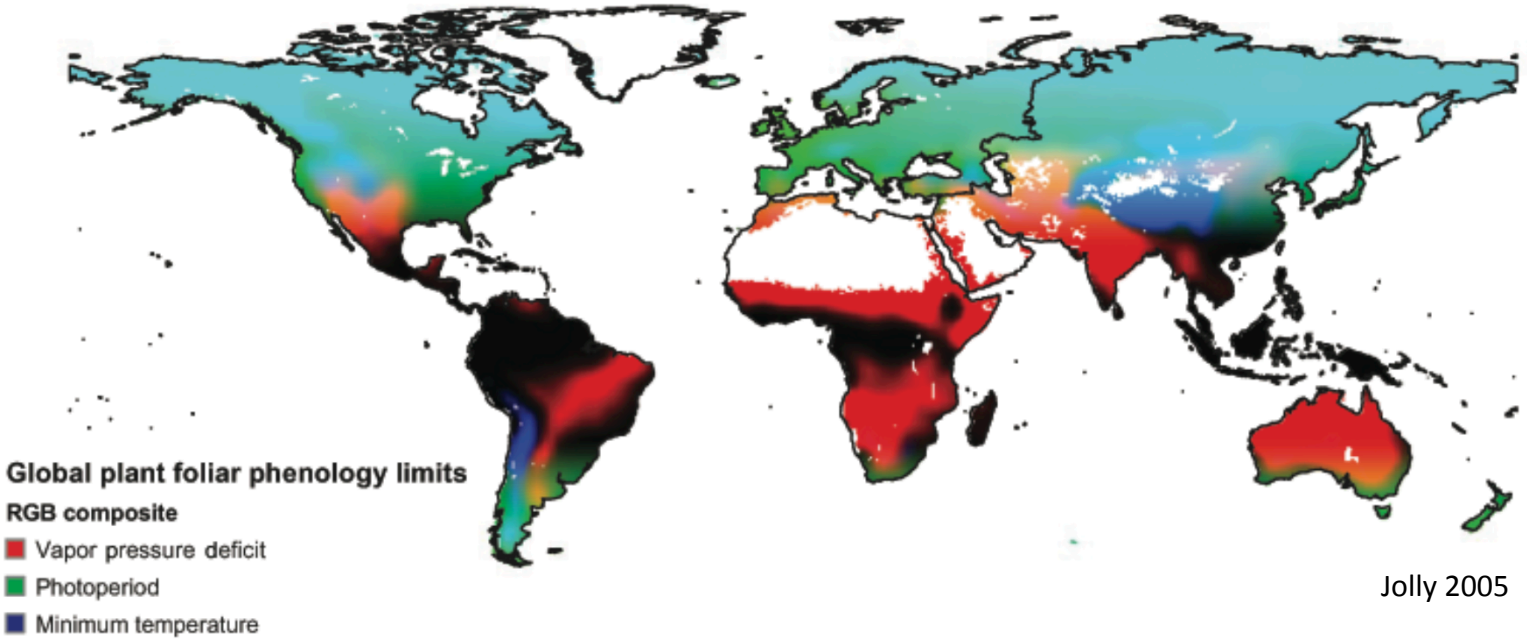
Assessing the impact of climatic controls on global changes in land surface phenology



Jolly 2005

MSc Concept Presentation
David Schenkel
UZH – Remote Sensing Laboratories
17 December 2014

Contents

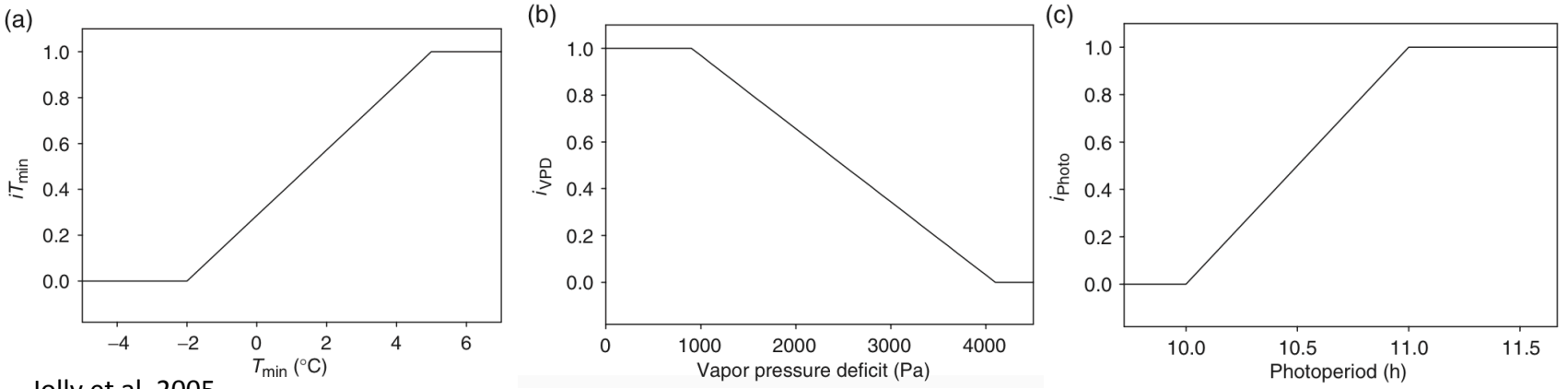
- **Introduction**
- Materials and Methods
- Expected Results
- Challenges
- Timetable

Land Surface Phenology

- Phenology key regulator of ecosystems
- Lots of research on measured and modelled LSP
  - NDVI/LAI trend analysis (e.g. Garonna et al. 2011)
- Lots of research on impact of climate on phenology
- Very little research on impact of climatic controls on LSP on global scales

Climatic Controls - GSI

- Jolly's (2005) Growing Season Index
  - Based on T_{min}, Vapour Pressure Deficit (VPD) and photoperiod
  - Simple linear relationships and thresholds
  - *GSI = iT_{min} * iVPD * iPhoto*



Jolly et al. 2005

Research Questions

- How does a modelled LAI compare to a remotely sensed LAI? (How) Do they differ?
- How do climatic controls impact different regions over time?
- (How) do changes in LSP depend on changes in climatic controls?

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Data & Data Pre-Processing

Available data

- LAI3g
  - Based on AVHRR/GIMMS NDVI3g
  - 30 years (1982-2011) of global, 15-day composite LAI data
  - spatial resolution: $^{1}/_{12}$ degree
- LAI-re
  - Modelled
  - 33 years (1980-2012) of global, daily LAI and climatic control data
  - spatial resolution ½ degree

Pre-Processing:

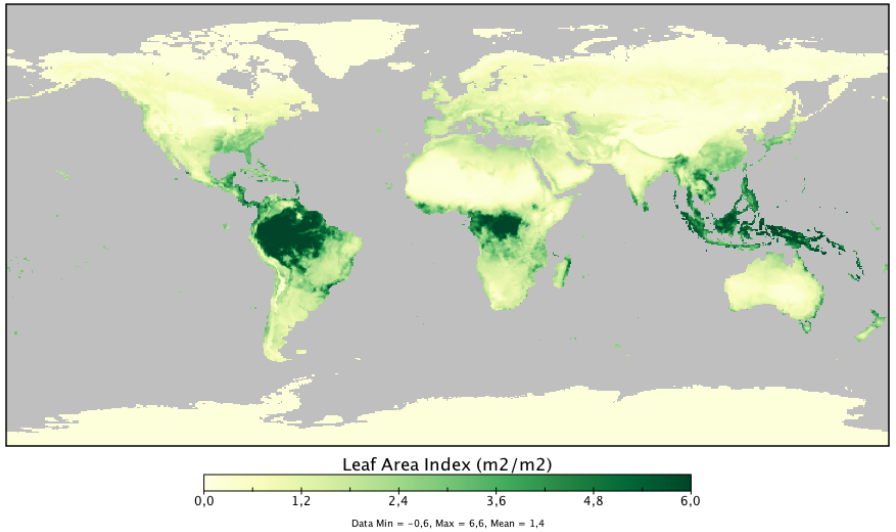
- Resize LAI3g to fit LAI-re resolution
- Resample temporal frequency of LAI-re (daily) to fit LAI3g (15 day composites)

LAI Reanalysed

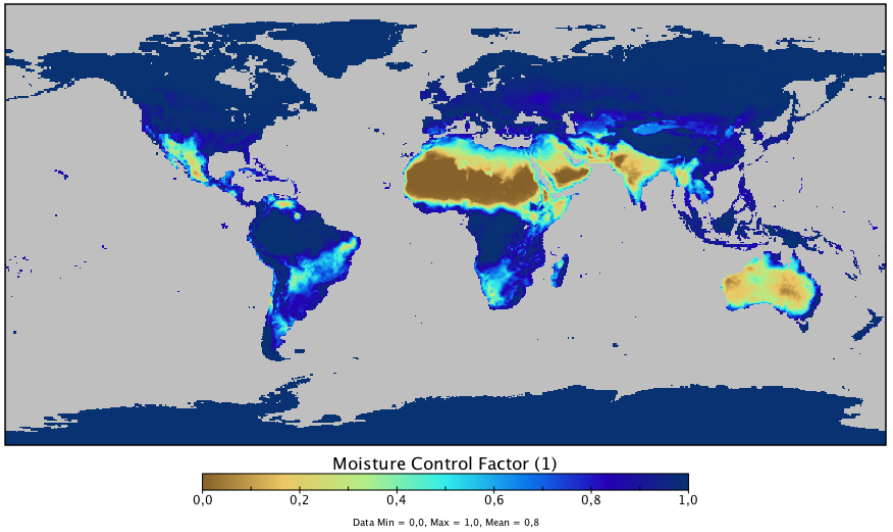
- Stöckli et al. (2011) **modelled** LAI based on GSI, Plant Functional Type and elevation classes
- Uses reanalysed meteorological data for T, VPD, incoming radiation
- Model assimilated with 10 years of MODIS LAI and FPAR data

Example: LAI-re for 18 April 2001

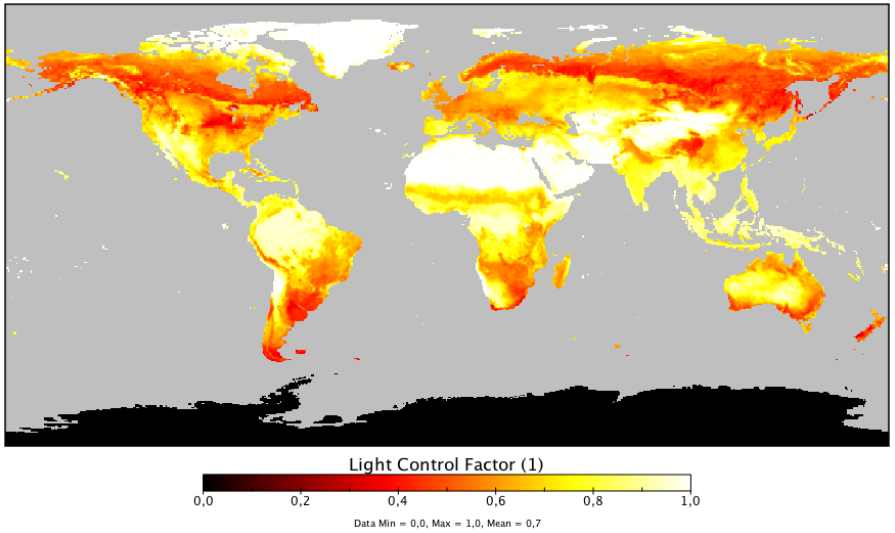
Leaf Area Index



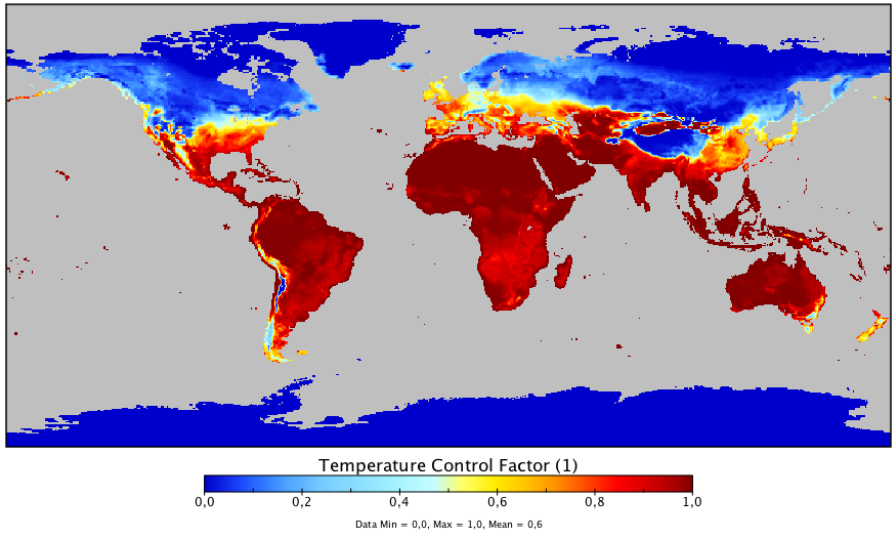
Moisture Control Factor



Light Control Factor



Temperature Control Factor

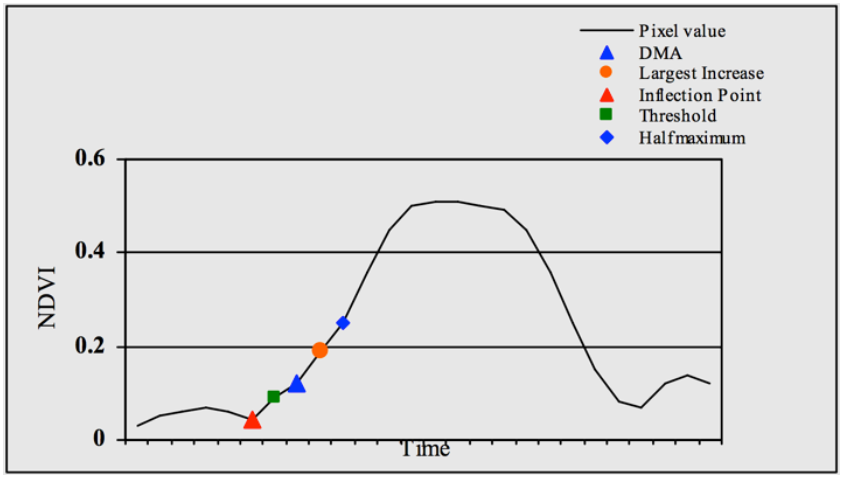


Comparison: Modelled vs. Measured

- LAI-re not yet tried and tested
  - Plausibility analysis necessary
- LAI3g as reference dataset
  - LAI3g and predecessors often used
  - Based on measurements
- Compare raw LAI-re data to LAI3g data (yearly averages, monthly averages)
- Compare extracted LSP indices and trend

Extracting LSP Indices

- Goal: Get *Start of Season*, *End of Season* and *Growing Season Length*
- Harmonic Analysis to get smooth yearly LAI profiles using HANTS-algorithm (Roerink et al. 2000)
  - Developed for NDVI, but same principle applies for LAI
- Several possibilities for definition of SOS/EOS
- GSL = EOS - SOS



Reed et al. (2003)

Analysing Changes in Climatic Controls

- Trend analysis for monthly and yearly averages
- Extract and analyse LSP indices

Compare Climatic Controls to LAI

- Calculate correlation coefficient for climate controls and LSP indices
- Different ways to go about it:
  - Compare SOS to control factors on this day/month
  - Compare SOS to control factors in the preceding month
  - Compare GSL to annual mean or monthly means
  - …

Expected Results

- *LAI3g-LAIre*: generally good agreement expected
- *Climatic Controls*:
  - rising temperatures global, differences regionally
  - VPD hard to predict
- Climatic Controls and LAI: GSL-lengthening with increase in T

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LAI Dataset Comparison

- Both datasets connected to MODIS LAI
- No absolute verification of LAI-re possible within the scope of thesis
- Differences in both datasets could arise for several reasons:
  - LAI3g could be limited by NDVI saturation
  - LAI-re could be limited by model assumptions or GSI

Climatic Controls

- Based on linear functions and thresholds
  - Oversimplified
- Analysis constrained by GSI data
  - No absolute T/VPD data

Effect of Climatic Controls on LSP

- Explorative approach
  - So many Possibilities, very little time
- (Almost) no prior work to draw on
- Classification of results (statistics by biome, PFT, pixelwise, …) not yet clear

Timetable

Month	Tasks	Writing
October	Reading, introduction to R coding, Data overview	
November	Data preprocessing (resizing)	Concept
December	Concept presentation (17th Dec), data processing (HANTS)	Concept Presentation
January	data processing (extracting LSP Indices), preliminary LAI comparison	start Methods
February	Holidays	
March	buffer	Methods, Results as they come in)
April	start work on extracted indices: Correlation coefficients, regression analysis	Results (as they come in)
May	Interpretation of trend analysis / doing/redoing statistics	finish Methods, Analysis (preliminary)
June	More time for statistics (Climatic Controls - LAI)	Analysis, start Discussion
July	buffer	
August	Writing & Layout, finishing touches	Analysis, Introduction, Discussion
September	Final Presentation, more finishing touches	more finishing touches, Final Presentation

Literature

- Garonna, I., de Jong, R., de Wit, A. J. W., Mücher, C. a, Schmid, B., & Schaepman, M. E. (2014). Strong contribution of autumn phenology to changes in satellite-derived growing season length estimates across Europe (1982-2011). Global Change Biology, 20(11), 3457–70.
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- Reed, B. C., Michael White, and Jesslyn F. Brown. (2003). “Remote Sensing Phenology.” Pp. 365–81 in Phenology: An Integra3ve Environmental Science SE - 23, vol. 39, edited by MarkD. Schwartz. Springer Netherlands.
- Roerink, G. J., Menenti, M., & Verhoef, W. (2000). Reconstructing cloudfree NDVI composites using Fourier analysis of time series. International Journal of Remote Sensing, 21(9), 1911–1917
- Stöckli, R., Rutishauser, T., Baker, I., Liniger, M. a., & Denning, a. S. (2011). A global reanalysis of vegetation phenology. Journal of Geophysical Research, 116(G3)

Thank you for your attention!

Question time…

MODIS! MODIS everywhere!

- Why not compare LAI-re to widely used MODIS LAI?
  - LAI-re and LAI3g both assimilated with MODIS LAI data
  - MODIS dataset only from year 2000 onwards
  - MODIS LAI has a much higher resolution – possible scaling effects (introduces more uncertainty)