The First Astronomers - A New Approach to Astronomy

August Muench
American Astronomical Society

Marta Entradas
Assistant Professor, Iscte

W. Patrick McCray
Professor of History, University of California, Santa Barbara

For a number of years, I've been working to understand the role of astronomy within cultures around Australia.When I first came to Australia back in 2003 as an American study abroad student, I had an experienced that changed my life. I first asked somebody about the star knowledge of Aboriginal people, and the response I got was not what I expected and it was not a positive one. And it was a very curious thing to happen. I thought, well, 'Why in the world do people think that there is no real astronomy or star knowledge here?' And it set me on a pathway to be where I am today. I moved back to the US, I finished my undergrad degree in physics and I came back to Australia to study astrophysics. But even though I was looking for planets orbiting distant stars, I became very drawn to this idea about Indigenous astronomy and I thought it's very curious. Why are no people looking at this and recognising this and understanding that there's got to be a lot of knowledge about astronomy in a country and a place that goes back as far in time as Aboriginal Australia does, 65,000 years or more. When I began looking into it, it became very obvious to me there is a wealth of star knowledge here that contains a tremendous degree of science that simply has not been recognised. I decided to pursue a PhD in that topic and for the last 15 years I've been working in this field, driven and supported by a number of Aboriginal and Torres Strait Islander mentors, colleagues, advisers and Elders. So I'm very happy to be coming and speaking to you about this topic today. I've been primarily working throughout the last ten years in the Torres Strait, and here you can see a beautiful image of Mer. This is a trio of islands in the Torres Strait. The Far Eastern Torres Strait at the very tip of the Great Barrier Reef. You can see Mer in the foreground and the two islets of Dauar and Waier in the background. When I begin learning from the Elders, I began working under the tutelage of Professor Martin Nakata.

Martin Nakata is a Torres Strait Islander, currently the Deputy Vice-Chancellor of Indigenous Education and Strategy at James Cook University in Townsville. But when I first met him, I was just coming out of my PhD, looking for work, and he invited me to work with him at the Nura Gili Indigenous Centre at the University of New South Wales. And I sat with Professor Nakata and he set forth a plan for the next decade to build up the world of Indigenous

Astronomy, because we both understood the public needs to know about this. We need to get this understanding of astronomy, science and star knowledge across all aspects of the public to help change the narrative of Australia for the better. We put in for a major grant and he took me to the Torres Strait as a first introduction here on Mer. And it's been a phenomenal experience over the last ten years and I've learned so much from the Elders. I'm happy to be here to share some of this knowledge with you, and of course to be joined tonight by Uncle Jimmy Smith. Wiradjuri Elder, who's been working in education in the Sydney region for a number of years. Now, when I began learning from the Elders, I noticed a few major themes coming out in all of this work that helps us to understand the context of it. And the Elders talk about how everything on the land is reflected in the sky and everything in the sky is reflected on the land. When we learn about Indigenous astronomy, or navigation, it's not just about the stars. The stars are a reference point. They're a way of linking the land to the sky as a memory space, as a map, as a scientific textbook and as a Law book. You encode this knowledge through oral tradition which is passed down through stories, through music, through dance, through art. And this knowledge can last thousands, even tens of thousands of years. We don't think about this much today because we're so focused on everything has to be written down. But if we understand the nature and the power of orality, we can begin to understand how and why this knowledge is passed down.

So we can see here Uncle Segar Passi, who's the Senior Elder on Mer, and he has been sharing knowledge for a number of years, and he's also quite a famous artist. And he told me that everything on the land is reflected in the sky. We can use that as a reference point. Professor Martin Nakata, you can see here in the middle, also sat me down a number of years ago, and he said, 'Duane, the reason that you were here working with us is because you're a scientist, and I want you to understand that, yes, we are a people of Culture. We are also a people of science'. So this helps to flip around the idea that Indigenous cultures in Australia and around the world, didn't have any science. Of course they have science and we're going to explore some of that, this evening. On the right we can see Uncle Alo Tapim, who is one of the Elders on Mer who's been helping me for a number of years. Uncle Alo explained to me that your ability to thrive in your environment depends on your ability to read the stars. What do we mean by read the stars? What we mean is your ability to observe and interpret every position or change in the properties of the stars, no matter how subtle, and link that information with the world around you. The positions of the stars when they rise or set at dusk or dawn, tell you about seasonal change, about the behaviour of animals, or even about when to plant crops, when animals are migrating, even how to forecast weather. But you also look at different elements of the sun the moon, the motions of the planets. Every subtle thing you can imagine or see in the sky is utilised, it is understood and it has meaning. In modern Western society. We have people like myself who were trained as astronomers, and what many people may not realise is Traditional Cultures around the world also have astronomers. And the Torres Strait, there is a special name for a person who was trained as an astronomer. They're called Zoogagal Mobye.

This literally translates to Constellation Person or Star Person. When they reach a certain age in their youth, they're taken from their family and placed in the Quad. The Quad is sort of like a University, Parliament House in the Torres Strait. They go through seven years of

intense instruction to learn the art and the science of astronomy. They gain that particular expertise in a certain part of the sky, which is very similar to how Western astronomy works, going through university earning your degrees. You have a broad knowledge of astronomy, but you also develop a specialised area of knowledge. Upon completion of their studies they go through an initiation and they continue learning throughout their life. It is the job of a Zoogagal Mobye to pay attention to every aspect of the sky and to inform the people about what is happening. Observing the positions of stars, changing seasons, forecasting weather all these things help people understand how to live and thrive and their environment. Now what's very interesting is one of the concluding elements for senior individuals who go through this training as a Zoogagal Mobye takes place during a particular ceremony. We can see on the left here an artwork that's describing this ceremony. On the right is one of the Dhari, one of the headdresses. Now during this ceremony, it is believed that the person must prove their bravery by taking the skull of an enemy on a different island. Now, this whole ceremony would take place at a very specific point in time that is linked to the positions of the moon and the sun. And you can look at this image on the left, and maybe you get a glimpse of what this might be. It's when there is a superposition of the sun and the moon. This ceremony takes place during a lunar eclipse. Now, this is special for a couple of reasons. Having a ceremony tied in to a very specific type of astronomical phenomenon is quite interesting. But what's more important is this ceremony was planned in advance by the Zoogagal Mobye.

He had to inform the people about when to hold the ceremony. Predicting eclipses is not an easy task, in fact, and the history and philosophy of science from Western perspective, no Indigenous oral cultures have ever been credited with being able to do this. So this is something that's very exciting, something that really changes the history of science. To be able to show definitively that these ancient cultures were able to predict something that modern science only thought was capable within relatively recent human history. Now, you also may recall that last week we had a total lunar eclipse of the moon. I couldn't see it from Germany, but it definitely was visible from Australia so I hope everybody was able to see that. Of course, it's not just the moon that we observe, it's the sun. The most prominent object in the sky the position of the sun when it rises and sets on the horizon at dusk or dawn, can tell us different things about changing seasons because the sun moves across the horizon from morning to morning or night to night throughout the year. In Western science we refer to these points that are reaches on the horizon as the solstices and the midpoint as the equinox. Of course, Indigenous cultures in Australia and around the world also observe this type of phenomenon. But thinking about it in a different way is important because not every culture was as concerned about the solstices or we think of as equinox, as modern Western society is. Of course the modern calendar now divides the seasons up based on these points of the sun. Summer, autumn, winter, spring. These are denoted by the solstices and the equinoxes. Now I learned from Elders on Moa Island in the Western Torres Strait, that it's a different way of conceptualising this. Now Elders have explained to me how you observe the angle of the sun in the sky and throughout the year, how it's higher in the summer and lower in winter, which gives rise to longer days in the summer and shorter days in the winter.

But it's also important to observe the points on the horizon where it rises and sets. Uncle David is a man from the village of Kubin in the Western Torres Strait, and what he explained to me is that what you want to do is look and see where the sun sets on the western horizon relative to an archipelago of islands in the distance, because throughout the year the sun is going to start at another northerly point and begin moving south each day of the year, reach the other solstice, and then begin moving back And what he explained to me is that you look at where the sun sets relative to these islands in the background. Because of one that sets over one particular island, it may denote that the seasons are changing from the wet season to the dry season. It may denote that the dugong are migrating, or the turtles are laying their eggs. And the way you can do this is actually look in the background. This is a simulated view of the sky that I used some computer software called Horizon to do and it shows the points of the solstices and the equinoxes. But again, it's not so important about those positions, but where the sun sets relative to the horizon behind or between these islands throughout the year. It's a different way of conceptualising it and helps us to understand the complexity of this knowledge. Now, the moon that I mentioned before with the lunar eclipse, is important for that particular ceremony. But there are so many aspects of the moon that are observed and read to understand about tides, seasons, ceremonies, and so many other things. Of course, we look at the moon and we notice it goes through phases. It goes from a new moon to a first quarter moon, begins waxing and getting bigger each night as it moves across the sky backwards to the direction of the sun from night to night, until it becomes a full moon and the begins of waning away until it appears to die for three days before coming back as a new moon again.

The Torres Strait Islanders, Aboriginal people, cultures around the world, especially those near the coast, have long recognised the links between lunar phases and activities that happen on the earth. For coastal saltwater people and seafaring people, the link between the tides and the moon is critically important. Knowing that high tide and low tide comes twice a day, but the higher the normal tide and lower than normal tide occurs during a full moon and a new moon. And this can help you with knowing how to navigate, knowing when to go fishing, the best time to do that, so many elements are tied in with that. There are other aspects of the moon we can look at as well. I'm not sure how many people may have seen this in the sky before, but if you look outside and you see a bright ring around the moon, it's called the Halo. The Torres Strait is called a Now this halo can tell you something very important about weather forecasting. Different traditions around the country in Australia and with many Aboriginal communities, talk about how the moon is a man and when it's about to rain, he builds a hut around himself to keep himself dry. So if you look at a ring around the moon, that can oftentimes indicate that rain is going to be imminent, it's going to be raining within a few days or even a week. And the Elders talk about how you look at the different properties of the halo. It's not just seeing a halo, but how big is the halo? Is there one ring or sometimes you can even see two rings? What colour does it appear? Can you see many stars inside that halo between the ring and the moon itself? Uncle Ghillar Michael Anderson, the Euahlayi Elder explained that if you look inside the ring of the moon, inside the halo, and you can count several stars, it may be days or even a week or two weeks before it rains, but if you look inside, you can't hardly count any stars inside

that ring, it means the rain is going to be imminent. And this is a great scientific observation. What does this mean? Well as we can learn from atmospheric studies, halo are caused by the refraction of ice crystals high in the atmosphere, and these ice crystals form in low fronts.

Low fronts bring rain. If there's a lot of humidity in the atmosphere, the sky's going to appear kind of fuzzy and you're not going to be able to count many stars. So with a low front and a lot of humidity, it will condense and fall as rain. But if you're looking at it's very clear and very crisp, you can see many distinct stars inside that halo, that means there's not a lot of humidity, which means there's nothing to condense and fall as rain. So these ideas, these observations are not necessarily something derived from modern Western science. They go back thousands, potentially tens of thousands of years, to First Cultures around the world who've been paying long, close attention to reading the stars. Now, many of you may have seen during a new moon, for example, little horns of the moon, which astronomers call cusps. You may notice when it's low on the horizon, just after a set for example, in the evening, that those horns of the moon can sometimes look a bit different throughout the year. And what I'm showing you here is a beautiful artwork by Uncle Segar Passi, and he does two art works. I'm going to show you both of them, back and forth. And I want you to look closely at these two images. And I want you to notice what similar and what's different about them, keeping in mind that these artworks are gorgeous. There are certainly aesthetically appealing, but that's not necessarily the main point of them. The main point is they are delivering knowledge. They're delivering important information. Every brushstroke every colour, every motif, every design has meaning, it has purpose and it's conveying information. And what Uncle Segar explains, is these two images are watching just after sunset at two different times of the year. During the wet season and during the dry season. The and the . And he talks about how the cusp of the moon pointing at different angles, the calmness or churniness of the ocean, the types of clouds in the atmosphere, even the reflection of the moonlight in the water tells you important things.

You can see in this image here, these puffy cumulonimbus clouds, the ocean looks a bit choppy and the points of the moon are pointing straight up. And you see in the other image, the points are off at an angle. You see thin cirrus clouds in the sky and the ocean looks very calm. The moonlight is reflected beautifully in the water. Now, when I first saw this, I thought well, this image here is one of the dry season. It looks beautiful out. I mean, that would make sense, right? And this one here, big would look like rain clouds. The water is very churning. This must be the wet season. And I asked Dr. Segar about this, he smiled and shook his head, that's not always the case, because it's not always about that exact moment in time. If you see the sky like this in the evening, the morning is going to be beautiful. It's because of the way the trade winds are taking the clouds and moving them around in the sky. It's right here when those cusps are pointed at an angle, that you actually have the wet season and those thin cirrus clouds in the sky that bring the low front, which will bring rain. So the angle of the moon cusps in the sky can tell you about annual seasonal rainfall throughout the year. And this is an idea that is shared by Aboriginal and First Nations Cultures all around the world. Now, another thing that I learned from the Elders is something that I found quite interesting for me as an astronomer and an astrophysicist. For

an astronomer observing the stars through a telescope, we need the calmest view of the sky as we possibly can get. So stars twinkling in the sky is really bad. We consider that a real problem. So we put telescopes on mountaintops to get away from the atmosphere that causes the stars to twinkle. We spend a lot of money and a lot of time developing adaptive optics systems that can cancel out that stellar scintillation, that twinkling.

We even spend billions of dollars putting telescopes into space to get away from the Earth's atmosphere, to get the best view of the stars that we can. Hubble and the James Webb Telescope are two famous examples. And what I learned from the Elders was something that completely changed my perception. The twinkling of stars or stellar scintillation is not a problem to be overcome. It's an extraordinarily useful tool in your astronomical toolkit. What does that mean? If you know how to read the way the stars twinkle, they will tell you things about the atmosphere. If you know things about the atmosphere, you can use that to predict weather and seasonal change. Now, stellar scintillation, as the elders explain, is caused by wind and turbulence in the atmosphere as the starlight comes into the atmosphere, these turbulent pockets of air change the refractive index of that light and make them twinkle. It can also make them change colour. The stars can sometimes appear very sharp. They can sometimes appear a bit fuzzy. The Elders explain it's really, really important that you pay close attention to understanding how that works. Now, Elders have explained to me that you look at the stars in the evening towards the end of the year, around the time of November into early December. When you look up, you're going to notice that on the ground level, the air is dead calm. What the Elders referred to as , not a breath of air. It's clear out, it's very hot and the stars are shining. But you'll also notice they're twinkling very, very quickly, even though at the ground level there's no air moving. And they say if you observe the way the stars are twinkling at this time of the year, it's going to tell you that we're moving out of the dry season, the , and we're moving towards the wet season, the . And what happens is around that time of the year, the trade winds begin shifting from the cooler drier southeasterly's to the warmer, more humid northwesterly's.

But those changes in trade winds are very high altitude, which means even on the ground level, you're not going to notice it. But if you look up at the sky and you see those stars twinkling, you can tell the changing of the trade winds. It's going to bring the wet monsoon season within a few weeks. Other Elders explained to me how you look at the behaviour of certain kinds of butterflies and they'll begin fluttering about. The males are very colourful, the colours of the flag, which one Elder explained to me. The females stay inside the bushes, when you see them out and about fluttering around and you notice the stars twinkling, that's going to tell you a storm is quickly approaching. Now in the Torres Strait, there is a song, in this song was shared to me by the Community of Mer, and it's called , which means 'the Twinkling Stars'. Now the entire community sings the song, everyone from Elders to children know it and it's a way of passing this knowledge down. And it's exactly discussing and describing what I just told you about the changing of the trade winds at the high altitudes as you go from the to the . Now, understanding weather patterns understanding seasonal change, understanding the behavior of plants and animals, is critically important to understanding navigation. The Torres Strait seafaring being seafaring culture, navigation is critically important. In fact, it's so important that the navigational star is the center of the

Torres Strait flag. The five points represent the five different island groups of the Torres Strait, but it also denotes the importance of having a navigational star. How to find your way from point A to point B by looking at the night sky. Now the way this works is each star rises and sets a particular point on the horizon. And if you memorise where on the horizon these stars rise and set using geometry and mathematics, you can work out what direction you need to go, but you have to look at those stars when they're low on the horizon.

So we can see this is a very famous part of navigation across Oceania and around the world. Now, that angle on the horizon is called the azimuth and the angle going up into the sky is called the altitude. And Elders will use their hands and other devices to be able to measure the positions of these stars. But you also have to memorise all the different stars, hundreds that can be used for navigation, and the point in the horizon where they rise and where they set to be able to get from point A to point B. In the Torres Strait, a symbol of navigation and a symbol of astronomy, links to the story of Tagai, one of the most important figures and Torres Strait Islander culture. Tagai was considered a fierce warrior, a leader and a spiritual man. He was also an expert fisherman and hunter. He commanded a crew of 12. He had a first mate named , and he had a crew of 12 men. Now the traditions about Tagai vary, a bit from Island Island, in the Western Torres Strait the crew were known as the , which is where the name comes from that I talked about before with the astronomer. Now the story of Tagai in the Eastern Torres Strait, as with many parts of the Strait, is that they were going on a major fishing expedition that was going to last several days. And and the crew, went out onto the reefs, and were not having much luck catching anything or finding anything. So Tagai went out onto one of the reefs to begin looking for a better spot. And while he was gone, the crew began consuming all of their rations. warned them against this, but they didn't pay any attention. When Tagai returned, he heard the sound of the empty shells where the water was being stored, and he wondered, why is there no water? And realised that the crew had drank all of his water and all of their rations before they even hardly got going on the expedition. He was enraged and flew into a fit of anger and killed 12 men.

He grouped them into two bundles of six and they ascended into the sky, become and . The stars we see today as the belt and scabbard of Orion and of these stars of the Pleiades. The positions of these stars throughout the year can tell you about seasonal change, behavior of plants and animals, and serve as an important cultural reference for Torres Strait Islanders. The left hand of Tagai is a gigantic constellation. It's the Southern Cross. His right hand is the Western constellation of Corvus the crow and a lot of stars in the sky trace out his body, his legs, and he's standing on his canoe, which is traced up by the Western constellation of Scorpius , his first mate, who did not consume any of the rations, joins him as the Red Star, Antares. He placed the two groups of men that became and on the opposite side of the sky to keep them far away from him. But as these stars rise and set throughout the year, they tell you different things. Now Tagai's left hand, the Southern Cross, is an important navigational aid because where it rises and sets in the sky, it always points towards the south. And that's very, very useful because in the Southern Hemisphere, we don't have a navigational star like we do in the northern hemisphere. The Northern Hemisphere, we have Polaris, which is almost exactly on the north celestial pole. So the star never really moves. We don't have that in the Southern Hemisphere. So we have to use other stars to

triangulate your position. This is something that's used by Aboriginal and Torres Strait Islander people across Australia. Now if you want to learn how to do this, it's something that many students learn in school, or if you did scouts, you would have learned this. You simply look at the top and the bottom star of the Southern Cross, the distance between them measure about four times that. And that shows you with a south celestial pull in the sky is that invisible point in the sky that never moves you simply travel straight down the horizon and you're going south.

But there's another important element of that, and that's the angle of the South Celestial Pole in the sky. How high up it is also tells you your latitude. Now, if you want to find North, you need to use a different set of stars. In the Torres Strait, they use a constellation of stars. It's very familiar to me being American. It's one of the most famous constellations in the Northern Hemisphere. It's called the Big Dipper. This is part of the constellation Ursa Major. Now, this is my view from the Northern Hemisphere. But of course Australia being below the equator is seen as being upside down. The islanders talk about this being the shark or in the Western Torres Strait. Now when the shark rises and sets throughout the year, tells you about its behaviour, tells you about the seasons and tells you about the important time to hold Ceremony. The Elders explain that when the nose of touches the horizon just after sunset, that's when the sharks begin breeding in the middle of the dry season. Now, I was taken by Professor Nakata to Mer number of years ago and I had heard about this before I went and when I asked him about this because we were going right in June, when this occurs He says, 'Wait till we get to Mer'. When we got to Mer, we dropped our gear off at the lodge. We walked down to the water. And sure enough, all along the island and the water just a few meters from shore, you could see sharks darting back and forth. It's the breeding season and a very dangerous time to be in the water. As the months pass and the shark dives deep into the sea, it begins rushing water through its gills, which goes into the sky and falls as seasonal rain. A couple of years ago, I was working with the Australian Royal Mint, and we commissioned three coins based on Indigenous Astronomy. One of them featured Beizam the Shark, which we can see here. The artwork in the inside was by Uncle Segar Passi, and it shows about how when the shark begins dipping into the horizon, you can start to see lightning in the background.

And this indicates that this seasonal change from the sager to the , the monsoon will begin coming relatively soon. And that's the time you want to begin planting and harvesting certain types of root vegetables. Another type of shark is seen not traced out by stars or constellations, but by dark spaces in the Milky Way itself. A very famous example of one of these types of constellations is the Great Emu in the Sky, which you've probably heard about at some point because it's become so famous now. If you want to learn more about that, you can watch a really great TEDx video by Wiradjuri woman and Astrophysicist, Kirsten Banks. Now, if you look up at the sky, you see this dark silhouette of the emu in the sky, imagine the same kind of dark spaces but flipped around backwards, and the Torres Strait Islanders talk about this being the Shovel Nose Shark or the Shovel Nose Ray. The angle of in the sky, tells you about the changing ocean currents throughout the year and is used as a navigational aid. So the main part of the Milky Way were Scorpius is, is seen as the main head, and the tail goes down to the Southern Cross, which is where you would see the head

of the Great Emu in the Sky. And the Elders talk about how as the as the evening sky changes as months progressed throughout the year, the angle of the Milky Way also changes. And this can tell you about how to navigate across space and how to predict the ocean currents that are going to be changing throughout the year. Another great constellation is used by Aboriginal people in the far southern part of Australia in the Kulin Nations, the and people, which is where I normally work in Melbourne, on their Country and they have a constellation called Barrukill which is comprised of the stars in Hydra. It's a very long linear constellation and that's used as a very interesting navigational aid because not only can you follow those stars, to know where you're going, but its angle in the sky being a long, linear constellation can help you keep track of time.

So you can use this constellation for time and for space. But we wanted to think about navigation in a slightly different context now, and we're going to go to far northern New South Wales, and the far southern part of Queensland. To Yuwaalaraay Country Uncle Michael Anderson, who I mentioned before, has been sharing knowledge from his Country for a number of years and he's taught us something very interesting about navigation, that's represented in Celestial Star Maps. In this context, this is not about following a particular star to go across the land or sea, it's about how you encode a journey from point A to point B, which can be hundreds of kilometres, knowing where to go along the landscape, knowing where to stop for food, water, to set up camp, for medicine. Once you figure out that best route, you've got to find a way of teaching that to younger generations. And the way he taught us that people do this, is not to go outside and try to follow a star at night necessarily, although that also was done. But in this case, you use the stars as waypoints on a journey. They're used as a celestial map. So you find stars that represent the rough orientation of those landscape points on your journey, and during the evening, earlier in the year, you teach that to the younger generations. It's used as a mnemonic, as a memory aid so later in the year when you're traveling for Ceremony to Carnarvon Gorge or the Bunya Mountains, if you're traveling during the day, you're not even traveling at night. But as you go on these journeys, you know where to go and how to get there based on a song line. These are the oral stories that are passed on through song that tell you about the landscape and you learn this by memorisation through the stars and the star maps. When Colonists first arrived to Australia and began spreading across the country in many places, including Yuwaalaraay Country, the Aboriginal people and the Elders were welcoming and they were trying to help guide the Colonists on their their journeys across the landscape and they showed them these same kinds of routes, these pathways that had been carved out by Aboriginal people for thousands of years.

The Colonists would begin going along these same pathways, turning them into roads and they would camp out at the same campsites Aboriginal people used, which evolved into towns. So today if you look at these star maps and their representations on the land, you see that they perfectly line up with the highway networks and the layout of towns, all across Australia. This isn't something that's just done in Yuwaalaraay Country, you see it in Western Australia, Northern Territory, everywhere. The layout of many towns and the highways that connect them are set out and based on Aboriginal star maps. Now there's another important element that I think is critical for us to understand, some of the scientific

observations that have not been recognised. In South Australia, south of Adelaide, is Ngarrindjeri Country along the Coorong. Now the Ngarrindjeri people have traditions about Waiyungari, Waiyungari means red man. This is a young initiate who's covered in ochre and has to go through a period of proving himself. Now there's a long story that goes about this, I'm not going to share all the details about that because certain elements of it are a bit secret. But what happens in this story is he breaks a very sacred taboo and him and two women are guilty of breaking this taboo and they face death as a punishment. Now to escape from this punishment of death, he cast a spear up into the Milky Way, which you can see on the top part of this beautiful artwork by artist Cedric Varco. And he pulls himself and the two women up into the sky, where they reside in the Milky Way, sitting within his canoe with the emu off to the west. And every year around springtime, you will see these stars very high in the sky.

It signals the time the winter is leaving and that summer is coming, and you can see Waiyungari in the sky with the two women flanking him on either side. Now, the people also talk about Waiyungari occasionally getting hotter and brighter in the sky before fading away again. This is very curious. When early anthropologists begin recording this information back in the 1800s, they didn't quite understand the astronomy behind what the elders were telling them. And they thought, oh, bright red star in the sky, well that must be the planet Mars. They didn't quite work out how this worked exactly, because it didn't make any sense. Mars is a planet. It wanders around the sky throughout the year, it's never going to be in the same position every year at every time. And also, the two wives didn't make any sense. Who are the two wives? Mars doesn't always have two stars sitting next to it. And some early anthropologists and astronomers thought it was two other planets coming together, but they're not. If you have the eyes of an astronomer like the Elders do, you can see very clearly exactly what these stars are. It's the star Antares, and the two stars on either side are Tau and Sigma Scorpii. These are the two women. They're in the celestial canoe, which is traced up by Scorpius, which is the same shape as Tagai's canoe in the sky. Now, what's interesting about this is, yes, this group of stars, Scorpius is very high in the sky just after sunset as we're coming out of winter and into spring. But what was missed by this was something really critically important that completely changed the history of science. That star is not Mars. It's Antares, which ironically means 'not Mars'. Antares is the Greek God of war, as Mars is the Roman God of war. They come very close together at certain times, and they're both bright. They're both red, they're both fighting as rivals in the sky. But as Wiradjuri astronomer Kirsten Banks pointed out, it almost literally means 'not Mars'.

Now, Antares is a variable star, which means it changes in brightness by a full magnitude over a period of about every four to four-and-a-half years, as the only little scientific diagram I'm going to show in the talk this evening. But this shows the brightness of entries changing over time. The brightness is looking at the the y axis up and down, the bottom axis is simply looking at time. If the star didn't change in brightness, it'd be a straight line, but it does change in brightness. This is something that was not recognized by Western Science until about 1840, right around the time that many of these traditions were being recorded by anthropologists. This shows us that Aboriginal people had already long known about the variability of stars, especially these really giant red stars like Antares. There's also traditions

from the Great Victoria Desert that talk about the variability of the bright red star, Betelgeuse in the sky as well. Now if Western astronomers had looked at these traditions and understood them from the scientific texts that they can be and not just dismissing them as myth and legend, they would have been able to figure out something that Aboriginal people have long known that would have led them to that discovery but they didn't. And it wasn't recognized until much later that Western science didn't discover this phenomenon that Aboriginal people had done this long ago. Now, when I first published this research a few years ago, there were a number of people who thought this was rubbish, didn't make any sense. How could Aboriginal people observe and notice something that Western science didn't figure out into the 1800s? It's not easy to observe the variability of a star over the course of several years. They thought it was completely made up. And we showed the research and what the Elders said. In fact, one Elder even described the tradition from the region of southern New South Wales that talks about Betelguese pulsating in the sky slowly.

But it didn't take long for the public to be able to see for themselves how this actually worked. Towards the end of 2019 Betelguese itself went through what was called 'the Great Dimming'. It started to drop in brightness quite significantly, going from, I believe the 11th brightest star in the sky to something like 23rd of 24th brightest star in the sky. It was very noticeable to the naked eye and that sent journalists around the world into a frenzy. You may have seen headlines in the news talking about 'Is Betelguese going to go supernova?' 'Is it going to explode?' Something crazy's happening here, What is it? By early 2020. Right about the time we started going into the pandemic, it had come back up to its normal brightness. But it was a great opportunity for everybody in the world to be able to see with their own eyes something Aboriginal people have long known, and that's some of these stars change in brightness. You can measure that brightness and understand what it means and incorporate that into your cultural traditions. Now, the last thing I want to talk about is something that I found very exciting learning from the Torres Strait Islander Elders as well as Aboriginal Elders across Australia. And that's about the shooting stars, these meteors, these fireballs and what they mean. In the Torres Strait, a bright shooting star or a fireball is called a Maier, and a Maier tells you that a person has just died or is just about to die. And the way it's described as a spirit takes that person's soul, their spirit to the top of the tallest palm tree and shoots across the sky like a rocket to beg the island of the dead. And we can see that as this Maier, this bright fireball streaking across the sky. It's trajectory tells you where that person's home is, if it fragments like you see in this image and lots of what are called sparks fall down, called 'uir uir'. That means this person left behind a large family. But you always listen for the doom, the booming sound that tells you that person has reached their destination.

A few years ago, I was working with the community and was contacted by the filmmaker Werner Herzog, who was doing a documentary called 'Fireball: Messengers from Darker Worlds'. It was all about this idea of meteorites and fireballs and culture and tradition all throughout history. And we filmed a segment of this in the Torres Strait, and it's about the Maier dance, the shooting star dance, which has to be done at sunset. And it was an amazing opportunity to see this film perform for the very first time. I hadn't seen the dance before. I just heard about it from the Elders, and we've got the film crew there. A number of

community members came together and four dancers stood there on the shore at sunset performing this dance. Now, what's so important about this dance, besides its cultural context, is a bit about its history. This dance has not been performed on the island since 1969. And when we arrived, the Elders explained to us that none of the dancers, none of the younger generation knew this dance. So they had to teach them how to do this dance there on the island, on camera. this is an important traditional 'kab kar' dance. It means an old sacred dance that is now being taught to the younger generations, and is being shared by the Elders with the world. It's important that we understand and that we recognize the value and importance of these ancient systems of knowledge and understand that if we're going to move forward as a society, if we're going to learn about our place in the world, we need to understand these ancient systems of knowledge and in fact, modern astrophysics is taking this cue. And we're now collaborating with Elders across Australia and around the world who are working with us on not just developing education programs, but on conducting modern astrophysical research. If you would like to learn more about this, I encourage you to pick up a copy of a book that we published called 'The First Astronomers; How Indigenous Elders Read the Stars'.

It was co-authored with six Elders, many of which I featured in this talk this evening. And 100% of all of the royalties go to charity. So please grab a copy, paperback e-book or an audio book that was narrated by Adam Sims. Thank you so much. What an absolutely fantastic lecturer as a lecture. As an astronomer myself, it's very humbling to realize that we are just part of this tapestry of scientists that stretched back so long into the past, and it was really wonderful to hear Duane explain that. I heartily recommend his book. It's extremely readable and fascinating from start to finish. So I believe Duane is going to be joining us tonight from Germany to answer your questions. But I'd also like to introduce to you the other member of our panel, Uncle Jimmy Smith. Uncle Jimmy is a Cultural Educator from the Erambie Mission outside Cowra. He's a Wiradjuri Koori with Gadigal bloodlines. He holds a degree in Adult Education and a Master's in Education in Indigenous studies. Uncle Jimmy teaches all the way from early childhood to university, the corporate sector and the community. His interests are in health and wellbeing and astronomy, education and the wellbeing of Australia. So welcome, Uncle Jimmy. Thank you very much. So okay. So Duane has explained to us a large amount of his work with the Torres Strait. Uncle Jimmy, would you like to tell us a little bit about astronomy on mainland Australia? Well, that's about most of what I know is about mainland Australia. Gosh, I call my astronomy practical astronomy, and it's how it affects us here on the ground and what it leads us into seasons and the tides and especially here in Sydney, we get them all the time. And I'm very lucky to be able to teach this to children in early childhood. And just as important, this is fulfilling the cultural paradigm of what we have done for thousands of years. We start with the children, albeit the spirits that govern Eora, Eora Countries have other ideas about where I should be and who I should be teaching.

And that takes me everywhere that you've just described from early childhood through primary. I try and avoid high schools, they're going through business that is beyond me. And something I don't necessarily want to go back to, but universities and the corporate sector and in community. And it's very, very fulfilling. I'm a very blessed blessed Koori to be able to

do this and to teach so many people. I love it like nothing else on this planet. So to keep it very practical, it's about the seasons and the best that I can teach the children is about the tides. And this morning I was lucky enough to go to work on Parramatta River with maybe two groups of children, second grade and fourth grade. And we went down and looked at Parramatta River from Breakfast Point in Wangal Country. So that was fantastic. And I was lucky enough to be able to do that every Monday morning for about five weeks in the big classroom and to take the children down to down to the river. They loved it. Who doesn't like to be outside? This Western paradigm is that it's all inside it's not all inside, it's all outside. It's where the air is clean. That's where people start to smile. Their heart and their lungs are being nourished by clean air. You get them inside and things change. They don't smile as much. And so it's a very, very healthy practice to go outside. And this is important. This is what Koori people have been doing for longer than I can think about. So it's a lot a lot of fun to be able to see people, take them out of the government departments, outside and they all start smiling. So it's a good indication of the health and wellbeing of the the knowledge base and epistemologies of First Nations People, especially here around Sydney and about the phases of the moon, and when to go fishing on the rivers. Any of these rivers that are within the Sydney Basin and especially on the Harbour as well. So it's taught and it's practiced and it rolls over just like our education system, just like the the planets roll over and continue to go around.

We are part of that cycle. We are part of nature. And it's such a big part of our world. And Duane was talking about how he couldn't figure out what wasn't so big in this country about our knowledge base of especially about astronomy. So it took an American to come here and open the eyes of so many people in this country. The delusions of white supremacy and that 'we are the ones', Uh, not the ones, you know? They don't know about land management and water management. These are big issues. And we're more than willing and happy to share these knowledges as well. What people need to do is have a humility to ask. And a lot of them don't. And it's kind of like when the the colony was on the verge of famine over here, they wouldn't ask the Koori's, 'Where do you get your food from?' And it's everywhere. And but one of the many things they did was overfished in the harbour and in Koori fishing grounds. So it didn't work the way that it should have worked. And just as important today, we can teach the world how to do it. We have a track record unparalleled on this planet and that's fantastic. And we share it. We're giving people we are not taking people. We are not colonial people. A big part of our world is altruistic. And that's where we help each other. We weren't a warlike people like Europeans when they went everywhere across the planet and destroying our knowledge systems However, as I said, I'm just lucky enough to be able to find myself in a place where I can share so much of our knowledge and our knowledge enriches the country and it nourishes those who whose minds are big enough and open enough and want to know the ways of First Nations People. We're all very grateful that this knowledge is finally being shared. So I believe that Duane is now here with us. And so I think it's time to open up the floor for any questions that anyone would like to ask.

I believe there's a microphone being passed around. If you could speak directly into that Hey, Duane, Why did Duane want us to see that dance at the end of the video? So why did I

want you to see that dance? Is that what you asked? I put that dance up because it was an important element of Islander Culture in the Torres Strait that talks about a kind of phenomenon that I'm very passionate about. That's why I'm here in Germany the moment I'm at the Centre for Apocalyptic and Post-Apocalyptic Studies. So looking at the role of meteorites and comets in history, linking to that sort of idea, but also that that dance in particular is one where you can see how knowledge is shared through dance and through song. But it's also a great opportunity to see how there are re-invigoration efforts to help teach the younger generations. When I say younger generations, I'm talking guys in their thirties, not necessarily just children, about dances that the Elders had been quite concerned about because the knowledge isn't being passed on. In places like Mer and other islands in the Torres Strait, the schools only, I mean, I think on Mer the school only has 50 or 60 children and only goes to year six. So when they reach year seven, they have to either go to Waibene or Thursday island or onto the mainland. And there aren't a lot of economic opportunities in the islands to come back. So a lot of people, when they leave, only come back to visit. Not many people come back to live. So because of that, the part of the larger corpus of knowledge and language isn't being passed down as much because the younger generations leave when they hit about 12, 13 years old and tend not to come back very often. So that particular dance hadn't been performed in 50 years, even though it was a very old traditional sacred dance there. So it was an exciting opportunity to show a part of that dance, that context and then and how the others were keen to share that with millions of people through these major documentaries.

Great. And any other questions? Yes. So I was wondering if you see the trajectory of the momentum of like respect for this, the First Nation astronomy to have any to basically be able to limit the amount of space pollution that is contributing to the light the light pollution and making it harder to see these stars that are the encyclopedias of these ancient knowledges. So there's there's quite a bit of work that we're doing in this space on light pollution and microsatellites and just the gradual erasure, the whitening of the sky, as we say. Because if everything on the land is encoded in the stars, then your ability to measure time and to understand the changing of seasons, the behavior of everything happening on the ground level, you have to have that anchor point, which is which is the stars. So if you can't see that, then you're going to have some serious problems and light pollution and microsatellites coming in and impacting that is a real concern. So we're looking at solutions on the ground level in terms of landscape architecture, engineering and design. How can we reduce light pollution? How can we help minimize it? And right now it's really getting bad because everybody is in love with LED lights. And yes, they are very low energy, but they produce a lot of light and they're emitting mostly the blue end of the spectrum, which is very bad, not only for our view of the stars, but for our own health and for the health of wildlife. And because they're so low energy when Councils are putting these lights in, they use more and more of them. So the problem is being exasperated and just minor changes like knowing what types of LED's to use. You can use amber LED's, that would help significantly. But also we're trying to help mitigate some of the situation with this enormous influx of microsatellites pouring into the space around us, and I feel like it's a bit of a losing

battle. There's not much we can really do except try to tell them, I don't know, put some kind of matte non-reflective paint on the satellites, try to do something.

I do feel it's a bit of a losing battle. So we're you know, we've had some lights in the sky for quite a long time anyway, but now it's becoming really, really bad. So, you know, we've published some research on this fairly recently, and it's an area that we're getting more and more into. But it is a really, really major concern. And is it a grievous encroachment on on traditional knowledges and our view of the stars, everyone in the world. If we can't see the stars, how can we connect to them? Absolutely. Uncle Jimmy, did you have anything to add to that? Yeah, well, our perception of of land and time and sky country is well, it is it is holistic. It is part of our world. And as I just said a bit earlier, it's about starting with the children and then we carry it right through. And it's part of a program that I'm lucky enough to have developed and to share with as many people around the Sydney Basin as possible. It sounds like a problem we should all be doing our bit to to address. Another question? Yes. You've managed to, I guess, map stories into our knowledge for things like Betelguese. Are there stories that haven't been mapped yet? That you don't have an explanation for yet? I feel that we've we've just scratched the surface in terms of this this work in this knowledge that I mean there's 300 plus different communities Language groups, each with numerous communities that are all going to have their own unique star knowledges. And I think over the last ten years, we can see examples of like myself and my research team and our you know, the students in our group, how our, how our perspective has been quite changed over the stuff. You know, when we initially saw some of these ideas about variable stars, we weren't even sure it was right. We were we're trying to be very rigorous about it, but there were initial hesitation on our part. And then we were looking through this and it was pretty obvious that was the case.

So I think there are ideas that even our group has in the past said, 'I'm not sure if that's right'. And now that's that's really changing. You know, the the idea that some of these knowledges can go back in time over 10,000 years. Initially, we were a little skeptical about that. But as I learned from the Elders about the nature of orality and memorisation and oral tradition and, you know, we see the way we learn about the memory techniques and the patterns that are used. We see geological and astronomical evidence converge together that show some of these traditions are 12- 13,000 years old, such as is the case for Tasmania. So there are going to be areas that we don't quite understand as much about. And that's just the ignorance of one part of myself and our group where we're coming and learning about new things we hadn't considered before. I hadn't considered that twinkling stars would be something beneficial. I knew they were caused by our atmosphere, but it didn't really occur to me that if you knew how to read the way the stars twinkle, you could learn about it as fair conditions. And Elders taught me that. And the research that we're doing on the moon cusps, the angle of those cusps, you know, that's for me, that's still kind of fairly new knowledge. When I go and I, I speak with colleagues around the world, I was just in Argentina last week for a Cultural Astronomy conference and there are a number of cultures around the world, from the Philippines to South Africa to Central America, who talk about the annual moon cusp being a really important factor in measuring annual rainfall. So to answer your question, there's a a lot more than we don't , don't know about this and

we're learning by working with the Elders. So, yes, what we may not know today we almost certainly will know tomorrow, but it's only it's only going to happen if we continue to work collaboratively with the Communities, with the Elders, Thanks for that.

Another question down front. Thanks for such a fabulous talk. You showed that beautiful fireball dance and how that is being reinvigorated in the community and told that fascinating story about the Torres Strait astronomy experts and the long apprenticeships that they'd take to learn the knowledge of the stars in the sky. I guess I'm wondering, does that practice still continue or is there some effort to try to retain that that detailed knowledge? It's a good question. I mean, we've got two different things happening. One is we've got a whole new generation of Aboriginal People who are earning degrees and in universities, in astronomy and astrophysics and building their profiles and careers. With respect of the Communities, Yes, it is still happening. Knowledge is still being passed down. I don't know in the case of the Zugubau Mabaig but those formal Ceremonies are still happening anymore. But one of the knowledge holders that I have been working with, he's only a few years older than I am, so that his father was trained as a Zugubau Mabaig. So, you know, obviously that's just one generation ago. So, you know, it was curious because I asked him about that and you know, it doesn't seem to be a common practice, but knowledge is still being passed down. And I've been on the island talking to, you know, seven or eight year old kids who have a pretty detailed knowledge of astronomy, many cases beyond the undergrad physics students that I teach Oh, sorry. I've got the microphone, that's ok. Maybe this is for Uncle Jimmy, I know Duane touched upon it in the lecture, but the Southern Cross is probably one of the most recognisable constellations on mainland Australia and in the Southern Hemisphere. How did mainland Australian mobs use the Southern Cross compared to maybe those up in the Torres Strait? about the Southern Cross. One of them is over there in South Aussie, Peoples. And another one is, is back over here on the East Coast. The one that I know about over there is about a shark pursuing a stingray in the ocean and that is how it's perceived in the night sky as well.

So I don't really know a lot about the the Southern Cross apart from that, and that is another story here on the East Coast about it. So, yeah, but just on what Duane was talking about, his undergrad students, the children I teach in early childhood, They know more about the land and connection to Country and about astronomy than their teachers and especially about the teachers who they're going to move into in primary school. And they're probably carrying a lot of that knowledge, well and truly into high school as well. So they are awesome. They're fantastic, and they are so smart. You can't help but love them. But this is a big part of the teaching process to have awesome relationships with their teachers. And research is out there now, that children learn much better when they have a good relationship with their teachers, which is something that I never have had. Indeed. Another question up the back. I know that what's been presented here this evening is about Australian and the Australian circumstance and First Nations peoples and their connection with astronomy. And through your studies though, have you found that there are common threads between First Nations peoples around the world and how they connect? Are there any similar stories? Are they all completely different or their connections to the sky, are different or similar? We've found that there are incredible similarities all around the world.

That work on twinkling stars, I published a paper with with a colleague who works in Alaska with Northern and Inuit communities, and they all used the twinkling stars in the same way. It's a different climate, different environment. But the foundational principles about what causes the stars to twinkle and change their visible properties is the same. So they they utilize that. The Great Emu in the sky that we see here across Australia and South America is seen as rhea in the sky.

And a rhea is a large, flightless bird, just like an emu, and its behavior patterns are very similar. So a lot of the traditions about how it got into the sky might be a bit different, but the underlying explanation of its position in the sky and what that tells you about the behaviour, are very similar. You know, like I said, the moon cusps angles are found all around the world. They're remarkable similarities, because if we look at the science that underlies all of this knowledge, the science works the same no matter where you are. Its application might be slightly different depending on the climate or the geography of the area, but the underlying foundations are the same. And in addition to that, we've been noticing people have been noticing for a long time that even the patterns of constellations are remarkably similar between cultures separated by space and time. Why is that? Why is Orion almost always seen as a man or group of men? Why are the Pleiades almost always seen as a group of women, one pursuing the other, Gemini are seen as twins. You can go across a number of different constellations and see extreme similarities in how they're put together. And at the University of Melbourne, we've got a whole team that's collaborating between myself and physics and a group of psychologists in the Melbourne School of Psychology. We've even got a graduate student who's doing her thesis, , on trying to explain this using perception and gestalt principles. And what we've realized through that study is that it's our perception of the way that we grouped things together to make patterns and we're actually running experiments in the planetarium where we can simulate the night sky, a different view of the night sky, not the one that we are used to seeing here. But simulate a whole different view of the night sky, let's say, from a distant planet or something, and then how people try to come up with their own kinds of constellations and see how those play together.

So there's actually a lot of interesting cutting edge research happening on answering that exact question. Hi, everyone. And thank you Duane for that lecture. It was wonderful. My question similar to the threat of space junk, is on climate change. And we know that sea levels are rising in landscapes are changing quite dramatically. How will that change or what threat does that pose to how Elders see the land reflected in the sky at the moment and how generations will read it based on landmarks in the future? Uncle Jimmy, do you want to start with that one? Well, I when the when the tides are getting bigger and with climate change, I'm thinking the moon is going to really kick these things in the air. And it does already. It always has with King Tides. So, again, knowledge of the phases of the moon, big, big tides on the new moon and even bigger on the full moon. And Duane was saying about when the the dark of the moon is over three days, the full of the moon is over three days as well. So that's when it's it's most intense and the tides are quite big. So it's an awareness and a connectivity to the land and to the oceans and to the moon as well. And it expands bigger from there and into more star stories. Which I'll be happy to share a couple of those

star stories with you. Thanks, Uncle. I find that up here that's in the Torres Strait, that's a real major problem. And then funnily enough, like I said, that's the reason I'm here in Heidelberg. We're looking at the apocalypse from above. What types of astronomic phenomena can cause the apocalypse? You know, we can look at solar flares and gamma rays, we can look at meteorite impacts, but we're causing it ourselves. The most prominent effect of climate change that relates to astronomy is exactly which you mentioned Uncle Jimmy, and that's the King Tides. So early January every year, the Earth reaches its closest point to the sun, its perihelion, and that caused the tides to be bigger than normal.

And if we get it, like you said, a new full moon during that time we get these super massive King Tides and the Torres Strait, there are islands that are almost getting complete and totally flooded right now because of that. And you look at places like Saibai, I think Saibai the highest point on the island is only one and a half meters above sea level. That's an enormous island. The entire thing will go underwater. So our destruction of the environment, the melting of the icecaps that are causing these sea levels to rise, it's not just about the average sea level. It's about those king tides and those high tides that are just going to gradually just be eroding and flooding away the coastlines and the Pacific and other parts of the world that are very low level, very low elevation that's destructive beyond any comprehension. You see in an entire island almost disappear during a King Tide, that really puts things in perspective. So we can spend time worrying about solar flares, meteorite impacts and supernova bursts, but we're causing our own apocalypse right now. Are there any more questions? I've got a question, I'd be very excited about some of these star knowledges from Uncle Jimmy. This is for Uncle Jimmy, I was wondering what the lifelong impact is with that you've seen with past students in these the cultural teachings and how sorry and how and what lessons can't be taught without those cultural teachings? Well I try and teach as much as I can. As I said a bit earlier, we are giving people where we're not Colonials, we're not taking, we give. And it's not only here in this country, it's right across the Pacific as well. The bulk of First Nations People in this corner of the world are giving people, we're not materialistic and these are greed and selfishness was not a part of our world. These some of these intangible diseases that came here with the Colonials. So yeah, and I try and teach as much as possible. So people get the reality of the Culture of the land that they live in and come to bring about change and to do it through education.

And Nelson Mandela said it is the most potent weapon that we can utilise is education, and he was a lawyer. So yeah, he knew. Can I please come back to the dancing episode in that film and ask what can viewers learn about fireballs from that dance? The main point I wanted to get across with that is to learn how every component of something observable in the sky every property of a celestial object has importance. It has meaning. So in the Torres Strait, you know, the colour of the fireball, the trajectory, does it break apart, the sound it makes, all those things have relevance and significance. So that's the main point I'm trying to convey there. What we do realise when we're looking at these studies of meteorites and meteoritic events is a little bit more about their history. So we've you know, when we're trying to look at, for example, the influx of meteorites over time, what is that rate? You know, how how often are meteorites coming into the atmosphere, different sizes? How destructive can these events be? What do we need to learn about them? The study of

meteoritics is relatively young in the grand scheme of the sciences, and by learning from the communities about meteors, fireballs, meteorite impacts, airburst, craters, all these types of things we can help scientifically, at least on that aspect of it. We can also help learn more about the influx rate and for, you know, to give a final example for this, the Henbury Meteorite Crater is in the central desert, about 120 kilometers south of Alice Springs. It's a crater field of about 16 impact craters spread out over a square kilometer and geological testing back in the 60's to 70's showed they were around four, four and a half thousand years old. But Aboriginal people have been passing knowledge about that down into the 1930's before was even confirmed to be a meteorite crater field, that it was were a fire had run down from the sky and set the land on fire and created all these large holes for people disobeying traditional Law.

So it showed that the oral traditions were passed on for about 4000 years. Well if we go over to Western Australia to Wolf Creek Crater or Kandimalal as the Djaru people call it, there were a number of traditions that seem to describe it in quite different ways. Some of them talked about how it was where a star fell from the sky, shook the land, caused massive destruction. But the famous geologist, Eugene Shoemaker, who when he studied that and found that it was somewhere between 30 and 300,000 years, he didn't he didn't get a chance to do a real detailed study of that. And unfortunately he died out in the Tanami Desert, driving on the road Because he was American, he was used to driving on the right side of the road and he came around a corner car was coming in the opposite direction. His instinct was to pull off the right side of the road, which in the U.S. would save you. In Australia, he pulled into oncoming traffic, and he was killed. His wife, Carolyn Shoemaker, went on to become a very famous comet hunter who only just passed away about a year or two ago. But a team of geologists and scientists at the University of Wollongong and other universities prompted in part not wholly, but in part by these traditions of Kandimalal, of Wolfe Creek Crater, wanted to go and more accurately date the structure and found that it's less than half the age they initially thought it was. That's probably on the order of 120,000 years old. So these traditions are having an impact and influence on on guiding modern, modern scientific research as well as us trying to understand these ancient systems of knowledge. That's the way these to these two ways of knowing are really helping each other out to learn new things.

References

Australian Government (2015) Benefits of social media, [online] http://www.business.gov.au/business-topics/business-planning/socialmedia/Pages/benefits-of-social-media.asp x, (13.11.2015).

Bernanke, B. S., n.d. The Great Moderation. [Online].

Bhattacharya, B., & Mukherjee, J. (2006), The nature of the causal relationship between stock market and macroeconomic aggregates in India: An empirical analysis, In 4th Annual Conference on Money and Finance, Mumbai.

Bodie, Z. (1976), "Common stocks as a hedge against inflation", The Journal of Finance,Vol. 31, No. 2, pp. 459- 470.

Brander, J. A. (1991). Election Polls, Free Trade, and the Stock Market: Evidence from the 1988 Canadian General Election. The Canadian Journal of Economics, 24(4), 827. doi: 10.2307/135695.

Castro, V., 2011. Can central banks' monetary policy be described by a linear (augmented) Taylor rule or by a nonlinear rule?. Journal of Financial Stability, pp. 228-246.

Chang H, Dong X, MacPhail F. Labor migration and time use patterns of the left-behind children and elderly in rural China. World Development, 2011.

Chen, N. F., Roll, R., & Ross, S. A. (1986), Economic forces and the stock market, Journal of business, Vol. 59, No. 3, pp. 383-403.

Chen, N., R. Roll and S. Ross. 1986. Economic forces and the stockmarket. Journal of Business.

Ciner, C. (2001), "On the long run relationship between gold and silver prices A note", Global Finance Journal, Vol. 12, No. 2, pp. 299-303.

Fisher, I. (1930), "The Theory of Interest". (MacMillan).

Impact of Covid-19 on Indian Economy. Times of India Blog. July 11, 2021. Accessed December 16, 2021. .

Johansen, S (1995). Likelihood-Based Inference in Cointegrated Vector Autoregressive Models (NewYork: Oxford University Press).

Johansen, S. and Juselius, C. (1990). Maximum Likelihood Estimation and Inference on Cointegration-With Applications to the Demand for Money. Oxford Bulletin of Economics and Statistics, 52(2), 169-210.

Kumari, J. & Mahakud, J. (2015), Relationship between Conditional Volatility of Domestic Macroeconomic Factors and Conditional Stock Market Volatility: Some Further Evidence from India, Asia-Pacific Financial Markets, 22(1), 87-111.

Mielach D. (2012) 10 Email Marketing Tips, „Business New Daily", 11 June 2012, [online] http://www.businessnewsdaily.com/2668-email-marketing-tips.html , (20.11.2015).

Murray, C. J., NIikoloso-Rzhevskyy, A. & Papell, D. H., 2015. Markov Switching and the Taylor Principle. Macroeconomic Dynamics, pp. 913-930.

Nguyen, T., 2011. US macroeconomic news spillover effects on Vietnamese stock market. The Journal of Risk Finance, 12(5), pp.389-399.

Osterwald-Lenum, M. (1992). A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics. Oxford Bulletin of Economics & Statistics, pp. 461–472. .

Parreñas, R. S. Children of global migration: Transnational families and gendered woes. Standford, 2005.

Parsons, T. The Social System. New York: Routledge & Kagan Paul, 1951.

Savita, & Ramesh, A. (2015). Return Volatility Around National Elections: Evidence from India. Procedia - Social and Behavioral Sciences, 189, 163–168. doi: 10.1016/j.sbspro.2015.03.210.

Shaw, E. S. (1973), "Financial deepening in economic development", Vol. 270. New York: Oxford University Press.