



National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California



Surface Water and Ocean Topography (SWOT) Mission

<http://swot.jpl.nasa.gov>

Level 2 Ocean Products

Bryan Stiles¹ and Nathalie Steunou²

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1. Jet Propulsion Laboratory, California Institute of Technology
2. Centre national d'études spatiales



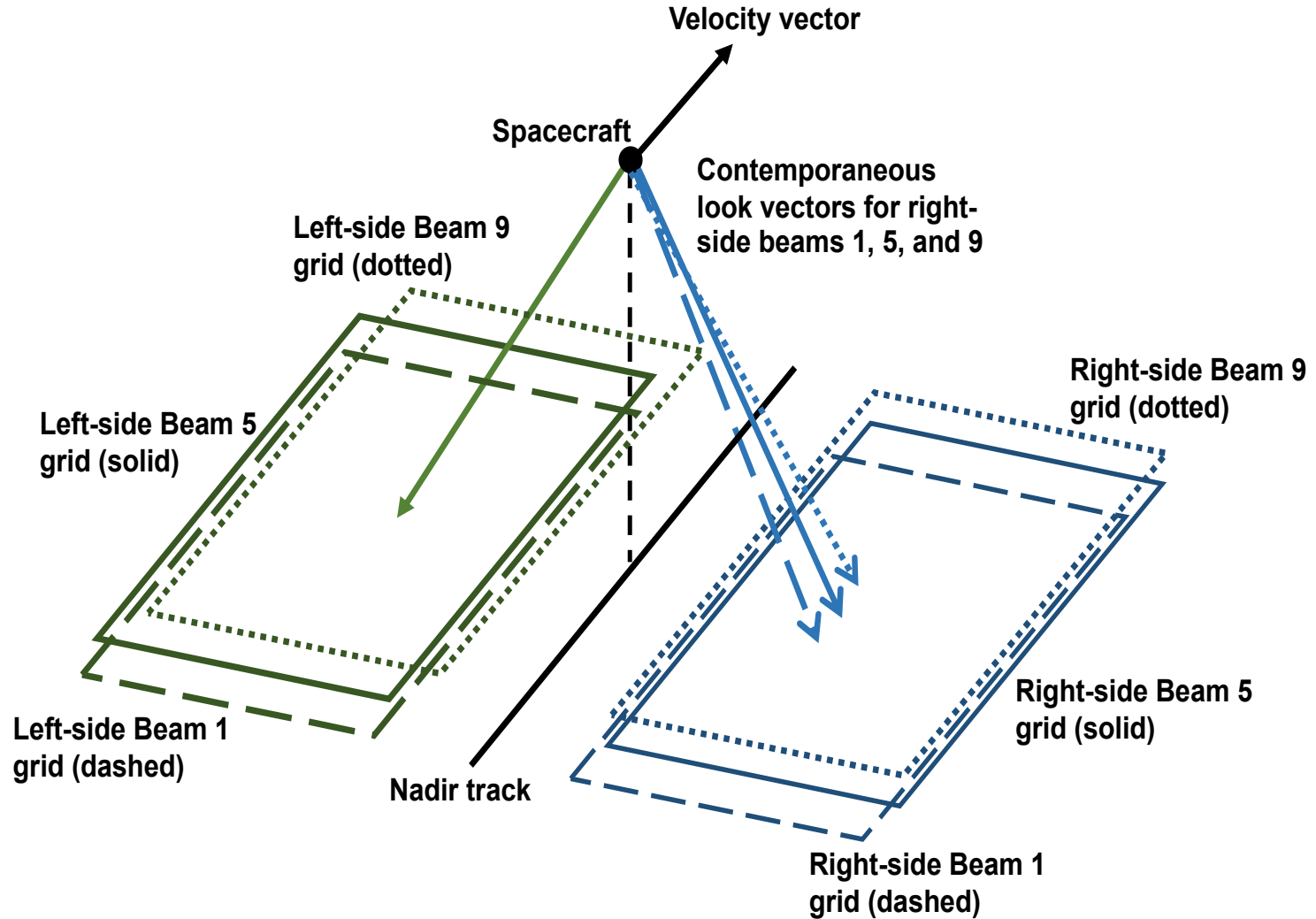
Overview



- Overview of SWOT LR measurement geometry
- Brief description of LR Level 1B interferogram product
- Overview of Level 2 processing approach
- Description of four Level 2 file types
 - Basic
 - Wind and Wave
 - Expert
 - Unsmoothed
- Summary



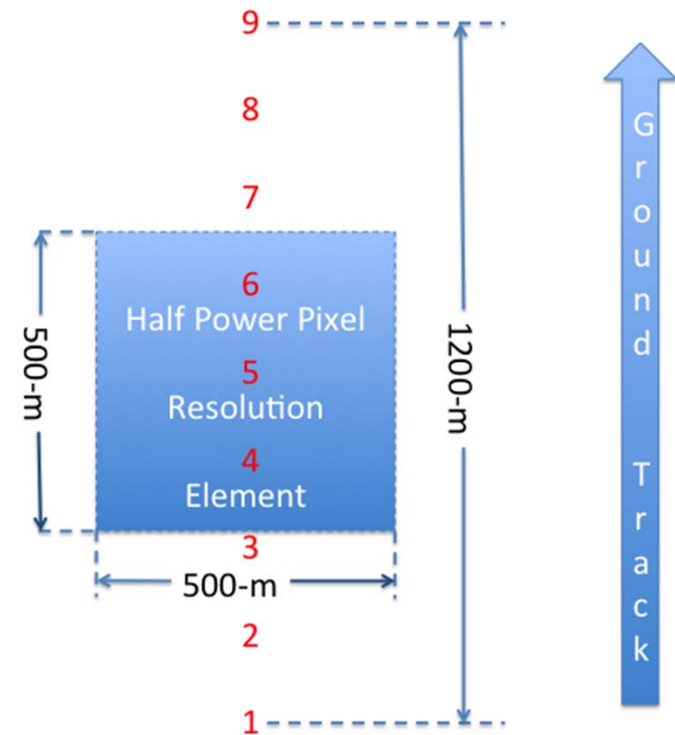
SWOT LR Measurement Geometry





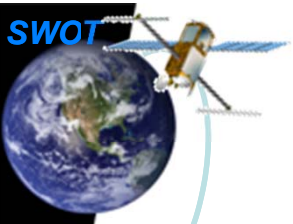
Level 1B Product

- Level 1B Product provides for each of 9 Doppler Beams:
 - Interferograms.
 - Calibrated estimates of normalized radar cross section (NRCS or σ_0).
 - Volumetric coherence.
 - Uncertainty estimates of measured quantities.
 - Spacecraft ephemeris and attitude information.
- Data from each beam is a 2-D image.
 - Each Image has spatial posting of 250 m in cross-track and along-track directions, and 500m resolution.
 - ◆ Filter in onboard processor has half-power width of 500x500 m.
- Center beam (beam 5) has highest SNR.



Spatial arrangement of beams

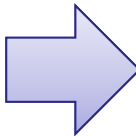
(There is a large overlap between consecutive measurements of the same beam.)



Level 2 Product: Processing Approach



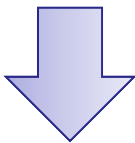
L1B*



Beams 1-9 (250/500-m) are:

1. Height reconstructed
2. Interpolated to center beam grid
3. Beam combined

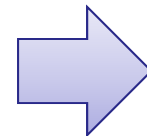
* PDD submitted to SMEs



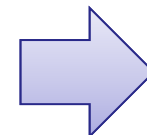
Unsmoothed

Unsmoothed Data is:

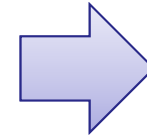
1. Interpolated to fixed grid
2. Averaged down to 2-km
3. Geophysically corrected to SSHA



Basic



Wind and Wave



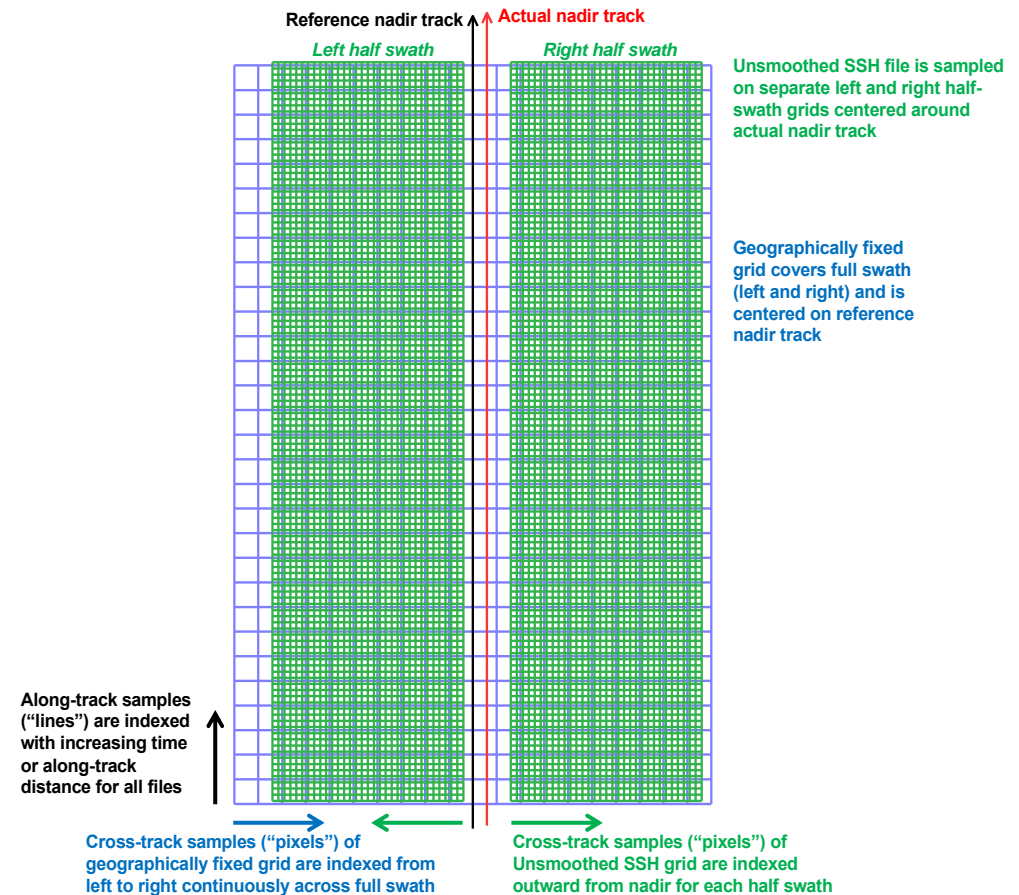
Expert



Spatial Sampling of Products

Basic, Wind and Wave, and Expert products use **only** 2 km geographically-fixed grid.

- Samples are 2 km apart in along-track and cross-track direction.
- SWOT ground track is required to repeat to within +/-1 km from cycle to cycle.
 - ◆ Extra bins on edges to accommodate +/-1 km deviations.
- Geographically-fixed grid is expected to be especially convenient for most users.
- No evidence to show value-added from providing measurements on 2-km native grid.
- Unsmoothed product provided on "native" 250x250 m grid.
 - Native grid is location of center beam measurements.
 - All other beams interpolated to center beam grid.





Baseline Level 2 Oceans Product Consists of 4 Half-orbit granule, Netcdf-4 files



File	Name	Description
1	Basic SSH [‘Basic’]	Provides corrected sea surface height (SSH) , sea surface height anomaly (SSHA) , flags to indicate data quality, geophysical reference fields , and the crossover height correction on a 2 km geographically fixed grid.
2	Wind and Wave [‘WindWave’]	Provides measured significant wave height (SWH) , normalized radar cross section (NRCS or backscatter cross section or sigma0), wind speed derived from sigma0 and SWH, model information on wind and waves, and quality flags on a 2 km geographically fixed grid.
3	Expert SSH with Wind and Wave [‘Expert’]	Includes copies of the Basic and the Wind and Wave files plus more detailed information on instrument and environmental corrections , radiometer data , and geophysical models on a 2 km geographically fixed grid.
4	Unsmoothed SSH [‘Unsmoothed’]	Provides sea surface height (SSH) , sigma0, and “mitigation” power without additional smoothing relative to the native KaRIn downlink resolution on a ~250 m native (center-beam) grid .



“Basic” SSH File

- Aimed towards users of KaRIn SSH measurements as provided.
 - Low volume (< 40 MB/pass) file with limited content for ease of use.
- Content includes: **(Recent changes in blue)**
 - Time and geolocation.
 - **Two values of sea surface height (SSH)** and one value of uncertainty.
 - ◆ ssh_karin: Using wet troposphere correction from radiometer measurements.
 - Computed as $ssh_karin = ssh_karin_2 + \text{equivalent vertical (model-radiometer) wet troposphere correction difference}$.
 - Defaulted where radiometer measurements contaminated by rain, ice, and land.
 - ◆ ssh_karin_2: Using wet troposphere correction from ECMWF model.
 - Mitigates loss/degraded KaRIn SSH measurements due to rain, ice, and land contamination of radiometer measurements.
 - ◆ Equivalent vertical corrections for wet (radiometer and model) and dry troposphere, ionosphere, sea state bias provided in “Expert” file.
 - **Two values of sea surface height anomaly (SSHA)**.
 - ◆ ssha_karin and ssha_karin_2: Computed from ssh_karin and ssh_karin_2, respectively.
 - ◆ Geophysical models used to correct SSH for contributions from mean sea surface, solid Earth tide, ocean tide, load tide, pole tide, and dynamic atmosphere correction.
 - Applied values provided in “Expert” file.
 - Mean sea surface (as applied to SSHA) and geoid.
 - Model for coherent internal tide provided separately. Not applied to SSH/SSHA.
 - Crossover height correction provided. Not applied to SSH/SSHA.
 - Surface type, ice (from EUMETSAT OSI SAF), and rain flags.



“Wind and Wave” File



- Aimed towards users of wind and wave measurements.
 - Low volume (< 40 MB/pass) file with limited content for ease of use.
- Content includes: **(Recent changes in blue)**
 - Time and geolocation.
 - Significant wave height (SWH) and uncertainty.
 - ◆ From volumetric coherence of interferograms.
 - **Two values of fully corrected sigma0/normalized radar cross section (NRCS) and uncertainty.**
 - ◆ sig0_karin: Using atmospheric attenuation from radiometer measurements.
 - Defaulted where radiometer measurements contaminated by rain, ice, and land.
 - ◆ sig0_karin_2: Using atmospheric attenuation from ECMWF model.
 - Mitigates loss/degraded measurements due to rain, ice, and land contamination of radiometer measurements.
 - ◆ Provided in linear units (not decibels) to allow for negative values.
 - **Two values of wind speed from a model function of KaRIn SWH and sigma0 measurements.**
 - ◆ wind_speed_karin: Using sig0_karin.
 - ◆ wind_speed_karin_2: Using sig0_karin_2
 - Models for SWH, wave direction, wave period, wind speed.
 - Radiometer estimate of wind speed.
 - Surface type, ice (from EUMETSAT OSI SAF), and rain flags.



“Expert” SSH with Wind and Wave File



- Aimed toward users interested in source of KaRIn measurements, media delays, models, and other details.
 - High volume (~120 MB/pass) file with detailed content.
- Content includes:
 - Exact copies of “Basic” and “Wind and Wave” files as separate NetCDF groups.
 - “Expert” NetCDF group with:
 - ◆ Nadir location.
 - ◆ Spacecraft altitude and altitude rate.
 - ◆ Spacecraft attitude information (roll, pitch, yaw, heading)
 - ◆ sigma0 calibration and corrections.
 - ◆ Radiometer brightness temperature measurements, water vapor, and liquid water.
 - ◆ Geophysical models:
 - All geophysical models are consistent with nadir altimeter product and Sentinel-6:
 - Second MSS model, two ocean/load tide models, second internal tide model, mean dynamic topography, solid Earth tide, pole tide, dynamic atmosphere correction, inverse barometer correction)
 - First MSS and internal tide models in “Basic” group.
 - ◆ Equivalent vertical media delay corrections :
 - Radiometer and model wet troposphere, model dry troposphere, model ionosphere.
 - ◆ Sea state bias with source of SWH.
 - ◆ Model-based rain rate



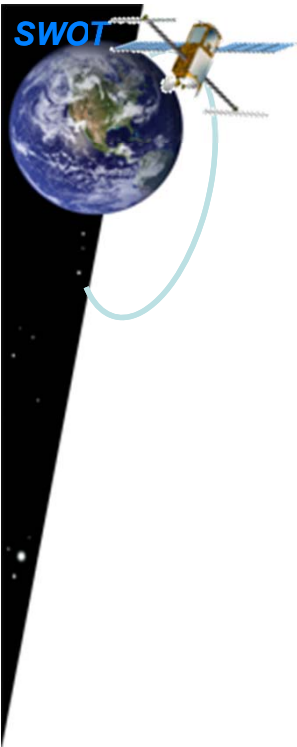
“Unsmoothed” SSH File

- Aimed towards users interested in measurements at posting/resolution (=250/500 m) of On-Board Processor.
 - Very high volume (~1500 MB/pass)
 - Enables users to apply their own resampling/smoothing.
- Content includes:
 - Separate groups for left and right swath.
 - Time and geolocation of center beam (beam 5).
 - Sea surface height (SSH) and uncertainty.
 - σ_0 (NRCS) and uncertainty
 - Interferometric coherence.
 - One model for mean sea surface.
 - ◆ Same model as on “Basic” file.
 - 250 m “Mitigation” power and variance (TBD).
 - Surface type.



Summary Product Table

Product	Target User	Contents	MB/granule
Basic	All SSH/SSHA Users	SSH, SSHA, and most geophysical corrections	<40
Wind and Wave	All SWH and wind speed Users	Wind speed, SWH, sigma0, and intermediate quantities	<40
Expert (Includes copies of Basic and Wind and Wave)	Expert Users who want all corrections	All corrections, alternate corrections, and intermediates	120
Unsmoothed	Expert Users who want full downlinked resolution	500 meter resolution SSH and sigma0 on native 250-m center beam grid	1,500
L1B	Expert Users who want to redo height reconstruction	Interferograms, sigma0, and volumetric correlation for all 9 beams on reference grids, and all geometry	42,000



Backup Slides

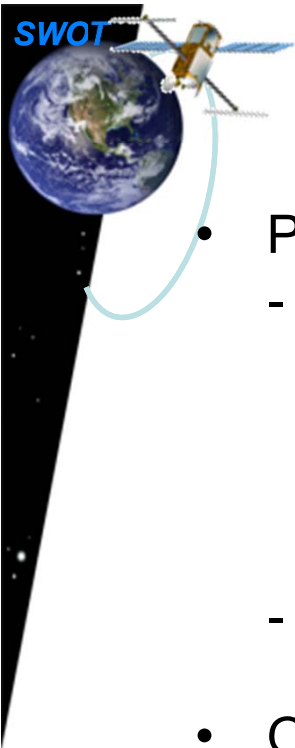




Level 2 Product: Processing Approach



- Eight outer beams (Beams 1-4, and 6-9) are resampled to to the common sampling grid of center beam (Beam 5).
 - Each beam has a different spatial sampling grid on the Earth's surface due to different Doppler frequencies.
- Weighted average of the 9 beams is used to compute a single “unsmoothed” measurement at the “native” center-beam location.
 - Often referred to as the “native” sampling grid of beam 5.
 - “Unsmoothed” refers to no significant spatial smoothing on ground.
 - Beam-combined measurements preserve On-Board Processor spatial posting of ~250 m and resolution of ~500 m in along-track and cross-track directions.
- Spatial resampling and smoothing of the “unsmoothed” measurements is then performed to generate measurements on a 2x2 km grid.
 - Selection of 2x2 km grid aimed to reduce sea surface height error to < 2 cm across the swath (10-60 km), based upon science team input.
 - Fine-scale details related to exact KaRIn sampling will be lost in smoothing to 2 km resolution, regardless of grid.



Changes with respect to last Science Team Meeting



- Product consists of 4 files instead of 7 files.
 - 2 km native center-beam grid “Basic”, “Wind and Wave”, and “Expert” files not provided.
 - ◆ No evidence to suggest that native-grid measurements add value to fixed-grid measurements.
 - ◆ Interested users can use the “Unsmoothed” file and resample/smooth as they wish.
 - Enables elimination of the L2A versus L2B nomenclature previously used to describe “native-grid” and “fixed-grid” files, respectively.
- Otherwise, product is the same as described at last science team meeting.
 - Some changes to details within each of the 4 files.