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

Maruhashi, J.; Dedoussi, I.C.; Grewe, V.

Publication date
2021

Document Version
Final published version

Citation (APA)
Maruhashi, J., Dedoussi, I. C., & Grewe, V. (2021). *Clustering of ATTILA Trajectories using a Neuroscience Algorithm (QuickBundles) for the Characterization of Emission Transport Pathways*. Poster session presented at 10th EMAC Symposium. https://www.acacia-project.eu/dissemination/EMAC_2021_Maruhashi_poster.pdf

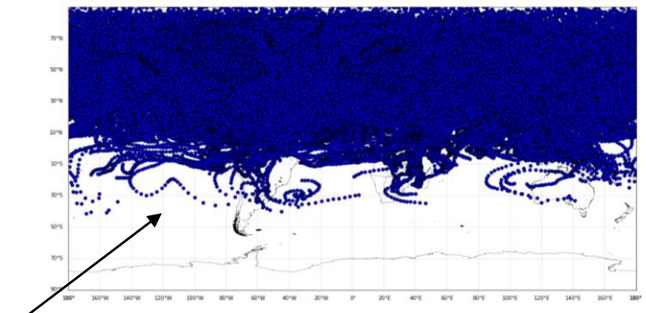
Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

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

Jin Maruhashi[1] (J.Maruhashi@tudelft.nl), Irene Dedoussi[1], Volker Grewe[1,2]
[1]Faculty of Aerospace Engineering, Section Aircraft Noise and Climate Effects, Delft University of Technology, the Netherlands
[2]Institut für Physik der Atmosphäre, Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen, Germany

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.



ATTILA Trajectory Output

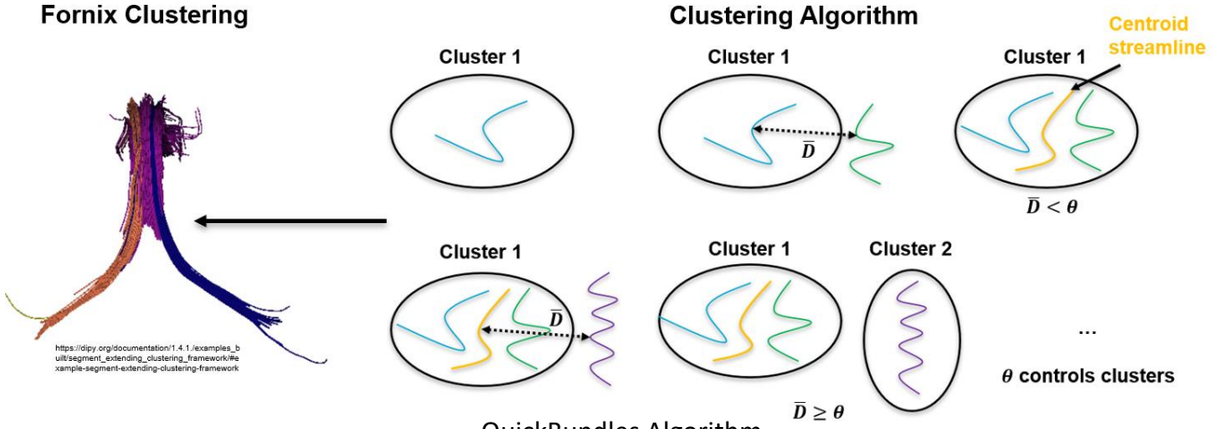
QuickBundles – Clustering Algorithm

- **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?**

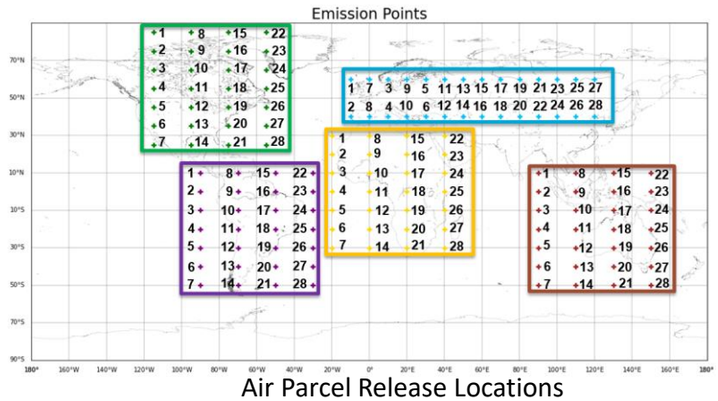
1) **Similarity** between 3D MRI streamlines and air parcel trajectories.
2) **Flexibility:** user can easily define a similarity function.
3) **Quick:** constructed to run quickly to be useful in a clinical setting.



QuickBundles Algorithm

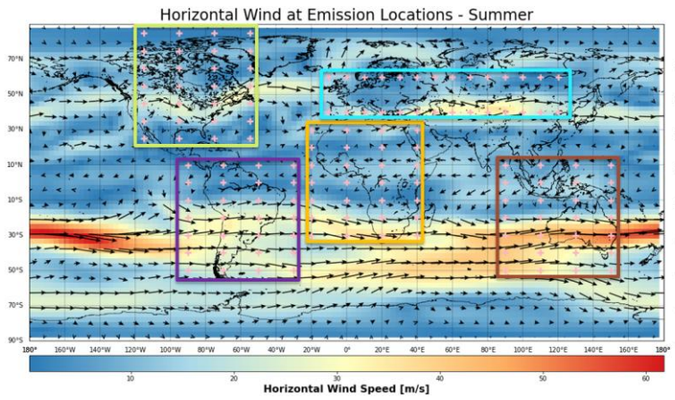
Simulation Setup

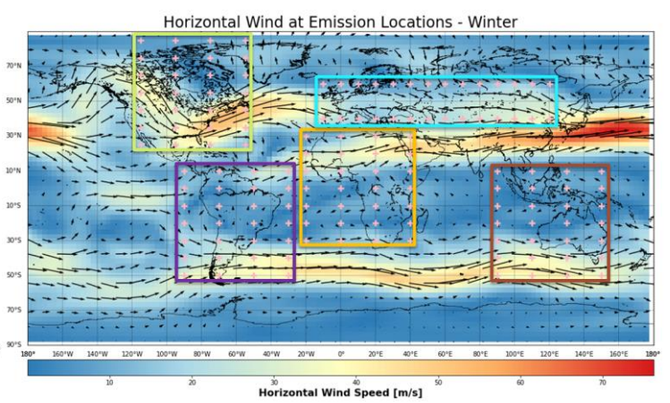
- EMAC Version 2.54, focus on **ATTILA**
- 10 1-month simulations (**5 regions** × **2 seasons**)
  - N. America, S. America, Africa, Eurasia, Australia
  - Winter and Summer
- Each region has 28 emission points in which 50 emission-carrying trajectories are initialized.
- Emissions released at **typical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



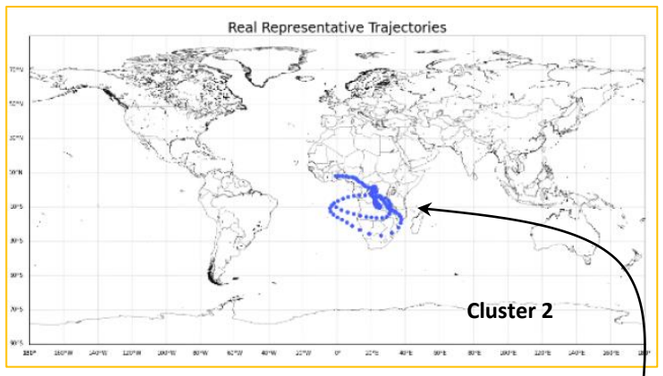
Air Parcel Release Locations

Clustering Outcome



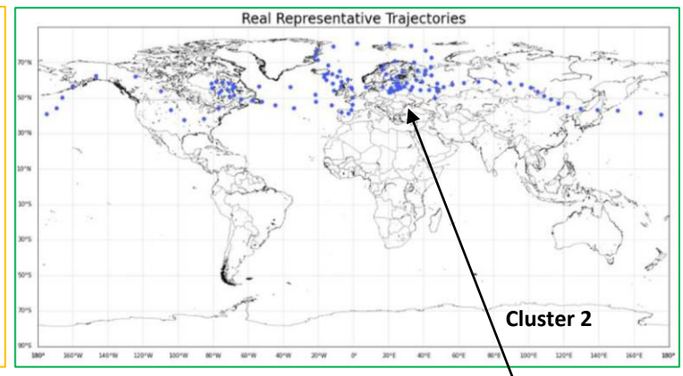


Africa (12/28~43%) - Summer

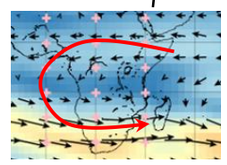


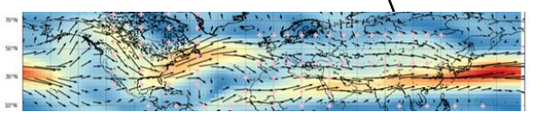
Most probable path of airmass released in Africa

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



Most probable path of airmass released in N. America





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

This project is funded by the European Commission under Grant Number 875036

TU Delft ACACIA