Bifrequency radiometer onboard AltiKa mission: issues and way of improving the retrieval

E. Obligis, B. Picard, ML. Frery, N. Picot
Radiometers onboard altimetry missions

NASA/CNES/NOAA/Eumetsat missions
- Topex-Poseidon/TMR
- Jason-1/JMR
- Jason-2/AMR

European missions
- ERS-1/MWR
- ERS-2/MWR
- Envisat/MWR
- S3/MWR

CNES/ISRO AltiKa

- 18 (18.7) GHz: Sea Surface
- 21 (23.8) GHz: Water Vapor Content = dh
- 37 (34) GHz: Cloud Liquid Water content
- 23.8 GHz: Altimeter wind $\sigma_0$ Ku, $\sigma_0$ Ka
- 36.5 (37) GHz

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Retrieval algorithms for bifrequency radiometers

• ERS 1 & 2 algorithm (Eymard et al, 1996)
  \[ dh = c_0 + c_1 \ln (280. - TB_{23.8}) + c_2 \ln (280. - TB_{36.5}) + c_3 (W_s - 7.) \]

• Envisat & S3 algorithm (Obligis et al, 2006)
  \[ dh = NN (TB_{23.8}, TB_{36.5}, \sigma_0 \text{ Ku}) \]

• What about AltiKa?

  => Formulation of radiometer algorithm similar to the Envisat ones
Inversion algorithm development

Simulated
TB23.8, TB37
Sigma 0 Ku or Ka

Direct model
MEAS = f(geoφ)

Radiative Transfer model

Inverse model
geoφ = f(MEAS)

Neural Net (Weights, Bias)

ECMWF analyses
2D surface: sst, wind
3D profiles: T, P, Wv, Wc

Computation of geoφ parameters

geoφ parameters
column-integrated
dh, Att, Wc, Wv
In-flight results

ECMWF – RADIOMETER \( dh \) (cm)

ALT IK A – cycle 1 (P1) Envisat – cycle 75

- Performances over measurements degraded with respect to the Envisat ones
- Additional analyses are required
- Algorithm formulated over simulations
- Consistency between simulations and measurements?

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Once in-flight: measurements vs simulations

ALTIKA – Raw 23.8 GHz TBs – 4 months of collocated data

Bias=-3.1 K
Stdev=2.8 K
Once in-flight: measurements vs simulations

ALTIIKA – Raw 37 GHz TBs – 4 months of collocated data

Bias=0.3 K
Stdev=3.0 K
Once in-flight: measurements vs simulations

Measurements

Adjusted measurements

Simulations

- Linear regression
  - $y = ax + b$
  - $a = 0.52073954$
  - $b = 3.33950150386$

- Order 1 fit polynomial
  - $y = ax + b$
  - $a = 0.722490094681$
  - $b = 3.33501650386$

Legend
- Linear regression
- Order 1 fit polynomial

Statistics

- $X$: mean = 10.17, std = 2.085
- $Y$: mean = 10.83, std = 1.819
- $X$: mean = 10.63, std = 1.376
Once in-flight: measurements vs simulations

- For the brightness temperatures, the agreement between measurements and simulations is not perfect but satisfactory, at the level of the one obtained with the Envisat mission

- For sigma0 in Ka band, necessity to better understand the discrepancies (mainly observed for high values = low wind speed)
  - Simulations: What is the ability of our emissivity model to simulate accurately the backscattering coefficient in Ka band for low and high winds?
  - Measurements: Sigma0 is not a direct measurement of the instrument. What is the accuracy of the estimation, what is the impact of the retracking?
  - Weak weight of the sigma0 in the retrieval algorithm: How to explain the observed impact on wet tropo correction?

- In parallel to these investigations, development of alternative L2 radiometer algorithm

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ERS 1 & 2 algorithm
\[ dh = c_0 + c_1 \ln(280 - TB_{23.8}) + c_2 \ln(280 - TB_{36.5}) + c_3 (WS_{\text{salt}} - 7.0) \]

Envisat algorithm
\[ dh = \text{NN}(TB_{23.8}, TB_{36.5}, \sigma_0 \text{Ku}) \]

First AltiKa algorithm
\[ dh = \text{NN}(TB_{23.8}, TB_{37}, \sigma_0 \text{Ka}) \]

What about a new AltiKa algorithm?
\[ dh = \text{NN}(TB_{23.8}, TB_{37}, W) \]

Building of the learning database
\[ dh = \text{NN}(TB_{23.8}, TB_{37}, \sigma_0 \text{Ka}) \Rightarrow dh = \text{NN}(TB_{23.8}, TB_{37}, W) \]

Not mature enough
Performances over simulations

ENV
dh=NN(TB23.8, TB36.5, sigKu)

ALTIKA
dh=NN(TB23.8, TB37, sigKa)

AltiKA
dh=NN(TB23.8, TB37, Ws)

• Over simulations, similar performances
• But over measurements?
• Algorithm applied with the ECMWF wind speed
Performances over measurements

ECMWF – RADIOMETER dh (cm)

ALTIKA (P1)  

\[ \text{Stdev} = 1.4 \text{ cm} \]

AltiKa – Ws  

\[ \text{Stdev} = 1.2 \text{ cm} \]
Performances over measurements

SSH crossovers

SSH crossovers : difference of variances (cm^2)

Mission al, cycles 1 to 4

VAR(SSH with TRO_HUM_RAD_ALG02) - VAR(SSH with TRO_HUM_RAD)

Mission al, cycles 1 to 4

SSH crossovers

Mission al, cycles 1 to 4

'AR(SSH with TRO_HUM_RAD_P1) - VAR(SSH with TRO_HUM_ECMWF

Mission al, cycles 1 to 4

SSH crossovers

Mission al, cycles 1 to 4

VAR(SSH with TRO_HUM_RAD_ALG02) - VAR(SSH with TRO_HUM_ECMWF

Mission al, cycles 1 to 4

About 1 cm^2 improvement

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Conclusions

• For the Altika mission, at that time, the quality of the radiometer wet tropospheric correction is not at the level of the Envisat one.
• This is mainly due to the fact that the sigma0 in Ka band, used in the retrieval algorithm, is poorly known:
  – No accurate emissivity model to simulate it
  – Quality of the sigma0 altimeter measurement to be assessed (dependency on retracking)
  – Especially in areas of low and high wind speed (inaccuracy of the model, poor representativity in the learning database)
• Development of a new algorithm based on wind speed to overcome these problems
  – Algorithm applied with the ECMWF wind speed
    ➢ Limitations: poor accuracy, low spatial and temporal resolution
  – But still improvements of the performances
• When available, use of altimeter wind speed instead of ECMWF wind speed in the new algorithm: should significantly improve the performances

• The potential of adding SST as an additional input (See Thao’s talk) should be studied

• In parallel, improvements in our knowledge of the interactions between sea surface and electromagnetic waves in Ka band is necessary. This will allow realistic simulations and development of accurate algorithms

• Impact on the other radiometer parameters seems to be minor, but this has to be assessed
Atmospheric attenuation

- Retrieval algorithm similar to the wet tropo one $\text{Att}_\text{Ka}=\text{NN}(TB_{23.8}, TB_{37}, \text{sigma0Ka})$
- Comparison with Lillibridge-Sharoo model attenuation:
  - After P1 adjustment no more bias between model and radiometer values
  - Model estimation is smoother than MWR one