Irrigation and precipitation consistency with SMOS, SMAP, ESA-CCI, Copernicus, AMSR2 remotely-sensed soil moisture

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Research questions

- A large variety of Surface Soil Moisture (SSM) products are obtained from Remote Sensing, with different sensing techniques, spatial resolution and electromagnetic frequencies

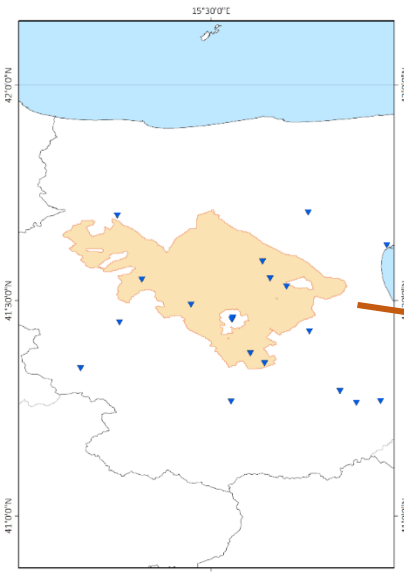
- Are all these products physically consistent with the recorded rainfall?

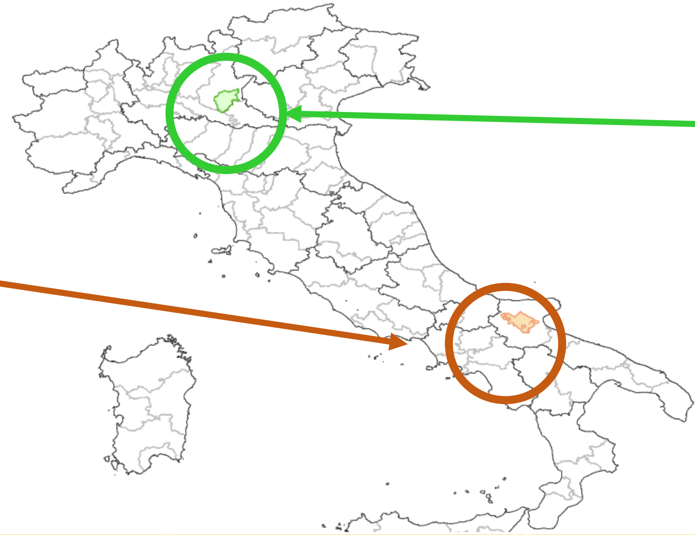
- Which is the most useful metric to “measure” this physical consistency?

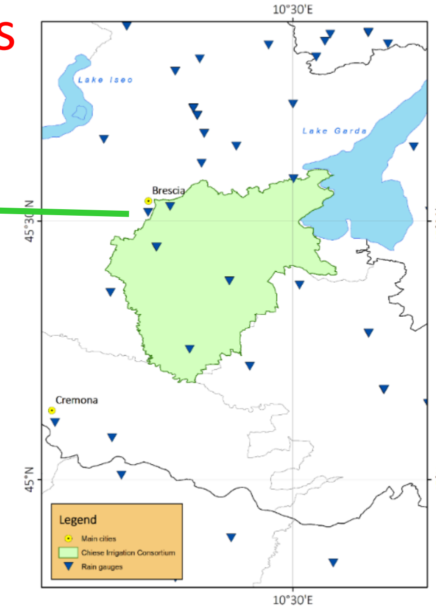
- Does this physical consistency depend on the products’ characteristics?

SOIL MOISTURE analysis: consistency with precipitation and irrigation

CAPITANATA & CHIESE case studies

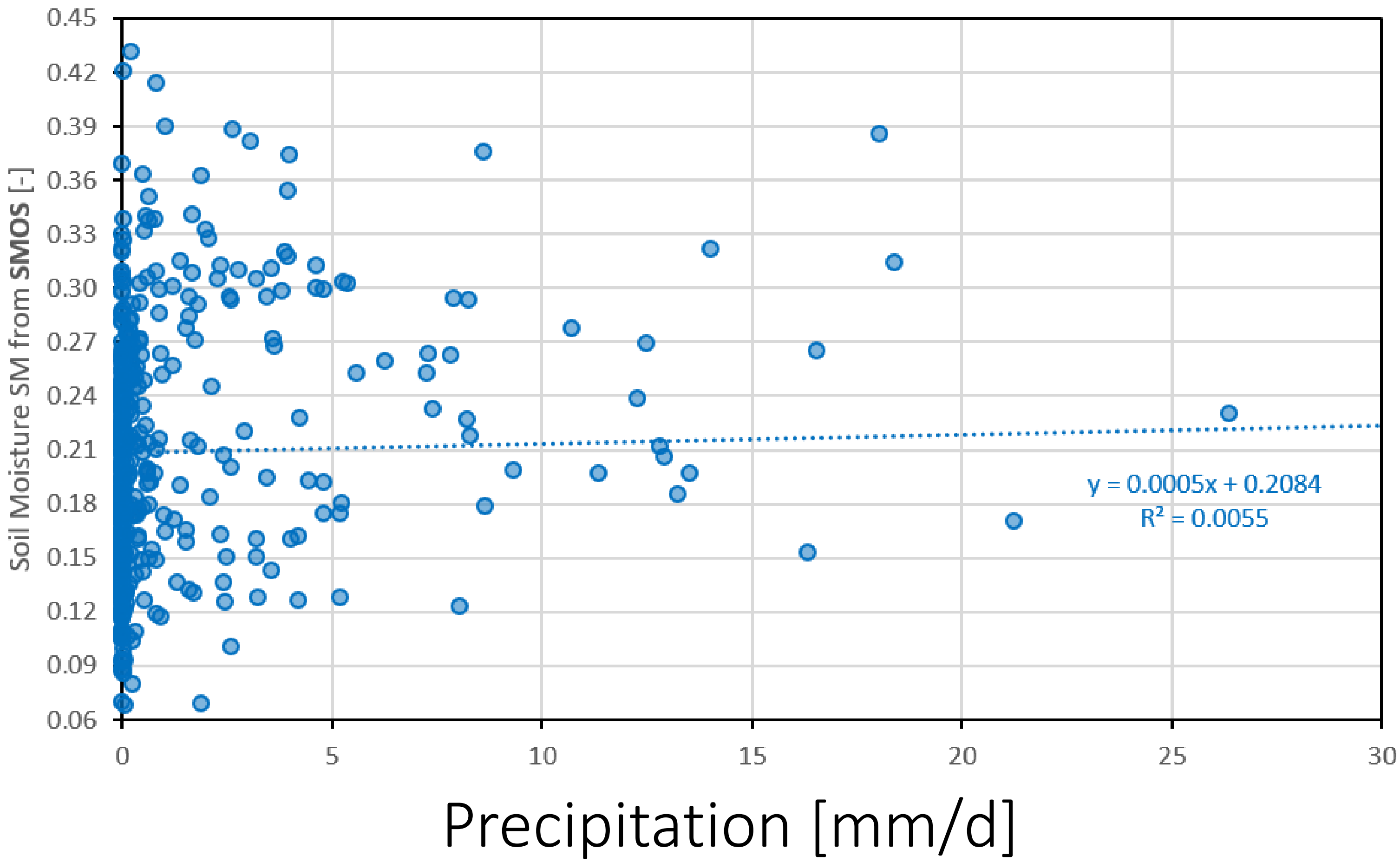






Dataset	Subproducts	Reference time	Acquisition System	E.M. spectrum	Effective Revisit Time	Spatial Resolution
SMOS	(1) Ascending (2) Descending	06:00 18:00	Passive	Band L	1-2 days	36km
SMAP	(3) Descending	18:00	Radiometer (Passive) SAR (Active)	Band L	2.2 days	36km
ESACCI	(4) Active (5) Passive (6) Combined	00:00	Active Passive Hybrid	Various microwaves	1.2 days	0.25° (ca. 24 km)
Copernicus	(7) Original (8) *Upscaled*	00:00	Active	Band C	4.1 days	1°/112 (<1km) 30km
AMSR-2	(9) Ascending (10) Descending	13:00 01:00	Passive	Band C	1.5 days	10km

SSM SMOS– Precipitation Pearson Correlation



$\rho = 0.0055$ → Not the right metric

Irrigation and precipitation consistency with SM

Each SSM retrieval has been compared with the precipitation in the days elapsed from the previous retrieval

Negative Agreement (A-)

- SSM decreases and there is Precipitation
- SSM increases and there is no Precipitation, **BUT**

Positive Agreement (A+) (rainfall-driven)

- SSM increases and there is Precipitation
- SSM decreases and there is no Precipitation

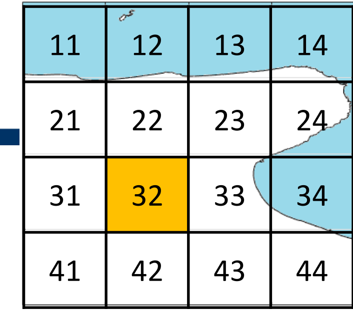
Negative Agreement (A-)

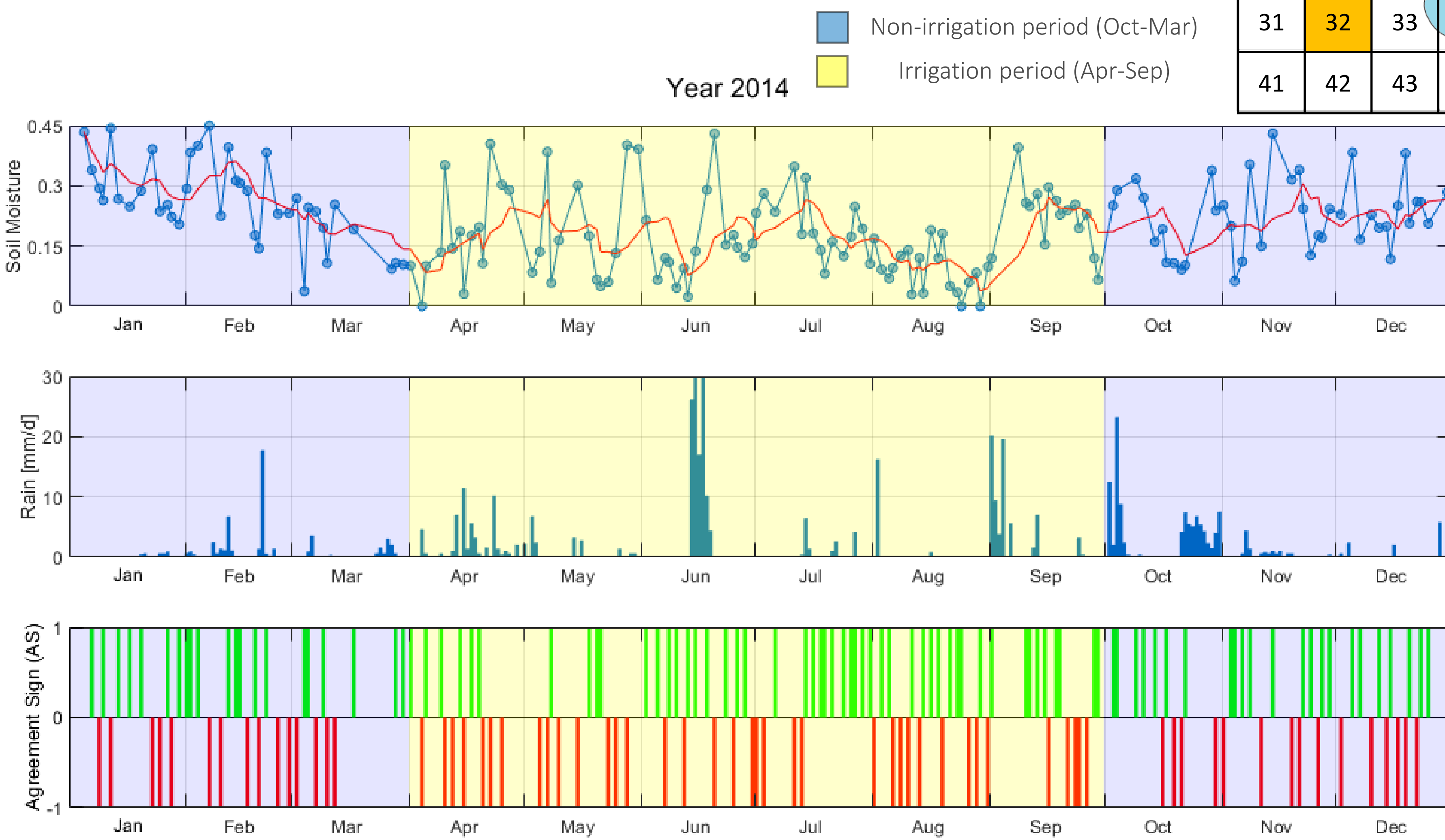
Outside of the Irrigation Period, any increase in Soil Moisture without any recorded precipitation is "unjustified"

Positive Agreement (IA+) (irrigation-driven)

During the Irrigation Period the presence of Irrigation can justify increases in Soil Moisture in absence of Precipitation

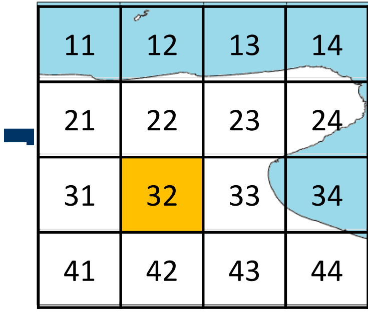
Precipitation and SMOS(a) consistency

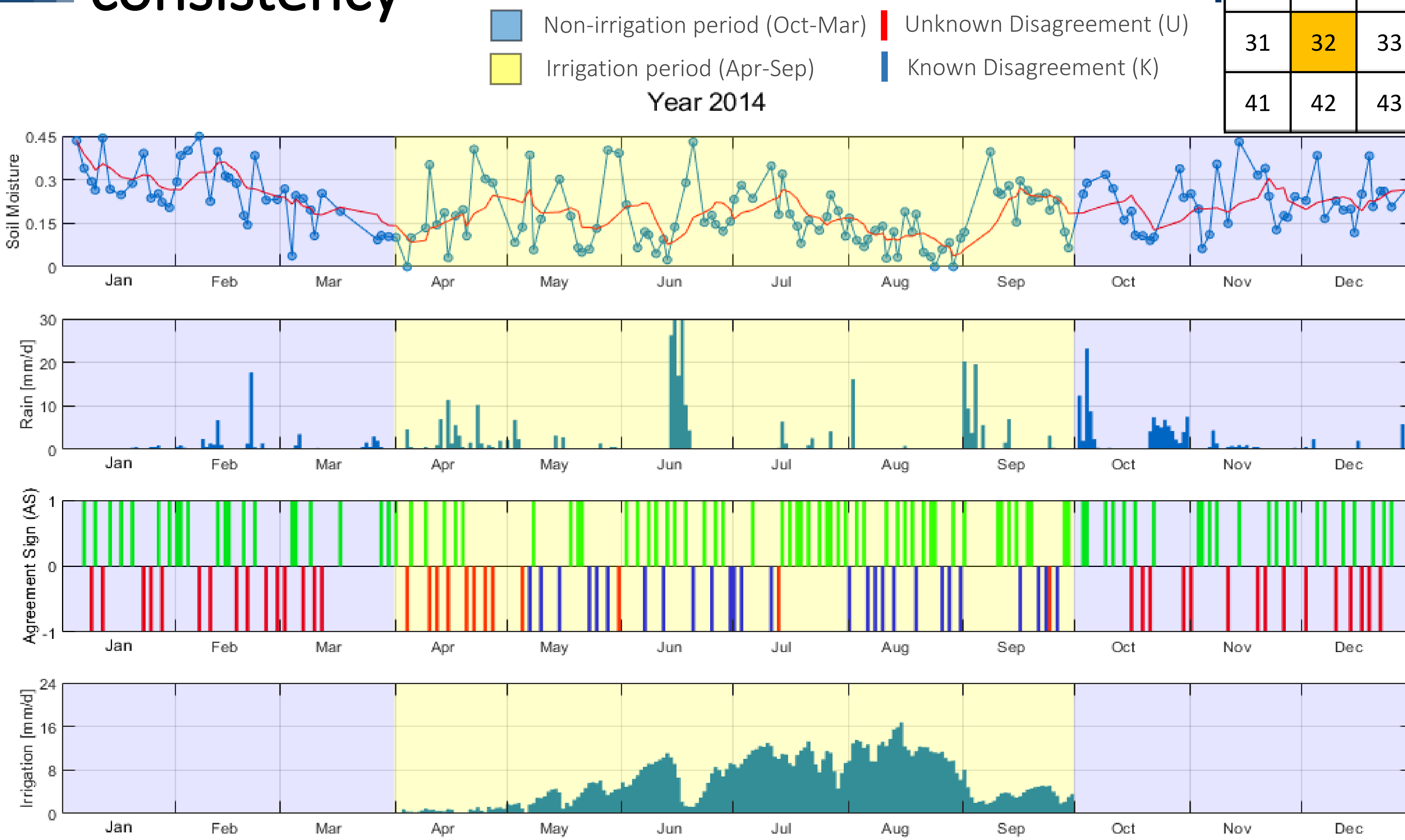




Year	Num. data	%A+	%A-	Non-irrigation		Irrigation	
				%A+	%A-	%A+	%A-
2014	162	58.0	42.0	58.7	41.3	57.5	42.5

Irrigation- precipitation and SMOS(a) consistency





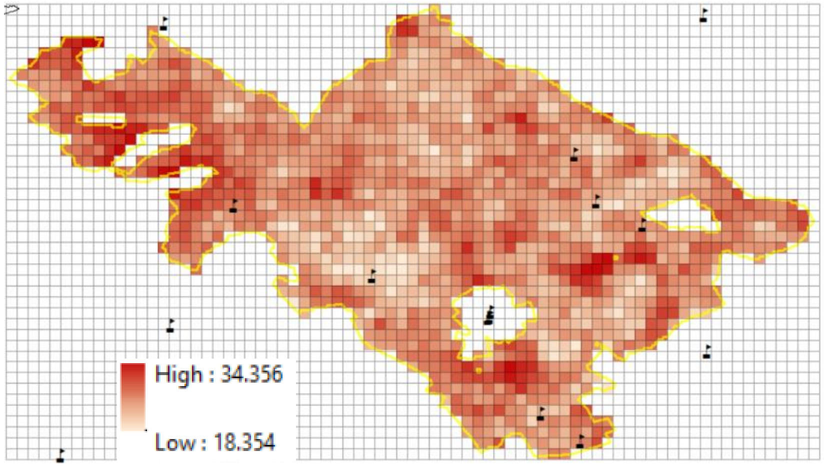
Year	Num. data	%A+	%A-	Non-irrigation		Irrigation		
				%A+	%A-	%A+	%A-	%IA+
2014	162	58.0	42.0	58.7	41.3	57.5	11.5	31.0

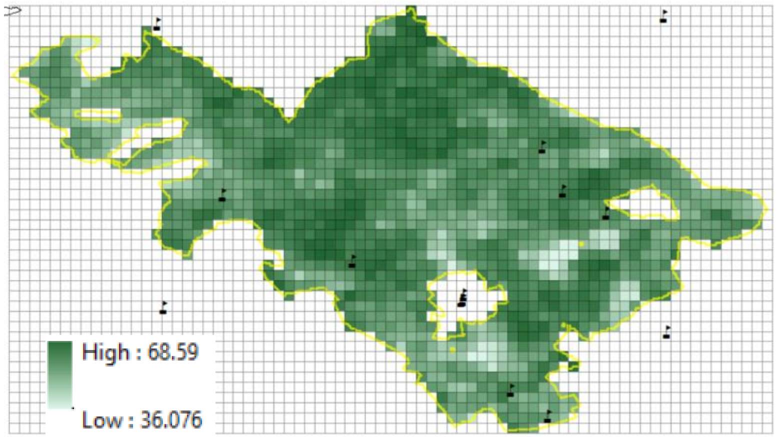
COPERNICUS consistency with precipitation-irrigation

A- $(\mu_{A-} = 25.7\%)$

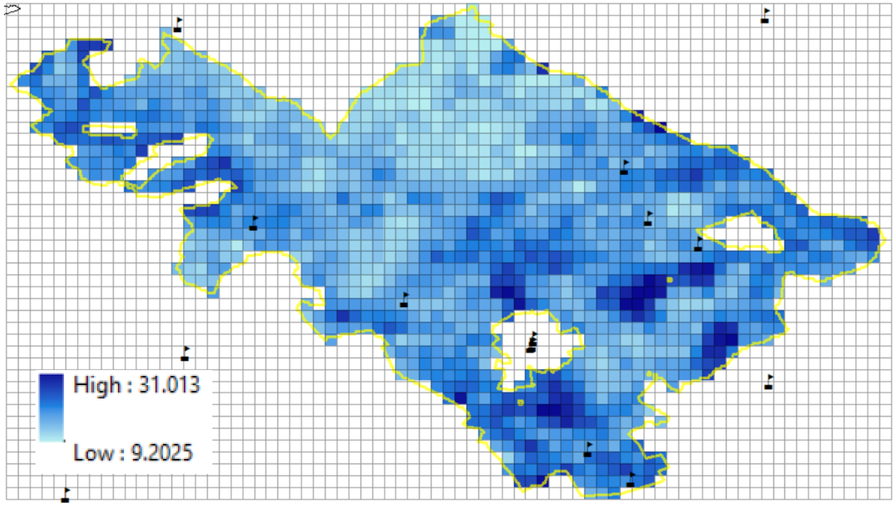
Irrigation period

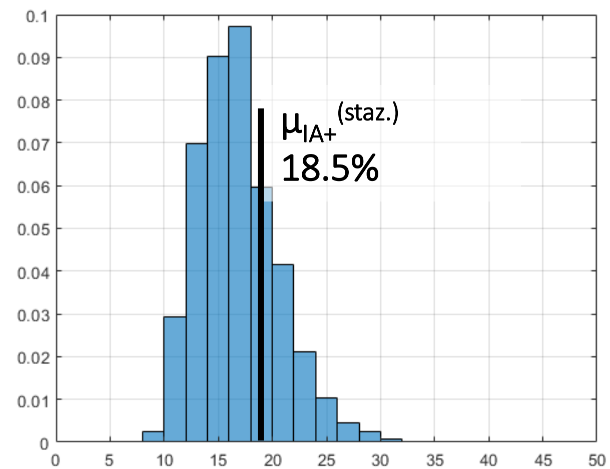
A+ $(\mu_{A+} = 57.0\%)$





IA+ $(\mu_{IA+} = 17.3\%)$





ALL-SOURCE consistency COMPARISON for Capitanata

Non-Irrigation	2015			2016			2017			2018		
	n	%A+	%A-	n	%A+	%A-	n	%A+	%A-	n	%A+	%A-
Active	104	57.7	42.3	94	56.4	43.6	148	56.1	43.9	72	43.1	56.9
Combined	26	61.5	38.5	19	73.7	26.3	32	68.8	31.2	21	57.1	42.9
Copernicus	24	52.4	47.6	25	38.3	61.7	59	47.0	53.0	54	42.1	57.9
Up. Copernicus	24	54.2	45.8	25	36.0	64.0	59	45.8	54.2	54	40.7	59.3
SMOS Asc.	58	48.3	51.7	50	40.0	60.0	23	60.9	39.1	24	50.0	50.0
SMOS Desc.	62	40.3	59.7	44	52.3	47.7	57	49.1	50.9	21	52.4	47.6
SMAP				56	58.9	42.9						
AMSR2 Asc.	87	46.0	54.0	83	57.8	42.2	130	53.8	46.2	126	46.8	53.2
AMSR2 Desc.	86	60.5	39.5	80	46.3	53.7	120	51.7	48.3	114	42.1	57.9

$\mu_{A+} = 51.1\%$

$\mu_{A-} = 49.9\%$

Irrigation	2015				2016				2017				2018			
	n	%A+	%A-	%IA+	n	%A+	%A-	%IA+	n	%A+	%A-	%IA+	n	%A+	%A-	%IA+
Active	188	54.8	20.2	25.0	207	57.0	24.6	18.4	149	49.0	14.8	36.2	76	55.3	23.7	21.0
Combined	40	67.5	15.0	17.5	63	76.2	17.5	6.3	29	75.9	10.3	13.8	30	76.7	16.7	6.6
Copernicus	47	56.7	30.8	12.5	39	47.3	40.7	12.0	57	60.4	23.4	16.2	46	54.8	23.0	22.2
Up. Copernicus	49	59.2	30.6	10.2	40	47.5	40.0	12.5	59	66.1	22.0	11.9	46	54.3	23.9	21.8
SMOS Asc.	120	60.8	20.0	19.2	98	69.4	21.4	9.2	70	58.6	14.3	27.1	31	67.7	19.4	12.9
SMOS Desc.	117	59.0	21.4	19.6	99	67.7	17.2	15.1	72	58.3	15.3	26.4	46	58.7	23.9	17.4
SMAP					102	83.3	10.8	4.9								
AMSR2 Asc.	162	58.0	16.7	25.3	167	73.1	10.2	16.7	123	65.0	10.6	24.4	123	60.2	14.6	25.2
AMSR2 Desc.	151	63.6	11.3	25.1	172	64.5	13.4	22.1	125	59.2	16.0	24.8	108	53.7	18.5	27.8

$\mu_{A+} = 63.2\%$

$\mu_{A-} = 18.8\%$

$\mu_{IA+} = 18.0\%$

ALL-SOURCE consistency COMPARISON for Chiese

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Non-Irrigation	2015			2016			2017			2018		
	n	%A+	%A-	n	%A+	%A-	n	%A+	%A-	n	%A+	%A-
Active	148	55.4	44.6	146	58.2	41.8	125	52.4	47.6	73	38.4	61.6
Passive	130	50.8	49.2	136	52.9	47.1	127	51.2	48.8	63	45.2	54.8
Combined	18	61.1	38.9	24	75.0	25.0	21	61.9	38.1	6	33.3	66.7
Copernicus	20	44.1	55.9	58	46.3	53.7	52	50.1	49.9	37	53.1	46.9
Up. Copernicus	21	38.1	61.9	62	45.2	54.8	67	58.2	41.8	38	57.9	42.1
SMOS Asc.	95	57.9	42.1	84	47.6	52.4	108	54.6	45.4	50	52.0	48.0
SMOS Desc.	86	52.3	47.7	62	41.9	58.1	82	48.8	51.2	47	53.2	46.8
SMAP				55	53.6	46.4						

$\mu_{A+} = 52.9\%$

$\mu_{A-} = 47.1\%$

$\mu_{A+} = 63.2\%$

$\mu_{A-} = 25.4\%$

$\mu_{IA+} = 11.4\%$

Irrigation	2015				2016				2017				2018			
	n	%A+	%A-	%IA+	n	%A+	%A-	%IA+	n	%A+	%A-	%IA+	N	%A+	%A-	%IA+
Active	125	51.2	27.2	21.6	155	50.3	31.6	18.1	154	56.2	27.5	16.3	79	46.8	45.6	7.6
Passive	148	75.0	9.5	15.5	147	70.7	14.3	15.0	147	70.7	12.9	16.4	74	65.3	26.7	8.0
Combined	42	83.3	2.4	14.3	61	83.6	4.9	11.5	58	79.3	12.1	8.6	34	76.5	17.6	5.9
Copernicus	43	54.0	41.1	4.9	33	61.0	32.8	6.2	73	63.9	29.1	7.0	69	58.7	36.6	4.7
Up. Copernicus	44	45.5	50.0	4.5	35	57.1	40.0	2.9	80	61.3	31.3	7.4	68	57.4	41.2	1.4
SMOS Asc.	102	69.6	14.7	15.7	100	58.0	25.0	17.0	101	59.4	22.8	17.8	76	63.2	30.3	6.6
SMOS Desc.	98	61.2	24.5	14.3	93	58.1	28.0	14.0	91	57.1	24.2	18.7	80	63.8	31.3	5.0
SMAP					43	85.7	14.3	0.0								

Conclusions

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- For both case studies and all products consistency analysis allows to explain SSM variability with similar percentage of agreement
- No SSM product shows a uniform and systematic consistency with the rainfall data
- In the non-irrigation period, some datasets show consistency just about half of the time
- During irrigation periods, consistency increases, mainly because of artificial irrigation
- Some inconsistencies may be due to the presence of unregistered irrigation volumes (private wells instead of consortium aqueduct)
- L-band products seem to perform slightly better than C-band ones