Chapter 12

# Discussions

The previous chapters of this book covered the most important contents of static and kinematic as well as dynamic GPS, including theory, algorithms, and applications. At the end of this book, the author will emphasize, discuss and comment on some important topics and remaining problems with GPS.

## 12.1 Independent Parameterisation and A Priori Information

### *A Priori Information*

As already discussed in the parameterisation of the GPS observation model (Sects. 9.1 and 9.2), clock errors and instrumental biases as well as ambiguities are partially over-parameterised or linearly correlated (related to themselves and between them). Cancelling the over-parameterised unknowns out of the equation or modelling them first and then keeping them fixed using the a priori method (Sect. 7.8) is, generally speaking, equivalent. As long as one knows which parameters should be kept fixed, the a priori information used is true one and is just used as a tool for fixing the parameters to zero. If the model is not parameterised regularly and one does not exactly know which parameters are over-parameterised, then the normal equation will be singular and cannot be solved. Again, using a priori information may make the equation solvable. However, in this case, the a priori information has the meaning of the direct "measures" on the related parameters. Therefore the a priori information used must be a true and reasonable one; otherwise, the given a priori information will affect the solution in some unreasonable ways. If different a priori information is given, different results will be obtained. Therefore, the a priori information used should be based on true information.

### *Independent Parameterisation of the Observation Model*

A priori information can be obtained from external surveys or from the experiences of long term data processing that does not use a priori information. A regular (independent) parameterisation of the GPS observation model is a precondition for a stable solution of the normal equation without using a priori information. As mentioned above, to parameterise the model independently or to fix the over-parameterised unknowns are equivalent. However, in order to keep some parameters fixed one has to know which parameters are over-parameterised and have to be fixed. Therefore, in any case, one has to know how to parameterise the GPS observation model regularly. Fixing the over-parameterised unknowns after a general parameterisation is equivalent to a direct independent parameterisation. Therefore, the parameterisation of the GPS observation model should be regular.

### *Inseparability of Some of the Bias Effects*

Independent parameterisation is necessary because of the linear correlation of some parameters. The linear correlation partially merges the different effects together so that these effects cannot be separated exactly from each other. The constant parts of the different effects are nearly impossible to be separated without precise physical models, whereas many model parameters are presented in the GPS observation equation and have to be codetermined. The inseparability of the bias effects comes partially from the physics of the surveys and depends on strategy of the surveys. Understanding the inseparability of the bias effects is important for designing surveys. The physical models have to be determined more precisely in order to separate the constant parts of the effects.

### *Changing of the Physical Meanings of the Parameters*

Because of the linear correlation and inseparability of some parameters, the parameters that are to be adjusted may sometimes change their physical meanings. For example, the instrumental biases of the reference frequency and channel are linearly correlated with the clock errors. This indicates that the mentioned biases cannot be modeled separately so that the clock error parameters represent the summation of the clock errors and the related instrumental biases. They may only be separated through extra surveys or alternative models. If the clock errors of the reference satellite and receiver are not adjusted, then the other clock errors represent the relative errors between the other clocks and the reference ones. If the other instrumental biases are not modelled, then they will be absorbed partly into the ambiguities. In such a case the ambiguities represent not only the ambiguities but also parts of instrumental biases so that the ambiguities are not integers anymore. The double difference may eliminate the instrumental biases so that the double differenced ambiguities are free from the effects of instrumental biases, whereas the un-differenced ambiguities include those biases. If the instrumental errors are not modeled, the un-differenced ambiguities are not integers anymore, whereas the double differenced ambiguities are integers (no data combinations are considered here).

### *Zero Setting and Fixing of the Parameters*

Setting a parameter to zero or fixing the parameter to a definite value must be done carefully. Any incorrect setting or fixing is similar to a linear transformation (translation) of the linearly correlated parameters. For example, the clock errors and instrumental biases of the reference station and satellite generally are not zero. Keeping the clock errors and instrumental biases of the reference as zero is similar to making a time system translation with an unknown amount, and such a translation is an inhomogeneous one, because the orbit data are given in the GPS time system. External surveys may help for a correct zero setting.

### *Independent Parameterisation of Physical Models*

Independent parameterisation of the bias parameters of the GPS observation model indicates the necessity of further study of the parameterisation problem. As long as the parameters of the physical models should be codetermined by the GPS observation equations, how to parameterise the physical models should be investigated with great care.

## 12.2 Equivalence of the GPS Data Processing Algorithms

### *Equivalence Principle*

For definitive measures and parameterisation of the observation model, the uncombined und combining algorithms, undifferenced and differencing algorithms, as well as their mixtures are equivalent. The results must be identical and the precisions are equivalent. The practical results should obey this principle.

The equivalence comes from the definite information contents of the surveys and the definitive parameterisation of the observation model. For better results or better precisions of the results, better measures should be made.

### *Traditional Combinations*

Under the traditional parameterisation, the combinations are equivalent. Under the independent parameterisation, the combinations are equivalent, too. However, the combinations under the traditional parameterisation and independent parameterisation are not equivalent. Due to the inexactness of the traditional parameterisation, traditional combinations will lead to inexact results.

### *Traditional Differencing Algorithms*

Traditional differencing algorithms usually only take the differencing equations into account and leave the undifferenced part aside. In this way, the differencing part of equations includes fewer parameters and the systematic effects are reduced. Meanwhile, however, the information contents of the observables are also reduced proportionally. The results of the interested parameters remain the same.

### *Equivalent Algorithms*

Equivalent algorithms are general forms of undifferenced and differencing algorithms. The observation equation can be separated into two diagonal parts, respectively. Each part uses the original observation vector (therefore the original weight matrix); however, the equation owns only a part of the unknown parameters. The normal equation of the original observation equation can be separated into two parts, too. This indicates that any solvable adjustment problem can be separated into two sub-problems.