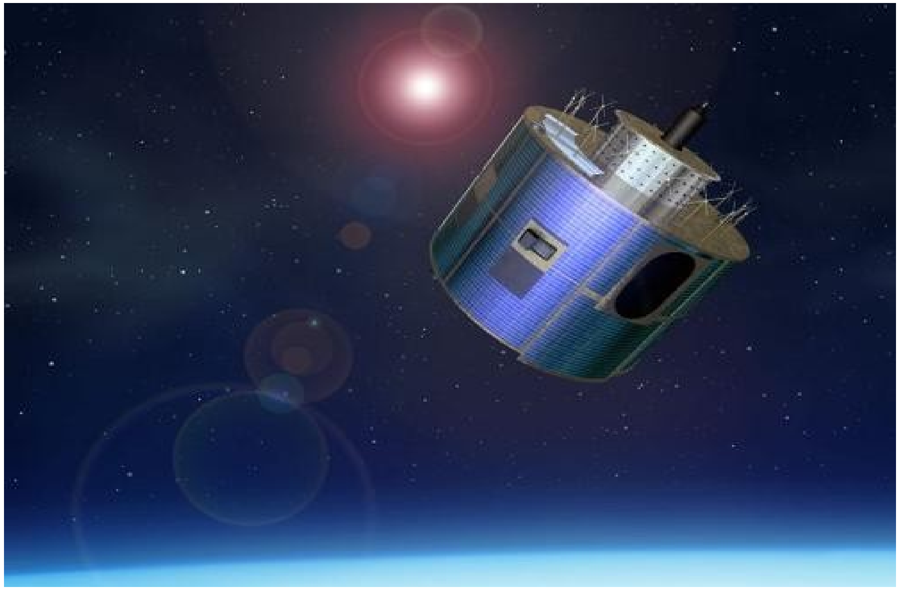

All-sky approach for the use of SEVIRI WV data

Axel Hutt

Deutscher Wetterdienst, Section FE12: Data Assimilation

Outlook

1. Motivation

2. Cloud detection

3. Next steps

Outlook

1. Motivation

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1. Motivation

Aim: assimilation of satellite data to improve weather forecast

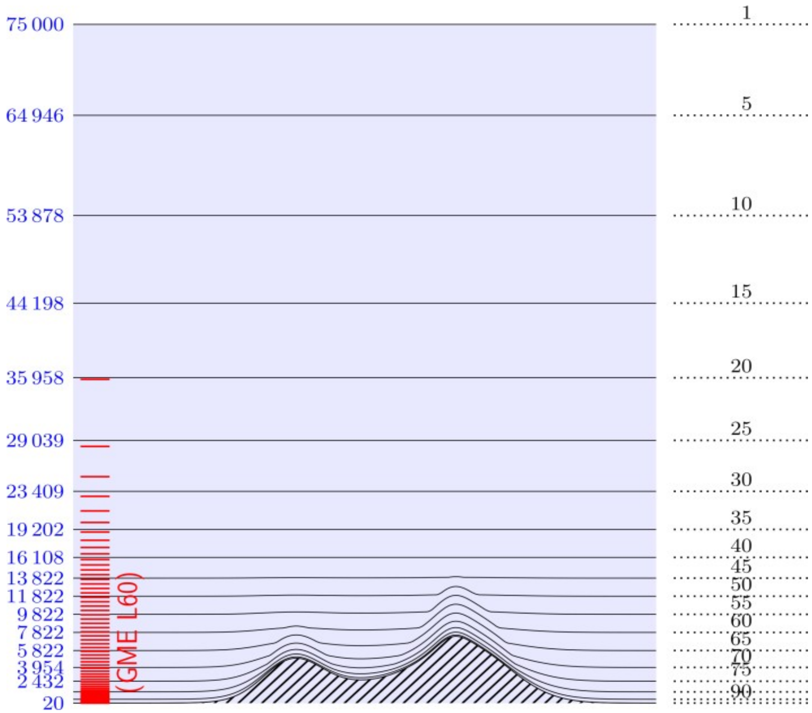
in current *global* ICON-model :

Assimilation of satellite data, e.g. of

- Infrared Atmospheric Sounding Interferometer (IASI): 3.6µm-15µm
- Advanced Microwave Sounding Unit (AMSU): 35µm-150µm

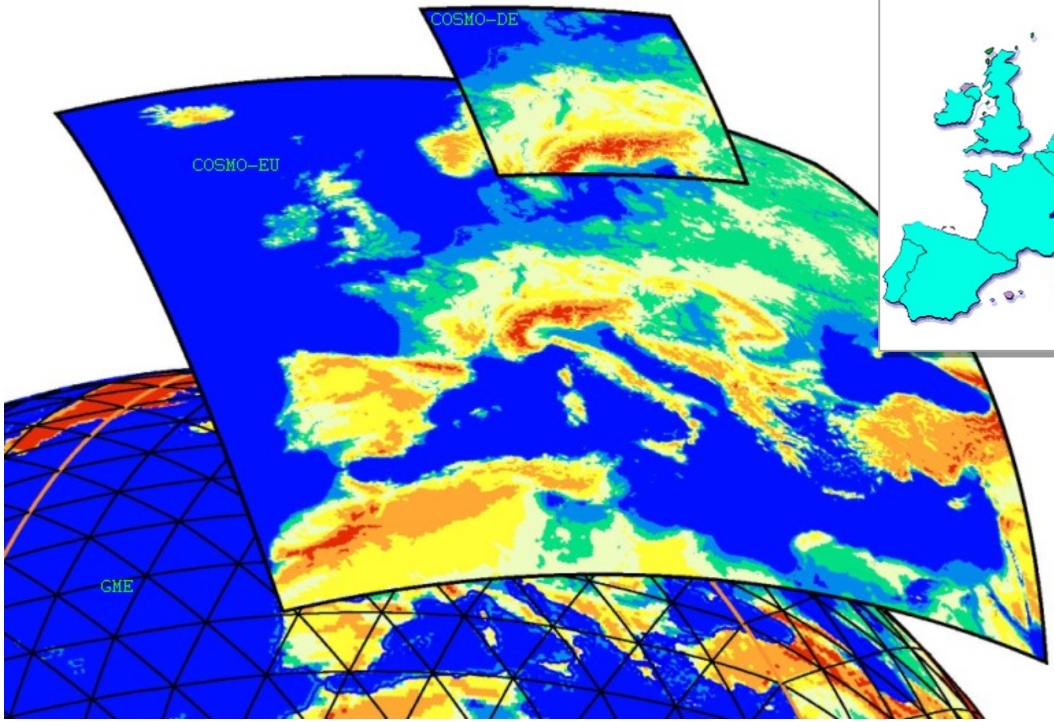
ICOsahedral Nonhydrostatic (ICON) model

- global model
- horizonal resolution: 13km
- Operational since 2015
- G. Zängl et al.



Images: Florian Prill

COSMO

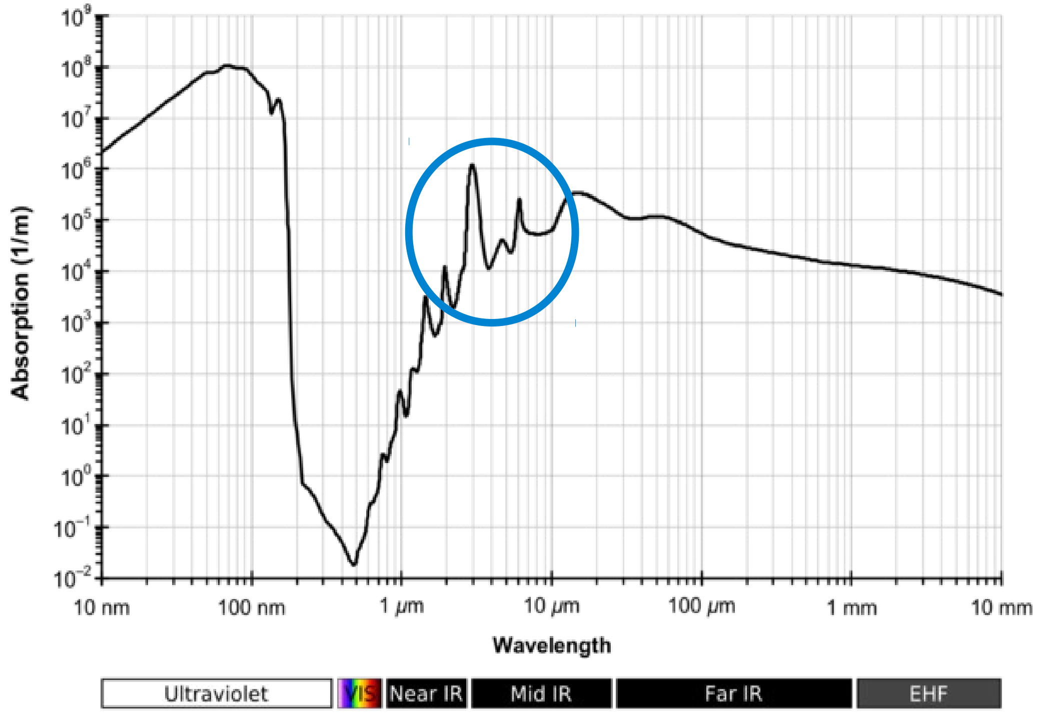


no assimilation of satellite data yet

1. Motivation

Problem: satellite data are affected by clouds

absorption of infrared radiation by cloud water



1. Motivation

in operational *global* ICON-model :

assimilation of satellite data under **clear-sky** conditions:

IASI (3.6µm-15µm) : cloud detection after McNally&Watts (2006)

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im *lokalen* COSMO-Modell :

aim: assimilation of satellite data considering cloud information (**all-sky**)

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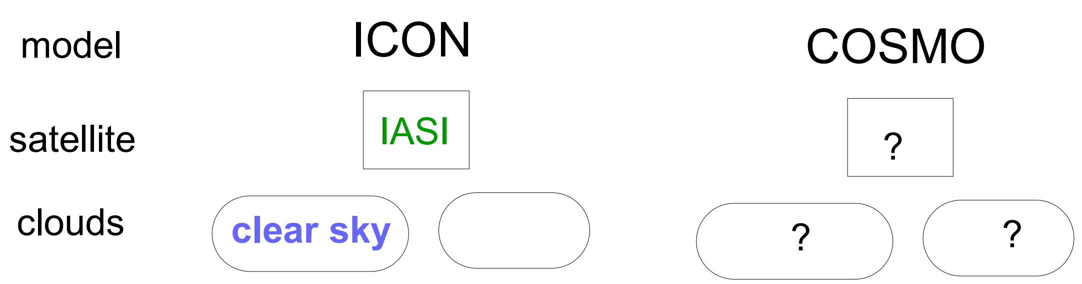

1. Motivation

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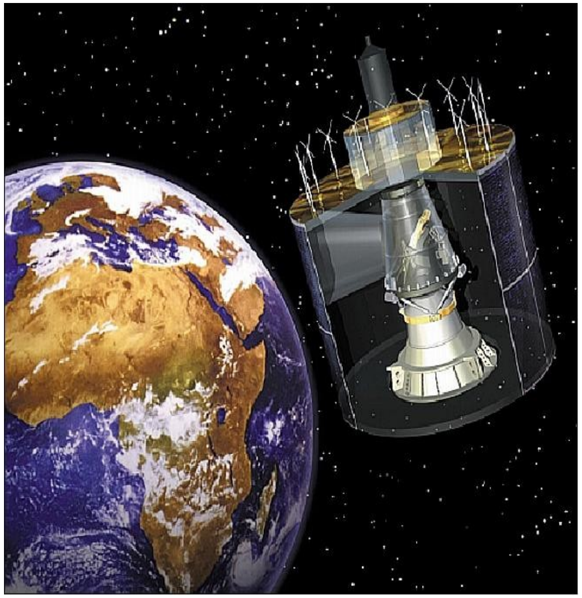
Wetter und Klima aus einer Hand

Choice of satellite instrument:

- Spinning Enhanced Visible and Infrared Imager (**SEVIRI**) on MSG3



- geostationary
- 12 spectral channels:
  - 11 channels with 3km resolution
  - 1 visual channel with 1km resolution
  - 8 infrared channels
  - 4 visual/near infrared - channels
- 15 minutes time resolution

1. Motivation

Assimilation:

- local model COSMO + data assimilation with KENDA

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- Implementation of DA of SEVIRI-data
  (a) no consideration of cloud information
  (b) with consideration of cloud information

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Wetter und Klima aus einer Hand

Assimilation:

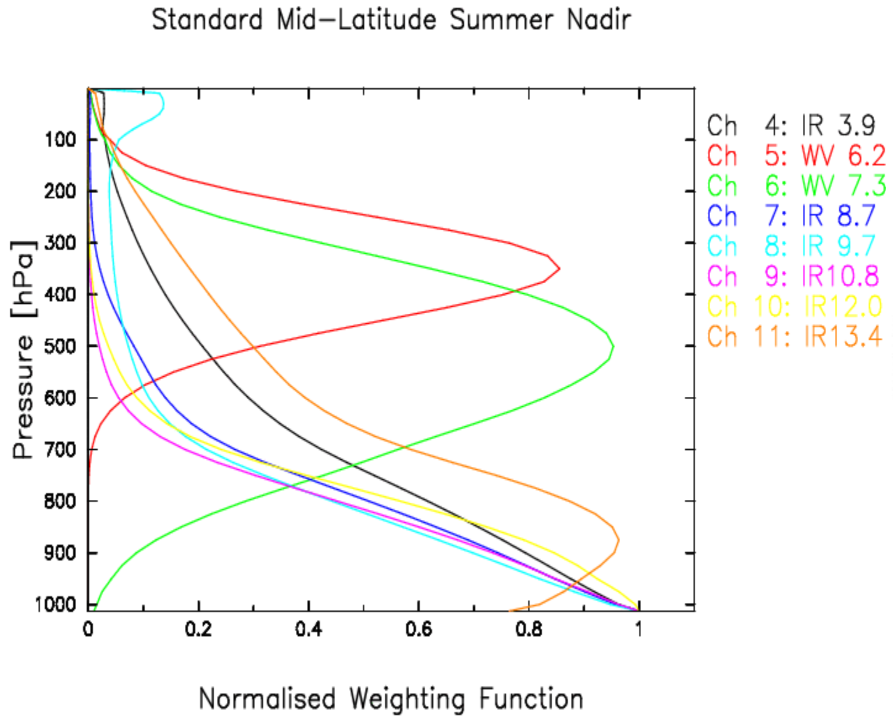
- local model COSMO + data assimilation with KENDA
- Implementation of DA of SEVIRI-data
  (a) no consideration of cloud information
  (b) with consideration of cloud information

model	ICON		COSMO	
satellite	IASI		SEVIRI	
clouds	clear sky			all sky

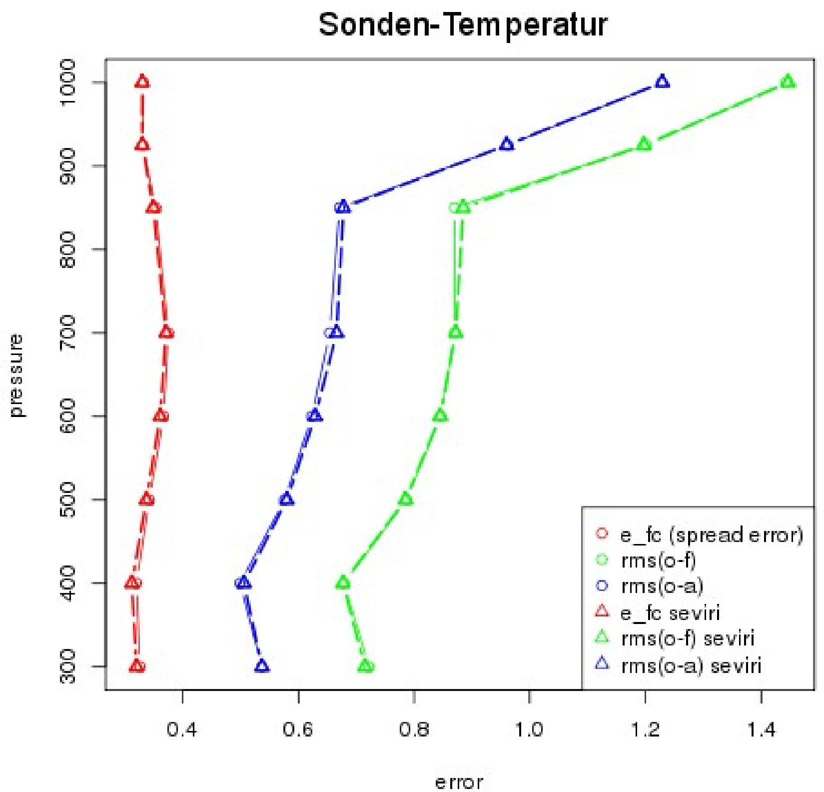
1. Motivation

very first result: DA of SEVIRI-Daten without cloud information

sensitivity of SEVIRI



DA in water vapour channel 7,3μm



SEVIRI-DA **worse without cloud information**

Outlook

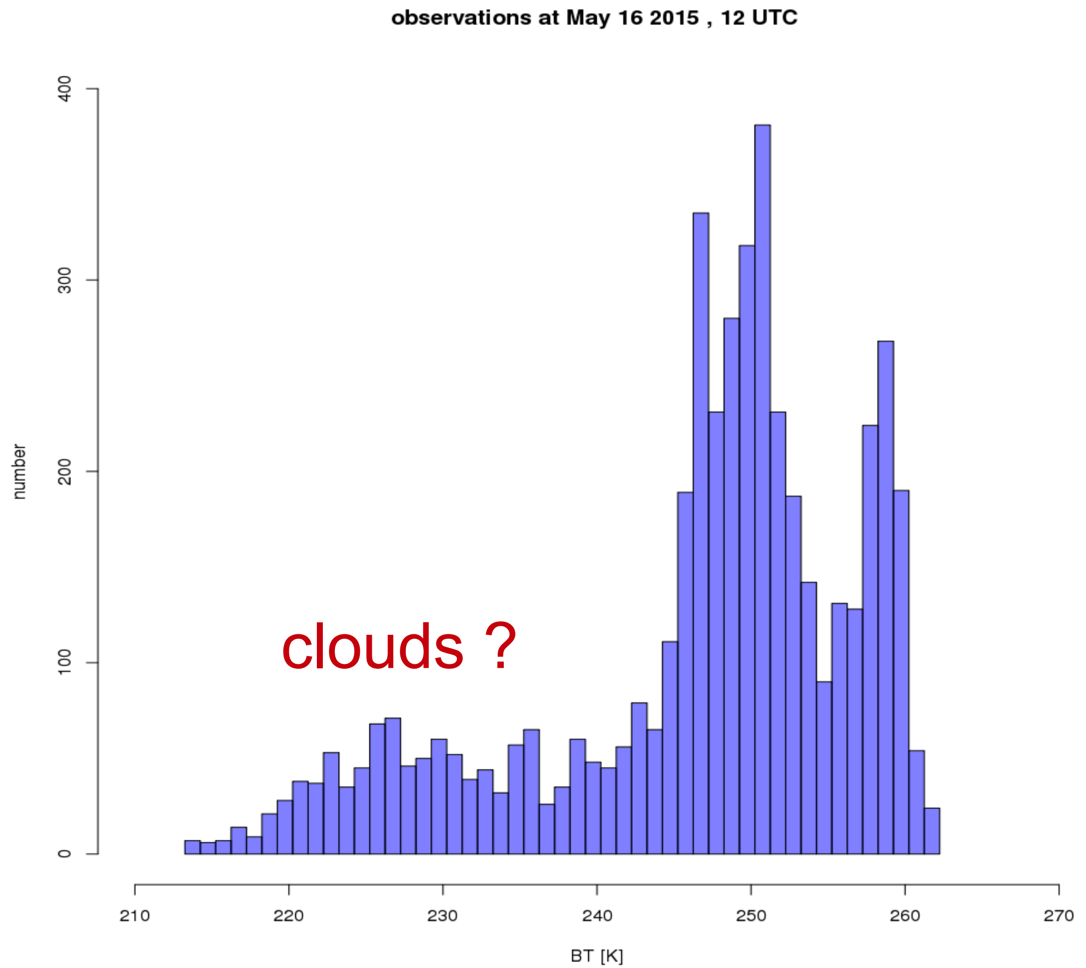
1. Motivation

2. Cloud detection

3. Next steps

2. cloud detection

experimental SEVIRI *brightness temperature* (BT) in channel 7.3µm



2. cloud detection

basic question:

cloud detection based on measured data

or

cloud detection based on the model

2. cloud detection

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Wetter und Klima aus einer Hand

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cloud detection based on measured data

advantage: various methods already exist
(esp. for hyperspectral sounders)

disadvantage: technically more complex in operational application
(since usage of additional software product)

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

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2. cloud detection

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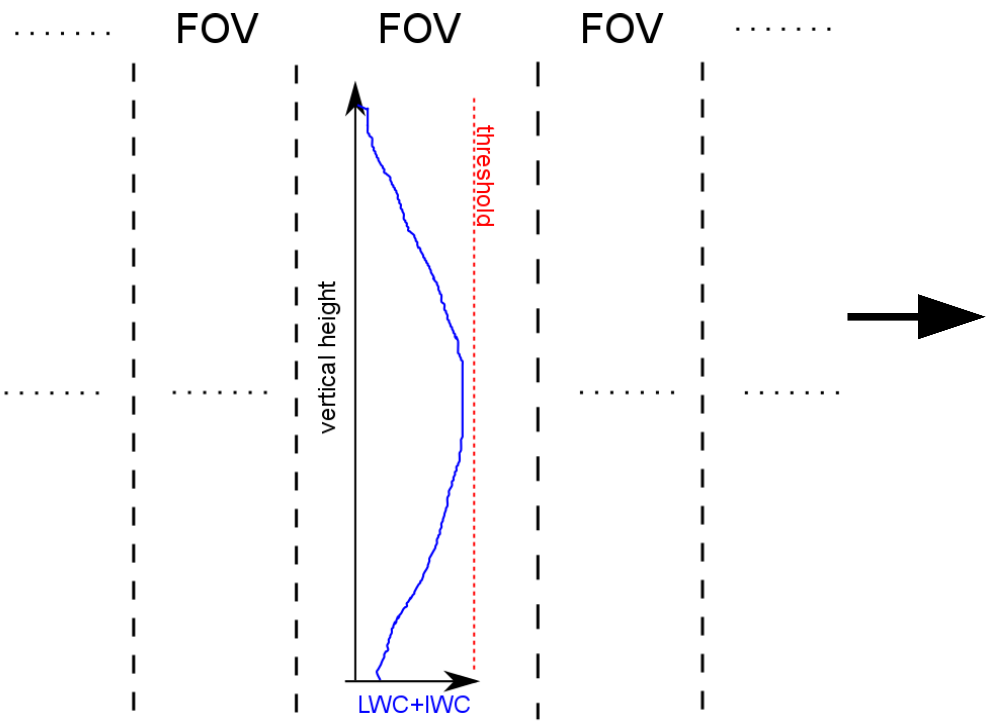
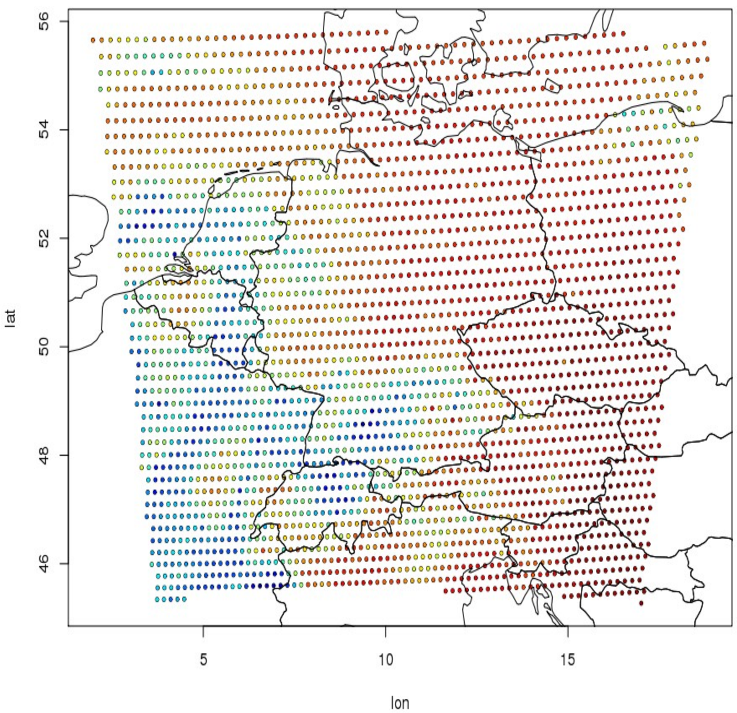
Harnisch et al., J. R. Meteorol. Soc. (2016):

model water content in atmosphere defines cloud existence

liquid and ice water content in COSMO-model



spatial segmentation in clear/cloudy areas



2. cloud detection

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If LWC+IWC > θ at spatial location:
model first guess and observation BT are affected by clouds

If LWC+IWC <= θ at spatial location:
model first guess and observation BT are clear

→ segmentation of Field Of Views (FOV) into clear and cloudy

2. cloud detection

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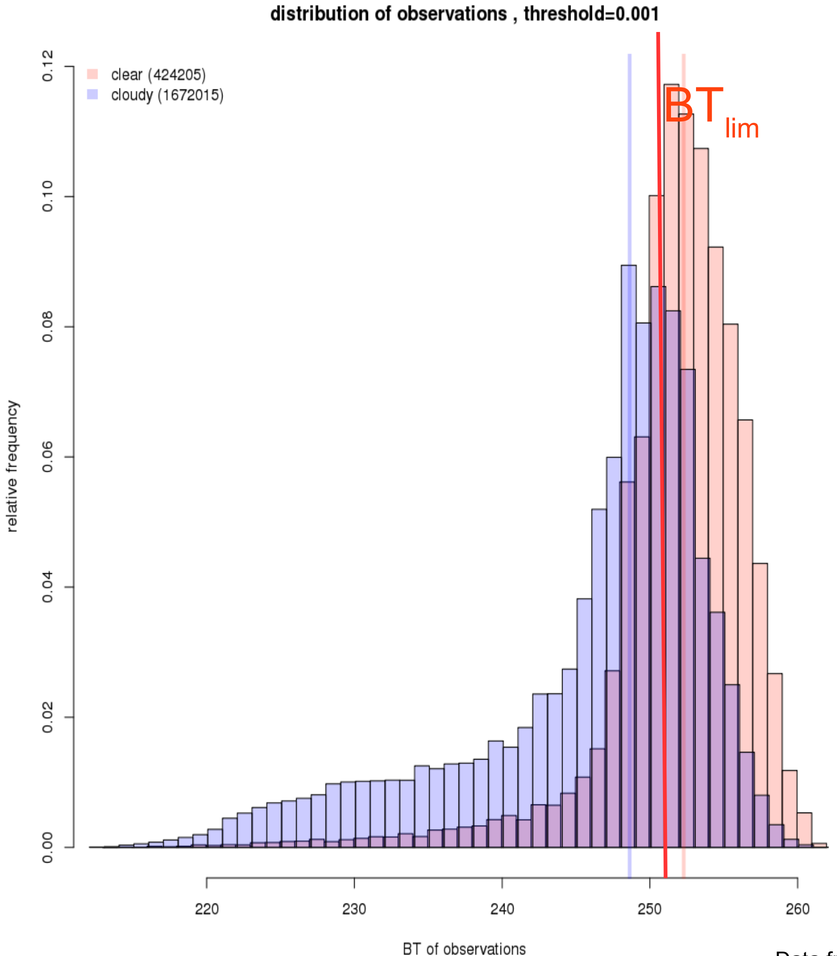
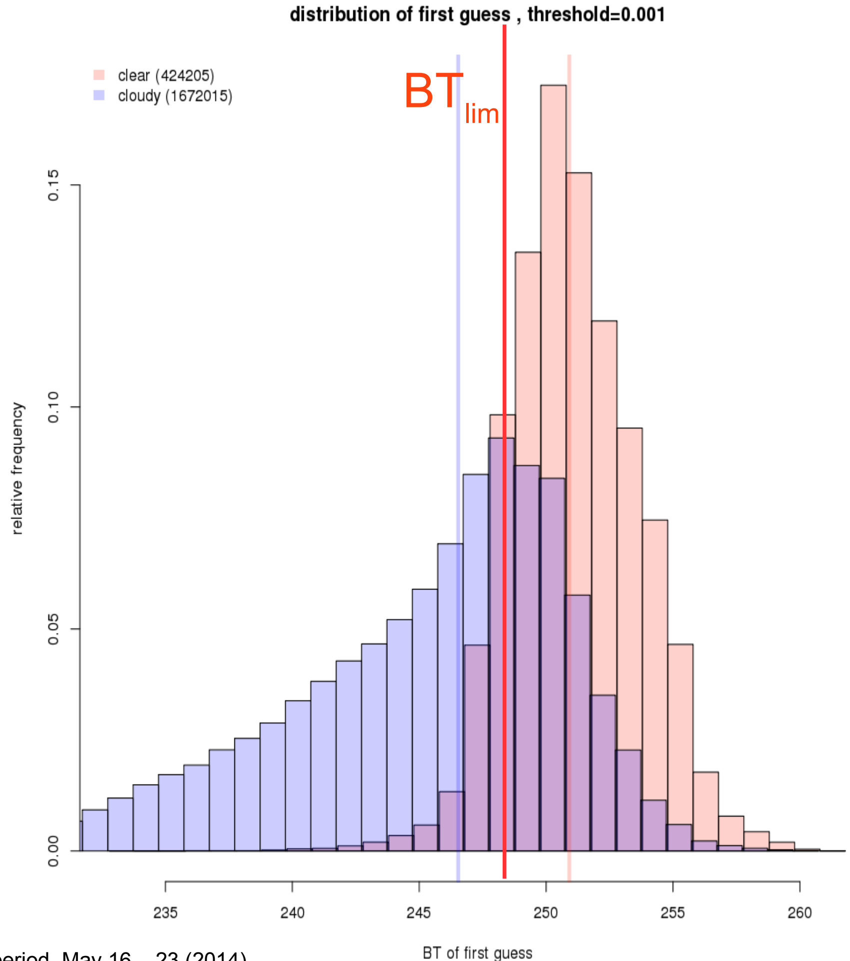
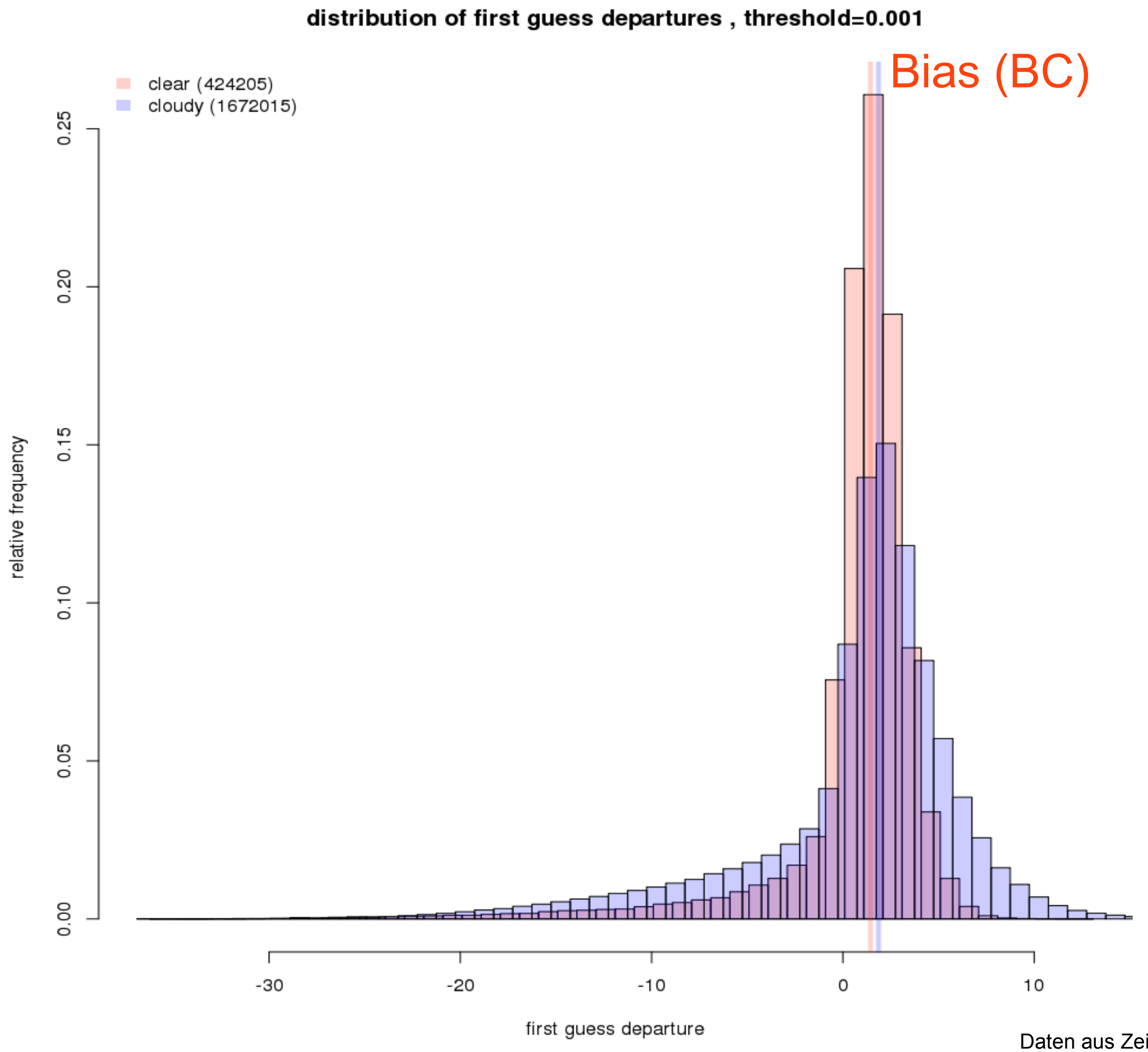




Data from time period May 16 – 23 (2014)

brightness temperature Bt_{lim} separates clear and cloudy BT

2. cloud detection

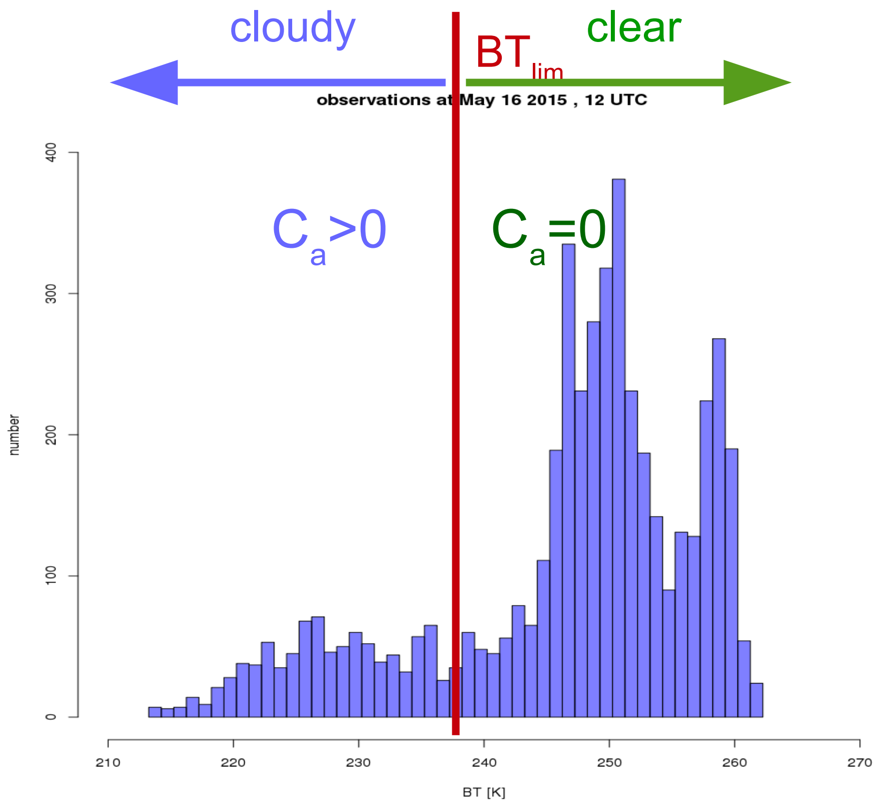


Daten aus Zeitraum 16-23 Mai 2014

2. cloud detection

impact of clouds on brightness temperature:

- average cloud impact C_a [K]
- average of cloud impact on observations and model first guess



2. cloud detection

impact of clouds on brightness temperature:

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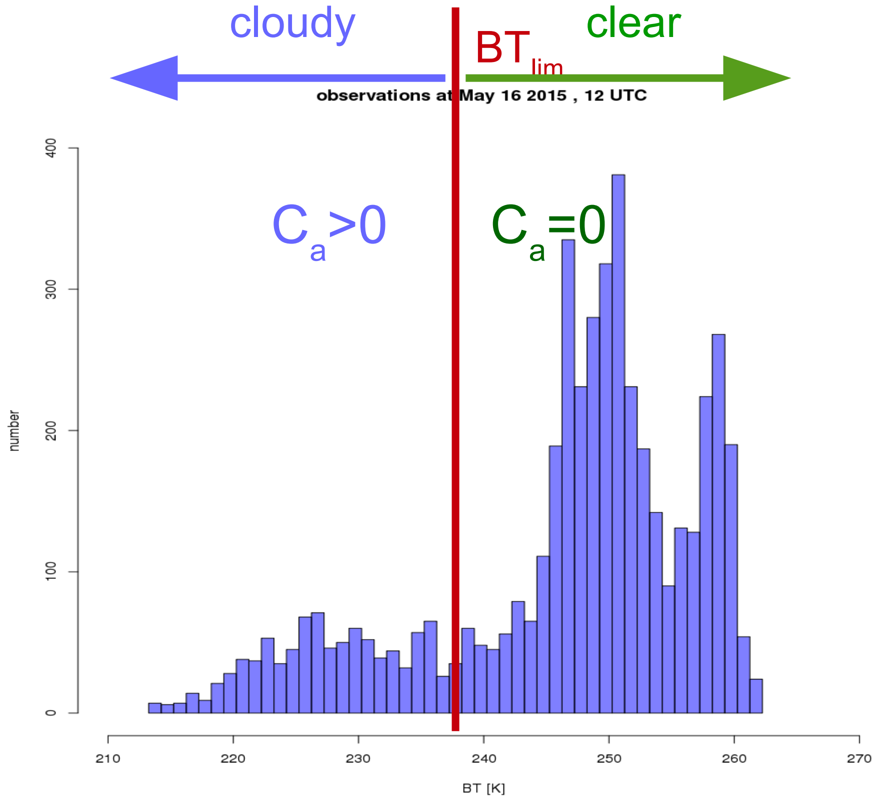
<u>Cloud impact on first guess:</u>

C_{fg}=max(0,BT_{lim}-BT)



2. cloud detection

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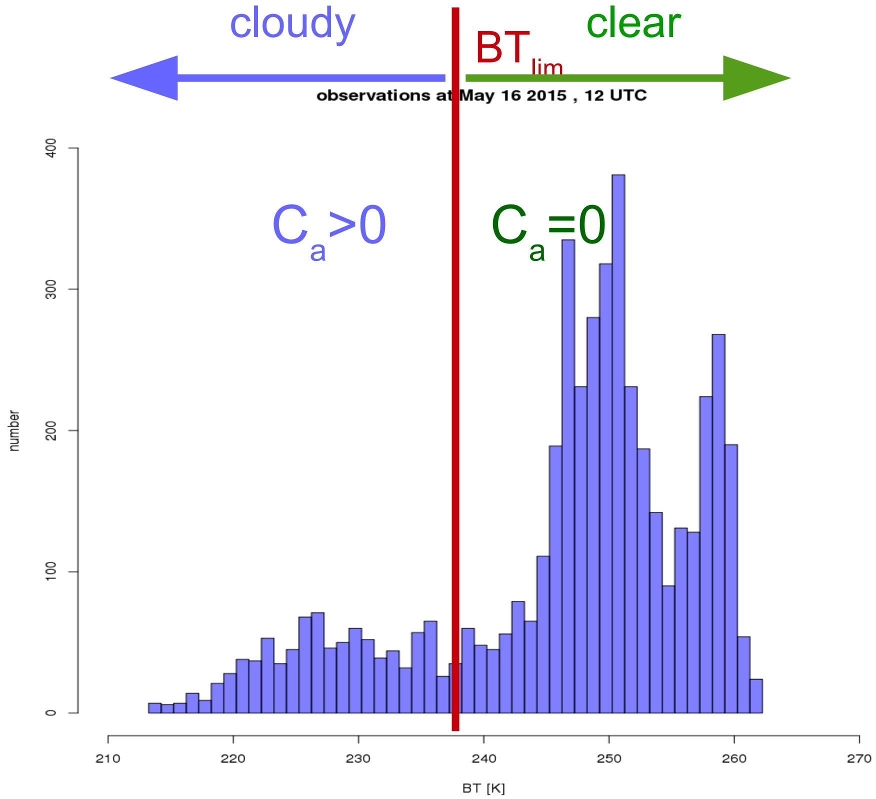
<u>Cloud impact on first guess:</u>

$$C_{fg}=\max(0,BT_{lim}-BT)$$

<u>Cloud impact on observations:</u>

$$C_{obs}=\max(0,BT_{lim}-(BT-BC))$$



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impact of clouds on brightness temperature:

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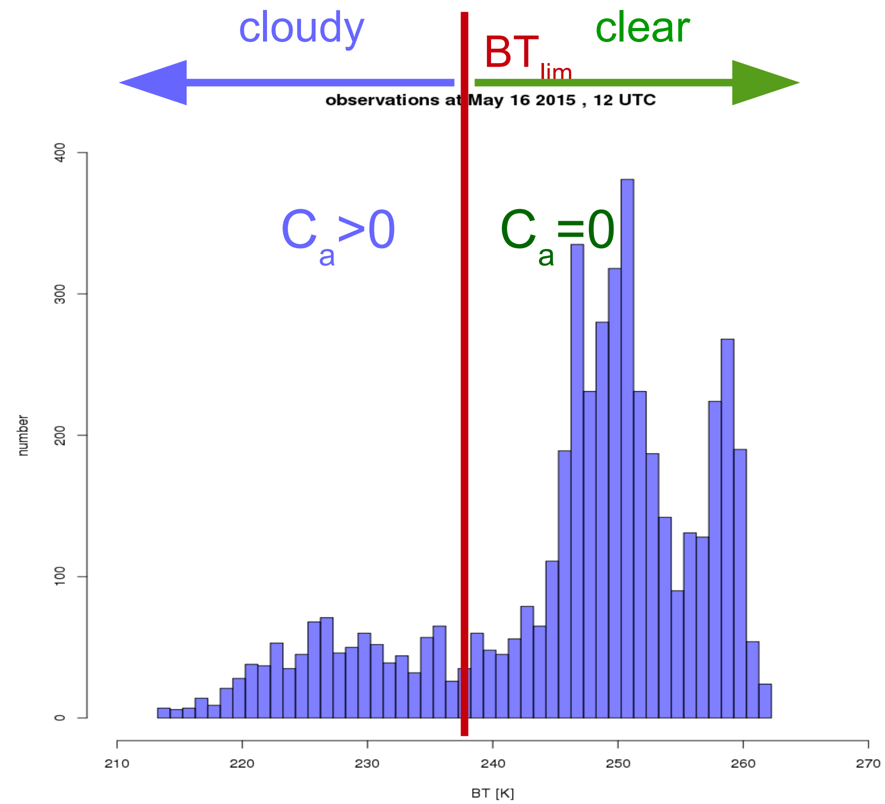


Cloud impact on first guess:

$$C_{fg}=\max(0,BT_{lim}-BT)$$

Cloud impact on observations:

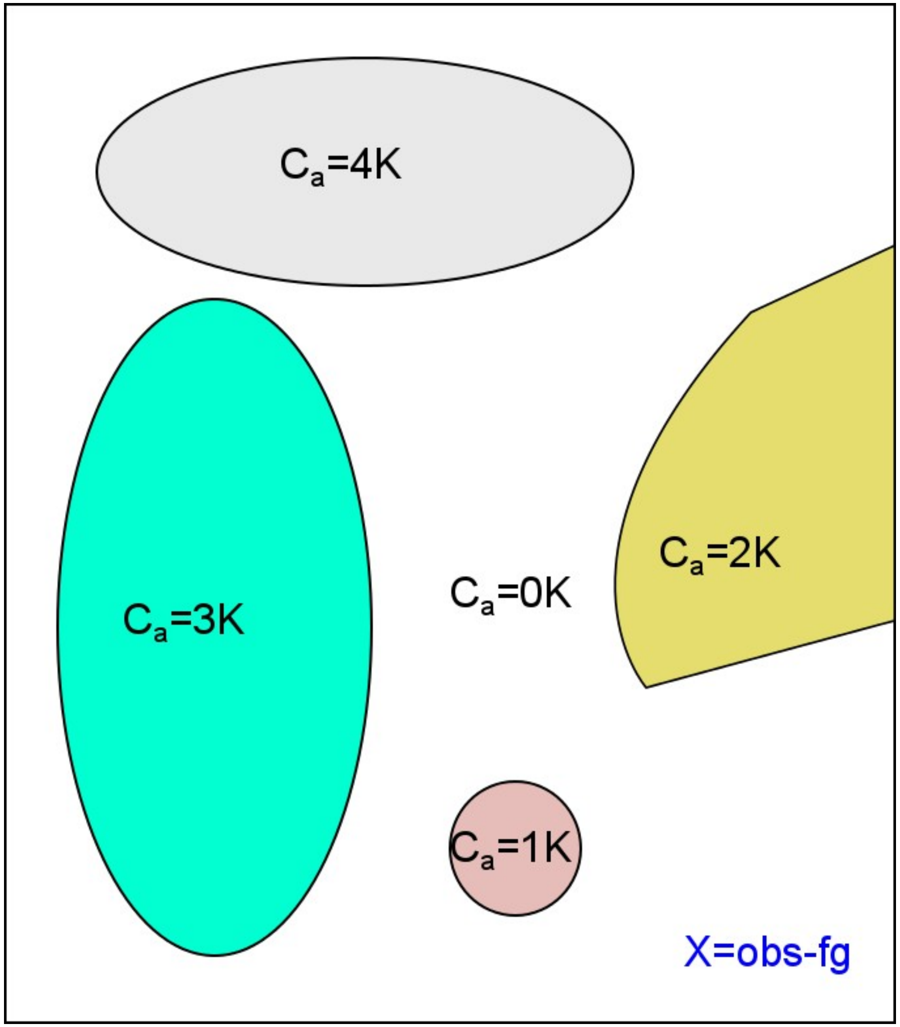
$$C_{obs}=\max(0,BT_{lim}-(BT-BC))$$

average cloud impact :

$$C_a=(C_{fg}+C_{obs})/2$$

2. cloud detection

One maps one value of C_a to each FOV

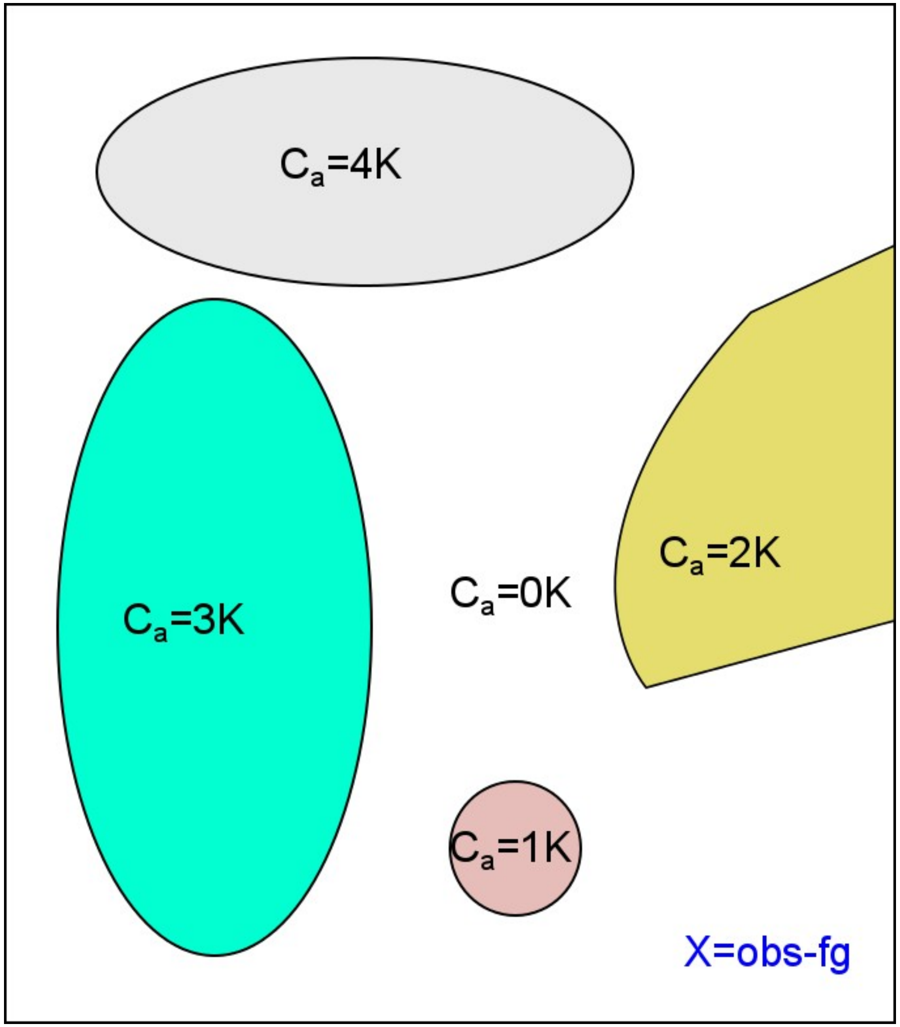


2. cloud detection

One maps one value of C_a to each FOV

binning all C_a values:

consider set of X=obs-first guess for each C_a



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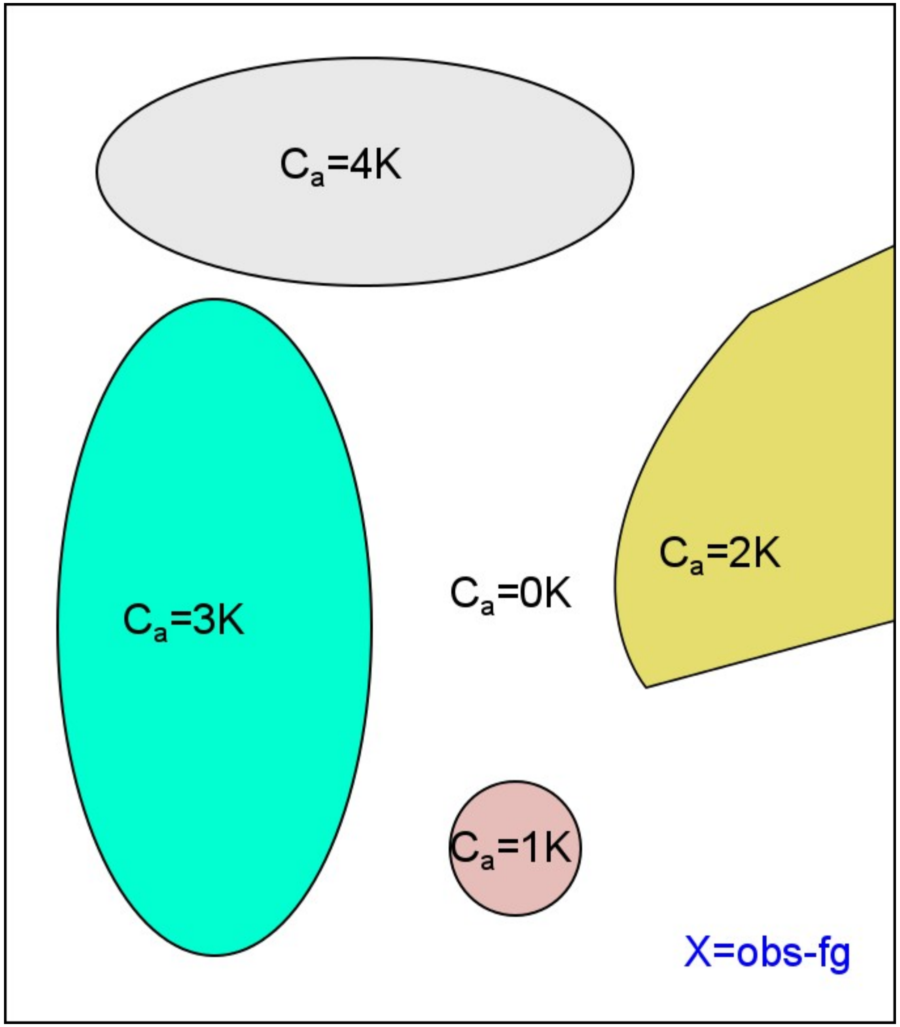
mean of {X}: bias

variance of {X}: $\sigma^2 = \sigma_{fg}^2 + \sigma_{obs}^2$ observation error



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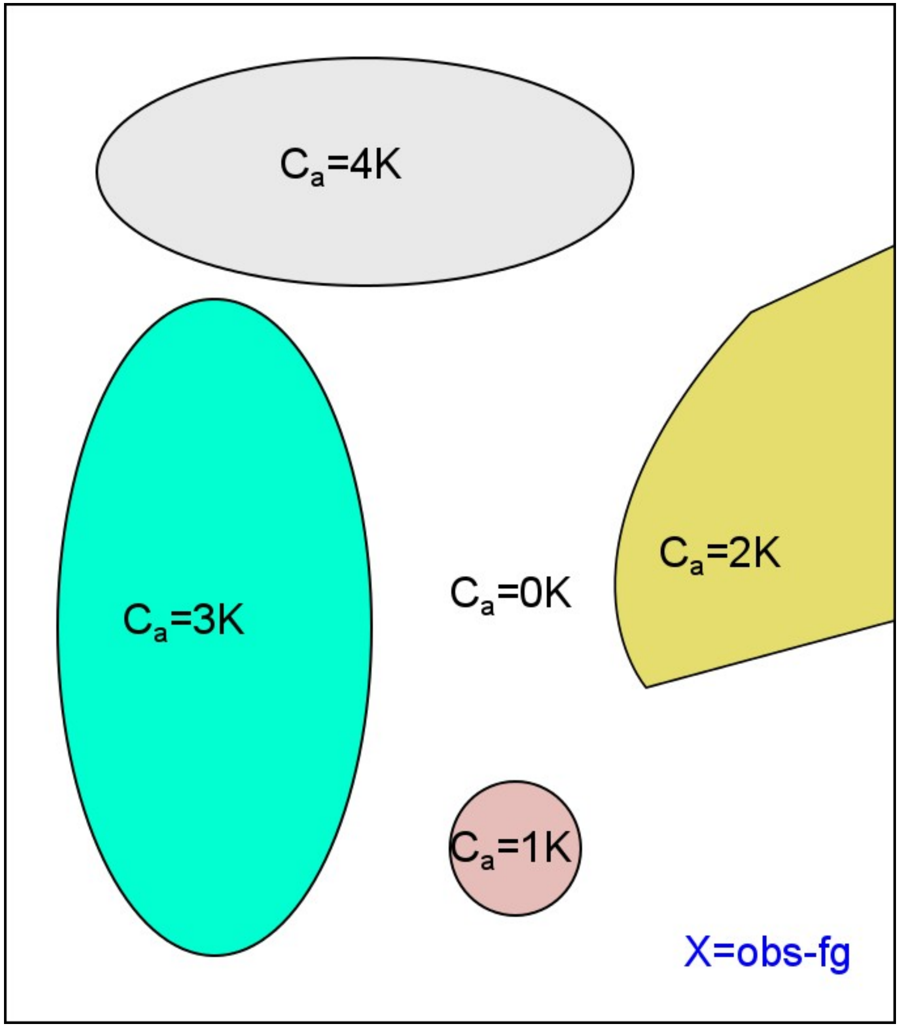
observation error

$Y = X/\sigma(C_a)$: normal distributed ?



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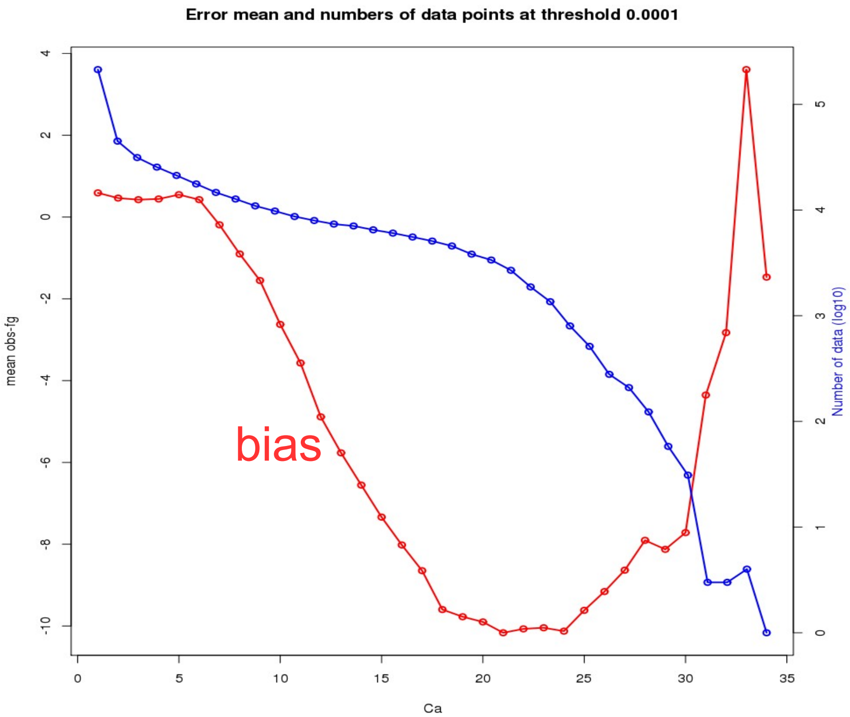

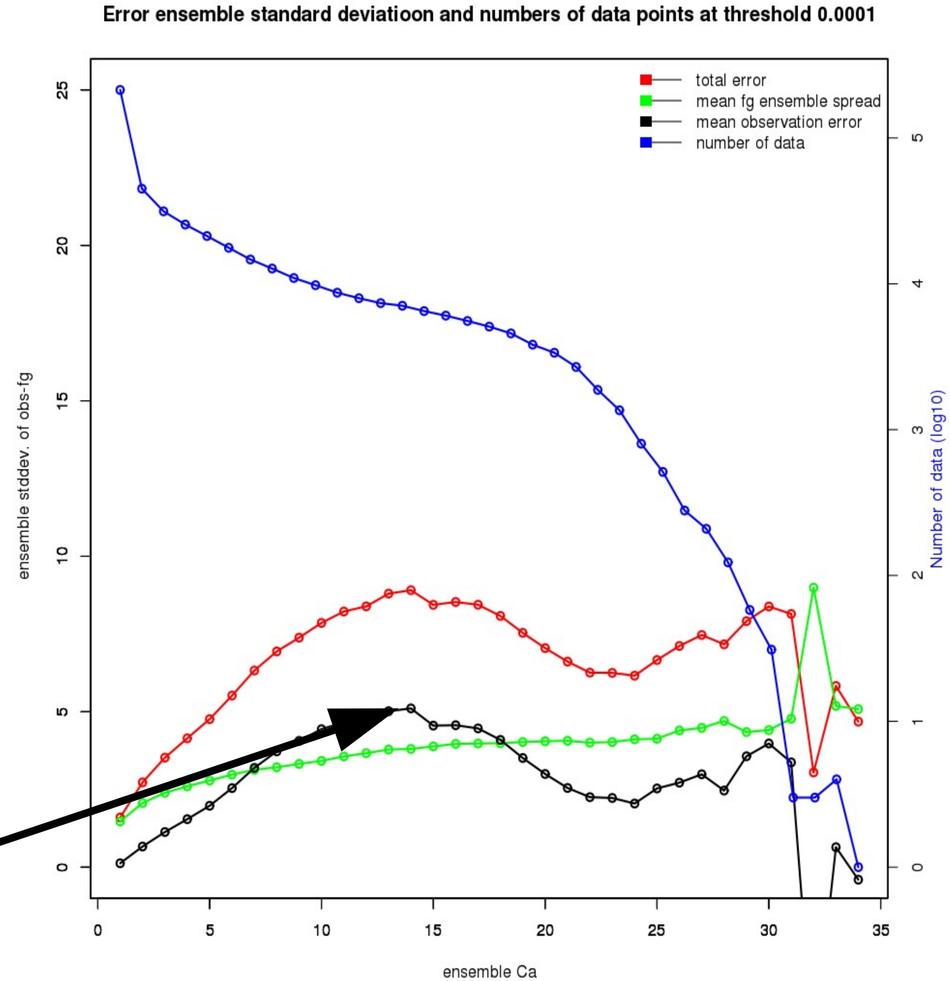

new observation error

Data from time period May 16-23 (2014)

2. cloud detection

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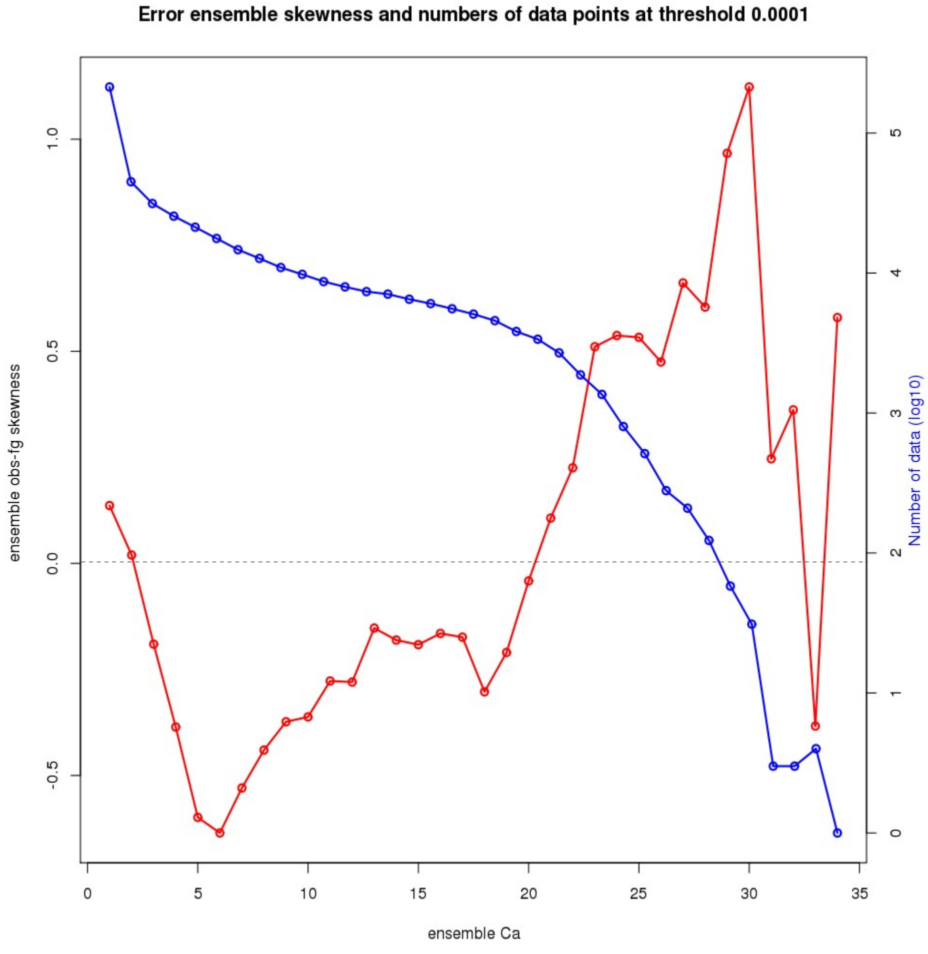
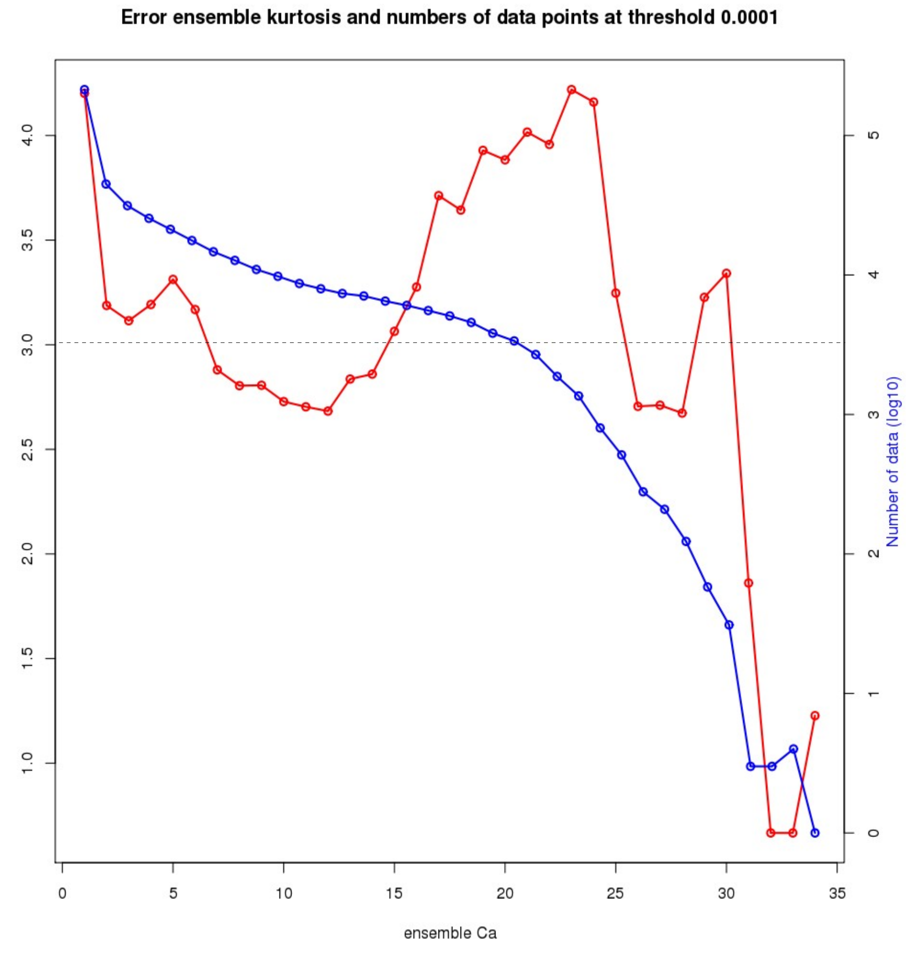
Wetter und Klima aus einer Hand

skewness

kurtosis





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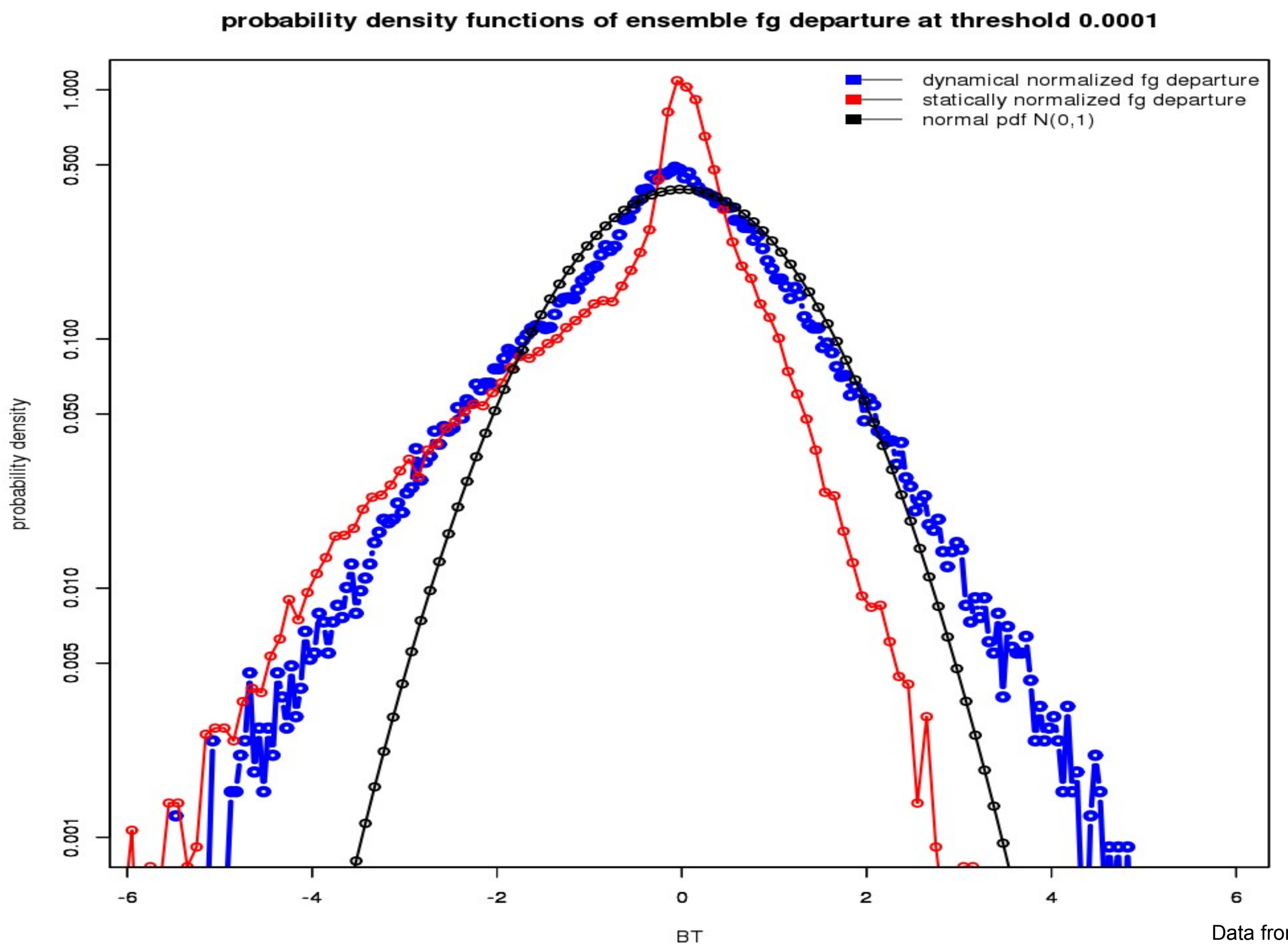

Data from time period May 16-23 (2014)

cloud-dependent classification of BT improves statistics

Outlook

1. Motivation

2. Cloud detection

3. Next steps

3. next steps

3. next steps

- Implementation of new observation error in KENDA

→ improvement of forecast ?

3. next steps

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- Implementation of new observation error in KENDA

  → improvement of forecast ?

- Improvement of cloud analysis in COSMO:
  - cloud fraction
  - precipitation

3. next steps

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Wetter und Klima aus einer Hand

- Implementation of new observation error in KENDA

  → improvement of forecast ?

- Improvement of cloud analysis in COSMO:
  - cloud fraction
  - precipitation

- comparison to cloud analysis based on observations, e.g.
  - Nowcasting SAF product (Schomburg et al. (2015))

Collaboration partners:

- R. Faulwetter, C. Schraff, H. Reich, A. Rhodin, H. Anlauf, R. Potthast (German Meteorological Service, Offenbach)

- Jason Otkin (University of Wisconsin-Madison)

Thank you for your attention