

SPRINGER BRIEFS IN ENVIRONMENTAL SCIENCE

Gunther Schmidt
Simon Schönrock
Winfried Schröder

Plant Phenology as a Biomonitor for Climate Change in Germany

A Modelling and Mapping Approach

 Springer

SpringerBriefs in Environmental Science

SpringerBriefs in Environmental Science present concise summaries of cutting-edge research and practical applications across a wide spectrum of environmental fields, with fast turnaround time to publication. Featuring compact volumes of 50 to 125 pages, the series covers a range of content from professional to academic. Monographs of new material are considered for the SpringerBriefs in Environmental Science series.

Typical topics might include: a timely report of state-of-the-art analytical techniques, a bridge between new research results, as published in journal articles and a contextual literature review, a snapshot of a hot or emerging topic, an in-depth case study or technical example, a presentation of core concepts that students must understand in order to make independent contributions, best practices or protocols to be followed, a series of short case studies/debates highlighting a specific angle.

SpringerBriefs in Environmental Science allow authors to present their ideas and readers to absorb them with minimal time investment. Both solicited and unsolicited manuscripts are considered for publication.

More information about this series at <http://www.springer.com/series/8868>

Gunther Schmidt • Simon Schönrock
Winfried Schröder

Plant Phenology as a Biomonitor for Climate Change in Germany

A Modelling and Mapping Approach

 Springer

Gunther Schmidt
University of Vechta
Vechta, Germany

Simon Schönrock
University of Vechta
Vechta, Germany

Winfried Schröder
Chair of Landscape Ecology
University of Vechta
Vechta, Germany

ISSN 2191-5547

ISBN 978-3-319-09089-4

DOI 10.1007/978-3-319-09090-0

Springer Cham Heidelberg New York Dordrecht London

ISSN 2191-5555 (electronic)

ISBN 978-3-319-09090-0 (e-Book)

Library of Congress Control Number: 2014944561

© The Author(s) 2014

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

1	Background and Goals	1
	References	4
2	Case Study 1: Phenological Trends in Germany	7
2.1	Background and Goals	8
2.2	Materials	9
2.2.1	Phenology Data	9
2.2.2	Data on Air Temperatures	10
2.2.3	Ecological Land Classification	15
2.3	Methods	15
2.4	Results	17
2.4.1	Phenological Development in the Past and Future	17
2.4.2	Spatially Discriminated Phenological Development	24
2.5	Discussion and Conclusions	25
	References	26
3	Case Study 2: Phenological Trends in the Federal State of Hesse	29
3.1	Background and Goals	30
3.2	Materials	31
3.2.1	Phenology Data	31
3.2.2	Data on Air Temperatures	33
3.3	Methods	39
3.3.1	Phenological Clocks	39
3.3.2	Correlation Analysis	40
3.3.3	Regression Analysis	41
3.3.4	Regression Kriging	41
3.4	Results	42
3.4.1	Phenological Development in the Past	42
3.4.2	Spatially Discriminated Phenological Development	43
3.4.3	Bivariate-Statistical Analysis	46
3.4.4	Mapping of Plant Phenological Development in Hesse	46
3.5	Discussion and Conclusions	59
	References	62

List of Figures

Fig. 2.1	Measurement networks on air temperature (<i>left</i>) and plant phenology (<i>right</i>) in Germany, both maintained by the German Weather Service (DWD)	10
Fig. 2.2	Long-term annual means on air temperatures in Germany for the climate reference period 1961–1990 (<i>left</i>) and the period 1991–2009 (<i>centre</i>) as well as according differences between both periods (<i>right</i>)	12
Fig. 2.3	Projected long-term annual means on air temperatures in Germany for the climate periods 1991–2020 (<i>left</i>), 2021–2050 (<i>centre</i>) and period 2051–2080 (<i>right</i>) according to climate model WettReg and considering emission scenario A1B (<i>upper row</i>) and B1 (<i>lower row</i>).....	13
Fig. 2.4	Projected long-term annual means on air temperatures in Germany for the climate periods 1991–2020 (<i>left</i>), 2021–2050 (<i>centre</i>) and period 2051–2080 (<i>right</i>) according to climate model REMO and considering emission scenario A1B (<i>upper row</i>) and B1 (<i>lower row</i>).....	14
Fig. 2.5	Ecoregions of Germany calculated by CART (Classification and Regression Trees) from the data in Table 2.1. (According to Schröder and Schmidt 2001)	16
Fig. 2.6	Regression analysis for the statistical association between the beginning of flowering of <i>Tilia platyphyllos</i> (large-leaved lime) and air temperatures in Germany for the climate period 1991–2005	18
Fig. 2.7	Observed (1961–1990, 1991–2005) and projected (1991–2020, 2021–2050, 2051–2080) onset of flowering of <i>Tilia platyphyllos</i> (large-leaved lime) in Germany according to climate model WettReg and emission scenario B1	19
Fig. 2.8	Observed (1961–1990, 1991–2005) and projected (1991–2020, 2021–2050, 2051–2080) onset of flowering of <i>Tilia platyphyllos</i> (large-leaved lime) in Germany according to climate model WettReg and emission scenario A1B....	20

Fig. 2.9	Observed (1961–1990, 1991–2005) and projected (1991–2020, 2021–2050, 2051–2080) onset of flowering of <i>Tilia platyphyllos</i> (large-leaved lime) in Germany according to climate model REMO and emission scenario B1	21
Fig. 2.10	Observed (1961–1990, 1991–2005) and projected (1991–2020, 2021–2050, 2051–2080) onset of flowering of <i>Tilia platyphyllos</i> (large-leaved lime) in Germany according to climate model REMO and emission scenario A1B.....	22
Fig. 2.11	Mean onset of lime bloom in ecoregion 12 (low mountain range) calculated using observations (1961–2005) on phenology (<i>obs.</i> data provided by the German Weather Service) and projections on phenological development based on modelled air temperatures (2020–2080) (<i>w</i> WettReg, <i>r</i> REMO) for two different climate emission scenarios (B1, A1B).....	24
Fig. 3.1	Outlier (•) analysis by example of phase 67 (ripening of <i>Sambucus nigra</i> , black elder). For the observation periods 1961–1990 and 1971–2000 there were 3 outliers for two sites (indicated by the site no.) detected showing conspicuous values for the long-term phase onset.....	33
Fig. 3.2	Spatiotemporal patterns of air temperature development in Hessian natural land units depicted by maps indicating the differences between the long-term annual means for the periods 1971–2000 and 1961–1990 (<i>left</i>), 1991–2009 and 1971–2000 (<i>centre</i>), and 1991–2009 and 1961–1990 (<i>right</i>)	34
Fig. 3.3	Annual mean air temperatures in Hesse. <i>Above</i> : measurements from 1961 to 2009 by DWD; <i>below</i> : projections for 1971–2000, 2031–2060, and 2071–2100 for emission scenario A1B based on the REMO/UBA climate model	35
Fig. 3.4	Annual mean air temperatures in Hesse. <i>Above</i> : measurements from 1961 to 2009 by DWD; <i>below</i> : projections for 1971–2000, 2031–2060, and 2071–2100 for emission scenario A1B based on the ECHAM5/COSMO-CLM climate model	36
Fig. 3.5	Annual mean air temperatures in Hesse. <i>Above</i> : measurements from 1961 to 2009 by DWD; <i>below</i> : projections for 1971–2000, 2031–2060, and 2071–2100 for emission scenario A1B based on the HADCM3/COSMO-CLM climate model.....	37
Fig. 3.6	Annual mean air temperatures in Hesse. <i>Above</i> : measurements from 1961 to 2009 by DWD; <i>below</i> : projections for 1971–2000, 2031–2060, and 2071–2100 for emission scenario A1B based on the WettReg2010 (run 0) climate model.....	38
Fig. 3.7	Development of the projected mean annual air temperatures in Hesse as based on the climate models ECHAM5/CLM, HADCM3/CLM, REMO/UBA and WettReg2010 (run 0) regarding emission scenario A1B for the periods 1971–2000, 2031–2060, and 2071–2100	40