ARPAL
Agenzia regionale per la protezione dell'ambiente ligure
Sistema Nazionale per la Protezione dell'Ambiente

RESEARCH FOUNDATION
cima
OBSERVE TO PREDICT, PREDICT TO PREVENT.

The use of H SAF soil moisture products for event-based hydrological modelling in Liguria (north of Italy)

H SAF - HEPEX Workshop
Reading, 25-28/11/2019

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Simone Gabellani

Contents

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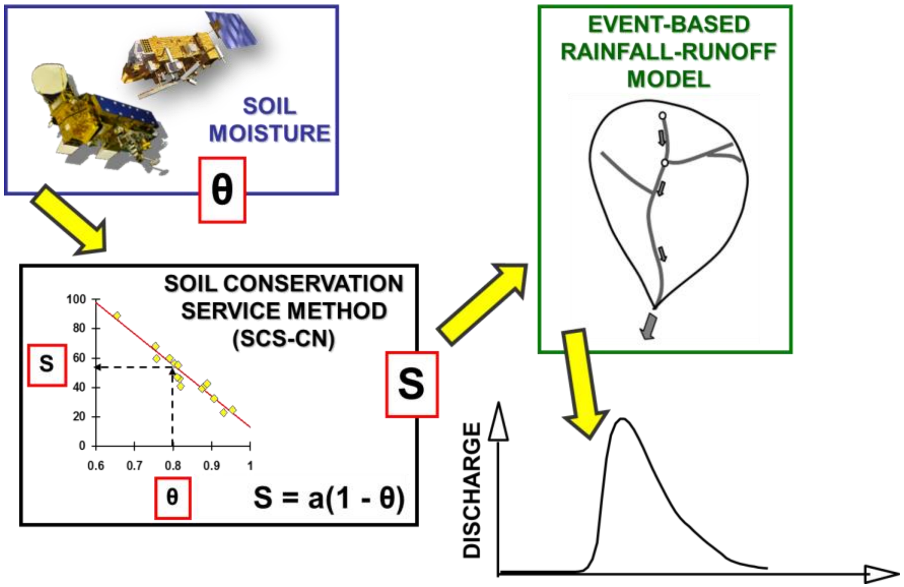
Objective

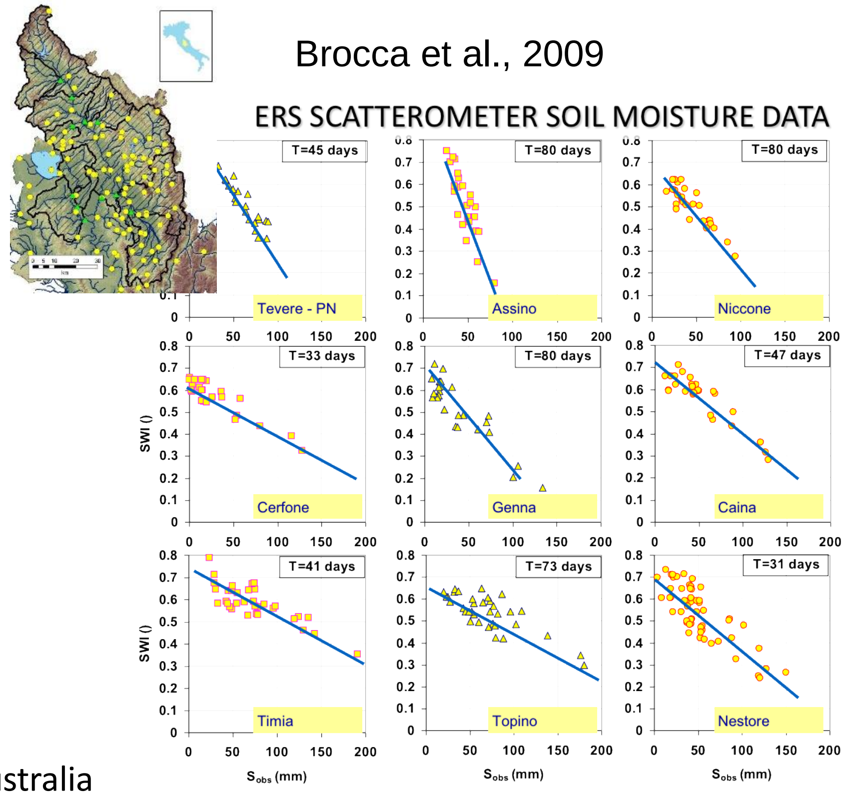
Investigate whether satellite data can improve soil moisture estimation for operational hydrological forecast purposes in Liguria, particularly given the lack of soil moisture ground sensors

Objective



Brocca et al., 2009

ERS SCATTEROMETER SOIL MOISTURE DATA



Beck et al., 2010 (JSTARS) → Australia

Tramblay et al., 2010 (JoH), 2011 (NHESS) → France

CMI – ARPAL

- The Clima – Meteo – Hydro operative unit of the Regional Environmental Protection Agency of Liguria (CMI – ARPAL) is the institutional regional office working for flood forecast and for operational meteo-hydrological alert. It has been working since 1995 concurring to design the system of the regional Functional Centres for Civil Protection, concluded with the publication of the Italian law DPCM 27/02/2004.

- Some numbers

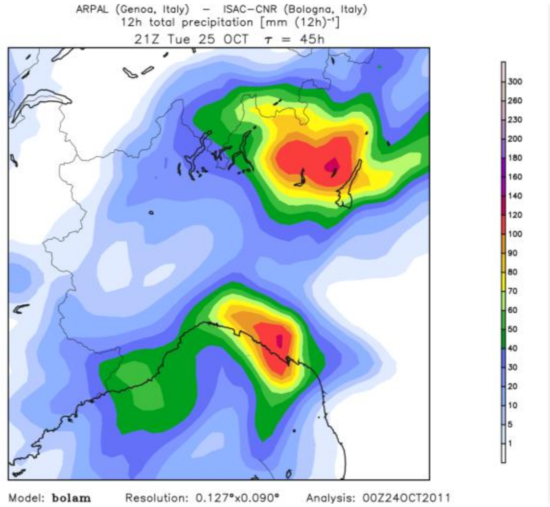
  … about office: 8 hydrologists, 10 meteorologists, 10 technicians for observational network, software and hardware maintenance, 1 manager

  … about job: daily meteorological and hydrological forecast, in-event monitoring, discharge measurements, publication of the hydrological time series, maintenance and development of the operative instruments, meteorological and hydrological models, hydro-meteorological public disclosure

CMI – ARPAL forecast procedures

Meteorologists

Meteorological evaluation on the models on the window of the next 48-72h on the Liguria, quantifying QPF (Quantitative Precipitation Forecast) on warning areas



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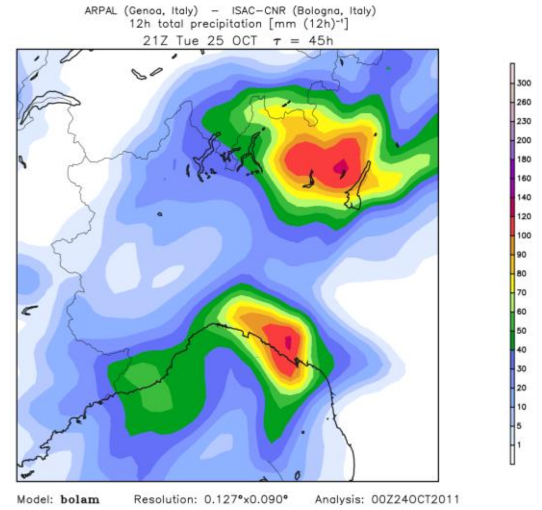

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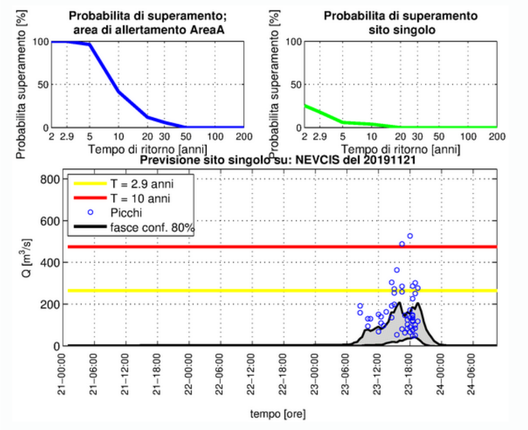

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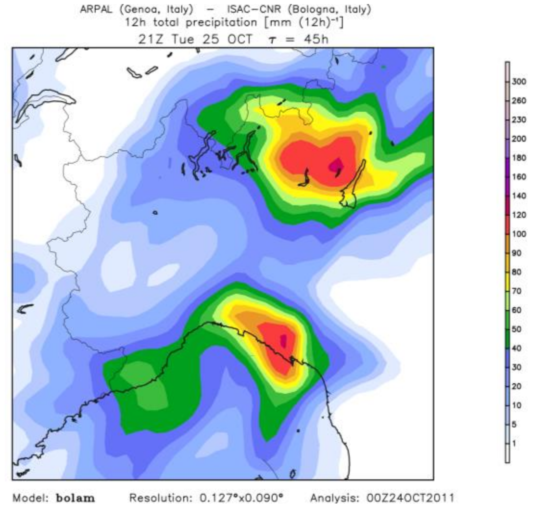

Evaluation of the **hydrological response** of ligurian rivers to rainfall, mainly supported by the event-based hydrological model DRiFt

Hydrologists

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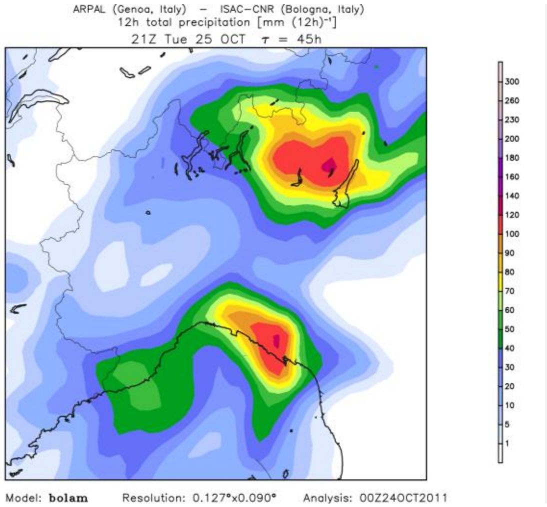

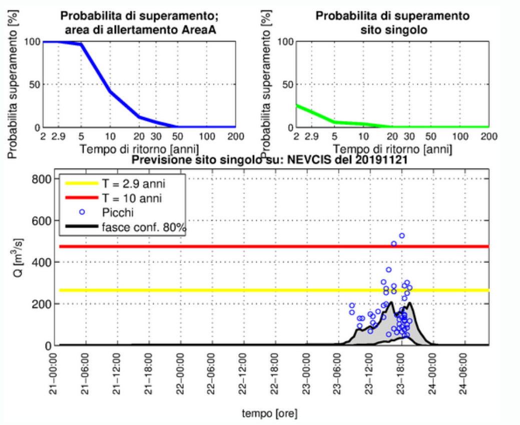

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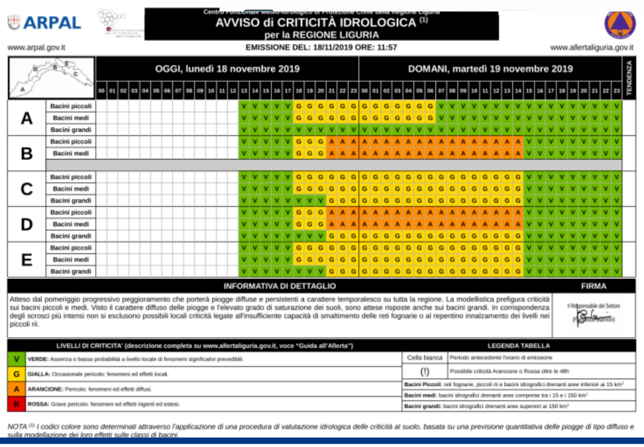
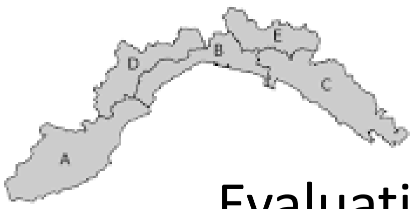
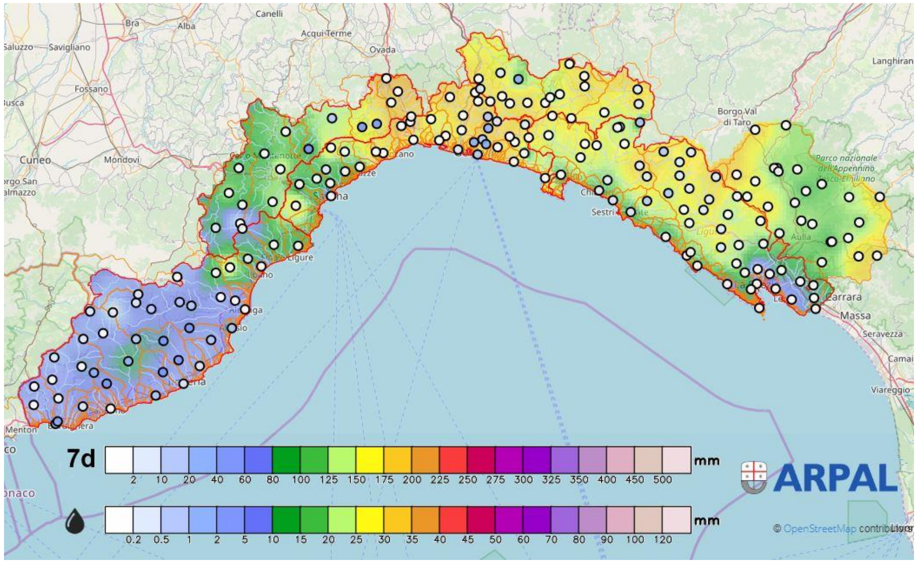




Evaluation of the hydrogeological **alert on warning areas**

DRiFt initialization with CPI method



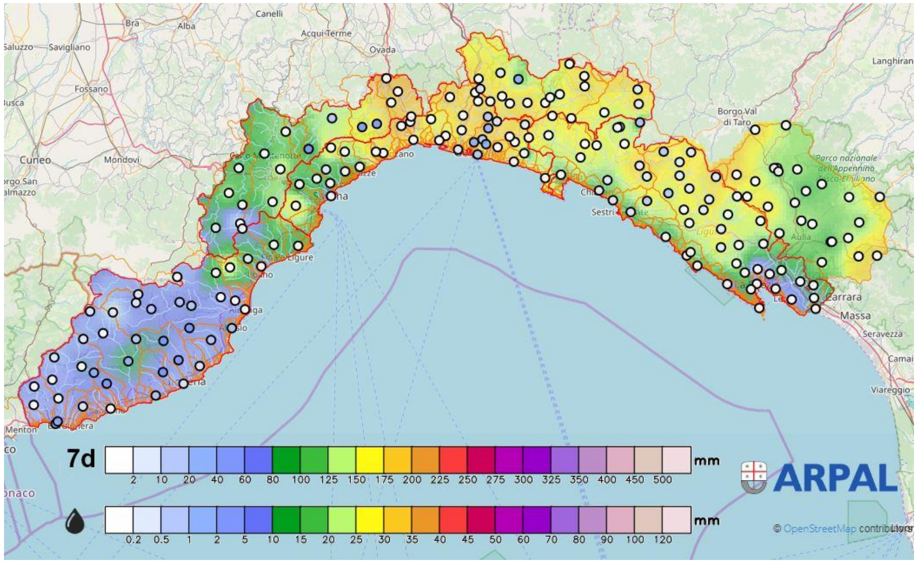
$$H = \sum_{t=1}^{D} h_t e^{\alpha t} \qquad \forall\ pluviometer$$

Weighted precipitation, spatially interpolated on the DRiFt model domain and related to $V_{max}(CN)$, provides the initial condition of the soil saturation degree for the model

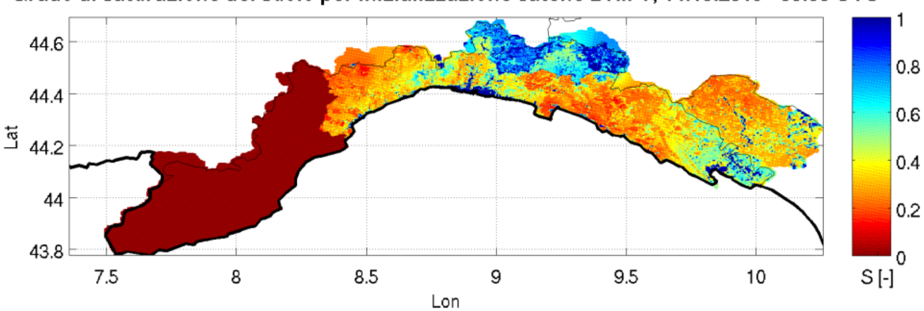
- t: antecedent day [days]
- D: antecedent period duration [days]
- h_t: cumulated precipitation [mm] during the last 24 h of day t
- α: exponential decay factor [1/day]

D, α variable on spatial and temporal scale (season, warning areas)

DRiFt initialization with CPI method



Grado di saturazione del suolo per inizializzazione catene DRIFT, 14.10.2019 - 00.00 UTC



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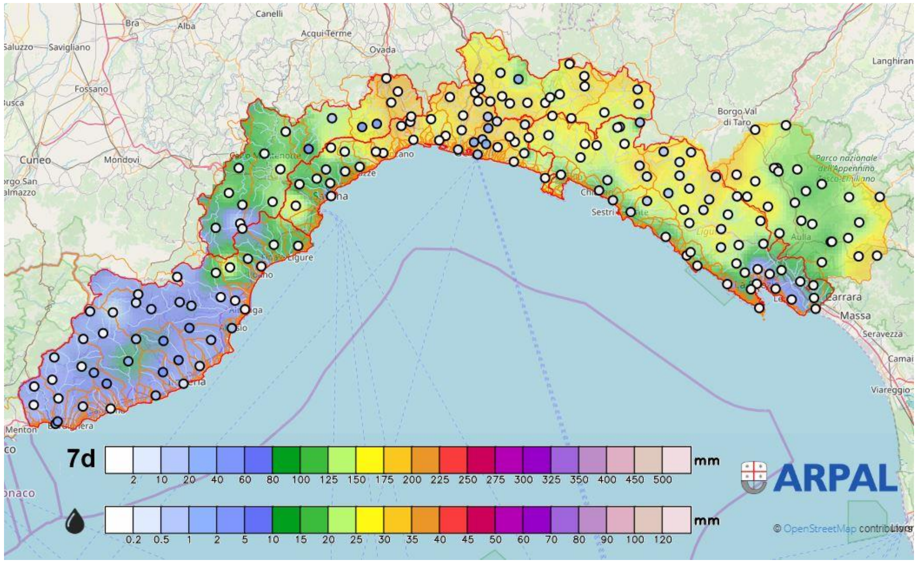

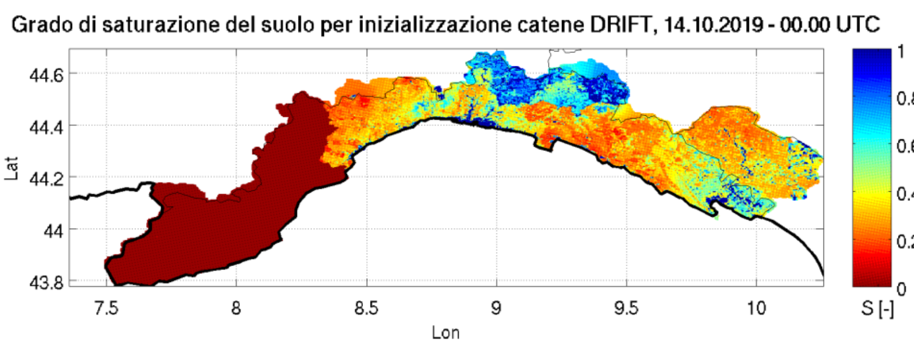

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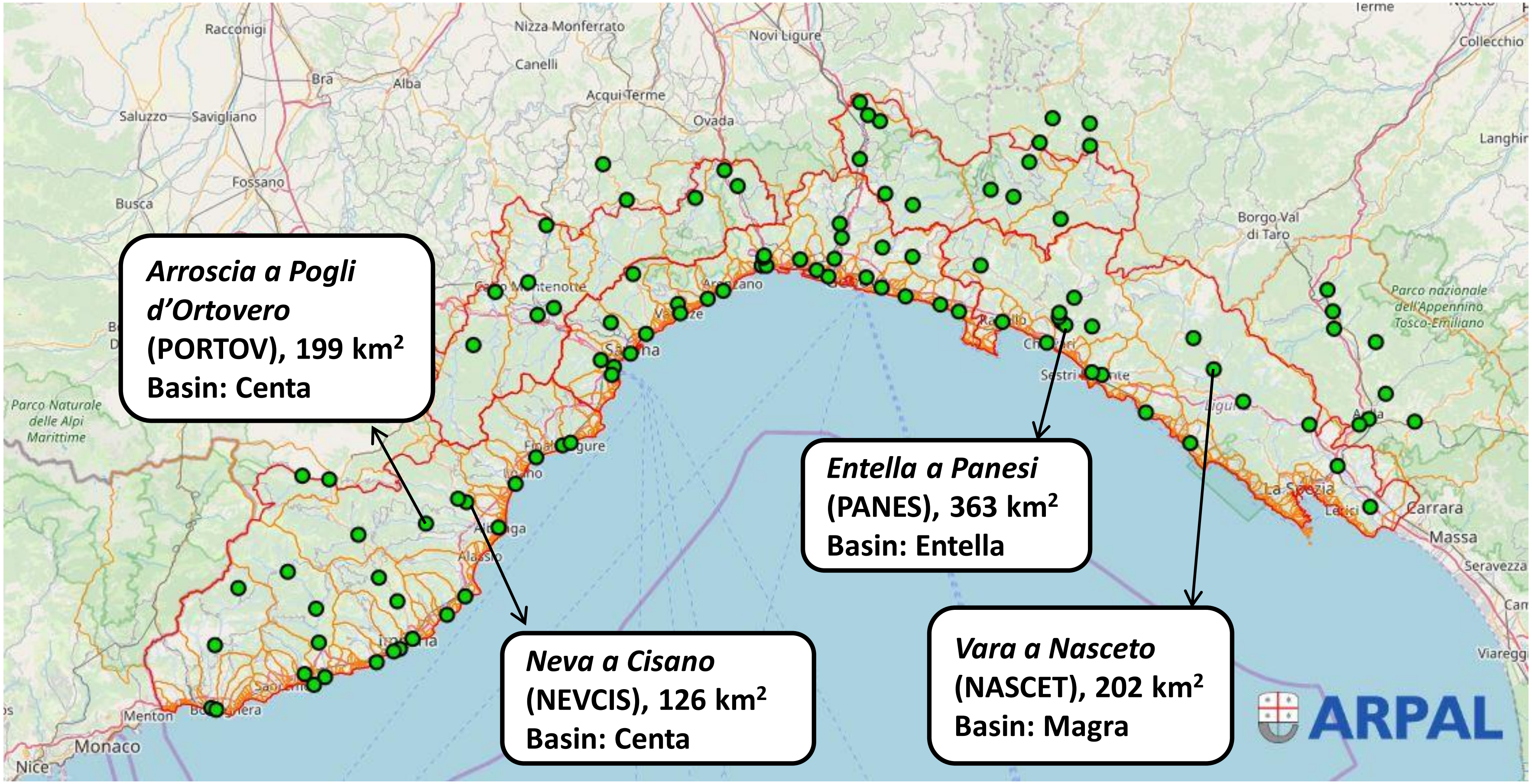
D, α variable on spatial and temporal scale (season, warning areas)

Can HSAF soil moisture satellite data improve DRiFt initialization? Are they a valid alternative?

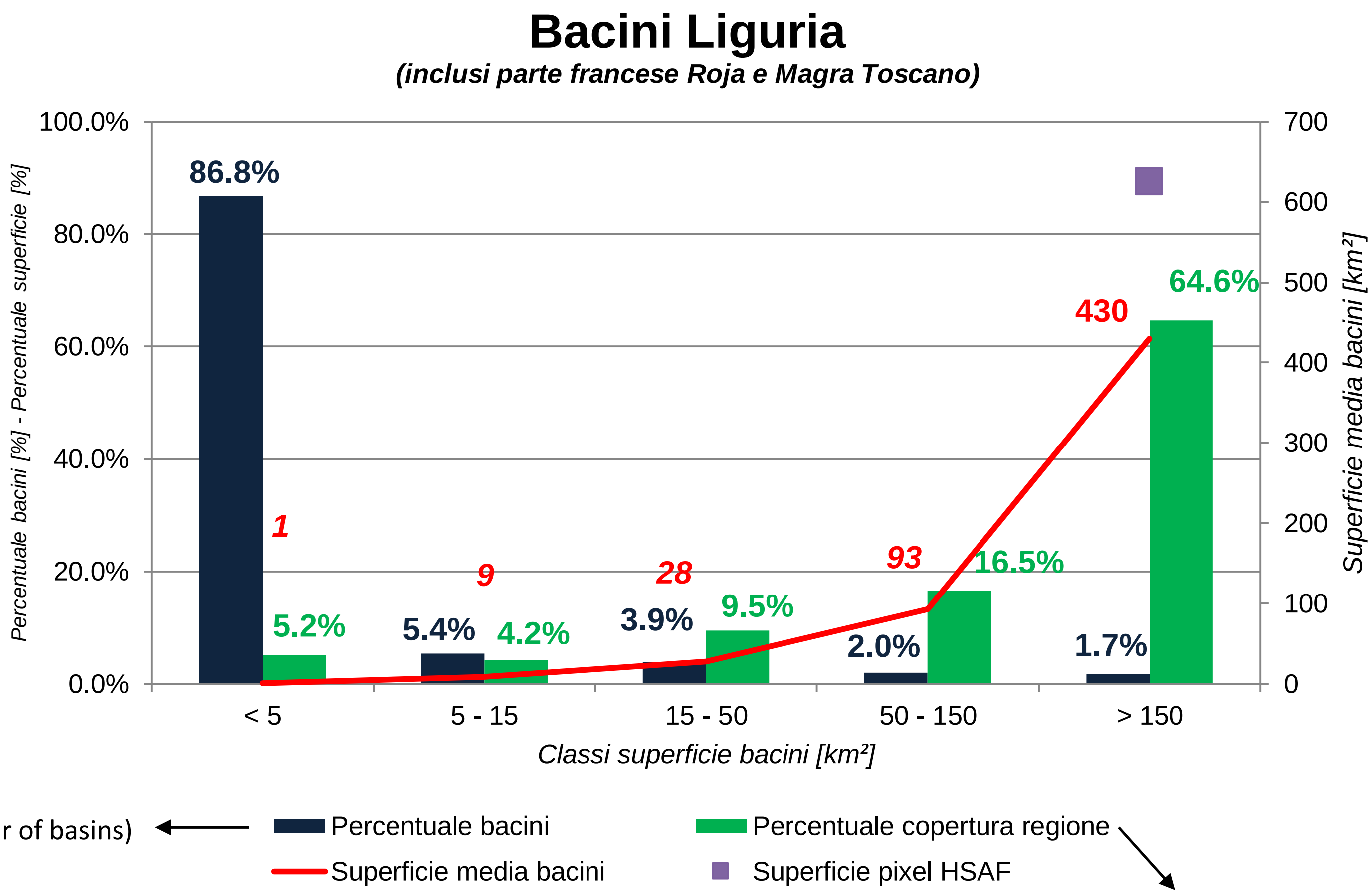
Study area

Modelled cross sections selected as study case



Study area

Drainage areas vs. spatial resolution of satellite data



(Percent number of basins)

(Percent regional areal coverage)

(Average basin surface)

(HSAF spatial grid)

Events

Autumn
03/11/2012
09/11/2012
20/10/2013
24/12/2013
07/10/2014
03/11/2014
10/11/2014
14/11/2014
19/11/2016
22/11/2016
10/12/2017
25/12/2017
09/10/2018
27/10/2018
31/10/2018

Spring
07/06/2011
14/05/2013

Winter
03/01/2014
15/01/2014
06/02/2016
27/02/2016
03/03/2016
02/02/2017
09/03/2018
14/03/2018
31/01/2019
02/04/2019
31/01/2019

Summer
12/09/2015
03/09/2011

Cross section: Panesi

Autumn: 15/09 - 31/12
Winter: 01/01 - 14/04
Spring: 15/04 - 30/06
Summer: 01/07 - 14/09

Cross section: Cisano sul Neva

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Best S0

S0 = 0 : 0.01 : 1

↓

DRiFt model

↓

Output hydrographs → Select best fits → S0 cost

Best S0

S0 = 0 : 0.01 : 1

↓

DRiFt model

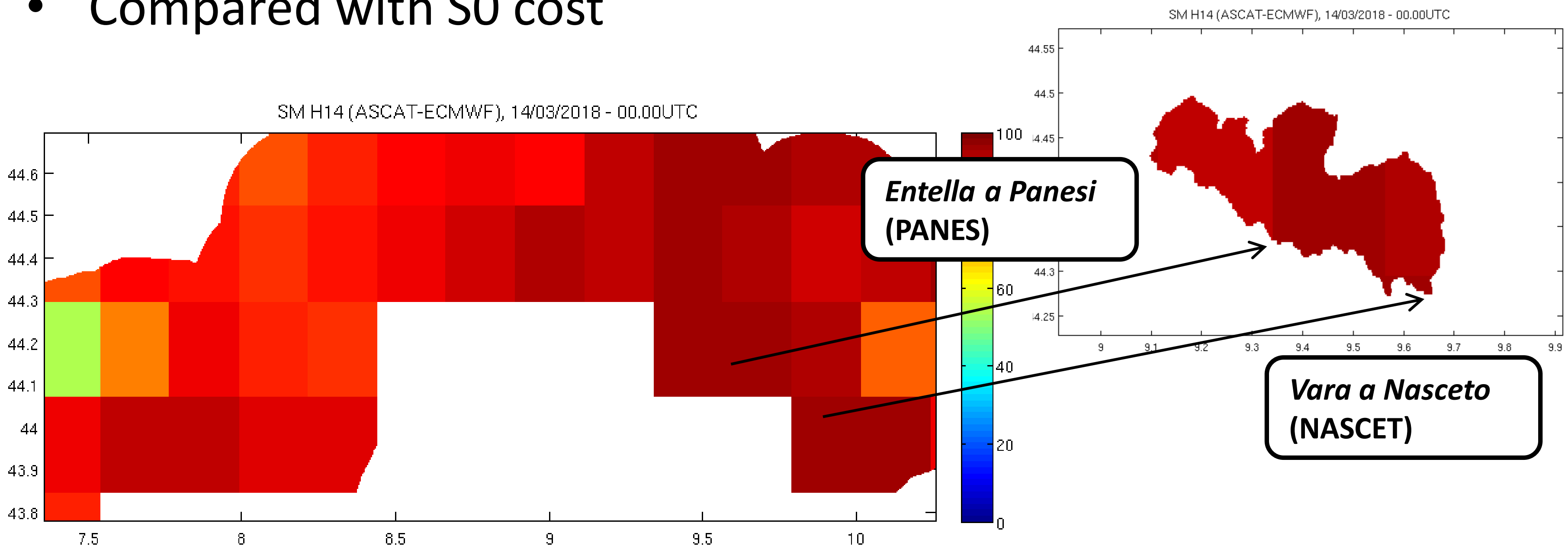
↓

Output hydrographs → Select best fits → S0 cost

Note: not observation, but, given model, S0 providing best fit

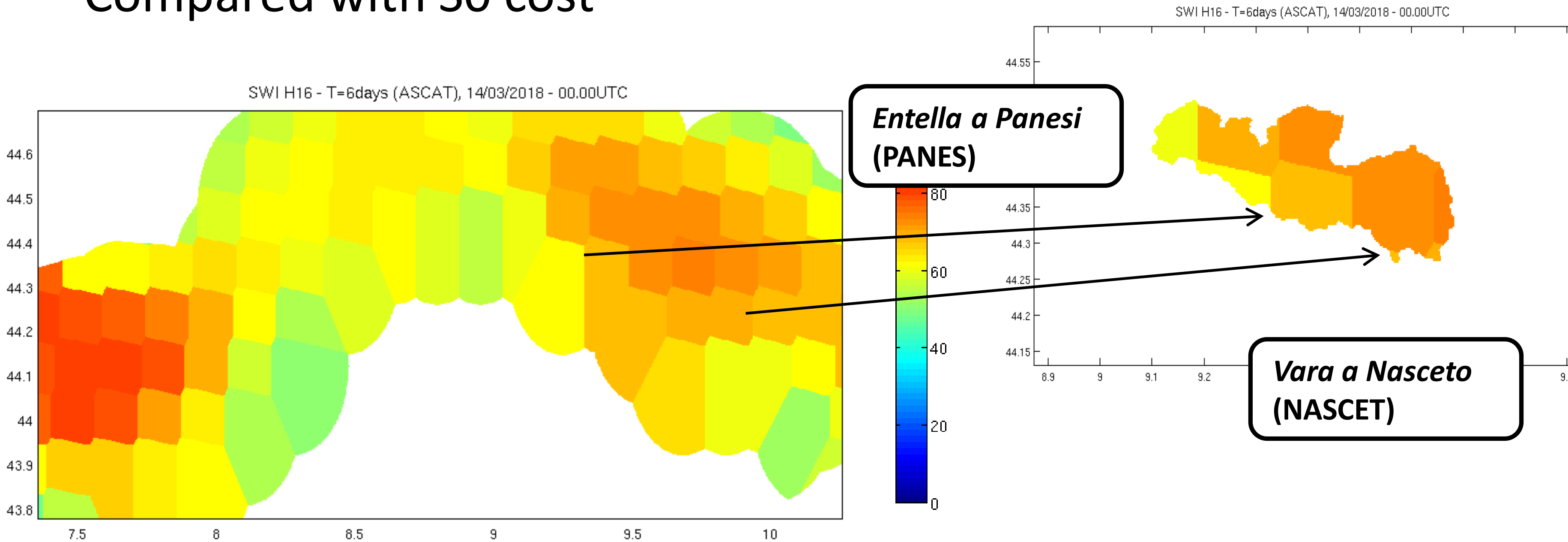
SM H14 (ASCAT-ECMWF)

- H14 pre-processed to obtain layers 0-7 cm and 0-28 cm from the surface – obtain values comparable with operational model input
- Masked on the selected basin drainage areas – daily maps extracted from the time series
- Compared with S0 cost

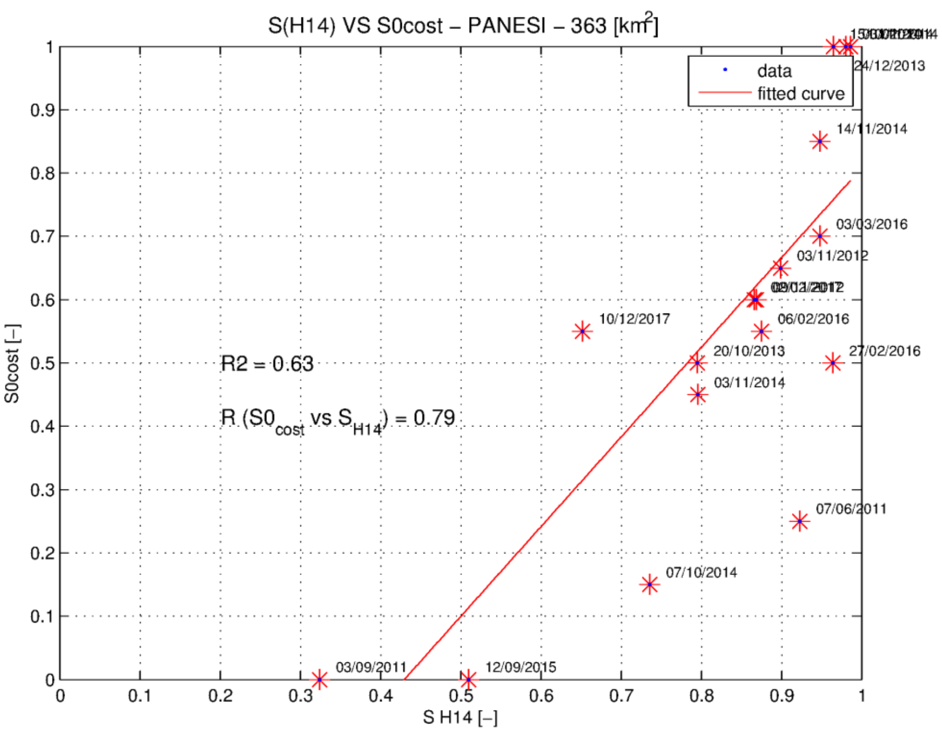


SWI T6 H16 (ASCAT)

- H16 pre-processed with exponential filter to obtain SWI – obtain values comparable with operational model input
- Masked on the selected basin drainage areas – maps composed with the SWI values detected between initialization DRiFt model date and 48 hours before
- Compared with S0 cost



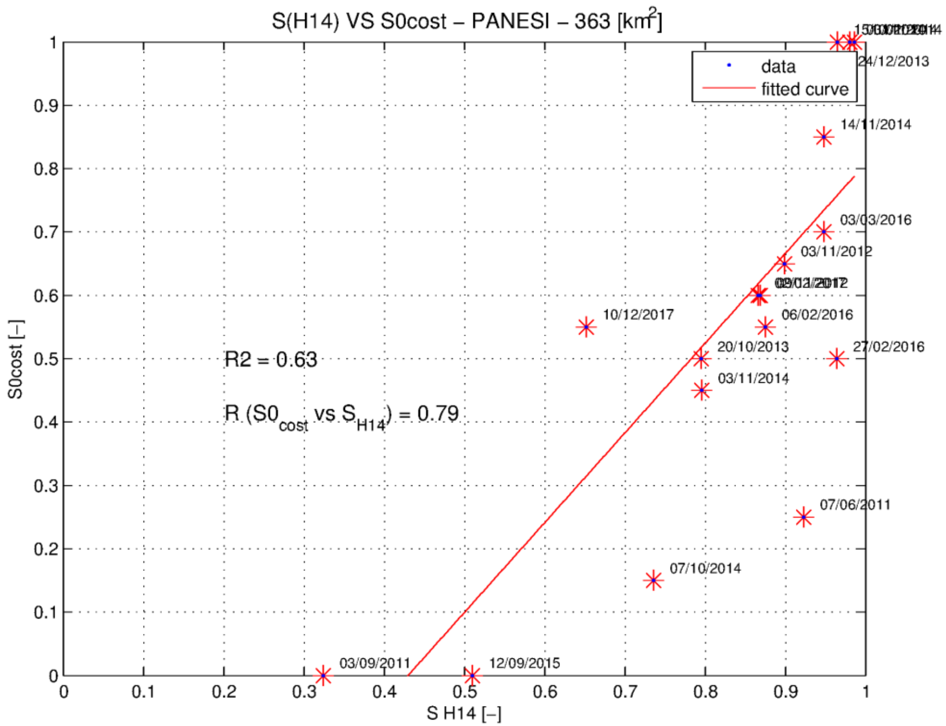
Regression curves

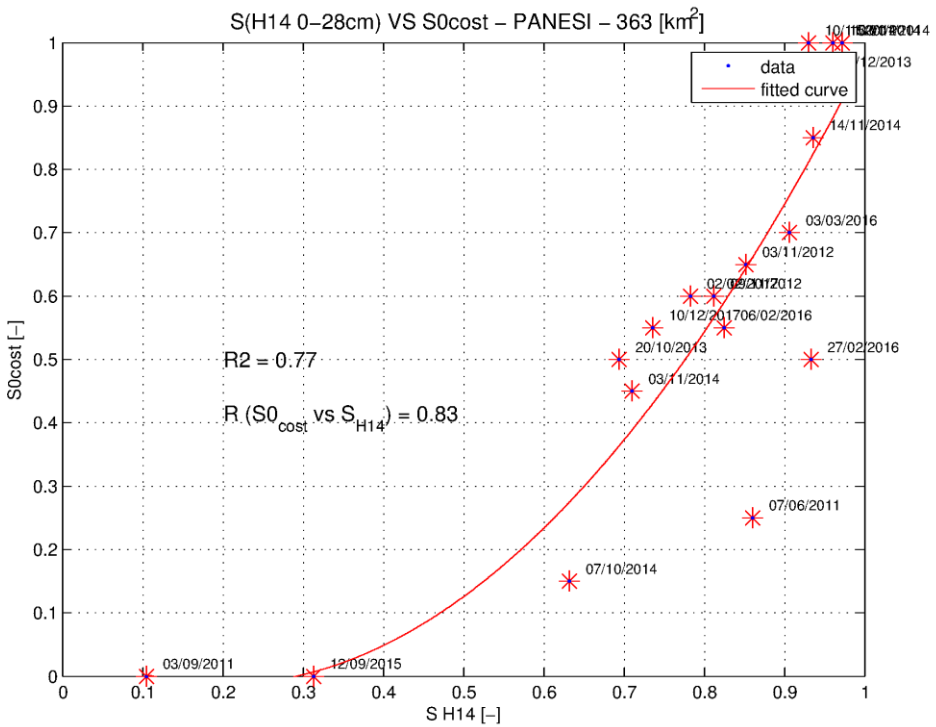


S0 cost
vs.
satellite data-derived S

1° or 2° order polynomial relationship

Regression curves





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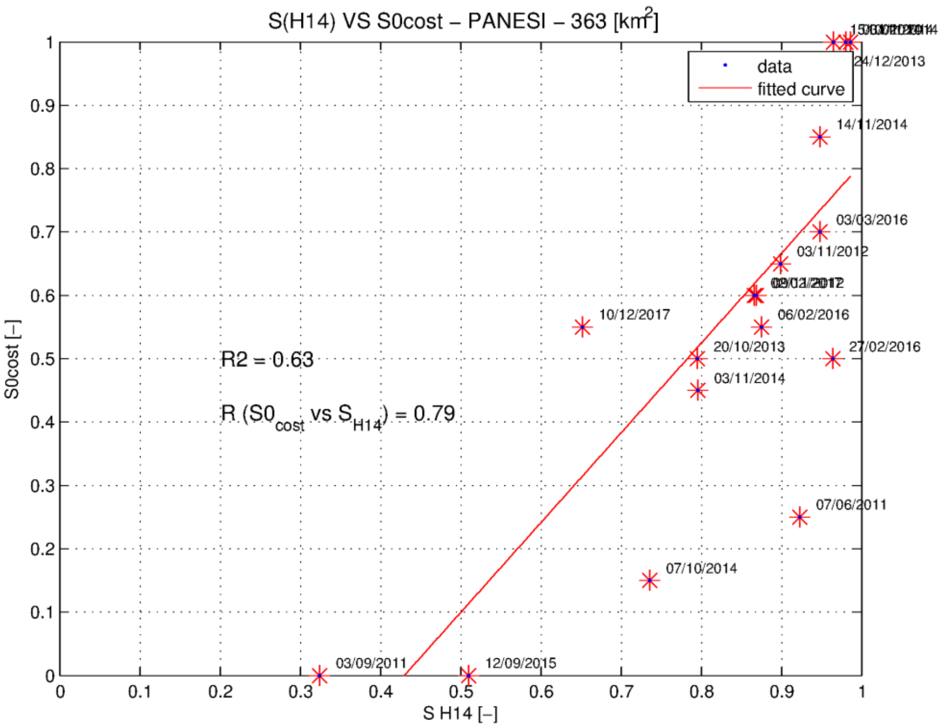
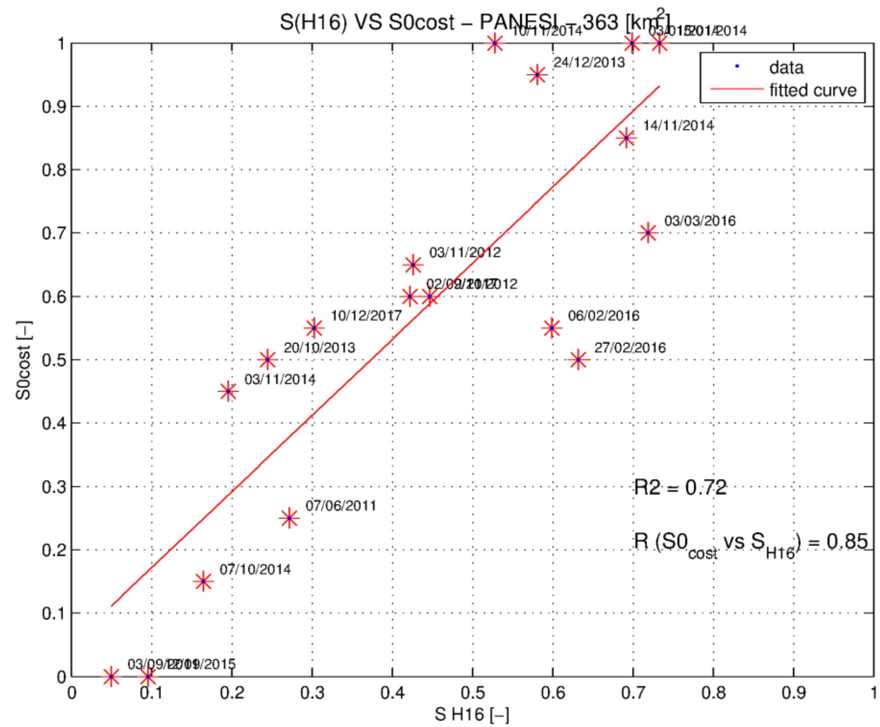
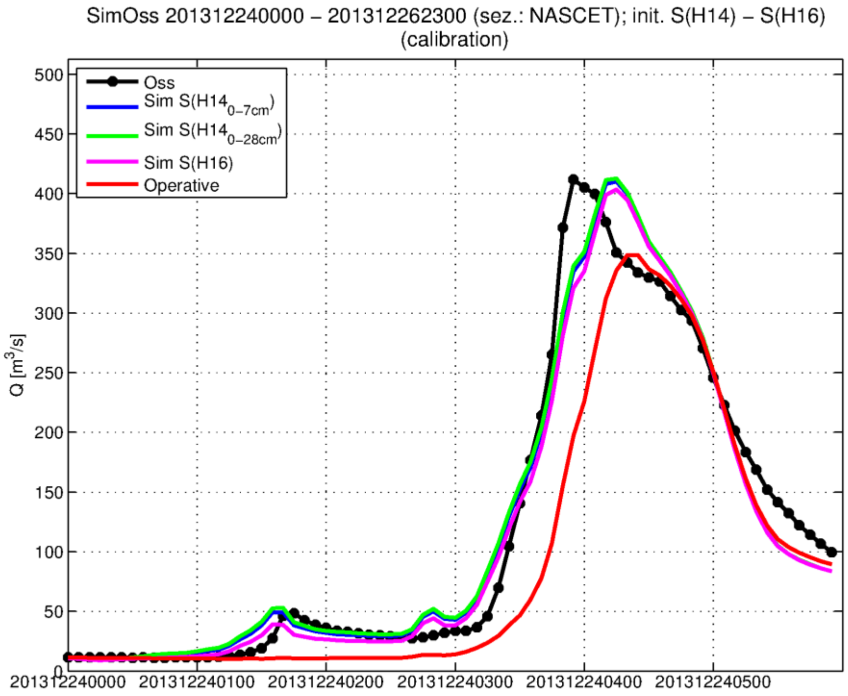
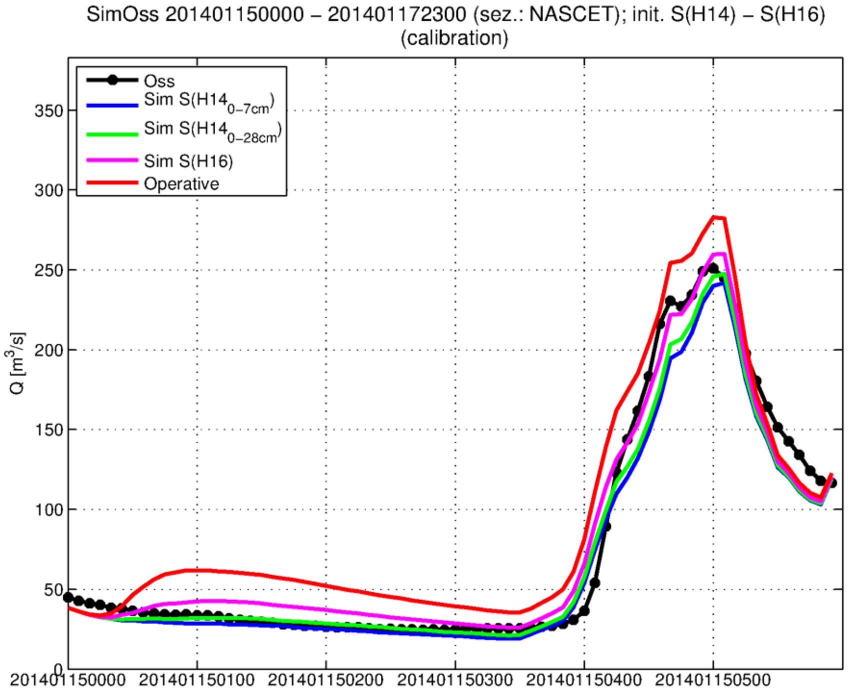




Results – events in calibration





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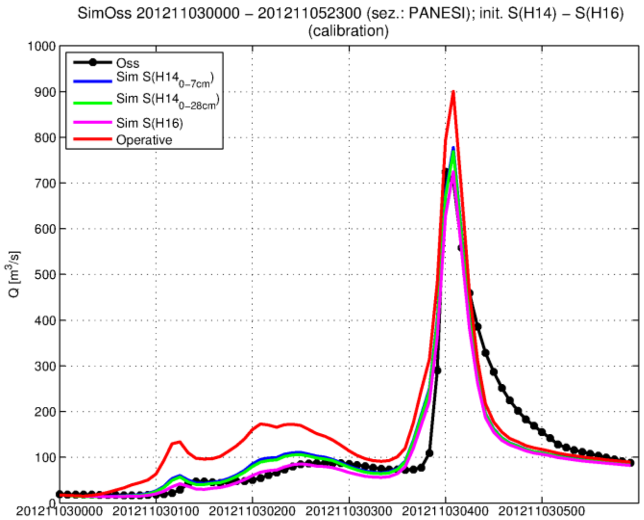
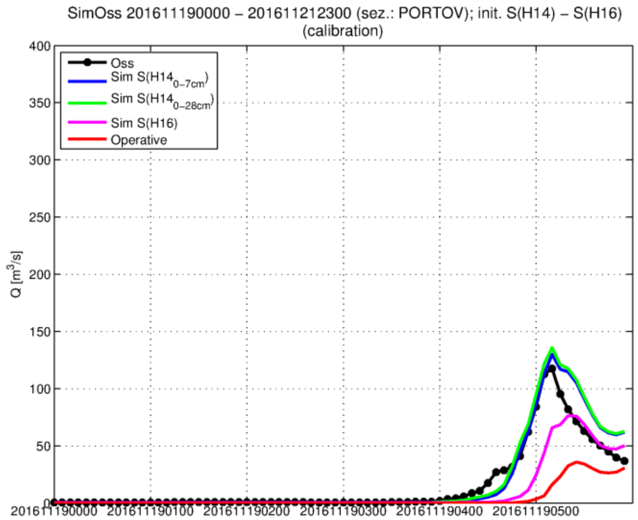
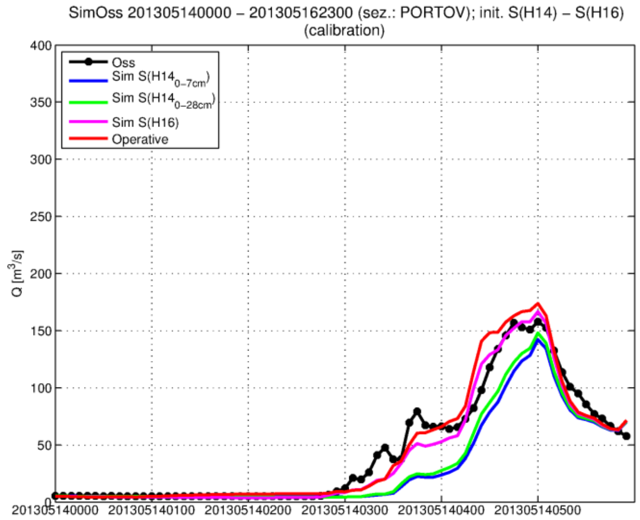
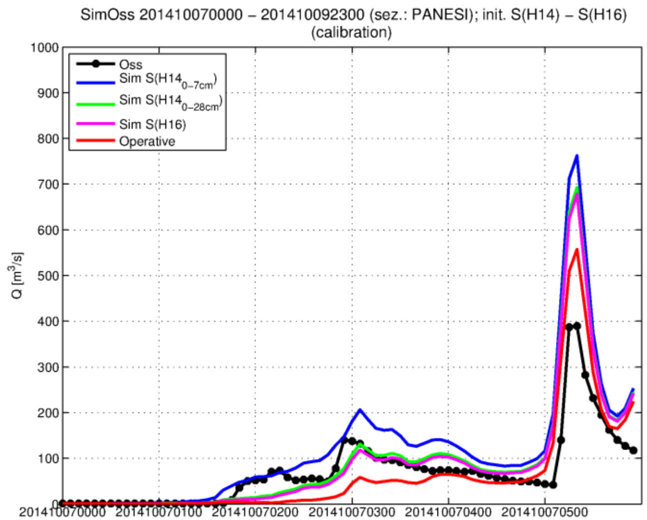
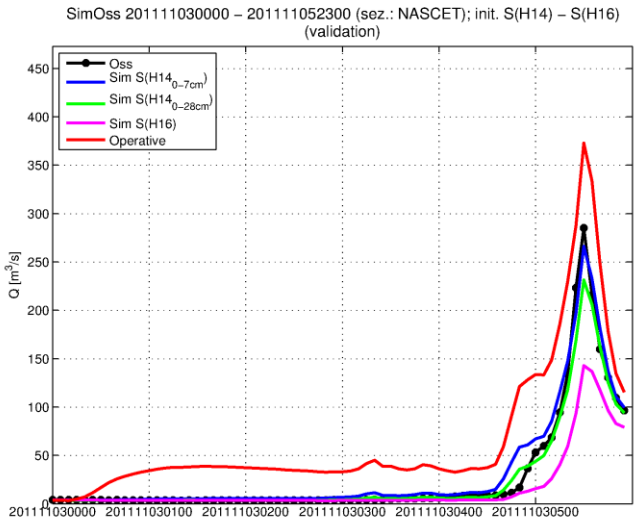


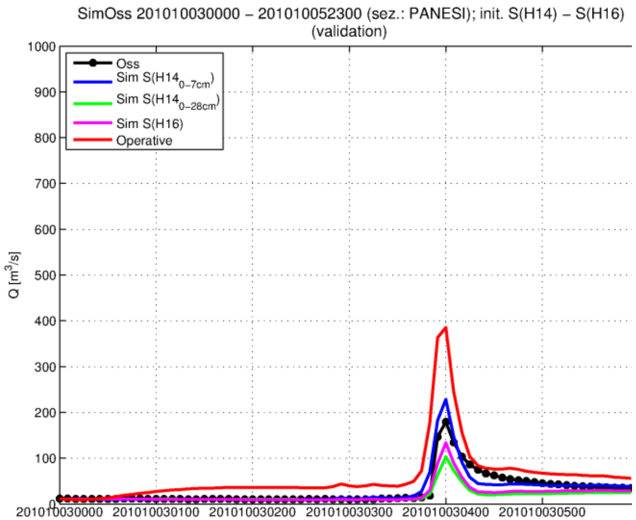


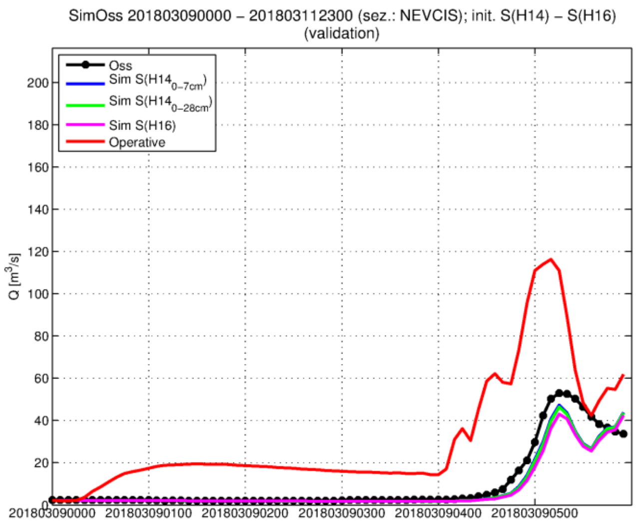


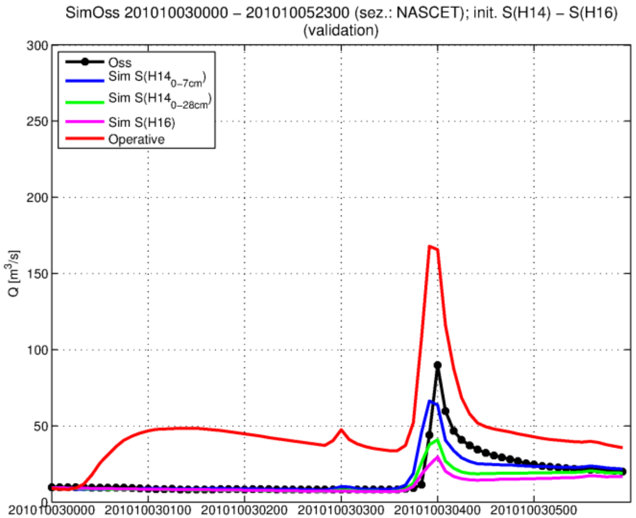


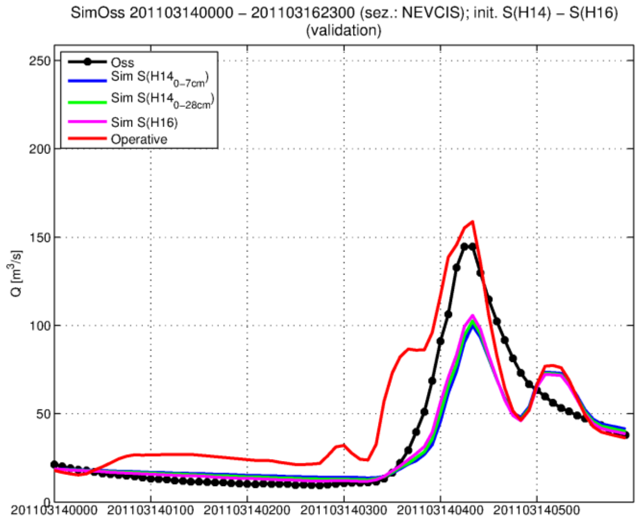
Results – events in validation

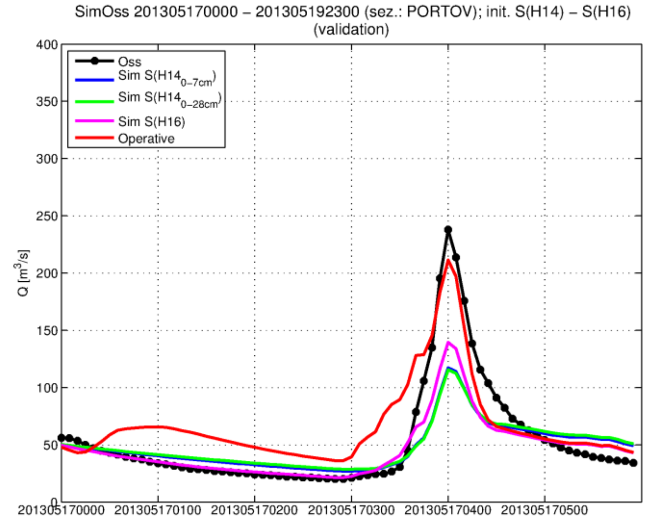












GOF criteria

PBIAS [−∞ ; +∞]

$$PBIAS = 100 * \frac{\sum_{i=1}^{n}(Sim_i - Oss_i)}{\sum_{i=1}^{n} Oss_i}$$

Nash-Sutcliffe [-∞;1]

$$NSE = 1 - \frac{\sum_{i=1}^{n}(Sim_i - Oss_i)^2}{\sum_{i=1}^{n}(Oss_i - \overline{Oss})^2}$$

MAE [0; +∞] m³/s

$$MAE = \frac{\sum_{i=1}^{n}|Sim_i - Oss_i|}{n}$$

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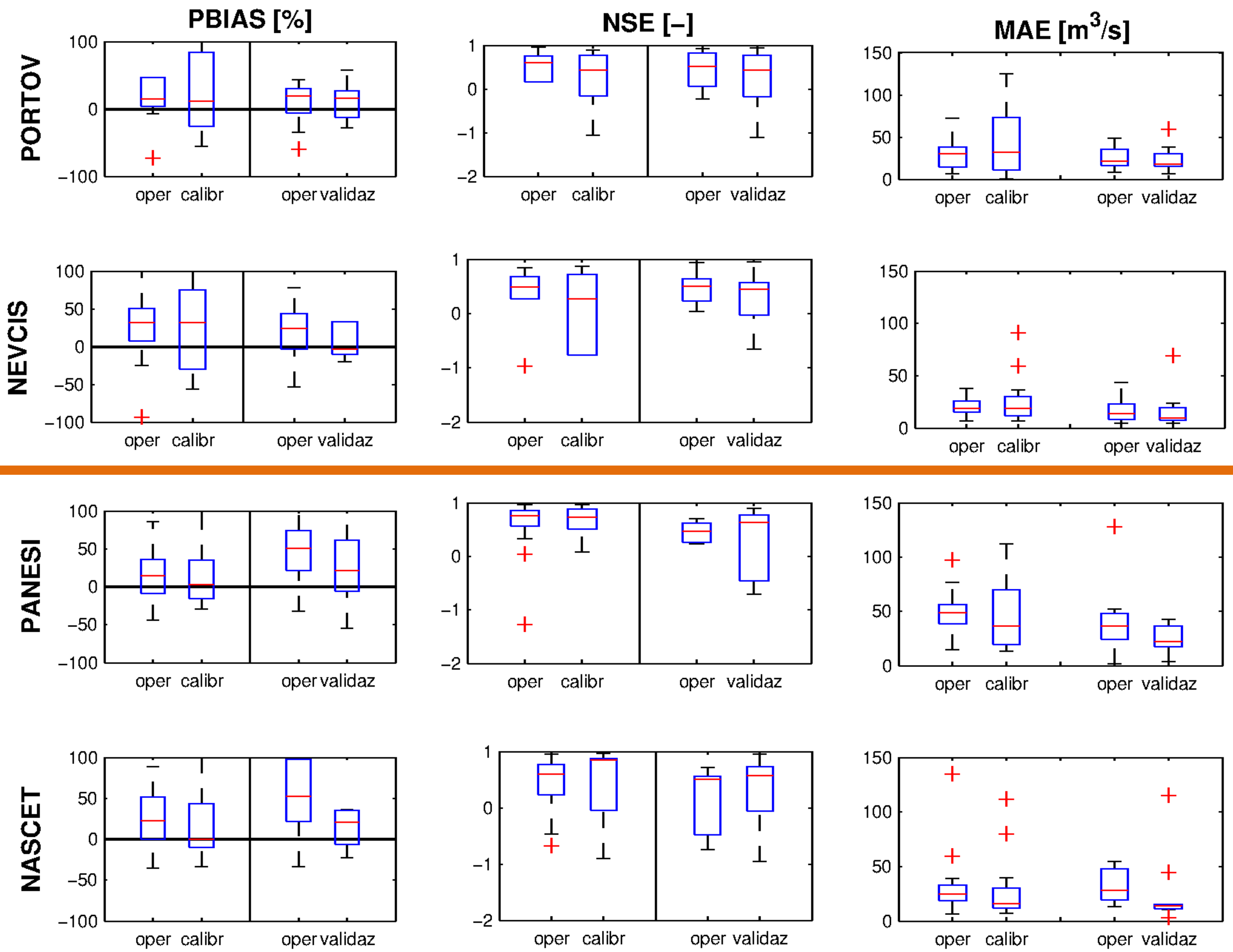
GOF init. SM H14 (layer 0-7cm)

WEST modelling sections

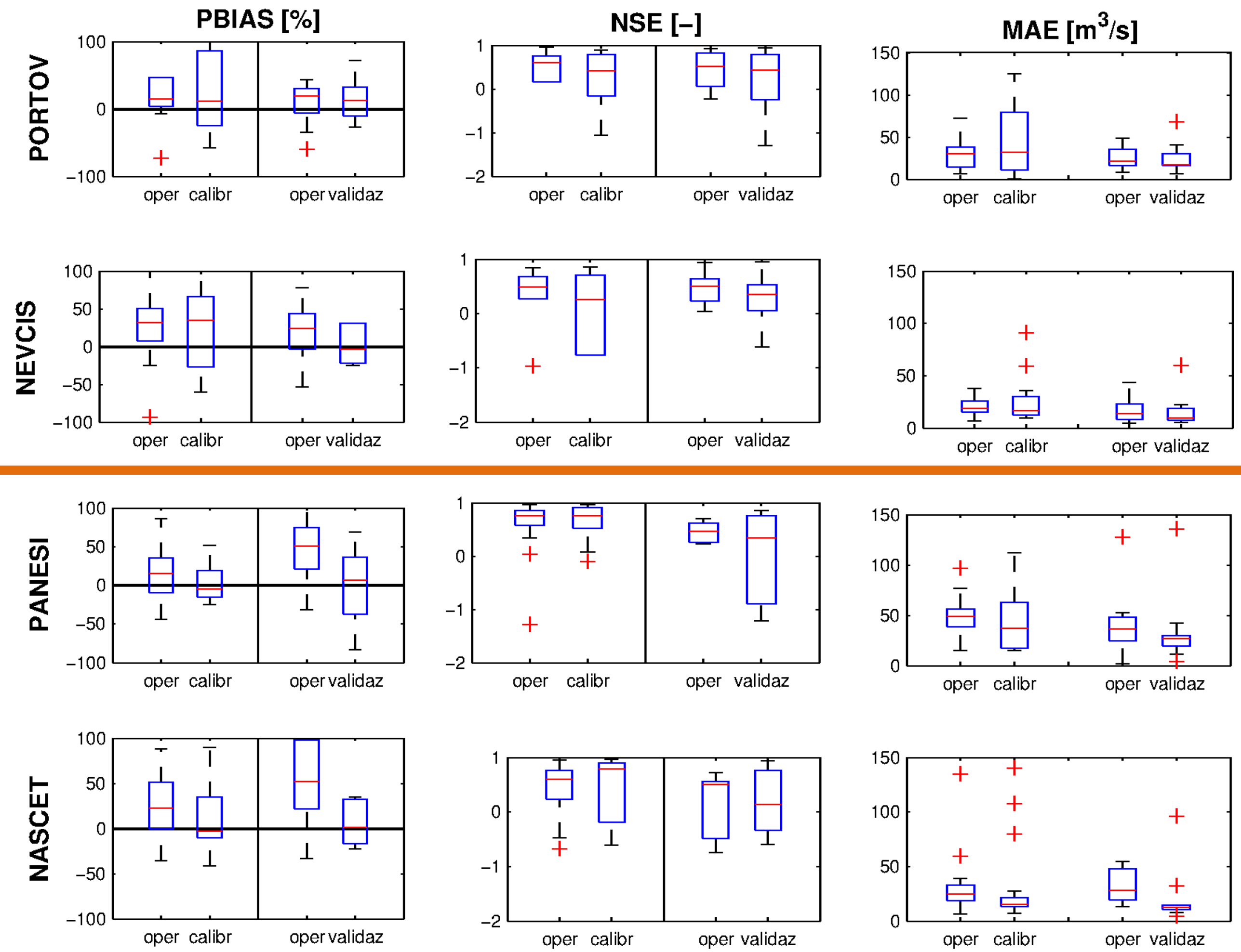
EAST modelling sections



GOF init. SM H14 (layer 0-28cm)

WEST modelling sections

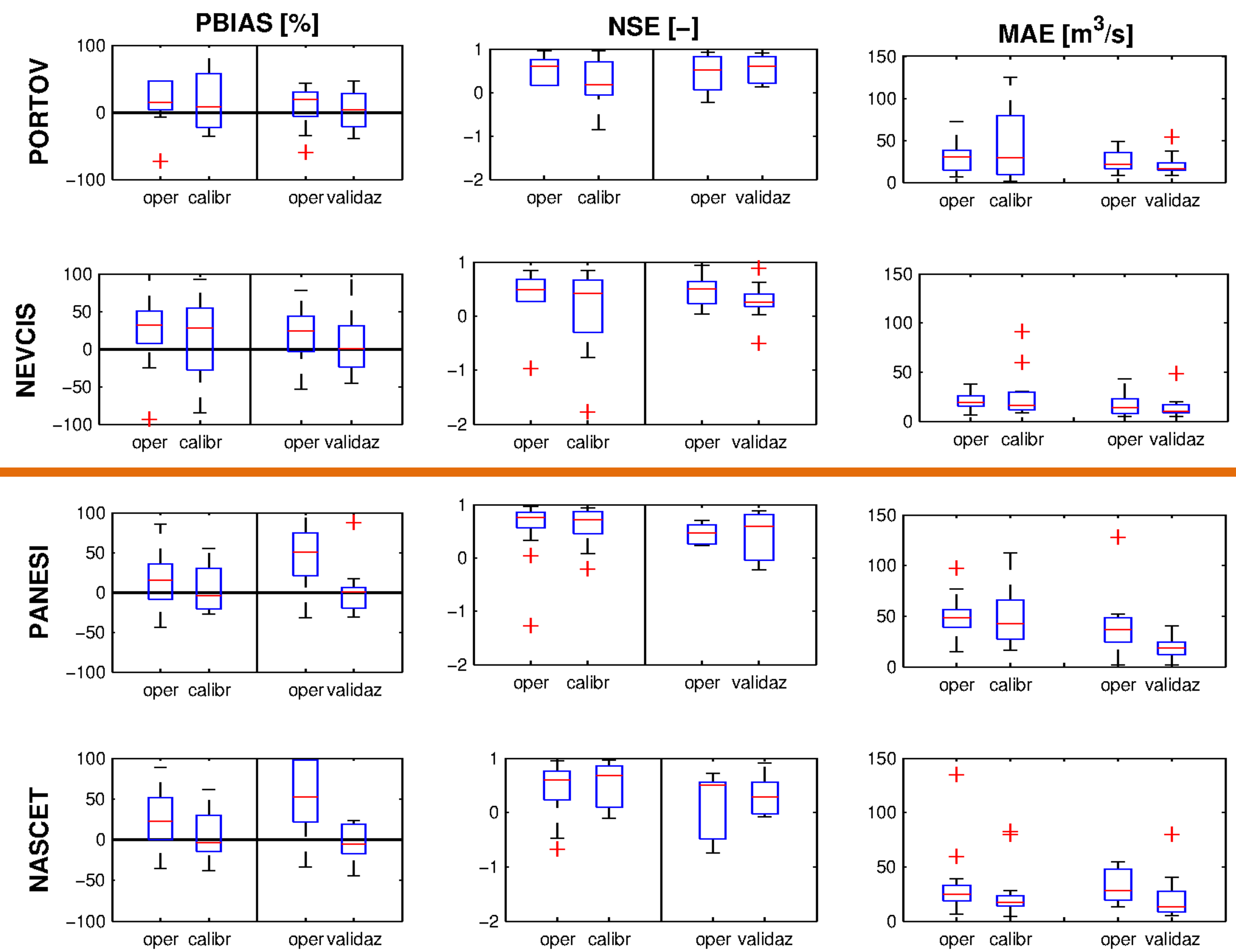
EAST modelling sections



GOF init. SWI T6 H16

WEST modelling sections

EAST modelling sections



Further remarks

- Operational aspects: few study cases (4 basins) vs need to achieve satisfactory results on several cross sections, many of which not provided with observations
- DRiFt is event-based, cannot compare time series of satellite data with modelled time series of S, as in continuous models

Outlook

1. Consider further research with use of higher resolution data - when available – and keep a distributed initial moisture instead of S0
2. CN-derived S0 (from observed P and R)
3. Deeper seasonal analysis – is there a clear seasonal trend?
4. Install ground station for satellite data validation

Conclusions

- Potential to improve SM estimation for model initialization, but limitation related to spatial data availability for H14 and temporal for H16, which hinder operative use.
  This limitation may be solved in case of future HSAF SM data distribution with finer spatial resolution (need for further investigation)
- Satellite data alone can not provide an alternative to operational CPI model initialization, but it could be used to correct it
- Useful for other hydrological evaluations during the operative phase, too, not only for the purely modelling aspect

Thank you for your attention

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