Using Remote Sensing to Monitor Soil Carbon Sequestration

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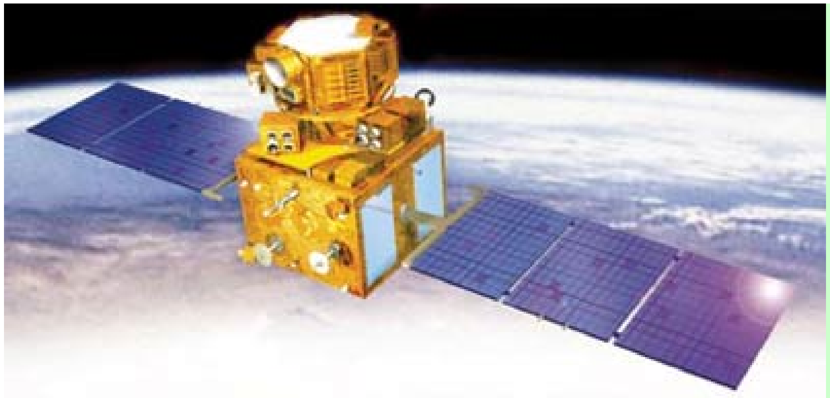


Introduction and Overview

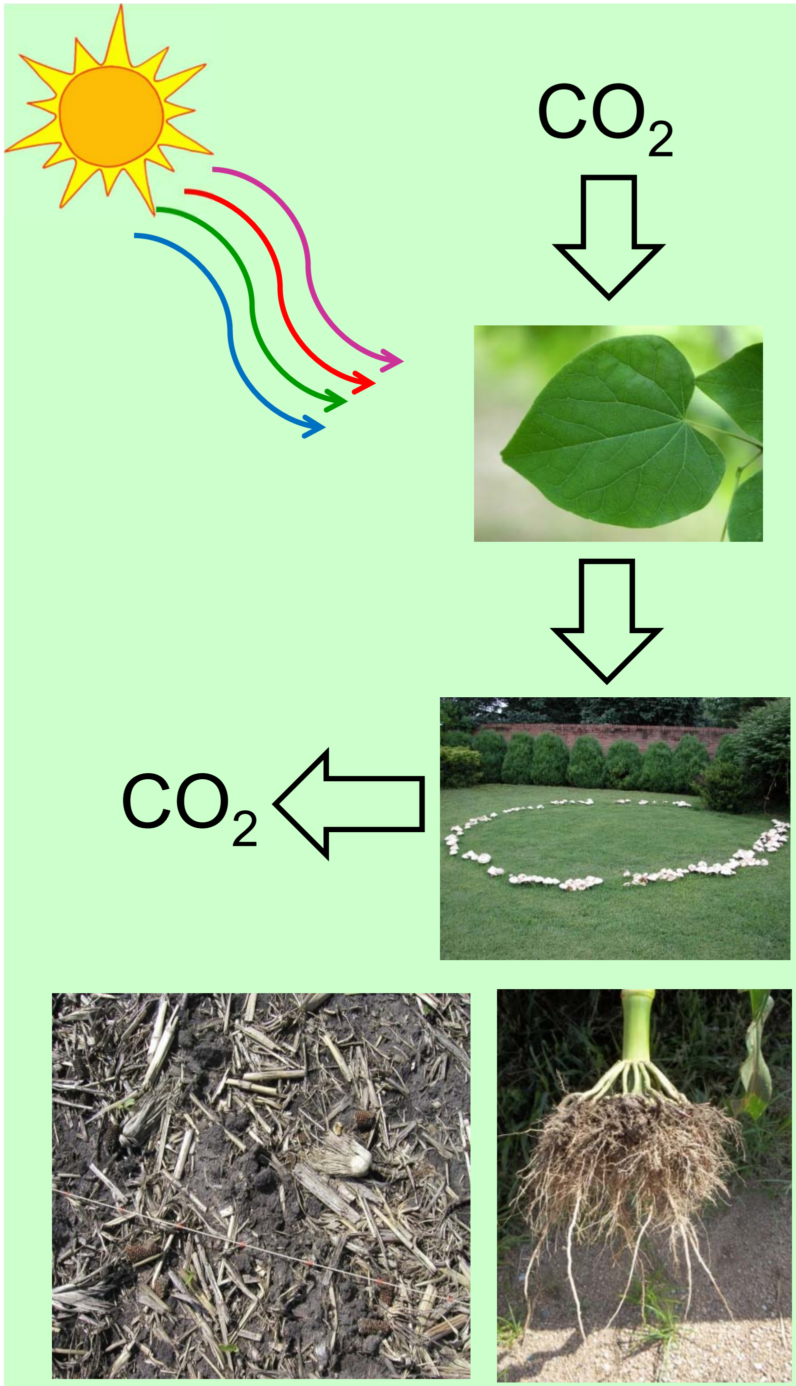
- The amount of carbon annually sequestered into the soil is small compared to the amount of soil organic carbon
- Need to monitor to 1-meter depth. Remote sensing organic carbon on the surface will not provide information about changes below the surface
- Instead, possibly use non-US satellites to monitor gross primary production of croplands, pastures and rangelands
- An “AGSAT” mission would provide much more relevant information for estimating carbon sequestration and farm management

Sequestration of carbon dioxide into the soil as stable soil organic matter is desirable because:

- long life time
- improves soil fertility and water holding capacity

Remote sensing may provide the monitoring technology at reasonable cost. Furthermore, remote sensing provides an opportunity to increase efficiency of farm management

Mollisol from central Iowa has high amounts of soil organic carbon. Sequestration essentially will replace soil organic carbon, which was lost from tillage



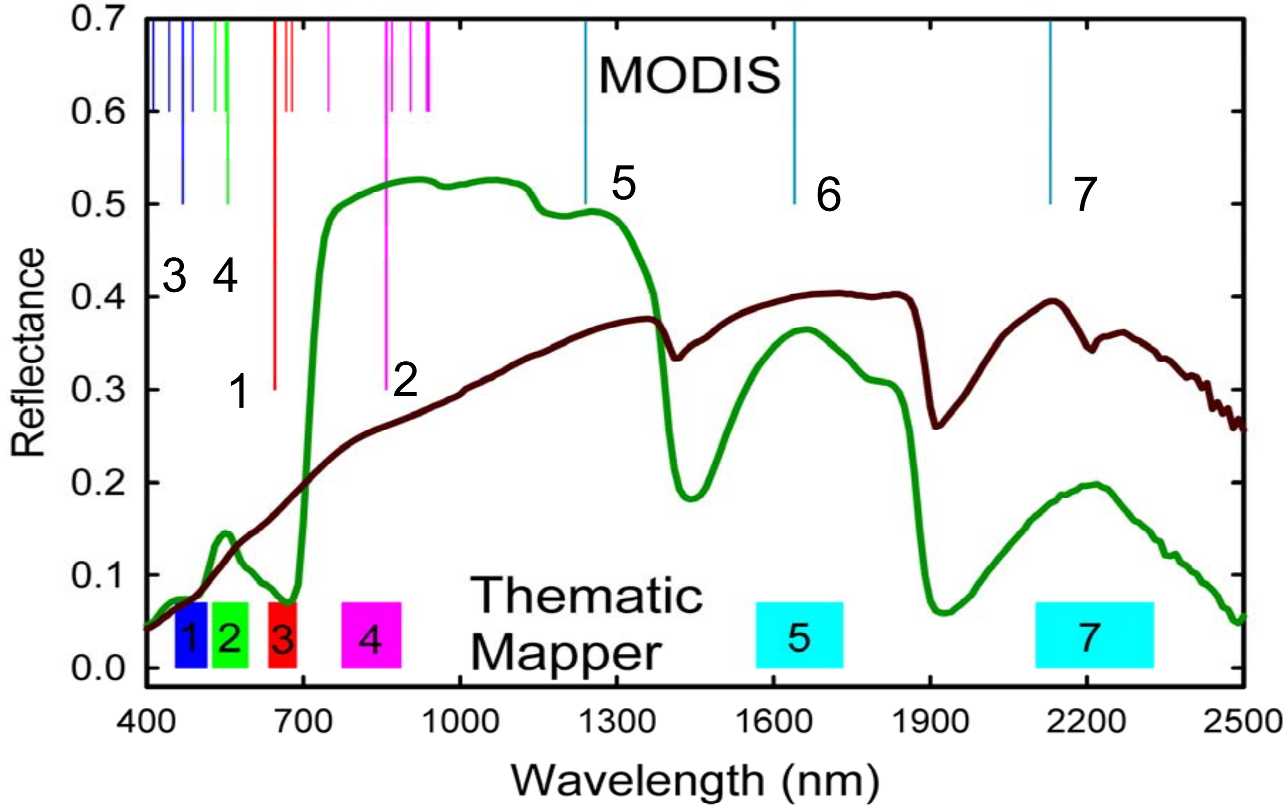
Steps from photosynthesis to carbon sequestration into the soil

Gross Primary Production based on the efficiency of converting absorbed photosynthetically active radiation into starch

Autotrophic and heterotrophic respiration

Incorporation of organic matter from residue and roots into the soil

Remote sensing is based on the spectral differences of soils and vegetation

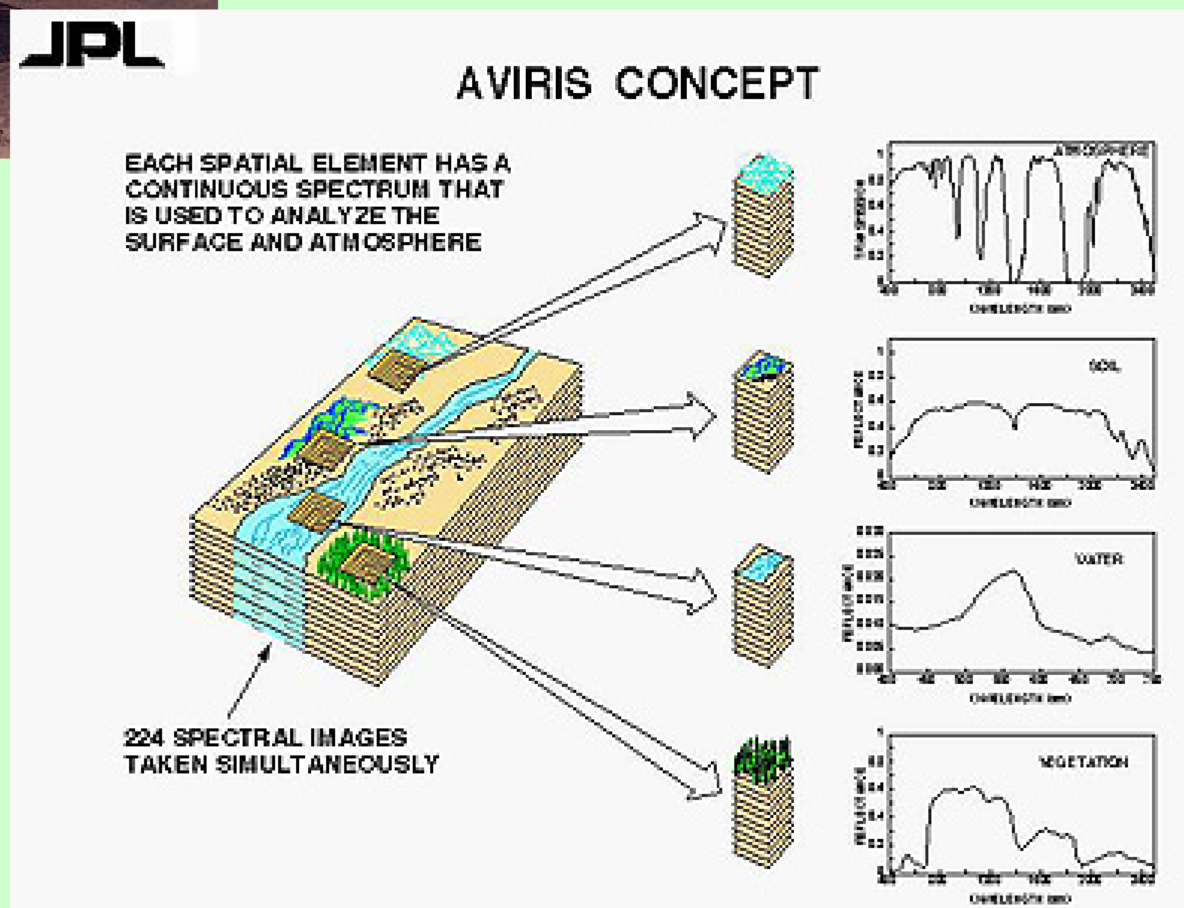


Normalized Difference Vegetation Index (NDVI) = (NIR – Red)/(NIR + Red)

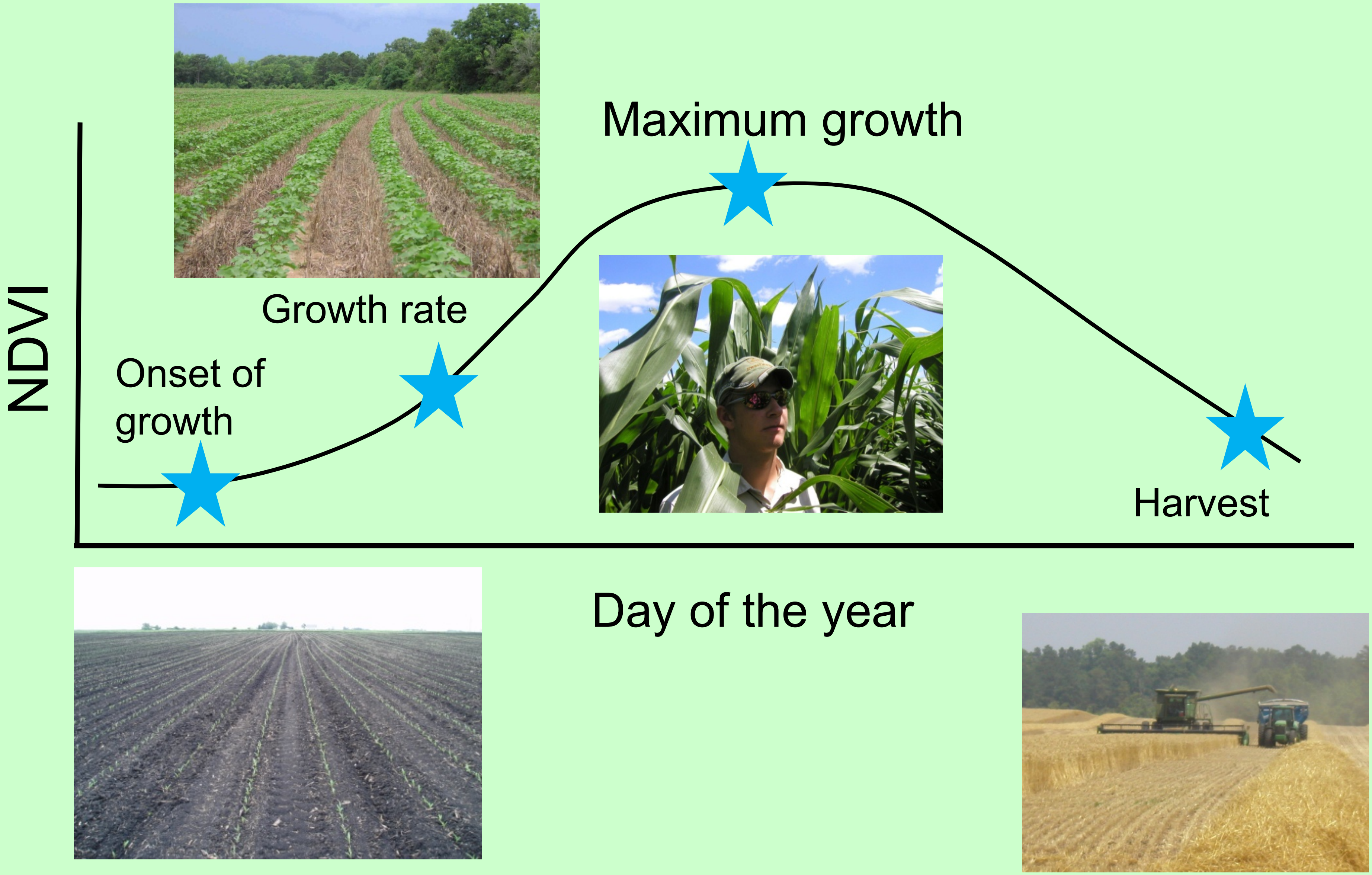
Airborne Visible Infrared Imaging Spectrometer (AVIRIS)

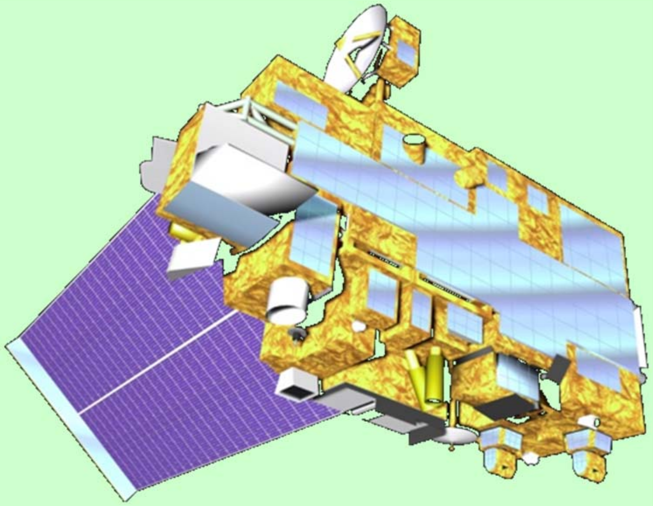
High altitude (20-m pixels) or low altitude (4-m pixels)

Spectral reflectances of the land surface may provide data on soil carbon at the surface. However, NASA's HyspIRI mission won't be launched until after 2018-2019



Gross Primary Production is calculated from vegetation indices integrated over the growing season





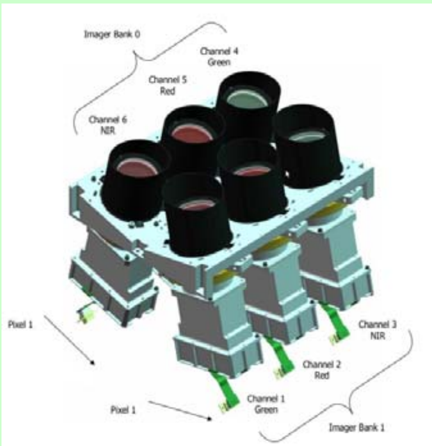
Terra launched December 18,1999; algorithms for GPP developed as a standard data product from MODIS (Moderate Resolution Imaging Spectroradiometer)

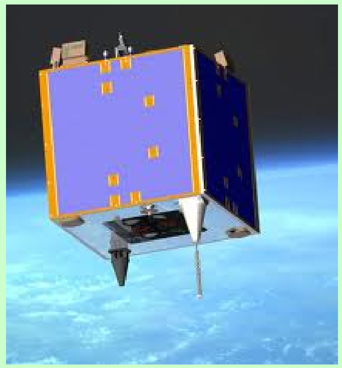
Suomi National Polar-orbiting Partnership (NOAA-NASA) launched October 28, 2011.
VIIRS continues satellite environmental data records of AVHRR and MODIS

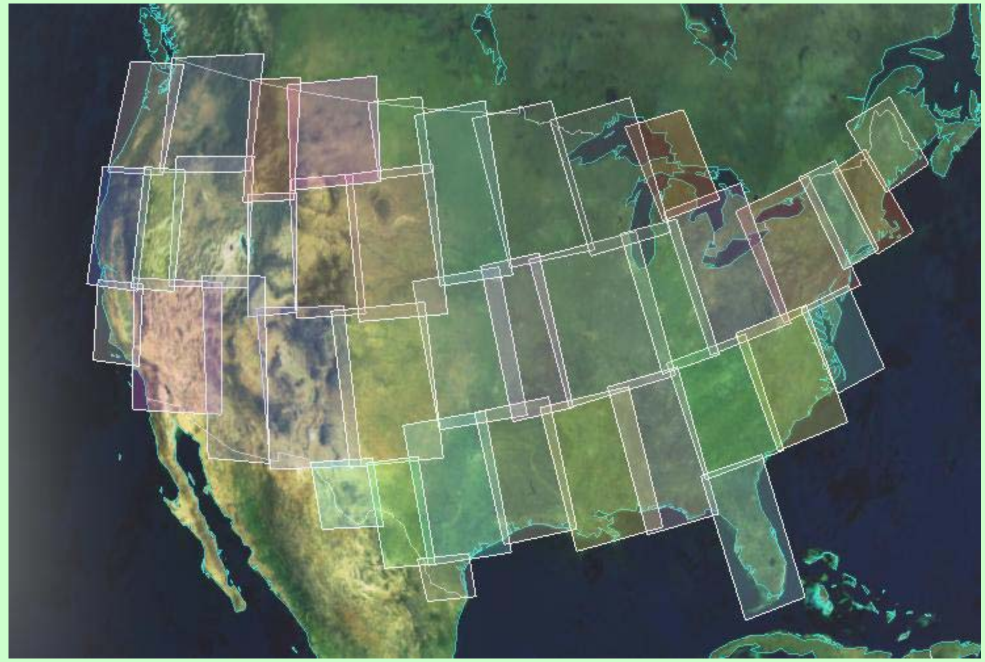
Large swath (≥ 2330 km) so frequent coverage;
but large pixel sizes (250-m for red and NIR bands), so individual fields can not be monitored.

deimos IMAGING

Deimos-1 launched July 29, 2009

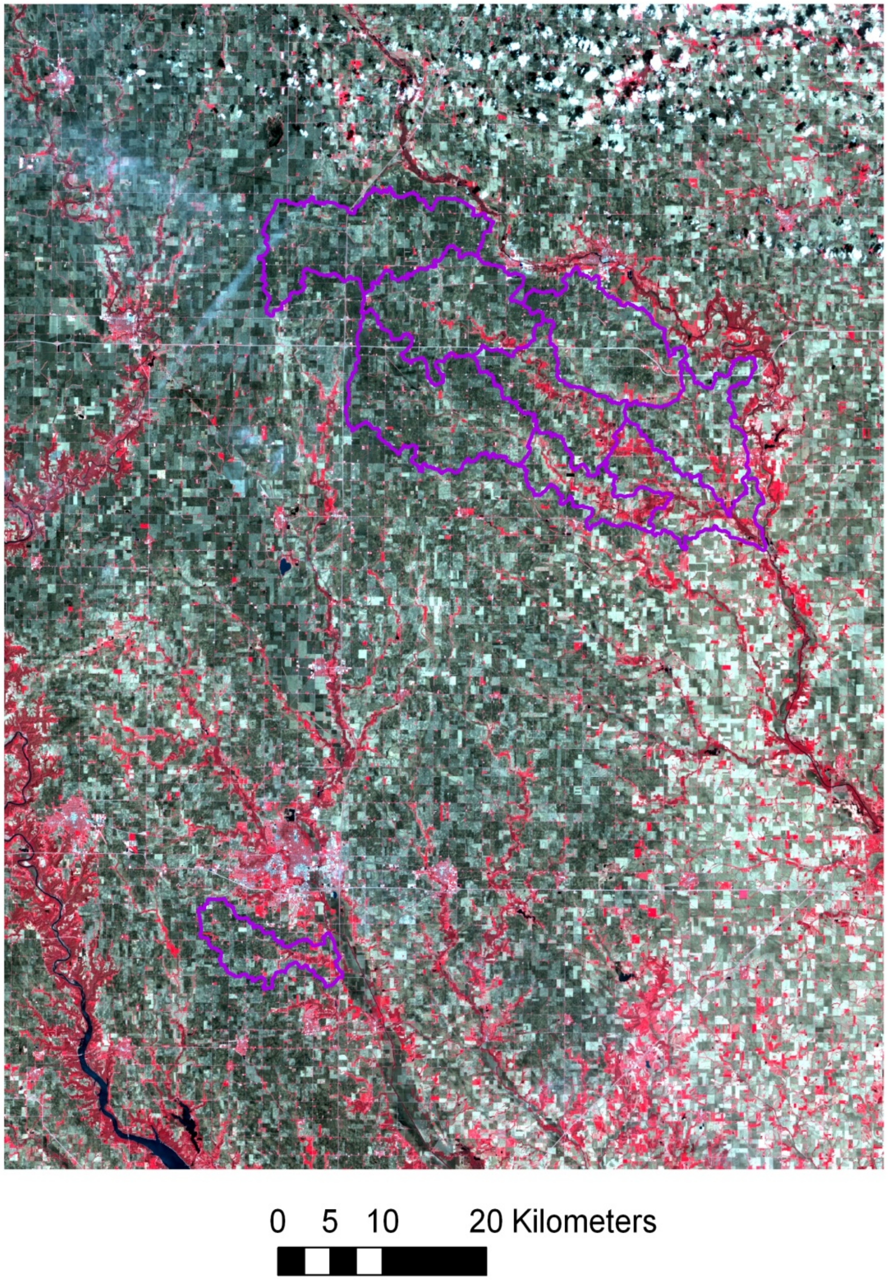






- 3 bands (green, red, NIR) compatible with Landsat TM
- 22-m pixel, very large swath (640 km)
- Acquired by USDA last year; we are testing GPP algorithms in central Iowa

Deimos - May 7, 2011 - False Color Image
South Fork and Walnut Creek watersheds

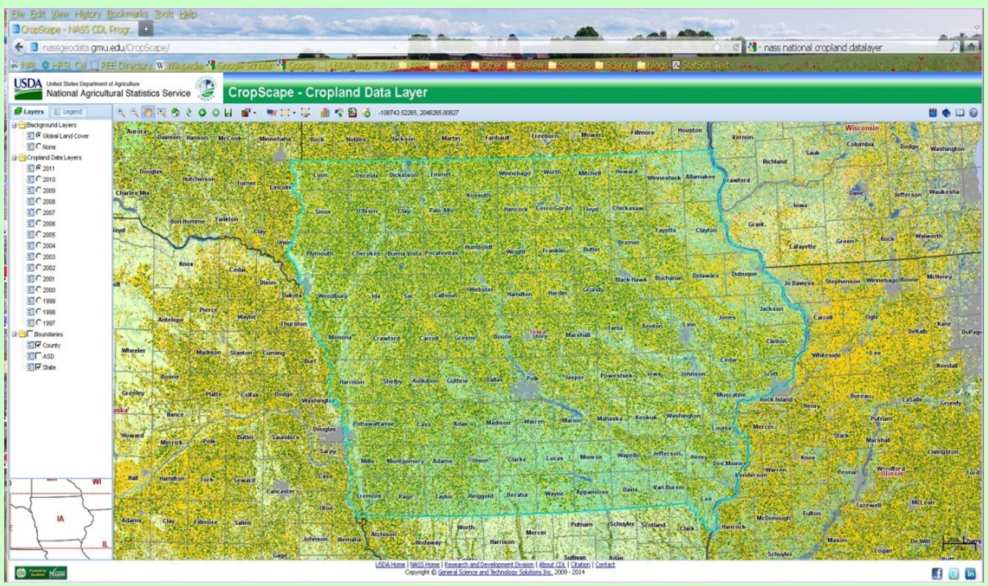


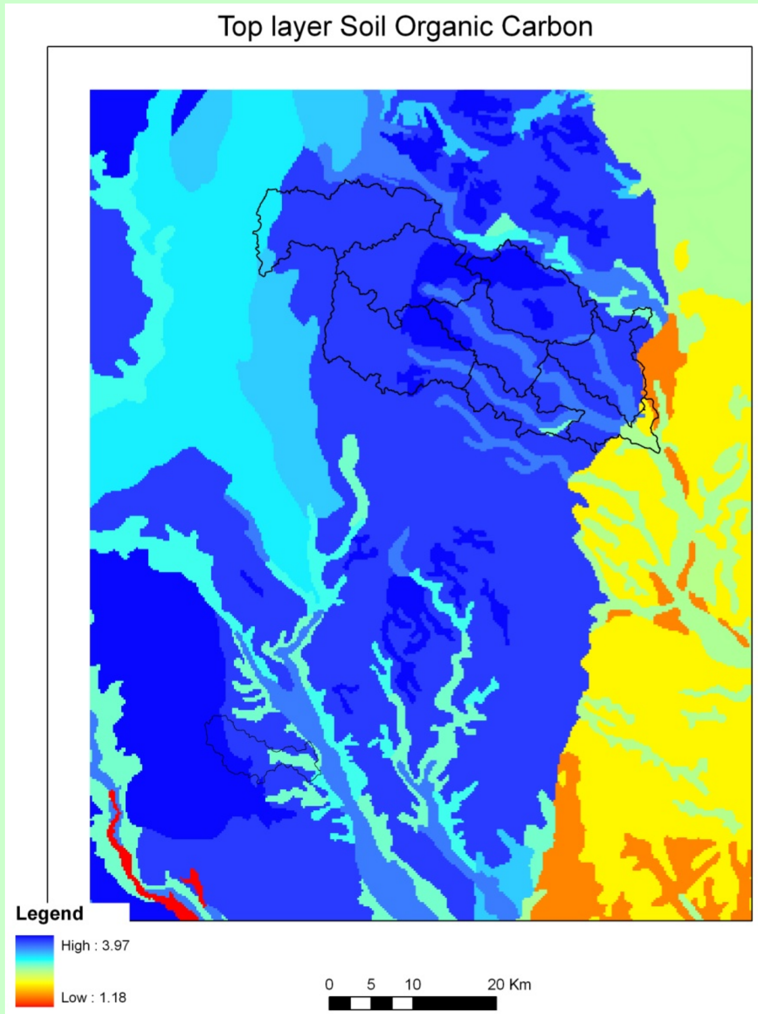
Large swath provides frequent coverage, so removing areas covered in clouds has small effect on estimated GPP

Small pixel size - fields and pastures may be individually monitored

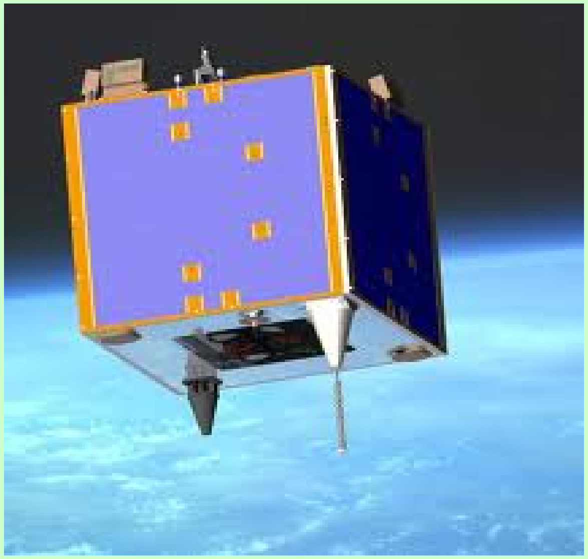
Simulation models and other geographic data layers are required to estimate amount of soil carbon sequestration based on a given GPP

- Weather data
- USDA-NRCS STATSGO/SSURGO
- USDA-NASS Cropland Data Layer





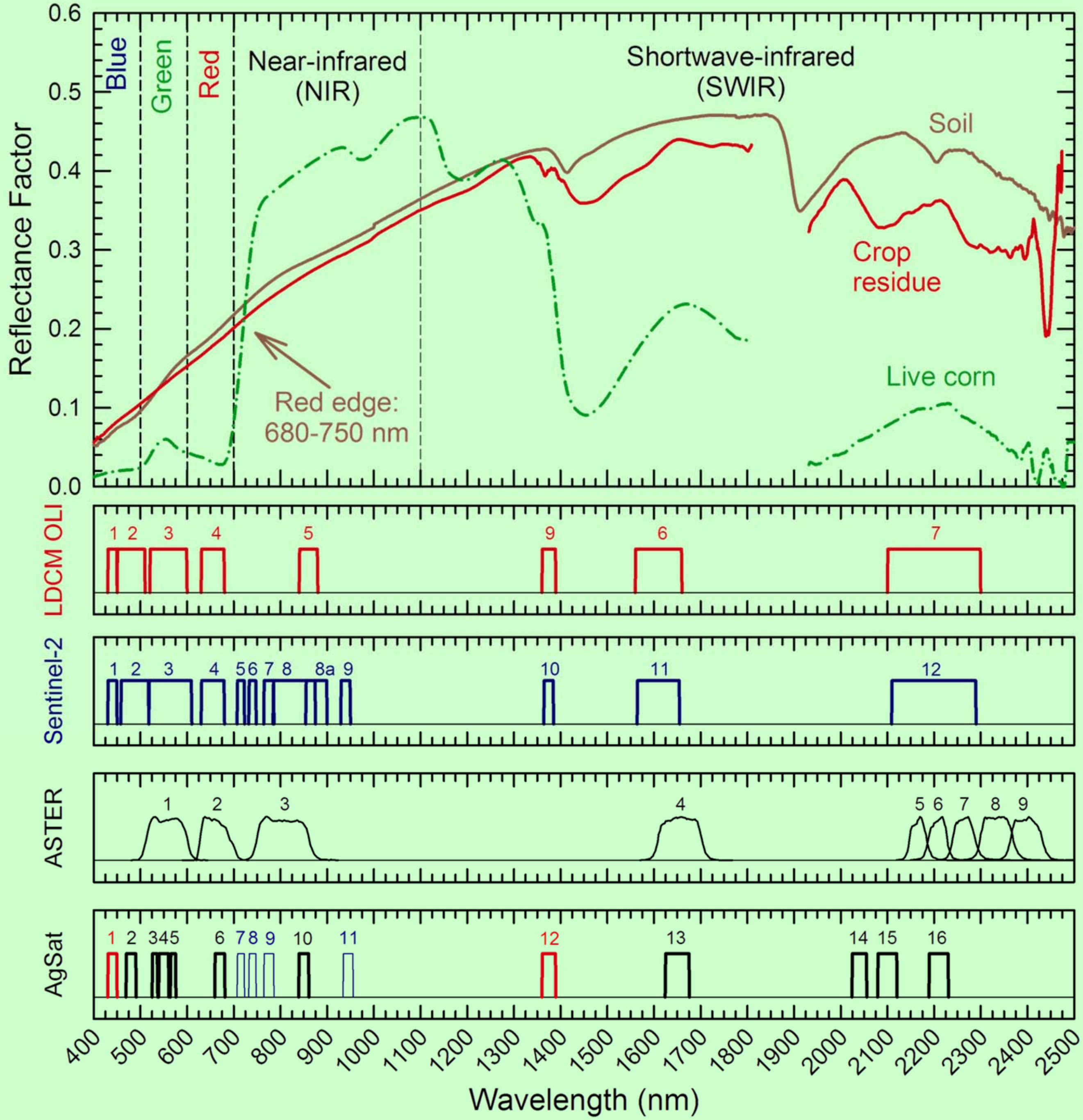
- Satellite GPP is not very accurate ± 25%
- Accuracy may be increased by including flux and field data, or by assimilation into crop models
- Accuracy may also be increased by including more spectral information to determine photosynthetic efficiency (e.g. water stress and nutrient status)
- Tillage will affect amount of sequestration; GPP is only one variable among many
- Best possible accuracy of GPP is ± 10%, limit from field sampling
- GPP is much larger than amount of carbon sequestered
- Calculations are done at the end of the growing season so possible pay for performance



Discussion point: does USDA needs its own satellite?

- There is no planned NASA/NOAA/USGS mission which has both small pixels and frequent coverage.
- Non-US satellites have filled this niche. Will this affect US policies or food security?
- With additional bands (visible, red-edge and thermal), crop nutrient and water status can be monitored for individual fields.
- Remote sensing requires software and hardware beyond typical needs of a farmer.
- Helping farmers reduce fertilizer applications will help reduce N_2O emissions, help water quality, and save farmers money.
- Consider providing farmers with information about nutrient status at the field scale from the year before.

The AgSat concept is for discussions on satellite data requirements and does not represent official USDA or ARS policy.



Thank you very much, questions?