TrigNet:
The South African Network of Continuously Operating GNSS Base Stations

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ESESA User Need Workshop

Thread 2: Status of Current GNSS Applications in South Africa

Somerset West

2 March 2011

Overview

- General Considerations
- TrigNet Architecture
- Post Processing and Real Time Services
- Methods of Delivery
- Co-ordinate System
- Current Status
- Non-positioning Applications
- Future
- Conclusion

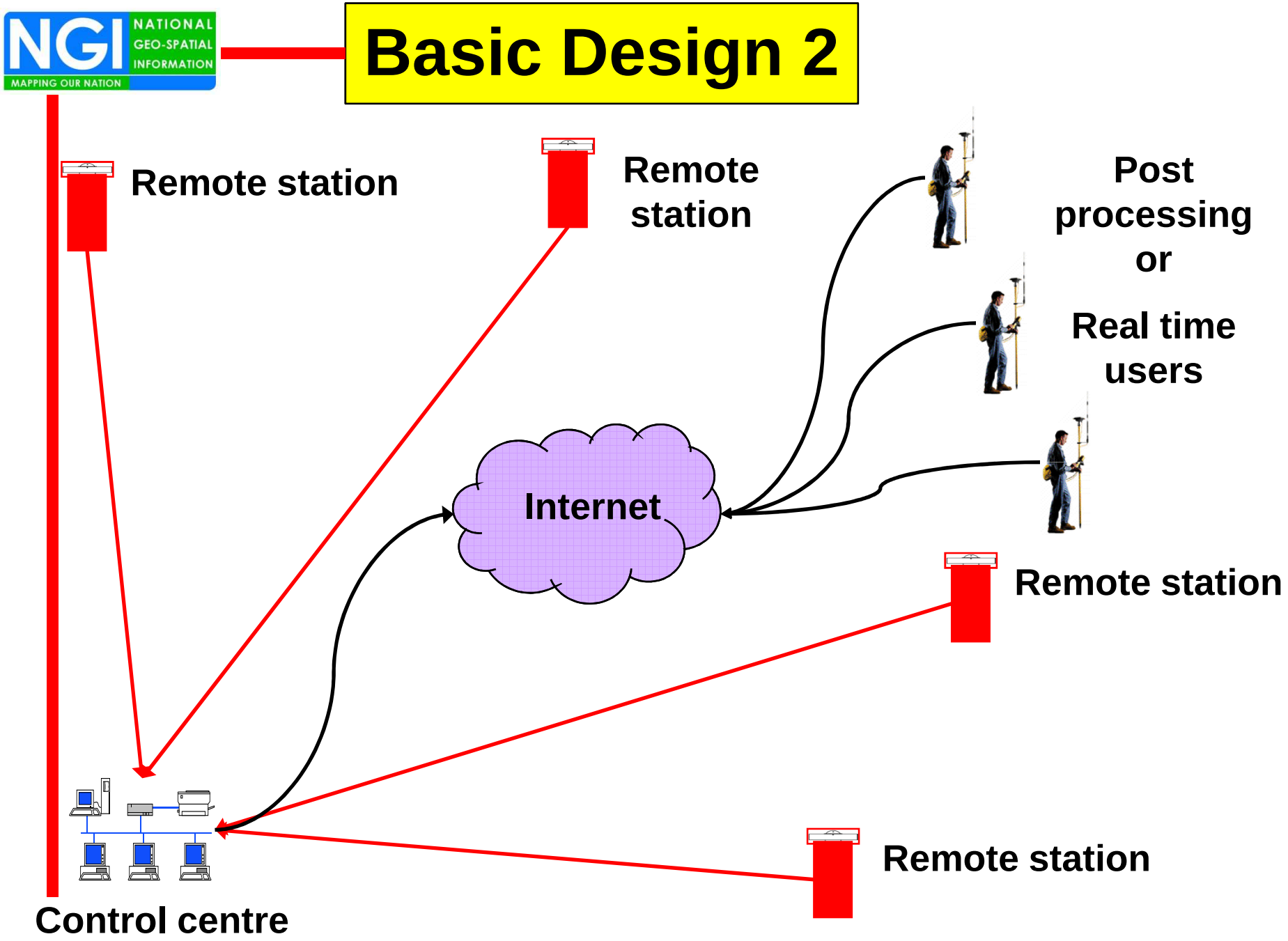
General Considerations

- System must be receiver independent - RINEX, RTCM
- System must be reliable through integrity monitoring and redundancy
- Post processing data must be as fresh as possible
- Real time services must be available as close to 24/7 as possible
- Cost of services must not be excessive to user
- System must be expandable and flexible
- System must meet the accuracy demands placed on it

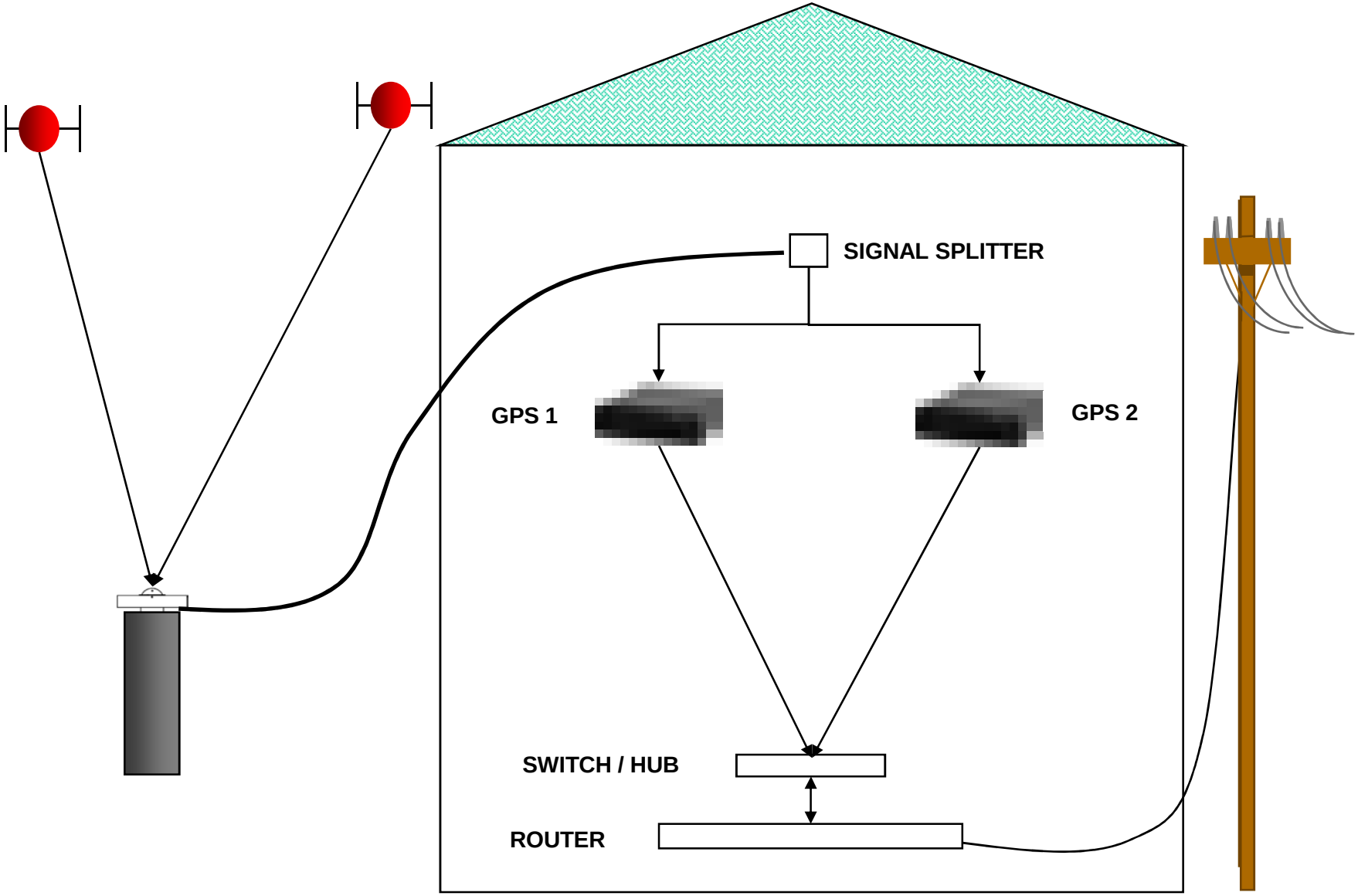
Basic Design 1

- One control station at Mowbray
- Redundancy built into network
- Provide a range of post-processing services and products and real time services
- Have 58 stations in full operation and in process of expanding (February 2011)
- Stations between 40 km and 300 km apart

Basic Design 2



Remote Station Layout



Post Processing Products 1

- **Data available in Receiver Independent Exchange format (RINEX V2.11 which includes L2C & L5 and other features).**
- **Hourly data from all stations available approximately 30 minutes after each hour of observation. - *Unchecked***
- **24 hour data available on following day from all stations. *Checked***
- **Data is available via internet (ftp) , e-mail, CD, DVD etc.**
- **Achievable accuracy could be 0.05 m or better depending on users receiver and antenna type, location, processing software, etc**

Post Processing Products 2

Standard RINEX products

- **1 hour 1 second L1, L2 data**
- **24 hour 5 second L1 data**
- **24 hour 1 second L1,L2 data**
- **24 hour 30 second L1,L2 data**

Customized RINEX products

- **Wide range of options available through “RINEX Shop” on web page**

Real Time Services

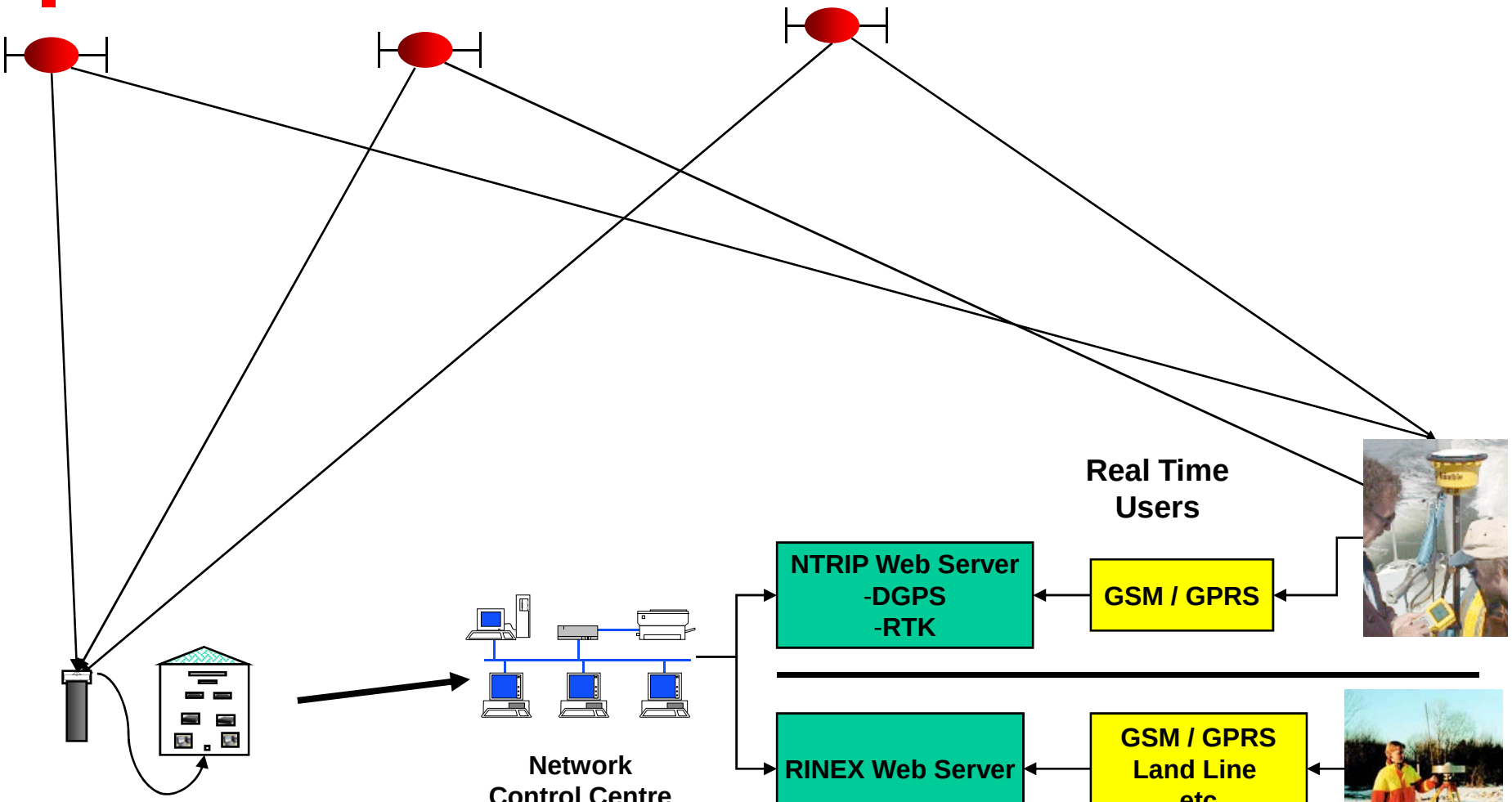
- Data available in Radio Technical Commission: Maritime format (RTCM)
- DGPS
  - pseudo range corrections provided in RTCM V 2.3
  - sub metre accuracy possible from single base station
    - ✓RMS 0.35 m Hor and 1 m Vert irrespective of distance
  - used for navigation and GIS applications
  - Country wide coverage
- RTK
  - carrier phase corrections provided in RTCM V 3.1
  - sub 5 cm accuracy possible from 40km of a single base station but generally
    - ✓2-3 cm Hor and ~ 10cm Vert
  - used for precise navigation and by surveyors and engineers

Delivery of RT Services 1

NTRIP (Network Transport of RTCM by Internet Protocol)

- Users download RTCM RTK observables or DGPS corrections from an Internet site in real time.
- Corrections or GPS observables received are based either on one station or on a network solution.
- Field connection to internet can be via any technology eg GSM, GPRS (3G), Satellite phone etc
- GSM & GPRS have disadvantages of coverage.
- Low cost GPRS costs ~R2/Mb. NTRIP uses ~400 Kb/hour
- Could be used for in-shore hydrographic work or navigation

Delivery of RT Services 2

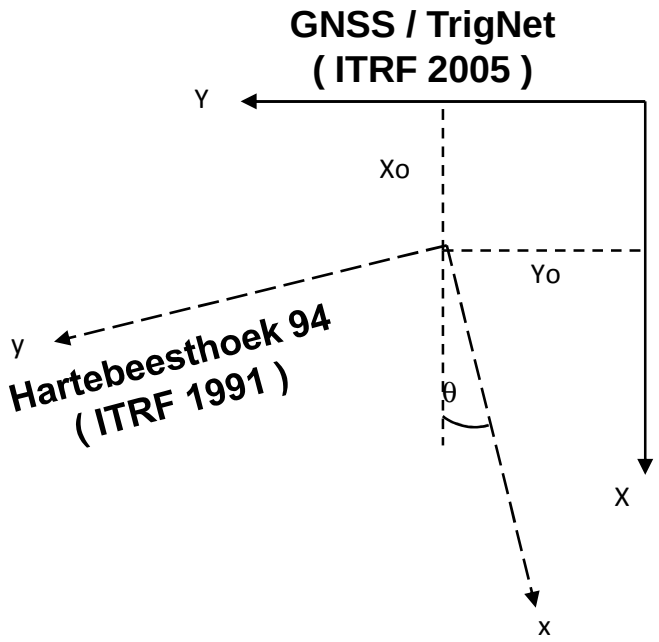


Base Station / User Seperation :	**Post processing**	**– Possible to get <5cm @ 500km or greater**
	DGPS	**– 35cm irrespective of distance**
	RTK	**– <5cm @ ~40 km**

Co-ordinate System 1

- GNSS and TrigNet are observing or measurement tools which operate in a co-ordinate reference frame different to Hartebeesthoek 94

- Users must transform surveys conducted using GNSS or TrigNet to the official Hartebeesthoek 94 co-ordinate system.



Co-ordinate System 2

Differences between:

TrigNet

(ITRF 2005 epoch 2010.02)

and

Hart94

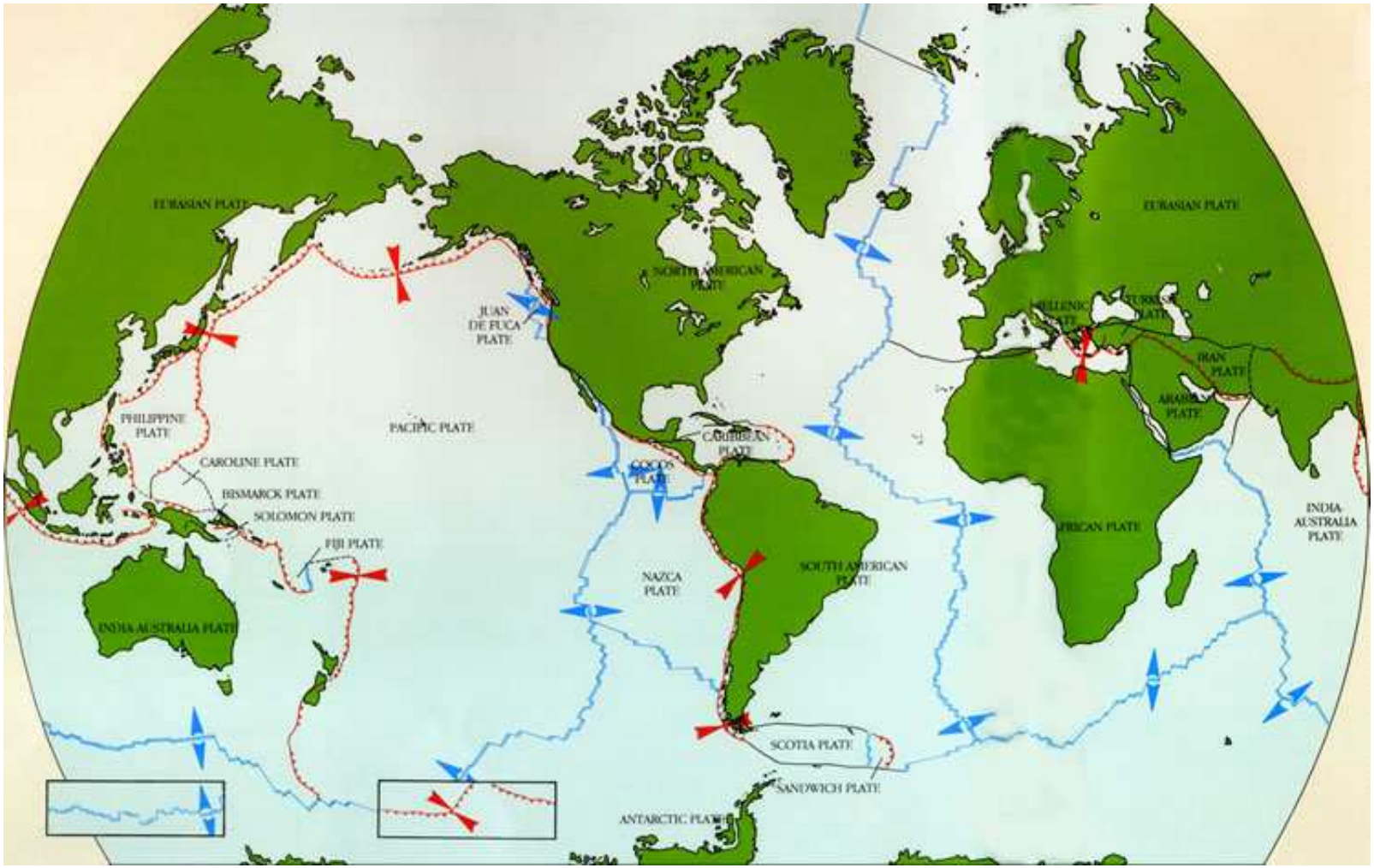
(ITRF 1991 epoch 1994.0)

(NB Gauss Conform Lo co-ordinates)

Short name	ITRF2005-Hart94	
	dy	dx
ANTH	-0.077	-0.426
BENI	-0.265	-0.386
BETH	-0.180	-0.417
BFTN	-0.039	-0.387
BRIT	-0.236	-0.387
BRNK	-0.241	-0.343
BWES	-0.140	-0.462
CALV	-0.248	-0.475
etc	"	"
etc	"	"
etc	"	"
Mean	-0.197	-0.413
Stdev	0.073	0.056

Co-ordinate System 3

Simple view of plate motions

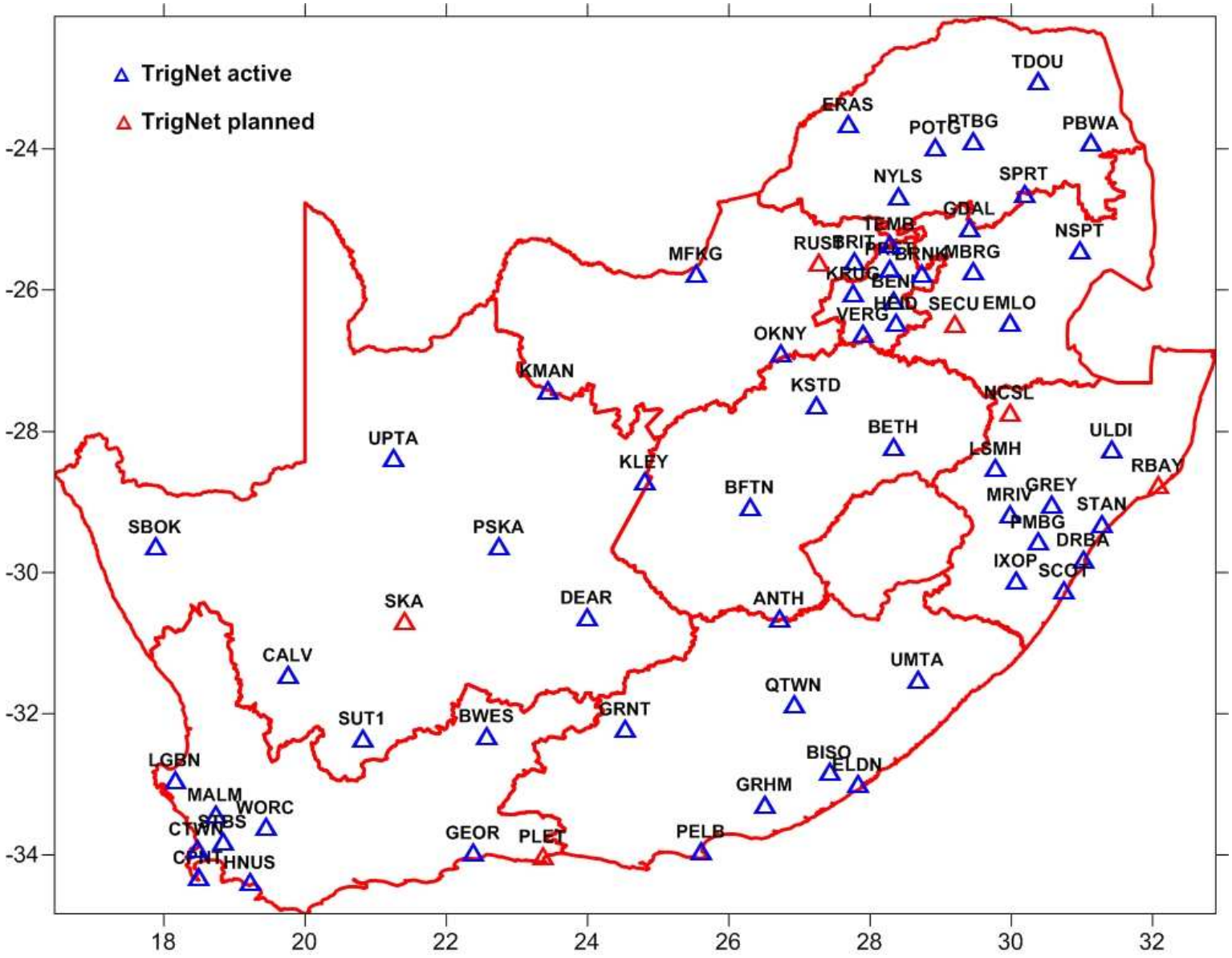


Co-ordinate System 4

Hartebeesthoek 94 remains the official co-ordinate reference frame for South Africa

NGI NATIONAL GEO-SPATIAL INFORMATION
MAPPING OUR NATION

Status 2011-02-16



Applications of TrigNet

Post processing applications

- Surveying and GIS
- Atmospheric science
  - Monitoring of atmospheric water vapour for climate monitoring
  - Monitoring of ionosphere for communication and positioning
- Geophysics
  - Long term monitoring of station positions – plate tectonics

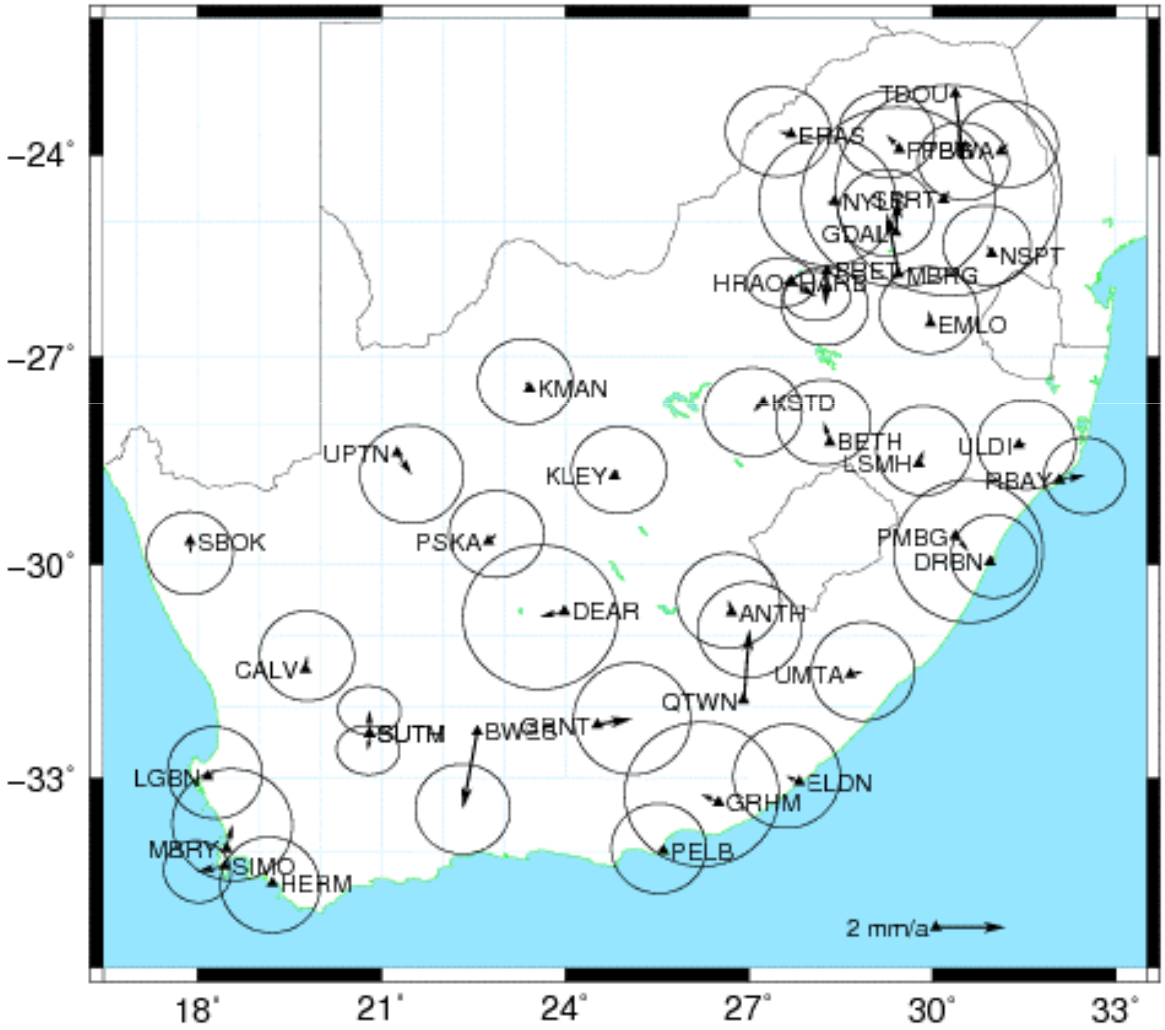
Real time applications

- Surveying and GIS
- Navigation
- Weather forecasting & ionosphere mapping
- Timing

Non-Navigation Applications 1

Plate Motions within South Africa

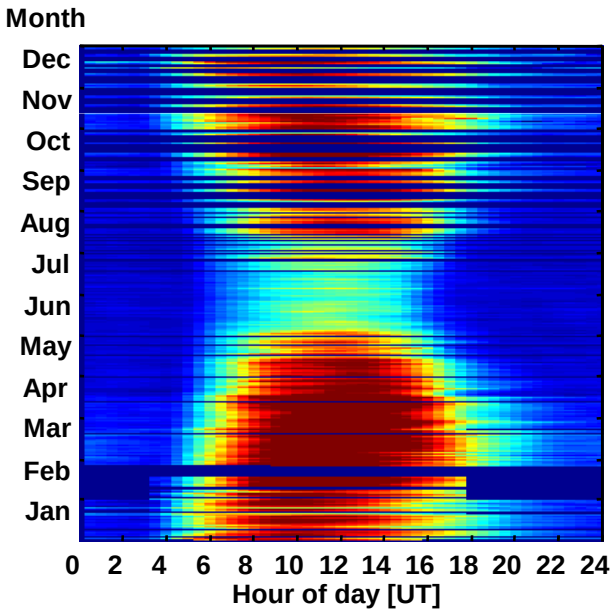
How rigid is a rigid plate?
Geodetic constraint from the TrigNet CGPS network, South Africa.
R. Malservisi,
U. Hugentobler,
R. Wonnacott,
R. Chacko
IAESPEI Cape Town 2009



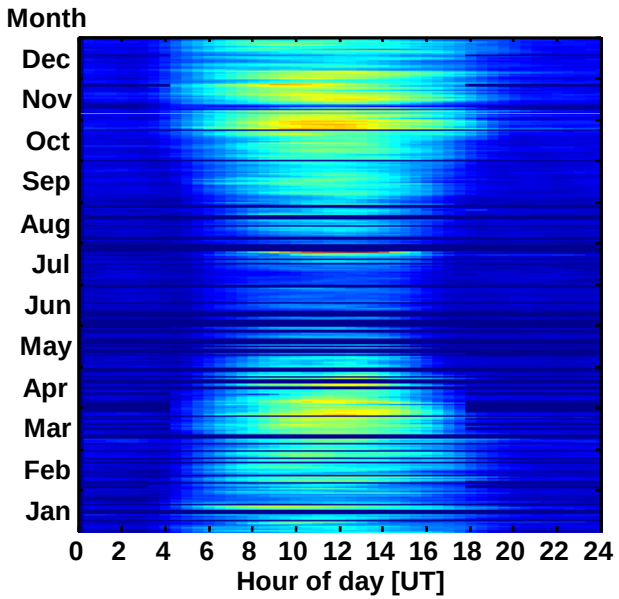
Non-Navigation Applications 2

Space weather

- Ionospheric mapping of variation of annual TEC over South Africa from network of GNSS base stations



2002



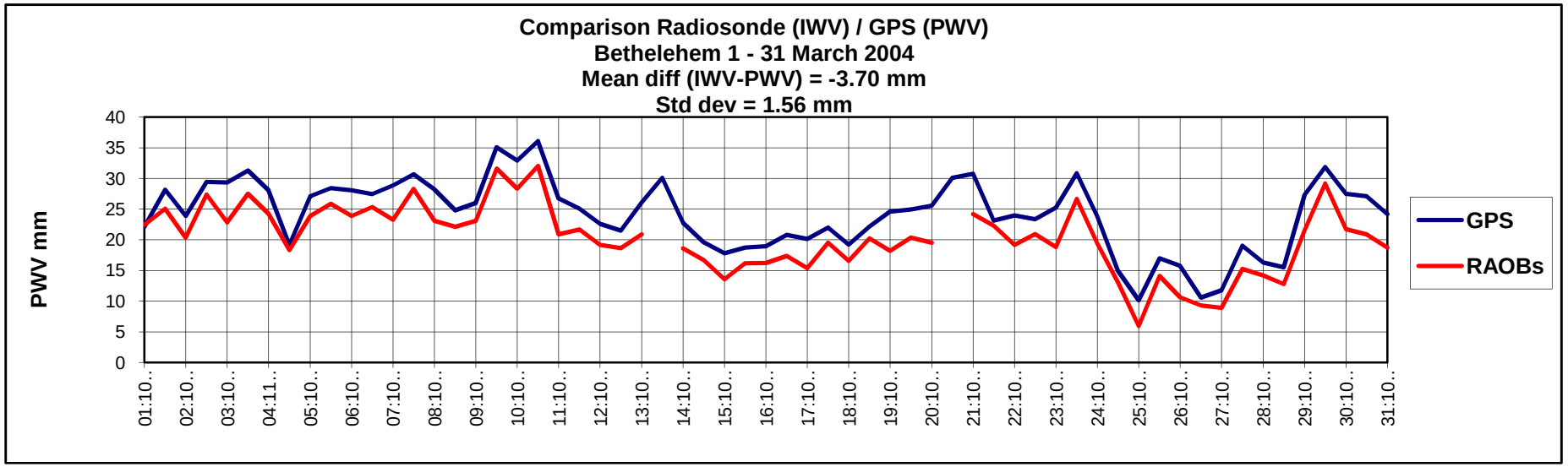
2004

Thanks to B Opperman of Hermanus Magnetic Observatory for plots

Non-Navigation Applications 3

Climate monitoring and Weather forecasting

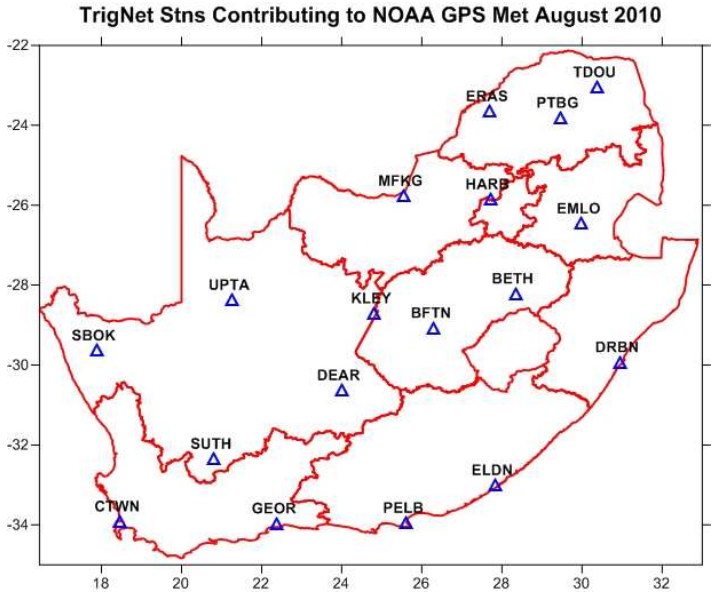
- **Comparison of GNSS with Radiosonde estimates of Precipitable Water Vapour (PWV)**
- **Less than 3 hour latency required for weather forecasting**



International Activities

TrigNet data being used for:

- **International GNSS Service (IGS) Real Time Working Group**
- **International GLONASS Service (IGLOS)**
- **Constellation Observing System for Meteorology, Ionosphere & Climate (COSMIC) and FORMOSAT-3 Taiwan's Formosa Satellite Mission #3**
- **National Oceanic and Atmospheric Adminstration (Meterology)**



Future

- Densification along Southern Cape Coast, Northern Free State, KwaZulu-Natal and Central Cape with link to SKA
- Increase number of GPS/GLONASS receivers
- Operationalize ionospheric mapping in co-operation with HMO
  Implications on single frequency positioning
- Increase co-operation with SAWS for weather forecasting and climate monitoring applications
- Will have to consider a rebuild from about 2012 to cater for GPS modernization plus GLONASS and Galileo (2013???)

Conclusion

- **The services available from TrigNet are easily available.**
- **NTRIP is “state of the art” in real time service provision.**
- **The applications of TrigNet are not confined to positioning.**
- **A rebuild is planned to accommodate GPS modernization, GLONASS and Galileo.**
- **TrigNet is building up a strong recognition within the International community as a provider of reliable and good quality data**

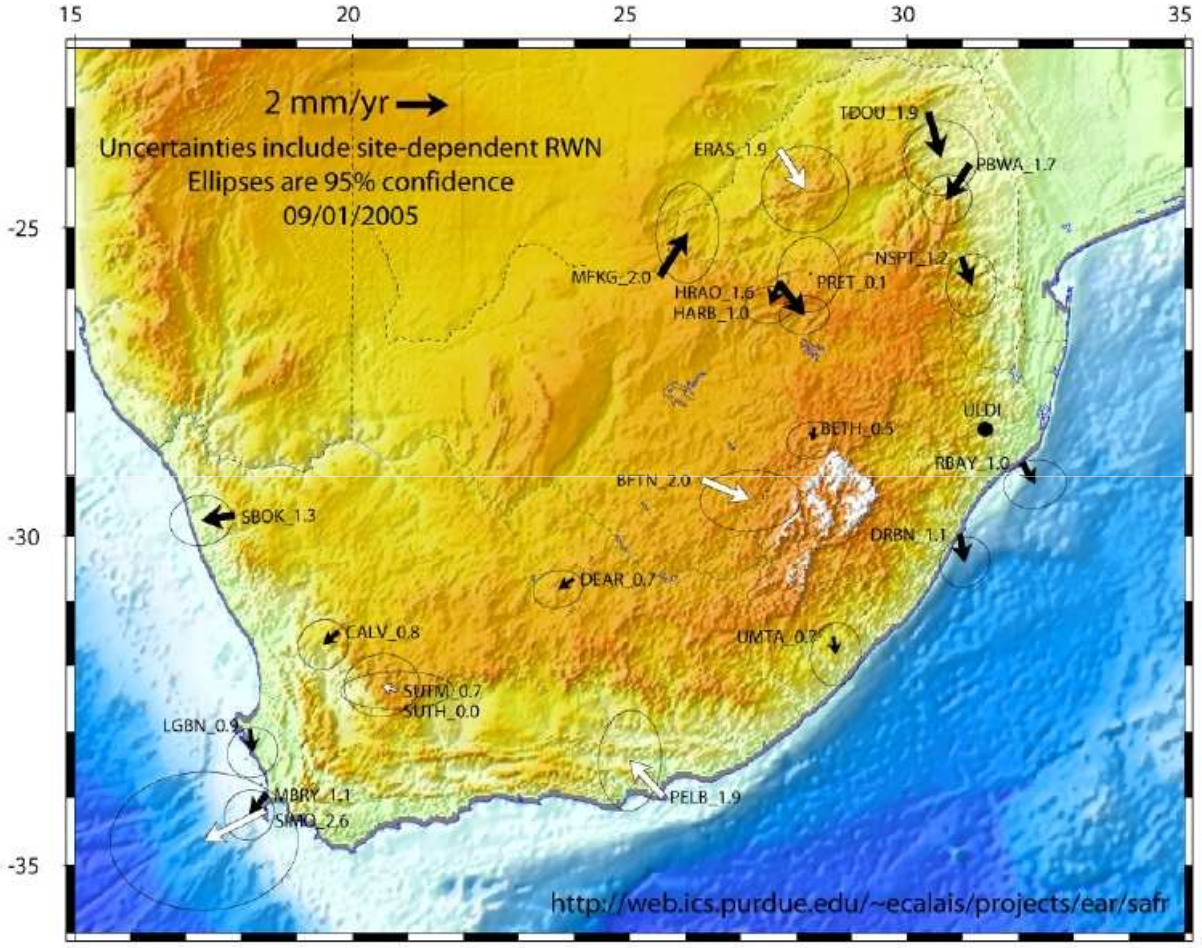
Thank You

Website for further information and data

www.trignet.co.za

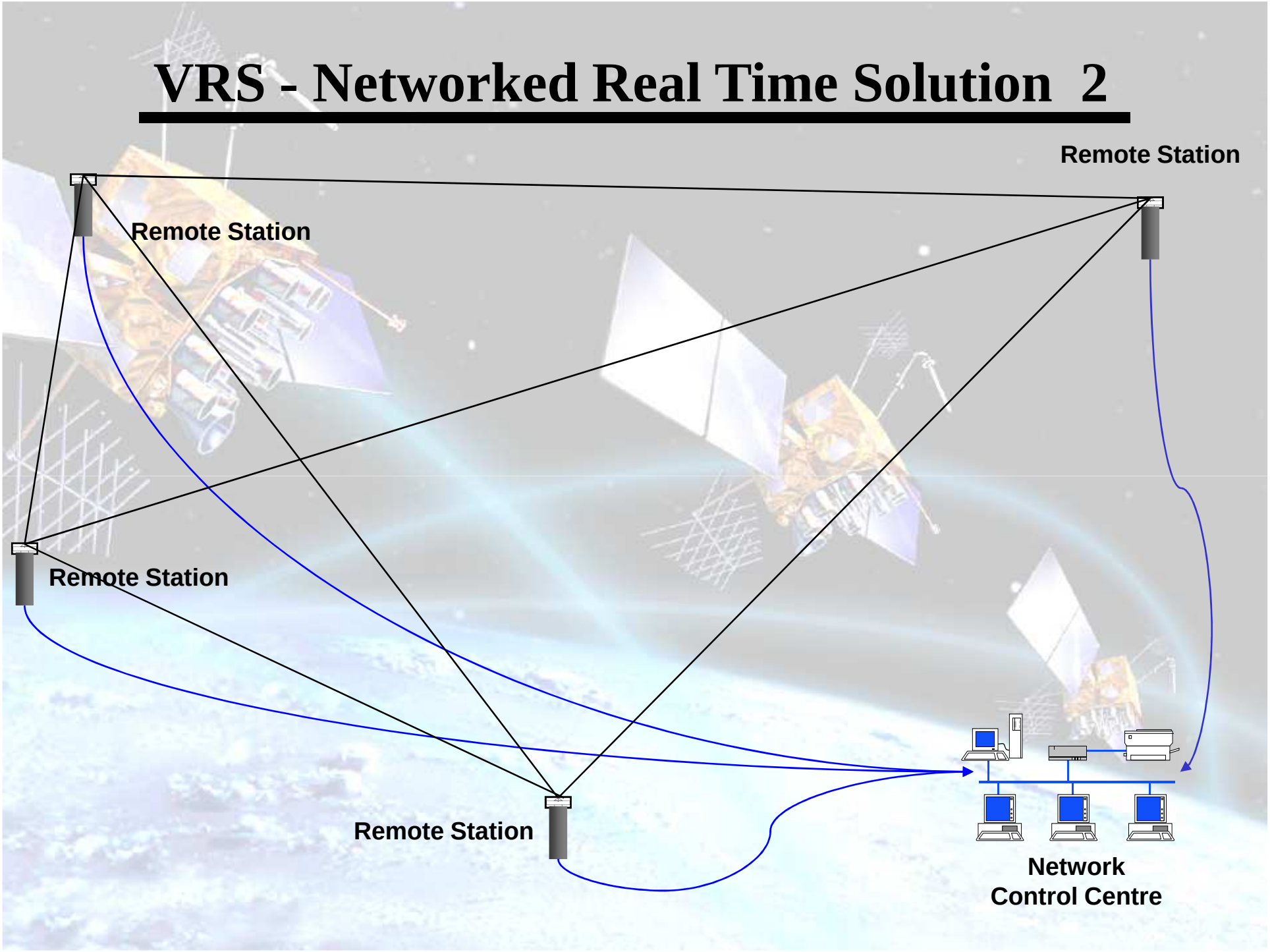
Non-Navigation Applications 1

Plate Motions within South Africa

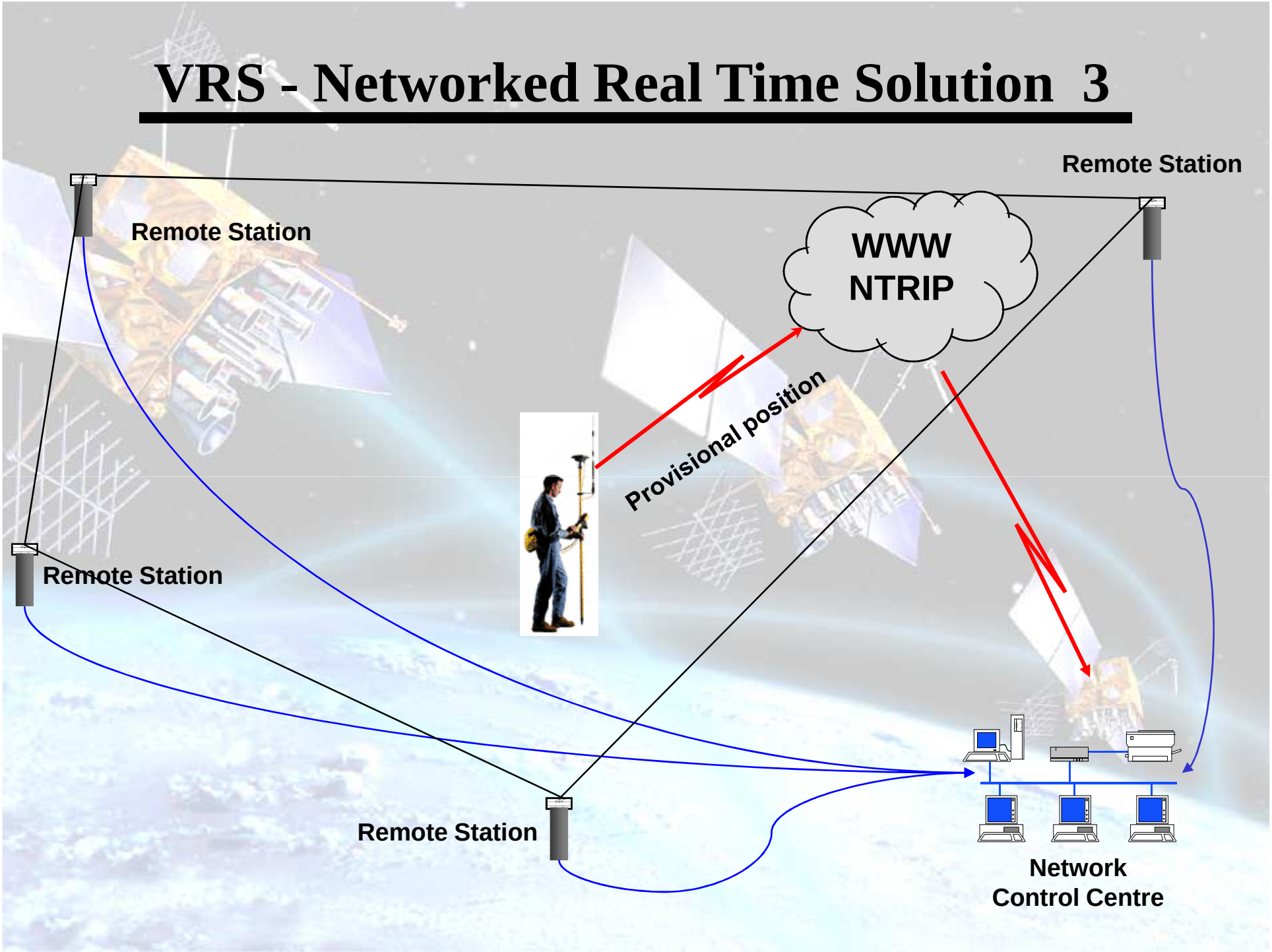


C.J.H. Hartnady, E. Calais & R. Wonnacott (2007): "ITRF2000 velocity field from the South African TrigNet GPS array and the African GNSS network: Implications for Nubia-(Rovuma-Lwandle-)Somalia plate motions" East African Rift Conference, Kampala

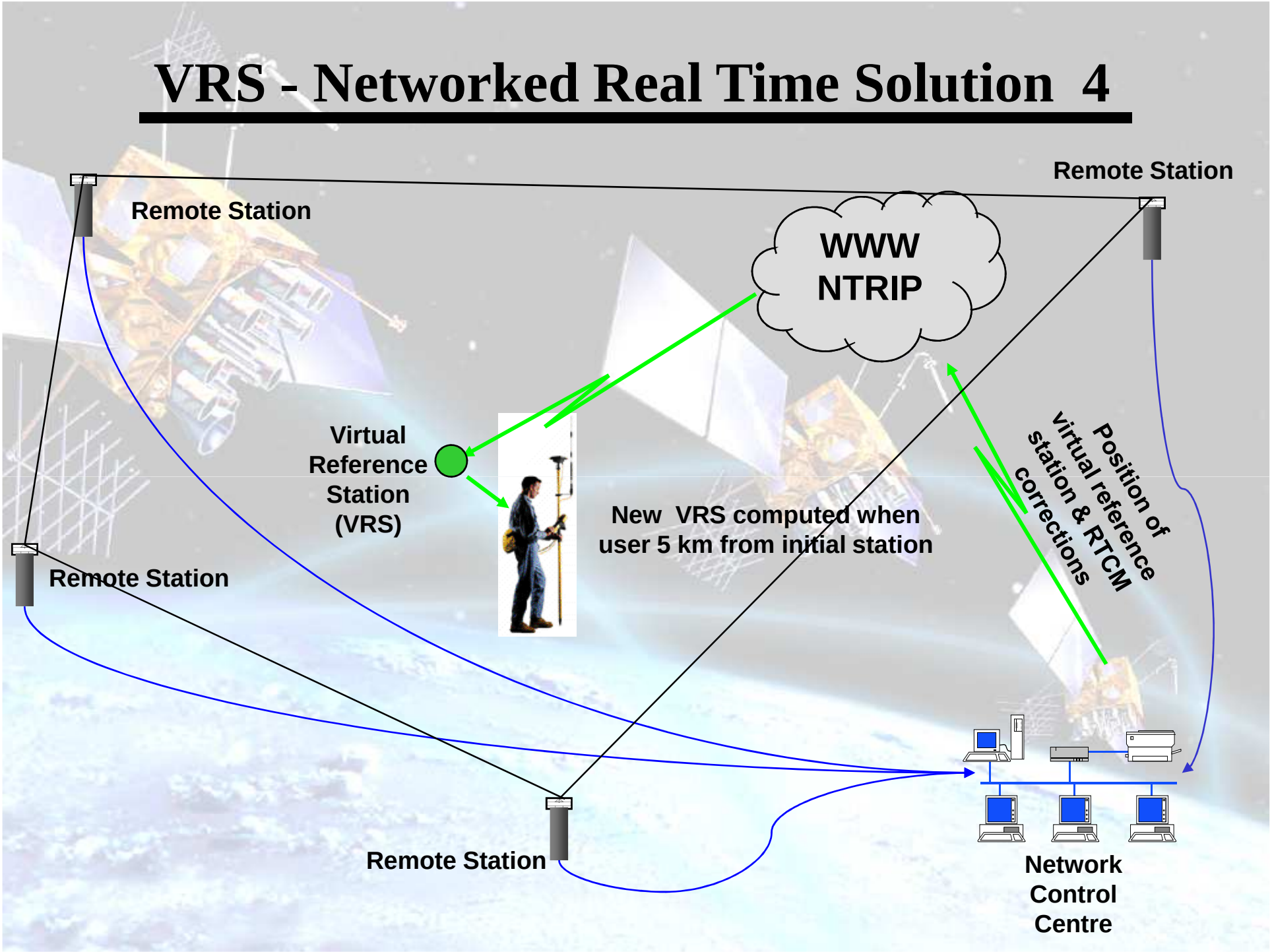
VRS - Networked Real Time Solution 2



VRS - Networked Real Time Solution 3



VRS - Networked Real Time Solution 4



Monthly Download of TrigNet Data

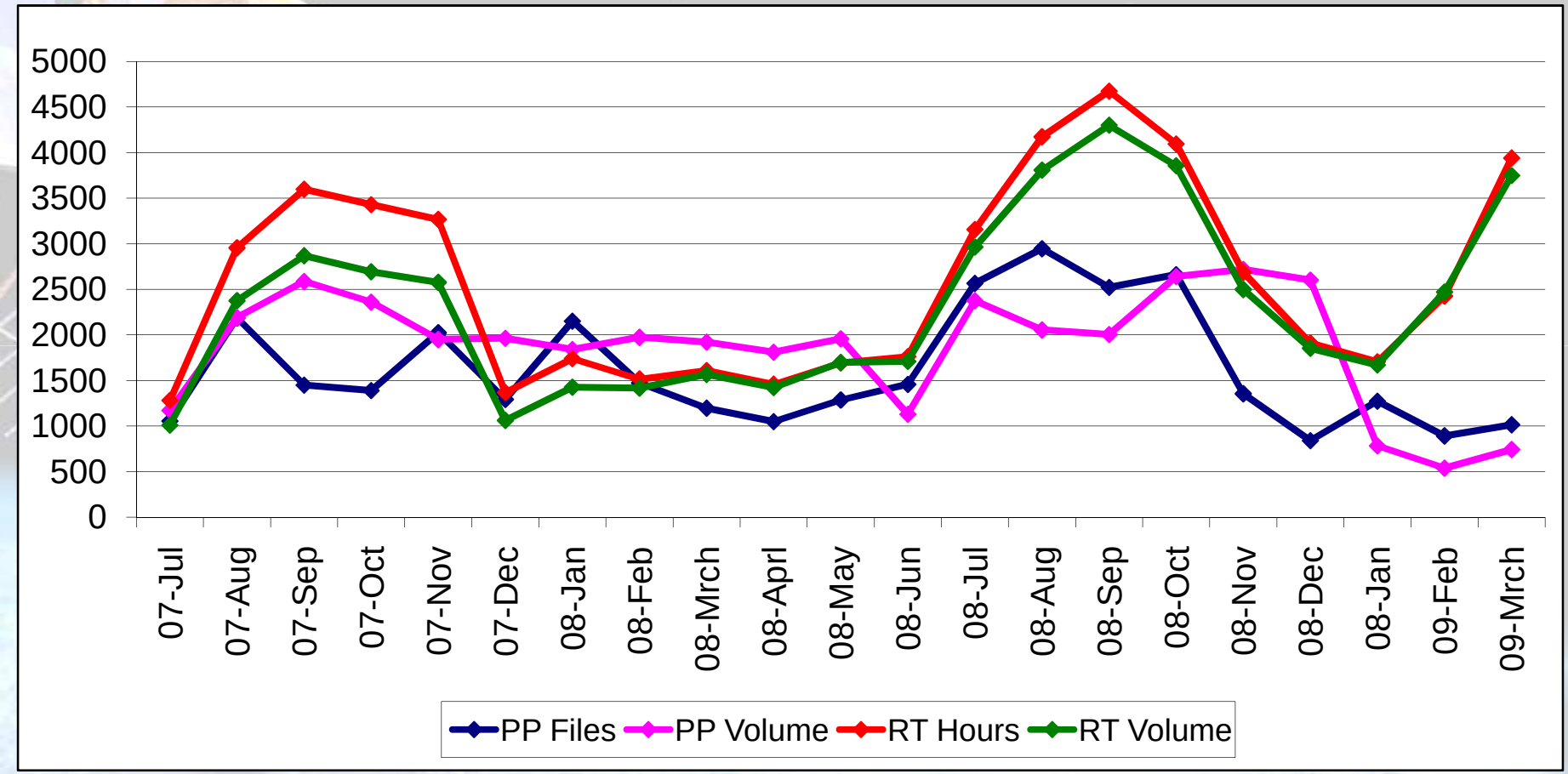


Plate Tectonics 1

- **It has been known for many years that the earth's crust is made up of many plates floating on the mantle. This knowledge gained through geological records. For example Mid Atlantic Ridge.**
- **By and large, the continents are located on these plates.**

  Some continents are located on two or more plates
- **Motion of the continents on these plates has given rise to the term "Continental Drift"**

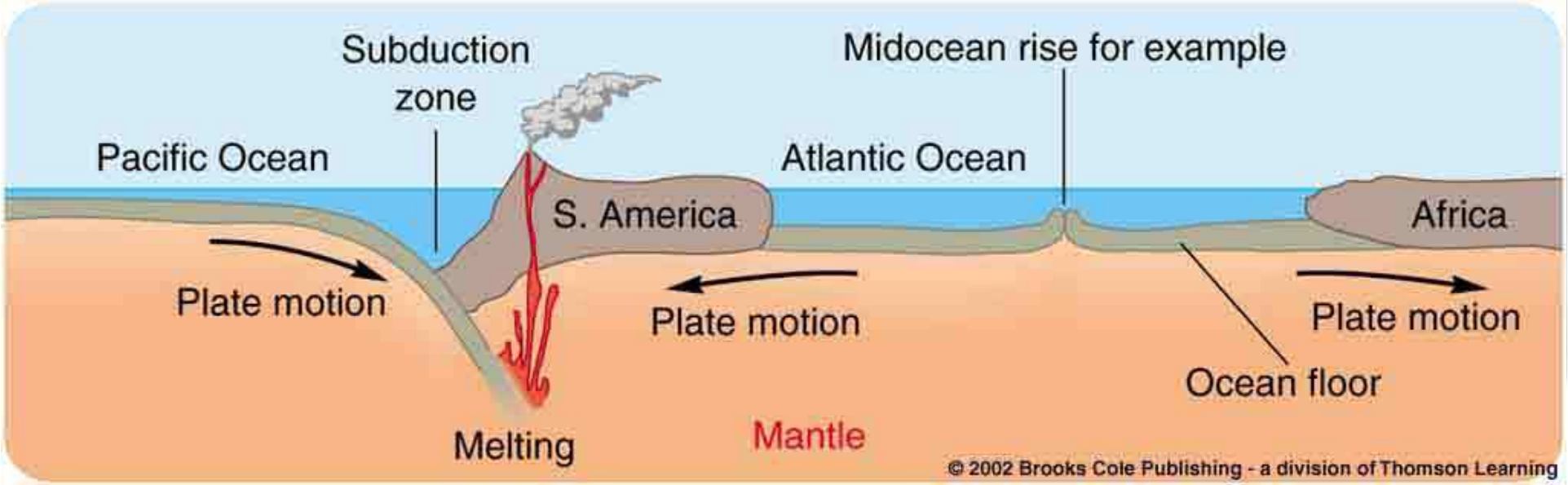
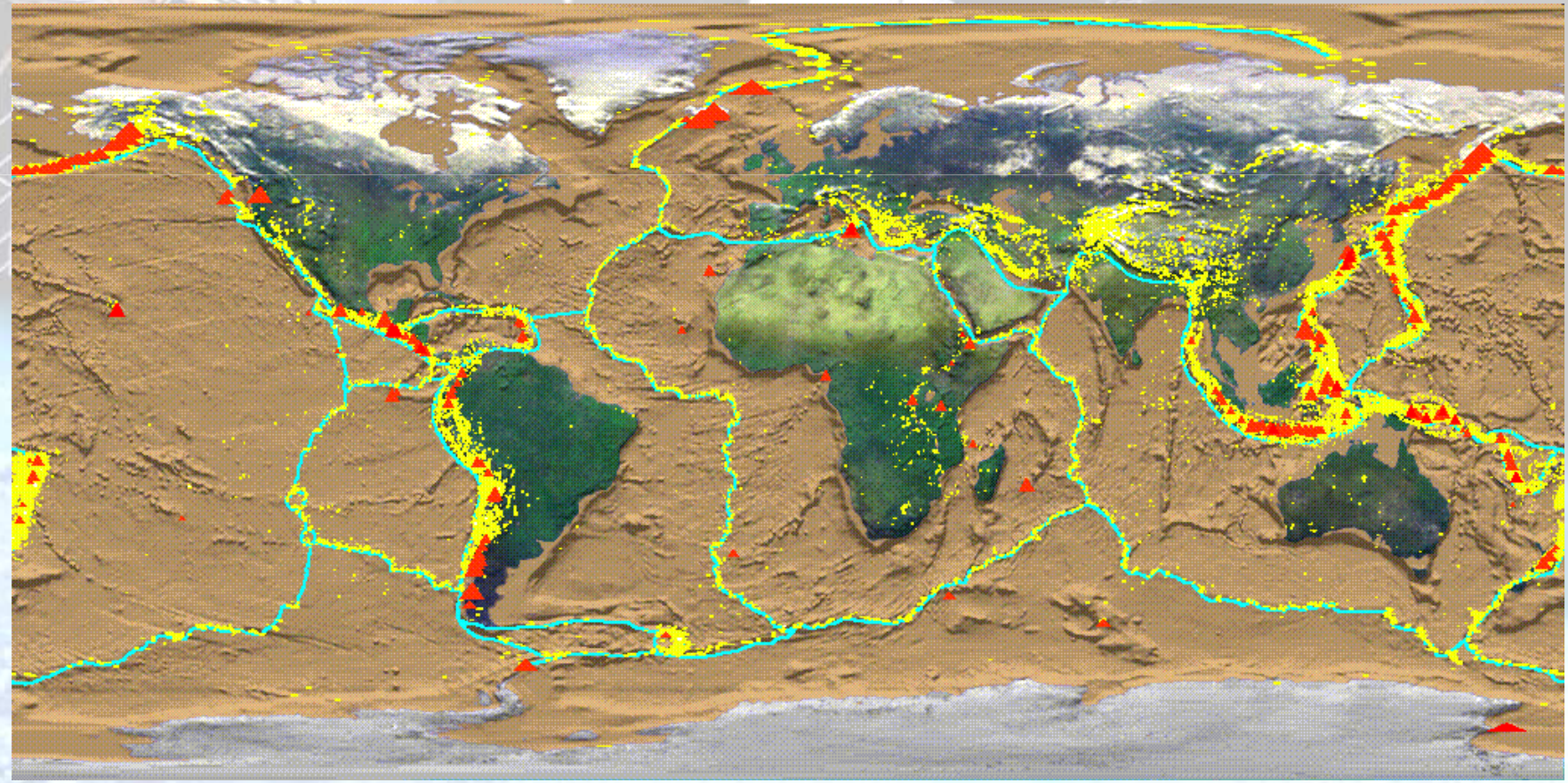


Plate Tectonics 2

Recent Earthquakes and Volcanoes

Yellow = earthquakes

Red = volcanoes