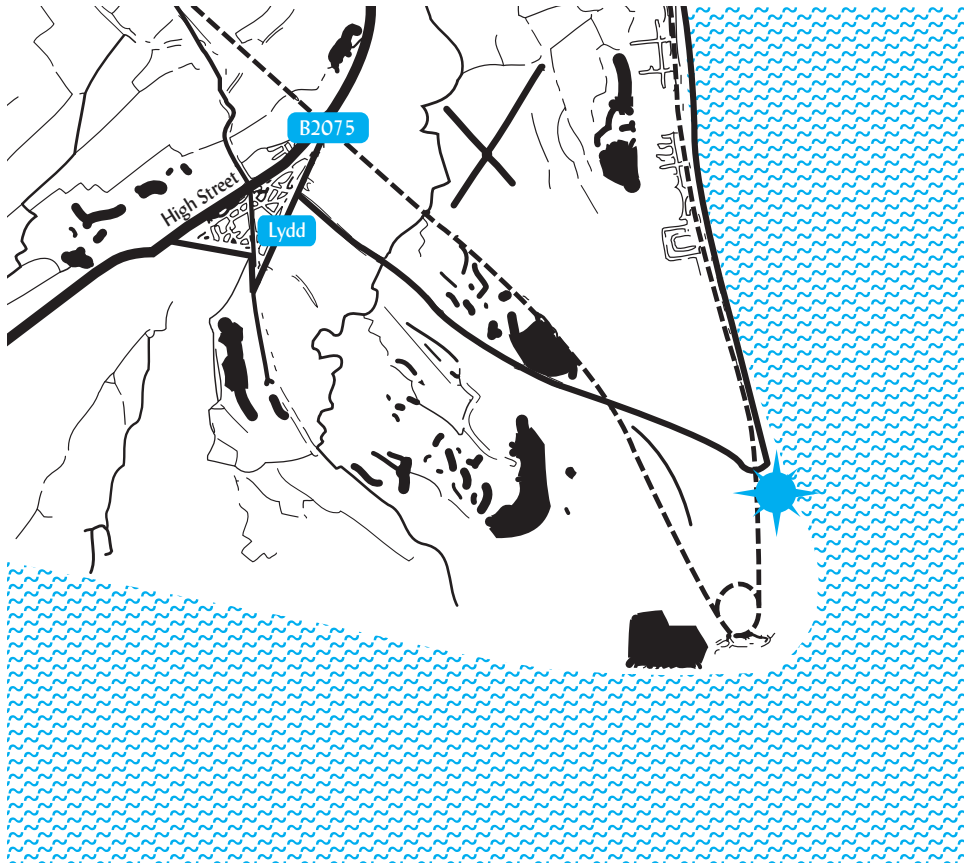




Variable 4

James Bulley and Daniel Jones
12:00pm - 12:00pm : 22-23 May 2010
Dungeness, Kent





This map is taken from OpenStreetMap
OpenStreetMap contributors, CC-BY-SA, <http://www.openstreetmap.org/>

Introduction

Since the earliest civilizations, a complex relationship has existed between human society and the weather systems that define the world around us. We make sense of seasonal cycles through rituals and folklore, passing down ways of harnessing the natural elements whilst constructing defences against those that threaten our existence.

Variable 4 transforms these weather patterns into a living musical composition with the same unpredictability as the elements themselves. Using meteorological sensors connected to a custom software environment developed by the artists, the wild weather conditions of the Kent coastland act as composer, navigating through a map of 24 specifically written movements. Every aspect of the piece, from broad harmonic progressions down to individual notes and timbres, is influenced by changes in the environment: wind speed, rainfall, solar radiation, humidity, tropospheric variance, temperature, and more.

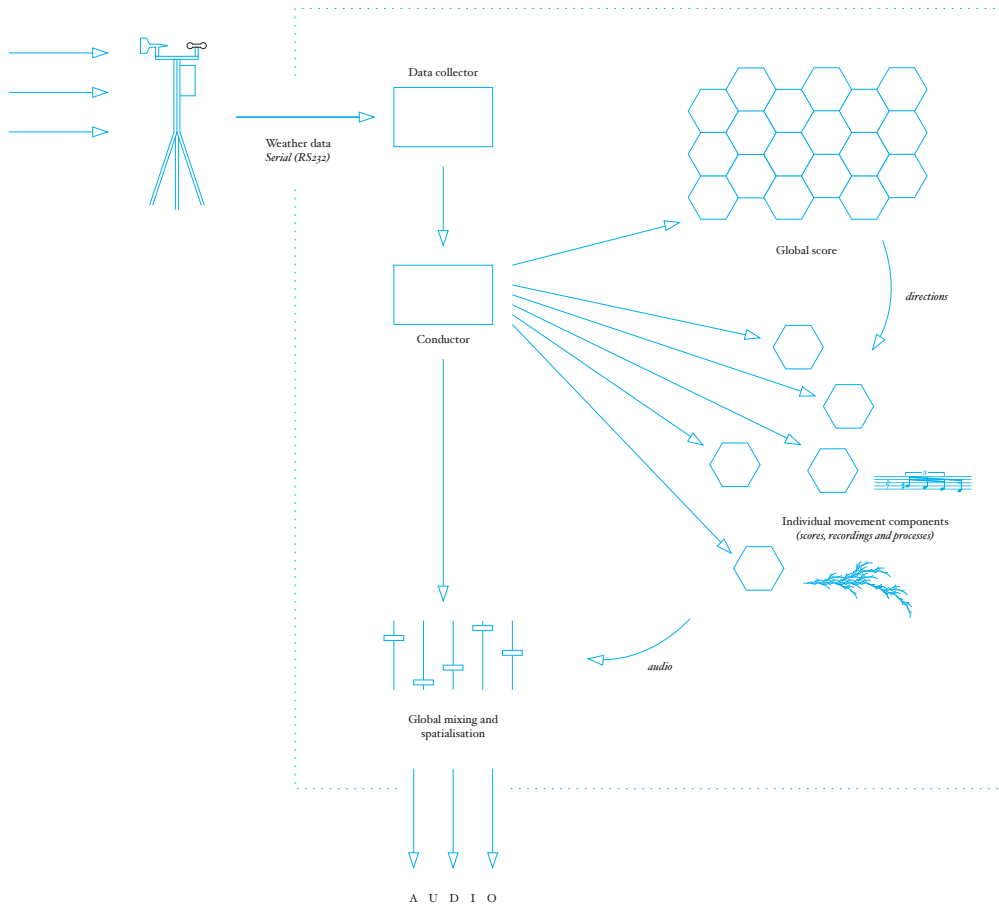
Linking together the sensor data and scored motifs is an array of algorithmic processes drawn from the natural world, modelling phenomena such as tree growth, swarm theory and evolutionary development. The resultant composition is performed over a 24-hour duration through a field of 8 speakers integrated into the landscape.

The piece will take place from midday May 22nd to midday May 23rd 2010 on the headland of Dungeness, a designated Site of Special Scientific Interest (SSSI) due to its unique and diverse wildlife. Variable 4 is made possible thanks to generous funding from the PRS for Music Foundation, and support from a number of independent sponsors.

The scores and program code underlying the installation are to be released freely into the public domain under the terms of open-source licenses. We'd like to thank everyone who has helped in the preparation for this endeavour and in advance to express our appreciation towards all those that have taken the time to visit the installation.

Best wishes

Daniel Jones and James Bulley



Installation Flowchart

Variable 4 takes live weather data from the environment using a research-grade weather station, Campbell Scientific's BWS-200. This information, updated every few seconds, is used to drive a web of compositional processes which result in a dynamic composition which responds in real-time to the current atmospheric conditions.

At the core of this process is a piece of software which plays the role of conductor, navigating across a map of movements which correspond to potential combinations of weather. This motion takes place over the course of minutes and hours. On a more fine-grained level, each movement itself comprises of score fragments and compositional processes, which are altered and recombined by second-to-second changes in the surrounding weather.

Finally, the combined output of these musical elements is diffused over an arrangement of 8 speakers by a spatialisation component, itself also determined by weather data.



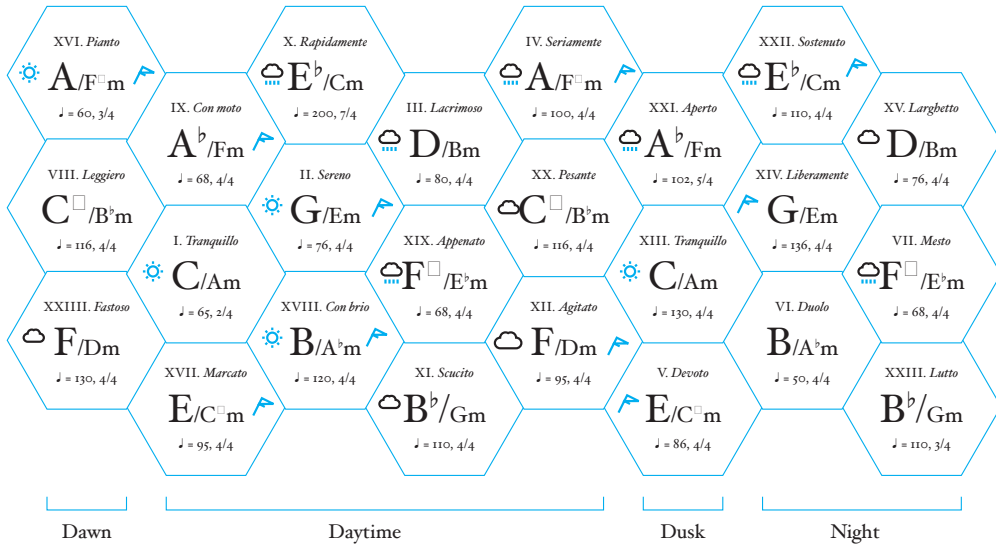
Algorithmic Processes

Alongside the precomposed parts of each movement are compositional processes, or algorithms: sets of instructions which encode musical behaviours, capable of recombining existing material and generating entirely new sequences of notes. These serve to massively increase the scope of potential patterns produced by Variable 4, and enable us to respond closely to the finer details of the meteorological conditions.

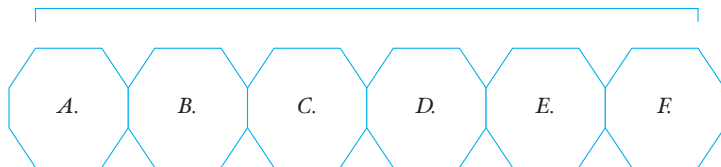
On a movement-wide level, chance procedures are used to move between fragments according to sets of relationships designed at the compositional stage. The dynamic recombinations of these parts generate polyrhythms and composite tonal structures.

At the level of individual notes, a second set of algorithms are used to compose original note patterns. With structures drawn from mathematics, statistics and biology (diagrams on left), these can continually produce sequences that are surprising even to the composers.

Descriptions of some of the algorithms used within Variable 4 can be found within the movement summaries contained later in this book.



Wormholes



Compositional Structure

The hexagonal lattice on the left maps out the 24 movements that make up Variable 4. Each hexagonal tile represents a movement, corresponding to a set of weather conditions: temperature, humidity, wind speed, solar radiation and rainfall. As the piece plays, its position can always be located on this map, constantly shifting between movements according to the changing atmosphere.

Each movement also has a key signature, tempo and metre, determined by its related weather state. These are spatially linked according to the circle of fifths (and circle of fourths), a musical relationship common within Western music, making it possible to move between movements without harmonic dissonance. Try moving diagonally north-east from any movement, wrapping from top to bottom, and you will see that you continue to move upwards in key by one fifth per tile.

If the weather changes so quickly that the location is caused to jump between distant movements, the piece enters what we term a 'wormhole': an arrhythmical and often atonal bridge, which serves to join two unrelated musical elements.

The following 24 pages chart each of the piece's movements, describing their musical parameters and corresponding weather conditions. Some are accompanied by excerpts of notated score whilst others are accompanied by graphs of relevant weather data, recorded near to the installation site during May 2009 and April 2010. A number of the movements were composed from graphic scores created specifically for the piece.

Thank you to Romney Marsh Weather for providing us with a thorough capture of weather data from the area over the last few years and to Patrick Fry, Ed Gillett and Joe Hales for their graphic scores (Movements 10, 7 and 8 respectively).

Movement 1, *Tranquilo*

BPM
65bpm

Key Signature
A Minor

Metre
2/4

The musical score is presented in two staves. The top staff is for the Celesta and the bottom staff is for the Pianoforte. Both are in 2/4 time. The Celesta part begins with a quarter note G4, followed by two eighth rests, then a quarter note A4 with a sharp sign, and a triplet of eighth notes (B4, C5, D5). The Pianoforte part begins with a quarter note G3, followed by quarter notes A3, B3, and C4. The second measure of the Pianoforte part features a triplet of eighth notes (D4, E4, F4) with a sharp sign on the D4 note. The Celesta part continues with a quarter note G4, followed by two eighth rests, and a quarter note F4 with a sharp sign.

Weather
Sunny, Dry, Still

Time Period
Day

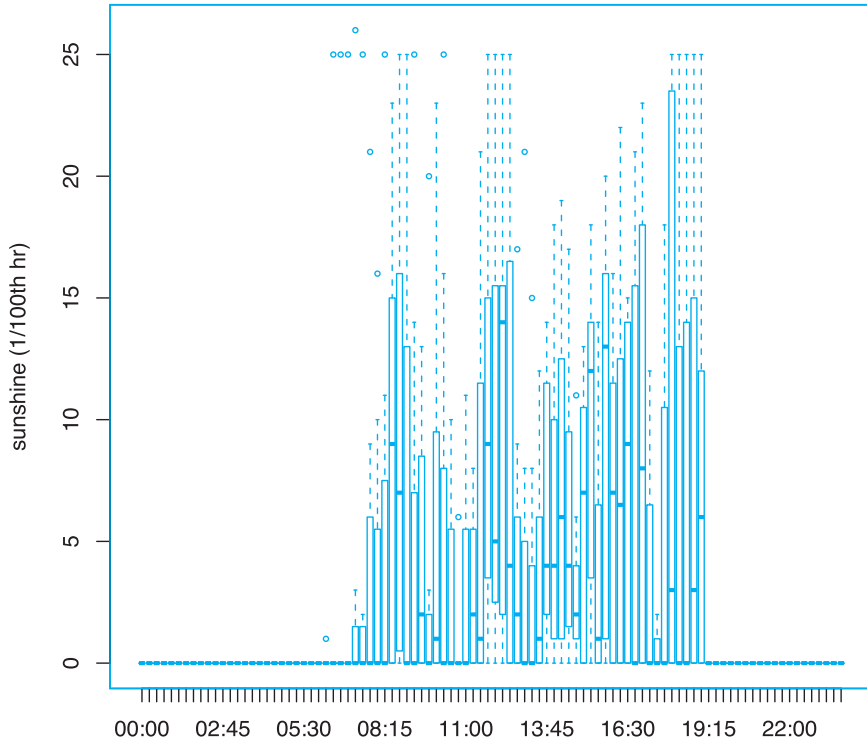
Instrumentation
*Celesta, Clarinet,
Pianoforte*

Movement 2, *Sereno*

BPM
76bpm

Key Signature
G Major

Metre
4/4



Weather
Sunny, Hot, Wind

Time Period
Day

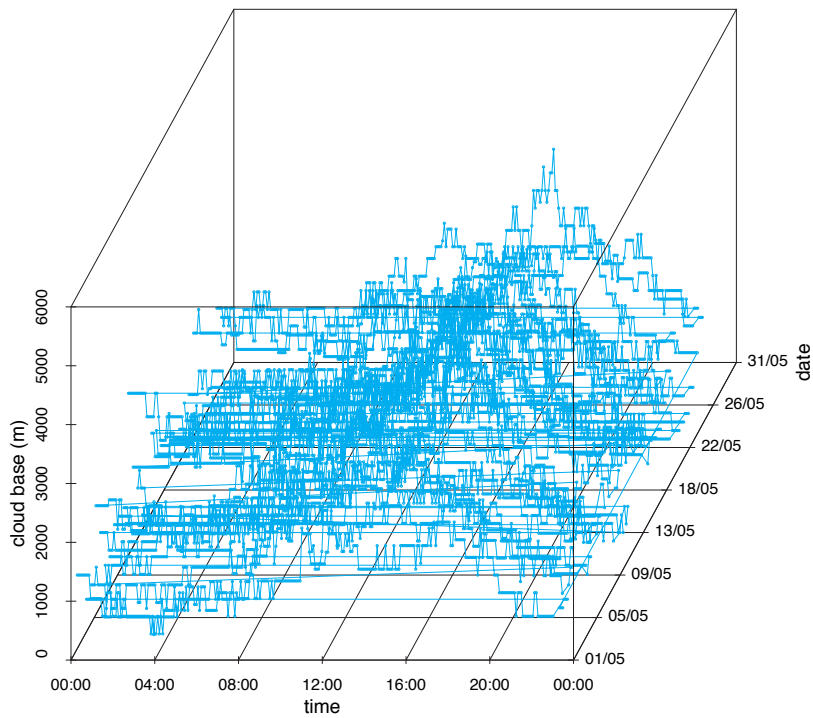
Instrumentation
*Autobarp, Violin,
Harmonium, Percussion,
Accordion*

Movement 3, *Lacrimoso*

BPM
80bpm

Key Signature
B Minor

Metre
4/4



Weather
Rain
(Light/Medium),
Warm, Still

Time Period
Day

Instrumentation
Cello, Pianoforte,
Percussion, Electronics

Movement 4, *Serriamente*

BPM
100bpm

Key Signature
F# Minor

Metre
4/4

Soprano Saxophone

Pianoforte

The image shows two staves of musical notation. The top staff is for Soprano Saxophone, written in treble clef with a key signature of two sharps (F# and C#) and a 4/4 time signature. The bottom staff is for Pianoforte, written in bass clef with the same key signature and time signature. Both staves contain rhythmic patterns of eighth and sixteenth notes, with some rests and accidentals.

Weather
*Rain (Light),
Cold,
Very Windy*

Time Period
Day

Instrumentation
*Soprano Saxophone,
Pianoforte, Cello*

Movement 5, *Devoto*

BPM
86bpm

Key Signature
C# Minor

Metre
4/4

Violin I

Pianoforte

Pia

Weather
*Bright, Dry,
Gusty*

Time Period
Dusk

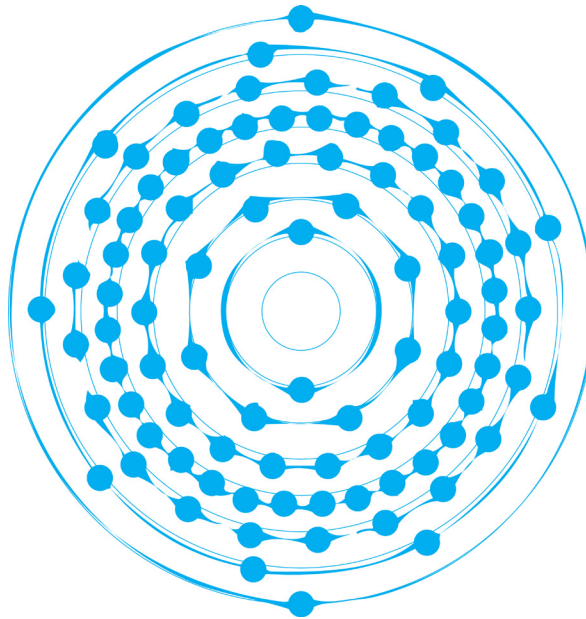
Instrumentation
*Violin, Piccolo, Pianoforte,
Cello, Marimba, Acoustic
Guitar*

Movement 7, *Mesto*

BPM
68bpm

Key Signature
F# Major

Metre
4/4



Weather
*Still, Warm,
Humid, Rainy*

Time Period
Night

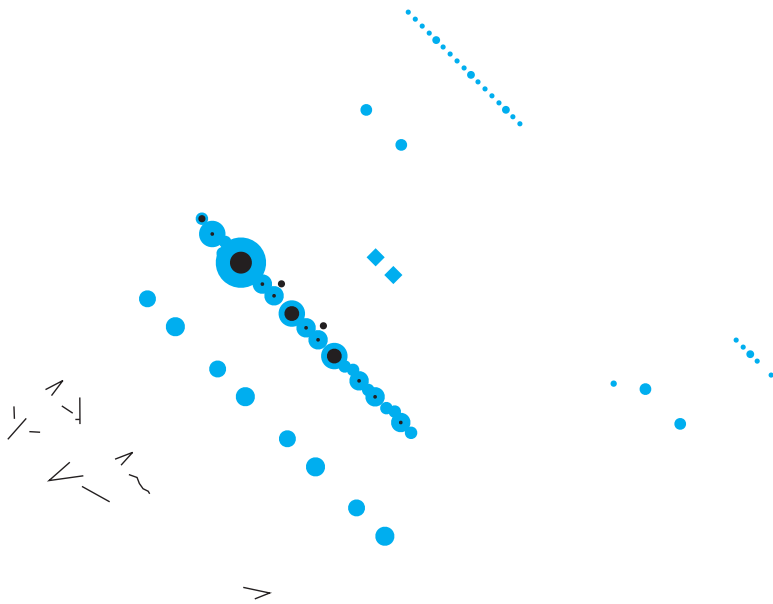
Instrumentation
*Cello, Pianoforte, Percussion,
Electronics, Marimba,
Harmonium*

Movement 8, *Leggiero*

BPM
116bpm

Key Signature
C# Major

Metre
4/4



Weather
Bright, Still

Time Period
Dawn

Instrumentation
Pianoforte

Movement 9, *Con Moto*

BPM
68bpm

Key Signature
Ab Major

Metre
4/4

Violin I

Violin II

The image shows two staves of musical notation. The top staff is labeled 'Violin I' and the bottom staff is labeled 'Violin II'. Both staves are in the treble clef, with a key signature of two flats (B-flat and E-flat) and a 4/4 time signature. The Violin I part begins with a melodic line of eighth notes, while the Violin II part provides a rhythmic accompaniment of eighth notes. The notation is presented in a clean, black-and-white style with blue highlights on the staff lines.

Weather
Dry, Bright, Gusty

Time Period
Night

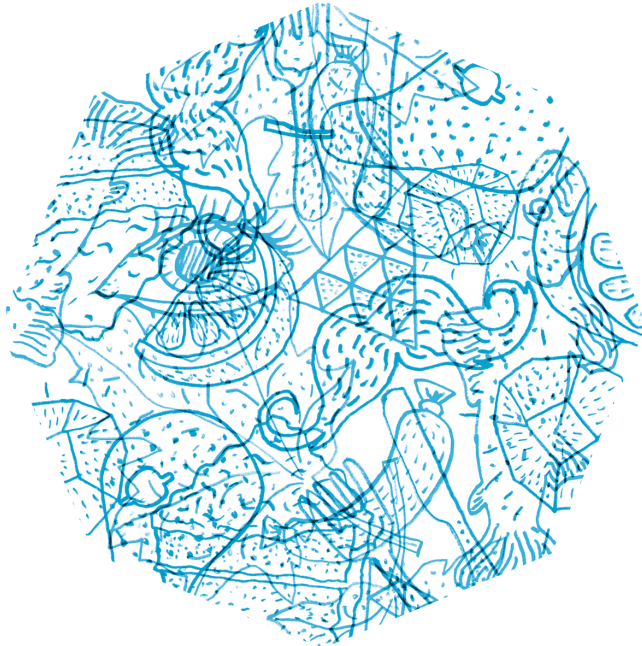
Instrumentation
*Violin, Cello, Tambourine,
Double Bass*

Movement 10, *Rapidamente*

BPM
100bpm

Key Signature
E♭ Major

Metre
7/4



Weather
*Warm, Grey,
Humid,
A Chance of Rain*

Time Period
Day

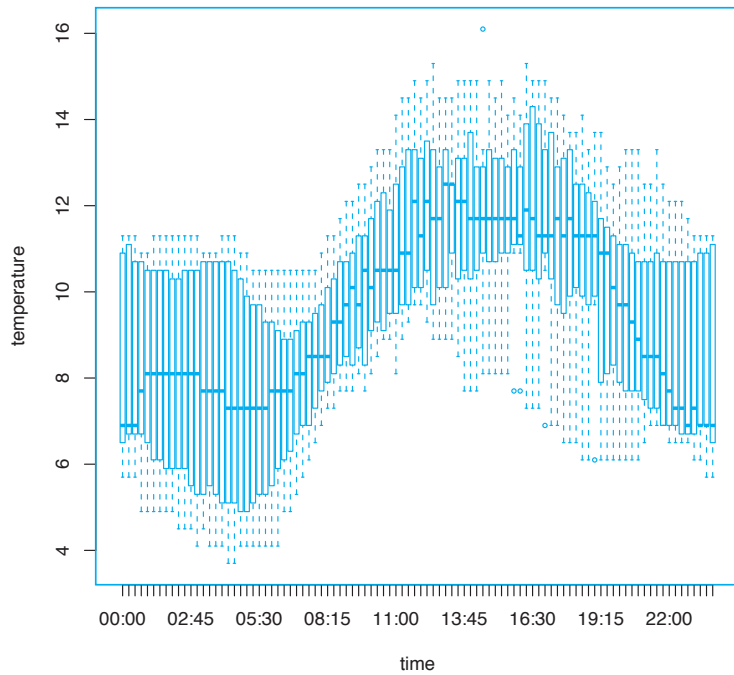
Instrumentation
*Pianoforte,
Soprano Saxophone*

Movement II, *Scucito*

BPM
110bpm

Key Signature
Bb Major

Metre
4/4



Weather
Cold, Grey, Still

Time Period
Day

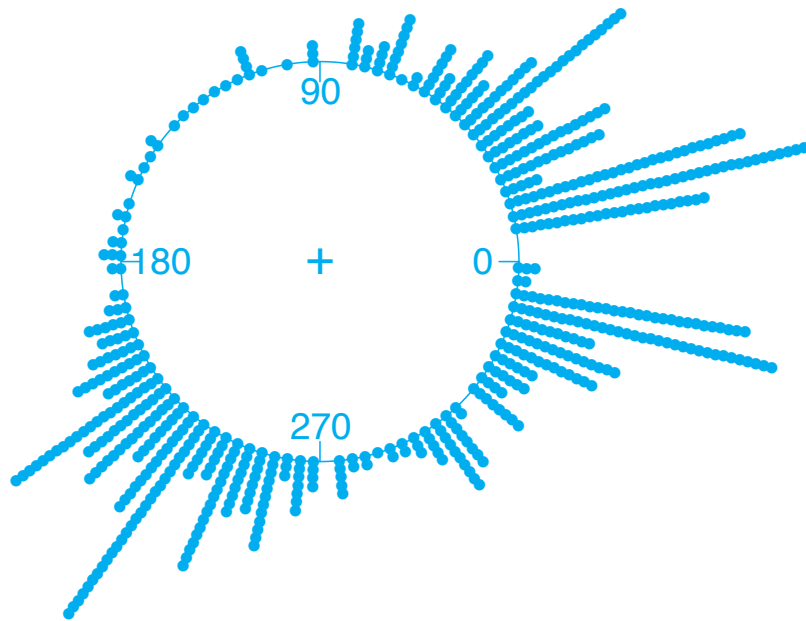
Instrumentation
Pianoforte

Movement 12, *Agitato*

BPM
95bpm

Key Signature
D Minor

Metre
4/4



Weather
*Chilly, Windy,
Changeable*

Time Period
Day

Instrumentation
Clarinet, Violin

Movement 13, *Tranquilo*

BPM
130bpm

Key Signature
C Major

Metre
4/4

The musical score is arranged in five staves. Violin I and Violin II are in the top two staves, both in treble clef. Piano I and Piano II are in the middle two staves, both in treble clef. Timpani is in the bottom staff, in bass clef. The music is in 4/4 time. Violin I plays a melodic line with eighth notes and rests. Violin II plays a rhythmic accompaniment with eighth notes and rests. Piano I plays a rhythmic accompaniment with eighth notes and rests, including a triplet. Piano II plays a rhythmic accompaniment with eighth notes and rests. Timpani plays a rhythmic accompaniment with eighth notes and rests.

Weather
Still, Warm

Time Period
Dusk

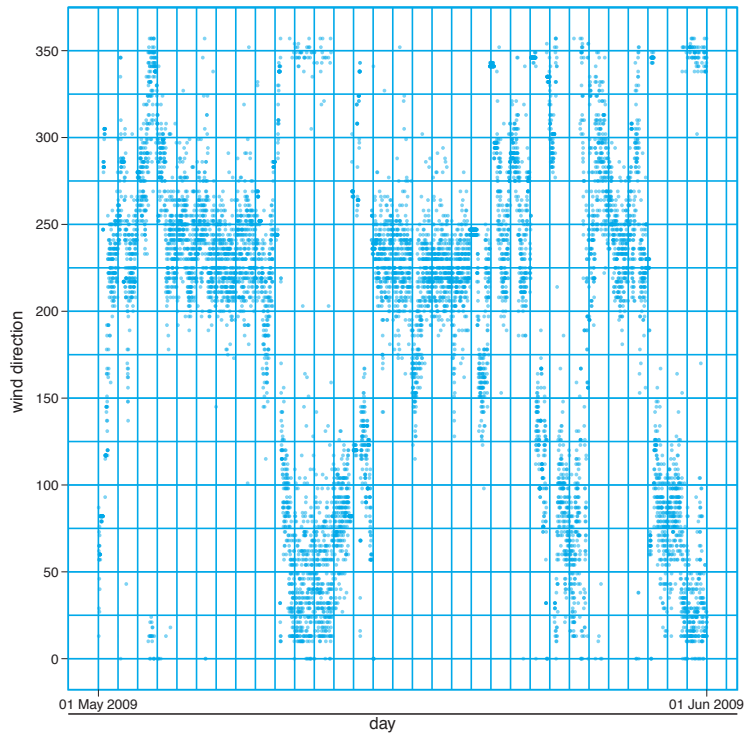
Instrumentation
*Pianoforte,
Violin, Cello,
Timpani*

Movement 14, *Liberamente*

BPM
136bpm

Key Signature
E Minor

Metre
4/4



Weather
*Gusty,
Mid Temperature,
Dry*

Time Period
Night

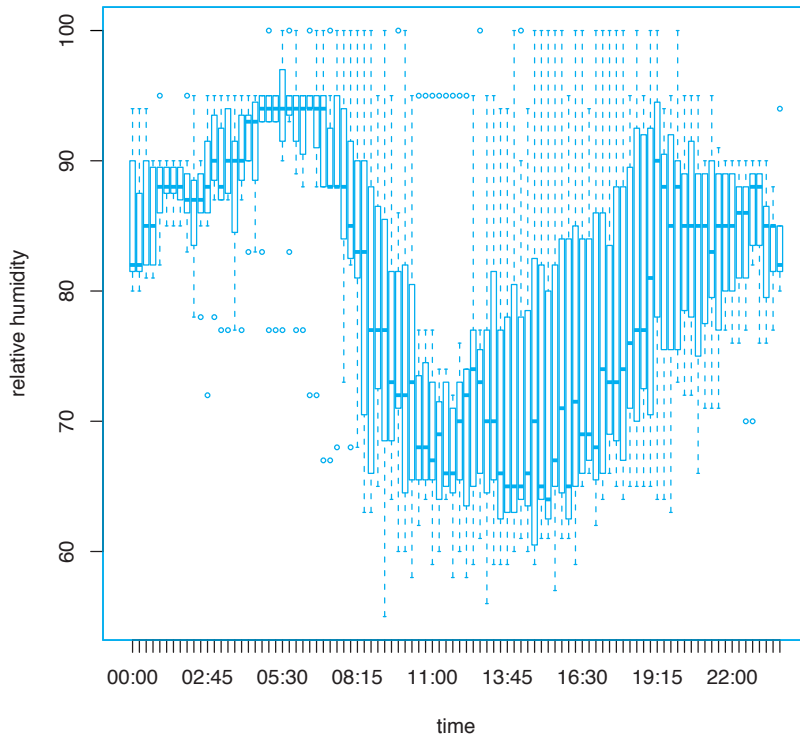
Instrumentation
*Pianoforte,
Electronics,
Drones*

Movement 15, *Larghetto*

BPM
76bpm

Key Signature
D Major

Metre
4/4



Weather
*Breezy, Humid,
A Chance of Rain*

Time Period
Night

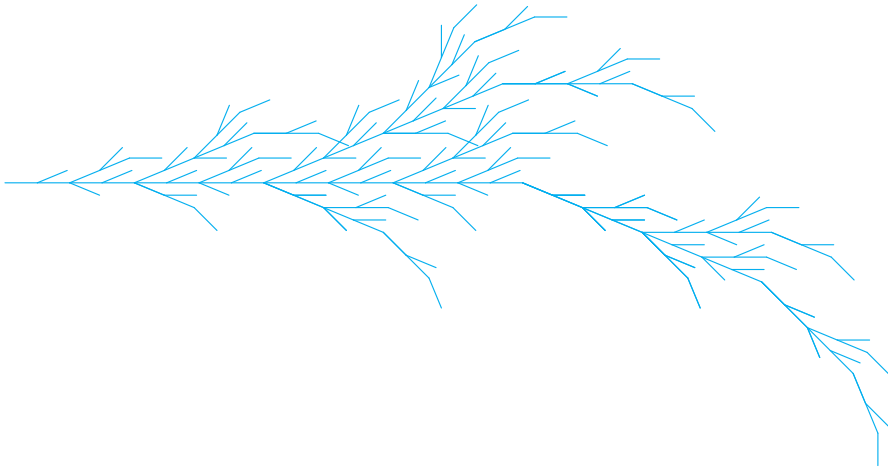
Instrumentation
*Middle Eastern Percussion,
Manipulated Drones,
Pianoforte,
Electronics*

Movement 16, *Pianto*

BPM
60bpm

Key Signature
F# Minor

Metre
3/4



Lindenmayer systems, or L-systems, are a type of grammar which can be used to describe and produce plant-like sprouting forms. They are here used to generate unpredictable yet organic arpeggio patterns.

Weather
*Sunny, Warm,
Windy,
A Chance of Rain*

Time Period
Dawn

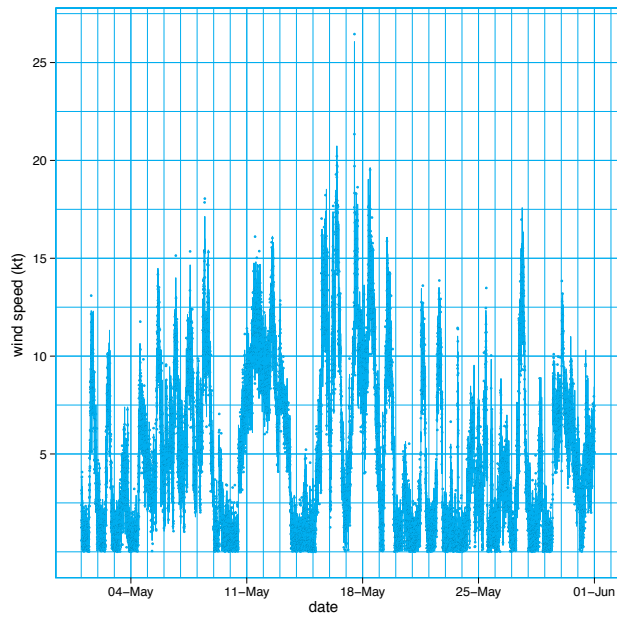
Instrumentation
*Cello, Double Bass, Viola,
Pianoforte, Celesta,
French Horn*

Movement 17, *Marcato*

BPM
95bpm

Key Signature
C# Minor

Metre
4/4



Weather
*Dry, Bright,
Gusty*

Time Period
Day

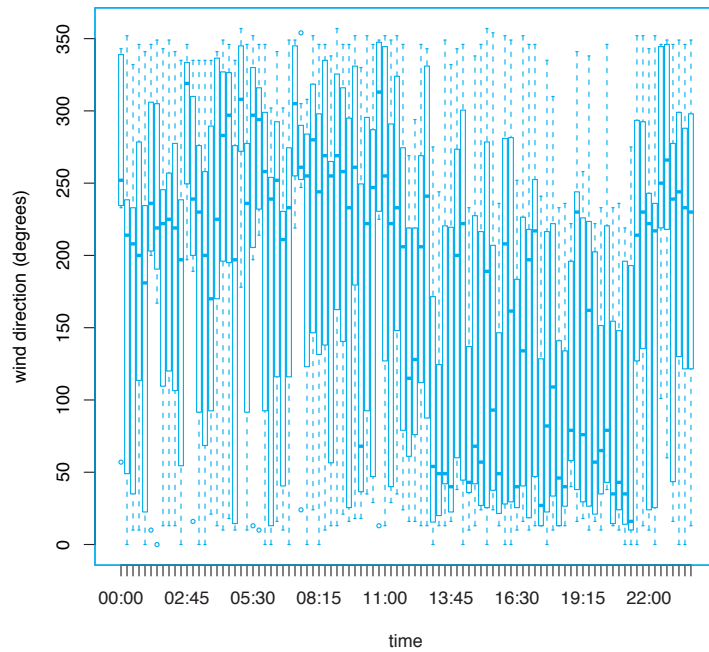
Instrumentation
*Cello, Double Bass,
Pianoforte, Celesta,
Harp, Percussion*

Movement 18, *Con Brio*

BPM
110bpm

Key Signature
Ab Minor

Metre
4/4



Weather
Sunny, Windy

Time Period
Day

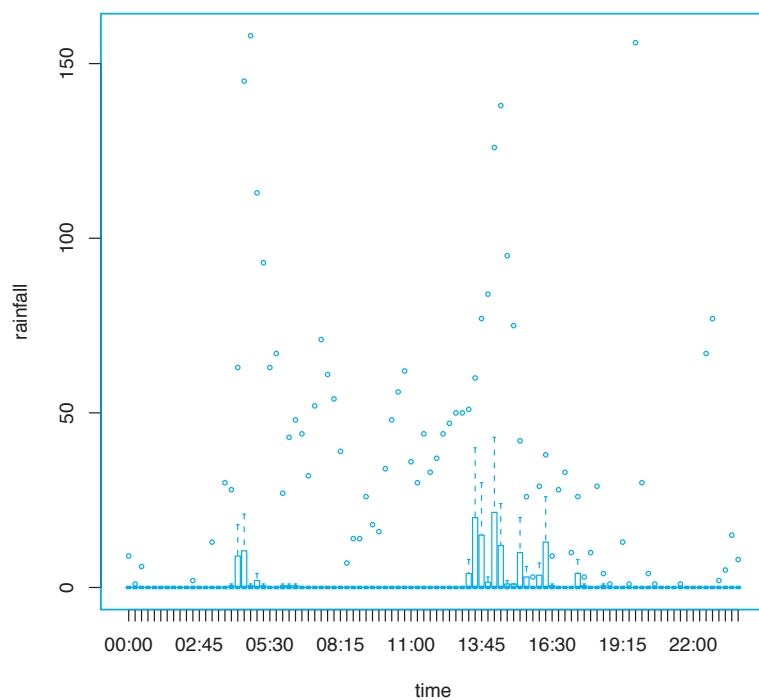
Instrumentation
*Accordion, Tambourine,
Violin, Cello*

Movement 19, *Appenato*

BPM
68bpm

Key Signature
Eb Minor

Metre
4/4



Weather
*Rain (Heavy),
Warm, Humid*

Time Period
Day

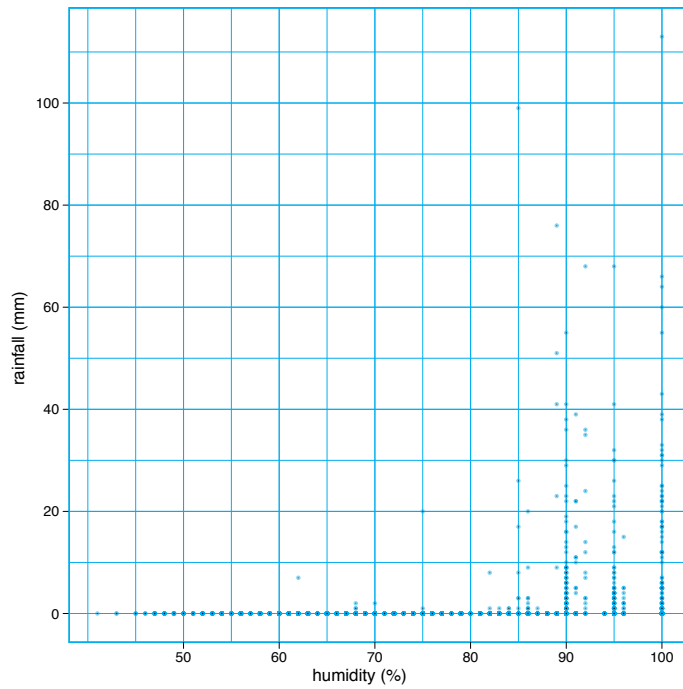
Instrumentation
*Double Bass, Harmonium,
Percussion, Pianoforte,
Timpani, Celesta*

Movement 20, *Pesante*

BPM
116bpm

Key Signature
Bb Minor

Metre
4/4



Weather
*Cold, Grey,
Humid*

Time Period
Day

Instrumentation
Pianoforte, Violin

Movement 21, *Aperto*

BPM <i>102bpm</i>	Key Signature <i>F Minor</i>	Metre <i>5/4</i>	
('A', 'B', 'C', 'D', 'E')	('B', 'C', 'A', 'D', 'E')	('C', 'D', 'A', 'B', 'E')	('D', 'E', 'A', 'B', 'C')
('A', 'B', 'C', 'E', 'D')	('B', 'C', 'A', 'E', 'D')	('C', 'D', 'A', 'E', 'B')	('D', 'E', 'A', 'C', 'B')
('A', 'B', 'D', 'C', 'E')	('B', 'C', 'D', 'A', 'E')	('C', 'D', 'B', 'A', 'E')	('D', 'E', 'B', 'A', 'C')
('A', 'B', 'D', 'E', 'C')	('B', 'C', 'D', 'E', 'A')	('C', 'D', 'B', 'E', 'A')	('D', 'E', 'B', 'C', 'A')
('A', 'B', 'E', 'C', 'D')	('B', 'C', 'E', 'A', 'D')	('C', 'D', 'E', 'A', 'B')	('D', 'E', 'C', 'A', 'B')
('A', 'B', 'E', 'D', 'C')	('B', 'C', 'E', 'D', 'A')	('C', 'D', 'E', 'B', 'A')	('D', 'E', 'C', 'B', 'A')
('A', 'C', 'B', 'D', 'E')	('B', 'D', 'A', 'C', 'E')	('C', 'E', 'A', 'B', 'D')	('E', 'A', 'B', 'C', 'D')
('A', 'C', 'B', 'E', 'D')	('B', 'D', 'A', 'E', 'C')	('C', 'E', 'A', 'D', 'B')	('E', 'A', 'B', 'D', 'C')
('A', 'C', 'D', 'B', 'E')	('B', 'D', 'C', 'A', 'E')	('C', 'E', 'B', 'A', 'D')	('E', 'A', 'C', 'B', 'D')
('A', 'C', 'D', 'E', 'B')	('B', 'D', 'C', 'E', 'A')	('C', 'E', 'B', 'D', 'A')	('E', 'A', 'C', 'D', 'B')
('A', 'C', 'E', 'B', 'D')	('B', 'D', 'E', 'A', 'C')	('C', 'E', 'D', 'A', 'B')	('E', 'A', 'D', 'B', 'C')
('A', 'C', 'E', 'D', 'B')	('B', 'D', 'E', 'C', 'A')	('C', 'E', 'D', 'B', 'A')	('E', 'A', 'D', 'C', 'B')
('A', 'D', 'B', 'C', 'E')	('B', 'E', 'A', 'C', 'D')	('D', 'A', 'B', 'C', 'E')	('E', 'B', 'A', 'C', 'D')
('A', 'D', 'B', 'E', 'C')	('B', 'E', 'A', 'D', 'C')	('D', 'A', 'B', 'E', 'C')	('E', 'B', 'A', 'D', 'C')
('A', 'D', 'C', 'B', 'E')	('B', 'E', 'C', 'A', 'D')	('D', 'A', 'C', 'B', 'E')	('E', 'B', 'C', 'A', 'D')
('A', 'D', 'C', 'E', 'B')	('B', 'E', 'C', 'D', 'A')	('D', 'A', 'C', 'E', 'B')	('E', 'B', 'C', 'D', 'A')
('A', 'D', 'E', 'B', 'C')	('B', 'E', 'D', 'A', 'C')	('D', 'A', 'E', 'B', 'C')	('E', 'B', 'D', 'A', 'C')
('A', 'D', 'E', 'C', 'B')	('B', 'E', 'D', 'C', 'A')	('D', 'A', 'E', 'C', 'B')	('E', 'B', 'D', 'C', 'A')
('A', 'E', 'B', 'C', 'D')	('C', 'A', 'B', 'D', 'E')	('D', 'B', 'A', 'C', 'E')	('E', 'C', 'A', 'B', 'D')
('A', 'E', 'B', 'D', 'C')	('C', 'A', 'B', 'E', 'D')	('D', 'B', 'A', 'E', 'C')	('E', 'C', 'A', 'D', 'B')
('A', 'E', 'C', 'B', 'D')	('C', 'A', 'D', 'B', 'E')	('D', 'B', 'C', 'A', 'E')	('E', 'C', 'B', 'A', 'D')
('A', 'E', 'C', 'D', 'B')	('C', 'A', 'D', 'E', 'B')	('D', 'B', 'C', 'E', 'A')	('E', 'C', 'B', 'D', 'A')
('A', 'E', 'D', 'B', 'C')	('C', 'A', 'E', 'B', 'D')	('D', 'B', 'E', 'A', 'C')	('E', 'C', 'D', 'A', 'B')
('A', 'E', 'D', 'C', 'B')	('C', 'A', 'E', 'D', 'B')	('D', 'B', 'E', 'C', 'A')	('E', 'C', 'D', 'B', 'A')
('B', 'A', 'C', 'D', 'E')	('C', 'B', 'A', 'D', 'E')	('D', 'C', 'A', 'B', 'E')	('E', 'D', 'A', 'B', 'C')
('B', 'A', 'C', 'E', 'D')	('C', 'B', 'A', 'E', 'D')	('D', 'C', 'A', 'E', 'B')	('E', 'D', 'A', 'C', 'B')
('B', 'A', 'D', 'C', 'E')	('C', 'B', 'D', 'A', 'E')	('D', 'C', 'B', 'A', 'E')	('E', 'D', 'B', 'A', 'C')
('B', 'A', 'D', 'E', 'C')	('C', 'B', 'D', 'E', 'A')	('D', 'C', 'B', 'E', 'A')	('E', 'D', 'B', 'C', 'A')
('B', 'A', 'E', 'C', 'D')	('C', 'B', 'E', 'A', 'D')	('D', 'C', 'E', 'A', 'B')	('E', 'D', 'C', 'A', 'B')
('B', 'A', 'E', 'D', 'C')	('C', 'B', 'E', 'D', 'A')	('D', 'C', 'E', 'B', 'A')	('E', 'D', 'C', 'B', 'A')

In mathematics, a permutation of a set of values is a rearrangement of that set into a particular order. By generating each possible permutation of a melody or rhythm, and iterating through each permutation in turn, we explore every potential musical sequence one by one.

Weather
*Cool, Humid,
Chance of Rain*

Time Period
Dusk

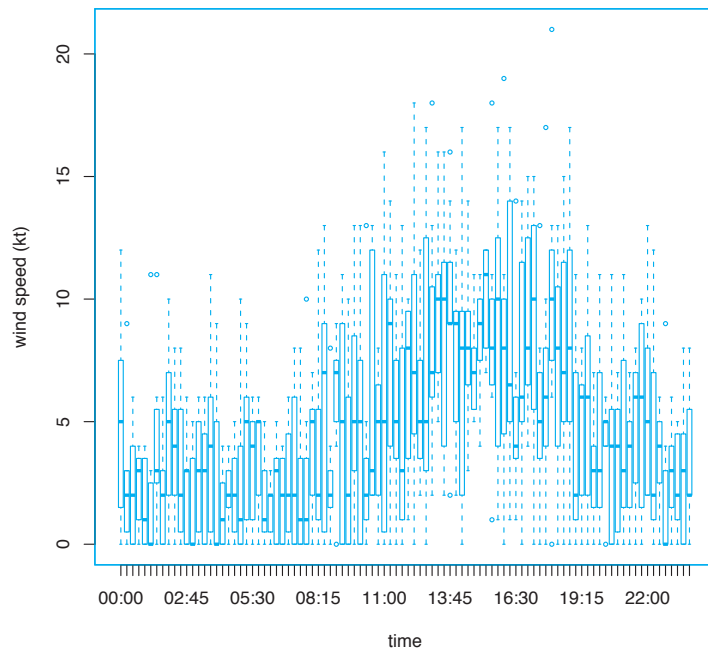
Instrumentation
Pianoforte, Percussion

Movement 22, *Sostenuto*

BPM
110bpm

Key Signature
E♭ Major

Metre
4/4



Weather
*Windy,
Mid-Temperature,
Drizzle*

Time Period
Night

Instrumentation
*Synthesiser, Cello,
Percussion*

Movement 23, *Lutto*

BPM
110 bpm

Key Signature
G Minor

Metre
3/4

Soprano Saxophone

Marimba

The image shows two staves of musical notation. The top staff is for the Soprano Saxophone, and the bottom staff is for the Marimba. Both are in G minor (one flat) and 3/4 time. The Soprano Saxophone part begins with a whole rest, followed by a half note G4, a quarter note A4, a quarter note Bb4, a quarter note C5, a quarter note Bb4, a quarter note A4, and a half note G4. The Marimba part begins with a quarter rest, followed by a quarter note G4, a quarter note A4, a quarter note Bb4, a quarter note C5, a quarter rest, a quarter note G4, a quarter note A4, a quarter note Bb4, a quarter note C5, a quarter rest, a quarter note G4, a quarter note A4, a quarter note Bb4, a quarter note C5, and a quarter rest.

Weather
*Still, Cool,
Dry*

Time Period
Night

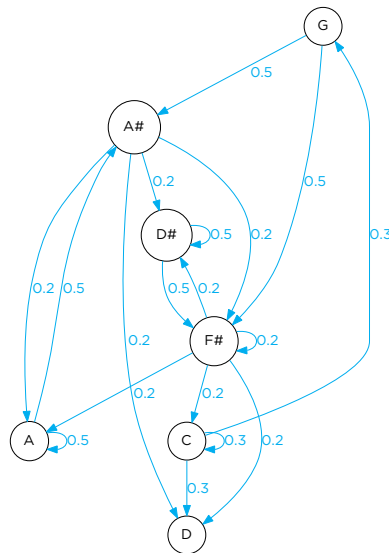
Instrumentation
*Soprano Saxophone,
Marimba, Percussion,
Pianoforte*

Movement 24, *Fastoso*

BPM
130bpm

Key Signature
F Major

Metre
4/4



A Markov chain is a statistical model of a sequence of events, describing the likelihood of moving from one element to the next. Popularised within composition by Xenakis, they can be used as a method of introducing some randomness whilst retaining a recognisable formal structure.

Weather
*Gloomy, Warm,
Humid*

Time Period
Dawn

Instrumentation
*Clarinet, Cello,
Double Bass*

Wormholes

In the context of this piece, a 'wormhole' is an arrhythmic and often atonal bridge, which serves to join two unrelated musical movements.

There are six wormholes within the piece, derived from a broad range of source material. Each wormhole will be algorithmically manipulated by the current weather conditions on a variety of different levels.

Wormhole A is most likely to play during Dawn, Day or Dusk. Granulated prepared Cello progressions rise and are composed over an undulating synthesised drone bed.

Wormhole B is most likely to play during the Night, and is inspired by the nuclear power stations of Dungeness. As it builds and progresses, the high piano figures weave in and out of the effected Cello drones whilst the Synthesised bass provides a counterpoint to their actions.

Wormhole C is most likely to play during the Day, with material derived from a recording session with Rashad Selim's 'Geopiano', a piano sculpture that is currently located in Brixton Village's Remade workshop.

Wormhole D is most likely to play during the Day or at Dawn. It is comprised of field recordings of the unique birdlife in Dungeness and the surrounding area.

Wormhole E is most likely to play during the Day or at Night. The material utilised is drawn from a wide range of field recordings taken on location at the installation, specifically focused upon the materials, textures and objects that you will see around you on site.

Wormhole F is temporally linked to high tide in Dungeness and will only play during the fifteen minute time period either side of that event. It is inspired by a series of field recordings of the sea and lighthouse at Dungeness that we have taken during our research period.

Th

Hav
Julia
Frar
Dav
Frec
Ma
Chr
Joe
Jam
Gile
Julia
Keit
Mik
Ow
Ron
Mir
Elea
Lou
Tho
Nig
Lall
Mic
Cha
Ras
Edw
Emi
Iain
Chr
Elea
Cec

Sp

PRS
Can
RN
KEI
Abl



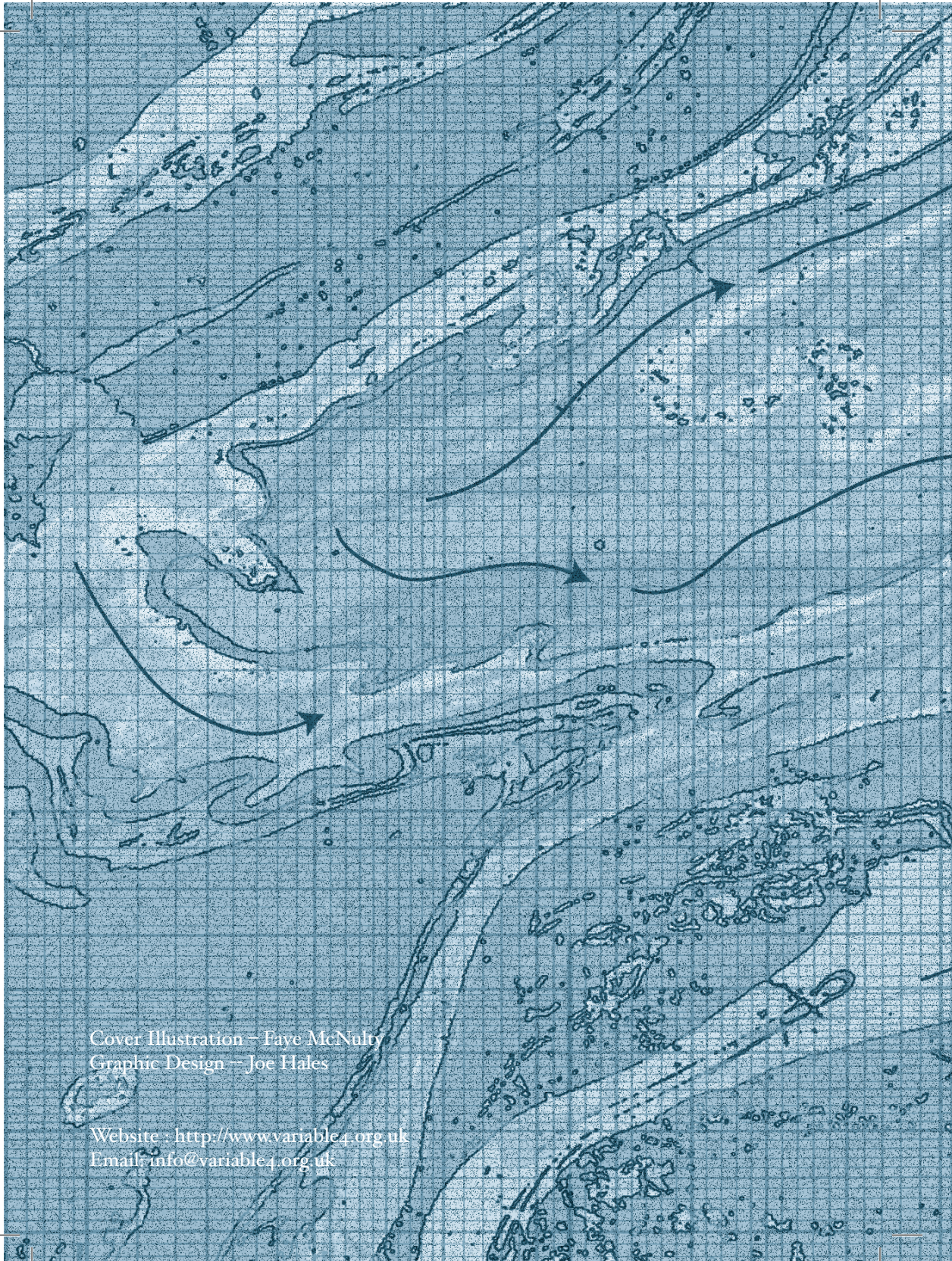
Thanks

Havva Basto
Julia Calver
Franco Casule (Campbell Scientific)
Dave Charlesworth
Fred Deakin
Maurice Ede (Dungeness Estate)
Christina Fischer (Ableton)
Joe Hales
James Hannam (PRS for Music Foundation)
Giles Henry Stogdon
Julia Hodgson
Keith Johnson (RNLI)
Mike Knowlden
Owen Leyshon (Dungeness Estate)
Ron Locke (KEF)
Mira Mattar
Eleanor McDowall
Faye McNulty
Louis Mustill
Thomas Oldham
Nigel Packer (RNLI)
Lally Pollen
Michael Reid
Charly Richardson
Rashad Selim
Edward Scott-Clarke
Emily Stuart
Iain Thornton (Campbell Scientific)
Chris Ubee (RNLI)
Eleanor Ward (PRS for Music Foundation)
Cecilia Wee

Sponsors

PRS for Music Foundation
Campbell Scientific
RNLI Dungeness
KEF
Ableton Max for Live





Cover Illustration – Faye McNulty
Graphic Design – Joe Hales

Website : <http://www.variable4.org.uk>
Email: info@variable4.org.uk