First assessment of the WRF-Chem carbon monoxide (CO) simulations for Africa and insights into source attribution

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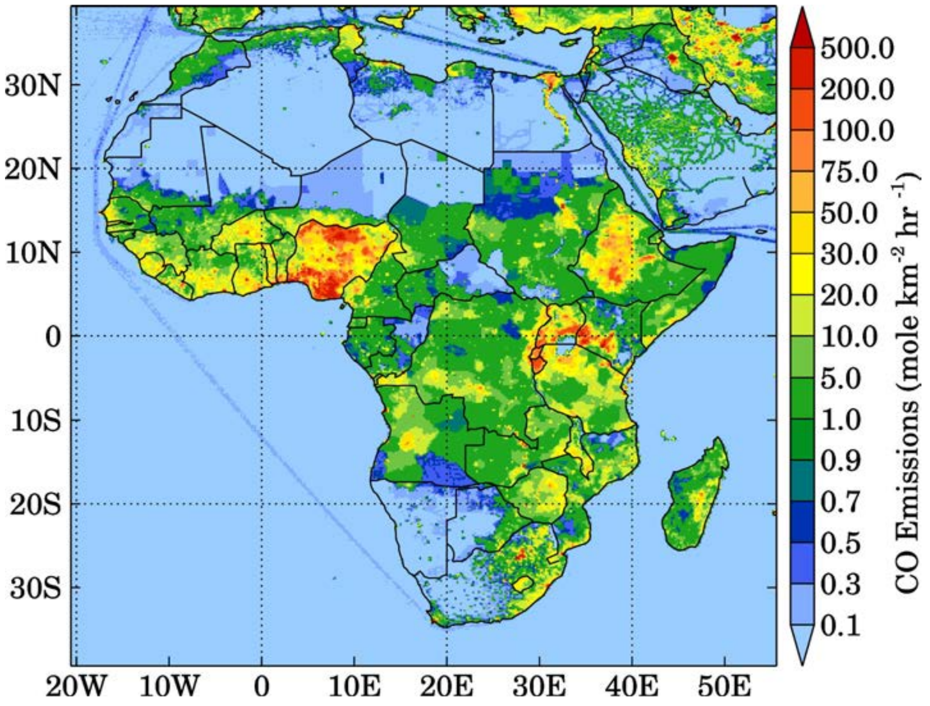
WRF-Chem Configuration

Model domain



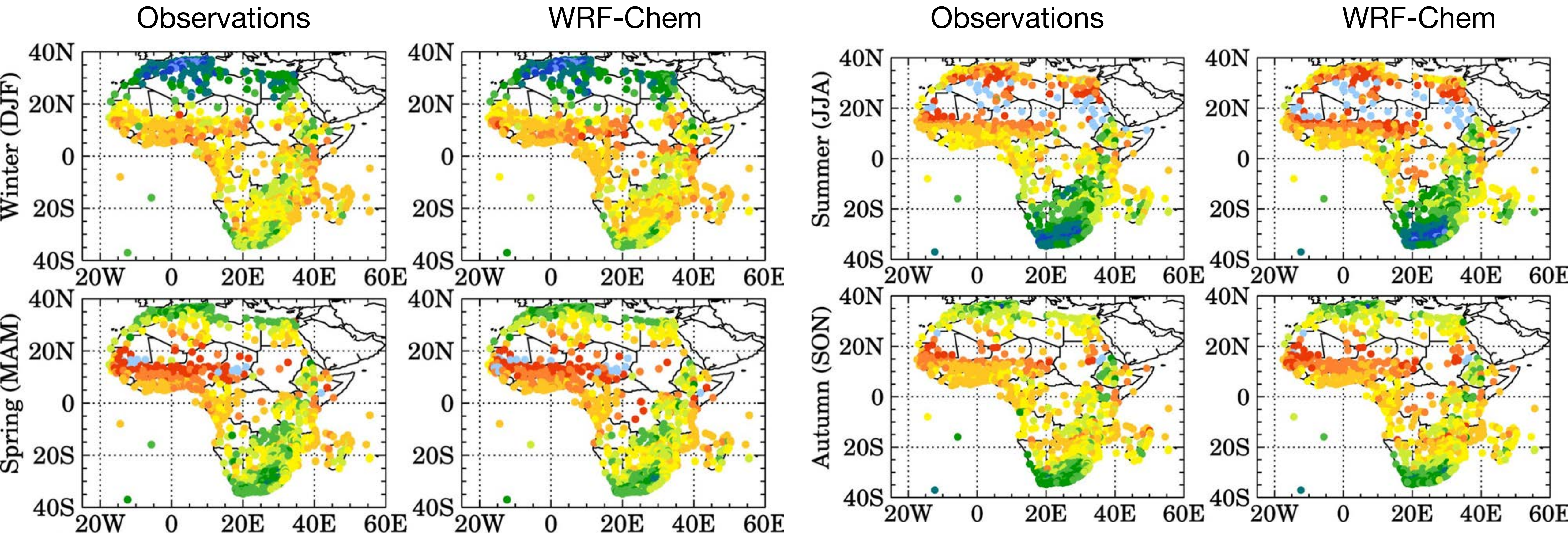
Region mask

- Model resolution: 20 km x 20 km
- Anthro emissions: EDGAR-HTAP v2
- Fire emissions: FINN v1.5
- Biogenic emissions: MEGAN
- Gas-phase chemistry: MOZART
- Aerosol processes: GOCART
- Run period: 1 Dec 2016 to 31 Dec 2017
- Dec 2016 left out as spin-up
- Simulations performed as a part of WMO PREFIA multi-model intercomparison exercise.

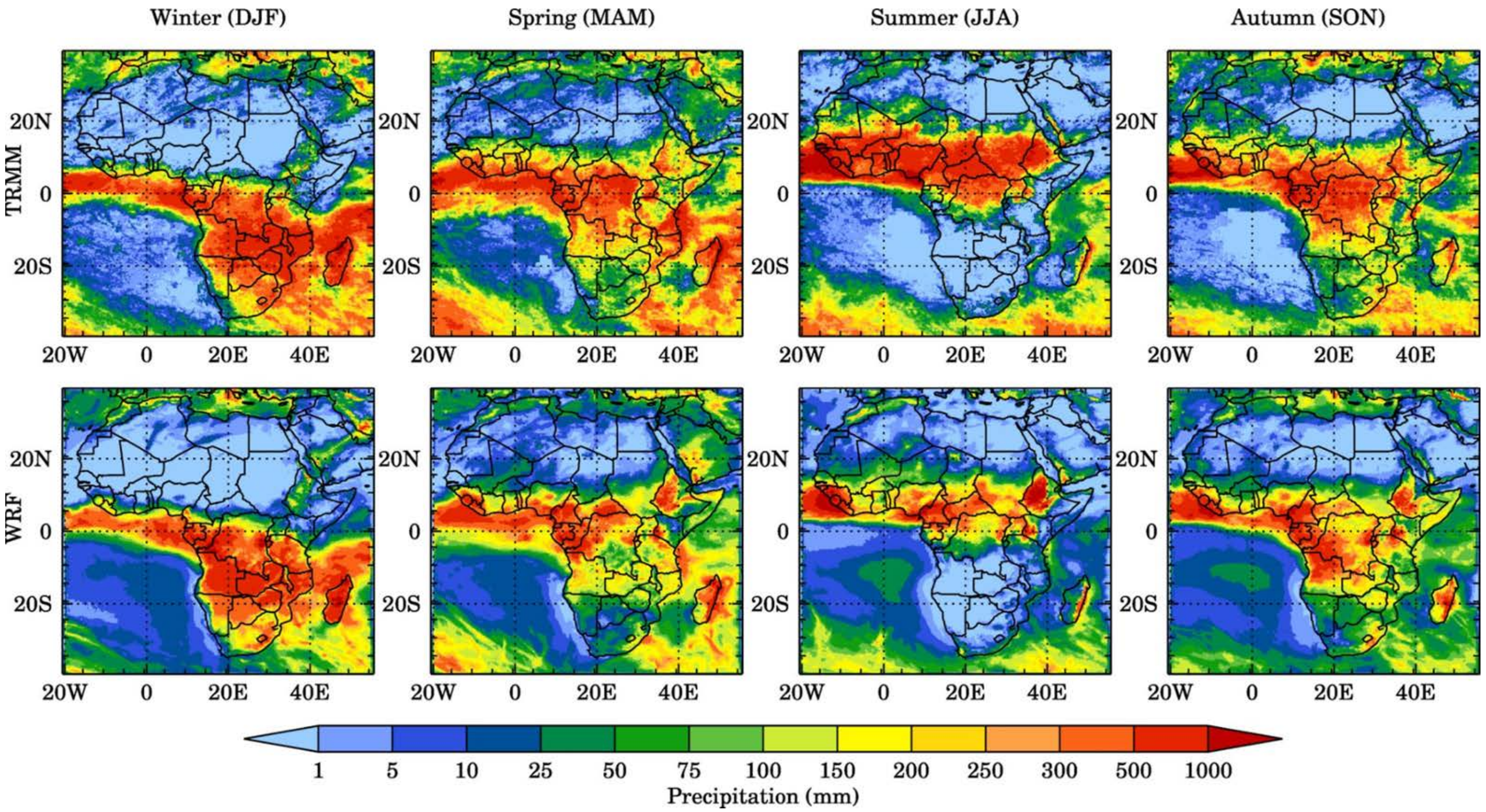
- Four CO tracers are included to track CO from anthropogenic emissions, fire emissions, inflow from the domain boundaries and photochemical production due to oxidation of NMVOCs.
- Twelve CO tracers are used to track CO from anthropogenic and fire emissions from six regions. Africa is divided in five regions namely North Africa (NA), West Africa (WA), East Africa (EA), Central Africa (CA), and Southern Africa (SA). All the grid boxes outside these five regions are classified as others.

WRF-Chem captures the seasonal cycle of temperature

The model captures the observed seasonal cycle of surface temperature in both the hemispheres. Temperature observations are obtained from NOAA's Integrated Surface Database (ISD)

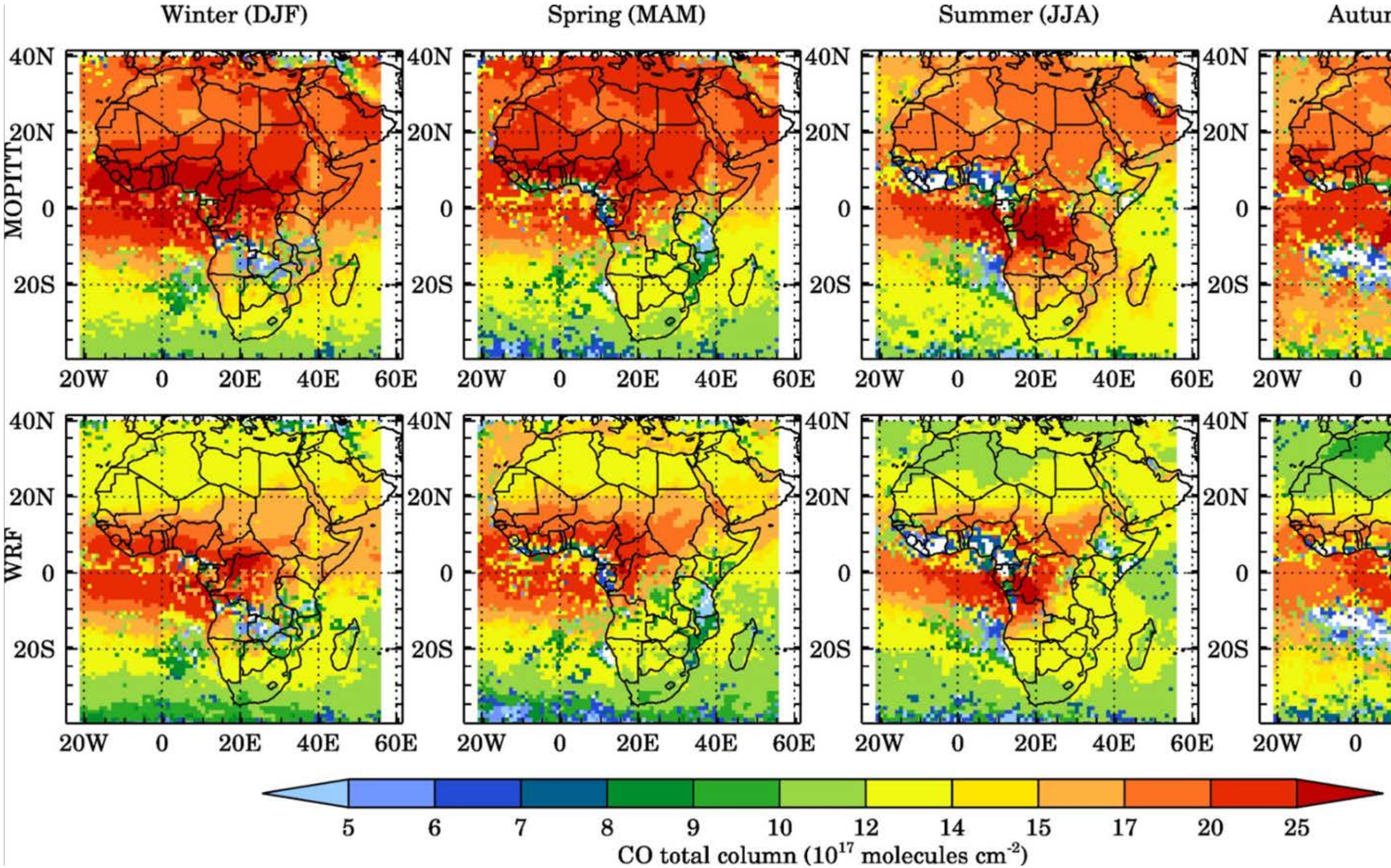


WRF-Chem captures the seasonal cycle of precipitation



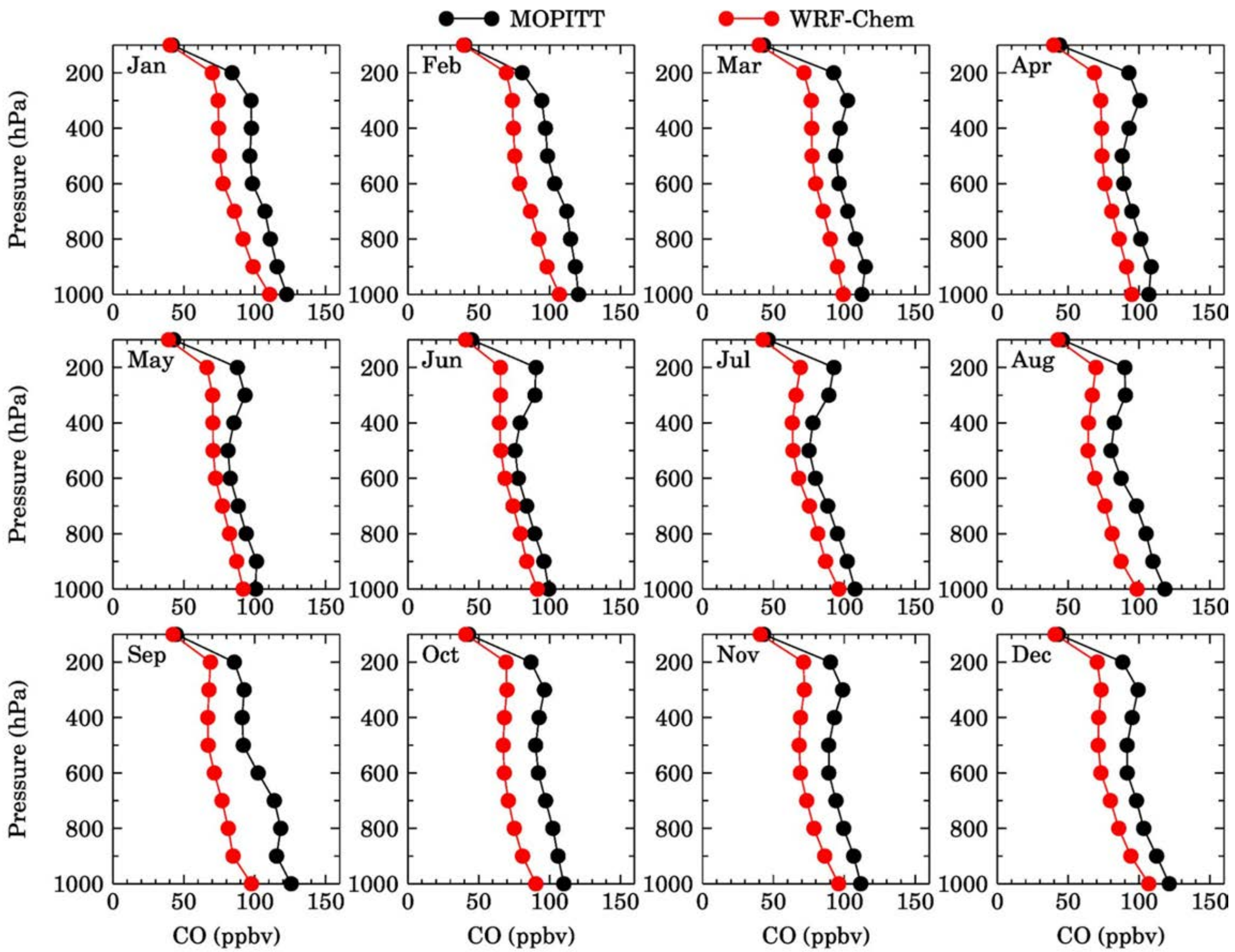
The model captures the observed seasonal cycle of precipitation in both the hemispheres but underestimates the TRMM retrieved precipitation amount.

WRF-Chem underestimates MOPITT total column CO



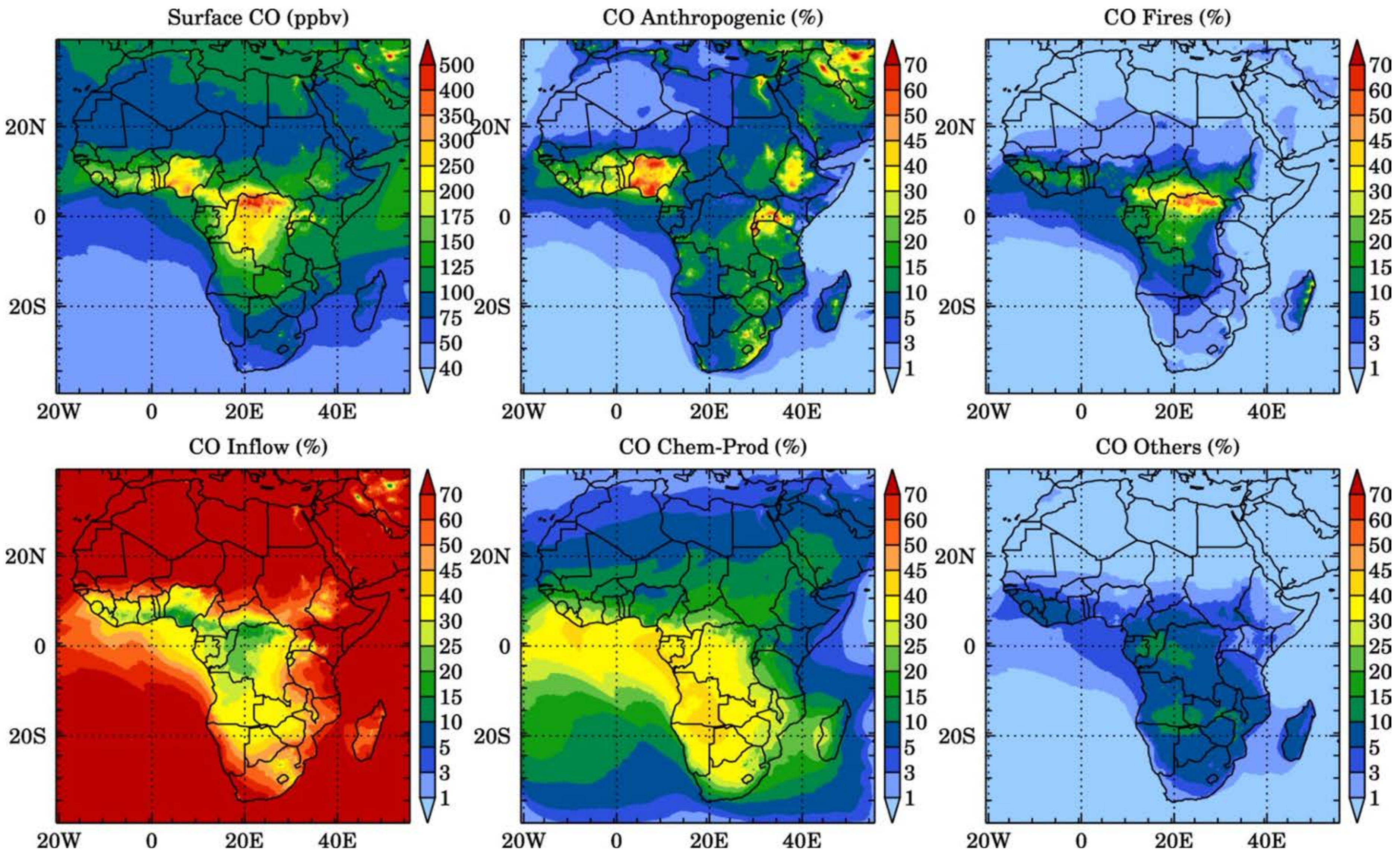
Larger underestimation in the northern hemisphere.

The underestimation is seen throughout the troposphere



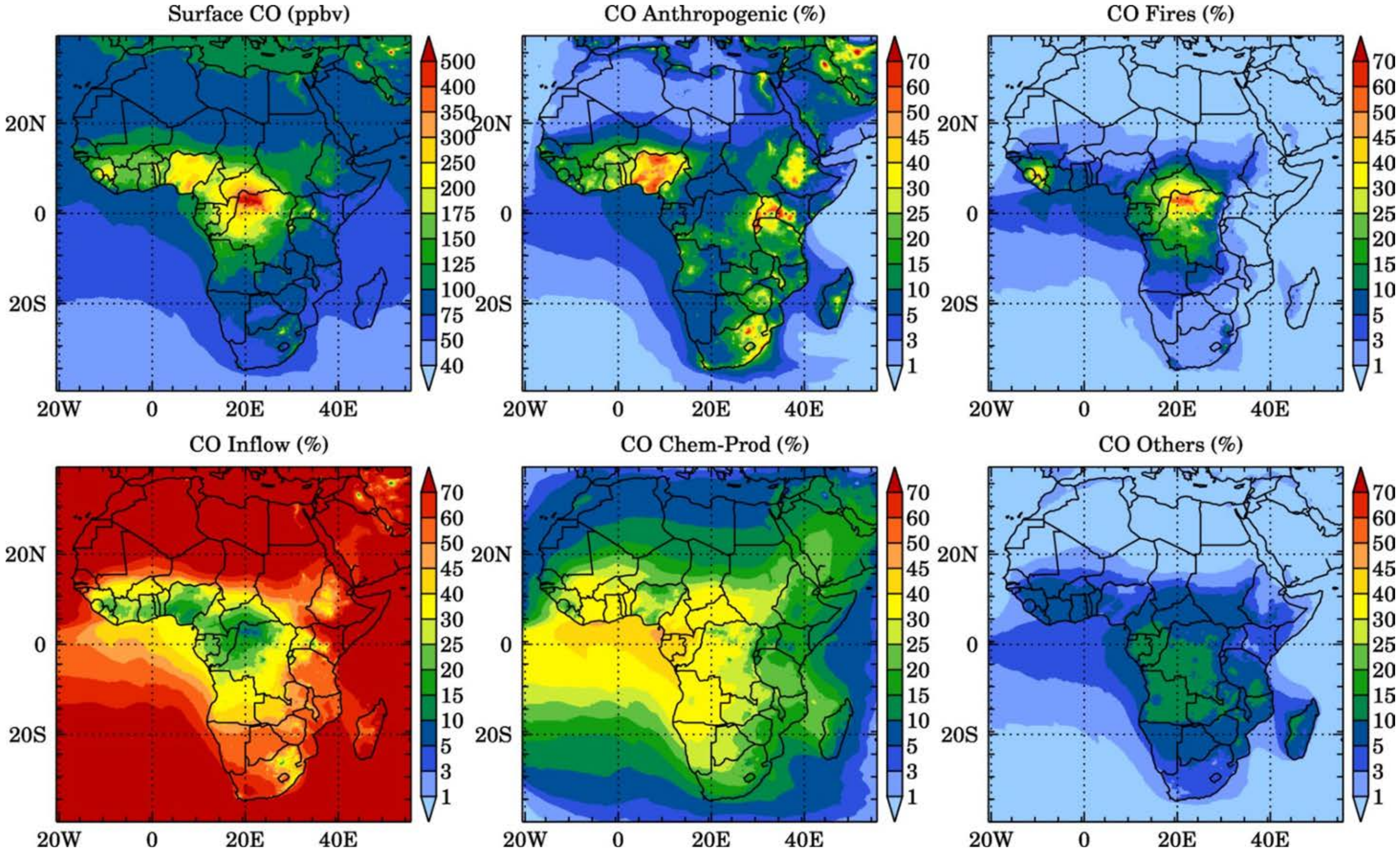
- The best agreement between the model and MOPITT CO profiles is seen during May-Jul except for the upper tropospheric peak.
- Largest difference between the model and observations are seen in September and October which appears to be related to the biomass burning in southern hemisphere of Africa.

Surface CO source contribution analysis (Winter)



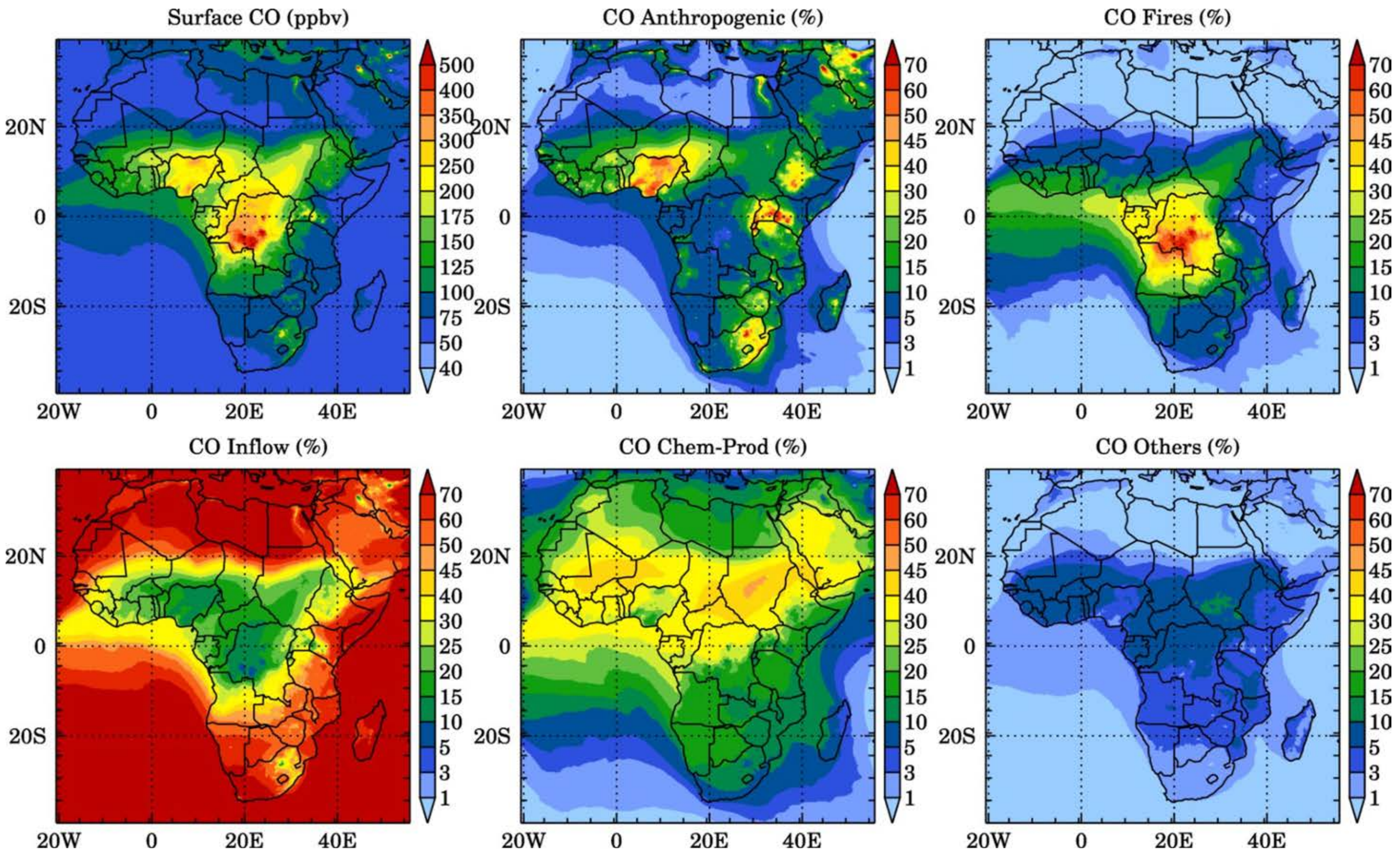
- Highest surface CO is seen in WA and CA.
- Anthropogenic emissions contribute the most to CO in WA and several other hotspots in EA and SA.
- Fire emissions contribute the most in DRC.
- Inflow from the domain boundaries is the most important contributor in NA and coastal regions of EA and SA.
- Chemical production is a significant contributor in CA, SA, and outflow over the Atlantic.

Surface CO source contribution analysis (Spring)



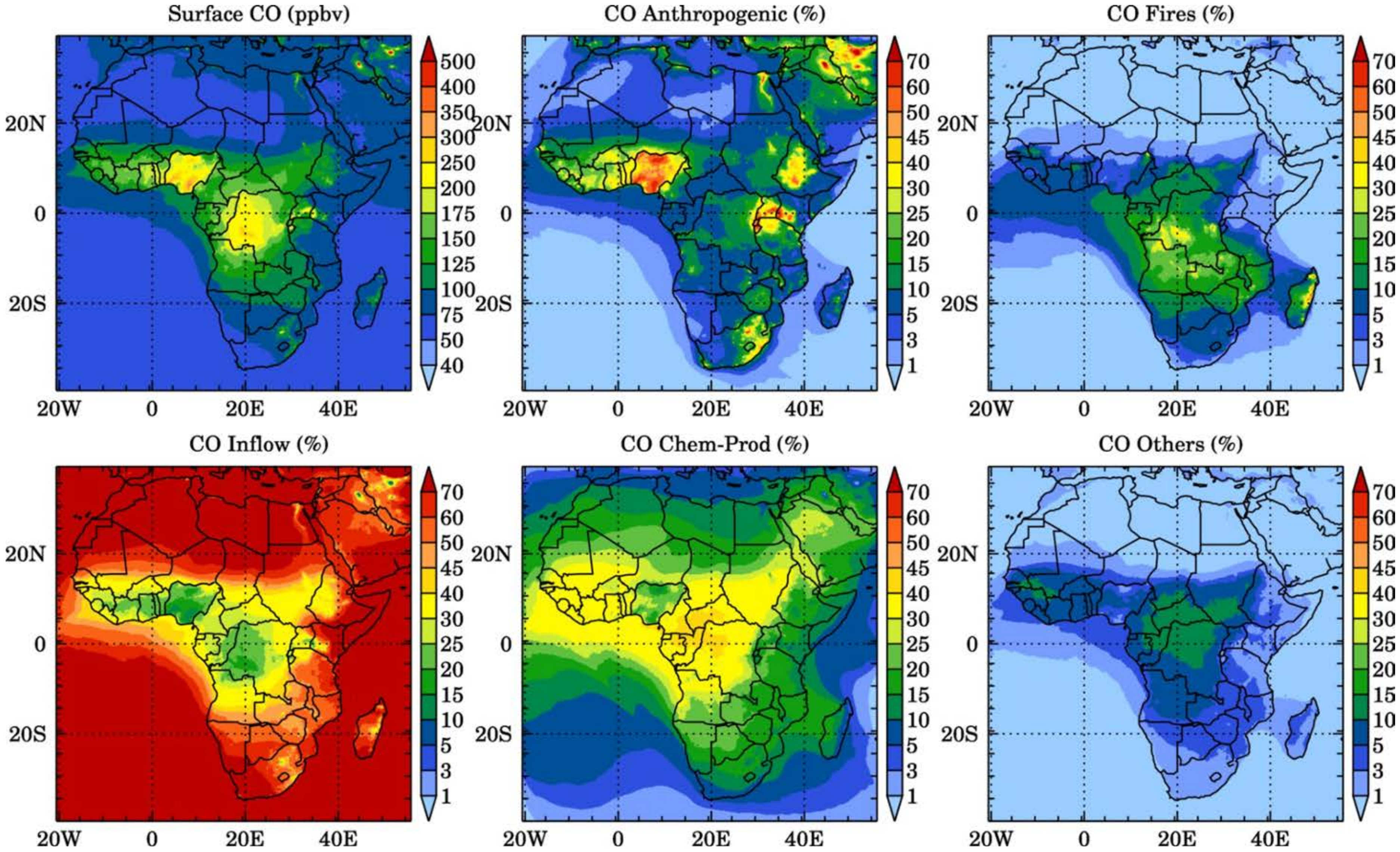
- Source contributions are similar to winter except that the contribution of chemical production increase in northern hemisphere of Africa relative to winter and decrease in southern parts.

Surface CO source contribution analysis (Summer)



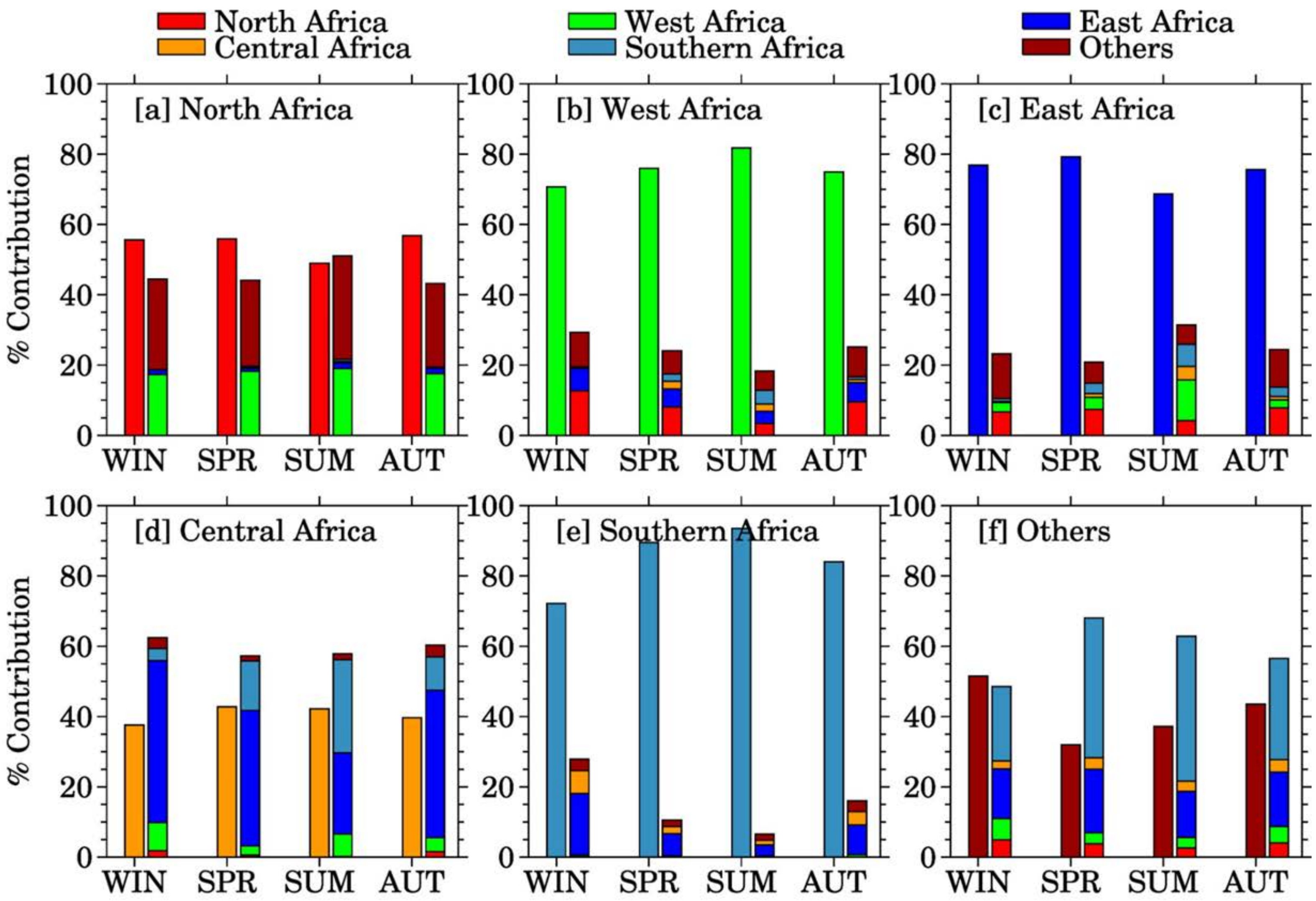
- Fires shift south to DRC/Angola and contributes the most in those regions.
- Chemical production is now the highest in northern hemisphere. and consequently the contribution of inflow from the domain boundaries reduces in NA.

Surface CO source contribution analysis (Autumn)



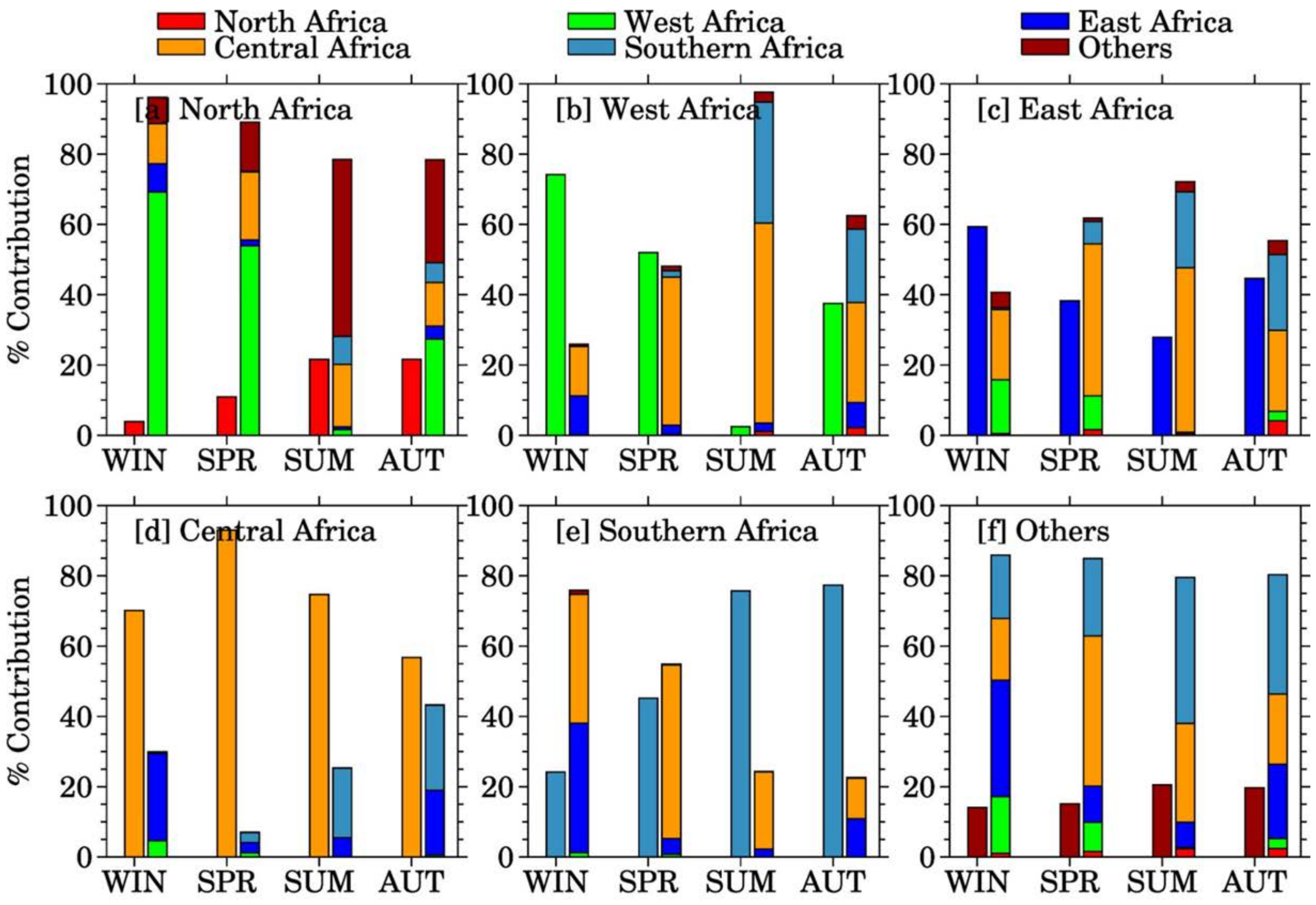
- Fires continue in DRC/Angola but their contributions decreases.
- Chemical production dominance is limited within ± 15^{o} of the equator.

Regional Transport of CO in Africa (Anthropogenic)



- Regional transport of CO makes significant contribution to the anthropogenic CO in all regions of Africa with the highest contribution in NA and CA.
- Contribution of regional sources exceeds the local contribution in CA with SA and EA providing the most significant contributions.
- African emissions from SA and NA contribute the most to anthropogenic CO loading in the surrounding oceanic regions.

Regional Transport of CO in Africa (Biomass Burning)



- Regional sources are more important for CO-Fires than the local sources except in CA during all the seasons, WA during winter and spring, EA in winter, and SA in summer and autumn.
- Fire emissions in CA make important contributions to all the regions except in NA where WA is the most important contributor.

Summary

- The WRF-Chem model captures with the seasonal cycle of temperature and precipitation but underestimates the precipitation.
- The model substantially underestimates the MOPITT retrieved total column CO and the underestimation is seen throughout the troposphere.
- All CO sources contribute significantly to surface CO in Africa but their importance varies by region. Anthropogenic emissions dominate in west Africa, fire emissions dominate in central Africa, inflow from the domain boundaries dominates in north Africa, and chemical production dominance changes by season and follows seasonal changes in solar radiation.
- Regional Transport also plays a very important role in distributing CO emissions across Africa and this must be taken into account while designing emission control strategies.

Thank You!