Science & Applications of Direct Broadcast for HyspIRI

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Any errors or omissions are the responsibility of the authors.

Rapid delivery applications

- HyspIRI TIR and VSWIR will deliver unprecedented spatial, spectral, and temporal resolution data compared to prior Multi and Hyper Spectral instruments (AVHRR, MODIS, ASTER, Hyperion,…)
- Many applications of this data benefit form rapid data delivery
  - Volcanoes, Wildfires, Ice, Ocean, Weather,...
- HyspIRI is considering a Direct Broadcast (DB) Option provided it does not significantly increase cost (HW, SW, Operations)

Methodology

- Studied current Direct Broadcast Applications
  - Primarily MODIS, but included others
- Contacted members of HyspIRI science working group (based on 2008 workshop package leads)
  - Contacted others based on disciplines
- Leveraged prior work with similar instruments
  - MODIS, ASTER, Hyperion, ALI, ETM+,…
- Studying bands required, ancillary information required, complexity of processing (benchmarking)
- <u>The following is a work in progress, we invite further participation to refine it further</u>

Applications

- Snow & Ice
- Dust
- Ecosystem, Vegetation, Plant Stress, Species
- Ocean and Coastal
- Volcanic
- Flood
- Fire

Snow & Ice Applications

- Products
  - Snow Water Ice Land maps
  - Lake ice, sea ice, glaciers
- Heritage
  - Hyperion, MODIS, ASTER, AVHRR, Landsat ETM+

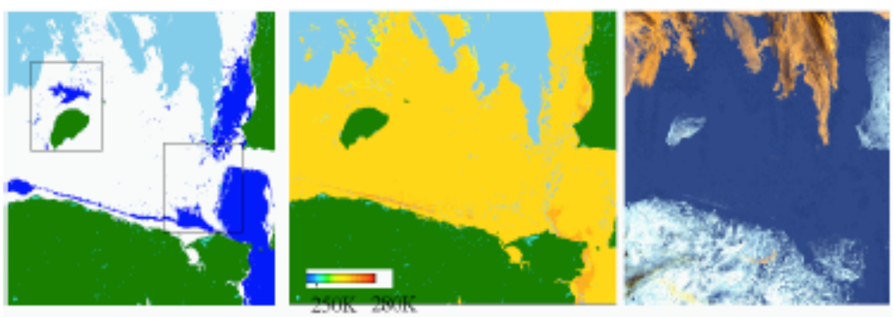


Figure 4: MODIS sea ice product by NDSI method (left), IST method calculated temperatures (center), and a composite image made from MODIS Bands 20 (3.7μm), 22 (3.9μm) and 23 (4.0μm) to highlight clouds (right).

Image courtesy of [Scharfen and Kalsa 2003]

- Applications
  - Global energy balance
  - Iceshelf breakup and freeze
  - Environmental sustainability
  - Climate models
  - Sea traffic

- Challenges
  - Discriminating between snow, ice, and cloud features
  - Snow/Ice-covered unobservable if under cloud-masked area
  - Low-light
  - Melt season when temperature of ice and ocean water are similar

Snow Heritage (ground) - MODIS

- MODIS snow cover product: MOD 10
- Snow/ice bands for mapping algorithms: 4, 6, 7, 13,16, 20, 26, 31, 32 (0.4-12μm)

- NDSI= (b4-b6)/(b4+b6)
- Snow determined if:

  NDSI ≥ 0.4

  B2 (NIR) ≥ 0.11

  B4 (green) ≥ 0.1

- NDSI and BTD (3.7μm - 11μm) differentiate snow from cloud

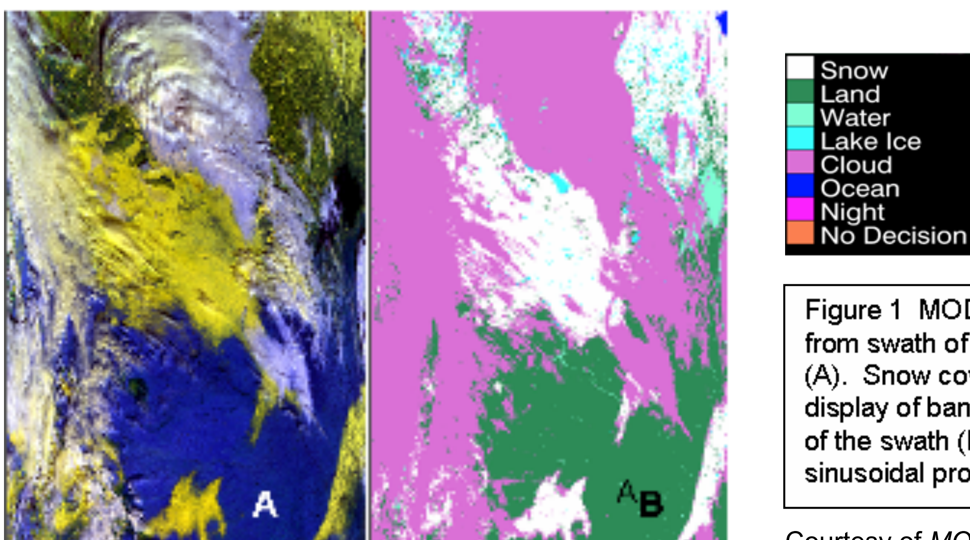


Figure 1 MODIS at-satellite reflectance image from swath of MOD02HKM for 3 January 2003 (A). Snow cover appears as yellow in this display of bands 1, 4 and 6. Snow cover map of the swath (B) and the snow cover map in sinusoidal projection (C).

Courtesy of *MODIS Snow Products User Guide, Riggs et al.*

Ice Heritage (ground)- MODIS

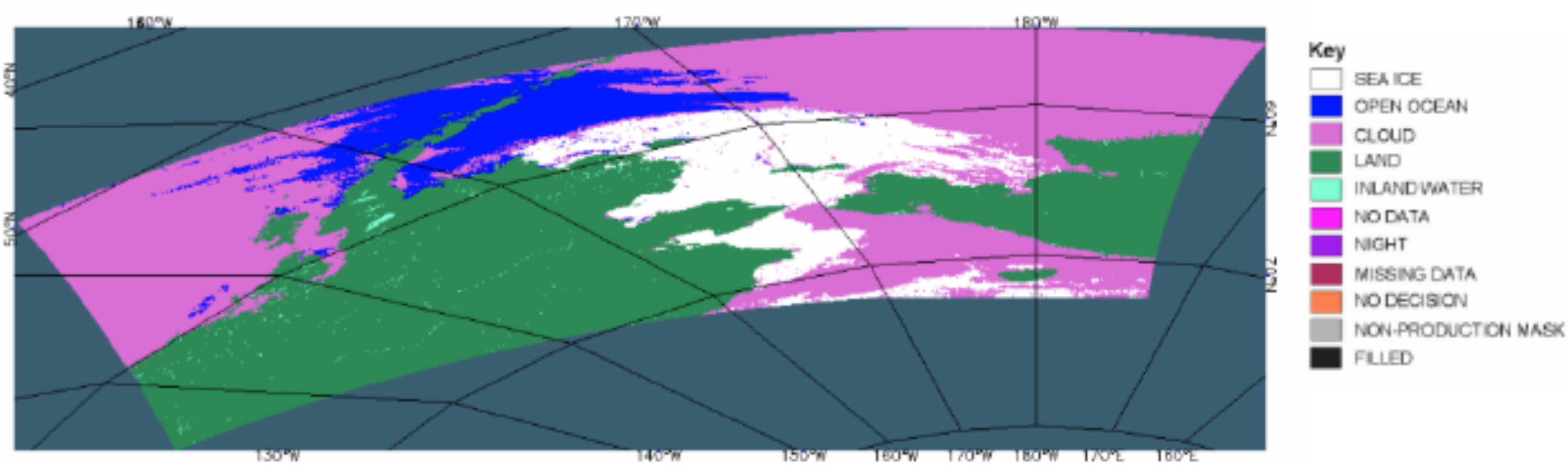
Classification methods:

- NDSI for snow-covered sea ice
- MODIS IST= a +bT11 + c(T11-T12) + d[(T11-T12)(secq-1)]

Classifiers biased to Terra because

- sea-ice algorithm based on VIS & NIR data at 1.6 μm, which is dysfunctional on Aqua
- Terra's sensors, data record, and pre-launch algorithms are better understood

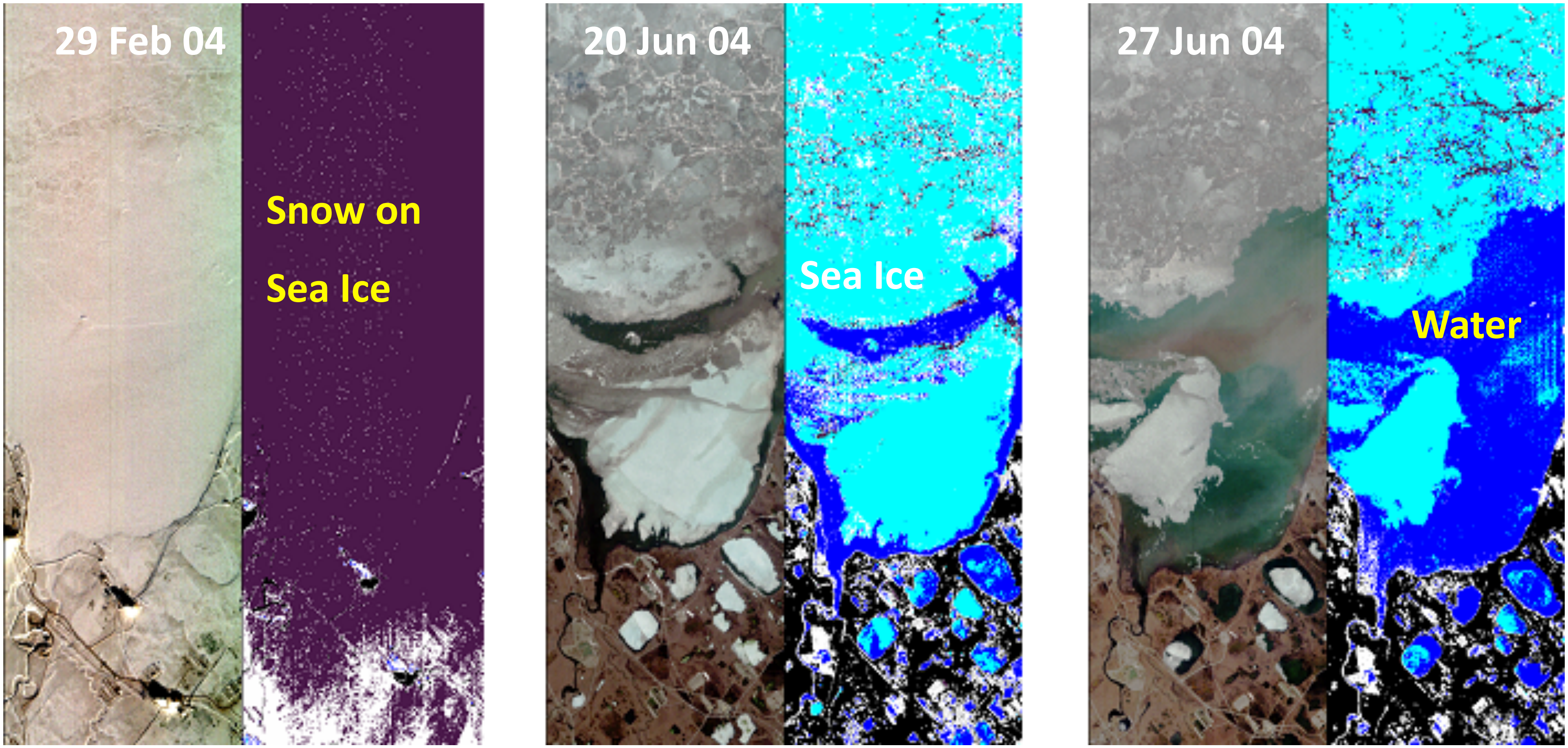
Figure 2. MOD29 2003 093 2240 UTC sea ice extent in Lambert Azimuthal equal area projection.



Courtesy of *MODIS Sea-Ice Products Users Guide, Riggs et al.*

Heritage (onboard) EO-1/ASE Hyperion Cryosphere Classifier

Deadhorse (Prudhoe Bay), Alaska



- Snow
- Water
- Ice
- Land
- Unclassified

EO1/Hyperion data
Wavelengths used in classifier:
0.43, 0.56, 0.66, 0.86 and 1.65 μm
Doggett et al. RSE 2006
Uses augmented Griffin et al. cloud detection

Arizona State University
Planetary Geology Group

Dust Applications

- Products
  - Aerosol detection
  - Dust storm detection over land and water
- Heritage
  - MODIS, ASTER, MISR, CERES, AVHRR, GMS-SEVIRI, CALIPSO
- Distinguished by
  - Color
  - Temperature
  - Transparency
  - Texture

Prime Wavelengths for Dust Detection

λ (μm)	Part of spectrum	Use
0.315-0.4	Ultra Violet (UV)	- Absorption
0.38-0.79	Visible (VIS)	- Scattering - Daytime dust over water
8-15	Thermal Infrared (TIR)	- Overland dust - BTD (11 & 12) differentiates cool air-born dust from cloud

Heritage (ground) - MODIS

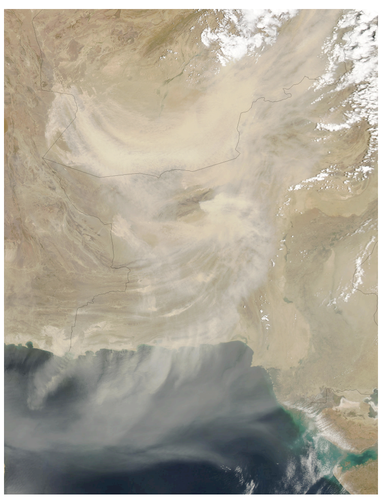
Uses a dark target approach

NDDI: (b7-b3)/(b7+b3)

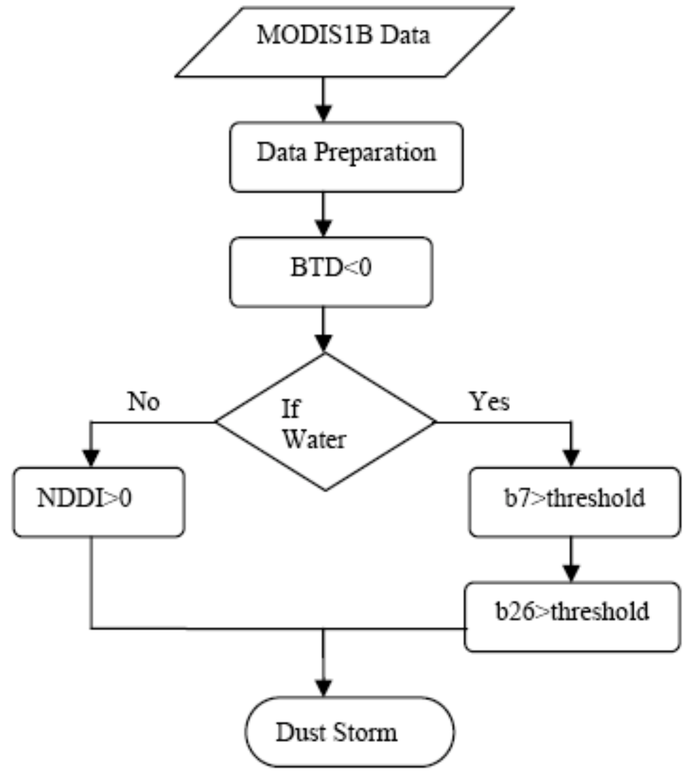
good us MODIS 2.1um band highly sensitive to moisture content

AOT (Aerosol Optical Thickness) only

works over dark surfaces

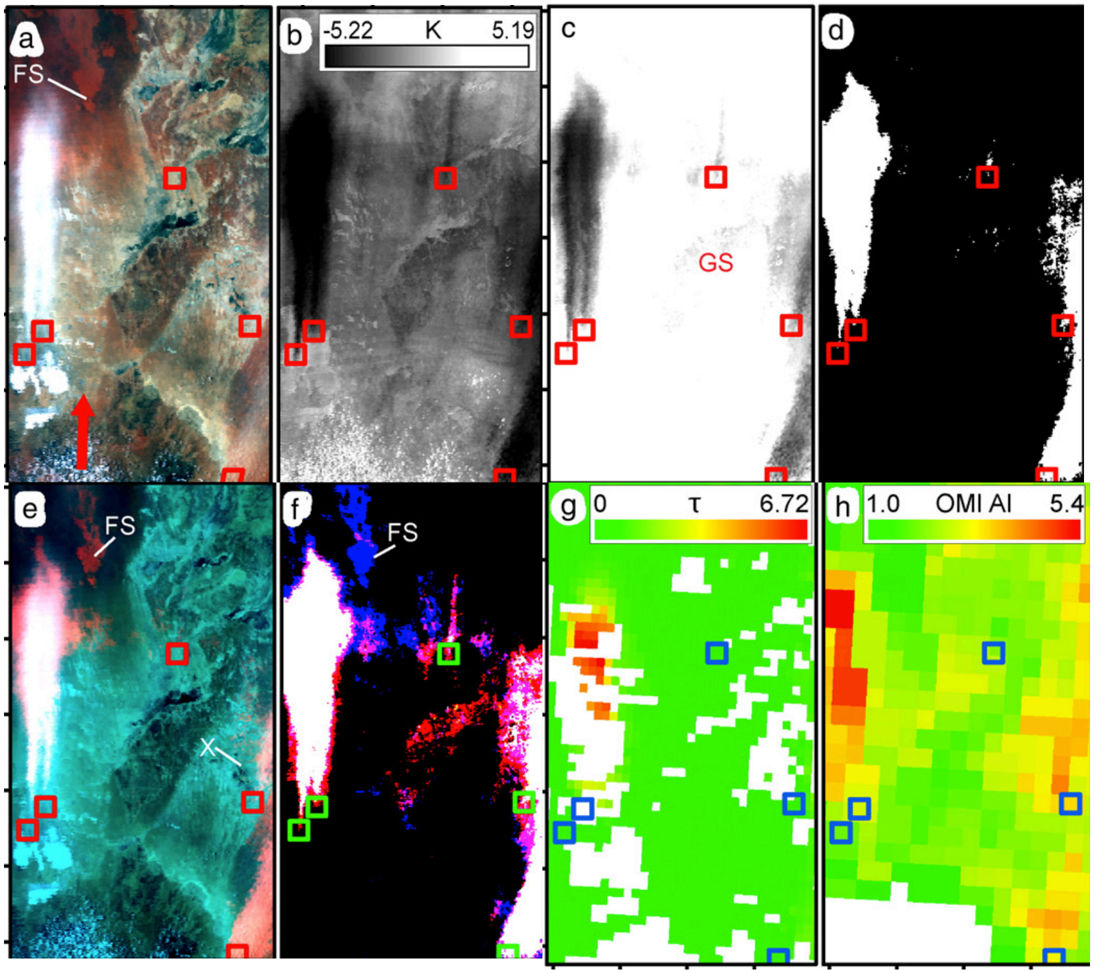


http://earthobservatory.nasa.gov/IOTD/view.php?id=4449



Concrete process for dust storm detection at daytime. Over dark backgrounds, dust is easier to detect during the day. [courtesy of Di et al. 2008]

Accomplishment: overland dust storm detection



[Baddock et al. 2009]

Miller's over-land algorithm:

$$D_{lnd} = L1 + L3 - L4 + (1.0 - L2)$$

Challenges:

- cloud cover
- dust mineralogy
- surface reflectance
- generic classification

Dust

- Importance of dust detection
  - Limits transportation
  - Hazardous to health
  - Reduces military equipments' visibility and performance
  - Influences climate change

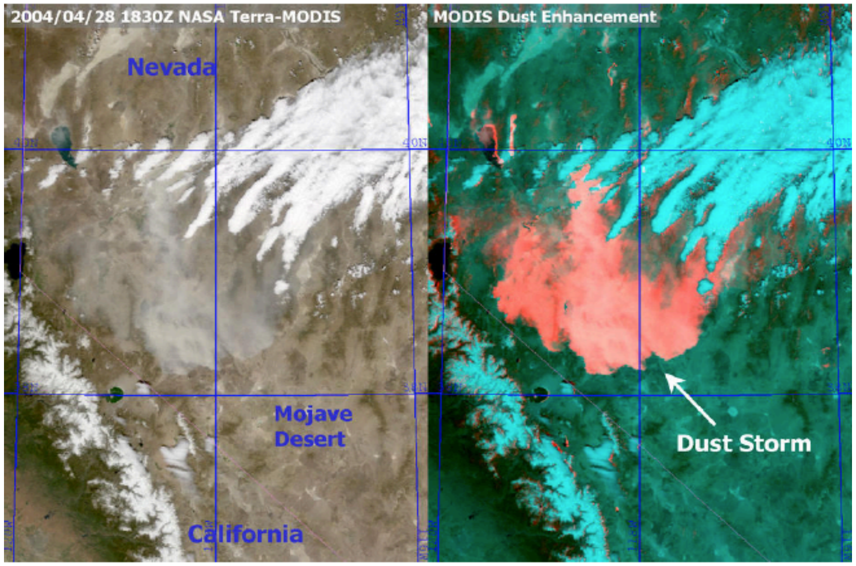


Image courtesy of *Satellite Product Tutorials: Desert Dust Storms, Miller.*

- Challenges
  - Dust particles vary in chemical composition
  - Particle concentration dynamically varies
  - Discriminating dust from cloud particles
  - Can only be evaluated now on a case-by-case basis

Ecosystem Applications

- Vegetation Stress Indices – water and nutrient stress via 500-1200 nm measurement
- Thermal Measurements – Thermal Infrared measurements for evapotranspiration (ET)
- Species Identification/biodiversity – species classification using hyperspectral signatures
- Products – above indices and/or required bands and mixtures
- Heritage -
  - NDVI, OSAVI, WDRVI, VARI, NNDVI, MCARI, TCARI, INP, Reciprocal reflectance, PRI, RVSI, NDWI, WI, EWT, VCI, TCI, EVI based on AVIRIS, Hyperion, AVHRR
  - ALEXI/DisALEXI based on ETM+, MODIS, GOES, GOES Sounder
- Applications – Crop management, irrigation management, drought reporting, disease vector estimation, invasive species
- Challenges – cloud cover

Heritage (Ground)

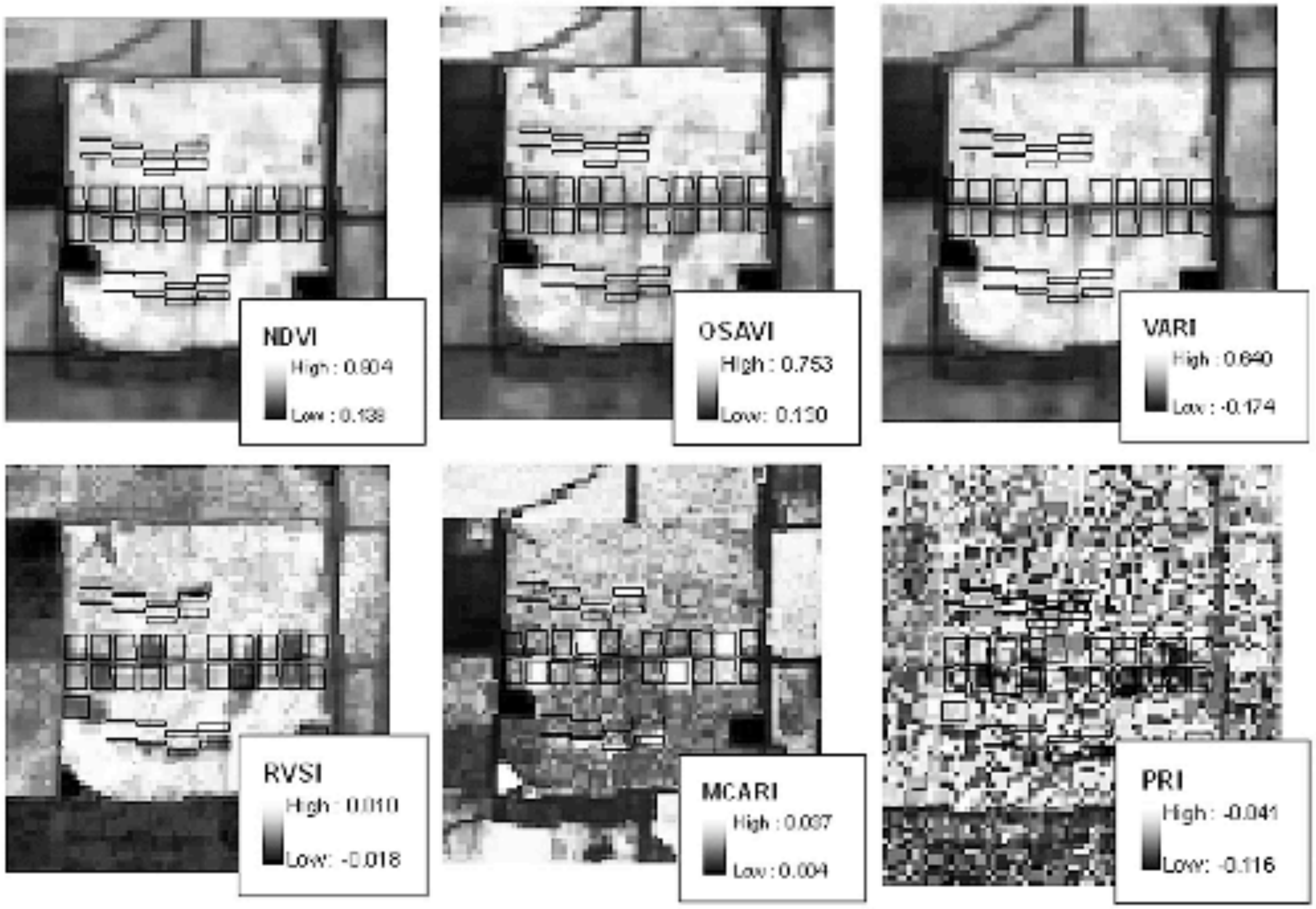


Fig. 3. Comparison of selected indices derived from 6 July Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) imagery (18-m spatial resolution) with locations of N trial plots and subpixel plots shown. The corresponding classification accuracies are shown in Table 7. Note the differences between the appearance of the subpixel areas and the classification accuracies. For example, the subpixel stressed areas for the Normalized Difference Vegetation Index (NDVI) and the Modified Chlorophyll Absorption in Reflectance Index (MCARI) are quite apparent, although the classification accuracies (Table 7) for the Photochemical Reflectance Index (PRI) are generally higher.

Aviris measurement of plant stress using NDVI, MCARI, and PRI [Perry & Roberts 2008]

Heritage (Ground)

- GOES, MODIS, ETM+, and airborne modeling of drought and evapotranspiration using the Alexi process
- Applications include
  - – Crop management
  - – Irrigation mgmt
  - – Drought estimation

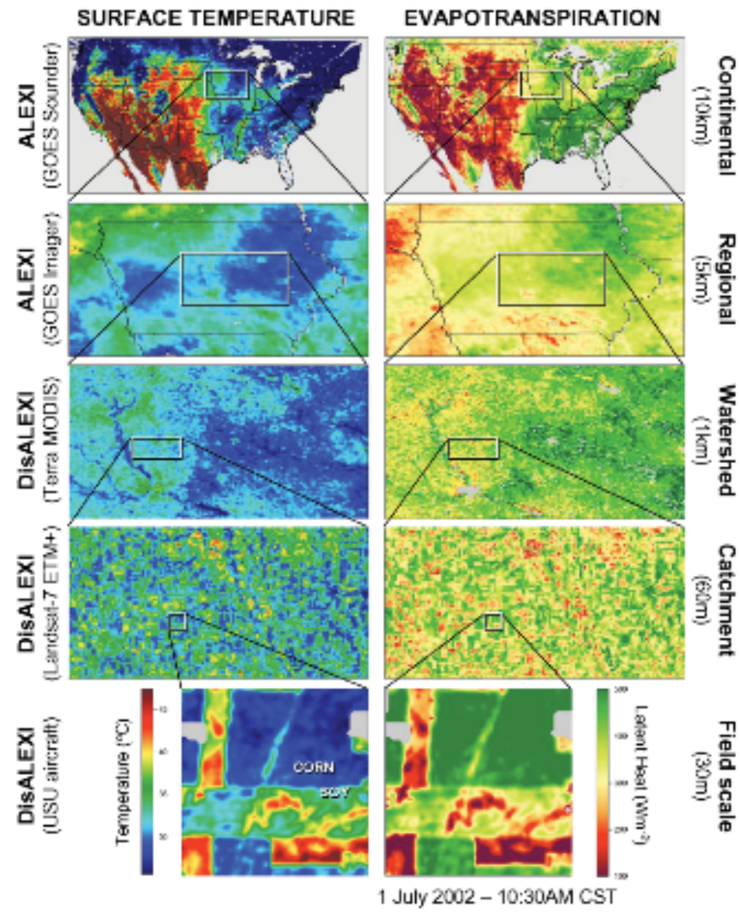


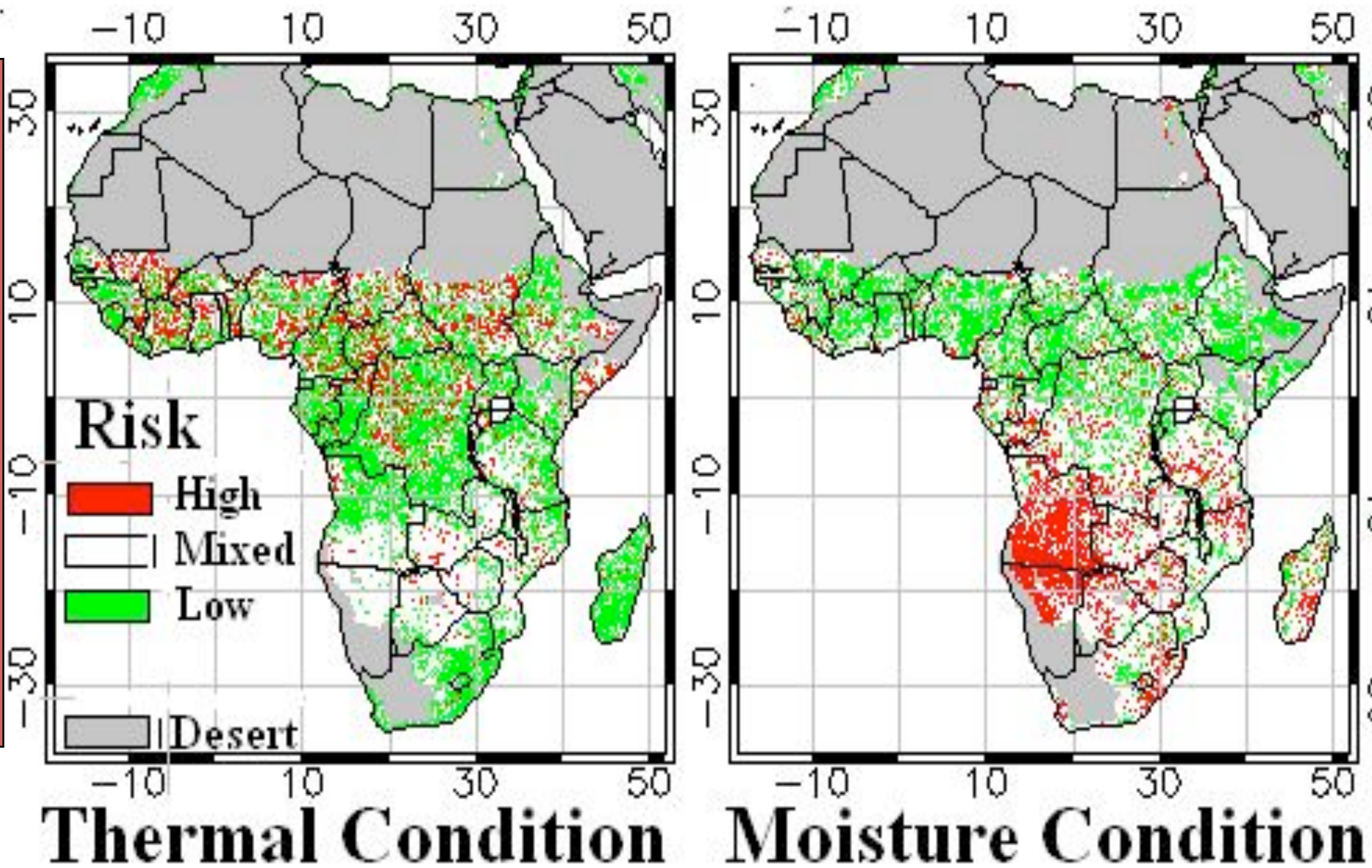
Fig. 1. Multiscale evapotranspiration (ET) maps for 1 July 2002, focused over the corn and soybean production region of central Iowa, produced with the ALEXI/DisALEXI (Atmosphere Land Exchange Inverse/Disaggregated ALEXI) surface energy balance models [Anderson et al., 2007a] using surface temperature data from aircraft (30-meter resolution), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) (60-meter), Terra Moderate Resolution Imaging Spectroradiometer (MODIS) (1-kilometer), GOES Imager (5-kilometer), and GOES Sounder (10-kilometer) instruments. The continental-scale ET map is a 14-day composite of clearsky model estimates.

Images courtesy [Anderson & Kustas 2008]

Heritage (Ground) – Disease Estimation

Strategy: WEATHER PROXY AUGUST 26, 2008

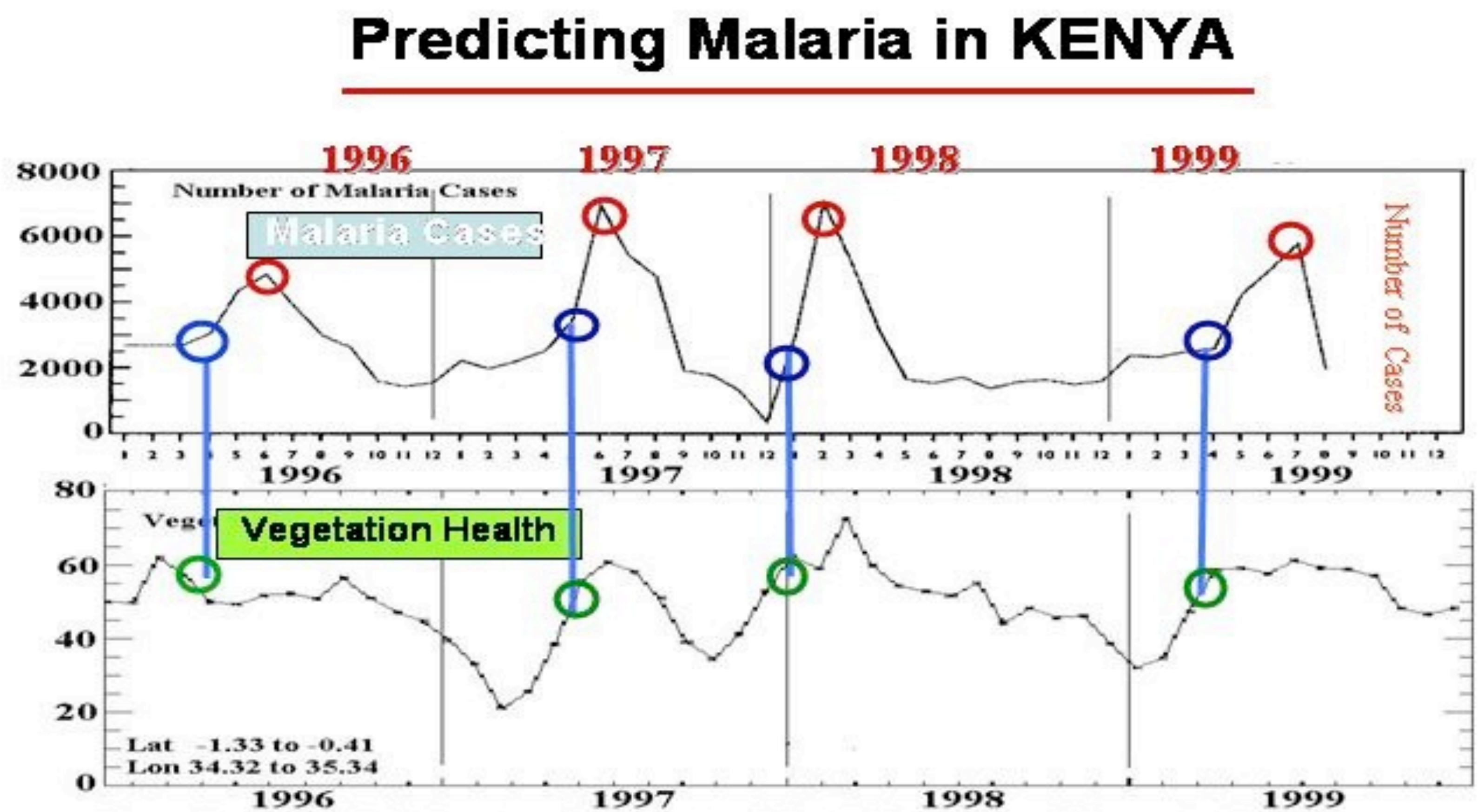
Malaria risk map identifies priority areas and additional resources needed to fight epidemics effectively



INTENSIVE MALARIA

F. Kogan/NOAA/NESDIS

Heritage (Ground) – Disease Estimation



Number of Malaria Cases in Kisii District Hospital, Western Kenya and AVHRR-based Vegetation Health Index (VHI)

VH provides up to 4 months advance malaria warning

F. Kogan/NOAA/NESDIS

Heritage (Ground)

- Disease risk estimation via species identification

Tecoma stans L.

Ricinus communis L.

Parthenium hysterophorus L.

Hamelia patens Jacq

Senna didymobotrya Fresen

Lantana camara L.

Preferred plants for Anopheles (in order of preference

- ❑ *T.stans ,S.didymobotrya*
- ❑ *R.communis*
- ❑ *H.patens*
- ❑ *Taraxacum officinale*
- ❑ *Hieracium pratense*

Least preferred plants

- ❑ *L. camara*
- ❑ *Viola sororia*