Fitting JASON 1 sea state bias

S. Labroue, P. Gaspar, J. Dorandeu and O.Z. Zanife

• 1 - Estimation of JASON 1 SSB
• 2 - Estimation of TOPEX SSB
• 3 - Conclusions
Data sets for SSB estimation

- The SSB provided in the GDR products has been fitted on IGDR data from cycles 19 to 30, with SSH differences from collinear tracks.

- The aim of this work is to compare the product SSB table with a new one derived from GDR data. The SSB is estimated from 3 different data sets:
  - crossover SSH differences
  - collinear SSH differences
  - direct measurements: SLA data

=> check the consistency between the 3 SSB estimates

- Same method and conditions for crossover and collinear: only the data sets change
- The direct estimate simply fits the SLA data using the non-parametric technique.

- The 3 data sets use the same corrections from GDR data:
  - radiometer wet tropospheric correction
  - dual frequency ionospheric correction (smoothed)

- The whole year 2002 is used (cycle 1 to 37) to take into account seasonal variations.
- JMR step around cycle 30: radiometer correction replaced by model correction => little impact on SSB.
Data sets for SSB estimation

- **Crossover SSH differences**
  => remove North/South errors
  => more data at high latitude
  => considering differences of SSH and SWH/U is very sensitive to a few millimetre errors

- **Collinear SSH differences**
  => remove ascending/descending errors
  => latitude distribution close to the 1Hz data
  => 10 day differences
  => considering differences of SSH and SWH/U is very sensitive to a few millimetre errors

- **Direct method**
  => averages all the errors (North/South/ascending/descending)
  => uses a lot of measurements
  => oceanic variability
Collinear SSB, Cycles 1-37
SSB difference : Collinear - Product SSB (Collinear IGDR 19-30)
Crossover and direct SSB, Cycles 1-37

Both estimates agree for the general shape.
The direct SSB shows less SWH gradient than the crossover estimate.
SSB differences

The difference magnitude is of 3.5 cm between 0 and 2.5 m of waves

=> same behavior with crossover and collinear estimation

=> the direct estimation shows less SWH gradient
Crossover SSH (no SSB correction)
SWH$_2$ - SWH$_1$ = + 2 cm

=> SSB$_2$ - SSB$_1$ = -0.05*(SWH$_2$ - SWH$_1$ )

= -1 mm
Impact of the crossover correction on SSB

Init SSB - corrected SSB

Correction = 0.2 * Lat + 0.05
=> 1 cm between -50° and +50°

The correction applied on the SSH differences decreases the SWH gradient in the SSB
=> Crossover SSB is closer to the direct SSB
Direct method: SLA data

SLA corrected with direct SSB
JASON 1-37

SLA corrected with direct SSB
TOPEX 344-380
Impact of an error depending on latitude on direct SSB

Correction = 0.0002 * Lat + 0.01
=> 2cm between -50° and +50°

The correction applied on the SLA data increases the SWH gradient in the SSB

8 mm
SSB differences: Crossover - Direct

- The SWH gradient for SWH<2m disappear after correcting the crossover SSH and SLA data before estimating the SSB.

Crossover Init - Direct Init

Crossover - Direct after SSH and SLA correction
Crossover and direct SSB after correction, Cycles 1-37
Conclusions

• An error depending on latitude affects the SSB estimates
  – an error of 1 cm on SSH difference => SWH gradient of 1.5 cm on the crossover SSB
  – an error of 2 cm on SLA => SWH gradient of 0.8 cm on the direct SSB
 => both estimates are closer after correcting crossover and SLA measurements for this effect

• Collinear : such a trend is not clearly detected => under investigation

• We need an independent criterion to compare the various SSB : analysing the variance reduction at crossover or collinear SSH always select the estimate fitted on the tested data set.

• Simulations tend to indicate that crossover SSB is more accurate and more stable than collinear SSB => more work is needed to confirm this result
TOPEX Crossover SSH

- Time tag bias: TP A = -0.23 ms
  TP B = +0.21 ms
- Crossover SSH mean close to 1 cm for TPB
- Change in the SSB estimation between side A and B using crossovers
SWH$_2$ - SWH$_1$ = + 5 cm

=> SSB$_2$ - SSB$_1$ = -0.03 * (SWH$_2$ - SWH$_1$)

= -1.5 mm
Impact of the crossover correction on SSB
TOPEX A, cycles 21-131

Corrected SSB - Init SSB

Correction = -7mm for North SSH
Impact of the crossover correction on SSB
TOPEX B, cycles 240-350

Corrected SSB - Init SSB

Correction for South SSH
=> SSH centred to +2 mm
Crossover SSB differences : TOPEX side A - TOPEX side B

- SSB for TOPEX side B is more in agreement with the SSB for TOPEX side A after correcting the SSH.
- The main differences are observed for strong sea conditions (U>10m/s and SWH>3m).

Crossover side A Init - Crossover side B Init  
Crossover side A - Crossover side B

After SSH correction
SSB differences : TOPEX side A - TOPEX side B

The main differences are observed for strong sea conditions (U>10m/s and SWH>3m).

Collinear side A - Collinear side B

Direct side A - Direct side B
Conclusions

• TOPEX A
  – collinear = direct
  – collinear - crossover = SWH gradient for SWH<2m
  – collinear = crossover after correcting north crossover SSH
    => the 3 estimates give the same answer after correction

• TOPEX B
  – collinear = direct with a small difference for SWH < 1m which behaves as iono correction
  – collinear - crossover : large SWH gradient for SWH<2m
  – closer to collinear after correcting south crossover SSH
    => a slight difference remains for the crossover SSB after correction

• JASON 1
  – crossover : SSH difference corrected for an error depending on the latitude
  – direct : SLA corrected for an error depending on the latitude
  – collinear : no correction
    => crossover close to direct SSB when correcting both data sets for the latitude trend
    => collinear SSB is apart, showing a larger SWH gradient
Conclusions

• An effect depending on the latitude in the SSH difference (orbit error, time tag bias…) does impact the SSB estimation for SWH<2m. Tests on TOPEX A, TOPEX B and JASON show it can add or remove some SWH gradient.

• This effect has to be studied more in details to understand how it affects the SSB estimation. Preliminary simulation made on TOPEX A show that taking the SSH differences as a simple constant give the same kind of result with a SWH gradient for SWH<2m. Some work is ongoing to clarify and explain these features.

• In the same way, an error as a function of latitude (MSS error …) does impact the SSB fitted with the direct estimation.

• The 3 data sets used to estimate the SSB should give the same results with differences less than 1 cm and without any particular structure in the difference.
  – OK for TOPEX A, slight difference for TOPEX B
  – Still too large differences for JASON => further work is needed to improve the SSB estimates

• A good criterion is needed to select the best SSB estimate for JASON :
  – crossover variance reduction => the crossover estimate has been fitted on this data set
  – TOPEX - JASON residuals as a function of SWH => what about the errors on TOPEX B SSB estimate and the errors depending on latitude which may affect the conclusions ?