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Assimilation of Metop ASCAT observations into the ISBA model: evaluation of the added-value of machine learning

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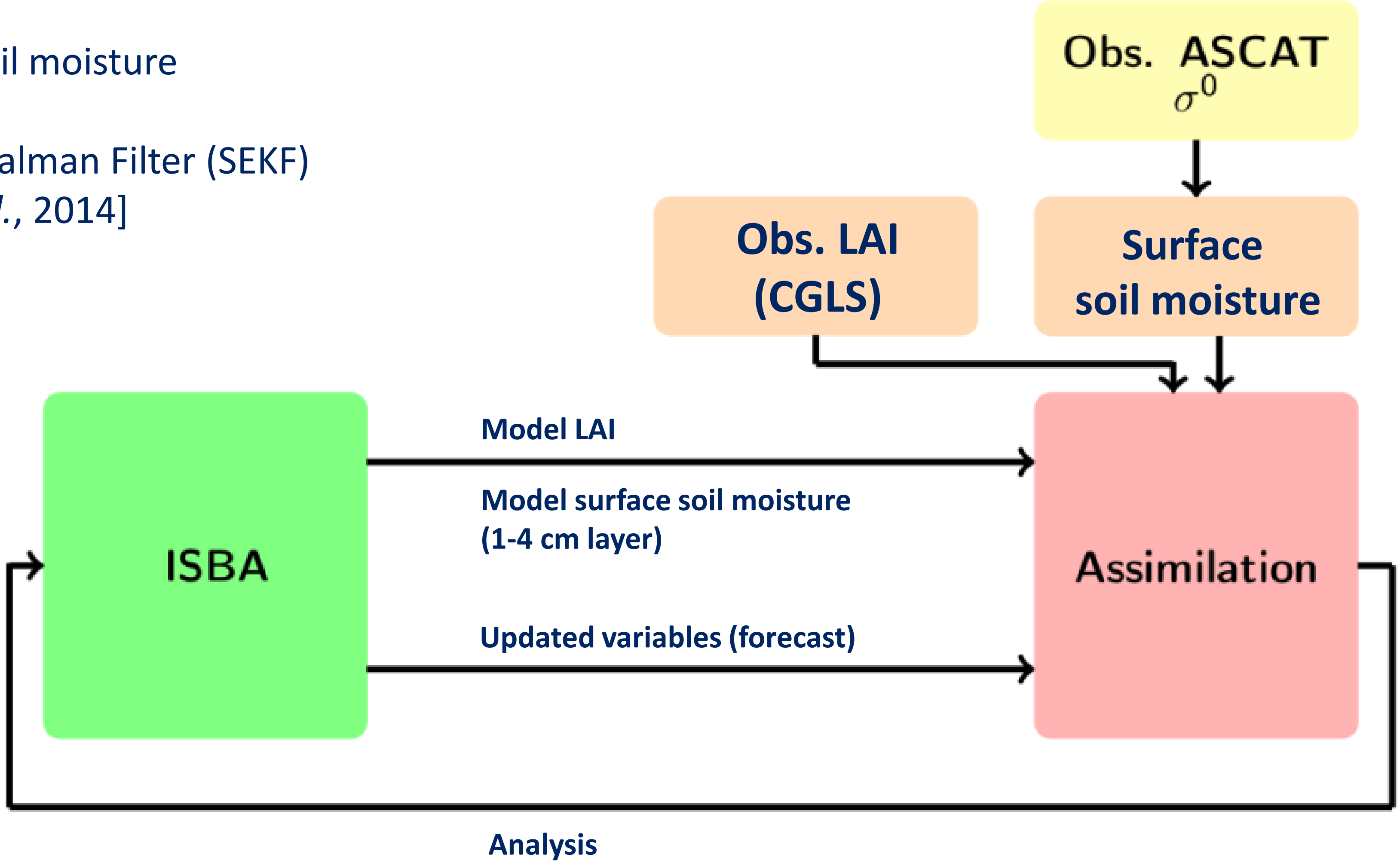
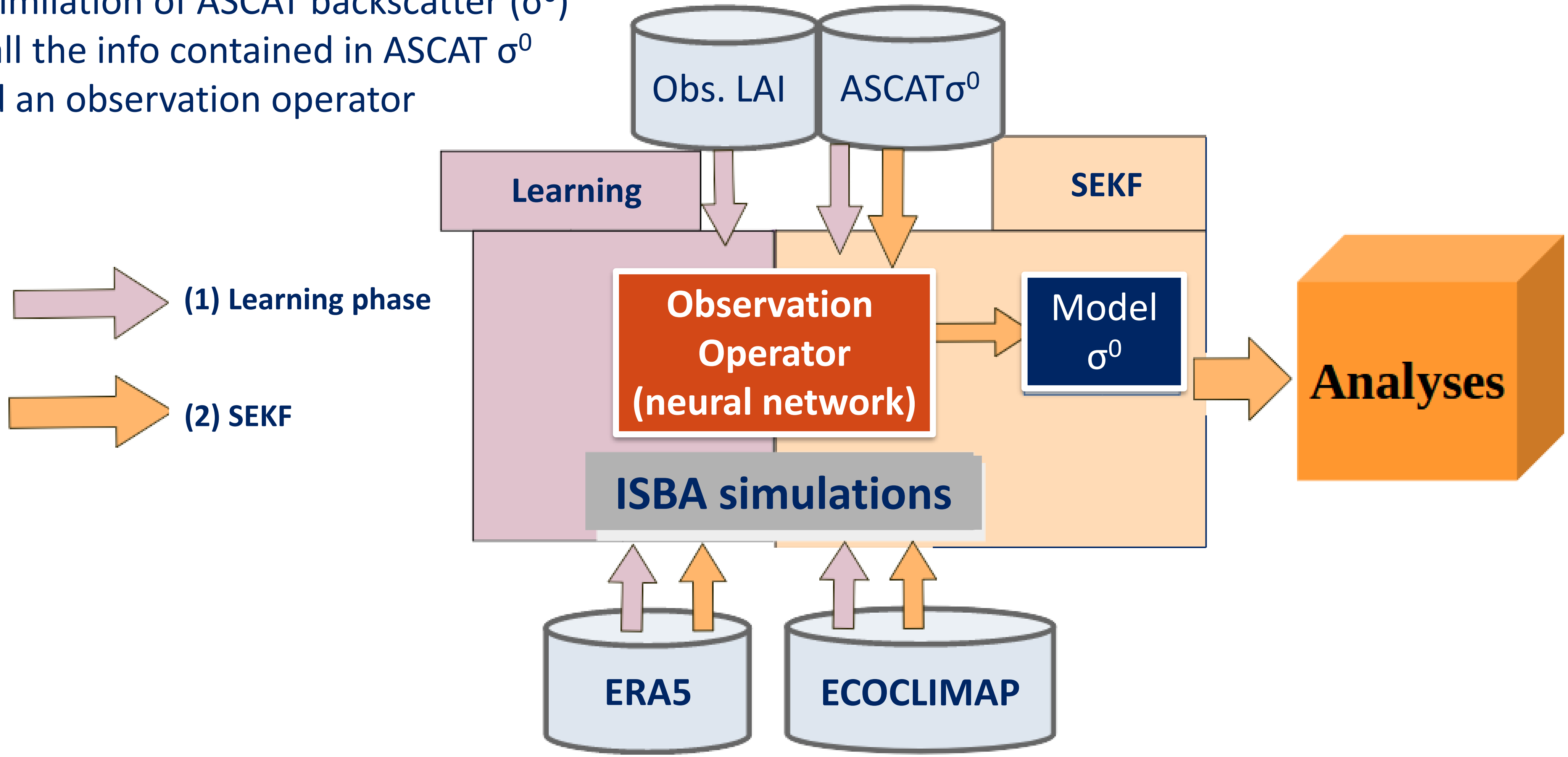
Assimilation of level 2 products in LDAS-Monde

- Leaf area index and/or Surface soil moisture
- Technique: Simplified Extended Kalman Filter (SEKF) [Mahfouf *et al.*, 2009; Barbu *et al.*, 2014]
- Analyzed variables:
    - Soil moisture of 7 soil layers (1 to 100 cm depths)
    - Leaf biomass



Assimilation of level 1 products in LDAS-Monde

- WHAT: Assimilation of ASCAT backscatter (σ^0)
- WHY: Use all the info contained in ASCAT σ^0
- HOW: Build an observation operator



Why machine learning?

	Semi-empirical model	Machine learning
Approach	Water cloud model (Attema and Ulaby 1978, Shamambo et al. 2019)	**Many possible approaches**
Complexity	4 parameters per grid cell	**As many as needed**
Input variables	- Observed LAI - ISBA surface soil moisture	- Observed LAI - ISBA surface soil moisture - **ISBA surface soil temperature** - **ISBA interception reservoir**

Observation operator

- **MACHINE LEARNING MODELS**
  - Support Vector Regression (SVR)
  - Gradient Boosting
  - Random Forest
  - Neural Network (NN)

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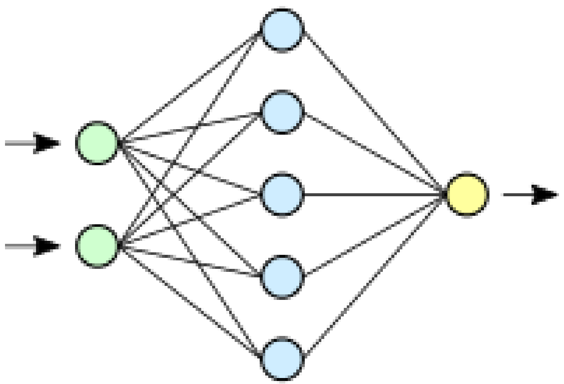

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Observation operator (neural network)

GLOBAL NN

(all ISBA gridcells)

OBSERVATION OPERATOR

ASCAT σ^0

forecasts in dB

LOCAL NN

(1 ISBA gridcell, 1 ISBA gridcell, 1 ISBA gridcell, 1 ISBA gridcell, …)

OBSERVATION OPERATOR

OBSERVATION OPERATOR

OBSERVATIO OPERATOR

OBSERVATION OPERATOR

ASCAT σ^0

forecasts in dB

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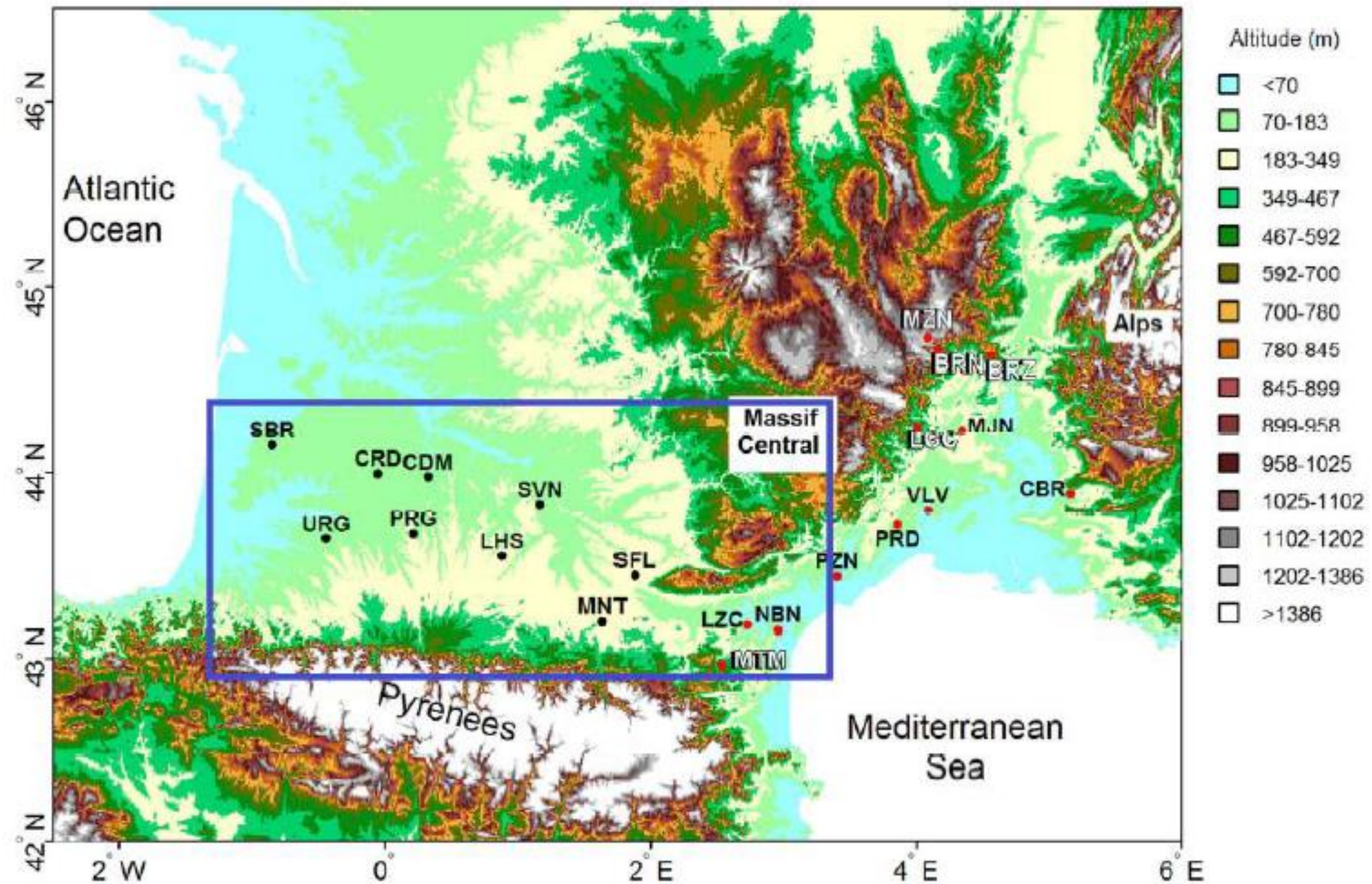
Model requirements

- **PERFORMANCE**
  - good scores (RMSD, R, ...)
- **PARSIMONY**
  - low number of parameters
  - low computing time
- **USABILITY IN APPLICATIONS**
  - LDAS-Monde
- **EXPLICABILITY**
  - physical processes

Assimilation of ASCAT σ^0



12 stations of the SMOSMANIA network in southwestern France

Performance of observation operator

- Simulated vs. Observed ASCAT σ^0 (all stations, 2013-2017 validation time period)

LOCAL MODEL	CONFIGURATION	R SCORE	RMSD SCORE (dB)	Nb parameters per gridcell
Water Cloud Model	4 parameters (A,B,C,D)	0.80	0.44	4
LOCAL NN	1 layer, 40 neurones	**0.84**	**0.40**	241

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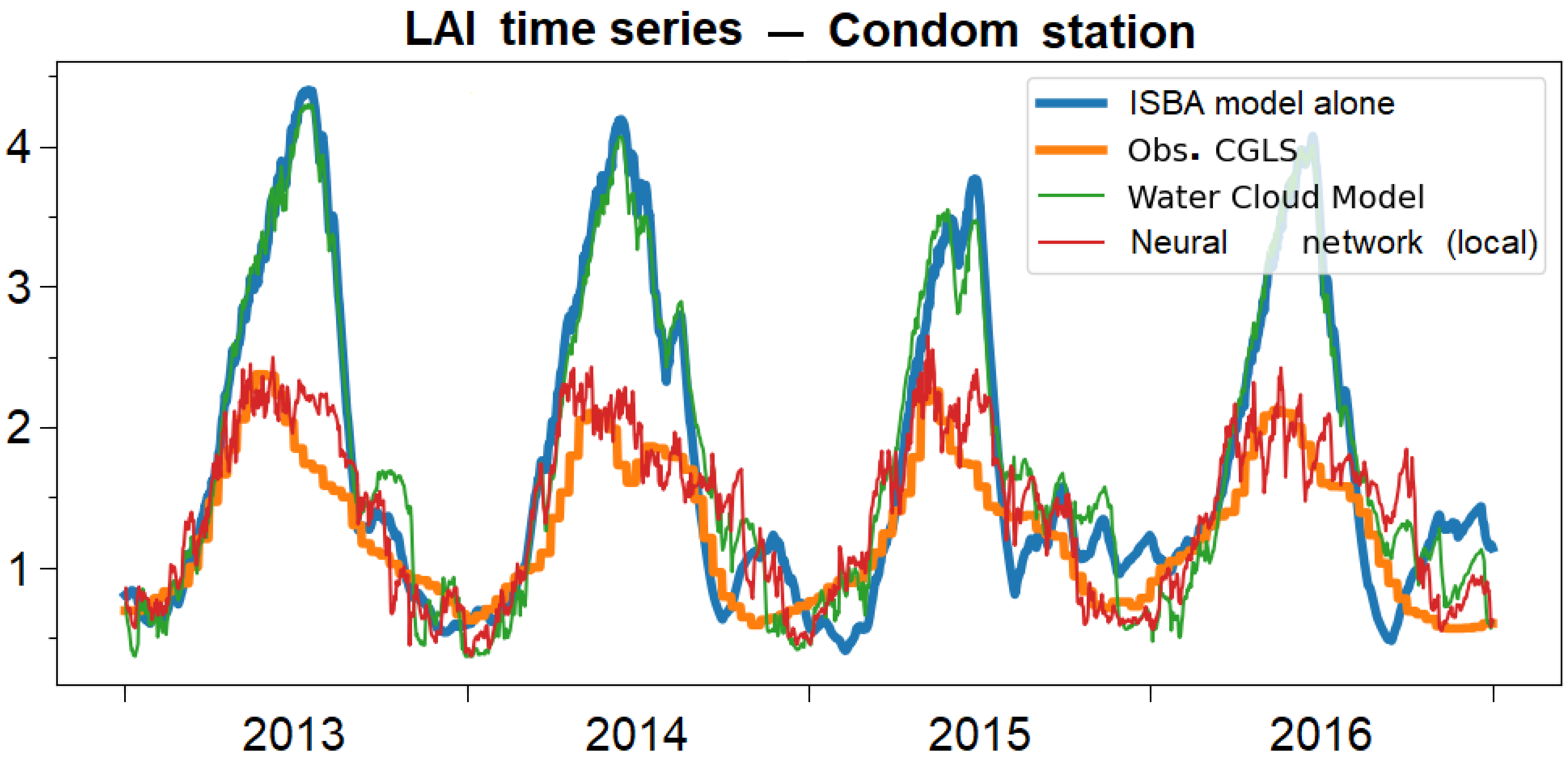
Assimilation results: LAI



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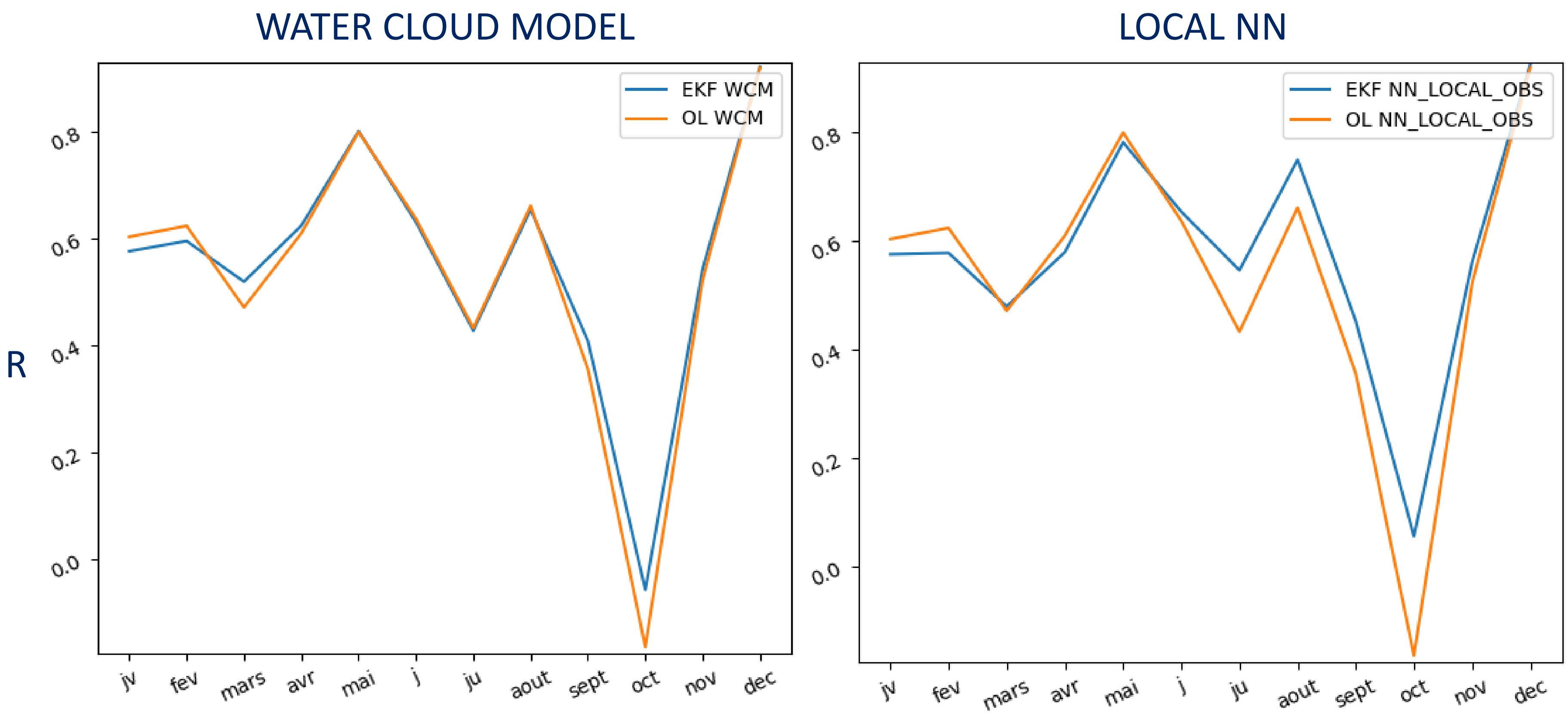
Assimilation results: LAI

SMOSMANIA station	ISBA LAI RMSD	Improvement using local NN
SBR	0.86	14 %
URG	0.97	8 %
CRD	0.56	12 %
PRG	1.16	**59 %**
CDM	0.89	**65 %**
LHS	1.25	**63 %**
SVN	0.75	**57 %**
MNT	1.20	**52 %**
SFL	1.44	**57 %**
MTM	0.81	- 6 %
LZC	0.77	7 %
NBN	0.60	4 %

Assimilation of ASCAT σ^0 markedly improves the simulated LAI, mainly over agricultural areas

Assimilation results: surface soil moisture



In situ soil moisture observations at the CDM station shows the added value on R of assimilating ASCAT σ^0 using a NN approach w.r.t. the ISBA open-loop simulation

Conclusions

- **MARKED IMPROVEMENTS OF ANALYSED VARIABLES**
  - **ASSIMILATING ASCAT σ^0 ONLY**
  - **USING LOCAL NN OBSERVATION OPERATOR**

- **POSSIBILITY TO ACCOUNT FOR NEW PREDICTORS**
  - **RAINWATER INTERCEPTION BY VEGETATION**
  - **SOIL TEMPERATURE**

Prospects

- GLOBAL NN IN CONTRASTING CONDITIONS
- APPLICATION TO SMOS TB
- APPLICATION TO OTHER VARIABLES (e.g. ALBEDO, SIF, …)

MANY THANKS FOR YOUR ATTENTION ☺

More info on LDAS-Monde:

https://www.umr-cnrm.fr/spip.php?article1022