Applications of soil moisture measurements from SMOS within the Copernicus European and global Flood Awareness Systems (EFAS & GloFAS)

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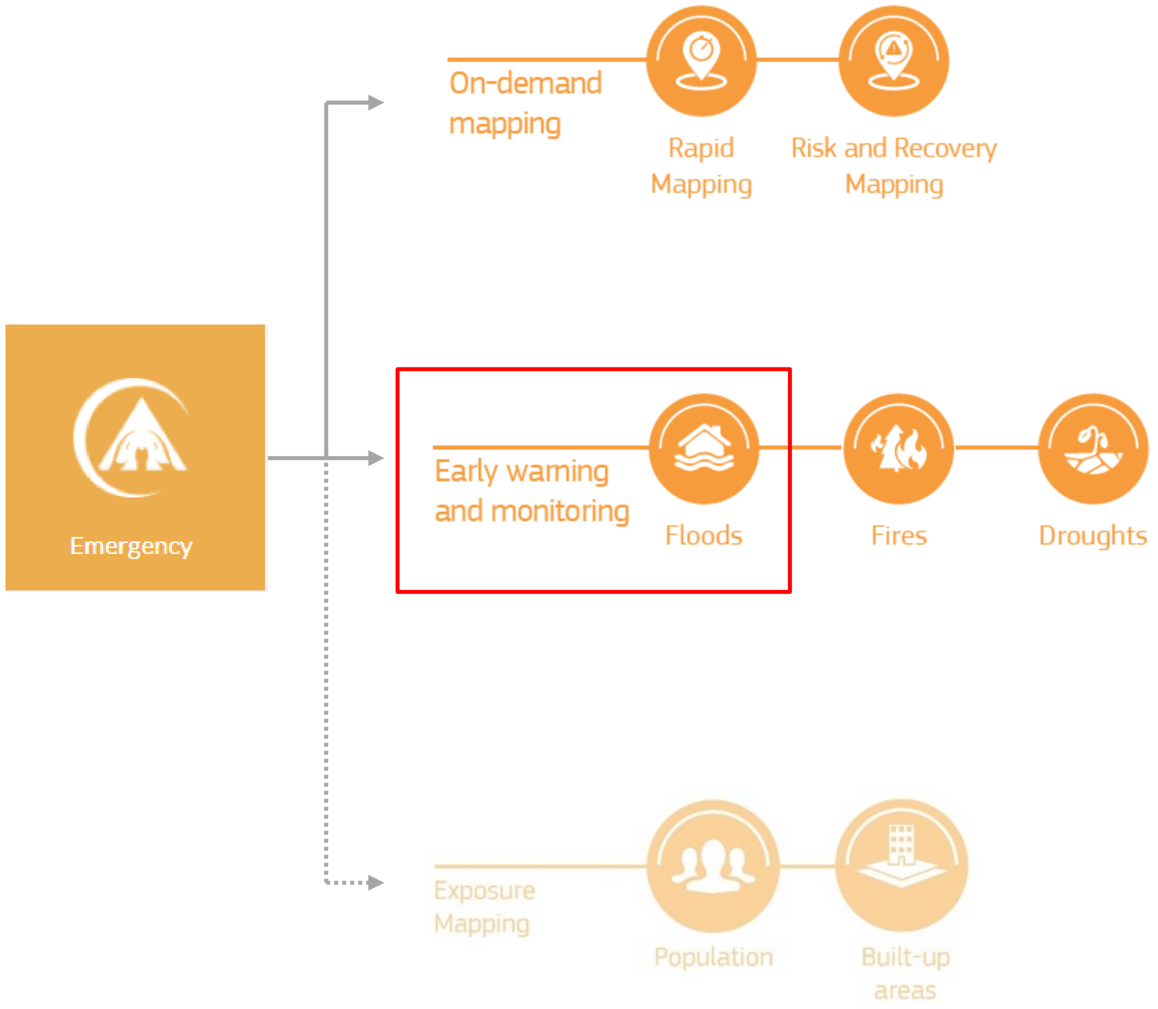
Outline

1. Introduction to Copernicus Emergency Management Service
2. Soil moisture experiments with SMOS data
   - GloFAS data assimilation
   - Estimation of irrigation
3. Conclusions

CEMS service components



Copernicus EMS On Demand Mapping provides on-demand detailed information for selected emergency situations that arise from natural or man-made disasters anywhere in the world.

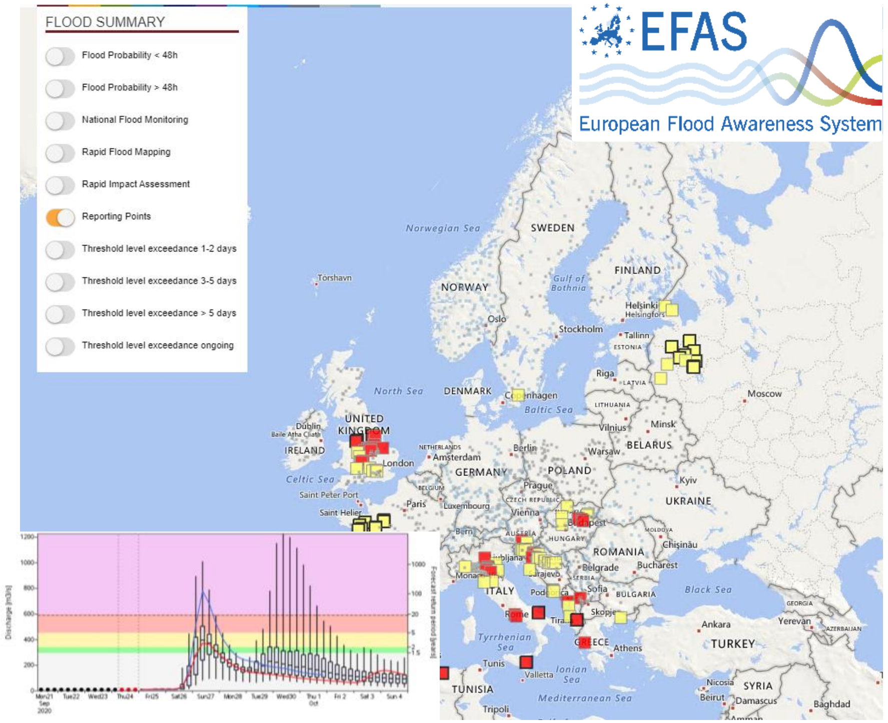
Copernicus EMS Early Warning and Monitoring offers critical geospatial information at European and global level through continuous observations and forecasts for floods, droughts and forest fires.

Copernicus EMS Exposure Mapping will offer global, harmonised and regularly updated information population, built-up areas and exposure.

CEMS Flood Forecast Systems

European Flood Awareness System (EFAS)

- European forecasts
- 5 km resolution, 6 hourly time step
  - Planned upgrade to ~1.6 km
- Open access 30 days after forecast has been produced
  - Before this data are restricted to flood warning agencies
- efas.eu

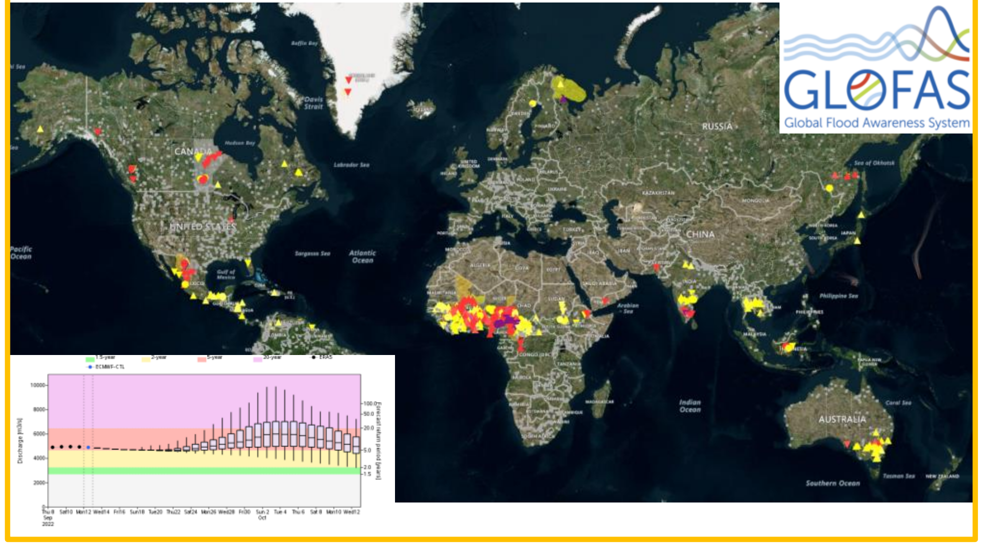


Global Flood Awareness System (GloFAS)

- Global forecasts
- ~10 km resolution, daily time step
  - Planned upgrade to ~5 km

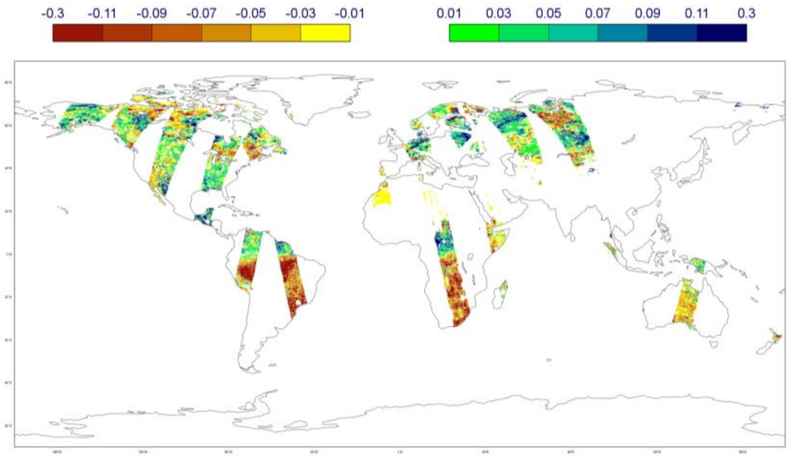
Open access, >2000 registered users

globalfloods.eu



Use of Satellite Data

1. Static input datasets
   - Topography – channel properties
   - Land cover – e.g. crop fractions
2. Data assimilation
   - ECMWF NWP forcings



SMOS soil moisture innovations [obs-model] *From Patricia de Rosnay*

LDAS adds large amounts of soil water e.g. Australia, southern Africa and Brazil

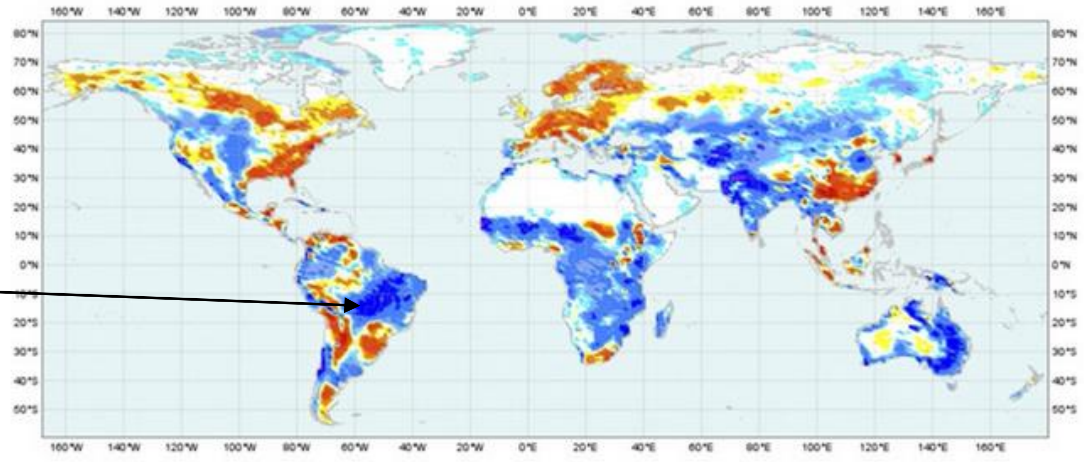
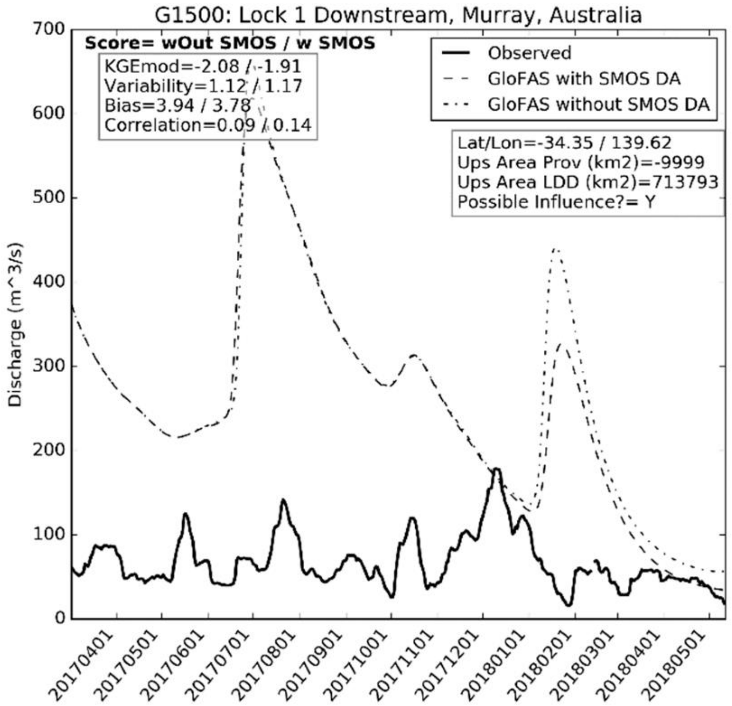


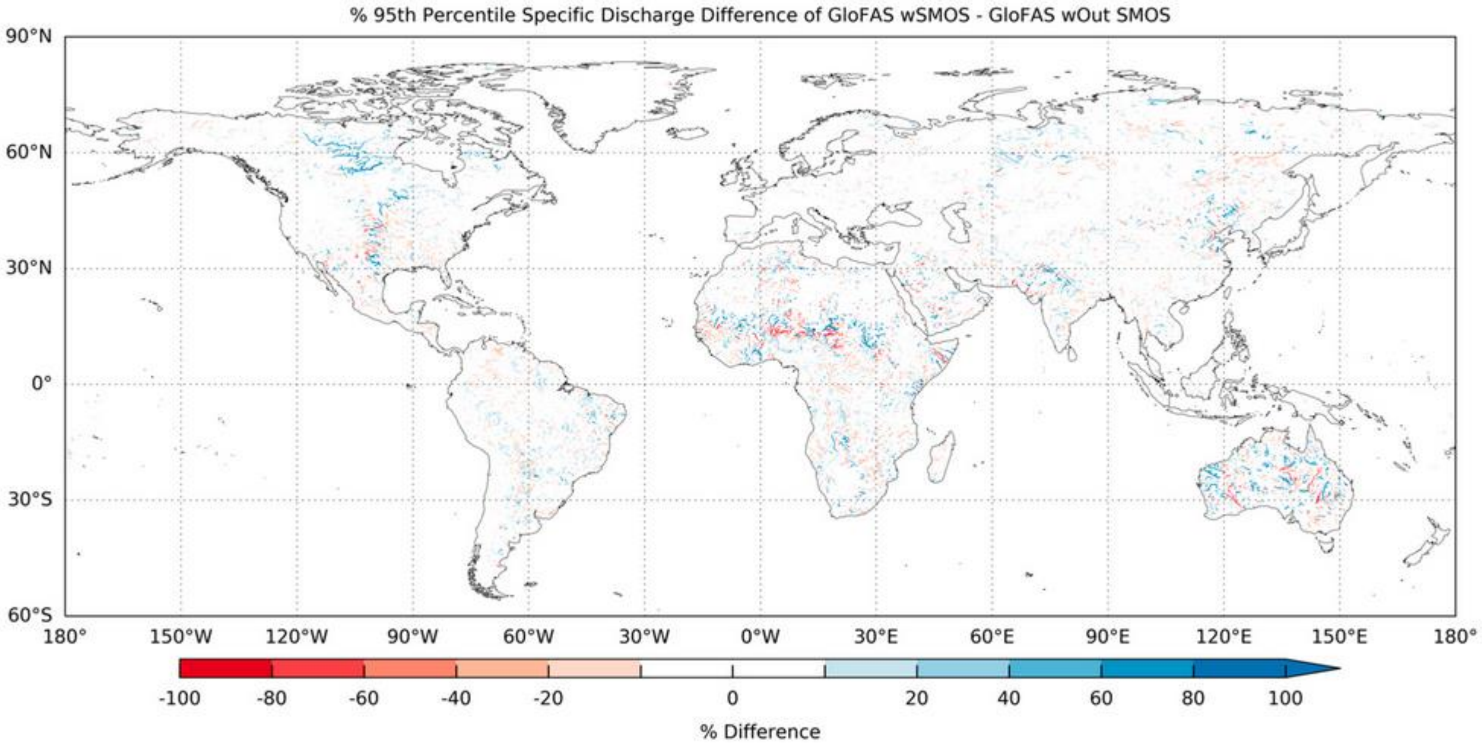
Figure from Zsoter *et al.*, 2019

SMOS Data Assimilation within GloFAS

Data denial experiments with SMOS show muted impact on streamflow

- Biases and poor correlation remain



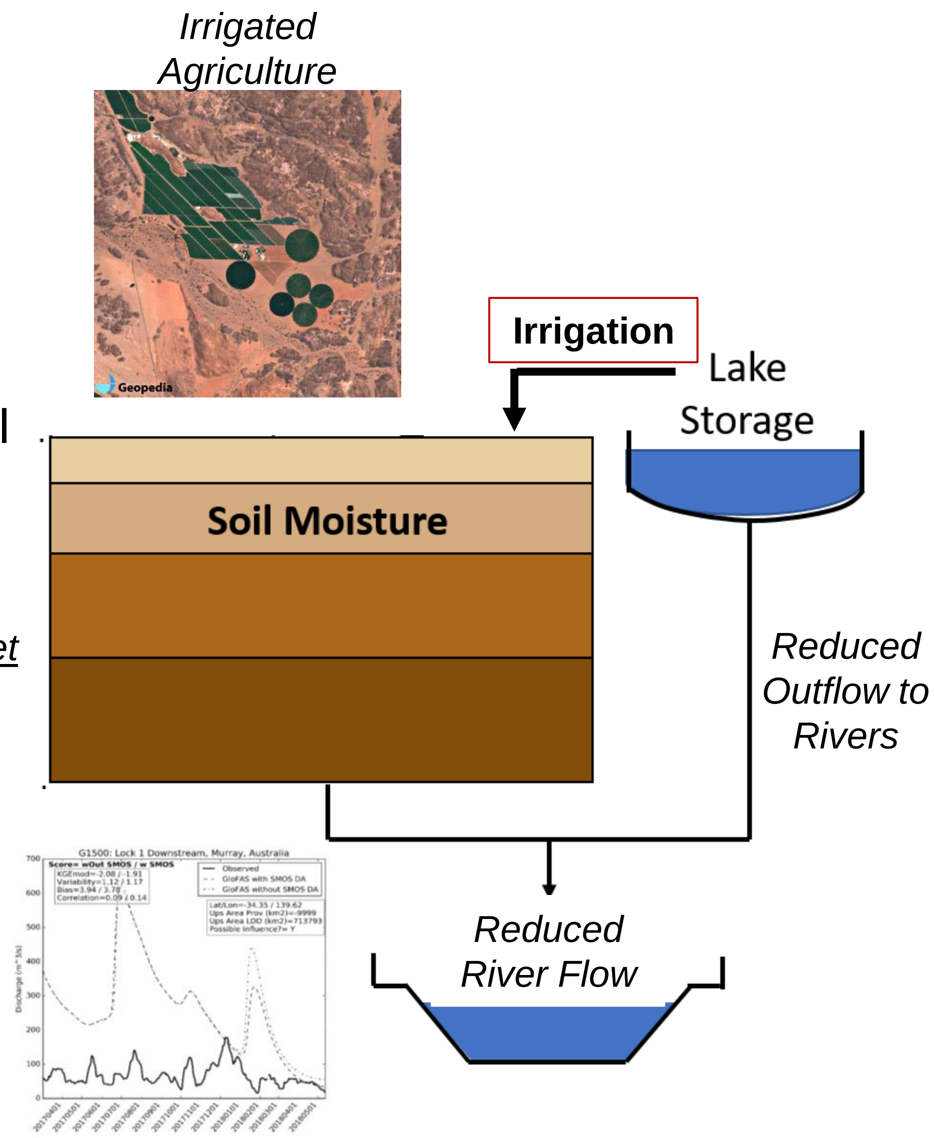


- ECMWF LDAS corrects for random errors, not systematic ones
- Process errors in Australia for example, maybe poor representation of processes such as irrigation and lake storage

Estimating Irrigation from SMOS

- Hydrological performance in irrigated basins is often poor
- Can EO identify & quantify irrigation?; How do we incorporate this into our hydrological modelling?
- Irrigation computed as difference in soil moisture between a model which doesn't consider irrigation and satellite soil moisture which does
- Using SMOS *(sat)* and ERA5-Land *(mod)*, irrigation *(I)* as: (Zaussinger et al., 2019)

$$I(t) = \frac{d\theta^{sat}}{dt} - \frac{d\theta^{mod}}{dt}$$

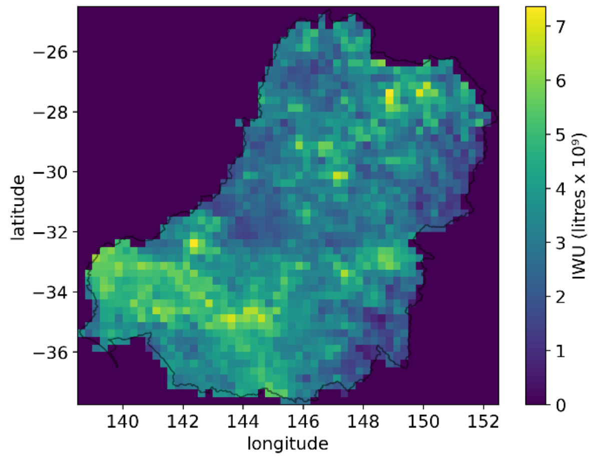


Estimating Irrigation from SMOS

Results: Murray-Darling, Australia

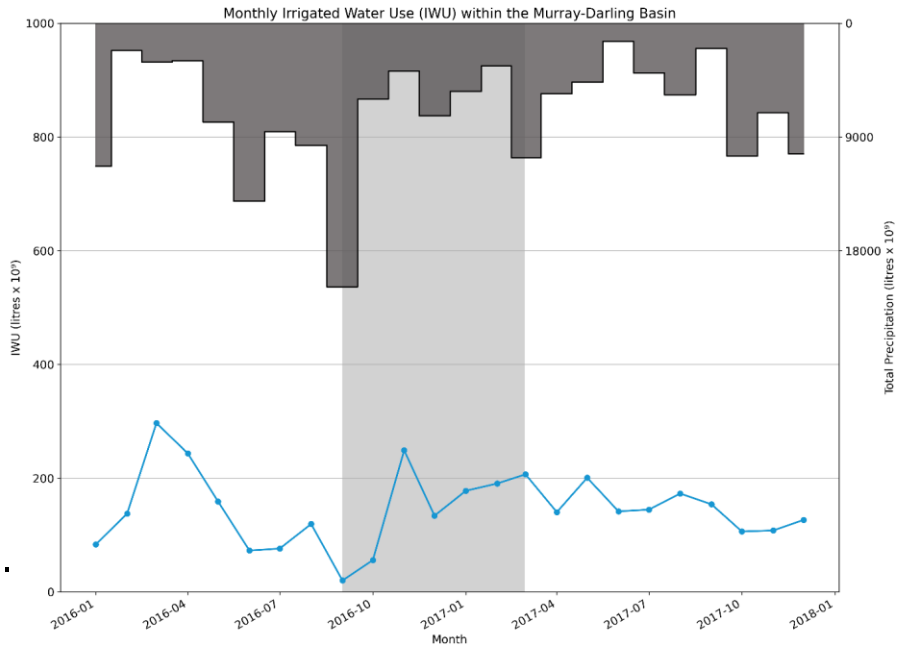
- Irrigation estimated too broadly spatially
- Temporal trend does not correlate to the growing season
- Estimated IWU volume under-estimates

Annual average irrigated water use estimated from SMOS

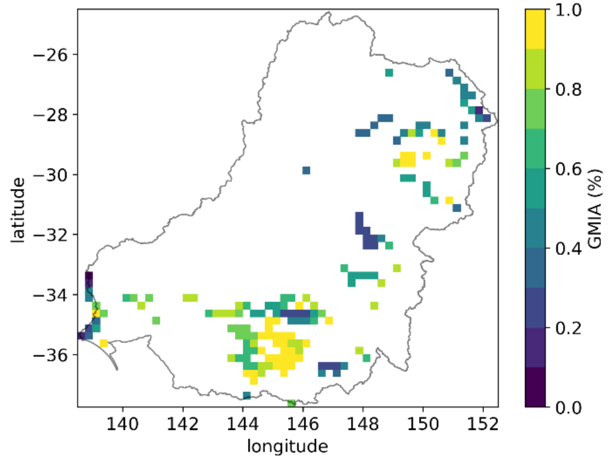


Time Period	Estimated IWU ($x10^9$ l)	Error ($x10^9$ l)
1st July 2016 - 30th June 2017	1,712	-4665
1st September 2016 - 28th February 2017 (growing season)	827	-5550

Estimated total IWU during specified time period. Error is versus reported irrigation totals from agricultural census



Estimated monthly basin total IWU (blue line). Light grey = growing season, dark grey = basin total precipitation



Observed irrigated fraction (GMIA)

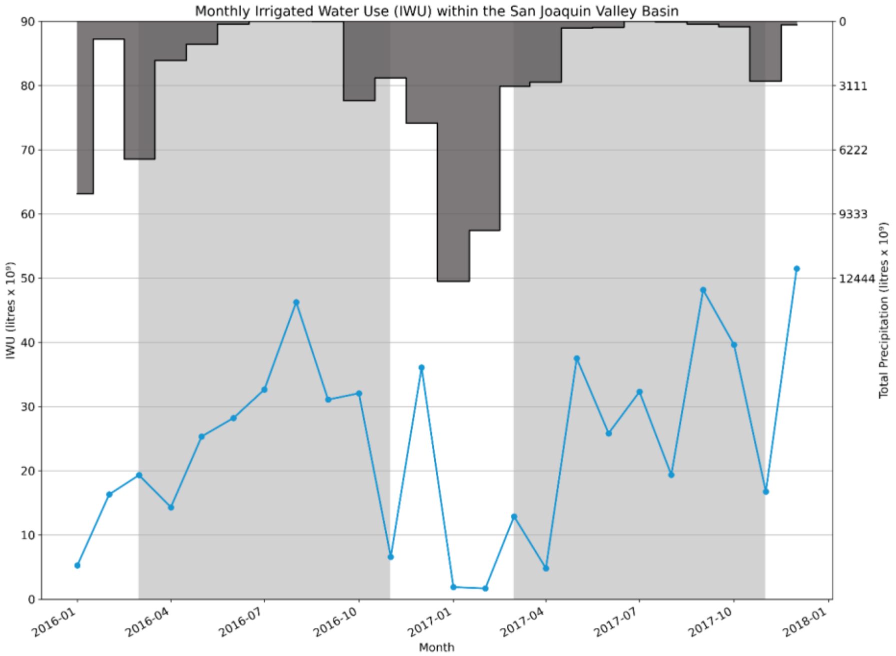
Estimating Irrigation from SMOS

Results: San Joaquin, USA

- Spatial estimates of irrigation extent are closer (but easier to match)
- Slightly better monthly trend of increasing irrigation during growing season
- Estimated IWU volume much larger than reported data

Time Period	Estimated IWU (x10⁹ l)	Error (x10⁹ l)
1st Jan 2017 – 31st Dec 2017	218	188
1st Mar 2017 – 30th Oct 2017 (growing season)	160	130

Estimated total IWU during specified time period. Error is versus reported irrigation totals from agricultural census



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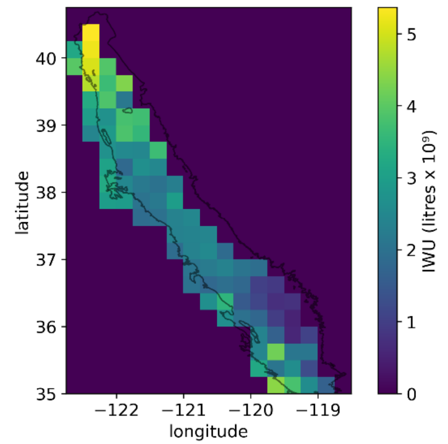

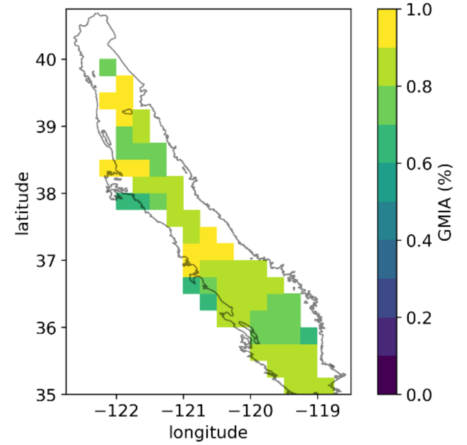

Observed irrigated fraction (GMIA)

Conclusions

- In our chosen study areas SMOS was not a reliable detector of irrigation
  - Irrigated and non-irrigated areas had similar signals
- Chosen areas could have efficient irrigation systems – require very high sensor accuracy to detect
  - Potentially more success in flood irrigated areas e.g. India, Spain
- Low spatial resolution – difficult to detect irrigation at field scales
- Previous studies with similar methods have had success
  - Perhaps an issue with our noise filtering

Future work:

- DestinE – high resolution land surface modelling and accompanying DA
- Post-processing of river discharge forecasts with EO estimated discharge