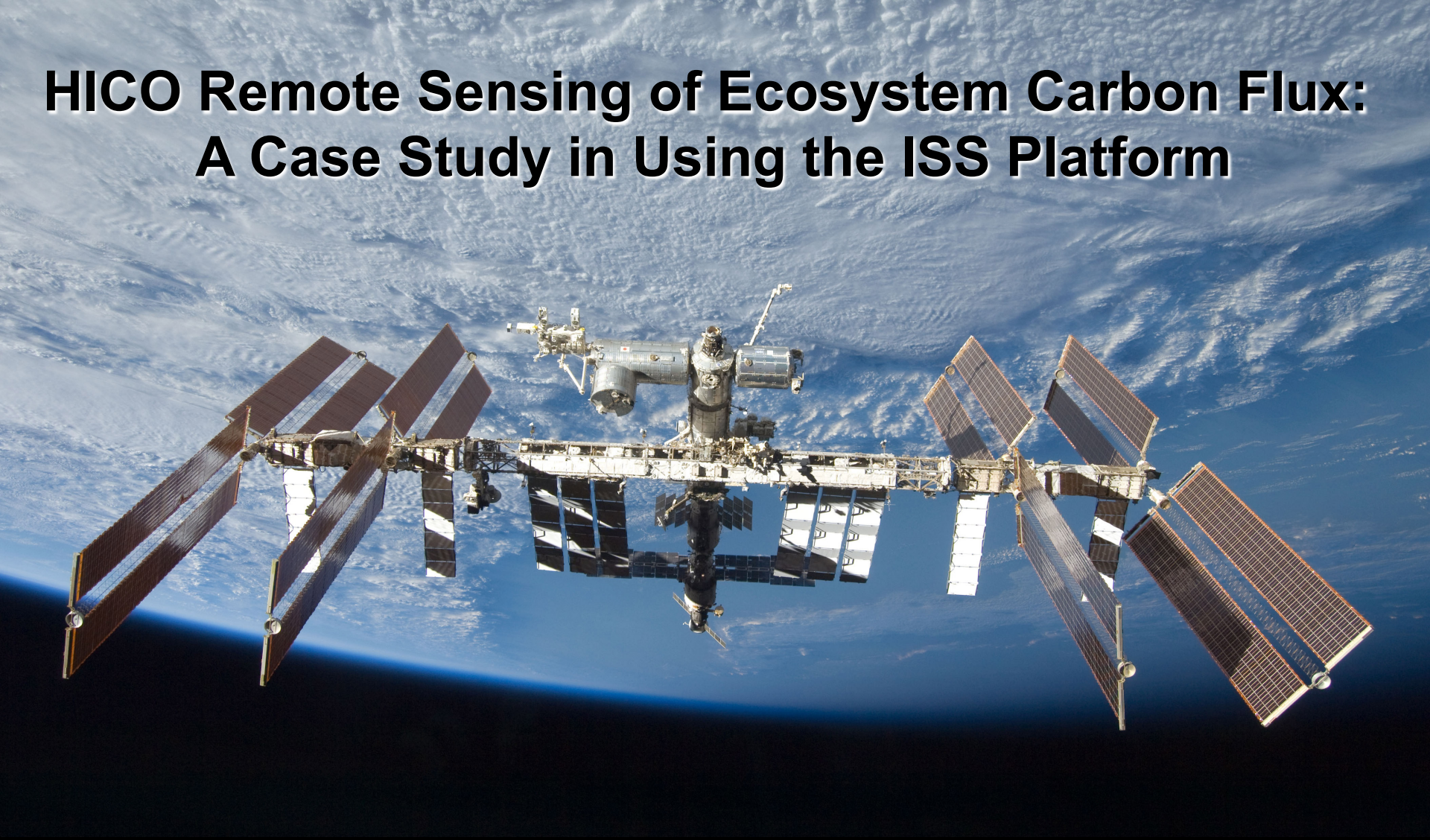
HICO Remote Sensing of Ecosystem Carbon Flux: A Case Study in Using the ISS Platform



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Petya Campbell
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ISS-HICO Terrestrial Ecosystem Study Goals

Determine Gross Ecosystem Production (GEP), the CO_2 uptake by ecosystems, using only spectral reflectance inputs

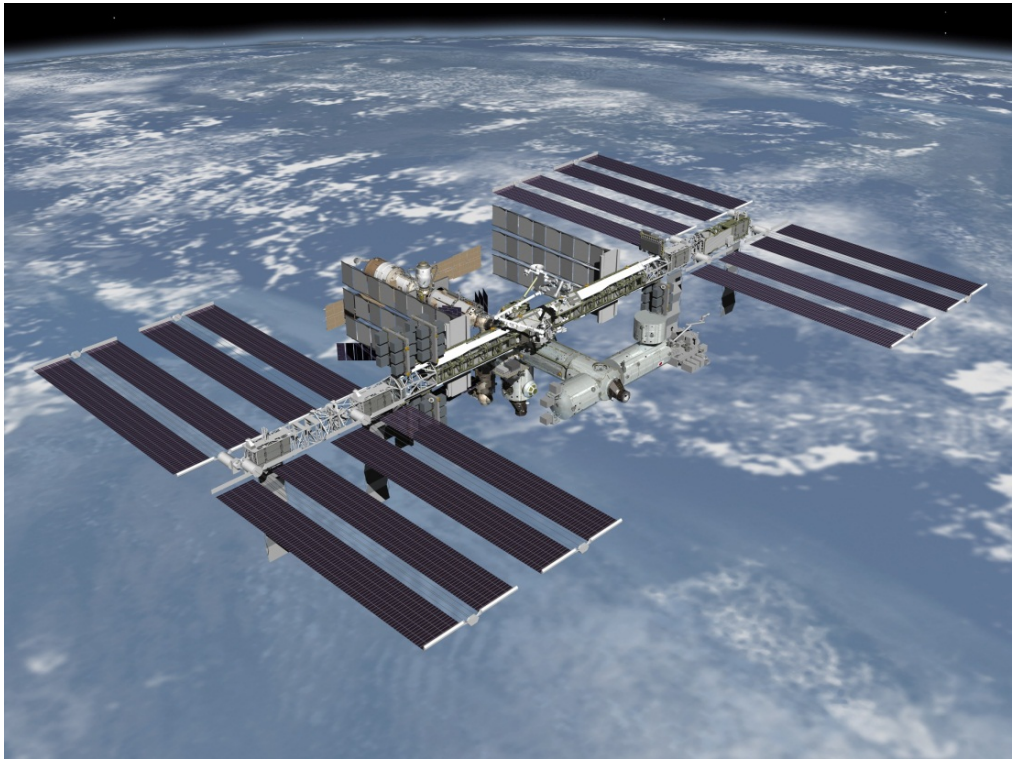
Evaluate the ability to use observations from ISS to examine GEP variability

- Spatially
  - Vegetation types
- Temporally
  - Diurnal
  - Seasonal

ISS Orbit Overview

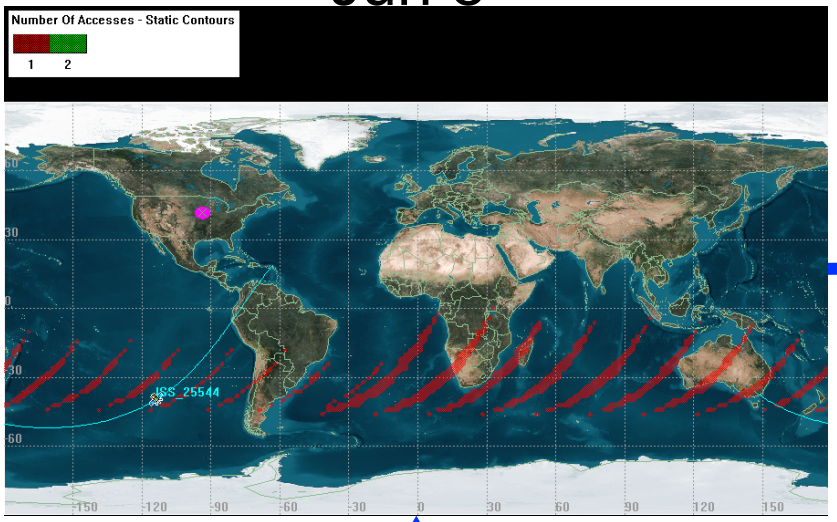
- The ISS orbits the earth at an altitude of about 400 km
  - Orbit altitude decays over time with aerodynamic drag
  - Visiting vehicles reboost the ISS periodically
- The ISS orbit is inclined at 51 degrees to the equator

- The ISS orbit is not sun synchronized
  - Advantage: allows observations of target locations at different times of day
  - Disadvantage: Availability of targets is sometimes constrained by darkness

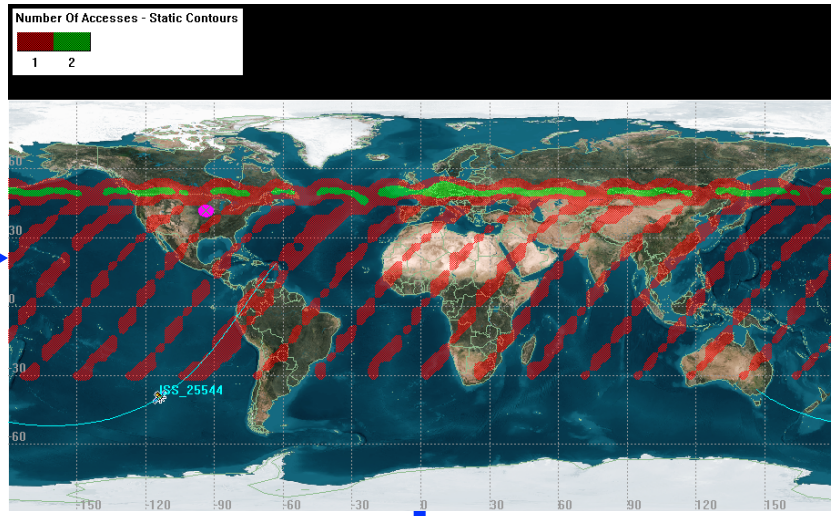


Sample ISS Daylight Observation Opportunities

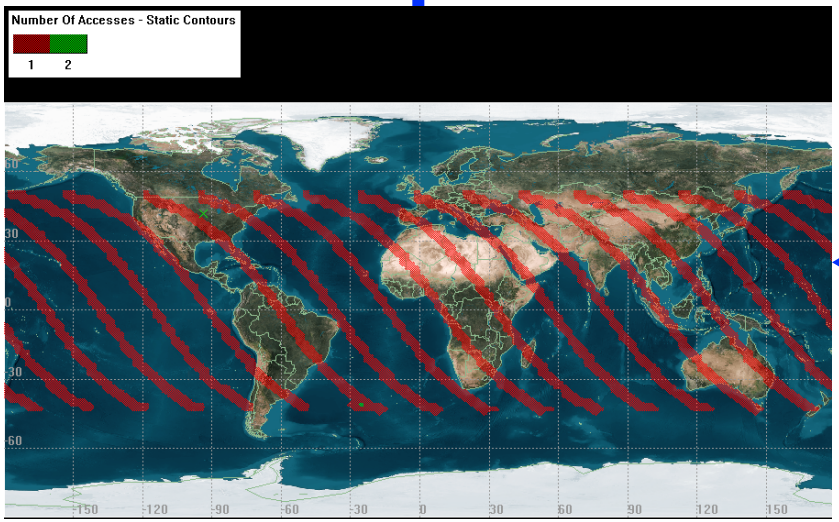
Jun 8



Jun 23



Jul 25



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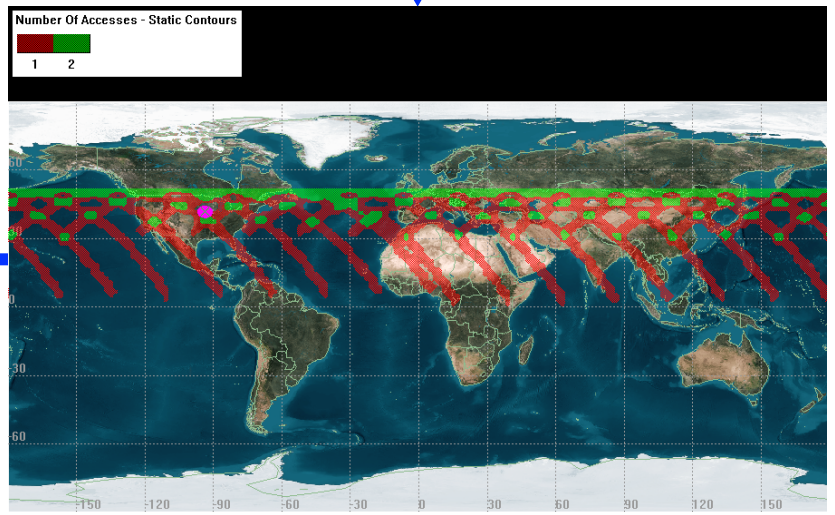
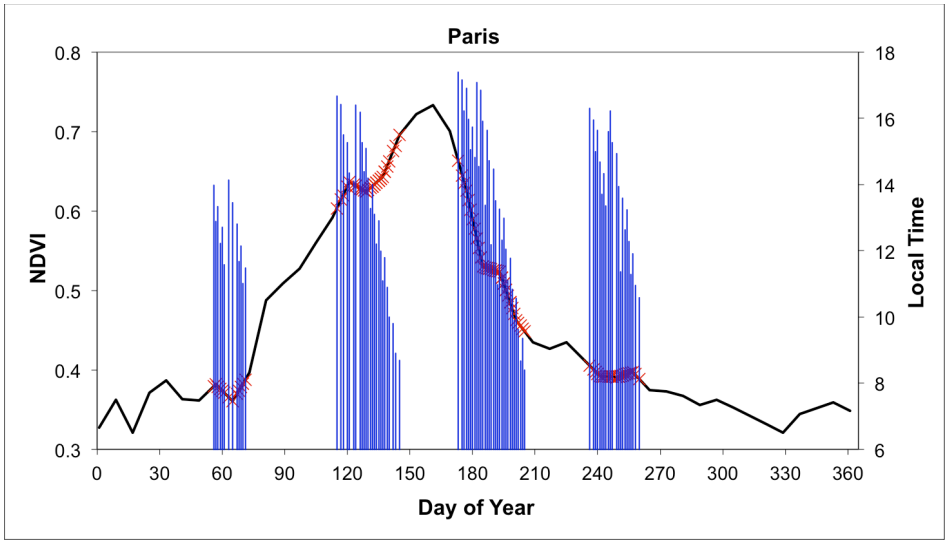
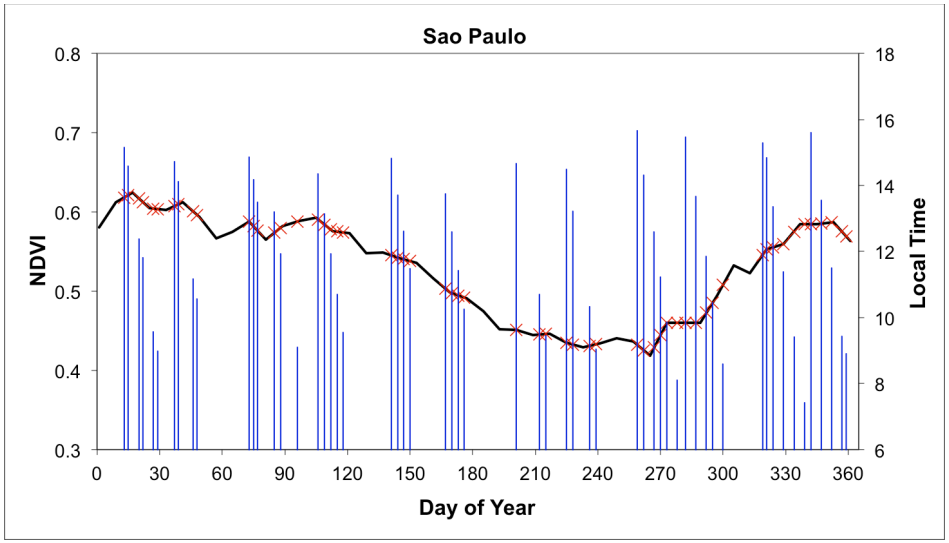


Examples of Timing of ISS Overpasses



Paris 48.9°N

Near the northernmost extent of ISS orbit



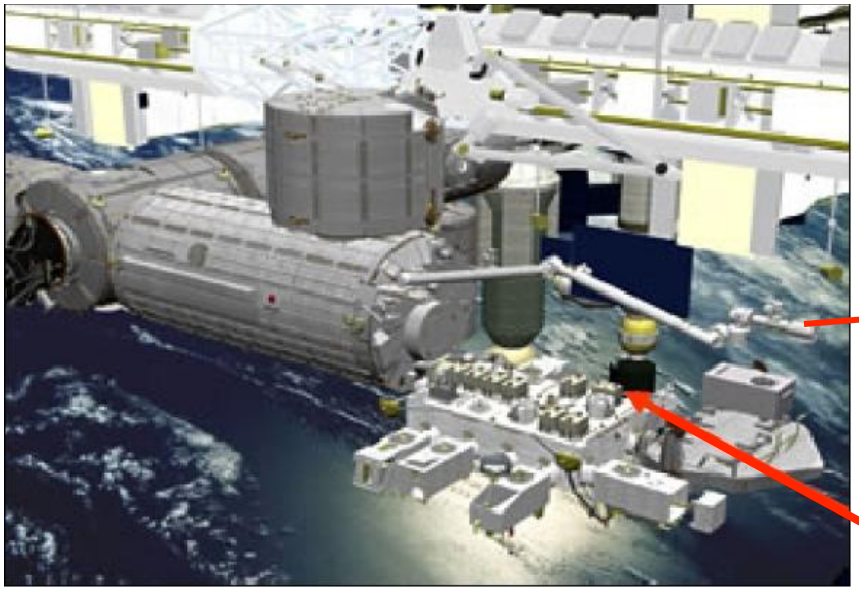
São Paulo 23.5°S

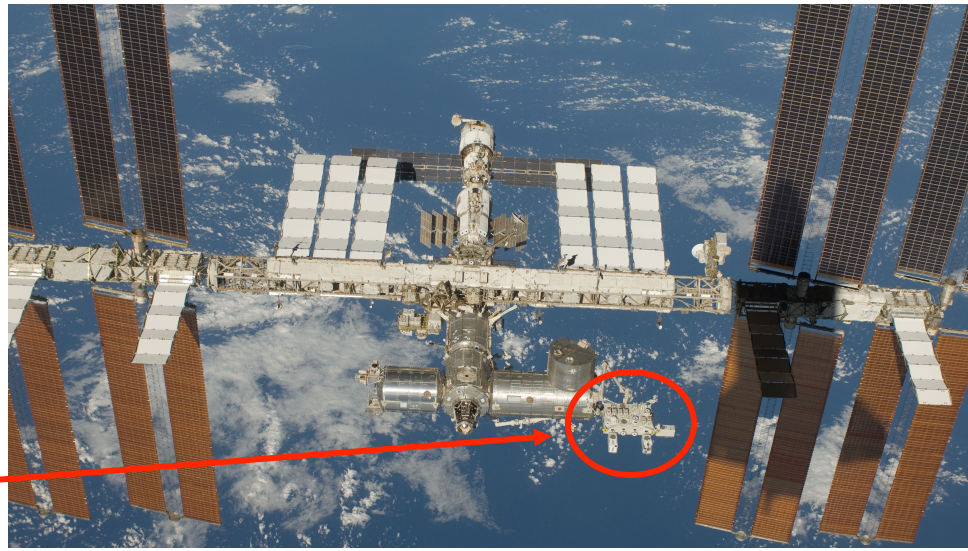
Nearer to the equator

Black line - MODIS NDVI
Position of blue lines - ISS overpass date
Height of blue lines - ISS overpass time

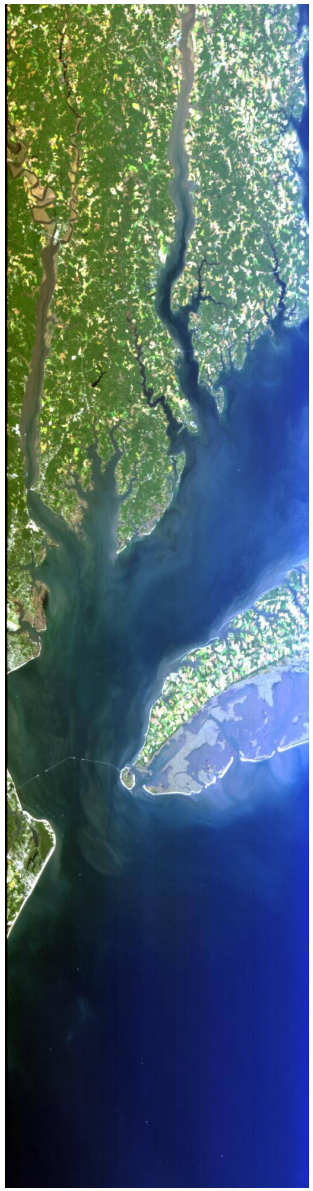
HICO (Hyperspectral Imager for the Coastal Ocean)

- Launched to ISS on September 10, 2009
  - operations ended in September 2014

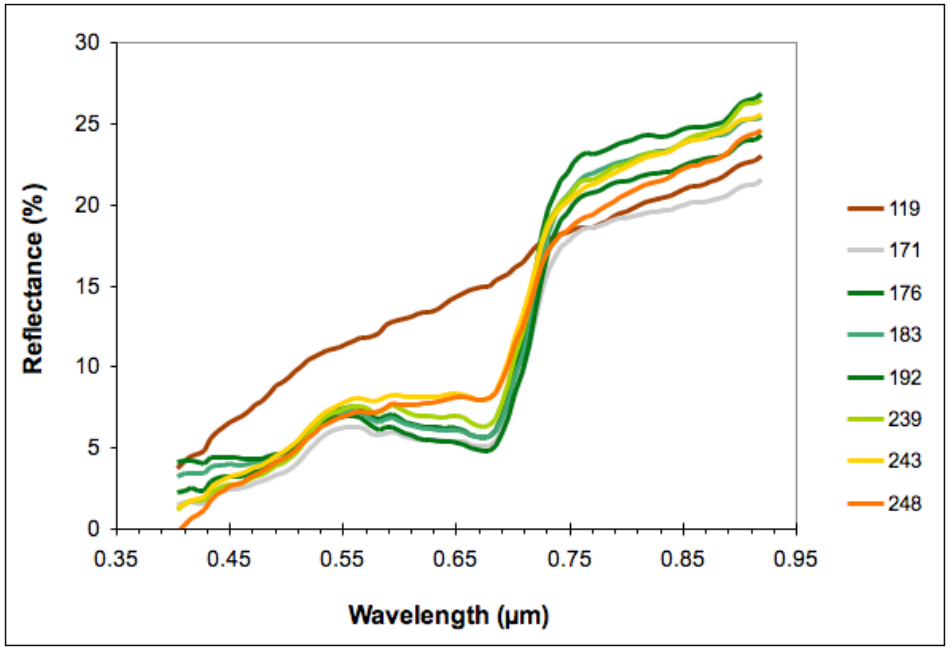




HICO Imagery

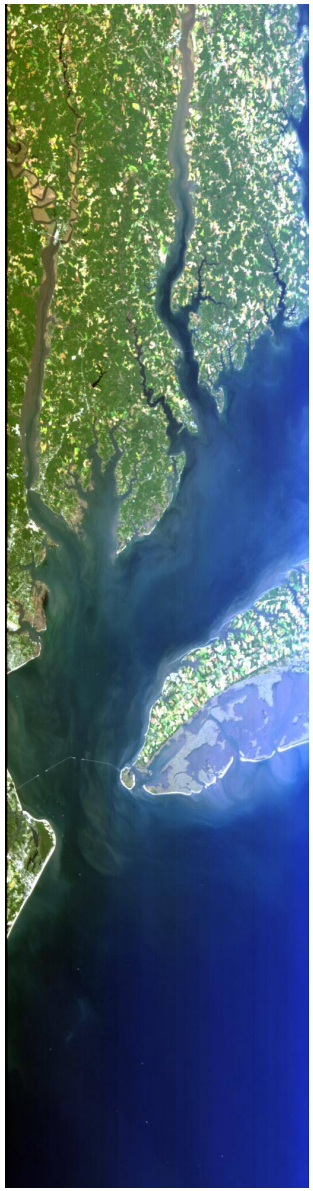


- GSD: ~100 m
- Image size: 42 x 192 km
- Spectral range: 352 - 1080 nm
  - 398 - 920 nm were used
  - 5.7 nm bins

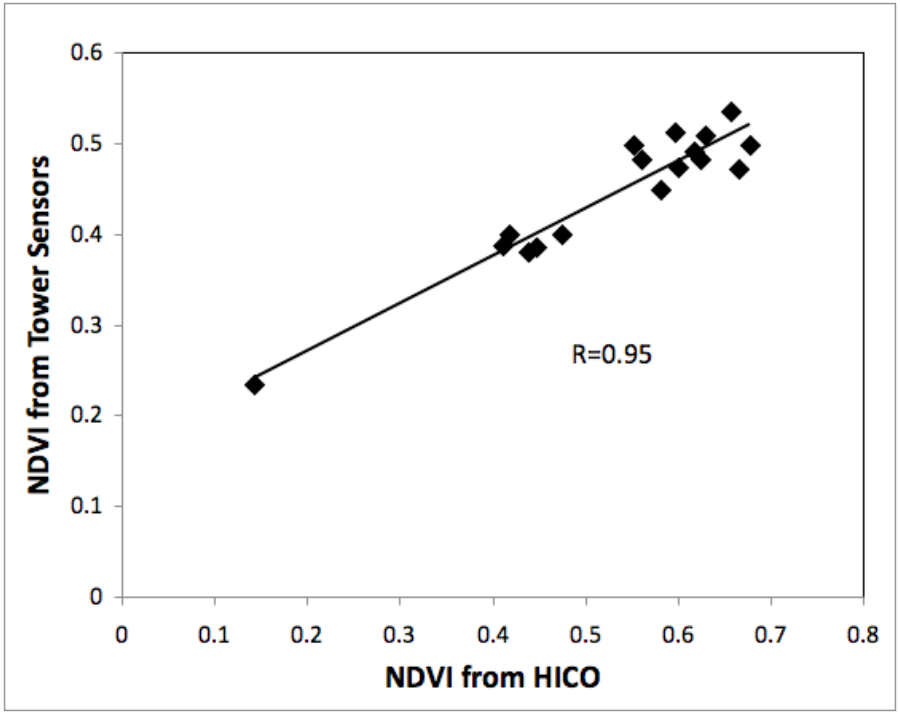


http://www.nasa.gov/mission_pages/station/science/experiments/HREP-HICO.html

HICO Processing

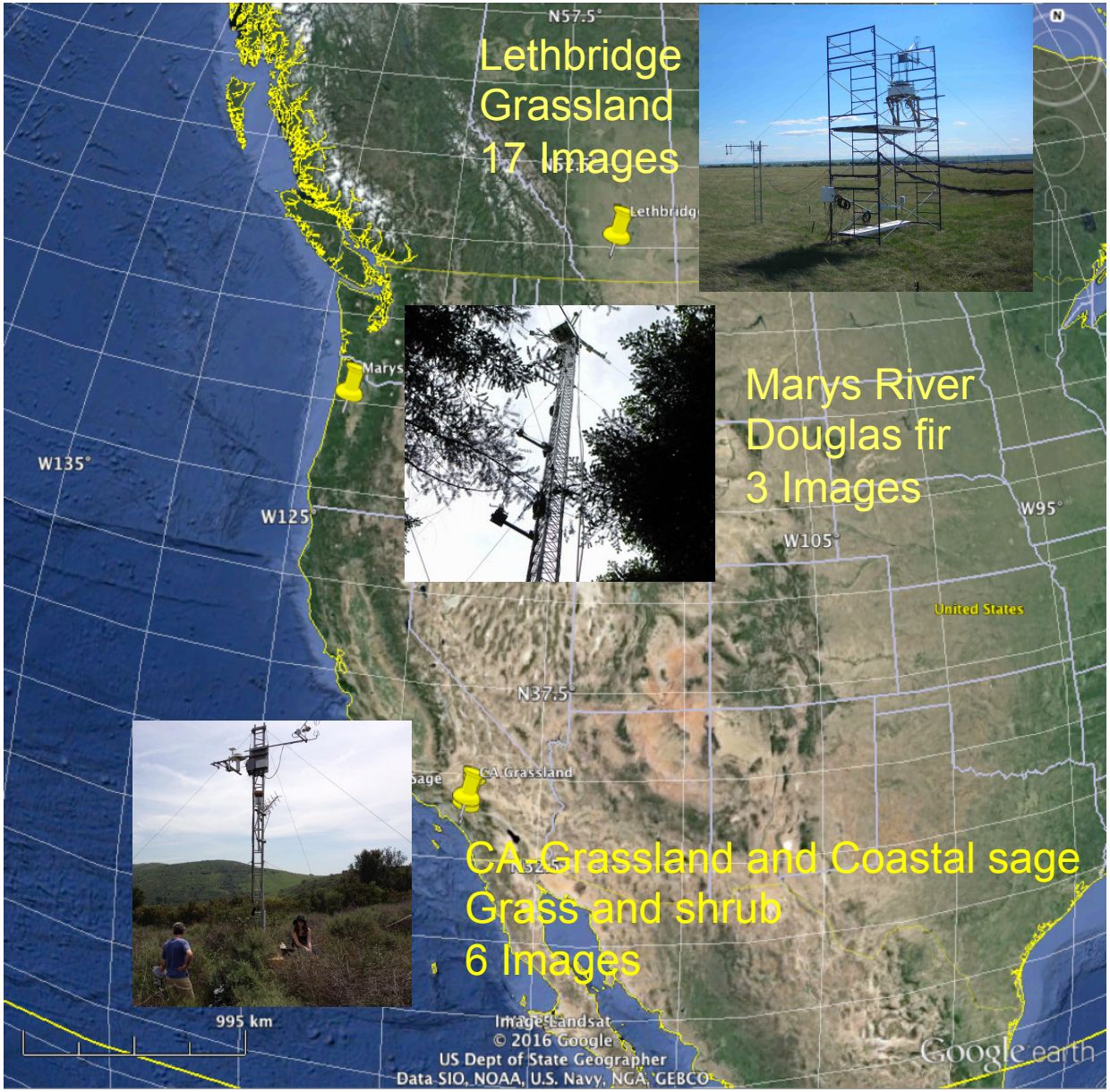


- Atmospherically corrected using ATREM
  - NDVI from HICO compares well with NDVI from tower-mounted radiance sensors

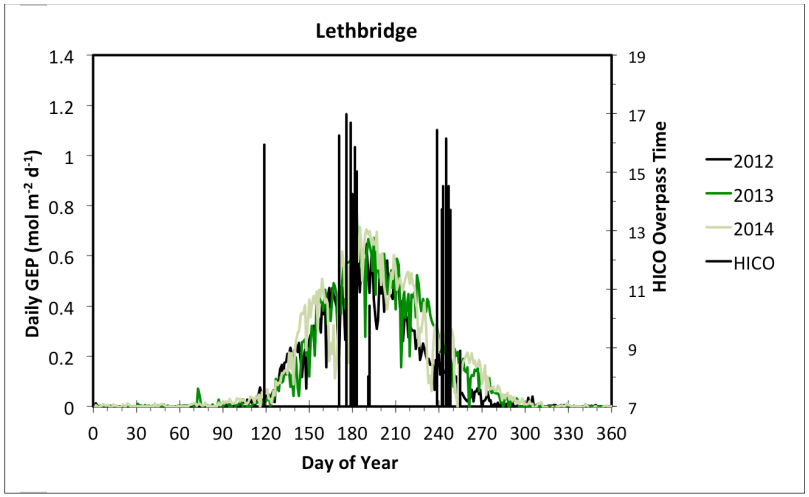


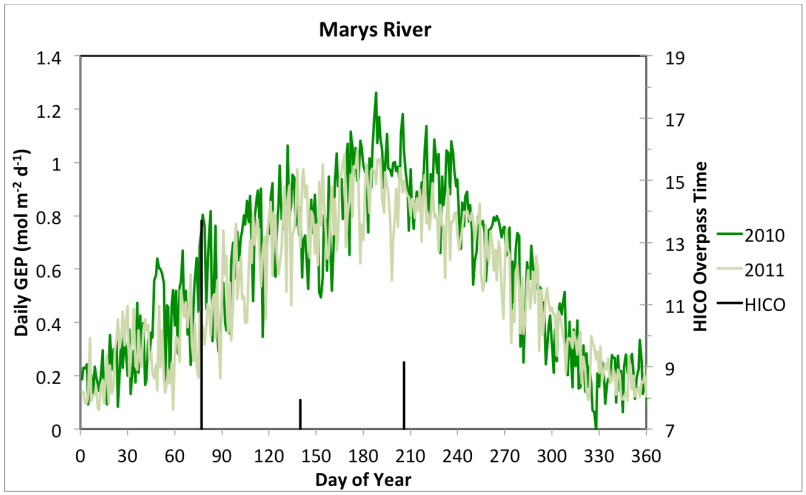
http://www.nasa.gov/mission_pages/station/science/experiments/HREP-HICO.html

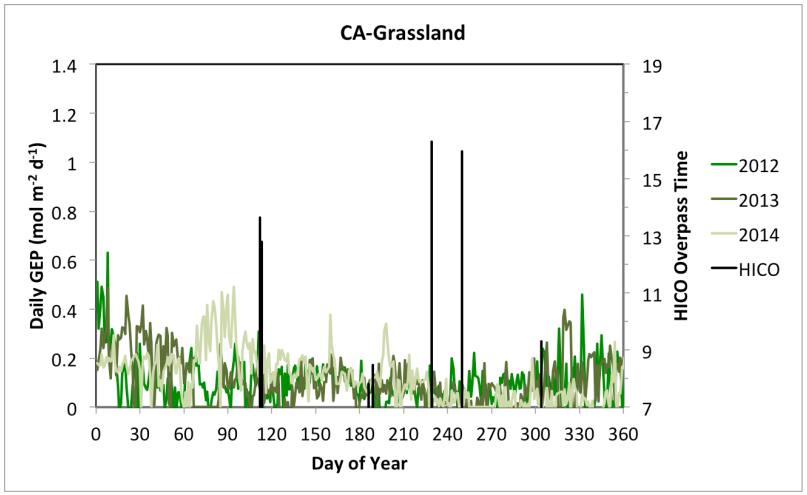
Study Sites

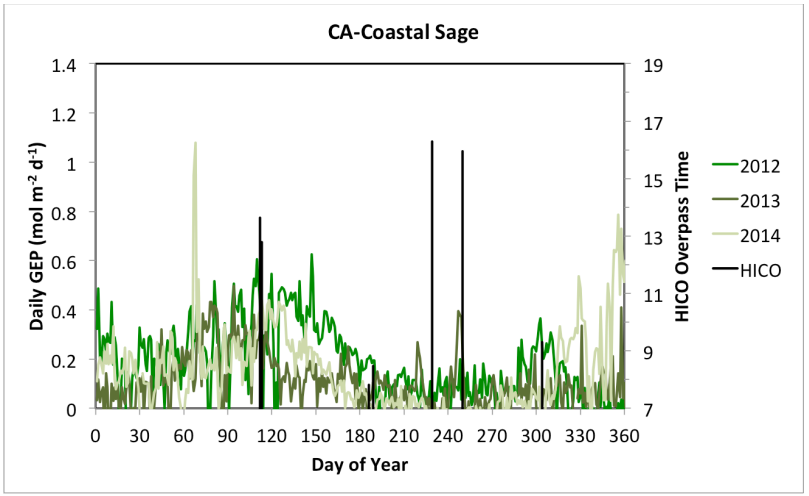

Lethbridge
Grassland
17 Images
Marys River
Douglas fir
3 Images
CA-Grassland and Coastal sage
Grass and shrub
6 Images
N57.5°
W135°
W125°
W105°
W95°
N37.5°
United States
Marys
CA Grassland
995 km
Image Landsat
© 2016 Google
US Dept of State Geographer
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth

Daily GEP and HICO at Study Sites

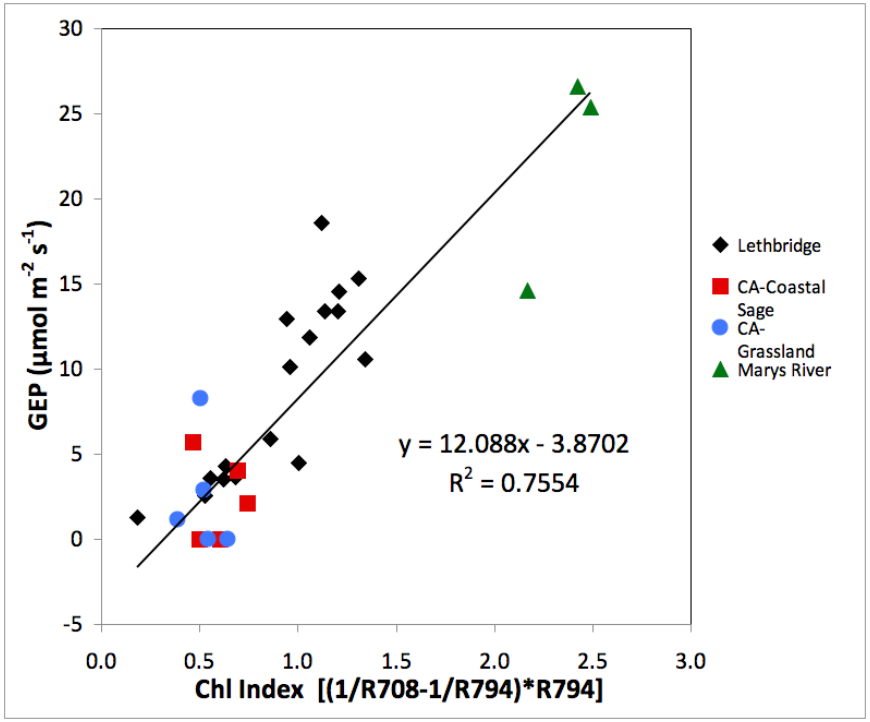


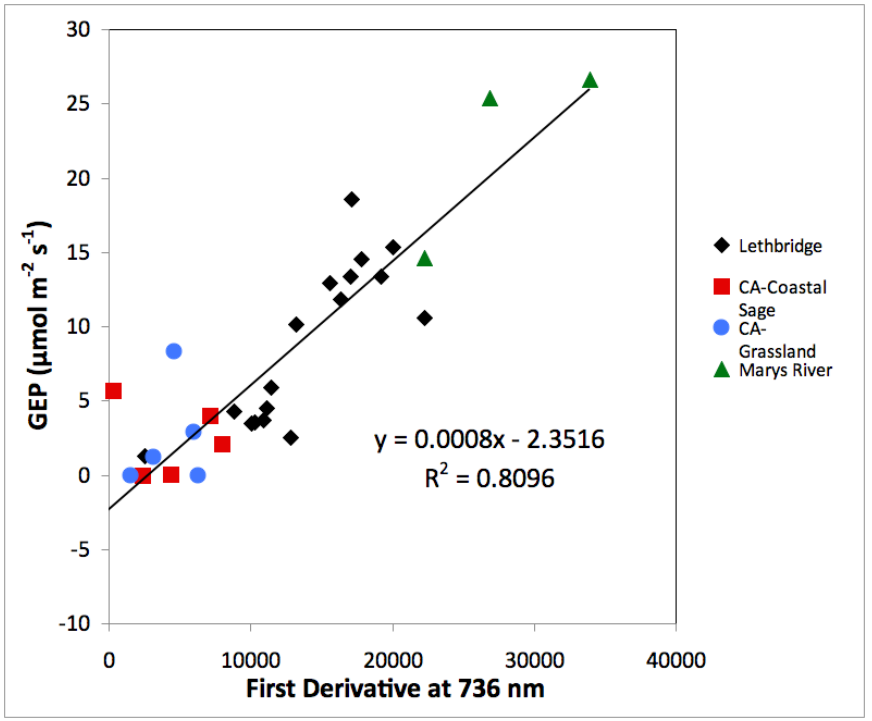


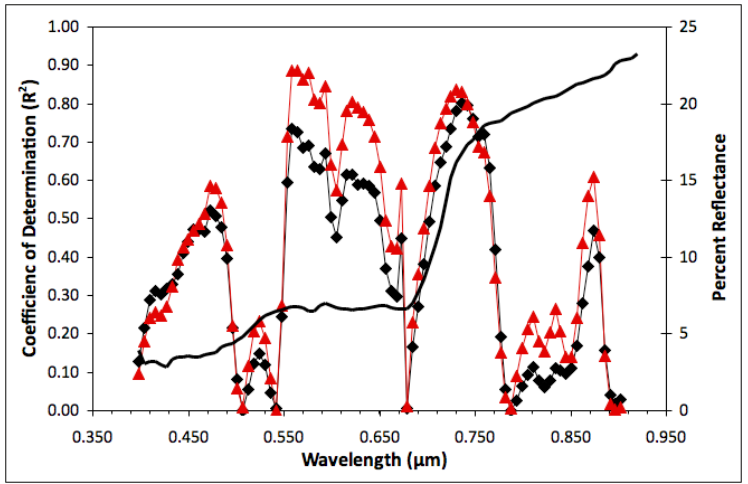




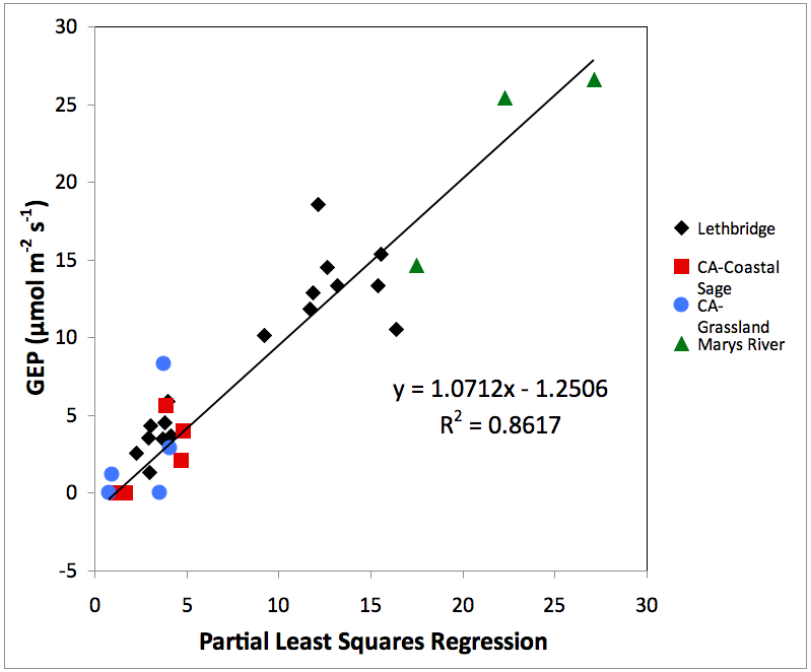
Estimating GEP Using Spectral Indices

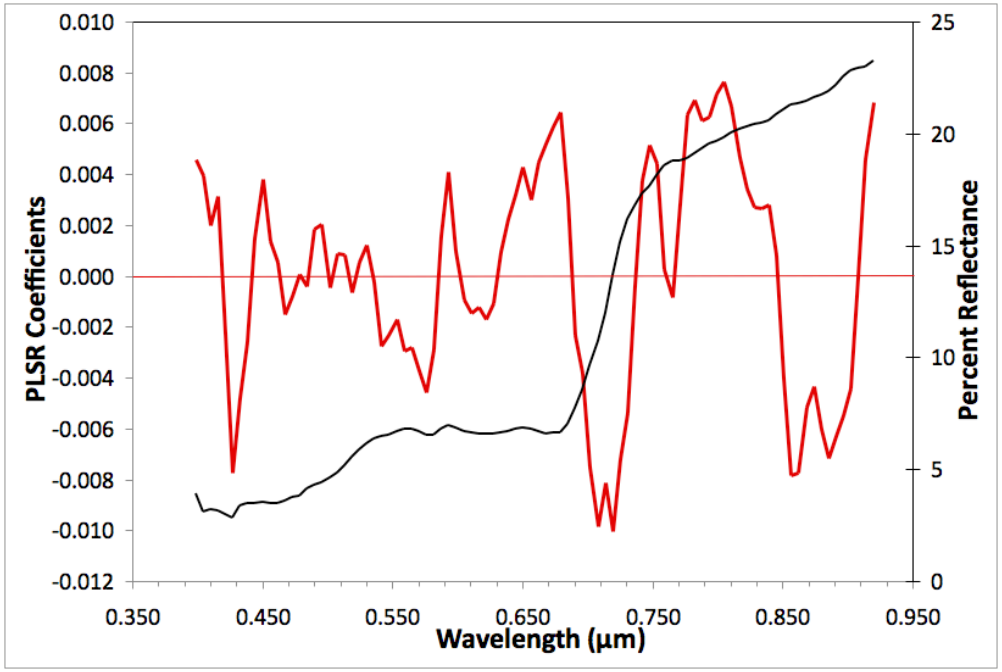






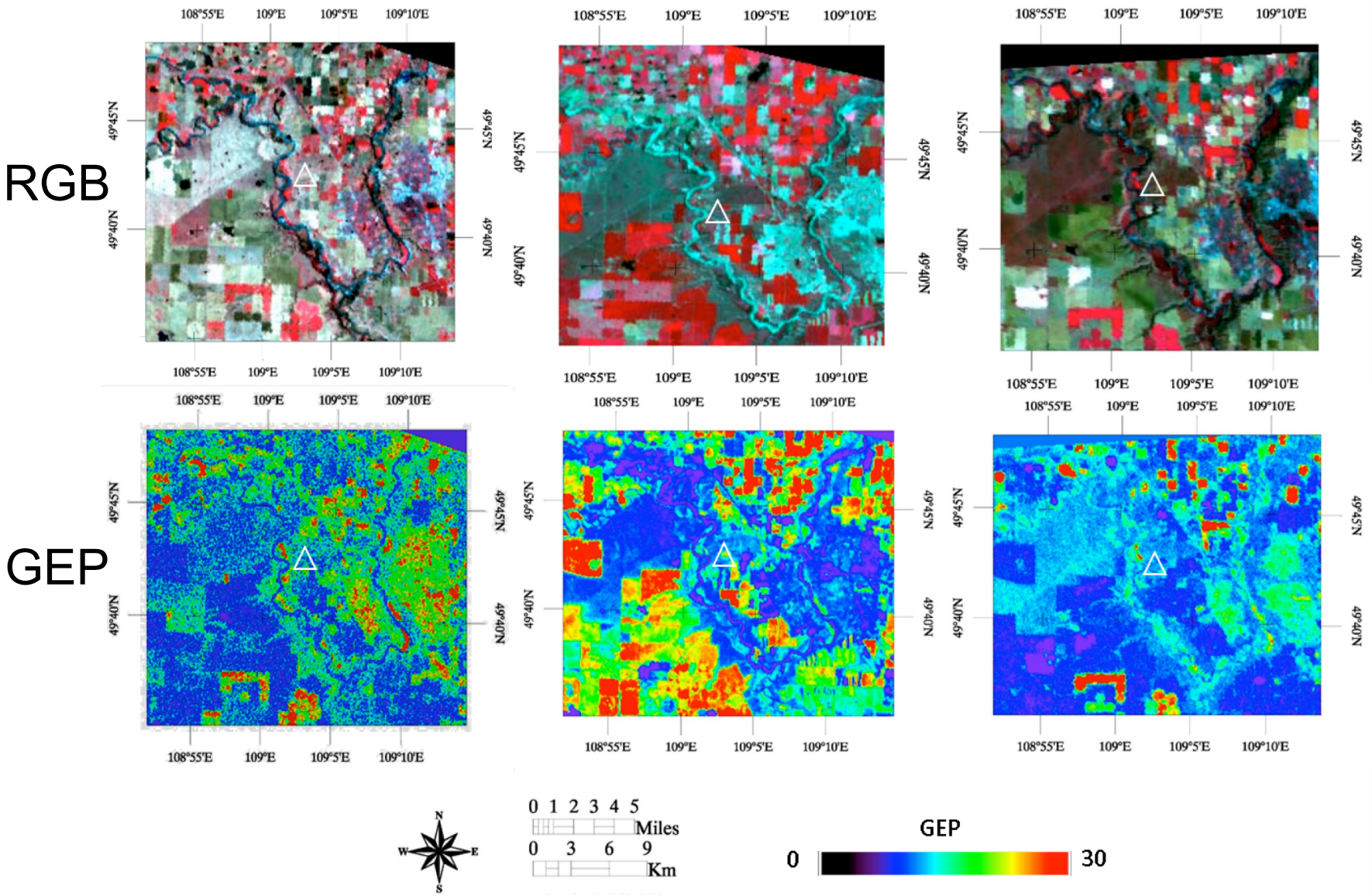
Estimating GEP Using PLSR





Partial Least Squares Regression uses information from all of the spectral bands

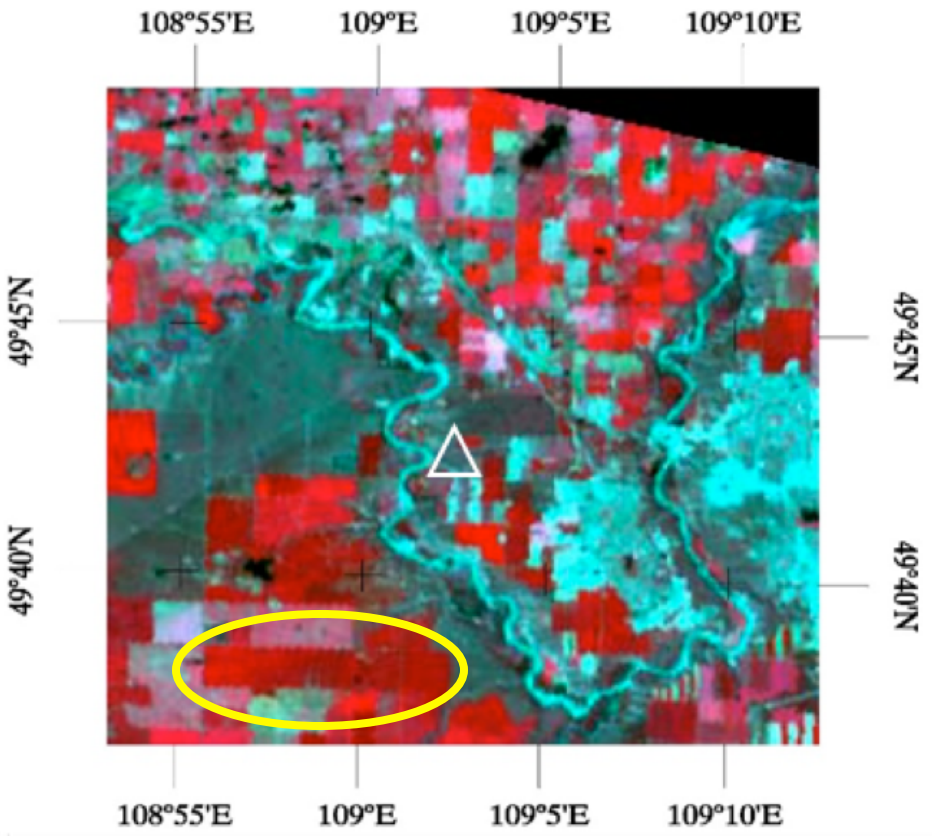
Seasonal Change at Lethbridge



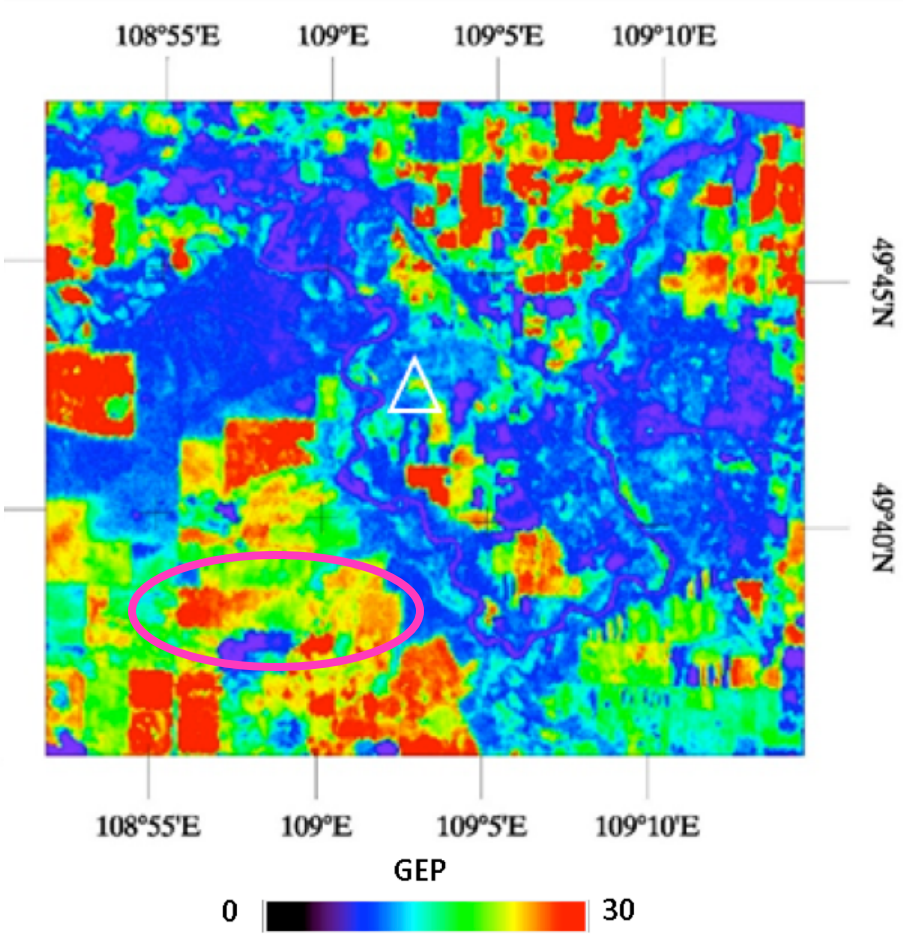
Lethbridge Summertime

Day 183, 2013

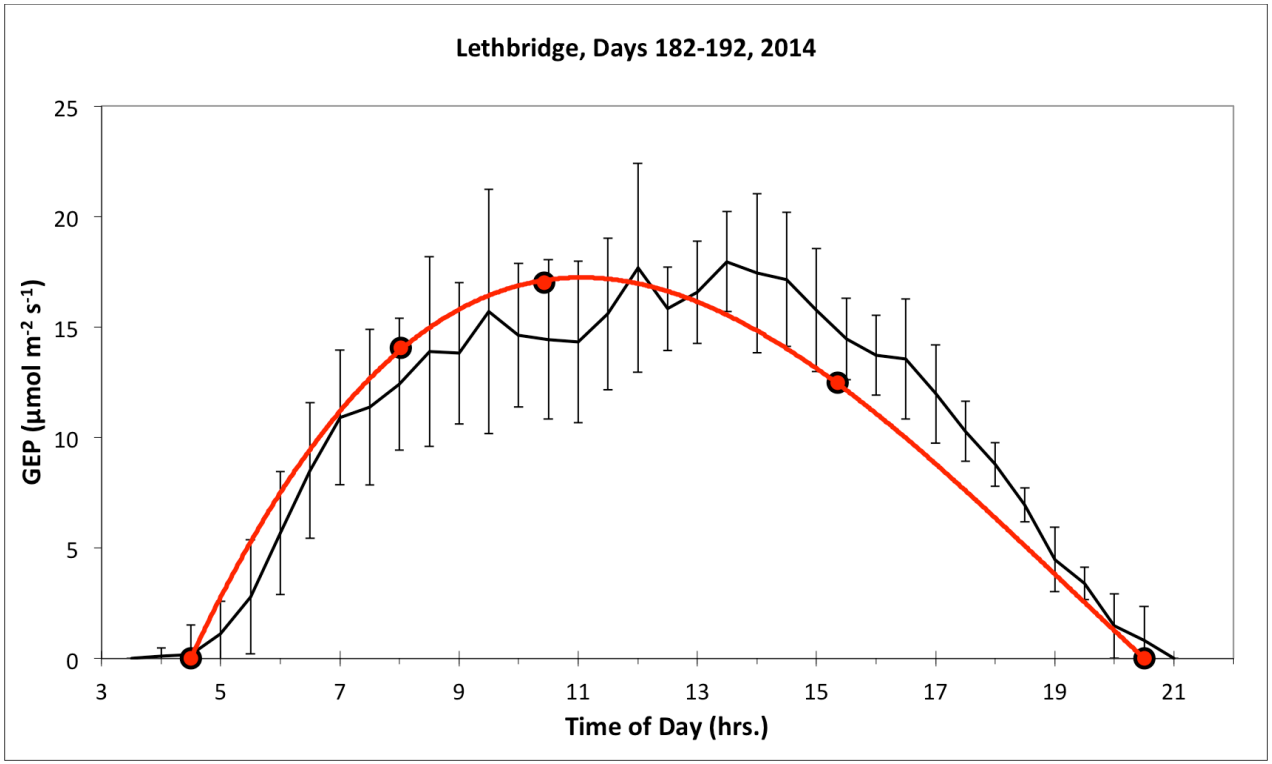
RGB



GEP

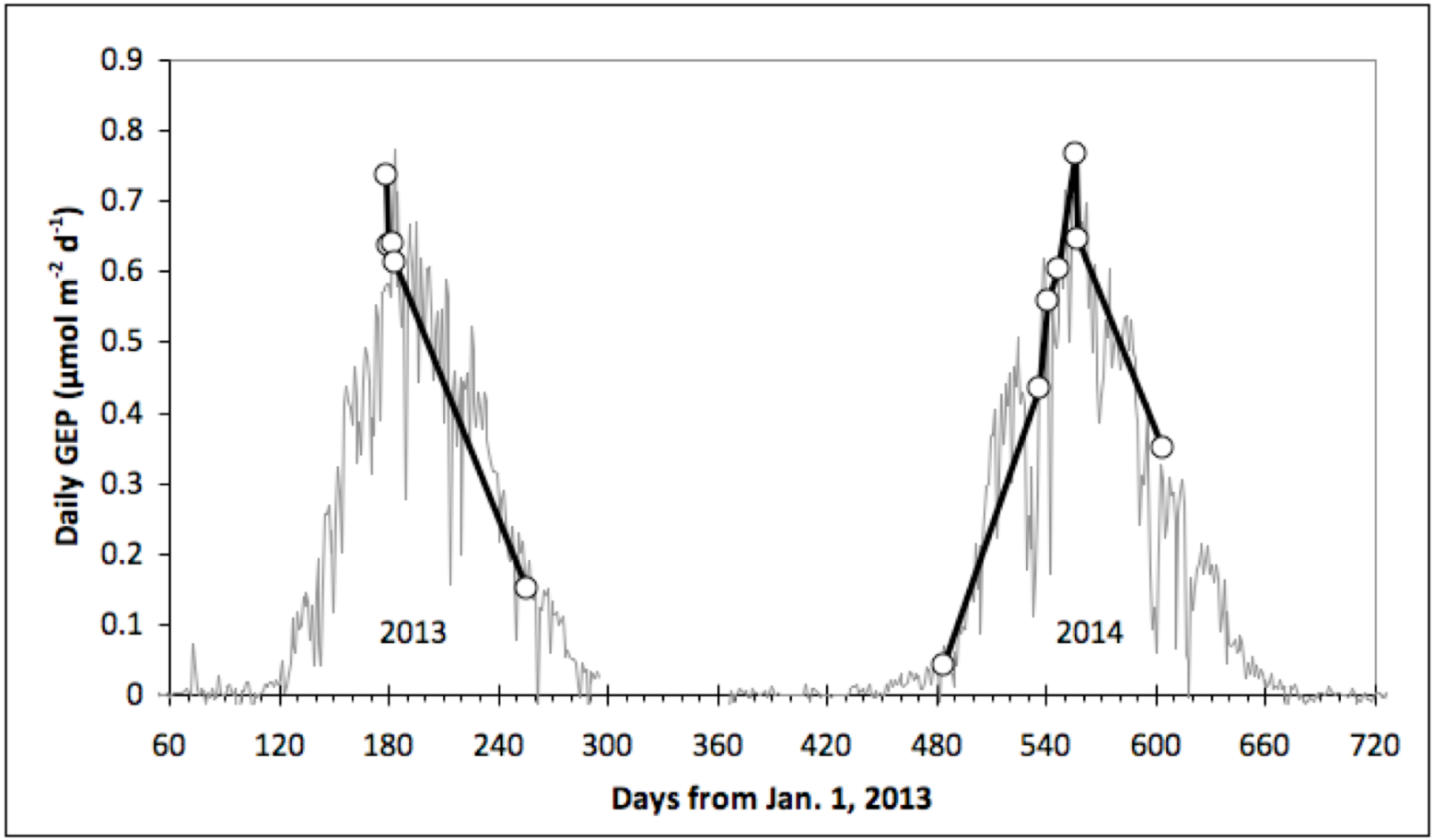


Estimation of Diurnal GEP



- 3 HICO observations within an 11-day period
  - during green-up near summer peak at Lethbridge
  - r^2=0.89 and RMSE=1.97 µmol m^{-2} s^{-1} compared to 30 minute averages of flux tower data over period

Estimation of Seasonal GEP



- Points are HICO estimations of daily GEP compared with flux tower measurements

Conclusions

- HICO quality data can be used to estimate terrestrial ecosystem productivity
  - Found multiple promising spectral approaches
  - Approaches work through the growing season, diurnally, over multiple years, and across sites
- ISS is a usable platform for these studies
  - There are periods during growing season with frequent observations
  - But also periods with no daylight observations
  - Variability in overpass times and data gaps may complicate development of time series

Thanks!

We would like to thank everyone who helped:

– The HICO mission office

– Bo-Cai Gao for atmospheric corrections of HICO data

– Dan MacKenzie for the ISS orbital calculations

– Dave Landis for help with graphics

– Larry Flanagan, Mike Goulden, and Bev Law for providing the flux data;

– The Center for the Advancement of Science in Space (CASIS) which supported this research through a grant for Remote Sensing from the International Space Station.