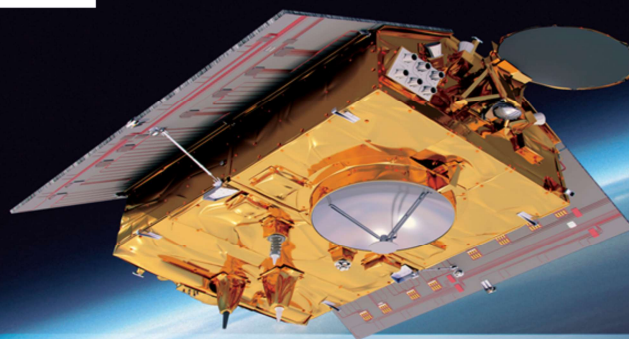# sentinel-6

Sentinel-6 Products: What's New?

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OSTST Virtual Meeting, 19-23 October 2020

Content

Pertinent questions now that we are getting close to the launch

- What type of products will become available?
- When will these products become available?
- How do these products compare to Jason-3's products?
- What is new in these products?
- How can consistency between Jason-3 and Sentinel-6 products be ensured?

What products?

Low Resolution Altimetry (ALT LR)
- Also known as LRM
- Ku-band and C-band
- Global (i.e. ocean and land)
- Level 2
  - In Jason language: OGDR (L2 NRT), IGDR (L2 STC), GDR (L2 NTC)
  - Retracked measurements, corrections, SSH, SWH, wind speed, etc.
  - Standard (1-Hz and 20-Hz) and Reduced (1-Hz only)
  - No SGDR! It is easy enough to combine L2 and L1B: they have the same coverage
- Level 1B
  - 20-Hz waveforms and other instrumental information
  - STC and NTC only (which is more than Jason-3 which had L1B information only in SGDR, i.e. at NTC)

- File length
  - In NRT: full orbit dump (as for J3 OGDR)
  - In STC and NTC: pass files (as for J3 IGDR and GDR)

Low-resolution mode data will be available everywhere, irrespective of whether and which type of high-resolution data that will be available simultaneously.

The Low-Resolution product will provide the ionospheric correction, which is now (finally) smoothed in order to reduce the noise introduced by applying the traditional unsmoothed correction.

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What products?

High Resolution Altimetry (ALT HR)
- Also known as SAR
- Ku-band only!
- Open ocean (SAR RMC) and coastal oceans (SAR RAW)
- Level 2
  - Retracked measurements, corrections, SSH, SWH, wind speed, etc.
  - Standard (1-Hz and 20-Hz) and Reduced (1-Hz only)
  - Dual-frequency ionospheric correction from LR product
- Level 1B
  - 20-Hz waveforms and other instrumental information
  - STC and NTC only
  - **No Level 1B-S!**
- Level 1A
  - Individual echoes (140-Hz "bursts")
- File length
  - In NRT: "granules" (10-minute chunks, as for Sentinel-3)
  - In STC and NTC: pass files (as for Sentinel-3)

The baseline is to have High-Resolution data only over oceans and coastal areas.

During the Commissioning several in-land areas are also selected for HR data.

Depending on the outcome of the comparison between SAR RAW and SAR RMC, it can be decided to go SAR RMC full-time.

What products?

AMR-C Product (AMR L2)

- New product for altimetry community!
- Tailored to "traditional" radiometer users
- Original data rate of ~16-Hz

- Level 2 (only)
  - Antenna temperatures
  - Brightness temperatures
  - Wet tropospheric correction
  - Water vapour content
  - Rain flag
  - etc.

- The wet tropospheric correction (etc.) on this product, which are already smoothed, are sampled at the altimeter rate in the ALT L2 product

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This new product opens the door to have AMR-C data be used more regularly outside of the altimeter community.

Near-Real time (NRT)	Short Time Critical (STC)	Non Time Critical (NTC)
• Mainly for **operational Met agencies** (wind and wave mainly) • Products split by **satellite dump/granules** (per ground station/10-minute chunks) • **NetCDF** and **BUFR**	• For **ocean modelling and assimilation** • Product split by pass (**pole to pole**) • **NetCDF**	• For **oceanographic and geophysical research and climate studies** • Products split by pass (**pole to pole**) • **NetCDF**
JASON-2/3		
• **3-hour latency** • **OGDR** • **1-Hz and 20-Hz** measurements (sea level, wind speed, wave height, etc.)	• **48-hour latency** • **IGDR** • **1-Hz and 20-Hz** measurements	• **60-day latency** • **GDR** • **1-Hz and 20-Hz** measurements • **SGDR** (including waveforms)
SENTINEL-6/JASON-CS		

• **3-hour latency**
• **Level 2:** Low- and high-resolution products
  • **Standard** (1-Hz and 20-Hz)
  • **Reduced** (1-Hz)
  • **BUFR** (1-Hz and 20-Hz)
• **Level 2P:** Harmonised L2 (1-Hz)
	• **36-hour latency**
	• **Level 1A:** Individual echoes (HR only)
	• **Level 1B:** LR and HR
	• **Level 2:** LR and HR
	  • **Standard** (1-Hz and 20-Hz)
	  • **Reduced** (1-Hz only)
	• **Level 2P:** Harmonised L2 (1-Hz)
	• **Level 3:** With orbit error correction, error information (1-Hz)
		• **60-day latency**
		• **Level 1A:** Individual echoes (HR only)
		• **Level 1B:** LR and HR
		• **Level 2:** LR and HR
		  • **Standard** (1-Hz and 20-Hz)
		  • **Reduced** (1-Hz only)
		• **Level 2P:** Harmonised L2 (1-Hz)
		• **Level 3:** With orbit error correction, error information (1-Hz)

• **Level 2P and 3** products are produced with some delay with respect to the timeliness shown above and will only come available by the end of commissioning.

Near-Real time (NRT)	Short Time Critical (STC)	Non Time Critical (NTC)
• Mainly for **operational Met agencies** (wind and wave mainly) • Products split by **satellite dump/granules** (per ground station/10-minute chunks) • **NetCDF** and **BUFR**	• For **ocean modelling and assimilation** • Product split by pass (**pole to pole**) • **NetCDF**	• For **oceanographic and geophysical research and climate studies** • Products split by pass (**pole to pole**) • **NetCDF**
JASON-2/3		
• **3-hour latency** • **OGDR** • **1-Hz and 20-Hz** measurements (sea level, wind speed, wave height, etc.)	• **48-hour latency** • **IGDR** • **1-Hz and 20-Hz** measurements	**"Annual" reprocessing of NTC products** • With any major product evolution • To ensure consistency of data standard throughout the mission • This is the new **"climate product"**
SENTINEL-6/JASON-CS		

• **3-hour latency**
• **Level 2:** Low- and high-resolution products
  • **Standard** (1-Hz and 20-Hz)
  • **Reduced** (1-Hz)
  • **BUFR** (1-Hz and 20-Hz)
• Level 2P: Harmonised L2 (1-Hz)
	• **36-hour latency**
	• **Level 1A:** Individual echoes (HR only)
	• **Level 1B:** LR and HR
	• **Level 2:** LR and HR
	  • **Standard** (1-Hz and 20-Hz)
	  • **Reduced** (1-Hz only)
	• Level 2P: Harmonised L2 (1-Hz)
	• Level 3: With orbit error correction, error information (1-Hz)
		• **Level 2:** LR and HR
		  • **Standard** (1-Hz and 20-Hz)
		  • **Reduced** (1-Hz only)
		• Level 2P: Harmonised L2 (1-Hz)
		• Level 3: With orbit error correction, error information (1-Hz)

• **Level 2P and 3** products are produced with some delay with respect to the timeliness shown above and will only come available by the end of commissioning.

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Sentinel-6 Operational Product Baseline

Product	Latency	Format	User Data Access		
			EUMETCast	GTS	Archive
ALT Low Resolution (LRM)	NRT	BUFR	L2	L2	L2
		NetCDF	L2, L2P	–	L2, L2P
	STC	NetCDF	L2P	–	L1b, L2, L2P, L3
	NTC	NetCDF	–	–	L1b, L2, L2P, L3
ALT High Resolution (SAR)	NRT	BUFR	L2	L2	L2
		NetCDF	L2, L2P	–	L2, L2P
	STC	NetCDF	L2P	–	L1a, L1b, L2, L2P, L3
	NTC	NetCDF	–	–	L1a, L1b, L2, L2P, L3
MWR	NRT	NetCDF	–	–	L2
	STC	NetCDF	–	–	L2
	NTC	NetCDF	–	–	L2

Note 1: ALT Level 2 NetCDF products: reduced (1-Hz only) and standard (1-Hz and 20-Hz)
Note 2: L2P and L3 products have slightly different latency

This slide outlines the various steps of validation exercises, key points, and data releases during the commissioning. The key points for the GNSS-RO commissioning are provided for reference.

Cal/Val Commissioning Timeline

L to L+1.5m (latest)
- Satellite drifts to tandem orbit
- Altimeter operates in Closed Loop
- LR processing starts

Until L+3.5m (latest)
- MPWG evaluates the **LR NRT and LR STC data**
- Recommends distribution to **S6VT** (with possible caveats identified)
- **Distribution to S6VT** starts from rolling archive (7 days)
- Release of BUFR-formatted data to selected Met Offices

Until L+5m
- S6VT evaluates **LR NRT and LR STC data**
- Presentations and reports at **S6VT meeting (L+5m)**
- MPWG recommends release of LR NRT and LR STC data to all users
- Joint Steering Group (JSG) to decide

L+6m (Mid-term Commissioning)
- Distribution **to all users** of LR NRT and LR STC data starts

First order of business is to have good low-resolution (LR) near-realtime (NRT) and short-time critical (STC) products

Cal/Val Commissioning Timeline

Until L+9m (latest)
- MPWG evaluates the **LR NTC and HR data**
- Recommends distribution to **S6VT** (with possible caveats identified)
- **Distribution to S6VT** starts from rolling archive (7 days)

Until L+11m
- S6VT evaluates **LR NTC and HR data**
- Presentations and reports at **S6VT meeting (L+11m)**
- MPWG recommends release of LR NTC and HR data to all users
- Joint Steering Group (JSG) to decide

L+12m (End of Commissioning)
- Distribution **to all users** of LR NTC and HR data starts
- **L2P and L3** services start

Reprocessing
- Reprocessing of all data collected since launch starts
- Homogenise processing to baseline established at end of commissioning and fill potential gaps
- Release **to all users** of reprocessed (NTC) data at L+15m

The low-resolution (LR) non-time critical (NTC) products and all high-resolution (HR) products come next.

Sentinel-6 Products for S6VT

Product	Latency	Format	Available through rolling archive (SFTP)	
			No later than L + 3.5 m	No later than L + 9 m
ALT Low Resolution (LRM)	NRT	BUFR	L2	L2
		NetCDF	L2	L2
	STC	NetCDF	L1b, L2	L1b, L2
	NTC	NetCDF		L1b, L2
ALT High Resolution (SAR)	NRT	BUFR		L2
		NetCDF		L2
	STC	NetCDF		L1a, L1b, L2
	NTC	NetCDF		L1a, L1b, L2
MWR	NRT	NetCDF	L2	L2
	STC	NetCDF	L2	L2
	NTC	NetCDF		L2

Note 1: ALT Level 2 NetCDF products: reduced (1-Hz only) and standard (1-Hz and 20-Hz)

Release to the Sentinel-6 Validation Team (S6VT) will be early for them the evaluate the products and help the project determine if the products are ready for general release.

Sentinel-6 Products for all users

Product	Latency	Format	EUMETSAT archive / EUMETCast / PO.DAAC	
			L + 6 m	L + 12 m
ALT Low Resolution (LRM)	NRT	BUFR	L2	L2
		NetCDF	L2	L2, L2P
	STC	NetCDF	L1b, L2	L1b, L2, L2P, L3
	NTC	NetCDF		L1b, L2, L2P, L3
ALT High Resolution (SAR)	NRT	BUFR		L2
		NetCDF		L2, L2P
	STC	NetCDF		L1a, L1b, L2, L2P, L3
	NTC	NetCDF		L1a, L1b, L2, L2P, L3
MWR	NRT	NetCDF	L2	L2
	STC	NetCDF	L2	L2
	NTC	NetCDF		L2

Note 1: ALT Level 2 NetCDF products: reduced (1-Hz only) and standard (1-Hz and 20-Hz)

LR NRT and LR STC products will be available to all users mid-way through Commissioning. All other products follow by the end of Commissioning

Reminder about Sentinel-6 Validation Team (S6VT)

Kick-off
- The S6VT at its first meeting 8-9 September 2020
- All presentations can be found on-line

You can still sign up to the S6VT
- Can you contribute with a Cal/Val activity to the S6VT?
- Are you willing to write a short proposal?

Join
- Read more at https://www.s6vt.org

Yes, you are still welcome to join, if you make the effort.

Product heritage

Jason-3
- Maintain similar variable names
- Same pole-to-pole pass numbering

Sentinel-3
- Level 1A and Level 1B products
  - L1A for HR; L1B as separate product
- HR data variables similar to S3
- SAFE packaging
  - Manifest (xml) and data files in directory per product (e.g. pass)
- Internal netCDF data compression
  - Reduced data volume without need for zipping/unzipping
- 1-Hz variables at integer seconds
- WGS84 reference ellipsoid!

Sentinel-6 will have 1-Hz variables at integer seconds, just like Sentinel-3. This will **not** be the case for Jason-3 GDR-F.

Product novelties

New in Sentinel-6

- Separate HR and LR products
  - Because of 100% (LR) versus ocean-only coverage (HR)
  - Quite different content (frequency bands, retrackers)
- No "enhanced" or SGDR product
  - L1B product linked to L2 (same number of 20-Hz records)
- SAFE packaging with (for L2) "unique" internal filename, à la Jason
  - PO.DAAC will "unpack" SAFE and provide only internal file
- NetCDF data grouping
  - For more convenient variable naming
  - Compartmentalise data
- Separate Level 2 MWR product
  - At original data rate (16 Hz)
  - Includes antenna temperatures and brightness temperatures

L1B and L2 products can easily be combined, if you want, running standard netCDF tools from your command line.

Because of the unique internal filenames (unlike just "measurement.nc", L2 products can be used easily outside of the SAFE packaging.

Grouping variables

Not grouped (as in Sentinel-3)
- Requires stringed variables like *time_20_ku, time_20_c*
- Creates confusing names like *sea_state_bias_c_20_ku*

Grouped (as in Sentinel-6)
- All variables of same posting rate contained in groups with same dimension name (*time*)
- Variable names can be reused in groups: e.g. *altitude* in **data_01** and **data_20/ku**

/ (root)			
Global attributes, common dimensions			
data_01		**data_20**	
1-Hz time dimension, 1-Hz variables common to Ku- and C-band (time, location, tides, MSS)		(none)	
ku	**c**	**ku**	**c**
1-Hz Ku-band measurements and corrections	1-Hz C-band measurements and corrections	20-Hz Ku-band time, location, measurements and corrections	20-Hz C-band time, location, measurements and corrections

Grouping variables is really much more convenient, once you get used to it.

Example: NetCDF groups in Level 2 LR product
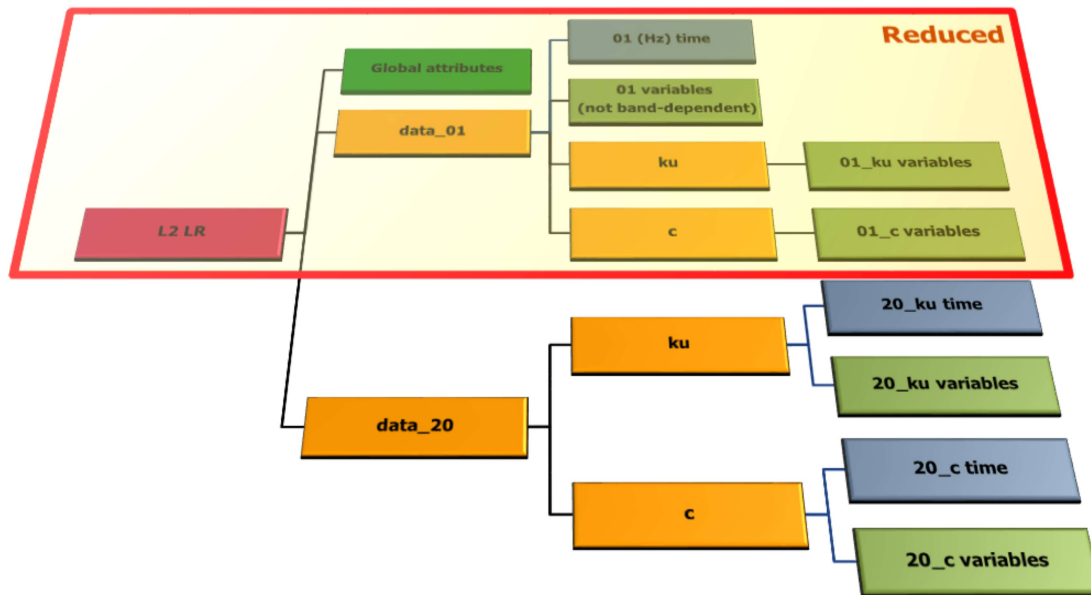
The Reduced or 1-Hz product encapsulates all of the 1-Hz variables, so no longer a subset of those, as in S3 and J3.

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Example: NetCDF groups in Level 2 HR product
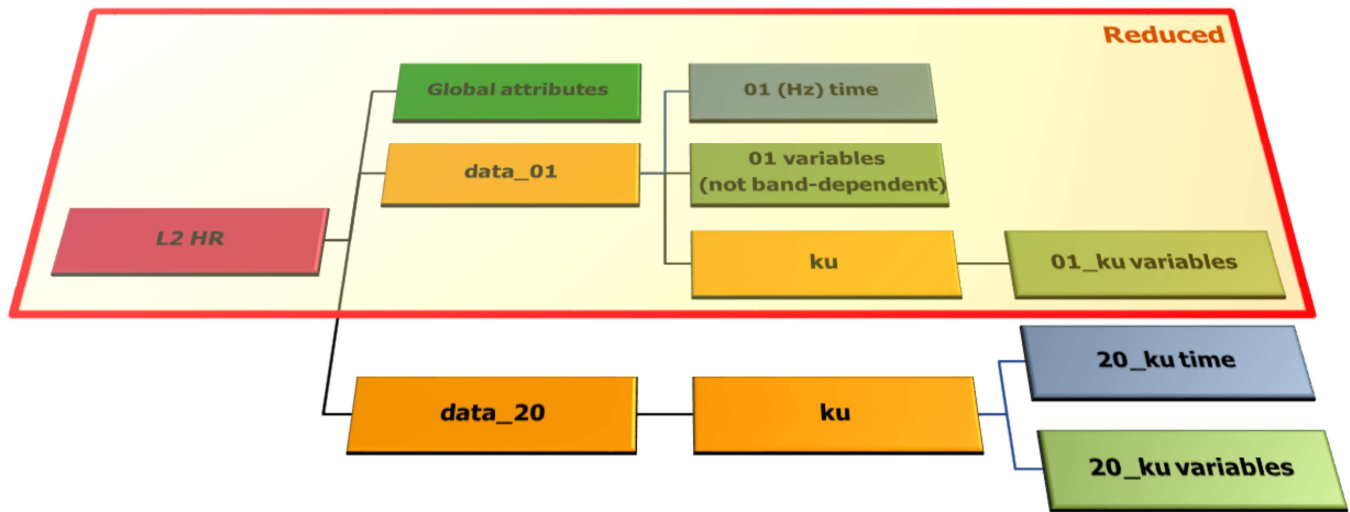
Again, the Reduced or 1-Hz product contains all the 1-Hz variables.

Example of netCDF variable grouping (Level 2)

Variable Name (dim)	Units	Scale factor	Format	LR		HR		Contained in groups
				data_01	data_20	data_01	data_20	
time (time)	s	-	double	x	ku, c	x	ku	1-Hz: **data_01** 20-Hz: **data_20/ku, data_20/c**
time_tai (time)	s	-	double	x	ku, c	x	ku	
latitude (time)	degrees_north	1.e-6	int	x	ku, c	x	ku	
longitude (time)	degrees_east	1.e-6	int	x	ku, c	x	ku	
altitude (time)	m	1.e-4	int	x	ku, c	x	ku	
range_ocean (time)	m	1.e-4	int	ku, c	ku, c	ku	ku	1-Hz: **data_01/ku, data_01/c** 20-Hz: **data_20/ku, data_20/c**
range_ocean_numval (time)	1	-	byte	ku, c		ku		1-Hz only: **data_01/ku, data_10/c**
range_ocog (time)	m	1.e-4	int		ku, c		ku	20-Hz only: **data_20/ku, data_20/c**

These are some examples of variables and where you would find them in the products:

- time, time_tai, latitude, longitude and altitude are in the data_01 group (shared by data_01/ku and data_01/c because the times are the same) and in the data_20/ku and data_20/c (because the times of 20-Hz and Ku- and C-band measurements in not the same)

- range_ocean is in all groups data_01/ku, data_01/c, data_20/ku, data_20/c

- range_ocean_numval is a 1-Hz variable in data_01/ku and data_01/c

- range_ocog is a 20-Hz variable in data_20/ku and data_20/c

LR ALT L2 file in Panoply
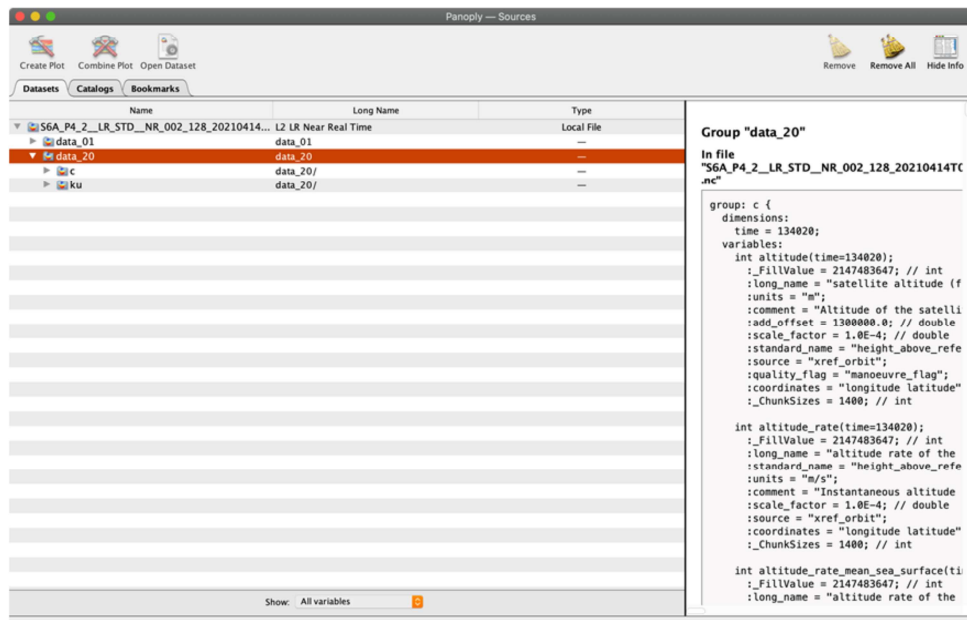
This how the groups look (collapsed) in Panoply

If you are not familiar with it, get it at https://www.giss.nasa.gov/tools/panoply/

LR ALT L2 file in Panoply (data_01 expanded)

Now expanding the data_01 group.

LR ALT L2 file in Panoply (data_01/c expanded)

And finally the data_01/c group.

Compatibility with Jason-3

GDR-F standards

- Sentinel-6 and Jason-3 projects have largely aligned their product format, content, and algorithm specification
- Products will therefore look very similar and will be easy to compare
- Jason-3 GDR-F will become operational in October 2020

GDR-F Standards have been coordinated extensively between EUMETSAT (for S6) and CNES (for J3).

New in GDR-F (common to Jason-3 and Sentinel-6)

Reference ellipsoid and time
- Change ellipsoid to WGS84 (difference with TOPEX ellipsoid provided as variable)
- Time in UTC and TAI (so no issue with leap seconds!)

Geophysical corrections
- Update geoid model to EGM 2008
- Update bathymetry to "ACE-2"
- Update CNES-CLS MSS to 2015 version
- Add DTU MSS 2018 version
- Update CNES-CLS MDT to 2018 version
- Add a 7 state flag to classify the surface, replacing the existing 4 state Surface Type flag
- Add the distance and angle to the coast
- Update GOT Tide Model to version 4.10c
- Update FES Tide Model to version 2014b (extrapolated)
- Update Pole Tide model to [Desai Issue 2017]
- Add internal tide solution (4 waves Zaron model M2, S2, K1, O1 HRET-v8.1 2019)
- Change the decomposition of the DAC: dac = inv_bar_corr + hf_fluctuations_corr

To make the change to WG84, the difference in height between the TOPEX ellipsoid and WGS84 is provided.

Time in TAI after enduring requests from those that do not like to lose data at leap seconds.

New in GDR-F (common to Jason-3 and Sentinel-6)

Geophysical corrections (cont'd)
- New DAC/MOG2D/T-UGO (using the grid from FES2014b)
- Add new wet & dry tropo model correction at sea level correction using 2D ECMWF "Sea Level Pressure" (formerly "Corrected Surface Pressure")
- Add wet & dry tropo model correction at measurement level computed with 3D ECMWF data
- Add GIM in OGDR products (predicted)
- Provide the smoothed ionospheric correction in L2 products

Orbit
- POE-F standard (was in fact already used for a while on Jason-3)

Height measurements
- 6-state rain flag, replacing the old 2-state rain flag
- Replace the ocean tide solution GOT by FES in the SSHA computation
- Correct SSHA variable for non-equilibrium ocean tide
- Use CNES_CLS MSS 2015 version in SSHA
- Correct SSHA variable for internal tide

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Closing remarks

Sample data

- Will be made available in the next weeks
- Based on simulations, of course, and thus have limitations

Available for questions

- Here at the virtual OSTST2020 Meeting
- Anytime: remko.scharroo *at* eumetsat.int

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Thank you for your attention