

Change to soil hydrology scheme in IFS cycle 32r3

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Cycle 32r3 of the ECMWF forecast and analysis system includes a change in the soil hydrology which affects soil moisture. The land surface scheme has been improved by the introduction of a global distribution of soil type (based on the FAO soil texture data set) and new soil drainage and runoff schemes.

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Further information and advice regarding the upgrade can be obtained from [User Support](#)

Implications of the new soil hydrology scheme

The implication of the change in the soil hydrology is that the effective soil moisture range varies geographically as the permanent wilting point (PWP) and field capacity (FC) vary. For instance, sandy soils will be dryer while the fine texture soils (e.g. clay) will have a higher soil moisture than before, in line with observations.

This model change may have consequences for applications where soil moisture (SM) is used as an initial condition for other models or for applications where soil moisture is used as a dryness indicator. For those applications it might be necessary to scale to the so-called soil moisture index (SMI) defined as $(SM - PWP) / (FC - PWP)$. This index is equal to zero at the permanent wilting point and one at field capacity but it can be larger than one after rain. It is also an indicator for the "wetness" of the soil and can be used as an intermediate step to scale soil moisture from one model to another in cases where these models use different soil characteristics.

Note that, even after scaling to the soil moisture index, the soil moisture fields from IFS cycle 32r3 can differ substantially from that given by the previous cycle. This is due to the major changes in the land surface scheme (revised runoff, new hydrology and new soil types).

Computing the Soil Moisture Index

An example MARS compute script together with the table below are provided for users that need to compute the SMI. The soil texture type (MARS parameter SLT, GRIB Code 43) as well as the soil moisture at different layers (MARS parameters SWVL1, SWVL2, SWVL3 and SWVL4, GRIB Codes 39, 40, 41 and 42, respectively) are needed as input.

| Old | Soil | PWP [m ³ /m ³] | FC [m ³ /m ³] |
|-----|-------|---------------------------------------|--------------------------------------|
| 1 | Loamy | 0.171 | 0.323 |

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| New | Soil | PWP [m ³ /m ³] | FC [m ³ /m ³] |
|-----|-------------|---------------------------------------|--------------------------------------|
| 1 | Coarse | 0.059 | 0.242 |
| 2 | Medium | 0.151 | 0.346 |
| 3 | Medium–fine | 0.133 | 0.382 |
| 4 | Fine | 0.279 | 0.448 |
| 5 | Very fine | 0.335 | 0.541 |
| 6 | Organic | 0.267 | 0.662 |

Example MARS script for computing the Soil Moisture Index

The following example MARS script computes the Soil Moisture Index for soil moisture layer 1 (0–7cm). In this case, soil type (SLT) and Volumetric Soil Water Layer 1 (SWVL1) are needed as input.

```

# Retrieve the soil type (parameter SLT) from MARS to
# fieldset slt
retrieve,
  class      = od,
  stream     = oper,
  expver     = 1,           # For test data use expver=35
  date       = -1,
  time       = 00:00:00,
  levtype    = sfc,
  param      = SLT,
  type       = an,
  fieldset   = slt

# Retrieve the Volumetric Soil Water Layer 1 (parameter
# SWVL1) from MARS to fieldset sm.
# To compute the SMI for other soil layers change
# the parameter to SWVL2, SWVL3 or SWVL4 as appropriate
retrieve,
  type       = fc,
  step       = 24,         # Or the required forecast step
  param      = SWVL1,
  fieldset   = sm

# Compute the SMI. At each grid point with a non-zero
# value for soil type (slt<>0): one and only one of the
# following will be non-zero.

```

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```
compute,
  fieldset = smi1,
  formula  = "(slt=1)*(sm-0.059)/(0.242-0.059)"

compute,
  fieldset = smi2,
  formula  = "(slt=2)*(sm-0.151)/(0.346-0.151)"

compute,
  fieldset = smi3,
  formula  = "(slt=3)*(sm-0.133)/(0.382-0.133)"

compute,
  fieldset = smi4,
  formula  = "(slt=4)*(sm-0.279)/(0.448-0.279)"

compute,
  fieldset = smi5,
  formula  = "(slt=5)*(sm-0.335)/(0.541-0.335)"

compute,
  fieldset = smi6,
  formula  = "(slt=6)*(sm-0.267)/(0.662-0.267)"

# Compute the SMI and write to the file "smi_output.grib"
compute,
  fieldset = smi,
  formula  = "smi1 + smi2 + smi3 + smi4 + smi5 + smi6"

write,
  fieldset = smi,
  target   = "smi_output.grib"
```

Note that the SMI can be used to re-compute the soil moisture consistently with the PWP and FC used by the application.

For example, to compute the soil moisture for layer 1 (SWVL1_old) as would be obtained with the old (pre-IFS cycle 32r3) scheme use:

$$\text{SMI} = (\text{SWVL1_old} - \text{PWP}) / (\text{FC} - \text{PWP})$$
$$\text{SMI} = (\text{SWVL1_old} - 0.171) / (0.323 - 0.171)$$

which gives

$$\text{SWVL1_old} = \text{SMI} * (0.323 - 0.171) + 0.171$$

where SMI is as calculated by the MARS request above and the values of FC and PWP are taken from the table for the old soil type 1. The calculation can be performed in MARS by adding the following lines to the script above:

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```
# Rescale the soil moisture for soil level 1 using the
# calculated SMI
compute,
  fieldset = smh,
  formula  = "(slt<>0)*(smi*(0.323-0.171)+0.171)"
compute,
  fieldset = sm_old,
  formula  = "(sm>0)*(smh>0)*smh"
# Write the "old" SWVL1 field to the file "swvl1_old.grib"
write,
  fieldset = sm_old,
  target   = "swvl1_old.grib"
```

For further information about mathematical computations in MARS please see the [MARS User Guide](#).

Test data sets from pre-operational e-suite

The IFS cycle 32r3 e-suite for the deterministic T799L91 forecasts has been run since 1 June 2007. All results are stored in MARS, available in near real-time and can be used for technical test purposes by Member State users. The version number of the e-suite is 35 (MARS parameter expver=0035).

The IFS cycle 32r3 e-suite for the Variable Resolution Ensemble Forecast System for all ensemble members was run for the 00 UTC cycle only throughout August 2007. All results are stored in MARS as version number 35 (MARS parameter expver=0035).

Only registered users of ECMWF computing systems will be able to access the test data sets in MARS.

- Deterministic atmospheric model (Class=od, Stream=da, Expver=35):
 - ◆ 1 June 2007 to present – 00 UTC and 12 UTC.
- Ensemble Prediction System (Class=od, Stream=enfo, Expver=35):
 - ◆ 2 August 2007 to 12 September 2007 – 00 UTC.

Please report any problems you find with this data to User Support