

Really Distributed Sensing

Howard L. Davidson
Sun Microsystems



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Sun Microsystems

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Problem

- How do you sense the distribution in time and space over the surface of the earth of parameters that don't have a direct electromagnetic signature?
- Examples:
 - Low concentrations of organic chemicals
 - Organisms
 - Low concentrations of metals in soil and water
 - Mineral and nutrient content of soil
 - Minefields

Why Not Look Directly on the Ground?

- It's expensive
 - May want millions of points
 - Inaccessible areas
 - Want data over long periods of time

Plants as Transducers

- Ordinary plants respond to common environmental variables
 - Can see drought and fertilizer use on croplands from orbit
 - Can see graves and ruins
- Bioengineering can add many new high specificity sensitivities

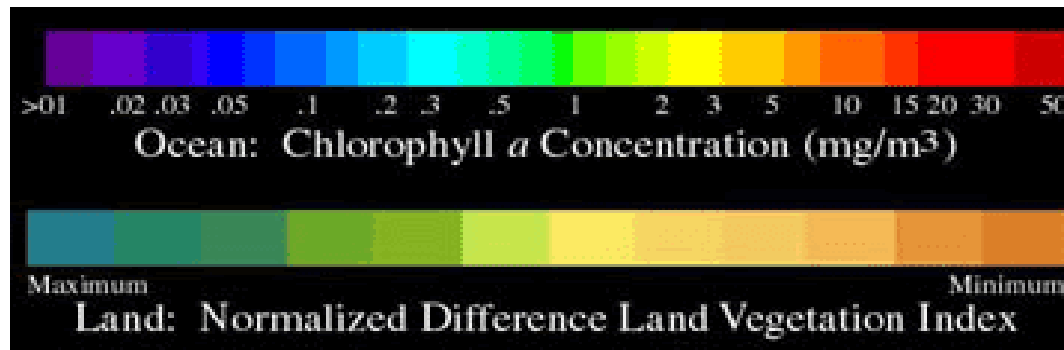
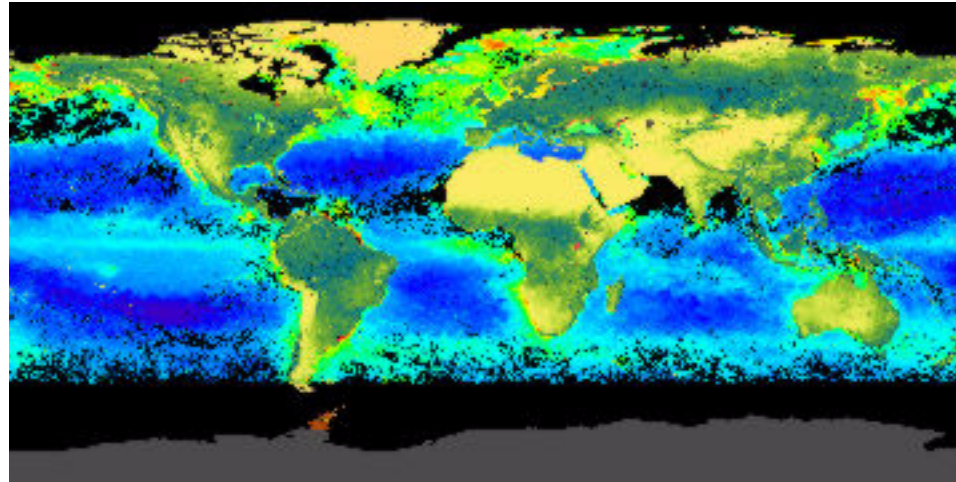
Engineering Plants as Sensors

- Easy output variables are color and fluorescence
 - Doesn't have to be in visible, near IR is accessible
 - Should have reference companion color
- Input variable must be coupled to plants metabolism
 - Upregulate or downregulate chromophore expression
- Many variables potentially available
 - Temperature, integrated sunlight, water, CO₂, nutrients are easy
 - Almost any element and protein potentially possible
 - TNT has been shown possible

Engineering Plants as Sensors...

- Depth of sensing controlled by root depth
 - Grass versus Canadian Thistle
- Hybrid soil fungus and plant systems can extend depth range
- Algae and aquatic plants for lakes, rivers, and oceans

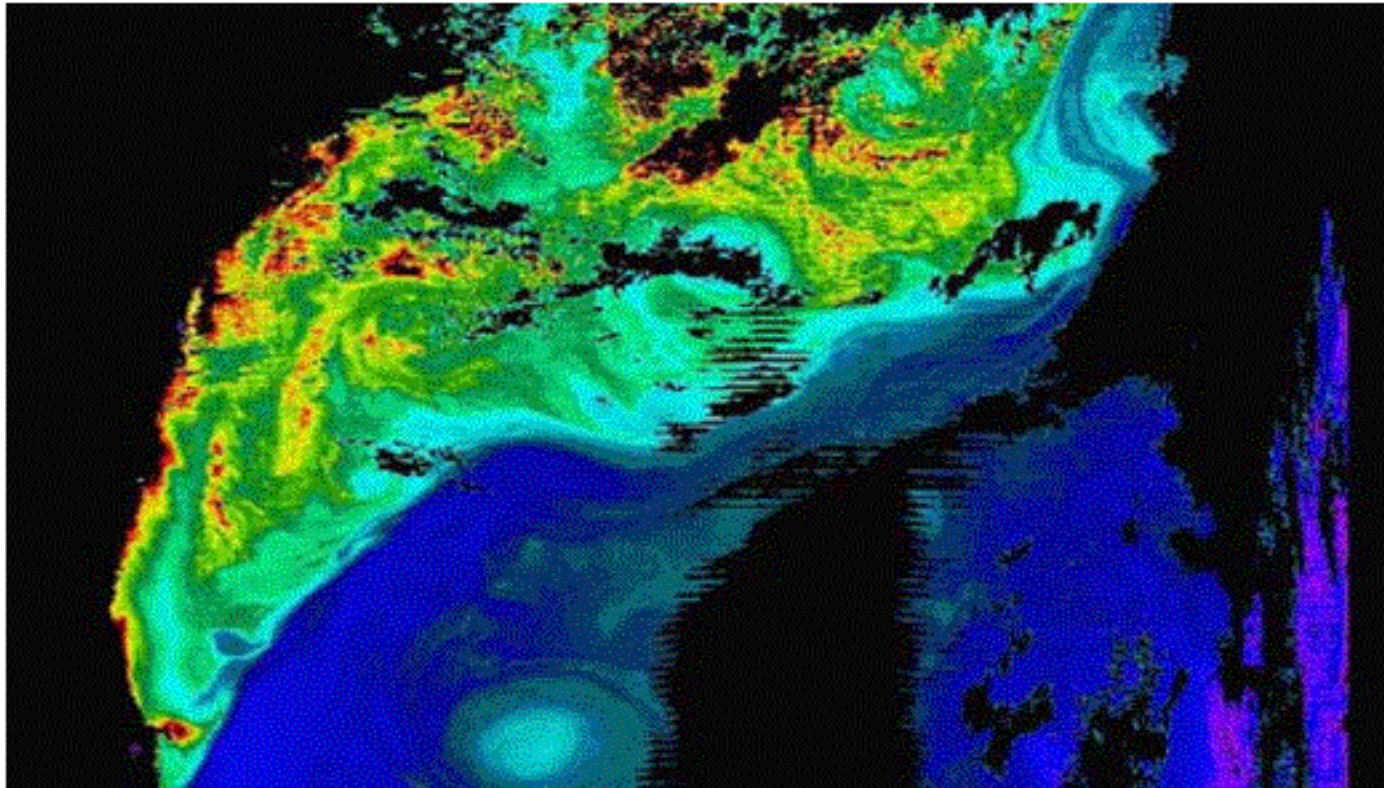
Chlorophyll and Vegetation



Processed Landsat data from www.nasa.gov



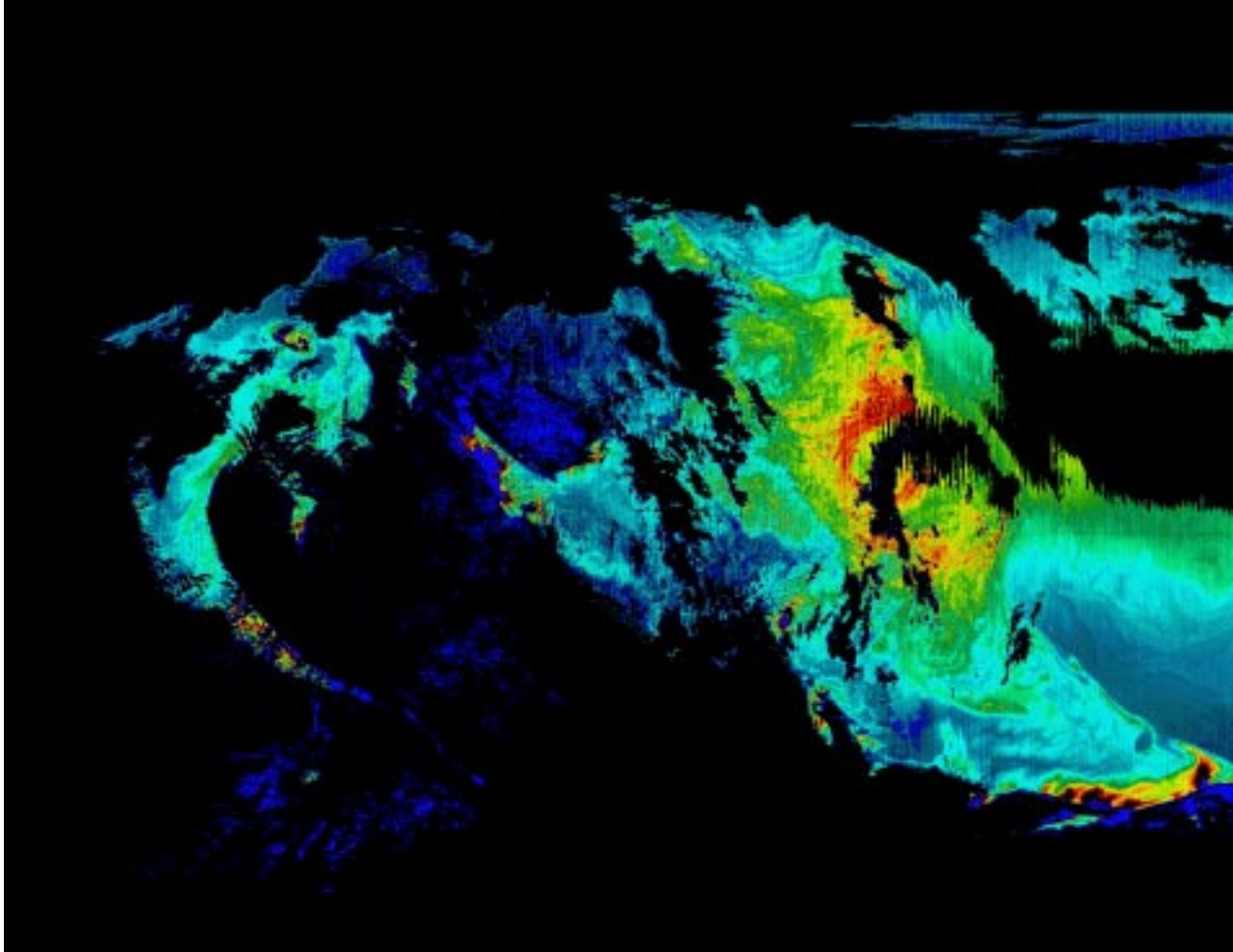
East Coast Chlorophyll for May 8, 2000



Red=high, blue= low. Glint correction, but no glint mask. Glint pattern shows where data saturate. Pattern near Gulf Stream and in rings reveals wind-current interactions in sfc wave & glint field, and correction is based only on NCEP winds.

MODIS Ocean/RSMAS/GSFC Sept 18, 2000

Chlorophyll Fluorescence



Mark Abbott, MOD-EC-129.1545_Lw_678_corrected.gif

Color

VIGS for identification of N-signal transduction pathway components

We are using virus induced gene silencing (VIGS) and the potato virus X (PVX) vector developed by the Baulcombe lab to test candidate genes for function in N-mediated resistance. We have successfully established the gene silencing system using the visual reporter geophytoene desaturase PDS and the N gene.

Virus induced gene silencing (VIGS) of phytoene desaturase (PDS) in *N. benthamiana*

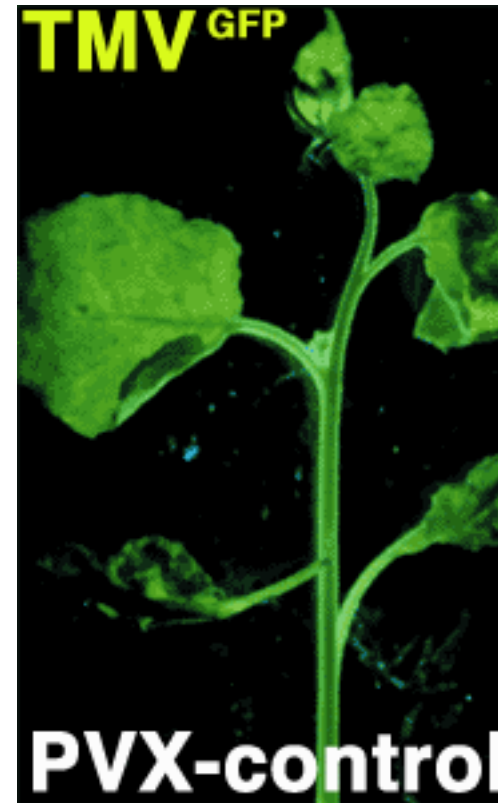
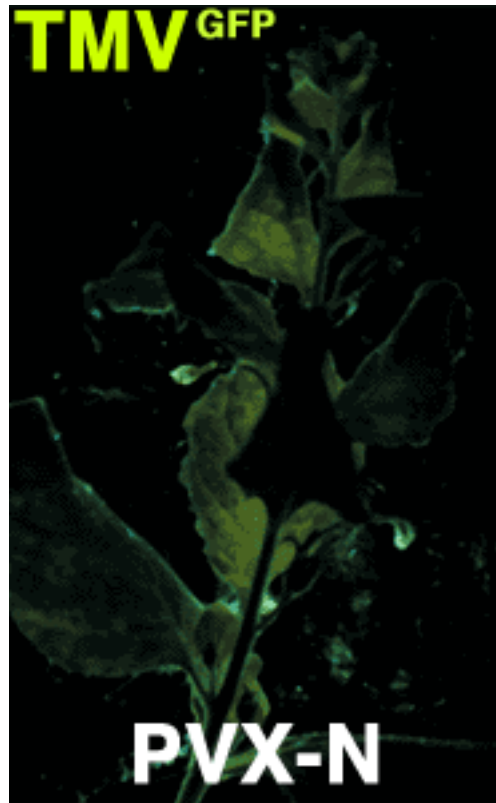


<http://www.bakerlab.usda.gov/BakerLab/research7.html>

Fluorescence

VIGS of N in *N. benthamiana*: NN leads to TMV-GFP spread

N silenced TMV: susceptible



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System Considerations

- Pixel size
 - 100 m X 100 m easy, 2 m X 2 m possible
- Non-food plants are good candidates
 - Highway median groundcover
 - Weeds
 - Fiber sources, i.e. cotton, pine trees
 - Lawns
 - Flowers
 - Decorative shrubs

Public Acceptance

- Don't use food crops
- May need to be sterile
- Plant should express no unusual proteins
 - Many existing plant chromophores available
 - Don't express insecticide or antibiotic resistance proteins
- Interesting, but unlikely, species
 - Kudzu, dandelions, kentucky blue grass, marijuana, cocoa, opium
- Good biotech portal: <http://www.nature.com/netguide/biotech/intro.html>