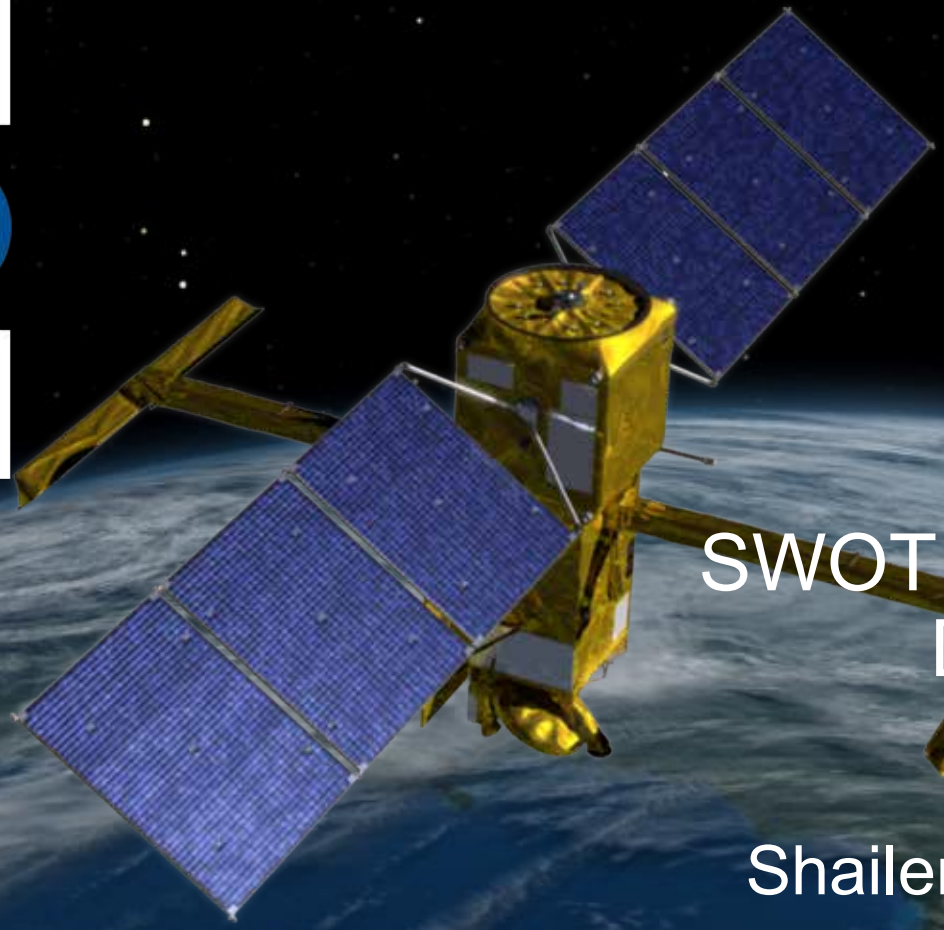
Surface Water and Ocean Topography (SWOT) Mission

June 26, 2018



SWOT Ancillary Data, Auxiliary Data, and Models

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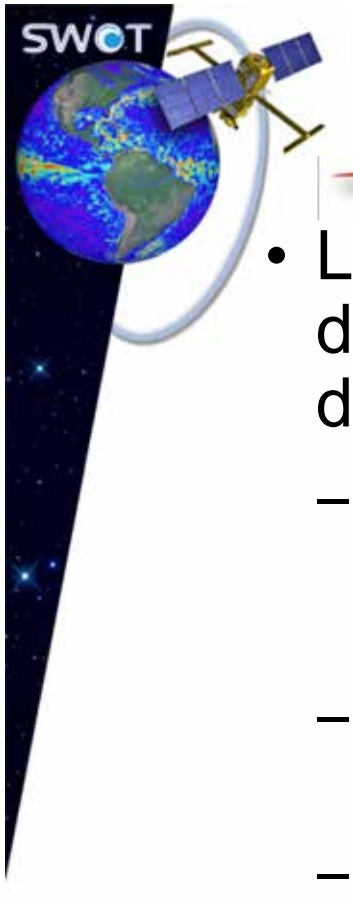


Introduction

- Level 1 and Level 2 KaRIn processing and/or science data products require variety of ancillary and auxiliary data.
  - Ancillary Data: Data other than instrument data within project systems required to perform instrument data processing.
    - E.g. orbit, attitude, calibration data, etc.
  - Auxiliary Data: External data required to perform processing.
    - E.g., Digital elevation models, tides, meteorological data, etc.
  - Dynamic Data: Changes periodically.
  - Static Data: Does not change.

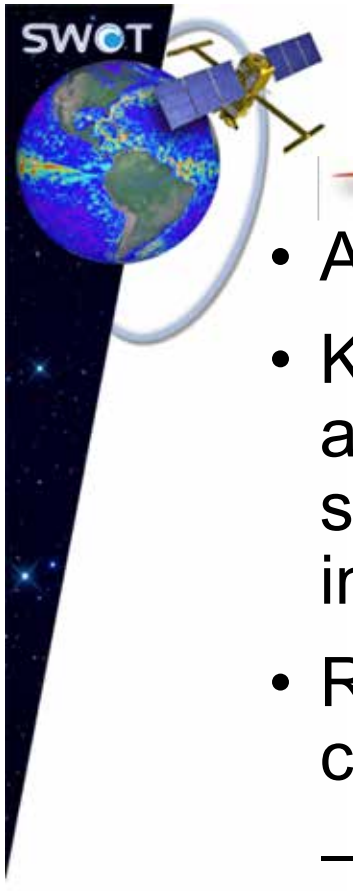
- Summarize current baseline choices for these data.
  - Science Team (Subject Matter Experts) can then consider potential for improvements prior to launch.
    - i.e., Intent not to to summarize performance of current baseline.

Orbit Determination Processing

- Applicable to Nadir Altimeter, Radiometer, KaRIn LR and KaRIn HR processing.
- Two primary orbit determination products for SWOT:

Product	Latency	Radial Accuracy
Medium-Accuracy Orbit Ephemeris (MOE)	Next Day	2 cm (RMS)
Precise Orbit Ephemeris (POE)	30 Days	1.5 cm (RMS)

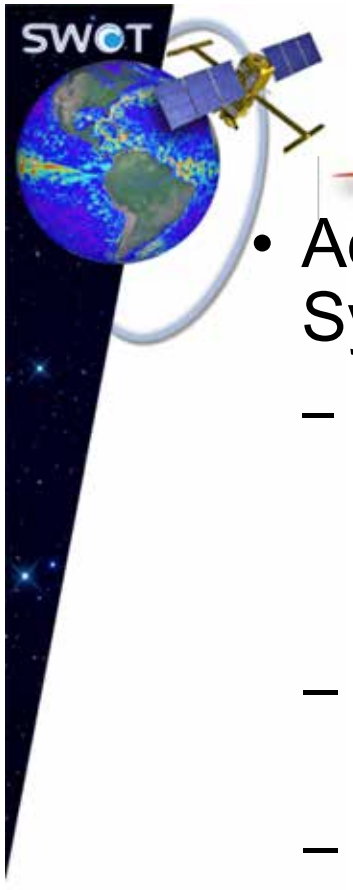
- Generated using combination of DORIS and GPS tracking data.
- Generated using heritage software at CNES Orbit Determination Center.
  - Proven capability to process DORIS, GPS, and SLR tracking data.
  - Current standards generate DORIS+GPS combined solutions for MOE and POE.
    - SLR data reserved for independent validation.
  - Performing orbit determination for multiple missions (Jason-series, Sentinel-3A).
    - < 1-cm radial orbit accuracy for Jason-3.
    - Simulation studies demonstrate higher orbit error for SWOT due to lower altitude (higher drag).



Attitude Determination

- Applicable to KaRIn LR and KaRIn HR processing.
- KaRIn pointing knowledge, which affects interferometric and radiometric calibration, relies on reconstructed spacecraft attitude (based on Gyro and Star Stracker information)
- Roll & Pitch knowledge errors are major contributor to cross-track slope errors
  - estimated through combination of reconstructed attitude and crossover calibration

Product	Latency	Radial Accuracy
Residual errors over Land	Next Day	4.1 cm
Residual errors over Land	45 Days	3.8 cm



Radiometer Calibration

- Adopts JPL's multi-mission AMR Radiometer Calibration System (ARCS).
  - Generates calibration parameters for the Advanced Microwave Radiometers (AMR).
    - Calibration parameters used to generate Level 2 radiometer science data products.
  - Uses in-flight data with vicarious cold and amazon hot references to calibrate radiometers.
  - **For SWOT, primary focus will be the inter-calibration of the two radiometers.**
    - Minimize cross-track slope errors.
      - Long-term overall stability for climate quality calibration is not a priority (e.g., no cold-sky maneuvers as used on Jason-2/3).
    - Updated once per repeat cycle with latency of 30 days.

Media Corrections

Parameter	Description
Dry Troposphere	• ECMWF 6-hourly meteorological pressure fields. • S1 and S2 tides in atmospheric pressure from Ray and Ponte.
Wet Troposphere	• ECMWF 6-hourly meteorological fields • Radiometer measurements for ocean products only.
Ionosphere	JPL's GPS-based Global Ionosphere Model (GIM).

- Line-of-sight media corrections to be applied on complex interferograms before height reconstruction and geolocation.
  - Based upon results of simulations.
  - LR: Applied when processing interferograms (L1B_LR_INTF)
  - HR: Applied in Pixel Cloud Processor (L2_HR_PIXC)
- Reported on data products as equivalent vertical delay.
  - LR: Computed when generating Level 2 Ocean Products (L2A_LR_SSH_PRECAL and L2B_LR_SSH_PRECAL)
  - HR: Computed in Pixel Cloud Processor (L2_HR_PIXC)

Reference Surfaces for Ocean Products

Parameter	Description
Mean Sea Surface	Two models MSS_CNES_CLS-2015, and DTU15_MSS
Mean Dynamic Topography	One model: MDT_CNES_CLS-2018
Bathymetry	DTM2000.1
Surface Type	DTM2000.1
Geoid	EGM2008

- All fields provided separately on ”expert” sea surface height product.
- Mean sea surface (MSS):
  - Used as reference surface when processing interferograms.
  - Used to generate sea surface height anomaly on products.
- MSS models likely to evolve when in-flight SWOT data become available.
  - Reevaluate prior to reprocessing opportunities.
- **Reference Ellipsoid for all SWOT science data products: WGS84**

Tide Models for Ocean Products

Parameter	Description
Solid Earth Tide	Static coefficients based upon Topex heritage (Cartwright/Taylor)
Ocean Tide	Two models: GOT4.10 and FES2014
Load Tide	Two models: GOT4.10 and FES2014
Pole Tide	Using Predicted and Analyzed Pole Location data from IERS.
Internal Ocean Tide	Two Models for Coherent Internal Tide Only. Primary model from R. Ray (GSFC). Second model to be recommend by tides working group.

- Models are used to generate sea surface height anomaly SSHA on products.
  - All provided separately on “expert” products.
  - Baseline approach is to NOT apply internal tide for SSHA. (can be changed).
- Solid Earth Tide model not exactly the same as IERS conventions, but consistent with best available models for barotropic ocean tides.
- Ocean (barotropic) and Load Tide models currently baselined to use Jason-series models.
- Recommendations/confirmation from tide working group welcome for barotropic ocean, load, and internal tides..

Other Models for Ocean Products

Parameter	Description
Dynamic Atmospheric Correction	CNES Mog-2D model (using ECMWF meteorological model for pressure and winds).
Wind Speed	Two models: • Geophysical Model Function (sigma0 and SWH) • ECMWF 6-hourly meteorological fields (U and V). • Radiometer wind speed also provided.
EM Bias	Baseline to use models from SARAL Ka-band.
Ice Map	Baseline to use EUMETSAT OSISAF operational maps (Global Sea Ice Concentration (SSMIS) for sea-ice flag.
Rain Rate	ECMWF model. Used for rain flagging in addition to radiometer flag
SWH Model	Meteo France

- EM Bias model to be revisited with in-flight SWOT data,

Geophysical Models for Hydrology

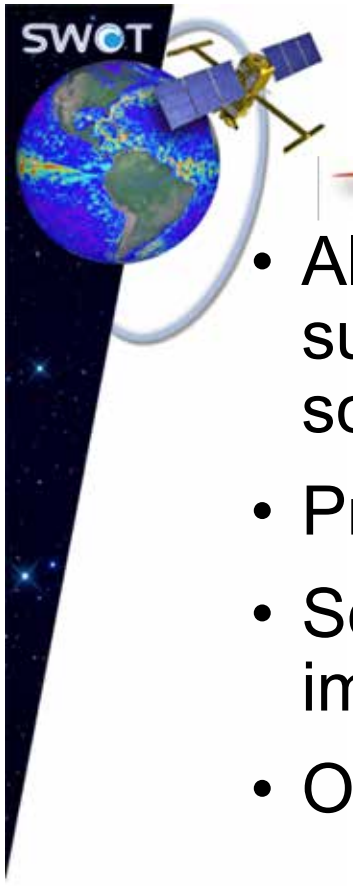
Parameter	Description
Solid Earth Tide	Static coefficients based upon Topex heritage (Cartwright/Taylor)
Load Tide	Two models: GOT4.10 and FES2014
Pole Tide	Using Predicted and Analyzed Pole Location data from IERS.
Geoid	EGM2008
Rain Rate	ECMWF model. Used for rain flagging
Atmospheric attenuation	ECMWF model. Used for sigma0 correction

- Preference to use identical standards for hydrology and ocean products.
  - i.e. same solid Earth, load, and pole tide models.
- **Reference Ellipsoid for all SWOT science data products: WGS84**

Hydrology Databases

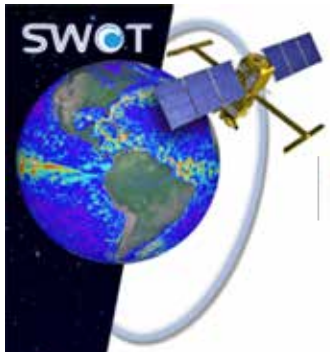
Parameter	Description
Reference Digital Elevation Model	From SRTM and Arctic DEM (MERIT under investigation)
Prior Water Probability Masks	From Pekel et al. (2016); others also under investigation.
River Database	Provided by Science Team based upon Landsat data.
Lake Database	Sheng *et al.* CIRCA-2015 + precise local databases
Ice Map	Climatology and/or optical provided by UNC (Pavelsky).

- Reference DEM used in SLC and PIXC processors for SAR focusing, projection of priors to slant plane, phase unwrapping, layover mitigation.
- Prior water mask used for water detection, dark water flagging, phase unwrapping, layover mitigation, and pixel cloud pruning.
- River database defines centerlines, nodes and reaches for science data products.
- Lake database links SWOT observations to monitor time evolution of lakes and reservoirs.
- Ice map climatology has been demonstrated to meet requirements.
  - Working with T. Pavelsky on potential use of optical data to provide improvements (e.g., especially during transition periods).

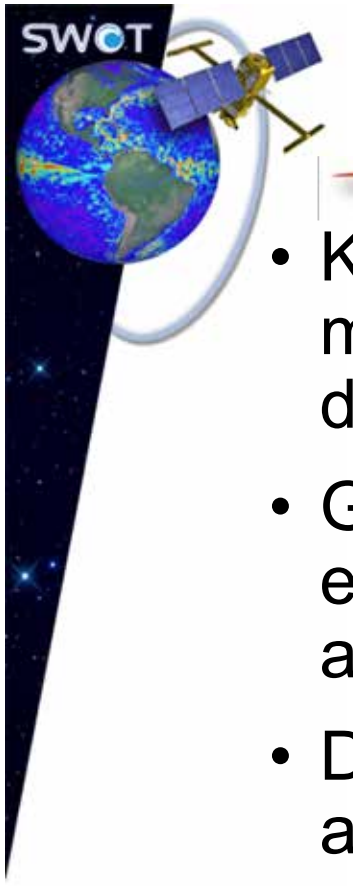


Conclusion

- Algorithm Development Team will generate document to summarize auxiliary data and models used for KaRIn science data products.
- Provide to science team for review and concurrence.
- Science team encouraged to direct ADT to potential improvements over the current baseline.
- Ongoing work by science team and others to improve:
  - Baseline MSS models with new altimetry data.
  - Barotropic ocean tide models.
  - Internal tide models.
  - Meteorological fields at hourly intervals
  - S1/S2 atmospheric pressure fields.
  - Dynamic atmosphere correction model (Mog-2D)



Backup



Dynamic KaRIn Calibration

- KaRIn hardware has built-in self calibration measurements (loopback, noise) whose results are downlinked in KaRIn telemetry
- Ground processing uses KaRIn calibration telemetry to estimate hardware gain and phase drifts, etc. that will affect science measurements
- Dynamic calibration parameters are passed to both LR and HR processing chains to be applied as compensations
- Does not rely on external data, so updated as soon as KaRIn telemetry become available
- Thermal-mechanical requirements are tight enough that effects should not need compensation on ground
  - Modeling is not part of baseline processing design
  - But processing architecture supports expansion if needed