Improving heavy rainfall forecast by assimilating surface precipitation in the convective scale model AROME: case study of the Mediterranean event of 04 November 2017

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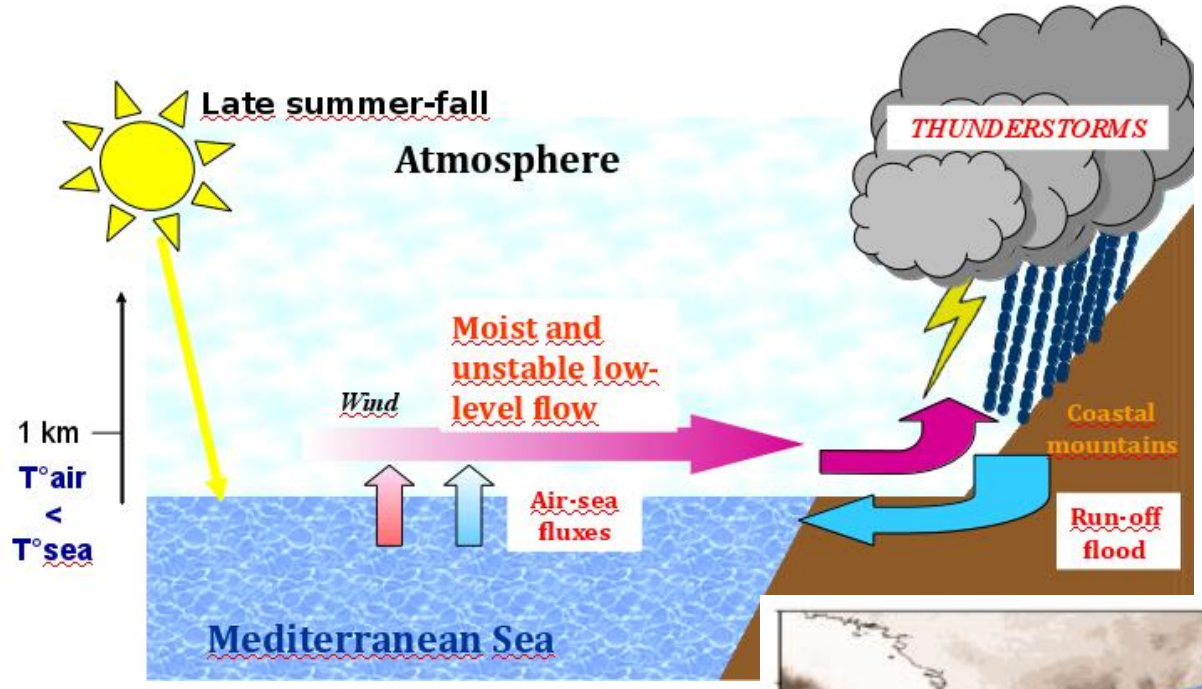
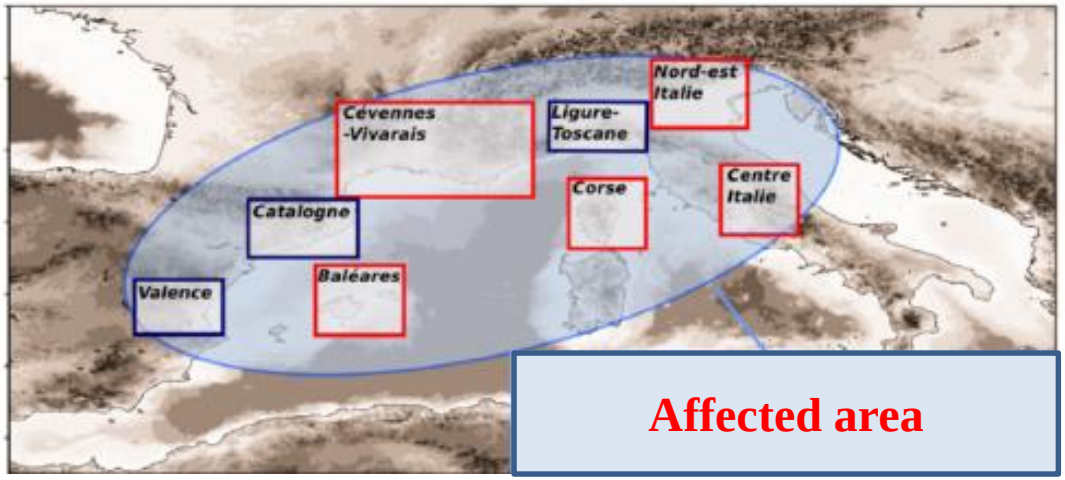
Introduction

Extreme precipitation events in the western Mediterranean Sea





1D-Var + 3D-Var assimilation of precipitation

1D-Var assimilation

The observation operator involves nonlinear moist processes such as condensation and convection

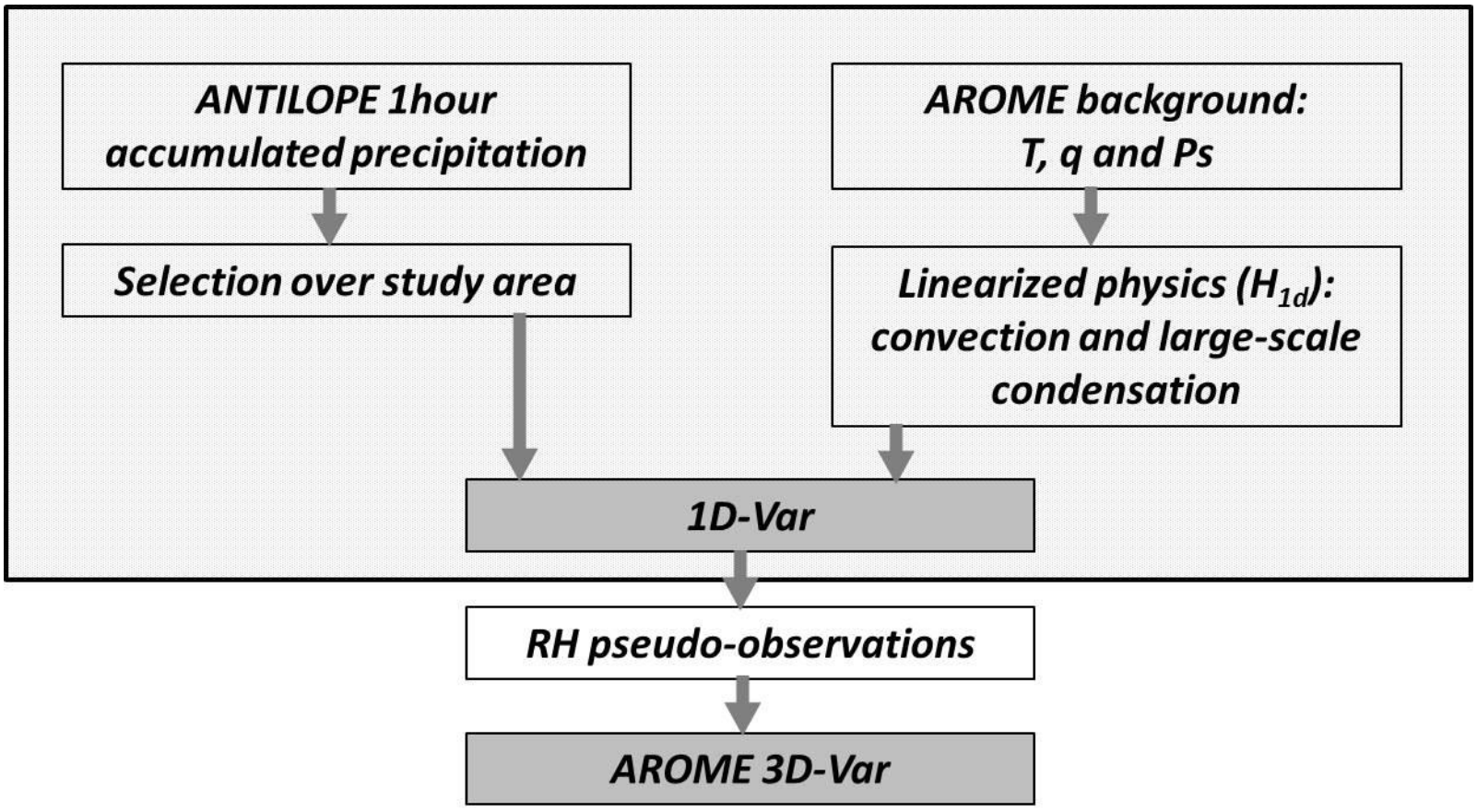
Linearized physics

1. **large-scale condensation scheme (Tompkins and Janisková, 2004)**
2. **convection scheme (Lopez and Moreau, 2005).**

$$J(x) = \frac{1}{2}(x - x_b)^T B^{-1}(x - x_b) + \frac{1}{2}\left[\frac{H_{1D}(x) - R_o}{\sigma_o}\right]^2$$

1D-Var + 3D-Var assimilation of precipitation

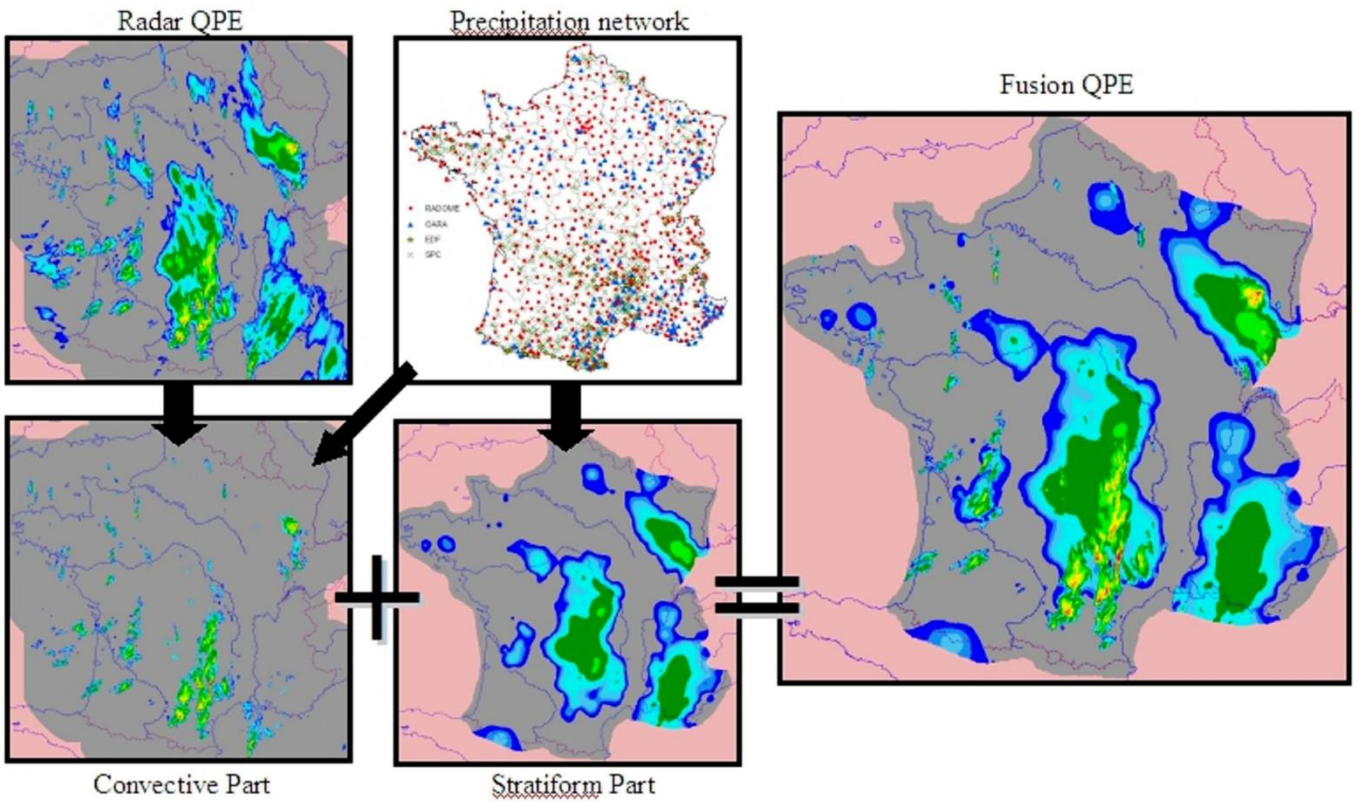
1D-Var assimilation



1D-Var + 3D-Var assimilation of precipitation
ANTILOPE precipitation analysis

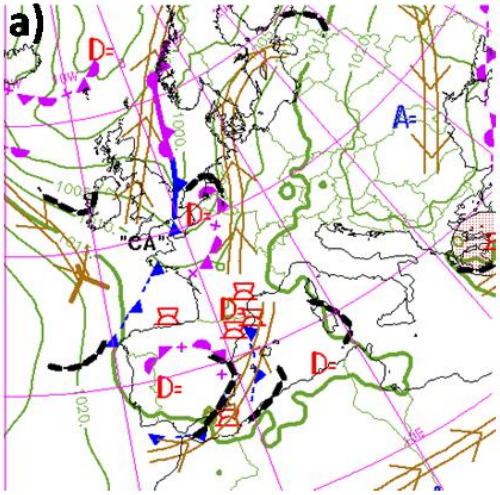
Champeaux, J.L., et al. (2011) Quantitative precipitation estimations using rain gauges and radar networks: inventory and prospects at Météo-France.

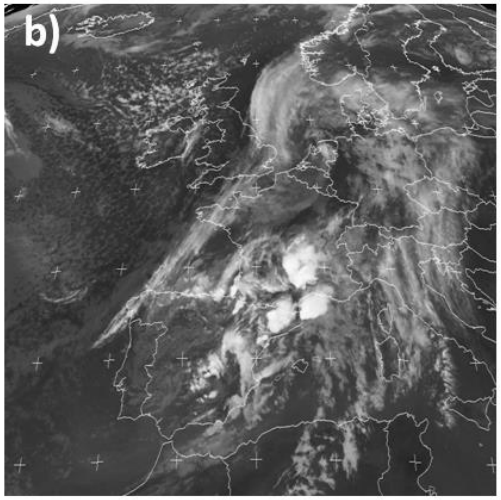
https://www.wmo.int/pages/prog/www/OSY/Meetings/ET-SBRSO_ET-RSO-2011/DocPlan/INF.3.3.2_Report_METEOFRANCE_QPE.pdf

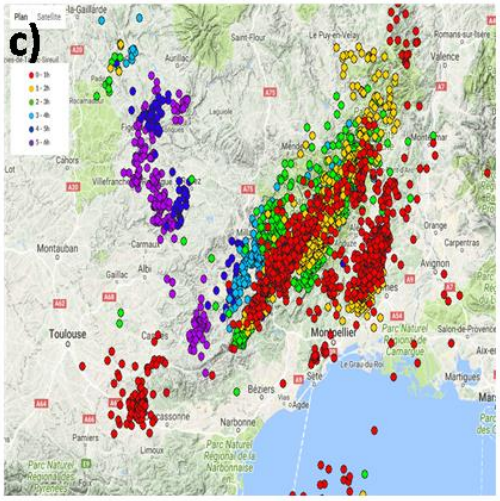


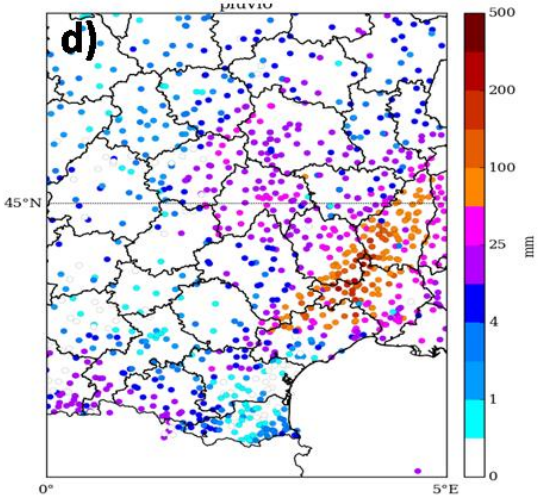
Impact of precipitation assimilation on heavy rain forecast

Case overview : November 04, 2017









a) Anasyg-Presyg

b) Satellite imagery

c) Lightning impact

d) Rain-gauge measurements

Impact of precipitation assimilation on heavy rain forecast

Experimental setup

Experiment name	Observations assimilated
REF	Conventional (radiosondes, wind profilers, ships and buoys reports, aircraft, automatic land station), SATOB wind, ATMS, SEVIRI, GNSS-ZTD and radar radial velocity.
RAD_Z	REF + radar reflectivity (1D-Bayesian, Wattrelot *et al* 2013)
RAD_RR	REF + radar rain

Wattrelot E, Caumont O and Mahfouf J-F. 2013. Operational Implementation of the 1D+3D-Var Assimilation Method of Radar Reflectivity Data in the AROME Model. MonthlyWeatherReview., 142: 1852-1873

Impact of precipitation assimilation on heavy rain forecast

1D-Var assessment

	FG	AN
Bias	1.96	0.51
stdv	2.44	1.17
DIFF	--	-1.45
RMSD	--	-1.85

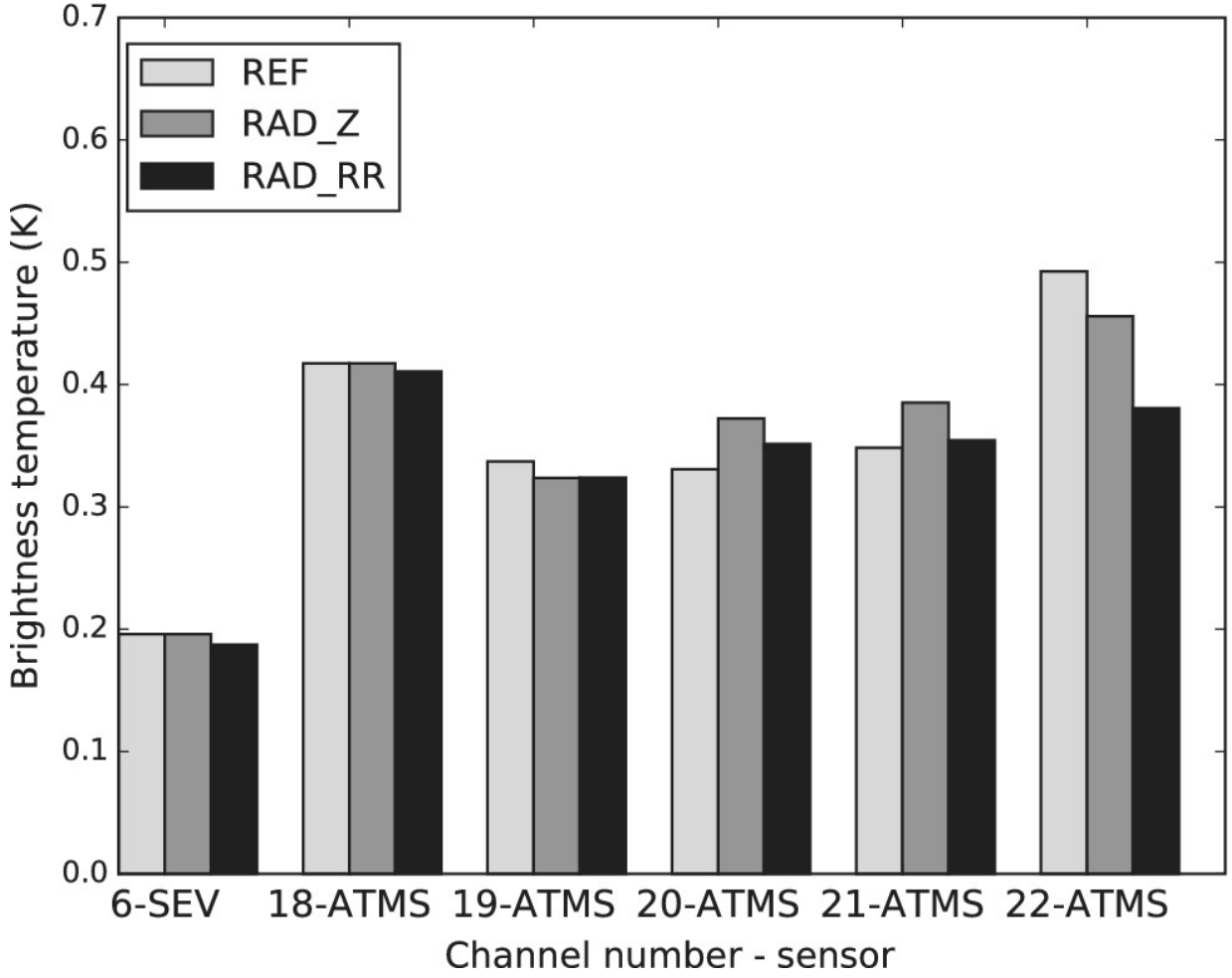
Surface precipitation (mm) bias and standard deviation (stdv) in terms of first guess and analysis departures.

DIFF = |observation – AN| – |observation – FG|
RMSD = rms(observation – AN) – rms(observation – FG)

Janisková, M. (2015) Assimilation of cloud information from space-borne radar and lidar: experimental study using a 1D+4D-Var technique.Q.J.R. Meteorol. Soc., 14, 2708-2725. doi:10.1002/qj.2558

Impact of precipitation assimilation on heavy rain forecast

Impact on humidity initial conditions

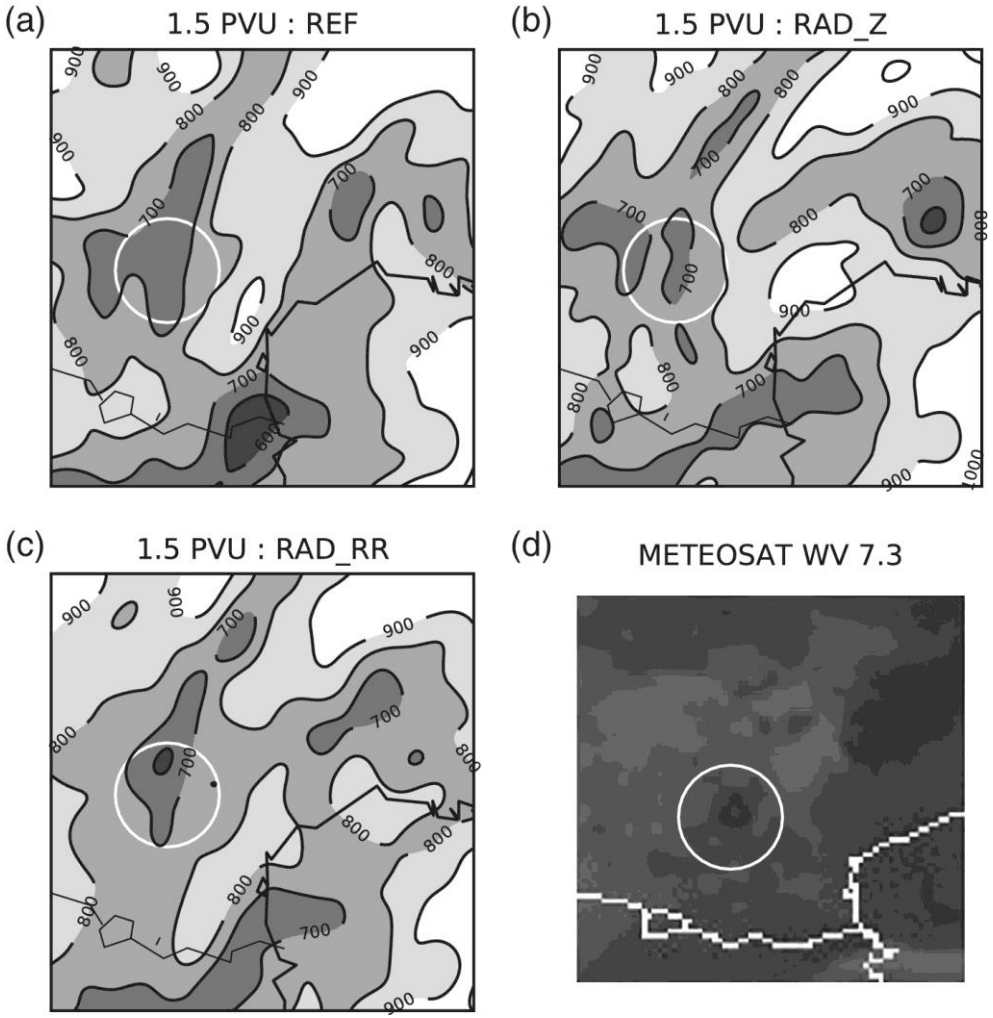


Analysis departures (RMSE) for the brightness temperature of SEVIRI and ATMS moist sensitive channels for the three experiments computed at 0000 UTC on November 4, 2017

Impact of precipitation assimilation on heavy rain forecast

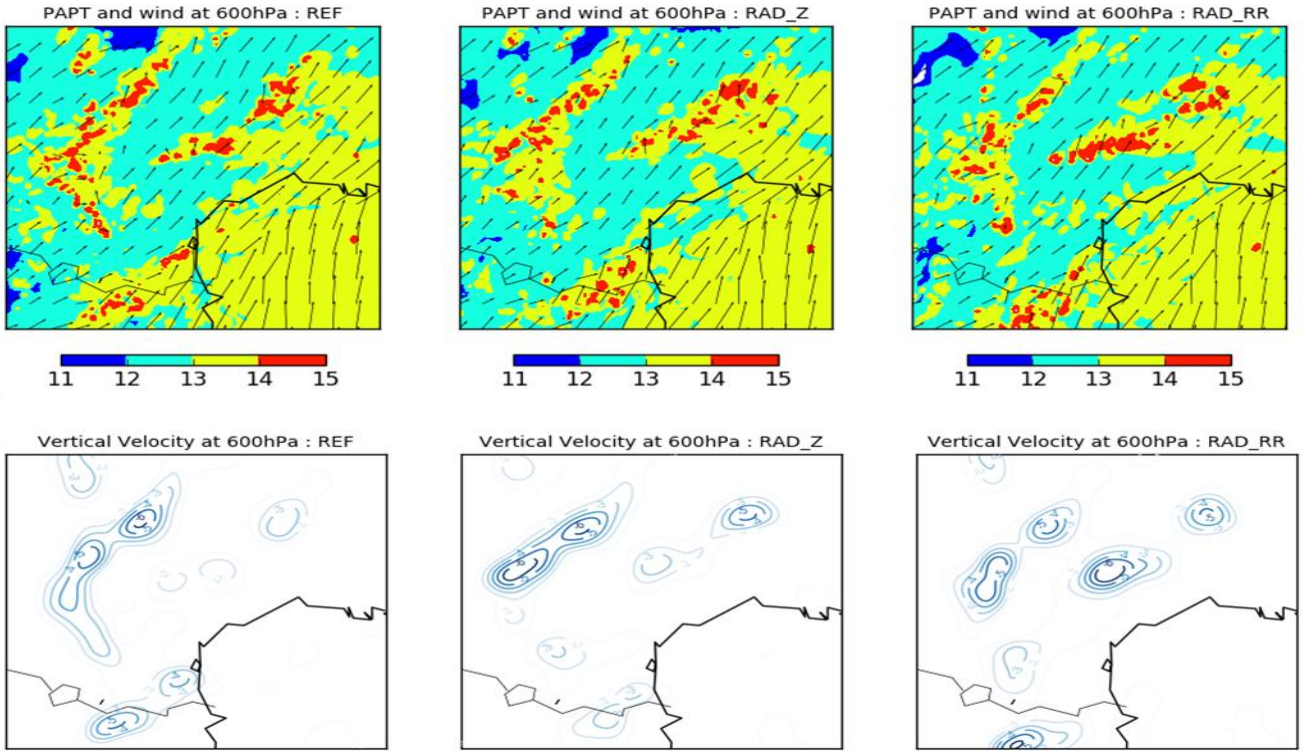
Impact on model dynamics

Geopotential height in decameter (gpdam) of the 1.5 PVU for REF, RAD_Z and RAD_RR at 1700 UTC on November 4, 2017, and the METEOSAT image (channel WV 7.3 µm) at 1742 UTC



Impact of precipitation assimilation on heavy rain forecast

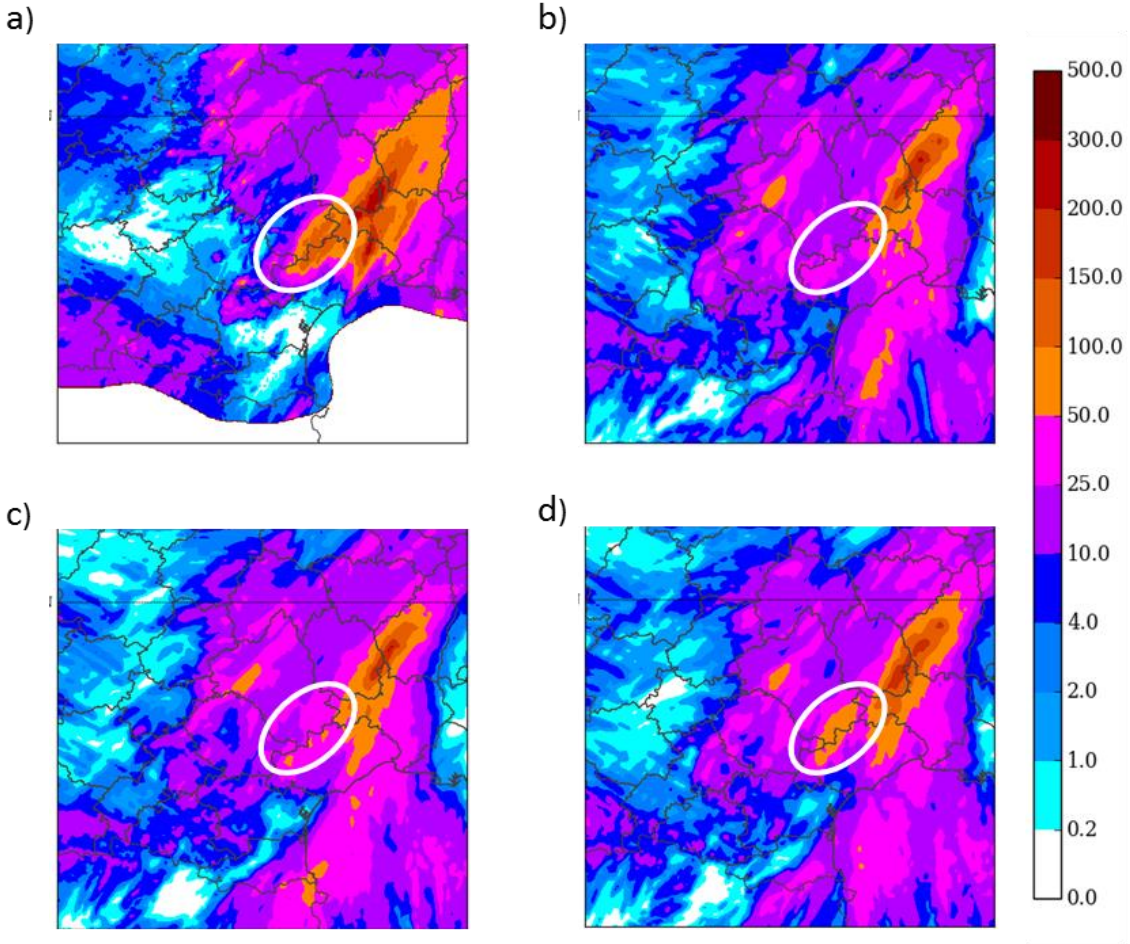
Impact on model dynamics



Pseudo-adiabatic potential temperature and vertical velocity at 600 hPa at 1700 UTC on November 4, 2017, for the REF, RAD_Z and RAD_RR

Impact of precipitation assimilation on heavy rain forecast

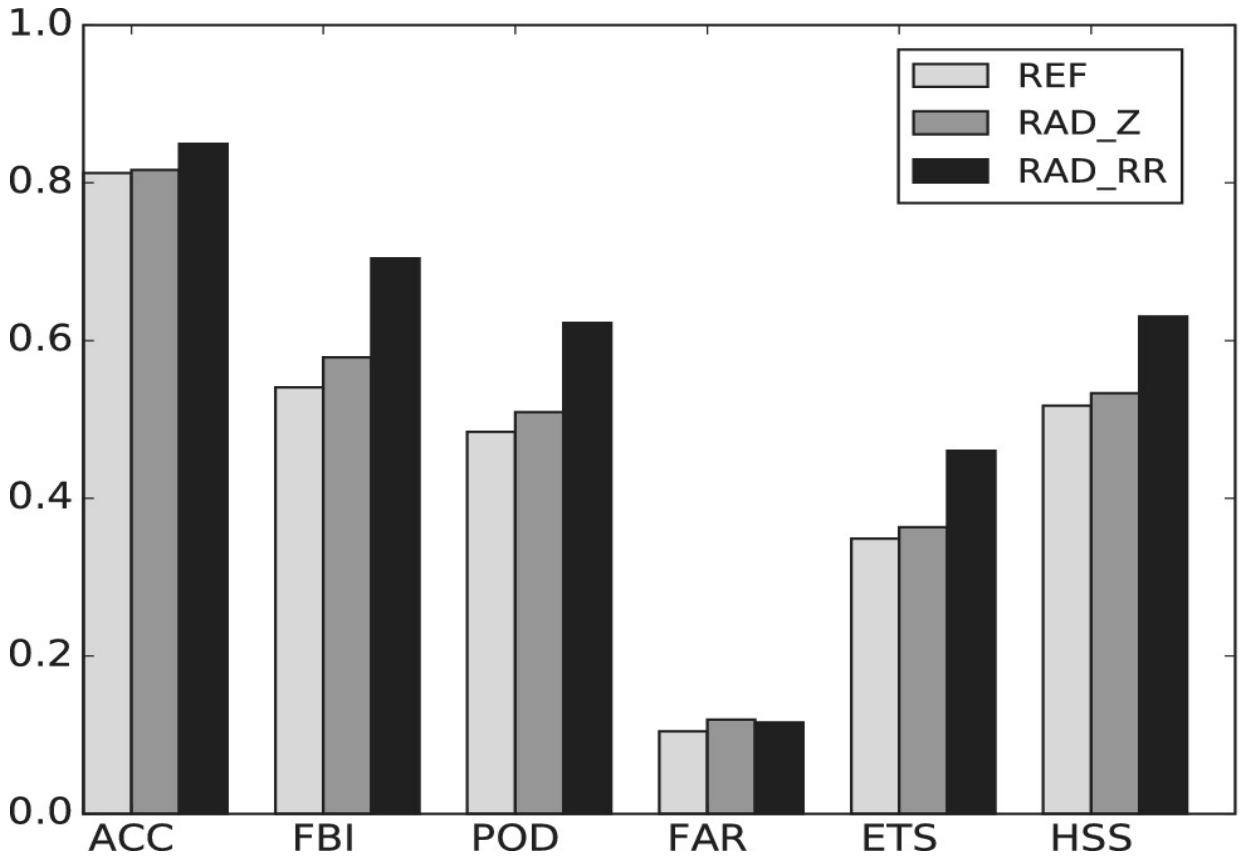
Impact on precipitation forecast



24-hours accumulated precipitation analysed by ANTILOPE (a) and simulated by AROME: REF (b), RAD_Z (c) and RAD_RR (d).); The differences against REF for RAD_Z (e) and RAD_RR (f).

Impact of precipitation assimilation on heavy rain forecast

Statistical verification



24 hours accumulated precipitation scores (threshold of 50mm) for the three experiments against rain gauges over the study area for 4thNovember 2017.

Conclusions and perspectives

- ✓ Two-step method :
  - ✓ 1D-Var to retrieve humidity profiles from precipitation observation
  - ✓ 3D-Var assimilation of the humidity pseudo profiles
- ✓ Case study : Mediterranean event of November 04, 2017
- ✓ Assimilation of precipitation :
  - ✓ dynamical fields : more favorable for convection occurrence.
  - ✓ positive impact on precipitation forecast
- ➢ Need for more case studies
- ➢ Quality control (bias correction, observation error …)
- ➢ TCWV (Total Column Water Vapor)?

Thank you for your attention