

Forest SOC monitoring in Estonia – challenges and needs for the future



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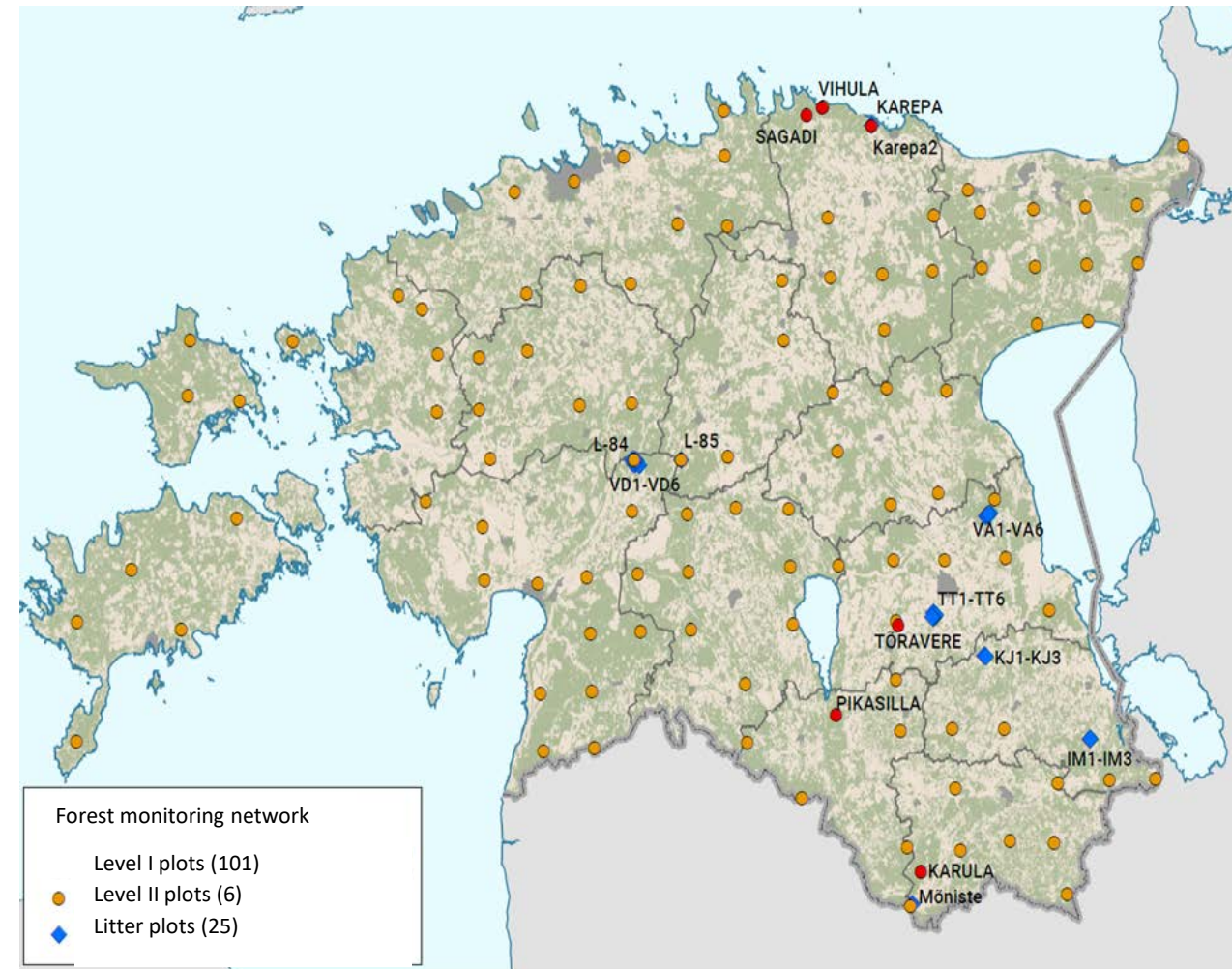


Challenges and needs with a contribution from Alex Kmoch, University of Tartu

NorForSoil: Integrating Soil Monitoring in Nordic Forests – data harmonization, future designs and studies to examine soil function at different scales; 8.-9.2.2023 kick-off in Ås, Norway

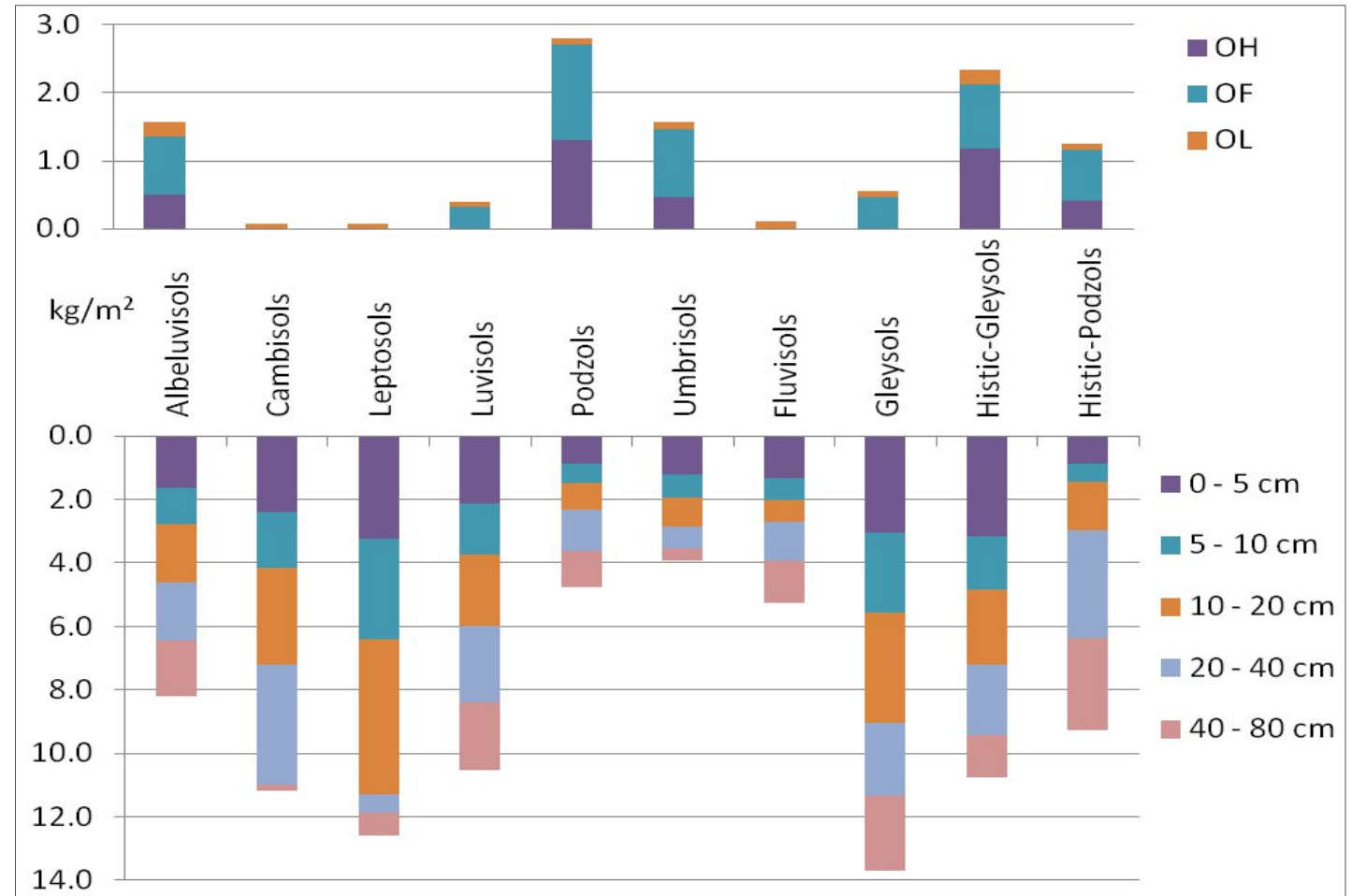
Forest SOC monitoring is conducted by Estonian Environment Agency

- Part of the state monitoring program ([Forest monitoring sub-program](#))
- Estonian forest monitoring is part of the Pan-European *ICP Forests* program
- Soil monitoring
 - ✓ Level I sites: 1990–1994 and 2006–2008
 - ✓ Level II sites: 1996 and 2009
 - ✓ Additional forest litter plots: 2017
- Next soil survey: 2020–2025: 101+6 (I and II sites)
- All three surveys followed the ICP methodology



C stocks in forest soils

- The highest SOC stocks were accumulated in Sapric (56.9 kg/m²) and Fibric Histosols (45.7 kg/m²)
- In Histic Podzols and Histic Gleysols, the SOC stocks were 19.1 and 18.1 kg/m², accordingly
- SOC stock in mineral soils is varied between 5.5 (Umbrisols) and 14.6 (Gleysols) kg/m²
- The majority (80-98%) of organic carbon of mineral and peaty soils are deposited in a 40 cm superficial layer.



E. Asi, T. Timmusk, V. Apuhtin, R. Kõlli (2012). Organic carbon accumulation in different forest soil types of Estonia

Modelling SOC changes in forest soils

- Implementing Yasso model for forest mineral soils
 - ✓ Yasso07 model overestimated C stocks in Estonian forest soils
 - ✓ Additional measurements of C fluxes have been conducted for model parametrization and validation



Towards complete and harmonized assessment of soil carbon stocks and balance in forests: The ability of the Yasso07 model across a wide gradient of climatic and forest conditions in Europe



Laura Hernández ^{a,*}, Robert Jandl ^b, Viorel N.B. Blujdea ^c, Aleksi Lehtonen ^d, Kaie Kriiska ^e, Iciar Alberdi ^a, Veiko Adermann ^f, Isabel Cañellas ^{aj}, Gheorghe Marin ^g, Daniel Moreno-Fernández ^{aj}, Ivika Ostonen ^e, Mats Varik ^h, Markus Didion ⁱ

Table 2

Total average C stock (Mg C ha^{-1}) and change ($\text{Mg C ha}^{-1} \text{ yr}^{-1}$) for soil, litter and dead wood estimated using the Yasso07 model for each country and type of forest. Period covered, spin up period and number of plots used for the application of Yasso07 (N_y) and for validation (N_v) are detailed. Standard error of the mean (SEM) is also listed. C stock observed and the ranges for each case study are shown. Negative changes indicate losses, positive values gains.

| Country (region/ N_y) | Type of forest | Period | | SOC stock Yasso07 simulated values (\pm SEM) | SOC change Yasso07 simulated values (\pm SEM or range) | Range of observed values (2.5 & 97.5 percentile) | Observed SOC change (\pm SEM) |
|--|----------------|-------------------|-------------------|--|--|---|-------------------------------------|
| | | Period covered | Spin up period | | | | |
| <i>Estonia</i> ($N_y = 4300$; $N_v \geq 200$) | | | | | | | |
| | All | 1990–2013 | Steady state | 79.4 (\pm 3.10) | 0.10 (\pm 0.02) | (65.0–113.3) ^a | – |

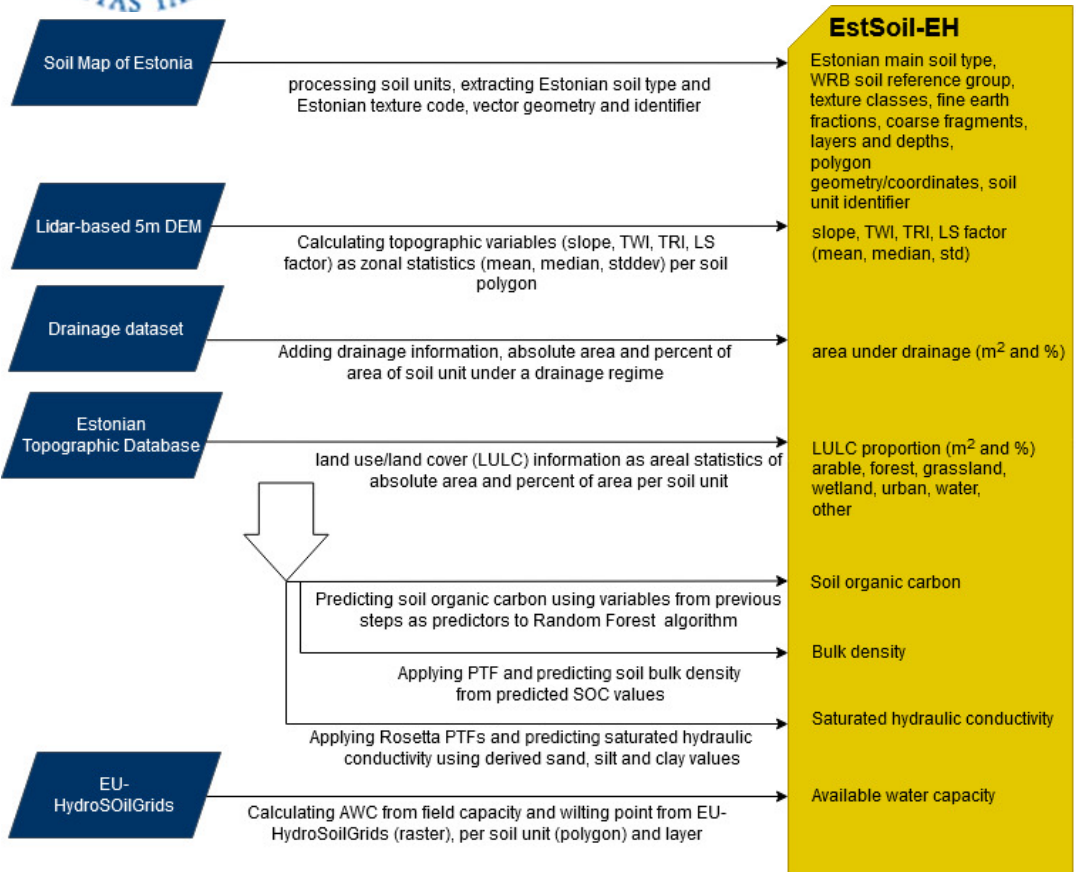
Further Yasso model implementation based on Estonian data is in process in cooperation Allan Sims from Estonian University of Life Sciences

Estonian Soil Map

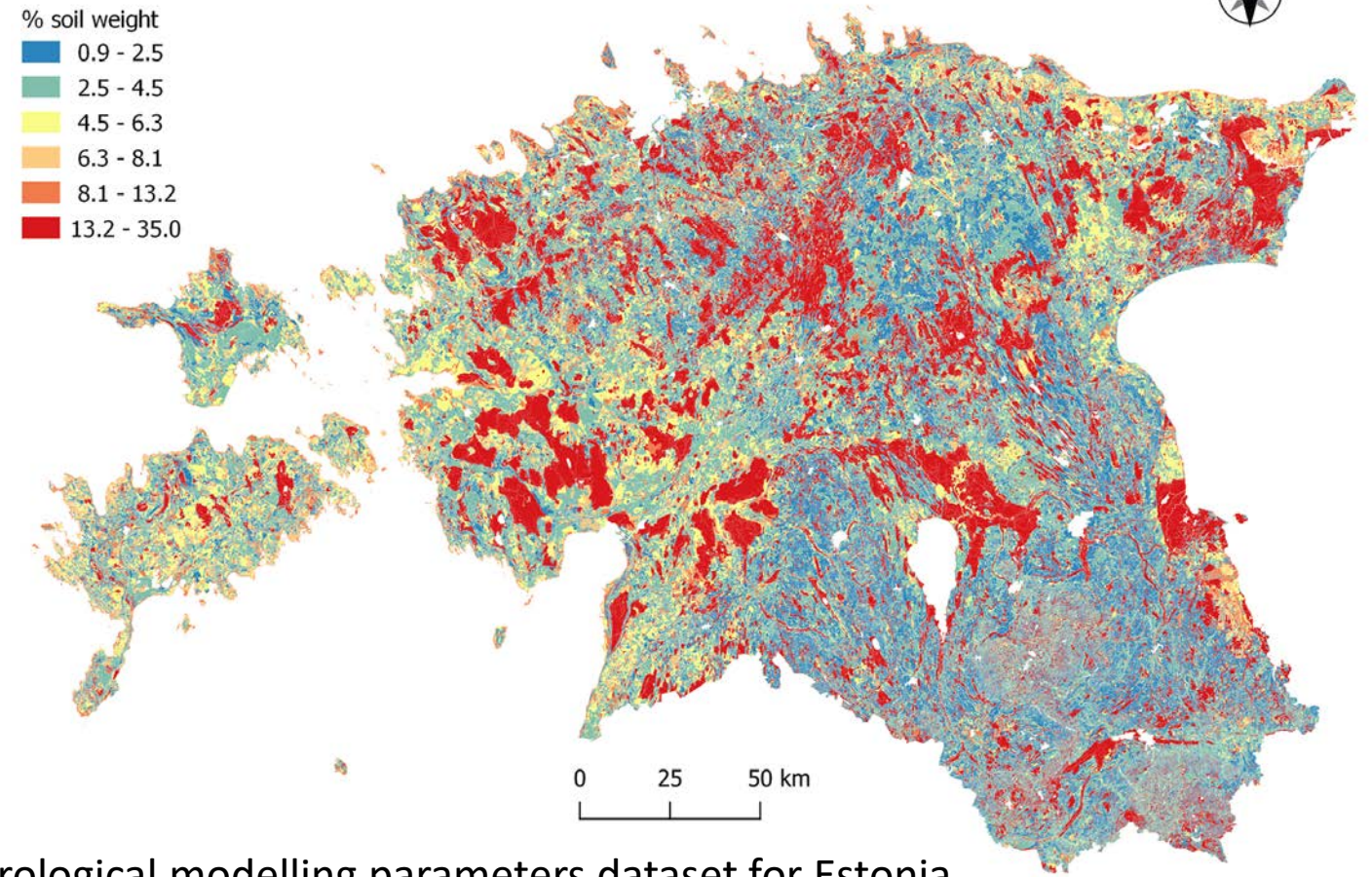
- Estonian large scale (1:10 000 soil map) is based on surveys conducted in 1958–1989
- Digitalized and available at: <https://geoportaal.maaamet.ee/eng/Spatial-Data/Estonian-Soil-Map-p316.html>
- Area of histosols needs updating, partly mineralized
- Monitoring reports and data are available on web page of Estonian environmental monitoring system

<https://kese.envir.ee/kese/welcome.action>

Modelling-EstSoil-EH

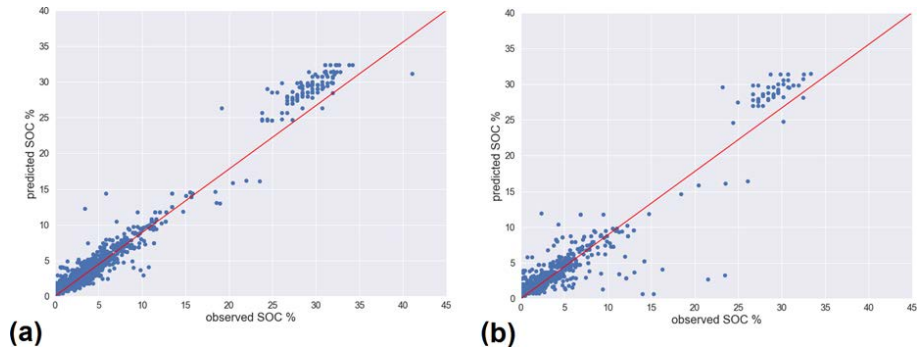


EstSoil-EH: Predicted Soil Organic Content in Topsoil



Kmoch et al 2021 EstSoil-EH: a high-resolution eco-hydrological modelling parameters dataset for Estonia
<https://doi.org/10.5194/essd-13-83-2021>

Israfilbayov, Y.2023 Soil organic carbon prediction with machine learning (MSc thesis, supervisor A. Kmoch)



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New dataset opens Estonian soil information for versatile use

18.02.2021



A comprehensive database of Estonian soils and a map application has been completed in cooperation with researchers of the University of Tartu and the Estonian University of Life Sciences. [The database makes Estonian soil information easily accessible and can be used from local farm-scale to national-level big data statistical analysis and machine-learning models.](#)

"Soil data is possibly the most undervalued and yet complicated type of environmental data there is. The diversity of organic, chemical, living and dead materials that make up a handful of dirt is astounding," said Alexander Kmoch, Research Fellow in Geoinformatics at the University of Tartu and the leading author of the study.

Estonia has had very detailed soil information available for decades. It is digitally available on the [Geoportal of the Estonian Land Board](#) in several formats under various open data licenses. Its main purposes include land

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Soilmap of Estonia - Mullastiku kaart

Kmoch, Alexander

| Name | Size | Description |
|--|---------|--|
| Mullakaart_SHP.zip | 817.9Mb | The complete soilmap with all original attributes in Shapefile format. Reliable UTF-8 encoded for special characters. (Kogu andmebaas ESRI Shape formaadis, 817.95 MB, 1.03.2017). |
| muldade_tabel.pdf | 166.6Kb | Estonian basic soil types. 2 pages PDF (Mullatüüpide loetelu, 166.62 KB, 11.12.2009) |
| mullalegend.pdf | 204.3Kb | Description of Estonian texture codes and additional indicators for coarse fragments and humus horizon, etc. (Tähistused mullakaardil, 204.33 KB, 11.12.2009) |
| mullakaardi_seletuskiri.pdf | 824.1Kb | 46 pages PDF including explanations on history etc. (Põhjalikuma ülevaate annab seletuskiri, 824.13 KB, 11.12.2009) |
| Maa-amet_Geoportaal_Mullastiku_k kaart_webpage.zip | 216.4Kb | HTML archive of the webpage at Maaamet Geoportaal where the soil data could be downloaded |
| checksums.txt | 1.119Kb | contains the md5 and sha256 checksums of the included files calculated on Windows 10 with the certutil.exe program in order to be able to check for changes or manipulations |
| Readme.txt | 3.610Kb | Additional plain text summary of contained files and links |

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Some specific publications

- Kõlli et al 2004. **Organic carbon pools in Estonian forest soils.** Baltic Forestry 10, 19-26
- Noreika et al. 2019 **Forest biomass, soil and biodiversity relationships originate from biogeographic affinity and direct ecological effects,** <https://doi.org/10.1111/oik.06693>
In this study they disentangle the indirect effects of the species pool and direct ecological effects on the complex relationships among wood volume, soil conditions and diversities of different plant and fungal groups in 100 old-growth forest sites (10 × 10 m)
- Kmoch et al 2021 EstSoil-EH: a high-resolution eco-hydrological modelling parameters dataset for Estonia <https://doi.org/10.5194/essd-13-83-2021>
- Kriiska, K 2019. **Variation in annual carbon fluxes affecting the soil organic carbon pool and the dynamics of decomposition in hemiboreal coniferous forests.** PhD thesis <https://dspace.ut.ee/handle/10062/64800>
Additional measurements (soil respiration, fine root biomass and production, decomposition...) at ICP sites

Challenges and needs for the future

- Data analyses (joint campaigns between the institutions)
- Missing metadata: better ways to characterize the environmental variables - when and where the soil sample was taken, the history of forest management, etc.
- New ideas which spatially distributed (and ideally continuous) covariates can serve as predictors (e.g., remotely-sensed spectral indicators, topographical variables etc.)
- Next-generation monitoring, sensing, sampling protocols
- Harmonization of sampling protocols
- Using data sampled in different ways, at different depths, by following different methodologies...