2017 IM^{2}C Solution

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1 Introduction

1.1 Meetings Are More Than Just Greetings

Whether it be for a company task or a location for chatting with friends, every social meeting will need a place to congregate, preferably with everyone considered. Sometimes the trip is only a few minutes; other times it is so long, it may affect the physical state of the participants. In the latter, extra care must be taken to deal with such nuances.

We have developed a fixed criteria and several models to find possible destinations that are suitable for hosting a long distance meeting, requiring only the starting destinations. We have also tested these models on several cases to compare and contrast them. To be exhaustive, different types of data sets will be considered, and we will determine the strengths of each model.

1.2 The Problem

As suggested by the introduction, we are required to locate a region of points on land that would be suitable as a location for a meeting given the home countries of the participants. We have prioritized the criteria for such a location as follows (in order of importance):

1. Minimize the total time zone discrepancy across all participants
2. Ensure time zone discrepancies among all participants are consistent (e.g. a distribution of 2, 2, 2, 2 is better than 0, 0, 3, 5, all else the same)
3. Minimize climate effects (this is *not* the same as climate differences, as we will discuss later)
4. Minimize the total expenses
   (i) Travel expenses (explained in the assumptions section)
   (ii) Accommodation expenses (participants should arrive at roughly the same time.)

This scenario is not entirely realistic, as we will only be using the factors above to judge a location; side issues such as political tensions or accessibility of countries are disregarded in our pursuit of choosing a destination. Also, we will assume that the meeting is short enough that participants will not be seasoned to the environment, and experience other issues when they return back.

As shown, we chose four guidelines as the foundation for our models. First and foremost, jet lag is a large factor for participants of an international meeting. Since the meetings are short, there is limited time for participants to get accustomed to new time zones and allowing meeting members to stay a week before the meeting is both costly and time consuming. Overall we want to mitigate the effects of time zone discrepancies for the participants.

The effects of time zones are extremely destructive to meeting productivity, particularly if participant's countries of origins has time zones many hours apart. For example, a twelve hour time zone difference would be very disruptive to the productivity of members since they would be extremely tired (originally they would be asleep at the time of the meeting). However, a lesser effect could be felt if there is a time zone difference of four or five hours. A jet lag of a few hours means that the participant would be awake at their home country. Accordingly, our models also take into consideration of ensuring that discrepancies are consistent among participants.

Depending on the distribution of the participants, equal discrepancies is not always realistic or possible. Take for example, a situation for which nine participants of a meeting are in location A and one person is in location B, which has a time zone difference of twelve hours with A. By the discrepancy equality criteria, everyone should have a time zone discrepancy of six hours. However, this is not realistic for the meeting because nine people are gaining six hours of jet lag to reduce the jet lag of one person by 6 hours. In this situation we believe that it is better to meet at location A or a location that has a time zone close to A.

Climate is also an important factor when considering the meeting location. A comfortable climate allows participants to be more productive and puts them in a better mood. For instance, people may get frustrated when their clothing is drenched with sweat. On the contrary, nice weather makes people feel much happier and their better mood leads to better exchanging of ideas at the meeting.

The International Meeting Management Corporation should also consider the travel costs of the participants. Although the productivity and transfer of information is of primary importance, we believe that this process should not be costly. In our models we will try to minimize the expenses involved. Particularly when our models show multiple possible locations, we will consider costs and eliminate locations that are too costly.

1.3 Assumptions Invoked and Their Justifications

We use assumptions to simplify calculations and ideas, so our the general framework of our idea becomes clear. The majority of the assumptions we make are practical, and we provide the motive for using them.

The earth is perfectly spherical. - This allows for the distance from the center of the Earth to the surface constant, which allows for easier calculations. Note that any elevation of the Earth is negligible given the large radius of the Earth.

Every country is accessible at any time. - The models presented attempt to minimize the overall stress of a meeting but will not consider the shifting political situation across countries.

Cost and travel distance is proportional. - This criteria helps to simplify the calculations involving total cost. Overall, more money is needed to go to further destinations, so this assumption is realistic.

Transportation is always available. - In current society most places are accessible by some mode of transportation. This assumption makes it easier to determine a meeting location.

Time is continuous. - Daylight saving time will not be taken into consideration.

Travel time affects each member equally. - It is reasonable to assume that as people travel further and experience more jet lag, their productivity decreases proportionally. With this assumption, we can deduce that a certain period of jet lag for one person, will not be more or less detrimental as if it had occurred to another person.

Temperature is same for points on the same line of latitude. - Temperature is continuous, so this is within the box to assume. This allows us to extrapolate from a single data point, values for a wide region on the surface.

1.4 Defining Useful Terms

Time zone: One of 24 equal vertical division of the Earth corresponding to differences in time of hour.
Time zone discrepancy: The difference in time a person experiences in moving from one location to another.
Climate zone: One of 12 horizontal divisions of the Earth of a range of 15° latitude.
UTC (Coordinated Universal Time): The time zone at the prime meridian.
Rectangular Coordinates: A system of labeling points in 3D space by associating a triple of real numbers (x, y, z) with a specific location.

2 Models

2.1 Approach 1: Minimizing Time Zone Discrepancies

This method focuses on finding a region for which the participants will collectively have a minimal jet lag. We shall denote the time zones of the globe as $i_1, i_2, \ldots, i_{24}$. If the destination is in time zone $i_k, 1 \leq k \leq 24$ and the n participants are from intervals in the multi-set of n intervals, $I = \{i_1, i_2, \ldots, i_n\}$, then we define the time zone difference function for interval i_k as $D_k^I = \sum_{l=1}^{24} d_l^k$ where $d_j^k, j = 1, \ldots, n$ are defined as follows:

$$d_j^k = \begin{cases} |i_k - i_j| \text{ if } |i_k - i_j| \leq 12 \\ 24 - |i_k - i_j| \text{ if } |i_k - i_j| > 12 \end{cases}$$

We then compute $\min(D_k^I)$ across all intervals $i_k, k = 1 \ldots 24$, which gives us the minimal total time discrepancy, and the intervals that give this minimum as optimal destinations.

This approach will always produce an output, and will ensure that overall, the time zone differences are minimal. Also, since the output is always a region, it will decrease the likelihood that the produced locations all lie in the ocean. If we treat productivity as directly proportional to the amount of time saved, then we see that this method increases efficiency the most. Furthermore, this model reduces total travel time, thus reducing the cost. For example, given a set of ten people at one location, and two people at another further away location, this model suggests the spot with the majority of participants. This will reduce the distance, as the weighted majority will contribute most to the the overall distance.

2.2 Approach 2: Spherical Approach

This model takes the problem in another perspective, and considers the Earth as a 3D surface. By mimicking the actual shape of the Earth, this allows us to accurately find distances between cities. This is particularly true at the poles when a 2D surface would skew the points on a map.

To determine the best location for the meeting, we find an average location that takes into consideration all the participants starting whereabouts. Treating each city as a point, the optimal location will calculated from the center of mass of the set of cities.

We will set up a 3D coordinate system where the x and y axes will be on the plane of the equator and the point $O(0, 0, 0)$ is set as the center of the Earth, where the radius of the earth is r. To have a frame of reference, the positive x-axis will point towards the prime meridian. The rectangular coordinates of the n cities will be $(x_1, y_1, z_1), (x_2, y_2, z_2), \ldots, (x_n, y_n, z_n)$. These are converted from the latitude and longitude of the cities as shown by the method below.

Suppose we have a point A on the surface of the earth with latitude θ and longitude ϕ (see figure 2.1). Connect A to the center of the earth O, and drop a perpendicular to the plane of equator at point B. Drop a perpendicular from B to the x-axis at point C.

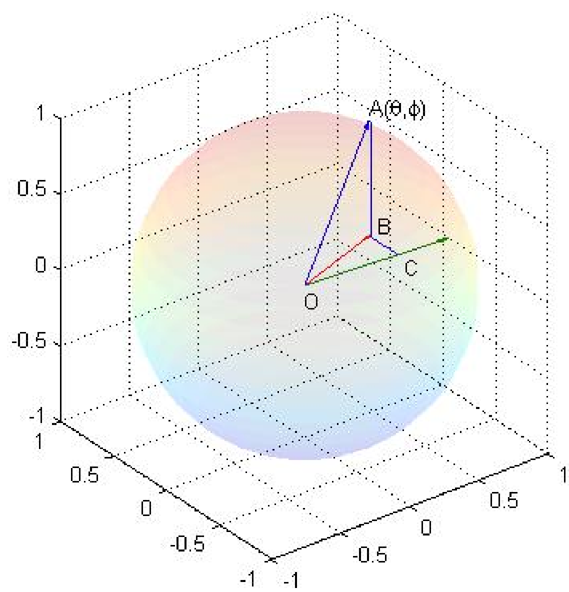

Figure 2.1

We can determine the z-coordinate of A by using a sine ratio in $\triangle OAB$:

$$\frac{z}{r} = \sin\theta$$

$$\Rightarrow z = r\sin\theta$$

Similarly, $\frac{OB}{r} = \cos\theta$ so $OB = r\cos\theta$. With the length of OB, we can calculate the coordinates of B in plane xy:

$$\frac{x}{OB} = \cos\phi$$

$$\Rightarrow x = r\cos\theta\cos\phi$$

$$\frac{y}{OB} = \sin\phi$$

$$\Rightarrow y = r\cos\theta\sin\phi$$

In conclusion, the point A with latitude θ and longitude ϕ has coordinates in the xyz plane $(r\sin\theta, r\cos\theta\cos\phi, r\cos\theta\sin\phi)$. After converting each point on the Earth to this form, we may calculate the optimal destination point with coordinates (x_O, y_O, z_O) as:

$$x_O = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$y_O = \frac{\sum_{i=1}^{n} y_i}{n}$$

$$z_O = \frac{\sum_{i=1}^{n} z_i}{n}$$

We can now convert these rectangular coordinates back to a latitude and longitude pair (θ_O, ϕ_O) by solving the system of equations

$$\begin{cases} x_O = r\cos\phi_O \\ y_O = r\cos\theta_O\cos\phi_O \\ z_O = r\cos\theta_O\sin\phi_O \end{cases}$$

This system can be solved finding two values of the longitude ϕ_O using the first equation, and then plugging these values of ϕ_O into the other two equations. Dividing the two equations will give the value of $\tan\theta_O$ from which we can find the two latitude values θ_O. We complete the conversion by finding the one out of these four possibilities that matches with the original rectangular coordinates.

By taking the average of the coordinates of all the cities, we essentially weight each city equally in the final result. This is the prime feature of this model. In fact, out of all the models, this one gives a distance and time zone discrepancy that is least variant. A drawback for this model however, is that there is no guarantee that the resulting point is on land. However, this can be solved by laying a circle with center at this point and expanding its radius until it hits a viable location.

2.3 Climate Zone Discrepancies

We analyze how the climate varies from top to the bottom of the Earth, and develop a model to ensure minimal changes from moving between locations.

We believe that a comfortable temperature for meeting is around $20°C$. This temperature does not deviate from either extremes and would not cause physical problems such as heat stroke or frostbite. Furthermore $20°C$ is an adaptable temperature for most people around a globe. People living in colder climates will get a chance to leave the cold weather. For example, citizens of Canada commonly go to warmer countries to spend the winter. For participants from warmer regions of the world, the meeting place provides a cool environment.

Regions with around $20°C$ is also appropriate even if all participants are from extremely hot or cold areas. While the participants may be more accustomed to the more extreme temperatures, it is not comfortable for individuals to meet in areas of $30°C$. Furthermore, in the current technologically advanced society, air conditioners and heaters are used to keep meeting rooms at manageable warmth. However, the temperature differences between outdoors and indoors may cause some participants to get sick and negatively affect the productivity of the meeting. These temperature differences can be avoided in an environment where outdoor and indoor temperatures are both manageable.

We determined temperatures for latitude intervals of $15°$ from $-75°$ to $60°$ by using various cities in that region, as shown in Table 2.1 and Table 2.2. We chose to ignore anything above or below the range because it is unlikely that the Arctic or Antarctic would be suitable to hold a meeting. In each interval, we chose a city to represent the average temperature for the interval. We believe that each city roughly represents their corresponding interval. The temperature across the globe varies as you get closer or further form the equator. Temperatures do not vary as much when ones distance from the equator is constant. Although the average temperature of the interval may differ due to changes in weather patterns, it is impossible to predict the exact temperature, so the average provides a good approximation.

Latitude	City	Months					
		Jan	Feb	Mar	Apr	May	Jun
[75,60)	Helsinki, Finland	-5	-6	-3	4	10	14
[60,45)	Ottawa, Canada	-10.5	-8.6	-2.4	6	13.6	18.4
[45,30)	Beijing, China	-4	-2	5	14	20	24
[30,15)	New Delhi, India	13	17	22	29	33	32
[15,0)	Bangkok, Thailand	27	28	30	31	30	30
[0,-15)	Jakarta, Indonesia	28	28	29	29	29	29
[-15,-30)	Rio De Janeiro, Brazil	26	27	26	25	23	22
[-30,-45)	Sydney, Australia	23	23	22	19	16	14
[-45,-60)	Rio Gallegos, Argentina	13	13	11	8	4	1

Table 2.1

Latitude	City						
		Jul	Aug	Sep	Oct	Nov	Dec
[75,60)	Helsinki, Finland	17	15	10	6	0	-4
[60,45)	Ottawa, Canada	21	19.7	14.7	8.2	1.5	-6.6
[45,30)	Beijing, China	27	25	20	13	5	-2
[30,15)	New Delhi, India	31	30	29	25	20	15
[15,0)	Bangkok, Thailand	30	30	29	29	28	26
[0,-15)	Jakarta, Indonesia	29	29	29	30	29	29
[-15,-30)	Rio De Janeiro, Brazil	21	22	22	23	24	25
[-30,-45)	Sydney, Australia	13	14	16	18	20	22
[-45,-60)	Rio Gallegos, Argentina	1	3	6	9	11	13

Table 2.2

While we will be using the above observations for the our models, another method we considered is if given the latitude of cities (distance from the equator), we can label each city as being hot, warm, or cold, where these label are relative to each other (i.e. no specific values). This categorization is useful for statistical purposes, and in the future we can adjust our models depending on the participant's level of satisfaction on climate. The code for this addition can be found in the Appendix.

2.4 Combining Models

We have created 4 models to address the issue of finding a suitable location. The time zone difference model focuses on longitude and time zones, the climate models focuses on latitude and climate, and the 3-D approach address both. While the models by themselves present possible regions, they do not reflect all the necessary criteria posed at the beginning. Thus, we will need to combine the models to generate locations that fit more of the criteria.

Time Zone Difference Approach With Climate Considered

Since the time zone difference model only consists of longitude points and the climate model only consists of latitude points, plotting the two regions generated by the models on the same globe yields areas of overlap. These areas are regions where both the total jet lag experienced and the climate is suitable for a meeting. This extended model will be called the *hybrid model*.

3D Modeling Approach With Climate Considered

The 3D model also outputs a longitude point that corresponds with a time zone. Finding the intersection of the latitude of the climate model and longitude of the 3D model reveals some of the possible locations. Since there are multiple possible latitude intervals with average temperatures of around 20C, there will be more than one possible region. We now consider the latitude point generated by the 3D model. Since this point minimizes the distance and costs we chose a point in the in the intersection closest to the latitude given by the 3D model. The combination of these two methods will be called the *spherical model*.

3 Testing Models

3.1 Using Data Sets

Sample 1: Time Zone Difference Approach

Using this model we looked at the time zones of each of the six cities and all possible time zones. The information is presented in table (i) in the appendix. Below the name of each city is the time zone of the location. The first vertical columns contain all possible choices of time zone. For example, if the meeting was held in a region with UTC -11, the participant at Monterey (with UTC -8), he or she would experience 3 hours of jet lag. The total time zone difference is presented in the total columns. The minimum occurs at UTC 8 with a total of 22 hours of total jet lag experienced. The time zone differences when traveling to the optimal location is shown below.

City	Time Zone Difference From Destination (Hours)
Monterey CA, USA	8
Zutphen, Netherlands	7
Melbourne, Australia	2
Shanghai, China	0
Hong Kong, China	0
Moscow, Russia	5

Table 3.1

Sample 1; Spherical Modelling

This model requires us to determine the latitude and longitude of the cities (which are shown in the table below). With this information, we then wrote a program that uses this method to find an optimal point. This program can be found in the Appendix The result was that the meeting would take place in Turkey. The time zone differences table are identical to the other model (shown above).

City	Latitude (degrees)	Longitude (degrees)
Monterey CA, USA	36.6	121.9
Zutphen, Netherlands	52.1	6.2
Melbourne, Australia	-37.8	145.0
Shanghai, China	31.2	121.5
Hong Kong, China	22.3	114.2
Moscow, Russia	55.8	37.6

Table 3.2

Sample 2; Time Zone Difference Approach

The chart below shows the results of the second data set with the differences in time zones from the optimal regions. A more thorough basis for our observations can be found in Table (ii) and Table (iii) in the Appendix.

City	Time Zone Difference From Destination (Hour)
Boston MA, USA (2 people)	8
Singapore	5
Beijing, China	5
Hong Kong (SAR), China (2 people)	5
Moscow, Russia	0
Utrecht, Netherlands	2
Warsaw, Poland	2
Copenhagen, Denmark	2
Melbourne, Australia	7

Table 3.3

Sample 2; Spherical Modelling

Unlike the previous data set, this data set produced different time zone difference results compared with the approach above. The latitude and longitude of the cities along with their time zone differences in relation to the optimal location are given in the tables below.

City	Latitude (degrees)	Longitude (degrees)
Boston MA, USA (2 people)	42.4	-71.1
Singapore	1.4	103.8
Beijing, China	40.0	116.4
Hong Kong (SAR), China (2 people)	22.4	114.1
Moscow, Russia	55.6	37.6
Utrecht, Netherlands	52.1	5.1
Warsaw, Poland	52.2	21.0
Copenhagen, Denmark	55.7	12.6
Melbourne, Australia	-37.8	145.0

Table 3.4

City	Time Zone Difference From Destination (Hour)
Boston MA, USA (2 people)	10
Singapore	3
Beijing, China	3
Hong Kong (SAR), China (2 people)	3
Moscow, Russia	2
Utrecht, Netherlands	4
Warsaw, Poland	4
Copenhagen, Denmark	4
Melbourne, Australia	5

Table 3.5

3.2 Comparison Of Models

We have divided different sets of data based on the property of distance between data points. In all of these definitions we shall assume that radius of the earth is 1 unit.

Type I Data (Spaced Out): Given a set of locations $\mathcal{L} = \{P_1, P_2, \ldots, P_n\}$, we say $\mathcal{L}$ is *spaced out* if for any three distinct locations $P_i, P_j, P_k \in \mathcal{L}$, the maximum distance between any of of the three points P_i, P_j, P_k is above a fixed number $c, c \in (0, 1)$.

Figure 3.1 (”Small meeting”)

Type II Data (Clustered): Defining similarly as in the first definition, we say the set $\mathcal{L}$ is *clustered* if for any three locations $P_i, P_j, P_k \in \mathcal{L}$, the maximum distance between any two of the three points P_i, P_j, P_k is below the fixed number c above.

Figure 3.2

Type III Data (Mixed): If $\mathcal{L}$ is of neither of the two types above, we say $\mathcal{L}$ is *mixed*.

Figure 3.3 ("Big Meeting")

3.2.1 Type I Data: Spaced Out

Spherical Model: Since each data point is far away from the other data points, the optimal location does not favor any particular point. The total time zone discrepancies will be affected primarily by points that are furthest away. The differences of these "extreme" cities will most significantly alter this sum of differences. This approach may give sub-optimal results for climate if for example, half the participants are from the northern hemisphere and the other half from the southern hemisphere. This model would produce a point at the equator, which is too hot for either group. Appended with the climate model however, this issue is negated.

Hybrid Model: The defining feature of this model is the minimization of both the total time zone discrepancies and climate disruption. The total distance traveled is not optimized, as there are points that can be chosen on the same latitude or longitude determined by the two approaches, that avoid having a small group of points altering the total distance.

3.2.2 Type II Data: Clustered

Spherical Model: Similar to type 1, each data point contributes nearly equally to the end result. However, the main difference here is that no data point deviates significantly from the optimal point. The overall time zone discrepancies will be close to zero (this point lies near or on the region given by the time zone approach). As the data is clustered, these discrepancies will be consistent, with any two being within c, the maximal distance between any two cities. This model gives differing results for climate from what may be expected. This because the point is located as an average of the z-coordinates, the climate zone is chosen without regard to how close it is to the optimal zone (20°C). On the other hand, it will not be too far off, as taking an average of the coordinates will lead to a location that is geographically similar to the original cities.

Hybrid Model: The time zone differences and distance traveled for all the participants will be similar, as the distance between cities is bounded above. The total time zone and climate differences will be optimized by combining the two independent models.

3.2.3 Type III Data: Mixed

Spherical Model: Suppose we have a point a location A and ten other points at location B, far away from A. Then for this mixed data set, this model will trade equalized time zone differences for sub-optimal total time zone differences and total distance traveled. If we take a less extreme example with more points at location A, then the results will be better distributed across the criteria.

Hybrid Model: Using the same example as above, this model outputs the point B. This essentially reduces total distance traveled and total time zone differences, at the expense of time zone equality. This result will not change if we replace it with the latter example in the other model.

4 Conclusions

To address the issue of an international meeting, we have created a set of criteria to determine best location for a meeting, along with three independent models that may be merged into two final models that may be used to optimally meet the requirements of a productive meeting.

We have tested these models on various data sets to determine when one may be used over the other, if a certain criteria is desired more so than other ones. Together, these models give enormous flexibility over the potential meeting locations, which may be enhanced by a deep understanding of their inner workings.

5 Appendix and References

	Monterey	Zutphen	Moscow	Shanghai	Hong Kong	Melbourne	Totals	Max
Time zones	-8	1	3	8	8	10		
-11	3	12	10	5	5	3	38	12
-10	2	11	11	6	6	4	40	11
-9	1	10	12	7	7	5	42	12
-8	0	9	11	8	8	6	42	11
-7	1	8	10	9	9	7	44	10
-6	2	7	9	10	10	8	46	10
-5	3	6	8	11	11	9	48	11
-4	4	5	7	12	12	10	50	12
-3	5	4	6	11	11	11	48	11
-2	6	3	5	10	10	12	46	12
-1	7	2	4	9	9	11	42	11
0	8	1	3	8	8	10	38	10
1	9	0	2	7	7	9	34	9
2	10	1	1	6	6	8	32	10
3	11	2	0	5	5	7	30	11
4	12	3	1	4	4	6	30	12
5	11	4	2	3	3	5	28	11
6	10	5	3	2	2	4	26	10
7	9	6	4	1	1	3	24	9
8	8	7	5	0	0	2	22	8
9	7	8	6	1	1	1	24	8
10	6	9	7	2	2	0	26	9
11	5	10	8	3	3	1	30	10
12	4	11	9	4	4	2	34	11

Table (i)

	Boston	Boston	Singapore	Beijing	Hong Kong	Hong Kong
Time zones	-5	-5	8	8	8	8
-11	6	6	5	5	5	5
-10	5	5	6	6	6	6
-9	4	4	7	7	7	7
-8	3	3	8	8	8	8
-7	2	2	9	9	9	9
-6	1	1	10	10	10	10
-5	0	0	11	11	11	11
-4	1	1	12	12	12	12
-3	2	2	11	11	11	11
-2	3	3	10	10	10	10
-1	4	4	9	9	9	9
0	5	5	8	8	8	8
1	6	6	7	7	7	7
2	7	7	6	6	6	6
3	8	8	5	5	5	5
4	9	9	4	4	4	4
5	10	10	3	3	3	3
6	11	11	2	2	2	2
7	12	12	1	1	1	1
8	11	11	0	0	0	0
9	10	10	1	1	1	1
10	9	9	2	2	2	2
11	8	8	3	3	3	3
12	7	7	4	4	4	4

Table (ii)

Moscow	Utrecht	Warsaw	Copenhagen	Melbourne	Total	Max
3	1	1	1	10		
10	12	12	12	3	81	12
11	11	11	11	4	82	11
12	10	10	10	5	83	12
11	9	9	9	6	82	11
10	8	8	8	7	81	10
9	7	7	7	8	80	10
8	6	6	6	9	79	11
7	5	5	5	10	82	12
6	4	4	4	11	77	11
5	3	3	3	12	72	12
4	2	2	2	11	65	11
3	1	1	1	10	58	10
2	0	0	0	9	51	9
1	1	1	1	8	50	8
0	2	2	2	7	49	8
1	3	3	3	6	50	9
2	4	4	4	5	51	10
3	5	5	5	4	52	11
4	6	6	6	3	53	12
5	7	7	7	2	50	11
6	8	8	8	1	55	10
7	9	9	9	0	60	9
8	10	10	10	1	67	10
9	11	11	11	2	74	11

Table (iii)

Code (Java):

```java
import java.util.*;
import java.io.*;
import java.lang.*;

public class JetLag {
   public static void main(String[] args) {

      Scanner sc = null;
      try{
      sc = new Scanner(new File("data.txt"));
      }catch(Exception e){}

      int month = sc.nextInt();
      int n = sc.nextInt();

      double[] latitudes = new double[n];

      double[][] coordinates = new double[3][n];
```

```
double totalX = 0, totalY = 0, totalZ = 0;

// time zone
for(int i = 0; i < n; i++) {
   latitudes[i] = sc.nextDouble();
   double latitude = Math.toRadians(latitudes[i]);
   double longitude = Math.toRadians(sc.nextDouble());

   coordinates[0][i] = Math.cos(latitude)*Math.cos(longitude);
   coordinates[1][i] = Math.cos(latitude)*Math.sin(longitude);
   coordinates[2][i] = Math.sin(latitude);

   totalX += coordinates[0][i];
   totalY += coordinates[1][i];
   totalZ += coordinates[2][i];
}

totalX /= n;
totalY /= n;
totalZ /= n;

double latitude = Math.toDegrees(Math.asin(totalZ));
double longitude = Math.toDegrees(Math.atan2(totalY, totalX));

System.out.println(latitude+", "+longitude);


// climate - comparison
int[] climate = new int[3]; // 0-cold, 1-warm, 2-hot

if(month==6 || month==7 || month==8){ // sun at north
   for(int i=0;i<n;i++){
      if(latitudes[i]>(-10) && latitudes[i]<40) climate[2]++;
      else if(latitudes[i]>75 || latitudes[i]<(-45)) climate[0]++;
      else climate[1]++;
   }
}
else if(month==12 || month==1 || month==2){ // sun at south
   for(int i=0;i<n;i++){
      if(latitudes[i]>(-40) && latitudes[i]<10) climate[2]++;
      else if(latitudes[i]>45 || latitudes[i]<(-75)) climate[0]++;
      else climate[1]++;
```

```
            }
        }
        else { // sun around equator
            for(int i=0;i<n;i++){
                if(latitudes[i]>(-25) && latitudes[i]<25) climate[2]++;
                else if(latitudes[i]>60 || latitudes[i]<(-60)) climate[0]++;
                else climate[1]++;
            }
        }

        System.out.println("Cold: " + climate[0]);
        System.out.println("Warm: " + climate[1]);
        System.out.println("Hot: " + climate[2]);
    }
}
```

This program reads from a data file with longitude and latitude, and outputs the location given by the time zone approach, along with the categorization described by our second climate model.

References

[1] (n.d.). Retrieved April 17, 2017, from http://www.holiday-weather.com/

[2] R. (n.d.). World map.... RB by RyleyB. Retrieved April 17, 2017, from https://www.thinglink.com/scene/581145802450141185

[3] Documentation. (n.d.). Retrieved April 17, 2017, from https://www.mathworks.com/help/map/globe.html