Meteorologisches Institut
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DAQUA

New results in Physical Initialization Bonn (PIB)

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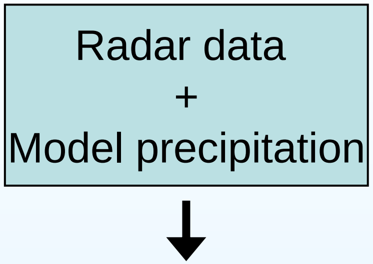
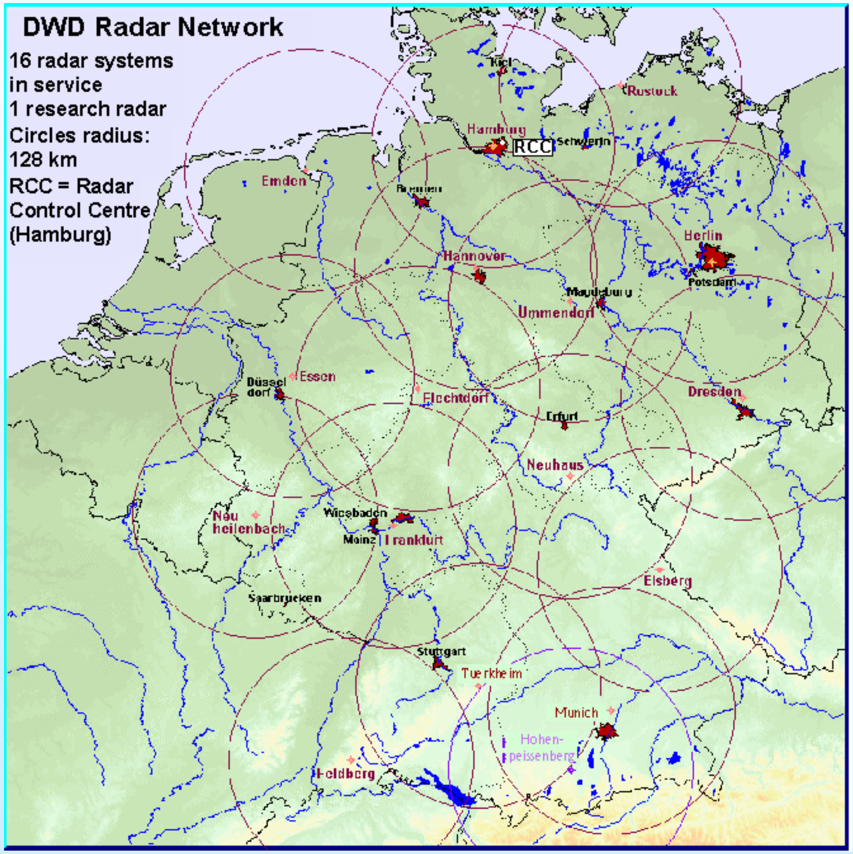
Description of the scheme



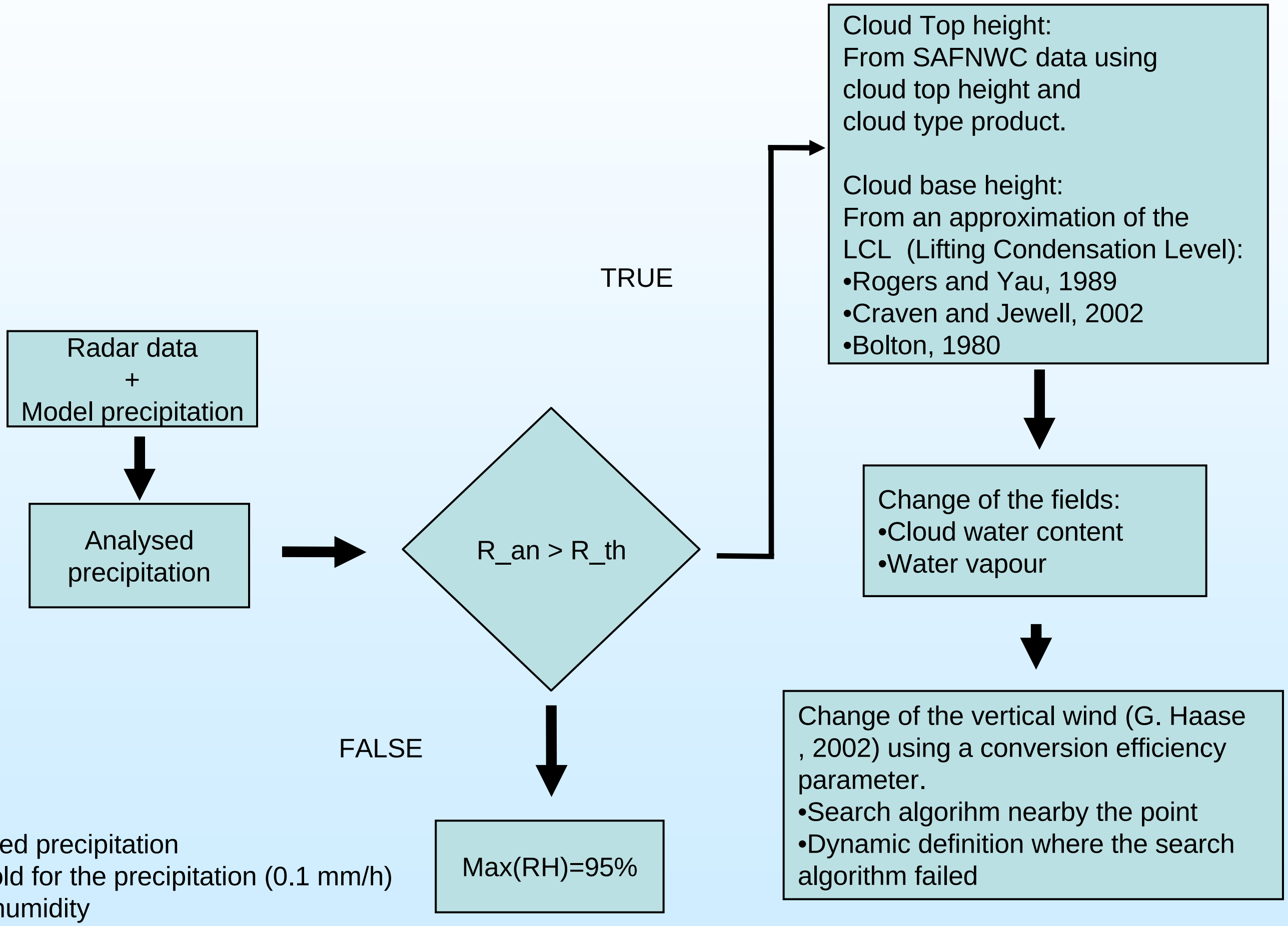
Radar data



The PIB uses the DWD national radar composite (DX-data).

- Two dimensional rain rate product
- Spatial resolution of 1 km
- Temporal resolution of 5 min.
- Sixteen radars
- Overlapping areas: Strongest signal

Description of the scheme



R_an = analysed precipitation
R_th = threshold for the precipitation (0.1 mm/h)
RH = relative humidity

Cloud top height

The PIB uses the observation of Meteosat second generation to derive the cloud top height.

- Use of SAFNWC (Satellite Application Facilities for Support to Nowcasting and Very Short-Range Forecasting) .
  - products generated from DWD.
  - temporal resolution 15 min (for the year 2005)
- The high semitransparent clouds and the high semitransparent clouds above low or medium clouds are not taken in account.
- An Optimal Interpolation scheme (from Felix Ament) is used to fill the gaps, for the multi layer clouds.

Cloud base height

- In Cumulus conditions
  - •LCL (Lifting Condensaton Level) and CCL (Convective Condensation Level) often agree closely with one another. (Rogers and Yau,1989)
- LCL estimate
  - Mean temperature and dewpoint
  - Near surface layer about 100 hPa deep *(Craven and Jewell, 2002).*
- The temperature of the LCL is calculated using *(Bolton,1980):*

$$T_L = \frac{1}{\frac{1}{T_D - 56} + \frac{\ln(T - T_D)}{800}} + 56$$

Where

T_L temperature of the LCL

T mean temperature of the model levels near the soil.

T_D mean dew point temperature calculated in the model levels near the soil.

Water vapor

The water vapor content is changed in this way:

- From the cloud bottom to the cloud top, the specific humidity is set to saturation.
- Below the cloud bottom the specific humidity is set to the saturation value of the cloud bottom. It is assumed that the specific water vapor content is a conservative quantity in the PBL, it is well mixed.
- Above the cloud top the specific humidity is set taking in account that the maximum of the relative humidity can be 95%.

Vertical wind

The vertical wind inside the clouds is changed using the following equation (*G. Haase, 2002*), with a do cycle from cloud top to cloud base:

$$\hat{w}_k = \left(\rho^*_{v,k}\right)^{-1}\left\{\rho^*_{v,k-1}\hat{w}_{k-1} - \left(z_{k-1} - z_k\right)\frac{R(z_{cb})}{z_{ct} - z_{cb}}\left[1 - \frac{\pi}{2}\left(1 + \frac{1}{c}\right)\sin\left(\frac{\pi}{2}\frac{z_{k-1/2} - z_{cb}}{z_{ct} - z_{cb}}\right)\right]\right\}$$

with

$$c = \left.\frac{R}{\rho^*_v \hat{w}}\right|_{z=z_{cb}} \qquad [0,1]$$

Where

c conversion efficiency of saturated water vapour into rain water, ρ_v^* partial densities of saturated water vapour, **R** precipitation flux, $\mathbf{z_{ct}}$ height of the cloud top, $\mathbf{z_{cb}}$ height of the cloud bottom and **w** vertical wind.

Below the cloud the vertical wind is calculated with a linear interpolation.
Above the cloud the vertical wind is set to 0

Search for the conversion efficiency

- Definition of „good“ forecast:

$$\frac{1}{3} \quad R_{ana} \leq R_{mod} \leq 3 \quad R_{ana}$$

- For „good“ forecasted points the c parameter is not changed (start value 0.4).
- Otherwise search in the surrounding grid points for the one with the best fit (model consistent).
- If we find at least a point that satisfied our request we calculate the c parameter using the model variables.
- Otherwise use a dynamical determination of the conversion efficiency.

Dynamical determination of the conversion efficiency

At this point the parameter (*c*) is dynamically adjusted by the comparison between the model precipitation and the radar precipitation.

– For the considered grid point the parameter *c* at time step *n* is function of its value at the step n-1 , the analysed precipitation *R_an* and the model precipitation *R_m* :

$$c(n) = c(n-1) \bullet \left[1 - \sin\left(\frac{\pi}{2} \bullet \left(\frac{R\_an - R\_m}{R\_an + R\_m} \right) \right) \right]$$

With :

$$0.25 \leq c(n) \leq 0.8$$

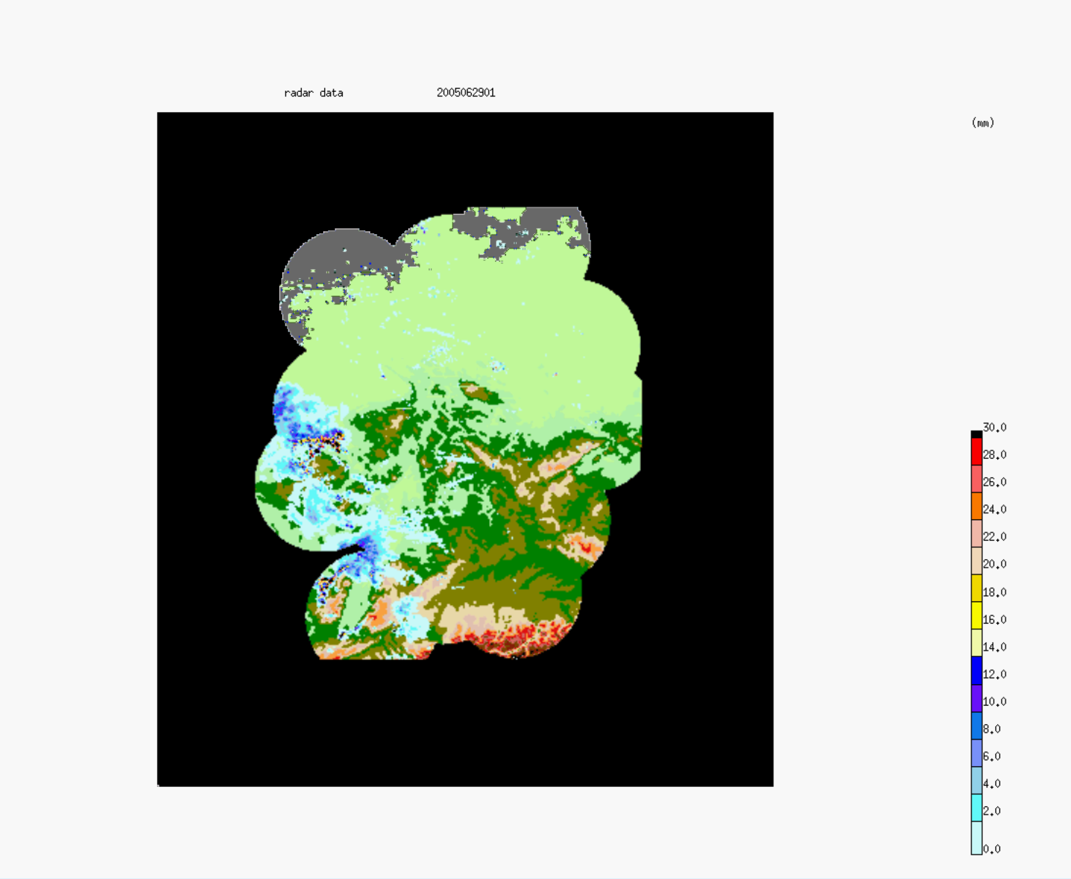
Deterministic runs

- 2.8 km horizontal resolution (421×461 points LMK area)
- 25s time step
- CFL:

$$|c|\frac{\Delta t}{\Delta x} \leq 1 \quad \Rightarrow \quad |c| \leq 112 \, {}^{m}\!/_{s}$$

- 29th June 2005, from 01:00 UTC to 11:00 UTC
- 19th August 2005, from 12:00 UTC to 22:00 UTC

29/06/2005



- Convective line moves across south and middle Germany.
- Event between 0 and 11 UTC.
- High temperature in southwest Germany in the afternoon of the day before.
- Very bad forecast for this event.

19/08/2005

- Cold front in the west part of Germany.
- Precipitation during the day, from 12:00 to 22:00 UTC.
- Presence of multicells

Identical Twin

- Five hours control run. The reference simulation.
- The output from the control run (cloud top height and precipitation) is now the input of the new run. The reference simulation is assumed perfect.
- Pseudo output are assimilate with the same time range of the real observation. 5 minutes for the precipitation, 15 minutes for the cloud top height.
- Run of LM with the use of PIB (the Identical Twin). 1hr control run, 2hr assimilation window, 2hr free forecast.

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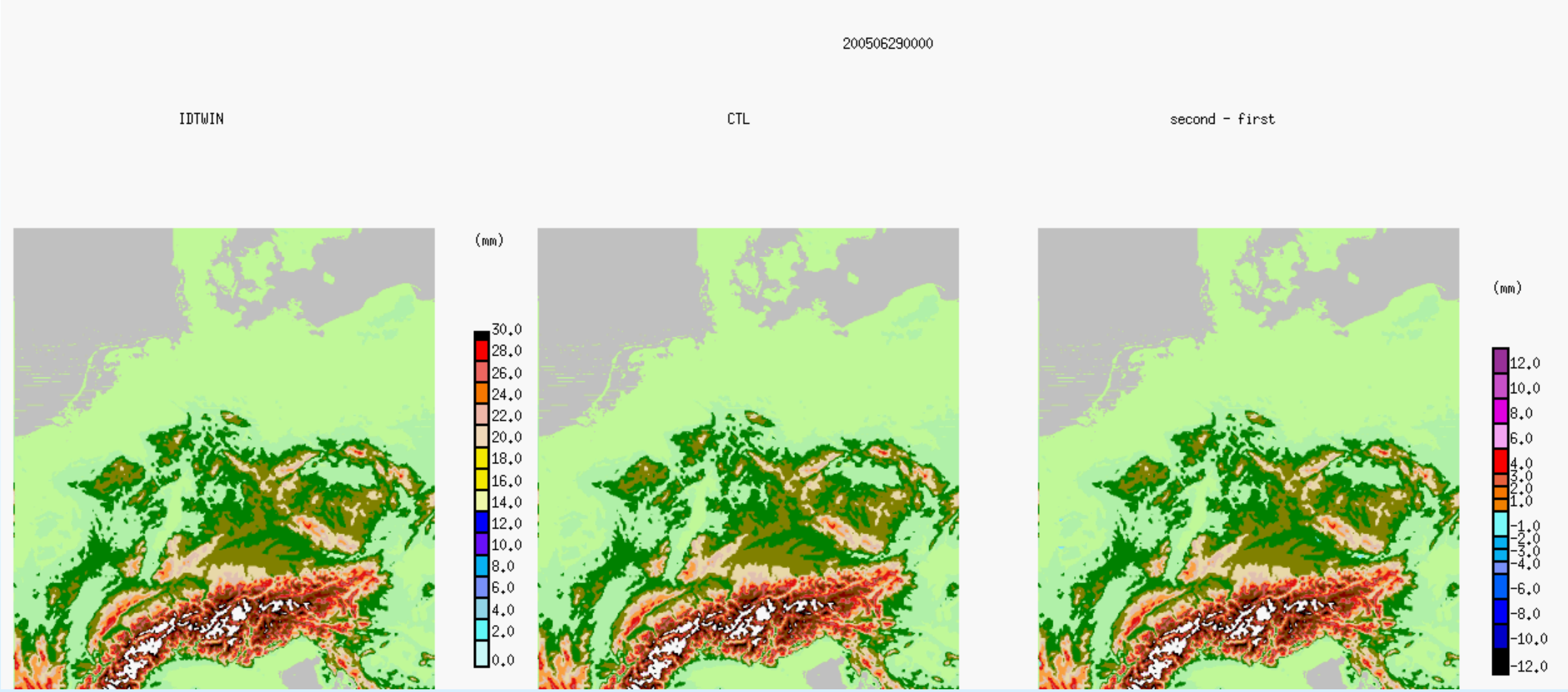

- Good performance for the precipitation area.
- Position error in the bigger convective cells.

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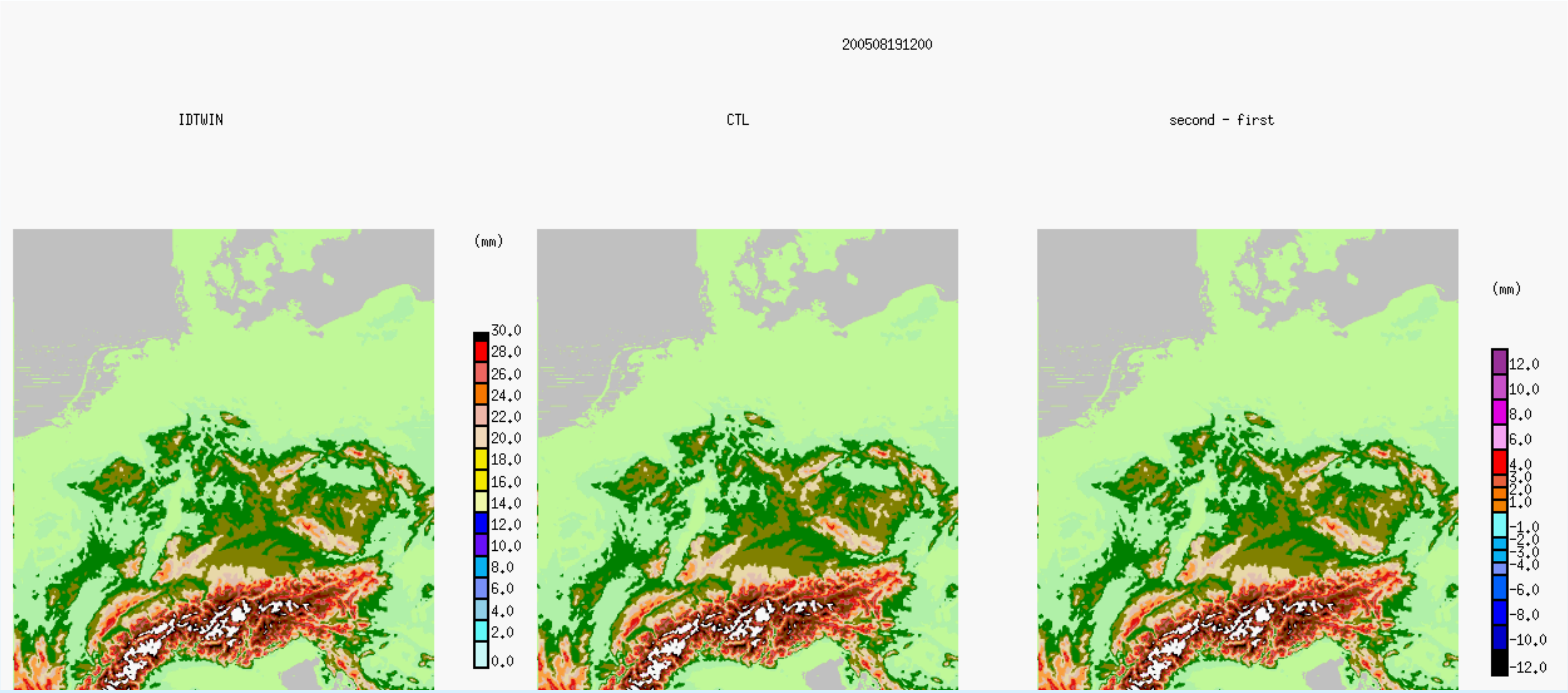


- We can assimilate the strong convection.
- Problems for the little cells.

Studies with Identical twin experiments

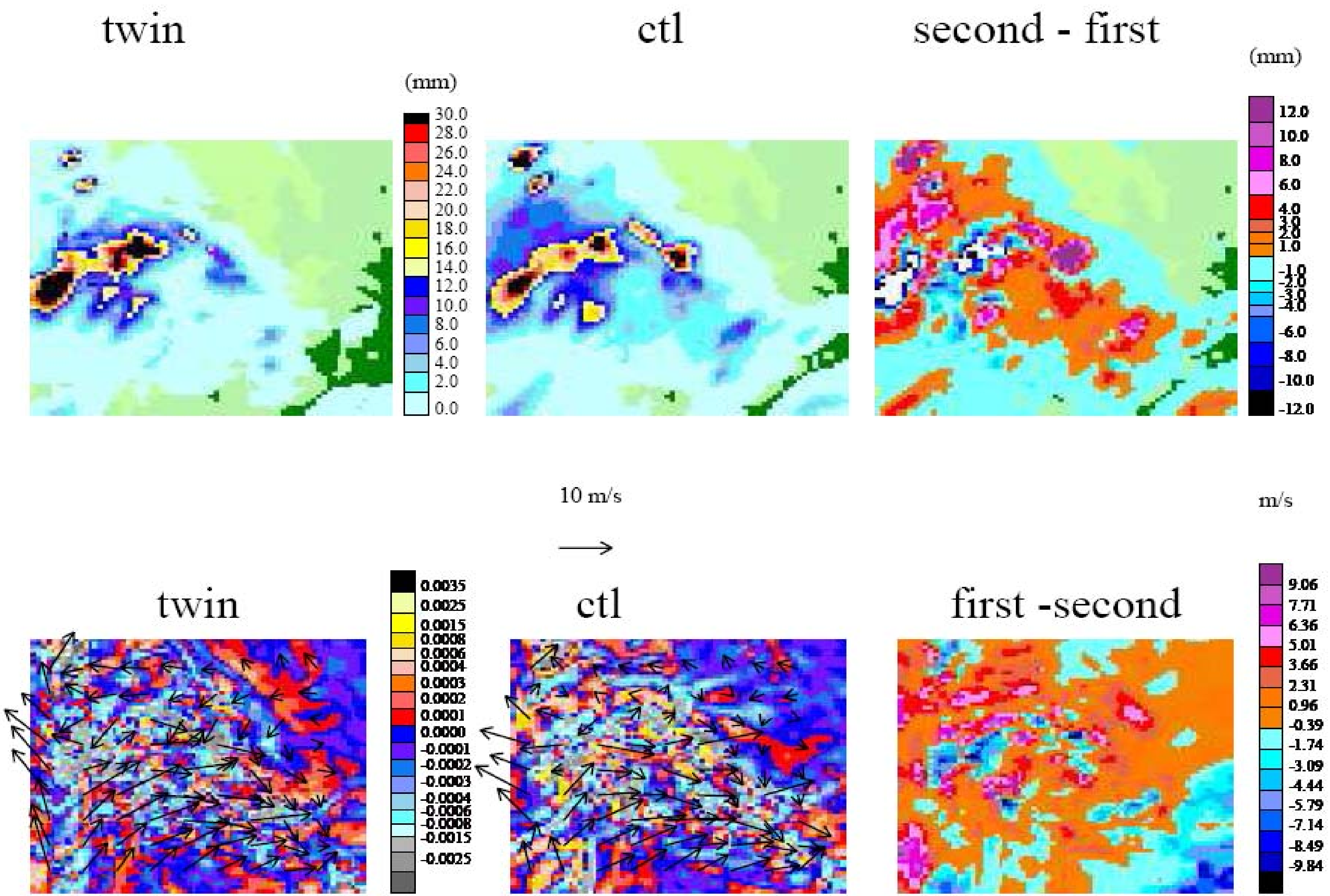
- We assumed that the modification of the vertical wind adjust also the horizontal wind field, from the mass conservation equation.

- We analyse this relationship in more detail.

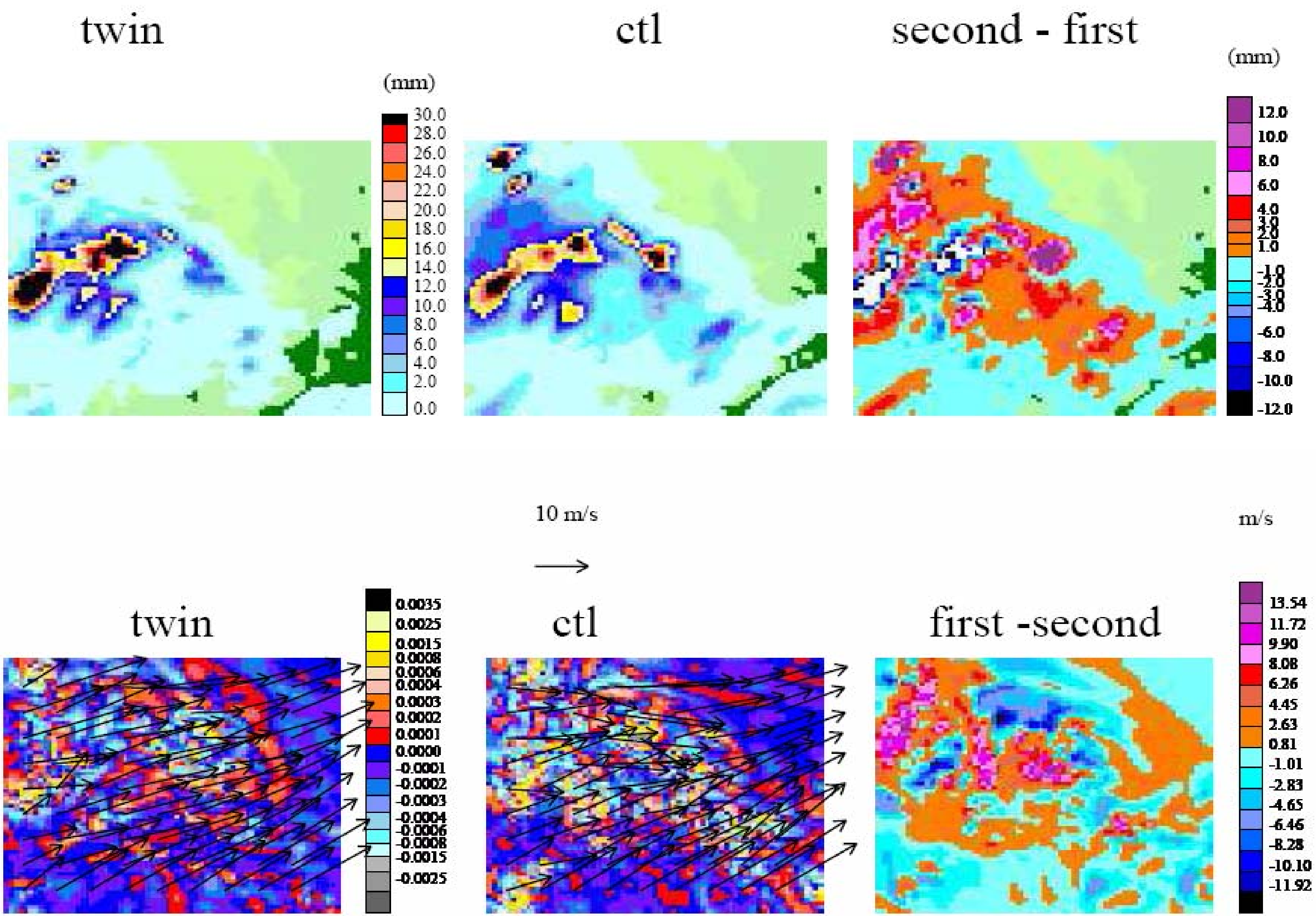
- Near the cloud base (model level 26) we should have a convergence in convective areas.

- Near the cloud top (model level 15) a divergence.

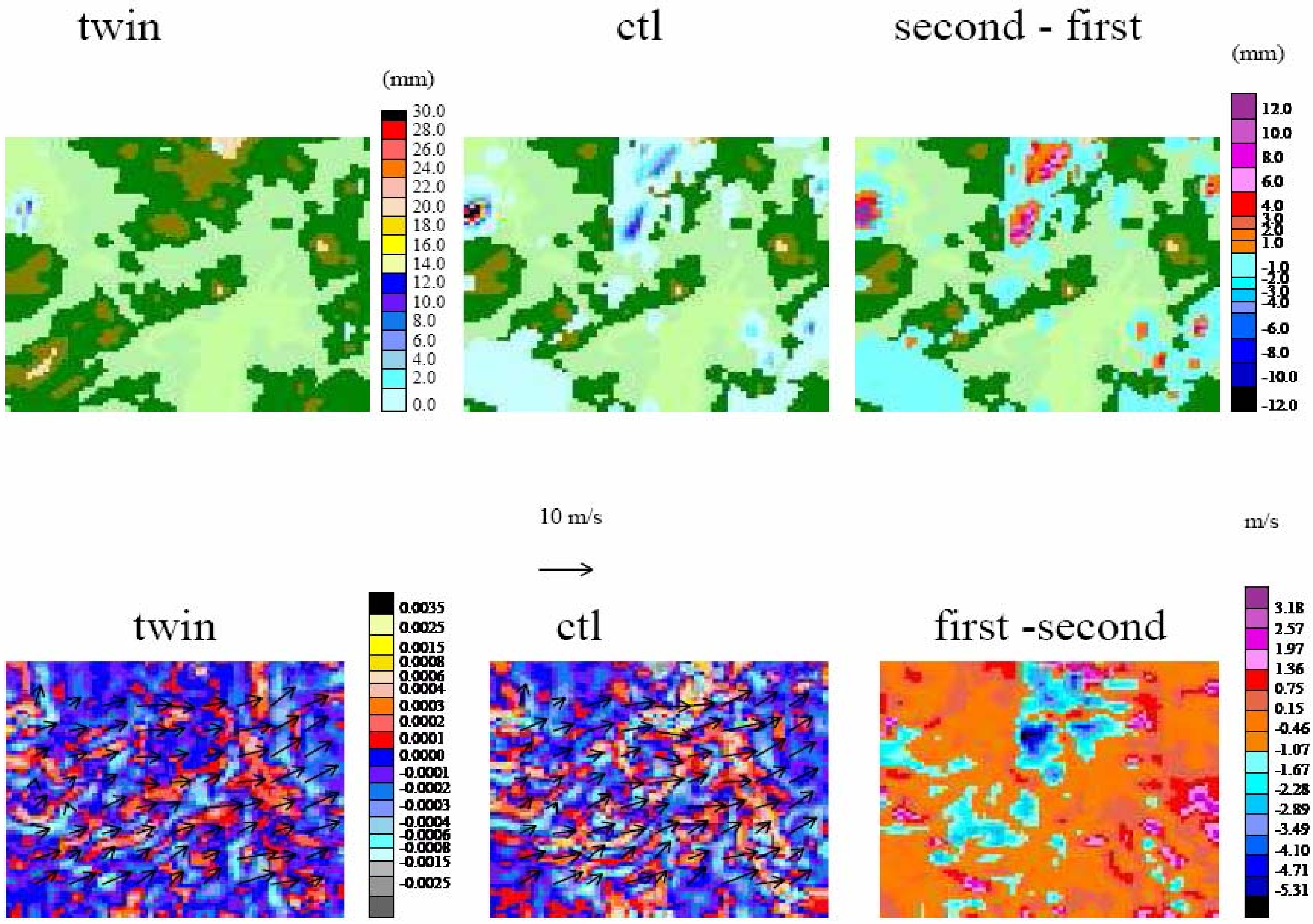
29/06/2005 end of assimilation (level 26)



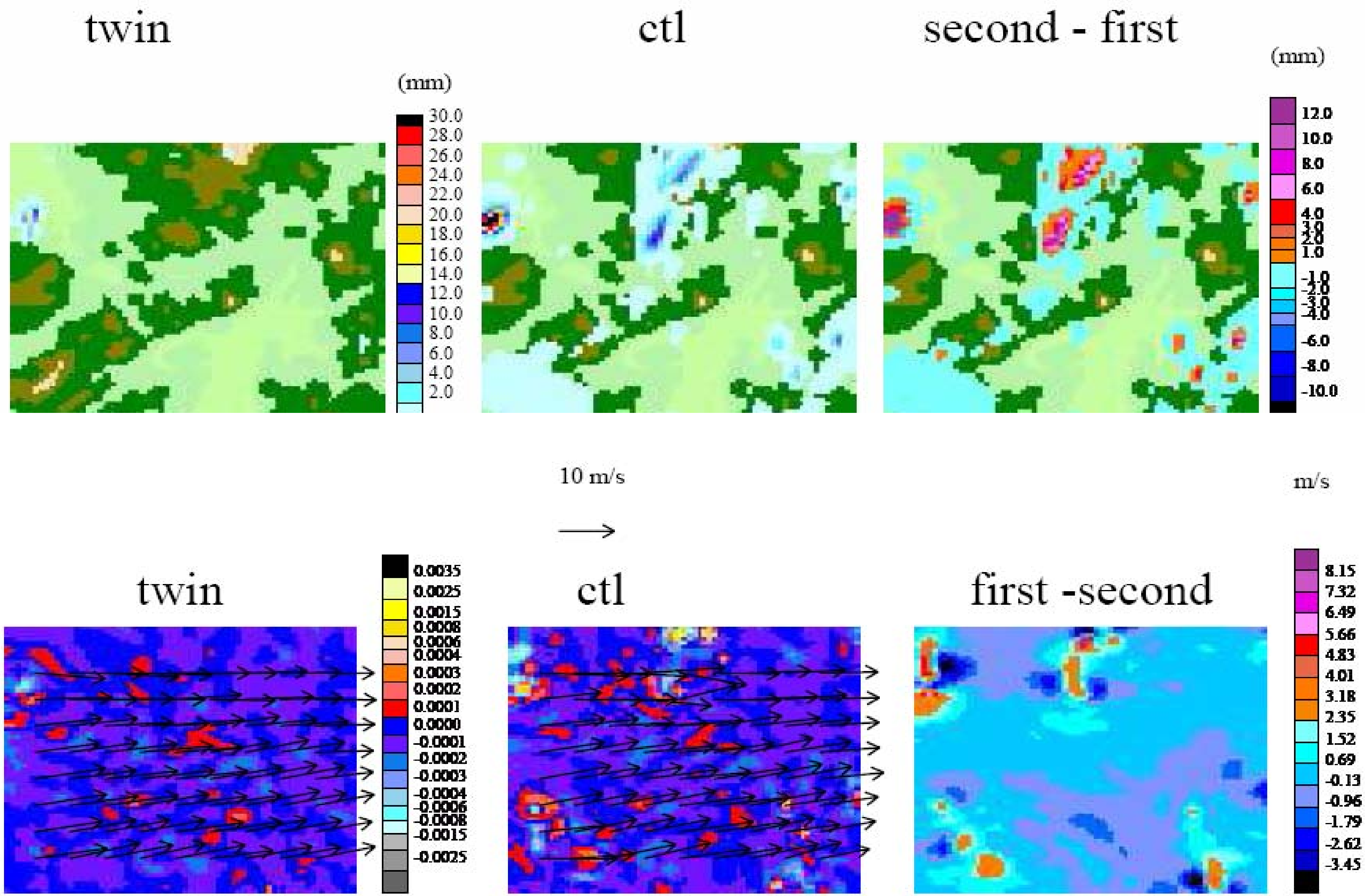
29/06/2005 end of assimilation (level 15)



19/08/2005 end of assimilation (level 26)



19/08/2005 end of assimilation (level 15)



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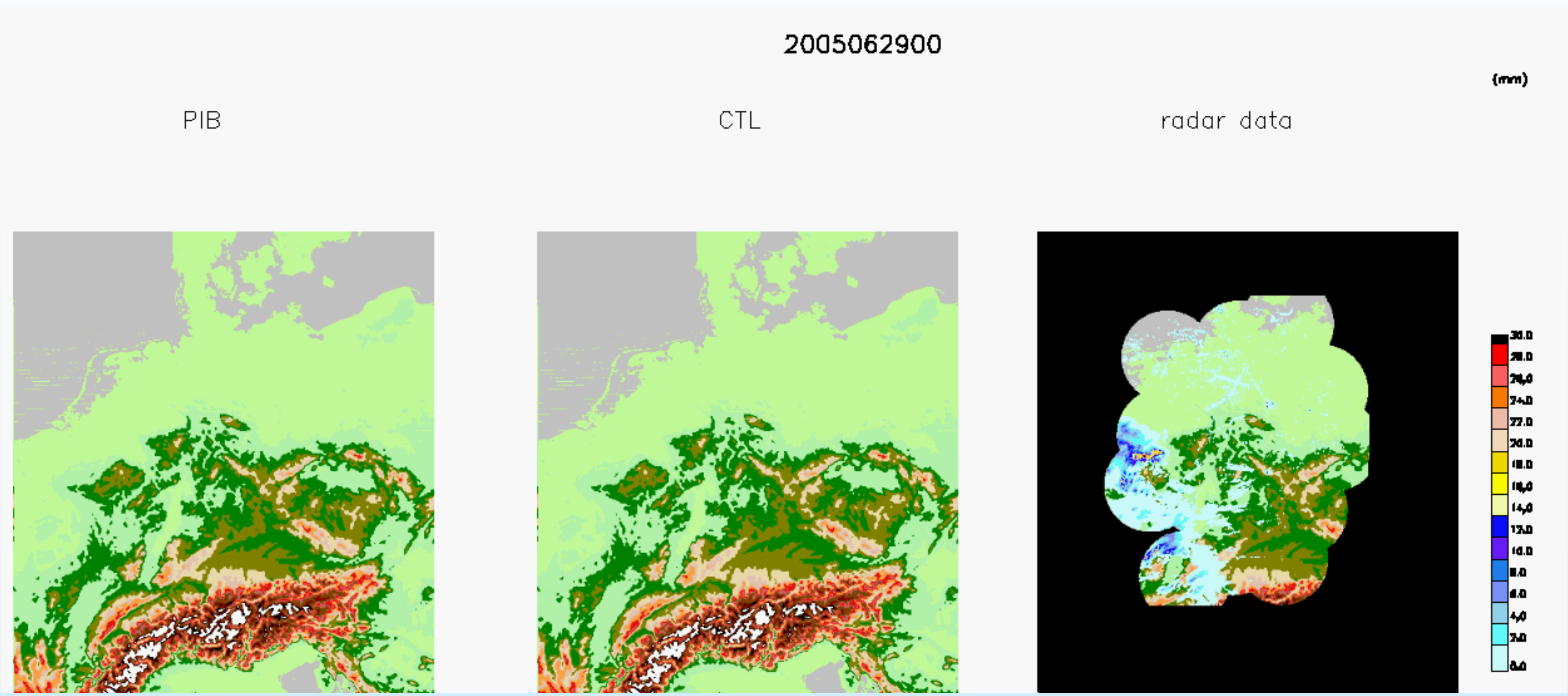
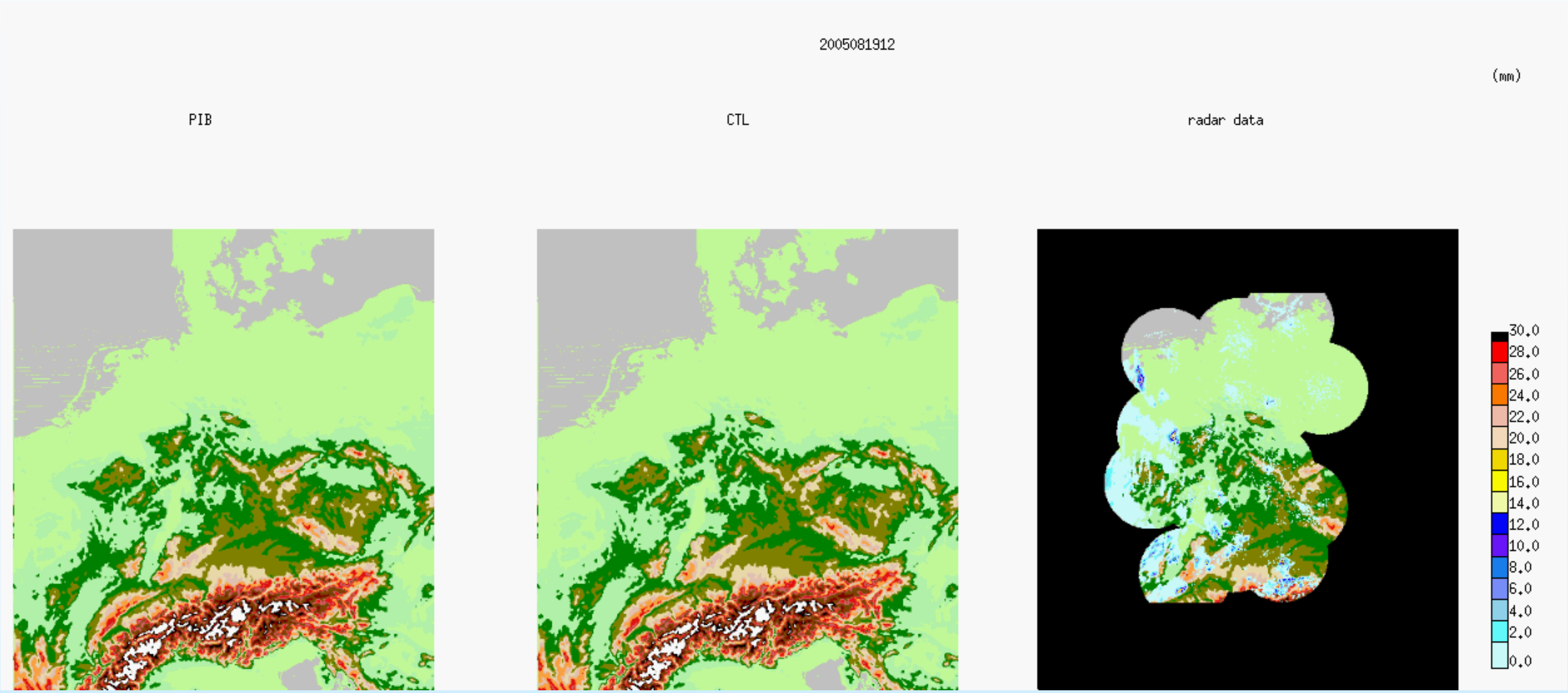


2.8 km resolution, time step 25s, two hours assimilation window and six hours of free forecast

19/08/2005



2.8 km resolution, time step 25s, two hours assimilation window and six hours of free forecast

Change of the assimilation window

Different experiments:

- 2 hours
- 60 minutes
- 45 minutes
- 30 minutes
- 15 minutes

How the model reacts to the assimilation with a short or very short (15 minutes) assimilation window

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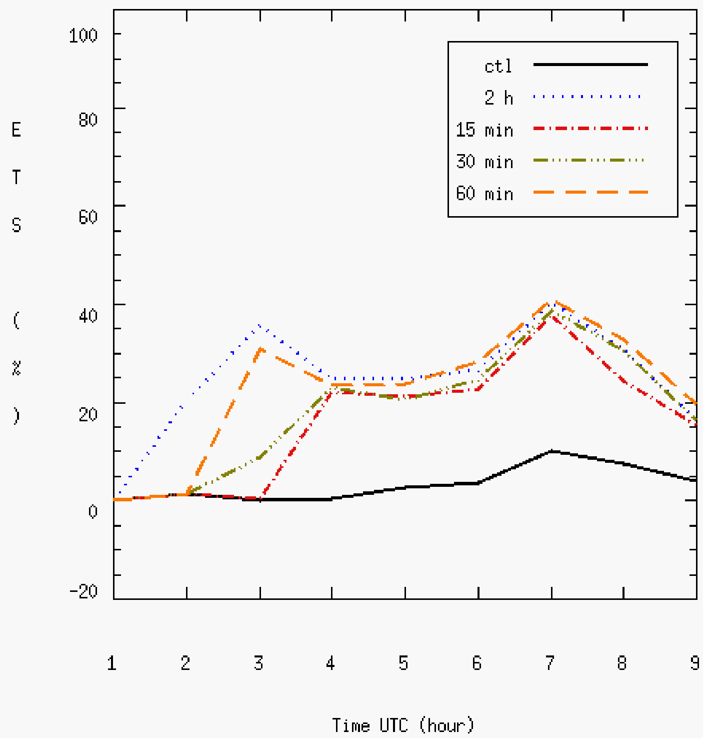
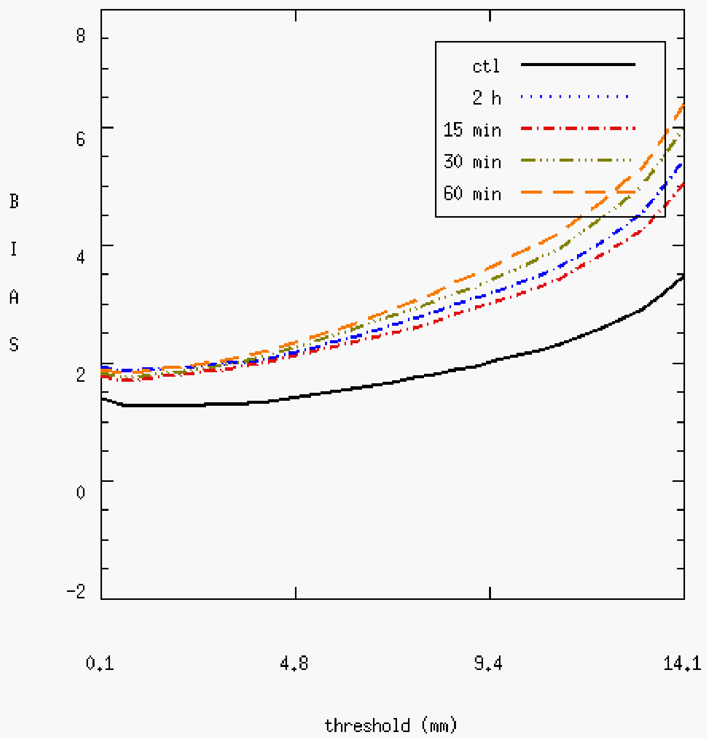
ETS



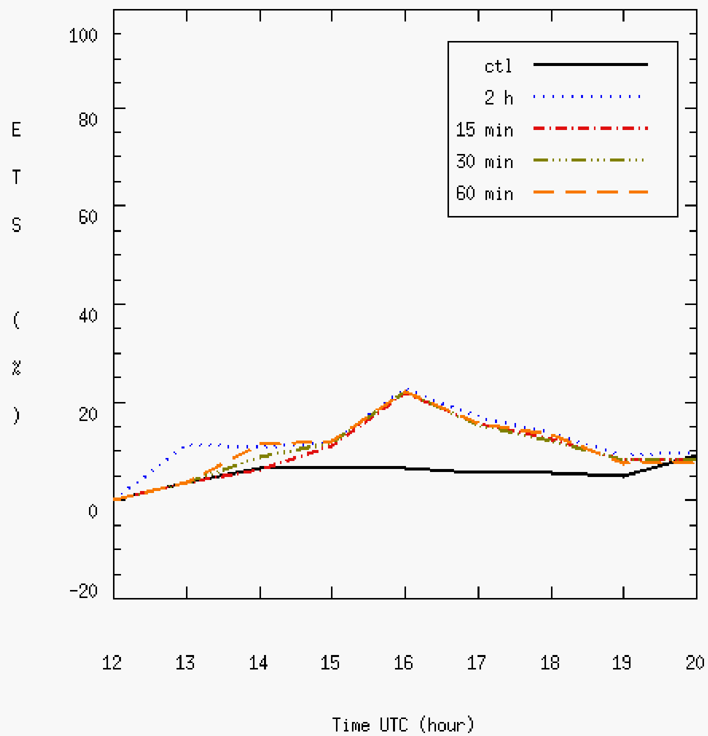
BIAS



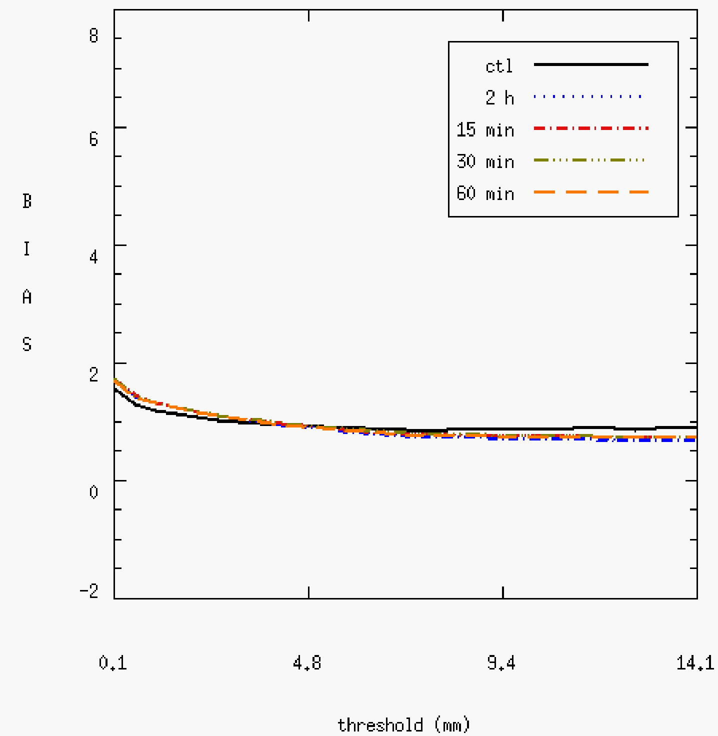
- The Bias is for the precipitation sum in the first 6 hours of forecast

19/08/2005

ETS



BIAS



- The Bias is for the precipitation sum in the first 6 hours of forecast

CONCLUSIONS

- We can make a good forecast of the convective cells, at least for the bigger ones, in the first hours of forecast.
- The organization of the meteorological events is good represented.
- The method is very fast.
- From the results of the Identical Twin experiments the modification of the vertical wind seems to adjust also the horizontal wind field. We have to analyse this relationship in more detail.
- We have still some bias problem. We have the tendency to overforecast the strong convection.

FUTURE WORK

- Combine the PIB with regional ensemble system generated by DLR. Find a way (parameter) to define the best member for the assimilation. In progress.
- Evaluation of PIB in different meteorological events in the LMK area.
- Reduction of the nudging period according to the results which I have shown today.
- Other Identical Twin experiments with the introduction of “observation errors”.
- Find a way to assimilate clouds without precipitation .
- Use of GPS tomography for a partial initialization of the water vapour field
- A better definition of the cloud base could be very usefull. Analyse of the cloud base for the Identical Twin experiments, source of error

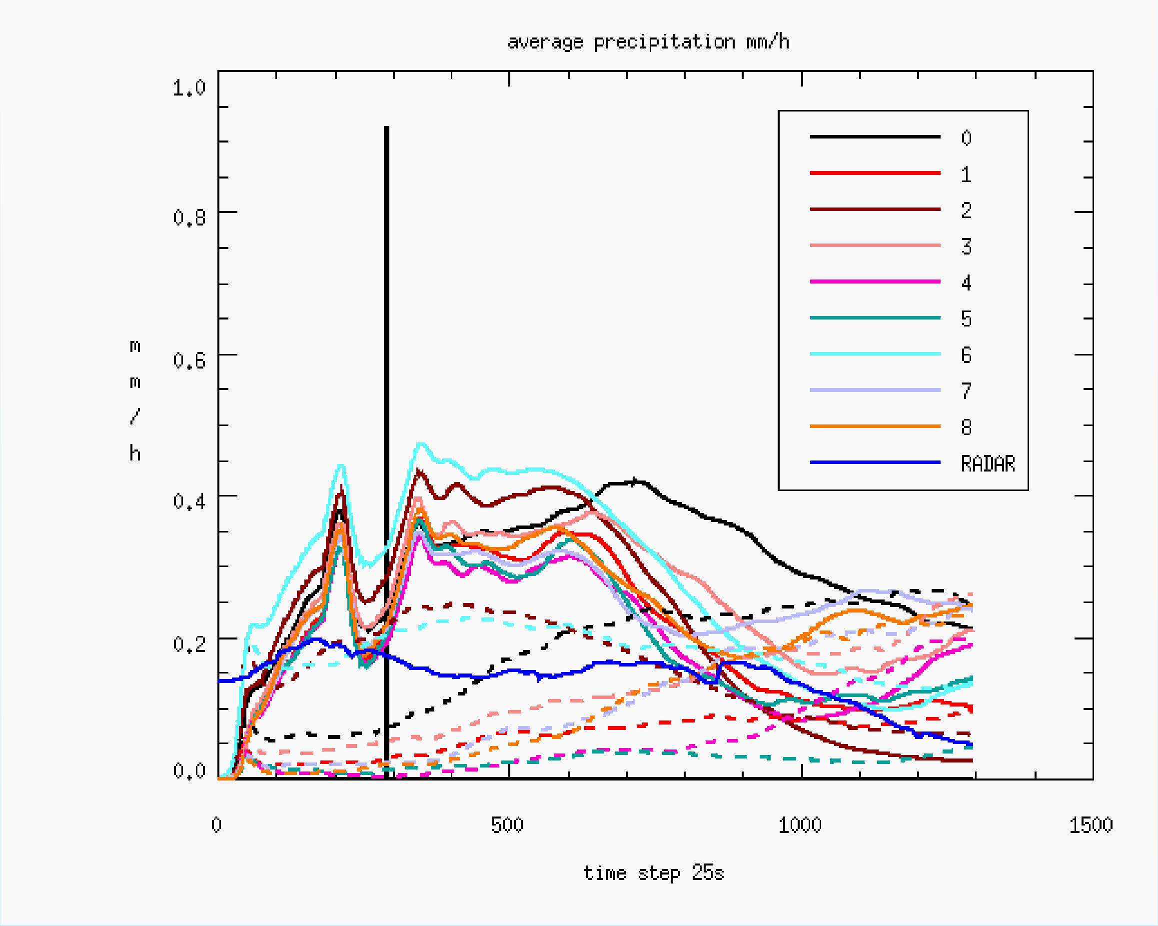
THANK YOU

Use of EPS

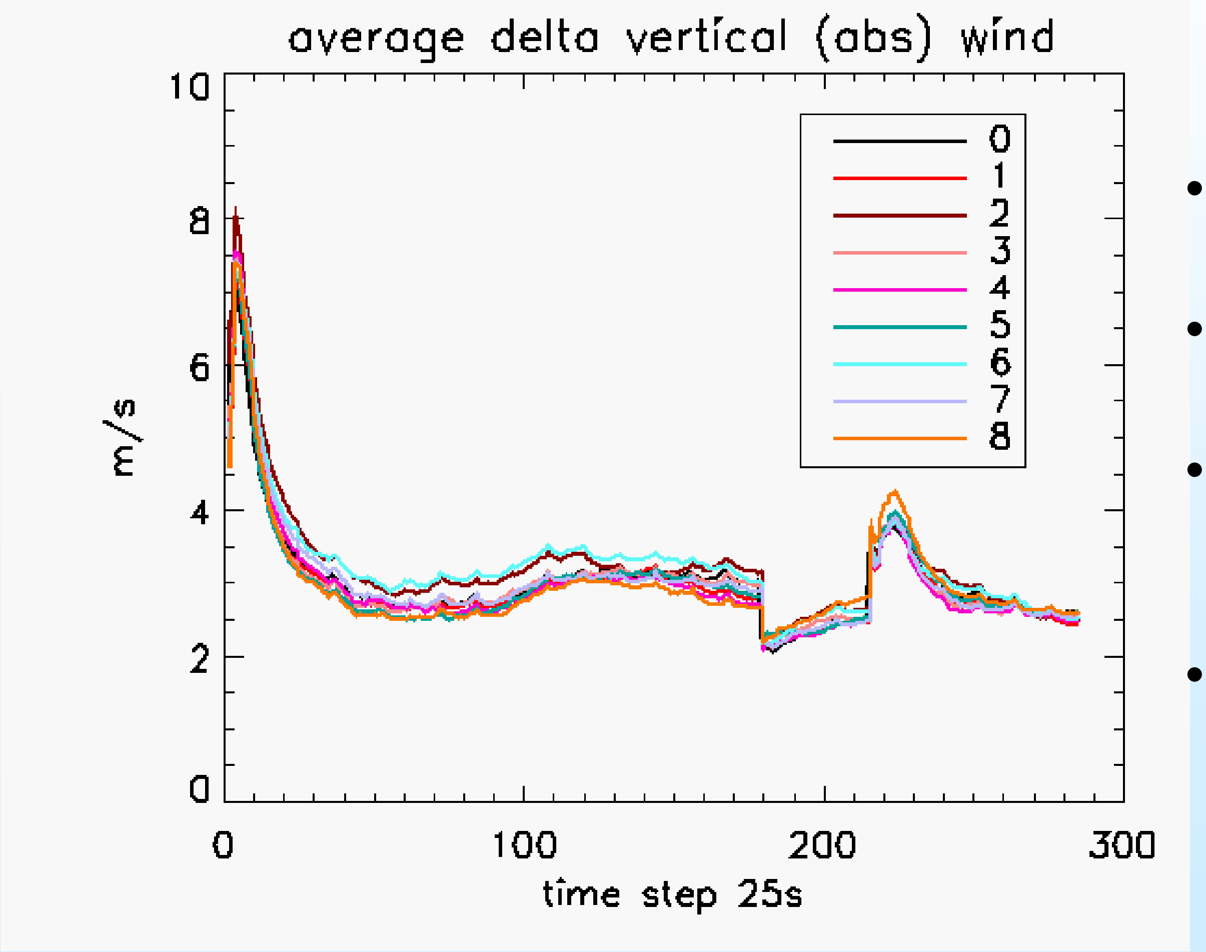
- A run is well initialized when after a period the initialization scheme changes the model less than at the beginning of the assimilation window.
- Check how the PIB changes the model variables:
  - Vertical wind
  - Specific humidity
- Take the “best” member.
- Create a new EPS from this member.
- New assimilation window.
- Forecast.

First EPS results (29/06/2005)

- Ten runs using boundary and initial conditions from the ten members of the EPS.

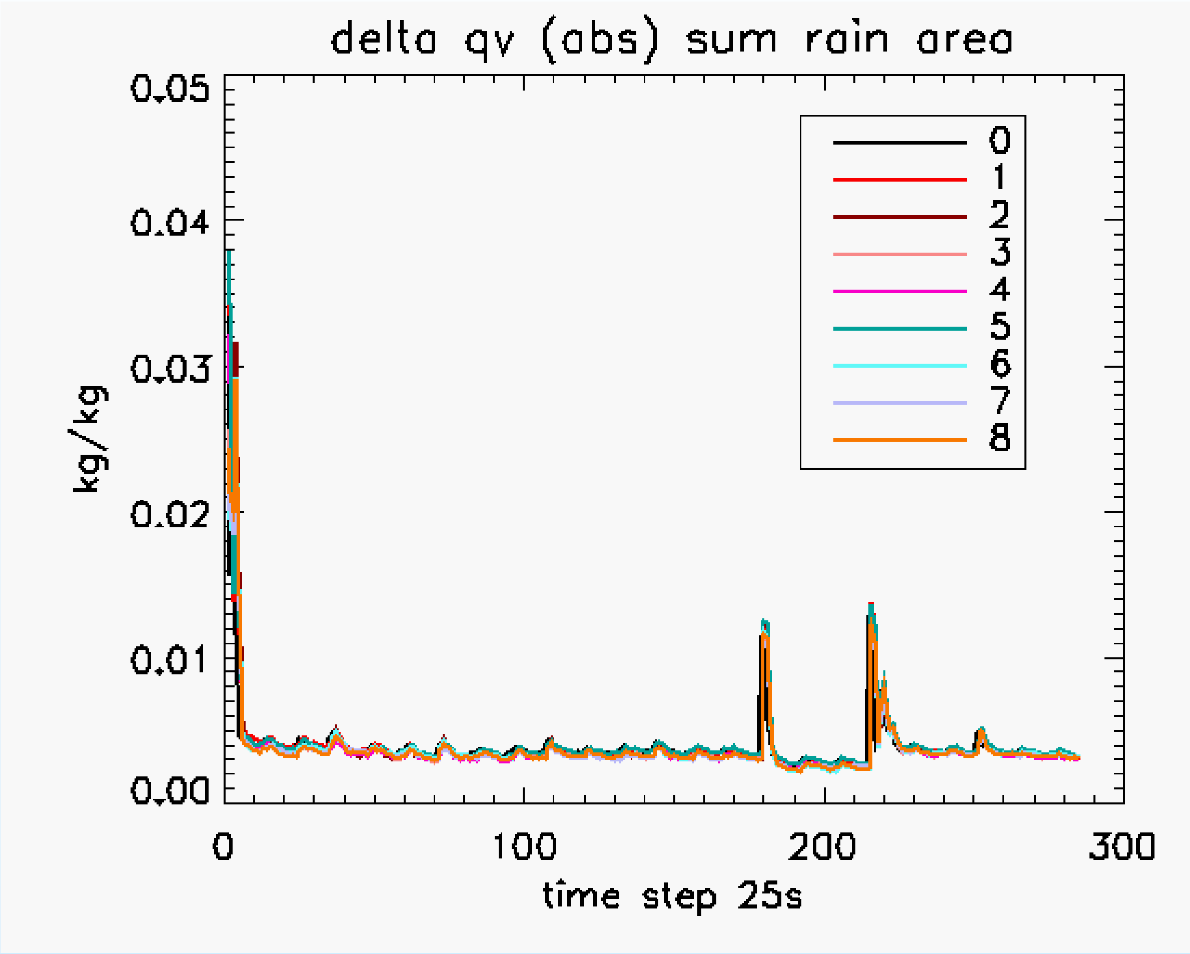


Vertical wind



- Difference between the model wind and the initialised wind.
- Average of the absolute value in the LMK area.
- Big energy input at the beginning.
- After less then 100 time steps the PIB hasn't to work a lot.
- After 2 hours there is no variability (for this parameter) between the members.

Specific Humidity



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OBJECTIVE EVALUATION

For an objective check of the forecast quality we can make a comparison with the radar data using:

•**FAR (**False alarm ratio, in %): *what fraction of observed "yes" events actually did not occur?*

•**TS** (threat score, in %): *How well did the forecast "yes" events correspond to the observed "yes" events?*

•**ETS** : (Equitable threat score, in %): How well did the forecast "yes" events correspond to the observed "yes" events (accounting for hits due to chance)?

BENCHMARKS: Control run (without assimilation), assimilation using LHN (Latent Heat Nudging), comparison for two cases. All the runs are with the prognostic precipitation.

$$TS = 100\frac{d}{b + c + d}$$

	$R_{rad} <= R_{th}$	$R_{rad} > R_{th}$
$R_{LM} <= R_h$	a	b
$R_{LM} > R_{th}$	c	d

$$FAR = 100\frac{c}{c + d}$$

$$ETS = \frac{d - CH}{b + c + d - CH}$$

$$CH = \frac{(c + d) \bullet (b + d)}{N_{TOT}}$$

Analysed precipitation

Temporal weight (α_t) : Linear interpolation in time

Spatial weight

$$R_{rad} > 0 : \alpha_s = 1 - 0.5\left(\frac{r_{rad}}{100} + \tanh\left(\frac{3r_{rad}}{100} - 3\right) - 1\right)$$

$$R_{rad} = 0 : \alpha_s = 1 - \tanh\left(\frac{3r_{rad}}{100} - 3\right)$$

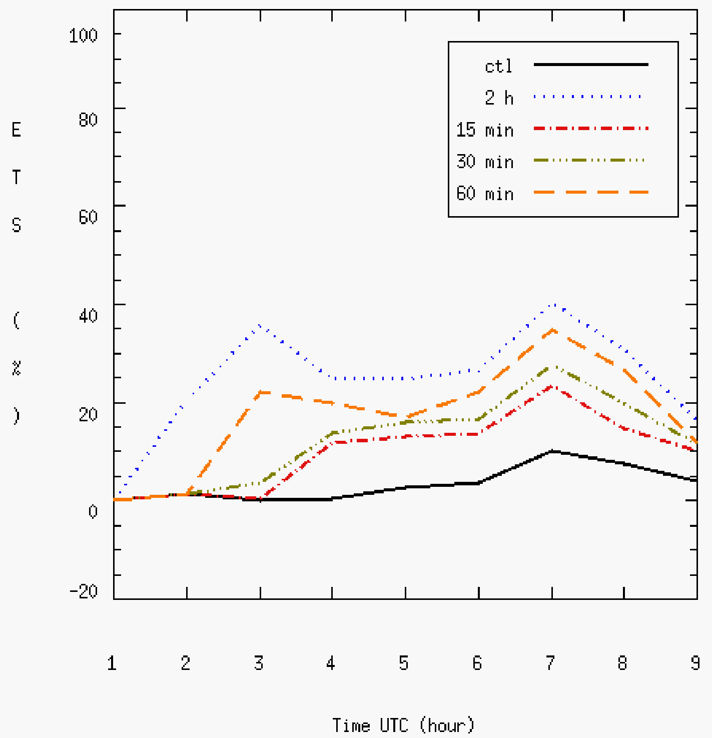
R_{rad} rain rate from radar
r_{rad} distances to the closest radar site

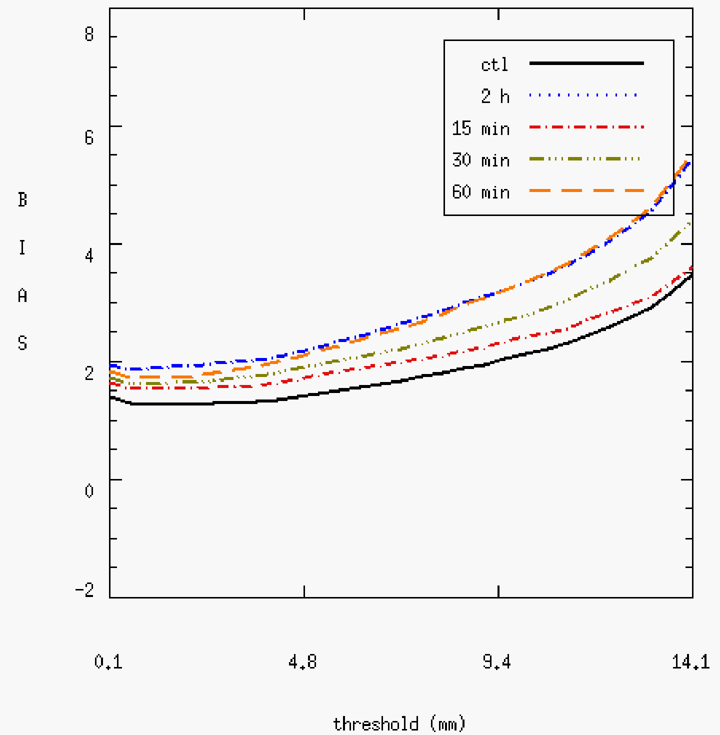
Analyzed precipitation

$$R_{ana} = \alpha R_{rad} + (1 - \alpha) R_{LM}$$

$$\alpha = \alpha_t \cdot \alpha_s$$

No wind assimilation 29/06/2005





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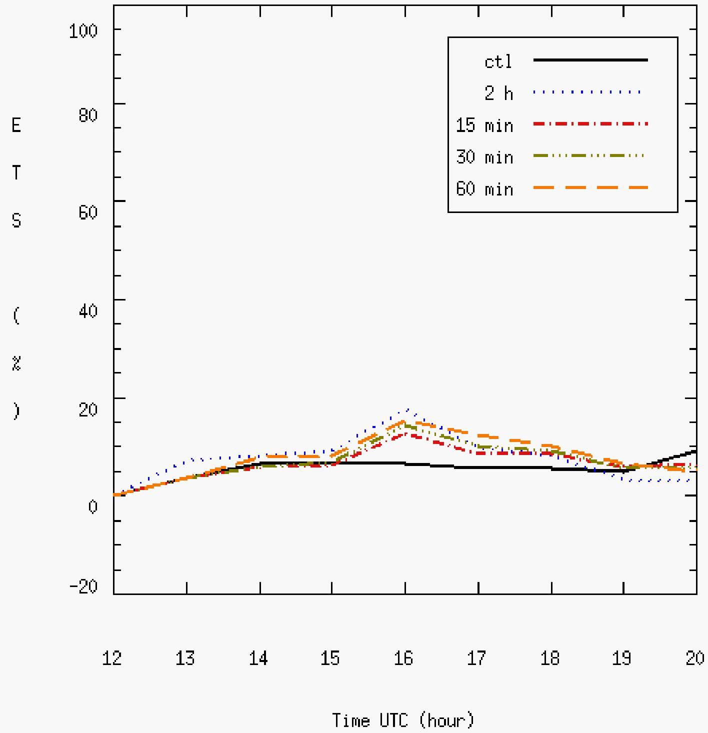
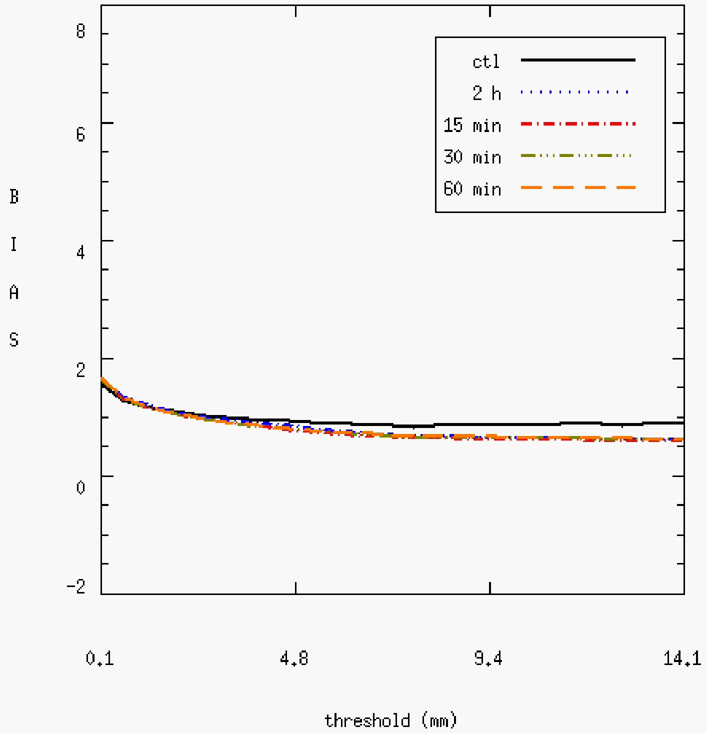
No wind assimilation 19/08/2005





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