FINNISH METEOROLOGICAL INSTITUTE

Forecasting energy wood moisture change with meteorological grid data

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Backround

- Energy wood (e.g. chipped harvesting residue and small diameter stem wood) is used in heating and power plants
- In Finland, 7.3 million cubic metres of forest chips were consumed in 2016
- The moisture content of energy wood is one important measure of quality and it effects to heating value and the amount of usable energy
- Transporting water increases transportation costs and CO_2 emissions
- Natural drying is used to decrease moisture content
- Projects with Natural Resources Institute Finland and University of Eastern Finland

Goals

- Model for estimating drying of energy wood
- Define conversion factor from mass to volume

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- Model for estimating drying of energy wood
    - helps operators in decision making (transporting schedule and location)
    - Small diameter stem wood and harvesting residues
    - both at roadside storage and also in stand
    - Previous approach: mainly ”educated guess”
    - **Simple** – easy to adopt in forest companies Enteprise Resource Planning (ERP) systems

- *Define conversion factor from mass to volume*

Field trial in Ilomantsi, Eastern Finland

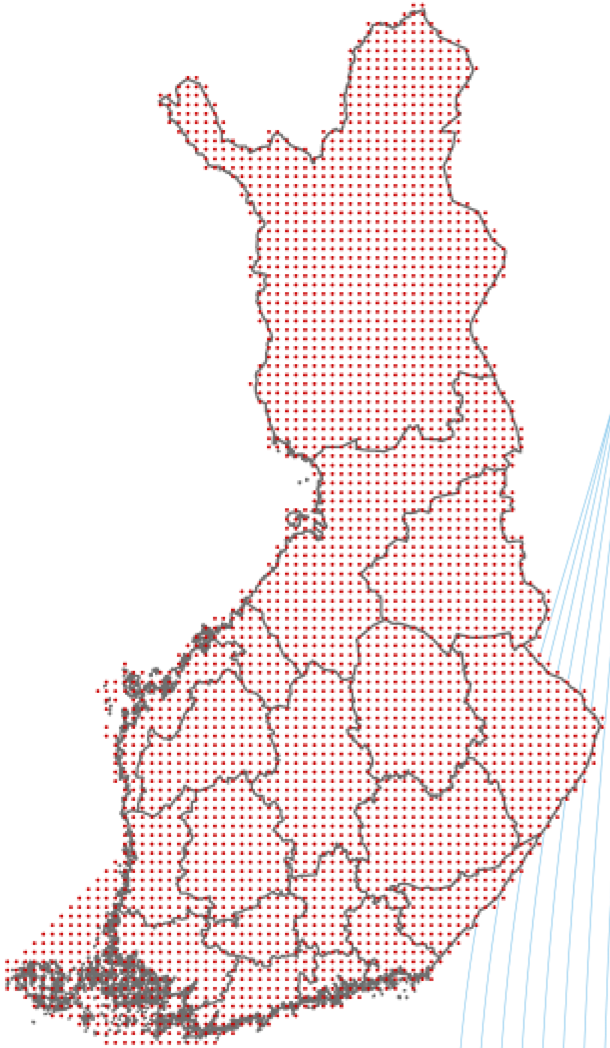
- 10 drying racks built on load cells
- Continuous weight measuring system
- Weight changes ~ moisture changes
- Cover papers in the sides and bottom of the racks
  - Minimize the difference between the trial and much bigger real road side storages

Energy wood drying ”park” at the Research Station

8 piles simulating road side storages and 2 simulating in stand storages
Piles contain stem wood and harvesting residue.
Some of the piles are covered also on top.

Weather data

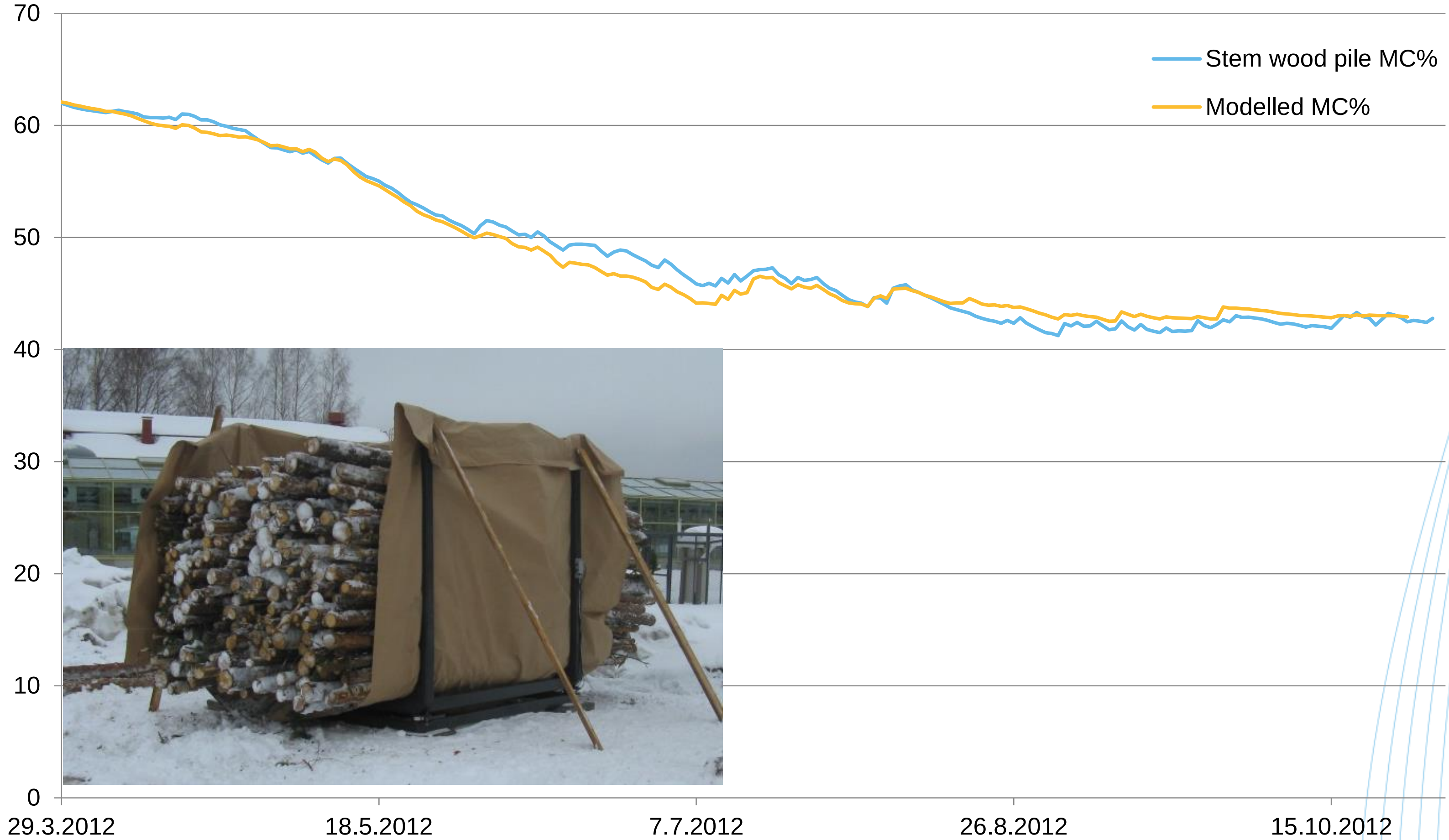
- Observations from weather station located at the Research Station
- 10km x 10km gridded data
    - Kriging interpolated weather observations
    - Also some nwp-model analyse data, because there is not enough radiation or manual cloud observations in Finland
    - Precipitation mainly from radar observations



Models

- Using precipitation and evaporation, estimated with Penman-Monteith equation, worked best
- Linear regression model
- DMC=a +b*net evaporation
    - DMC Daily Moisture Change
    - a and b constants
    - net evaporation= evaporation – precipitation
- Moisture content $MC_n=MC_{n-1}-DMC_n$
- Different constants for stem wood and harvesting residues, cover and non cover, different wood species, in stand and road side storages

Modelling stem wood

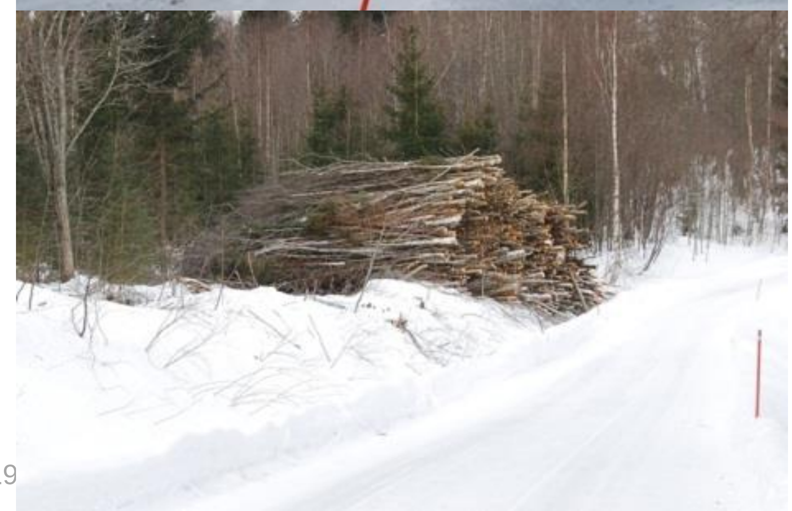


Challenges

- Harvesting residues
  - higher surface area to volume ratio
  - effects on evaporation rate and precipitation runoff
- Microclimate
  - Height and structure of the pile
  - Location, shadows
  - Some inaccuracies with radar and radiation data
  - Snow under and above the pile

Snow under and above

Examples of road side storages



Goals

- *Model for estimating drying of energy wood*
- Define **conversion factor** from mass to volume
    - harvesting residues
    - Previous approach: table with large geografical areas, seasons, averages
    - needed in legal transactions (e.g. paying stumpage fees and transportation fees)
    - weather based moisture content model with higher accuracy

Weight class	**Moisture content %**	**Time period**				**Green density factor kg/m³**
		1.4.–30.4.	**1.5.–15.8.**	**16.8.–30.9.**	**1.10.–31.3.**	
1	> 50	Non-seasoned or wet residues, with snow and ice				950
2	45–50	fresh, 20 days ↓	fresh, 10 days ↓	fresh, 20 days ↓	fresh	840
3	40–44	≥ 20 days	→ 15 days ↓	≥ 20 days	≥ 20 days	770
4	35–39	-	20 days ↓	20 days ↑	20 days ↑	700
5	30–34	-	35 days ↓	20 days ↑	-	650
6	< 30	-	≥ 80 days	20 days ↑	-	600

New models 1 and 2

$$MCwet = 100 \times MCdry / (1 + MCdry)$$

$$MCdry_{i+1} = MCdry_i + b \times P_R + S_{i+1} \times a \times E_R$$

$$b = b_{11} \times (b_{12} - MCdry_i)$$

$$P_R = b_{21} \times (1 - \exp(P_{i+1} / b_{22}))$$

$$a = a_{11} \times (a_{12} + MCdry_i)$$

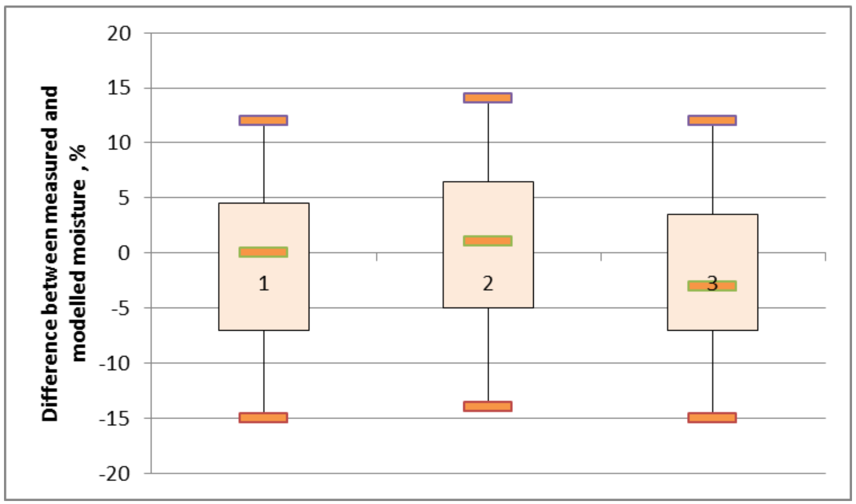
$$E_R = a_{21} \times (1 - \exp(E_{i+1} / a_{22}))$$

$$MCwet_m = MCwet_0 - \Delta MCwet$$

$$\Delta MCwet = -16{,}397 \times \frac{\sum_{i=0}^{m} P_i}{\sum_{i=0}^{m} E_i} + 20{,}6$$

Validation

- Used field data from four different locations, 49 harvesting areas in total
- Median difference was smaller in the new models 1 and 2
- In model 3, the current method, about -3%
- underestimates observed moisture content



Summary

- We have developed models to predict energy wood moisture
- Integrated in some forest companies Enteprise Resource Planning (ERP) systems
- According to field material, the new harvesting residue models are slightly better than the current method
- More research is needed

Thank you!