FRESHWATER CENTRE

Integrated use of weather, climate, water quantity and quality expertise in hydrological services in Finland

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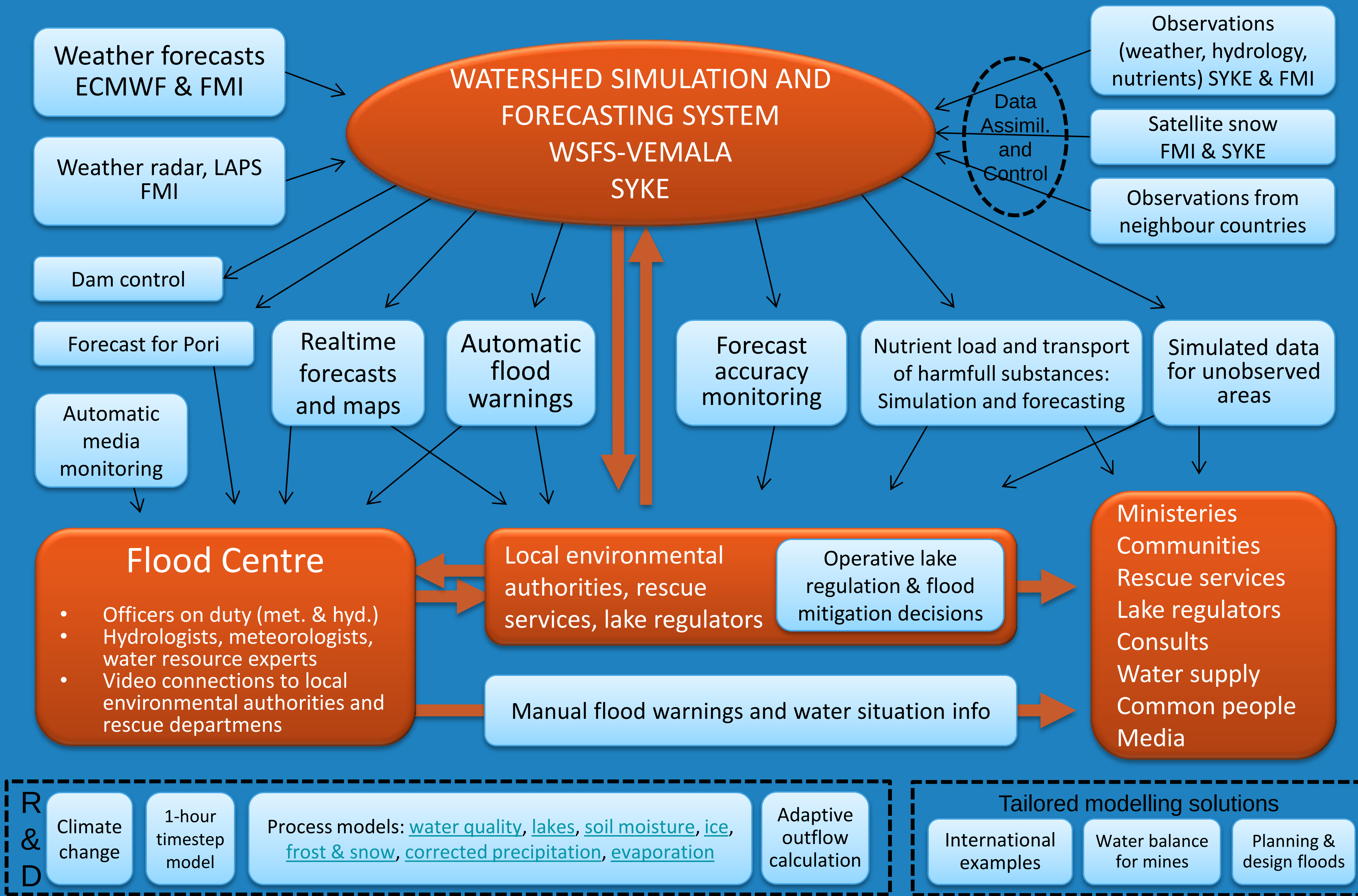
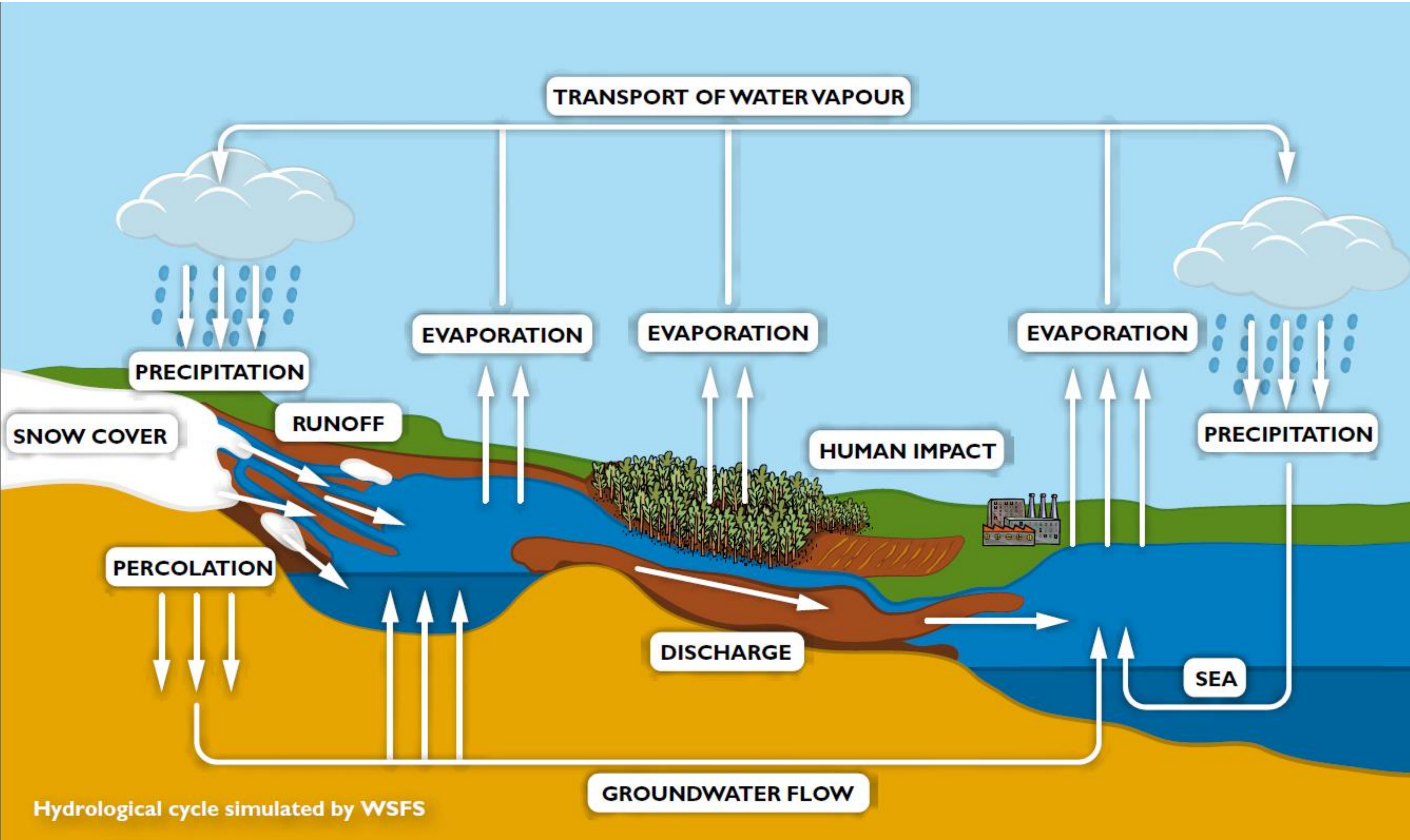
Finnish Environment Institute SYKE

SYKE

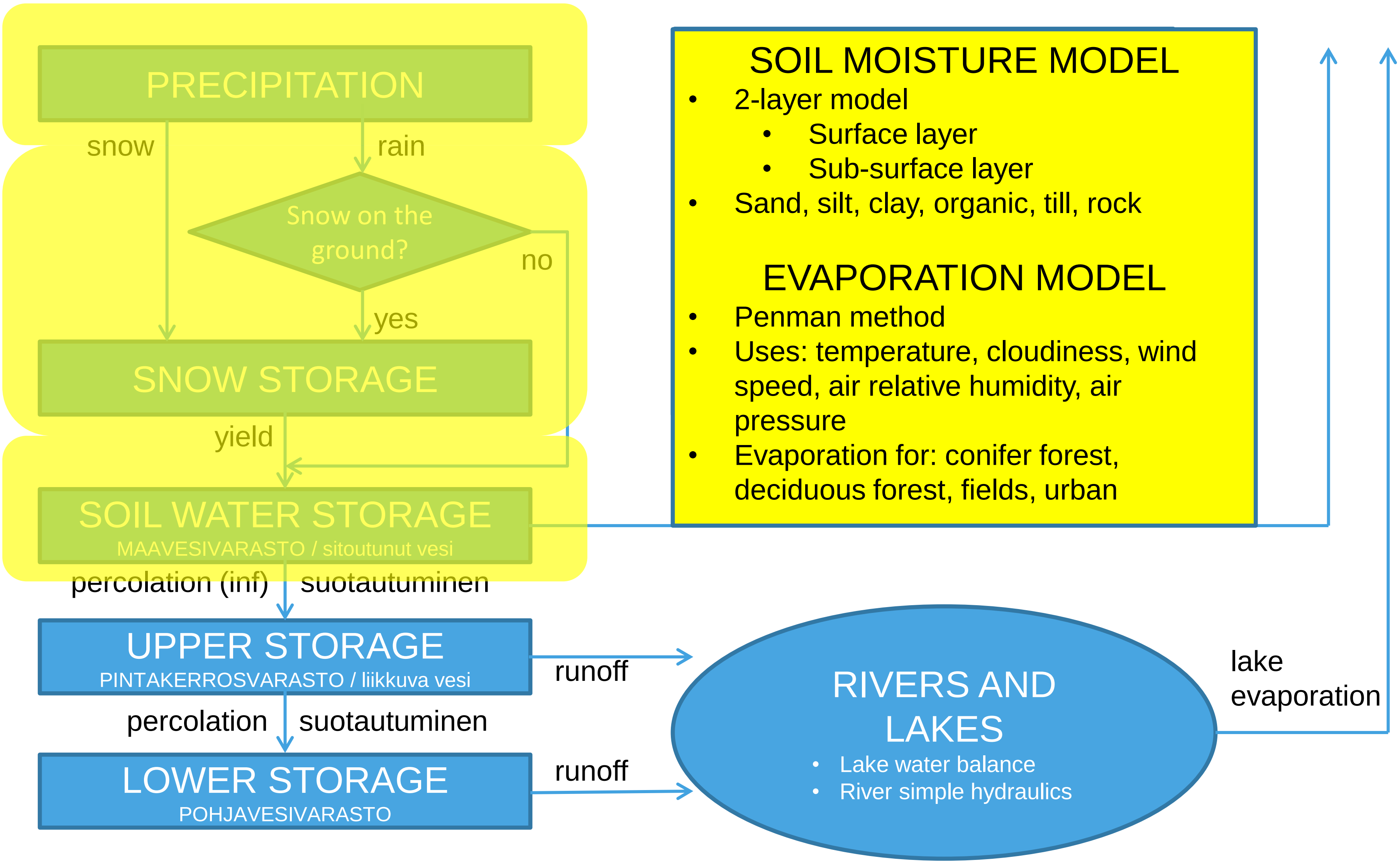
Integrated use of weather, climate, water quantity and quality expertise in hydrological services in Finland



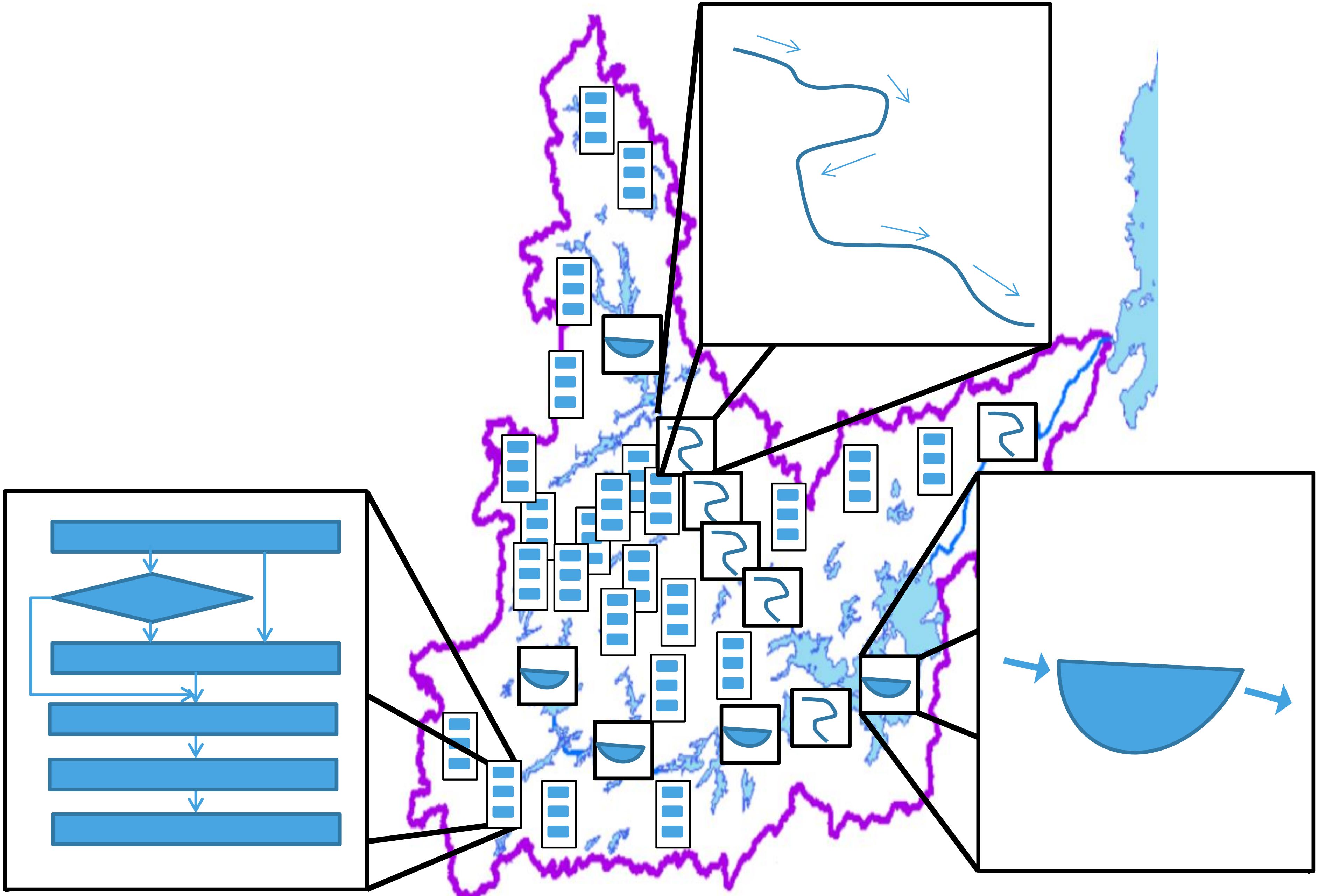
Hydrological cycle



WSFS model concept

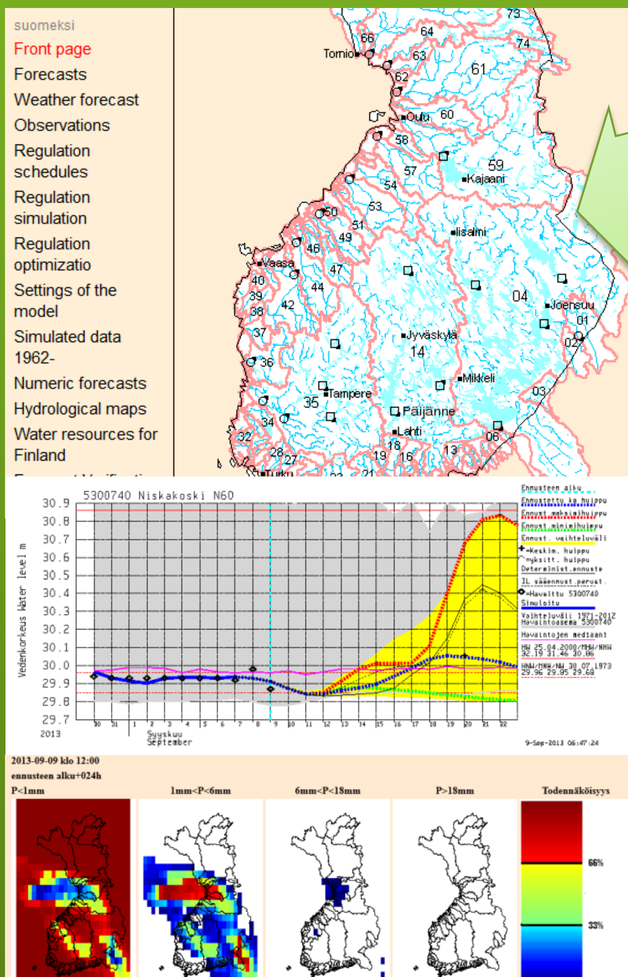


Hydrological Modeling and Forecasting System (3/6)



User and operator interface (mobile)

http://wsfs.vyh.fi



Full system control

All products and system information

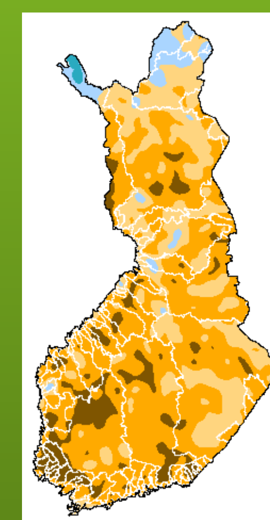
HYDROLOGICAL MODELING AND FORECASTING SYSTEM

Automatic forecasts and maps

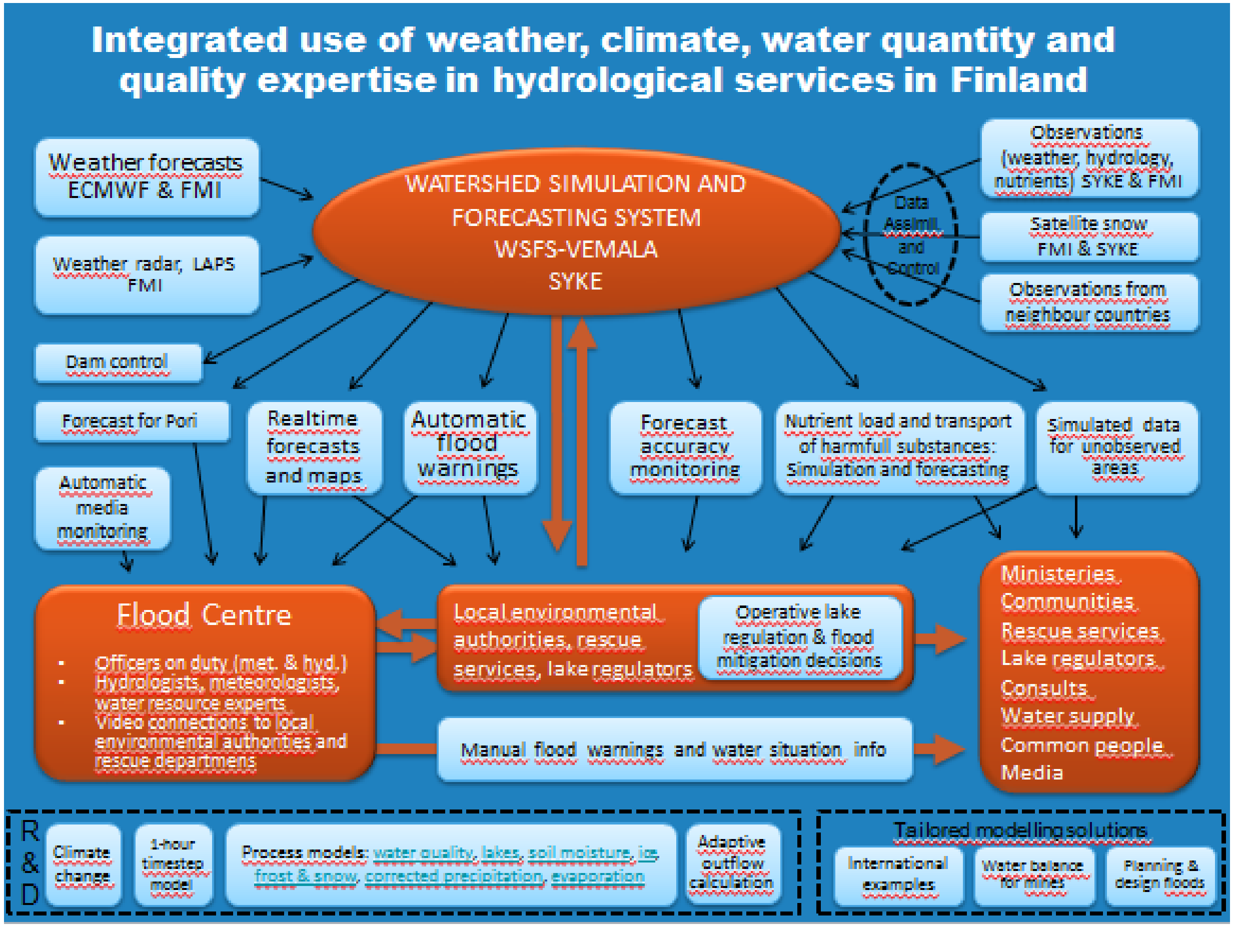
Water situation description

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…



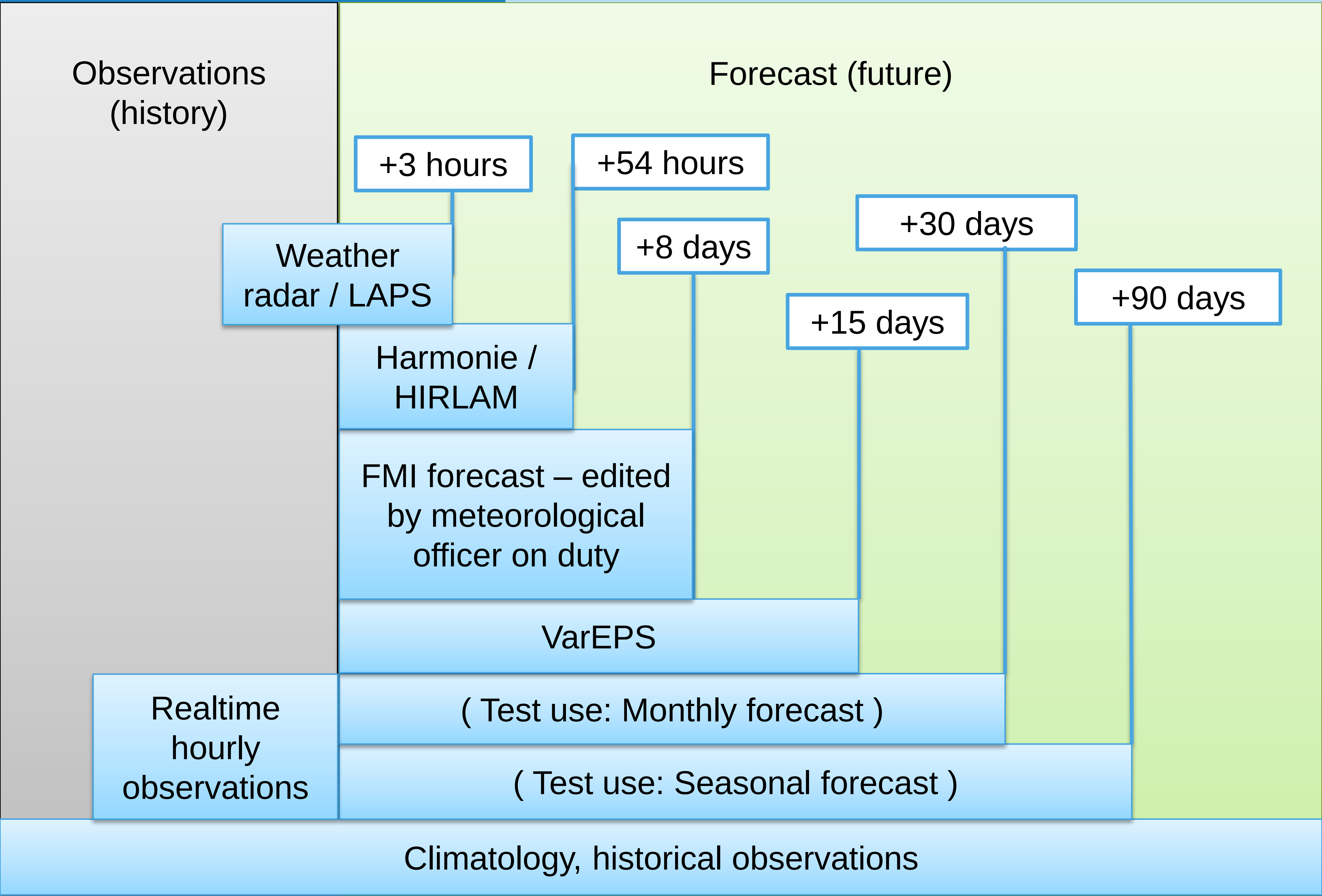
Presentation video (in Youtube https://www.youtube.com/watch?feature=player_embedded&v=aWl3UamQXpY):



Publications

- Vehviläinen, B. 1994. The watershed simulation and forecasting system in the National Board of Waters and Environment. Publications of the Water and Environment Research Institute. National Board of Waters and the Environment, Finland. No. 17.
- Vehviläinen, B. 1992. Snow cover models in operational watershed forecasting. Publications of Water and Environment Research Institute 11. Helsinki. 112 p.
- A national scale nutrient loading model for Finnish watersheds - VEMALA / Inese Huttunen, Markus Huttunen, Vanamo Piirainen, Marie Korppoo, Ahti Lepistö, Antti Räike, Sirkka Tattari, Bertel Vehviläinen Environmental modeling and assessment, ISSN: 1573-2967
- Vehviläinen, B., Huttunen, M. and Huttunen, I. 2005. Hydrological forecasting and real time monitoring in Finland: The watershed simulation and forecasting system (WSFS). In Innovation, Advances and Implementation of Flood Forecasting Technology, conference papers, Tromso, Norway, 17 to 19 October 2005. ISBN Book 1-898485-13-5.

Weather forecasts (1/8)

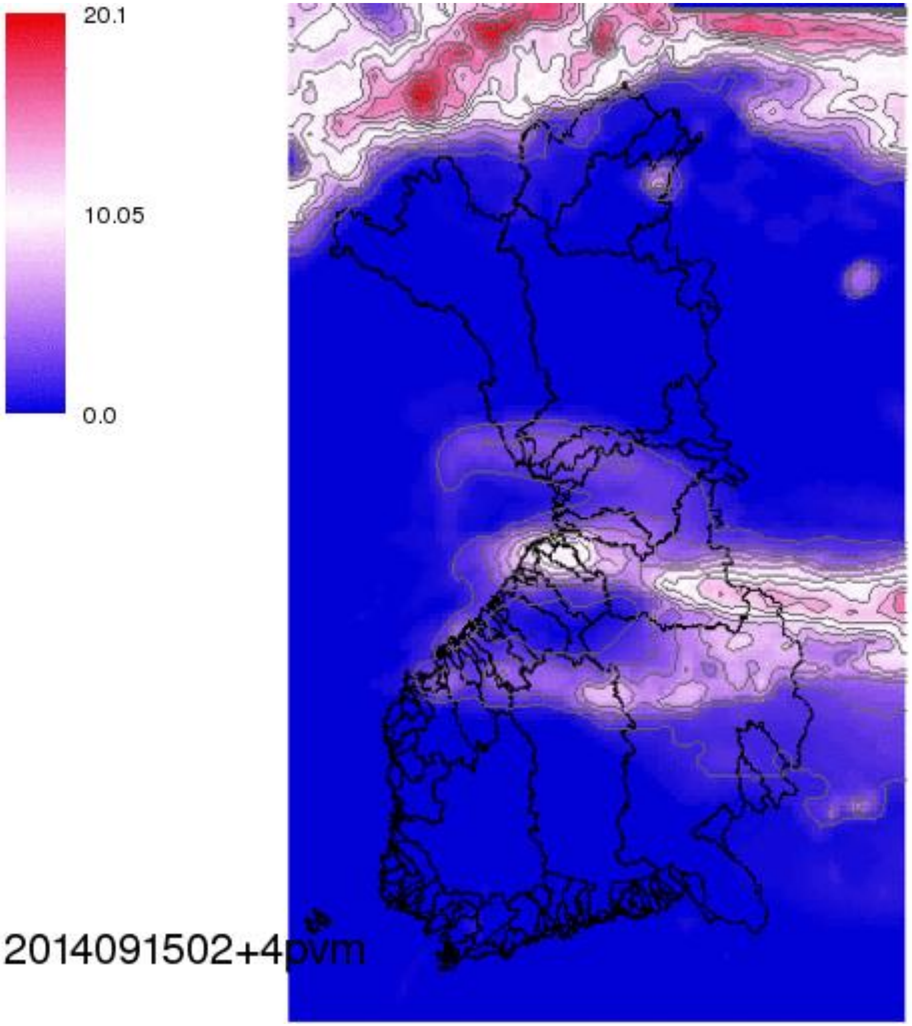


Weather forecasts (2/8)

Name	Type	Forecast length	Delivery	Time-step	Resolution	Variables
FMI edited forecast	Determ.	6 days	4 times a day	1 h		• air temp. • prec.
Harmonie	Determ. (possibly ensemble in future?)	54 h	4 times a day	1 h	2.5 km	• liquid prec. • solid prec. • air temp. • wind speed • wind dir. • radiation • humidity
ECMWF EPS	Ensemble	15 days	Twice a day	6 h	0.5°	• prec. • air temp. • ground temp. • cloudiness • wind speed • wind dir • dew point • radiation • Evaporation
Monthly	Ensemble	30 days	Once a week	6 h	1.5°	• prec. • air temp.
Seasonal	Ensemble	90 days	Once a month	6 h	1.5°	• prec. • air temp.

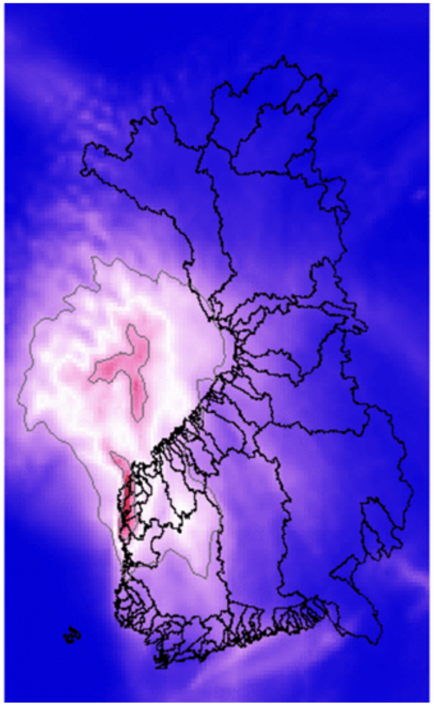
High resolution FMI forecast – edited by meteorologist on duty

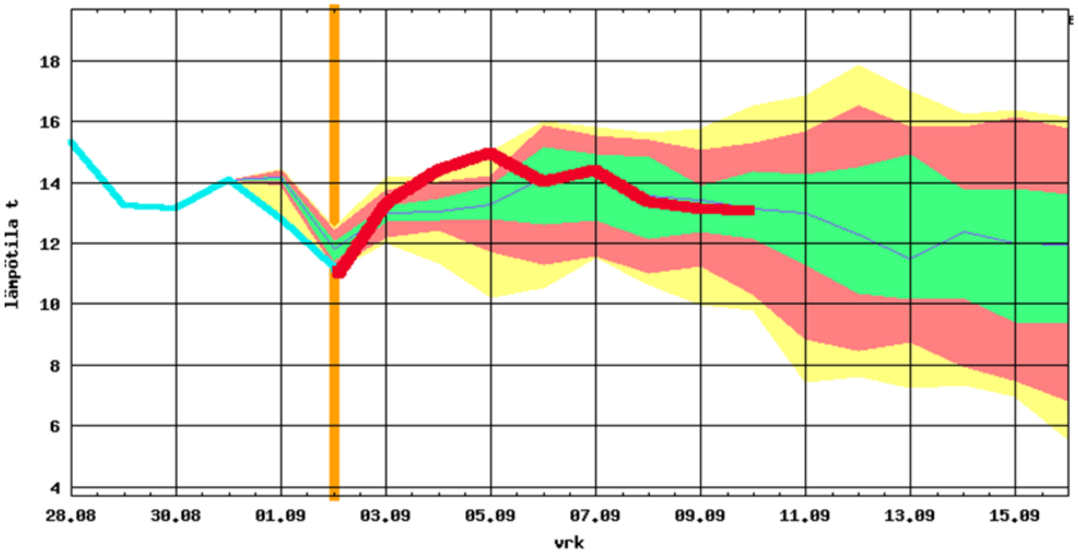
- Based on high resolution weather forecast models
- Edited by meteorologist on duty
- Combines best knowledge of phenomenons with best observations and forecast models available



Short range weather forecasts

- Hirlam 54h
  - optional
- Edited 8 days
  - Ensamble T moved towards edited
- Nowcasting 3h
  - Precipitation from radar



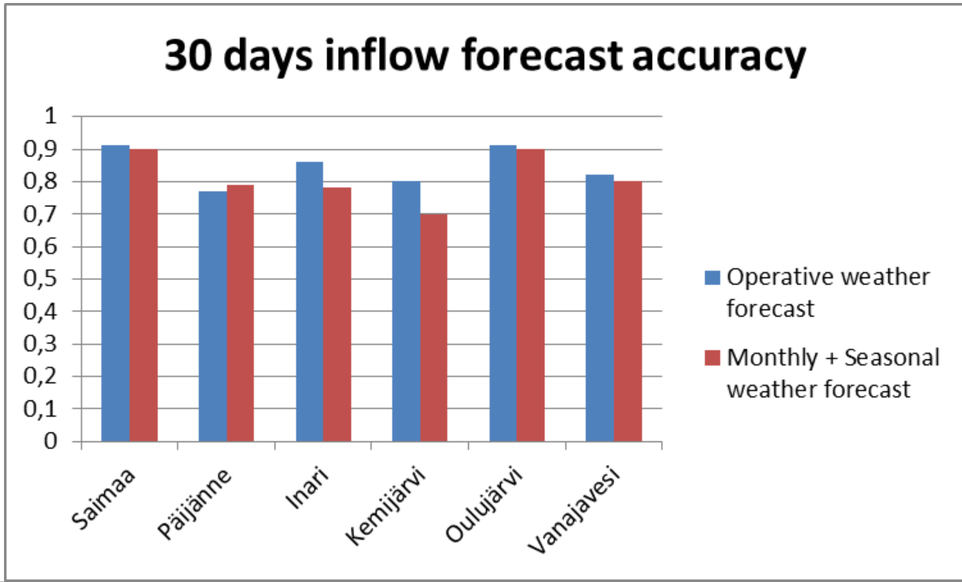


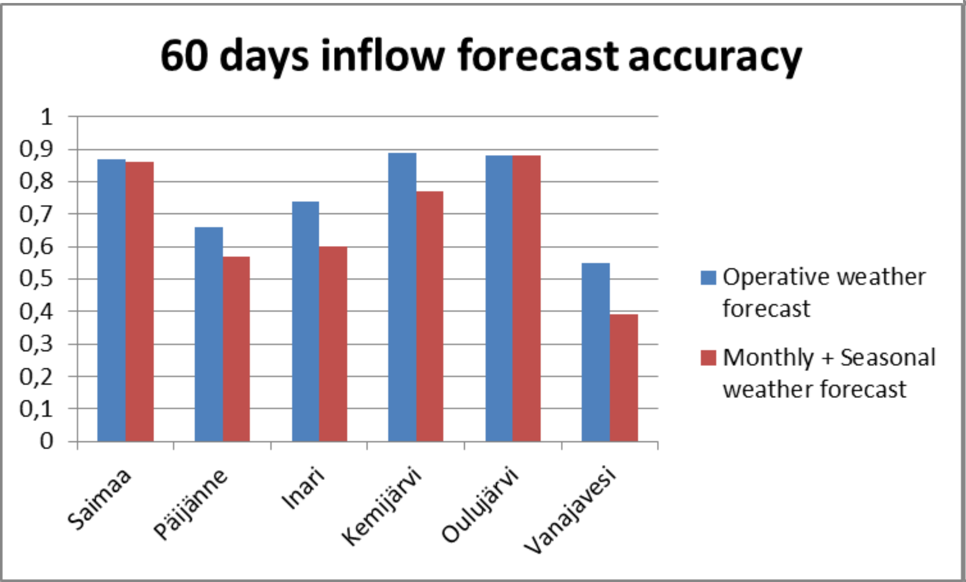
Weather forecasts (5/8)

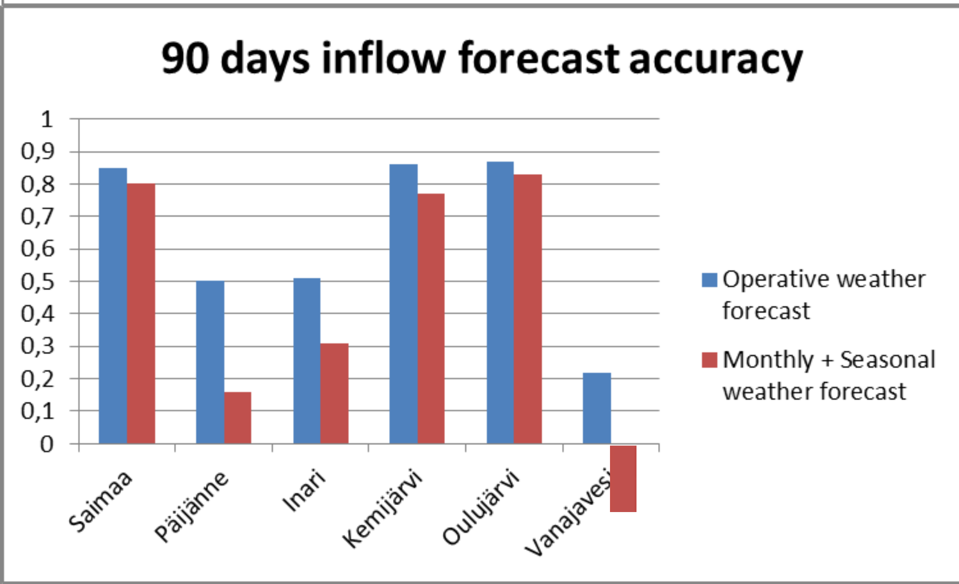
- The input of the operational model is
  - Observed weather (in history)
  - **ECMWF 15 days VarEPS**, 50 members. The first days are corrected against FMI deterministic forecast.
  - Climatology of the last 50 years: every member of VarEPS is continued by data from a certain historical year
  - Result: 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.**

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

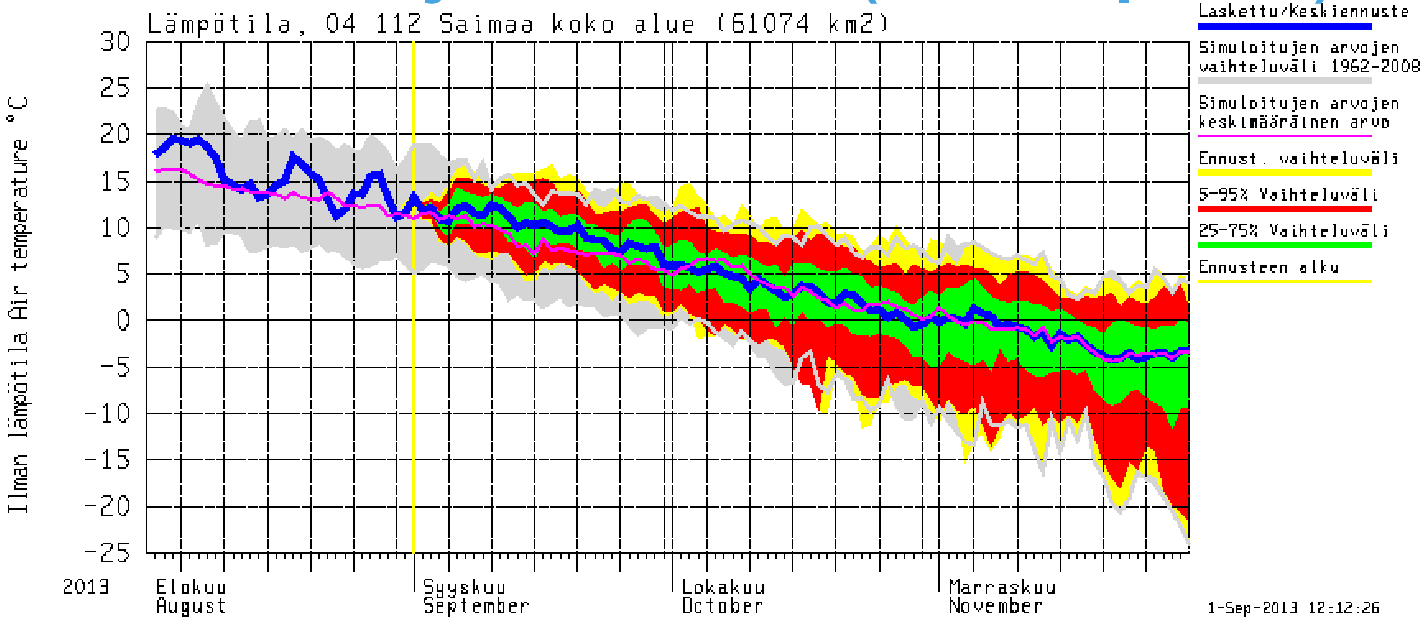
- Comparing inflow forecasts of 2013 shows that using operative weather forecast gave better results than using experimental use monthly and seasonal EPS weather forecasts

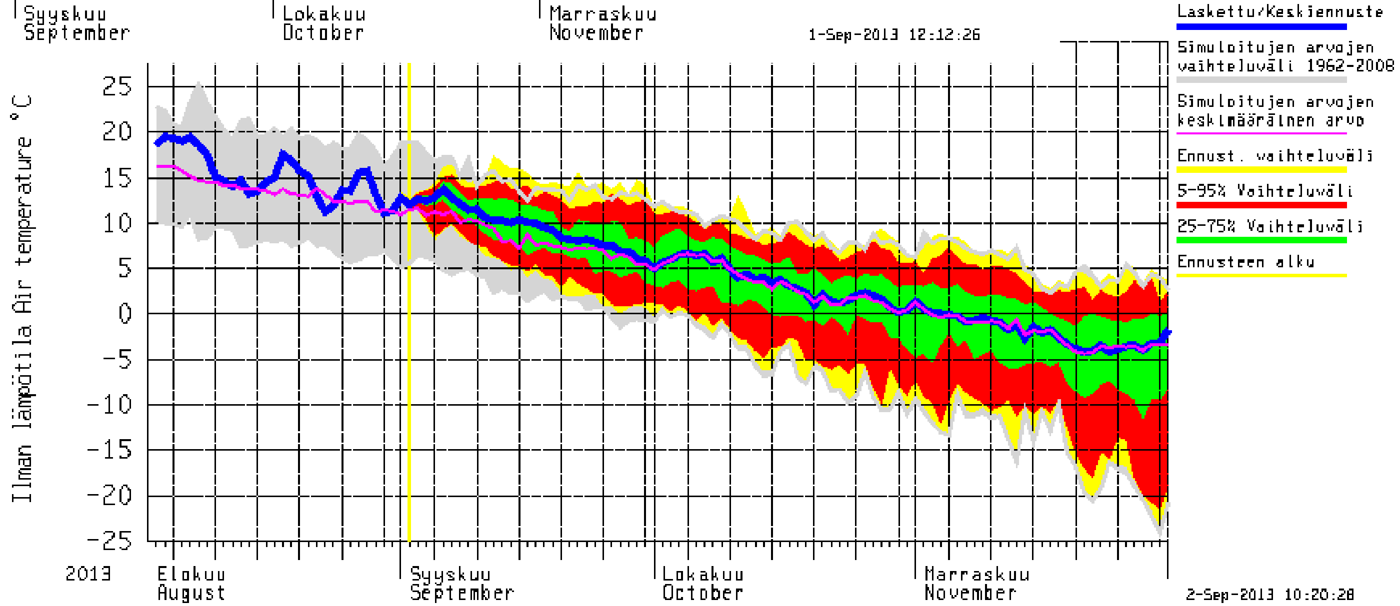






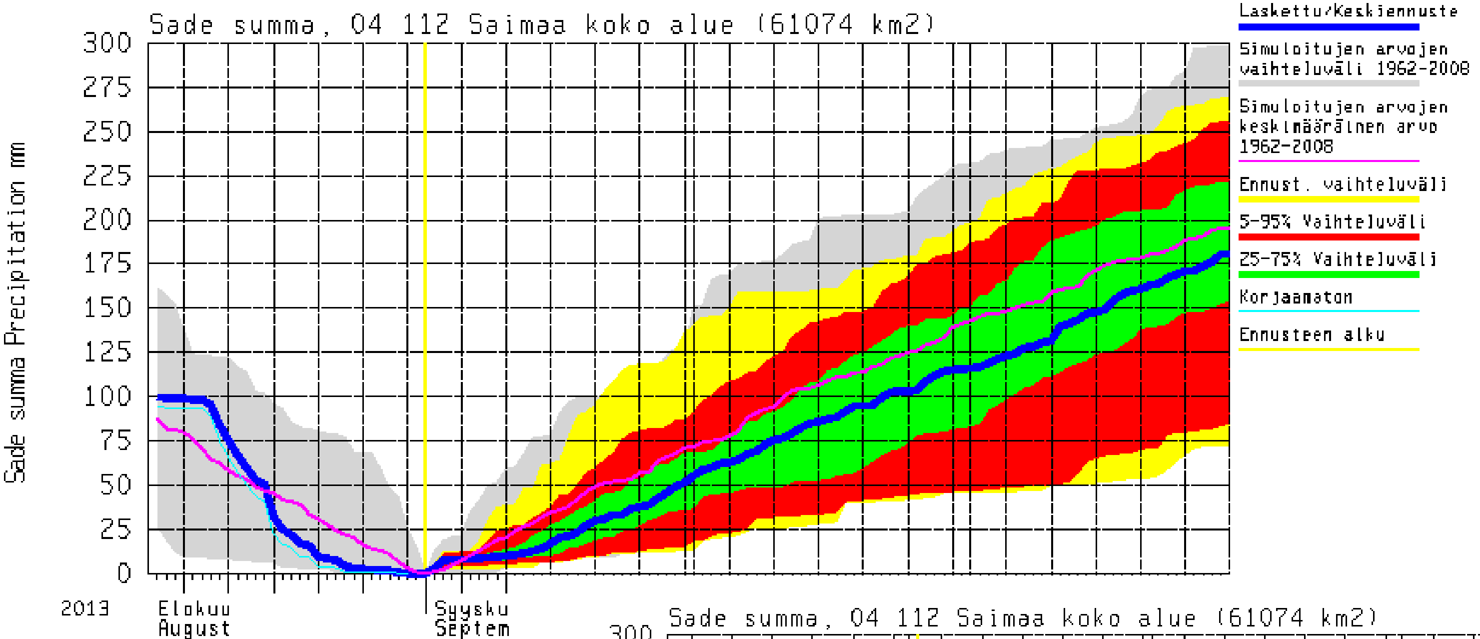
Temperature, lake Saimaa: right now there is not big difference between monthly/seasonal EPS (the first picture) and climatology

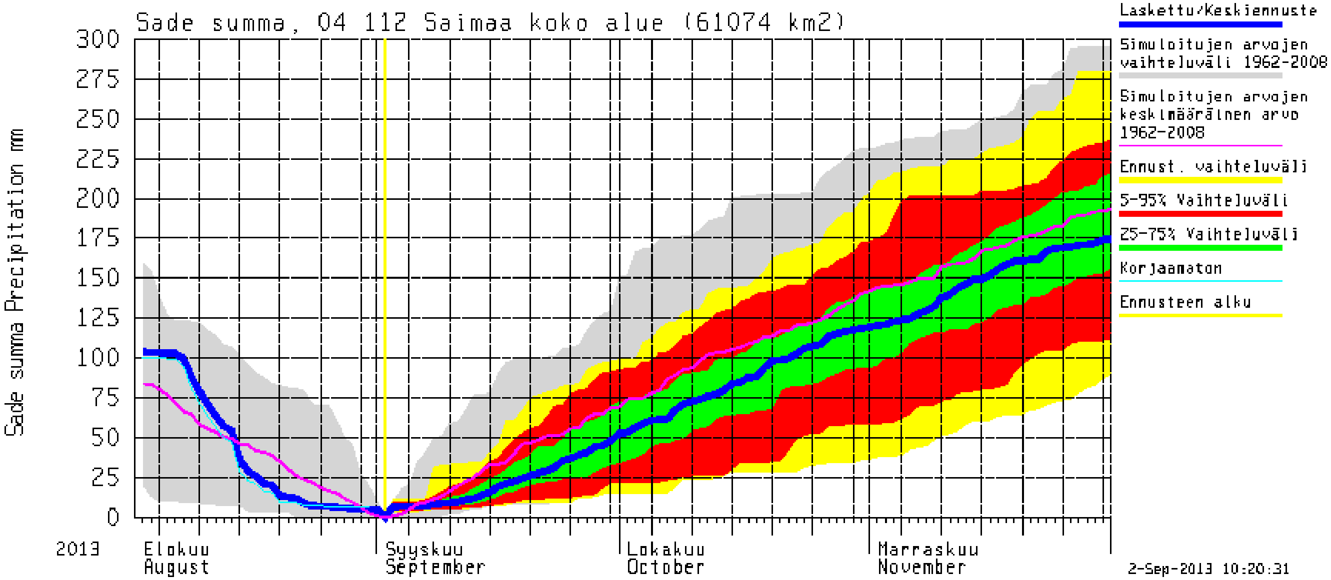




Weather forecasts (8/8)

Precipitation, lake Saimaa. First monthly/seasonal EPS, then climatology. (No significant difference in forecasted water level.)





Weather radar and LAPS in WSFS

Weather radar

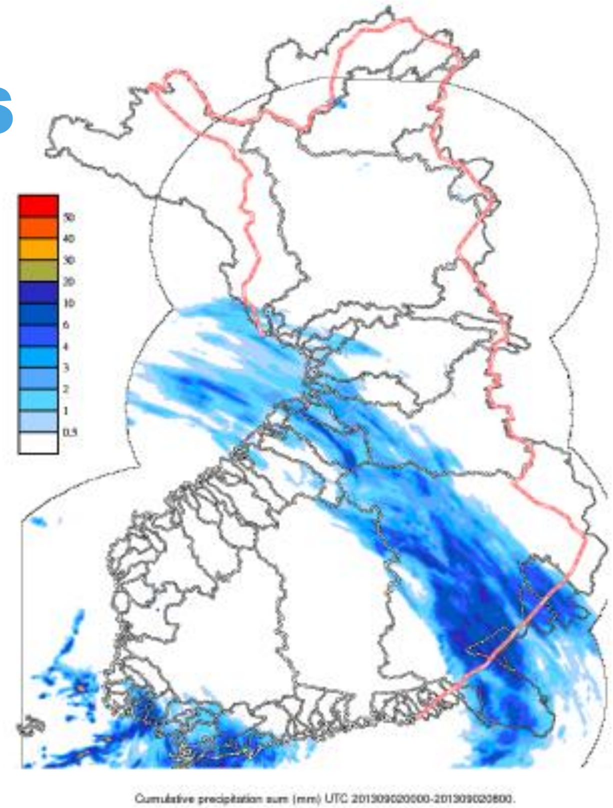
- Hourly radar data in 2x2km grid
- Used for 2 days in model
- Underestimates large rainfalls
    - Corrected manually against rain gauges

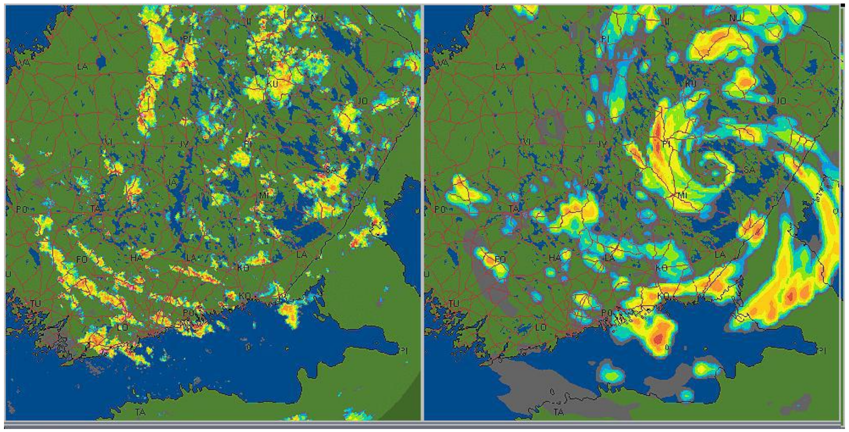
Radar nowcasting

- 3hrs in Southern Finland
- Ensamble of 50 members

LAPS

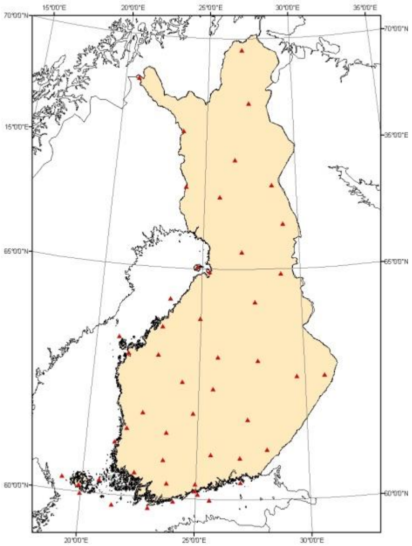
- Combines information from weather radar, automatic real-time rain gauges, road weather measurements, …
- Will probably be used in WSFS as a weather radar replacement in near future



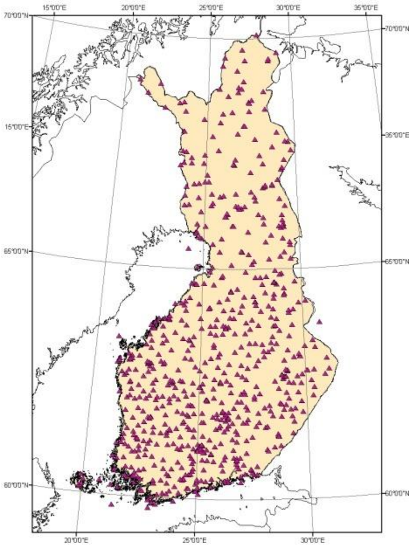


Observation networks

- 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



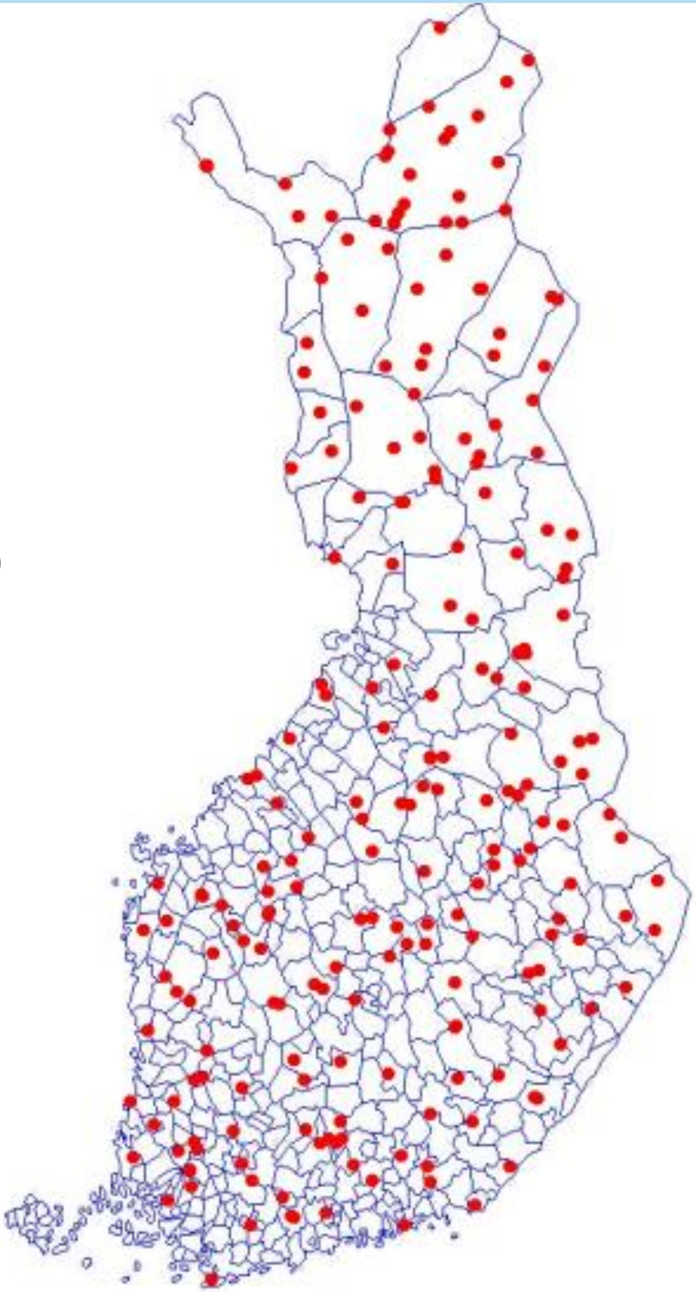
Synoptic weather stations, 50
daily measurements



Other weather stations, 200
daily measurements

Measuring the snow water equivalent

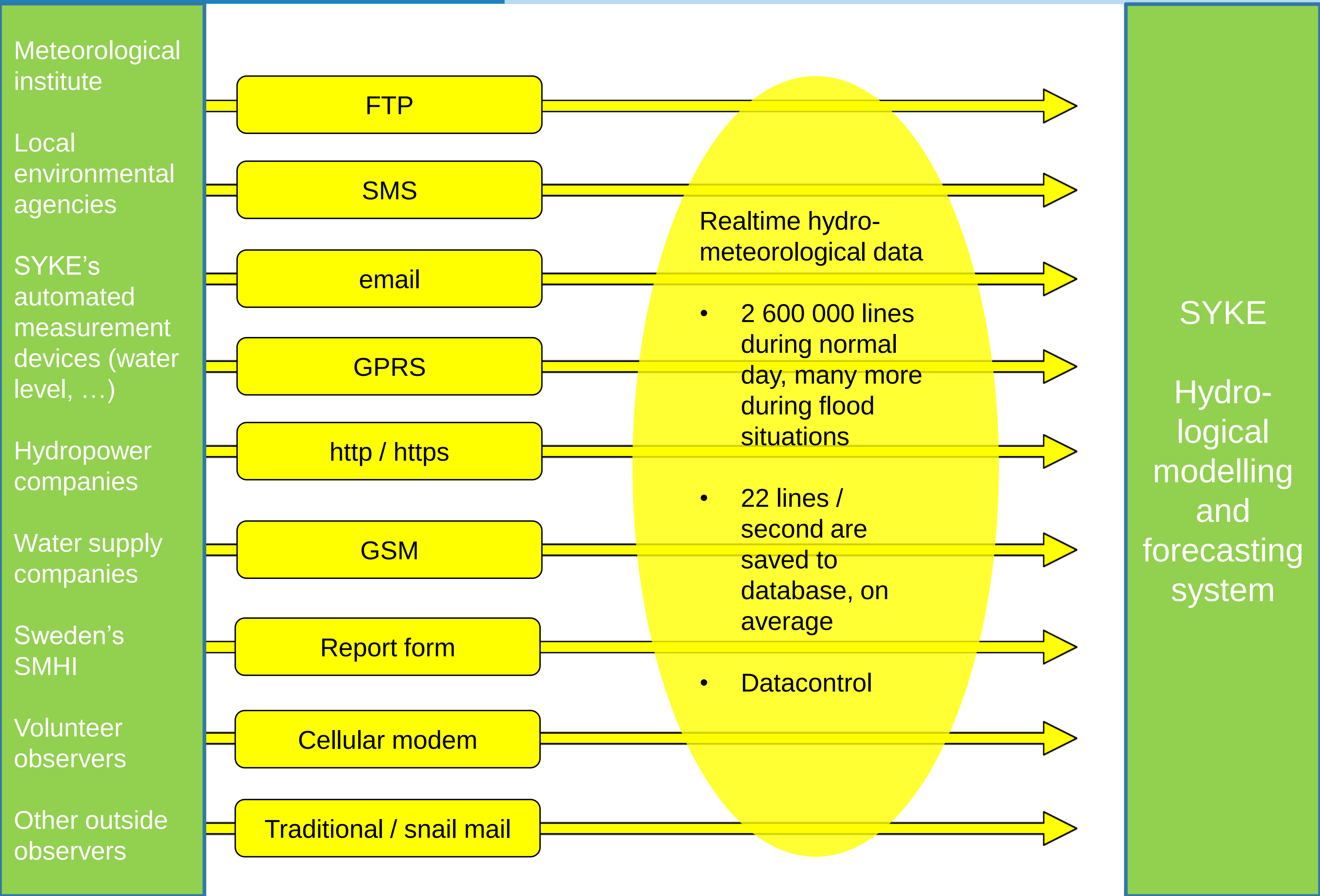
- Snow water equivalent is measured by snow course measurements
  - About 140 snow courses in Finland (less than what is shown at the map)
- Areal snow water equivalents are calculated for approximately 110 areas
- Snow courses are 2-4 km long routes through various terrains
  - 80 depth measurements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



Measuring the snow water equivalent

Hydrological expertise in Finland

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



Data assimilation and control (1/6)

Manual measurements

- Manual river discharge measurement
- Manual precipitation observations
- Snow line measurements

Automatic observations

- Automatic river water level observation
- Automatic precipitation observations
- Snow depth from automatic stations

Derived results / algorithmic data

- Weather radar precipitation
- Wind corrected precipitation observations
- ”Near-by-complemented” precipitation observations
- Satellite value for snow water equivalent
- Interpolated snow water equivalent

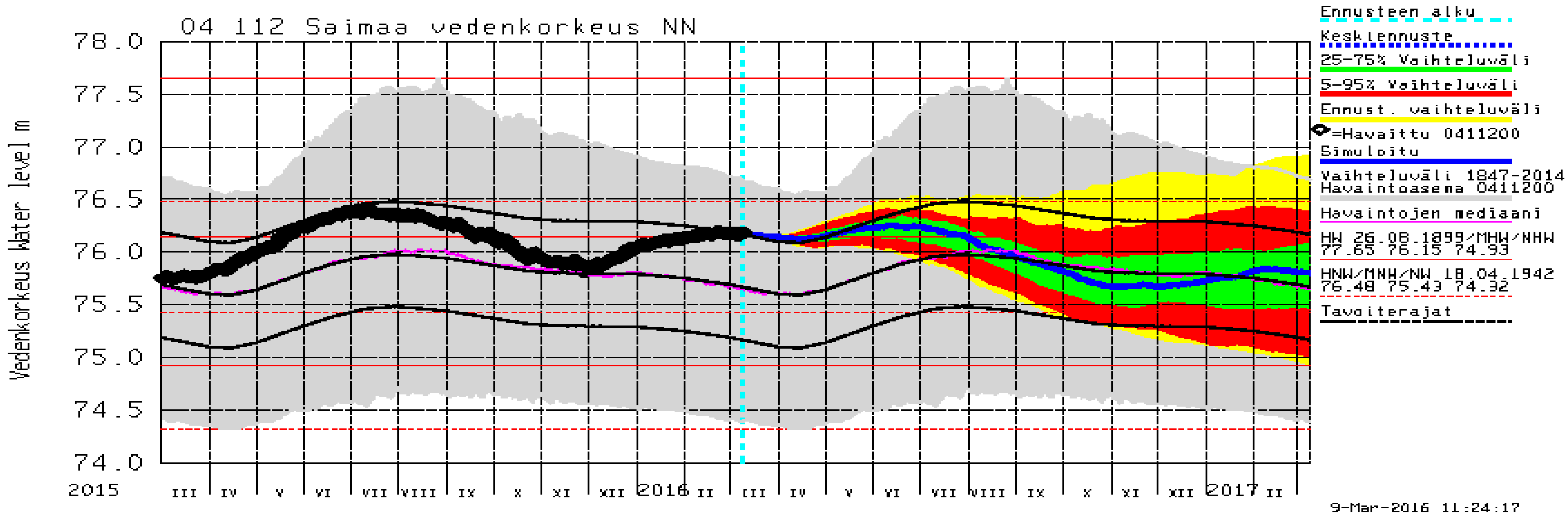
Simulations

- Areal precipitation
- Runoff, discharge, water level, soil moisture, …
- Areal precipitation corrected to match water balance
- Snow water equivalent, snow depth, ground frost depth
- Ice thickness

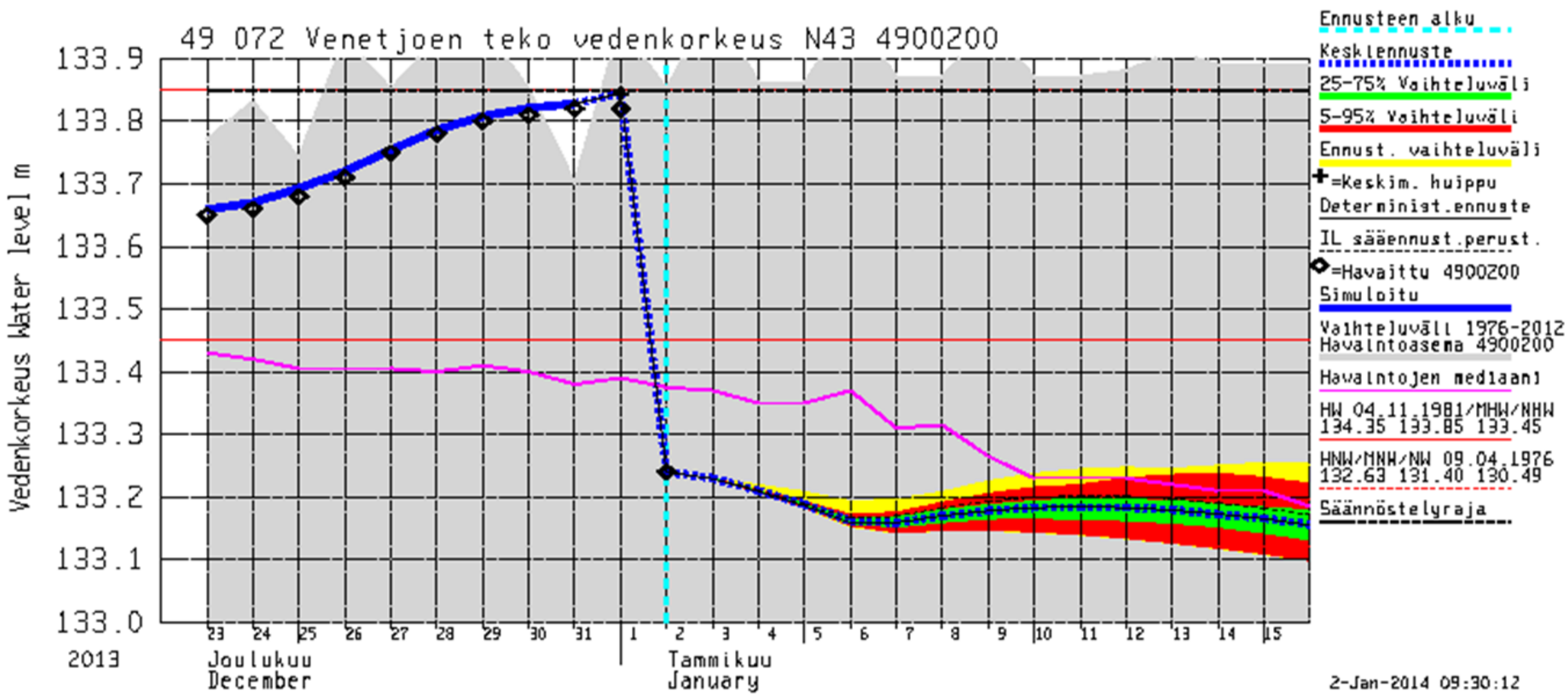
Observed data ⟷ Calculated data

Data assimilation algorithm

- To estimate the state of the hydrological system today
- Assimilation observations of:
  - discharge and water levels (over 400 stations)
  - snow water equivalent (over 150 stations)
  - SCA satellite data
  - flood cover area (experimental)
- Corrects inputs of the model (daily precipitation and temperature)
- Simulation is corrected to agree with observations on a 1-2 year long period backward



Example: forecast gone wrong when data is not filtered



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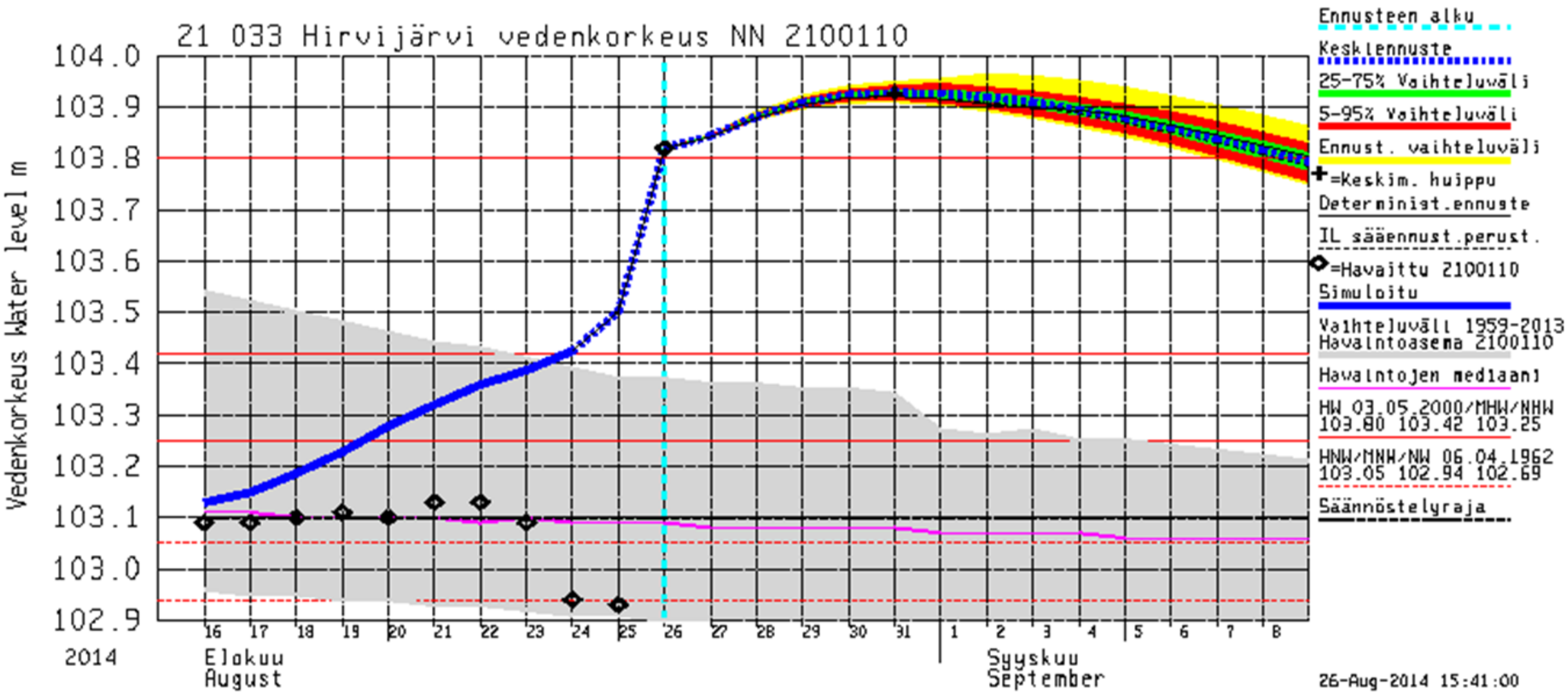
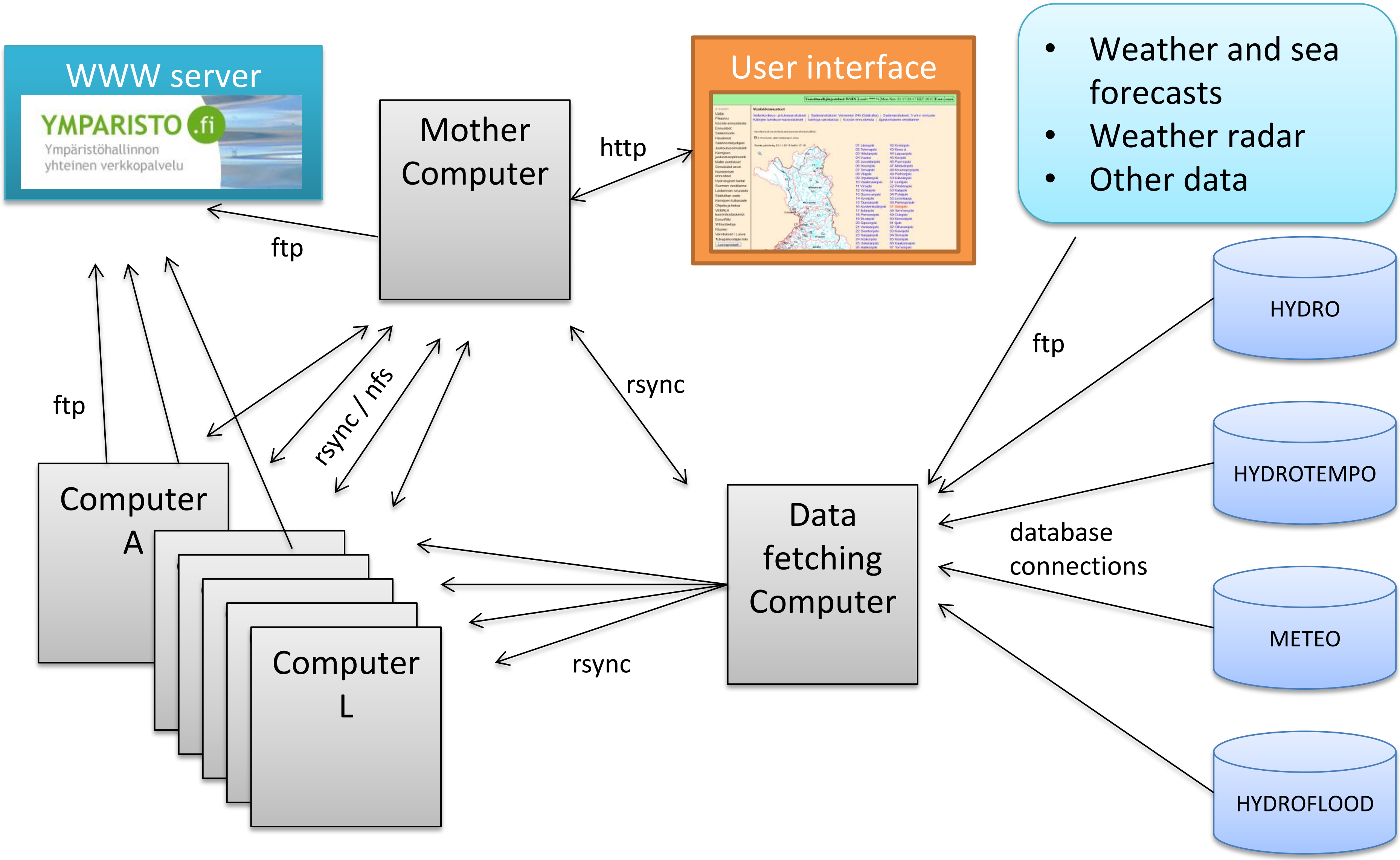


Data transfers in Watershed Simulation and Forecasting System



Data Control State Machine

State: UNKNOWN (at the beginning)

U_AO (accept observ.)
→ U_FO

U_FO (fetch observ.)
→ U_RF

U_RF (read flag)
- ACCEPTABL. → U_AO
- REVISED → O_AO
- SUSPICIOUS → U_AO
- NULL → O_AO

State: OK

O_AO (accept observ.)
→ O_FO

O_FO (fetch observ.)
→ O_RF

O_RF (read flag)
- ACCEPTABLE → O_AO
- REVISED → O_AO
- SUSPICIOUS → O_TR
- NULL → O_TR

O_TR (test rejection)
- PASS → O_TS
- FAIL → D_FO

O_TS (test suspicion)
- PASS → O_AO
- FAIL → S_AO

State: DISCARD

D_AO (accept observ.)
→ D_FO

D_FO (fetch observ.)
→ D_RF

D_RF (read flag)
- ACCEPTABLE → D_AO
- REVISED → O_AO
- SUSPICIOUS → D_TR
- NULL → D_TR

D_TR (test rejection)
- PASS → D_TS
- FAIL → D_FO

D_TS (test suspicion)
- PASS → O_AO
- FAIL → S_AO

State: SUSPICION

S_AO (accept observ.)
→ S_FO

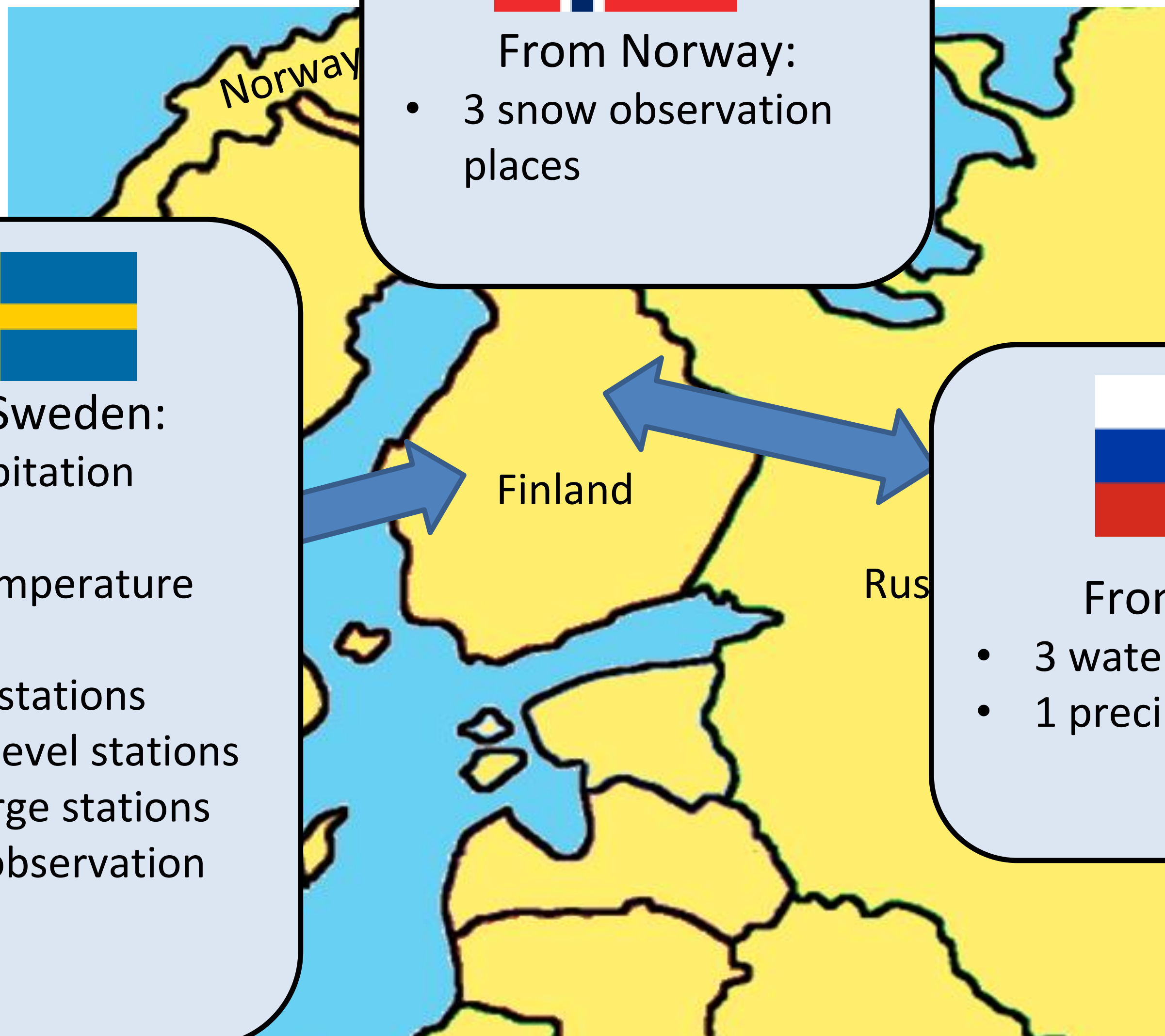
S_FO (fetch observ.)
→ S_RF

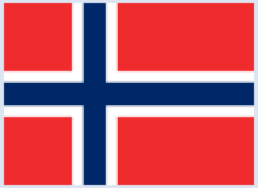
S_RF (read flag)
- ACCEPTABLE → S_AO
- REVISED → O_AO
- SUSPICIOUS → S_TR
- NULL → S_TR

S_TR (test rejection)
- PASS → S_TS
- FAIL → D_FO

S_TS (test suspicion)
- PASS → O_AO
- FAIL → S_AO

Observations from neighbour countries (1/1)



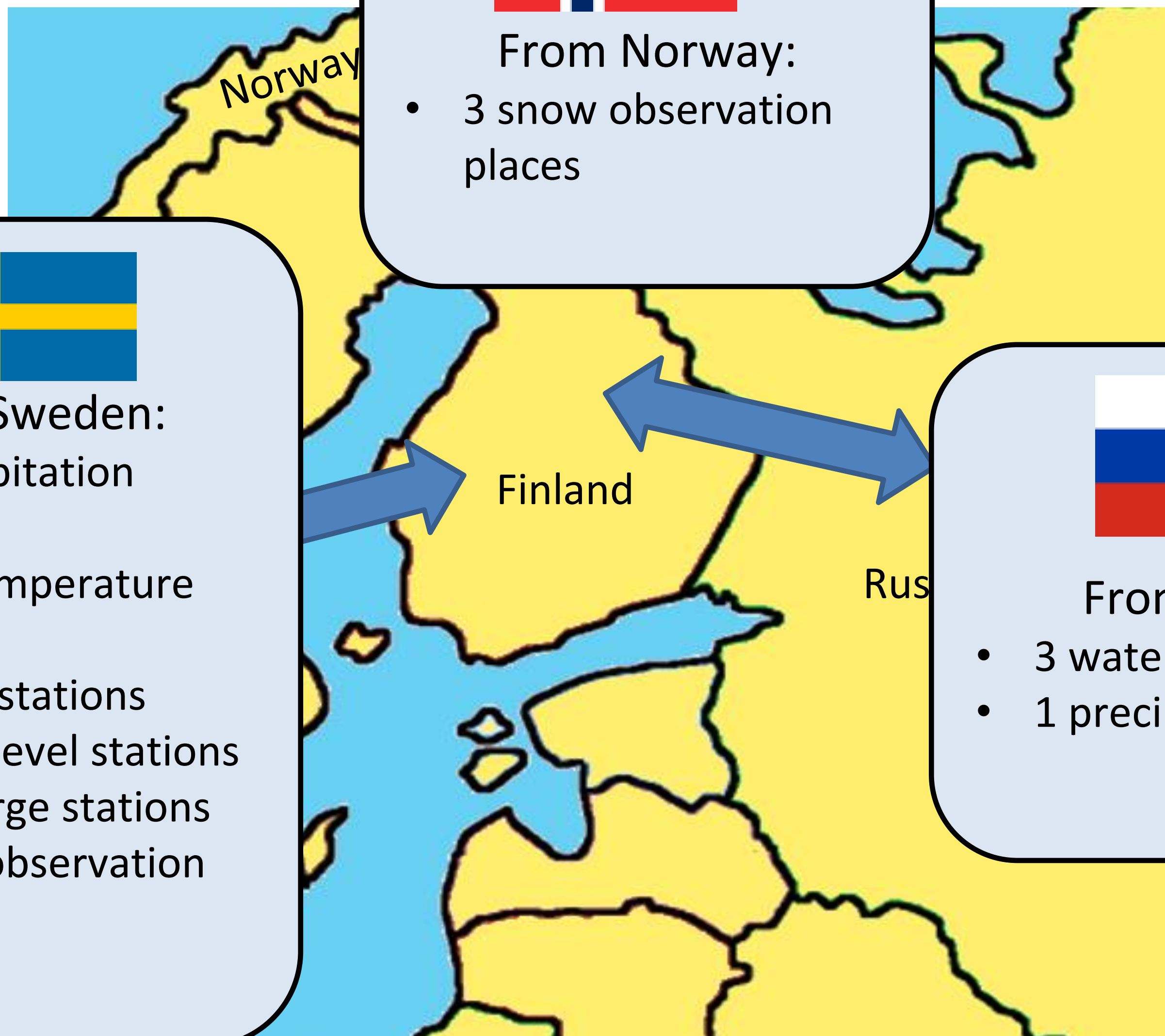


From Norway:
- 3 snow observation places

From Sweden:
- 16 precipitation stations
- 15 air temperature stations
- 11 wind stations
- 9 water level stations
- 8 discharge stations
- 8 snow observation places

From Russia:
- 3 water level stations
- 1 precipitation station

Observations from neighbour countries (1/1)



From Norway:

- 3 snow observation places

From Sweden:

- 16 precipitation stations
- 15 air temperature stations
- 11 wind stations
- 9 water level stations
- 8 discharge stations
- 8 snow observation places

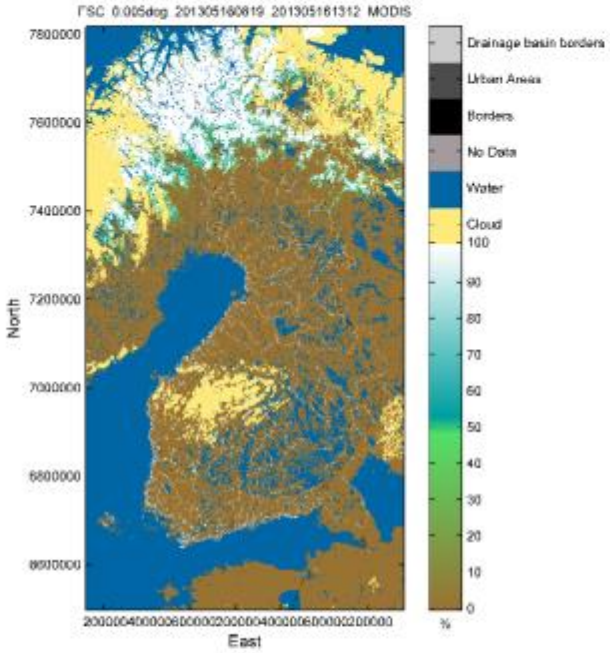
From Russia:

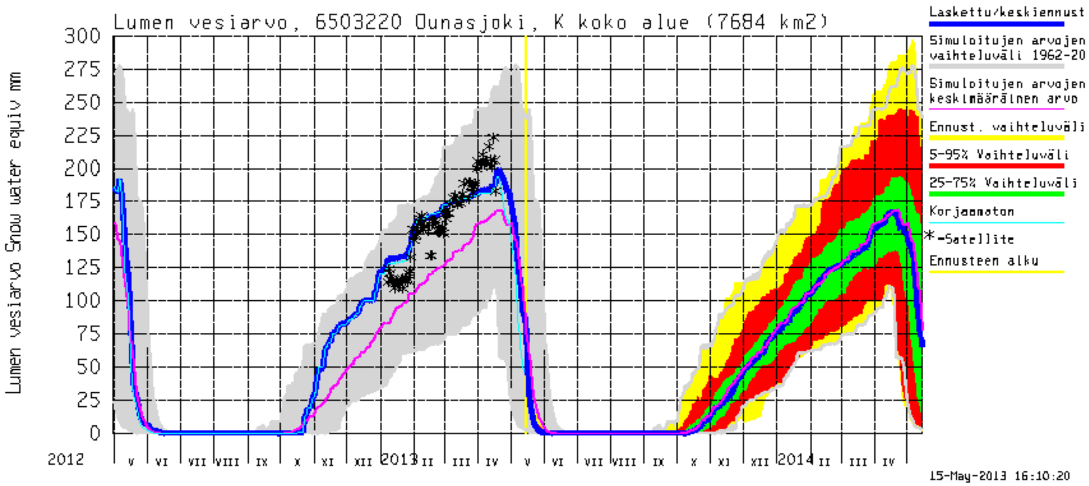
- 3 water level stations
- 1 precipitation station

Satellite snow products in WSFS

CryoLand

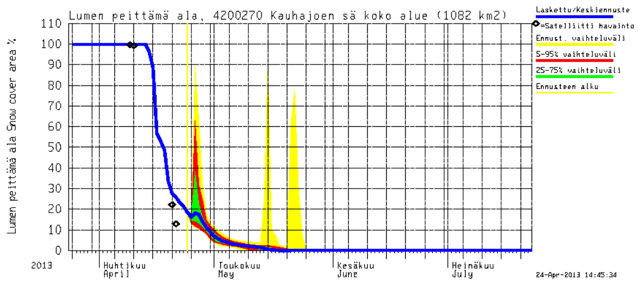
- Fractional snow cover
- Snow water equivalent

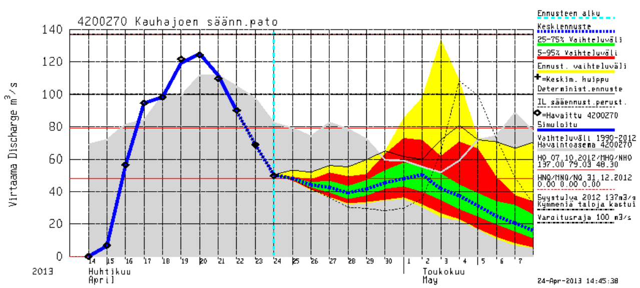




Satellite snow products in WSFS

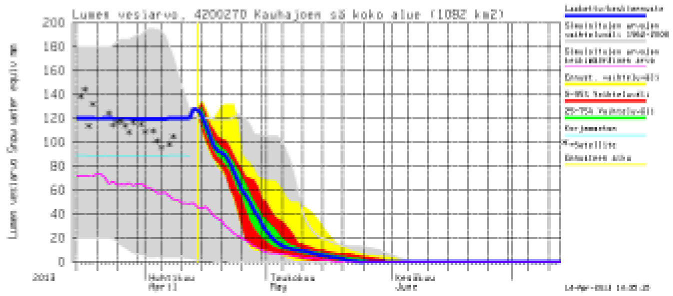
Fractional snow cover





- 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

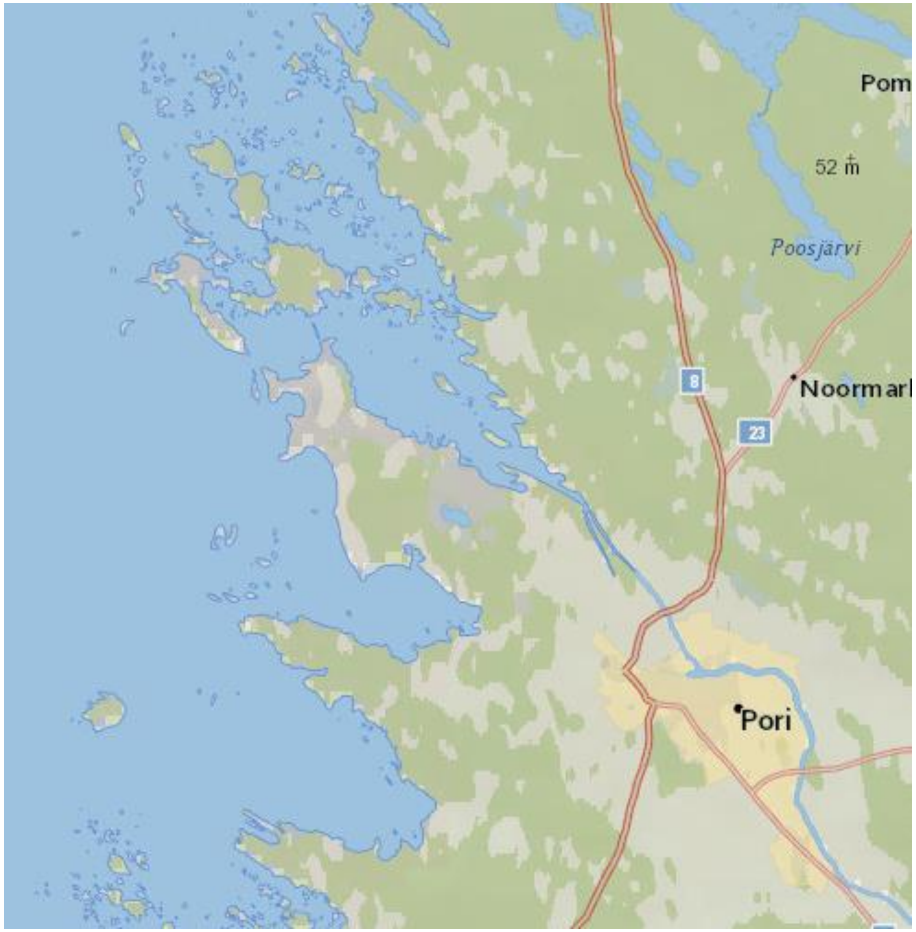
Forecast for Pori (1/2)

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

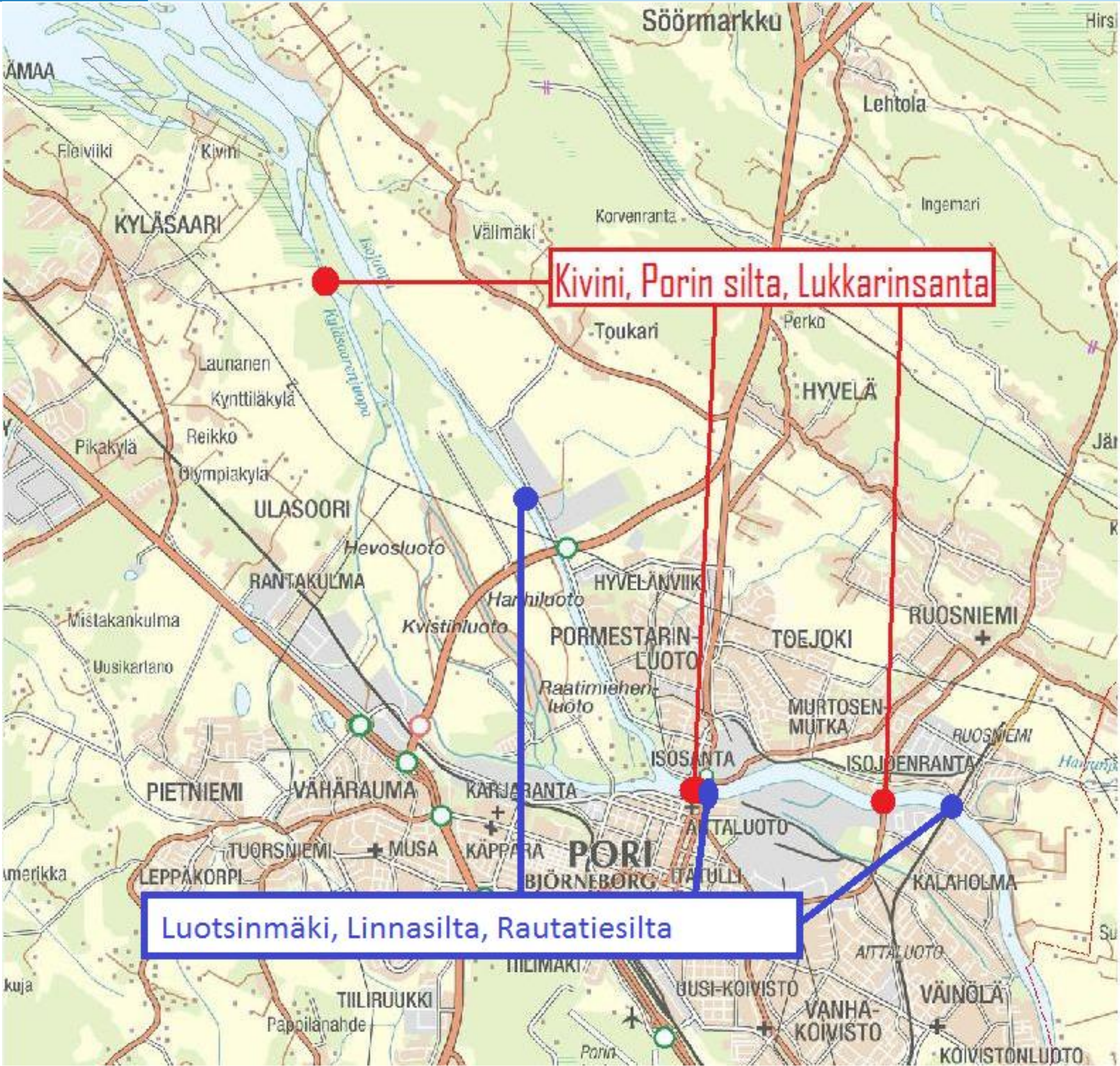
- City of Pori has biggest risk for major flood damages in Finland

For River Water level simulation we need:

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

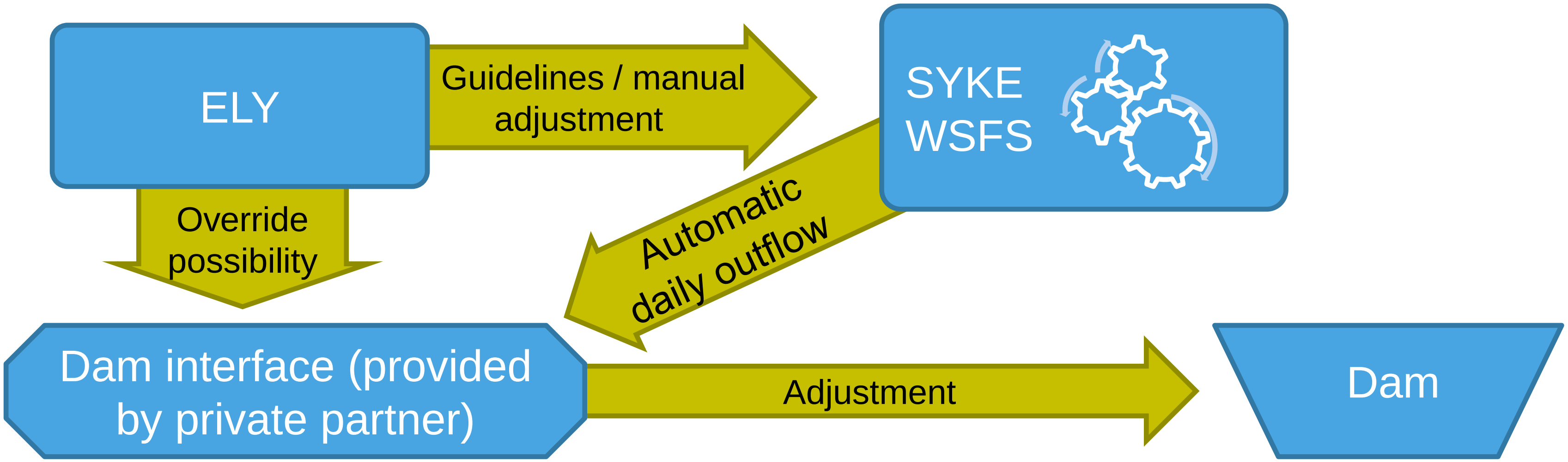


Forecast for Pori (2/2)



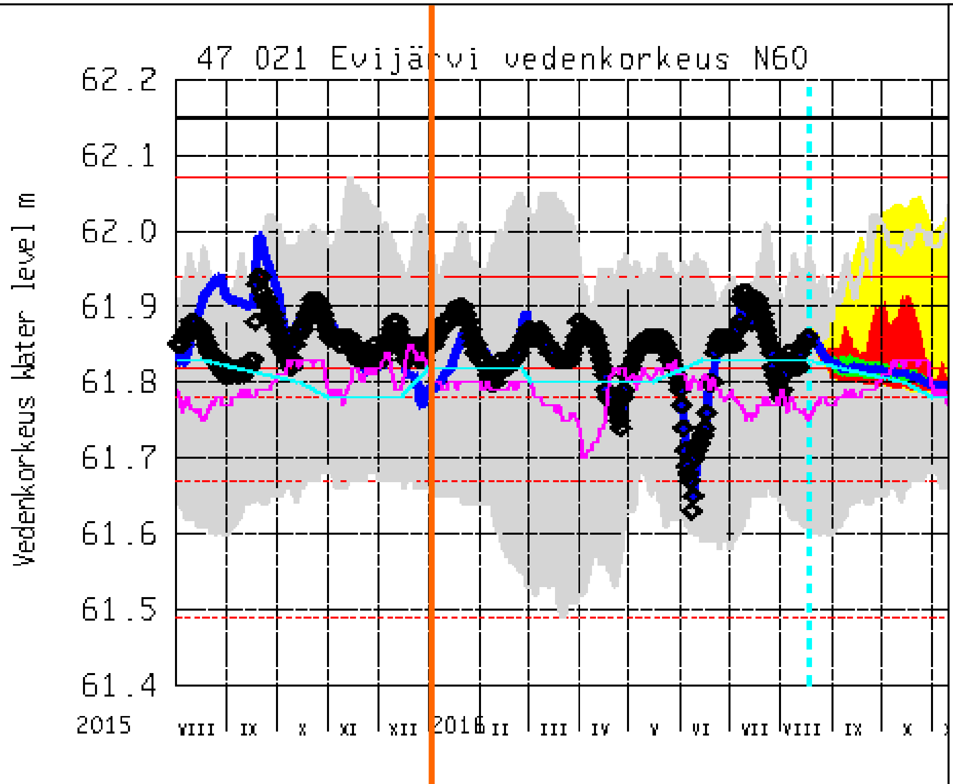
Regulation dam controlled by the hydrological model

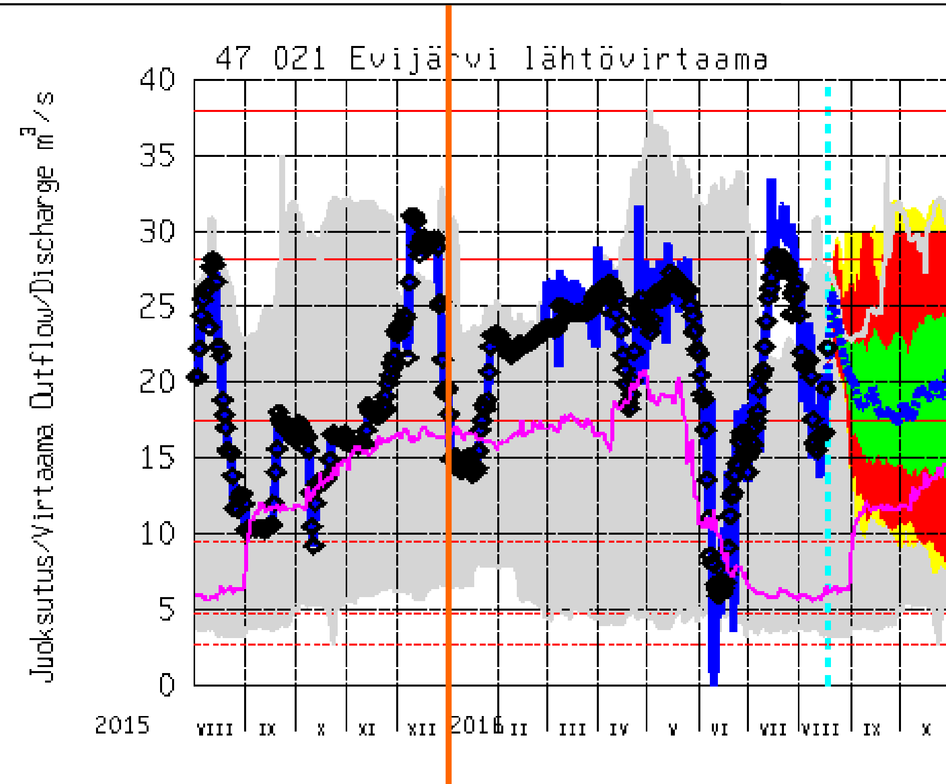
- Kaarenhaara dam at Evijärvi is controlled by Watershed Simulation and Forecasting System SYKE-WSFS
- The WSFS model calculates the daily outflow need, based on the inflow forecast (adaptive outflow calculation), and the result is sent to the dam
- The dam adjusts the outflow according to the model, 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



Kaarenhaara dam controlled by WSFS

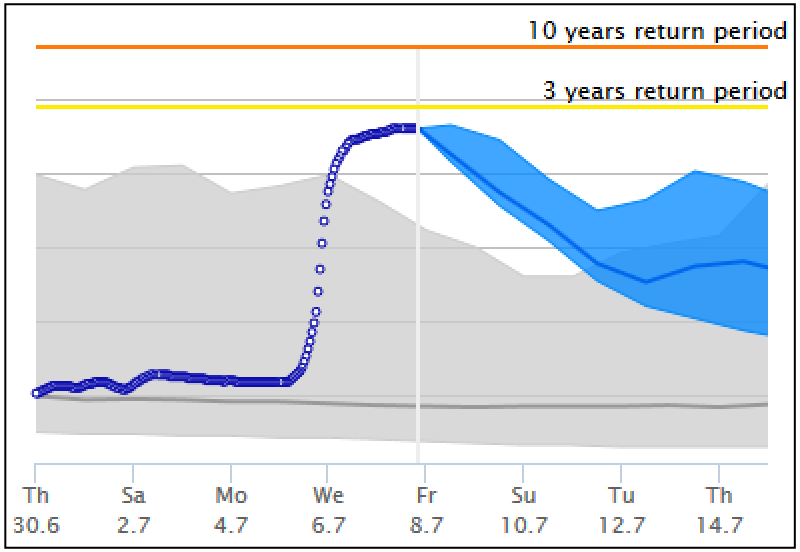
- Operational since 1.1.2016 (orange vertical line on pictures)
- A ”new software’s problem” occurred in the beginning of June, and dam control was manually overriden until the problem was fixed

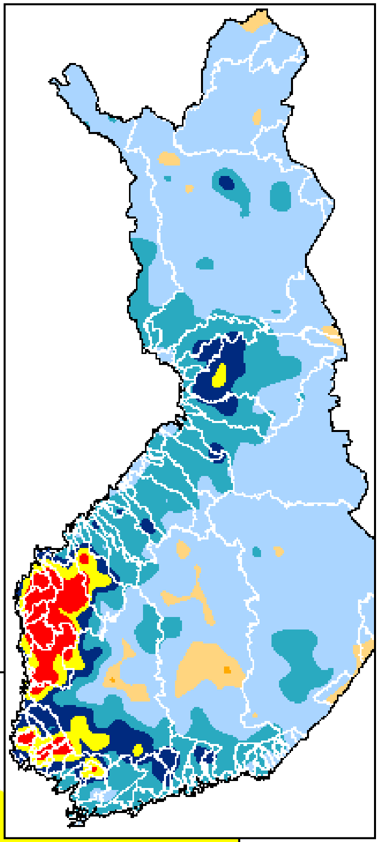


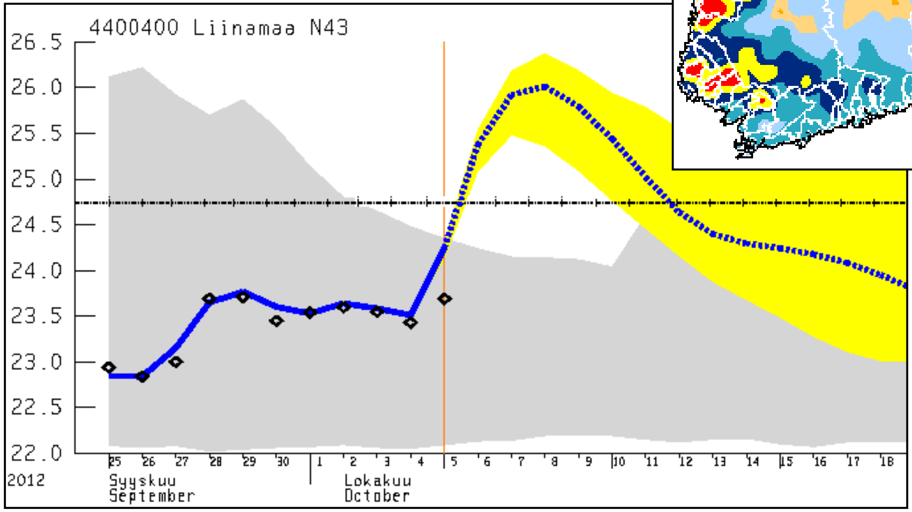


Realtime forecasts and maps (1/3)

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







Realtime forecasts and maps (2/3)

www.ymparisto.fi

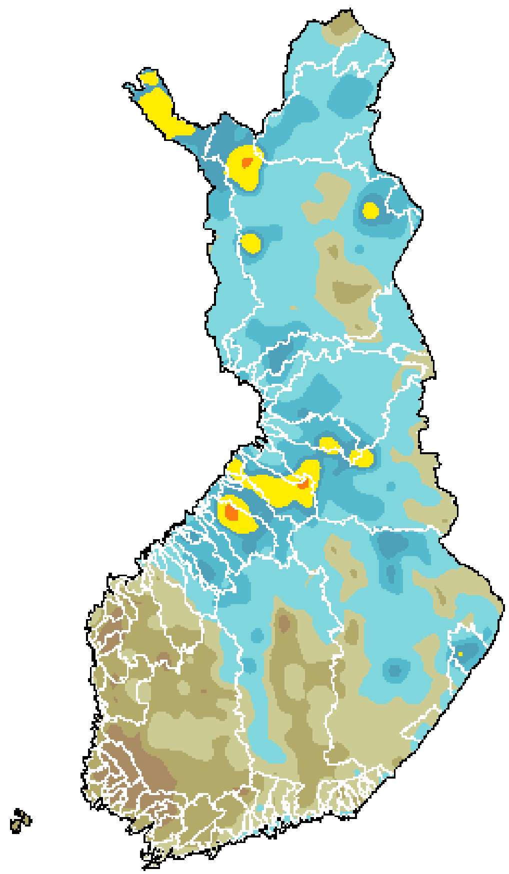
wwwi2.ymparisto.fi/i2/90/qrxx2/vesitilanne.html

Vesitilannekartat: Valunta Tulvatilanne

Kuva päivältä:
06.07.2016

Vesitilannekartat

- Valunta / Tulvatilanne
- Vedenkorkeus
- Tulvavaara
- Vuorokausisadanta
- 30 vrk sadesumma
- Järven jäänpaksuus
- Lumen vesiarvo / Lumikuorma
- Lumen syvyys
- Lumen sulanta
- Lumen tiheys
- Lumen tiheys aukealla
- Lumen tiheys metsässä
- Routa
- 30 vrk maahaihduntasumma
- Maankosteuden vajaus
- Pohjavesi
- Vuorokauden keskilämpötila
- Järven pintalämpötila
- Tarkemmat kartat



TULVA / RUNSASVETINEN	>20 mm/vrk
	15-20 mm/vrk
	7-15 mm/vrk
NORMAALI	5-7 mm/vrk
	3-5 mm/vrk
	1-3 mm/vrk
VÄHÄVETINEN	0,5-1,0 mm/vrk
	0,2-0,5 mm/vrk
	< 0,2 mm/vrk

- 28.06.2016
- 29.06.2016
- 30.06.2016
- 01.07.2016
- 02.07.2016
- 03.07.2016
- 04.07.2016
- 05.07.2016
- 06.07.2016
- tänään
- 08.07.2016
- 09.07.2016
- 10.07.2016
- 11.07.2016
- 12.07.2016
- 13.07.2016
- 14.07.2016

Päivitetty 07.07.2016 20:00

Kartta on linkki vesistöennusteisiin

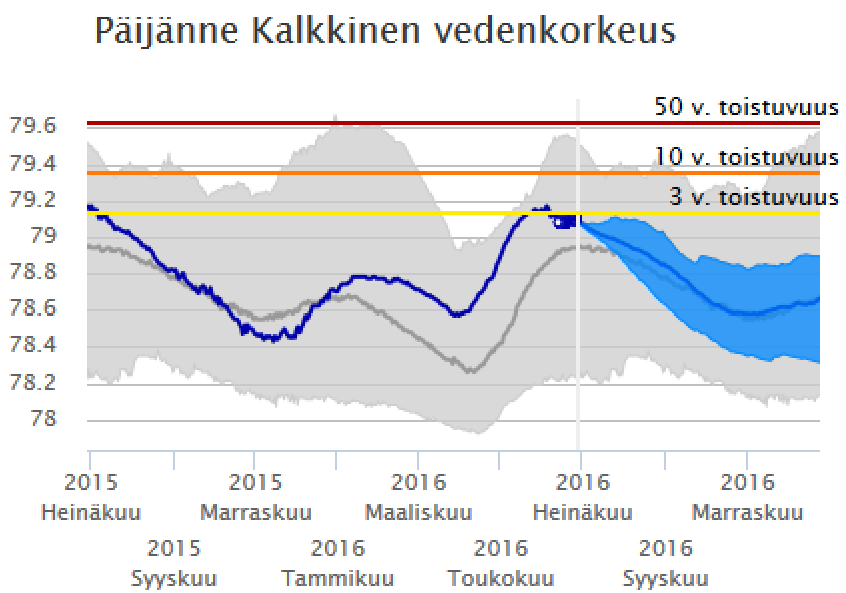
Kartta kuvaa parhaiten

Realtime forecasts and maps (3/3)

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

http://www.environment.fi/waterforecast

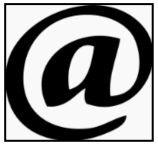
http://www.ymparisto.fi/vesistoennusteet (in Finnish)



Automatic impact based flood warnings (1/5)

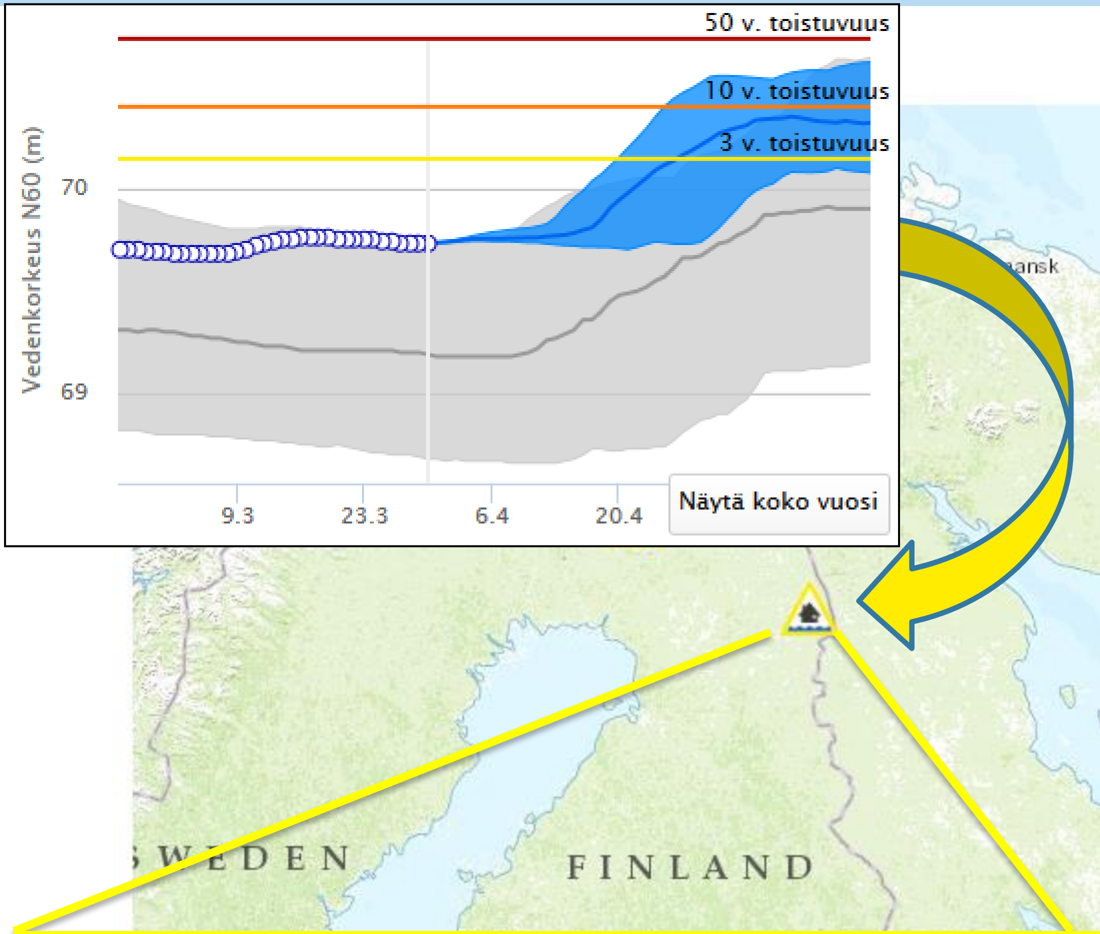
AUTOMATIC WARNINGS FOR HIGH WATER LEVELS AND GREAT DISCHARGES

- 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:

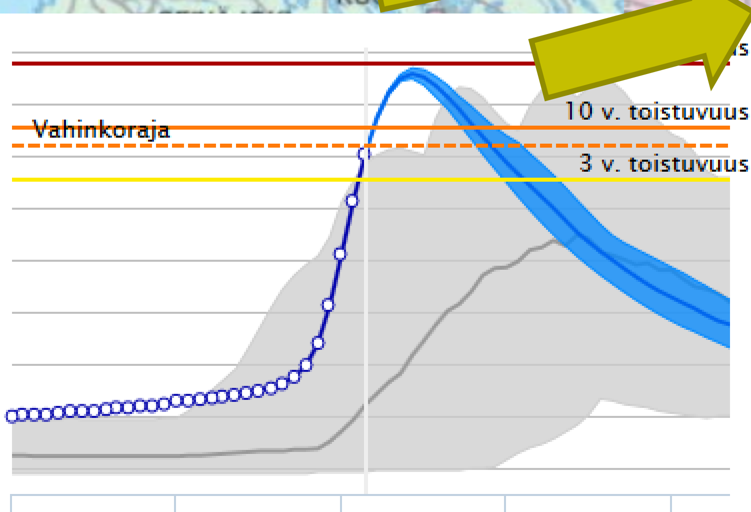
www.environment.fi/waterforecast

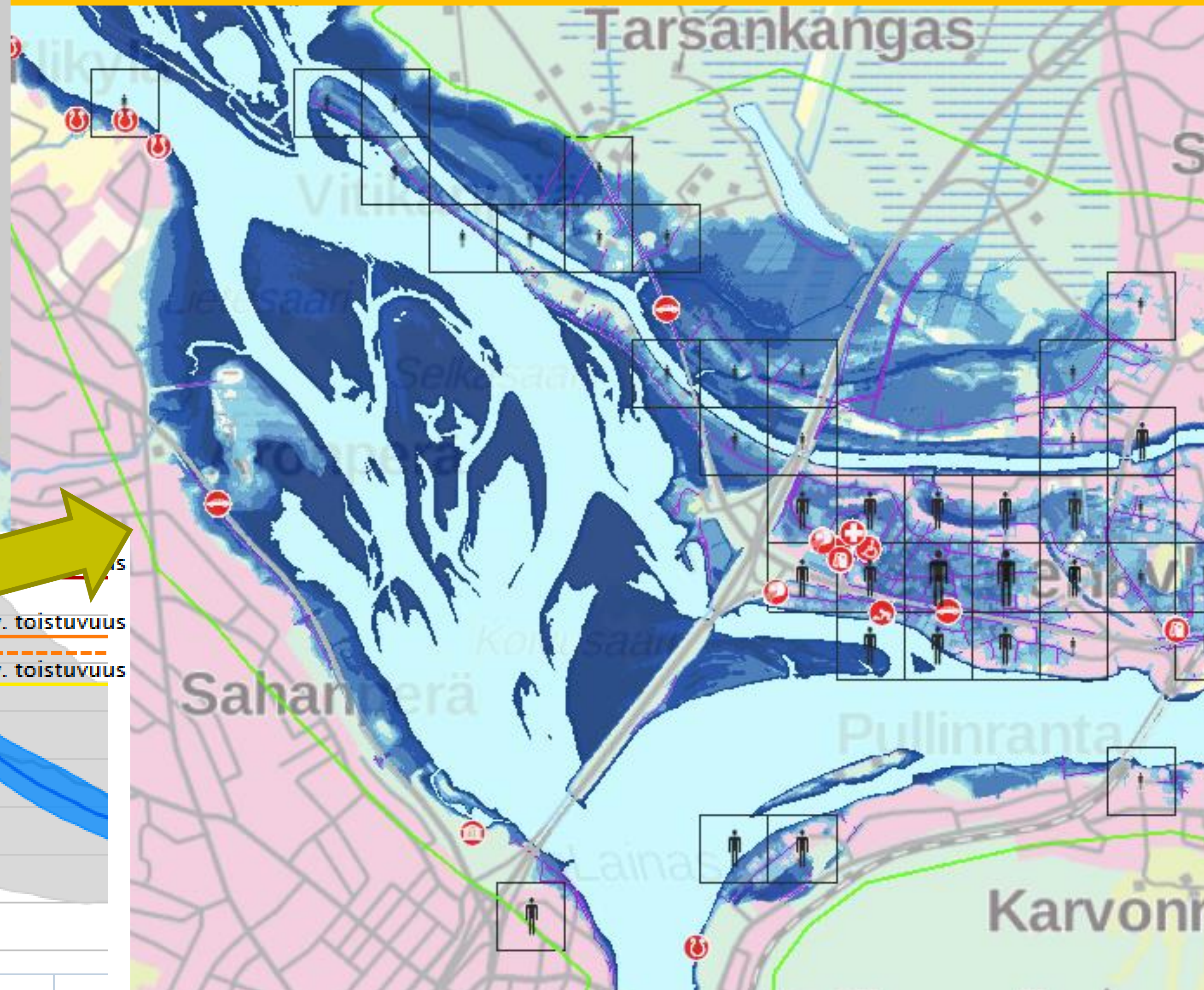


Oulankajoki (Kiutaköngäs)
Warning: forecasted water level exceeds limit of Karhunkierros hiking route to be cut off.
Observed water level 26.5.2014 klo 12 is NN+88,92 m.
Karhunkierros hiking route will be cut off if water level exceeds NN+90.00 m.
Forecasted water level peak NN+90.50 m is at 29.5.2014.

Automatic impact based flood warnings (2/5)

Warning: forecasted water level exceeds flood damage limit 77.45 m, causing 0,5 km² flood area with 50 inhabitants and flood damages at Citymarket shopping mall.
Observed water level 26.5.2014 klo 12 is 76.32 m.

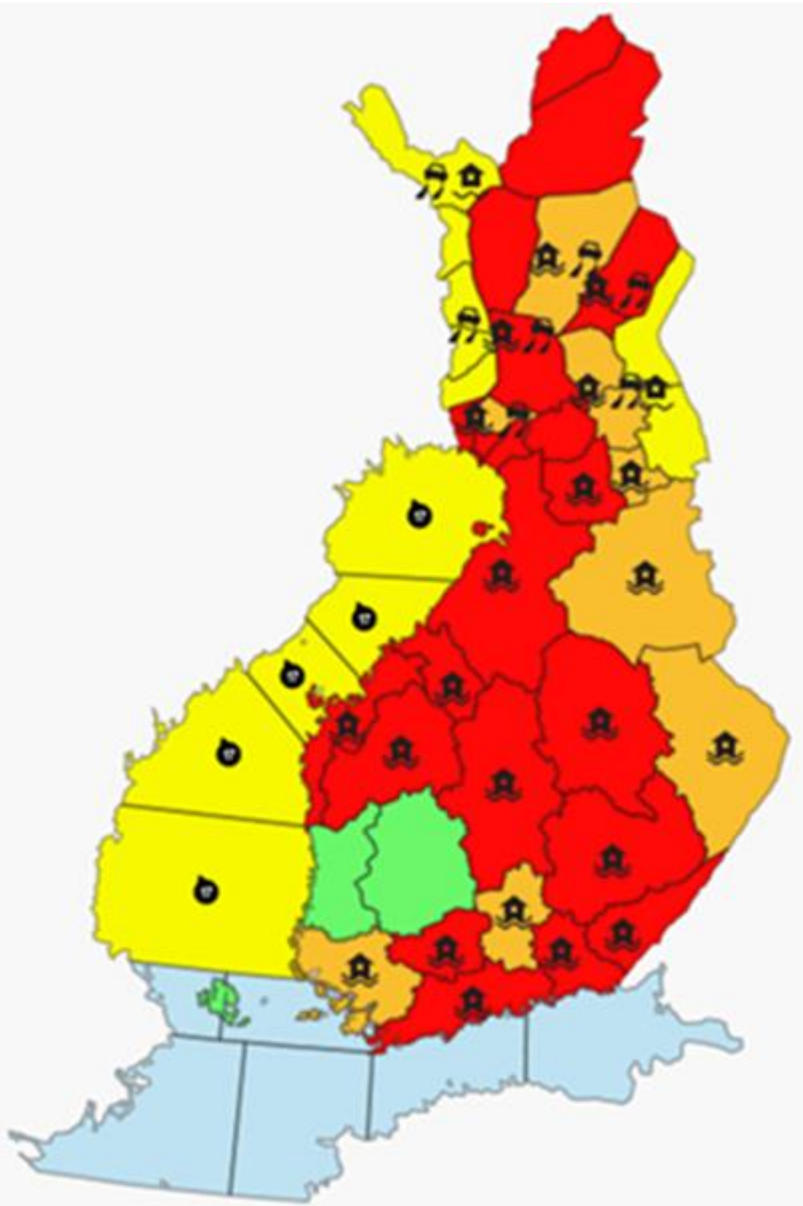




Warnings are based on impact / potential damages and consequences, when possible (otherwise return period)

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

Automatic impact based flood warnings (4/5)

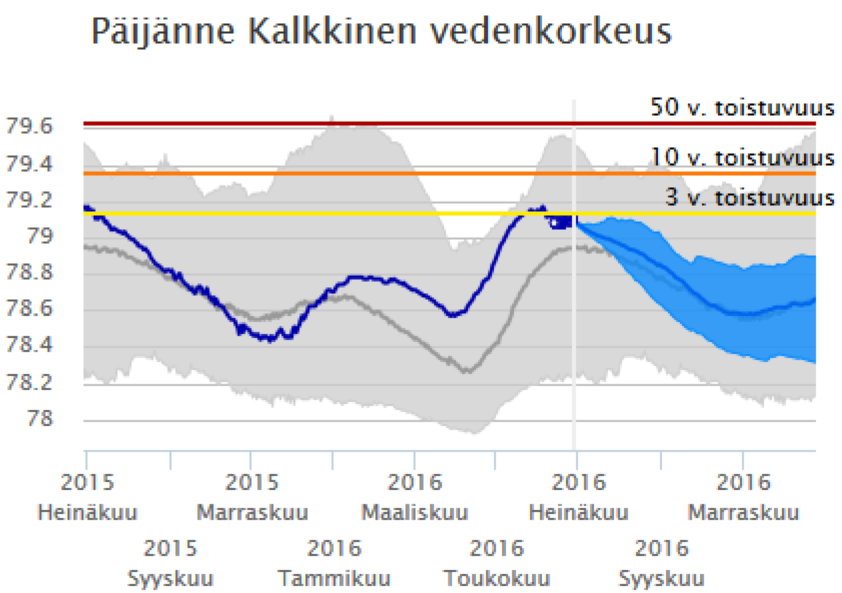


Automatic impact based flood warnings (5/5)

Realtime forecasts and warnings are available online:

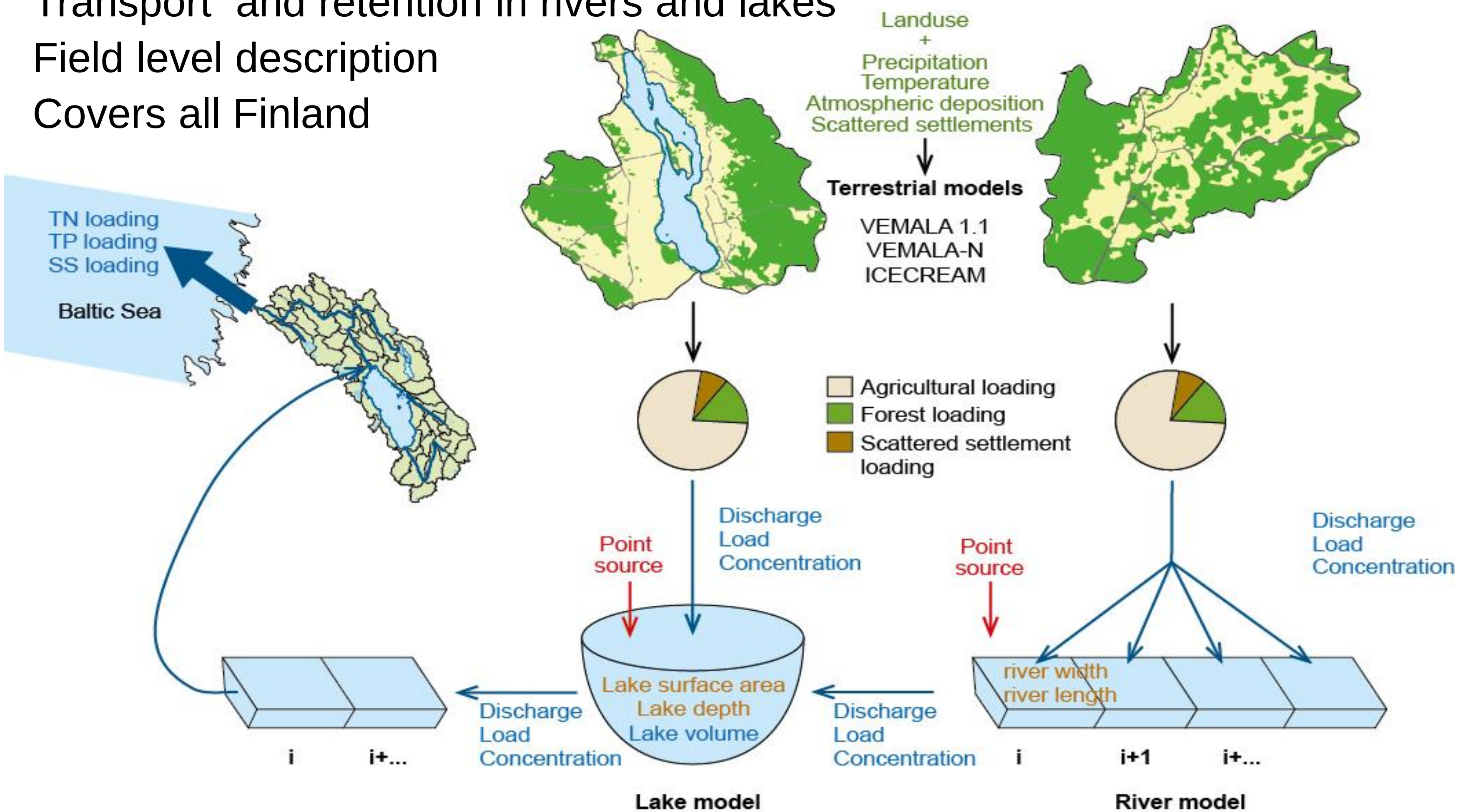
http://www.ymparisto.fi/ennusteetjavaroitukset

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

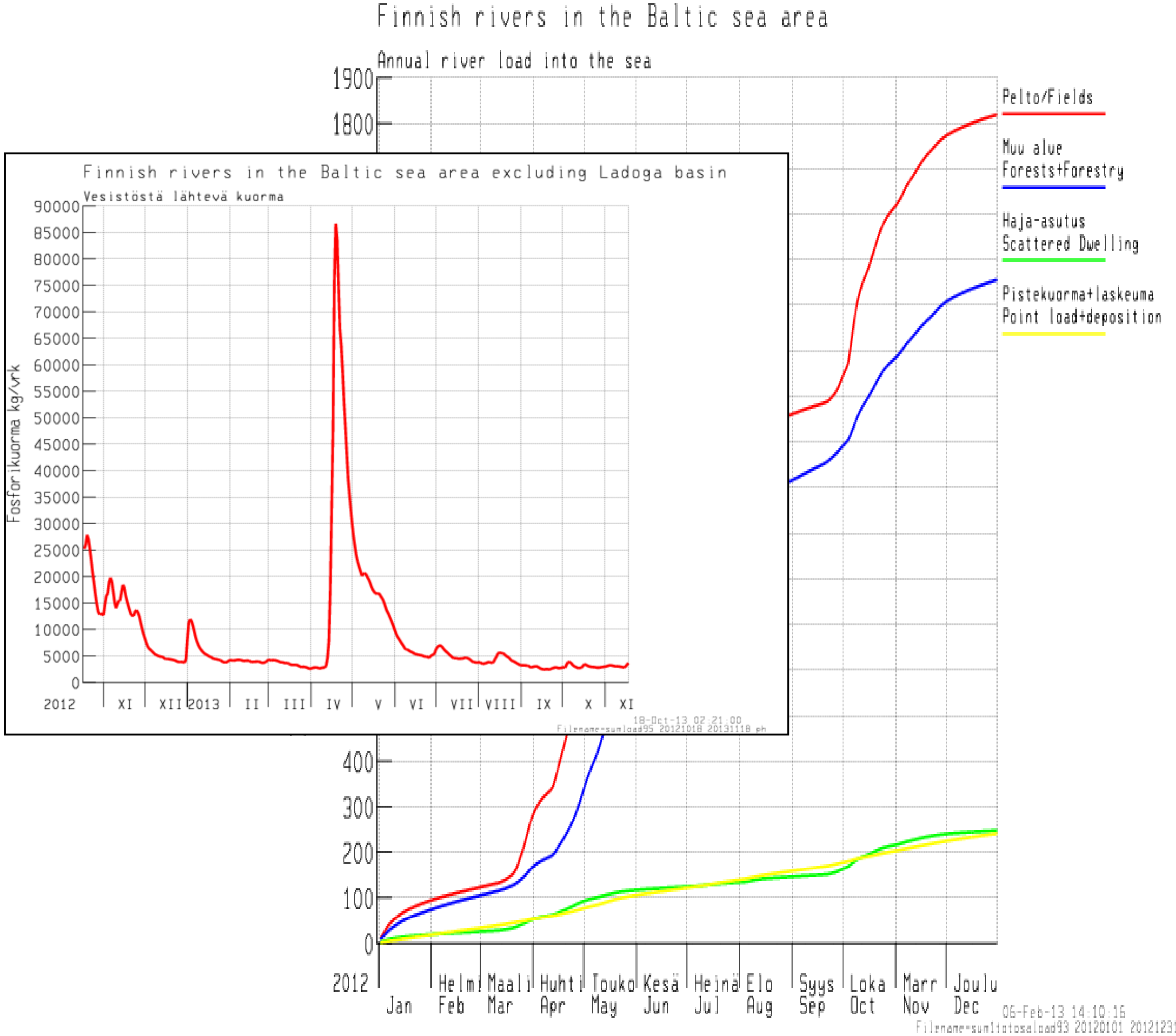


Structure of WSFS-Vemala water quality model

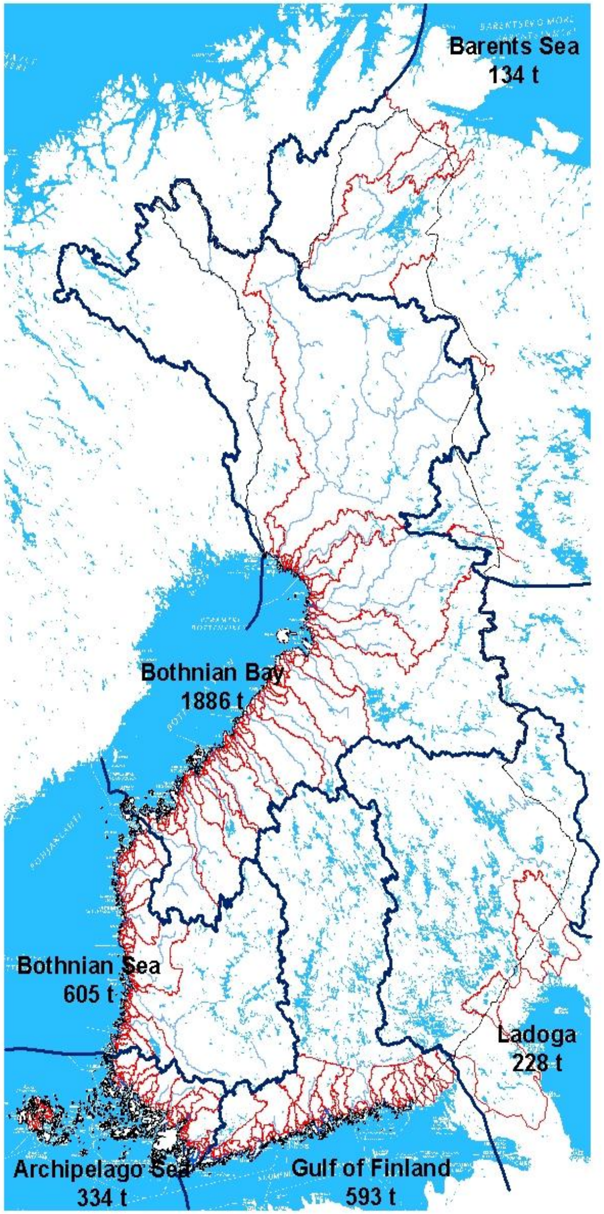
- Phosphorus and nitrogen leaching from fields and forest
- Point sources, scattered dwelling and deposition
- Transport and retention in rivers and lakes
- Field level description
- Covers all Finland



Realtime and annual phosphorus load from Finland to Baltic sea



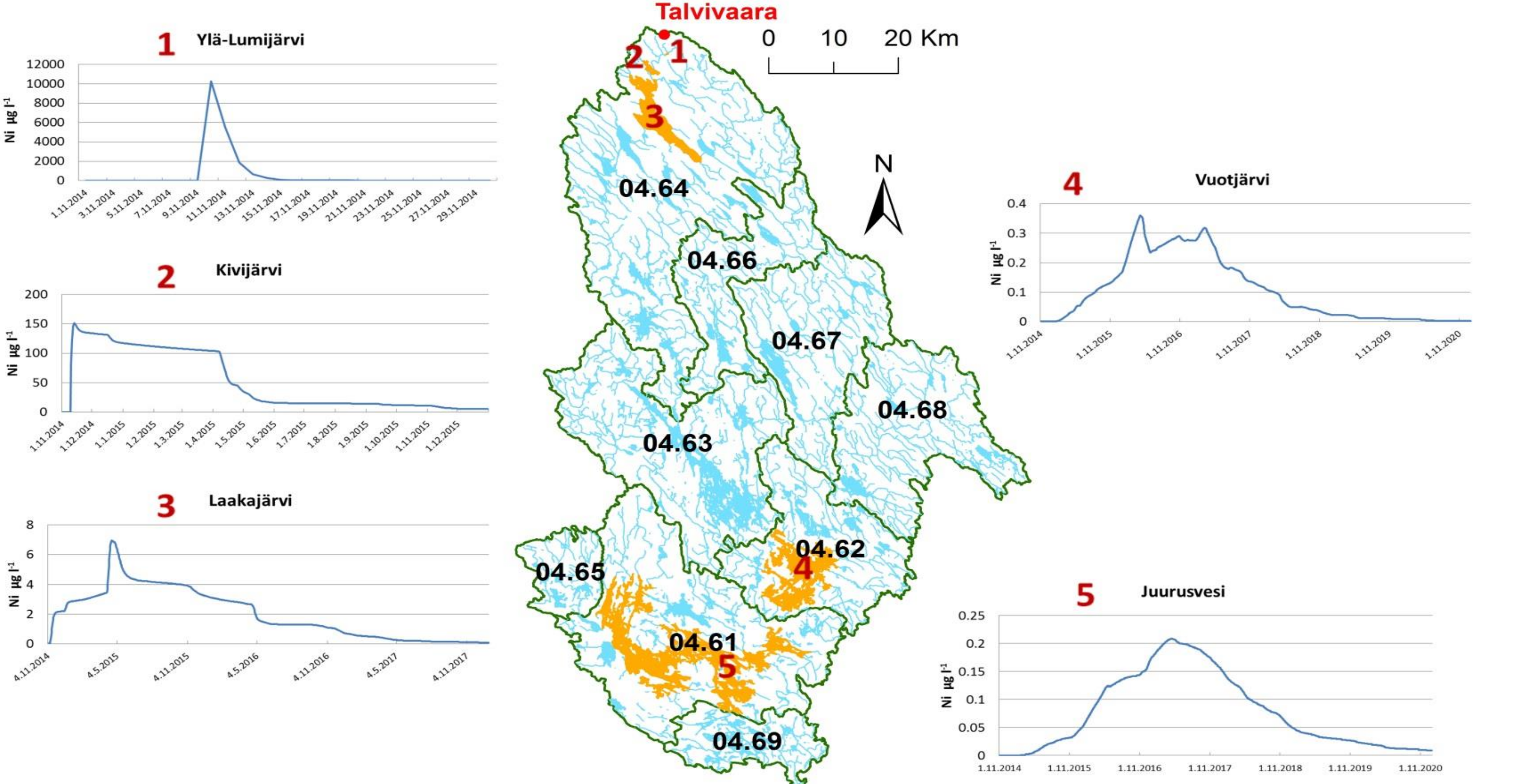
Mean annual riverine phosphorus load from Finland (3750 t / year)



Simulation of a leak from mine

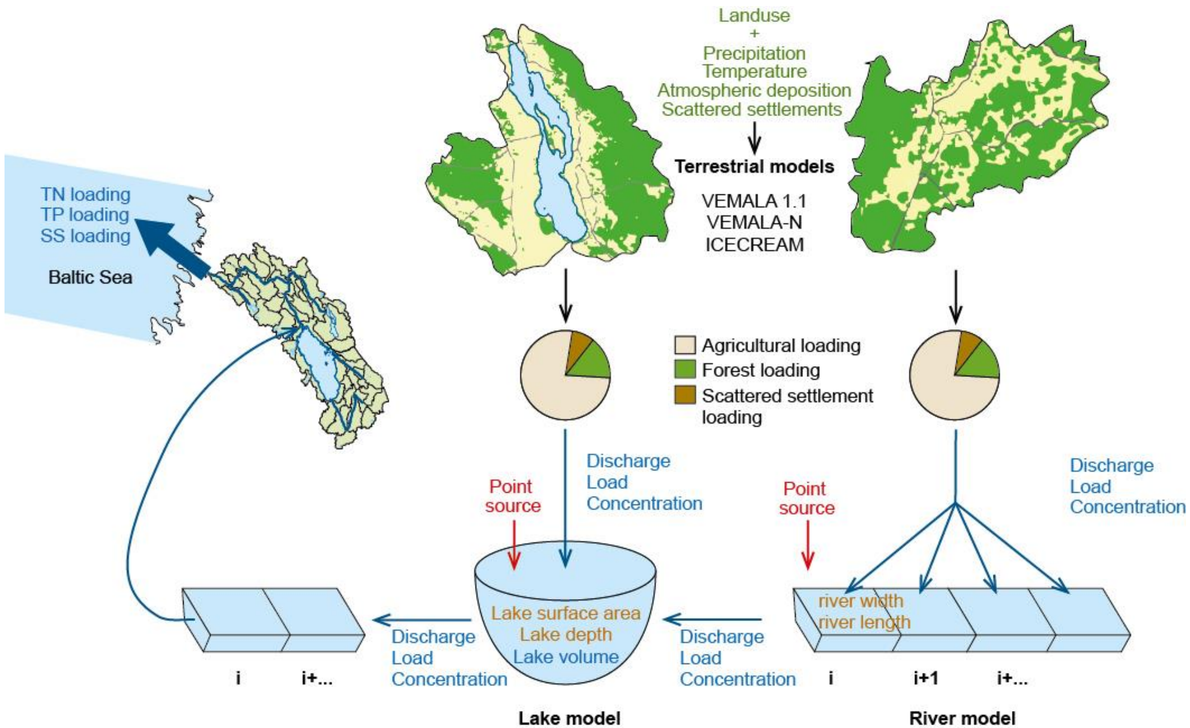
The aim is to better predict the transport of substances in rivers and lakes downstream of an industrial leak for determining toxicity risks:

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



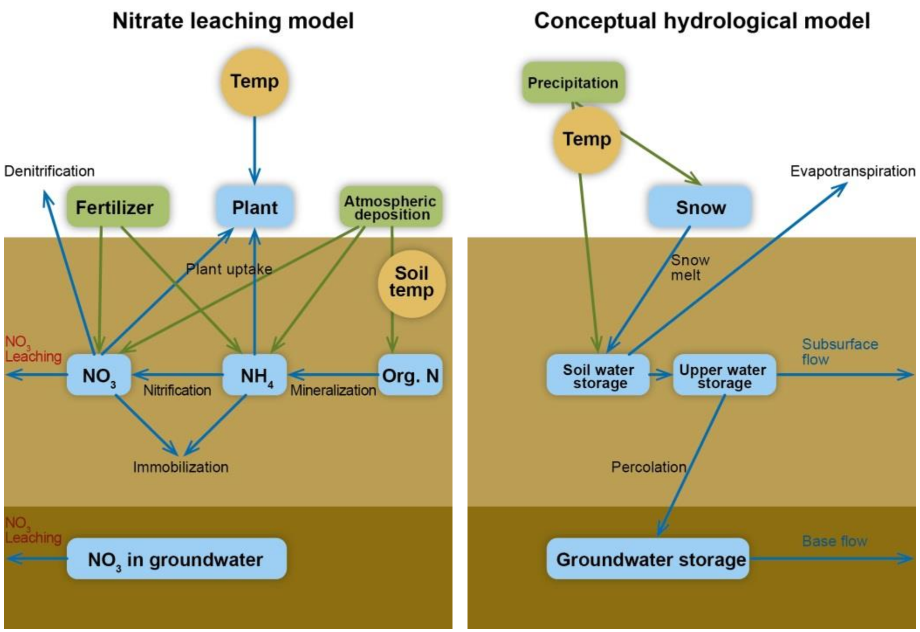
Nutrient load simulation and forecasting (4/13)

Version	Substance	Hydrological model	Terrestrial model		River model	Lake model
			agricultural loading	non-agricultural loading		
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



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

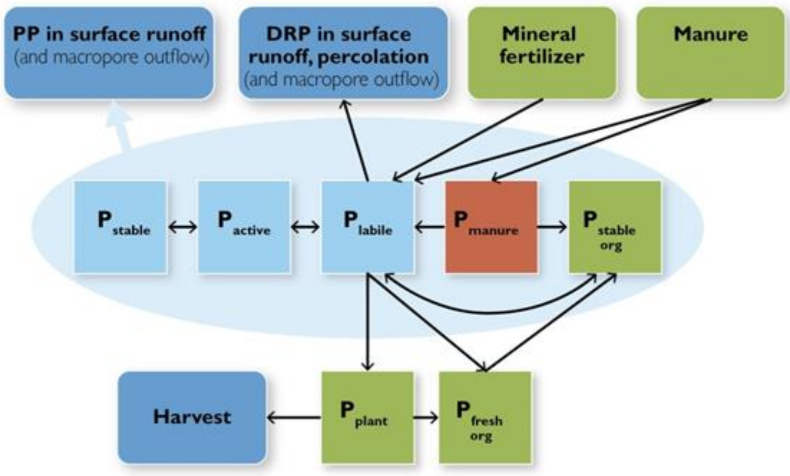


Scenarios:

- 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

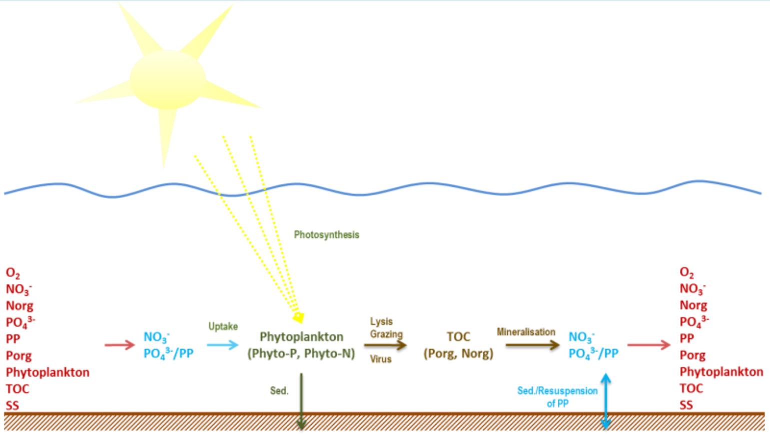
VEMALA-ICECREAM

- 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

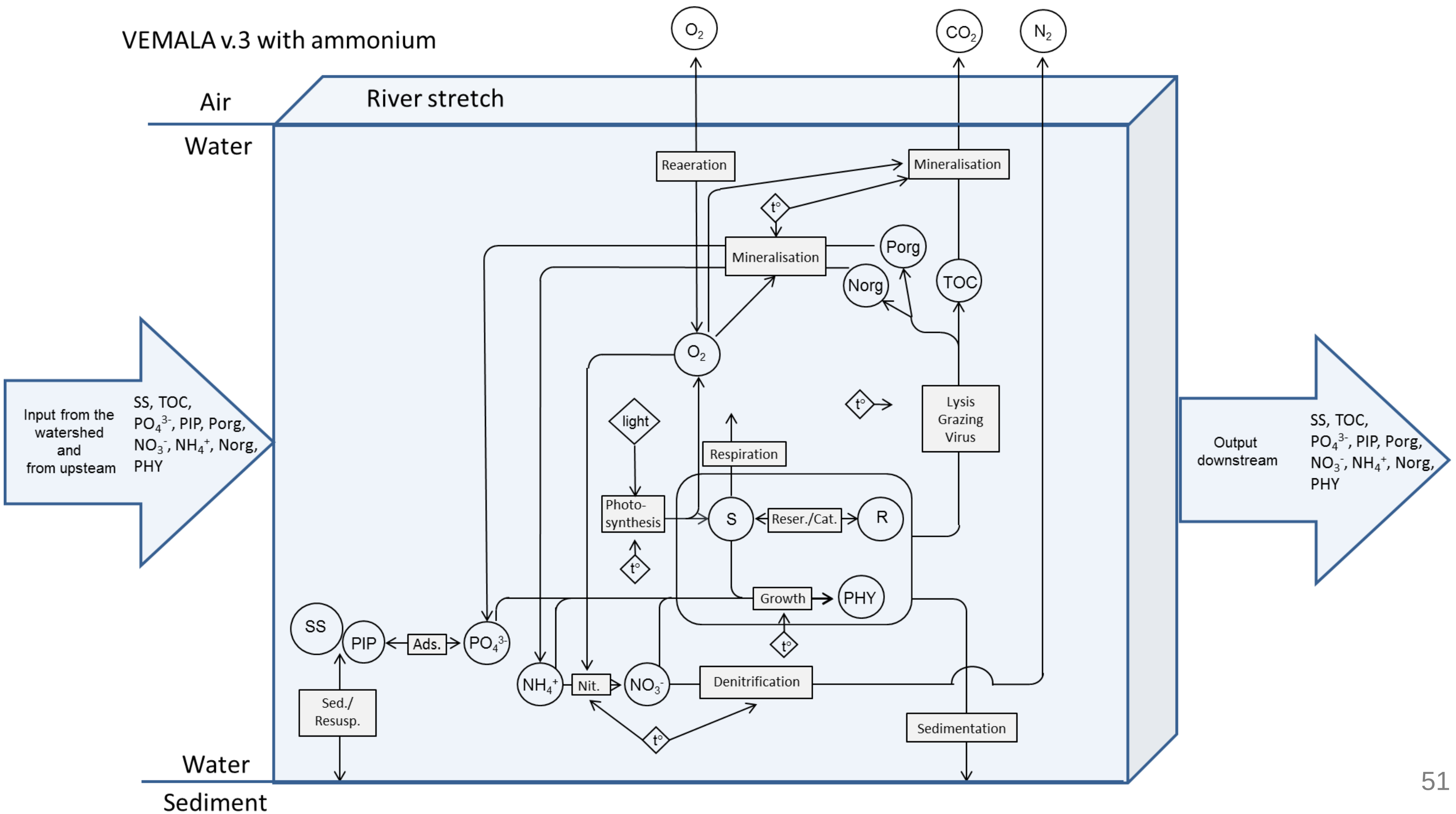
VEMALA v.3



- 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

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)



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

For implementation of WFD it provides:

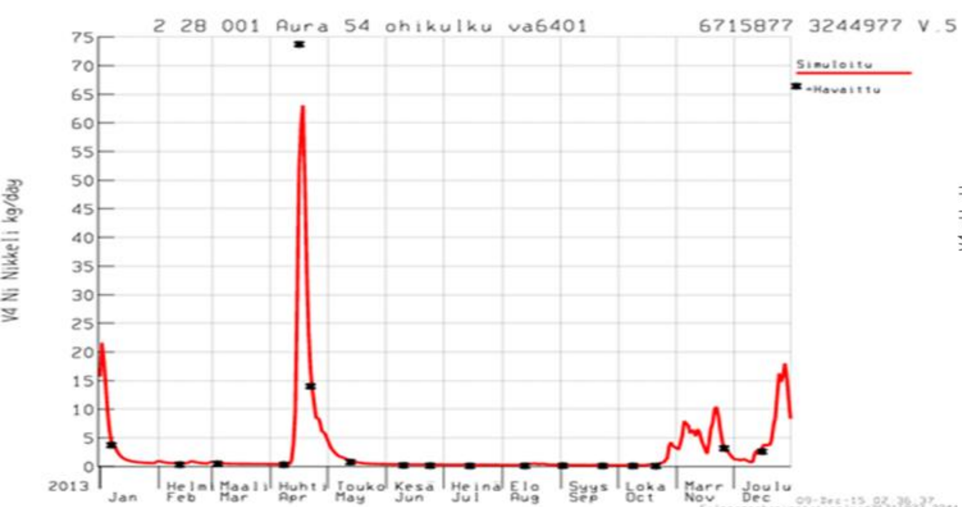
- For each about 58 000 lakes an estimate of the present state
- Understanding reasons for the state of the lake by dividing the loading by sources
- Scenarios for future with different load reduction options and the effects of climate change

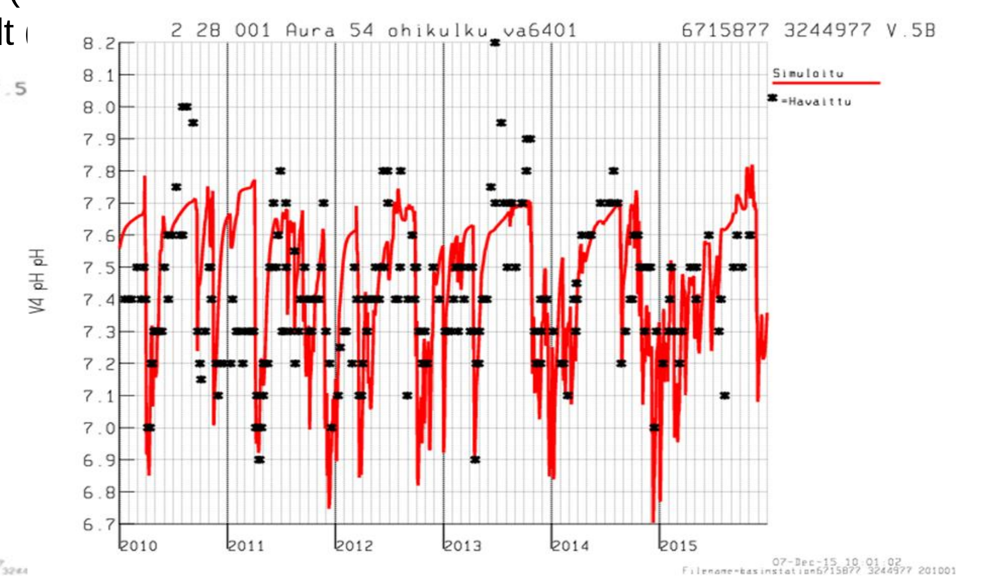
Field id	Name	Slope %	Area ha	Phosphorus leaching kg/ha/a
7620256645	Pihantaus	4.47	16.93	1.7
7620330205	Rikkasuo 1	5.34	6.59	1.61
7620520262	Nivonniska	3.47	4.02	1.59
7620254827	Inganmäki	3.75	3.8	1.54
7620239164	Koskenniska	0.69	2.71	1.4
7620262305	Väliaho	3.03	4.02	1.22
1400111639	Paskosuo	2.29	3.47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

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 (



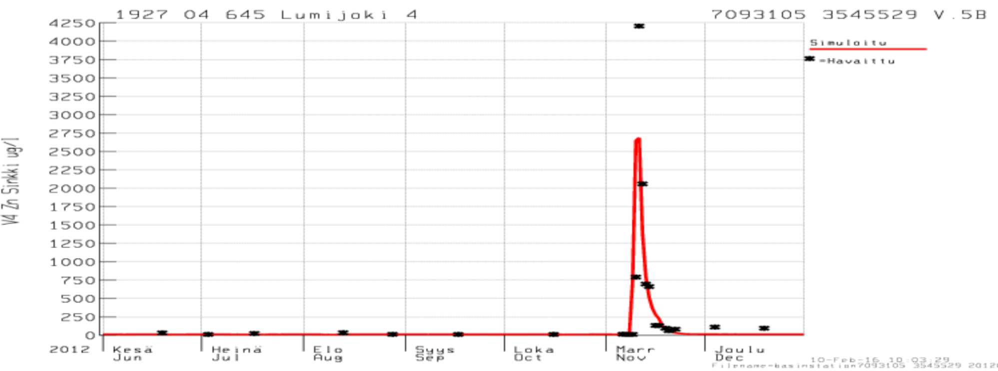


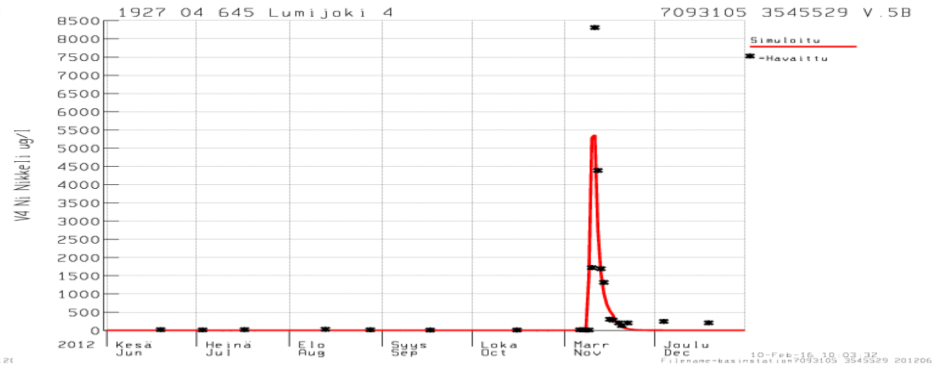
VEMALA

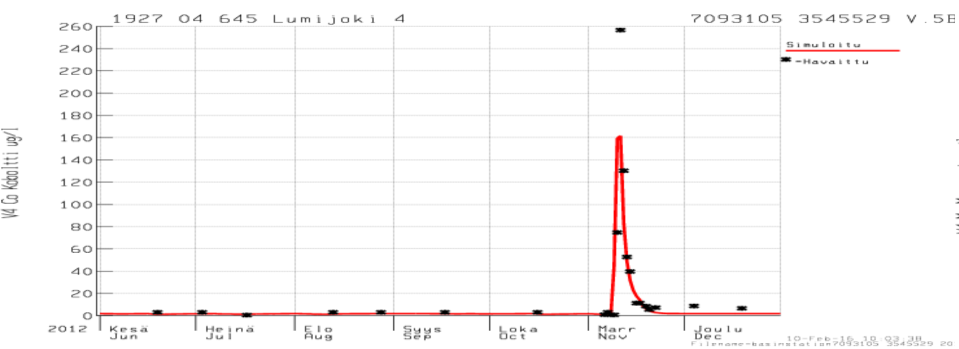
- Water quality model
- Operational over Finnish waters
- It simulates nutrient processes, leaching and transport on land, and in rivers and lakes.
- Simulates from the Finnish water basins to the Baltic Sea:
    - Nutrient gross loading
    - Retention in lakes and in the river network
    - Nutrient 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)

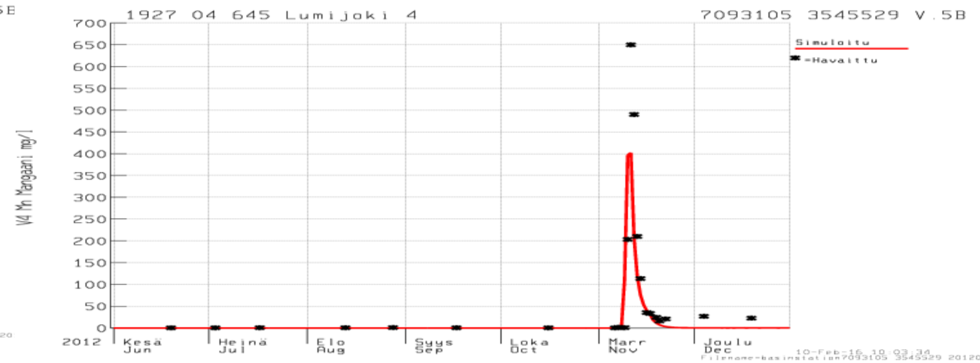
Etunimi Sukunimi

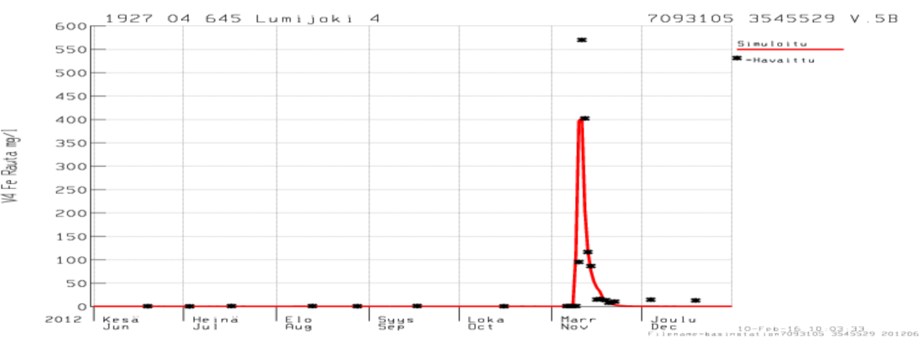
Talvivaara 2012 leak: Zn, Ni, Co, Mn, Fe ja U





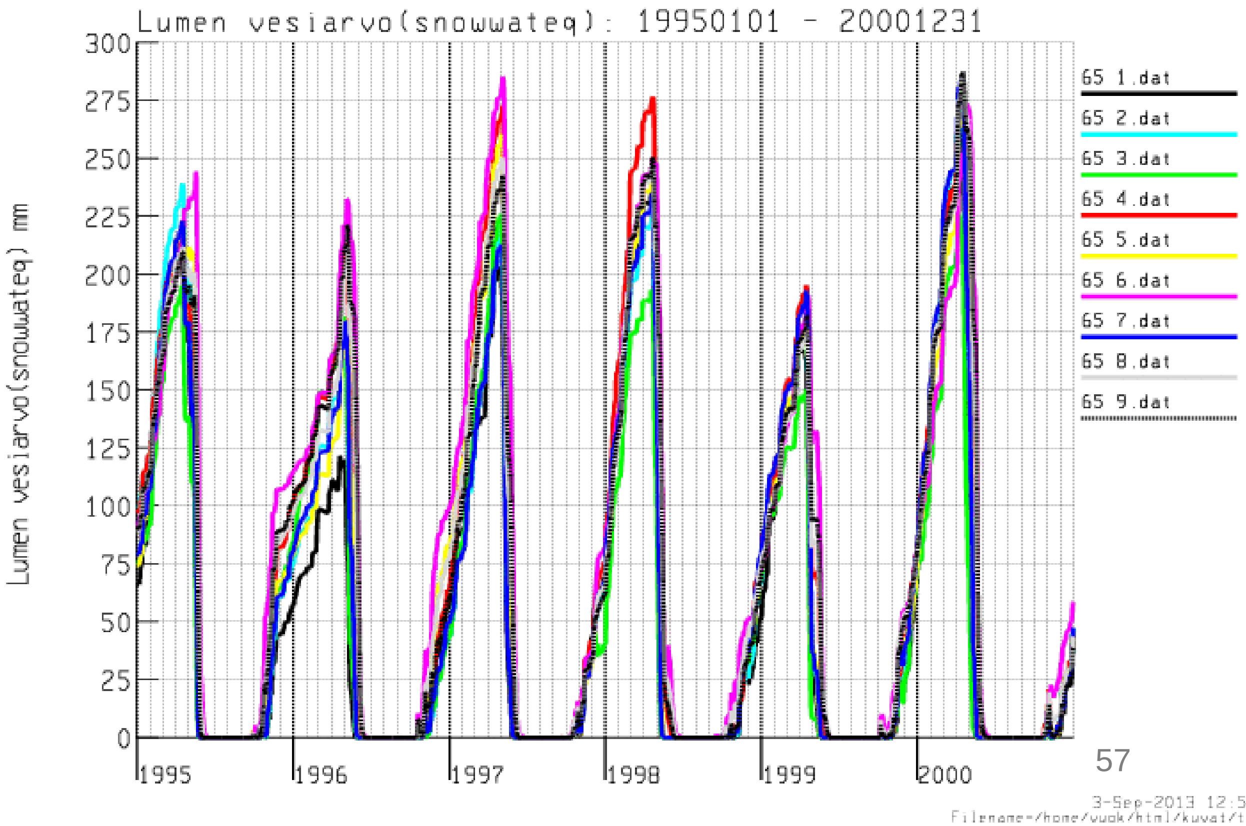






Simulated data for unobserved areas (1/2)

- 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?

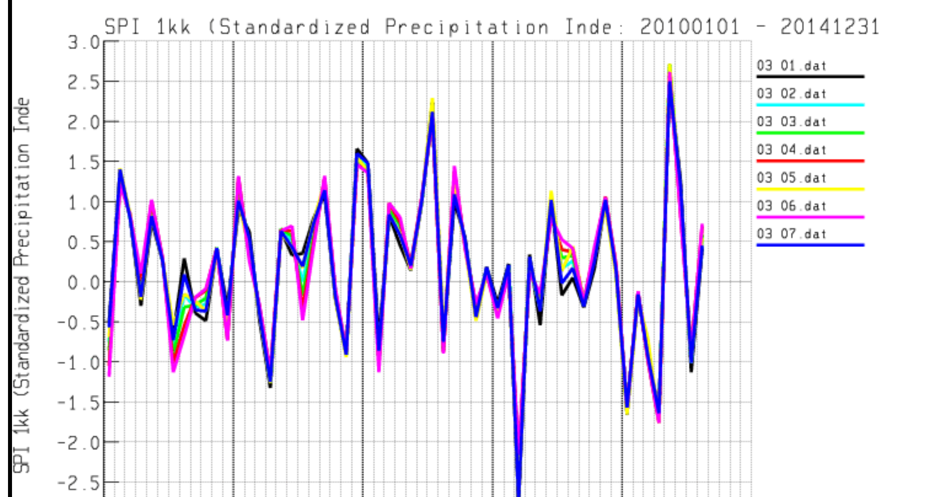


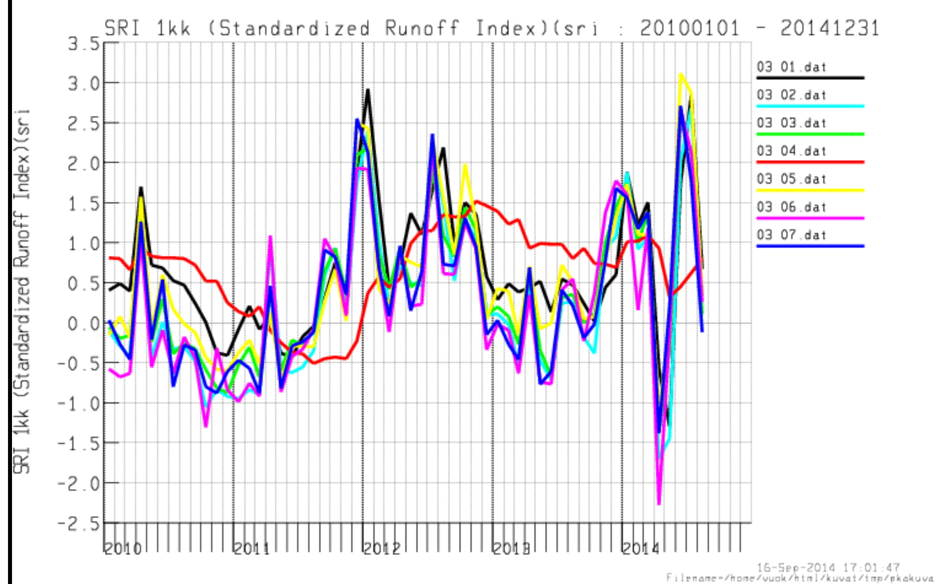
Simulated data for unobserved areas (2/2)

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

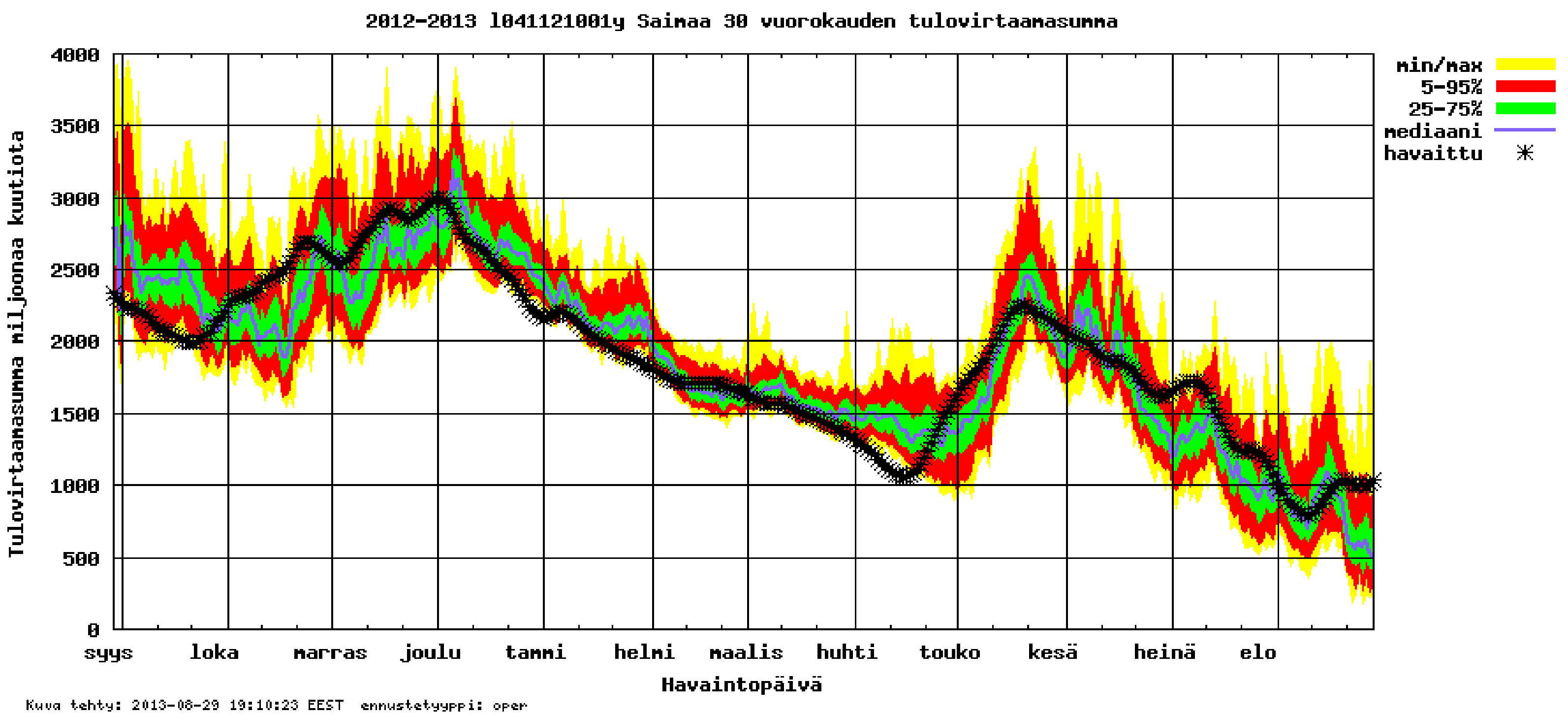
Indicator values	Droughtness	Cumulative probability	Category probability
-1.0 to 0.0	Normal	0.159 – 0.5	34.1 %
-1.5 to -1.0	Moderate	0.067 – 0.159	9.2 %
-2.0 to -1.5	Severe	0.023 – 0.067	4.4 %
-∞ to -2.0	Extreme	0.0 – 0.023	2.3 %



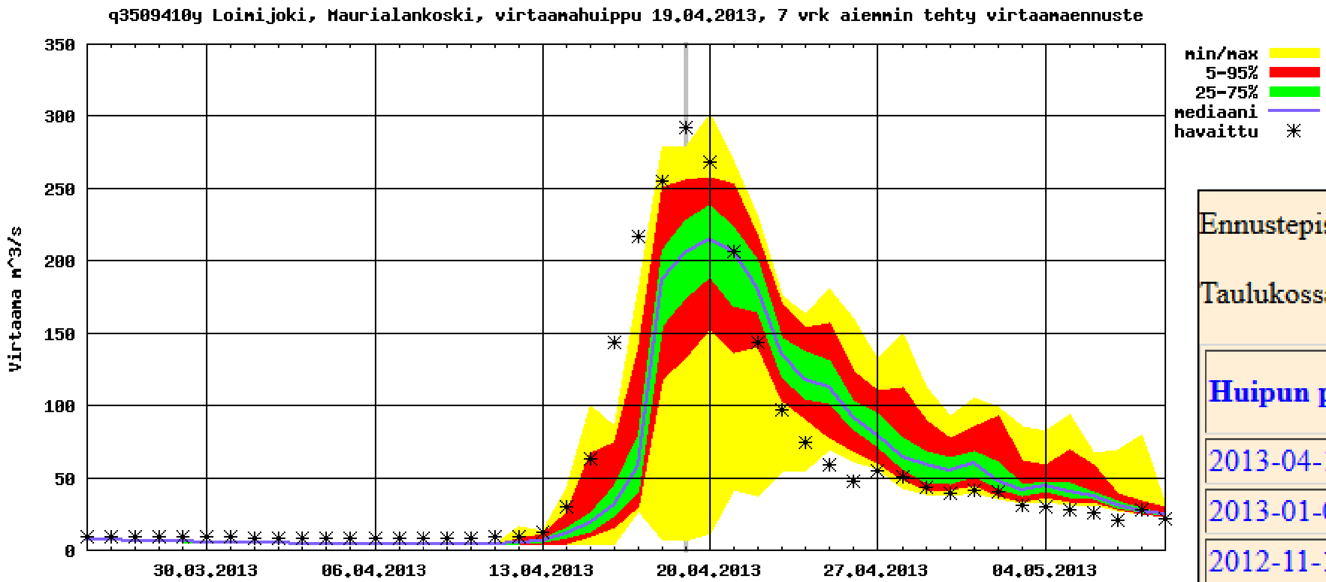


Forecast accuracy monitoring

- 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.



Forecast accuracy monitoring (2/2)



Kuva t

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

7 vrk

		Tulovirtaamasumma					Sadesumma					Lämpötilan keskiarvo			
Vuosi		R²	E [%]	E [Mm³]	N		R²	E [%]	E [mm]	N		R²	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

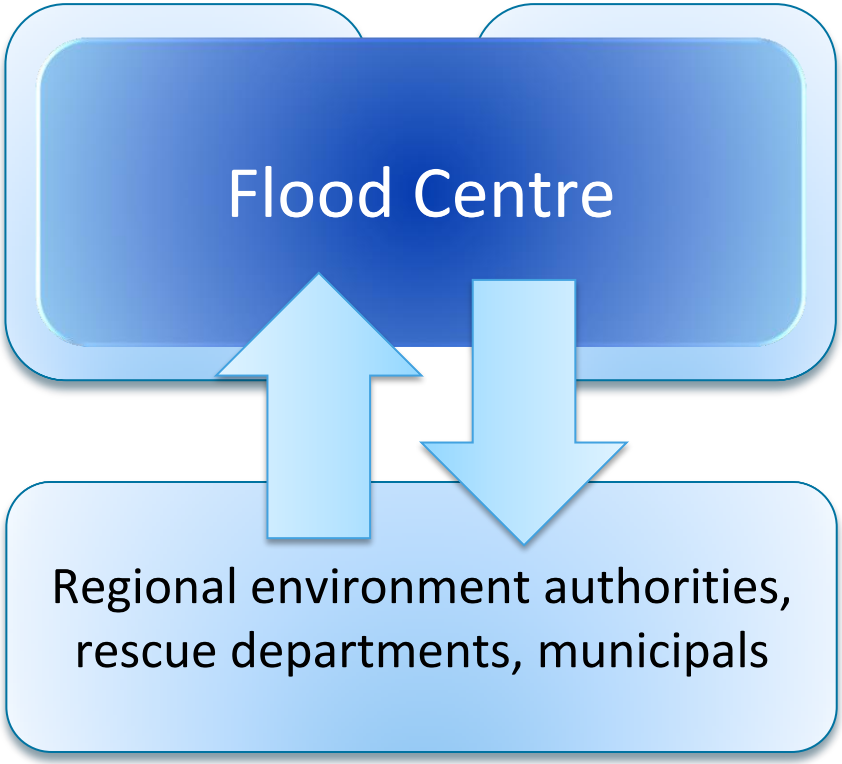
Ennustepiste q3509410y, koko valuma-alue. Kaikkien pist

Taulukossa on virheiden keskiarvot ennusteista, jotka on t

Huipun pvm	Huippuvirtaama [m³/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		

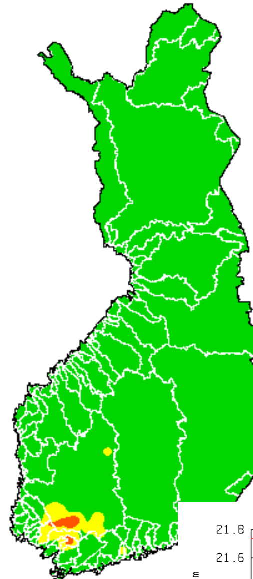
Flood Centre

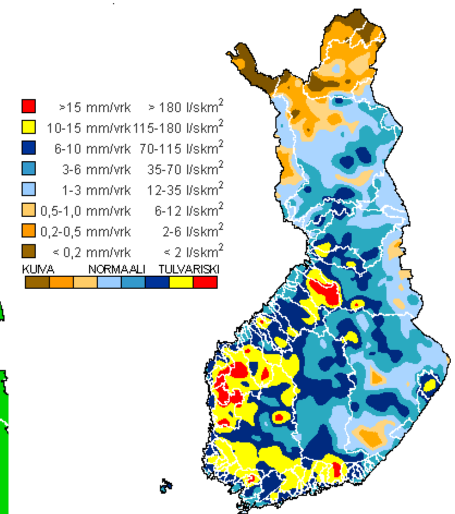
- Joint flood service of Finnish Environment Institute (SYKE) and Finnish Meteorological Institute (FMI)
- National water situation and flood information, forecasts and warnings 24/7
- All types of flooding:
  - Watershed
  - Sea coast
  - Urban
- Solid co-operation with regional flood management authorities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

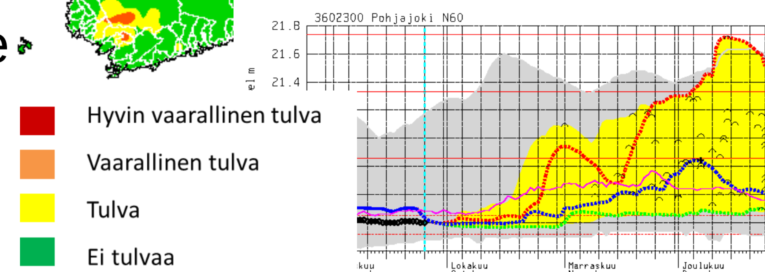


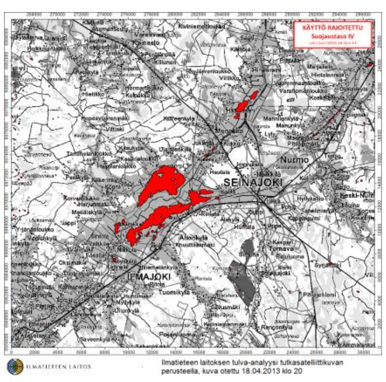
Flood Centre products

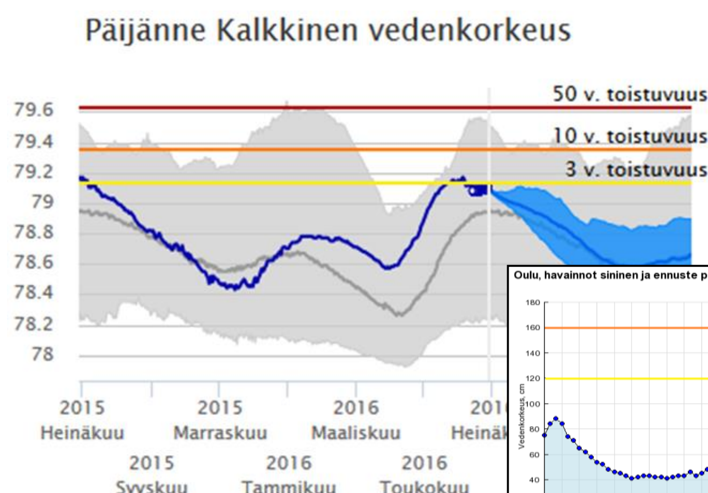
- Water situation information
- Flood warnings to authorities and public
- Flood situation picture
- LUOVA (National natural disaster warning and information system) warnings to authorities
- Flood damage and effect forecasts and maps
- Flood expectionality statements to insurance companies

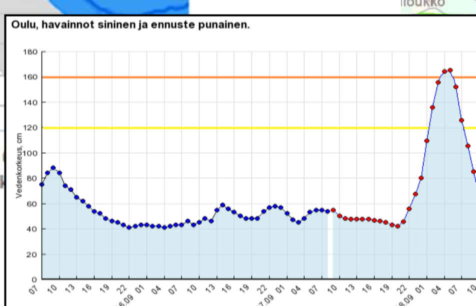


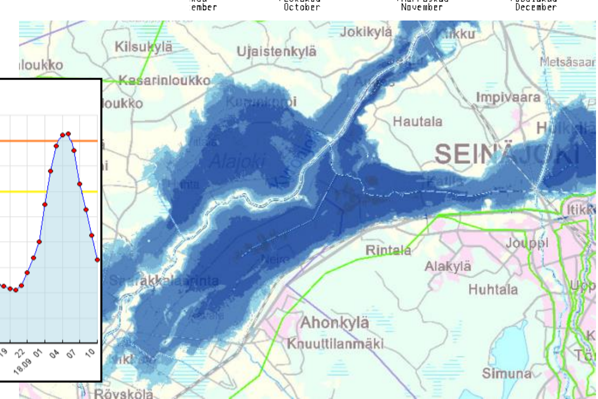






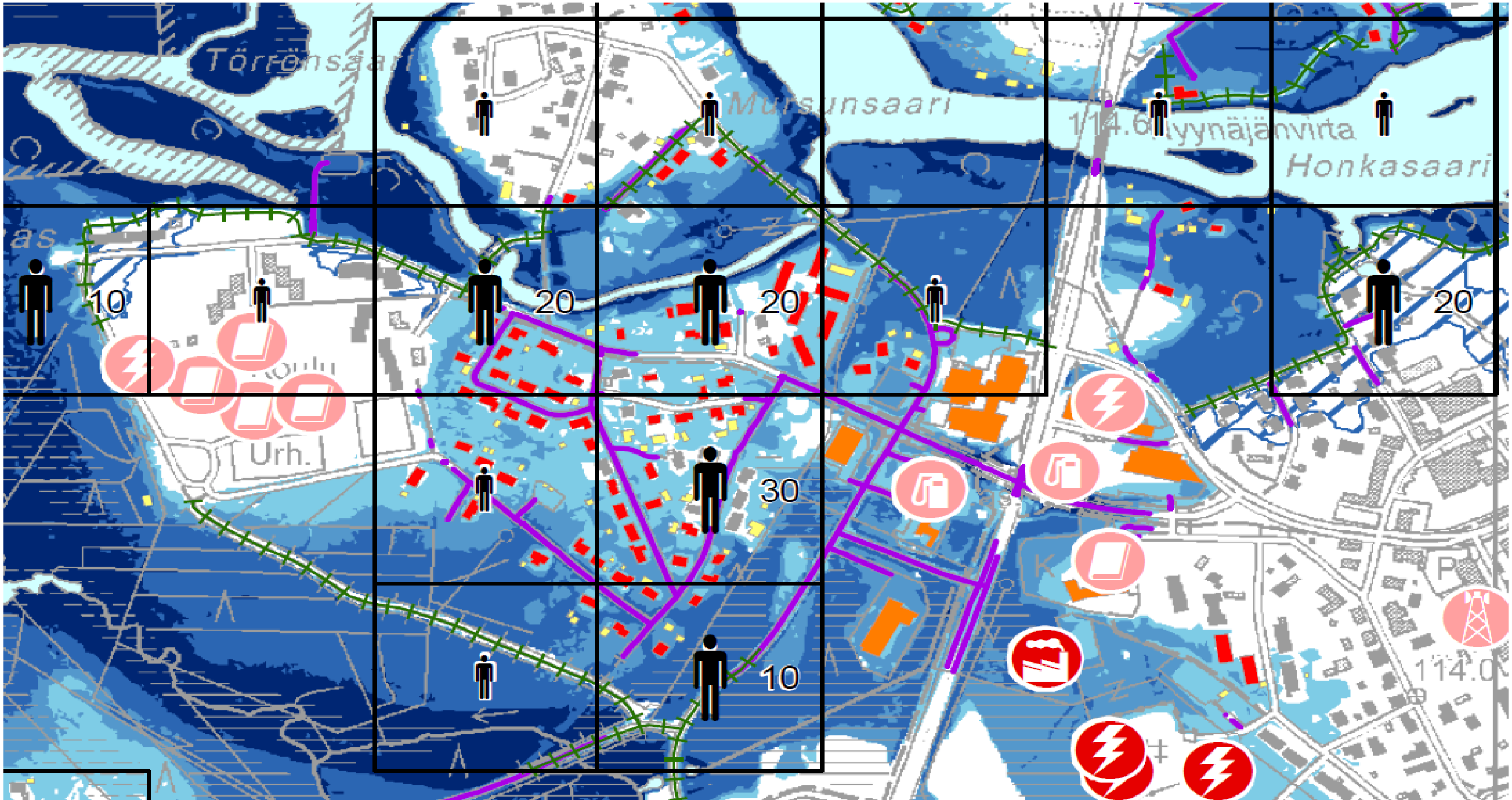




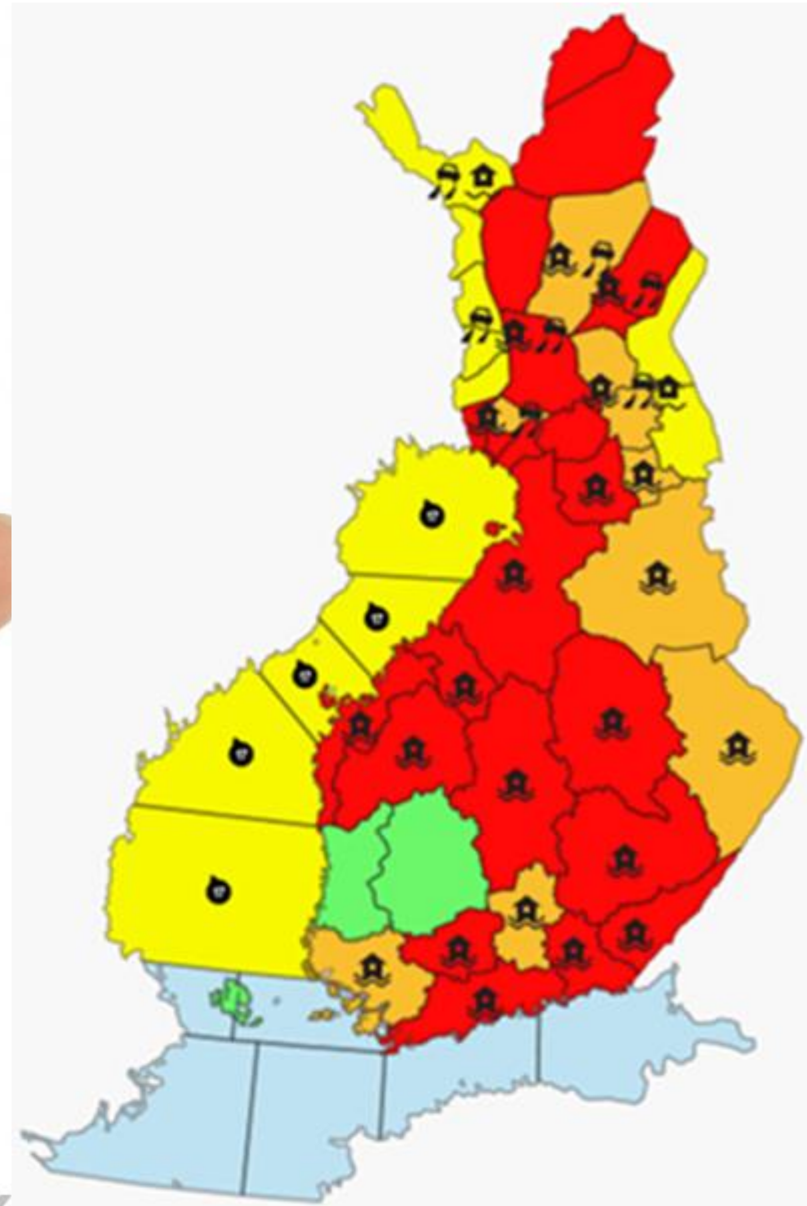


Water situation maps in television broadcast with weather forecast

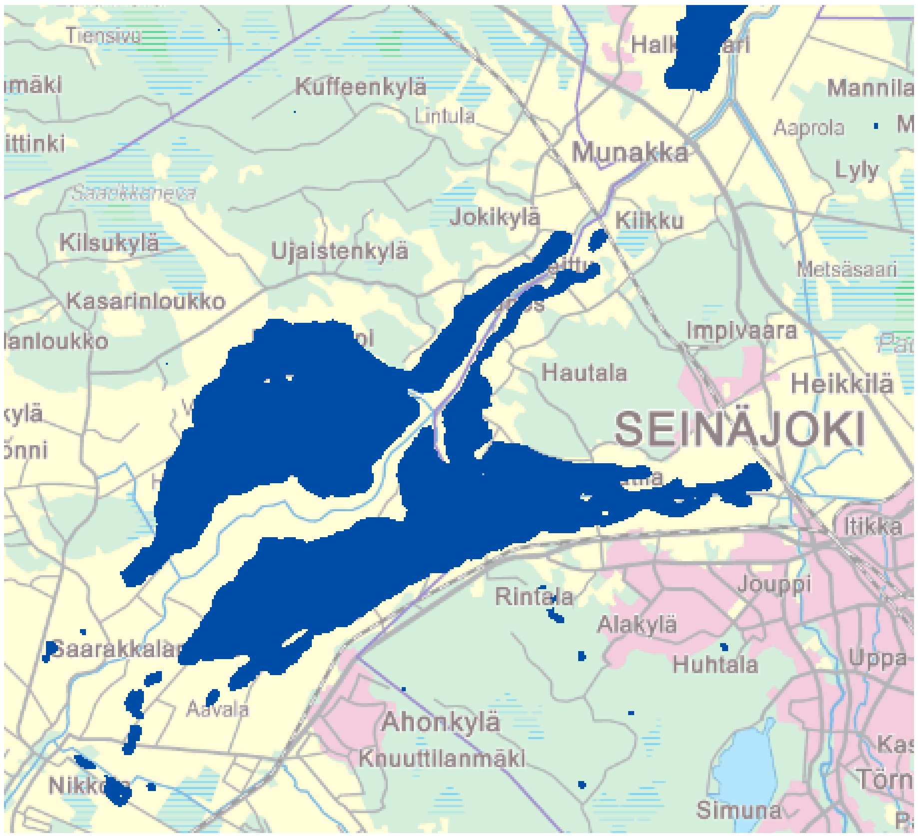
- Flood map service online
  http://paikkatieto.ymparisto.fi/tulvakartat/html5
- Flood risk maps show the potential adverse consequences associated with flood scenarios



Flood Centre (5/9)



Using COSMO-SkyMed satellite to test flood area mapping on live flood situations



Seinäjoki 23.4.2013 klo 06:45

Kittilä 23.5.2014 klo 05:25

Flood situation meetings

National authorities:

- Flood Centre
- Ministries

Video conferences

- Up-to-date situation picture among all authorities
- Flood forecasts and flood damage forecasts directly from forecasters to end users
- Regional information directly from the flood area
- Custom services (i.e. flood maps from special areas) to regional authorities

Regional authorities at flood area:

- Environmental authorities
- Rescue departments
- Municipals / communities

Other possible authorities:

- Lake regulation operators
- Hydropower companies
- Government situation center

National flood situation picture (assessment of the situation) – for authorities

- Collects regional and local information and contains information about flood situation, suffered and forecasted flood damages, weather and flood forecast
- Example of flood danger table used in situation picture:

Flood danger level

5%	Very dangerous flood	”Danger to human life and health”
80%	Dangerous flood	”Damages to buildings”
15%	Flood	”Anything which differs flood-wise from normal casual everyday life”
0%	No flood	

Flood Centre operations model

Level of preparedness	Flood service extra actions
Special situation	In addition to raised level actions Flood Centre forms a Special Situation Expert Team • Status meetings with local flood authorities via video conference whenever needed • On 24/7 alert to help local flood authorities by all means available (e.g. custom made flood risk maps, forecasts and estimates) • Gathers and distributes national flood situation picture • Crisis communications
Raised	In addition to normal level actions: • Strenghtened duty services • Strenghtened communications • Secured essential product services • Getting prepared for special situation
Normal	Normal actions: • Situation monitoring and forecasting • Warnings • Officers on duty co-operation • Daily / bi-weekly status meetings

National water situation and flood information (1/4)

National water situation online:

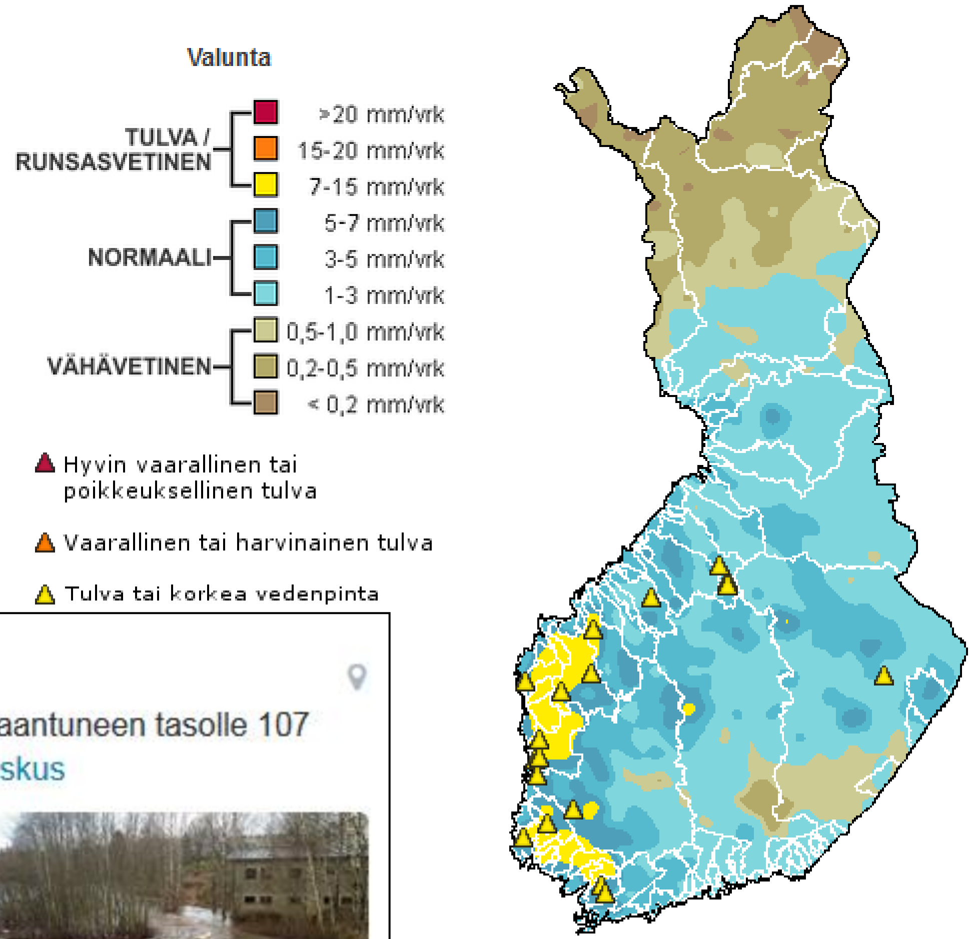
http://www.ymparisto.fi/vesitilanne (in Finnish)

- Edited, up-to-date information about water situation in Finland
- Flood information during floods
- Written hydrological forecasts for basins
- Overall and detailed versions

Joet tulvakorkeuksissa Etelä- ja Keski-Pohjanmaalla sekä Lounais-Suomessa (Tulvakeskus 6.12.)

Länsirannikon jokien vedenpinnat ovat paikoin tulvakorkeuksissa sateisen ja lauhan sään johdosta. Lapväärtinjoella, Teuvanjoella, Närpiönjoella ja Maalahdenjoella vesi on noussut tulvakorkeuteen. Vesi on noussut pelloille Loimijoella ja Lapuanjoen Liinamaassa. Tälle päivälle ennustetut sateet kasvattavat jokien virtaamia vielä paikoin Etelä- ja Keski-Pohjanmaalla ja Lounais-Suomessa. Sateiden vaikutukset ulottuvat myös Etelä- ja Itä-Suomen vesistöihin nostaen jokien vedenkorkeuksia. Vesi nousee jokiuomissa paikoin vastaaman keskimääräistä tulvaa Etelä- ja Keski-Pohjanmaalla sekä Lounais-Suomessa. Lisää

6.12.2015



SYKEn hydrologit uudelleentwiittasi

ELY Tulvatpohjanmaa @tulvatpohjanmaa · 14 t

#Närpiönjoki 'en virtaaman nousu näyttää tasaantuneen tasolle 107 m3/s ja aurinko paistaa joen alaosalla #elykeskus

Vesitilanne ja ennuste 7.2.2014

Tulvakeskuksen vesitilanne ja ennuste 7.- 12.2.2014

Laadittu 7.2.2014

LAATIJAT
Tulvapäivystäjä Juho Jakkila
LUOVA-päivystäjä Helena Laakso/Paavo Korpela
Meripäivystäjä -

VAARATASOJEN TODENNÄKÖISYYDET
[0%] Hyvin vaarallinen tulva
[0%] Vaarallinen tulva
[5%] Tulva
[95%] Ei tulvaa

VESISTÖJEN TILANNE TIIVISTETYSTI
Viikonloppuna lauhtuva sää ja vesisateet lisäävät valuntaa ja rannikkoalueiden pienten jokien virtaamia Etelä- ja Lounais-Suomessa. Rannikkoalueiden lumimäärät ja viikonlopuksi ennustetut sateet eivät kuitenkaan nosta jokien vedenkorkeuksia tulvalukemiin. Mikäli sää jatkuu leutona ja sateisena voi tilanne muuttua ensi viikon aikana.

ARVIOT VAHINGOISTA
Todennäköisesti ei uusia vahinkoja.

EPÄVARMUUSTEKIJÖITÄ
Lauhtuva keli saattaa irrottaa jokien suppokasaumia ja synnyttää uusia jääpatoja, mikä voi aiheuttaa paikallista tulvimista. Tämä ei kuitenkaan ole kovin todennäköistä.

SÄÄ- ja RANKKASADETILANNE TIIVISTETYSTI
Suomessa vallitsee viikonlopun ajan lauha etelänpuoleinen ilmavirtaus. Lauantaina lumisadealue liikkuu Suomen yli. Lounaassa sataa myös räntää, ehkä vettäkin. Sadetta kertyy vedeksi muutettuna 2-10 mm, Pohjois-Lapissa 0-2 mm. Sunnuntaina alkuviikolla tulee paikoin vähäisiä lumi- tai jäätäviä tihkusateita.

MERIVESITILANNE TIIVISTETYSTI
Ennustejakson aikana ei ole odotettavissa merivesitulvia.

Vesitilanne ja ennuste 29.11.2015

Tulvakeskuksen vesitilanne viranomaisille
29.11. - 1.12.2015

LAATIJAT
Tulvapäivystäjä Tiia Vento
Meripäivystäjä -
Luova-päivystäjä Hannu Valta

LAATIJAT
Tulvapäivystäjä Tiia Vento

VAARATASOJEN TODENNÄKÖISYYDET

Vesistötulvat:
[0 %] Hyvin vaarallinen tulva
[2 %] Vaarallinen tulva
[78 %] Tulva: Pohjanmaa, Etelä-Pohjanmaa
[20 %] Ei tulvaa

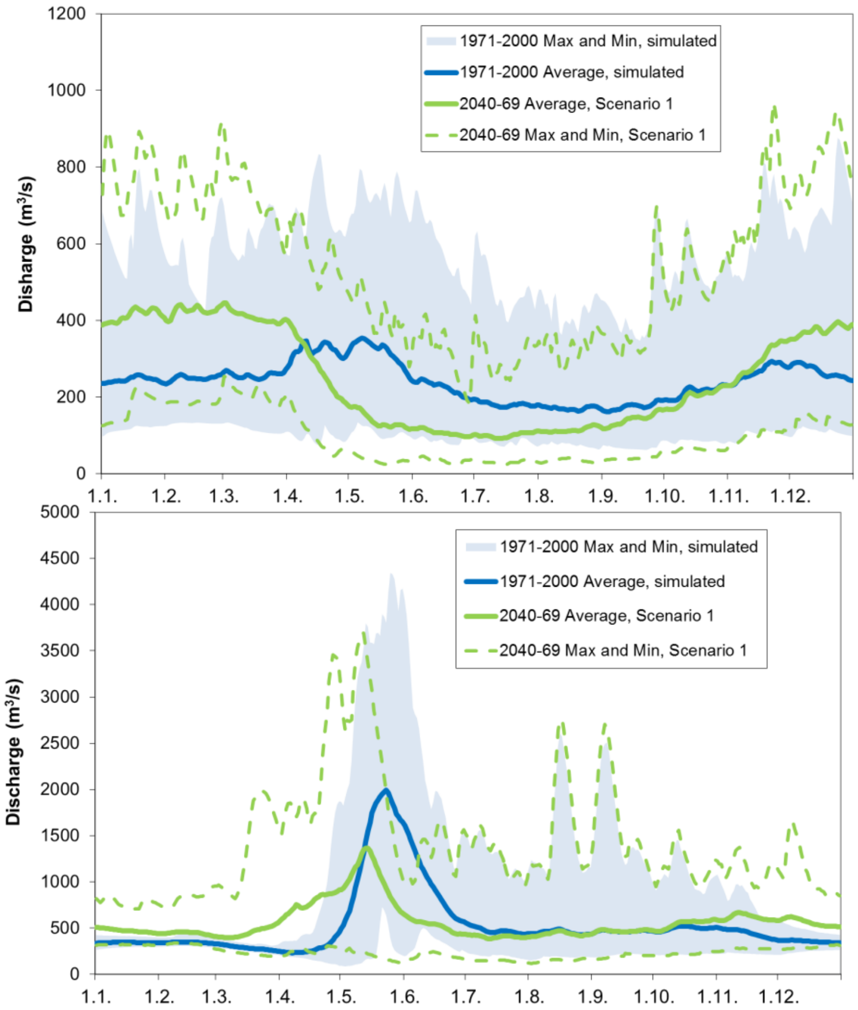
VESISTÖJEN TILANNE TIIVISTETYSTI
Sateinen ja lauha sää on kasvattanut virtaamia etenkin Pohjanmaan alueella tällä viikolla. Vaasan eteläpuolisissa pienissä vesistöissä jokien pinnat ovat nousseet korkealle yön ja aamun aikana. Matalapaine tuo lisää sateita Pohjanmaan alueelle ja sadekertymä lähipäiville on ennusteen mukaan 20-30 mm. Jos sateet tulevat vetenä ne nostavat virtaamia nopeasti sillä maaperä on märkää. Vesi voi nousta alaville pelloille ja myös tulviminen paikallisteille on mahdollista.

MERIVESITILANNE TIIVISTETYSTI
Tuulista johtuen merenpinta on viikonvaihteessa paikoin
korkealla eritoten Saaristomerellä ja Pohjanlandella.

RANKKASADETILANNE TIIVISTETYSTI
Rankkasateiden todennäköisyys on vähäinen.

Climate change and hydrology

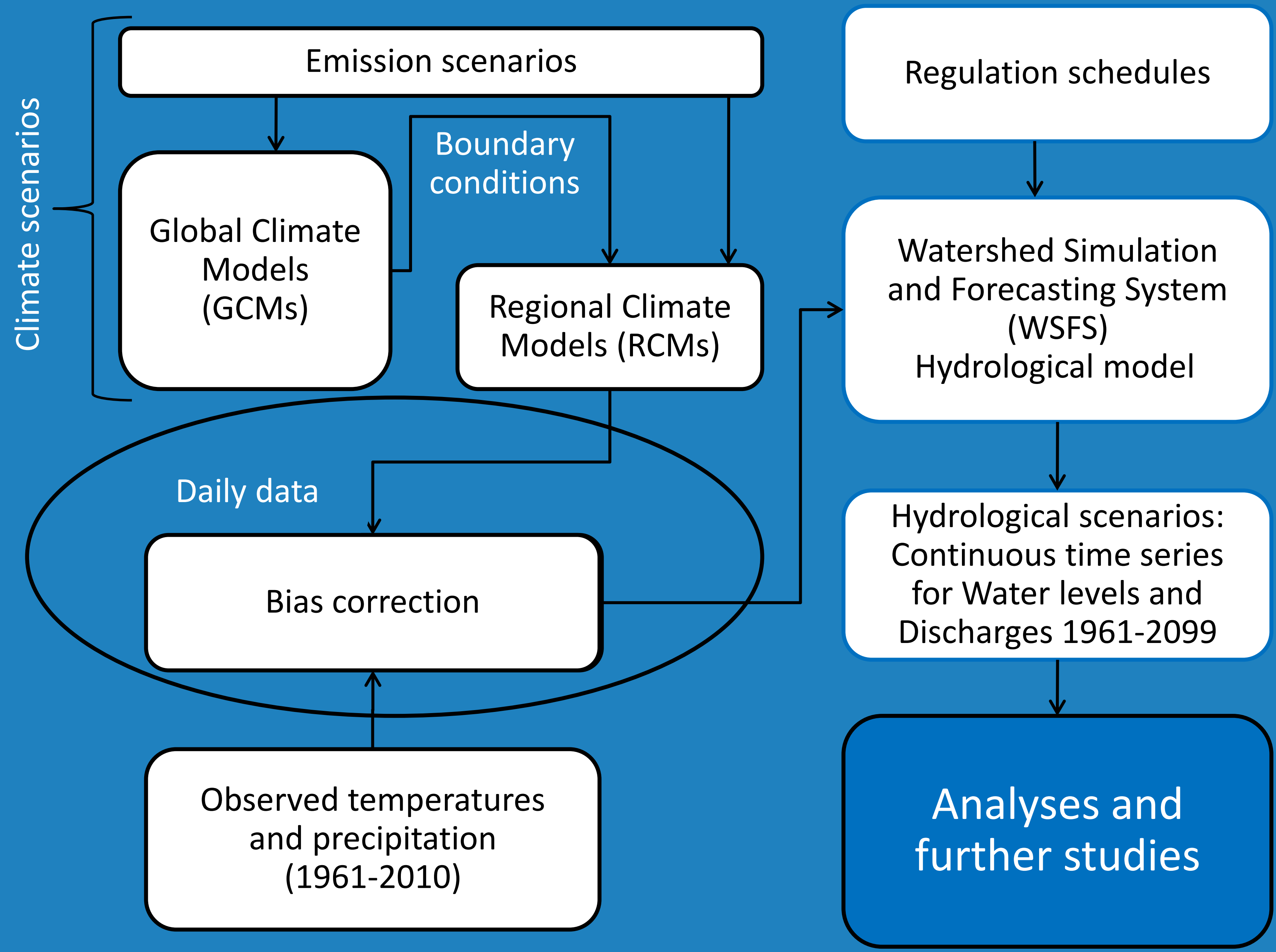
- Effects of climate change on hydrology
  - Floods and droughts
  - Regulation planning
  - Groundwater level
  - Water quality
- Adaptation to climate change impacts
  - Changes in lake regulation
  - Flood risk management



Climate change: methods

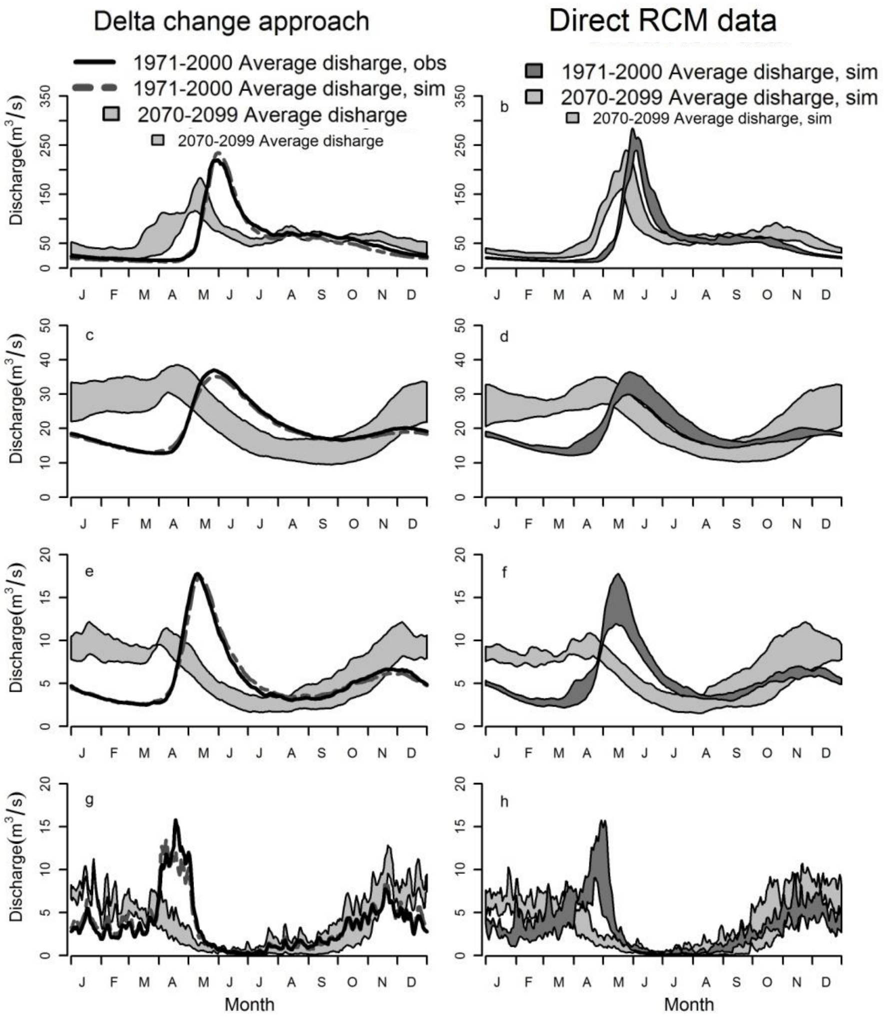
- Global and regional climate scenarios
  - European meteorological institutes, ENSEMBLES project
    - European Rossby Centre: RCA3
    - Max-Planck Institute: Echam, REMO
    - Danish Meteorological Institute: HIRHAM
    - METEO-FRANCE: ARPEGE
    - Bergen climate model: BCM
    - The National Center for Atmospheric Research (US): NCAR
  - SRES-scenarios a2, a1b and b1
- Delta change and Bias correction methods
- Co-operation with FMI
- In the future CMIP5

Climate change research (3/4)



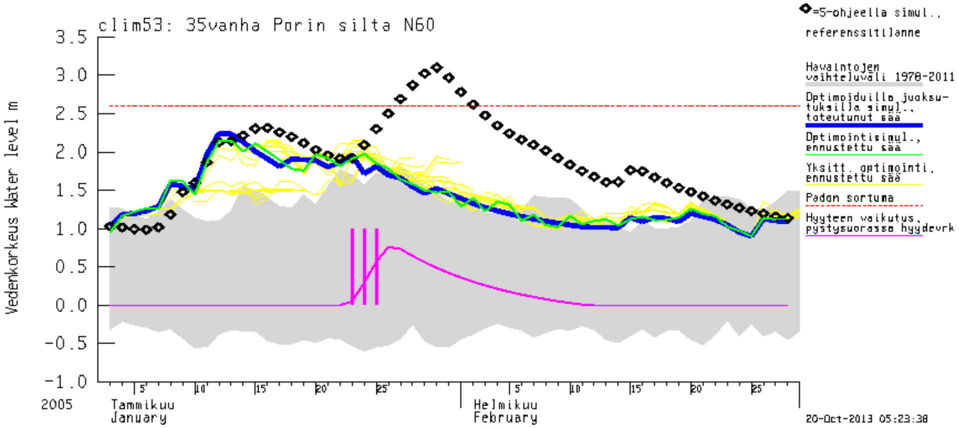
Comparison of the results with delta-change and bias correction methods

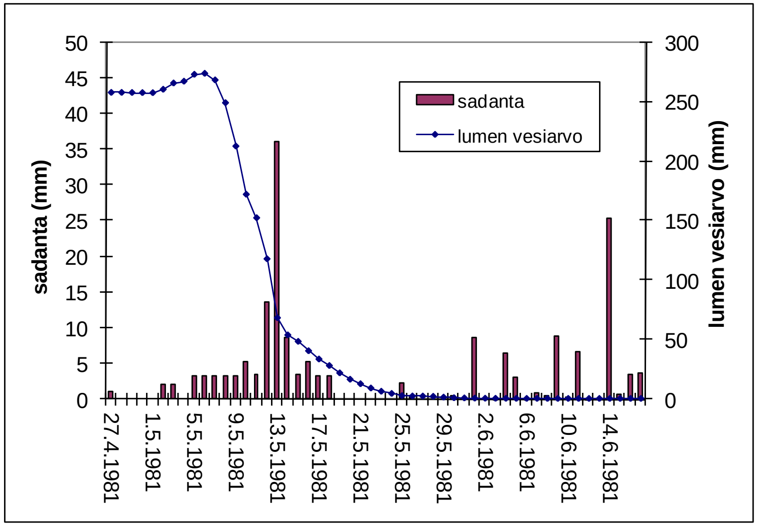
- Differences between delta-change and q-q-mapping studied with 4 scenarios in 4 test sites
- Similar results in mean discharges with different methods
- Different changes e.g. in spring in Northern Finland
- Bias correction is expected to improve the estimation of the changes in summer and autumn floods

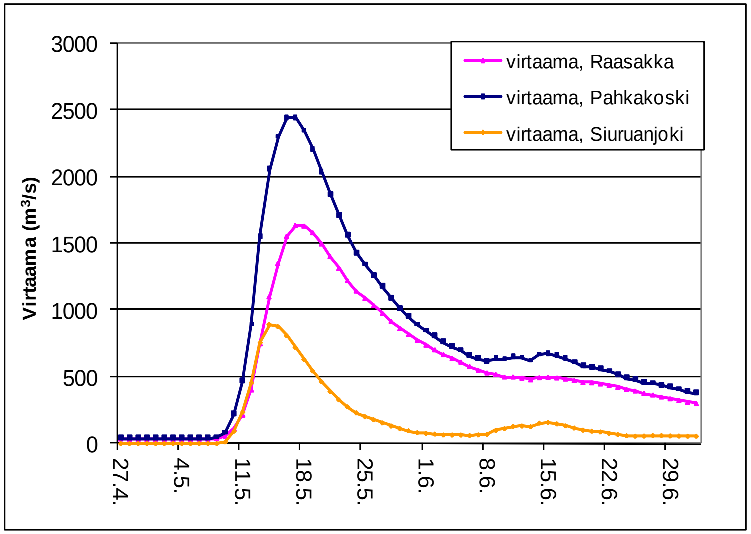


WSFS can be used for planning and rehearsal purposes

- Estimation of design floods for dams
- Tailored made scenarios and forecasts for major flood rehearsals

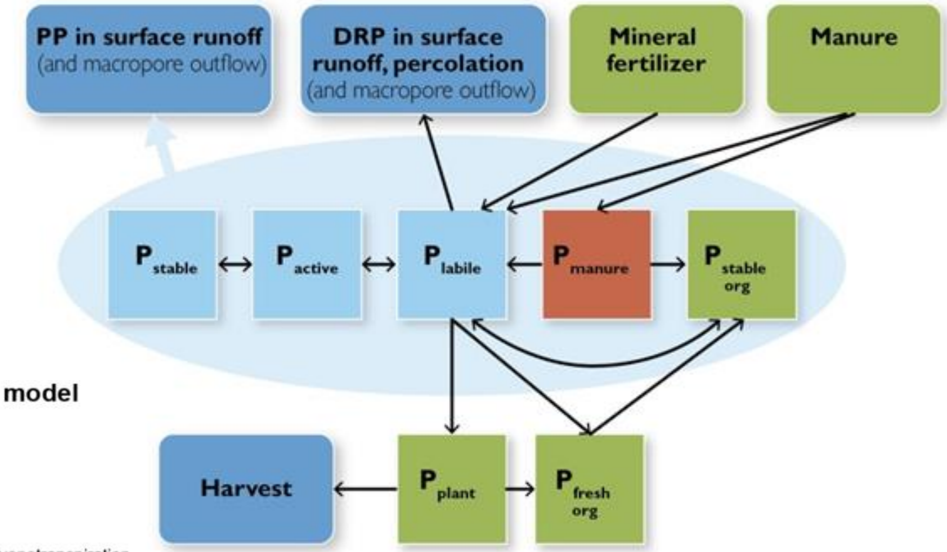


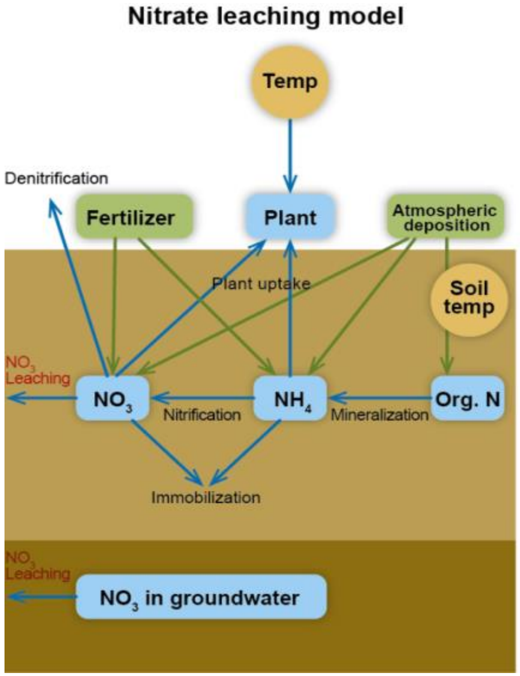


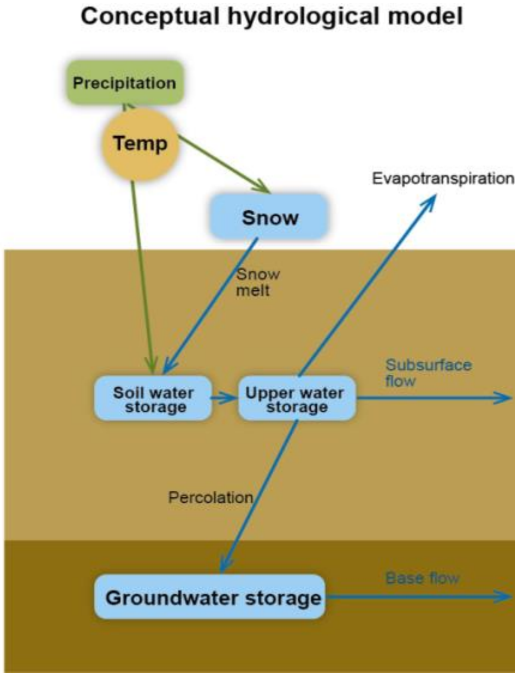


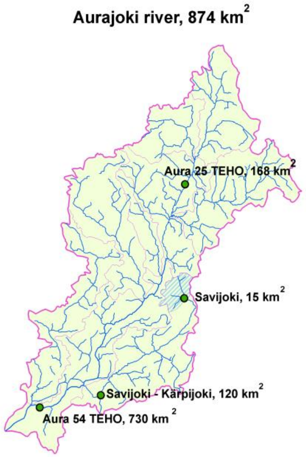
Process model development
Water quality (1/8)

- Water quality process model development





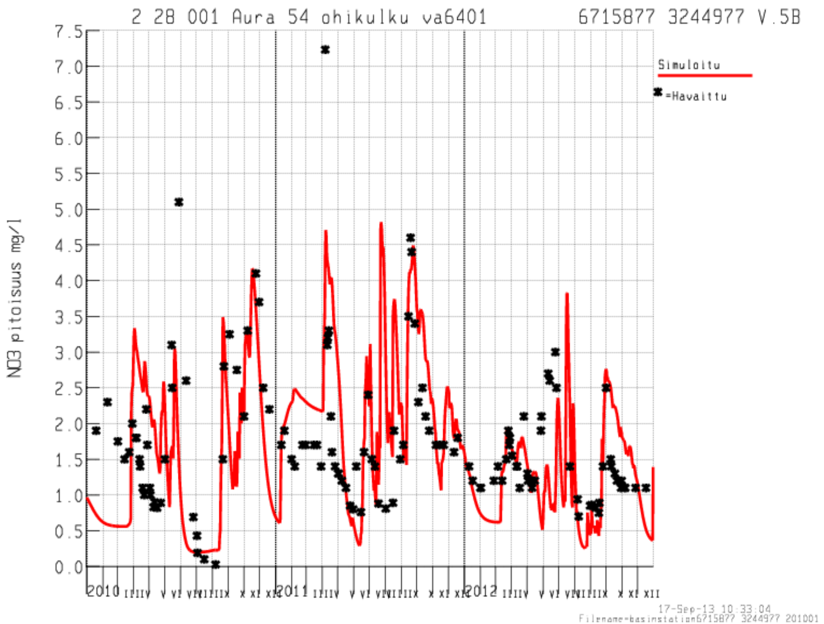


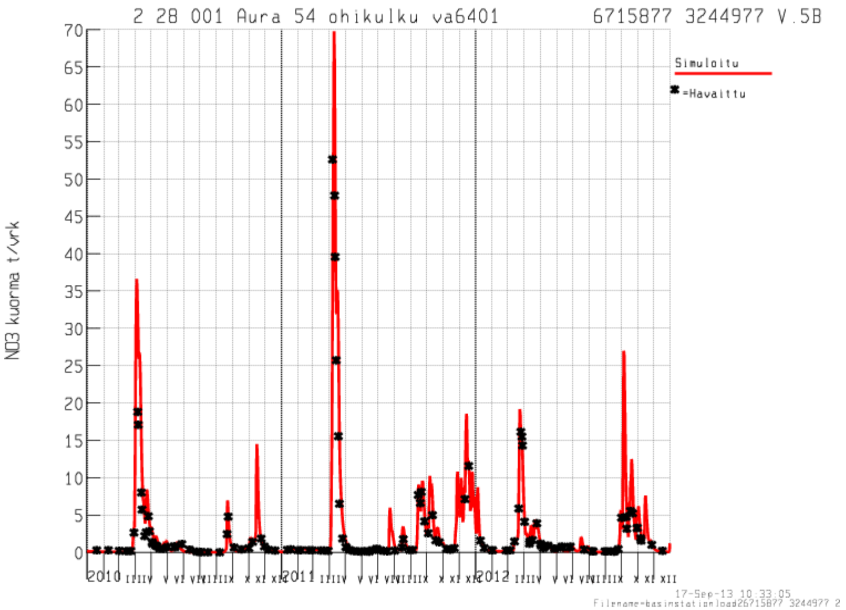


Simulated daily NO_3^- concentration and load

- Example: Aurajoki watershed (874 km²): cultivated land 37 %, from which 47 % is clay

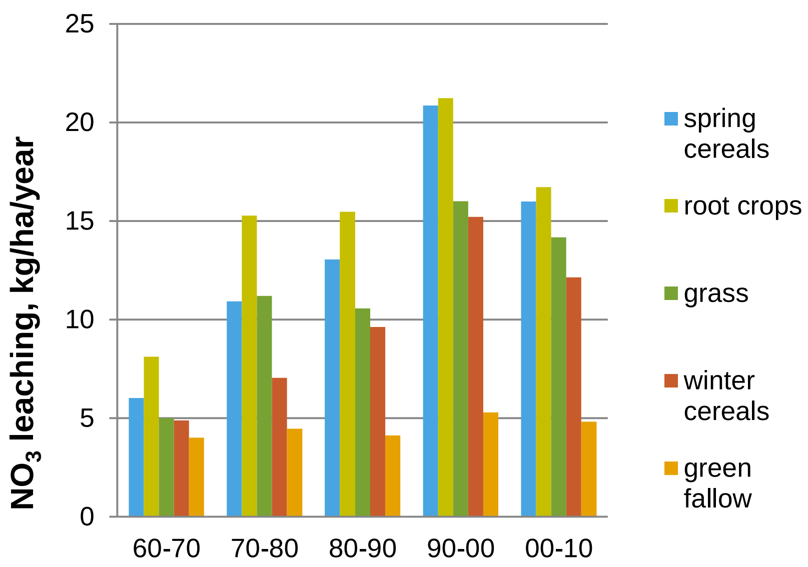
- Simulated NO_3^- concentration
- Simulated NO_3^- load



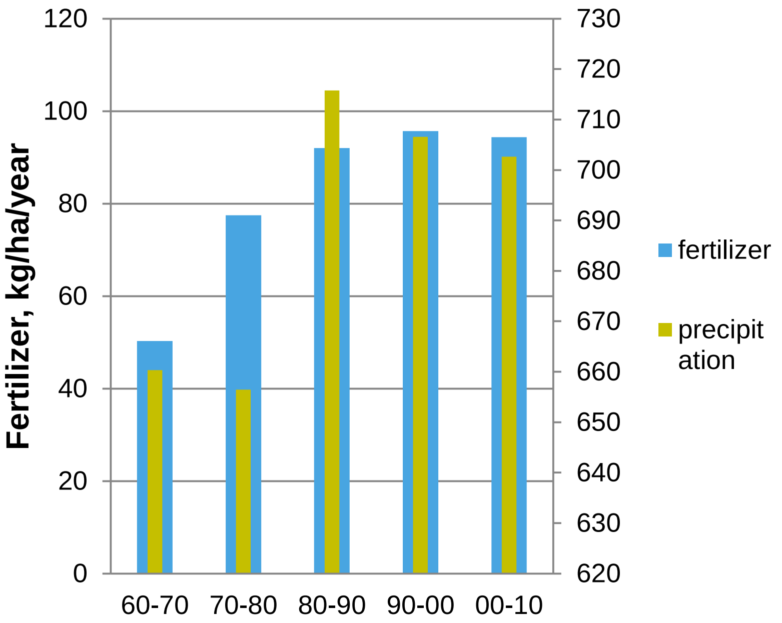


Model can be used to simulate effect of changing crop and fertilization on the nitrate leaching

- Nitrate leaching is the highest for root crops, then spring cereals, grasslands, winter cereals and the least from green fallow



- Amount of fertilizer use and precipitation effects the amount of nitrate leaching



Daily biomass growth based on global radiation (Karvonen and Varis, 1992)

$$G = 10 * E_{rad} * f_{LAI} * 0.48 * R_s * MIN(f_W, f_N, f_P, f_T)$$

$$f_{LAI} = (1 - e^{k_E LAI})$$

G – daily biomass growth, kg Dry Matter/ha/day

R_s- global short wave radiation MJ/m^2/day,

E_{rad}- light use efficiency LUE constant (crop specific), g dry matter/MJ, clover 1.6, spring wheat 1.4-1.8, LUE depends on CO_2 concetration in atmosphere

0.48 – fraction of PAR (photosynthetically active radiation) from total daily global radiation,

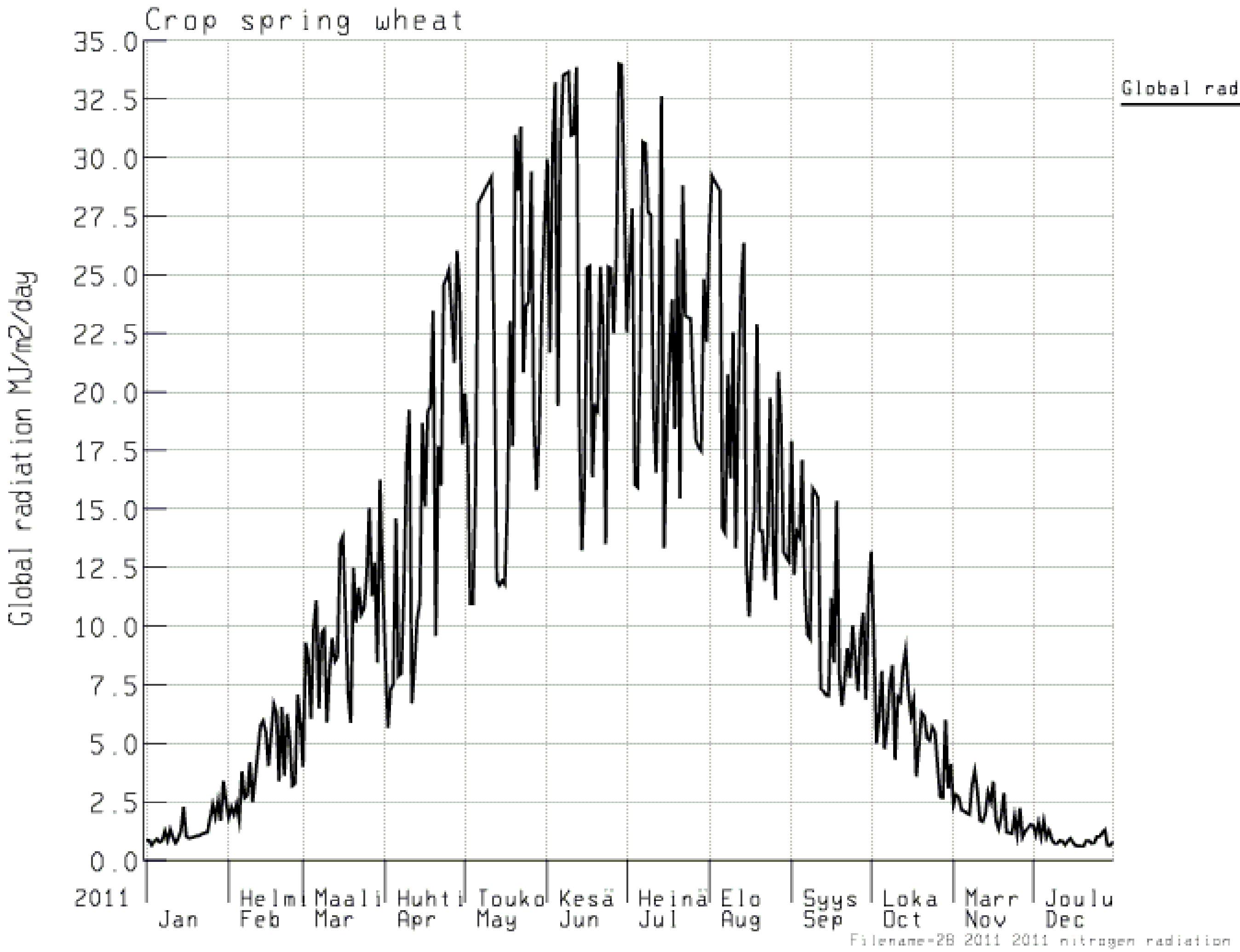
f_{LAI}- the effect of incomplete canopy

k_E- radiation attenuation by plants (0.6…0.7)

f_w – soil moisture effect on photosyntesis, f_N- N shortage coefficient, f_P- P shortage coefficient, f_T – temperature effect coefficient

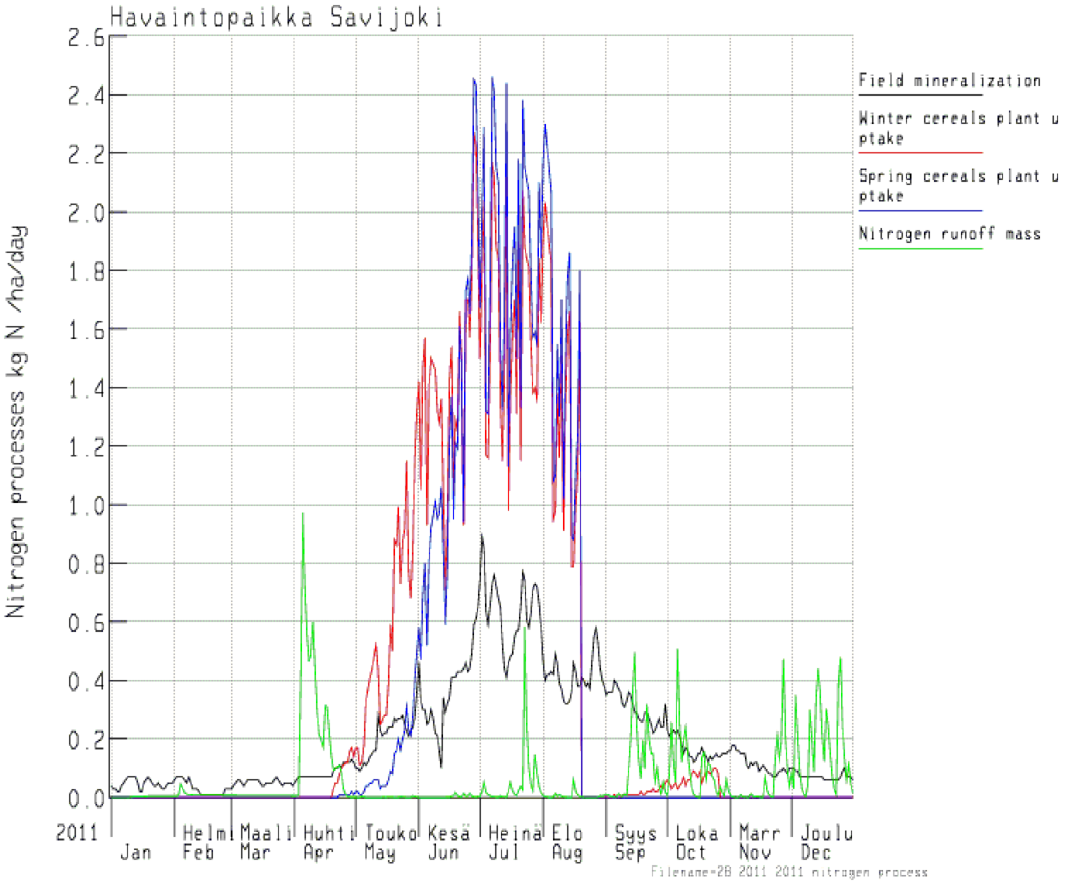
MIN is searching for the limiting factor of the 4 above mentioned factors.

Simulated short wave radiation, max observed at Jokionen around 30 MJ/m2/day



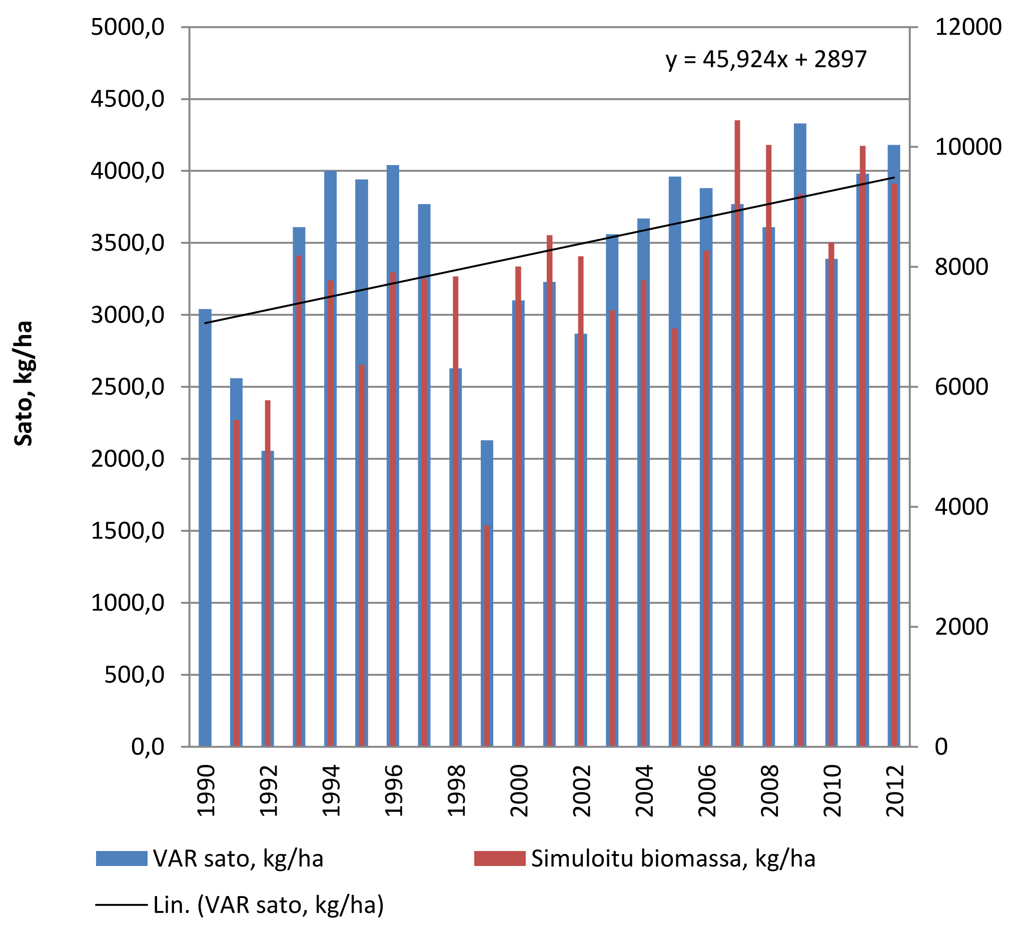
Simulated daily N uptake for spring and winter cereals

- Spring cereals –
  N uptake 110 kg/ha, biomass 7828 kg/ha
- Winter cereals –
  N upake 139 kg/ha, biomass 9205 kg/ha
- Winter cereals start to grow in autumn and faster is taking nutrients up in spring



Annual spring cereal yields (VAR-ely) and simulated biomass (Aurajoki)

- Annual spring cereal yields are increasing during the ast two decades
- Model can well simulate the effect of dry years on the biomass development (1992, 1999)



Use of the biomass growth model

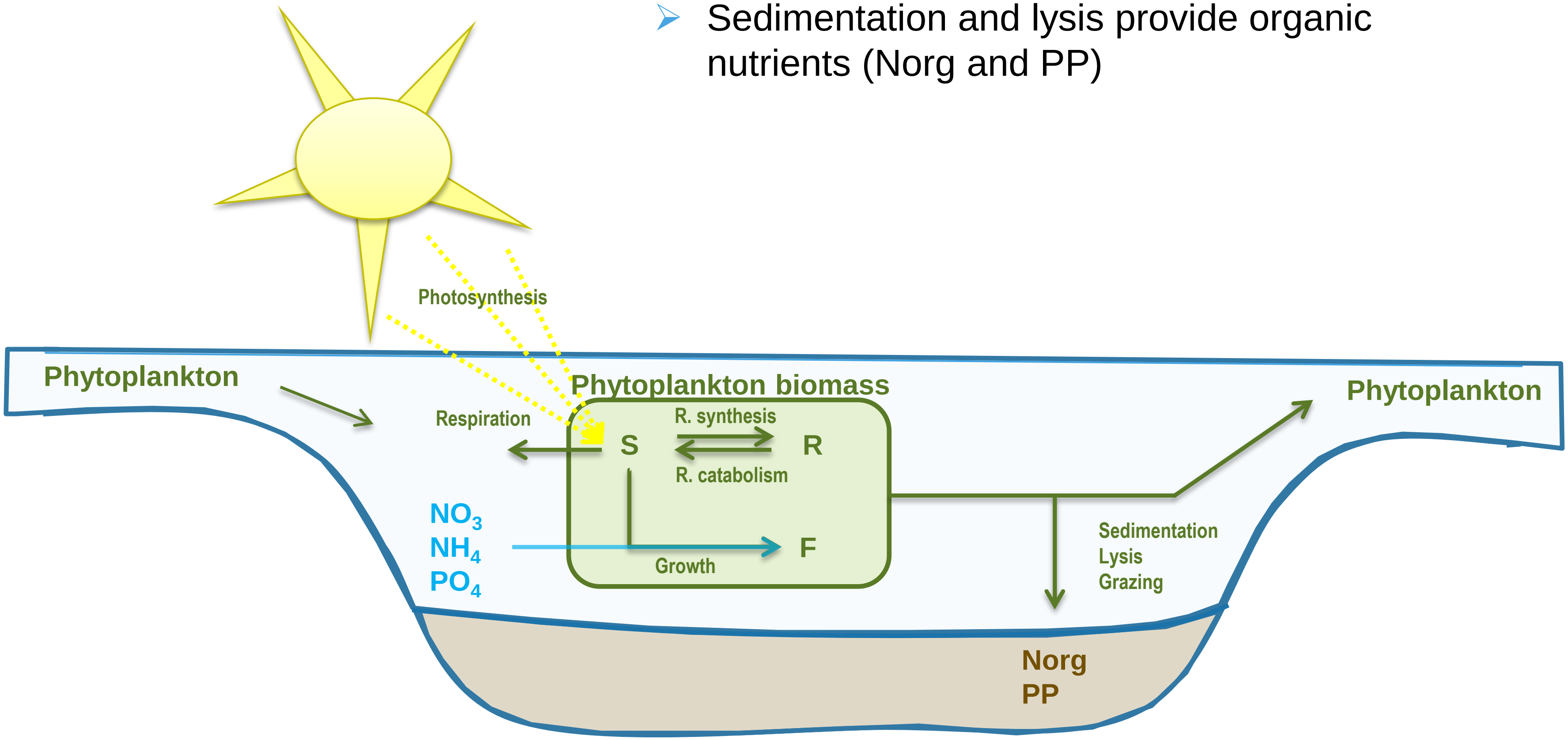
- Biomass growth model is used in simulating N demand/uptake
- Biomass growth model simulates Leaf are index (LAI) and it can be used in actual evapotranspiration model development

Introduction

- The VEMALA model is developed towards a more process-based model where the same processes are applied in lakes and rivers but the conditions change (water velocity, depth and mixing)
- The variables included in the future VEMALA model are:
  - Nitrogen (Norg, NO_3, NH_4)
  - Phosphorus (PP, PO_4)
  - Phytoplankton (2 different species)
  - Oxygen
- The modeling of these variables requires the development of:
  - Sediment processes for the nutrient cycling
  - Lake stratification for the nutrients and oxygen cycling

Phytoplankton model based on the AQUAPHY model (Lancelot et al., 1991)

- Interaction of nutrients and phytoplankton:
  - Nutrient uptake of dissolved nutrients (NO_3, NH_4 & PO_4)
  - Sedimentation and lysis provide organic nutrients (Norg and PP)

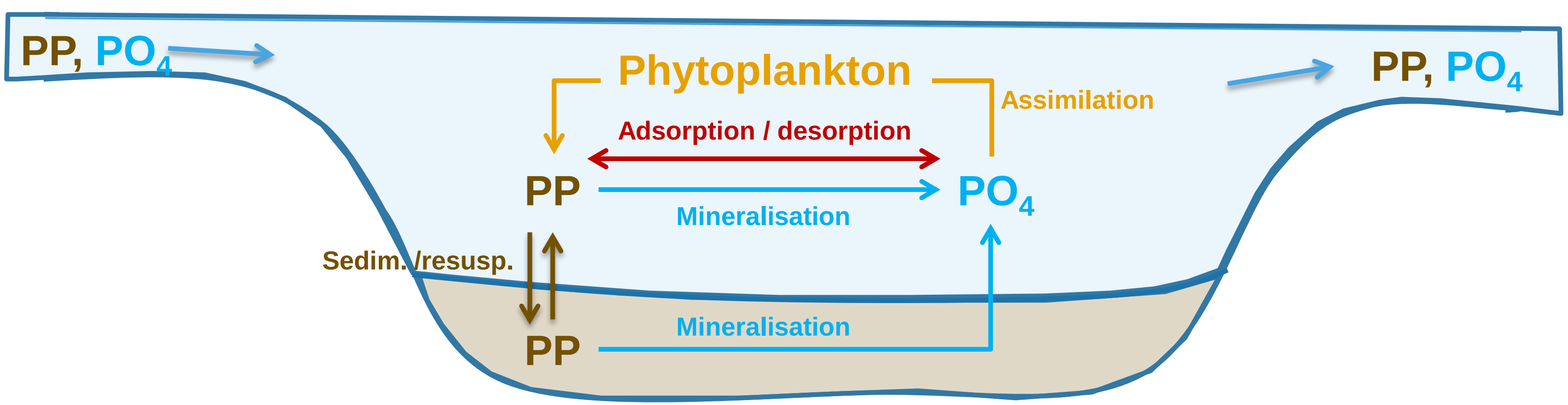


- The phytoplankton model is based on the idea that phytoplanktonic cells synthesize storage material for the future requirement of growth allowing growth to continue in the dark.

Phosphorus cycling: particulate phosphorus (PP) and phosphate (PO_4)

Phosphorus processes in lakes include:

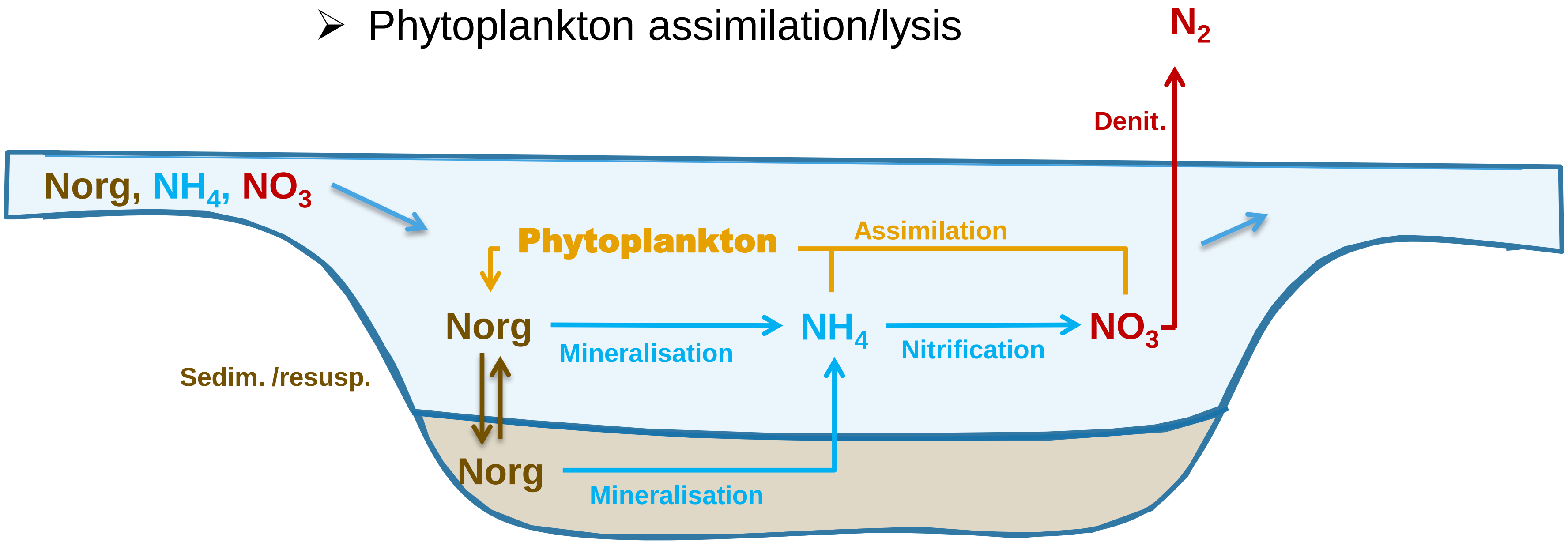
- Transport
- Sedimentation / Resuspension
- Mineralisation
- Adsorption / Desorption
- Phytoplankton assimilation/lysis



Nitrogen cycling: nitrate (NO_3), ammonium (NH_4) and organic nitrogen (Norg)

Nitrogen processes in the water include:

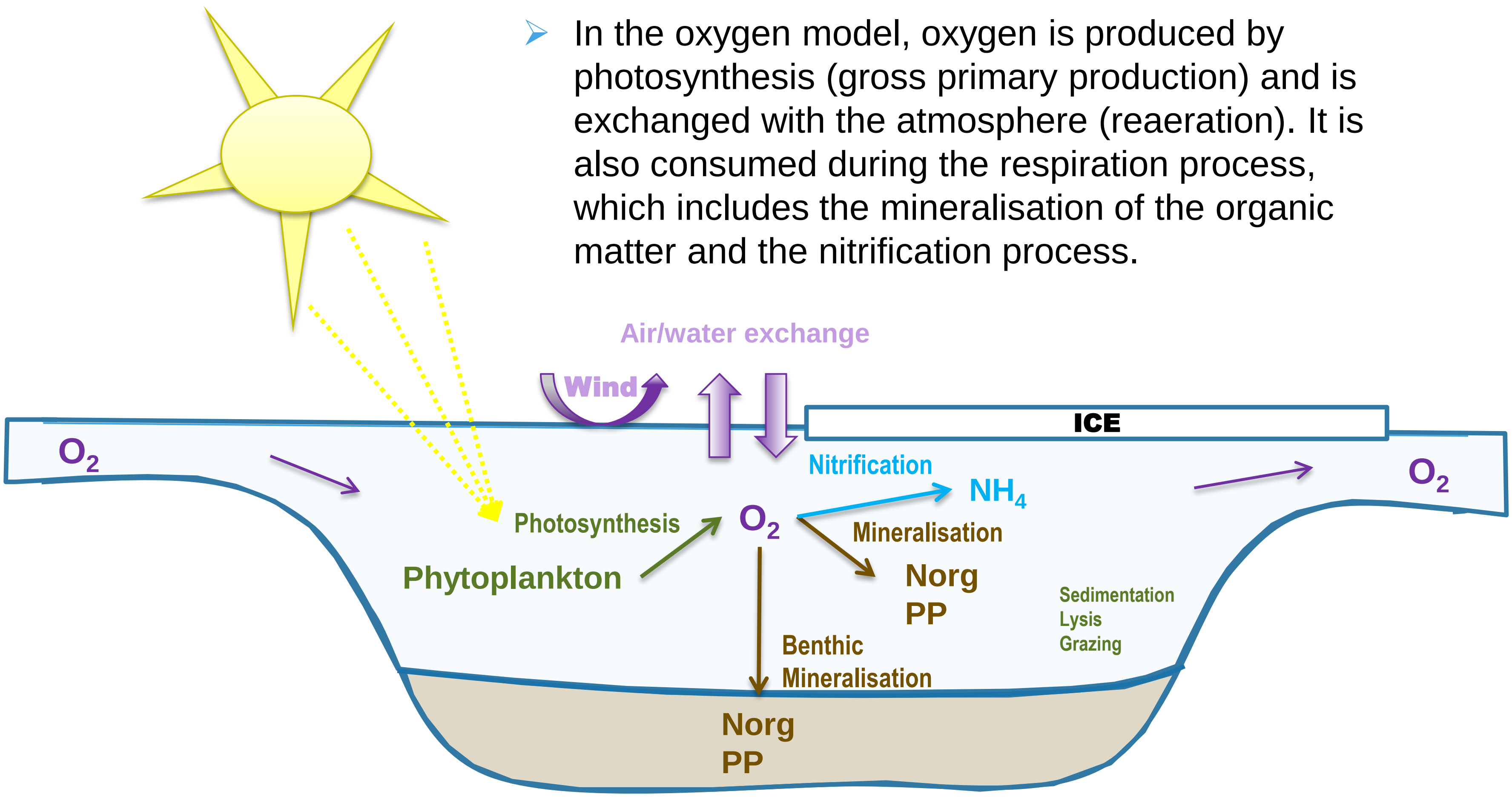
- Transport
- Sedimentation / Resuspension
- Mineralisation
- Nitrification
- Denitrification
- Phytoplankton assimilation/lysis



Oxygen (Hanson et al., 2008)

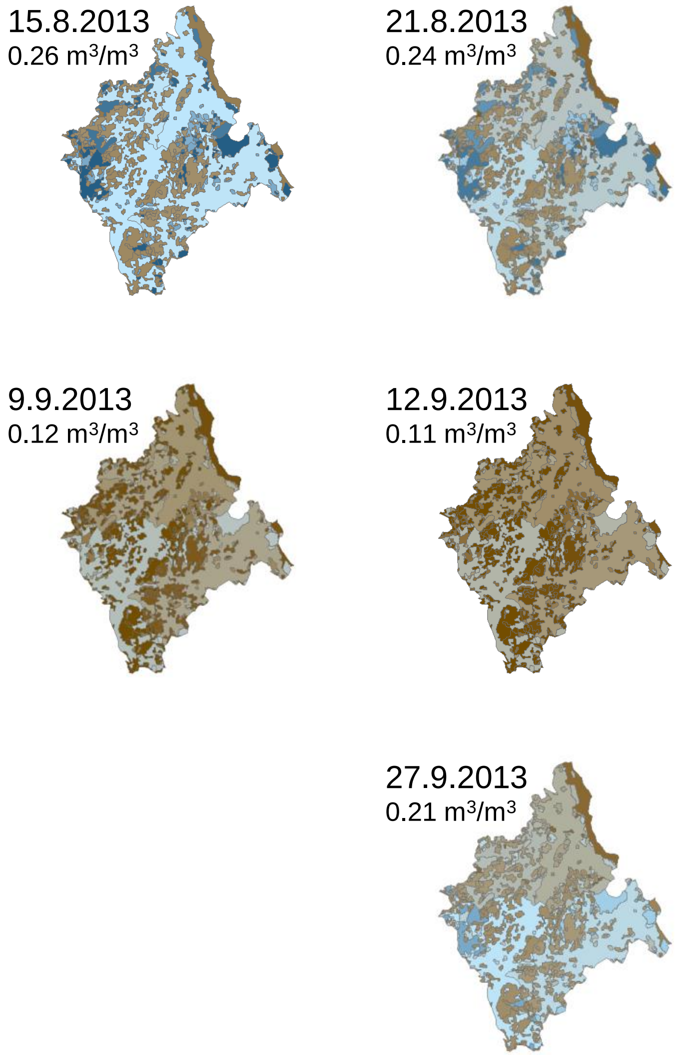
$$\frac{dO2}{dt} = O_{2t-1} + Photo_{t-1} - Miner_{t-1} + Reaeration_{t-1}$$

- In the oxygen model, oxygen is produced by photosynthesis (gross primary production) and is exchanged with the atmosphere (reaeration). It is also consumed during the respiration process, which includes the mineralisation of the organic matter and the nitrification process.



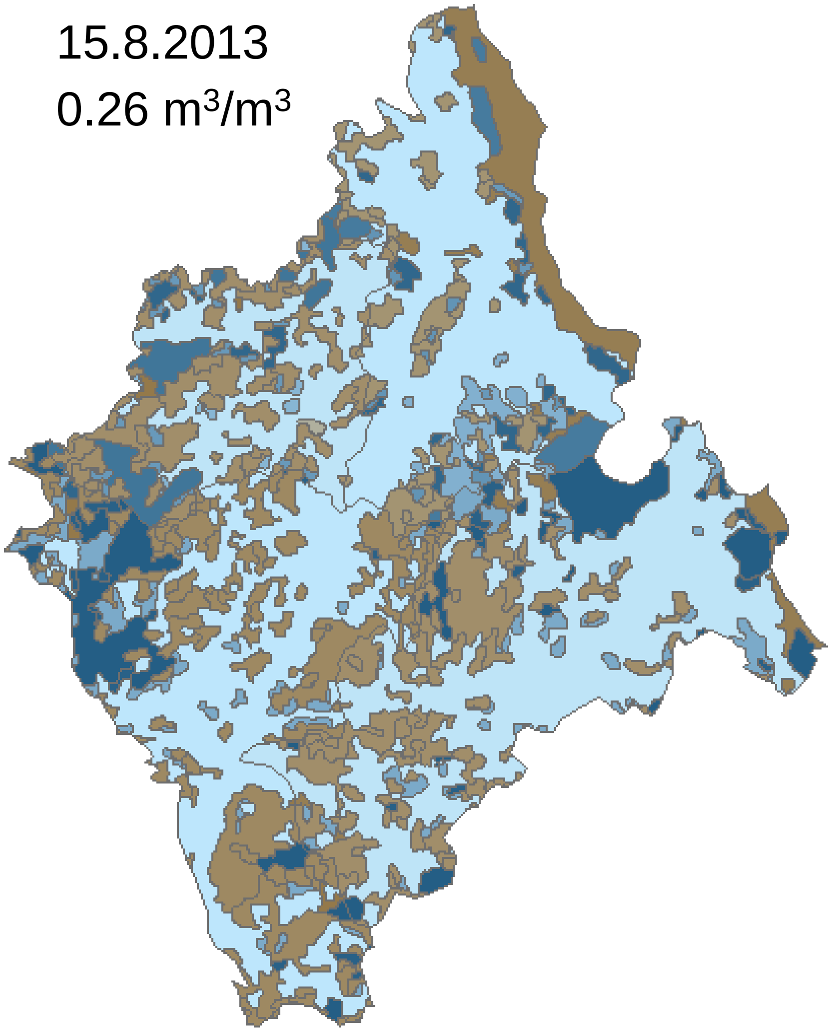
Maankosteuden kaksikerrosmalli

- Operatiivisen maankosteusmallin pohjalta kehitetty fysikaalisempi maankosteusmalli
  - Simuloi maankosteutta maaperän pinta- ja pohjakerroksessa
  - Hyödyntää Suomen maannostietokannan maaperätietoja
  - Kalibroitu käyttäen SYKEn maankosteushavaintoverkkoa
- Edut aiempaan malliin verrattuna
  - Realistisempi maankosteuden alueellinen vaihtelu
  - Mallin tuloksia voidaan verrata suoraan
    - SYKEn maankosteushavaintoihin
    - Maankosteuden kaukokartoitustuotteisiin



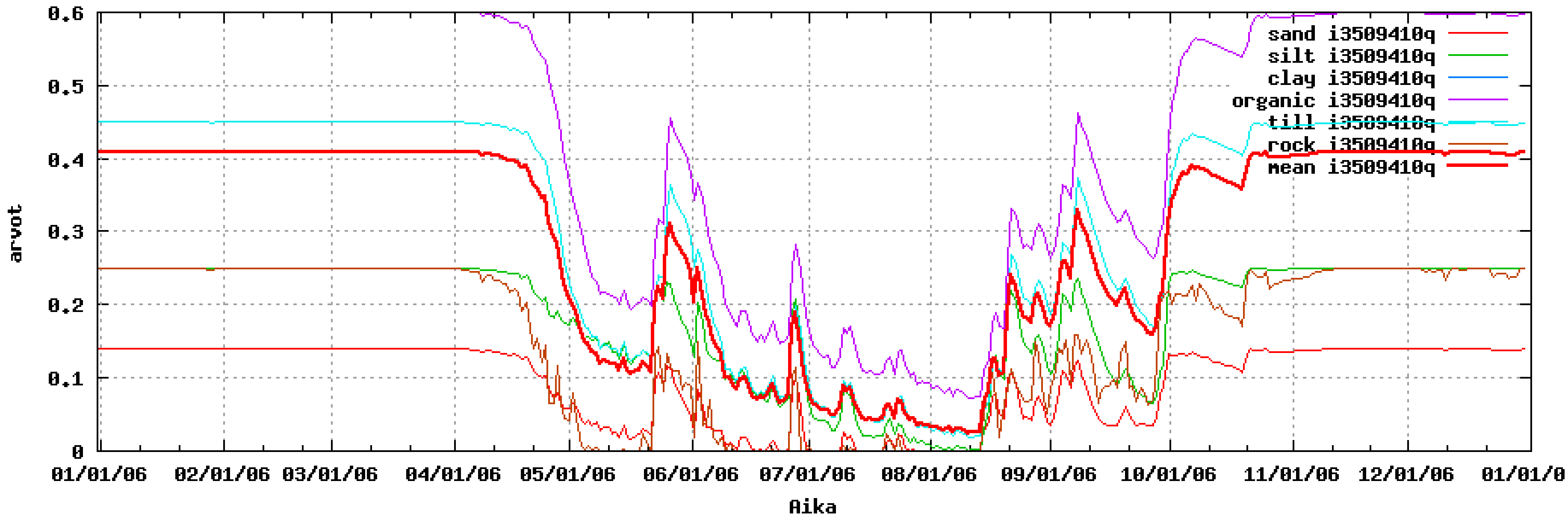
Maankosteuden kaksikerrosmalli

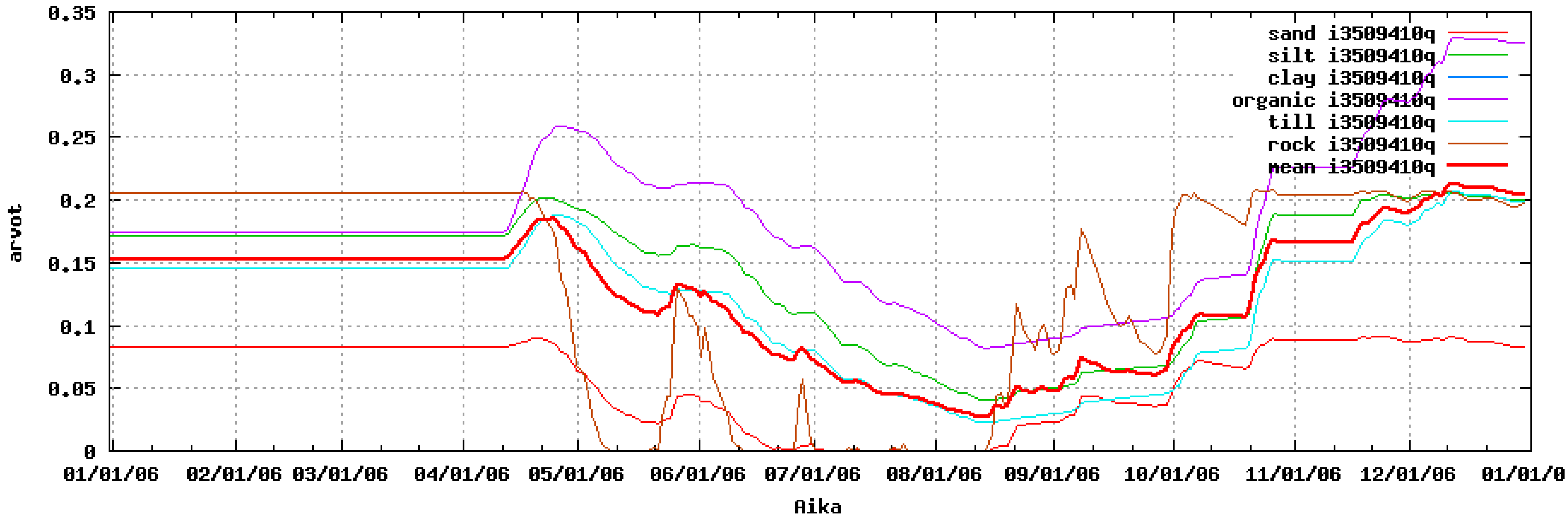
15.8.2013
0.26 m³/m³



12.9.2013
0.11 m³/m³

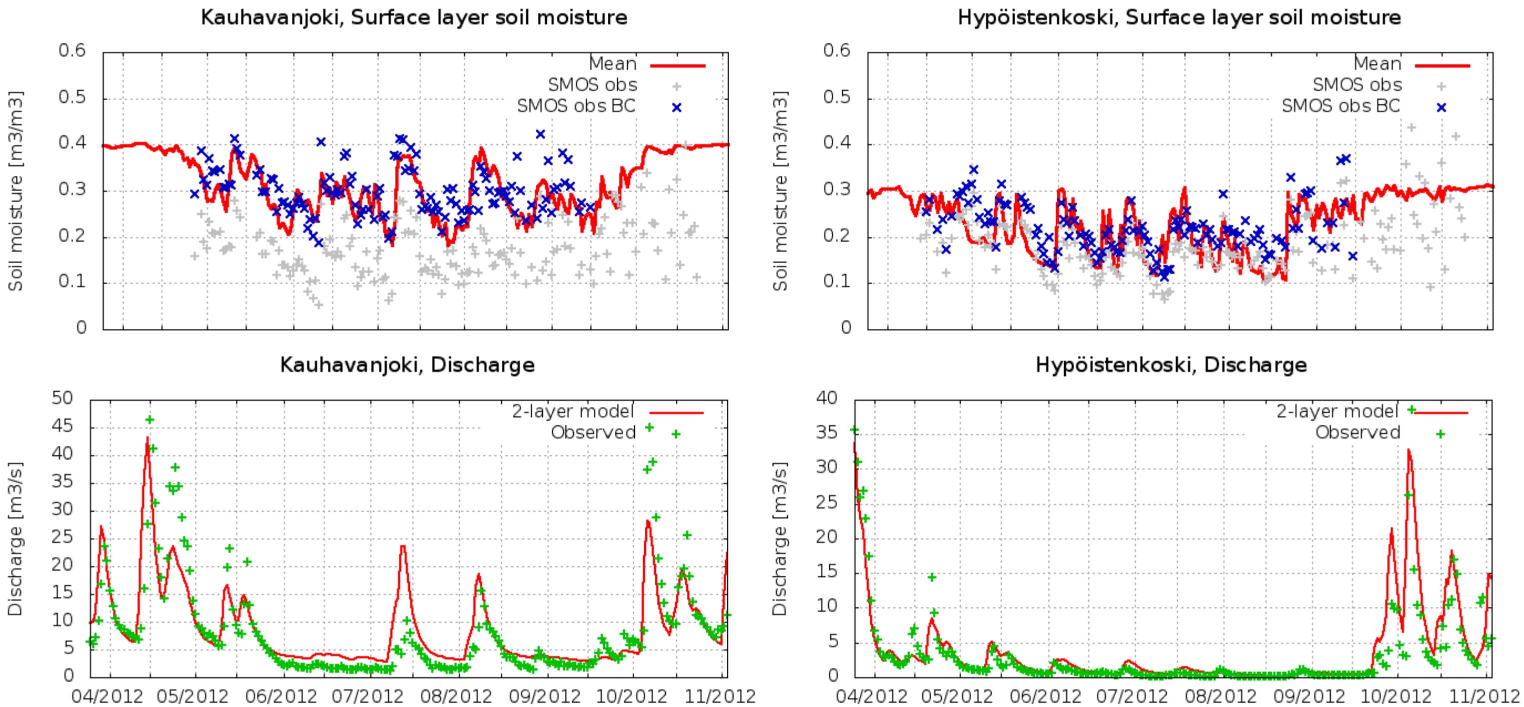
Process model development
Soil moisture (3/5)



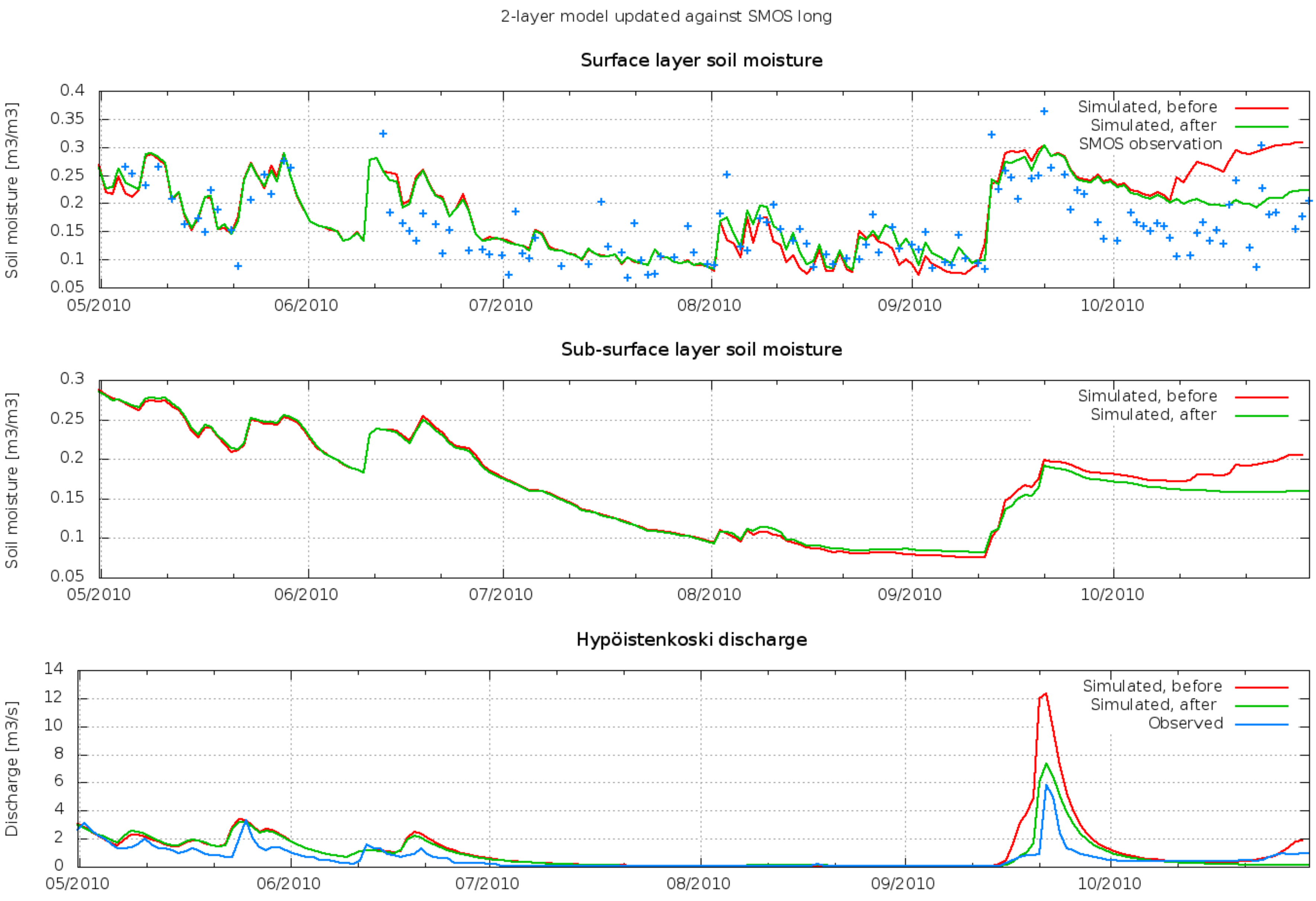


Maankosteuden kaksikerrosmalli

- Testattu neljässä vesistössä
  - Pintakerroksen maankosteuden vertailu SMOS-satelliitin maankosteustuotteeseen
    - Satelliittituotteen käyttö mallin päivityksessä
- Pintakerroksen maankosteuden alueellista vaihtelua vertailtu lentokoneesta tehtyjen HUT-2D-spektrometrin arvoihin
  - Satelliittia tarkempiresoluutioinen kaukokartoitustuote



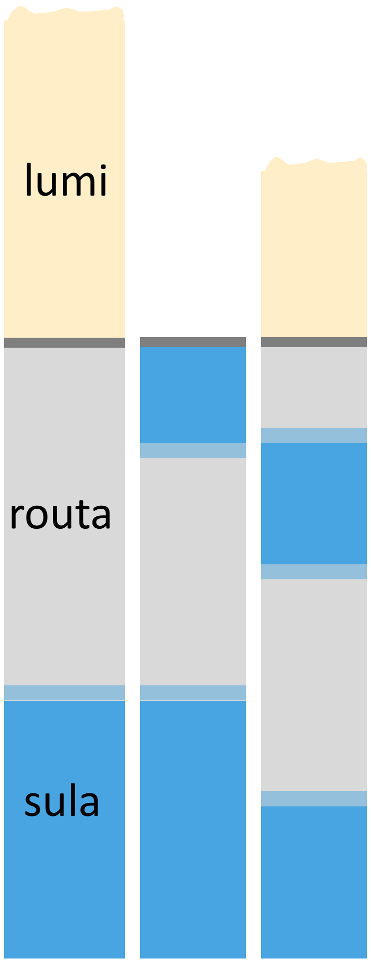
Process model development
Soil moisture (5/5)

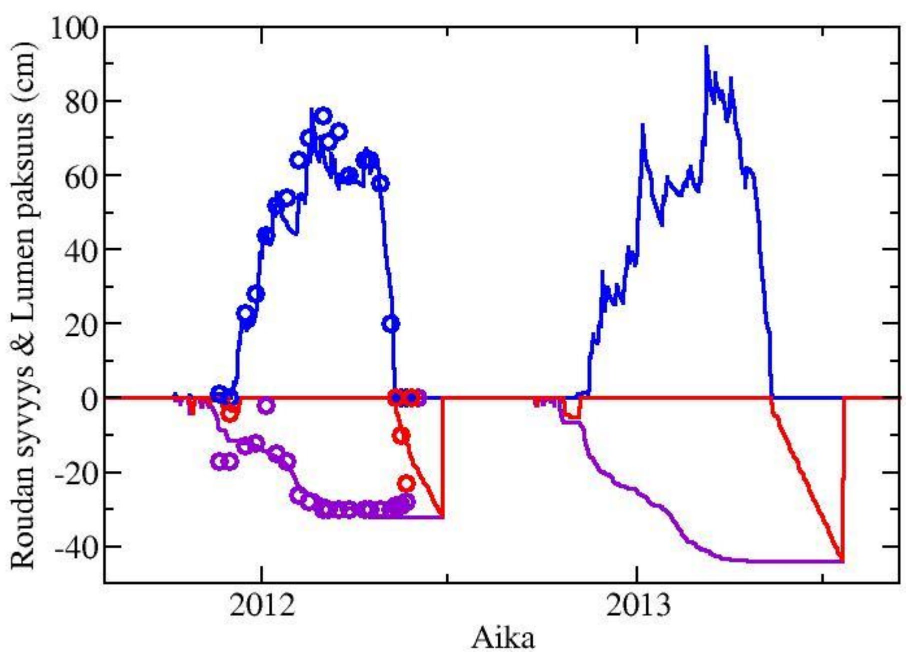


Ground frost modelling

- Tavoitteena on lisätä routamalli operatiiviseen käyttöön.
- Eri aluetyypit huomioidaan erikseen (metsä, aukea, suo)
- Sula-routa kerroksia voi olla useampia

- Malli on yksinkertainen:
  - Kaikki lämpöenergia käytetään sulamiseen / jäätymiseen.
  - Maan lämmönjohtumisen mallintamiseen käytetään sovitettavia parametrejä.

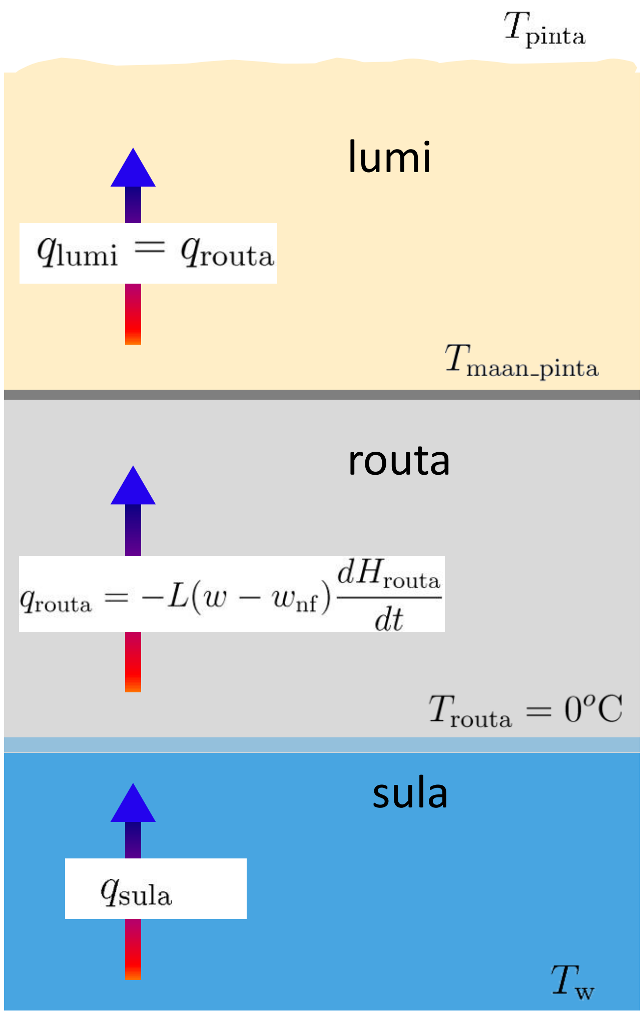




Esimerkki: Suo, Ylitornio Meltosjärvi (alustavia tuloksia)

Lumi
Jäätymisraja
Sulamisraja

Roudan mallintaminen – malli tarkemmin



Lähtökohta on lämmön johtumisen yhtälö:

$$q = -k\frac{dT}{dz}, \quad C \approx 0$$

Routakerroksen kasvu:

$$H_{\text{routa,t+}\Delta\text{t}} = -\frac{k_{\text{routa}}}{k_{\text{lumi}}}H_{\text{lumi}} + \sqrt{\left(\frac{k_{\text{routa}}}{k_{\text{lumi}}}H_{\text{lumi}} + H_{\text{routa,t}}\right)^2 - \frac{2k_{\text{routa}}T_{\text{pinta}}\Delta t}{L(w - w_{\text{nf}})}}$$

Vastaavasti sulan maan kerroksen kasvu:

q_{sula}

$$H_{\text{sula,t+}\Delta\text{t}} = \sqrt{(H_{\text{sula,t}})^2 - \frac{2k_{\text{sula}}T_{\text{pinta}}\Delta t}{L(w - w_{\text{nf}})}}$$

Lämmönjohtavuudet $k_{\text{lumi}}, k_{\text{sula}}, k_{\text{routa}}$) riippuvat lämpötilasta, maaperän tyypistä, kosteudesta, lumen tiheydestä ja mikrorakenteesta. Tässä käytetään yksinkertaisia kaavoja yhdistettynä sovitettaviin parametreihin niiden laskemisessa.

Lumimalli

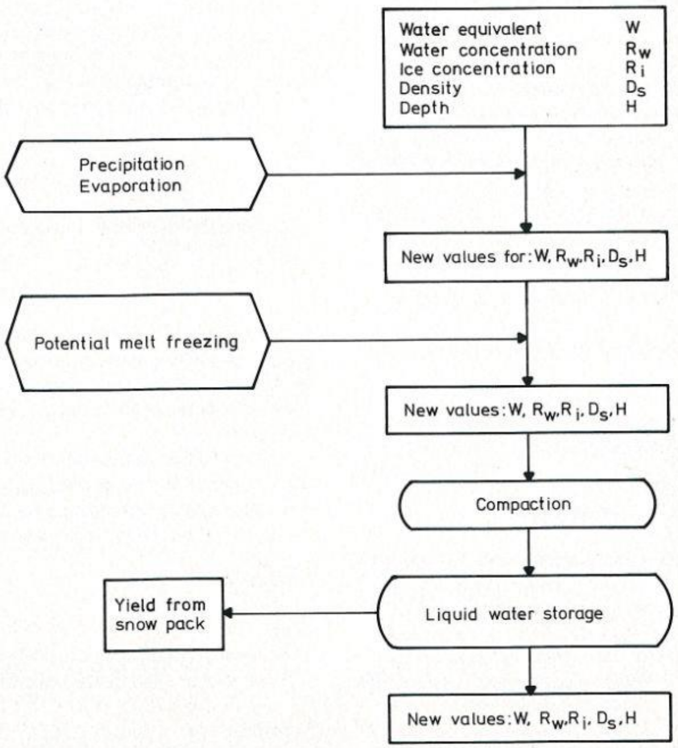


Fig. 24. The structure of the snow cover model.

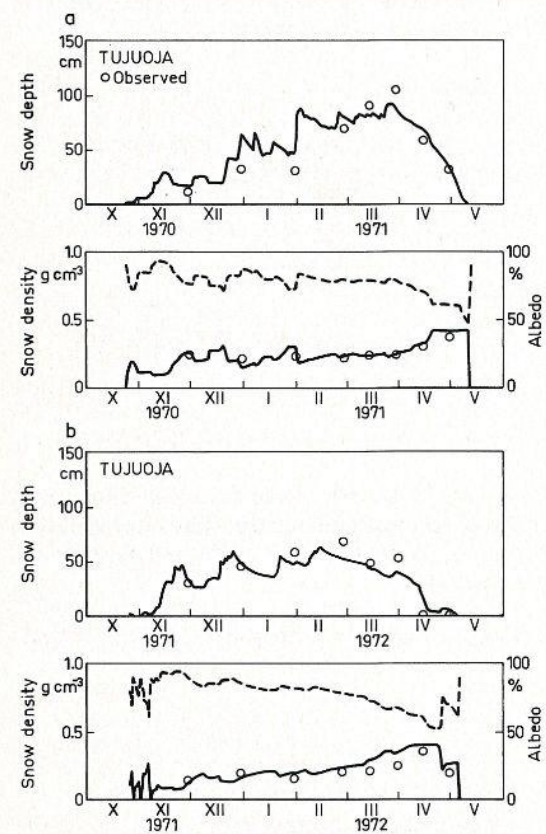


Fig. 25. Simulation of the density (——), depth (——) and albedo (- - -) of snow in the Tujuoja basin during the winters of 1970—1971 (a) and 1971—1972 (b). The observed values from one snow course are marked by (o).

Lumimalli

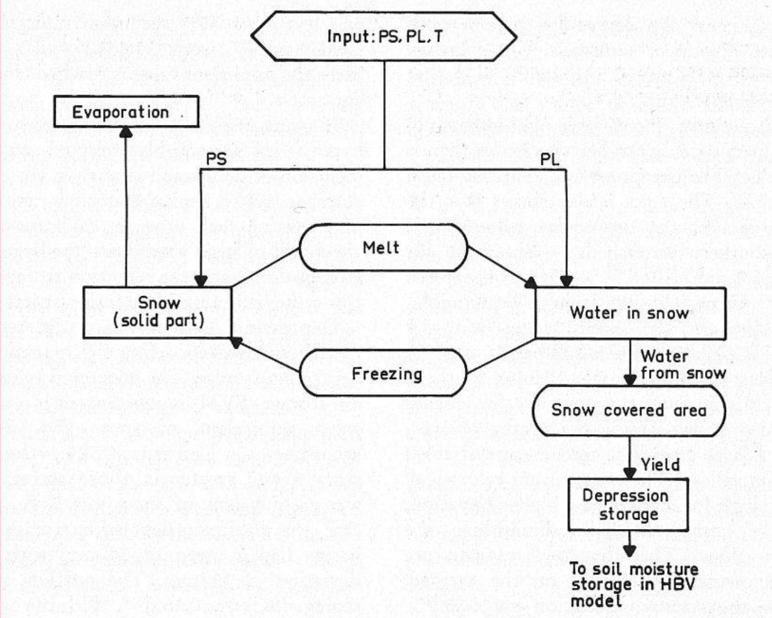


Fig. 7. The basic temperature index snowmelt model.

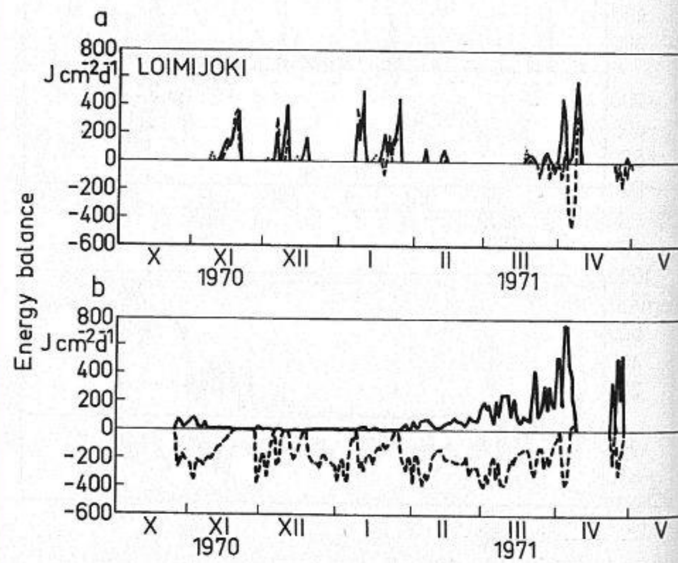
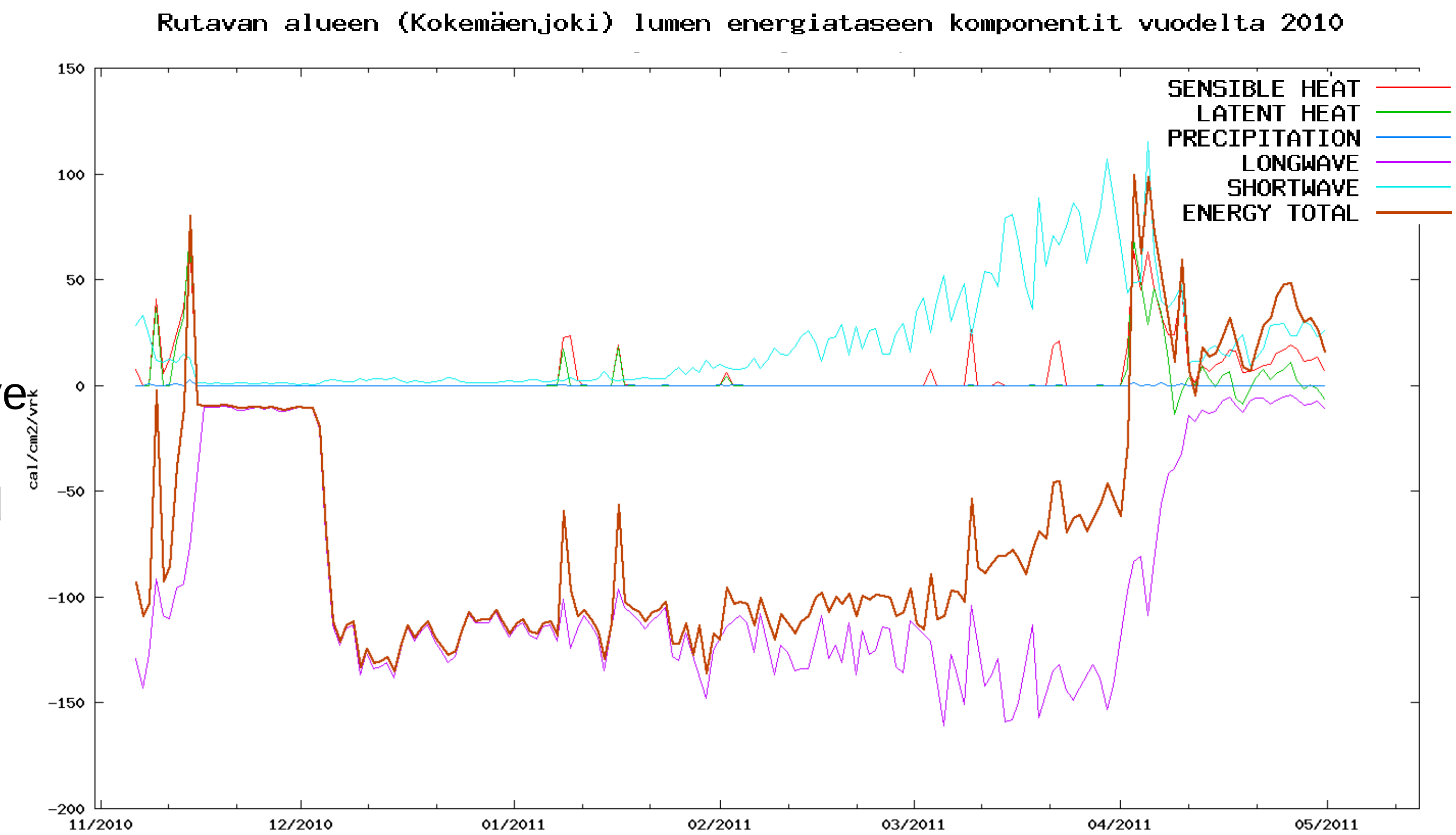


Fig. 35. Simulation of the snowmelt energy balance terms in the basin of Lomijoki during the winter of 1970—71. Snow albedo is calculated from the simulated snow density. a) Sensible heat (—), latent heat (– – –), precipitation heat (···). b) Short-wave radiation (—), long-wave radiation (– – –).

Snow energy balance

- Snow melt simulation is based on energy fluxes affecting to snow layer
- More physical approach to snow melt process compared to simpler day-degree method

- Important factors: precipitation heat, shortwave and longwave radiation, sensible and latent heat fluxes



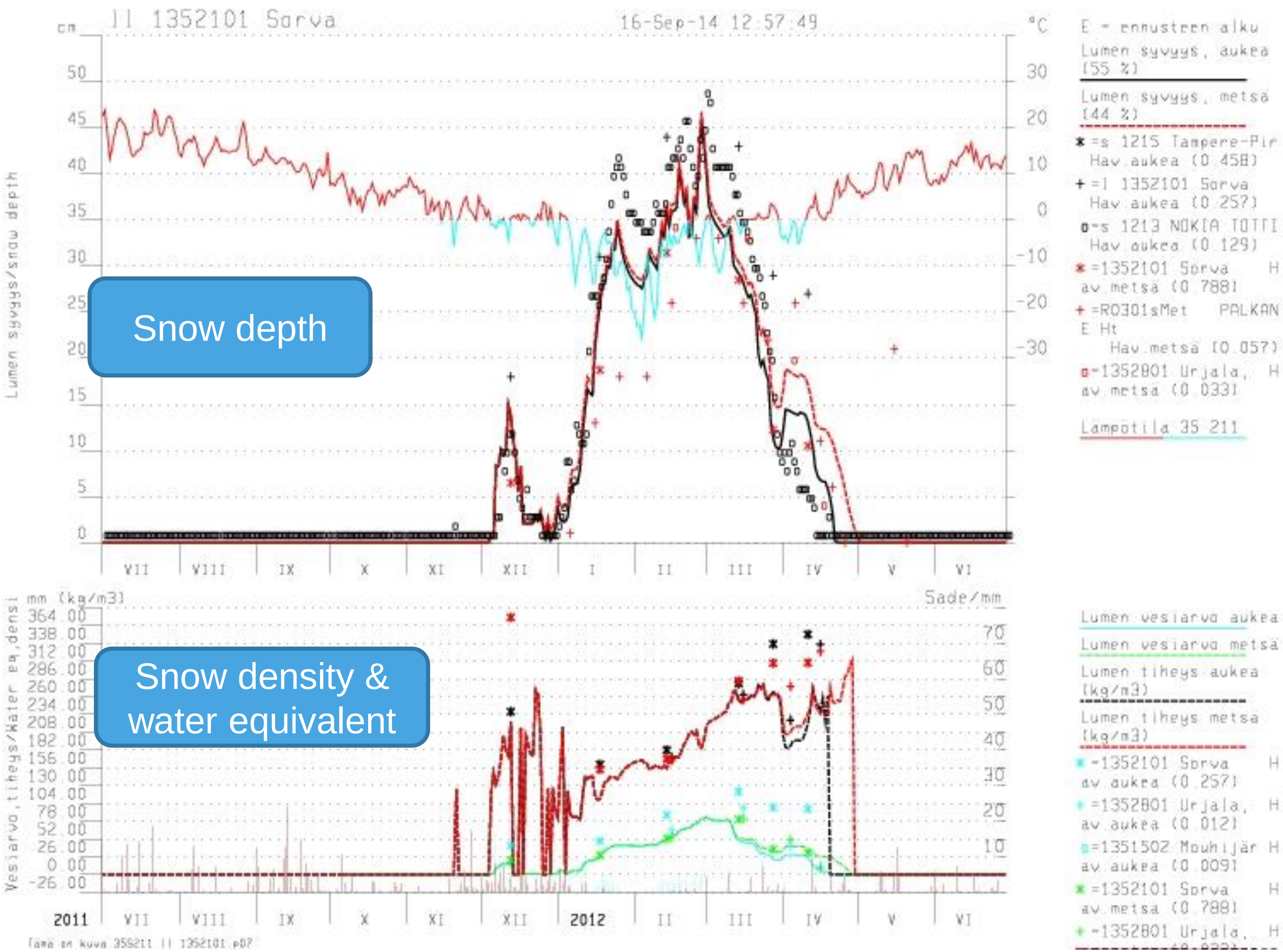
Development

- Implementation to WSFS
  - replaces the current day degree snow melt method
  - Support processes: shortwave radiation simulation using cloudiness observations, snow internal energy
  - Parameter calibration
  - Testing and validation

- Expected to improve snow simulation especially during the spring time due more physically correct method

Hydrological expertise in Finland

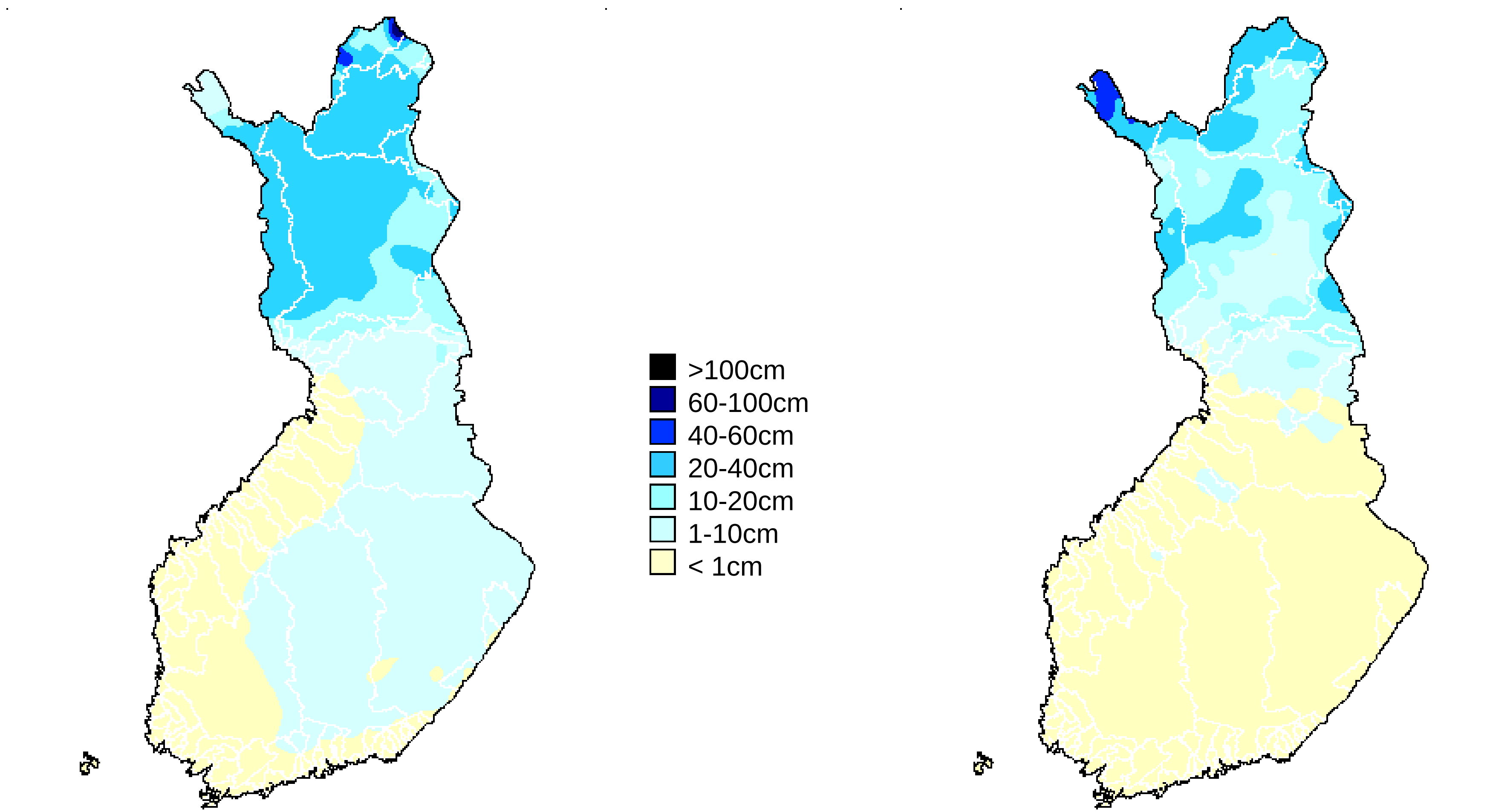
Process model development
Ground frost and snow (7/8)



Roudan ja lumen mallintaminen –esimerkki

Roudan paksuus

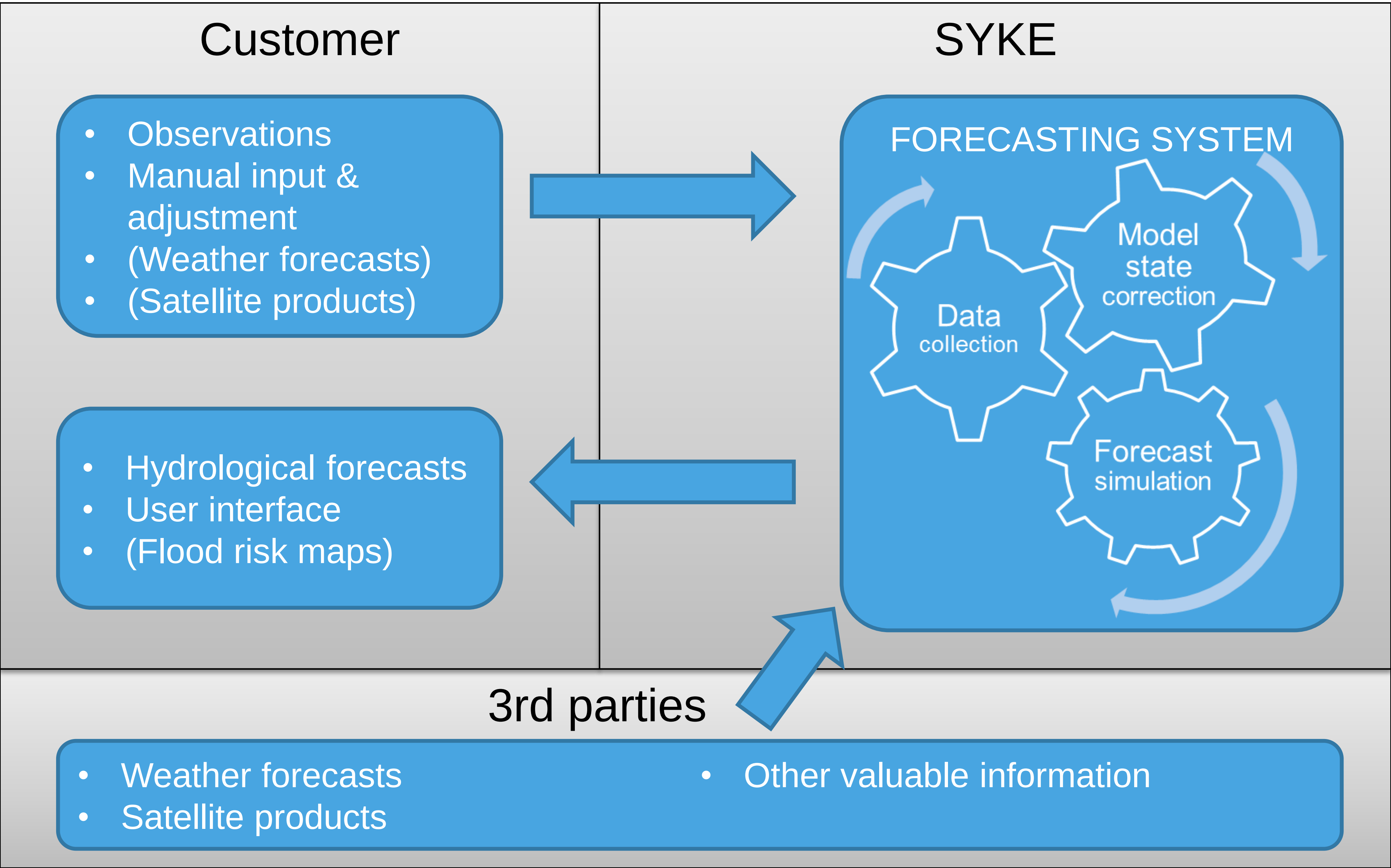
Lumen paksuus



Tailored hydrological modelling solutions

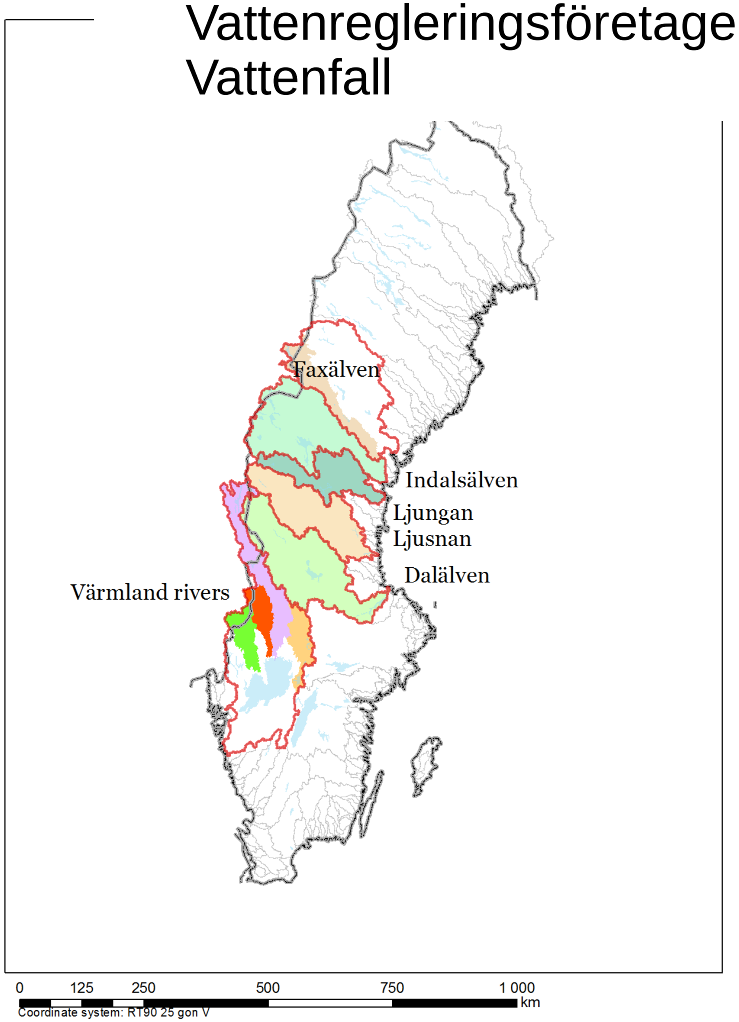
- Minimum data requirements for hydrological model:
  - 1 time series of discharge observations
  - 1 time series of precipitation observations
  - basin information (area, location)
- Other data: we will use all available data for the model
  - Observations
  - Forecasts
  - Radar products
  - Satellite products
- We will provide a **FULL FORECASTING SYSTEM**
  - Automatic forecast simulations (also an option for manual runs)
  - Correction of model state according to the latest observations
  - Online user interface
  - Flood risk maps (additional)

Tailored solutions, daily data flow example



Example in Sweden

- 6 catchments modelled
- Users: Fortum, Vattenregleringsföretagen VRF, Vattenfall



Example in Russia

- Tuloma-river
- User: TGC-1 in Murmansk Oblast
- Tailor-made PC solution in place

Tailored modelling solutions, international examples (4/5)

Lakes

04 001 001	**Sloka floodplain**
04 002 001	**Kalnciems floodplain**
04 003 001	**Jelgava floodplain**
04 004 001	**Stalgene floodplain**
04 005 001	**Mezotne floodplain**
04 002 002	Slokas lake
04 009 001	Babites lake
04 022 001	Viesites lake

River points

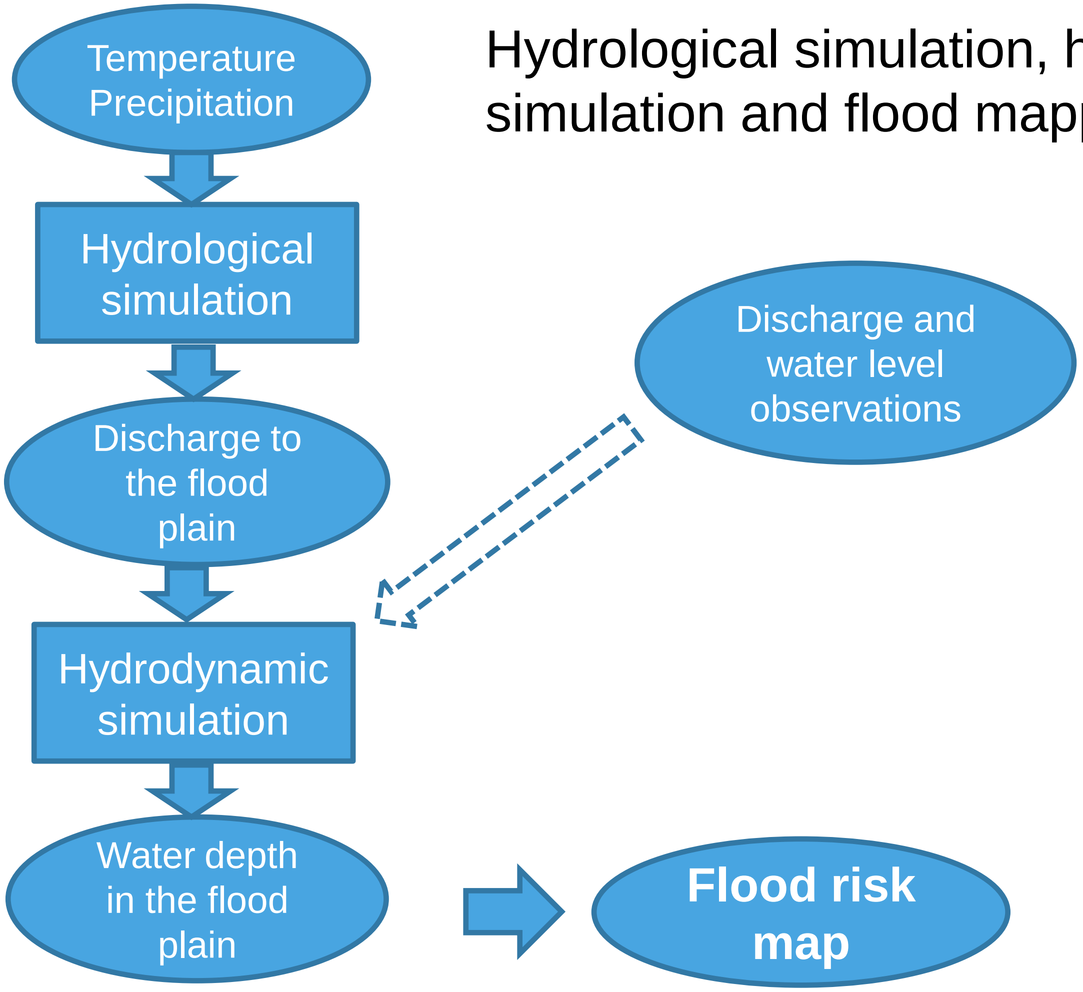
04.001	0473804 Lielupe Lielupesgrlv
04.002	0411202 Zvirbulu Strauts*
04.002	0473803 Lielupe Sloka
04.003	0473802 Lielupe Kalnciems
04.004	0473520 Platone, Lielplatone*
04.004	0473801 Lielupe Jelgava
04.005	0473424 Lielupe Stalgene
04.006	0473422 **Lielupe Mezotne**

Lielupe watershed

Maps: Gauja Lielupe Venta

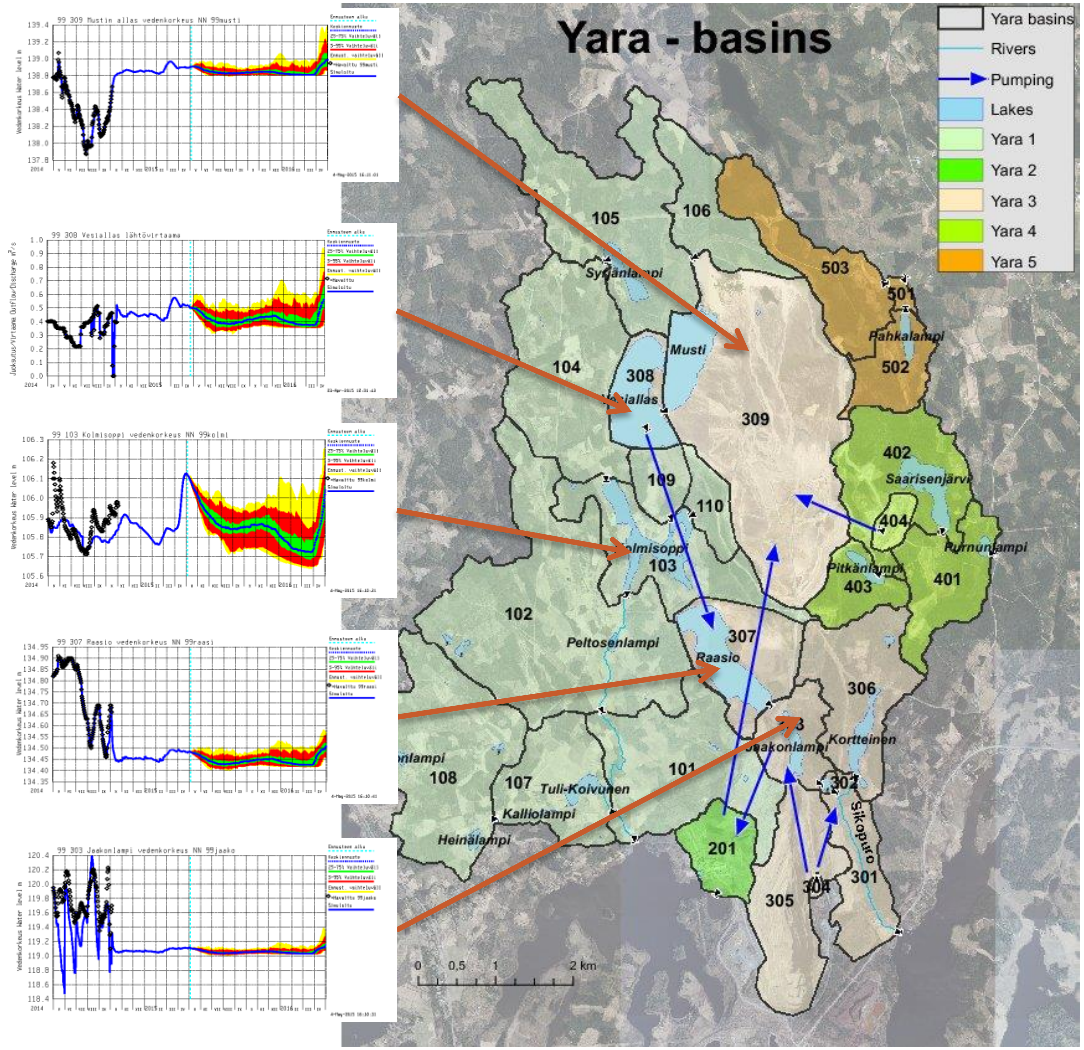
Example in Latvia

Hydrological simulation, hydrodynamic simulation and flood mapping



Watersmart: simulating water balance of mining areas

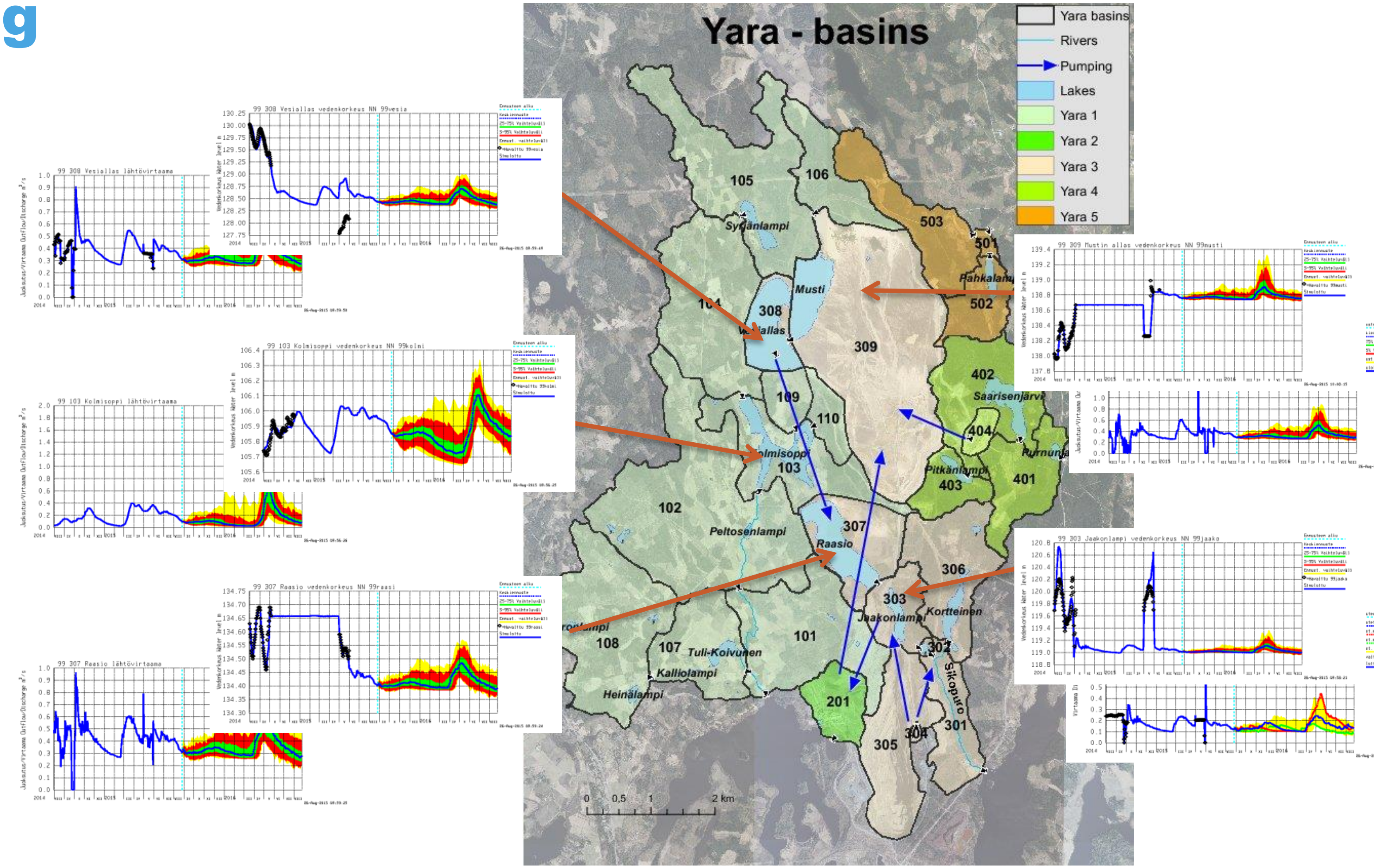
- **Aims to** simulate water balance of mining areas
    - Water level, discharge
    - Ground water
    - Water balance components
    - Real-time forecasts
    - Transport of marker substances
- Currently developed in YARA Siilinjärvi mine
- WSFS modified to mining area
    - Description of watersheds in the area
    - Observations from area (water level, discharge, pumping) or from nearby weather stations



Example: Yara mining area

Example: Yara mining area

Lake / reservoir water levels and outflow discharges

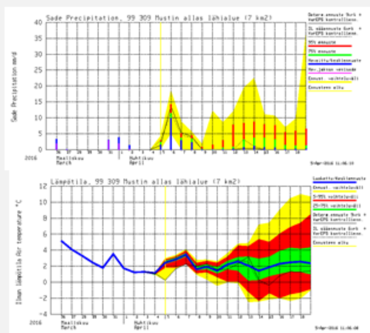


Tailored modelling solutions, water balance for mines (4/8)

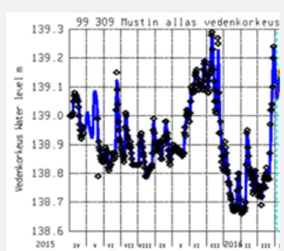
Example: Yara mining area

Input

Weather data and forecasts

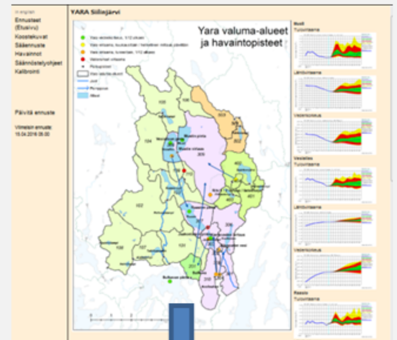


Pumping data, water level and discharge data



Model

User interface (www)

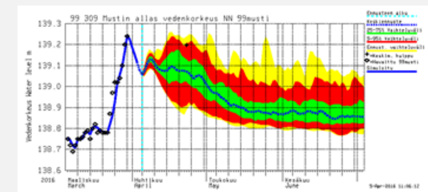


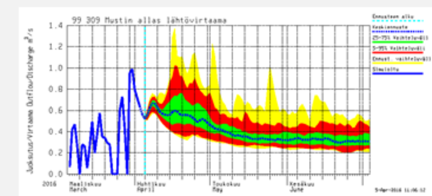
Water balance model

Description of channel system

Results

Water balance and forecasts



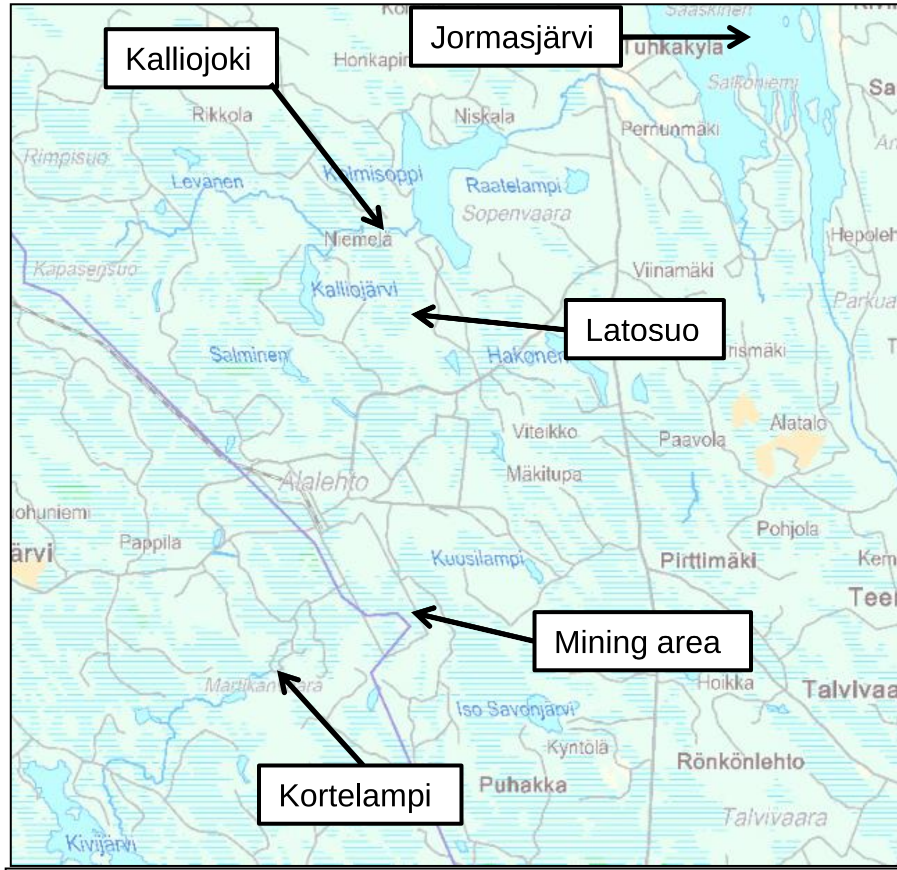


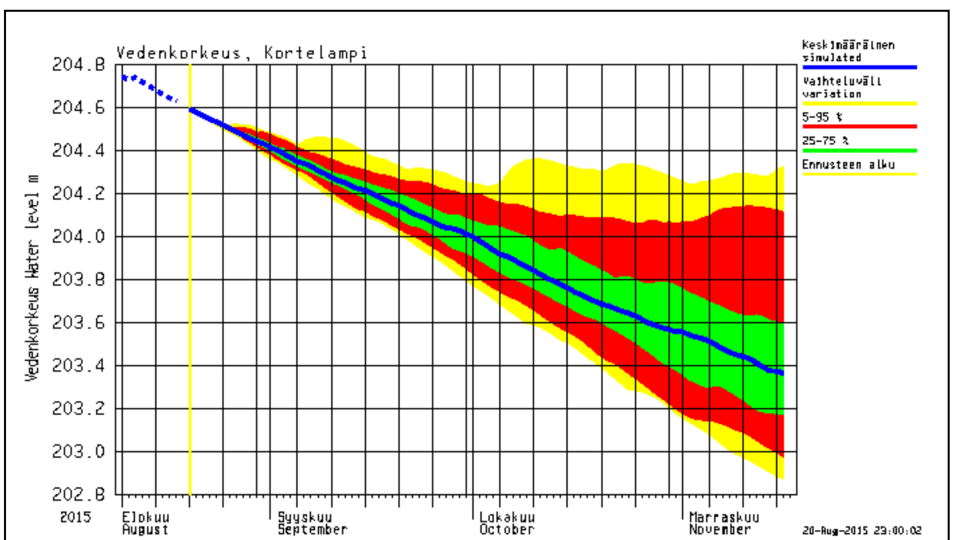
Mine operators
Other parties

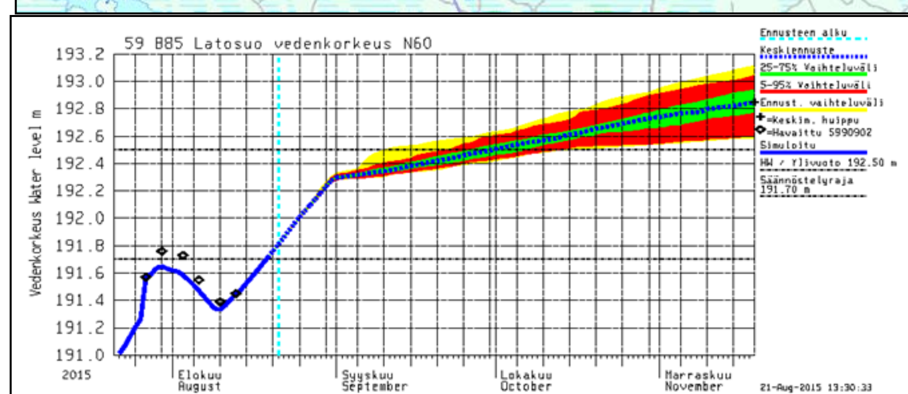
Ground water model

Operative forecasts for Talvivaara mining area

- Main lakes and water flows between them in Talvivaara mining area are in the operative WSFS model
- Forecast also for runoff of Kalliojoki, which is the limiting factor for discharge of Latosuo and Kortelampi
- Forecasts run daily and are sent directly to Talvivaara







Operative forecasts for Talvivaara mining area

- Weekly reporting of Talvivaara water situation (also daily reporting if needed)

Talvivaaran patoaltaiden vesitilanne ja ennusteet

Raportti 21.8.2015

Harri Myllyniemi
Juho Jakkila

Ennusteet tiivistetysti

Kortelammen vedenkorkeus ylittää ylärajan 204.20 m viimeisimmän havainnon (13.8.) mukaan 52 cm:llä. Ennustemallin mukaan vedenkorkeus on laskenut tämän jälkeen 10-15 cm. **Kipsisakka-altaiden vedet eivät mahdu Kortelammen altaaseen ja Lumelan allas on edelleen ylärajan 207.00 m yläpuolella.** Tämänhetkisen luvan mukaan konkurssipesä ei saa jatkaa juoksutuksia etelään. **Konkurssipesä on aloittanut heinäkuun puolivälissä pumppaukset Kortelammen ja Lumelan altaista Tammalammen jälkikäsittely-yksikköön. Pumppauksen suuruus on tällä hetkellä 500 m³/h, mikä riittää ennusteen mukaan pitämään Kortelammen vedenkorkeuden laskussa.**

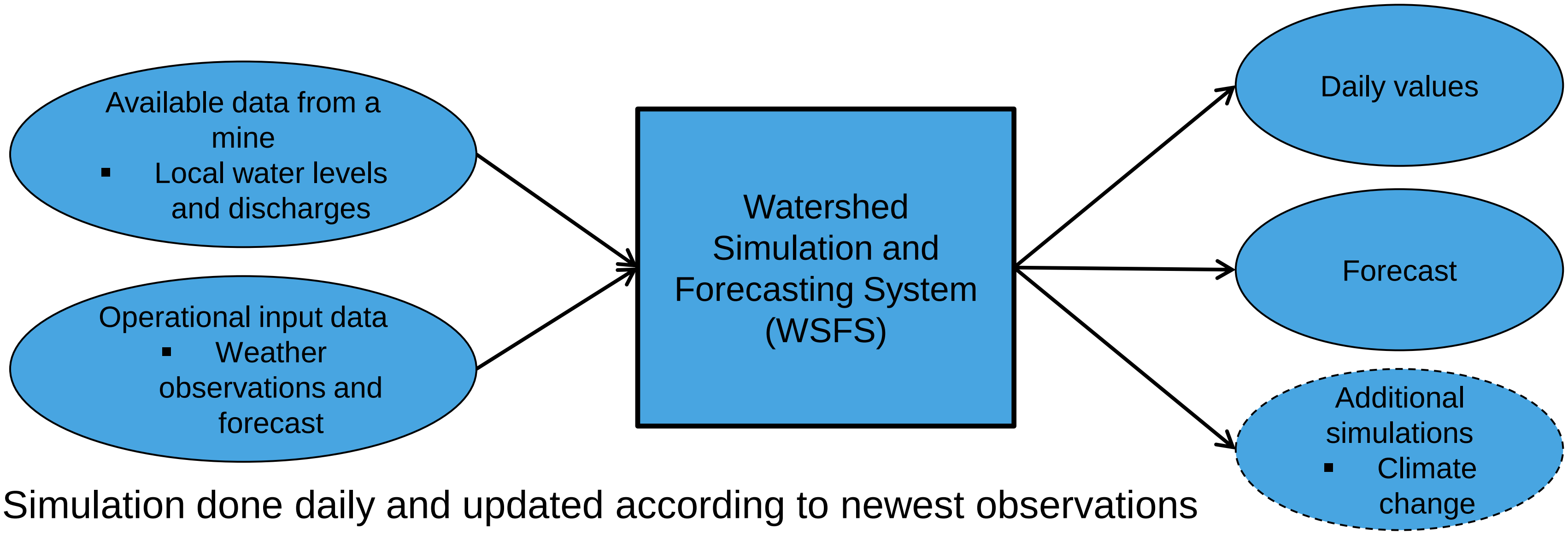
Latosuon tuorein vedenkorkeushavainto on 13.8., vedenkorkeuden ollessa tasolla 191,46 eli 24 cm säännöstelyn ylärajan alapuolella. Mallin mukaan **pinta on ylittänyt 10 cm säännöstelyn ylärajan**. Latosuon vedenkorkeus on ollut nousussa siitä lähtien kun juoksutus Kuusilammelta aloitettiin 10.8.. **Latosuolta juoksutetaan vettä luontoon Kalliojoen virtaamaan suhteutettu määrä ainakin elokuun loppuun asti.**

Vesienhallinnan kannalta **suosittelemme automaattiasemien perustamista** ainakin tärkeimmille altaille, kuten Kortelammelle ja Latosuolle. Ilman reaaliaikaisia havaintoja vesitilanteen ennustaminen on kriittisessä tilanteessa vain suuntaa-antavaa. Tulvan ja muiden ääritilanteiden yhteydessä ennustaminen riippuu enemmän havainnoista kuin tavanomaisessa tilanteessa.

Muutos edelliseen raporttiin

Kortelammen pinta on laskenut viikossa noin 10-15 cm, mutta vastaavasti Latosuon allas on täyttymässä. Kulunut viikko on ollut sateeton ja ennusteen mukaan myös lähipäivien sää jatkuu sateettomana, joten Kortelampi saataneen elokuun loppuun mennessä tasolle jolla kipsisakka-altaan vedet mahtuvat sinne tarvittaessa. Mikäli pumppauksia Tammalampeen jatketaan nykyisellä tasolla vedenkorkeus laskee todennäköisesti ylärajan 204.20 m alapuolelle syyskuun puolivälissä, jollei syyskuun alussa tule runsaita sateita.

Work flow for water balance simulation for mines



Simulation done daily and updated according to newest observations

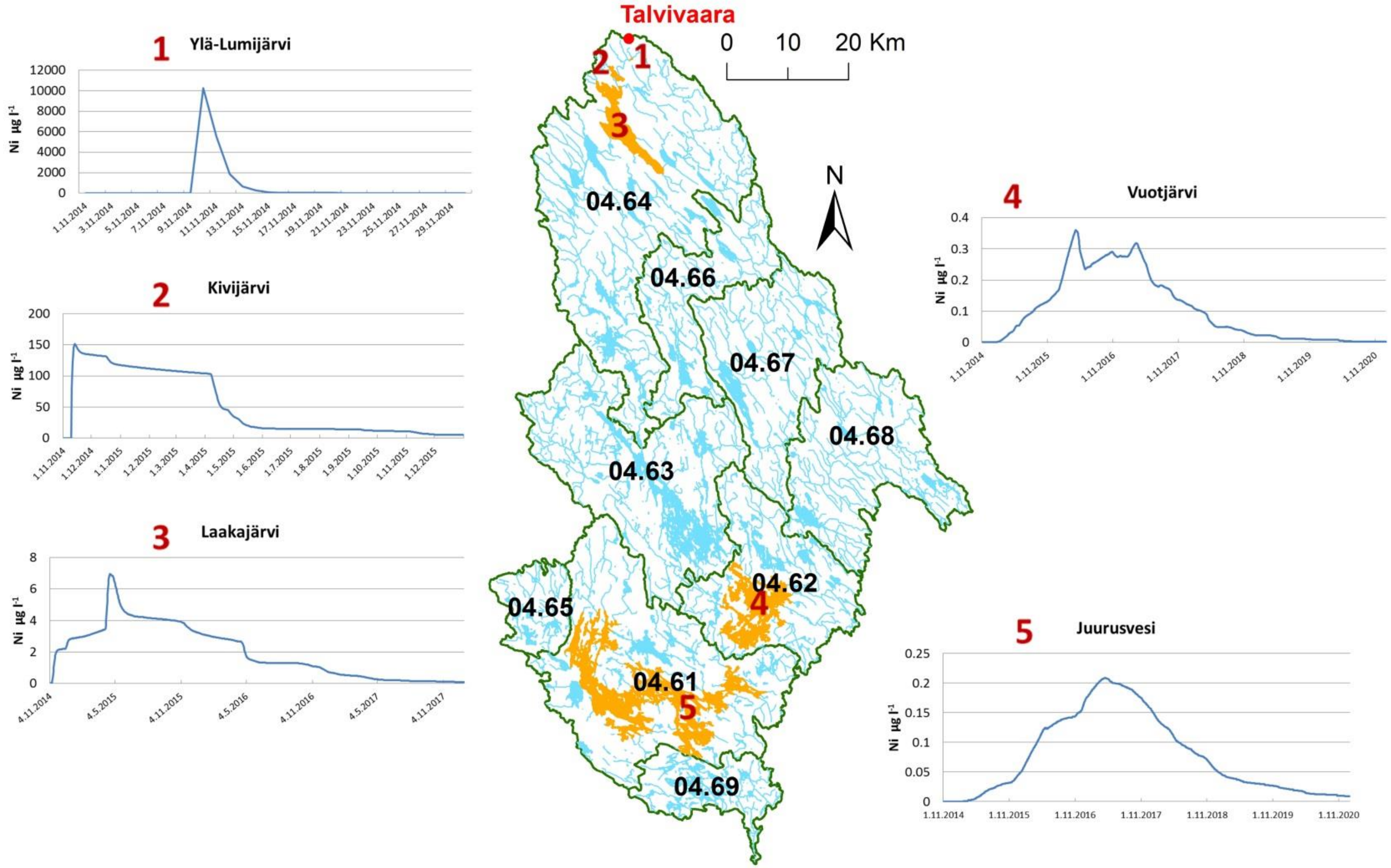
Case Kittilä mine in SAM project

- Areal water balance simulation of Kittilä mine local area as a case subject
- A part of the operational system
- Results and forecasts presented in the webpage for easier accessibility
  - Daily updates
  - Figures and numerical forecasts

Tailored modelling solutions, water balance for mines (8/8)

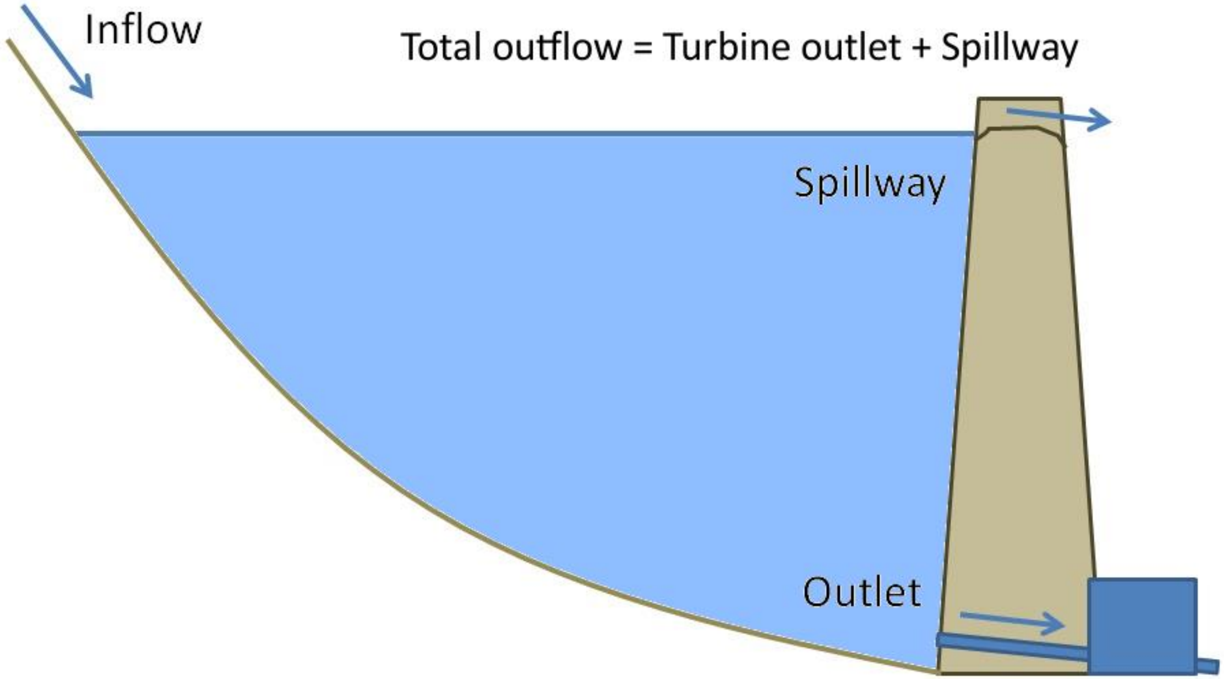
VEMALA can simulate the transport of inert components in rivers downstream of an industrial leak for determining toxicity risks (MINEVIEW project):

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



Adaptive lake outflow calculation (1/9)

- In real life, regulated lake outflows are decided by regulation operators (human beings making decisions)



- When forecasting future, it is impossible to know what decisions the real-life operators are going to make in the future

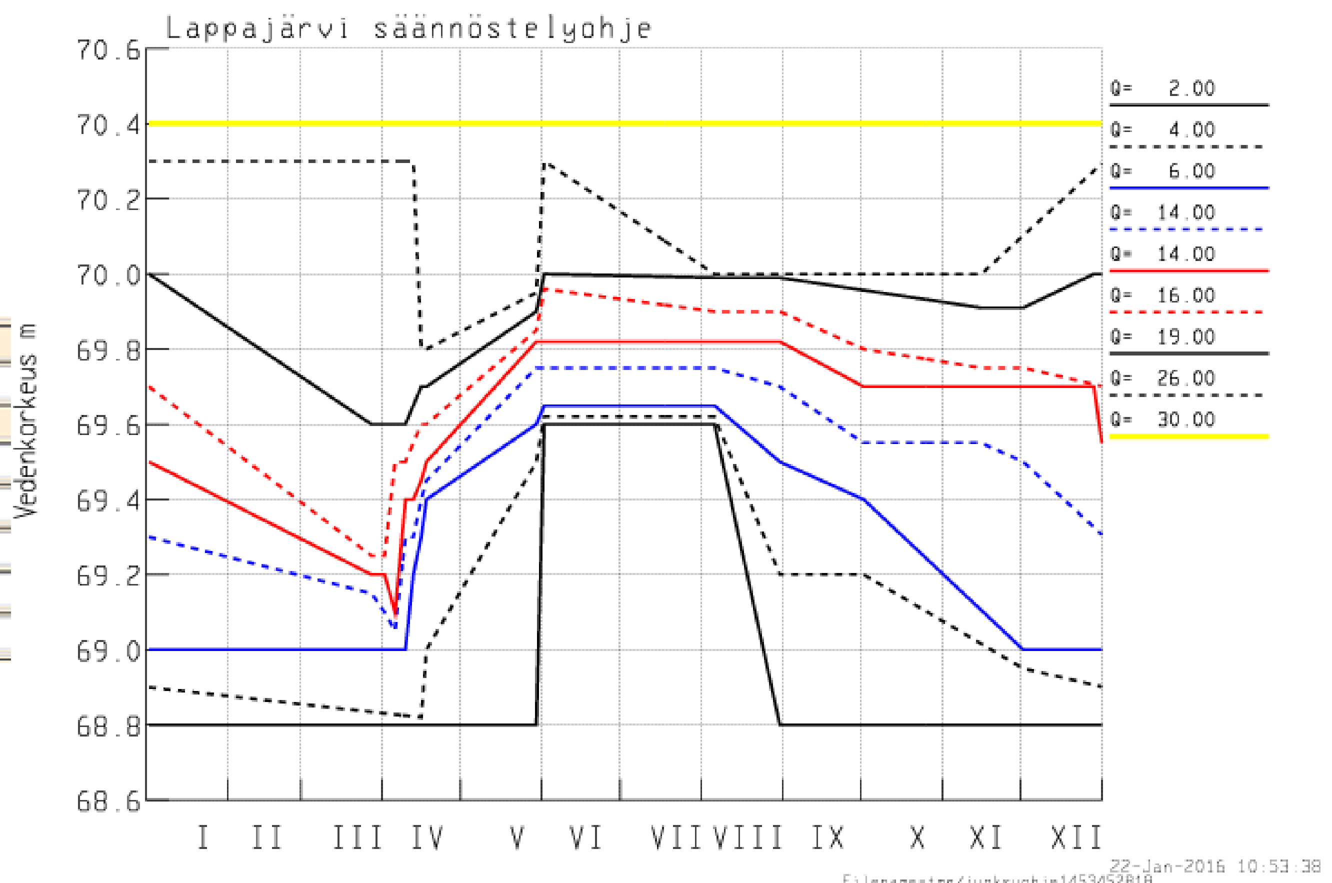
  → We have to ”guess” their future decisions, because otherwise we wouldn’t be able to make forecasts

Adaptive lake outflow calculation (2/9)

- Traditionally in the SYKE Watershed Forecasting and Simulation System, the ”guessing” of the future regulation decisions is done with *lake outflow tables* (finnish ”säännöstelyohje”)

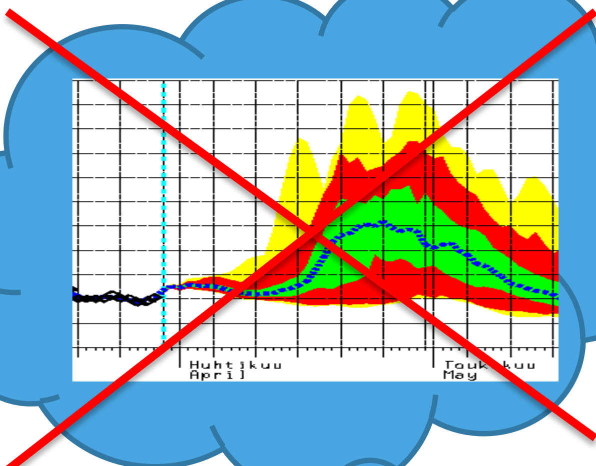
- Lake outflow tables define the outflow based on *water level* and *date*

		Juoksutus			
		2.00	14.00	14.00	16.00
kk	pp	Vedenkorkeus			
1	1	68.80	69.30	69.50	69.70
3	27	68.80	69.15	69.20	69.25
4	1	68.80	69.10	69.20	69.25
4	5	68.80	69.05	69.10	69.50
4	9	68.80	69.30	69.40	69.50



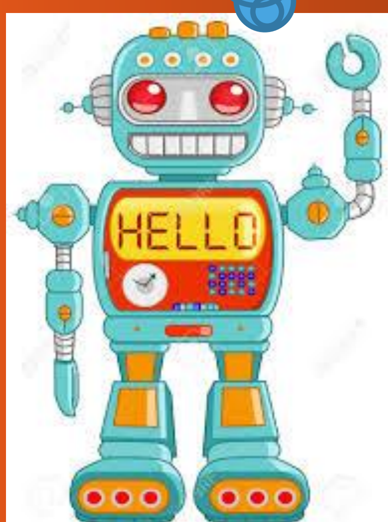
Adaptive lake outflow calculation (3/9)

- Forecasting future with lake outflow tables is like *simulating a ”blind operator who doesn’t look around”*

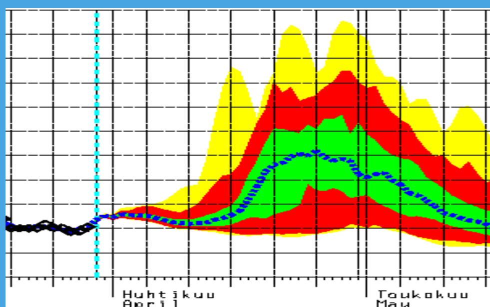


I am not looking current snow situation or weather forecasts, I only look calendar and water level when I decide outflow

WATERSHED SIMULATION AND FORECASTING SYSTEM
WSFS-VEMALA



- We *should* simulate operators in the forecasts like this:



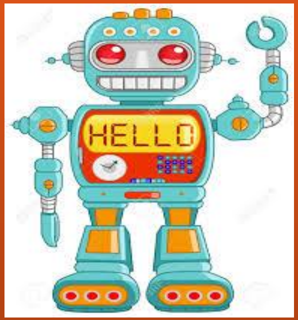
I see there will be great inflow in the future, so I will lower the water level in advance to make room for the flood water

WATERSHED SIMULATION AND FORECASTING SYSTEM
WSFS-VEMALA

Adaptive lake outflow calculation (5/9)

WATERSHED SIMULATION AND
FORECASTING SYSTEM
WSFS-VEMALA

”blind regulation operator who doesn’t look around”



”more realistic regulation operator”

We are developing adaptive lake outflow calculation in order to:

- make better **watershed forecasts**
- make better **simulations** for climate change research, regulation development studies, etc…

How adaptive lake outflow calculation is done? (the next sentences and slides might be difficult to explain so please forgive the presenter all that is not understandable… ☺)

Simulation world is NOT the same thing as real world:

- For example, if today in the real world is January 1st, and we are simulating the period from Jan 1st to Jan 21st, the today of the simulation world can be any day from Jan 1st to Jan 21st.

For one day in the simulation world:

- 1) ONE TIME SERIE of future daily inflows is generated
- 2) One LAKE OUTFLOW TIME SERIE is calculated to match that one inflow time serie
- 3) Lake is simulated for THAT ONE DAY

And for the next day in the simulation world, steps 1-3 are done according to that day.

Generating the time serie of future inflows is not straighforward:

- The today of the simulation world is in the future of the real world
- The future of the simulation world is in the ”future of the future” of the real world

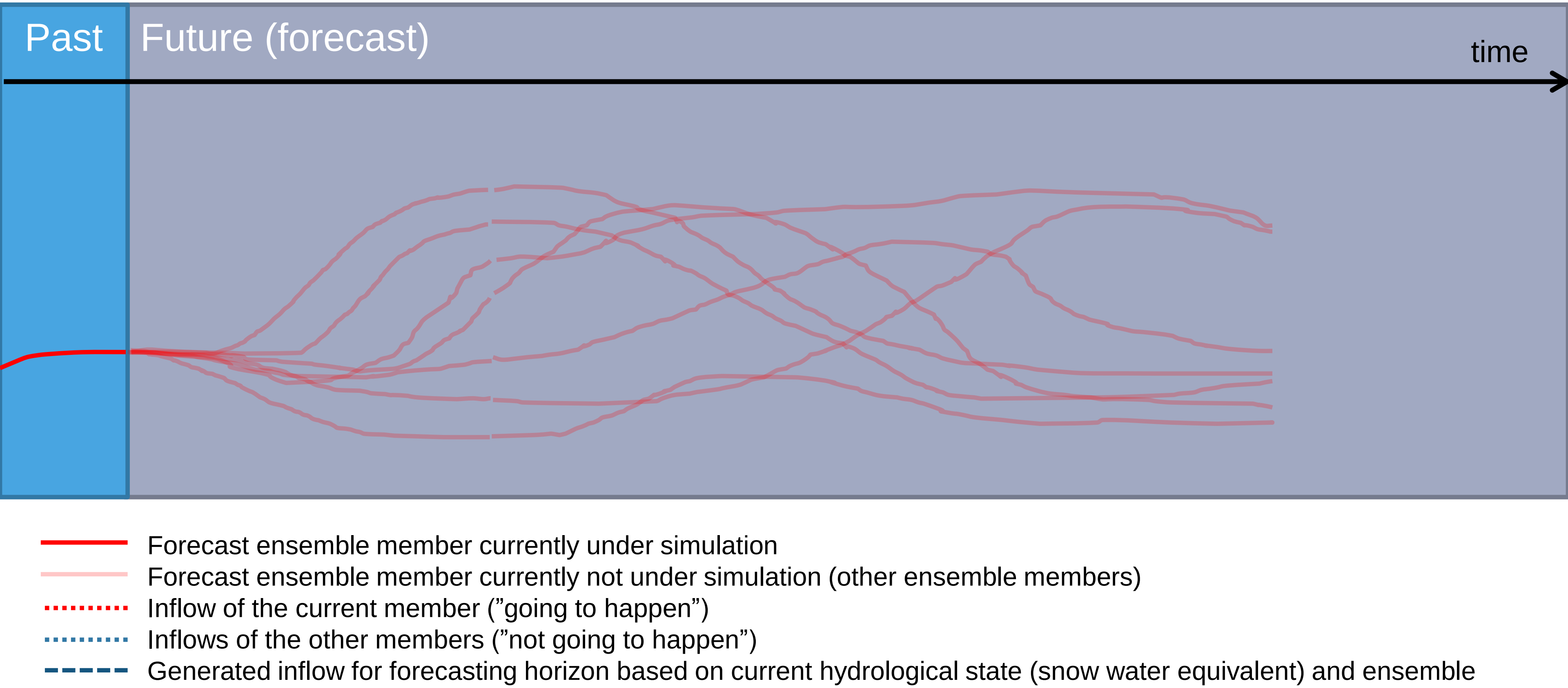
And usually we simulate ENSEMBLE instead of just one time serie:

- Ensemble consists of many time series, which are all alike in statistical probability

So how to generate that one time serie of future inflows? The next slide tries to answer..

How to generate appropriate inflow for forecasting horizon of the reservoir operator simulator?

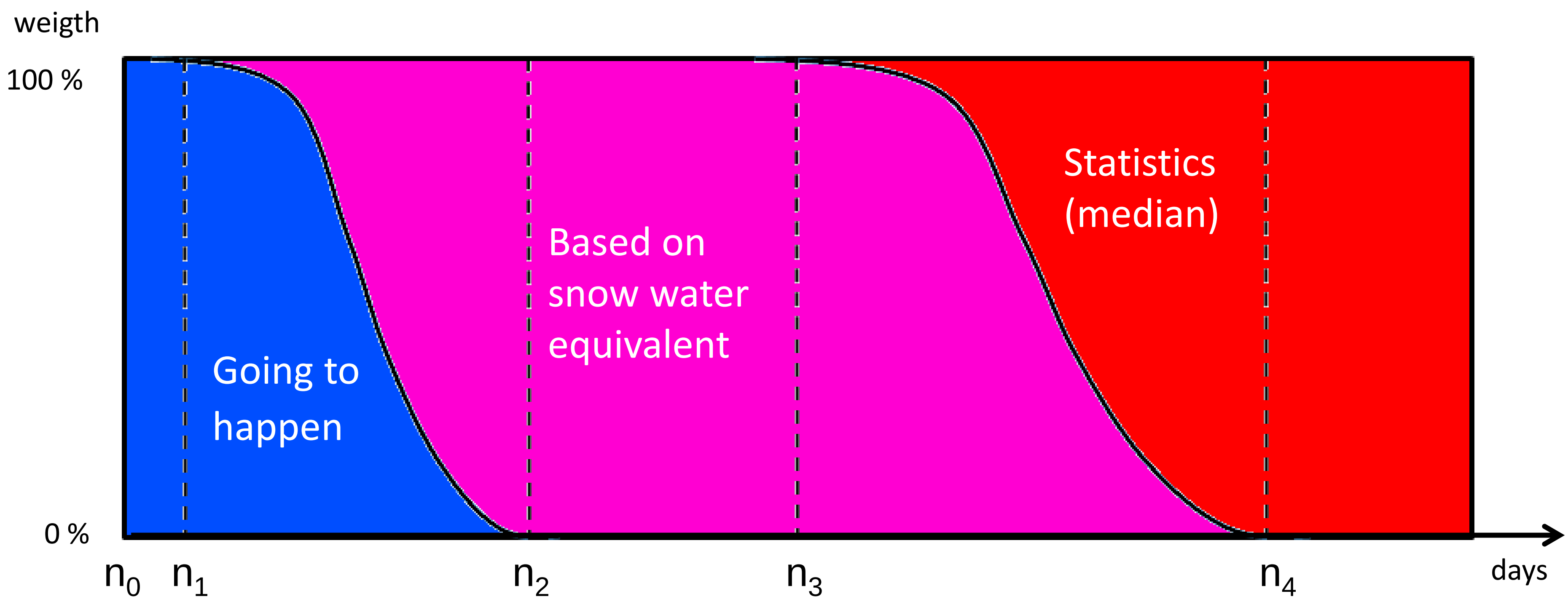
An example: If we are doing forecast today, and in that forecast we are simulating the actions of reservoir operator 2 months ahead from now, how can we generate the artificial forecasting horizon beginning 2 months from now and ending 2 months + N days from now?



Adaptive lake outflow calculation (8/9)

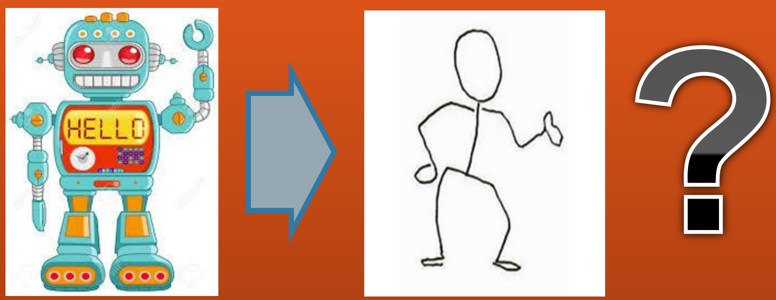
Inflow for forecasting horizon is generated as a weighted combination of

- Current ensemble member (”Going to happen”)
- Selected ensemble members, which have similar snow water equivalent to current ensemble member
- Median of all ensemble members



Adaptive lake outflow calculation (9/9)

WATERSHED SIMULATION AND FORECASTING SYSTEM WSFS-VEMALA

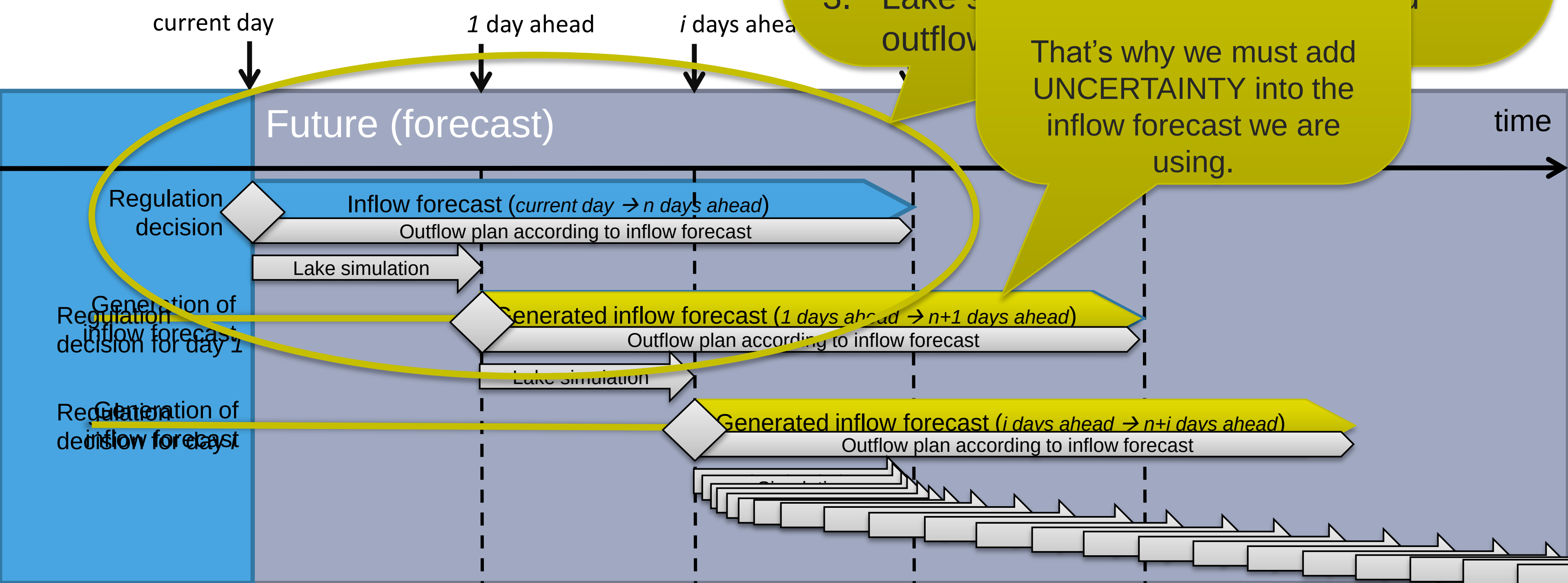


THE PRIN
1. Acquir ... ater
   - T ... e
2. Calcul ... s inflow
   - C ... re
     -
     - ... utflow
     -
3. Lake s ... d outflow

This is the inflow that WILL HAPPEN in the simulation.

It would be unrealistic to use that inflow as a basis of the outflow calculation, because in real life, the regulator operator DOESN'T KNOW EXACTLY the future inflow.

That's why we must add UNCERTAINTY into the inflow forecast we are using.

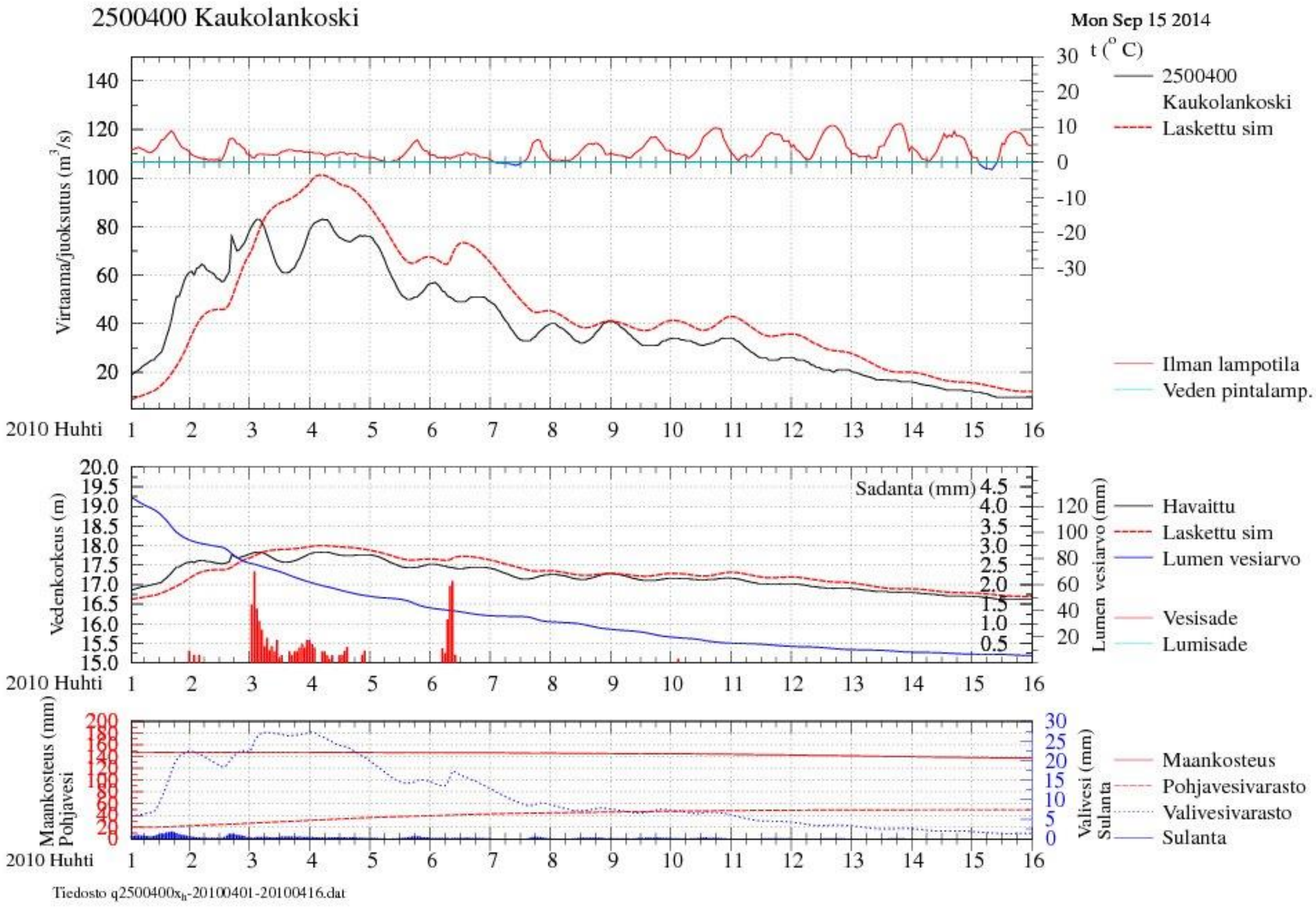


1-hour timestep forecast model

- Simulation time-steps
  - Operative flood forecast model: 1 day
  - Flood forecast model under development: 1 hour
- Reasons for one-hour-time-step development:
  - One-day-time-step is not enough for quick rivers
  - Temperature, precipitation, discharge, …, they change during the day

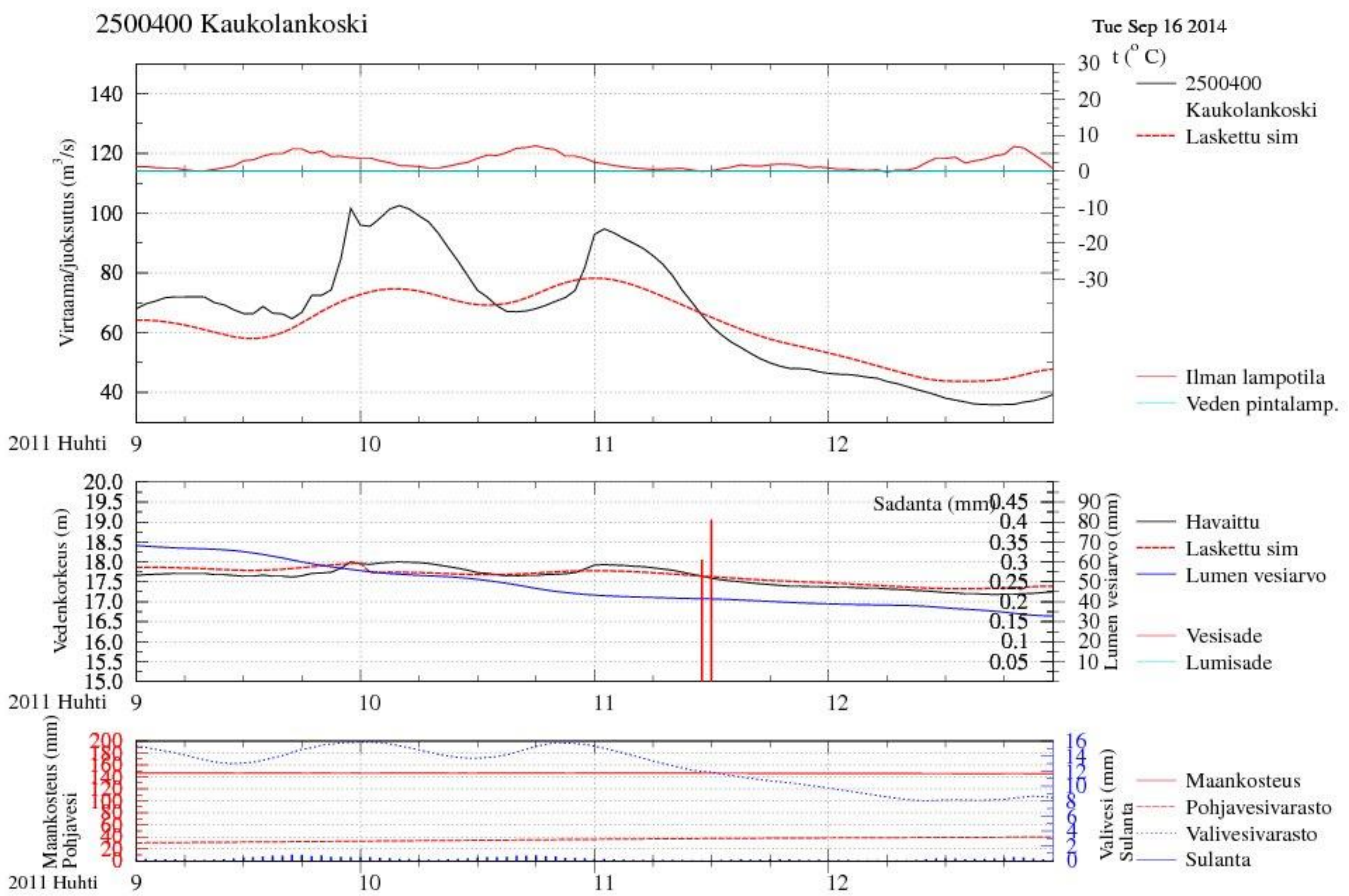
  → Using 1 hour time-step is essential for making good forecasts in small rivers with significant changes during day
- Test case: Uskelanjoki watershed
  - Test model is underway for valuation
  - Calibration of model parameters continues
  - Later on: 1 hour time-step for whole country model

Kaukolankoski, Uskelanjoki

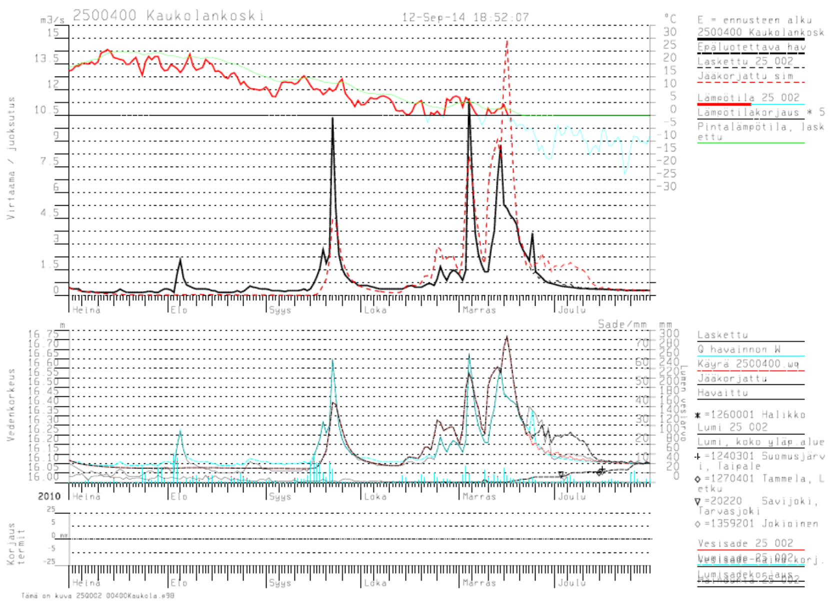


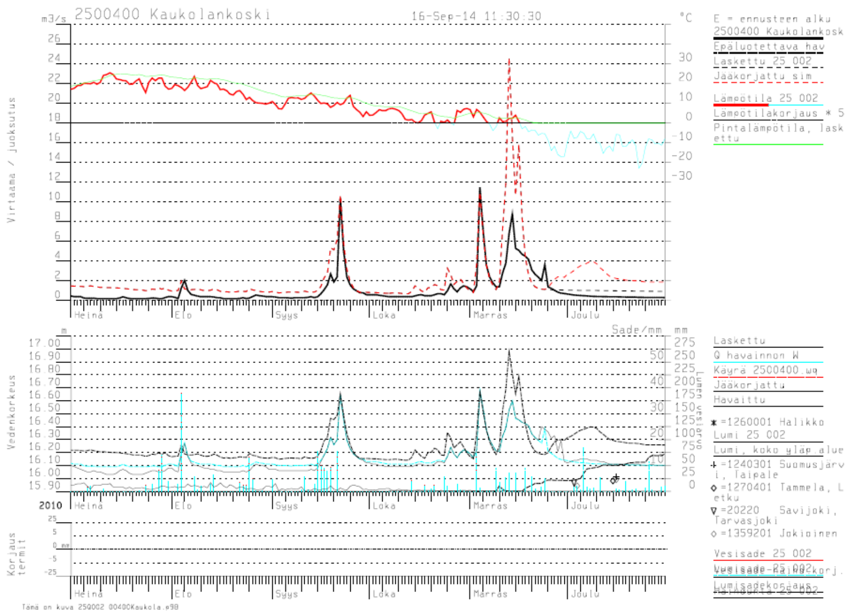
High temporal simulation: 1 h timestep and hourly data

1-hour timestep model (3/5)



Kaukolankoski, Uskelanjoki

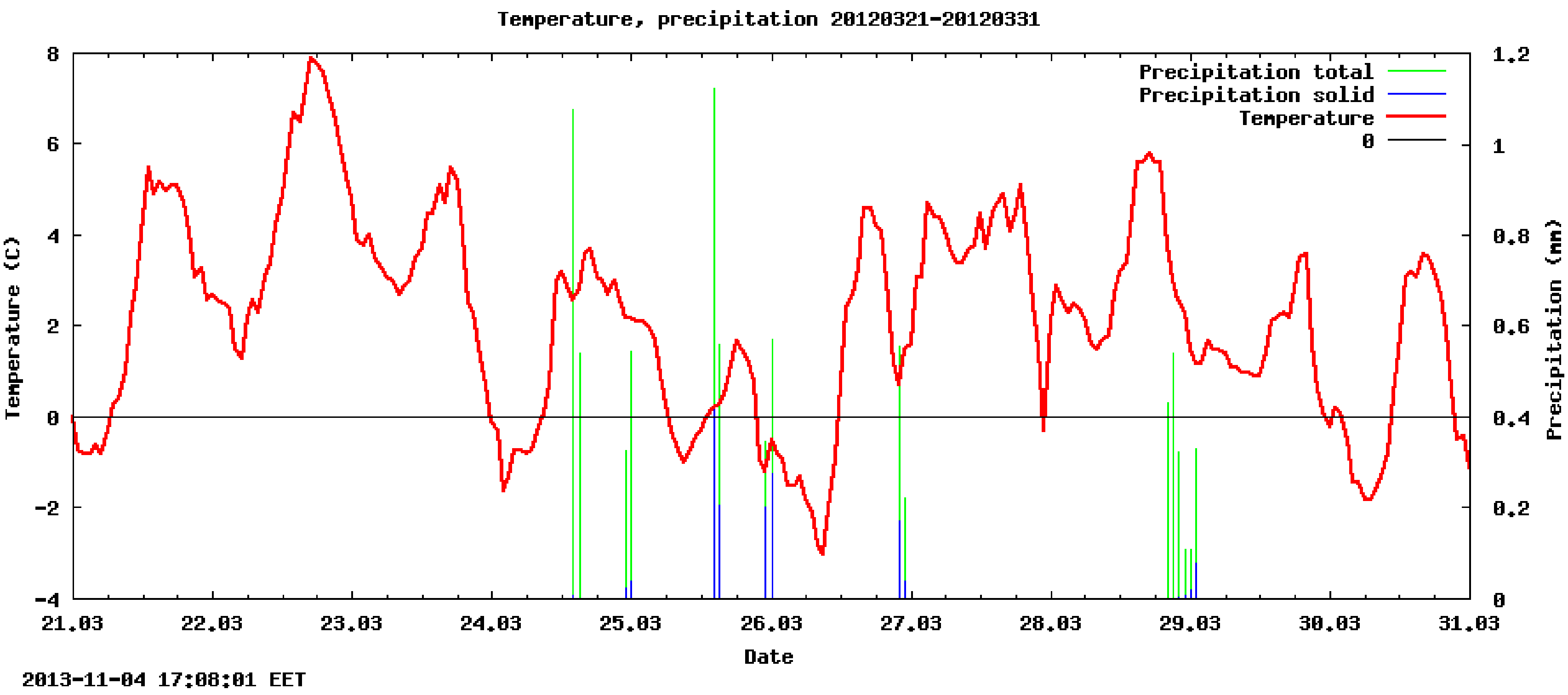




Operational forecast version
Daily values

1h timestep version
Daily averages, 1 h simulation step

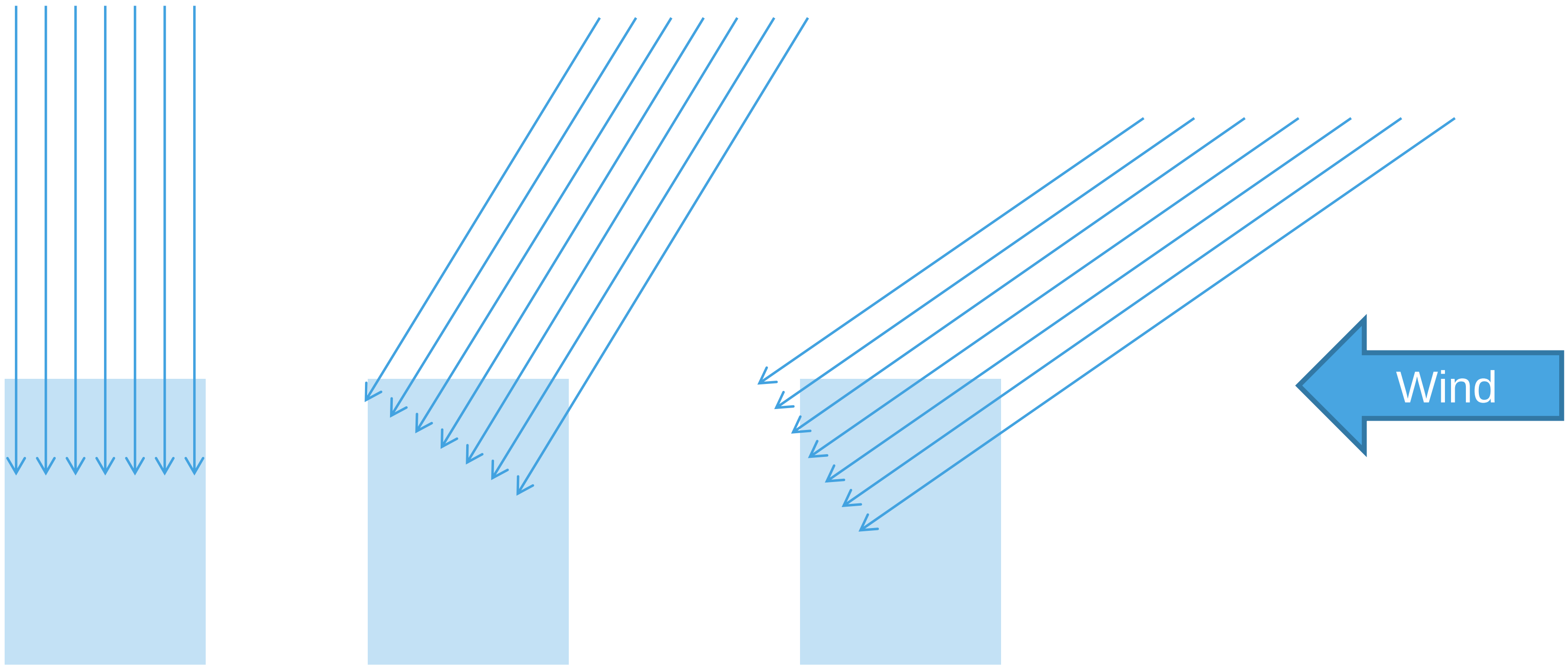
Temperature and precipitation

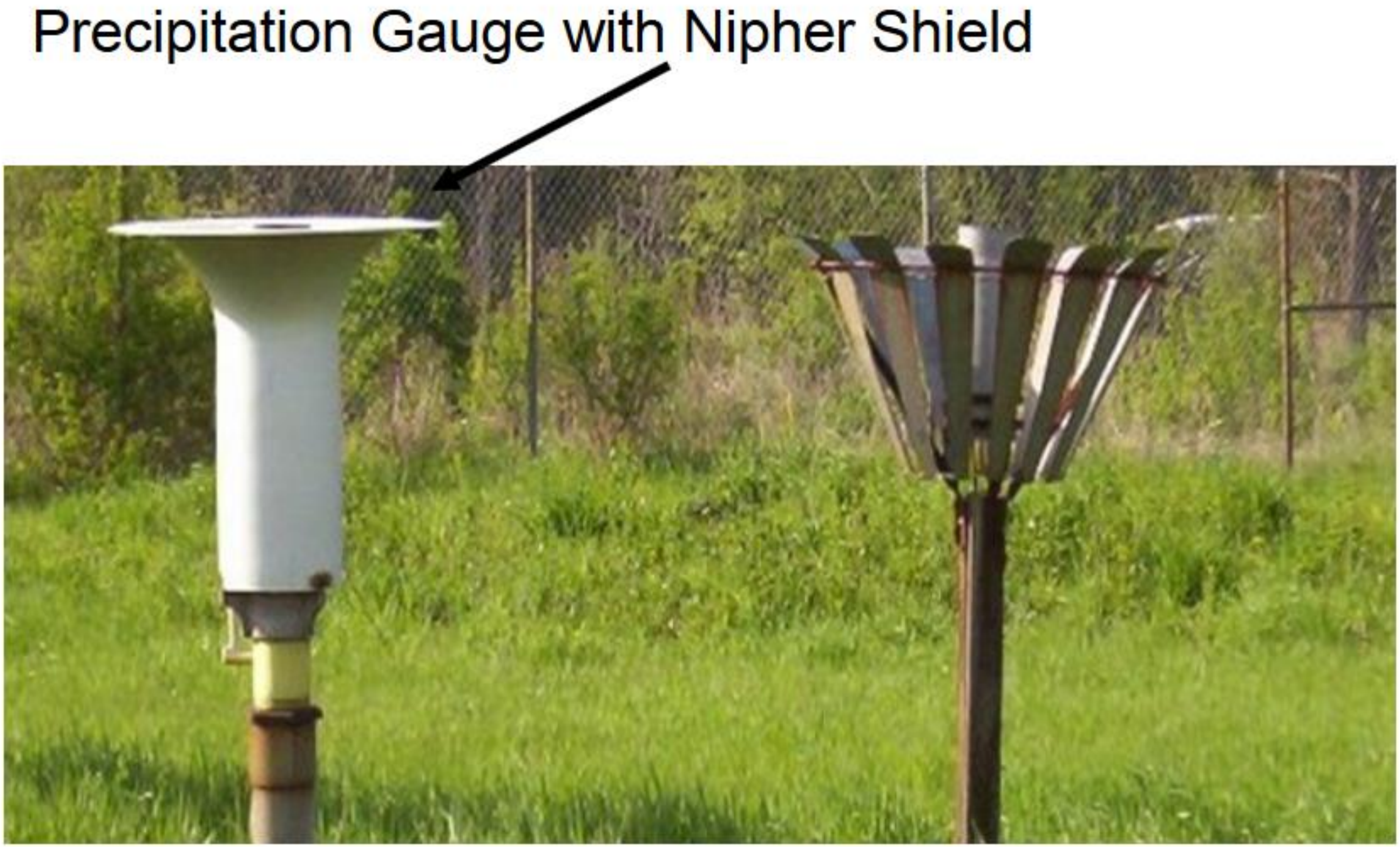


Model input: hourly observations of precipitation (snow, total) and temperature.

Wind effect on precipitation gauge measurements

- Areal precipitation is based on gauge measurements, which have systematic errors due to measurement techniques

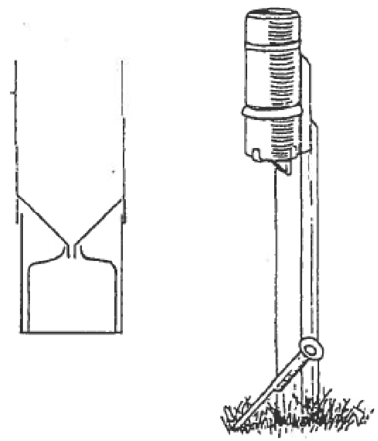



Precipitation Gauge with Nipher Shield

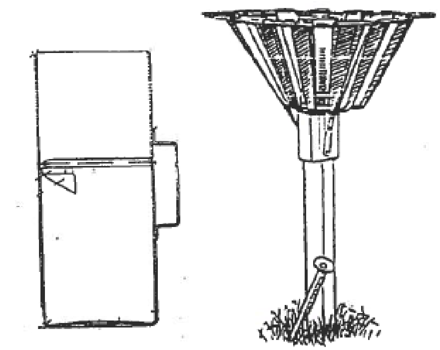
Tretjakov wind shield

Process model development
Point-corrected precipitation (4/14)

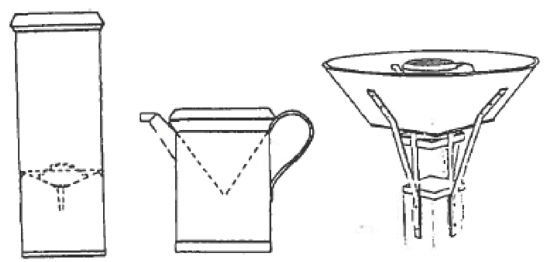
Nordic gauges



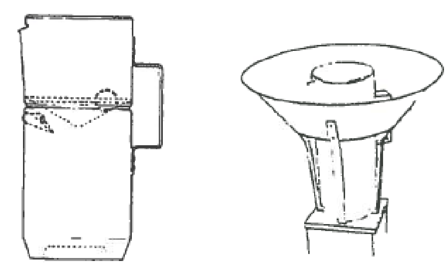
Gauge 15: Hellmann (Denmark)



Gauge 22: Finnish H&H-90) (Finland)



Gauge 8: DNMI (Norway)



Gauge 11: SMHI (Sweden & Norway)

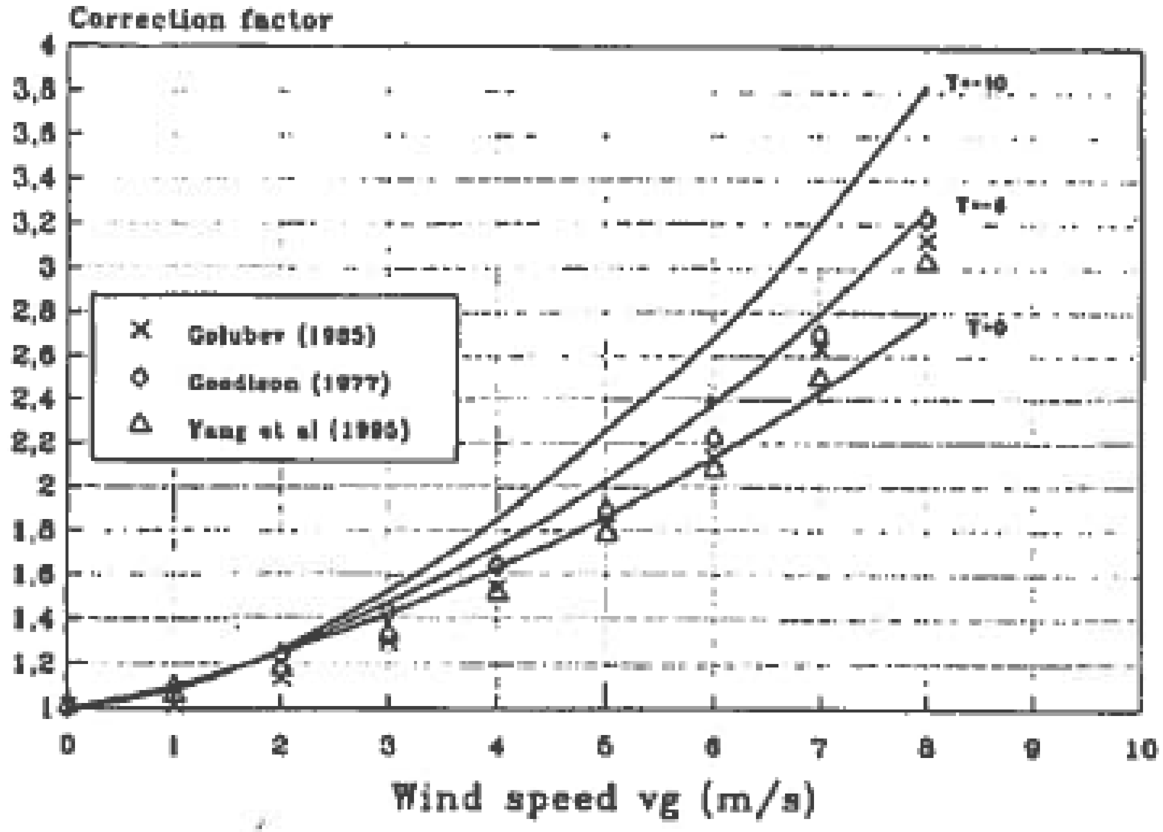
Alter wind shield

Examples of precipitation gauge catch ratio

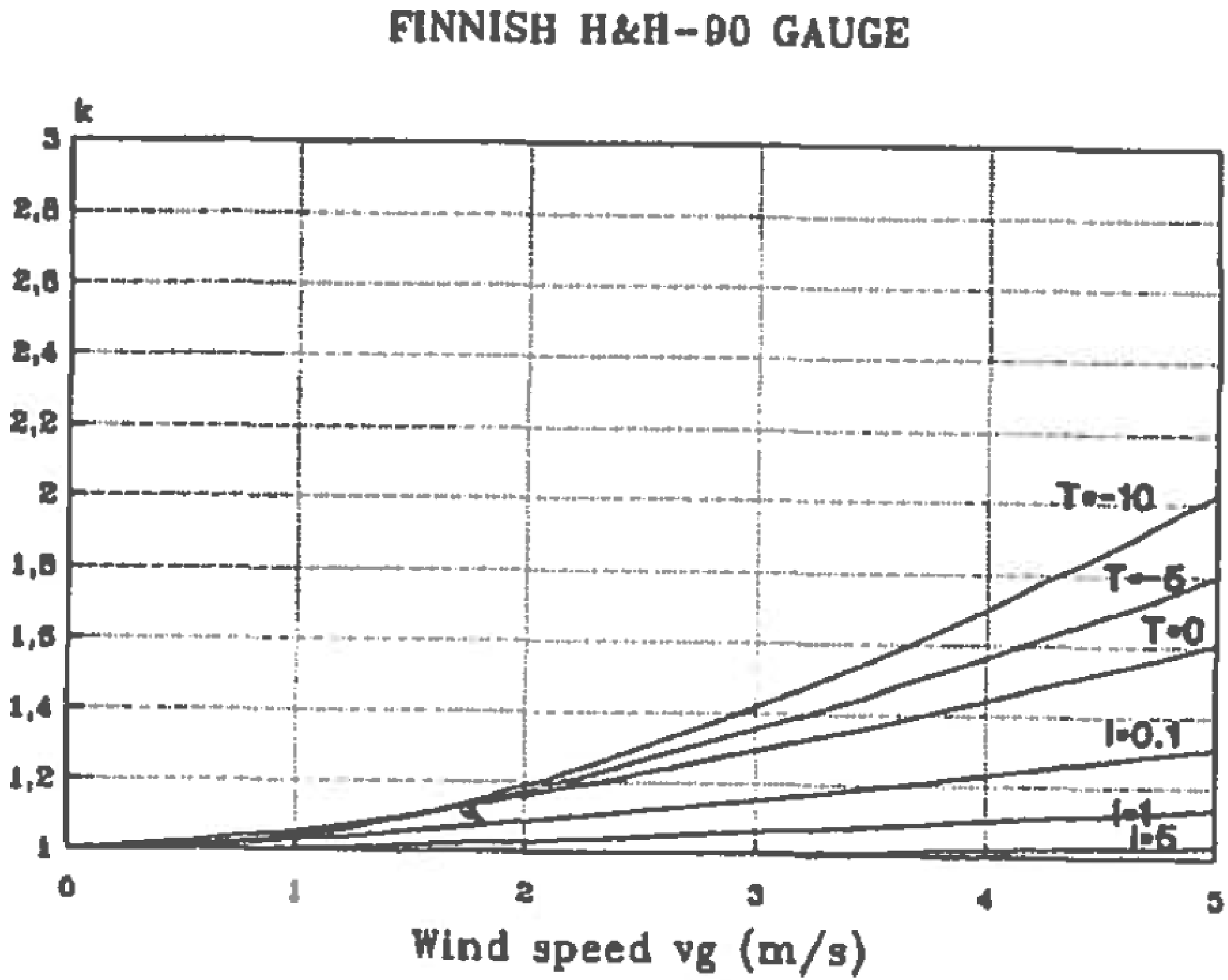
- Rain gauge measurements have systematic errors due to measurement techniques
  - → Aerodynamic correction
  - → Evaporation correction (manual measurements)
  - → Wetting correction (manual measurements)

- Annual precipitation correction
  - Snow: at least +20 – +30 %
  - Rain: +3 – +4 %

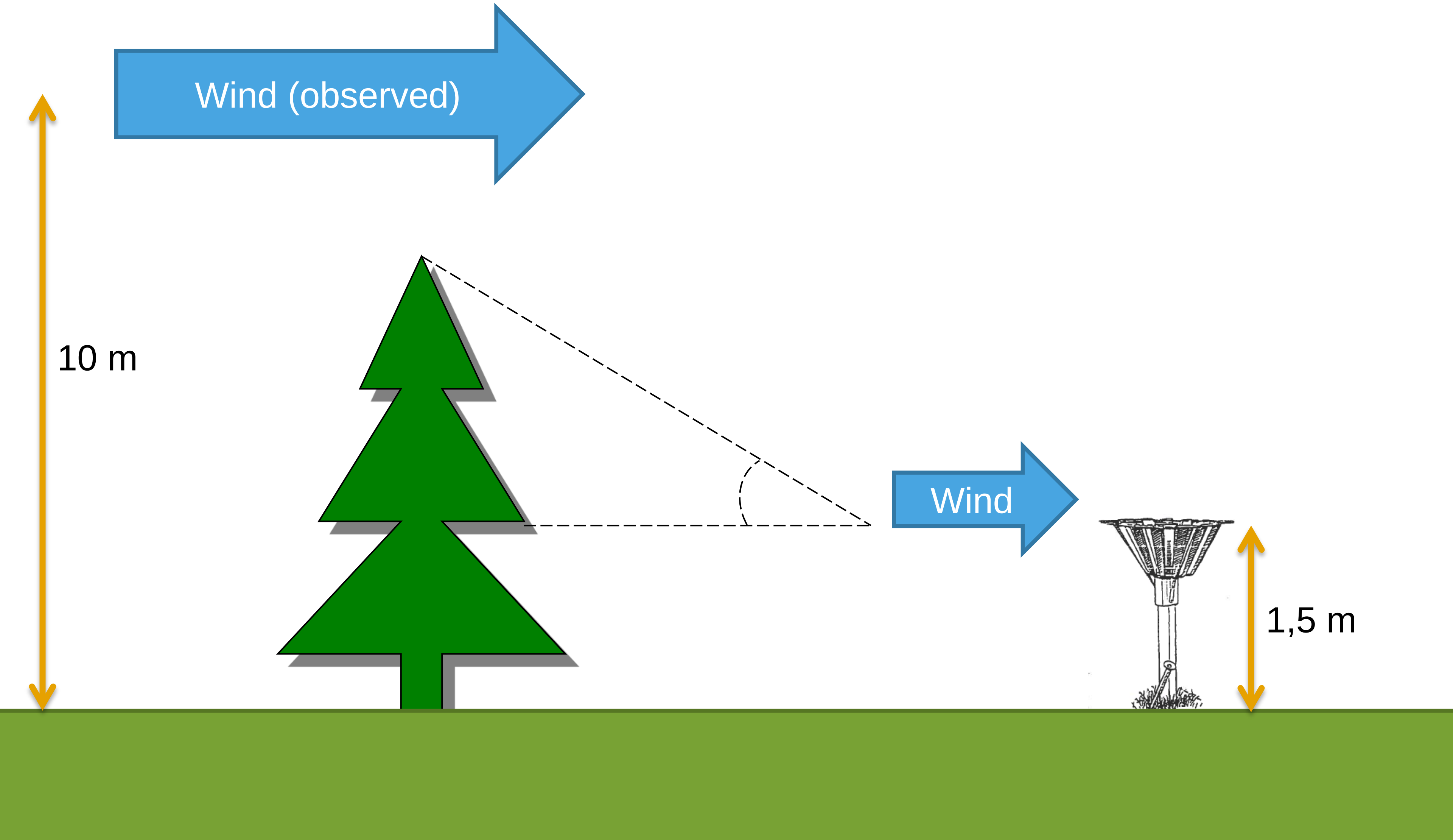
Examples of precipitation gauge catch ratio



3 *Correction factors for solid precipitation in shielded Tretyakov gauge.*
Full drawn lines are based on eq. 4.12. Correction factors for three earlier studies (see
are also included


FINNISH H&H-90 GAUGE
k
3
2,8
2,6
2,4
2,2
2
1,8
1,6
1,4
1,2
1
0
1
2
3
4
5
Wind speed vg (m/s)
T=-10
T=-5
T=0
I=0.1
I=1
I=6

Calculating wind at gauge



Point-corrected precipitation

- Hourly correction:
  - 1) Calculate wind speed at gauge using interpolated wind data from nearest wind stations and rain gauge site exposure data
  - 2) Determine aerodynamical coefficient for correction by using wind speed at gauge
  - 3) Determine evaporation and wetting loss corrections
  - 4) Calculate precipitation correction from aerodynamical coefficient and evaporation and wetting loss corrections

DNMI klima: Manual for operational correction of nordic precipitation data, 1996

4.3 Recommended model 1 : "DYNAMIC CORRECTION MODEL".

As stated in chapter 2, the most important ΔP_{im} terms in the Nordic countries, are evaporation (ΔP_E) and wetting loss (ΔP_W), i.e. eq. (4.1) may be simplified to

(4.8) $P_c \sim k\,(P_m + \Delta P_E + \Delta P_W)$

Aerodynamic coefficient k for snow:

(4.12) $k_s = \exp[\beta_0 + \beta_1 \cdot v_g + \beta_2 \cdot T + \beta_3 \cdot v_g \cdot T]$

where v_g is wind speed (m/s) at gauge level and T temperature (°C). The constants β_0, β_1, β_2 and β_3 have been estimated for the four Nordic gauges, taking into account the correction of the DFIR according to eq. (3.1) of Golubev (see Table 5.6).

Aerodynamic coefficient k for rain:

(4.11) $k_l = \exp[-0.00101 \cdot \ln I - 0.012177 \cdot v_g \cdot \ln I + 0.034331 \cdot v_g + 0.007697 + c]$

depending on gauge coefficient c (unshielded gauge c=0.0, shielded gauge c=-0.05), windspeed v_g (m/s) measured at gauge level and rain intensity I (mm/h).

Process model development
Point-corrected precipitation (12/14)

v_g

The wind speed (v_g) should preferably be measured at the level of the gauge orifice. If wind speed is measured at another level, WMO (1994) states: The reduction of wind speed to the level of the gauge orifice should be made according to the following formula:

$$(4.10) \qquad v_g = (\log h z_0^{-1}) \cdot (\log H z_0^{-1})^{-1} \cdot (1 - 0.024\alpha) \cdot v_H$$

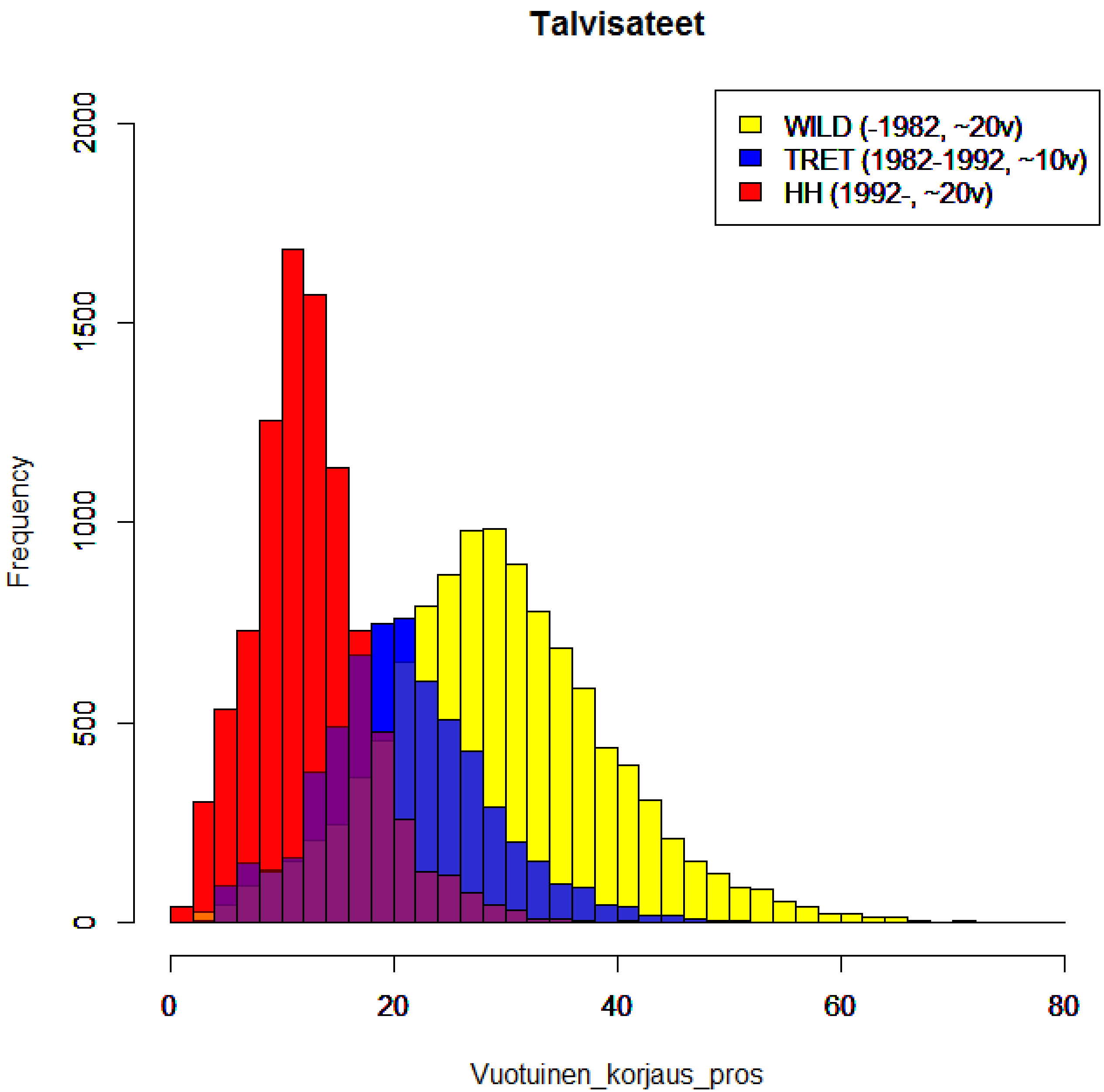
where

- v_g = wind speed (m/s) at the level of the gauge orifice
- h = height (m) of the gauge orifice above the ground
- z_0 = roughness length (m): 0.01 m for winter and 0.03 m for summer
- H = height (m) of the wind speed measuring instrument above the ground
- v_H = wind speed (m/s) measured at the height H above the ground
- α = average vertical angle (degrees) of obstacles around the gauge

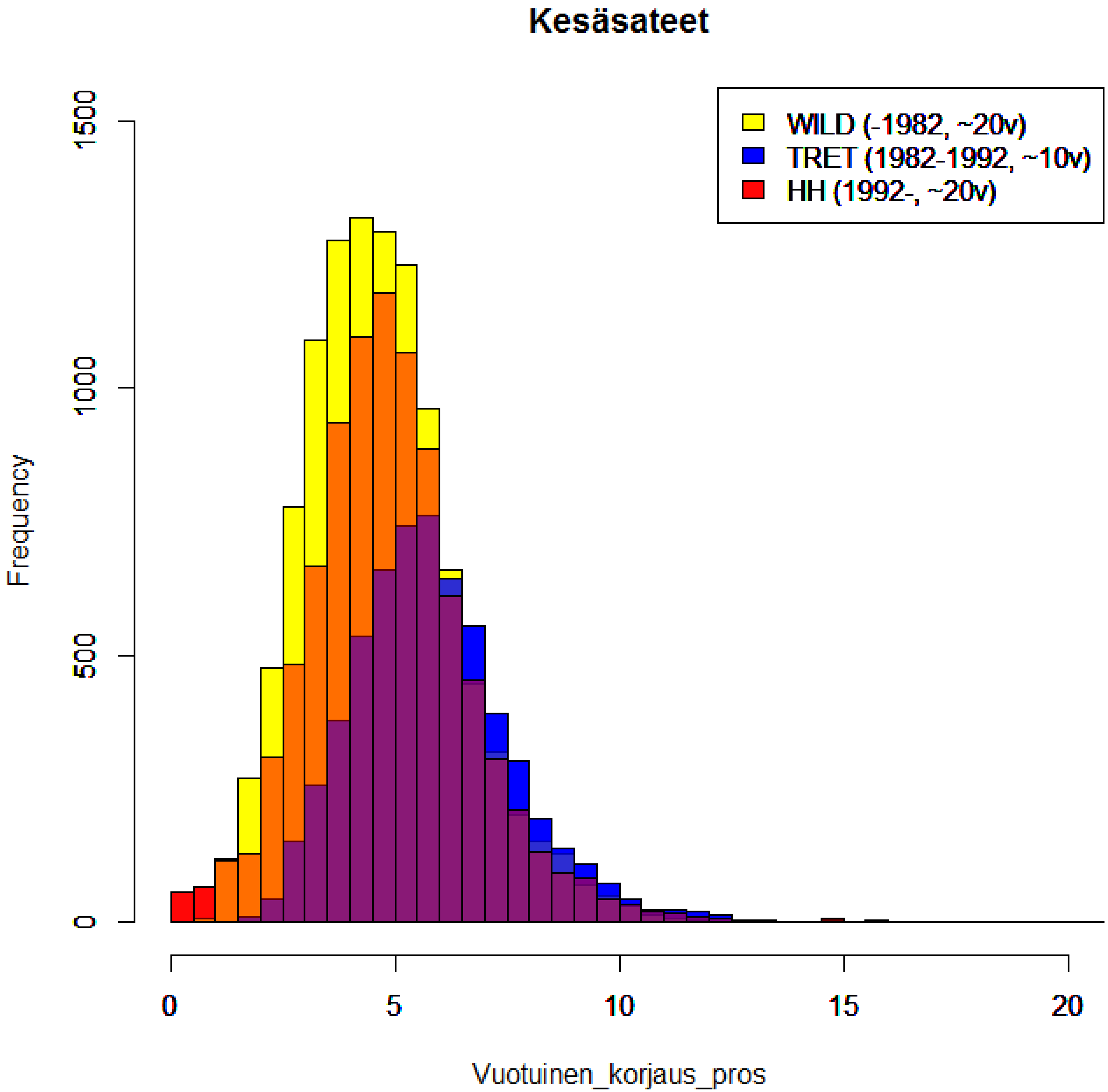
v_H

- Based on 3 nearest representative observations
- Distance weighted mean

Process model development
Point-corrected precipitation (13/14)



Process model development
Point-corrected precipitation (14/14)



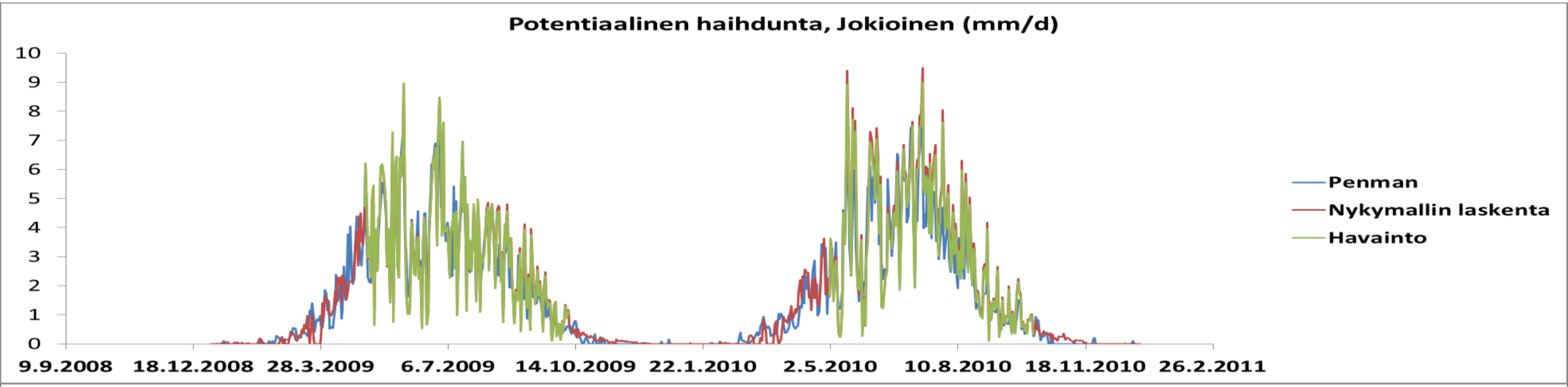
Uusi potentiaalisen haihdunnan prosessimalli

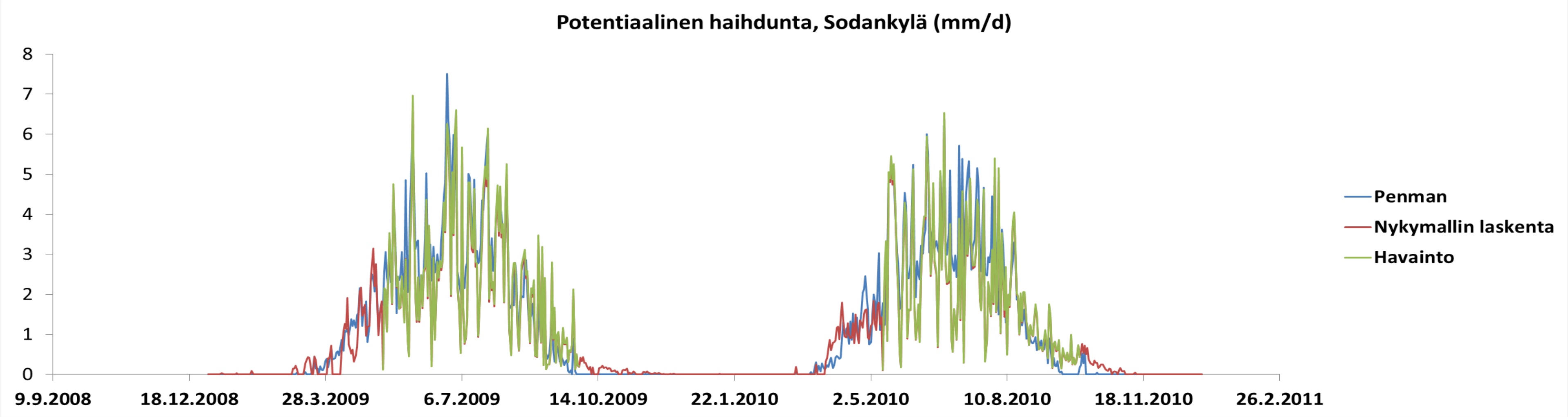
- Potentiaalisen haihdunnan määrittäminen Class A-havainnon sijasta Penmanin menetelmällä laskemalla
  - Kaava: $$E_p = \frac{\Delta}{\Delta+\gamma}(R_n) + \frac{\gamma}{\Delta+\gamma}\frac{6{,}43(1+0{,}536U_2)D}{\lambda}$$
    - Jossa Δ = kulmakerroin vesihöyryn kyllästyspaine – lämpötila –käyrälle
    - γ = psykometrivakio
    - ʎ = veden höyrystymisen latenttilämpö
    - Rn = nettosäteily
    - U2 = tuulen nopeus 2 m:n korkeudella
    - D = vesihöyryn painevaje
  - Lähtötietoina lämpötila (T), pilvisyys (Cl), tuulen nopeus (Ws), ilman suhteellinen kosteus (U), ilmanpaine (Ba) ja sijainti
    - Havainnot Ilmatieteen laitoksen havaintoasemilta
  - Hyötynä laskenta myös alkukeväisin, loppusyksyisin ja talvisin, jolloin Class A-havaintoja ei ole, sekä tarkempien lähtötietojen ja ennustesuureiden käyttö

Kalibrointi Class A –havaintoja vastaan

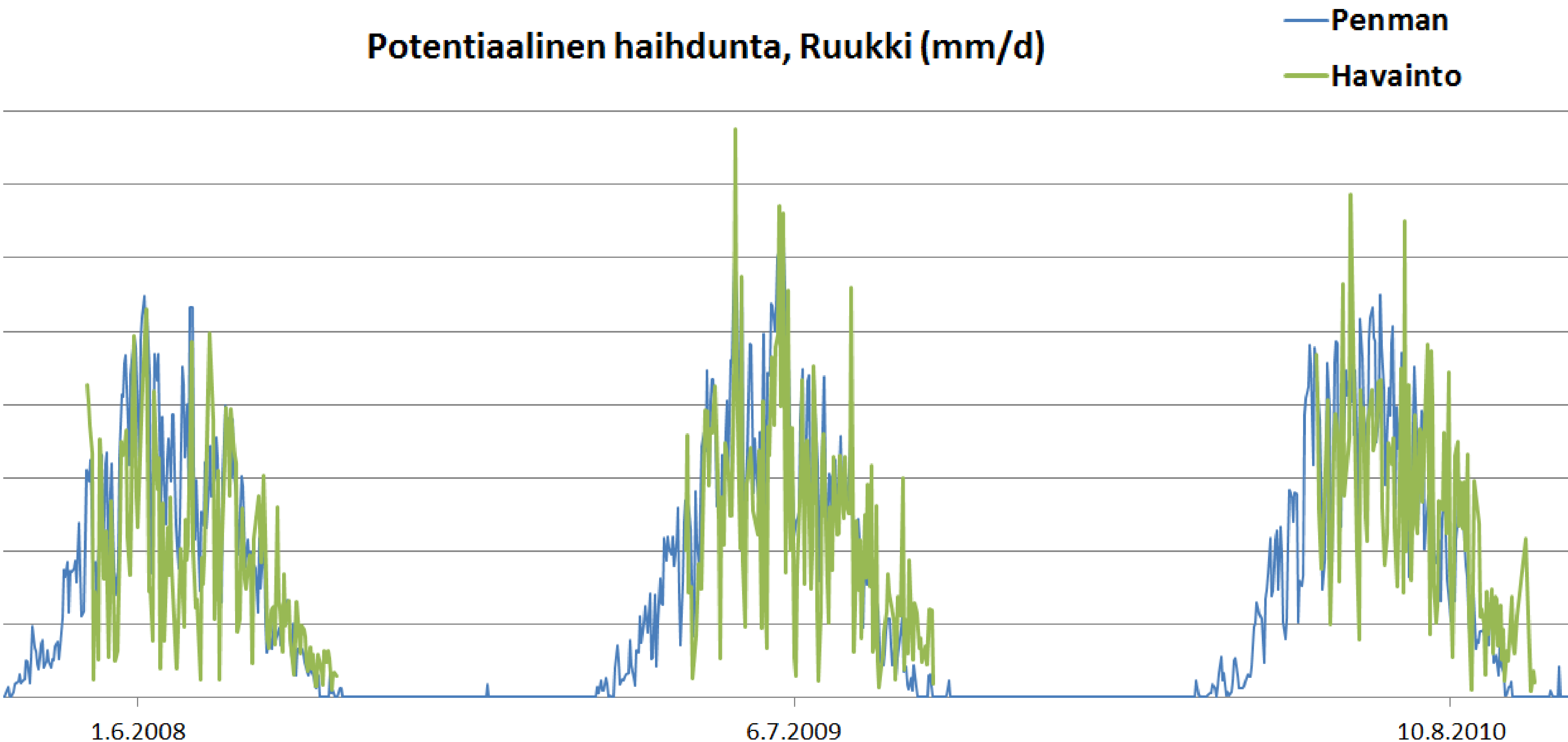
- Pitkäaaltosäteilyn laskennassa käytettävät parametrit (2 kpl) kalibroitu Class A –haihduntahavaintoja vastaan kullekin havaintoasemalle
- Kalibroinnin tuloksena saadut hyvyysluvut haihdunta-asemille ovat vaihtelevia, välillä 0,19 - 0,83, suurin osa kuitenkin parempia kuin 0,6
- Huonoimmat hyvyysluvut saaneet asemat (Sodankylä Vuotso II, Suomussalmi, upotettu Class A) tarkastellaan erikseen ja ainakin Suomussalmen asema hylätään
- Havaintoasemille kalibroidut parametrit levitetty muille alueille interpoloimalla -> koko Suomen kattava laskenta

Potentiaalisen haihdunnan päiväarvoja nykymallilla (Class A –havainto käytössä, yksinkertaisella kaavalla laskettu kun ei ole havaintoa) ja Penmanin menetelmällä laskettuna



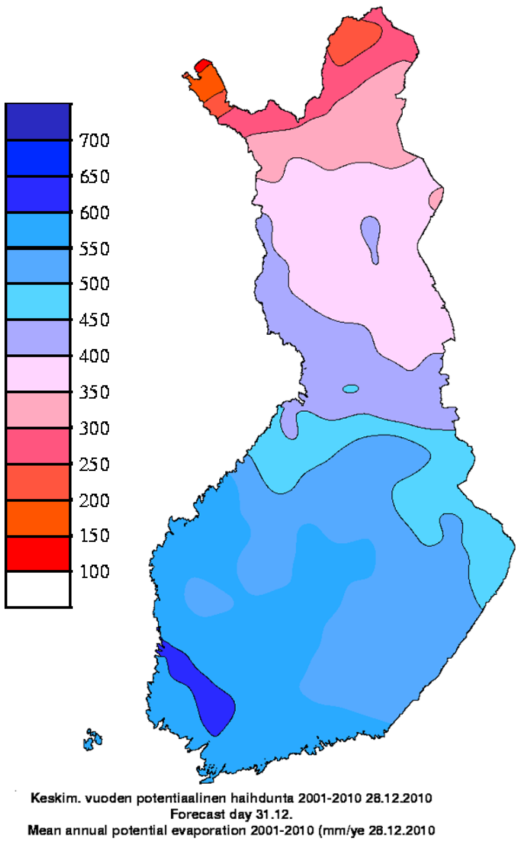


Ruukin Class A –asema:

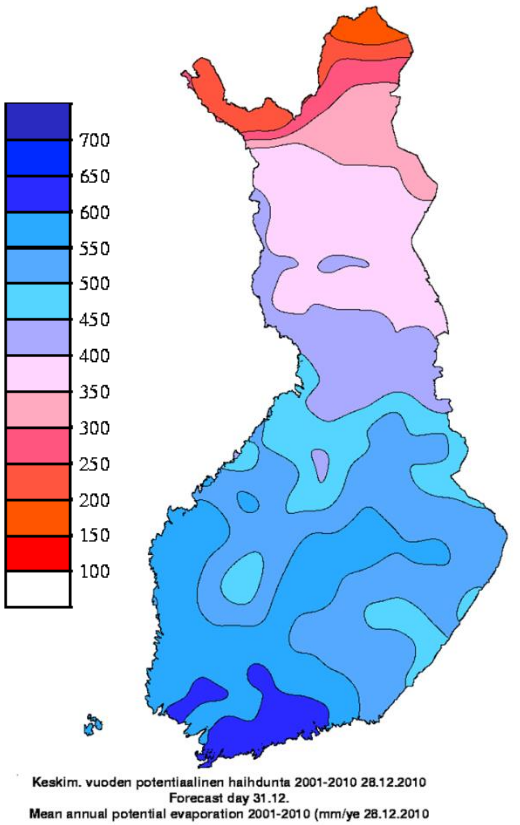


Vuosien 2001-2010 keskimääräinen potentiaalinen vuosihaihdunta

Nykymalli



Penmanin menetelmä



Jatkokehitys

- Uuden kehitetyn mallin testaus / kalibrointi ja käyttöönotto
- Mahdollisesti tuntilaskentaan siirtyminen
- Todellisen haihdunnan laskennan kehitys
  - Tavoitteena eri kasvillisuustyyppien ja mahdollisesti interseption huomioon ottaminen sekä maaperän ja maankäytön paikkatietoaineiston hyödyntäminen
  - Mahdollisesti Penman-Monteithin kaavan käyttö matalalle kasvustolle sekä puustolle
  - Maankosteuden rajoittava vaikutus huomioidaan
- Nykyisin maahaihdunta lasketaan potentiaalisesta haihdunnasta maankosteuden vajauksen ja kalibroitavien parametrien avulla

Kasvillisuushaihdunnan laskennan kehitys

- Potentiaaliselle haihdunnalle kehitetty malli pohjana -> laajennettu Penman-Monteithin yhtälöksi tietylle referenssikasville (Handbook of Hydrology)

- Kasvillisuustyyppi huomioidaan kasvukauden mukaan vaihtelevan kasvillisuuskertoimen avulla
- Maankäyttötiedot käytössä (6 luokkaa)
- Metsissä lasketaan myös interseptio
- Tarvitaan lisäksi rajoittavia tekijöitä mm. maankosteus

- Nykyisin maahaihdunta lasketaan potentiaalisesta haihdunnasta maankosteuden vajauksen ja kalibroitavien parametrien avulla

- Potentiaalisen haihdunnan määrittäminen Class A-havainnon sijasta Penmanin menetelmällä laskemalla
  - Kaava: $$E_p = \frac{\Delta}{\Delta+\gamma}(R_n) + \frac{\gamma}{\Delta+\gamma}\frac{6{,}43(1+0{,}536U_2)D}{\lambda}$$
    - Jossa Δ = kulmakerroin vesihöyryn kyllästyspaine – lämpötila –käyrälle
    - γ = psykometrivakio
    - ʎ = veden höyrystymisen latenttilämpö
    - Rn = nettosäteily
    - U2 = tuulen nopeus 2 m:n korkeudella
    - D = vesihöyryn painevaje
  - Lähtötietoina lämpötila (T), pilvisyys (Cl), tuulen nopeus (Ws), ilman suhteellinen kosteus (U), ilmanpaine (Ba) ja sijainti
    - Havainnot Ilmatieteen laitoksen havaintoasemilta
  - Hyötynä laskenta myös alkukeväisin, loppusyksyisin ja talvisin, jolloin Class A-havaintoja ei ole, sekä tarkempien lähtötietojen ja ennustesuureiden käyttö (tuntilaskenta, ilmastonmuutos)

Kasvillisuushaihdunnan prosessimalli

- Kullekin maankäyttöluokalle:

  $E = Ks(\theta) Kco Erc$ (mm/vrk)

  Erc = referenssikasvin haihdunta

  Kco = kasvillisuuskerroin

  Ks(θ) = maankosteuden rajoittava vaikutus

- Kasvillisuuskerroin koostuu kasvikohtaisesta lämpösumman laskennasta ja kasvin koosta verrattuna referenssikasviin
  - Lämpösumman eli kasvukauden vaikutus lasketaan erikseen pellolle, suolle ja lehtimetsälle
  - Havumetsässä, rakennetulla alueella ja vesialueella kasvukauden vaikutusta ei huomioida

Maankosteuden vaikutus haihduntaan

- Maankosteudelle testattu nykyiseen vesistömalliversioon pohjautuvaa laskentaa sekä kehitteillä olevaa tarkempaa maankosteuden kaksikerrosmallia

- Vesistömallin parametreihin ja laskentaan perustuva vaikutus

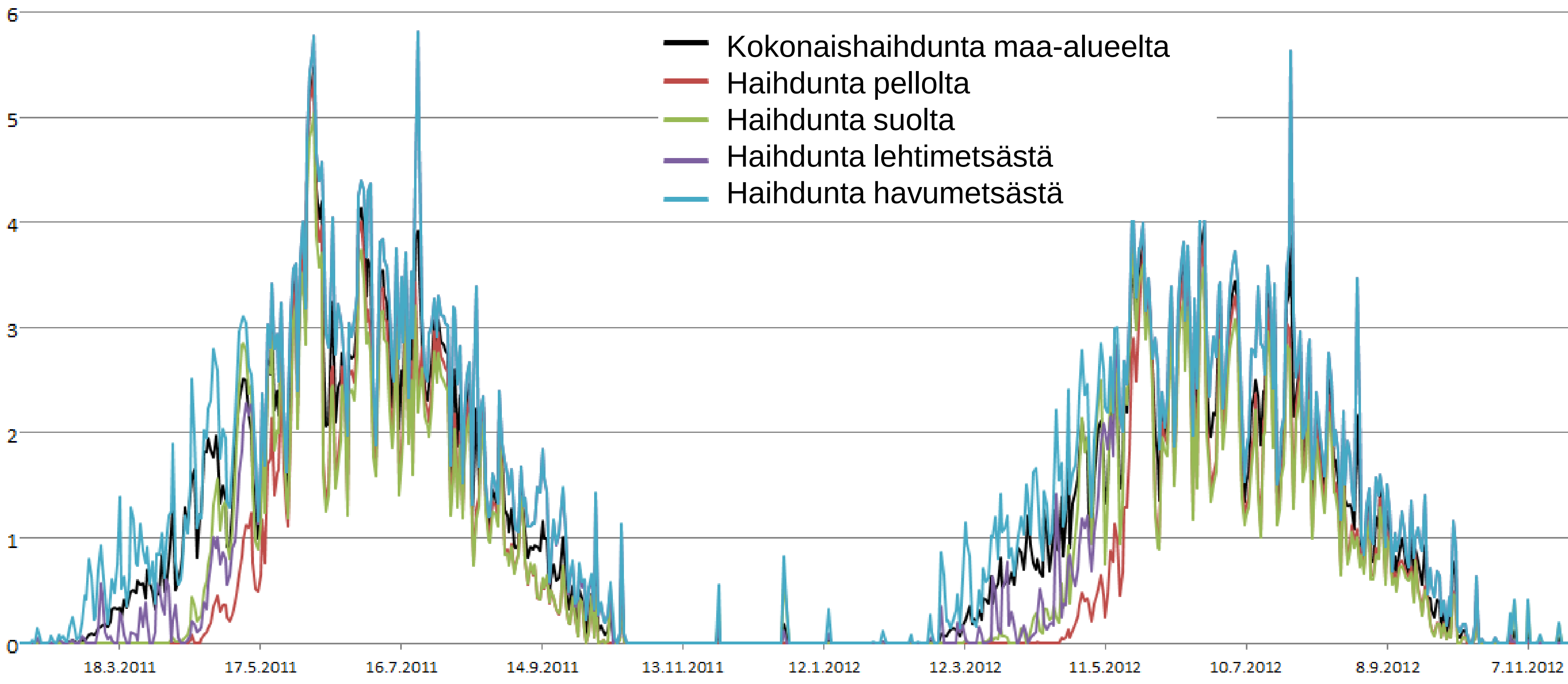
  = Neliöjuuri(maankosteus / maavesivaraston koko)

  (huom. sama vaikutus koko vesistön 3 jv. alueella)

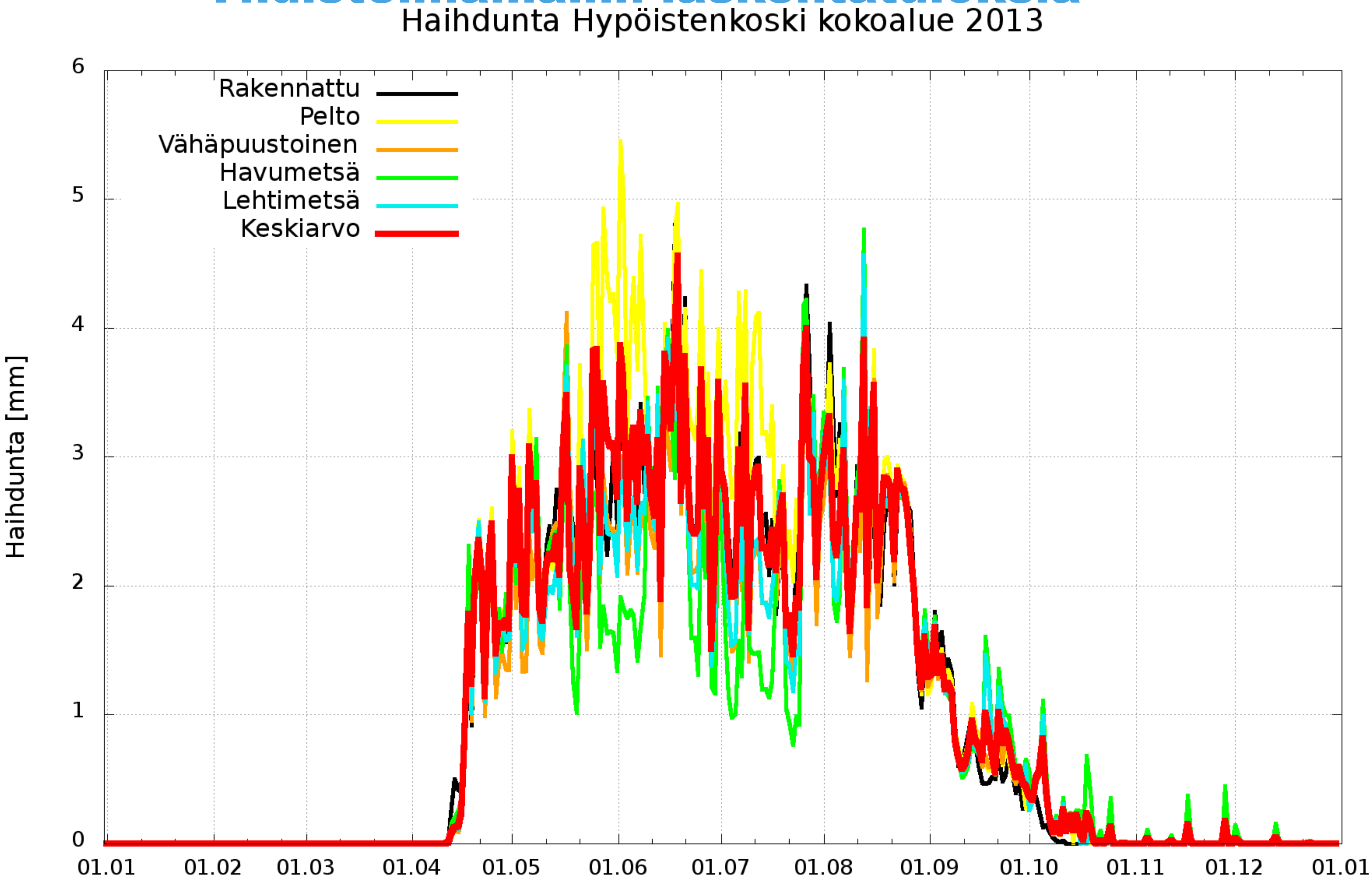
- Kaksikerrosmalli ottaa huomioon erilaisten maannosten osuudet 3 jv. alueella ja niiden vaikutuksen maankosteuteen
  - Maankäyttö- ja maaperäluokat yhdistelty paikkatieto-ohjelmalla Aurajoen vesistölle
  - Yhdistelmäluokkia testataan malliversiossa, jossa on yhdistetty maankosteuden kaksikerrosmalli ja kasvillisuushaihdunnan uusi laskentamalli

Maahaihdunta kasvillisuusluokittain Aurajoella, mm (huom. tässä kaikilla sama maankosteus)

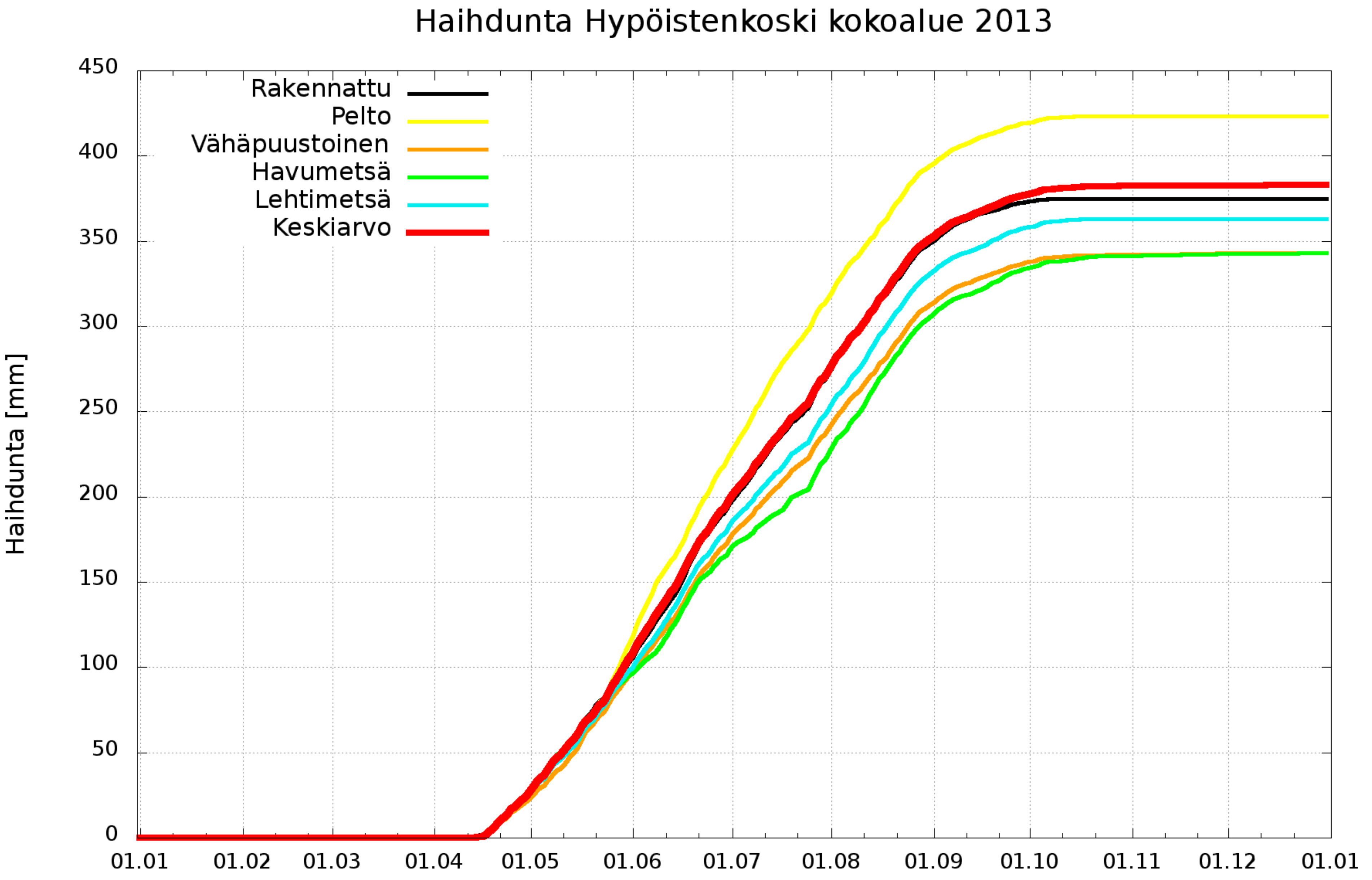
Rakennettu alue, %	1.4
Vesi	0.01
Pelto	33.69
Suo, vähäpuustoinen alue	19.03
Havumetsä, räme, havukorpi	10.32
Lehtimetsä, lehtikorpi, sekametsä	35.55



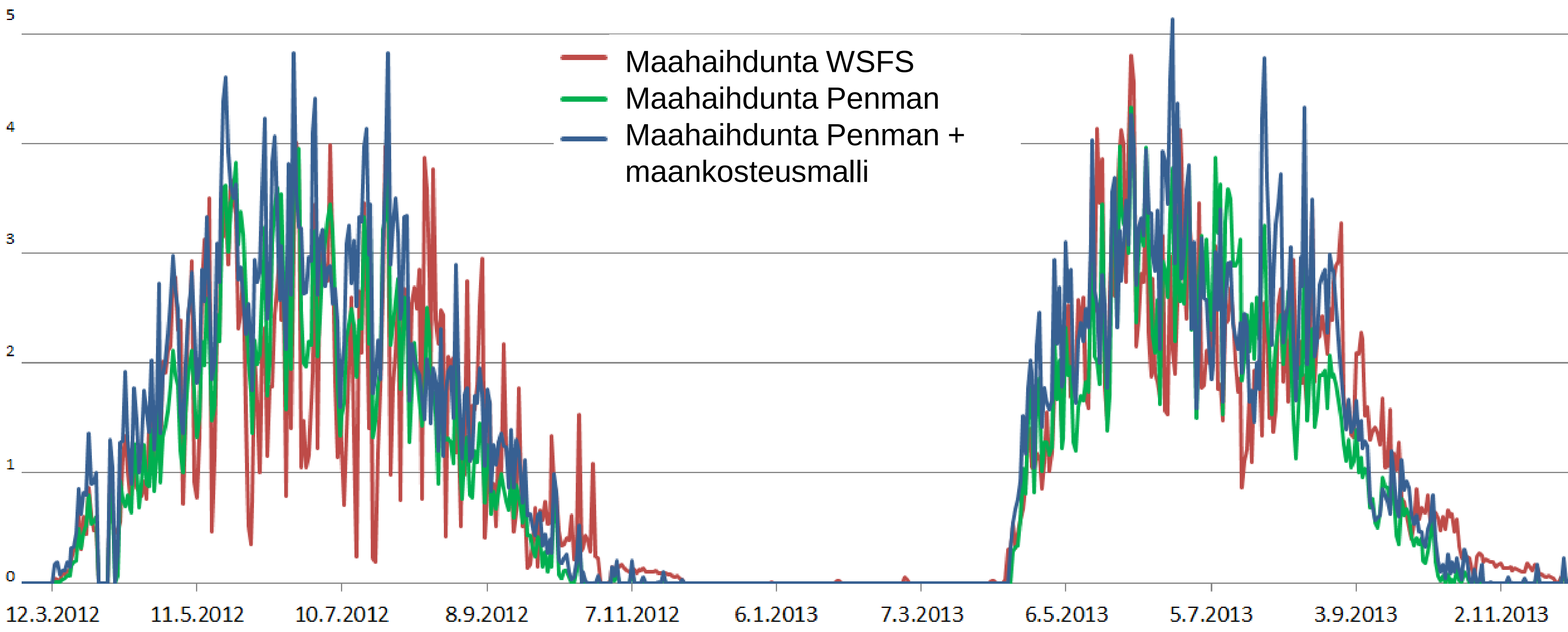
Yhdistelmämallin laskentatuloksia



Yhdistelmämallin laskentatuloksia

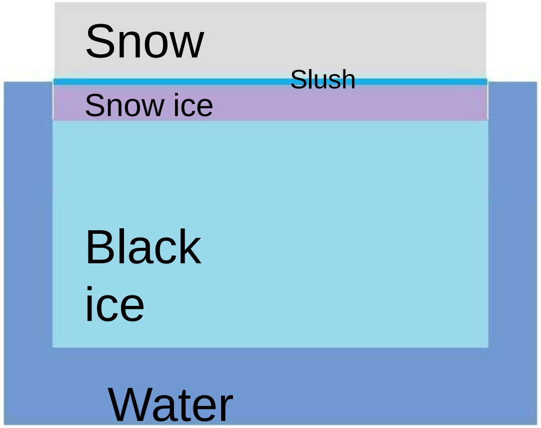


Malliversioiden vertailu operatiiviseen vesistömalliin



Ice thickness model

- Calculates ice thickness at observation points
    - All lake and river points in entire Finland
    - Simulates black ice, snow ice, slush and snow on ice
- Ice growth is driven by
    - Air temperature
    - Water temperature (beginning of freezing)
    - Thickness of snow and slush
    - Thickness of snow ice and black ice
- Melting of ice
    - Air temperature, snow



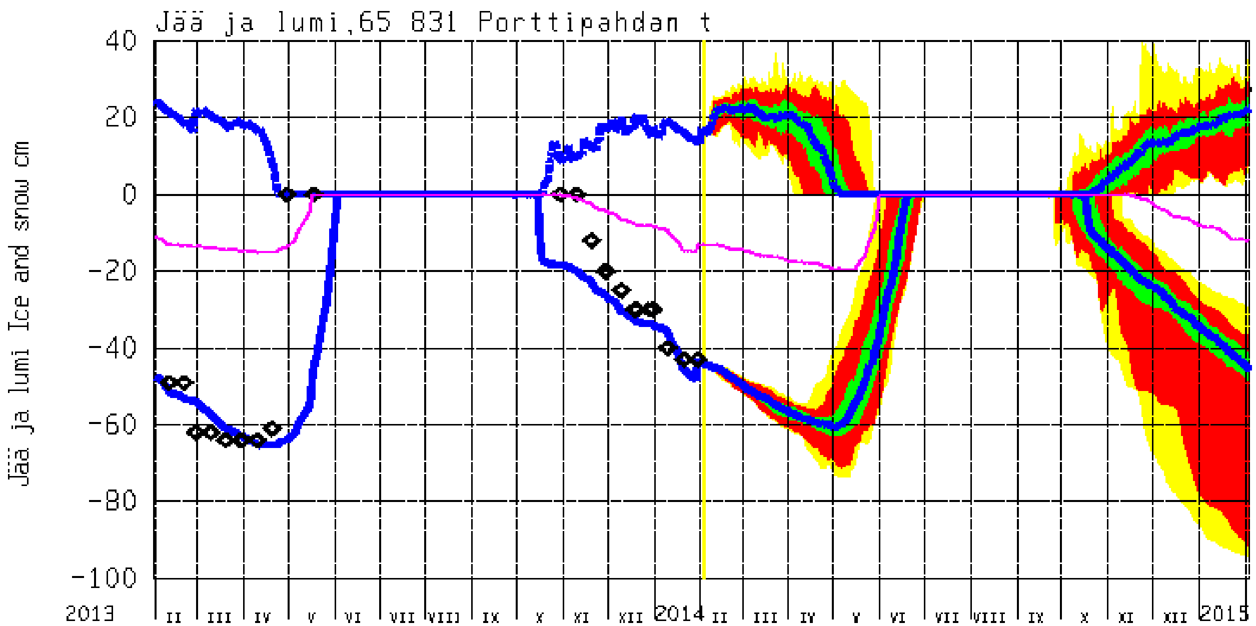
Ice thickness model

- Ice growth is calcalated by using heat transfer
  - Stefan's equations
  - Snow ice and black ice separated
  - T_a =Air temperature, L =thermal capacity,
  - $h_{i,}$, h_s ja h_{si} = height of black ice, snow ice and slush
  - ρ_{si} ja ρ_i = density of snow ice and black ice
  - $k_{i,}$, k_s ja k_{si} = coefficient of heat transform
  - Indexes i, s ja si : black ice, snow and snow ice
- Sulaminen lasketaan astepäivätekijällä

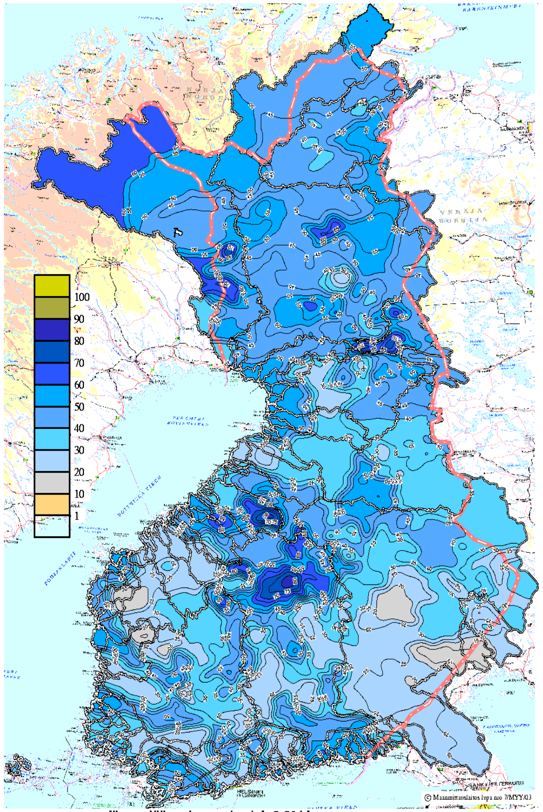
$$\begin{cases} \dfrac{dh_{si}}{dt} = \dfrac{-k_s T_a}{(h_s + \dfrac{k_s}{k_{si}} h_{sl})\rho_{si} L} \\ \dfrac{dh_i}{dt} = \dfrac{-k_i T_a}{(h_i + \dfrac{k_i}{k_s} h_s + \dfrac{k_i}{k_{si}} h_{si})\rho_i L} \end{cases}$$

$$\begin{cases} h_{si}^{t+1} = h_{si}^t - m_{si} T_a^t \\ h_i^{t+1} = h_i^t - m_i T_a^t \end{cases}$$

Ice thickness model 4.2.2014



Vesistömallijärjestelmä - SYKE-WSFS Watershed models

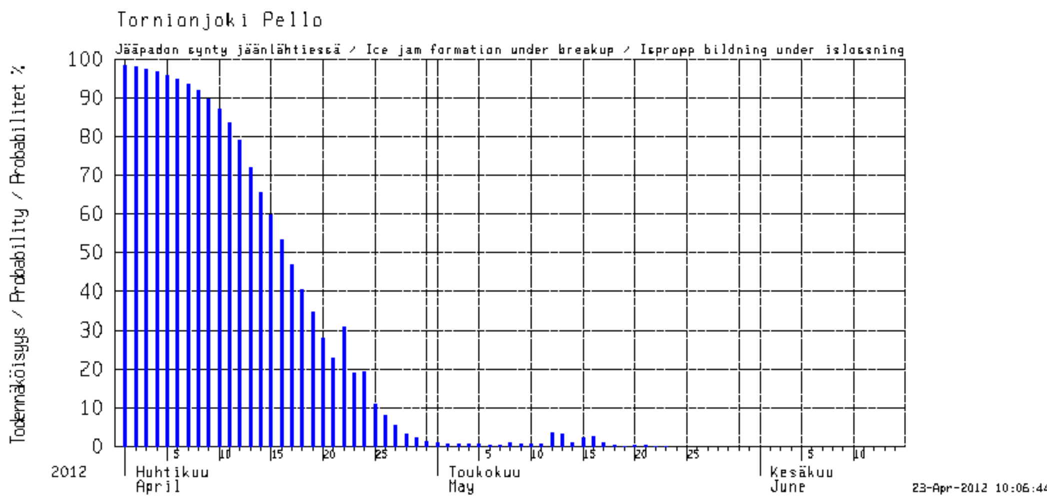


Järven jäänpaksuus (cm) 4. 2.2014
Forecast day 4. 2.
Lake ice thickness (cm) 4. 2.2014

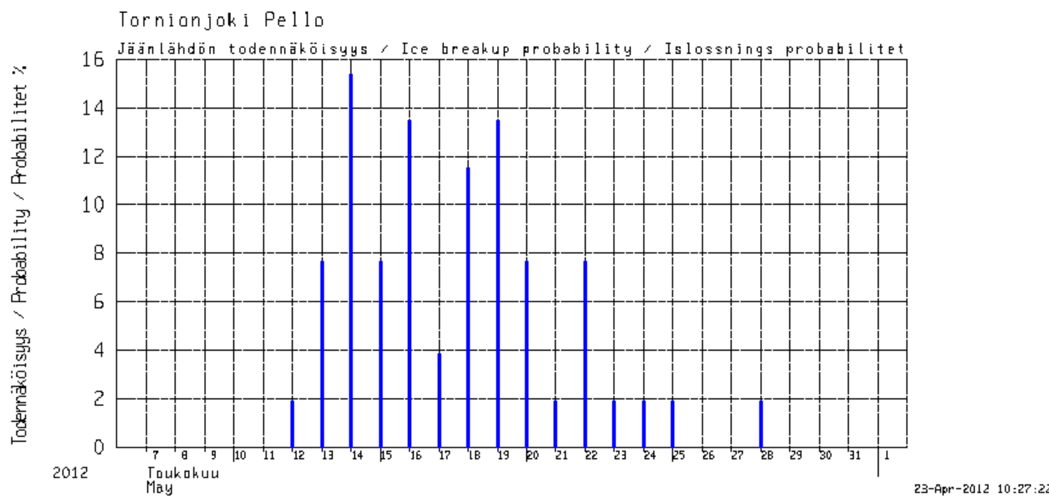
Observed (black diamond) and simulated total ice (solid blue line), snow ice (solid cyan line) and snow (dashed blue line above zero level)

Forecasting ice jams

- Probability of ice jam formation under breakup

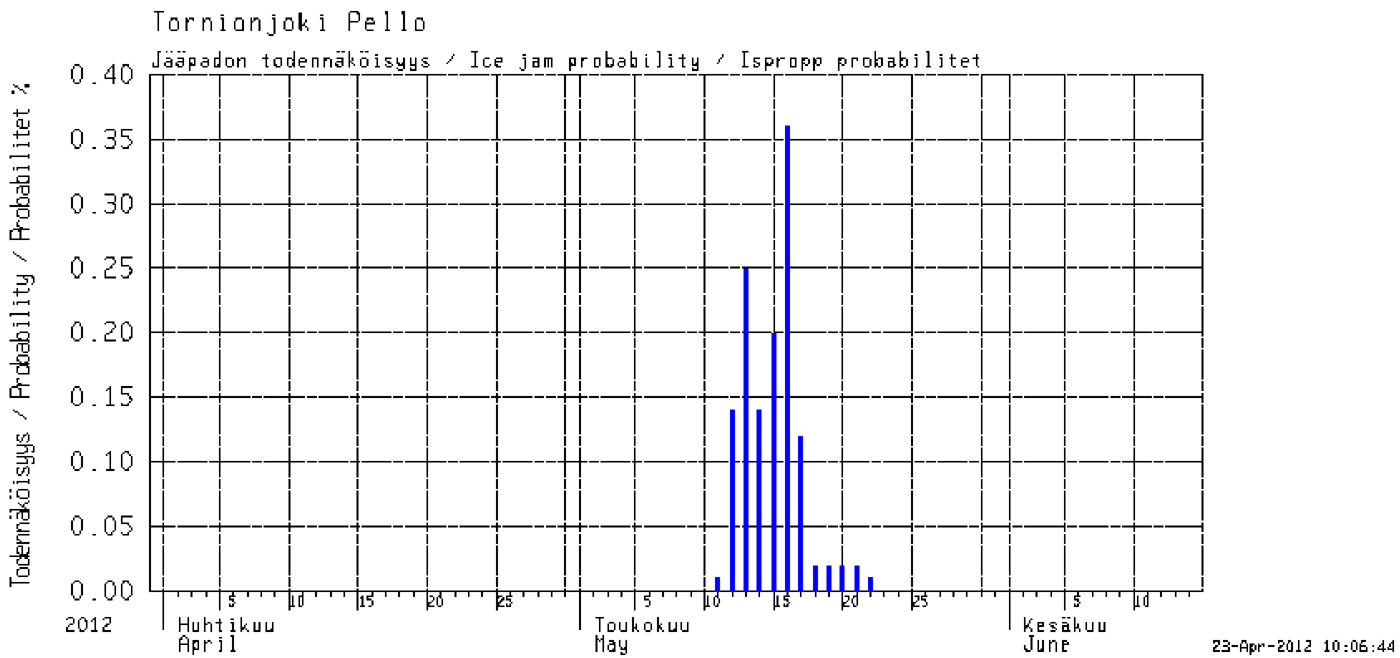


- Ice breakup probability for each day



Forecasting ice jams

- Combining the previous results gives the ice jam probability for each day
- Ice jam forecasts are highly reliable few days ahead, after that the reliability decreases
- www.ymparisto.fi/vesistoennusteet -> Tornionjoki

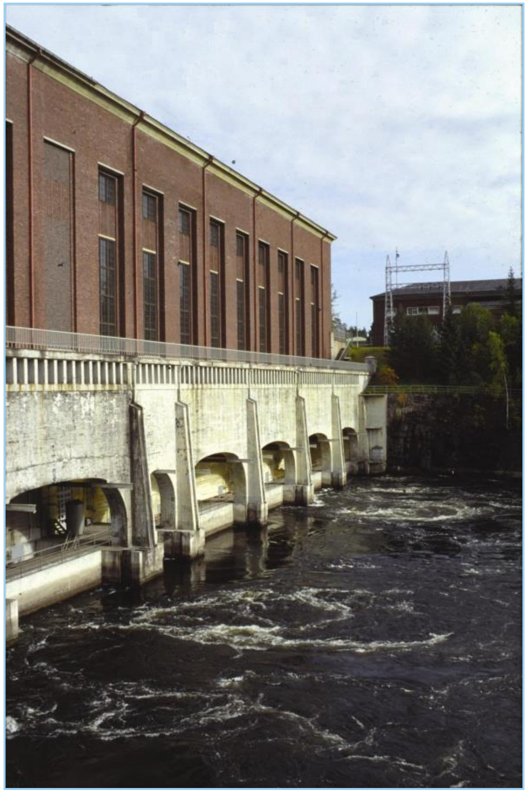


Frazil ice effect to water level model

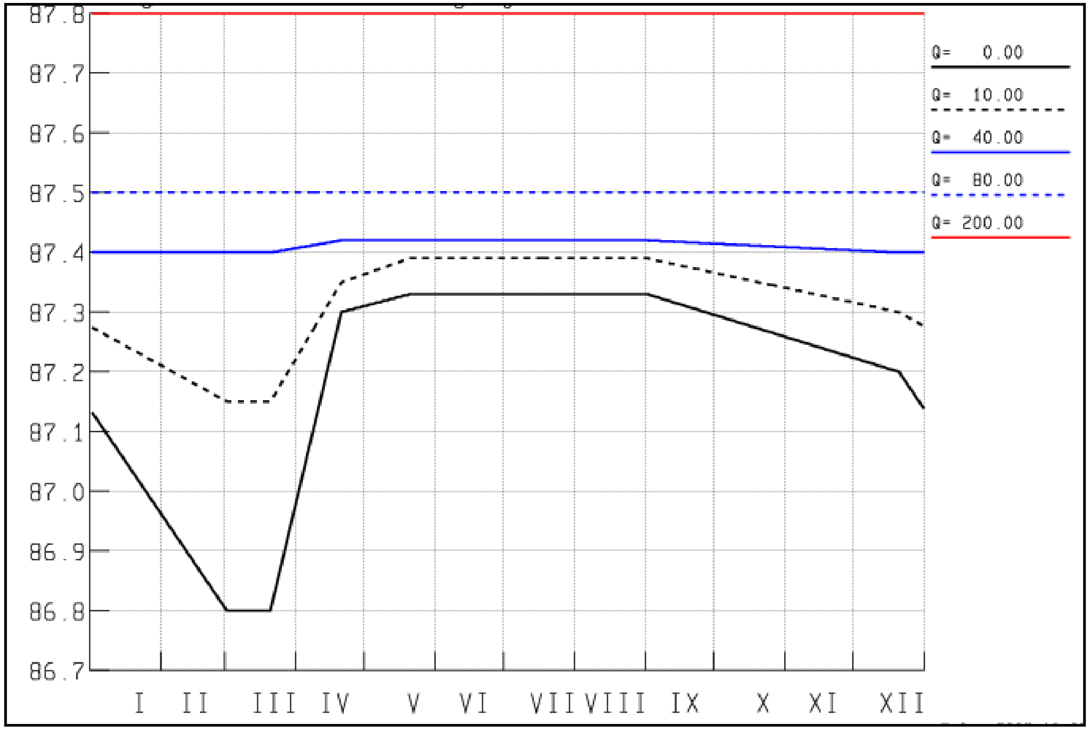
- Discharge is normalized to average conditions
  - Q_{relat}=Q/station mean Q * 350
- 1 and 3 day average air temperature limits frazil ice growth
  - $T_{frazil}=0.0087*Q_{relat}-13.913$ (1vrk)
  - $T_{3\_mean\_frazil}=0.0174*Q_{relat}-13.826$ (3vrk)
- If 1 and 3 day air temperatures are below frazil ice growth limit temperatures, water level will increase meters per day
  - $\Delta H_{frazil}=(0.0001*Q_{relat}-0.0102)*(T_{air}+10)$
- Frazil ice effect to the water level decrease if $T_{air} > -6.0$ C or T_{air} increases over 4 C per day
  - $\Delta H_{frazil}=-1*(0.0009*T_{air}^2+0.0281*T_{air}+0.2195)$

Forecasts provide predictions on hydrological phenomena for the needs of:

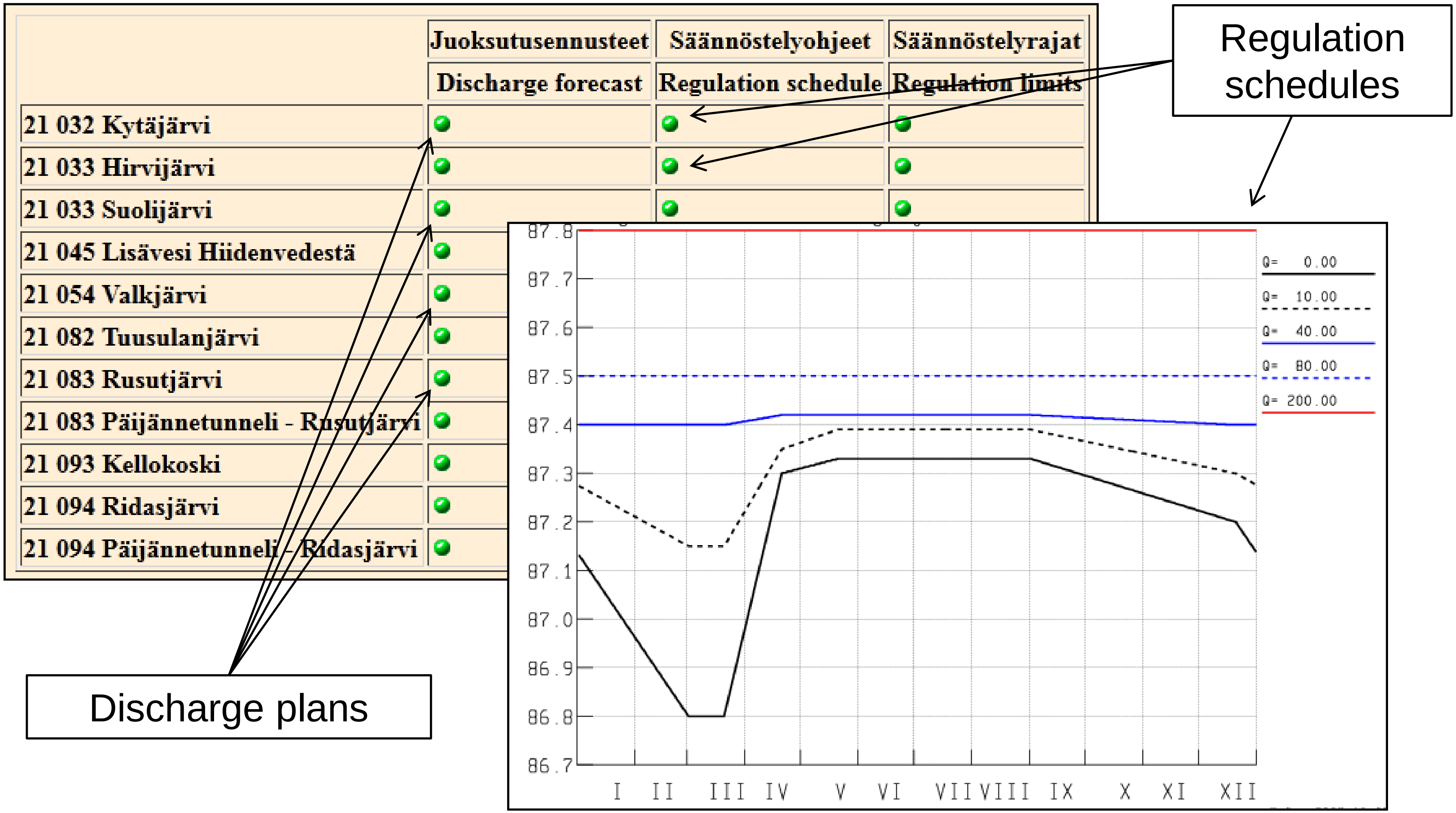
Hydropower industry



Operational lake regulation

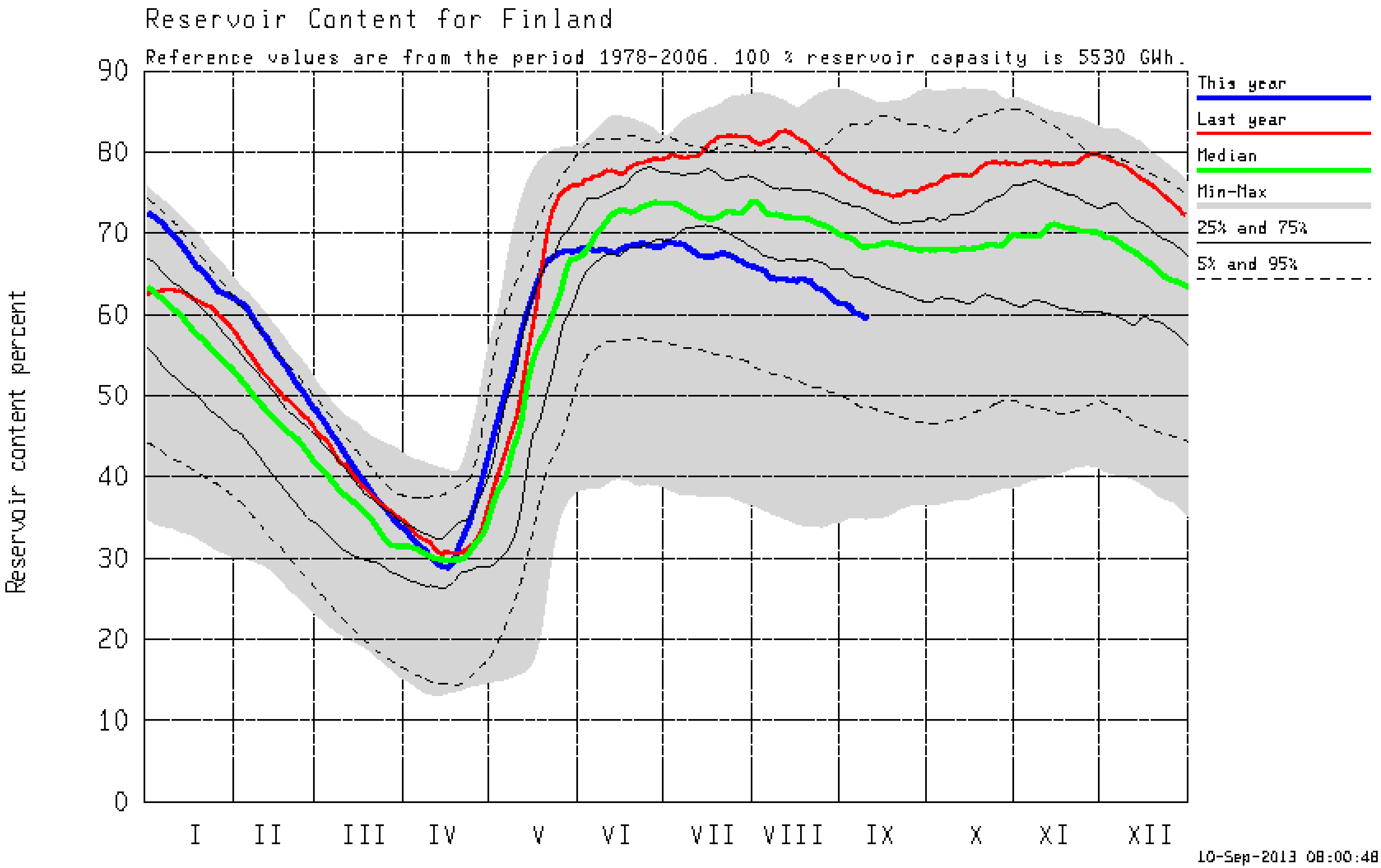


Hydropower companies save regulation plans into WSFS to get accurate forecasts



	Juoksutusennusteet Discharge forecast	Säännöstelyohjeet Regulation schedule	Säännöstelyrajat Regulation limits
21 032 Kytäjärvi	●	●	●
21 033 Hirvijärvi	●	●	●
21 033 Suolijärvi	●	●	●
21 045 Lisävesi Hiidenvedestä	●		
21 054 Valkjärvi	●		
21 082 Tuusulanjärvi	●		
21 083 Rusutjärvi	●		
21 083 Päijännetunneli - Rusutjärvi	●		
21 093 Kellokoski	●		
21 094 Ridasjärvi	●		
21 094 Päijännetunneli - Ridasjärvi	●		

Operative lake regulation & flood mitigation decisions (3/3)



Automatic media monitor (1/1)

Internet, local media www-news

Flood Centre

Automatic media monitoring

Officers on duty (met. & hyd.)

Manual flood warnings and water situation info (1/9)

Danger level	Description / impact / potential damages	Dissemination channels
Very dangerous flood	”Danger to human life and health”	• Danger alerts (interrupts radio and television broadcasts)
Dangerous flood	”Damages to buildings”	• LUOVA (Natural disaster warning system) warnings
Flood	”Anything which differs flood-wise from normal casual everyday life”	• Automatic flood warnings from lakes and rivers • Water Situation Bulletin for authorities • FMI and SYKE www-pages • Mobile application • LUOVA notices • Television weather news (YLE) • Media • Twitter

Manual flood warnings and water situation info (2/9)

National water situation online:

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

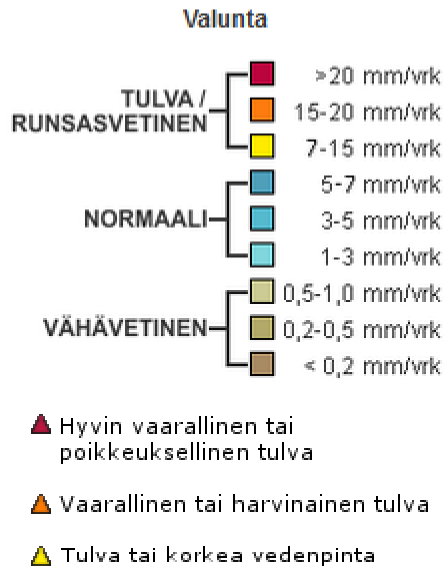
- Edited, up-to-date information about water situation in Finland
- Flood information during floods
- Written hydrological forecasts for basins
- Overall and detailed versions

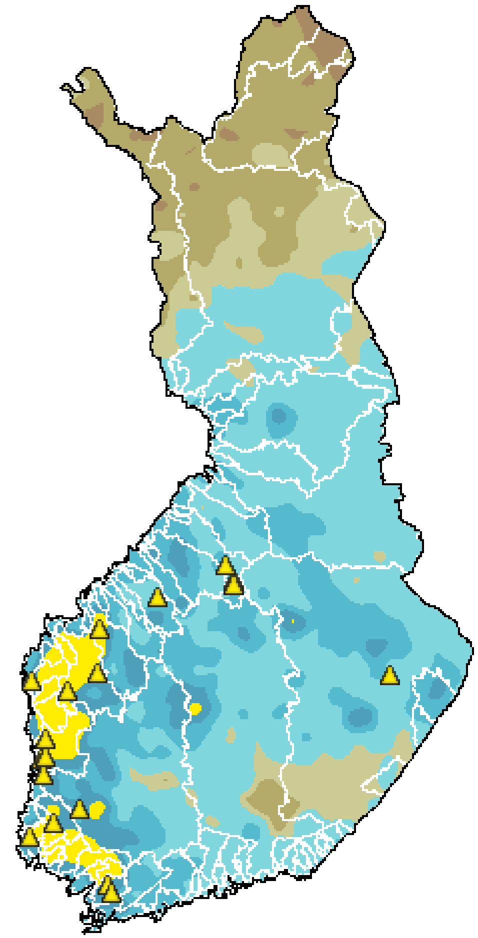
Manual flood warnings and water situation info (3/9)

Joet tulvakorkeuksissa Etelä- ja Keski-Pohjanmaalla sekä Lounais-Suomessa (Tulvakeskus 6.12.)

Länsirannikon jokien vedenpinnat ovat paikoin tulvakorkeuksissa sateisen ja lauhan sään johdosta. Lapväärtinjoella, Teuvanjoella, Närpiönjoella ja Maalahdenjoella vesi on noussut tulvakorkeuteen. Vesi on noussut pelloille Loimijoella ja Lapuanjoen Liinamaassa. Tälle päivälle ennustetut sateet kasvattavat jokien virtaamia vielä paikoin Etelä- ja Keski-Pohjanmaalla ja Lounais-Suomessa. Sateiden vaikutukset ulottuvat myös Etelä- ja Itä-Suomen vesistöihin nostaen jokien vedenkorkeuksia. Vesi nousee jokiuomissa paikoin vastaaman keskimääräistä tulvaa Etelä- ja Keski-Pohjanmaalla sekä Lounais-Suomessa. Lisää

6.12.2015





SYKEn hydrologit uudelleentwiittasi

ELY Tulvatpohjanmaa @tulvatpohjanmaa · 14 t

#Närpiönjoki 'en virtaaman nousu näyttää tasaantuneen tasolle 107 m3/s ja aurinko paistaa joen alaosalla #elykeskus

Water Situation Bulletin for authorities 7.2.2014

Tulvakeskuksen vesitilanne ja ennuste 7.- 12.2.2014

Laadittu 7.2.2014

LAATIJAT
Tulvapäivystäjä Juho Jakkila
LUOVA-päivystäjä Helena Laakso/Paavo Korpela
Meripäivystäjä -

VAARATASOJEN TODENNÄKÖISYYDET
[0%] Hyvin vaarallinen tulva
[0%] Vaarallinen tulva
[5%] Tulva
[95%] Ei tulvaa

VESISTÖJEN TILANNE TIIVISTETYSTI
Viikonloppuna lauhtuva sää ja vesisateet lisäävät valuntaa ja rannikkoalueiden pienten jokien virtaamia Etelä- ja Lounais-Suomessa. Rannikkoalueiden lumimäärät ja viikonlopuksi ennustetut sateet eivät kuitenkaan nosta jokien vedenkorkeuksia tulvalukemiin. Mikäli sää jatkuu leutona ja sateisena voi tilanne muuttua ensi viikon aikana.

ARVIOT VAHINGOISTA
Todennäköisesti ei uusia vahinkoja.

EPÄVARMUUSTEKIJÖITÄ
Lauhtuva keli saattaa irrottaa jokien suppokasaumia ja synnyttää uusia jääpatoja, mikä voi aiheuttaa paikallista tulvimista. Tämä ei kuitenkaan ole kovin todennäköistä.

SÄÄ- ja RANKKASADETILANNE TIIVISTETYSTI
Suomessa vallitsee viikonlopun ajan lauha etelänpuoleinen ilmavirtaus. Lauantaina lumisadealue liikkuu Suomen yli. Lounaassa sataa myös räntää, ehkä vettäkin. Sadetta kertyy vedeksi muutettuna 2-10 mm, Pohjois-Lapissa 0-2 mm. Sunnuntaina alkuviikolla tulee paikoin vähäisiä lumi- tai jäätäviä tihkusateita.

MERIVESITILANNE TIIVISTETYSTI
Ennustejakson aikana ei ole odotettavissa merivesitulvia.

Water Situation Bulletin for authorities 29.11.2015

Tulvakeskuksen vesitilanne viranomaisille
29.11. - 1.12.2015

LAATIJAT
Tulvapäivystäjä Tiia Vento
Meripäivystäjä -
Luova-päivystäjä Hannu Valta

LAATIJAT
Tulvapäivystäjä Tiia Vento

VAARATASOJEN TODENNÄKÖISYYDET

Vesistötulvat:
[0 %] Hyvin vaarallinen tulva
[2 %] Vaarallinen tulva
[78 %] Tulva: Pohjanmaa, Etelä-Pohjanmaa
[20 %] Ei tulvaa

VESISTÖJEN TILANNE TIIVISTETYSTI
Sateinen ja lauha sää on kasvattanut virtaamia etenkin Pohjanmaan alueella tällä viikolla. Vaasan eteläpuolisissa pienissä vesistöissä jokien pinnat ovat nousseet korkealle yön ja aamun aikana. Matalapaine tuo lisää sateita Pohjanmaan alueelle ja sadekertymä lähipäiville on ennusteen mukaan 20-30 mm. Jos sateet tulevat vetenä ne nostavat virtaamia nopeasti sillä maaperä on märkää. Vesi voi nousta alaville pelloille ja myös tulviminen paikallisteille on mahdollista.

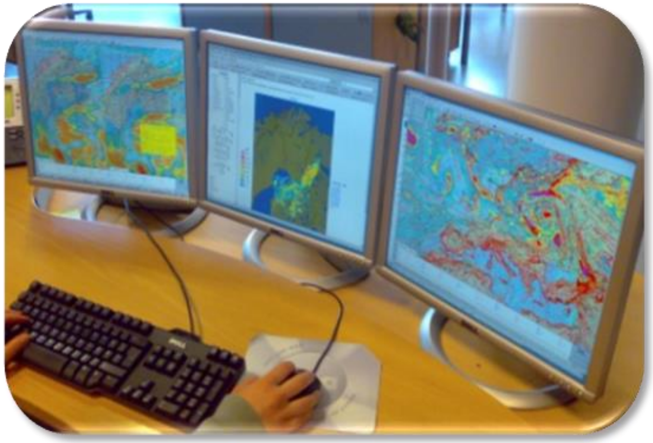
MERIVESITILANNE TIIVISTETYSTI
Tuulista johtuen merenpinta on viikonvaihteessa paikoin
korkealla eritoten Saaristomerellä ja Pohjanlandella.

RANKKASADETILANNE TIIVISTETYSTI
Rankkasateiden todennäköisyys on vähäinen.

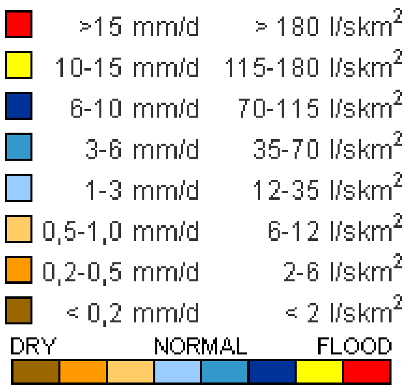
Water situation maps in television broadcast with weather forecast

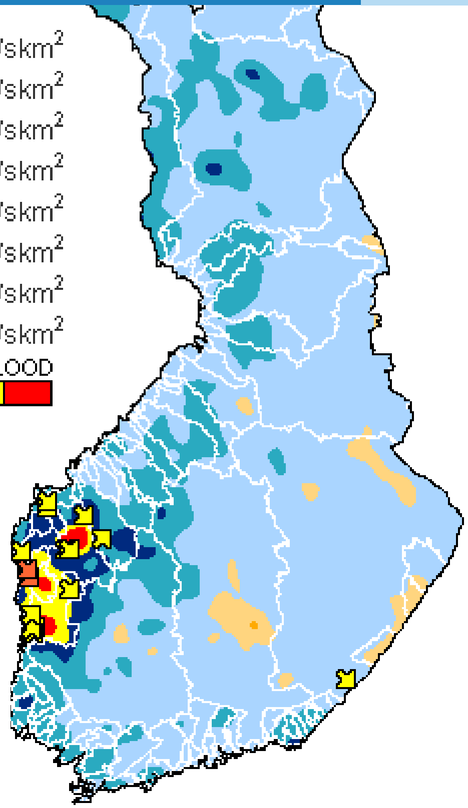
Natural disaster warning system LUOVA

- Closed warning and situation picture system for security authorities and state management
- Joint service of Meteorological Institute (FMI, main operator of LUOVA), Environmental Institute (SYKE) and Seismology Institute (HY)
- Warning messages with SMS and email, ”whole story” at web-portal
- IL LUOVA-officer on duty monitors national situation 24/7 (in flood situations also hydrologist and/or marine expert 24/7)



Manual flood warnings and water situation info (8/9)





Summary:
Flood threat at river Kyrönjoki

Area of danger:
South Ostrobothnia, Kyrönjoki

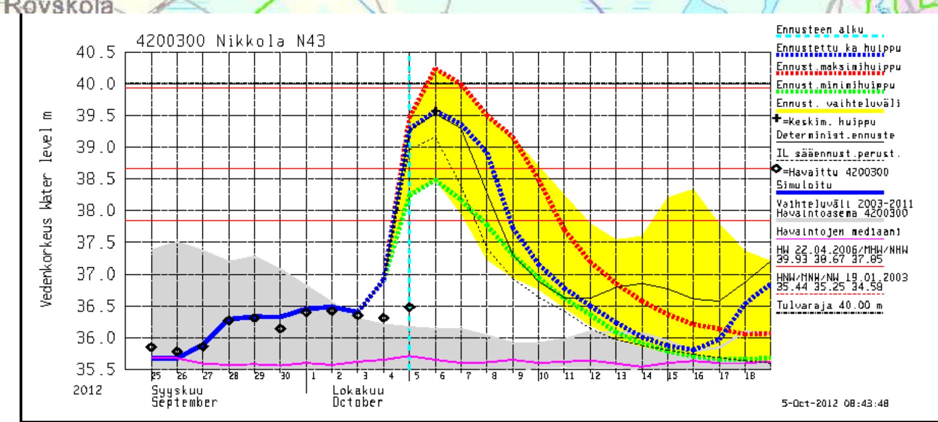
Time of danger:
6.10.2012-13.10.2012

Flood situation and forecast
Water level at Nikkola has risen above flooding level N43+40.00m today at 11AM. Flood gates have been opened to prevent further damage by running water to fields. Water level is forecasted to …

Weather situation and forecast:
Today will rain water in general 10-15mm, and…

Possible damages and human influences:
100 hectare of fields under flood, residents of Tuomikylä, Ilmajoki are blocked by flood

Critical infrastucture on area:



Manual flood warnings and water situation info (9/9)

LUOVA
LUONNONONNETTOMUUKSIEN VAROITUSJÄRJESTELMÄ

Yhteydenotot | Linkit | Palaute | LUOVA | Kirjaudu ulos

Vaaratasot: Ei vaaraa · Mahdollisesti vaarallinen · Vaarallinen · Hyvin vaarallinen

| Varoitukset nyt | Tietoja ilmiöistä | Tietoja varoituksista | Arkisto |

Tilannekuva
- Myrskyt
- Hirmumyrskyt
- Ukkoset
- Rankkasadetulvat
- Lumisateet
- Metsäpalot
- Vesistötulvat
- Meriveden korkeus
- Maanjäristykset
- Tsunamit
- Tulivuoren purkaukset
- Aurinkomyrskyt
- Muut ilmiöt

Vaarataso: Mahdollisesti vaarallinen

Vesistötulva

Pohjois- ja Keski-Pohjanmaa, Kymijoen ja Vuoksen vesistöalueet, Häme, Kainuu

RSS

24.1.2014 21:17

Yhteenveto:

Hyydetulvatilanne jatkuu - asuinrakennuksia vaarassa

Vaara-alue:

Pohjois- ja Keski-Pohjanmaa, Kymijoen ja Vuoksen vesistöalueet, Häme, Kainuu

Vaara-aika:

24.-31.1.2014

Tulvatilanne ja -ennuste:

Hyydetulvatilanne jatkuu monin paikoin lähes koko maassa Lappia lukuun ottamatta, kunnes kovat pakkaset