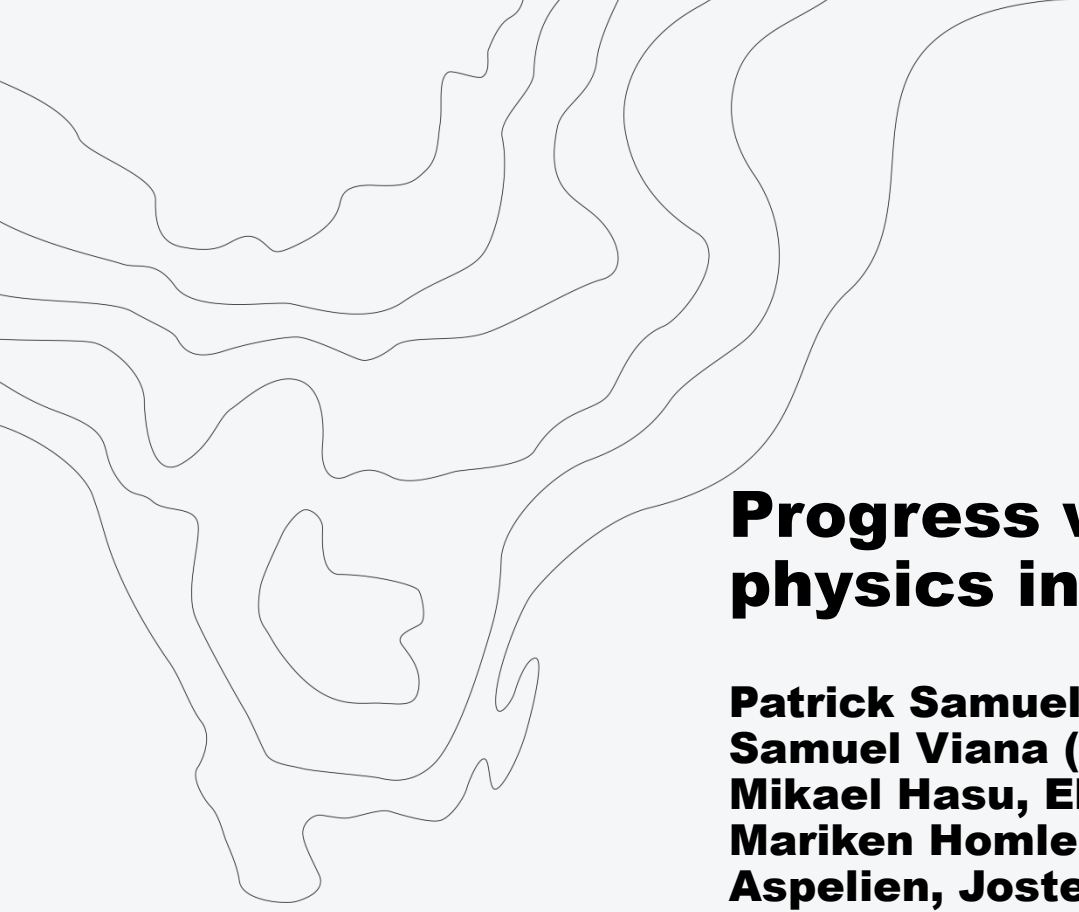


Progress with multi-layer surface physics in HARMONIE-AROME

Patrick Samuelsson, Karl-Ivar Ivarsson (SMHI)
Samuel Viana (AEMET)
Mikael Hasu, Ekaterina Kurzeneva (FMI)
Mariken Homleid, Åsmund Bakketun, Trygve Aspelien, Jostein Blyverket (MetNorway)
Bolli Palmason (IMO)

ACCORD surface multi-layer physics WW in Toulouse last October

We have experienced a few issues in our experiments with multi-layer physics. This WW focused mainly on atmosphere-surface-soil feedbacks related to the diffusion soil scheme but also included ECOCLIMAP/PGD aspects and hydrological aspects. See WW wiki here.

WW dinner

Patrick LM Anne-Lise Patrick S
Adrien Helene Samuel Trygve
Aaron Panu

Since then some development and experiments have continued in the HARMONIE-AROME framework…

A recent status update with links to presentations and results is available via this wiki.

SMHI

HARMONIE-AROME cy46h with new surface options

We use the HARMONIE-AROME cy46h system. Default settings are used for the atmosphere with 3D-VAR assimilation (conventional observations). The surface is based on SURFEXv8.1

Reference setup (close to operational)

- ECOCLIMAP Second Generation
- 2 patches (forest and open land)
- ForceRestore (3-L)
- D95 snow

- OI surface assimilation for the soil temperature and moisture from SYNOP T2m, Rh2m

- Snow update from SYNOP snow depth
- ECUME6

CANARI is used for SYNOP quality control and surface analysis

Experiment setup with new surface options

- ECOCLIMAP Second Generation
- 2 patches (forest and open land)
- Diffusion soil scheme (14 layers)
- Explicit snow scheme (12 layers)
- Explicit canopy for the forest patch (MEB)
- Simplified EKF surface assimilation for the soil temperature and moisture from SYNOP T2m, Rh2m
- Snow update from SYNOP snow depth
- ECUME6

PySurfex, with TITAN and gridPP, is used for SYNOP quality control and surface analysis

SMHI

Summary and some details to be presented

The new surface physics is less dependent on surface data assimilation than the ForceRestore/D95 combination and gives often good or reasonable results even without SEKF activated.

This is true especially during winter and spring seasons.

However, SEKF does improve scores when bias deviations occur.

SMHI

Summary and some details to be presented

The winter period in northern Europe tends to be better with new surface physics with respect to T2m, although still too cold (larger snow roughness and lower snow emissivity helps).

But the bias depends also on diagnostics formulation (recent CARRA2 experience, Marvin Kähnert will present more on this at Thursday's physics side meeting).

Near-surface humidity is too dry though, not sure why yet…

SMHI

Summary and some details to be presented

The spring (snowmelt) period in northern Europe is in general better described by the new surface physics, especially for near surface humidity which shows a significant positive bias in current operational systems.

Such a humidity bias is bothering e.g. the warning system for spring grass fires.

Summary and some details to be presented

For the summer/warmer period the new surface physics has given a general dry near-surface bias (and too warm bias).

This has been seen especially over the Iberian peninsula but also over agricultural-dominated areas of the MetCoOp domain. Excess bare soil evaporation has been identified as the most probable cause for this bias.

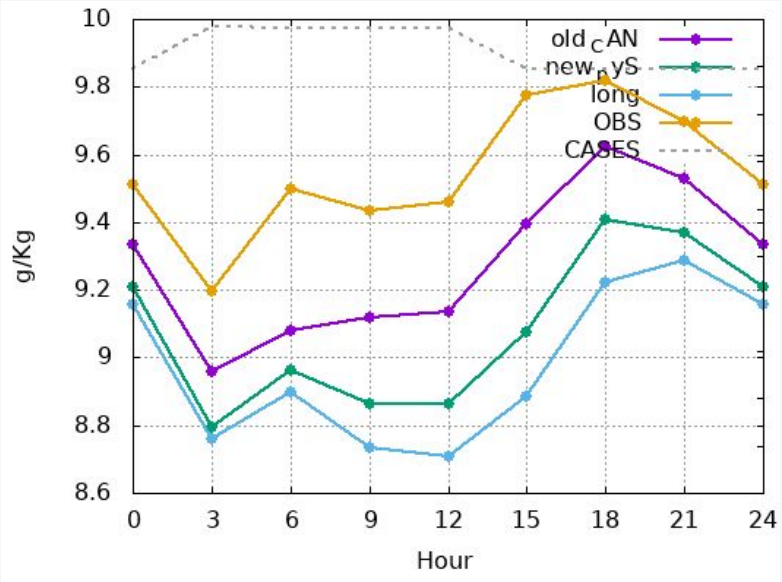
Samuel Viana has a poster dedicated to this summer dryness problem where he describes how the Dry Soil Layer parameterization helps.

MetCoOp domain, summer, Q2m diurnal cycle

SMHI

Analysing period: July 15-25, 2022 (2 weeks or 2 months spinup before that)

Denmark



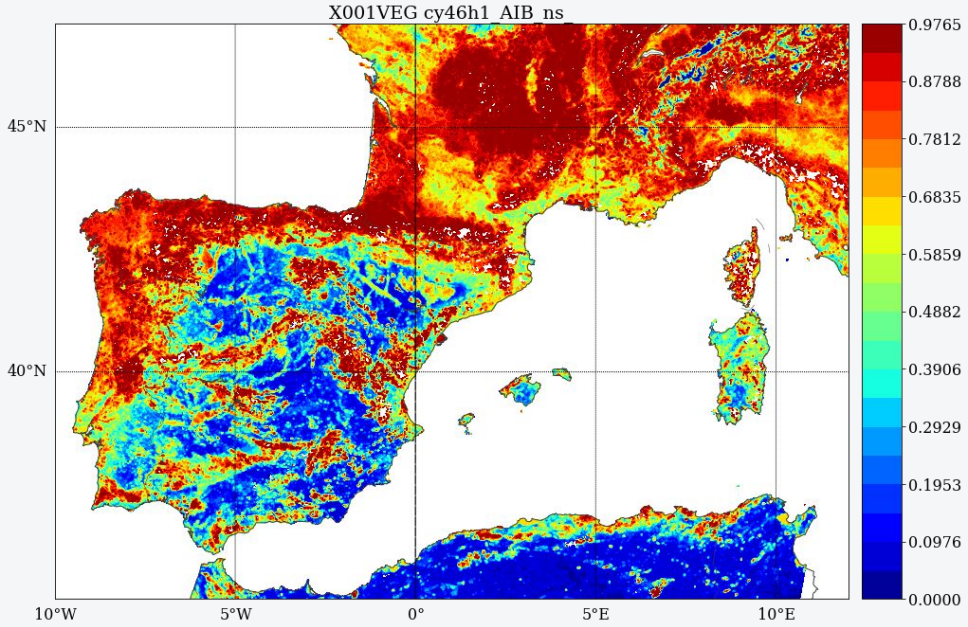
DIFF+MEB with 2 weeks spinup gives a dry bias compared to observations (and is also drier than ForceRestore). One hypothesis was that a longer spinup might help. But, 2 months spinup looks even drier. What can make longer spinup drier?

VEG and LAI for open land patch over AEMET domain in summer

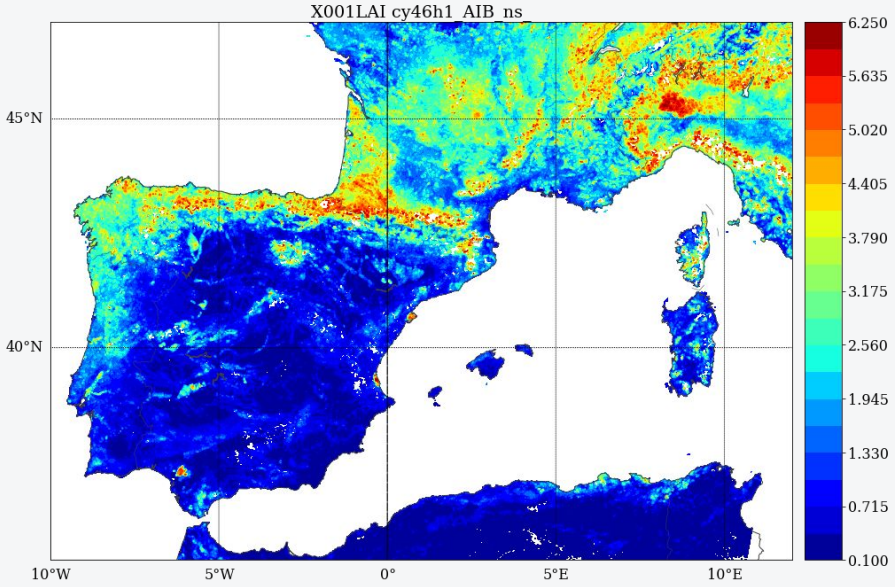
SMHI

Further investigation connected the problem to agricultural areas and to the occasional high fraction of bare soil.
As shown by Samuel, over Spain we see very low summer values of LAI (often < 1) and consequently also low VEG values (often < 0.3).

X001VEG



X001LAI



What does low LAI and VEG for crop areas mean in SURFEX?

SMHI

We have come to the conclusion that we need to improve both the bare soil processes and the dead vegetation material processes connected to the diffusion soil scheme:

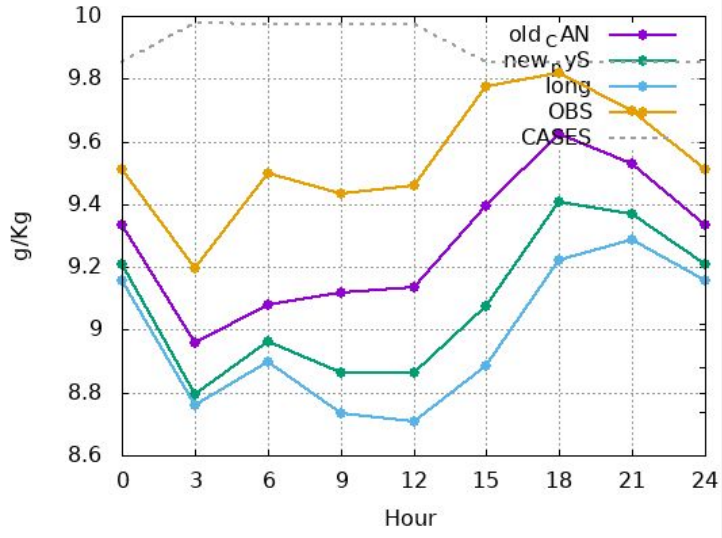
For the bare soil we now apply and test the Dry Soil Layer (DSL) parameterization described in the poster by Samuel Viana et al. It reduces bare soil evaporation and prevents the soil to dry out.

For the dead vegetation material we plan to introduce modified heat capacity and heat transfer characteristics for the top soil layers which will resemble more porous soil characteristics.

MetCoOp domain, summer, Q2m diurnal cycle over Denmark

SMHI

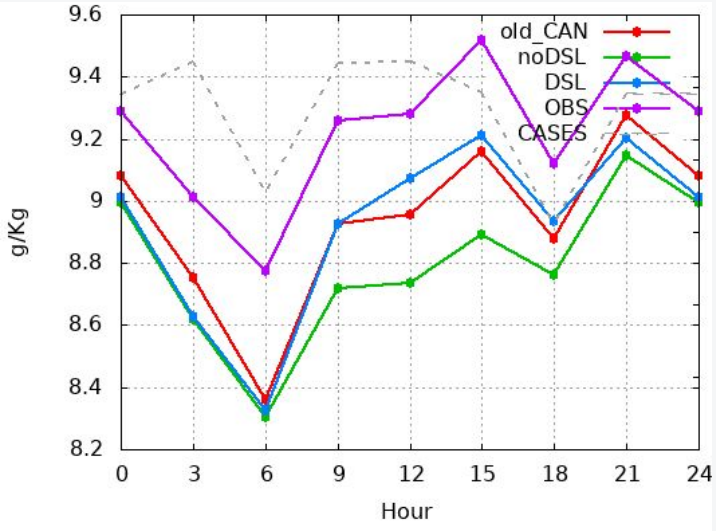
Analysing period: July 15-25, 2022
2 weeks or 2 months spinup before that



DIFF+MEB with 2 weeks spinup gives a dry bias compared to observations (and is also drier than ForceRestore). One hypothesis was that a longer spinup might help. But, 2 months spinup looks even drier. What can make longer spinup drier?

With DSL activated

Analysing period: July 15-26, 2022
2 weeks spinup before that



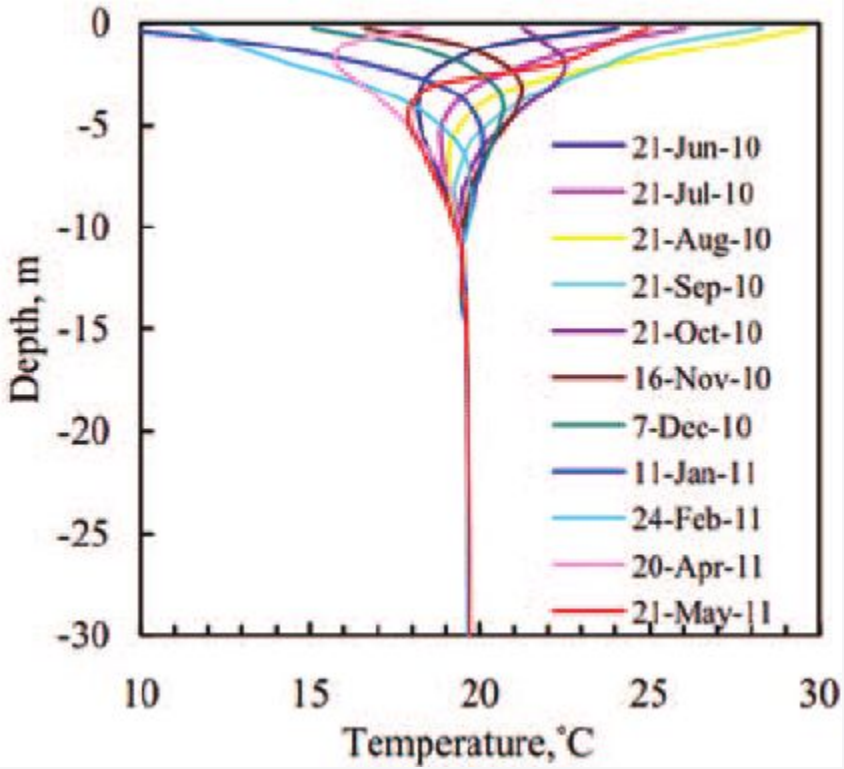
DSL activated for open land Vegtypes reduces the dry bias seen without DSL activated compared to Observations.

SMHI

Experiments and results related to initialisation of deep soil temperature

Typical annual variations in soil-temperature profile

SMHI

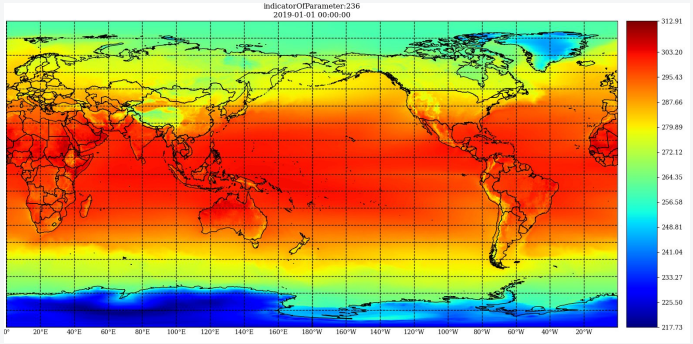


Over one year the variation does not penetrate deeper than some 10 m.

The default SURFEX DIF soil profile is divided over 14 layers with maximum depth at 12 m. The middle of the deepest layer is located at 10 m.

Thus, a multi-year mean temperature as a cold start (initial condition) value for 10 m would be a good approximation…

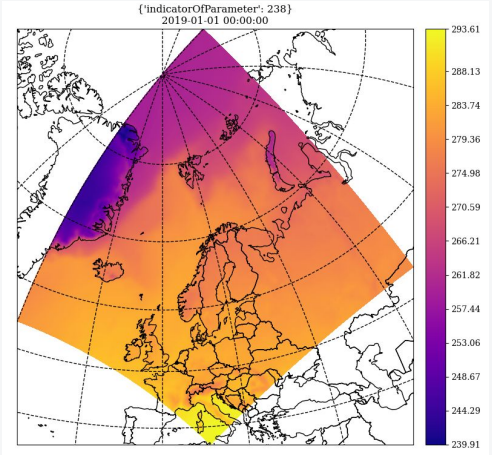
Improved deep soil cold start approach for PREP with ECMWF GRIB boundaries



Pre-processing done only once:

Mean of ERA5 soil temperature at TESSEL level 4 over period 2019-2021.

Interpolating done at each cold start (in HARMONIE-AROME in Prep_ini_surfex):



This soil temperature field is read by SURFEX in the PREP step.

Please note that this specific implementation is not yet in the common SURFEX branch since it depends on external data and script (python and Pysurfex)…

CARRA2_2500 domain TG vertical profiles

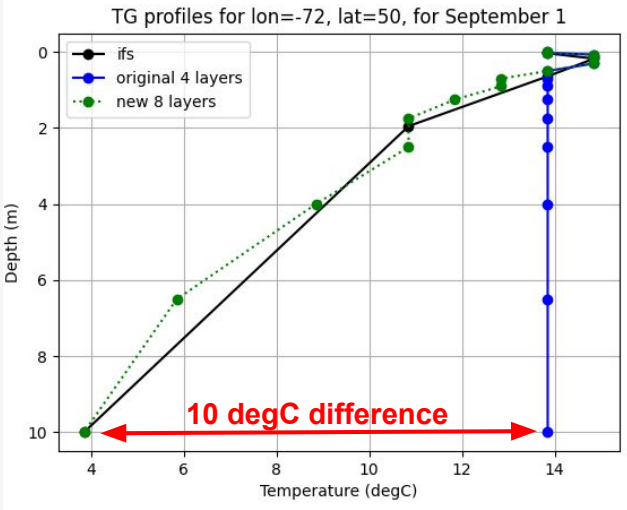
SMHI

In addition to the ERA5 climatology:

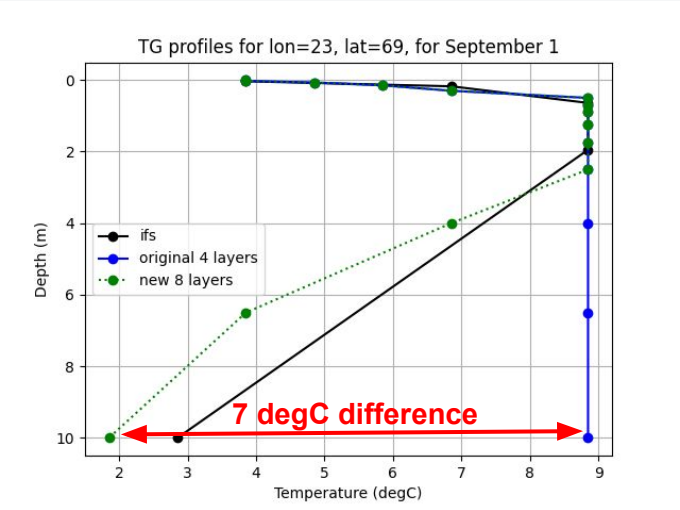
- **A modified/corrected vertical interpolation routine, vertical_grid_nat.F90, used in PREP.**
- **Additional layers in mode_read_grib.F90 for a more realistic deep profile shape.**

Cold start profiles by PREP for the CARRA2_2500 domain for time 2022-09-01 00Z

Quebec, Canada



Northern Norway



Legend:
ECMWF 4+1(ERA5) layer profile
Default DIF profile without ERA5 deep climatology
New DIF profile including ERA5 deep climatology

SMHI

Comments

- A new, Toulouse-continuation, ACCORD working week devoted to surface multi-layer physics will happen in coming autumn. It will be hosted by Jan De Pue at RMI in Brussels.
- Currently this new surface physics setup is running with SEKF surface data assimilation. However, SEKF is not developed anymore in HARMONIE-AROME. Efforts now goes into LETKF (see poster by Åsmund) and EnKF based algorithms.