Meteorologisches Institut
Universität Bonn

DAQUA

Assimilation of radar precipitation and satellite data into a NWP model using PIB (Physical Initialization Bonn)

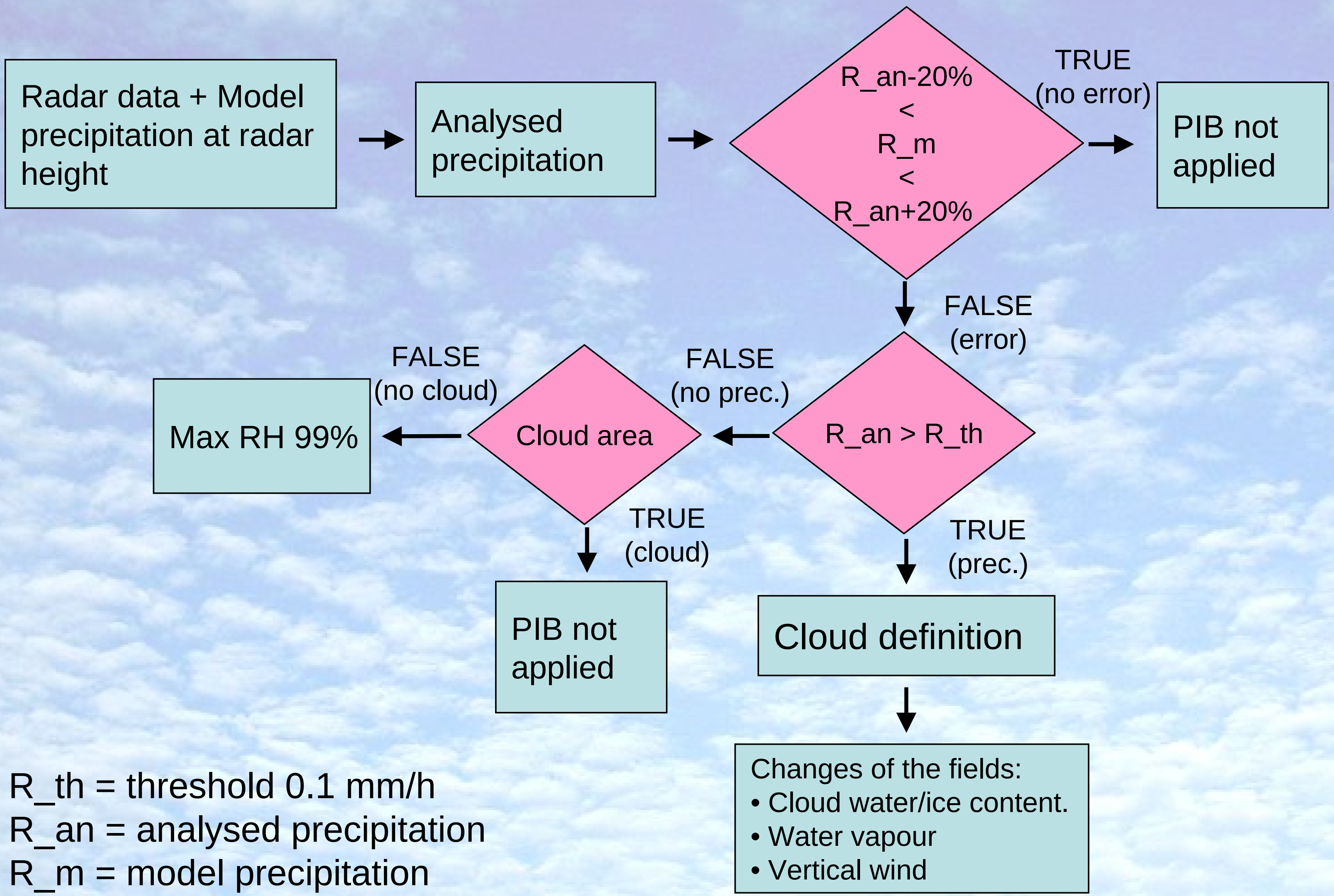
Marco Milan, Victor Venema,

Dirk Schüttemeyer and Clemens Simmer

OUTLINE

- Description of PIB scheme (details in *Assimilation of radar and satellite data in mesoscale models: A physical initialization scheme*. Milan at al. 2008).
- Model consistency of PIB using an Identical twin experiment.
- The new DAQUA systems using SIRF (Sequantial Importance Resampling Filter).
- Conclusions and outlook

PIB scheme



R_th = threshold 0.1 mm/h
R_an = analysed precipitation
R_m = model precipitation

Simple cloud model

- Cloud top height:

The PIB uses the observation of Meteosat second generation (SAFNWC product from the German weather service, DWD).

- Cloud base height:
  - Search algorithm in the nearby points.
  - If failed,
    - LCL (Lifting Condensation Level) and CCL (Convective Condensation Level) often agree closely with one another Rogers and Yau,1989).
    - Approximation for LCL.
    - Approximation for CCL.
    - Use of the average and correction taking into account deep and shallow convection.

Water vapour

The water vapour content is changed in this way:

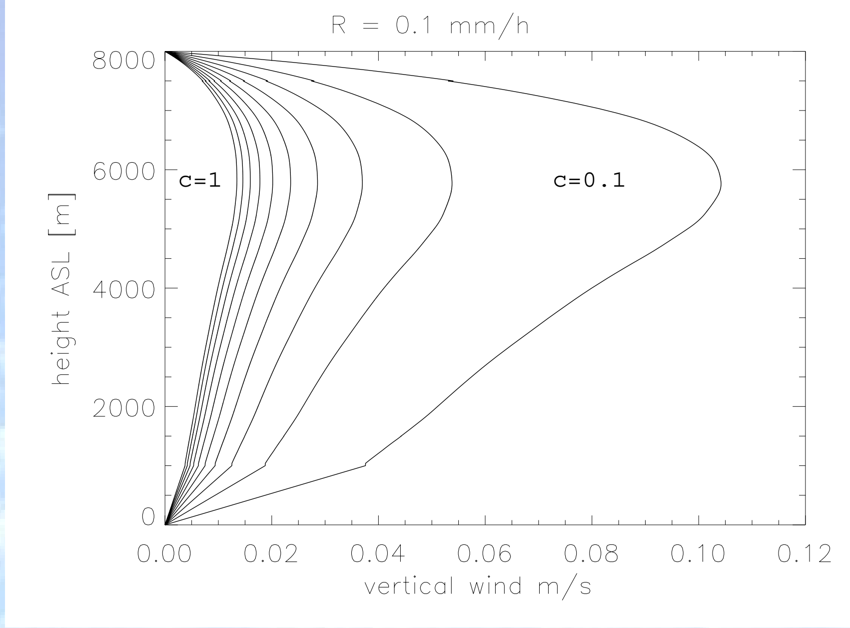
- From the cloud bottom to the cloud top, the specific humidity is set to saturation.
- Below the cloud bottom the specific humidity is set to the saturation value of the cloud bottom. It is assumed that the specific water vapour content is a conservative quantity in the PBL, it is well mixed.
- Above the cloud top the specific humidity is set taking into account that the maximum of the relative humidity can be 99%.

Vertical wind

The vertical wind inside the clouds is changed using a parameterisation from G. Haase (2002), depending on:

- Rain rate.
- Partial densities of saturated water vapour.
- Height of cloud bottom and cloud top.
- Conversion efficiency of saturated water vapour into rain water. Arbitrary at the first time step then adjusted taking into account the quality of the forecast.

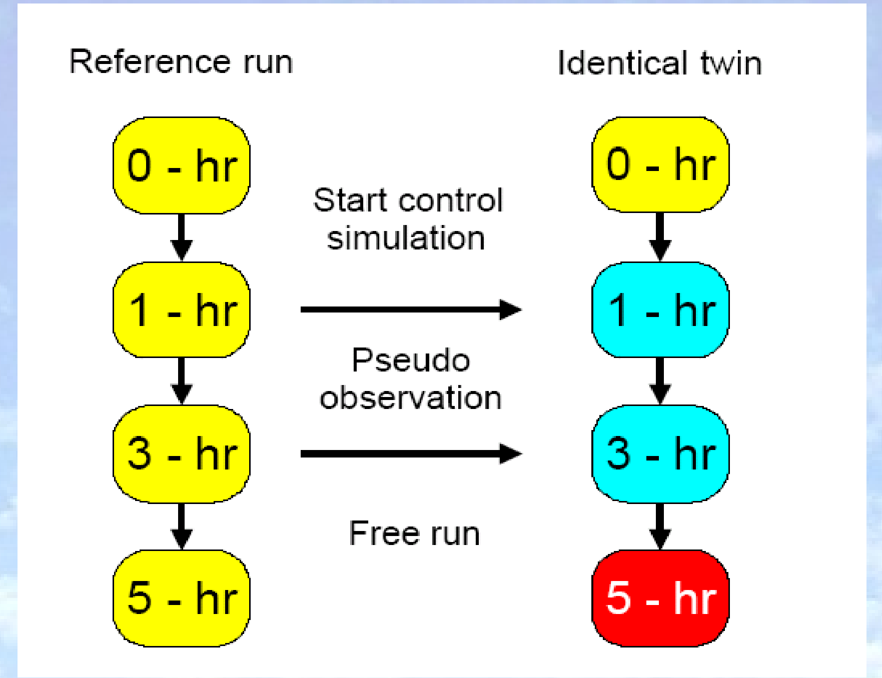
Below the cloud the vertical wind is calculated with a linear interpolation. Above the cloud the vertical wind is set to 0.



c=conversion efficiency

Identical Twin

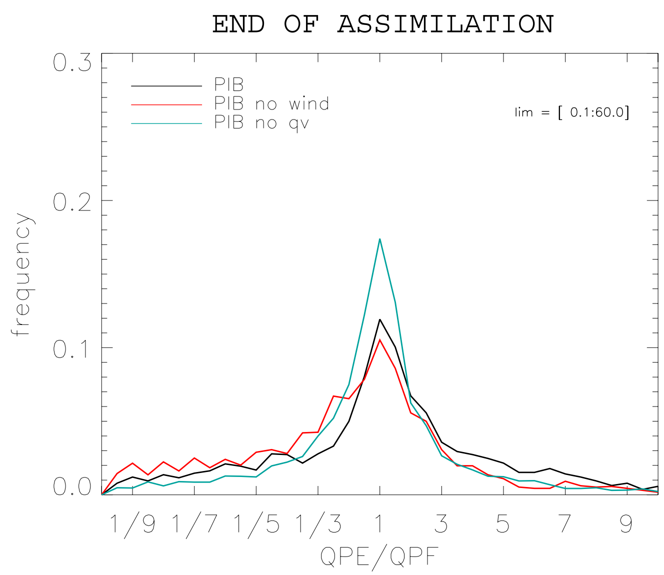
- The PIB scheme must be consistent with the NWP model (Cosmo model 4.6).
- Five hours control run. The reference simulation.
- The output from the control run (cloud top height and precipitation) is now the input of the new run. The reference simulation is assumed perfect.
- Run of COSMO with the use of PIB (the Identical Twin). 1hr control run, 2hr assimilation window, 2hr free forecast.
- PIB applied in all the points, but not in the points where both runs have no precipitation.

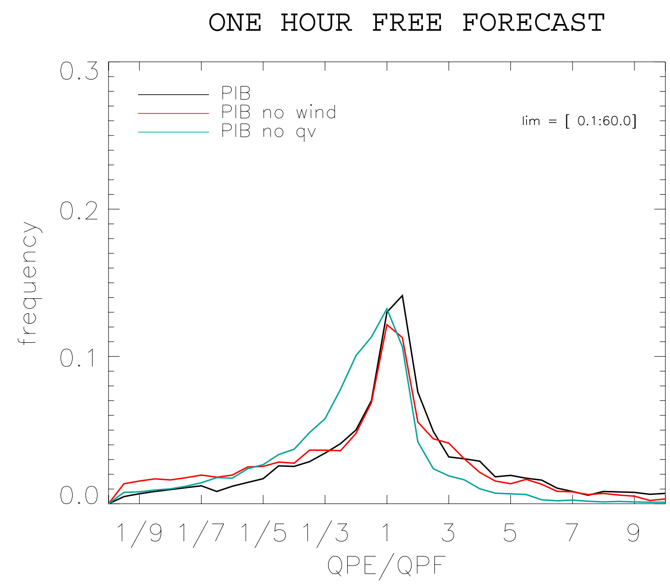


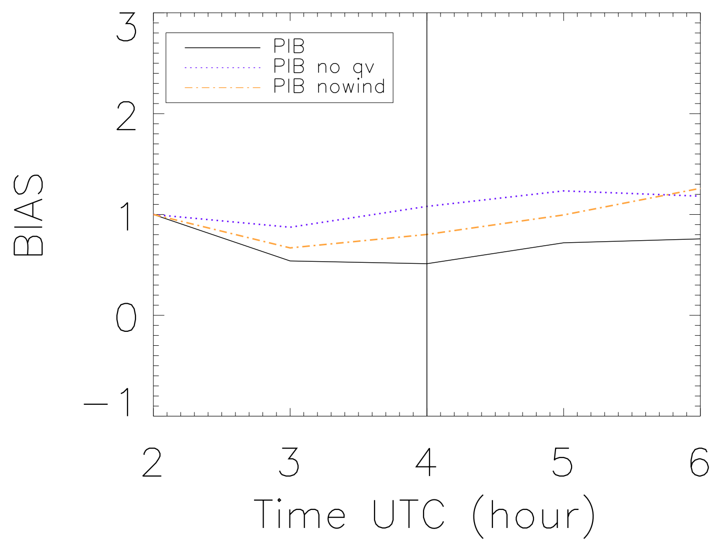
Comparison

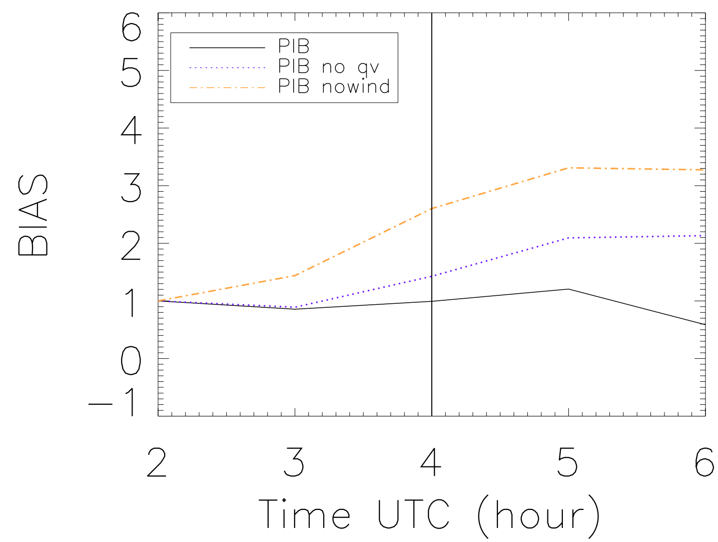
- Three case studies (convection).
- Objective skill score: Frequency BIAS.
- PDF of QPE/QPF precipitation. The right part of x axis (x>1) is divided into equidistant intervals, the left part is the inverse of the right part. A value of one means a perfect approximation of the Idtwin in relationship of the CTL precipitation field.

CASE 1





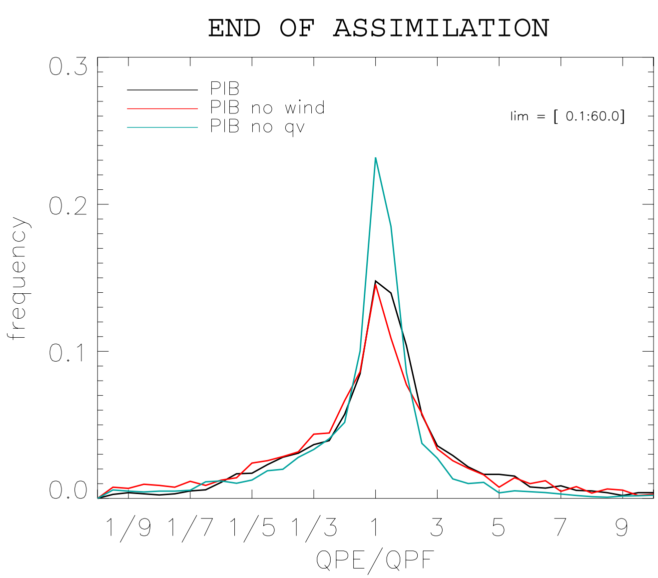


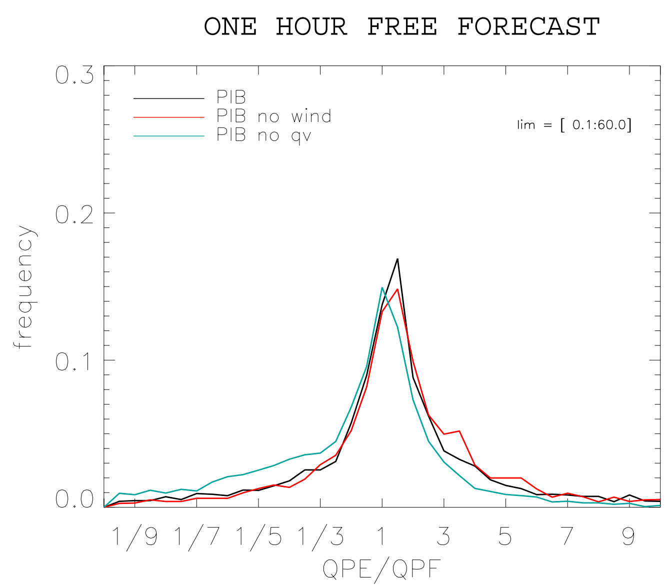


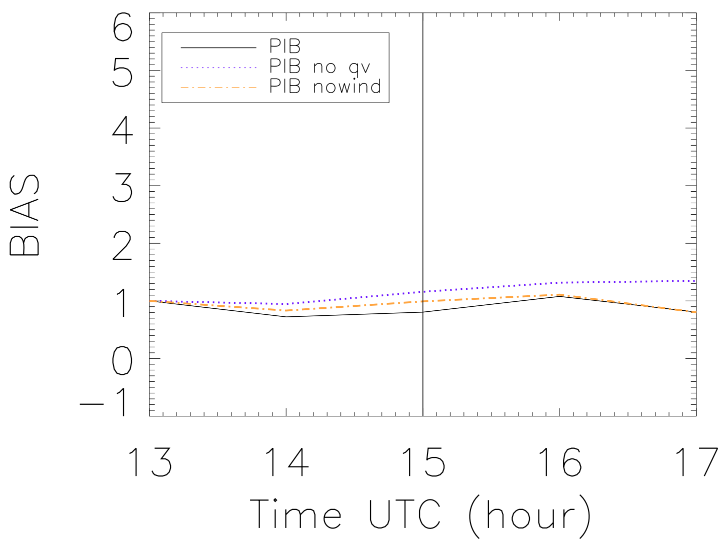
R_th=0.1 mm/h

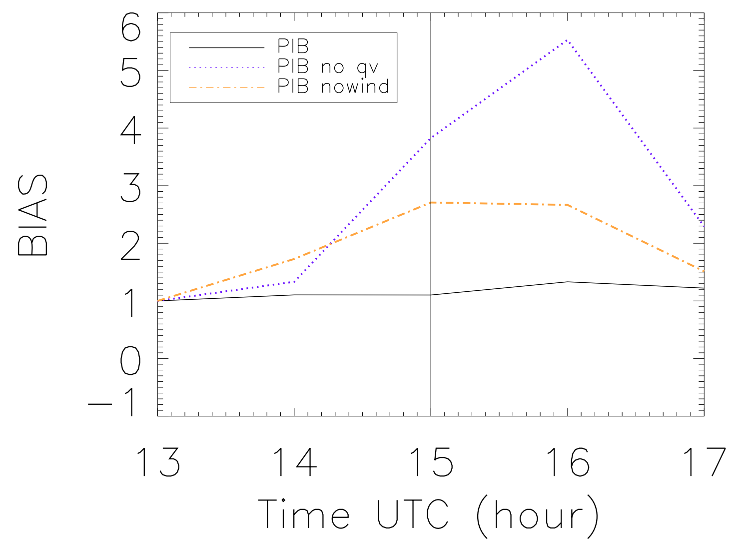
R_th= 5 mm

CASE 2





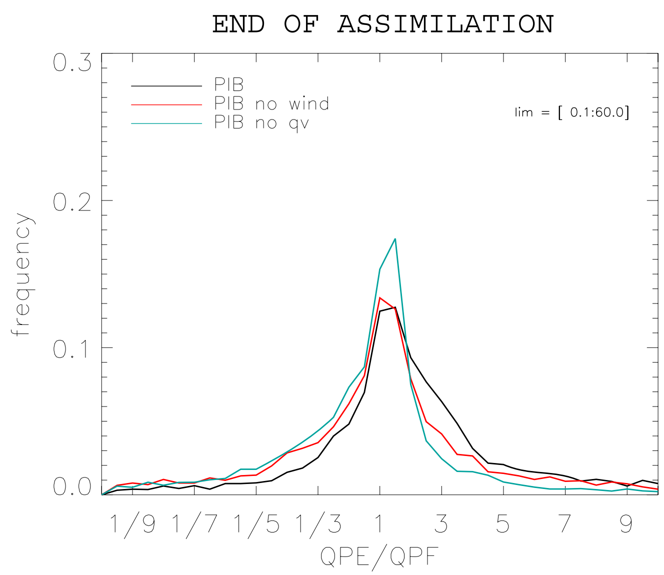


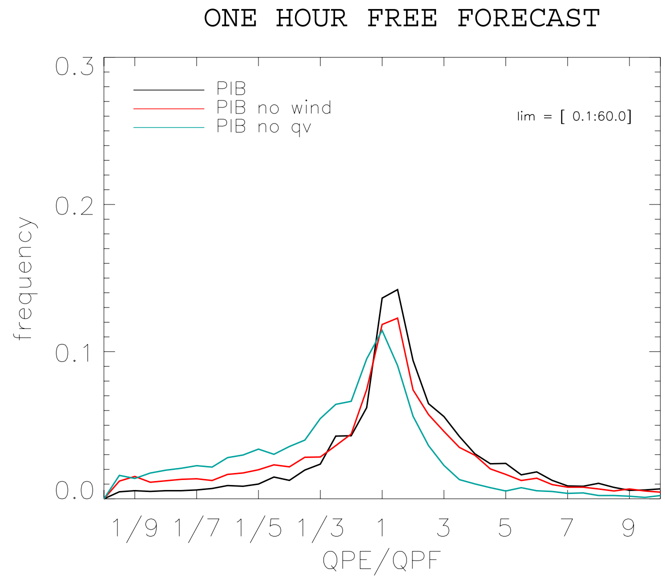


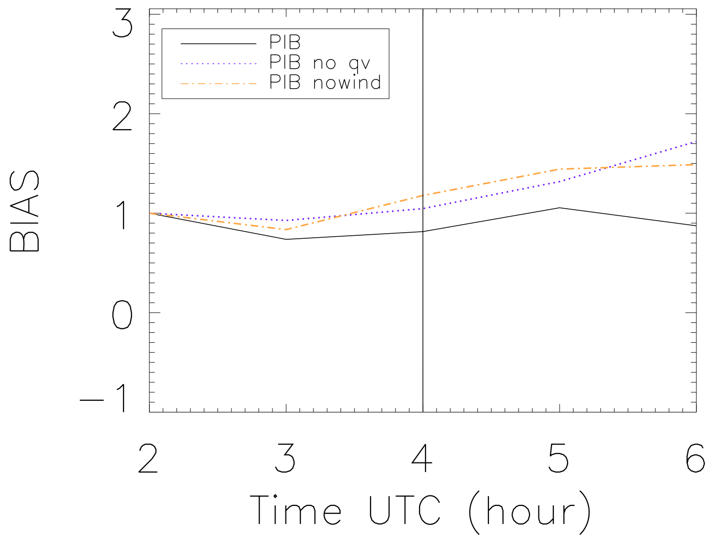
R_th=0.1 mm/h

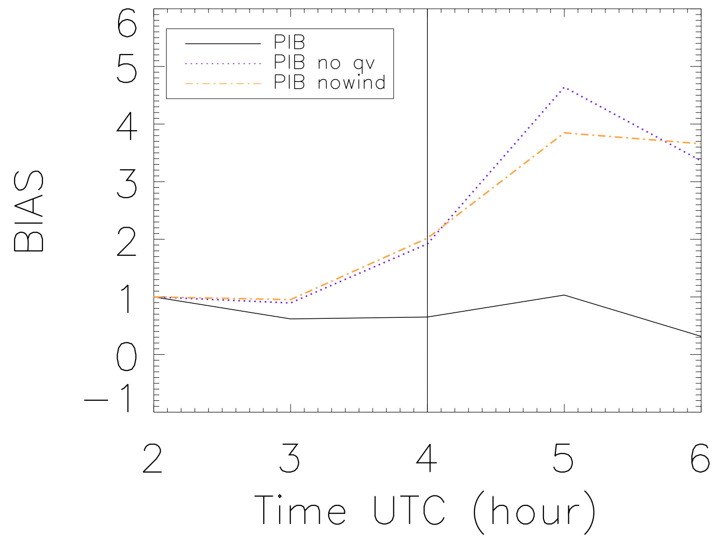
R_th= 5 mm

CASE 3









R_th=0.1 mm/h

R_th= 5 mm

Conclusions PIB

- Consistent with the model dynamic, its application to the model does not disturb the model state to an excessive degree.
- Both, humidity and wind, adjustments are useful to obtain the consistency.
- The PIB system is fast. An assimilation window of 15 minutes is sufficient to achieve acceptable results.
- Useful for nowcasting, the QPF is improved for 4-6 hours in the free run.
- A PIB evaluation using a larger data set (the whole august 2007) is in doing.

Data assimilation – Ensemble methods

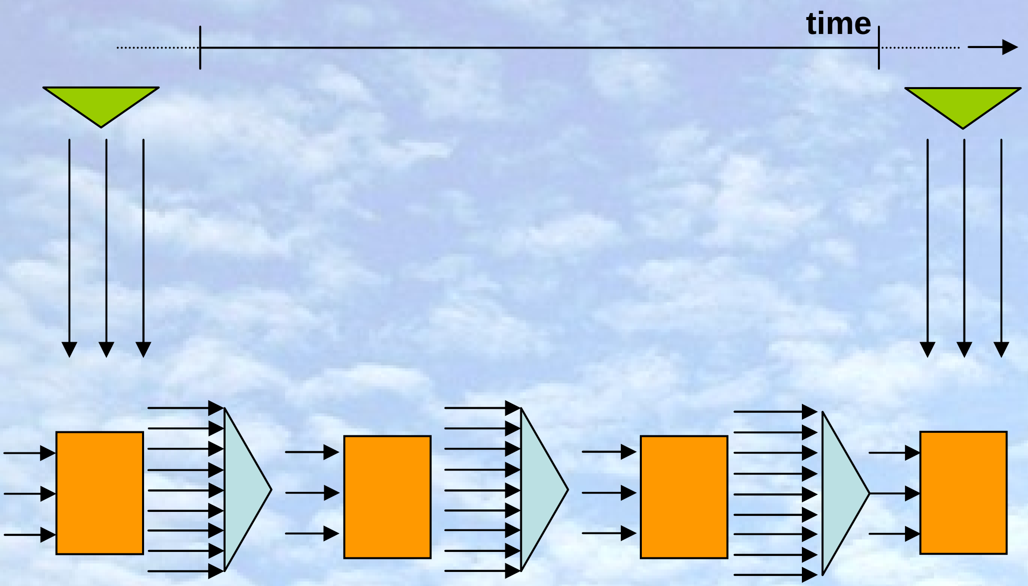
- PIB is a deterministic way for nowcasting.
- Ensemble prediction system, every dynamical system with instabilities leads to really different state in the phase space if the initial conditions are disturbed.
- Combination of the two methods: Ensemble Kalman Filter. All random components have Gaussian distributions.

SIRF

- Initial phase no results will be shown.
- Very elegant way to connect data assimilation and ensemble approach.
- The observation are used in order to attach weights to the members and re-sample the ensemble.
- SIRF needs a metric (DLR, Meteo Swiss, next talk) to define the distance between the state of the observations and the model state.
- Resampling (MIUB): members with low probability will be excluded, other members will be resampled.

SIRF system

Driving EPS
(COSMO-DE EPS)



HREAS
(High-resolution ensemble assimilation System)

Best-Member-Selection 1
Working on driving EPS, based on
- Satellite and Radar data
- conventional observations

Best-Member-Selection 2
Working on HREAS

Ensemble Enhancement/Resampling

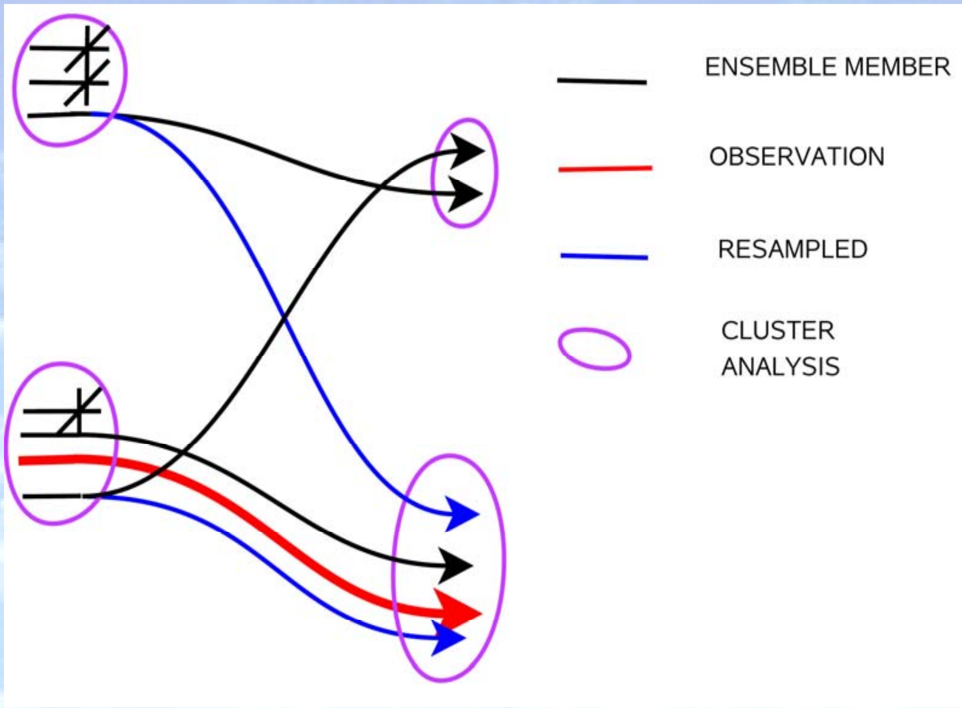
Resampling

- Cluster analysis of the ensemble.

- The most probable members, taking into account the metric, will be duplicated.

- The less probable clusters will be discouraged but not excluded at all. At least one member remains, maintaining the chance of a non linear evolution of the system.

- Resampling: breeding, use of PIB, …

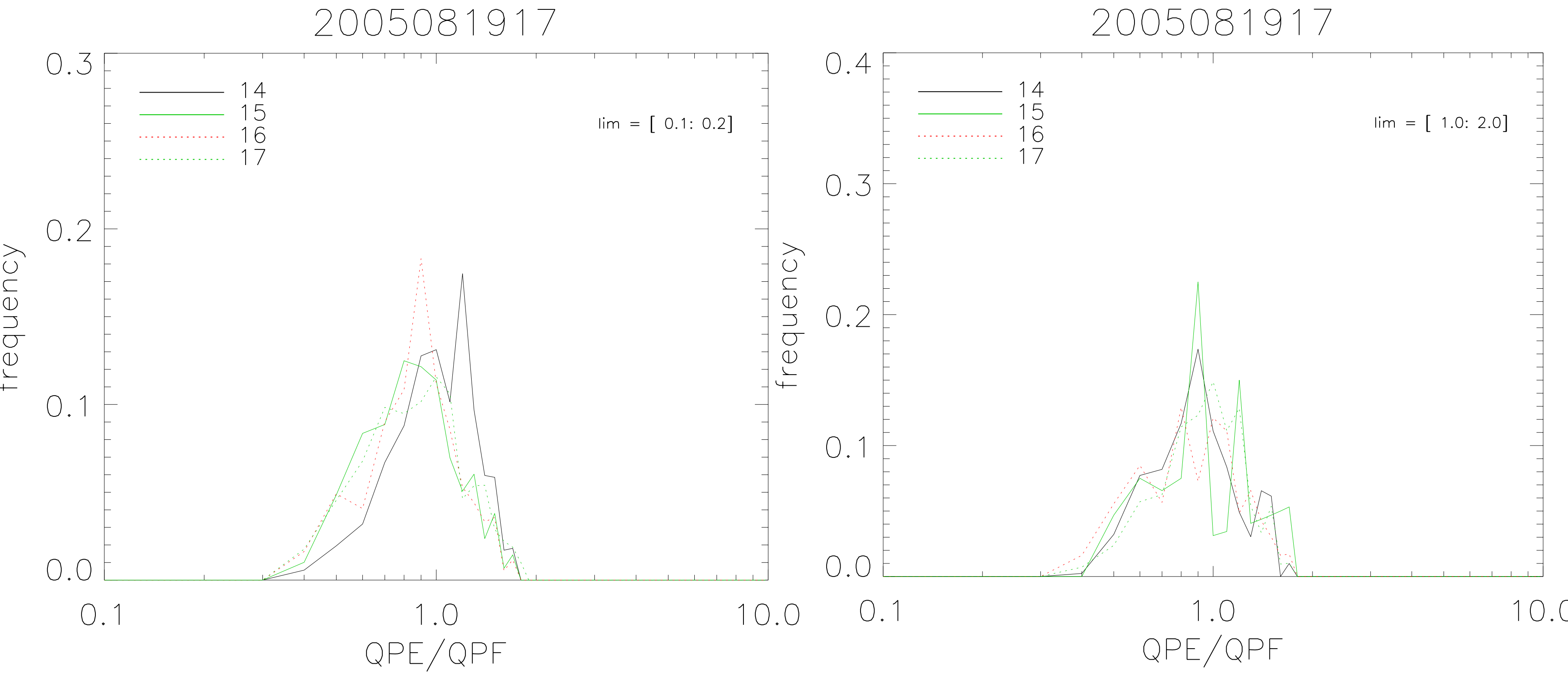


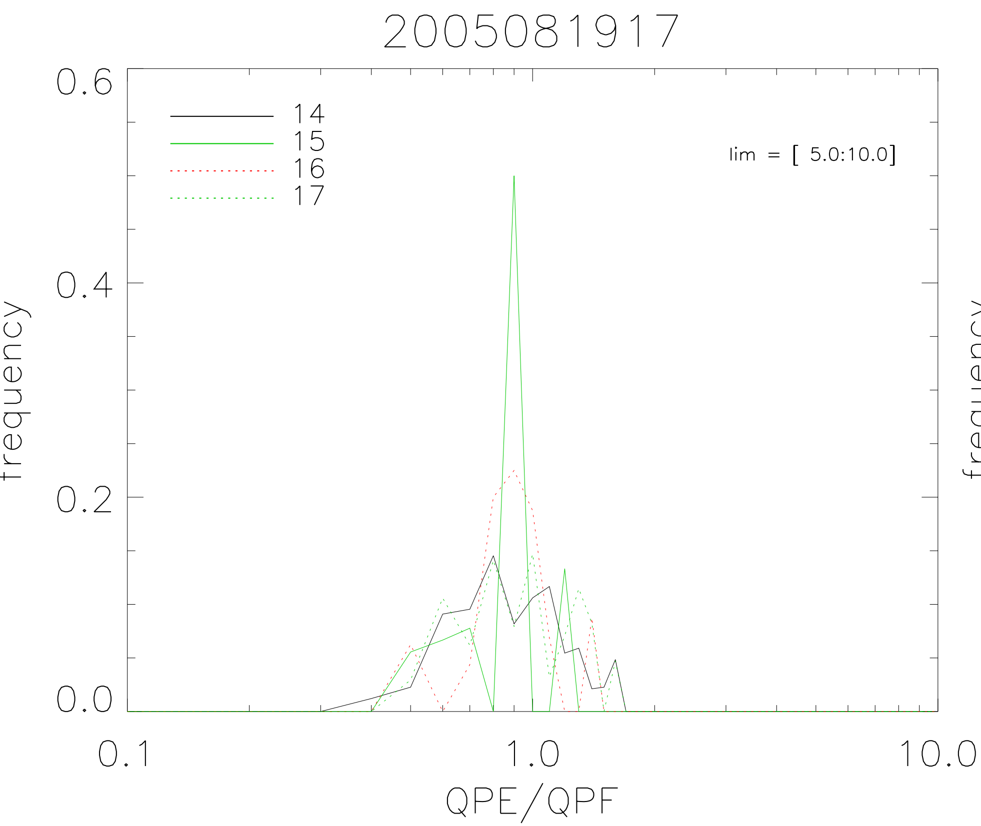
Conclusions SIRF

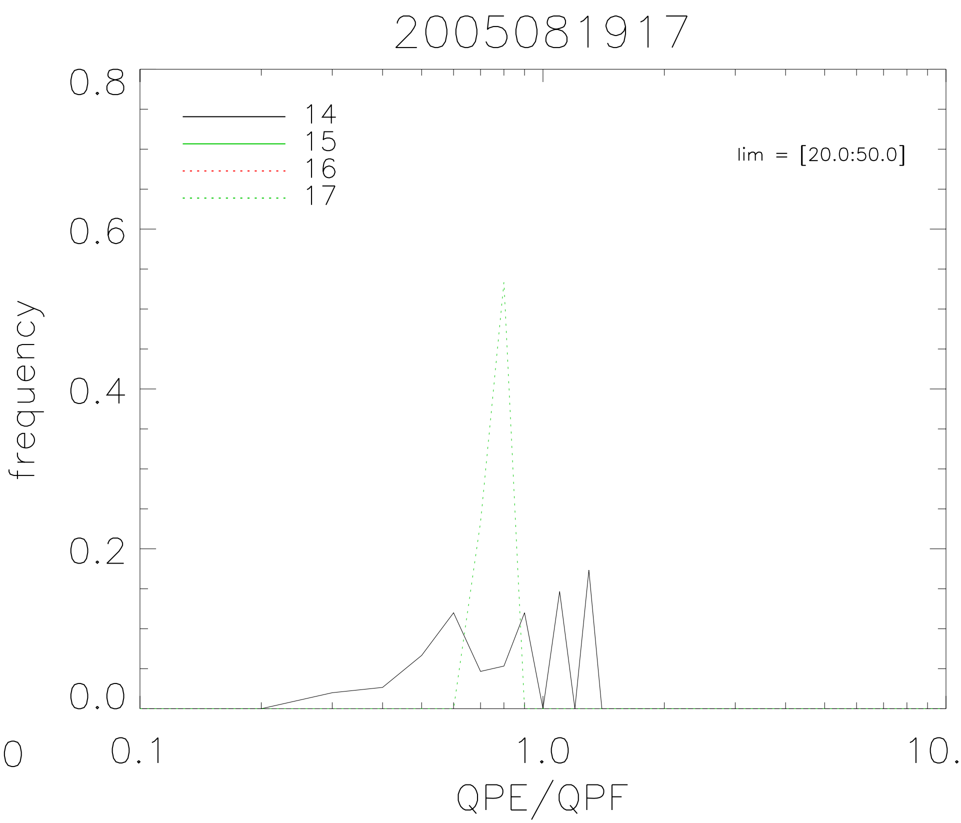
- Improve QPF of short and very short term.
- Focus on convective rain.
- Combination operational COSMO-DE ensemble with Data assimilation systems.
- Enhance ensemble density close to the observations.
- Change of the ensemble PDF with the condition of good representation of available information.
- Very sensitive parameter is the used metrics (Meteo Swiss, DLR).

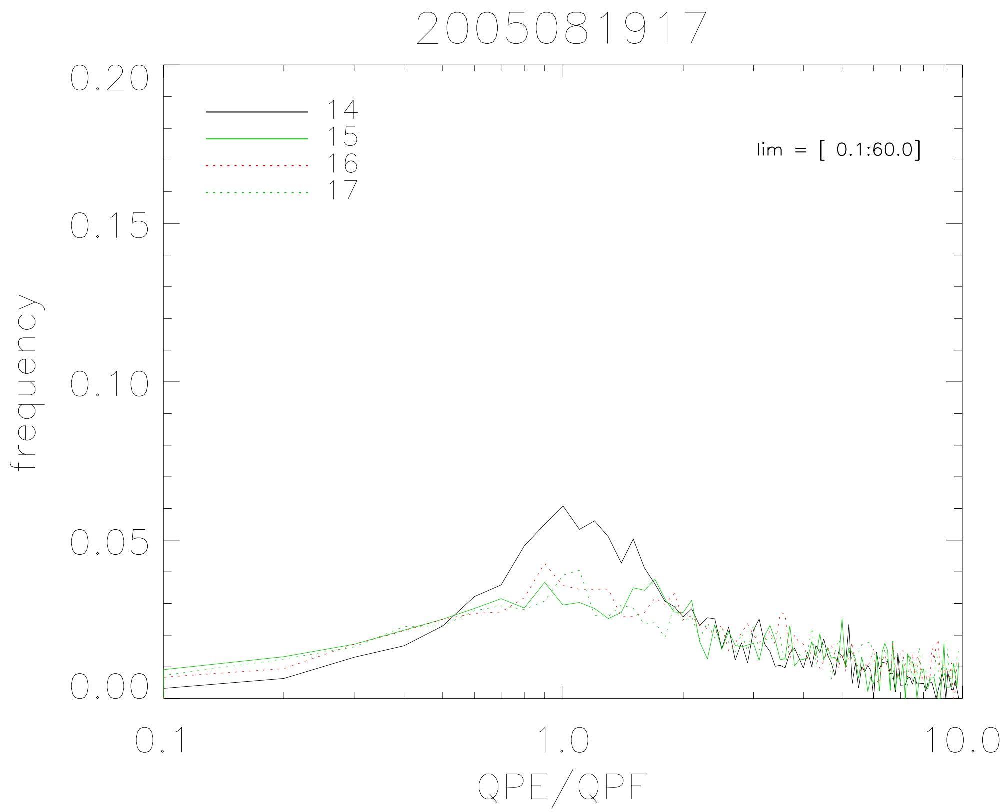

THANK YOU


THANK YOU


2005081917
0.3
0.2
0.1
0.0
frequency
14
15
16
17
lim = [0.1: 0.2]
0.1
1.0
10.0
QPE/QPF
2005081917
0.4
0.3
0.2
0.1
0.0
frequency
14
15
16
17
lim = [1.0: 2.0]
0.1
1.0
QPE/QPF


2005081917
0.6
0.4
0.2
0.0
frequency
14
15
16
17
lim = [5.0:10.0]
0.1
1.0
10.0
QPE/QPF

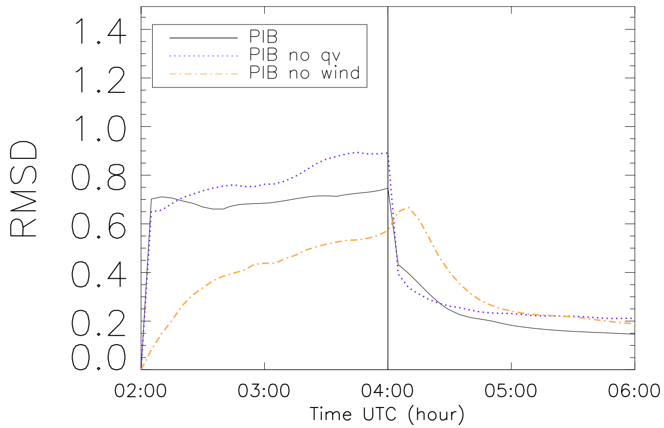

2005081917
0.8
0.6
0.4
0.2
0.0
frequency
14
15
16
17
lim = [20.0:50.0]
0.1
1.0
10.
QPE/QPF



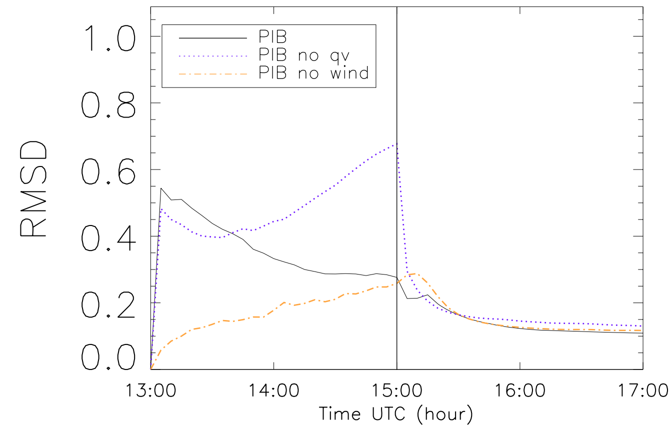
2005081917
0.20
0.15
0.10
0.05
0.00
frequency
14
15
16
17
lim = [0.1:60.0]
0.1
1.0
10.0
QPE/QPF

Wind adjustment

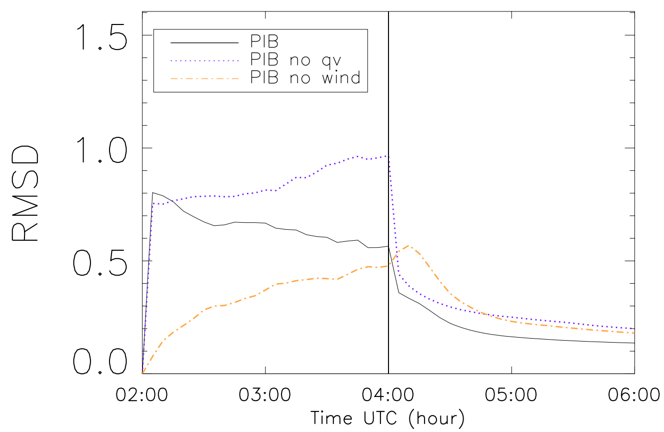
CASE1



CASE2



CASE3



Error in the vertical wind

- The PIB error decrease during the assimilation window, prove of model consistency.
- The error for the partial algorithms increase with the assimilation window.

Shallow and deep choice

Based on Tiedke parameterization:

- Deep convection in connection with strong low level convergent flows.
- Use the three dimensional humidity convergence (Q) and boundary layer turbulent diffusion (Ω) .
- Deep convection in case of:

$$\frac{g}{R_d}\int_0^H \frac{Q \cdot p}{T} dz > -1.1 \cdot \Omega \cdot g$$

In case of deep convection we set the cloud thickness at least at 250 hPa, the reference point is the cloud top. For shallow convection the cloud thickness is at most 250 hPa