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RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITÄT

The Physical Initialization Bonn (PIB) scheme

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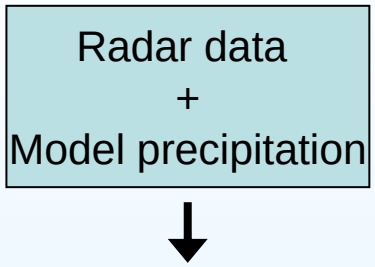
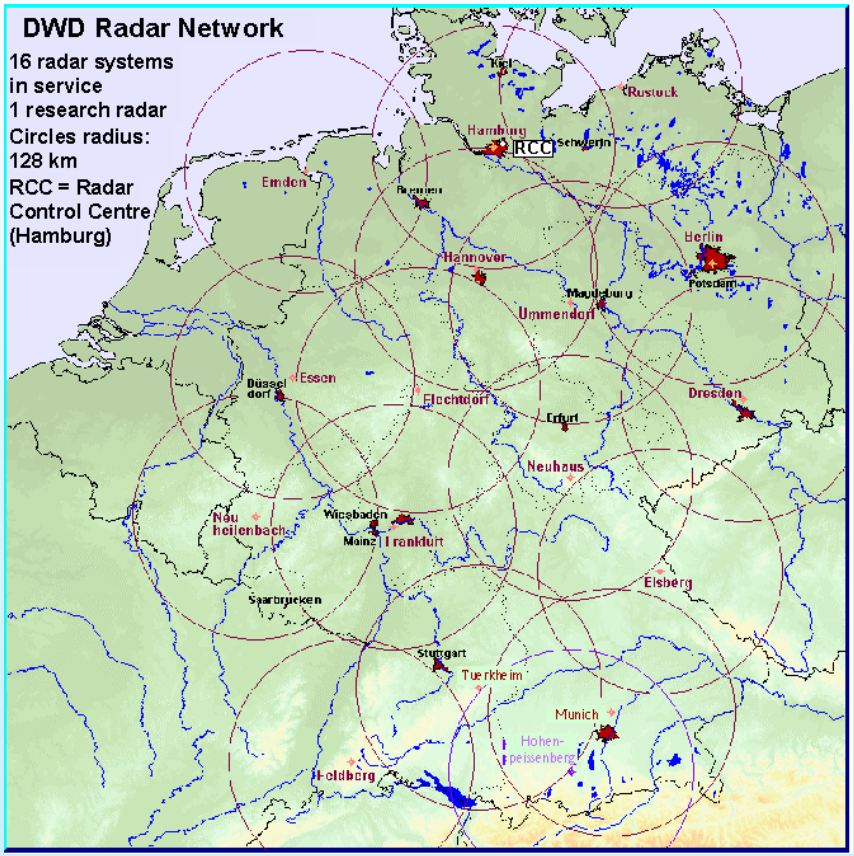
Description of the scheme



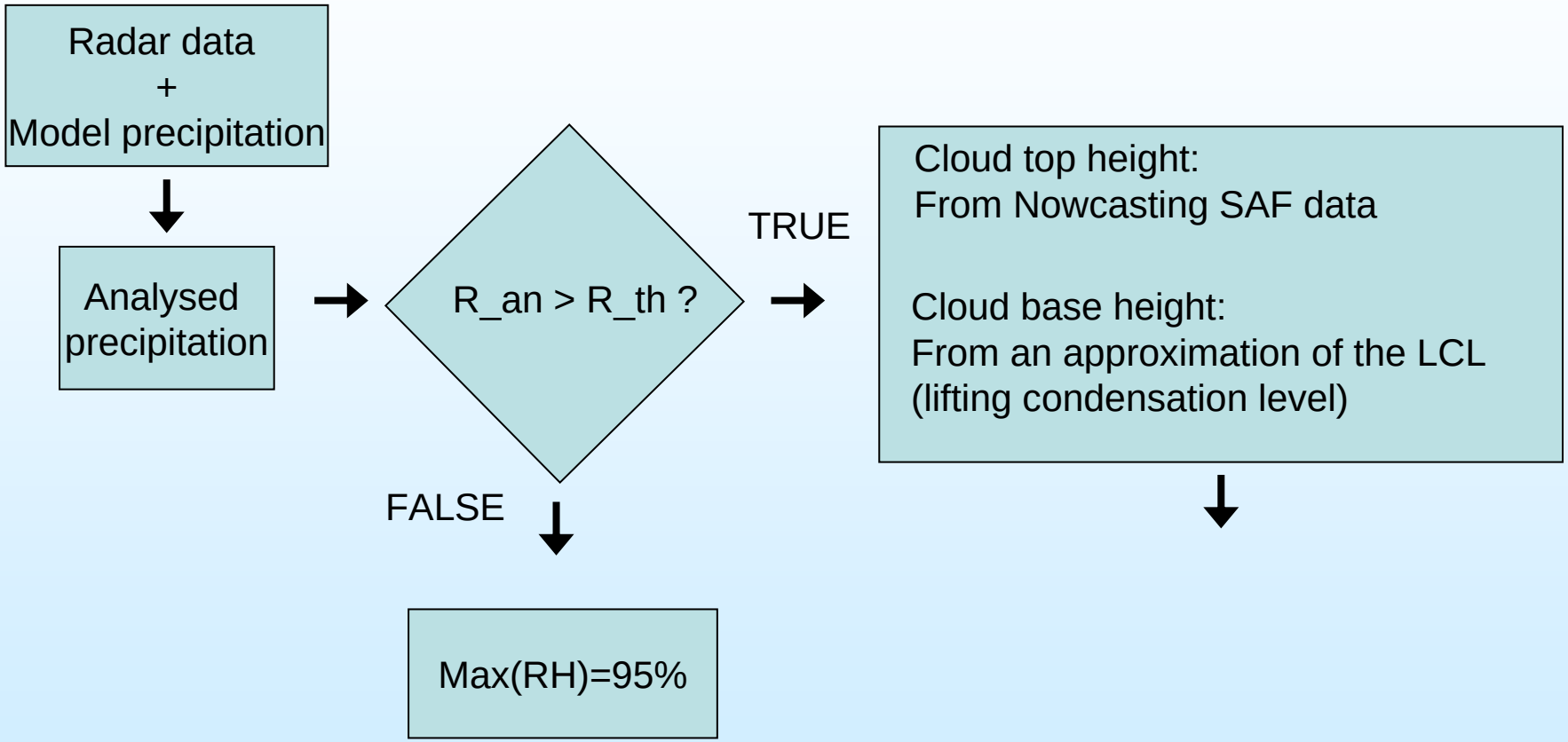
Radar data



The PIB use 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



Cloud top height

The PIB use 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 and 1 hour for the year 2004.
- The high semi transparent 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 filling the gaps.

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):*

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

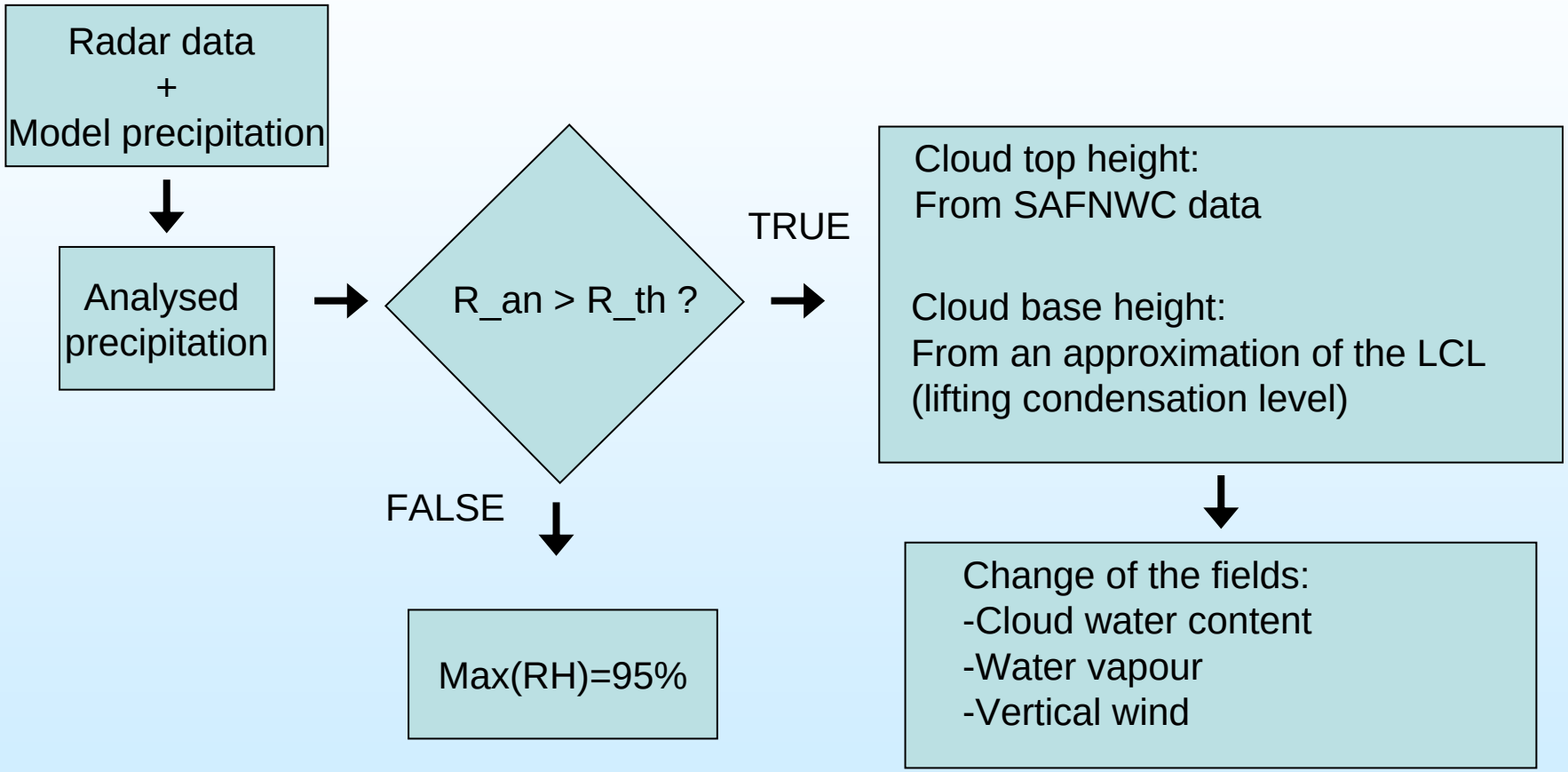
Where

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

Description of the scheme



Cloud water content

- In the PIB scheme snow and other frozen particles are not considered.
- The cloud water content inside the clouds is calculated using *(Karstens et al., 1994)*:

$$q_{c,ad}(z) = \int_{z_{cb}}^{z} \rho_{air}(z') \frac{c_p}{L} (\Gamma_d - \Gamma_s) dz'$$

Where:

ρ_{air} the density of the air, c_p specific heat at constant pressure, L latent heat of vaporization, Γ_d dry adiabatic lapse rate and Γ_s pseudoadiabatic lapse rate.

The reduction of the liquid water content due to entrainment of unsaturated air, precipitation formation and freezing is considered using *(Warner, 1955)*:

$$q_c(z) = q_{c,ad}(z)\left[1.239 - 0.145 \ln(z - z_{cb})\right]$$

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*):

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

with

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

Where

c conversion efficiency of saturated water vapor 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

Determination of the conversion efficiency

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

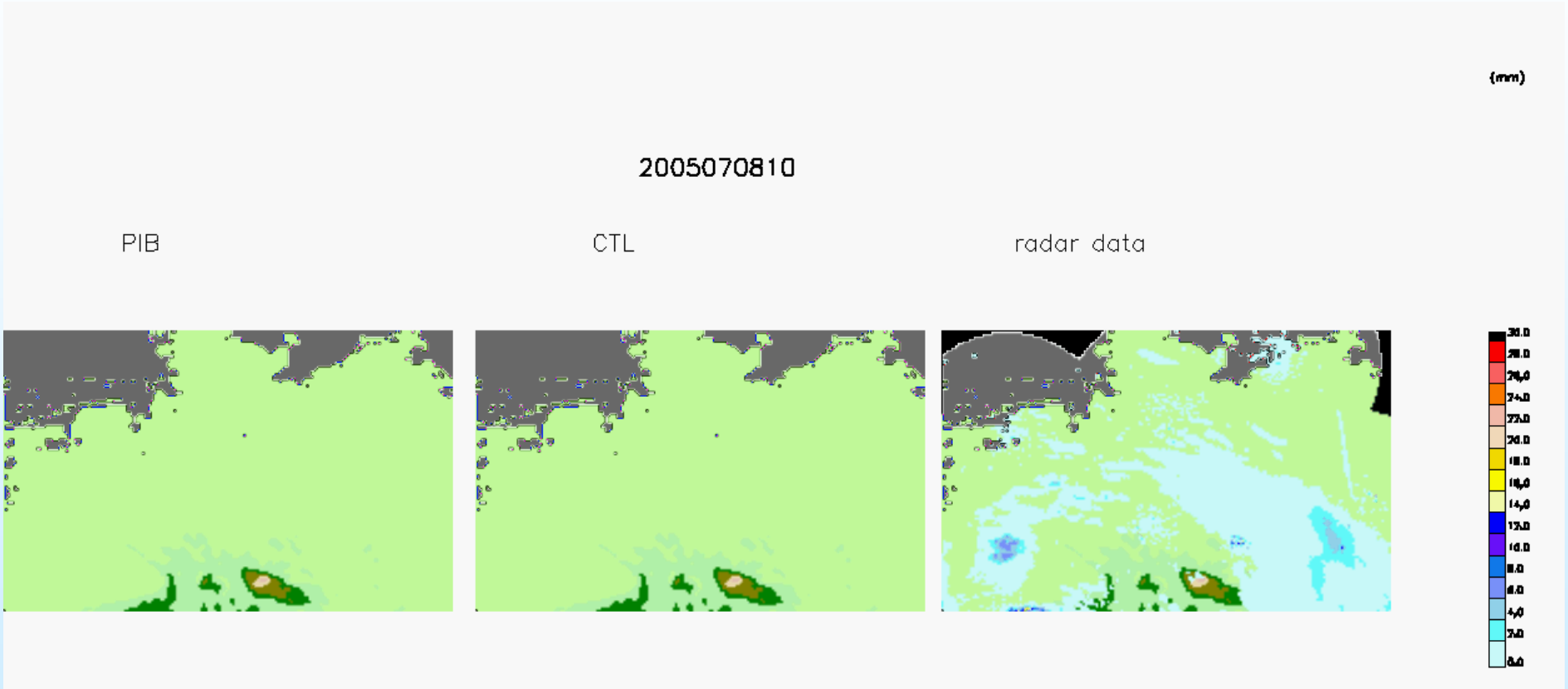
- For every grid point *c at* time step *n* is function of its value at the step n-1 , the analysed precipitation *R_an* and the model precipitation *R_m*

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

With :

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

A convective case: 08/07/2005



•RUN:

2.8 km resolution, time step 25s, 200 points in x direction and 125 points in y direction, two hours assimilation of radar data and six hours of free forecast

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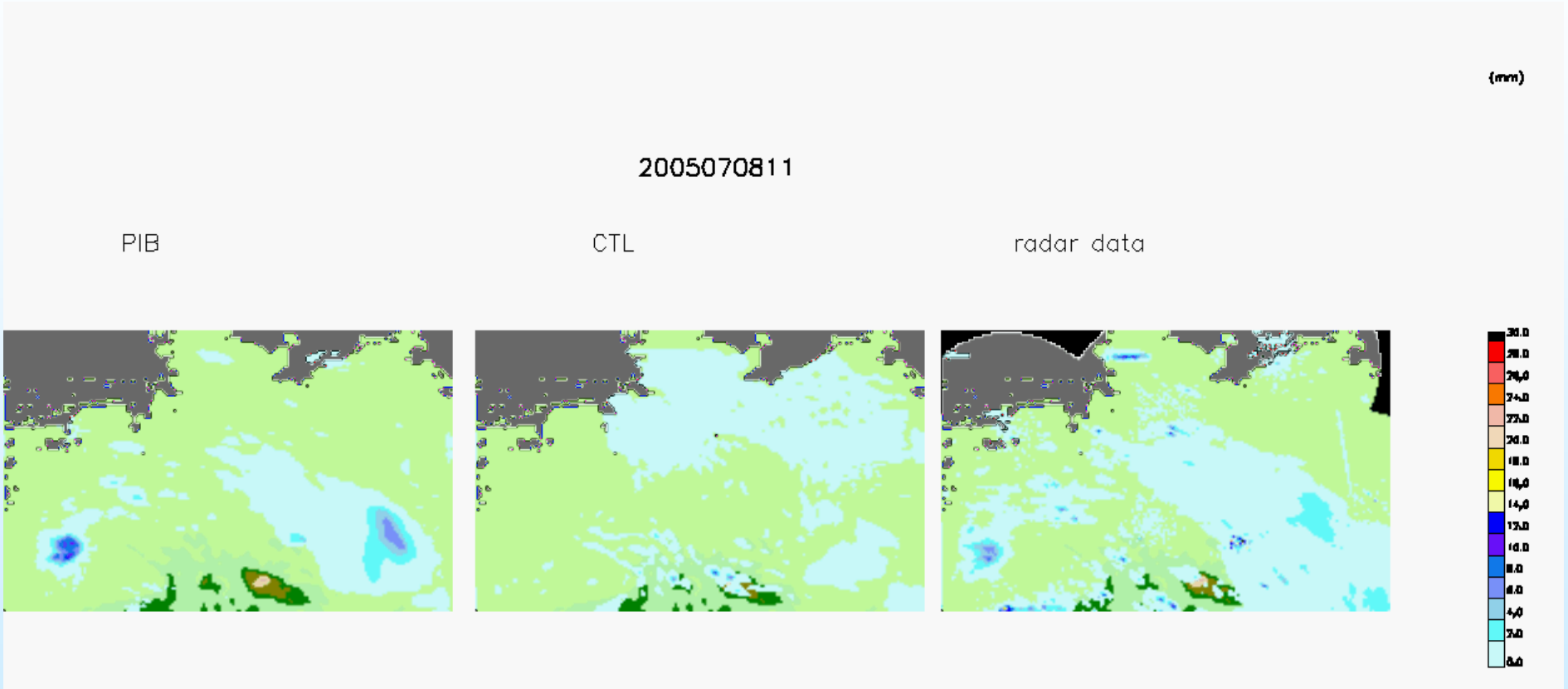

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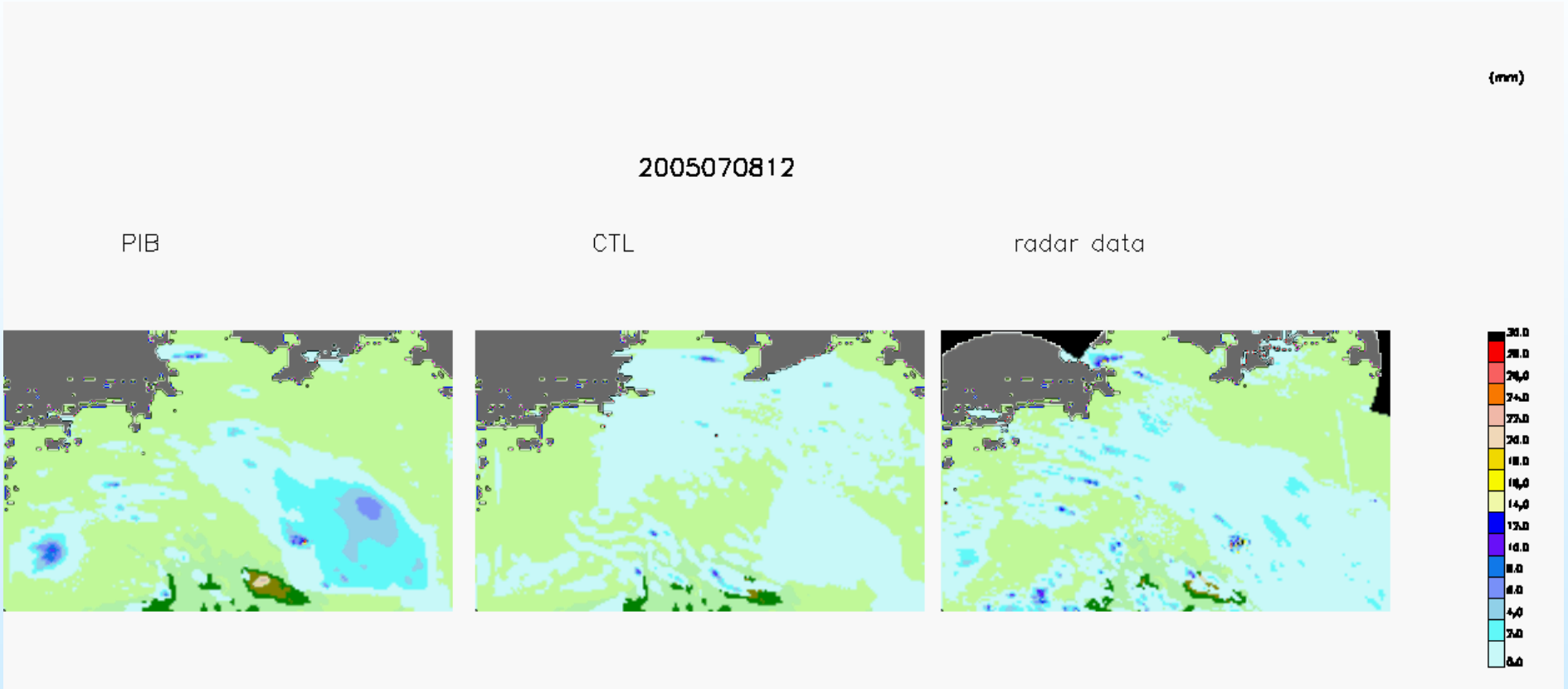

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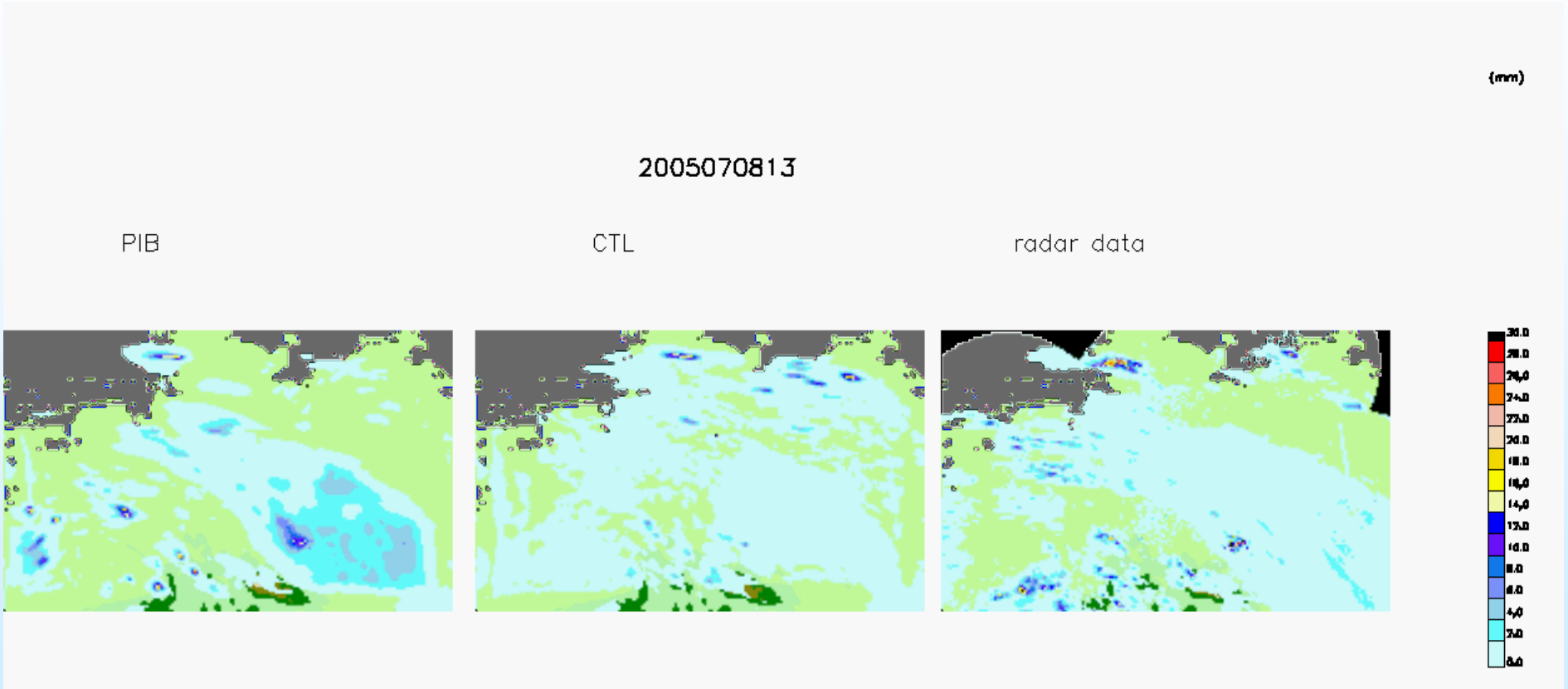

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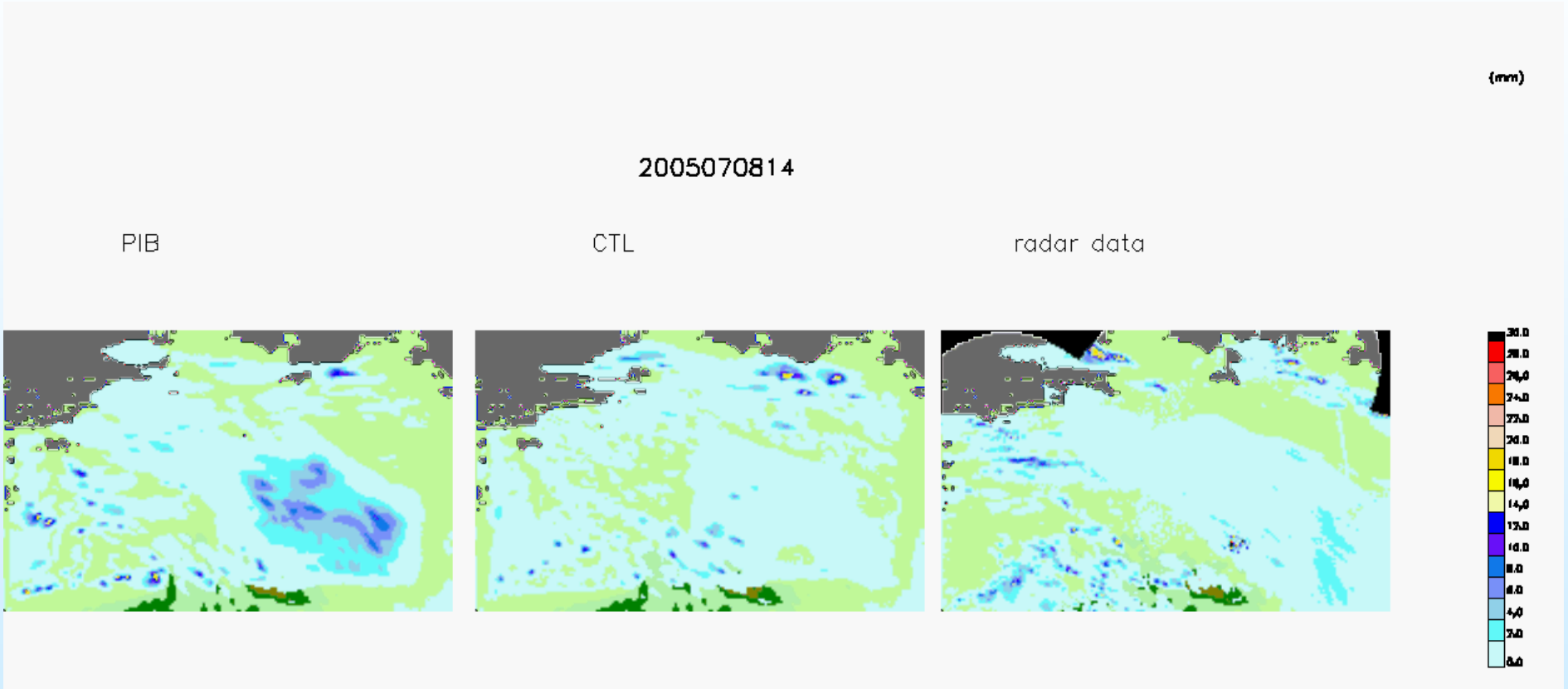

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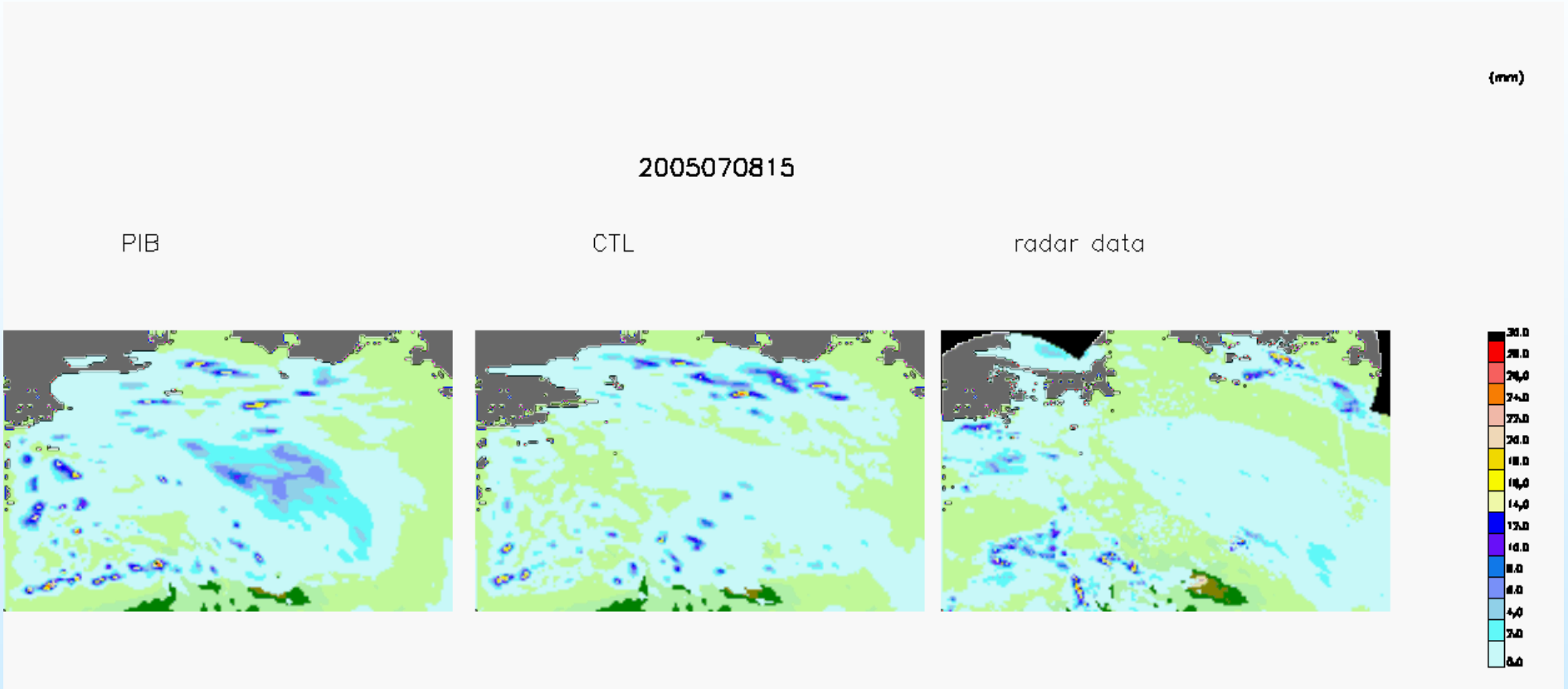

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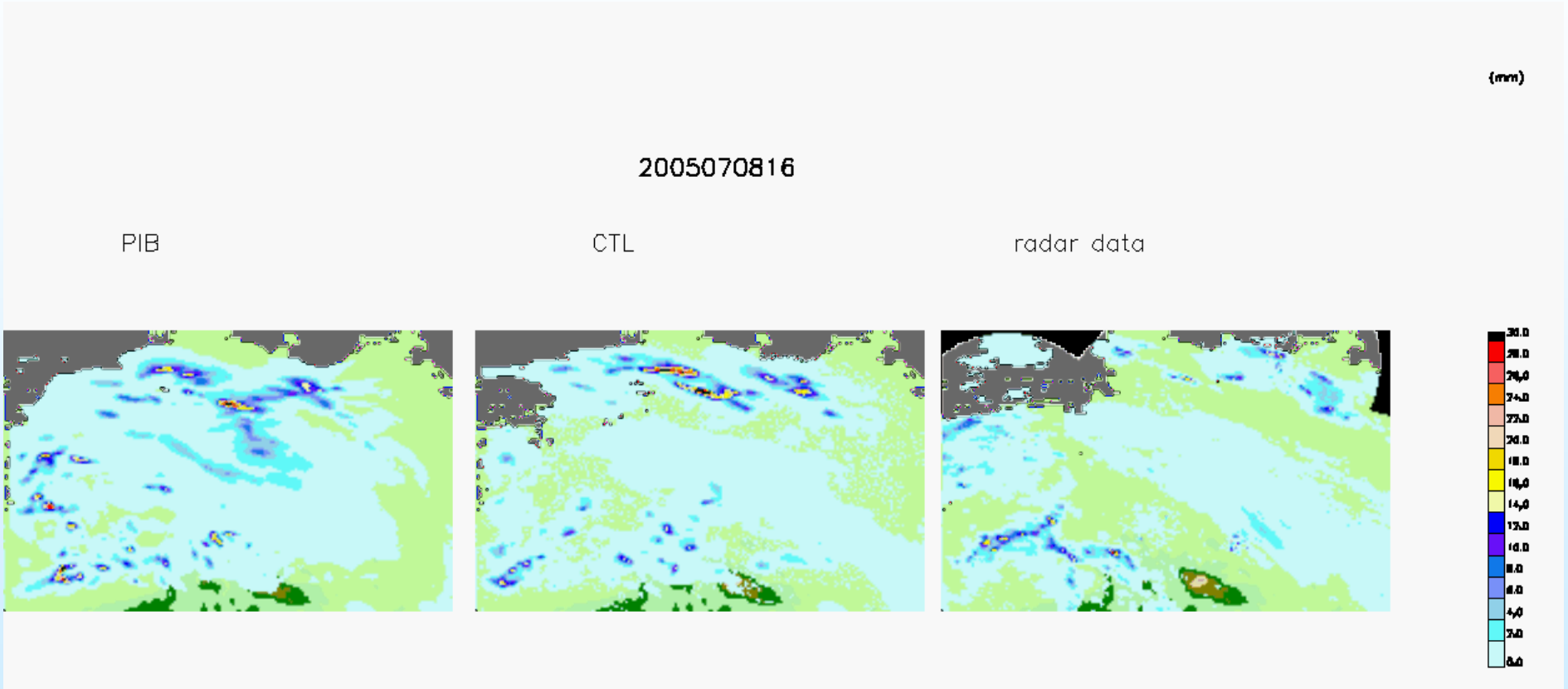

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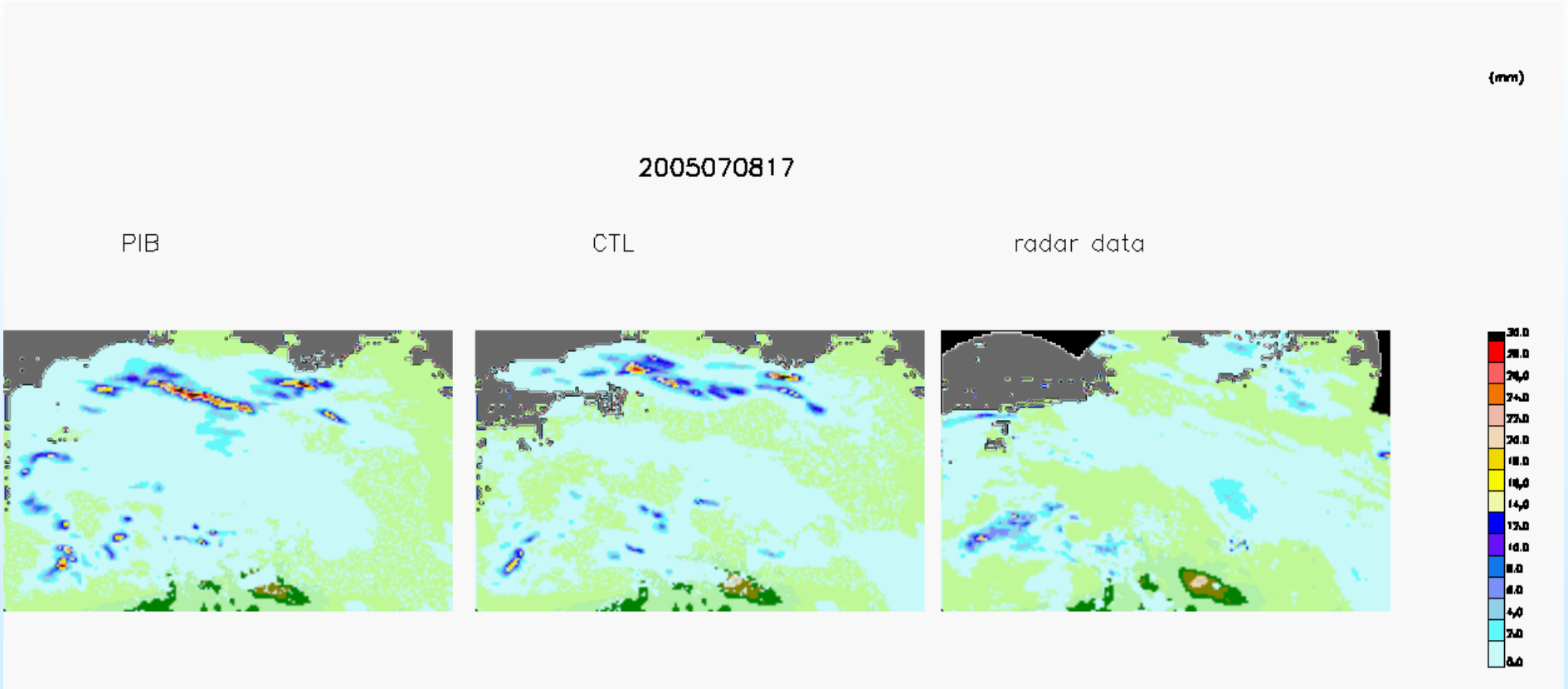

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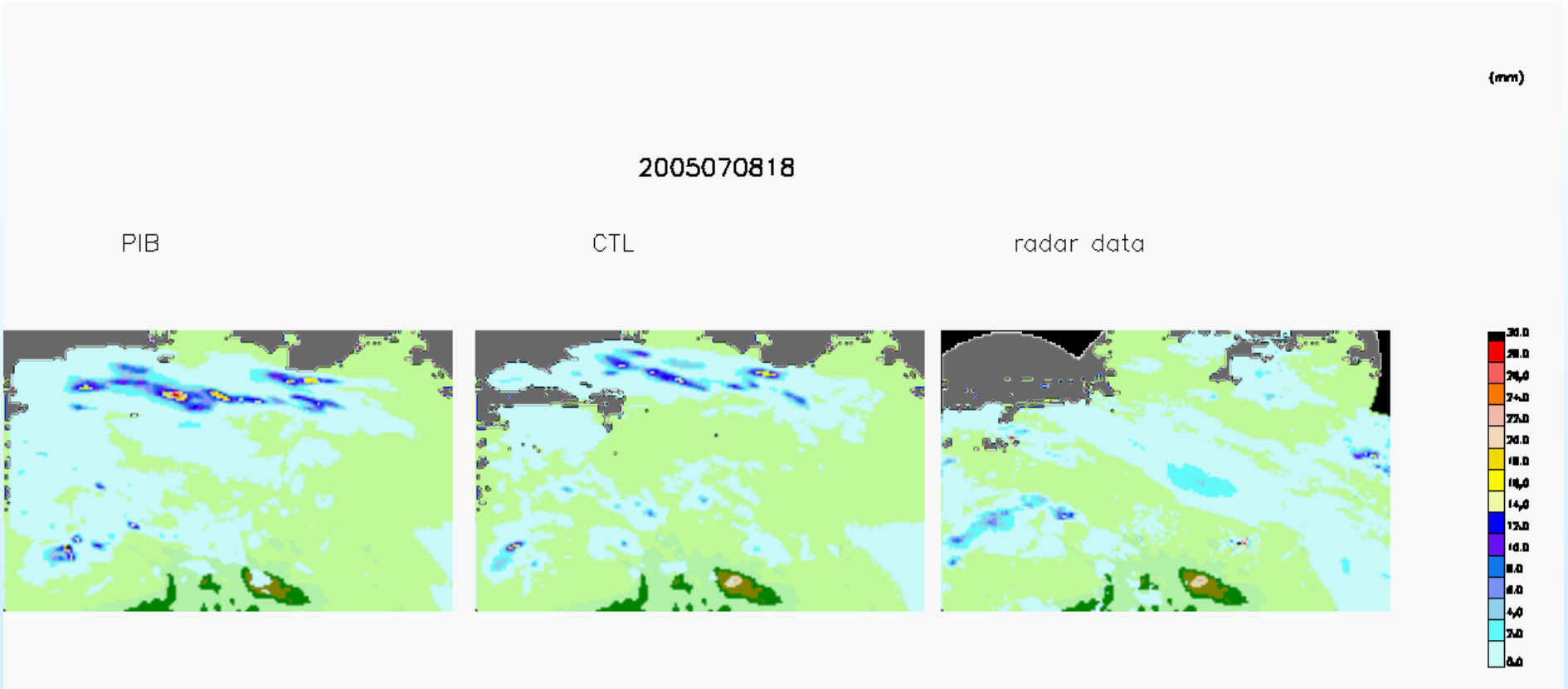

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OBJECTIVE EVALUATION

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?*

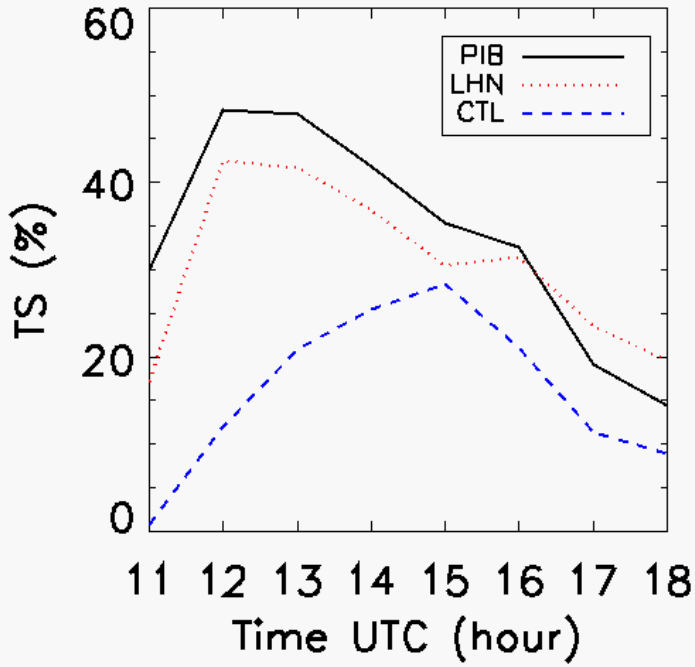
•**TS** (threat score, in %): *How well did the forecast "yes" events correspond to the observed "yes" events?*

•**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.

Threat score

08/07/2005



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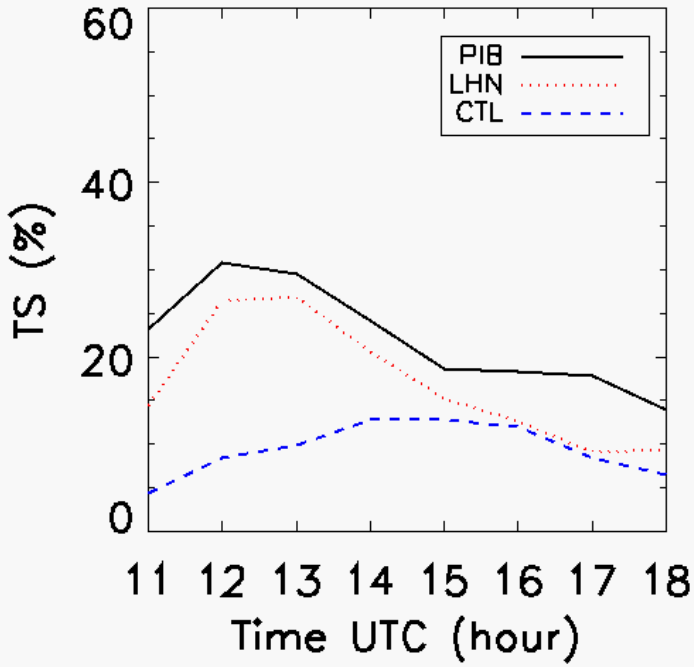
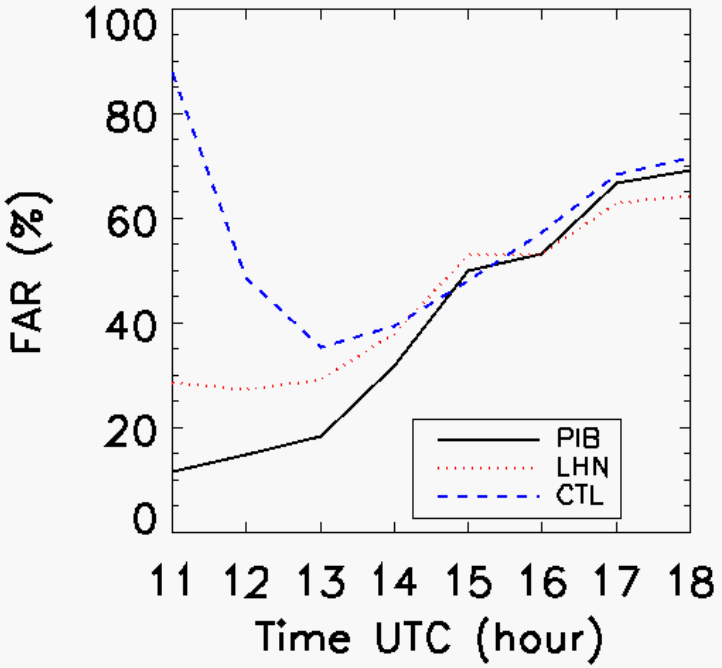


False alarm ratio

08/07/2005



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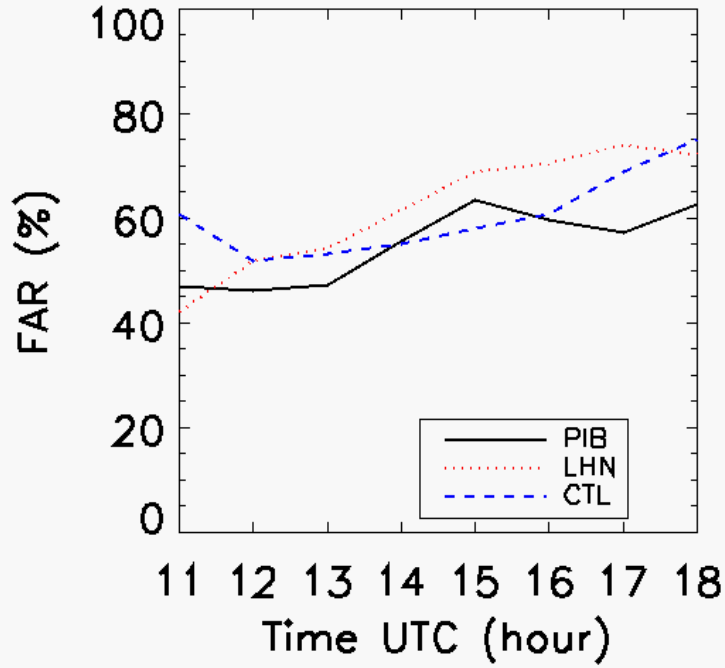
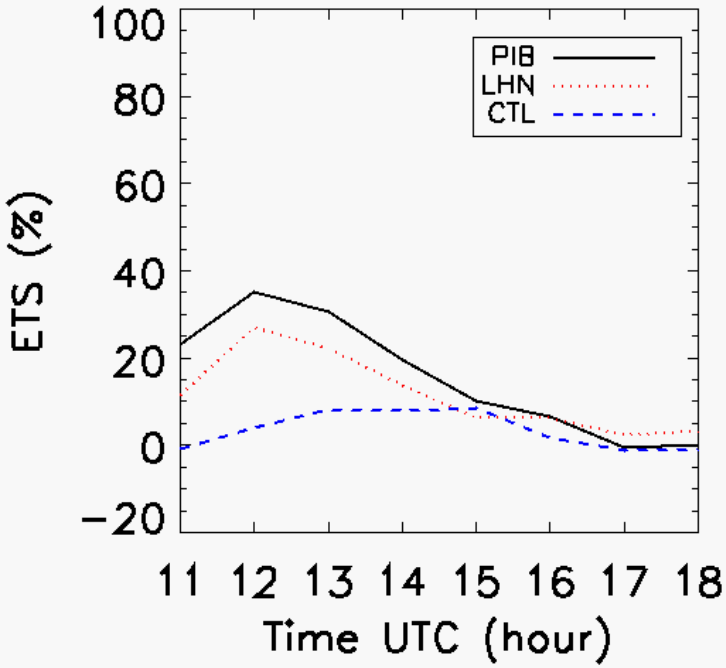


Equitable threat score

08/07/2005



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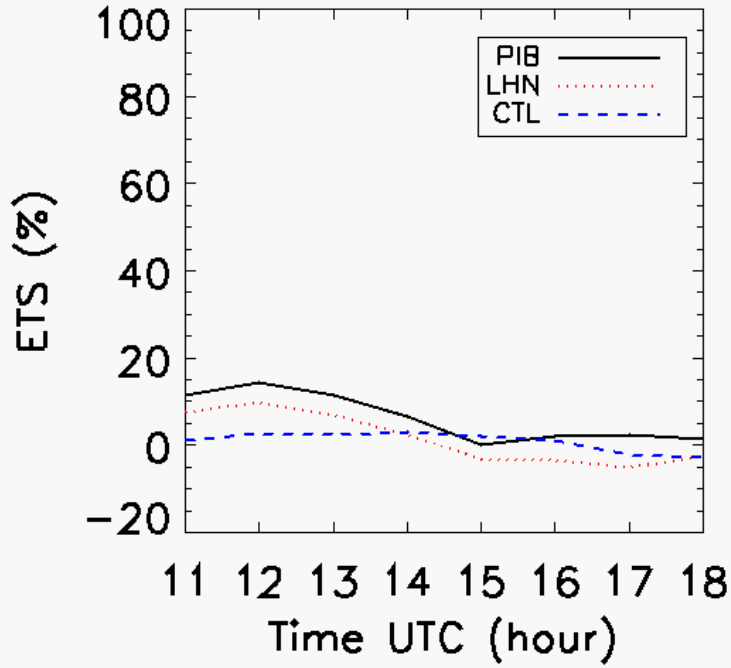


CONCLUSIONS

- Spin-up and position errors of precipitation forecasts, are reduced
- We can see the impact of the PIB scheme in the forecast for about three hours.
- The modification of the vertical wind seems to adjust also the horizontal wind field, from the mass conservation. We have to analyze this relationship in more detail.
- The computational costs are acceptable.
- We have to find other cases for test the scheme in more meteorological events.

REFERENCES

- Bolton D., 1980: The computation of equivalent potential temperature.
  Monthly weather review, 108. 1046-1053
- Craven J.P. and R. E. Jewell, 2002: Comparison between observed convective cloud-base heights and lifting condensation level for two different lifted parcels.
  Weather and Forecasting, 17. 885-890
- Haase G., 2002: A physical initialization algorithm for non-hydrostatic weather prediction models using radar derived rain rates.
  Phd thesis, Meteorological Institute, University of Bonn, 98pp
- Karstens, U.C., C. Simmer and E. Ruprecht, 1994: Remote sensing of cloud liquid water.
  Meteorology and Atmospheric Physics, 54,157-171.
- Rogers, R.r. and M.K. Yau, 1989: A short course in cloud physics.
  Pergamon Press
- Warner, 1955: The water content of cumuliform cloud.
  Tellus, 7, 449-457

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

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

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

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

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

Analyzed 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

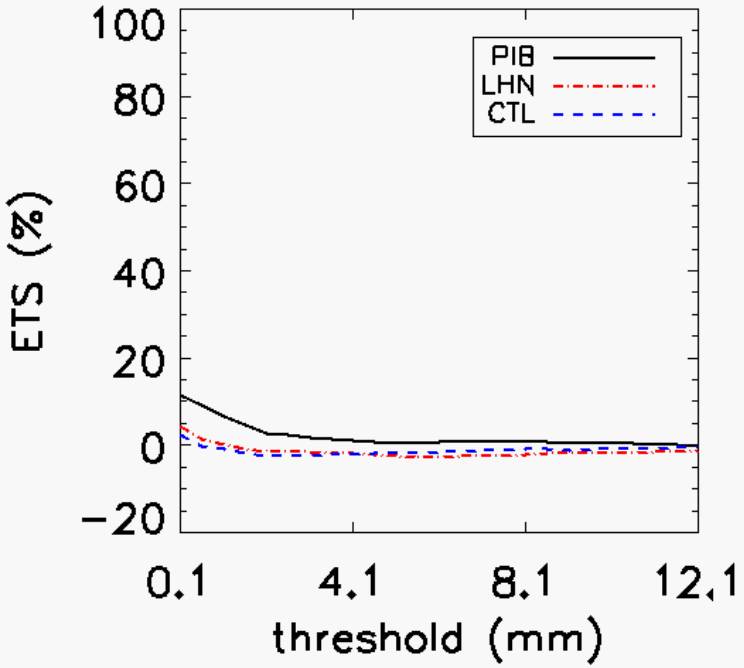
Analyzed precipitation

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

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

Equitable threat score

08/07/2005



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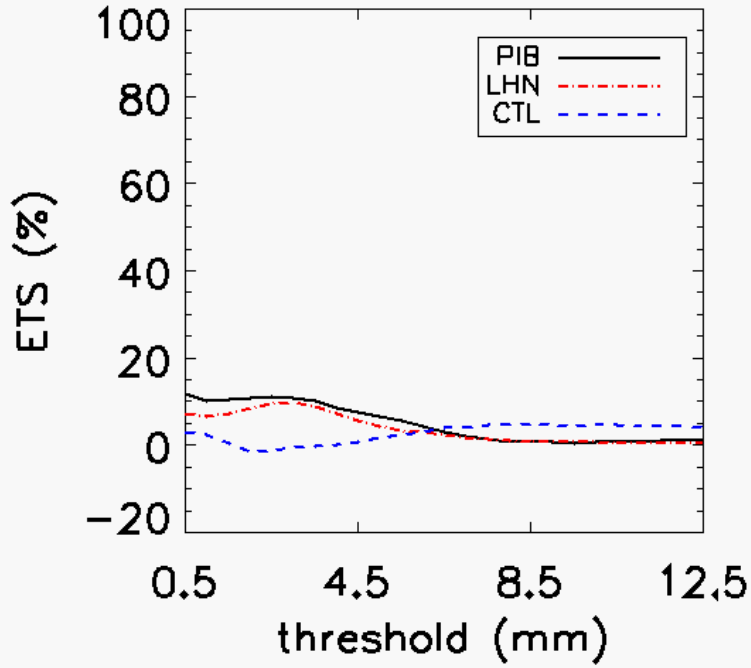

False alarm ratio

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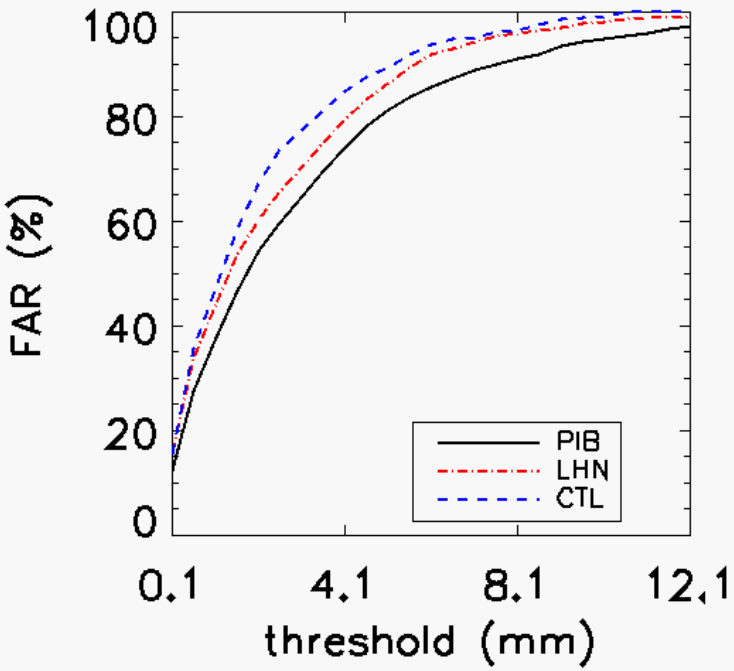

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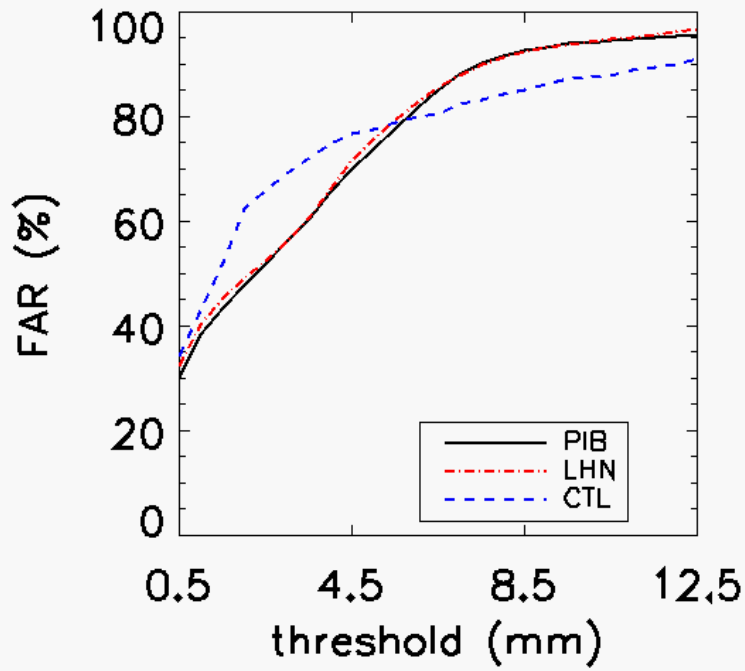

Threat score

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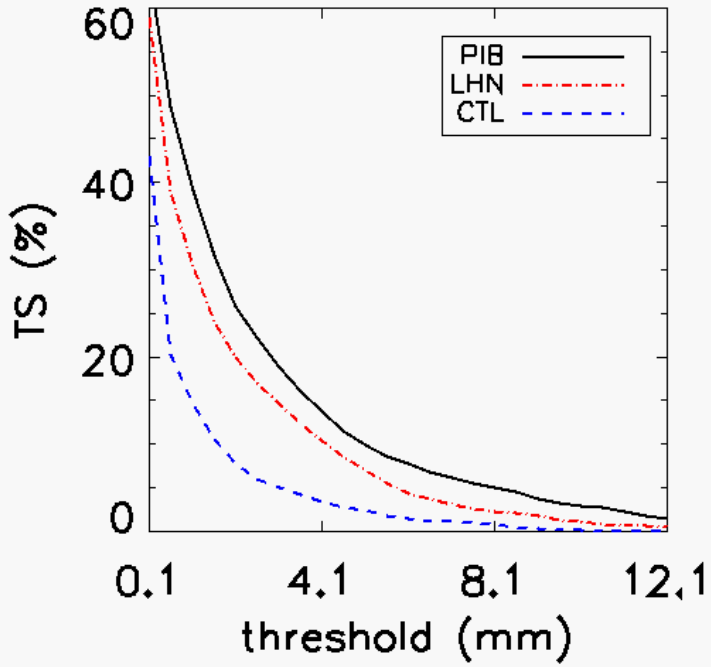

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