WCRP CORDEX
25-29 SEPTEMBER 2023 TRIESTE, ITALY
ICRC-CORDEX 2023
International Conference On Regional Climate

Study of the atmospheric nitrogen cycle over Africa based on regional climate chemistry modelling

Eric Martial YAO[1,2], Fabien SOLMON[2], Marcellin ADON[1], Claire DELON[2], Corinne GALY-LACAUX[2]

Thanks to G.Giuliani and the ICTP / RegCM5 dev team

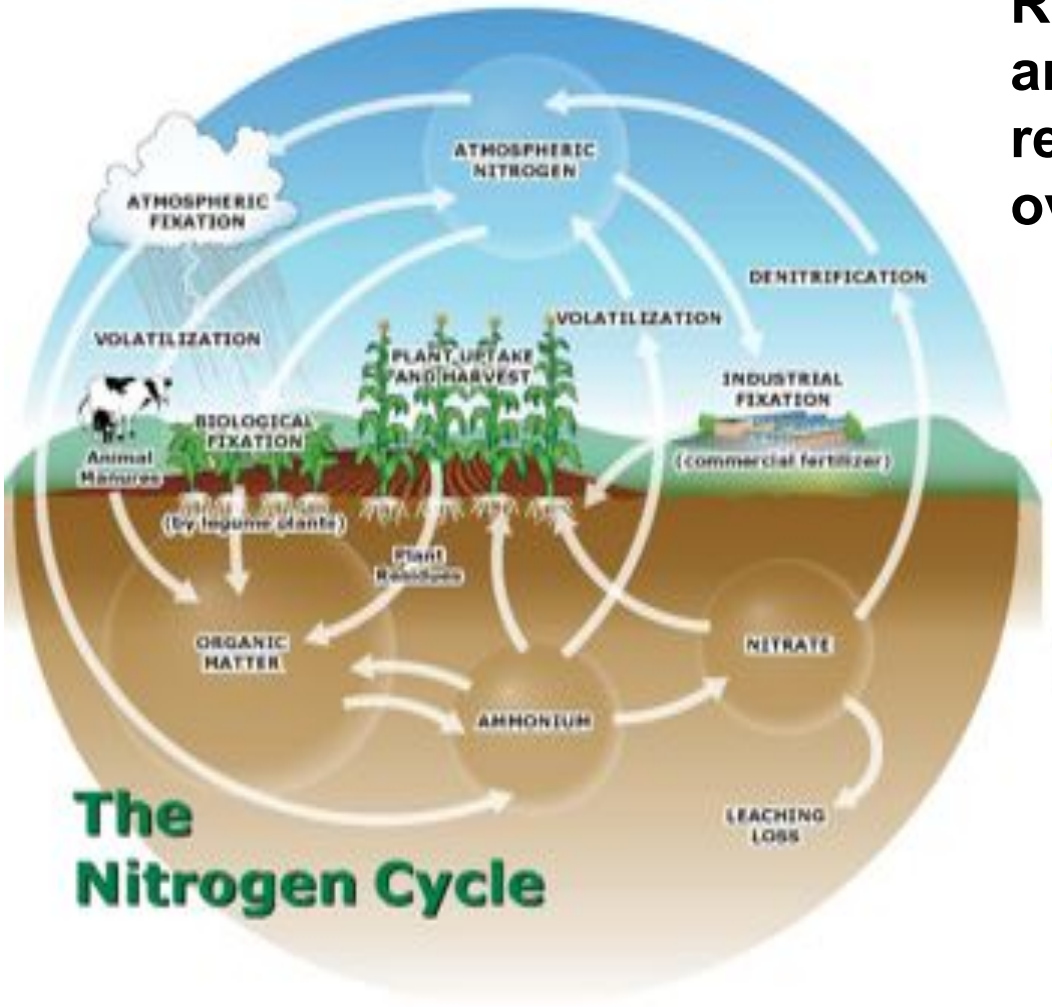
1 UJLoG UNIVERSITE JEAN LOROUGNON GUEDE

2 UNIVERSITÉ TOULOUSE III PAUL SABATIER Laero

INSA Integrated Nitrogen Studies in Africa

INDAAF IGAC/DEBITS/AFRICA

Context and Objectives



Role of climate variability, climate change and anthropogenic activity in the present and future regional nitrogen budgets, and associated impacts over Africa ?

INSA
Integrated Nitrogen Studies in Africa

Integrated modelling tool based on RCM (ICTP/RegCM5)

- **Model Setup and validations of the regional climate**
- **Analyse concentrations level of the for key species.**
- **Assessment of the impact of bogenic NO emissions.**

Model and Simulation description

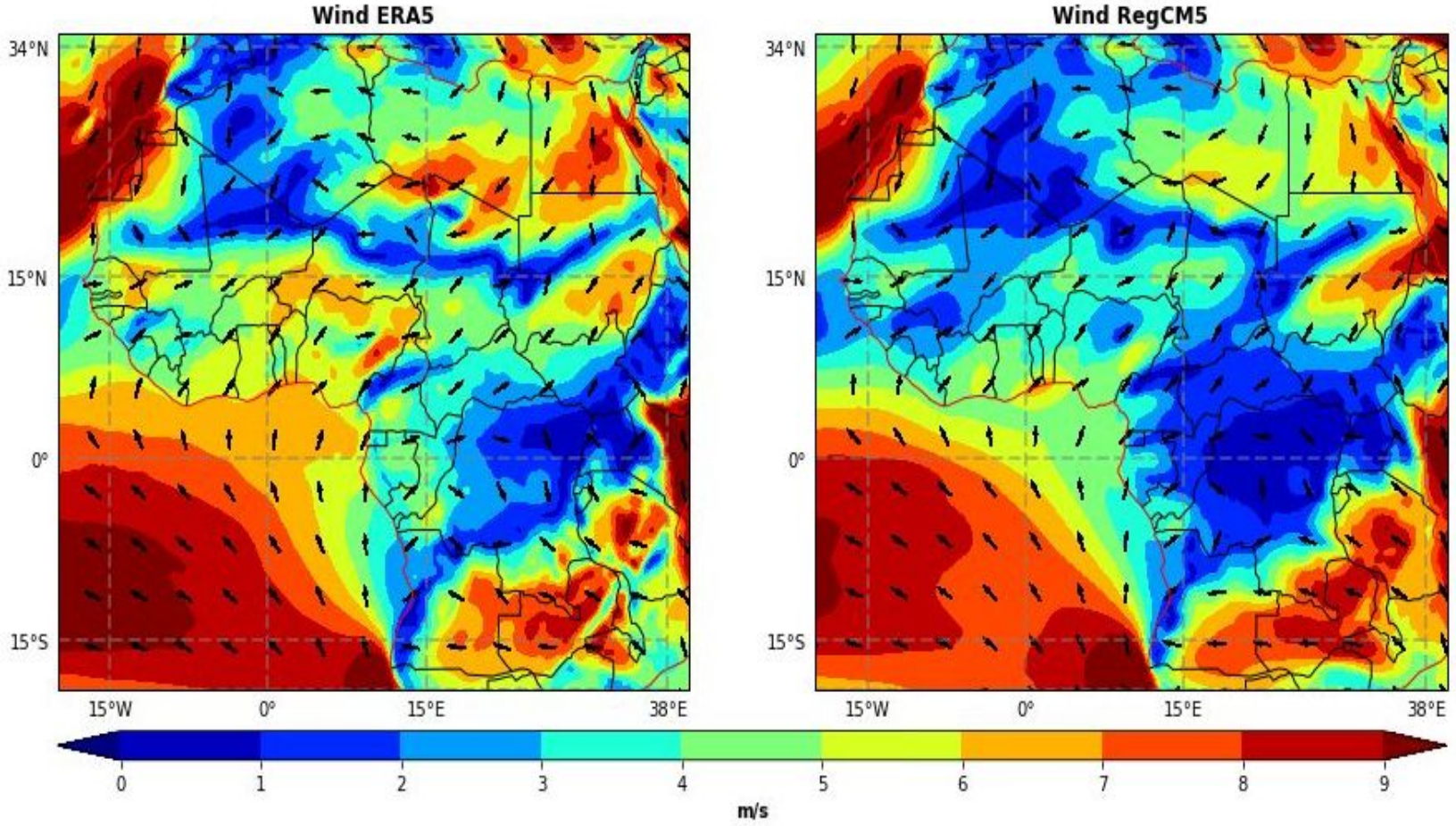
Description

- Based on ICTP RegCM5 model (Giorgi et al., 2023).
- Forced by the 6-hourly ERA5 for dynamics
- Physics Config :
  - RRTM radiative scheme
  - UW turbulence scheme
  - Tiedtke convective scheme
  - CLM4.5 continental surface scheme
- Simulation:
  - Africa
  - Period of Jan 2014 to Dec 2014 for now.
  - 30 km spatial resolution
  - 35 vertical level

Important upgrades for chemistry

- Updated and speciated daily gas phase emissions for biomass burning (GFED4) and anthropogenic emissions CAMS-81.
- New chemical boundary conditions with 6 hourly CAMS atmospheric chemical treanalysis for gas and aerosol. New stratospheric boundary condition treatment.
- Inclusion of biogenic NOx emission and activation of lightning NOx parameterization. Use of MEGAN for BVOCs.
- Convective gas and aerosol wet deposition fully consistent with Tiedtke scheme. Improved large scale wet deposition.
- Improved treatment of dry deposition (+ interactive with CLM4.5).

Monsoon Wind



✔ Reproduction of the main features:

★ Monsoon circulation (southwesterly flow)
★ Harmattan circulation (northern Africa)
★ Monsoon front position on the sahel region.

✔ Underestimation of the mean monsoon intensity (from Gulf of guinea to Sahel regions).

Figure 1. JJA-2014 Monsoon wind speed at 875 hpa for ERA5 reanalysis and RegCM simulation.

Precipitation and Temperature

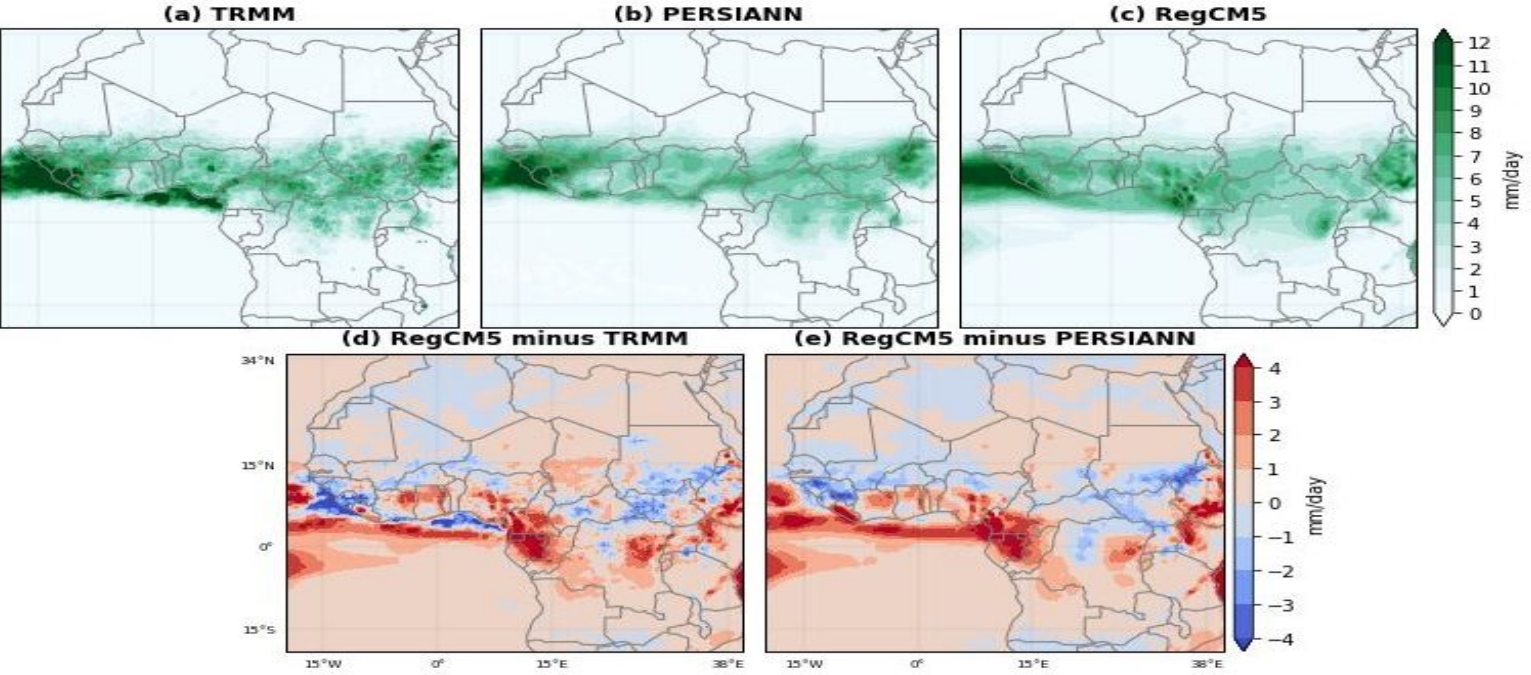


Figure 2. JJA-2014 Observed (TRMM and PERSIANN) vs simulated (RegCM5) precipitation (mm/day).

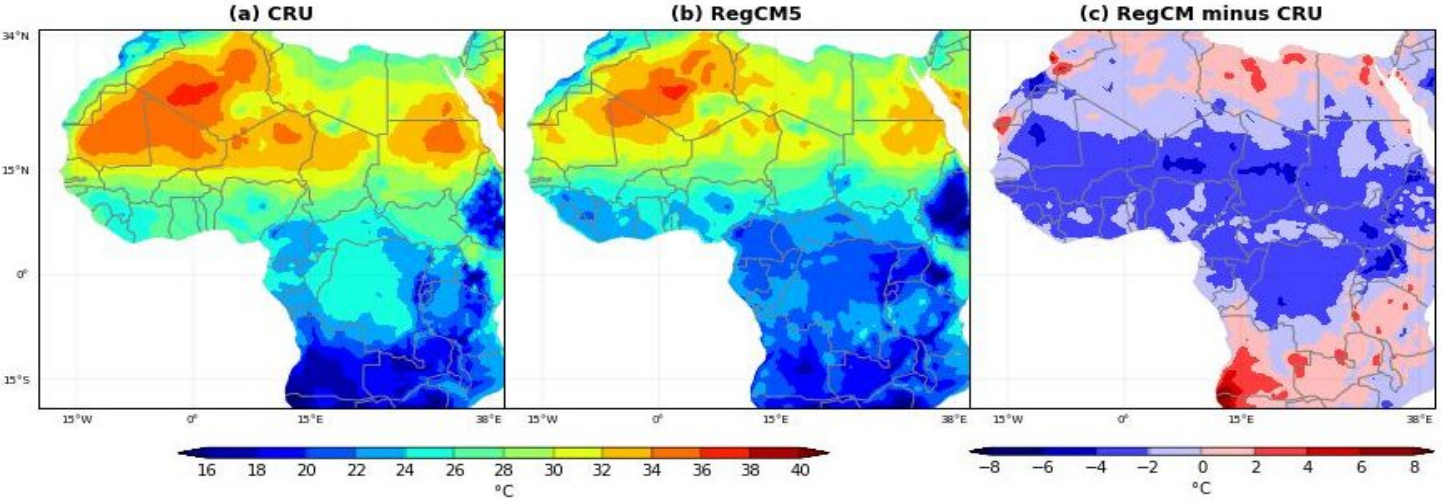
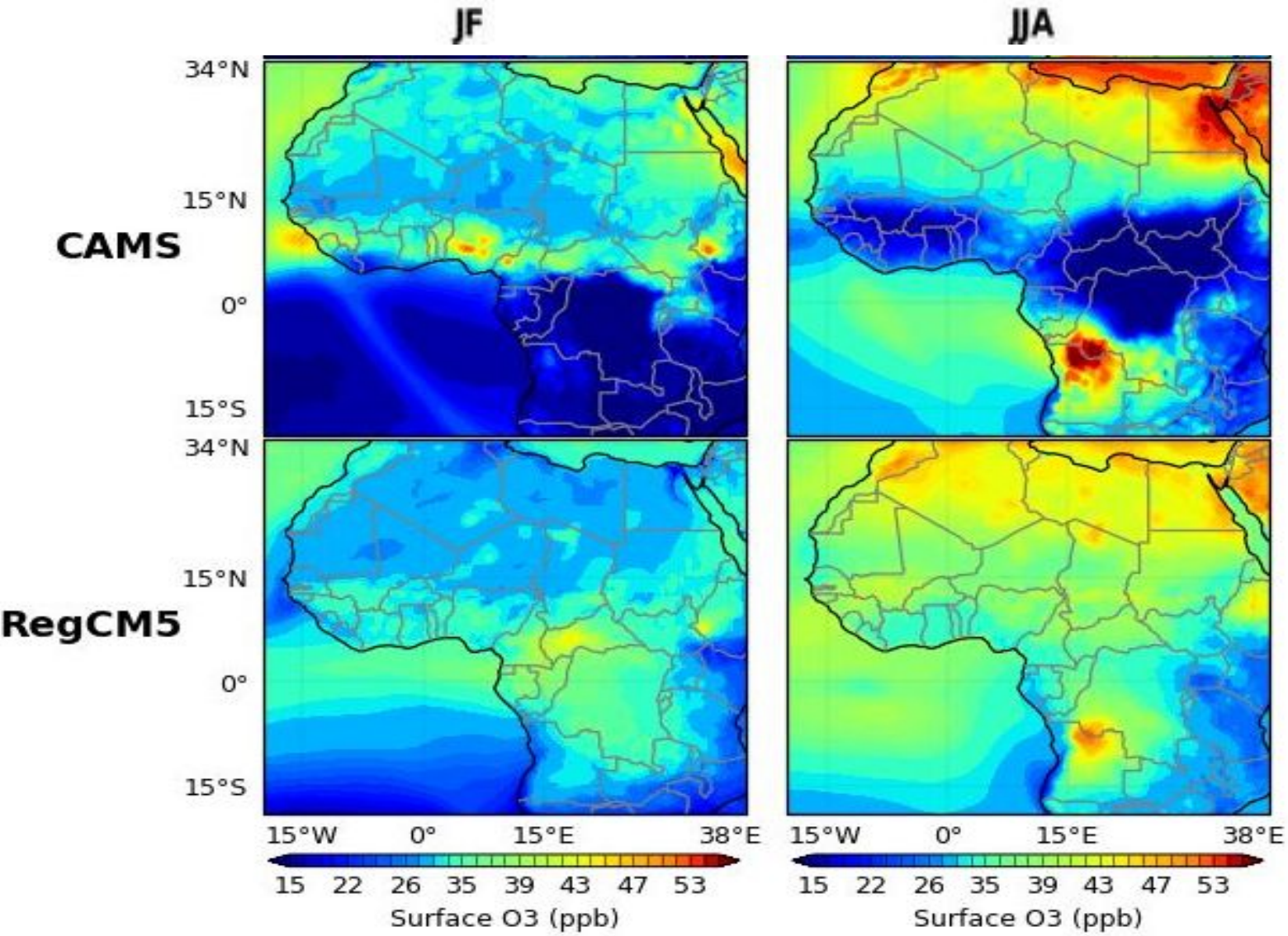


Figure 3. JJA-2014 Air temperature (°C) for CRU observation and RegCM5 simulation.

- ✔ Spatial precipitation distribution reproduced.
- ✔ Limited bias over the domain (remains reasonable/CORDEX RCMs).
- ✔ Main spatial gradients of surface temperature captured.
- ✔ Limited bias over the northern Sahel.

Surface O3

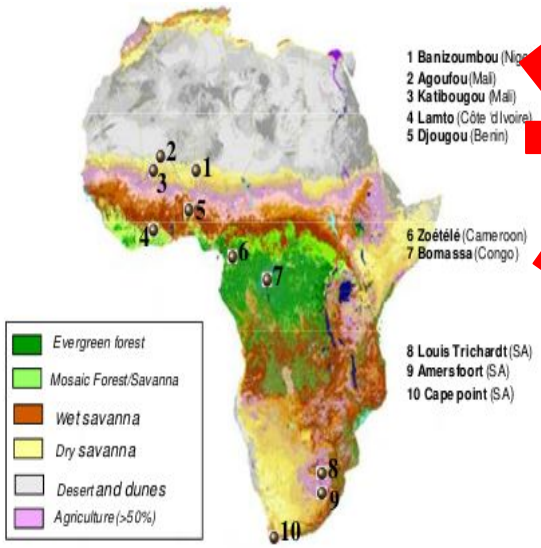


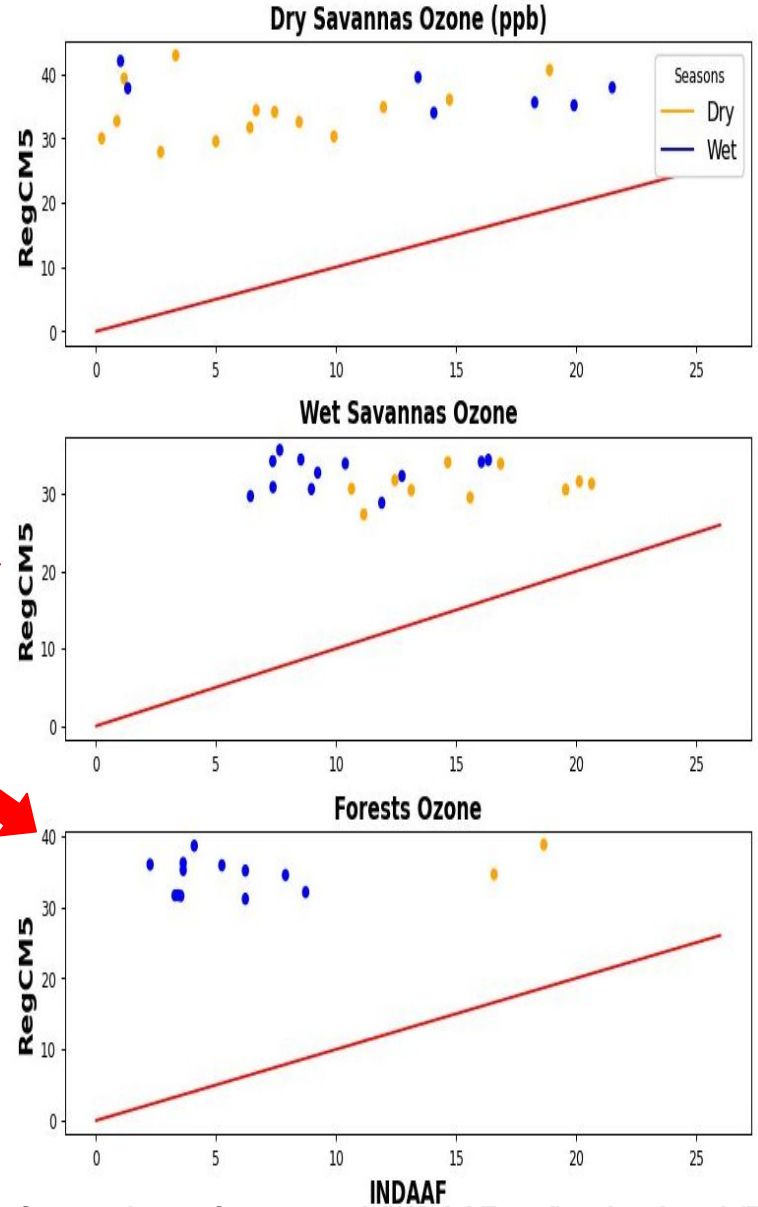
- ✔ Consistent pattern with CAMS reanalysis / Overestimation over the domain.
- ✔ Difference linked to difference in model parameterizations: Emissions inventories, Biomass burning injection height, Dry deposition treatment, Chemical boundary conditions and upper tropospheric transport.

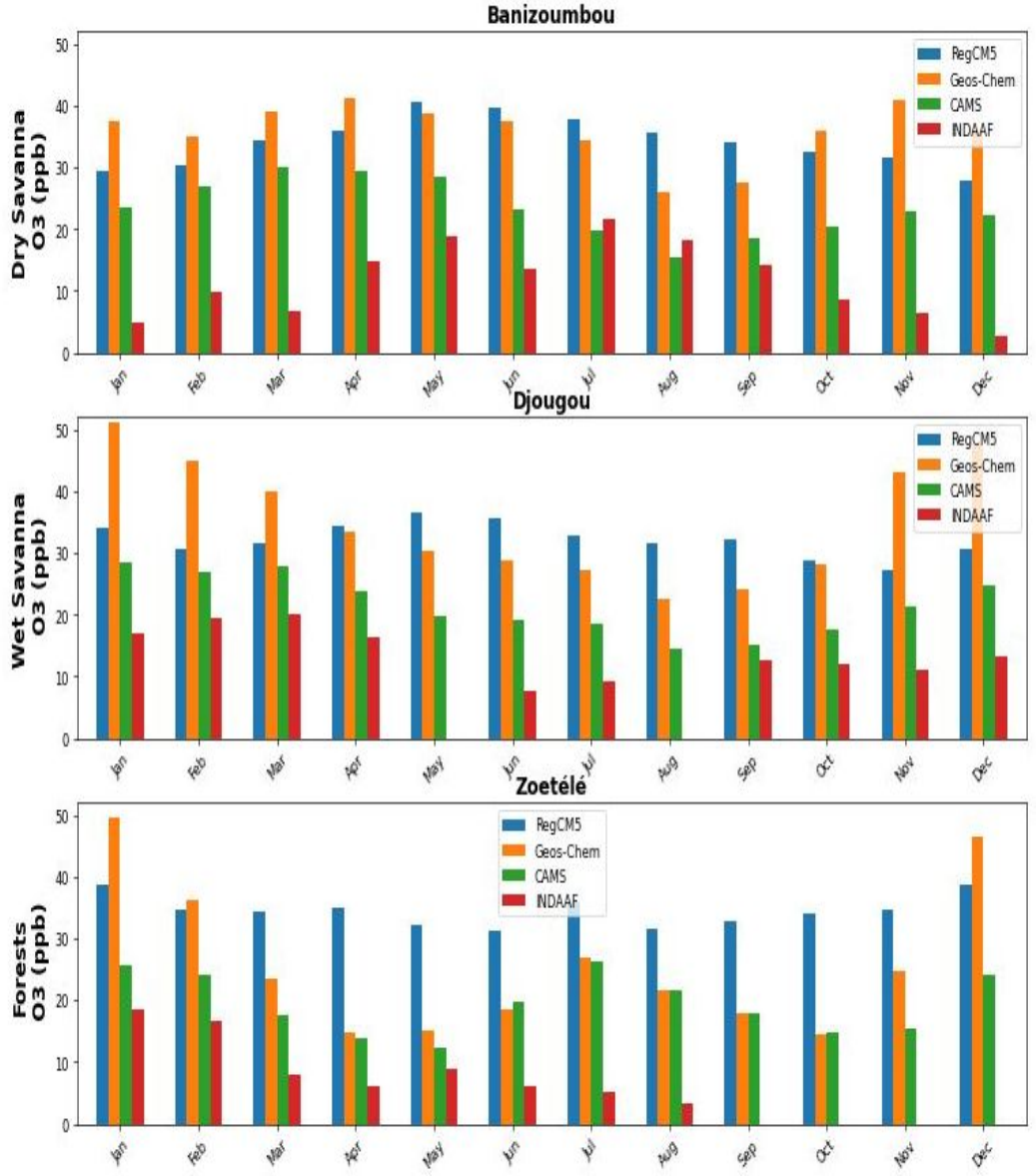
Figure 4. Surface ozone concentration from CAMS reanalysis and simulated with RegCM5.

INDAAF Sites Ozone

- ✔ Overestimation over the ecosystems
- ✔ Seasonal evolution captured

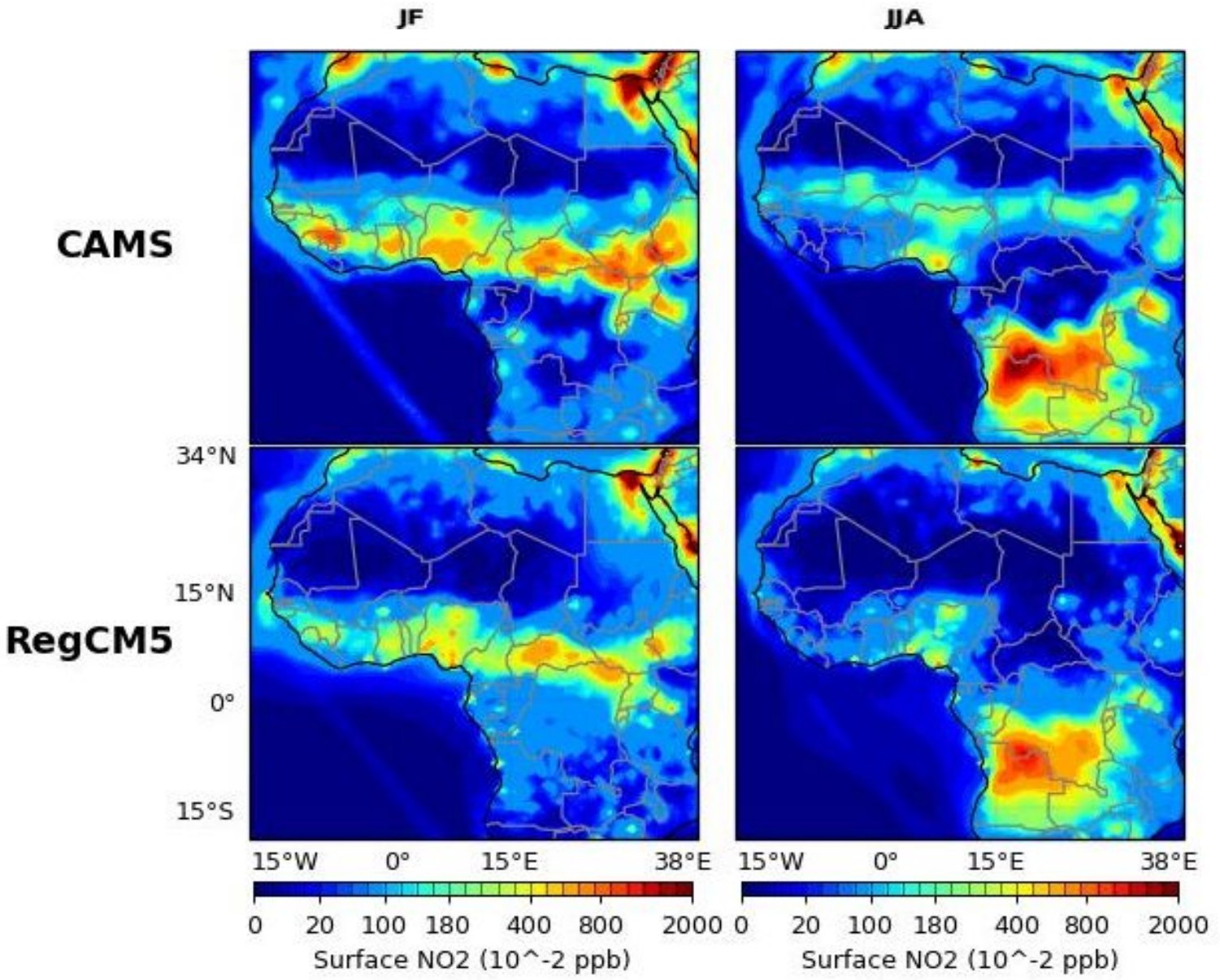






Figures: 5. Comparison of INDAAF and RegCM5 datas, 7. Comparison of measured (INDAAF, red) , simulated (RegCM, blue…Geos-Chem, orange)), and CAMS reanalysis (green) surface m ozone concentrations for 2014.

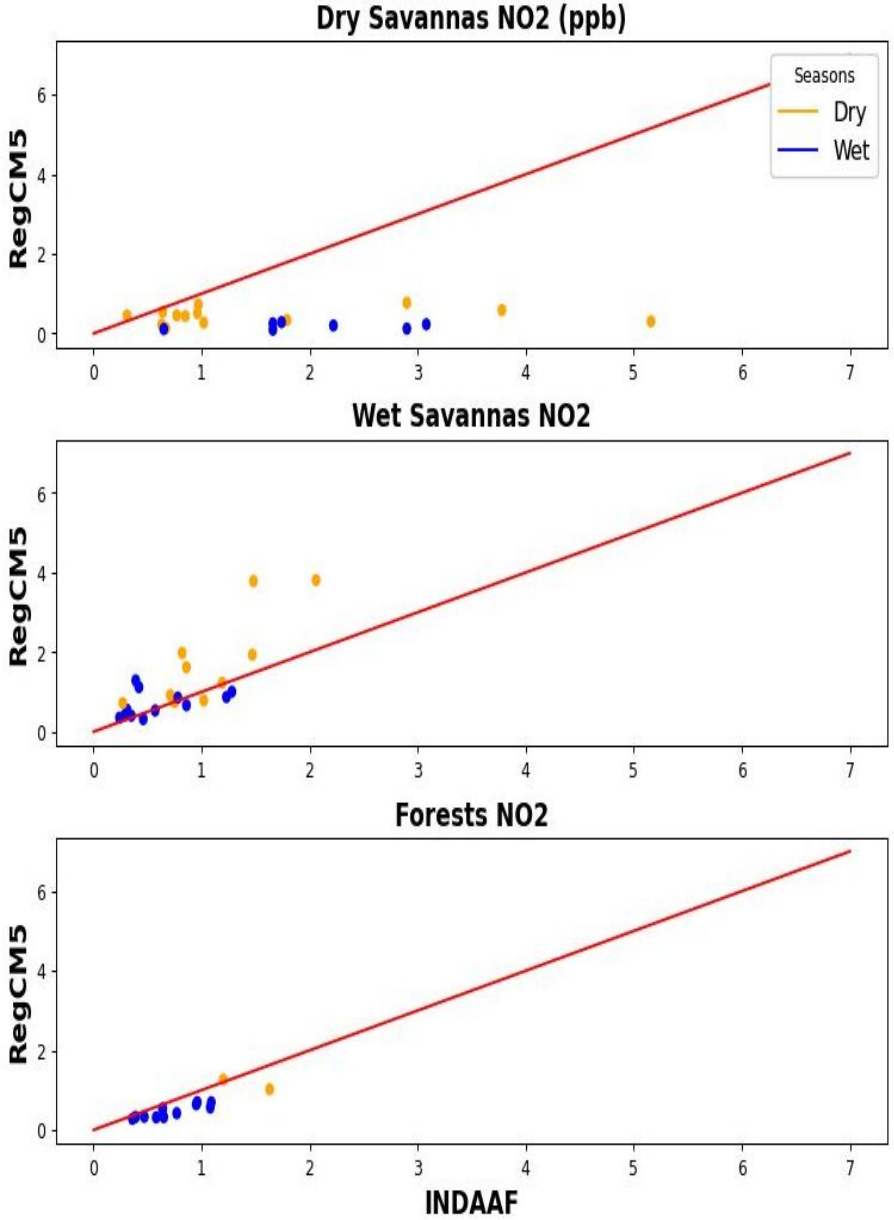
Surface NO2

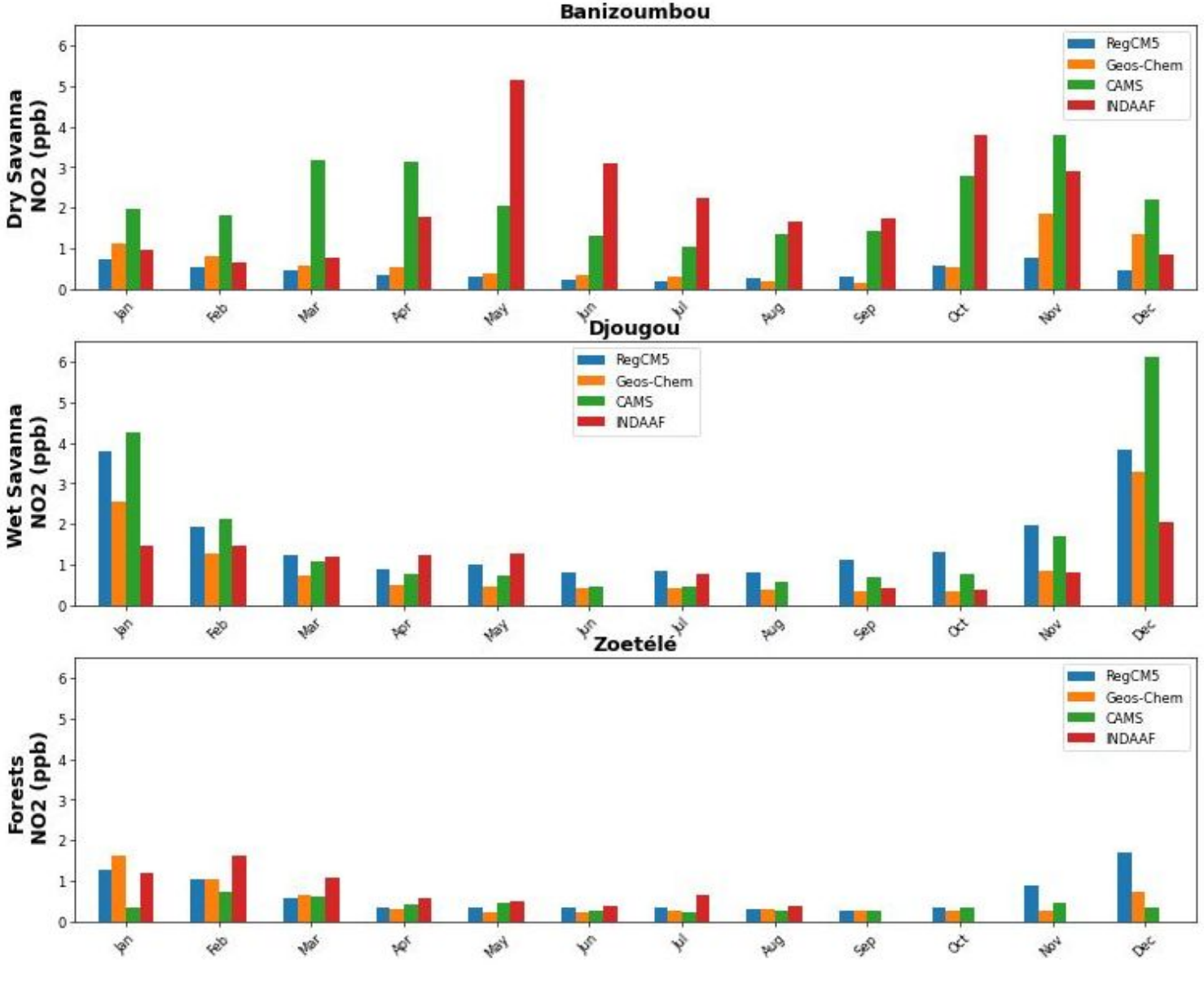


- ✔ Consistent spatial and seasonal patterns between RegCM5 and CAMS.
- ✔ Surface NO2 driven by biomass burning emissions.
- ✔ Lower concentrations in wet season over Sahel regions.

Figure 7. Surface NO2 concentration from CAMS reanalysis and simulated with RegCM5.

INDAAF sites NO2





Figures: 8. Comparison of INDAAF and RegCM5 datas, 9. Comparison of measured (INDAAF, red) , simulated (RegCM, blue…Geos-Chem, orange)), and CAMS reanalysis (green) surface monthly NO2 concentrations for 2014.

Biogenic NO emission impact on surface NO2 and O3

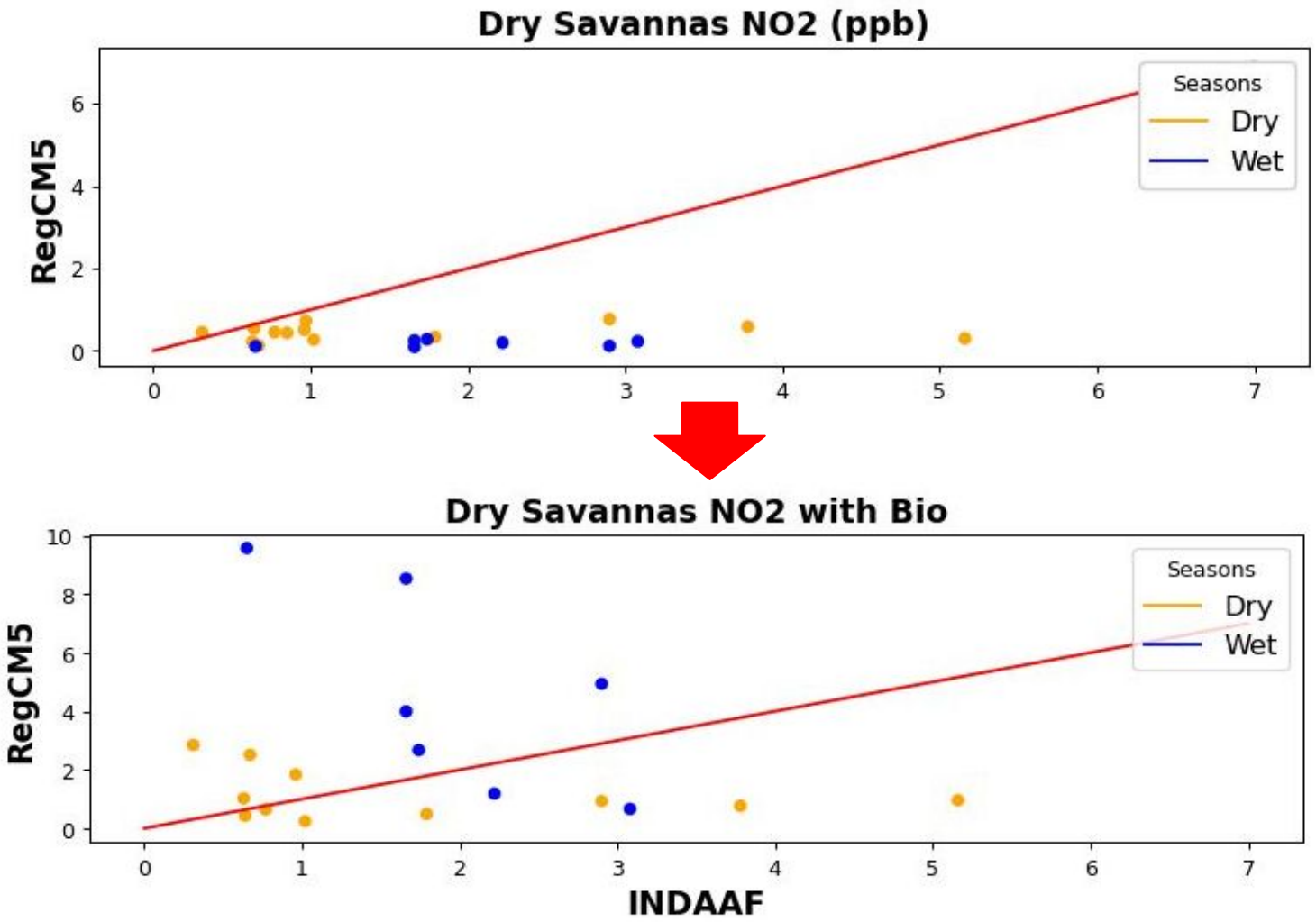


Figure 10. Surface observed NO2 concentration (INDAAF) vs simulated with RegCM5. Biogenic NO emissions are considered (NO2 with bio).

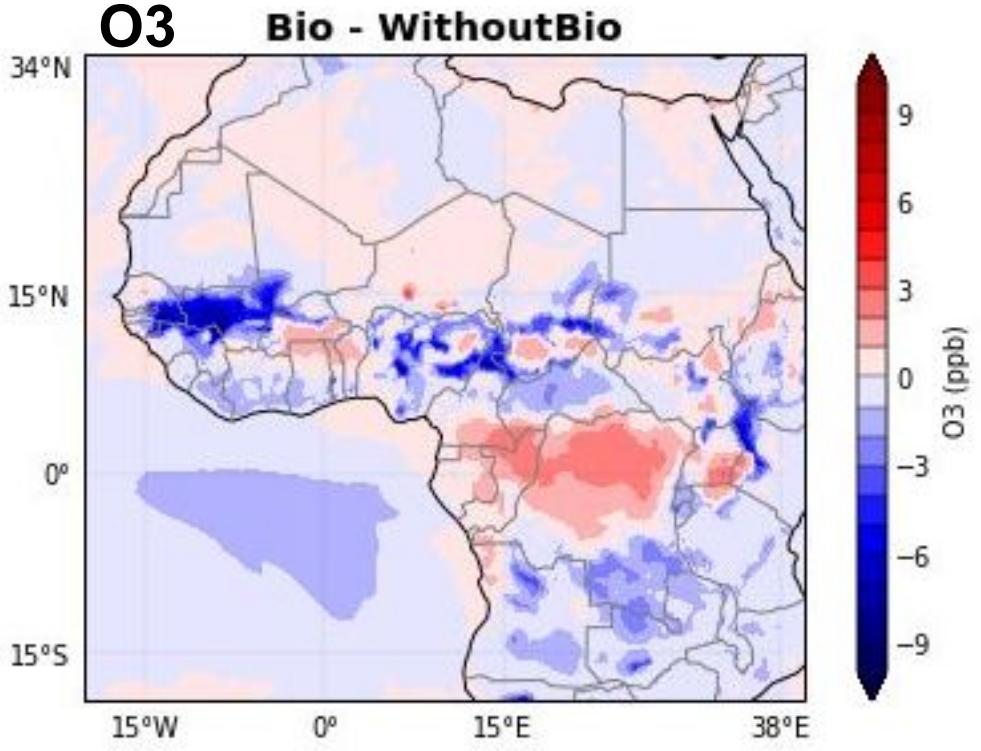


Figure 11. Difference between surface O3 concentration : NO bio minus without bio (JJA 2204).

Conclusion and Outlook

- The model captures the main features of the regional climate/atmospheric chemistry over the region when compared to reanalysis and state of the art CTMs.

- Surface O3 simulated by models and reanalysis are systematically overestimated compared to ground based stations (known bias in the community).

- The Biogenic NO emissions improve the surface concentration levels for key species, especially for NO2 and O3, which is decreased by titration, in wet season.

- In perspectives : multi-annual simulations to analyse the impact of climate variability and climate change vs. anthropogenic emissions evolution on the regional atmospheric nitrogen budget.


WCRP
CORDEX
25-29 SEPTEMBER 2023 TRIESTE, ITALY
ICRC-CORDEX 2023
International Conference On Regional Climate
Thanks you for your kind attention!