The International Soil Moisture Network in support of SMAP calibration and validation

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The International Soil Moisture Network (ISMN)

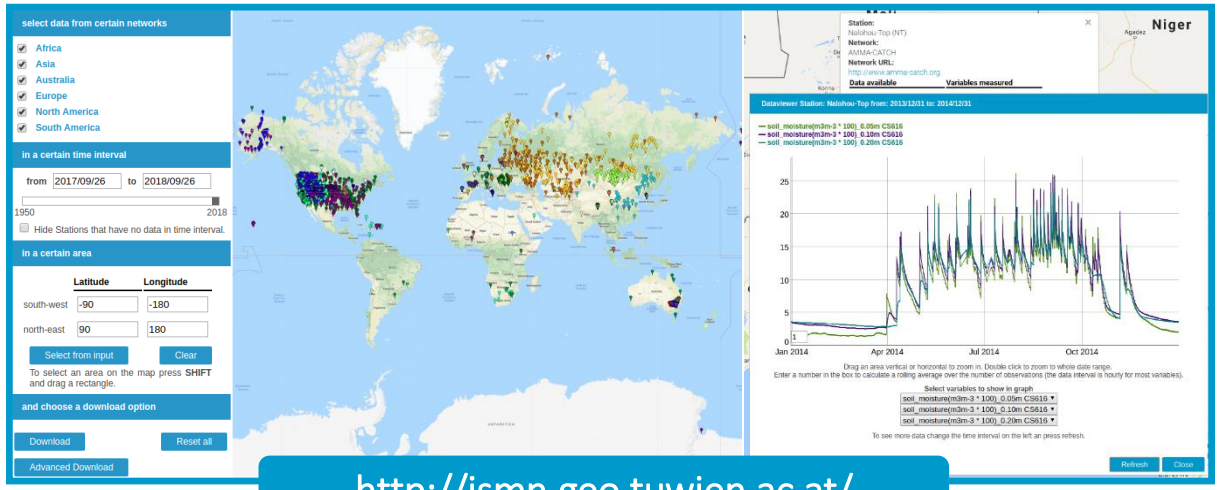
= a global **in situ** (surface and subsurface) soil moisture database

- established in 2009
- international cooperation
- motivation = validation of satellite soil moisture based products
  - climate monitoring : soil moisture key role
  - long term observations of major interest
- crucial for soil moisture products = reliable/consistent validation datasets

Functionality of the ISMN

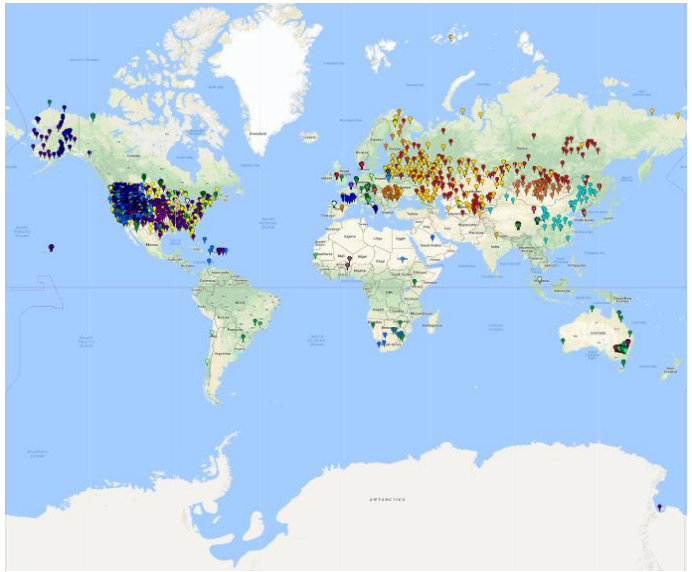
Data collection → Data harmonization → Quality control → Database storage → Data portal

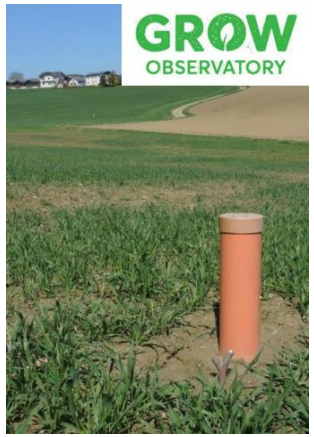
Metadata

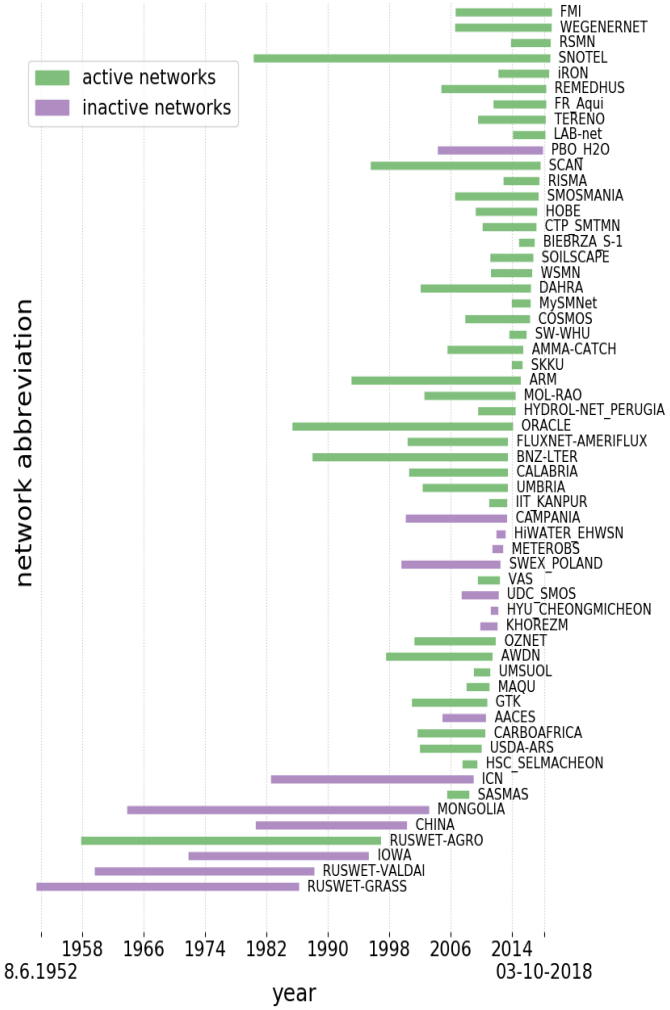


http://ismn.geo.tuwien.ac.at/

Data Collection → Data Harmonization → Quality Control → Database Storage → Data Portal







- only in situ data + metadata
- 8 different variables
- 59 networks (status October 2018)
- 2438 stations (status October 2018)
- measurements from several depths
- data from 1952 up to near real time
- about 10.000 datasets available

- metadata from provider
  - e.g.: coordinates, sensor type, depth, etc.
- model based metadata
  - 3 additional datasets used (**climate class**, **land cover** and **soil texture**)

KÖPPEN-GEIGER CLIMATE CLASSIFICATION

land cover cci

Harmonized World Soil Database

Info for each station

quantity_name	unit	depth_from[m]	depth_to[m]	value	description	quantity_source_name	quantity_source_description	quantity_source_provider	quantit
saturation	m^3*m^-3	0.00	0.30	0.62		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Research/LU
clay fraction	% weight	0.00	0.30	11.00		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Researc
organic carbon	% weight	0.00	0.30	4.38		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Researc
sand fraction	% weight	0.00	0.30	46.00		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Researc
silt fraction	% weight	0.00	0.30	43.00		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Researc
saturation	m^3*m^-3	0.30	1.00	0.45		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Research/LU
clay fraction	% weight	0.30	1.00	12.00		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Researc
organic carbon	% weight	0.30	1.00	1.47		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Researc
sand fraction	% weight	0.30	1.00	56.00		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Researc
silt fraction	% weight	0.30	1.00	32.00		HWSD	Harmonized World Soil Database v1.1 by IIASA	IIASA	v1.1;30";;http://webarchive.iiasa.ac.at/Researc
land cover classification				70	Tree cover, needleleaved, evergreen, closed to open (>15%)	CCI_landcover_2000	ESA CCI Land Cover	ESA	2000-v1.6.1
land cover classification				70	Tree cover, needleleaved, evergreen, closed to open (>15%)	CCI_landcover_2005	ESA CCI Land Cover	ESA	2005-v1.6.1
land cover classification				70	Tree cover, needleleaved, evergreen, closed to open (>15%)	CCI_landcover_2010	ESA CCI Land Cover	ESA	2010-v1.6.1
climate classification				Dsb	Cold - Dry Summer - Warm Summer	koeppen geiger 2007	Koeppen-Geiger Climate Classification		Peel2007	0.1°		http://w

Example of metadata stored in ISMN database.

PROVIDER

ISMN standard

Data Harmonization:

- every network provider has its own system
  - data access (http, ftp, E-Mail)
  - data format
  - unit
- unit conversion
- unified data format

Quality Control:

- data is flagged not erased
- quality flag added to each measurement (CEOP standards)
  - **Geophysical Dynamic Range** (threshold for each variable)
  - **Geophysical Consistency** (additional variable → Nasa`s GLDAS Noah data)
  - **Spectrum– Based Approach** (data spikes , data plateaus)

Data Collection → Data Harmonization → **Quality Control** → Database Storage → Data Portal

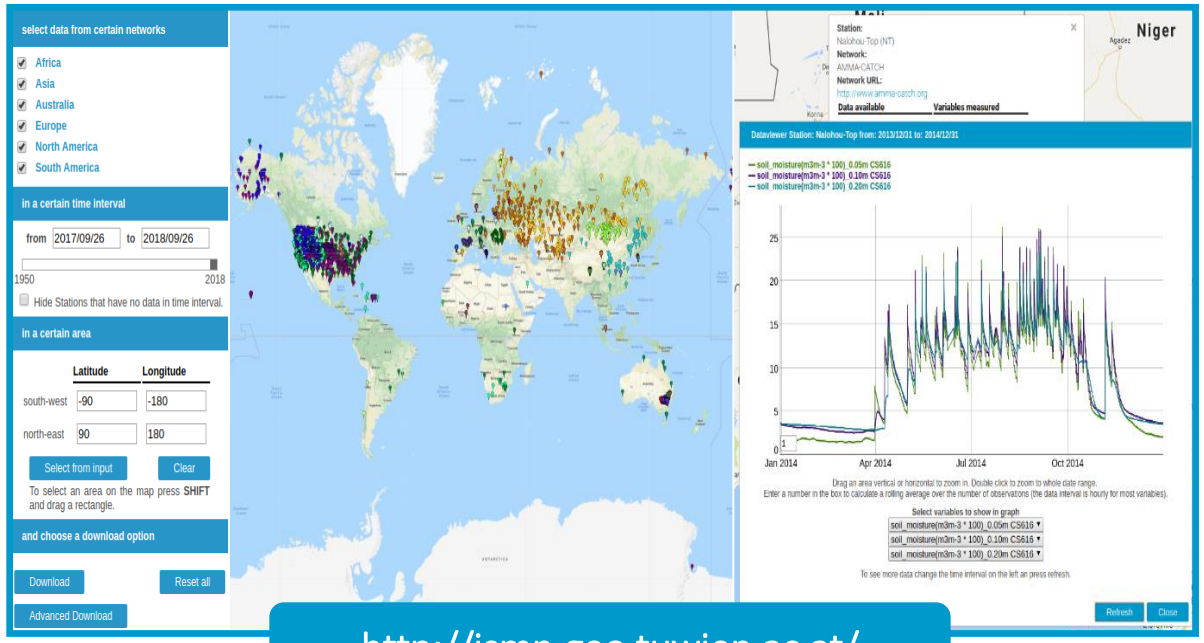
A quality flag is added to each measurement, following the CEOP standards.

Flag value	Definition
C	Reported value exceeds output format field size OR was negative precipitation.
M	Parameter value missing OR derived parameter can not be computed.
D	Questionable/dubious
G	Good

C - reported value exceeds output format field size	C01	soil moisture < 0.0 m^3/m^3
	C02	soil moisture > 0.6 m^3/m^3
	C03	soil moisture > saturation point (derived from HWSD parameter values)

- **Database storage :**
  metadata + data timeseries + flags (+ network related flags (rarely))

- **ISMN Webpage**



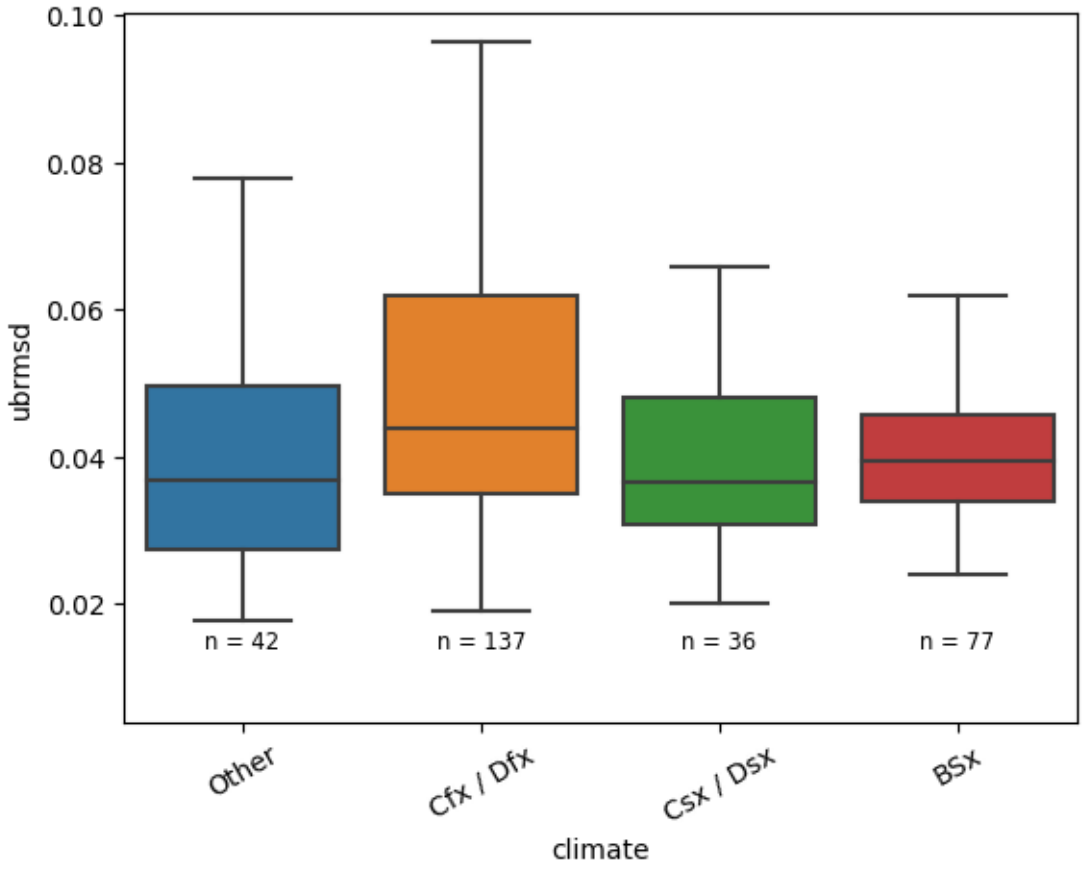
http://ismn.geo.tuwien.ac.at/

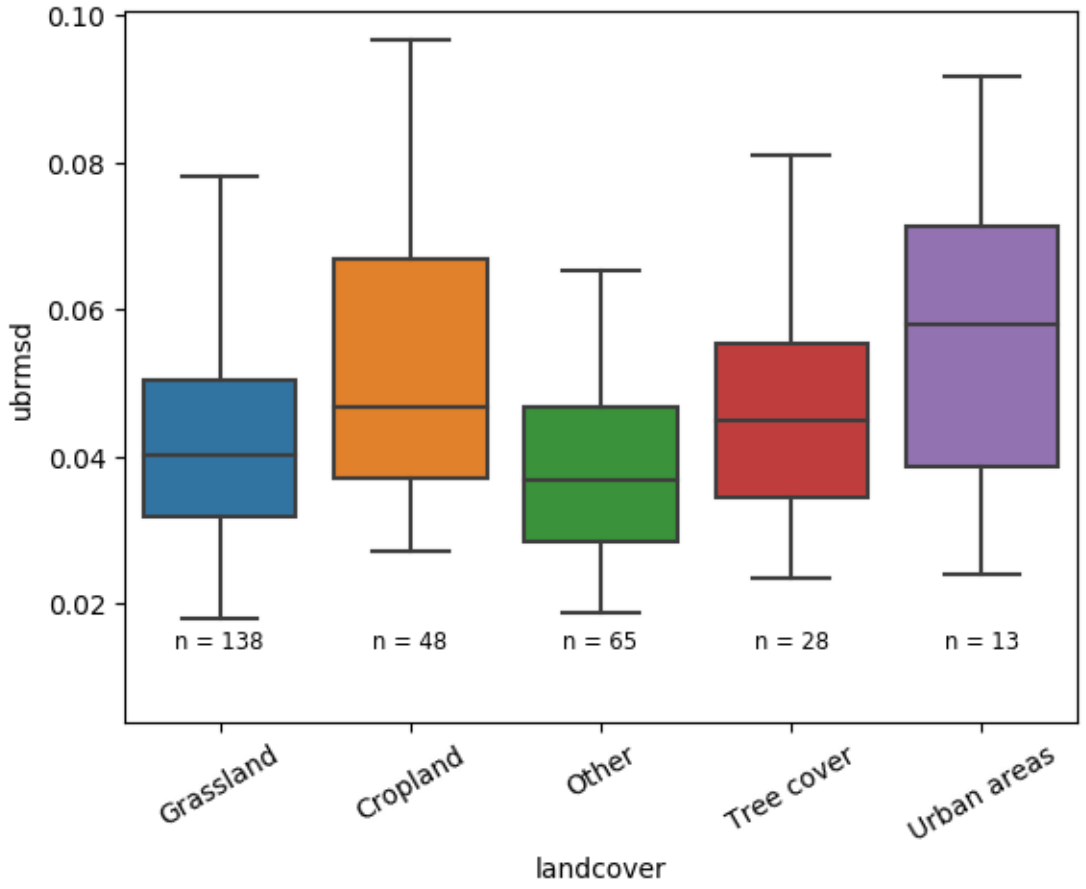
- viewing data is always possible
- free data access only when registered
- 2 text formats are available

- SQL quering directly from database possible (advanced download)

- > 2600 users
- > 300 new users /year

ISMN for SMAP validation





Tools

Python packages on github:

ismn

Readers for the data from the International Soil Moisture Network

remote-sensing | soil-moisture | ismn | in-situ

Python | 3 | MIT | Updated on Jul 25

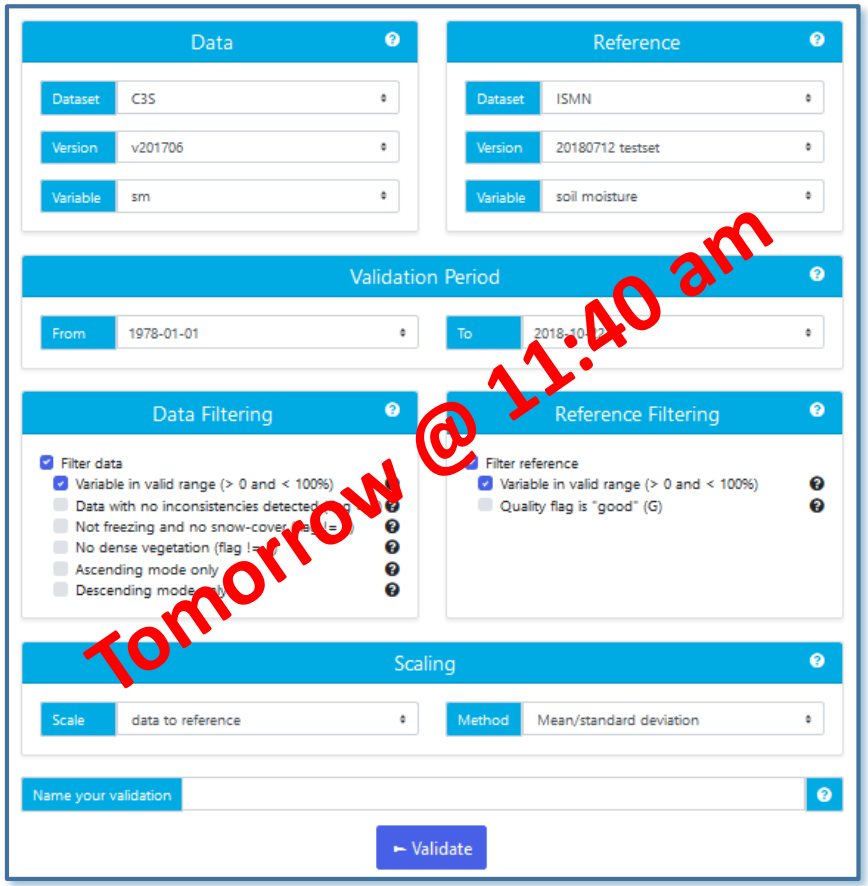
pytesmo

python Toolbox for the Evaluation of Soil Moisture Observations

python | validation | remote-sensing | earth-science | soil-moisture

Python | 13 | 21 | Updated on Aug 29

QA4SM:



Questions?

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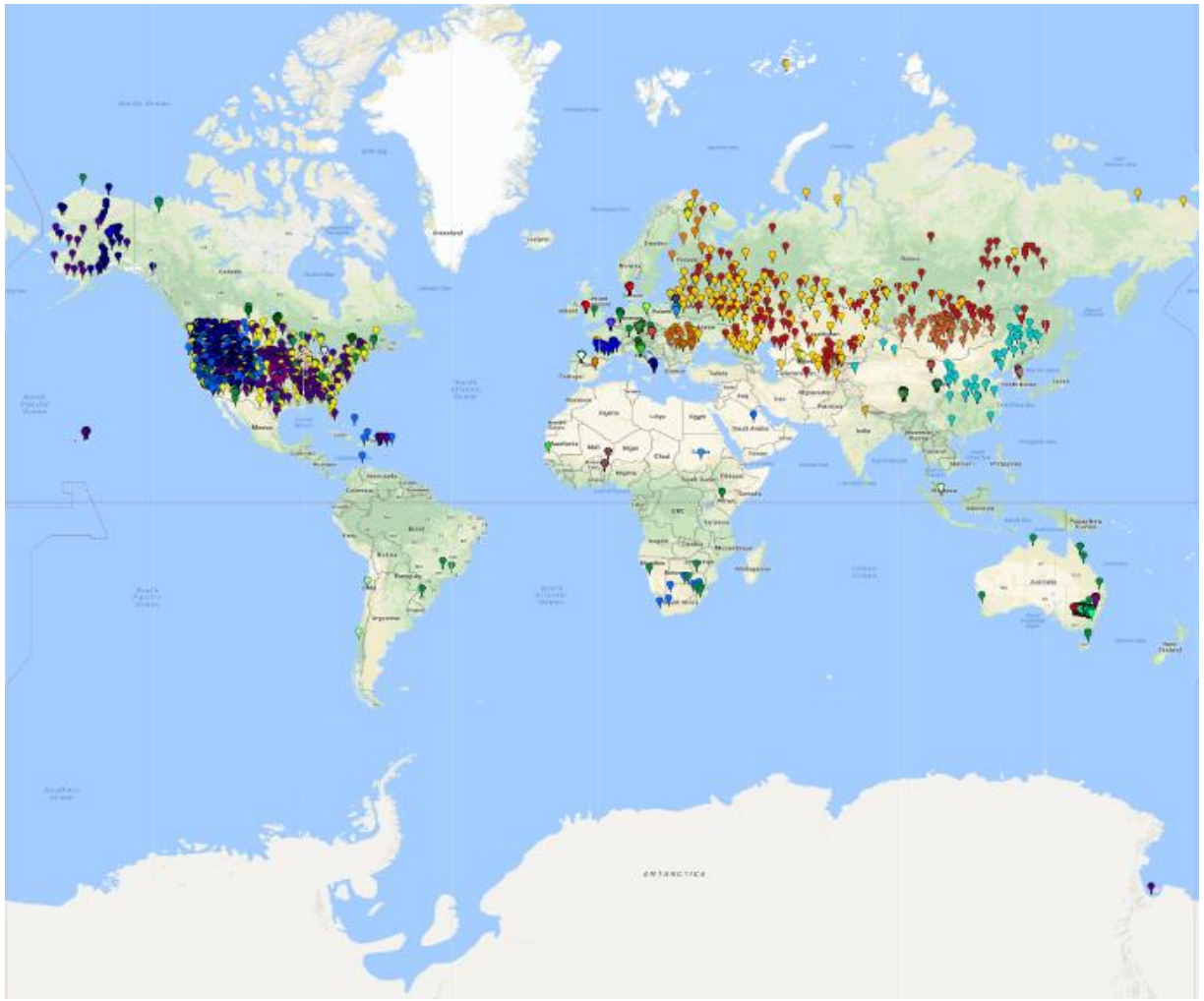
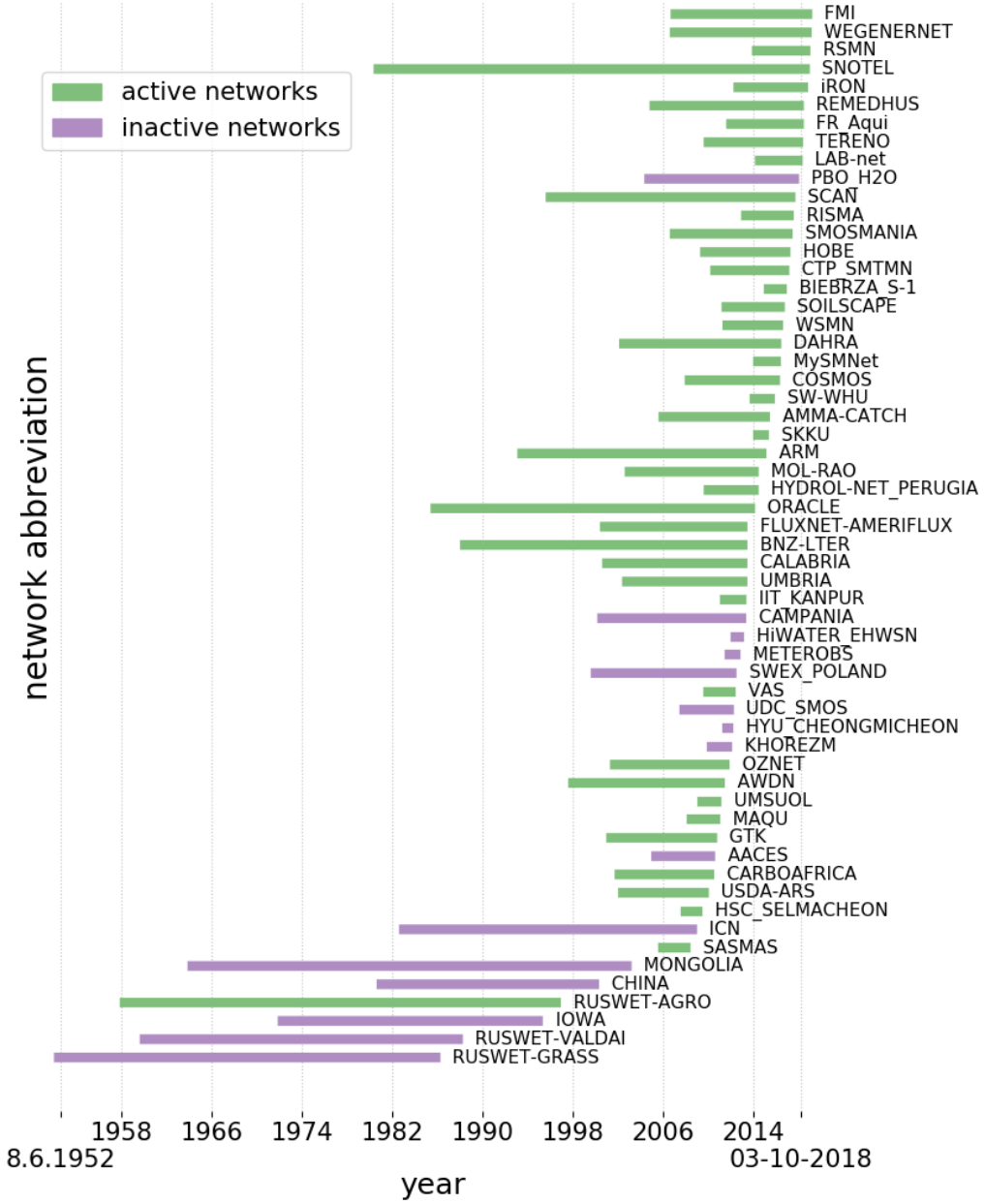
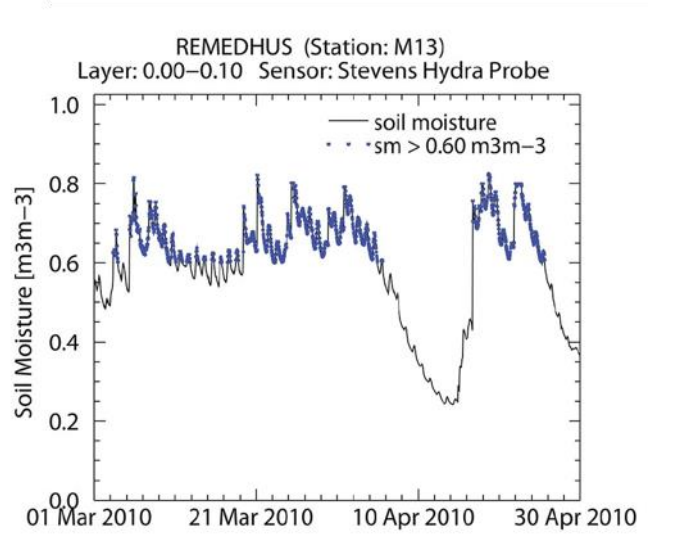
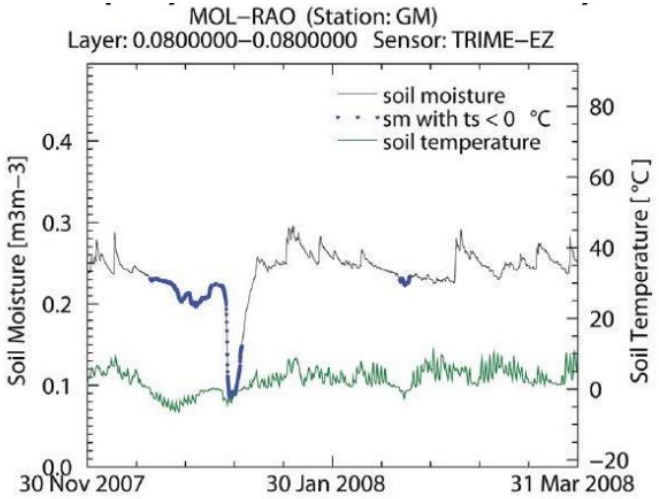
http://climers.geo.tuwien.ac.at

Supplementary Slides




active networks
inactive networks
network abbreviation
FMI
WEGENERNET
RSMN
SNOTEL
iRON
REMEDHUS
FR_Aqui
TERENO
LAB-net
PBO_H2O
SCAN
RISMA
SMOSMANIA
HOBE
CTP_SMTMN
BIEBRZA_S-1
SOILSCAPE
WSMN
DAHRA
MySMNet
COSMOS
SW-WHU
AMMA-CATCH
SKKU
ARM
MOL-RAO
HYDROL-NET_PERUGIA
ORACLE
FLUXNET-AMERIFLUX
BNZ-LTER
CALABRIA
UMBRIA
IIT_KANPUR
CAMPANIA
HiWATER_EHWSN
METEROBS
SWEX_POLAND
VAS
UDC_SMOS
HYU_CHEONGMICHEON
KHOREZM
OZNET
AWDN
UMSUOL
MAQU
GTK
AACES
CARBOAFRICA
USDA-ARS
HSC_SELMACHEON
ICN
SASMAS
MONGOLIA
CHINA
RUSWET-AGRO
IOWA
RUSWET-VALDAI
RUSWET-GRASS
1958
1966
1974
1982
1990
1998
2006
2014
8.6.1952
03-10-2018
year



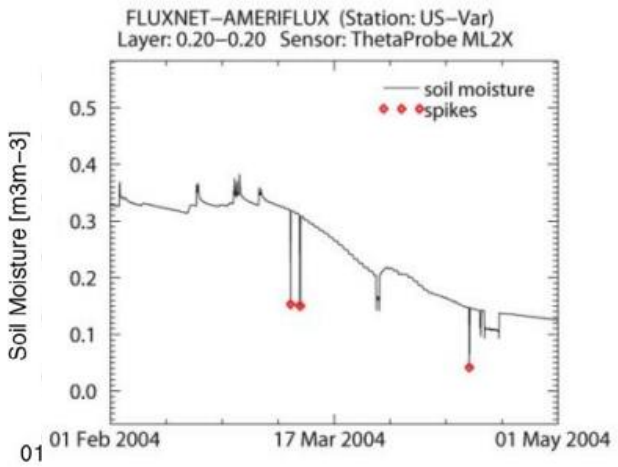


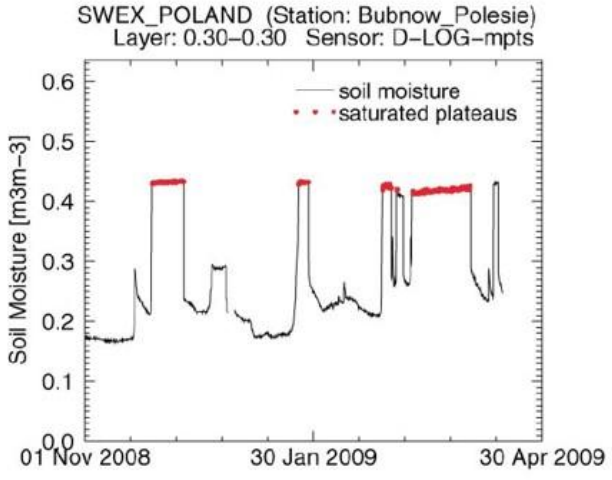
Geophysical Dynamic Range (flag values C01 – C03)

- simple threshold method
  (e.g. lower/upper boundary, saturation point, etc.)
- detects observations exceeding the geophysical plausibility range
- applied to all variables

Geophysical consistency (flag values D01 – D05)

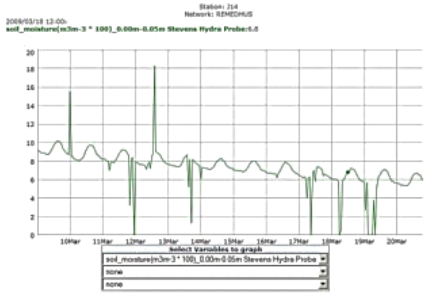
- additional variables needed
- information on reliability of observations
  (e.g.: soil moisture is flagged when soil temperature < 0°C)
- also with Nasa`s GLDAS NOAH datasets flagged

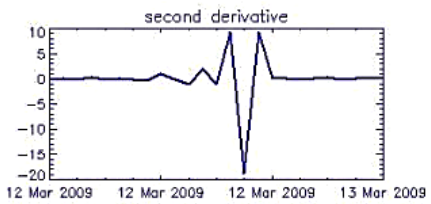


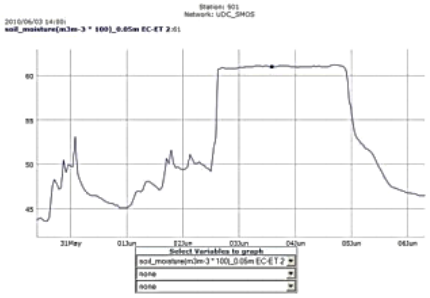


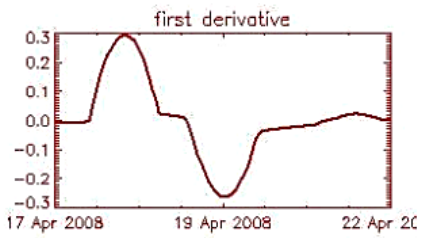
Spectrum– Based Approach (flag values D06 – D10)

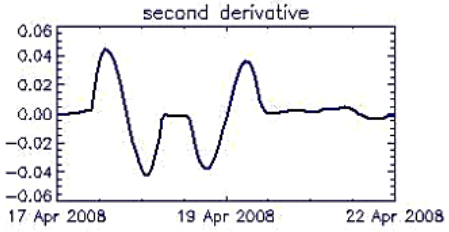
- detects erroneous measurements within the thresholds
- Savitzky- Golay filter is applied
  - finds first two derivatives of the observation





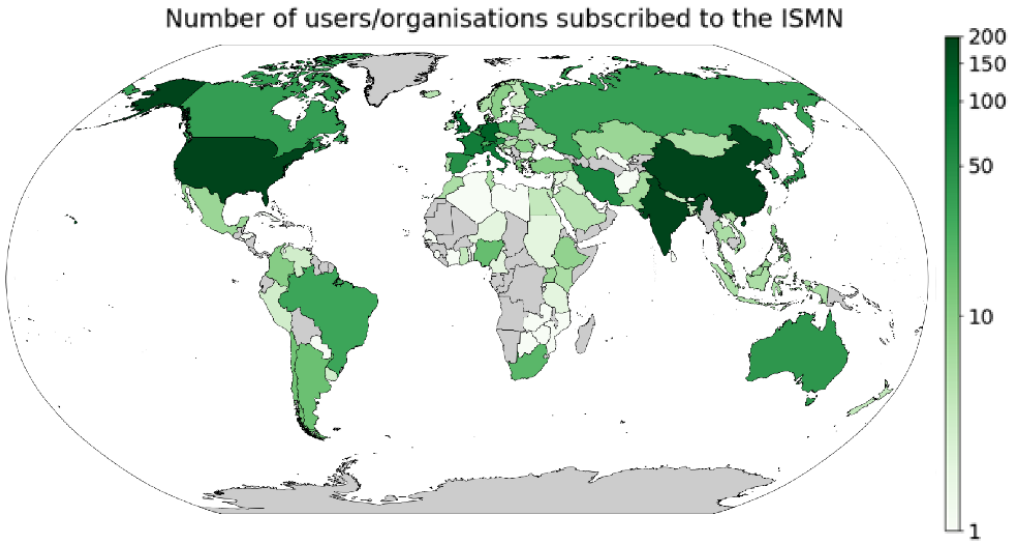


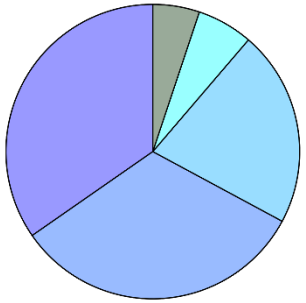


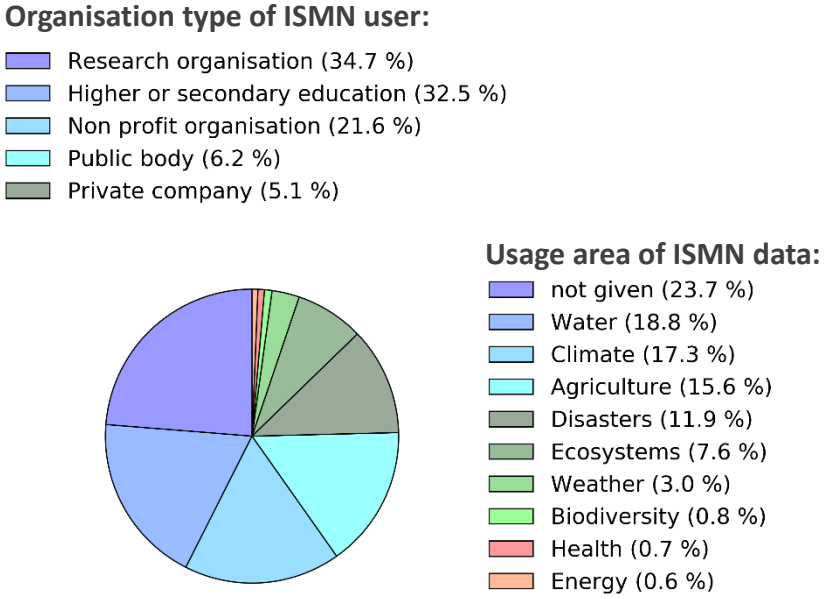


Data provider and user community

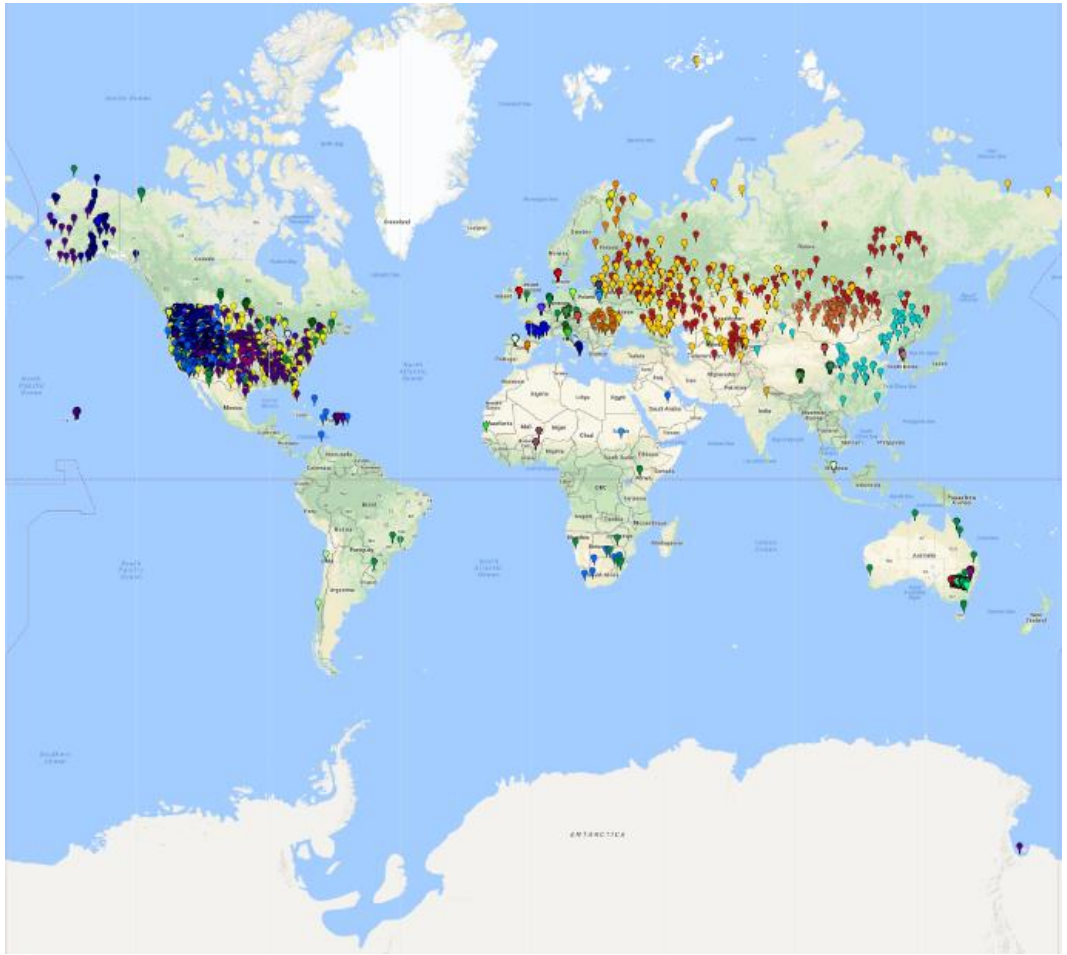
- **Provider**
  - ISMN platform for distributing their data
  - ½ yearly provider report: e.g. how many downloads of their data, etc.
- **User**







Status update and future ideas



- Several ISMN stations also SMAP cal/val sites
  - SCAN (USA), TERENO (Germany), etc.
  - soon: TXSON (USA, 42 stations) → nrt
  - future: HOAL (Austria)
- 578 peer-reviewed publications (making use of ISMN data)
  - 31 in 2018

Future ideas:

- New networks in data sparse regions
- Searching for high density networks

→ possible inclusion of low cost sensor data collected by citizen scientists!!

GROW OBSERVATORY