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Atmospheric Response to SST in the Eastern Tropical Atlantic in July-August

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CONTEXT AND OBJECTIVES

The sea surface temperature (SST) in the Eastern Tropical Atlantic is characterized by a strong seasonal cycle. The SST becomes very warm in boreal summer in the north, off Senegal / Mauritania, while a seasonal cold tongue takes place in the south, around the Equator.

Along the zonally-extended SST maximum, the Intertropical Convergence Zone (ITCZ) corresponds to a region of surface wind convergence and intense precipitation.

The aim of this study is to document the SST control on the seasonal evolution of the ITCZ latitude with a regional atmospheric model (WRF), by manually removing any SST warming (« Frozen North ») or cooling (« Frozen South ») from June in the eastern Tropical Atlantic.

WRF EXPERIMENTAL DESIGN & ENSEMBLE RUN WITH MODIFIED EASTERN TROPICAL ATLANTIC SST

WRF-ARW: version 3.9.1 non-hydrostatic.

Parameterization schemes: MYJ (PBL), BMJ (cumulus) & WSM6-Class (microphysics)

Period of simulation: climatological 1 April – 30 September 2000 – 2009

Grid: 25km x 25km, 51 vertical levels.

Forcing data-set: ERA-Interim & SST Reynolds initial and lateral forcing.

We performed an ensemble of 11 runs for each experiment.

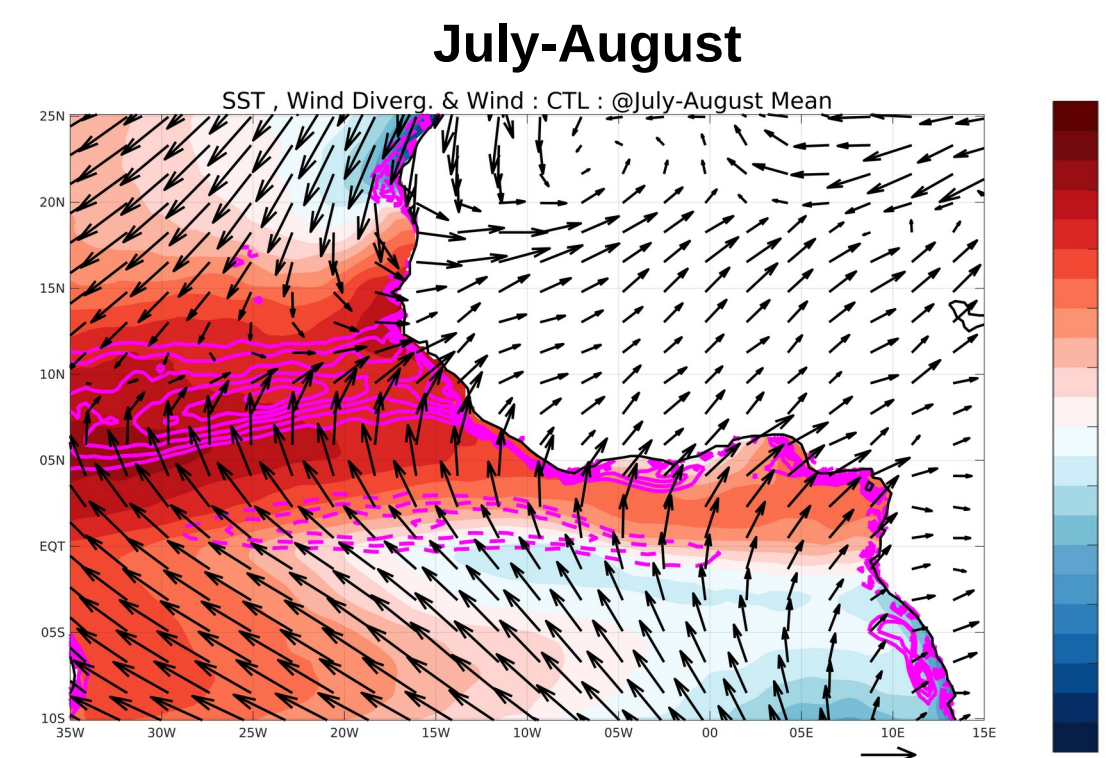


Figure 1a. **Control (CTL)** run, July-August average: SST (color), surface wind (vectors) and wind divergence (contours).

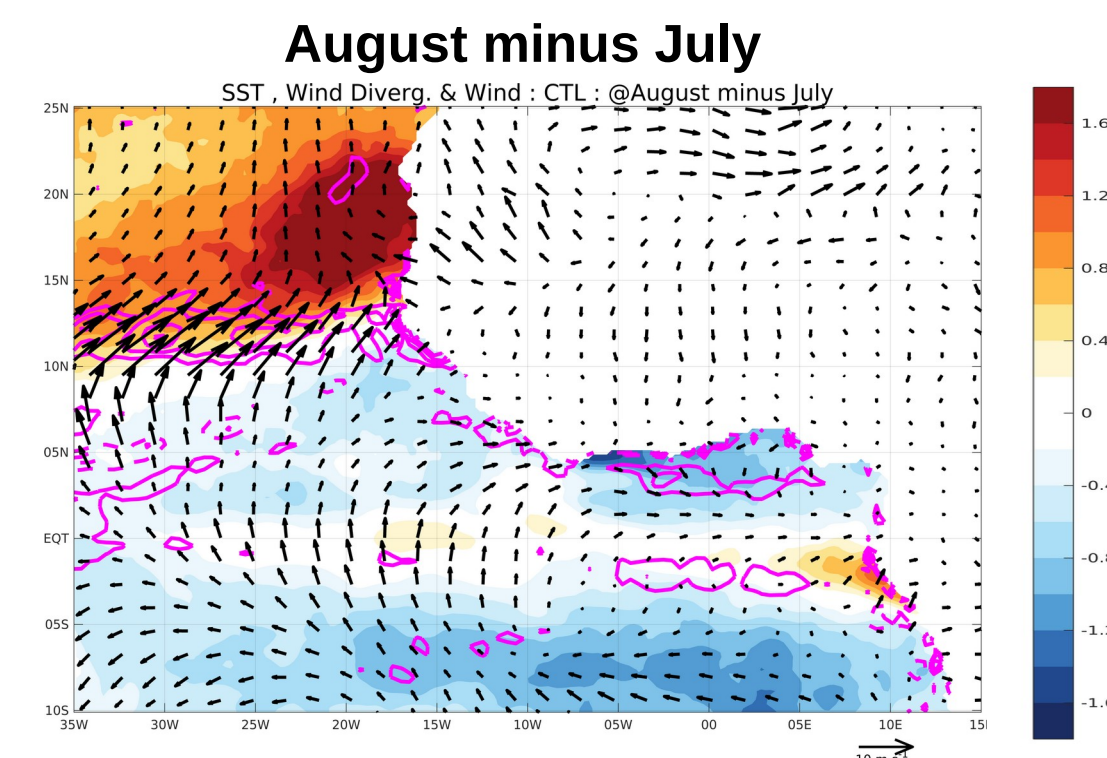


Figure 1b. Seasonal trend from July to August in the **CTL** run: SST (color), surface wind (vectors) and wind divergence (contour).

Control simulations (Fig. 1a) are very close to observations (not shown). From July to August, the SST warms up to the north of ITCZ and cools to the south, and the ITCZ migrates north (Fig. 1b): to what extent this northward migration of ITCZ is controlled by changes in SST ?

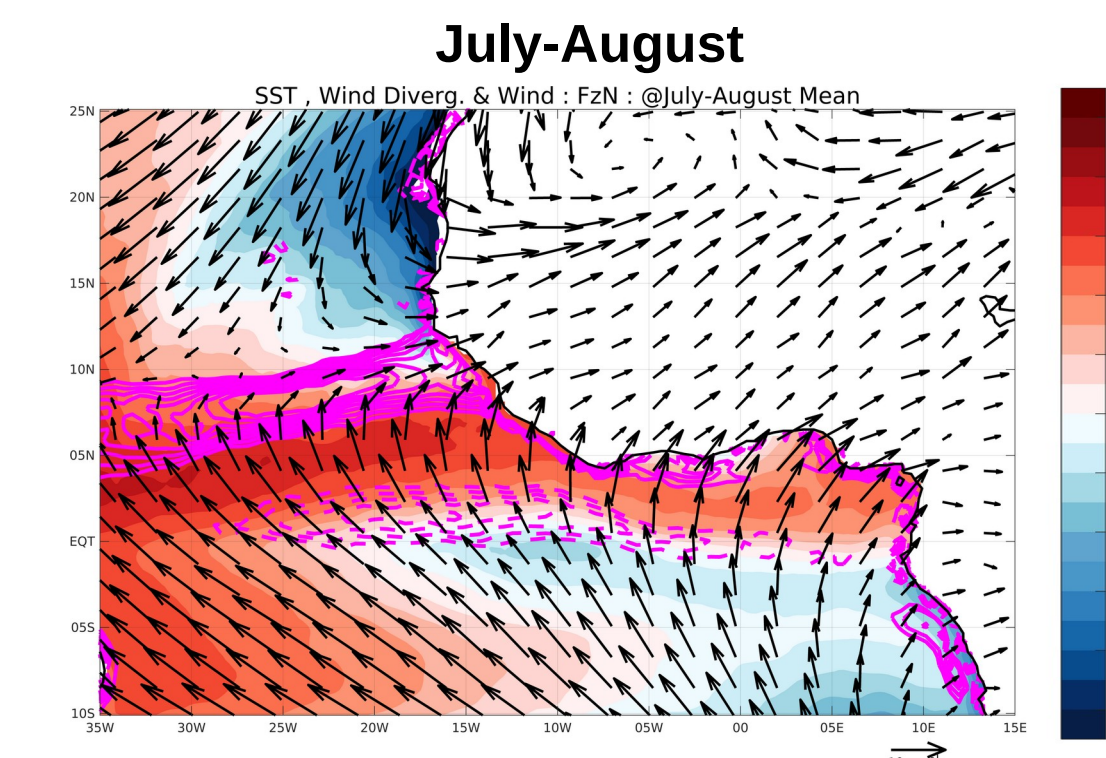


Figure 2. **Frozen North (FzN)** experiment, July-August average: no seasonal SST warming in the eastern tropical Atlantic from 10 June.

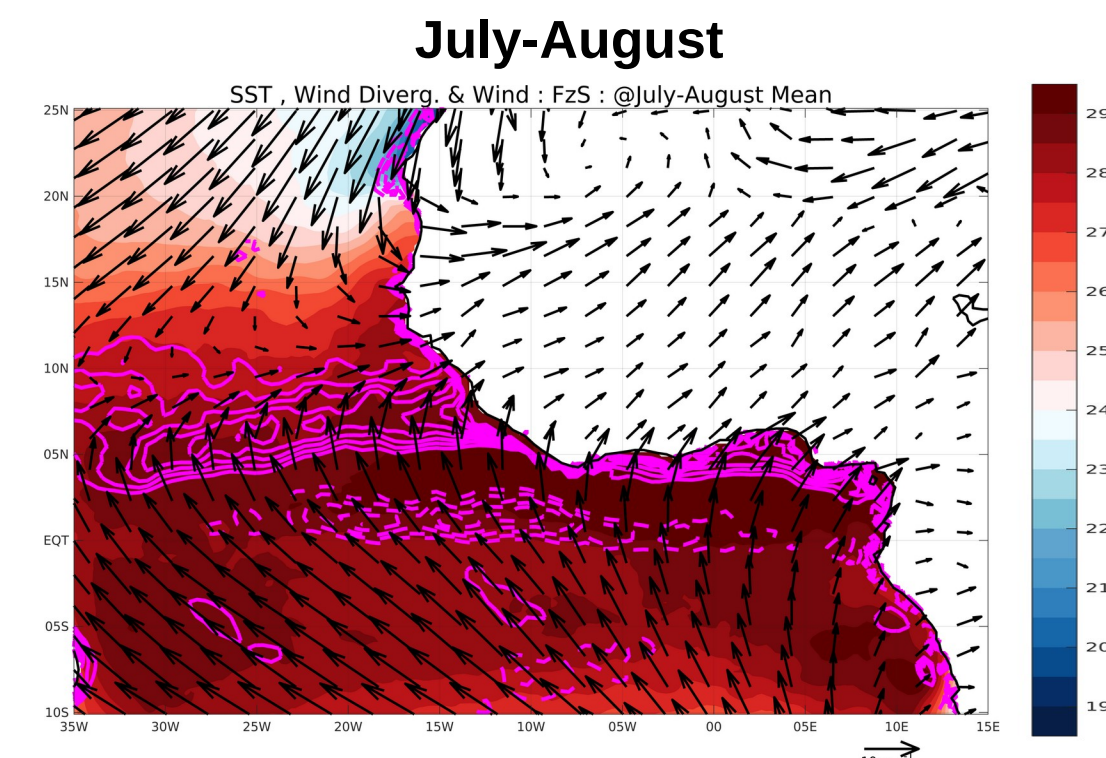
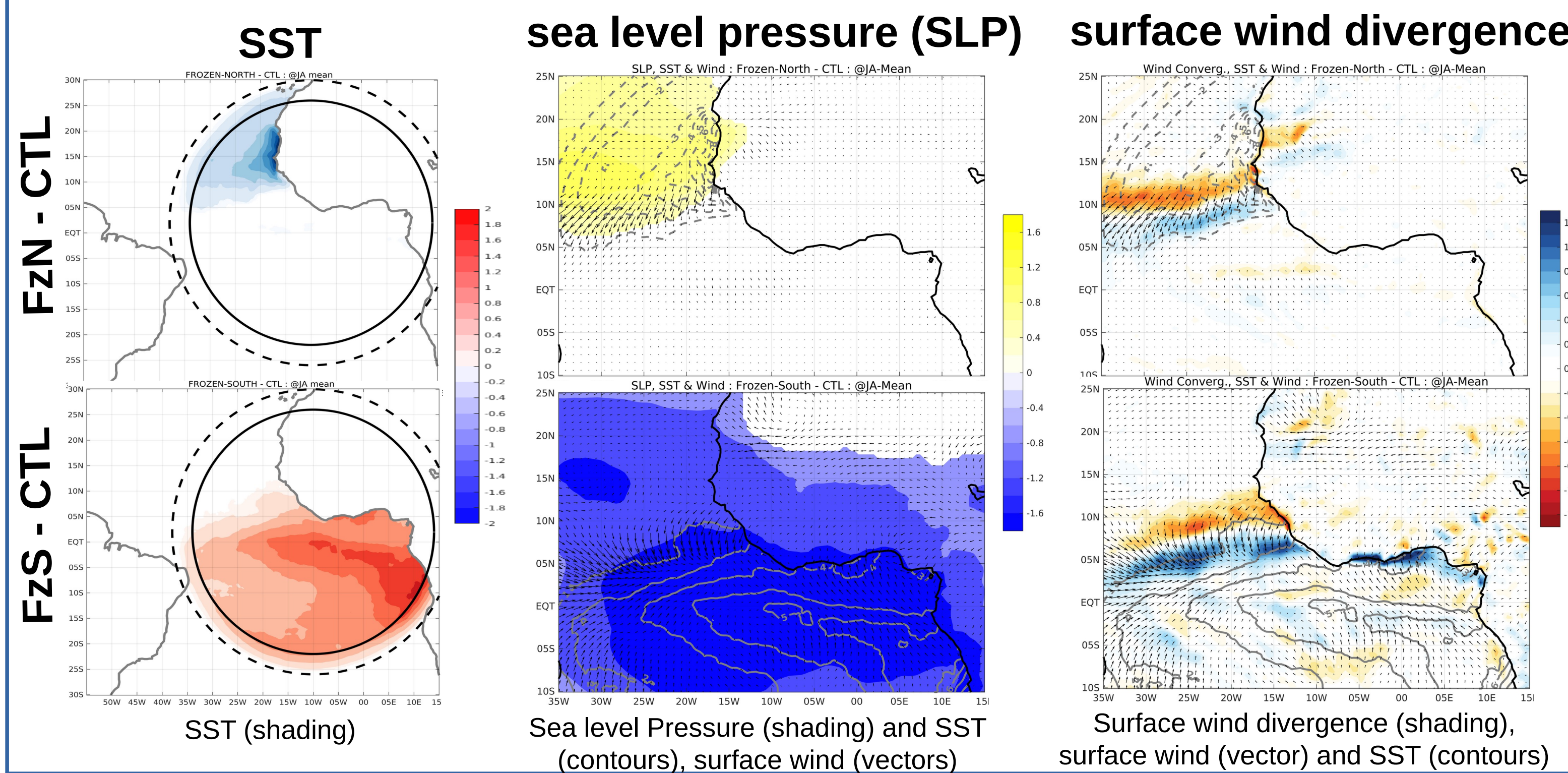


Figure 3. **Frozen South (FzS)** experiment, July-August average: no seasonal SST cooling in the eastern tropical Atlantic from 10 June.

The experiment consists in blocking any warming (FzN, Fig. 2) or cooling (FzS, Fig. 3) of the SST in the Eastern Tropical Atlantic from 10 June. The impact of the resulting SST anomalies on the migration of the ITCZ and precipitation in West Africa is investigated by showing the **difference between CTL and FzN / FzS experiments in July-August seasonal trends.**

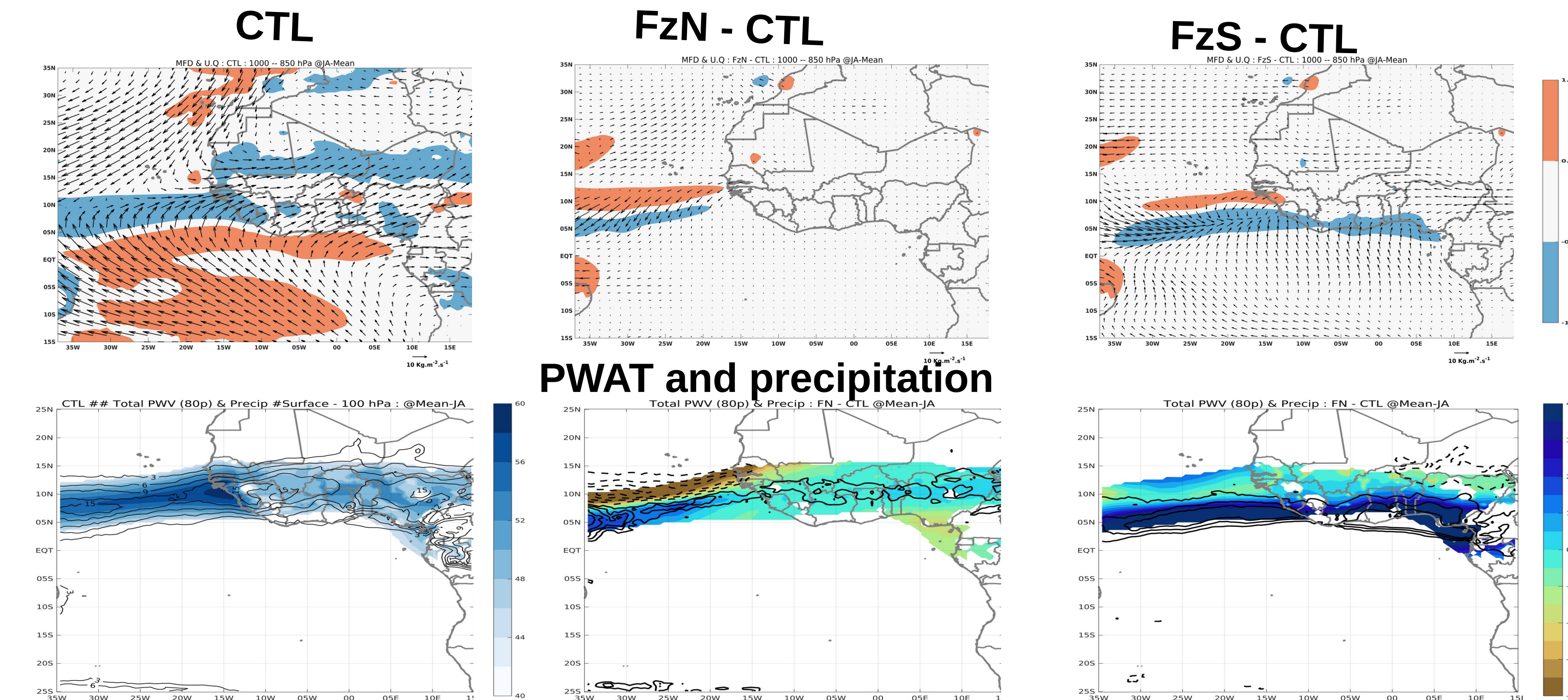
RESULTS : FROZEN SIMULATIONS MINUS CTL SIMULATION IN AVERAGE JULY-AUGUST



Sensitivity experiments result in regional SST and sea level pressure (SLP) anomalies : a cold (warm) SST anomaly forces a positive (negative) SLP anomaly.

Surface winds are also impacted: their divergence anomaly counter the northward migration of the ITCZ from July to August in both experiments.

Humidity transport and divergence

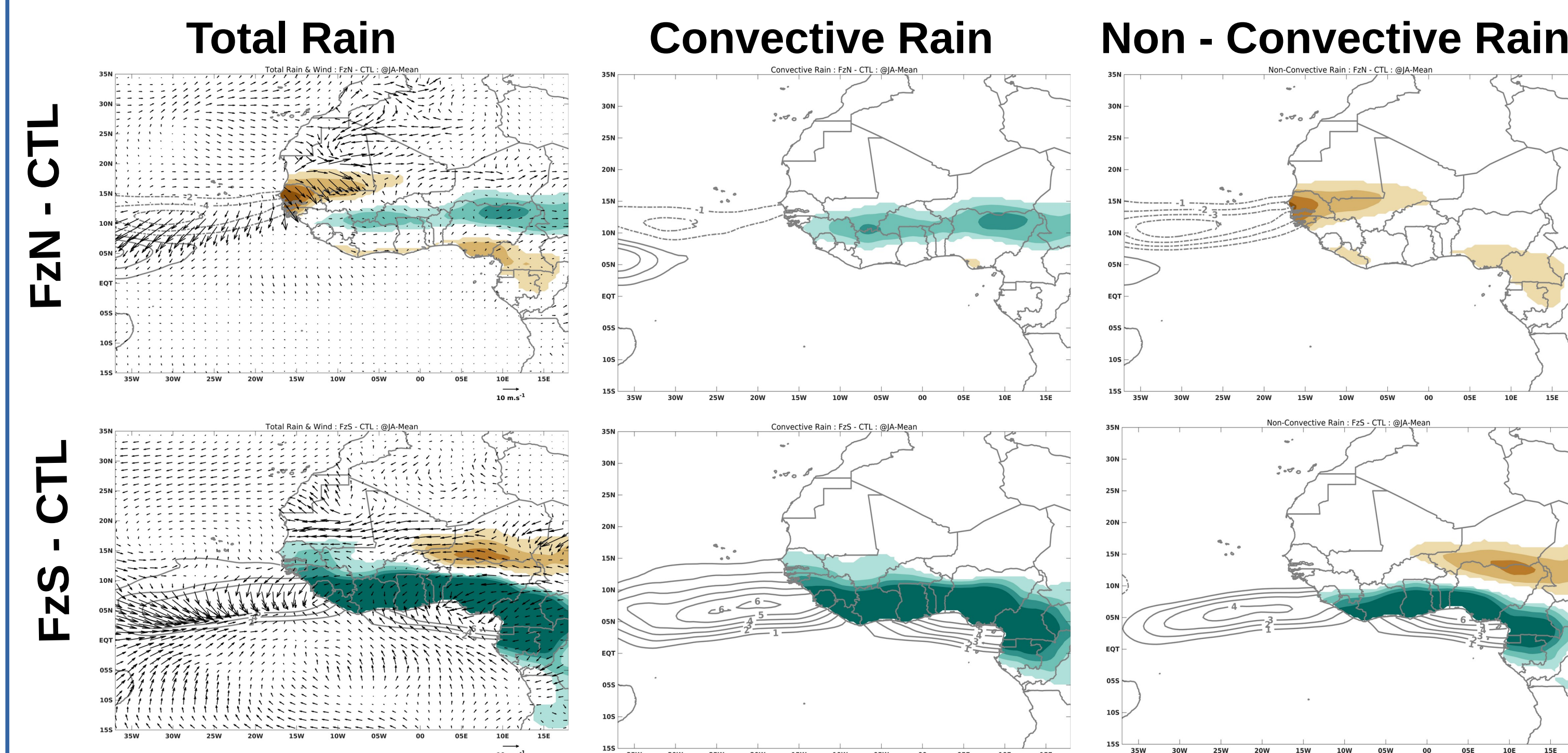


Most of the humidity is transported in the lower layers (1000-850 hPa).

The cold north (warm south) SST anomaly decreases (increases) the convergence of humidity along the north (south) flank of the ITCZ, resulting in a decrease (increase) in PWAT and precipitation.

The SST anomalies therefore counter the northward July-August migration of PWAT and precipitation in the two experiments.

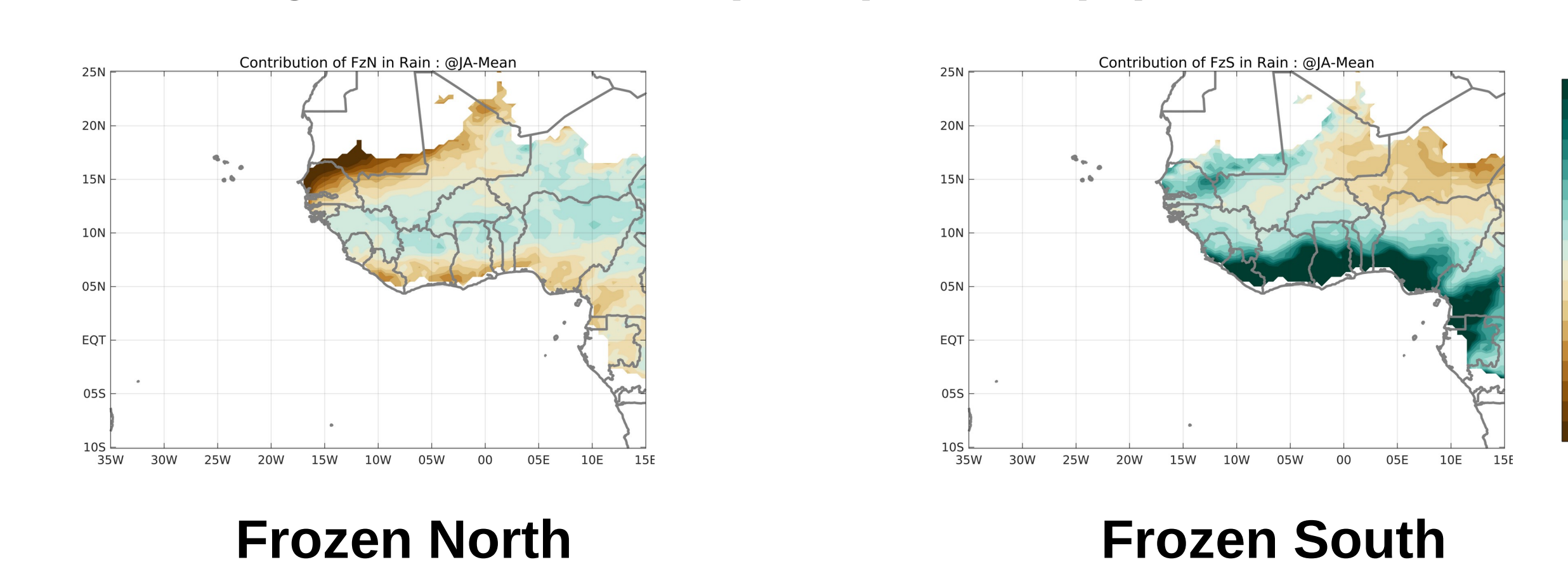
Convective and non-convective precipitation



The cold north SST anomaly dries up the northern flank of the ITCZ over the ocean and Senegal, mostly by decreasing non-convective rain. Further east, it moistens a little the Sahel (10N-15N) via convective rain.

The warm south SST anomaly widely increases precipitation south of the ITCZ over the ocean and along Guinea Coast regions, mostly via convective precipitation, but a wet / dry dipole is also found in non-convective precipitation.

Relative change in West Africa precipitation (%) associated with FzN and FzS



The cold north SST anomaly induces a large precipitation decrease (40 to 100%) north of 13N, a smaller (up to 30%) increase between 8N and 13N, and decrease south of 8N.

The warm south SST anomaly induces a large increase (40 to 100%) of precipitation along Guinea coastal regions, a decrease (up to 40%) in eastern Sahel and a slight increase (less than 30%) in Senegal and west Sahel.

CONCLUSIONS

The SST seasonal evolution in eastern Tropical Atlantic during boreal summer has a significant impact on surface wind divergence and low troposphere dynamics.

Blocking SST warming north of the ITCZ induces a southward migration of precipitation in West Africa, in particular a reduction of rainfall in western Sahel (Senegal). Blocking SST cooling south of the ITCZ leads to a southward expansion of the marine ITCZ, and a slight increase (strong reduction) of rainfall in western (eastern) Sahel.

The SST impact on the latitude of the marine ICTZ and precipitation in coastal regions of West Africa is therefore clearly shown in WRF simulations. Significant impacts on Sahel precipitation are also found and will need further investigations.

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