

中国测绘学会
全国十大科技创新人物推荐表

附
件
材
料

姓 名：姜卫平

推荐单位：中国测绘学会位置服务工作委员会

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国家科学技术进步奖 证书

为表彰国家科学技术进步奖获得者，
特颁发此证书。

项目名称：海洋测绘和内陆水域监测的卫星
大地测量关键技术及应用

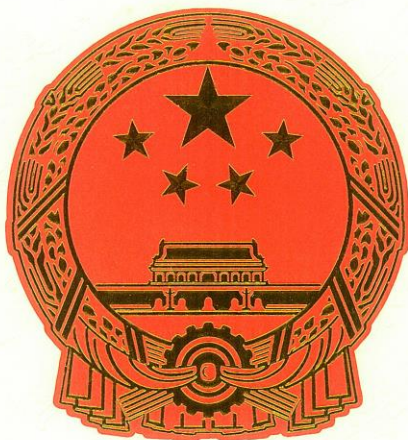
奖励等级：二等

获奖者：姜卫平



2018年12月12日

证书号：2018-J-25201-2-03-R01



国家科学技术进步奖 证书

为表彰国家科学技术进步奖获得者，
特颁发此证书。

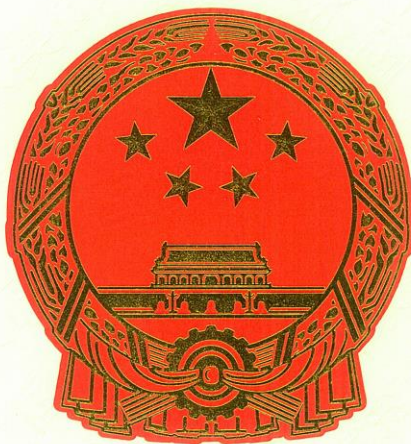
项目名称：测绘基准和空间信息快速获取关键技术及其在灾害应急测绘中的应用

奖励等级：二等

获奖者：姜卫平



证书号：2011-J-252-2-11-R02



国家科学技术进步奖 证书

为表彰国家科学技术进步奖获得者，
特颁发此证书。

项目名称：我国区域精密高程基准面建立的
关键技术及推广应用

奖励等级：二等

获 奖 者：姜卫平



证书号：2008-J-210-2-04-R02









地理信息科技进步奖

证书

项目名称：内蒙古高精度空间定位和数字高程
基准建立的技术及其应用

奖励等级：壹等奖

获奖者：姜卫平 名次：序(3)



证书号：2016-01-11



测绘科技进步奖

证书

为表彰测绘科技进步奖获得者，特颁发此证书。

项目名称：_____
利用卫星定位系统建立与维持高精度坐标
框架的关键技术及推广应用

奖励等级：_____
一等奖

获奖者：_____
姜卫平

名次：_____
序(01)



证书号：2013-01-01 2013年 10月 11日



测绘科技进步奖

证书

为表彰测绘科技进步奖获得者，特颁发此证书。

项目名称：汶川震区精密高程基准确定关键
技术在应急测绘中的应用

奖励等级：一等奖

获奖者：姜卫平 名次：第(02)



证书号：2010-01-01-05 2010 年 11 月 09 日

测绘科技进步奖 证书

国测科 1595 号

为表彰在促进测绘科学技术进步工作中做出突出贡献者，特颁发测绘科技进步奖证书，以资鼓励。

获奖项目： 青藏高原地壳运动与形变的GPS研究

奖励等级： 一等

获奖者： 姜卫平（名次7）



1999 年 12 月 8 日









地理信息科技进步奖

证书

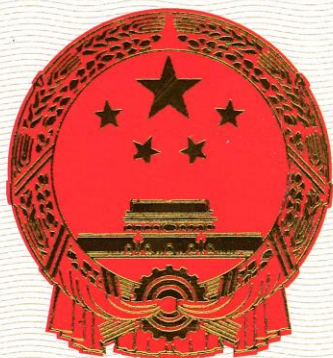
项目名称：珠海高精度三维陆海统一测绘基准建立及其理论与技术研究

奖励等级：壹等奖

获奖者：姜卫平 名次：序(4)



证书号：2015-01-02



青海省科学技术奖励 证书

为表彰青海省科学技术进步奖
获得者，特颁发此证书。

项目名称：青海省现代测绘基准构建的关键技术与实现

获奖等级：二等奖

获奖者：姜卫平



二〇一八年三月二十二日

获奖编号：2017-KJJB-2-1-R1



地理信息技术进步奖

证书

项目名称：内蒙古高精度空间定位和数字高程基准建立的技术及其应用

奖励等级：壹等奖

获奖者：姜卫平 名次：序(3)



证书号：2016-01-11





测绘科技进步奖

证书

为表彰测绘科技进步奖获得者，特颁发此证书。

广东省现代大地空间定位系统

项目名称：——大地水准面精化研究

奖励等级：——二等奖

获奖者：姜卫平 名次：序(6)



证书号：2006-01-02-04 2006年10月20日

测绘科技进步奖 证书

国测科 1484 号

为表彰在促进测绘科学技术进步工作中做出突出贡献者，特颁发测绘科技进步奖证书，以资鼓励。

海南高精度高分辨率大地水

获奖项目：

准面的确定及 GPS 网的建立

奖励等级：

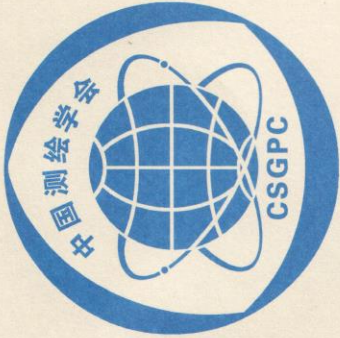
二等

获奖者：

姜卫平（名次 6）



1999 年 12 月 8 日



为表彰测绘科技进步奖获得者，特颁发此证书。

项目名称：重庆市高精度数字高程基准建立的关键技术与应用

奖励等级：二等奖

测绘科技进步奖

获奖者：姜卫平 名次：序(03)

证书



证书号：2018-01-02-51

2018年9月

证书号第 2925895 号



发明专利证书

发明名称: 区域 GPS 基准站坐标时间序列的噪声模型获得方法

发明人: 姜卫平;李昭;周晓慧;马一方

专利号: ZL 2014 1 0462401.9

专利申请日: 2014 年 09 月 11 日

专利权人: 武汉大学

地址: 430072 湖北省武汉市武昌区珞珈山武汉大学

授权公告日: 2018 年 05 月 15 日

授权公告号: CN 104200036 B

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第 1 页 (共 1 页)

证书号第 3157578 号



发明专利证书

发明名称：热膨胀效应对 GPS 坐标时间序列影响的精确量化方法

发明人：姜卫平；王锴华；邓连生；李昭；陈华；周晓慧；马一方

专利号：ZL 2016 1 1141116.2

专利申请日：2016 年 12 月 12 日

专利权人：武汉大学

地址：430072 湖北省武汉市武昌区珞珈山武汉大学

授权公告日：2018 年 11 月 23 日

授权公告号：CN 106597484 B

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第 1 页 (共 1 页)

证书号第 3221252 号



发明专利证书

发明名称：高阶项电离层延迟对 GPS 坐标时间序列影响的量化方法

发明人：姜卫平;王锴华;邓连生;李昭;陈华;马俊;马一方

专利号：ZL 2016 1 1140210.6

专利申请日：2016 年 12 月 12 日

专利权人：武汉大学

地址：430072 湖北省武汉市武昌区珞珈山武汉大学

授权公告日：2019 年 01 月 18 日

授权公告号：CN 106772446 B

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第 1 页 (共 2 页)

证书号第2252641号



发明专利证书

发明名称: GPS 坐标时间序列环境负载修正方法及系统

发明人: 姜卫平;李昭;周晓慧;马一方

专利号: ZL 2014 1 0468973.8

专利申请日: 2014 年 09 月 15 日

专利权人: 武汉大学

授权公告日: 2016 年 09 月 28 日

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第 1 页 (共 1 页)

证书号第2521597号



发明专利证书

发明名称：一种利用多系统 GNSS 观测值的高精度基线解算方法

发明人：姜卫平;肖玉钢;陈华;袁鹏;席瑞杰;马符讯

专利号：ZL 2016 1 0447389.3

专利申请日：2016 年 06 月 20 日

专利权人：武汉大学

授权公告日：2017 年 06 月 16 日

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第 1 页 (共 1 页)

161230

证书号第 2445930 号



发明专利证书

发明名称：基于相关系数的削弱坐标时间序列中 CME 影响的方法

发明人：周晓慧;姜卫平;潘鹏飞

专利号：ZL 2014 1 0092166.0

专利申请日：2014 年 03 月 13 日

专利权人：武汉大学

授权公告日：2017 年 04 月 12 日

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专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。



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第 1 页 (共 1 页)

140326

证书号第3083763号



发明专利证书

发明名称：基于共模误差的GPS坐标时间序列不连续性的补足方法

发明人：周晓慧;姜卫平;陈华;马一方

专利号：ZL 2017 1 0297705.8

专利申请日：2017年04月28日

专利权人：武汉大学

地址：430072 湖北省武汉市武昌区珞珈山武汉大学

授权公告日：2018年09月21日

授权公告号：CN 107102342 B

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专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。



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第1页(共1页)

中华人民共和国国家版权局 计算机软件著作权登记证书

证书号：软著登字第2416150号

软件名称：高精度GNSS结构健康监测软件
[简称：SHMGNSS]
V1.0

著作权人：武汉大学

开发完成日期：2016年10月31日

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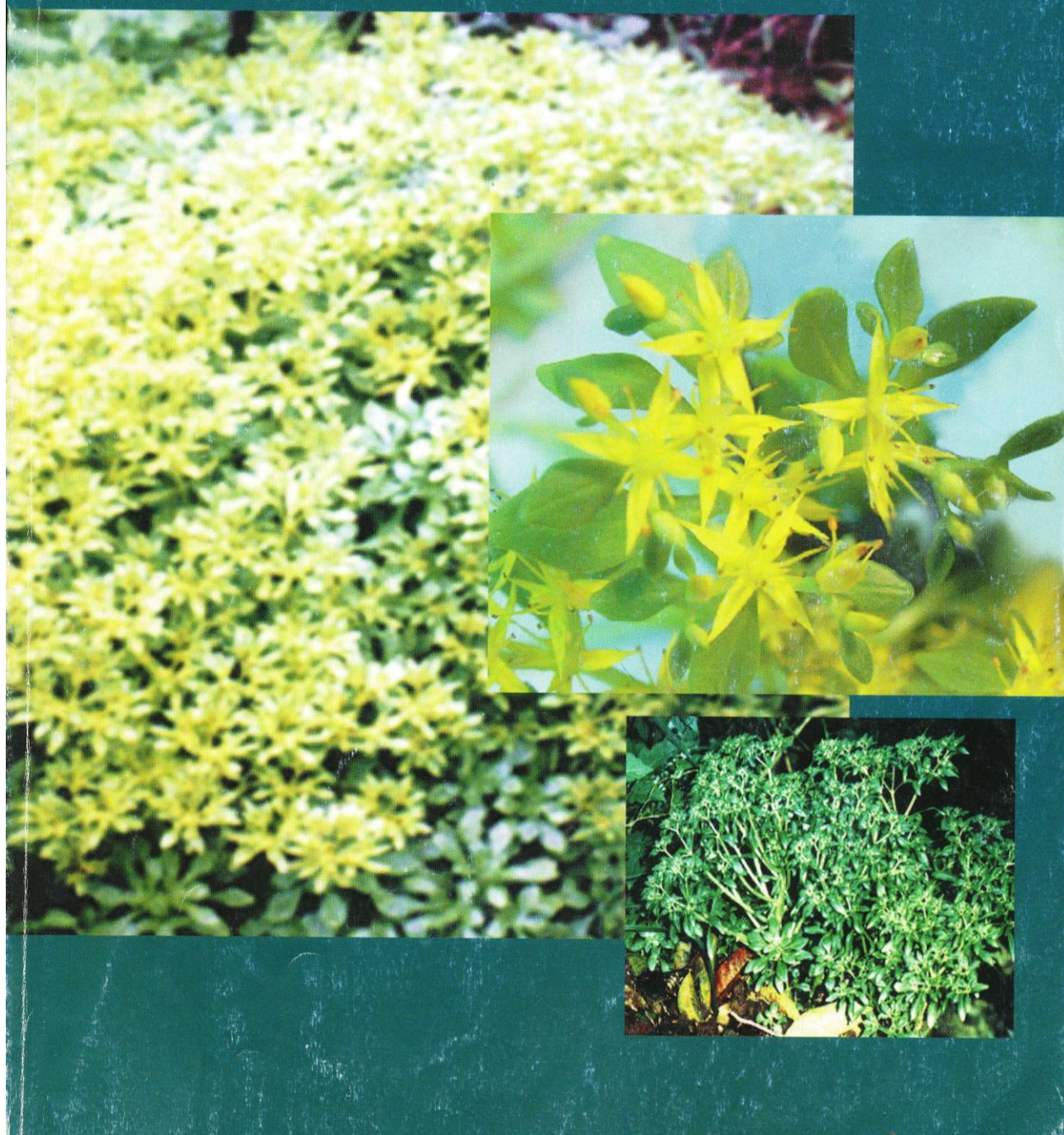
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Cover: *Sedum alfredii* Hance is a zinc-hyperaccumulating plant species newly found in China. It could tolerate Zn level of 240 mg Zn/L in solution and total Zn of 7422 mg/kg and DTPA-extractable Zn of 703 mg/kg in the polluted soil. It can accumulate about 1.9% zinc in shoots on dry matter basis. It is a perennial herb with fleshy stems and leaves. The rootstock of *Sedum alfredii* Hance is stolon, and its leaves are alternate with the lower leaves falling off frequently. The leaf shapes like cochlear, upside-down oval-shaped. Yellow stalkless flower has 4 sepals, 4 petals, 8 stamens and 4 carpels. This Zn-hyperaccumulating plant species has favorable characteristics including the fast growth rate, large biomass, asexual reproduction, and the plants can cover nearly 100% of the land surface. Besides, *Sedum alfredii* Hance could propagate 3 to 4 times a year when the environmental conditions are favorable. According to the field survey, shoot dry matter of *S. alfredii* Hance could be as high as 1800 kg/ha². Therefore, it is a potential good plant species for phytoremediation of heavy metal polluted soils (see the text by Yang Xiao'e et al. on page of 1634; photo by Yang Xiao'e).



NOTES

Determination of global mean sea surface WHU2000 using multi-satellite altimetric data

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Abstract In this study, the overall editing criteria for altimetric data are considered and the geophysical correction models is improved. The datum for various altimetric data is also unified and the method of a full-combined crossover adjustment for different altimetric tracks is used to improve the radial orbits of Geosat, ERS-1 and ERS-2 data. In addition, the method for determining mean sea surface (MSS) by using multi-altimetric data is developed. The data used to compute WHU2000 MSS include 7-year Topex/Poseidon data (cycles 11—249), 2-year Geosat ERM data (cycles 1—44), 5-year ERS2 data (cycles 1—52) and all ERS-1 168-day data. The WHU2000 MSS is determined with a grid resolution of $2' \times 2'$ within the $\pm 82^\circ$ latitude and its precision is better than 0.05 m. Comparing WHU 2000MSS with $3.75' \times 3.75'$ CLS_SHOM98.2 MSS, $3' \times 3'$ GFZ MSS95A and $3.75' \times 3.75'$ OSU MSS95, as external checks, the corresponding standard deviation (STD) of their differences is 0.090 m, 0.211 m and 0.079 m respectively.

Keywords: altimetry, mean sea surface, crossover adjustment.

The determination of mean sea surface (MSS) is an important scientific problem in the fields of geoscience and environment science nowadays. MSS referenced to an earth ellipsoid contains the information of geoid and sea surface topography (SST), thus it is widely used in geoid determination and in the study of sea surface temporal variability, crust movement, ocean circulation, etc. Satellite altimetry is a technique of space geodesy developed in the 1970s with the high techniques of space, electronics and microwave to measure the global sea surface heights (SSHs). Since satellite altimetry can provide highly repeated observations of the sea surface height on all days and weather, it has been extended to the multi-applied fields of geoscience instead of the initial single purpose of determining sea geoid figure¹⁾. Since 1973, 10 satellites with 11 altimeters have been launched

which are Skylab, Geos-3, Seasat, Geosat, ERS-1, ERS-2, Topex/Poseidon (T/P) GFO, Jason-1 and Enisat. Millions of altimetric measurements have been acquired which provide plenty of information for the investigation of global sea level changes, the earth gravity field, submarine topography, ocean lithosphere and ocean circulation^[4,9—13]. Some institutes abroad have released many MSS models using these information resources, which include OSU MSS95 in $3.75'$ grids²⁾, CLS_SHOM98.2 in $3.75'$ grids³⁾, GFZ MSS95A in $3'$ grids, KMS99 MSS in $3.75'$ grids^[8], etc. In China, some researchers also presented the MSS models China Sea and its adjacent area^[2,3]. The typical models among them are the first three ones. OSU MSS95 is a MSS with relatively high precision developed by OSU of the United States using Geosat, ERS-1 and T/P altimetric data, and the model is usually taken as the reference sea surface for the altimetric data processing of Geosat and T/P satellite, and it is widely used in oceanography and geophysics. GFZ MSS95A was developed by GFZ, and the last version of this model was taken as the reference sea surface for the data processing of ERS-1. CLS_SHOM98.2 MSS was presented by CLS of France using multi-altimetric data and its ultimate aim is to provide a reference sea surface for the altimetric data of Jason-1 and Envisat⁴⁾, the first of which was launched on December 7, 2001 and the second one on February 28, 2002. The development trend in this field is to combine more altimetric data for the determination of mean sea surface with higher resolution and higher precision. There are three main factors which continuously affect the accurate description MSS, the first is the precision of geophysical corrections and environment models. The second is effects of orbit errors. Although T/P has high orbit precision, the radial orbit errors of Geosat, ERS-1 and ERS-2 still exist, which should be reduced to improve the precision of MSS. The third is the inconsistency of coordinate datums between different altimetry satellites launched on different ages and for different missions, which were based on different reference frames with different earth ellipsoid parameters. The efforts should continuously be made to overcome the above unfavorable factors for further improving the precision of the MSS.

1 Data and pre-processing

The data used in the computation of WHU2000 MSS is described as follows: 7-year T/P data (11 cycle—249 cycle); all the ERS-1/168 data including Phase E from

1) Jiang, W. P., Ph.D. Thesis, The application of satellite altimetry in geodesy (in Chinese), Wuhan University, Wuhan February 28, 2001.

2) Yi, Y. C., Determination of gridded Mean Sea Surface from Topex, ERS-1 and Geosat altimeter data, Report No. 434, Dept. Of Geodetic Science and Surveying, The Ohio State University, Columbus, 1995.

3) Wang, H. Y., Ph. D. Thesis, Satellite altimeter data processing and its application in China seas and vicinity (in Chinese), Institute of Geodesy and Geophysics, the Chinese Academy of Sciences, Wuhan, 1999.

4) Hernandez, E., schaeffer, P., Altimetric Mean Sea Surface and Gravity Anomaly Maps Inter-comparisons, AVISO, Technical Report: AVI-NT-011-5242-CLS, 2000.

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ORIGINAL ARTICLE

Comparative analysis of different environmental loading methods and their impacts on the GPS height time series

Weiping Jiang · Zhao Li · Tonie van Dam · Wenwu Ding

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Abstract Three different environmental loading methods are used to estimate surface displacements and correct non-linear variations in a set of GPS weekly height time series. Loading data are provided by (1) Global Geophysical Fluid Center (GGFC), (2) Loading Model of Quasi-Observation Combination Analysis software (QLM) and (3) our own daily loading time series (we call it OMD for optimum model data). We find that OMD has the smallest scatter in height across the selected 233 globally distributed GPS reference stations, GGFC has the next smallest variability, and QLM has the largest scatter. By removing the load-induced height changes from the GPS height time series, we are able to reduce the scatter on 74, 64 and 41 % of the stations using the OMD models, the GGFC model and QLM model respectively. We demonstrate that the discrepancy between the center of earth (CE) and the center of figure (CF) reference frames can be ignored. The most important differences between the predicted models are caused by (1) differences in the hydrol-

ogy data from the National Center for Atmospheric Research (NCEP) vs. those from the Global Land Data Assimilation System (GLDAS), (2) grid interpolation, and (3) whether the topographic effect is removed or not. Both QLM and GGFC are extremely convenient tools for non-specialists to use to calculate loading effects. Due to the limitation of NCEP reanalysis hydrology data compared with the GLDAS model, the GGFC dataset is much more suitable than QLM for applying environmental loading corrections to GPS height time series. However, loading results for Greenland from GGFC should be discarded since hydrology data from GLDAS in this region are not accurate. The QLM model is equivalent to OMD in Greenland and, hence, could be used as a complement to the GGFC product to model the load in this region. We find that the predicted loading from all three models cannot reduce the scatter of the height coordinate for some stations in Europe.

Keywords Environmental loading · GGFC · QOCA · GPS height coordinate time series

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1 Introduction

GPS coordinate time series residuals derived from a long-term linear trend exhibit significant variation. The strong annual signal observed at most sites is now known to be true physical site motion driven by environmental mass redistribution (Blewitt et al. 2001; Blewitt and Lavallée 2002). However, some fraction of the annual signal (amplitude and phase) is driven by GPS technique errors (van Dam et al. 2010; Tregoning et al. 2009, etc). Previous research has established the significance of environmental loading, i.e. loading contributions due to changes in atmospheric pressure (ATML), continental water storage (CWS), and non-tidal ocean loading



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Effects on noise properties of GPS time series caused by higher-order ionospheric corrections

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Abstract

Higher-order ionospheric (HOI) effects are one of the principal technique-specific error sources in precise global positioning system (GPS) analysis. These effects also influence the non-linear characteristics of GPS coordinate time series. In this paper, we investigate these effects on coordinate time series in terms of seasonal variations and noise amplitudes. Both power spectral techniques and maximum likelihood estimators (MLE) are used to evaluate these effects quantitatively and qualitatively. Our results show an overall improvement for the analysis of global sites if HOI effects are considered. We note that the noise spectral index that is used for the determination of the optimal noise models in our analysis ranged between -1 and 0 both with and without HOI corrections, implying that the coloured noise cannot be removed by these corrections. However, the corrections were found to have improved noise properties for global sites. After the corrections were applied, the noise amplitudes at most sites decreased, among which the white noise amplitudes decreased remarkably. The white noise amplitudes of up to 81.8% of the selected sites decreased in the up component, and the flicker noise of 67.5% of the sites decreased in the north component. Stacked periodogram results show that, no matter whether the HOI effects are considered or not, a common fundamental period of 1.04 cycles per year (cpy), together with the expected annual and semi-annual signals, can explain all peaks of the north and up components well. For the east component, however, reasonable results can be obtained only based on HOI corrections. HOI corrections are useful for better detecting the periodic signals in GPS coordinate time series. Moreover, the corrections contributed partly to the seasonal variations of the selected sites, especially for the up component. Statistically, HOI corrections reduced more than 50% and more than 65% of the annual and semi-annual amplitudes respectively at the selected sites.

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Keywords: Coordinate time series; Higher-order ionospheric effects; Periodic characteristics; Noise analysis

1. Introduction

Global positioning system (GPS) coordinate time series are used widely to study the geophysical signals and to establish the international terrestrial reference frame (ITRF). A number of investigators have studied the characteristics of GPS coordinate time series (Mao et al.,

1999; Nikolaidis, 2002; Penna et al., 2007; Ray et al., 2008; Williams et al., 2004). The general features are considered relatively well known. Seasonal signals (defined as annual plus semi-annual variations) are pervasive, superposed against approximately power-law backgrounds. Overall, residual power declines with increasing frequency, consistent with a flicker noise distribution plus white noise at high frequencies. An improved understanding of the related mechanisms that cause seasonal variations is expected to separate signal from noise in GPS positions better. Possible errors include both geophysical effects (e.g., mis-modelled tides and unmodelled non-tidal loading

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A new method for GLONASS inter-frequency bias estimation based on long baselines

Weiping Jiang^{1,2} · Xiangdong An¹ · Hua Chen² · Wen Zhao²

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Abstract Frequency division multiplexing of GLONASS signals causes inter-frequency bias (IFB) in receiving equipment. IFB significantly increases the difficulties of fixing GLONASS ambiguities and limits the accuracy and reliability of GLONASS positioning and orbit determination. Accurately estimating and calibrating IFB can effectively solve such a problem. However, at present, most methods of IFB estimation are based on zero and short baselines, in which case it is not only difficult to realize fast and efficient IFB estimation but also one cannot fully utilize publicly available IGS and CORS data. Therefore, we present a new method for GLONASS IFB estimation based on long baselines. First, to weaken the influence of inter-frequency code bias, the wide-lane ambiguities are calculated directly based on the wide-lane combinations of observations. Then, according to the range of inter-frequency phase bias (IFPB) rates, a IFPB defined as the difference in IFPBs between adjacent frequencies, a step-by-step search schedule is designed to remove the impacts of IFPB on wide-lane and narrow-lane ambiguity resolution. Finally, after fixing integer wide-lane and narrow-lane ambiguities, the IFPB rate can be estimated. An experimental network is set up to verify the validity of this method; the experiment includes the data observed for 31 days at 542 stations in Europe and North America. The IFPB rates of 38 receiver types from nine manufacturers are successfully determined. Experimental results show

that the estimated IFPB rates for the same receiver type stabilize within a month with a standard deviation of less than 1.4 mm/Δ*f* (millimeters per frequency number increment, Δ*f* denotes the frequency difference of adjacent GLONASS frequencies with frequency number increment of 1). Generally, the difference in IFPB rates of receiver types from the same manufacturer does not exceed 2.5 mm/Δ*f*. However, the estimated IFPB rates of Septentrio's newly produced receivers, as compared with that of the old receiver types, show a rate difference of up to 50 mm/Δ*f*. This significant difference should be considered for practical applications.

Keywords GLONASS · Long baselines · Ionospheric-free ambiguity resolution · Inter-frequency bias

Introduction

In addition to GPS, GLONASS is currently another global navigation satellite system (GNSS) with independent operation and global coverage. As of March 2017, GLONASS has 27 satellites in orbit, of which 24 are in operation (<https://www.glonass-iac.ru/en/GLONASS/>). Unlike GPS, GLONASS employs frequency division multiple access (FDMA) technology and transmits signals on 14 frequencies (frequency number from −7 to 6), and its antipodal satellites share the same frequency. Therefore, individual satellites emit distinguishable signals (ICD 2008). Although FDMA will be replaced gradually with code division multiple access technology (Revnivkykh 2010), only GLONASS FDMA signals can provide continuous dual-frequency coverage over the next decade. Frequency division multiplexing of GLONASS signals causes inter-frequency bias (IFB) in the receiving

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Accuracy analysis of continuous deformation monitoring using BeiDou Navigation Satellite System at middle and high latitudes in China

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Abstract

As BeiDou Navigation Satellite System (BDS) has been operational in the whole Asia-Pacific region, it means a new GNSS system with a different satellite orbit structure will become available for deformation monitoring in the future. Conversely, GNSS deformation monitoring data are always processed with a regular interval to form displacement time series for deformation analysis, where the interval can neither be too long from the time perspective nor too short from the precision of determined displacements angle.

In this paper, two experimental platforms were designed, with one being at mid-latitude and another at higher latitude in China. BDS data processing software was also developed for investigating the accuracy of continuous deformation monitoring using current in-orbit BDS satellites. Data over 20 days at both platforms were obtained and were processed every 2, 4 and 6 h to generate 3 displacement time series for comparison. The results show that with the current in-orbit BDS satellites, in the mid-latitude area it is easy to achieve accuracy of 1 mm in horizontal component and 2–3 mm in vertical component; the accuracy could be further improved to approximately 1 mm in both horizontal and vertical directions when combined BDS/GPS measurements are employed. At higher latitude, however, the results are not as good as expected due to poor satellite geometry, even the 6 h solutions could only achieve accuracy of 4–6 and 6–10 mm in horizontal and vertical components, respectively, which implies that it may not be applicable to very high-precision deformation monitoring at high latitude using the current BDS. With the integration of BDS and GPS observations, however, in 4-h session, the accuracy can achieve 2 mm in horizontal component and 4 mm in vertical component, which would be an optimal choice for high-accuracy structural deformation monitoring at high latitude.

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Keywords: Beidou Navigation Satellite System; Continuous deformation monitoring; Middle and high latitudes of China; Accuracy analysis

1. Introduction

GNSS has been a major means used in all types of structural deformation monitoring in recent years due to its continuous, all-weather, automated and highly accurate measurement services. Normally, long-term continuous

deformation monitoring and real-time dynamic deformation monitoring are the two typical patterns in the monitoring realm (Im et al., 2013). Currently, long-term continuous monitoring achieved by either ground-based GNSS receivers or robust telemetry are always adopted for monitoring the health of engineered structures, such as dams, land subsidence, landslide, and earthquake engineering, where a high precision is required for detecting small and slow displacements (Deloach, 1989). GPS baseline processing has been demonstrated to be capable of

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Article

Analysis of Ionospheric Vertical Total Electron Content before the 2014 Mw8.2 Chile Earthquake

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Abstract: This paper studies ionospheric vertical total electron content (VTEC) variations before the 2014 Mw8.2 Chile earthquake. VTEC derived from 14 GPS (Global Positioning System) stations and GIM (Global Ionospheric Map) were used to analyze ionospheric variations before the earthquake using the sliding interquartile range method, and results showed that significant positive VTEC anomalies occurred on 28 March. To explore possible causes of these anomalies, effects of solar and geomagnetic activities were examined, and VTEC variations during 17 March to 31 March in 2009-2013 were cross-compared. Also, VTEC for a full year before the earthquake was investigated. Results indicated that these anomalies were weakly associated with high solar activities and geomagnetic storms and that these anomalies were not normal seasonal and diurnal variations. An analysis of the spatial distribution of the observed anomalies was also presented, and it demonstrated that anomalies specifically appeared around the epicenter on 28 March. It suggests that observed anomalies may be associated with the subsequent Chile earthquake. Equatorial anomaly variations were analyzed to discuss the possible physical mechanism, and results showed that the equatorial anomaly unusually increased on 28 March, which indicates that anomalous electric fields generated in the earthquake preparation area and the meridional wind are possible causes of the observed ionospheric anomalies.

Keywords: ionosphere; vertical total electron content (VTEC); seismo-ionospheric anomaly

1. Introduction

Since the 1960s, a multitude of studies have identified abnormal variations of ionospheric parameters before many large earthquakes [1–8]. In recent years, GPS, with numerous worldwide and regional networks, has created a potentially powerful tool to investigate ionospheric TEC variations. Many researchers analyzed GPS TEC variations before devastating earthquakes worldwide, and suggested that GPS TEC could be used to detect possible ionospheric anomalies associated with subsequent earthquakes. For instance, Zhou et al. used 22 GPS stations in China to study VTEC variations during the Wenchuan earthquake, and the results indicated that VTEC around the epicenter increased both 9 and 3 days before the earthquake and decreased 6 days before the earthquake [9]; Yao et al. analyzed ionospheric variations occurring before the 2011 Mw 9.0 Japan earthquake, and proposed that the ionospheric anomaly occurring on 8 March might be a precursor of the earthquake [10]; Ho et al. investigated the ionospheric variations using TEC and electron density during the 2010 M8.8 Chile earthquake, and the results showed that TEC and electron density increased 9 to 19 days before the earthquake and specifically over the epicenter [11].

Although there are many papers reporting the identification of ionospheric anomalies before earthquakes, it remains controversial whether these anomalies are actually related to forthcoming earthquakes [12–16]. There was no statistically significant correlation between TEC anomalies and

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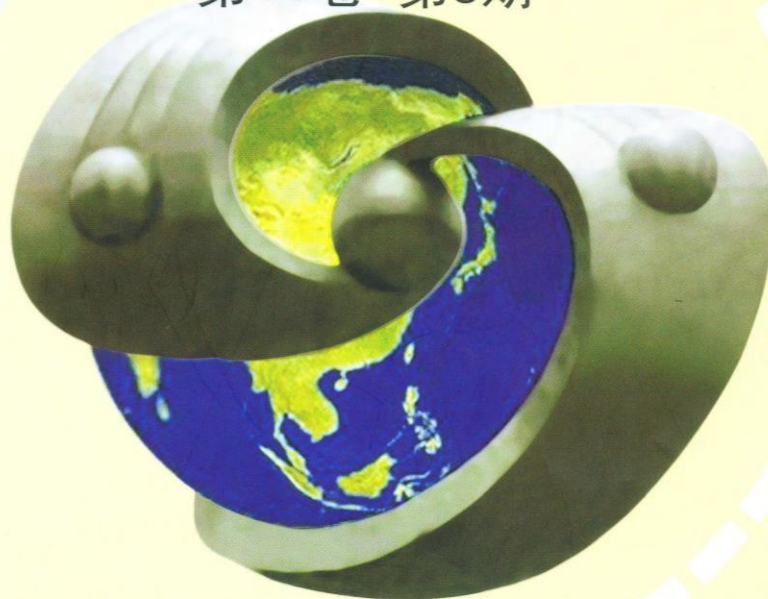
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CORS 系统中坐标移动转换方法及应用

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摘要: 针对目前 CORS 系统中坐标转换存在的不足, 提出了坐标移动转换方法, 并利用广州市和江苏省 C 级 GPS 点数据进行了测试。结果表明, 坐标移动转换方法能够有效地提高坐标转换的精度, 且简单实用。

关键词: CORS; 坐标转换; GPS

中图法分类号: P226.3; P228.42

自 2000 年深圳 CORS 系统建立以来, CORS 系统在我国得到了迅速的推广和发展^[1]。目前, 广东、江苏、广州、武汉、东莞等多个省、市已建成了 CORS 系统。通过 CORS 系统得到的流动站的初始坐标是 WGS84 坐标, 而在实际生产中一般需要的是国家或地方坐标, 这就需要根据具体情况将 WGS84 坐标转换到所需的国家(地方)坐标系下, 以满足各种工程的需要。一般情况下, 先按区域(如一个城市)求出转换参数, 然后利用转换参数进行坐标转换。这种作业模式固然有它的优点, 但对于较大范围(如一个省或大城市)会造成很多不便。如对于一个省, 由于提供多个区域的转换参数, 这样会造成在区域的边缘地区不但坐标转换精度不好, 而且在相邻的重合区域, 转换后的坐标不惟一。对于一个较大面积的城市, 由于大多只使用一个转换参数, 造成有些区域的坐标转换后的精度明显偏低, 不能很好地与局部地区的坐标符合。因此, 如何对流动测点进行坐标转换, 以获得高精度的坐标, 是一个亟需解决的问题。鉴于此, 本文提出了一种新的坐标转换方法——坐标移动转换法, 以克服现有方法的局限性。

1 坐标移动转换法

坐标移动转换法的基本思路是: 以流动点为中心, 采用一定的距离为半径画圆, 形成一个搜索

范围, 选取该范围内的已知点坐标, 求取坐标转换参数, 然后利用这套参数对流动点坐标进行转换。对于一个区域, 不需求取统一的区域转换参数, 只需对每个点按上述思路进行坐标转换即可。由于在求转换参数时, 并不是一个区域的所有已知点都参与计算, 而是根据需要将离中心点(待转换点)一定距离范围内的点筛选出来参与求解, 距离范围的设定根据实际情况而定。这样确定的转换参数不但转换精度高, 而且也能统一到所需要的基准上。

转换参数既可以是四参数, 也可以是七参数。本文以七参数转换法^[2]为例进行讨论。

2 高程误差对七参数转换的影响

2.1 高程趋近法

由于国家(地方)坐标系一般采用二维的平面坐标系, 没有精确的大地高, 因此, 采用七参数转换时, 必须考虑大地高的误差对转换精度的影响^[3,4]。本文采用高程趋近法^[5]。

高程趋近法的具体过程如下: 先用 GPS 大地高 H_{84} 代替国家(地方)坐标系所对应的高 H_a 进行七参数求解, 然后根据求出的七个参数求出第一组 H_{84} 所对应的国家(地方)坐标系下的大地高, 记为 H_1^{84} , 利用新求得的 H_1^{84} 重新求解七参数, 再用七个参数求得 H_{84} 所对应的国家(地方)坐标系下的大

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10	NCET-07-0639	任 放	武汉大学	教育部	20	2008-2010
11	NCET-07-0638	秦前红	武汉大学	教育部	20	2008-2010
12	NCET-07-0637	彭天石	武汉大学	教育部	50	2008-2010
13	NCET-07-0636	潘 敏	武汉大学	教育部	20	2008-2010
14	NCET-07-0635	罗志才	武汉大学	教育部	50	2008-2010
15	NCET-07-0634	李立家	武汉大学	教育部	50	2008-2010
16	NCET-07-0633	姜卫平	武汉大学	教育部	50	2008-2010
17	NCET-07-0632	姜清辉	武汉大学	教育部	50	2008-2010
18	NCET-07-0631	黄如花	武汉大学	教育部	20	2008-2010
19	NCET-07-0630	何小华	武汉大学	教育部	50	2008-2010
20	NCET 07-0629	龚 威	武汉大学	教育部	50	2008-2010
21	NCET-07-0628	程永光	武汉大学	教育部	50	2008-2010

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