Application of a Global Reference Frame in Tuvalu

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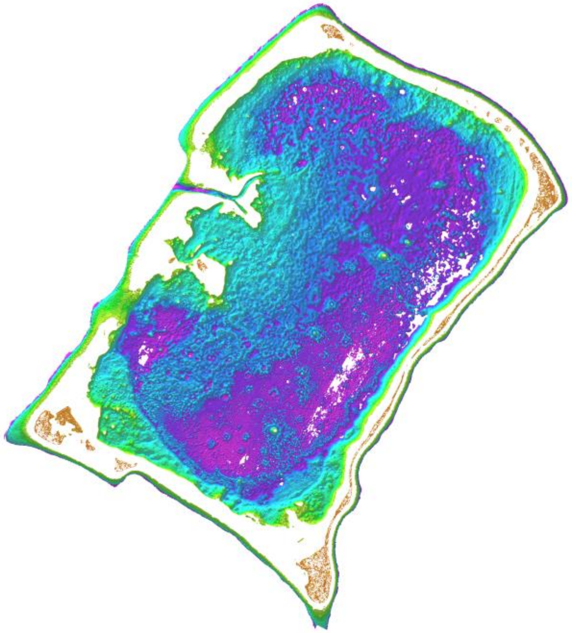
Outline

- GNSS in brief
- Geodetic Survey Campaign 2016- 18
- Benefits of GNSS
- PGSC
- Challenges
- Conclusion



History: Global Reference Frame - Tuvalu

- late 90s: handheld gps; In- shore and near- shore fishing, navigation

- 2000: CGPS TUVA CORS station; Pacific Sea Level & Climate Monitoring Programme (PSLM) - Relative to Absolute Sea Level (Astech Precision - Static and Kinematic Mode; Topo & GIS)

- 2003: GPS Campaign for Development of Maritime Boundary Baselines; Charts & Maps geo- referenced on WGS84 (AUSPOS, MARZONE Software)

- 2005: Maritime Boundary Zones Developed on WGS84; 12nm TW, 24nm CZ, Median Lines, 200nm EEZ

- 2012: Maritime Zones Act 2012; WGS84 (Treaty signed with Kiribati)

- 2013- 15: Cadastral Maps scanned & digitised on Local Grid
  - aerial photos (1940s & 1980s) scanned, geo- referenced on WGS84
  - satellite images acquired (Quickbird, WorldView..)
  - export, geolink of vector/ raster data to Google earth

- **2015: UN GGIM Roadmap; UN General Assembly Resolution** "A Global Geodetic Reference Frame for Sustainable Development"

  - Archipelagic baselines developed; Revised legislation - declarations of the Outer Limits of Continental Shelf and Maritime Boundary Zones - UNCLOS (partial deposit to DOALOS)
 - Maritime Boundary Treaties signed with Fiji & France
 - Tuvalu Land Information System (TUVLIS) - Local Grid & WGS84

- **2016 - 2018: Tuvalu Geodetic Survey Project; GNSS Survey of all the islands in Tuvalu**

- **May - June 2019: Lidar Survey of Tuvalu islands by Fugro (GNSS survey conducted on Funafuti for callibration of Lidar data)**

- 2015 UN-GGIM Roadmap: Migration of TUVLIS from Local Grid to ITRF2014

Note: Cadastral coordinates need to be in both grid - GNSS coordinates changes over time; Local Grid does not change



Geodetic Survey Project : 2016- 2018

KfW TC-PAM recovery Project overview (SPC, TUvalu, UKHO, GA)

- Purchase of Survey Drone and software
- Knowledge transfer: drone operation
- Knowledge transfer: drone survey operation for topography mapping
- Collection of historical Inundation event data in outer island
- Purchase High end computer for Drone imagery processing
- Purchase of GNSS system
- Knowledge transfer: GNSS survey
- Knowledge transfer: Hazard and impact survey

cont...

- Planning of Survey Campaign (Protocols, Equipment, Survey Teams and Transportations)
- Reconnaissance Survey of all islands and atolls
- GNSS Geodetic Surveys
- GNSS Topographical Surveys
- Installation of Tide Gauges
- UAV Surveys
- GNSS survey data processing & analysis
- GNSS Surveys - Reporting

Tuvalu Geodetic Survey Campaign Activities: 2016- 2018

1. Reconnaissance Survey

a. Recovery of old survey marks

b. Establishment of new survey marks as per Geodetic Survey Control Network

2. Static Geodetic Control Surveys (GNSS) @ 1 sec epoch for six-hour occupations; primary base station be occupied for more than four days

3. Installation of Gauges (water pressure sensor and barometric pressure sensor) at appropriate locations in the channel and on the ground respectively (Sensor data logging @ 10 sec epoch

4. Pole to Gauge calibration (PPK GNSS @ 1 sec epoch; Occupation time – 25hours)

5. Cadastral Boundary Surveys (PPK GNSS @ 1 sec epoch; Occupation time - 30mins)

6. Post Processing Kinematic GNSS Surveys of Islands (topography) - (PPK GNSS@ 5 sec epoch; Fixed Time); using vehicle drive around the island

7. Survey Transects across the islands (PPK GNSS); carry out survey in x-y direction; Base @ 1 sec epoch and Rover @ 15 sec occupation time per feature

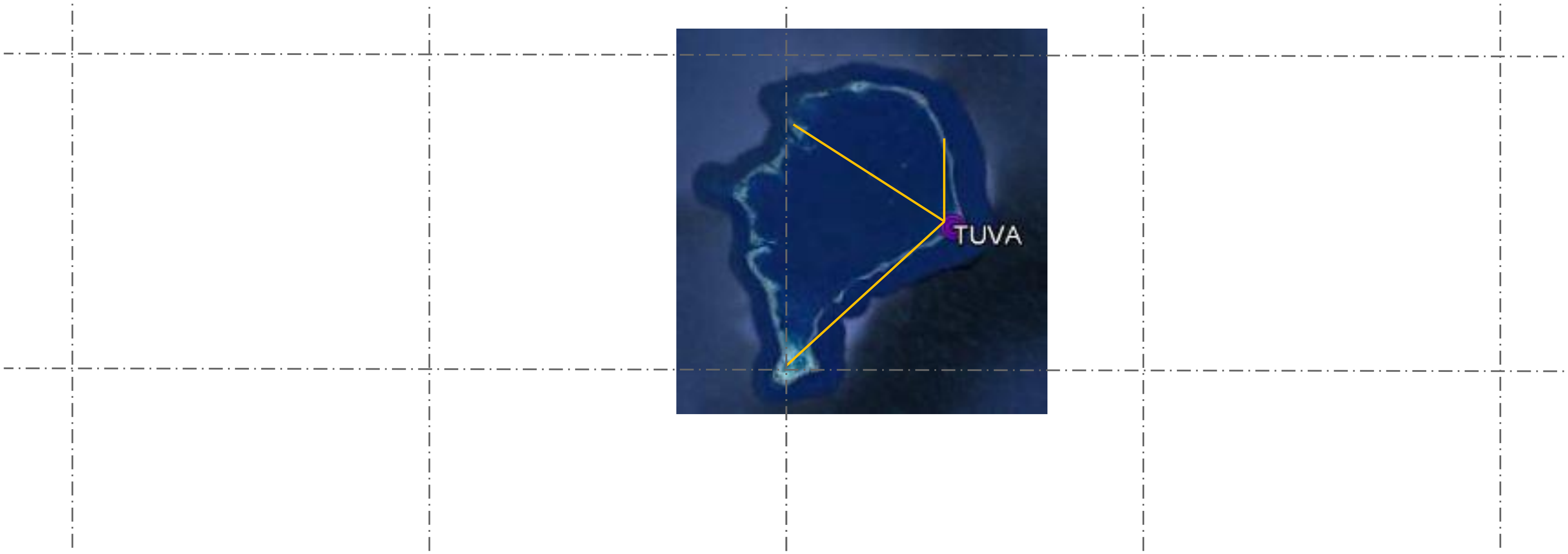
8. UAV Ground Control Points Survey (GNSS) – well spread as per UAV survey site; minimum of 1 hour observation per station for GCP; these GCP can be part of the geodetic control network which are well established marks that can be used in future for other surveys.

9. UAV (Drone) Topography Surveys – Main community areas

10. Coastal Inundation Community Survey (mark on satellite images of highly inundated areas)

Benefits of GNSS CORS to local Surveying

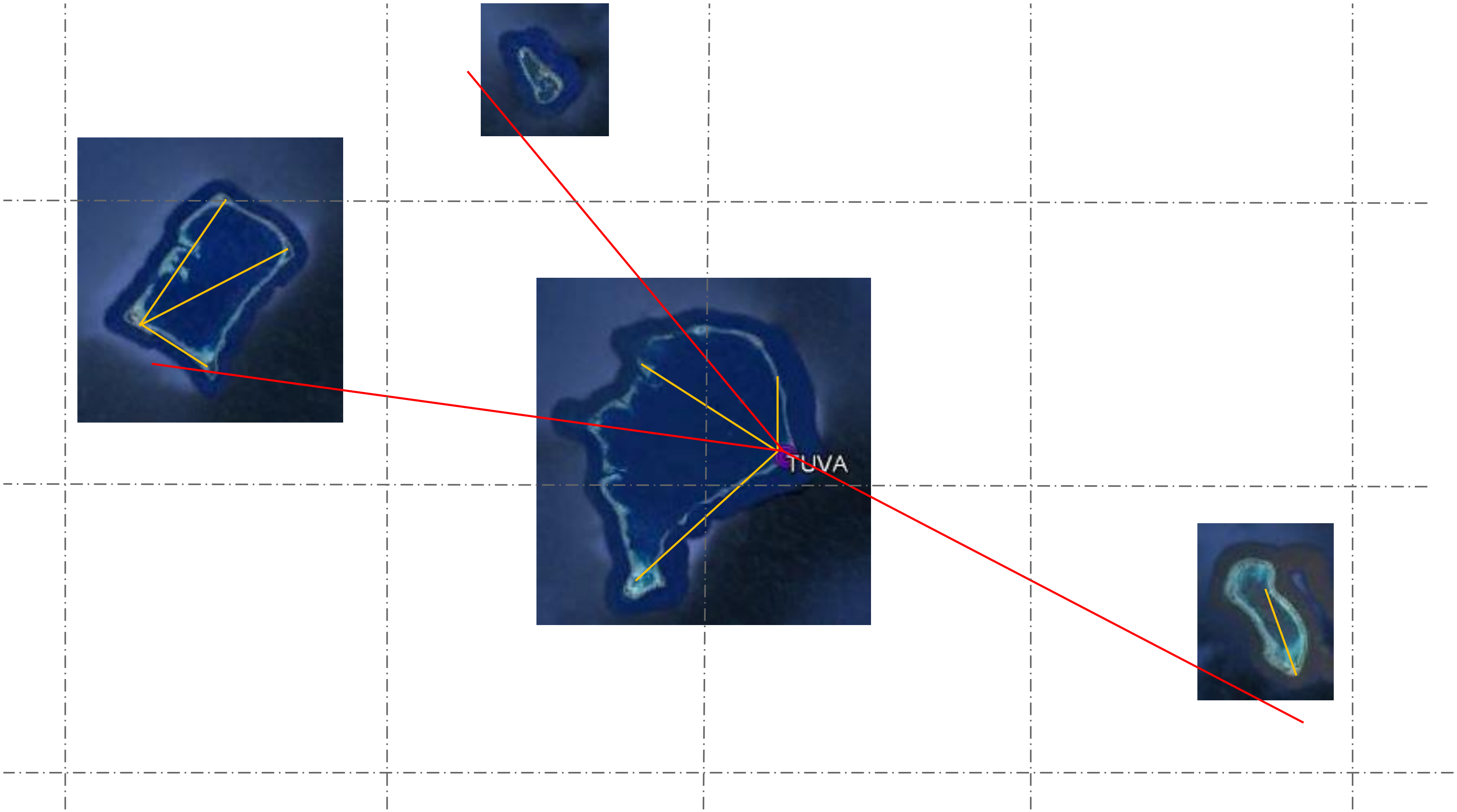
- A local GNSS CORS site can provide the opportunity to preform accurate baseline measurements when the user only has 1 geodetic quality GNSS receiver available.



Having observations from a permanent reference station available will allow local Lands & Survey departments to update their current network of survey control from a Local coordinate system onto the International Terrestrial Reference Frame [currently ITRF2008]. (Geoscience Australia)

•2 GNSS CORS on Funafuti (PSLM)

cont...Benefits of GNSS CORS



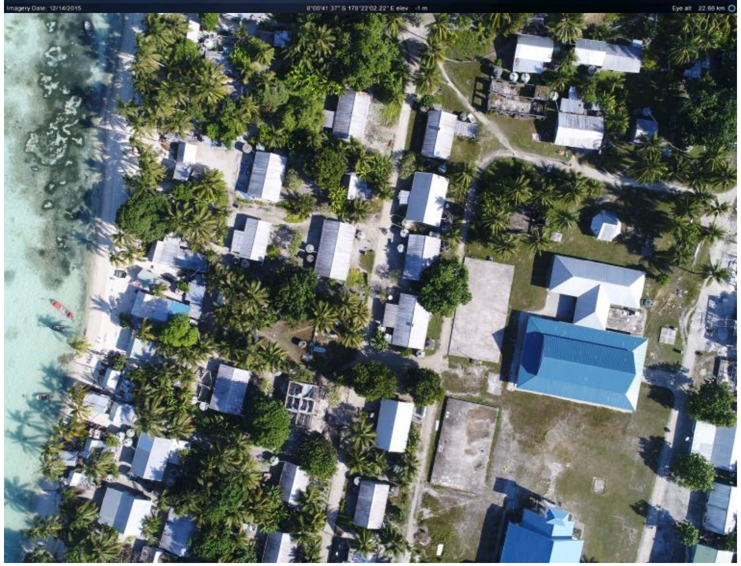
The distance & azimuth between parts of the country that may once have been known to only a low accuracy, can now be measured to the mm (Geoscience Australia)

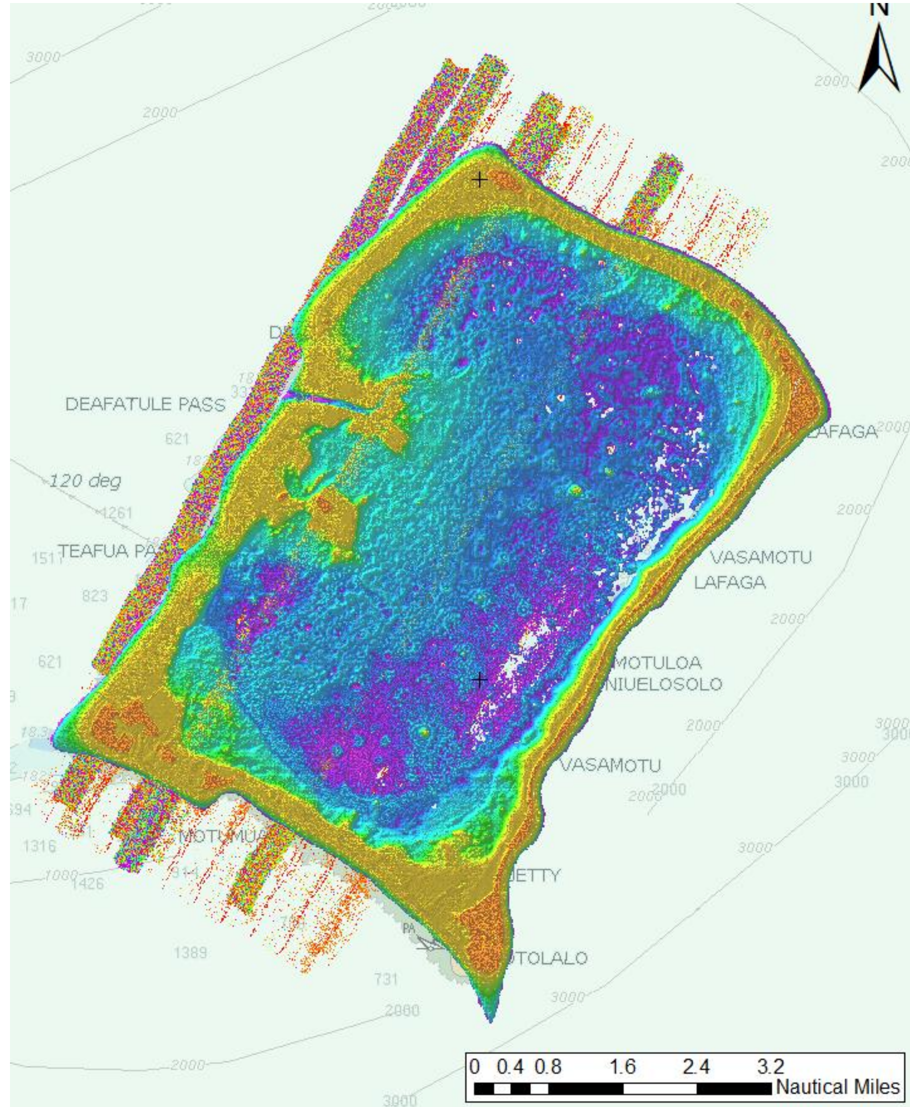
Local & Regional Benefits:

- **Strong local coordinated network is necessary for infrastructure and asset management.**
- **Provide a common reference between local data sets (sea floor mapping, land surveys, aerial photography) & allowing various GIS applications**
- **Integration of data sets across the region (fisheries, maritime boundaries, large scale environmental monitoring, disaster management)**

- **Tuvalu Maritime Boundary Delimitation - signing treaties with Kiribati, Fiji, France. Deposit of data to UN- DOALOS (UNCLOS)**
- **Tuvalu Joint Extended Continental Shelf (ECS) Claim with France & New Zealand**
- **Monitoring the Impacts of Climate Change & Sea Level Rise**
- **Surveying & Geospatial Data mapped on a Global Reference Frame (ITRF2014)**

Google Earth, UAV, Satellite image and Lidar Data





AUSPOS Online Processing

3.2 Geodetic, GRS80 Ellipsoid, ITRF2008

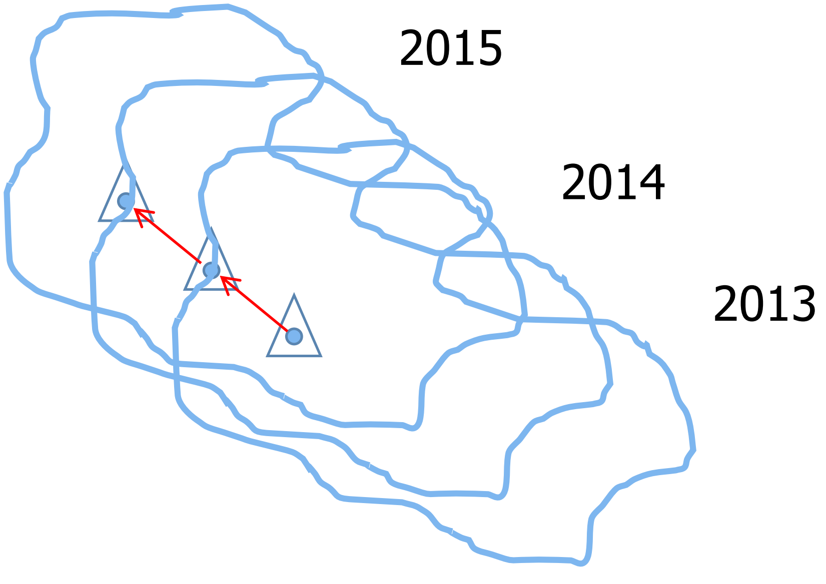
Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
4243	-8 31 28.47451	179 11 43.67802	36.939	2.088
TUVA	-8 31 31.03847	179 11 47.59823	38.328	3.489
AUCK	-36 36 10.22215	174 50 03.79032	132.679	97.746
HNLC	21 18 11.84779	-157 51 52.38359	21.962	6.217
KIRI	1 21 16.50350	172 55 22.40610	36.153	4.842
KOKB	22 07 34.55634	-159 39 53.76032	1167.364	1150.340
KOUC	-20 33 31.28150	164 17 14.41766	84.141	23.694
LAUT	-17 36 31.72016	177 26 47.69375	89.658	31.698
MAUI	20 42 23.96647	-156 15 25.30610	3062.095	3044.157
NAUR	0 33 06.22231	166 55 31.96294	46.241	6.066
NIUM	-19 04 35.49042	-169 55 37.45398	89.686	59.067
PTVL	-17 44 57.95719	168 18 54.08502	86.470	22.652
SAMO	-13 50 57.14628	-171 44 18.33220	76.775	39.534
TOW2	-19 16 09.39143	147 03 20.48596	88.096	30.161

AUSPOS – Online Processing

- Don’t forget the EPOCH of the coordinate is at the time of observation!

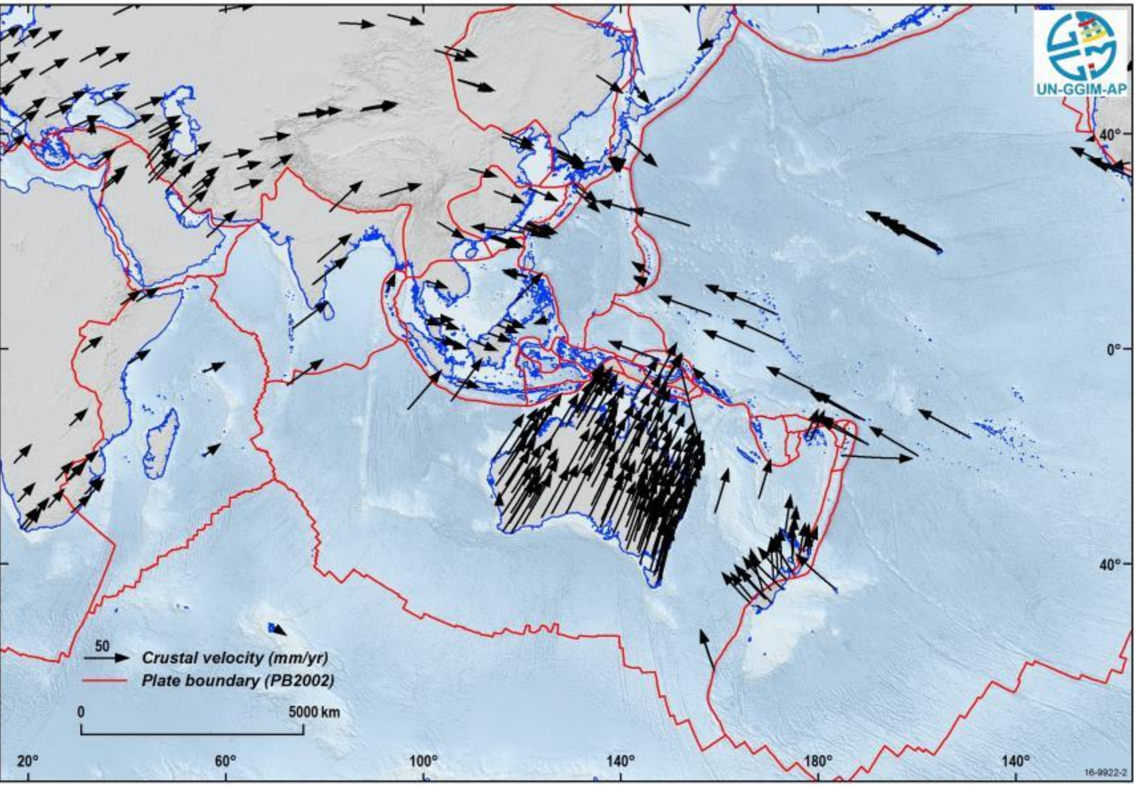
- Coordinates will change over time

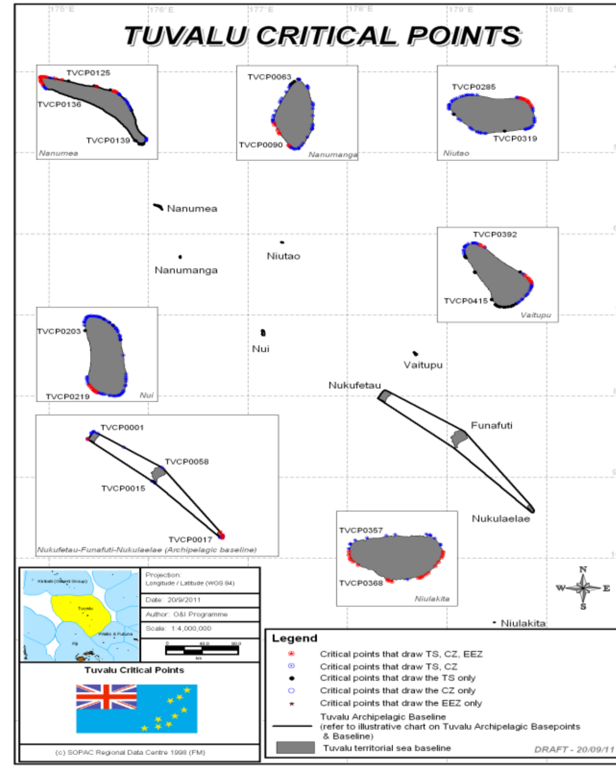


- Use known vector to convert to a previous timeset

Global Geodetic Monitoring of Crustal Velocities : Understanding Local Impacts of Sea Level Rise & Climate Change through GNSS

Crustal velocities of Asia and the Pacific





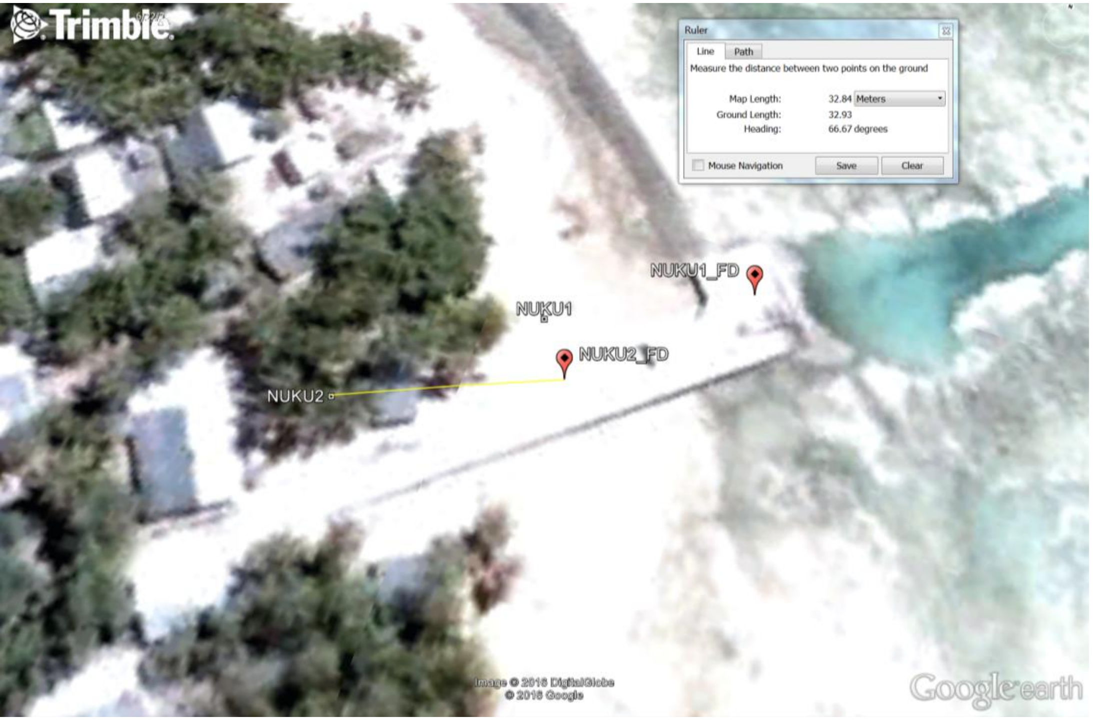
- Mapping Tuvalu Baselines in GGRF to define present, and future sovereign rights
- Maritime boundary delimitation, Extended continental shelf (ECS) claim on global reference frame WGS84 (comply with UNCLOS and signed treaties with 3 states)

GNSS Survey 2016



- Maintenance of existing Survey Control BMs
- Establish one GNSS Primary Control on each island – 4 days observation; used as base for survey
- Training & technology transfer to local staff on GNSS by SPC experts

Photo Control GNSS Survey



- Google Map positional error – 32 metres
- RTK GNSS Surveys – Reference Image Points

Cadastral Survey using GNSS

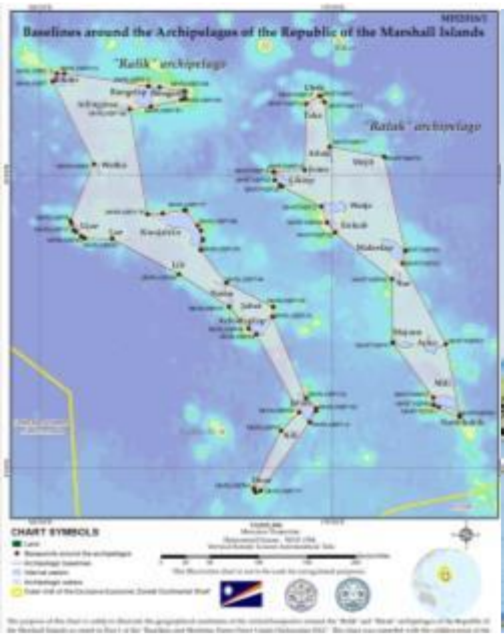
- RTK GNSS Surveys – Boundary Definition
- Shift of Local Grid (digitized cadastre vs GNSS

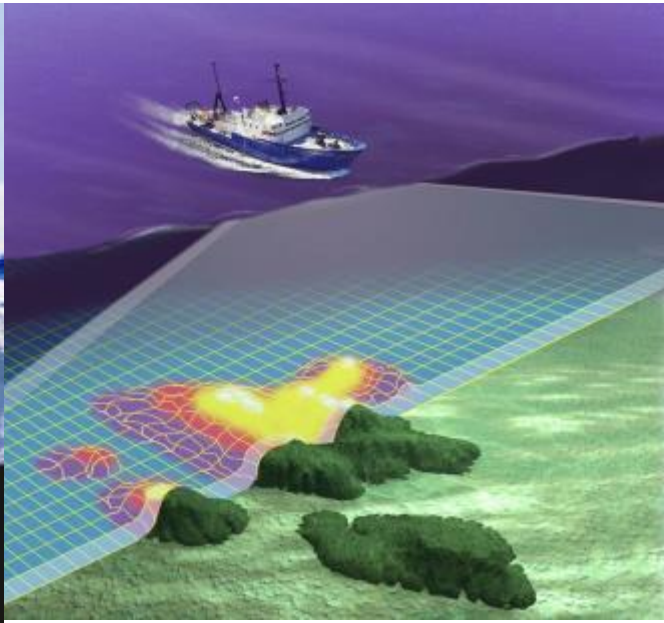
Tide Monitoring – defining & finalizing vertical datum in outer islands

- Tide watch to establish LAT,HAT and MSL
- Installation of RBR to monitor local sea level – 6 months
- Re- visit Tidal Survey with SPC in July (next month)

PGSC Vision

Sustainable development in the Pacific enabled by world class geospatial information and surveying services





PGSC Strategy Goals

1. Leadership and Visibility

- The PGSC enables regional leadership, guidance and support for members to engage stakeholders and the community on geospatial and surveying activities

2. Standards and Technology

- Countries across the region adopt a modern Geodetic Reference Frame (GRF) and improved technology underpinning geospatial systems and applications

3. Sustainability

- Geospatial and surveying activities at the national and regional level are supported by a diverse and sustainable resource base.

4. Capacity Building

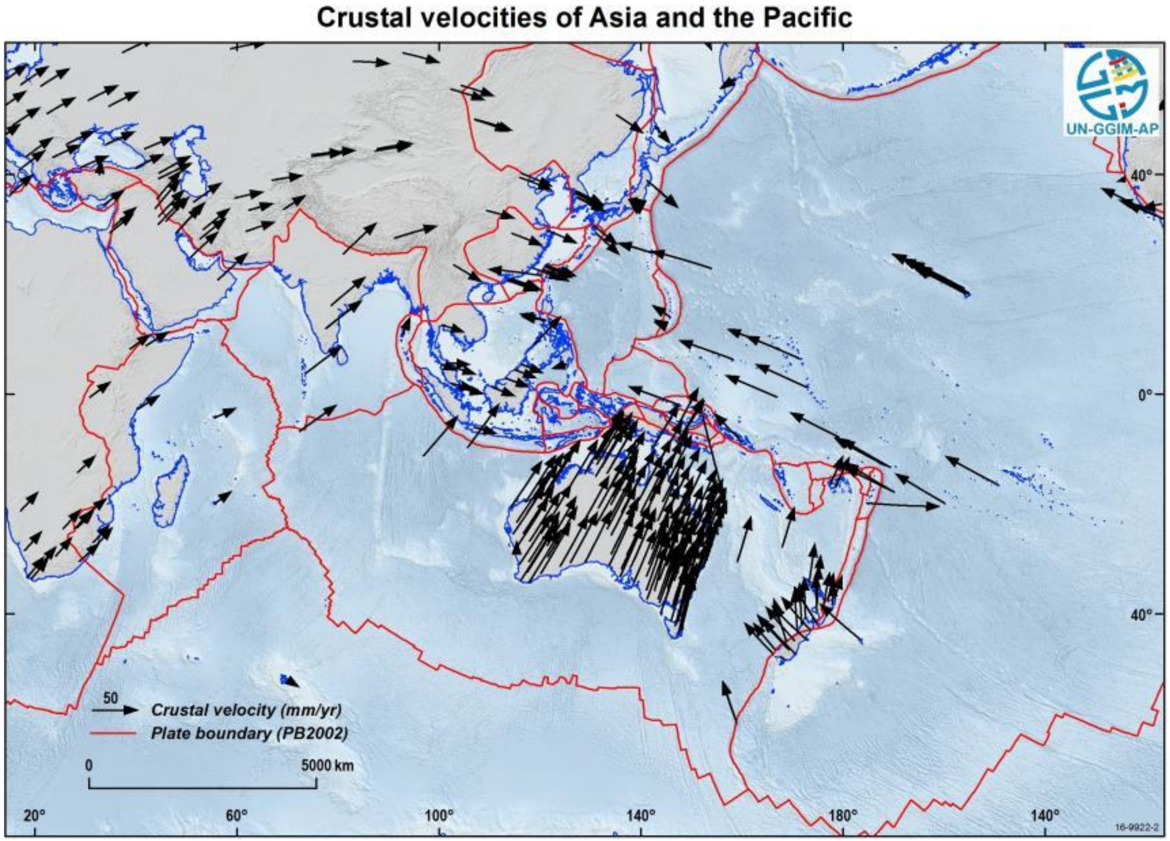
- The geospatial and surveying community is self-reliant with a culture supportive of learning innovation and gender equity.

Challenges

- Small steps taken to meet PGSC Stragety Goals
- Projects are subject to donor funding
- Fit for purpose aproach - need support on standards & specs on surveying & geospatial development
- Need support on TUVLIS upgrade to maximize outputs for planning and decision making - under development

Acknowledge support: PGSC Partnership Desk SPC, Geoscience Australia, UKHO, Tuvalu Govt

Conclusion



- Understanding crustal velocity in horizontal, and vertical plane - near real time to real time positioning, short to long- term planning for sustainable environment economic, social benefits of country and population
- Understanding Absolute Sea Level in the islands - GNSS CORS

Thank You