



UKUGCINA ILISO KULWANDLEKAZI LWE-EARTH'S KUNYE NEEROBHOZI ZE-ARGO

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Wake wazibuza ukuthi ososayensi bazi kanjani ukuthi kwenzekani ekujuleni kolwandle? Kunentlobo ezimbalwa zamarobhozi akwazi ukutshuza ngaphansi kwamanzi olwandle futhi abuyise idatha esuka ngaphansi kwamanzi. Olunye uhlobo lwerobhozi, olubizwa ngokuthi i-Argo float, luhamba phakathi ekujuleni kolwandle nemisinga bese lufika phezulu kanye njalo ezinsukwini ezilishumi (10), ukuze luxelele ososayensi ngolwazi oluqokeleliwe. Njengangoku, kunamarobhozi e-Argo angaba yi-4,000 agcina iliso elwandle olwandle zonke insuku. La marobhozi akala izinga lokutshisa nokuba netyiwa elwandle, kanti amanye abheka imingcele eyahlukahlukene yamakhemikhali neyebhayoloji. Amarobhozi e-Argo anikeza ixhoba le-oceanographer, ukunceda ososayensi baqonde ukuba ulwandle lusebenza kanjani nokuba alukhomayevelana nje nezinto eziphila elwandle, kodwa luxhumana nomhlaba wonke.

KUTHENI IZAZINZULU ZIBEKA ILISO KULWANDLEKAZI LWE-EARTH'S?

Ulwandle lubaluleke kakhulu empilweni yabantu ngoba lusinika ukudla, imithi, izinto zokuhamba, Kanye nokungebeleka. Ulwandle luphinde lube likhaya lentlobo ezininzi zolwandle ezenza uMhlaba ube nobuhlobo kubantu. Umzekelo, **i-plankton** encinane elwandle ikhupha ngaphezulu kwe-50% womoya esiwuphefumlayo. Ulwandle lwakha ngaphezu kuka-70% wendawo yoMhlaba futhi ludlala indima enkulu kwiplanethi.

I-PLANKTON

Izityalo ezikhuphayo, ubulembu (algae), kunye nezinye iibhaktheriya ezinokufota.

IMOZULU

Inkcazo yepateni yexesha elide yemozulu kwindawo ethile. Oku ngokuqhelekileyo kuqikelelwa njengomyinge wedatha eqokelelweyo (umzekelo, ubushushu) ubuncinane kwiminyaka engamashumi amabini.

I-GREENHOUSE GASES

Igesi ezibamba ubushushu emoyeni kuquka i-carbon dioxide, i-methane, i-nitrous oxide kunye negesi ezine-fluorinated.

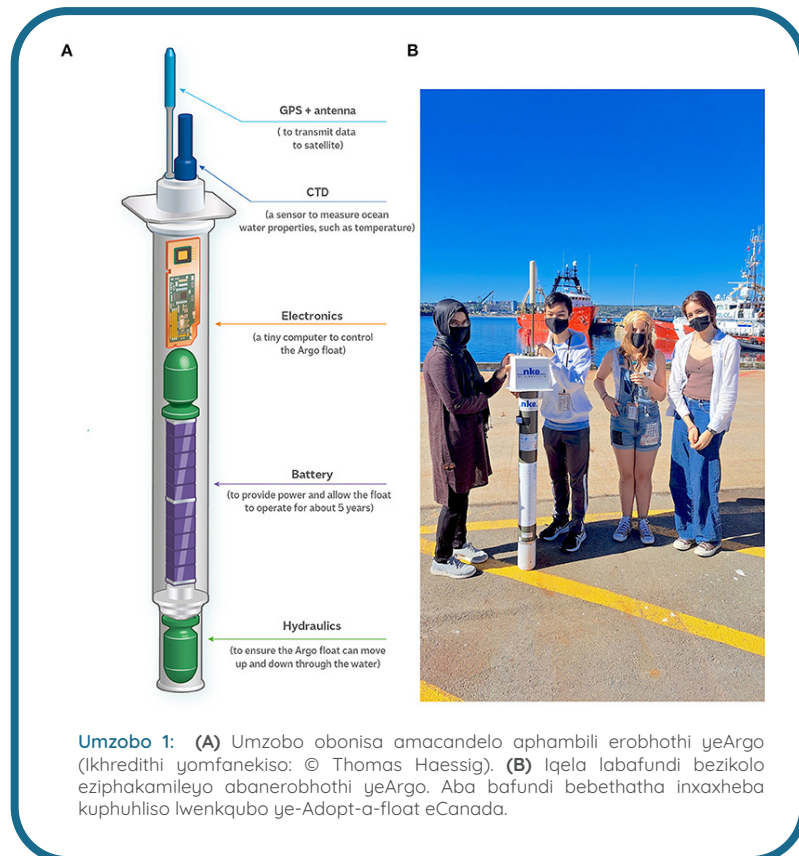
Ngenxa yazo zonke ezi zizathu, ososayensi sebeneminyaka emininzi bazi ukuba kubalulekile ukuhlola ulwandle, ukuluqonda bhelele nokuyaleza inguquko ezingase zenzeke.

Izazinzulu ezifunda nge atmosfera nazo zinomdla wokuqwalasela ulwandle kuba **imozulu** esiyifumanayo yonke imihla iphenjelelwa lulwandlekazi. Umzekelo, ngaba ukhe wawabona amanzi ephuma ngumphunga kwindlela eshushu? Kwenzeka into efanayo elwandle, xa amaqondo obushushu elwandle ashushu abangela ukuba abe ngumphunga, nto leyo ehambisa amanzi ukusuka elwandle ukuya emoyeni. Xa sele esemoyeni, amanzianceda ekwenzeni amafu, ikhephu nemvula. Ke, ukubeka iliso ngcono kweemeko zolwandle kukhokelela kuqikelelo lwemozulu olungcono.

Ezinye izazinzulu ziingcali zokufunda imozulu yomhlaba. Imimandla ene-“tropical climate” ifumana ukukhanya kwelanga okuninzi ngonyaka. Oko kwenza umphezulu wolwandle ufudumale kwaye uvelise amafu kunye nemvula, ngoko ke imozulu kule mimandla idla ngokuba shushu kwaye ifumile. Kodwa imozulu inokutshintsha ngokuhamba kwexesha. Ngokomzekelo, ezinye izinto ezenziwa ngabantu, ezinjengokuqhuba iimoto okanye ukufudumeza amakhaya ethu, zinokongeza **iigesi ze-greenhouse** emoyeni. Igesi zeGreenhouse zisebenza njengengubo, zibamba ubushushu kunye nokufudumeza umphezulu womhlaba. Ukuqwalaselwa kolwandle kubalulekile ekuqondeni indlela iigesi zegreenhouse ezinegalelo ngayo kutshintsho lwemozulu kuba ulwandle lunokufunxa ikharbon dioxide kunye nobushushu obuvela kwiatmosfera yomhlaba kwaye luzijikeleze ngemisinga yolwandle.

IROBHOTHI ZE-ARGO: ABADLALI BOLWANDLE LWESIHLALA!

Ukufunda ulwandle, izazinzulu kufuneka ziqokelele idatha iminyaka emininzi. Enye indlela ebalulekileyo yokufumana olu lwazi kukuhamba ngeenqanawa ukuya kuthatha imilinganiselo (*Jonga kwakhona le nqaku leMida yeNgqondo eNtsha*). Kodwa kukho iindawo ekunzima ukuba iinqanawa zifike kuzo, njengeArctic neAntarctic. Ebusika bukwavelisa ulwandle olulwayo ekunzima ukuba iinqanawa zisebenze kulo. Ukuqokelela imilinganiselo kwiilwandlekazi ze-Earth’s kuwo onke amaxesha onyaka, izazinzulu zayila iirobhothi zeArgo (*Umfanekiso 1*).

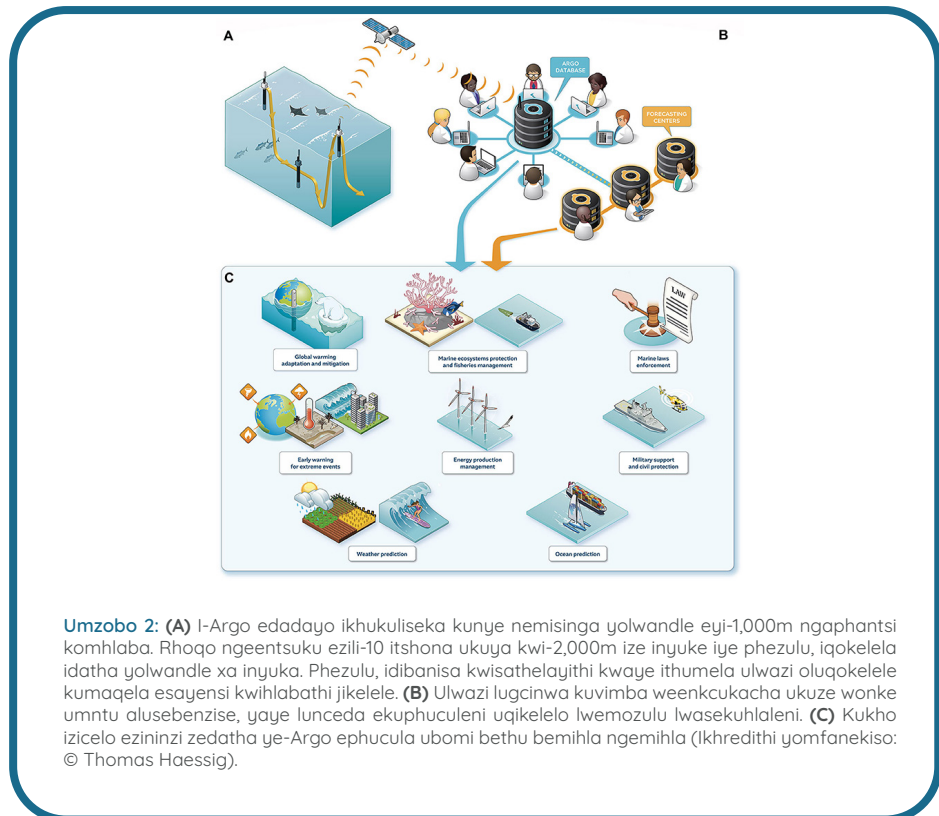


Umzobo 1: (A) Umzobo obonisa amacandelo aphambili erobhothi yeArgo (Ikhredithi yomfanekiso: © Thomas Haessig). (B) Iqela labafundi bezikolo eziphakamileyo abanerobhothi yeArgo. Aba bafundi bebethatha inxaxheba kuphuhliso lwenkqubo ye-Adopt-a-float eCanada.

I-SENSORS

Isixhobo esibona kwaye siphendule kuhlolo oluthile lwegalelo elivela kwindawo ebonakalayo.

Ezi robhothi zeArgo zibizwa ngokuba yi-“floats,” kwaye ziphethe **izinzwa** zokuqokelela idatha yolwandle. Nangona sizibiza ezi robhothi “zidada,” zinyuka zisihla elwandle. Izazinzulu zibeka iirobhothi zeArgo elwandle zisuka ezinqanaweni. Zakuba ziselwandle, zitshona kwi-1,000m kwaye zihamba ngokukhululekileyo kunye nemisinga yolwandle kobo bunzulu kangangeentsuku ezili-9. Ngomhla we-10, bantywila baye kwi-2,000m, emva koko banyuke baye phezulu, bethatha imilinganiselo yolwandle xa benyuka. Xa befika kumphezulu, bathumela idatha abayiqokeleleyo kunye nendawo yabo kwizazinzulu ngokusebenzisa iisathelayithi, ngaloo ndlela bevumela izazinzulu ukuba zakhe i-database yolwazi malunga nale nxalenye yolwandle. Emva koko, babuyela kwi-1,000m kwaye baqale umjikelo kwakhona (*Umfanekiso 2A*). Izazinzulu zisebenzisa iinkqubo zekhompuyutha ukujonga umgangatho wokulinganisa kunye nokudlulisela ulwazi kwisiseko sedatha (*Umfanekiso 2B*). Imilinganiselo ifumaneka ngokukhululekileyo kuye wonke umntu ngaphakathi kwe-24 h yeerobhothi ezibonakala phezulu (*Umfanekiso 2C*).



UBUTYUWA

Umlinganiselo wokuxinana kwetyuwa elwandle. Oku kunokubizwa ngokuba yityuwa.

UXINANISO

Ubungakanani bento kwinto (ubunzima bayo) yahlulwe ngokuba ingakanani indawo ethathwa yinto (umthamo wayo).

Iirobhothi zeArgo zirekhoda uxinzelelo, ubushushu kunye nemilinganiselo yetyuwa. **Ubutyuwa** ngumlinganiselo wokuxinana kwetyuwa elwandle. Ubutyuwa kunye nobushushu kunye bumisela ukuxinana kwamanzi olwandle. **Uxinzelelo** luxelela izazinzulu ngobunzulu apho imilinganiselo yobushushu kunye netyuwa ithathwa khona. Elwandle, imitha enye (m) ubunzulu imalunga nokufana nedecibar enye (dbar) kuxinzelelo. Emoyeni, uxinzelelo oluphezulu noluphantsi ludala iinkqubo zethu zemozulu. Elwandle, iindawo ezinineneyo eziphezulu nezisezantsi zidala imisinga, ehambisa amanzi amaninzi kwihlabathi jikelele. Ukuqonda indlela amanzi ahamba ngayo elwandle kubalulekile kuphando ngemozulu, kunye nokukhusela izityalo nezilwanyana ezihlala elwandle.

Xa izazinzulu zaqala ukuyila uthungelwano lweerobhothi zeArgo ngasekupheleni kweminyaka yoo-1990, zazifuna ukuba idatha incedise imilinganiselo yobude bolwandle eqokelelwe yisathelayithi egama linguJason. Kwintsoni yamaGrike, uJason wakhwela inqanawa egama linguArgo, ekhangela uboya begolide. Ke ngoko, izazinzulu zolwandle zazibiza ezi robhothi iArgo idada. Idatha yobude bomphezulu wolwandle ukusuka kwisathelayithi inokudityaniswa nedatha ye-Argo ukwazisa izazinzulu malunga notshintsho kwimisinga yolwandle. Iirobhothi zeArgo bezizulazula elwandle kule minyaka ingama-20 idlulileyo kwaye ziqokelele ngaphezulu kwezigididi ezi-2 zemilinganiselo kwihlabathi liphela¹. Namhlanje kukho phantse i-4,000 yeerobhothi zeArgo eziqokelela imilinganiselo yolwandle.

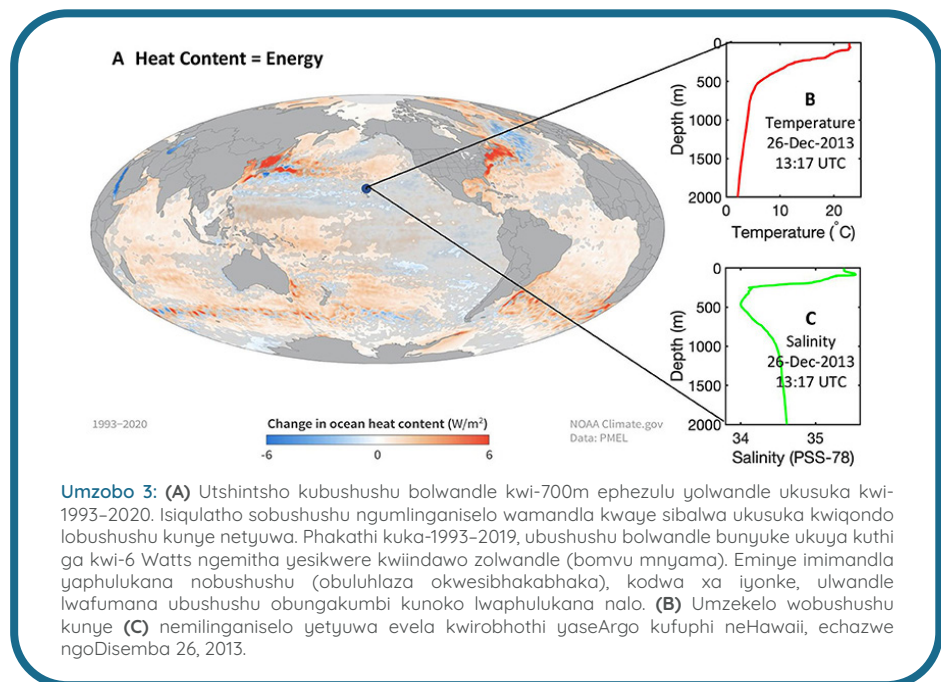
Irobhothi zeArgo zinikwa amandla ziibhetri kwaye zisebenza ubusuku nemini yonke imihla yonyaka. Ngenxa yezi robhothi, izazinzulu ngoku zinokubeka iliso kulwandlekazi lwe-Earth' kunanini na ngaphambili. Iibhetri kwiirobhothi zeArgo zihlala ngaphezulu kweminyaka emihlanu. Xa iibhetri zisetyenziswa phezulu, ezi robhothi ziya kungasebenzi kwaye zizike emazantsi olwandle. Ngelixa oku kunokubonakala ngathi kungcolisa ulwandle, impembelelo yokusingqongileyo elwandle incinci kakhulu xa ithelekiswa nezinye izinto ezingcolisayo, kwaye idatha yolwandle eqokelelweyo ixabiseke kakhulu ekuqondeni uMhlaba.

IROBHOTHI ZEARGO ZINOKUSIXELELA NTONI NGOLWANDLE?

Ukususela ngo-1970, ulwandle luthathe ngaphezu kwe-90% yobushushu obudalwe yigesi ye-greenhouse evela kwimisebenzi yabantu. Amaqondo obushushu kwiindawo ezininzi zeelwandle zehlabathi anyukile. Enye indlela izazinzulu ezibeka eswini ngayo oku kukusebenzisa imilinganiselo yobushushu netyuwa ukubala ukuba bungakanani na ubushushu obongeziweyo kumaleko wolwandle, obizwa ngokuba bubushushu bolwandle (*Umfanekiso 3*). Ngokusebenzisa idatha eqokelelwe ziirrobhothi ze-Argo, izazinzulu ziye zafumanisa ukuba iziganeko ezigqithisileyo ezifana namaza obushushu zenzeka rhoqo elwandle, kanye njengokuba zisemoyeni. La maza obushushu baselwandle abangela ukuba izilwanyana zaselwandle zifudukele kwezinye iindawo ukuze zifumane amanzi apholileyo. Noko ke, izityalo nezilwanyana ezingakwaziyo ukushukuma ziya kuthwaxwa ngala maza obushushu aselwandle.

ISIQULATHO SOBUSHUSHU BE-OCEAN

Ubungakanani bamandla ngendlela yobushushu obugcinwe elwandle.



Ukunyuka komphakamo wolwandle lwehlabathi sesinye isiphumo esikhulu sokutshintsha kwemozulu. Njengoko amanzi olwandle efudumala, nawo ayanda, nto leyo engomnye woonobangela abaphambili bokunyuka komphakamo wolwandle. Ukunyuka komphakamo wolwandle kunokuba neempembelelo ezimangalisayo kubomi bethu bemihla ngemihla kuba kunokubangela izikhukula, ukhukuliseko, kunye nokwenza amanzi acocekileyo angaselwa ngenxa yokuxutywa namanzi olwandle anetyuwa (*Jonga le nqaku leFrontiers for Young Minds ngolwazi oluthe kratya malunga nokunyuka komphakamo wolwandle*). Irobhothi zeArgo sisixhobo esiphambili ekubekeni iliso ekunyukeni komphakamo wolwandle lwehlabathi kuba zibeka iliso kwindlela iilwandle ezitshintsha ngayo i-Earth's.

Ukugcina umkhondo wolwandle nako kukhokelele kuphuculo loqikelelo lwemozulu. Ukusebenzisa iqondo lokushisa kunye nedatha yetyuwa ethunyelwe emva kweerobhothi ze-Argo, izazinzulu zongeze **imodeli yekhompyutheni** yolwandle kwizibalo zabo zemozulu. Ukuba nedatha yokwenyani yolwandle kule mifuziselo kuphucula ukuqonda kwenzululwazi malunga nendlela umoya kunye nolwandle ezinxibelelana ngayo. Oku kubaluleke kakhulu ekuqikeleleni izaqhwathi ezinamandla ezifana nezaqhwathi, iinkanyamba, kunye nezaqhwathi, ezifumana amandla azo amaninzi kwiindawo ezifudumeleyo zolwandle.

IMODELI YEKHOMPYUTHA

Inkqubo esebenza kwikhompyuter ukulinganisa inkqubo yehlabathi yokwenyani efana neatmosfera yoMhlaba okanye iilwandlekazi.

UKUHAMBA NZULU KWAYE KUMACALA AMATSHA

Ngaphambili, iirobhothi ze-Argo zazithintelwe kwi-2,000m ephezulu yolwandle, emele <50% yomthamo wolwandle lwehlabathi. Kunzima kakhulu ukuyila iirobhothi ezinokuhamba ziye emazantsi olwandle, kodwa izazinzulu neenjini zisandul' ukuphumelela ekwenzeni iirobhothi ezithile ezinokuntiywila nzulu kangange-6 000m². Ukwenza isampulu yolwandle ukusuka phezulu ukuya ezantsi kuya kwenza ukuba izazinzulu ziqonde ngcono utshintsho kubushushu nakumanzi acocekileyo, kwaye oku kuya kubonelela ngolwazi olungcono malunga nokunyuka komphakamo wolwandle lwehlabathi.

Sikwiqalwe entsha apho oomatshini be-Argo ngoku bekwazi ukwenza imilinganiselo enxulumene neekhemikhali kunye nobomi baselwandle³. Oku kuya kunika ulwazi ngotshintsho kumyinge weoksijini kunye nekarbon dayoksayidi elwandle, umzekelo. Ulwandle lwehlabathi okwangoku luphulukana neoksijini kwaye lufunxa ikarbon dayoksayidi engakumbi evela kumoya womhlaba. Olu tshintsho luneempembelelo kwindalo yaselwandle, kuquka nakwizazisi ezixhasa ukutya kwabaninzi bethu.

Iirobhothi zeArgo sisixhobo esinye kwibhokisi yezixhobo ze-oceanographer's. Bayinxalenye yenkqubo yehlabathi ebizwa ngokuba yiGlobal Ocean Observing System (GOOS). Kunye namanye amaqabane kwi-GOOS, ukuqhubela phambili kwi-robhothi ze-Argo kuya kusinceda ukuba sakhe umfanekiso wehlabathi wempilo yolwandle kunye nendlela etshintsha ngayo ngokuhamba kwexesha. Nawe ungazibandakanya naba bakhi-mkhanyo baselwandle. Njani? [Ngokwamkela idada](#). Unokukhetha i-robhothi yeArgo, uyinike igama, kwaye ulandele uhambo lwayo lokujikeleza ihlabathi. Unokufunda ngakumbi [malunga ne-Argo kwiSikolo se-Intanethi se-Argo](#) [nakwi-Ocean Observers](#). I-adventure yolwandle ilindle!

IZIKHANKANYO

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2. [Roemmich, D., Alford, M. H., Claustre, H., Johnson, K., King, B., Moum, J. et al. 2019. On the future of argo: a global, full-depth, multi-disciplinary array. Front. Mar. Sci. 6:439. doi: 10.3389/fmars.2019.00439](#)
3. [Bittig, H. C., Maurer, T. L., Plant, J. N., Schmechtig, C., Wong, A. P. S., Claustre, H., et al. 2019: A BGC-argo guide: planning, deployment, data handling and usage. Front. Mar. Sci. 6:502. doi: 10.3389/fmars.2019.00502](#)

INGENISIWE: 13 Meyi 2022

YAMKELWE: 21 Septemba 2023

IPAPASHWE KWI-INTANETHI: 06 Okthobha 2023

UMHLELI: Pedro Morais, Florida International University, United States

ABACEBISI BENZULULWAZI: Laura Lorenzoni and Sagi Dalryot

I-CONFLICT OF INTEREST: Ababhali bavakalisa ukuba uphando lwenziwe ngokungabikho kobudlelwane borhwebo okanye bezemali obunokuthi buthathwe njengokungqubuzana komdla.

ABAHALALUTYI ABANCINCI

DENIZ, UBUDALA: 12

Molo, igama lam nguDeniz kwaye ndiyathanda ukubukela iinkwenkwezi kwaye ndidlale imidlalo yevidiyo nabahlobo. Iqela lam lenkwenkwezi endilithandayo nguMessier 45 kwaye iqela lam endilithandayo libhanti leOrion. Umdlalo wam wevidiyo endiwuthandayo yiCall of Duty 2.

LÉO, UBUDALA: 12

ULeo wazalelwa eFlorida kwaye uyaluthanda ulwandle; uyakonwabela kakhulu ukuntiywila emanzini. Uthanda imbali kunye neentsomi, ngakumbi ukuba ngaphantsi kwamanzi. Udlala i-cello kwaye unezinja ezimbini, kwaye uyakonwabela ukudlala imidlalo yevidiyo ngexesha lakhe lokuphumla.





OMER, UBUDALA: 14

Ndinomdla kwezopolitiko zamazwe ngamazwe, kwaye ndiyathanda ukufunda ngezopolitiko, ifilosofi kunye nembali. Ndiyathanda ukudlala imidlalo yevidiyo kwi-Nintendo switch yam kunye ne-pc, kwaye ndiyakuthanda ukumamela umculo kunye nokudlala imidlalo yokudlala indima njenge-D&D kunye ne-Warhammer 40K.

ABABHALI

BLAIR J. GREENAN

UBlair Greenan ngusosayensi wophando kwiBedford Institute of Oceanography eseHalifax, eNova Scotia, eCanada. Ulawula igalelo laseKhanada kwinkqubo yeArgo yamazwe ngamazwe. Uphando lwakhe lugxile ekuncedeni uluntu lwaselunxwemeni luziqhelanise nokutshintsha kwemozulu yolwandle. Oku kuquka ukujongana nemiba yeziseko ezingundoqo ngokubonelela ngezixhobo ezisekelwe kwisayensi ngolwazi malunga notshintsho lwengingqi kumphakamo wolwandle olubangelwa kukutshintsha kwemozulu.

ANNIE P. WONG

UAnnie ngusosayensi wophando kwiYunivesithi yaseWashington eSeattle, WA, eUnited States. Uyingcali yolwandle eyaqala kwisayensi yaselwandle iqokelela idatha yolwandle kwiinqanawa. Ngoku usebenzisa idatha ye-Argo ukufunda ubutyuwa bolwandle kwaye unomdla kwiilwandle ezijikeleze i-Antarctica. Ujinxalenye yeQela le-Argo DataManagement elinceda ukusabalalisa idatha ye-Argo kuluntu.

TAMMY MORRIS

UTammy Morris yinzululwazi ephezulu kwiYunithi yaseLwandle yeNkonzo yeMozulu yaseMzantsi Afrika eseKapa, eMzantsi Afrika. Uyingcali yezolwandle ephotonongayo echithe iinyanga ezininzi elwandle kwiinqanawa zophando ezisebenza ngezixhobo zokujonga ulwandle ezifana neArgo floats, drifters, kunye ne-mornings. Uphando lwakhe lugxile kwinkqubo enkulu ye-Agulhas yangoku, kunye nonxibelelwano lwakutsha nje noLwandlekazi oluMazantsi.

EMILY A. SMITH

UEmily ngumphathi weenkqubo ezininzi ezibandakanya i-US Inkqubo yeArgo, iGlobal Sea Level Observing System (GLOSS), izilayidi zolwandle kwimisinga yemida, kunye neemveliso zobushushu bolwandle. U-Emily unoxanduva lokulawula uhlahlo lwabiwo-mali kunye nocwangciso lobuchule lweenkqubo zokuqwalasela. Ukwalungelelanisa inkqubo ye-Adopt a Drifter, eququzelela intsebenziswano nezikolo zase-US nakwamanye amazwe, ukuze bakwazi ukulandelela iibhoji ezikhukulisekayo kwaye basebenzise idatha ngexesha lokwenyani kumagumbi abo okufundela. Ngaphambi kokuza kwi-NOAA, u-Emily uchithe iminyaka eliqela efundisa abafundi besikolo esiphakathi, kwaye le nkqubo inceda ukumgcina enxibelelene nehlabathi lezemfundo.

MARINE BOLLARD

I-Marine inoxanduva lwemisebenzi yokufikelela kwi-Euro-Argo European Research Infrastructure Consortium (ERIC). I-ERIC izinikele ekuphuhliseni igalelo lexesha elide laseYurophu kwinkqubo yokubeka iliso yolwandle ye-Argo yehlabathi, ngenjongo yokuxhasa ukuqonda okungcono kunye nokuqikelelwa kolwandle, indima yalo kwinkqubo yemozulu, kunye nempilo yolwandle. Unezidanga ezimbini ze-master's kubunjinieli be-hydrogeology kunye nobuntatheli besayensi. Ngaphambi kokuza kwi-Euro-Argo, uMarine uchithe iminyaka eliqela epapasha iincwadi zesayensi kunye namanqaku ngeenjongo zemfundo kunye noluntu.

UKUCAPHULA: Greenan BJ, Wong AP, Morris T, Smith EA and Bollard M (2023) Keeping an Eye on Earth's Oceans With Argo Robots Front. Young Minds 11:943491. doi: 10.3389/frym.2023.943491

ABAGUQULELI: Thomas Mtantsi and Nomvelo Mapinda
ILUNGelo LOKUSHicilela © 2023 Greenan, Wong, Morris, Smith and Bollard. Eli linqaku lofikelelo oluvulelekileyo elisasazwe phantsi kwemigathango yeLayisensi ye-Creative Commons Attribution (CC BY). Ukusetyenziswa, ukuhanjiswa okanye ukuvulwa kwakhona kwezinye iiforam kuvumelekile, ngaphandle kokuba umbhali (ababhali) bokuqala kunye nomnini welungelo lokushicilela banikwe ikhredithi kwaye upapasho lokuqala kule jenali lucatshulwe, ngokuhambelana nesenzo esamkelweyo semfundo. Akukho kusetyenziswa, ukuhanjiswa okanye ukuvulwa kwakhona kuvumelekileyo okungahambelaniyo nale migaqo.

