A New, Automated Technique for the Construction of More Accurate Composite Depths

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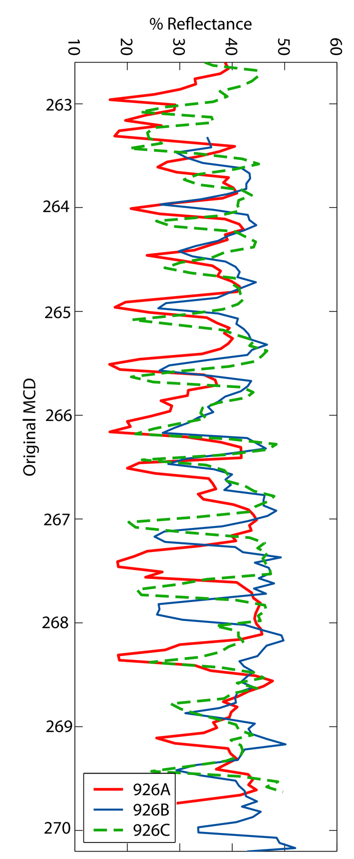
Abstract

A composite depth section reconstructs a continuous record of the sediment at a drilling site by splicing together cores from holes drilled a few hundred meters apart; its corresponding composite depth scale describes the correlation of the sediments between holes. Both are important tools for analyzing the sediment recovered from a drilling site. However, the standard splicing technique for creating composite depth sections does not correct for distortion within cores so that a sedimentary feature may have a slightly different composite depth in each hole. Additionally, the splicing technique often results in composite depths which are 10-15% greater than recorded drill depths. We present a new automated compositing technique, based on the graphic correlation algorithm of *Lisiecki and Lisiecki* [2002], which aligns features between holes and prevents an artificial increase in composite depth. The new technique increases the interhole correlation of reflectance for cores from ODP Leg 138 from 0.70 with the published composite depth scale to 0.76 with the new one and from 0.74 to 0.81 for ODP Leg 154. We also analyze the deformation due to drilling and extraction in 598 cores from ODP Legs 138 and 154.

Problem

Hagelberg et al. [1991] developed a technique for the construction of composite depth sections on Leg 138 as a way to construct an uninterrupted record from multiple holes drilled at the same site. They align cores from nearby holes by defining an offset from mbsf (meters below sea floor) for each core to match the cores' continuously sampled lithologic characteristics such as color reflectance or magnetic susceptibility. However, they do not stretch or squeeze the depth scale within cores. This technique is successful in creating continuous composite sections and is performed aboard ODP cruises today. However, *Hagelberg et al.* [1991] identify several deficiencies in the results of their technique. We present a new, automated compositing technique which solves the following problems of the original technique:



1 Inter-hole misalignment

No correction is made for distortion within core sections, leading some "identical" events in adjacent holes to be assigned different composite depths. This is an indication that some distortion is occurring within cores and creating uncertainty about the correct depth of specific features. This represents a major problem because the composite depth scale is inadequate for directly comparing samples from different offset holes.

2 Core deformation

An additional problem for researchers using ODP sediment cores is a lack of understanding of how the drilling and extraction process affect the recovered sediment cores. Core deformation has the potential to affect estimates of sedimentation rates and sediment density. Downhole logs are inadequate for studying this deformation because they are not available at all depths and because they have significantly less resolution.

3 Depth inflation

The composite sections consistently exceed the maximum drilling depth, measured in mbsf, by at least 10%. This depth inflation is not well understood. *MacKillop et al.* [1995] determined that elastic sediment rebound accounts for approximately one-third of the accumulation in composite depth offset on Leg 138. Other possible sources of depth inflation include the duplicate sampling of material and human bias during compositing.

Method

The software used for this compositing technique is available at http://Lorraine-Lisiecki.com

1 Alignment

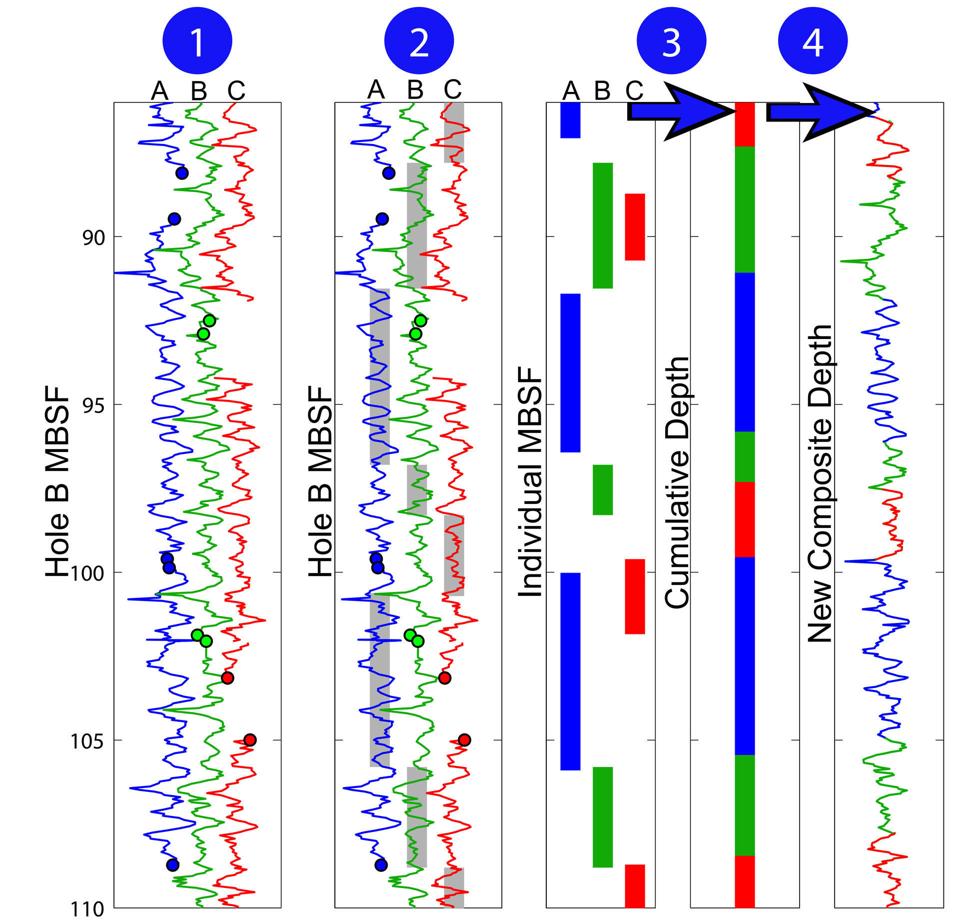
All holes at a given site are aligned to a single target hole using an automated graphic correlation program.

2 Component selection

Compositing software automatically selects portions of cores from the aligned holes to be included in the continuous record of the composite section.

3 Cumulative composite

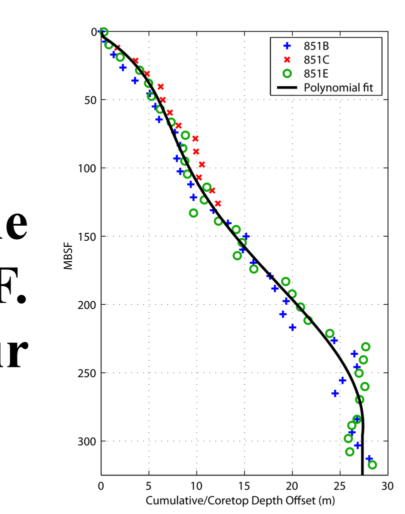
The selected sections (with their original MBSF depth scales) are placed end-to-end to create a cumulative composite depth (CCD) scale.



Composite Depth Scale Construction
ODP Site 926 (Reflectance)

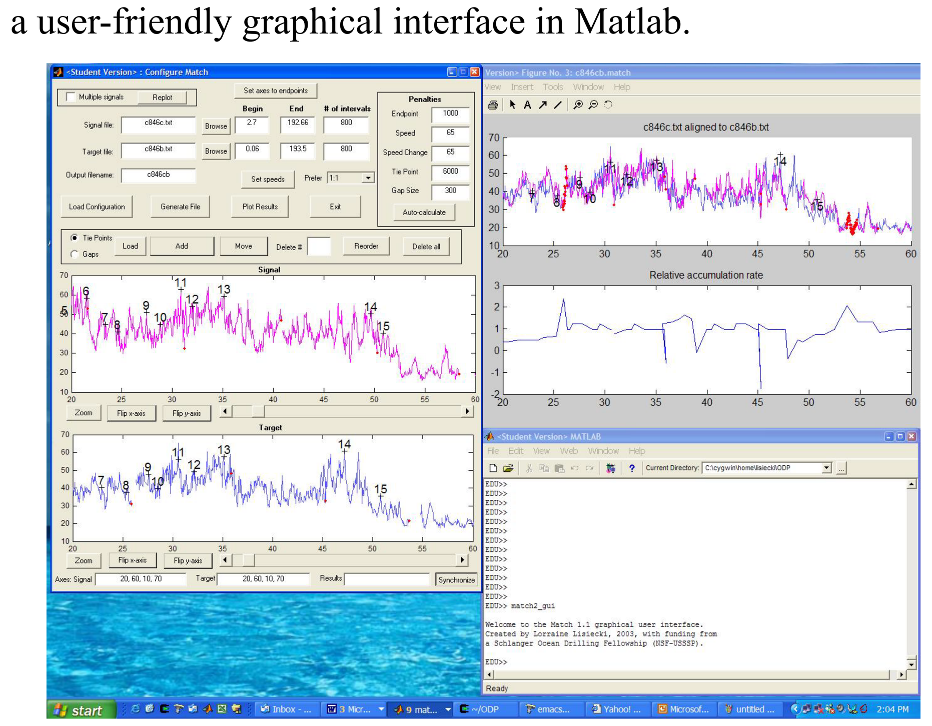
4 Depth adjustment for core-top constraints

The CCD scale is converted to composite depth by modeling the offset between the CCD of coretops and their measured MBSF. This insures that the composite depth scale is consistent with our best estimate of in-situ depth.

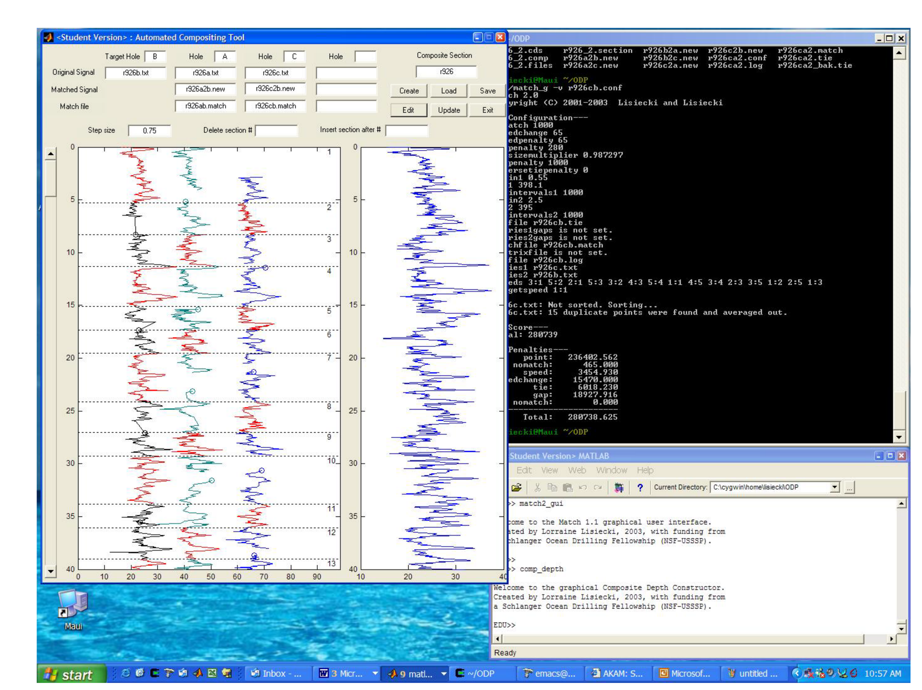


Software Details

The Match software [*Lisiecki and Lisiecki,* 2002], written in C++, uses dynamic programming and penalty functions to find a globally optimal and physically realistic alignment of two paleoclimate records. Version 2.0 of this software can perform multi-proxy matches, treat inter-core gaps realistically, and has a user-friendly graphical interface in Matlab.



The compositing software, written in Matlab, generates a composite section which avoids the inclusion of gaps or core material that is likely to be highly deformed. A graphical interface allows users to modify the composite section easily.



Results

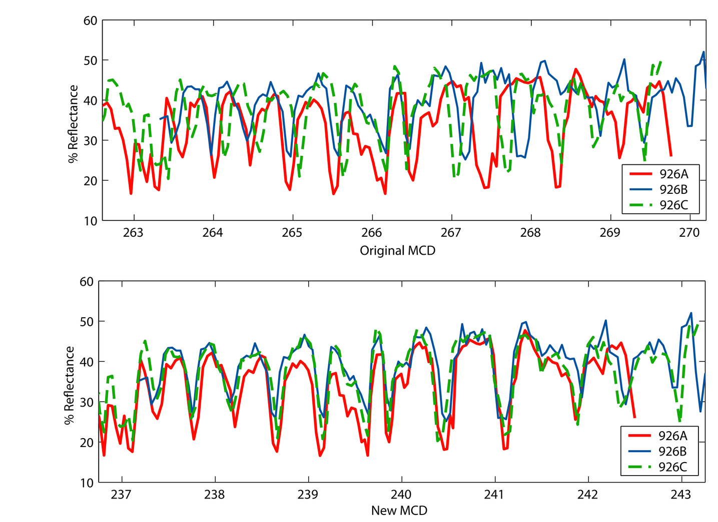
The new compositing technique is applied to 235 cores from ODP Leg 138 (sites 846, 849, and 851) and to 363 cores from ODP Leg 154 (sites 925, 926, 927, and 929). The new composite depth scales are compared to the composite depths published in the ODP Initial Reports [*Mayer et al.*, 1991; *Curry et al.*, 1995].

1 Inter-hole correlation

Because the new compositing technique allows for deformation within cores, sediment properties can be aligned much more closely across cores. The table below contains the average correlation of reflectance across holes using the composite depth scales generated by the standard and new techniques.

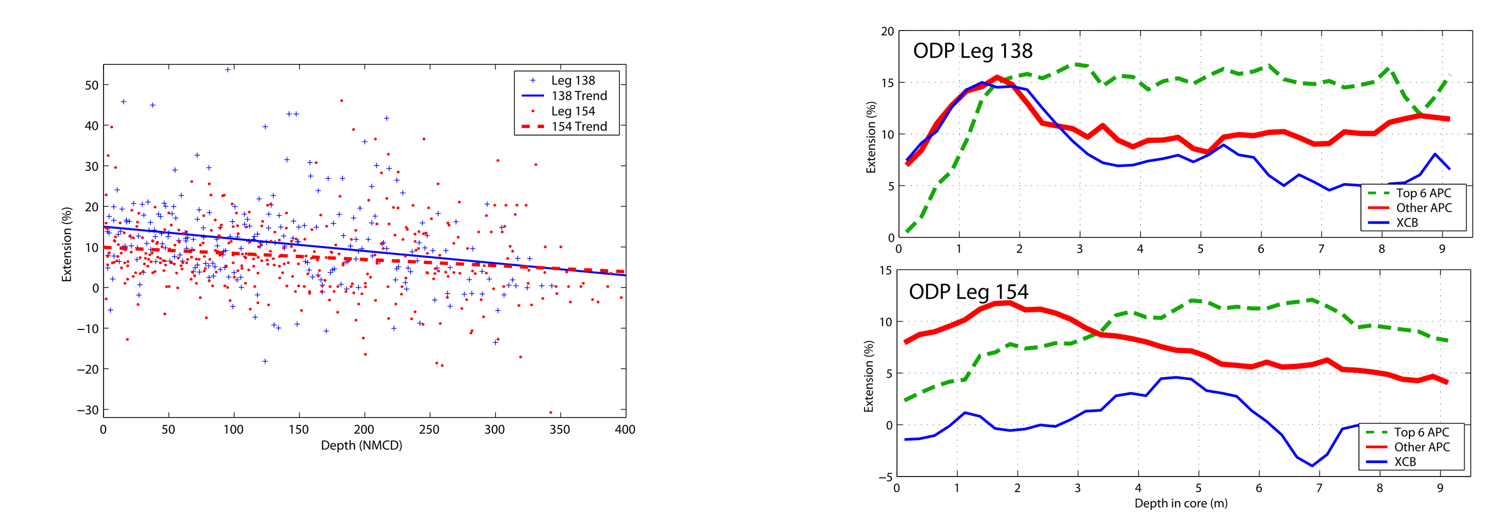
Correlation of reflectance between holes

	ODP Leg 138	ODP Leg 154
Original MCD	0.70	0.74
New MCD	0.76	0.81



2 Core deformation

Core deformation is calculated as the average of each core's extension relative to the new composite section. Both legs show similar patterns of deformation within each ~9.5-m core and a change in deformation as a function of depth in hole, possibly due to sediment consolidation.



3 Depth Inflation

Most of the depth inflation observed in the published composite depth scales of Legs 138 and 154 can be explained as a combination of core extension and gap size errors. Gap size errors in the original MCD scale are most likely the result of bias introduced during composite construction.

	Leg 138	Leg 154
Original MCD depth inflation	14.7 %	10.3%
Estimated core extension	9.7%	6.9%
Estimated gap size error	4.1%	4.7%
Remaining difference	0.9%	-1.3%

Acknowledgments

I would like to thank my advisor Timothy Herbert for the initial idea to do this research and Philip Lisiecki for his help in modifying the Match software to allow for the inclusion of core gaps. This research used samples and/or data provided by the Ocean Drilling Program (ODP). The ODP is sponsored by the U.S. National Science Foundation (NSF) and participating countries under the management of Joint Oceanographic Institutions (JOI) Inc. Funding for this research was provided by a Schlanger Ocean Drilling Fellowship, which is part of the NSF-sponsored U.S. Science Support Program (USSSP). Travel funding was provided by the NOAA Postdoctoral Program in Climate and Global Change, administered by the University Corporation for Atmospheric Research.

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