Overview of HIRLAM surface activities

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SMHI

with contributions as acknowledged

General surface comments

cy40h1.1.1 is our latest release of the ALADIN-HIRLAM NWP system with the HARMONIE-AROME model configuration.
cy43h2.1 is our current development cycle (including SURFEXv8.1) where new options will be activated (e.g. convection updates, soil updates).
cy43hxx represents our next big step with respect to land processes.

	cy40h1.1.1	**cy43h2.1**	**cy43hxx**
Land			
Patches	**1 or 2 (no SBL model)**	2	2 (separated forest and open land)
Vegetation	Bulk soil/veg/snow	Bulk soil/veg/snow	Explicit canopy (MEB)
Soil	Force-restore	Force-restore	Diffusion (14 layers)
Snow	D95 (bulk)	D95 (bulk)	Explicit snow (12 layers)
Glacier	-	-	Explicit snow as glacier
Assimilation	CANARI-OI	CANARI-OI	TITAN/gridPP(?)-SEKF
Sea	SICE	SICE	SICE
Lake	**FLake (optional)**	FLake	FLake (later with EKF)
Town	TEB	TEB	TEB (more options)
Physiog.	**ECOCLIMAP (modified)**	ECOCLIMAP II or 2nd generation	ECOCLIMAP 2nd generation

New potential surface options in combination with Force-restore and bulk snow in cy43h2.1

Land use physiography: Evaluate ECOCLIMAP-SG (Second Generation)

Why? We have a few problems with current physiography (ECOCLIMAP II): (i) Annual cycle of LAI is not realistic, especially in spring when LAI increases too early, which induces excess transpiration. (ii) The urban properties seem to be more realistic. For more info: https://opensource.umr-cnrm.fr/projects/ecoclimap-sg/wiki

New flux formulation over the sea (ECUME)

The new ECUME scheme fits better with measurement campaign data. Would like to see if this may help identified problems with e.g. fog over sea (in combination with modified turbulence scheme HARATU which increases vertical transport of humidity in the boundary layer). For more info: Presentation by Patrick Le Moigne (slides 11-12) http://www.umr-cnrm.fr/aladin/IMG/pdf/lemoigne_asm_tls.pdf

Drag due to sub-grid orography (OROTUR)

HARMONIE-AROME now runs on 2.5 km resolution without any sub-grid orography influence. Not considered to be realistic. OROTUR increases momentum flux at lowest model level due to sub-grid orography statistics. For more info: Presentation by Laura Rontu et al. http://www.umr-cnrm.fr/aladin/IMG/pdf/rontu_asw18.pdf

New potential surface options in combination with Force-restore and bulk snow in cy43h2.1

Modified values of minimum stomatal resistance Rsmin

According to Hoshika et al. (2018) (doi: https://doi.org/10.1111/geb.12681) Rsmin in SURFEX should be 1.5 – 3 times larger for a few vegetation types. Modified values decreases transpiration when no other effects limit transpiration. Tests are ongoing...

New system for quality control (TITAN) and surface analysis (gridPP) of near-surface in-situ observations

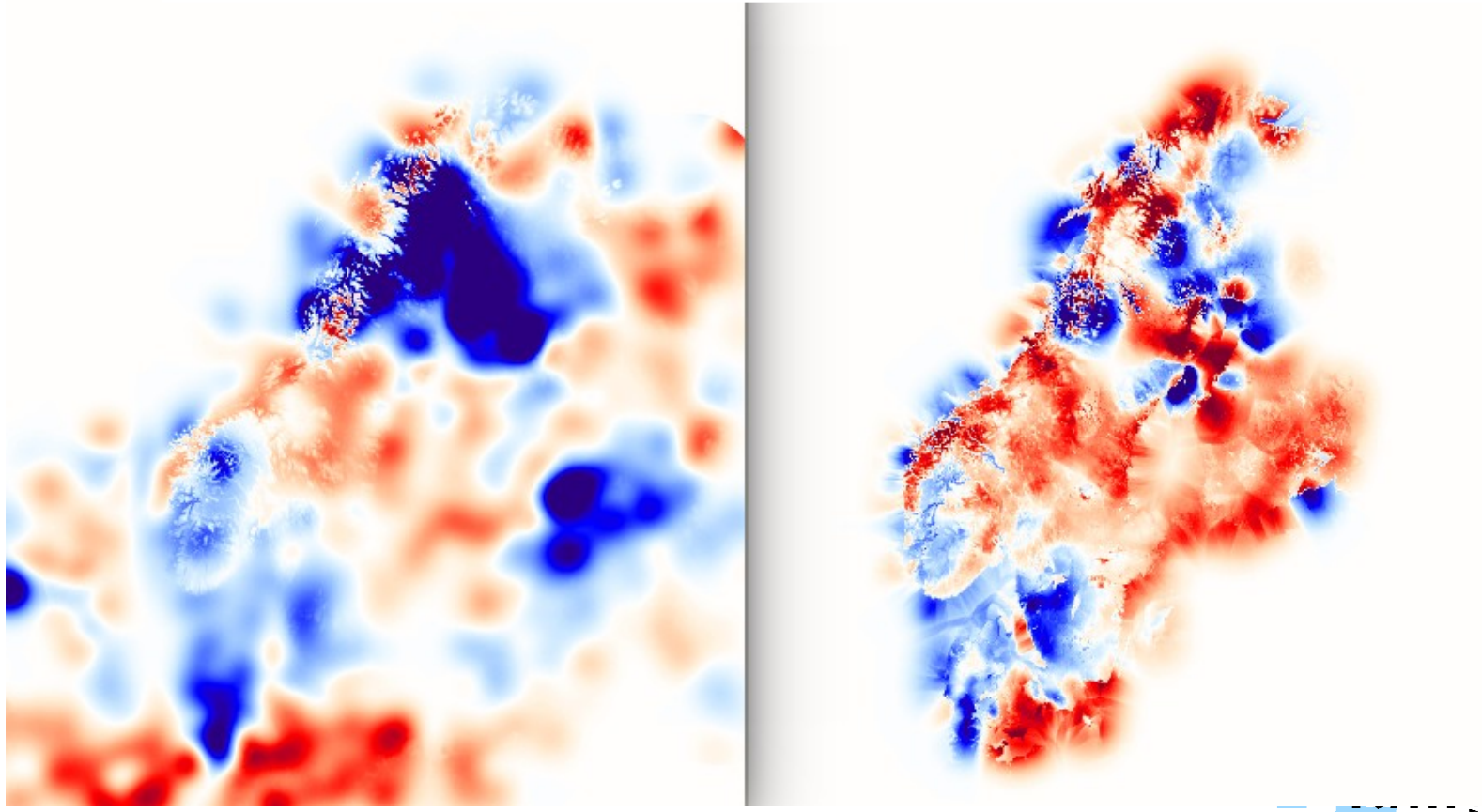
At MetNorway TITAN/gridPP has been developed for postprocessing of NWP output (includes e.g. NETATMO amateur weather stations). TITAN/gridpp is now implemented in cy43h2.1 alpha version for tests and evaluation. Offers a stand-alone and flexible environment for surface analysis.

New system for quality control (TITAN) and surface analysis (gridPP)

These are both open source development: https://github.com/metno/TITAN and https://github.com/metno/gridpp

- TITAN and gridPP are separate modules.
- TITAN/gridPP provides a 2D analysis of T2m, RH2m and snow to the vertical assimilation of soil variables (SODA).
- SODA is run as separate binary.
- For snow, observed SWE or snow depth can be used as input.
- TITAN/gridPP also reads NETATMO amateur observations. Specific quality control for high density network with large individual observation errors (representativeness).

A visual example of 2D analysis of T2m using SYNOP only (left) and NETATMO amateur observations only (right).



Trygve Aspelien, Cristian Lussana, Thomas Nipen, Christian Skarby et al. (MetNorway)

New potential surface options in combination with Force-restore and bulk snow in cy43h2.1

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Assimilation of satellite product of snow extent

Operationally we have snow DA based on SYNOP observations. Assimilation of satellite product of snow extent is implemented in cy40h for CARRA reanalysis (Mariken Homleid). Considered now also for operational implementation in cy43h2.1 (Ekaterina Kourzeneva and Mariken Homleid)

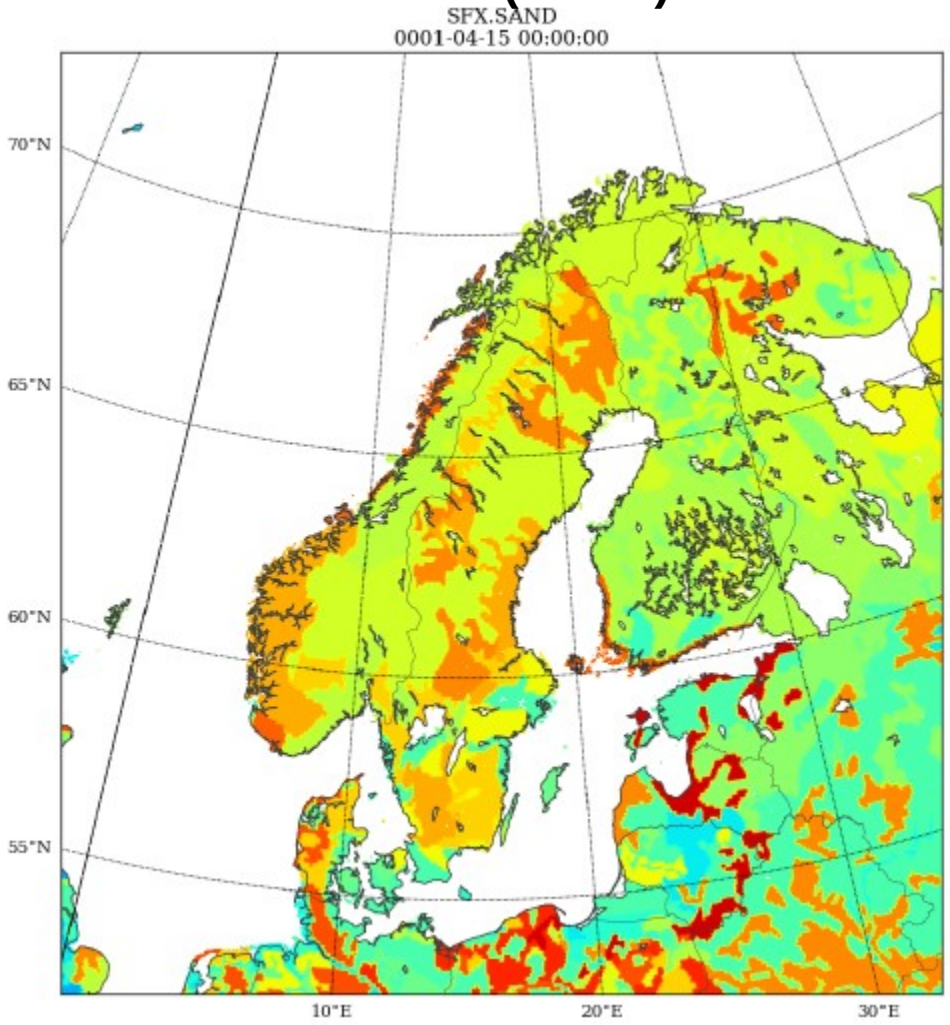
New clay and sand database SoilGrids3D (https://soilgrids.org)

In cy40h FAO (10 km) is the official sand/clay data. HSWD (1 km) has been considered but showed funny patterns e,g, in Scandinavia. SoilGrids3D (250 m) will be our next official sand/clay data base (processed to 2D and 1 km resolution).

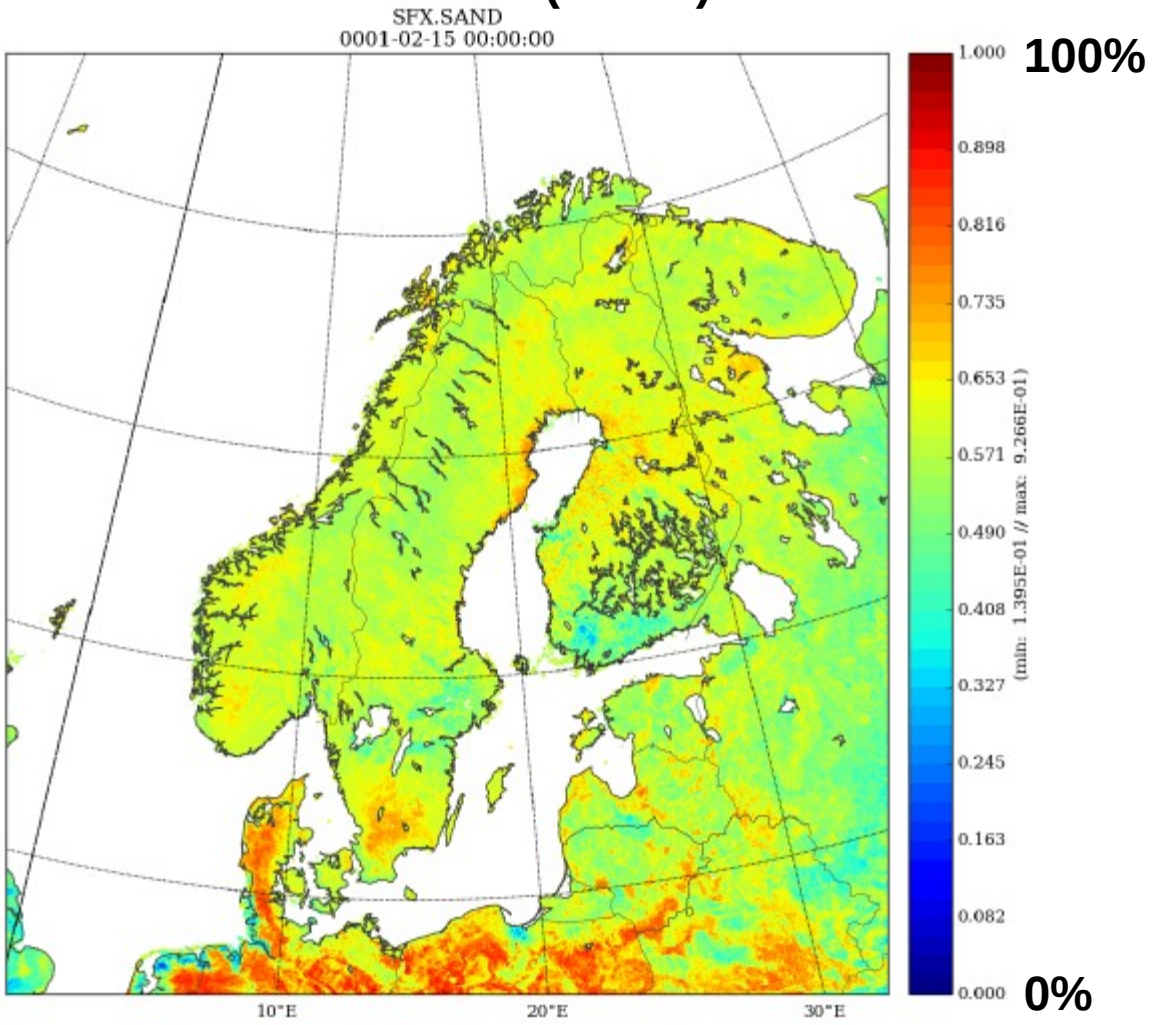
New clay and sand database SoilGrids (https://soilgrids.org)

Soil sand content according to

FAO (10 km)



SoilGrids (250 m)



100%

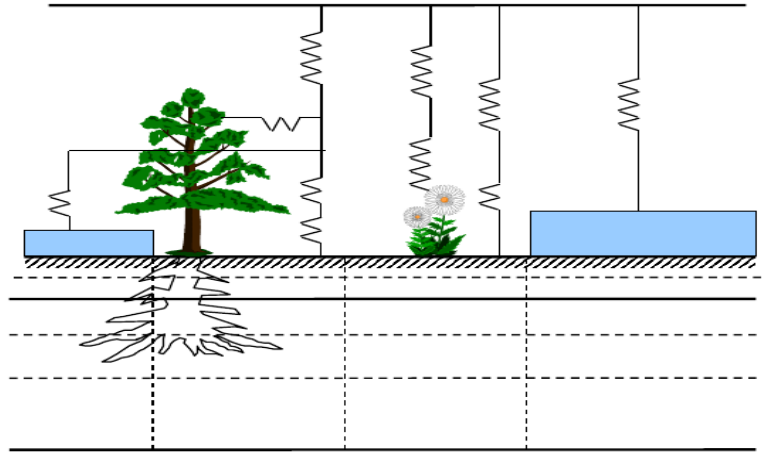
0%

Laura Rontu, Ekaterina Kurzeneva, Esbjörn Olsson, Bolli Palmason, Kristian Pagh Nielsen, Matti Horttanainen, Teresea Valkonen, Ulf Andrae, Patrick Samuelsson

HIRLAM – cy40h SURFEXv7.3 – cy43h SURFEXv8.1

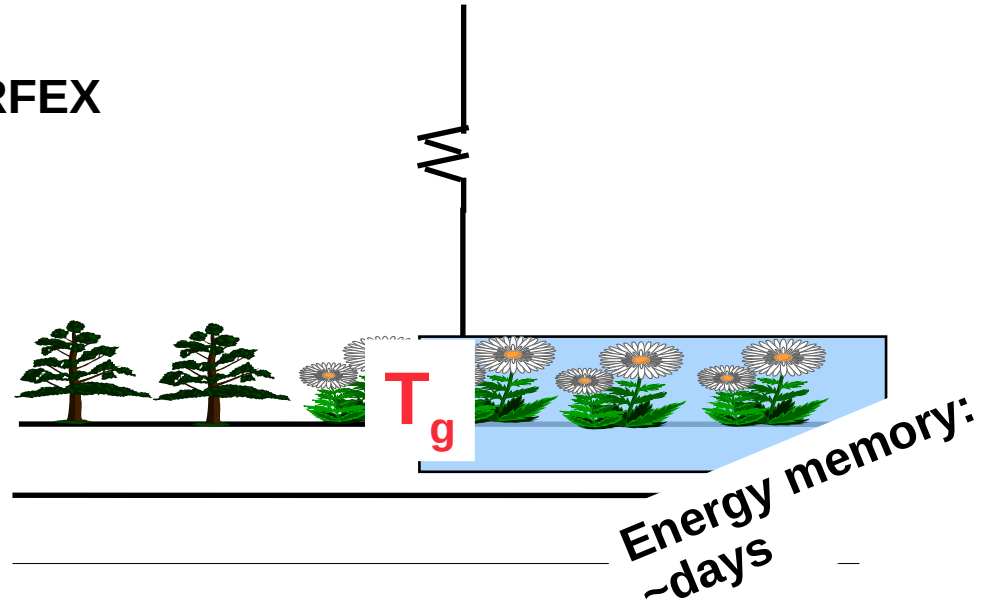
HIRLAM

Multi level/energy with OI

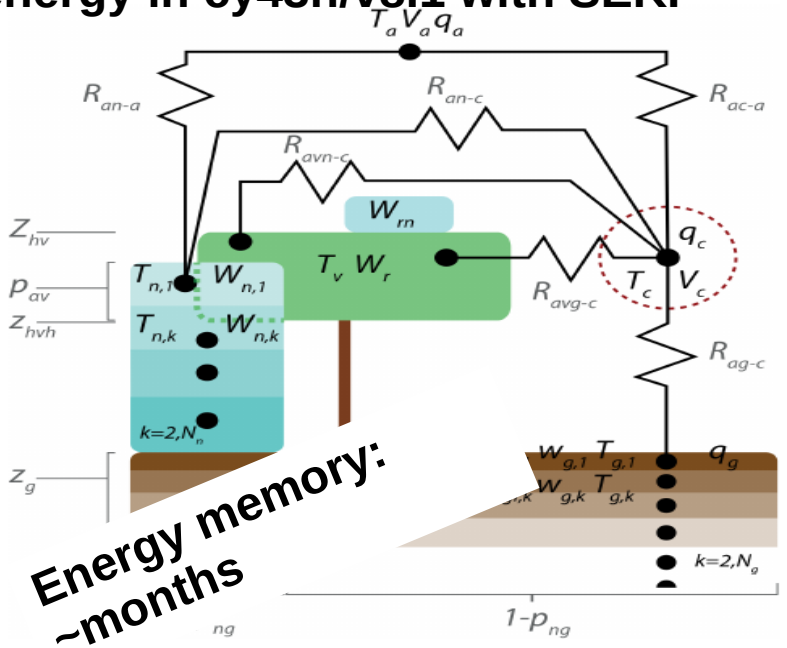


SURFEX

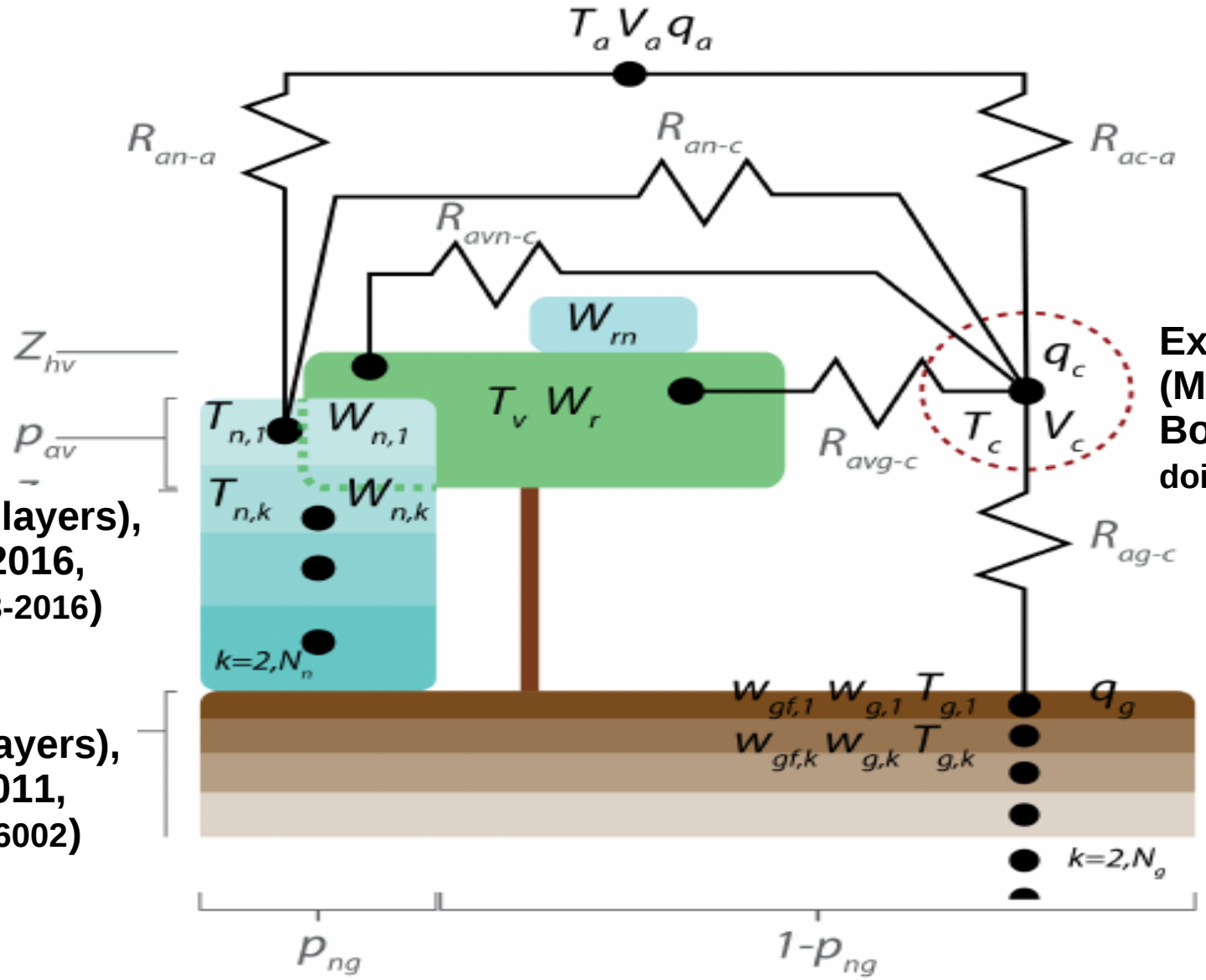
Force-restore in cy40h/v7.3 with OI



Multi level/energy in cy43h/v8.1 with SEKF



Diffusion soil and explicit snow and canopy in cy43h/SURFEXv8.1



Explicit snow (12 layers), Decharme et al. (2016, doi:10.5194/tc-10-853-2016)

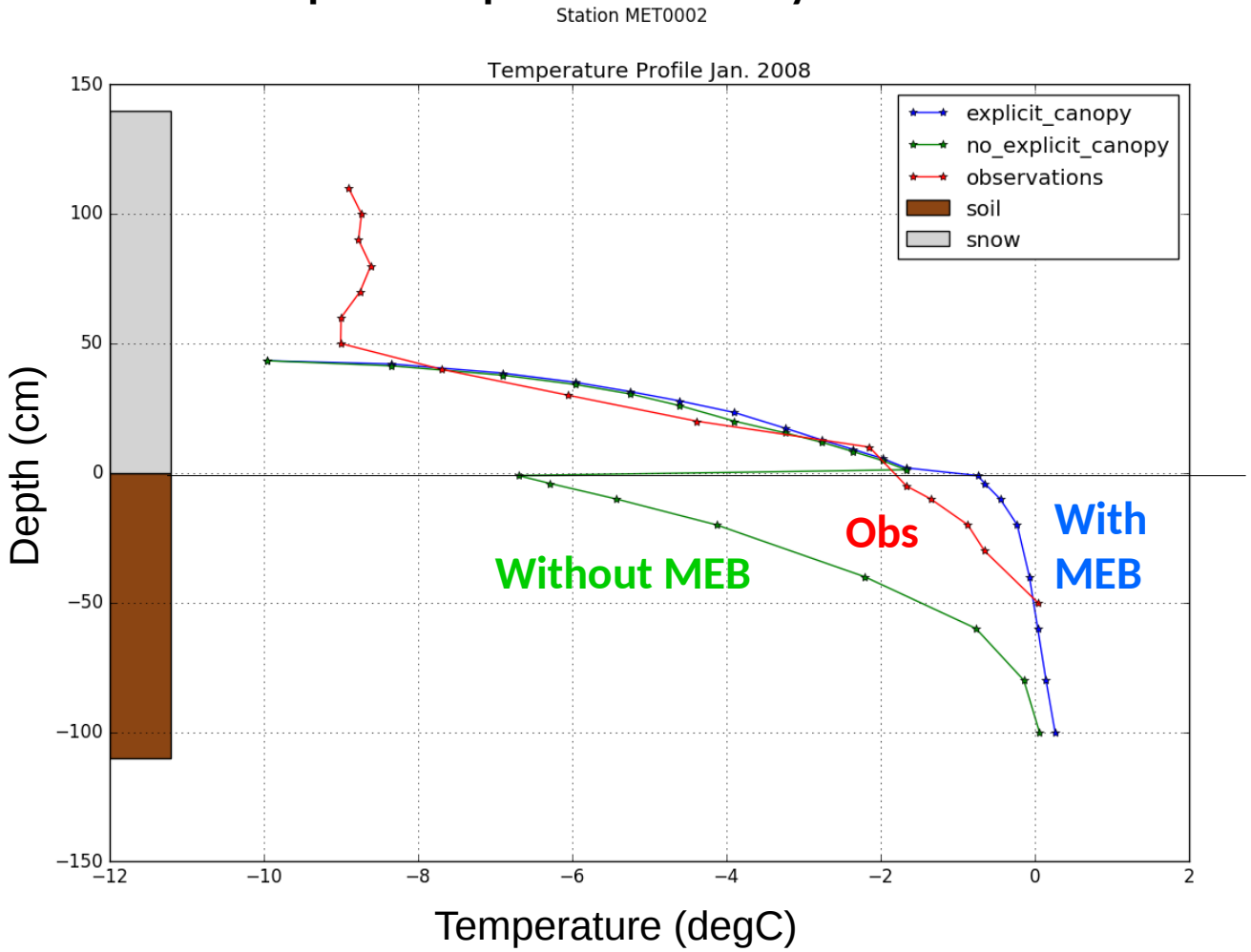
Diffusion soil (14 layers), Decharme et al. (2011, doi:10.1029/2011JD016002)

Explicit canopy: MEB (Multi-Energy Balance), Boone et al. (2017, doi:10.5194/gmd-10-843-2017)

Litter layer Napoly et al. (2017, doi:10.5194/gmd-10-1621-2017) Low heat capacity. Stores energy and water/ice.

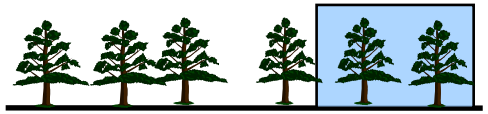
Why an explicit canopy (MEB) is important (in combination with snow/soil)

Simulated (offline open loop) versus observed soil-temperature profile in Sodankylä, northern Finland.
Mean temperature profile in January 2008



Observed temperature profile

Without MEB (no_explicit)



<25% snow cover

With MEB (explicit)

>95% snow cover

When the soil is exposed during winter (without MEB) the soil column cools unrealistically.
In principle data assimilation can help (although it is not the purpose of DA to cure bad physics) but it will lead to problems anyway during spring time since the soil memory is long O(months).

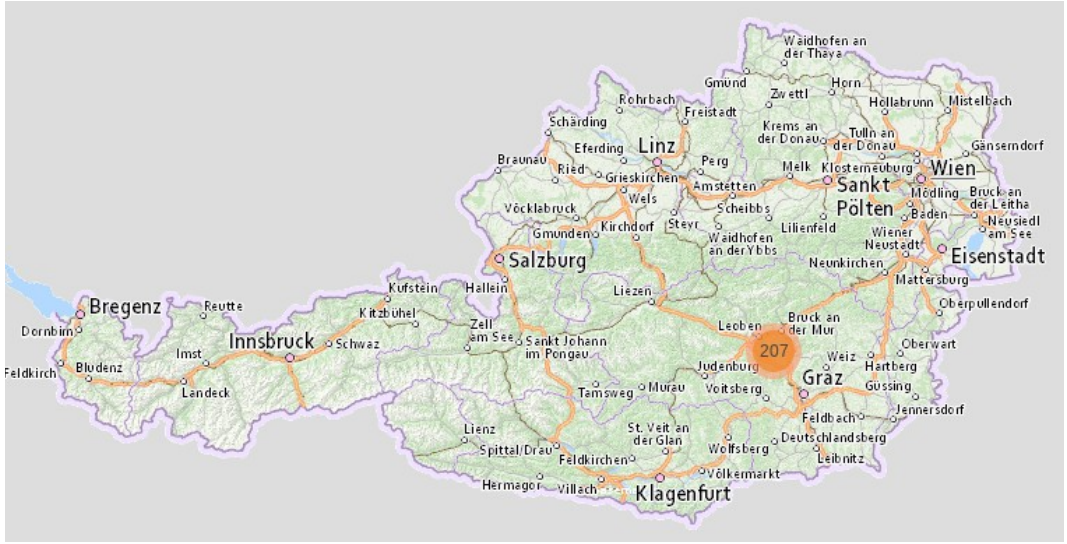
Note, same soil column below snow and for bare soil

Tests of cy43h/SURFEXv8.1 in climate mode

Tests with new physics in cy43h/SURFEXv8.1 are currently ongoing.
That means diffusion soil scheme, explicit snow scheme multi-energy balance, certain hydrological options. All with two patches, i.e. separation of forest and open land.

Test are done in climate mode with the purpose to identify and reduce any biases before data assimilation is activated.

Climate mode means downscaling of lateral boundary conditions (ERA5) without any data assimilation but nudging to the large scales of the BCs. Typically some three years of integration will be used.



Idea to set up a model domain over Austria to utilize the WegenerNet climate observation network for validation which includes e.g. gridded energy flux data: https://wegenernet.org/

Samuel Viana, Emily Gleeson, Patrick Samuelsson

Summary road map for HIRLAM surface Data Assimilation

Now: 2D OI for surface parameters (T2m, RH2m, Snow) followed by 1D vertical OI for TG1, TG2, WG1, WG2 in SURFEX force restore.

Soon: Replace 1D vertical OI with 1D SEKF and force restore + bulk snow with diffusion (14 layers) and explicit snow (12 layers). Add ASCAT Soil Moisture product.

Later: Replace 1D vertical SEKF with 1D EnKF.

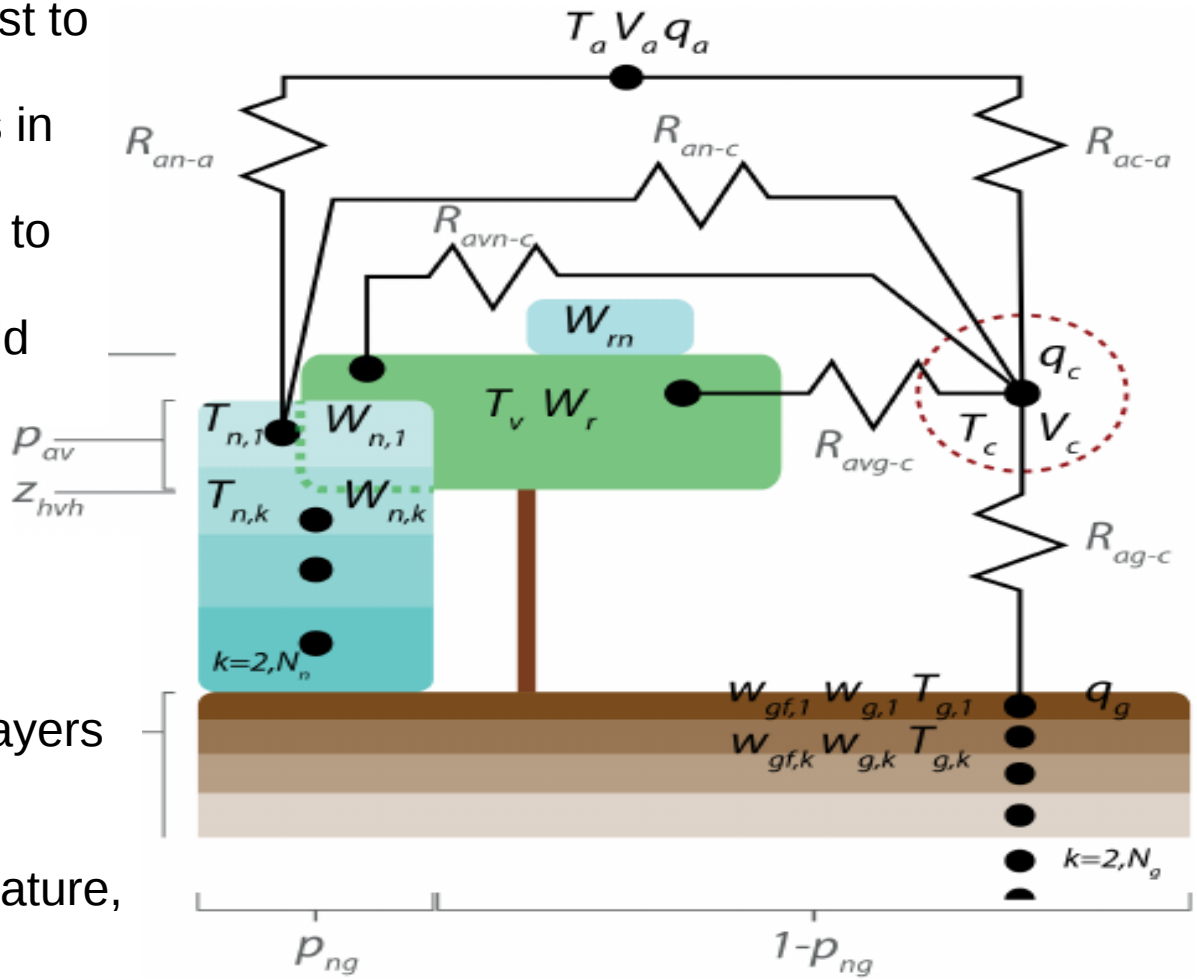
Future: Replace OI analysis & 1D DA with 3D EnKF and products with radiances.

Vision: Coupled DA for atmosphere and surface based on 4D EnKF.

by Tomas Landelius

Assimilation of new land-surface physics using SEKF

Snow (12 layers):
Top layers too thin/fast to assimilate.
Use control variables in layers 3-5…?
Layers 6-12 too slow to assimilate…?
Control variables: cold content,



MEB variables:
Too fast to assimilate (canopy temperature, intercepted water and snow)

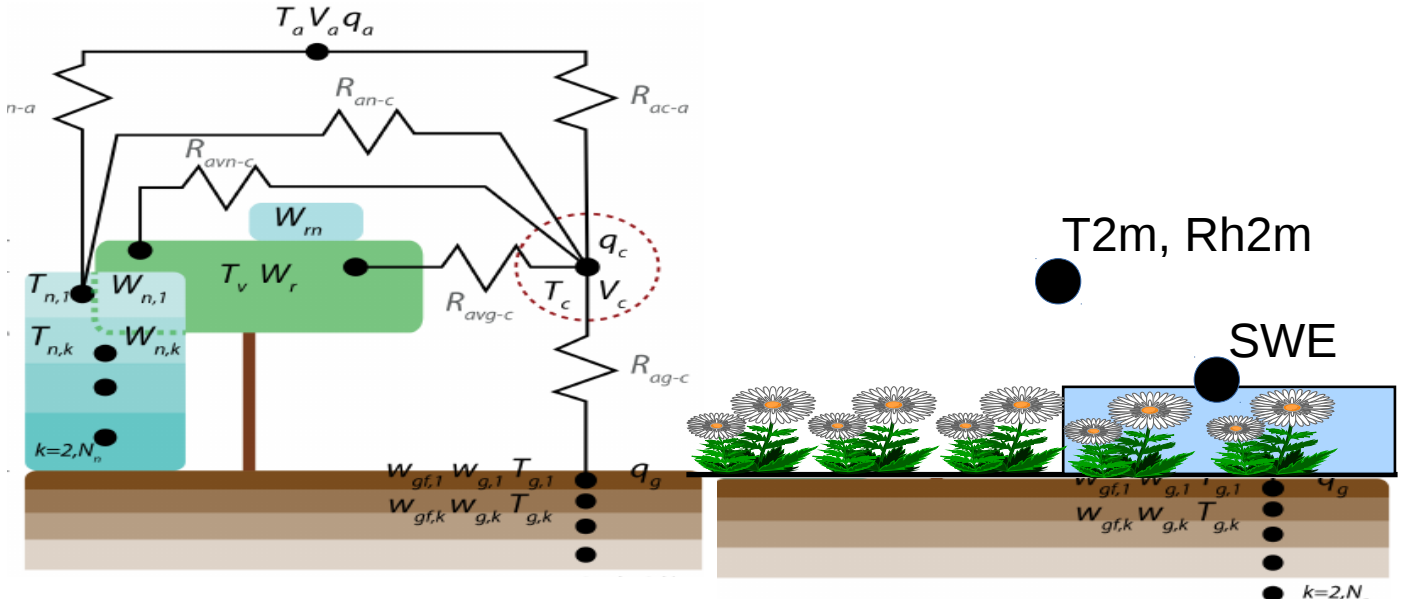
Soil (14 layers):
Top layers too thin/fast to assimilate.
Use control variables in layers 3-6…?
Layers 7-14 too slow…
Control variables: temperature, water, ice

Litter layer:
Too fast to assimilate (temperature, water and ice)

Magnus Lindskog, Åsmund Bakketun, Trygve Aspelien, Patrick Samuelsson, Jelena Bojarova, Tomas Landelius

Observations represent open land… What about the forest…?

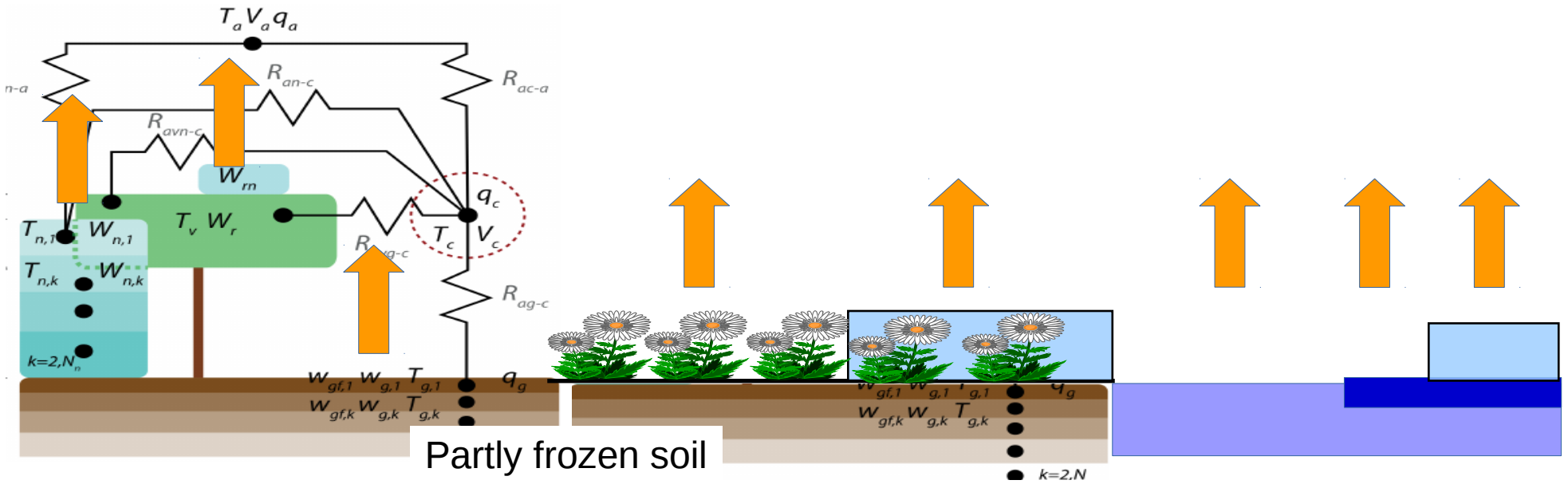
Currently only SYNOP observations are available, representing open-land conditions.
So, we get an innovation for the open land from the 2D-analysis. How to use that for the forest patch?



Shall we use the same innovation for forest as for open land? Probably not correct, but what to do?
The risk is that the long term memory of the energy and water content of the deep soil column may drift away…
Maybe better to nudge the forest soil column towards the open land soil column….

Another idea: Use analysed near-surface atmospheric conditions (T, U, q, SW, LW, rain, snow) to force SURFEX offline to create a long term memory of the soil. Use these offline prognostic variables as first guess for the inline system….

But, using satellite radiances representing the whole grid box surface will help, or?



The total radiance seen from the satellite represents contributions from many different surfaces. Thus, we need a physically representative model in combination with a forward model to estimate the model equivalence of the satellite radiance.

How reality can look…

Pictures from presentation by Terhikki Manninen (FMI) at Snow data assimilation school 12-16 March, 2018, Bormio, Italy (see link below)

Lakes Ladoga and Onega, Russia

Lakes Ladoga and Onega, Russia
Copernicus Sentinel-3 data (2017), processed by ESA, CC BY-SA 3.0

Wetland area Aapa, Finland

Aapa mire, Sodankylä, Finland

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwi6pruMmOvdAhUKQ8AKHfvWBqAQFjAAegQIBBAC&url=http%3A%2F%2Fcostsnow.fmi.fi%2Fschools%2Fbormio%2Flectures%2FOptical_RS_snow_TM.pdf&usg=AOvVaw0Fml2RJsBe06CYm0tvh3P7

THANKS!!

HIRLAM Surface working week in Tromsø, northern Norway, May 2018