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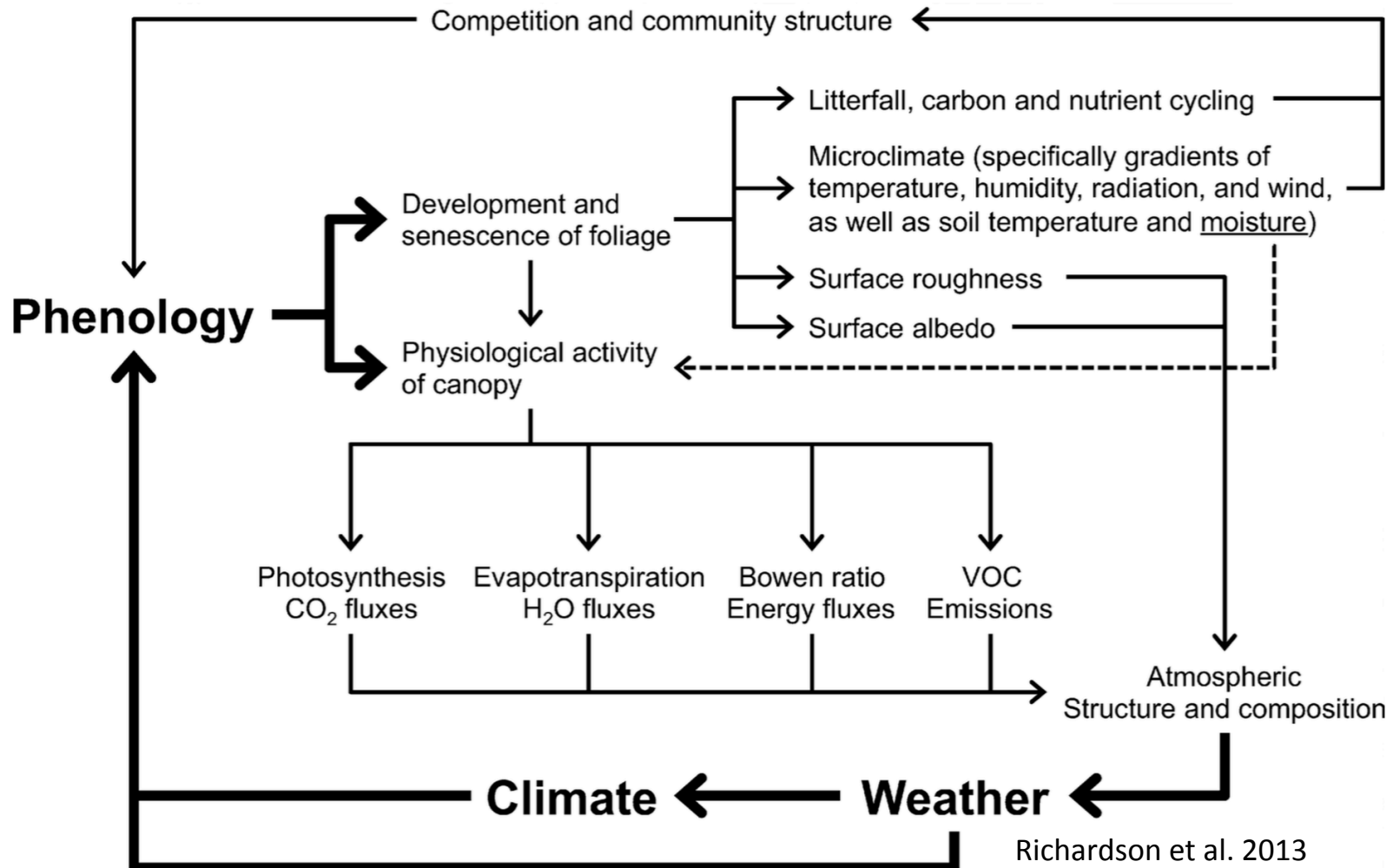

Global plant foliar phenology limits
RGB composite
- ■ Vapor pressure deficit
- ■ Photoperiod
- ■ Minimum temperature

Jolly 2005
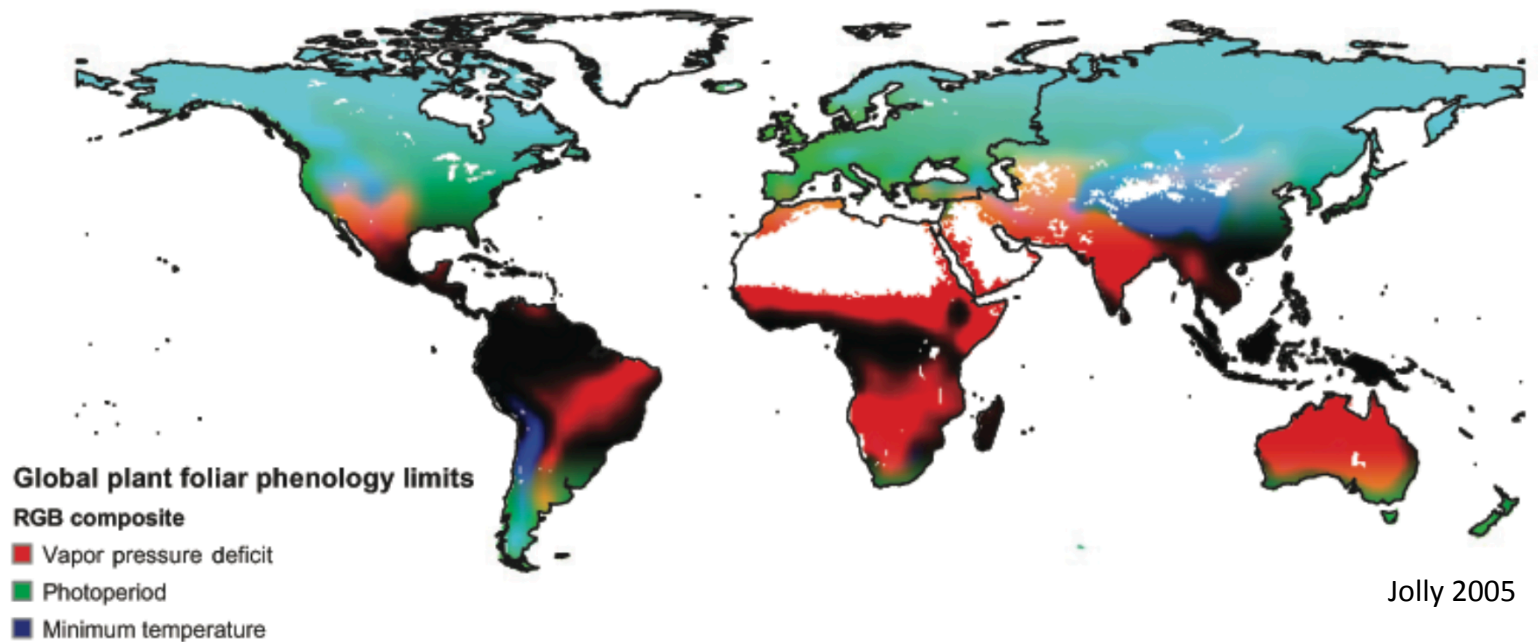
MSc Concept Presentation
David Schenkel

UZH – Remote Sensing Laboratories

17 December 2014

Contents

- **Introduction**
- Data & Methods
- Expected Results
- Challenges
- Timetable

Climate – Phenology Feedbacks
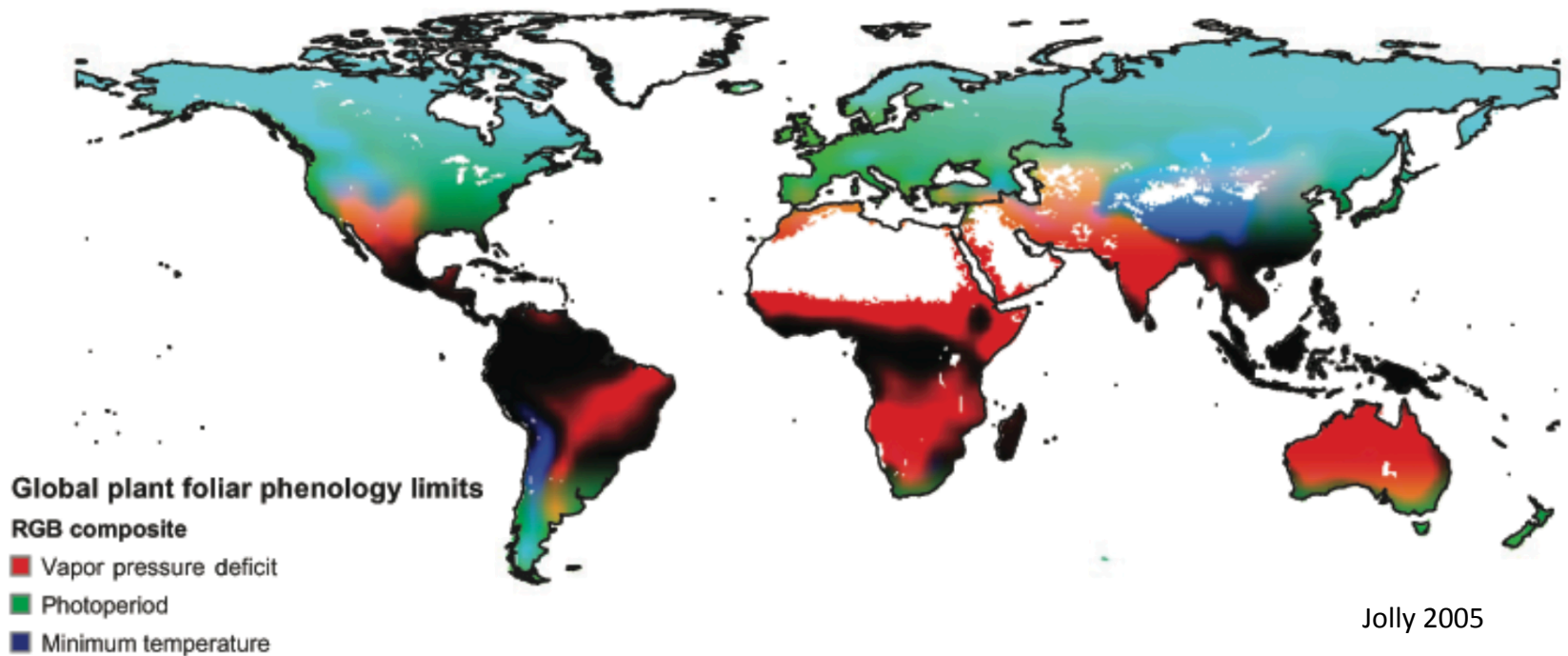

Richardson et al. 2013

Quantifying Land Surface Phenology

- Land surface phenology can be observed
  - Time series of vegetation indices (NDVI, LAI)

- Phenology can be modelled (e.g. LAI)
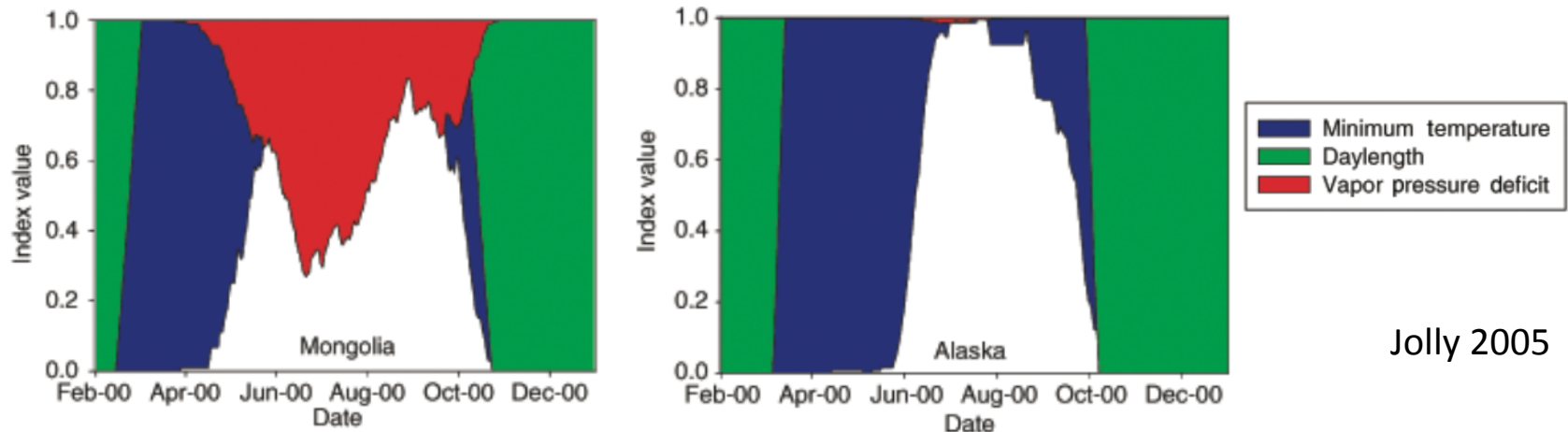 - Based on climatic controls

Phenology and Climatic Controls

- What are limiting climatic factors for phenology?

Global plant foliar phenology limits
RGB composite
- 🟥 Vapor pressure deficit
- 🟩 Photoperiod
- 🟦 Minimum temperature

Jolly 2005

Climatic Controls

- ## Influence of climatic controls change over time
  - – Intra-annually
  - – Over the years?

Jolly 2005

Research Questions

1. How does a modelled LAI compare to a remotely sensed LAI? Where do they differ?

2. Does the relative impact of climatic controls change over time?

3. Do changes in LSP depend on changes in climatic controls?

Contents

- Introduction
- **Data & Methods**
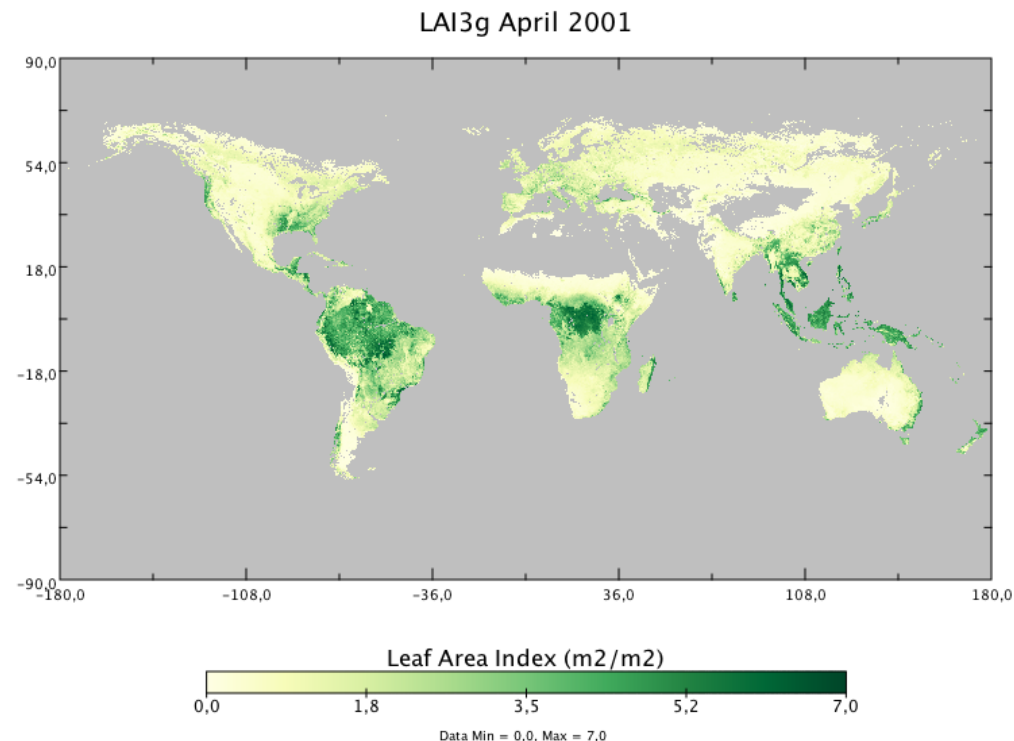- Expected Results
- Challenges
- Timetable

Data

Available data over 30 years:

- LAI3g
  - Measured
  - 15-day composite LAI data
  - spatial resolution: $^1/_{12}$ degree
- LAI-re
  - Modelled
  - daily LAI and climatic control data
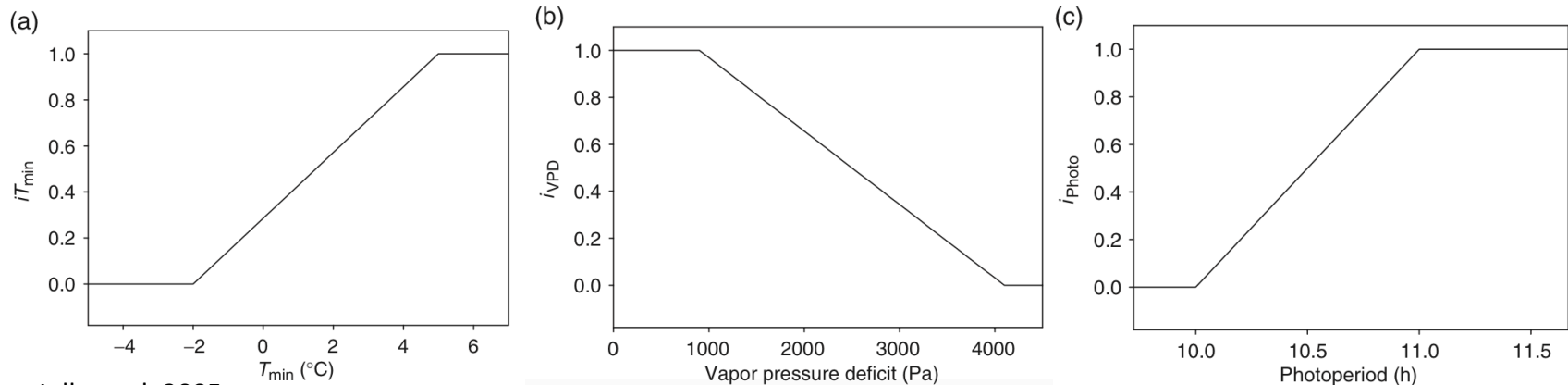 - spatial resolution: ½ degree

Measured LAI: LAI3g

- Based on GIMMS/AVHRR NDVI3g
- MODIS LAI used as training data

LAI3g April 2001

LAI-re: Modelling Climatic Controls

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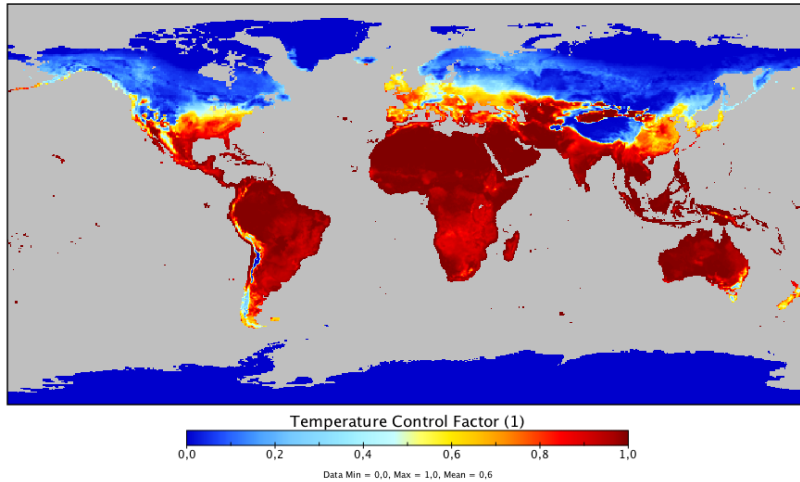 - *GSI = iT$_{min}$ * iVPD * iPhoto*

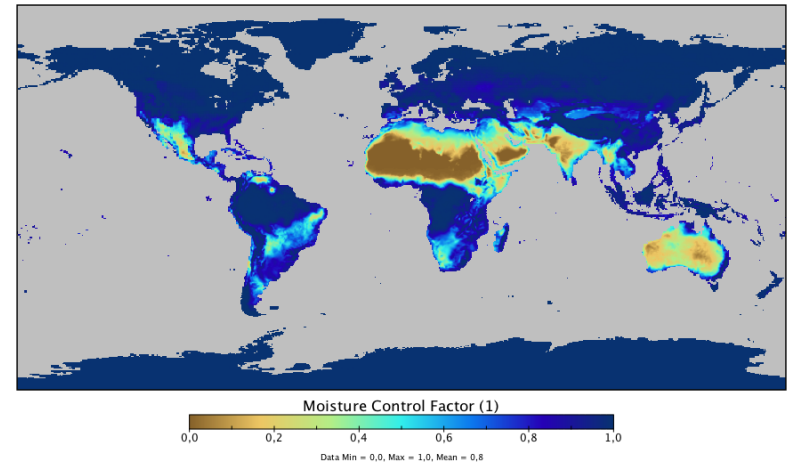
Jolly et al. 2005

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
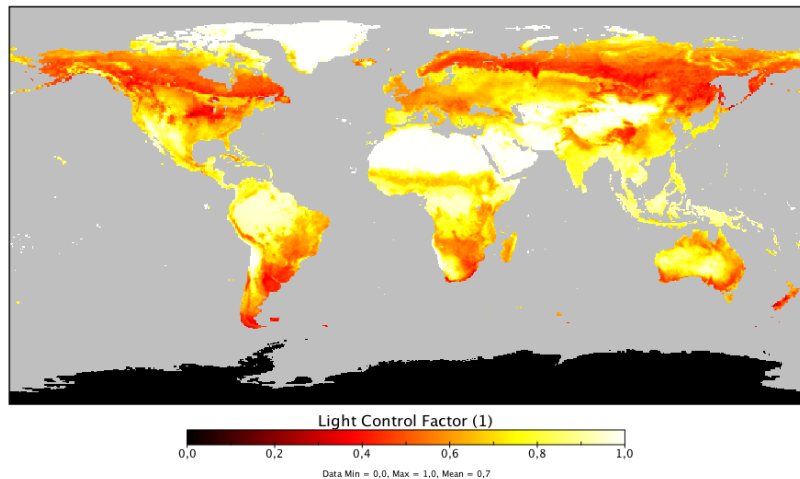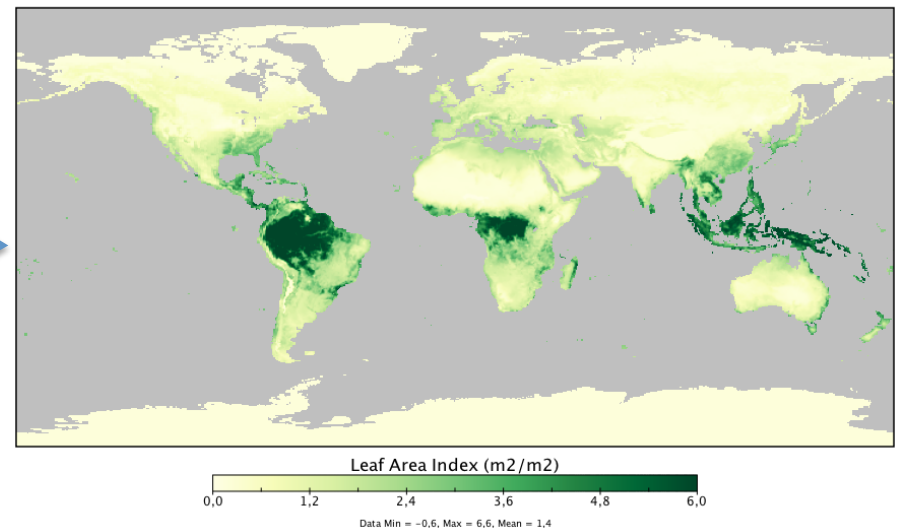
Extracting LSP Indices

- Goal: Extract *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
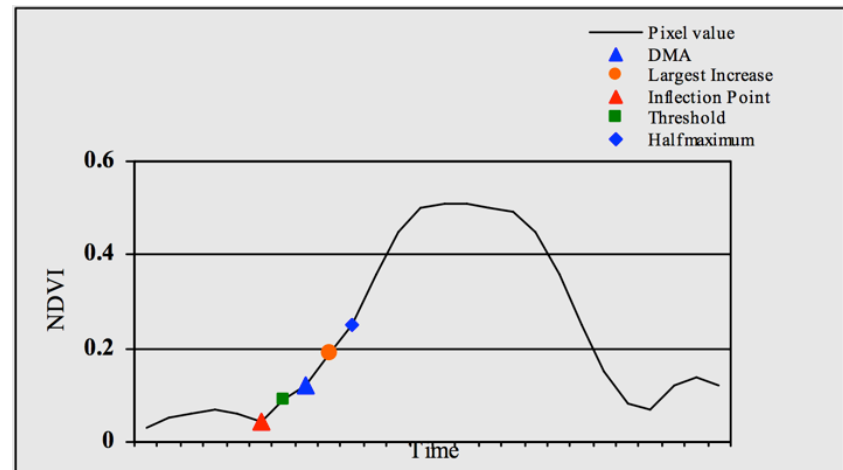
Reed et al. (2003)

RQ1: Comparing LAI datasets

- Compare LAI averages (monthly, yearly)
- Compare extracted LSP indices and trends

RQ2: Analysing the impact of climatic controls over time

- Trend analysis for monthly and yearly averages of T_{min} and VPD
- Extract and analyse onset of changes
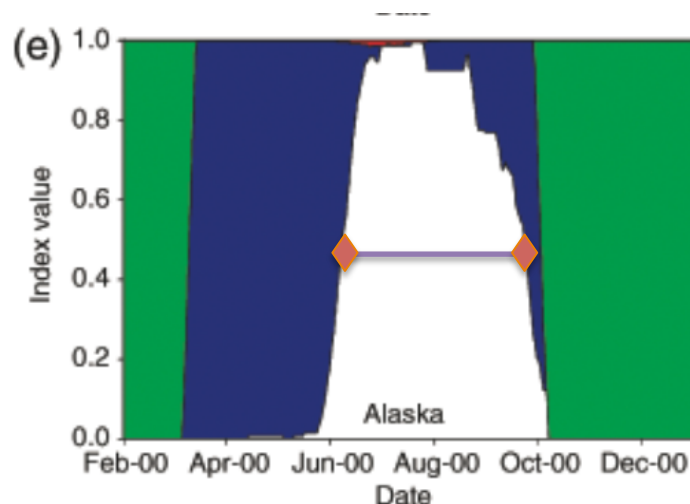
RQ3: Compare Climatic Controls to LAI

- 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 seasonal means
  - …

Expected Results

- LAI3g-LAIre comparison
  - Statistical analysis
  - Maps showing differences
- Climatic Controls
  - Statistical analysis
  - Maps showing **changes** in climatic controls over time
- Climatic Controls – LAI comparison
  - Statistical analysis

Challenges

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

Timetable

TASK	2014			2015											
	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Literature Review	■	■	■												
Processing		■	■	■	■	■	■	■	■						
Pre-Processing (resizing/resampling)		■													
LSP extraction: HANTS			■												
LSP extraction: Indices				■											
Analysis: LAI comparison						■									
Analysis: Climatic Controls							■								
Analysis: LAI-Climatic Controls								■							
Writing		■	■	■	■	■	■	■	■	■	■	■			
Concept		■													
Methods				■											
Results						■									
Analysis								■							
Introduction											■				
Layout & finishing touches												■			

Literature

- *Jolly, W. M., Nemani, R., & Running, S. W. (2005)*. A generalized, bioclimatic index to predict foliar phenology in response to climate. Global Change Biology, 11(4), 619–632.

- *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.

- *Richardson, A. D., Keenan, T. F., Migliavacca, M., Ryu, Y., Sonnentag, O., & Toomey, M. (2013)*. Climate change, phenology, and phenological control of vegetation feedbacks to the climate system. Agricultural and Forest Meteorology, 169, 156–173. doi:10.1016/j.agrformet.2012.09.012

- *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…

Limitations: LAI datasets

- 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

Limitations: Climatic Controls

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

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)