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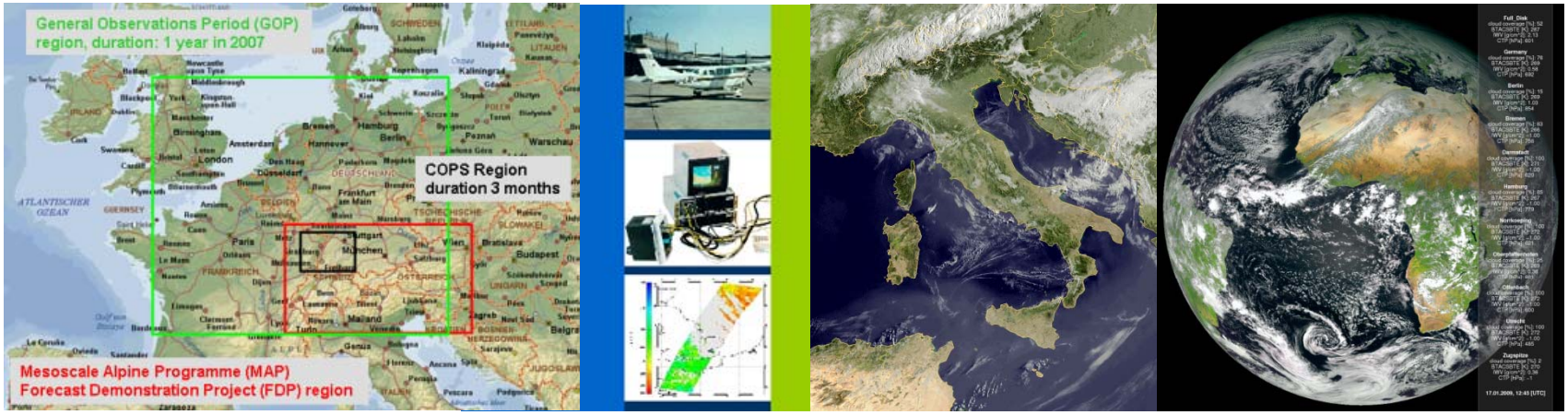

Long Term Evaluation of the diurnal cycle of COSMO DE/EU with Meteosat Second Generation (MSG)

Stefan Stapelberg (FUB), Prof. Dr. Jürgen Fischer (FUB), Tim Böhme (KUL)
Tom Akkermans (KUL), Thorsten Rheinhardt (IGMK), Christoph Selbach (IGMK)
+ QUEST Team

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Long-term evaluation of water cycle variables

- Analysis of the process chain from the water vapor to surface precipitation
- Use of ground-based networks
  - GPS (integrated water vapor IWV)
  - RANIE (gauge/radar precipitation)
  - ceilometers (cloud base height CBH)
- METEOSAT Second Generation (MSG) SEVIRI instrument provides high spatial and temporal resolution information
- SEVIRI products like cloud mask (CM), cloud top pressure (CTP)

MSG View

[81W,81S,81E,81N]

SEVIRI (instrument) Data

Spinning Enhanced Visible and Infrared Imager

- scan rate : 15-min repeat
- channels : 4 VIS, 8 IR
- resolution : 3km (1km HRV) at SSP

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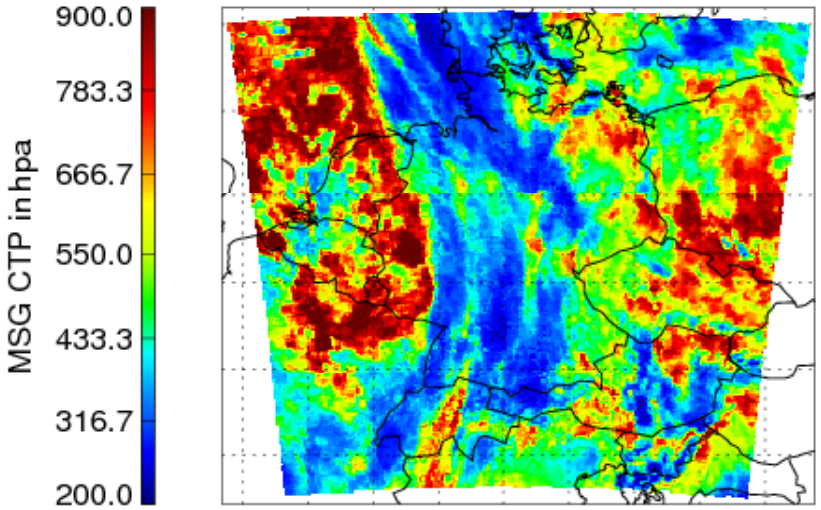
Cloud Top Pressure (CTP)

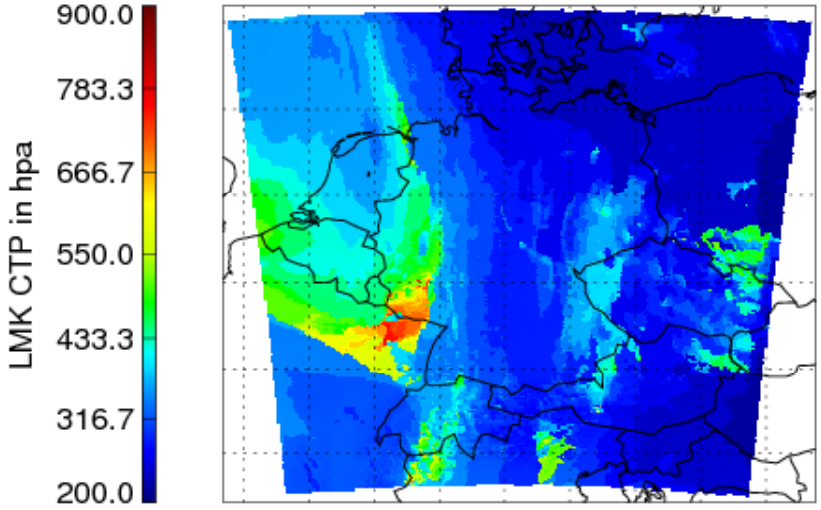
MSG

2008/01/05 12:00UTC



COSMO-DE

2008/01/05 12:00UTC



Why does COSMO-DE show so many clouds at low CTP (high altitude)?

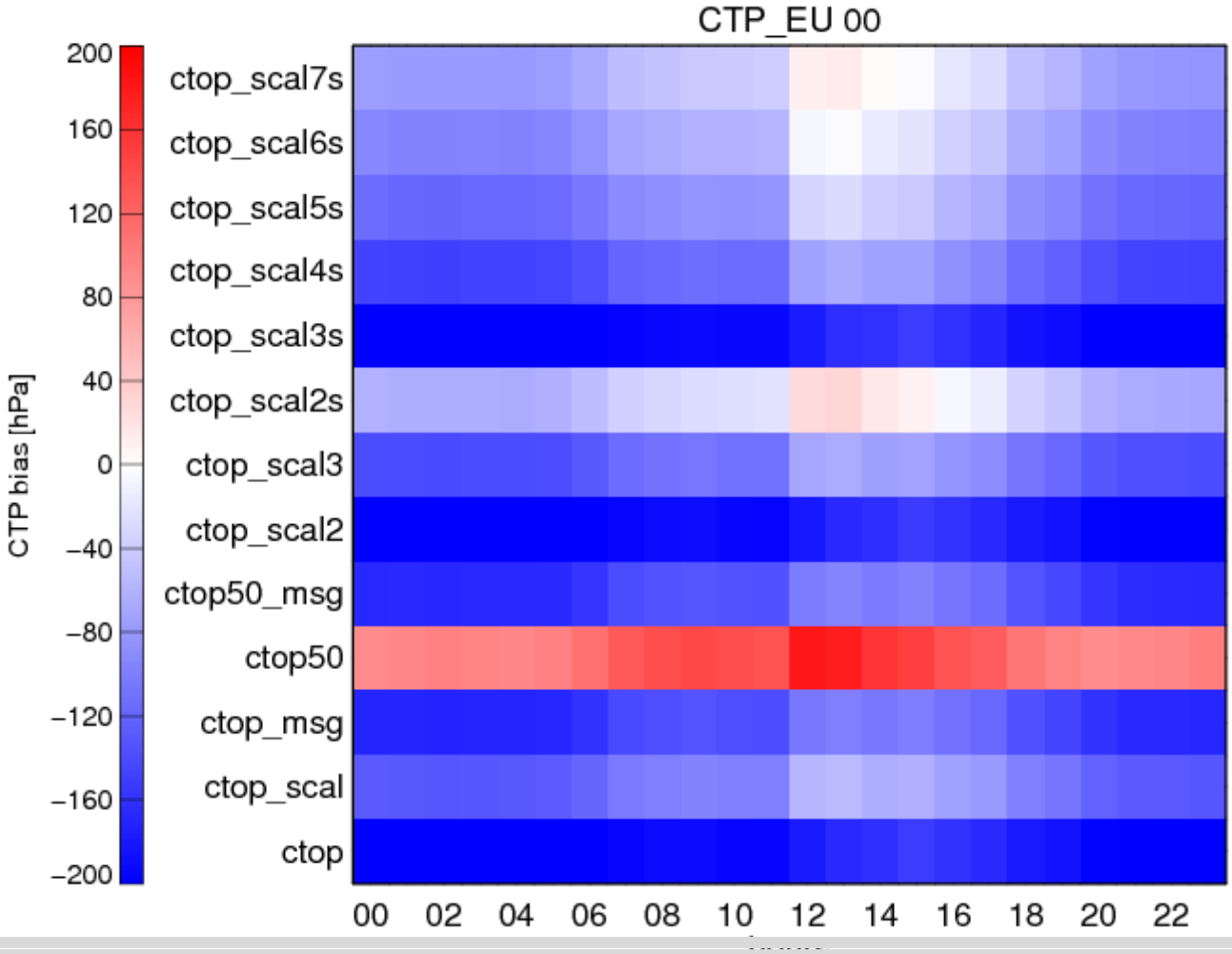
CTP is not a direct model variable but has to be derived from cloud cover, cloud ice & water and snow using thresholds

Mean CTP Bias (Model-Obs) May 2008

13 different methods to derive CTP from COSMO-EU output

Worst result using only cloud cover

Best results for grid scale clouds with additional thresholds for snow and ice mass mixing ratio



➔ better use better constrained variables (i.e., BT) in long-term evaluation

Brightness Temperatures and Sensitivities

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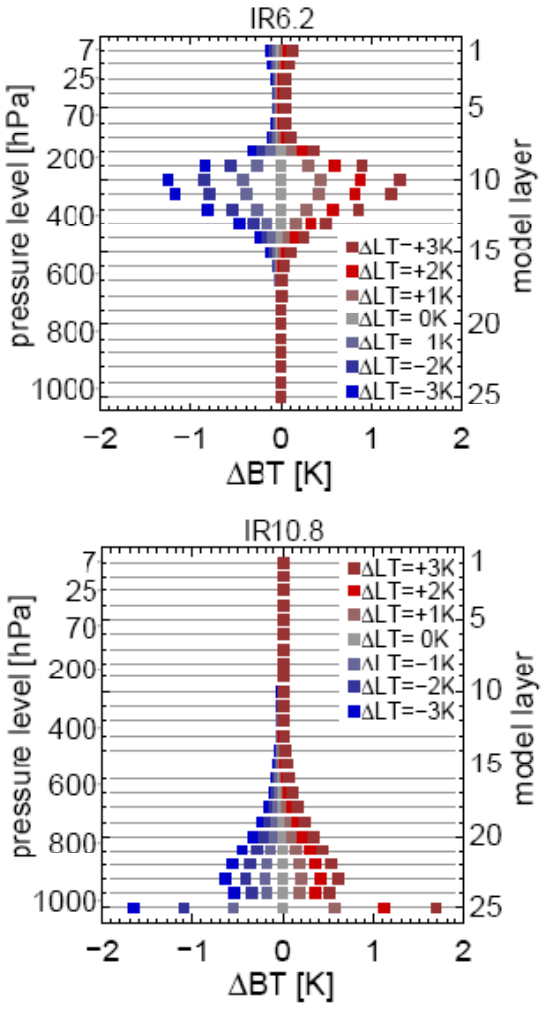
brightness temperatures (BT)

Gas absorption takes place at different wavelength, higher Brightness temperature values can be related to less absorption.

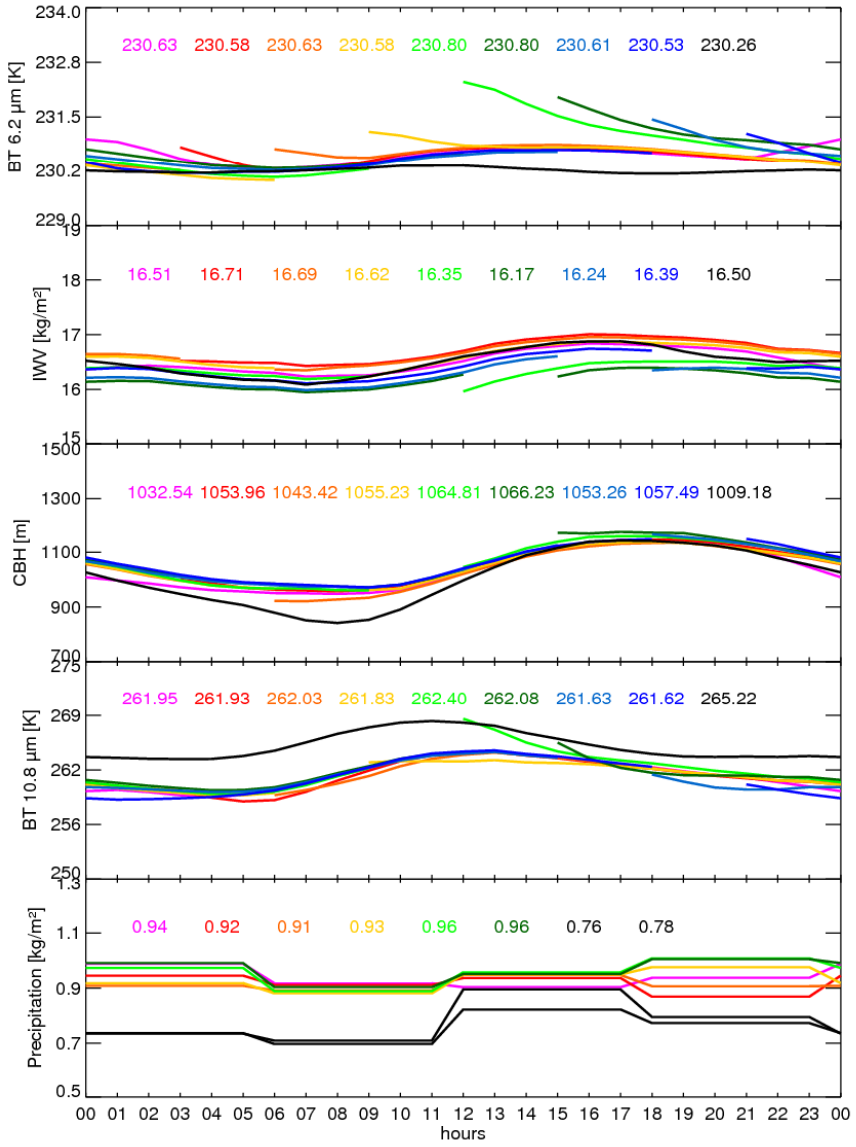
Examples :
- Water Vapor absorption at 6.2 µm
  - sensitive to middle and higher layers
  - increase of H_2O leads to a BT decrease
- Cloud/Surface Detection at 10.8 µm
  - sensitive to lower troposphere layers
  - higher Temperatures indicates lower clouds or no clouds



images: M.Stengel, diploma thesis

EXAMPLARY RESULTS

COSMO-DE +12h water cycle diurnal cycle



BT062 – strong spin up phases low bias

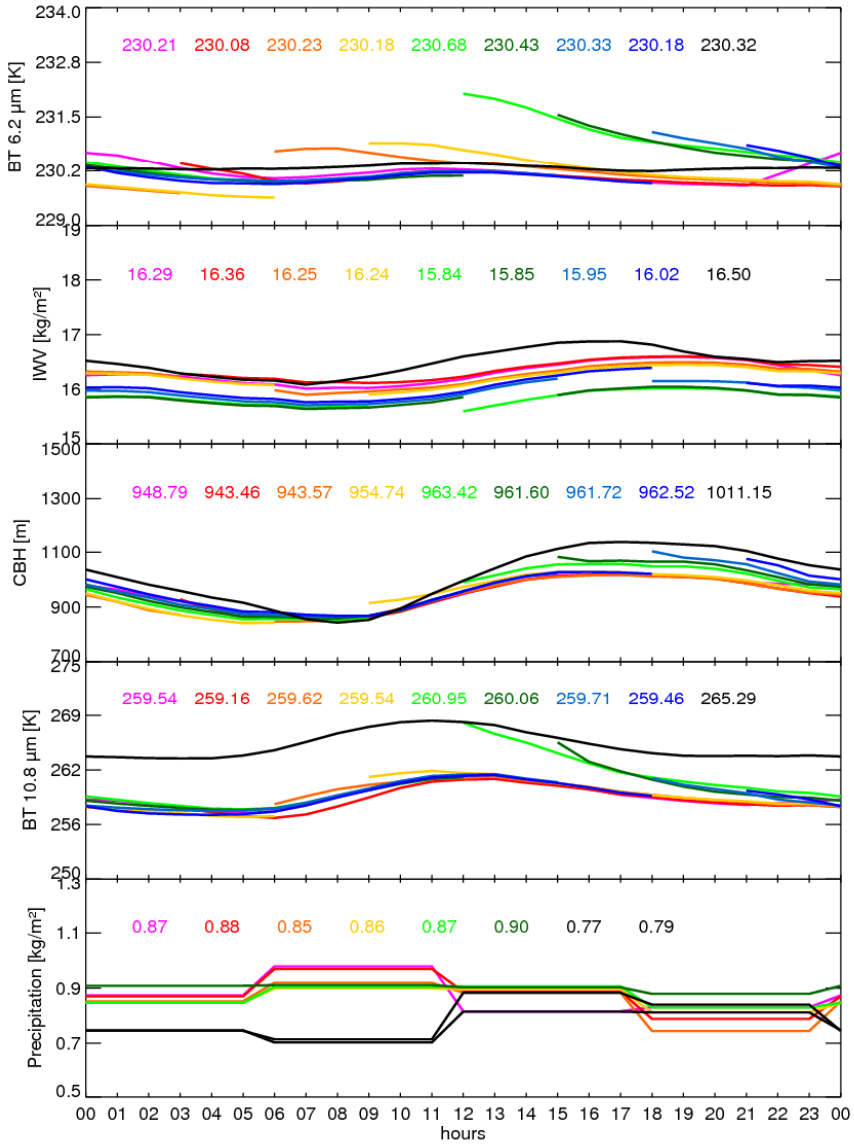
IWV – good correlation / low bias

CBH – Morning hours over – estimated -> fog ?

BT108 – higher cloud height and cover phase shift -> later Surface heating caused by high Nocturnal cloud cover

Ranie 1/2 – overestimating of the morning hours not much variation Over the day

COSMO-EU+12h water cycle diurnal cycle



BT062 – strong spin up phases low bias

IWV – low dry bias

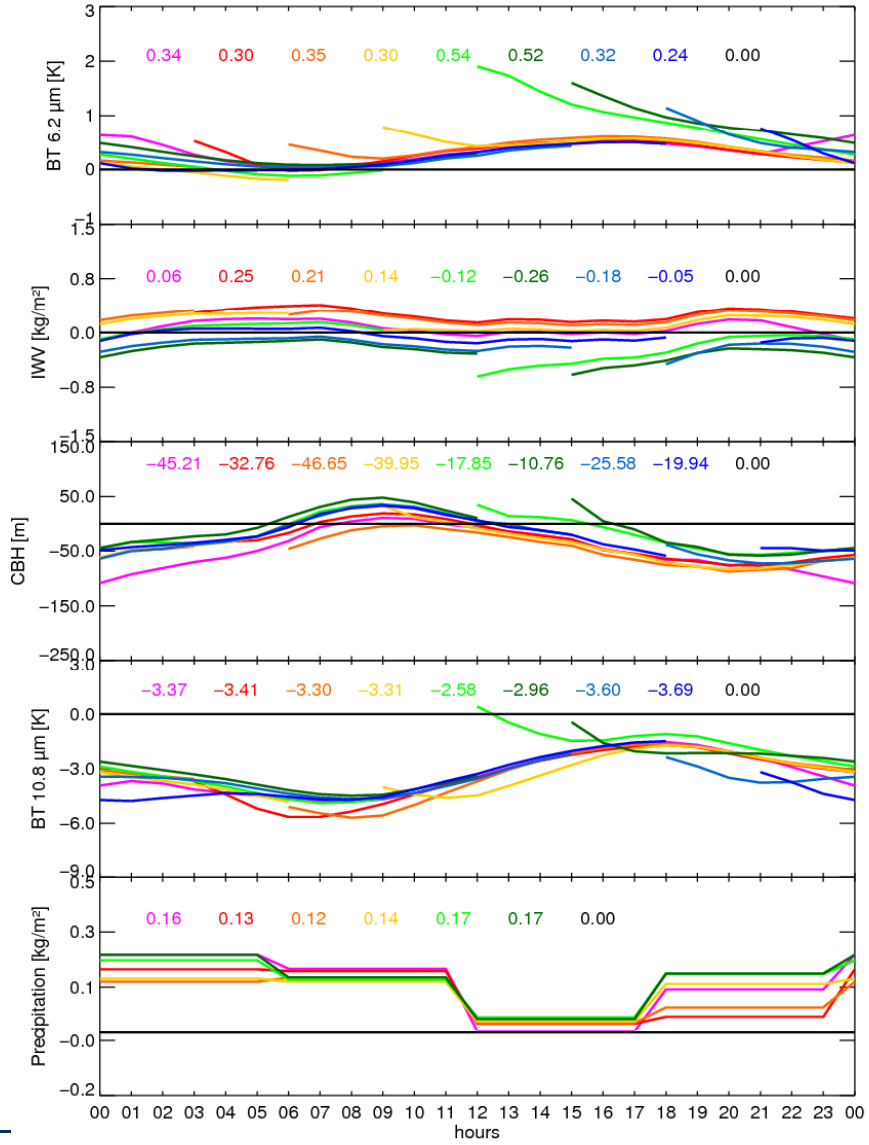
CBH – Afternoon hours under – estimated

Possible reasons for Bias (4K) error in

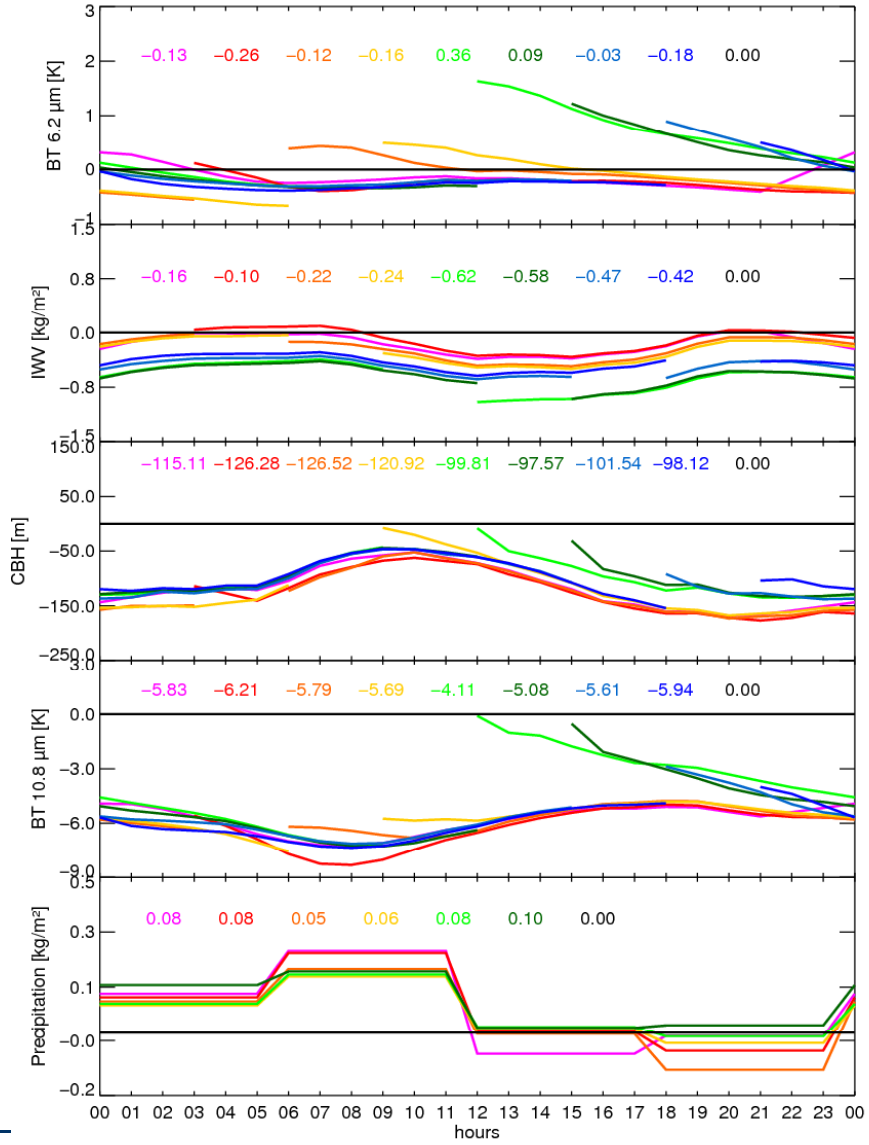
- **cloud fraction in COSMO is too high**
  - ➔ too low fraction of warm surface BTs
- clouds are positioned too high (to cold)

Ranie 1/2 – overestimating of the morning hours not much variation Over the day

COSMO-DE Bias

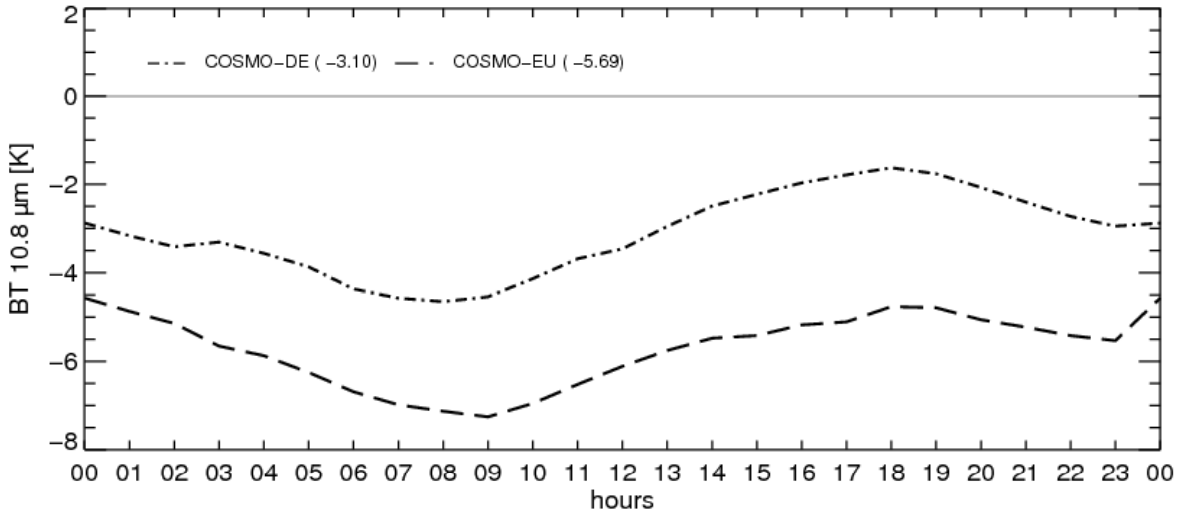


COSMO-EU Bias

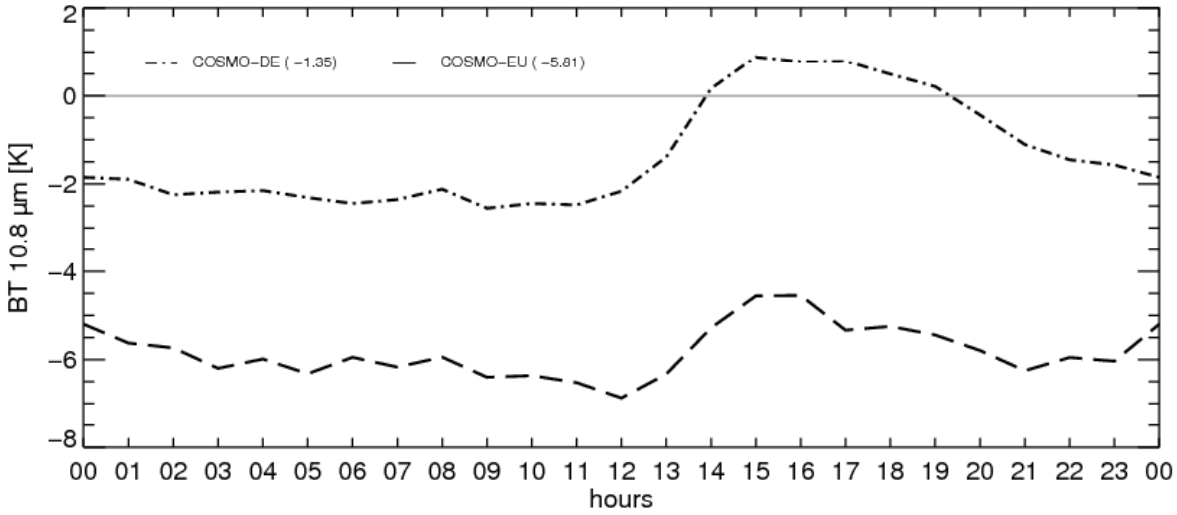


Bt108 Bias all pixel vs. cloudy pixel

Bias cloudy+clear pixel



Bias cloudy pixel; MSG/COSMO: 99% prob/CLC



Since the allover bias (top) includes informations about cloud cover as well as cloud top height the difference in bias values for COSMO-DE show a strong hint for over-estimation of cloud height and cloud cover.
The bias for COSMO-EU does not differ that much which indicates that COSMO-EU overestimates mainly the cloud height.

FBI Over- / Underestimating of cloud occurrence

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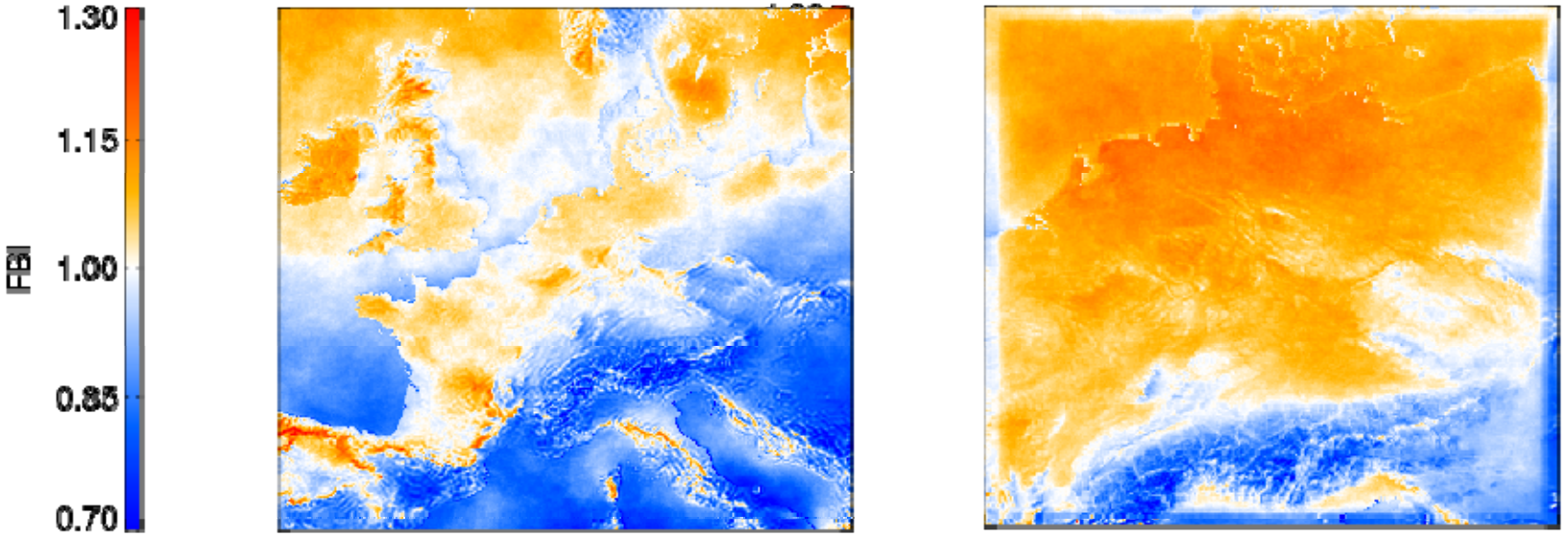
COSMO – EU

COSMO - DE

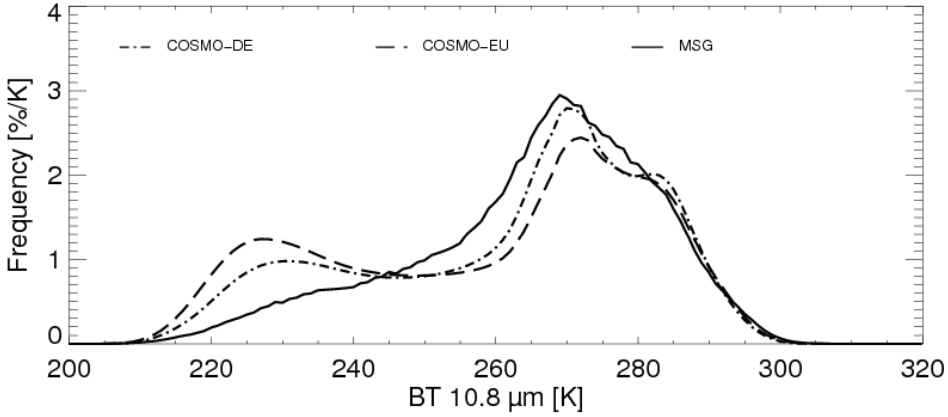


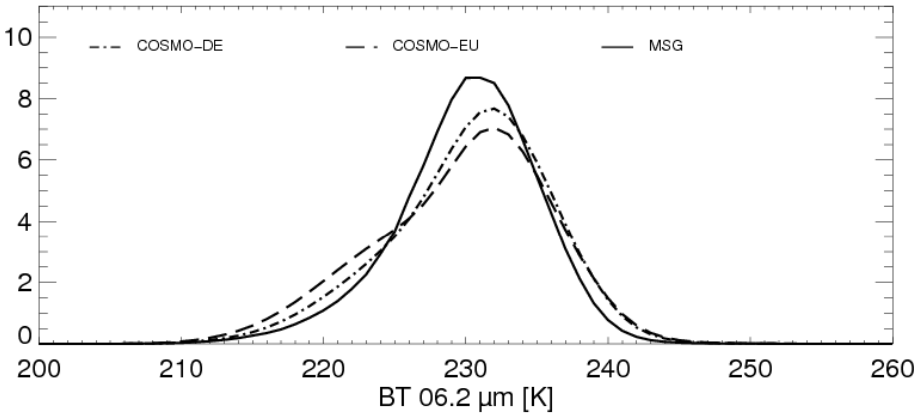
Lower TSS scores mainly due to Cloud Occurrence overestimating of the Model

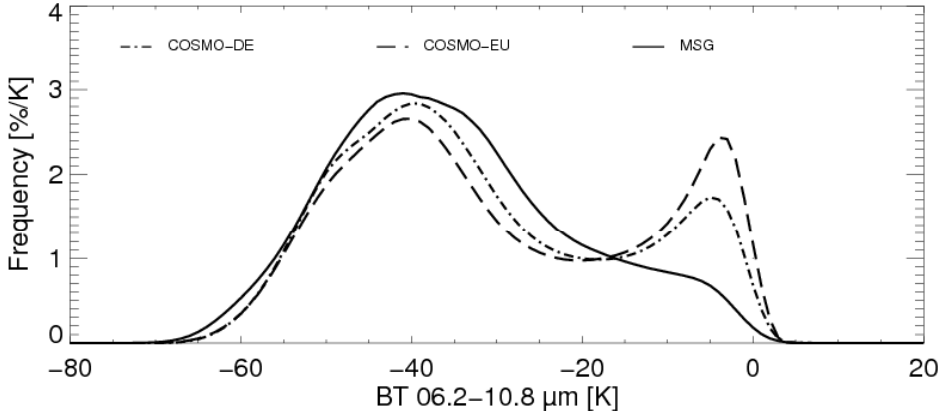
COSMO – DE shows a stronger overestimating over north - and Baltic sea but less Land/SEA dependencies

Catchment area of the NW storms in North Germany is mainly overestimated

Frequency Plots







Frequency:
BT062 indicates a in general dryer upper troposphere
BT108 too much high clouds with BT‘s around 230K for both models
BT062-BT108 : low diff indicate occurrence of high clouds. Both models show a more significant peak
At low temperature differences. -> too much high clouds

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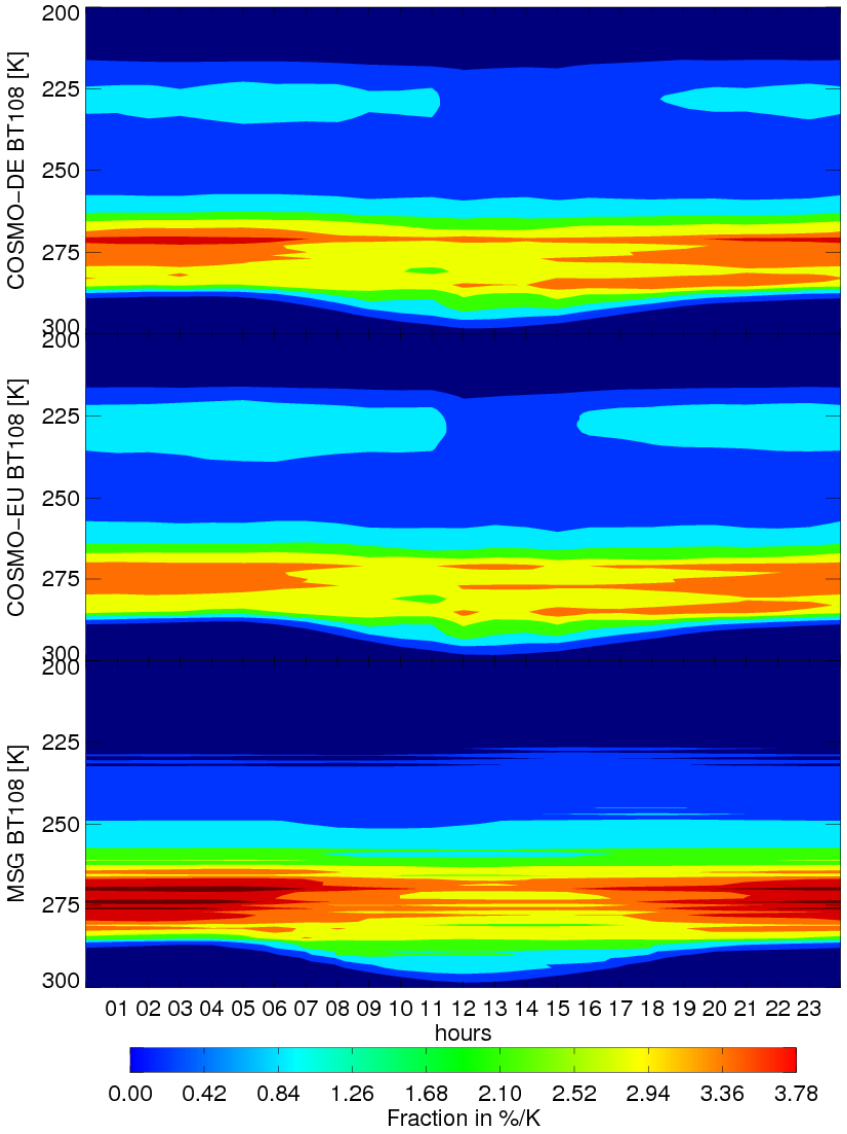
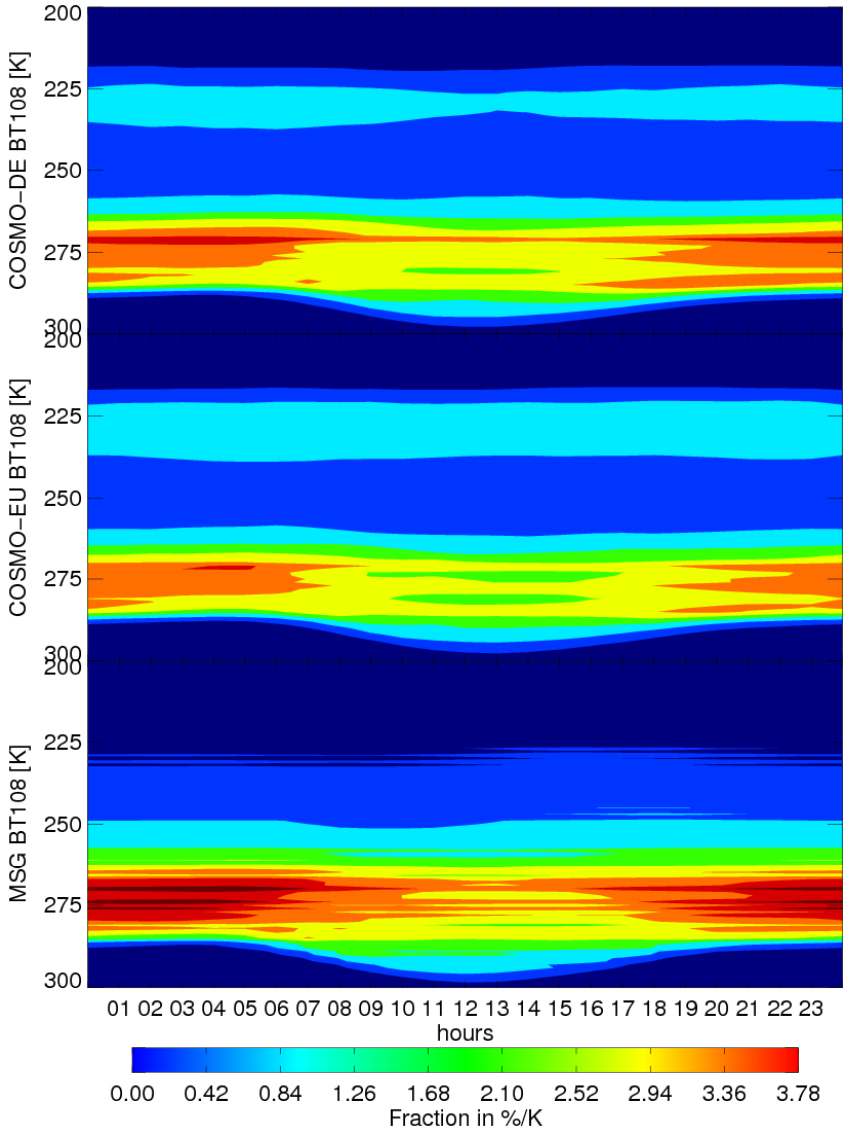
COSMO+00h



COSMO+12h

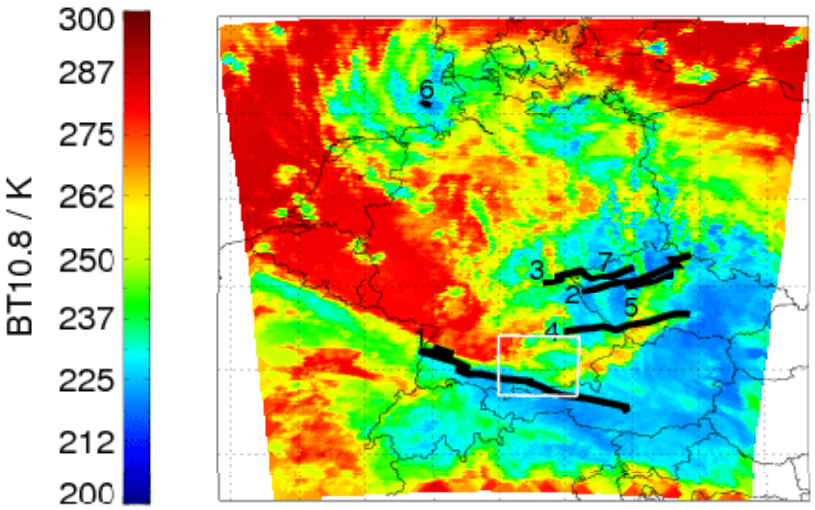


How to make sure that only cloudy pixels are compared?
➔ no sub pixel cloudiness

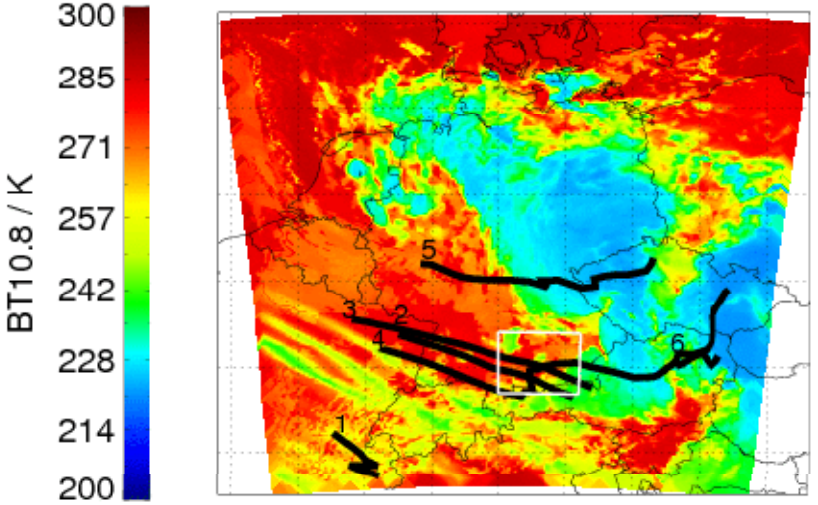
Exploit MSG high resolution via tracking of convective systems in observation and model

Example: 28.8. 2006

MSG



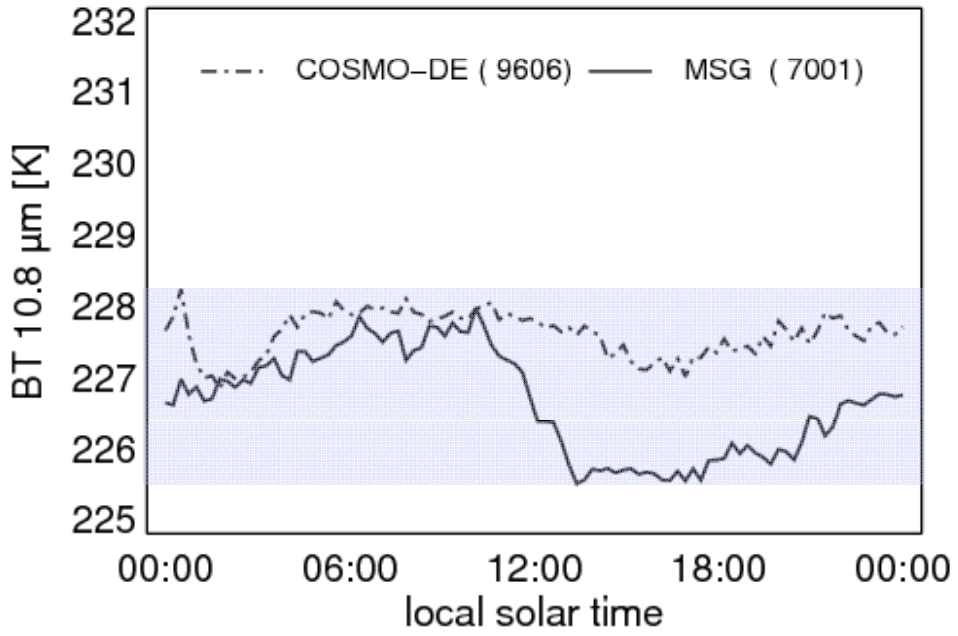
COSMO-DE



Mean diurnal cycle of BT108 brightness temperatures of all tracked clouds during COPS period 2007 for MSG and COSMO-DE.

Missing diurnal cycle for convective cores in model

➔ coldest temperatures around 17 UTC and amplitude of about 2 K



Tracking COSMO-DE 2007 / 2008 / 2009

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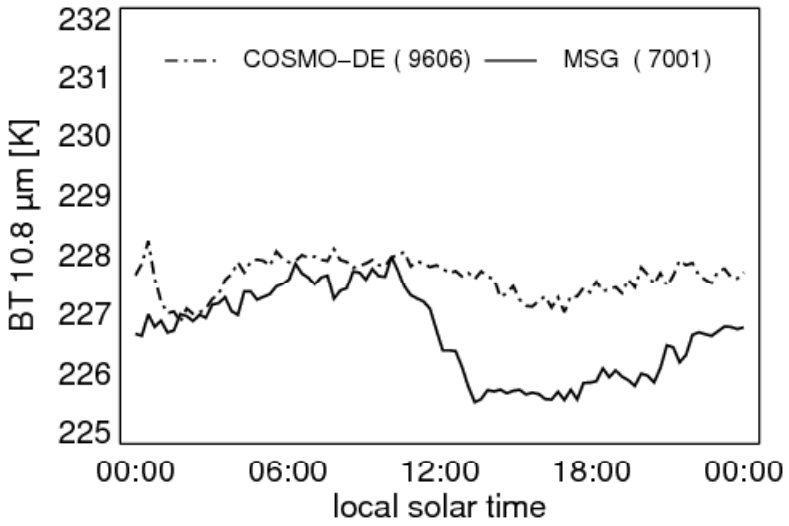
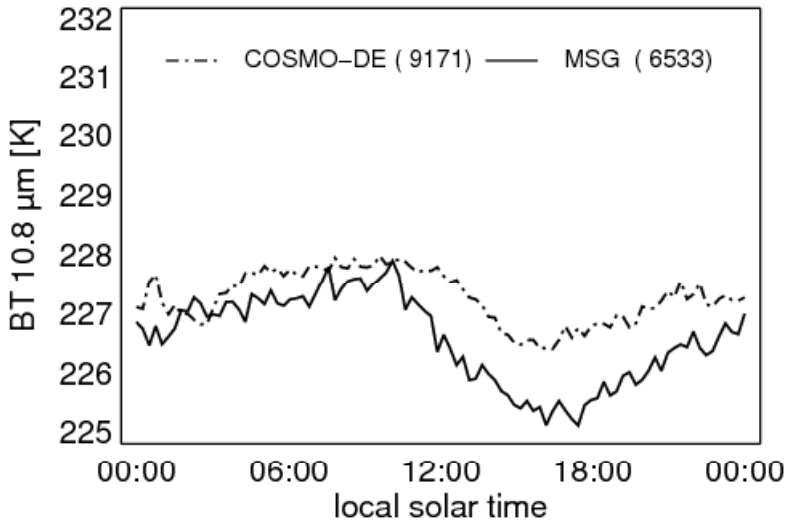
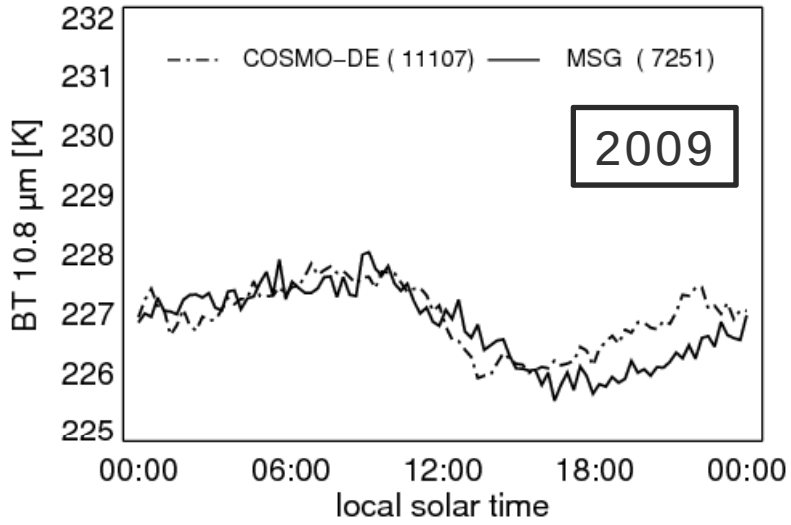
2007



2008



Cosmo-DE produce too much clouds and dismisses dynamically cloud ascending during the day in 2007. Better agreements in cloud height and dynamic observed in 2008 and 2009. Modifications of boundary layer parameterizations and latent heat nudging assimilation were introduced to COSMO-DE.



Summary

Clouds :

Cloud height is mainly overestimated by both models, especially at morning.

COSMO-EU overestimates mainly the cloud height

COSMO-DE overestimates cloud height and cloud cover.

Phase shift observed in the diurnal cycle is probably caused by too late surface heating caused by too high cloud cover in the morning.

Mainly high clouds reaching tropopause are overestimated.

COSMO-DE CBH is overestimated in the morning, indicating the occurrence of fog that is not seen in the model.

The CBH in COSMO-EU is generally lower than in COSMO-DE.

Similarities in the bias between CBH and BT108 are observed. Times with highest neg. BT108 bias correspond to CBH overestimation in COSMO-DE.

Cloud tracking COSMO-DE:

Significantly more clouds are tracked, dynamically cloud ascending missed 2007.

Better agreements for the years 2008 and 2009; modifications of boundary layer parameterizations and latent heat nudging assimilation were introduced to COSMO-DE.

Summary and outlook

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Water vapor IWV+BT062:

Water vapor is a well forecasted quantity.

COSMO-DE show good agreements with GPS IWV and BT062.

COSMO-EU dry bias especially hours around noon are underestimated.

Strong spin up features for both models, especially in BT062

Frequency of BT062 indicates a dryer upper troposphere for both models.

Precipitation RANIE 1/2:

Models show too much precipitation during the night and in the morning hours.
Highest uncertainties at night;high variability between the different model starts.
Main overestimation from 6-12 UTC in both models correspond to highest cloud cover bias.

Next steps for paper:

- Sensitivity studies with RTTOV
- Synsat input
- Land and Sea surface process studies

Thank You

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COMPARISONS WITH FUB CLOUD MASK

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

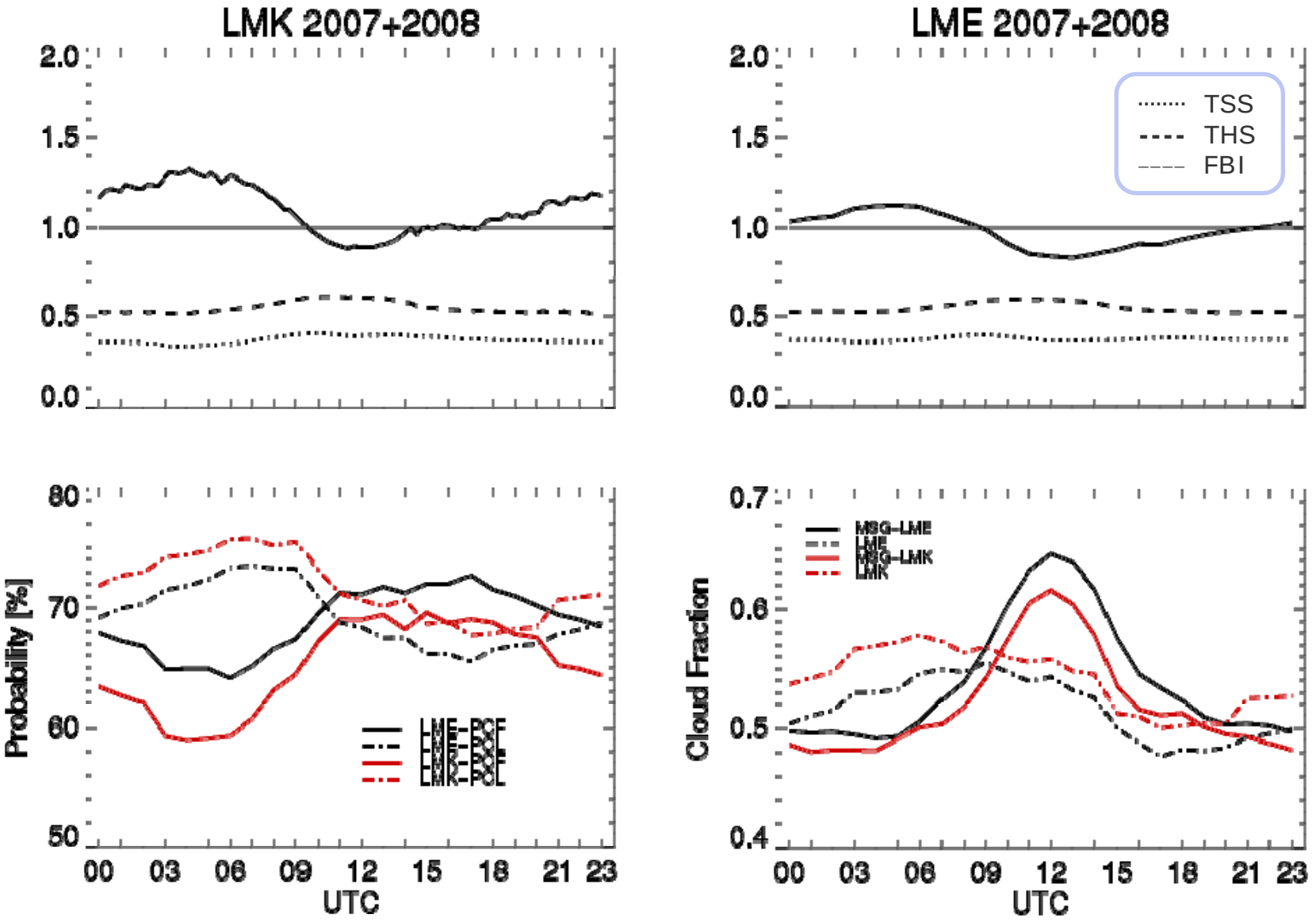
False [(b + c) / N_{pix}] : Ratio of misses and false alarm cases

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)

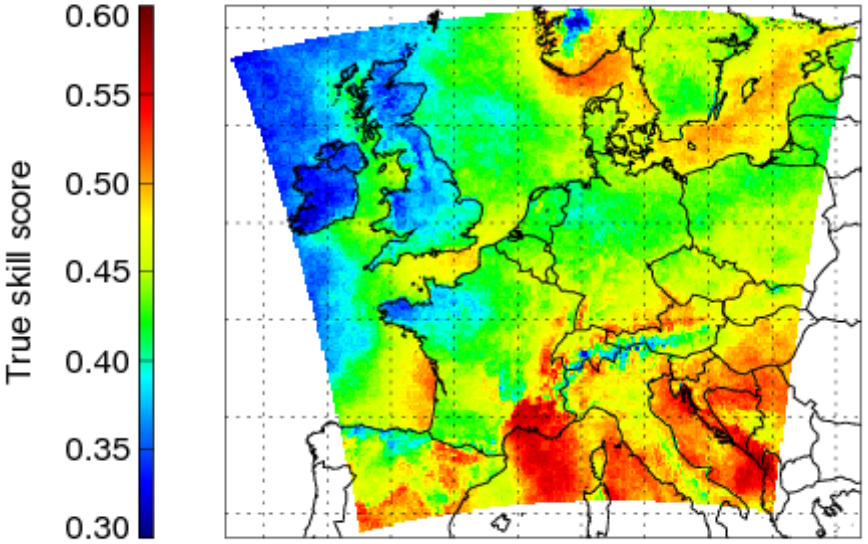
Diurnal Cycle 2007 + 2008



True Skill Score

COSMO – EU

COSMO - DE



FBI Over- / Underestimating of cloud occurrence

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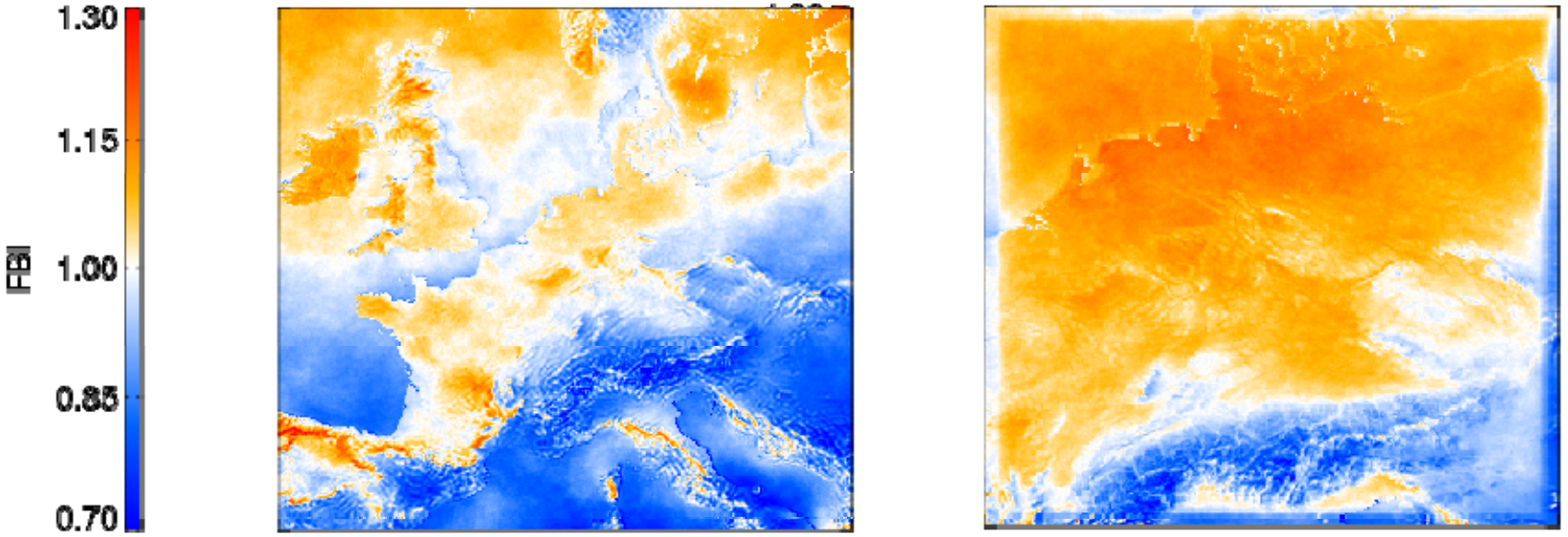
COSMO – EU

COSMO - DE



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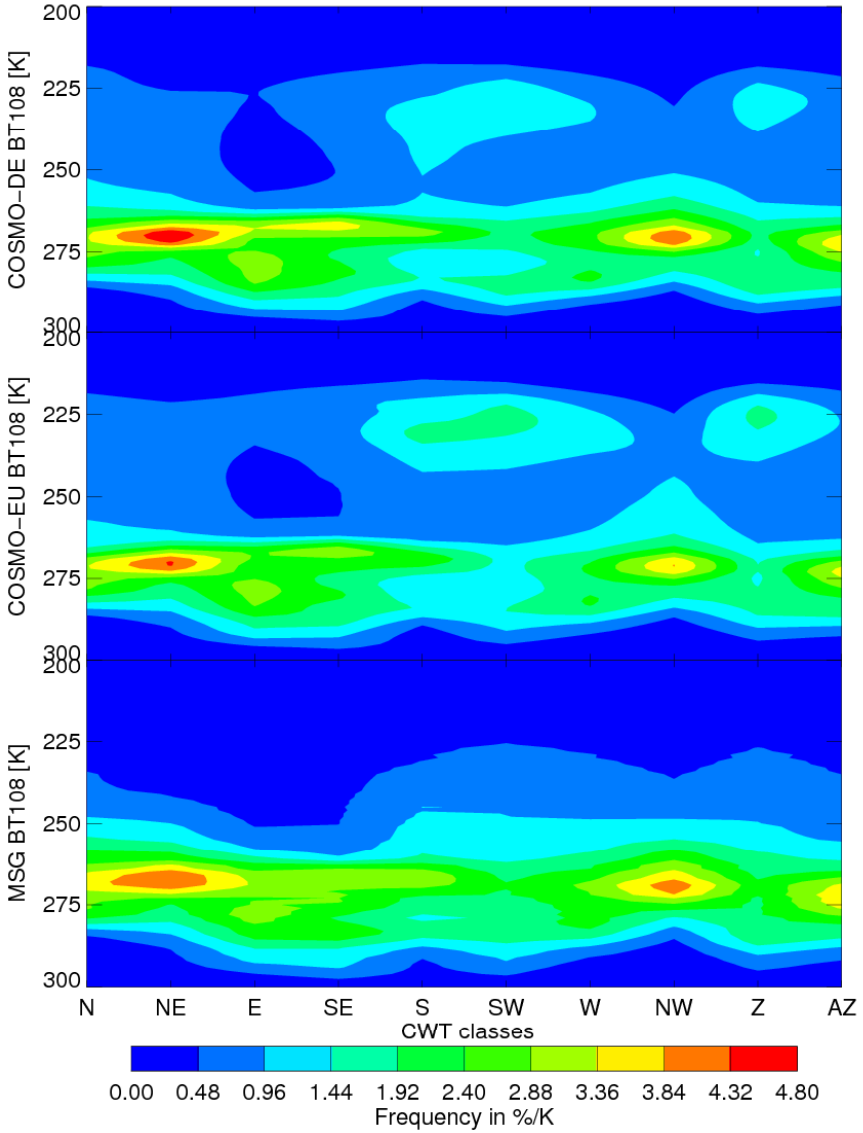
COSMO–DE BT108 [K]
COSMO–EU BT108 [K]
MSG BT108 [K]
200
225
250
275
300
N
NE
E
SE
S
SW
W
NW
Z
AZ
CWT classes
0.00 0.48 0.96 1.44 1.92 2.40 2.88 3.36 3.84 4.32 4.80
Frequency in %/K