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MESSy on-line diagnostics in COSMO-CLM and ICON-CLM

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Abstract:

Long-term and/or high resolution simulations with geoscientic models become more and more limited by storage space. Therefore, on-line diagnostic tools calculating the target variables directly during the model simulation become increasingly important.

One option is to use the MESSy-fied versions of the CLM-Community models. MESSy provides a huge range of on-line diagnostic tools, e.g.

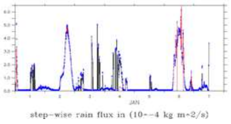
1) simple statistics w.r.t. time, such as monthly mean, standard deviation, minimum, maximum or event counting,
2) the output on distinct surfaces (e.g., pressure levels, potential vorticity iso-surfaces),
3) output of data along sun-synchronous satellite orbits or radiosonde tracks,
4) the renaming of variables, as e.g. required by the CMOR standard,
5) redirection of a set of variables into specific output files, etc.,
6) diagnostics for tracers (such as hydrological variables),
7) tendency diagnostics.

Further, the modular MESSy infrastructure gives the possibility to integrate tailor-made on-line diagnostics into the model without modifying the COSMO-CLM / ICON-CLM code itself. COSMO-CLM/MESSy is already provided to the CLM-community members. The diagnostic tools are implemented in ICON/MESSy.

Here we provide a general overview of the features of the diagnostic capabilities of the MESSy-fied CLM-Community models.

SCALC

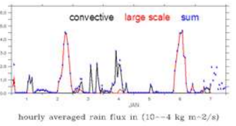
simple calculations on channel objects
e.g. summation, division, multiplication: including scaling factors



step-wise rain flux in (10−−4 kg m−2/s)

Example:

calculate sum of large scale and convective rain flux



hourly averaged rain flux in (10−−4 kg m−2/s)

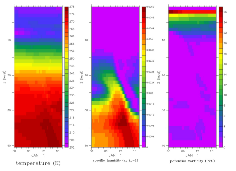
```
&CPL
CALC( 2)='prc','COSMO_ORI:PRR_CON,PRS_CON',                        'SUM', 'messy_convec'
CALC( 3)='prr', 'COSMO_ORI:PRR_GSP,PRS_GSP',                       'SUM', 'messy_convec'
CALC( 4)='tpr', 'COSMO_ORI:PRR_CON,PRS_CON,PRR_GSP,PRS_GSP', 'SUM', 'messy_global_end'
/
```

OUTPUT at distinct locations

SORBIT: Sampling of model data on sun-synchronous satellite orbits

S4D: Sampling in 4 Dimensions interpolates the requested model data to the track of moving observation platforms (aircraft, ship, train, etc.) on-line, i.e., during the model simulation. The platform location(s) in space and time are provided as input file(s).

SCOUT: Stationary Column OUTput
enables on-line high-frequency output of model data at the position of observation stations



SCOUT: 5-min output over 20 hours for Bonn, Germany

OUTPUT on arbitrary vertical axis

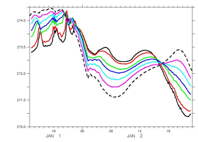
VAXTRA: vertical axis transformation

Definition of vertical axis, i.e. pressure levels, potential temperature or height in namelist

```
VAX(1) = zaxKARLS','COSMO','geopot',0.1019,
'm', F, F, 6,  20.0, 40.0, 80.0, 100.0, 130.0,
160.0, 200.0, 94*0.0,
```

definition of variables interpolated to vertical axis:

```
TRA(1)= 'KARLS_tm1','COSMO','tm1','zaxKARLS', ,
TRA(2)= 'KARLS_um1','COSMO','um1','zaxKARLS', ,
TRA(8)= 'KARLS_p',  'COSMO', 'p', 'zaxKARLS', ,
```



temperature [K] on vertical levels defined in VAXTRA for the Karlsruhe flux tower

Literature: Jöckel, P., et al., GMD, 2010, Development cycle 2 of the Modular Earth Submodel System (MESSy2), doi: 10.5194/gmd-3-717-2010,(2010)

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On-line statistics using the CHANNEL submodel

The generic submodel **CHANNEL** provides a powerful application programming interface (API) for the flexible and efficient data exchange / sharing between different processes (submodels). It is written in Fortran95 (ISO/IEC-1539-1) following an object-oriented approach to the extent possible. The basic entities, implemented as Fortran95 structures, of CHANNEL are

- attributes, representing time independent, scalar characteristics, e.g., the measuring unit,
- dimension variables, representing specific coordinate axes, e.g., the latitude in degrees north, the zonal wave number, the trajectory number,
- dimensions, representing the basic geometry in one dimension, e.g., the number of latitude points, the number of trajectories,
- representations, describing multidimensional geometric structures (based on dimensions), e.g., Eulerian (or gridpoint), spectral, Lagrangian,
- channel objects, representing data fields including their meta information (attributes) and their underlying geometric structure (representation), e.g., the 3-D vorticity in spectral representation, the ozone mixing ratio in Eulerian representation, the pressure altitude of trajectories in Lagrangian representation,
- channels, representing sets of "related" channel objects with additional meta information. The "relation" can be, for instance, the simple fact that the channel objects are defined by the same submodel.

CHANNEL further serves the output into data files and input/output (IO) from/into check-point (restart) files. The implemented IO features comprise

- a complete control (user interface) via two Fortran95 namelists,
- a powerful check-pointing facility for simulation chains,
- output redirection to create tailor-made output files,
- a flexible choice of the output file format, of the output method, of the output precision, of the output frequency, and
- the capability to conduct basic statistical analyses w.r.t. time on-line, i.e., to output in addition (or alternative) to the instantaneous data (i.e., at a specific model time step) the average, standard deviation, minimum, maximum, event counts, and event averages for the output time interval.

Example CHANNEL namelist

```
&CTRL
ADD_CHANNEL(1) = 'demo_mm',
ADD_CHANNEL(2) = 'demo_dm',
ADD_CHANNEL(3) = 'demo_6hm',
!-----------------------------------------------------------------
…
ADD_REF(10) = 'COSMO_ORI', 'T_2m',   'demo_mm', 'tas',
ADD_REF(11) = 'COSMO_ORI', 'U_10m',  'demo_mm', 'uas',
ADD_REF(12) = 'COSMO_ORI', 'V_10m',  'demo_mm', 'vas',
!-----------------------------------------------------------------
ADD_REF(20) = 'COSMO_ORI', 'T_2m',   'demo_dm', 'tas',
ADD_REF(21) = 'COSMO_ORI', 'U_10m',  'demo_dm', 'uas',
ADD_REF(22) = 'COSMO_ORI', 'V_10m',  'demo_dm', 'vas',
!-----------------------------------------------------------------
ADD_REF(30) = 'COSMO_ORI', 'T_2m',   'demo_6hm', 'tas',
ADD_REF(31) = 'COSMO_ORI', 'U_10m',  'demo_6hm', 'uas',
ADD_REF(32) = 'COSMO_ORI', 'V_10m',  'demo_6hm', 'vas',
!-----------------------------------------------------------------
…

OUT_CHANNEL(5) = 'demo_mm',  2,2, 10, F,F, F,T,F,F,F, F,F,  ,  ,
OUT_CHANNEL(5) = 'demo_mm',  2,2, 10, F,F, F,T,F,F,F, F,F,  ,  ,
OUT_CHANNEL(5) = 'demo_mm',  2,2, 10, F,F, F,T,F,F,F, F,F,  ,  ,

!-----------------------------------------------------------------
…
OUT_OBJECT(47) = 'demo_mm', 'U_10M',  F,F, F,T,T,F,F, , ,
…
/

&CPL
TIMER_DEFAULT = ' ',1,'days','first',0
…
TIMER_CHANNEL(1) = 'demo_mm', 1, `'months','first',0
TIMER_CHANNEL(1) = 'demo_mm', 1, `'months','first',0
TIMER_CHANNEL(1) = 'demo_mm', 1, `'months','first',0
…
/
```

create 3 additional output channels

create references of channel objects

Model variables **T_2m**, **U_10m** and **V_10m** are additionally processed in channels 'demo_mm', 'demo_dm' and 'demo_6hm'. Additionally, they are renamed to their respective CMOR names **tas**, **uas** and **vas**

number of time steps written to one file

choice of written values

output precision

instantaneous
average
standard deviation
minimum
maximum

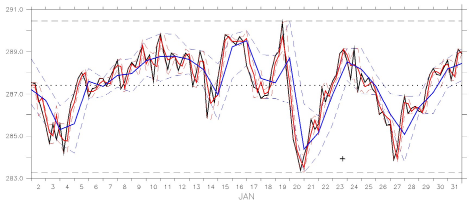
event statistic: count number, average and range

define data written by respective channel…

Note: output precision and output step number are channel properites

… or define output individually for each channel object

define output frequency



Example

2m temperature
at 20.95 W, 32.21 N

6h instantaneous
6h average
daily average
monthly avaerage

6h min/max
daily min/max
monthly min/max