Zentralanstalt für Meteorologie und Geodynamik

Overview to Training Session

- Introduction to Observation of Soil Moisture
- Exercises

- Introduction to Assimilated Soil Moisture
- Exercises

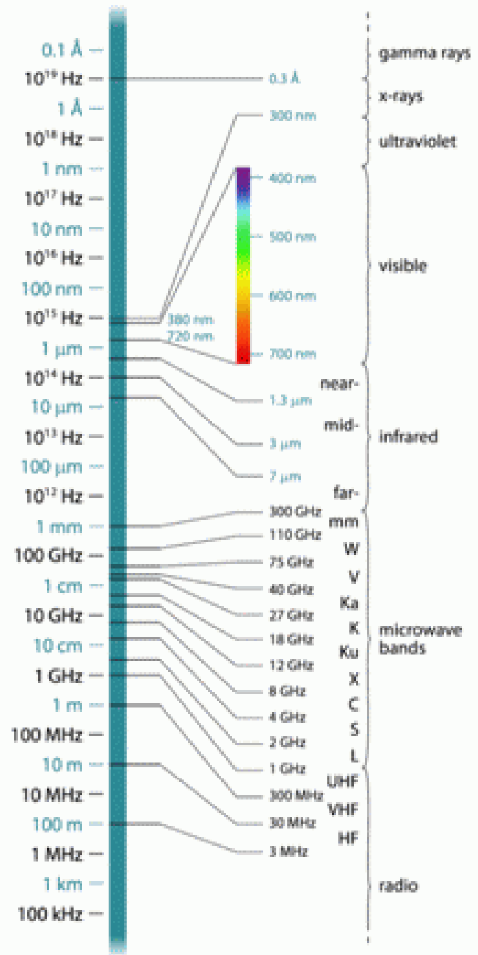
- Training on actual cases

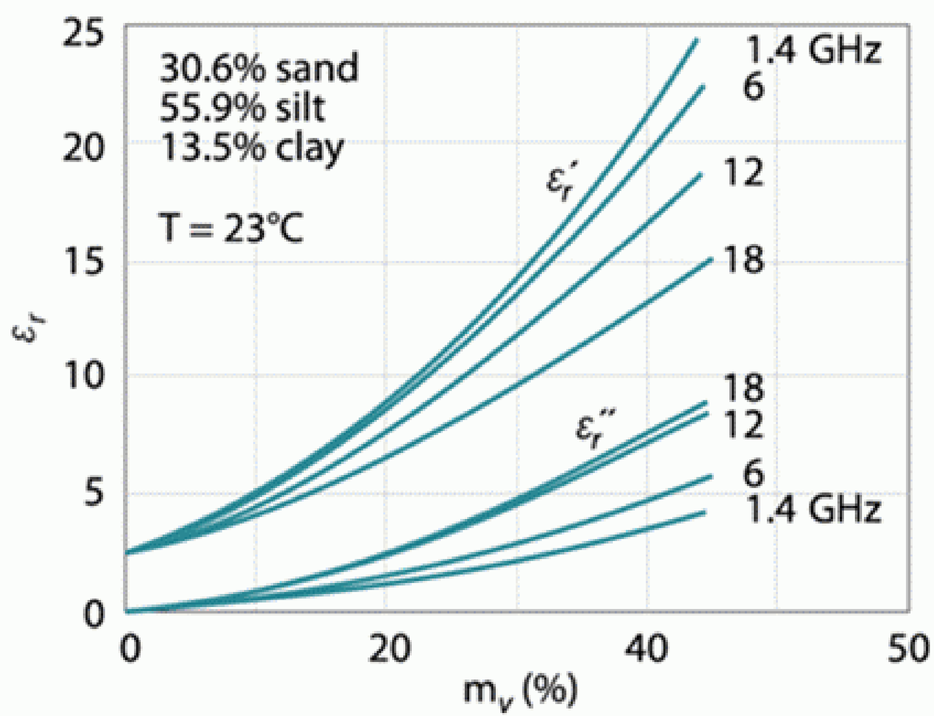
Observation of Soil Moisture

Microwaves and Soil Moisture

- The microwave region: 0.3 to 300 GHz (which equals 1 m to 1 mm wavelength)
- designated into several bands, which are indicated by a letter (see next slide).
- reasons for using microwaves are:
  - their capability to penetrate the atmosphere (particularly at lower frequencies)
  - independence of the sun as source of illumination. This means
  - all-weather and day-round.
- strong relationship between the dielectric properties and the backscatter intensity due to the dipole characteristics of water molecules. Figure on next slide shows the dependency of the dielectric constant on soil wetness for a specific soil type at several frequencies.

Microwaves and Soil Moisture





Satellite and Sensor Geometry

- The ASCAT (Advanced SCATterometer) instrument onboard the MetOp-A satellite is a real aperture radar operating at 5.255 GHz (C-band). It transmits a long pulse and receives ground echoes. The backscattered signal is then spectrally analyzed and detected.

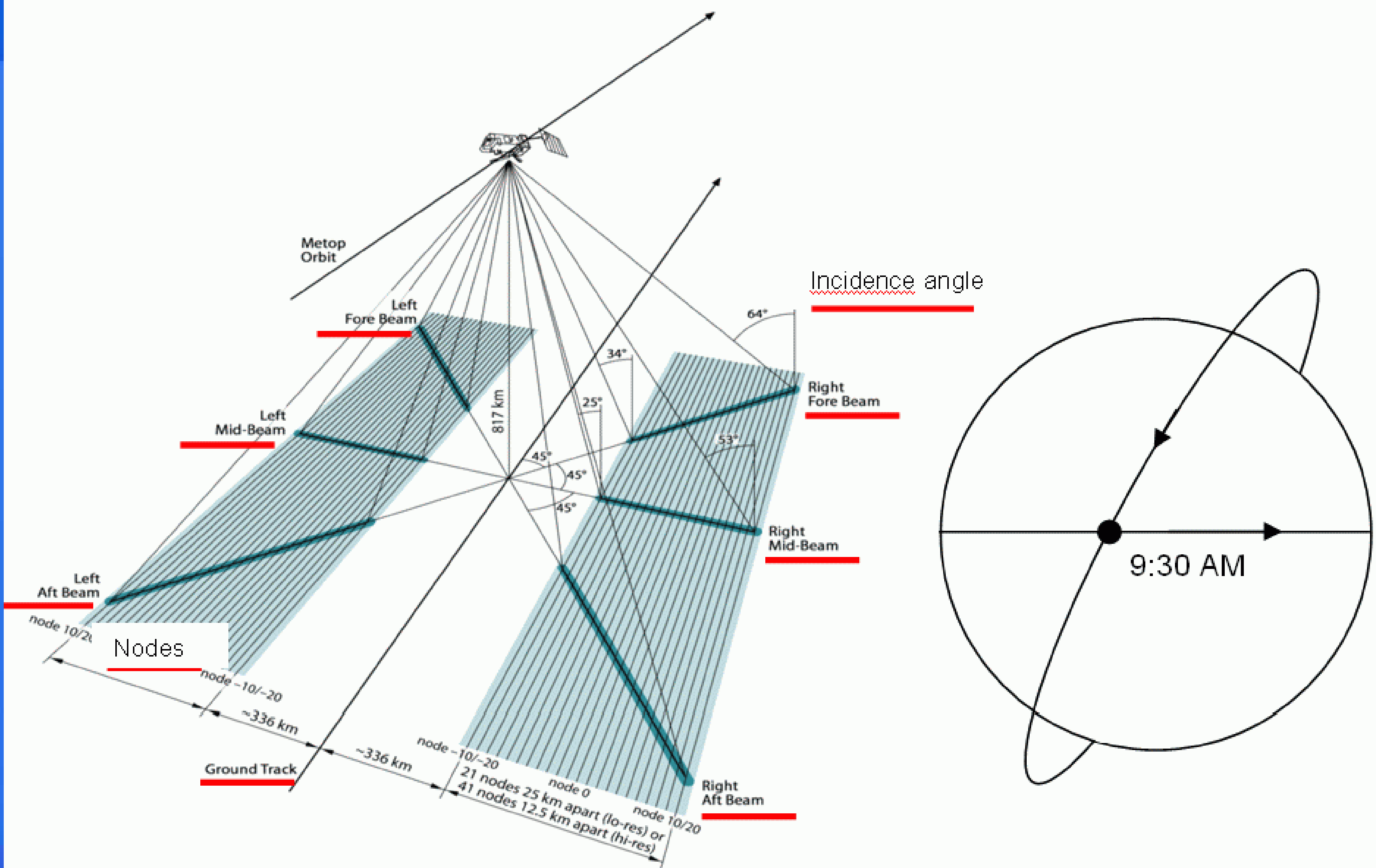


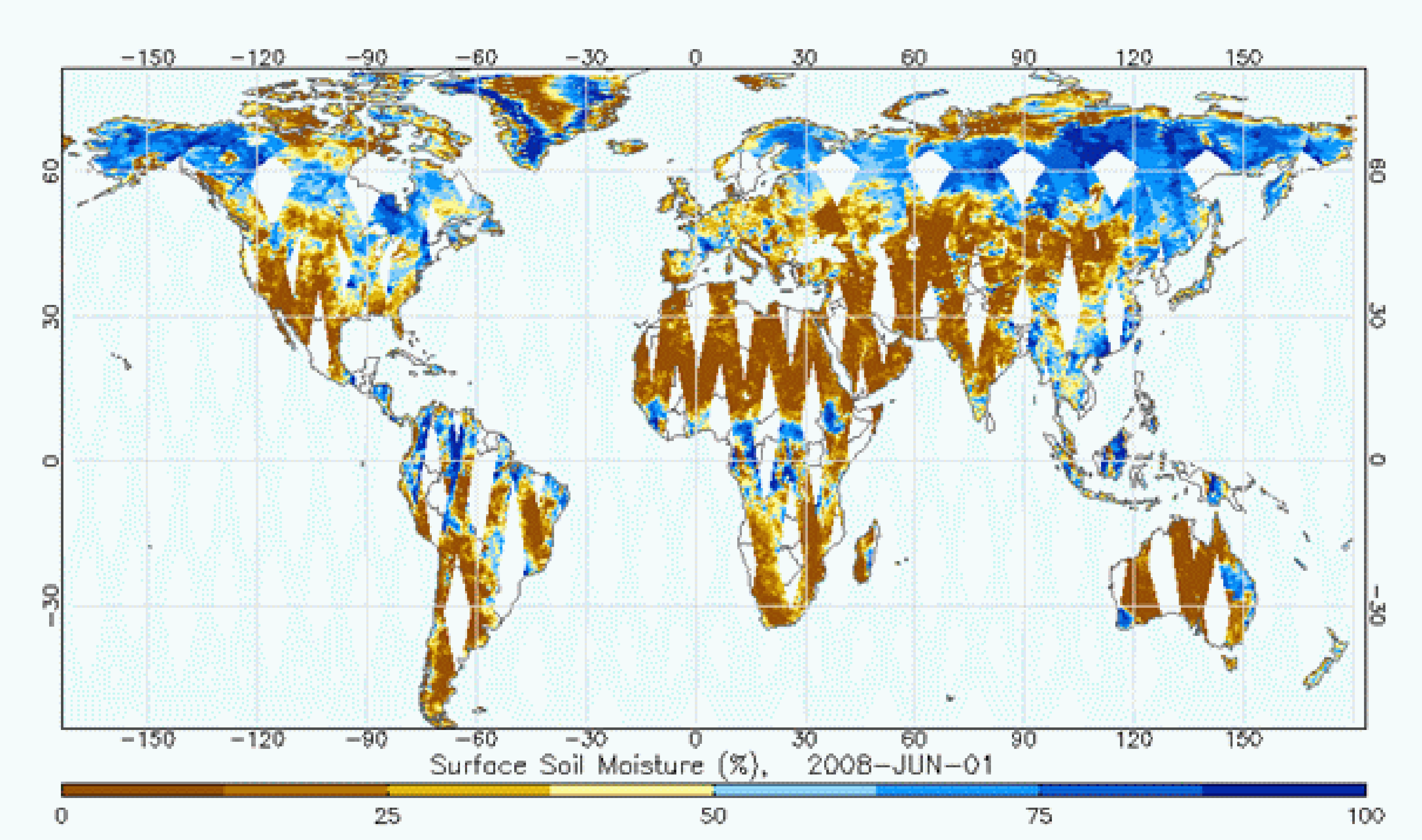
Figure 2: MetOp ASCAT geometry

Coverage of the products

The ASCAT geometry of the MetOp-A satellite illuminates the earth surface in six beams on the left and right hand side (according to flight direction). The beams are called Fore, Mid and Aft beam according to their viewing direction. The beams illuminate the surface at fixed incidence angles. Left and right beam are approximately 500 km in width, leaving a ~660 km gap in between. The ground track is not illuminated. Each beam measures the backscatter at fixed positions called nodes (21 or 41 according to the product) which are alienated along node-lines. In effect, a point on the earth surface is measured 3 times (fore, mid, aft-beam). Therefore, we often speak of the backscatter-triplet at a certain position.

- polar sun-synchronous orbit with an inclination of ~98° at an altitude of 817 km
- from north to south pole at roughly the same time each day while the Earth turns below it.
- MetOp crosses the equator at 9:30 local solar time, called the descending node, followed by an ascending node completing one full revolution.

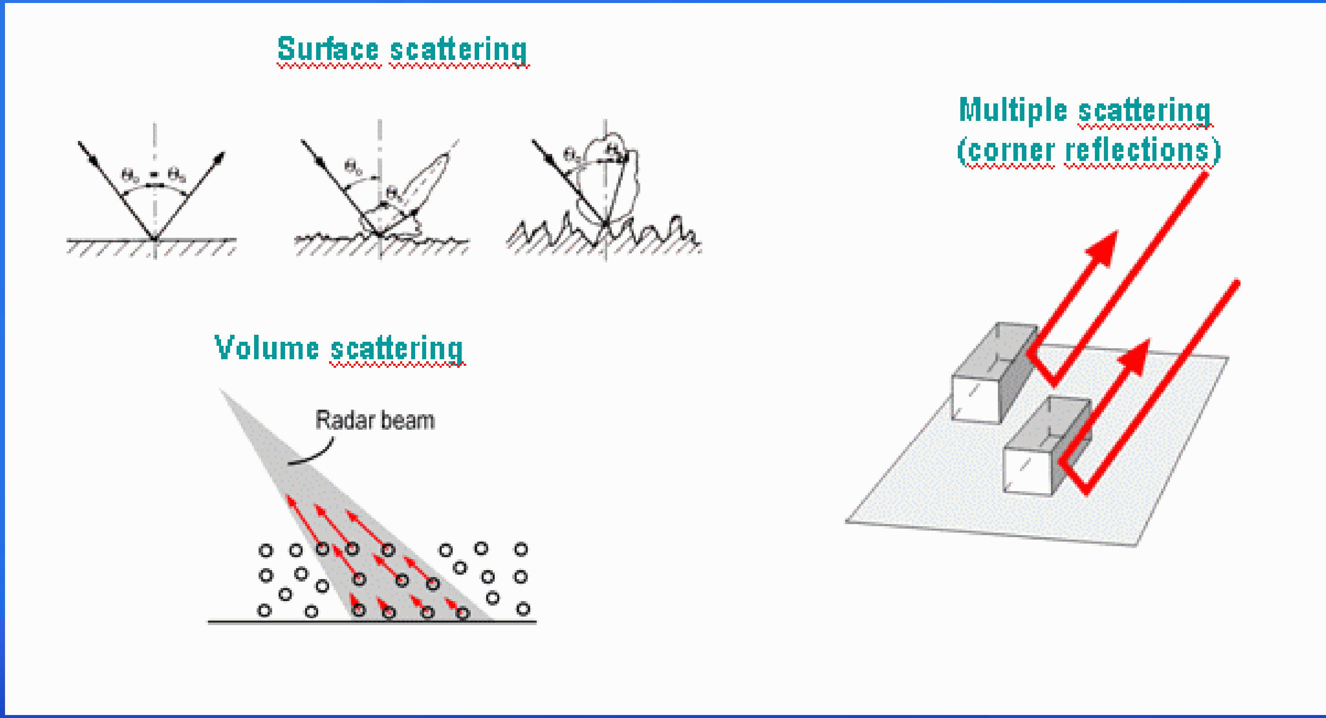
Coverage of the products



- http://www.ipf.tuwien.ac.at/radar/pix/gallery/img/ascat_lores.wmv

Factors influencing the backscatter characteristics

- viewing geometry, wavelength, azimuth and incidence angle,
- surface roughness, where the signal is attenuated by surface scattering,
- volume scattering
- multiple scattering

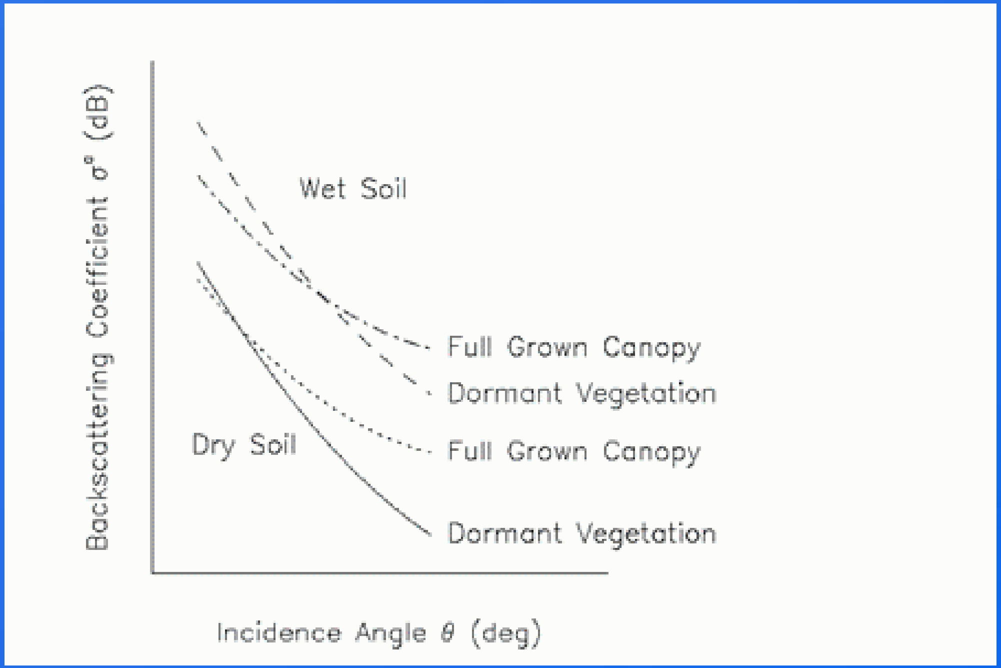


Factors influencing the backscatter characteristics

Another influence is that of vegetation (structure, depth and orientation of the canopy).

- higher incidence angles - lesser of the emitted signal is scattered back.
- This is the case for bare soil or dormant vegetation.
- When vegetation is growing the emitted waves experience volume scattering of the canopy and the backscatter increases also at higher incidence angles.
- At a specific incidence angle the two curves intersect each other. At this position, it is assumed that the effect of vegetation is minimal. These angles are determined “crossover angles” for dry and wet soil conditions, respectively

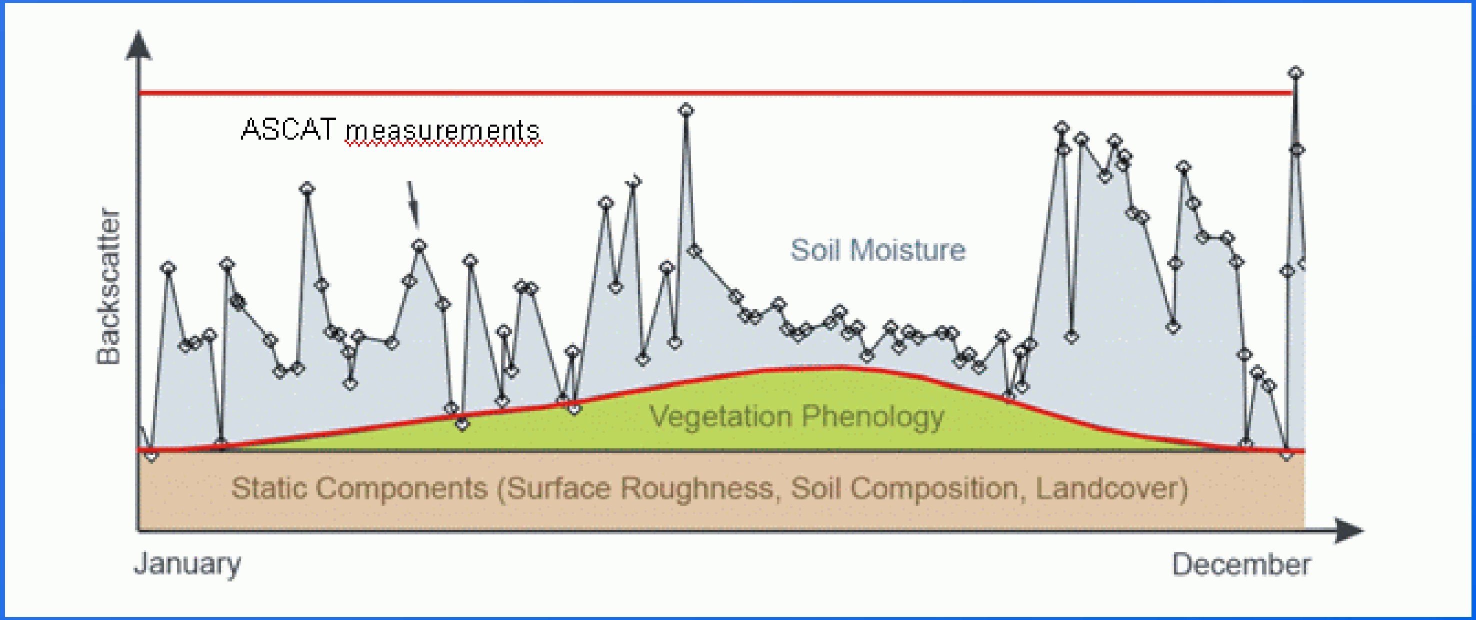
Factors influencing the backscatter characteristics



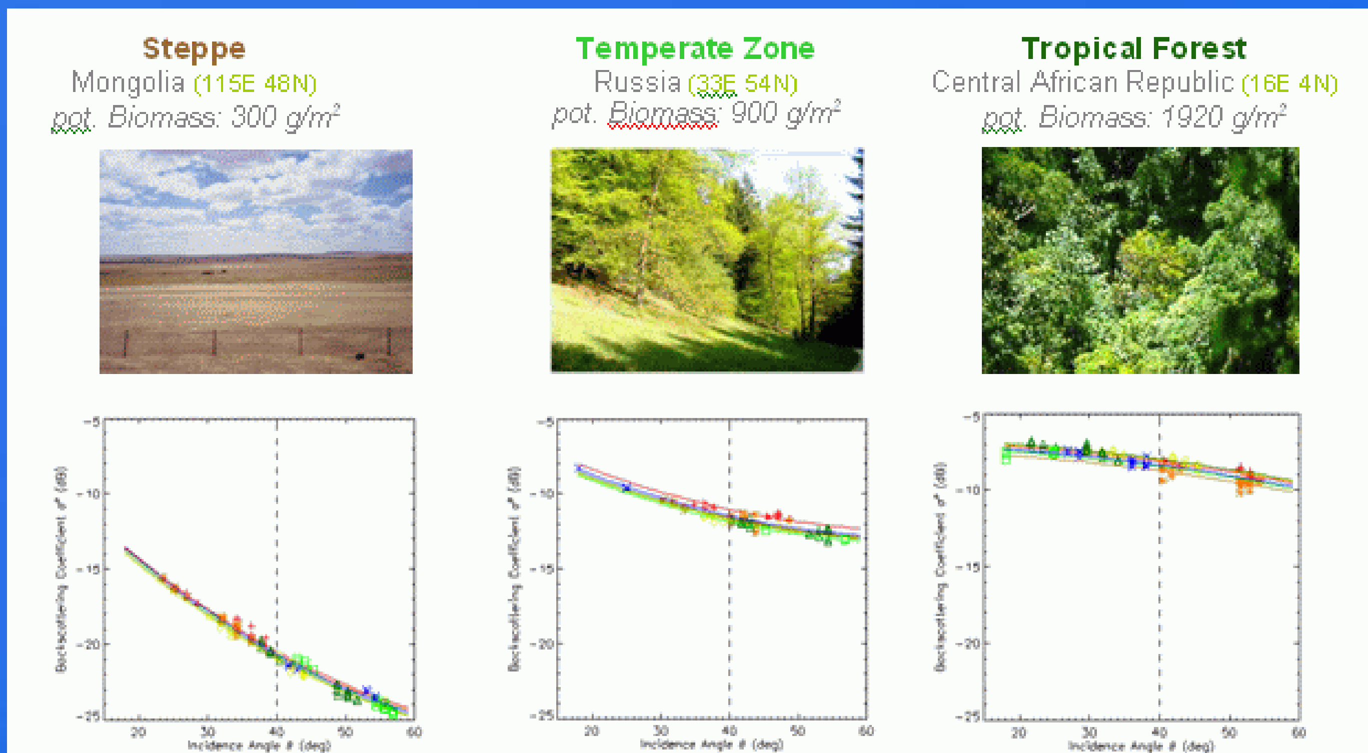
Soil moisture retrieval: time-series approach

- data-based time-series approach
- starting from the backscatter observations
- no need of external model considerations (like radiative transfer models etc).
- long-term datasets available .
  - the predecessor of MetOp, the ERS satellites, were in orbit since 1991, with similar sensor geometry and ASCAT was brought into orbit in 2007.
- identification of static components which are due to surface roughness, soil types, land cover and characterises the influence of vegetation phenology on the backscatter signal

Soil moisture retrieval: time-series approach



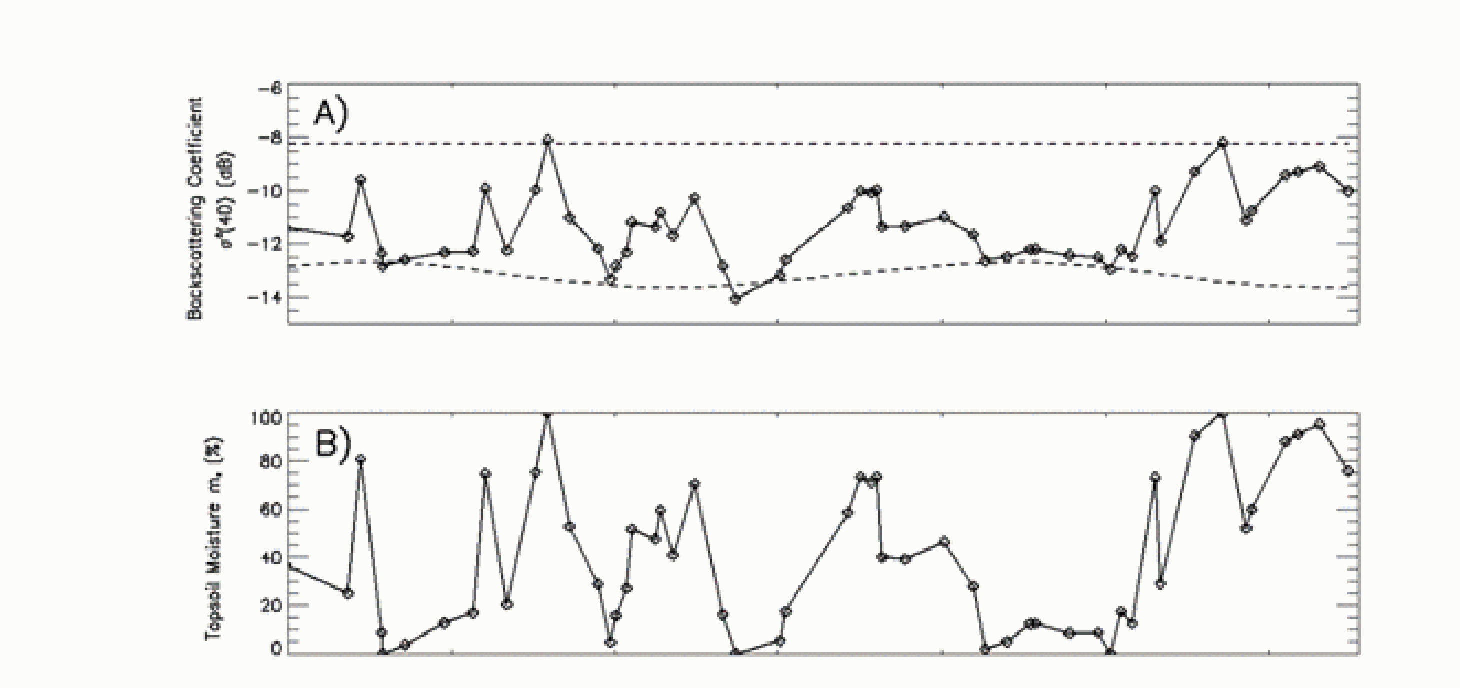
Estimation of model parameters from multi-incidence angle information



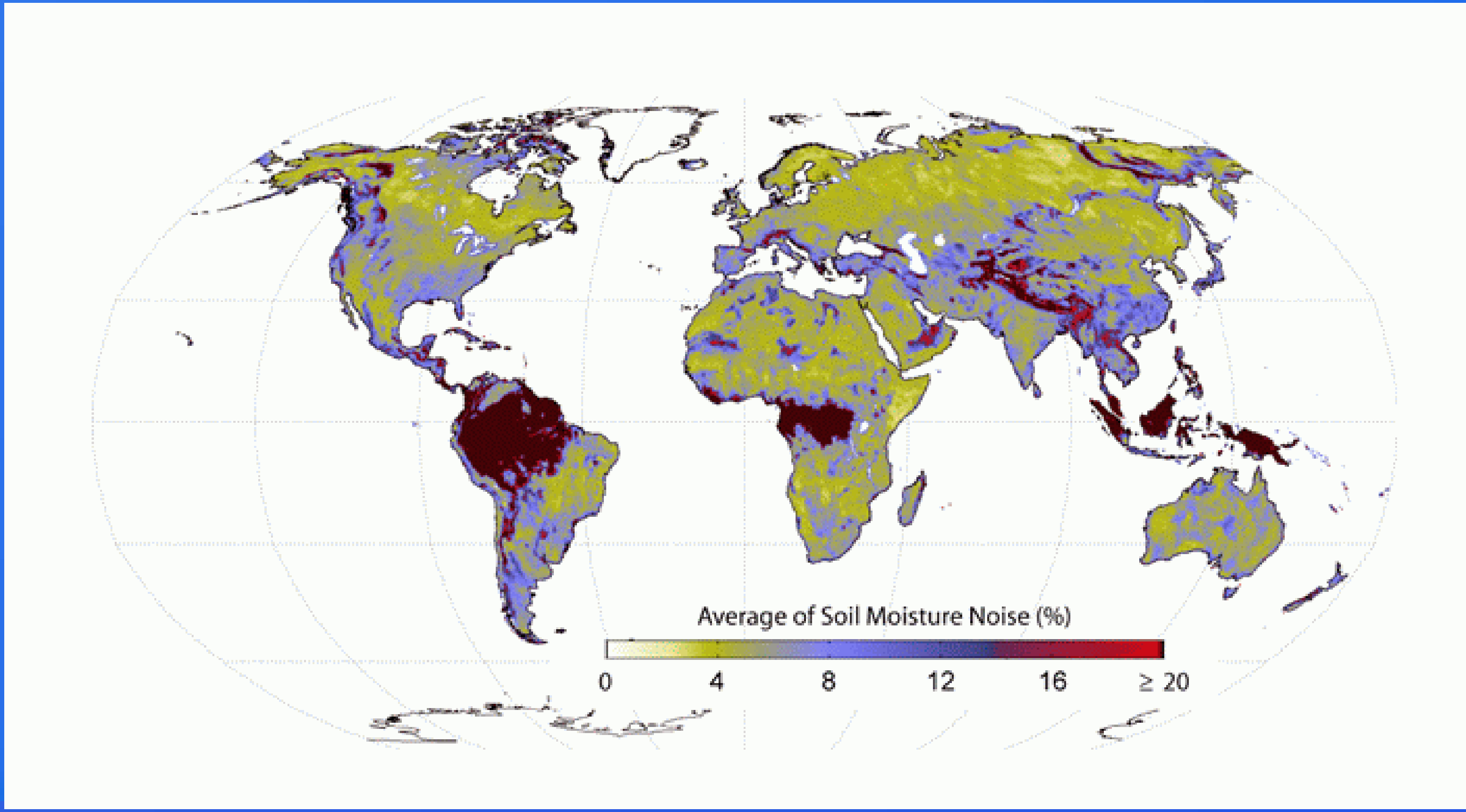
Estimation of model parameters from multi-incidence angle information

- With a high number of measurements (> 50) the backscattering properties of individual points can be well described.
- for bare soil or low vegetated areas the estimated curve is rather steep
- tropical forests act as perfect volume scatterer and the relationship is nearly a flat line
- parameters like the seasonal variation of slope, curvature, minimum and maximum backscatter are estimated.

Estimation of model parameters from multi-incidence angle information



Applicability of Soil Moisture Retrieval



Applicability of Soil Moisture Retrieval

Areas with the highest uncertainties in soil moisture calculation

- mountainous areas with high standard deviation of elevation
- water bodies
- sand desert
- dense vegetated areas (such as tropical rainforest)

Conditions causing high noise level

- snow covered areas
- frozen soil surface

Exercises

- http://www.satreponline.org/hydro/print.htm#page_6.0.0

Assimilated Soil Moisture

- http://www.ecmwf.int/research/EUMETSAT_projects/