Spatial scaling techniques

Scaling processes

- Upscaling
  - Convert fine resolution → coarse resolution
  - Disaggregation
- Downscaling
  - Convert coarse resolution → fine resolution
  - Aggregation

Upscaling methods

- Land surfaces are very heterogeneous
- Liang explored upscaling laws of directional reflectance, albedo & LAI – 30 m → to 1 km, using atmospheric & canopy radiative transfer simulations
- Asked: are retrieved LAI values from coarse-resolution RS data equivalent to ground *true* values; should BRDF be aggregated & then calculate albedo at coarse resolution or calculate albedo from BRDF at fine scale & then aggregate albedo to coarse scale

Upscaling methods

- Found BRDF upscaling is linear
- *Effective* LAI from coarse-resolution RS data could be quite different from *true* values if surface is heterogeneous – difference is linearly related to LAI variance
- Upscaling laws of spectral albedos is linear from 30 m to coarser resolutions (200, 500, 1000 m) & not significantly subject to atmospheric conditions

Upscaling methods

- Findings on BRDF & albedo scaling are significant to RS validation
- If can map land surface BRDF & albedo at fine resolutions (30 m) in summer, these fine-resolution BRDF & albedo values can be linearly aggregated to coarser resolutions (200, 500, 1000 m)

Upscaling methods

- If ground *point/plot* measurements are used to calibrate fine-resolution products, carry surface measurement information to the validation of the coarser resolution satellite products
- ∴Upscaling from *ground* point measurements to the MODIS resolutions using high resolution RS imagery is necessary & critical

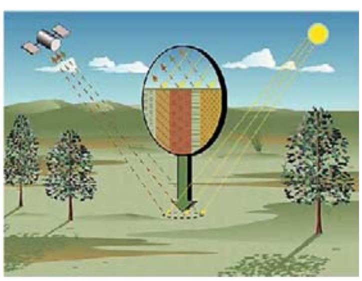
Downscaling methods

- Some pixels at any spatial resolution that contain multiple cover types
- Coarser pixel size → # mixed pixels increases dramatically
- Determining subpixel information – downscaling process

Linear unmixing methods

- Endmembers – pixel reflectance for a spectral band defined (see eq. 12-3)
- Purpose of unmixing members – estimate endmember reflectance r_j and fractional abundances p_{ij} from a group of pixels at multiple wavelength bands
  - Assume endmembers are already known, or seek endmembers, or estimate both quantities at the same time
- Approximation of reality

Linear mixing model



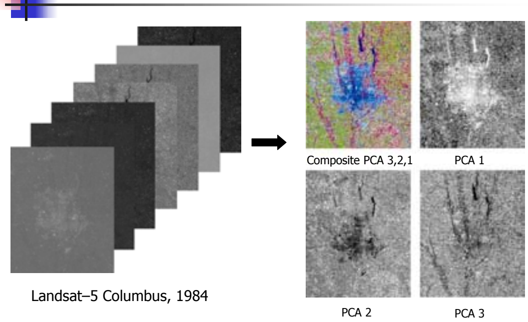
Unmixing algorithm

- 3 sequential procedures
  - Dimension reduction
  - Endmember determination
  - Inversion

Dimension reduction of data

- Reduces computational load
- Principal-components analysis (PCA)
  - Determines orthogonal axes by performing an eigendecomposition of the sample covariance of the data
  - Other types of PCA – maximum noise fraction, noise adjusted PCA

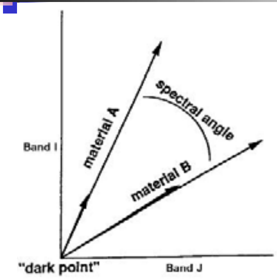
Principal components analysis



Endmember determination

- Interactive or automated
  - Interactive – trial & error method
  - Automated – use clustering analysis, parametric methods, geometric approaches
- Mixture analysis
  - Represent each endmember by a set or bundle of spectra – gives max & min fraction images bounding the correct cover fractions & specifying error due to endmember variability

Endmember



Spectral angle mapper (SAM)

Inversion

- Includes least squares methods, regularization method, minimum variance methods, variable endmember methods

Methods to generate continuous fields

- Global to regional scales – AVHRR – characterization of terrestrial vegetation
- Rather than describing land cover as discrete classes, represent land cover as continuous fields of vegetation characteristics
  - Use linear mixture model
  - Technique described by Liang (fig. 12.18)

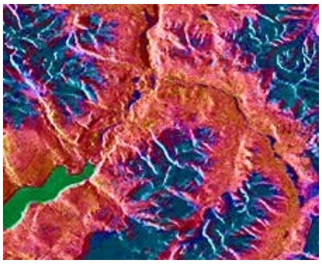
Decomposition of NDVI temporal profiles

- Spatial downscaling using temporal information
- Idea – decompose the temporal NDVI profile of a mixed pixel into the temporal profiles of several specific covers within the mixed pixel
- See fig. 12.19

Multiresolution data fusion

- Merge coarse-resolution images with fine-resolution images – coarse resolution imagery obtain the details at the scale of fine resolution
- Downscaling procedure
- Images need to be registered geometrically
- Sharpen low-resolution images – merges spatial-information from *high-resolution image* with radiometric information from a *low-resolution image*

Multi-sensor data fusion



Multispectral imagery with SAR

Source: Canadian Center for Remote Sensing

Multiresolution data fusion

- 2 types of algorithms
  - Spectral substitute methods
  - Spatial domain methods

Spectral component substitution techniques

- Fuse XS and pan images
- Replace spectral component of low-resolution XS image by radiometrically-adjusted pan image
- Use hue-intensity-saturation (HIS) methods, PCA methods and regression methods

Spatial domain techniques

- Transfer high-resolution info from a hi-res image to all the low-resolution spectral bands using deterministic or statistical predictors
- Do this by highpass filtration in image domain or by various multiresolution representations

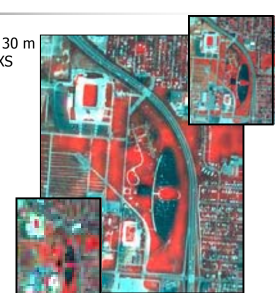
Multiresolution representations

- Hue-intensity-saturation (HIS) methods
- PCA methods
- Regression methods
- Classification-based methods
- Wavelet methods
- See p. 460-464

Multi-resolution data merging

SPOT 10 m Pan & SPOT 20 m XS

Landsat-7 ETM+ 30 m & Ikonos 4 m XS



Source: Canadian Center for Remote Sensing

Statistical downscaling of GCM outputs

- GCM outputs – coarse spatiotemporal resolution
- Statistical downscaling methods
  - Regression methods
  - Weather-pattern-based methods
  - Stochastic weather generators
  - Limited-area modeling methods
- Possible use to develop corresponding downscaling algorithms in quantitative RS