



# Around the world with Space VLBI: A sense of many places

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International scientific collaboration is a hallmark of space research, nowhere more so than Space VLBI, with the involvement of radio telescopes on every continent connecting together with the space radio telescope. As a form of scientific collaboration VLBI is unusual in that the scientific return increases as the number of participating radio telescopes increases. Starting with the move from the basic two antennas to three, the scientific return increases from the single one baseline amplitude to three baselines plus one closure phase. Adding a fourth antenna yields six baselines, four closure triangles, and further adds one amplitude closure. Thus the scientific return continues to increase rapidly with increased participation.

The late Professor Masaki Morimoto expressed the appeal of VLBI in his preface to the Proceedings of the 1993 XXIV General Assembly of the URSI Meeting in Kyoto:

*VLBI ties the world. It connects radio astronomers by coherence and covers the world by a network of friendship*

COSPAR recognized the importance of international cooperation with the 2017 Biennial Report on the status of international cooperation in space research, which states “Astronomy from space is a model for international scientific cooperation”. The Space VLBI missions VSOP and RadioAstron are excellent examples of such collaboration with up to fifty ground radio telescopes from more than twenty countries taking part.

I have tried to reflect this global collaboration by making sketches of many of the places visited as part of the Space VLBI collaborations, where possible at the meetings or afterwards on later scientific visits. These twenty-three

sketches represent my deep appreciation for the breadth of this international collaboration. Sketching is a wonderful way to remember places; you not only draw what you see, but also see what you draw. This is a journey around the world of Space VLBI one sketch at a time.

Following the success of the 1986 TDRSS demonstration observations (Levy et al., 1986), the following years saw a dramatic evolution of the scientific and operational structures of the dedicated space VLBI Missions, the Russian-led RadioAstron and Japanese-led VSOP. The meeting of cooperating agencies in Yalta, Crimea, USSR in late 1988 led to the setting up of the RadioAstron International Science Council, the RISC, which was organized to oversee the international coordination and participation in the RadioAstron mission. For RadioAstron the arrangement was to schedule alternate Russian and Western locations for RISC meetings. Then, following the International VSOP Symposium in December 1989, ‘Frontiers of VLBI’ (Nishimura, 1991), and the Space VLBI Work Week meeting held in Sydney, Australia in April 1991, the first VSOP International Science Council, the VISC, met at ISAS in Sagamihara, Japan in 1992.

These collaborative International Science Councils give each contributing organization a direct involvement, in providing a significant contribution to the planning and operation of these international space VLBI missions. I was fortunate to have been a part of the three Space VLBI programs, which has heightened my appreciation of the importance and value of international scientific collaboration.

In parallel with these Council meetings, the Inter Agency Consultative Group, IACG, recognizing the potential significance of the missions, set up Panel 1 specifically for Space VLBI at the meeting in Padova in October

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1986. Moreover, the scientific meetings of the International Astronomical Union, IAU, the International Radio Science Union, URSI, and COSPAR, were also venues for following the progress of the missions as well as the remarkable scientific results produced as the missions became operational.

In the years following, SVLBI and SVLBI-related meetings have been held across the globe in many of the places possessing collaborating radio telescopes. The early meetings were amongst the most important in terms of setting in place many of the operational structures of both missions. A highlight of these meetings was the 2005 Award



Picture 1. The Sydney Harbour Bridge from the Opera House, where my journey begins. Sydney is an appropriate place to start as it was the scene of the 1991 Space VLBI Week meeting, together with a RISC meeting. More than 80 representatives from space agencies in a dozen countries gathered for detailed discussion of both the RadioAstron and VSOP projects.



Picture 2. Mount Wellington overlooks the city of Hobart. The Mount Pleasant observatory, which played a major role in the VSOP and RadioAstron AGN Surveys and other observations, lies just east of Hobart.



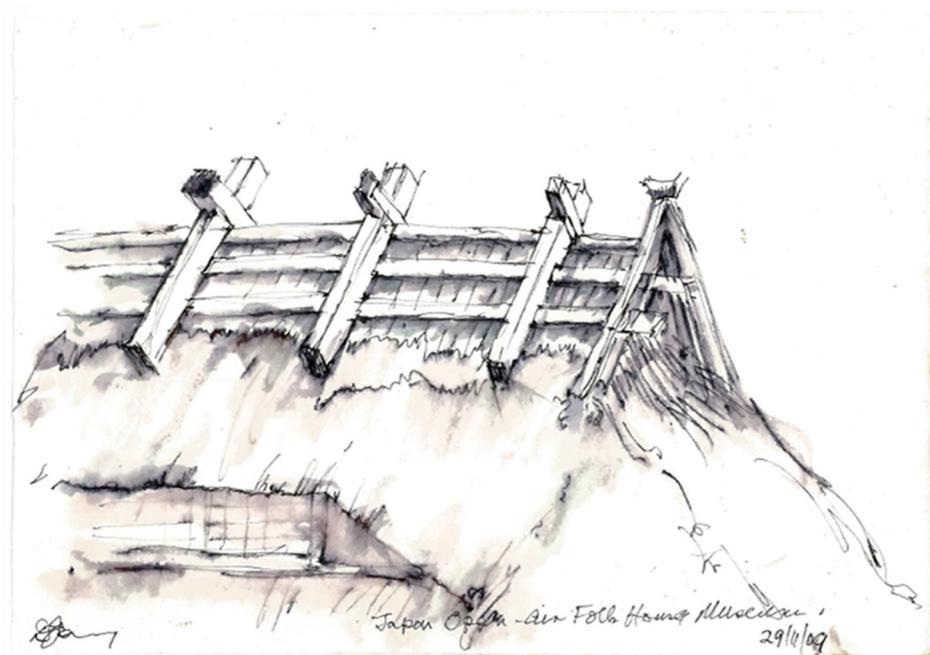
Picture 3. The Clock Tower at Auckland University. Following the trans-Tasman meeting in November 2011, New Zealand now has a strong role in Southern Hemisphere VLBI and actively participates in RadioAstron observations with the Warkworth Observatory operated by the Auckland University of Technology.



Picture 4. The Olympic Tower in Beijing, China, where the XXVIII IAU General Assembly was held in August 2012. Considerable discussion took place leading to the development of a proposal for a Chinese-led future SVLBI mission, presented at the Space VLBI Forum in Beijing in September 2013.



Picture 5. The sakura (cherry tree) by the ISAS dormitory, Sagamihara, Kanagawa, Japan, where I have spent many happy and productive weeks over many years working with the VSOP International Science Council, VISC, whose first meeting was held at ISAS in 1992.



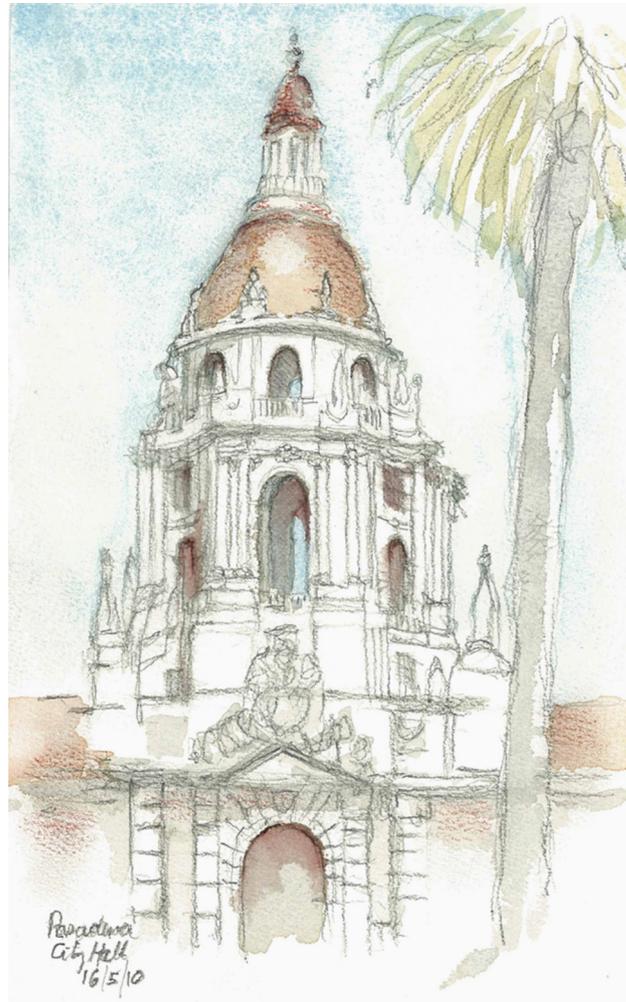
Picture 6. Not far from ISAS, the home of the VSOP mission, in Sagamihara, Kanagawa Prefecture is the Open Air Folk House Museum.



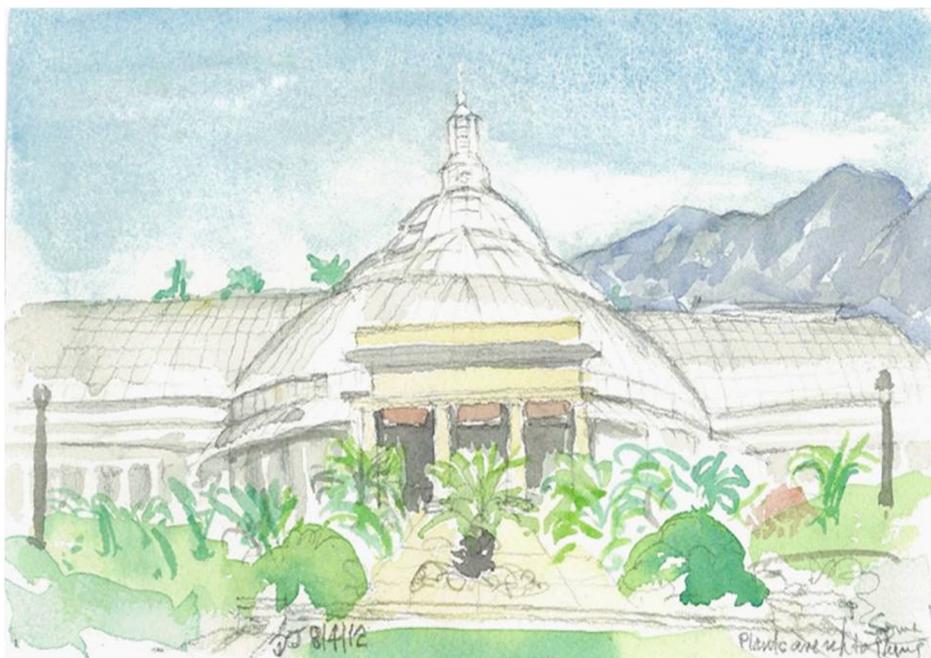
Picture 7. Mount Fuji was the scene of an organized visit following the HakoneVSOP-2 meeting. Sadly the VSOP-2 Mission proposal was unsuccessful.



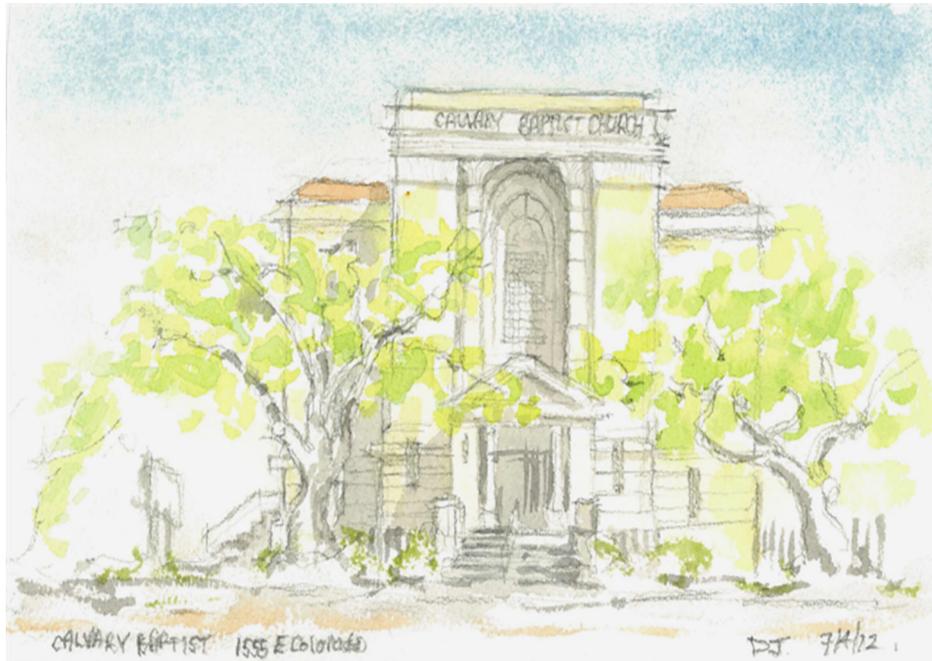
Picture 8. Cherry Blossom time strolling in the Hamarikyu Gardens on the Sumida River, Tokyo, Japan. This sketch was made immediately following the “Black Hole Astrophysics” meeting held at NAOJ to celebrate the retirement of Professor Makoto Inoue in March 2017.



Picture 9. The Pasadena City Hall is a landmark of the city. Pasadena hosted the 42nd COSPAR Assembly, where a number of SVLBI papers were presented.



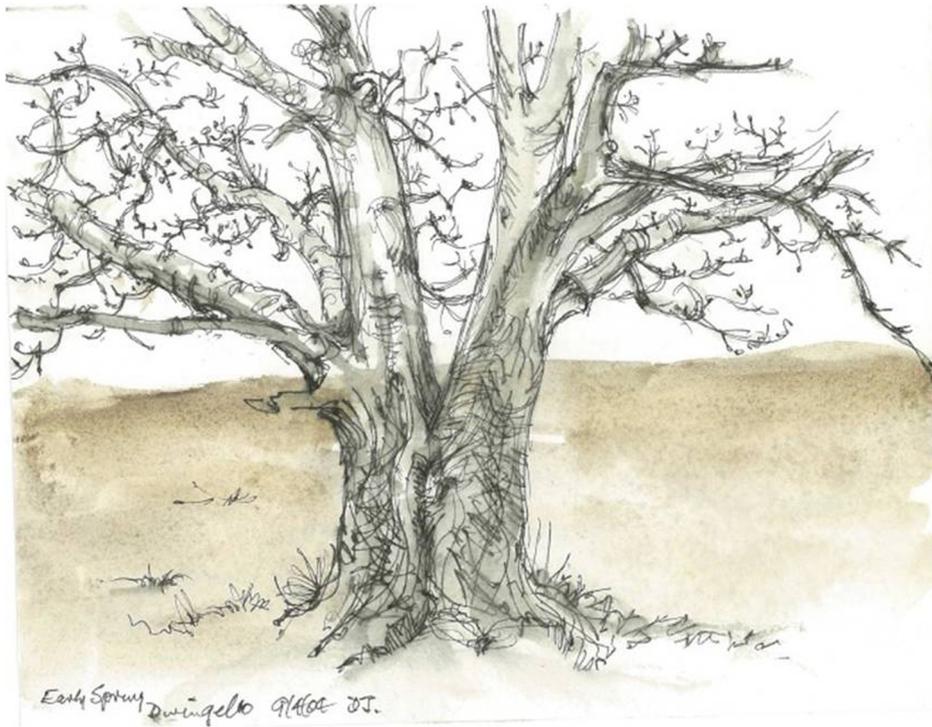
Picture 10. The Huntington Gardens Pasadena “where plants are important”, is just the place to relax after a busy week of Conferencing.



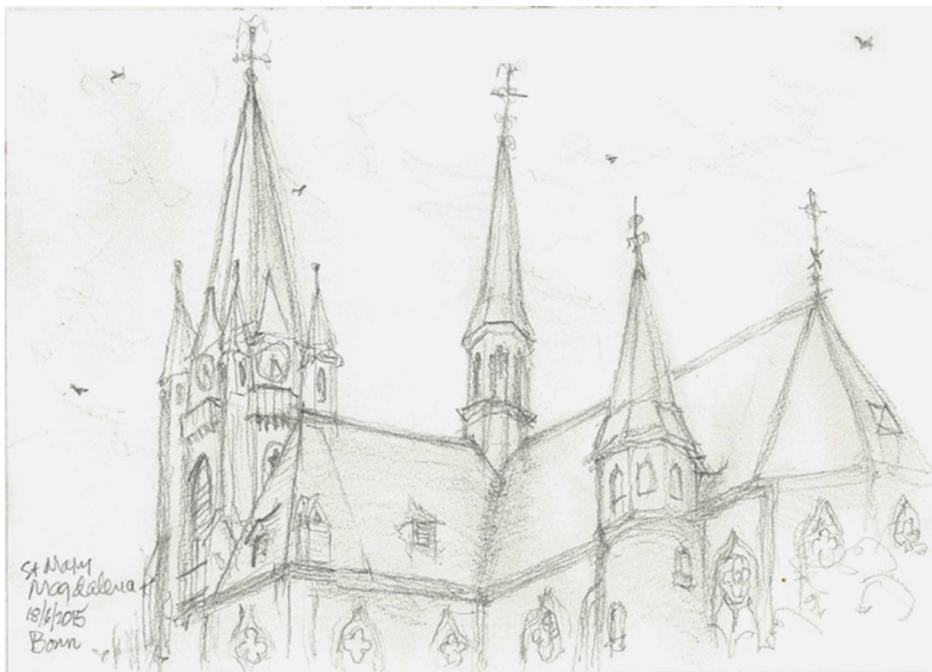
Picture 11. Calvary Baptist Church, a classic old Pasadena building is just a few steps from a favourite motel in Pasadena, California, USA.



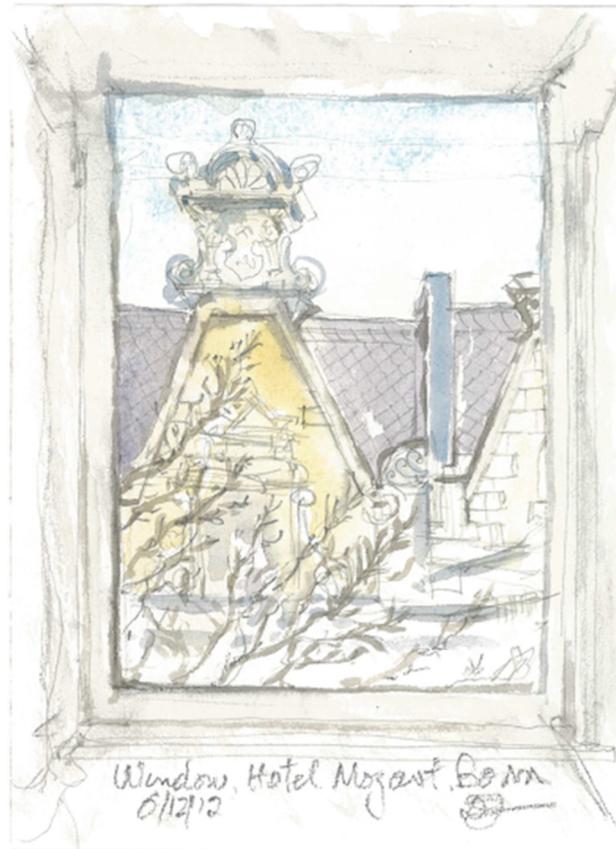
Picture 12. Puerta de Alcalá Madrid, Spain is one of the landmarks on the way to the NASA Deep Space Tracking Station in Robledo, which was one of the data acquisition stations of the VSOP mission.



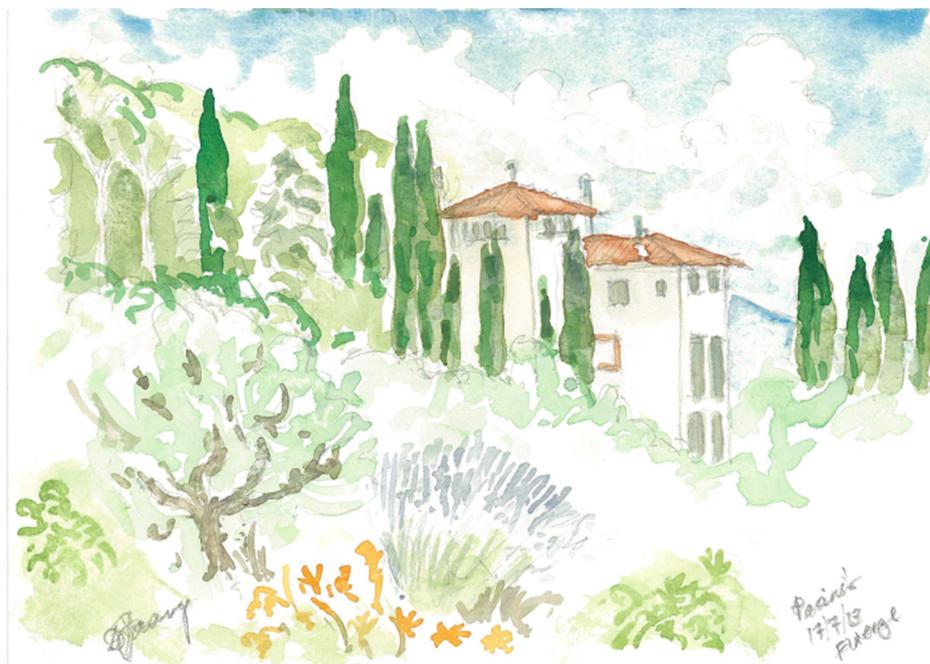
Picture 13. Early spring in Dwingello, the Netherlands. This is the home village of the institutes, ASTRON and JIVE, actively involved in both the VSOP and RadioAstron missions.



Picture 14. Church of St Mary Magdalene in Endenich, Bonn, Germany, is not far from the Max-Planck-Planck-Institut fuer Radioastronomie, the scene of the June 2015 RISC meeting where important new scientific results from the RadioAstron mission were presented.



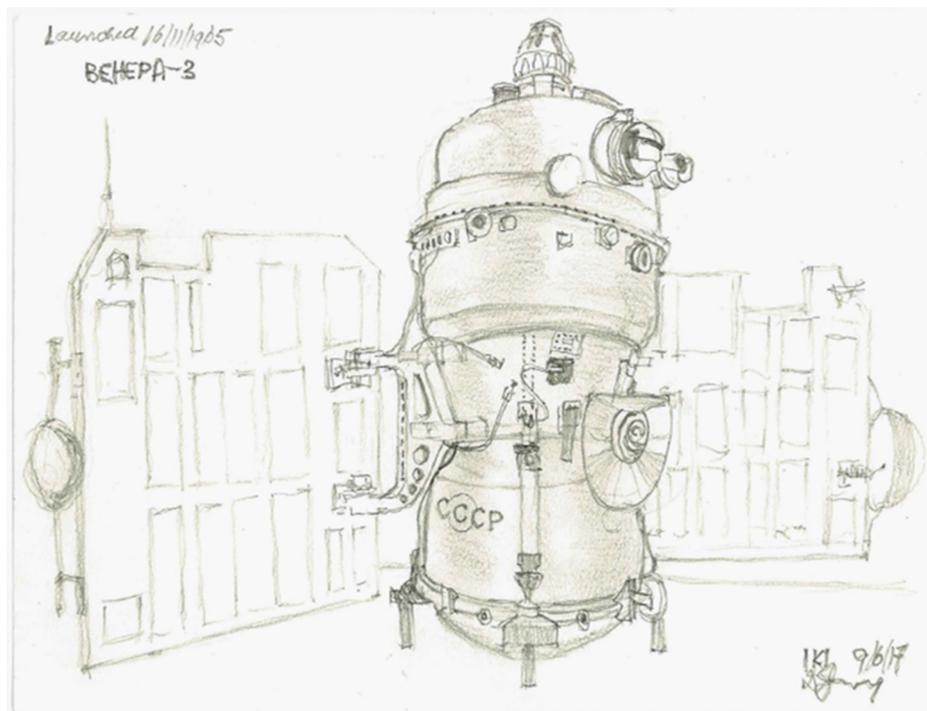
Picture 15. On a working visit to the Max-Planck-Institut fuer Radioastronomie, this is a most enjoyable view, Endenich, Bonn, Germany.



Picture 16. A Florence landscape seen from the Franco Pacini's house. The historic house of Galileo, Casa Galileo, lies not far from here in Arcetri. Visiting Casa Galileo today brings a strong appreciation of Galileo's role in the early history of astronomy.



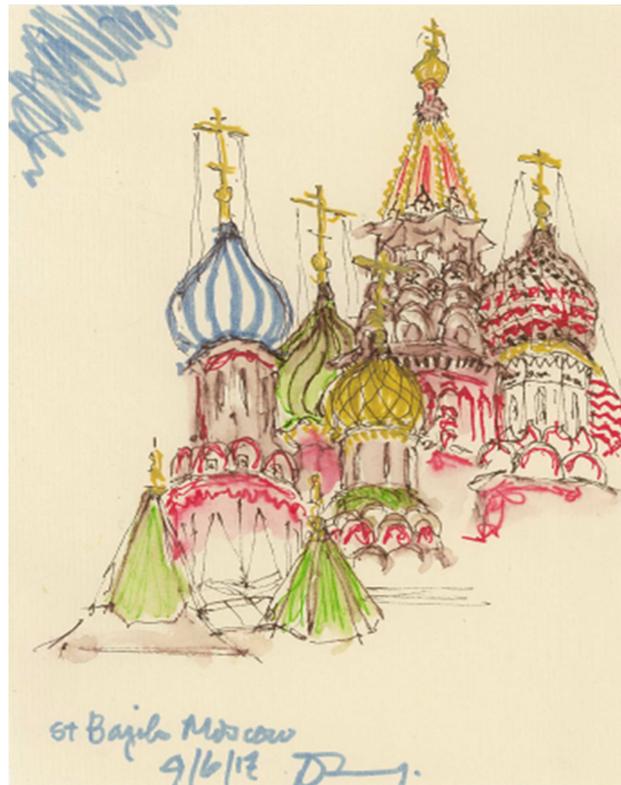
Picture 17. The Turku Cathedral, Finland, opened in 1300, is regarded as one of the major records of Finnish architectural history. The July 2013 meeting of the European Week of Astronomy and Astrophysics, EWASS, in Turku delivered some of the very first scientific presentations from RadioAstron.



Picture 18. An engineering model of the Soviet Venera 3 (Venus mission), spacecraft at the IKI (Space Research Institute) museum in Moscow, Russia. In the early stages of the RadioAstron project, it was expected that its service module would be based on a re-worked spacecraft of the Venera series.



Picture 19. Znamensky Cathedral, Moscow, drawn from the steps of the old Rossiya Hotel a few months after the hotel was closed down (before being demolished a few years later).



Picture 20. Saint Basil's Cathedral in Red Square, Moscow, is a favourite place to visit. During the 2003 RISC meeting in Moscow I made my first visit to the Bolshoi Theatre and thoroughly enjoyed the ballet Giselle and the music of Adolphe Adam.



Picture 21. Monument to the 900-days long Siege of Leningrad in 1941–1944 during World War II, St. Petersburg, Russia.



Picture 22. Summer at the Pulkovo Astronomical Observatory near St. Petersburg, Russia. The May 1993 RISC meeting at Pulkovo was my introduction to optical observing in Russia. In August 2011 this provided the opportunity to obtain optical spectra of a number of important radio sources with the BTA 6 m telescope in the Caucasus Mountains in southern Russia.



Picture 23. A view from the hotel “Sputnik” in Moscow. In the foreground, with the dome-like roof, is one of the buildings of the Institute of Chemical Physics of the Russian Academy of Sciences. In the upper left corner, the main building of the M.V. Lomonosov Moscow State University is the alma mater of many participants of the RadioAstron project. It was at the RISC meeting held at the Headquarters of the Russian Academy of Sciences near this place in 2008 that the decision was made to mount a small plaque, dedicated to Grote Reber, on the RadioAstron spacecraft.



Picture 23a. The Grote Reber memorial plaque mounted on the RadioAstron Spektr-R spacecraft at the Lavochkin assembly facility, Khimki, Moscow area, Russia, December 2010. Courtesy N.G. Babakin and Lavochkin Scientific and Production Association.

on October 16th at the International Astronautical Congress in Fukuoka, of the Laurels for Team Achievement to the international VSOP Team.

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See [Pictures 1–23 and 23a](#).

## References

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