Calibration

• What we need
• Where we stand
  – On-ground characterization plan
  – In-orbit calibration plan
  – Onboard references
  – Selected and possible external sources
  – Applicable vicarious calibration methods
• What to do
  – Calibration methods performance assessment
  – Matching performances with needs
  – Commissioning plan
    • Specific verification activities
    • Special attention to non calibrated parameters
  – Validation
**Calibration needs**

**Calibration:** The process of quantitatively defining the system response to a known, controlled signal.

- Correct or model as many as possible of sensor related error sources in the recorded signal.
- Calibration driven by error classification
  - Drifts: Effect of ageing on components.
  - Harmonic: Cyclic changes of the instrument, wrt orbit, season, solar cycle...
  - Random: Everything else. Not accessible to calibration
- Drifts and Harmonic amplitudes determine intercalibration periods
- Assessment relies on on-ground, in-flight or both
Instrument model

- From correlations to visibilities
  - Amplitude
  - Phase
  - Correlation offset

\[ \mu = \frac{1}{H_{12}} \cdot Q \cdot V_{12}(u,v) + \mu_{12\text{off}} \]

- From visibilities to brightness temperatures
  - Antenna patterns
  - End-to-end frequency response

\[ V_{12}(u,v) = \frac{1}{[\Omega_1 \cdot \Omega_2]^{1/2}} \int \int T_B(\xi,\eta) \cdot F_{n1}(\xi,\eta) \cdot F_{n2}^*(\xi,\eta) \cdot r_{12}(\xi,\eta) \cdot e^{j2\pi(u_{12}\xi + v_{12}\eta)} \cdot \sqrt{1 - \xi^2 - \eta^2} \, d\xi d\eta \]
Where we stand

- On-ground characterization plan
- In-orbit calibration plan
- Onboard references description
- Selected and possible external sources
- Applicable vicarious calibration methods
On-ground characterisation - 1

• Antenna measurements
  – Radiation Patterns
    • Coupling
    • Phase reference point
    • Physical temperature variations
  – Cross polarisation
  – Switch isolation

• NIR absolute calibration
  – End-to-end frequency response
  – Linearity
  – Stability
  – Dependence on physical temperature: modelling and reliability
  – Can we provide a reliable model of the kind:
    \[
    \text{Signal} = a(T_{\text{phys}}) T_B^2 + b(T_{\text{phys}}) T_B + c(T_{\text{phys}})
    \]
    that we could monitor in time?
On-ground characterisation - 2

- **LICEF**
  - Noise figure
  - End-to-end frequency response
  - PMS response
  - PMS calibration – 4 point concept (based on NIR)
  - Linearity ?

- **Radiometric Sensitivity**

- **CAS**
  - NDN characteristics
  - Sources
  - No monitoring of CAS -> in-depth characterisation and temperature dependence assessment
In-orbit calibration

- Onboard references
  - NIR
    - Absolute calibration
  - LICEF
    - Amplitude
    - Phase
  - Correlators
    - Offset correction
    - FWF verification

- Side effects
  - The many modes of NIR and LICEF operation

- External sources
  - Deep sky
  - Moon
  - Sun glint?
    - NIR
      - Absolute calibration
  - Antenna
    - Gain pattern
  - Instrument
    - Flat target response

- Side effects
  - Earth in back lobes
  - Thermal conditions
Calibration Process

• L0 to L1a
  – NIR depends on deep space and CAS
  – Amplitude calibration relies on NIR and on CAS
  – Quadrature is self-calibrated
  – Phase, FWF relies on CAS.

• L1a to L1b
  – FWF relies on CAS.
  – Antenna patterns is measured on-ground and assumed constant.
Vicarious calibration

• Level 1
  – NIR drifts and biases
    • Statistics over ocean
    • Antarctica
    • Airborne and/or in-situ based measurements
    • Sun glint ?
  – Geo localisation biases and harmonic errors
    • Isolated islands
    • Linear oriented transitions

• Level 2
  – SSS
  – Soil moisture (how to address scale issues ?)
  – How to make sure not to integrate model errors in calibration ?
Validation

- Sea surface networks
  - Wind speed
  - Scale

- Ground Campaigns for soil moisture
  - Scale ++

- SMOS/HYDROS/Aquarius intercomparison: need to ensure “compatibility”
What to do – Open issues

• Assessment of calibration method performances
  – To summarize an end-to-end error budget accounting for all calibration error sources. But need for performance measurements on EM.

• Matching of calibration and performance requirement
  – This is the way to specify frequency and duration of calibration periods
    So far between 3 and 10 calibration periods are assumed.

• Calibration periods/coverage loss trade-off
  – One full orbit per month and short calibration periods (24s and 80s)

• Side effects of ageing
  – How to account for gradual failures?

• Stability of terms inaccessible to calibration need to be verified in orbit: methods to define and verify
  – e.g. Antenna Patterns

• Commissioning phase calibration plan to initialise.

• …