Improved Altimetric Retrievals in the Coastal Zone

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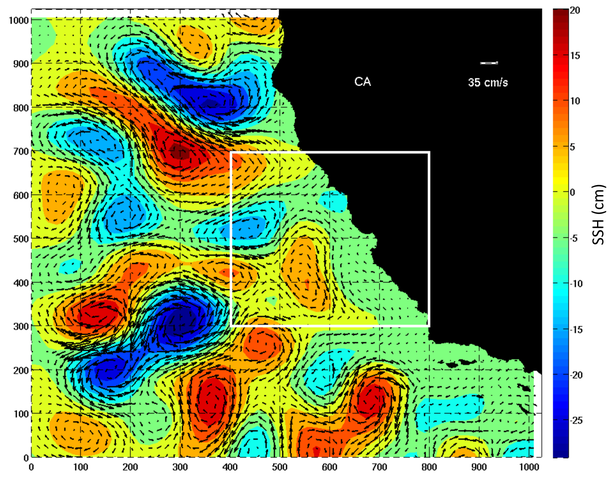
Pseudo high spatial resolution dynamic topography from currents

Ia Currents - MCC

Ocean surface currents, in both opean ocean and the coastal zones, can be estimated from sequential thermal IR (AVHRR) and ocean-color (MODIS, SeaWiFs) imagery using the well-developed MCC (Maximum Cross Correlation) method *[1]*.

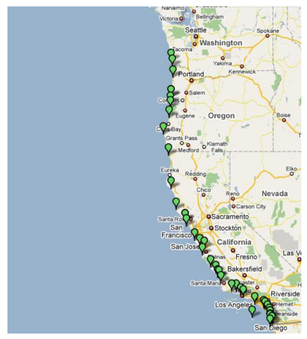
1024 x 1024 AVHRR scene grid – 1 unit = 1 km



MCC pseudo SSH & OI geostrophic current vectors – AVHRR composite 15-17 Oct. '07
The white box indicates the area containing the corresponding CODAR coincident current field.

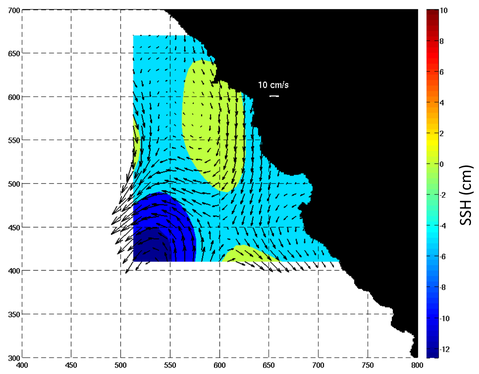
Ib Currents - CODAR

High frequency CODAR (Coastal Ocean Dynamics Applications Radar) stations measure real-time surface currents up to 50-70 km off the coast with a nominal spatial resolution of 1 km and up to 500 m in certain cases. CODAR stations cover a vast portion of the US West Coast and give hourly high-temporal resolution data independent of weather conditions.



CODAR stations on the US West coast

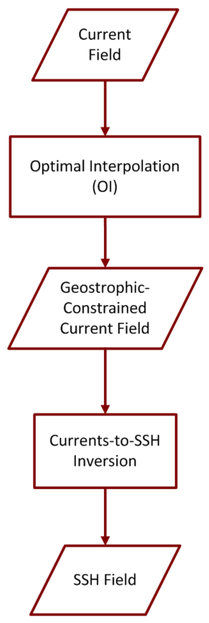
Subregion of 1024 x 1024 AVHRR scene grid – 1 unit = 1 km



Pseudo SSH & OI geostrophic current vectors – CODAR composite 15-17 Oct. '07
Data from following CODAR stations was used: ANVO, MNTY, SFOO

II Currents-to-SSH Inversion

The current field is constrained to a geostrophic streamfunction using OI (Optimal Interpolation), which is then inverted to give a SSH (sea surface height) field *[2]*.



Process flowchart

III Analysis / Conclusions

- Optimally interpolated currents from AVHRR MCC and CODAR in the figures above cannot be directly compared because of the latter's higher resolution and smaller covered area, which is not large enough to demonstrate large-scale current field patterns.
- However, optimal interpolation of CODAR datasets along the whole coast is expected to depict the general large-scale pattern and thus allow favorable comparison with MCC-derived current field.
- Utilizing data from all CODAR across the length of the coast along with the MCC currents will increase the spatial and temporal resolution of current fields in the coastal regions.

IV Future Work

1. Using wind data from satellite and/ or coastal measurements to explicitly account for the Ekman component.
2. Using a tidal model to explicitly correct for tides, which are eliminated now by compositing over adequate number of days.
3. Merging the MCC-derived and CODAR-measured current fields to achieve a higher spatial and temporal resolution dataset.
4. Using variants of the MCC method with weather-independent TerraSAR-X radar data to estimate currents.

References:
[1] Crocker, R. I., Emery, W. J., Matthews, D., & Baldwin, D. (2007). Computing ocean surface currents from IR and ocean color imagery. *IEEE Trans. Geosci. Rem. Sens.*, Vol. 45, Issue 2, p. 435-447.
[2] Wilkin, J. L., Bowen, M., & Emery, W. J. (2002). Mapping mesoscale currents by optimal interpolation of satellite radiometer and altimeter data. *Ocean Dynamics*, Vol. 52, p. 95-103.
[3] Chesters D., Robinson, W. D., Uccellini, L. W. (1987). Optimized retrieval of precipitable water from the VAS split window' *J.Clim.Appl. Meteorol.*, Vol. 26, p. 1059-1066.

Improved coastal wet tropospheric correction using IR satellite data

I Concept

Use AVHRR and MODIS sensors to retrieve the columnar Integrated Water Vapor (IWV) from an empirically optimized split window model, given the open ocean ground truth IWV derived from coincident Microwave Radiometers (MR)*[3]*.

~ 1 km IR sensors MODIS , AVHRR T11 µm, T12 µm At zenith angle θ

Cloud filter

Regrid to the MR resolution

~ 25 km ground truth IWV from coincident open ocean MRs

Least Squares

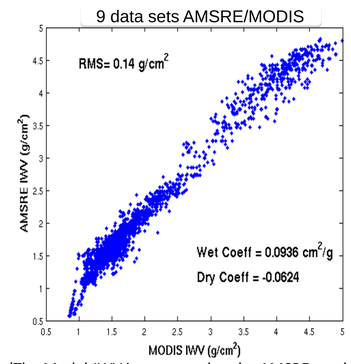
$$IWV = \frac{1}{\Delta\alpha}\left\{\cos\theta \ln\left[\frac{T_{11}-T_{air}}{T_{12}-T_{air}}\right] - \Delta k\right\}$$

Retrieve the 2 + N parameters

Global	N sub -regions with length scale 10s of km
Δk : dry absorption coefficient Δα: wet absorption coefficient	T_{air} : an average air temp

IIa Estimation of the two absorption coefficients

Combining 9 non cloudy data sets , gives a broad range of temperature and water vapor values.



(The Model-IWV is computed at the AMSRE resolution)
Uses 150 km² T_{air} Sub-regions

The RMS is of the order of the AMSRE accuracy .
It lowers for single data sets and with smaller sub regions.
Although the RMS seems higher for wet conditions.

II Preliminary results MODIS and AMSRE onboard Aqua

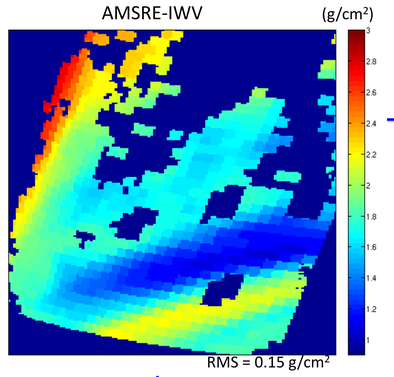
MODIS: T11 and T12
(1 km resolution at nadir)

AMSRE: 0.25° x 0.25° IWV product

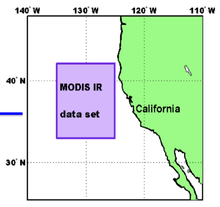
Region: Open ocean off US west coast

IIb Open ocean 5 km IR Model-Modis-IWP product

AMSRE-IWV (g/cm²)



RMS = 0.15 g/cm²

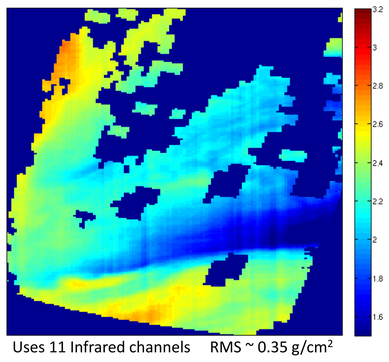


AMSRE IWV — T11 T12

Least Squares

Global : Δα , Δk
Tair at 25 km²

5 km MODIS MOD07 Infrared IWV (g/cm²)

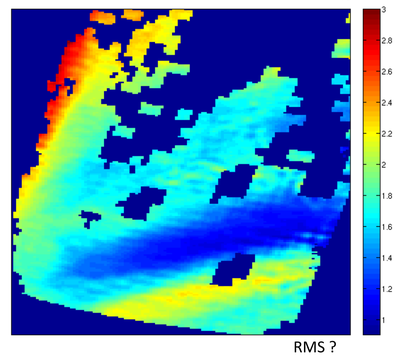


Uses 11 Infrared channels RMS ~ 0.35 g/cm²

Absolute IWV values related

Quality and IWV spatial gradients agree well

5 km Model-MODIS-IWV (g/cm²)



RMS ?

III Application : 5 km coastal altimetry wet path delay

Daily/weekly Δα, Δβ known

Last valid along track IWV altimeter MR

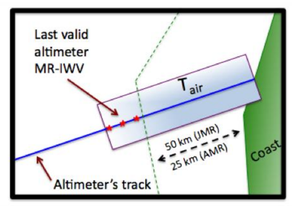
Least Squares retrieve coastal T_{air}

Adjustments from ECMWF, NCEP Coastal stations

Compute 5 km IR-Model-IWV

Reduce noise by combining time coincident MODIS and AVHRR IR-Model-IWV

Convert to 5 km wet path delay with an expected accuracy of ~ 1cm



Advantages: valid in coastal regions
high resolution

Drawbacks: affected by clouds
Won't work for low contrasts temp.
for very low and high IWV

Pseudo height field

Improved Coastal retracking

Altimeter retracked waveforms ⟶ altimeter coastal SSH

Various retracking methods exist
Select the optimal regional retracking system by comparing
the altimeter coastal SSH with our high resolution pseudo height field

Wet path delay correction

Coastal tidal corrections provided by Goddard Space Flight Center (courtesy of Richard Ray)