Consiglio Nazionale delle Ricerche
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Accademia dei Georgofili

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Marine air particle trajectories fed into the Indian-African monsoonal system

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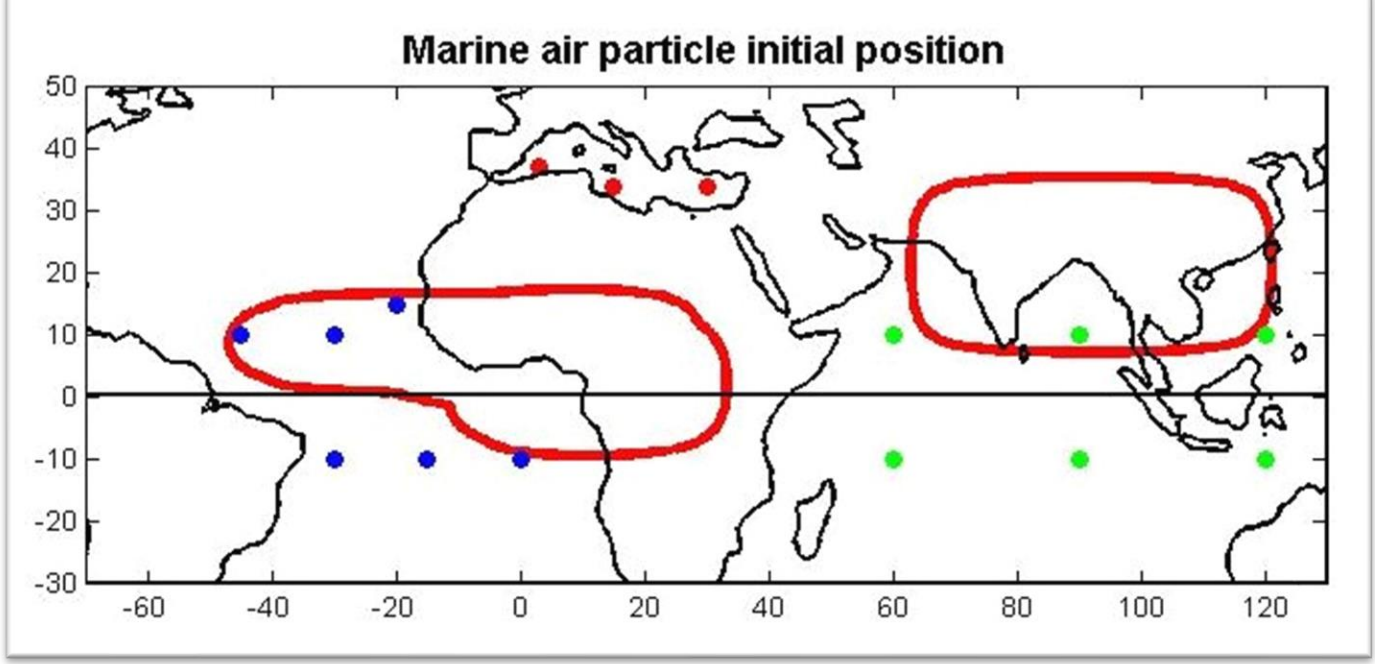
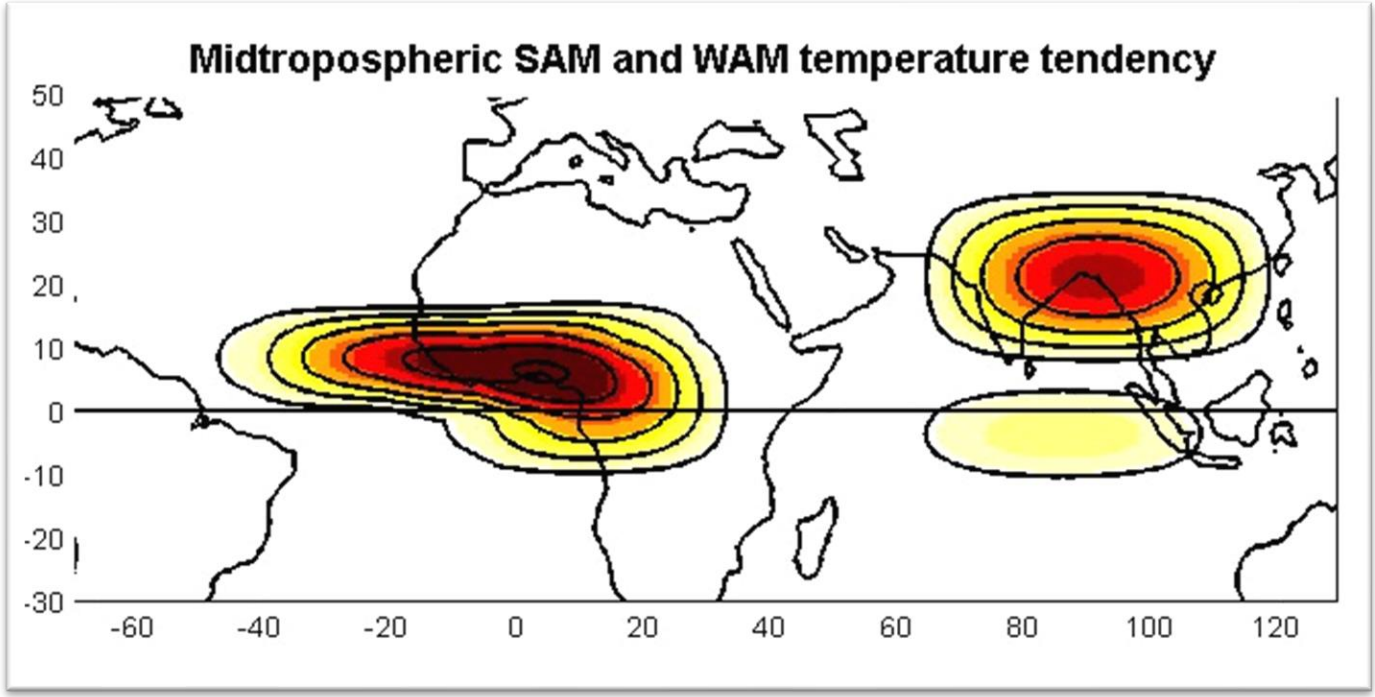
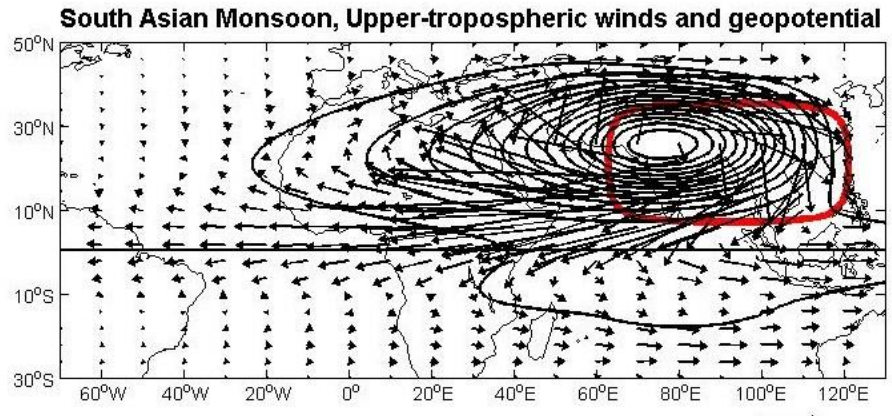
Monsoons are large scale atmospheric circulations fueled by the latent heat released by the marine air masses, which cyclonically spiral inland from nearby tropical oceans in the warm season. More than half world population lives in these regions.

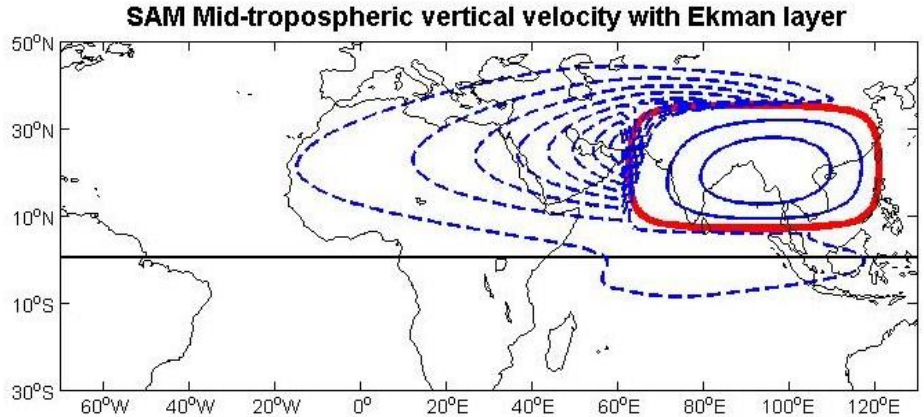
We track marine air particles originated in the Mediterranean sea, in the Atlantic and Indian oceans.

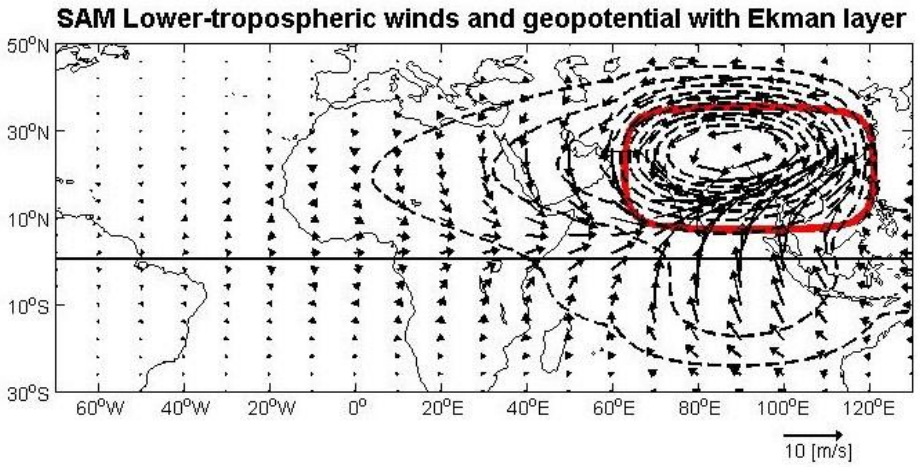


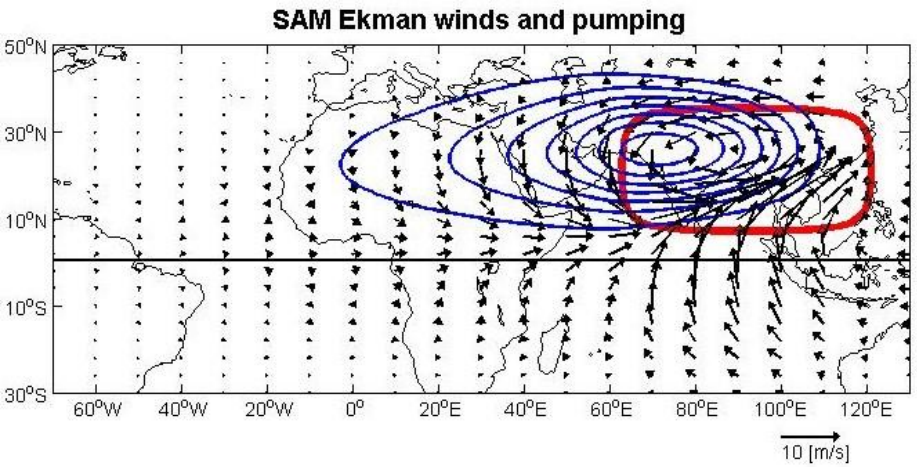


Monsoons are composed by a lower cyclone coupled to an upper anticyclone by an intense mid-tropospheric updraft, surrounded by a larger region of weaker downdraft.
The monsoonal dynamics are here analyzed using ***Gill's tropospheric model*** with the addition of a lower Ekman frictional layer.
The Ekman pumping weakens the low level subsidence about the monsoons, favoring the lifting of the air particles from the sea surface.

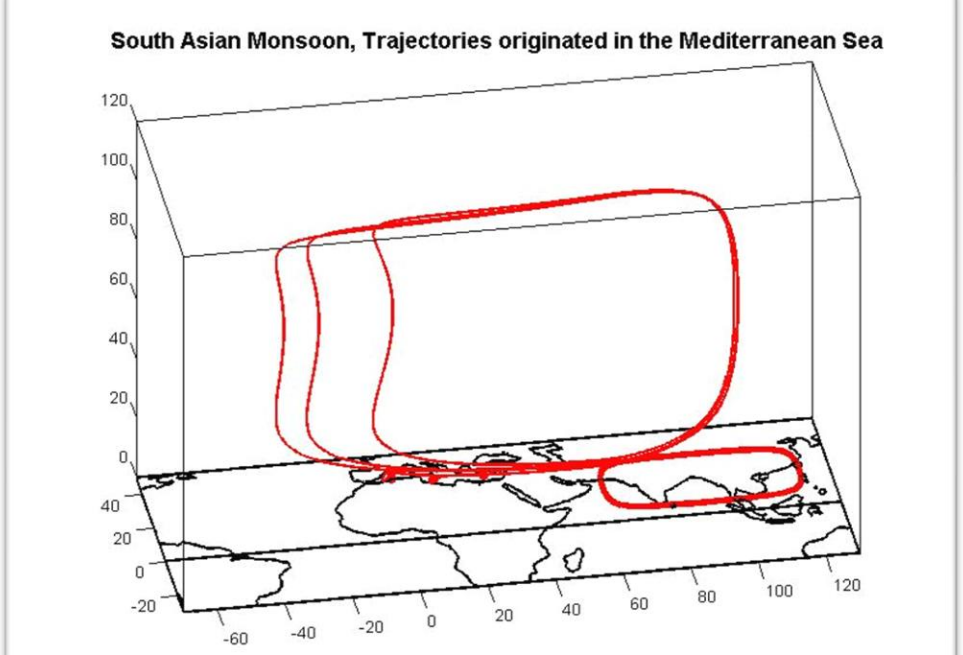






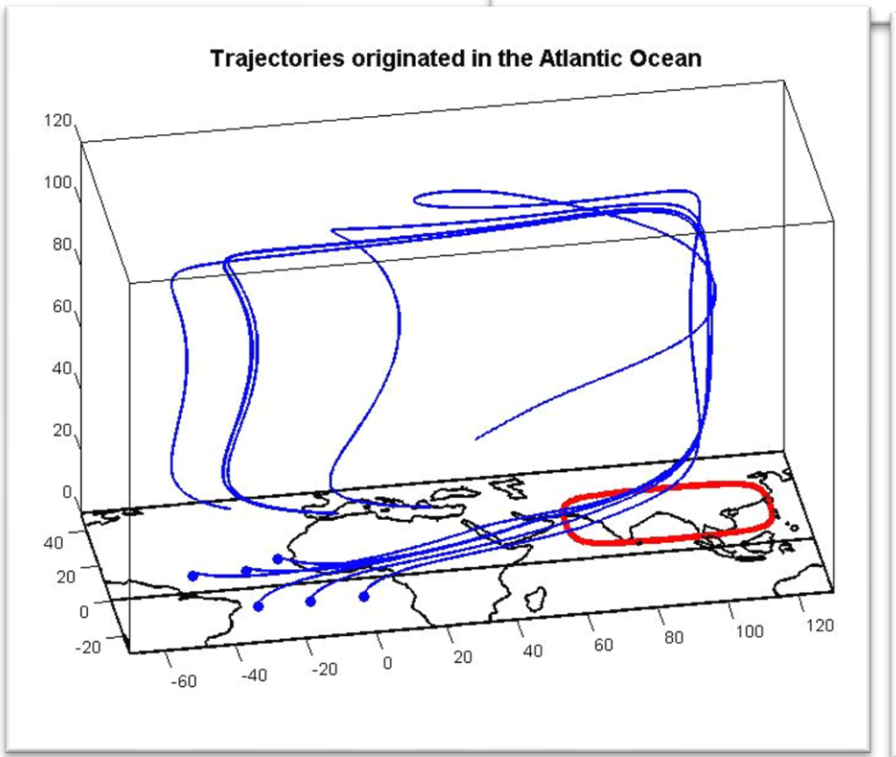


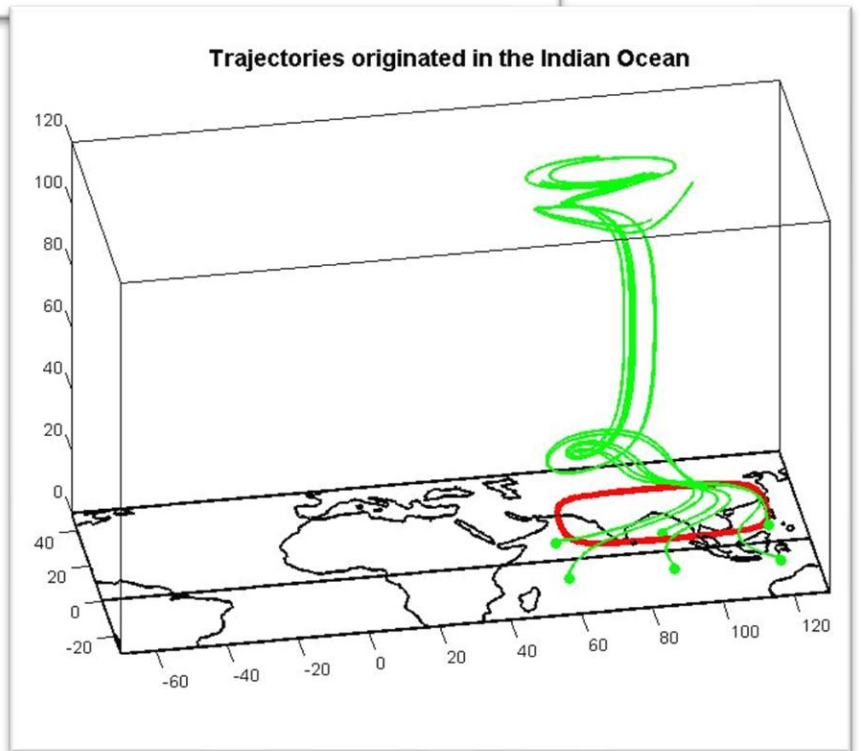
In the Indian monsoon, the **Mediterranean** air particles rise over the monsoon to subside over the Mediterranean sea and Eastern Atlantic.



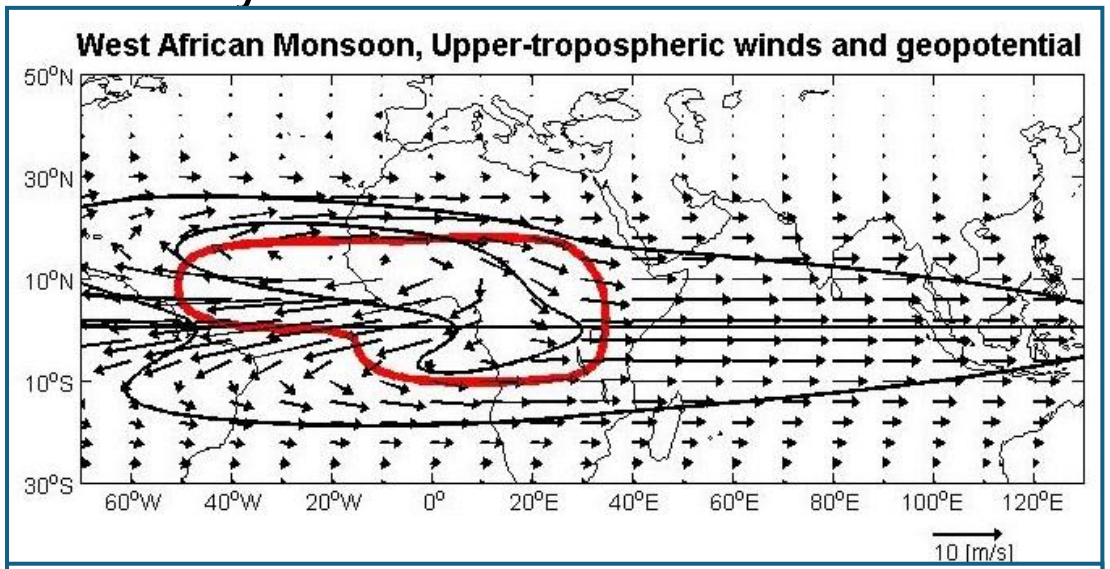
The **Atlantic** air particles subside over the Mediterranean sea and Eastern Atlantic.

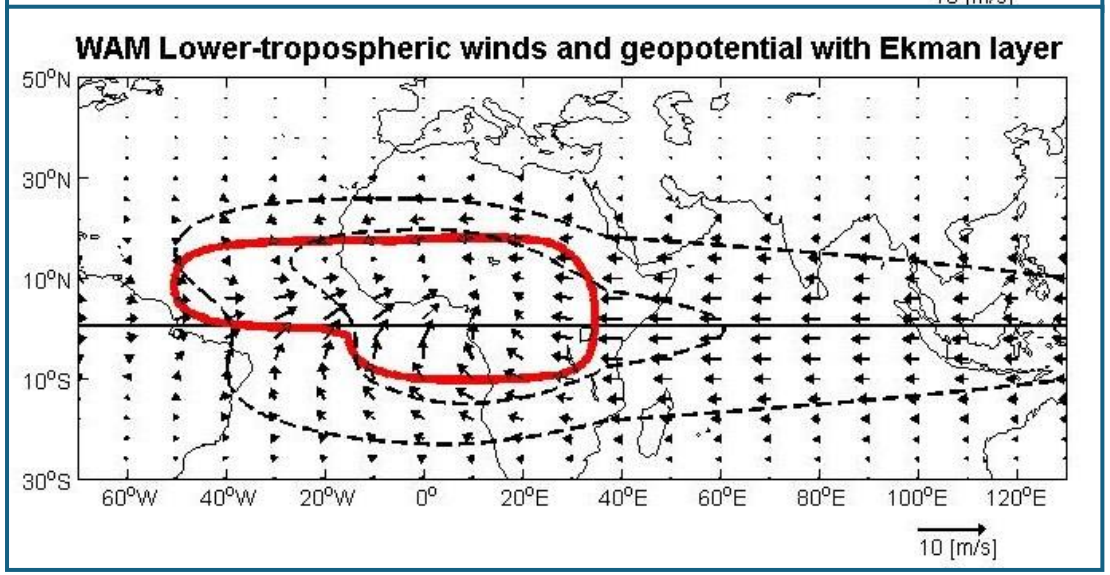
The **Indian** ocean air particles spiral up above the monsoon.

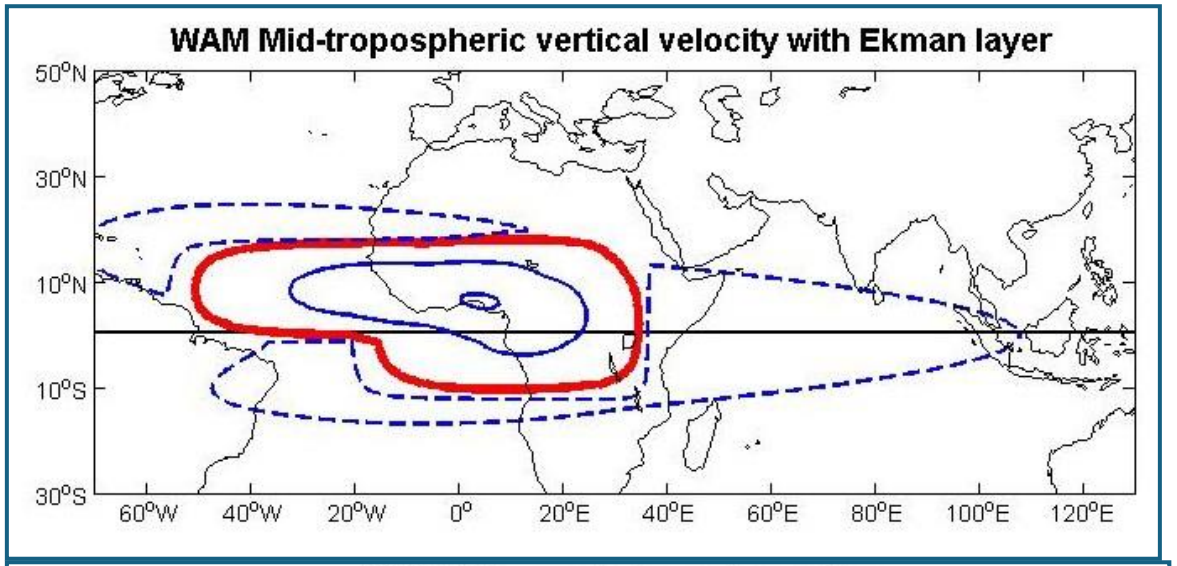


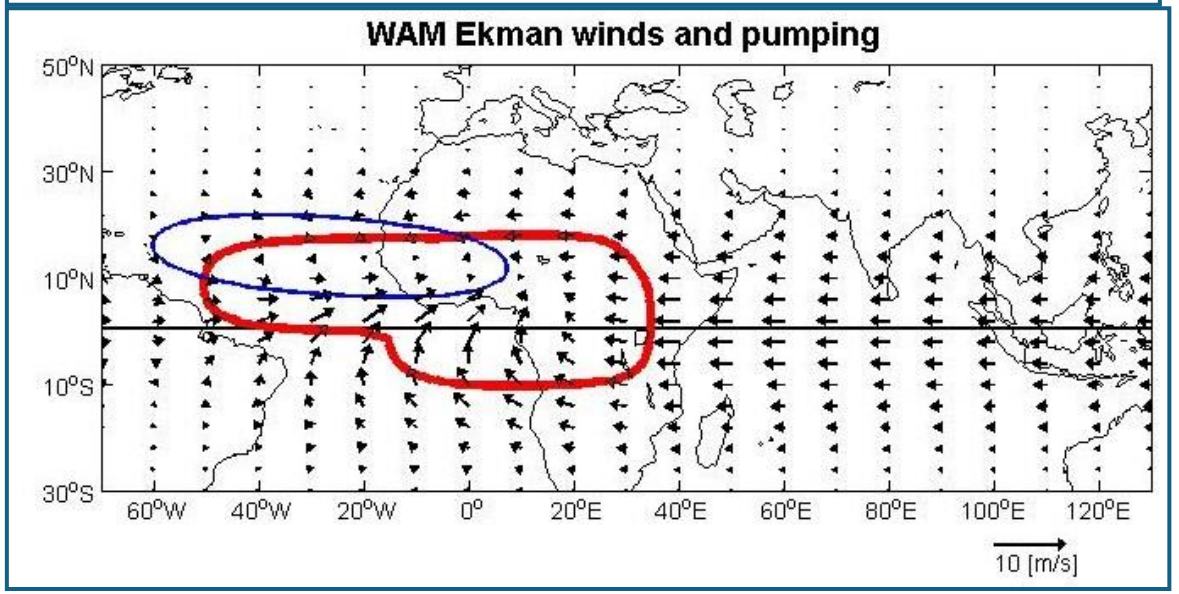


The **African monsoon** resides at a lower latitude than the Indian monsoon, thus is dominated by lower order long planetary waves and by a Walker like circulation forced by Kelvin waves.





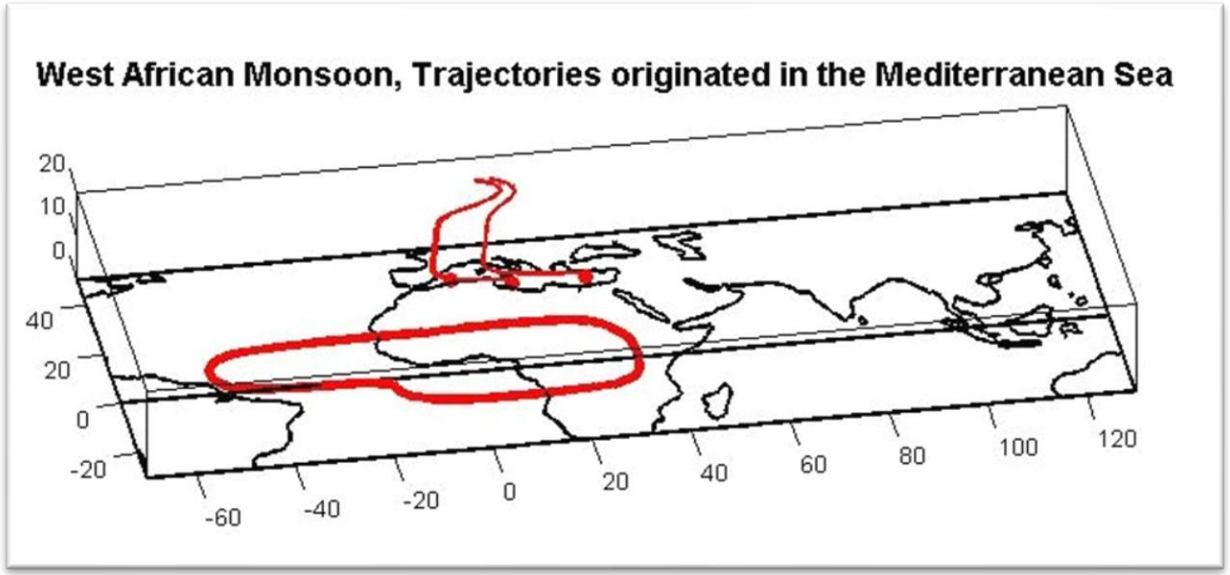


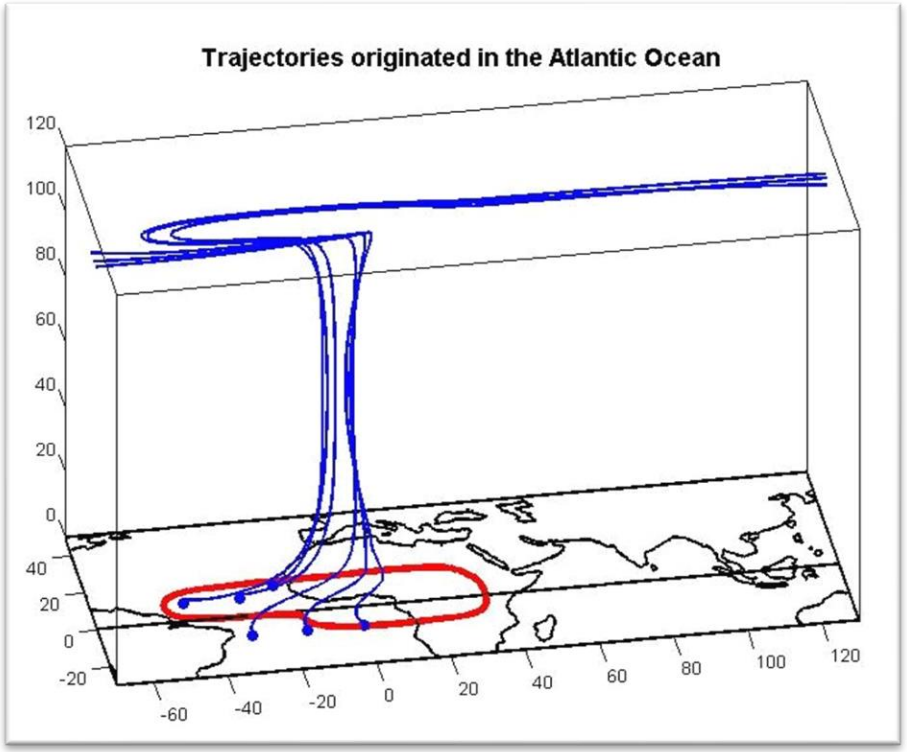


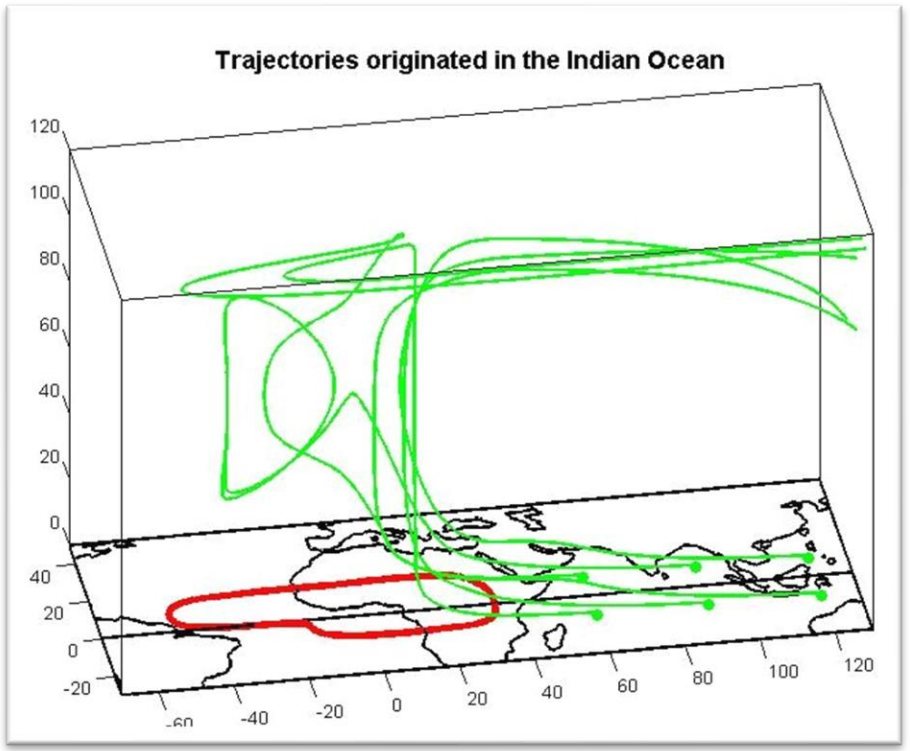
The **Mediterranean** air particles are too far north for the African monsoon.

The **Atlantic** air particles rise over the monsoon to subside far away.

The **Indian** ocean air particles are carried towards the African monsoon by the Walker like circulation forced by the Kelvin waves.



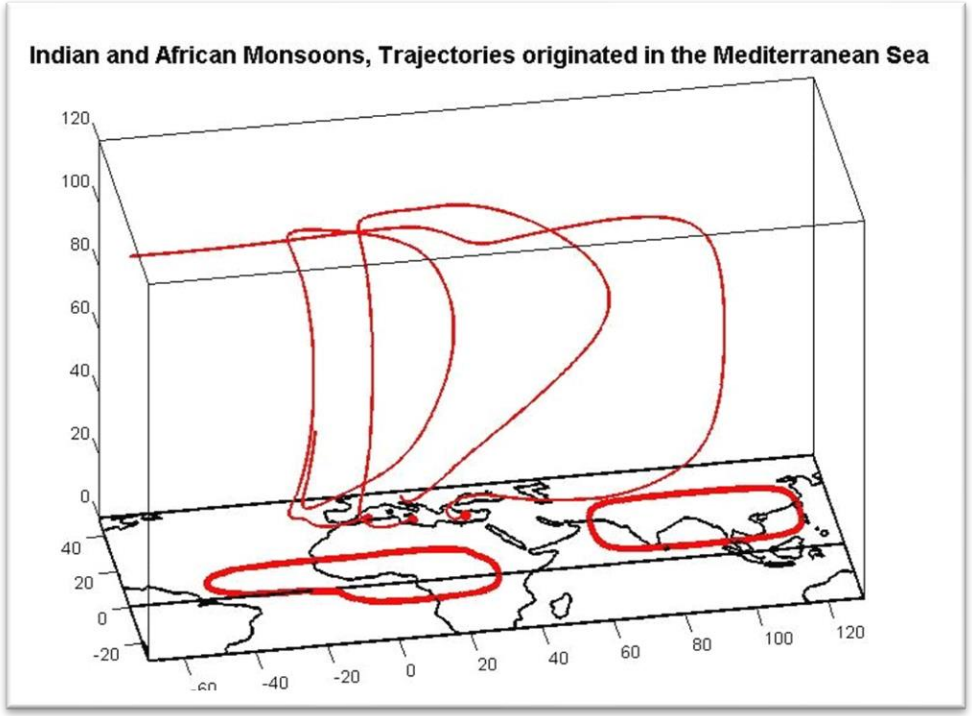


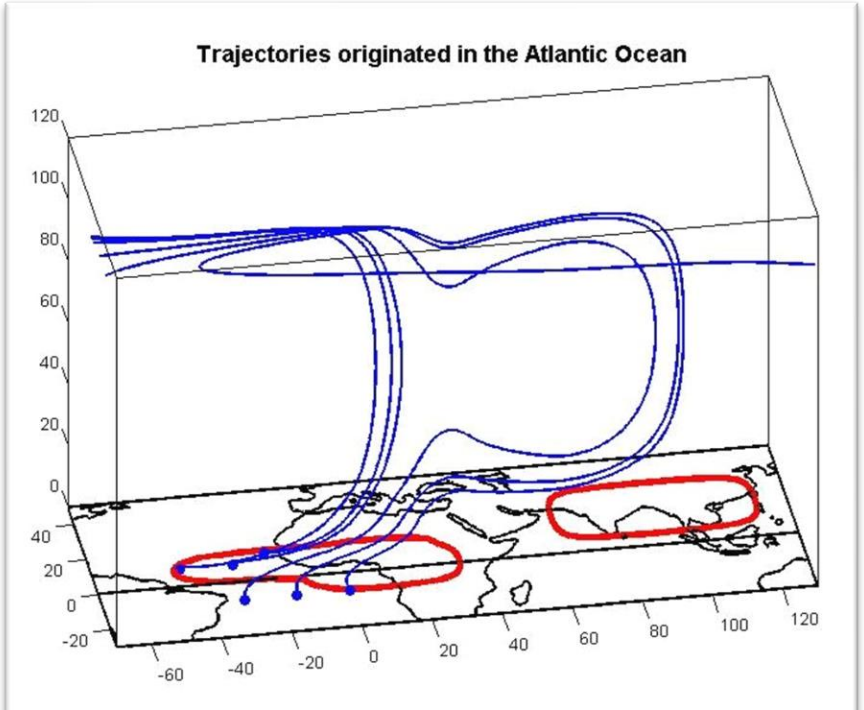


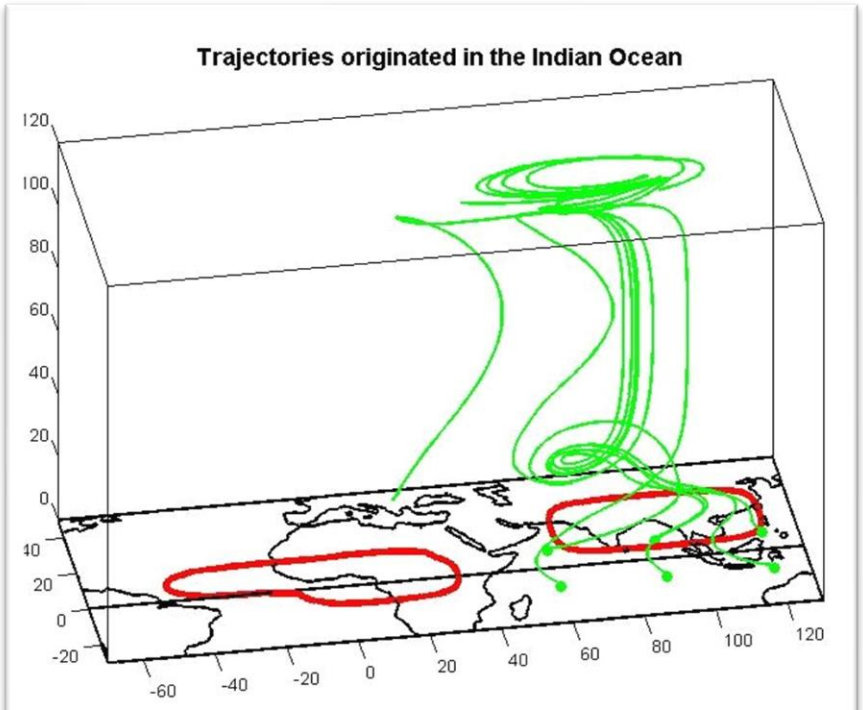
In the **Indian-African** monsoonal system, the **western Mediterranean** and the **Atlantic** air particles reach the African monsoon.

The **Gulf of Guinea** and the **eastern Mediterranean** particles reach the Indian monsoon.

The **Indian ocean** air particles spiral upwards over the Indian monsoon.

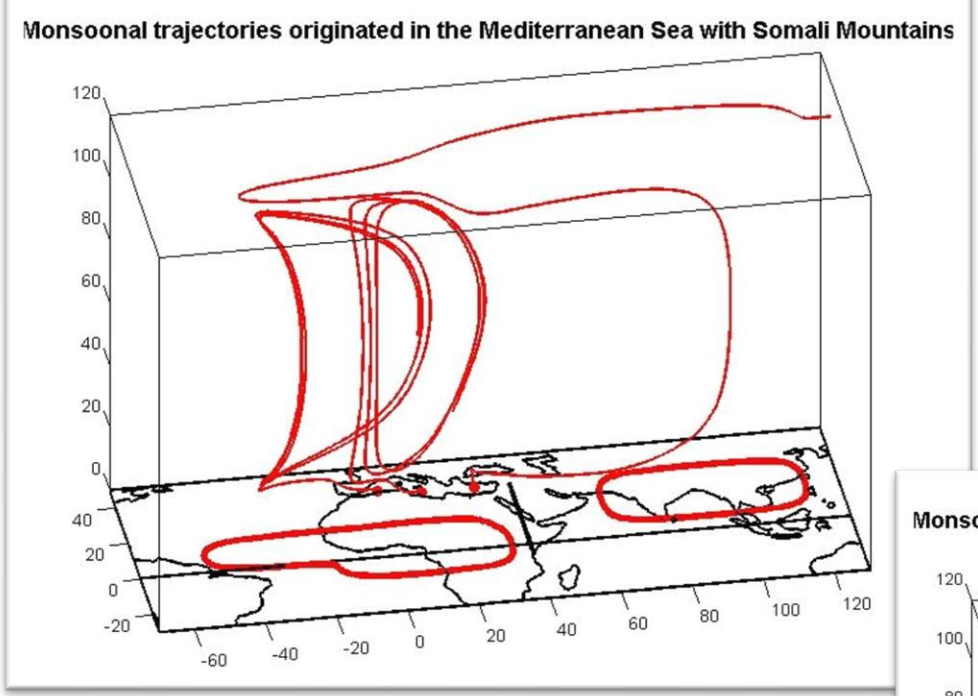


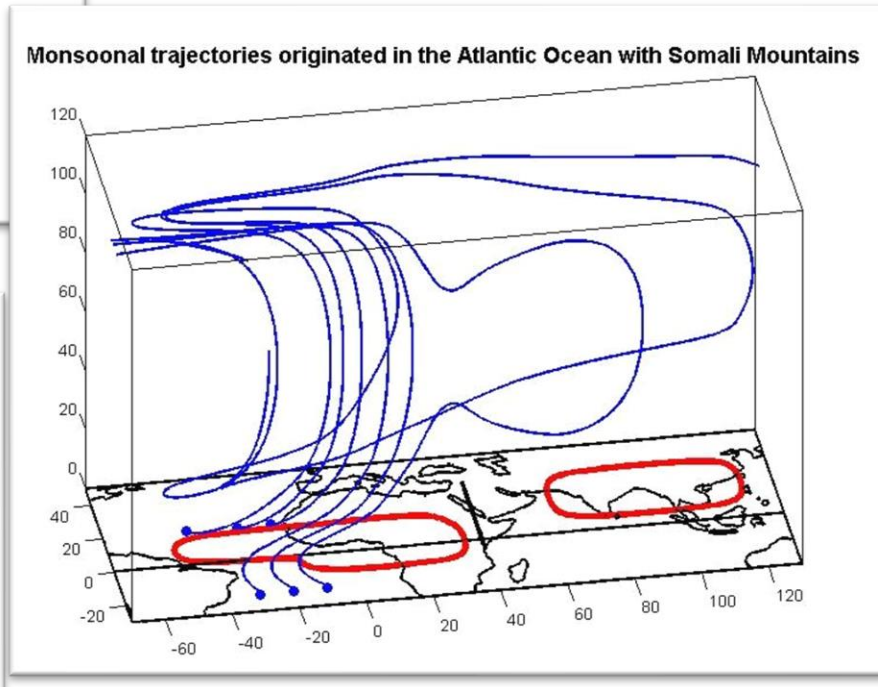


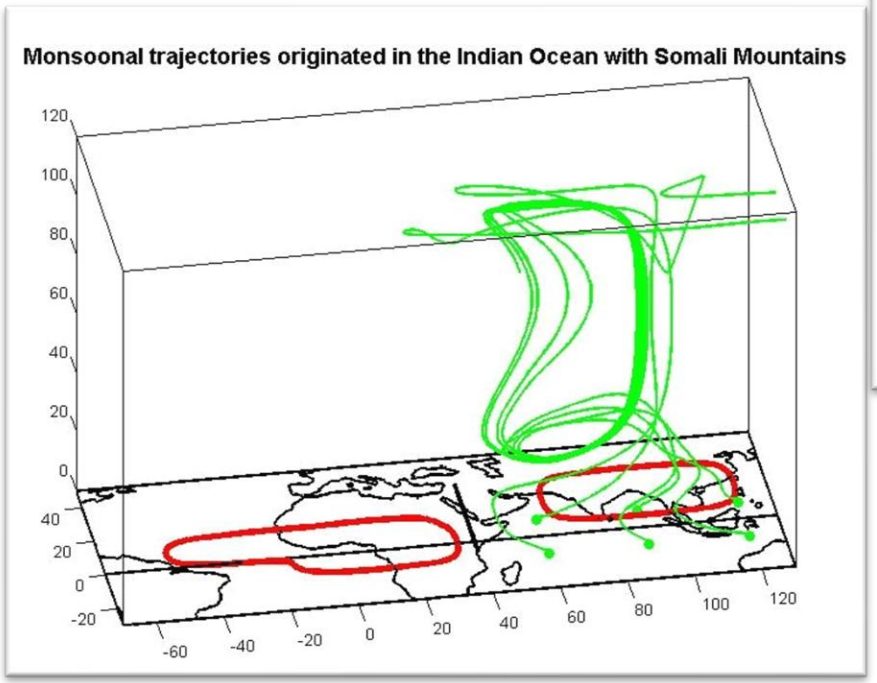


If we add the **Somali mountains** as a north-south reflecting barrier 2000 meters high, most of the Mediterranean and the Atlantic air particles reach the African monsoon.

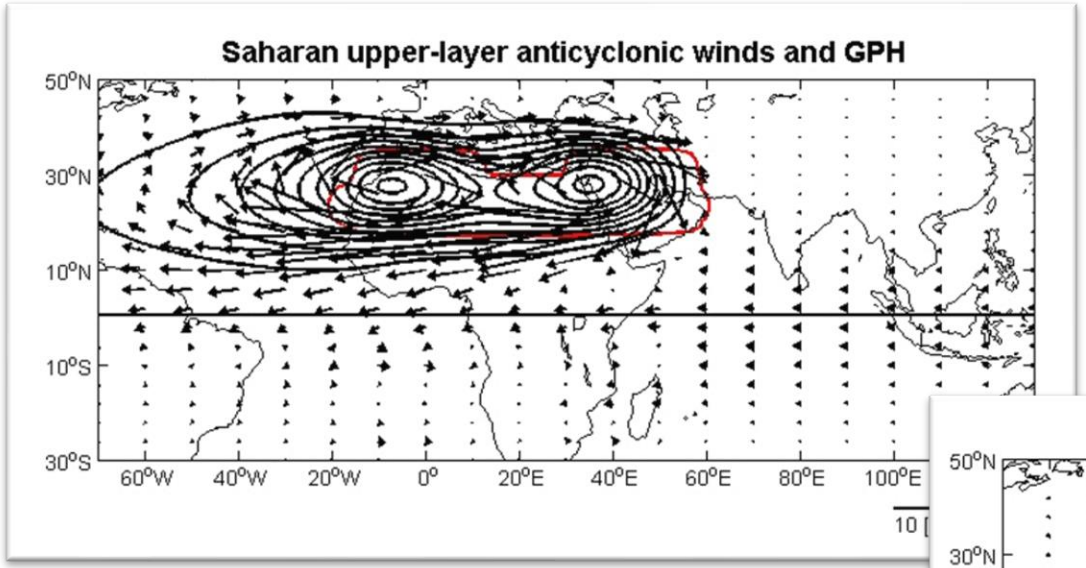
The Indian ocean air particles spiral upwards over the Indian monsoon.

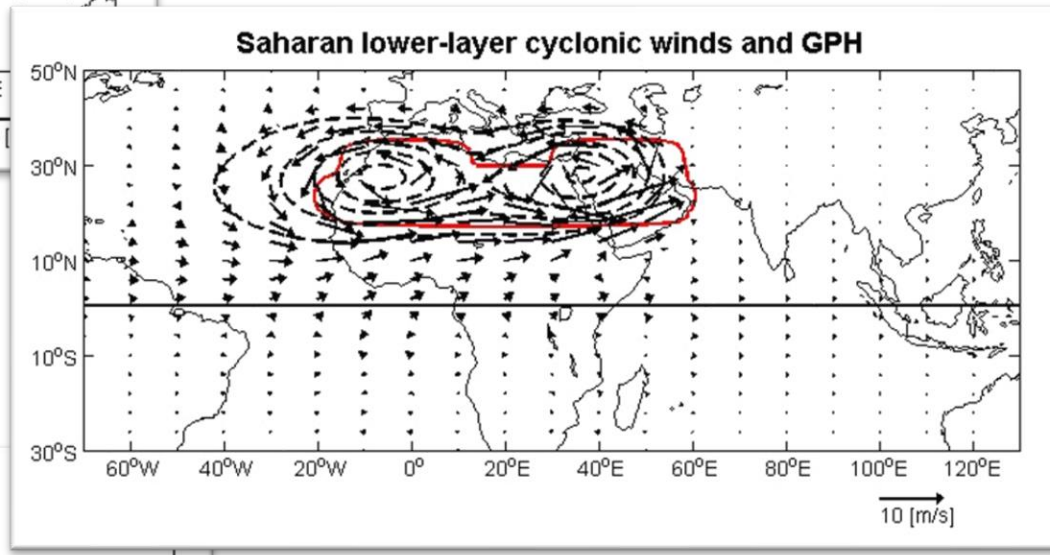


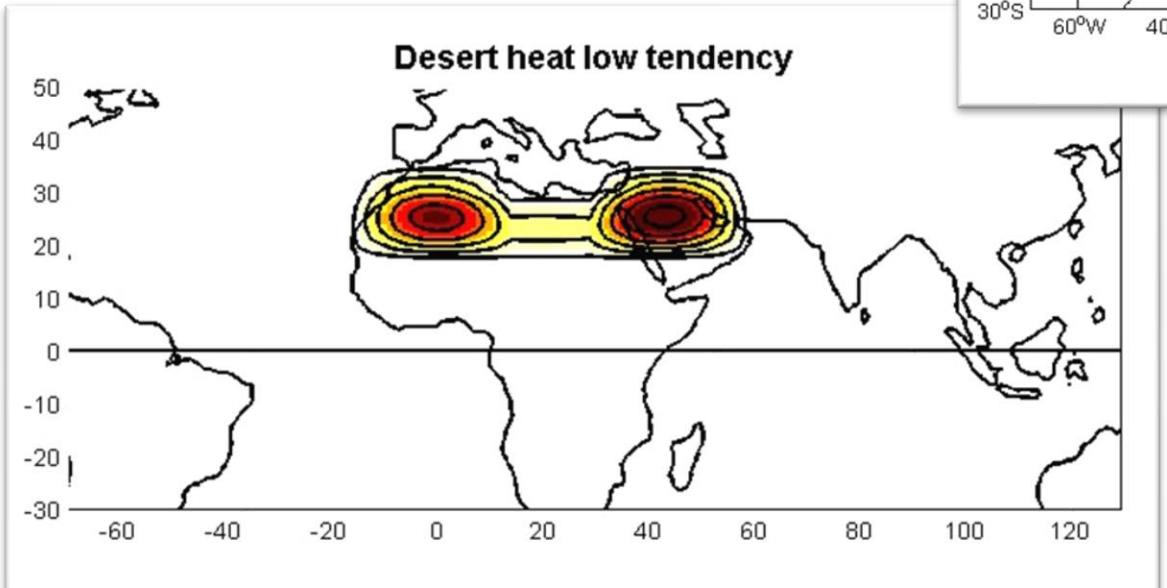




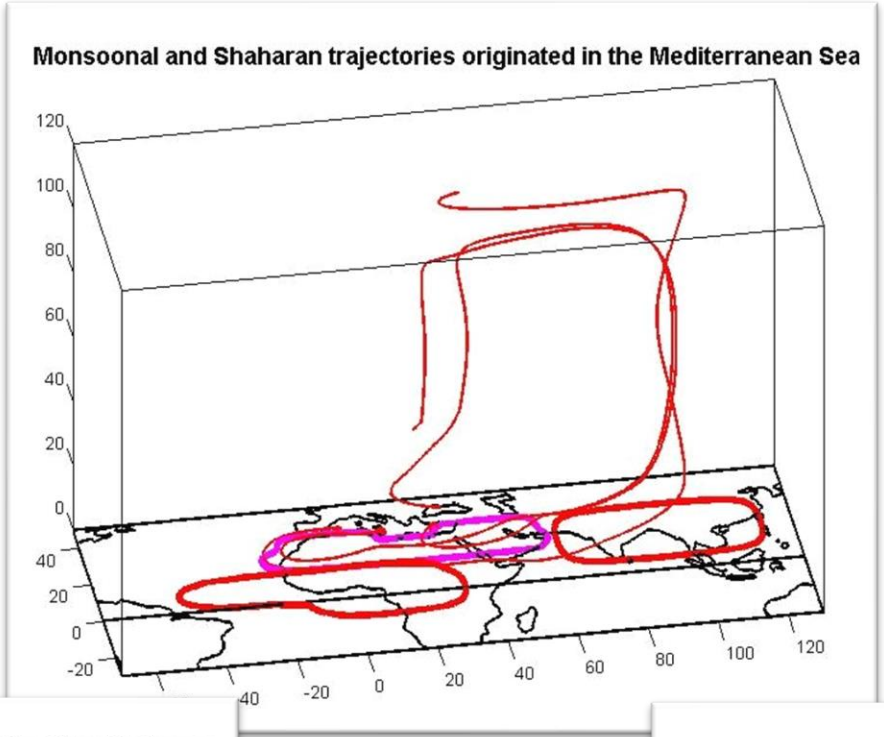
The **Sahara desert winds** are forced by the intense sensible heat which drives strong winds in the lower half of the troposphere. They are cyclonic near the surface and anticyclonic in mid-troposphere.

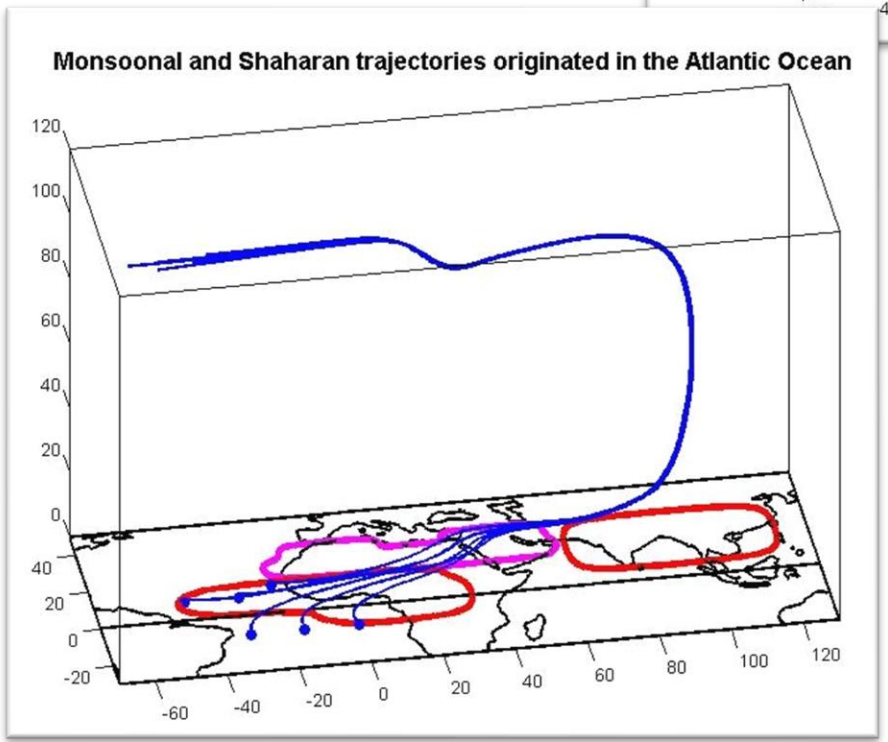


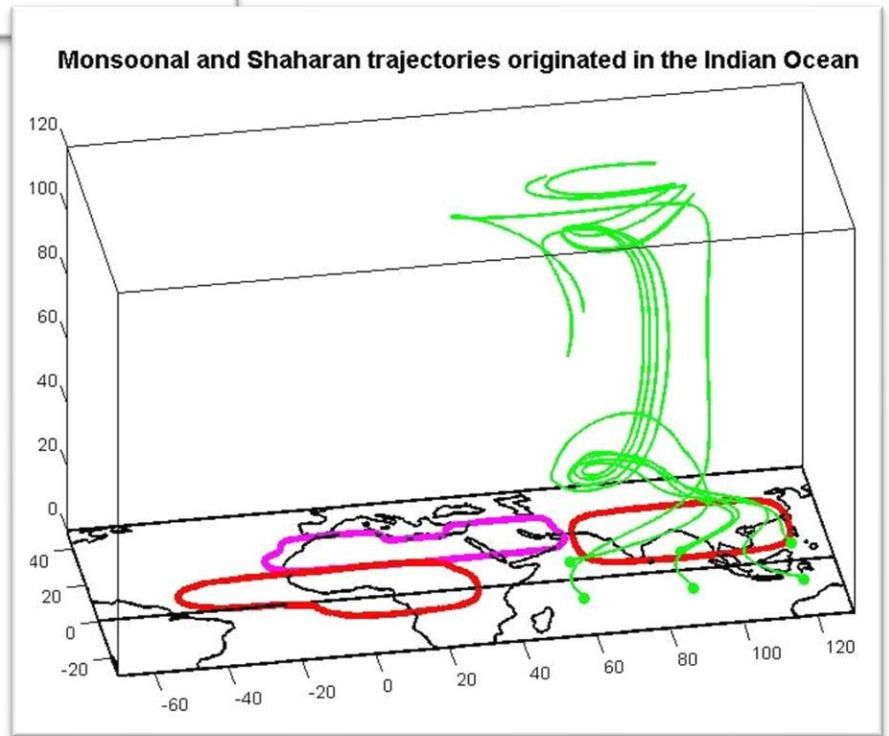




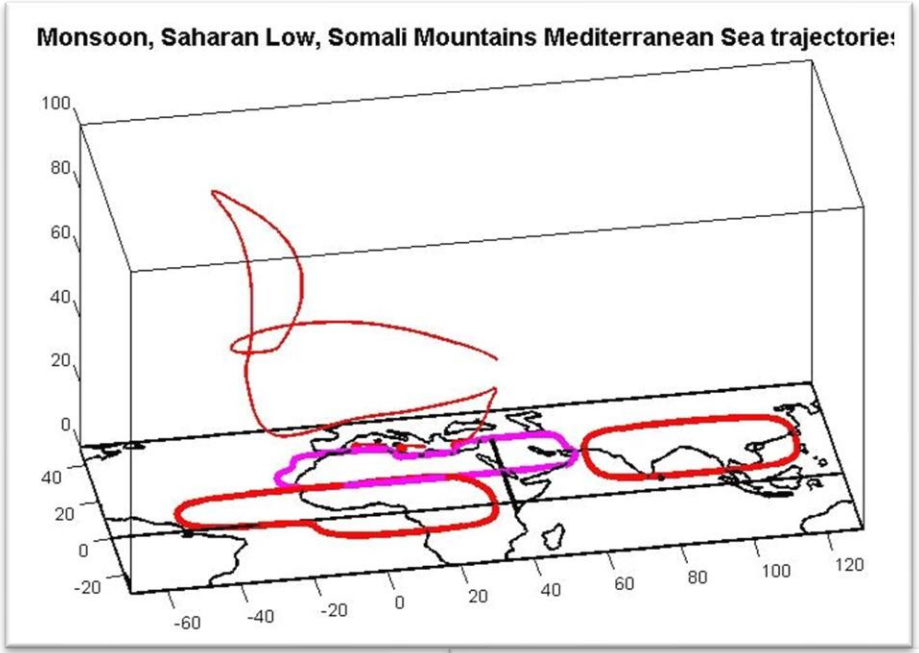
In the presence of the **desert winds**, but in the absence of Somali mountains, all the marine air particles are diverted towards the Indian monsoon.

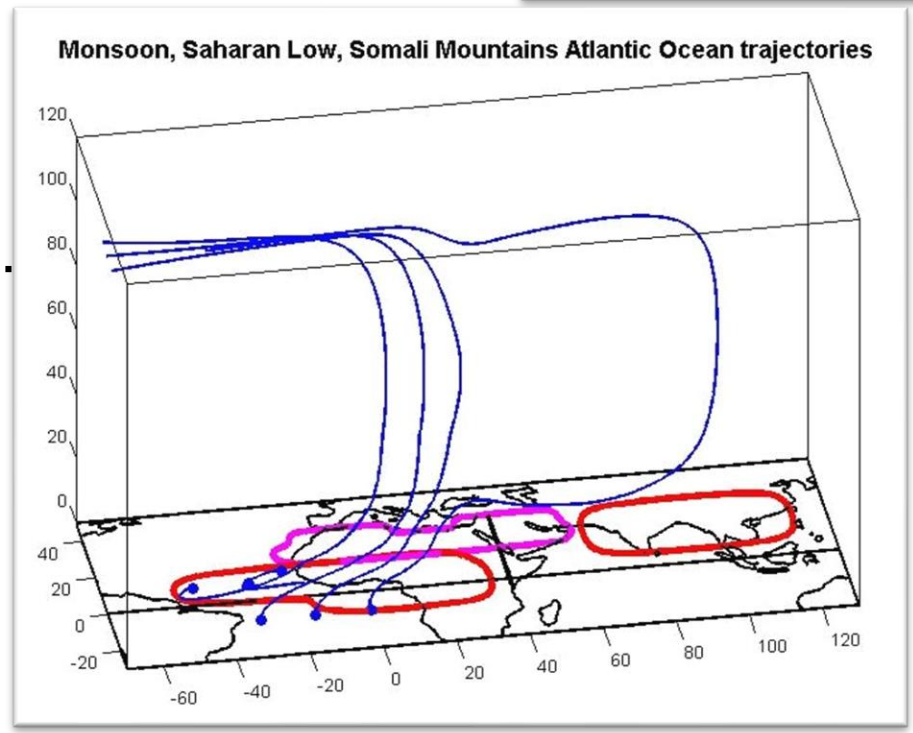


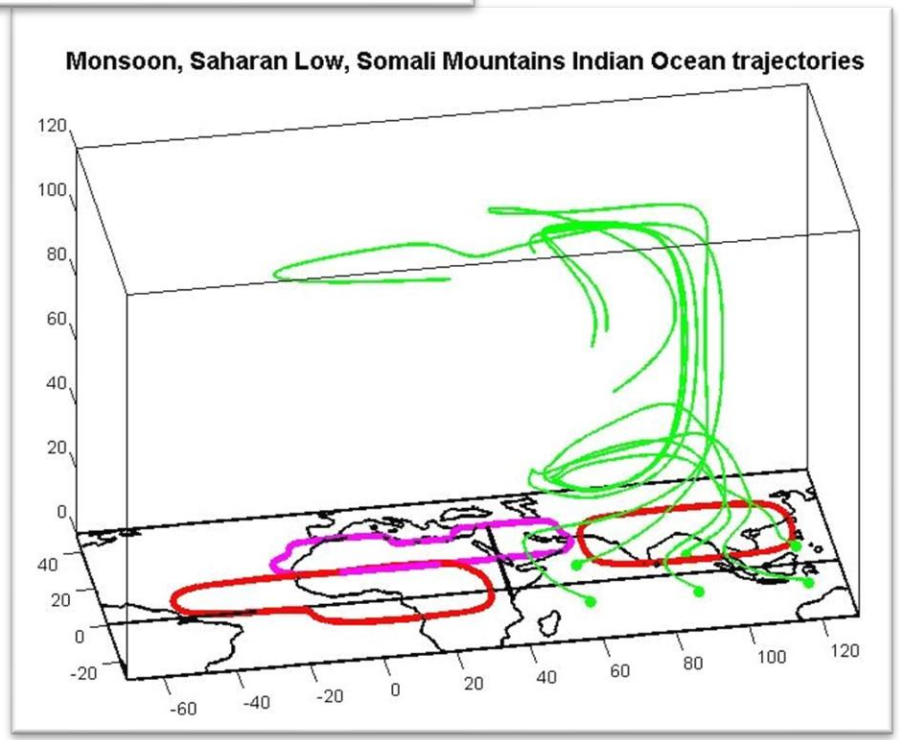




In the presence of **the desert winds and of the Somali mountains**, the Eastern Mediterranean particles and most of the Atlantic air particles reach the African monsoon.
All the Indian ocean air particles spiral upwards over the Indian monsoon.







Conclusions

The Ekman layer, the Saharan desert winds and the Somali mountains are essential ingredients of the Indian-African monsoonal system.

The Ekman pumping lifts the marine air particles from the sea surface.

The Saharan-Arabian deserts confine the African monsoon to the north and to the east.

The Somali mountains separate the African monsoon from the Indian monsoon in the low atmospheric level, but the two monsoons are still connected in the upper troposphere.

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