First results from the PEACHI Jason-3 prototype

A processing laboratory for innovative altimetry products based on Jason-3 data

Sophie LE GAC, CNES

and the PEACHI-J3 team :

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Overview

- **PEACHI = Prototype for Expertise in Altimetry, Coastal, Hydrology and Ice**
- Heritage from PEACHI AltiKa prototype *[Valladeau et al., OSTST 2014]*
- The prototype is seen as a **laboratory for processing Jason-3 data** and **delivering experimental products with foreseen added-value**, such as estimates from the **numerical retracking** *[Le Gac et al., OSTST 2015 – Boy et al. OSTST 2014]*
- Prime objective of PEACHI Jason-3 is to **ensure and demonstrate** the **quality of new algorithms** before deciding their implementation into Jason-3 operational ground segment

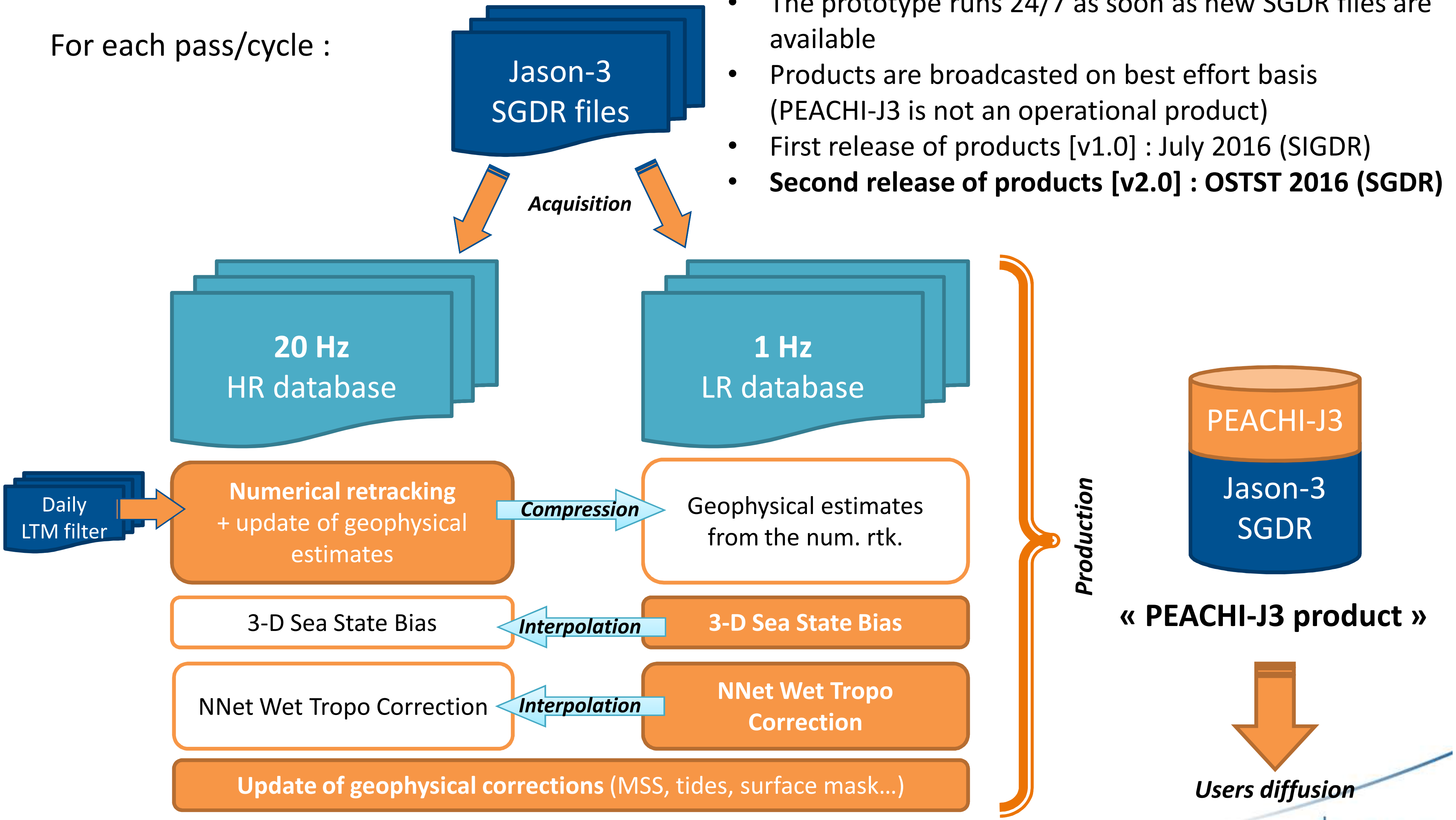
Summary

- The PEACHI-J3 **processing prototype**
- **Description** of the PEACHI-J3 product
- **Validation** of PEACHI-J3 algorithms
- **Conclusion and perspectives**

The PEACHI-J3 prototype

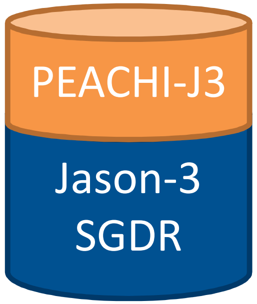
- The prototype runs 24/7 as soon as new SGDR files are available
- Products are broadcasted on best effort basis (PEACHI-J3 is not an operational product)
- First release of products [v1.0] : July 2016 (SIGDR)
- **Second release of products [v2.0] : OSTST 2016 (SGDR)**

For each pass/cycle :



The PEACHI-J3 product [1/2]

- PEACHI-J3 algorithms outputs are merged with official SGDR file contents
  - » 1 file per pass/cycle : filename = PEACHI_J3_SGDR_Cxxxx_Pxxxx.nc
  - » NetCDF format, CF-1.1 convention
  - » All SGDR fields unchanged
  - » PEACHI-J3 fields clearly identified



- First release (v1.0) : July 2016 – Based on S-IGDR data

  Some technical issues corrected in the next release
- **[Current]** Release version 2.0 : November 2016
  - » Example :

```
$ ncdump -h PEACHI_J3_SGDR_C0005_P0024.nc
```

```
netcdf PEACHI_J3_SGDR_C0005_P0024 {
dimensions:
        time = 3324 ;
        meas_ind = 20 ;
        wvf_ind = 104 ;
variables:
        double lat_20hz(time, meas_ind) ;
                lat_20hz:standard_name = "latitude" ;
                lat_20hz:units = "degrees_north" ;
                lat_20hz:long_name = "20 Hz latitude" ;
                lat_20hz:comments = "Positive latitude is North latitude, negative latitude is South latitude." ;
                lat_20hz:_FillValue = 2147483647 ;
                lat_20hz:scale_factor = 1.e-06 ;
                lat_20hz:comment = "Positive latitude is North latitude, negative latitude is South latitude. See Jason-3 User Handbook" ;
        (…)
        int range_20hz_ku(time, meas_ind) ;
                range_20hz_ku:_FillValue = 2147483647 ;
                range_20hz_ku:long_name = "20 Hz Ku band corrected altimeter range" ;
                range_20hz_ku:standard_name = "altimeter_range" ;
                range_20hz_ku:units = "m" ;
                range_20hz_ku:add_offset = 1300000. ;
                range_20hz_ku:scale_factor = 0.0001 ;
                range_20hz_ku:coordinates = "lon_20hz lat_20hz" ;
                range_20hz_ku:comment = "All instrumental corrections included, i.e. distance antenna-COG (cog_corr), USO drift correction (uso_corr),
                internal path correction (internal_path_delay_corr_ku), Doppler correction (doppler_corr_ku), modeled instrumental errors correction
                (modeled_instr_corr_range_ku) and system bias" ;
        (…)
        double range_20hz_num_nelder_mead(time, meas_ind) ;
                range_20hz_num_nelder_mead:_FillValue = 9.96920996838687e+36 ;
                range_20hz_num_nelder_mead:long_name = "corrected altimeter range derived from numerical Nelder Mead MLE4 retracking
                algorithm. From the PEACHI prototype." ;
                range_20hz_num_nelder_mead:standard_name = "altimeter_range" ;
                range_20hz_num_nelder_mead:units = "m" ;
// global attributes:
                :first_meas_time = "2016-03-28 23:55:51.543310" ;
                :last_meas_time = "2016-03-29 00:52:03.935205" ;
                :equator_time = "2016-03-29 00:23:57.772000" ;
                (…)
}
```

Example of Pass 24 / Cycle 5

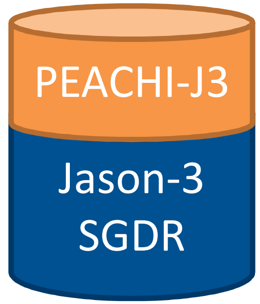
→ 3,324 samples at 1 Hz rate
→ 20 samples in each 20 Hz variable
→ 104 samples for waveforms

Fields from SGDR file

PEACHI-J3 field

All the necessary auxiliary information

The PEACHI-J3 product [1/2]



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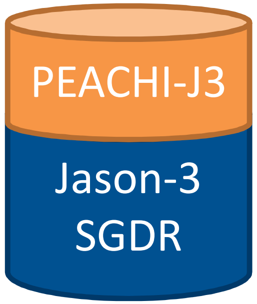
- **PEACHI-J3 specific outputs include :**
  - » **Numerical retracker** estimates (range, SWH, σ^0, ξ^2, quality flags, …)
  - » **Geophysical corrections** e.g. PEACHI-J3 NNet wet tropospheric correction, 3-D SSB
  - » **Latest versions** of tide models, MSS, and **other innovative algorithms** (editing, rain flag, distance to nearest coast,…)
  - » **SSHA value** computed using numerical retracker and updated geophysical corrections

The PEACHI-J3 product [2/2]



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Where to get the products ?

» **ftp.jason3.oceanobs.com** using the Jason-3 PIs login & password

» Soon, PEACHI-J3 products will be available to all users on ODES (Online Data Extraction Service)
http://odes.altimetry.cnes.fr
[Bronner et al. OSTST 2016]

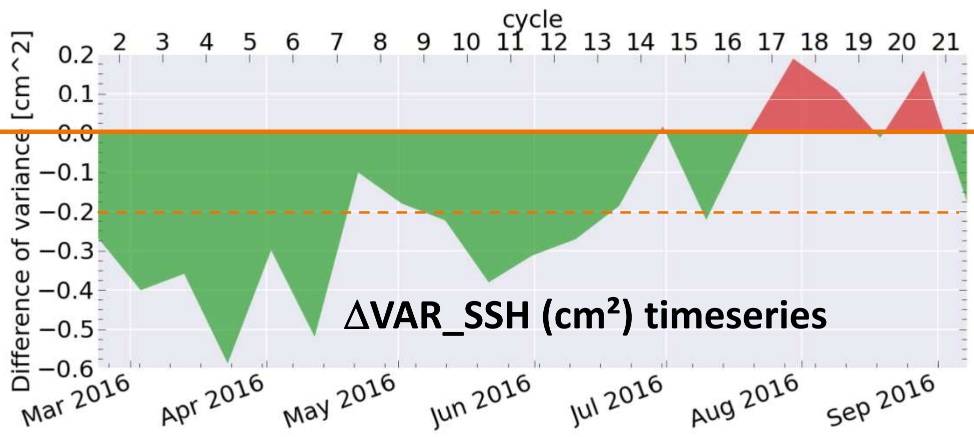
PEACHI-J3 product validation [1/4]

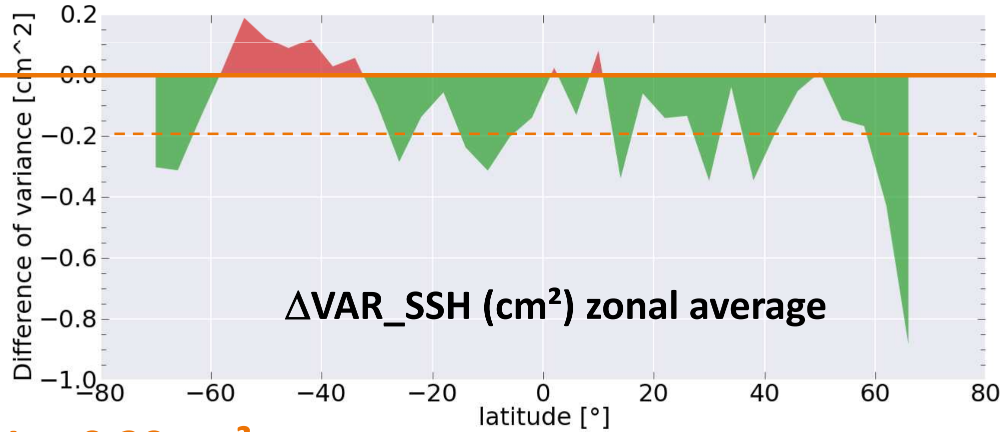
Wet Troposheric Correction

Fréry et al.

- CLS method to retrieve the Wet Tropospheric Correction (WTC) is based on :
  - » ECWMF analysis (2-D surface + 3-D profiles) to compute the reference WTC
  - » A radiative transfer code to simulate Brightness Temperatures (BTs)
  - » **A stratified neural network to retrieve the WTC from simulated BTs**
- This method has been validated using Jason-2 measurements and **applied to Jason-3 (GDR, cycles 1-21)**
- Performance is evaluated **at crossovers** : **ΔVAR_SSH = VAR_SSH_WTCref - VAR_SSH_WTCNNet**

← Improvement





Mean ΔVAR_SSH ≈ -0.20 cm²

- **Global improvement is obtained using CLS NNet WTC**, in particular at high latitudes
- Further validation needed to fully correct from AMR 34 GHz channel TB drift (Lauret et al.) and from J2/J3 bias
- **This WTC is in PEACHI-J3 SGDR product**

PEACHI-J3 product validation [2/4]

Sea-State Bias solution

Tran et al.

- Preliminary 3-D Sea State Bias (SSB) solution developed for Jason-3

CLS
COLLECTE LOCALISATION SATELLITES

Preliminary Jason-3 3D SSB

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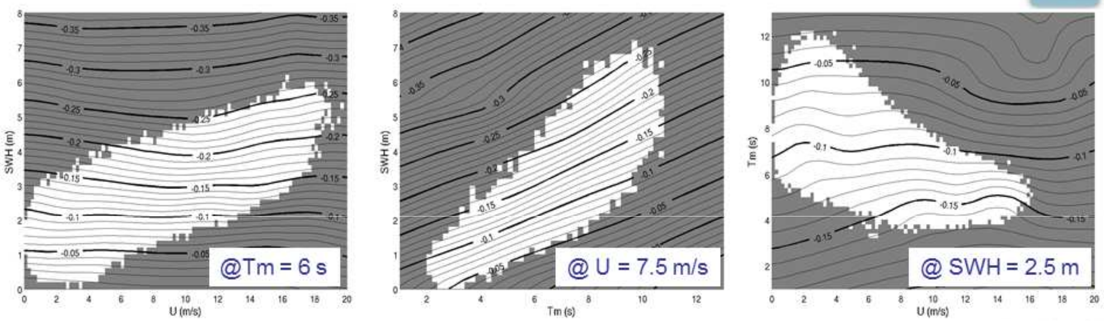


➢ Jason-3 3D SSB model (SWH, U, Tm) developed with the collinear SSH differences approach within the CNES Jason-3 PEACHI project

- use of mean wave period (Tm) from IFREMER WaveWatch3 products
- to better model SSB behavior with improved description of the sea state
- commonly 3D models are derived with the direct method [Vandemark et al, 2002]
- Jason-3 data from cycles 4 to 7
- when U and Tm are fixed, the magnitude of the SSB is an increasing function of SWH
- when SWH is fixed, variations with Tm are larger than those with U
- crossover variance reduction: -1.54 cm² wrt GDR SSB values (5 times more than with the preliminary Jason-3 2D SSB solution)
- such model will be consolidated when 1-year of data will be available

http://www.cls.fr

- 3-D SSB Model :
  - » **SWH from MLE4**
    (for comparison with current SSB solutions)
  - » Mean wave period Tm
  - » Wind speed U

- **Performance**

(based on 4 cycles of Jason-3 IGDR data)

→ **Crossover variance reduction** of

-1.54 cm² wrt current GDR SSB value

- **Promising solution,** needs to be consolidated with 1-year of J3 GDR data

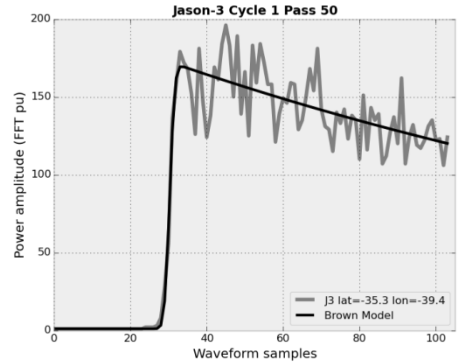
- 3-D SSB Model will be evaluated with SWH from numerical retracker
- **This 3-D SSB solution will be available in the PEACHI-J3 product in 2017**

cnes

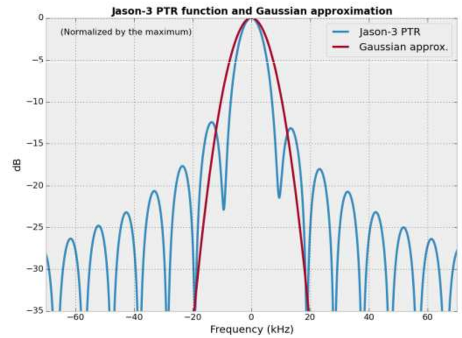
PEACHI-J3 product validation [3/4]

Numerical retracking

- Initially developed by CNES in the frame of SAR altimeter processing. Presented in preparation for Jason-3 by *Boy et al.* (OSTST 2014)
- **Current retracking in Jason-3 ground-segment is MLE-4** to estimate the range, SWH, Sigma0 and mispointing angle. **MLE-4 is based on an analytical model (Brown Model)** used to fit the measured waveform.



- In the Brown Model, a **Gaussian approximation is used for the instrument PTR**
  → This approximation leads to errors in estimates : **Look-Up Tables** are necessary to correct for this approximation
  - » Range : ≈ 1-2 cm
  - » SWH : ≈ 20 cm
  - » Sigma0 : few 10^{-2} dB



- **Numerical retracking can greatly improve the retracking strategy and performance**
  - » Helps **improving the radar echo modeling** (numerical vs. analytical)
  - » **No correction LUTs needed anymore!**
  - » Ensures the **sea level product quality over time**

→ **Important work has been performed to define a numerical retracker based on a non-biased convergence algorithm, accounting for speckle noise statistics** *[Poisson et al. OSTST 2016]*

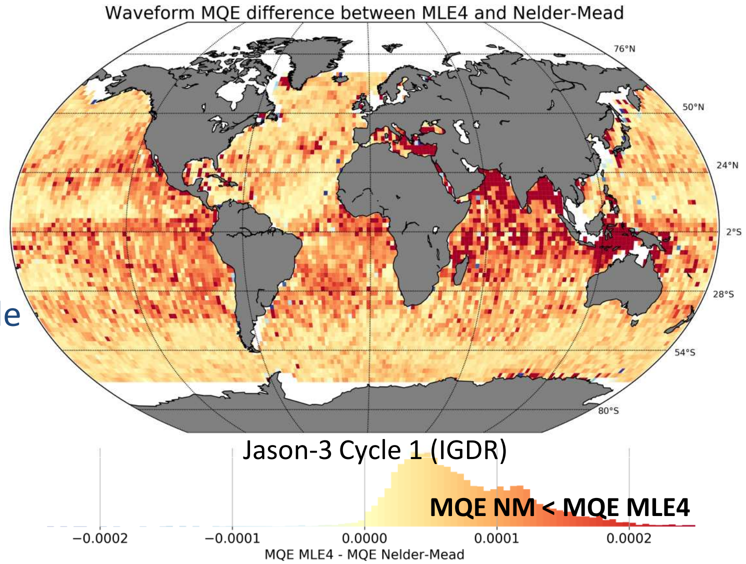
PEACHI-J3 product validation [4/4]

Numerical retracking

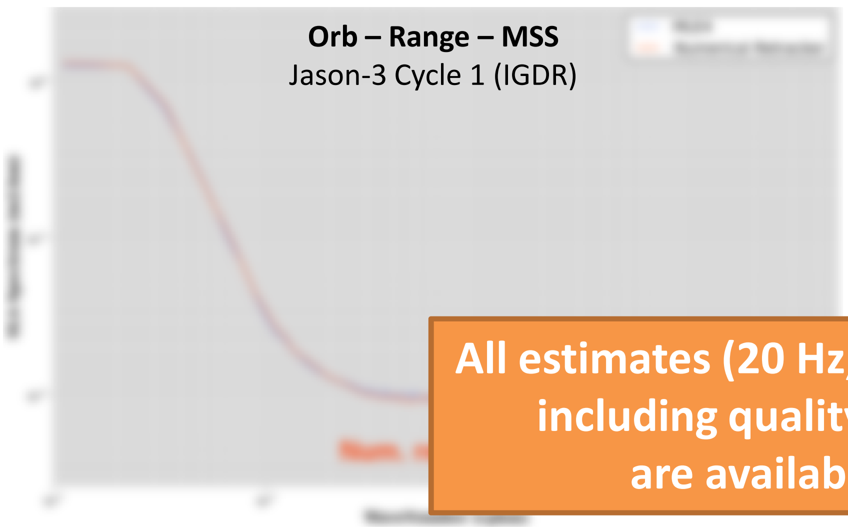
Poisson et al.

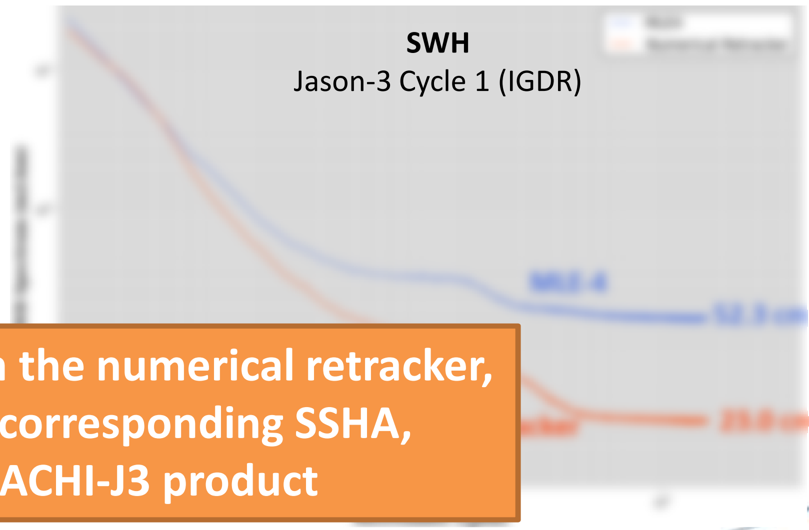
- The numerical retracker uses a **real maximum likehood** convergence criterion

Retracker	MLE4	Numerical retracker
Convergence criterion	Least squares	**Maximum likelihood**
Convergence method	Newton-Raphson	**Nelder-Mead**
Model	Brown(σ_p=0.513T)	Brown(σ_p=0) ⊗ **true PTR**



- **The fit between waveforms and model (MQE) is largely improved** at the global scale
- Spectral analysis shows **20 Hz significant noise level reduction when using the numerical retracker** wrt. MLE4
  - » **-10% for SLA**
  - » **-60% for SWH**





All estimates (20 Hz, 1 Hz) from the numerical retracker, including quality flags and corresponding SSHA, are available in the PEACHI-J3 product

Conclusion and perspectives

- PEACHI-J3 intends to deliver results from **innovative algorithms** and most possible up-to-date geophysical corrections.

- **PEACHI-Jason-3 products are currently being processed in SGDR version – available in November**
  - Users feedback is important !
  - Download at **ftp.jason3.oceanobs.com** or later through ODES

- Several years of work and progress on numerical retracking have lead to the **numerical Nelder-Mead retracker**
- **CNES recommends including this retracker in future Jason-3 GDR releases and on all missions (high potential for reprocessing past altimeters)**

- Ongoing work includes :
  - Documentation & publication
  - Next processing planned Q1 2017 with 1 year of Jason-3 data

PEACHI-J3 related presentations

- **Talks**

  [OUT] New features and attractive products in ODES, Bronner et al.
  [IPC] Jason-3 SSB solutions, Tran et al. – earlier this afternoon

  [IPM] New powerful numerical retracker, Poisson et al. – next talk by P. Thibaut

  [NRT] CFOSat/SWIM Near-Real Time products, Tourain et al. – Wednesday pm

- **Posters on Thursday**

  [CVL_013] JPL validation of PEACHI-J3 product, Shah et al.

  [IPC_007] PEACHI-J3 Wet Tropospheric Correction (NN approach), Fréry et al.

  [IPM_004] Status of PEACHI AltiKa, Valladeau et al.

  [IPM_011] Rain flag for Jason-3 from Continuous Wavelet Transform, Poisson et al.

{ Thank you for your attention }

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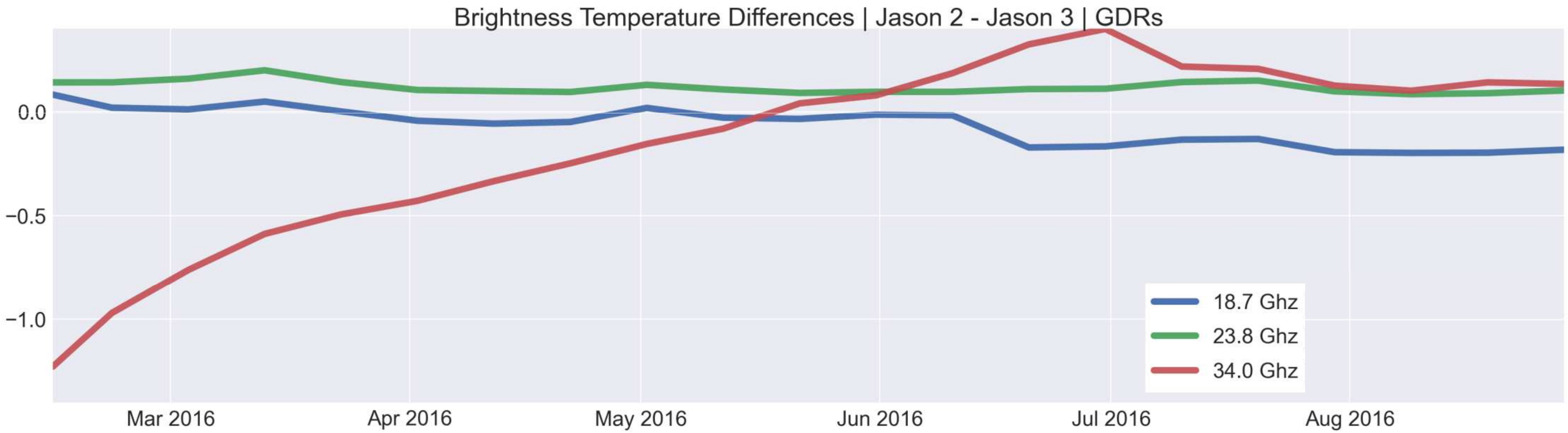
Back-up slides

Back-up slides

Wet Tropospheric Correction (see slide #11)

Cf. Lauret et al.
Jason-3 vs. Jason-2 AMR BTs differences



AMR Channel 34.0 GHz shows a J3-J2 drift
→ This drift impacts Jason-3 BTs and the associated simulations vs. measures bias correction in the WTC retrieval