



Sensitivity Evaluation of Various Implementations of the SGS Cloud Scheme over Greece

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PRESENTATION OUTLINE

- ◆ **The Main Scheme**
- ◆ **Test Cases Tabulation and Model Set up**
- ◆ **SGS Cloud Scheme Implementation**
- ◆ **Results for Rad. Budgets, Cloud Cover,
T_2M, TL3, RH ...**
- ◆ **Comments-Conclusions**

◆ The Main Scheme

Stratiform Cloud Fraction (Sommeria Deardorff, 1976):

$$R = \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} H(q_w - q_s) G dq_w d\theta_l$$

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

$$H(x) = \begin{cases} 0, & x < 0 \\ 1, & x \geq 0 \end{cases}$$

$$\theta_l' \equiv \theta_l - \bar{\theta}_l$$

$$r = \overline{\theta_l' q_w'} / (\sigma_{\theta_l} \sigma_{q_w})$$

$$q_w' = q_w - \bar{q}_w$$

Where q_w and q_s are *liquid* water and vapor specific humidities, θ_l is liquid water potential temperature and the average values \bar{q}_w and $\bar{\theta}_l$ are the grid point values calculated by the model.

- ◆ 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

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

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

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

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

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

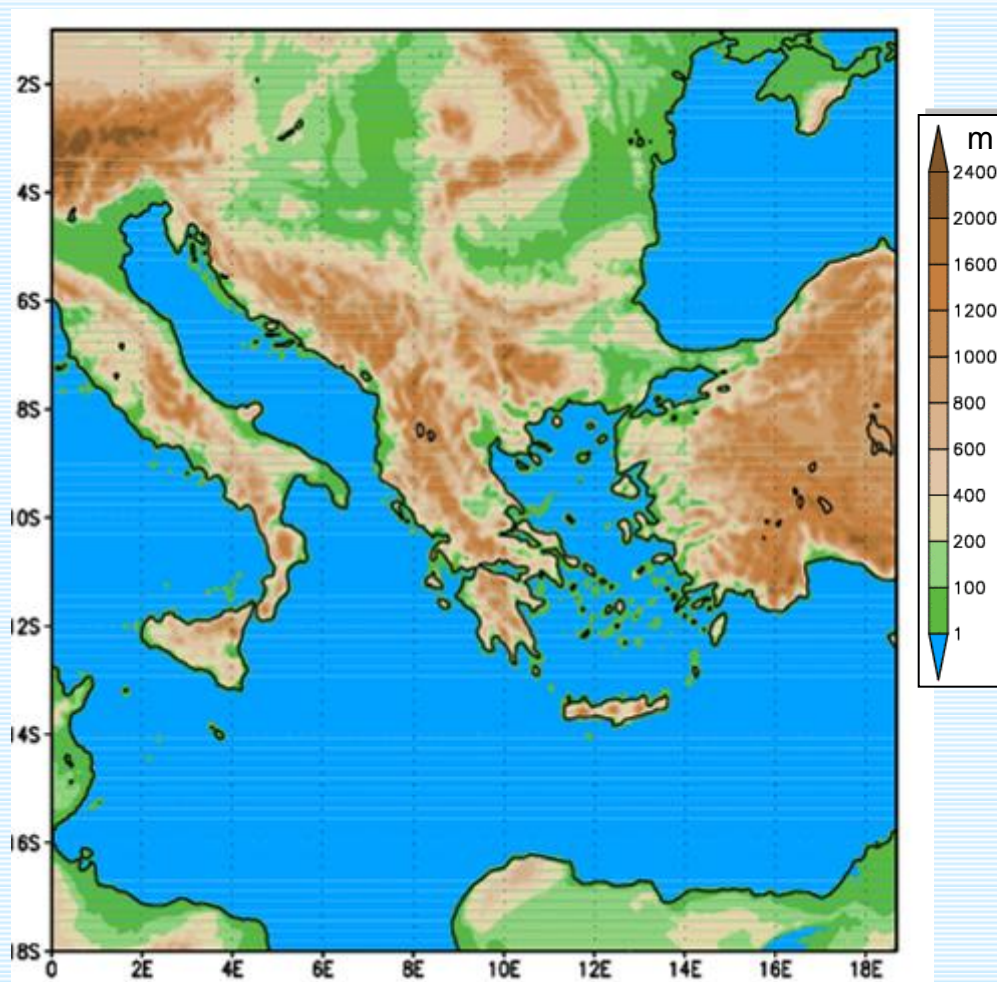
- ◆ Parameter A refers to cloud cover at saturation and B refers to critical value of saturation deficit. The default values of these parameters are set 0.5 and 4.0 respectively.

◆ Test Cases Tabulation and Model set-up

Five cases were investigated, with 48 hour runs as follows:

| # | Starting Date |
|---|----------------------------------|
| 1 | Jan. 1 2005 12UTC (d050101_12) |
| 2 | Dec. 24 2007 12UTC (d071224_12) |
| 3 | Apr. 25 2006 12 UTC (d060425_12) |
| 4 | May 9 2008 12 UTC (d080509_12) |
| 5 | May 1 2009 12 UTC (d090501_12) |

- COSMO_4.11 (4.6)
- Horizontal grid 0.0625° (~7 Km)
273×273 points
- 40 vertical levels
- time step: 30 sec
- GME (0.5°) 3 hs 48 hs
- IBM HPC Cluster 1600 (P4+)



◆ SGS Cloud Scheme Implementations

RH : Reference run of COSMO_4.11. SGS not activated. Cloud Cover is calculated on the default **Relative Humidity (RH)** scheme.

SGS_def: SGS is activated in COSMO 4.11 through its default implementation where cloud cover is set equal to 1.0 if any cloud ice is present.

SGS_E-7: SGS is activated in COSMO_4.11 and cloud cover is set equal to 1.0 if cloud ice is greater than 10^{-7} Kg/Kg.

SGS_mix: A generalization of SGS with the inclusion of *cloud ice* into total water specific humidity is implemented in COSMO_4.6 (Deardorff 1976, test version provided by Matthias Raschendorfer).

SGS_low: SGS is activated in lower troposphere ($klv > 500$). The default RH scheme remains in the upper troposphere.

SGS_RH: SGS is activated for grid points without any cloud ice and RH scheme is used for cloud cover for the rest grid points.

The goal is to obtain an understanding on how SGS implementation perturbs cloud cover in reference to cloud-ice which is an issue (Smith S. A. and Del Genio A. D., 2002).

◆ Results

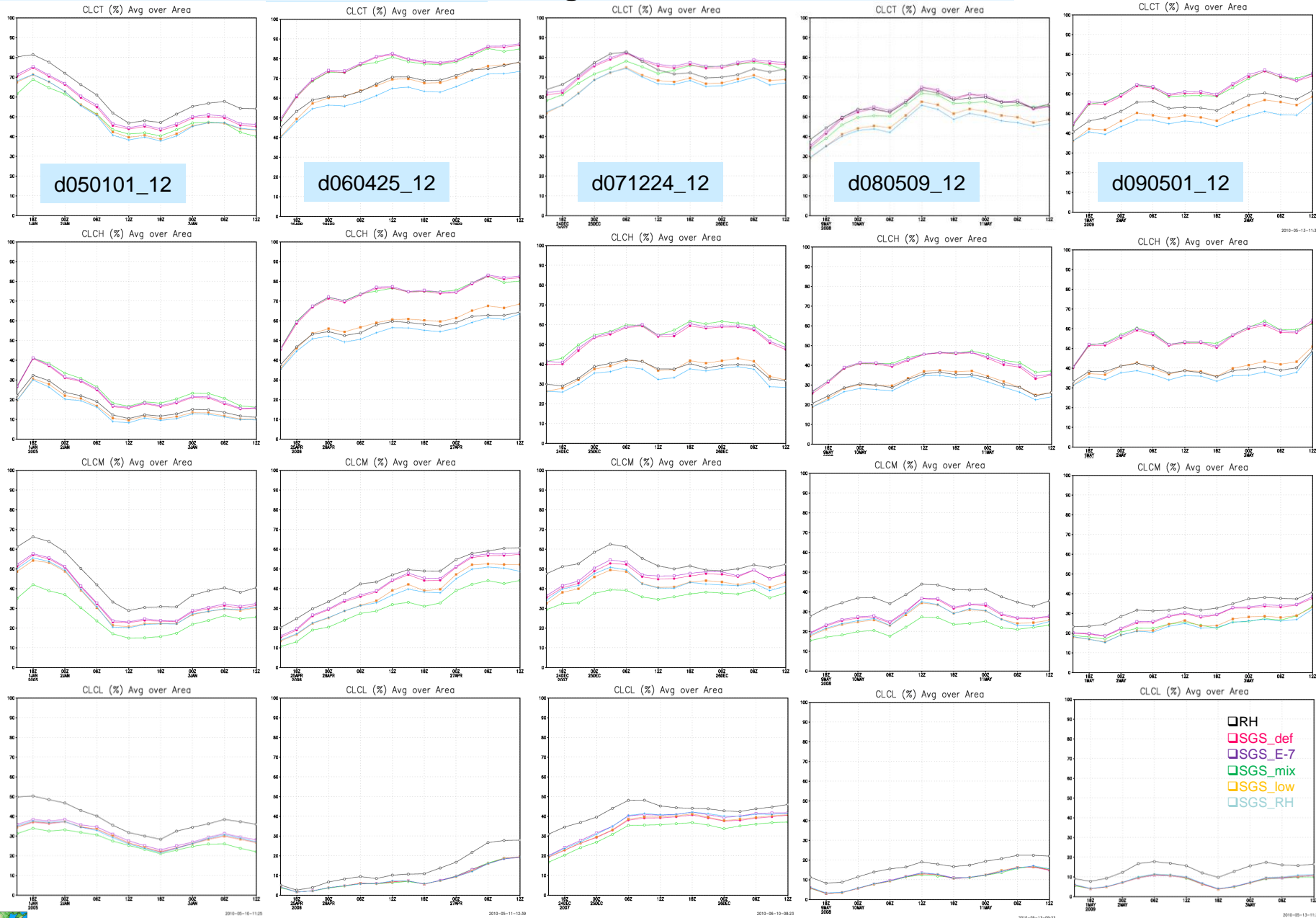
The results are presented in reference to the default RH scheme, satellite pictures (MSG Infrared), station observations.

Considered Variables

- **ASOB_T**: Solar radiation budget at the top of the atmosphere
- **ATHB_S**: Thermal radiation budget at the surface
- **ASOB_S**: Solar radiation budget at the surface
- **ATHB_T**: Solar radiation budget at the top of the atmosphere
- **CLCT**: Total Cloud Cover
- **CLCH**: High Cloud Cover
- **CLCM**: Medium Cloud Cover
- **CLCL**: Low Cloud Cover
- **CLC**: Cloud Cover over station
- **T_2M**: 2 meter Temperature
- **TL3**: Temperature at the third model level (~100m)
- **RH**: Relative Humidity over station
- **Cloud T**: Artificial Satellite Images (MSG IR 10.8 nm)

! A larger set is available for further consideration.

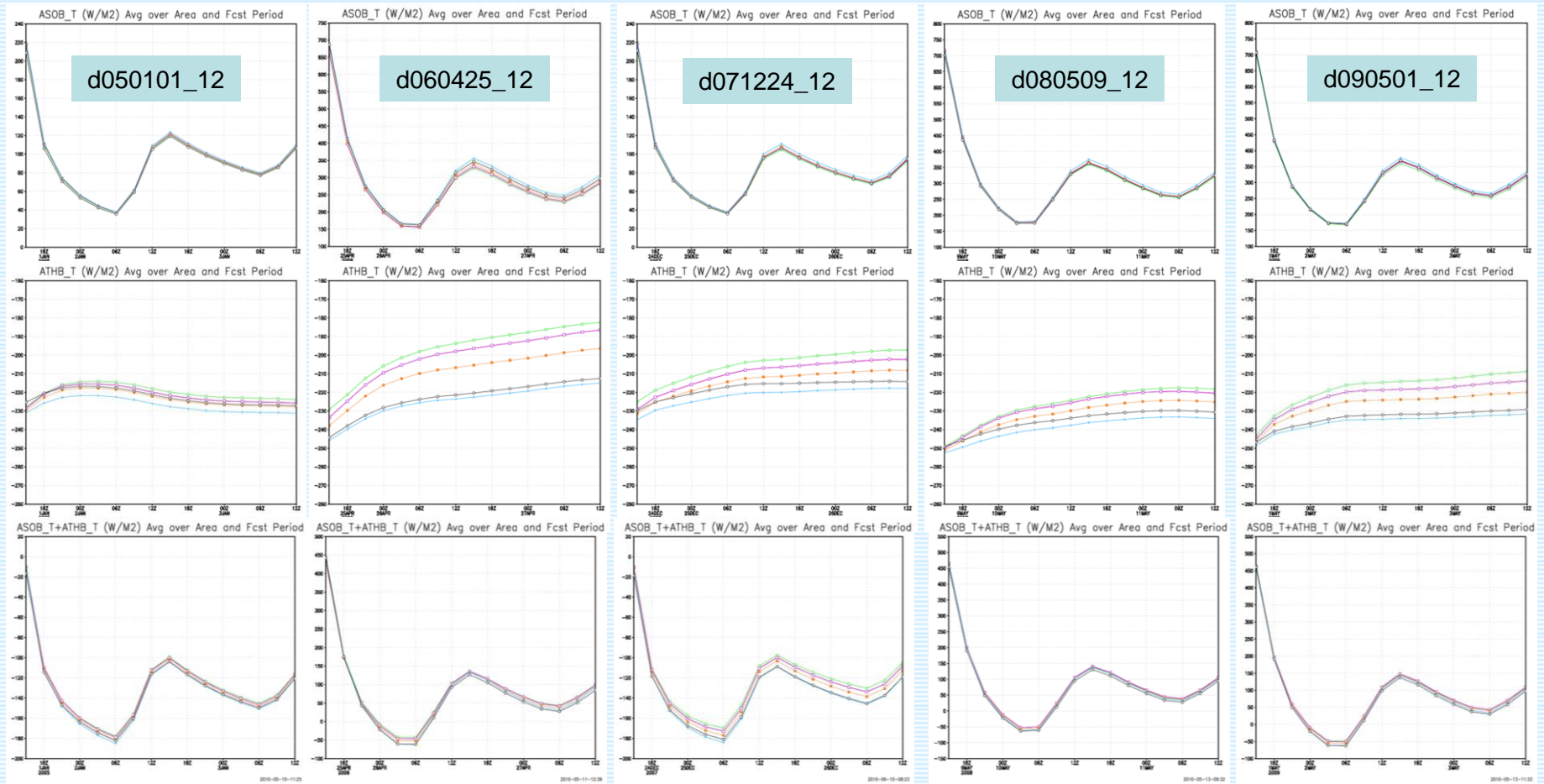
Average Cloud Cover



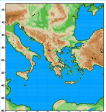
Less High clouds when RH scheme is invoked. More Medium and Low clouds for RH (default) scheme.
Less Medium and Low clouds for SGS_mix scheme.

□ RH
 ■ SGS_def
 ■ SGS_E-7
 ■ SGS_mix
 ■ SGS_low
 ■ SGS_RH

Average Radiation Balance at the top of the Atmosphere

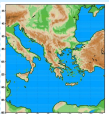
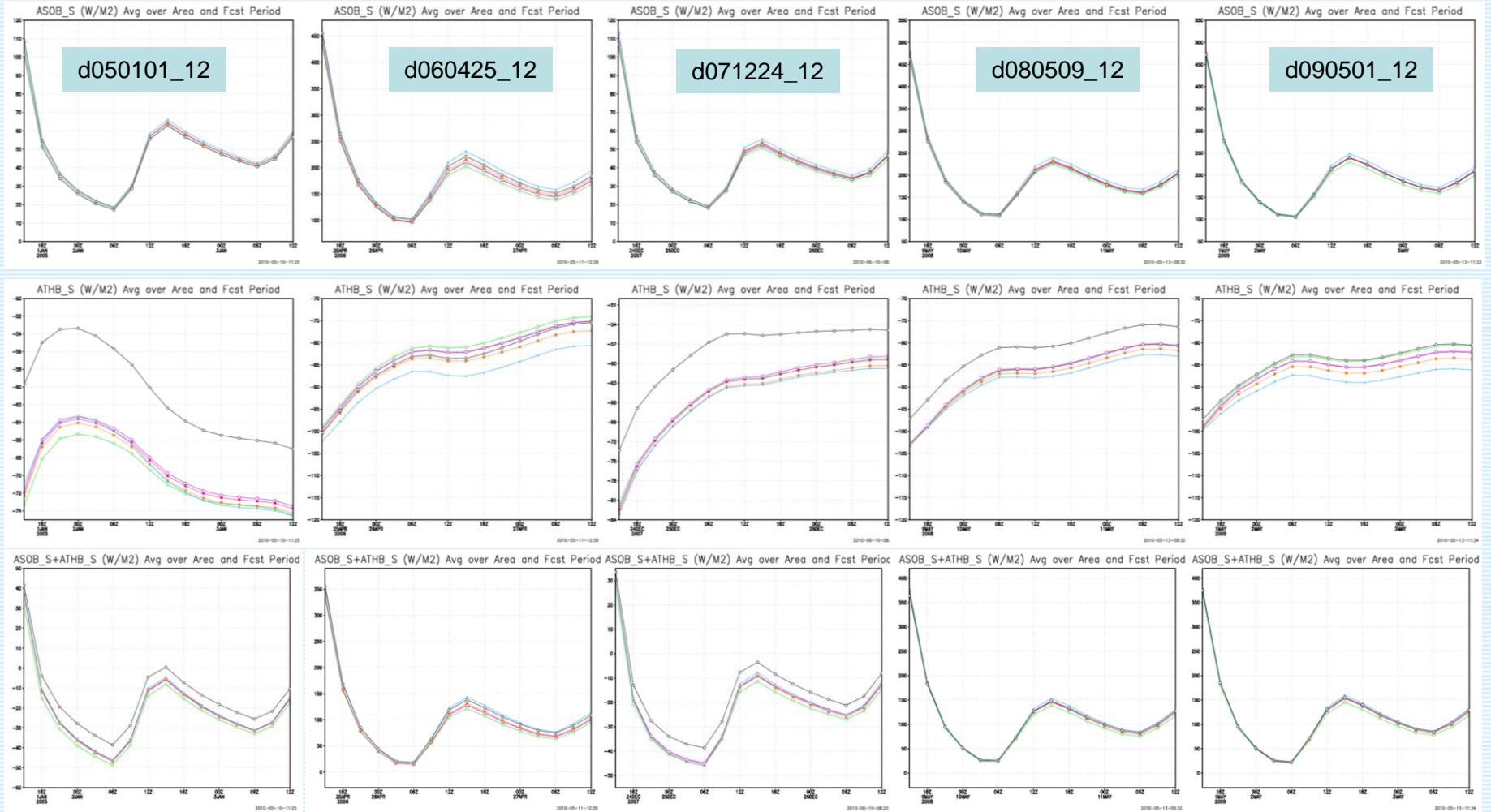


Relative differences for ATHB_T are observed.



□ RH
 ■ SGS_def
 ■ SGS_E-7
 ■ SGS_mix
 ■ SGS_low
 ■ SGS_RH

Average Radiation Balance at the Surface



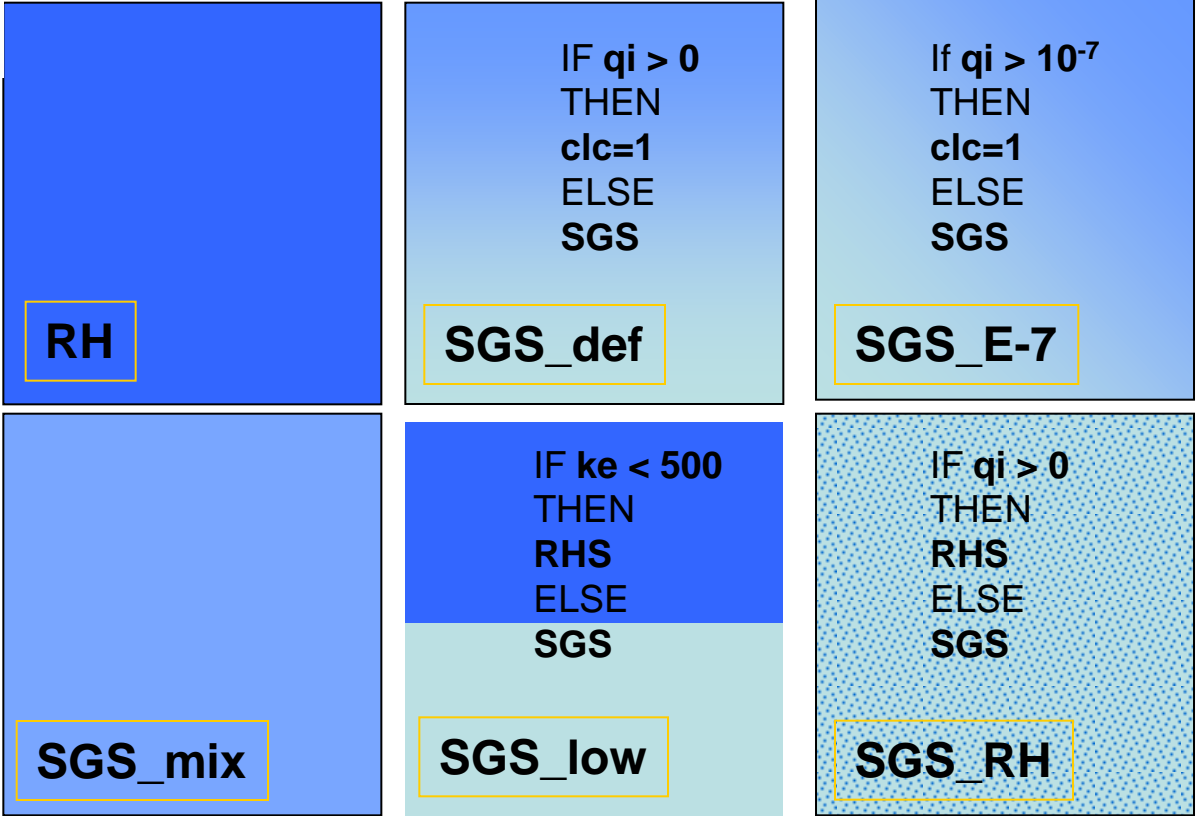
Relative differences for ATHB_S are observed, mainly for winter cases.



Results upon individual cases

| | |
|----------|---|
| <u>1</u> | Jan. 1 2005 12UTC (<i>d050101_12</i>) |
| <u>2</u> | Dec. 24 2007 12UTC (<i>d071224_12</i>) |
| <u>3</u> | Apr. 25 2006 12 UTC (<i>d060425_12</i>) |
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! Guide to figures



CONCLUSIONS

- ◆ The forecasted cloud cover is sensitive to the statistical cloud scheme and looks consistent with the default RH cloud scheme to the extent of a perturbation, especially the SGS_RH cloud scheme.
- ◆ In general cloud cover patterns were similar for all implementations.
- ◆ Less High clouds are produced when the RH scheme is invoked.
- ◆ In general more medium and low clouds are produced by the RH default scheme. However SGS scheme is parameterized and this can change.
- ◆ A small improvement to T_{2m} min was observed for some cases.
- ◆ Significant differences were found over thermal radiation budgets. Especially those at the top of the atmosphere can be further tested with satellite data.
- ◆ Within the framework provided by these experiments the subgrid cloud cover scheme (especially the SGS_RH scheme) looks like a flexible alternative to the default scheme of COSMO model.

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