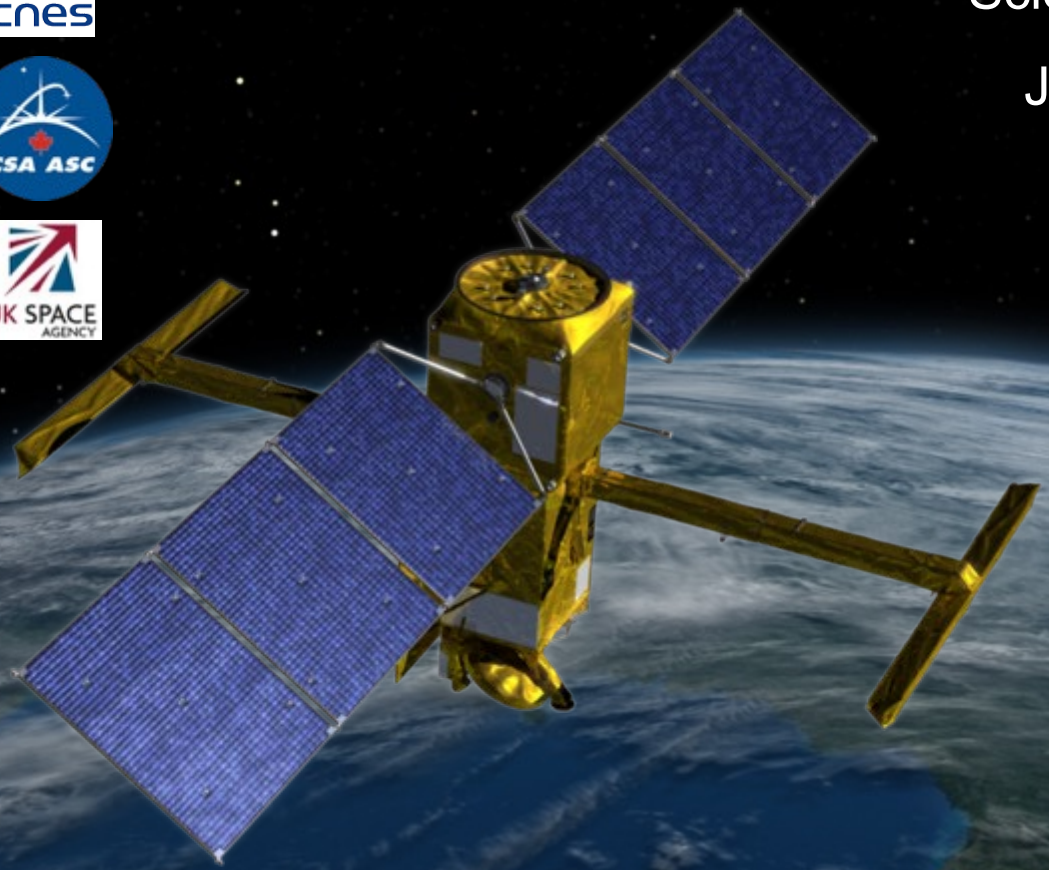
National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Surface Water and Ocean Topography (SWOT) Mission

Science Team Meeting

June 27–30, 2022



CNES Ocean Cal/Val activities

CNES Ocean CalVal activities

- CNES contribution to KaRIn Ocean CalVal activities will mainly rely on a global & statistical approach.
  - Note that SWOT nadir products will be validated, based on Jason-3 approach / experience.
- CNES also provide some support to in situ campaign (Duacs or other dedicated products required by PIs), and we do not recall here the CNES support to PIs for the different Calval activities

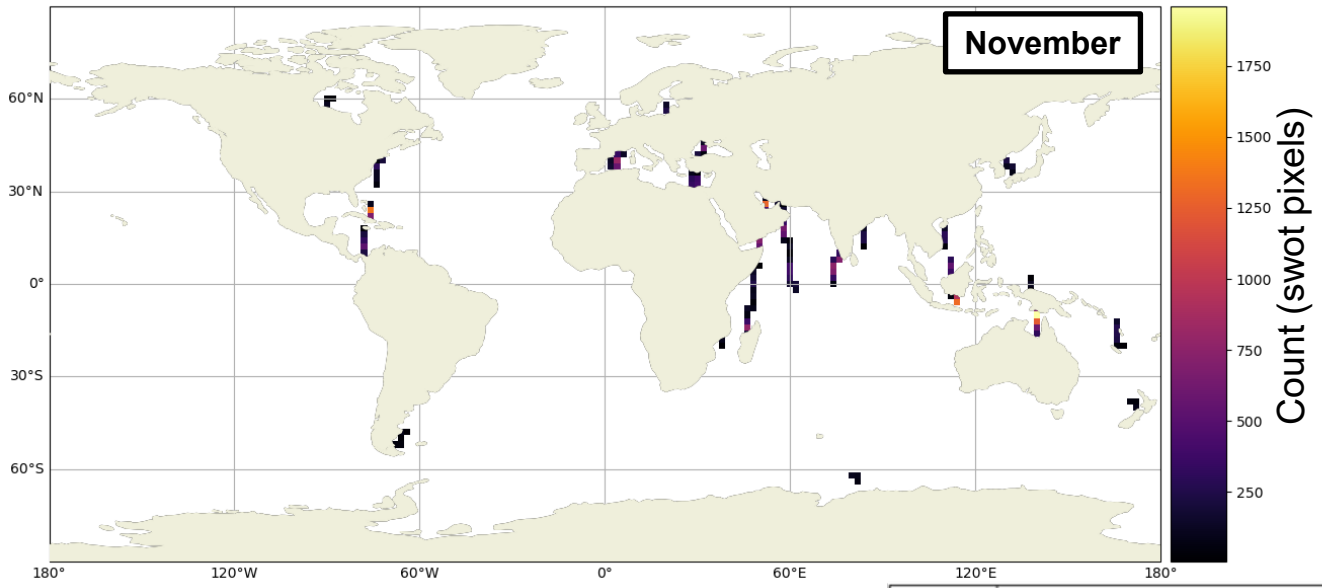
CNES Ocean CalVal activities

Support to calibration activities

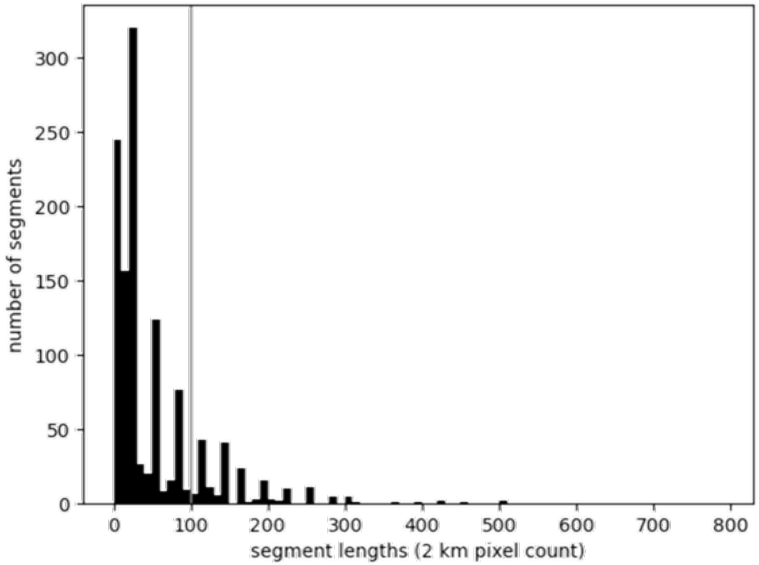
- Calibration of antennas alignment requires specific ocean/atmosphere conditions (no rain att, low SWH, low sigma0 variability, low wind speed …)

- Use of climatology and forecast geophysical information to identify the most suitable areas, confirm that conditions are met.

CNES Ocean CalVal activities



- Prevision and identification of KaRIn long segments respecting given geophysical criteria



CNES Ocean CalVal activities

- Requirements validation :

  - Requirements related to products space & time sampling will be addressed

  - Ocean performance requirements will be verified (SSH error budget validation will be limited to scales [70:1000 km])

Requirement ID	description	adressed in sec
Mission payload requirements		
n/a		
Mission liftetime requirements		
n/a		
Space time sampling requirements		
BSM 2.5.1	Minimalization of the tidal aliasing	
BSM 2.5.2	Orbit inclination shall lie between 74 and 78°	
BSM 2.5.3.a	Swot orbit shall be a repeat orbit of period ranged between 21 and 23 days	
BSM 2.5.3.b	Swot ground track shall be controlled to within +/- 2.5 km and in 90% (over 1 year) shall not exceed +/-1 km	
BSM 2.5.4.a	Data availability should be >= 90% over open ocean	
BSM 2.5.4.b	maneuvers, thermal snaps and sun tracking operations should not exceed 5% of the mission operation time	
Science Data Products and Data Product Delivery		
n/a		
Ocean Science Performance Specification		
BSM 2.7.1.a	The spatial posting of KaRIn sea surface height measurements shall be no coarser than 2 km.	
BSM 2.7.1.b	KaRIn sea surface height measurements at scales finer than 2 km shall be provided with the same average spatial posting interval that is available from downloaded instrument data	
BSM 2.7.2.a	The sea surface height error spectrum (cross-track average of the along-track spectra computed at different cross-track locations over the swath) in the wavelength range smaller than 1,000 km shall not exceed the spectrum envelope given in Figure 1 and the formulas below. This requirement holds for significant waveheights (SWH) less than 2 meters	
GOAL requirement 2.7.2.b	The white noise component of the error spectrum will not exceed 1cm2/cycle/km	
TSM 2.7.2.c	The Threshold Science Mission white noise component of the error spectrum shall not exceed 4 cm2/cycle/km	
BSM 2.7.3	The height postings shall be geographically fixed, and independent of spacecraft position and attitude	
BSM 2.7.4	SWOT shall provide flagging of height postings affected by rain with 68 % accuracy of the rain (More than 68% of rain-contaminated data must be correctly flagged	
BSM 2.7.5	SWOT shall provide flagging of sea ice over the ocean with 68 % accuracy of the sea ice flag. (More than 68% of sea-ice-contaminated data must be correctly flagged.)	

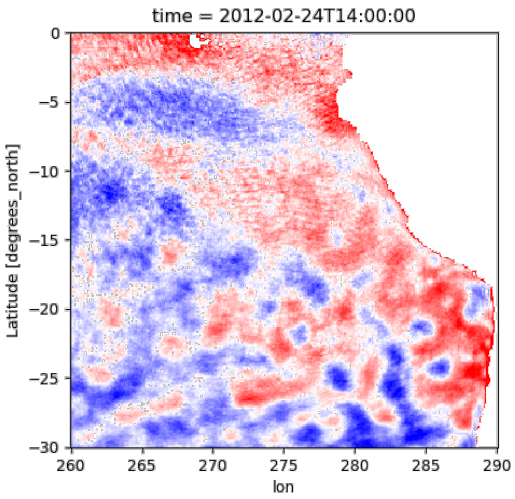
CNES Ocean CalVal activities

SSH Error budget validation

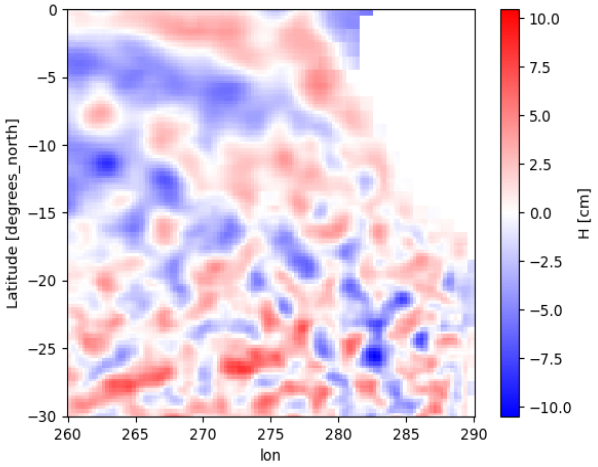
- Pre-analyses based on simulated datasets have been performed to anticipate potential limitations:
  - Number of long (2000 km) KaRIn colinear transects (@ t0 & t0 +/- 1day) that meet the requirement conditions SWH <= 2m
  - Quantification of the SSH variance reduction brought by L4 CMEMS & L2 Swot_nadir products
  - Measure the impact of 1 day oceanic variability (1 day orbit configuration)

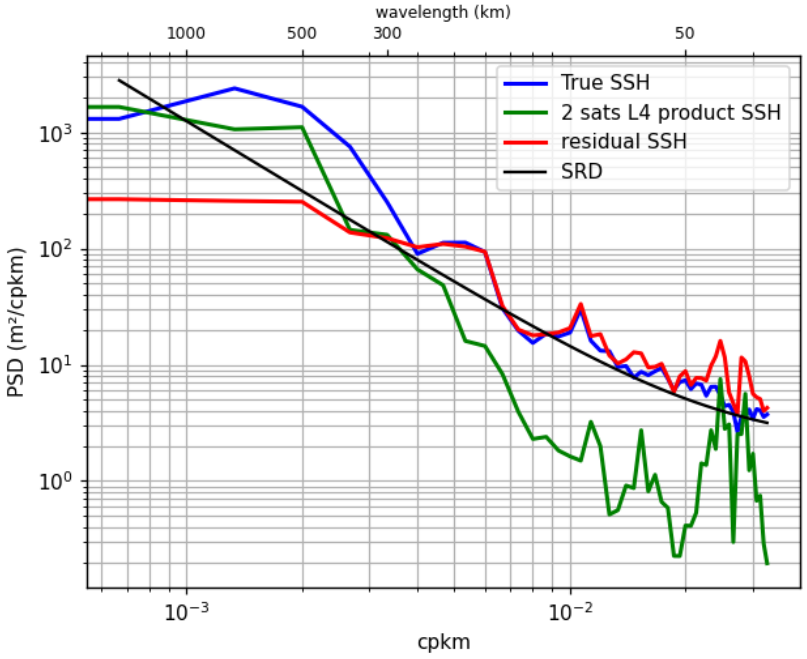
CNES Ocean CalVal activities

MITgcm



L4 ssha (S3A/J3)

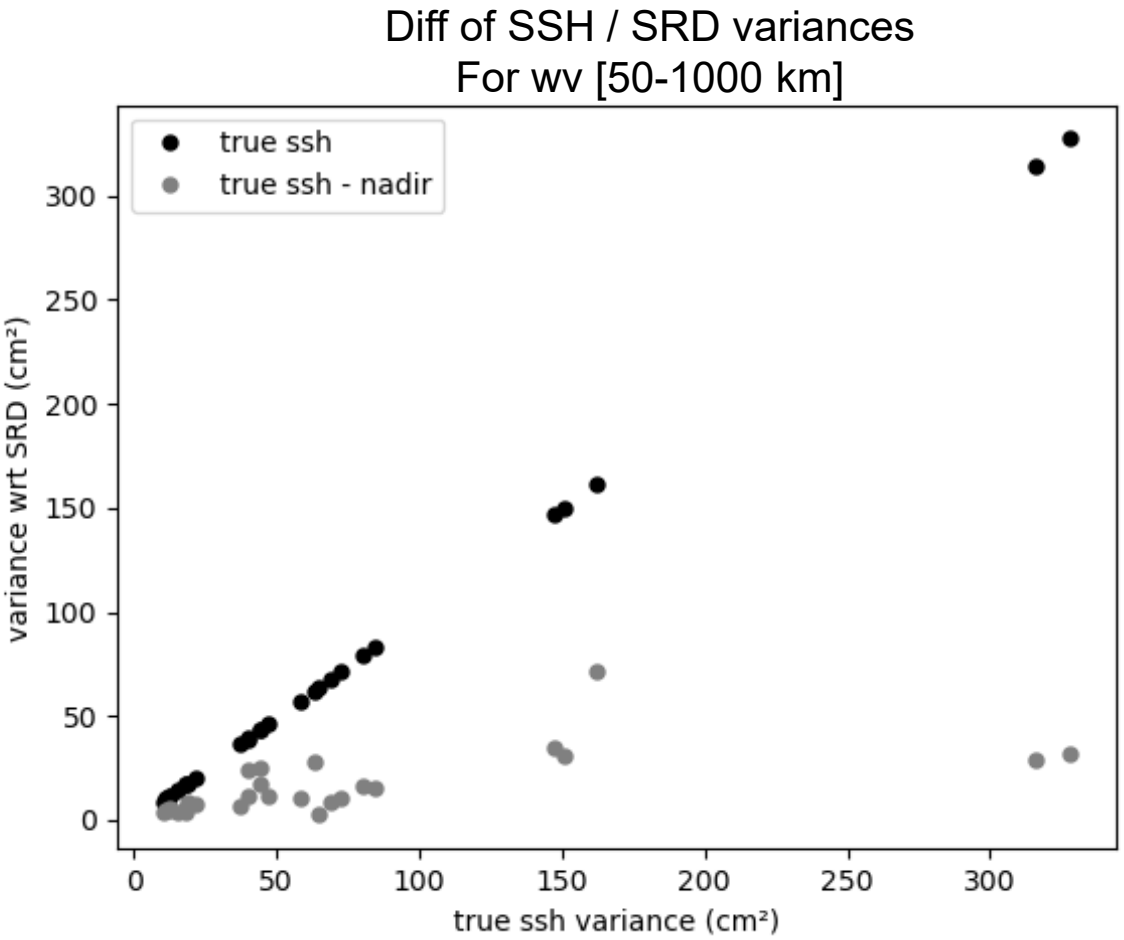




- Local example of SSH variance reduction brought by simulated L4 products (2 sats only ..)

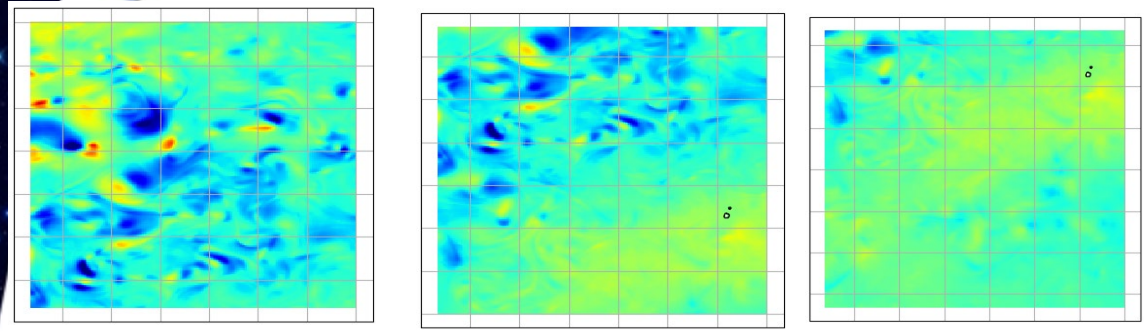
CNES Ocean CalVal activities

- Reduction of the along-track SSH variance using SWOT_nadir

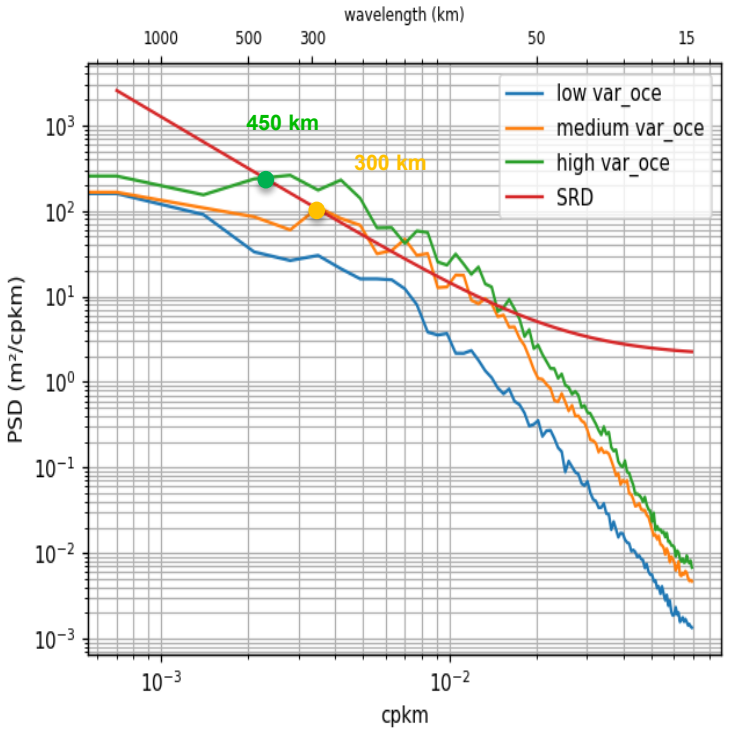


CNES Ocean CalVal activities

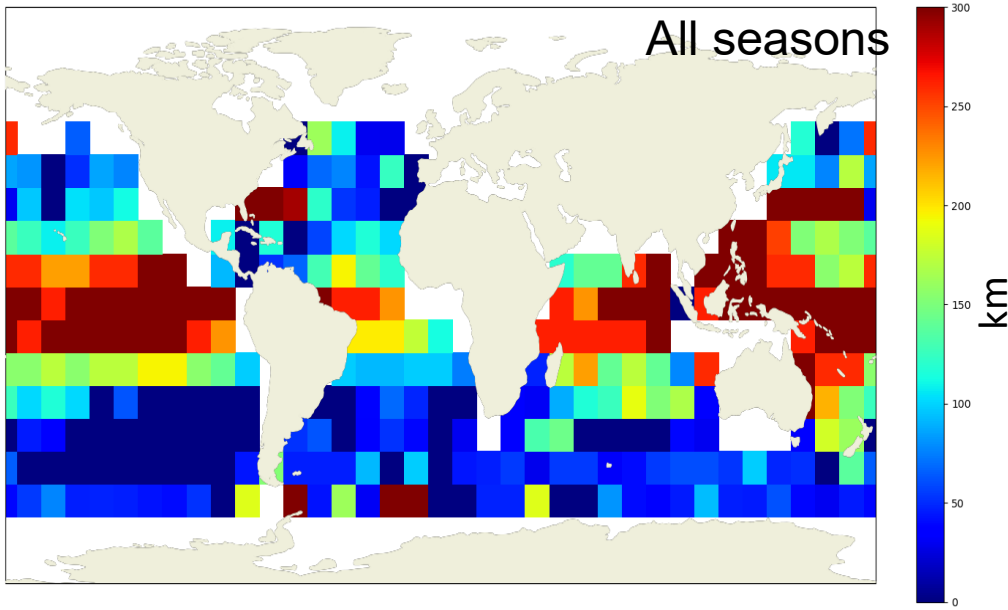
1 day var_oce



- How oceanic variability may prevent the validation of KaRIn SSH error spectrum with 1 day colinear residuals



wavelength where
var_oce(1d) <= SSH error requirement



CNES Ocean CalVal activities

KaRIn performances & L2 LR products validation

- Implementation Plan in progress, describes CNES contribution to KaRIn CalVal activities.

- Tools prototyping and pre-analysis (simulated dataset) to prepare the KaRIn L2 LR CalVal (global statistical approach):

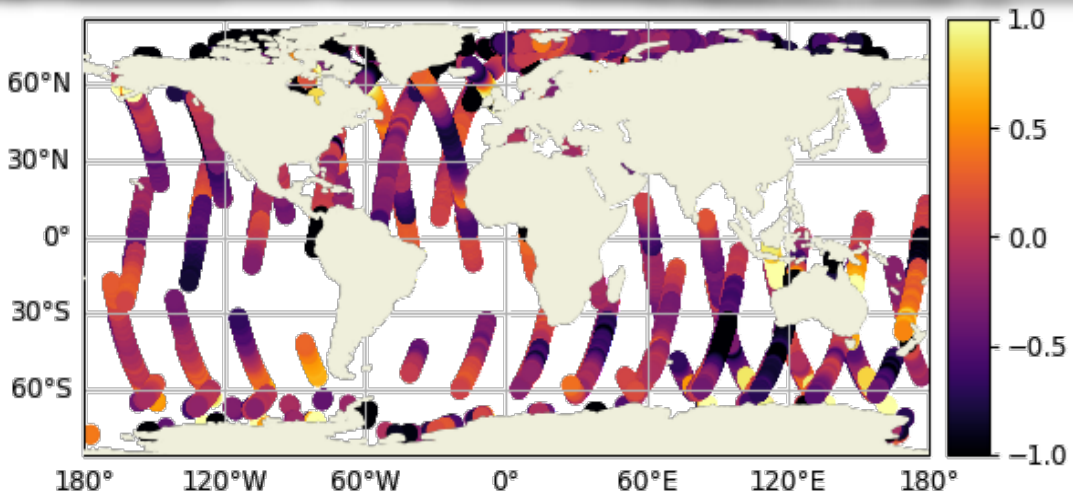
  - Editing strategy, filtering, interpolation / gaps filling, noise reduction, …

  - KaRIn/KaRIn crossovers and overlaps analyses

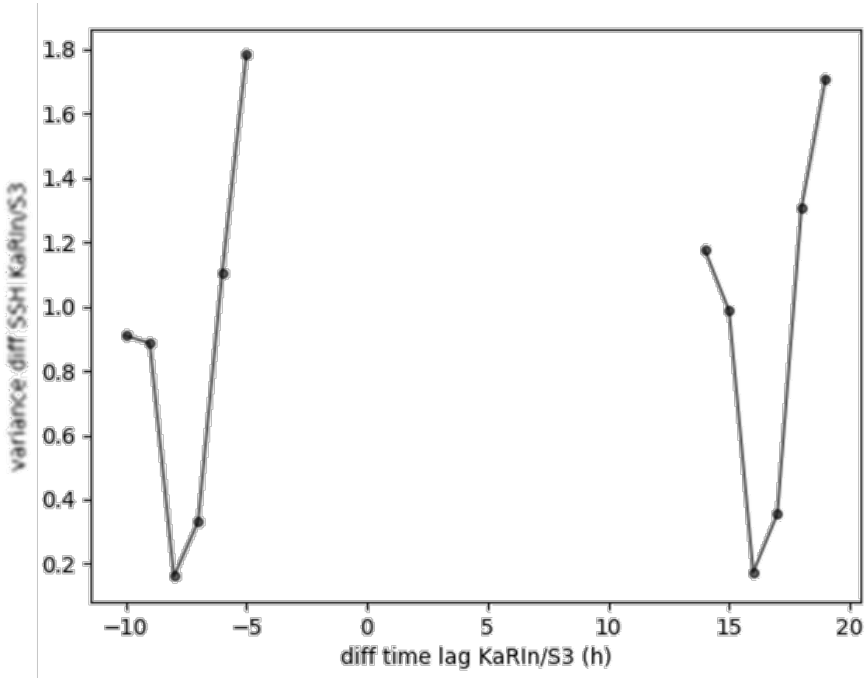
  - KaRIn/Swot_nadir & KaRIn/nadir_constellation analyses

  - KaRin / other sensors matchups

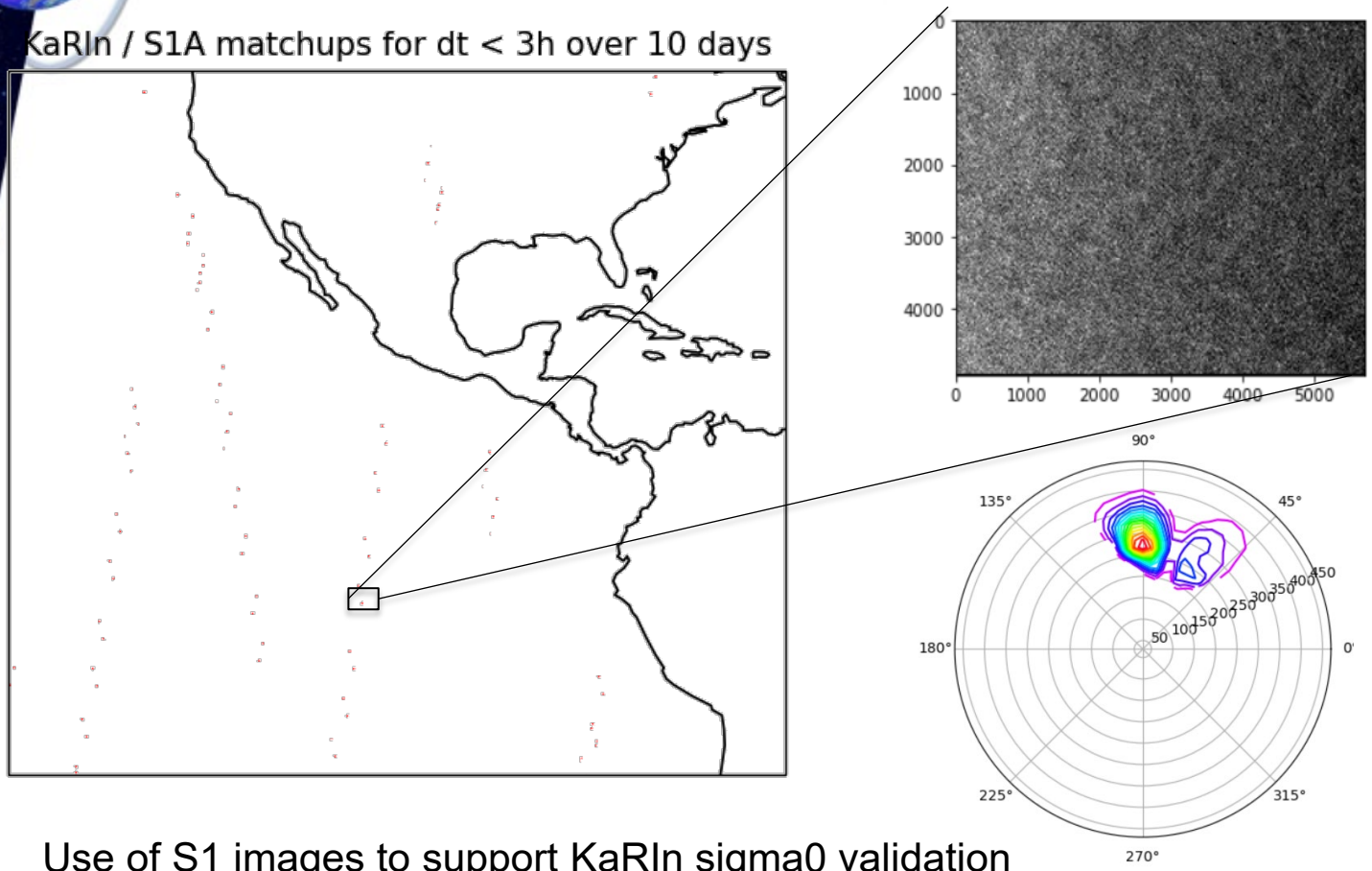
CNES Ocean CalVal activities



- 10 days of KaRIn/S3A crossovers
- Map of differences
- Variance of SSH residuals wrt time lag



CNES Ocean CalVal activities



- Use of S1 images to support KaRIn sigma0 validation
- Use of S1 L2 OCN products to support SSH & waves validation
- Possibility to exploit the S1 image classification (C. Wang et al., 2019) to identify specific oceanic / atmospheric events

CNES Ocean CalVal activities

CalVal tools (& diagnostics) developed will be used to support:

- XCAL validation (estimation of XCAL performance metrics)
- CNES&CLS ADT team for Algorithm tuning & prototyping (comparison between different algorithm versions, investigations)
- In-situ / KaRIn comparisons (provision of ocean tides / DAC corrections, post-processed / improved KaRIn products, …)
- Some Key Pis involved in calval analysis

CNES Ocean CalVal activities

```
[7]: collection = swot_calval.io.open_collection(collection_path)
```

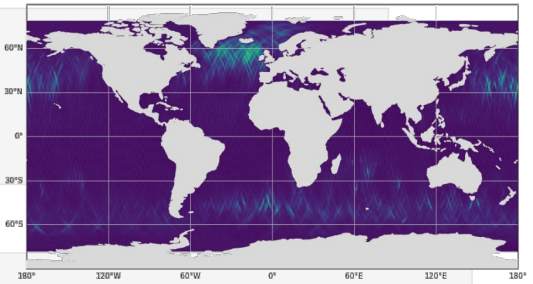
```
[8]: %%time
polygon = swot_calval.natural_earth.mediterranean_sea()

zds = collection.query(cycle_numbers=14,
                       polygon=polygon,
                       selected_variables=("longitude", "latitude","cross_track_distance","swh_karin",
                                           "ssh_karin","ssha_karin","time","simulated_true_ssh_karin","distance_to_coast")
                      )
ds = zds.to_xarray()
```

```
CPU times: user 1.07 s, sys: 243 ms, total: 1.32 s
Wall time: 5.6 s
```

```
[11]: %%time
bin2d = swot_calval.statistics.binning2d(
    zds["longitude"].data,
    zds["latitude"].data,
    zds["simulated_error_karin"].data,
    x_axis=swot_calval.statistics.Axis(720, (0, 359.5), is_circle=True),
    y_axis=swot_calval.statistics.Axis(360, (-90, 90), is_circle=False),
    )
```

```
CPU times: user 141 ms, sys: 46.5 ms, total: 188 ms
Wall time: 16.5 s
```

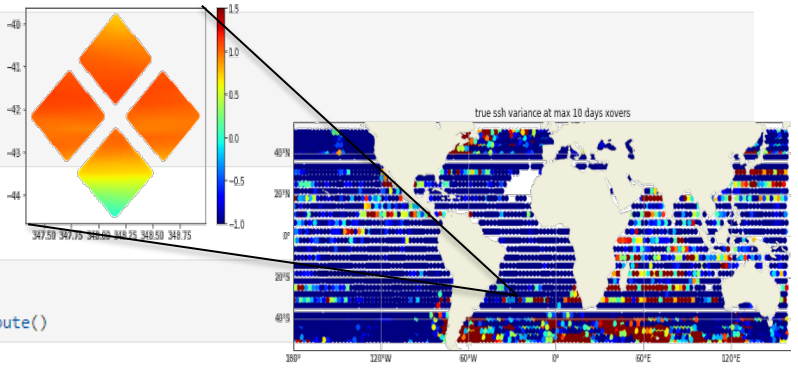


```
[7]: crossover_table = swot_calval.io.load_science_crossover_table(latitude=50, percentage_of_land=25)
```

```
[16]: %%time
xovers = swot_calval.crossover.calculate(zds,
                                         delta_t=np.timedelta64(10, "D"),
                                         cartesian_plane=True,
                                         crossover_table=crossover_table,
                                        partition_size=128)

print("%d crossovers trouvés"%len(xovers))
```

```
5658 crossovers trouvés
CPU times: user 898 ms, sys: 74.4 ms, total: 973 ms
Wall time: 1min 42s
```




```
[14]: %%time
bag = dask.bag.from_sequence(xovers)
data = bag.map(compute_ssh_residual, zds=client.scatter(zds), varname="swh_karin").compute()
```

```
CPU times: user 3.81 s, sys: 455 ms, total: 4.26 s
Wall time: 7min 52s
```

- Quick & non-exhaustive illustration of CalVal methods developed ➔ High computing performance
- Important point: possibility for users to create linked database (views) and define/save their own variables

CNES Ocean CalVal activities