Comparing and combining ARGO data with altimeter data

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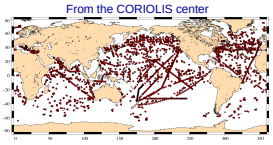
- I - Data

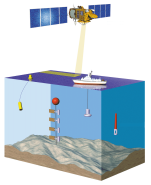
T(z), S(z)

From the CORIOLIS center

On month of data (26/08/03→25/09/03)



In-situ data



Remote-sensing data

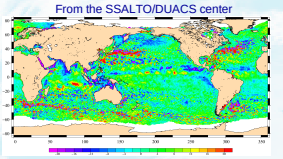
Sea Level Anomaly

From the SSALTO/DUACS center

Weekly combined map of Jason (T/P), ERS-2, GFO

Resolution: 1/3° Mercator

(10/09/03)



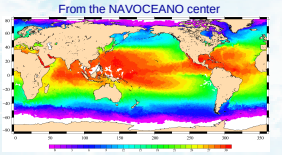
Sea Surface Temperature

From the NAVOCEANO center

Weekly mean of MCSST AVHRR

Resolution: 18 km

(10/09/03)



- Sparse resolution
- Precise estimation of the ocean vertical structure

- High resolution (spatial and temporal)
- Surface signal = integrated measurements

- High resolution (spatial and temporal)
- Surface signal = constraint in the near surface layers

- II - Comparison

Objectives :

✓ Study the **differences** and **complementarities** between altimeter and in-situ T/S profiles data

✓ Analyze the **physical content of altimeter measurements** (e.g. **barotropic/baroclinic** signals) - (Guinehut et al., 2003)

✓ Understand the **vertical structure of the variability of the ocean**

The **method** consists in comparing Sea Level Anomaly (SLA) deduced from altimeter measurements and dynamic height anomalies calculated from in-situ T/S profiles data.

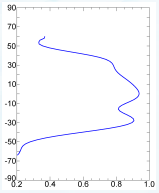


Figure 1 : Regression coefficient between altimeter SLA and in-situ SLA as a function of latitude for the Pacific Ocean. Observations used are from the 1993-2001 period and dynamic height are calculated relatively to 700 m.

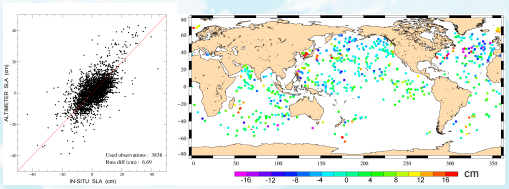


Figure 2 : Left, altimeter/in-situ SLA scatter plot. Right, altimeter/in-situ SLA differences. Observations correspond to one month of data (26/08/03 → 25/09/03) and dynamic height are calculated relatively to 700 m. (Unit: cm)

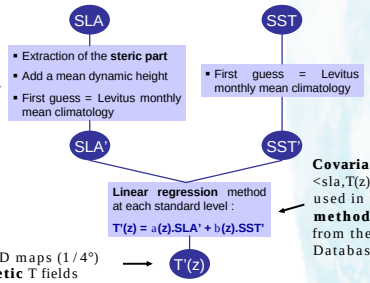
- III - Combination

Objectives :

✓ Merge **accurate** but **sparse in-situ T/S profiles** data with **high resolution altimeter** and **SST** data

✓ Reconstruct **instantaneous** thermohaline fields at **high temporal** and **spatial resolution**

Step1 : On each Levitus standard level from the surface down to 700 m, **synthetic T profiles are estimated through a multiple linear regression method from SLA and SST data.**



The **steric part** is extracted using regression coefficients deduced from an altimeter/in-situ data comparison study (see Figure 1)

Covariances <sla,T(z)>, <SST,T(z)> used in the **regression method** are deduced from the World Ocean Database (1998)

Weekly 3D maps (1/4°) of **synthetic** T fields

Validation :

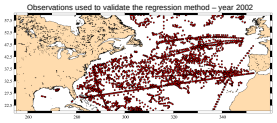
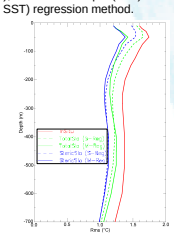


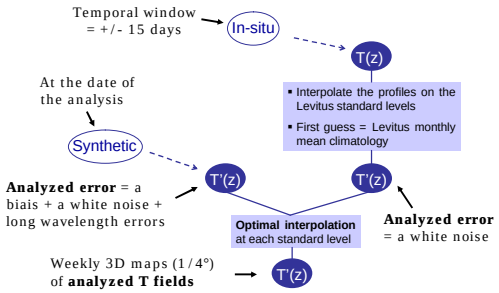
Figure 3 : Rms of the anomalies of the in-situ T fields (red) – anomalies calculated from the Levitus climatology. Rms of the differences between the in-situ T fields and the synthetic profiles deduced from total SLA (green) and steric SLA (blue), and from a simple (SLA) or a multiple (SLA + SST) regression method.

→ The extraction of the **steric part of the SLA** reduces largely the differences between the reference field and the reconstructed synthetic field (compare the green and the blue dotted lines).

→ The impact of the **SST** is also clearly visible from the surface down to 200 m depth which means that **SST is very complementary to SLA** to deduce T profiles from remote-sensing measurements.



Step 2 : On each Levitus standard level from the surface down to 700 m, **in-situ T profiles are combine with the synthetic T fields deduced from step 1 using an optimal interpolation method.** The methodology was first adjusted and tested using simulated data from a primitive equation model of the North Atlantic Ocean (Guinehut et al., 2003).



Merging method performances :

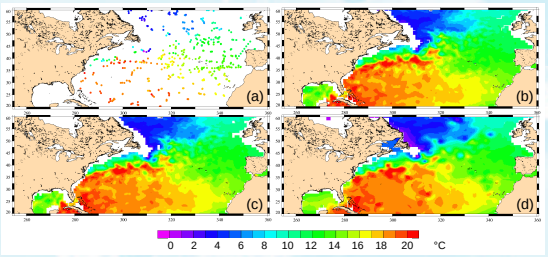


Figure 4 : Instantaneous T field at 200 m (02/10/02) from, (a) individual in-situ T data, (b) synthetic T (see -IV-), (c) the merging of synthetic and in-situ T data (see -V-) and (d) the mapping of in-situ T data.

→ Figure 4 demonstrates the ability of the merging method to take into account the information contains in the sparse in-situ measurements to correct the synthetic T fields.

Validation of the merging method with independent data :

The in-situ data set of the year 2002 is divided into two sets :
- Set 1: to be combined with the synthetic estimations of the T field
- Set 2: to be used to validate the combined fields.

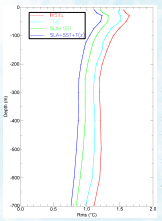
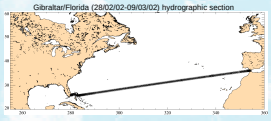


Figure 5 : Red: Rms of instantaneous T field (anomalies/Levitus from the in-situ profiles – set 2) and rms error in predicting subsurface T anomalies using only in-situ profiles from set 1 (Turquoise), using only synthetic profiles (Green) and using in-situ combined to synthetic profiles (Blue). Statistics are calculated over the whole domain.

→ Statistics over the year 2002 indicate that rms of mapping error is largely reduced for all depths when combining synthetic and in-situ profiles compared to the results obtained using only in-situ (T(z)) or remote-sensing (SLA+SST) data.

→ They also illustrate the difficulty to derive fields at high temporal and spatial resolution with in-situ profiles alone due to aliasing of mesoscale variability (see also Figure 2d).

The method is now illustrated along a cross-Atlantic section between Gibraltar and Florida :



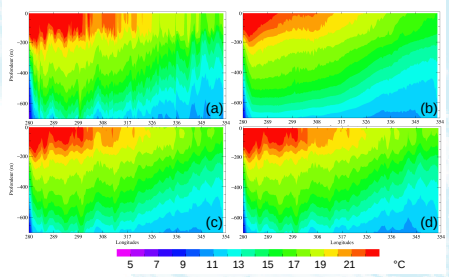


Figure 6 : T field from (a) the Gibraltar/Florida section, (b) Levitus monthly mean climatology, (c) the vertical projection of SLA and SST and (d) the combination of synthetic and in-situ (except the ones from the Gibraltar/Florida section) profiles (in °C).

→ Even if the merging method is performed individually on each vertical level, the combined field shows very **good vertical coherence.**

→ Statistics calculated over the 180 profiles of the section indicate that the combination provides an **rms error of 0.5°C** (twice as small as the rms difference between the section and the monthly Levitus climatology).

- IV - Conclusion

Vertical projection of SLA and SST data :
- it is crucial to extract the steric part of the SLA before the projection (work on the comparison between altimeter/in-situ SLA to be continued)
- significant impact of SST in the mixed layer

Combination of synthetic and in-situ T profiles :
- clear improvement from the combination
- very good vertical coherence of the merged fields

Perspectives :
→ Study the subsurface temperature variability from the estimated 3D fields
→ Compared the estimated 3D fields with outputs from MERCATOR model

- V - References

Guinehut S., P.-Y. Le Traon and G. Larnicol, 2003: A comparison between altimeter data and in situ temperature and salinity profile measurements over the global ocean during 1993 – 2001, to be submitted.

Guinehut S., P.-Y. Le Traon, G. Larnicol and S. Philipps, 2003: Combining altimeter and profiling float data to better estimate the 3D thermohaline variability, accepted in the J. Mar. Sys.

- VI - Acknowledgements

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