Assessment of the Sub-Grid Stratiform Cloud Schemes of COSMO Model in Reference to Satellite Data

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14th COSMO General Meeting
MeteoSchweiz, Lugano Switzerland 10-14 September 2012

PRESENTATION OUTLINE

- Motivation.
- The theoretical framework of the sub-grid liquid-ice mixed scheme.
- Test-case choice and Model set-up.
- The comparison with MSG set-up via CineSat software.
- Results for Cloud Cover and Radiation Temperatures.
- Some musings on the effect of turbulent diffusion coefficients
- Conclusions and Assessment.

Motivation

- **COSMO model uses operationally different sub-grid schemes to calculate stratiform clouds.**
  - **Radiation: a semi-empirical scheme based on relative humidity (SGRH).**
    www.clm-community.eu/dokumente/upload/54d9a_Training12_Microphysics_Blahak.pdf
  - **Turbulence: a statistical scheme based on oversaturation and liquid water potential temperature (SGSL).**
    www.clm-community.eu/dokumente/upload/88929_Training12_TurbParam_Raschendorfer.pdf
- **Justify the use of SGSL also in the radiation scheme within the scope of UTCS (Unified Turbulence Closure Scheme) priority project of COSMO consortium.**
  www.cosmo-model.org/content/tasks/priorityProjects/utcs/default.htm
- **The necessity to include cloud-ice into the cloud-cover led to a modification of SGSL to a "mixed" sub-grid statistical liquid-ice scheme (SGSLI) through the introduction of a mixed phase condensation heat via an icing factor.**

Note: SGRH is also denoted as rel_hum and and SGSLI is also denoted as stat_mix_0.5_4.0 scheme

Highlights of the sub-grid liquid-ice mixed scheme

Stratiform Cloud Fraction (*R*) (Sommeria, Deardorff, 1976)

$$R = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} H(q_w - q_s) G\, dq_w\, d\theta_{li} \qquad H(x) = \begin{cases} 0, & x < 0 \\ 1, & x \geq 0 \end{cases}$$

$$G = \frac{1}{2\pi\sigma_{\theta_{li}}\sigma_{q_w}\left(1-r^2\right)^{1/2}} \exp\left[\frac{-1}{1-r^2}\left(\frac{\theta_{li}'^2}{2\sigma_{\theta_{li}}^2} - r\frac{\theta_{li}' q_w'}{\sigma_{\theta_{li}}\sigma_{q_w}} + \frac{q_w'^2}{2\sigma_{q_w}^2}\right)\right]$$

$$\theta_{li}' \equiv \theta_{li} - \overline{\theta}_{li} \qquad r = \overline{\theta_{li}' q_w'} \Big/ \left(\sigma_{\theta_{li}}\sigma_{q_w}\right) \qquad q_w' = q_w - \overline{q}_w$$

$$\theta_{li} = \theta - \frac{\theta}{T}\frac{L_c}{c_{p_d}} q_c, \text{ total "water - ice" potential temperature}$$

$$\underbrace{q_w}_{\textit{total}\ \text{water}} = \underbrace{q_v}_{\textit{vapour}} + \underbrace{q_l}_{\text{liquid}} + \underbrace{q_i}_{\textit{ice}}, \quad q_c = q_l + q_i$$

$$L_c := (1 - r_i) L_l + r_i L_i, \text{ "mixed phase" condensation heat}$$

$$r_i := \frac{q_i}{q_c}, \text{ icing factor}$$

- A first order approximation for q_s is assumed in reference to $\bar{q}_s$ and by using Clausius-Clapeyron equation cloud fraction R is given by

$$R = \frac{1}{2}\left[1 + erf\left(\frac{Q}{\sqrt{2}}\right)\right] \qquad Q = \frac{\bar{q}_w - \bar{q}_s}{\sigma} \qquad \sigma = \left(\overline{q_w^2} + \overline{q_s^2} - 2\overline{q_w q_s}\right)^{\frac{1}{2}}$$

- Sommeria και Deardorff (1977) further approximated R empirically :

$$R \approx \frac{1}{2}\left(1 + \frac{Q}{1.6}\right), 0 \le R \le 1$$

- In analogy, a SubGgrid Statistical (SGS) cloud scheme is implemented to COSMO model (Raschendorfer) where the stratiform cloud cover is approximated by a two-parameter relation:

$$R \approx A\left(1 + \frac{Q}{B}\right), 0 \le R \le 1$$

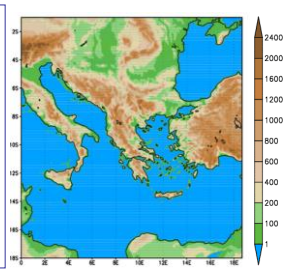
- Parameter *A* refers to cloud cover at saturation and *B* refers to critical value of oversaturation. The default values of these parameters are set **0.5** and **4.0** respectively.

Test Case Choices

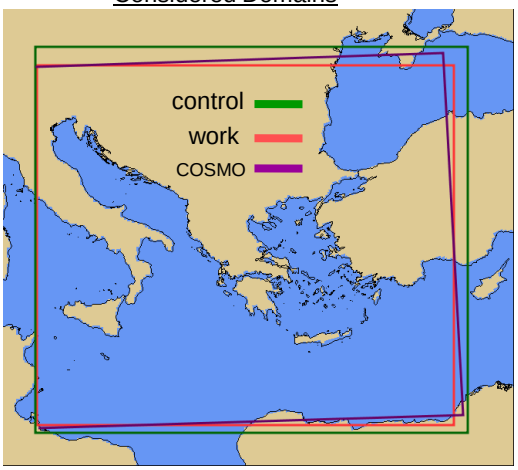
- Relatively weak synoptic conditions that favor the formulation of low and medium clouds over a wide area of Central-Eastern Mediterranean centered around Greece.
- Choice of relatively recent dates for Spring (1), Autumn (2) and Winter (1) of 2011.

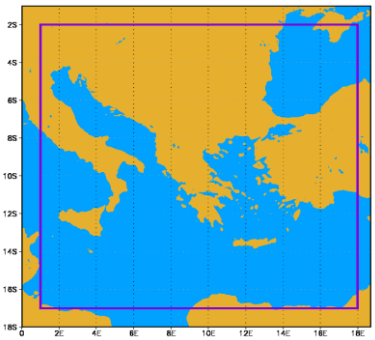
Model Set-up

- COSMO_4.6 (Modified by M.R)
- Horizontal grid 0.0625^0 (~7 Km) 273x273 points
- 40 vertical levels
- Integration time step: 30 sec
- GME (Analysis mode 0.5^0) 3hr intervals
- IBM HPC Cluster 1600 (P4+)



Considered Domains



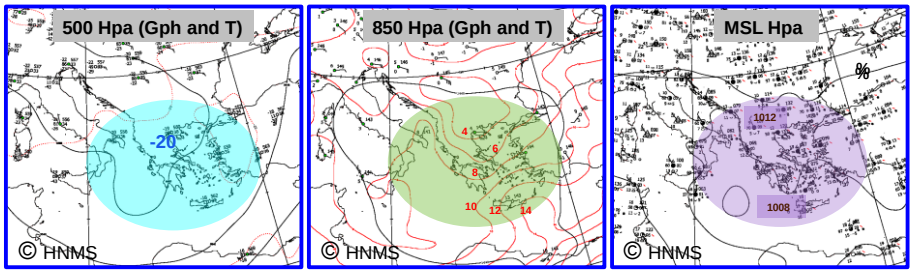


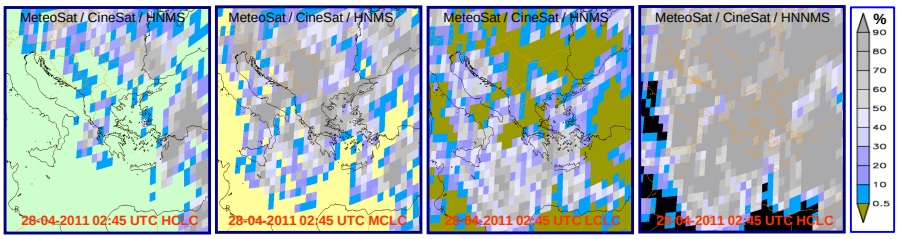
•The average MSG satellite values were derived from “work” domain using CineSat software.

•The average COSMO values were derived from “COSMO” domain.

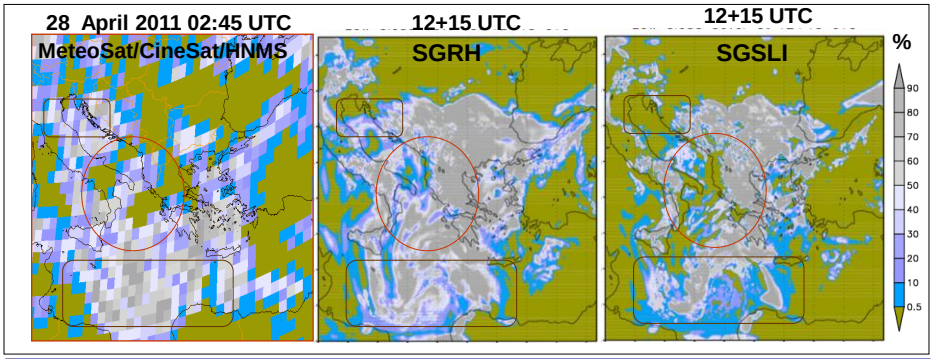
•The (one-sided) “error” was estimated from “control” domain. It should be mentioned that the error favored colder brightness temperatures up to 1.0 Kelvin for channels 3.9μm, 8.7 μm and 10.8 μm degrees Kelvin and 0.5 Kelvin for channels 6.2 μm and 7.3 μm that’s why it is one-sided.

28 April 2011 00 UTC



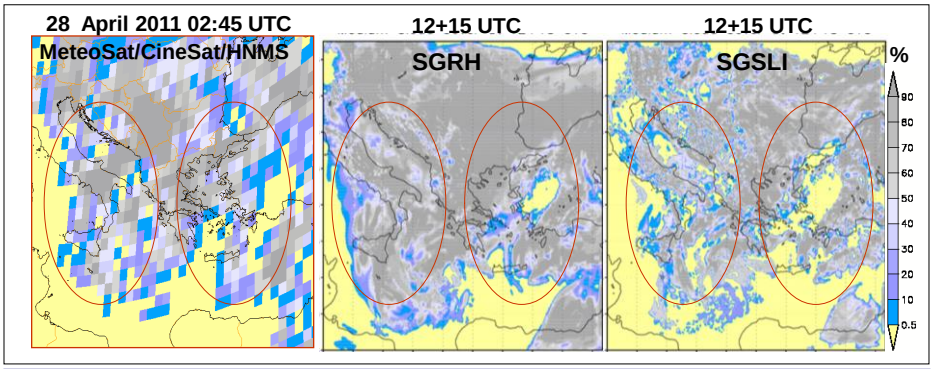


Low Cloud Cover



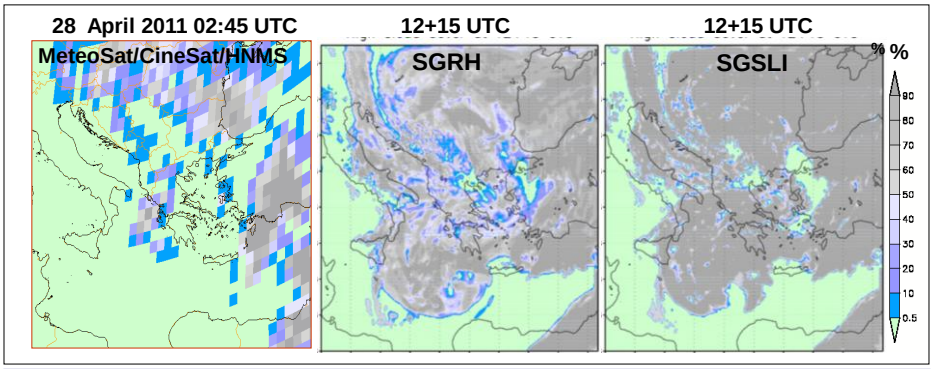
- SGSLI scheme shows a relative preponderance over the default SGRH scheme in the encircled area while in the rectangular areas the situation is reversed.
- SGSLI scheme provides a better tendency to resolve the cloudiness in contrast to the cloud structure of the SGRH scheme which has the tendency to remain more compact. The feature is similar to Medium Cloud Cover.

Medium Cloud Cover



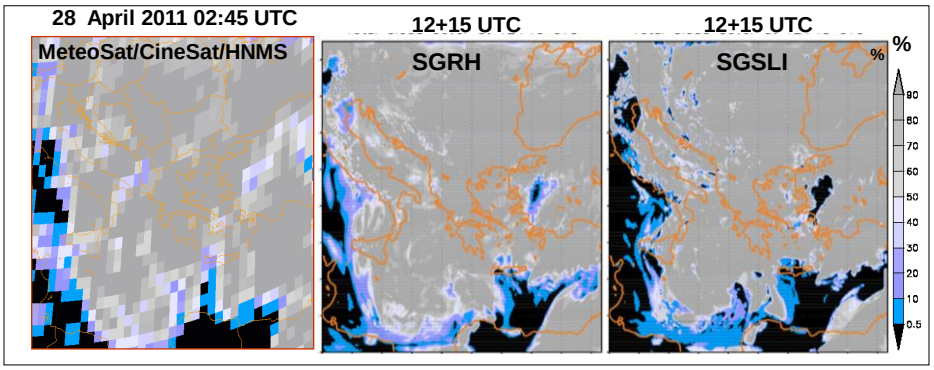
- SGSLI scheme shows an overall preponderance over the default SGRH scheme in reference to the satellite image, especially in the encircled areas.
- Similarly to LCC, we note that in reference to the satellite picture, the mixed-phase scheme provides a better tendency to resolve the cloudiness, while the cloud structure of the relative humidity scheme has the tendency to remain more compact.

High Cloud Cover



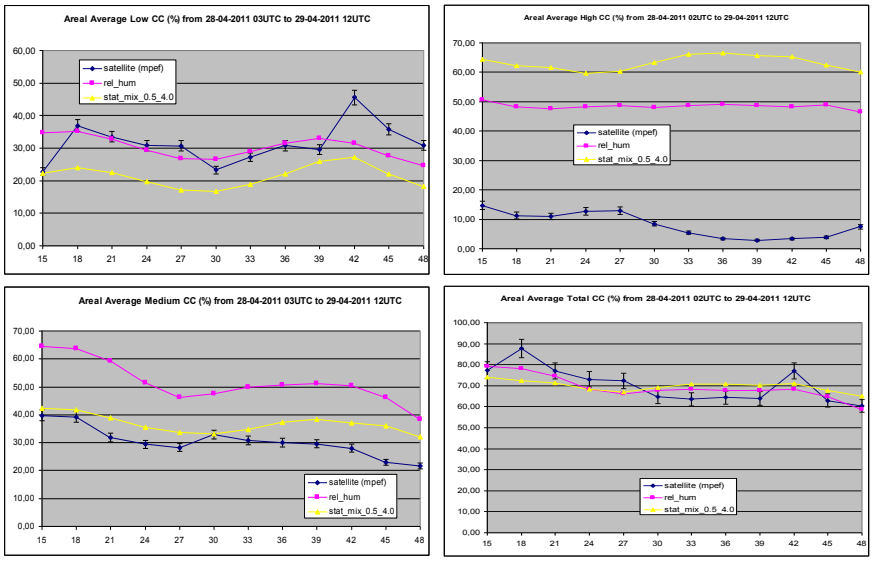
- Both cloud schemes overestimate HCC, especially over the West/South-West parts, addressing the issue of proper accounting of cloud-ice content.
- In contrast to LCC and MCC, the SGRH scheme provides a better tendency to resolve the cloudiness, while the cloud structure of the SGSLI scheme has the tendency to remain more compact.

Total Cloud Cover

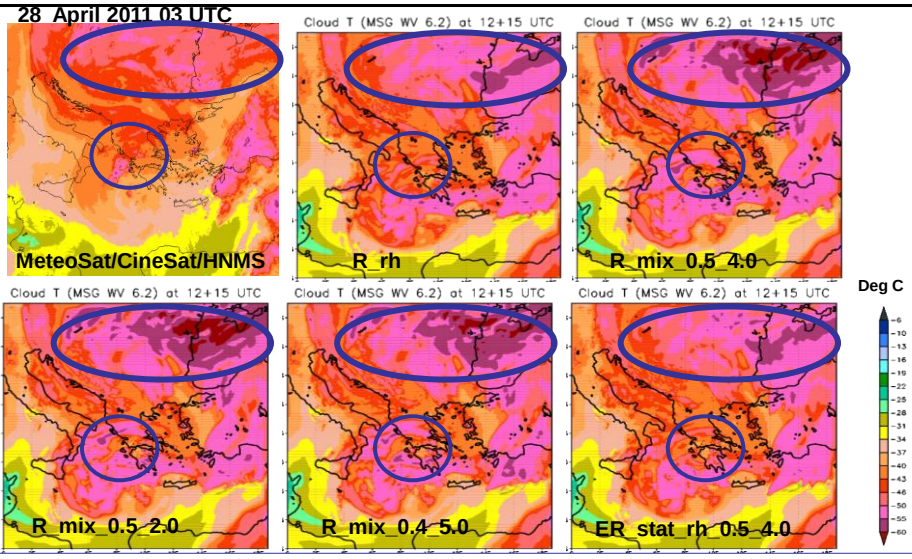


Both cloud schemes are in very good agreement with each other as well as with MSG picture. This feature demonstrates that the relative differences in Low, Middle and High cloud-cover layers between the two schemes are converging towards very similar Total Cloud Cover.

Average Low, Medium, High and Total Cloud Cover from 28-04-2011 03 UTC to 29-04-2011 12 UTC

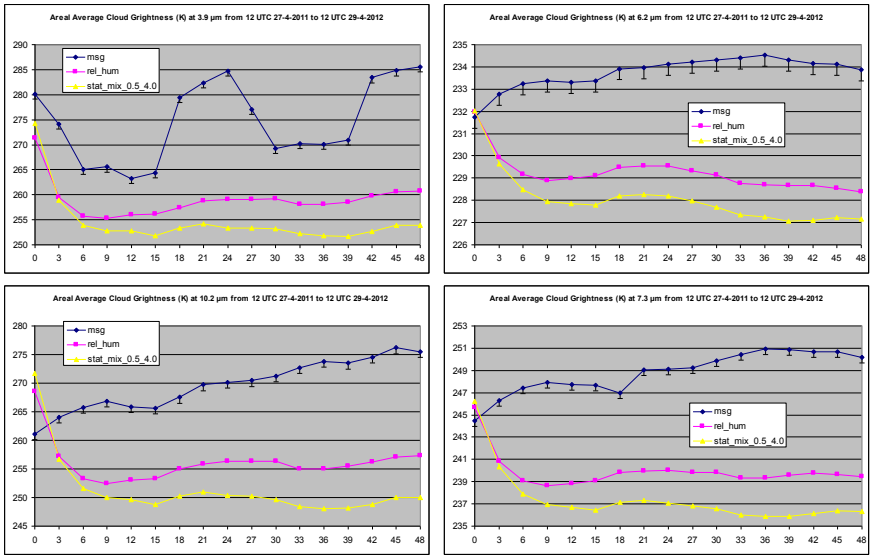


28 April 2011 03 UTC

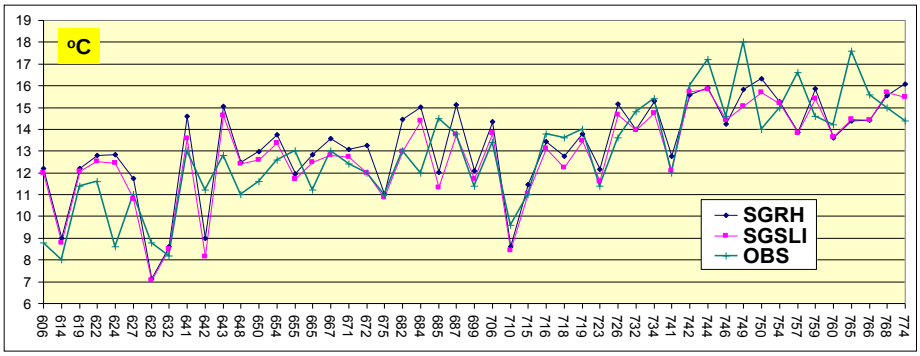


Comparison of cloud radiation temperatures (CRTs) of artificial satellite images at the water-vapor Channel at 6.2 microns against Meteosat satellite image (upper right) manipulated with Synesat software available at HNMS. The general trend (especially in the encircled areas) is that model CRTs for the mixed-phase scheme (R_mix_0.5_4.0, R_mix_0.5_2.0 and R_mix_0.4_5.0) are overall lower to those of the default relative humidity scheme (R_rh) in reference to Meteosat satellite picture (Meteosat/synesat). However, it looks that this difference is mainly due to the treatment of cloud ice by the mixed-phase scheme as it can be infered by a "control" test were the relative-humidity and the statistical scheme are mixed (ER_stat_rh_0.5_4.0).

Average Cloud Brightness Temperature at 3.9, 6.2, 7.3 and 10.8 microns from 27-04-2011 12 UTC to 29-04-2011 12 UTC



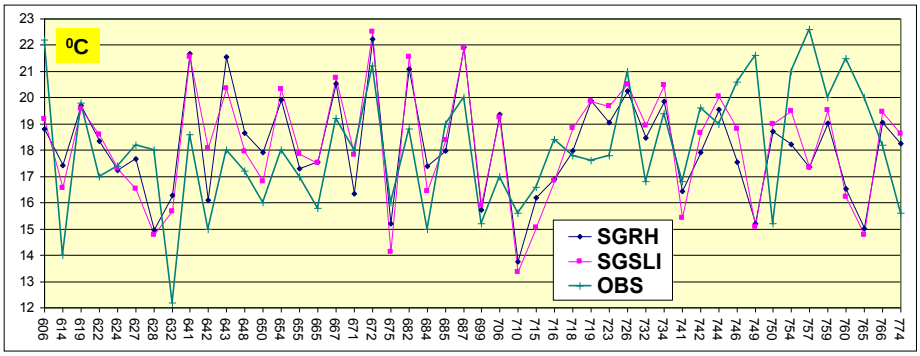
28-April-2011 T2m_min



Station #

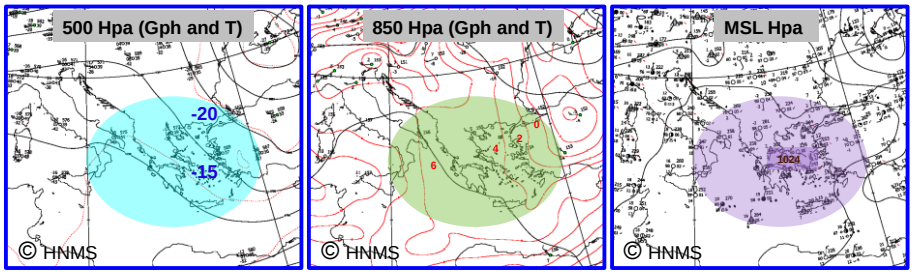
The vast majority of values from the SGSLI scheme are relatively closer to observations than the corresponding values of the SGRH scheme.

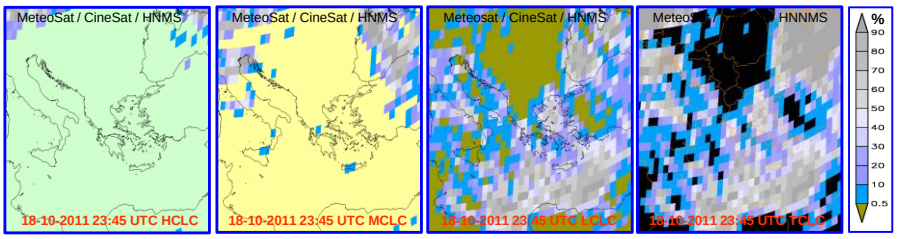
28-April-2011 T2m_max

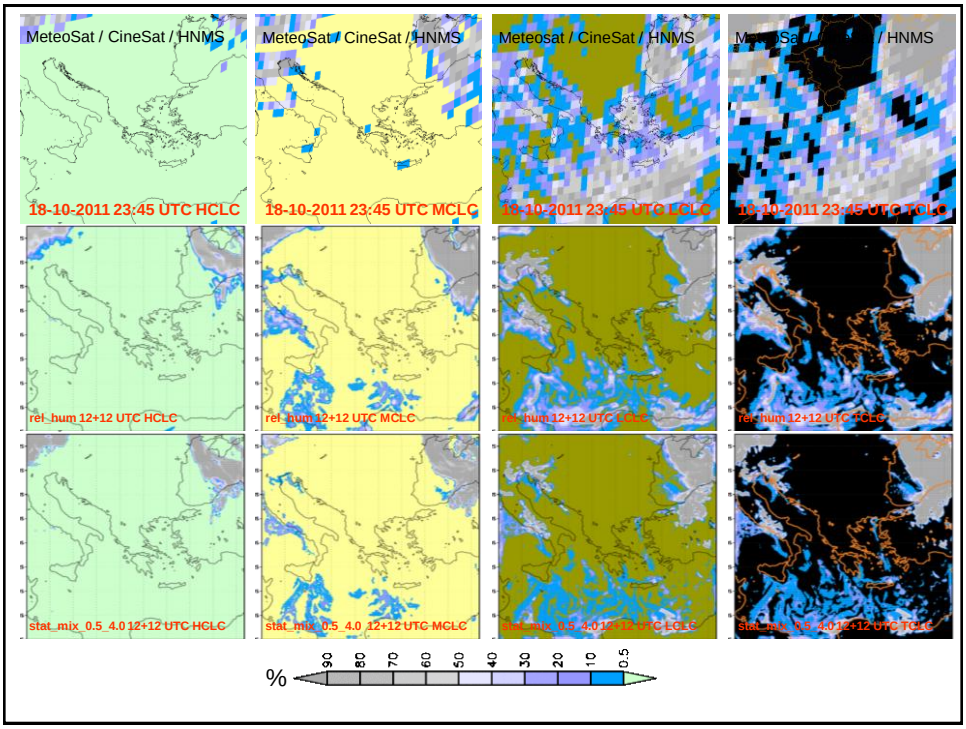


The values for the maximum daily 2-meter temperatures from the implementation of the default SGRH scheme in COSMO model are relatively closer to observations than the analogous values of the SGSLI scheme 2011, however the trend is more balanced towards both schemes than T2m_min.

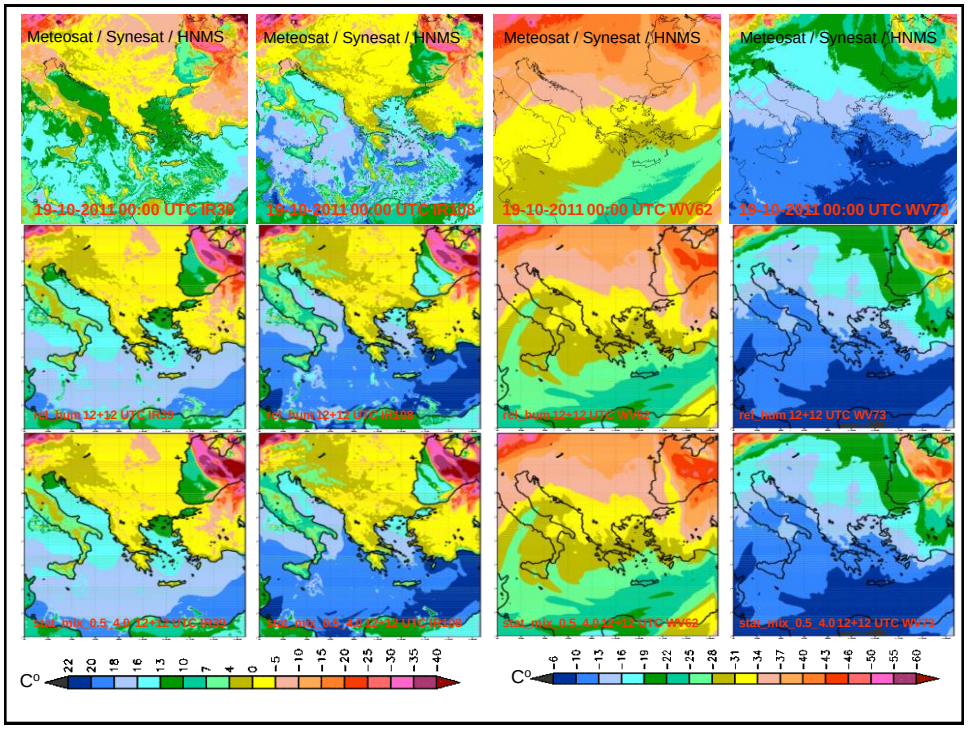
19 Oct 2011 00 UTC



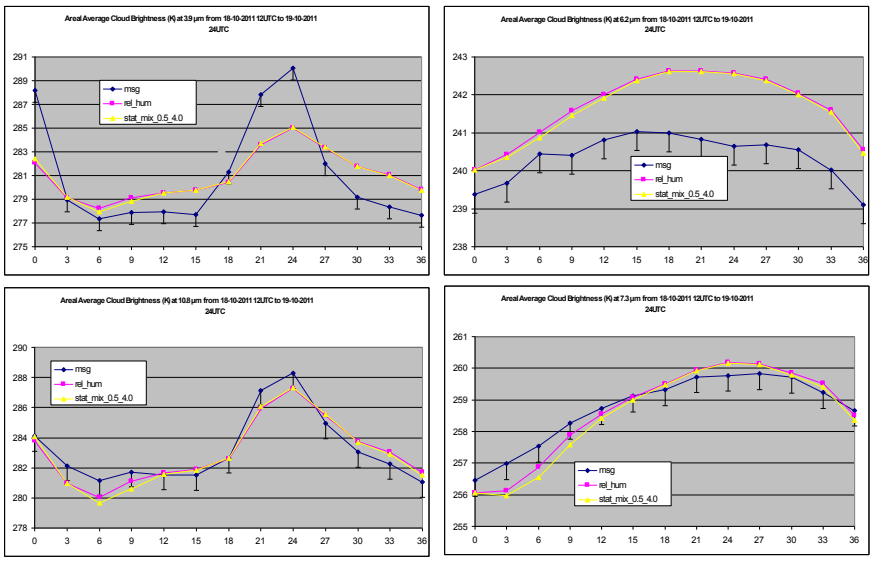




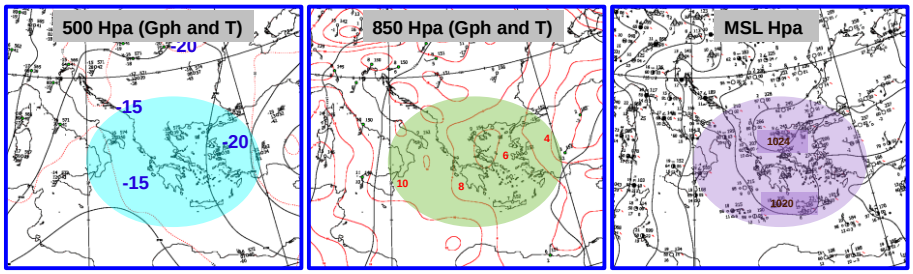
Average Low, Medium, High and Total Cloud Cover from 18-10-2011 12 UTC to 19-10-2011 24 UTC

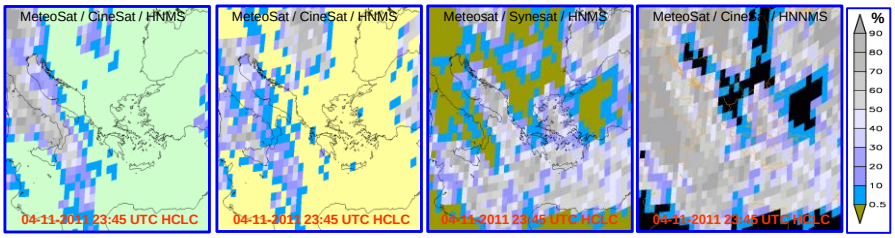


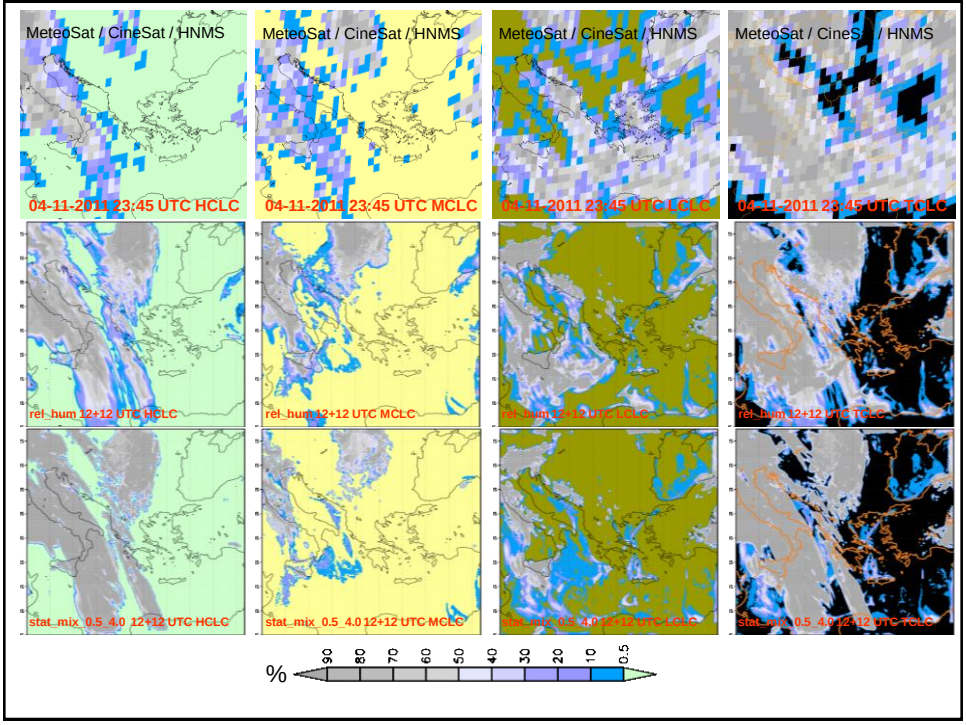
Average Cloud Brightness Temperature at 3.9, 6.2, 7.3 and 10.8 microns from 18-10-2011 12 UTC to 19-10-2011 24 UTC



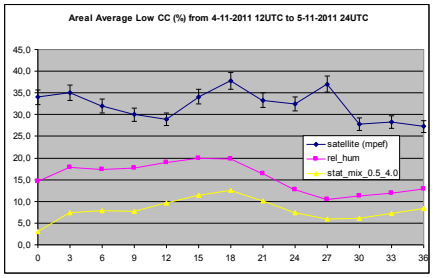
5 Nov 2011 00 UTC

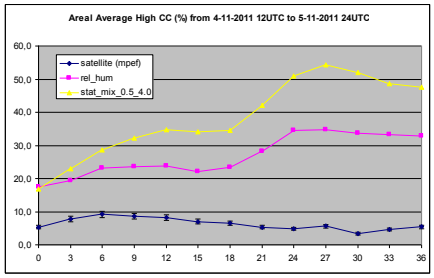


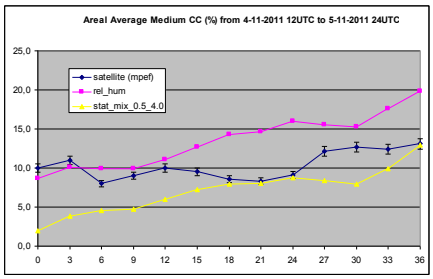


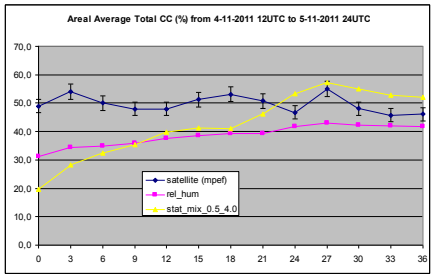


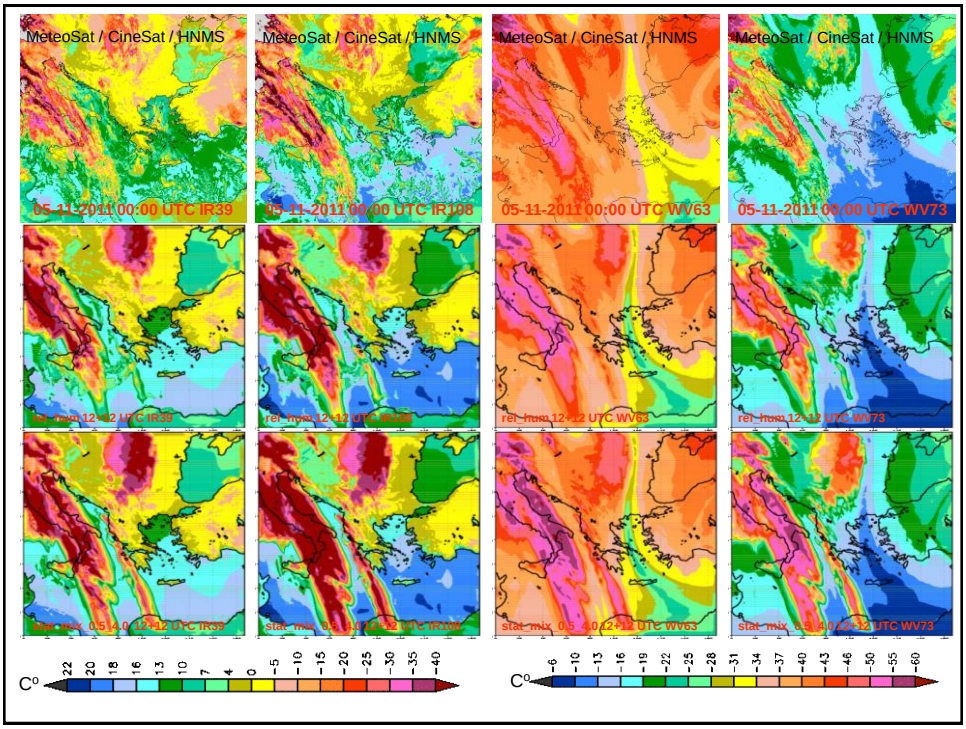
Average Low, Medium, High and Total Cloud Cover from 04-11-2011 12 UTC to 05-11-2011 24 UTC



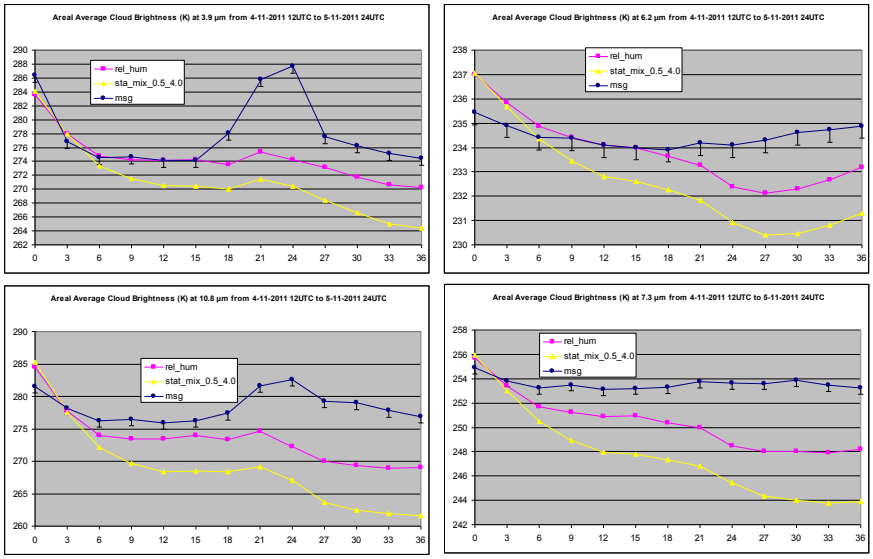




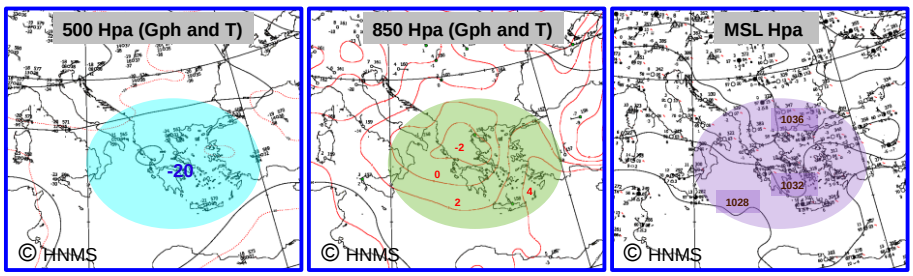


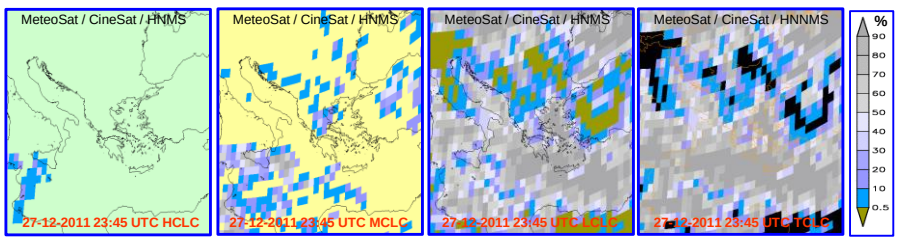


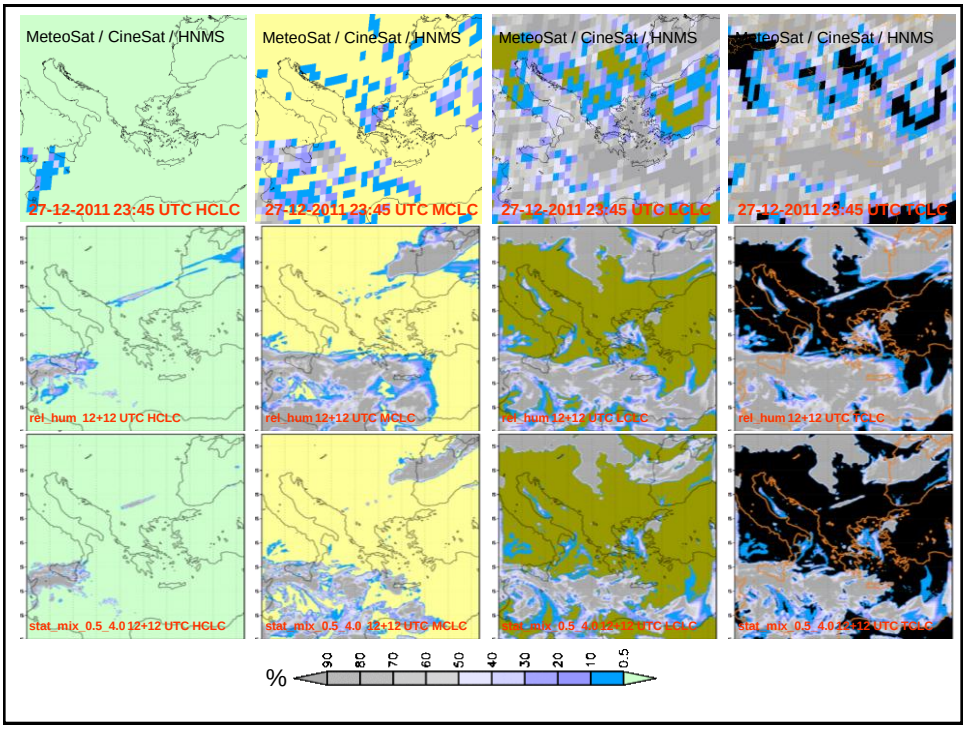
Average Cloud Brightness Temperature at 3.9, 6.2, 7.3 and 10.8 microns from 04-11-2011 12 UTC to 05-11-2011 12 UTC



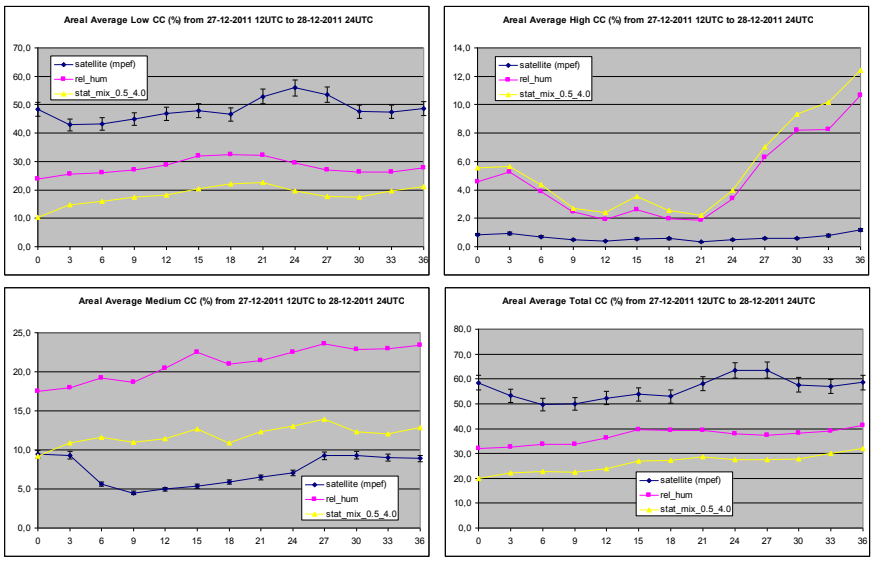
28 Dec 2011 00 UTC

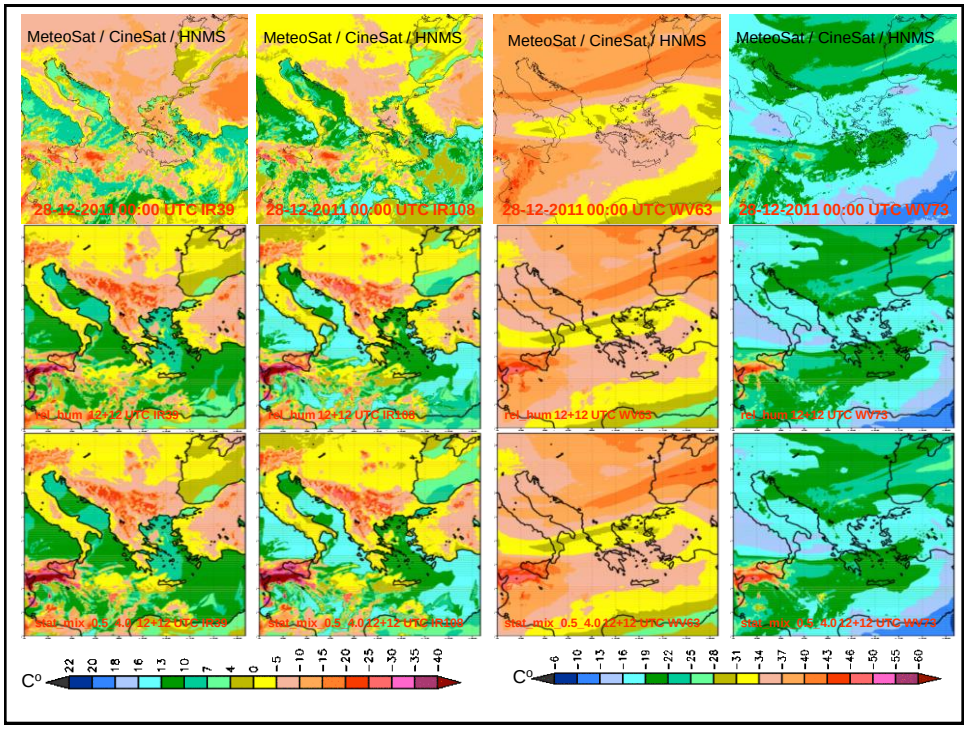




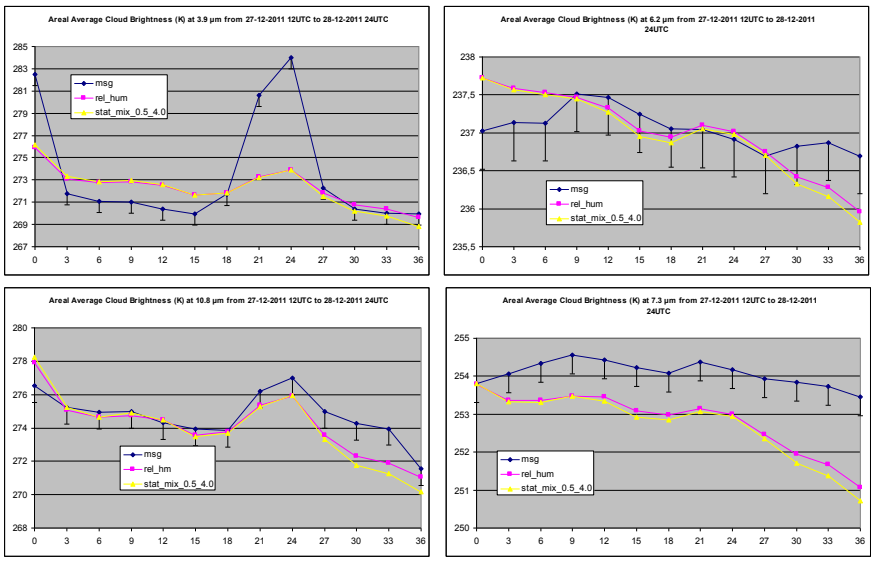


Average Low, Medium, High and Total Cloud Cover from 27-12-2011 12 UTC to 28-12-2011 24 UTC

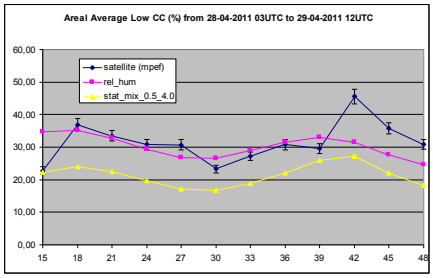


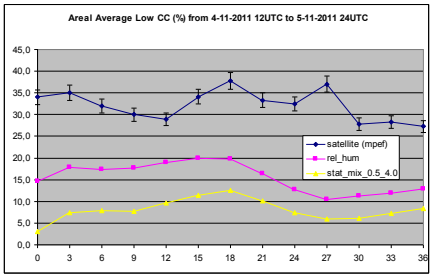


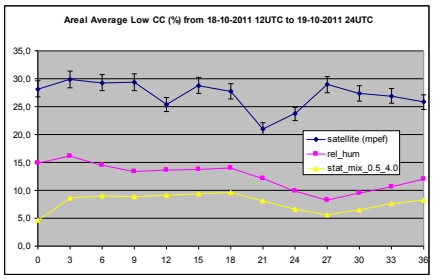
Average Cloud Brightness Temperature at 3.9, 6.2, 7.3 and 10.8 microns from 27-12-2011 12 UTC to 28-12-2011 24 UTC

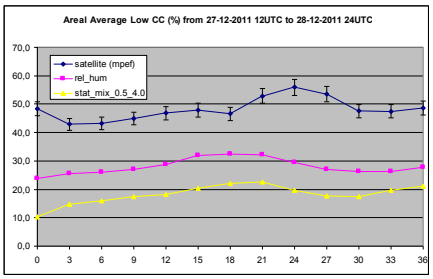


Average Low Cloud Cover for all Test Cases

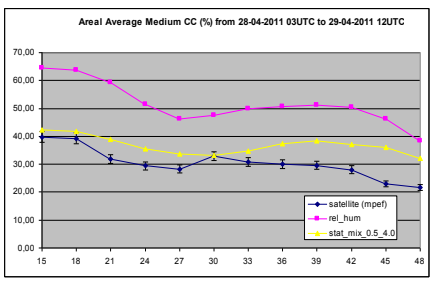


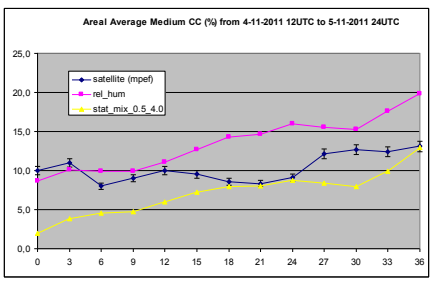


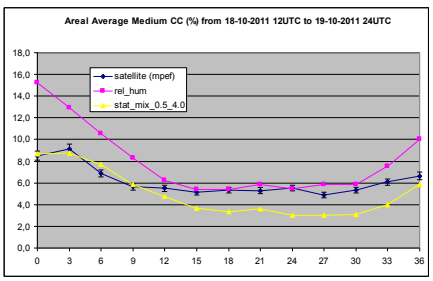


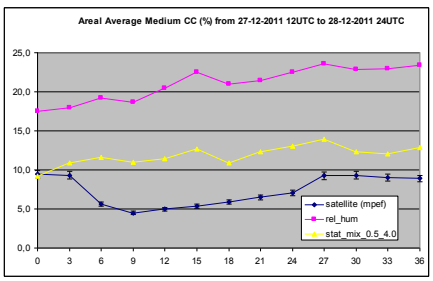


Average Medium Cloud Cover for all Test Cases

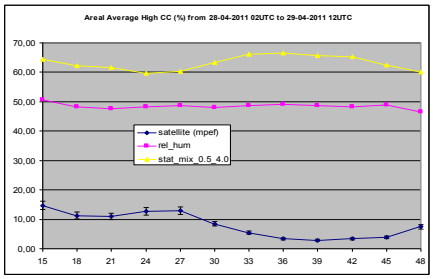


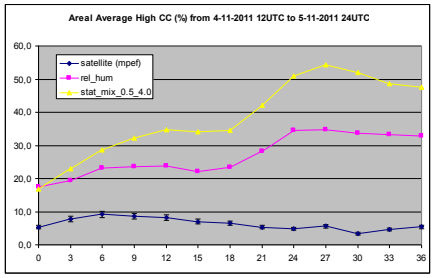


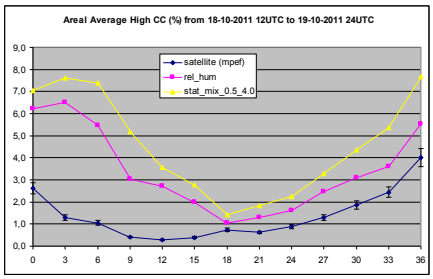


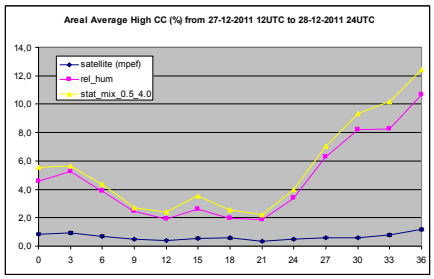


Average High Cloud Cover for all Test Cases

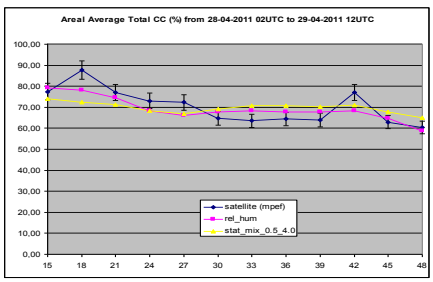


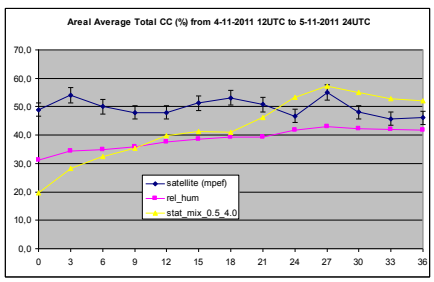


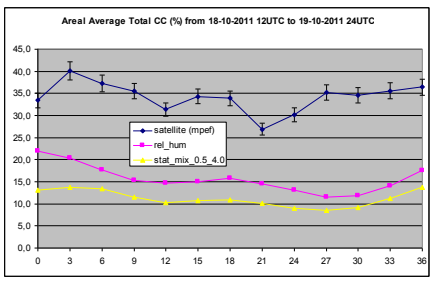


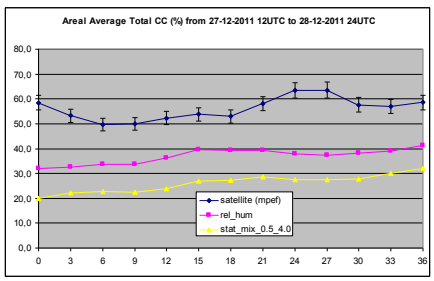


Average Total Cloud Cover for all Test Cases

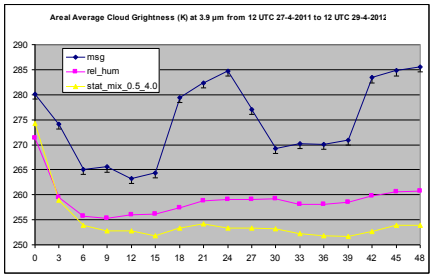


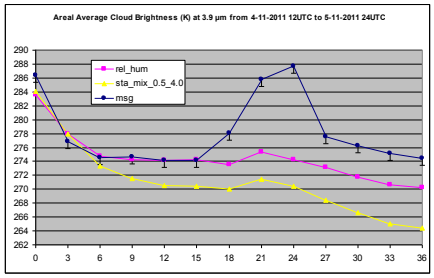


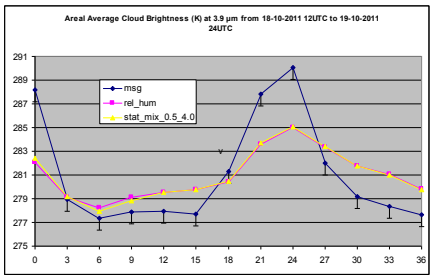


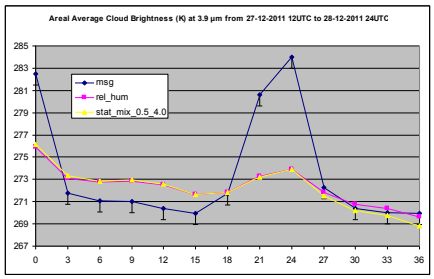


Average Cloud Brightness Temperature at 3.9 microns for all Test Cases

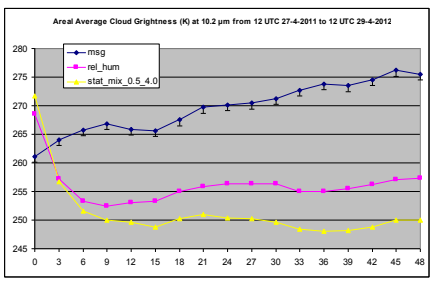


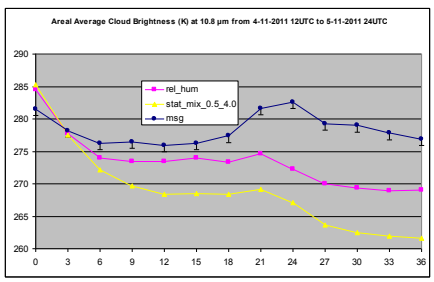


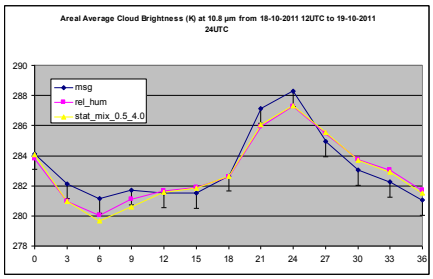


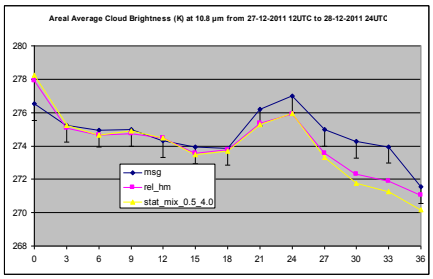


Average Cloud Brightness Temperature at 10.2 microns for all Test Cases

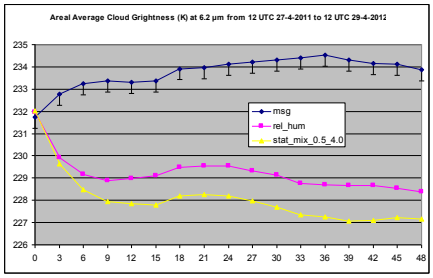


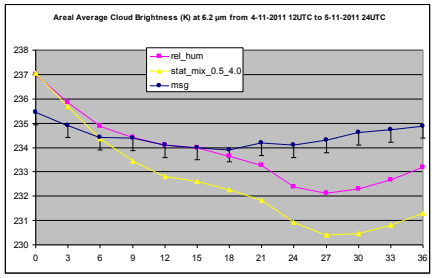


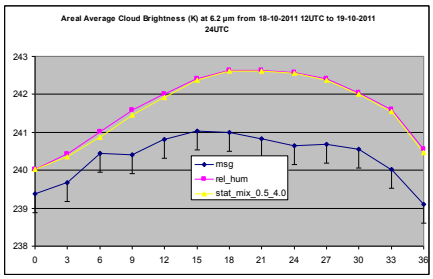


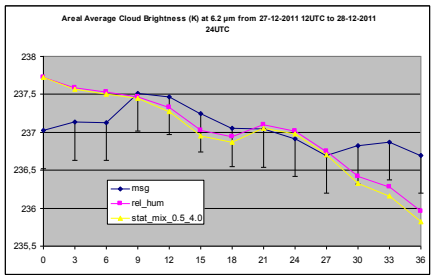


Average Cloud Brightness Temperature at 6.2 microns for all Test Cases

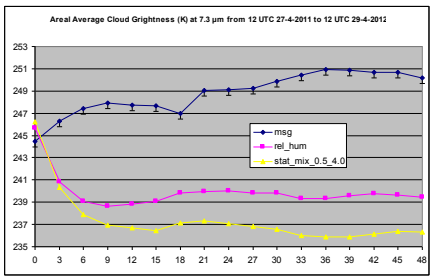


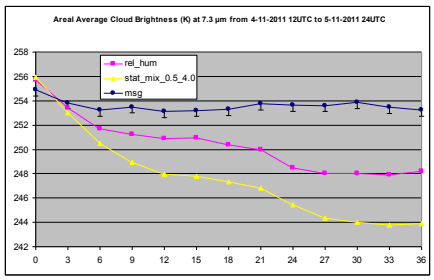


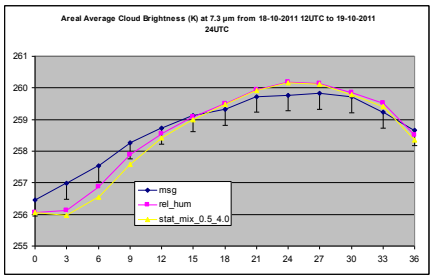


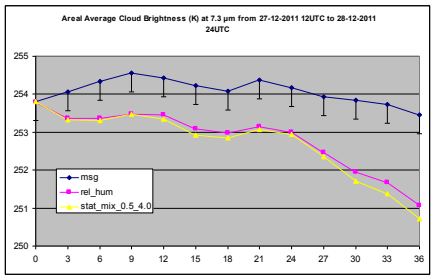


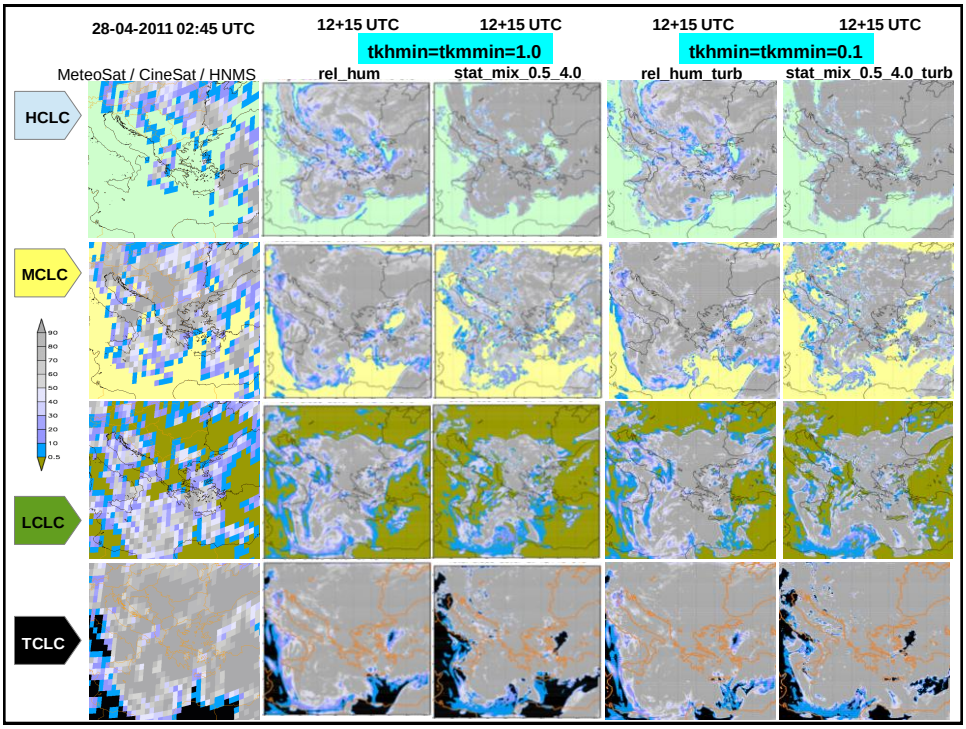
Average Cloud Brightness Temperature at 7.3 microns for all Test Cases

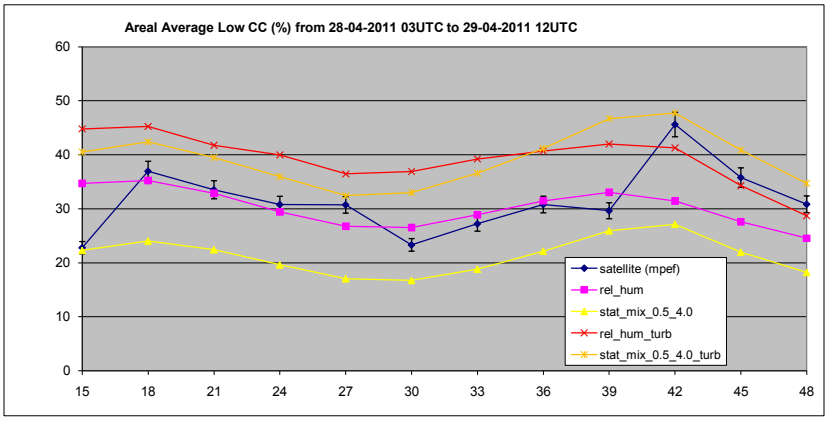


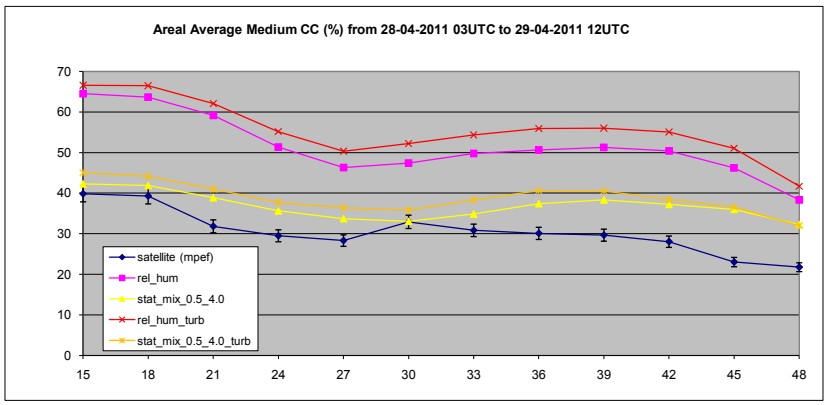


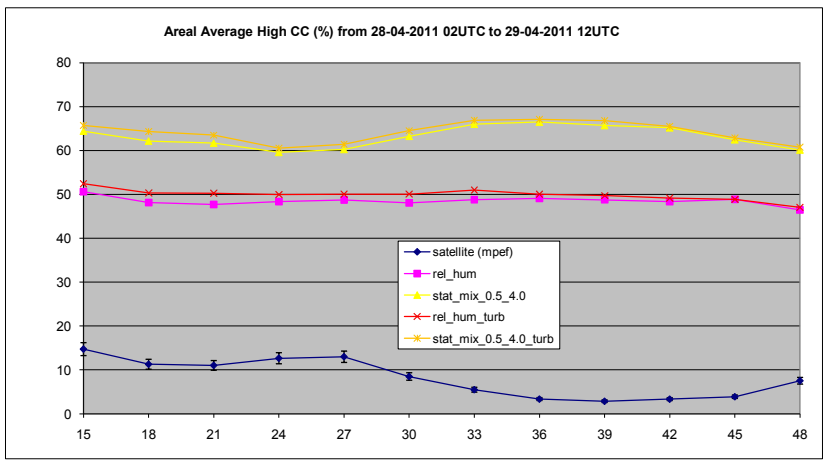


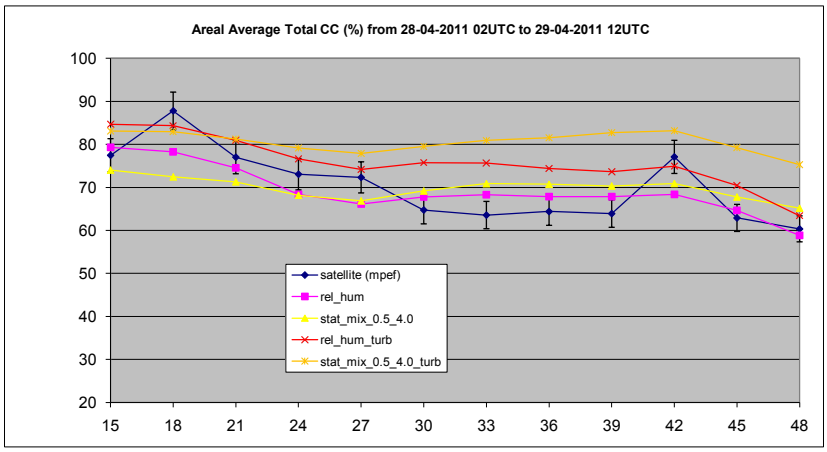


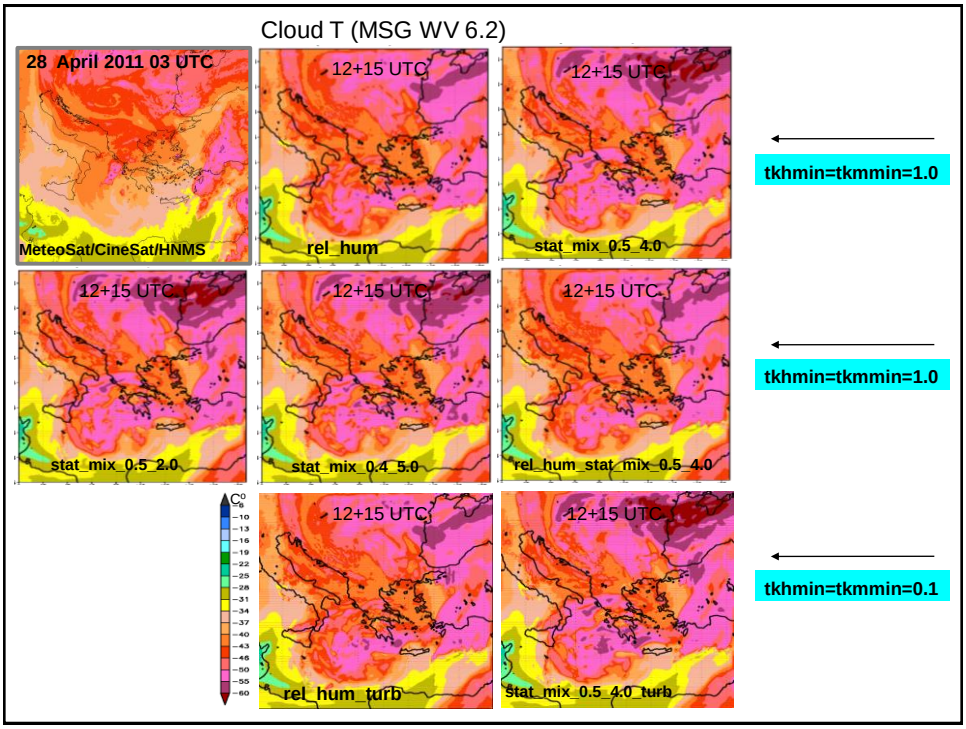

28-04-2011 02:45 UTC
MeteoSat / CineSat / HNMS
12+15 UTC
12+15 UTC
tkhmin=tkmmin=1.0
rel_hum
stat_mix_0.5_4.0
12+15 UTC
12+15 UTC
tkhmin=tkmmin=0.1
rel_hum_turb
stat_mix_0.5_4.0_turb
HCLC
MCLC
LCLC
TCLC
90
80
70
60
50
40
30
20
10
0.5

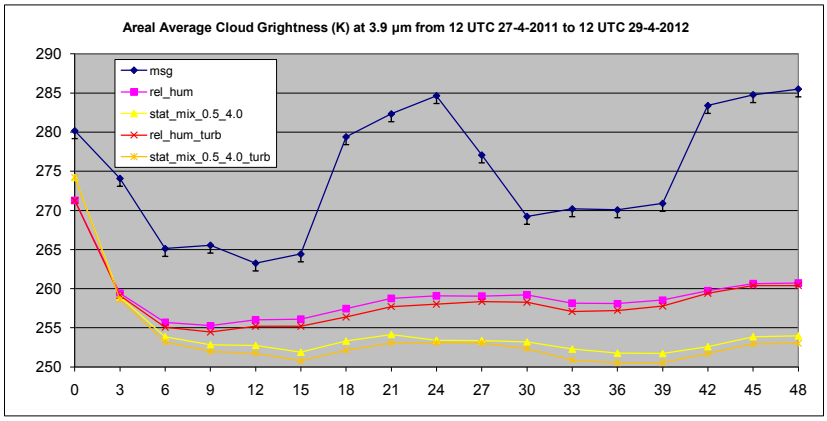

Areal Average Low CC (%) from 28-04-2011 03UTC to 29-04-2011 12UTC
60
50
40
30
20
10
0
15
18
21
24
27
30
33
36
39
42
45
48
satellite (mpef)
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb

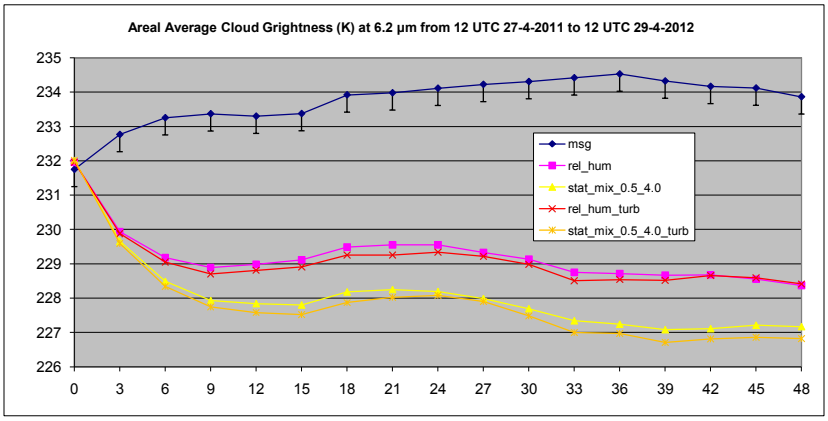

Areal Average Medium CC (%) from 28-04-2011 03UTC to 29-04-2011 12UTC
70
60
50
40
30
20
10
0
15
18
21
24
27
30
33
36
39
42
45
48
satellite (mpef)
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb

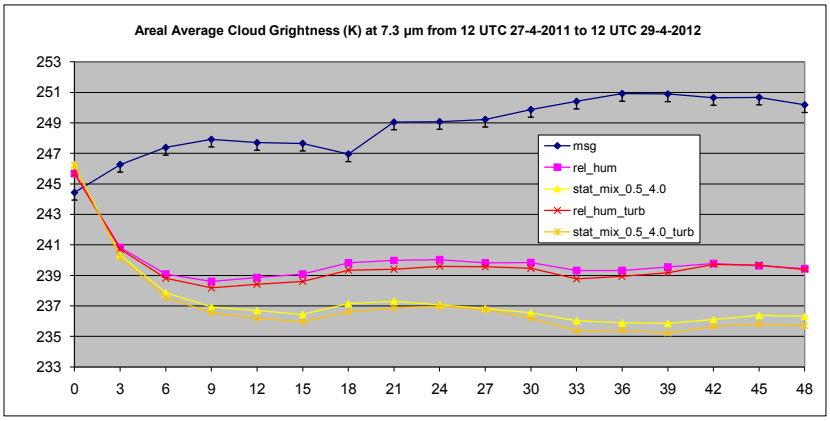

Areal Average High CC (%) from 28-04-2011 02UTC to 29-04-2011 12UTC
80
70
60
50
40
30
20
10
0
15
18
21
24
27
30
33
36
39
42
45
48
satellite (mpef)
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb

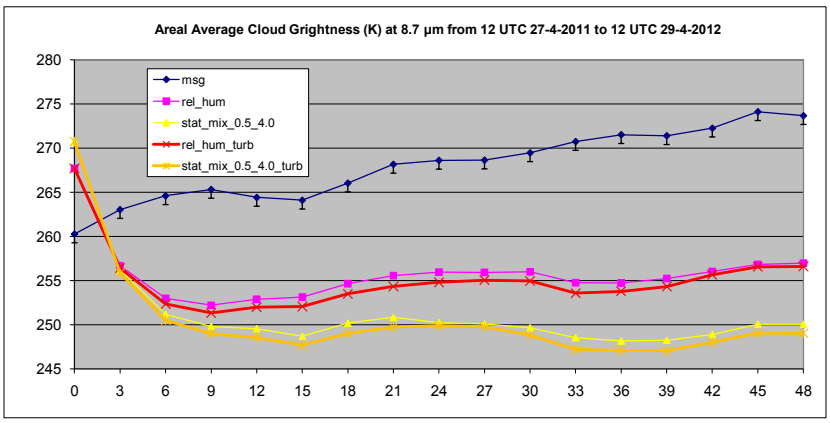

Areal Average Total CC (%) from 28-04-2011 02UTC to 29-04-2011 12UTC
100
90
80
70
60
50
40
30
20
15
18
21
24
27
30
33
36
39
42
45
48
satellite (mpef)
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb

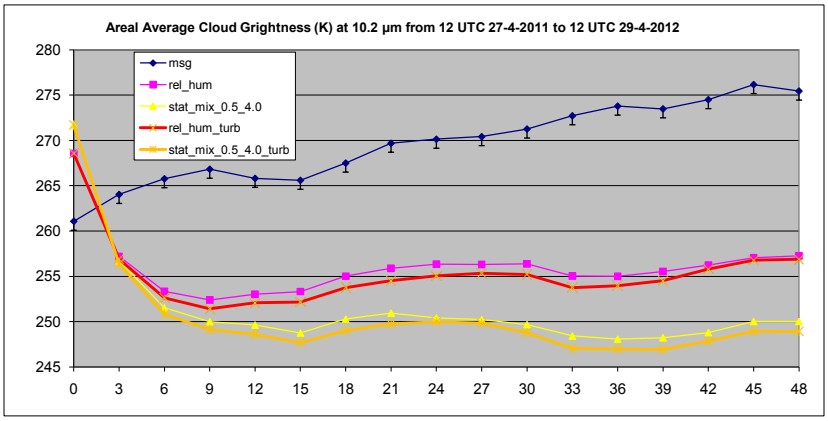

Cloud T (MSG WV 6.2)
28 April 2011 03 UTC
MeteoSat/CineSat/HNMS
12+15 UTC
rel_hum
12+15 UTC
stat_mix_0.5_4.0
tkhmin=tkmmin=1.0
12+15 UTC
stat_mix_0.5_2.0
12+15 UTC
stat_mix_0.4_5.0
12+15 UTC
rel_hum_stat_mix_0.5_4.0
tkhmin=tkmmin=1.0
12+15 UTC
rel_hum_turb
12+15 UTC
stat_mix_0.5_4.0_turb
tkhmin=tkmmin=0.1

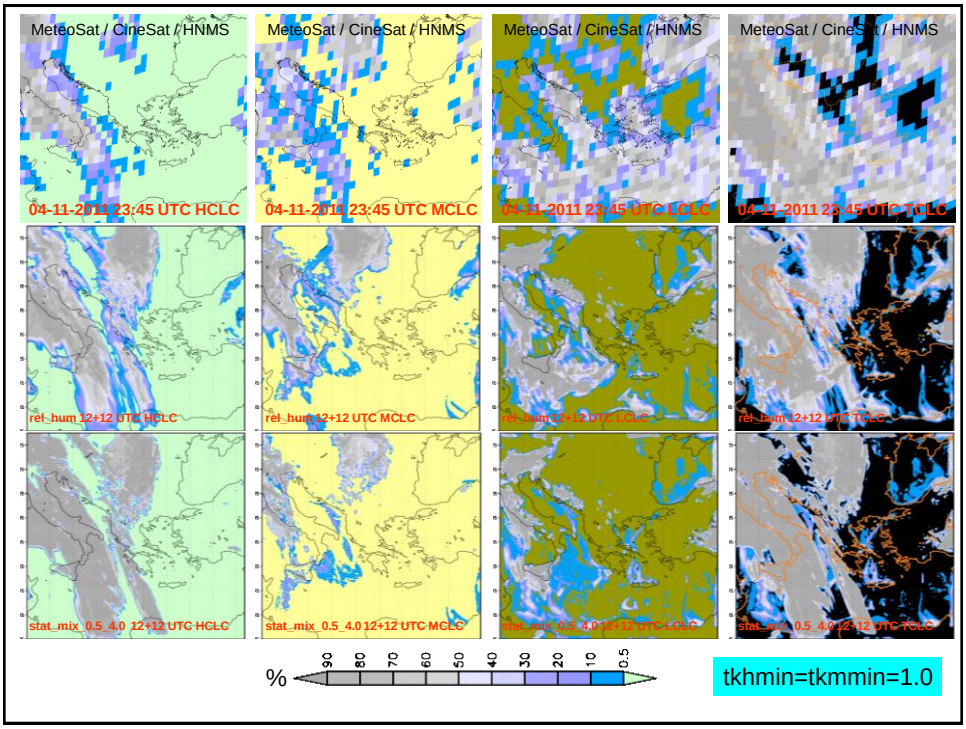

Areal Average Cloud Grightness (K) at 3.9 µm from 12 UTC 27-4-2011 to 12 UTC 29-4-2012
290
285
280
275
270
265
260
255
250
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
msg
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb

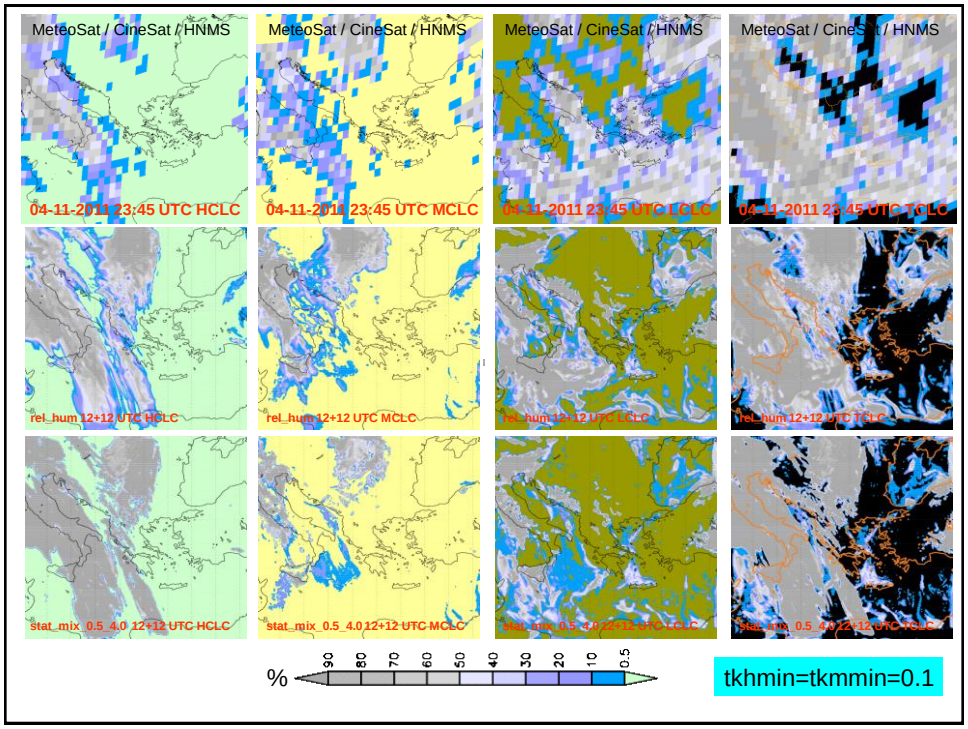

Areal Average Cloud Grightness (K) at 6.2 µm from 12 UTC 27-4-2011 to 12 UTC 29-4-2012
235
234
233
232
231
230
229
228
227
226
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
msg
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb

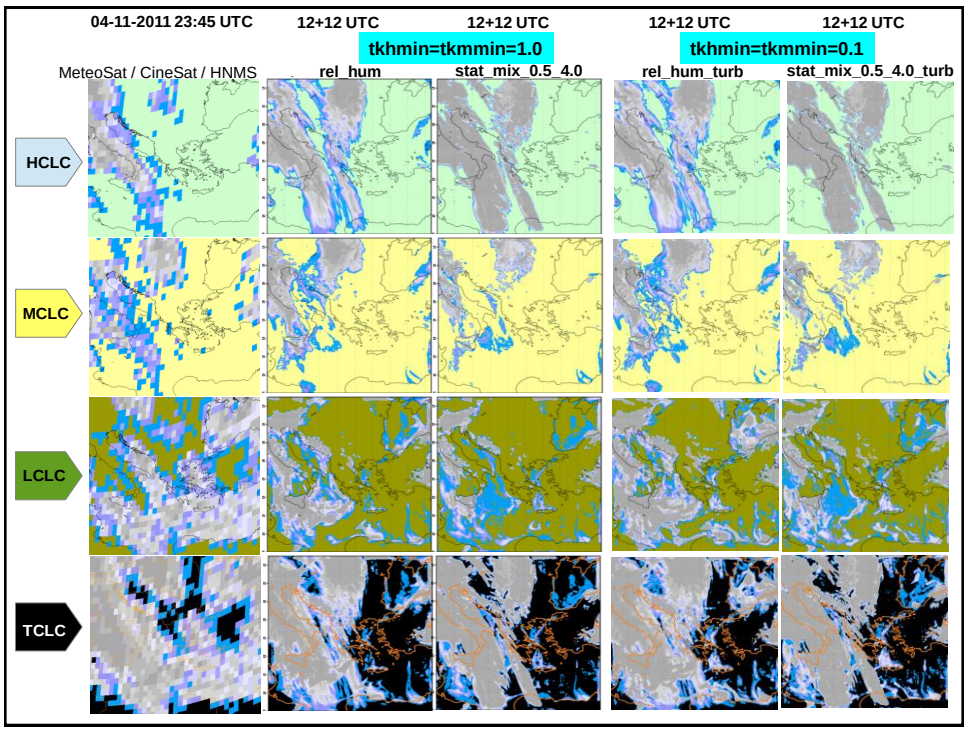

Areal Average Cloud Grightness (K) at 7.3 µm from 12 UTC 27-4-2011 to 12 UTC 29-4-2012
253
251
249
247
245
243
241
239
237
235
233
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
msg
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb

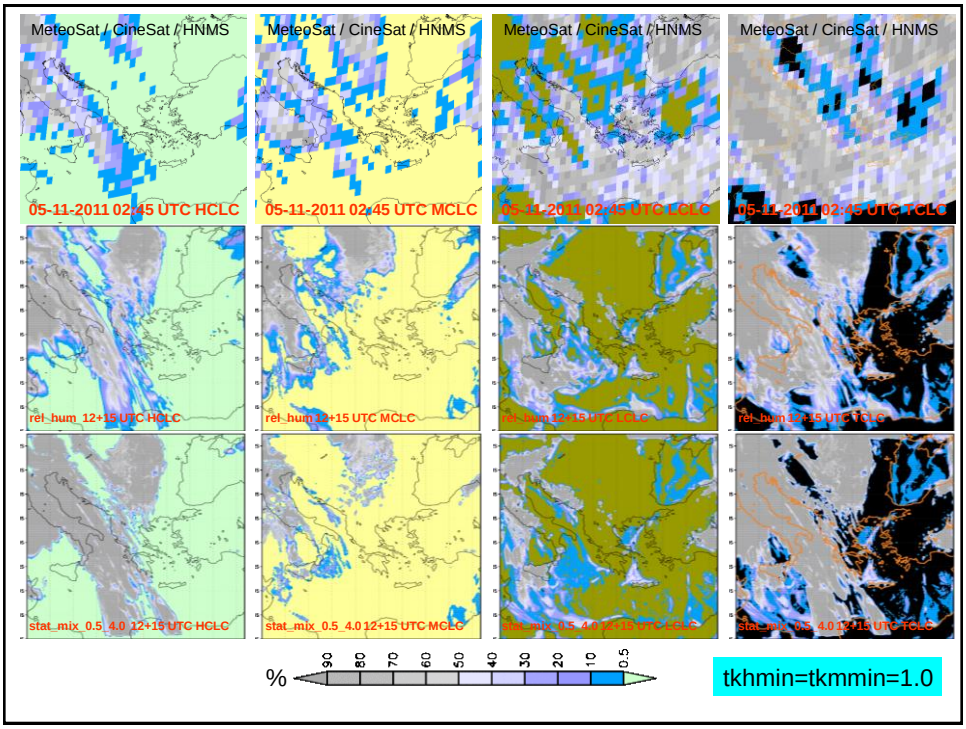

Areal Average Cloud Grightness (K) at 8.7 µm from 12 UTC 27-4-2011 to 12 UTC 29-4-2012
280
275
270
265
260
255
250
245
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
msg
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb

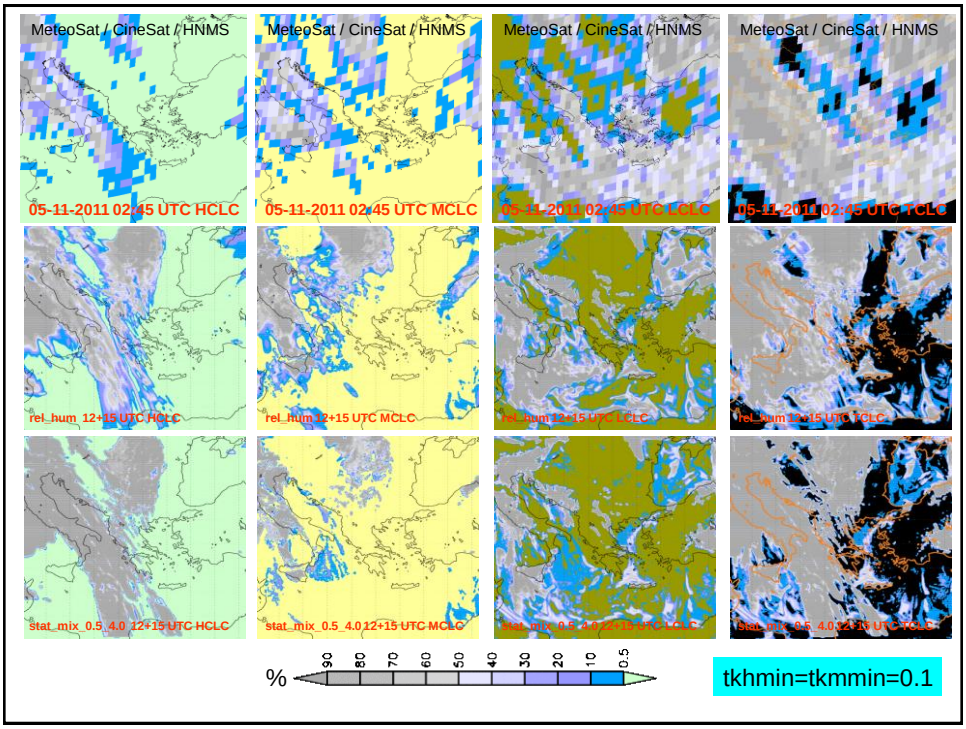

Areal Average Cloud Grightness (K) at 10.2 µm from 12 UTC 27-4-2011 to 12 UTC 29-4-2012
msg
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb
280
275
270
265
260
255
250
245
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48

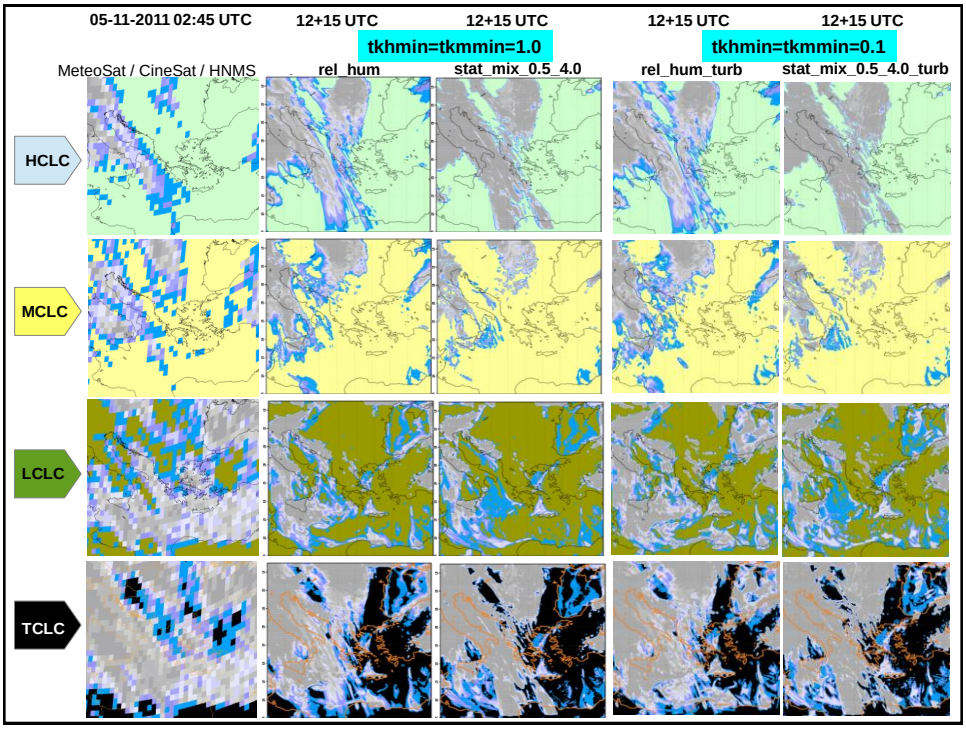

MeteoSat / CineSat / HNMS
04-11-2011 23:45 UTC HCLC
MeteoSat / CineSat / HNMS
04-11-2011 23:45 UTC MCLC
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
rel_hum 12+12 UTC HCLC
rel_hum 12+12 UTC MCLC
stat_mix_0.5_4.0 12+12 UTC HCLC
stat_mix_0.5_4.0 12+12 UTC MCLC
%
90
80
70
60
50
40
30
20
10
0.5
tkhmin=tkmmin=1.0

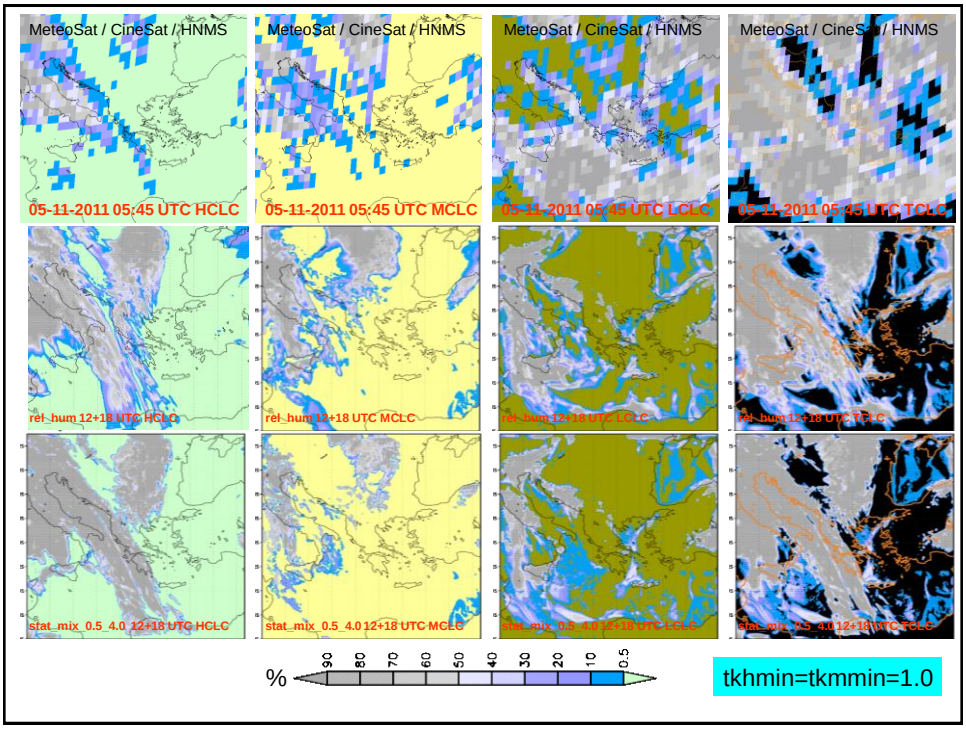

MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
04-11-2011 23:45 UTC HCLC
04-11-2011 23:45 UTC MCLC
04-11-2011 23:45 UTC LCLC
04-11-2011 23:45 UTC TCLC
rel_hum 12+12 UTC HCLC
rel_hum 12+12 UTC MCLC
rel_hum 12+12 UTC LCLC
rel_hum 12+12 UTC TCLC
stat_mix_0.5_4.0 12+12 UTC HCLC
stat_mix_0.5_4.0 12+12 UTC MCLC
stat_mix_0.5_4.0 12+12 UTC LCLC
stat_mix_0.5_4.0 12+12 UTC TCLC
%
90
80
70
60
50
40
30
20
10
0.5
tkhmin=tkmmin=0.1

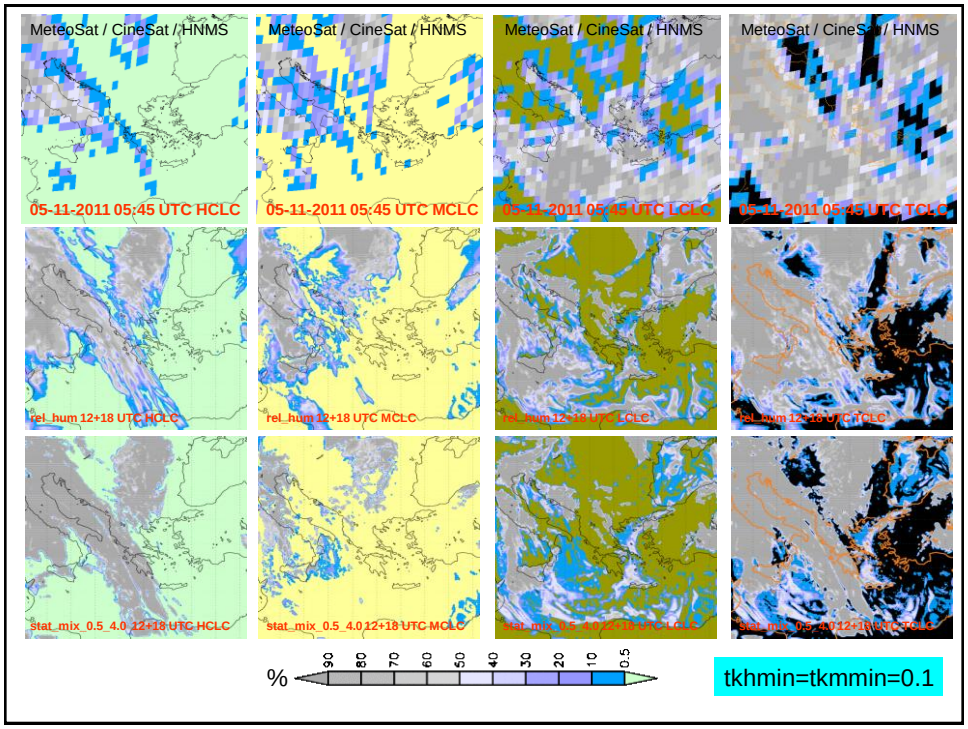

04-11-2011 23:45 UTC
12+12 UTC
12+12 UTC
12+12 UTC
12+12 UTC
tkhmin=tkmmin=1.0
tkhmin=tkmmin=0.1
MeteoSat / CineSat / HNMS
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb
HCLC
MCLC
LCLC
TCLC

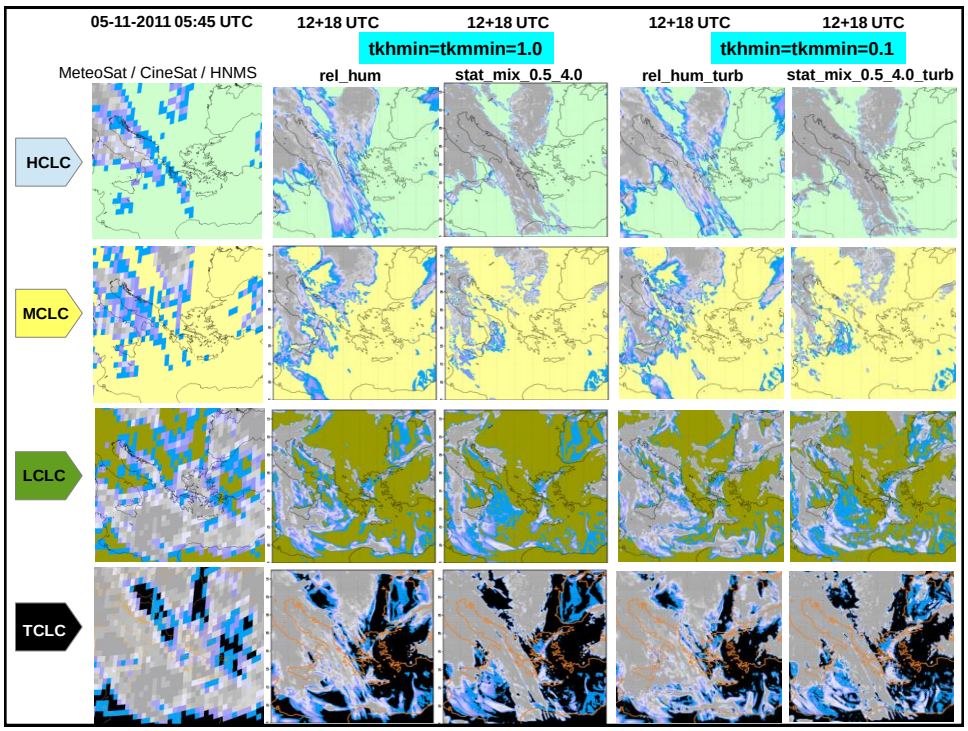

MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
05-11-2011 02:45 UTC HCLC
05-11-2011 02:45 UTC MCLC
05-11-2011 02:45 UTC LCLC
05-11-2011 02:45 UTC TCLC
rel_hum 12+15 UTC HCLC
rel_hum 12+15 UTC MCLC
rel_hum 12+15 UTC LCLC
rel_hum 12+15 UTC TCLC
stat_mix 0.5_4.0 12+15 UTC HCLC
stat_mix 0.5_4.0 12+15 UTC MCLC
stat_mix 0.5_4.0 12+15 UTC LCLC
stat_mix 0.5_4.0 12+15 UTC TCLC
%
90 80 70 60 50 40 30 20 10 0.5
tkhmin=tkmmin=1.0

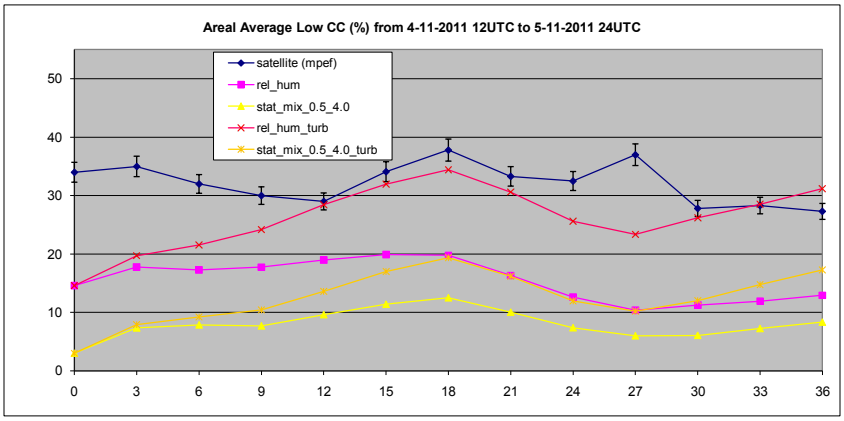

MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
05-11-2011 02:45 UTC HCLC
05-11-2011 02:45 UTC MCLC
05-11-2011 02:45 UTC LCLC
05-11-2011 02:45 UTC TCLC
rel_hum 12+15 UTC HCLC
rel_hum 12+15 UTC MCLC
rel_hum 12+15 UTC LCLC
rel_hum 12+15 UTC TCLC
stat_mix 0.5_4.0 12+15 UTC HCLC
stat_mix 0.5_4.0 12+15 UTC MCLC
stat_mix 0.5_4.0 12+15 UTC LCLC
stat_mix 0.5_4.0 12+15 UTC TCLC
%
90 80 70 60 50 40 30 20 10 0.5
tkhmin=tkmmin=0.1

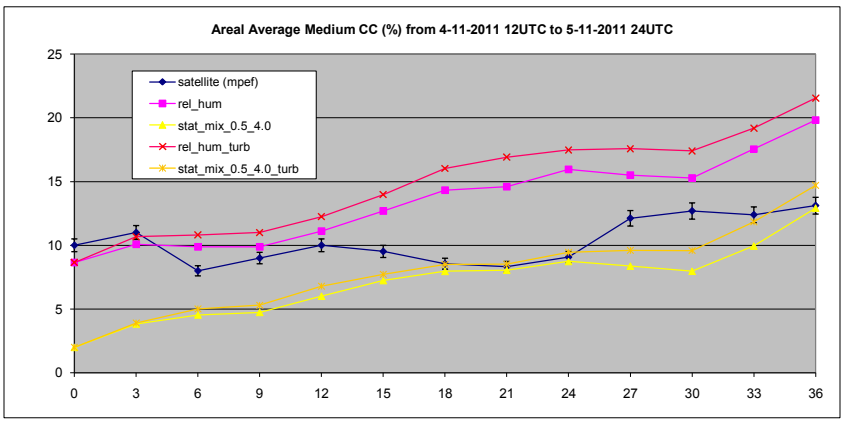

05-11-2011 02:45 UTC
12+15 UTC
12+15 UTC
tkhmin=tkmmin=1.0
12+15 UTC
12+15 UTC
tkhmin=tkmmin=0.1
MeteoSat / CineSat / HNMS
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb
HCLC
MCLC
LCLC
TCLC

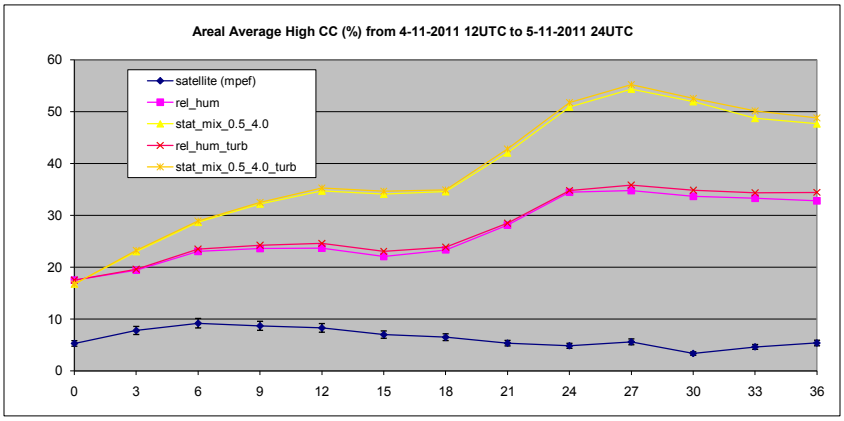

MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
05-11-2011 05:45 UTC HCLC
05-11-2011 05:45 UTC MCLC
05-11-2011 05:45 UTC LCLC
05-11-2011 05:45 UTC TCLC
rel_hum 12+18 UTC HCLC
rel_hum 12+18 UTC MCLC
rel_hum 12+18 UTC LCLC
rel_hum 12+18 UTC TCLC
stat_mix_0.5_4.0 12+18 UTC HCLC
stat_mix_0.5_4.0 12+18 UTC MCLC
stat_mix_0.5_4.0 12+18 UTC LCLC
stat_mix_0.5_4.0 12+18 UTC TCLC
%
90
80
70
60
50
40
30
20
10
0.5
tkhmin=tkmmin=1.0

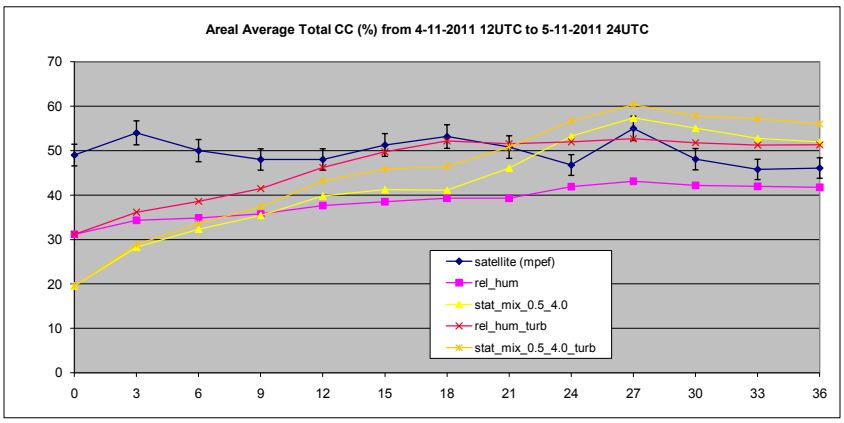

MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
MeteoSat / CineSat / HNMS
05-11-2011 05:45 UTC HCLC
05-11-2011 05:45 UTC MCLC
05-11-2011 05:45 UTC LCLC
05-11-2011 05:45 UTC TCLC
rel_hum 12+18 UTC HCLC
rel_hum 12+18 UTC MCLC
rel_hum 12+18 UTC LCLC
rel_hum 12+18 UTC TCLC
stat_mix_0.5_4.0 12+18 UTC HCLC
stat_mix_0.5_4.0 12+18 UTC MCLC
stat_mix_0.5_4.0 12+18 UTC LCLC
stat_mix_0.5_4.0 12+18 UTC TCLC
%
90
80
70
60
50
40
30
20
10
0.5
tkhmin=tkmmin=0.1

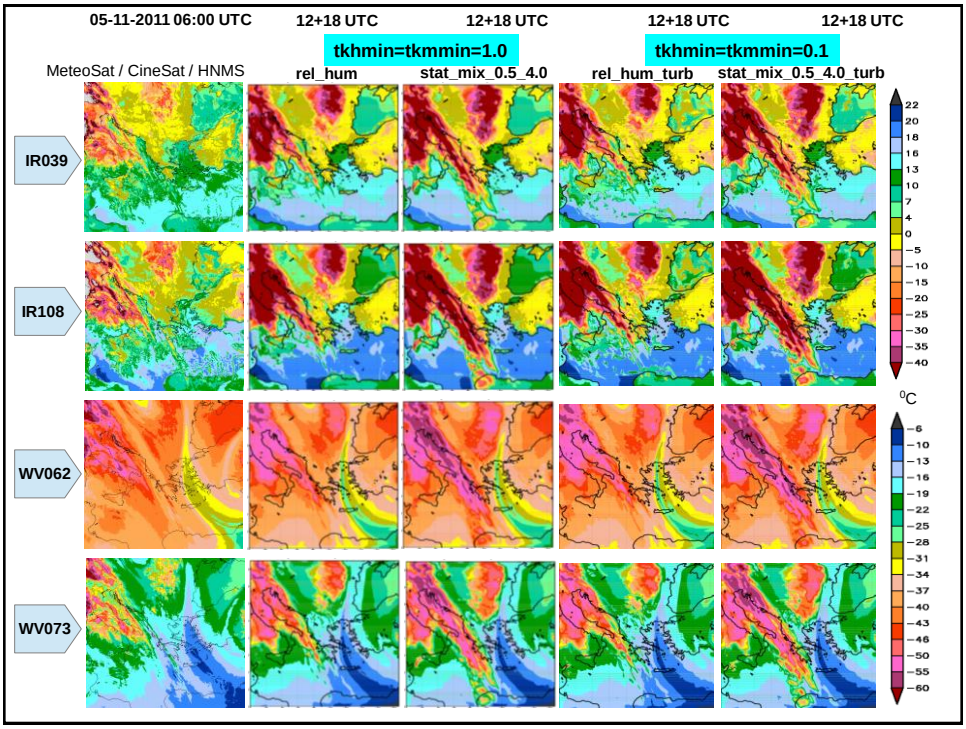

05-11-2011 05:45 UTC
12+18 UTC
12+18 UTC
12+18 UTC
12+18 UTC
tkhmin=tkmmin=1.0
tkhmin=tkmmin=0.1
MeteoSat / CineSat / HNMS
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb
HCLC
MCLC
LCLC
TCLC

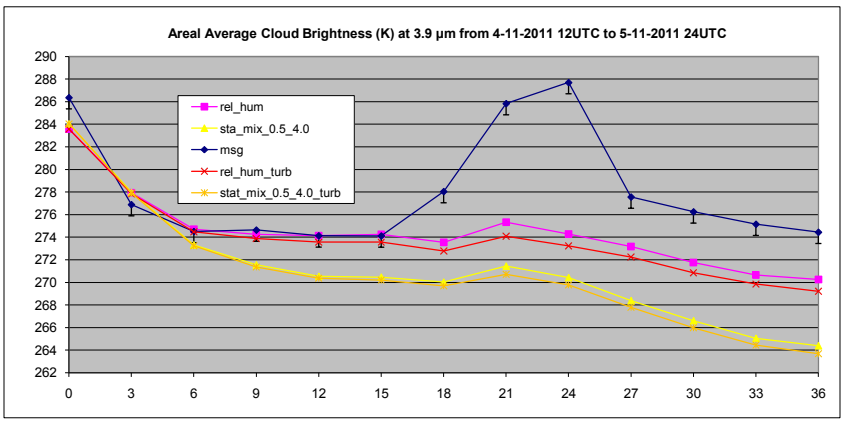

Areal Average Low CC (%) from 4-11-2011 12UTC to 5-11-2011 24UTC
satellite (mpef)
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb
0
10
20
30
40
50
0
3
6
9
12
15
18
21
24
27
30
33
36

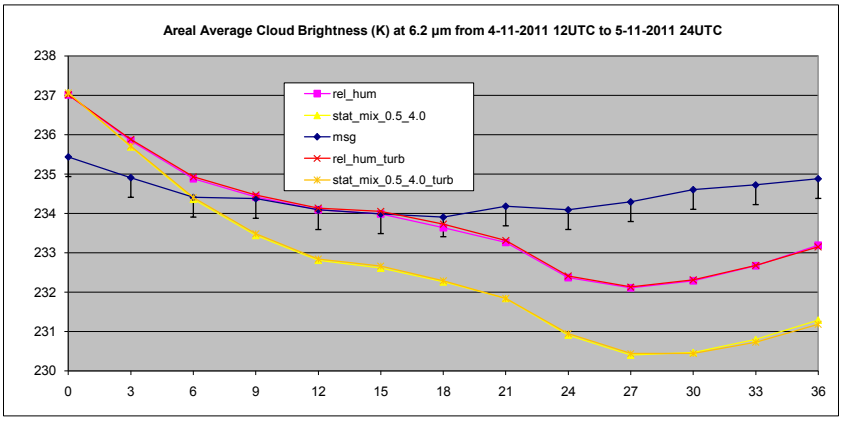

Areal Average Medium CC (%) from 4-11-2011 12UTC to 5-11-2011 24UTC
satellite (mpef)
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb
0
5
10
15
20
25
0
3
6
9
12
15
18
21
24
27
30
33
36

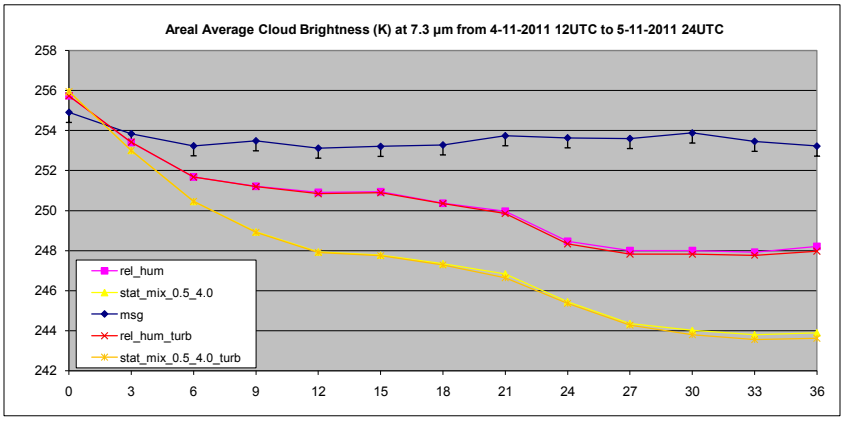

Areal Average High CC (%) from 4-11-2011 12UTC to 5-11-2011 24UTC
satellite (mpef)
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb
60
50
40
30
20
10
0
0
3
6
9
12
15
18
21
24
27
30
33
36

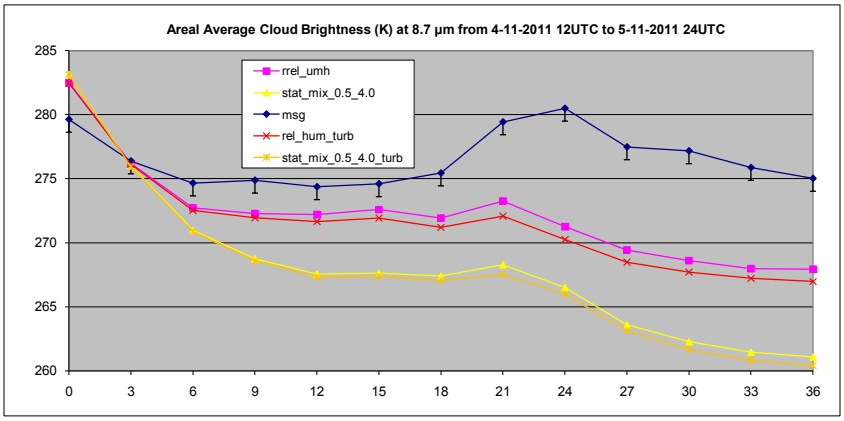

Areal Average Total CC (%) from 4-11-2011 12UTC to 5-11-2011 24UTC
satellite (mpef)
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb
70
60
50
40
30
20
10
0
0
3
6
9
12
15
18
21
24
27
30
33
36

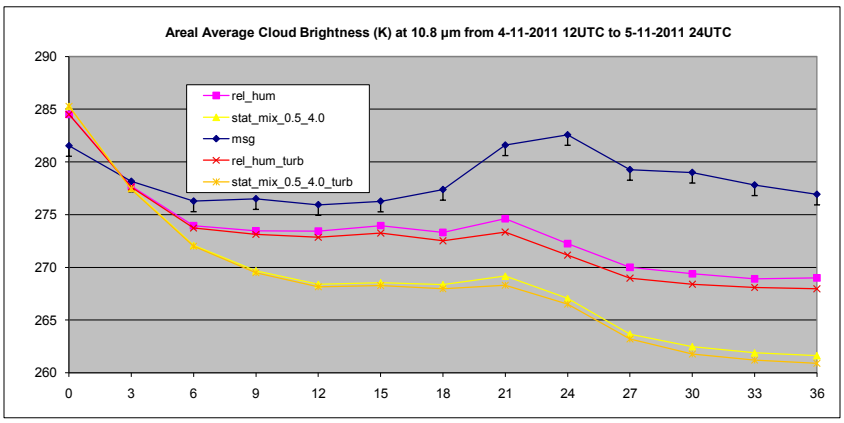

05-11-2011 06:00 UTC
12+18 UTC
12+18 UTC
12+18 UTC
12+18 UTC
tkhmin=tkmmin=1.0
tkhmin=tkmmin=0.1
MeteoSat / CineSat / HNMS
rel_hum
stat_mix_0.5_4.0
rel_hum_turb
stat_mix_0.5_4.0_turb
IR039
IR108
WV062
WV073
22
20
18
16
13
10
7
4
0
−5
−10
−15
−20
−25
−30
−35
−40
°C
−6
−10
−13
−16
−19
−22
−25
−28
−31
−34
−37
−40
−43
−46
−50
−55
−60


Areal Average Cloud Brightness (K) at 3.9 µm from 4-11-2011 12UTC to 5-11-2011 24UTC
290
288
286
284
282
280
278
276
274
272
270
268
266
264
262
0
3
6
9
12
15
18
21
24
27
30
33
36
rel_hum
sta_mix_0.5_4.0
msg
rel_hum_turb
stat_mix_0.5_4.0_turb


Areal Average Cloud Brightness (K) at 6.2 µm from 4-11-2011 12UTC to 5-11-2011 24UTC
238
237
236
235
234
233
232
231
230
0
3
6
9
12
15
18
21
24
27
30
33
36
rel_hum
stat_mix_0.5_4.0
msg
rel_hum_turb
stat_mix_0.5_4.0_turb


Areal Average Cloud Brightness (K) at 7.3 µm from 4-11-2011 12UTC to 5-11-2011 24UTC
258
256
254
252
250
248
246
244
242
0
3
6
9
12
15
18
21
24
27
30
33
36
rel_hum
stat_mix_0.5_4.0
msg
rel_hum_turb
stat_mix_0.5_4.0_turb


Areal Average Cloud Brightness (K) at 8.7 µm from 4-11-2011 12UTC to 5-11-2011 24UTC
rrel_umh
stat_mix_0.5_4.0
msg
rel_hum_turb
stat_mix_0.5_4.0_turb
285
280
275
270
265
260
0
3
6
9
12
15
18
21
24
27
30
33
36


Areal Average Cloud Brightness (K) at 10.8 µm from 4-11-2011 12UTC to 5-11-2011 24UTC
rel_hum
stat_mix_0.5_4.0
msg
rel_hum_turb
stat_mix_0.5_4.0_turb
290
285
280
275
270
265
260
0
3
6
9
12
15
18
21
24
27
30
33
36

Conclusions and Assessment

- These comparisons were accomplished via the CineSat software and became possible via the *gratefully acknowledged* courtesy of the Remote Sensing Division of the Hellenic National Meteorological Service that provided access to the available tools and database structure in order to create the necessary look-up tables and perform the statistics.
- From these direct comparisons, it became clear that the implementation of the SGSLI scheme leads to an underestimation of low cloud-cover by the model in contrast to the implementation of the default SGRH scheme.
- An important boost towards the relative impact of the cloud schemes came from a close comparison of artificial satellite images provided by the model with the real ones provided directly at the Hellenic Meteorological Service by MSG.
- However another important feature was that the implementation of the SGSLI scheme leads to a relatively better simulation for medium cloud-cover.
- Nevertheless, the total cloud cover is better estimated by the default relative humidity scheme as well as the radiation temperatures in the 10.8, 3.9, 6.2 and 7.3 microns.
- Although the SGSLI scheme cannot in its present form replace the SGRH scheme in the radiation module, it is an important asset to COSMO model that can be used as a basis to support the ongoing research in this crucial area of atmospheric physics.