The ASCAT tandem operation scenario and its implications on soil moisture retrievals

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ASCAT tandem operation

- ASCAT tandem phase initiated in Sept. 2012 with the launch of ASCAT-B
- ASCAT-A and B in same sun-synchronous orbit
  - phasing ~48 min. (~half an orbit)
- Phasing suboptimal for ASCAT sensor geometry around the equator
  - ASCAT-A right overlap ASCAT-B left swath
  - min. revisit times at equator ~ 48 min.

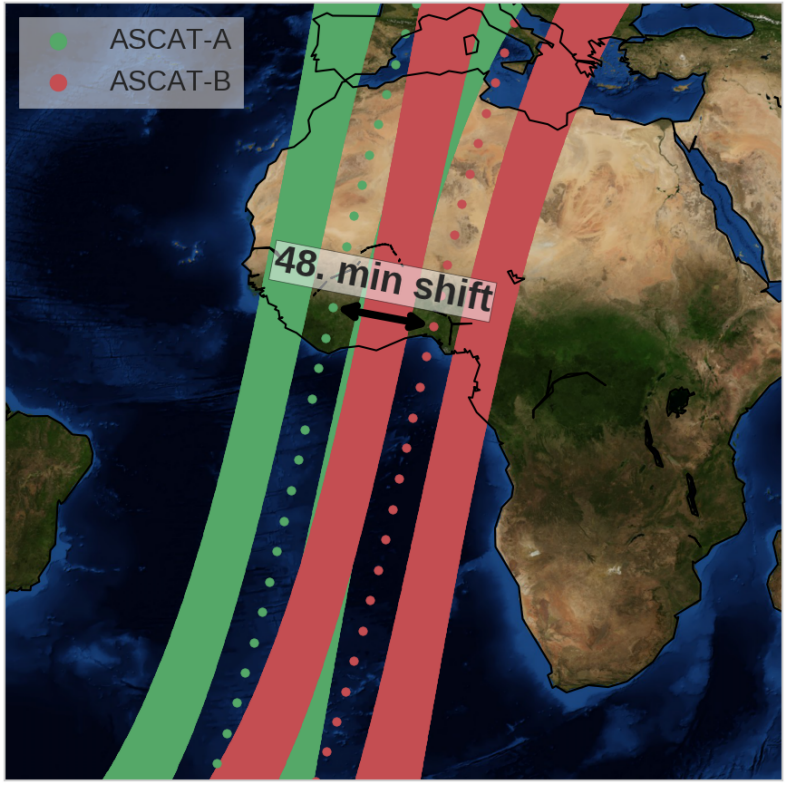
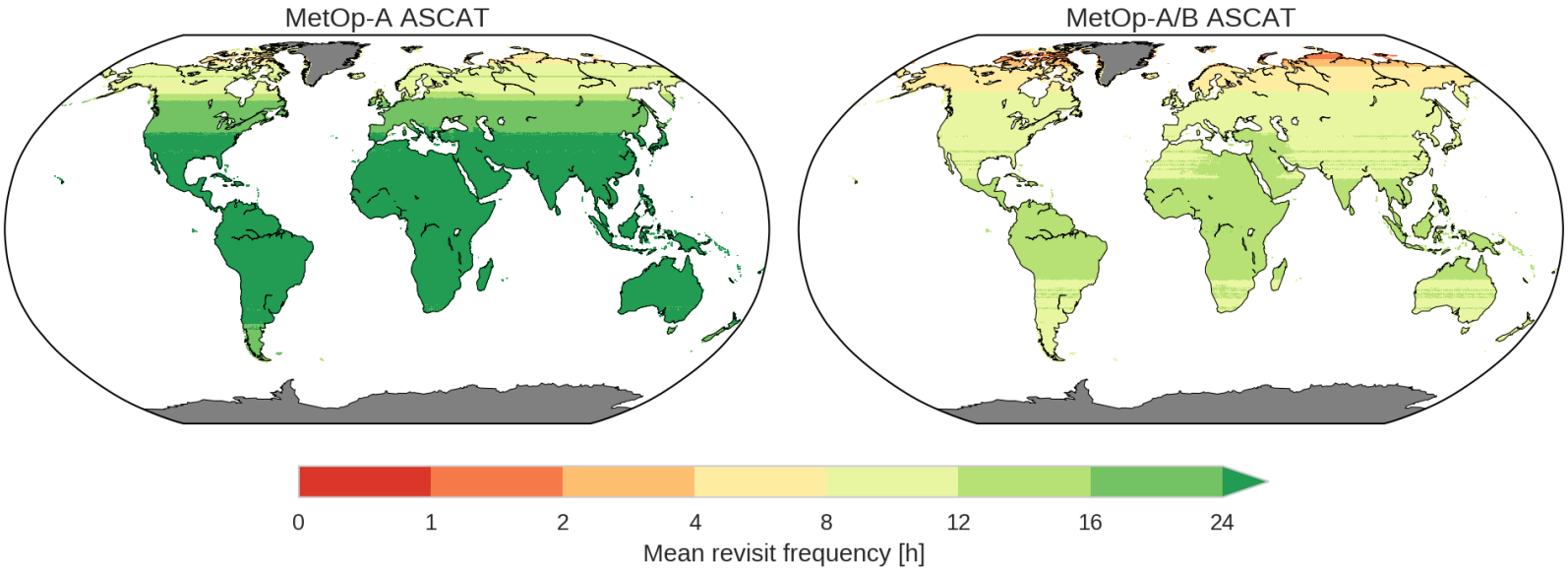
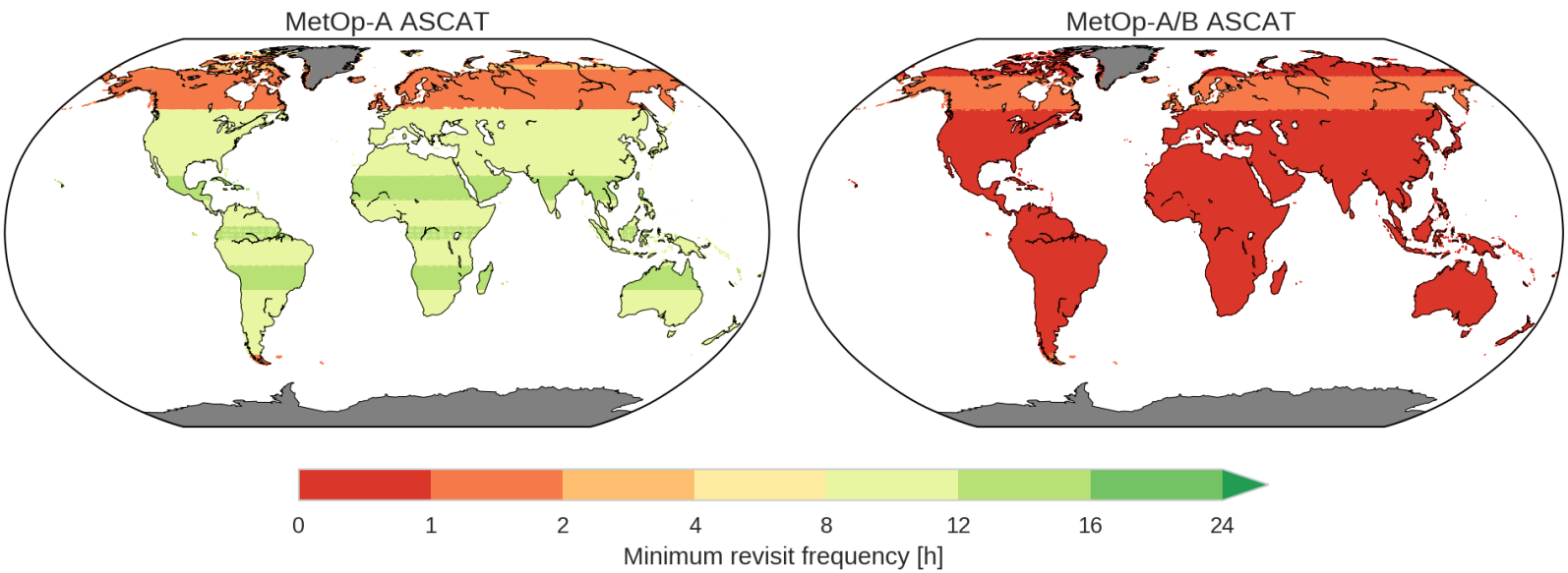


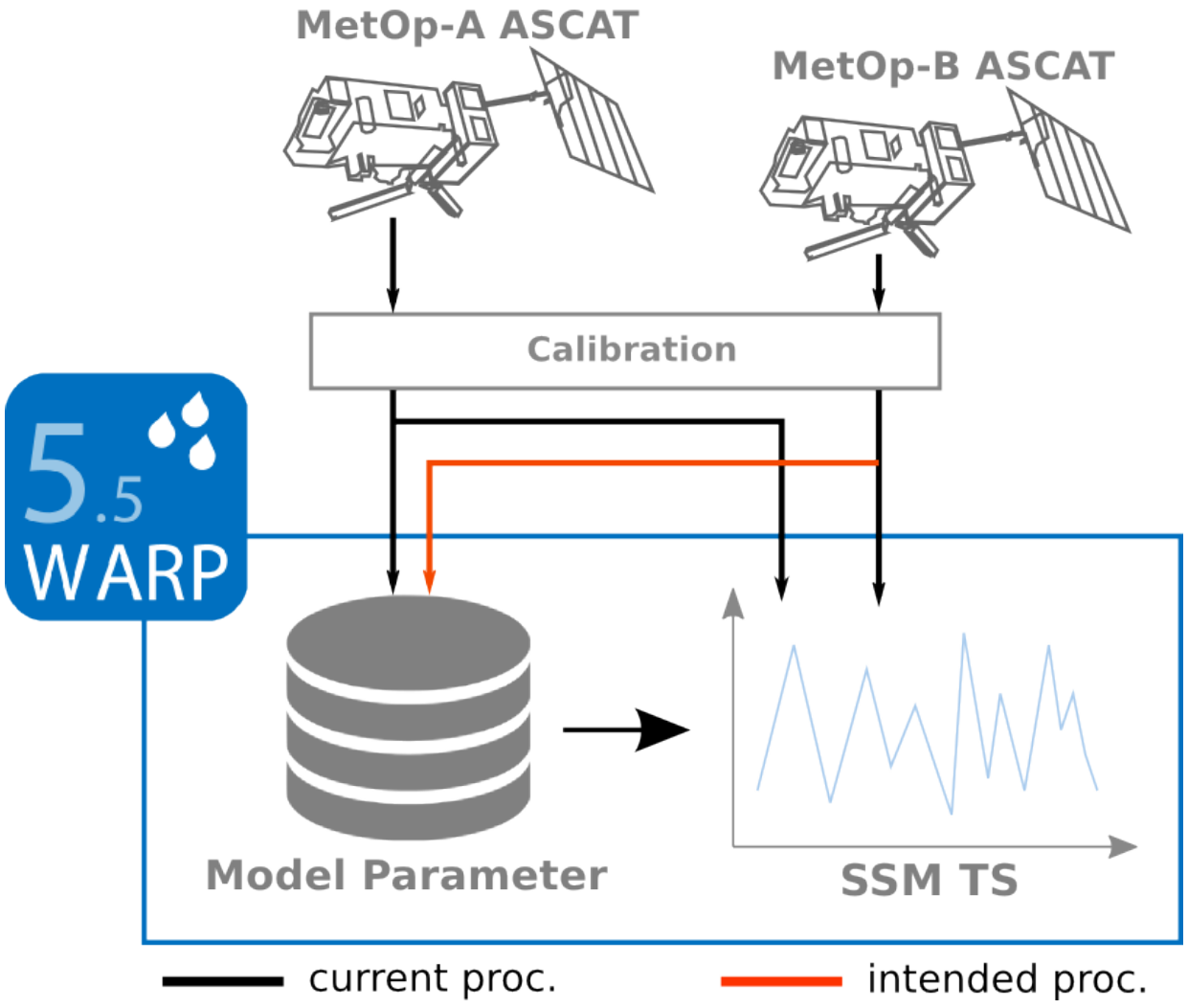
Figure 1 : Orbit Phasing ASCAT-A and ASCAT-B

Revisit time statistics





Soil Moisture Processing @ TU Wien

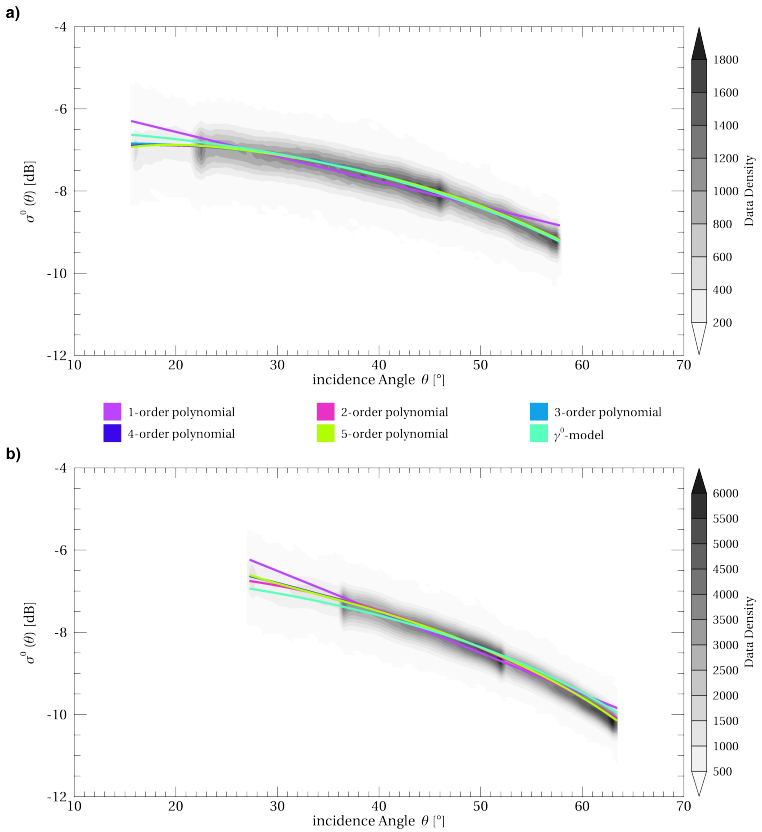


optimal solution to use both sensors for MP.

What do we have to consider in MP estimation?

ASCAT-B Level 1b calibration status

- Soil moisture retrieval requires long-term stability
- Instrument monitoring over Rainforests
  - Amazon, Congo and Indonesia Rainforest
- Gamma model vs. TU Wien model (2nd order polynomial)



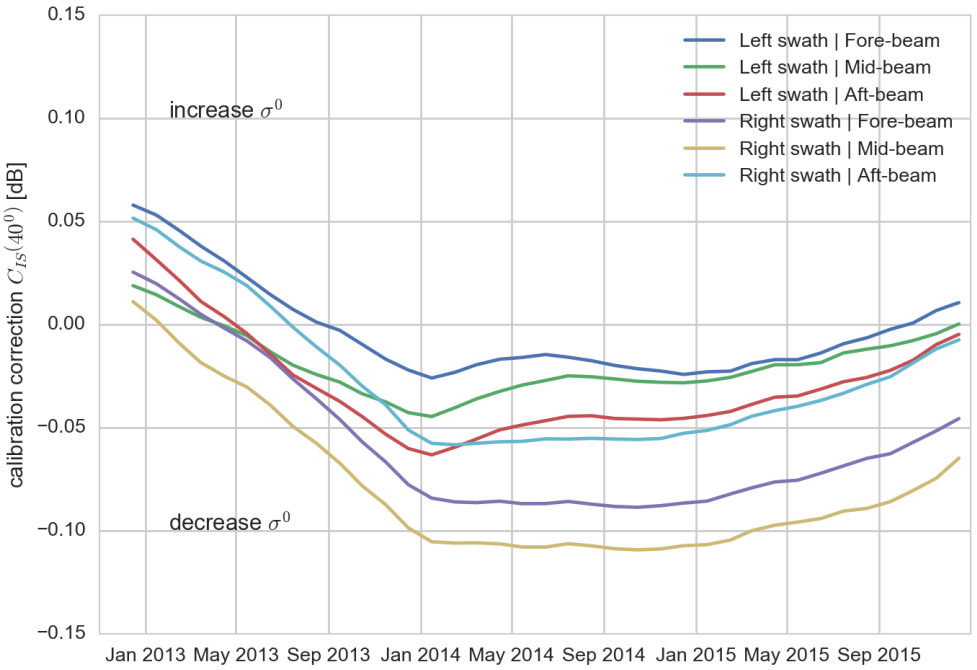
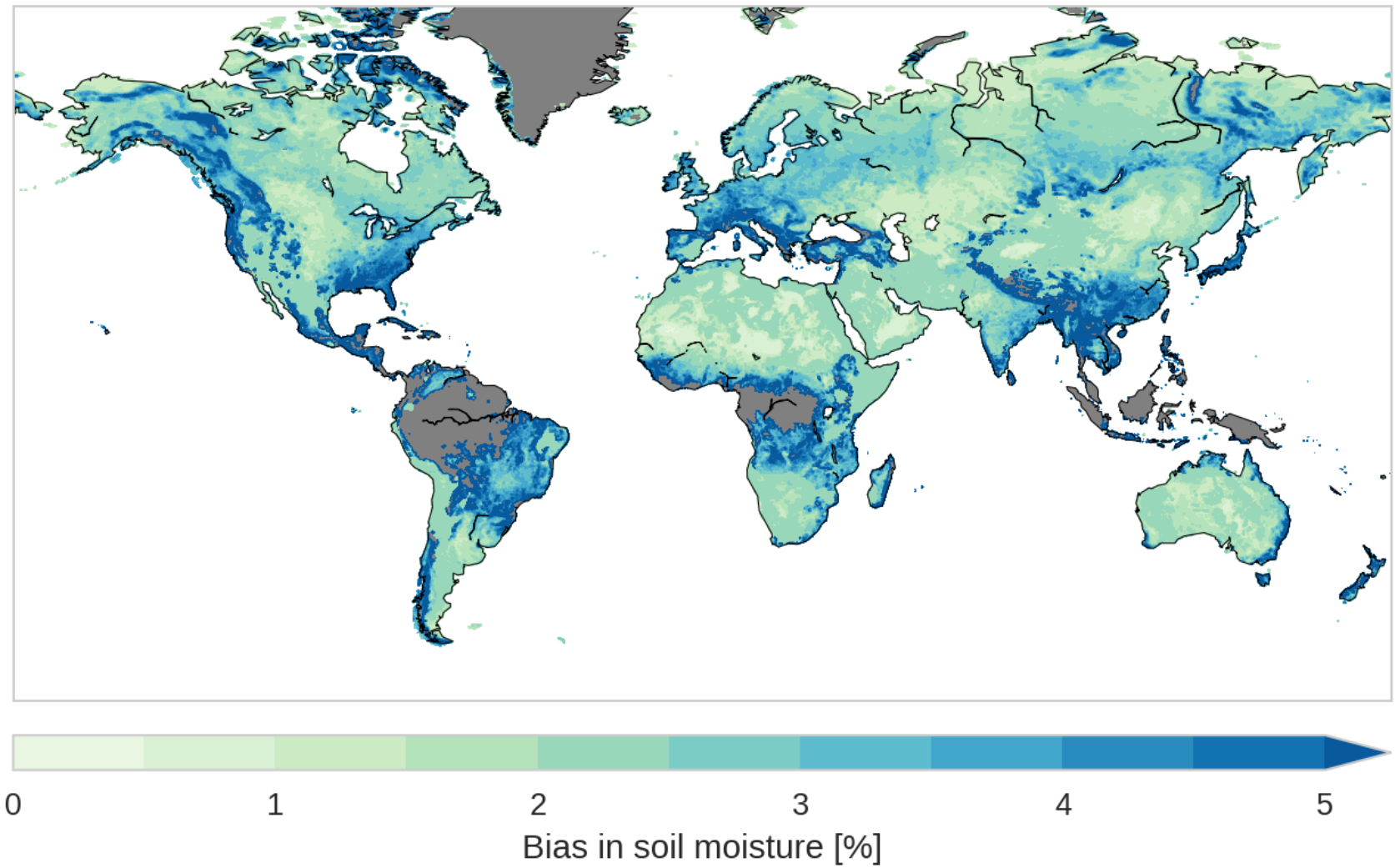


Figure 2 : a) ERS-2 ESCAT b) MetOp-A ASCAT

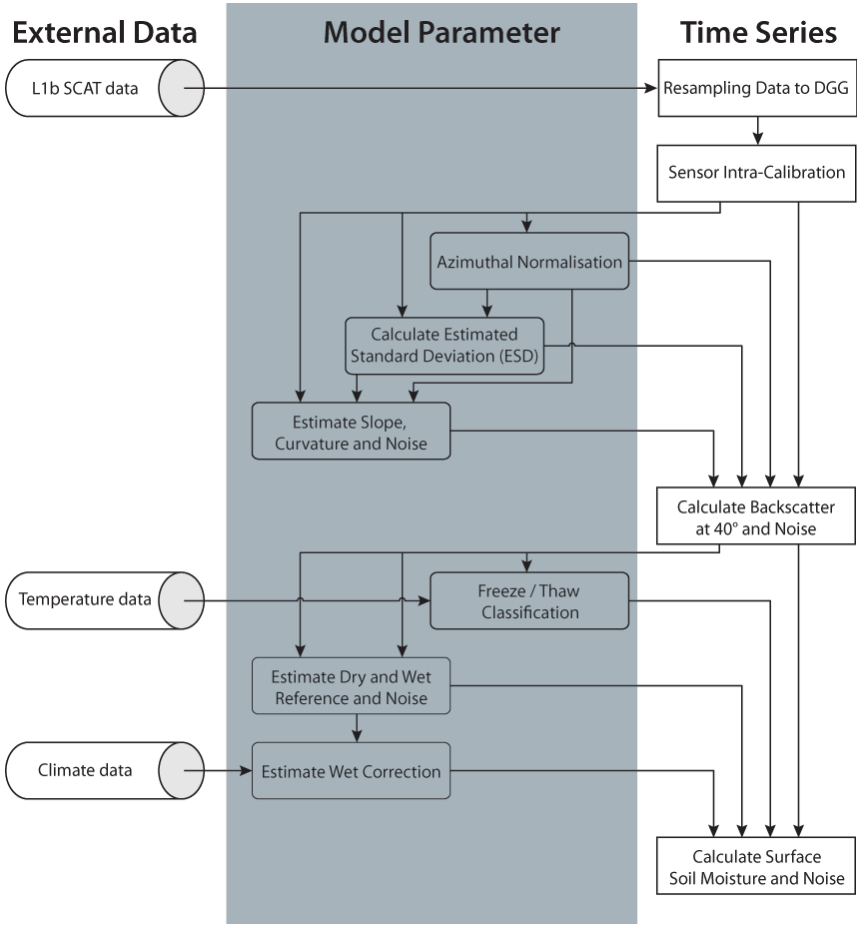
Calibration induced SM bias

Level 1 calibration bias of 0.1 dB between ASCAT-A and ASCAT-B



Soil moisture model parameter estimation

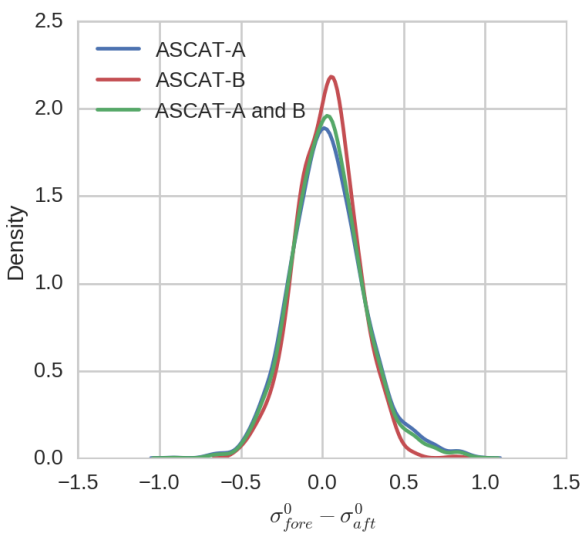
- TU Wien SM retrieval is a physically motivated semi-empirical change detection method
- Calibration of model parameters (MP) required to separate different backscatter contributions
  - MP estimation is based on 'inter-annual' time series analysis
- Comparison of MP derived from
  - ASCAT-A (2007 - 2015)
  - ASCAT-B (2013 - 2015)
  - ASCAT-AB (2007- 2015)

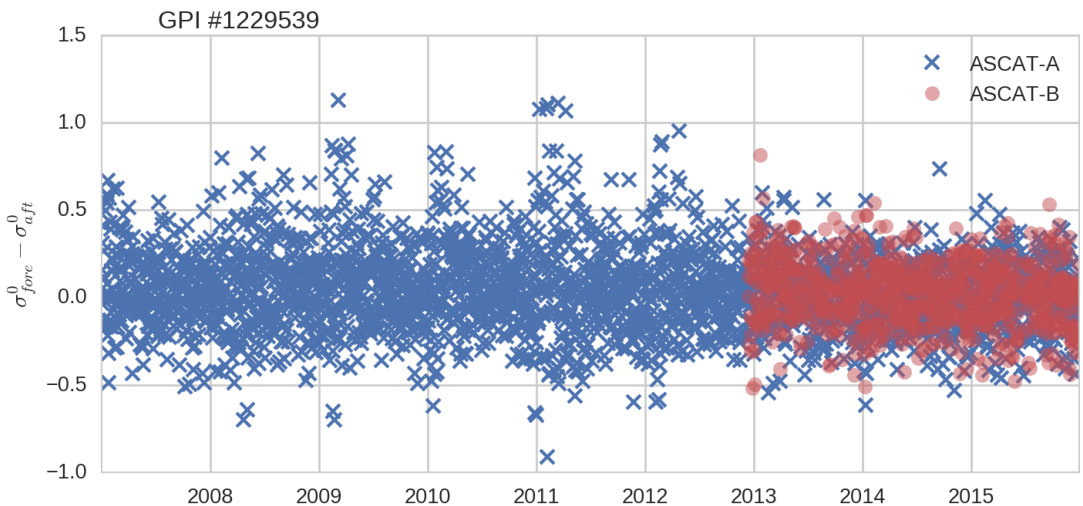


Estimated Standard Deviation (ESD)

- Backscatter noise estimate for SM error model
- Estimated using: $\delta = \sigma^0_{\text{fore}} - \sigma^0_{\text{aft}}$

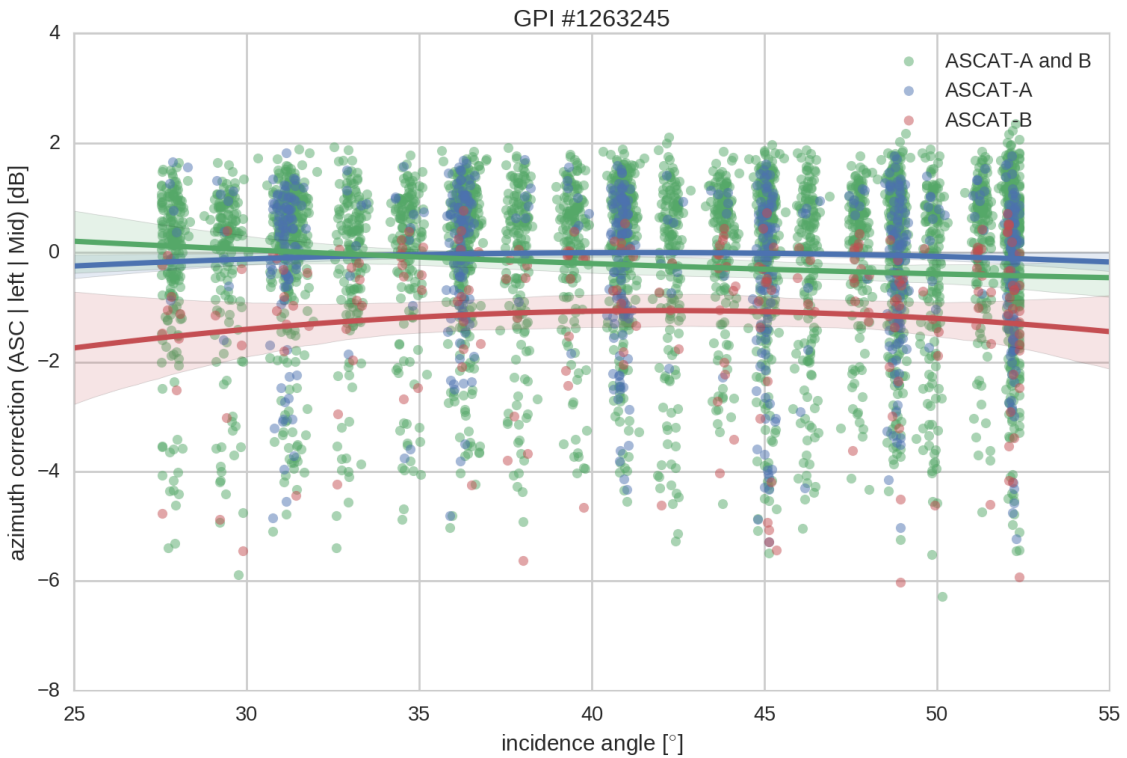
$$\text{ESD}(\sigma^\circ) = \frac{\text{SD}[\delta]}{\sqrt{2}}$$





Azimuth normalisation coefficients

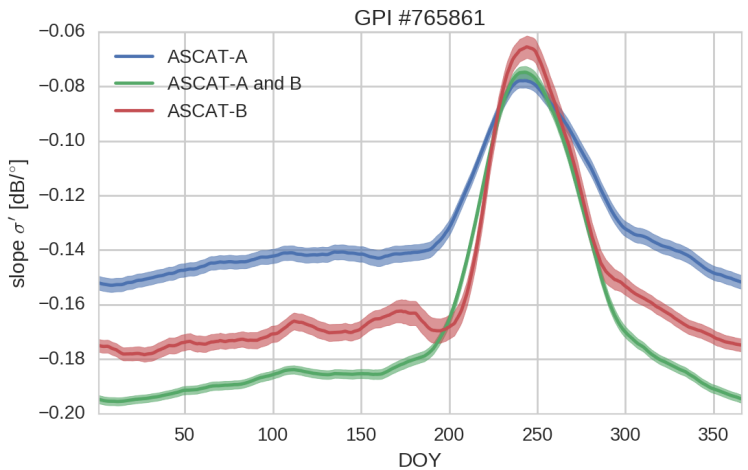
- Account for azimuthal anisotropy effects in backscatter
- 12 azimuth observation configurations (3 x beams, 2 x swath, 2 x overpasses)
- Difference to statistically expected backscatter
  - 2nd order polynomial

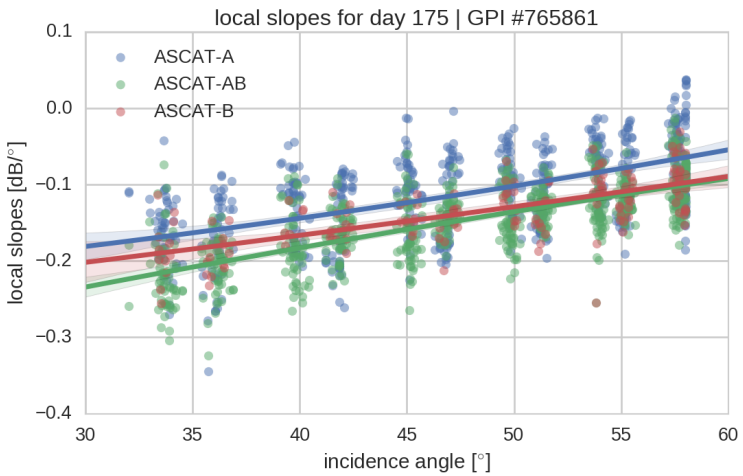


Incidence angle normalisation (Slope)

- Inc. angle behaviour modelled via 2nd order Taylor polynomial
- Slope σ' = first derivative of inc. angle behaviour

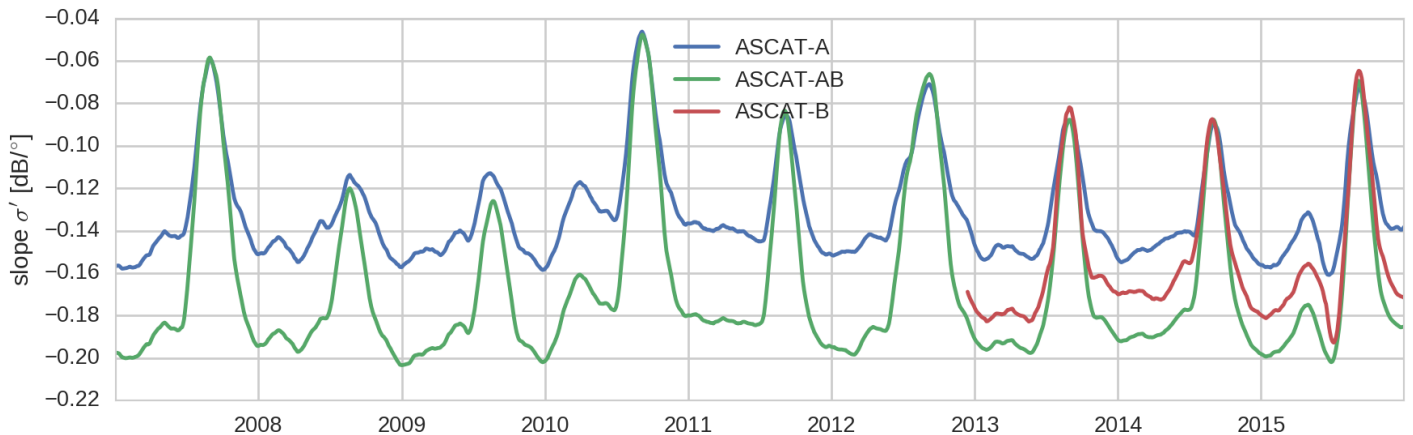
$$\sigma^{\circ}(\theta, t) = \sigma^{\circ}(\theta_{ref}, t) + \sigma'(\theta_{ref}, t)(\theta - \theta_{ref}) + \frac{1}{2} \cdot \sigma''(\theta_{ref}, t)(\theta - \theta_{ref})^2$$





Daily Slope estimation

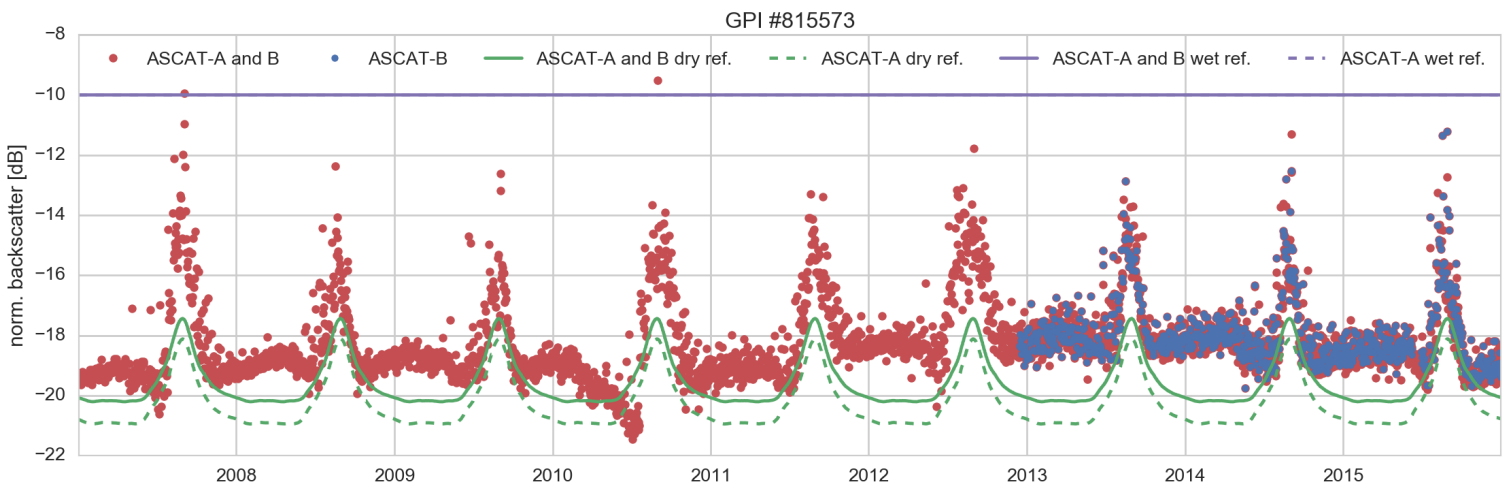
- Make use of LLR for lope estimation over time
  - critical parameter $\Rightarrow$ time window length
- Bias in Slope due to bias in azimuth norm.
  - identical temporal behaviour of ASCAT-A / ASCAT-B



Dry/Wet reference

- Representing the driest and wettest observed soil moisture condition.

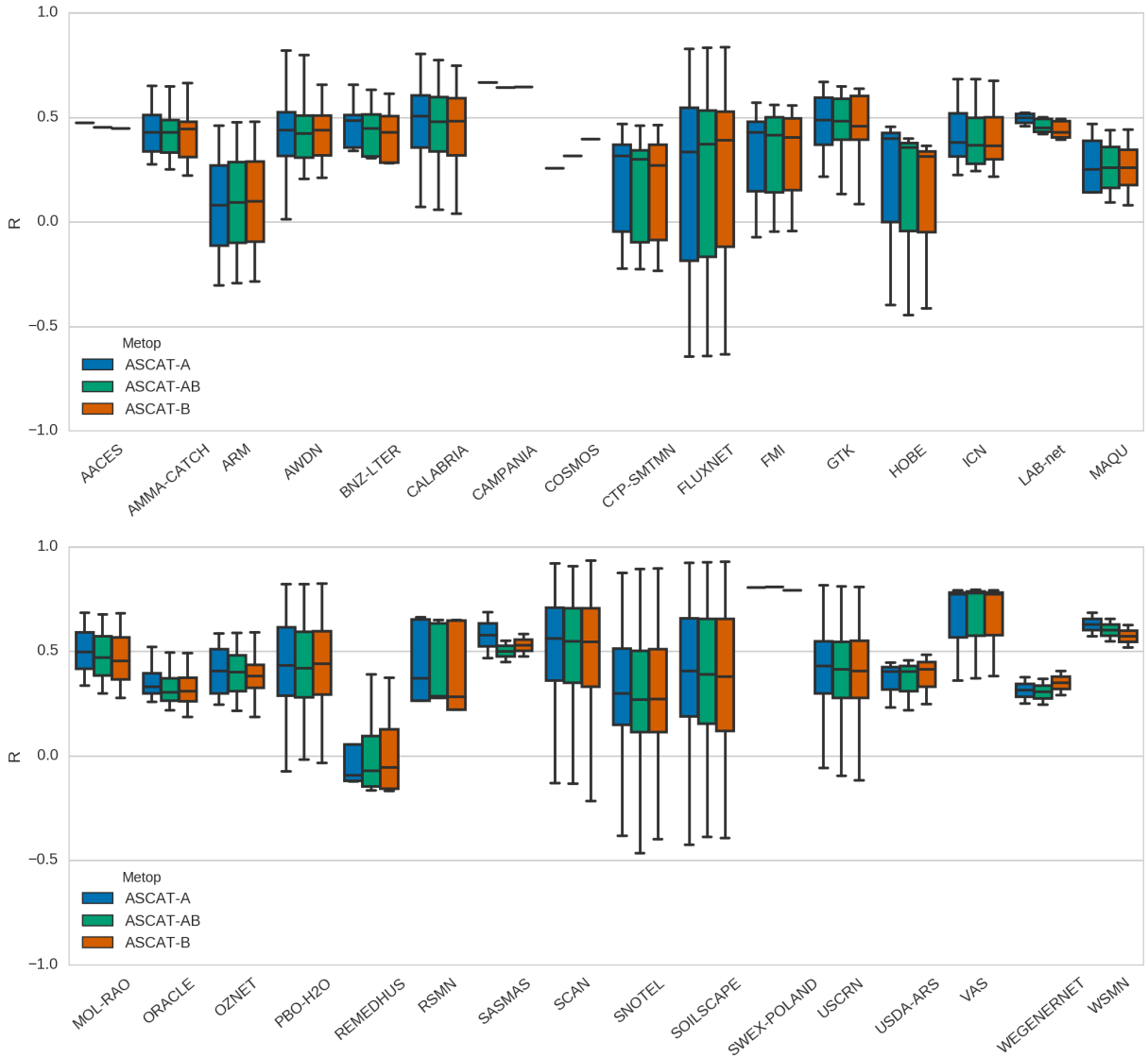
$$m_s(t) = \frac{\sigma^\circ(\theta_{ref},t) - \sigma^\circ_{dry}(\theta_{ref},t)}{\sigma^\circ_{wet}(\theta_{ref},t) - \sigma^\circ_{dry}(\theta_{ref},t)} \qquad \text{[degree of saturation]}$$



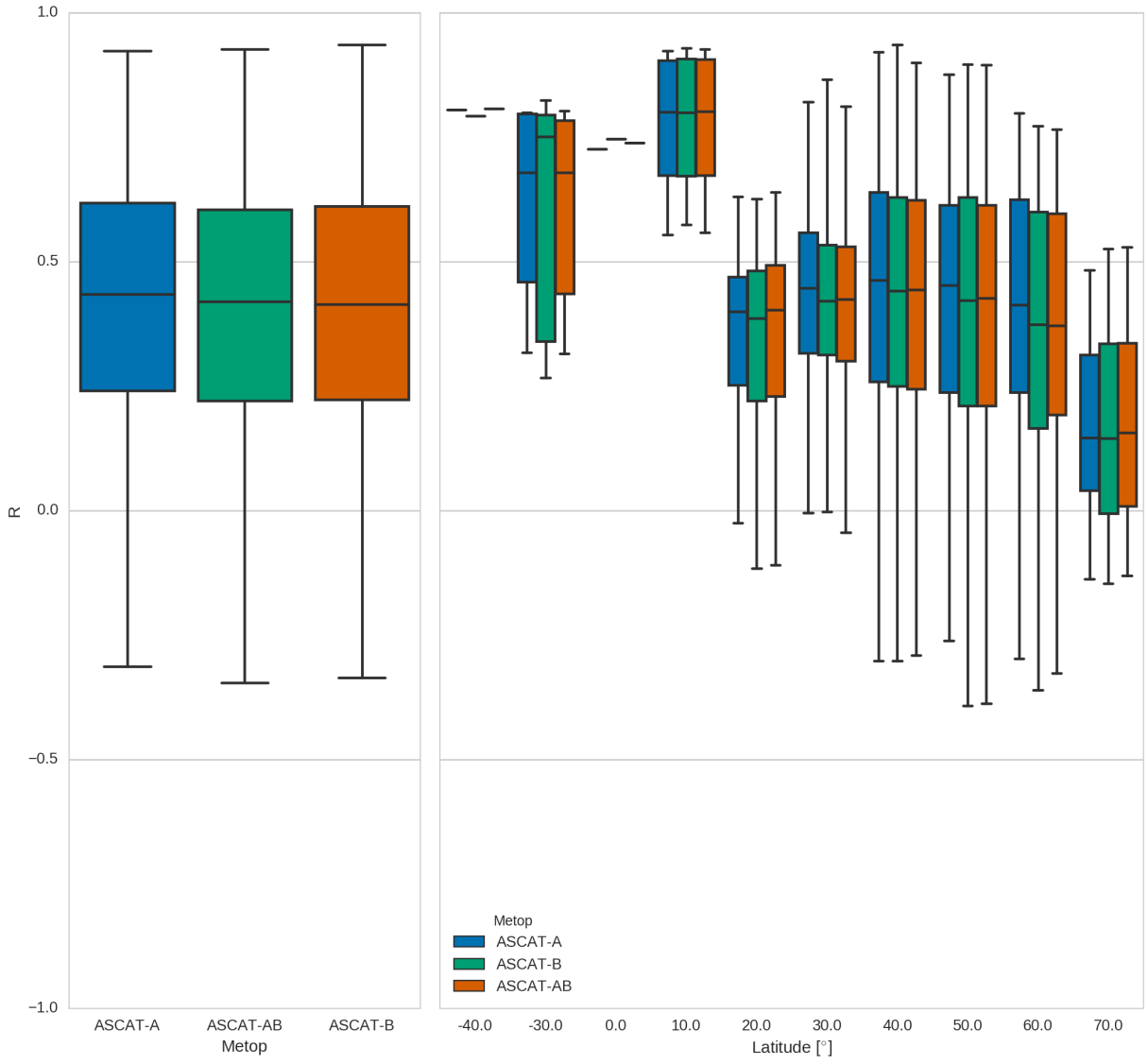
Validation with respect to in-situ soil moisture

- What is the impact on the final SM retrievals?
  - Validation of three ASCAT SM products
- ISMN in-situ data
  - 32 networks with 789 stations in total
  - Sensor depths: 0 – 0.10m
- Data Manipulation
  - Masking for snow, soil temperature, Freeze/Thaw state
  - Min / Max scaling of ASCAT to in-situ soil moisture
  - Temporal collocation with 8h time window

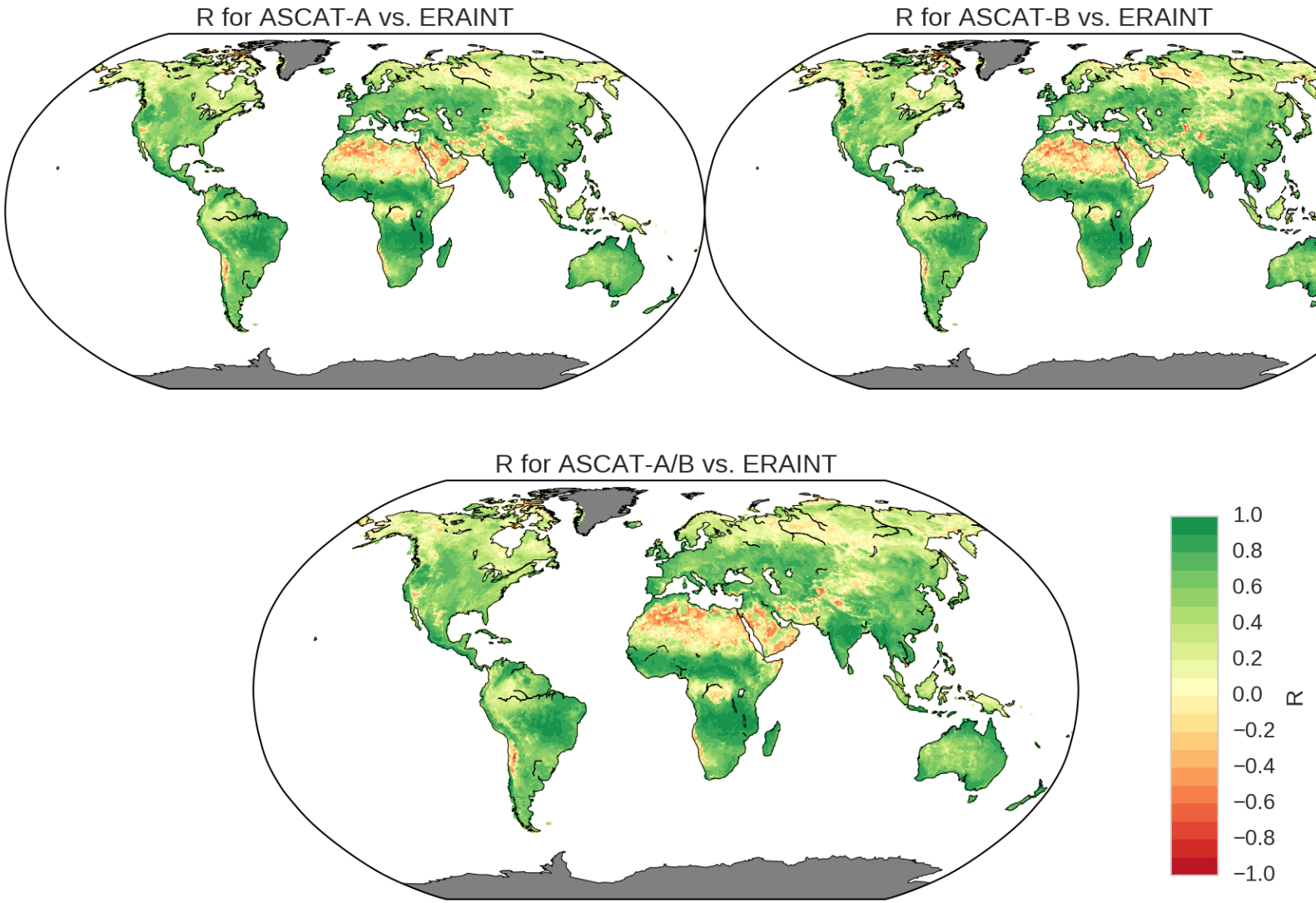
In-situ validation results per network



In-situ validation results global summary



Soil Moisture Validation ERA-interim



Negative impact over desert regions.

Conclusion

- Tandem scenario of ASCAT result in a mean revisit time of less than 16 h globally.
- Inter-calibration of ASCAT-A and ASCAT-B critical for SM retrieval
  - A 0.1 dB difference will introduce a bias of about 3% in soil moisture
- Impact of tandem phase scenario on model parameter estimation
  - Good agreement with latest MPs in general
  - Sensitivity of model parameters are different
  - Account for correlations in ASCAT-A/B, by applying a weighting in the MP estimation
- In-situ validation indicates neutral impact
- Validation against ERA-interim
  - Overall neutral impact
  - Desert regions are exceptions