Geocoding Remote Sensing Data

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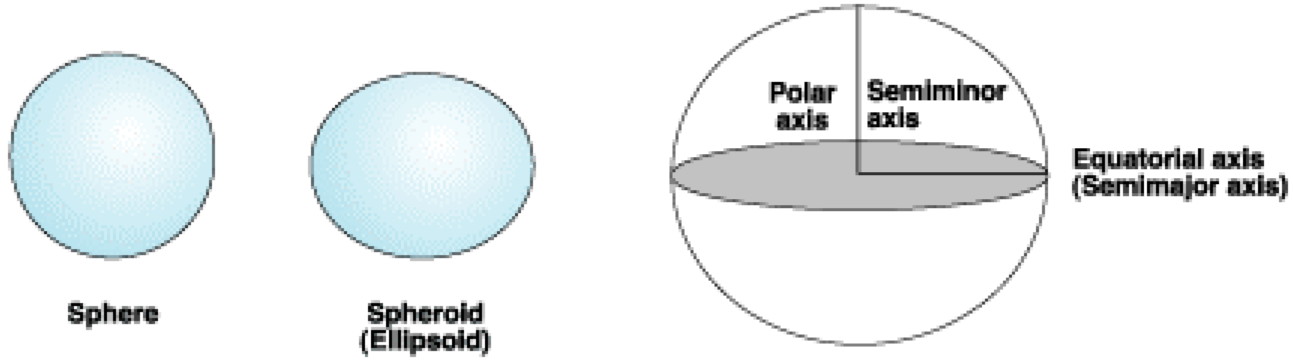
Outline

- definitions
- cocktail ingredients for geocoding
  - spheroid
  - datum
  - map projection
  - resampling
  - interpolation
- various geocoding methods

Definitions

- geocoding
  - geometric transformation of an image into a cartographic map projection
- georeferencing
  - relating image coordinates to map coordinates by defining control points (usually image corners)
- geometric correction and image rectification are sometimes used synonymously
  - geocoding maybe part of geometric correction

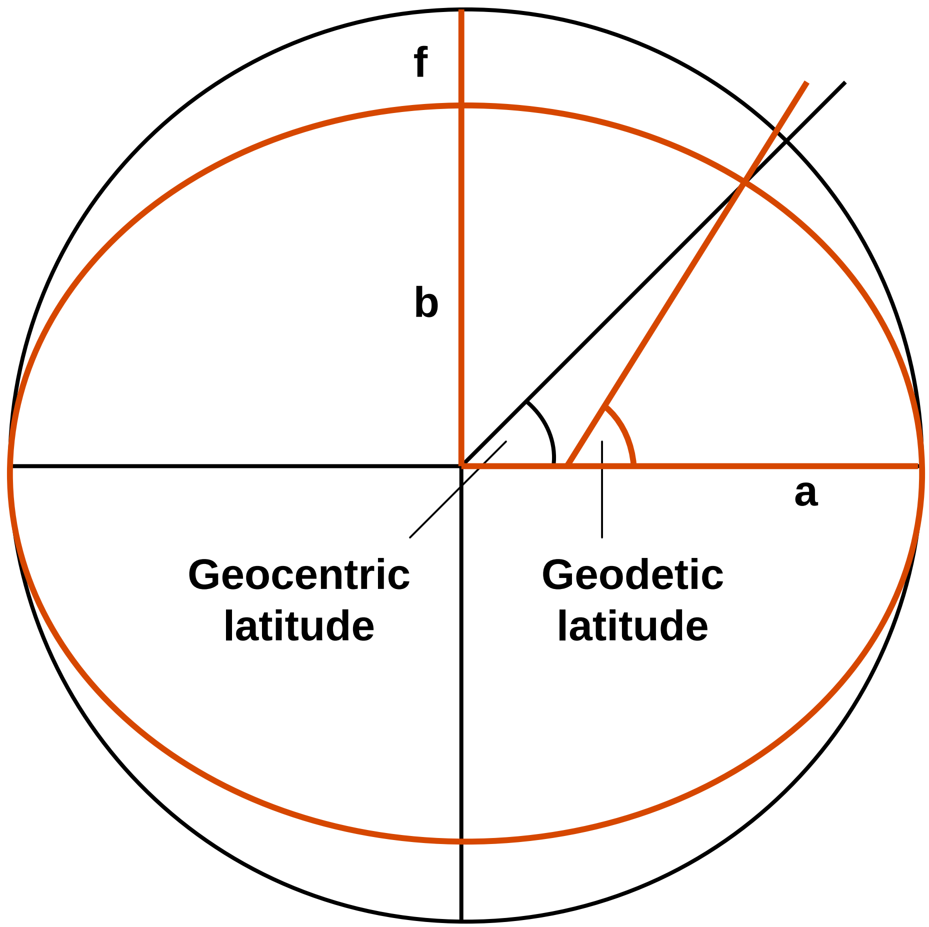
Sphere versus spheroid



Source: ArcGIS help file

- assumption that the earth is a sphere is possible for small-scale maps (smaller than 1:5000000)
- to maintain accuracy for larger-scale maps (scales of 1: 1000000 or larger) a spheroid is necessary

Sphere versus spheroid



Common Spheroids

- Bessel 1841
- Clarke 1866, Clarke 1880
- GEM 6, GEM 10C
- GRS 1967, GRS 1980
- International 1924, International 1967
- WGS 72, WGS 84

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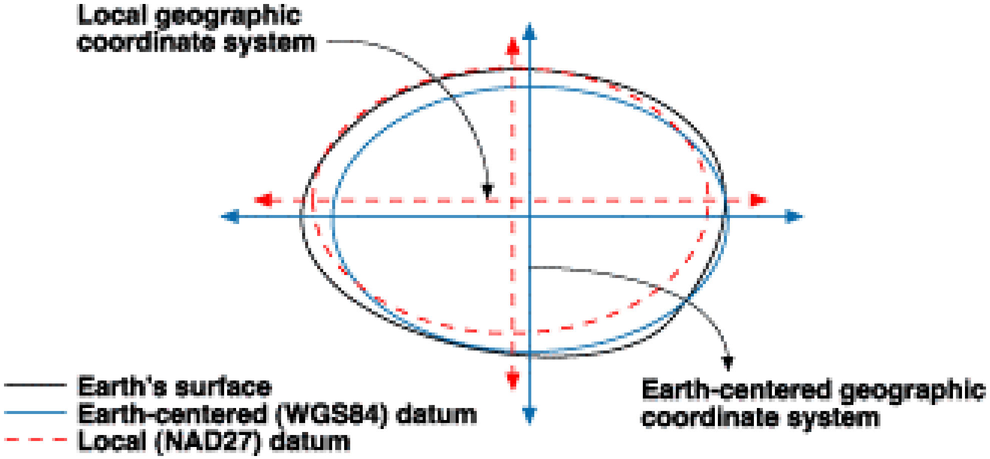
Datum



Source: ArcGIS help file

- defines the position of the spheroid relative to the center of the earth
- provides a reference frame for measuring locations on the surface of the earth
- defines the origin and orientation of latitude and longitude lines

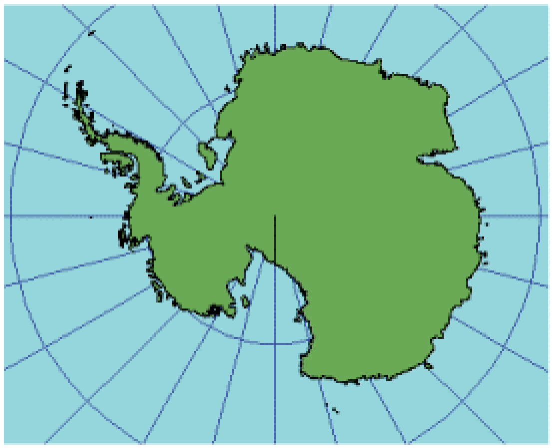
Common Datums

- World Geodetic System 1972 (WGS 72)
- World Geodetic System 1984 (WGS 84)
- North American Datum 1927 (NAD 27)
- North American Datum 1983 (NAD 83)
- European Datum 1950 (ED 50)
- South American Datum 1969 (SAD 69)

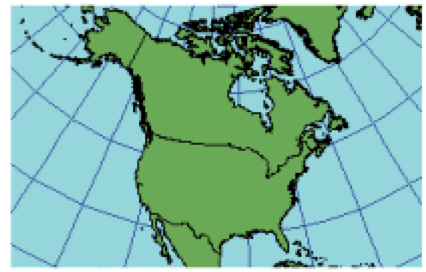
Map projections

- "orange peel problem"
  - distortion in the shape, area, distance, or direction of the data
- three general types
  - conic
  - cylindrical
  - planar

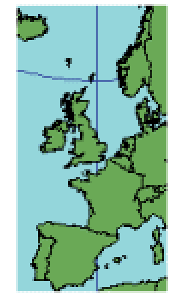
Most common map projections



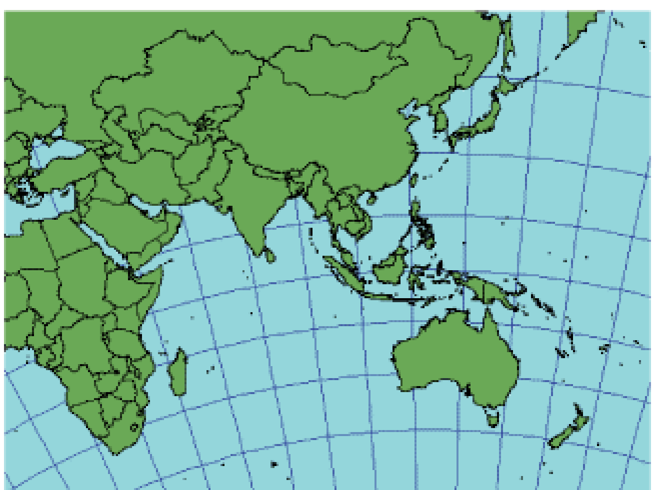
Polar Stereographic



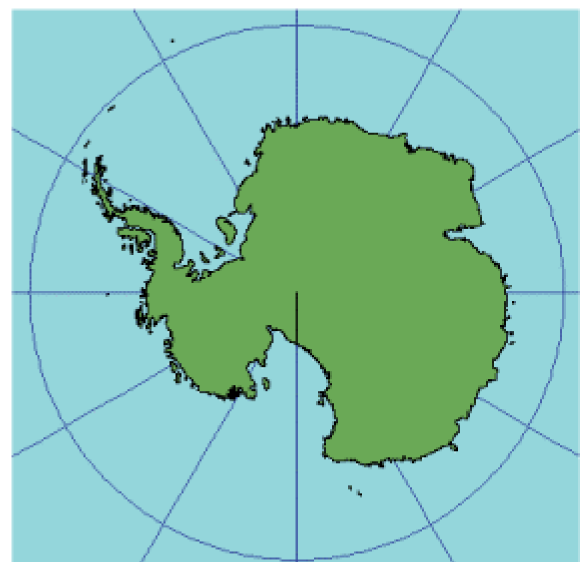
Albers Equal Area Conic



Universal Transverse Mercator



Lambert Conformal Conic



Lambert Azimuthal Equal Area

Source: ArcGIS help

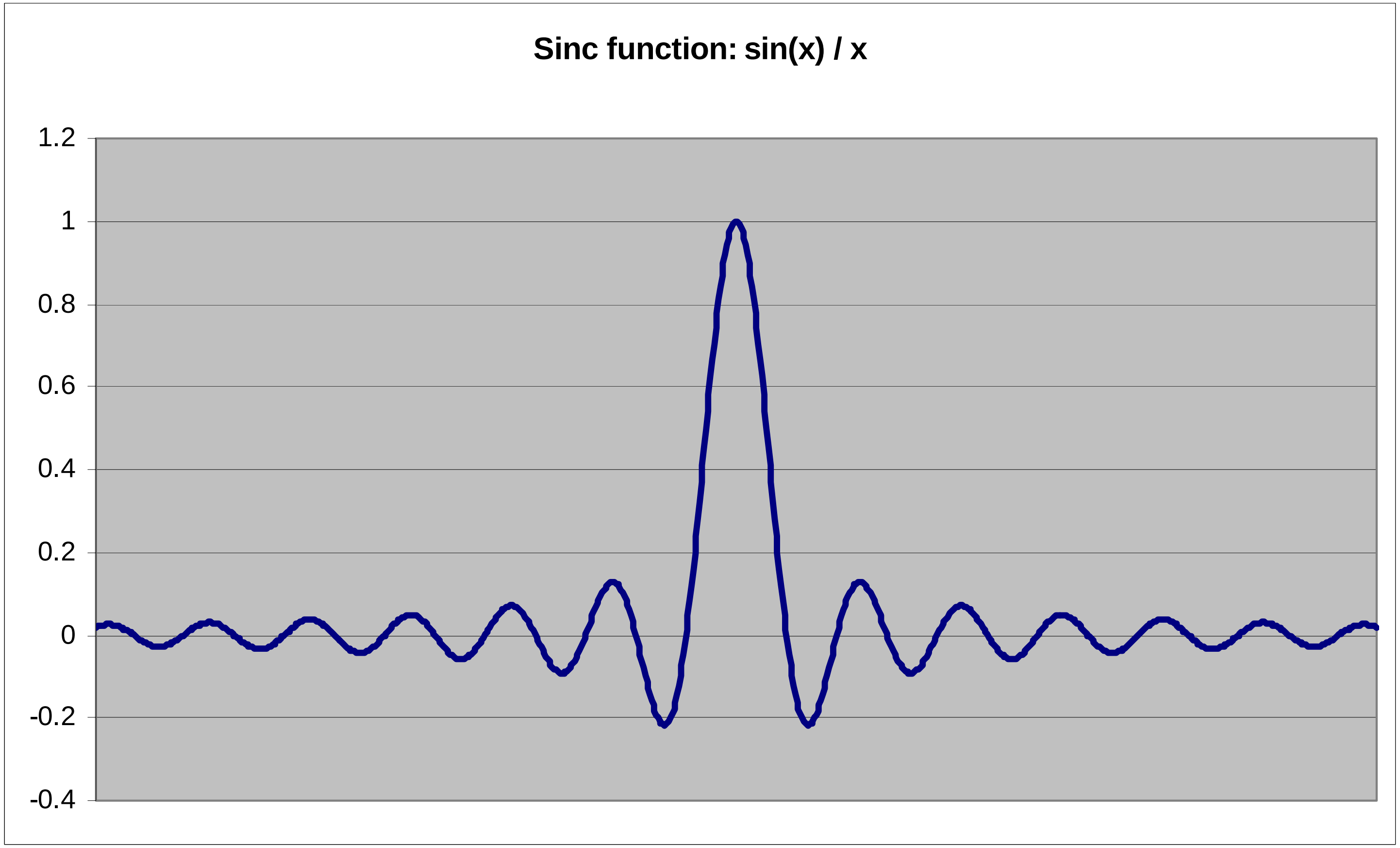
Resampling

- transformation of image coordinates into projection coordinates using a mapping function
  - usually determined as a polynomial fit
  - accounts for user defined output pixel size
- determination of the resulting pixel value using an interpolation method

Standard interpolation methods

- Nearest neighbor interpolation
  - takes pixel value closest to calculated location
  - preserves original pixel values
- Bilinear interpolation
  - weighted average (2x2 kernel)
  - smoothing effect
- Cubic convolution
  - third degree polynomial fit (4x4 kernel)
  - essentially low-pass filter

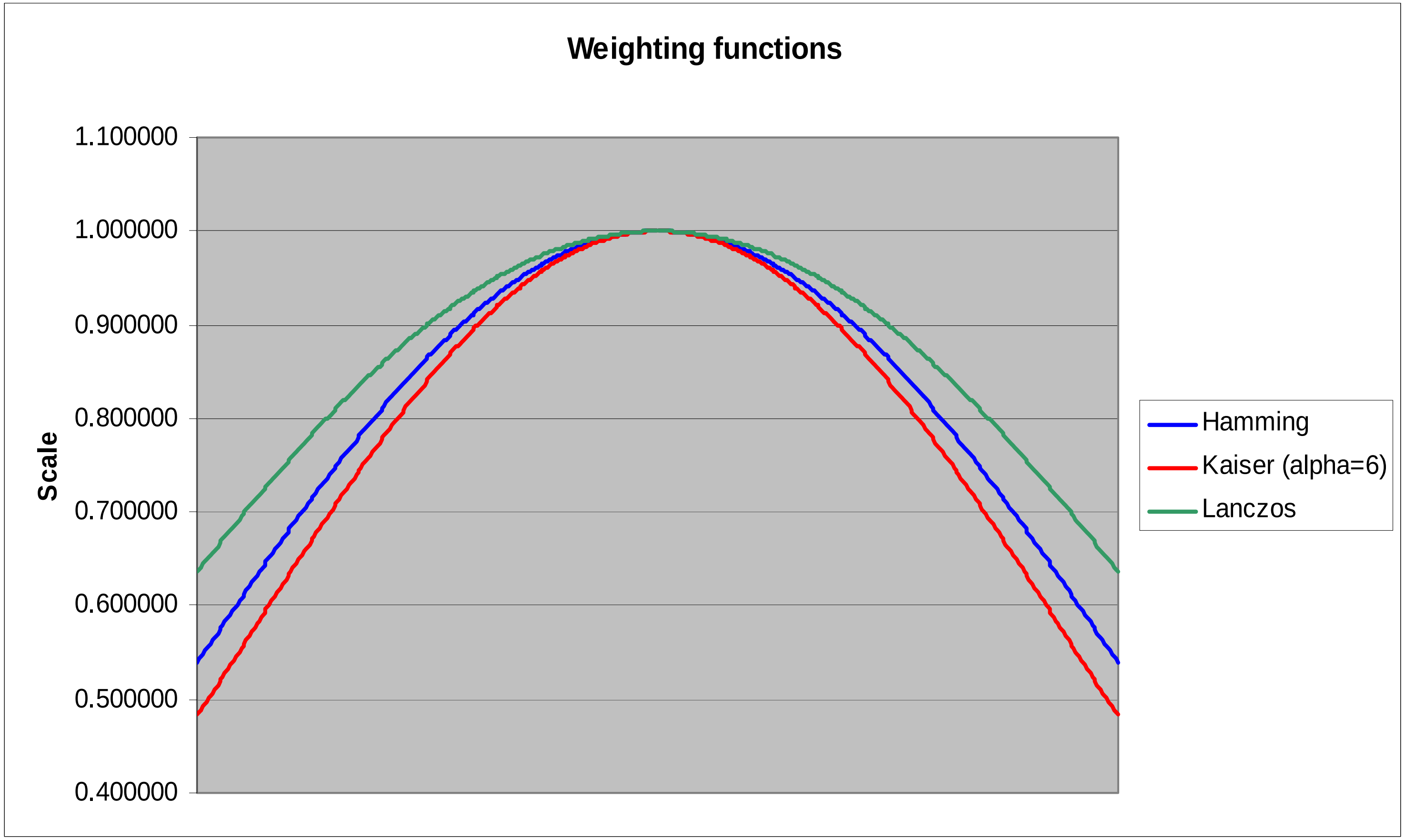
Interpolation using Sincs



Interpolation using Sincs

- theoretically ideal filter
  - provides error-free interpolation of the band-limited functions
- problem: no function can be at the same time band-limited and finite-support
- solution: truncation
- practical problem: slowest of the slowest as it requires large kernel sizes

Weighting functions



Weighting functions

- Hamming

$$\text{Hamming}(x,\tau,\alpha)=\begin{cases}\alpha+(1-\alpha)\cos\left(\pi\frac{x}{\tau}\right) & for\,|x|<\tau\\ 0 & else\end{cases}$$

  - α usually 0.54

- Kaiser

$$Kaiser(x,\tau,\alpha)=\begin{cases}\dfrac{I_0\left(\alpha\sqrt{1-(x/\tau)^2}\right)}{I_0(\alpha)} & for\,|x|\leq\tau\\ 0 & else\end{cases}$$

  - where *I0(x)* is the zeroth order modified Bessel function

- Lanczos

$$\text{Lanczos}\,(x,\tau)=\begin{cases}\dfrac{\sin\left(\pi\frac{x}{\tau}\right)}{\pi\frac{x}{\tau}} & for\,|x|<\tau\\ 0 & else\end{cases}$$

Cubic B-Splines

- piecewise polynomial function of degree three
- very good approximation of sinc function
- generally as fast as cubic convolution

➔ best bang for the buck

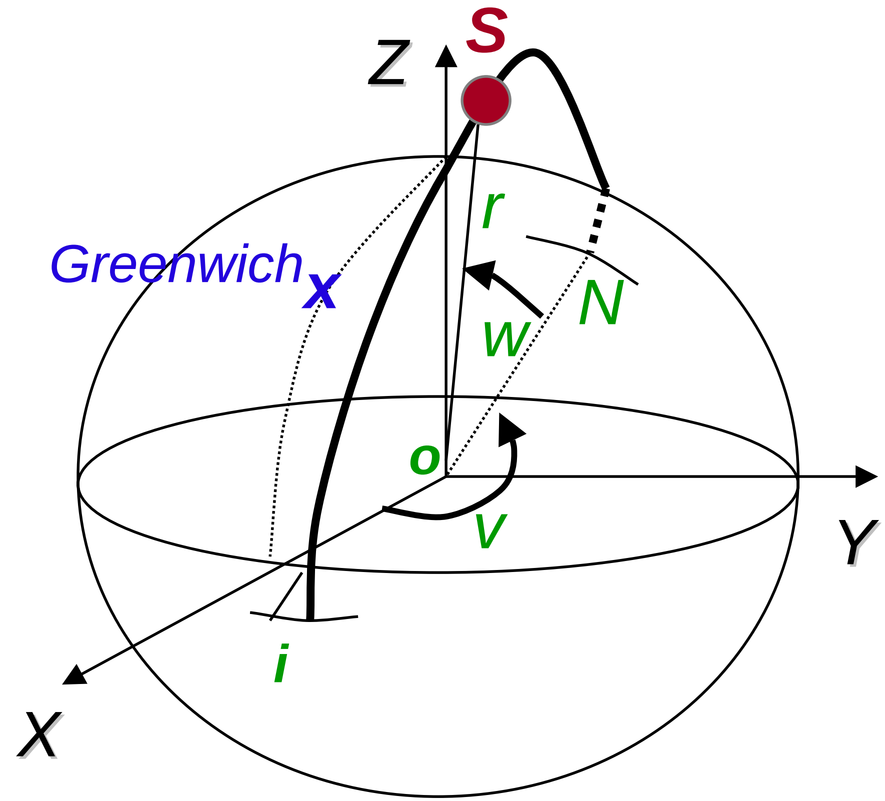
Geocoding by co-registration

- image to image
  - reference needs to be map projected
- image to map
  - map in raster or vector format
  - map needs to have map coordinates
- image with measured ground control points
  - ground control points (GCPs) need to be identified in the image
  - GCPs need to be known in some map coordinate system

Sensor Geometric Model

Geocoding remote sensing data

- Sensor Model
  - sensor specific
  - analytical reconstruction of image formation using orbit and sensor parameters
  - corrects image globally
  - small number of ground control points to improve parameters
  - DEM



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Examples for sensor model

- optical data
  - Landsat (level 1G)
  - MODIS (level 1B)
  - SPOT (level 2A and 2B)
- radar data
  - any beam mode

Geocoding steps

- relation between image coordinates and geographic coordinates using image geometry
  - line / sample → latitude / longitude
- conversion of geographic coordinates into map projected coordinates
  - latitude / longitude → x_{map} / y_{map}
  - choice of map projection and datum

Geocoding steps

- determination of a transformation function to map image coordinates into projection coordinates
  - usually quadratic, at times cubic
  - linear least squares polynomial fit
- resampling using mapping function
  - determination of pixel value in the map projected using one of the interpolation methods

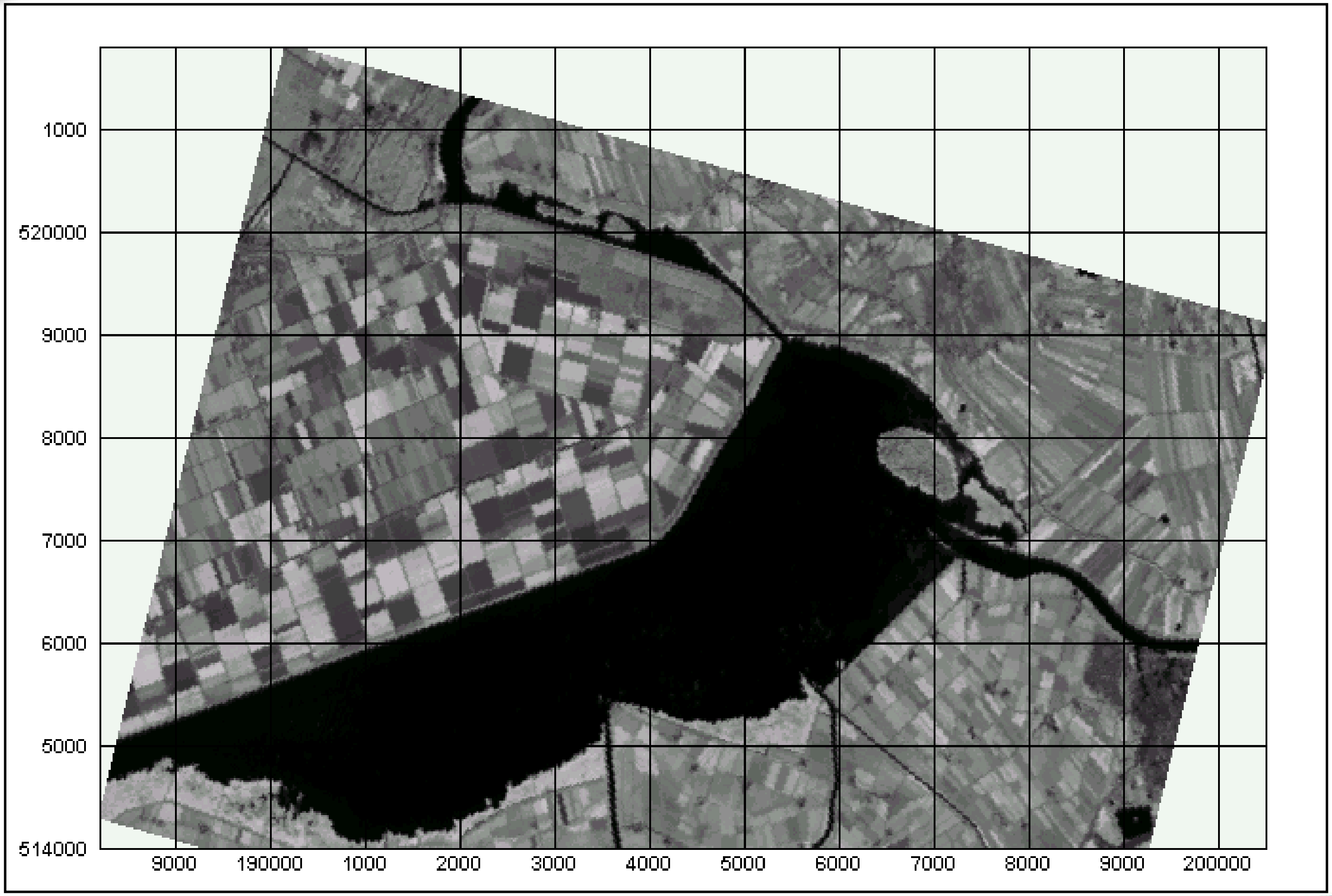
Example: Original image

Source: ITC

Example: Transformed image

Source: ITC

Example: Geocoded image



Source: ITC

Light at the end of the tunnel*

- asf_geocode
  - currently under development
  - supports all major map projections
  - supports all major datums
  - supports all standard interpolation methods

***for SAR data**

More background information

- image processing literature
  - medical imaging
  - astronomy
  - signal processing
- remote sensing data providers
  - product descriptions for the various satellite imagery

Questions

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