

# Overview of HIRLAM surface activities

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**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 next release (including SURFEXv8.1) expected this summer.

**cy46h** represents our next big step with respect to land processes.

	<b>cy40h1.1.1</b>	<b>cy43h2.1</b>	<b>cy46h</b>
<b>Land</b>			
Patches	1 or 2 (no SBL model)	<b>2 (separated forest and open land)</b>	2
Vegetation	Bulk soil/veg/snow	Bulk soil/veg/snow	<b>Explicit canopy (MEB)</b>
Soil	Force-restore	Force-restore	<b>Diffusion (14 layers)</b>
Snow	D95 (bulk)	D95 (bulk)	<b>Explicit snow (12 layers)</b>
Glacier	-	-	Explicit snow as glacier
Assimilation	CANARI-OI	CANARI-OI	<b>TITAN/gridPP-SODA-SEKF</b>
<b>Sea</b>	SICE	SICE	SICE
<b>Lake</b>	FLake (optional)	FLake	FLake (later with EKF)
<b>Town</b>	TEB	TEB	TEB (other options?)
<b>Physiog.</b>	ECOCLIMAP (modified)	<b>ECOCLIMAP 2<sup>nd</sup> generation</b>	ECOCLIMAP 2 <sup>nd</sup> generation

# ECOCLIMAP Second Generation

After many tests HIRLAM has decided to use ECOCLIMAP Second Generation (ECOSG) as land cover physiography in the release of cy43h2.1. Main reasons for this are:

- **In general ECOSG shows more realistic characteristics than ECOCLIMAP-II-Europe (ECOV2), as used in cy38h and cy40h:**
  - i. Better representation of coast line and land/sea/water mask.
  - ii. More realistic annual cycle in Leaf Area Index.
  - iii. Better representation of urban areas.
- **Overall meteorological scores for T2m and Rh2m are not very different but we see some improvements in diurnal cycles. And coastal areas show in general better scores.**
- **With 300 m resolution ECOSG is more suitable for hectometric model setups than ECOV2 with 1 km resolution.**

Problems that have been needed to tackle:

- **A clear positive wind bias in U10m over open-land areas has been tackled by increasing the roughness length as a function of LAI for crops and grass.**
- **The tree height has been scaled by a factor  $\sim 0.7$  to reach good U10m over forest dominated areas.**

## **ECOCLIMAP Second Generation – examples from Newsletter**

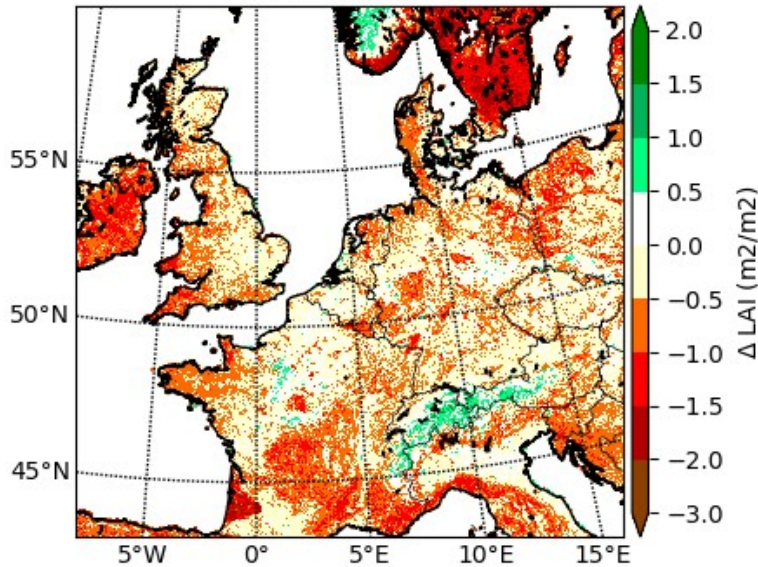
**Samuelsson P., Kourzeneva E., de Vries J. and Viana S., 2020: HIRLAM experience with ECOCLIMAP Second Generation. ALADIN-HIRLAM Newsletter no 14, 154-188.**

**Examples on conclusions of examination of ECOSG versus ECOv2. These represent the global perspective by Ekaterina Kourzeneva (see Newsletter for details):**

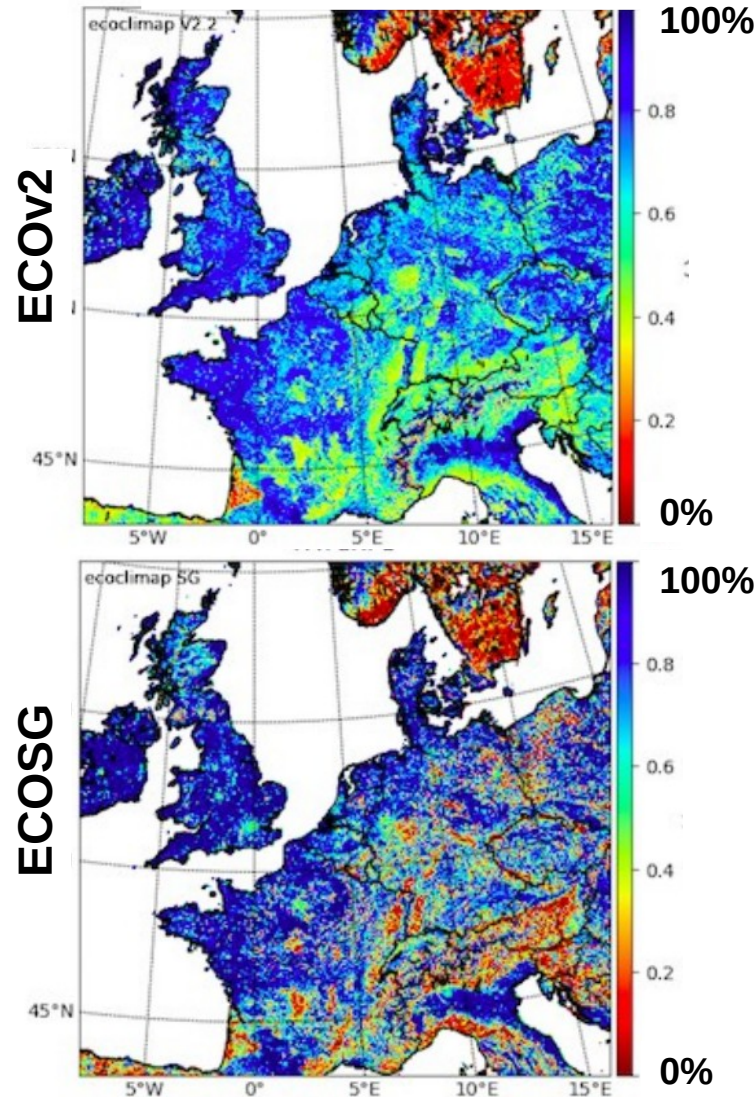
- ECOv2 and ECOSG are shifted with respect to each other. In some regions this shift reaches 20 km. This is an improvement in ECOSG.**
- Many new reservoirs appeared in ECOSG. This is an improvement in ECOSG.**
- Bays and fjords miss-classified as lakes exist in ECOSG (also a ECOv2 problem). Correction is needed.**
- Lakes miss-classified as sea water exist in both maps along the sea coast, but in ECOSG there are much more of them. Correction is needed.**
- Rivers in ECOSG are in general good.**

# How does ECOCLIMAP-SG compare with ECOCLIMAPv2 Leaf Area Index (LAI) and distribution of open-land/forest

LAI  
ECOSG – ECOv2  
April 5<sup>th</sup>



Open land fraction



In general less LAI in ECOSG (often half of ECOCLIMAPv2), especially over continental Europe, the British Isles and Ireland and central Spain.

Reduction in seasonality of LAI in ECOSG over Sweden and Finland.

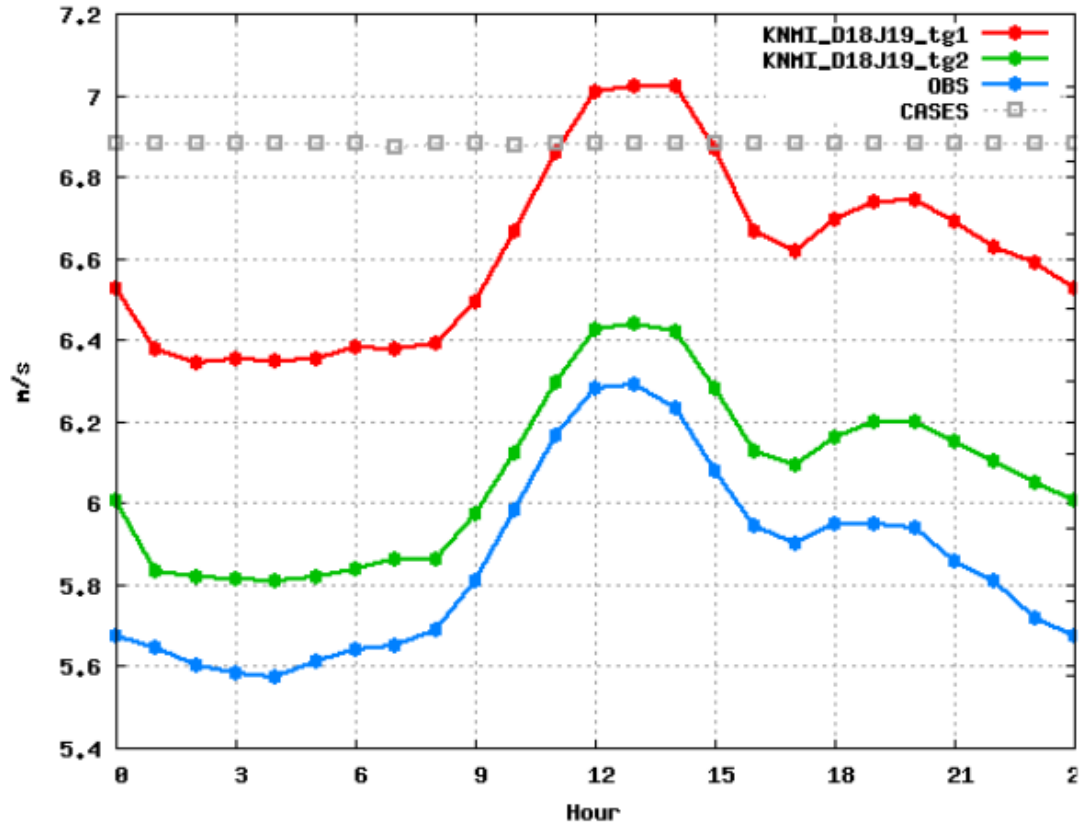
In general ECOSG compares better with other estimates of LAI.

More open land patches over continental Europe and more forest areas in the Alps.

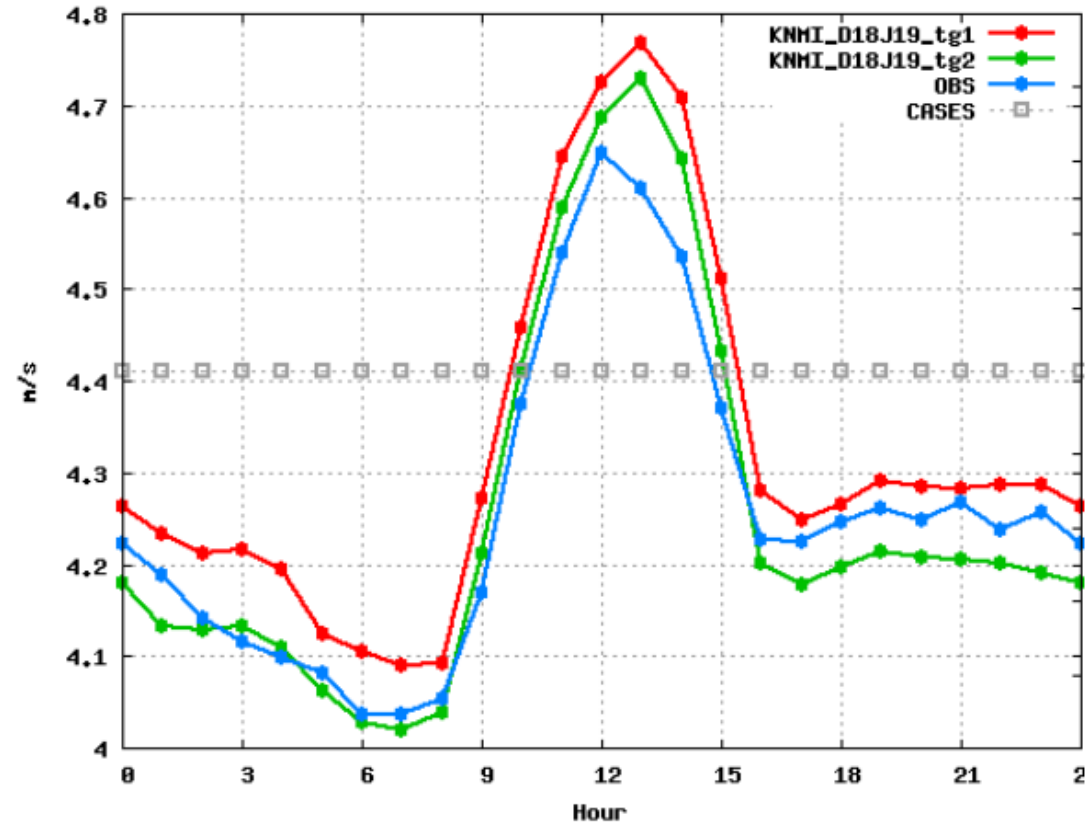
# ECOSG – Meteorological performance in cy43h – Wind speed

The Dutch/KNMI domain for the two months winter period Dec 2018 – Jan 2019.  
Mean diurnal cycle of wind speed (U10m)

### The Netherlands (open land)



### A forested area in Germany



ECOSG  
ECOV2  
OBS

How we tackle the positive bias in wind speed over open-land areas with ECOSG will be discussed by Samuel Viana...

## **ECOSG – Meteorological performance in cy43h – Temperature and humidity**

**In general T2m is slightly warmer for ECOSG than for ECOv2, especially during daytime. The warmer daytime conditions are expected due to the lower LAI values in ECOSG which imply less latent heat and more sensible heat.**

**Looked over all seasons Q2m is in general drier in ECOSG than in ECOv2. However, an exception is over the Dutch/KNMI domain which shows almost no difference.**

**Again, please see the Newsletter article on ECOCLIMAP Second Generation for more details:**

**Samuelsson P., Kourzeneva E., de Vries J. and Viana S., 2020: HIRLAM experience with ECOCLIMAP Second Generation. ALADIN-HIRLAM Newsletter no 14, 154-188.**

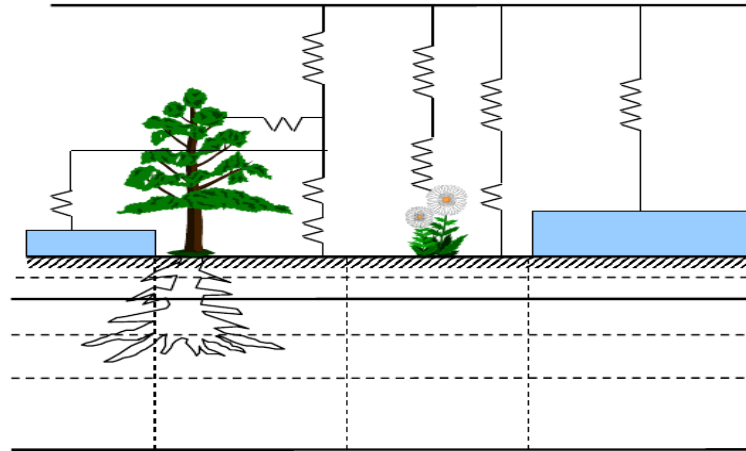
**Experiences based on a number of sensitivity tests with respect to e.g. shape of stable exchange coefficient formulations have been gathered on this wiki page:**

**[https://hirlam.org/trac/wiki/Surface\\_physis\\_assimilation/First\\_cy43h\\_setup](https://hirlam.org/trac/wiki/Surface_physis_assimilation/First_cy43h_setup)**

# HIRLAM - cy40h SURFEXv7.3 - cy43h SURFEXv8.1

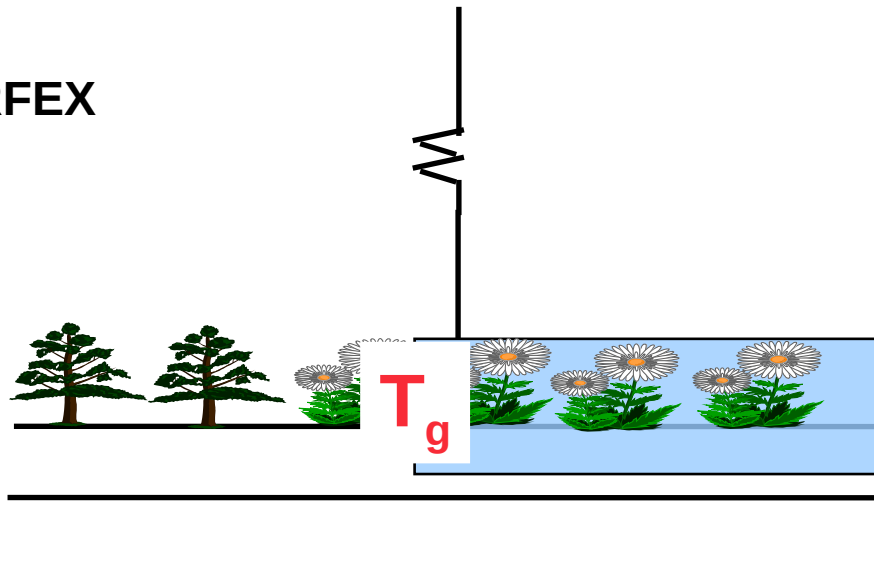
HIRLAM

Multi level/energy with OI

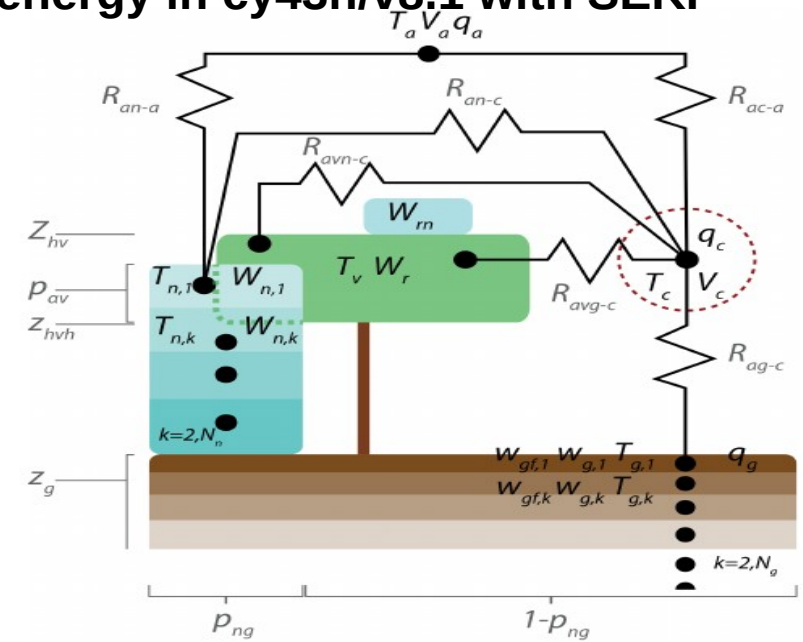


Force-restore in cy40h/v7.3 with OI

SURFEX

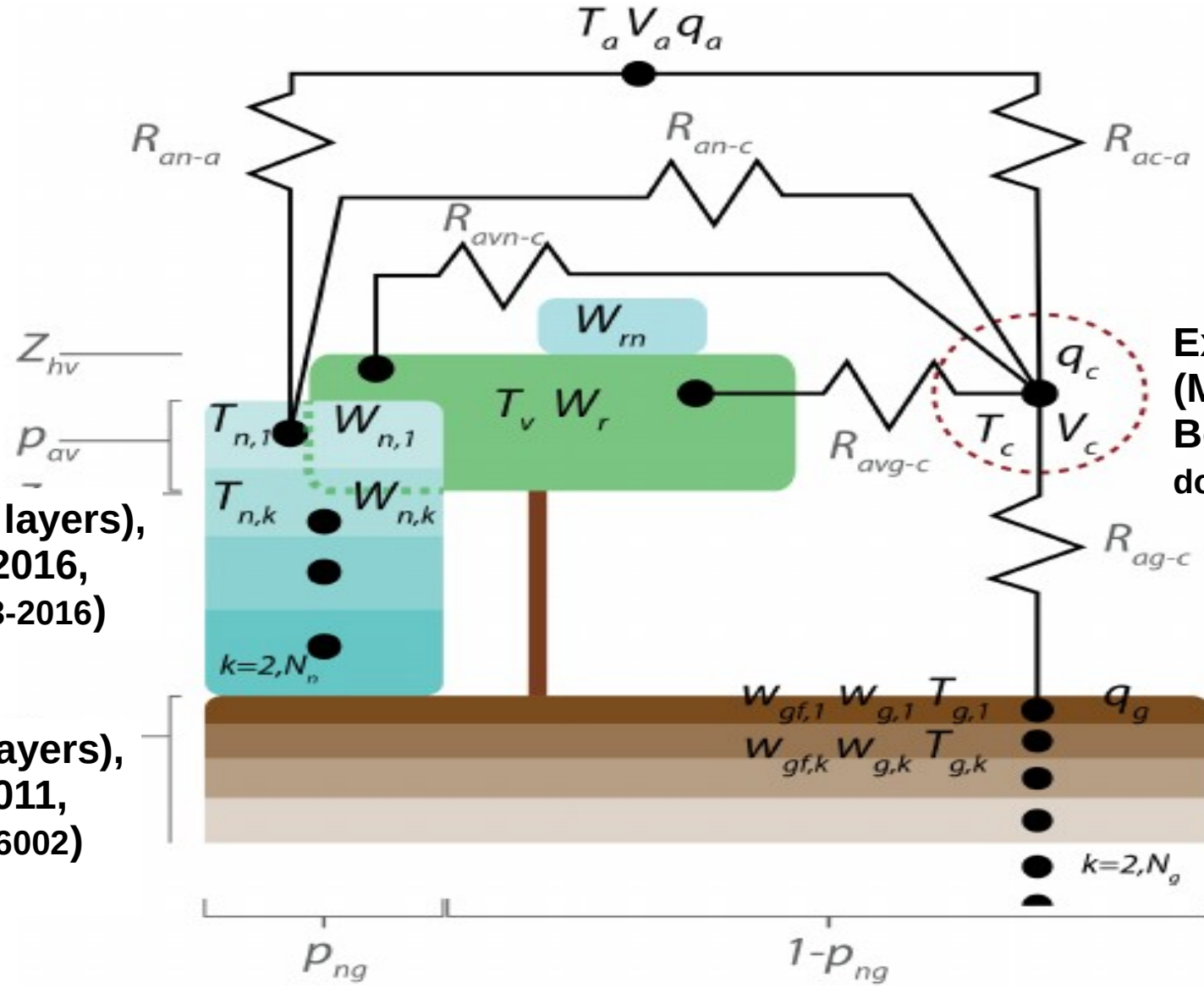


Multi level/energy in cy43h/v8.1 with SEKF





# Diffusion soil, explicit snow and explicit 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.

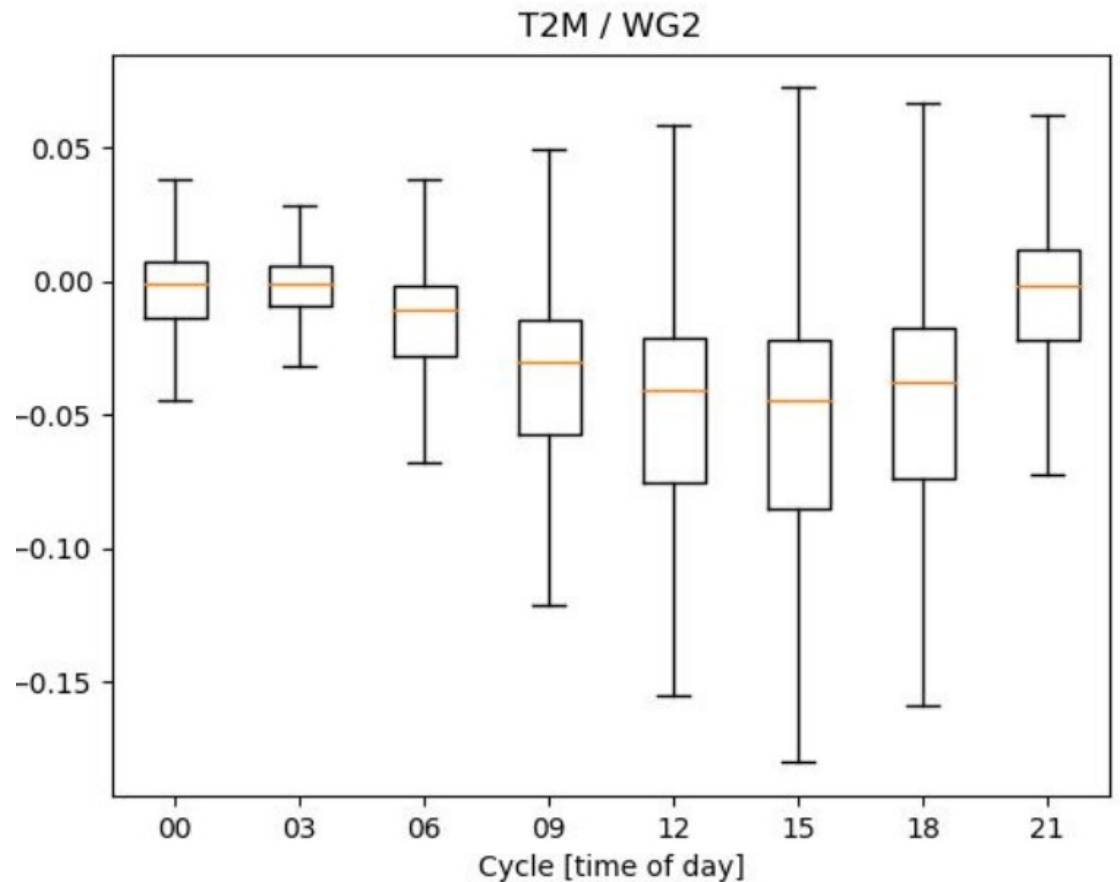
Main development by the SURFEX team at Météo-France and their collaborators.

# Simplified Extended Kalman Filter and new surface physics

A development version of cy43h is currently used with new surface physics in combination with SEKF surface data assimilation.

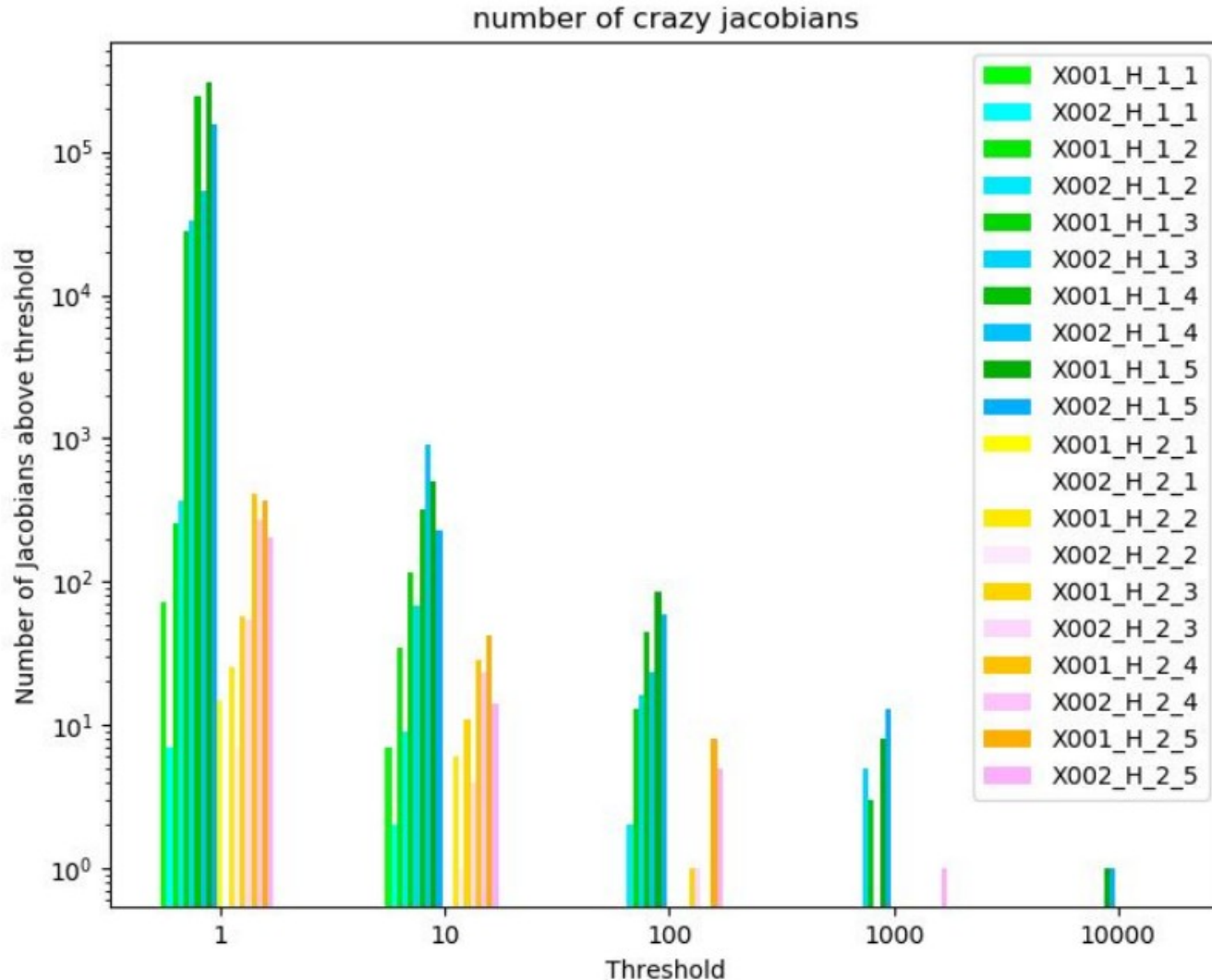
The setup is tested over the MetCoOp domain for a week in May 2018.

There is a diurnal dependence in Jacobian elements but the elements are also in general quite small, i.e. weak relationship between 2m and soil.



# Simplified Extended Kalman Filter and new surface physics

How to tackle  
“crazy” Jacobian  
values which  
appear due to  
violation of the  
assumption of  
linear response in  
the system?



**X00a\_H\_b\_c**

**a: patch number**

1 = open land

2 = forest

**b: observation**

1 = T2m

2 = Rh2m

**c: control variable**

1 = WG6

2 = WG5

3 = WG4

4 = WG3

5 = WG2

**Numbers cover**

**175 analyses**

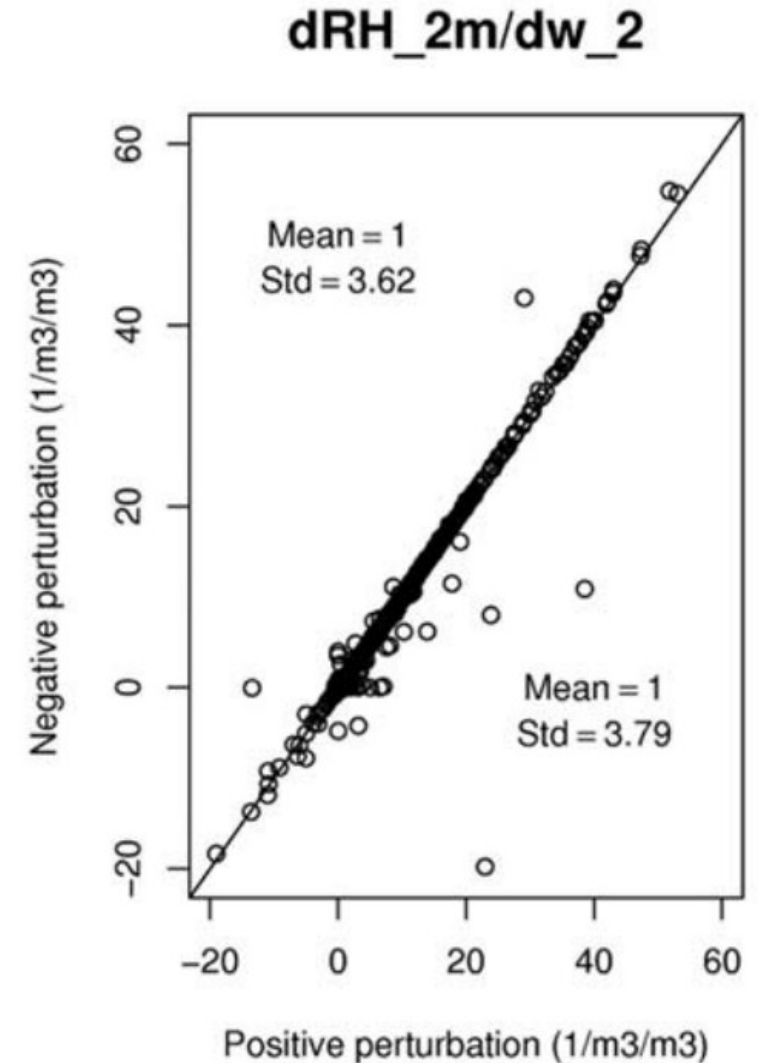
# Simplified Extended Kalman Filter and new surface physics

**Mahfouf et al. (2009) investigated the sensitivity for size/sign of perturbations on the linearity of the elements of Jacobian matrix of the observation operator.**

**Idea: decide for each assimilation cycle which Jacobians should be used depending on how well they fulfil the linear behaviour depending on sign of perturbation.**

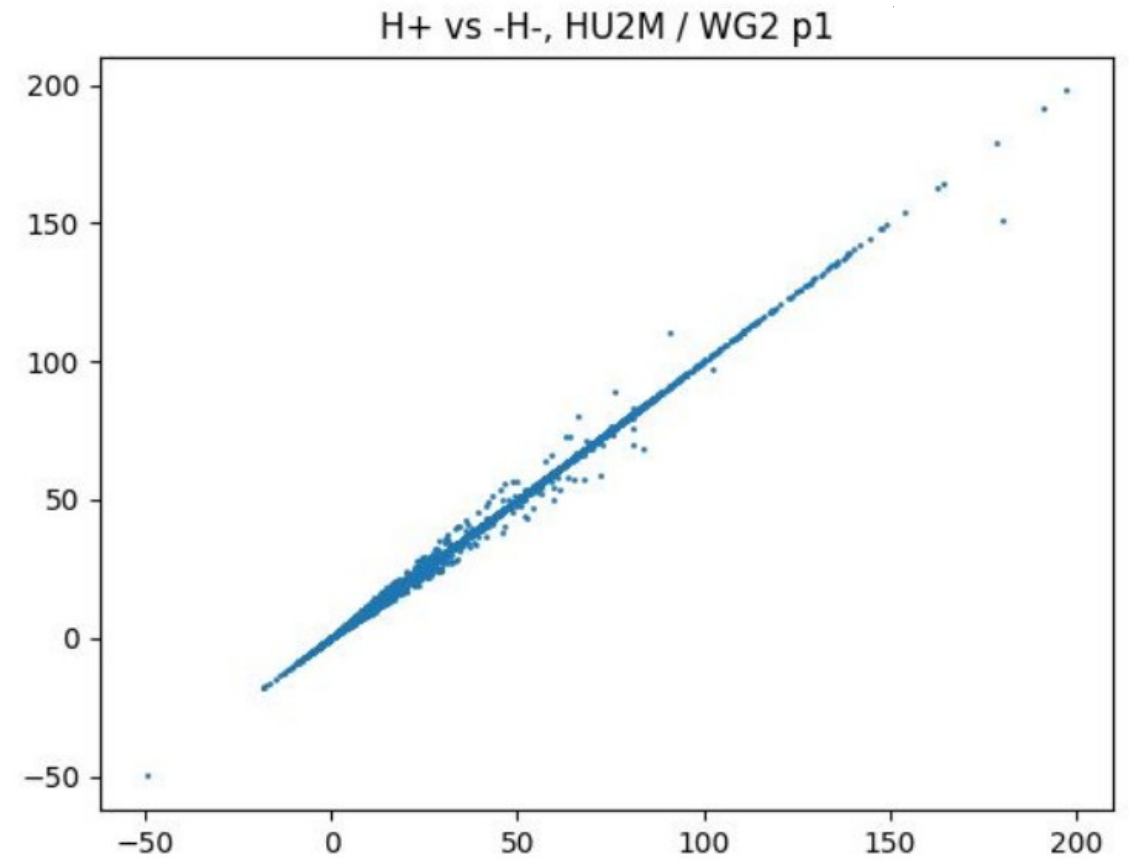
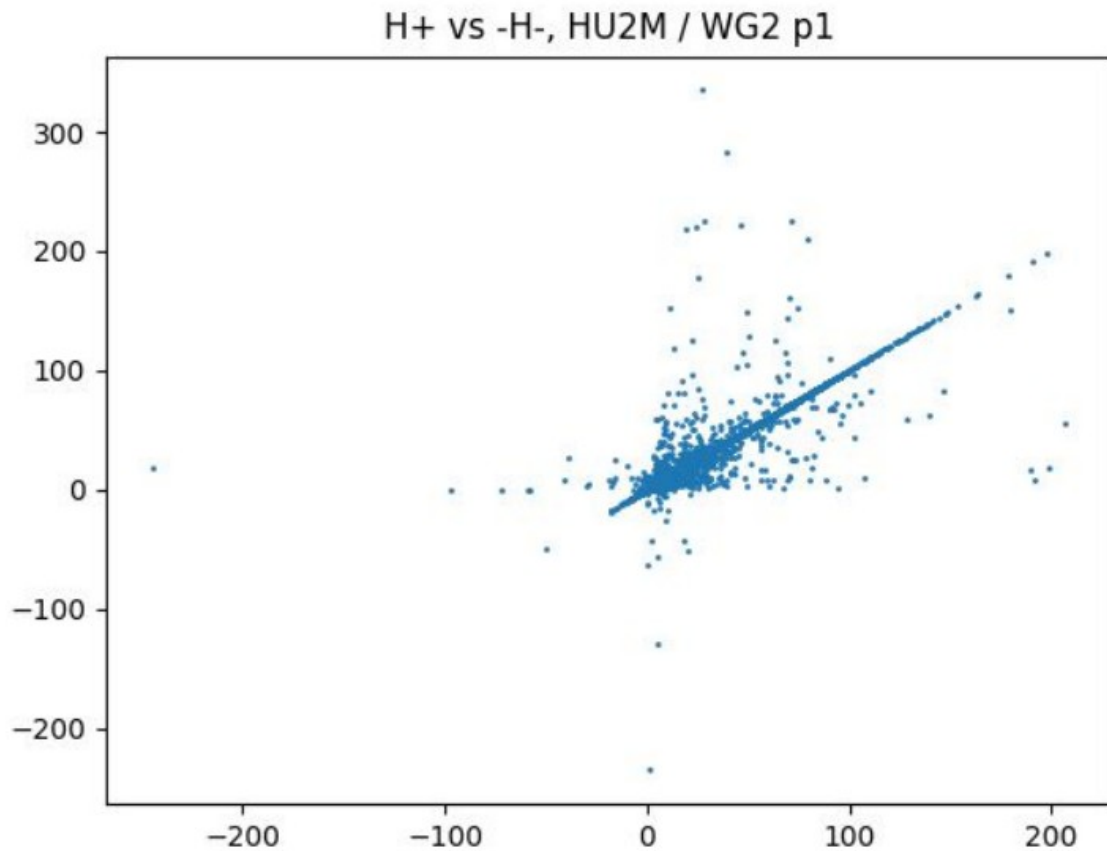
**Consequence: for each control variable we need two offline perturbation runs with SURFEX.**

Mahfouf, J.F. et al. 2009: A comparison of two off-line soil analysis schemes for assimilation of screen level observations. *Journal of Geophysical Research: Atmospheres*, 114(D8). doi:10.1029/2008JD011077.



# Simplified Extended Kalman Filter and new surface physics

If a specific Jacobian element is too non-linear, i.e. if the sum of the positive and negative elements is large compared to the elements themselves, then we disregard this specific element. Or as “code” expression:  
If  $(|H^+ + H^-|) > \varepsilon(|H^+| + |H^-|)/2$  then  $H=0$ ;  $\varepsilon = 0.2$



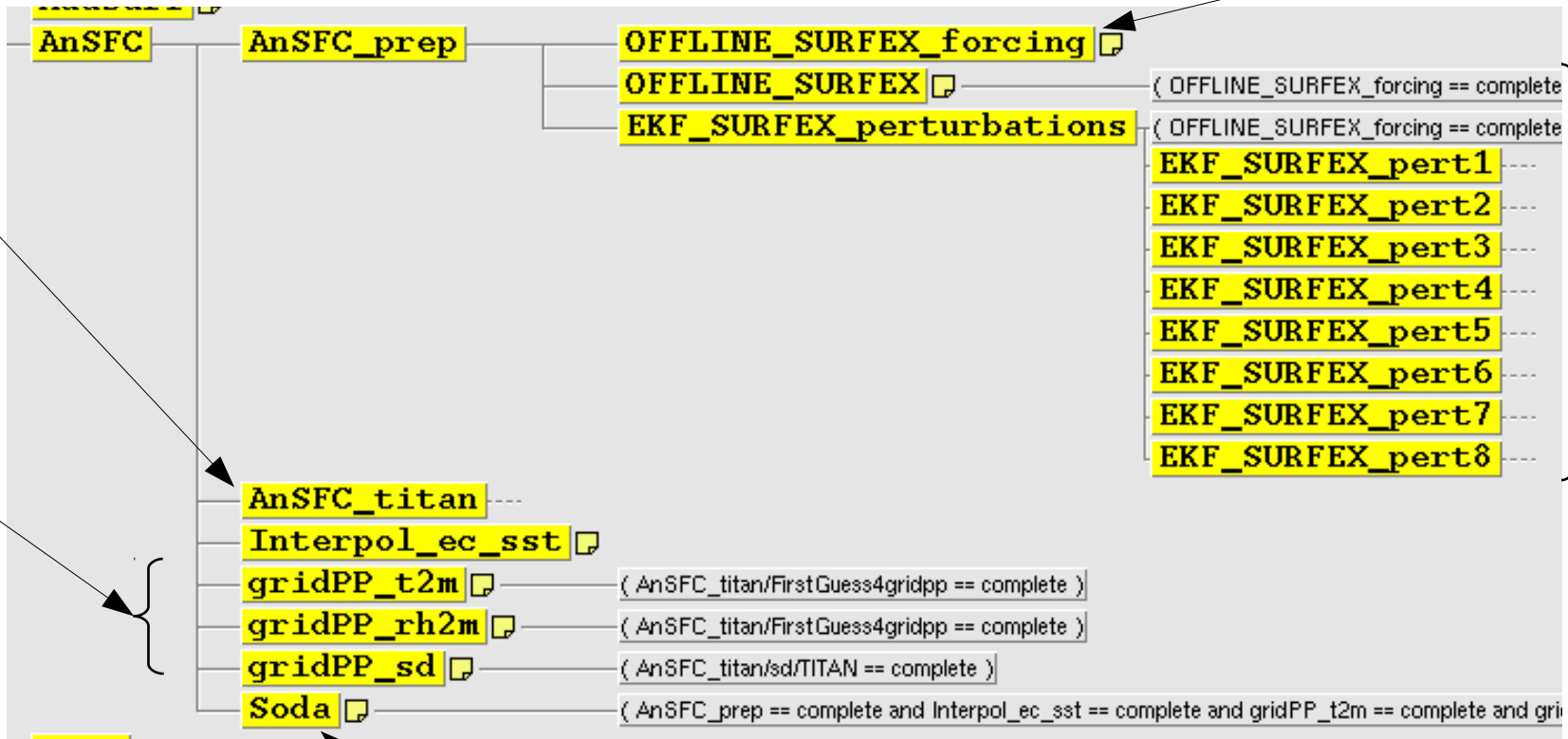
# Simplified Extended Kalman Filter and new surface physics

## The cy43h-SEKF EcfLOWview part of the surface analysis

Prepare forcing for SURFEX offline by this open-source API package (python): <https://github.com/metno/offline-surfex-forcing>  
Allow e.g. NetCDF, GRIB, FA, ASCII file formats

Quality control by the open-source TITAN library: <https://github.com/metno/TITAN/>  
Allow e.g. Netatmo crowdsouce data.

2D spatialisation by the open-source gridPP library: <https://github.com/metno/gridpp>  
Allow e.g. grid, tile or patch first guess. And a variety of non-homogeneous structure functions.



The control and the perturbed runs for estimation of Jacobian elements, H<sup>+</sup> and H<sup>-</sup>

SURFEX Offline Data Assimilation (SODA)

## **Examples of other activities going on**

**Ekaterina Kourzeneva, Laura Rontu, Kerttu Kouki, Niilo Siljamo and Terhikki Manninen (FMI):**

- Problems in CANARI analysis related to different land-water distribution fields (e923, SURFEX, boundary (ECMWF)) which affect e.g. snow analysis, especially along the coast. Development also related to exclusion of binary land-sea mask in CANARI and with observation operators in CANARI.**
- Erroneous snow analysis in connection to glaciers.**
- Assimilation of the snow extent (SE) from remote sensing - HSAF data. (See also snow presentation by Mariken).**

**Olli Saranko and Carl Fortelius (FMI) have implemented the Universal Thermal Climate Index (UTCI) into SURFEX in order to improve heat-health meteorological products in urban areas.**

**Erin Thomas et al. (MET Norway) have coupled the ocean Wave Watch III model to cy43h via the OASIS coupler (provided with SURFEX8.1). Results are promising but the system is still too expensive to run operationally. Work on this is ongoing.**

**THANKS!!**



**HIRLAM Surface working week in Maynooth, Ireland, November 2019**

