Workshop Report

Improving the representation of biodiversity in vegetation modelling:
A joint TRY/BBS workshop

Cape Town, (16)17-18 October 2009

BBS: Advanced prediction of Biome Boundary Shifts in regional and global dynamic vegetation models.

TRY: Refining plant functional classifications for earth system modelling.

Funded by: DIVERSITAS, QUEST, MPI-BGC, GIS Climat France

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Local organizer: DIVERSITAS Secretariat

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I. Objectives

Models of vegetation dynamics and ecosystem function provide a powerful means to understand and quantitatively project the impact of global change on terrestrial biodiversity and on a broad range of ecosystem services including carbon storage, climate regulation, water provision, etc. For example, these models have played a key role in developing biodiversity scenarios and have been used to show that regional and global climate depends heavily on vegetation characteristics (e.g., IPCC 2007). However, very large uncertainties remain in these models; e.g., global vegetation models differ in their projections of 21st century terrestrial carbon storage by a factor equivalent to about 50 years of current anthropogenic CO_2 emissions (Sitch et al. 2008).

In order to better understand and improve the behaviour of models of vegetation dynamics and ecosystem function, substantial efforts have gone into improving the representation of biogeochemical and ecophysiological processes. However, less effort has gone into ameliorating and benchmarking the representation of biological complexity.

Three of the key roadblocks to making improvements in modelling biological complexity have been: 1) lack of data to parameterize models, 2) weak representation of key processes such as migration, response to disturbance, mortality, etc. and 3) few efforts to benchmark modelled shifts in vegetation structure.

The goal of the "TRY/BBS" workshop is to provide the impetus and tools to overcome these roadblocks. First, the development of a global plant functional trait database is providing the means for a quantitative parameterization or validation of vegetation models depending on the model type. Second, collaboration on methods for representing key processes is allowing rapid strides in improving the representation of migration, mortality and response to disturbance in vegetation models. Third, consultation on the data sets needed for benchmarking is setting the stage for rigorous testing of models. The details of these efforts are provided below.

1) Progress towards a showcase paper, presenting the improved potential of the TRY database to estimate key vegetation model parameters (e.g., maximum photosynthetic rates, baseline decay rates, etc.).

2) Progress towards an overview paper describing the need and the means for improving the representation of biological complexity in models of vegetation dynamics and ecosystem function (e.g., fire is a globally important processes in controlling biodiversity, ecosystem function and ecosystem services and a larger range of plant functional types is necessary to properly account for the response of ecosystems to fire).

3) A second call for proposals to use the TRY plant functional trait database.

4) The expansion and maintenance of a network of scientists contributing to the plant trait database and working on model development and testing.

II. Outcomes

a) TRY

TRY Background

TRY is a joint initiative of IGBP, QUEST, DIVERSITAS and the Organismic Biogeochemistry Group at the Max-Planck Institute for Biogeochemistry. Two meetings have been held: one in Alicante, Spain in 2007 and a second in Paris in March 2008. The main objectives of the TRY initiative are to (1) develop a global plant functional trait database, which in a first phase will be used for (2) parameterizing and testing regional and global vegetation models. The TRY database currently contains more than 700 traits (47 "core" traits), 65,000 species, and 2,500,000 trait records from more than 50 contributors. 16 projects have been accepted so far to use this database.

TRY's statement of mission is as follows: "Plant functional classifications were proposed in the early-mid 1990's as a tool to model vegetation dynamics and ecosystem functioning (esp. biogeochemical cycles) in response to climate and CO_2. Since then, plant functional type (PFT) research has been a flourishing field, well beyond the realm of global change research. However a disconnect remains between modellers, working at the regional scale or beyond, who still tend to use rather coarse classifications, with few PFTs that are based on a small number of plant traits (e.g. life form, phenology, photosynthetic pathway), and experimental scientists who focus on a greater range of plant traits, and nowadays tend to prefer continuous descriptions rather than classifications into discrete PFTs." The TRY initiative seeks to bridge this gap between knowledge and modelling.

Progress since last workshop

Since the last workshop in spring 2008 the TRY initiative has expanded the database of plant traits and facilitated data exchange to support several projects. Information about database and projects has been made available at the TRY website (try-db.org).

Due to the high number of data contributions TRY has managed to become the largest global consortium on plant functional traits. This exercise of plant functional trait data collation has reached unprecedented community contribution. This situation now opens the chance for TRY to become a communal plant trait data repository with long-term continuity and funding.

Workshop Results

1) Adaptation of Intellectual Property Guidelines

TRY is evolving fast. Therefore the Intellectual Property Guidelines will most probably need to be revised periodically, based on additional experience. Nevertheless, whenever changes are necessary they will be made with caution and considering the intellectual property rights of data contributors.

The wording about the availability of trait data has been modified for clarity, without changing their meaning: “Data from the TRY database are available for data-contributors and modelling projects, depending on permission of the respective data custodians.”

The Intellectual Property Guidelines have been adapted to (1) facilitate data release without the need for data custodians to provide permission for each single request individually and (2) explicitly addressing the citation of original data sources.

Regulations about co-authorship were discussed in plenary, with respect to contributions with small numbers of trait entries, as well as with respect to co-authorship of the database management team. These issues will be addressed again as soon as first experiences are available. Until then the Intellectual Property Guidelines recommend a rather inclusive attitude.

Please find the Intellectual Property Guidelines attached and/or at the TRY website: www.try-db.org.

2) Progress towards the showcase paper

At the TRY workshop 2008 it was agreed to attempt to publish a description of the TRY initiative and database in a peer-reviewed journal as soon as possible. Jens Kattge and the TRY steering committee should lead the development of the manuscript. All data custodians will be offered authorship. This will be the standard reference that should be cited in all studies that benefit from this initiative. The general outline of the manuscript has been presented, discussed and agreed upon at the workshop 2009.

The manuscript will focus on different aspects of coverage for the key traits that have been proposed at the workshop 2007 and will present first examples for applications in different contexts, e.g. intra-specific trait variation versus inter-specific variation; trait-climate relationship; estimation of vegetation model parameters; use of trait data for model evaluation.

It was suggested to additionally provide look-up tables derived from the TRY database for the following categorical traits: photosynthetic pathway, leaf compoundness, plant growth form, leaf phenology, N-fixing capacity and leaf type. Information about taxonomy will be added and about species distribution (biome) if possible. Please let us know if you would like to add additional information for these categorical traits, or if you do not agree that data you contributed will be used in this context.

The manuscript will be submitted to Global Change Biology, as this Journal addresses both the plant ecology and the modelling community.

3) Identification of challenges for the TRY initiative

During the workshop three major challenges for the TRY initiative have been identified:

1) Availability of information about data: It currently seems difficult to derive relevant information about data coverage with respect to species and spatial distribution. It was mentioned that neither is this information adequately available at the TRY website, nor had this information been made available at the workshop. It was therefore deemed difficult to find out if data in the TRY database might be useful in the context of a project.

2) Availability of data: The data in the TRY database are not easily and promptly available, not even the data considered public by data contributors. To retrieve data from the TRY database a proposal has to be submitted and data contributors have to be asked for permission in each case. This was considered to be very cumbersome and inefficient.

3) Contextual information about canopy structure: The TRY database does not contain relevant information about community structure, like species abundance. It was argued that adding this information to the trait data might substantially help for a better understanding of vegetation development and functioning. It was therefore suggested to either add these data to the TRY database or make contact to groups compiling the respective data.

Perspective

At first and with high priority the TRY showcase paper needs to be finished and submitted.

A second call for data contributions and for proposals to use data from the TRY plant trait database has been envisaged for 2010.

TRY will aim at providing a web-interface, which will for example enable queries with respect to species and regional coverage of the different traits. This web-interface will also allow making parts of the trait data in the TRY database public accessible, depending on explicit permission of respective data contributors. Thus, given the permission of the respective data contributors, some of the data in the TRY database may become public accessible, while in general access to data will remain restricted.

The TRY database is appropriate to additionally compile data about community structure and species distribution. Nevertheless, TRY will first get in contact with initiatives, which provide such information and link this information to the trait data compiled in the TRY database.

The Max Planck Institute for Biogeochemistry in Jena (MPI-BGC) has offered a 3 year extension of the current post-doc position, which will terminate on 31 October 2010. Contingent upon future success of the TRY initiative permanent support for TRY will be discussed at MPI-BGC.

b) BBS

BBS Background

The first workshop of the BBS initiative was held in Yokohama, Japan, 4-7 March 2008. It was funded by the Frontier Research Center of Global Change, the Japan Agency for Marine-Earth Science and Technology, the Swiss Federal Research Institute - WSL, DIVERSITAS, and the Global Land Project.

BBS stand for advance prediction of Biome Boundary Shifts in regional and global dynamic vegetation models. The main objectives of the BBS initiative are to better understand and predict mechanisms that drive shifts in vegetation structure and lead to major changes in biodiversity, ecosystem functioning and ecosystem services. So far, the group has focused on the development of regional and global models with improved representations of

Migration
Mortality
Disturbance (fire, land use, herbivory)
Mechanisms leading to co-existence

In order to achieve the objectives of the BBS initiative, most models require substantial improvements in the representation of processes and of biological diversity. A longer-term goal is to facilitate the benchmarking of modelled responses of vegetation dynamics to global change by using palaeo-data, recent historical observations as well as experiments.

Planned Workshop Outcomes

- An overview paper describing the need and the means for improving the representation of biological complexity in models of vegetation dynamics and ecosystem function (e.g., fire is a globally important processes in controlling biodiversity, ecosystem function and ecosystem services and a larger range of plant functional types is necessary to properly account for the response of ecosystems to fire) – NB: part of the planned products for 2008. Draft was circulated before workshop.
- The expansion and maintenance of a network of scientists working on model development and testing. A follow-up meeting is foreseen for 2010.

Workshop results

Current challenges for the development of dynamic vegetation models

Current DGVMs do reasonably at predicting global carbon and water cycle dynamics, broadscale biogeographic pattern, trace gas emissions as well as occurrence of fire. They work well at the global scale but differ regionally in terms of vegetation fluxes and distribution of functional types, leading to very different predictions of e.g. biome shifts.

To improve the currently used DGVMs and to develop “new generation DGVMs”, the following key needs should be addressed:

- appropriate representation of “biodiversity” in models, e.g. in the form of

    - inclusion of more / different plant functional types
    - development of entirely trait-based models
    - "mimicking" adaptation of species to environments
    - adding variance to mean parameter values
    - inclusion of trait trade-offs
- representation of dispersal and establishment
    - "normal" migration / dispersal rates of species
    - human movement of species (esp. invasives)
    - species movement in complex, fragmented landscapes
- representation of human-related disturbance regimes
    - Forestry
    - Grazing
    - Fire (and fire suppression)
    - Deforestation, etc.
- Mortality (especially in tree dominated systems)
- Linkage of physiological models / model outputs (e.g. photosynthesis, plant hydraulics, nutrient uptake) into DGVMs – allowing for feedback loops in e.g. carbon, water and nutrient cycle
- Scaling issues – many models work reasonably well at regional scales, but do poorly when adapted to other vegetation types, making comparisons or generalisations difficult.
    - Use of new parametrisation and validation techniques (e.g. Bayesian hierarchical models)
- Validation of models through e.g. experiments, palaeo-data

How can plant trait data contribute to the development of a new generation of vegetation models?

DGVM predictions are currently limited by the use of discrete PFTs (plant functional types) rather then representation of the continuous vegetation response through traits. The use of traits would allow the modelling of continuous feed back loops.
However, in order to do this, combinations of functionally different traits representing plants from different biomes need to be identified. The distribution of traits, or especially trait combinations can be used to predict extent of biomes. The calibration and validation of such models requires large trait databases, such as TRY.

Furthermore, trait data can be improved by using a "meta-phenomics" approach (standardisation across experiments, suggested by Poorter), which allows data to be summarized across experiments, yields quantitative response curves and normal limits of traits. The method is applicable to most environmental factors as well as to all plant traits, and is thus extremely useful for modelling.

The current "statistical mess" due to datasets having different temporal or spatial resolution can be addressed by using a hierarchical bayesian mode approach to scaling up (in comparison to "normal" up-scaling) .

Problems that might be encountered when developing this new generation of models

- Coexistence of species or PFTs
  - How to deal with this when increasing number of PFTs?
    - What mechanisms should we use to generate coexistence, since we still don't fully understand mechanisms underlying coexistence
    - computer power needed to handle large number of PFTs and interactions
  - Correct representation of disturbance regimes could help simulate coexistence
    - availability of observational / experimental data?
  - May need to "force" coexistence to match observed trait variation in communities
    - availability of observational / experimental data?
  - Intra- vs inter specific variation
  - Data from transplantation experiments ***?

- Trait tradeoffs - how can this be handled?
  - use known trait trade-offs (e.g., leaf economic spectrum)
    - how to include in current models
  - explore trait trade-offs using models - see what wins, compare with known communities
    - availability of observational / experimental data
  - create trait manifolds (i.e., identify groupings of traits based on analysis of very large trait databases)
  -
- Trait variation within communities
  - idea: coupling TRY (i.e., traits per species) with community structure databases (species within communities)

- Coupling of traits with other data / databases
  - GEO-BON? Like ideas → provision of observational data on global scale
  - georeferencing of data → allows for crossreferences with other data bases
  - look up tables for simple categorical data, C3/C4, morph, tree, grass

Bridging the gap from individuals to traits to functional groups (PFTs) to ecosystems

This can be addressed by using mechanistic models representing environmental constraints (at global scale, climate) to “select” a realised trait space from a potential trait space, the traits are then assembled along trade-off axis. A PCA can be used to identify trait trade-offs in multidimensional space. “Trade-off strength” indicates species richness, while “trade-off identity” identifies biomes. How can this approach be applied in DVGMs?

The development of “adaptive” DGVMs (aDGVM,e.g. Higgins savanna model) allows for objective parameterisation of traits using trait databases. However, model development is constrained by observational data, and brainstorming on developing benchmark experiments is required.

Use of TRY database for parametrisation of traits, validation of models (model

predicts trait combinations based on selection), and optimisation (through the identification of "optimal" trait combinations). However, again, the combination of the trait data with community composition data is of utmost importance.

Perspectives and proposed BBS products

Ongoing

- Workshops
  - to stimulate discussions and networking on Understanding and Simulating Biome / Vegetation Shifts
  - to identify people working on key issues in improving the understanding and modeling of biome / vegetation shifts
- Synthesis / Perspectives Papers
  - Paper on Understanding and Simulating Biome / Vegetation Shifts (from 2008 Workshop)

Medium Term (1.5 years)

- Importance of migration for modeling tundra / boreal / temperate forest biome shifts – workshop 2010
- Fire: interactions between land use, climate and vegetation structure. Can general models predict regional differences? - Workshop 2010
- Intra and inter-PFT variability and mortality in tropical trees
- Modeling C3 / C4 grass / tree competition along a climatic gradient
- Herbivore impacts on vegetation structure: model development and data synthesis

Longer Term (3 years)

- Global and regional analyses of the effects of climate change on vegetation shifts
  - Common drivers data sets
  - Common benchmarking data sets, including paleo datasets (possible collaboration with PAGES program)
- Tests of important properties that are key for understanding regional vegetation shifts
- Model / data comparisons
  - Powerful message
  - Strong incentive to bring together benchmarking data
- Development of a structured network to bring modellers and data people together (expansion of bioDISCOVERY core project within DIVERSITAS)

c) BBS / TRY

During the workshop two mismatches between the modelling approaches in BBS and the data compilation in TRY have been identified: In the context of BBS (1) model-specific parameters are relevant for (2) regionally focussed case studies. On the other hand data compilation in TRY is focussed (1) on few general key traits (which may

only loosely be related to parameters of models relevant in the context of BBS) and (2) without regional focus. It will be the next step in the cooperation of BBS and TRY to overcome this mismatch, such that modellers are asked to identify the most relevant parameters/traits for the development of their models and specification of regional focus. Based on this information TRY will adopt the focus of future data retrieval accordingly.

A joint project of TRY and BBS has not been initiated at the workshop, but is planned as soon as the observed mismatches have been resolved in a first instance.

d) Next workshop

A follow-up workshop is foreseen for November / December 2010.

III. Presentations

The talks presented at the workshop will be made available at the internal section of the bioDISCOVERY website. The site, as well as user name and password, will be made available as soon as all presentations are uploaded (end of April 2010). In the order of appearance:

In the order of appearance:

Jens Kattge: TRY - a communal effort to compile information about ecological traits of plant species at world scale

Paul Leadley: Improving the representation of biodiversity in vegetation modelling:

A joint TRY/BBS workshop

Colin Prentice: What DGVMs can and cannot do

Ian Woodward: Current challenges of Dynamic Global Vegetation Models

Bob Douma: A first step towards a new DGVM based on plant traits (TRICYCLE)

Hendrik Poorter: The response curves of 'plant' traits

Christian Wirth: About traits and models

Eric Garnier:

Farshid Ahrestani:

Björn Reu: Understanding plant functional traits from constraints and trade-offs

Steve Higgins:

Rosie Fisher: Scale limits in second generation DVGMs

Soenke Zaehle: Model development constrained by observations: what is a good benchmark?

IV. Participants

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V. Workshop programme

Friday 16th October

17:00 – 19:00 Meeting of the TRY and BBS Steering Committee

19:30 Welcome Dinner at Restaurant 'Mama Africa' (178 Long Street, Cape Town)

Saturday 17th October - SANBI Laboratories at Kirstenbosch Gardens

9:00 – 9:15 Welcome (Paul Leadley, Guy Midgley)

9:15 – 10:00 TRY: Objectives, plant trait database, projects and perspectives (Presentation: Jens Kattge; Chair: Sandra Lavorel)

10:00 – 10:30 BBS: Objectives, models involved, projects and perspectives (Presentation: Paul Leadley; Chair: George Hurtt)

10:30 – 11:00 Coffee break

11:00 – 12:30 Current challenges for the development of dynamic vegetation models (Presentations Colin Prentice, Ian Woodward followed by discussion, Chair: Steve Higgins)

12:30 – 14:00 Lunch break

14:00 – 15:30 Contribution of plant trait data to the development of a new generation of vegetation models? Highlighting the gap between plant traits mostly needed and traits currently available. Which additional information, like covariates, abundances, phylogeny or categorical traits, is essential to efficiently use plant traits in the context of model development? (Presentations: Bob Douma, Hendrik Poorter, Christian Wirth (ca. 10 min. each) followed by discussion, Chair: Jean-Francois Soussana)

15:30 – 16:00 Coffee break

16:00 – 17:30 Split sessions

– Consolidation of the TRY initiative and future perspectives. Updating the Intellectual Property Guidelines. What do we want TRY to be in a few years? Cooperation and synergies with other initiatives. Plant trait ontologies. (Presentations: Eric Garnier, Farshid Ahrestani (ca. 10 min. each), Chair: Dandra Diaz)

– Revisiting the BBS goals. Developing a roadmap for improving key mechanisms in regional and global vegetation models: migration, disturbance and adaptation (Discussion leaders: George Hurtt, Paul Leadley, Heike Lischke, Hisashi Sato (tbc))

19:30 Dinner

Sunday 18th October - SANBI Laboratories at Kirstenbosch Gardens

9:00 – 10:00. Report of split sessions from day 1 (Chair: Sandra Lavorel)

10:00 – 11:00 Split sessions

– Breakout group: TRY paper writing

– Revisiting the modeller's dilemma of few fixed PFTs versus continuous descriptions. Bridging the gaps between distinct plant functional types, continuous trait spectra, and the representation of plant trait manifolds. (Presentations: Björn Reu, Steve Higgins (ca. 10 min. each) followed by discussion, Chair: Heike Lischke)

11:00 – 11:30 Coffee break

11:00 – 12:30 Split sessions

– Breakout group: TRY paper writing

– Model development constrained by observational data. Brainstorming on developing benchmark experiment(s) (Presentations: Rosie Fisher, Soenke Zaehle (ca. 10 min. each) followed by discussion, Chair: Colin Prentice)

12:30 – 14:00 Lunch break

14:00 – 15:00 Report of split sessions from day 2. Discussion and approval of TRY intellectual property guidelines and initial paper (Chair: Sandra Diaz)

15:00 – 15.30 Coffee break

15:30 – 16:30 Outlining the role of international programs (e.g. DIVERSITAS, IGBP, GLP, etc.) and national funding (e.g., UK QUEST, German MPI Jena, French GIS CES, etc.) in supporting joint TRY / BBS initiatives (Discussion leaders: Colin Prentice, Paul Leadley, Sandra Lavorel, Christian Wirth)

16:30 – 17:30 Workshop summary (TRY and BBS organizing committees)

17:30 End of workshop