



Ocean Circulation Velocities over the Continents during Noah's Flood

Raj Prabhu, M.S., P.O. Box 127, Mississippi State, MS 39762

Mark F. Horstemeyer, Ph.D., 1292 Chapel Hill Rd, Starkville, MS 39759

Wesley Brewer, Ph.D., 901 Friedel Avenue, Vancouver, WA 98664

Abstract

This paper focuses on numerical experiments that qualitatively explore the velocities and patterns of ocean circulations that could have risen when the earth's continental surface was mostly flooded during the catastrophic event of Noah's day. Velocities and flow patterns are observed resulting from the earth's rotation and gravity and other pertinent parameters: change in latitude, water depth, supercontinent size, number of days, and mesh size. This parametric study can provide insight into the water velocities that carried Noah's Ark and insight regarding the hydraulic mechanisms that transported millions of cubic kilometers of sediment during Noah's Flood. The hydraulic sedimentation may explain many present-day geological formations, which reveal sudden and catastrophic formation. In many cases the sedimentary distributions horizontally extended hundreds and thousands of kilometers and accomplished a vast amount of geological work in a matter of months. The geological conditions were assumed to be similar to that of late Paleozoic and early Mesozoic era, when the Pangea supercontinent existed. The numerical calculations employ two codes, one written by National Center for Atmospheric Research (NCAR) and the other by Dr. Baumgardner (1994). Both codes solve the 2-D shallow water equations on a rotating sphere with surface topography. The calculations from Dr. Baumgardner's code showed a surprising yet persistent result with high velocities of the ocean currents over the Pangean-like continental configurations. The magnitudes of these velocities were around 40–80 m/s at higher latitudes. Catastrophic cavitation occurs for water velocities around 20–30 m/s and for free stream conditions lead to vaporous cavitation (Brennen, 1995; 2005, p.142; Brewer, 2002, p.4). This depends on the cavitation number for the prevailing conditions. Around such velocities, one would expect severe and rapid erosion to be associated with any major transgression of the continents by the ocean currents. Such currents would be expected to arise in the context of the scripture "all the high mountains everywhere under the heavens were covered with water" (Genesis 7:19). The NCAR code results showed some slightly lower velocities ranging up to the mid-20 m/s range. Even with these velocities, which are lower than those of the Dr. Baumgardner's code results, the velocities are still sufficiently large to induce a global movement of sedimentation. As such, these types of calculations strengthen the evidence for Noah's Flood and the associated consequences on the geological history of sedimentary rocks.

Keywords

Genesis Flood, Ocean currents, Sediment transport, Sedimentation patterns, Shallow water equations, Current velocities, Cavitations.

Introduction

The great Flood of Noah's day was a time of unthinkable geological upheaval, such that "the world that then was, being overflowed with water, perished" (2 Peter 3:6). No flood in human history has rivaled its destructive magnitude. Though we are far from a full understanding of the Flood, the Bible does give us a clue when it says, on that "same day were all the fountains of the great deep broken up, and the windows of heaven were opened. And the rain was upon the earth forty days and forty nights" (Genesis 7:11–12). Noah's Flood is of critical importance in understanding the true history of the earth. It holds the key to understanding the

geological fossil record found today. The geological fossil record is used as a strong evidence for the evolutionary transition of one class of organism to another. However, Genesis 6-9 says that every air-breathing land creature died on the earth, except for those on Noah's Ark. This indicates that most of the fossils we see in the geological record worldwide are a result of large-scale sudden death in just a few months' time. The Flood was responsible for the catastrophic geological upheaval. Central to understanding the Flood catastrophe is the hydraulic mechanism that was able to rapidly transport vast amounts of sediment and cause the present day geological record.

The importance of the current flow over the continents due to the flood is two-fold. The first issue is the sedimentation record arising from the flood, which indicates that mass transport including dead vegetation and animals is really the cause for the fossil record. The second issue is related to the dynamic stability of the ark, which must withstand the turbulent random vibration loads generated by the water's motion.

Both Dr. Baumgardner's and the NCAR codes give qualitative results on the possible conditions that could have produced currents capable of catastrophic sediment transportation and cavitation. These state-of-the-art codes are still too simple and crude to address the details of how the geological record was formed. However, they can be used to qualitatively provide insight into general velocity magnitudes and patterns under different varying parameters related to the general aspects of the Paleozoic and Mesozoic geologic records. To the authors' best knowledge, codes capable of addressing the details of geological formations, "fountains of the deep," and temperature and saline variations do not currently exist. Albeit, Clark and Voss (1990) investigated resonant lunar tides as the primary mechanism of geological upheaval. Their simulations showed that tides were capable of eroding the continents and transporting huge volumes of sediment, depositing them across vast areas. However, one main problem with this mechanism is that for resonance to occur on a smooth earth, the water depth on the continents needed to be approximately 8000 m (Clark & Voss, 1990; Hough, 1897). This water depth would require the volume of water to be three times the amount present in modern oceans, and no plausible explanation was given.

Another important result of analyzing the Flood related current flows is to study the dynamic stability of the Ark. Horstemeyer, Sherburn, Polk, and Bryan (2008) have analyzed the fundamental frequency response of Noah's Ark and the associated mode shapes in response to dynamic loads. To accurately quantify the ark's response, one must have some reasonable estimate of the boundary conditions. The water flow simulations in this present study provide some constraints for the current velocities impacting the ark. Ochi (1964; Ochi & Motter, 1974) and Szebehely and Todd (1955) discuss the relationship between ocean currents and waves and modern ships.

One question that can be raised is the following: can the break-up of the fountains of the deep and the subsequent 40 days and nights of global rain be enough to transport the sediment that is observed in the geological record? The answer is probably not. If one examines the massive scale of continental sediments for several thousand kilometers and looks

at the deposition of zircon grains (Vardiman, Snelling, & Chaffin, 2000) in igneous rock and sand grains that originated from the eastern U.S but transported to the western U.S., one would require coherent currents of *sustained* velocities capable of causing cavitation. It is difficult to imagine that rain could cause transportation through such distance. Also, it is hard to imagine that just 40 days of rain and currents could reduce the large early Appalachian Mountain Chain (which was on the order of the current Himalaya Mountains) to its current state. As such, longer time periods for sustained, high velocities that could induce cavitation and erosion are warranted. The total flood time was until the decrease of the water height, which started after 150 days (Genesis 8:3 "And the waters returned from off the earth continually: and after the end of the hundred and fifty days the waters were abated"). As such, the sustained water currents that caused the sedimentary geological record lasted at least up until this time period and probably up to the end of the Flood recession at 371 days.

Barnette and Baumgardner (1994), while investigating a localized tidal resonance in the large bay area on the eastern side of the Pangea continent found that the Coriolis force arising from the earth's rotation produced strong ocean currents on flooded continents. These ocean currents were found to be independent of tidal forcing as they formed closed paths and were cyclonic in nature. Holroyd (1990) suggested that if the velocities of ocean currents were to reach tens of meters per second, cavitation processes would be adequate to erode the continents and transport huge volumes of relatively coarse clastic sediment over extensive distances. Barnette and Baumgardner (1994) performed numerical calculations using shallow water equations (SLSWM) on a rotating sphere, with suitable parameters to simulate the earth with flooded continents. A table of appropriate parameters chosen for the simulations is given in Table 1. They found that for flooded continents with water depths around 2500–5000 m above the ocean floor, the continents yielded closed flow patterns of velocities of 40 to 80 m/s. Ocean currents with such velocities, combined with cavitation, would be capable of eroding huge volumes of rock and transporting the resulting sediments over extensive areas in a short amount of time.

Table 1. Table of suitable variables considered for NCAR STSWM simulation.

Parameters	Values
α (angle of earth's axis of rotation)	0.0 rad
A radius of the earth	6371220 m
g (acceleration due to gravity)	9.80161 m/s ²
Ω angular speed of earth's rotation	7.202×10^{-5} rad/s

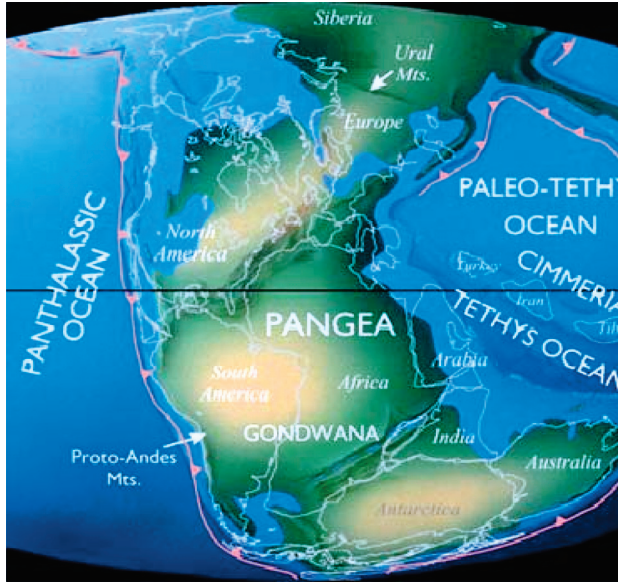


Figure 1. Pangea map from www.paleoportal.org. This website is run by University of California Museum of Paleontology, the Paleontological Society, the Society of Vertebrate Paleontology, and the United States Geological Survey

This paper focuses on evaluating the numerical velocity results obtained by Barnette and Baumgardner (1994). This work differs from the Barnette and Baumgardner study in its use of a different code to verify and further explore the variation of continent size and position of the continents on the flow pattern. The Spectral Transform Shallow Water Method (STSWM) code developed by the National Center for Atmospheric Research (NCAR) is used to further investigate and validate the dynamics of ocean currents driven by the Coriolis force and geopotential as well as the effects of using a fixed frame of reference by implementing Euler's equations in STSWM.

Flooded continents were assumed as initial conditions. Here the authors assume a Pangea-like supercontinent topography, similar to the one in Figure 1, flooded with a certain height of water. The height of water of over the ocean floor was considered to be around 3000 m. This gives an amount of water present currently on earth. The locations of the continents were chosen around 0° longitude to simulate the Pangea-like supercontinent. The simulations were performed for 40–100 days depending on the configuration of the continents.

Both the codes, SLSWM and STSWM, have been tested with a suite of test cases developed by NCAR (Williamson, Drake, Hack, Jakob, & Swartrauber, 1992) for validation. These test cases were considered as the standard for validation of shallow water codes.

Mathematical Formulation

In vector form, the horizontal momentum and continuity equations governing the behavior of a rotating, homogeneous, incompressible, inviscid and hydrostatic fluid are given as (Hack & Jakob, 1992)

$$\frac{d\mathbf{V}}{dt} = -f\mathbf{k} \times \mathbf{V} - \nabla\Phi \quad (1)$$

$$\frac{d\Phi}{dt} = -\Phi \nabla \cdot \mathbf{V} \quad (2)$$

where $\mathbf{V} = u\mathbf{i} + v\mathbf{j}$ is the horizontal velocity vector, \mathbf{i} and \mathbf{j} are the unit vectors in the eastward and northward directions, respectively; u and v are the eastward and northward velocity amplitudes, respectively; $\Phi = gh$ is the free surface geopotential; g is the gravitational acceleration; $f = 2\Omega \sin\phi$ is the Coriolis parameter; Ω is the angular velocity of the earth; ϕ denotes latitude, and Λ denotes longitude. The D/Dt operator is the substantial derivative, and ∇ the spherical gradient operator. These equations are valid when the depth of the fluid is small compared to the horizontal length scales. This condition is valid for the case of worldwide Flood as the water depth is typically less than 4,000 m while the horizontal length of the oceans of the order of thousands of kilometers. The main driving force for the water current is the geopotential over the continental ridge. This initiates the flow over continents, while the Coriolis force gives the water direction. The influence of geopotential and Coriolis force shapes the circular motion over the continents.

The formulation of the shallow water equations are based on additional assumptions: the static location of the continental landmass, no pressure gradients in the water, no temperature gradients in the water, no salinity gradients in the water, no compressibility, no friction in the water, and no turbulence. Having no salinity, no pressure gradients, and no friction probably yields higher velocities than in actual scenarios. Also turbulence and temperature gradients would probably lower current velocities due to apparent viscosities and drag and would result in turbulent mixing (White, 2002). As such, the simulation velocities determined in this study would represent maximum limits given the parametric variations. Lowering effects of turbulence on the velocity profiles would require implementing turbulent mixing subroutine in STSWM code.

A Semi-Lagrangian Shallow Water Method (SLSWM) (Barnette & Baumgardner, 1994) solves these equations in a discrete fashion on a regular icosahedron mesh. The number of nodes in the mesh was 40962. A Semi-Lagrangian formulation (Staniforth & Cote, 1991; Williamson, Kiehl, Ramanathan, Dickinson, & Hack, 1987) of equations (1) and (2) was used to compute the trajectories at each time step. The Semi-Lagrangian method eliminated

Table 2. Comparison of differences and similarities between SLSWM and STSWM (Barnette & Baumgardner, 1994; Hack & Jakob, 1992).

Attributes	SLSWM	STSWM
Differences		
Numerical scheme	Spectral Transform Method	Semi-Lagrangian Method
Mesh	Regular Icosahedron Mesh	Regular Rectangular Mesh
Number of Nodes	40962	8192
Time differencing scheme	Semi-Implicit	Implicit
Similarities		
Governing Equations	Euler's Equations	Euler's Equations
Assumptions	Shallow Water	Shallow Water

numerical diffusion that is associated with Eulerian schemes. A second order interpolation method was used to find the starting values of the trajectories. STSWM solved equations (1) and (2) using a spectral transform method on a spherical geometry, and the time differencing scheme was semi-implicit. The STSWM code solved the shallow water equations using a spectral decomposition of the shallow water equations. Here spherical harmonic functions were used in the spectral expansion of eigenvalue solutions of the shallow water equations. The equations were solved on a regular structured mesh. The number of nodes used in this study were 8192, 18432, 49600, 131072 and 204800. Table 2 summarizes the similarities and differences between the SLSWM and STSWM codes.

The water motion strictly arises from the earth's rotation. Any meteorological and hydrodynamical forcing terms are not included in these studies, which would provide some initial conditions similar to the Genesis Flood. Certainly, we would expect some initial conditions that are different from the ones that we assumed here due to the transients related to the initial break-up of the foundations of the deep and the pre-flood protocontinent movement. However, simulations of these conditions need to come from other codes, which is outside the realm of this study. For example, TERRA (Baumgardner, 1994) could be used to help determine the subduction-induced continental motion, which is assumed to be zero here in our study. The continental velocities from the TERRA simulations can be either subtracted or added to the "still continent" current velocities determined in the present study to realize the true relative water velocities. The peak velocities for the continental movement are in the range of 0.37–1.04 m/s over a period of 70 days (Baumgardner). As such, the simulations presented in this study are "steady state" like conditions related to the Genesis Flood.

Results and Discussion

To verify the results obtained from SLSWM and STSWM, a small set of problems with similar topography during the flood were investigated. The

geometry considered two circular continents placed in the northern and southern hemisphere. Using SLSWM, Barnette and Baumgardner (1994) observed that two circular continents, with a diameter of 5560 km, at 45° latitude in each hemisphere produced cyclonic (or clockwise in the northern hemisphere) currents. These currents occurred on each continent and peaked at 40 m/s for an initial water depth of 1000 m above the continents (Figure 2).

The average water depth over the oceans was 3000 m. When the continents were moved to points centered at 60° latitude, the character of the solution remained the same but the magnitude of the current velocities increased to peak values of about 55 m/s. On the other hand, when the circular continents were centered at 30° latitude in each hemisphere, the peak velocity was approximately 37 m/s. This variation of velocities indicated that the Coriolis force played an essential role in generating the currents.

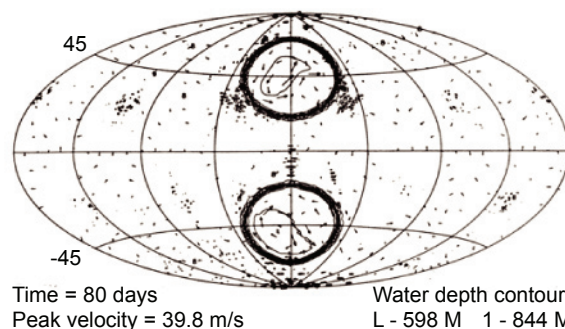


Figure 2. Two-dimensional snapshot at 80 days using SLSWM with two circular continents 5560 km in diameter centered at 45° latitude in each hemisphere. Initial flood depth over continents is 1000 m and water depth over oceans is 3000 m (Barnette & Baumgardner, 1994).

Incorporating the same configuration of continents into the NCAR STSWM code revealed that the variation of latitude increased the peak velocities over the continents similar to the SLSWM code. Figure 3 shows that at 80 days the peak velocity attained over the continents was approximately 20 m/s. The ocean currents produced were anti-cyclonic (or clockwise in the southern hemisphere) in nature, unlike the SLSWM results. The centers of the continents were located at 45° latitude in each hemisphere. When the centers of the continents were shifted to 60° latitude the peak velocity was 21 m/s (Figure 4). When the centers of the continents were at 30° in the northern and southern hemisphere, the peak velocity was observed to be 14.6 m/s (Figure 5). This reflects a strong presence of the Coriolis force and similar velocity trend as the SLSWM results described by

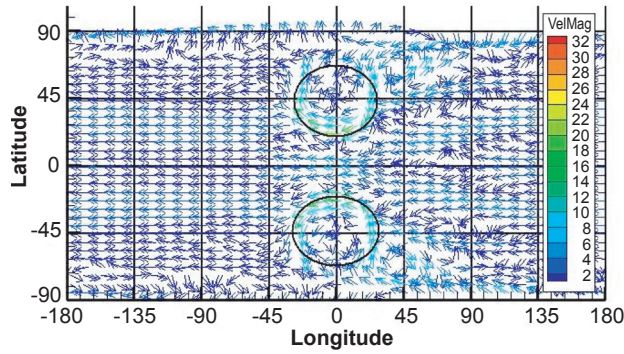


Figure 3. Two-dimensional snapshot (Mercator projection) at 80 days using the NCAR code STSWM with two circular continents 5560 km in diameter centered at 45° latitude in each hemisphere. Initial flood depth over continents is 1000 m and water depth over oceans is 3000 m. The peak velocity resulting from the simulations was 20 m/s. The number of nodes used for this simulation was 8192.

Barnette and Baumgardner (1994). However, two differences between the code results arose, as the STSWM generated cyclonic currents while SLSWM yielded anti-cyclonic currents above the continents and the STSWM velocities were approximately 50% less than the SLSWM velocities.

The next parameter that was analyzed was the size of the continents as designated by the horizontal length (diameter). Two circular continents, in each hemisphere at 45° latitude, were considered. For a diameter of 3330 km and a water depth of 250 m, Barnette and Baumgardner (1994) observed that the peak velocity at 40 days was about 40 m/s (Figure 6), while a diameter of 2220 km produced no prominent ocean current feature. This indicates that below a threshold diameter of approximately 2500 km ocean currents will be not generated from the presence of the land mass undergoing flooding. STSWM simulations for a continent diameter of 2220 km also

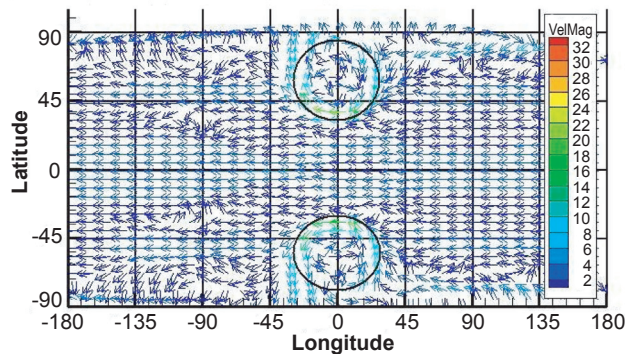


Figure 4. Two-dimensional snapshot (Mercator projection) at 80 days using STSWM with two circular continents 5560 km in diameter centered at 60° latitude in each hemisphere. Initial flood depth over continents is 1000 m and water depth over oceans is 3000 m. The peak velocity from the simulations was 21 m/s. The number of nodes used for this simulation was 8192.

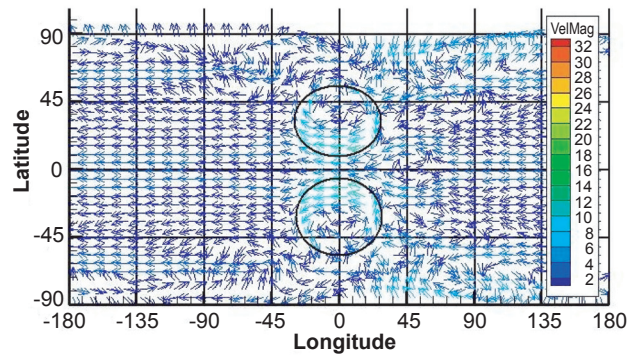


Figure 5. Two-dimensional snapshot (Mercator projection) at 80 days using the NCAR code STSWM with two circular continents 5560 km in diameter centered at 30° latitude in each hemisphere. Initial flood depth over continents is 1000 m, and water depth over oceans is 3000 m. The peak velocity from the simulations was 14.6 m/s. The number of nodes used for this simulation was 8192.

showed that no consistent pattern of ocean currents above the continents arose similar to the SLSWM results. However, for a continent diameter of 3330 km STSWM did not yield a consistent circular pattern for the currents above the continents (Figure 7) and produced a slightly lower peak velocity of 9 m/s.

Figure 8 shows two continents of 9772 km diameter placed in the northern and southern hemisphere. The area of the configuration shown in Figure 8 corresponds to present-day land mass area. The simulation for the configuration in Figure 8 was carried out using STSWM. A simulation with the same configuration (Figure 8) was not carried out by Barnette and Baumgardner (1994). Here the trend in the water velocities was similar to that of results shown in Figures 3, 4, 5, and 7. They are circular in nature and counter-clockwise in the northern hemisphere. The peak velocity above the continents was 28.2 m/s at 80 days.

Comparison of peak velocities obtained using SLSWM and STSWM show that they follow the

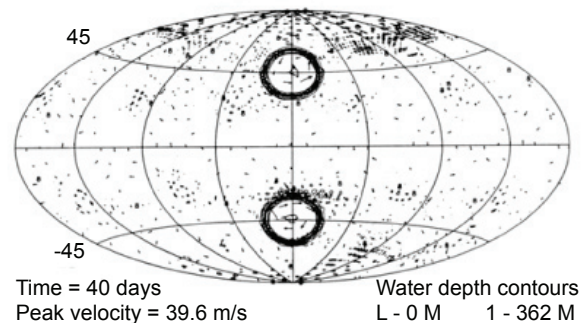


Figure 6. Two-dimensional snapshot at 40 days using SLSWM with two circular continents 3330 km in diameter centered at 45° latitude in each hemisphere. Initial flood depth over continents is 250 m (Barnette & Baumgardner, 1994).

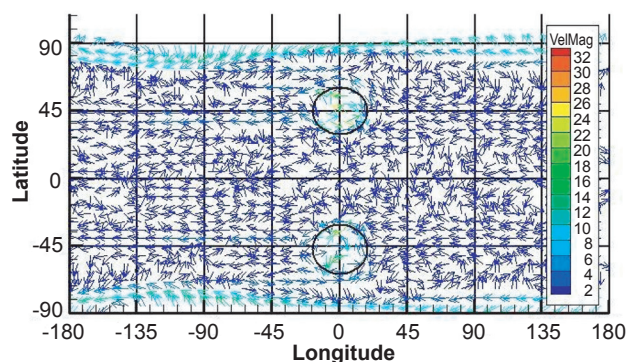


Figure 7. Two-dimensional snapshot (Mercator projection) at 40 days using the NCAR code STSWM with two circular continents 3330 km in diameter centered at 45° latitude in each hemisphere. Initial flood depth over continents is 250 m. The peak velocity from the simulations was 9.0 m/s. The number of nodes used for this simulation was 8192.

same trend in peak velocity change over different latitude positions of continents (Figure 9). However, the magnitude differences were about 50% different. In either case, velocities above 20 m/s were observed. Certainly, these velocities are large enough to induce the sedimentation layering that was observed by Berthault (1994). Now the question can be raised, what role do the other assumptions of no pressure gradients, no salinity gradients, no temperature gradients, no turbulence, and no continent motion play in lowering the velocity. We simply do not know now. We assume that each of these factors would probably decrease the magnitude of the velocities but simply do not know the magnitudes of the effects. On the other hand, as the mesh resolution increased, the velocities increased. Figure 10 gives a plot of peak velocities versus the number of nodes used for the simulations. The peak velocities in Figure 10 for the highest

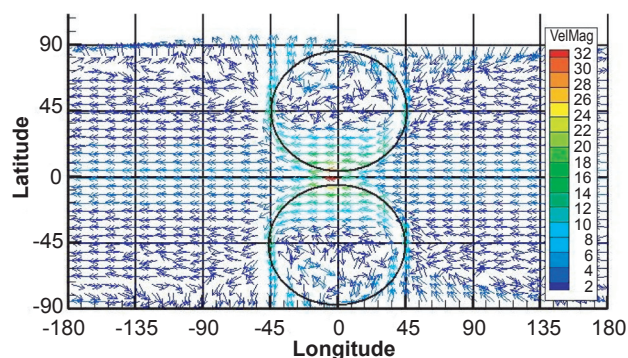


Figure 8. Two-dimensional snapshot (Mercator projection) at 80 days using the NCAR code STSWM with two circular continents 9772 km in diameter centered at 45° latitude in each hemisphere. Initial flood depth over continents is 1000 m. The area of the continents corresponds to current continental area. The peak velocity from the simulations above the continents was 28.2 m/s. The number of nodes used for this simulation was 8192.

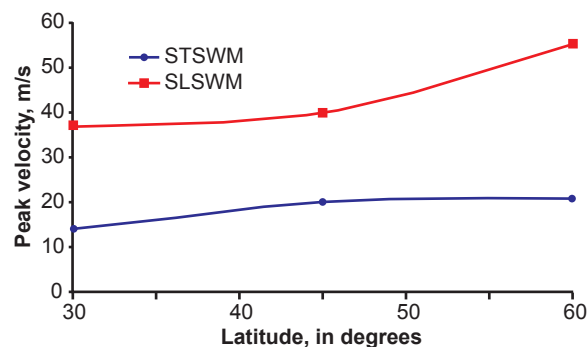


Figure 9. Plot of variation of peak velocity with Latitude position of continents using SLSWM and the NCAR code STSWM. These velocities were observed at 80 days. The continents were 5560 km in diameter.

mesh refinement using STSWM correspond to peak velocities from SLSWM simulations with 4.1×10^4 nodes. Also Figure 10 shows that the STSWM code is sensitive to mesh resolution, but finer mesh refinement comes at the cost both of memory requirements and computational time. Hence the mesh refinement was constrained to the order of 2.5×10^5 nodes. The state-of-the-art numerical codes currently do not allow the quantitative assessment of the velocities, because of the limitations from the aforementioned assumptions. Hopefully, future codes will address these issues.

Figure 11 indicates that the peak velocities calculated using STSWM is sustained over the entire period of time considered (100 days). The continents in the northern and southern hemisphere were 5560 km in diameter with 500 m water depth. This would imply that if during the Flood continents moved away from the equator, the peak velocities increase and vast amount of sediment transportation would have been possible due to sustained water velocities capable of producing cavitation. These water velocities could have also propelled Noah's Ark away from the continents, where much of the sediment deposition would have occurred.

Figure 12 shows the plots of peak water velocities over the continents for different water depths over

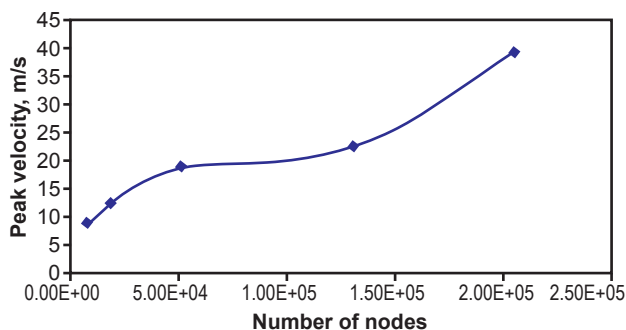


Figure 10. Mesh refinement—plot of peak velocities above flooded continents versus number of nodes. The continents were 5560 km in diameter centered at 45° latitude north and south. The continents were with a water depth of 1000 m at the fortieth day.

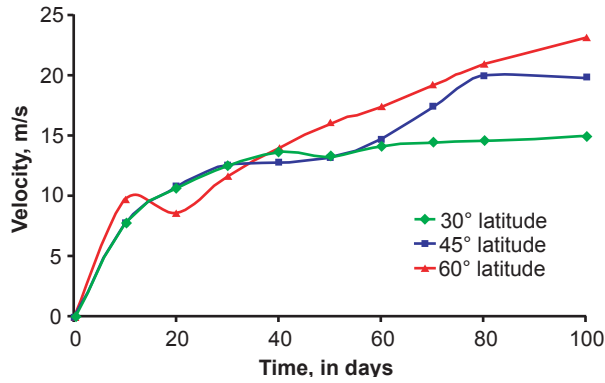


Figure 11. Plot of sustained peak velocities 500m the above flooded continents over time. STSWM was used for the calculation. The diameters of the continents were 5560 km. The number of nodes used for these simulations were 8192.

the continents indicating that the peak velocities initially increased as the water depth increased until a water depth of 1000m, after which the water velocities decreased. The results shown in Figure 12 were obtained from different simulations at the same locations. Also when the water depth was increased with time, the peak velocity reached a maximum at a certain depth (approximately 1000m). A further increase in water depth with time showed a decreasing trend in the peak velocity (Figure 13), which would give stable conditions for Noah's Ark to return over the continents as the time increased (Genesis 8:1b "... God made a wind to pass over the earth, and the waters asswaged.")

Figure 14 is similar to Figure 3 except that the earth's rotational angle was opposite in direction. The continents were of 5560km in diameter and placed at 45° latitude north and south. Here the angular speed of the earth's rotation was reversed to -7.292×10^{-5} rad/s. Since the purpose of this parametric study was to analyze the velocity effects and compare with the Barnette and Baumgardner (1994) results, the different cyclonic and anti-cyclonic velocities still

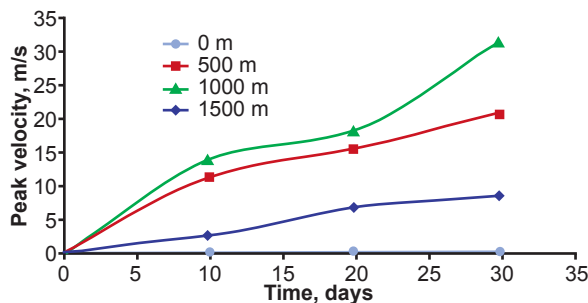


Figure 12. Plots of peak velocities above flooded continents over time. The water depth over the continents was varied from 0m to 1500m. The continents were 5560km in diameter centered at 45° latitude north and south. The number of nodes used for these simulations were 49600.

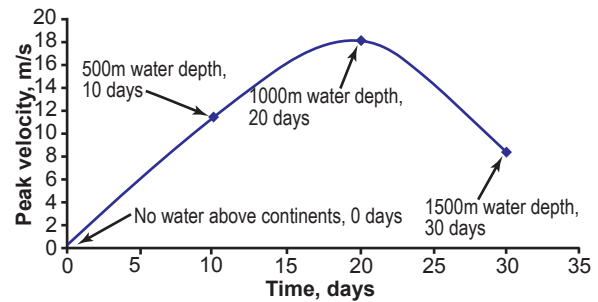


Figure 13. Plot of peak velocity above continents with increasing water depth (over the continents) over time. The continents were 5560km in diameter centered at 45° latitude north and south. These results were obtained from different simulations at the same location. The number of nodes used for these simulations were 49600.

gave rather high values. Figure 14 shows cyclonic currents similar to Barnette and Baumgardner, which is clockwise in the northern hemisphere; however, the peak velocity was 12.4 m/s at a latitude of 45° over the flooded continents compared the Barnette and Baumgardner value of 39.8 m/s. Recall that the anti-cyclonic velocity values at 45° were 14.6 m/s. Similar to the rest of comparisons, the NCAR STSWM simulation velocities were approximately half of the SLSWM results.

Conclusions

Numerical calculations of shallow water equations using SLSWM and STSWM show that for an earth with flooded continents, ocean currents reach velocities on the order of tens of meters per second in a few months time. Despite the differences between the two codes (Table 1), the results indicate that peak velocities approximating 20 m/s over the continents were sustained over the time period of simulations (Figures 9 and 10) up to 80 days. We suspect that

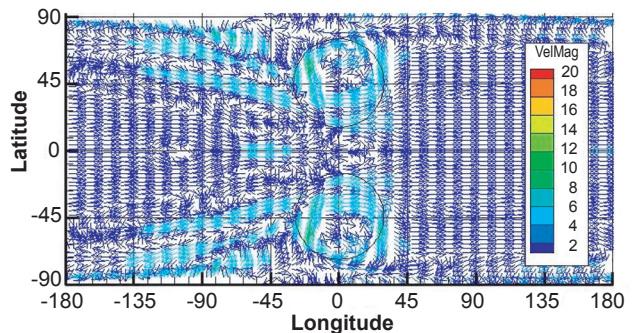


Figure 14. Two-dimensional snapshot (Mercator projection) at 80 days using the NCAR code STSWM with two circular continents 5660 km in diameter centered at 45° latitude in each hemisphere. Initial flood depth over continents is 1000m. The angular speed of the earth's rotation is -7.292×10^{-5} rad/s. The peak velocity above the continents is 12.4 m/s. The number of nodes used for this simulation was 8192.

the length of time would even be longer but at some point turbulence and viscous drag would dampen the peak velocities. Both of the codes give results for peak velocities that are capable of transporting huge volumes of sediments (Berthault, 1994). Both codes also give qualitatively similar water circulation patterns.

The fact that peak velocities increased as the latitude of continent centers changed indicates a strong influence of geopotential and Coriolis force (Figure 9). However the difference in direction of ocean currents obtained from both codes needs further investigation. Further investigation needs to occur on the issues of the assumptions related to salinity gradients, temperature gradients, pressure gradients, turbulence, and mesh regularization.

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Nomenclature

- SLSWM: Semi-Lagrangian Shallow Water Method.
 STSWM: Spectral Transform Shallow Water Method.