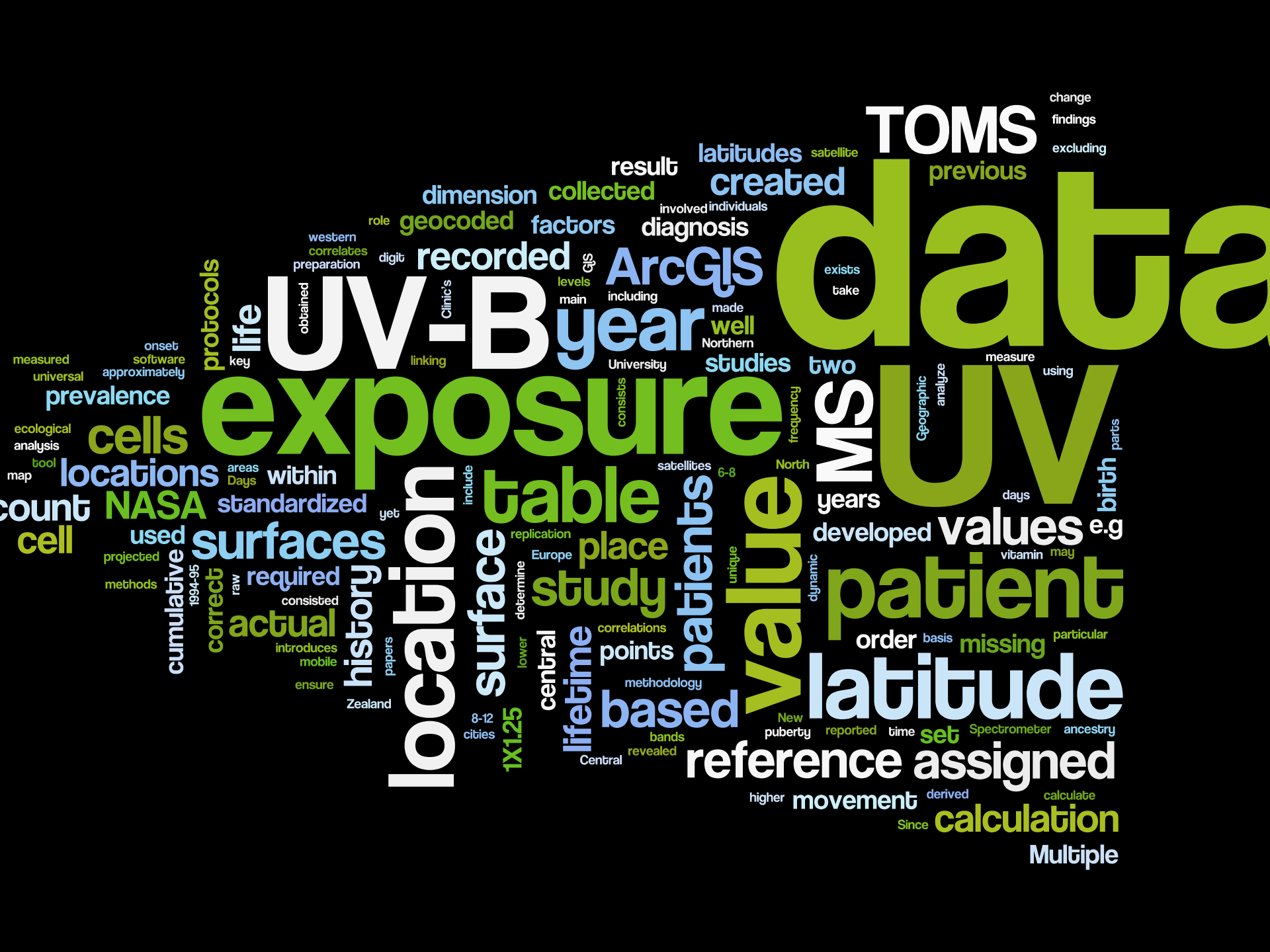
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Since
Multiple

*Spatio-Temporal Visualization of individuals Life Time Exposure to UVB

Ofer Amram, Nadine Schuurman and Helen Tremlett

SFU SIMON FRASER UNIVERSITY
THINKING OF THE WORLD

*UVB and Multiple Sclerosis

* Multiple sclerosis (MS) is a chronic, inflammatory demyelinating disease of the central nervous system for which the exact etiology is not yet understood.

* Multiple risk factors may be involved, including autoimmunity and environmental factors in genetically susceptible individuals.

* Since 1922, Vitamin D levels – measured by ultraviolet B exposure- have been correlated with MS.

*Latitude and UV-B

* Early papers reported that the frequency of MS was greater between 45 and 64 degrees latitude – than at lower latitudes.

* These reports were organized geographically by Kurtzke (1980) in a map that revealed bands of higher prevalence in Northern and Central Europe as well as North America and parts of Southern New Zealand and Australia

Fig. 13. World-wide distribution of multiple sclerosis: High frequency (heavy shading), medium frequency (dotted shading) and low frequency (diagona dashes). Urshadec regions are without data

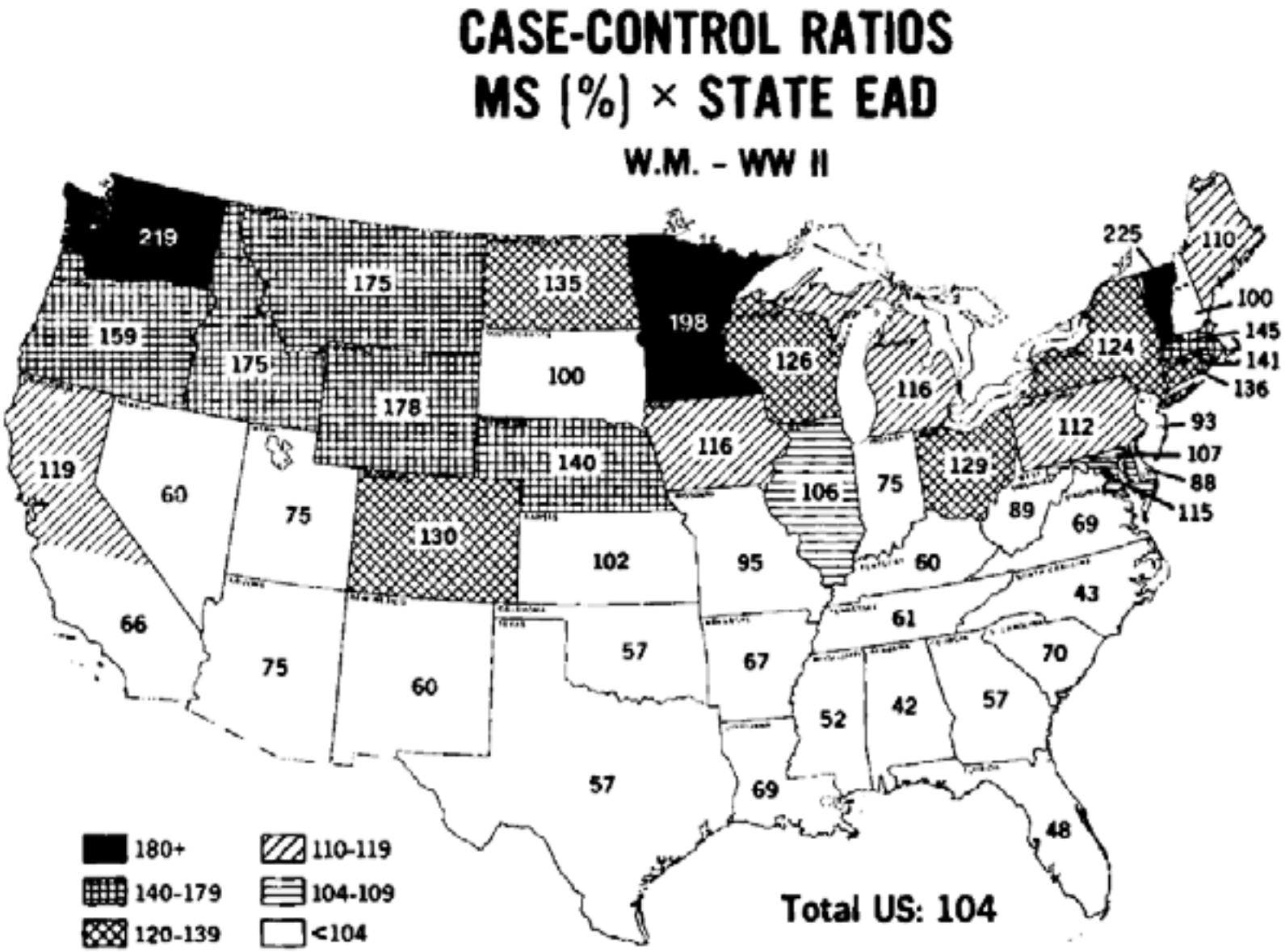


Fig. 4. Case-control ratios for US white male veterans of World War II service-connected for MS, according to state of residence at entry into military service. Ratios below 75 % are medium frequency. Modified from Kurtzke *(1978).*

*Problems with calculation

* Assignations of latitude were variously derived based on place of birth, location at puberty and place of diagnosis
* Shortcoming: a single latitude for assignation of UV-B exposure does not take into account the role of life history (e.g. movement, migration).
* Plus, latitude does not equal UV-B exposure.

*Our goal

* We have developed a method to calculate patient UV-B exposure at critical points as well as cumulative exposure over the course of their life history.

*We are calculating and mapping patients' exposure year by year over the course of their lives.

*Patient Data

* 4011 MS patients with 4 Caucasian grandparents of Northern or Central European ancestry were selected from the University of British Columbia (UBC) MS Clinic's database.

* The data includes patient movement from birth to diagnosis and indicates the date (year) and location of each change in place of residency.(~16,500 movements)

Patient Table

ID	MOVE_SEQUENCE	YEAR_MOVED_TO	CITY	PROV	COUNTRY
1	1	1977	PORT HARDY	BRITISH COLUMBIA	CANADA
1	2	1994	BURNS LAKE	BRITISH COLUMBIA	CANADA
1	3	1995	PORT HARDY	BRITISH COLUMBIA	CANADA
1	4	1996	MEDICINE HAT	ALBERTA	CANADA
1	5	1997	PORT HARDY	BRITISH COLUMBIA	CANADA

*Data preparation flow

*UV Data

* UV data were obtained from the NASA Total Ozone Mapping Spectrometer (TOMS) data set.
* TOMS data consists of several data sets collected by NASA satellites during the period 1979 to 2005 (excluding 1994-95).
* Our study used TOMS' Eurythmical UV data as it provides a record of UV values reflected from the earth's surface.
* The raw data is collected and recorded daily and covers the world's surface

*Preparing the analysis

* A UV value was assigned to each year of each patient's life.
* A UV reference table, was developed providing a patient-specific UV value for each location and each year included in the study.
* The reference table allowed us to assign the correct UV value to the patient movement table based on time and location.
* To populate the table, each unique patient location was geocoded (approximately 2500 locations).

*Missing data

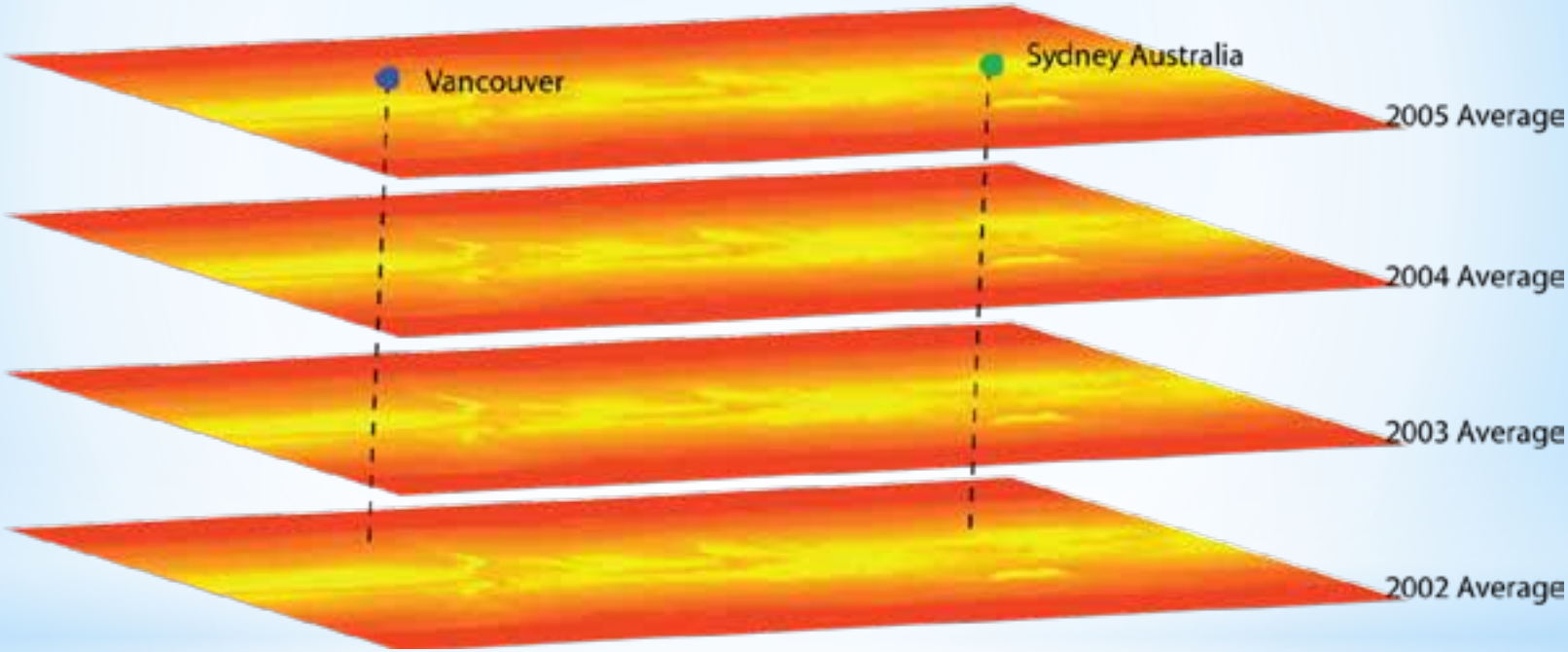
* Annual UV surfaces were created for each year for which data were available.
* For years in which no UV data were recorded, averaged surfaces were created based on years for which data existed.

*Some GIS details

* ArcGIS was the primary tool used to prepare the data.

*After all the UV surfaces were created, the reference table was created by overlaying the surfaces with the geocoded cities and extracting the UV value for each surface year.

Vancouver	71.5	66.4	70.2	69.9
Sydney	134.1	139.6	135.4	136.0



*Finding cumulative UV-B exposure for individuals

Target Table

ID	Age1	Age2	Age3
1			
2			
3			
5			
6			

Patient Table

ID	MOVE_SEQUENCE	YEAR_MOVED_TO	CITY	PROV	COUNTRY
1	1	1977	PORT HARDY	BRITISH COLUMBIA	CANADA
1	2	1994	BURNS LAKE	BRITISH COLUMBIA	CANADA
1	3	1995	PORT HARDY	BRITISH COLUMBIA	CANADA
1	4	1996	MEDICINE HAT	ALBERTA	CANADA
1	5	1997	PORT HARDY	BRITISH COLUMBIA	CANADA

Reference Table

CITY	1978	1979	1980	1981	1982
PORT HARDY	80.1	81.6	76.8	77.7	75.5
PORT HOPE	110.7	104.8	106.7	105.0	103.6
PORT MACLEOD	83.1	81.1	81.8	79.9	79.8
PORT MC NEIL	80.1	81.6	76.8	77.7	75.5

*Data preparation flow

Target Table

ID	Age1	Age2	Age3
1			
2			
3			
5			
6			

Patient Table

ID	MOVE_SEQUENCE	YEAR_MOVED_TO	CITY	PROV	COUNTRY
1	1	1977	PORT HARDY	BRITISH COLUMBIA	CANADA
1	2	1994	BURNS LAKE	BRITISH COLUMBIA	CANADA
1	3	1995	PORT HARDY	BRITISH COLUMBIA	CANADA
1	4	1996	MEDICINE HAT	ALBERTA	CANADA
1	5	1997	PORT HARDY	BRITISH COLUMBIA	CANADA

Reference Table

CITY	1978	1979	1980	1981	1982
PORT HARDY	80.1	81.6	76.8	77.7	75.5
PORT HOPE	110.7	104.8	106.7	105.0	103.6
PORT MACLEOD	83.1	81.1	81.8	79.9	79.8
PORT MC NEIL	80.1	81.6	76.8	77.7	75.5

*Data preparation flow

Target Table

ID	Age1	Age2	Age3
1			
2			
3			
5			
6			

Patient Table

ID	MOVE_SEQUENCE	YEAR_MOVED_TO	CITY	PROV	COUNTRY
1	1	1977	PORT HARDY	BRITISH COLUMBIA	CANADA
1	2	1994	BURNS LAKE	BRITISH COLUMBIA	CANADA
1	3	1995	PORT HARDY	BRITISH COLUMBIA	CANADA
1	4	1996	MEDICINE HAT	ALBERTA	CANADA
1	5	1997	PORT HARDY	BRITISH COLUMBIA	CANADA

Reference Table

CITY	1978	1979	1980	1981	1982
PORT HARDY	80.1	81.6	76.8	77.7	75.5
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Target Table

ID	Age1	Age2	Age3
1			
2			
3			
5			
6			

Patient Table

ID	MOVE_SEQUENCE	YEAR_MOVED_TO	CITY	PROV	COUNTRY
1	1	1977	PORT HARDY	BRITISH COLUMBIA	CANADA
	2	1994	BURNS LAKE	BRITISH COLUMBIA	CANADA
	3	1995	PORT HARDY	BRITISH COLUMBIA	CANADA
	4	1996	MEDICINE HAT	ALBERTA	CANADA
1	5	1997	PORT HARDY	BRITISH COLUMBIA	CANADA

Between 1977 – 1994
in Port Hardy

Reference Table

CITY	1978	1979	1980	1981	1982
PORT HARDY	80.1	81.6	76.8	77.7	75.5
PORT HOPE	110.7	104.8	106.7	105.0	103.6
PORT MACLEOD	83.1	81.1	81.8	79.9	79.8
PORT MC NEIL	80.1	81.6	76.8	77.7	75.5

*Data preparation flow

Target Table

ID	Age1	Age2	Age3
1			
2			
3			
5			
6			

Patient Table

ID	MOVE_SEQUENCE	YEAR_MOVED_TO	CITY	PROV	COUNTRY
1	1	1977	PORT HARDY	BRITISH COLUMBIA	CANADA
	2	1994	BURNS LAKE	BRITISH COLUMBIA	CANADA
	3	1995	PORT HARDY	BRITISH COLUMBIA	CANADA
	4	1996	MEDICINE HAT	ALBERTA	CANADA
1	5	1997	PORT HARDY	BRITISH COLUMBIA	CANADA

Between 1977 – 1994
in Port Hardy

Reference Table

CITY	1978	1979	1980	1981	1982
PORT HARDY	80.1	81.6	76.8	77.7	75.5
PORT HOPE	110.7	104.8	106.7	105.0	103.6
PORT MACLEOD	83.1	81.1	81.8	79.9	79.8
PORT MC NEIL	80.1	81.6	76.8	77.7	75.5

*Data preparation flow

Target Table

ID	Age1	Age2	Age3
1	80.1		
2			
3			
5			
6			

Patient Table

ID	MOVE_SEQUENCE	YEAR_MOVED_TO	CITY	PROV	COUNTRY
1	1	1977	PORT HARDY	BRITISH COLUMBIA	CANADA
	2	1994	BURNS LAKE	BRITISH COLUMBIA	CANADA
	3	1995	PORT HARDY	BRITISH COLUMBIA	CANADA
	4	1996	MEDICINE HAT	ALBERTA	CANADA
1	5	1997	PORT HARDY	BRITISH COLUMBIA	CANADA

Between 1977 – 1994
in Port Hardy

Reference Table

CITY	1978	1979	1980	1981	1982
PORT HARDY	80.1	81.6	76.8	77.7	75.5
PORT HOPE	110.7	104.8	106.7	105.0	103.6
PORT MACLEOD	83.1	81.1	81.8	79.9	79.8
PORT MC NEIL	80.1	81.6	76.8	77.7	75.5

*Data preparation flow

Target Table

ID	Age1	Age2	Age3
1	80.1	80.1	
2			
3			
5			
6			

Patient Table

ID	MOVE_SEQUENCE	YEAR_MOVED_TO	CITY	PROV	COUNTRY
1	1	1977	PORT HARDY	BRITISH COLUMBIA	CANADA
	2	1994	BURNS LAKE	BRITISH COLUMBIA	CANADA
	3	1995	PORT HARDY	BRITISH COLUMBIA	CANADA
	4	1996	MEDICINE HAT	ALBERTA	CANADA
1	5	1997	PORT HARDY	BRITISH COLUMBIA	CANADA

Between 1977 – 1994 in Port Hardy

Reference Table

CITY	1978	1979	1980	1981	1982
PORT HARDY	80.1	81.6	76.8	77.7	75.5
PORT HOPE	110.7	104.8	106.7	105.0	103.6
PORT MACLEOD	83.1	81.1	81.8	79.9	79.8
PORT MC NEIL	80.1	81.6	76.8	77.7	75.5

*Data preparation flow

Target Table

ID	Age1	Age2	Age3
1	80.1	80.1	81.6
2			
3			
5			
6			

Patient Table

ID	MOVE_SEQUENCE	YEAR_MOVED_TO	CITY	PROV	COUNTRY
1	1	1977	PORT HARDY	BRITISH COLUMBIA	CANADA
	2	1994	BURNS LAKE	BRITISH COLUMBIA	CANADA
	3	1995	PORT HARDY	BRITISH COLUMBIA	CANADA
	4	1996	MEDICINE HAT	ALBERTA	CANADA
1	5	1997	PORT HARDY	BRITISH COLUMBIA	CANADA

Between 1977 – 1994 in Port Hardy

Reference Table

CITY	1978	1979	1980	1981	1982
PORT HARDY	80.1	81.6	76.8	77.7	75.5
PORT HOPE	110.7	104.8	106.7	105.0	103.6
PORT MACLEOD	83.1	81.1	81.8	79.9	79.8
PORT MC NEIL	80.1	81.6	76.8	77.7	75.5

*Data preparation flow

Target Table

ID	Age1	Age2	Age3	Age4	Age5	Age6
1	80.1	80.1	81.6	76.8	77.7	75.5
2	86.3	86.3	86.3	86.3	86.3	86.3
3	73.1	73.1	90.5	74.9	74.9	74.9
5	90.5	90.5	90.5	90.5	90.5	90.5
6	78.2	78.2	78.2	86.4	86.4	86.4
37	86.3	86.3	86.3	86.3	86.3	86.3
45	123.7	123.7	90.5	90.5	90.5	90.5
55	67.1	67.1	67.1	67.1	67.1	67.1
60	79.1	79.1	79.1	79.1	79.1	79.1
79	74.7	74.7	74.7	74.7	74.7	74.7
86	54.9	54.9	54.9	54.9	54.9	47.4

*Data preparation flow

*Results

* We were able to calculate individual patient exposure by year.

* This allows for very detailed analysis as there is increasing evidence that UV-B exposure matters more at critical moments in a life history.

* This research provides a means of determining average UV exposure at critical points in each patient's life.

ID	Move	YearMoved	City	Prov	Country	Birth	Age	CumUV
377	1	1926	DUNSFOLD		ENGLAND	Y	30	2176
377	2	1956	TORONTO	ONTARIO	CANADA	N	48	4161
377	3	1974	VICTORIA	BRITISH COLUMBIA	CANADA	N	79	6947
UV Birth	*72.53*	**UV 15years**	*1088*	**UV Diagnosis**	*6947*			
ID	**Move**	**YearMoved**	**City**	**Prov**	**Country**	**Birth**	**Age**	**CumUV**
1924	1	1943	VANCOUVER	BRITISH COLUMBIA	CANADA	Y	10	863
1924	2	1953	BAKERSFIELD/LONG BEACH	CALIFORNIA	USA	N	15	1641
1924	3	1958	VANCOUVER	BRITISH COLUMBIA	CANADA	N	62	5684
UV Birth	*86.3*	**UV 15years**	*1641*	**UV Diagnosis**	*5684*			

*Cumulative UV-B exposure

*Visualization

* The goal were to show patient movement from birth and to visualize accumulative UV exposure throughout the patient's lifetime

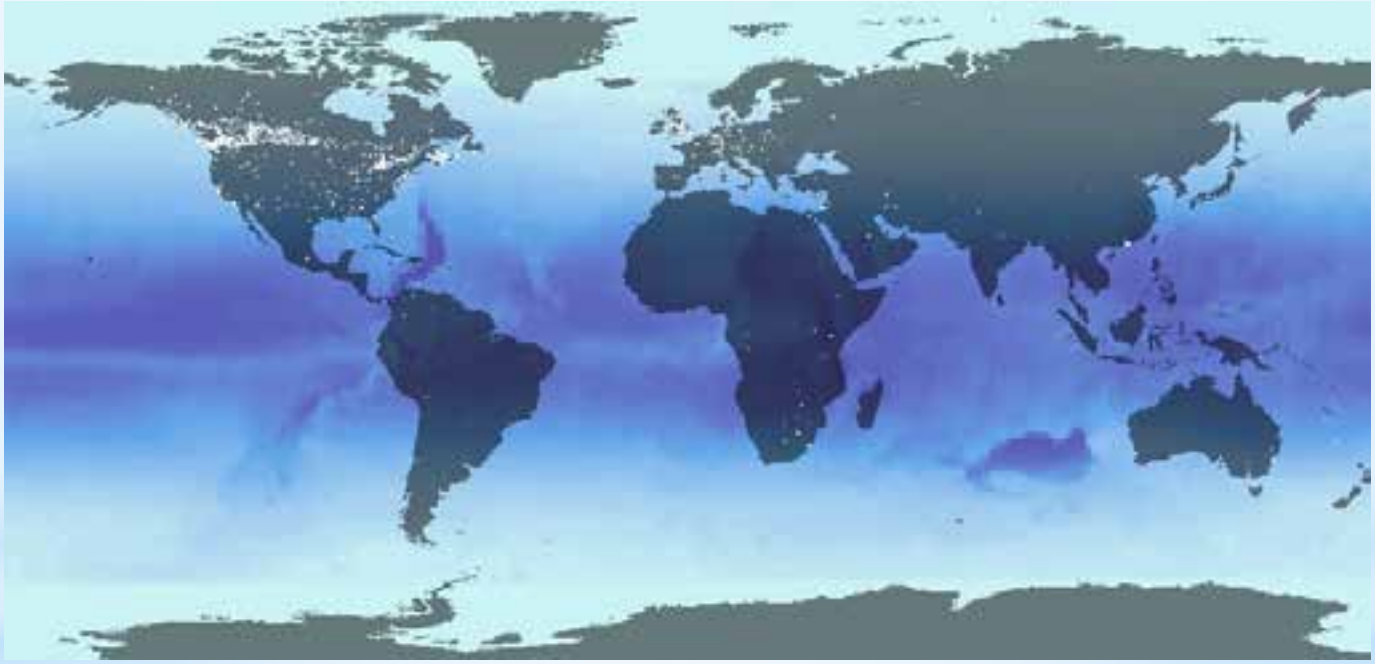
Challenges:

- Large amounts of data
- No distinct trend within the data

(i.e no aggregation)

- Static Map

* ArcScene was used for its ability to visualize and manipulate data in 3D



*Visualization

* ArcScene was used for its ability to visualize and manipulate data in 3D

*Visualization

Patient Movement

* 3D trajectories connecting all places of residency since birth

*Visualization

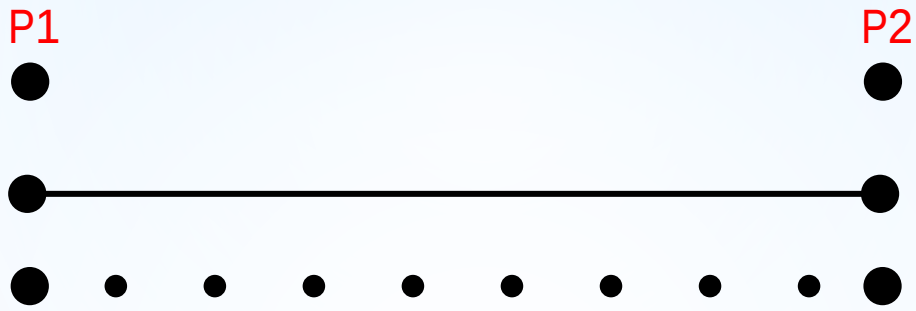
Patient Movement

* 3D trajectories connecting all places of residency since birth

*Visualization

Patient Movement

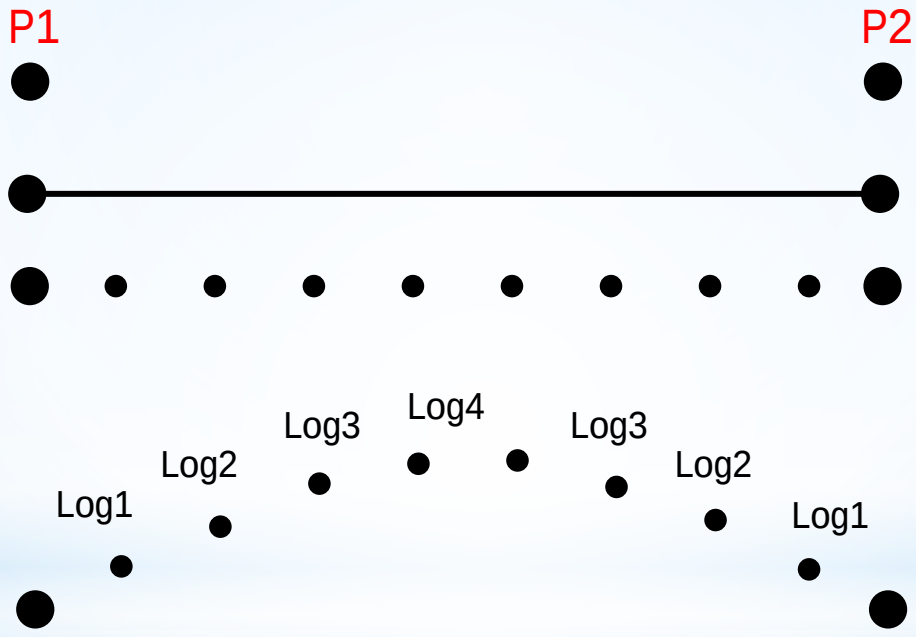
* 3D trajectories connecting all places of residency since birth



*Visualization

Patient Movement

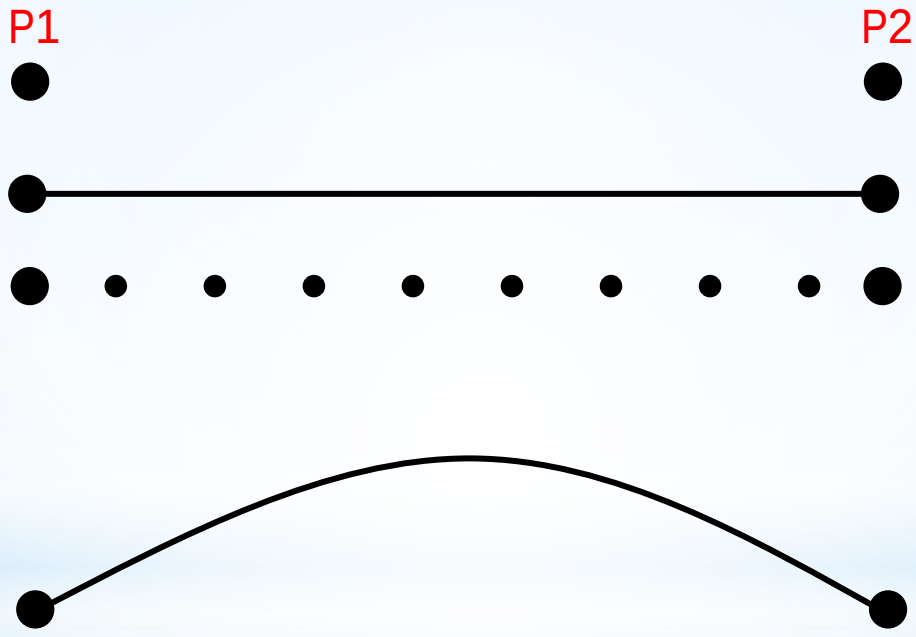
*3D trajectories connecting all places of residency since birth



*Visualization

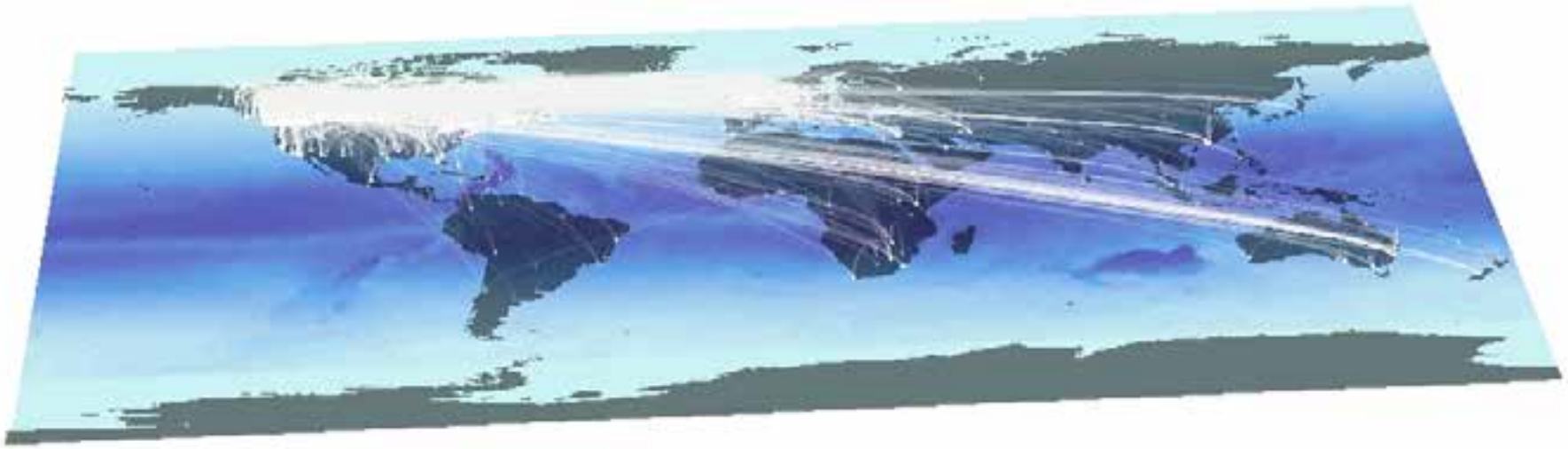
Patient Movement

* 3D trajectories connecting all places of residency since birth



*Visualization

Creating 3D Trajectories



*Visualization

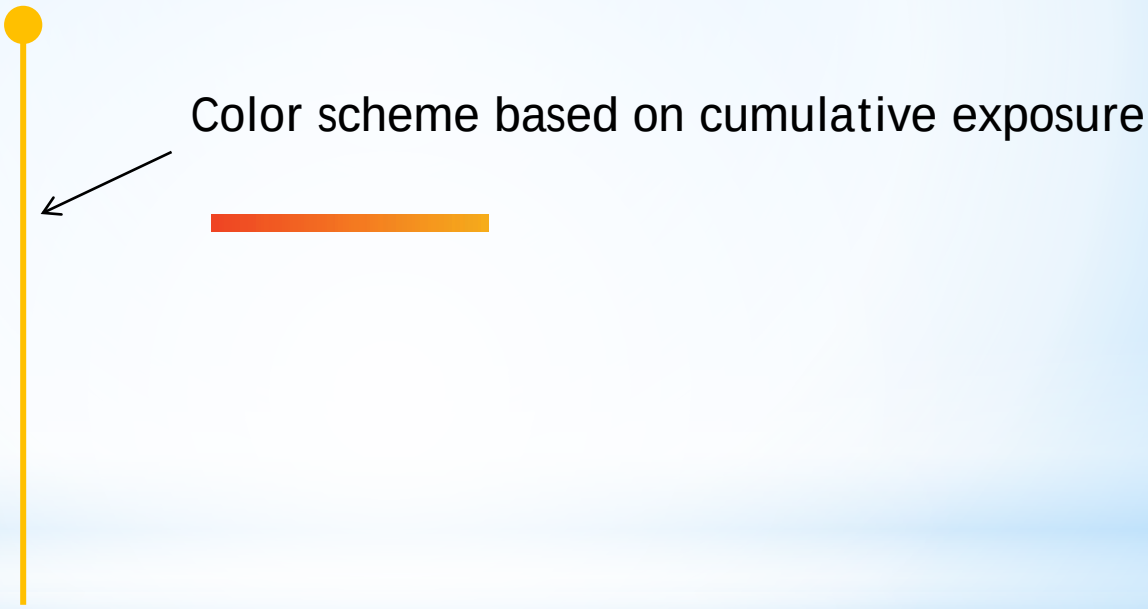
Patient Age and cumulative exposure

* At each location we assigned a line height which corresponded to the patient's age

*Visualization

Patient Age and cumulative exposure

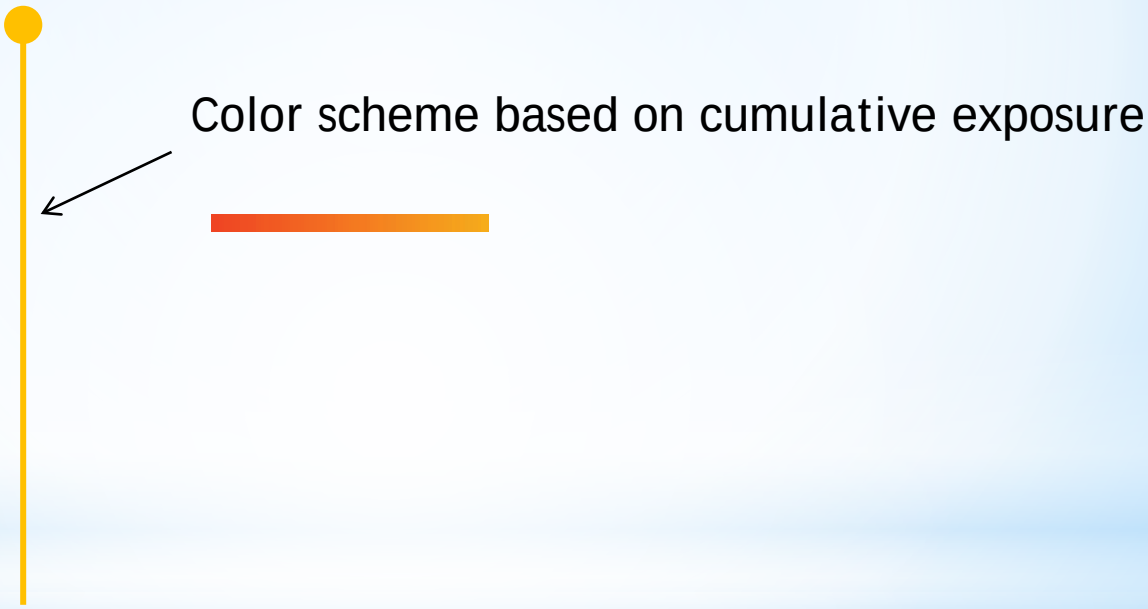
* At each location we assigned a line height which corresponded to the patient's age



*Visualization

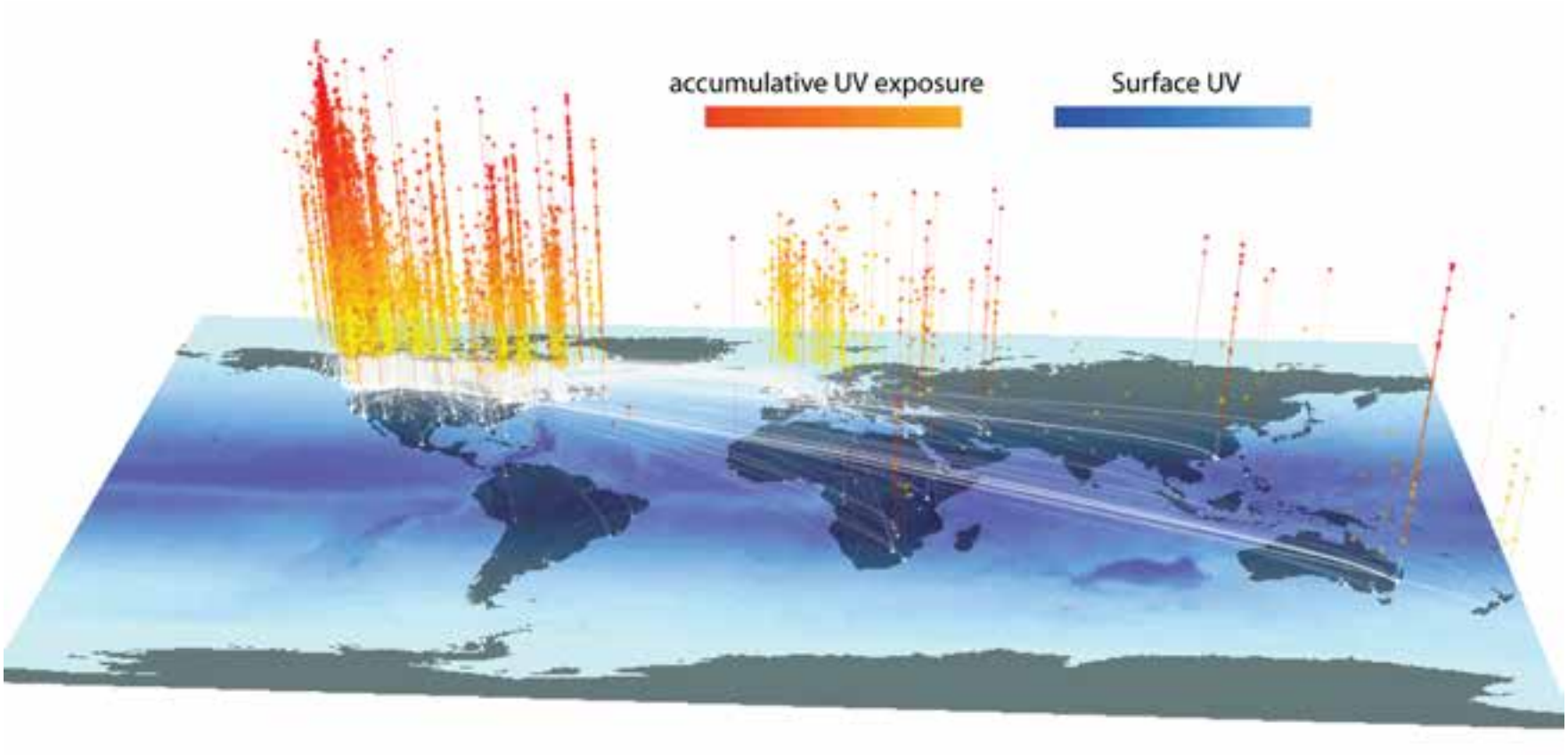
Patient Age and cumulative exposure

* At each location we assigned a line height which corresponded to the patient's age

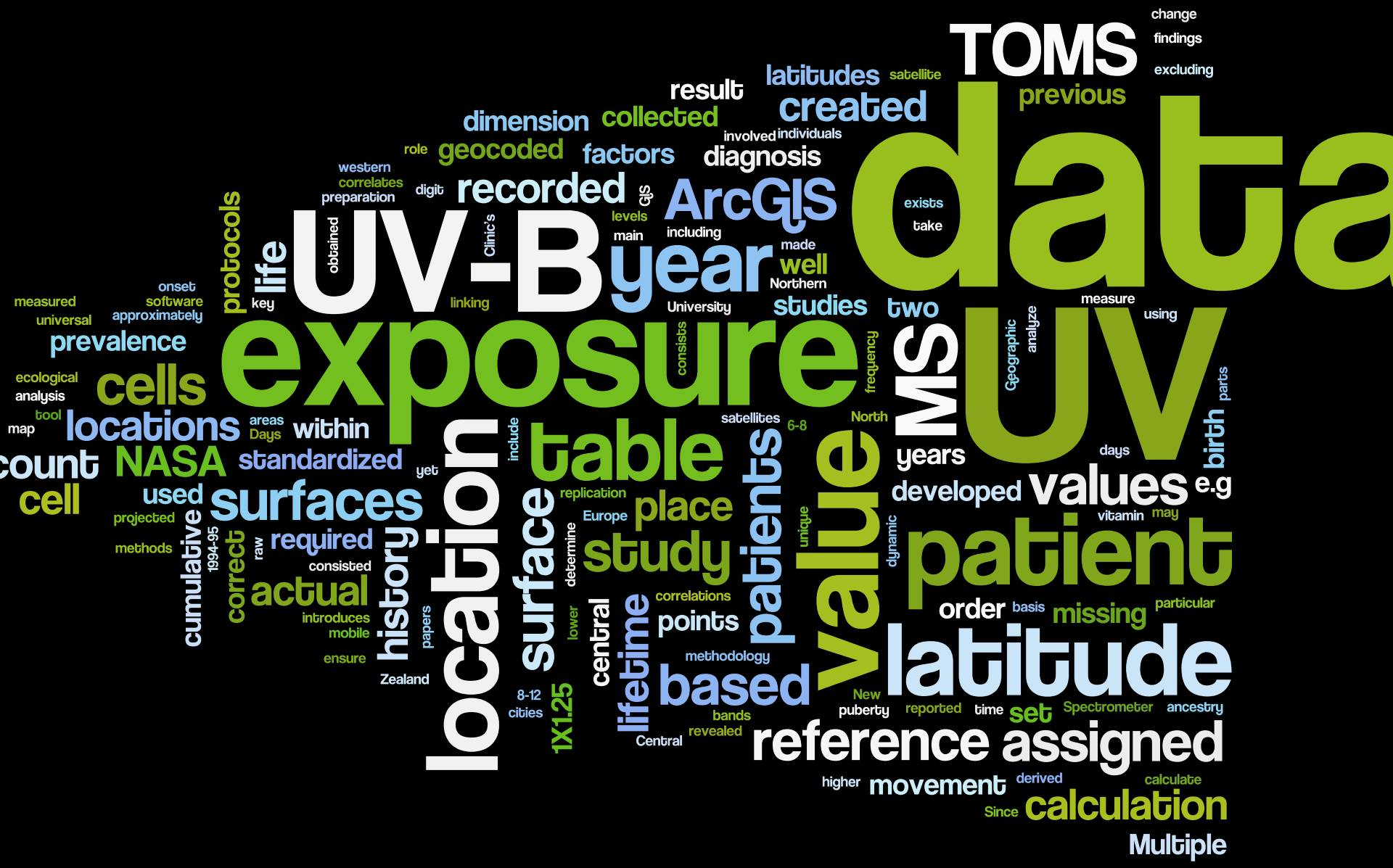


*Visualization

Final Image



*Visualization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locations
NASA
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study
place
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correlations
methodology
bands
revealed
Central
New
puberty
reported
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Spectrometer
ancestry
higher
derived
calculate
Since
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consisted
introduces
mobile
ensure
Zealand
papers
lower
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western
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Questions?