Modeling in aquatic environment

Lecture 2

Catchment models

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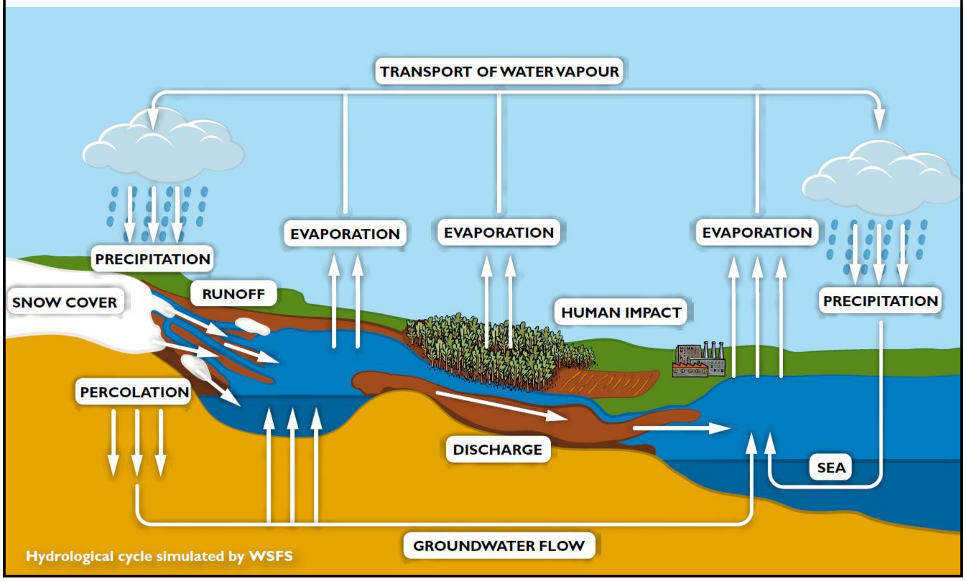
Hydrological expertise in Finland | Hydrological Modeling and Forecasting System (1/4)

Hydrological cycle



Mass balance in catchment (or watershed)

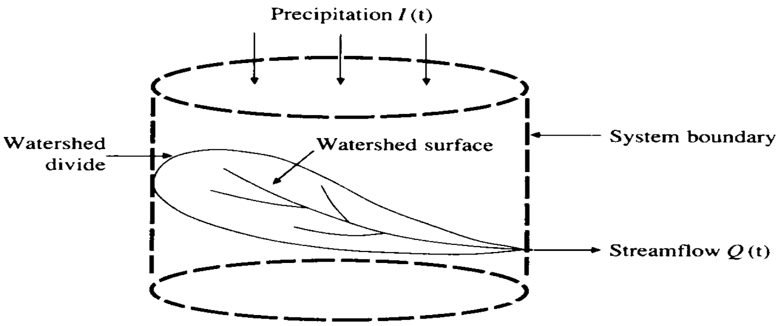


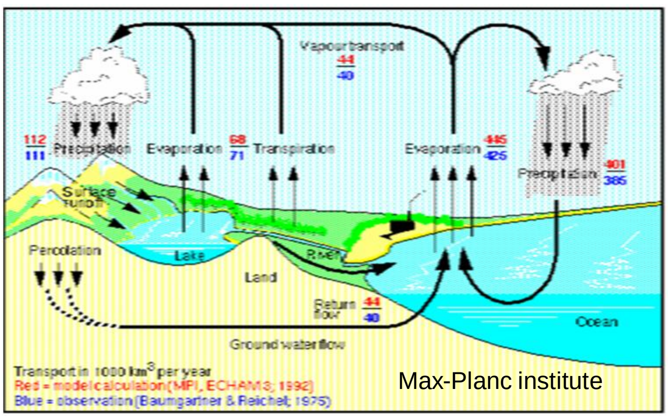
FIGURE 1.2.3
The watershed as a hydrologic system.

Water balance model (continuity equation):
a simple and good mathematical model

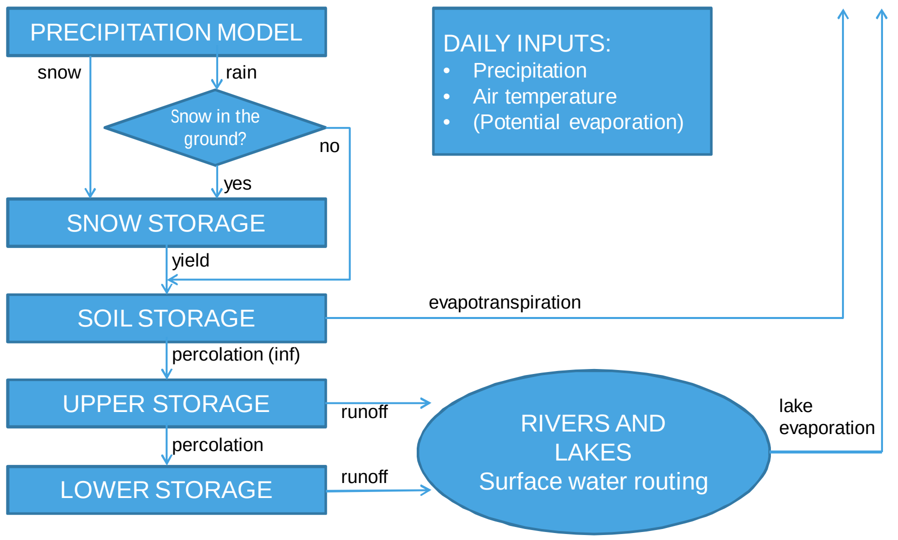
P = ET + dS + R

For example for oceans:
P = ET + R + dS

P=precipitation
R=runoff
ET=evapotranspiration
dS = change in water storage; like water in ice, snow. In short term water soil, ground, reservoirs and lakes



Hydrological expertise in Finland | Hydrological Modeling and Forecasting System (2/4)



R CENTRE

Calibration example of a catchment model

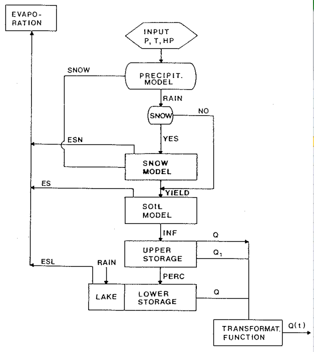
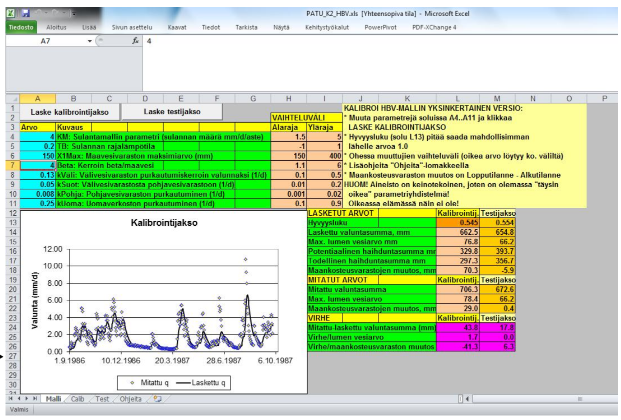


Fig. 2. General structure of snowmelt-runoff model.



- Demo developed by prof. Tuomo Karvonen at Helsinki University of Technology
- ..\..\..\..\PATU\PATU_K2_HBV.xls

SYKE

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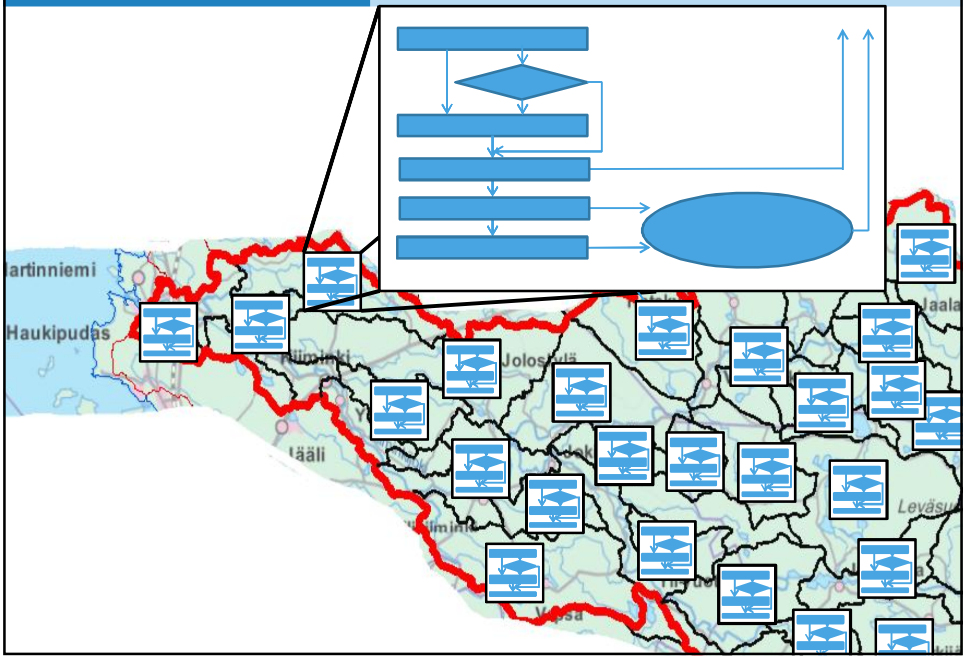
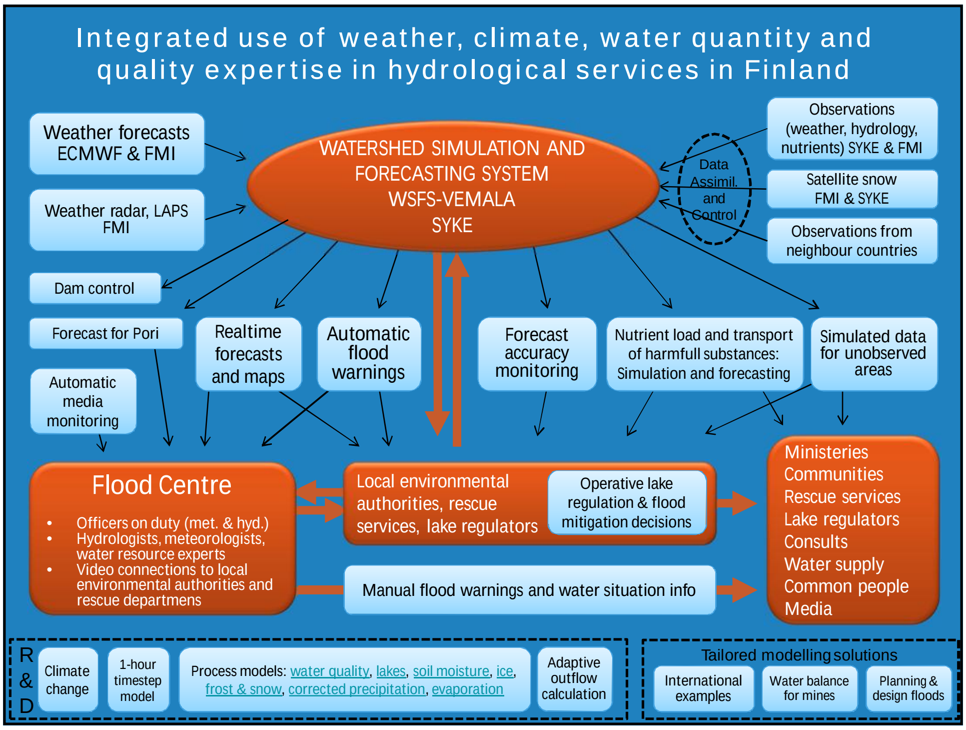
Hydrological expertise in Finland | Hydrological Modeling and Forecasting System (3/4)

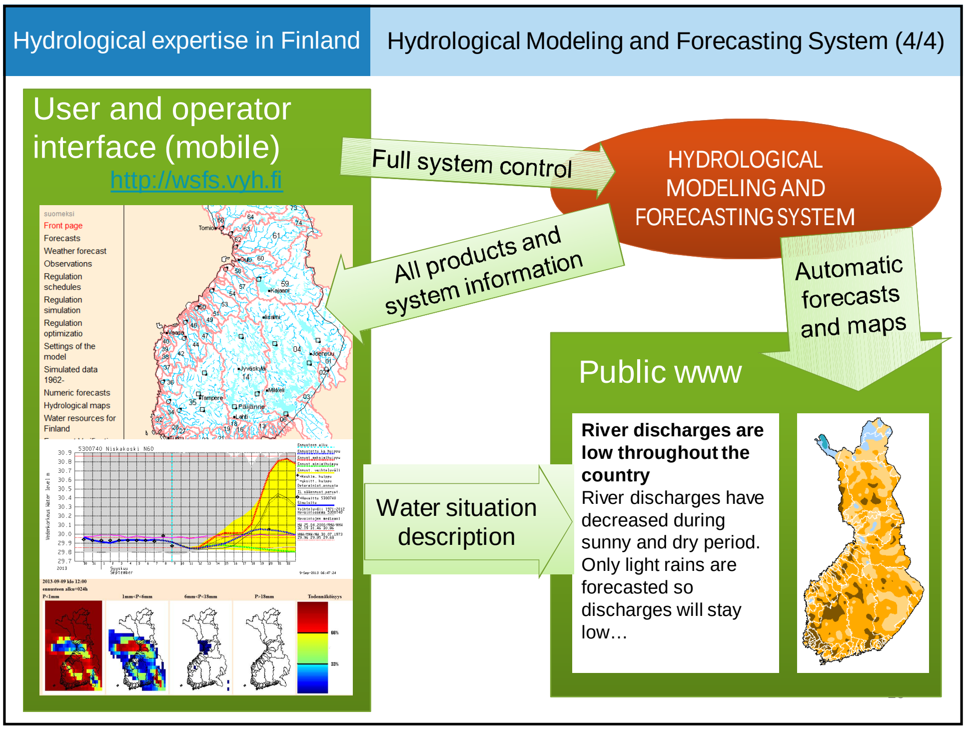


Hydrological simulation and forecast

- A country wide system (WSFS):
  - http://www.ymparisto.fi/en-US/Waters_and_sea/Hydrological_situation_and_forecasts/Hydrological_forecasts_and_maps/Hydrological_forecasts_and_maps%2826174%29
  - Used for operational forecasts
  - Used also for research
  - Based on water balance computation on watersheds (3rd division level)
- Dynamic links
  - Meteorological data forecasts (FMI)
  - Hydrological observations (water levels, river discharges, water temperature, ground water level)
  - Links to satellite automated imaging products (snow coverage, snow water equivalent)
- Automatic and tailored products

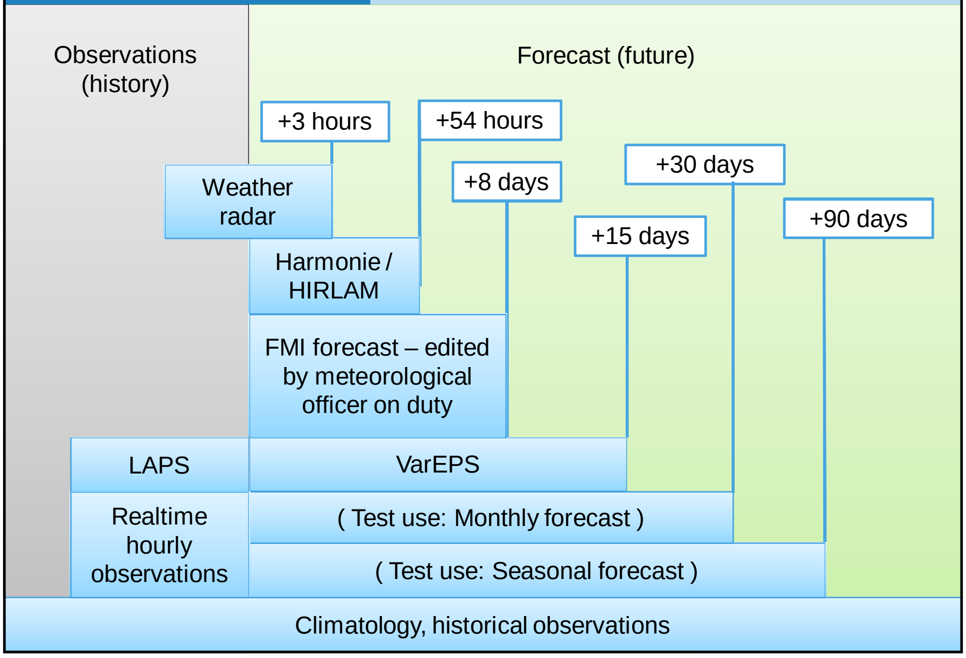
11/16/2016


Integrated use of weather, climate, water quantity and quality expertise in hydrological services in Finland
Weather forecasts ECMWF & FMI
Weather radar, LAPS FMI
WATERSHED SIMULATION AND FORECASTING SYSTEM WSFS-VEMALA SYKE
Observations (weather, hydrology, nutrients) SYKE & FMI
Satellite snow FMI & SYKE
Observations from neighbour countries
Data Assimil. and Control
Dam control
Forecast for Pori
Automatic media monitoring
Realtime forecasts and maps
Automatic flood warnings
Forecast accuracy monitoring
Nutrient load and transport of harmfull substances: Simulation and forecasting
Simulated data for unobserved areas
Flood Centre
Officers on duty (met. & hyd.)
Hydrologists, meteorologists, water resource experts
Video connections to local environmental authorities and rescue departmens
Local environmental authorities, rescue services, lake regulators
Operative lake regulation & flood mitigation decisions
Manual flood warnings and water situation info
Ministeries
Communities
Rescue services
Lake regulators
Consults
Water supply
Common people
Media
R & D
Climate change
1-hour timestep model
Process models: water quality, lakes, soil moisture, ice, frost & snow, corrected precipitation, evaporation
Adaptive outflow calculation
Tailored modelling solutions
International examples
Water balance for mines
Planning & design floods


Hydrological expertise in Finland
Hydrological Modeling and Forecasting System (4/4)
User and operator interface (mobile)
http://wsfs.vyh.fi
Full system control
HYDROLOGICAL MODELING AND FORECASTING SYSTEM
All products and system information
Automatic forecasts and maps
Water situation description
Public www
River discharges are low throughout the country
River discharges have decreased during sunny and dry period. Only light rains are forecasted so discharges will stay low…

Hydrological expertise in Finland

Weather forecasts (1/8)



Hydrological expertise in Finland

Weather forecasts (5/8)

- The input of the operational model is
  - Observed weather (in history)
  - **ECMWF 15 days VarEPS**, 50 members. The first days are corrected against FMI deterministic forecast.
  - Climatology of the last 50 years: every member of VarEPS is continued by data from a certain historical year
  - Result: probabilistic hydrological forecast for 1 year.
- Since 2007 experimental forecasts have been made using **monthly and seasonal EPS**:
  - ECMWF monthly EPS, produced weekly, time span 30 days (two weeks after VarEPS).
  - ECMWF seasonal EPS, produced monthly, time span 90 days (30-60 days after the monthly EPS).
  - The length of the period based on various weather forecasts is 60-90 days, and climatology is used only after that.
  - **During very warm winters 2007-08 and 2008-09 the hydrological forecasts made using monthly/seasonal EPS were clearly better, but overall performance cannot be said to be better than climatology.**

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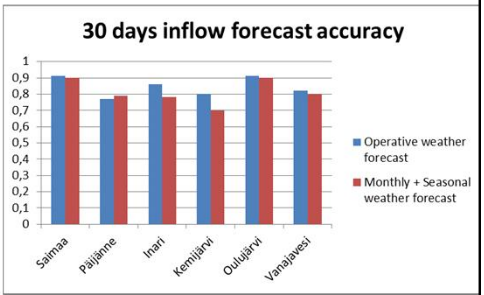
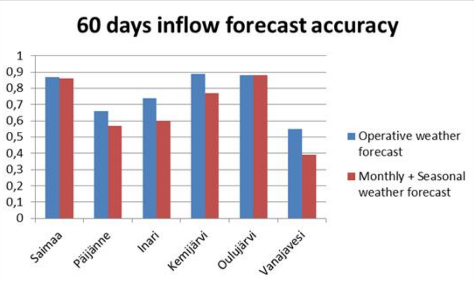
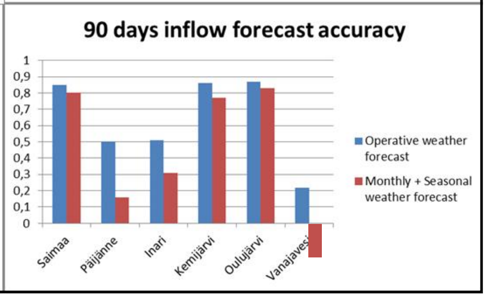
Mean forecast goodness of fit values for lake inflow 30, 60 and 90 days ahead

- Comparing inflow forecasts of 2013 shows that using operative weather forecast gave better results than using experimental use monthly and seasonal EPS weather forecasts







Weather radar and LAPS in WSFS

Weather radar

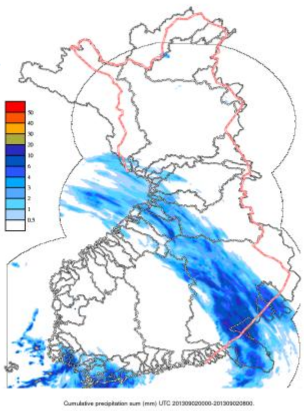
- Hourly radar data in 2x2km grid
- Used for 2 days in model
- Underestimates large rainfalls
  - Corrected manually against rain gauges

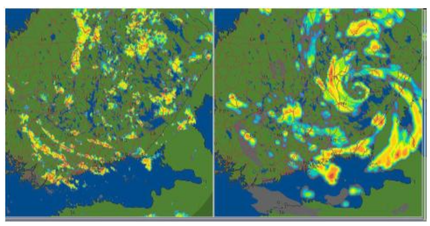
Radar nowcasting

- 3hrs in Southern Finland
- Ensamble of 50 members

LAPS

- Combines information from weather radar, automatic real-time rain gauges, road weather measurements, …
- Will probably be used in WSFS as a weather radar replacement in near future



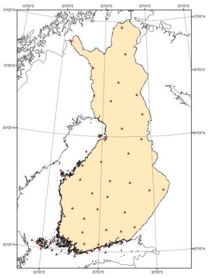


Hydrological expertise in Finland

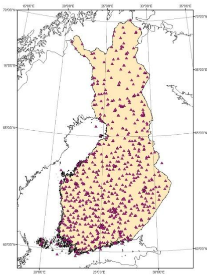
Realtime and historical hydrometeorological and nutrients observations (1/4)

Observation networks

- Automatic realtime precipitation 1-hour measurements from 100 stations
- 380 discharge stations
  - 220 with daily measurements
  - 160 external stations with usually daily measurements
- 660 water level stations
  - 400 with daily measurements
  - 260 external stations with usually daily measurements
- Snow courses
  - 140 montly measurements
- Water quality measurements



Synoptic weather stations, 50 daily measurements



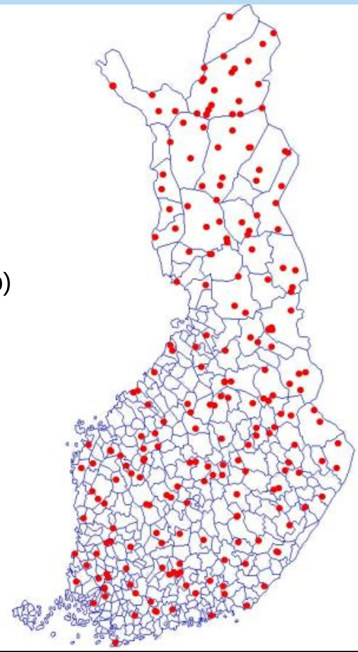
Other weather stations, 200 daily measurements

Hydrological expertise in Finland

Realtime and historical hydrometeorological and nutrients observations (2/4)

Measuring the snow water equivalent

- Snow water equivalent is measured by snow course measurements
  - About 140 snow courses in Finland (less than what is shown at the map)
- Areal snow water equivalents are calculated for approximately 110 areas
- Snow courses are 2-4 km long routes through various terrains
  - 80 depth measurements
  - 8 manual weightings
- Measurements are made once or twice a month



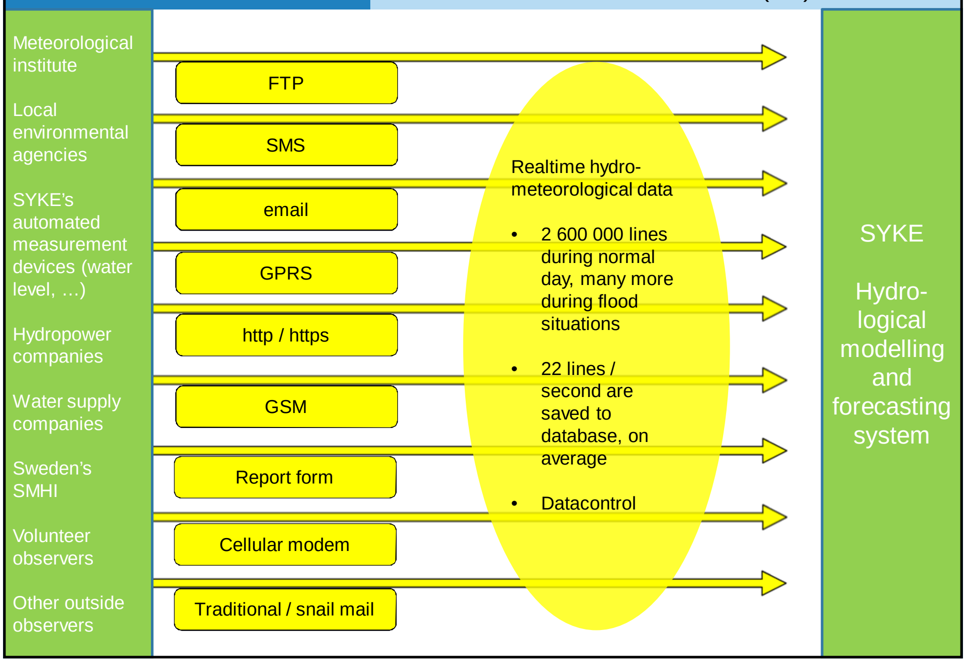
Hydrological expertise in Finland

Realtime and historical hydrometeorological and nutrients observations (3/4)

Measuring the snow water equivalent

Hydrological expertise in Finland

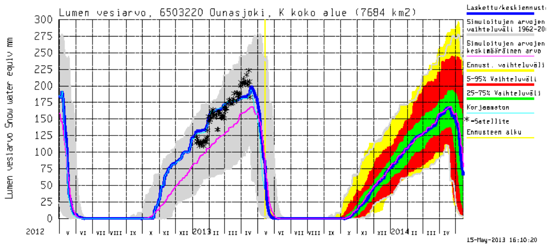
Realtime and historical hydrometeorological and nutrients observations (4/4)

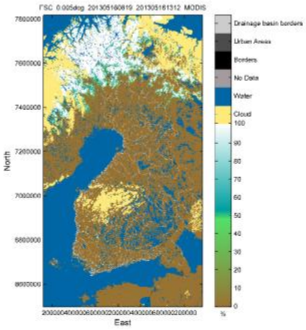


Hydrological expertise in Finland | Satellite snow observations (1/2)

Satellite snow products in WSFS

CryoLand
- Fractional snow cover
- Snow water equivalent



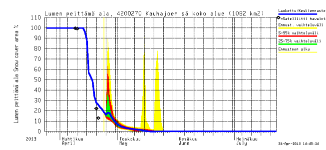


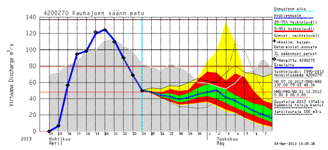
Hydrological expertise in Finland | Satellite snow observations (2/2)

Satellite snow products in WSFS

Fractional snow cover

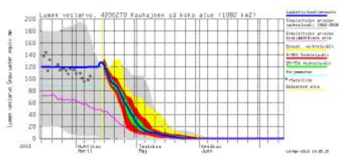
- Areal snow difficult to estimate
  - FSC provides information about remaining snow in final stage of melting





Snow water equivalent

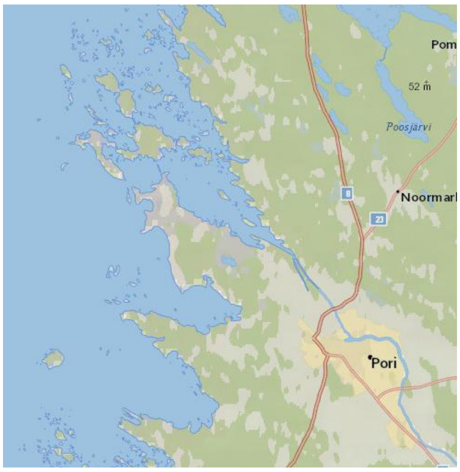
- If modelled snow differs from prec.sum SWE helps
- Has not yet been as helpful as areal snow



Hydrological expertise in Finland — Forecast for Pori (1/2)

Sea water level realtime observations and forecast 2-5 days ahead for river water level simulation at City of Pori

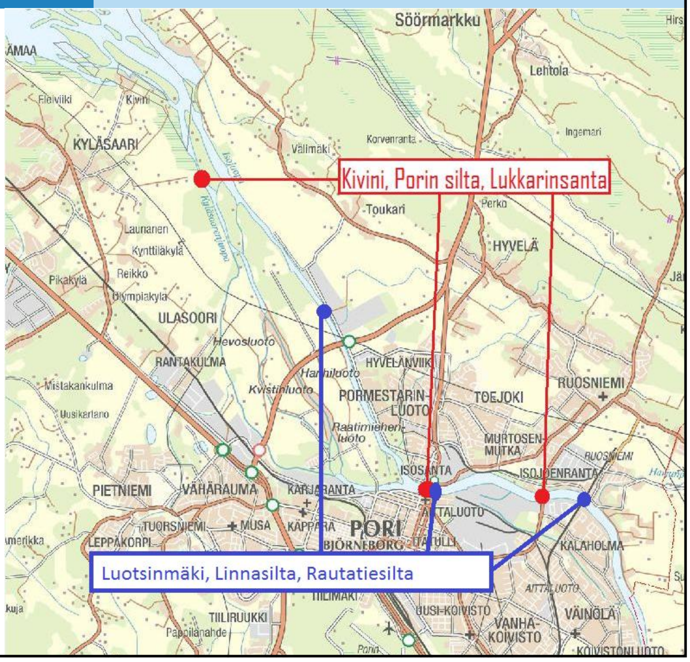
- City of Pori has biggest risk for major flood damages in Finland



For River Water level simulation we need:

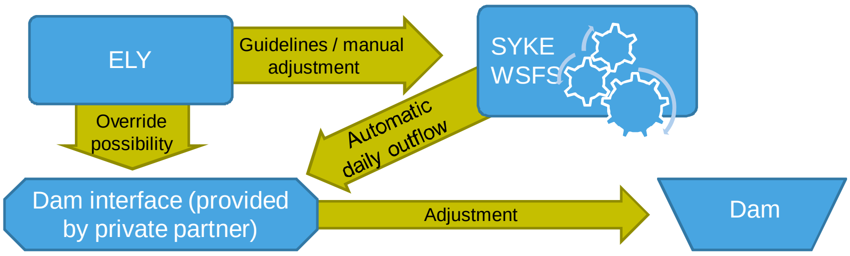
- Discharge simulation and forecast
- Sea water level observations and forecast
- Wind speed & direction observations and forecast

Hydrological expertise in Finland — Forecast for Pori (2/2)

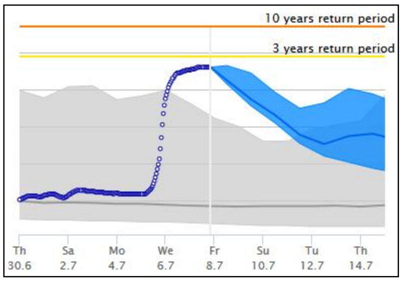


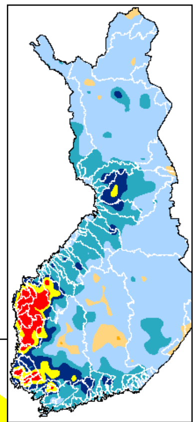
Regulation dam controlled by the hydrological model

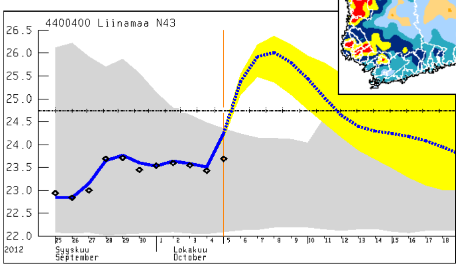
- Kaarenhaara dam at Evijärvi is controlled by Watershed Simulation and Forecasting System SYKE-WSFS
- The WSFS model calculates the daily runoff based on the inflow forecast (adaptive outflow calculation), and the result is sent to the dam
- The dam adjusts the outflow according to the model, but applies also a safety logic on top of the model's calculation
- The model's outflow for the dam can be manually overriden, if necessary



- Water level
- Discharge
- Ice dam risk
- Ice breakup
- Nutrient load
- Evaporation
- Snow
- Runoff
- Groundwater
- Soil moisture
- Hydropower situation

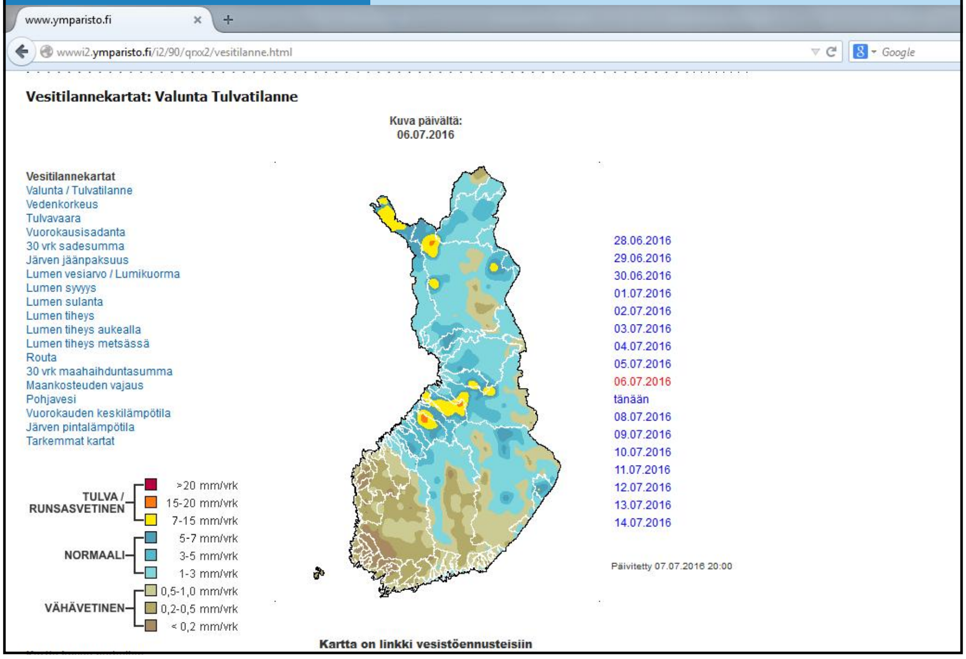






Hydrological expertise in Finland

Realtime forecasts and maps (2/3)



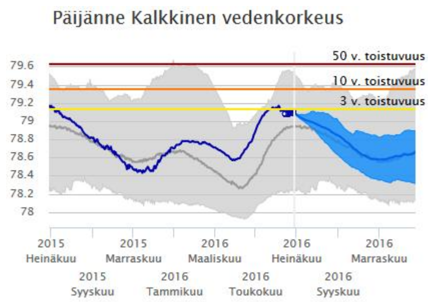
Hydrological expertise in Finland

Realtime forecasts and maps (3/3)

Realtime forecasts and maps for over 600 lakes and rivers available online:

http://www.environment.fi/waterforecast

http://www.ymparisto.fi/vesistoennusteet (in Finnish)



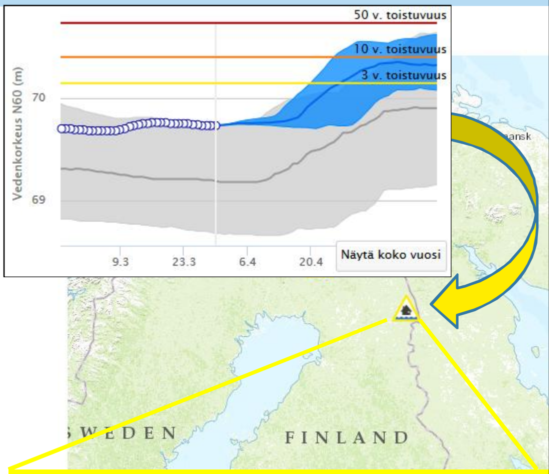
Hydrological expertise in Finland | Automatic flood warnings (1/4)

AUTOMATIC WARNINGS FROM HIGH WATER LEVELS AND GREAT DISCHARGES

- Up to 9 days ahead, even 30 days ahead with big slowly changing lakes like Saimaa
- Warnings are based on
  - *realtime observations* and *forecasts*
  - *potential damages* and consequences
- Direct delivery to subscribers

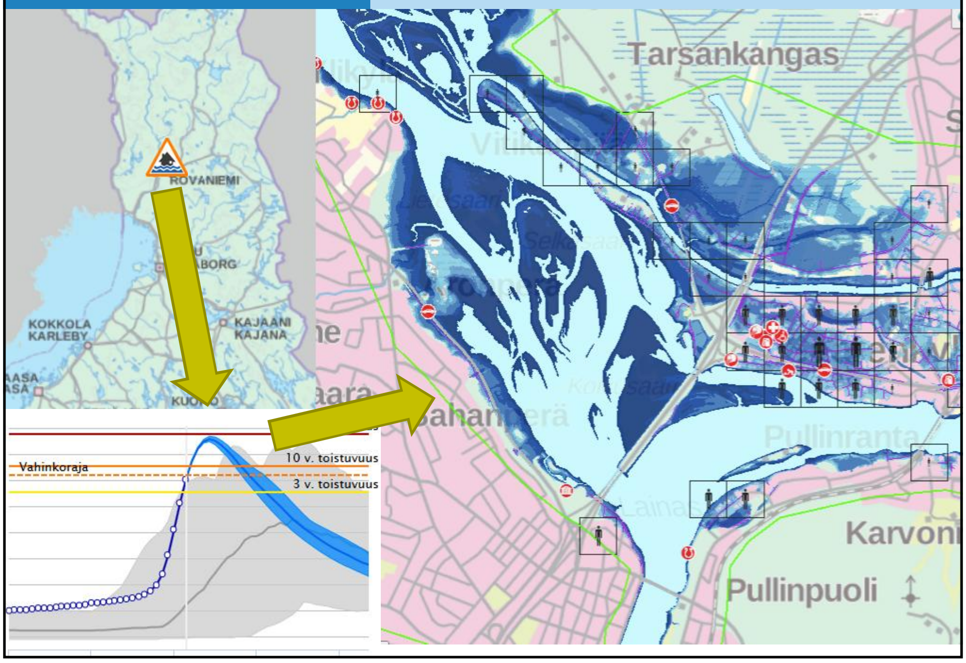
- Warnings available online:

www.environment.fi/waterforecast



Oulankajoki (Kiutaköngäs)
Warning: forecasted water level exceeds limit of Karhunkierros hiking route to be cut off.
Observed water level 26.5.2014 klo 12 is NN+88,92 m.
Karhunkierros hiking route will be cut off if water level exceeds NN+90.00 m.
Forecasted water level peak NN+90.50 m is at 29.5.2014.

Hydrological expertise in Finland | Automatic flood warnings (2/4)



Hydrological expertise in Finland | Automatic flood warnings (3/4)

Warnings are based on impact / potential damages and consequences, when possible (otherwise return period)

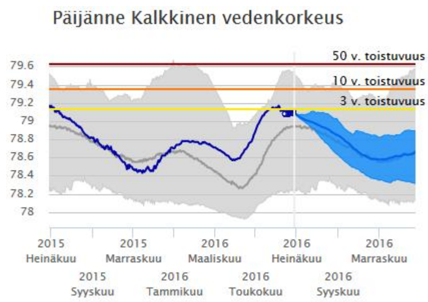
Symbol	Warning	Description / impact / potential damages	Return period (preliminary value)
	Very dangerous flood	”Danger to human life and health”	Over 50 years
	Dangerous flood	”Damage to buildings”	10-50 years
	Flood	”Anything which differs flood-wise from normal casual everyday life”	3-10 years

Hydrological expertise in Finland | Automatic flood warnings (4/4)

Realtime forecasts and warnings are available online:

http://www.ymparisto.fi/ennusteetjavaroitukset

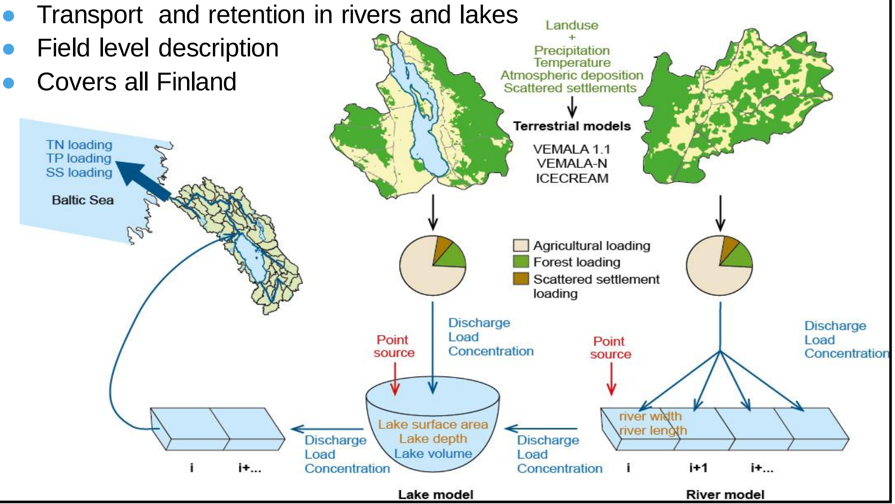
(In Finnish, Swedish and English, and in Russian for transboundary waters)



Hydrological expertise in Finland | Nutrient load simulation and forecasting (1/13)

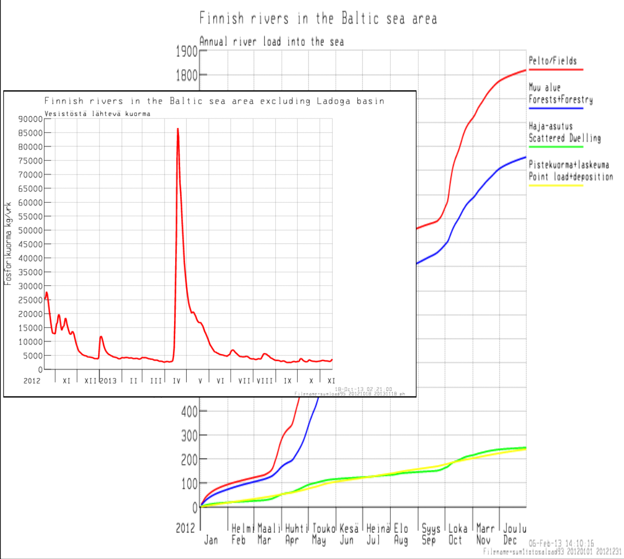
Structure of WSFS-Vemala water quality model

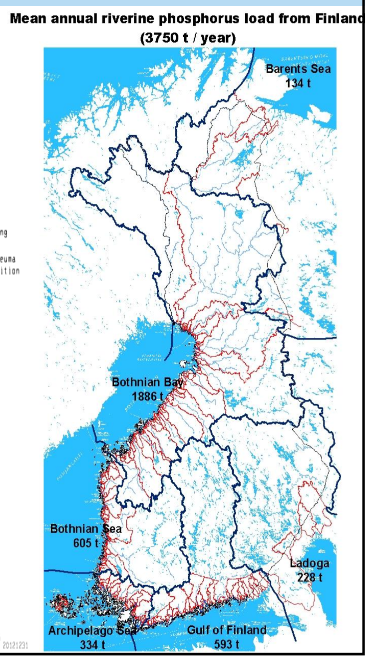
- Phosphorus and nitrogen leaching from fields and forest
- Point sources, scattered dwelling and deposition
- Transport and retention in rivers and lakes
- Field level description
- Covers all Finland



Hydrological expertise in Finland | Nutrient load simulation and forecasting (2/13)

Realtime and annual phosphorus load from Finland to Baltic sea

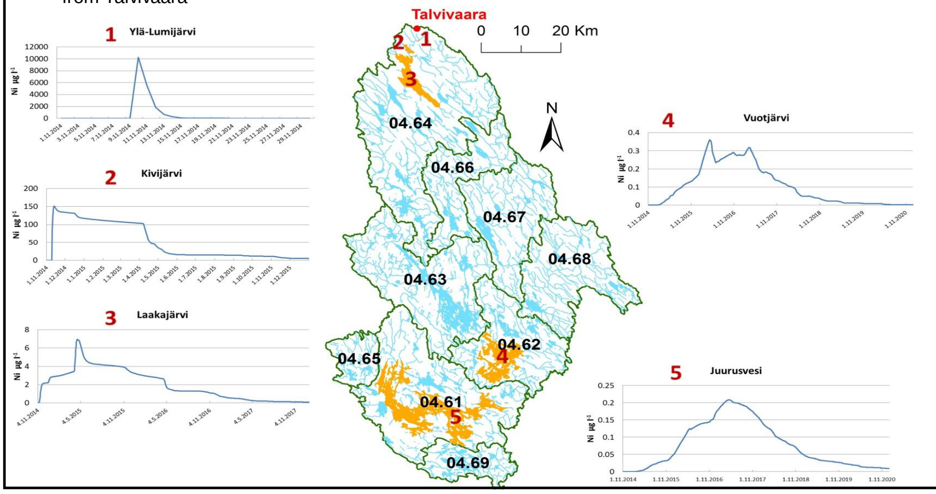




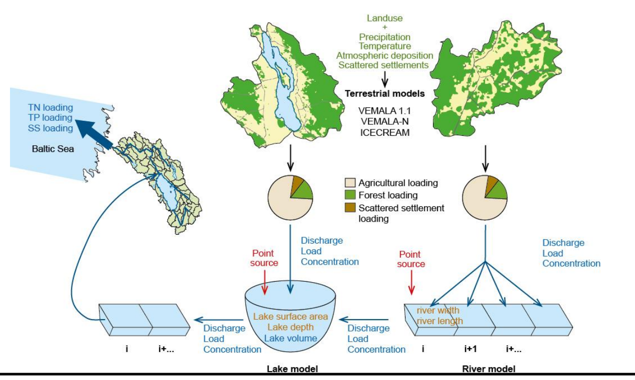
Simulation of a leak from mine

The aim is to better predict the transport of substances in rivers and lakes downstream of an industrial leak for determining toxicity risks:

- Simulation of a hypothetical 1 tonne of Nickel discharged on the 09/11/2014 into the freshwater ecosystem from Talvivaara



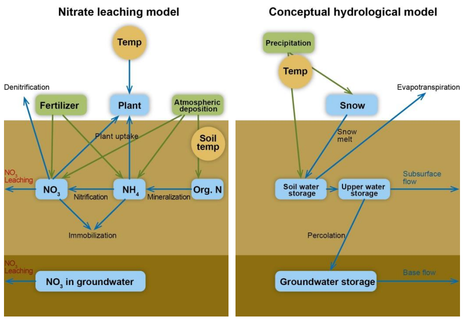
Version	Substance	Hydrological model	Terrestrial model: agricultural loading	Terrestrial model: non-agricultural loading	River model	Lake model
VEMALA 1.1	TP, TN, SS	WSFS	concentration-runoff relationship	concentration-runoff relationship	nutrient transport model (Section 2.1.5.)	nutrient mass balance model (Section.2.1.6.)
VEMALA-ICECREAM	TP	WSFS	field scale process based model	concentration-runoff relationship		
VEMALA-N	TN, NO_3^-	WSFS	semi-process based, 5 crop classes	semi-process based, 1 forest class		
VEMALA v.3	TN, TP, SS, TOC, PO_4^{3-}, PP, Porg, NO_3^-, NH_4^+, Norg, Phytoplankton, O_2	WSFS	VEMALA-ICECREAM (TP), VEMALA-N (NO_3^-, Norg), VEMALA 1.1 (SS, TOC)		Biogeochemical model	Biogeochemical model



Hydrological expertise in Finland | Nutrient load simulation and forecasting (5/13)

VEMALA-N

- Simulates NO_3^-, Norg and TN leaching and load formation at a catchment scale
- Simulation unit is crop/land use class and there are 5 agricultural crop classes and forest
- Model simulates dependancy of the main processes (mineralization, nitrification, denitrification, plant uptake) on the soil moisture and temperature

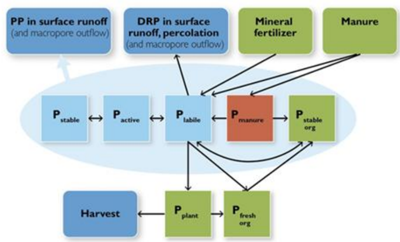


Scenarios:

- Model can be used to simulate the effect of changing climate on the nitrate leaching and it's sub-processes
- Model can be used to simulate effect of changing crop and fertilization (both mineral and organic) on the nitrate leaching

Hydrological expertise in Finland | Nutrient load simulation and forecasting (6/13)

VEMALA-ICECREAM



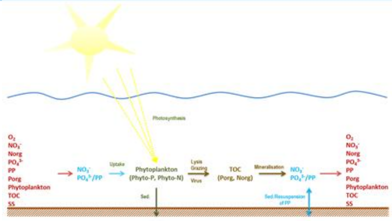
- Simulates particle bound and dissolved phosphorus (PP and DP) load and erosion from agricultural areas
- Field-scale, process based model, applied to all fields in Finland
- Field characteristics: soil type (clay, silt, coarse and peat), field slope and the size of a rectangle-shaped field plot
- Output from ICECREAM (daily total P load) is used as input to VEMALA

- Agricultural measures in ICECREAM:
  - Amount, depth of application and type of fertilizer (mineral/manure)
  - Annual crops (also over winter), perennials and root crops, 13 different crops parameterized
  - Conventional tillage, direct sowing
  - Dates for agricultural practices
  - Buffer zones/strips

Hydrological expertise in Finland

Nutrient load simulation and forecasting (7/13)

VEMALA v.3

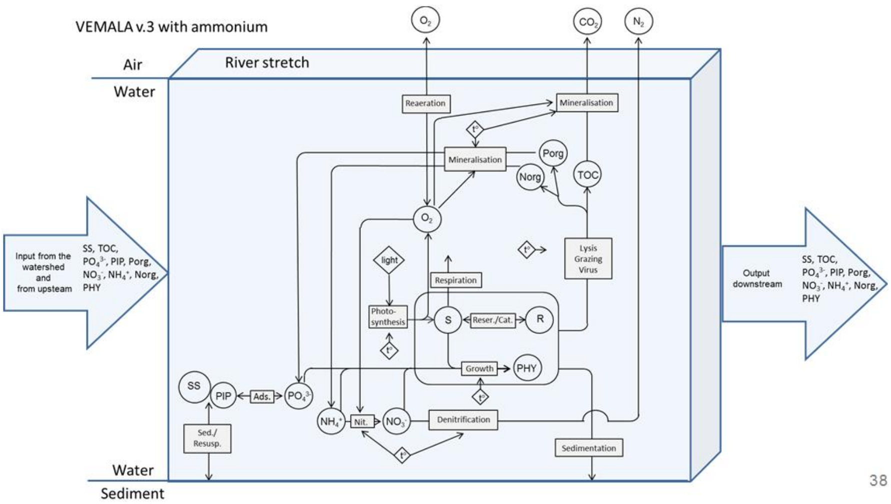


- VEMALA v.3 uses the terrestrial input from VEMALA-N for NO_3^- and Norg, VEMALA-ICECREAM for PO_4^{3-}, PP and Porg and VEMALA 1.1 for TOC and SS.
- The phytoplankton growth is simulated using the AQUAPHY model (Lancelot et al. 1991) and the nutrient cycling using a simplified version of the biogeochemical model RIVE (Billen et al., 1994).
- In this new model, the bioavailable nutrients are no longer modeled separately but are linked in the aquatic ecosystem to one another through phytoplankton dynamics, organic matter degradation and sedimentation.
- It can simulate:
  - The proportion of biologically available fractions in the run off to the Sea
  - The contribution of the different loading sources to the biologically available nutrients
  - The impact of the different farming actions and loading reduction actions on the biologically available nutrient loads
  - The phytoplankton growth in Finnish water bodies
  - The better simulation of retention in the river network.
  - The effect of climate change on the biologically available nutrient fractions

Hydrological expertise in Finland

Nutrient load simulation and forecasting (8/13)

- Variables simulated in VEMALA v.3
  - Phosphate (PO_4^{3-}), dissolved organic phosphorus (Porg) and particulate inorganic phosphorus (PP)
  - Nitrate (NO_3^-), ammonium (NH_4^+) and organic nitrogen (Norg)
  - Phytoplankton
  - Suspended solids (SS)
  - Total organic carbon (TOC)
  - Oxygen (O_2)



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Hydrological expertise in Finland | Nutrient load simulation and forecasting (9/13)

Where can it be used?

- It can simulate:
  - The proportion of total or biologically available fractions in the run off to the Sea
  - The contribution of the different loading sources to the total or biologically available nutrients
  - The retention in lakes and the river network.
  - The phytoplankton growth in Finnish water bodies
  - Scenarios:
    - The impact of the different farming actions and loading reduction actions on the total or biologically available nutrient loads
    - The effect of climate change on the total or biologically available nutrient fractions
- VEMALA can help in the WFD implementation
- Impact of the mining industry

Hydrological expertise in Finland | Nutrient load simulation and forecasting (10/13)

For implementation of WFD it provides:

- For each about 58 000 lakes an estimate of the present state
- Understanding reasons for the state of the lake by dividing the loading by sources
- Scenarios for future with different load reduction options and the effects of climate change

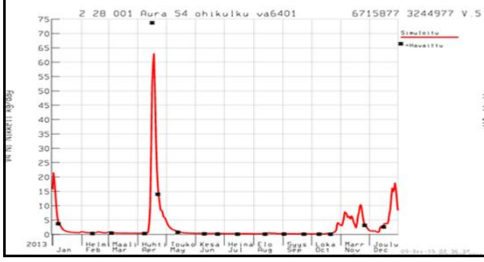
Field id	Name	Slope %	Area ha	Phosphorus leaching kg/ha/a
7620256645	Pihantaus	4.47	16.93	1.7
7620330205	Rikkasuo 1	5.34	6.59	1.61
7620520262	Nivonniska	3.47	4.02	1.59
7620254827	Inganmäki	3.75	3.8	1.54
7620239164	Koskenniska	0.69	2.71	1.4
7620262305	Väliaho	3.03	4.02	1.22
1400111639	Paskosuo	2.29	3.47	1.02
1400072031	Vinkuanlahti	2.35	6.08	0.9

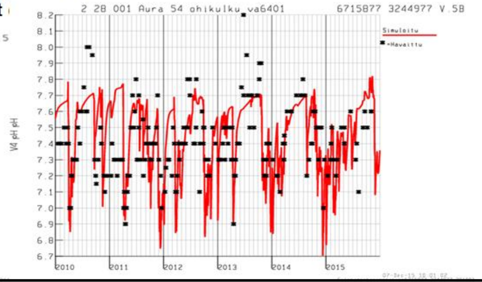
Lake id	Name	Phosphorus concentration ug/l	Incoming load kg/a	Fields kg/a	Forest kg/a	Scattered dwelling kg/a	Point sources kg/a	Load out kg/a
04 582 001	Vinkuanlahti	42.84	15172.83	6235.78	7238.96	660.38	1037.68	15114.44
04 582 002	Sulkavanlahti	134	139.04	115.47	15.3	7.41	0.86	137.43
04 582 003	Vehkalampi	115.09	4.3	3.71	0.29	0.17	0.13	2.72
04 582 004	Kivilampi	104.29	27.66	21.22	4.33	1.84	0.28	26.52
04 582 005	Rajalahti	60.23	17.05	8.85	5.07	1.8	1.33	13.86
04 582 006	Pentanlahti	41.61	14876.35	6082.15	7256.38	647.03	890.75	14745.66

Hydrological expertise in Finland | Nutrient load simulation and forecasting (11/13)

VEMALA tool for simulation transport of heavy metals and harmfull substances

- Real time forecast for transport of a leak or waste water
  - Concentration downstream of the leak
  - Comparasion to harmfull concentration levels
- Operational over Finnish waters
- Simulated substances:
  - Zinc (Zn), Lead (Pb), Mercury (Hg), Aluminium (Al), Cadmium (Cd), Nickel (Ni), Uranium (U), Iron (Fe), Chromium (Cr), Manganese (Mn), Magnesium (Mg), Sodium (Na), Copper (Cu), Sulphur (S), Calcium (Ca), Sulphate (SO_4^{2-}), Silica (SiO_2), Cobalt





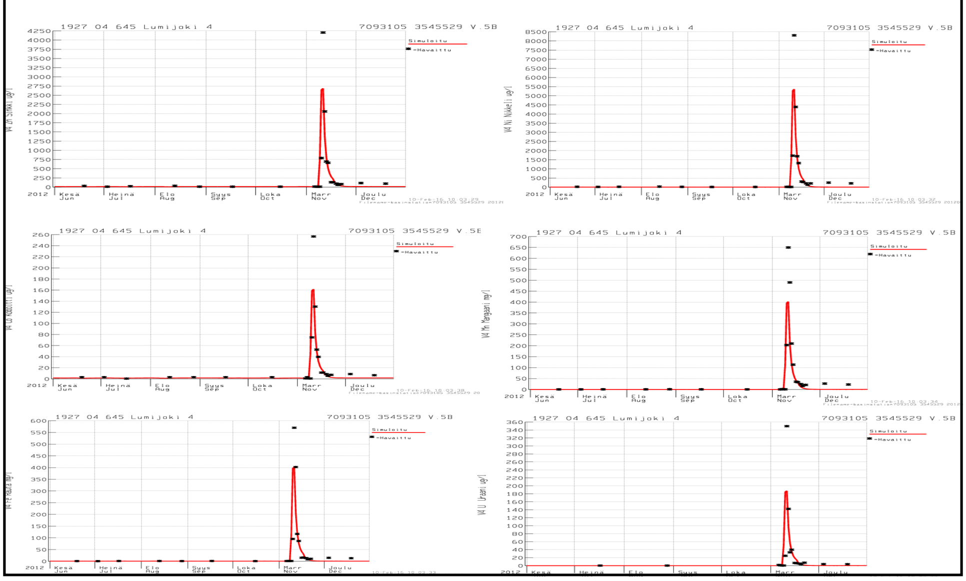
Hydrological expertise in Finland | Nutrient load simulation and forecasting (12/13)

VEMALA

- Water quality model
- Operational over Finnish waters
- It simulates nutrient processes, leaching and transport on land, and in rivers and lakes.
- Simulates from the Finnish water basins to the Baltic Sea:
  - Nutrient gross loading
  - Retention in lakes and in the river network
  - Nutrient net loading
- Nutrient species modelled:
  - Phosphorus: Total phosphorus (TP), phosphate (PO_4^{3-}), organic phosphorus (Porg) and particulate phosphorus (PP)
  - Nitrogen: Total nitrogen (TN), nitrate (NO_3^-), ammonium (NH_4^+) and organic nitrogen (Norg)
  - Suspended solids (SS)
  - Total organic carbon (TOC)
  - Phytoplankton
  - Oxygen (O_2)

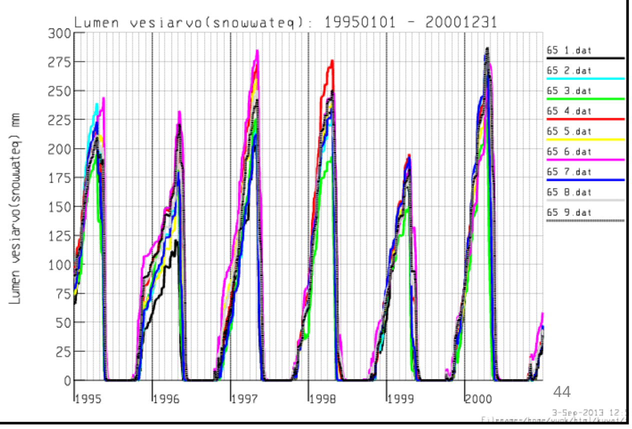
Hydrological expertise in Finland | Nutrient load simulation and forecasting (13/13)

Talvivaara 2012 leak: Zn, Ni, Co, Mn, Fe ja U



Hydrological expertise in Finland | Simulated data for unobserved areas (1/2)

- Daily simulation of 20 hydrological variables (From areal precipitation…to runoff)
  - For each subcatchment (total 6500)
  - For each lake bigger than 1 km^2
  - For each day since 1.1.1962 → current day
- Common usages
  - What is the discharge at the end of certain arbitrary area?
  - How has the water equivalent of snow been in certain arbitrary areas in past 20 years? In past 50 years? Past 20 years compared to past 50 years?



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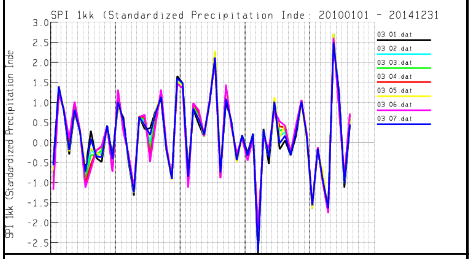
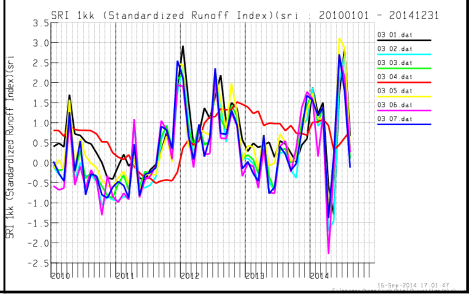
Hydrological expertise in Finland | Simulated data for unobserved areas (2/2)

Standardized index

- Compares short-term values with long-term distribution
- Statistical indicator based on a transformation into standard normal variable with zero mean and variance equal to one
- Available for 1, 3, 6, 12 and 24 months periods
- Precipitation (SPI)
  - For meteorological drought situations
- Runoff (SRI)
  - For hydrological drought situations
  - Takes into account, in addition to precipitation, other relevant elements of hydrological cycle
- Both SPI and SRI are "only indicators" of the phenomenon, and it might be wise to use them together instead using just the other

Indicator values	Droughtness	Cumulative probability	Category probability
-1.0 to 0.0	Normal	0.159 – 0.5	34.1 %
-1.5 to -1.0	Moderate	0.067 – 0.159	9.2 %
-2.0 to -1.5	Severe	0.023 – 0.067	4.4 %
-∞ to -2.0	Extreme	0.0 – 0.023	2.3 %

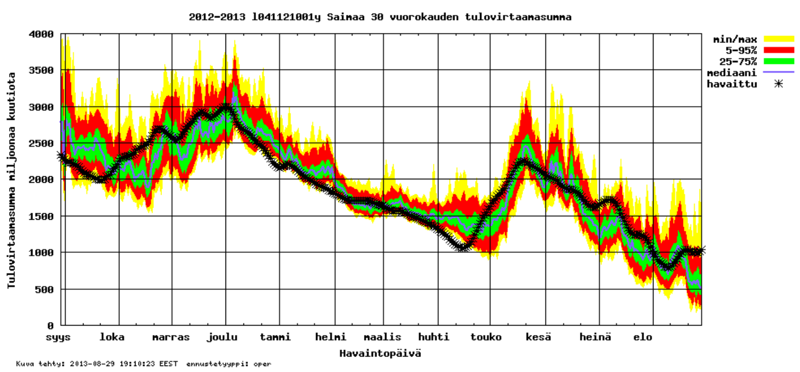




Hydrological expertise in Finland | Forecast accuracy monitoring (1/2)

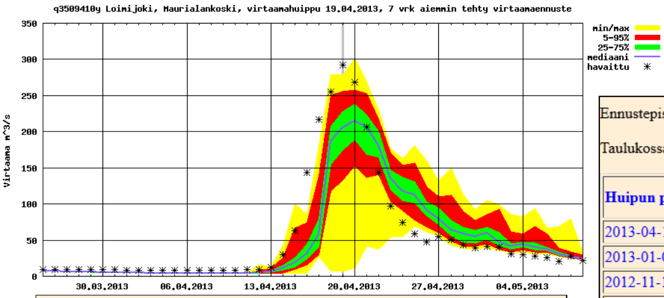
Forecast accuracy monitoring

- WSFS operational model forecast input (precipitation and temperature) and output (lake inflow and river peak flow) is archived and later verified against observations.
- Archiving and verification is completely automatic, and results are shown in continuously updating web interface.
- The web interface shows many verification criteria, tables for comparison, and verification graph types for WSFS forecasting locations in Finland.



Hydrological expertise in Finland

Forecast accuracy monitoring (2/2)



Seurattu havainto/ennuste: Oulujärvi (kaikki osat), tulovirtaama (4 vrk ka)

7 vrk

		Tulovirtaamasumma					Sadesumma					Lämpötilan keskiarvo			
Vuosi		R^2	E [%]	E [Mm^3]	N		R^2	E [%]	E [mm]	N		R^2	E [%]	E [°C]	N
2013		0.77	10	24.31	355		0.66	9	3.88	363		0.98	3	1.14	363
2012		0.85	5	27.33	353		0.43	6	6.56	358		0.97	3	1.30	358
2011		0.58	10	21.84	345		0.57	8	5.42	362		0.97	3	1.24	362
2010		0.35	12	30.24	309		0.37	11	5.15	318		0.98	3	1.46	318
2009		0.83	6	15.70	347		0.51	11	4.39	357		0.97	4	1.23	357
2008		0.83	7	26.67	345		0.35	12	6.32	345		0.94	4	1.41	345
2007		0.44	12	27.01	284		0.33	11	5.01	297		0.95	3	1.42	297
2006		0.80	6	30.07	338		0.54	10	5.39	338		0.94	4	1.85	338
2005		0.70	8	21.51	333		0.18	14	5.71	342		0.95	4	1.56	342
2004		0.45	12	36.45	333		0.24	11	7.30	333		0.96	4	1.38	333
2003		-0.18	16	22.75	153		-3.25	62	16.44	6		0.48	27	2.91	6

Ennustepiste q3509410y, koko valuma-alue. Kaikkien pis

Taulukossa on virheiden keskiarvot ennusteista, jotka on t

Huipun pvm	Huippuvirtaama [m^3/s]	Huippuvirt. virhe [%]	Ajoitus-virhe [d]
2013-04-19	291.67	15	0.3
2013-01-03	90	37.8	0.4
2012-11-16	86.72	22.1	0.8
2012-10-22	105.69	11.5	1.8
2012-10-06	165.52	41.8	2.9
2012-04-15	104	31.9	2
2012-03-29	170.81	11.5	1.8
2011-12-16	131.39	8.1	0.3
2011-11-28	94.4	28.1	2.1
2011-09-16	65.75	56.3	2.5
2011-04-11	233.76	15.5	1.6
2010-04-06	200.53	5.9	1.1
2009-04-06	166	11.1	3.56
2008-12-02	126.49	10.1	0.7
2008-11-13	154	28.4	0.4
2008-11-01	116.34	11.9	1.9
2008-04-15	128		

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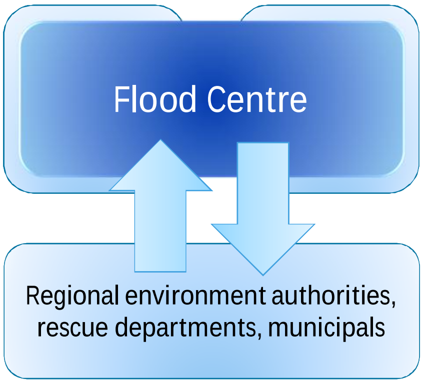
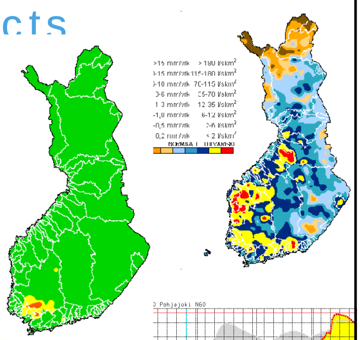
Flood Centre

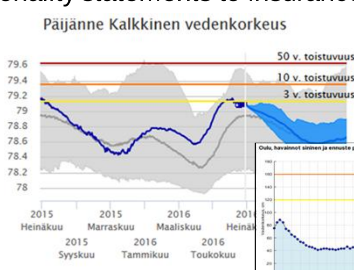
- Joint flood service of Finnish Environment Institute (SYKE) and Finnish Meteorological Institute (FMI)
- National water situation and flood information, forecasts and warnings 24/7
- All types of flooding:
  - Watershed
  - Sea coast
  - Urban
- Solid co-operation with regional flood management authorities (ELY-centres, rescue departments)

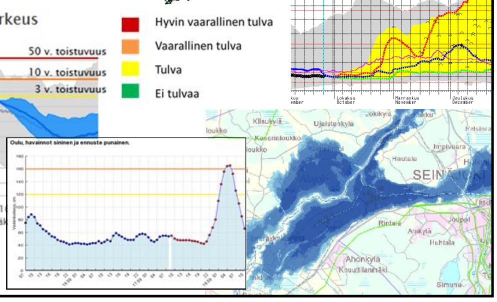


Flood Centre products

- Water situation information
- Flood warnings to authorities and public
- Flood situation picture
- LUOVA (National natural disaster warning an
  information system) warnings to authorities
- Flood damage and effect forecasts and maps
- Flood expectionality statements to insurance companies



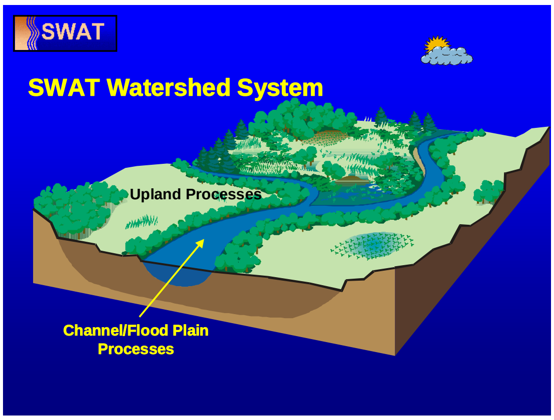




Water situation maps in television broadcast with weather forecast

SWAT

- Continuous time model, operates on a daily time step at catchment scale
- Simulates suspended sediment & nutrient loading on catchment scale
- In European wide use
- Collaboration with Okayama University (Lake Kojima catchment)
- Has potential to include agricultural management actions



(See more in the the project report: http://www.ymparisto.fi/download.asp?contentid=85389&lan=fi)

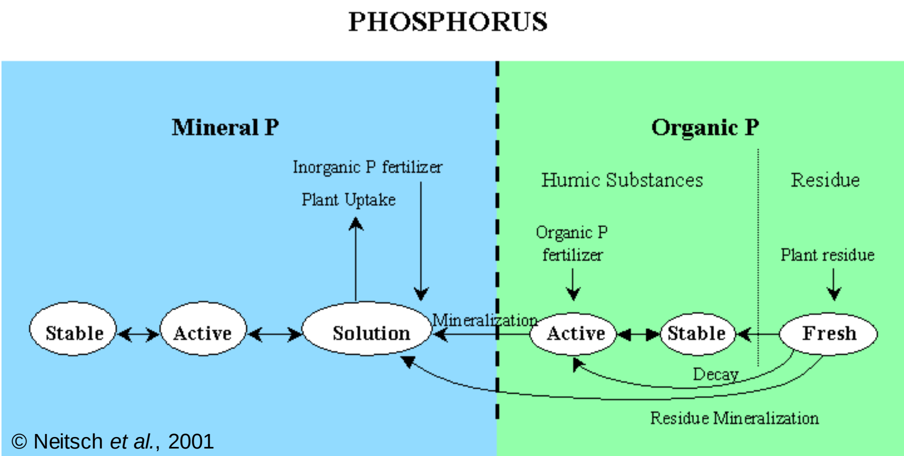
SWAT- P cycle

- The three major forms of P in mineral soils are:

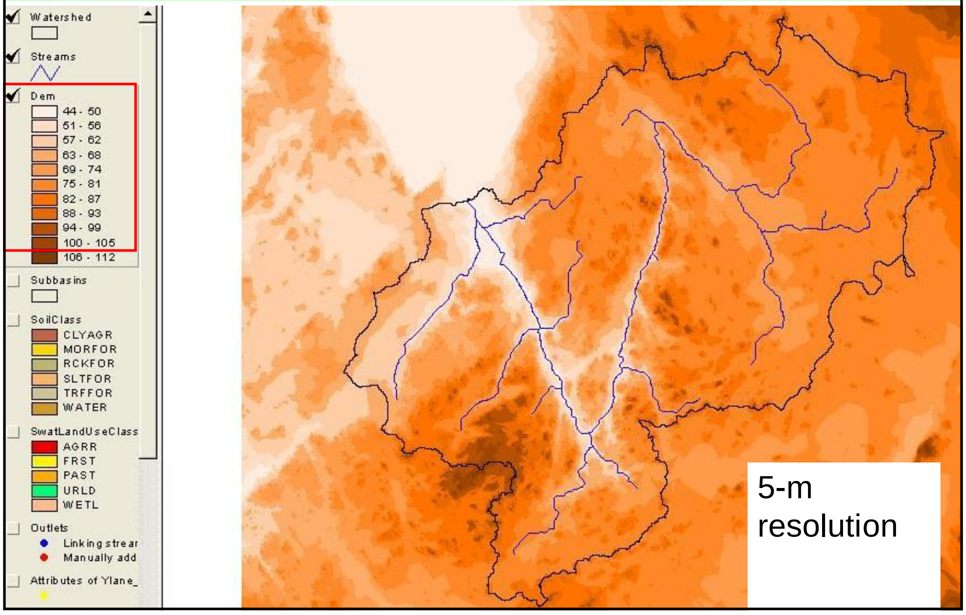
1. Organic P associated with humus
2. Insoluble forms of mineral P
3. Plant available P in soil solution

- P may be added to the soil by fertilizer, manure or residue application
- P is removed from the soil by plant uptake and erosion

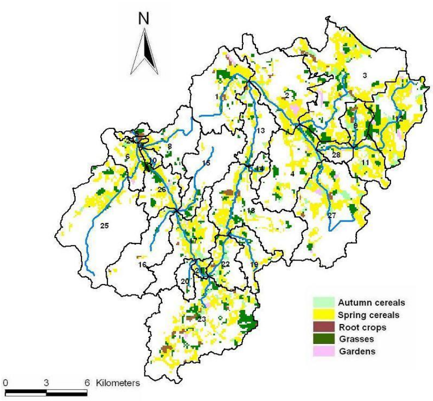
SWAT – Soil Water Assessment Tool

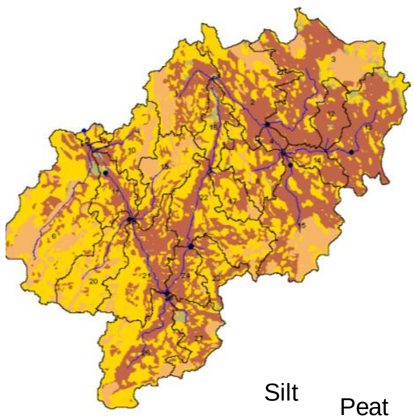


DEM, Yläneenjoki river basin, 233 km^2

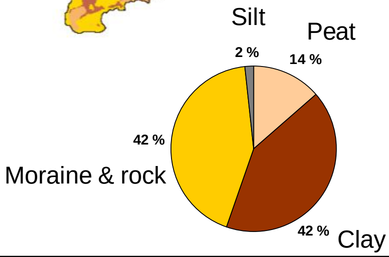


Land use & soil in Yläneenjoki catchment

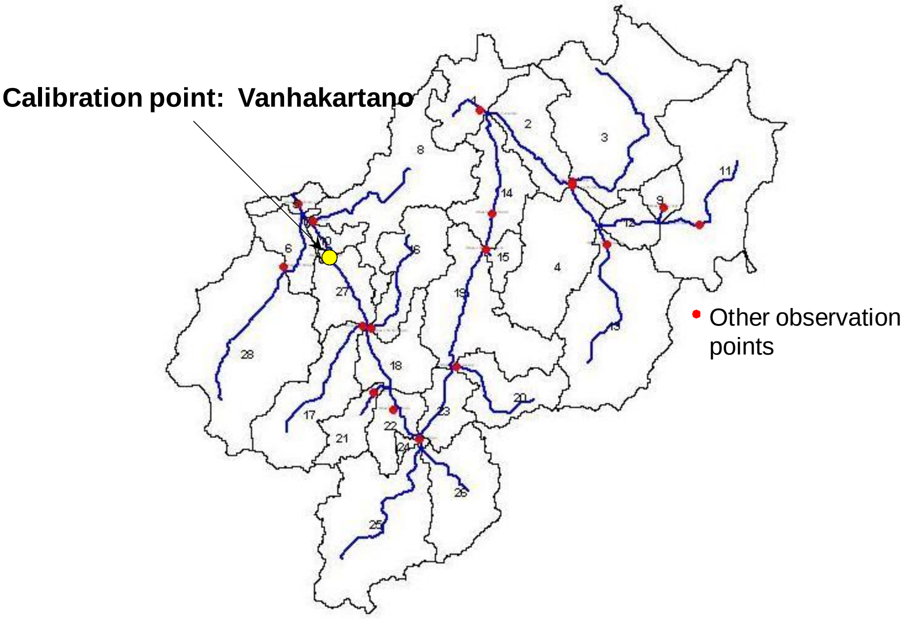




Autumn cereals	**8 %**
Spring cereals	**66 %**
Root crops	**4 %**
Grasses	**20 %**
Gardens	**2 %**



Yläneenjoki SWAT application - sub basins



Vanhakartano observation point

SWAT : loading estimates & various agricultural management practices

Inside the field

Intensity and timing of ploughing

- land use change
- drainage
- fertilization
- etc.

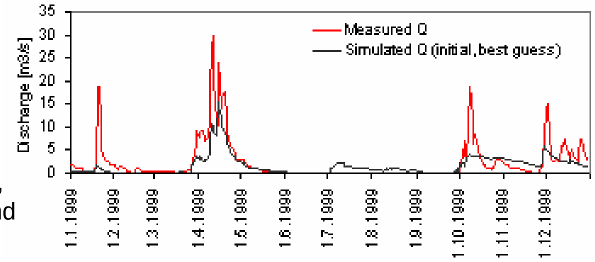
… ”outside the field”

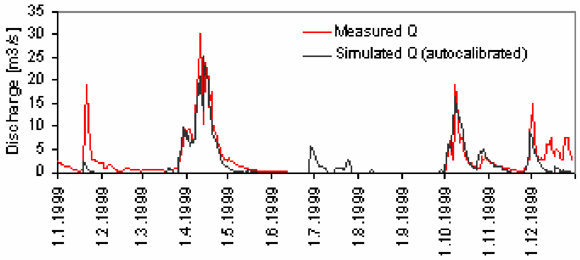
- buffer zones
- wetlands
- sedimentation ponds

SWAT calibration

- **Discharge in Vanhakartano**

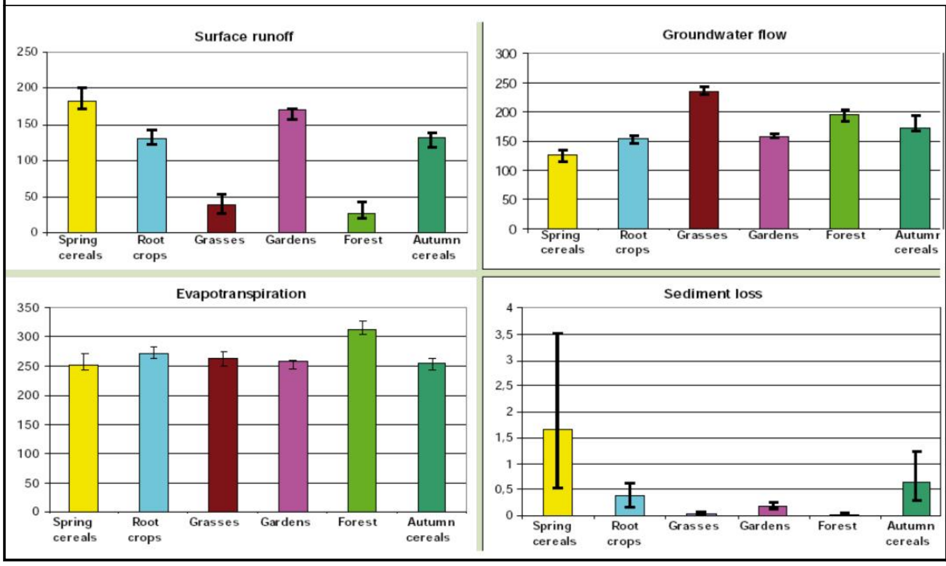
Parameters GWQMN, TIMP, ESCO, SOL_AWC, CN2, SMTMP, SFTMP and SURLAG were chosen for autocalibration runs made for daily discharge.





SWAT calibration

- **Hydrology and erosion**



SWAT scenarios

Scenario	Action		
	Buffer zones	Date for autumn ploughing	Fertilization
0-scenario	No buffer zones	Ploughing 1.9. (spring cereals) and 20.10. (beets)	Average fertilization levels used in Yläneenjoki region
Scenario 1	21 meter wide buffer zones along the main channel for all sub basins and for spring cereals and beets(*	Ploughing for both spring cereals and beets on 10.12=delayed ploughing datum.	Maximum fertilization levels used in Yläneenjoki region
Scenario 2	Buffer zones according to scen 1 but additional 15 meter width buffer zones for spring cereals and beets	Dates for ploughing same as in 0-scen. but normal ploughing repalced by cultivation	Chicken manure 5000 kg/ha for grass crops, other crops according to scen 0. Pig manure 10000 kg/ha for grass crops, othercrops, scen 0

SWAT scenario, results

- **Effect on annual P-load at the river outlet (change-% compared to 0-scenario)**

Scenario	Action		
	Buffer zones	Datum for autumn ploughing	Fertilization
	P change in %	P	P
Scenario 1	-19	-8	+17
Scenario 2	-36	-22	+25 (chicken) +27 (pig)