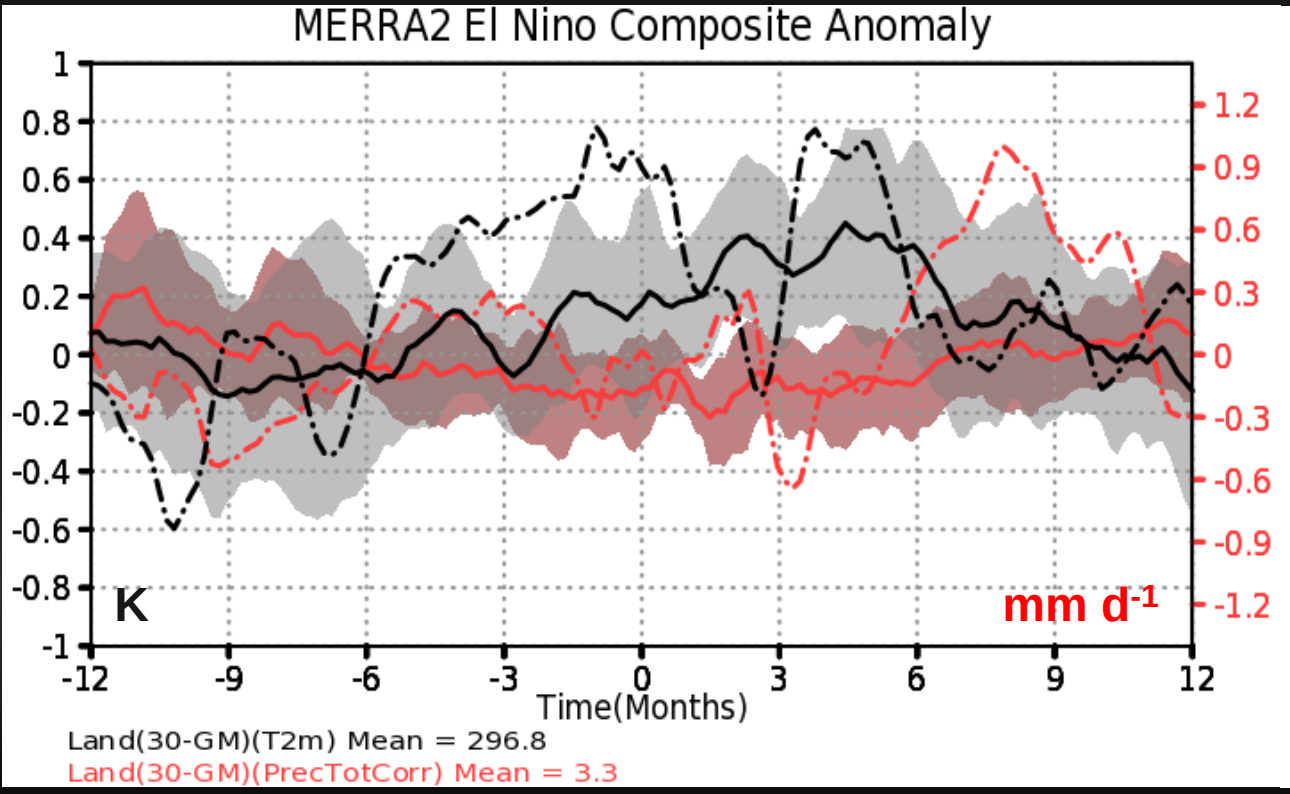
Examining Variations within the Composite

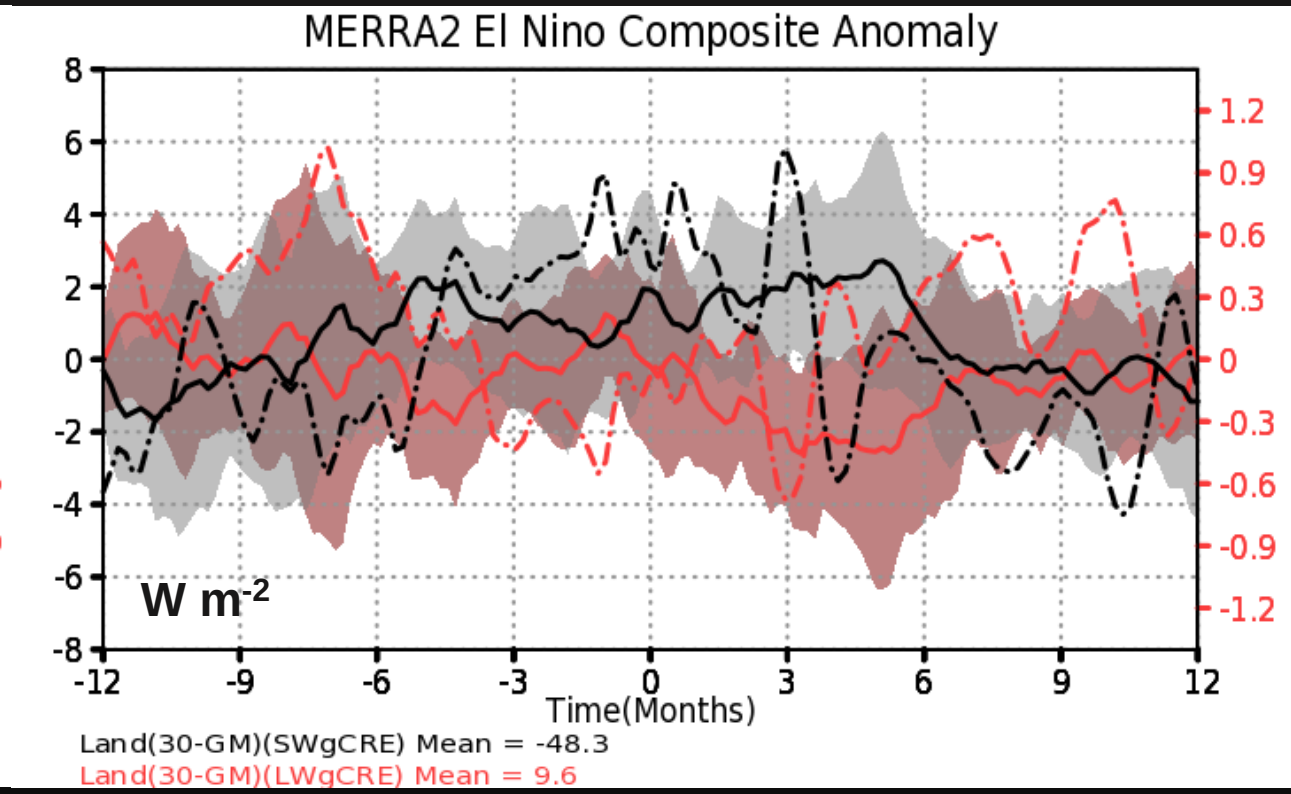
- Monthly means facilitated the comparison with the AMIP and global observed data
  - MERRA-2 hourly data reduced to **pentads** to examine higher frequency variability in the composite El Niño
- 8 El Niño events were composited over the 36 years of MERRA-2
  - 2015-16 El Niño was not included
  - One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



2015-16 compared to Composite: Tropics Land

T2m **Prec** **SWgCRE** **LWgCRE**

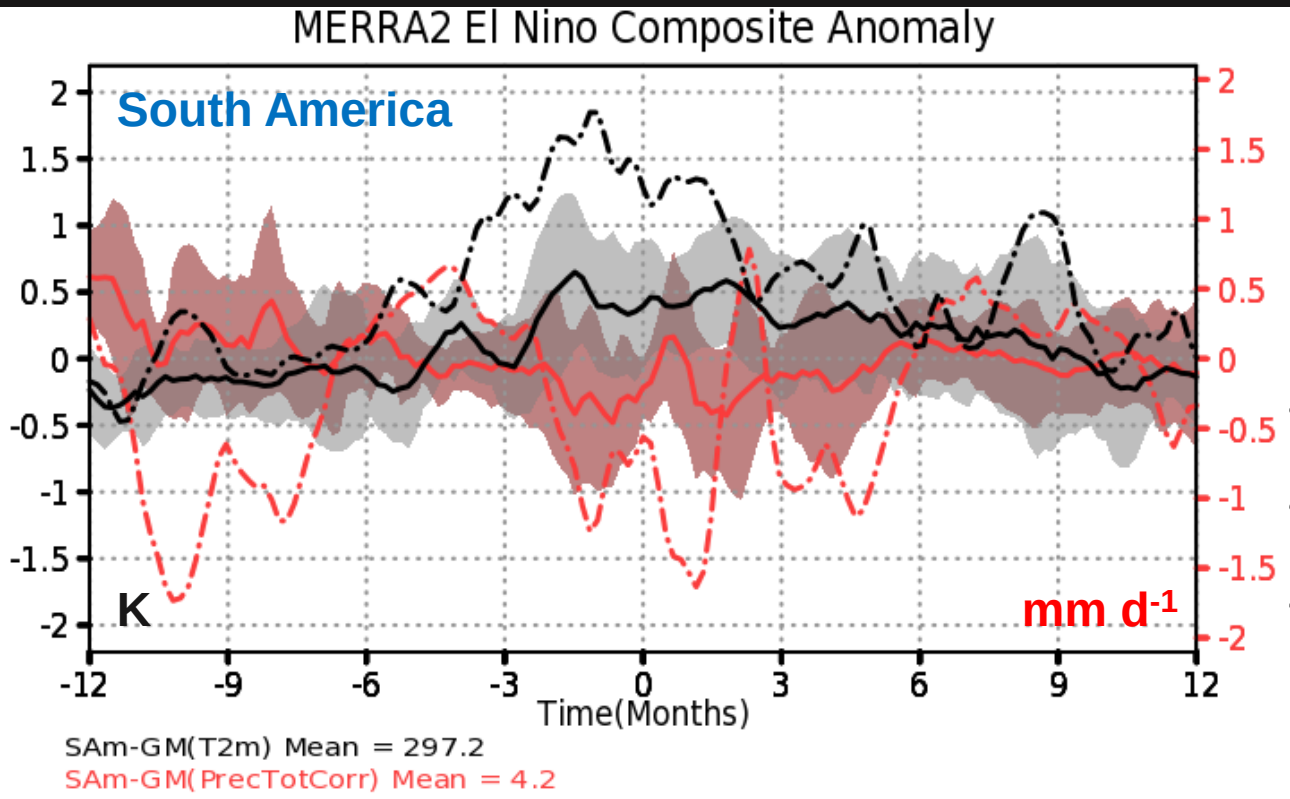


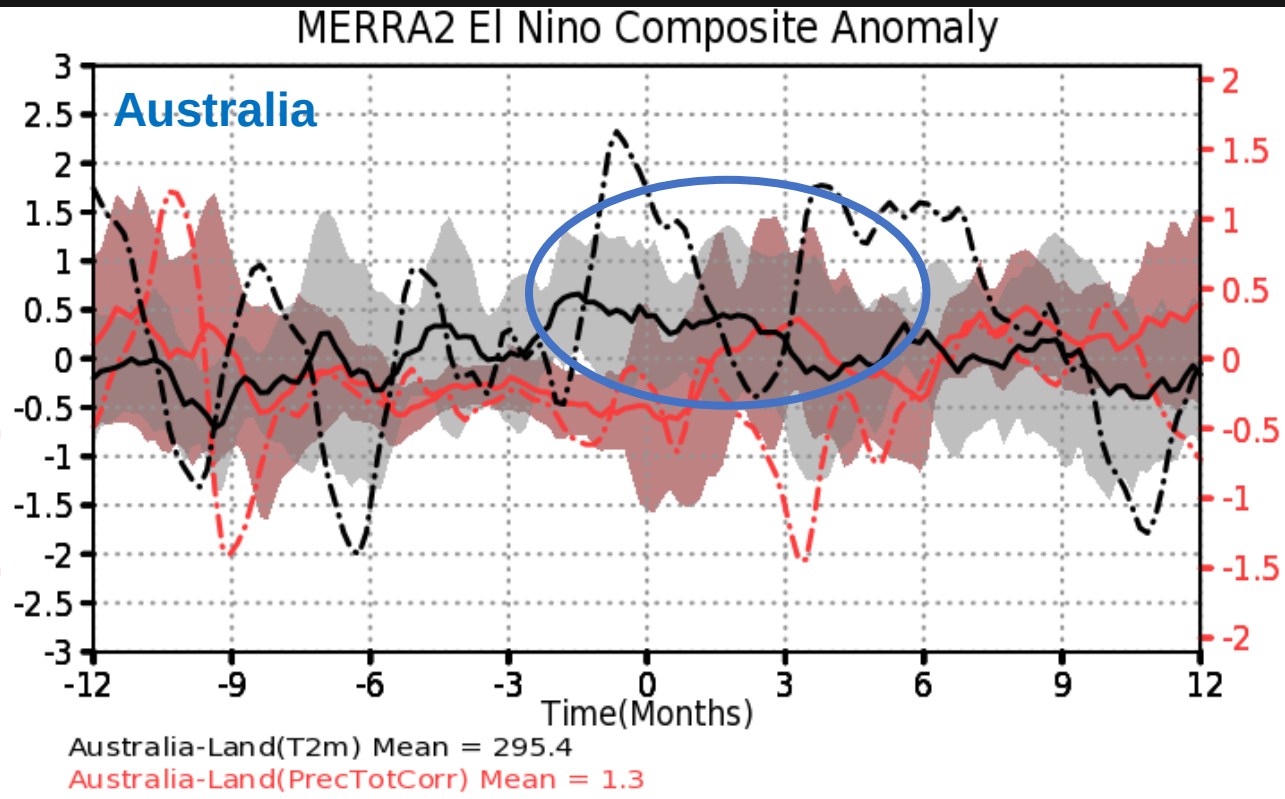


With Precipitation above composite El Niño, 2m temperature is also warm, clouds (and the SWgCRE) appear as a strong driving force, in the first part of the composite

Regional Pentad Temperature and Precipitation

T2m **Prec**



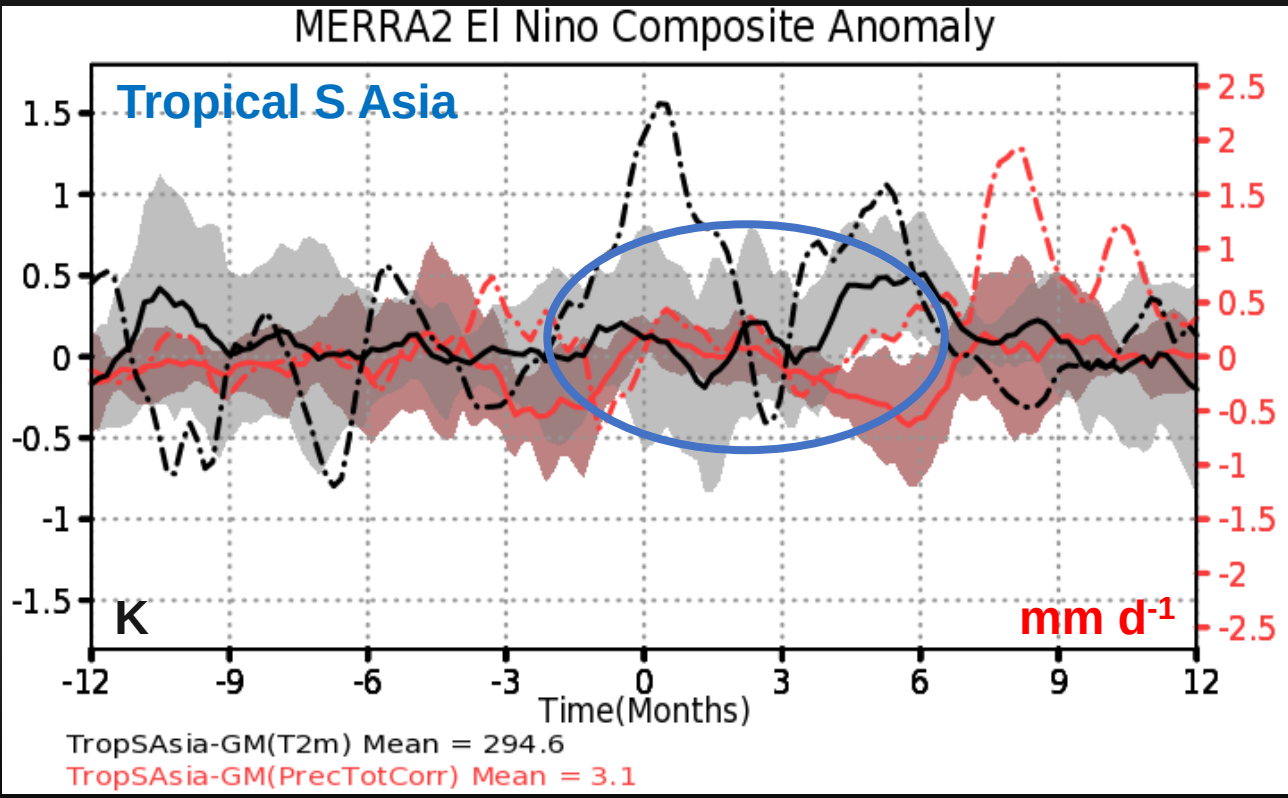


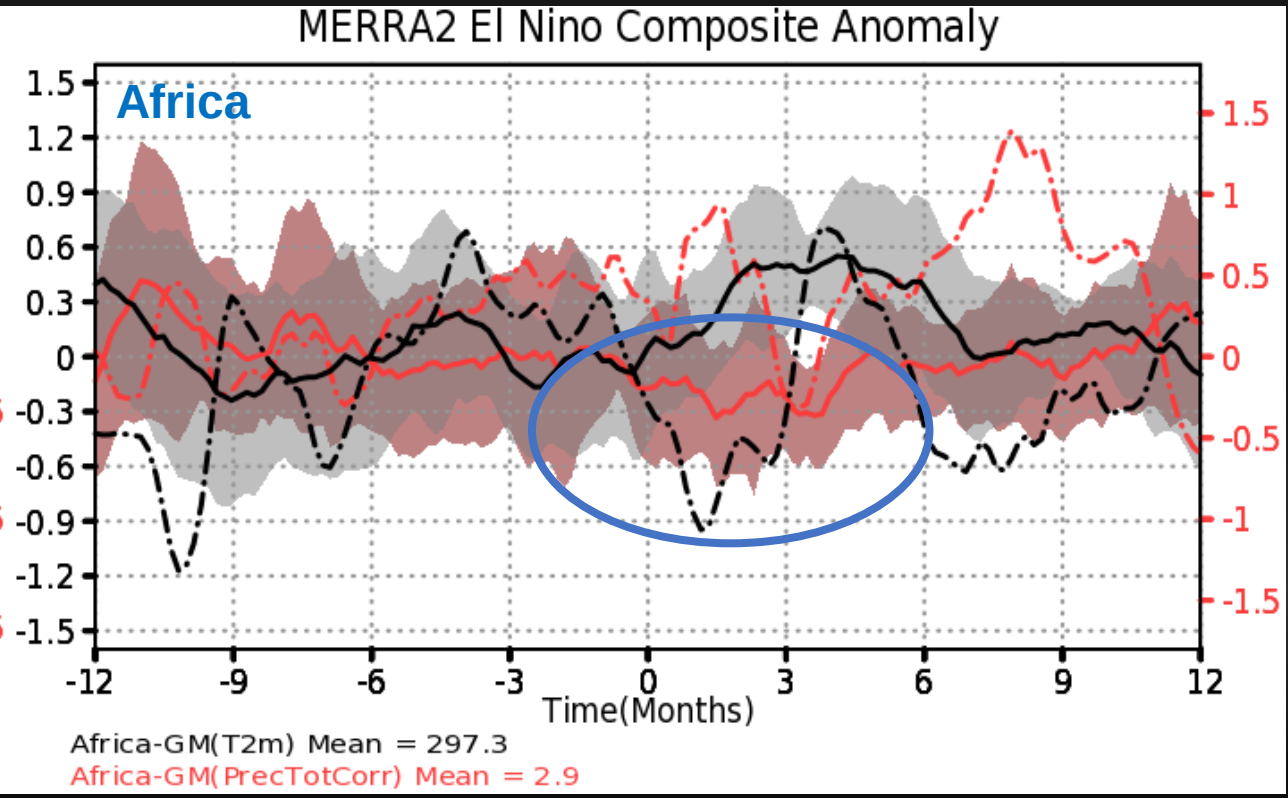
South America warm temperatures with precipitation reduction

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

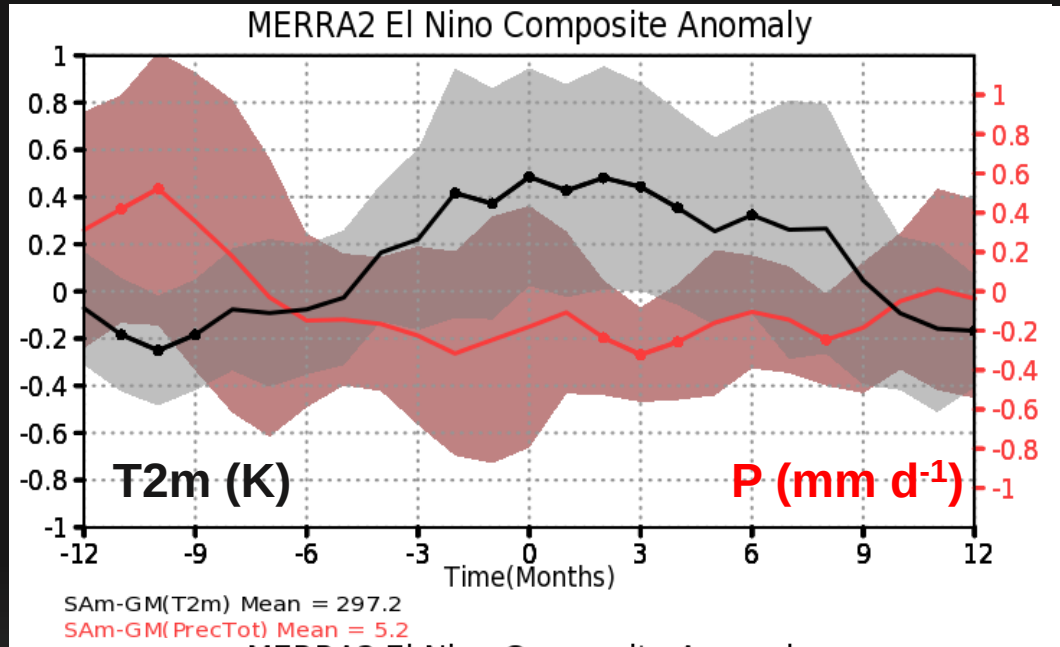
Summary

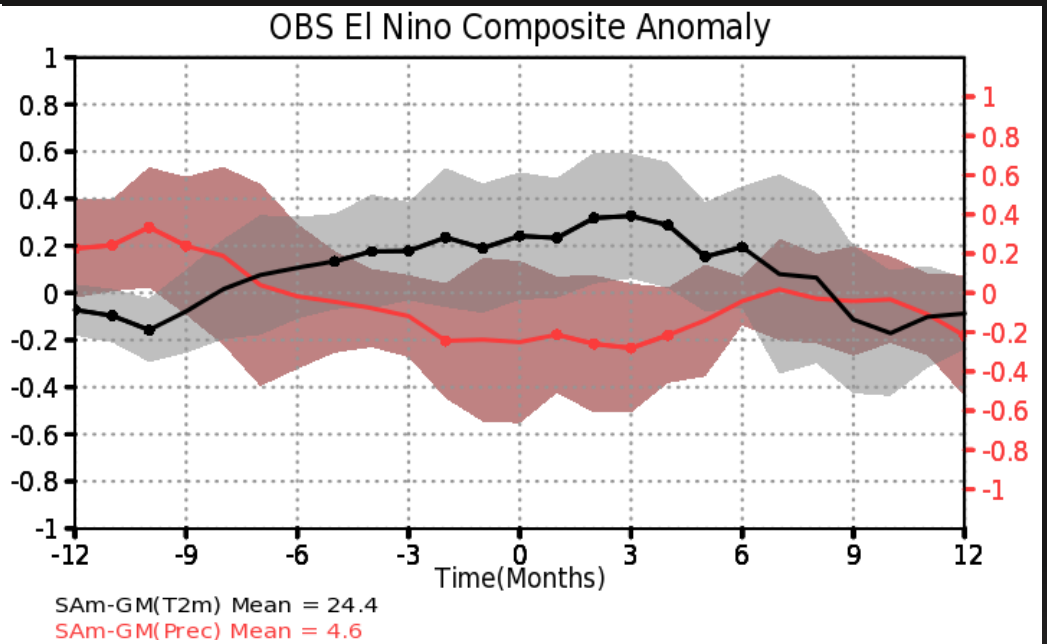
- MERRA-2 and M2AMIP capture broad warming over land following El Niño
- Shortwave cloud radiative effect is a dominant forcing process for the warming
  - More downward motion over the continents, clearer skies
  - Reduced precipitation and evaporation coincides **Needs more analysis**
  - Dynamical 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

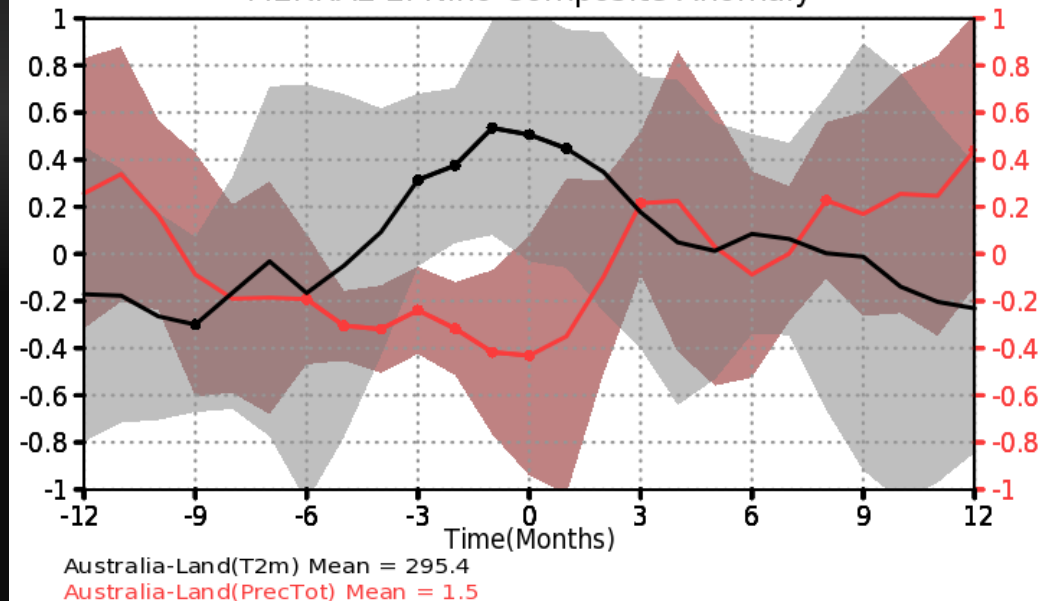
OBS

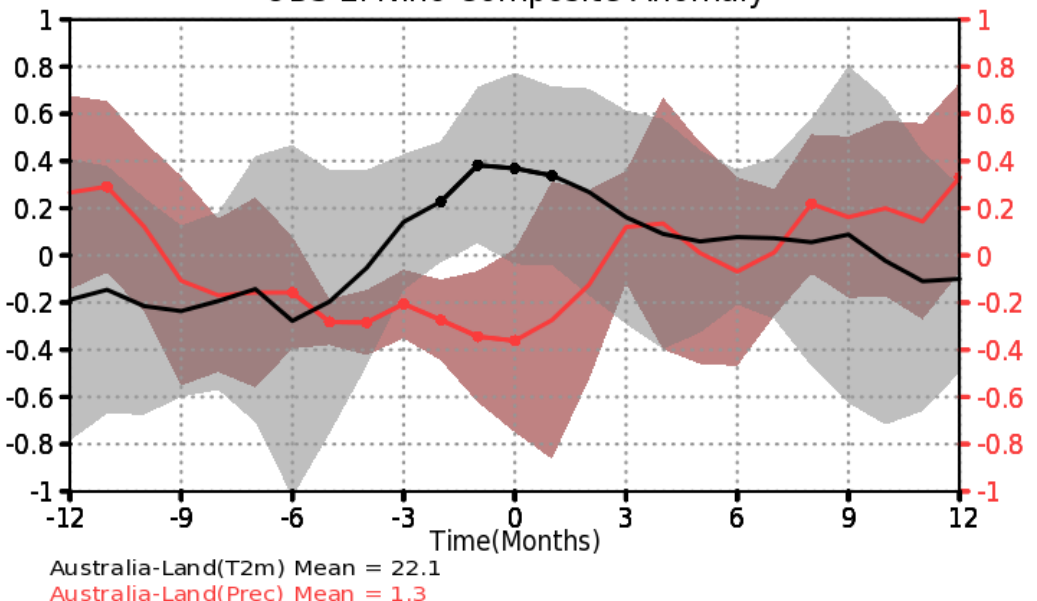
South America





Australia

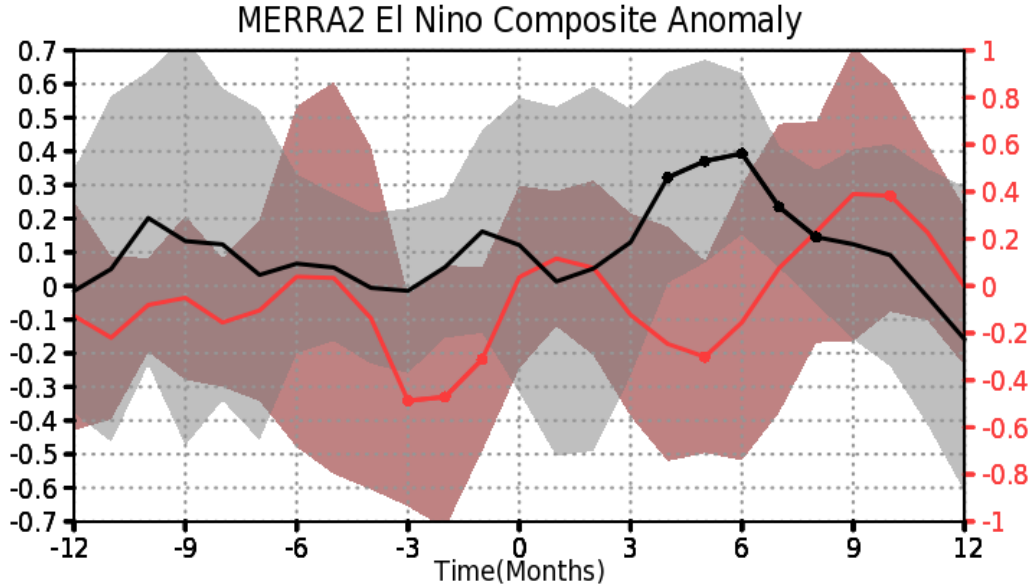


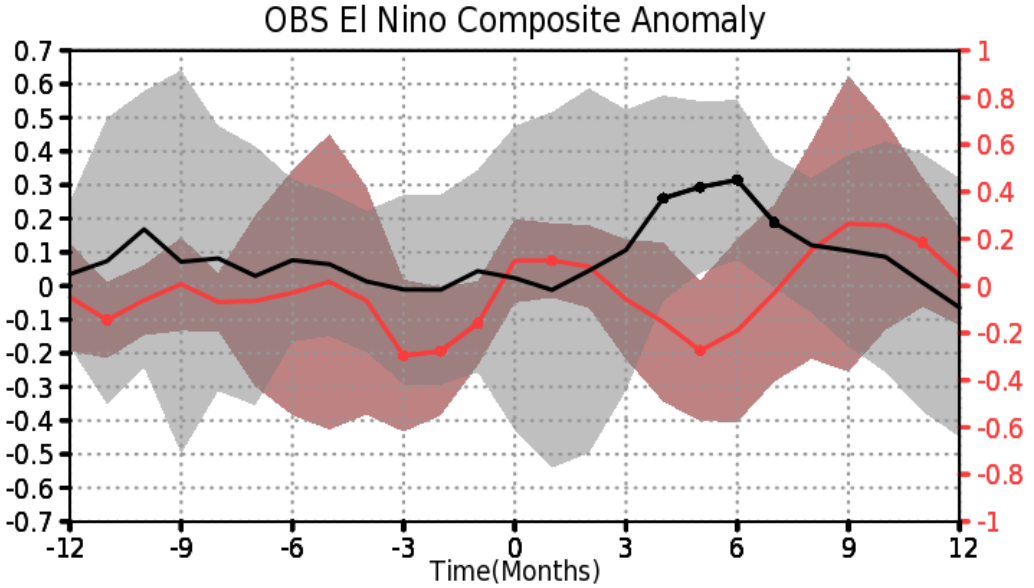


MERRA-2

OBS

Tropical South Asia





Africa