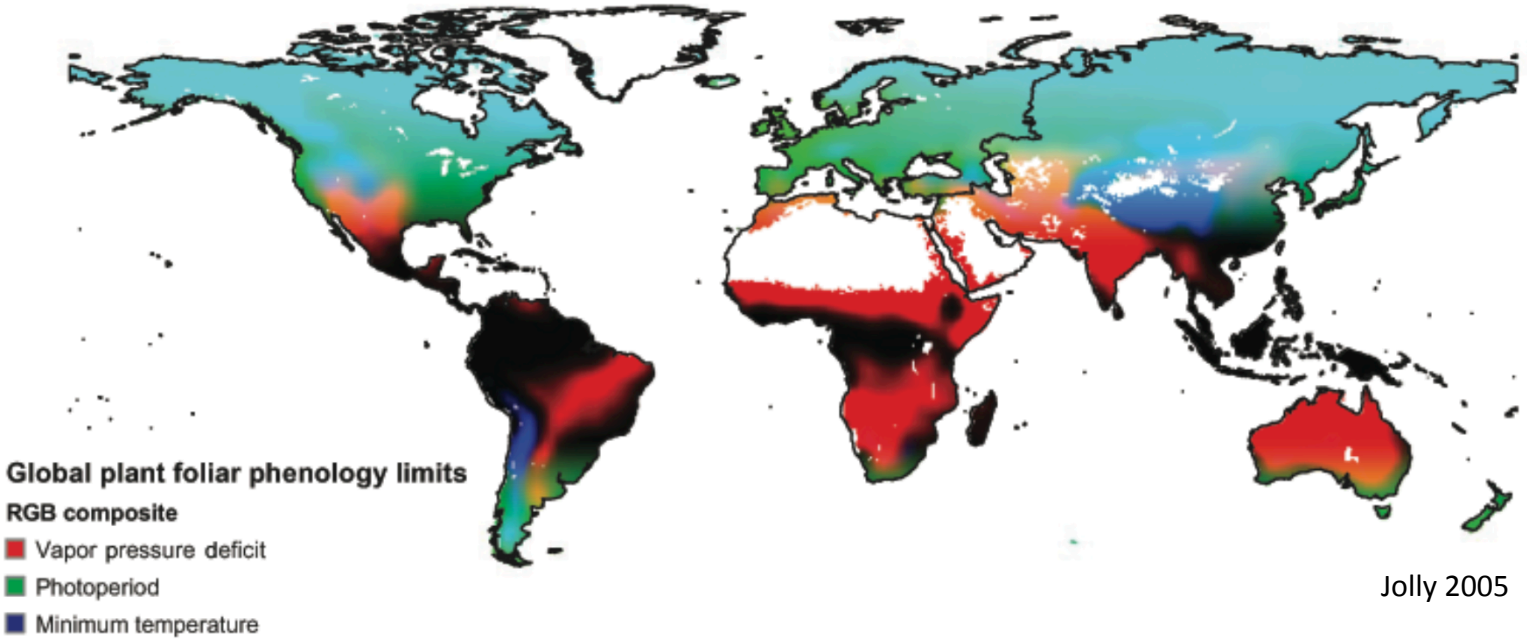
Assessing the impact of climatic controls on global changes in land surface phenology



Jolly 2005

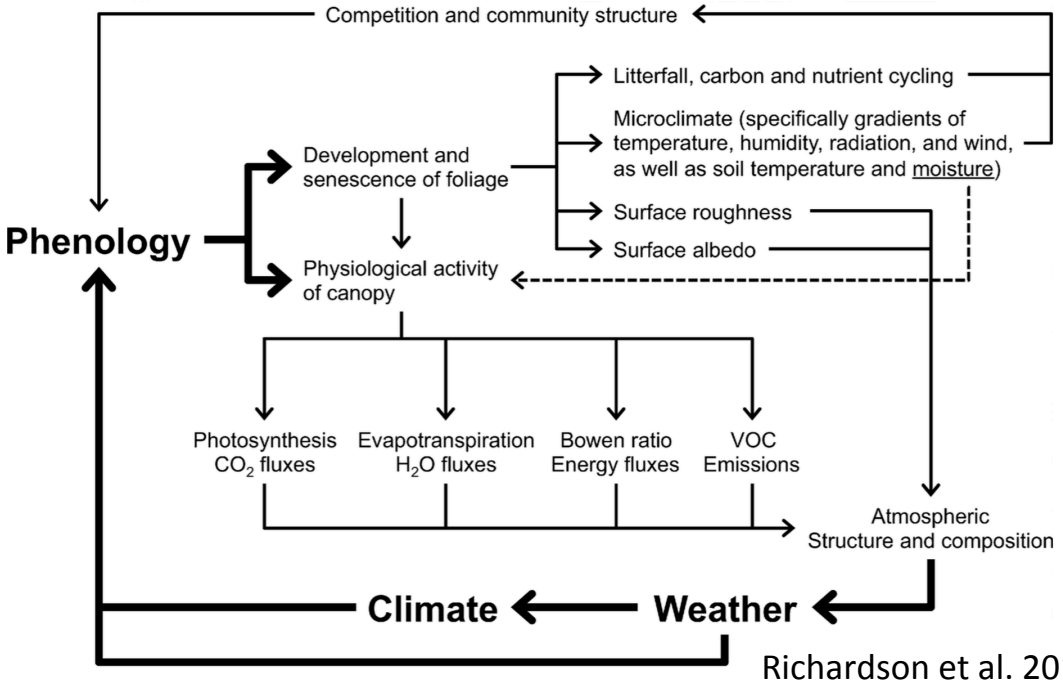
MSc Concept Presentation
David Schenkel
UZH – Remote Sensing Laboratories
17 December 2014

Contents

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

Phenology

- Phenology important driver for ecosystems
- Mainly influenced by weather and climate



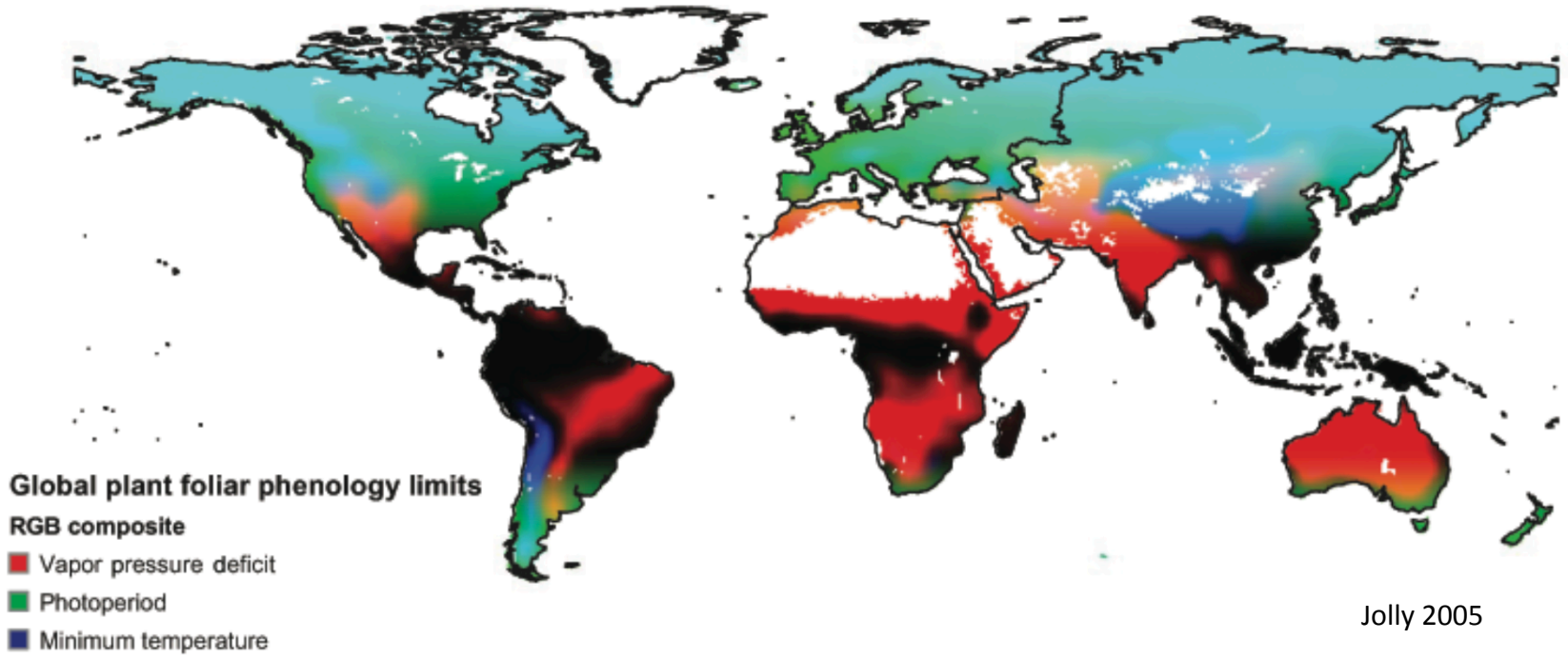
Richardson et al. 2013

Quantifying Phenology

- Phenology can be measured
  - Time series of vegetation indices (NVDI, LAI)
- Phenology can be modelled (e.g. LAI)
  - Based on climatic controls

Phenology and Climatic Controls

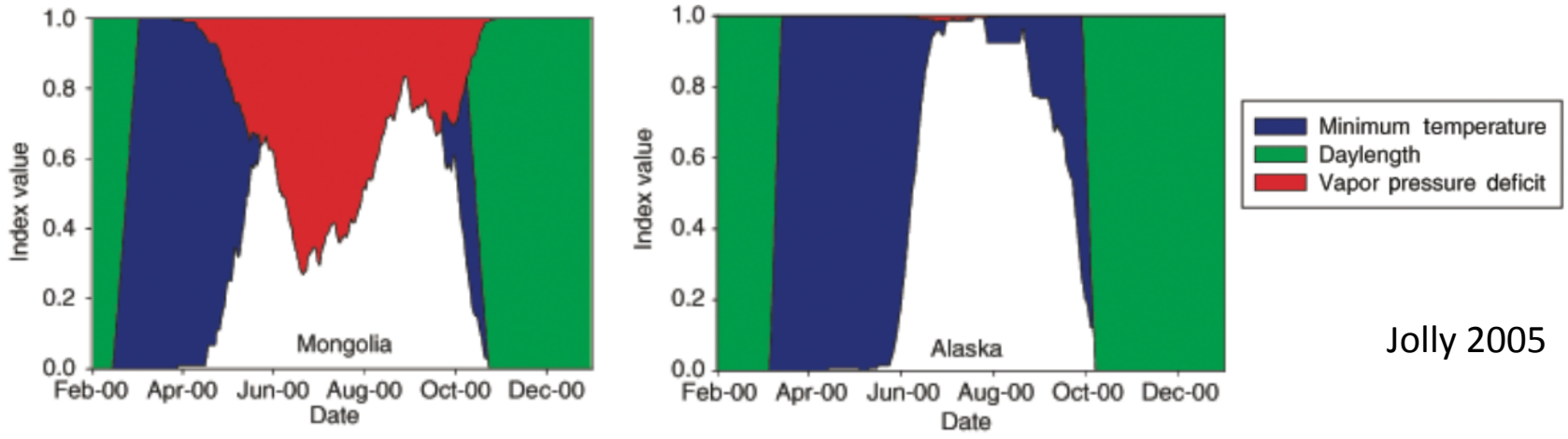
- What are limiting climatic factors for phenology?



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

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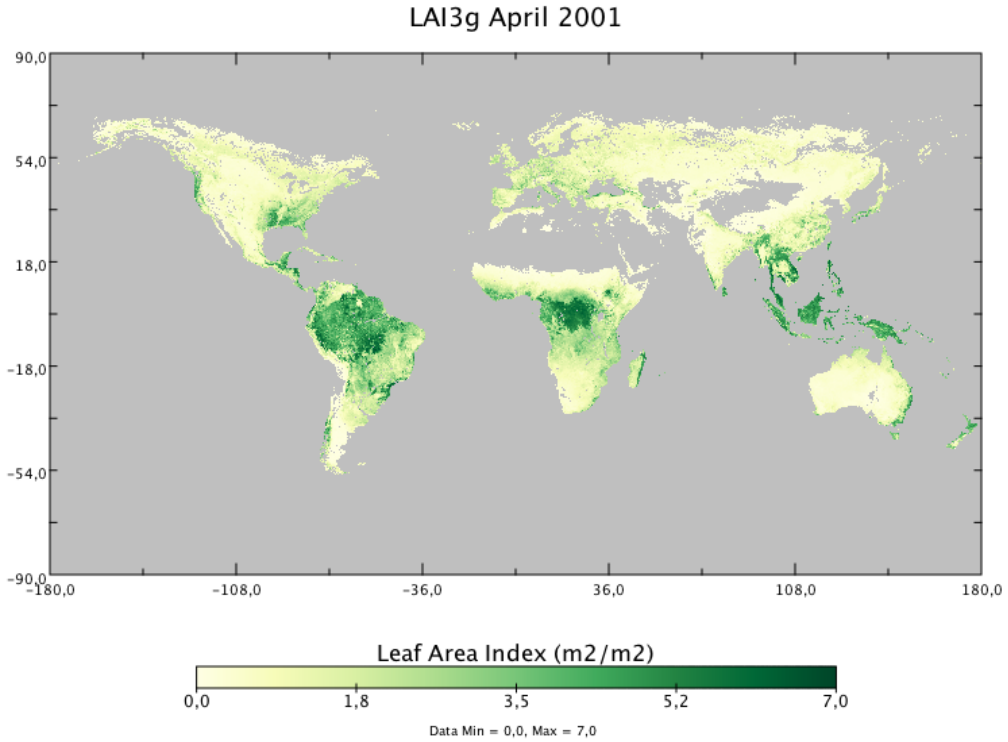
Data

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

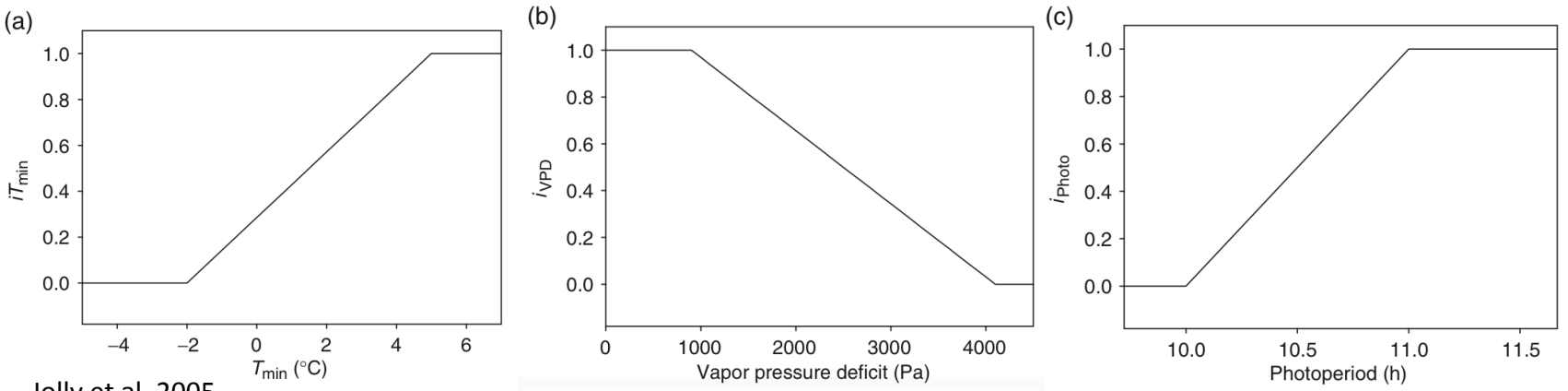
Measured LAI: LAI3g

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



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*



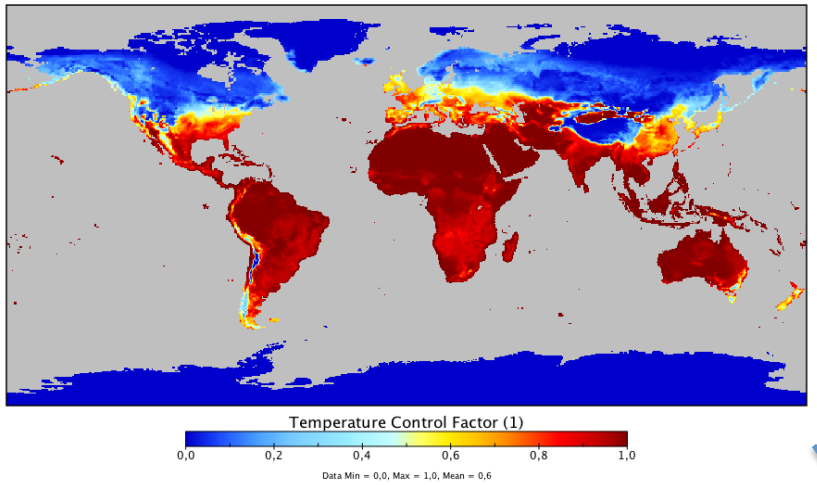
Jolly et al. 2005

LAI Reanalysed

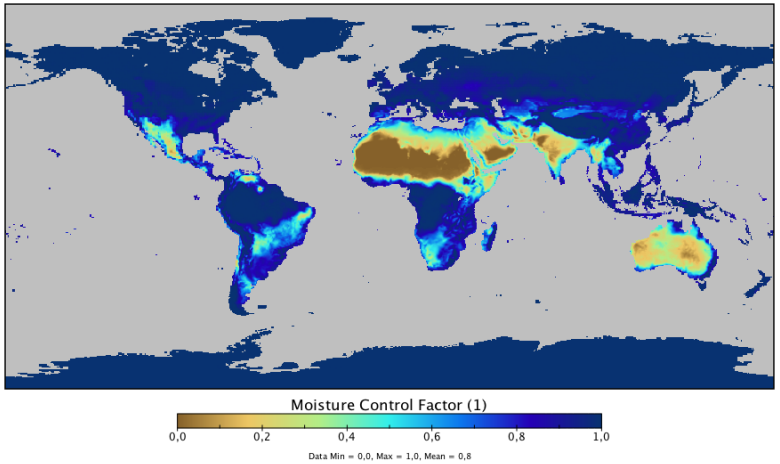
- Stöckli *et al.* (2011) **modelled** LAI based on GSI, Plant Functional Type and elevation classes
- Uses reanalysed meteorological data for T, VPD, incoming radiation
- Model assimilated with 10 years of MODIS LAI and FPAR data

Example: LAI-re for 18 April 2001

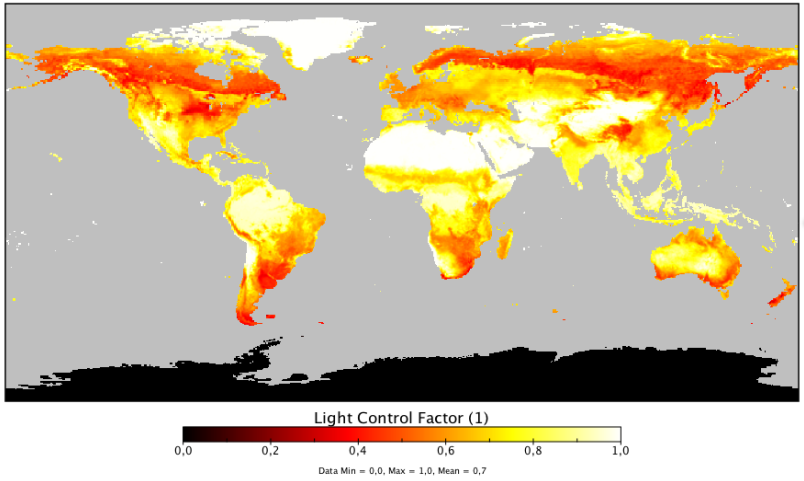
Temperature Control Factor



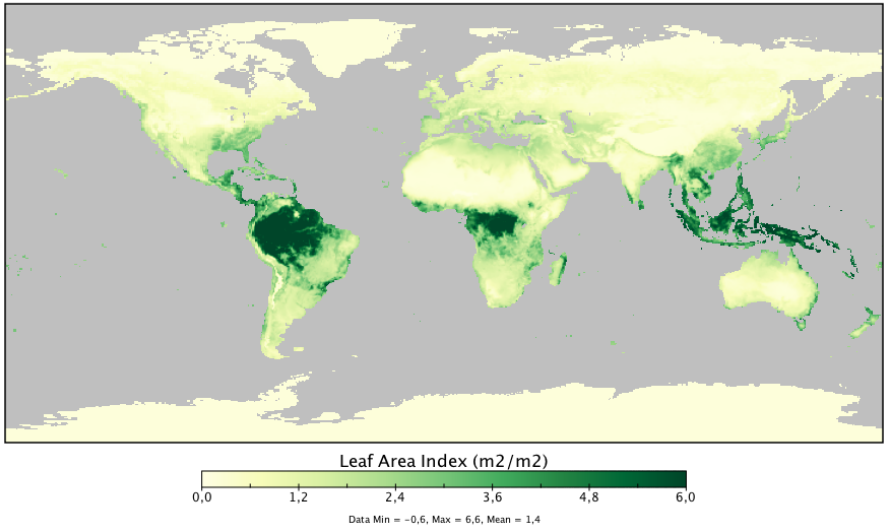
Moisture Control Factor



Light Control Factor

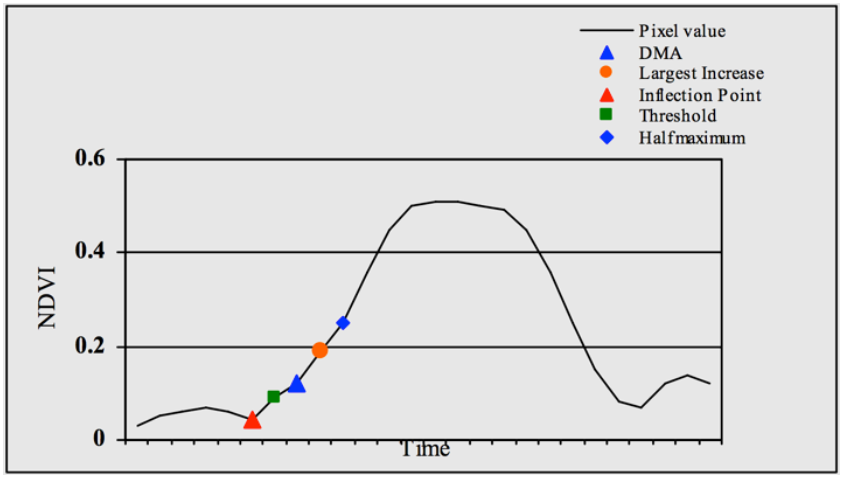


Leaf Area Index



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



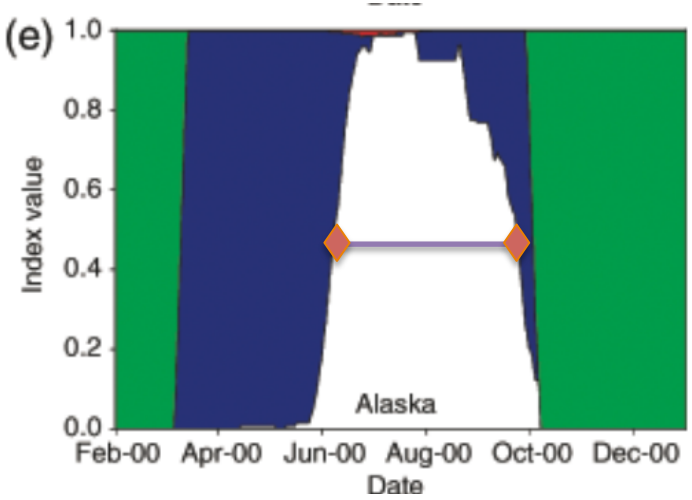
Reed et al. (2003)

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 monthly means
  - …

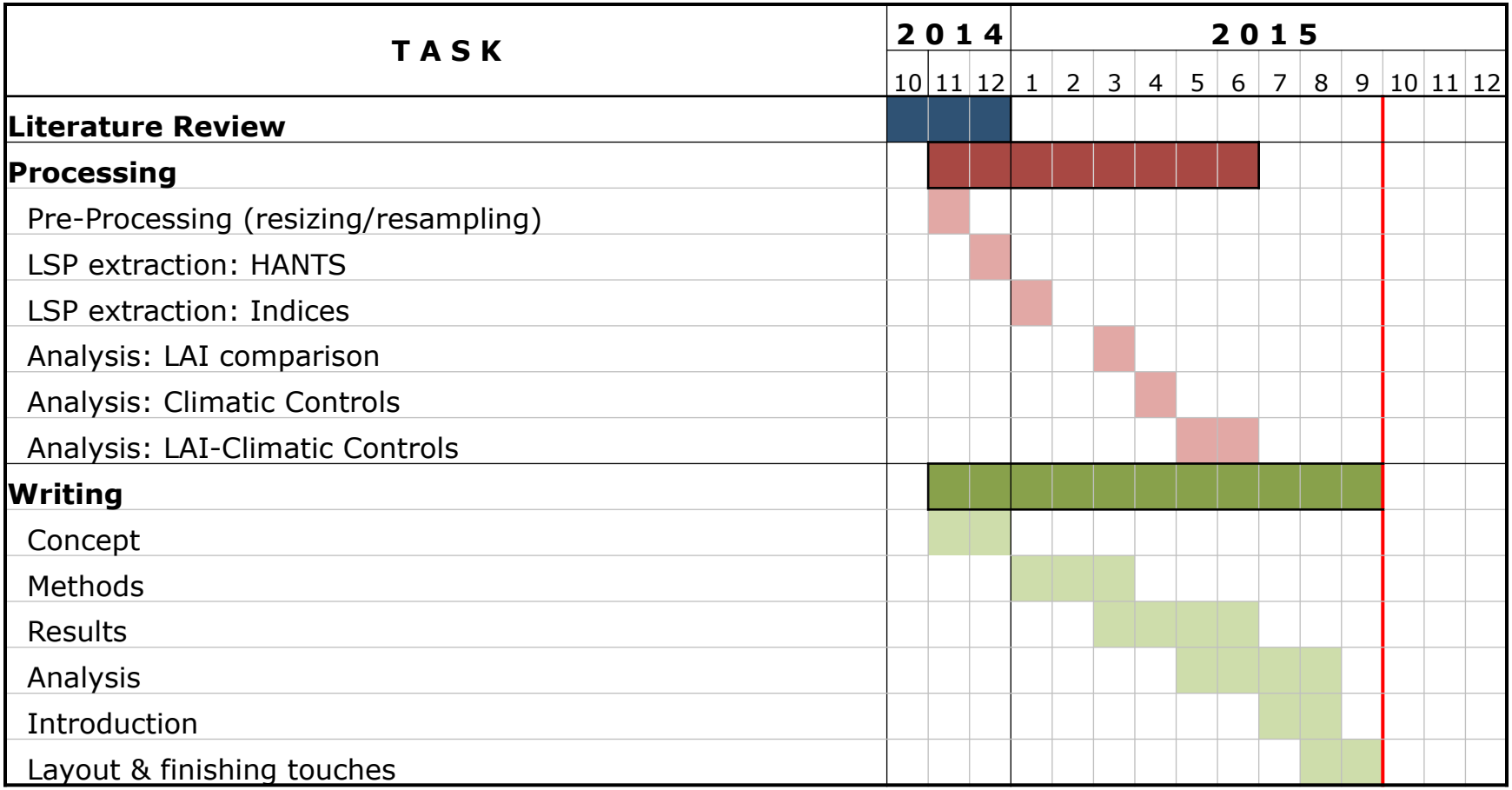
Expected Results

- 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)