

Data fusion workflow for process monitoring and control

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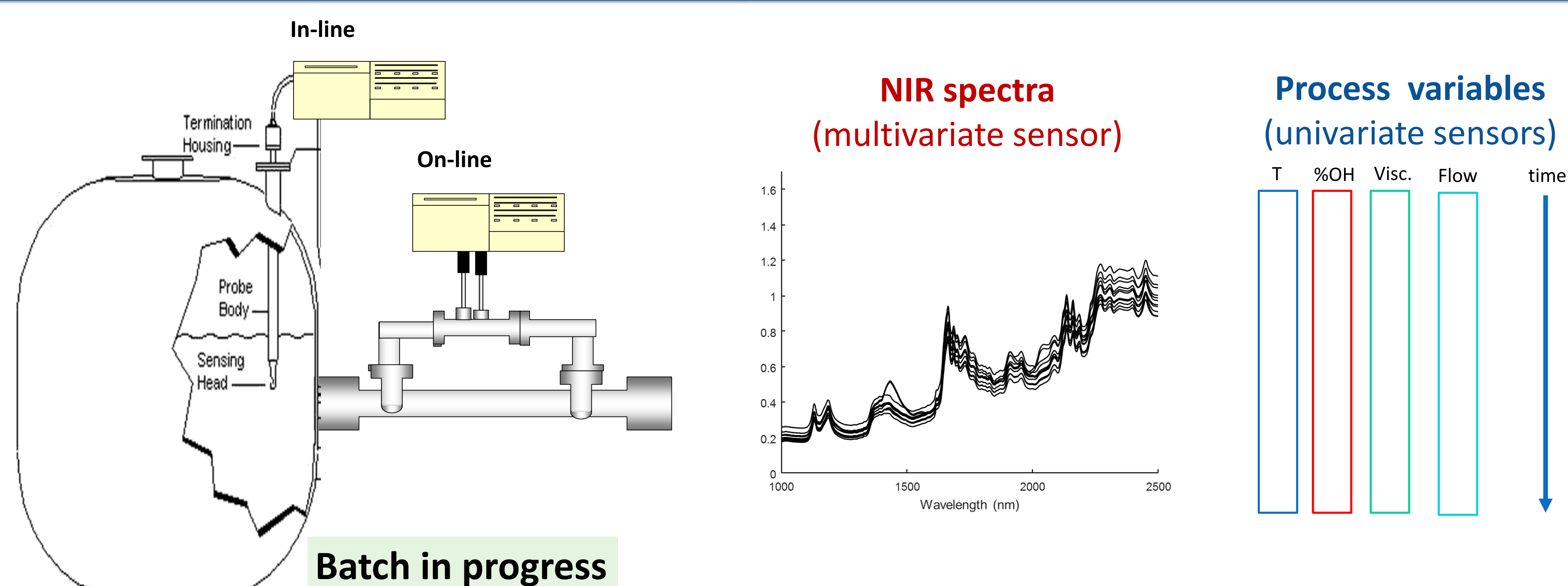
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Nowadays, integral process control requires monitoring of many process parameters and use of multivariate sensors related to product composition and physical properties. Data fusion is the term defining the simultaneous use of the diverse sensor outputs together to build a single model for global process control. Multivariate Statistical Process Control (MSPC) tools are used for this purpose.

Data fusion oriented to process monitoring requires synchronized registration of output sensors to obtain measurements linked to the same exact stage of the process and the same monitored material. Whenever this is not possible, clear knowledge of the delay allowed in process probing among sensors should be known.

Data fusion-based process control models can be built following a low-level fusion scheme (raw sensor outputs concatenated) or a mid-level fusion framework (relevant sensor features concatenated when sensors are too diverse in scale and output size). Data fusion-based control provides an integral vision of the process behavior, defined by boundaries associated with the fused sensor space, that reflect individual sensor limits and correct correlation among process parameters.

Multisensor process monitoring

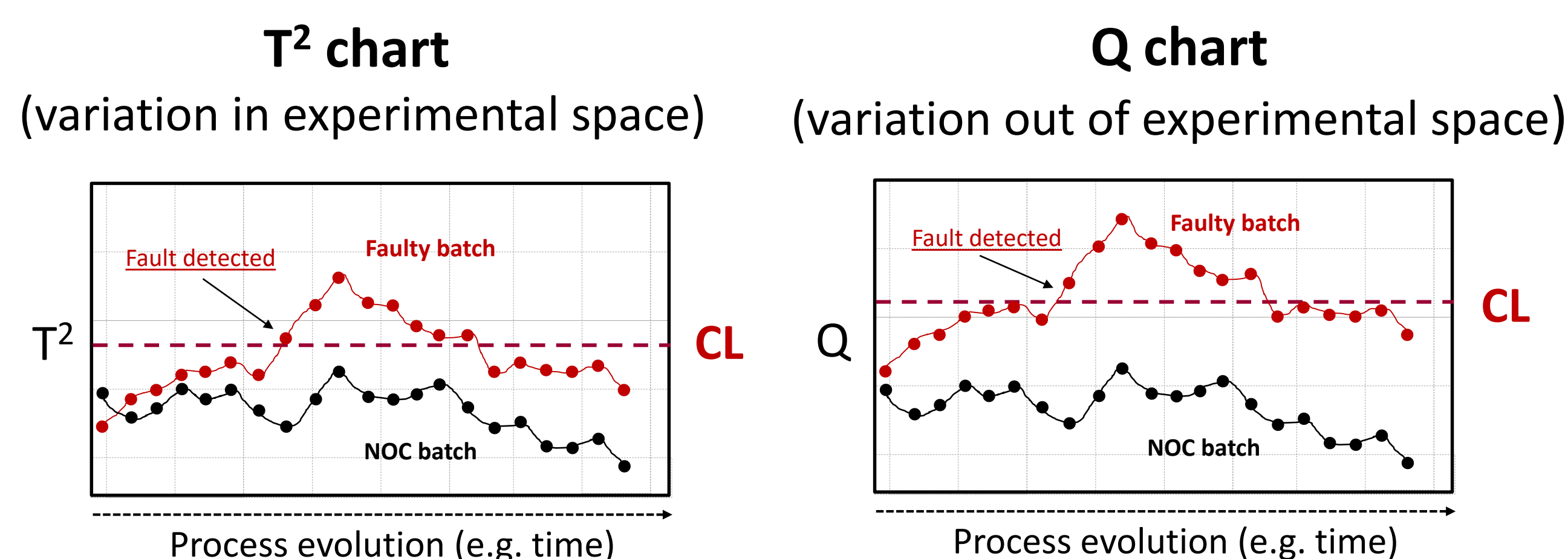


- ❖ Acquisition of representative and synchronous process information is needed.

Individual sensor process control

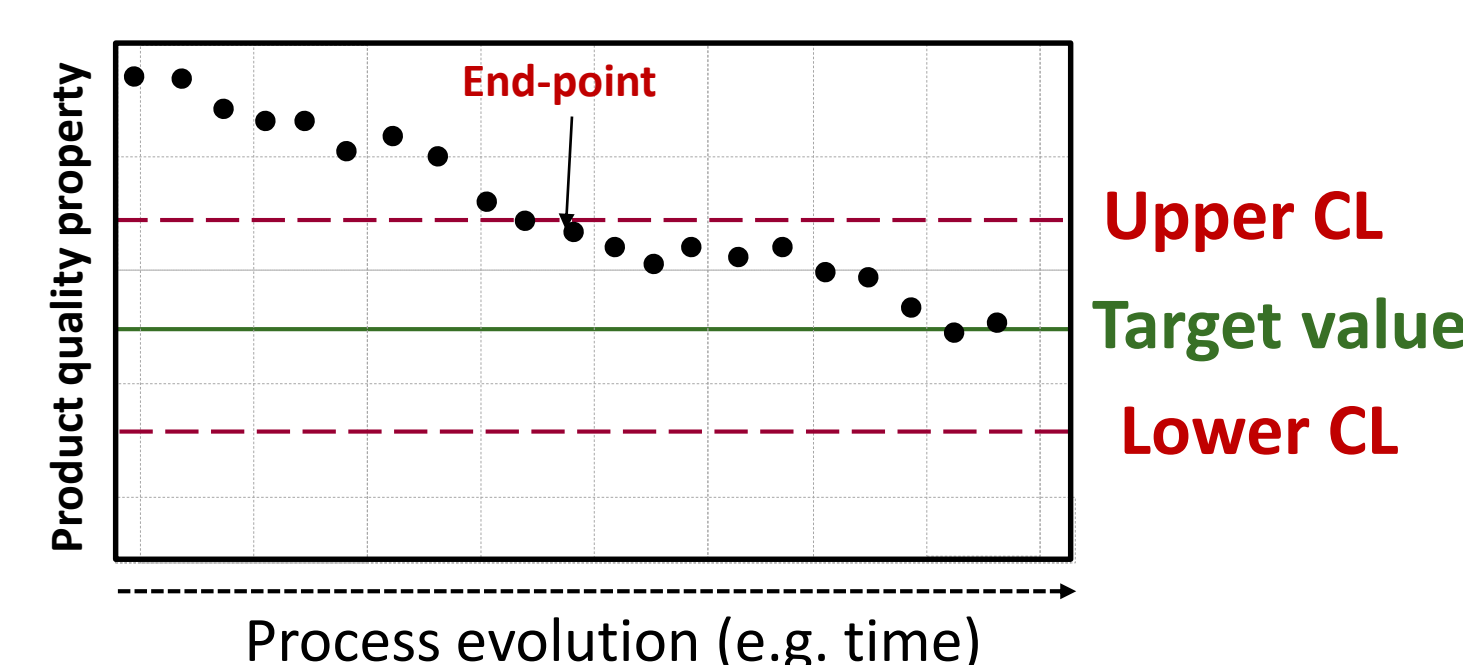
Multivariate sensors (e.g. NIR)

Multivariate control charts



Univariate sensors (e.g. T)

Univariate Shewhart control charts (variation around target value)



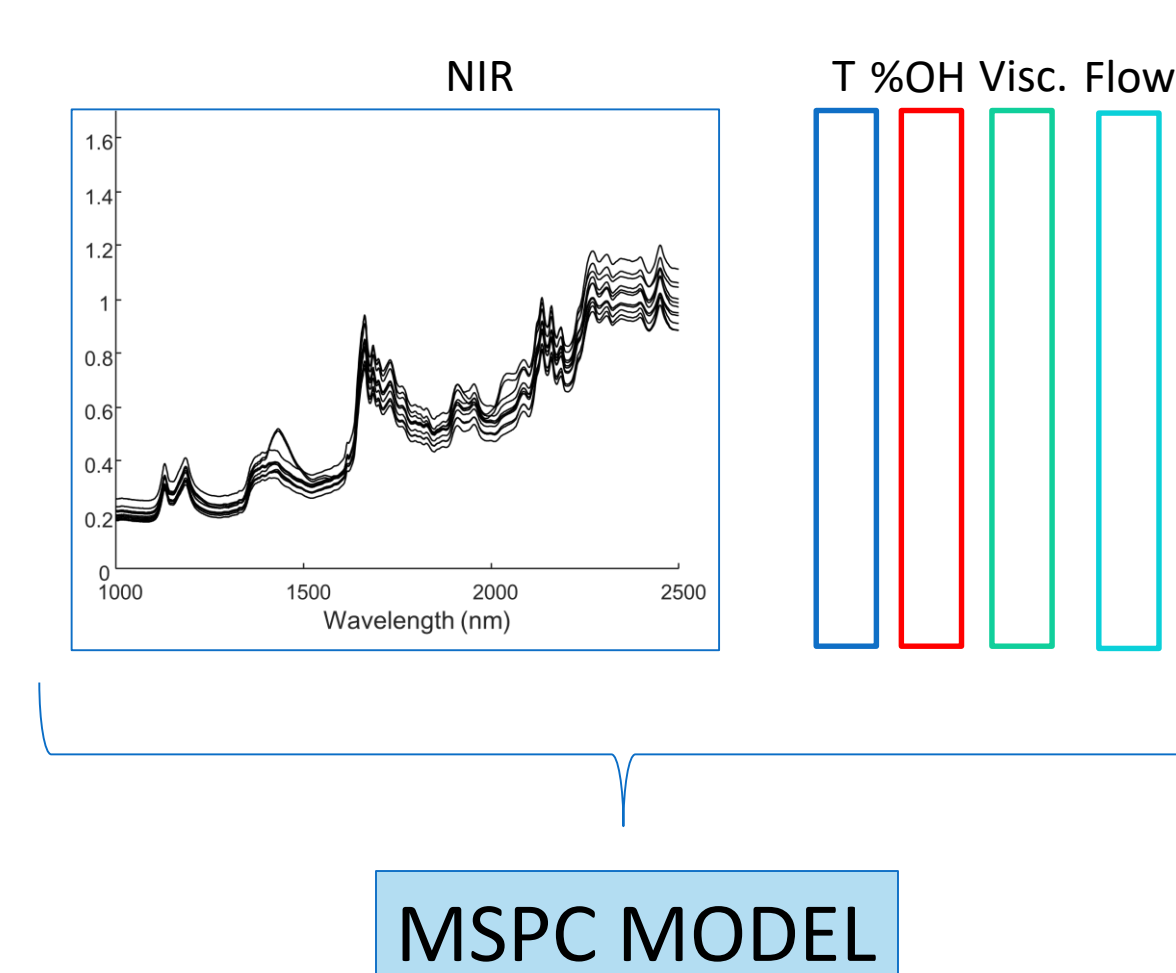
- ❖ Checks whether individual sensor outputs are within allowed boundaries
- ❖ In- or out- of control situations respond to a single sensor.
- ❖ General vision of process operation is missing.

----- Control limit (CL) of charts are related to boundaries of individual sensors

Data fusion process control

Low-Level fusion

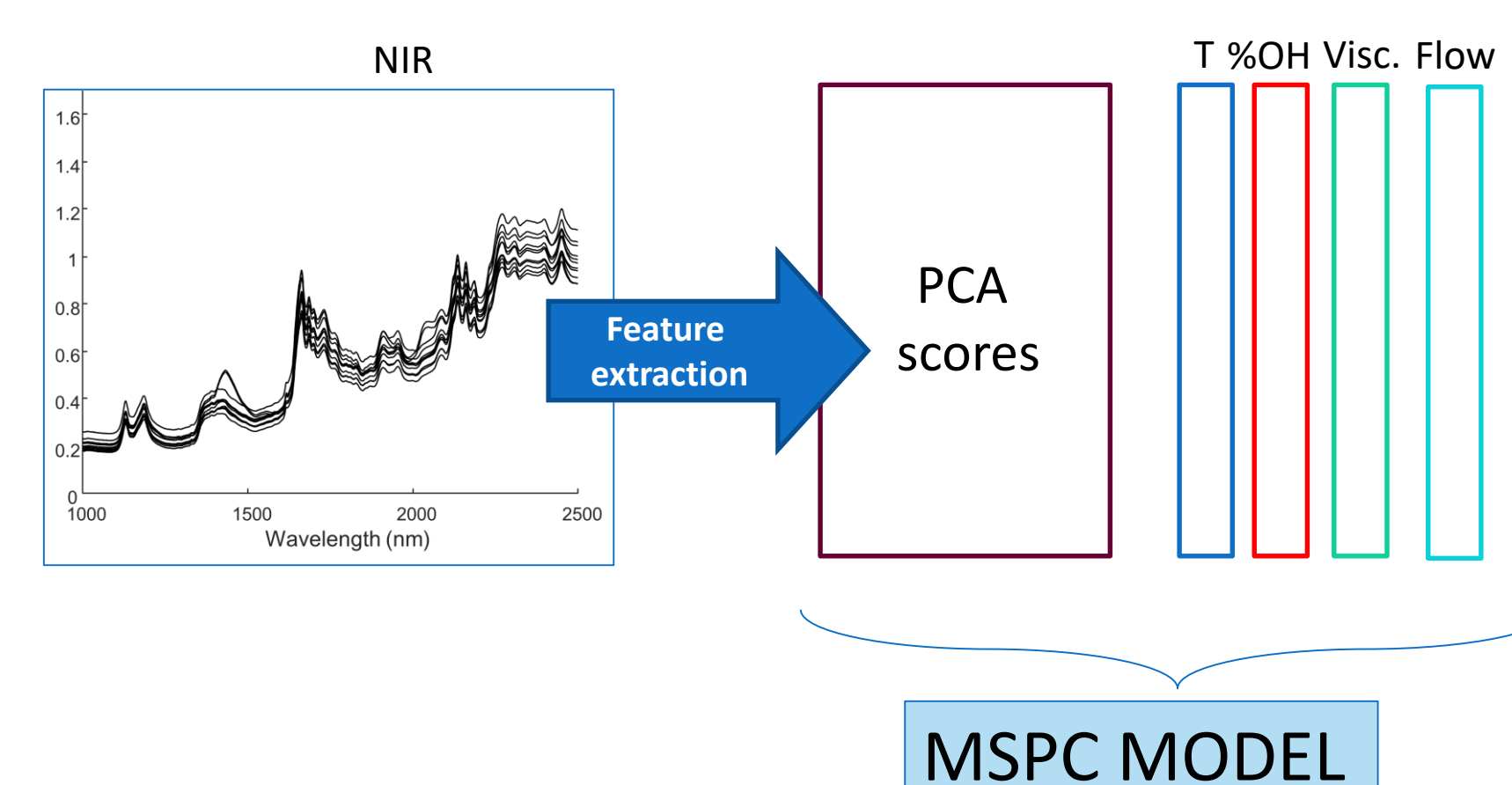
Raw sensor outputs are concatenated in a single data structure



Low-level fusion requires that measurement blocks of individual sensors be balanced in size and scale

Mid-Level data fusion

Sensor outputs are replaced by **relevant features** and concatenated in a single data structure



Size of fused information is decreased in mid-level fusion
Balancing output sensor weight becomes easier

----- Control limit (CL) of charts are related to boundaries of fused sensors space

- ❖ Fused information checks individual sensor functioning and correct correlation among sensor outputs during the process.
- ❖ Integral process control is performed