Comparison of COSMO-CLM results with CM-SAF data

Andreas Will and Michael Woldt (BTU Cottbus)
Configuration CCLM-GME

Boundary conditions:
GME 60/40 km, ke=40 1.2001-12.2007, DWD soil-vegetation data

Models: int2lm_1.7.2_clm_1, cosmo_4.2_clm_1

CCLM-grid: \( \Delta x = \Delta y = 0.167^\circ, 193 \times 217, \text{ke}=40, 10 \text{ soil levels, } z(10)=15.34 \text{ m} \)

Dynamics: 3\text{rd} order RK p\(^\prime\)T\(^\prime\), 5\text{th} order hor. adv., impl. vert. adv., 208 km lateral boundary zone, dyn. bottom bc

Physics: Tiedtke conv.; prognostic precipitation, cloud water and ice; TKE-scheme
Selected regions

Water (WAS)

Land (LND)

South-West-Europe (SWE)

Scandinavia (SCA)

and also

Germany (DTL)

Alpine Region (ALP)
## CMSAF and COSMO variables

<table>
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<th>CMSAF</th>
<th>CMS-SAF-Accuracy</th>
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<td>ASODT</td>
<td>TIS</td>
<td>1W/m²</td>
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<td>TOA up SW</td>
<td>ASOU_T</td>
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<td>10W/m²</td>
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<tr>
<td>*TOA net SW</td>
<td>ASOB_T</td>
<td>TES</td>
<td>0.12 %</td>
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<tr>
<td>TOA net LW</td>
<td>ATHB_T</td>
<td>-TET</td>
<td>0.06 %</td>
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<td>*TOA net radiation</td>
<td>ANRB_T</td>
<td>TER</td>
<td>15W/m²</td>
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<td>Total cloud cover</td>
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<td>CFC</td>
<td>0.10 % LND</td>
<td>0.15 % WAS</td>
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<td>Cloud top height</td>
<td>HTOP_CON</td>
<td>CTH</td>
<td>1000m</td>
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<td>Vertic. integr. water vapor</td>
<td>TQV</td>
<td>HTW_TPW</td>
<td>1mm</td>
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<td><strong>3. NEAR SURFACE</strong></td>
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<td>surface down SW</td>
<td>ASWG_S</td>
<td>SIS</td>
<td>10W/m²</td>
<td></td>
</tr>
<tr>
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<td>ALB_RAD</td>
<td>SAL</td>
<td>0.25 %</td>
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<tr>
<td>surface up SW</td>
<td>ASWDIFU_S</td>
<td>SRS</td>
<td>10W/m²</td>
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<tr>
<td>surface net SW</td>
<td>ASOB_S</td>
<td>SNS</td>
<td>15W/m²</td>
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<td>surface down LW</td>
<td>ALWD_S</td>
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<td>surface up LW</td>
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<tr>
<td>surface net LW</td>
<td>ATHB_S</td>
<td>SNL</td>
<td>15W/m²</td>
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<tr>
<td>*surface net radiation</td>
<td>ANRB_S</td>
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<td>T_2M</td>
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<td>Total Precipitation</td>
<td>TOT_PREC</td>
<td>PRECIP</td>
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</tbody>
</table>
Comparisons of absolute values and differences between model results (GME008, GME010) and between model results and SAF products for – annual means, – monthly means and – annual cycles of spatial averages for 35 selected regions and the year 2006.

Accuracy of SAF data: Bias and RMSE of monthly means. Derived from - Comparison with GUAN global radiosond network Other verifications (see validation report for each product)
Structures of occurring bias

in COSMO variables

– land-sea contrast,
– spatial structure defined by a typical local climate,
– seasonal structure,
– cloud free to cloudy contrast
– model domain boundary symmetry.

in SAF-variables

– North-South contrast,
– annual cycle,
– land-sea contrast,
– day-night contrast and/or
– cloud free to cloudy contrast
1. Radiation

1.4 ToA net LW, 2005-2006

CCLM: ATHB_T
SAF: TNT=-TET, Satellite
$\Delta s = \pm 8 \text{ W (month)}$
1.4 ToA net LW, 
AVE 2005-2006, $\Delta s = \pm 2$ W

CCLM

Thermal net TOA GME008 2005–2006 00

SAF 120

Thermal net TOA SAF120 2005–2006 00
1.4 ToA net LW, AVE 2005-2006
CCLM–SAF, $\Delta s = \pm 2 \, \text{W}$
1.4 ToA net LW, AVE 2005-2006
CCLM–SAF, $\Delta s = \pm 7$ W
1.4 ToA net LW, AVE 2005, 2006, 2005-2006
CCLM–SAF, $\Delta_s = \pm 10$ W
1.4 ToA net LW, AVE 2006, Data-CCLM, $\Delta_s = \pm 10$ W
1.4 TOA net LW, 2006

Summary

- **ToA outgoing LW is downward positive**

- **Annual Means**
  - the mean deviations over WAS (−7.6W), over SWE (−6.9W) and over MED (−10.6W) are strongly significant.
  - A strongly significant gradient of the deviations can be found perpendicular to the boundaries.
  - At the inflow boundaries the gradient is much weaker indicating a strong effect of the inflow conditions on the formation of clouds, especially over water surfaces.
  - The land-sea contrast is also different in CMSAF and GME008. It can be seen from the significant difference MED-SWE, which is about 9W for TET and 12.5W for ATHB_T

- **Monthly means**
  - significant negative deviation of −16.1W over WAS and −6.9W over LND.
  - in July positive deviations dominate with significant values of 9.4W over SCA.
  - annual cycle of 10W over LND, 13W over WAS, 23W over SCA and no annual cycle over SWE.

- **Hypothesis:** underestimation of convection over WAS or bias in CMSAF data
2. Clouds

2.1 Total Cloud Cover

CCLM: CLCT
SAF: CFC, Satellite

over land: $\Delta_s = \pm 0.05 \text{ (month)}$
over oceans: $\Delta_s = \pm 0.09 \text{ (month)}$
2.1 Total Cloud Cover, AVE 2006, $\Delta s = \pm 0.014 (0.026)$

**CCLM**

Total Cloud Cover GME008, 2006–200600

**SAF 150**

Total Cloud Cover SAF150, 2006–200600
2.1 Total Cloud Cover, AVE 2006
CCLM–SAF, $\Delta s = \pm 0,014 (0,026)$
2.1 Total Cloud Cover, AVE 2006
CCLM–SAF150, $\Delta_s = \pm 0.05 (0.09)$

Jan.  

Apr.  

Jul.  

Oct.
2.1 Total Cloud Cover, $\Delta_s = \pm 0.05 (0.09)$

DATA-CCLM, 2006
2.1 Total Cloud Cover, 2006

Summary

- **Annual mean**
  - positive differences over SCA (0.16)
  - negative differences over MED (−0.20) and over WAS (−0.13)
  - strong land-sea contrast in the CFC data due to significantly higher CFC over WAS (0.75) in comparison to CLCT over WAS (0.59),
  - strongly significant negative peak bias at the boundaries of up to −0.35 for the differences with influence on the differences within the model domain and
  - significant differences between the CMSAF data of 0.07 over WAS and LND points.

- **Monthly mean**
  - the summer positive difference pattern of 0.25 over SCA and 0.13 over central Europe (MEU and EEU)
  - the winter negative differences over WAS of −0.32
  - no decrease of CLCT in spring to summer in GME008

**hypothesis:** possible CMSAF bias or underestimated model convection.
2. Clouds

2.2 Convective Cloud Top Height

CCLM: HTOP_CON
SAF: CTH, GME-model

\[ \Delta_s = \pm 1000\text{m} \text{ (month)} \]
2.2 Convective Cloud Top Height, AVE 2006, Δs = ± 300 m

CCLM

Height of Convective Cloud Top GME008 2006–2006 00

SAF 150

Height of Convective Cloud Top SAF150 2006–2006 00
2.2 Convective Cloud Top Height, AVE 2006, CCLM–SAF150, $\Delta s = \pm 300$ m
2.2 Convective Cloud Top Height, AVE 2006, CCLM–SAF150, $\Delta s = \pm 1000$ m
2.2 Convective Cloud Top Height, CCLM, SAF 2006

$\Delta s = \pm 1000$ m
2.2 Convective Cloud Top Height
DATA-CCLM, 2006  \( \Delta s = \pm 1000m \)
2.2 Convective Cloud Top Height, 2006

Summary

- **Annual mean**
  - negative values over NEL, NEW (~1500) and
  - significant differences between the CMSAF data SAF150 and SAF210 for most of the regions (SAF210−SAF150 ≥ 1000m).

- **Monthly mean**
  - The differences CCLM-SAF have an annual cycle of nearly 1000m to 2000m for all land regions with higher deviations in winter.

- The criteria of cloud top height in SAF and in the model have to be compared in detail with each other before drawing conclusions.
2. Clouds

2.3 Vertically Integrated Water Vapor

CCLM: IWV
SAF: HTW, Satellite

$\Delta_s = \pm 1 \text{ mm (month)}$
2.3 Vertically Integrated Water Vapor,
AVE 2006, $\Delta s = \pm 0.3 \text{ kg/m}^2$

CCLM

SAF H30

Precipitable Water GME008 2006–2006 00

Precipitable Water SAFH30 2006–2006 00
2.3 Vertically Integrated Water Vapor,
AVE 2006, CCLM–SAFH30, $\Delta s = \pm 0.3 \text{ kg/m}^2$
2.3 Vertically Integrated Water Vapor, AVE 2006, CCLM–SAFH30, $\Delta s = \pm 1 \text{ kg/m}^2$
2.3 Vertically Integrated Water Vapor, DATA-CCLM, 2006 \( \Delta s = \pm 1 \text{ kg/m}^2 \)
2.3 Vertically Integrated Water Vapor, 2006

Summary

- Annual mean
  - strongly significant positive differences in POE (0.93), negative differences over southern Europe with up to −2.01 over SUE
  - strong decrease of TQV in the model over land with 20.65 mm over MED and 16.42 mm over SUE in comparison with 20.92 mm and 18.42 mm for HTW.
  - clear fingerprint of topography in the differences $TQV - HTW$. Over the mountains in southern Europe the model exhibits maximal negative deviations indicating an overestimation of convection.

Monthly mean
  - winter negative difference pattern of −1.23 over WAS and −2.34 over SCA
  - summer negative differences −2.84 over southern Europe
  - summer positive difference 2.64 over the POE region
2. Vertical profiles

2.1 Temperature, 2006

CCLM: \( T(p), QV(p) \)

SAFH30: \( HLW_T, HLW_{LPW} \)

\( \Delta s = 1 \text{ K}, 1.5 \text{ mm} \)
T (p)  

MEU  

RELHUM(p)  

250  

600  

925
Summary

- Annual mean
  - T and RELHUM exhibit no significant differences

- Monthly mean
  - The temperature differences remain below 2K
  - The main part of the differences in RELHUM can be explained by the temperature differences
3. Radiation at the Surface

3.2 Surface Albedo, 2006

CCLM: ALB_RAD
SAF: SAL (210 and 150)
Satellites and GME
\( \delta_s = 0.25 \) (month)
\( \Delta_s = 0.04 \) (month)
3.2 Surface Albedo (60°),
AVE 2006, $\Delta s = 0.08$

CCLM
Surface Albedo GME008, 2006–200600

SAF 150
Surface Albedo SAF150, 2006–200600
3.2 Surface Albedo, AVE 2006
CCLM – SAF150, $\Delta s = 0.08$
3.2 Surface Albedo, AVE 2006

CCLM–SAF150, $\Delta_s = 0.25$

Jan.

Apr.

Jul.

Oct.
3.2 Surface Albedo, 2006, CCLM, SAF $\Delta_s = 0.25$
3.2 Surface Albedo, 2006, DATA-CCLM $\Delta_s = 0.25$
3.2 Surface albedo, 2006
Summary

- Annual mean
  - Available SAF data coverage not sufficient for most parts of the model domain
  - In the Alpine region (ALP) the model exhibits higher values (0.1).

- Monthly means
  - For ALP higher values in snow-months up to 0.3 in the model. Similar result for SCA and other snow-covered regions. This might be caused by missing evergreen forest in the simulation.
  - Differences between SAF150 and SAF210 approx. 0.1, which is similar to the differences CCLM-SAF for most regions.
  - The precision of 0.25 is very low.
3. Radiation at the Surface

3.3 Surface outgoing SW, 2006

CCLM: ASWDIFU_S
SAF: SIS-SNS (210 and 150)
Satellites and GME
\[ \Delta s = \pm 18 \text{ W (month)} \]
3.3 Surface outgoing SW, AVE 2006, $\Delta s = \pm 5$ W

CCLM

Solar outgoing SW GME008 2006–2006 00

SAF 210

Solar outgoing SW SAF210 2006–2006 00
3.3 Surface outgoing SW, AVE 2006

CCLM – SAF210, $\Delta s = \pm 5 \text{ W}$
3.3 Surface outgoing SW, AVE 2006
CCLM–SAF210, $\Delta_{s} = \pm 18$ W

Jan.        Apr.

3.3 Surface outgoing SW, AVE 2006, CCLM, SAF $\Delta s = \pm 18$ W
3.3 Surface outgoing SW, AVE 2006, Data-CCLM $\Delta s = \pm 18$ W
3.3 Surface outgoing SW, 2006
Summary

- Annual mean
  - Over land and water significantly lower values (8 W) in the model.

- Monthly means
  - SAF-Data available for all regions and months, although the albedo is not.
  - Difference in SCA in April highest
3. Radiation at the Surface

3.5 Surface down LW, 2006

CCLM: ALWD_S
SAF: SDL (210 and 150)
Satellite and GME
\[ \Delta_s = \pm 10 \text{ W} \]
3.5 Surface down LW
AVE 2006, $\Delta s = \pm 3$ W

CCLM

SAF 210
3.5 Surface down LW, AVE 2006
CCLM – SAF210, $\Delta s = \pm 3$ W
3.5 Surface down LW, AVE 2006
CCLM–SAF210, $\Delta s = \pm 10$ W

Jan.  
Apr.  
Jul.  
Oct.
### 3.5 Surface down LW, AVE 2006, CCLM–SAF

\[ \Delta s = \pm 10 \text{ W} \]
3.5 Surface down LW, 2006
Summary

- Annual means
  - Lower incoming LW radiation in the model in the boundary zone due to reduced cloud cover.

- Monthly means
  - Tendency to higher incoming LW radiation in the model over Scandinavia (10W), especially in the autumn.
3. Radiation at the Surface

3.6 Surface up LW, 2006

CCLM: ALWU_S
SAF: SOL (210 and 150)
GME
\[ \Delta s = \pm 10 \text{ W}, \text{ GME} \]
3.6 Surface up LW,
AVE 2006, $\Delta s = ?? W$

CCLM

SAF 210
3.6 Surface up LW, AVE 2006
CCLM – SAF210, $\Delta s = ?? \text{ W}$
3.6 Surface up LW, AVE 2006
CCLM–SAF210, $\Delta_s = ?? W$

Jan.  
Apr.  
Jul.  
Oct.
3.6 Surface up LW, AVE 2006, CCLM–SAF $\Delta_s = \pm 10$ W

LND

Mean: 351.73
Mean: 350.00
Mean: 352.32

SWE

Mean: 382.74
Mean: 378.90
Mean: 352.90

WAT

Mean: 371.84
Mean: 367.57
Mean: 370.73

SCA

Mean: 327.10
Mean: 339.28
Mean: 318.08
3.6 Surface up LW, AVE 2006, CCLM–SAF $\Delta s = \pm 10$ W

DIFF 205: AREA MEAN LND (19925 POINTS, GRID: GRD010)

DIFF 205: AREA MEAN WAS (21956 POINTS, GRID: GRD010)

DIFF 205: AREA MEAN SWE (2264 POINTS, GRID: GRD010)

DIFF 205: AREA MEAN SCA (3352 POINTS, GRID: GRD010)
- Monthly mean
  - Significantly lower summer temperatures over Scandinavia and central Europe in the CCLM in comparison to GME
Summary:

Suggestions on possible causes of the deviations

1. model deficiencies
   - Boundary conditions inconsistent with cloud conditions in the model
   - Overestimation of CLCT in the model over central to northern Europe of up to 0.5 in May to September
   - Overestimation of the model surface albedo in regions covered by snow
   - Underestimation of deep convection
     – over water surfaces or CMSAF data bias
     – over land or different criteria in model and CMSAF data
   - Overestimation of formation of clouds
   - Cold bias of the model coming from the GME
   - Summer cold bias of GME008 configuration

2. CMSAF data distinctive features:
   - Higher north-south gradient in SIS than in ASOD_S in January
   - Inconsistent land-sea contrast in CMSAF data in CLC and TRS
   - Strong land-sea contrast in SDL

See the report for further details