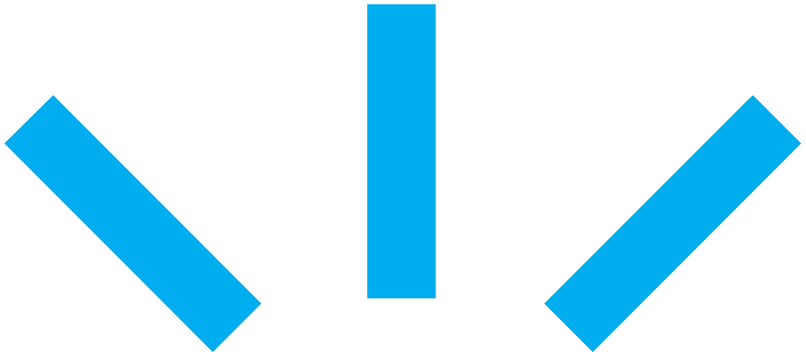


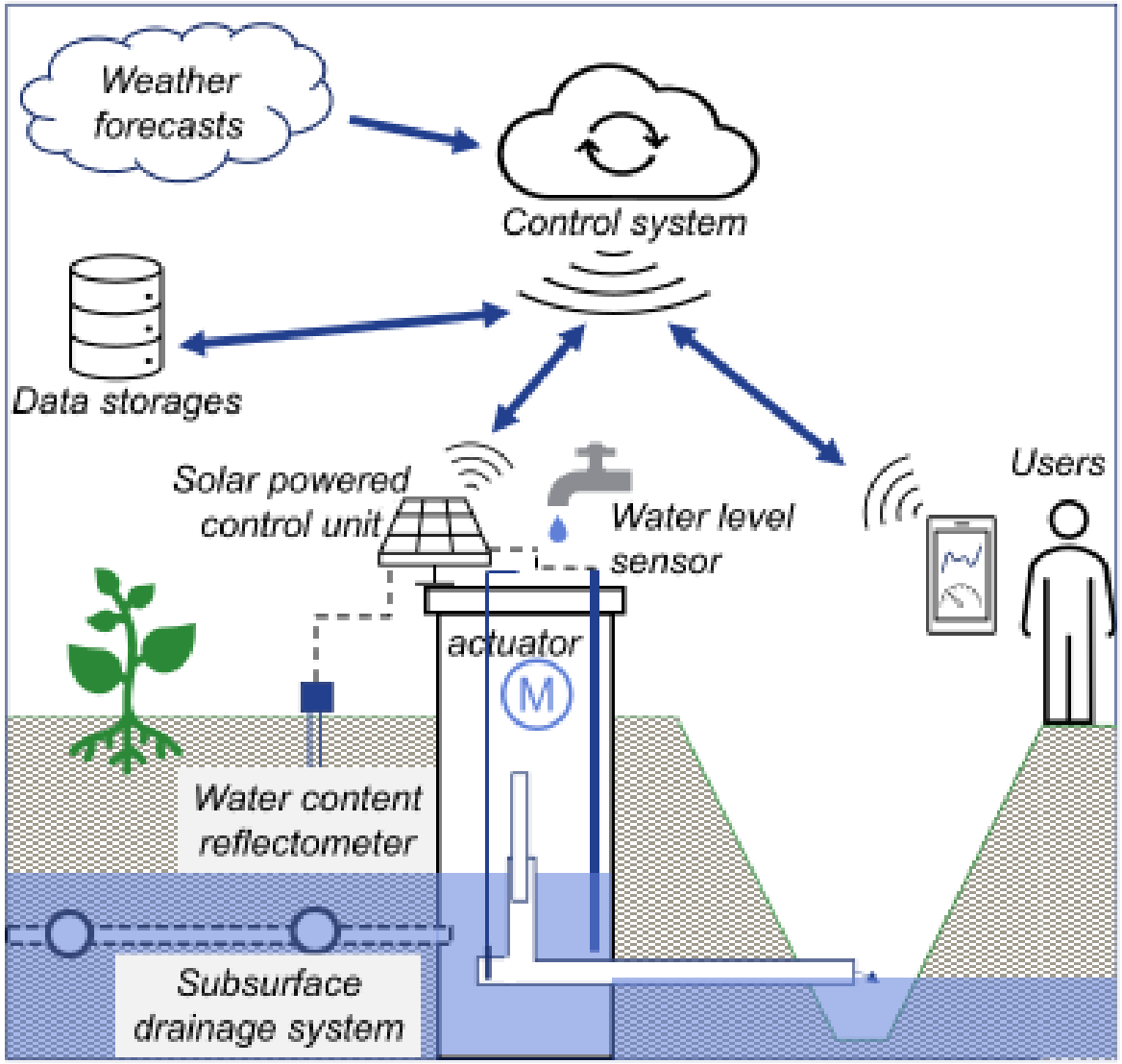
Model predictive controlled subsurface drainage and irrigation for peatland groundwater management

Enso IKONEN, Joni VASARA and Toni LIEDES
University of Oulu, Finland
Intelligent Machines and Systems

Enso.Ikonen@oulu.fi

Cultivated land groundwater management

- Driving forces for water table control
  - ensure crop growth & field carrying capacity
  - efficient use of water resources, reduce water loading
  - mitigation of greenhouse gas emissions, carbon sequestration
- Monitoring and control of ground water table requires the development of
  - suitable actuators,
  - power supplies,
  - data transmission, cloud services
  - predictive/anticipating modeling capabilities,
  - optimization facilities,
  - user interface supporting the decision making of the farmer.



Controlled well prototype

- A complete re-design of the control gate valve
  - improved robustness and minimal energy consumption.
  - A prototype of a motorized valve
  - attaches into an existing gate valve inside a manually controlled well.
- A suite of sensors for monitoring
  - ground water level
  - soil moisture conditions
- Battery backed solar powered electricity supply
  - smart energy management
- Communication
  - Cellular 4G radio device for communicating with information systems online
  - thinger.io cloud mobile, Matlab on PC

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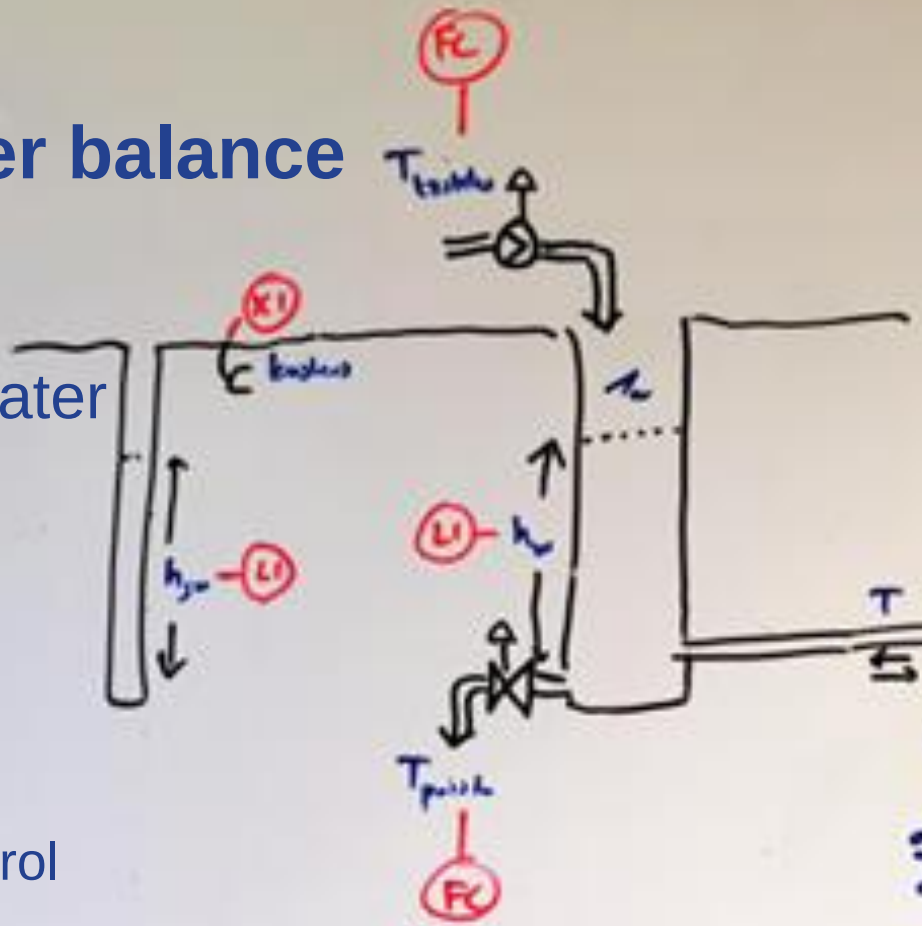
Dynamic water balance

1-D mass balance for water

- precipitation – evapotranspiration
- non-saturated layer
  - ground water loading (ode)
- saturated layer
  - ground water height (ode)
- subsurface drainage control well
  - well (ode) with irrigation
- ode solver / MPC
- see paper for details



$$Q = P - ET$$

$$\frac{dR}{dt} = \frac{K}{d-h}\left(\frac{1}{\varepsilon}Q - R\right)$$

$$S = \frac{2}{3}(\Delta h)\left(a/\Delta h + b/\Delta h^2\right)$$

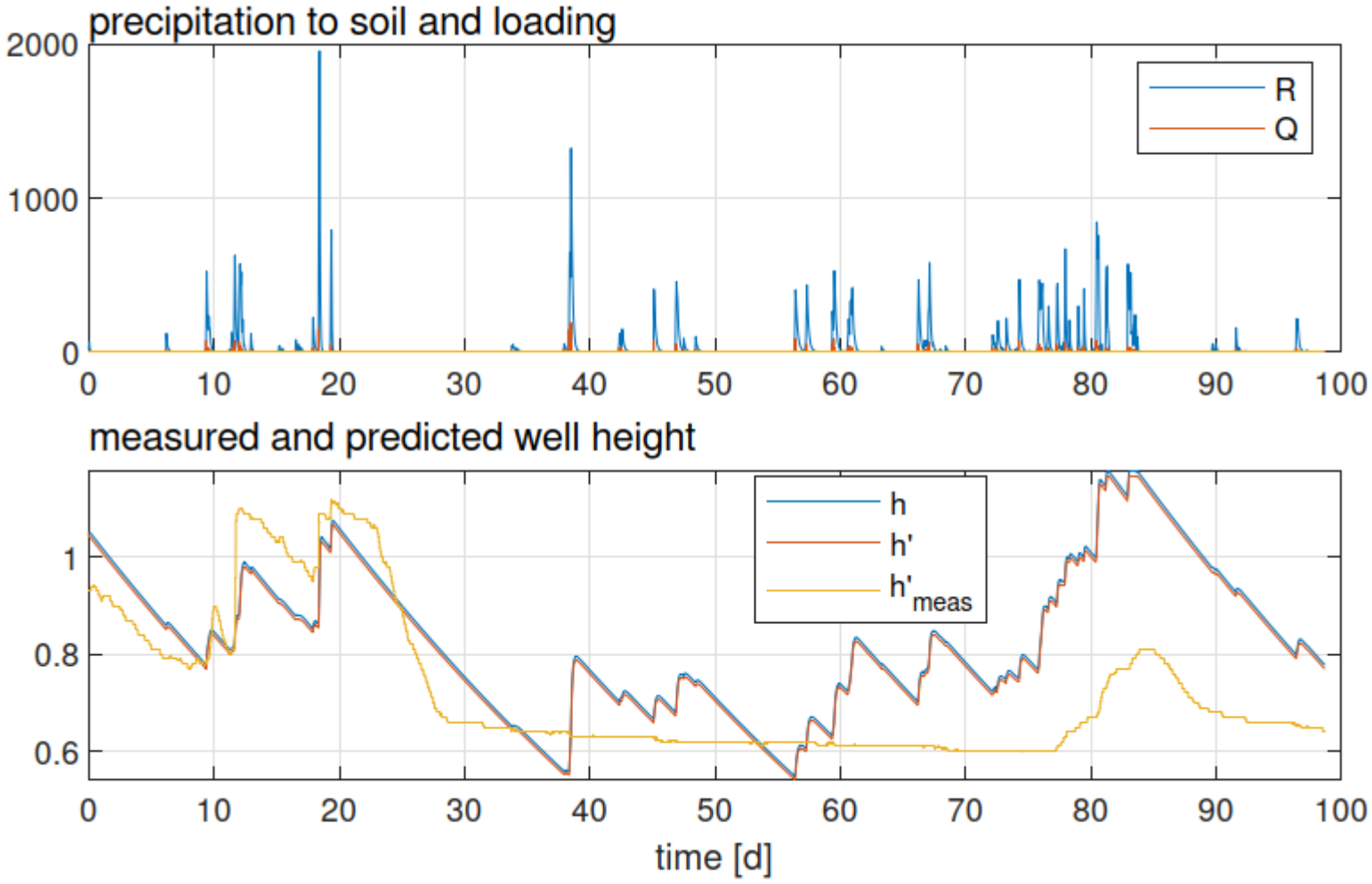
$$\frac{dh}{dt} = R - \frac{1}{\varepsilon A}S$$

$$T = \varepsilon S$$

$$\frac{dh_w}{dt} = \frac{1}{A_w}\left(T - T_{pump} + T_{leaks}\right)$$

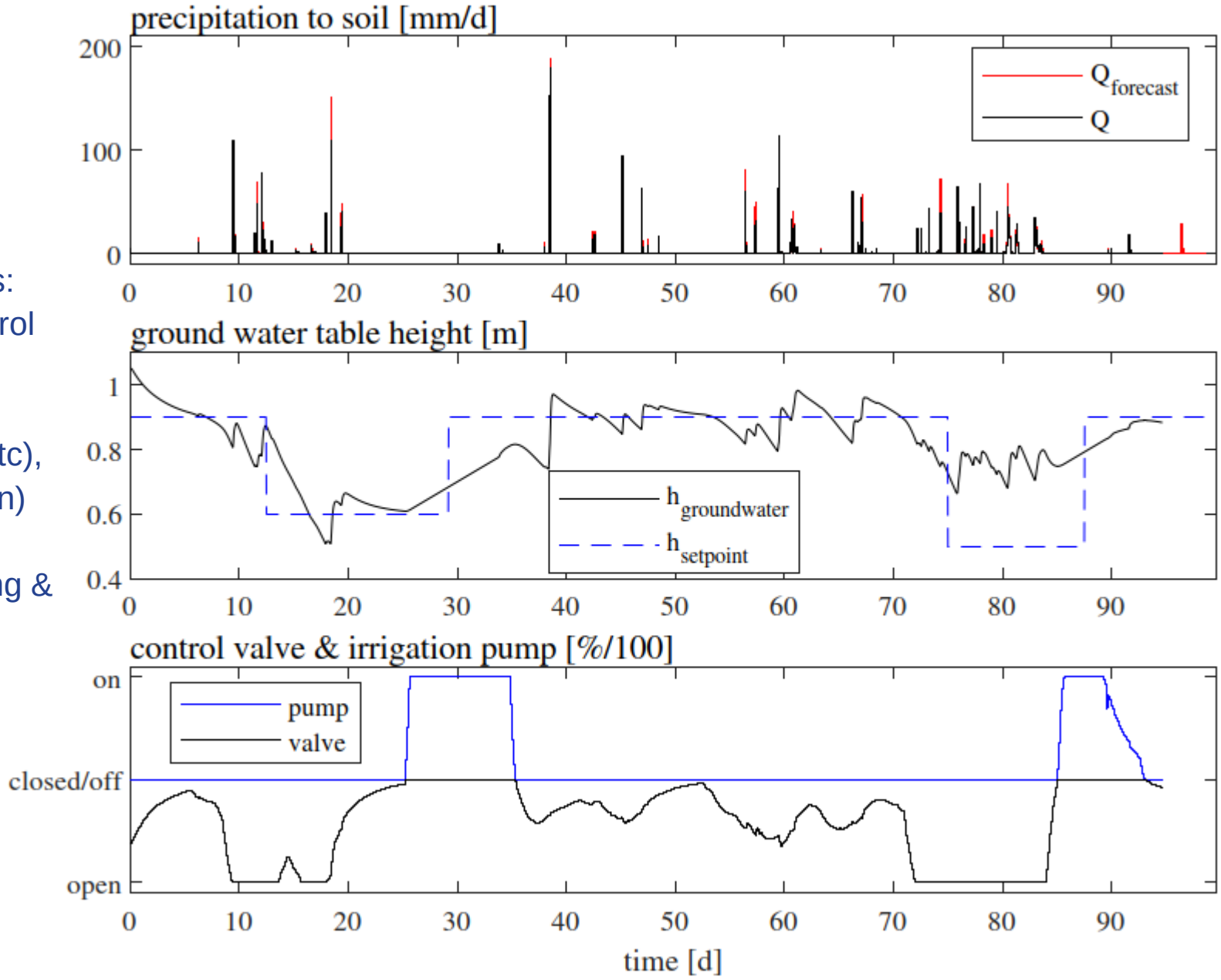
MPC model tuning

- Measurement campaign (summer 2021)
  - precipitation
  - loading
  - predictions on well/groundwater table height
  - measured well level



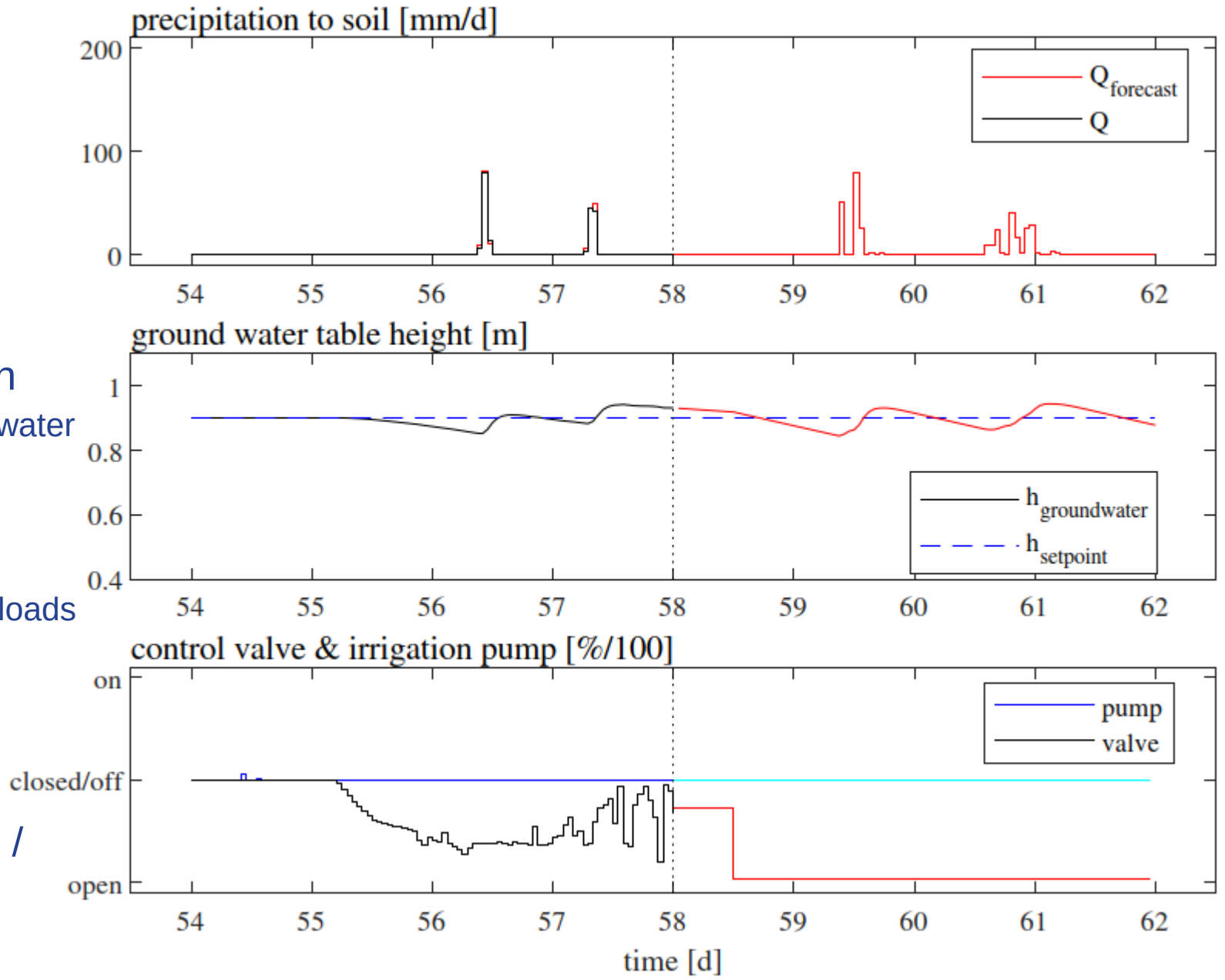
MPC simulation

- MPC tuning
  - MPC tuning parameters: prediction horizon, control horizon & blocking
  - constraints (geometry, valve/pump min/max, etc), costs (setpoint, irrigation)
  - uncertainties in modeling & measurements



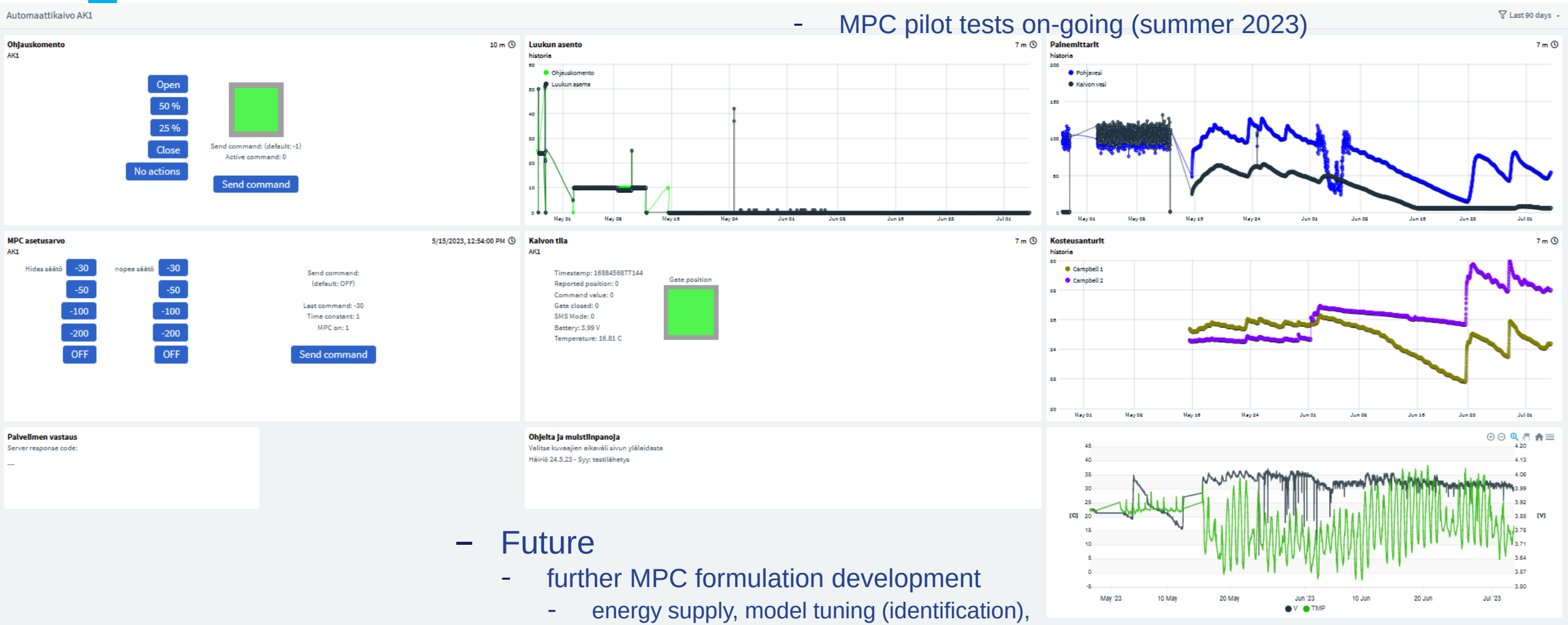
MPC UI/UX

- monitoring
  - water reserves / soil moisture, alerts, maintenance
- forecast & optimization
  - weather forecasts, soil water balance anticipation, resource optimization
- user decision support
  - many wells, cyclic workloads
- automation
  - sequences, automatic control
- new operational goals / uses for drainage & irrigation



Conclusions & future

- Status
  - prototype tests on-going (summer 2022-)
  - MPC linearized MIMO
  - MPC pilot tests on-going (summer 2023)



- Future
  - further MPC formulation development
    - energy supply, model tuning (identification), uncertainties ...
  - monitoring and user needs
    - new user policies, winter monitoring

ありがとう

Thank you

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