USING RADAR FOR WETLAND MAPPING
SOIL MOISTURE AND WETLAND CLASSIFICATION

Slides modified from a presentation by Charlotte Gabrielsen for this class.

From C. Wang et al. 2004, Remote Sensing of Environment 90, 178-189

IMPORTANT OF SOIL MOISTURE

- Commercial purposes—agriculture and irrigation
  - Crop yield: pre-planting moisture; irrigation scheduling; denitrification
  - Sediment transport: runoff producing zones
- Climate studies
- Meteorology
  - Evapotranspiration: partitioning of available energy into sensible and latent heat exchange
- Hydrology
  - Rainfall runoff: infiltration rate; water supply

TRADITIONAL METHODS TO MEASURE SOIL MOISTURE

- Feel method
- Electrical resistance
- Neutron probe
- Soil tension

Flooding in Pakistan in 2009: Envisat SAR-based image.

Inundated land under forest canopy in Australia mapped using radar—water and tree trunks cause strong double backscatter.

Southeast Arizona: Winter wet period

http://cals.arizona.edu
DIELECTRIC CONSTANT

- Dielectric constant:
  - Measure of the capacity of a material to store a charge from an applied electromagnetic field and then transmit the energy.
  - The higher the dielectric constant, the less permeable a material is to radar signal.
  - The more water there is in soil, the stronger the return signal (all other things being equal).

DIELECTRIC CONSTANT AND EFFECT OF SOIL TYPE

- Soil dielectric constant is directly proportional to its moisture content.

MOISTURE CONTENT

- Moisture increases dielectric constant.
- Identical materials can look different in radar imagery due to differences in moisture content.
- Brightness (reflectance) of plants and surfaces increase with moisture content.
- Radar can penetrate deeply into dry materials but not into wet materials (quantifies 0 – 15 cm moisture).

MAPPING SOIL MOISTURE

- Timing is important because soil moisture is very dynamic.
- Environmental conditions and precipitation history are important.
- Can't estimate in frozen soil.
- Depth of penetration depends on soil moisture and incidence angle and is important to understand for modeling.
SMAP: SOIL MOISTURE ACTIVE PASSIVE (LAUNCHED JAN. 31, 2015!)

Provided global soil moisture and freeze thaw info with 2-3 day return time at coarse (1-3 km) spatial rez.

SMAP: SOIL MOISTURE ACTIVE PASSIVE

DETECTION OF WETLANDS

- Soil moisture is a good indicator of wetland presence
- High temporal resolution radar can help characterize wetland hydroperiod

REMOTE SENSING OF WETLANDS

- Wetlands defined by...
  - Presence of water at, above, or near ground surface
  - Hydric soils
  - Vegetation species adapted to or tolerant of wet soil

- Remote sensing can be used to map and monitor two of the defining wetland features, vegetation type and surface water/wet soils
- Historically, wetlands have been one of the most difficult ecosystems to classify using remotely sensed data

REMOTE SENSING OF WETLANDS

WETLAND ECOSYSTEM SERVICES

- Flood control
- Groundwater replenishment
- Sediment and nutrient retention and export
- Water purification
- Reservoirs of biodiversity
- Recreation and tourism
- Climate change mitigation and adaptation

TRADITIONAL METHODS FOR WETLAND MAPPING (NWI)

- Aerial photography interpretation or single date optical imagery common source for wetland maps
- Err more by omission than commission
- May not represent dynamic nature of wetlands

TRADITIONAL METHODS FOR WETLAND MAPPING

- NWI often underestimates proportion of water on the landscape
SAR WAVELENGTHS

- Commercially available SAR satellites:
  - **L-band** (~23 cm wavelength)
    - Useful for mapping forested and high biomass herbaceous wetlands
  - **C-band** (~5.7 cm wavelength)
    - Most useful in forests during leaf-off condition and for sparse canopies
  - **X-band** (~3.5 cm wavelength)
    - Useful for detection of water level changes

SAR POLARIZATION

- Horizontal send and receive (HH) polarization is most useful for detecting wetlands
- Cross polarizations (HV) can discriminate woody versus herbaceous vegetation types due to their sensitivity to biomass
- Vertical send and receive (VV) polarization is sensitive to soil moisture and flood condition

SURFACE INUNDATION (FLOODING)

- Can increase radar backscatter in forests
  - "Double-bounce" scatter: energy emitted from sensor bounces off the water surface away from the sensor and then off a tree trunk back to sensor
- But can decrease backscatter in open areas due to specular reflectance

SCATTERING OF C-BAND ENERGY

SCATTERING OF C-BAND ENERGY

RADAR AND OPTICAL DATA FUSION

- Can improve wetland characterization by combining multiple remotely sensed data types
- Uses multiple sensors
- Multi-temporal data
- Fusion of sensors operating in different frequencies (thermal, optical, lidar, radar, infrared) measure various aspects of wetlands for improved mapping accuracy
STUDY AREA: PLAINS AND PRAIRIE POTHOLE REGION, U.S.A

STRESSORS IN THE PPR
- Climate change
- Ag/Development
- Truncated hydroperiod
- Reduced connectivity

PRAIRIE POTHOLE REGION RESEARCH
- Using a combination of optical and radar data to map wetlands in wet and dry years to obtain information about wetland hydroperiod
- For ephemeral wetlands, soil moisture is important
- By determining wetland extent, aim to predict hydroperiod and wetland location for future climate change scenarios
- Projections can be used to support ecological and landscape-based vulnerability assessments and climate change adaptation planning.

SUMMARY
- Radar data has broad application for the detection of soil moisture and mapping.
- Fusion of radar data with optical data can improve map accuracy.
- Use of radar sensors for wetland mapping has implications for an operational wetland hydrology monitoring solution.