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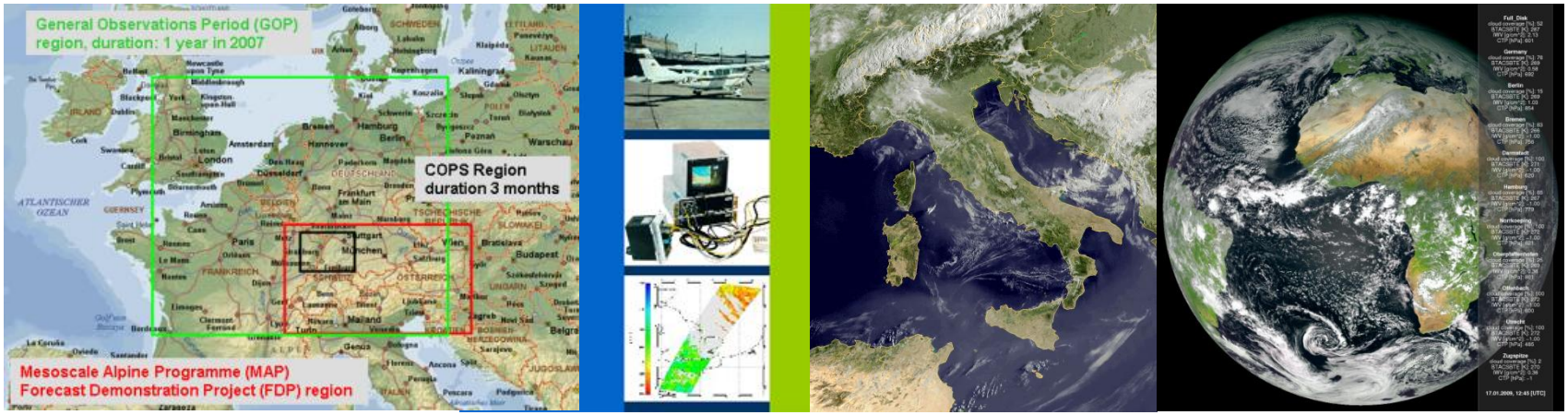

Quest: Quantitative Evaluation of Regional Precipitation Forecasts Using Multi-Dimensional Remote Sensing Observations

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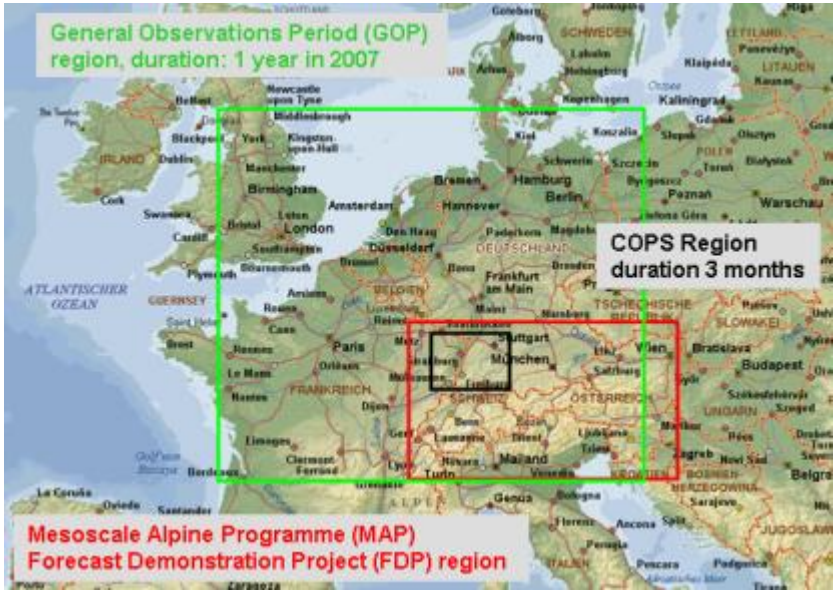
overview

- cloud detection
  - cloud cover COSMO-DE / COSMO-EU
  - cloud probability MSG
- comparison between Models and MSG
  - cloud fraction
  - Diurnal cycles of skill scores
  - Area statistics (land/sea, DE (North,Mid,South))
  - Maps with best agreements
- summary

satellite

MSG ~ 5km; 15min
- cloud mask
- cloud top pressure CTP
- IR brightness temperature BT
- optical thickness



Background informations

Data for Cloud Mask Comparisons :

Models	: COSMO - DE and COSMO - EU
Period	: 2007 + 2008
Temp. Res.	: every quarter of an hour (COSMO - DE)
	: every full hour (COSMO - EU)
COSMO runs	: at least 3h since start of run
MSG	: Date of COSMO - 15 min

Statistics :

Day / Night definition [UTC]	: 7-15 / 21 – 4
Threshold for cloudy pixels[MSG/Model]	: 90% P /90% CLC
COSMO-DE land/sea cover	: 80% / 20%
COSMO-EU land/sea cover	: 59% / 41%

Skills 'n Scores Definitions

True Skill Score (TSS) : prob. of detection – prob. of false det. ;range [-1,1]

$$\frac{a \cdot d - c \cdot b}{(a+b) \cdot (c+d)}$$

TSS = 0.55 forecast is in 55% the cases able to separate hit - from negative hit -cases

Threat Score (THS) : score of the cloudy/cloudy cases ; range [0,1]

$$\frac{a}{a+b+c}$$

THS =0.5, 50% of hit-cases are correctly forecasted

Frequency Bias(FBI) : over-/ underforecasting; range [0, inf] , perfect 1

$$\frac{a+b}{a+c}$$

		MSG (obs) Yes	MSG (obs) no
Model (forecast)	yes	a (hit)	b (false alarm)
	no	c (misses)	d (neg hit)

Skills n‘ Scores Definitions

PCF [d / (d+b)] : Probability of correct cloud free forecast

PCL [a / (a+c)] : Probability of correct cloudiness forecast

False [(b + c) / N_{pix}] : Ratio of misses and false alarm cases

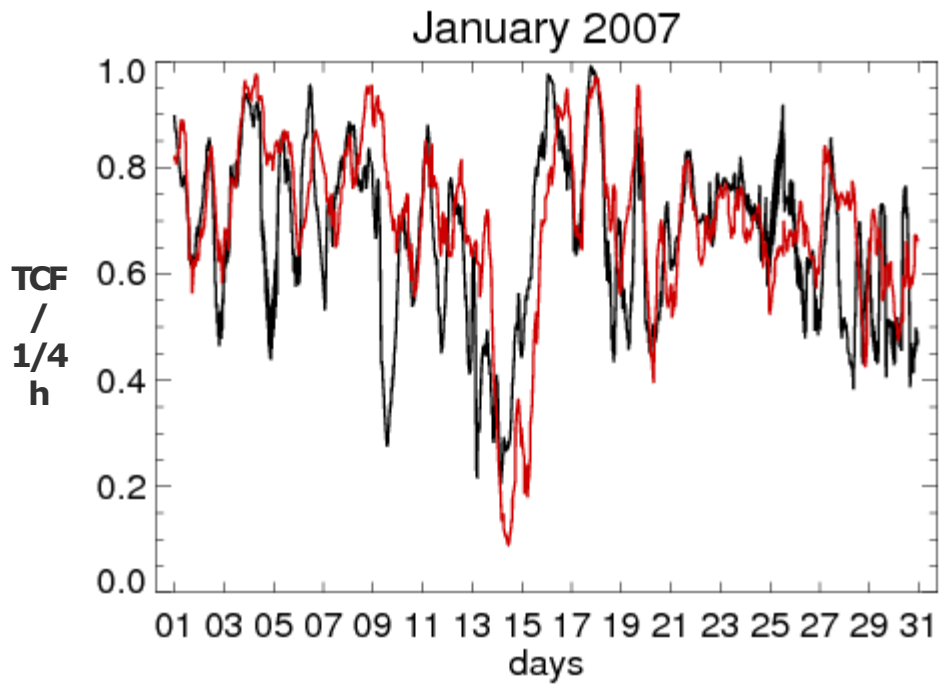
TCF [$N_{cloudy\ pixel}$ / $N_{valid\ pixel}$] : Total Cloud Fraction per hour (1/4 hour)

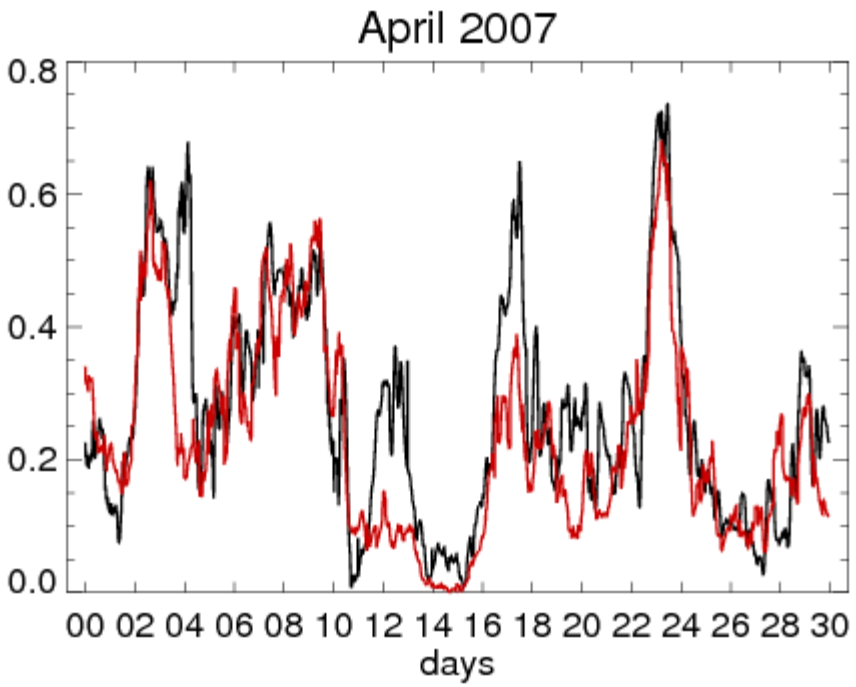
TCF_{diff} [TCF_{msg}-TCF_{Model}/N_{hours}] : mean TCF Difference (MSG – Model) [%]

		MSG (obs) Yes	MSG (obs) no
COSMO (forecast)	yes	a (hit)	b (false alarm)
	no	c (misses)	d (neg hit)

CLOUD FRACTION

Total Cloud Fraction Jan + April 2007 MSG / LMK



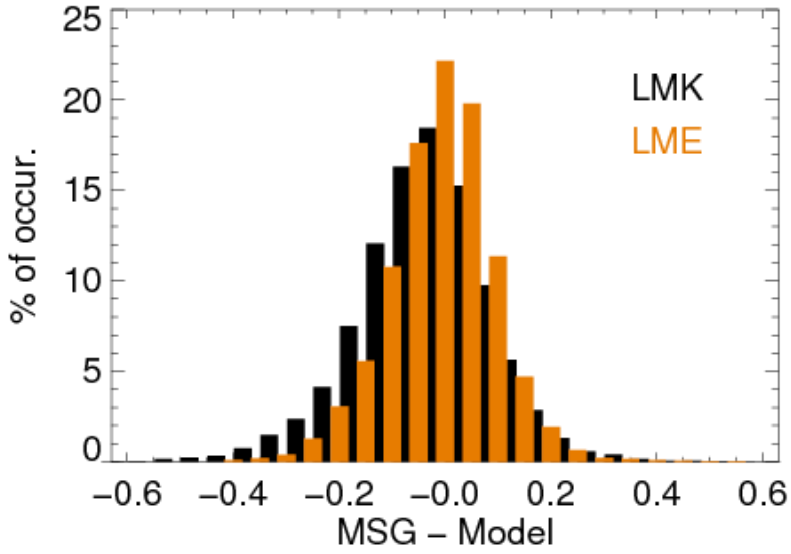


Mean	: 0.67 / 0.70
Stddev	: 0.16 / 0.16
Bias(MSG,LMK)	: -0.029
Rmse	: 0.142
Correlation	: 0.620

Mean	: 0.27 / 0.23
Stddev	: 0.17 / 0.15
Bias	: 0.042
Rmse	: 0.106
Correlation	: 0.814

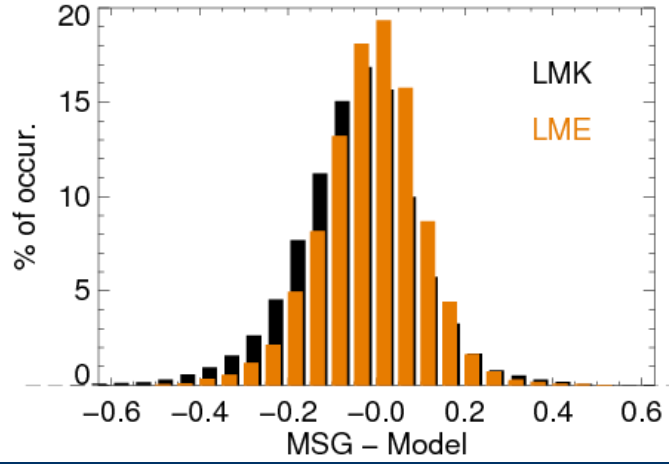
Difference Cloud Fraction 2007, 2008

Overall



Mean : - 0.023 / 0.022
Stddev : 0.127 / 0.099

Land



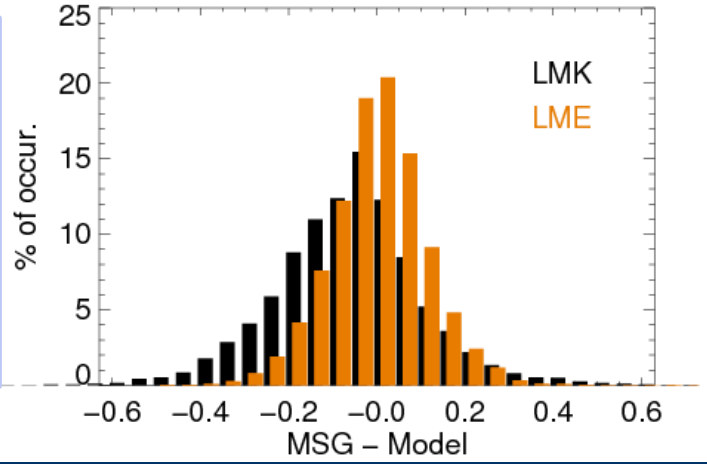
Land:

Mean : -0.019 / 0.014
Stdev : 0.138 / 0.113

Sea:

Mean : -0.042 / 0.034
Stddev : 0.168 / 0.110

Sea



Difference Cloud Fraction 2007, 2008 table

difference in cloud occurence statistics

year	model	area	Mean/Bias	median	stddev	variance
2007	MSG - LMK	All	-0.034	-0.026	0.128	0.016
2007	MSG - LMK	Land	-0.029	-0.018	0.139	0.019
2007	MSG - LMK	Sea	-0.052	-0.046	0.174	0.030
2007	MSG - LME	All	0.023	0.027	0.097	0.009
2007	MSG - LME	Land	0.014	0.020	0.111	0.012
2007	MSG - LME	Sea	0.036	0.037	0.107	0.012
2008	MSG - LMK	All	-0.013	-0.011	0.124	0.015
2008	MSG - LMK	Land	-0.008	-0.007	0.136	0.019
2008	MSG - LMK	Sea	-0.031	-0.026	0.161	0.026
2008	MSG - LME	All	0.021	0.023	0.101	0.010
2008	MSG - LME	Land	0.014	0.019	0.115	0.013
2008	MSG - LME	Sea	0.032	0.031	0.112	0.013

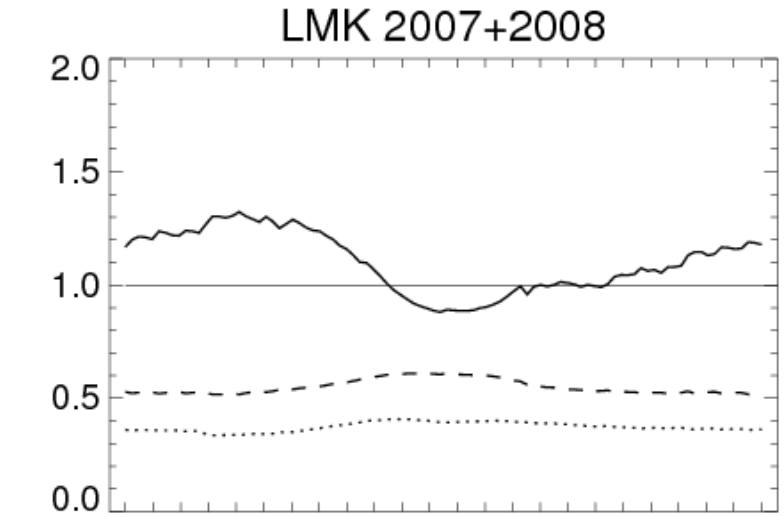
Neg. Bias overestimating of cloud cover by the model
Pos. Bias underestimating of cloud cover by the model

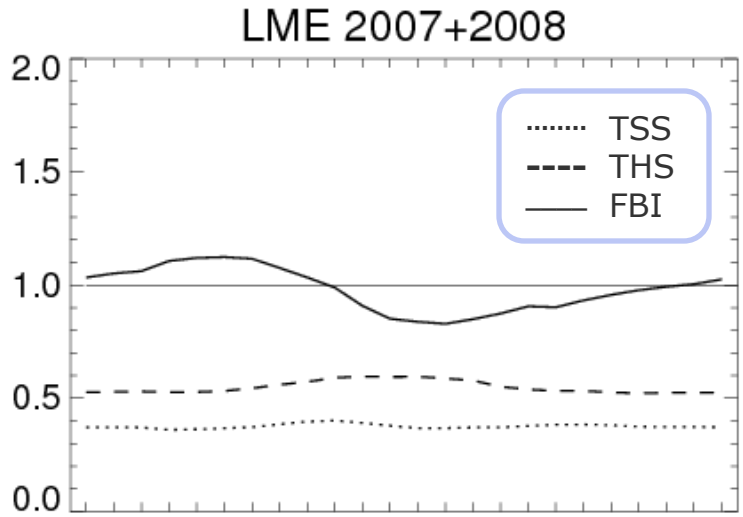
Cloud fraction summery

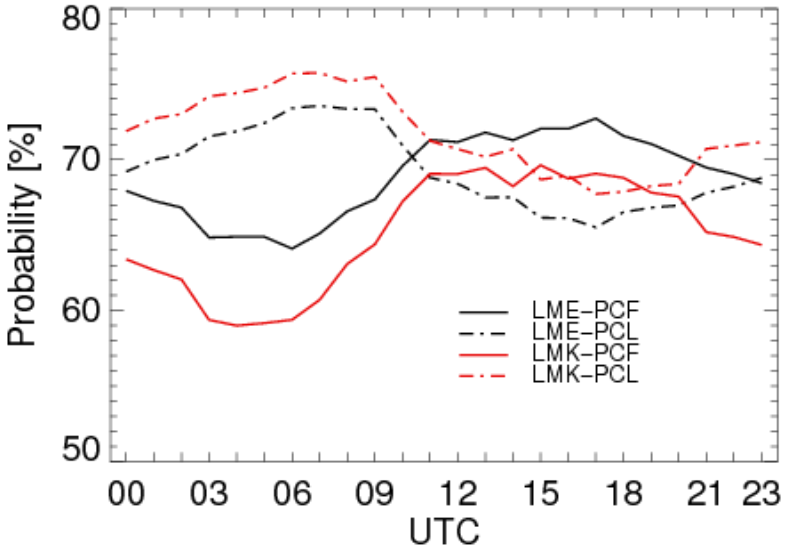
- COSMO-DE
  - negative Bias (-3%) -> overestimating of cloud fraction in January (very cloudy)
  - Positive bias (+4%) -> underestimating of cloud fraction in April (less clouds)
  - Overall 2007+2008 negative Bias () (overestimating of cloud fraction)
  - Highest bias + Error over sea surfaces
- COSMO-EU
  - Overall 2007+2008 positive Bias (underestimating of cloud fraction)
  - Highest Bias over Sea surfaces

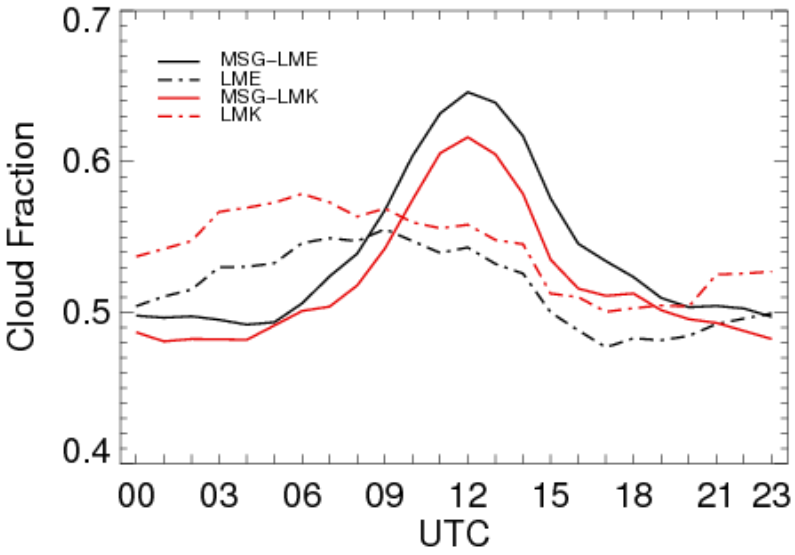
DIURNAL CYCLES

Diurnal Cycle 2007 +2008



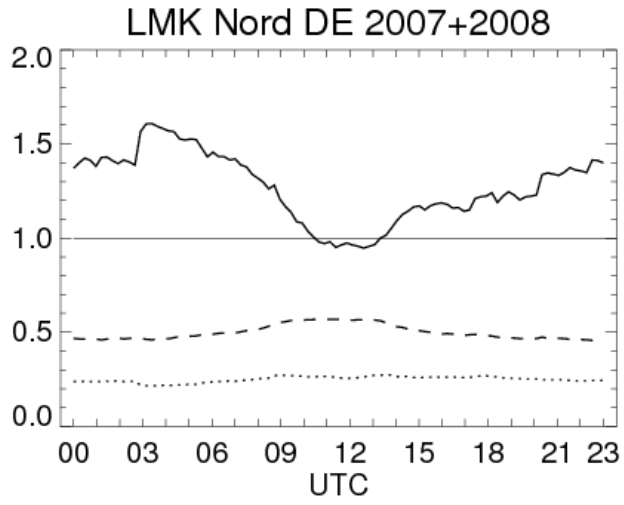


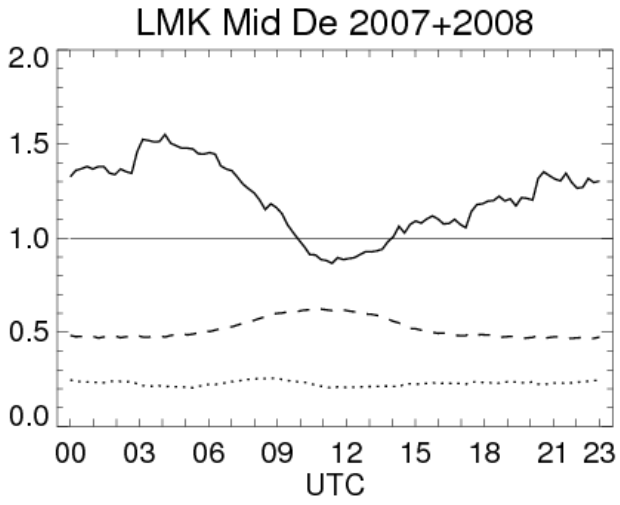


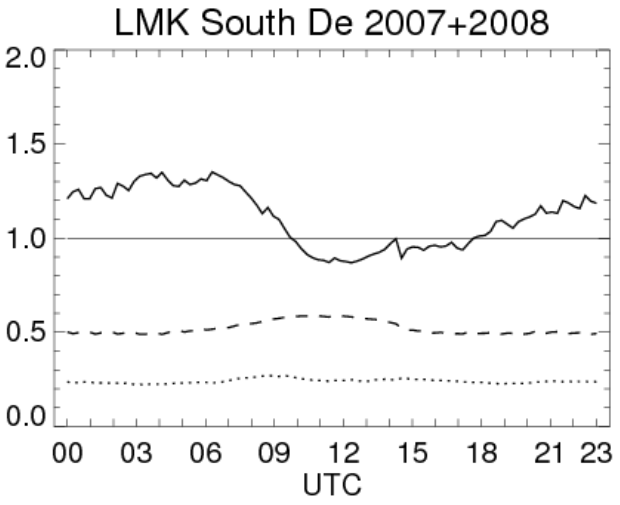


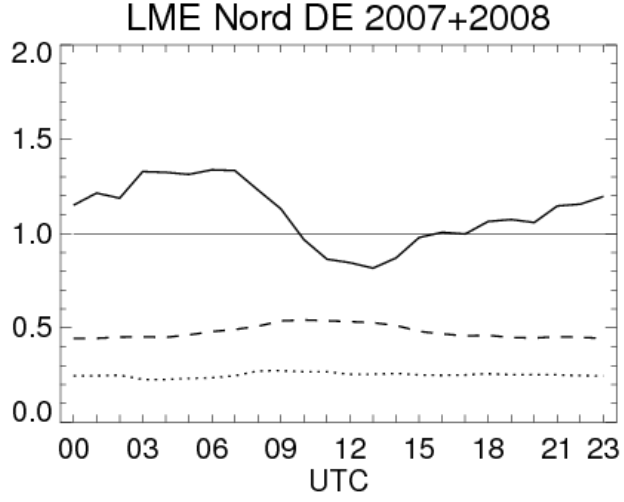
AREA STATISTICS

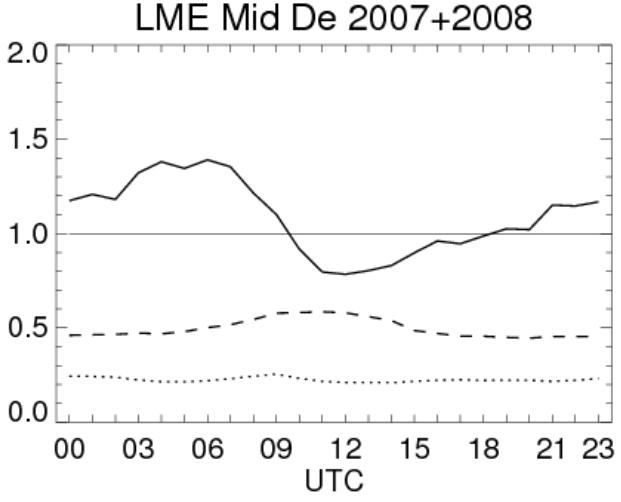
Diurnal Cycle 2007+2008

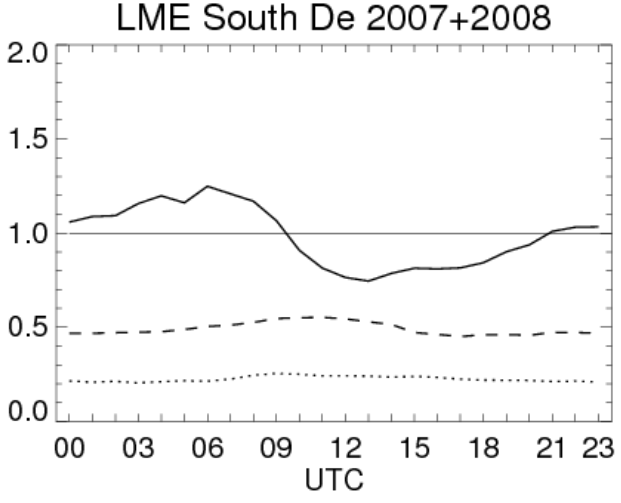












LMK 2007+2008 Area Statistics [#65604]

Area	TSS	THS	FBI	PCF	PCL	False	TCF Diff [%]
Nord	0.250	0.499	4.522	0.540	0.692	0.283	nV
Mid	0.228	0.519	5.181	0.525	0.697	0.274	nV
South	0.240	0.521	3.458	0.569	0.666	0.253	nV
DE	0.317	0.545	1.591	0.586	0.720	0.270	nV
LMK	0.373	0.550	1.114	0.650	0.717	0.270	-2.335
Land	0.355	0.546	1.128	0.644	0.709	0.268	-1.878
Sea	0.332	0.510	1.685	0.630	0.690	0.276	-4.151

TSS : True Skill Score
THS : Threat Score
FBI : Frequency Bias
PCF : Probability of correct cloud free forecast
PCL : Probability of correct cloudy forecast
False : Ratio of Cases when Model and MSG differ
TCF Diff : Mean difference of cloud fraction MSG – Model in %

the red color indicates the best values of the DE areas (North, Mid, South)

LME 2007+2008 Area Statistics [#16220]

Area	TSS	THS	FBI	PCF	PCL	False	TCF Diff [%]
Nord	0.250	0.478	2.311	0.612	0.630	0.281	nV
Mid	0.225	0.496	2.273	0.582	0.643	0.280	nV
South	0.225	0.491	1.884	0.626	0.607	0.264	nV
DE	0.308	0.519	1.246	0.648	0.659	0.275	nV
LME	0.376	0.549	0.981	0.688	0.694	0.294	2.214
Land	0.378	0.543	1.007	0.690	0.694	0.288	1.414
Sea	0.345	0.547	0.967	0.667	0.686	0.304	3.396

TSS : True Skill Score
THS : Threat Score
FBI : Frequency Bias
PCF : Probability of correct cloud free forecast
PCL : Probability of correct cloudy forecast
False : Ratio of Cases when Model and MSG differ
TCF Diff : Mean difference of cloud fraction MSG – Model in %

the red color indicates the best values of the DE areas (North, Mid, South)

COSMO-DE : Area Statistics Table Day/ Night

LMK 2007+2008 Day Area Statistics [#22487]

Area	TSS	THS	FBI	PCF	PCL	False	TCF Diff [%]
Nord	0.261	0.546	3.318	0.540	0.700	0.261	nV
Mid	0.227	0.588	3.577	0.524	0.712	0.240	nV
South	0.252	0.565	3.464	0.581	0.679	0.229	nV
DE	0.332	0.596	1.258	0.600	0.729	0.244	nV
LMK	0.395	0.590	1.004	0.668	0.724	0.251	1.292
Land	0.379	0.599	0.989	0.669	0.719	0.244	2.922
Sea	0.324	0.502	1.379	0.619	0.690	0.280	-5.186

LMK 2007+2008 Night Area Statistics [#22635]

Area	TSS	THS	FBI	PCF	PCL	False	TCF Diff [%]
Nord	0.239	0.464	5.953	0.536	0.687	0.299	nV
Mid	0.232	0.474	4.821	0.522	0.691	0.296	nV
South	0.232	0.495	2.610	0.547	0.669	0.268	nV
DE	0.306	0.511	1.508	0.570	0.721	0.288	nV
LMK	0.358	0.523	1.201	0.631	0.719	0.282	-5.488
Land	0.338	0.511	1.231	0.621	0.709	0.284	-5.765
Sea	0.337	0.515	1.623	0.630	0.696	0.275	-4.383

the red color indicates the best values in contrast to Land/Sea and Day/night of the model area

COSMO-EU : Area Statistics Table Day/ Night

LME 2007+2008 Day Area Statistics [#6069]

Area	TSS	THS	FBI	PCF	PCL	False	TCF Diff [%]
Nord	0.260	0.519	1.400	0.612	0.644	0.269	nV
Mid	0.225	0.552	1.736	0.580	0.660	0.259	nV
South	0.241	0.527	1.784	0.639	0.622	0.249	nV
DE	0.322	0.561	1.004	0.661	0.672	0.259	nV
LME	0.381	0.580	0.916	0.696	0.699	0.289	5.603
Land	0.411	0.587	0.917	0.725	0.702	0.269	5.802
Sea	0.288	0.561	0.937	0.617	0.688	0.326	5.242

LME 2007+2008 Night Area Statistics [#6105]

Area	TSS	THS	FBI	PCF	PCL	False	TCF Diff [%]
Nord	0.244	0.448	3.020	0.608	0.622	0.289	nV
Mid	0.228	0.460	2.633	0.578	0.639	0.294	nV
South	0.211	0.470	1.880	0.606	0.606	0.275	nV
DE	0.299	0.492	1.364	0.633	0.657	0.286	nV
LME	0.370	0.526	1.041	0.677	0.694	0.298	-0.833
Land	0.352	0.512	1.087	0.660	0.693	0.302	-2.417
Sea	0.383	0.539	0.998	0.696	0.688	0.292	1.527

the red color indicates the best values in contrast to Land/Sea and Day/night comparisons of the model area

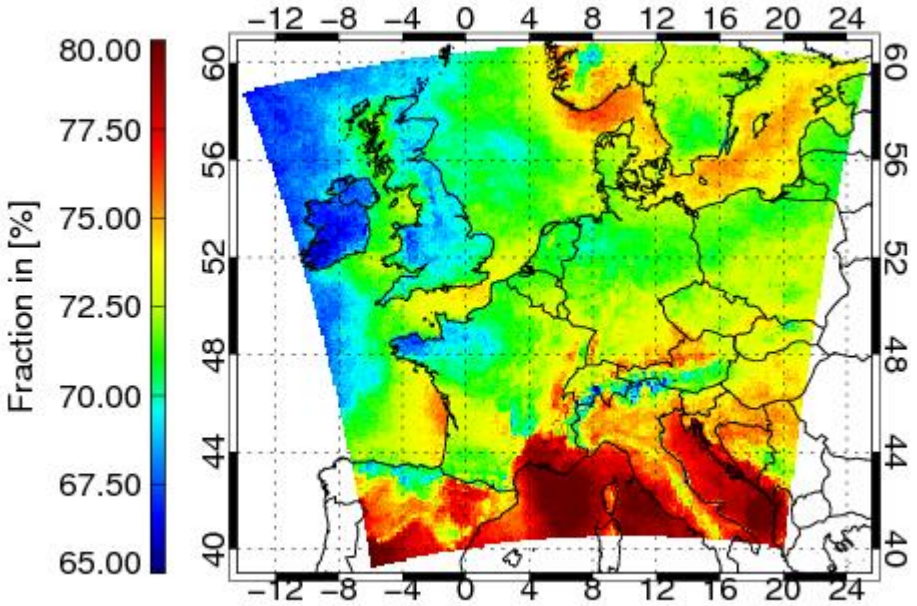
Area statistics and diurnal cycle summery

- COSMO-DE, COSMO-EU
  - Overestimating of clouds in the morning hours and the evening
  - Underestimating during noon
  - THS and TSS highest at noon
  - Lowest PCF in morning hours , highest after noon
  - Highest PCL in morning hours , lowest after noon
  - Diurnal cycle of cloud fraction is not well captured , peak at noon is missing more slided to the morning -> overestimating morning, underestimating at noon
  - Same features in for the different areas in Germany with a bit lower overestimation in southern Germany
- Overall best agreement with MSG at Daytime and over Land
- PCL in COSMO-DE higher than in COSMO-EU
- PCF in COSMO-DE lower than in COSMO-EU

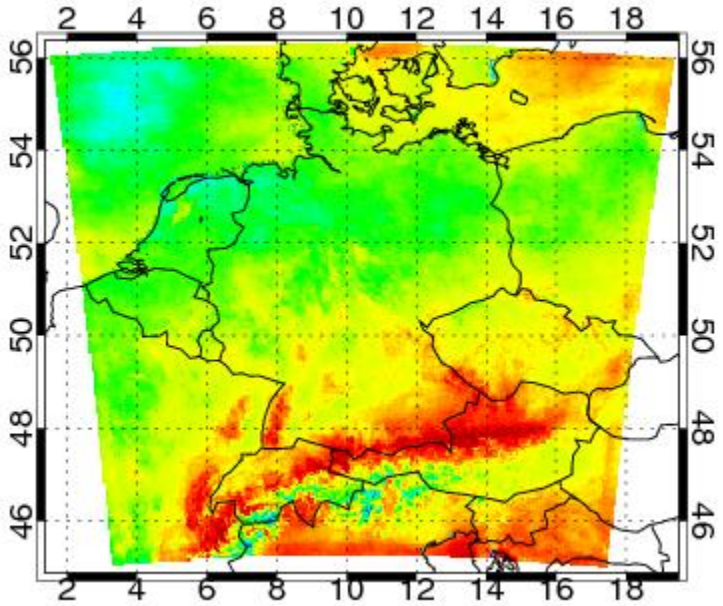
Agreements in classification 2007+2008

Model / MSG : neg. Hit + Hit classified pixel 2007+2008

COSMO-EU

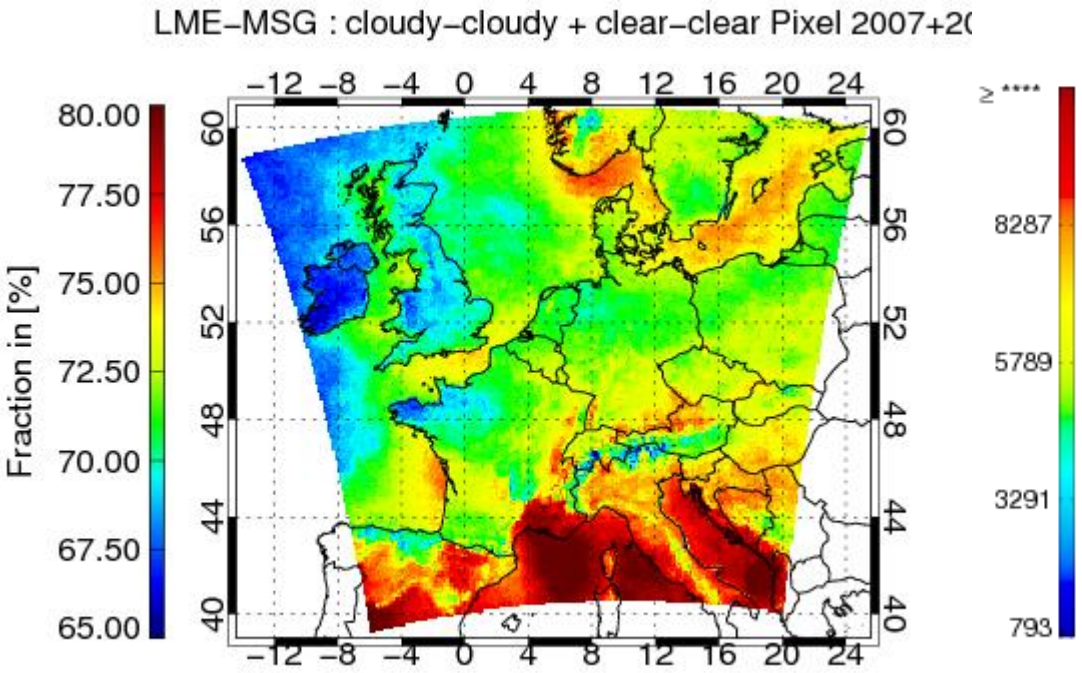


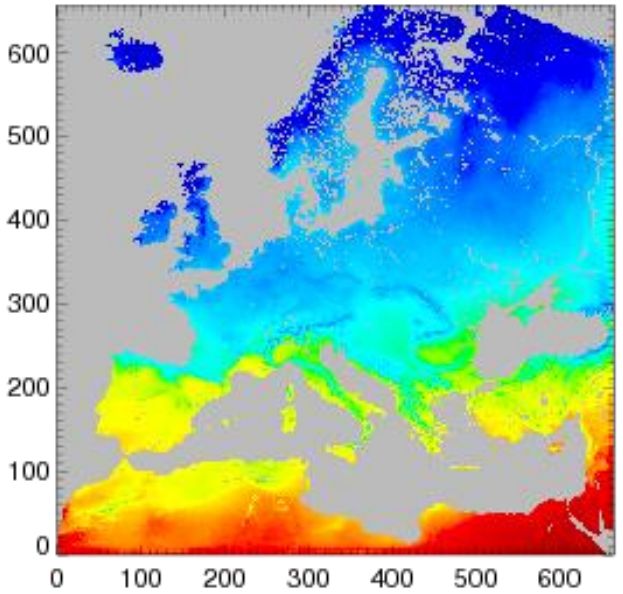
COSMO-DE



Threshold : 90 %
Above Threshold -> cloudy
Under Threshold -> clear

Best agreements are Biased to the areas with mostly clear sky at daytime

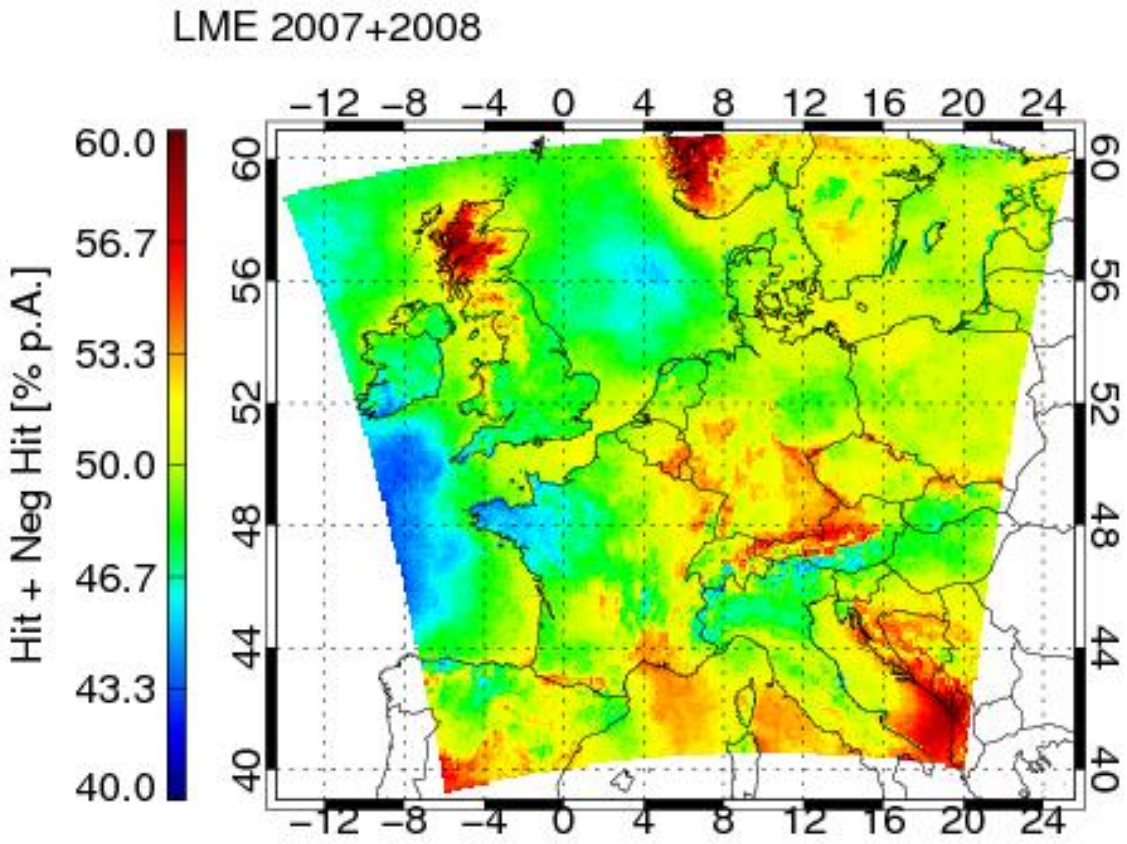




Number of cloud free observations (2005-2009) Of MSG SEVIRI . during daytime.

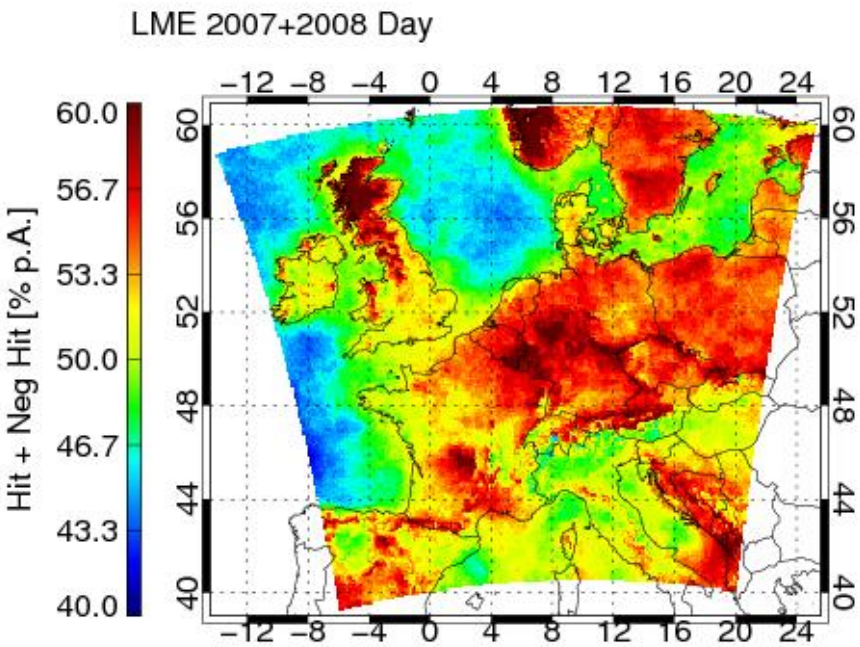
Picture R. Leinweber

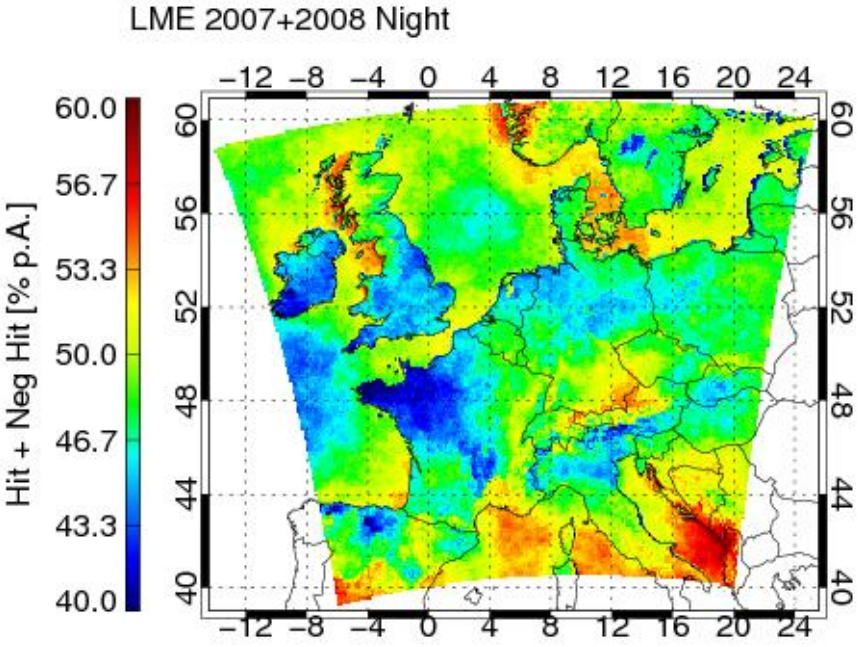
Allocation of COSMO-EU and MSG Agreements



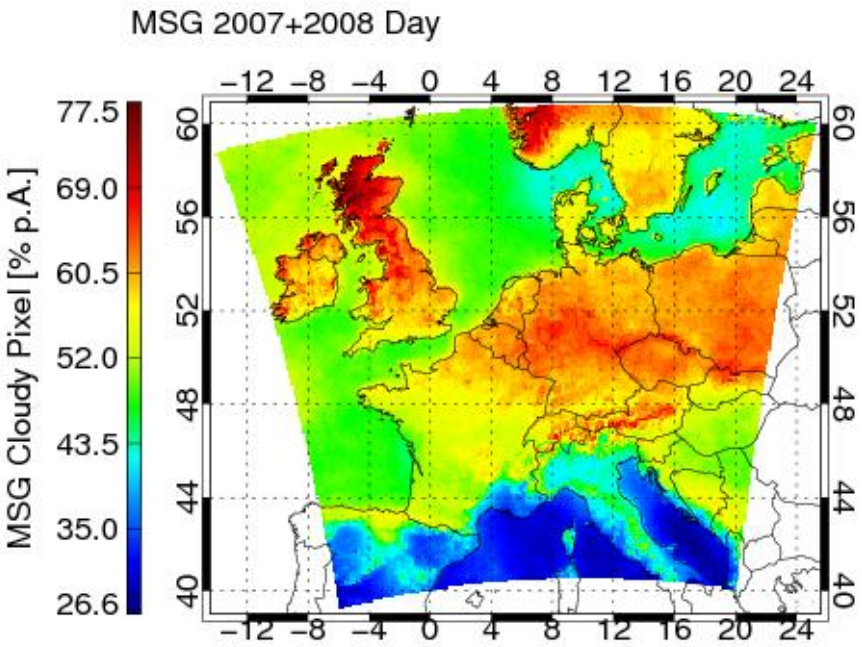
Hit : MSG and COSMO-EU greater than 90%
Neg Hit : MSG and COSMO-EU lower than 10 %

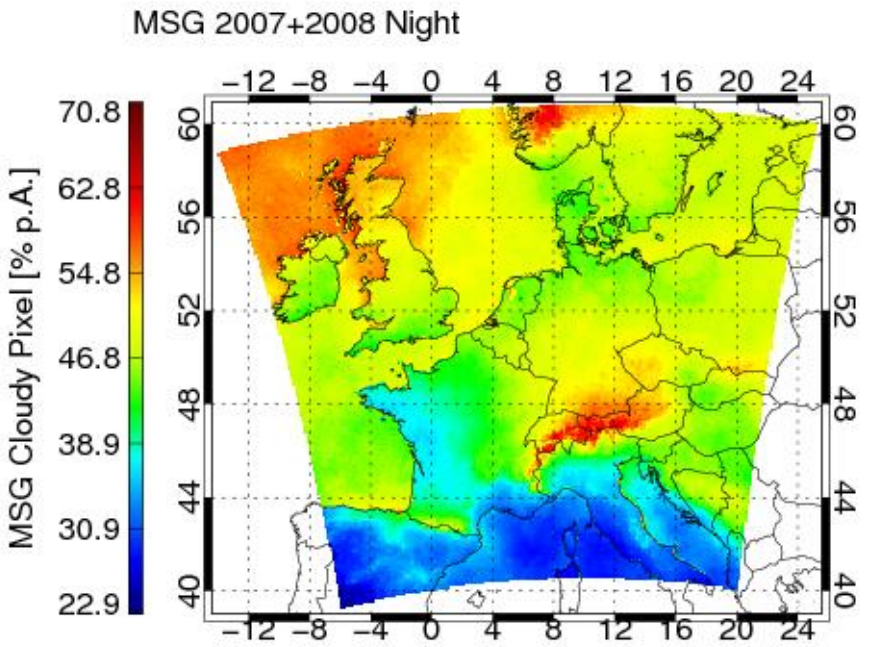
LME Day / Night Hit+Neg Hit allocation



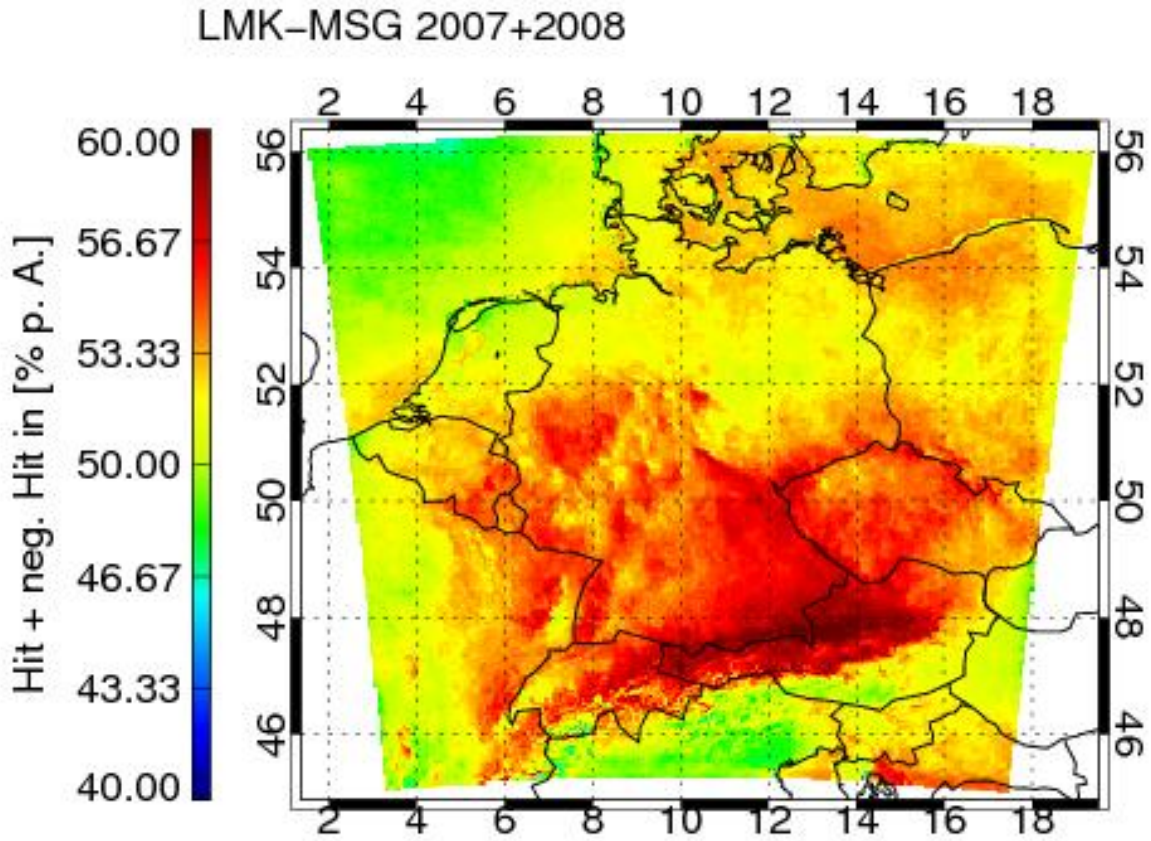


MSG allocation of cloudy classified Pixel

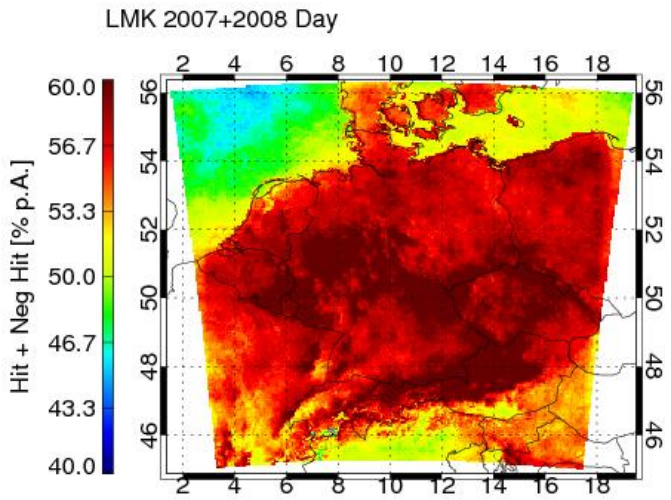


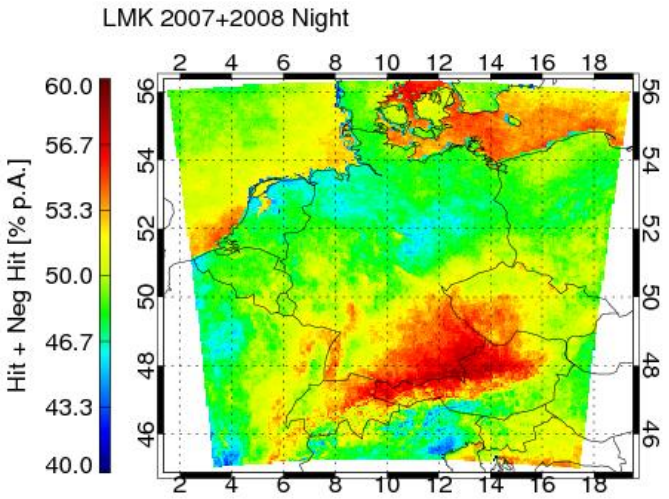


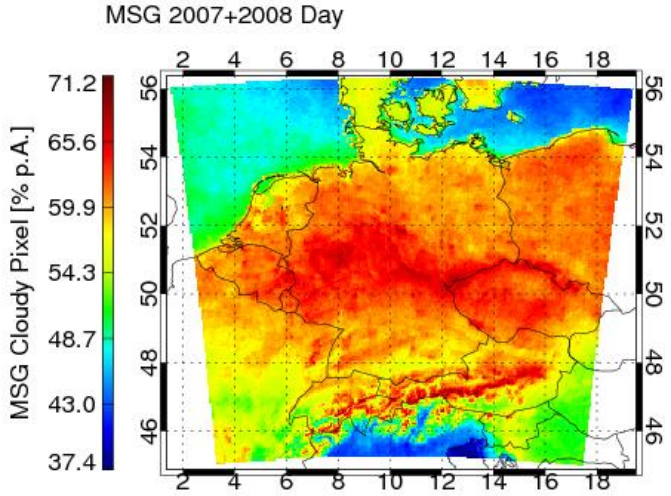
Allocation of COSMO-DE and MSG Agreements

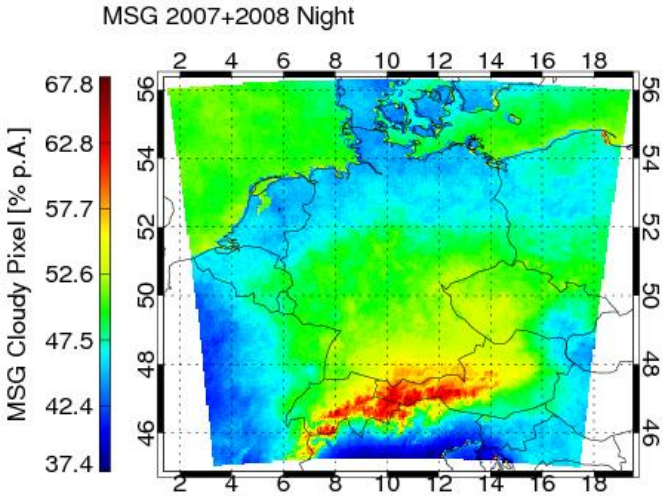


Allocation of COSMO-DE MSG Agreements Day / Night









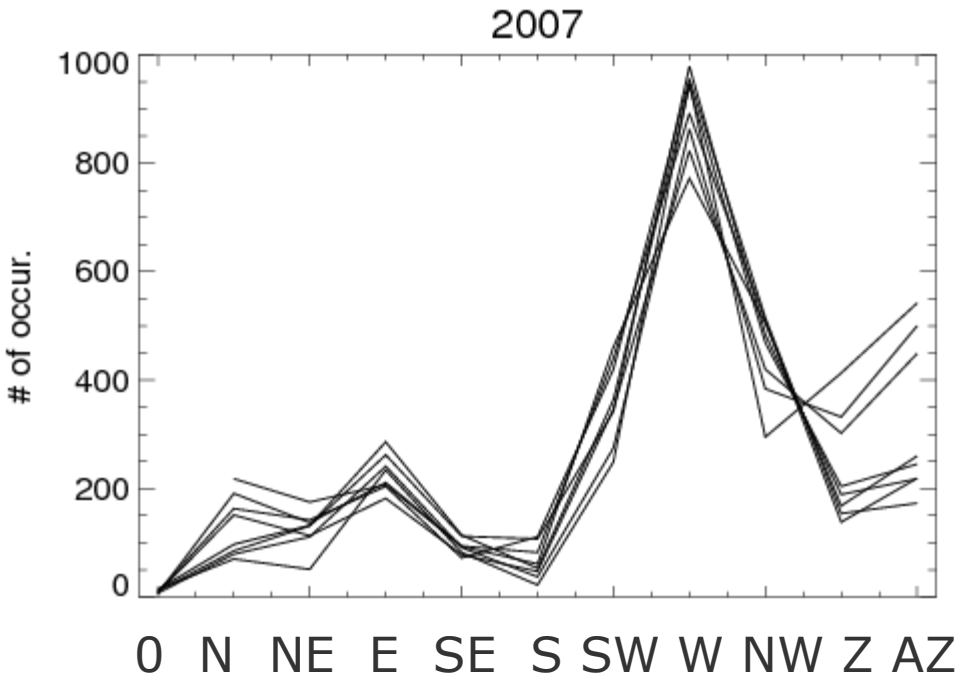
Summery

- Cloud Fraction :
  - COSMO-DE : overestimating of cloudy cases (mean over 2007+2008)
  - COSMO-EU : underestimating of cloudy cases (mean over 2007+2008)
  - Both : diurnal cycles show overestimating in morning hours and underestimating at noon
- Area statistics :
  - Best agreement at daytime over landsurfaces
    - Probability of correct cloudy cases forecast (DE/EU) 72%/70%
    - Probability of correct cloud free forecast (DE/EU) 67%/72 %
    - Underestimating of cloud cover at daytime and overestimating at nighttime
- Hit + neg Hit Maps
  - Strong Day/ Night dependence
  - Land /Sea dependence esp. -> due to MSG dependencies
  - Overall LMK/LME better Agreement in South Germany

Thank You

CIRCULATION CLASSIFICATIONS

Circulation Classifications



Mostly West winds

Statistics of Classification [T. Akkerman]

LMK-DE 2007 850 hPa Classification

Klassi	#	TSS	THS	FBI	PCF	PCL	TCF Diff [%]
0	6	0.451	0.417	0.929	0.777	0.573	-0.895
N	73	0.350	0.606	1.350	0.517	0.814	-6.035
NE	108	0.342	0.631	1.180	0.483	0.809	-4.121
E	232	0.329	0.454	1.350	0.684	0.657	-2.781
SE	88	0.243	0.224	1.002	0.847	0.360	0.153
S	34	0.223	0.333	1.039	0.744	0.476	4.667
SW	245	0.305	0.502	2.702	0.643	0.679	-1.047
W	782	0.279	0.602	1.340	0.482	0.780	-3.907
NW	370	0.328	0.581	1.253	0.482	0.790	-6.400
Zyk	318	0.301	0.593	1.178	0.550	0.749	-0.881
A-Zyk	474	0.315	0.446	3.231	0.676	0.640	-2.899

LME-DE 2007 850 hPa Classification

Klassi	#	TSS	THS	FBI	PCF	PCL	TCF Diff [%]
0	6	0.448	0.358	0.704	0.844	0.446	2.789
N	70	0.334	0.583	1.288	0.569	0.771	-0.554
NE	108	0.330	0.616	1.079	0.556	0.763	1.367
E	232	0.305	0.401	1.157	0.733	0.551	4.146
SE	89	0.300	0.200	0.777	0.865	0.299	3.406
S	34	0.251	0.322	0.841	0.805	0.433	5.176
SW	246	0.303	0.470	2.705	0.719	0.598	2.004
W	769	0.268	0.562	1.114	0.567	0.704	1.905
NW	358	0.303	0.551	1.150	0.556	0.729	0.193
Zyk	318	0.289	0.558	1.014	0.629	0.672	3.917
A-Zyk	462	0.301	0.420	2.249	0.717	0.580	2.119

Statistics of Classification [T. Akkerman]

LMK-DE 2007 500 hPa Classification

Klassi	#	TSS	THS	FBI	PCF	PCL	TCF Diff [%]
0	8	0.221	0.282	0.759	0.817	0.388	1.822
N	138	0.286	0.467	1.387	0.577	0.689	-6.088
NE	110	0.326	0.571	1.159	0.550	0.754	-2.276
E	180	0.293	0.456	1.313	0.645	0.651	-3.441
SE	74	0.305	0.458	1.085	0.682	0.600	-0.643
S	45	0.282	0.498	1.057	0.582	0.667	-1.428
SW	315	0.334	0.577	1.249	0.565	0.768	-3.937
W	731	0.280	0.581	1.836	0.516	0.754	-2.586
NW	404	0.314	0.557	1.215	0.532	0.745	-4.588
Zyk	288	0.300	0.505	1.197	0.623	0.675	-0.738
A-Zyk	437	0.323	0.493	3.402	0.623	0.686	-3.877

LME-DE 2007 500 hPa Classification

Klassi	#	TSS	THS	FBI	PCF	PCL	TCF Diff [%]
0	7	0.138	0.165	0.509	0.910	0.225	7.408
N	136	0.266	0.452	1.457	0.610	0.658	-2.141
NE	110	0.326	0.560	1.087	0.597	0.722	2.727
E	180	0.299	0.424	1.092	0.690	0.575	3.447
SE	75	0.303	0.427	0.876	0.748	0.522	3.479
S	45	0.257	0.436	0.908	0.668	0.567	2.814
SW	311	0.301	0.523	1.015	0.661	0.657	2.216
W	724	0.280	0.548	1.684	0.599	0.686	2.803
NW	390	0.296	0.530	1.094	0.598	0.685	0.489
Zyk	287	0.294	0.466	1.009	0.688	0.591	4.051
A-Zyk	427	0.306	0.458	2.336	0.675	0.616	1.585