

Spatially Complete Global Spectral Surface Albedos: Value-Added Datasets Derived From *Terra* MODIS Land Products

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$$\text{Albedo} = \frac{\text{Reflected Radiation}}{\text{Incoming Radiation}}$$

- ▶ Spectral, Spatial, Temporal Dependence
 - Inherent Ecosystem Class Dependency

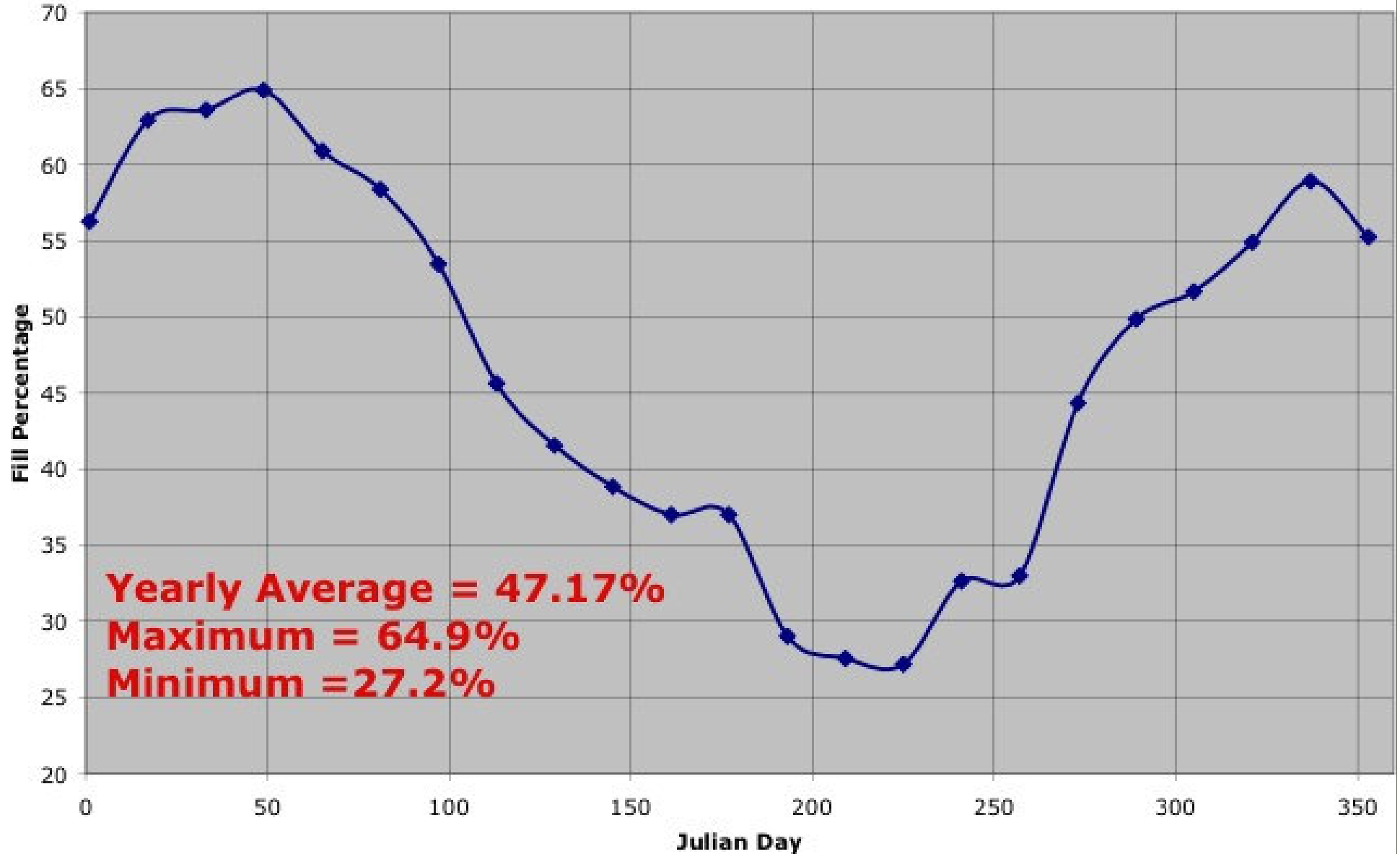
- ▶ Ancillary input for:
 - Ground, Airborne, and Remote Sensing Radiative Transfer Applications.
 - Land Surface and Climate Modeling.
 - Global Change Research Projects.

MOD43B3 - MODIS Land Surface Albedo

QuickTime™ and a
Video decompressor
are needed to see this picture.

- ▶ 0.47, 0.555, 0.67, 0.858, 1.24, 1.64, 2.1 μm
- ▶ 0.3-5.0, 0.7-5.0, 0.3-0.7 μm .
- ▶ 16-day periodicity (001, 017, ..., 353).
- ▶ Sinusoidal Projection Tiled Storage.

Percentage of Year 2001 MOD43B3 Land Pixels that are Fill.



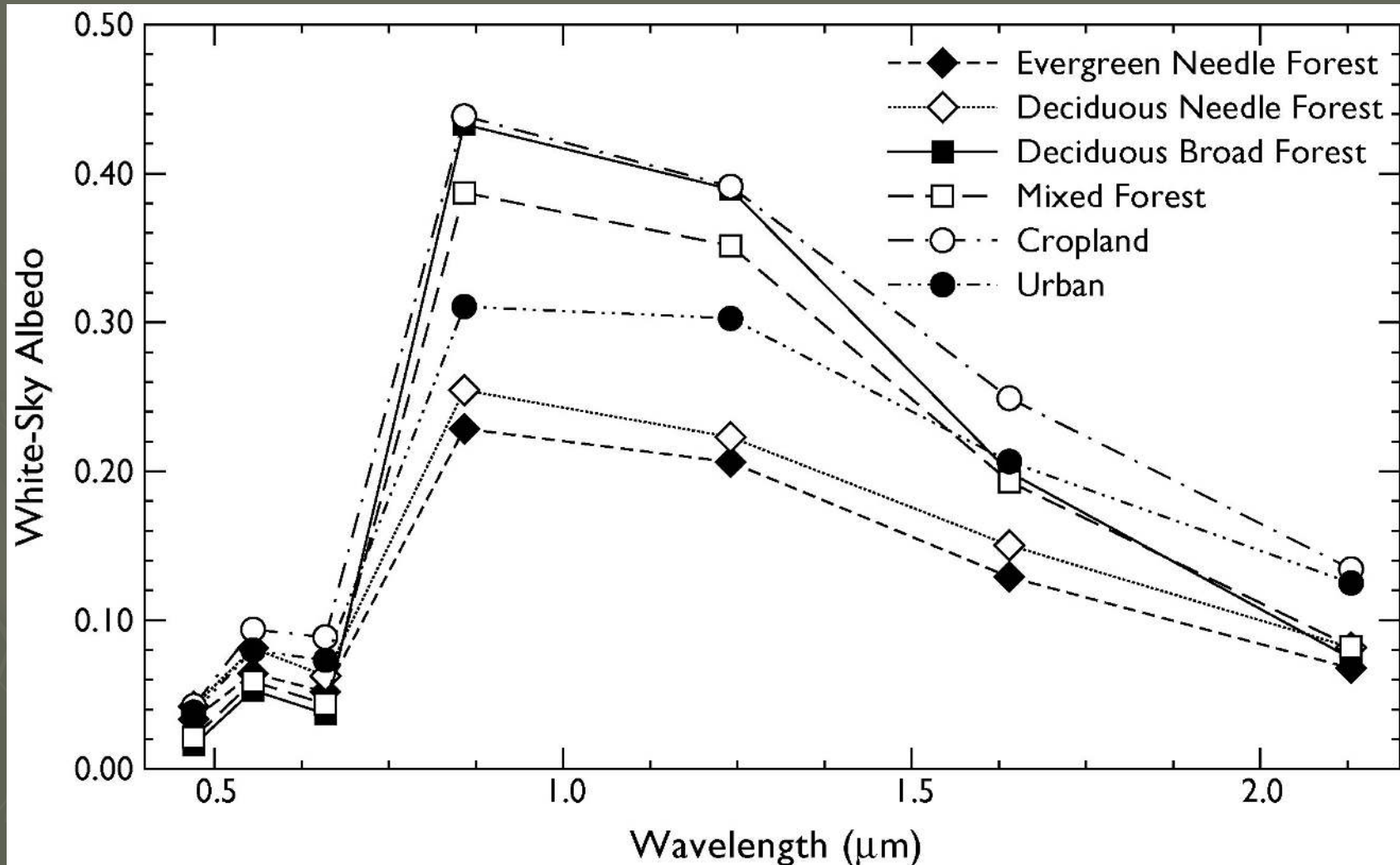
MOD43B3

0.858 μ m

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Filled Map

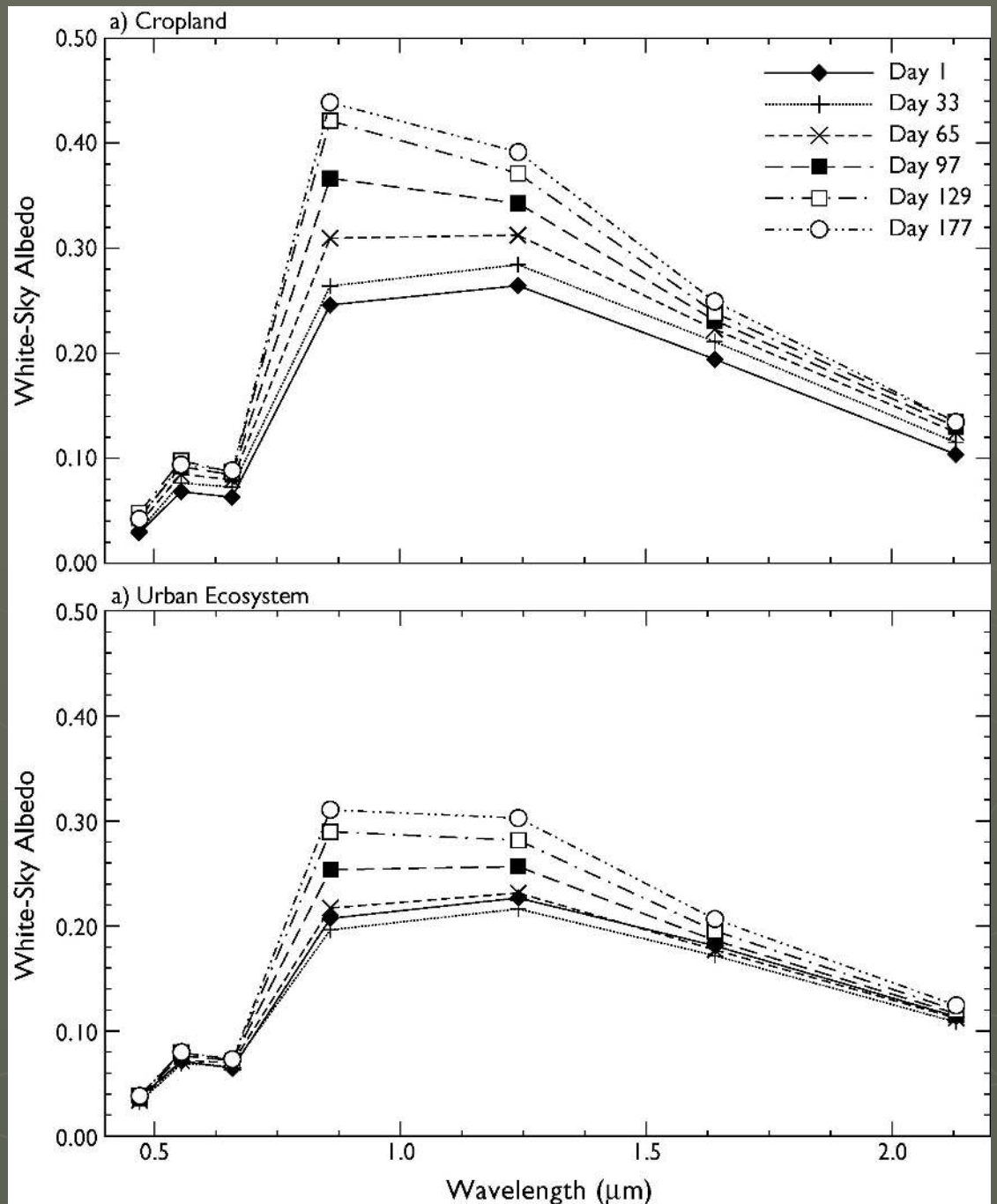
Spectral Variability by Ecosystem Class.



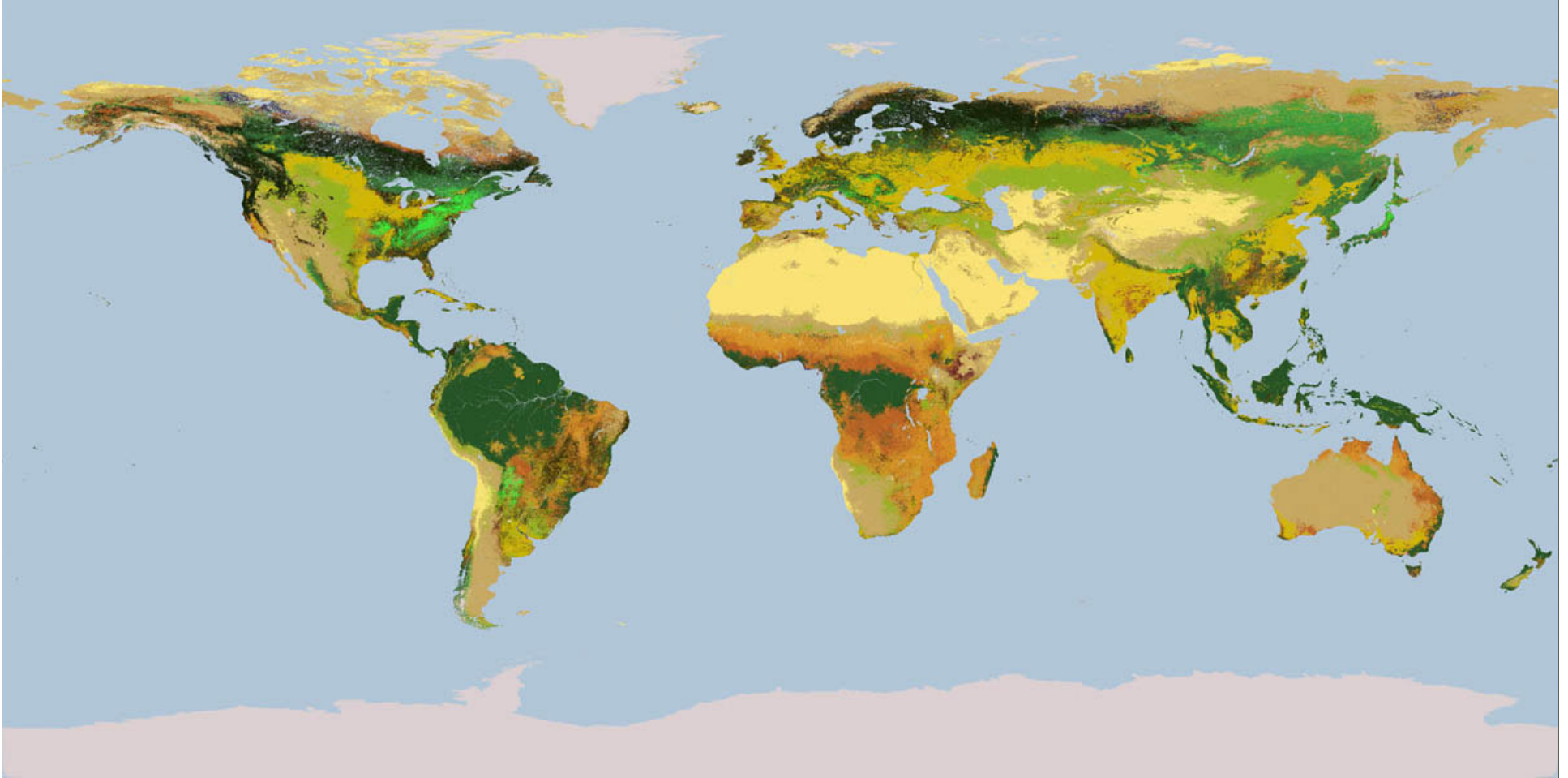
Temporal Variability.

Cropland Ecosystem

Urban Ecosystem



▶ IGBP Ecosystem Classification Map



▶ MOD12Q1. *Friedl, Hodges, et al.*

Phenological Concept

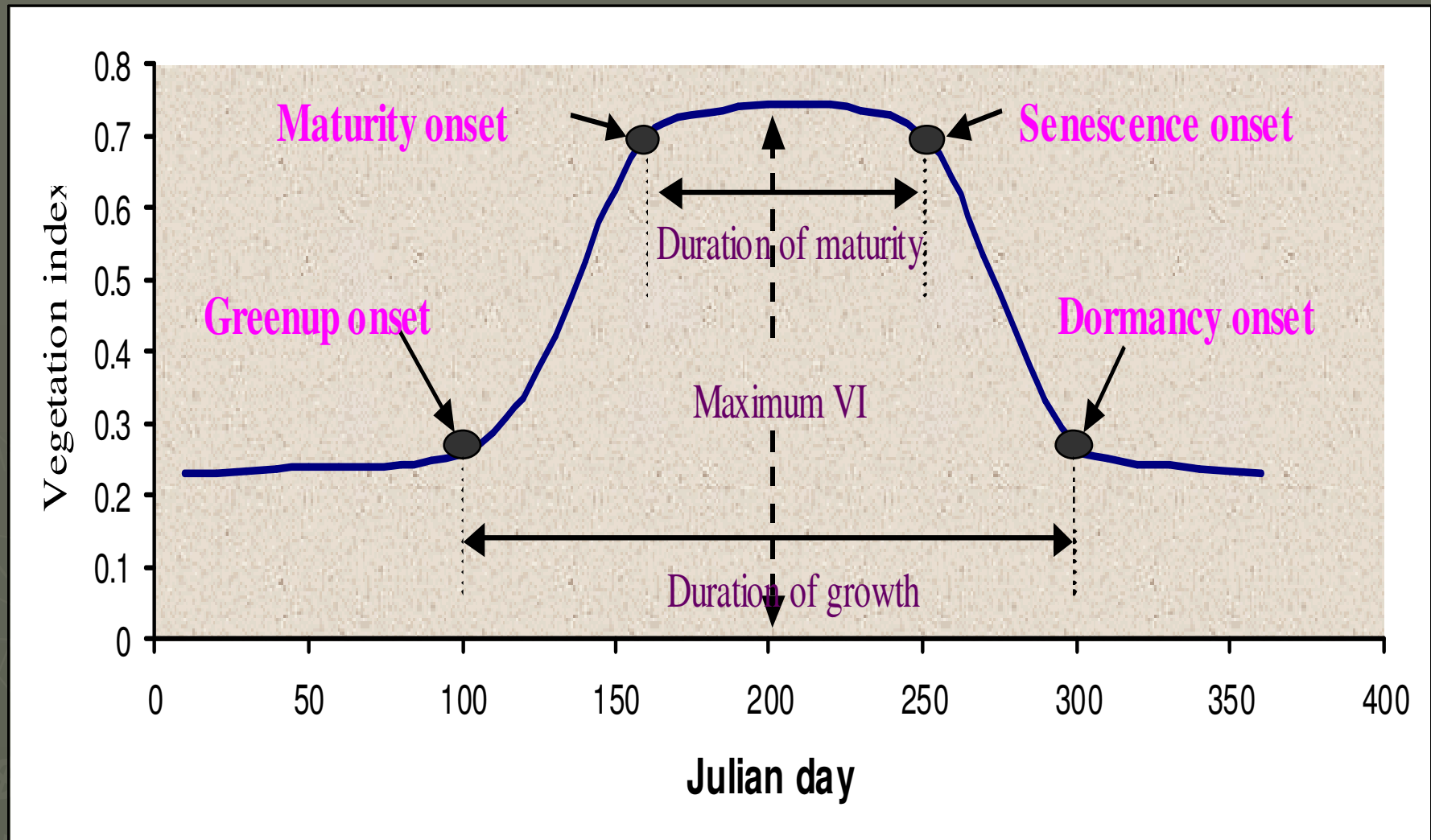


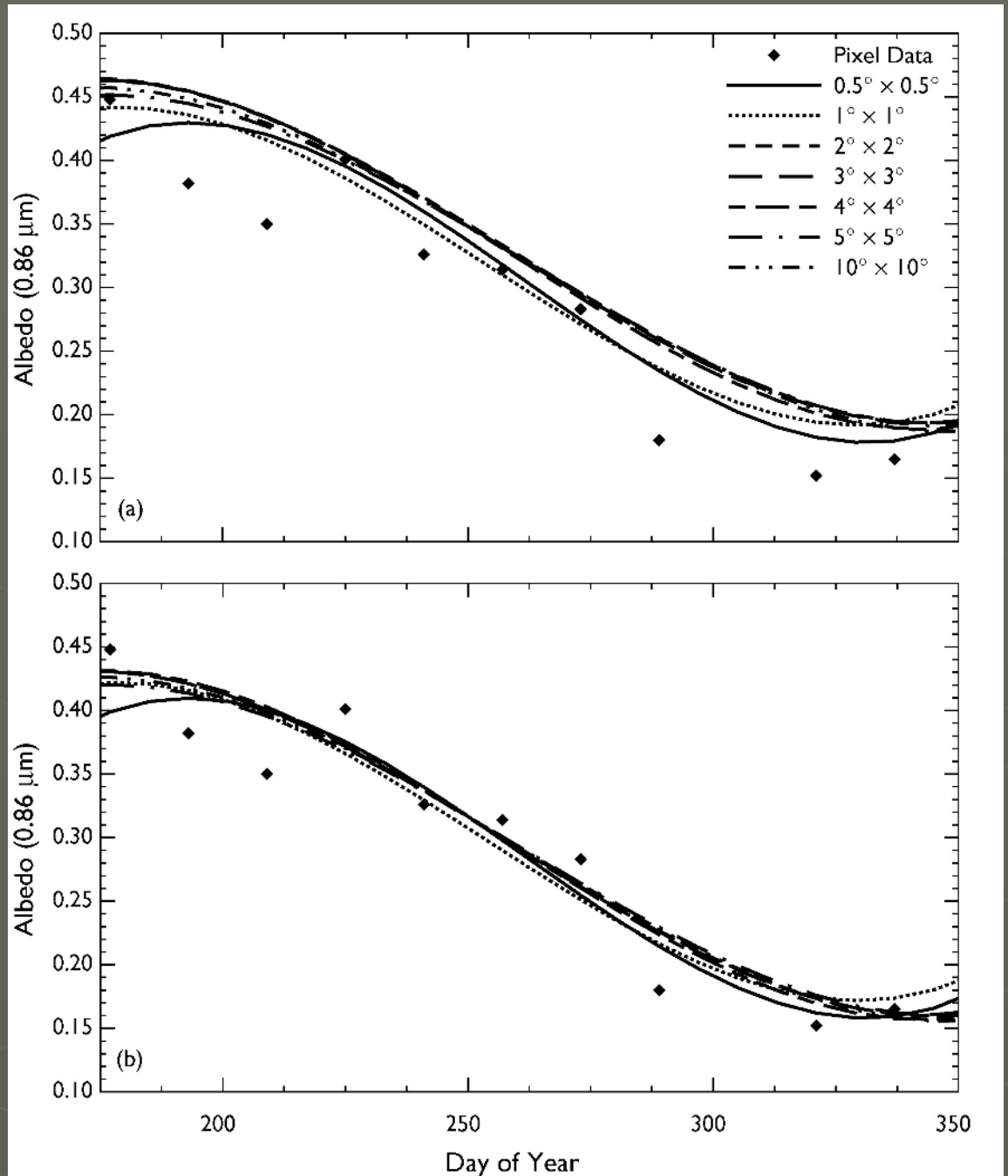
Image provided by Xiaoyang Zhang, Boston University

modis-atmos.gsfc.nasa.gov

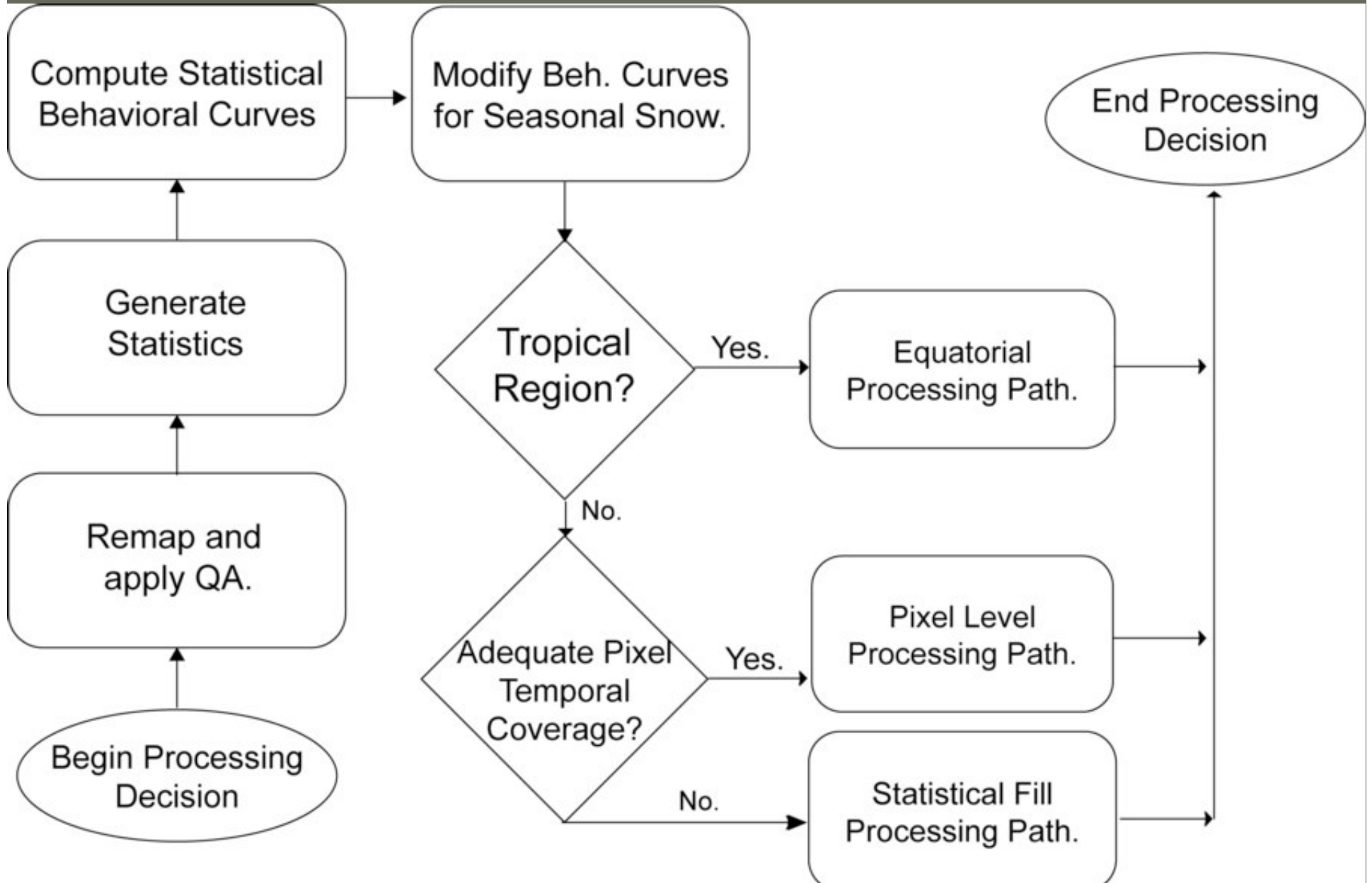
Deciduous Broadleaf Forest, Vermont US.

Phenological Curves

Phenological Curves with Offset Applied



Processing Path.



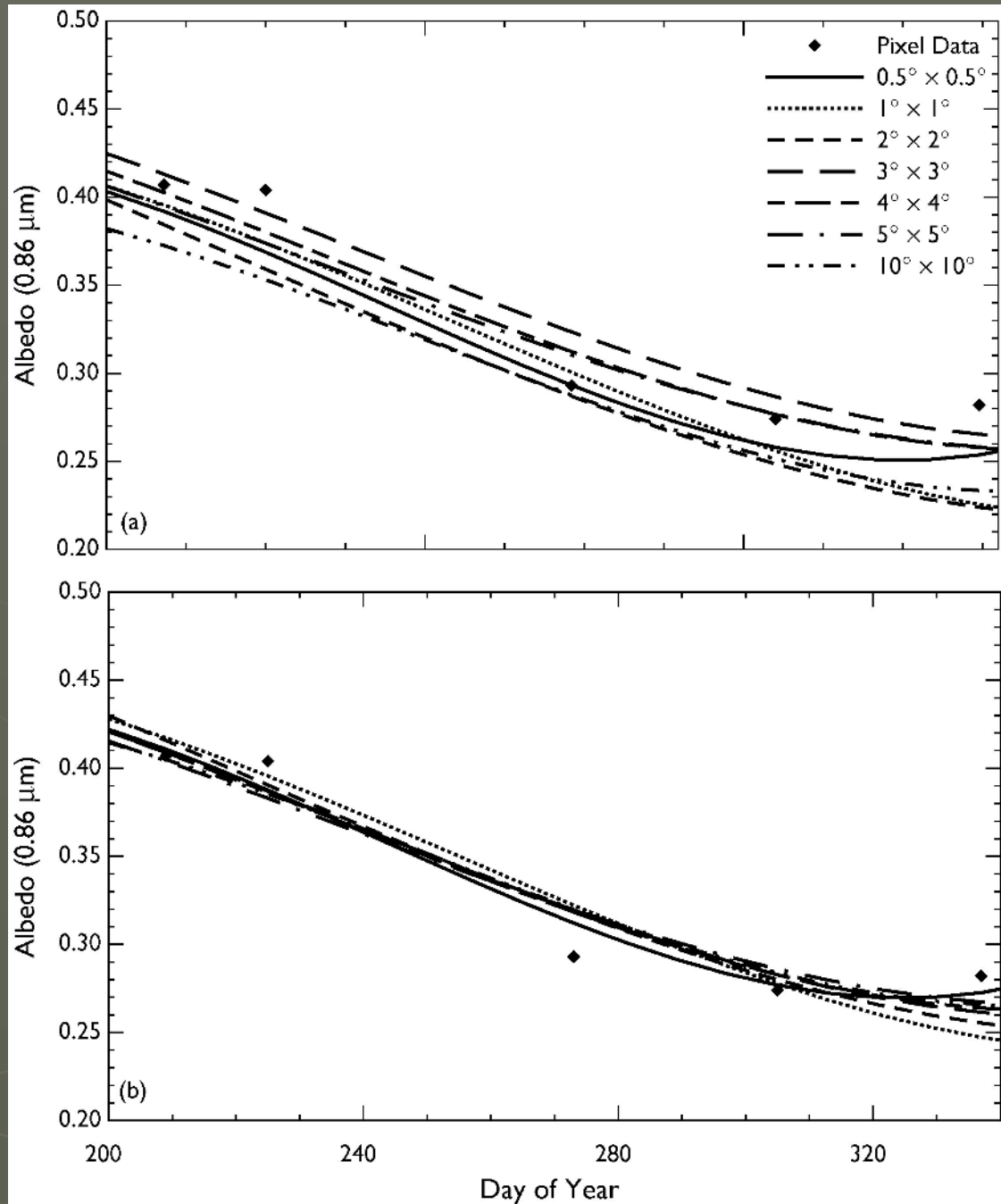
General Methodology

- ▶ Temporally Interpolate using Pixel-level or Regional Ecosystem Statistical Data.
- ▶ If statistical data:
 - Compute behavioral curve and apply offset.
 - ▶ $1/2^\circ$, $1-5^\circ$, $10^\circ \times 10^\circ$, and $10^\circ \times 20^\circ$, $10^\circ \times 30^\circ$ resolution.
 - ▶ Least Squares Polynomial Fit.
 - 1st - 3rd degree, with standard deviation weighting.
 - Select statistical size based on:
 - ▶ Temporal coverage.
 - ▶ Representation of pixel data.
 - ▶ Bias towards smaller box sizes.
 - Fill in only missing days.

Cropland, Midwestern US.

Phenological Curves

Phenological Curves with Offset Applied



▶ MOD43B3

▶ 0.858 μ m

▶ Filled Map

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▶ MOD43B3

▶ 0.858 μ m

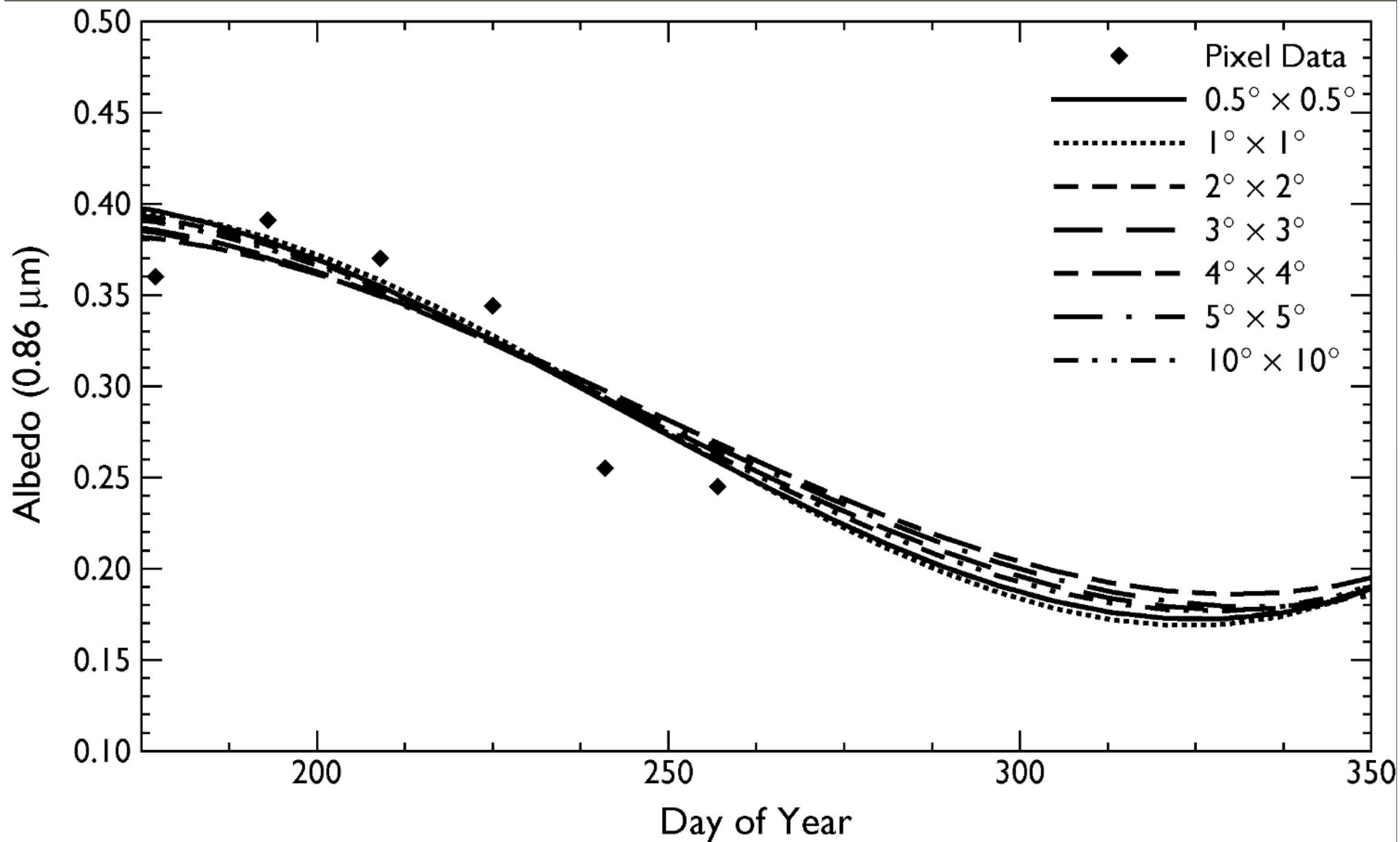
▶ Filled Map

QuickTime™ and a
Video decompressor
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Seasonal Snow Methodology

- ▶ Cloud and snow cover obscure full decay state.
- ▶ Over Hemisphere Average of High Latitudes:
 - Unique ecosystem and wavelength extrema percent change.
 - Compute % change from pixels with adequate representation.
- ▶ For each Pixel/Statistical Curve:
 - Summer extrema known.
 - Compute winter extrema from
 - ▶ Percent change.
 - ▶ Summer extrema.
 - Pin winter endpoints with computed value.

Mixed Forest, Northern Russia. Seasonally Snow Impacted.



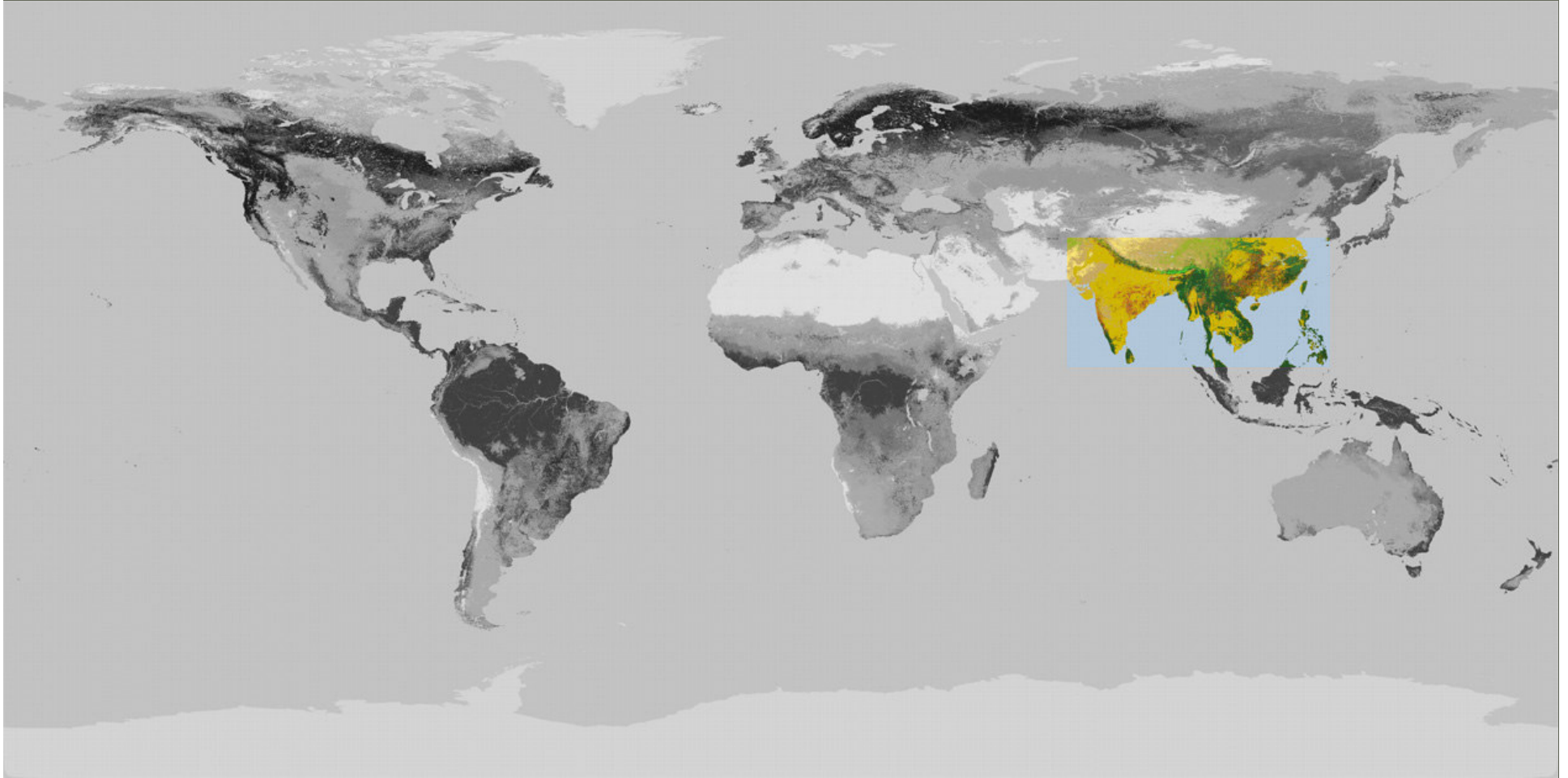
▶ MOD43B3

▶ 0.858 μ m

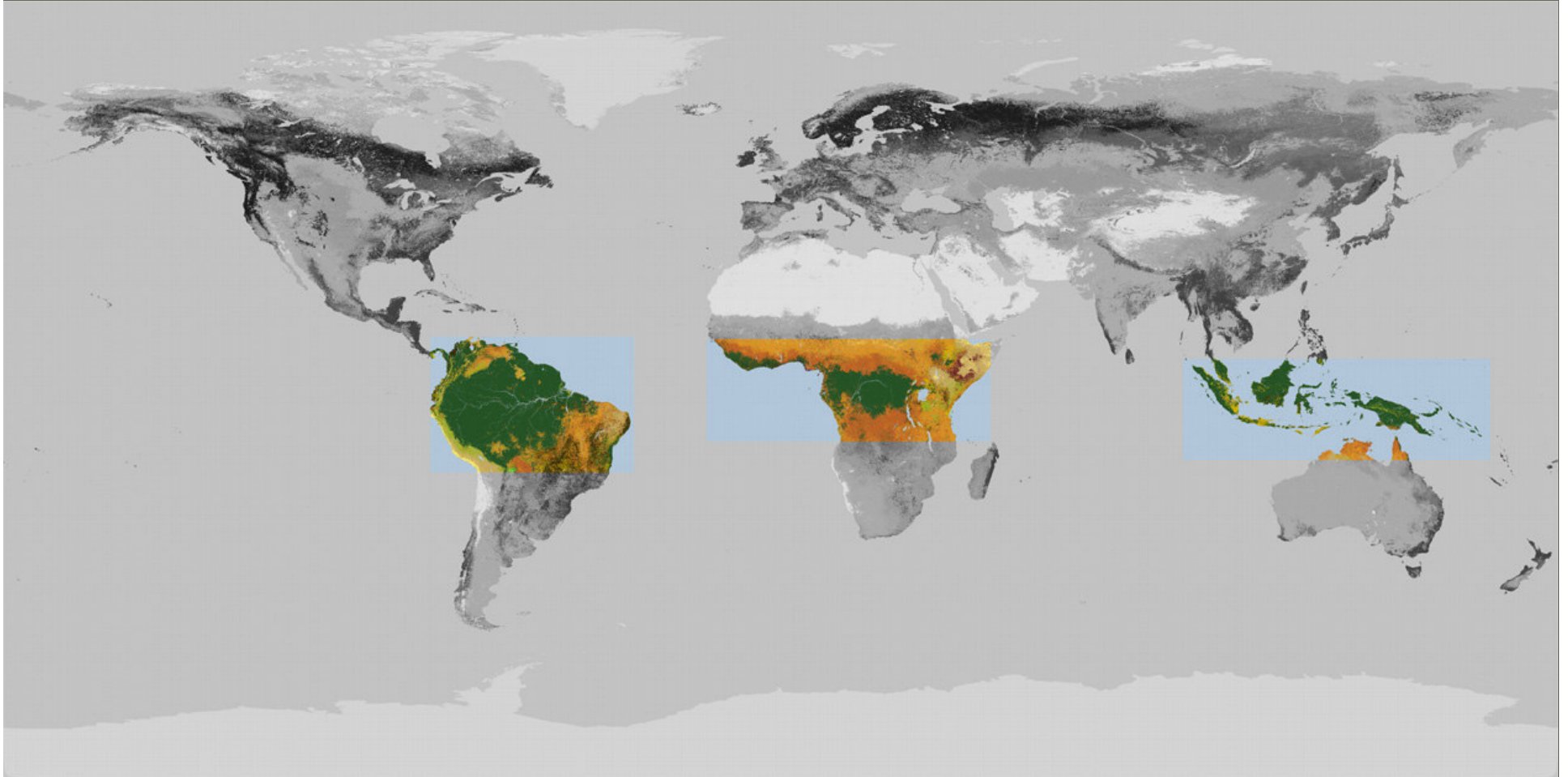
▶ Filled Map

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► Special Case: Missing Season.



► Special Case: Limited Yearly Data.



▶ MOD43B3

▶ 0.858 μ m

▶ Filled Map

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Persistent Cloud Methodology

- ▶ Clouds obscure trends over large regions.
 - Usually full growth stage is obscured.
 - Even 10x30 may not observe complete temporal trend.
- ▶ Compute 1 statistical curve per ecosystem class.
 - 5-15° Latitude belts.
 - ▶ Centered around pixel's latitude.
 - Yearly phenological behavior curves
 - ▶ Instead of 2 half year curves.
- ▶ Impose shape of curve onto existing pixel data.

Pixel with No Temporal Points

- ▶ Substitute ecosystem statistics.
 - Smallest statistical box size that has some temporal data.
- ▶ Process pixel through one of the methodologies.

▶ MOD43B3

▶ 0.858 μ m

▶ Filled Map

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Video decompressor
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▶ MOD43B3

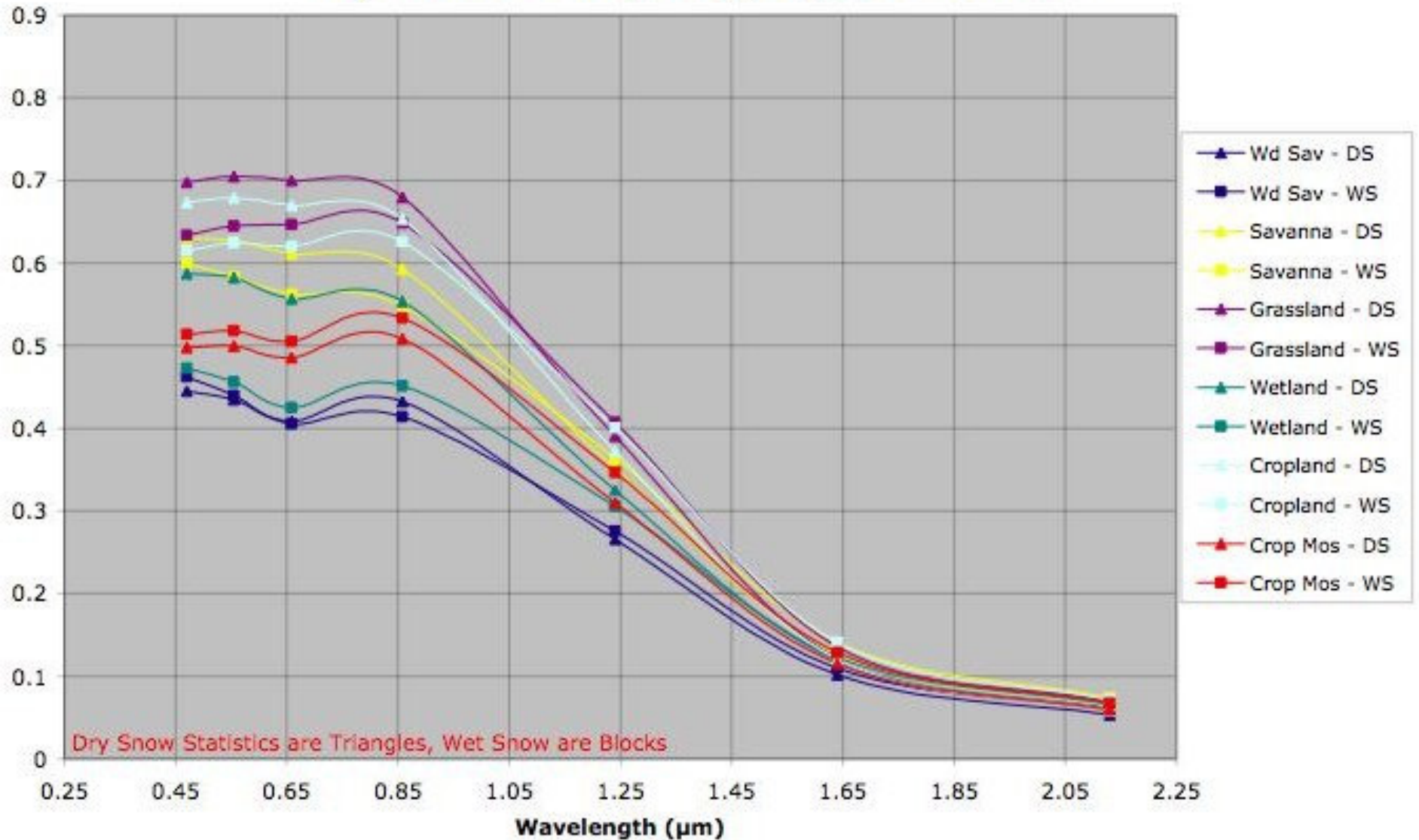
▶ 0.858 μm

▶ Filled Map

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Snow Albedo By Vegetated Classes.

2001 White-Sky Albedo, Northern Hemisphere Yearly Averages - Dry and Wet Snow (NISE), Vegetated Surfaces.



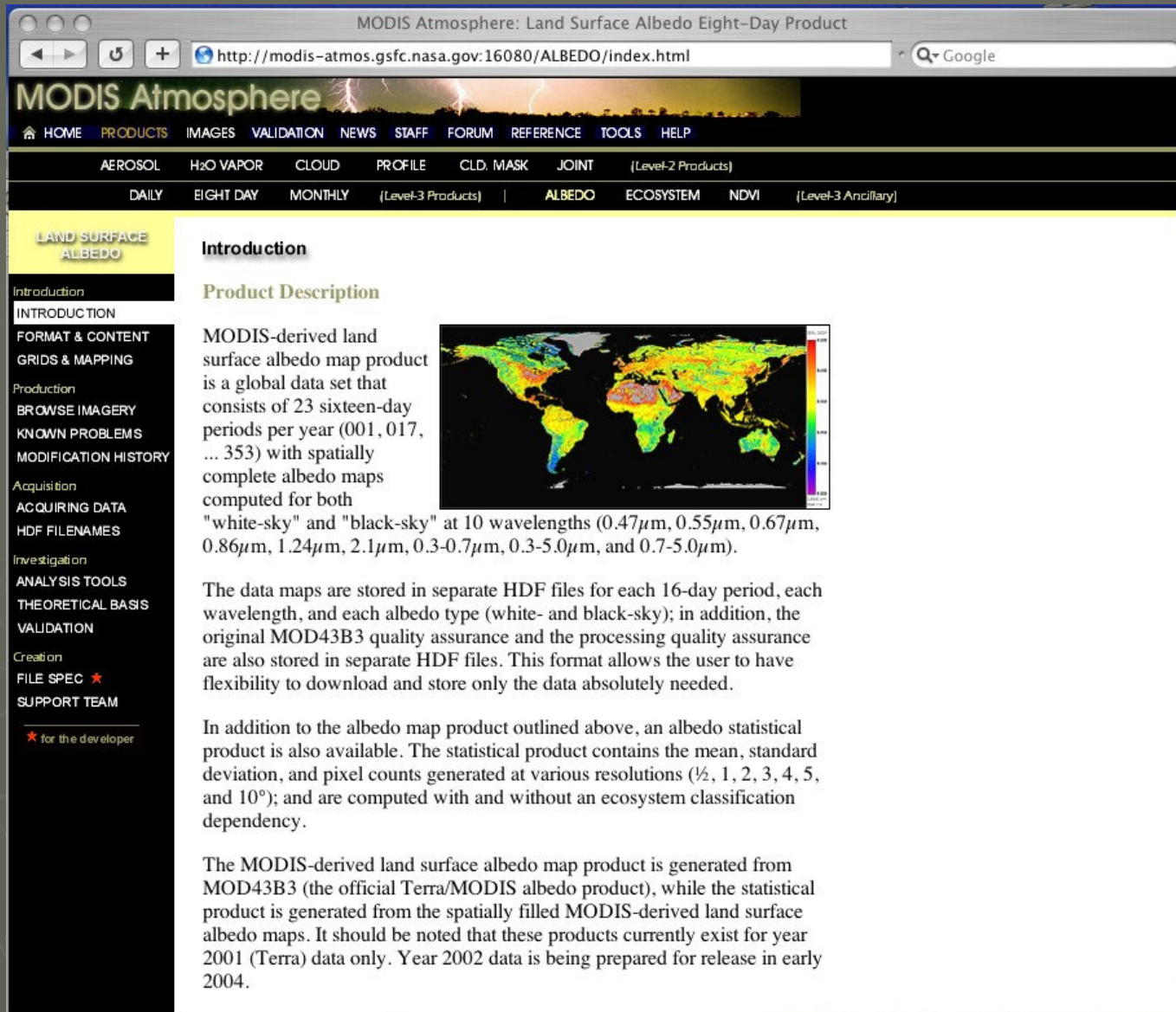
Available Products

- ▶ **Spatially Complete Albedo Maps**
 - Maps and QA Stored in 1-minute Rectangular Coordinates.
 - First Seven MODIS Wavelengths and 3 Broadband.
 - White- and Black-sky albedo values.
- ▶ **Statistics of Filled Albedo Maps**
 - 1/2, 1, 2, 3, 4, 5, 10 Degree Box Sizes.
 - Statistics Computed in Boxes and by Ecosystem Class in Boxes.
- ▶ **Statistics of Snow Albedos.**
 - Hemispheric averages of MOD43B3 validated data.
 - Separated by Ecosystem class and NISE wet/dry classification.
- ▶ **IGBP Ecosystem Classification Map**
 - Maps and QA Stored in 1-minute Rectangular Coordinates.

Format and File Sizes.

- ▶ All data stored in HDF format with/without internal GZIP compression.
- ▶ Spatially Complete Albedo Maps
 - 1 file contains 1 band and either white- or black-sky albedo per 16-day period.
 - QA and data stored in separate files.
 - 1 data file ~ 60 MB gzipped, 445 MB non-zipped.
 - 1 QA file ~ 10-25 MB gzipped, 225-445 MB non-zipped.
- ▶ Statistics of Filled Albedo Maps
 - Only data, no QA.
 - Variable file size depending on resolution.
- ▶ Statistics of Snow Albedo
 - 1 file, ~16 KB.
- ▶ IGBP Ecosystem Classification Map
 - 1 static map ~ 90 MB gzipped, 1.1 GB non-zipped.

► <http://modis-atmos.gsfc.nasa.gov>



The screenshot shows a web browser window with the address bar containing <http://modis-atmos.gsfc.nasa.gov:16080/ALBEDO/index.html>. The page title is "MODIS Atmosphere: Land Surface Albedo Eight-Day Product". The navigation menu includes: HOME, PRODUCTS, IMAGES, VALIDATION, NEWS, STAFF, FORUM, REFERENCE, TOOLS, HELP. Below this, there are sub-menus for AEROSOL, H₂O VAPOR, CLOUD, PROFILE, CLD. MASK, JOINT, (Level-2 Products), and DAILY, EIGHT DAY, MONTHLY, (Level-3 Products), ALBEDO, ECOSYSTEM, NDVI, (Level-3 Ancillary). The main content area is titled "LAND SURFACE ALBEDO" and features a sidebar with a table of contents: Introduction, INTRODUCTION, FORMAT & CONTENT, GRIDS & MAPPING, Production, BROWSE IMAGERY, KNOWN PROBLEMS, MODIFICATION HISTORY, Acquisition, ACQUIRING DATA, HDF FILENAMES, Investigation, ANALYSIS TOOLS, THEORETICAL BASIS, VALIDATION, Creation, FILE SPEC ★, SUPPORT TEAM, and ★ for the developer. The main text includes sections for "Introduction", "Product Description", and a world map showing albedo data. The "Product Description" text states: "MODIS-derived land surface albedo map product is a global data set that consists of 23 sixteen-day periods per year (001, 017, ... 353) with spatially complete albedo maps computed for both 'white-sky' and 'black-sky' at 10 wavelengths (0.47 μ m, 0.55 μ m, 0.67 μ m, 0.86 μ m, 1.24 μ m, 2.1 μ m, 0.3-0.7 μ m, 0.3-5.0 μ m, and 0.7-5.0 μ m). The data maps are stored in separate HDF files for each 16-day period, each wavelength, and each albedo type (white- and black-sky); in addition, the original MOD43B3 quality assurance and the processing quality assurance are also stored in separate HDF files. This format allows the user to have flexibility to download and store only the data absolutely needed. In addition to the albedo map product outlined above, an albedo statistical product is also available. The statistical product contains the mean, standard deviation, and pixel counts generated at various resolutions (1/2, 1, 2, 3, 4, 5, and 10°); and are computed with and without an ecosystem classification dependency. The MODIS-derived land surface albedo map product is generated from MOD43B3 (the official Terra/MODIS albedo product), while the statistical product is generated from the spatially filled MODIS-derived land surface albedo maps. It should be noted that these products currently exist for year 2001 (Terra) data only. Year 2002 data is being prepared for release in early 2004.

► <http://modis-atmos.gsfc.nasa.gov>

The screenshot shows a web browser window with the URL <http://modis-atmos.gsfc.nasa.gov/ALBEDO/acquiring.html>. The page title is "MODIS Atmosphere: Land Surface Albedo Eight-Day Product: Acquiring Data". The main content area is titled "Acquiring Data" and "Anonymous FTP Download". It lists several product types for download, each with radio button options for organization and resolution.

Acquiring Data

Anonymous FTP Download

1. Select Product Type To Download:

Maps

Filled Albedo Maps

- Black Sky Organized By Date
- Black Sky Organized By Wavelength
- White Sky Organized By Date
- White Sky Organized By Wavelength

Filled Albedo Map Run-Time QA

- Run-Time QA Organized By Date
- Run-Time QA Organized By Wavelength

MOD43B3 Albedo Map Band Specific QA

- Band Specific QA Organized By Date
- Band Specific QA Organized By Wavelength

Statistics

Filled Albedo Map Statistics

- Black Sky Organized By Date
- Black Sky Organized By Resolution
- White Sky Organized By Date
- White Sky Organized By Resolution

Filled Albedo Map By Ecosystem Type Statistics

NDVI

Computed from Filled Albedo Maps.

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