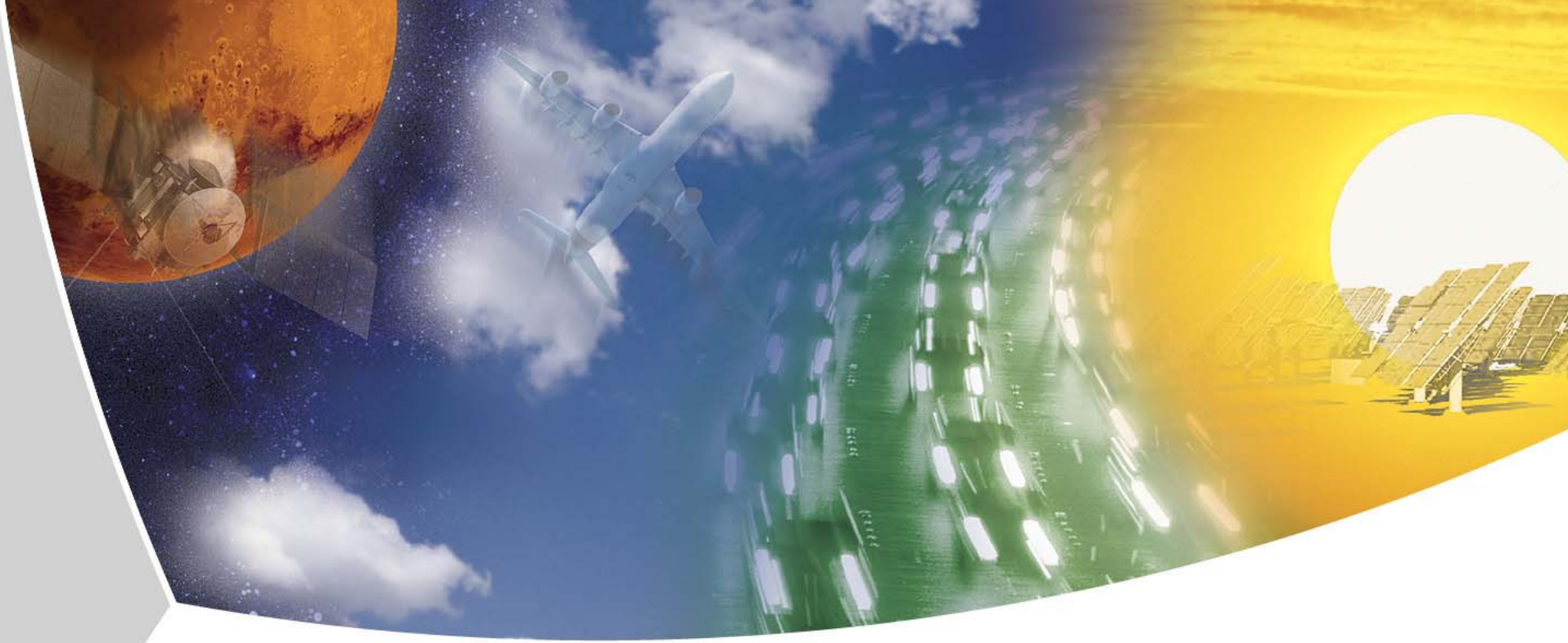

How do humidity variations impact QPF?

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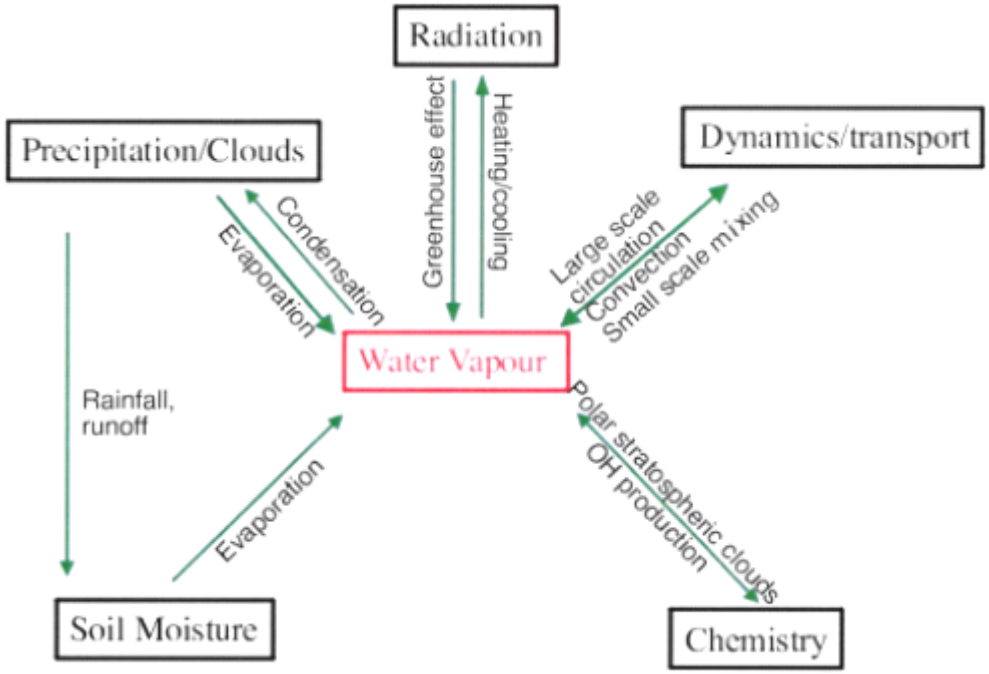
Institut für Physik der Atmosphäre

Motivation

Humidity is a key atmospheric variable.



(Gerard et al., 2004)

Motivation

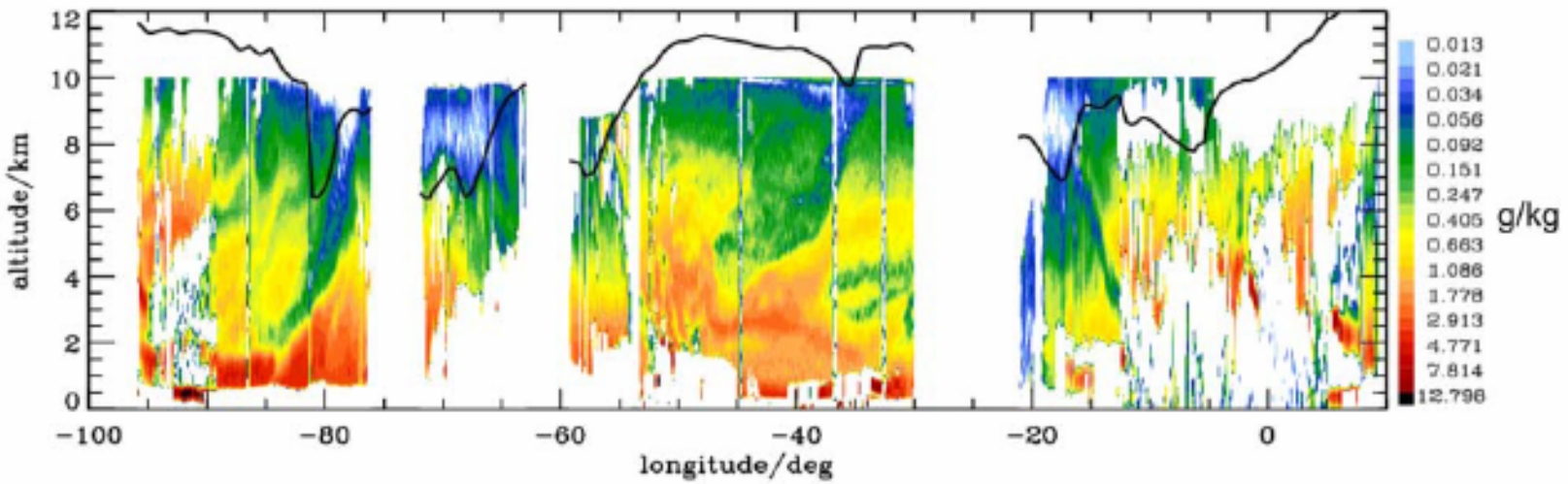
Humidity is,
however,
poorly observed
by the current humidity
observing sytems.

Humidity measurement dataset	Daily number of data	Number of channels (available)	Main humidity information	Typical data coverage of used data
SSMI, DMSP-13, 14, 15 Polar orbiting microwave radiances	220,000	7 (of 7)	Total column, except in clouds/rain	Ice free ocean
TEMP Radiosonde specific humidity	21,500	–	Tropospheric humidity profiles with high vertical resolution	Concentrations over North America, Europe, Eastern Asia and Australia
SYNOP 2m relative humidity	13,200	–	Boundary layer humidity	Irregular with concentrations in populated regions
GEOS, Meteosat 5,7, GOES-9, 10, 12 Geostationary IR radiances	141,500	1 (of 2)	Upper troposphere, clear air	Within 50° of the equator, cloud free only
AMSUB, NOAA-16, 17 Polar orbiting microwave radiances	131,500	3 (of 5)	Upper and mid troposphere	Irregular, emissivity dependent over land and ice; good over ice free ocean
HIRS, NOAA-16, 17 Polar orbiting IR radiances	120,000	6 (of 19)	Mostly upper troposphere, clear air	Cloud free ocean and ice
AIRS, AQUA Polar orbiting IR radiances	280,000	230 (of 2378)	Upper and mid troposphere, clear air	Cloud free ocean and ice

Humidity observing systems used in ECMWF data assimilation
(Andersson et al, 2006, ECMWF NL)

Motivation

DIAL *(airborne differential absorption lidar)* observations offer a new data source with high precision at high spatio-temporal resolution



Observed vertical profile of humidity across the North Atlantic *(Flentje et al., 2005)*

WALES *(water vapour lidar experiment in space)*

- vertical resolution up to 500m
- Random error 5%, Systematic error < 2%

(Gerard et al., 2003)

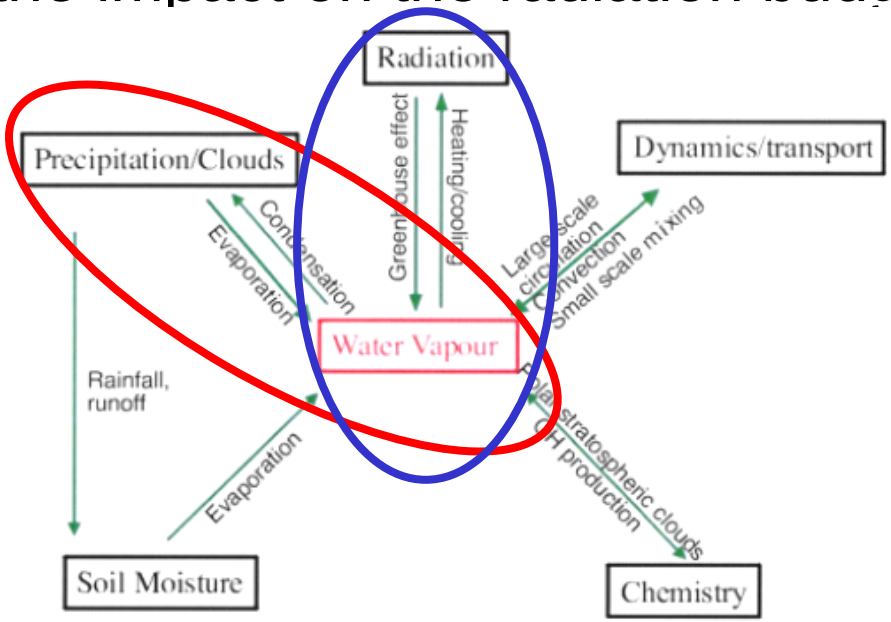
Motivation

An accurate depiction of the humidity distribution is a necessary requirement of successful weather forecasting in particular for convective and severe precipitation events:

- the intensity of convection is crucially determined by the humidity in the PBL *(Crook, 1996)*
- in the mid-troposphere en-/detrainment of ambient air impacts the convection *(Derbyshire et al., 2004)*
- assimilation of humidity data locally increases rainfall in Europe *(Andersson et al, 2006, ECMWF NL)*

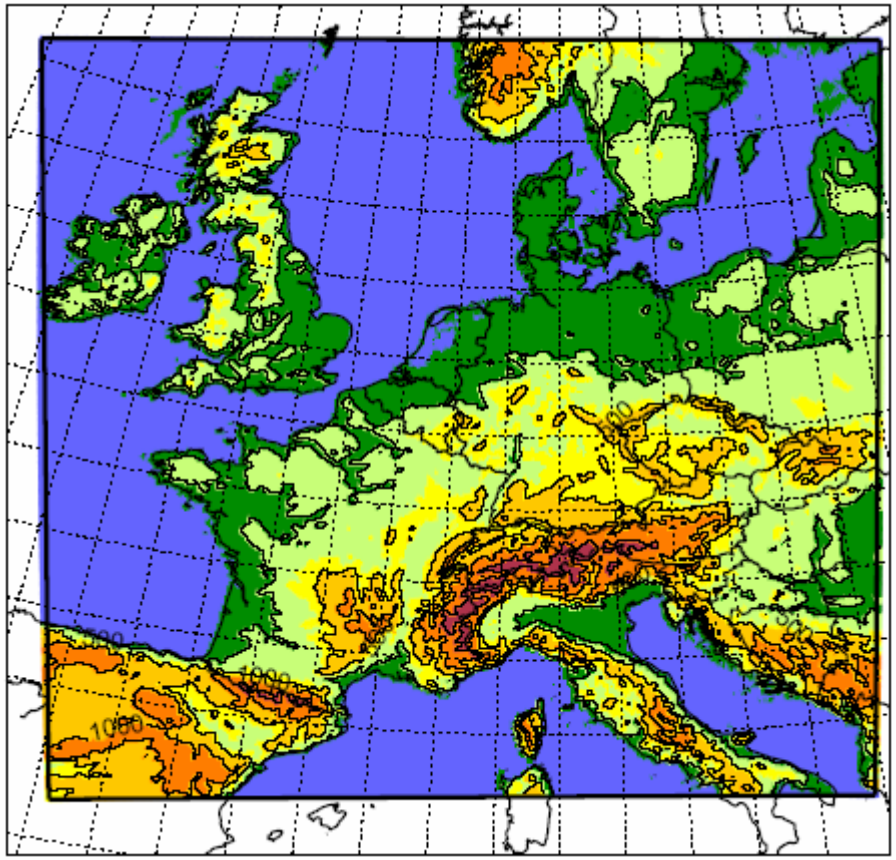
Key questions

1. How do humidity variations in different heights impact QPF?
2. Are there differences in regions with predominant stratiform vs convective regions?
3. How important are variations in the boundary data?
4. What is the impact on the radiation budget?



Tool: Lokal-Modell

- operational @ DWD
- non-hydrostatic
- 325x325x35 GP
- meshsize 7km
- Param. subgrid-scale processes, i.e. moist convection (Tiedtke)
- grid-scale precip incl. cloud ice (since 09/03)
- progn. precipitation (since 04/04)



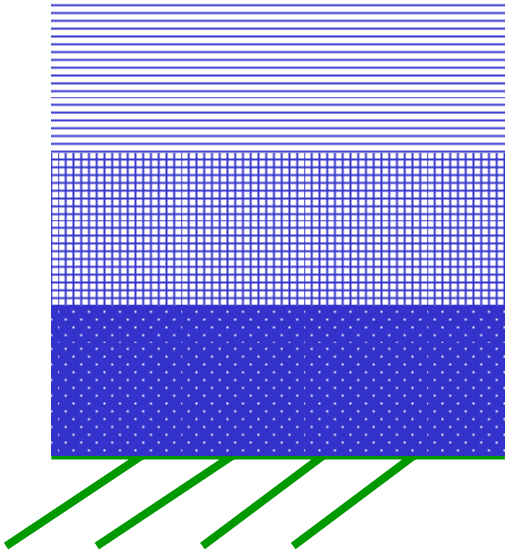
- progn. variables: u,v,w,T,p',qv,qc,qi,qs,qr

Experimental setup:
Variation of humidity in 3 layers

h

m

g



-Model layers 17- 7 (600-200 hPa)

-Model layers 24-18 (830-600 hPa)

-Model layers 35-25 (1000-830 hPa)

no relative humidity exceeding 100%

Numerous LM Experiments: (1) case study on 25 June 2006
(2) 11day period 14 till 24 June 2006

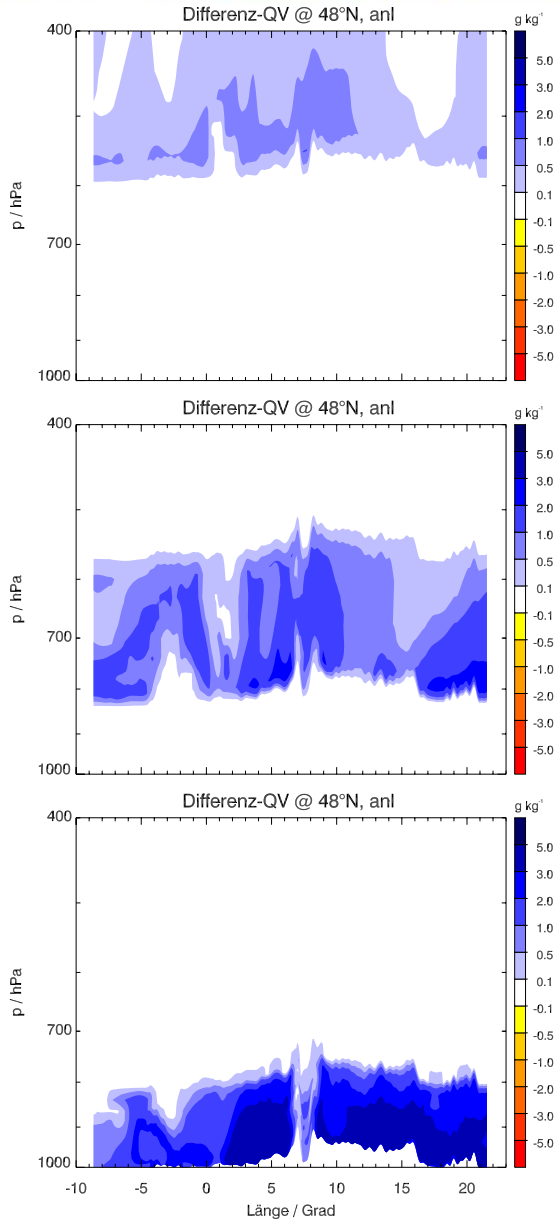
Schicht	Variation	
	Referenzlauf	ref
h	10%	hplus10
	30%	hplus30
	-10%	hminus10
	-30%	hminus30
m	10%	mplus10
	30%	mplus30
	-10%	mminus10
	-30%	mminus30
g	10%	gplus10
	30%	gplus30
	-10%	gminus10
	-30%	gminus30

Example: vertical cross section along 48°N

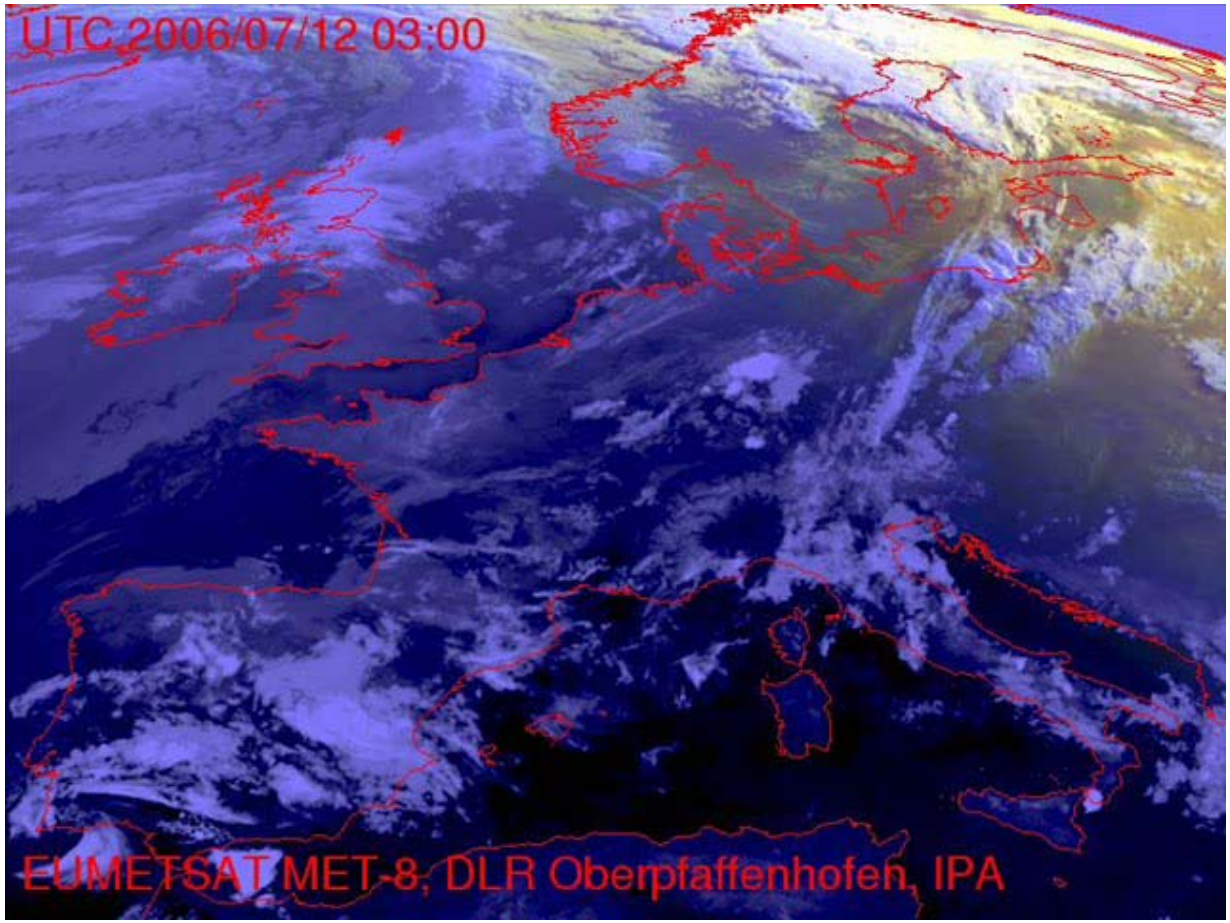
hplus30

mplus30

gplus30



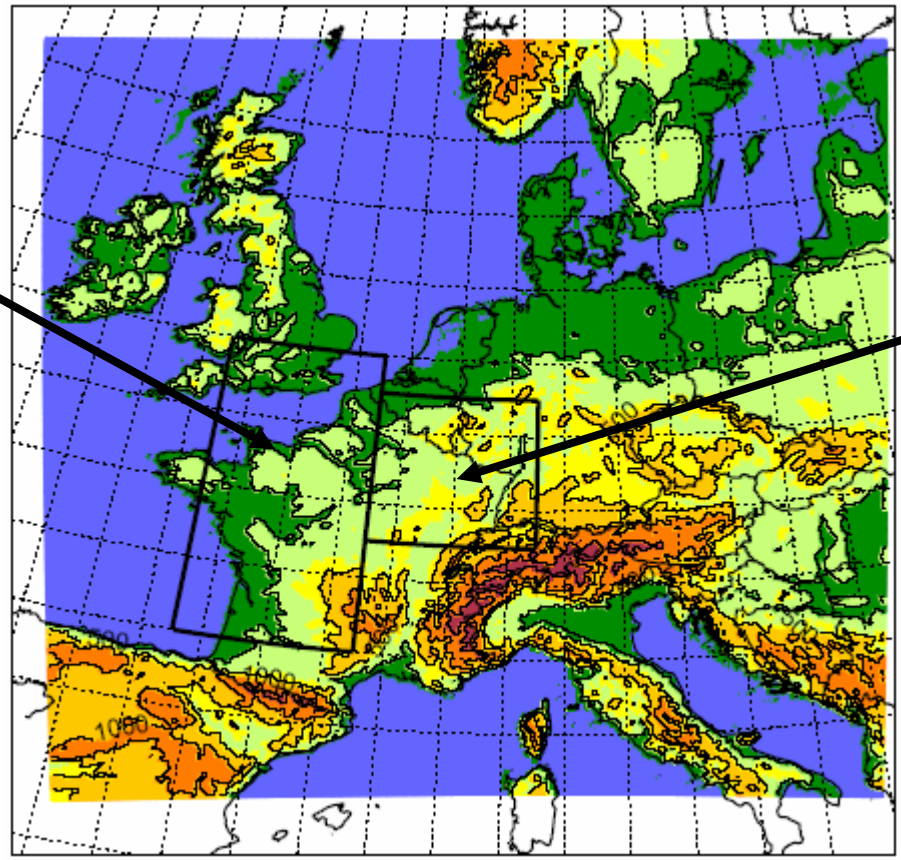
IR imagery 25 June 2006



2 areas: stratiform vs convective rainfall region

Area with predominantly stratiform rainfall

8327
ca. 400 000 km²

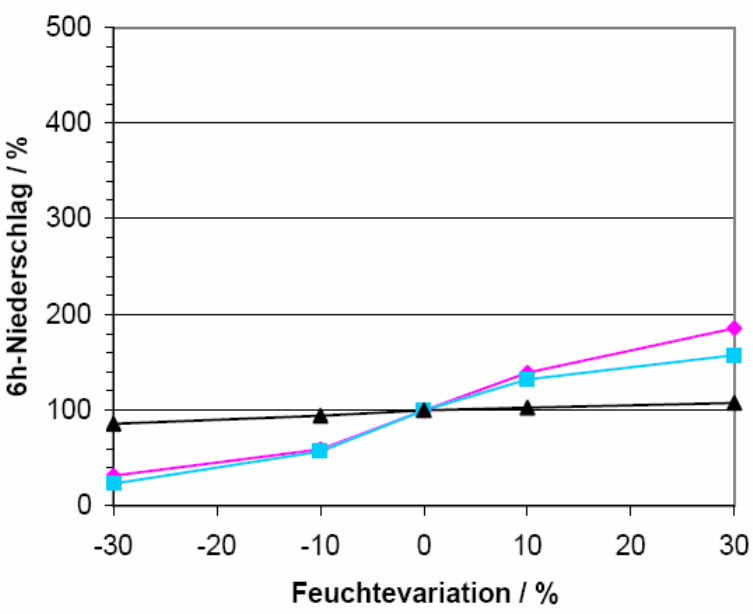


Area with predominantly convective rainfall

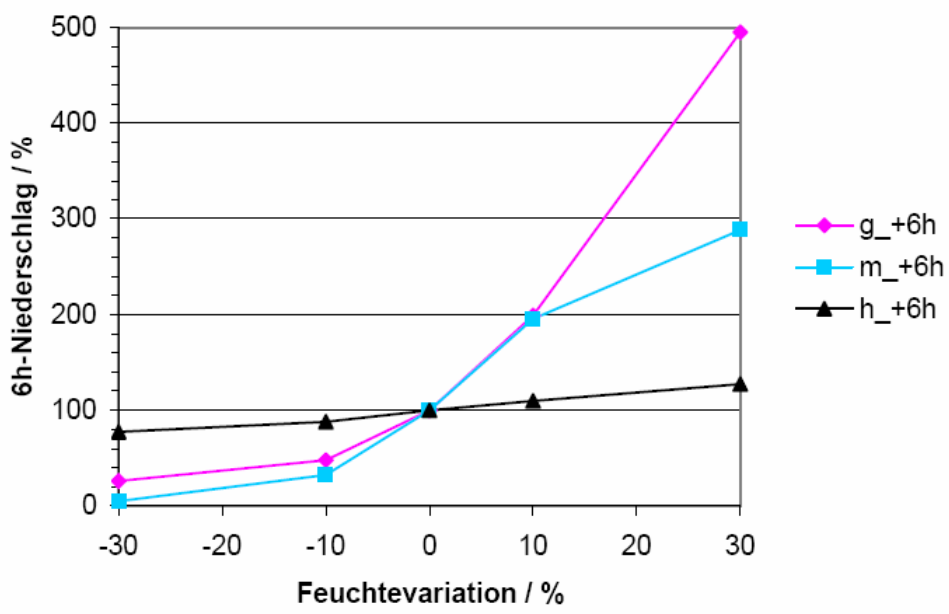
4076
ca. 200 000 km²

2 areas: stratiform vs convective rainfall region

averaged over stratiform rainfall region

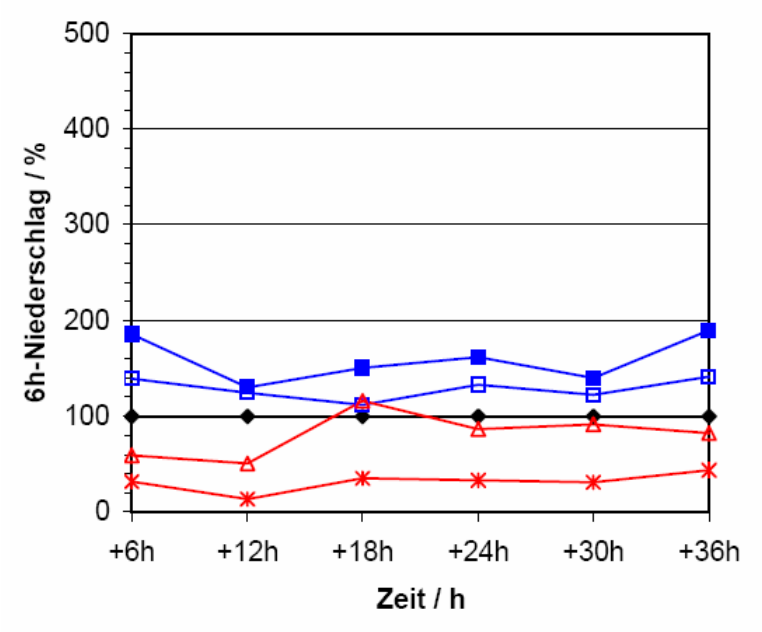


averaged over convective rainfall region

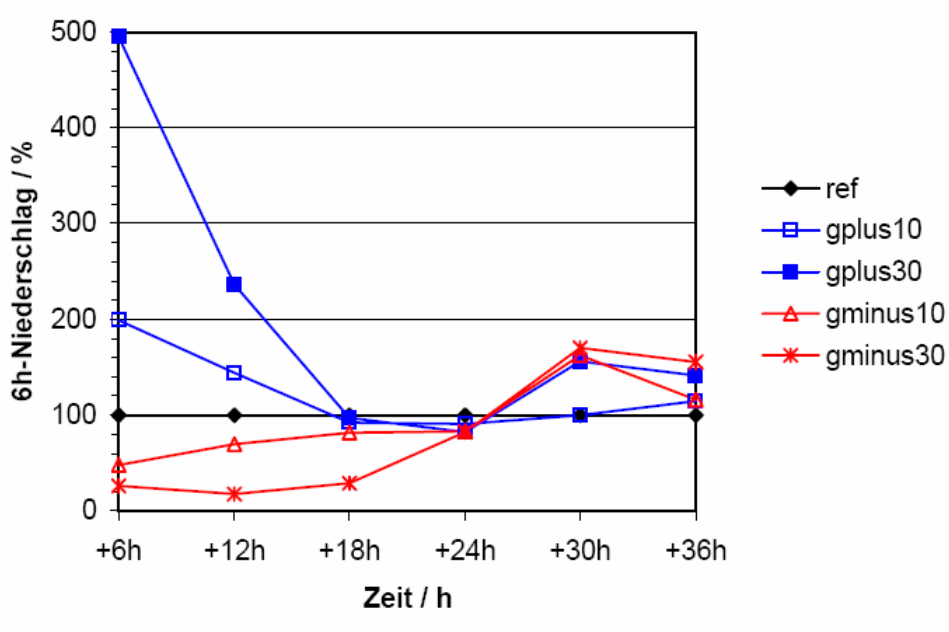


Time series of stratiform vs convective rainfall region

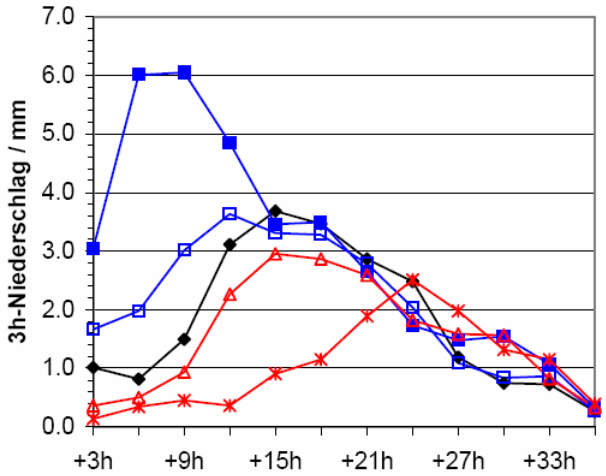
averaged over stratiform rainfall region

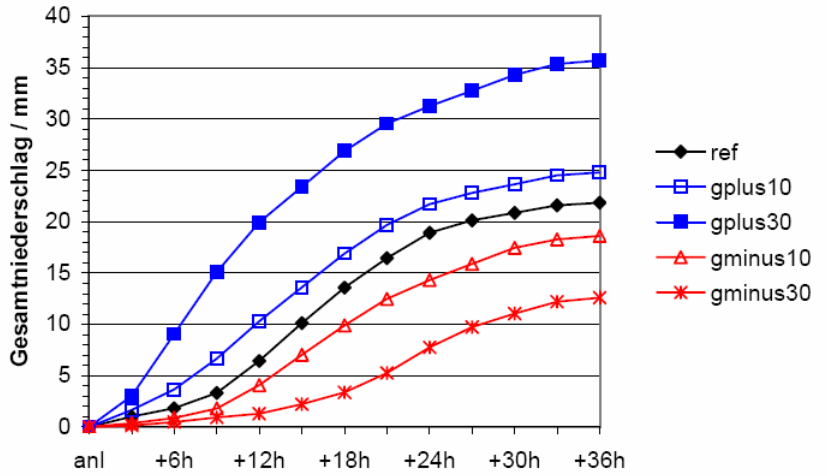


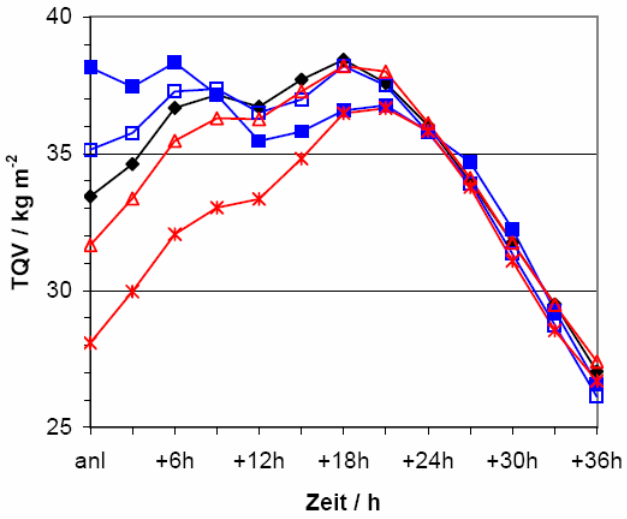
averaged over convective rainfall region

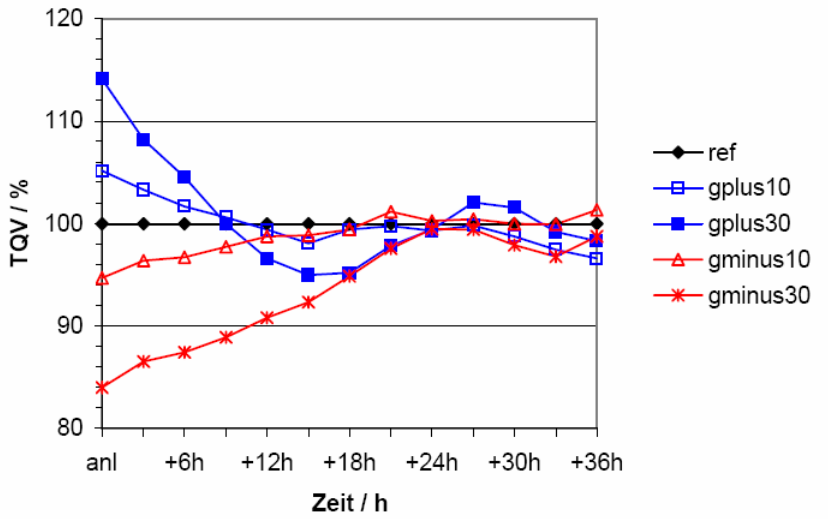


Convective rainfall region

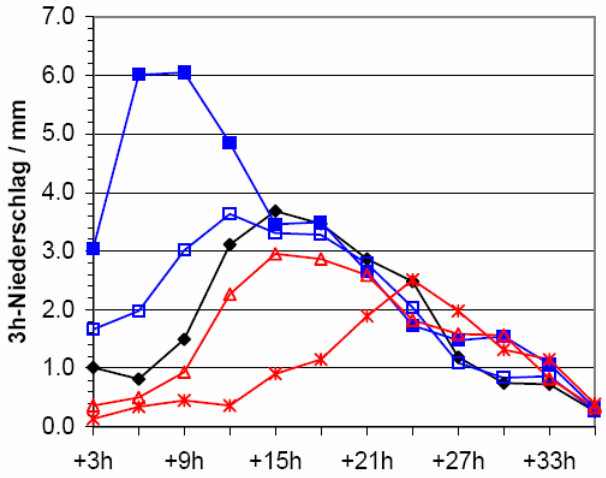


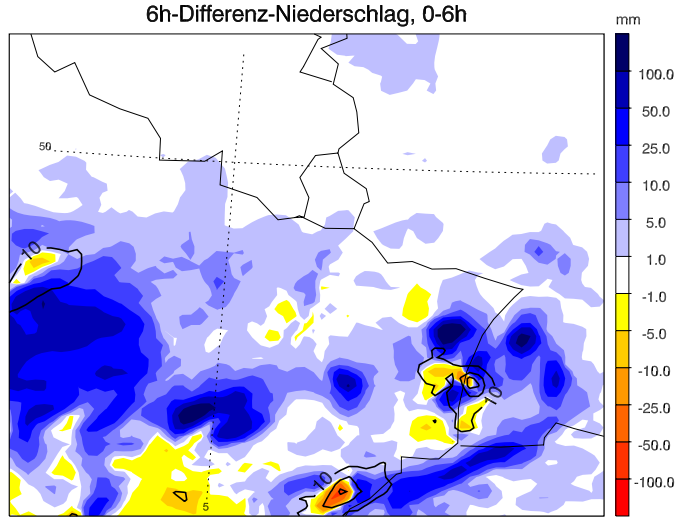






Convective rainfall region





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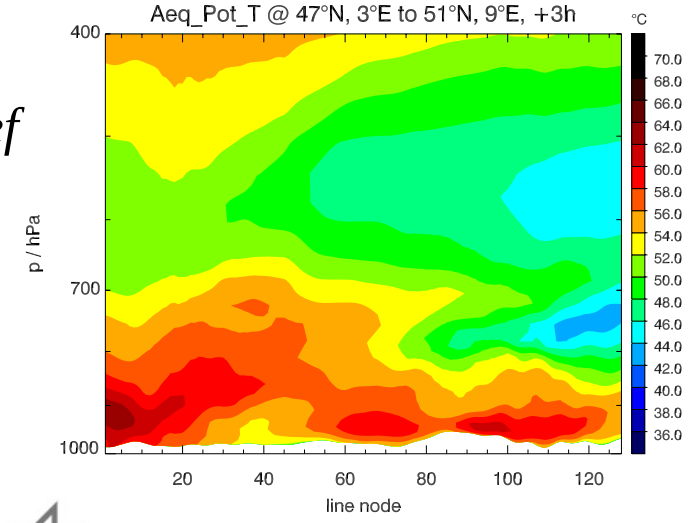
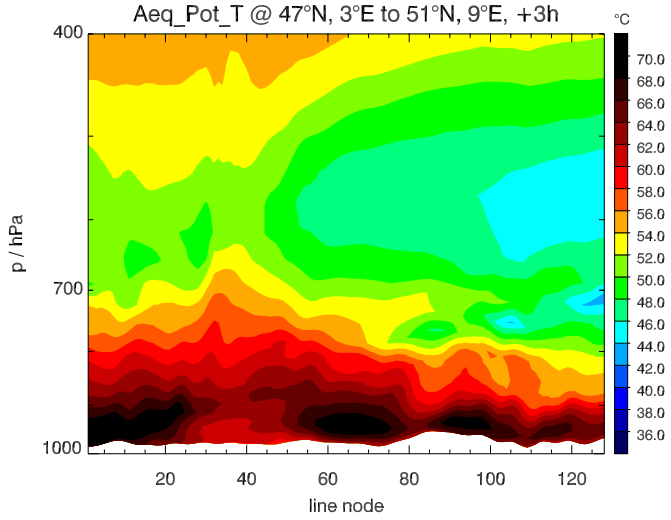


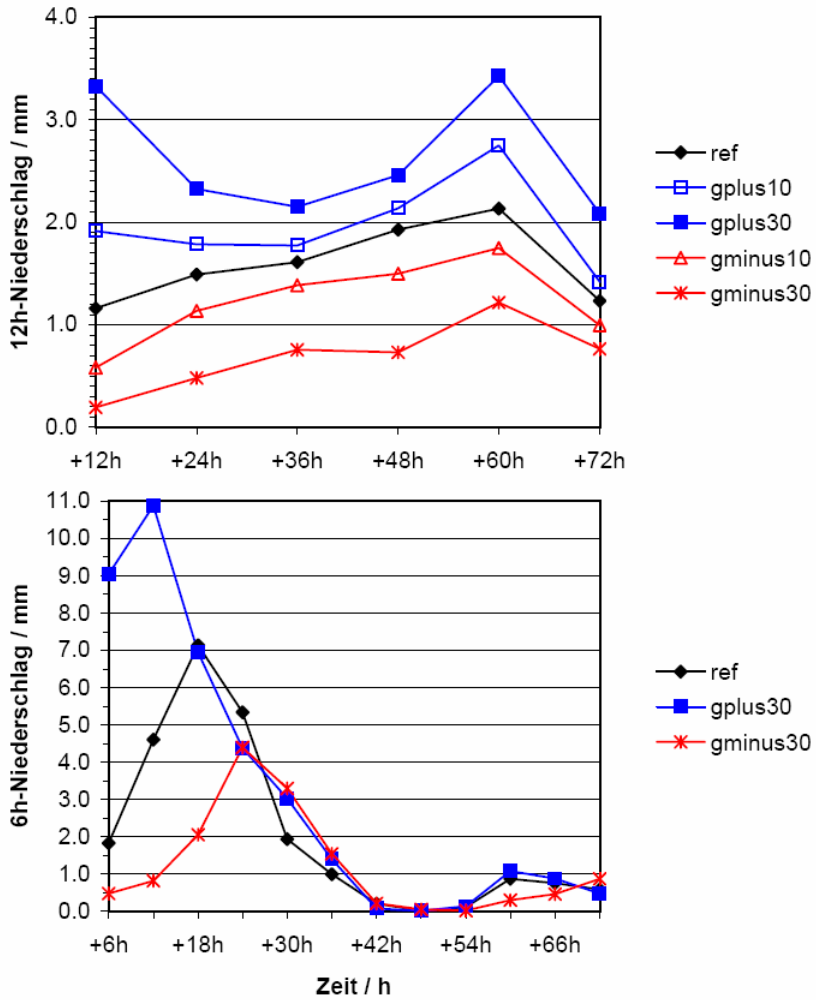


gplus30

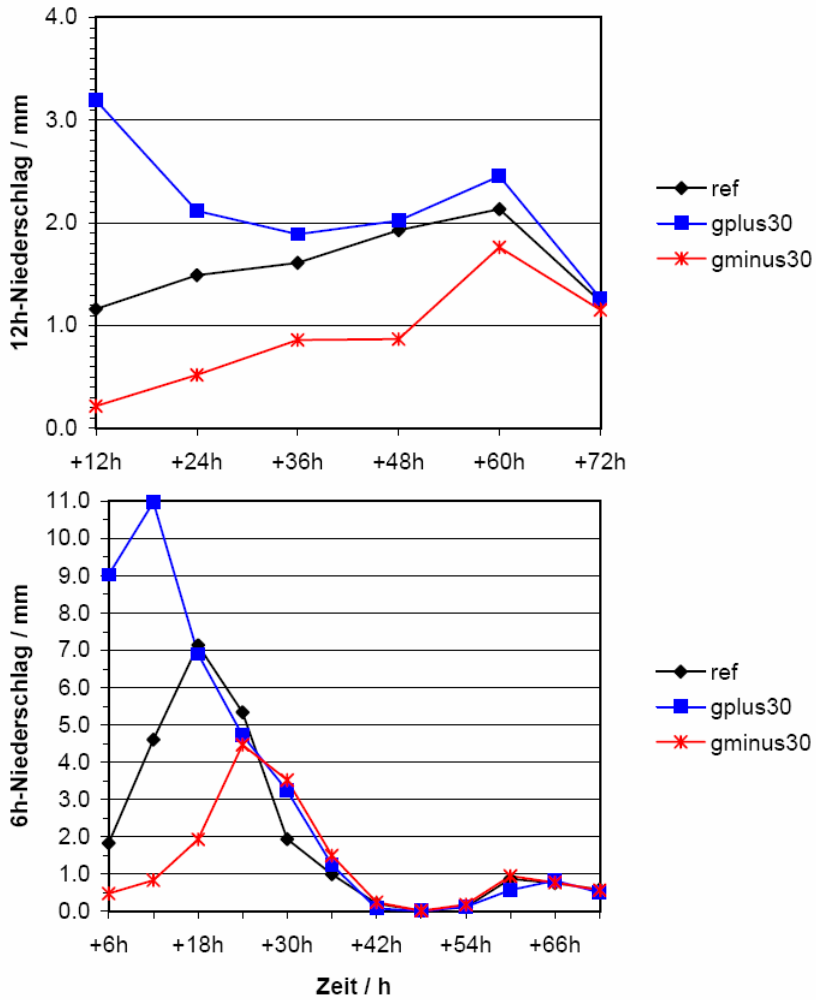
Impact of boundary data

convective domain LM domain

IC & BC



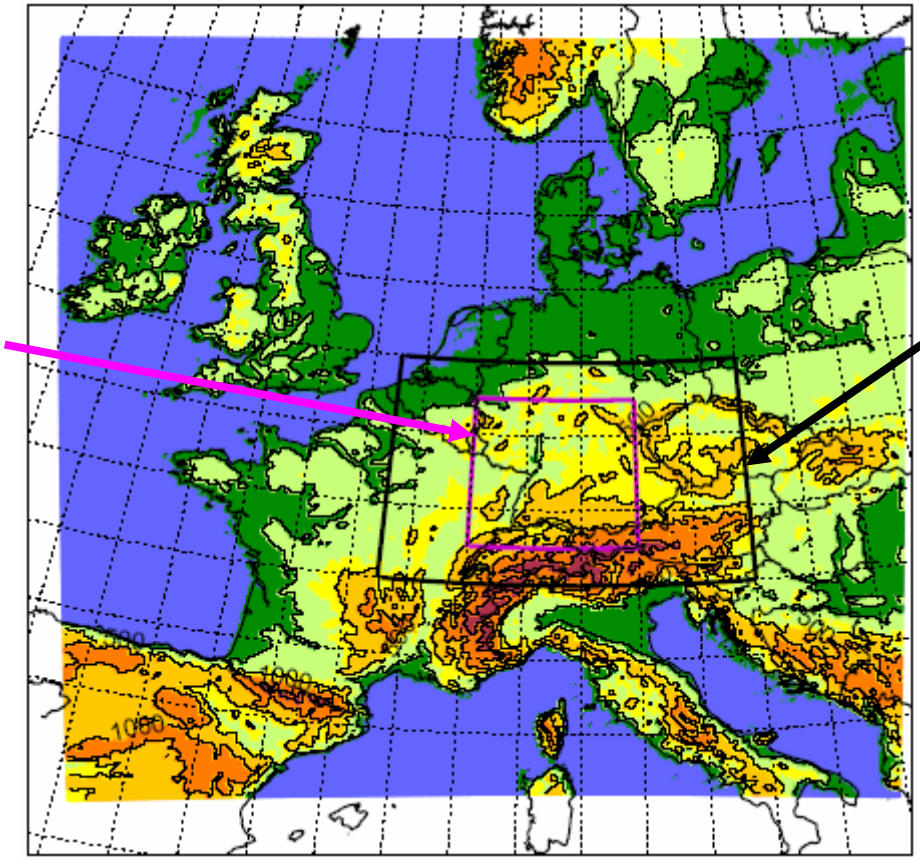
IC only



11 day episode: 14 till 24 June 2006

Domain 3
(3-day-average)

4072
ca. 200 000 km²



Domain 11
(11-day-average)

13248
ca. 640 000 km²

11 day average

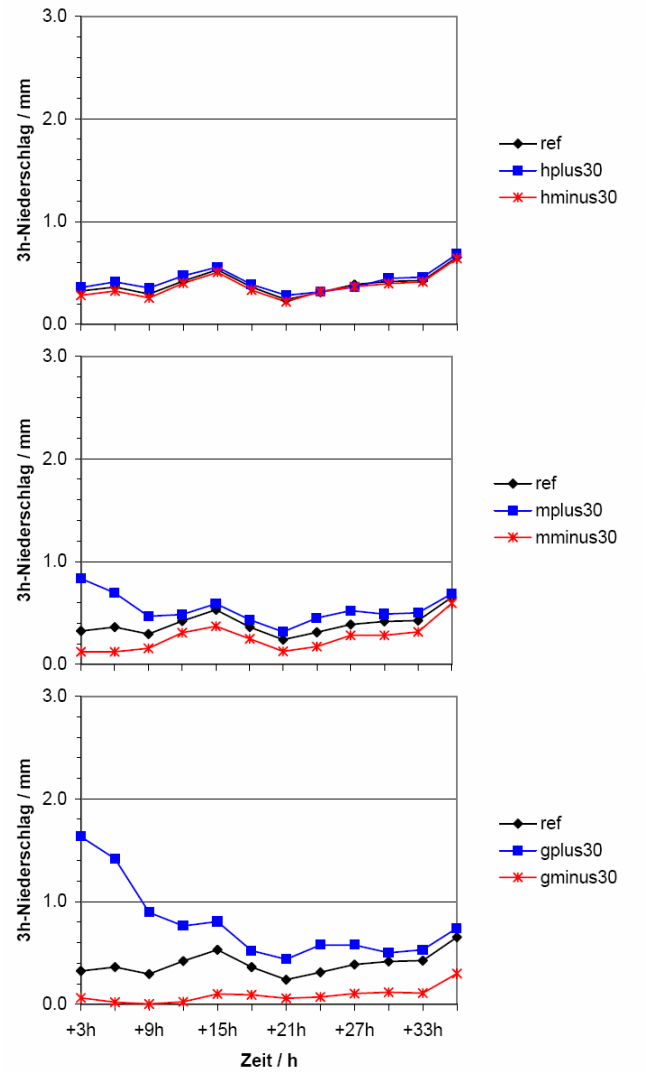
3 day average

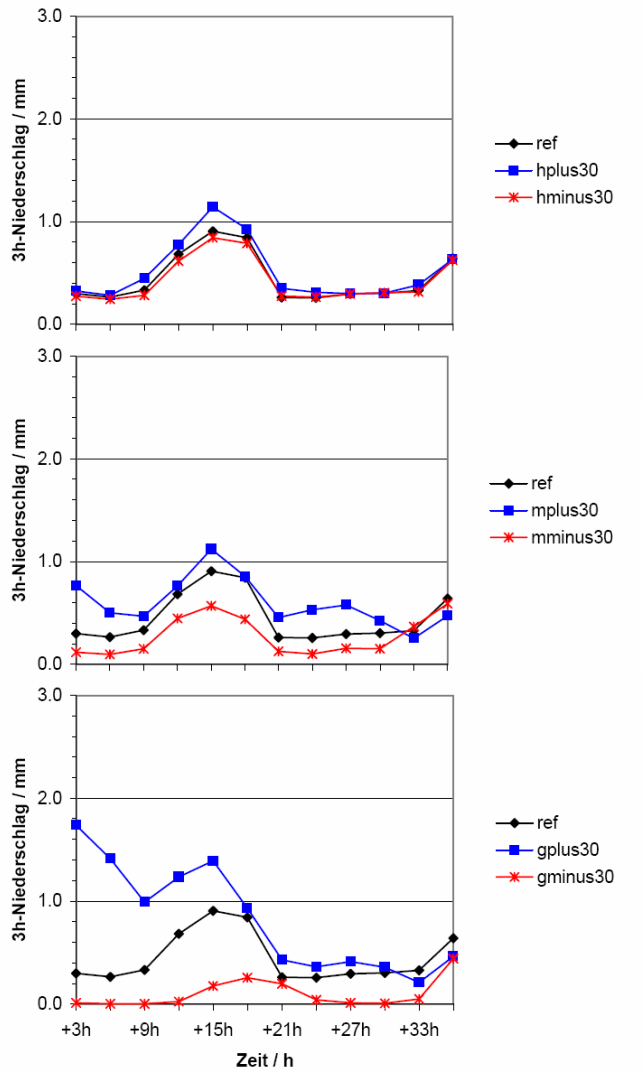
z

h

m

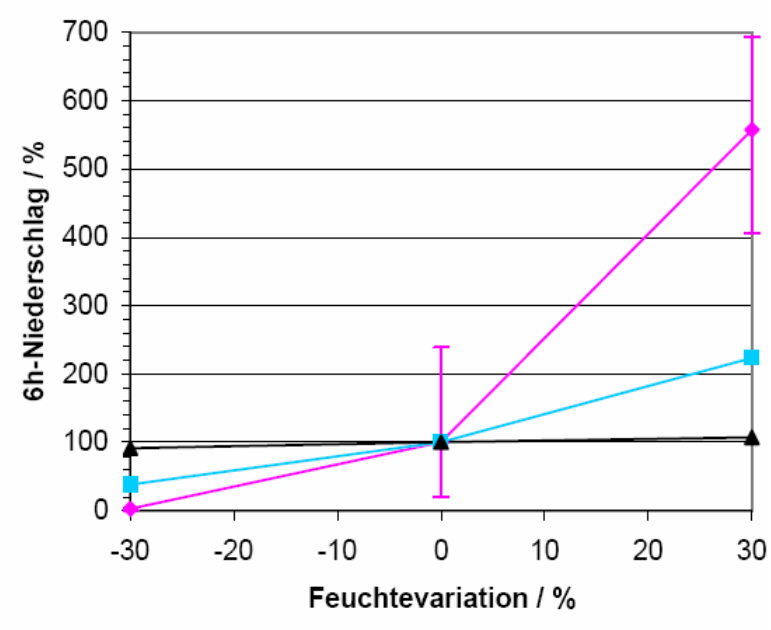
g



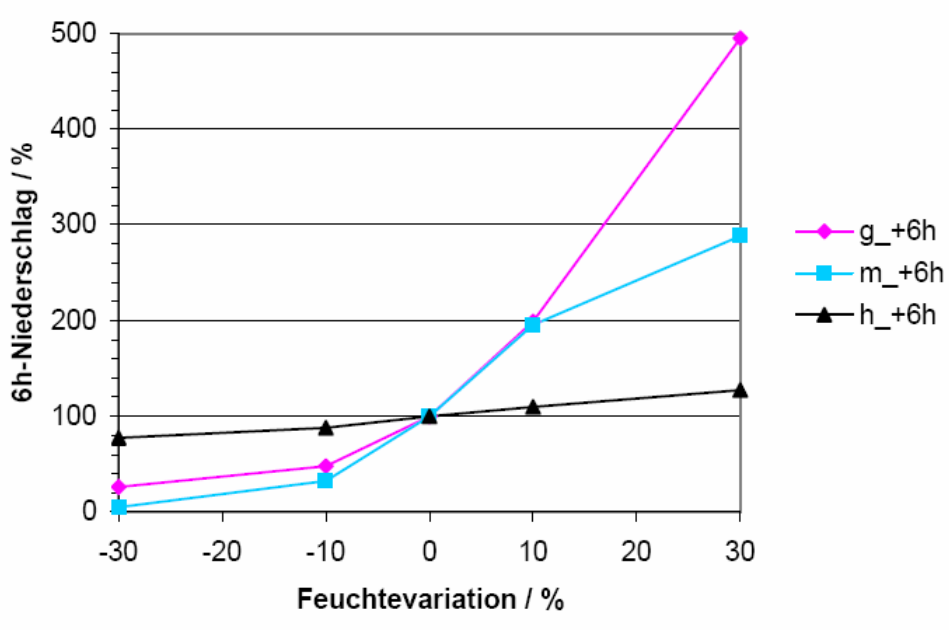


3 day average vs case study 25 June 2006

averaged over convective rainfall region (domain 3)



averaged over convective rainfall region

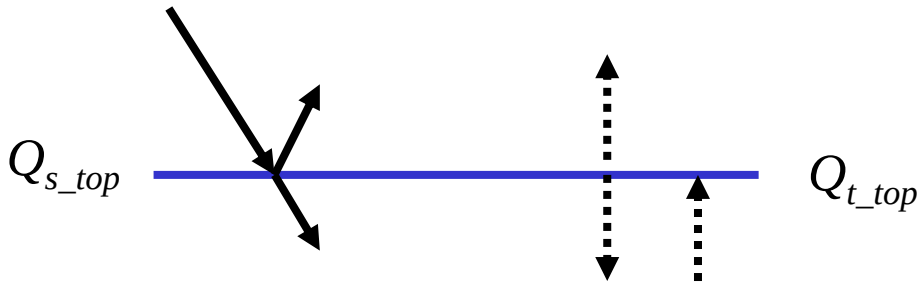


Impact on radiation: solar vs terrestrial

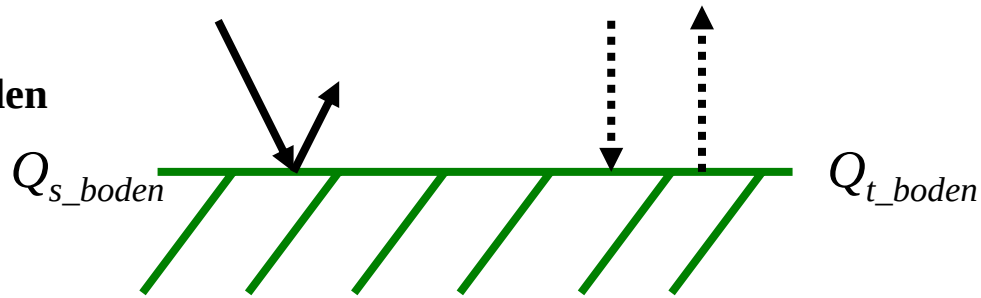
solare Strahlung:
0.3 bis 3.5 µm

terrestrische Strahlung:
3.5 bis 60 µm

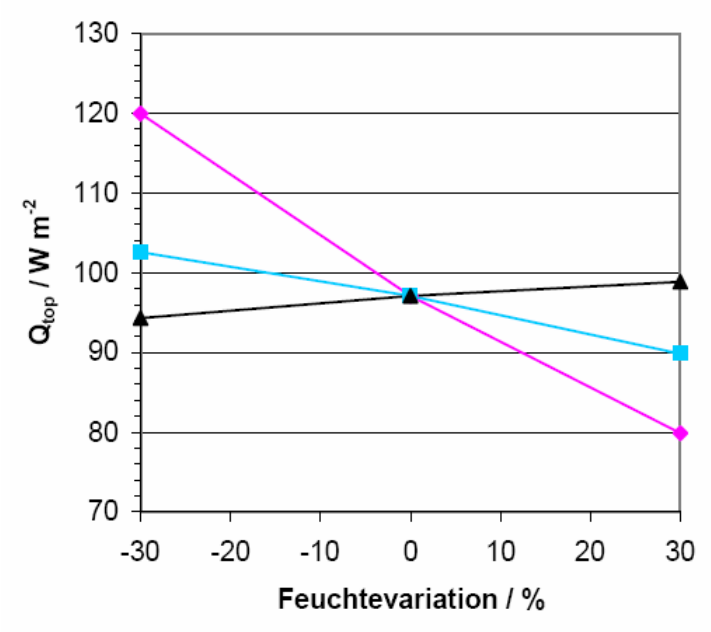
$$Q_{top} = Q_{s\_top} + Q_{t\_top}$$

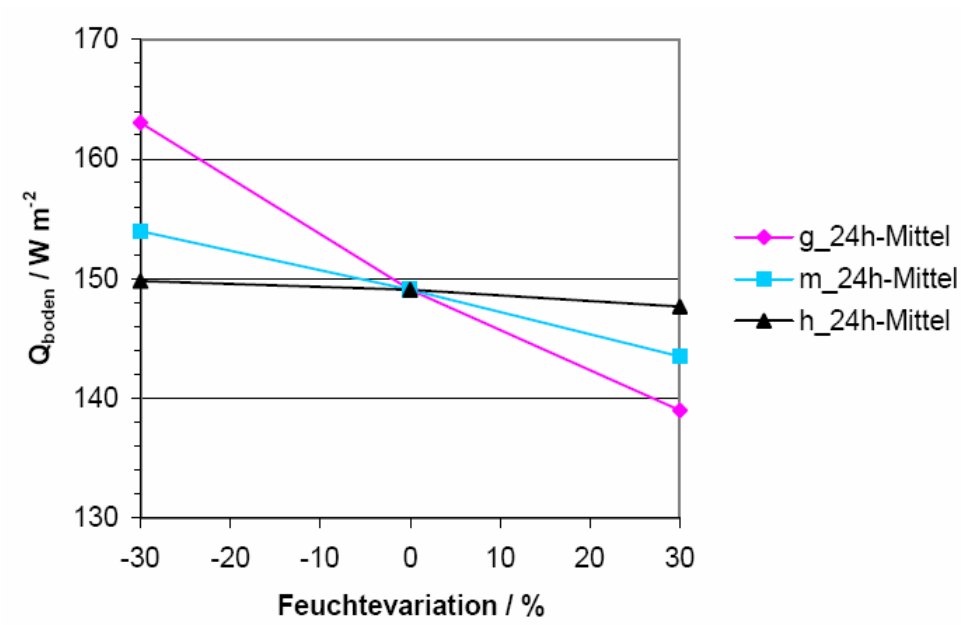


$$Q_{boden} = Q_{s\_boden} + Q_{t\_boden}$$

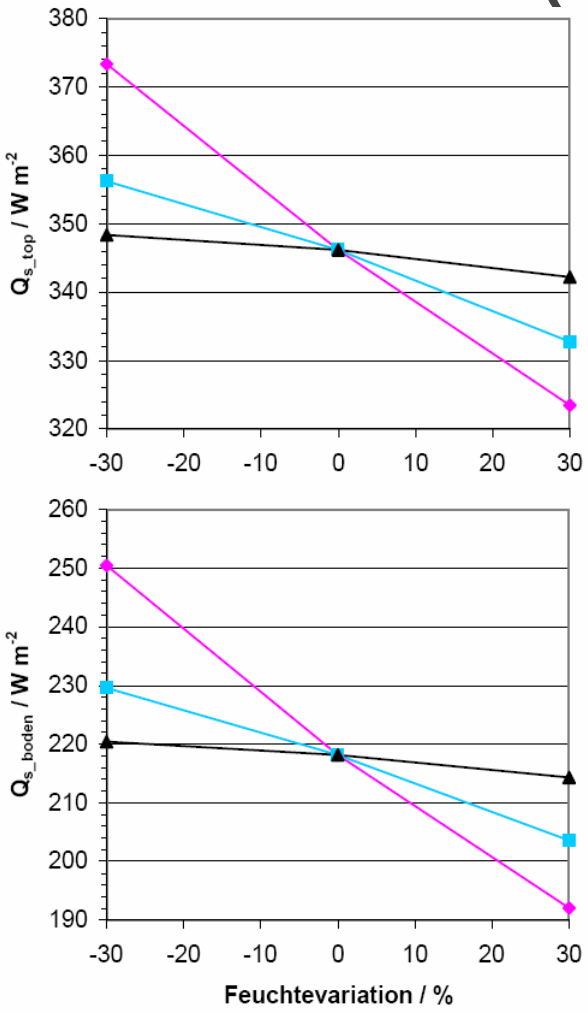


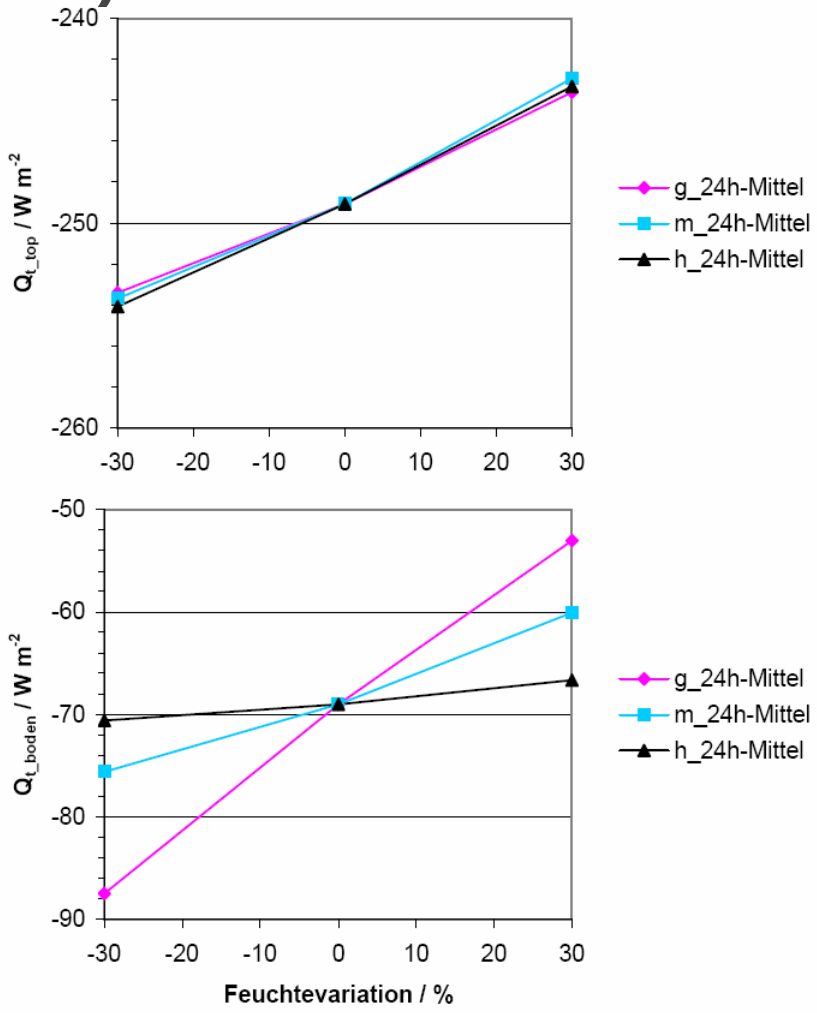
Radiation budget at the TOA and the earth surface (11day av.)





Solar vs terrestrial radiation budget at the TOA and the earth surface (11day av.)





Summary

1. How do humidity variations in different heights impact QPF?
   - Sensitivity of rainfall decreases with height
   - variation of humidity in BL dominant
   - TQV(g+10%) corresponds TQV(m+20%)

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Summary

1. How do humidity variations in different heights impact QPF?
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   - TQV(g+10%) corresponds TQV(m+20%)
2. Are there differences in regions with predominant stratiform vs convective regions?
   - Convection is responding sensitive on humidity variations (gplus30: conv. 500%, strati. 200%)
   - Phase shift: convection starts earlier
3. What is the impact on the radiation budget?
   - Terrestrial radiation at TOA shows similar impact w.r.t. humidity variations in different layers