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Clustering of ATTILA Trajectories using a Neuroscience Algorithm (QuickBundles) for the Characterization of Emission Transport Pathways

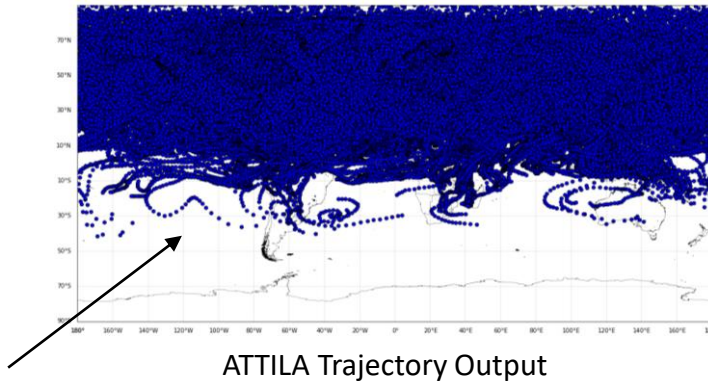
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Motivation

- Purpose:** Characterize the main transport pathways of gas-phase emissions across the globe and seasons (Winter and Summer) using the ATTILA sub-model. Discern how the weather pattern affects these trajectories in different regions.
- Challenge:** identify transport patterns from the abundance of Lagrangian trajectories. Clustering is a solution.



QuickBundles – Clustering Algorithm

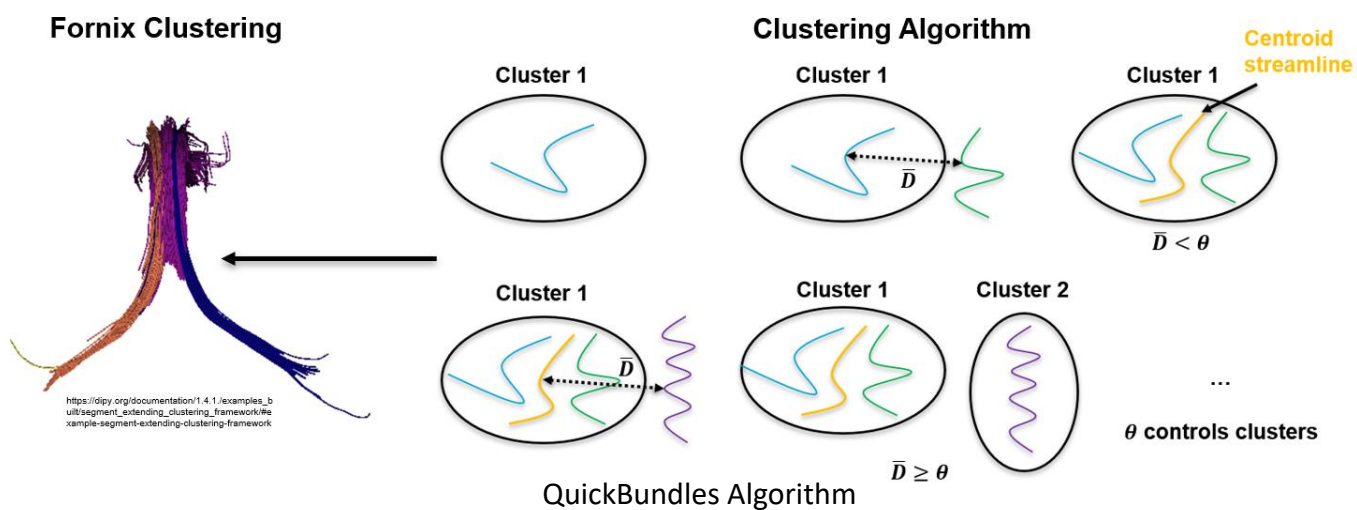
- What is it?** An agglomerative hierarchical clustering algorithm that was produced for use with MRI (Magnetic Resonance Imaging) output data with the intent of classifying nerve bundles (Garyfallidis, 2012).

How does it work?

- Step 1:** The first trajectory is placed into a cluster.
- Step 2:** The pointwise mean distance between it and the second trajectory is calculated.
- Step 3:** If this distance is less than a clustering threshold θ (user-defined), trajectory 2 is clustered with trajectory 1. The centroidal (averaged) trajectory is computed.
- Step 4:** Mean distance between centroidal and candidate trajectories compared with θ .
- Step 5:** If $\bar{D} \geq \theta$, the next candidate trajectory is placed into a new cluster. Process continues.

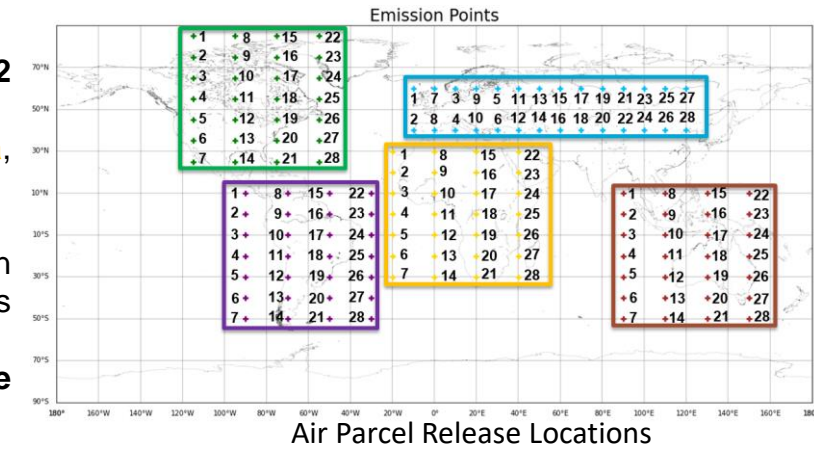
Why use this specific clustering method in atmospheric sciences?

- Similarity** between 3D MRI streamlines and air parcel trajectories.
- Flexibility:** user can easily define a similarity function.
- Quick:** constructed to run quickly to be useful in a clinical setting.

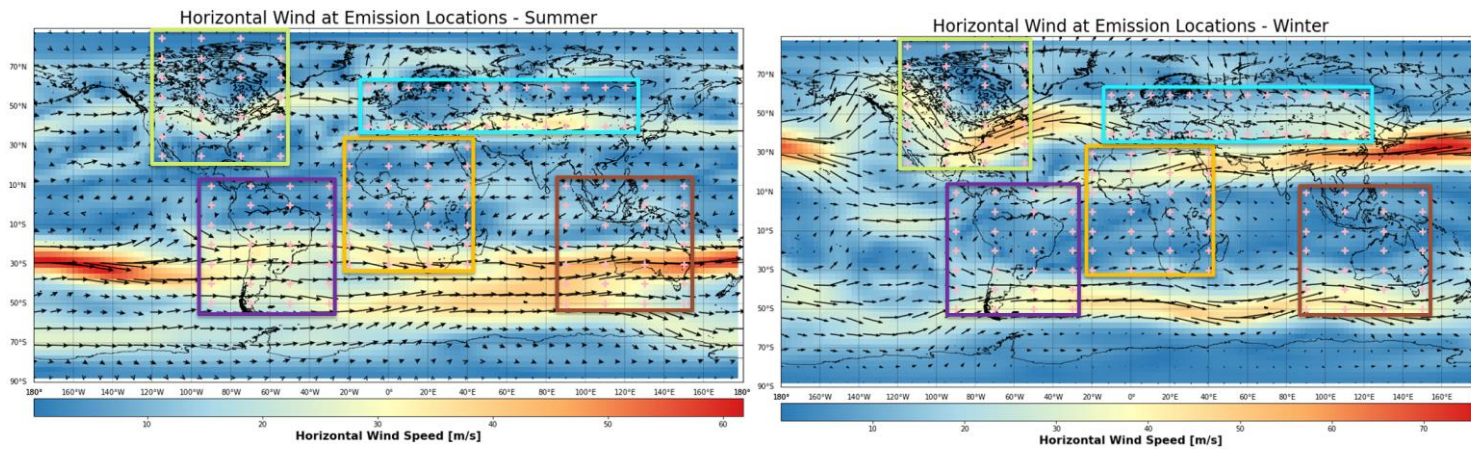


Simulation Setup

- EMAC Version 2.54, focus on ATTILA
- 10 1-month simulations (5 regions \times 2 seasons)
 - N. America, S. America, Africa, Eurasia, Australia
 - Winter and Summer
- Each region has 28 emission points in which 50 emission-carrying trajectories are initialized.
- Emissions released at typical cruise altitude of 250 hPa.
- Resolution: T42L41

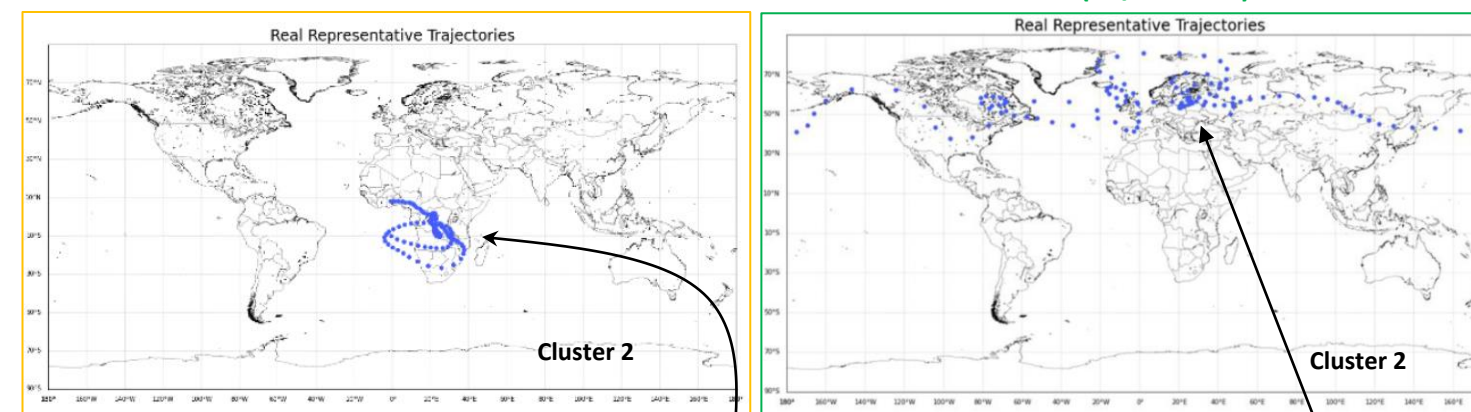


Clustering Outcome



Africa (12/28~43%) - Summer

N. America (16/28~57%) - Winter



Summary

- Dependence of transport pattern with meteorology.
- Seasonal effects: change in trade winds and westerlies affect airmass dynamics.
- Framework for clustering developed with QuickBundles

References

Garyfallidis, E., Brett, M., Correia, M. M., Williams, G. B., & Nimmo-Smith, I. (2012). QuickBundles, a Method for Tractography Simplification. *Frontiers in neuroscience*, 6, 175. <https://doi.org/10.3389/fnins.2012.00175>