东亚季风和中国暴雨

——庆贺陶诗言院士八十华诞

中国科学院大气物理研究所 编

气象出版社

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——庆贺陶诗言院士八十华诞文集

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内 容 提 要

本书内容共分三部分。第一部分是陶诗言院士关于东亚季风及中国暴雨研究方面的代表作；第二部分集中反映陶诗言院士在季风、暴雨、卫星气象及中小尺度研究方面的突出贡献；第三部分体现了陶诗言院士的国内外弟子及友人在季风、暴雨、卫星气象、中小尺度等方面研究的最新观点和成果，以及在辐射、波流相互作用及稳定性等研究方面的新进展。

本书对关心陶诗言院士在季风及暴雨方面研究成就的人，以及对关心季风及暴雨研究最新进展的人来说具有重要的参考价值。

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陶诗言院士近照

庆贺陶诗言院士八十华诞

１９４２年陶诗言先生毕业于重庆中央大学

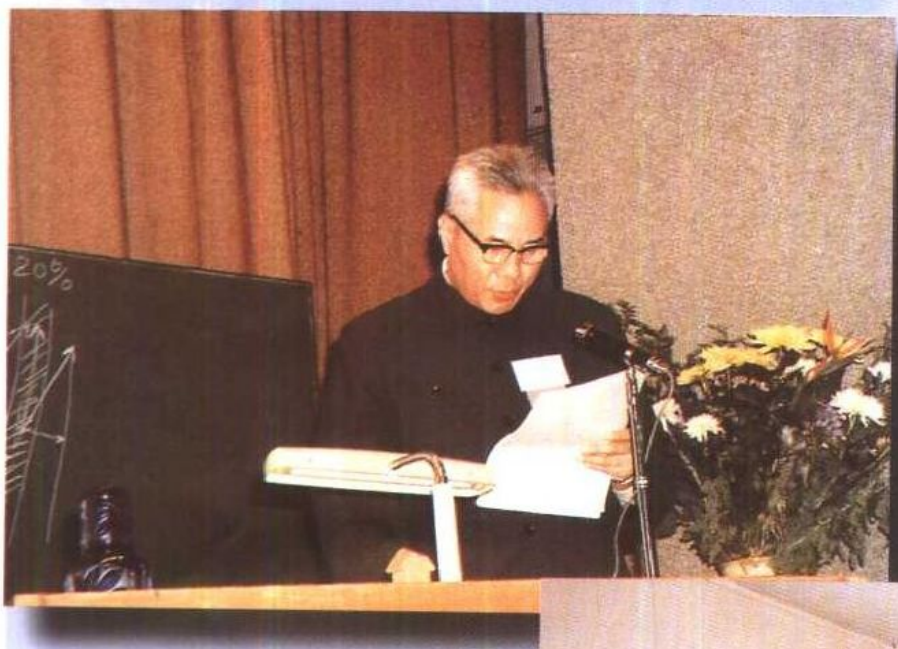
１９４０年陶诗言先生（左二）在重庆中央大学校园内与气象组同学顾震潮（左一）、黄士松（右二）和陈其恭（右一）合影

１９５６年陶诗言先生当选为全国先进生产者

１９５０年陶诗言先生（右一）任联合天气分析预报中心副主任时，与曹恩爵副主任（左一）和顾震潮主任（中）于西郊动物园合影

１９９４年陶诗言先生和夫人与孙子孙女在家中庆祝生日

庆贺陶诗言院士八十华诞



1975年中国气象学会代表团访美期间，陶诗言先生在美国国家飓风中心讲学

1980年陶诗言先生在中央气象台进行天气会商

1995年陶诗言院士（左二）在国家气候中心专家咨询委员会上接受聘书

《东亚季风和中国暴雨》
——庆贺陶诗言院士八十华诞文集
编 委 会

序

陶诗言院士是我国天气预报理论和方法的开拓者之一，是国际上著名的气象学家。今年欣逢他八十华诞，为庆贺他为我国气象事业做出的杰出贡献，中国科学院大气物理研究所特编辑此论文集。

我和他是五十多年的同事，在五十多年来和他共同工作和交往的过程中，他急国家之所急的态度深深地感染着我，五十多年来他的工作都是从国家之所急出发，抓住国际前沿问题进行研究。

50年代为提高我国天气预报的水平，我们共同研究了东亚大气环流。当时对冬季寒潮的预报深深地困扰着广大预报员，他对此进行了大量研究，他从北半球大气环流出发，提出影响我国的寒潮主要有三条路径。这个研究一方面大大地提高了寒潮预报水平，另一方面也为研究冬季欧亚大气环流形成的机理做出了贡献；60年代他看到卫星云图已在发达国家用于天气预报，为解决气象卫星云图在我国天气预报中的应用问题，他率领学生开展了卫星气象学研究，总结出一套卫星云图应用方法推广到全国，大大提高了我国短期预报的水平；70年代，他又针对我国暴雨灾害的严重性，对暴雨以及中、小尺度系统的天气学特征及动力学进行了系统而全面的研究，大大提高了我们对我国暴雨系统的认识；季风是影响我国降水和旱涝最重要的天气和气候系统，也是国际前沿研究课题，为提高长期天气和短期气候预报水平，80年代后，他在大气物理研究所和中国气象局指导开展东亚季风研究，对东亚季风变化和异常、成因与预测进行了系统研究，使我国在季风研究方面跨进世界先进行列。

《东亚季风和中国暴雨》这部论文集不仅收集了反映陶诗言院士关于季风、暴雨，以及中、小尺度系统研究方面的代表论著，还刊登了陶诗言院士的合作者和学生近期关于季风、暴雨、卫星气象学等方面尚未发表的30余篇研究论文。因此，这部论文集不仅记述了陶诗言院士在东亚季风和中国暴雨方面的研究成就，而且反映了此领域近年来研究的新进展。

此论文集的出版，可以使我们更深刻地感受到陶诗言院士开拓我国当代天气预报理论和方法的艰难历程和奋斗不息的献身精神，它将激励我们继续前进，努力攀登大气科学的新高峰。

叶笃正

1998年6月8日

Preface

Academician TAO Shiyan, a world well-known meteorologist, is one of the pioneers of the theory and methods of weather forecasting in China. 1998 will witness his eightieth birthday. The Institute of Atmospheric Physics of Chinese Academy of Sciences compiles this collection of papers to celebrate his outstanding contributions to the Chinese meteorological service.

We have been colleagues for more than fifty years. In that last fifty years and more of our associations, he impressed me deeply with his attitude of being eager to meet the needs of the country in the first place and has been working on the world frontier of science.

In order to improve our weather forecast, we worked together to study the atmospheric circulation over East Asia in 1950s. At that time, cold waves in winter was a problem puzzling the weather forcasters. He therefore did a lot of research work on that problem. He concluded that the cold waves resulting from the Northern Hemispheric atmospheric circulation invaded China mainly with three types of paths which he identified. This research greatly improved our forecast of cold waves. Besides, it was also a contribution to the research on the generation mechanism of the Eurasian atmospheric circulation in winter. In 1960s, he found that satellite images were used in weather forecast in the developed countries. In order to apply the satellite images to the weather forecast in China, he led his students to conduct research on satellite meteorology and summarized a set of methods of using satellite images for use in China which greatly improved the quality of China's short-range weather forecast. In 1970s, in view of the severe disasters caused by torrential rain, he undertook systematic and comprehensive studies of the synoptic features and dynamics of torrential rains, and associated with meso- and small-scale weather system as well. His research greatly improved our understanding on the torrential rain system in China. Monsoon is an important weather and climate system affecting the precipitation and drought/flood in China and is also the front of subject of world research. In order to improve our long-range weather forecast and short-term climate prediction, he have been guiding the research on East Asia monsoon in the Institute of Atmospheric Physics and China Meteorological Administration since 1980. Systematic studies of the changes, anomaly, causes, and prediction of the East Asian monsoon are carried out. This brings China to the front in the world monsoon research.

The collection of papers entitled *East Asian Monsoon and Torrential Rain in China* collected not only the representative academic papers of Academician TAO Shiyan on monsoon, torrential rain as well as meso- and small-scale weather system, but also more than 30 update papers by his co-authors and students on monsoon, torrential rain and satellite meteorology. It not only records the research achievements of Academician TAO Shiyan in East Asian monsoon and torrential rain research but also reflects the progress and up-date

achievements in these research fields.

The publication of this collection of papers can make us feel the difficult course and the spirit of devotion and dedication of Academician TAO Shiyan in pioneering the modern theory and methods of weather forecast. His spirit will inspire us to march forward and to climb the new height of atmospheric sciences.

YE Duzheng
June 8, 1998

前　言

陶诗言院士是我国当代天气预报理论和方法的开拓者之一，是国际知名的季风研究专家。他诞生于浙江省嘉兴县，1942年毕业于中央大学地理学系，1944年跟随我国著名气象学家赵九章先生在中央研究院气象研究所从事科研工作。50年代初期，国家成立了“联合天气分析预报中心”，陶诗言任中心副主任，该中心是现国家气象中心的前身，成立时承担了国家气象保障的重任，每天都要向全国各有关部门提供短期和中期天气预报。在这期间，陶诗言先生为全国气象预报保障做出了具有历史意义的贡献，并积累了大量关于中国和东亚地区天气分析和预报方法的宝贵经验，为他以后的理论研究打下了坚实的基础；1954年7月，长江流域发生了百年未遇的洪水，当时汉口危在旦夕，陶诗言先生及他的同事们作出准确的天气预报，预测暴雨即将终止，使汉口脱险。由于他在天气预报上的突出贡献，1956年获得全国先进工作者称号；50年代中后期，陶诗言先生同叶笃正先生、顾震潮先生等一起合作完成“东亚大气环流的研究”论文3篇，均发表在国际著名气象学杂志《Tellus》上，深受国际大气科学界的重视。

60年代以后，我国开展了国防尖端科学技术攻关和试验，组织上把气象保障任务交给了他。从1963年到1967年，他不仅多次为这些国防科学技术的试验提供了准确的气象保障，而且还培养了一大批青年技术骨干。因此他分别于1964年及1966年荣立二等功及一等功各一次。

60年代末，为填补气象卫星云图应用于日常的天气预报业务这项国内空白，陶诗言先生组织了一支队伍，着手研制卫星云图的接收设备，编纂了《中国卫星云图使用手册》。陶诗言先生还利用卫星云图发展了一套识别天气系统的方法，特别是预报台风发生、发展的方法，至今还为广大气象台站所使用；70年代中期到80年代，陶诗言先生又专心致力于暴雨的研究，提出了暴雨形成过程中多尺度相互作用的概念及暴雨落区预报方法，撰写了《中国之暴雨》这本专著。

除以上成就外，陶诗言先生又长期从事东亚季风的研究，包括东亚夏季风系统的平均结构及其与印度季风系统的异同，东亚夏季风的年际变化及季内变化，以及南海季风同印度季风的差异等。他在季风方面的研究成就为国际所公认。

陶诗言院士为我国当代天气预报的理论和方法撰写了许多论著，已发表科学论文80余篇，专著8本。他于1978年获全国科学大会奖，1980年获国家科委和国家农委颁发的科学技术成果推广应用奖，1987年因东亚大气环流研究（与叶笃正院士等合作）获国家自然科学一等奖，他的《中国之暴雨》研究获1992年中国科学院自然科学一等奖。由于他的突出成就，于1996年获何梁何利科学进步奖。

陶诗言院士在国际大气科学界享有崇高的声望。60年代日本《气象纪要》杂志的一期有一半以上篇幅用来登载陶诗言院士的学术论文；1978年10月陶诗言先生作为会议主席主持召开了由WMO组织的有50多个国家参加的国际台风会议，并一直担任中美关于大气CO_2气候效应合作研究的中方首席科学家，并多次应美国、日本、法国等国家邀请进行学术交流和讲学。

陶诗言院士对气象事业的贡献，得到了党和人民的信任和尊敬。1978年到1984年陶诗言

院士任中国科学院大气物理研究所副所长，代所长；1980 年当选为中国科学院学部委员（院士）；1978～1992 年为第五届、第六届及第七届全国政协委员；1982 年他被选为第 20 届中国气象学会副理事长，1986 年被选为第 21 届中国气象学会理事长；1977～1996 年任联合国世界气象组织大气科学委员会中国首席代表；1988～1992 年任第四届科联和联合国世界气象组织联合科学委员会（JSC）委员；1978 年至今一直担任中国科学院大气物理研究所的学术委员会主任；自 80 年代初至今担任中国环境科学学会常务理事；1995 年起任中国科学院减灾中心学术委员会主任；他是《大气科学进展》（Advances in Atmospheric Sciences）的主编，《地理学报》、《气象学报》、《大气科学》和《中国环境学报》的编委。

在陶诗言院士八十华诞到来之际，为了表达对我国气象事业开拓者之一陶诗言院士近 60 年来奋斗不息、耕耘不止，对祖国气象和大气物理事业的发展所做出的卓越贡献的敬仰和对陶诗言院士八十华诞的庆贺，我们将数十年来陶诗言院士在东亚季风及中国暴雨方面研究的代表性论文以及在他培育下成长起来的他的学生、同他相处的国内外学者的有关季风、暴雨等方面的论文共 40 余篇汇集成册出版。这部论文集反映了陶诗言院士在气象领域中不断开拓和辛勤耕耘的业绩，也反映了在陶诗言院士等老一辈气象学家的培育和感召下，我国气象及大气物理事业后继有人，在前人开辟的道路上奋发进取，为实现“四个现代化”正在做出积极贡献。

在此论文集的编辑过程中，高守亭、张庆云研究员、耿淑兰编审和责任编辑郭彩丽同志在组稿、编审和稿件修改方面做了大量工作，韩佳新同志在稿件的打印方面付出大量精力，对这些同志的辛勤劳动，谨表感谢。

中国气象局、LASG 国家重点开放实验室、国家气候中心、中国气象科学研究院、LAPC 国家重点开放实验室等单位为出版本文集提供了经费支持，特此致谢。

《东亚季风和中国暴雨》编委会

主　编：王明星

1998 年 6 月 1 日

Foreword

Academician TAO Shiyan is one of the pioneers of the modern weather forecast theory and methods in this country and a world well-known expert in monsoon research. He was born in Jiaxing County, Zhejiang Province. In 1942, he graduated from the Department of Geography of the Central University. In 1944, he followed Prof. ZHAO Jiuzhang, a well-known meteorologist in China, to take up research in the Institute of Meteorology of the Central Academy of Sciences. In the early 1950s, the United Weather Analysis and Forecast Center, the predecessor of the National Meteorological Center, was established. Mr. TAO Shiyan was appointed as its Deputy Director. The center in its early days undertook the important task of providing meteorological services. Every day it provided short and medium range weather forecast to the relevant departments in this country. During that period, he made historic contribution in the provision of meteorological services. At the same time, he accumulated rich and valuable experience in weather analysis and forecast methods for China and East Asia. This laid a solid foundation for his theoretical research later. In July 1954, severe flood rare in one hundred years occurred along the Yangtze River. Hankou was then in imminent danger. Mr. TAO Shiyan and his colleagues made accurate forecast that the torrential rain was coming to an end. The danger of Hankou was therefore relieved. He was therefore awarded the title of national level advanced worker in 1956 for his outstanding contribution in weather forecast. In the mid and late 1950s, Mr. TAO Shiyan, Mr. YE Duzheng and Mr. GU Zhenchao jointly wrote 3 papers on their research entitled *On the General Circulation over the Eastern Asia* published in the world meteorological magazine *Tellus*. These papers won the attention of the world meteorological community.

After 1960, China undertook to tackle the frontiers of science and technology in national defense and conducted a series of experiments. Mr. TAO Shiyan was entrusted with the task of providing meteorological services. From 1963 to 1967, he not only provided meteorological services for the scientific and technological experiment for national defense on many occasions but also cultivated a large group of young technological backbones. Therefore he won a Second Class and a First Class Merit Citation in 1964 and 1966 respectively.

In late 1960s, in order to fill the gap in the application of satellite images in the routine weather forecast operations, Mr. TAO Shiyan set up a group to develop and manufacture satellite groud receiving facilities. He compiled the *Manual on the Use of Satellite Images in China*. Mr. TAO Shiyan also invented a set of methods of identifying weather systems with satellite images, especially methods of forecasting the generation and evolution of typhoons which are still widely used at the weather stations in China. During the period from mid-1970s to 1980s, Mr. TAO Shiyan devoted himself to torrential rain research and put forward the concept of multi-scale interactions in the process of torrential rain formation and

suggested new methods of torrential rain forecast for the rainy season. He published the monograph entitled *Torrential Rain in China*.

In addition to the above achievements, Academician TAO Shiyan has also long been engaged in the East Asia monsoon research, including the mean structure of the East Asian monsoon system and its difference and similarity with the Indian monsoon system, the interannual as well as intraseasonal changes of East Asian summer monsoon and the difference between South-China Sea monsoon and the Indian monsoon. His achievements in monsoon research have been recognized internationally.

Academician TAO Shiyan wrote many books on the theory and methods of weather forecasting in China. He has published more than 80 academic papers and 8 monographs. He won the Award of the National Scientific and Technological Conference in 1978, the Award for the Popularization and Application of the Scientific and Technological Achievement of the State Science and Technology Commision and the State Science and Technology Commission and the State Agricultural Commission in 1980. In 1987, he won the Class I National Science Award for his book entitled *Research on the Atmospheric Circulation in East Asia* (coauthored with Academician YE Duzheng). His book *Torrential Rain in China* won the Class I National Science Award of the Chinese Academy of Sciences in 1992. In 1996, he won the Ho Leung and Ho Lee Award of Scientific and Technological progress for his outstanding achievements.

Mr. TAO Shiyan enjoys great prestige in the international atmospheric science community. In 1960s, one edition of the Japanese magazine *Meteorological Note* used more than half of its space to carry his academic papers. In October 1978, he chaired to the WMO-sponsored International Seminar on Typhoon which was attented by experts from more than 50 countries and regions. He was appointed as the Chief Chinese Scientist for the Sino-US cooperative project of the effect of Atmospheric CO_2 on climate. He visited the United States, Japan and France for many times for academic exchanges or to give lectures at the invitation of the above countries.

Academician TAO Shiyan won the trust and respect of the Party and the people for his contribution to the Chinese meteorological service. From 1978 to 1984, Academician TAO Shiyan assumed the office of Deputy Director and Acting Director of the Institute of Atmospheric Physics of the Chinese Academy of Sciences. In 1980 he was elected member of the National Committee of the Fifth, Sixth and Seventh People's Political Consultative Conference of China. He was elected Vice President of the Chinese Meteorological Society at its 20th Congress in 1982 and President at its 21st Congress in 1986. From 1977 to 1996 he was the Principal Delegate of China to the Commission for Atmospheric Sciences of the World Meteorological Organization. From 1988 to 1992, he was a member of the ISCU/WMO Joint Scientific Committee. He has been being Chairman of the Academic Committee of the Institute of Atmospheric Physics of the Chinese Academy of Sciences since 1978, a member of Standing Committee of the Chinese Society of Environmental Sciences since early 1980s and Chairman of the Academy Committee of the Disaster Reduction Center of the Chinese Acade-

my of Sciences since 1995. He is the Chief Editor of the *Advances in Atmospheric Sciences* and a member of editing board of the *Journal of Geography*, *Acta Meteorologica Sinica*, *Journal of Atmospheric Sciences* and the *Chinese Journal of Environmental Sciences*.

On the occasion of the 80th birthday of Academician TAO Shiyan, we compiled the more than 40 of his representative papers in his dozens of years research on East Asian monsoon and torrential rain in China as well as academic papers by his students and his colleagues both at home and abroad on monsoon and torrential rain to express our admiration for his nearly 60 years of life devotion as a pioneer of the Chinese meteorological service and for his contribution to the cause of the Chinese meteorology and atmospheric physics and to extend our congratulation to him on his 80th birthday. This collection of papers reflects the achievements of Academician TAO Shiyan's continuous pioneering efforts and hard work. It also shows that under the cultivation and influence of Academician TAO Shiyan and other meteorologists of the elder generation, our meteorological and atmospheric physical service has successors who are working hard to make progress on the road pioneered by their predecessors. They are making active contribution to the four modernizations.

In the process of editing this collection of papers, Profs. GAO Shouting and ZHANG Qingyun, Senior Editer GENG Shulan, and Responsible Editor of this book GUO Caili assumed great responsibilities in soliciting, editing and revising the papers. Mr. HAN Jiaxin did the typing work. I would like to express my thanks to them for their hard work.

We would like to thank China Meteorological Administration, State Key Laboratory of Numerical Modelling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), National Climatic Center, Chinese Academy of Meteorological Sciences, and State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry (LAPC) etc. for supporting the publication of this volume.

WANG Mingxing
Chairman
Editing Committee of
East Asian Monsoon and
Torrential Rain in China

陶诗言先生与中国气象局

——贺陶诗言先生八十华诞

马鹤年

（中国气象局，北京 100081）

在庆贺陶诗言先生八十华诞的日子里，中国气象局的同仁们深情地回忆起先生几十年来始终如一地给予中国气象事业的热情指导和无私支持。

在学术上，陶诗言先生始终坚持理论联系实际的优良学风，从我国气象业务应用的实际出发，注重研究与我国重大气象灾害有关联的主要科学问题，在中国天气的研究方面做出了卓越的贡献：

陶先生从大气环流的季节突变的观点研究了中国梅雨问题。他的《中国的梅雨》等许多论著都是首先在中国气象局刊印的。在梅雨的研究中，他同时强调了东亚阻塞系统和亚洲季风的作用。梅雨主要发生在乌拉尔和鄂霍茨克海阻塞高压盛行的时期。先生指出，稳定的阻塞高压使急流分支，从而使西风带的扰动南下，到达长江流域，为暴雨形成提供了基本条件。另一方面，印度季风的爆发为梅雨带来了充足的水汽。通过多年的研究，先生和他的同事们提出了东亚季风系统的新概念，认为东亚季风系统是一个既独立于印度季风系统又与其相互作用的单独的季风系统。它的爆发和演变直接与中国雨带的进退和旱涝的发生有更密切的关系。这一看法也成为目前正在进行的南海季风试验的科学依据之一。

根据国外的降水模型及中国实际情况，陶先生提出了中国几种主要降水系统的概念模型。如：气旋性降水模型。他指出，虽然在中国气旋内也存在着三支气流，但其气流的来源、位置及其对降水的作用与英国的模型并不相同。这对我国降水预报的改进具有理论和实际的意义。先生还十分关心暴雨预报业务的发展。他通过“75.8”暴雨的会战研究，并在总结广大台站经验的基础上提出了适合我国国情的暴雨落区预报方法。这是一种半经验半定量的暴雨预报方法，在我国台站推广后，对提高暴雨的预报水平起到了相当大的作用。先生还以高度的热情和充沛的精力指导了中国气象局组织的一些暴雨协作组或协作片的研究工作。在“七五”和“八五”期间，他对中国气象局主持的攻关项目，特别是对四个中尺度基地的建设给予了很多科学指导。

陶诗言先生对青藏高原气象学有着很深入的研究，取得许多突出的成果。他专门研究了高原系统（包括印缅槽）产生和移动的过程及其对下游地区的影响，发现在中国的很多重大暴雨洪涝事件中，天气扰动大多由高原的扰动发展和东移而来。他最早提出，受中纬度的影响，南亚高压可以发生准周期性的振荡。目前，他是第二次青藏高原试验项目双首席科学家之一，耄耋之年，陶先生仍为这一项目的推进和成功倾注着心血。

陶先生以他的非常有创见性的学术成就，尤其是在季风和暴雨研究方面的成就，被誉为这个领域公认的权威科学家，在国内外享有很高的声誉。在探索赶超气象科技国际先进水平的道路上，陶先生的卓识和成就使我们深受启迪和鼓舞。

陶先生是我们最亲密的朋友和师长。他始终站在学术进步和业务发展的高度，在许多关键

时刻，对中国气象局的建设和发展提出宝贵的指导性的意见和建议。

曾在50年代担任军委气象局联合天气分析预报中心副主任的陶先生为培养新中国第一代预报员倾注了大量的心血和劳动。经他培养的老一代预报员在50年代～70年代中国气象事业的发展中发挥了重要作用。70年代，先生再次受中国气象局委托，在北京大学举办了卫星应用分析训练班，在全国预报员中普及卫星资料的使用方法。他为当时新建的100多个台站和有关单位的卫星接收、天气分析人员讲解了基本应用技术，为我国气象业务培养了第一代能够使用卫星资料的天气分析人员。同时，他还通过各种暴雨训练班和讲座，介绍国内外暴雨研究成果，为中国暴雨研究和预报技术的发展付出了艰苦的劳动。

80年代，陶先生致力于季风和暴雨研究计划的实施，曾担任中国气象局主持下的“东亚季风及其旱涝预报”重点项目顾问，并成为这一项目的主要参加人之一。此外，他还积极参加和热情指导了1954年长江大水、1958年黄河大水、1975年河南“75.8”暴雨与洪涝，以及1991年江淮流域持续性的大暴雨的预报和研究。

陶诗言先生是一位严谨、求实的气象科学家，他更是中国气象局的良师益友。在中国气象局科研、业务发展的过程中，陶先生以无私的精神和强烈的事业心做出了杰出的贡献。因而，他获得了中国气象局广大气象工作者深深的尊敬和爱戴。

愿先生八秩康健，晚霞更绚丽。