TEMPLATE PHENOLOGY FOR VEGETATION MODELS.

Andrew Bradley[1]*, France Gerard[2], Nicolas Barbier[3], Graham Weedon[2], Christopher Huntingford[2], Liana Anderson[3], Przemyslaw Zelazowski[3], and Luiz Eduardo O.C. de Aragão[3]

[1]Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire, PE28 2LS, United Kingdom

[2]Centre for Ecology and Hydrology, Wallingford, Oxfordshire, OX10 8BB, U.K.

[3]Environmental Change Institute, Oxford University Centre for the Environment, Oxford, OX1 3QY, United Kingdom.

*Contact information: E: abrad@ceh.ac.uk: T: +0044 (0) 1487 772400: F: +0044 (0) 1487 773467

INTRODUCTION

Satellite remote sensing products, such as vegetation indices, represent annual and inter annual vegetation activity and can be used to record the state of the vegetation on the Earth's surface [1]. These continual time series of vegetation state can be used as an analogy to identify the timing of annual phenology events such as bud burst, leaf growth, leaf flushing and dieback. These phenology events or physiological changes in vegetation influence biogeochemical processes that exchange moisture, nutrients and gases between the atmosphere and soils. Global vegetation models aim to simulate these processes and each time one of these key phenology events passes vegetation models may alter the timing and duration of a set of conditions changing the rate of flux of moisture, nutrients and gases between soils and the atmosphere. Currently phenology cycles in models are mathematically simulated and the ability of models to replicate the correct timing of phenology events is often inconsistent, for example, some events such as green up may be well represented and other events such as the timing and duration of dieback can be poorly simulated. A contributory factor to the simulation of phenology events is that phenology is driven by the prevailing environmental conditions, e.g. temperature, radiation and water availability, which influence the timing and the amplitude of vegetation vigour. Despite the consistent synoptic view of satellite data products these data sets are relatively underused by the vegetation modelling community. Since satellites can monitor vegetation and some of the prevailing environmental conditions that drive phenology it is possible to make a more accurate simulation in the timing and driving forces of phenology, information that can only contribute to the improved accuracy of vegetation models. In this research we build on previous work [2] that identified phase and time series correlations between phenology cycles and the corresponding environmental conditions. Our aims are to identify characteristic phenology types determined by a set of environmental conditions to provide a reference data source of phenology events that can be included in vegetation models such as the JULES vegetation model.

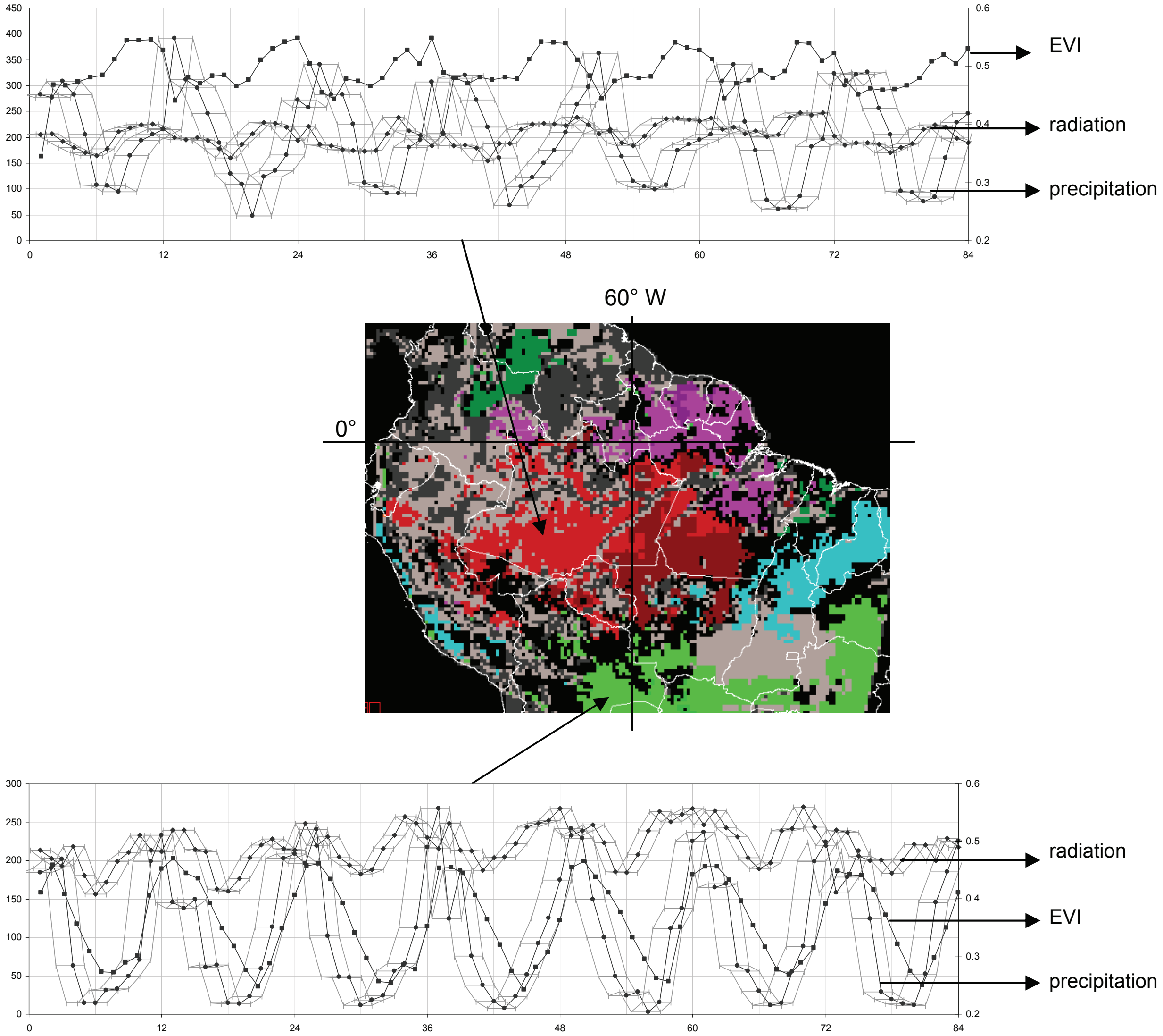
METHODOLOGY

Focussing on Amazonia, where models predict the beginning of vegetation die-back by 2050, we used time series data between 2000 and 2007 from MODIS EVI to represent the annual phenology cycle, TRMM to represent precipitation and CPTEC as our radiation measure. We had previously employed a Fourier transform and a cross spectral analysis [3] on the EVI, precipitation and radiation time seriesto identify the level of correlation between the two data sets (coherency) and phase differences [2]. We re-examined the cross spectral analysis, and using a 95% confidence limit we set a threshold where we could be most confident explaining the relationships between the driver and phenology. We plot these phase differences as a frequency distribution and identified typical phase differences from peaks in the graph. We identified three major phase ranges of phenology and four major phase ranges in the phenology radiation frequency distribution. Each pixel was classed according to the phase range it represented then the two data sets were combined by re classing each pixel according to the combination of phenology / precipitation and phenology / radiation phase ranges. These new classes were then spatially aggregated and the underlying EVI time series was averaged to create a representative phenology for that class.

RESEARCH PROGRESS

Amazonia has several different combinations of phenology /driver phase relationships demonstrating that the timing of precipitation and radiation is variable and occurs in distinct regions (figure 1). For example radiation can be in phase with phenology and around 6 months out of phase with precipitation (figure 1, top plot) or precipitation and radiation can be in phase with phenology (figure 1 bottom plot). Averages of the underlying phenology also show that the characteristics of the phenology curves vary from region to region, and these estimates can be used as templates of phenology. The future challenge of this research is to design ways that these phenology templates can be integrated into vegetation models. As a starting point we can now calculate realistic metrics that represent the timing and duration of phenology events such as bud burst, green up period, growth season and dieback period in each region and relate these processes to their driving forces. There is also scope to subdivide these regions as preliminary inspection with land cover types, shows that these regions cross the boundaries of different land cover types such as humid forest and savanna. Phenology can also be influenced by other factors such as temperature and soil moisture, and more research on these drivers would be beneficial.

Figure 1; Spatial distribution of precipitation and radiation phase zones in Amazonia. Coloured regions – represent different phase difference combinations of precipitation and radiation, light grey – coherent with only one driver, dark grey – below coherence threshold. Average time series curves: top plot, scarlet red area, radiation ~ in phase with EVI phenology, precipitation ~ 6 months lagged, bottom plot, light green area, precipitation and radiation ~ in phase with EVI phenology. Error bars indicate the possible phase range of each driver determined from the frequency distribution plots described in the method.



BIBLIOGRAPHY

[1] Heumann, B. W., J. W. Seaquist, et al. (2007). "AVHRR derived phenological change in the Sahel and Soudan, Africa, 1982-2005." Remote Sensing of Environment 108 (4): 385-392.

[2] Bradley, AV, Gerard, F, Weedon, G, Huntingford, C, Zelazowski, P, Anderson, L, Barbier, N, Aragão, Luiz Eduardo, (2008). '*Exploring the biophysical drivers of Amazon Pheneology: Preparing data sets to improve dynamic global vegetation models.*', IEEE International Geoscience & Remote Sensing Symposium. July 6th -11th, Boston, Massachusetts, U.S.A.

[3] Weedon, G. 2003.Time-Series Analysis and Cyclostratigraphy. Cambridge University Press, pp 259.