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Real-time Monitoring Land Surface Vegetation Phenology from VIIRS Observations

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Abstract- **Vegetation phenology investigates the timing and magnitude of vegetation progress over the vegetated land surface. Real-time monitoring and short term forecasting of vegetation progress from satellite data are particularly important for numerical weather modeling, ecosystem forecasting, forest and crop management, and health risk warning, although they are currently very challenging. We present here an innovative approach to monitor and forecast spring green vegetation growth and autumn color foliage statuses (including low coloration, moderate coloration, near-peak coloration, peak coloration, and post-peak coloration) using timely available JPSS VIIRS observations.**

1. Phenological Model

The temporal development of vegetation greenness can be described using the following model (**Fig. 1**):

$$VI(t) = \frac{c}{1 + e^{a+bt}} + VI_b$$

t is time in days

$VI_{(t)}$ is the enhanced vegetation index (EVI)

a and ***b*** are vegetation growth parameters

$c+VI_b$ is the maximum EVI value

VI_b is the background EVI value

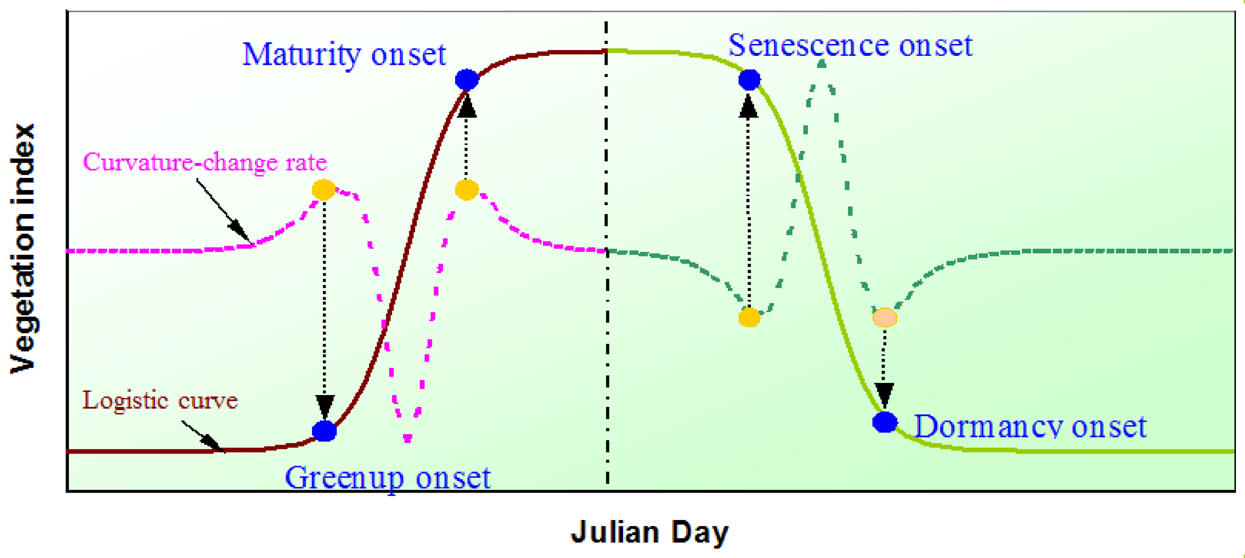

Fig.1. Temporal VI trajectory (solid line) from the phenological model. The phenological transition dates are identified from the curvature change rate (doted line) deduced from the phenological model. The blue dots indicate: (1) greenup onset: onset of greenness increase, (2) maturity onset: onset of greeness maximum, (3) senescent onset: onset of greenness decrease, and (4) dormancy onset: onset of greenness minimum.

2. Phenological climatology

Phenological climatology and variance (timing and green vegetation cover) were established using MODIS and AVHRR observations from 1982-2012, which represent the prior knowledge or potential phenological development beyond timely available satellite observations (**Fig. 2**). These parameters are used to constrain the variation in modeling temporal greenness trajectories.

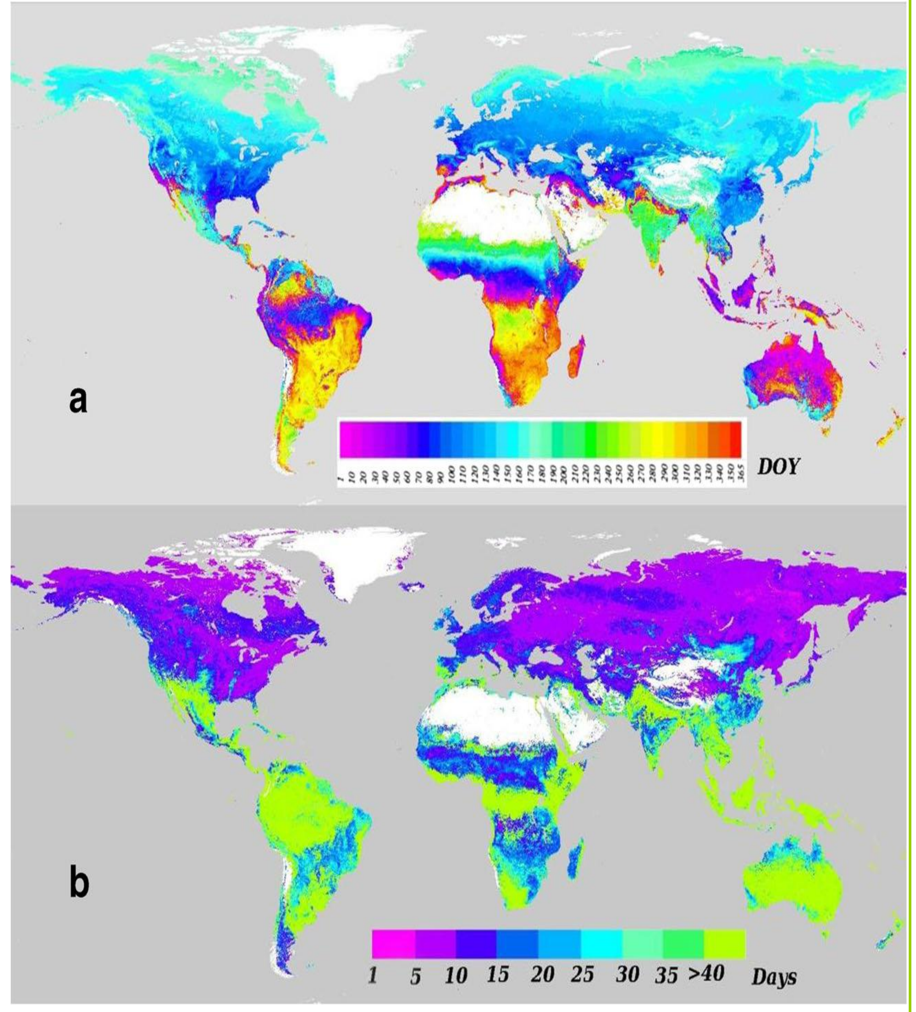

Fig2. Climatology of the start of growing season derived from AVHRR and MODIS data from 1982 to 2010. (a) average timing and (b) standard deviation. Note that the white color indicates no vegetaton phenology detection because of either permanent snow cover or desert.

3. Monitoring Spring Vegetation Growth

Spring vegetation development emerges from the vegetation dormancy phase. The simulation of potential trajectory of vegetation greenness (EVI) begins after land surface temperature is higher than 5°C and available VIIRS EVI observations appear increases relative to the dormancy EVI in a pixel (**Fig. 3**). Based on available VIIRS observations, climatological phenology and variance, a set of potential phenological models are established. The models are further used to calculate and predict the phenological timing and greenness leaf cover.

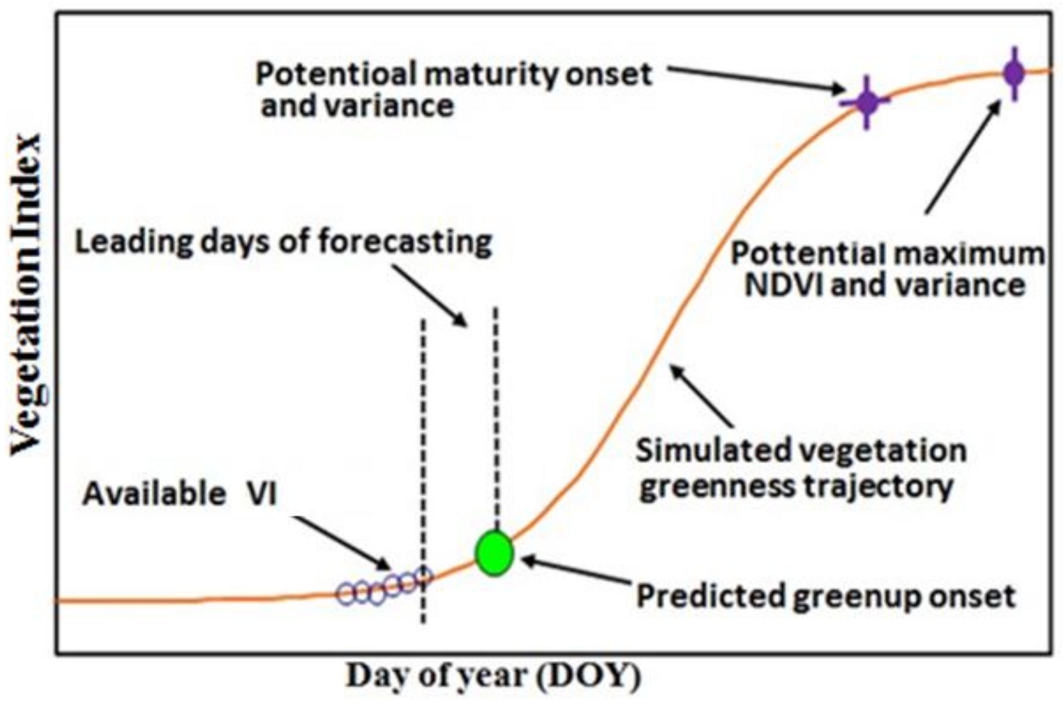

Fig. 3. Simulating potential temporal trajectory from available daily EVI data (circles) and monitoring and forecasting phenological events during the spring green-up phase.

4. Monitoring Fall Foliage Coloration

Fall foliage development starts from maximum green leaf cover in individual pixels. The basic approach is similar to the monitoring of spring vegetation development, which simulates the temporal trajectories of fall foliage development by combining available VIIRS observations and climatological phenology (**Fig. 4**). The greenness trajectory is further converted to the temporally-normalized brownness (TNB), which is used to calculate the proportion of colored leaves on the plant canopy for the determination of the statuses of fall foliage development.

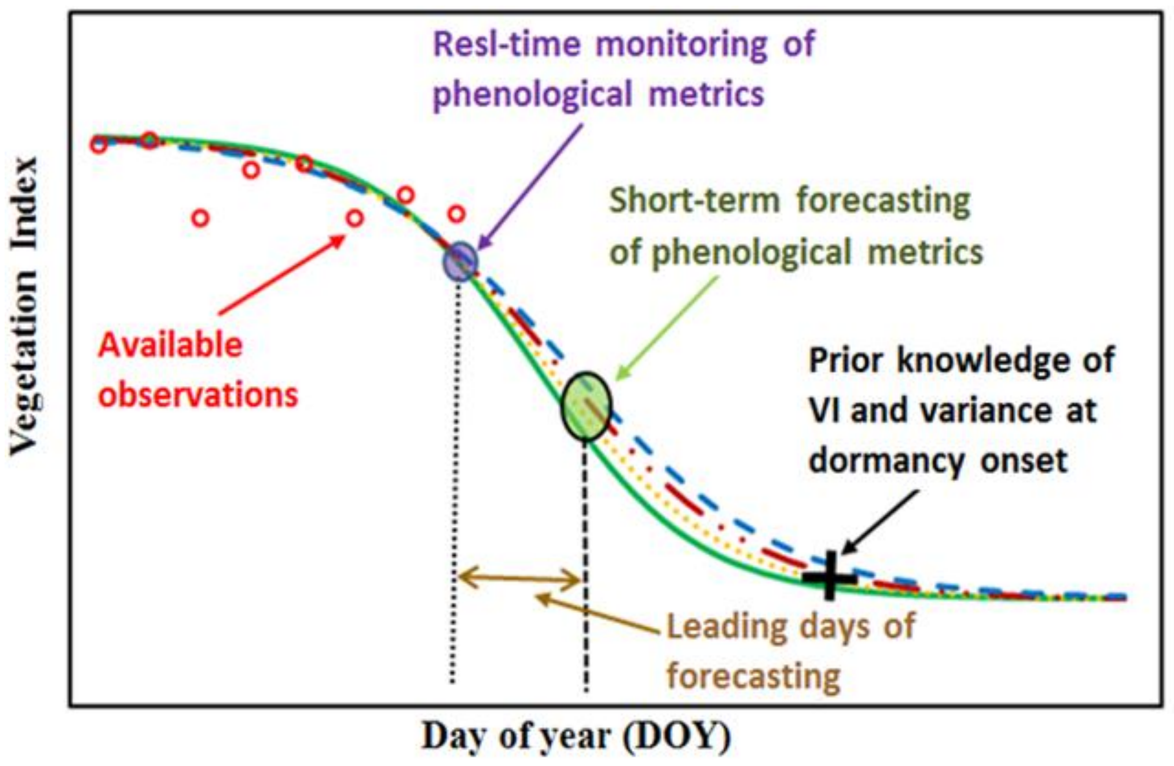

Fig. 4. Simulating the potential temporal trajectory from available daily EVI data (red circles) and monitoring and forecasting the fall foliage coloration statuses.

5. Results

Fig. 5 shows the time series of VIIRS EVI simulated using the phenology model. It removes spurious and irregular daily VIIRS observations contaminated by snow and clouds.

Fig. 6 exhibits the percent green leaves within a pixel in near-real time and 10-days ahead in middle April, 2015. The spatial pattern indicates the surface had turned green in middle west, which was about one month early than that in 2014. In south region, spring green leaf cover was over 50%, where the green leaves started to emerge in Funerary.

Fig. 7 displays the fall foliage statuses in 2014. It shows a clear pattern that colored foliage shifted from southwards and the brown leaves appeared early in croplands relative to surround natural vegetation. Foliage statuses derived from VIIRS data are comparable to the field observations.

The monitoring and forecasting of VIIRS phenology are updated every three days(**http://star.nesdis.noaa.gov/star/news2015_201504_SpringFoliage.php**)

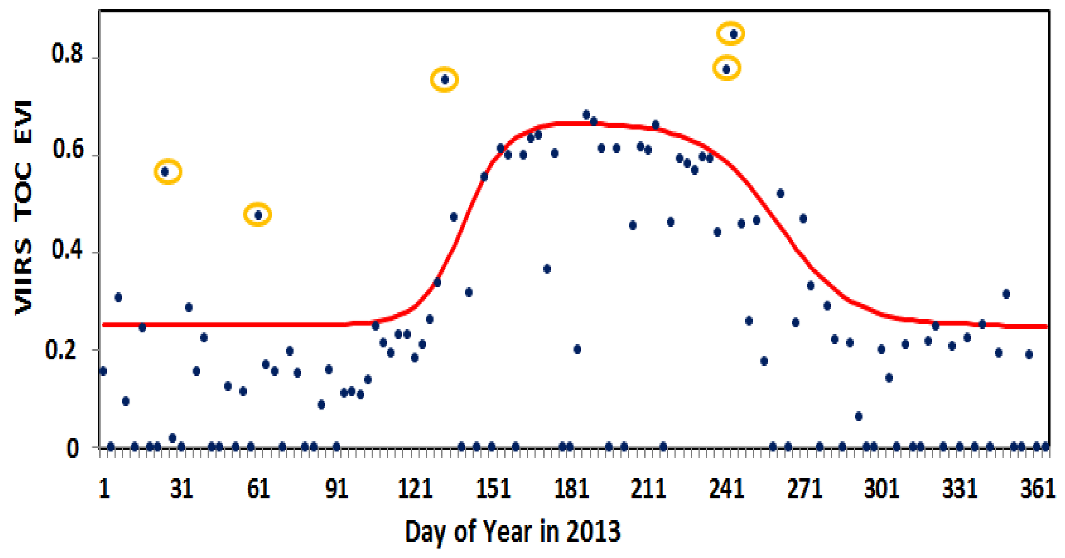

Fig. 5. Reconstructed annual time series EVI. The spuriously high EVI values are denoted using yellow circles and low EVI values are mainly associated with cloud cover.

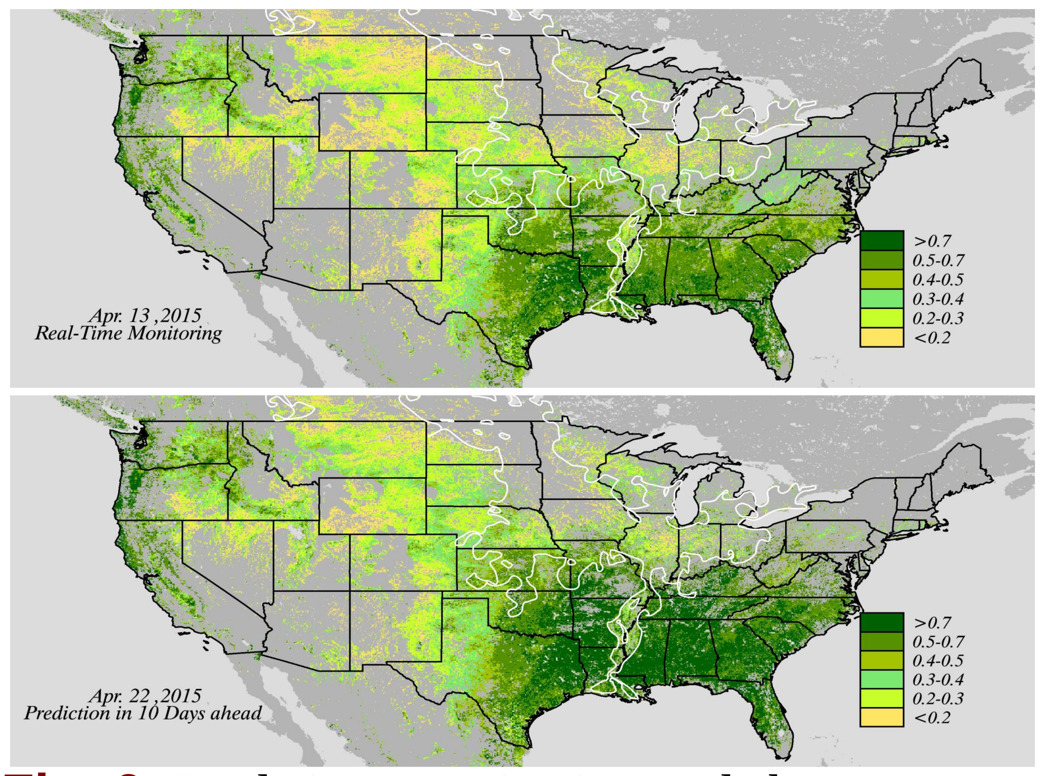

Fig. 6. Real-time monitoring and short-term forecasting of spring green vegetation fraction. The top panel is the green vegetation fraction monitored in real time. The bottom panel is the values predicted 10 days ahead. The grey color indicates the vegetation remains dormant.

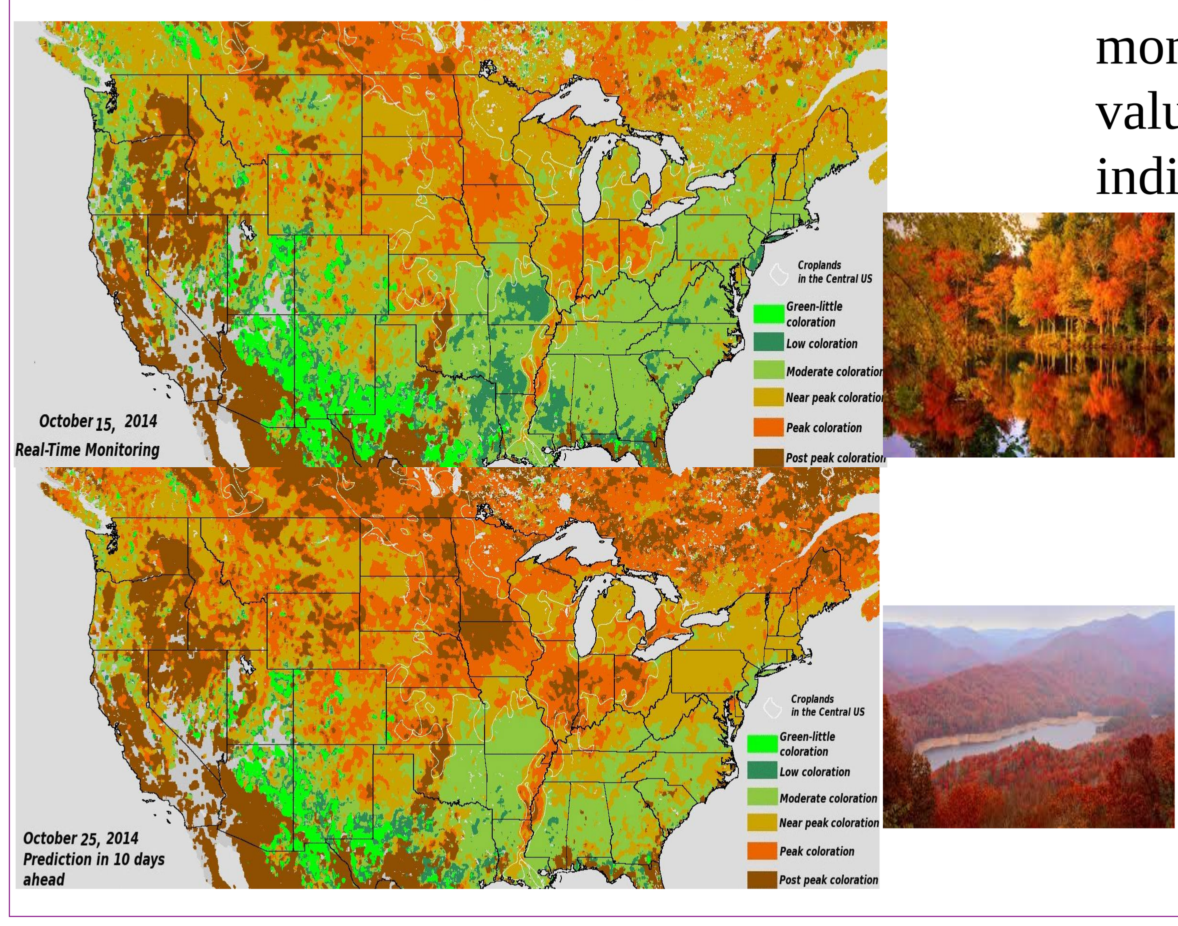

Fig. 7. Real-time monitoring and short-term forecasting of fall foliage coloration using daily VIIRS data.

6. Conclusions

- Potential temporal trajectories of vegetation development at a given time and pixel can be simulated from timely available VIIRS observations
- The phenological models are capable of monitoring in near real time and forecasting in 10 days ahead the spring green vegetation growth and fall color foliage statuses
- GOES-R ABI could improve the monitoring quality of temporal foliage development greatly because diurnal observations can highly increase cloud free EVI values
- Real time monitoring and short-term forecasting of vegetation dynamics provides critical data timely for land models and land managements