KØBENHAVNS UNIVERSITET

Cosmic-ray neutron detection and modeling
- estimating biomass and canopy interception

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Objective: To estimate intermediate scale biomass and canopy interception

Canopy interception:

- is the precipitation intercepted by the canopy of a tree/forest
- the interception loss can be important for the water balance
    - Skjern River catchment: 16% forest and approx. 200 rainy days per year. Earlier studies estimate canopy interception loss to be around 40% of the total forest evaporation (Apr-Oct 2010)
- is traditionally measured on a small scale (e.g. through-fall stations)

Biomass:

- detection is important given interests in bioenergy, climate change, wood production etc.
- is traditionally estimated through e.g. tree surveys, satellite/images retrievals
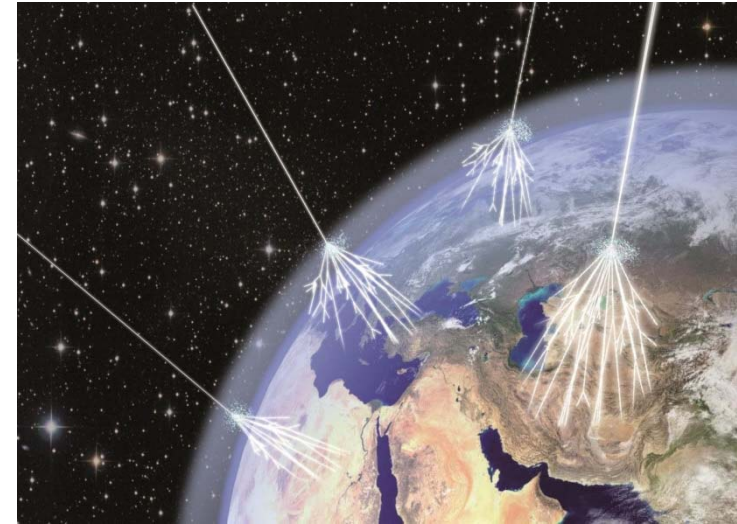

Through-fall station

Cosmic-ray transport

High energy particles

Earth´s protecting forces:
-the magnetic fields
-the atmosphere (*Moderation and absorption of the particles*)

Inverse relationship between the cosmic-ray neutron intensity and the hydrogen content (*Unique ability of hydrogen to moderate neutrons*)
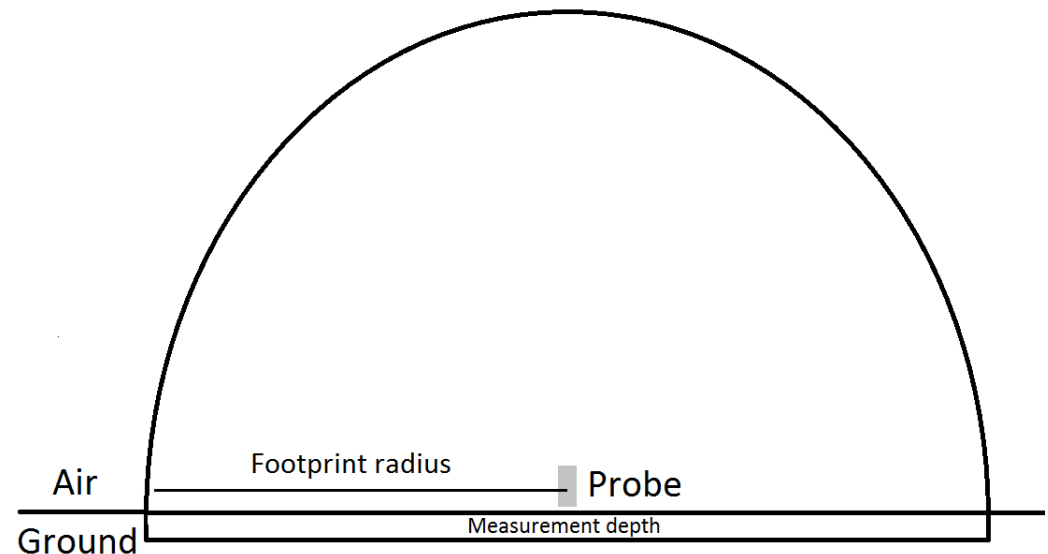

Footprint

In the scale of <u>hectometers</u> in the air and <u>decimeters</u> in the ground

Hydrogen is pooled in the:
-biomass
-canopy interception
-surface water
-water vapour
-soil moisture
-soil organic compounds etc.

Air   Footprint radius   Probe

Ground   Measurement depth

Method

Field equipment

Cosmic-ray neutron probes:

- BARE probe; detects <u>low-energy</u> neutrons
- MOD probe; detects <u>high-energy</u> neutrons

Measurements

- multiple level measurements
- multiple neutron energy detection
- reference detection (above a water body)

Modeling, MCNPX

- an extended version of the Monte Carlo N-Particle Transport Code
- a radiation transport code for simulating nuclear processes

Gludsted Plantation

Forest characteristics:

-latitude: 56° N and 50 m abs.

-flat terrain and sandy soils

-a coniferous plantation
  primarily Norway spruce; 20 and 40 years

-forest area: approx. 3500 ha

-biomass: approx. 100 t/ha above ground
 dry biomass *(from Lidar images, 2006/2007)*

-thick litter layer *(5-7 cm)*

Model conceptualization
- to setup a representative model

MCNPX model

- steady state model

Energy bins

- thermal neutrons; 0 - 0.5 eV

- fast/epithermal neutrons; 0.5 - 10^6 eV

A homogenous forest is simulated using average values for the forest and the soil:
- tree radius and height
- tree density
- forest biomass
- bulk density
- porosity
- carbon content
  etc.

Forest layer seen from above →
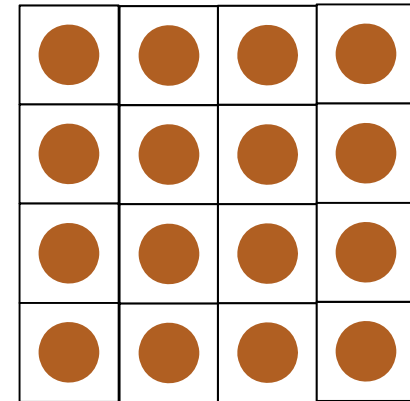
Forest layer seen from the side →

Forest layer

Atmosphere

Litter layer

Soil layer
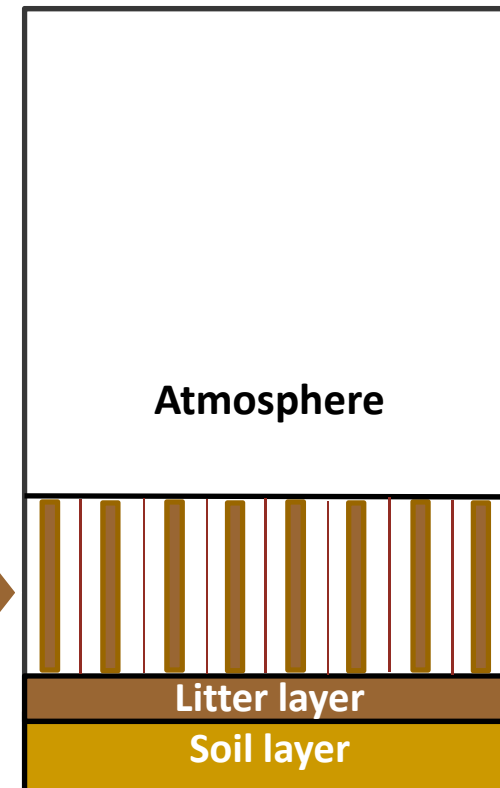
Cosmic-ray neutron intensity profiles
- Measurements vs. Model

Measurements:
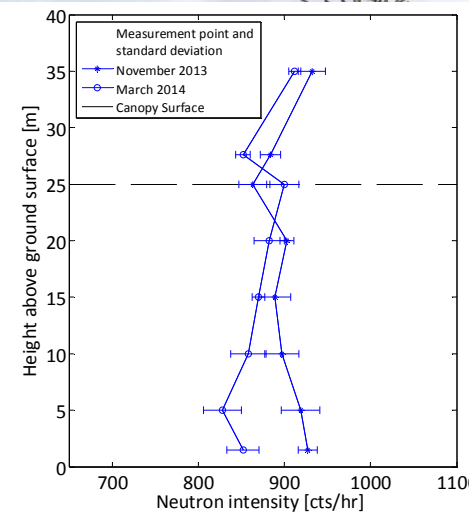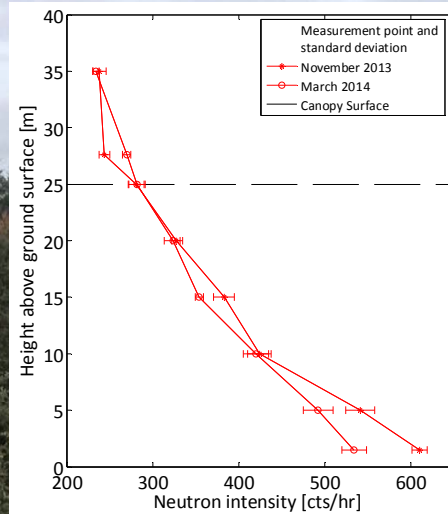
Model:

Mismatch between the measured and modeled high-energy neutron intensity
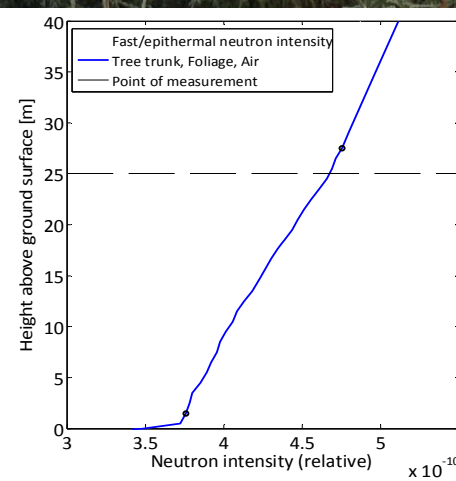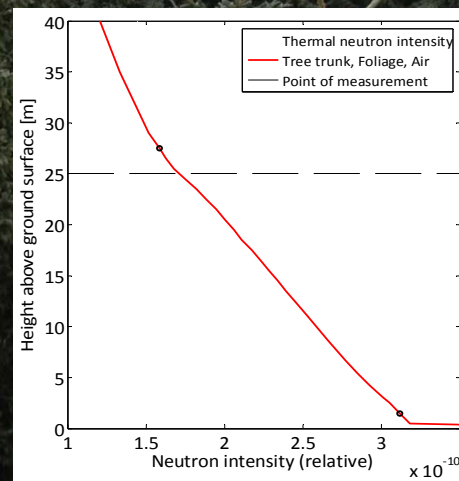
Ringkøbing Fjord – Cadmium shield experiment

A cosmic-ray neutron probe shielded by cadmium foil will detect neutrons with energies > 0.5 eV

Reference measurements
   - *conversion factor - relative count rates (model) to actual count rates*
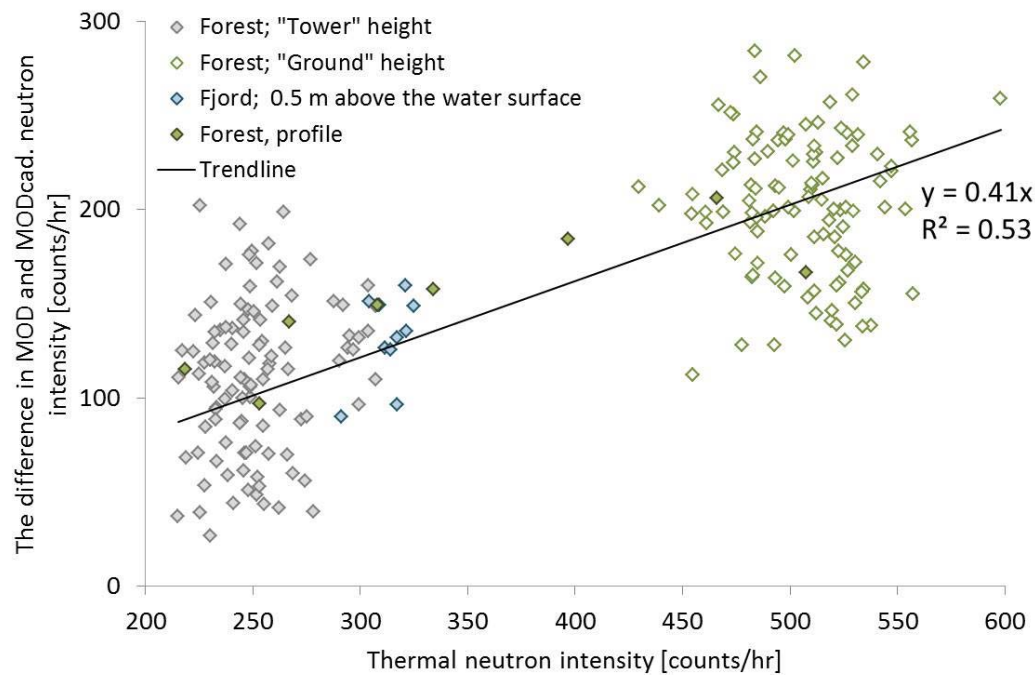   *> a chemical analysis of the fjord water is necessary!*

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Dias 8
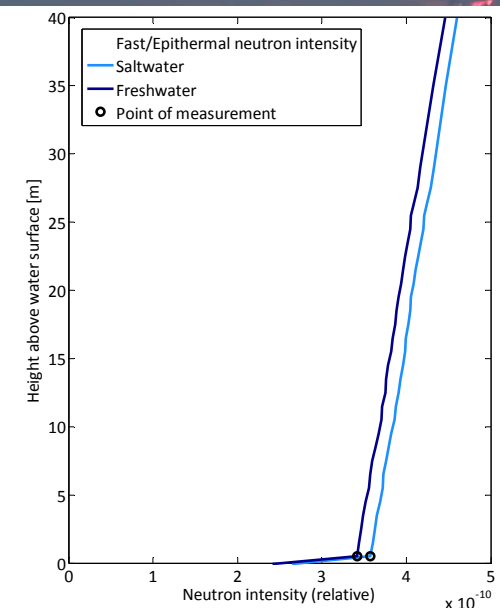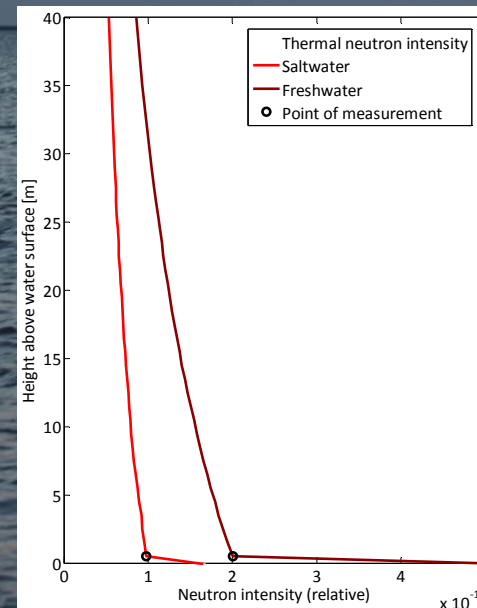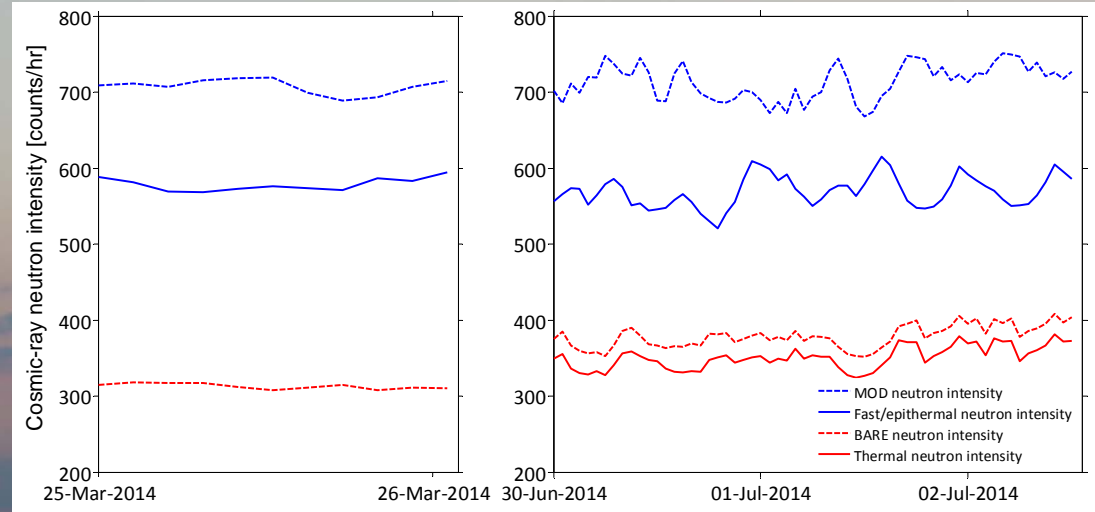
Cadmium shield experiments
– Correction factors

Correction factors for BARE and MOD probes has been calculated based on cadmium field experiment conducted at different:
- land covers
- heights above the ground surface
- soil types *(not included in the figure below)*

A Cosmic-ray neutron intensity profile *(incl. a cadmium shielded MOD probe)*
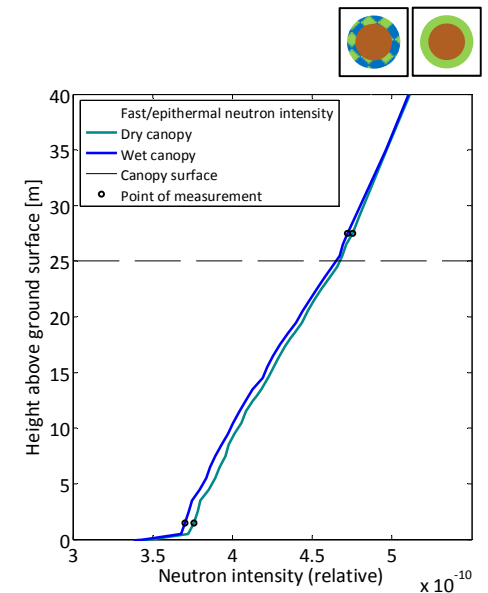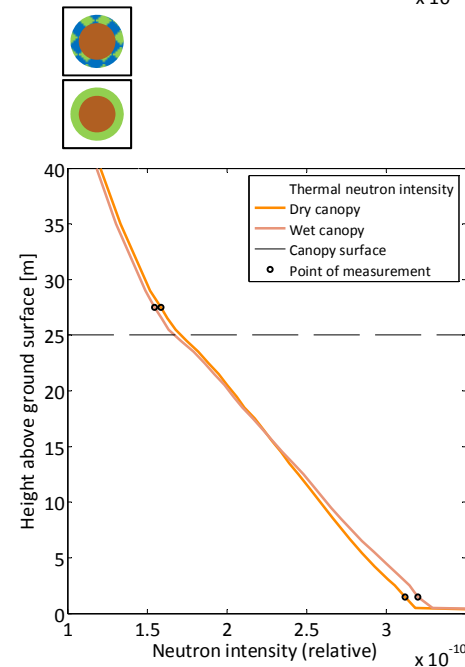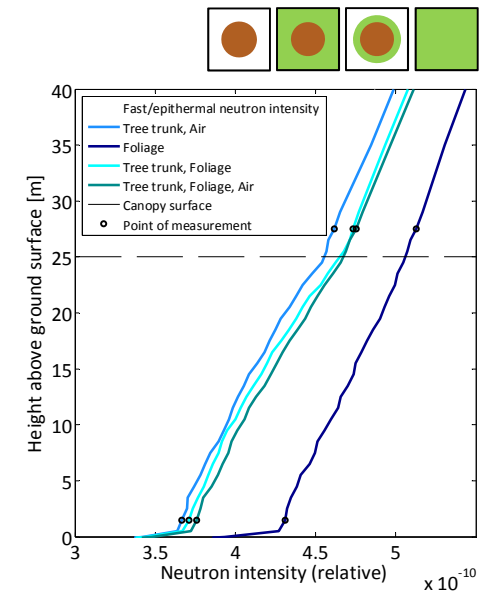## - Measurements (March 2013) vs. Model
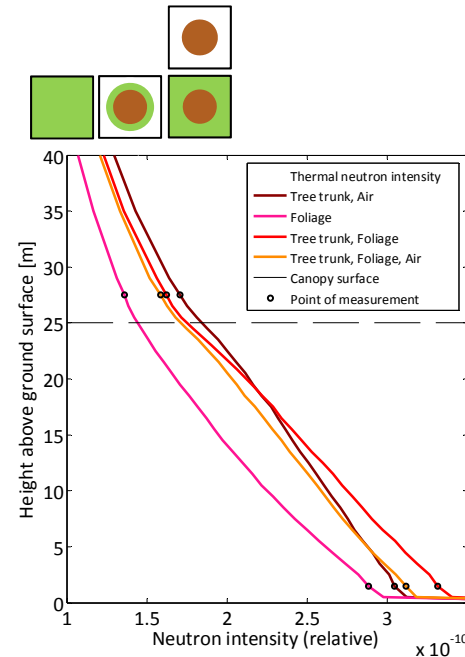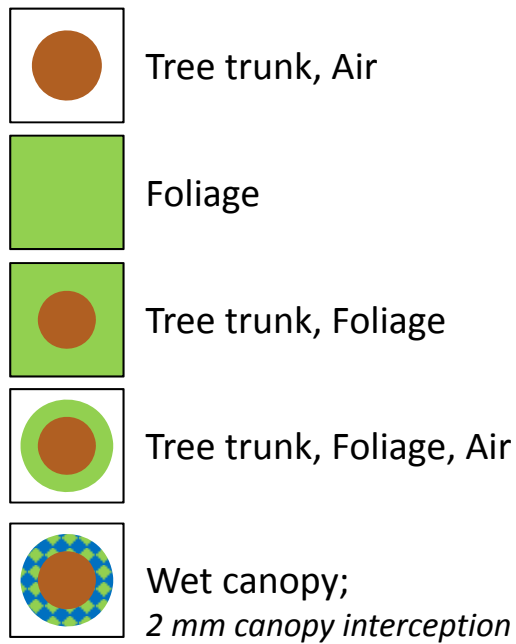
Measurements:
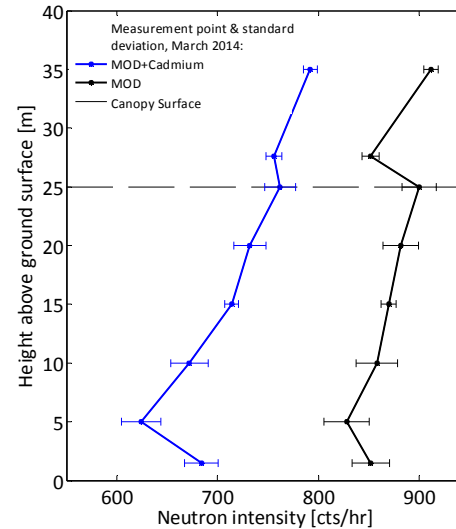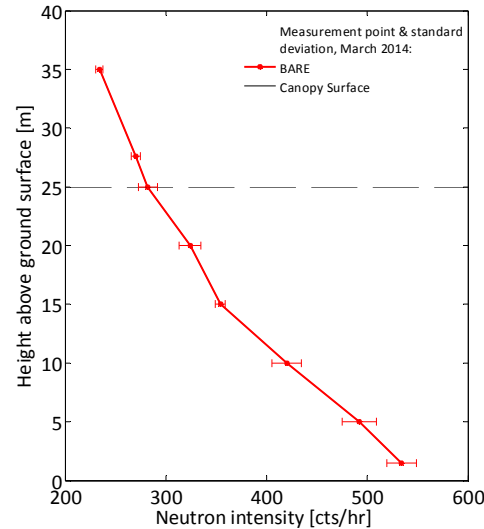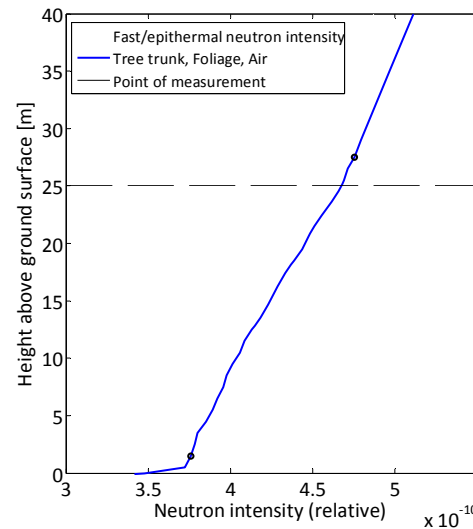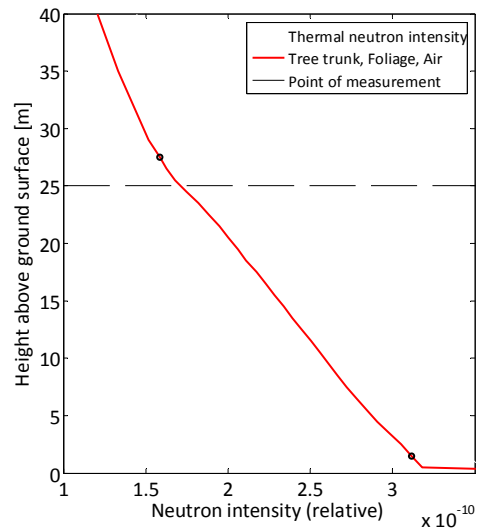
Model:

The modeled fast/epithermal neutron intensity is more in line with the measured cadmium shielded MOD neutron intensity
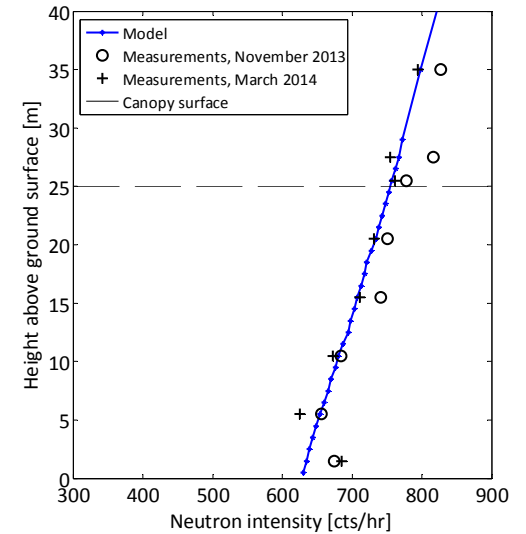
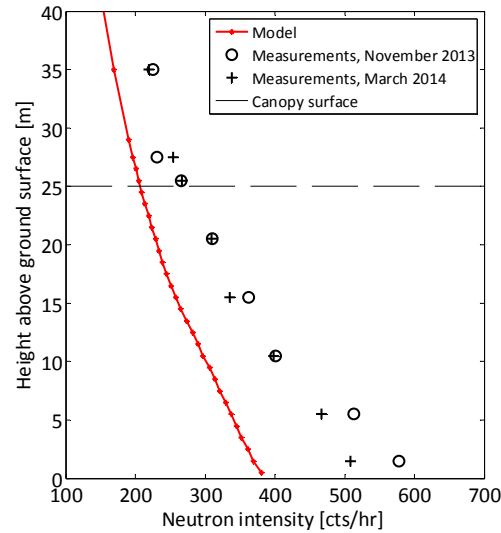TERENO International Conference 2014

Dias 10
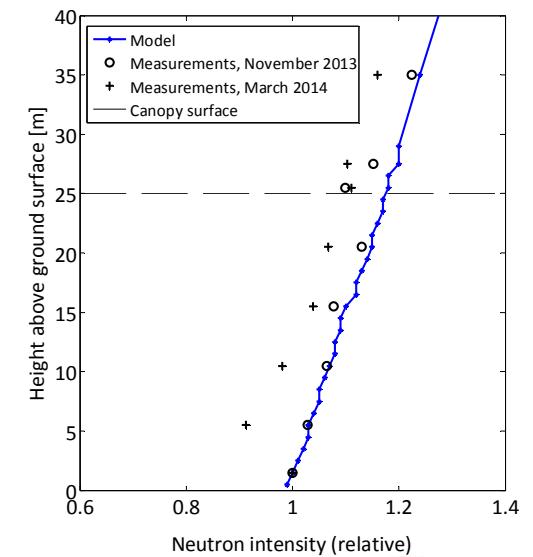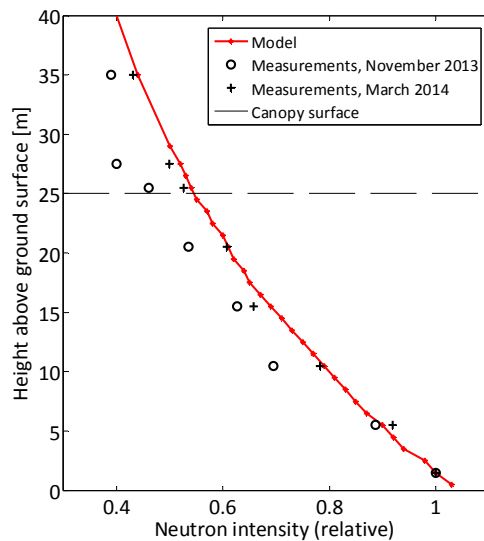
Model conceptualization

A comparison of modeled and measured neutron intensities
- Preliminary

Actual counts rates:
a preliminary conversion factor derived from the boat experiment is used

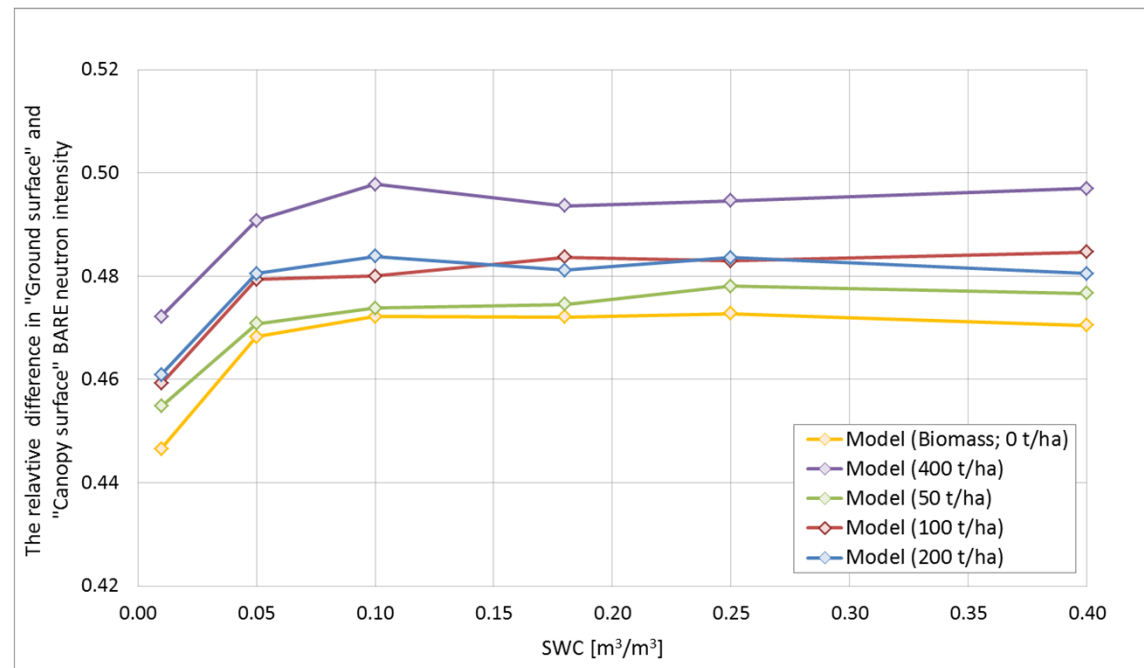**Relative to ground surface values:**

Biomass modeling
- the effect of changing biomass and soil moisture

Thank you for your attention