

## Asia Pacific Regional Geodetic Project

International Symposium on GPS (GPS99)

October 18-22, 1999  
Tsukuba, Ibaraki, Japan.

Ramesh Govind, John Dawson and Geoff Luton  
Australian Surveying and Land Information Group



## Asia Pacific Regional Geodetic Project

- **Presentation Overview**
  - Regional GPS Solution
    - APRGP98 + IGS + Keystone GPS
  - GPS Computations
  - Combination GPS (+SLR, DORIS, VLBI)
  - Multi-technique comparison
    - Example; Japanese Keystone Network

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

- **APRGP98 Summary**
  - Asia Pacific Regional Geodetic Project 98
  - 2<sup>nd</sup> regional geodetic campaign
  - multi-technique campaign
    - GPS (coordinated by AUSLIG)
    - SLR (WPLTN)
    - DORIS (CNES/IGN)
    - VLBI (coordinated by Shanghai Observatory)

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

- **APRGP98 Outcomes**
  - densification of ITRF
  - providing links to local datum for datum transformation derivation
  - links to vertical datum (tide gauge sites)

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

- GPS Observations
  - APRGP98
    - 19<sup>th</sup> - 28<sup>th</sup> November 1998
    - 17 countries
    - 92 GPS stations
  - Other
    - 30+ IGS stations in Asia Pacific
    - 4 Keystone GPS Stations

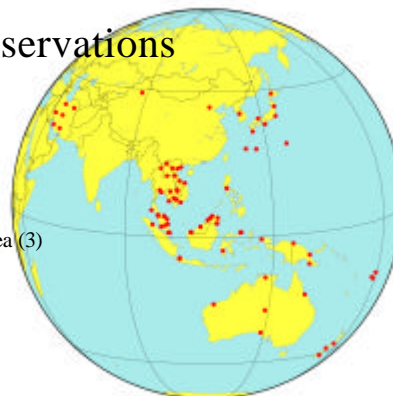
International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

### • APRGP98 - GPS Observations

|                       |                      |
|-----------------------|----------------------|
| Australia (5)         | Cambodia (6)         |
| China (3)             | Fiji (3)             |
| Vietnam (4)           | Indonesia (7)        |
| Iran (6)              | Japan (9)            |
| Lao (7)               | Malaysia (25)        |
| New Zealand (3)       | Papua New Guinea (3) |
| Philippines (2)       | Singapore (3)        |
| South Korea (1)       | Thailand (4)         |
| Hong Kong (China) (1) |                      |



International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

- Global GPS solution
  - global GPS (x 10 days)
    - orbit parameters
    - Earth Orientation Parameters
    - ~ 38 IGS stations

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

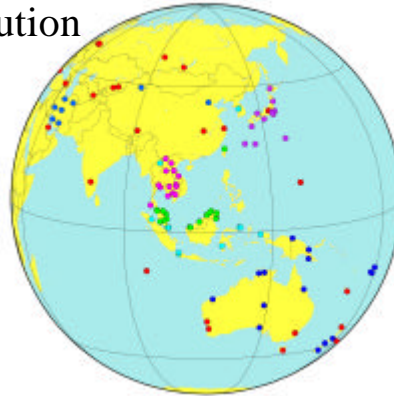
- Regional GPS Solution
  - split into convenient regional solutions
    - Iran and China
    - Cambodia, Vietnam, Thailand and Laos
    - Malaysia
    - Singapore, Hong Kong, Philippines and Indonesia
    - Japan (+ Keystone)
    - Australia, Papua New Guinea and Fiji

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

- Regional GPS Solution
  - APRGP98
  - IGS
  - Keystone



International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

- AUSLIG GPS Processing
  - Data Processing/Parameter Estimation
    - MicroCosm Software
  - Normal Equation Combination
    - SOLVE Software (GSFC)

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

- Daily normal equation combination
  - daily solutions (x 10 days)
  - 70 normal equations sets
  - ITRF96
    - solution constrained to subset of the 47 IGS reference stations
  - final output SINEX

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.

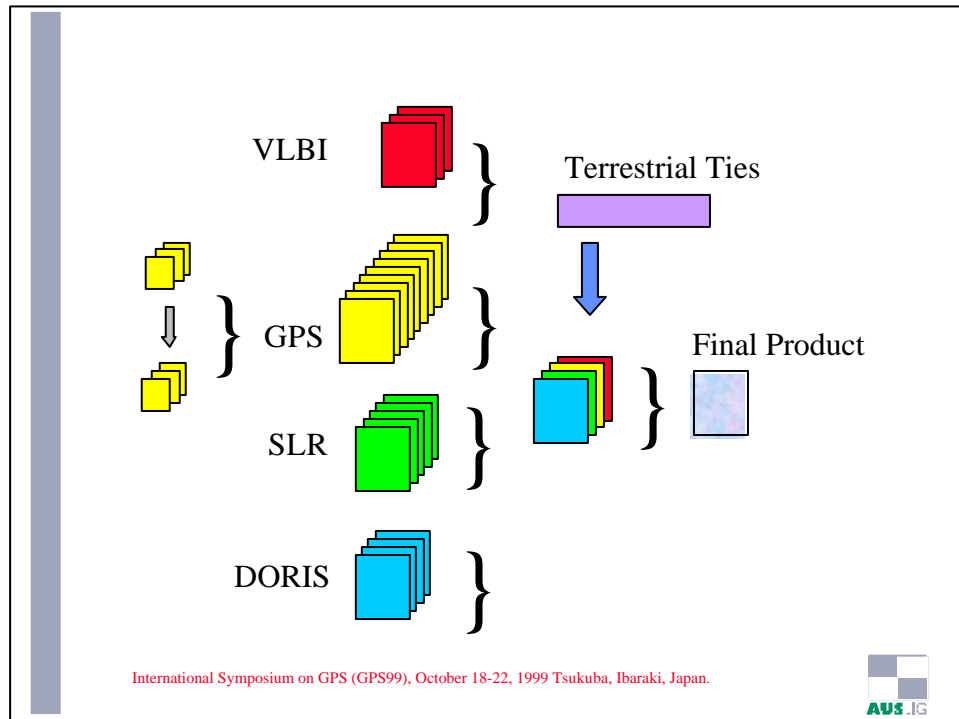


## Asia Pacific Regional Geodetic Project

- GPS Results
  - AUSLIG Orbit RMS 7-10cm radial (against IGS)
  - AUSLIG global SSC
    - RMS difference to ITRF96: 13,7,19 mm (E,N,U)
    - RMS difference to NCL: 9,5,14 mm (E,N,U)
    - < 1cm horizontal accuracy
    - ~1cm vertical accuracy
  - Daily coordinate repeatability
    - 13,5,21 mm (E,N,U)

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



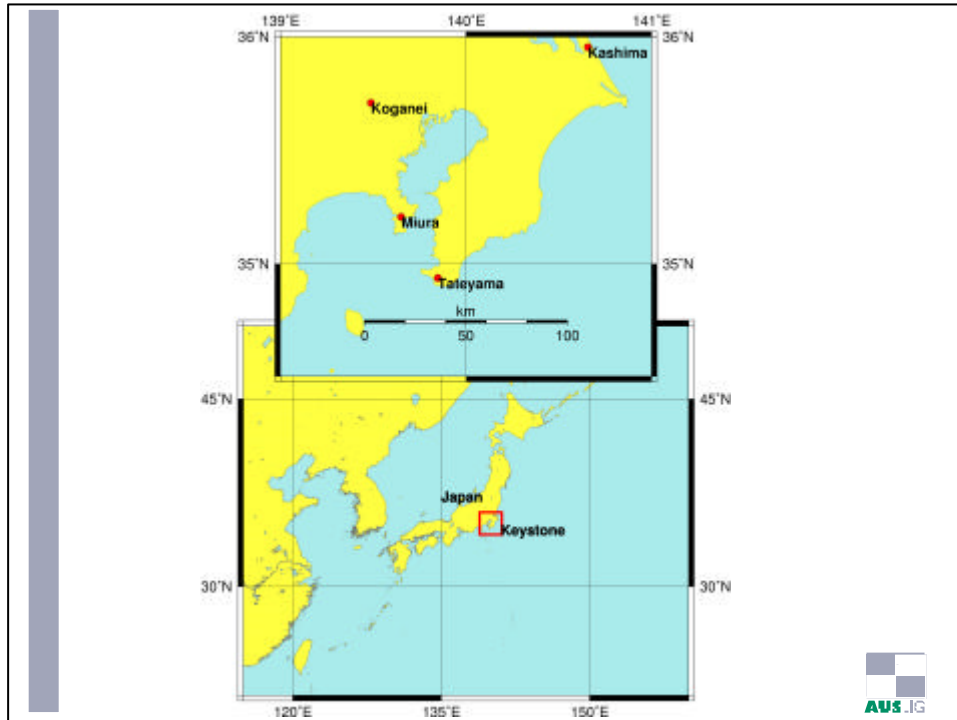


## Asia Pacific Regional Geodetic Project

- Multi-Technique Combinations
  - SINEX
    - SINEX validation and testing software
    - de-constraint of SINEX
    - GEODYN II Ematrix output
  - normal equation combination
    - SOLVE (GSFC)
  - SOLVE to SINEX output software

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.





## Asia Pacific Regional Geodetic Project

- Multi-Technique Comparisons
  - GPS Solution (AUSLIG)
    - APRGP98 + IGS + Keystone (x 1)
  - SLR Solution (AUSLIG)
    - Lageos 1 + Lageos 2 November 1998 (x 1)
  - VLBI Solutions (CRL)
    - November 1998 SINEX solutions (x 15)
  - Local Ties
    - Gemstone; Koyama et al (CRL), 1999

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



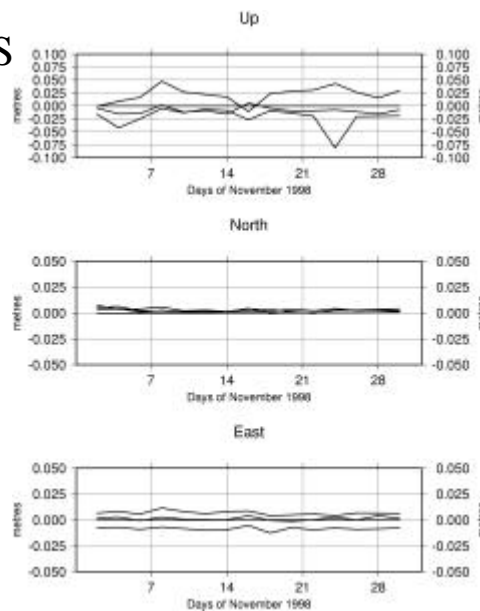
## Asia Pacific Regional Geodetic Project

- Multi-Technique Comparisons
  - apply local tie corrections
    - GPS + Local Tie = VLBI<sub>GPS</sub>
    - SLR + Local Tie = VLBI<sub>SLR</sub>
  - transform CRL VLBI onto GPS and SLR
    - differences at Kashima constrained to zero
  - 15 x 1 day VLBI solutions comparisons

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



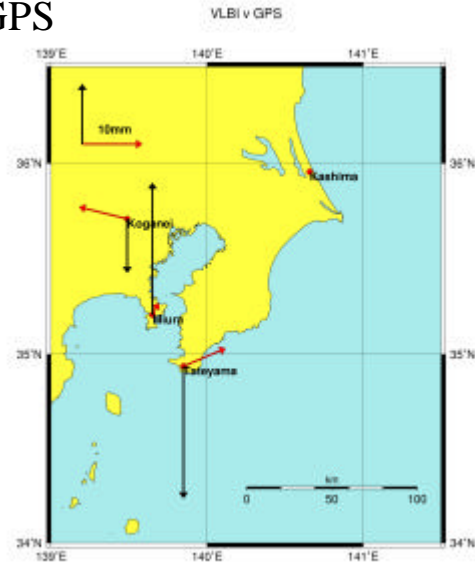
### • VLBI v GPS



International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



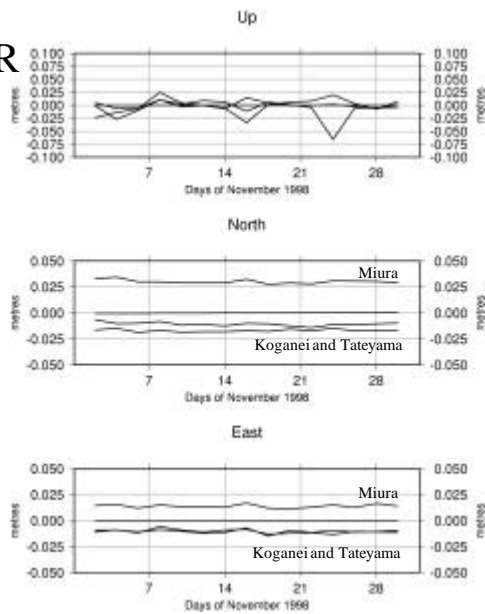
- VLBI v GPS



International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



- VLBI v SLR



International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



- VLBI v SLR



International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

- RMS Differences
  - Kashima, Koganei, Miura and Tateyama

|            | East (mm) | North (mm) | Up (mm) | Comment       |
|------------|-----------|------------|---------|---------------|
| VLBI – SLR | 15        | 29         | 19      | Untransformed |
| VLBI – GPS | 7         | 15         | 26      | Untransformed |
| VLBI – SLR | 10        | 18         | 13      | Transformed   |
| VLBI – GPS | 5         | 3          | 19      | Transformed   |

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.



## Asia Pacific Regional Geodetic Project

- **Final Comments**
  - note success of APRGP (97/98/99)
    - densification of ITRF
    - fundamental geodetic network (in ITRF)
  - demonstrate/developed combination system
  - contribute to IERS time series pilot project
- **Future Plans**
  - establish relationship/compatibility
    - GPS, SLR, DORIS and VLBI
  - implement co-location at spacecraft
    - GPS, DORIS and SLR

International Symposium on GPS (GPS99), October 18-22, 1999 Tsukuba, Ibaraki, Japan.

