WELCOME!

Hierarchical Modelling of Species Communities with the R-package Hmsc

Teachers:

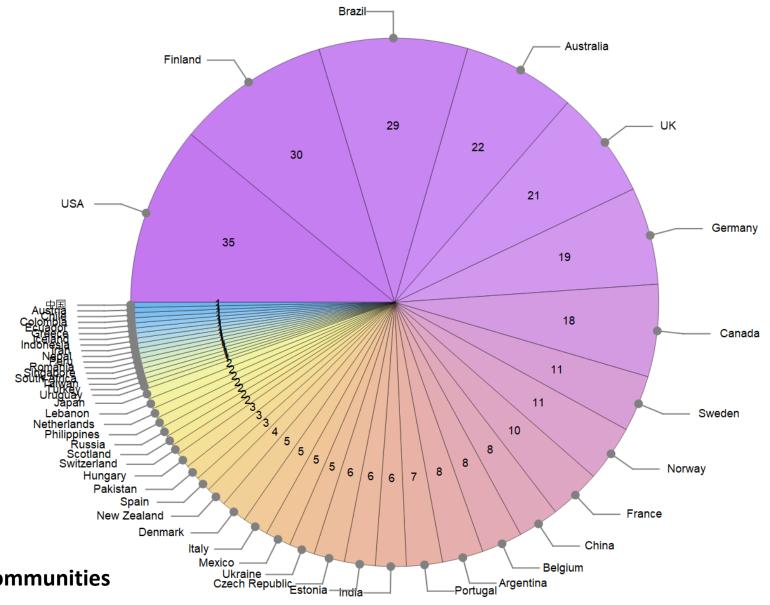
- Prof. Otso Ovaskainen (Universities of Jyväskylä, University of Helsinki & Norwegian University of Science and Technology)
- Dr. Nerea Abrego (University of Jyväskylä & University of Helsinki)
- Dr. Gleb Tikhonov (Aalto University)
- Prof. Emeritus Jari Oksanen (University of Helsinki)
- Dr. Øystein Opedal (Lund University)
- Dr. Mirkka Jones (University of Helsinki)
- Project planner Bess Hardwick (University of Helsinki)

ANY QUESTIONS? PLACE THEM IN CHAT!

319 participants from 49 countries!

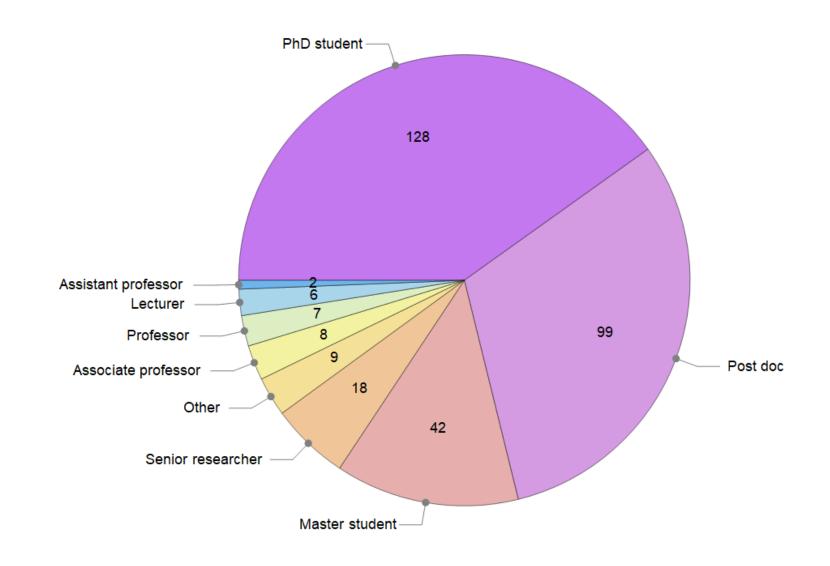


#HMSCmarathon



HMSC = Hierarchical Modelling of Species Communities

Majority of the participants are PhD students, post docs & master students

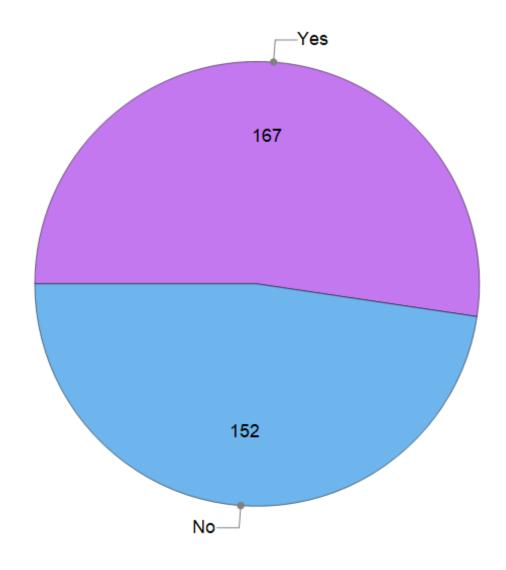


Need study credits (2 ECTS)?

- You can receive a signed certificate stating that you have successfully completed this 2ECTS course – hopefully your university will then accept to register the credits.
- To achieve the study credits, you should turn in a learning diary at the end of the course (2-5 pages in total, pdf-file), where you summarize in your own words what you learned during each of the course days. Send the pdf file to hmsc-course@helsinki.fi, with email subject learning_diary_surname_firstname, e.g. learning_diary_ovaskainen_otso.
- If you are a student at Helsinki, we can register your credits directly.

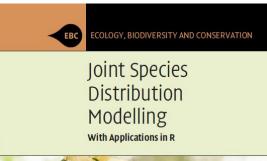
More than half planned to come with their own data

- >60 datasets received
- Pilot models fitted for 39 datasets
- We aim to set up pilot models for everybody – latest after the course!



Course material

1. Book





Cambridge University Press (2020)

2. R-package Hmsc (in CRAN)



Methods in Ecology & Evolution (2020)

3. R-scripts (at the www-page)

Additional recommended reading



Computationally efficient joint species distribution modeling of big spatial data

GLEB TIKHONOV (10, 1.2.8 LI DUAN, 3 NEREA ABREGO, 4 GRAEME NEWELL, 5 MATT WHITE, 5 DAVID DUNSON, 6 AND OTSO OVASKAINEN (10)1.7

Modeling species co-occurrence by multivariate logistic regression generates new hypotheses on fungal interactions

Otso Ovaskainen, 1,3 Jenni Hottola, 1,2 and Juha Siitonen²

Testing the heterospecific attraction hypothesis with time-series data on species co-occurrence

Esther Sebastián-González^{1,2,*}, José Antonio Sánchez-Zapata², Francisco Botella² and Otso Ovaskainen³

Making more out of sparse data: hierarchical modeling of species communities

Otso Ovaskainen^{1,3} and Janne Soininen²

Bryophyte Species Richness on Retention Aspens Recovers in Time but Community Structure Does Not

Anna Oldén¹", Otso Ovaskainen², Janne S. Kotiaho¹, Sanna Laaka-Lindberg³, Panu Halme

Using joint species distribution models for evaluating how species-to-species associations depend on the environmental context

Gleb Tikhonov*.1, Nerea Abrego2, David Dunson3 and Otso Ovaskainen1.2

Wood-inhabiting fungi with tight associations with other species have declined as a response to forest management

Nerea Abrego, David Dunson, Panu Halme, Isabel Salcedo and Otso Ovaskainen

So Many Variables: Joint Modeling in Community Ecology

David I. Warton, 1.* F. Guillaume Blanchet, 2 Robert B. O'Hara, 3 Otso Ovaskainen, 4.5 Sara Taskinen, 6 Steven C. Walker, 2 and Francis K.C. Hui⁷

How are species interactions structured in species-rich communities? A new method for analysing time-series data

Otso Ovaskainen^{1,2}, Gleb Tikhonov¹, David Dunson³, Vidar Grøtan², Steinar Engen⁴, Bernt-Erik Sæther² and Nerea Abrego^{2,5}

Uncovering hidden spatial structure in species communities with spatially explicit joint species distribution models

Otso Ovaskainen^{1,2}*, David B. Roy³, Richard Fox⁴ and Barbara J. Anderson⁵

Measuring and predicting the influence of traits on the assembly processes of wood-inhabiting fungi

Nerea Abrego*+1.2, Anna Norberg+3 and Otso Ovaskainen1.3

Using latent variable models to identify large networks of species-to-species associations at different spatial scales

Otso Ovaskainen^{1,2}*, Nerea Abrego^{2,3,4}, Panu Halme^{3,5} and David Dunson⁴

Course programme

https://www.helsinki.fi/en/researchgroups/statistical-ecology/hmsc

How the course relates to the book?

0			
Co	nte	nt.	S

	Preface Adenowledgements	page xi xiv
Part I	Introduction to Community Ecology: Theory and Methods	1
1	Historical Development of Community Ecology	3
	1.1 What Is Community Ecology?	3
	1.2 What Is an Ecological Community?	4
	1.3 Early Community Ecology: A Descriptive Science	6
	1.4 Emergence of the First Theories	9
	1.5 Current Community Ecology: Search for the	
	Unifying Theory	11
2	Typical Data Collected by Community	
	Ecologists	19
	2.1 Community Data	20
	2.2 Environmental Data	23
	2.3 Spatio-temporal Context	24
	2.4 Trait Data	26
	2.5 Phylogenetic Data	27
	2.6 Some Remarks about How to Organise Data	28
3	Typical Statistical Methods Applied by Commun	ity
	Ecologists	30
	3.1 Ordination Methods	30
	3.2 Co-occurrence Analysis	33
	3.3 Analyses of Diversity Metrics	34
	3.4 Species Distribution Modelling	35
4	An Overview of the Structure and Use of HMSC	39
	4.1 HMSC Is a Multivariate Hierarchical Generalised	
	Linear Mixed Model	39

viii	٠	Contents	
		4.2 The Overall Structure of HMSC	41
		4.3 Linking HMSC to Community Ecology Theory	45
		4.4 The Overall Workflow for Applying HMSC	47
Part	ŧΠ	Building a Joint Species Distribution Model Step	
		by Step	51
	5	Single-Species Distribution Modelling	53
		5.1 How Do Species Distribution Models Link	
		to Species Niches?	53
		5.2 The Linear Model	55
		5.3 Generalised Linear Models	58
		5.4 Mixed Models	63
		5.5 Partitioning Explained Variation among Groups of	
		Explanatory Variables	69
		5.6 Simulated Case Studies with HMSC	70
		5.7 Real Data Case Study with HMSC:	
		The Distribution of Corvus Monedula in Finland	92
	6	Joint Species Distribution Modelling: Variation in	
		Species Niches	104
		6.1 Stacked versus Joint Species Distribution Models	104
		6.2 Modelling Variation in Species Niches in a	
		Community	107
		6.3 Explaining Variation in Species Niches by Their	
		Traits	110
		6.4 Explaining Variation in Species Niches by	
		Phylogenetic Relatedness	114
		6.5 Explaining Variation in Species Niches by Both	
		Traits and Phylogeny	117
		6.6 Simulated Case Studies with HMSC	120
		6.7 Real Case Study with HMSC: How Do	400
		Plant Traits Influence Their Distribution?	133
	7	Joint Species Distribution Modelling: Biotic	
		Interactions	142
		7.1 Strategies for Estimating Biotic Interactions in	
		Species Distribution Models	143
		7.2 Occurrence and Co-occurrence Probabilities	144
		7.3 Using Latent Variables to Model Co-occurrence	147

	Contents	' IX	
	7.4 Accounting for the Spatio-temporal Context		
	through Latent Variables	152	
	7.5 Covariate-Dependent Species Associations	156	
	7.6 A Cautionary Note about Interpreting Residual		
	Associations as Biotic Interactions	159	
	7.7 Using Residual Species Associations for Making		
	Improved Predictions	160	
	7.8 Simulated Case Studies with HMSC	165	
	7.9 Real Case Study with HMSC: Sequencing		
	Data on Dead Wood-Inhabiting Fungi	172	
8	Bayesian Inference in HMSC	184	
	8.1 The Core HMSC Model	185	
	8.2 Basics of Bayesian Inference: Prior and Posterior		
	Distributions and Likelihood of Data	187	
	8.3 The Prior Distribution of Species Niches	188	
	8.4 The Prior Distribution of Species Associations	197	
	8.5 The Prior Distribution of Data Models	206	
	8.6 What HMSC Users Need and Do Not		
	Need to Know about Posterior Sampling	207	
	8.7 Sampling from the Prior with HMSC	210	
	8.8 How Long Does It Take to Fit an	24.5	
	HMSC Model?	215	
9	Evaluating Model Fit and Selecting among		
	Multiple Models	217	
	9.1 Preselection of Candidate Models	218	
	9.2 The Many Ways of Measuring Model Fit	219	
	9.3 The Widely Applicable Information		
	Criterion (WAIC)	225	
	9.4 Variable Selection by a Spike and Slab Prior	228	
	9.5 Reduced Rank Regression (RRR)	242	
Part III	Applications and Perspectives	253	
10	Linking HMSC Back to Community Assembly Processes	255	
	10.1 Simulating an Agent-Based Model of a	200	
	Competitive Metacommunity	256	
	10.2 Statistical Analyses of the Spatial Data Collected	230	
	by a Virtual Ecologist	266	

Contents

	10.3 Statistical Analyses of the Time-Series Data	
	Collected by a Virtual Ecologist	288
	10.4 What Did the Virtual Ecologists Learn from	
	Their Data?	297
11	Illustration of HMSC Analyses: Case Study of	
	Finnish Birds	300
	11.1 Steps 1-5 of the HMSC Workflow	300
	11.2 Measuring the Level of Statistical Support and	
	Propagating Uncertainty into Predictions	316
	11.3 Using HMSC for Conservation Prioritisation	321
	11.4 Using HMSC for Bioregionalisation: Regions of	
	Common Profile	324
	11.5 Comparing HMSC to Other Statistical Methods	
	in Community Ecology	329
12	Conclusions and Future Directions	337
	12.1 The Ten Key Strengths of HMSC	337
	12.2 Future Development Needs	341
	Epilogue	347
	References	350
	Index	369

The colour plates appear between pages 336 and 337





How the course relates to the book?

Contents

	Preface Adenowledgements	page xi xiv
Part I	Introduction to Community Ecology: Theory and Methods	1
1	Historical Development of Community Ecology 1.1 What Is Community Ecology? 1.2 What Is an Ecological Community? 1.3 Early Community Ecology: A Descriptive Science 1.4 Emergence of the First Theories 1.5 Current CECTURE 2	3 3 4 6 9
2	Typical Data Collected by Community Ecologists 2.1 Community Data 2.2 Environmental Data 2.3 Spatio-temporal Context 2.4 Trait Data 2.5 Phylogenetic Data 2.6 Som Remarks show How to Organice Data	19 20 23 24 26 27
3	Typical Statistical Methods Applied by Communi Ecologists 3.1 Ordination Methods 3.2 Co-occurrence Analysis 3.3 Analyses of Diversity Metrics 3.4 Species Distribution Modelling	30 30 33 34 35
4	An Overview of the Structure and Use of HMSC 4.1 HMSC Is a Multivariate Hierarchical Generalised Linear NECCTURE 3	39

viii ·	Contents LECTURE 4	
	4.2 The Overall Structure of Thylsc	
	4.3 Linking HMSC to Community Ecology Theory 4.4 The Overall Workflow for Applying HMSC	45
		-
Part II	Building a Joint Species Distribution Model Step by Step	
5	Single-Species Distribution Modelling 5.1 How DESECTS BRECGS Link	
	to species intelies:	
	5.2 The Linear Model 5.3 Generalised Linear Models	
(5.4 Mixed Models	
	5.5 Partitioning Explained Variation among Groups of	0.0
$\overline{}$	Explanatory Variables	69
	Description 1	
	R-demonstration 1 The Distribution of Corrus Monedula in Finland	
6	Joint Species Distribution Modelling: Variation in	$\overline{}$
(Species Niches	
	6.1 Stacked versus Joint Species Distribution Models 6.2 Modelling Variation in Species Niches in a	
	Commu LECTURE 6.3 Explain Exp	
	Traits	
(6.4 Explaining Variation in Species Niches by	
	Phylogenetic Relatedness 6.5 Explaining Variation in Species Niches by Both	114
$\overline{}$	Traits and Phylogeny	117
	R-demonstration 2	
	Plant Traits Influence Their Distribution?	133
7	Joint Species Distribution Modelling: Biotic	
	Interactions	
	7.1 Strategies for Estimating Biotic Interactions in	
	Species DisECTURE 7.2 Occurre LECTURE Pr. 7 Abilities	
	7.3 Using Latent Variables to Model Co-occurrence	

	Contents	· ix
	7.4 Accounting for the Spatio-temporal Context	
	through Latent Variables	
	7.5 Covariate-Dependent Species Associations	
	7.5 Covariate—Dependent Species Associations 7.6 A Cauth ECTURE re7g Residual Associations as Brouc Interactions	
	7.7 Using Residual Species Associations for Making	
	Improved Predictions 7.8 Simulated Case Studies with HMSC	
	7.9 Real Case Study with HMSC: Sequencing	
	Data on Dead Wood-Inhabiting Fungi	172
8	Bayesian Interence in HMSC	184
	8.1 The Core HMSC Model	185
/	8.2 Basics of Bayesian Inference: Prior and Posterior	
	Distributions and Likelihood of Data 8.3 The Prior Distribution of Species Niches	
	8.4 The Prior Distribution of Species Associations	
	8.5 The Prior Distribution of Data Models	
	8.6 What HMSC Users Need and Do Not	
	Need to Know about Posterior Sampling	
	8.7 Sampling from the Prior with HMSC	
	All R-demonstration	C
•	HMSC Moder	215
9	Evaluating Model Fit and Selecting among	
	Multiple Models	
	9.1 Preselection of Candidate Models	
	9.2 The Many Ways of Measuring Model Fit	
	9.3 The Widely Applicable Information	
	Criterion (WAIC)	
	9.4 Variable Selection by a Spike and Slab Prior	
	9.5 Reduced Rank Regression (RRR)	242/
D	A P d 1D d	253
Part III	Applications and Perspectives	253
10	Linking HMSC Back to Community Assembly	
	Processes	255
	10.1 Simulating an Agent-Based Model of a	
	Competitive Metacommunity	256
	10.2 Statistical Analyses of the Spatial Data Collected	266
	by a Virtual Ecologist	266

10.3 Statistical Analyses of the Time-Series Data Collected by a Virtual Ecologist 10.4 What Did the Virtual Ecologists Learn from	288
Their Data?	297
Illustration of HMSC Analyses: Case Study of	
Finnish Birds	
11.1 Steps 1–5 of the HMSC Workflow 11.2 Measuring the Level of Statistical Support and	
	26
R-demonstration	$\sum_{i=1}^{n}$
11.4 Using HMSC for Bioregionalisation: Regions of	
Common Profile	
11.5 Comparing HMSC to Other Statistical Methods	
in Community Ecology	329
Conclusions and Future Directions	
12.1 The Ten Key Strengths of HMSC	
12.2 Future Development Needs	
Epilogue LECTLIDE 10	
Epilogue References LECTURE 10	
Index	

LECTURE 1:
Welcome!
LECTURE 11:
Closing words

to write materials and methods?

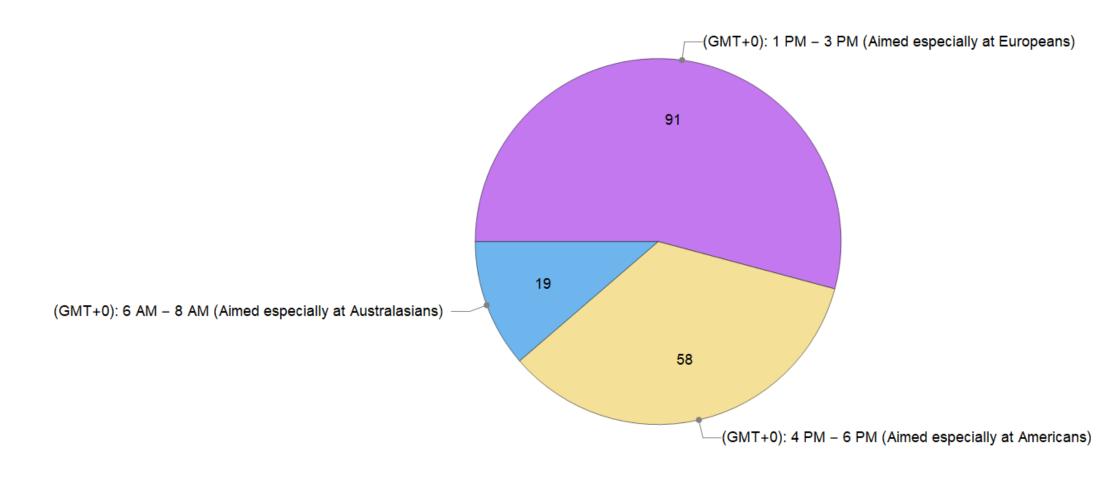
LECTURE 9: how to write results?

R-demonstrations
4 & 5: your own
case studies!

Break-out groups 1 & 2

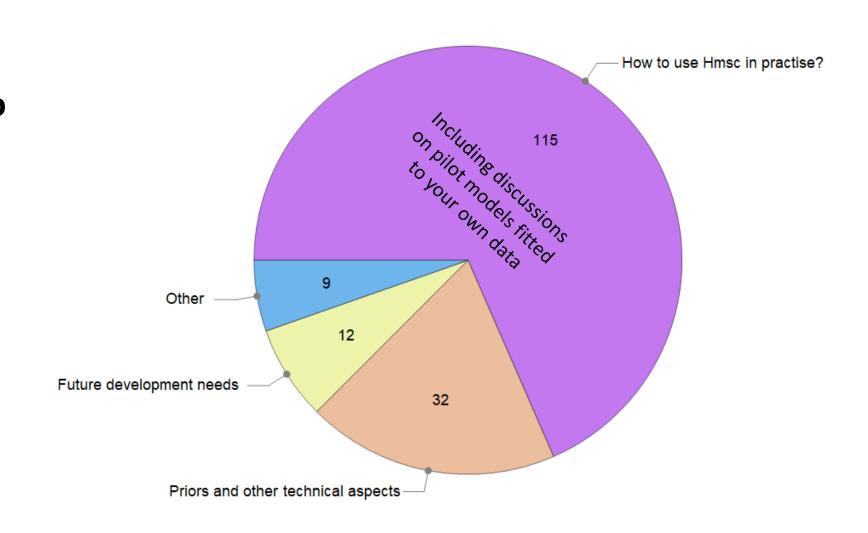
What happens in the break-out groups?

There are two break-out groups Both of them have three time options



What happens in the break-out groups?

What do you want to talk about in the break-out groups?



Thank you for listening, and welcome again to this course!

ANY QUESTIONS ABOUT THE COURSE ARRANGEMENTS?

ASK IN CHAT!