Space Engineering 3

Assignment 1

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Orbit Simulation and Determination

Lydia Drabsch
311217591
ldra3557@uni.sydney.edu.au

STUDENT PLAGIARISM: COURSE WORK - POLICY AND PROCEDURE COMPLIANCE STATEMENT

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(3) this Work is substantially my/our own, and to the extent that any part of this Work is not my/our own I/we have indicated that it is not my/our own by Acknowledging the Source of that part or those parts of the Work.

Name(s): Lydia Drabsch

Signature(s):
Lydia Drabsch

Date: 24/3/16

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1. Introduction

Each mainQN.m file has a section called 'User Input' where the animations and state plots can be turned on/off. Also the timestep and the number of days to simulate are defined. The default settings are dt = 100 seconds and days = 1.

2. Tracking UAV from GPS

2.1 Introduction

2.1.1 GPS Simulation

The ephemeris data in keplerian orbital parameters was provided and used to simulate all of the satellites in the GPS constellation.

2.2 Methodology

2.2.1 GPS Simulation

The satellites were simulated using the keplerian model. The positions in ECI, ECEF and LLH frames were calculated and stored in a 3D matrices with dimensions (position axis, time, satellite). The orbits are sorted into colours by the value of the right ascending node in the ephemeris data. Kepler's method relates the mean and eccentric anomalies (Mt and E) and solved using newtowns method.

2.3 Results/Discussion

2.3.1 GPS Simulation

See Figures 4.1 to 4.5 for the ECI frame, ECEF frame and ground trace of the 24 hour simulation. The GPS constellation was in 6 orbits with a period of 12 hrs.

2.3.2 title

3. GLONASS Orbital Determination

3.1 Introduction

The Russian GNSS is called GLONASS, a system that requires 24 satellites in three orbital planes to have full global coverage. The satellites are in nearly circular orbits at an average altitude of 19130 km, approximate period of 11 hrs and 15 min and an inclination of 65°. Each orbital plane is separated by 120°in the ascending node and consists of eight satellites. There is currently 28 satellites in orbit with 23 operational. For the following analysis, only the operational satellites are used.

3.2 Methodology

Done:
TLEs for GLONASS and simulated - 3d and ground trace
brute force characterisation of the time
optimisation of ground stations

next: simulate ground station readings?

Table 3.1: Ground stations in the order chosen by the optimisation algorithm (Latitude grid size = 100, Longitude grid size = 200, Duration = 1 day, Time step = 100 sec)

Number	Location	Latitude	Longitude	Altitude (m)	Unique Timesteps
1	Antarctica	-90°	0°	2805	7584
2	Svalbard, Norway	78°	14 °	251	7553
3	Hawaii	19°	-156°	166	2263
4	Kenya	-2°	38°	849	1585
5	Brazil	-12°	-62 °	366	589
6	China	30°	105°	352	321

3.2.1 Optimisation of Ground Station Locations

The ground station locations were chosen based on a brute force recursion algorithm that ensures all satellites are visible to a ground station (5°mask) at all times. A 4-D logical matrix was created with the dimensions (longitude,latitude,time,satellite) where the element was set if the satellite was visible at that point in time from that location. Only locations that are on land were considered using **landmask.m** (Chad Greene, 2014) and the altitude was estimated using **ITU_P1511.m** (Luis Emiliani, 2009). For each location the total observed time of all satellites was summed and the location with the maximum observations was chosen as a ground station. For the satellites that were observed over certain times from the new ground station, the observations were removed from all other locations in the 4-D matrix. The function was called again with the unobserved satellites and the next maximum point set as a new ground station. The function **optimise.m** continues to call itself until all the satellites are always observed by at least one ground station.

The latitude grid was divided up uniformly across the spherical surface by the function $lat = \cos^{-1}(2x-1) - \pi/2$, where $x = [0 : dx : 1]$. If there are multiple locations with the same maximum value, the centre of the largest area is selected using **regionprops.m**.

The fact that GLONASS belongs to Russia and that it would be desirable to have a ground station in Russia was not considered, nor was global politics or structural feasibility of the location.

3.2.2 Model the observation of a satellite

- sensor model
- error model

3.2.3 Calculating Orbital Parameters from Observations

- herrick gibbs method to calculate the velocity vector from three position measurements

3.3 Results

3.3.1 Optimisation of Ground Station Locations

It was found that four ground stations located as in Table 3.1

4. Appendix A: Question 1

Figure 4.1: GPS 24 hr simulation with dt = 100 in ECI frame

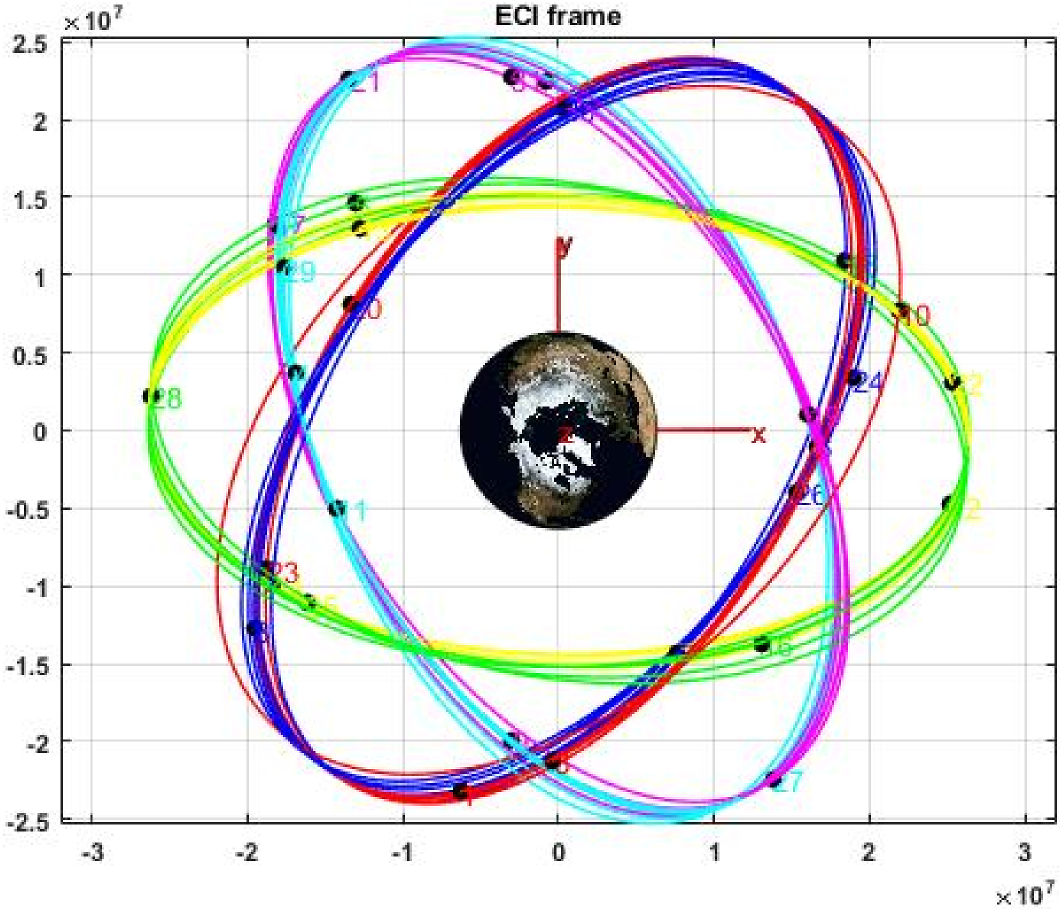


Figure 4.2: GPS 24 hr simulation with dt = 100 in ECI frame

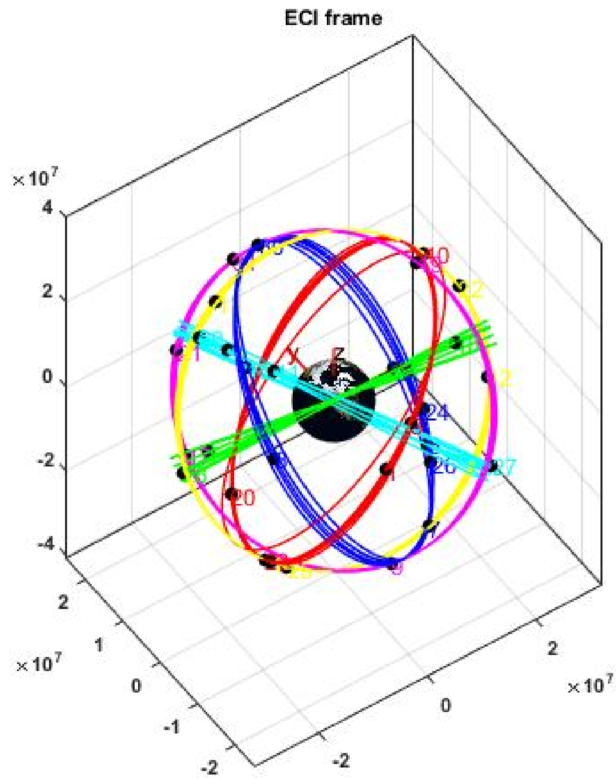


Figure 4.3: GPS 24 hr simulation with dt = 100 in ECEF frame

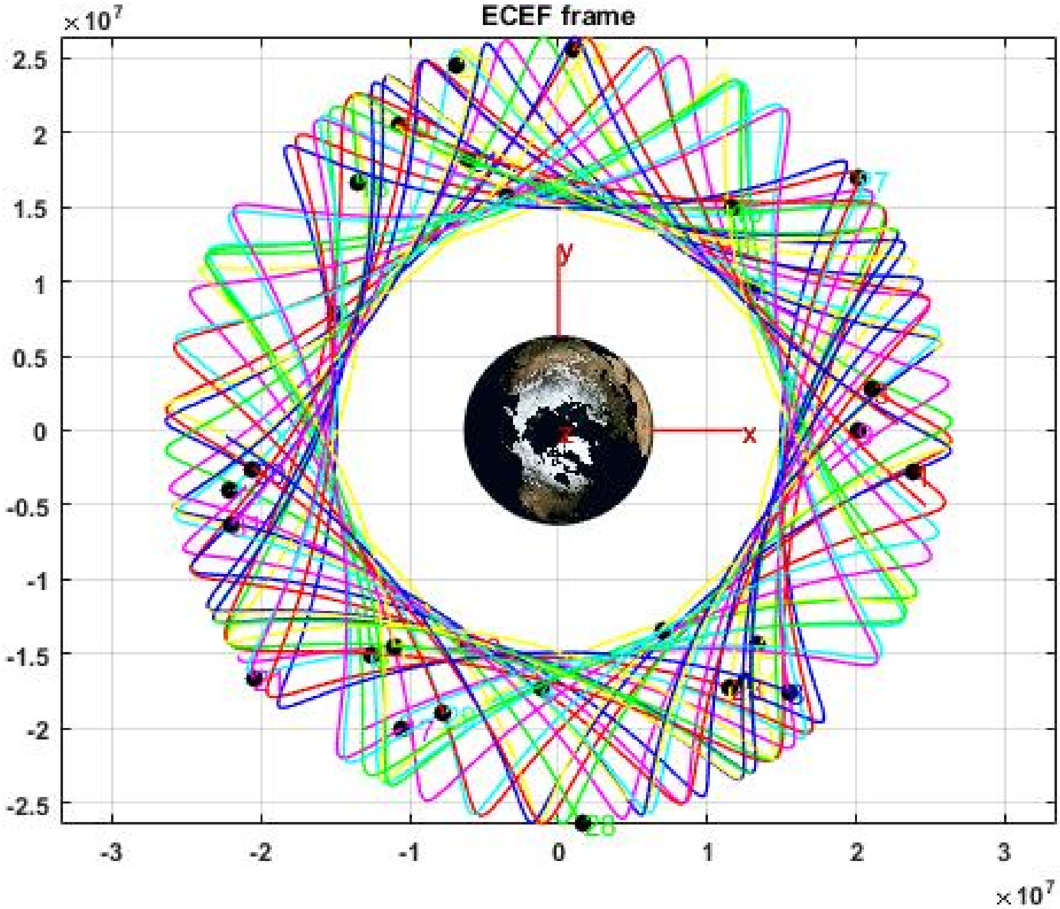


Figure 4.4: GPS 24 hr simulation with dt = 100 in ECEF frame

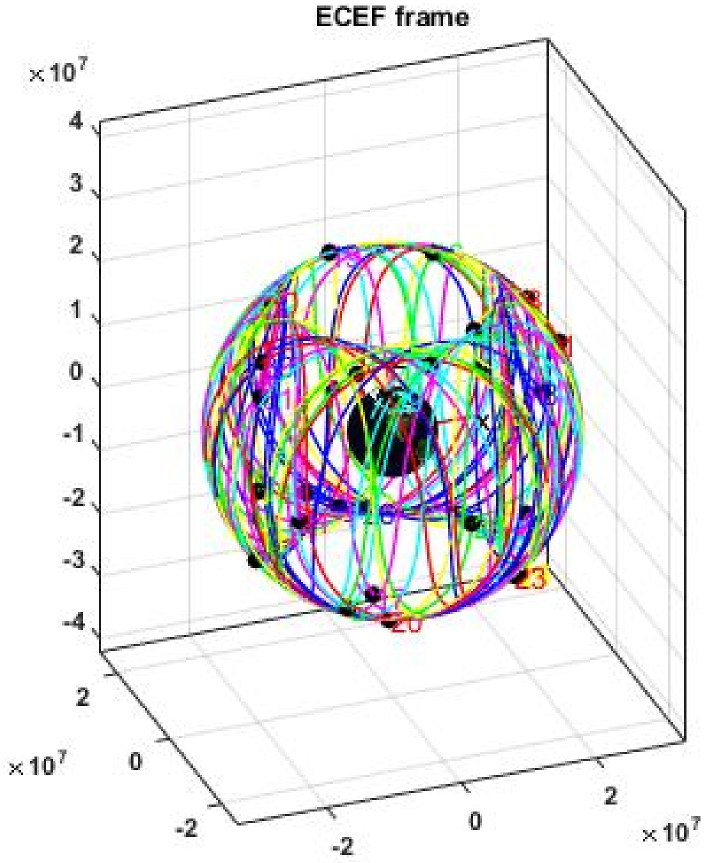


Figure 4.5: GPS 24 hr simulation with dt = 100 Ground Trace

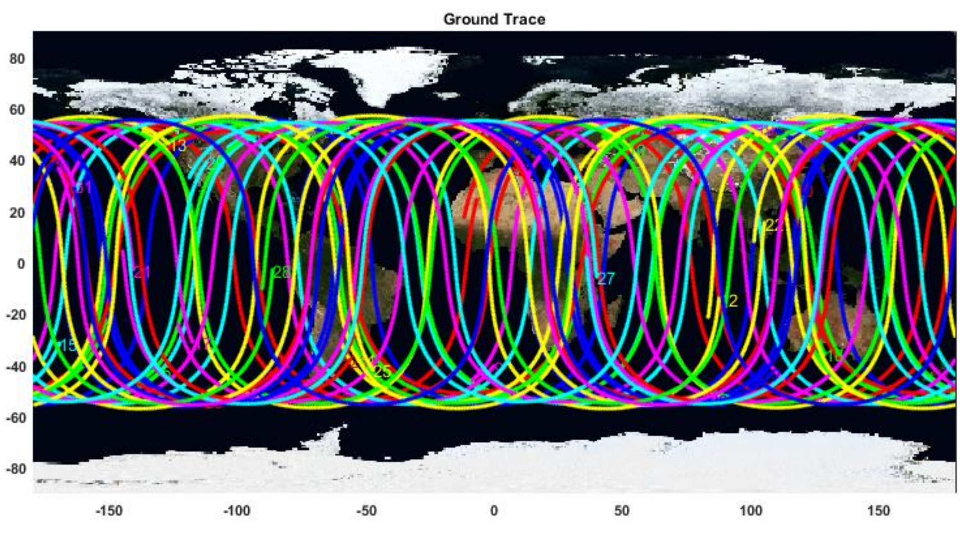


Figure 4.6: UAV trace in NED coordinates from the ground station at [Lat 34.76°,Long: 150.03°E, Alt: 680m]

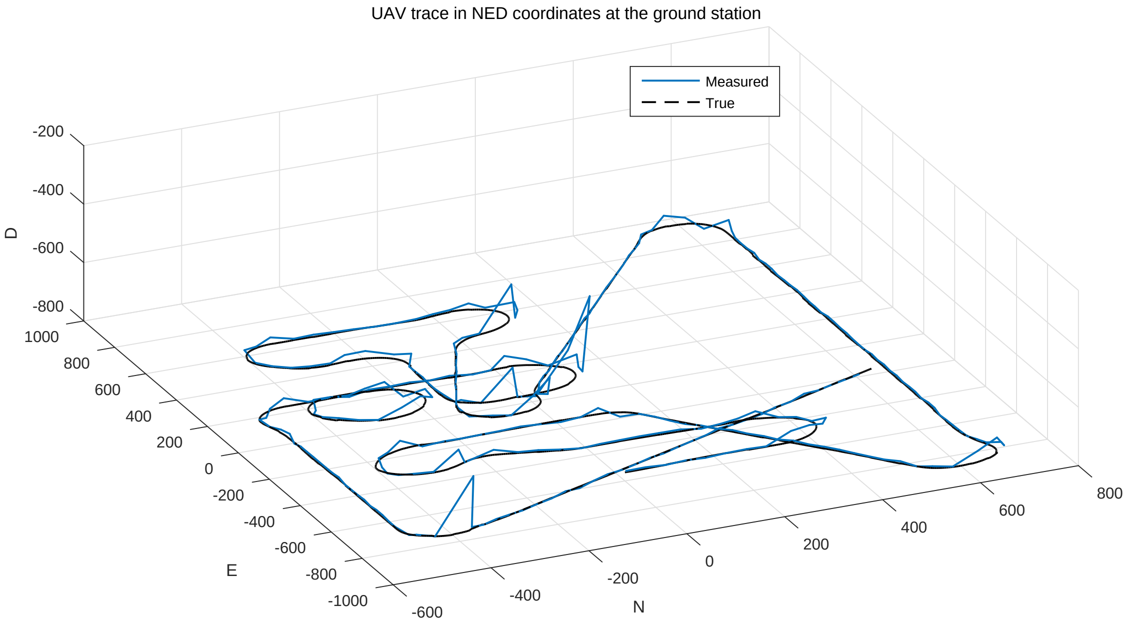
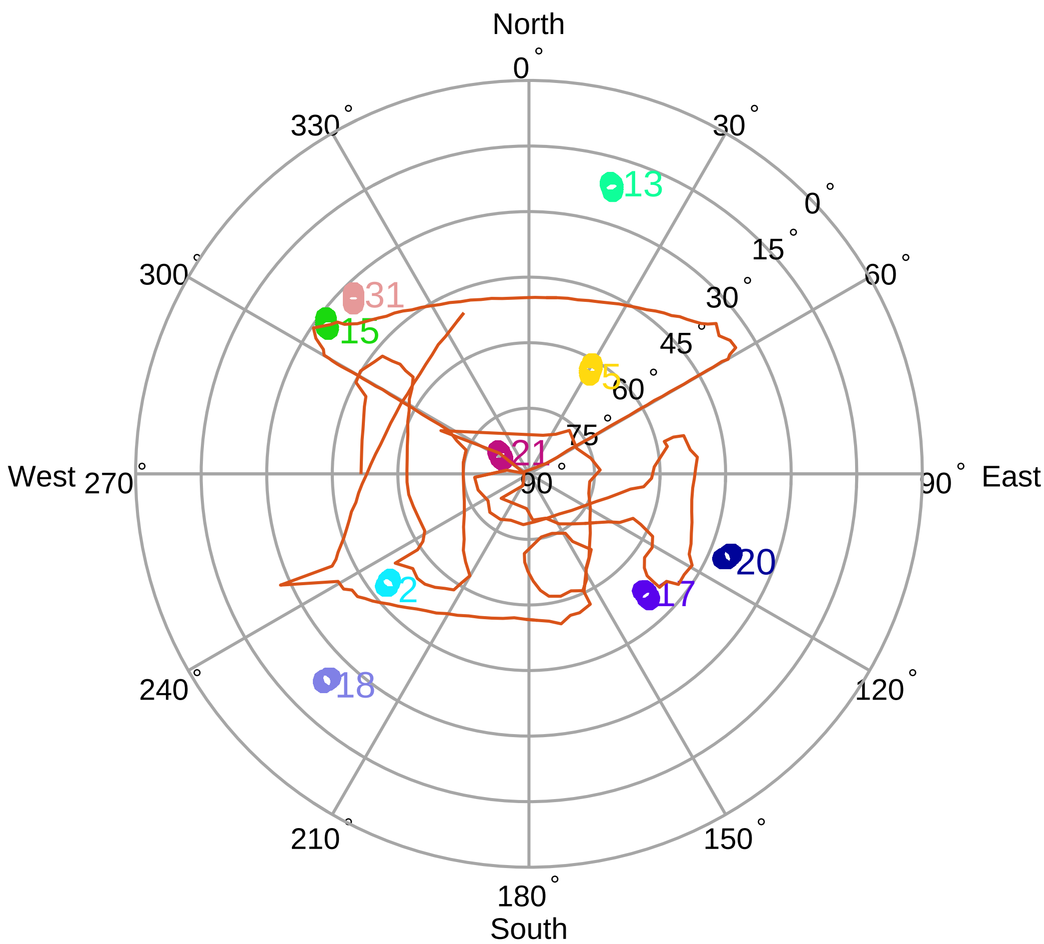


Figure 4.7: UAV polar trace of azimuth and elevation and location of observed satellites from ground station at [Lat 34.76°,Long: 150.03°E, Alt: 680m]



5. Appendix B: Question 2

5.1 Optimisation of Ground Station Locations

Figure 5.1: text

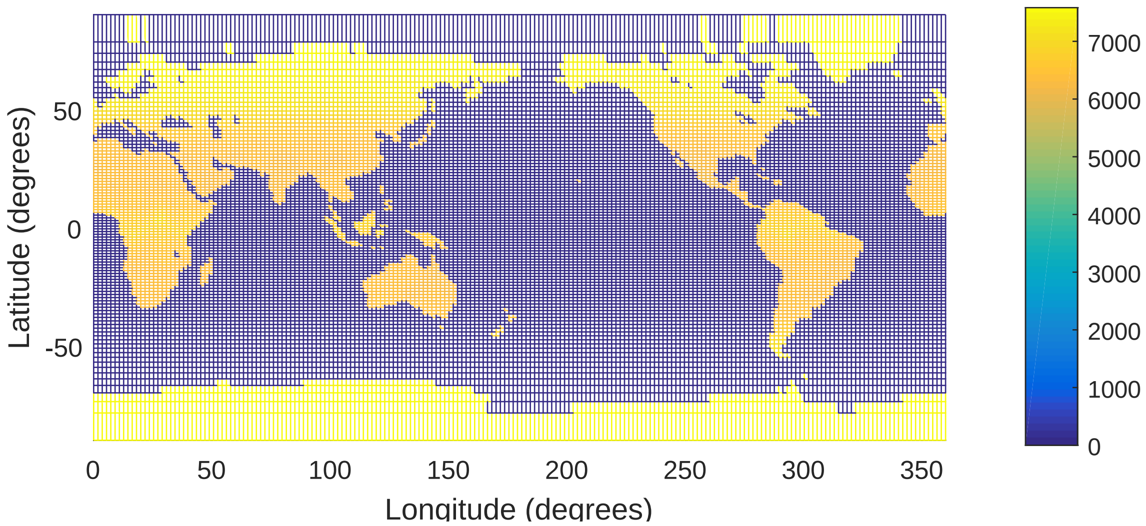


Figure 5.2: text

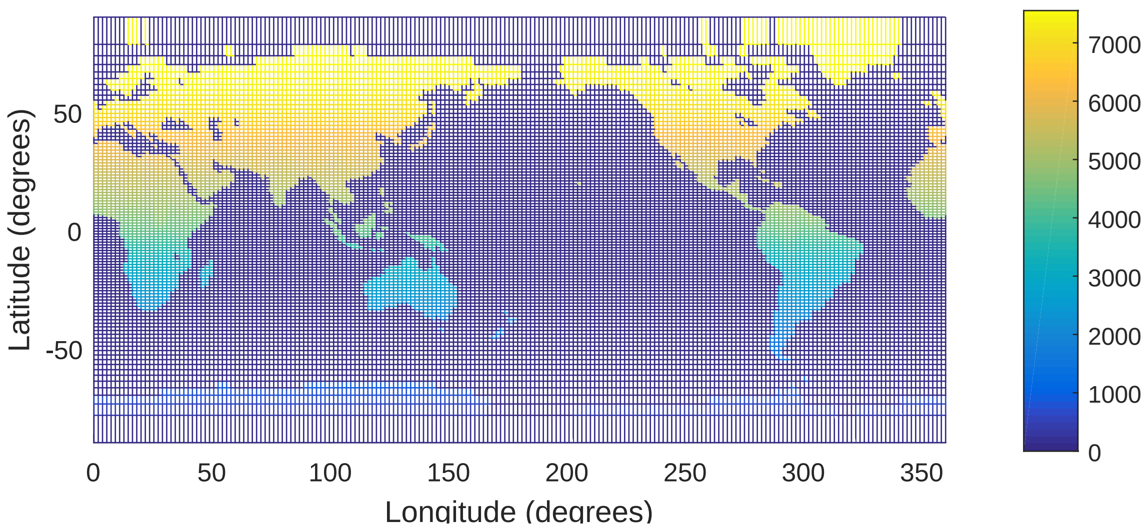


Figure 5.3: text

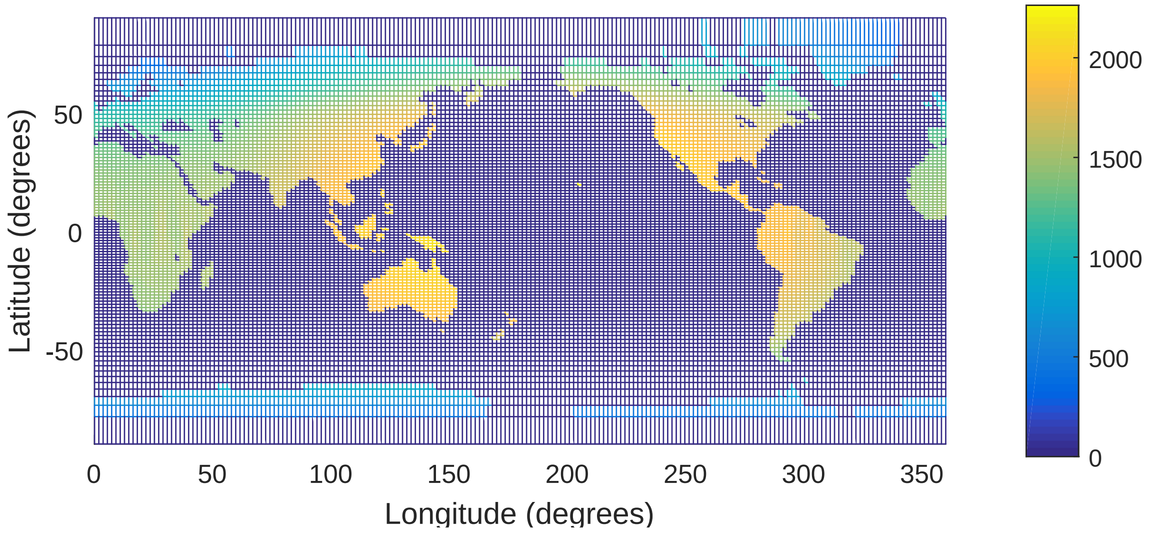


Figure 5.4: text

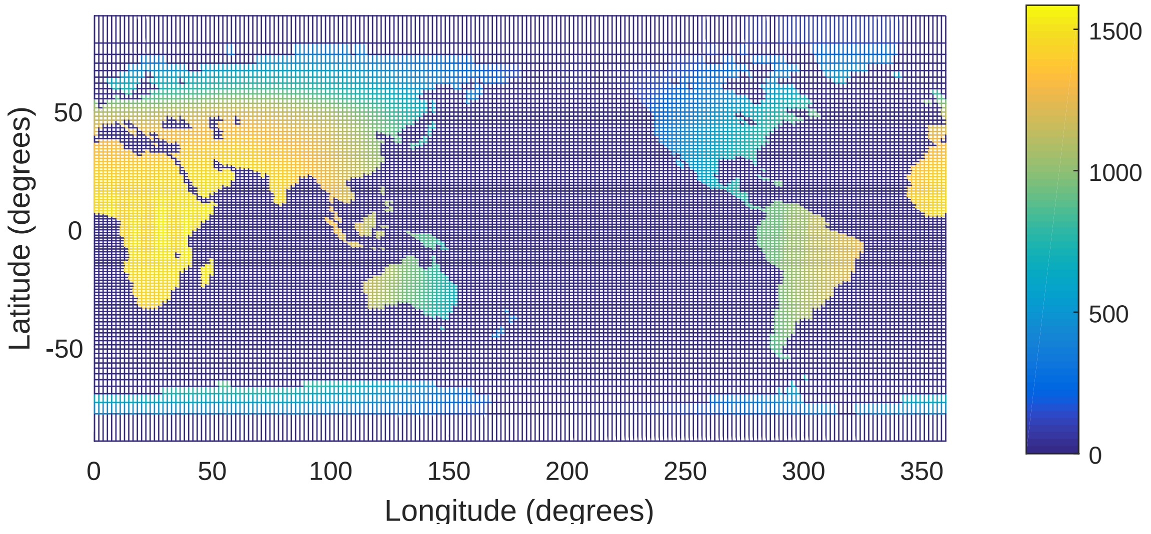


Figure 5.5: text

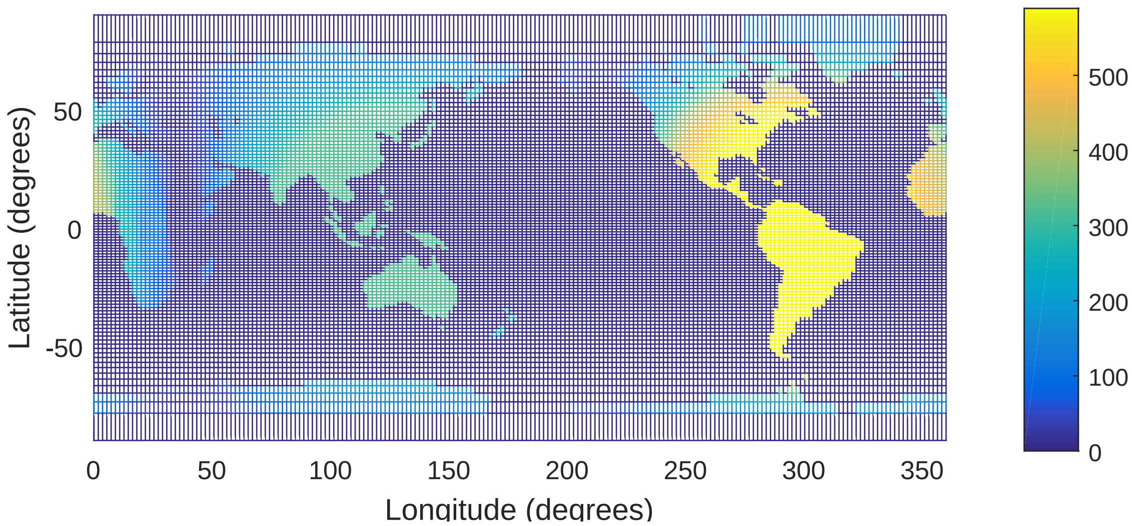


Figure 5.6: text

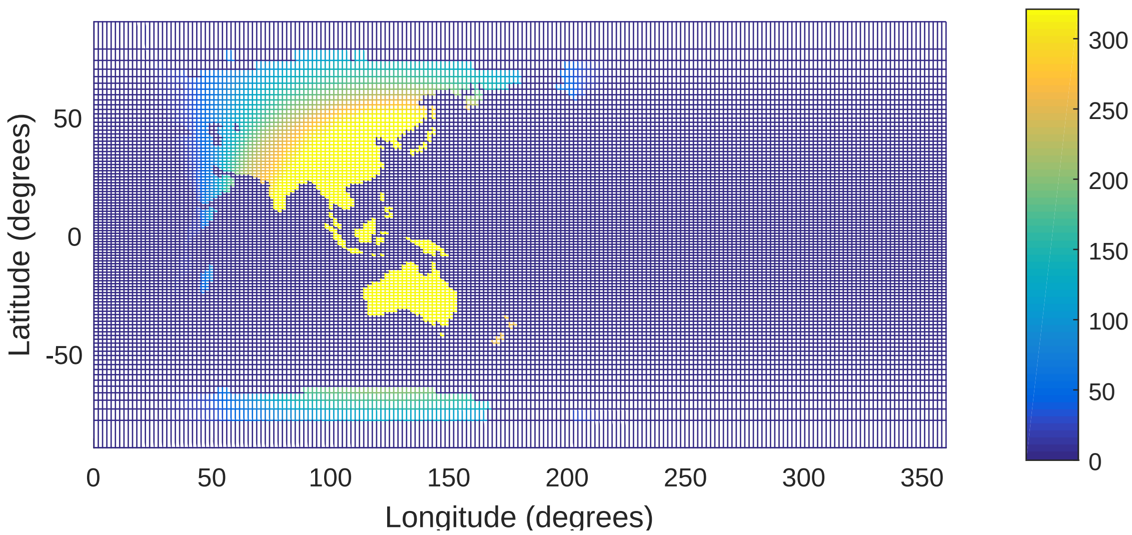


Figure 5.7: text