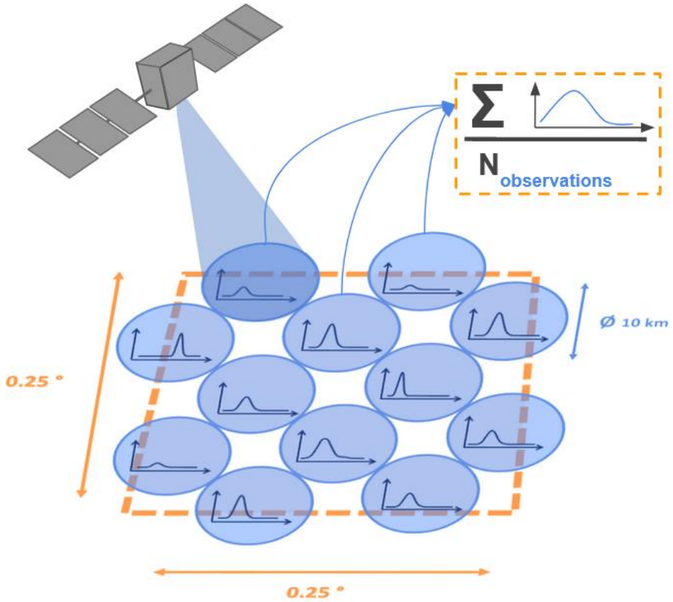
EGU 2023
PICO 2 min madness
ESSI3.6 27/04/2023

Using satellite probabilistic estimates to assess modeled relative humidity : application to a NWP model

C. Radice (chloe.radice@latmos.ipsl.fr), H. Brogniez, P.-E. Kirstetter, P. Chambon

Deterministic method : is the simulated value within a fixed interval around the mean observed value ?

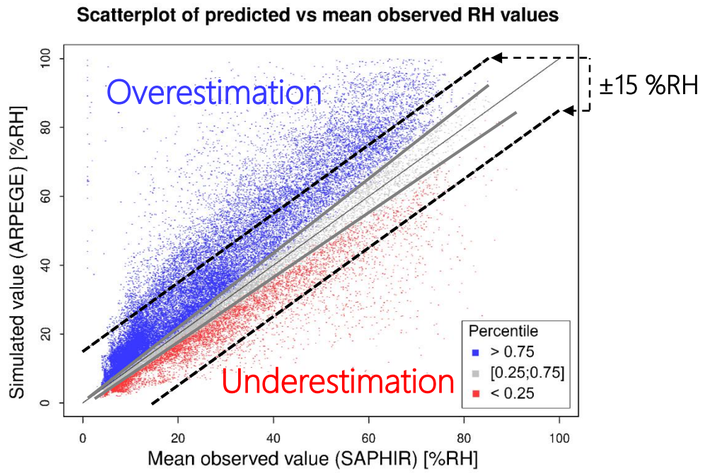
Probabilistic method : uses the full estimated distribution to determine the probability of the simulated value being an over- or underestimation

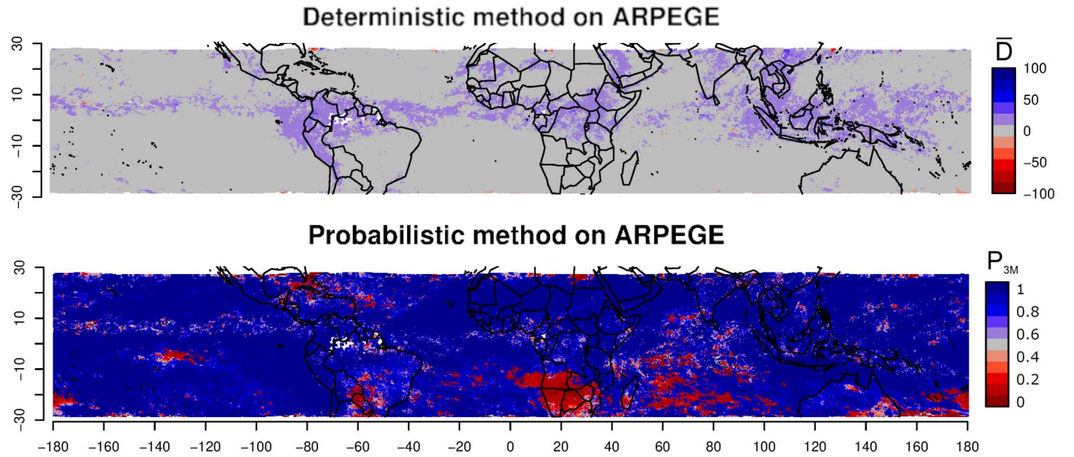


Probabilistic RH estimates from microwave sounder **SAPHIR** aboard satellite Megha-Tropiques

Simulated RH by the Numerical Weather Prediction model **ARPEGE** developed by Météo France

Both methods were applied to 3 months worth of the ARPEGE-SAPHIR colocated dataset (April-May-June 2018)





Deterministic assessment: slight humid bias over the ITCZ
Probabilistic assessment: overall overestimation with local patches of underestimation

Even when the simulated values are close to the mean estimation, they actually correspond to the extreme ends of the entire subgrid distribution.

→ Complementary to a deterministic approach + adds contrast within the deterministic interval

Using satellite probabilistic estimates to assess modeled relative humidity : application to a NWP model

C. RADICE (CHLOE.RADICE@LATMOS.IPSL.FR), H. BROGNIEZ, P.-E. KIRSTETTER, P. CHAMBON

Context
Datasets

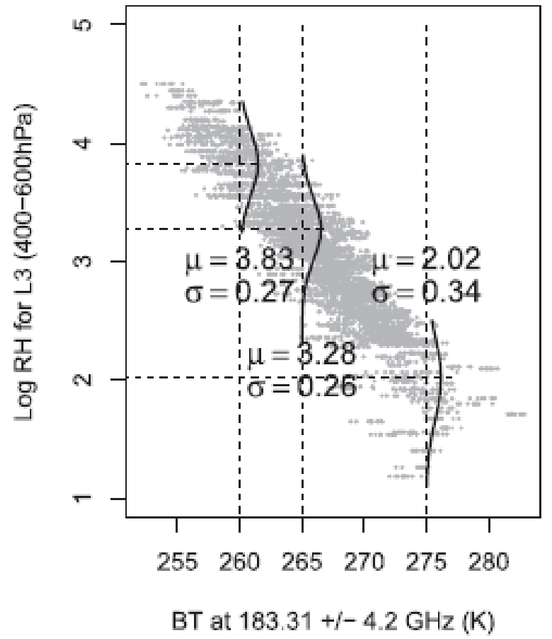
ARPEGE at Météo-France

- Numerical weather forecasting model operated by Météo-France
- Forecasts initialized with a four dimensional variational system with 6h windows (00:00, 06:00, 12:00 and 18:00 UTC)
- For this study : 6-hourly instantaneous simulated RH fields at 6 hour lead time for the months April, May and June 2018.
- The resolution of the model grid used is 0.25° x 0.25°

SAPHIR microwave sounder

- 6 channels sampling the 183 GHz water vapour absorption line
- Onboard Indo-French (ISRO x CNES) satellite Megha-Tropiques
- Scans the tropical belt (between 30°N and 30°S)

- Retrieval scheme for a profile of RH over 6 layers (100 to 950 hPa)
- For each layer : expected $\overline{RH}$ as well as its PDF to account for uncertainty in the retrieval (Sivira et al 2015, Brogniez et al 2016).



© Brogniez et al, 2016

Methodology

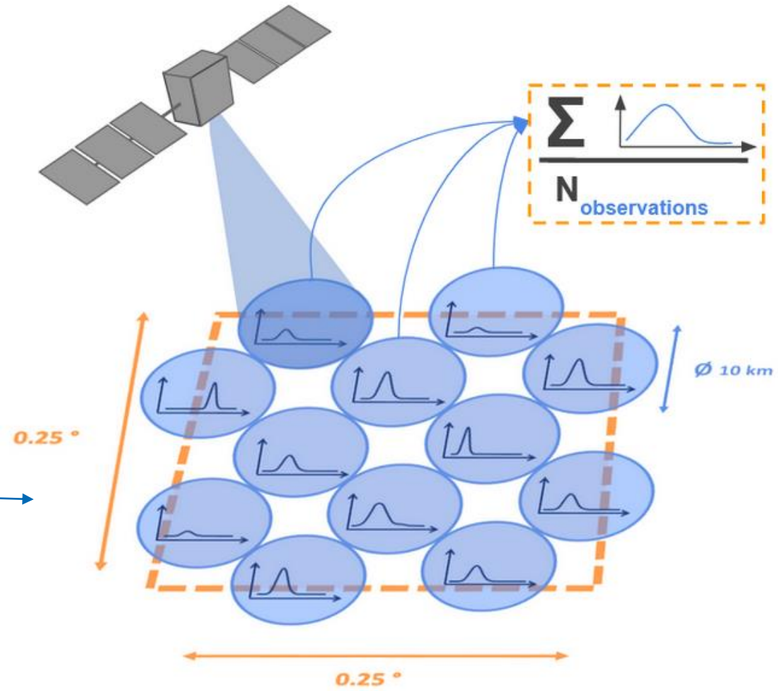
Assessing forecasts with satellite observations

Colocation

- ± 30 min time frame around the ARPEGE simulation
- Atmospheric levels of the simulations are aggregated together to mimic the vertical resolution of the SAPHIR RH profiles (6 pressure layers)

Our probabilistic method

- Convoluting the PDF of every footprints within each gridbox of ARPEGE
- Projecting the simulated value (SV) onto the distribution



Deterministic comparison

- For every gridbox of ARPEGE, spatial average of SAPHIR $\overline{\mathrm{RH}}$
- Confronting the simulated value (SV) to this averaged value

Methodology
Application

Deterministic comparison

- $\overline{\mathrm{RH}}$ computed from the PDF

  + Confidence interval arbitrarily set to ±15 %RH

  (defined from a global evaluation of the retrieval using radiosoundings)
- Difference : $\mathrm{D} = SV - \overline{\mathrm{RH}}$
- Example : ARPEGE SV = 30 %RH → D = 11 %RH

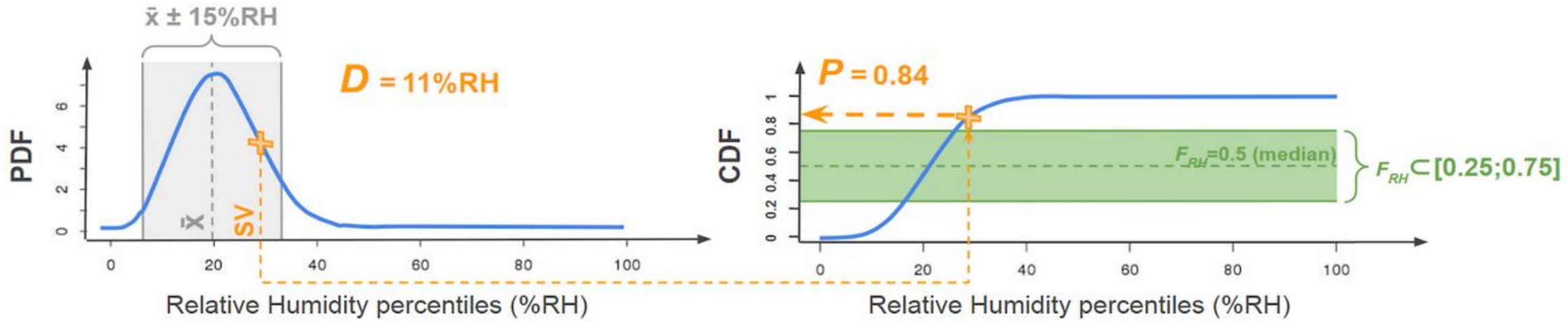
Our probabilistic method

- PDF → Cumulative Density Function (CDF)
- $CDF(SV) = \mathcal{P}(RH \leq SV) = \mathrm{P}$
- Situates *SV* in the estimated CDF within or outside the inter-quartile 0.25-0.75
- Example : P=0.84

  → probability of 84% that the true RH estimate is lower than SV

  → SV falls within the upper quarter of the distribution (P>0.75)

  ⇒ High probability that the model overestimates the RH



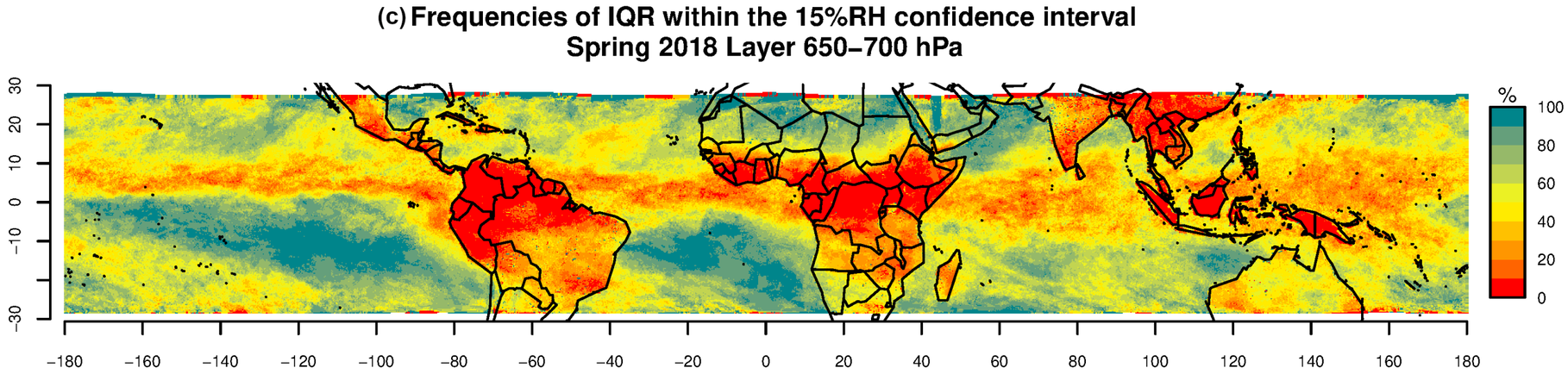
Motivations

Comparing to the same deterministic interval does not account for the shape of the whole distribution.

IQR = Interquartile Range (Q3-Q1 or $X_{P(X)=0.75} - X_{P(X)=0.25}$) of the subgrid distributions

IQR < 15%RH → the subgrid distribution has a smaller uncertainty than the ± 15%RH deterministic interval
→ the ±15%RH error works

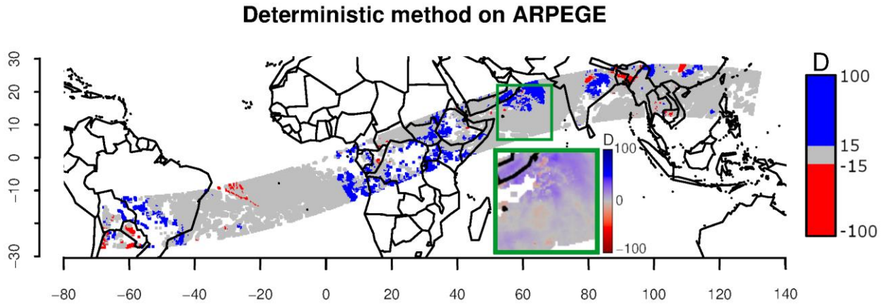
IQR > 15%RH → the subgrid distribution is too wide to fit the ± 15%RH deterministic interval
→ need to have a wider error than ±15%RH



Results
Maps

One time step, one atmospheric layer

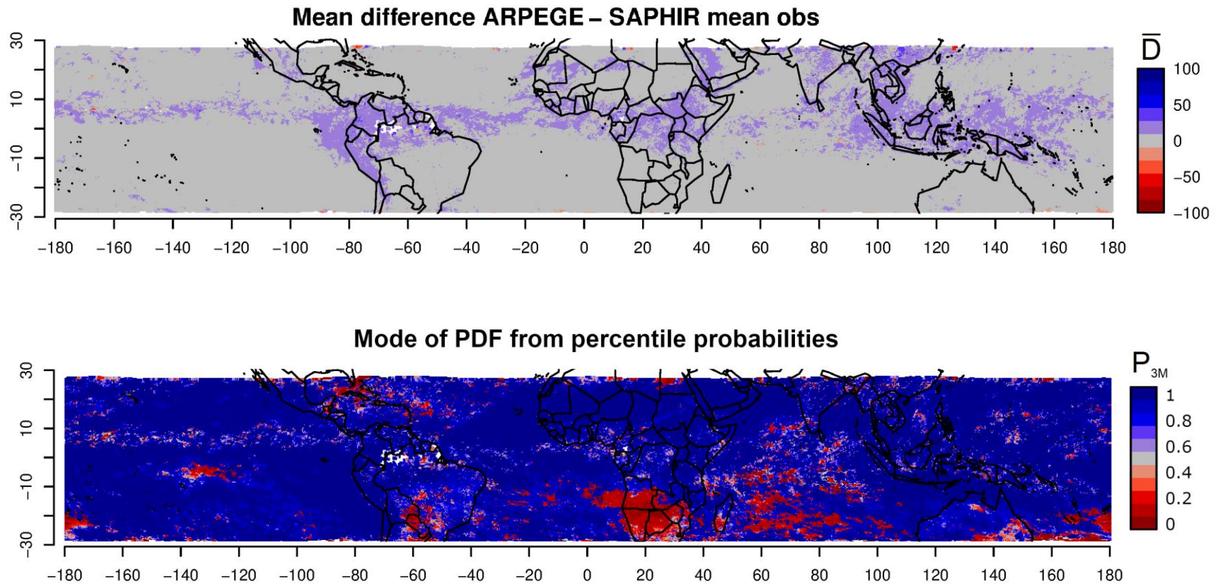
01/04/2018 – 00UTC – 400 to 600 hPa



- Same structures of biases highlighted by the two methods (see zoomed areas)
- Overall, with the deterministic method, ARPEGE SV close to the mean estimate (within the ±15%RH interval)
- The probabilistic method shows very contrasting patterns (<0.25 or >0.75)

3-month period, one layer

April to June 2018 – 400 to 600 hPa



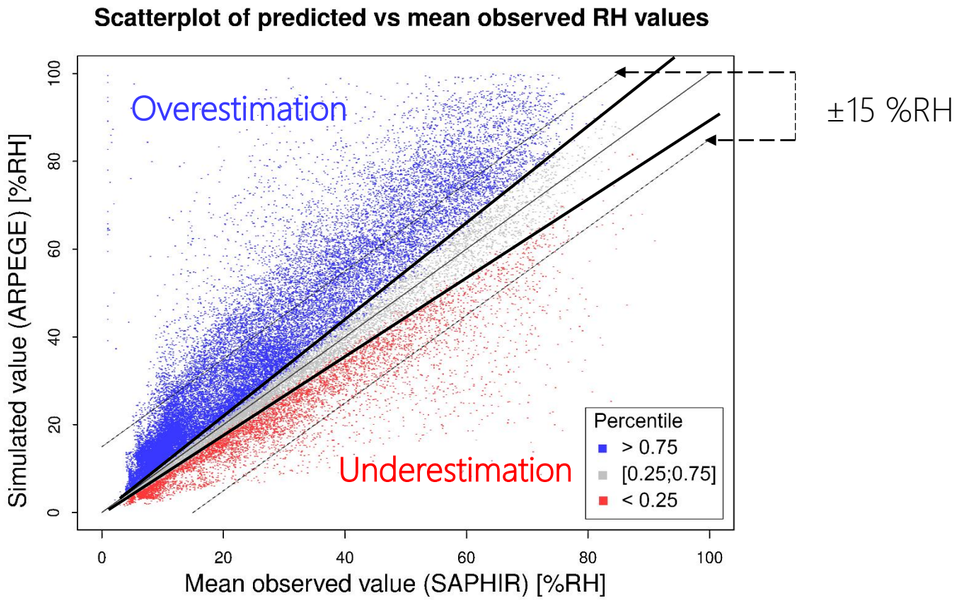
- The deterministic method only highlights a slight moist bias ($\overline{D}$ between 15 and 30 %RH) in the Intertropical Convergence Zone (ITCZ)
- The probabilistic method shows a very high probability (>0.8) that the model overestimates the atmospheric RH for this pressure layer
- Some patches of probable underestimation of RH (<0.2) appear only with this method (above the south of Africa, the Indian Ocean, equatorial Pacific Ocean, etc.)

Results

Distributions for the whole tropical belt (30°N-30°S)

1 time step, 1 atmospheric layer

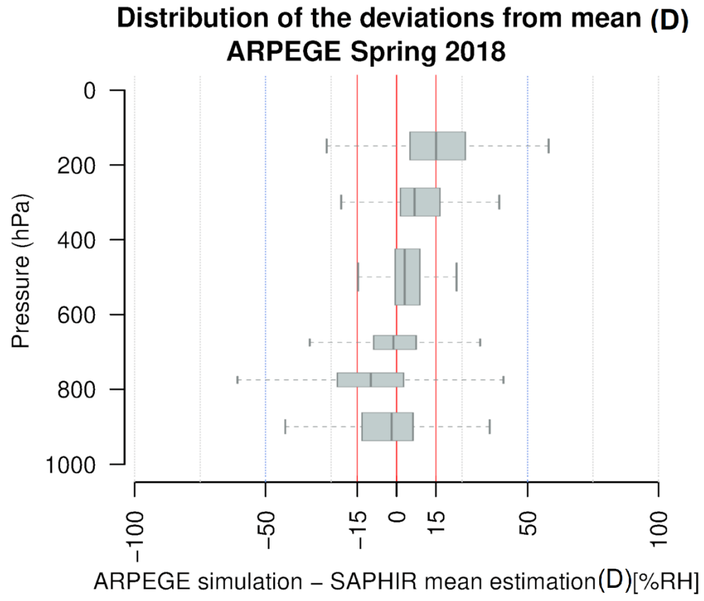
01/04/2018 – 00UTC – 400 to 600 hPa

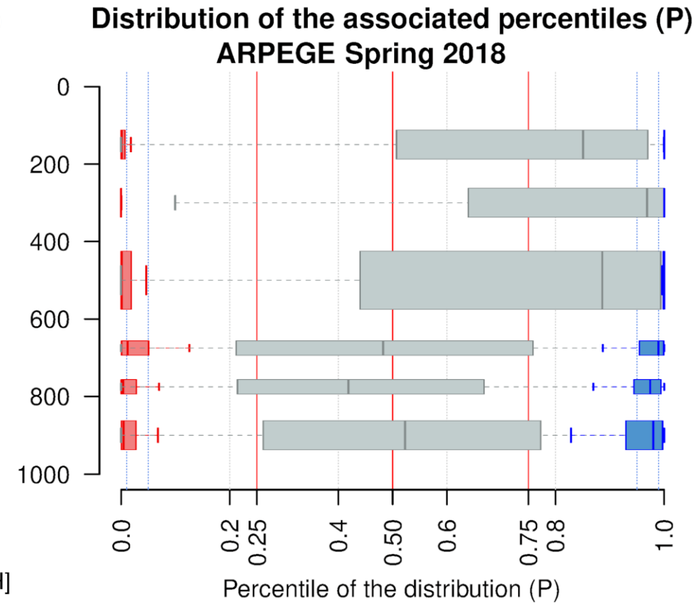


- Grey area not symmetrical around the y=x line
  → [0.25;0.75] interval not centred around the mean
- A fixed confidence interval (ex. ±15 %RH) is not suitable and the knowledge of the spread of the retrieval (PDF/CDF) better quantifies the assessment of the model

3-month period, all layers

April to June 2018 – 100 to 950 hPa



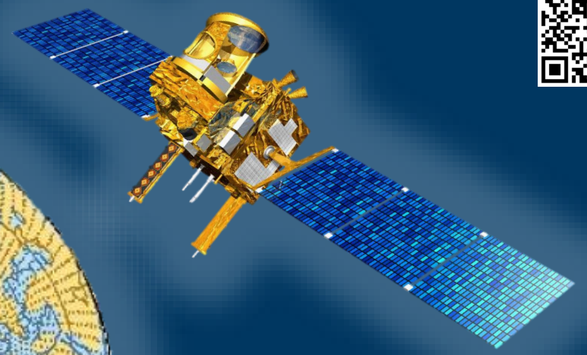


- Grey : distribution of P when D ($SV - \overline{RH}$) within the ±15%RH interval
- Red : distribution of P when D < -15%RH
- Blue : distribution of P when D > +15%RH

→ When SV outside ±15%RH, P in majority in the extreme 5% of the distributions (<0.5 or >0.95)
→ Added information content in the probabilistic results (wide distributions) wrt the deterministic method (narrower distributions with few extreme values)

Conclusion

- The probabilistic method adds significant information to the comparisons, adapts to each situation and allows a both robust and precise diagnosis.
- This probabilistic method shows promising results on this data set but is perfectly adaptable to any other variable, model and reference PDF
- Check out radice et al., 2022 for more details !



Atmospheric water cycle studying satellite Megha-Tropiques
© CNES/ISRO

Grid of the numerical weather forecasting model ARPEGE
© Météo-France

Scan me to get to Radice et al., 2022

Chloé Radice (chloe.radice@latmos.ipsl.fr) – LATMOS/IPSL – Université Paris-Saclay