

2019 IEEE INTERNATIONAL WORKSHOP ON METROLOGY FOR AGRICULTURE AND FORESTRY

PORTICI, ITALY
OCTOBER 24-26, 2019

PROCEEDINGS

Saturday, October 26

Special Session - Advanced ground-based technologies for assessing vadose zone properties and processes

Room: Chinese Hall - Sala Cinese, Royal Palace of Portici

Chairs: *Giorgio Cassiani, Università di Padova, Italy*

Paolo Castiglione, Metergroup Inc. and Washington State Uni. USA

272 Integrating ground-based and remote sensing-based monitoring of near-surface soil moisture in a Mediterranean environment

Paolo Nasta, University of Naples 'Federico II', Italy

Sarah Schönbrodt-Stitt, University of Würzburg, Germany

Heye Bogena, Agrosphere Institute Forschungszentrum Jülich GmbH, Germany

Markus Kurtenbach, University of Würzburg, Germany

Nima Ahmadian, University of Würzburg, Germany

Harry Vereecken, Agrosphere Institute Forschungszentrum Jülich GmbH, Germany

Christopher Conrad, University of Halle-Wittenberg, Germany

Nunzio Romano, University of Naples 'Federico II', Italy

278 A complex dielectric sensor for measurement of water content and salinity in porous media

Paolo Castiglione, METER Group Inc. Washington State University, USA

Gaylon S. Campbell, METER Group Inc. USA

Aaron Parker, Meter Group Inc., USA

Agnelo Silva, Meter Group Inc., USA

284 On reducing VOCs concentration from groundwater for irrigation purposes: A detailed monitoring program to test the stripping efficiency of a sprinkler system

Mario Palladino, University of Naples 'Federico II', Italy

Benedetto Sica, University of Naples 'Federico II', Italy

Salvatore Chiavarini, ENEA, Italy

Juri Rimauro, ENEA, Italy

Antonio Salluzzo, ENEA, Italy

Benjamin Mary, University of Padova, Italy

Jacopo Boaga, University of Padova, Italy

Giorgio Cassiani, University of Padova, Italy

Nunzio Romano, University of Naples 'Federico II', Italy

Special Session - Remote and proximal sensing metrics for the characterization of agricultural and forestry systems - PART I

Room: White Hall - Sala Bianca, Royal Palace of Portici

Chairs: *Guido D'Urso, University of Naples, Italy*

Francesco Vuolo, BOKU, Austria

289 Combining satellite data and Machine Learning techniques for irrigation Decision Support Systems

Loris Francesco Termite, Radarmeteo S.r.l, Italy

Alberto Garine, Guglielmo Marconi University, Italy

Andrea Marini, Idea-re S.r.l., Italy

Marcello Marconi, Guglielmo Marconi University, Italy

Lorenzo Biondi, Guglielmo Marconi University, Italy

295 Exploring the utility of time series seasonality parameters for identifying land processes derived from corine land cover products

Juan Miguel Ramírez-Cuesta, Centro de Edafología y Biología Aplicada del Segura (CEBAS-CSIC), Spain

Daniela Vanella, Università degli Studi di Catania, Italy

Diego S. Intrigliolo, Centro de Edafología y Biología Aplicada del Segura (CEBAS-CSIC), Spain

Mario Minacapilli, Università degli Studi di Palermo, Italy

Antonio Motisi, Università degli Studi di Palermo, Italy

Simona Consoli, Università degli Studi di Catania, Italy



2019 IEEE INTERNATIONAL WORKSHOP ON
METROLOGY FOR AGRICULTURE
AND FORESTRY

PORTICI, ITALY - OCTOBER 24-26, 2019

**COMBINING SATELLITE DATA AND MACHINE
LEARNING TECHNIQUES FOR IRRIGATION
DECISION SUPPORT SYSTEMS**

Loris Francesco Termitè, Radarmeteo Srl, Italy
Alberto Garinei, Guglielmo Marconi University, Italy
Andrea Marini, Idea-Re Srl, Italy
Marcello Marconi, Guglielmo Marconi University, Italy
Lorenzo Biondi, Guglielmo Marconi University, Italy

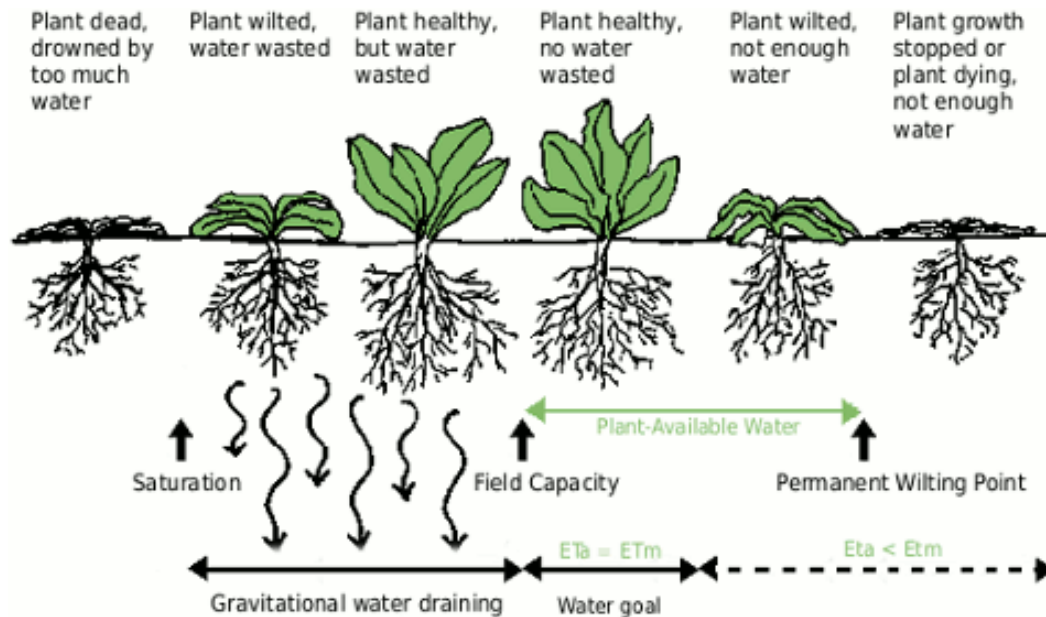


Irrigation water management

Inefficient irrigation practices are among the primary sources of freshwater waste.



Irrigation scheduling may be inconsistent with the actual crop needs.



(image source: theorangegardener.org)

Decision Support Systems

Managing irrigation systems is not straightforward.

Decision Support Systems (DSS) could be powerful tools helping authorities and stakeholders.



Benefits include water waste reduction, optimal crop growth and hazard mitigation.

Soil Moisture: a key variable

Knowing the current and expected soil moisture (SM) is fundamental in developing an efficient irrigation DSS.

Direct SM measurement

- high accuracy
- low representiveness over extended areas



Remote SM measurement

- worldwide coverage
- easily accessible
- less accurate than probes



(image source: sentinel.esa.int)

Soil Water Index

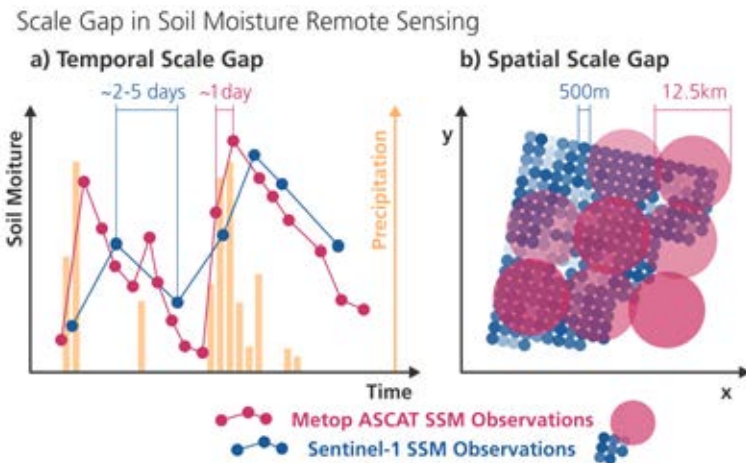
In this research SM is described through the **Soil Water Index (SWI)**, available on *Copernicus Global Land Service*, providing an estimate the degree of saturation at various depths in the soil starting from satellite surface SM measurements.

Sentinel-1/C-band surface SM
(high spatial resolution, low frequency)

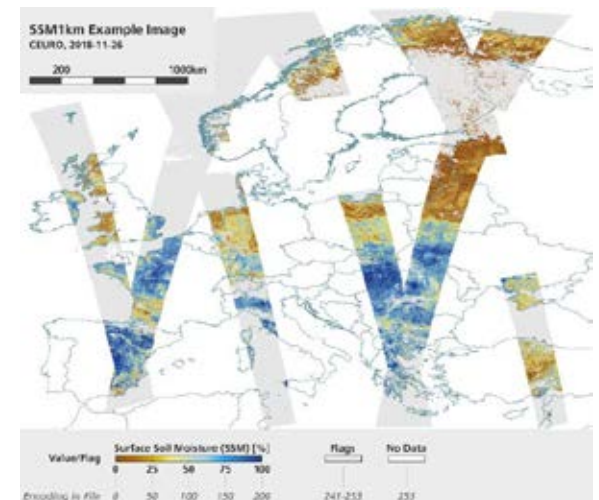


MetOP/ASCAT surface SM
(low spatial resolution, high frequency)

➔ **New product released in April 2019 with 1-km resolution and daily frequency**



(image source: Bauer-Marschallinger et al., 2018)



(image source: land.copernicus.eu)

Reference: Bauer-Marschallinger, et al. (2018). Soil moisture from fusion of scatterometer and SAR: closing the scale gap with temporal filtering. *Remote Sensing*, 10(7), 1030.

Soil Moisture forecast

The SWI evolution is forecasted through a **data-driven approach** and two techniques are tested: an **Artificial Neural Network** (ANN) and the **ANFIS** model.

Meteorological data and past SWI observations are used as inputs.

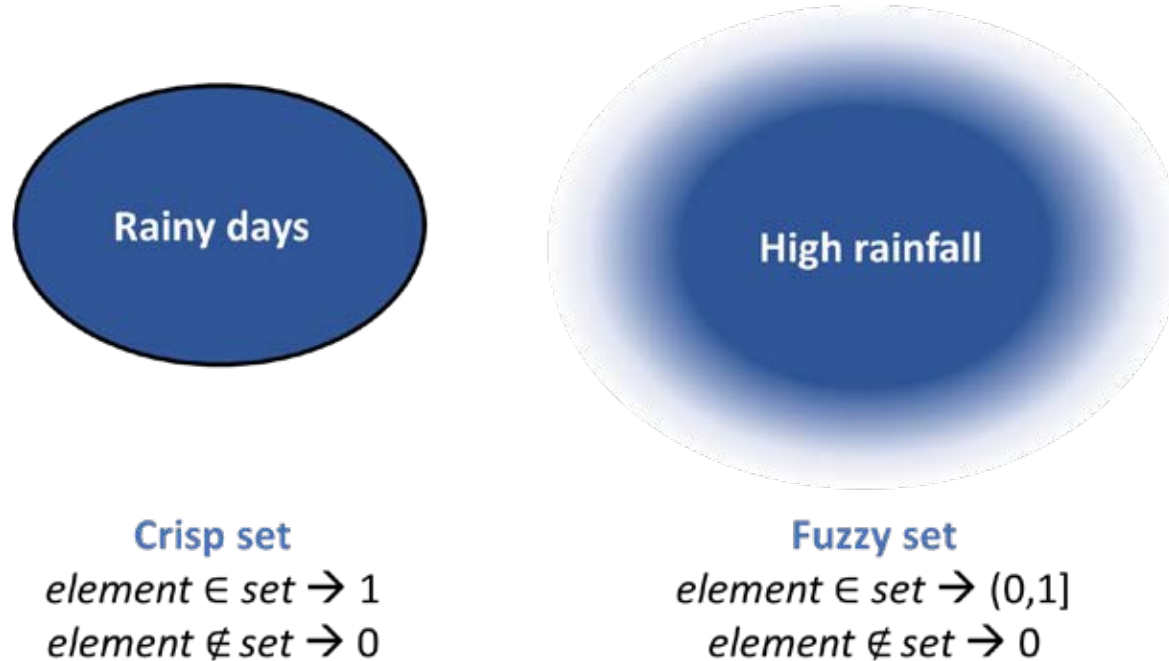


Study area

Agricultural fields in the Veneto region (Italy), between Venice and Padua. Irrigation here is managed through the help of a wide network of channels.

ANFIS: what is it?

ANFIS (Adaptive Network-based Fuzzy Inference System) is a particular type of artificial neural network that performs a **fuzzy logic** *if-then* inference.

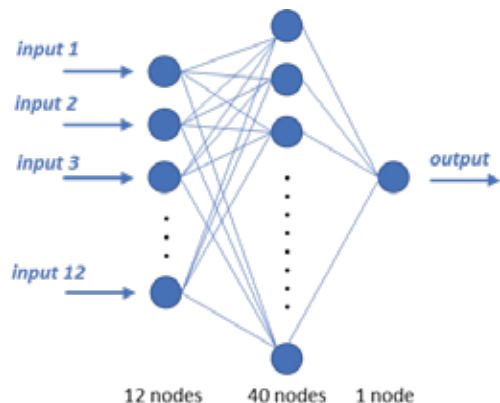


In this research, 3 membership functions have been defined for each input:

$$f_{\text{memb}}(x; \mu, \sigma, \nu, \alpha) = \exp \left[-\frac{|x - \mu|^\nu}{\sigma^2} \frac{1}{1 + e^{-\alpha x}} \right]$$

Models structure and inputs

ANN



$$R_t, R_{t-1}, R_{t-2}, R_{t-3}, R_{t-4},$$

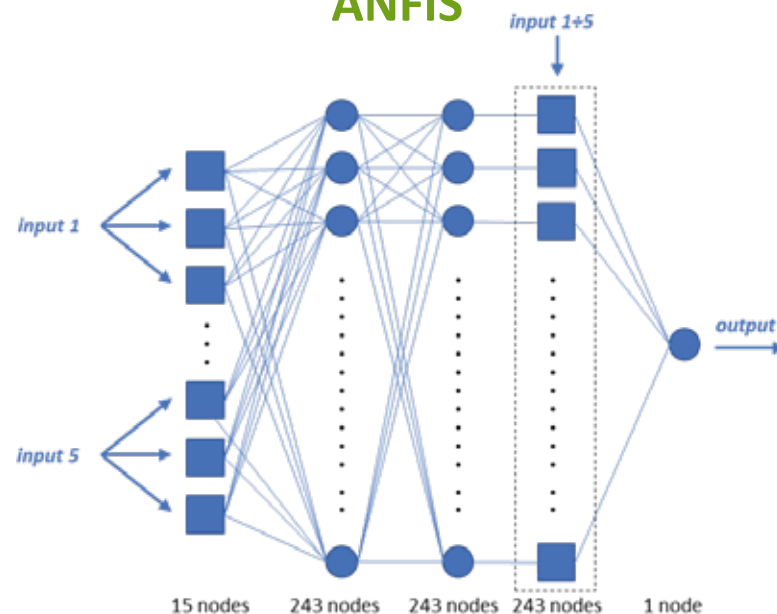
$$T_t, \bar{T}_{t-3,t-1},$$

$$RH_t, \overline{RH}_{t-3,t-1},$$

$$ws_t, \overline{ws}_{t-3,t-1},$$

$$SWI_{t-4}$$

ANFIS



$$R_{t-4,t}^{cum}, \bar{T}_{t-4,t-1}, \overline{RH}_{t-4,t-1}, \overline{ws}_{t-4,t-1}, SWI_{t-4}$$

Symbol	Description
R_t	Rainfall on day t
T_t	Mean temperature on day t^a
RH_t	Mean relative humidity on day t
ws_t	Mean wind speed on day t
SWI_t	Soil Water Index on day t
\bar{X}_{t_1,t_2}	Mean of variable X over days $t_1 \div t_2$
X_{t_1,t_2}^{cum}	Cumulative value of variable X over days $t_1 \div t_2$

^a The mean temperature T_t has been computed as the arithmetic mean of the minimum and maximum daily temperature.

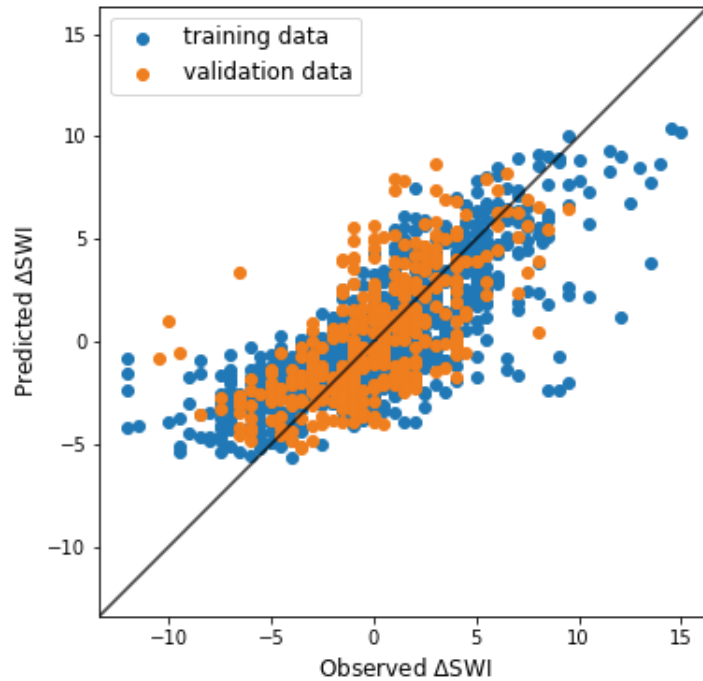
Target/Output: $\Delta SWI_{t-4,t}$

2015÷2017 → calibration

2018 → validation

Results

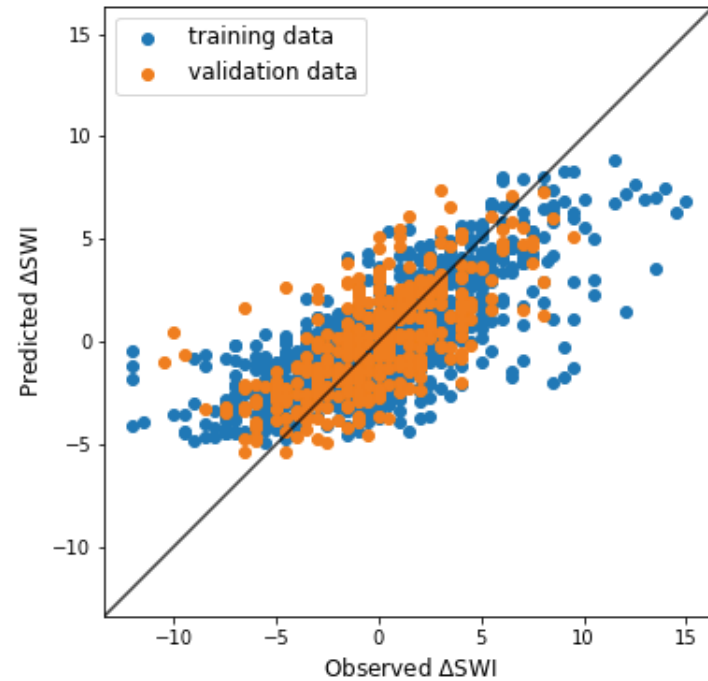
ANN



Training $NSE = 0.599$
Training $RMSE = 2.55 \%$

Validation $NSE = 0.371$
Validation $RMSE = 2.65 \%$

ANFIS



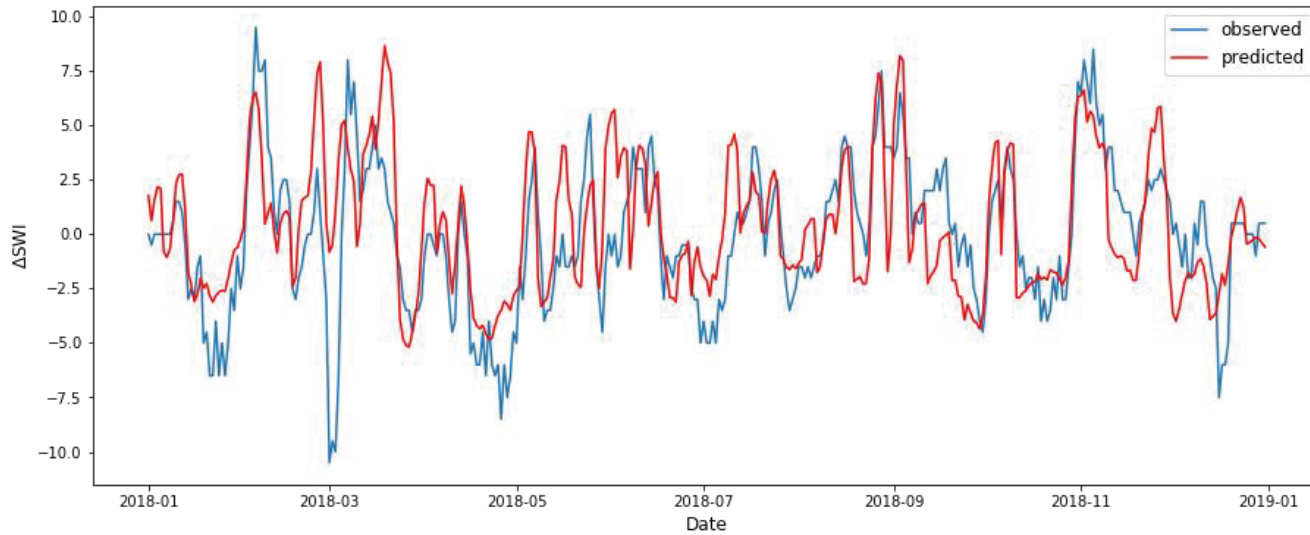
Training $NSE = 0.553$
Training $RMSE = 2.70 \%$

Validation $NSE = 0.460$
Validation $RMSE = 2.46 \%$

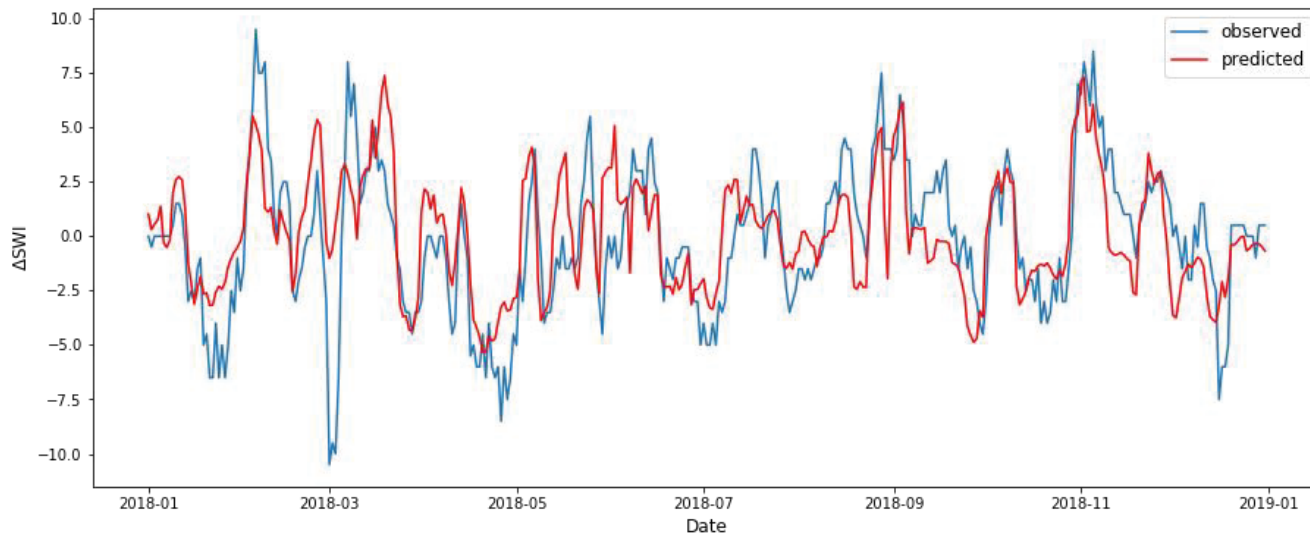
Results

Validation data

ANN

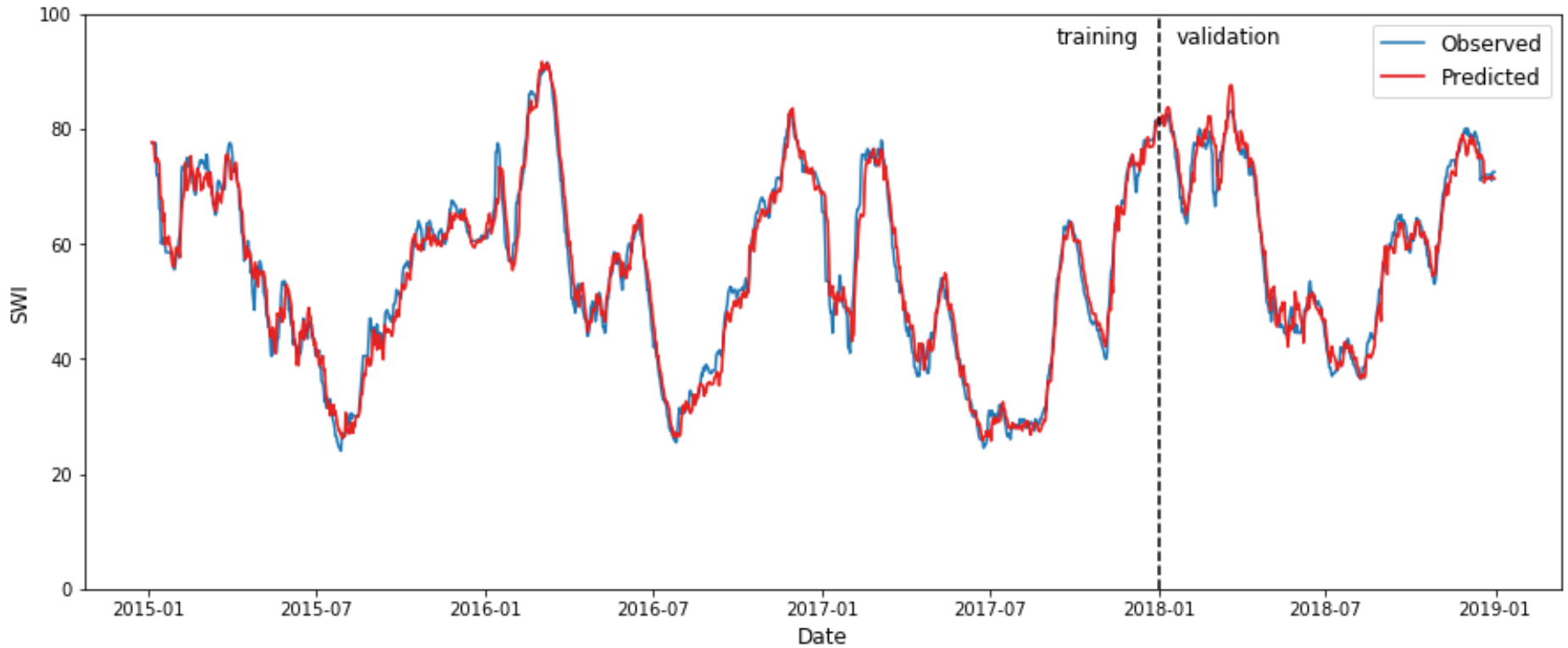


ANFIS



Results

ANFIS



Conclusions

Recap

- DSS are powerful tools for water management
- SM is a fundamental variable for an irrigation DSS
- Satellite SM measurements are easily accessible and accurate
- Machine Learning techniques are proper to predict SM evolution
- ANFIS seems to perform better than ANN

Further developments

- More data, better results!
- Consider actual crops and phenological stages
- Consider human intervention (irrigation)
- SWI calibration through *in situ* measurements