Atmos. Chem. Phys. Discuss., 14, C8161–C8163, 2014
www.atmos-chem-phys-discuss.net/14/C8161/2014/

Atmospheric Chemistry and Physics
Discussions
Open Access

Interactive comment on "Ergodicity test of the eddy correlation method" *by* J. Chen et al.

J. Chen et al.

chenjinbei@lzb.ac.cn

Received and published: 17 October 2014

The ergodic assumption was first raised by Boltzmann (1871) in his study of ensemble theory of statistical dynamics. The stationarity and ergodicity turns into two central concepts (required conditions) used to link field measurements and the NS equations or field measurements to "boundary conditions" at the land-atmosphere interface. The ergodic hypothesis is a basic hypothesis in atmospheric turbulent experiment. Stationarity, homogeneity, and ergodicity are routinely used to link the ensemble statistics (mean and higher-order moments) of turbulence field measurements collected in the ASL and CSL to land surface processes. Many literatures habitually referred to the ergodic assumption, as some descriptions such as "when satisfying ergodicity hypothesis, ……" or "something indicates that ergodicity hypothesis is satisfied". Though the evidence of the validity of the ergodic hypothesis in the ASL is just the success of

Monin-Obukhov similarity theory (MOST) for unstable and near-neutral conditions in atmospheric surface layer, the success of similarity theory, as a necessary condition for ergodicity in the ASL, does not prove ergodicity (Katul et al., 2004). However, the direct testing of the ergodic hypothesis in the ASL has frustrated all experimental efforts and frames the compass of this work (Higgins et al., 2013). So the theoretical demonstration or quantitative testing of direct observational experiment, which is relating to the ergodicity of the atmospheric turbulence, was hardly found. The lidar technique opens up new possibilities for atmospheric measurements and analysis by providing simultaneous high-resolution spatial and temporal atmospheric information (Eichinger et al., 2001). The stationarity and ergodicity can be tested for such ensembles of experiments. Recent advances in LIDAR (Light Detection and Ranging) measurements offer a promising first step for direct evaluation of such hypotheses for ASL flows (Higgins et al., 2013). However, after Boltzmann's ergodic assumption, the notable advances have occurred with the theoretical demonstration and testing of direct experiment in the mathematics and physics, as shown in our article. Especially, the ergodic theorem of the stationary random processes is proved in the mathematics and the ergodicity of turbulence in the physics is tested. And that the necessary and sufficient condition of the ergodicity for stationary random processes is offered. Obviously, the advances of research on the ergodicity in the mathematics and physics are far more quickly than the atmospheric science. This paper tries firstly to introduce the ergodic theorem of the stationary random processes to atmospheric turbulence in surface layer. However, the base of this work is not assumed in MOST, but also going from the ergodic theorem for stationary random processes. The results shown MOST is satisfy the ergodicity condition. It is obvious that the study is conditioned by stationary random processes. Firstly, was the turbulent flow in ASL a stationary random process? In the spatial scale, the atmospheric turbulence from the dissipation range, inertial sub-range to energy range, and further large eddy of turbulent flow is extremely broad. Following the diurnal variation of atmosphere, an eddy of which the temporal scale is larger than 1 hour can hardly meet stationary random process or steady flow, but a smaller-scale eddy (for example 2 min scale) is frequently stationary. The eddies in different scales are also different in terms of their spatial structure and physical properties, and even their transport characteristics are not all the same. It is thus reasonable that the eddies with different transport characteristics are separated and studied by using filtering method. Because the study is just a try to introduce firstly the ergodic theorem of the stationary random processes to atmospheric turbulence, we did not select data involve of complex surface in order to avoid disturbances of terrain. Even so, a neutrally stratified result during 7:00-8:00 has led to a great confusion. Because the 7:00-8:00 is a transition period, there were large differences among the stratifications of the eddies in different scales. But the small-scale eddies had kept stationarity in a certain degree. In the future, we will study the ergodicity of turbulence involve of complex surface. We think privately that the complex surface can only influence on the large-scale eddies, but the small-scale eddies are still steady due to the isotropous eddies and the scaling law of -5/3 from the dissipation range to inertial sub-range.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/14/C8161/2014/acpd-14-C8161-2014-supplement.pdf

---

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 18207, 2014.