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Applications of data assimilation

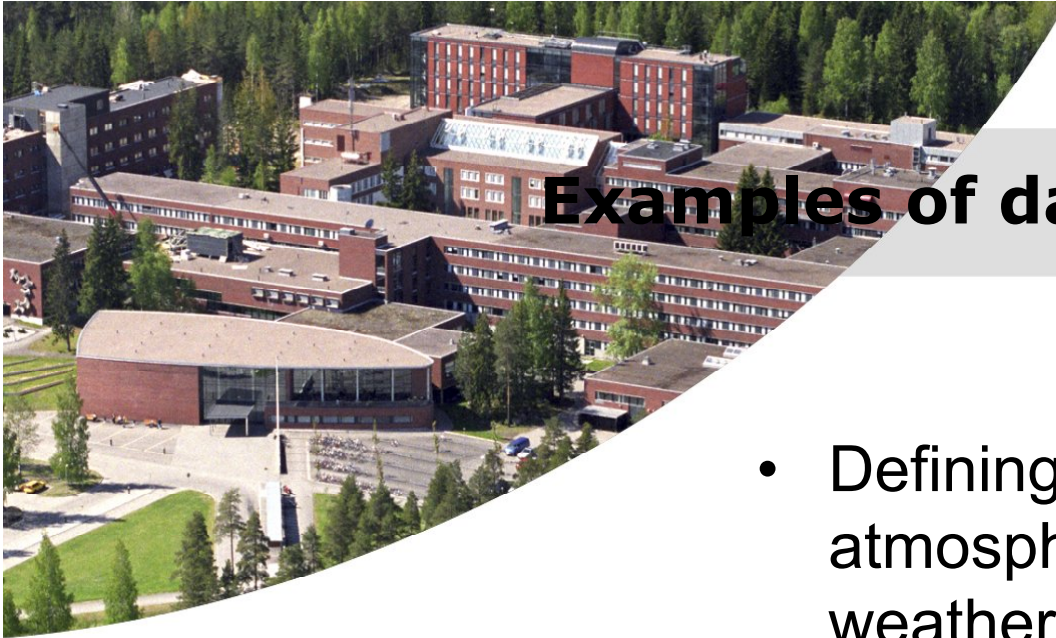
Tuomo Kauranne
Department of Mathematics





Data assimilation

- Data assimilation is a combination of
- A ***mathematical model*** of a system, implemented as a computer model
- ***Measurements or observations*** made on the system
- A statistical least squares estimation process that makes an ***optimal compromise*** between the model's forecast and observations



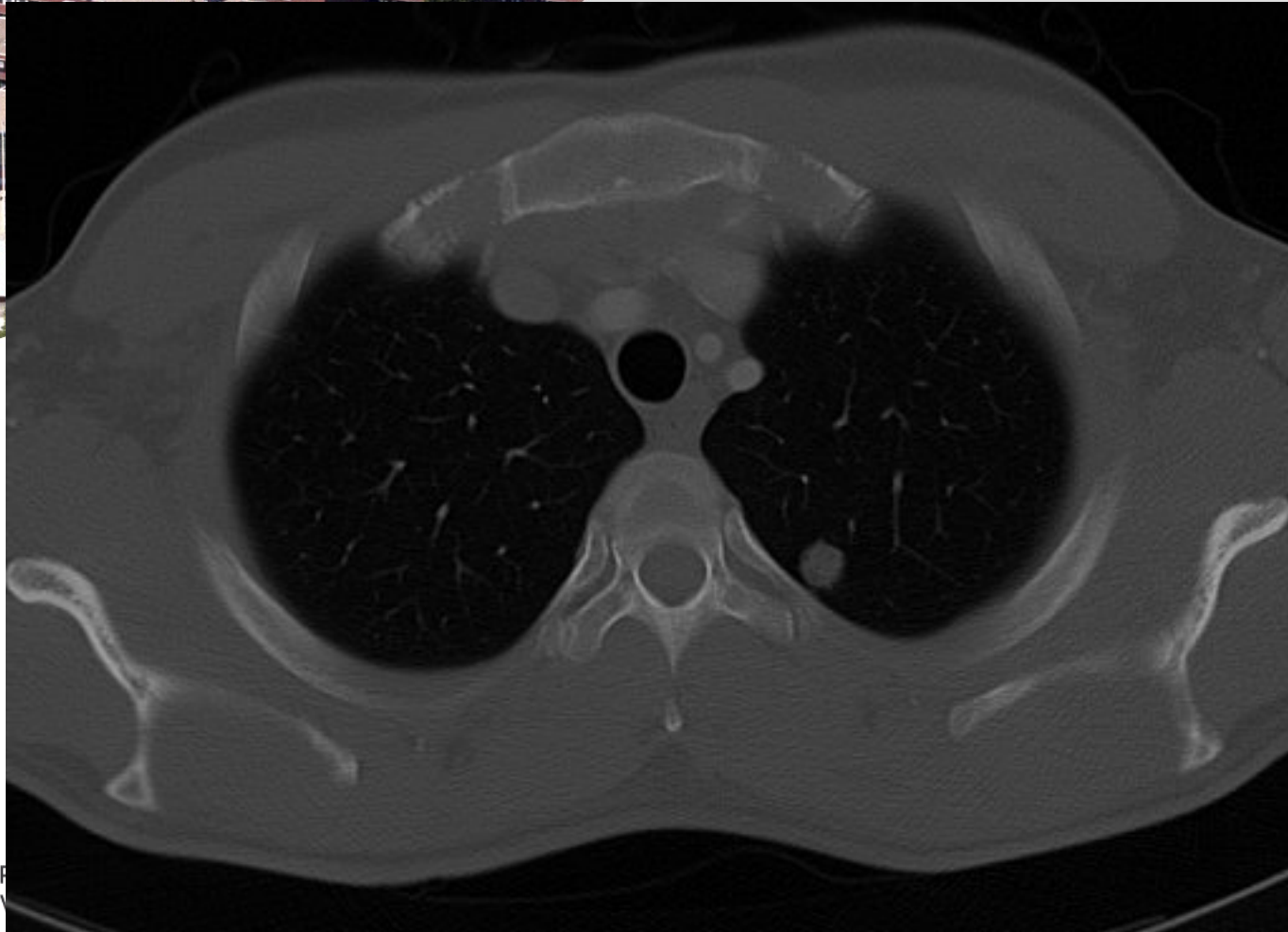
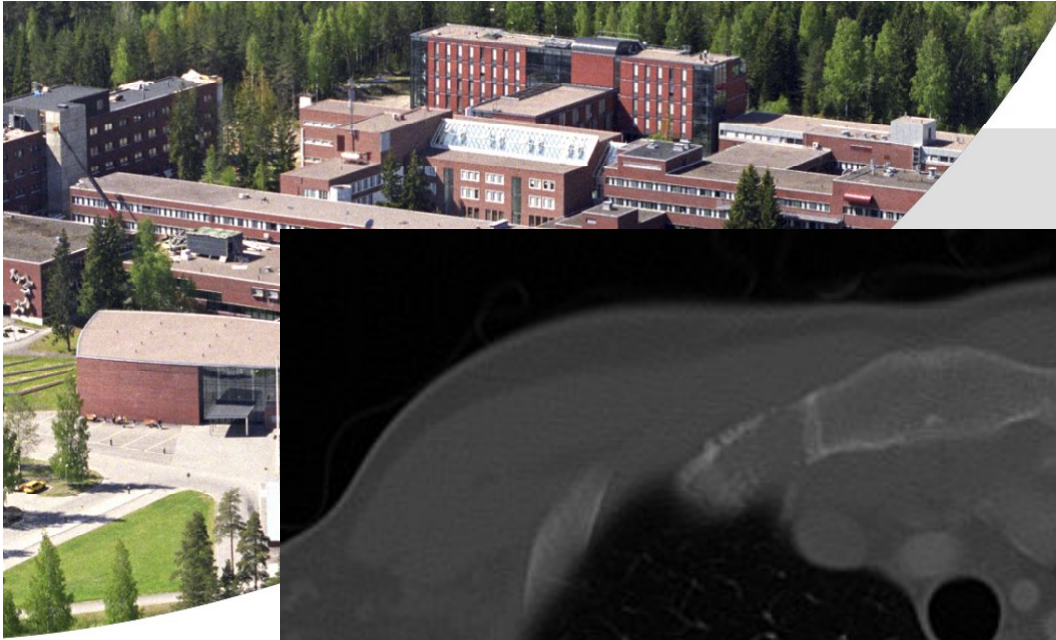
Examples of data assimilation

- Defining the initial state of the atmosphere for a subsequent weather forecast
- Medical computer tomography
- Identifying reaction coefficients in a chemical process
- Industrial on-line process control
- Interpreting remote sensing images

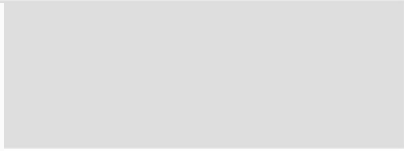


Data assimilation in Computer Tomography (CT)

- The model here is a static model of X-ray optical transmissivity of different human tissue types
- Measurements are made outside the body and they represent absorption of different X-ray wave lengths across body cross-sections
- The goal is to define the 3D tissue geometry
- Statistical estimation regularized LS (the problem is an inverse problem – hence ill-posed)



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Weather data assimilation

- A weather model is a computer program that discretizes a Partial Differential Equation (PDE) system
- This PDE is often called the Primitive Equations, which are the Navier-Stokes equations on a thin spherical shell
- There are MANY different types of weather observations
- Statistical estimation based on a Least Squares (LS) cost functional that is minimized

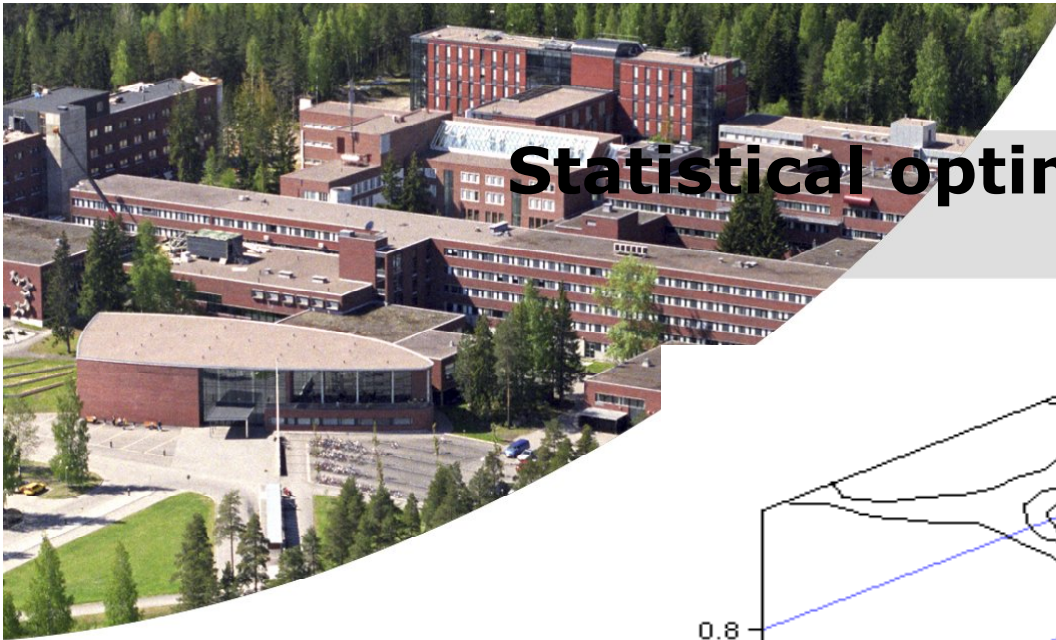


Algorithms for data assimilation

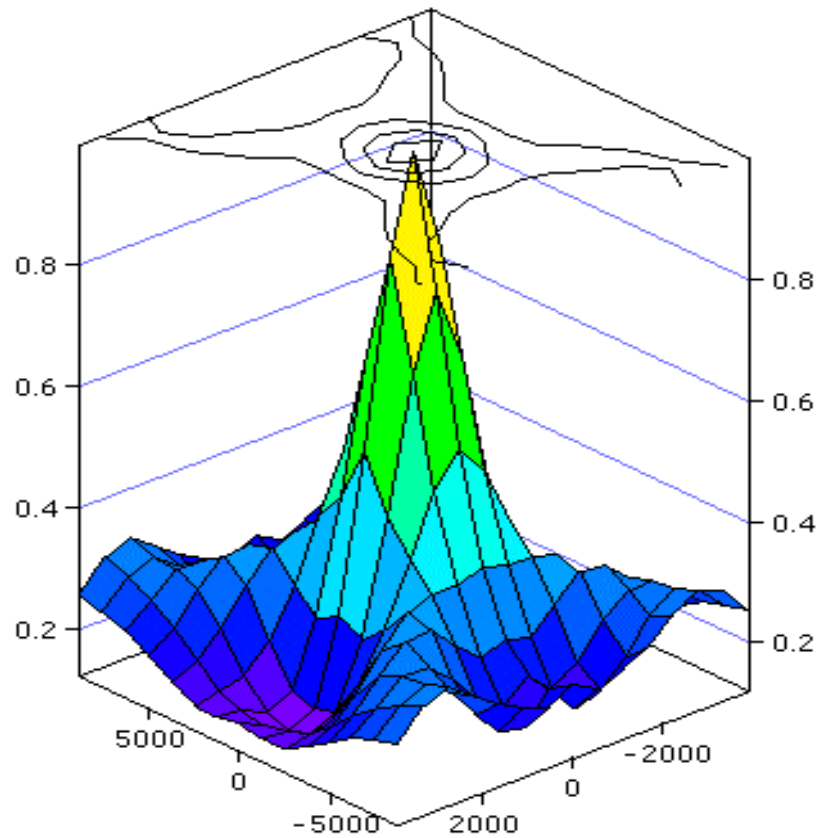


Algorithms for data assimilation

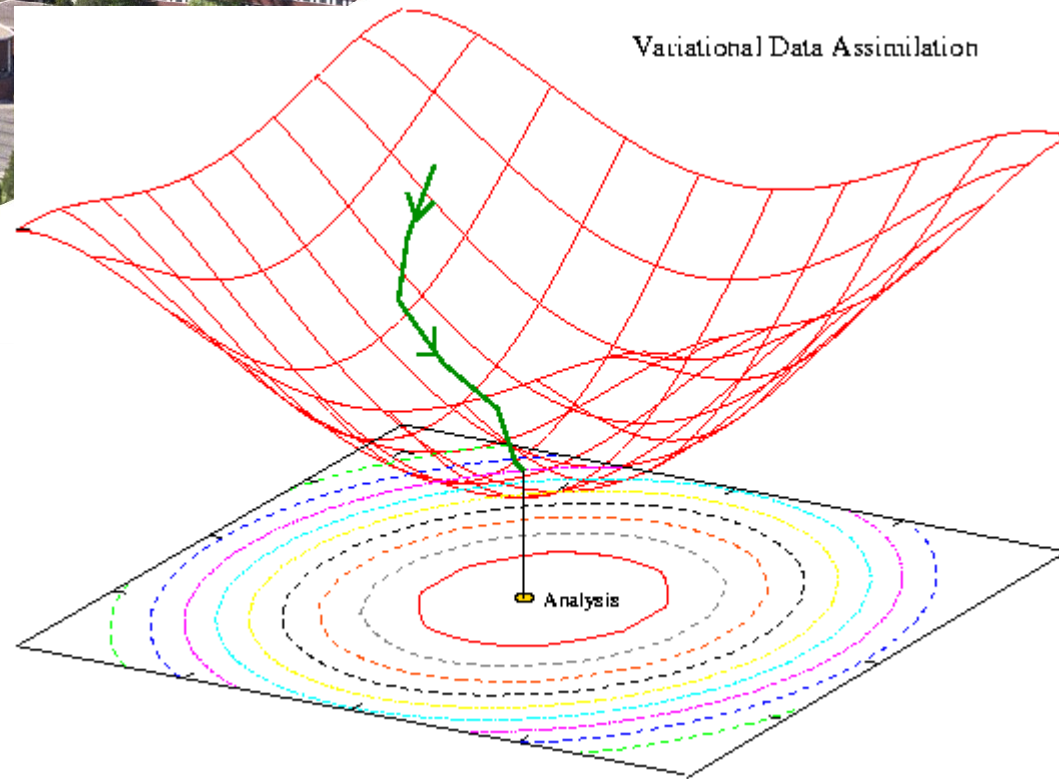
- Statistical optimal interpolation
- Variational data assimilation
- Kalman filtering
- Ensemble data assimilation



Statistical optimal interpolation

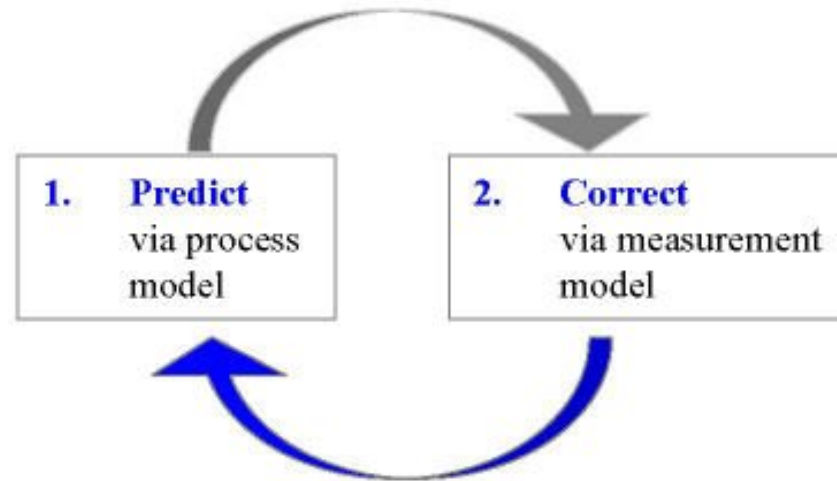


Variational data assimilation





Kalman filtering





Data assimilation in chemical processes

- The goal is to define unknown reaction coefficients
- The model is a system of Ordinary Differential Equations (ODEs) that is known from chemical stoichiometry
- Measurements are laboratory measurements of concentrations as a function of time or temperature
- Statistics is least squares



Data assimilation in industrial process control

- The model is often a black box statistical model because of real-time control requirement
- Measurements are based on on-line scans of process output (e.g. paper, oil products, fermentation,...)
- Statistics is least squares or min-max estimation
- Process state estimate is fed back to process control



Data assimilation in remote sensing

- The model is often a black box statistical model because of a very complex interpretation task
- Say, telling forest or wetland type from microwave radar from a satellite
- Bayesian regression models based on ground truthing are good here
- Feature extraction from images is a necessary first step



Now on to more
detail...

