Finale QUEST meeting at DWD in Offenbach, 20.10.-21.10.2010

Long-term evaluation of COSMO forecasting using combined observational data of the GOP period

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Content:

- QUEST project
- Observations → ***G****eneral* ***O****bservation* ***P****eriod* (GOP)
- Instrumentation
- COSMO model
- Long-term analysis:
  - Time series
  - Temperature spectra
  - Weather classification analysis
- Summary
- Outlook

QUEST project:

- ***Qu**antitative **E**valuation of Regional Precipitation Forecasts Using Multi-Dimensional Remote **S**ensing Observa**t**ions*

- Joint project within the **priority program SPP 1167** granted by the German Research Community (DFG)

- Objectives:
  - Establish a **data base of quality controlled ground-based and satellite remote sensing observations** matched with COSMO model simulations
  - Develop a set of forward **modelling tools** to simulate as completely and as accurately as possible the multi-dimensional observations from model output
  - Use data from field experiments (e.g. COPS) to **investigate the process chain** from **water vapour to precipitation** at the ground
  - Perform a **long-term (GOP) evaluation of COSMO model forecasts** using the observation-to-model and model-to-observation approaches

- Project time from 2007 to 2010 (DFG project)

Observations:

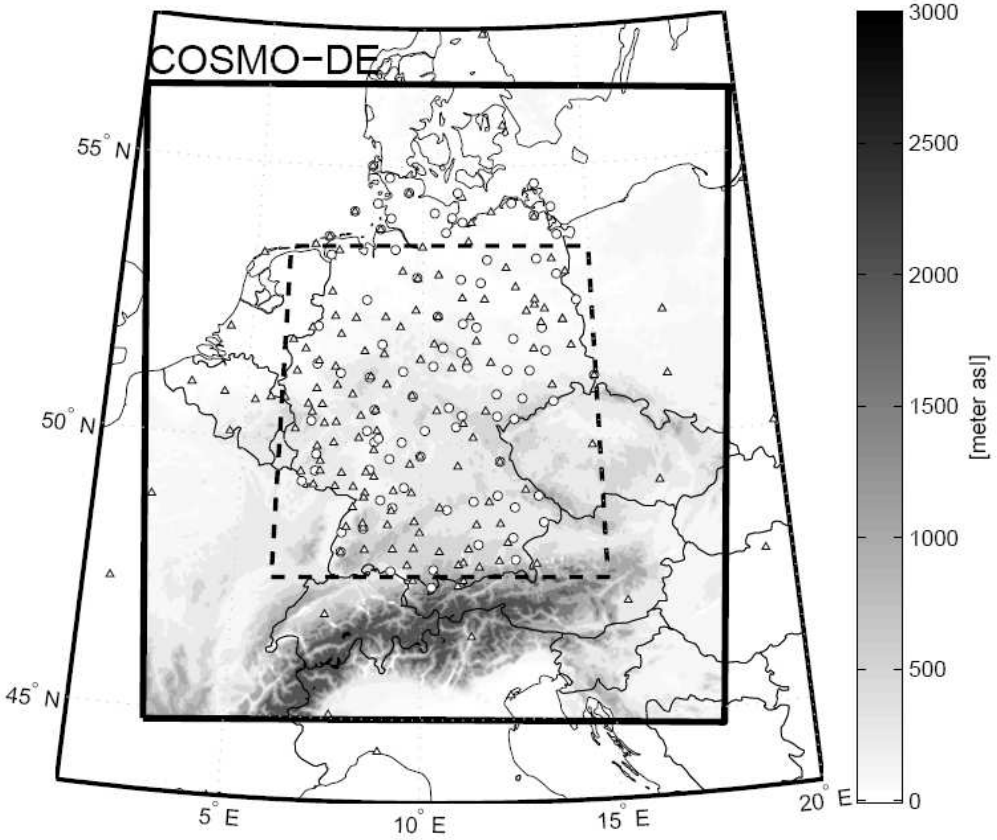
- GPS → Integrated water vapour (IWV)
- Ceilometer → Cloud base height (CBH)
- Satellite (MSG) → Brightness temperature (BT), different channels
- Ground observations
  + radar → Precipitation amount

Observations – **IWV + CBH:**

GPS- (circles) and ceilometer (triangles) network

——— COSMO-DE domain

– – – – satellite (MSG) data

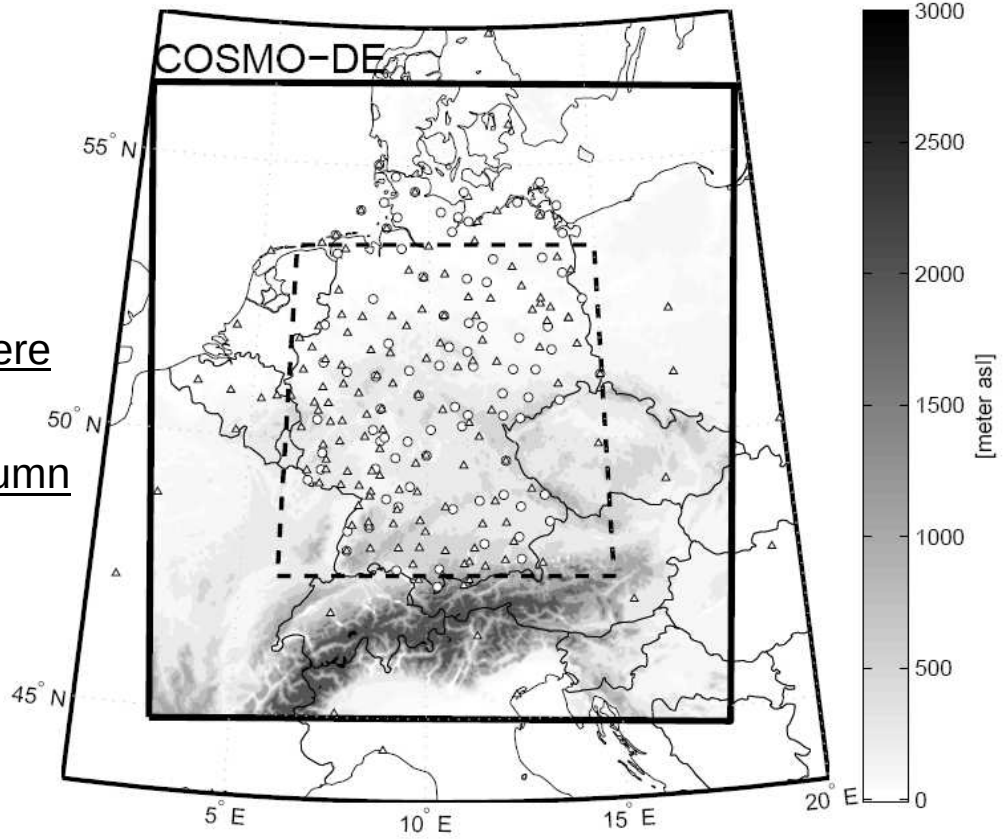


Observations – **BT:**

MSG 6.2 µm and 10.8 µm channels:

6.2 µm data: BT → clouds / humidity
in <u>upper troposphere</u>

10.8 µm data: BT → clouds / humidity
in <u>total vertical column</u>

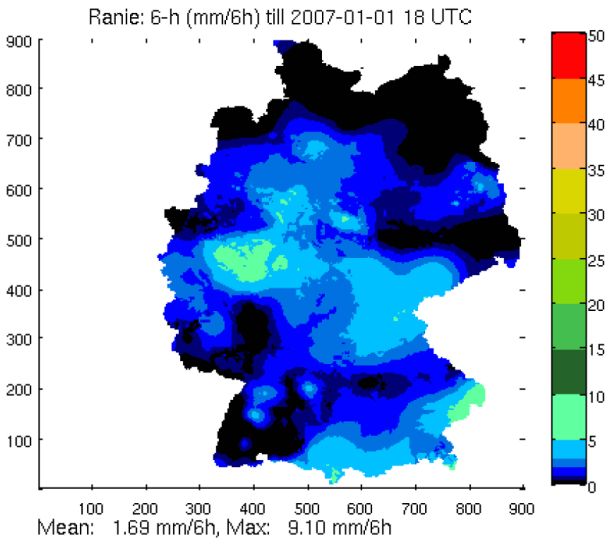


COSMO-DE domain

satellite (MSG) data

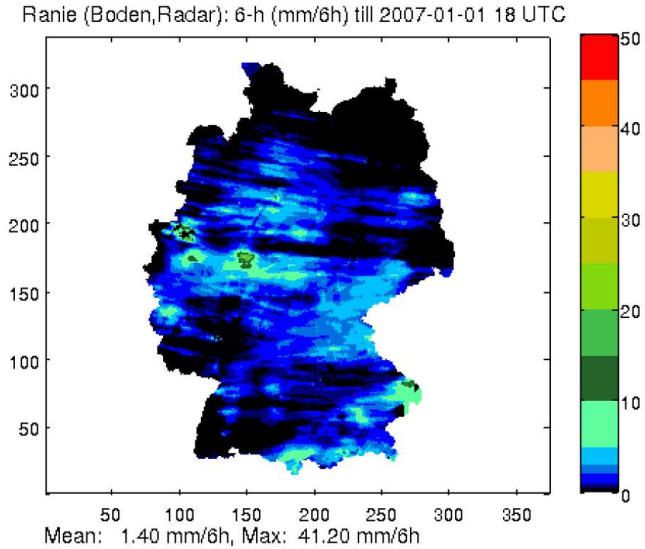
Observations – **Precipitation amount:**

RANIE-1 data



only ground observations

RANIE-2 data

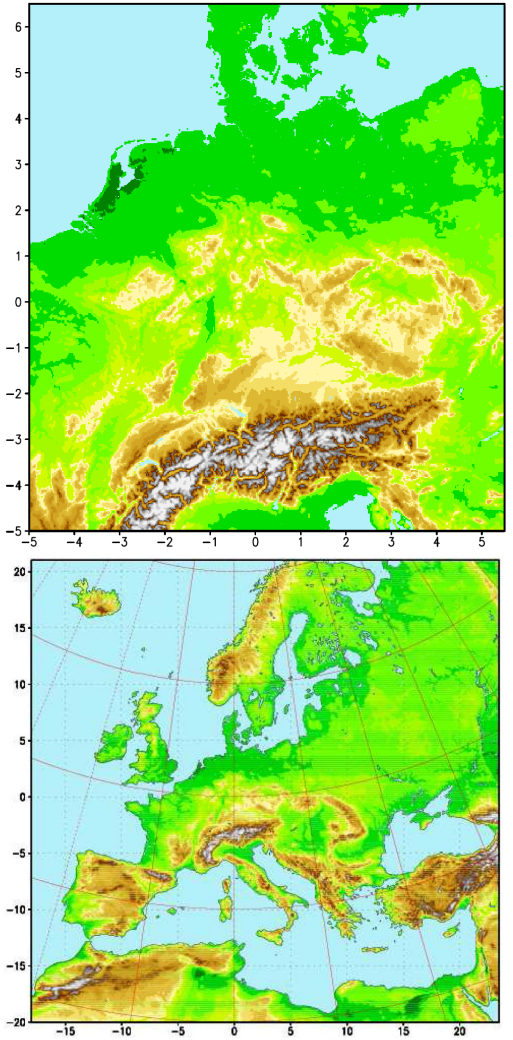


combined ground + radar observations

COSMO model:

- **COSMO-DE**
  - 2.8 km horizontal resolution
  - 50 vertical layers
  - operational version

- **COSMO-EU**
  - 7.0 km horizontal resolution
  - 40 vertical layers
  - operational version



COSMO model:

Modifications in COSMO-DE/-EU between 01/2007 and 12/2008

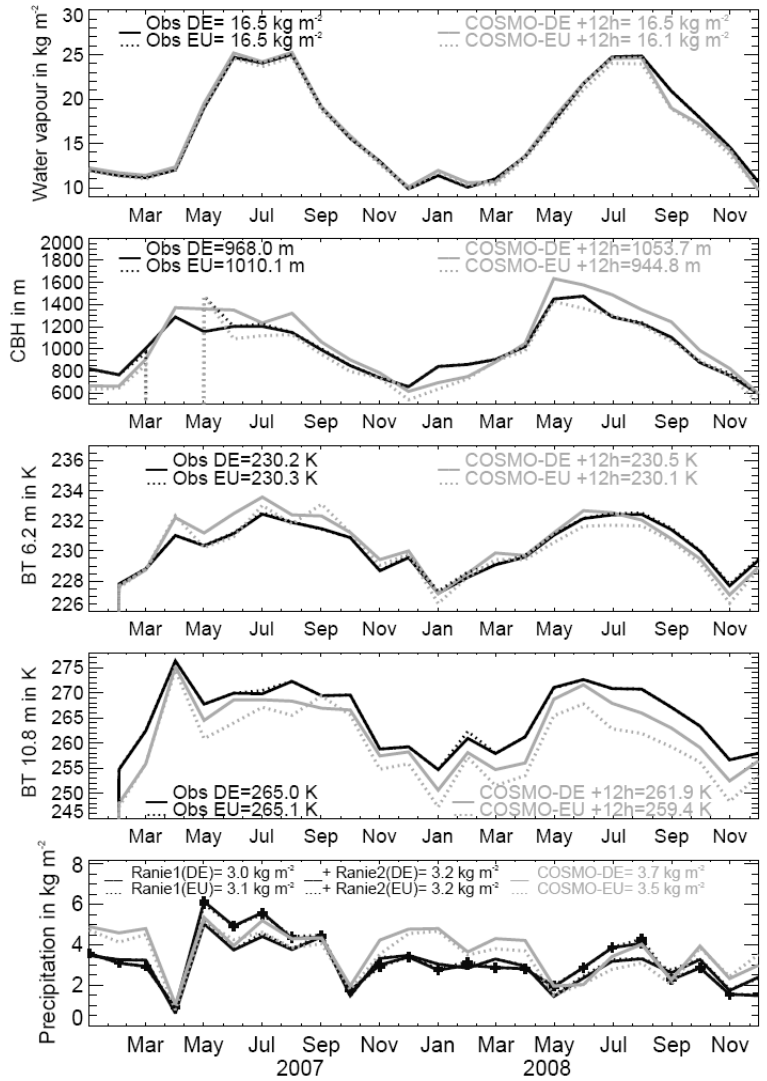
Date	Application	Change
17.01.2007	COSMO-DE*/ COSMO-EU	Snow analysis: Changes in choice of observations
31.01.2007	COSMO-EU	New COSMO version (3.22) Change in microphysics: Increasing drifting of orographic precipitation
06.02.2007	COSMO-DE*	New COSMO version (3.22) Change in microphysics: Replacement of graupel scheme by new COSMO-EU microphysics
04.04.2007	COSMO-DE*	Activation of new graupel scheme
16.04.2007	COSMO-DE	COSMO-DE declared operational
17.07.2007	COSMO-DE/ COSMO-EU	Improved quality control for radiosonde humidity
10.10.2007	COSMO-DE	Data assimilation: Modified definition of reference precipitation in latent heat nudging
12.03.2008	COSMO-DE/ COSMO-EU	Modified diagnostics of 2-m temperature and dewpoint
23.07.2008	COSMO-EU	Modification of the Tiedtke cumulus convection scheme
10.09.2008	COSMO-DE COSMO-EU	Reduced mixing length and modified subgrid-scale cloudiness in moist turbulence scheme Change of the reference atmosphere and bug in interpolation (both removed early Oct 2008)
02.11.2008	COSMO-DE	Use of semi-Lagrangian advection for moisture-related varaibles and TKE
12.11.2008	COSMO-EU	New COSMO version (4.6) Switching on sub-grid scale orography scheme (SSP)

Time-series analysis:

absolute values
(monthly mean values)
Jan 2007 – Dec 2008:

full lines: _____
COSMO-**DE** &
Observations on COSMO-**DE** grid

broken lines: ·····
COSMO-**EU** &
Observations on COSMO-**EU** grid



IWV

CBH

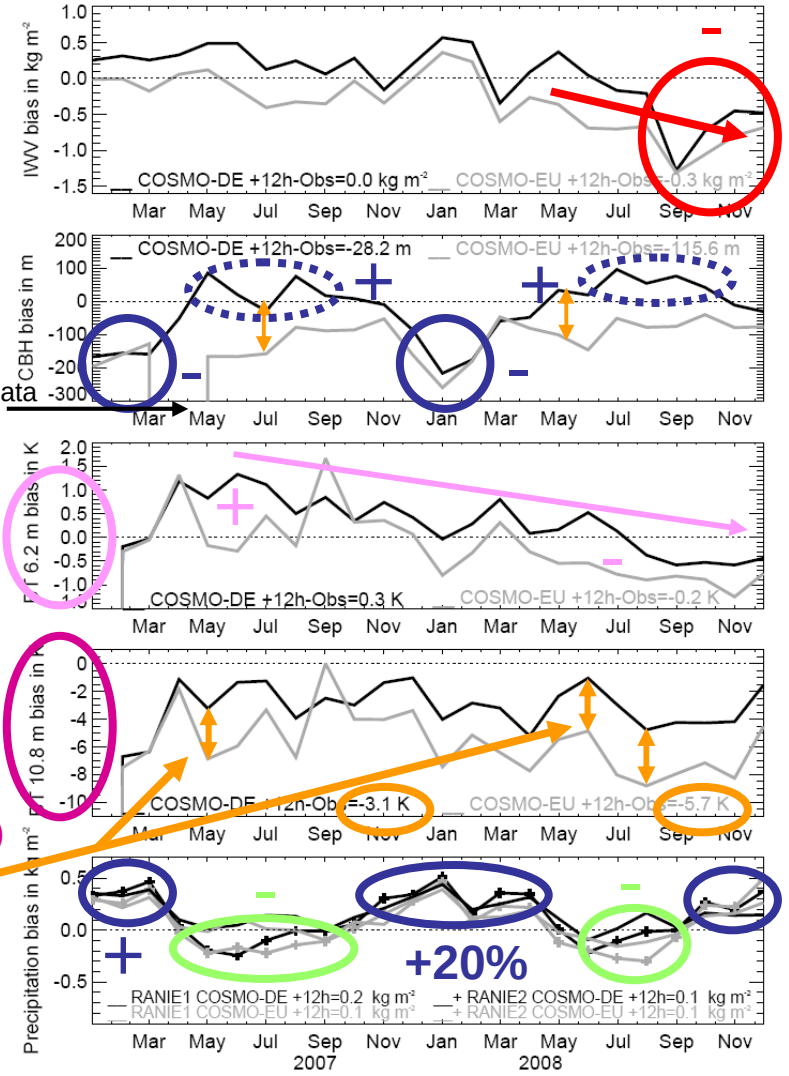
BT – 6.2 µm

BT – 10.8 µm

Precipitation

Time-series analysis:

bias
(monthly mean values)
Jan 2007 – Dec 2008:



bias = COSMO – OBS
(COSMO-DE ——
versus
COSMO-EU ——)

Effect of
high clouds
(both COSMO-DE
and COSMO-EU)

Difference COSMO-EU
and COSMO-DE

IWV
-15% to GPS

CBH
especially COSMO-DE:
overprediction of
seasonal cycle

BT – 6.2 µm

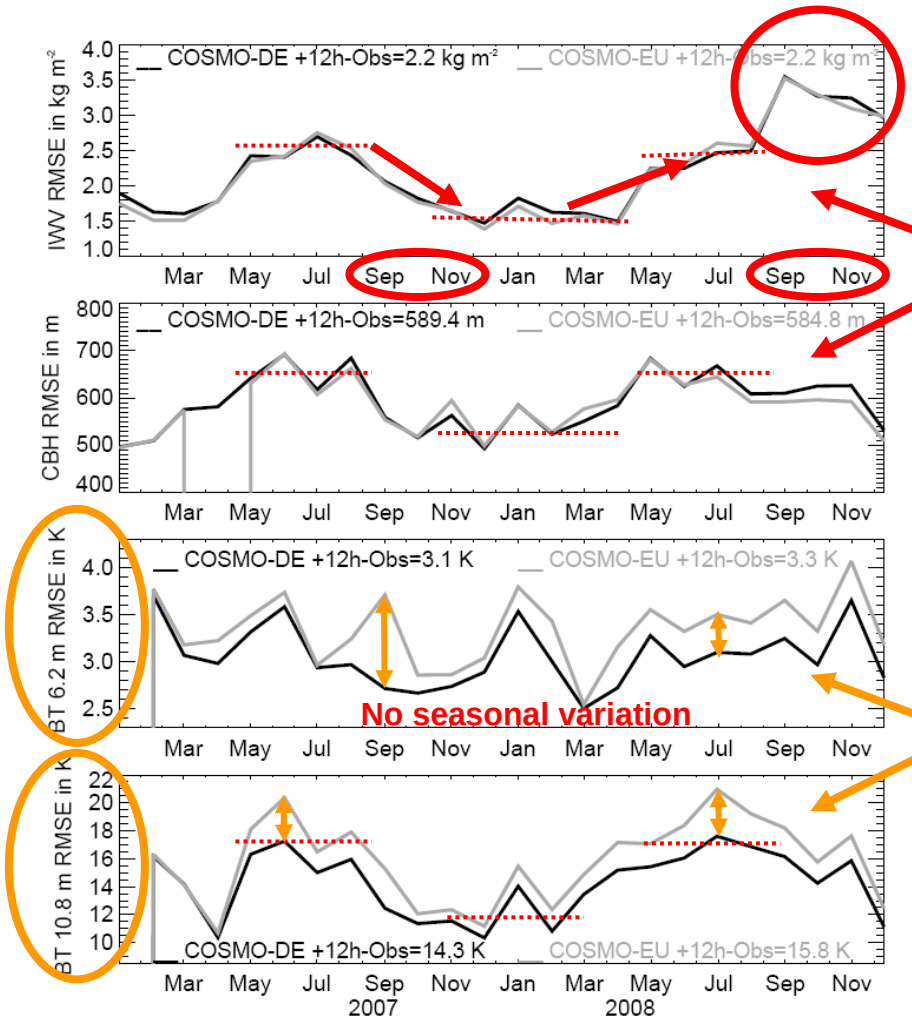
BT – 10.8 µm
especially in summer:
COSMO-DE bias is
much smaller than -EU

Precipitation

Seasonal differences
(stratiform vs. convective
Precipitation)

Time-series analysis:

rmse
Jan 2007 – Dec 2008:



jump in rmse in Sept 2008

IWV

increase in rmse in summer

CBH

BT – 6.2 µm

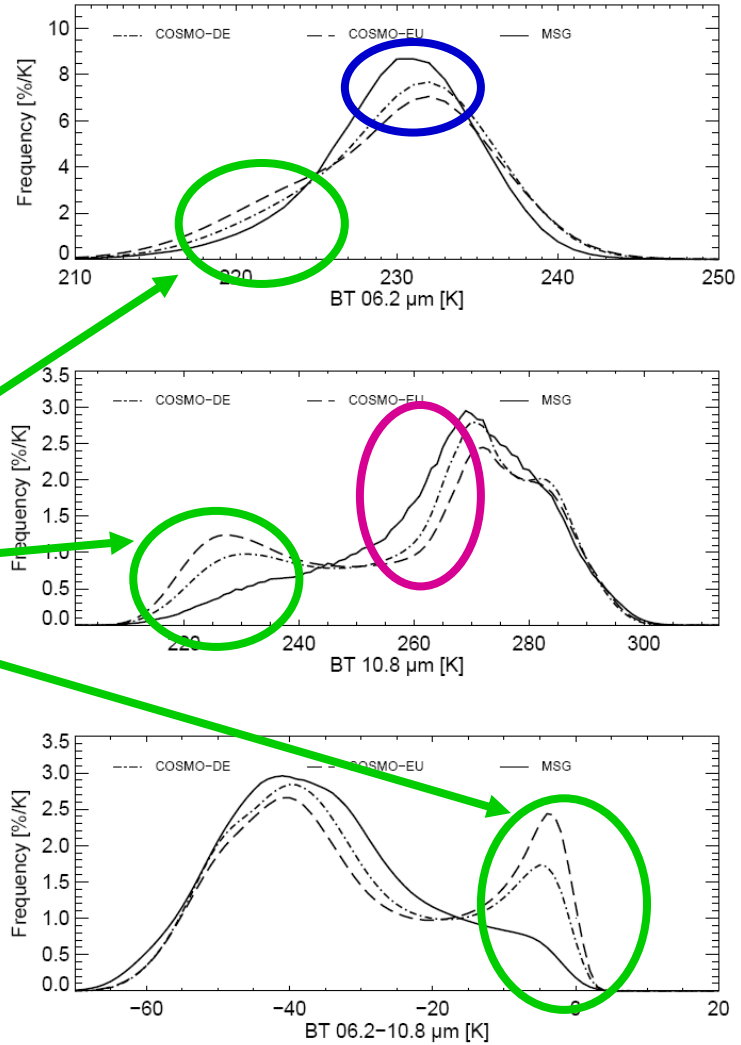
especially in summer: COSMO-DE rmse is much smaller than -EU

BT – 10.8 µm

Spectral analysis:

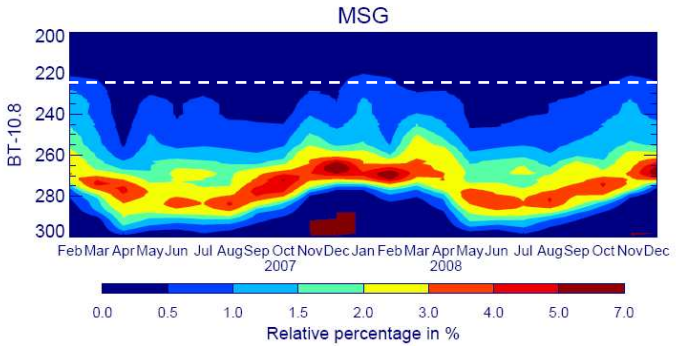
Comparison BT spectrum
– observations and COSMO:

Effect of high clouds



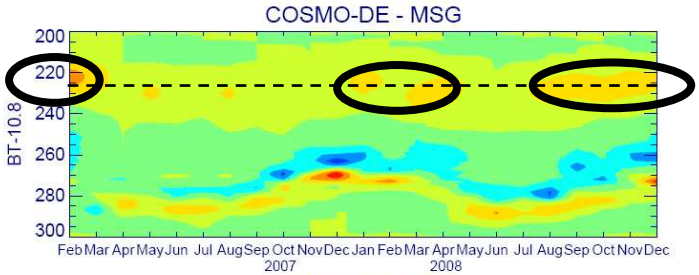
Spectral analysis:

Comparison BT-10.8 spectrum – observations and COSMO:

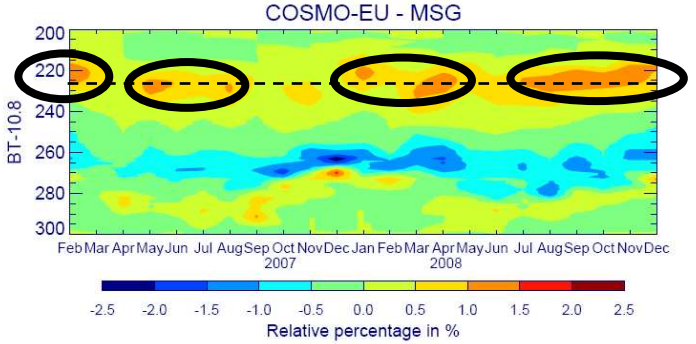


Satellite MSG

Effect of high clouds



COSMO-DE (- MSG)

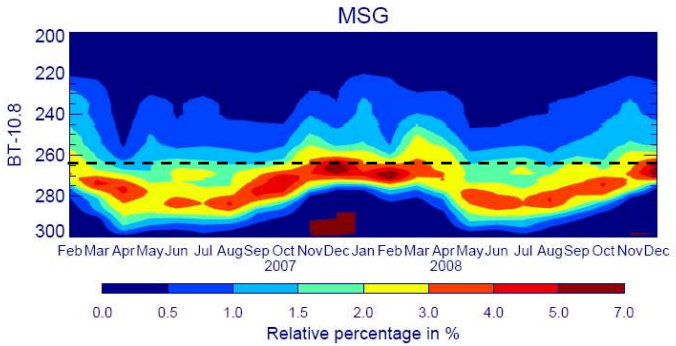


COSMO-EU (- MSG)

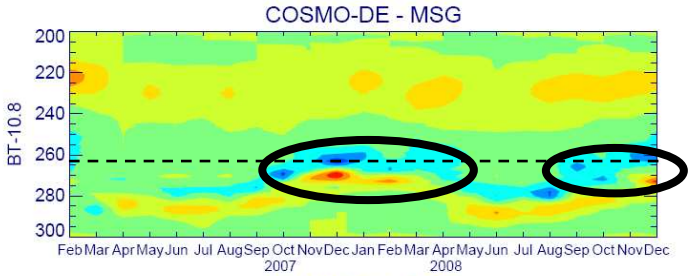
Spectral analysis:

Comparison BT spectrum – observations and COSMO:

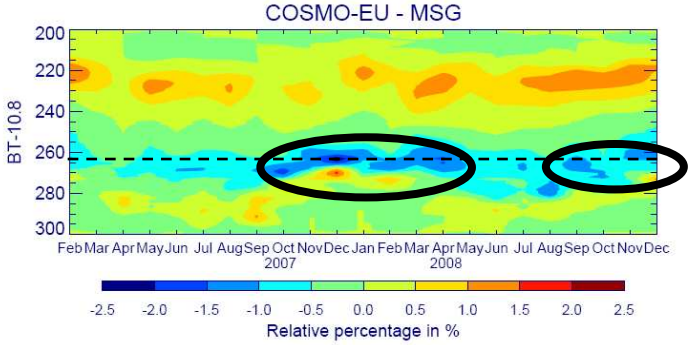
Too low CBH in winter



Satellite MSG



COSMO-DE



COSMO-EU

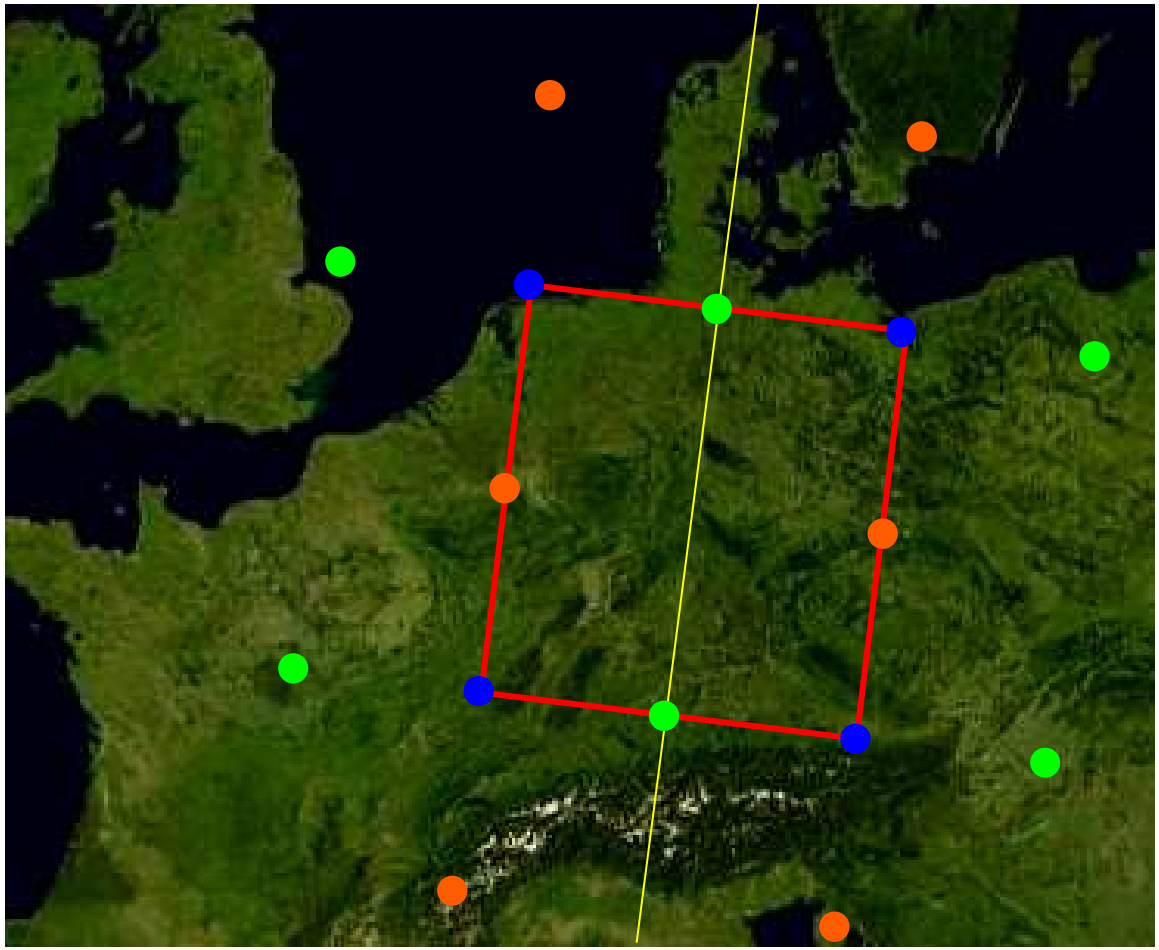
Weather classification analysis:

- Method bases on Jenkinson and Collison (1977) and Lamb (1972)
- Calculation of horizontal pressure / **geopotential differences** (**850 hPa level**)
- Comparison of **geostrophic wind** and scaled **vorticity**
  (large domain : 5.0º x 8.0º ≈ 560 km x 560 km
  small domains: 2.5º x 4.0º ≈ 280 km x 280 km)
- COSMO-DE **analysis data**
- Calculation in 3-hours intervals (1 January 2007 - 31 December 2008)
- Classification in 10 classes:

  8 wind classes (N, NE, E, SE, S, SW, W, NW)
  2 vorticity classes (cyclonic C + anticyclonic A)

Weather classification analysis:

Large domain
(**GERMANY**)



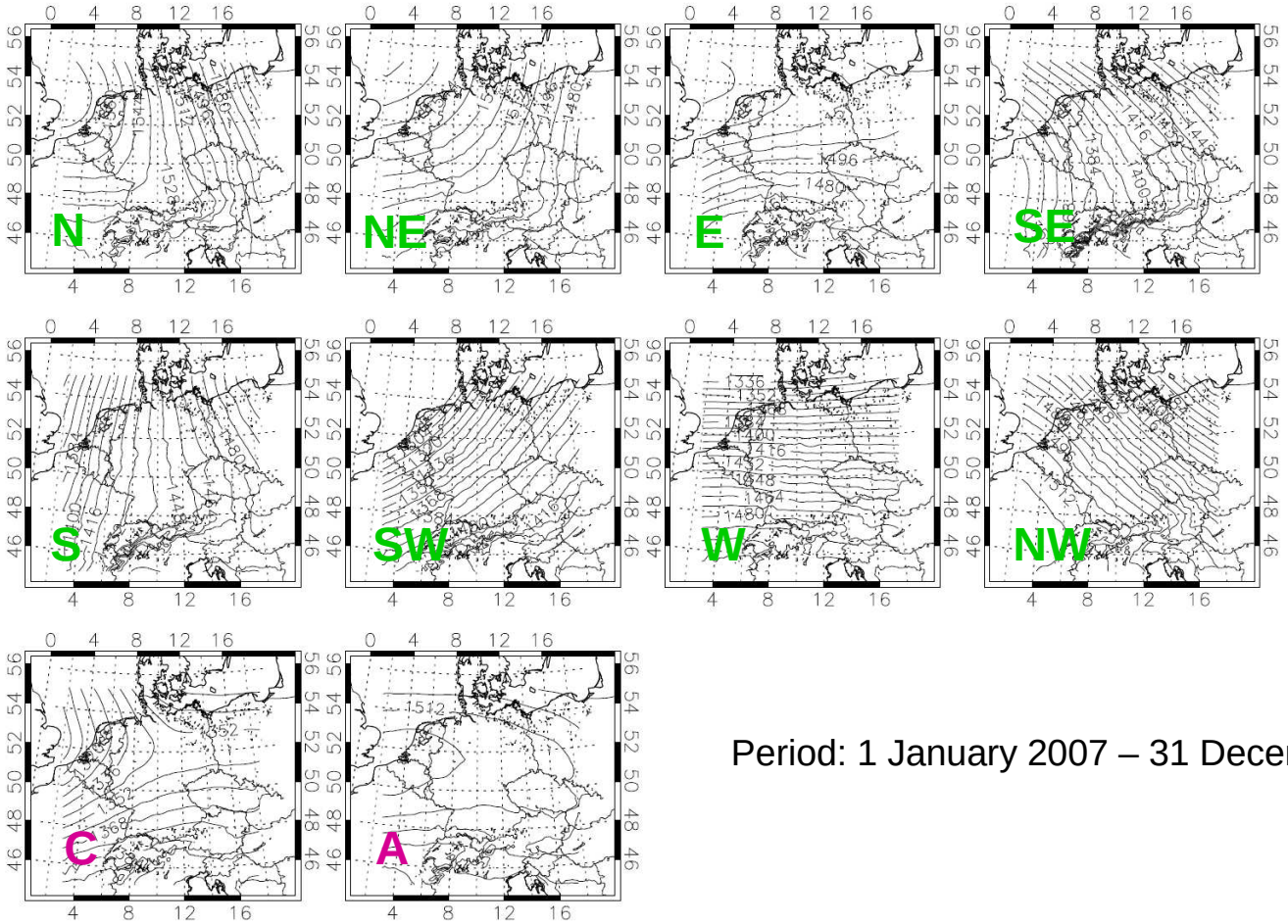
● Φ value for v_g

● Φ value for ξ_{lon}

● Φ value for ξ_{lat}

Weather classification analysis:

Distribution of weather classes

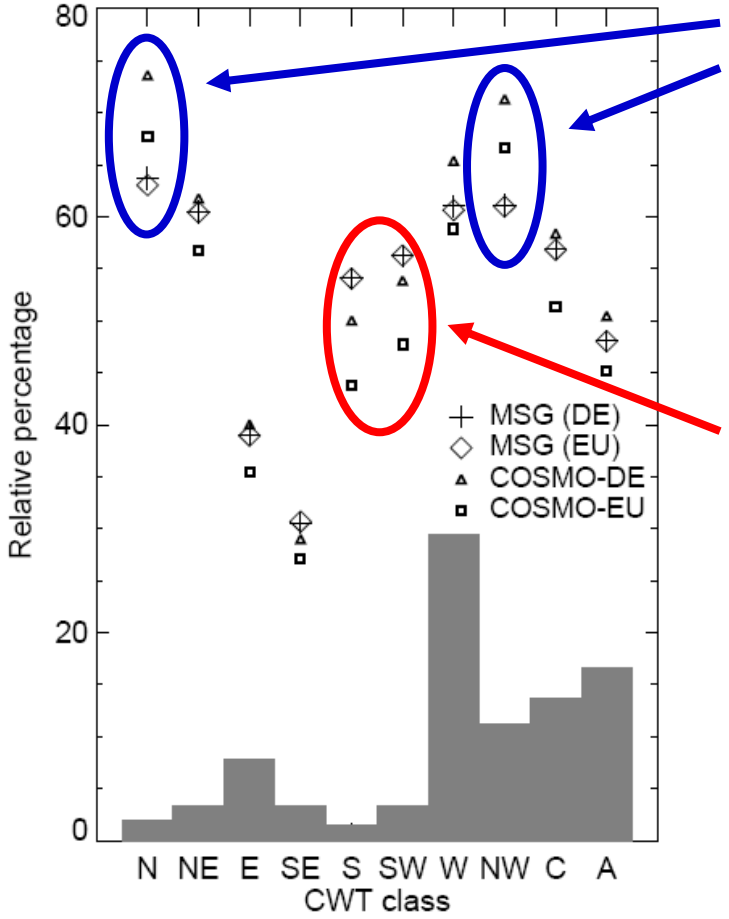


Period: 1 January 2007 – 31 December 2008

Weather classification analysis:

Histogram of cloud cover

Histogram of weather classes



Overprediction of cloud cover in COSMO

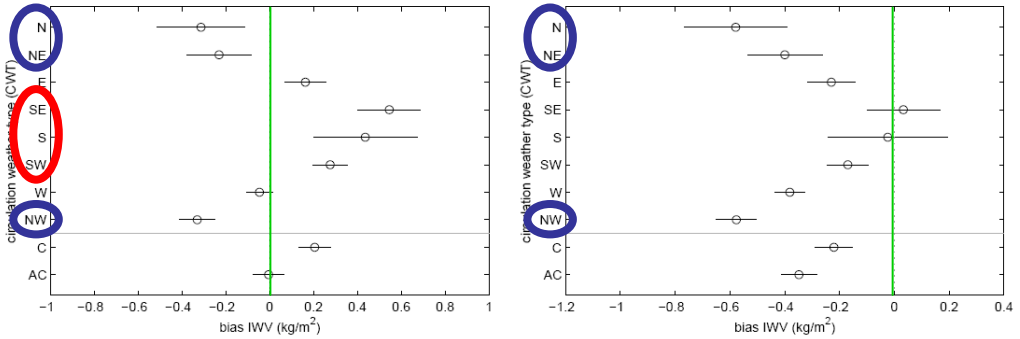
Percentage of cloud cover for different classes

Underprediction of cloud cover in COSMO

Percentage of occurence of different classes

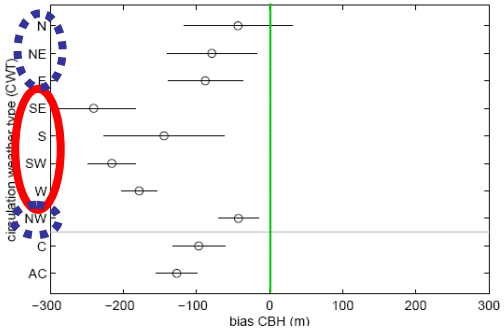
Weather classification analysis:

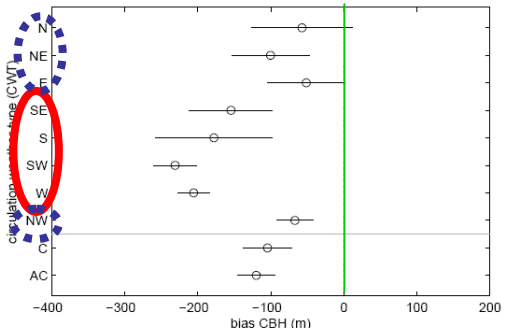
bias IWV



GERMANY

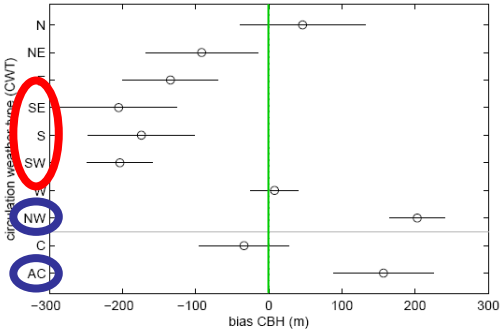
bias CBH

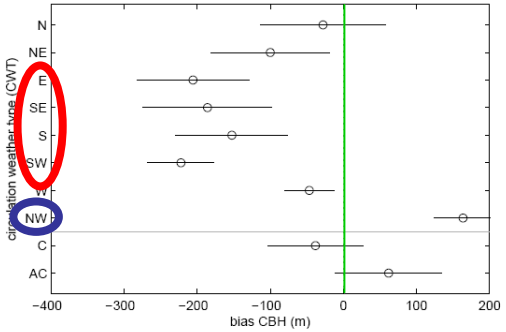




GERMANY

bias CBH





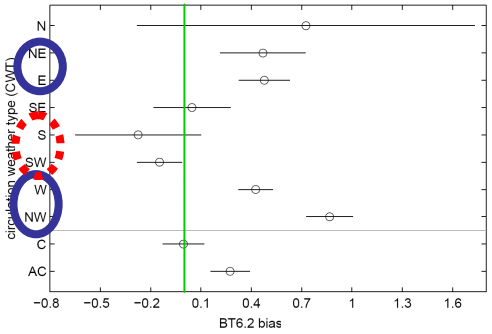
NORTHERN GERMANY

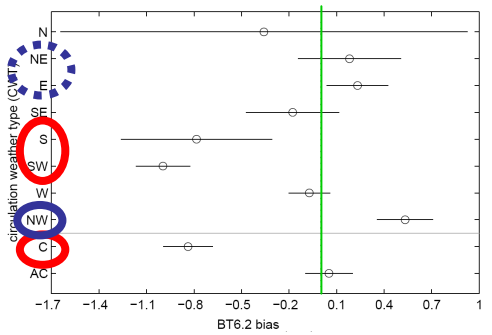
COSMO-DE

COSMO-EU

Weather classification analysis:

bias BT-6.2



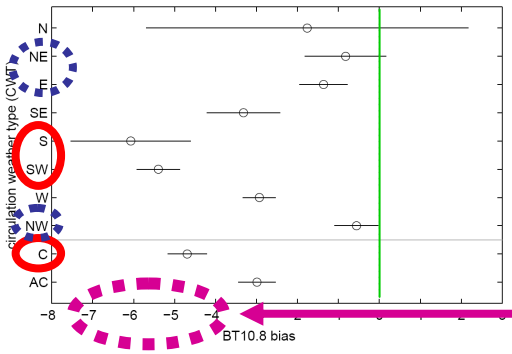


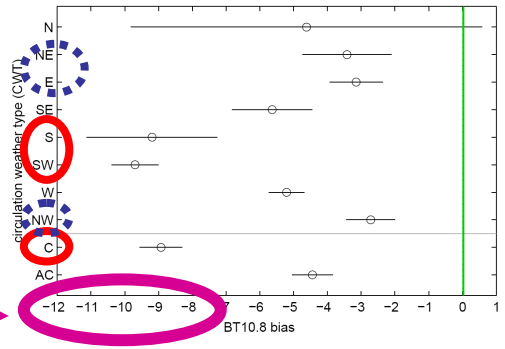
GERMANY

COSMO-DE

COSMO-EU

bias BT-10.8





GERMANY

Weather classification analysis:

- Extreme bias values for air masses from NW/NE and S

- For **NW / NE** classes:
  - **over**prediction of cloud cover in COSMO-DE/-EU
  - **under**prediction of IWV in COSMO-DE/-EU
  - **reduced** CBH bias in COSMO-DE/-EU
  - too **high** BT-6.2 in COSMO-DE
  - **reduced** BT-10.8 bias in COSMO-DE/-EU
    (still negative!)

  → Problem in description of ice nucleation (Pfeifer et al. 2010)

- For **S / SW** classes:
  - **under**prediction of cloud cover in COSMO-DE/-EU
  - **over**prediction of IWV in COSMO-DE
  - too **low** CBH in COSMO-DE/-EU
  - too **low** BT-6.2 in COSMO-EU
  - too **low** BT-10.8 in COSMO-DE/-EU

→ bias = combination of humidity and temperature effects ??
(no extreme values for westerly streaming!!)

Summary:

- Long-term time series / spectral analysis:
  - small differences for **IWV** BUT: differences in **fall 2008** (jump!)
  - overprediction of **CBH seasonal cycle** especially in COSMO-DE
    → too low CBH in winter (influence of stratus) and too high CBH in summer
    → BT-10.8 bias maximum at 270 K / minimum at 263 K in winter
    → overprediction of winter precipitation
  - **BT** differ clearly from COSMO forecasts
    → negative trend in for BT-6.2 (?)
    → strong negative bias for BT-10.8 (effect of **high clouds**)
    → reduction of bias especially in summer time (**resolution effect**)

    yearly average: COSMO-EU → COSMO-DE
    -5.7 K → -3.1 K

- Weather classification analysis:
  Extreme bias values for air masses from **NW/NE** (underprediction IWV)
  and **S** (overprediction IWV) → combination of humidity and temperature effects (?)

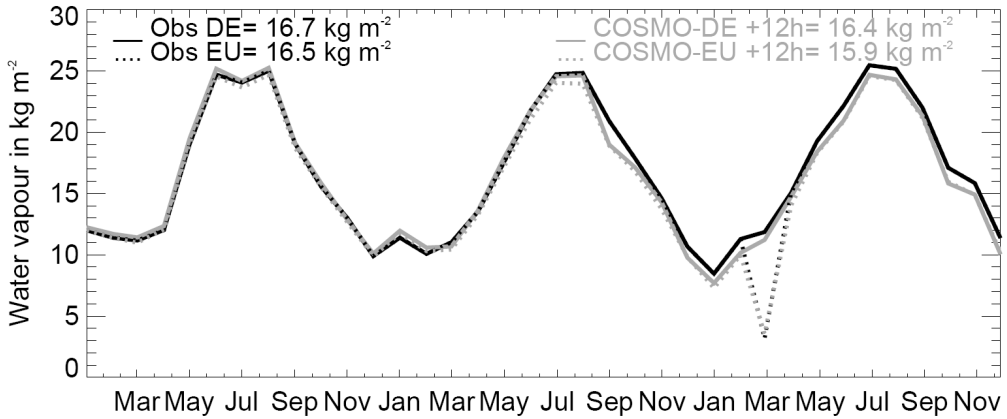
Outlook:

- Further analysis
  - on **regional** characteristics (i.e., see characteristics for **NORTHERN GERMANY**)
  - on **diurnal cycle** (convective precipitation)
  - extension to **2009** (2010) (effects of newest COSMO modifications, i.e., reduced mixing length on water vapour content and cloud formation)

- Submission of paper (Böhme et al.) in *Meteorologische Zeitschrift*
  → special PQP issue

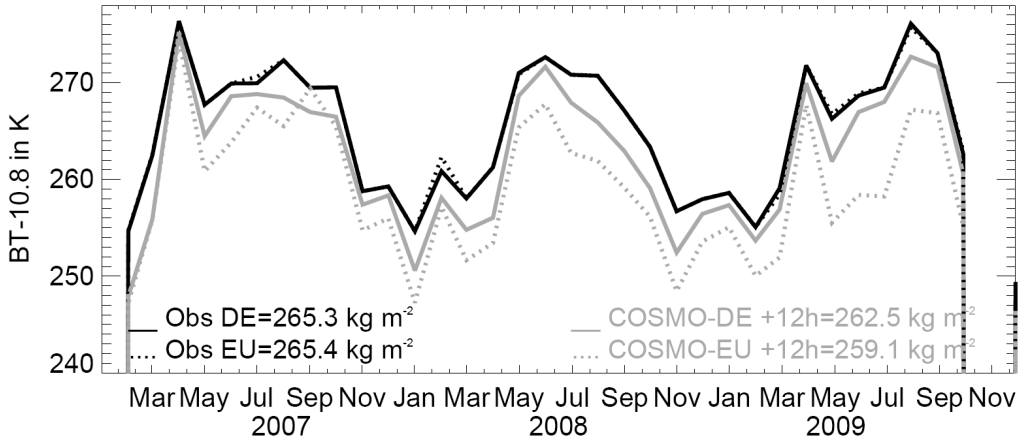
Outlook:

IWV
2007-2009



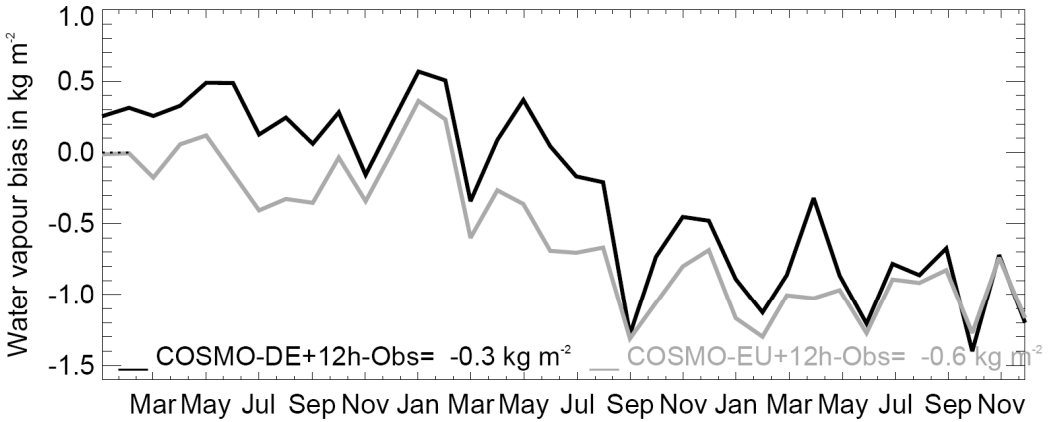
absolute values

BT-10.8
2007-2009



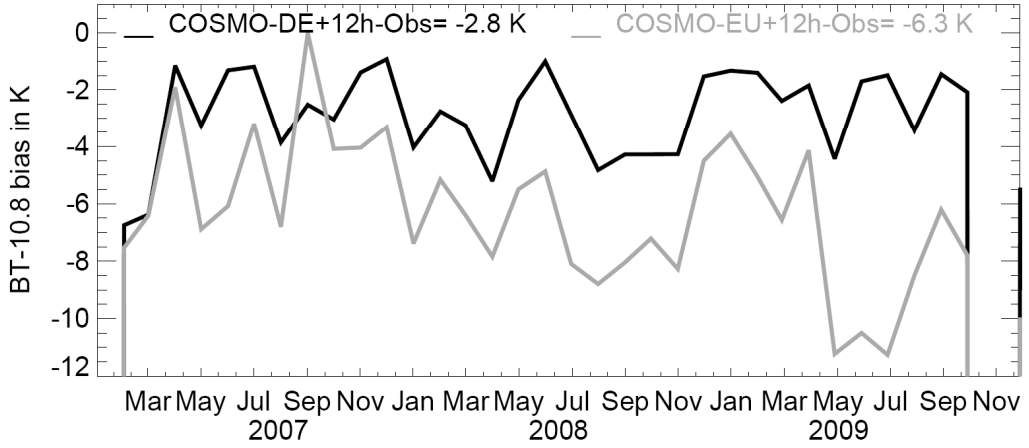
Outlook:

IWV
2007-2009



bias

BT-10.8
2007-2009



Thank you for your attention !