Tackling measurements of evapotranspiration at the field scale with superconducting gravimeters

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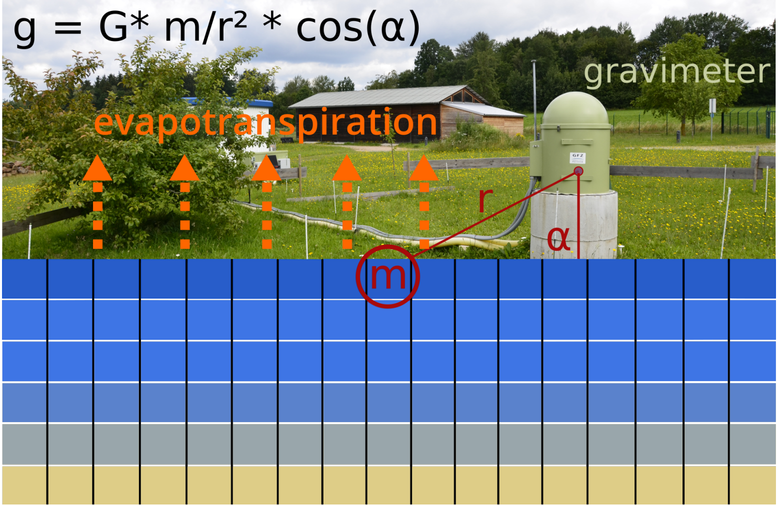
Overview

1. How do gravimeters measure what?
2. iGrav superconducting gravimeter (SG) at Wettzell
3. New approach for ET estimation with iGrav at Merzenhausen
4. (Preliminary) Conclusions

How do gravimeters measure what?



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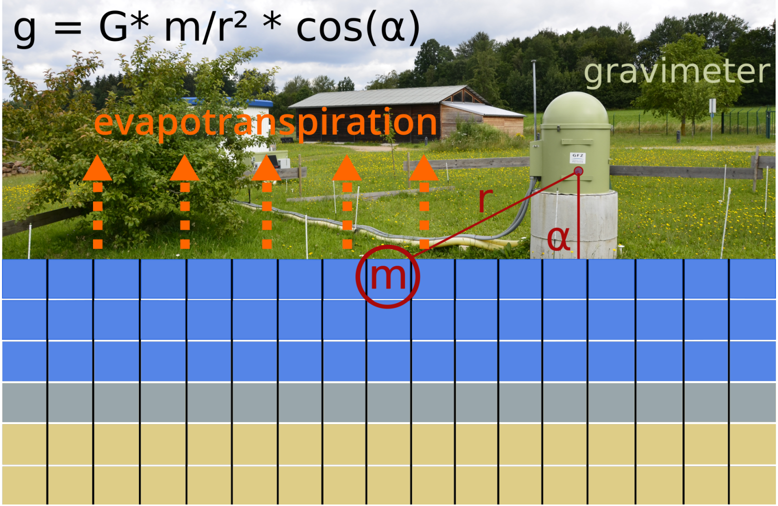

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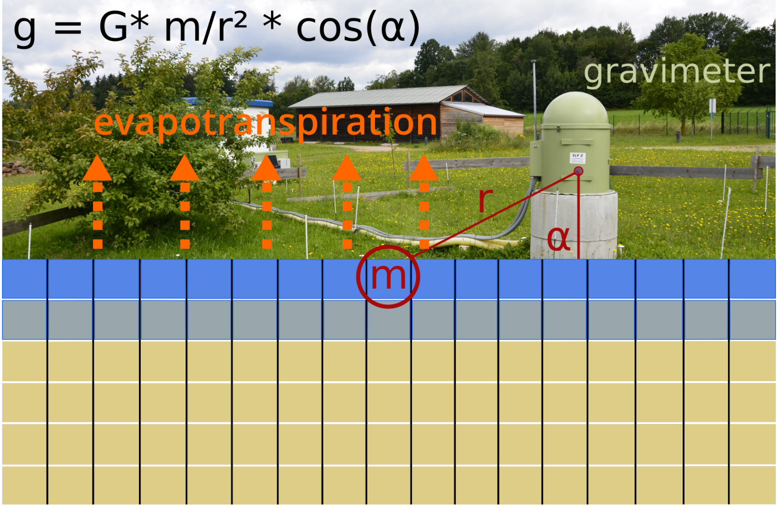
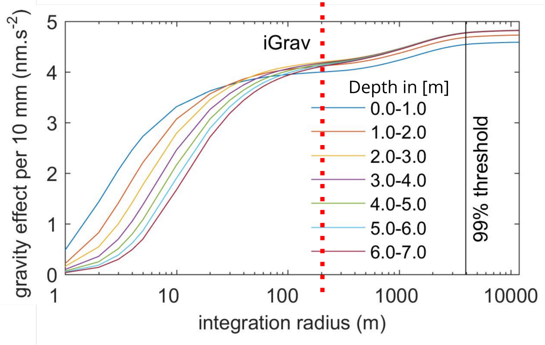


Geodetic Observatory Wettzell (South-East Germany)

- Superconducting gravimeter (iGrav) in field enclosure
- Extensive long-term hydrological monitoring network (TDR-cluster, lysimeter, groundwater wells)
- 2 years time series of first SG deployed in the field

iGrav in field enclosure

- Higher sensitivity to water storage dynamics (less umbrella effect) than conventional gravimeters
- Enables integrative monitoring of storage changes independent of their depth



Güntner et al. (2017)

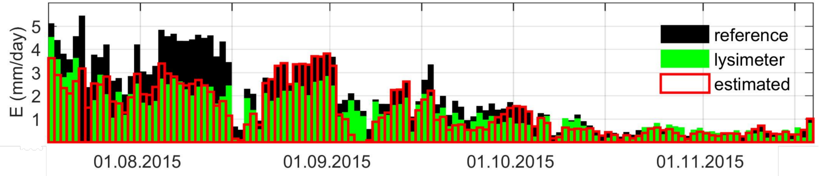
Water balance components from gravity observations

- Gravity signal has to be corrected for non-desired components (atmosphere, tides, global hydrology, etc.)
- $\frac{\delta S}{\delta t} = s * \frac{\delta g}{\delta t} = u * P - a * E_{ref} - c * R$
- Estimate factors via optimization, based on daily gravity variations
- Validation with data from lysimeter
- Evapotranspiration factor a by optimization: 0.69 (0.68 by lysimeter)

Güntner et al. (2017)

Estimating ET: lysimeter vs. water balance by iGrav

- ET estimated based on time series of gravity residuals
- Daily ET values via moving average (11 days window length)
- Compared and validated against ET based on lysimeter and reference ET
- Average error from ET_{grav} relative to $ET_{lysimeter}$: 0.4 mm / day



Güntner et al. (2017)

Extracting ET information from gravity observations

Goal: Direct extraction of daily ET from gravity observations

Suggested method:

1. Correct gravity observations for all non-desired components
2. Estimate daily ET rate as the difference of night-time gravity values of consecutive days
3. Compare to daily ET fom Eddy Covariance measurments and estimate errors

→ **First application on data from joint project between GFZ and FZJ**

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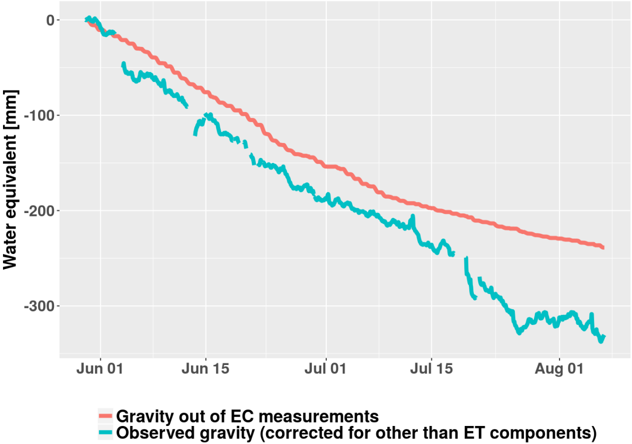
Merzenhausen (TERENO Eiffel / Lower Rhine Valley)

- Eddy Flux Tower, iGrav, climate station, cosmic ray, soilNET
- Joint dataset for one crop growing season
- Investigate possibility to use gravimetry for direct ET estimation
- Verify with additional measurements (soil moisture, precipitation)

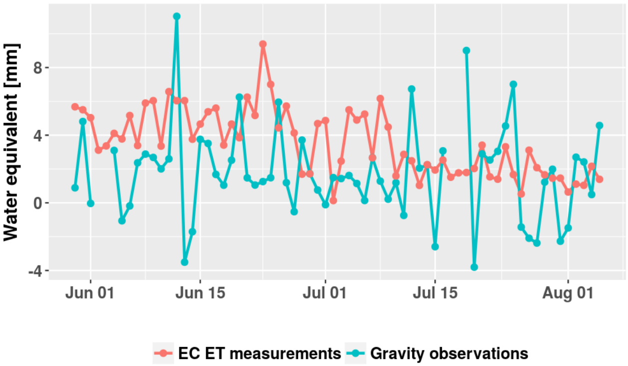
Time series of ET at Merzenhausen

- Observed gravity signal was corrected for all components except ET
- Trend similar
- Still contains some unexplained signal component

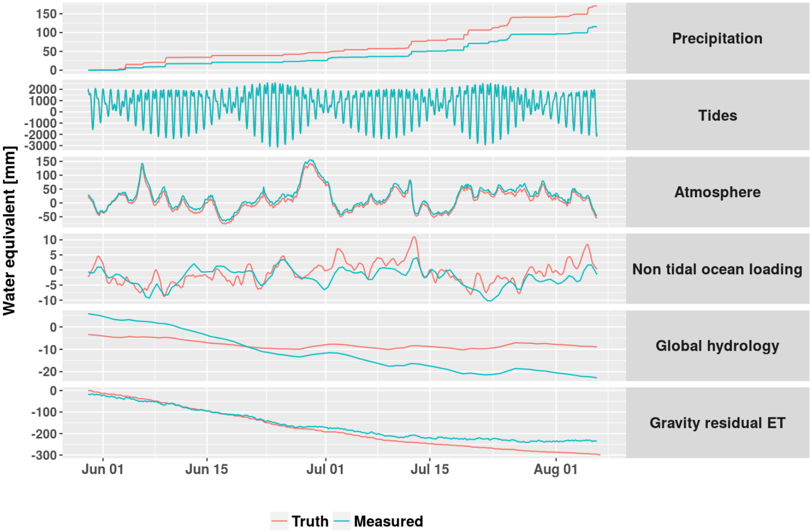


Preliminary results of daily ET estimation

- Method for differences of daily night-time gravity values applied to observed and corrected gravity signal



Components of gravity time series and their uncertainty

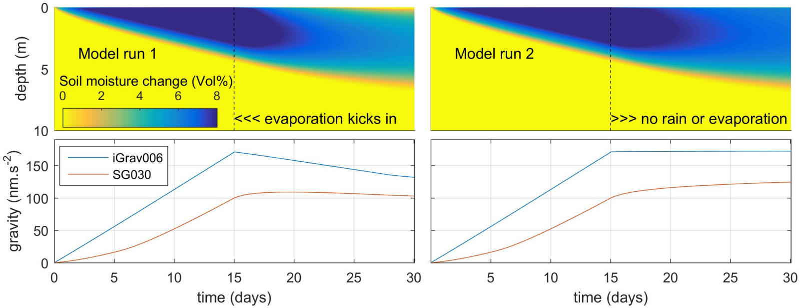


(Preliminary) Conclusions

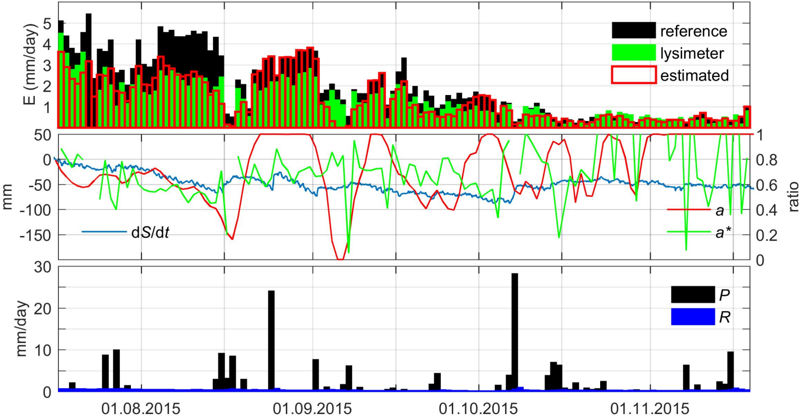
- Gravimeters in field enclosure improve direct monitoring of hydrological processes
- Water balance can be successfully described at field scale
- Long-term ET can reasonably be resolved
- ET estimation at (sub-)daily scale is still challenging
- For short periods of experiments, gravity component corrections need to be available with high accuracy

Direct monitoring of water balance

- Gravity residual is proportional to water storage changes
- Virtual experiments (HYDRUS) of infiltration and evapotranspiration to compare both OSG and iGrav
- iGrav measures constant precipitation with a quasi-linear relationship, OSG signal influenced by umbrella effect



Estimating ET: lysimeter vs. water balance by iGrav



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