3rd MedCyclones Workshop 2024

ESA – ESRIN

Frascati (Rome), Italy

Geometrical Properties and Cloud Types during Mediterranean Cyclones using decadal dataset

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Motivation

- Methodology
- Overview and Statistics above the Mediterranean
- Mediterranean Cyclone representation based on the clouds classification
- Cloud Fraction and Cyclogenesis
- Cloud Tops during Mediterranean cyclones
- Next steps

MOTIVATION

- Clouds affect Earth's energy budget, climate system and weather intensely.
- Different cloud types have different radiative effects.
- GCMs’ fail to correctly describe cloud albedo and ice content in clouds.
- Eastern Mediterranean is a climate “hot-spot” with large variability of cloud systems.
- Increasing trend of the intensity of the Mediterranean cyclones.

Necessity of :

- Insight to clouds’ patterns not only from a dynamical approach but also from a microphysical perspective.
- Retrieval of clouds vertical distribution.
- Climatological study of the cloud characteristics during Mediterranean Cyclones.
- Study of the mechanisms of the deep convective clouds formation.

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METHODOLOGY

- Data analysis of **CloudSat 94-GHz Cloud Profiling Radar (CPR)** & **CALIPSO Cloud/Aerosol Lidar**

- Spatial Resolution:
  - CPR: 1.4 km cross-track | 1.7 km along-track | 500 m vertical
  - CALIPSO: 1.0 km horizontal | 60 m vertical

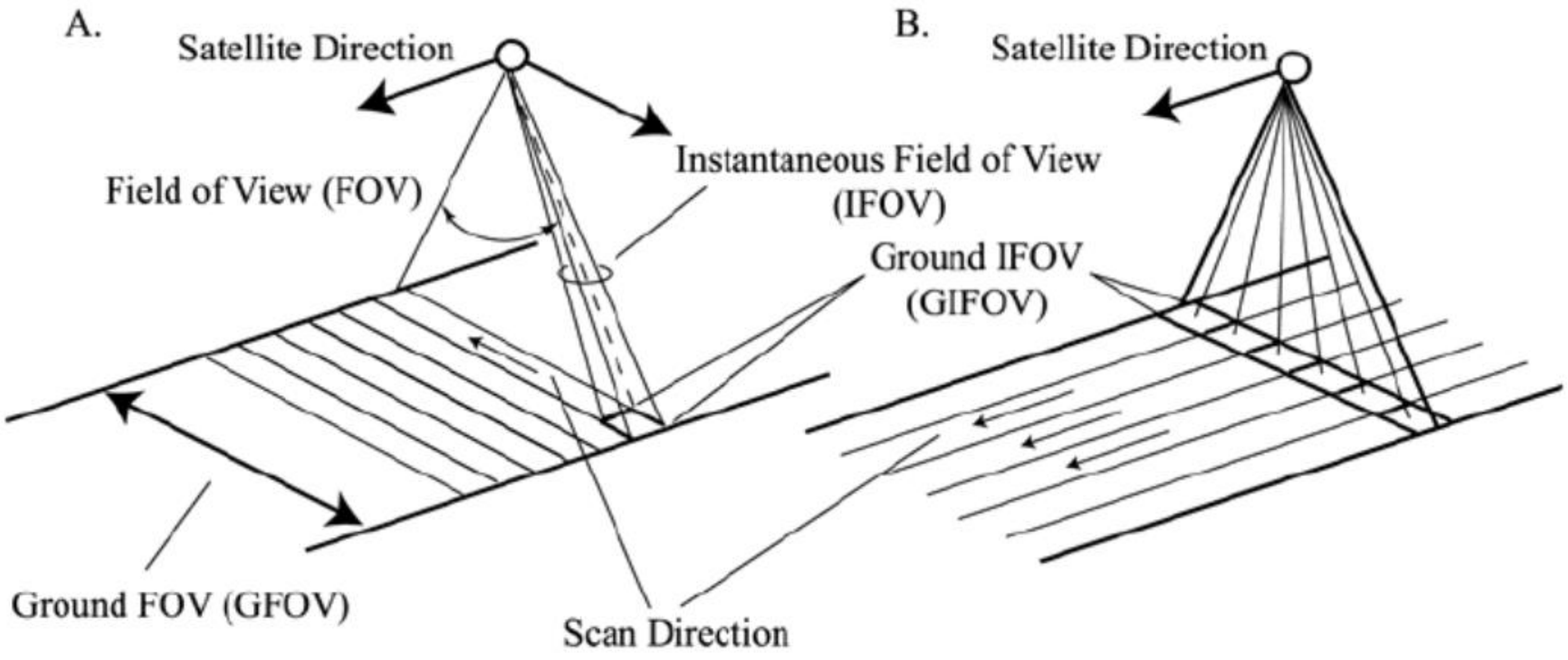

*Figure 1. Cross-track **(A)** και Along-track **(B)** (Brown et al. 2005)*

METHODOLOGY

- Temporal Resolution: **January 2007 – December 2017**
- **Every 16 days** (only day measurements after 2011)

- Region: 1. Mediterranean basin
  2. Path of Mediterranean Cyclones for 5 cases

- 2B – GEOPROF for clouds detection
  - Cloud Mask (**≥ 30** → cloud)
  - Radar Reflectivity (dBZe)

- 2B – CLDCLASS – LIDAR for clouds classification
  - Cloud Top height (km)
  - Cloud Base height (km) (Surface – 25 km)
  - Cloud Type (8 categories)

high	Cirrus & Cirrostratus
As	Altostratus
Ac	Altocumulus
St	Stratus
Sc	Stratocumulus
Cu	Cumulus (and cumulus congestus)
Ns	Nimbostratus
deep	Deep Convective (Cumulonimbus)

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OVERVIEW

- 29˚N– 47˚N, 11˚W– 40˚E

West Med	Central Med	East Med
34.9˚N – 44.5˚N 5.5˚W – 9.2˚E	30.2˚N – 45.9˚N 9.2˚W – 19.7˚E	30.2˚N – 41.2˚N 19.7˚W – 36.2˚E

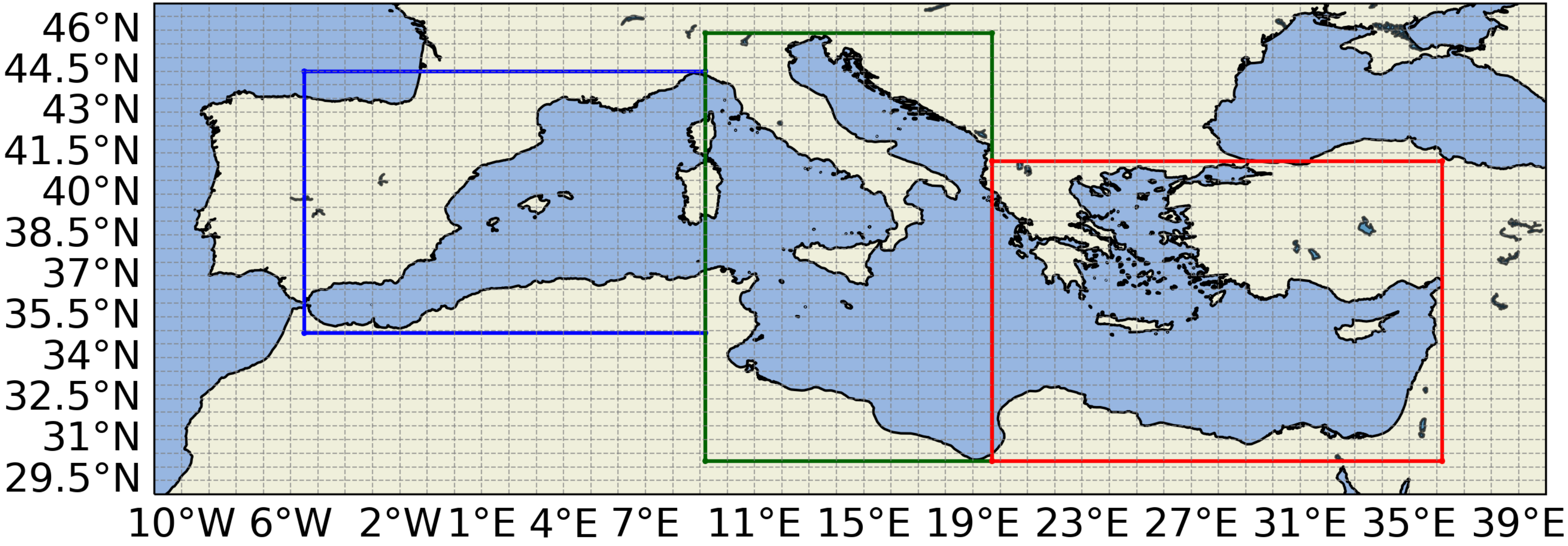
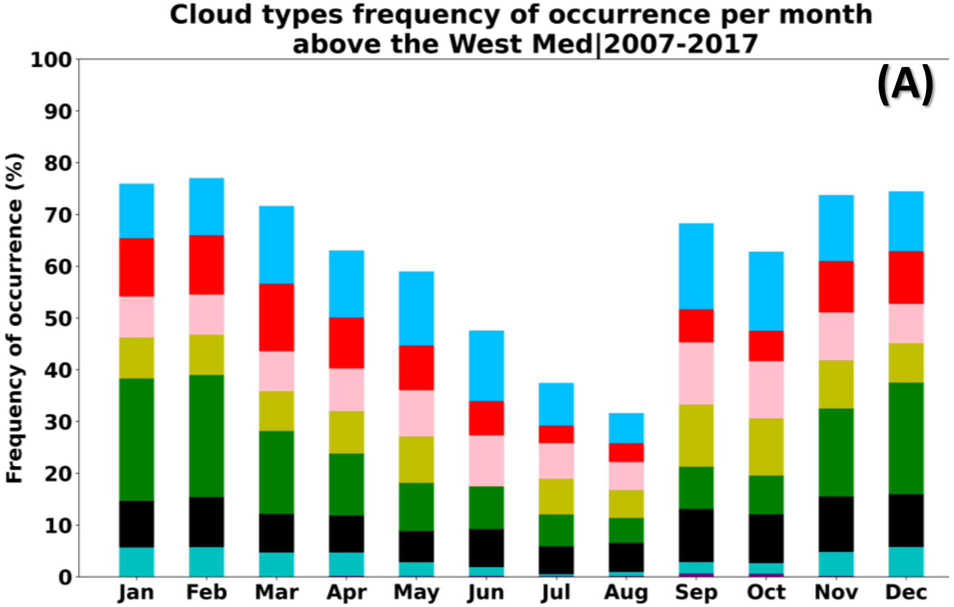


Figure 2. The regions selected for cloud data analysis

STATISTICS ABOVE THE MEDITERRANEAN AND CLOUD CHARACTERISTICS



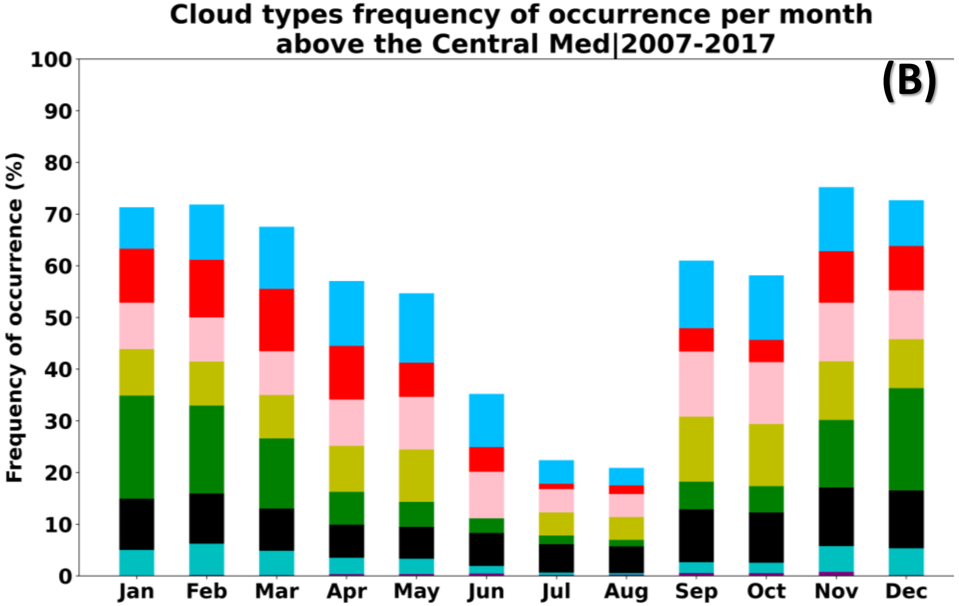
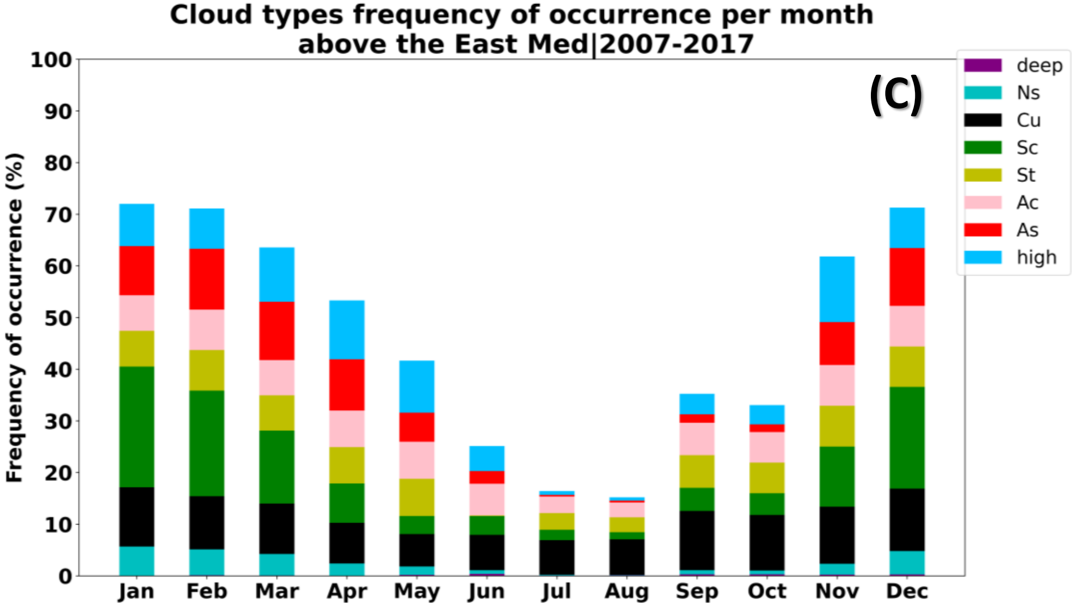


*Figure 3. Frequency of occurrence of different cloud types above West **(A)**, Central **(B)** and East **(C)** Mediterranean.*



- West Med.: Max frequency of occurrence during winter
- East Med.: Min frequency of occurrence during summer
- More differences during autumn
- Similarities between West and Central Med

VERTICAL DISTRIBUTION OF THE CLOUD TYPES ABOVE THE MEDITERRANEAN

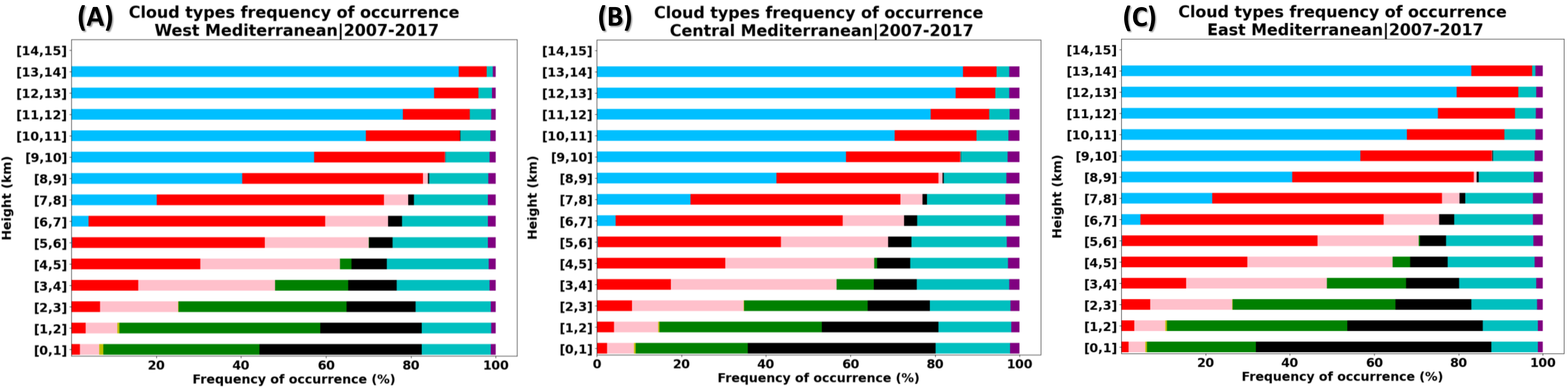


*Figure 4. Normalized vertical distribution of the cloud types above the West **(A)**, Central **(B)** and East **(C)** Mediterranean.*

- More Deep Convective clouds and Nimbostratus above the West and Central Med.
- More Cumulus above the East Med.

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QENDRESA

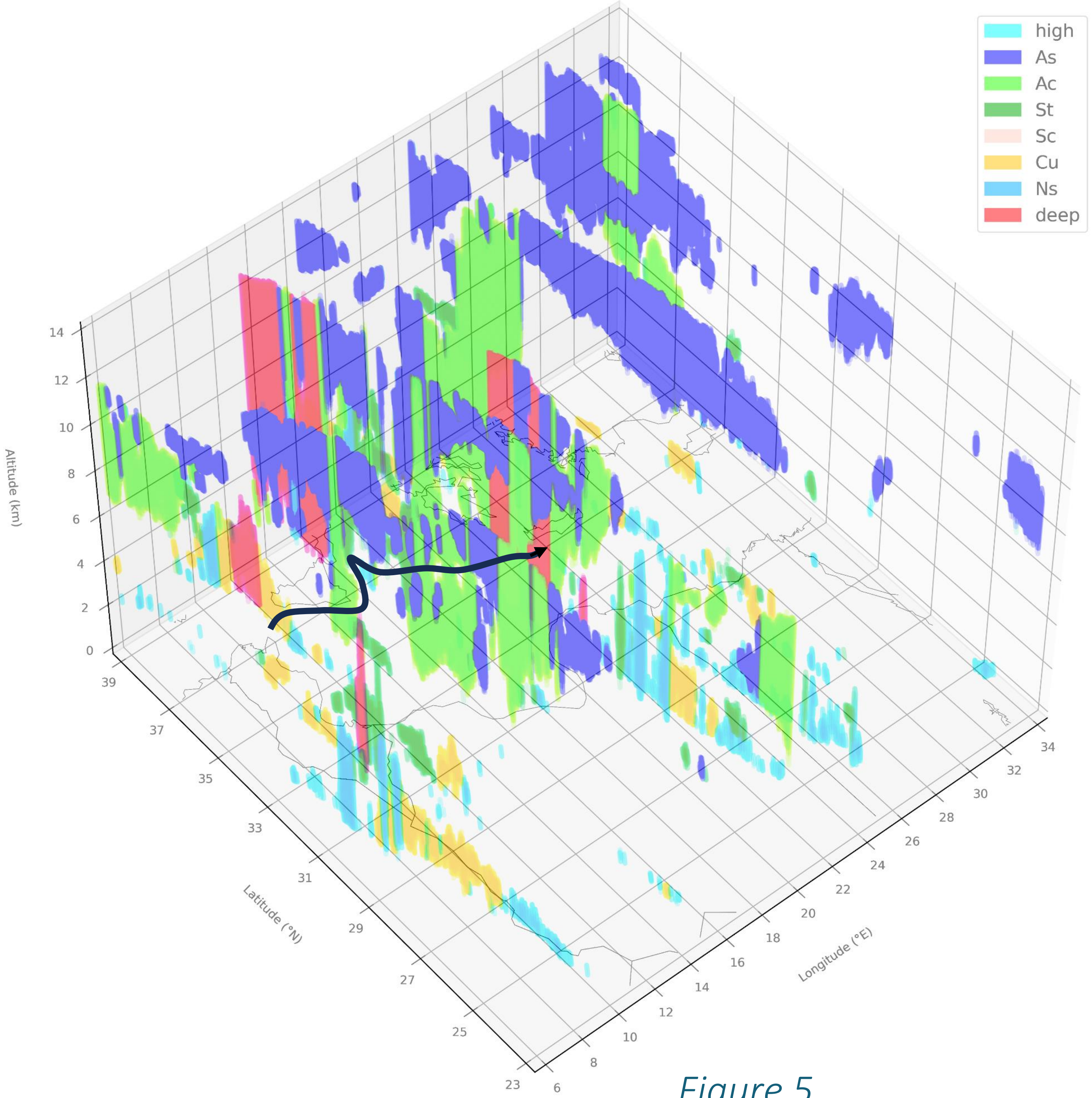

Figure 5.

QUERIDA

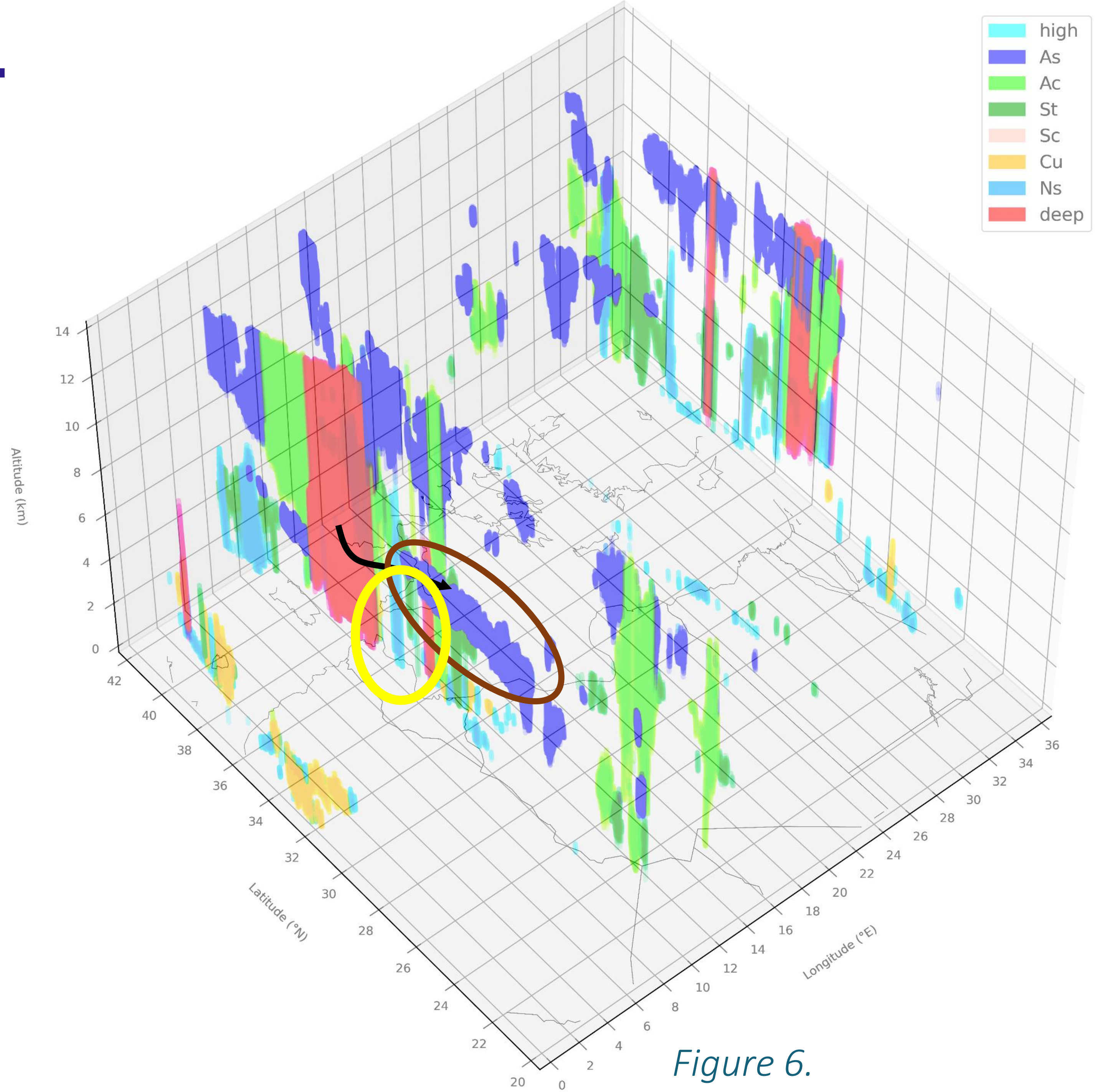

Figure 6.

NUMA

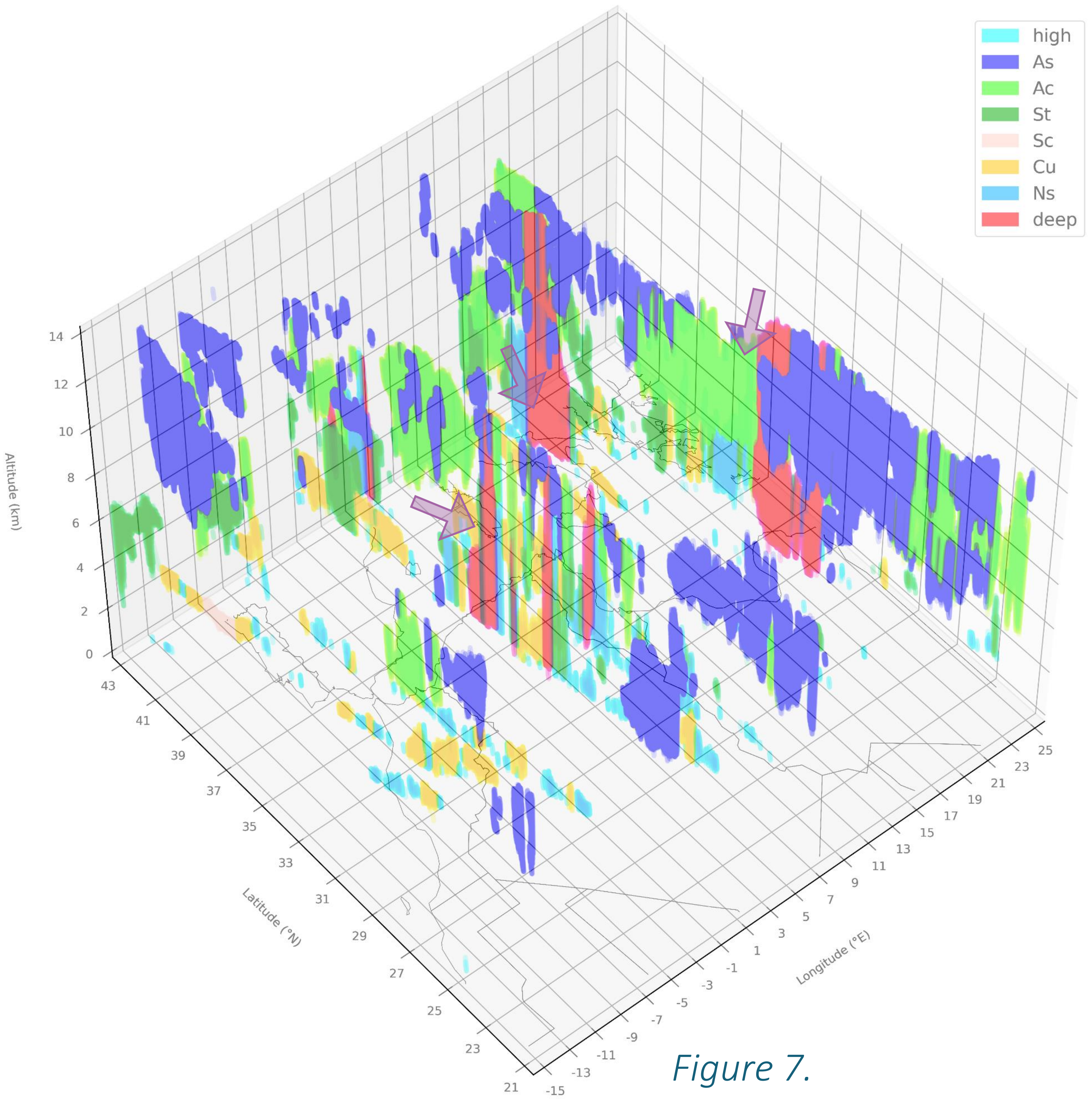

Figure 7.

TRIXI

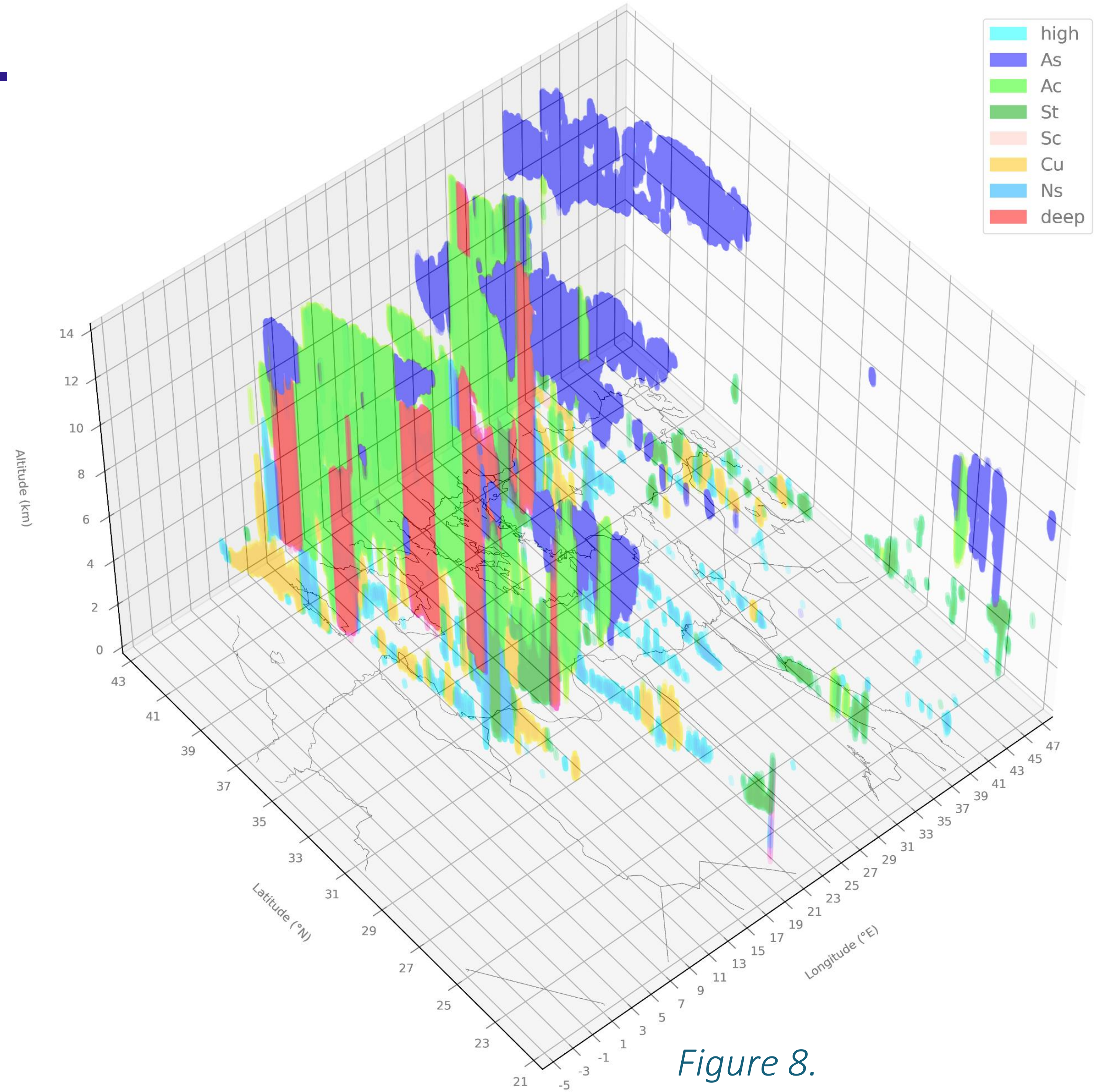

Figure 8.

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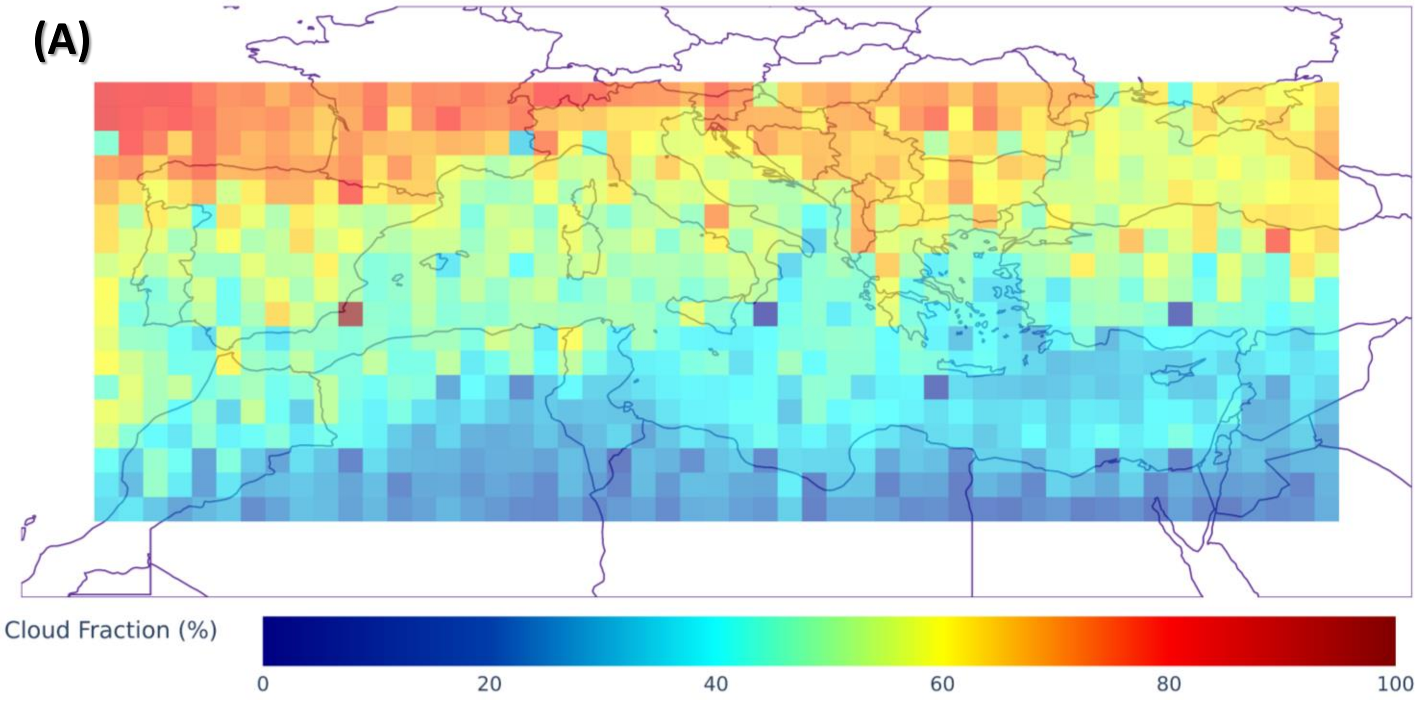
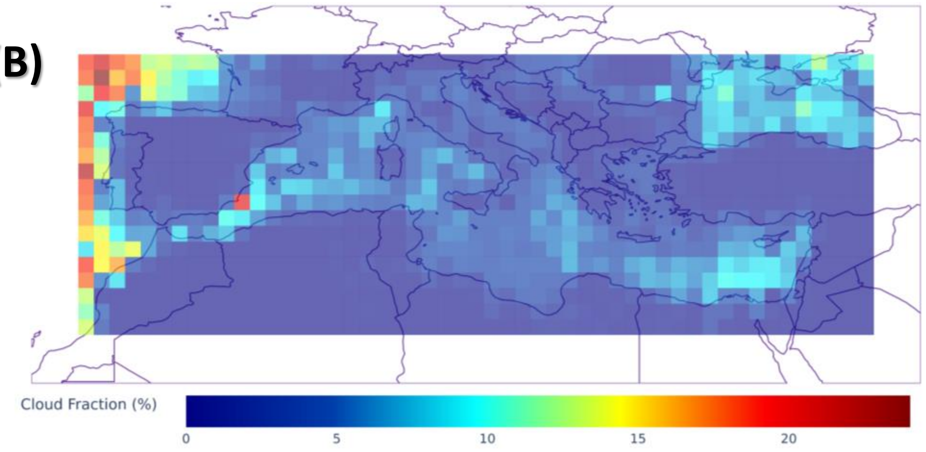
CLOUD FRACTION

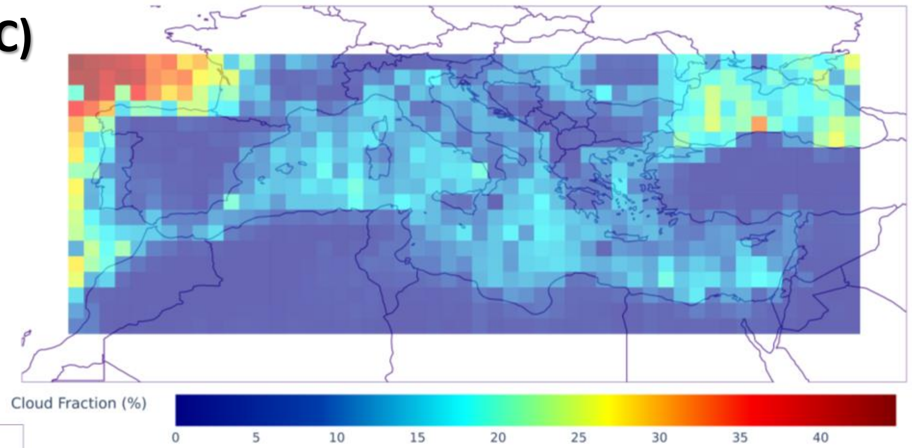
(A)



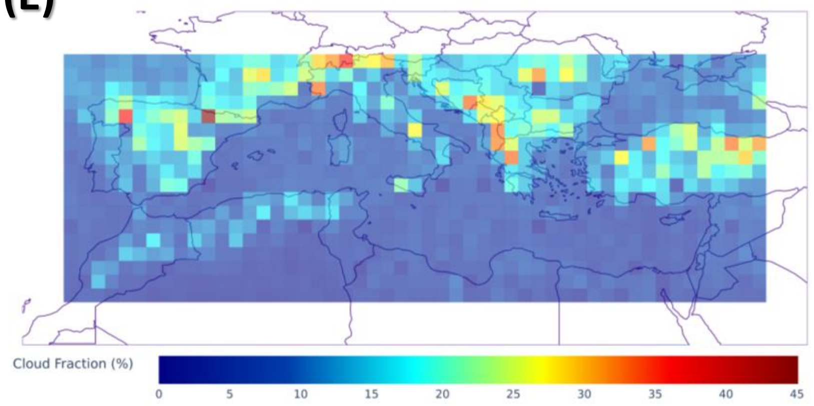
(B)



(C)



(E)



(D)

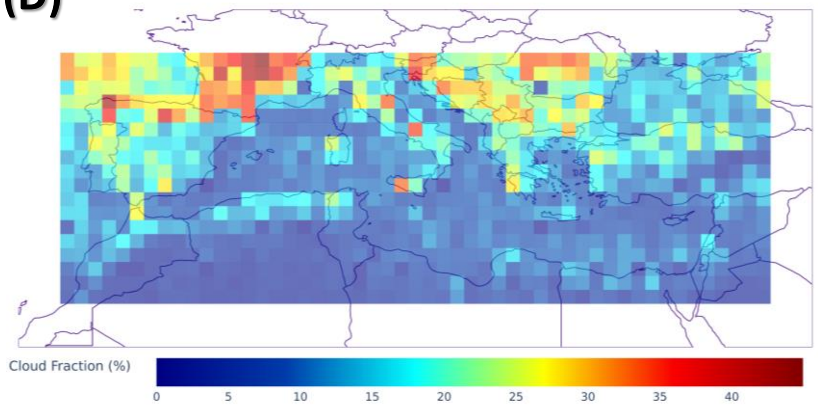


*Figure 9. Cloud Fraction **(A)** surface up to 25 km, **(B)** surface up to 0.5 km, **(C)** 0.5 – 1.0 km, **(D)** 1.0 – 2.0 km, **(E)** 2.0 – 3.0 km*

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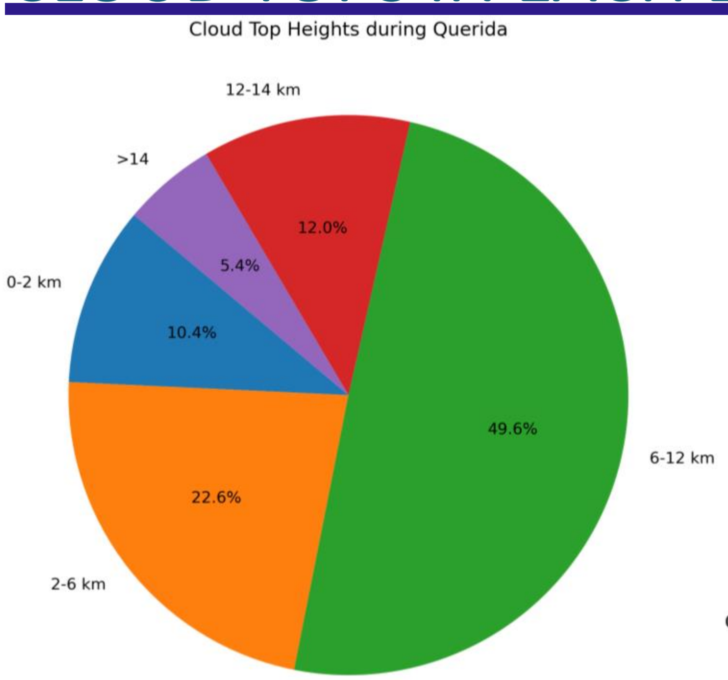
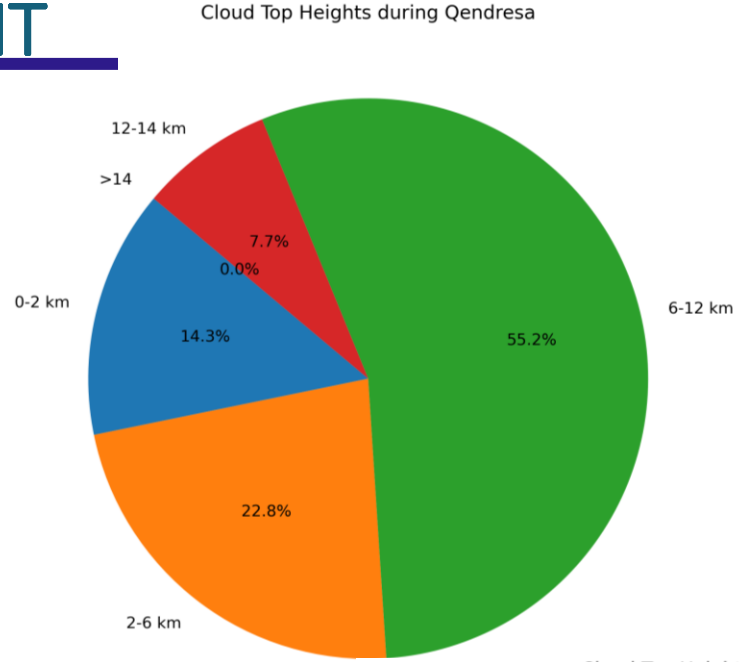
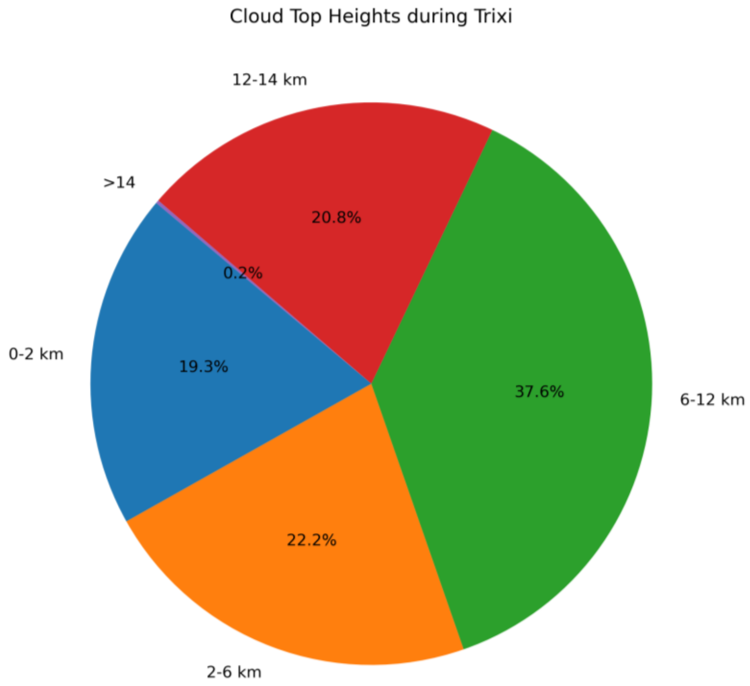
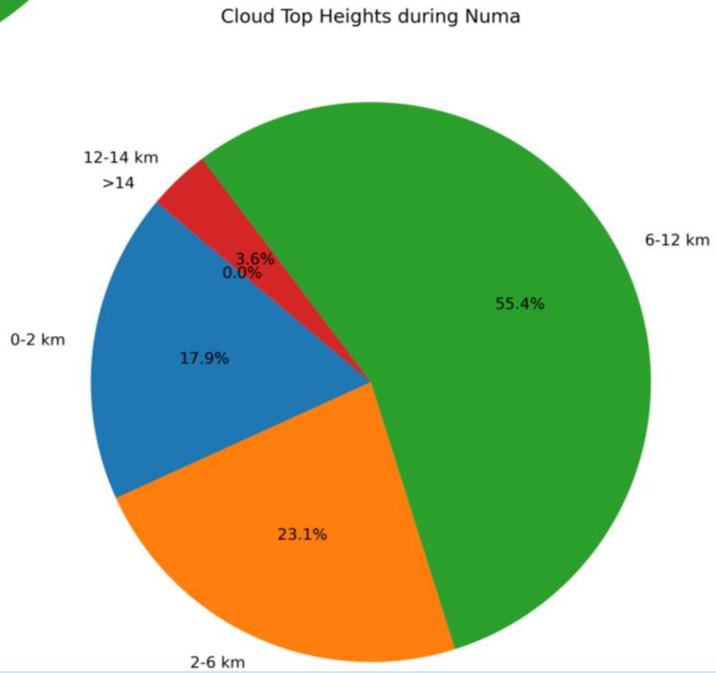
CLOUD TOPS IN EACH EVENT









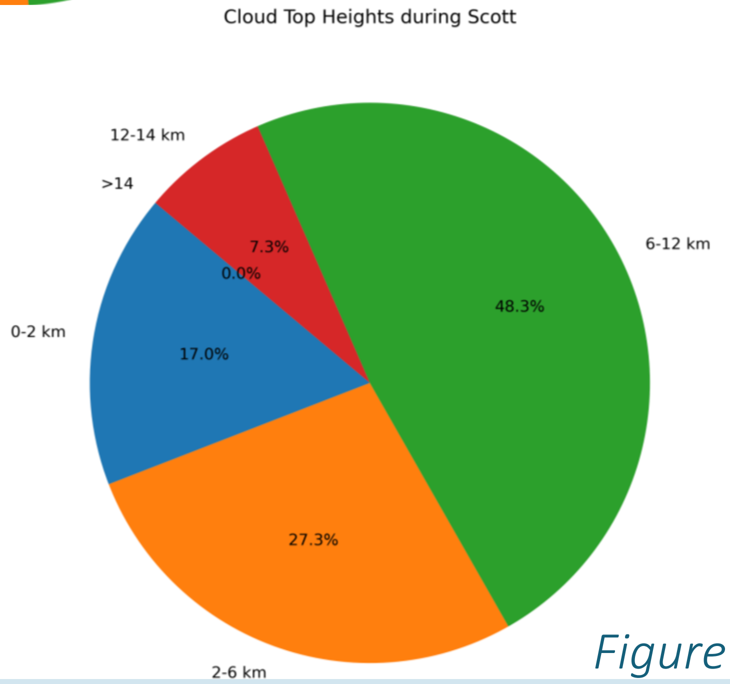


Figure 10.

CLOUDS BASES & TOPS

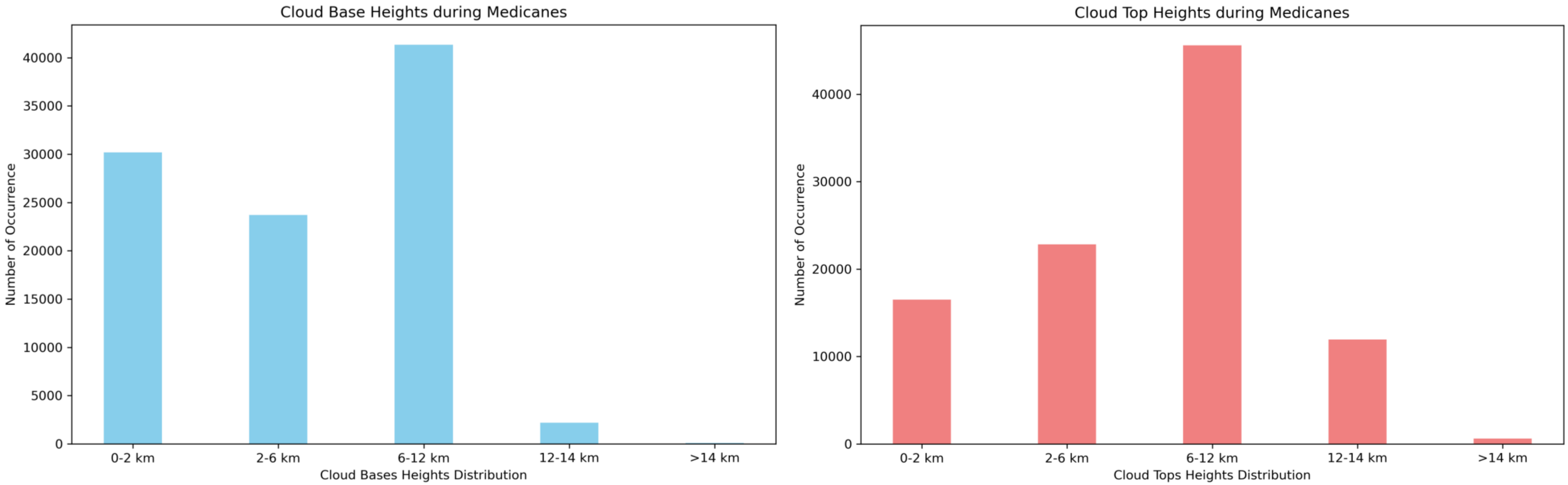


Figure 11.

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CONCLUSIONS

1. Ac & As mostly present indicating frontal structure
2. Cu & Ns before medicane forming
3. Deep Convective Clouds around the core

1. Only a slice / curtain of observations → only general structure
2. Not enough overpasses
3. Severe attenuation during convective systems
4. Not enough sampling

5. Space-borne measurements are more accurate than ground-based data during medicanes (lidar get wet and radar and microwave radiometer reaches attenuation at 1 km)
6. Most of the convective shells are observed above sea, where we do not have ground-based measurements

NEXT STEPS

1. Compare our results with the regional and global models' outputs
2. Use the EarthCARE's CPR products for retrieving more cloud properties
3. Retrieve the wind profiles using radar datasets (Doppler velocity) during Mediterranean cyclones and understand updrafts
4. Study the impact of the aerosols in the Mediterranean in the clouds formation
5. Compare our cloud statistics with ground-based measurements
6. Climatological study of clouds characteristics during Mediterranean Cyclones
7. Correlate the lightning events with the intensity and cloud thickness of the medicanes

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Thank you

Time for questions

16-05-2024 | 17:41 | Mont Saint Michel,
Normandy, France

REFERENCES

1. Brown, Christopher & Connor, L.N. & Lillibridge, John & Nalli, Nicholas & Legeckis, R.V.. (2005). An introduction to satellite sensors, observations and techniques.
2. Sassen, K., Z. Wang, and D. Liu, (2008) Global distribution of cirrus clouds from CloudSat/Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) measurements, J. Geophys. Res., 113, D00A12, doi:10.1029/2008JD009972.
3. Leahy, L. V., R. Wood, R. J. Charlson, C. A. Hostetler, R. R. Rogers, M. A. Vaughan, and D. M. Winker (2012), On the nature and extent of optically thin marine low clouds, *J. Geophys. Res.*, 117, D22201, doi:10.1029/2012JD017929.
4. Toomey, T., Amores, A., Marcos, M., Orfila, A., & Romero, R. (2022). Coastal hazards of tropical-like cyclones over the Mediterranean Sea. Journal of Geophysical Research: Oceans, 127, e2021JC017964. https://doi.org/10.1029/2021JC017964