On the decreasing Arabian Peninsula Winter Precipitation and its teleconnections

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Abstract

The precipitation variability on the Earth is strongly influenced by the changes in the Sea Surface Temperature (SST) anomalies in the tropical oceans. Like wise Arabian Peninsula (AP) wet season (Nov-April: NDJFMA) precipitation is also strongly impacted by the SST anomalies in tropical Pacific ocean related to El Nino Southern Oscillation (ENSO), warm pool western Pacific and Indian Ocean SSTs. The wet season AP-Prcp shows strong statistically significant decreasing trend during last three decades. The goal of this research is to identify important factors related to SSTs that bring long term drought conditions over the AP. In the 70-year period (1949-2018), Indo-Pacific warm pool SSTs are correlated negatively with the AP-Prcp. In the recent 35-year period (1984-2018), it is strongly positively correlated to the SSTs anomalies in ENSO region. The recent ENSO SSTs accompanied negative 200-hPa geopotential height anomalies over the AP, resulting an increase of precipitation over the region, but they are offset by the strong opposite relationship, of Indo-Pacific warm pool SSTs, resulting overall decrease of precipitation. The observed findings are confirmed by various AGCM experiments as well as a suit of CMIP5 models.

Models, Data and Methodology

The Saudi-KAU Global Climate Model (GCM) is used in this research (Almazroui et al. 2017; Ehsan et al. 2017a,b). Several different experiments have been performed to study the NDJFMA AP-Prcp variability, and its continuously decreasing trend. These includes;

1) SST-Forced AGCM EXP (1901-2016).
2) SST-Climatology EXP (CLIM).
3) "Warm" and "Cold" ENSO Pattern Added to CLIM.
4) Long-term SST trend added to the CLIM.
5) AMIP and AMIP4K of CMIP5 are also used.

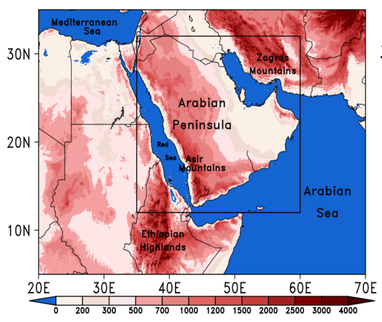
The (1) provides the influence of the prescribed OBS SSTs over the AP.

The difference between the (3) and (2), provide us the response of the ENSO idealized pattern, while difference between (4) and (2) provide the response of warming SSTs. The diff. of AMIP4K and AMIP provide response of 4K warming.

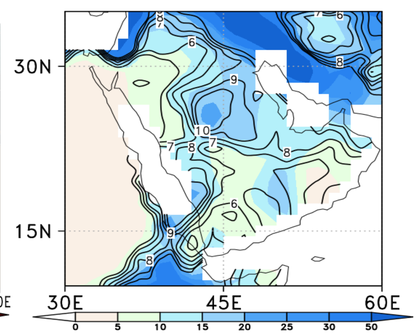
➢ HadISST and GPCC V7 are used as observation.

The Arabian Peninsula (AP) Winter Prcp.

AP & Neighborhood



NDJFMA AP-Prcp Clim & STD

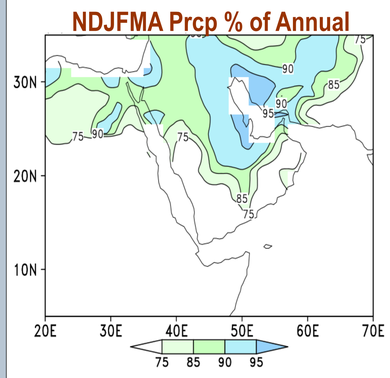


The AP receives its most of the rainfall during winter months Nov-April (NDJFMA), which is known as wet season of the AP. The main characteristics of the winter AP-Prcp are;

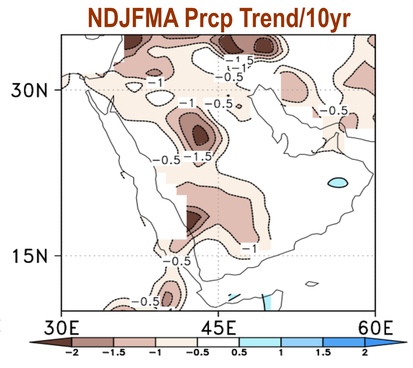
- ✓ The mean NDJFMA AP-Prcp is about 15 mm.
- ✓ The standard deviation is 7.75 mm.
- ✓ The coefficient of variation (CV) is 68 %.

NDJFMA AP-Prcp variability & Trend

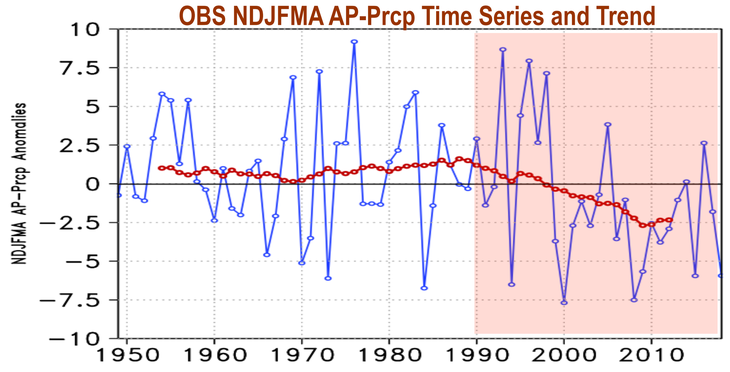
NDJFMA Prcp % of Annual



NDJFMA Prcp Trend/10yr



OBS NDJFMA AP-Prcp Time Series and Trend

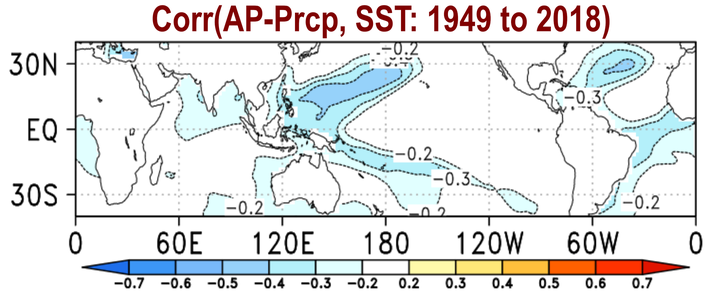


Further winter precipitation properties are;

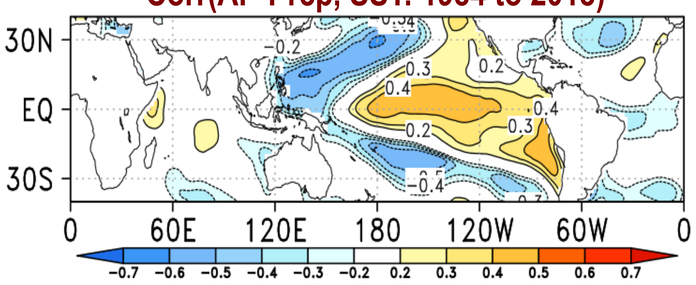
- ✓ NDJFMA Prcp over the AP region is about **70%** of annual.
- ✓ Strong interannual variability and decreasing trend is evident over the AP in recent decades.

Obs. Teleconnection

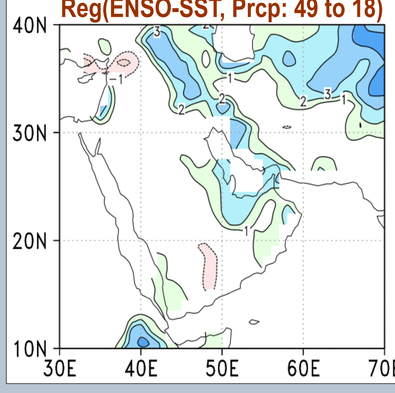
Corr(AP-Prcp, SST: 1949 to 2018)



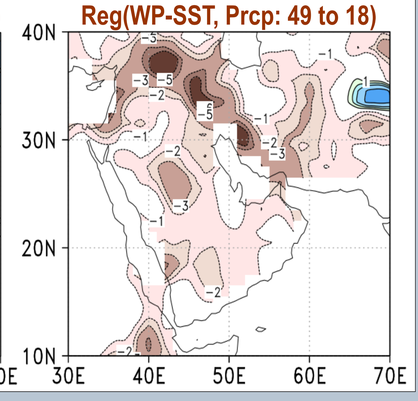
Corr(AP-Prcp, SST: 1984 to 2018)



Reg(ENSO-SST, Prcp: 49 to 18)

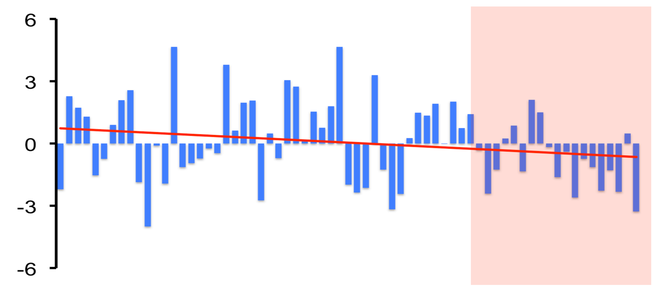


Reg(WP-SST, Prcp: 49 to 18)



Modeling Results

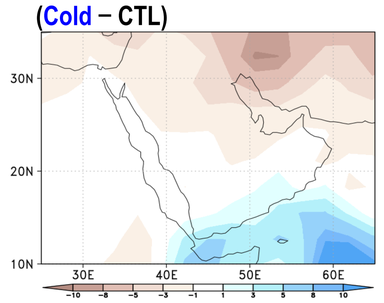
Simulated NDJFMA AP-Prcp Time Series and Trend



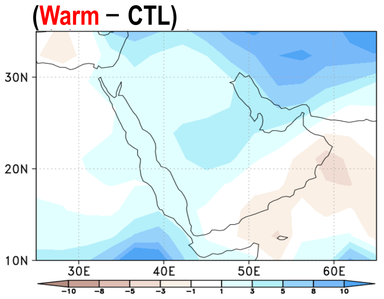
The **SST-forced realization** of NDJFMA AP-Prcp anomalies shows considerable similarity to the observed anomalies, with prominent recent drought years.

Simulated NDJFMA AP-Prcp Response

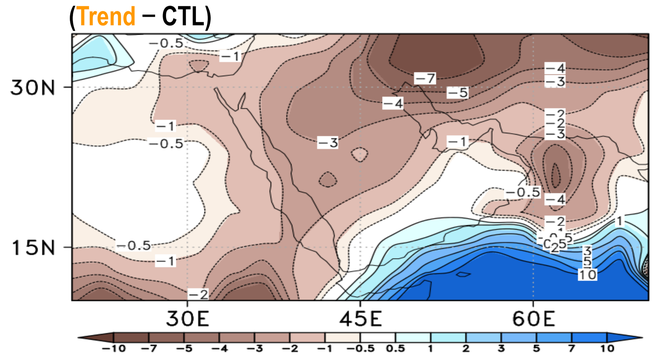
(Cold – CTL)



(Warm – CTL)

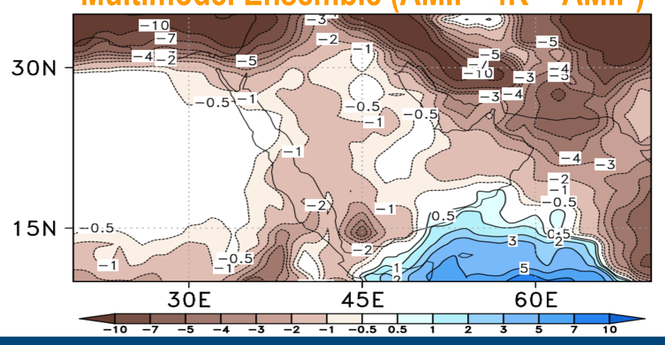


(Trend – CTL)



1) Cold/Warm Pacific SSTs associated with La Nina induce dry/wet conditions over the AP.
2) **Trend imposed** on SST CLIM, is an other major drought inducer over region of interest.

Multimodel Ensemble (AMIP−4K − AMIP)



Summary and Conclusion

- ✓ **NDJFMA AP-Prcp** have robust decreasing trend, which is more sharp and steady during recent decades.
- ✓ **NDJFMA AP-Prcp** is well correlated with western Pacific Warm Pool region, for whole 70 years and with ENSO SSTs in recent decades.

This study investigates the variability and teleconnection mechanism for wet season precipitation over the Arabian Peninsula. Of the identified proximate drought factors, climate change does not appear important for SSTs in the ENSO region. The other factor, tropical northwest Pacific SSTs (WP), and Indian Ocean SSTs exhibits a strong warming trend, but attribution is still an open question.

✓Further research is in progress to pinpoint the underlying Physical Mechanism.