

ZEFIR : AN IGOR TOOL FOR GEOGRAPHICAL ORIGINS

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WHY?

If answering « what are the sources? » is crucial, answering « where do they come from? » is just as much important !

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receptor approaches : **WIND** or **BACKTRAJECTORIES**

Wind analyses are best for sources within a relatively short geographical range. As wind measured at the receptor site is not necessarily representative of the global origin of the air mass, it is not very precise for long-range advected pollution.

Trajectory analyses are best for long-range pollution. They conceptually fail to provide meaningful information for local sources.

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Wind analyses are best for sources within a relatively short geographical range. As wind measured at the receptor site is not necessarily representative of the global origin of the air mass, it is not very precise for long-range advected pollution.

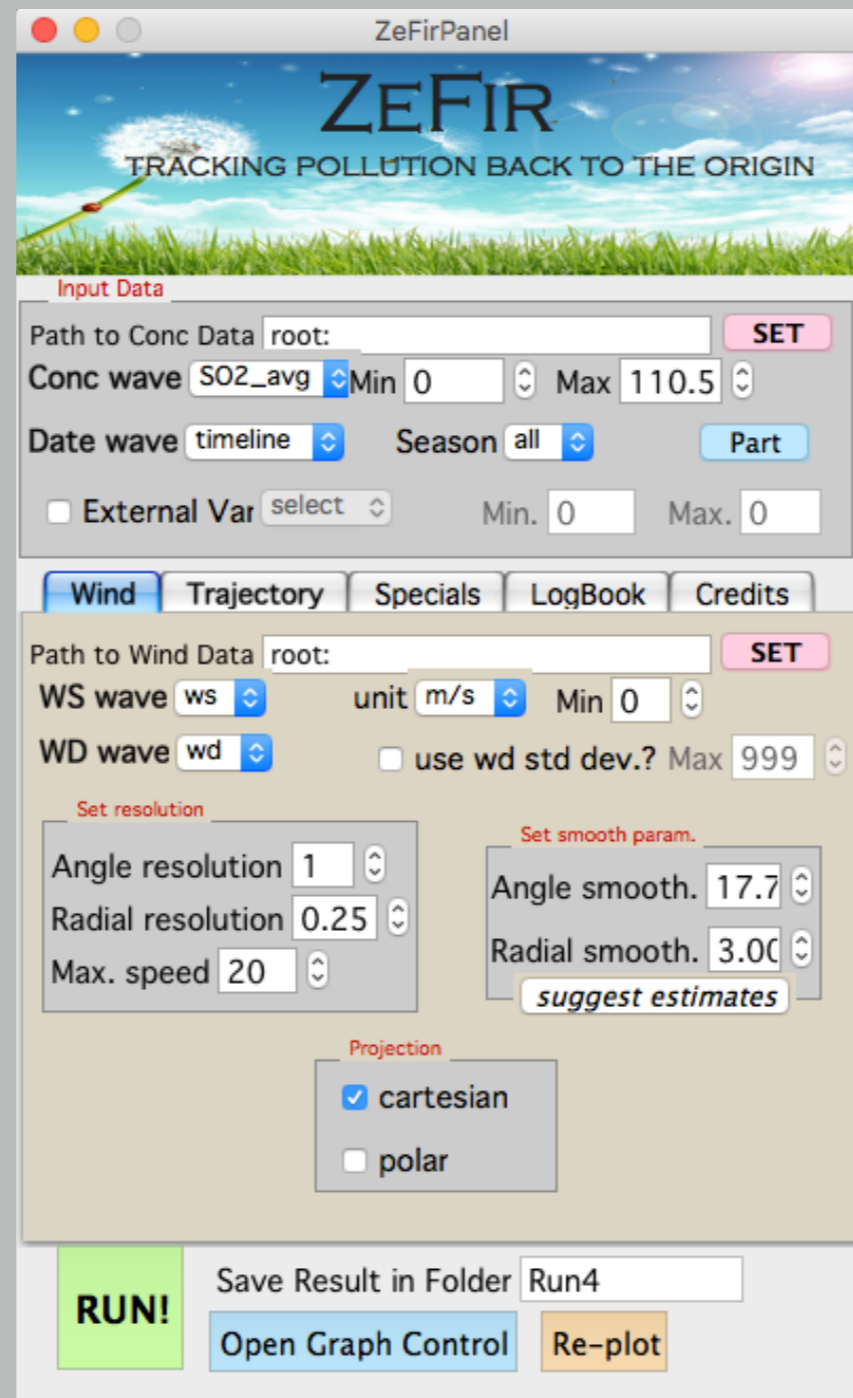
Trajectory analyses are best for long-range pollution. They conceptually fail to provide meaningful information for local sources.

TrajStat : user-friendly soft for trajectory analyses only

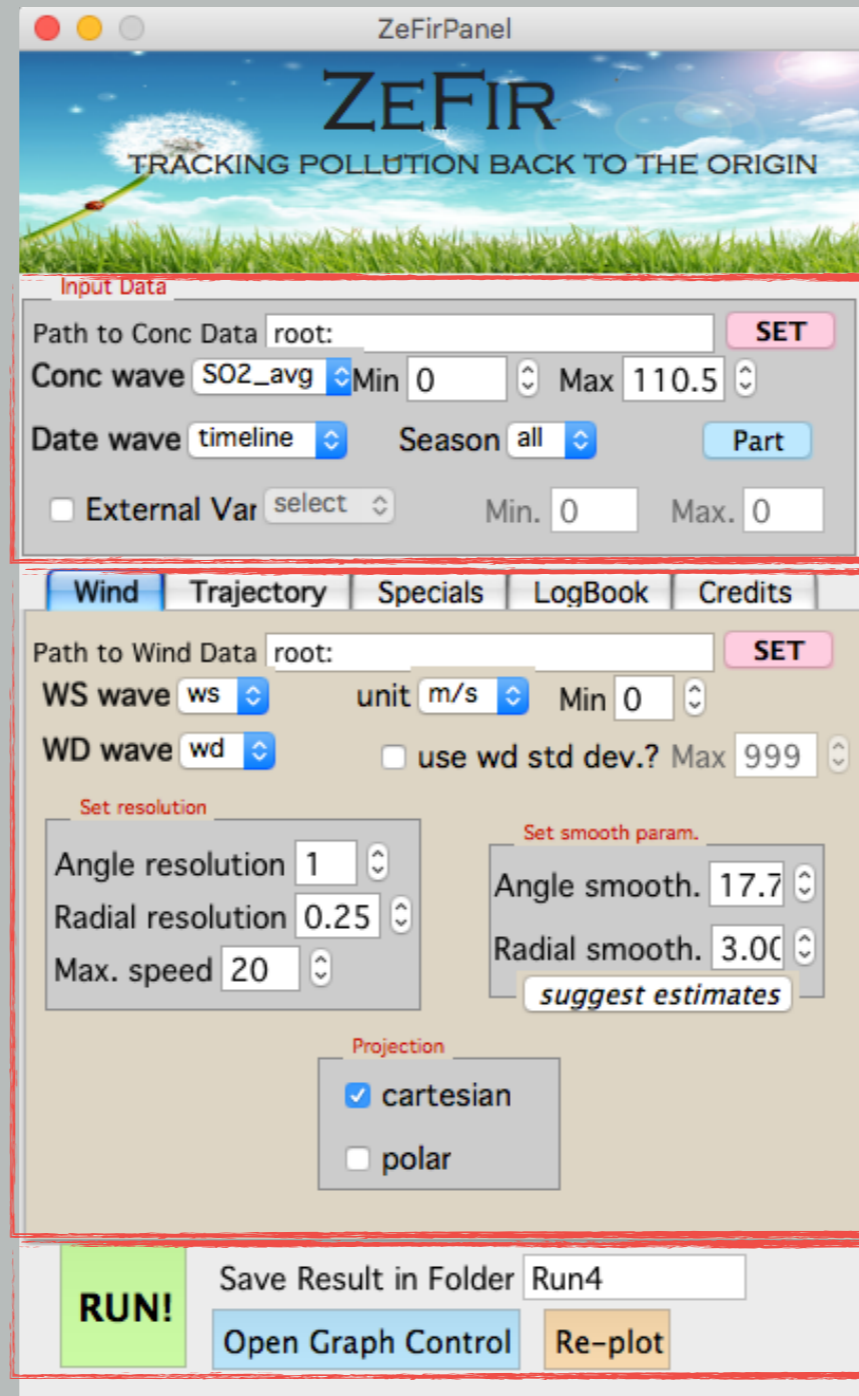
Openair: can do both, but not user-friendly

need of a user-friendly soft to do both

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1- Input Data

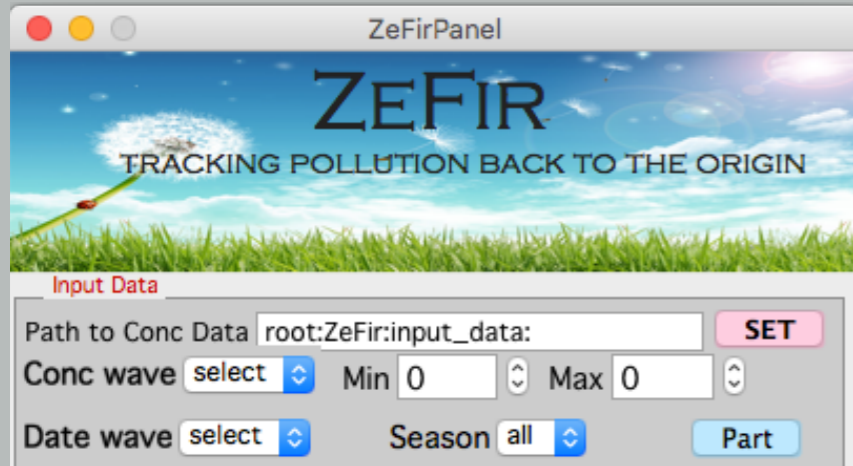
2- Wind / Traj Analysis
+ Special runs

3- Run & options

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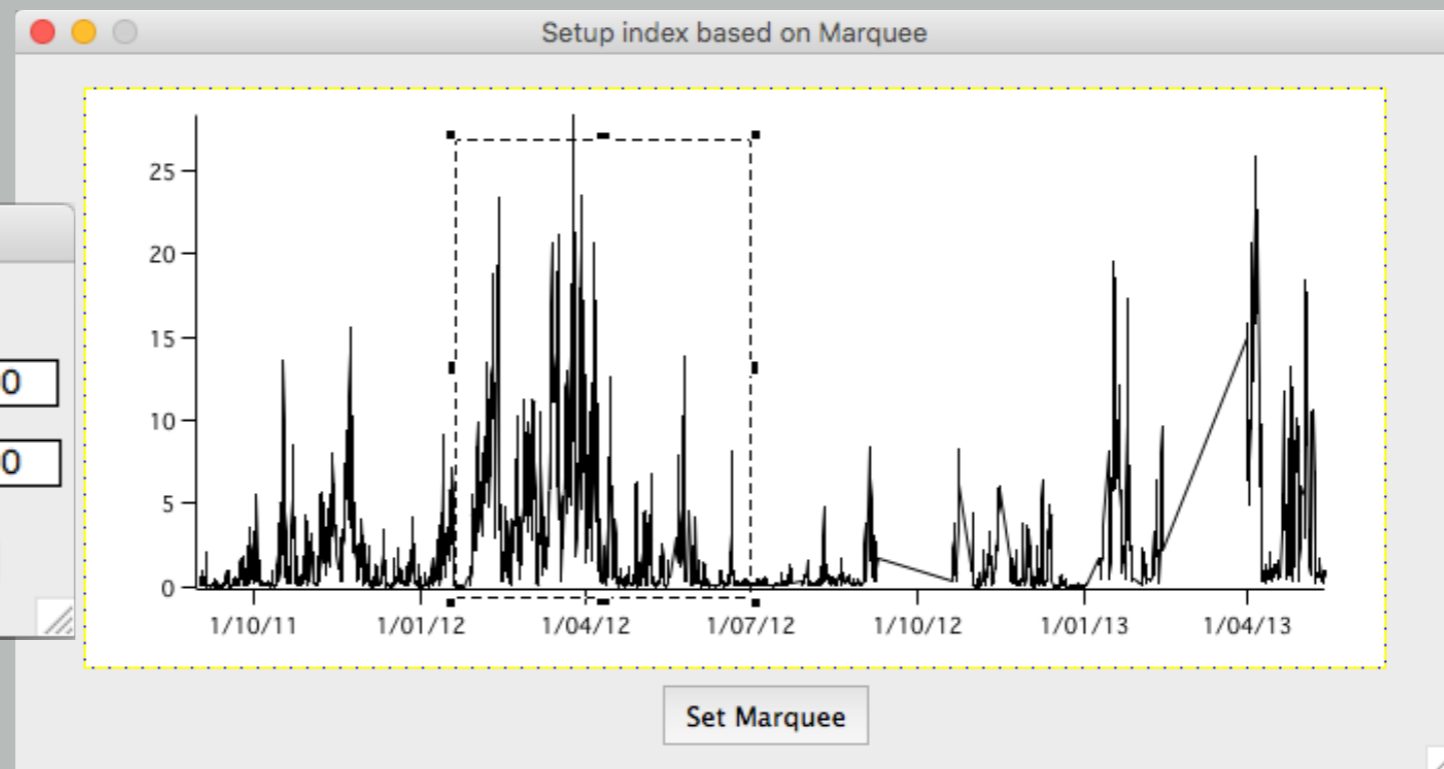
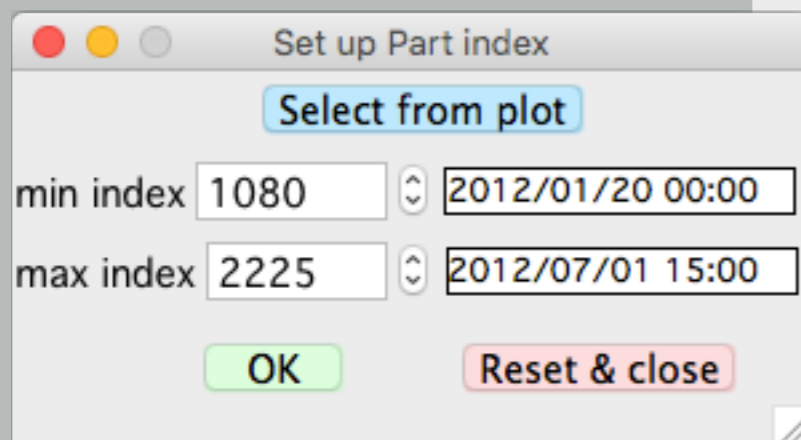
INPUT DATA

what you need: **concentration & date/time**



Filtering input data by:

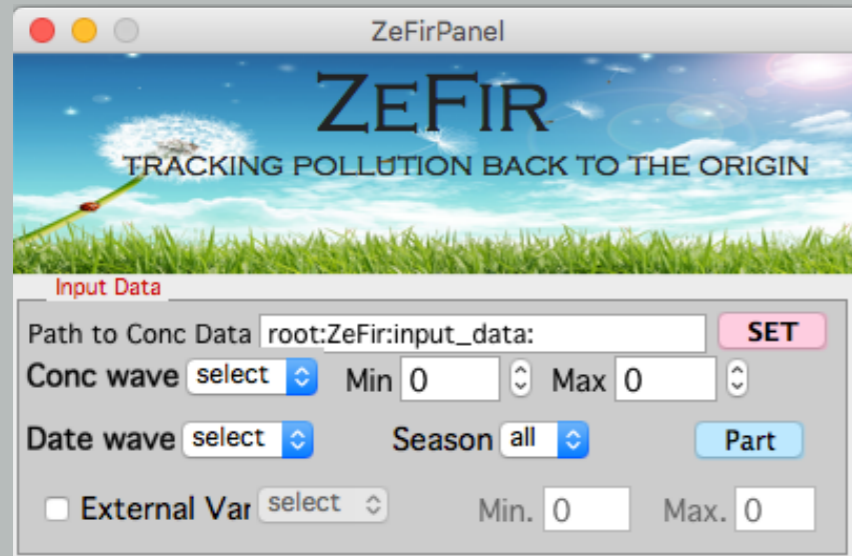
- ▶ concentration (min/max)
- ▶ seasons (all / DJF / MAM / JJA / SON)
- ▶ customized temporal window



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INPUT DATA

what you need: **concentration & date/time**



Filtering input data by:

- ▶ concentration (min/max)
- ▶ seasons (all / DJF / MAM / JJA / SON)
- ▶ customized temporal window
- ▶ external variable (min/max)

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WIND ANALYSIS

performed by 2-D Non-Parametric Wind Regression (Henry et al., 2009)

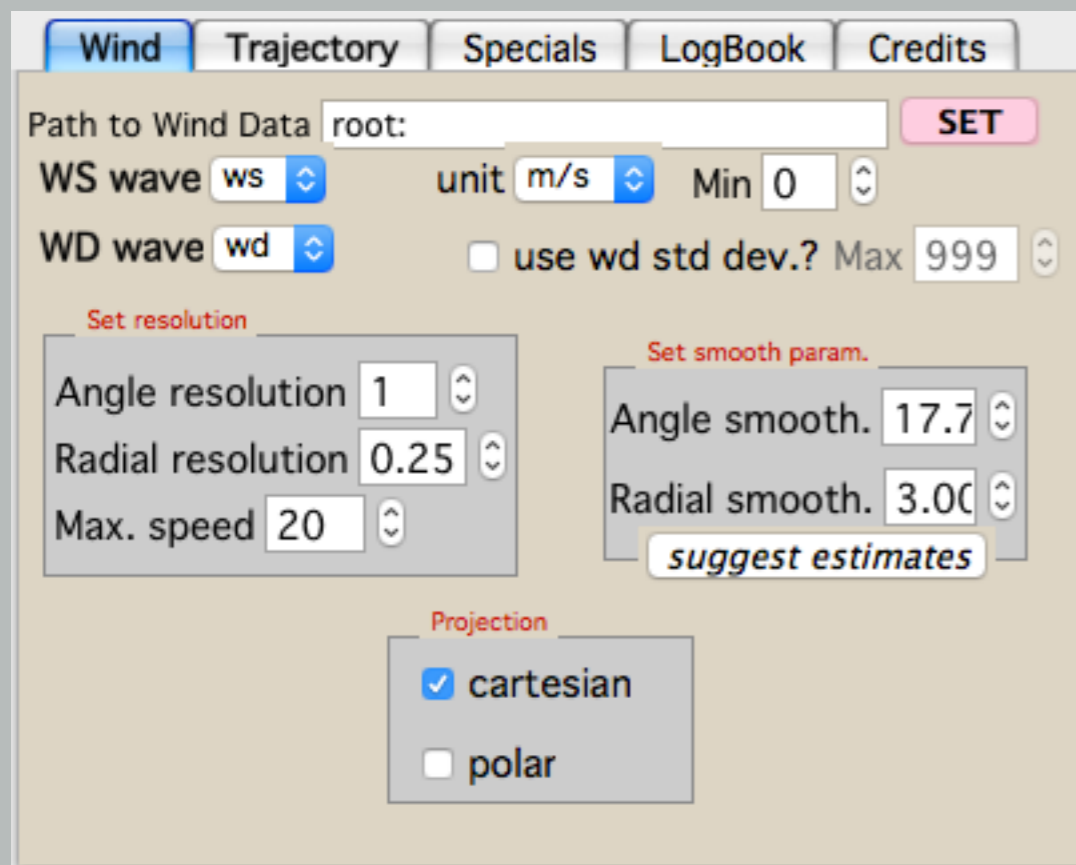
$$E(\theta, u) = \frac{\sum_i^N K_1\left(\frac{\theta - W_i}{\sigma}\right) \cdot K_2\left(\frac{u - Y_i}{h}\right) \cdot C_i}{\sum_i^N K_1\left(\frac{\theta - W_i}{\sigma}\right) \cdot K_2\left(\frac{u - Y_i}{h}\right)}$$

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what you need: **wind direction and speed**

additional filtering by

- ▶ wind speed values (min)
- ▶ wind direction standard deviation (max)

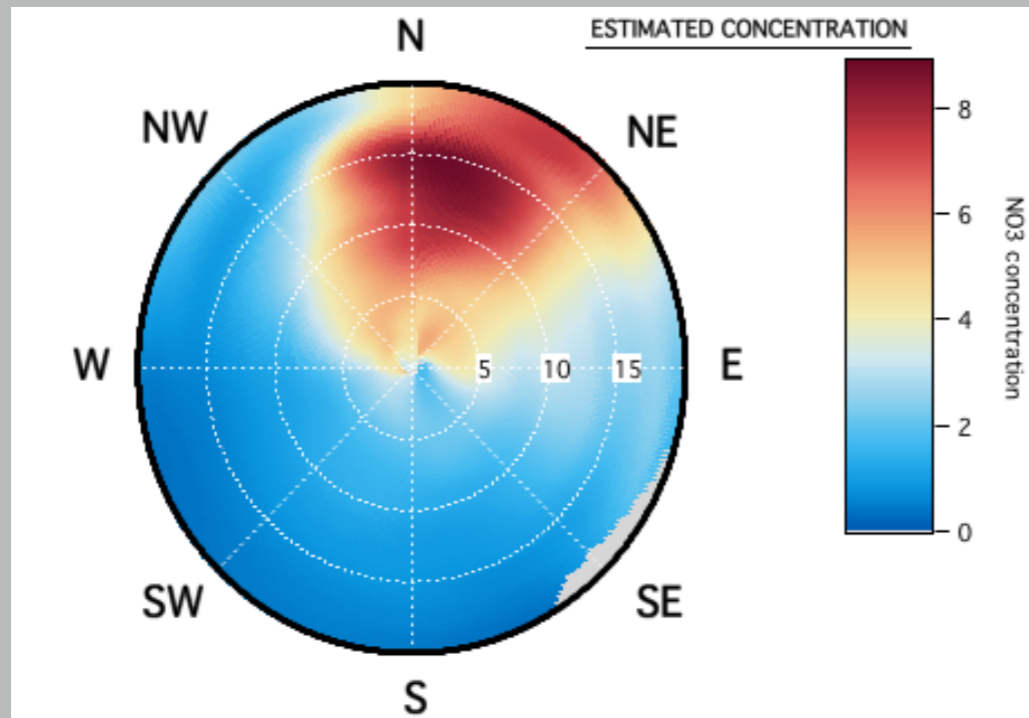
suggest estimates provides an estimation of theoretical smoothing parameters

cartesian or polar projections to display the results

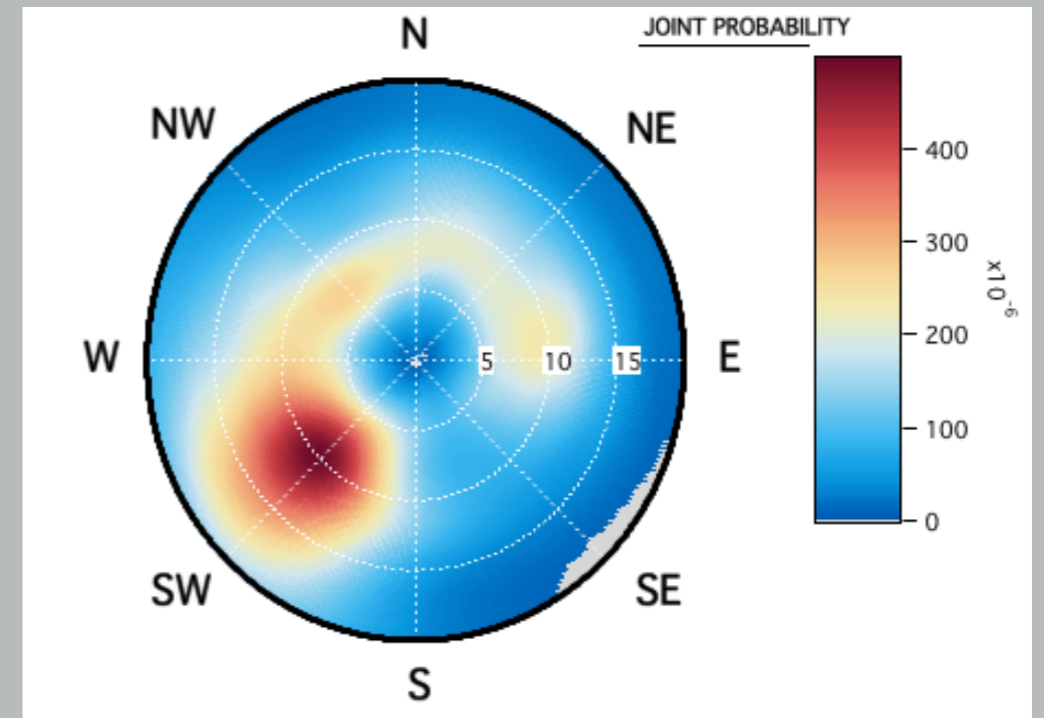
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WIND ANALYSIS

ESTIMATED CONCENTRATION

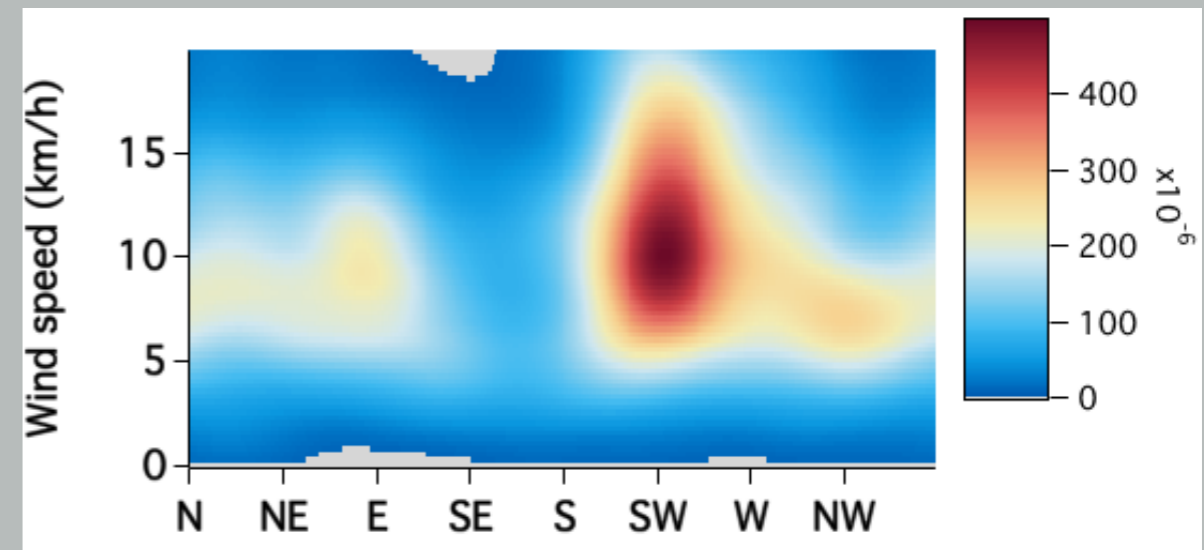
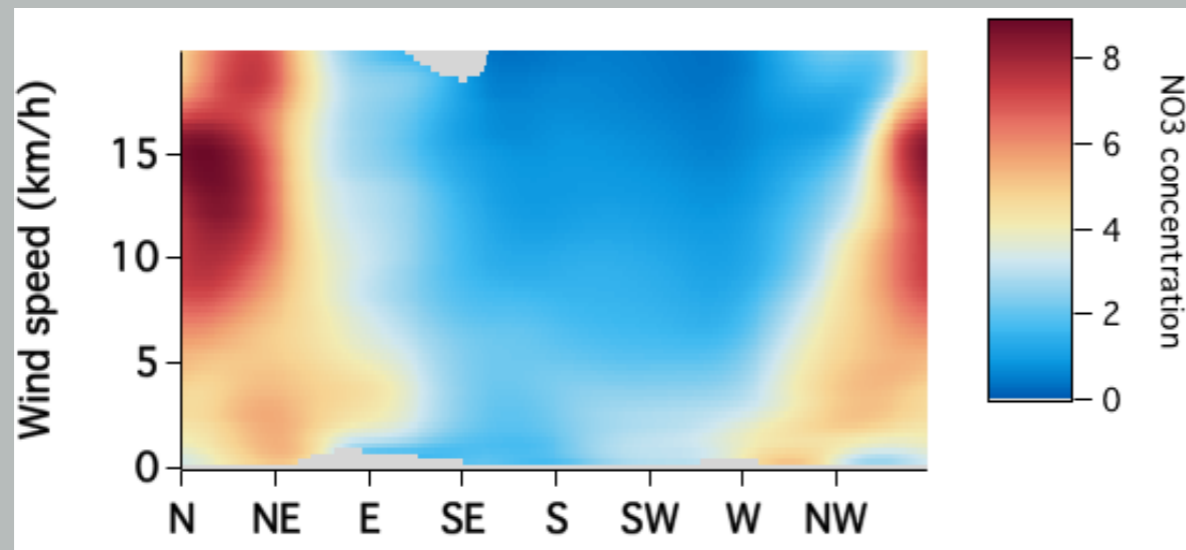


JOINT PROBABILITY \equiv WIND ROSE



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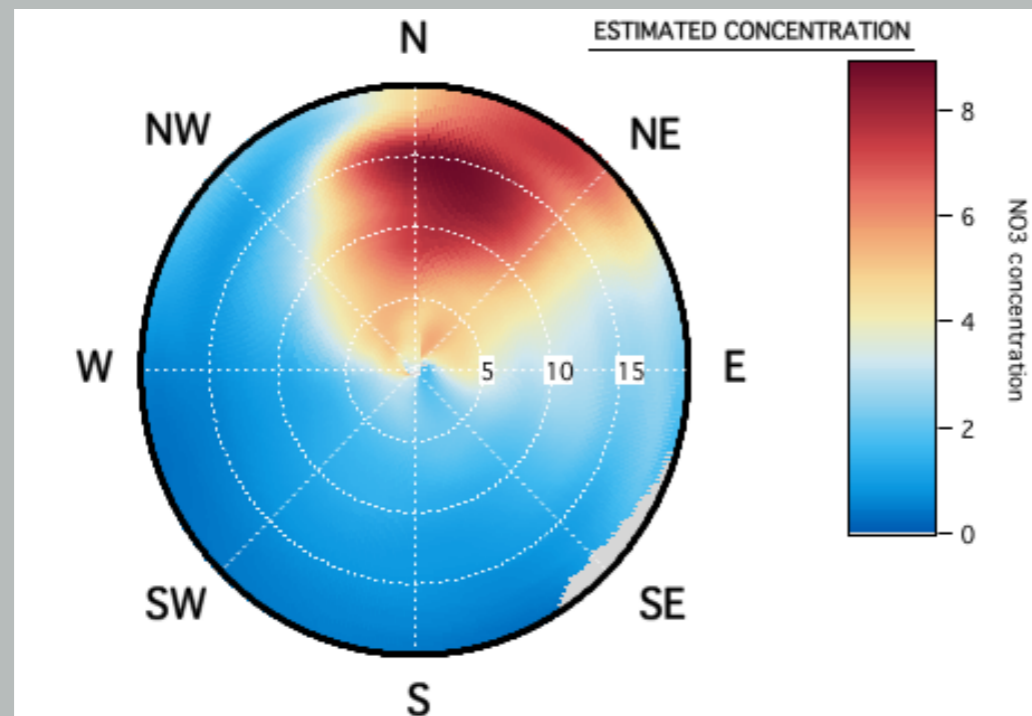


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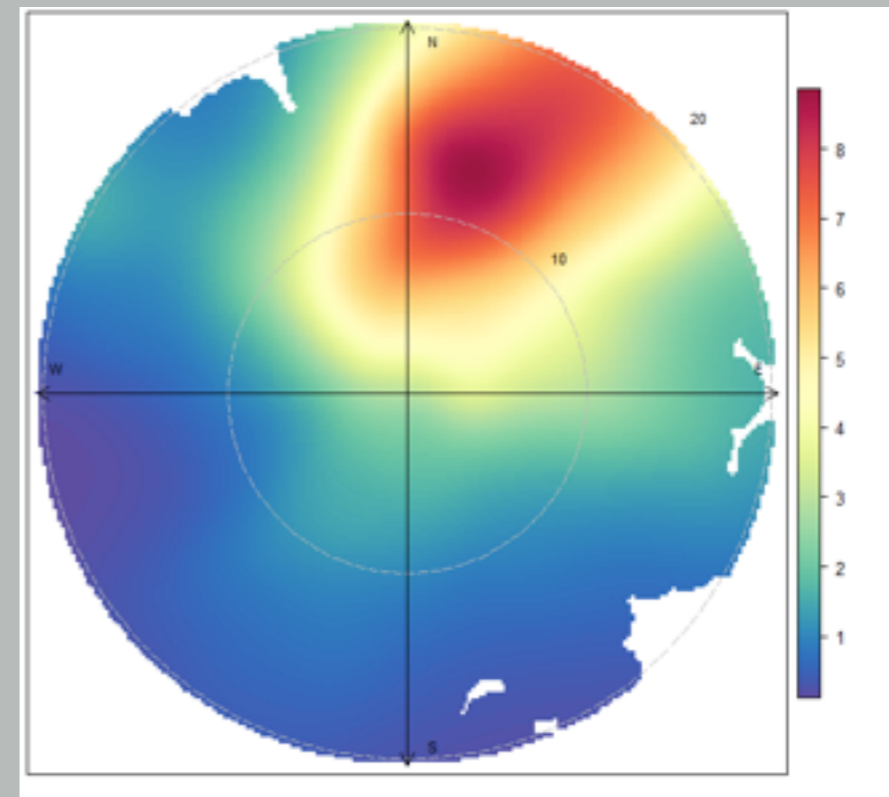
WIND ANALYSIS

Comparison with Openair

ZEFIR



OPENAIR



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TRAJECTORY ANALYSIS

performed by PSCF / CWT / CF

$$M_{ij} = \frac{m_{ij}}{n_{ij}}$$

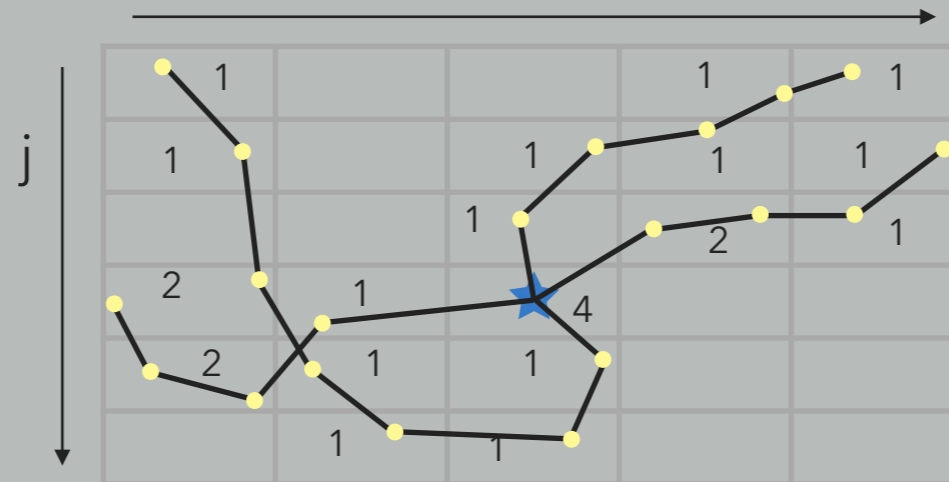
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TRAJECTORY ANALYSIS

performed by PSCF / CWT / CF

$$M_{ij} = \frac{m_{ij}}{n_{ij}}$$

n_{ij} :
1 in cell where endpoint falls



- ★ measuring site
- endpoint

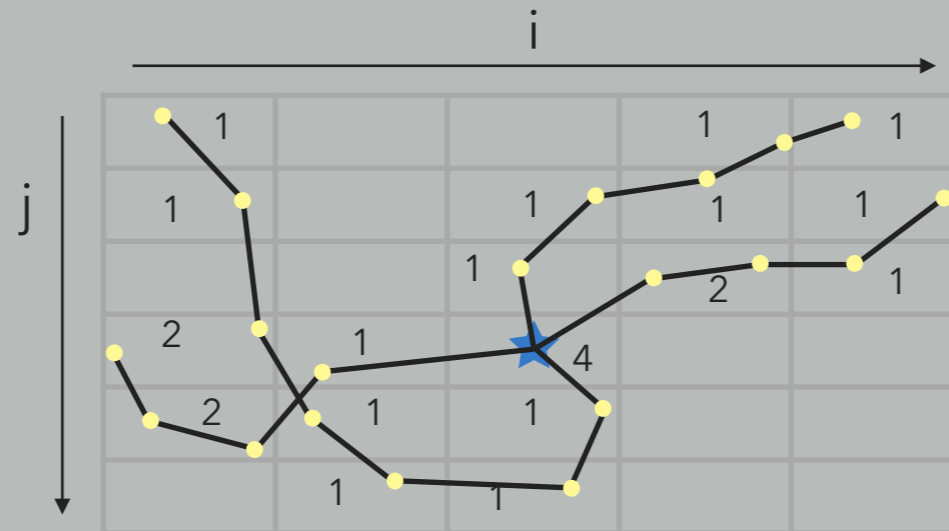
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TRAJECTORY ANALYSIS

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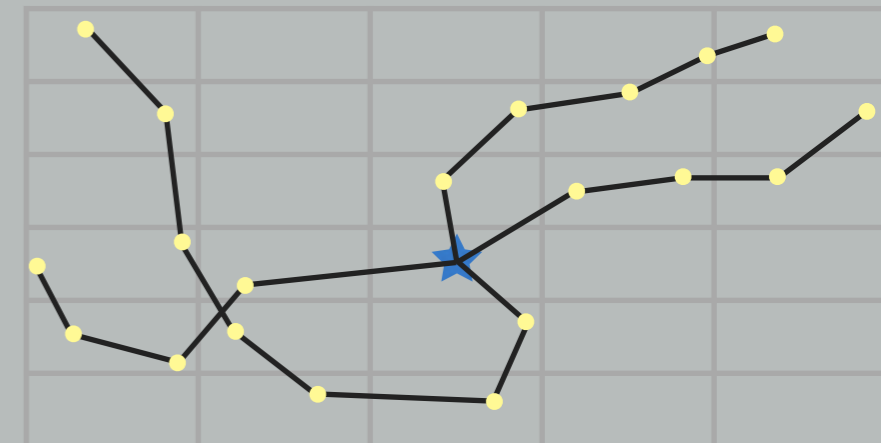
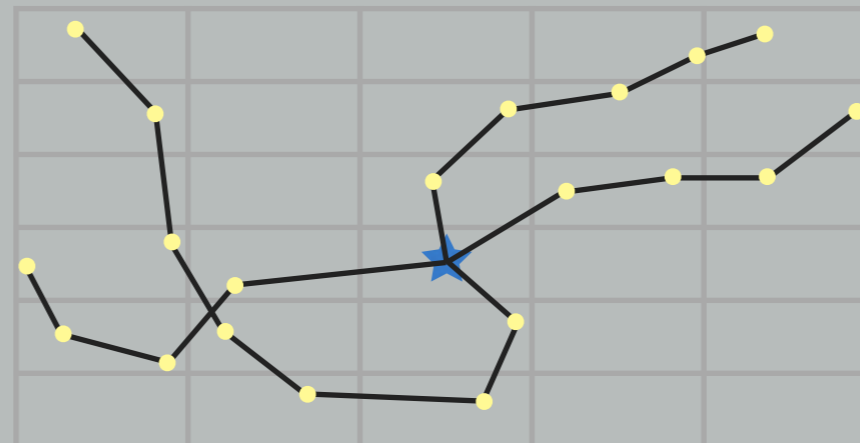
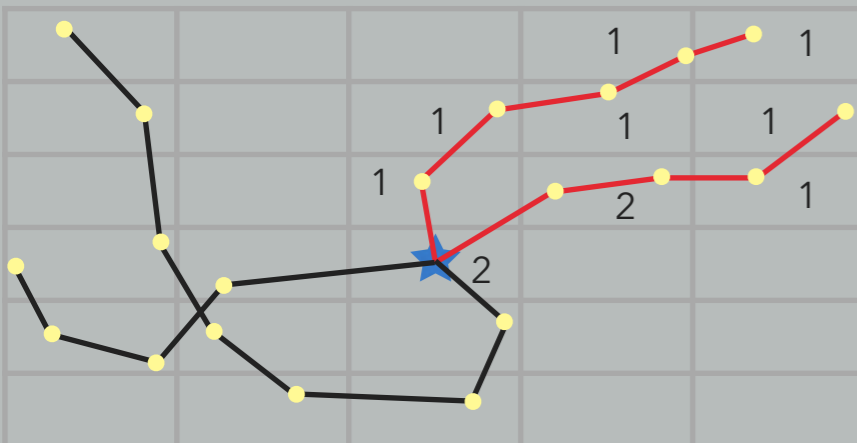
- ★ measuring site
- endpoint

m_{ij} :

PSCF : 1 in cells if $C_i > C_{crit}$

CWT : C_i in cells at each endpoint

CF : $\log(C_i)$ in cells



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TRAJECTORY ANALYSIS

performed by PSCF / CWT / CF

what you need: **trajectory files from Hysplit**

The screenshot shows the 'Trajectory' tab of the ZEFIR software interface. At the top, there are tabs for 'Wind', 'Trajectory', 'Specials', 'LogBook', and 'Credits'. The 'Trajectory' tab is active. Below the tabs, there is an 'Enlarge' button and 'Site coordinates' fields for 'Lon' (0) and 'Lat' (0). The 'Path to Traj. Folder' is set to 'Macintosh HD:Users:admin:Downloads:zip:Example:T' with a 'SET' button. The 'Traj. prefix' is 'trajDundee' and the 'Ext.' is '.select'. The 'Analysis' dropdown is set to 'CF'. Under 'Trajectory cut-off', there is a 'Max. Traj. Duration' of 72, and checkboxes for 'Use Rain?' (with 'Provide Column n°' set to 0) and 'Use Altitude?' (with 'Thres. (m)' set to 0). Under 'Graph param.', there is a 'Cell Size' of 0.5 and a 'Smooth' value of 15. The 'WorldMap' section has 'lon_min' (-30), 'lon_max' (15), 'lat_min' (33), and 'lat_max' (79) fields, with a 'Load WorldMap' button and a 'Set from Map' button. At the bottom, there is a 'Use Weighing Function?' checkbox and a 'SET' button.

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TRAJECTORY ANALYSIS

performed by PSCF / CWT / CF

Enlarge dataset

The screenshot displays the ZEFIR software interface. On the left, a control panel is visible with the 'Trajectory' tab selected. The 'Enlarge' button is highlighted with a red box. Below it, the 'Path to Traj. Folder' is set to 'Macintosh HD:Users:a...', the 'Traj. prefix' is 'trajDundee', and the 'Analysis' is set to 'CF'. The 'Trajectory cut-off' section includes 'Max. Traj. Duration' set to 72, and checkboxes for 'Use Rain?' and 'Use Altitude?'. The 'WorldMap' section has 'lon_min' at -30 and 'lat_min' at 33. A 'Load WorldMap' button is also present.

The main window, titled 'EnlargeP', contains three data tables:

- Original Data:** A table with columns 'Point', 'DateWave', and 'ConcWave'. The data is for the date '01/01/2015'. The first three rows are: (0, '01/01/2015 00:00:00', 5.3), (1, '02/01/2015 00:00:00', 18), and (2, '03/01/2015 00:00:00', 11.9). The 'DateWave' cell for point 0 is highlighted with a blue box.
- Enlarge wave:** A table with columns 'Point' and 'Enlarge_W'. The data is: (0, 0), (1, 6), (2, 12), (3, 18), (4, 18). The 'Enlarge_W' cell for point 3 is highlighted with a red box.
- Enlarged Data:** A table with columns 'Point', 'EnlargedDate', and 'EnlargedConc'. The data is for the date '01/01/2015 00:00:00'. The first three rows are: (0, '01/01/2015 00:00:00', 5.3), (1, '01/01/2015 06:00:00', 5.3), (2, '01/01/2015 12:00:00', 5.3). The 'EnlargedDate' cell for point 0 is highlighted with a blue box.

Below the tables are three buttons: 'Preview' (blue), 'Reset' (red), and 'Apply Setting' (green).

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TRAJECTORY ANALYSIS

performed by PSCF / CWT / CF

Trajectory cut-off

Wind Trajectory Specials LogBook Credits

Enlarge Site coordinates: Lon 0 Lat 0

Path to Traj. Folder Macintosh HD:Users:admin:Downloads:zip:Example:T SET

Traj. prefix trajDundee Ext. .select

Analysis CF

Trajectory cut-off

Max. Traj. Duration 72

Use Rain? Provide Column n= 0

Use Altitude? Thres. (m) 0

Graph param.

Cell Size 0.5

Smooth. 15

WorldMap

lon_min -30 lon_max 15

lat_min 33 lat_max 79

Load WorldMap Set from Map

Use Weighing Function? SET

- ▶ max. traj. duration (in hours)
- ▶ precipitation data along traj.
- ▶ altitude (in meters)

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TRAJECTORY ANALYSIS

performed by PSCF / CWT / CF

Trajectory cut-off

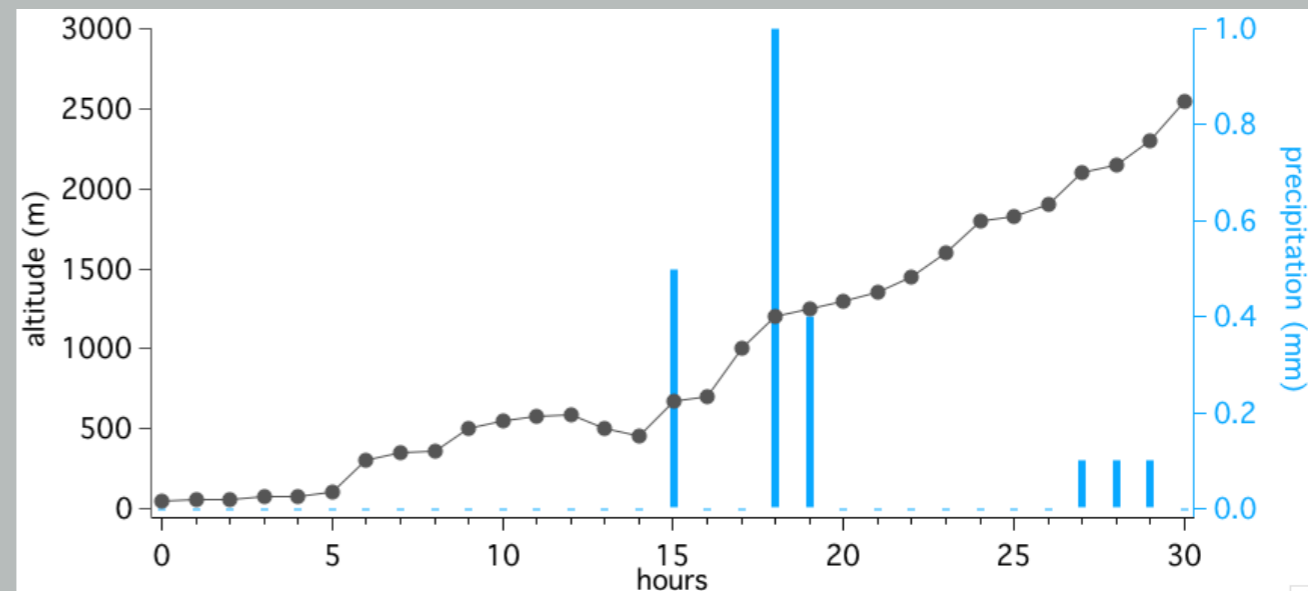
The screenshot shows the 'Trajectory' tab of the ZEFIR software. The 'Trajectory cut-off' section is highlighted with a red box and contains the following settings:

- Max. Traj. Duration: 72
- Use Rain?: Provide Column n°: 0
- Use Altitude?: Thres. (m): 0

Other visible settings include:

- Site coordinates: Lon 0, Lat 0
- Path to Traj. Folder: Macintosh HD:Users:admin:Downloads:zip:Example:T (SET)
- Traj. prefix: trajDundee, Ext. .select
- Analysis: CF
- Graph param.: Cell Size 0.5, Smooth 15
- WorldMap: lon_min -30, lon_max 15, lat_min 33, lat_max 79 (Set from Map)
- Use Weighing Function?: (SET)

- ▶ max. traj. duration (in hours)
- ▶ precipitation data along traj.
- ▶ altitude (in meters)



ZEFIR: AN IGOR TOOL FOR GEOGRAPHICAL ORIGINS

TRAJECTORY ANALYSIS

performed by PSCF / CWT / CF

Trajectory cut-off

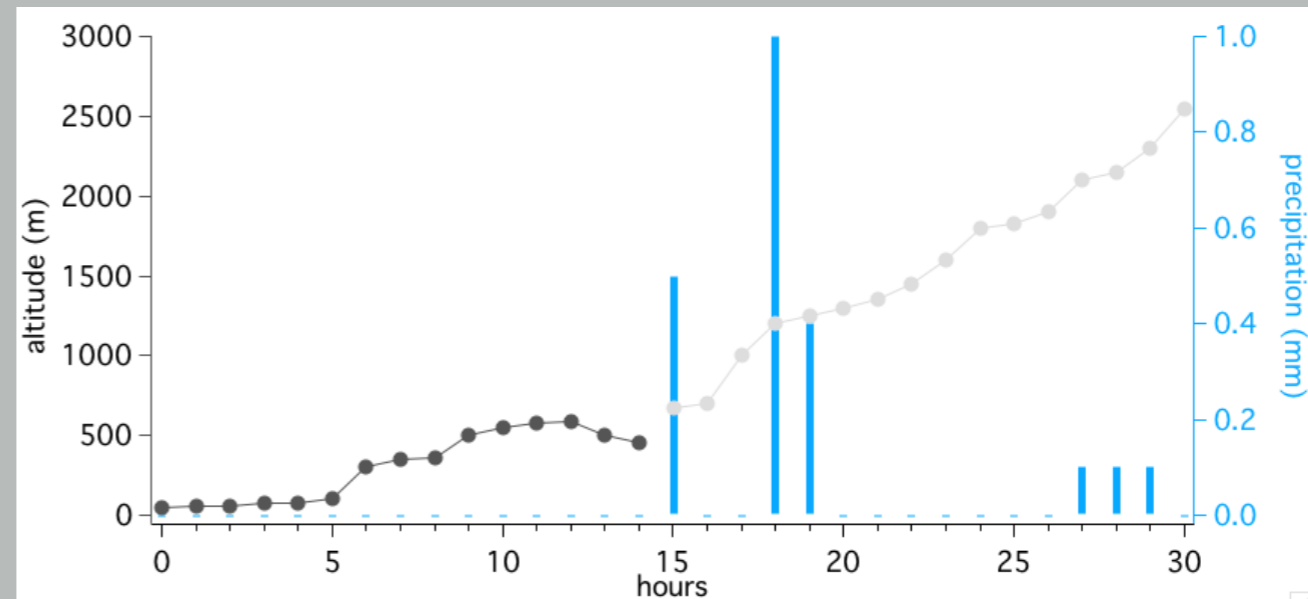
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Other visible settings include:

- Site coordinates: Lon 0, Lat 0
- Path to Traj. Folder: Macintosh HD:Users:admin:Downloads:zip:Example:T
- Traj. prefix: trajDundee, Ext. .select
- Analysis: CF
- Graph param.: Cell Size 0.5, Smooth 15
- WorldMap: lon_min -30, lon_max 15, lat_min 33, lat_max 79
- Use Weighing Function?:

- ▶ max. traj. duration (in hours)
- ▶ precipitation data along traj.
- ▶ altitude (in meters)



ZEFIR: AN IGOR TOOL FOR GEOGRAPHICAL ORIGINS

TRAJECTORY ANALYSIS

performed by PSCF / CWT / CF

Trajectory cut-off

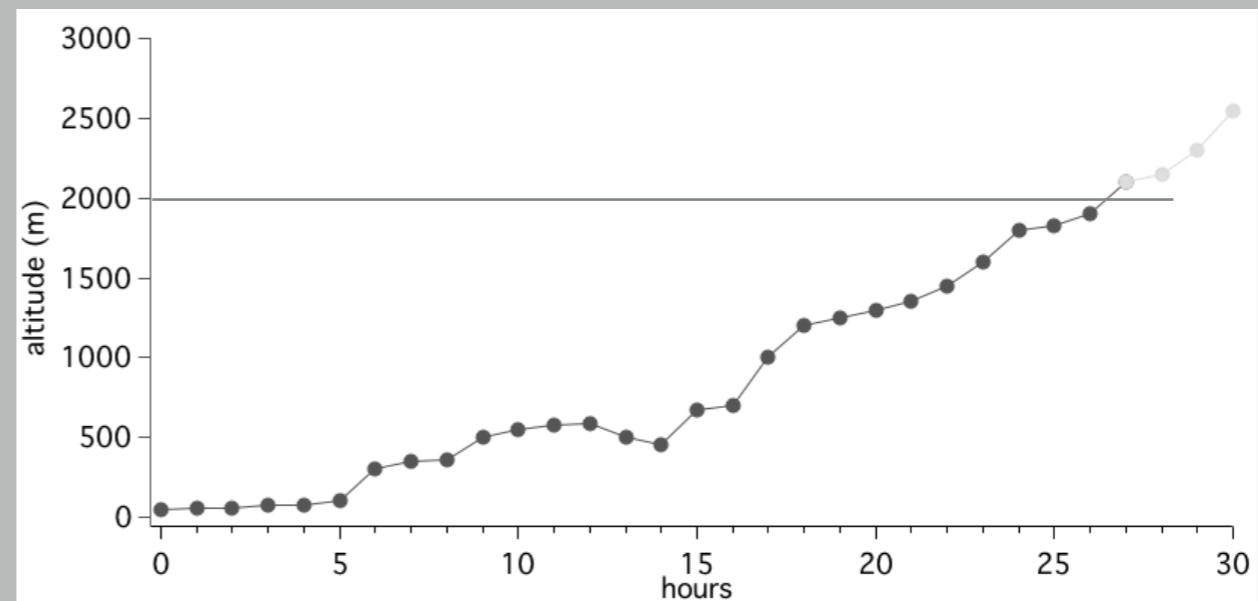
The screenshot shows the ZEFIR software interface with the 'Trajectory' tab selected. The 'Trajectory cut-off' section is highlighted with a red box. It contains the following settings:

- Max. Traj. Duration: 72
- Use Rain?: Provide Column n°: 0
- Use Altitude?: Thres. (m): 0

Other visible settings include:

- Site coordinates: Lon 0, Lat 0
- Path to Traj. Folder: Macintosh HD:Users:admin:Downloads:zip:Example:T
- Traj. prefix: trajDundee, Ext. .select
- Analysis: CF
- Graph param.: Cell Size 0.5, Smooth. 15
- WorldMap: lon_min -30, lon_max 15, lat_min 33, lat_max 79
- Use Weighing Function?:

- ▶ max. traj. duration (in hours)
- ▶ precipitation data along traj.
- ▶ altitude (in meters)



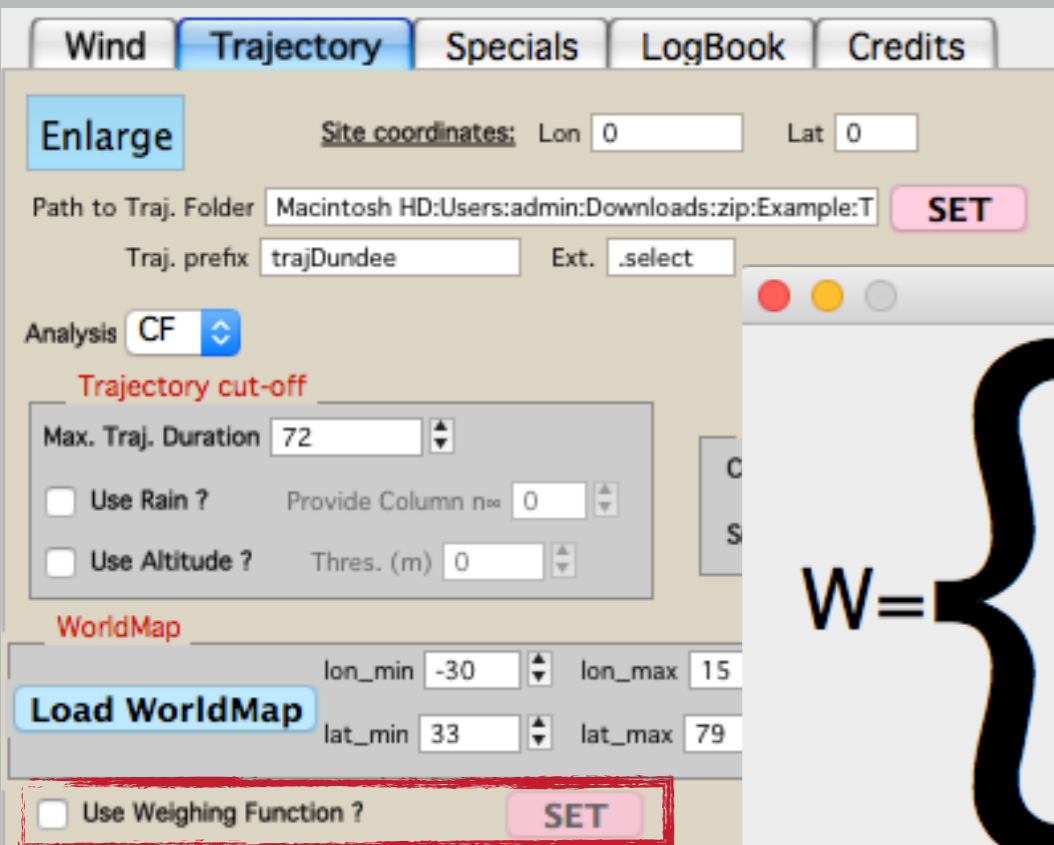
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TRAJECTORY ANALYSIS

performed by PSCF / CWT / CF

Weighing Function

Weighing function is important to downweight cells associated with low n_{ij} .



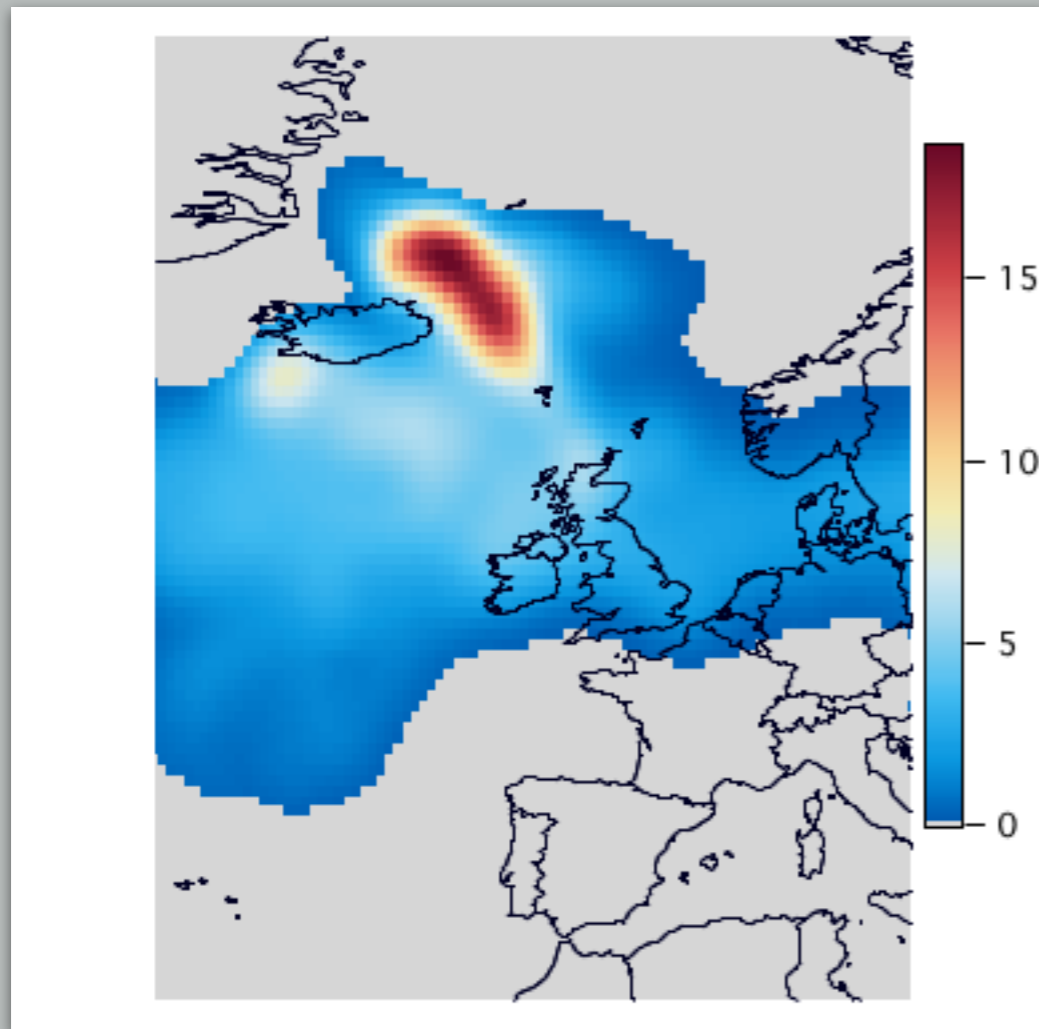
$$W = \begin{cases} 1 & \text{for } \log(n+1) \geq 0.85 * \max_{\log(n+1)} \\ 0.725 & \text{for } 0.6 * \max_{\log(n+1)} > \log(n+1) \geq 0.85 * \max_{\log(n+1)} \\ 0.475 & \text{for } 0.35 * \max_{\log(n+1)} > \log(n+1) \geq 0.6 * \max_{\log(n+1)} \\ 0.175 & \text{for } \log(n+1) < 0.35 * \max_{\log(n+1)} \end{cases}$$

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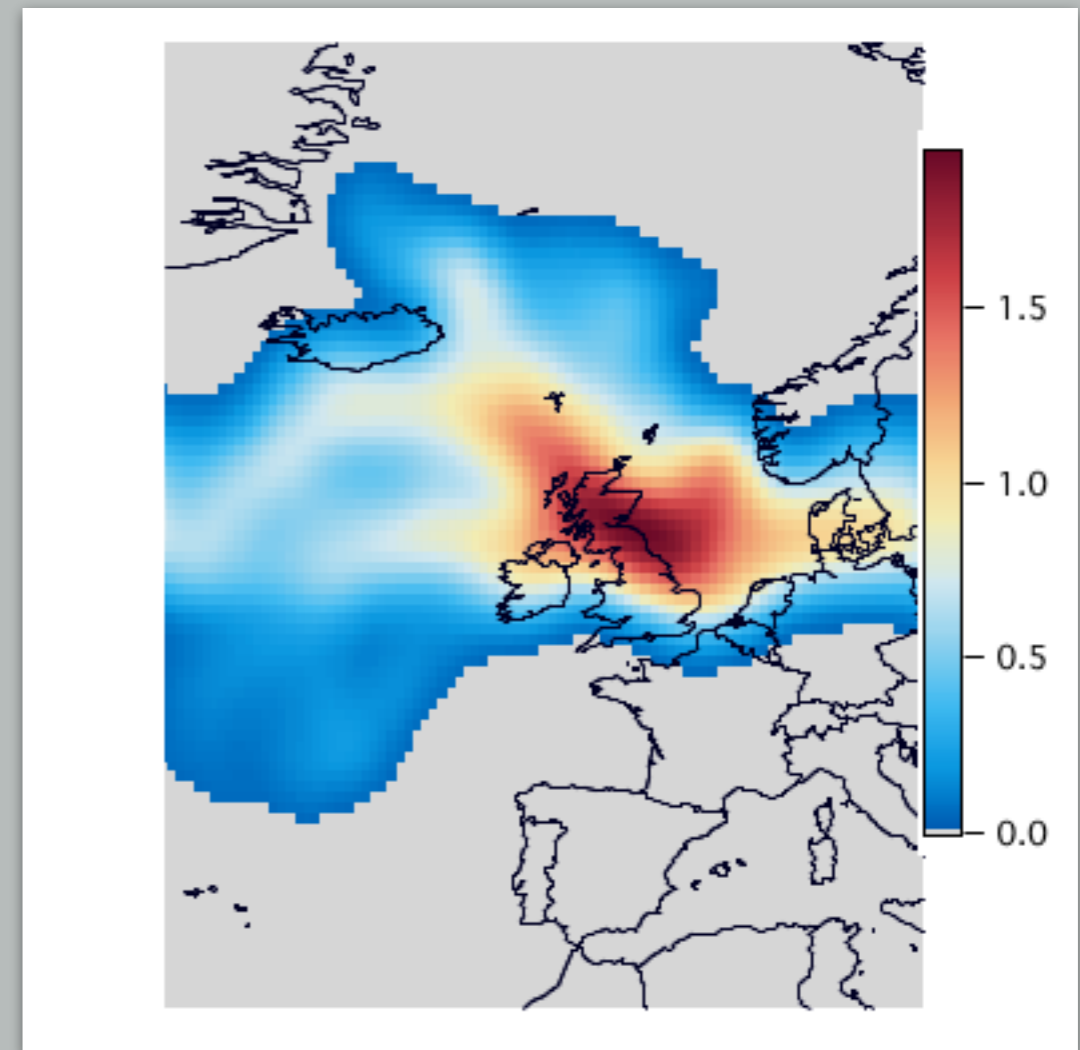
TRAJECTORY ANALYSIS

example SO₂ in Dundee (Scotland) during 09/2014 with hourly traj. CF method

ESTIMATED CONCENTRATION



TRAJECTORY DENSITY

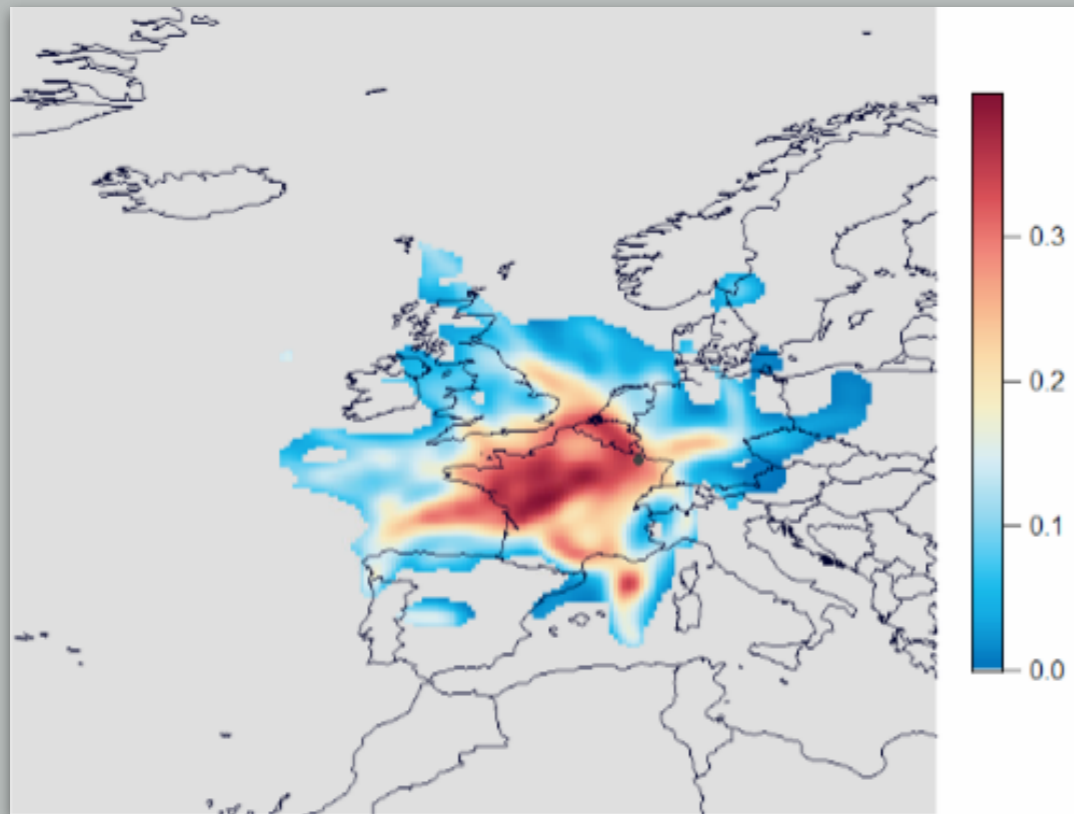


ZEFIR: AN IGOR TOOL FOR GEOGRAPHICAL ORIGINS

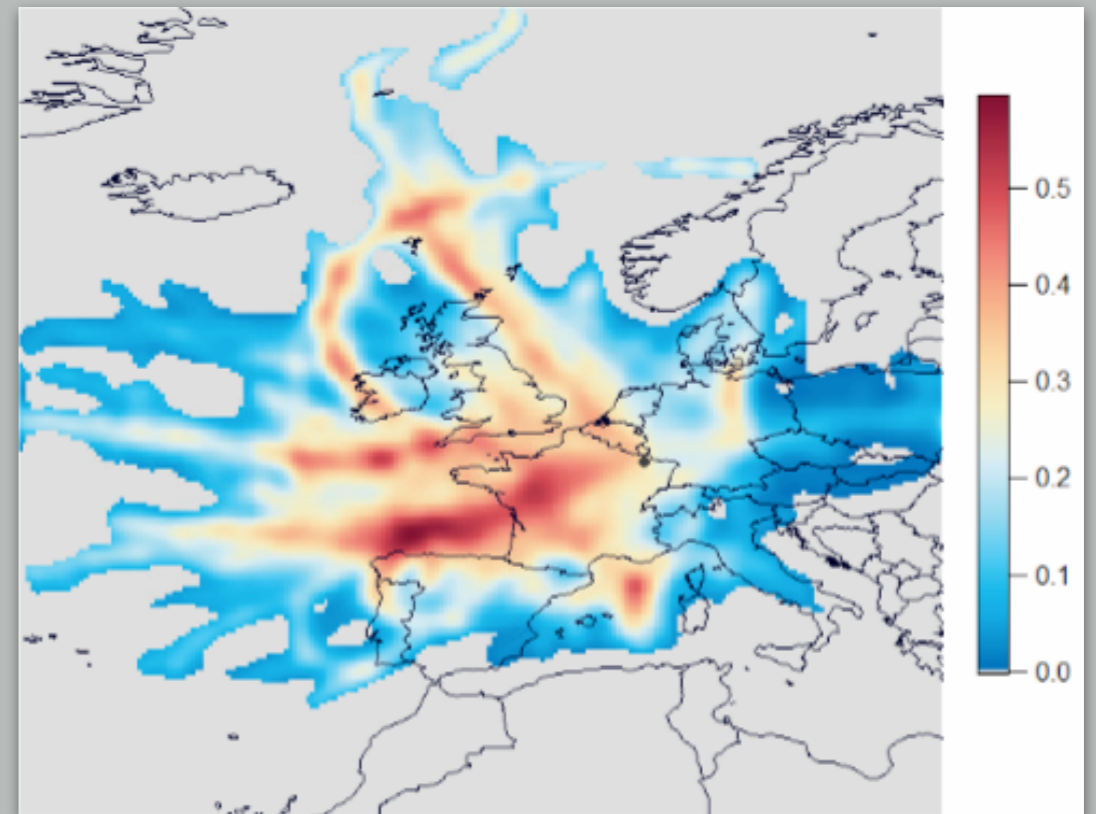
TRAJECTORY ANALYSIS

example Na⁺ in Metz (East of France) between 04/2015 and 03/2016
daily filter sampling 1day/3
CWT method

WITHOUT data enlargement



WITH data enlargement

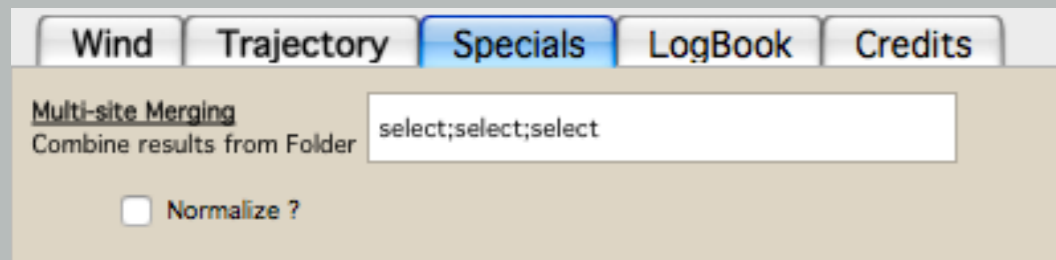


added traj at +3h, +6h, +9h, +12h, +15h, +18h & +21h
multiplied size of dataset by 8 !

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SPECIAL RUNS

Multisite Merging



Combines N trajectory analyses :

$$M_{ij} = \frac{\sum_{k=1}^N m_{ij}}{\sum_{k=1}^N n_{ij}}$$

Geographical origin phenomenology from Michael's ACSM dataset?

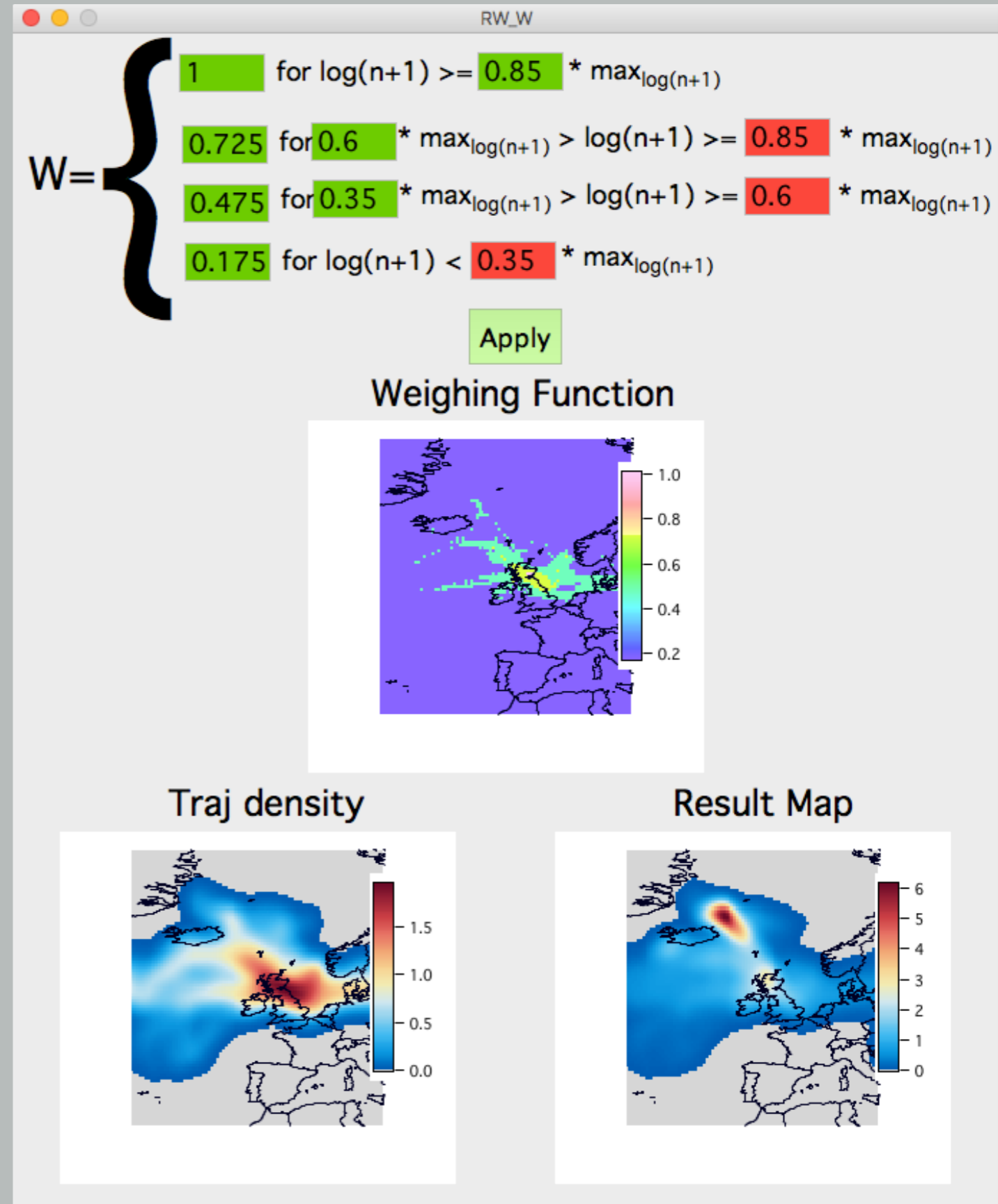
ZEFIR: AN IGOR TOOL FOR GEOGRAPHICAL ORIGINS

SPECIAL RUNS

Weighing Function

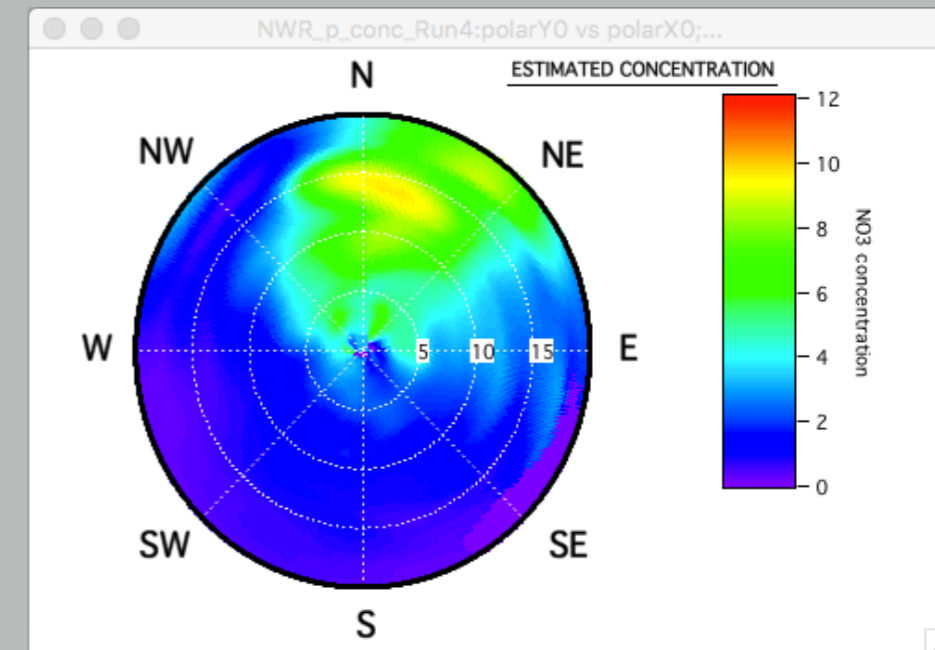
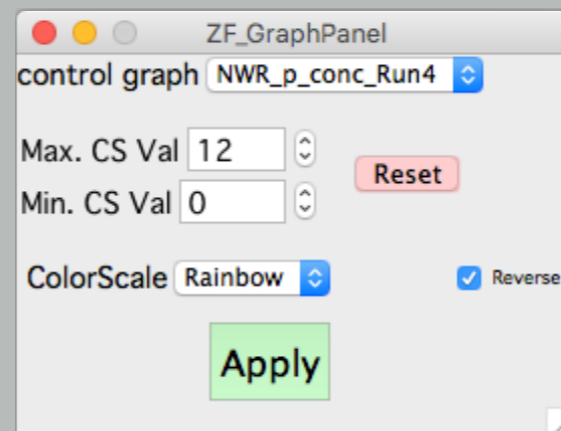
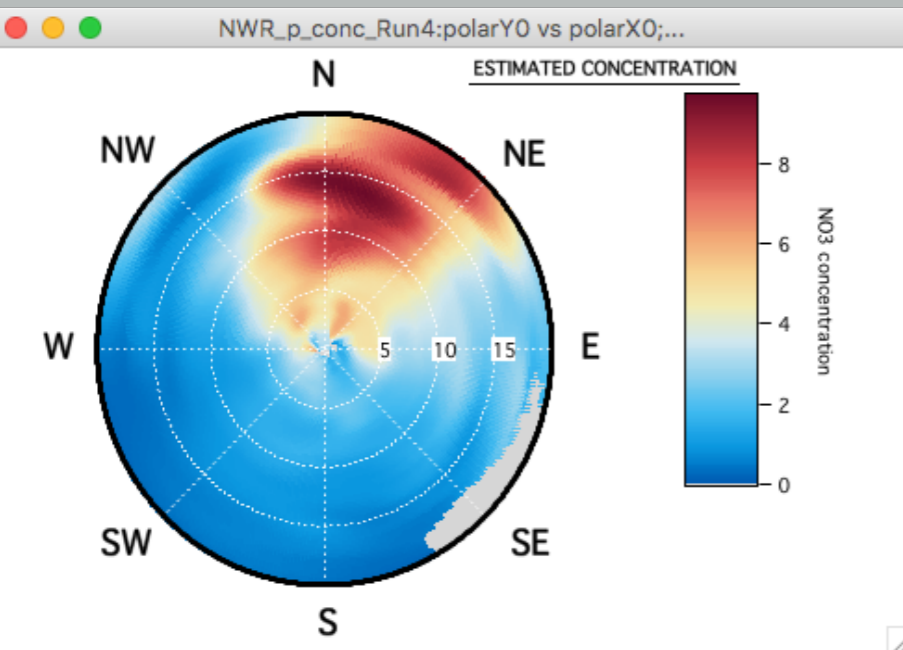
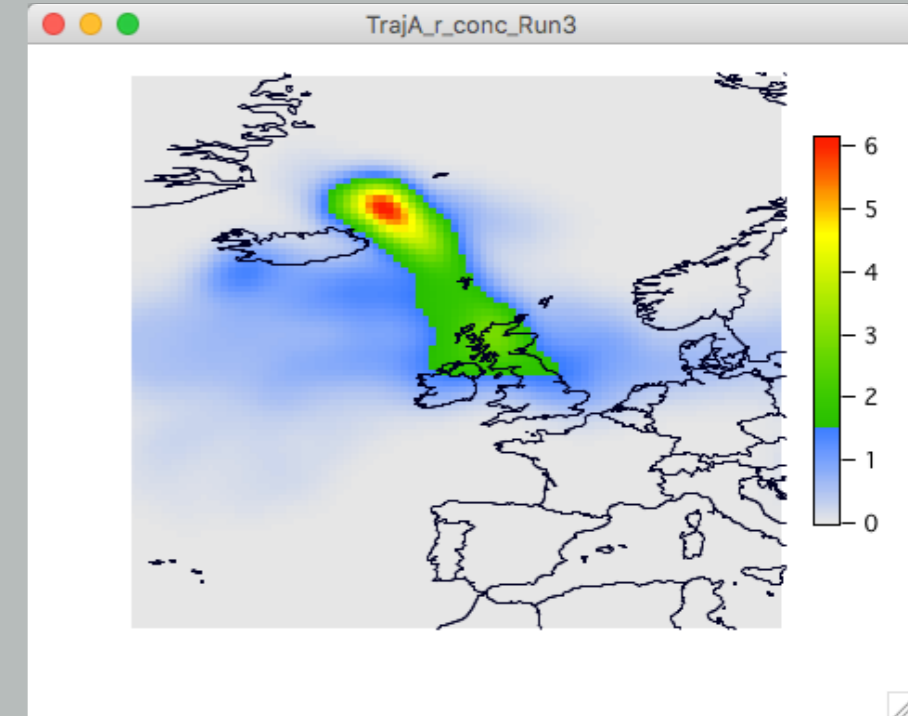
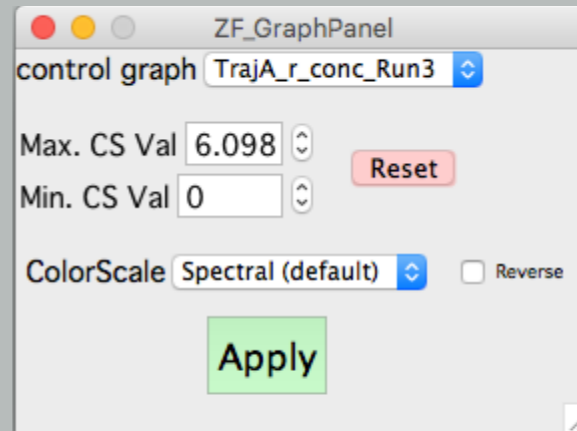
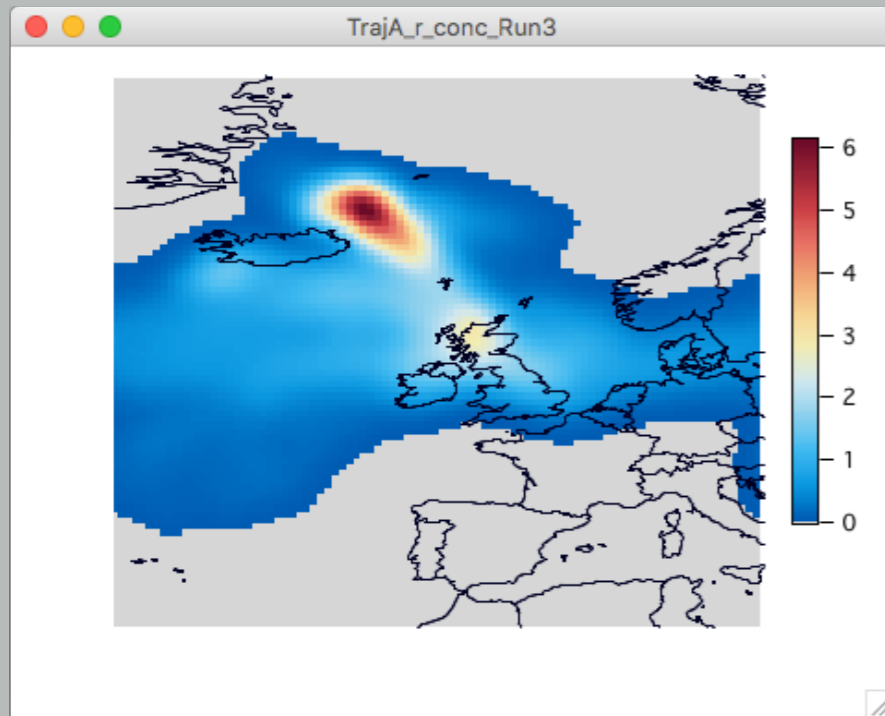
As for now, its empirical determination was performed by running as analyses as necessary.

With ZeFir, you only need **one single run**, and **interactively** adjust the weighing function



ZEFIR: AN IGOR TOOL FOR GEOGRAPHICAL ORIGINS

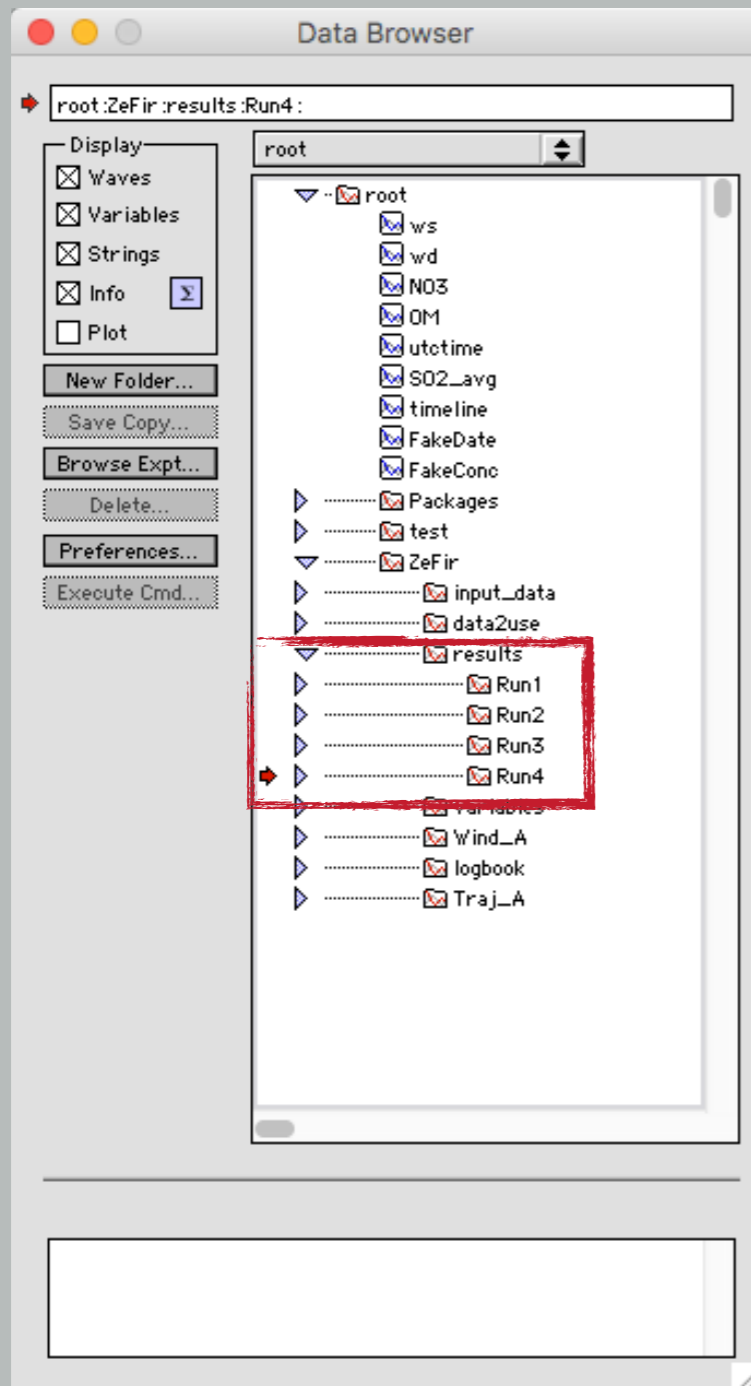
GRAPH_CONTROL



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RE-PLOT

Make the red arrow points towards the result folder of interest, and press re-plot results will be automatically re-displayed



ZEFIR: AN IGOR TOOL FOR GEOGRAPHICAL ORIGINS

LOGBOOK

The screenshot displays the 'LogBook' tab of the ZEFIR software interface. At the top, there are five tabs: 'Wind', 'Trajectory', 'Specials', 'LogBook' (which is selected and highlighted in blue), and 'Credits'. Below the tabs is a table with the following data:

Point	Run #	Result Folder	Analysis	Pollutant
0	1	Run1	NWR	NO3
1	2	Run2	NWR	NO3
2	3	Run3	CF	SO2_avg
3	4	Run4	NWR	NO3
4				

Below the table, there are two buttons: 'Kill Graph' and 'Kill Log'. The 'LogBook' tab also shows a dropdown menu with the number '1' and a downward arrow icon.

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Paper submitted on Environmental Modeling and Software (under review).

Petit, J.-E., Favez, O., Albinet, A., Canonaco, F.: An Igor-based tool for comprehensive evaluation of the geographical origins of atmospheric pollution: wind and trajectory analyses. Environmental Modelling and Software, submitted.

Procedure available on : - <http://www.air-lorraine.org/zefir>
- zefir.contact@gmail.com
- je.petit@air-lorraine.org

Package (~5 Mb) contains: .ipf procedure, manual, worldmap, example data for wind analysis and trajectory analysis