The Remote Sensing of Tropospheric Composition from Space

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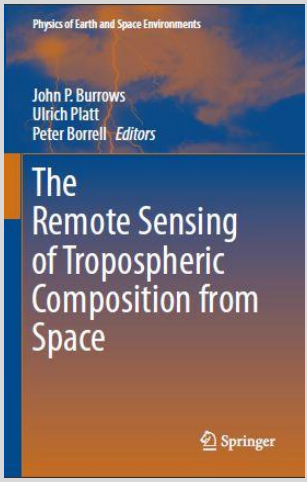

Pages 515 to 538

Appendices

Publisher: Springer Verlag, Heidelberg
Springer Book Web Page
Springer on line Page for the Book
ISBN 978-3-642-14790-6
DOI 10.1007/978-3-642-14791-3

February 2011

Appendices

Appendix A: Satellite Instruments for the Remote Sensing in the UV, Visible and IR

Tables of microwave instruments are given in Tables 4.1 and 4.2. However MLS on Aura is included here as well.

Abbreviations Used in the Table

Aerosol Properties: *AOD* aerosol optical depth, *AOT* aerosol optical thickness, *AE* Ångström exponent, *FMF* fine mode fraction, *CMF* coarse mode fraction, *NS* non-spherical, *PSD* particle size distribution, type, *AAI* absorbing aerosol index, *ssa* single scattering albedo

Cloud Properties: *CA* cloud albedo, *CER* cloud effective radius, *CF* cloud fraction, *COT* cloud optical thickness, *CP* cloud phase, *CPP* cloud particle phase, *CPS* cloud particle size, *CTH* cloud top height, *CTP* cloud top pressure, *CTT* cloud top temperature, *LWP* liquid water path, *DZ* droplet size, *CZ* crystal size

Viewing: *N* nadir, *L* limb, *O* occultation

Sounding: *Tot* total column, *Sp* stratospheric profile, *Tp* tropospheric profile, *Tc* tropospheric column, *Sc* stratospheric column, *Mp* mesospheric profile

Spectral region: UV/vis/NIR, ultraviolet visible and near infrared; *IR* infrared; continuous spectrum taken or selected spectral channels. For IR Fourier Transform Spectrosocopy (FTS), the resolution is given as the optical path difference, OPD

J.P. Burrows et al. (eds.), *The Remote Sensing of Tropospheric Composition from Space*, Physics of Earth and Space Environments, DOI 10.1007/978-3-642-14791-3,

AATSR	Advanced Along-Track Scanning Radiometer *Satellite*; *lifetime*: ESA ENVISAT; 2002 – present; *re-visit period*: 5 days; *equator crossing time:* 10.00 ascending; *species:* sea surface temperature; *cloud properties*: CF, COT, CP, CPS, CTH, CTP, CTT, LWP, DZ, CZ; *aerosol properties*: AOD, AE, aerosol mixing ratio; *viewing*: N and 55° forward; s*ounding* Tot; *footprint*: 1 × 1 km, swath 512 km; *spectral region*: vis/IR, 2 views; *channels*: 555, 659, 865, 1,600, 3,700, 11,000, 12,000 nm; *resolution*: 20 nm (1–3), 300 nm (4–5), 1,000 nm (6–7)
ACE-FTS	Atmospheric Chemistry Experiment – FTS *Satellite*; *lifetime*: CSA SCISAT-1; 2003 – present; *species:* H_2O, CO_2, CH_4, N_2O, O_3, CO, CFC-11, CFC-12, $ClNO_3$, HCl, HF, HNO_3, NO_2, NO, N_2O_5 and more; *viewing*: O; s*ounding* Tp (upper); *spectral region*: IR; FTS, contin. spectrum; *resolution*: OPD 25 cm
AIRS	Atmospheric Infrared Sounder *Satellite*; *lifetime*: NASA Aqua, 2002 – present; *re-visit period*: twice a day; *equator crossing time:* 13.30; *species:* H_2O, CO_2, CH_4, O_3, CO; *viewing*: N + scan; s*ounding* Tot, Tc; *footprint*: 13.5 × 13.5 km; *spectral region*: IR; 650–1,136, 1,216–1,613, 2,170–2,674 cm^{-1}; *resolution*: $\lambda/\Delta\lambda = 1{,}200$
ATMOS	Atmospheric Trace Molecule Spectroscopy *Satellite*; *lifetime*: NASA Spacelab, 1985, ATLAS: 1992, 1993, 1994; *re-visit period and equator crossing time:* not applicable; *species:* O_3, NO_x, N_2O_5 $ClONO_2$, HCl, HF, CH_4, CFCs; *viewing*: O; *sounding* Sc, Tc (upper); *spectral region*: IR; continuous; *resolution*: 0.01–1 cm^{-1}
ATSR-2	Along Track Scanning Radiometer *Satellite*; *lifetime*: ESA ERS-1, 2; 1991–2002; *re-visit period*: 5 days; e*quator crossing time:* 10.00; *species:* sea surface temperature; *cloud properties*: CF, COT, CP, CPS, CTH, CTP, CTT, LWP, DZ, CZ; *aerosol properties*: AOD, AE, aerosol mixing ratio; *viewing*: N; *sounding* Tot; *footprint*:1 × 1 km; *spectral region*: vis/IR, 2 views; channels: 555, 659, 865, 1,600, 3,700, 11,000, 12,000 nm; resolution: 20 nm (1–3), 300 nm (4–5), 1,000 nm (6–7)
AVHRR	Advanced Very High Resolution Radiometer *Satellite*; *lifetime*: NASA TIROS-N, NOAA-6, NOAA 15 Metop A; 1978 – present; *re-visit period*: 2days; *equator crossing time:* 06:00 to 10:00 and 09:30; *species:* fire, vegetation, aerosol properties; *cloud properties*: CTH, COT, CTT, LWP, DZ, CZ; *viewing*: N; s*ounding* Tot; *footprint*: 1.25 km × 1.25 km, 5 km × 5 km, and 25 km × 25 km; *spectral region*: vis/IR; 0.58–0.68 μm, 0.725–1.0 μm; IR 1.58–1.64 μm, 3.55–3.93 μm, 10.3–11.3 μm, 11.5–12.5 μm
BUV	Backscatter Ultraviolet Ozone Experiment *Satellite*; *lifetime*: NASA Nimbus 4; 1970–1974; *re-visit period*: 6 days; *species:* O_3; *viewing*: N; s*ounding* Sp, Tc; *footprint*:230 km × 230 km; *spectral region*: UV; *resolution*: 1–5 nm
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarization *Satellite*; *lifetime*: NASA CALIPSO (A TRAIN); 2006; e*quator crossing time:* 13.30, ascending; *species: aerosol properties*: see Table 6.4; *viewing*: N; *sounding* Tot; *footprint*: 330 × 100 m; vert. 30–60 m; *spectral region*: lidar; 532 (polarised), 1,064 nm

(*continued*)

CLAES	Cryogenic Limb Array Etalon Spectrometer *Satellite*; *lifetime*: NASA UARS; 1991–1993; e*quator crossing time:* asynchronous; *species:* temperature, pressure, O_3, H_2O, CH_4, N_2O, NO, NO_2, N_2O_5, HNO_3 , $ClONO_2$, HCl, CFC-11, CFC-12, and aerosol absorption coefficients; *viewing*: L; *sounding* Sp; *spectral channels*: IR; 780, 792, 843, 879, 925, 1,257, 1,605, 1,897, 2,843 cm^{-1}; *resolution*: 0.19, 0.25, 0.26, 0.22, 0.22, 0.26, 0.39, 0.47, 0.65 cm^{-1}
GLAS	Geoscience Laser Altimeter System *Satellite* ICESat; *viewing*: N; *sounding*: altimeter
GOME	Global Ozone Monitoring Experiment *Satellite*; *lifetime*: ESA ERS-1, 1995 – present; *re-visit period*: 3 days; e*quator crossing time:* 10.30; *species:* O_3, NO_2, H_2O, BrO, OClO, SO_2, HCHO, CHOCHO, IO, H_2O, O_2, O_4; *cloud properties*: CTH, CF, COT; CA; and aerosols; *viewing*: N; s*ounding* Tot, Tc; *footprint*: 320 × 40 km; *spectral region*: UV/vis; continuous; *resolution*: 0.2 nm
GOME-2	Global Ozone Monitoring Experiment-2 *Satellite*; *lifetime*: ESA EUMETSAT MetOp-A, 2006 – present; *re-visit period*: 1.5 days; e*quator crossing time:* 09.30; *species:* O_3, NO_2, H_2O, BrO, OClO, SO_2, HCHO; *cloud properties*: CTH, CF, COT, CA; and aerosols; *sounding* Tot; *viewing*: N; *footprint*: 80 × 40 km; *spectral region*: UV/vis; continuous; *resolution*: ~0.2 nm
GOMOS	Global Ozone Monitoring by Occultation of Stars *Satellite*; *lifetime*: ESA ENVISAT; 2002 – present; e*quator crossing time:* 10:00; *species:* O_3, NO_2, NO_3, H_2O, O_2; *viewing*: O; *sounding:* Tp; Sp, Tot, Me; *spectral regions*: UV/vis; 248–693 nm, NIR; 750–776 nm, 915–956 nm; *resolution*: 1.2 nm (UV/vis), 0.2 nm (NIR)
HALOE	Halogen Occultation Experiment *Satellite*; *lifetime*: NASA UARS; 1991–2005; *species:* CO_2, H_2O, O_3, NO_2, HF, HCl, CH_4, NO; *viewing*: O; *sounding* Sp, (Tp); *spectral region*: several channels from 2.45 to 10.04 μm; *resolution*: gas correlation radiometer
HIRDLS	The High Resolution Dynamics Limb Sounder *Satellite; lifetime*: NASA Aura, 2004 – present; *re-visit period*: twice a day; e*quator crossing time:* 01.43; *species:* H_2O, CH_4, N_2O, O_3, CFC-11, CFC-12, $ClONO_2$, NO_2, N_2O_5, HNO_3, T; and cloud properties; *viewing*: L + scan; *sounding:*Sp ;*spectral region*: 21 channels from 6.12 to 17.76 μm; *resolution*: channel dependent
IASI	Infrared Atmospheric Sounding Interferometer *Satellite; lifetime*: EUMETSAT MetOp; 2006 – present; *re-visit period*: twice a day; e*quator crossing time:* 09.30; *species:* H_2O, HDO, CO_2, CH_4, N_2O, O_3, CO, CFC-11, CFC-12, HCFC22, HNO_3, SO_2, NH_3, C_2H_4, HCOOH, CH_3OH *et al*. *viewing*: N + scan; s*ounding* Tot, Tc, Tp; *footprint*: 12 km diameter; *spectral region*: IR, Michelson interferometer; continuous; *resolution*: OPD 2 cm
ILAS I, II	Improved Limb Atmospheric Spectrometer *Satellite; lifetime*: I: NASDA ADEOS; 1996–1997; II ADEOS II; 1999; *species:* O_3, NO_2, N_2O, H_2O, CF_3Cl, CH_4, $ClONO_2$, T, P; *viewing*: O; s*ounding* Sp (Tp); *footprint*: 2 × 2 km (NIR) and 2 × 13 (TIR); *spectral region*: 753–784 nm (NIR), 6.21–11.77 μm (TIR); *resolution*: 0.15 nm (NIR), 0.12 μm (TIR)

(*continued*)

IMG	Atmospheric Infrared Sounder *Satellite*; *lifetime*: NASDA ADEOS, 1996–1997; *re-visit period*: 10 days; e*quator crossing time:* 10.30 descending; *species:* H_2O, CO_2, CH_4, O_3, CO; *viewing*: N; s*ounding* Tot, Tc, Tp; *footprint*: 8 × 8 km; *spectral region*: IR; continuous; *resolution*: OPD = 10 cm
ISAMS	Improved Stratospheric and Mesospheric Sounder *Satellite; lifetime*: NASA UARS; 1991–1992; *species:* CO_2, H_2O, CO, N_2O, CH_4, NO, NO_2, N_2O_5, HNO_3, O_3; *viewing*: L + scan ; *sounding* Sp, Mp; *footprint*: 2.6 × 13 km; *spectral region*: 605–2,257 cm^{-1} (14 Bands); *resolution*: gas correlation
LIMS	Limb Infrared Monitor of the Stratosphere *Satellite; lifetime*: NASA Nimbus 7; 1978–1979; *species:* CO_2, HNO_3, O_3, H_2O, NO_2; *viewing*: L + scan; *sounding* Sp; *spectral regions*: 637–673, 579–755, 844–917, 926–114, 1,237–1,560, 1,560–1,630 cm^{-1}
LITE	Lidar In-space Technology Experiment *Satellite* Space Shuttle Discovery*; lifetime*: 9 days; *species*: aerosols, clouds; *viewing*: N; *sounding* Tot, Np; *footprint*: 300 m; *spectral region*: 355 nm, 532 nm, 1,064 nm
LRIR	Limb Radiance Inversion Radiometer *Satellite; lifetime*: NASA Nimbus 7; e*quator crossing time:* local noon; *species:* CO_2, O_3; *viewing*: L; s*ounding* Sp; *spectral regions*: IR; 14.6–15.9 μm, 14.2–17.3 μm, 8.8–10.1 μm, 20–25 μm
MAPS	Measurement of Air Pollution from Satellites *Satellite; lifetime*: NASA Space Shuttle; 1981, 1984, 1994; *species:* CO; *viewing*: N; *sounding* Tc; *spectral method*: Gas Correlation (uses CO and N_2O as reference)
MAS	Millimeter Wave Atmospheric Sounder *Satellite*; *lifetime*: Shuttle ATLAS 1, 2 and 3:1992, 1993, 1994; *species:* ClO, O_3, H_2O; *viewing*: L + scan; s*ounding* Sp; *spectral bands*: 60 GHz, 183 GHz, 184 GHz, 204 GHz
MERIS	Medium Resolution Imaging Spectrometer for Passive Atmospheric Sounding *Satellite*; *lifetime*: ESA-ENVISAT; 2002 – present; *re-visit period*:1–2 days; e*quator crossing time:* 10.00 ascending; *species:* H_2O; *aerosol properties:* AOD, AE; *cloud properties*: CA, COT, CTH, CTP; *viewing*: N; s*ounding* Tc; *footprint*: 0.3 × 0.3 km *swath*: 1,150 km; *spectral channels*: vis/NIR: 412.5, 442.5, 490, 510, 560, 620, 665, 681.25, 705, 753.75, 760, 775, 865, 890, 900 nm; *resolution*: 1.8 nm
MIPAS	Michelson Interferometer for Passive Atmospheric Sounding *Satellite*; *lifetime*: ESA ENVISAT, 2002 – present; *re-visit period*: 6 days; e*quator crossing time:* 10.00 ascending; *species:* H_2O, CO_2, CH_4, N_2O, O_3, CO, CFC-11, CFC-12, ClO, $ClONO_2$, OClO, HNO_3, C_2H_6, SF_6, NO_2, NO, NH_3, OCS, SO_2; *viewing*: L; s*ounding* Tc (upper); *spectral region*: IR; FTS continuous; *resolution*: OPD: 20–8 cm
MLS (UARS)	Microwave Limb Sounder *Satellite*; *lifetime*: NASA UARS; 1994–2001; *species:* ClO, CH_3CN, H_2O, HNO_3, O_3, SO_2, temp., geopotential height, ice water content, ice water path, relative humidity with respect to ice; *viewing*: L; *sounding:* Sp; *spectral bands*, 63 GHz, 183 GHz, 205 GHz

(*continued*)

MLS (Aura)	Microwave Limb Sounder *Satellite*; *lifetime*: NASA (A-TRAIN) Aura; 2004 – present ; e*quator crossing time:* 13.38; *species:* BrO, CH_3CN, ClO, CO, H_2O, HCl, HCN, HNO_3, HO_2, HOCl, N_2O, O_3, OH, SO_2, temp., geopotential height, ice water content, ice water path, relative humidity with respect to ice; *viewing*: L; s*ounding:* Sp; *spectral bands*, 118, 190, 240, 640, 2,250 GHz
MODIS	Moderate Resolution Imaging Spectroradiometer *Satellite*; *lifetime*: Terra 1999 – present; Aqua (A TRAIN); 2002 – present; *re-visit period*:1–2 days; e*quator crossing:* 10.30 descending (T); 13.30 ascending (A); *aerosol properties*: AOD, FM AOD, CM AOD, type, psd (over ocean); *cloud properties*: CER, CIWP, COT, CPP, CTP, CTH, CTT, LWP, DZ, CZ; *viewing*: N; s*ounding* Tot; *footprint*: bands 1–2: 0.25 × 0.25 km; bands 3–7: 0.5 × 0.5 km; bands 8–36: 1 × 1 km; swath 2,330 km; *spectral channels*: UV/vis/NIR; 412.5, 443, 469, 488, 531, 551, 555, 645, 667, 678, 748, 858, 869.5, 905, 936, 940, 1,240, 1,375, 1,640, 2,130, 3,750, 3,859, 4,050, 4,465, 4,516, 6,715, 7,325, 8,550, 9,730, 11,030, 12,020, 13,335, 13,635, 13,935, 14,235 nm; *resolution*: variable
MOPITT	Measurement of Pollution in the Troposphere *Satellite*; *lifetime*: NASA Terra 1999 – present; *re-visit period*: 3 days; e*quator crossing time*: 10.30 descending; *species*: CO; *viewing*: N + scan; *sounding*: Tc, Tp; *footprint*: 22 × 22 km; *spectral region*: IR; correlation radiometer, 3 bands, 8 channels; *resolution*: 0.04 cm^{-1} (effective); length and pressure modulated correlation spectrometer
OMI	Ozone Monitoring Instrument *Satellite*; *lifetime*: NASA Aura (A TRAIN), 2004 – present; *re-visit period*: 1 day; e*quator crossing time:* 13.00 ascending; *species:* O_3, NO_2, SO_2, BrO, OClO, HCHO, CHOCHO, O_4; *aerosol properties*: AOD, AAI, ssa; *cloud properties*: CF, CP, CTH; *viewing*: N; s*ounding* Tot, Tc; *footprint*: 24 × 13 km swath: 2,600 km; *spectral region*: UV/vis; continuous; *resolution*: ~0.5 nm
OSIRIS/IRI	Optical Spectrograph and Infrared Imaging System *Satellite*; *lifetime*: Swedish ODIN, 2001 – present; e*quator crossing time:* 06.00; *species:* O_3, BrO; *viewing*: L ; s*ounding* Sp; *spectral regions*: 280–800 nm (OSIRIS); 2 bands, 1.27 μm and 1.53 μm (IRI); *resolution*: 1 nm (OSIRIS)
POLDER (PARASOL)	Polarization and Anisotropy of Reflectances for Atmospheric Science coupled with Observations from a LIDAR *Satellite*; *lifetime*: NASA PARASOL (A TRAIN); 2004 – present; *re-visit period*: 1 day; *equator crossing time:* 13.30, ascending; *aerosol properties*: AOD, FM AOD, CF AOD, NS AOD; *cloud properties*: CER, CF, COT, CP, CTH, CTP, LWP, SW albedo; *viewing*: N, multi-directional; *sounding:* Tot; *footprint*: 6 × 6 km; *swath*: 2,400 km *spectral region*: vis/NIR; *polarised channels*: 443, 490, 565, 670, 763, 765, 865, 910, 1,020 nm
POAM-II	Polar Ozone and Aerosol Measurement II *Satellite*; *lifetime*: SPOT-3, 1993–1996; e*quator crossing time:* 10.30 descending; *species:* O_3, H_2O, NO_2, aerosol properties, temperature; *viewing*: O; s*ounding* Sp; *orbit:* sun-synchronous polar; *spectral region*: UV/vis/NIR; *channels*, 353.0, 442.0, 448.3, 600.0, 760.8, 780.0, 920.0, 935.5, 1,059.0 nm; *resolution*: 2–16 nm

(*continued*)

POAM-III	Polar Ozone and Aerosol Measurement III *Satellite*; *lifetime*: SPOT-4, 1998–2005; e*quator crossing time:* 10.30 decending; *species:* O_3, H_2O, NO_2, aerosol properties, temperature; *viewing*: O; s*ounding* Sp; *orbit:* sun-synchronous polar; *spectral channels*: UV/vis/NIR; 354.0, 439.6, 442.2, 603.0, 761.3, 779.0, 922.4, 935.9, 1,018.0 nm; *resolution*: 2–16 nm
SAGE-1	Stratospheric Aerosol and Gas Experiment I *Satellite*; *lifetime*: NASA Atm. Explorer, 1979–1981; *species:* O_3, NO_2, aerosol properties; *viewing*: O; s*ounding* Sp, Tp (upper); *spectral region*: vis/NIR; *channels*: 380, 450, 600, 1,000 nm; *resolution*: 2–20 nm
SAGE-2	Stratospheric Aerosol and Gas Experiment II *Satellite*; *lifetime:* NASA Earth Radiation Budget,1984 – present; *species:* O_3, NO_2, H_2O, aerosol properties; *viewing*: O; s*ounding* Sp, Tp (upper); *spectral region*: vis/NIR; *channels*: 385 nm, 448 nm, 453 nm, 525 nm, 600 nm, 940 nm, 1,020 nm; *resolution*: 2–20 nm
SAGE-3	Stratospheric Aerosol and Gas Experiment III *Satellite*; *lifetime*: NASA Meteo 3M, 1999; ISS, 2002; *species:* O_3, NO_2, OClO, BrO, NO_3, aerosol properties; *viewing*: O; *sounding* Sp, Tp (upper); *spectral channels*: vis/NIR; 290, 385, 430–450, 525, 600, 740–780, 920–960, 1,020, 1,500 nm; *resolution*: 2–20 nm
SAM II	Stratospheric Aerosol Measurement II *Satellite*; *lifetime*: Nimbus 7; 1979–1990; e*quator crossing time:* local noon; *species:* aerosol properties; *viewing*: O; s*ounding* Sp/Tp; *footprint*: 30-arc-second circle; *spectral region*: IR; 1 channel at 1 μm with 0.038 μm bandpass
SAMS	Stratospheric and Mesospheric Sounder *Satellite*; *lifetime*: NASA Nimbus 7; 1979–1990; e*quator crossing time:* local noon; *species:* CO_2, H_2O, CO, N_2O, CH_4, NO, temperature; *viewing*: L + scan; s*ounding* Sp, Mp (20–100 km); *footprint*: 10 H × 100 L km; *spectral channels*: IR; 4.3, 5.3, 7.7, 15, 100 μm, 25–100 μm; *resolution*: gas pressure modulation technique
SBUV	Solar Backscatter Ultraviolet Ozone Experiment *Satellite*; *lifetime*: NASA Nimbus 7; 1979–1990; e*quator crossing time:* 12:00; *species:* O_3; *viewing*: N; s*ounding:* SP; *footprint*: 200 × 200 km; *spectral channels*: UV; 252, 273, 283, 288, 292, 298, 302, 306, 312, 318, 331, 340 nm; *resolution*: ~1 nm
SBUV-2	Solar Backscatter Ultraviolet Ozone Experiment *Satellite*; *lifetime*: NOAA-9, NOAA- 11, NOAA-14 (1985 – present); e*quator crossing time:* variable due to the satellite drift; *species:* O_3; *viewing*: N; s*ounding:* SP; *footprint*: 200 × 200 km; *spectral region*: UV; *channels*: 252, 273, 283, 288, 292, 298, 302, 306, 312, 318, 331, 340 nm; *resolution*: ~1 nm
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Cartography *Satellite*; *lifetime*: ESA-ENVISAT, 2002 – present; *re-visit period*: 6 days; e*quator crossing time:* 10.00 ascending; *species:*O_3, NO, N_2O, NO_2, CO, CO, CO_2, CH_4, BrO, OClO, HCHO, SO_2, CHOCHO, IO, H_2O, O_2, O_4, and aerosols ; *cloud properties*: CTH, COT, LWP, DZ, CZ; *viewing*: N, L, O; s*ounding* Tot, Sp, Tp, Me; *footprint*: 60 × 30 km; *spectral region*: UV/vis/NIR; continuous: 240–1,750 nm, 1,940–2,040 nm, 2,265–2,380 nm; *resolution*: 0.2–1.5 nm

(*continued*)

SEVIRI	Spinning Enhanced Visible and InfraRed Imager *Satellite*; *lifetime:* MSG (Meteosat 2nd Gen.); 2005 – present; *geostationary, scan repeat*: 15 min; *species: aerosol properties*: AOD, *cloud properties*: CTT, CTP; *viewing:* GEO*; sounding:* Tot*; footprint:* 1 × 1 km (high resolution vis channel); 3 × 3 km (IR and other vis channels); *spectral region:* vis/IR; *channels* 635, 810, 1,640, 3,920, 6,250, 7,350, 8,700, 9,660, 10,800, 12,000, 13,400 nm
TANSO	Thermal and short wave infra-red Sensor for observing greenhouse gases *Satellite*; *lifetime*: JAXA GOSAT, 2009; *re-visit period*: 3 days; e*quator crossing time:* 13.00; *species:* O_2, CO_2, CH_4, H_2O; cloud and aerosol properties; *viewing*: N; s*ounding* Tot; *footprint*: 10 × 10 km; *spectral bands*: vis/NIR/IR; 750–780, 1,560–1,730, 1,920–2,090, 5,500–14,300 nm, *resolution*: 0.015–4 nm
SCR	Selective Chopper Radiometer *Satellite*; *lifetime*: NASA Nimbus 4,5; 1970–1975; *species:* CO_2 temperature profile, water vapour, ice; *viewing*: nadir; s*ounding* Tot ; *footprint*: 25 × 25 km; *spectral region*: IR(1) 4 CO_2 channels between 13.8 and 14.8 μm, (2) four channels at 15.0 μm, (3) an IR window channel at 11.1 μm, H_2O at 18.6 μm, two channels at 49.5 and 133.3 μm, and (4) four channels at 2.08, 2.59, 2.65,and 3.5 μm
SeaWiFS	Sea-viewing Wide Field-of-View Sensor *Satellite*; *lifetime*: SeaStar, August 1997 – present; *re-visit period*: 1 day; *equator crossing time:* 12.20 descending; *swath:* 2,801 km; *species:* AOT (at 865 nm); *viewing*: N; *footprint*: 1.1 × 4.5 km; *spectral channels*: UV/vis; 412, 443, 490, 510, 555, 670, 765, 865 nm; *bandwidths (FWHM)*: 20, 20, 20, 20, 20, 20, 40, 40 nm; *other features*: hyperspectral image, normalized water leaving radiance, attenuation coefficient, Angstrom coefficient, photosynthetically active radiation, land reflectance
SME	Solar Mesospheric Experiment(SME was a mission consisting of 5 single instruments) *Satellite; lifetime*: NASA SME: 1983; e*quator crossing time:* 03.00–15.00 Sun-synchronous orbit; *species:* O_3, $O_2(^1\Delta_g)$, NO_2 s*ounding* Sp, Me; *spectral region*: UV/vis
TES	Tropospheric Emission Spectrometer *Satellite*; *lifetime*: NASA Aura, 2003 – present; *re-visit period*: several days; e*quator crossing time:* 01.45; *species:* H_2O, CH_4, N_2O, O_3, CO, NO, NO_2, HNO_3; *viewing*: N, L; s*ounding* Tot, Tc, Tp; *footprint*: 5 × 8 km; *spectral region*: IR; FTS continuous spectrum; *resolution:* OPD: 8.45 cm
TOMS	Total Ozone Monitoring Spectrometer *Satellite*; *lifetime*: NASA Nimbus 7, 1979–1992; ADEOS, 1996–1997; Meteor, 1992–1094; Earth Probe, 1996 to present; *re-visit period*: 1.5 days; e*quator crossing time:* 12.00; *species:* O_3; SO_2; *viewing*: N; s*ounding* Tot, Tc; *footprint*: 50 × 50 km; *spectral region*: UV; *channels*: 379.95, 359.88, 339.66, 331.06, 317.35, 312.34 nm; *resolution*: ~1 nm

Appendix B: Atlas of Ancillary Global Data

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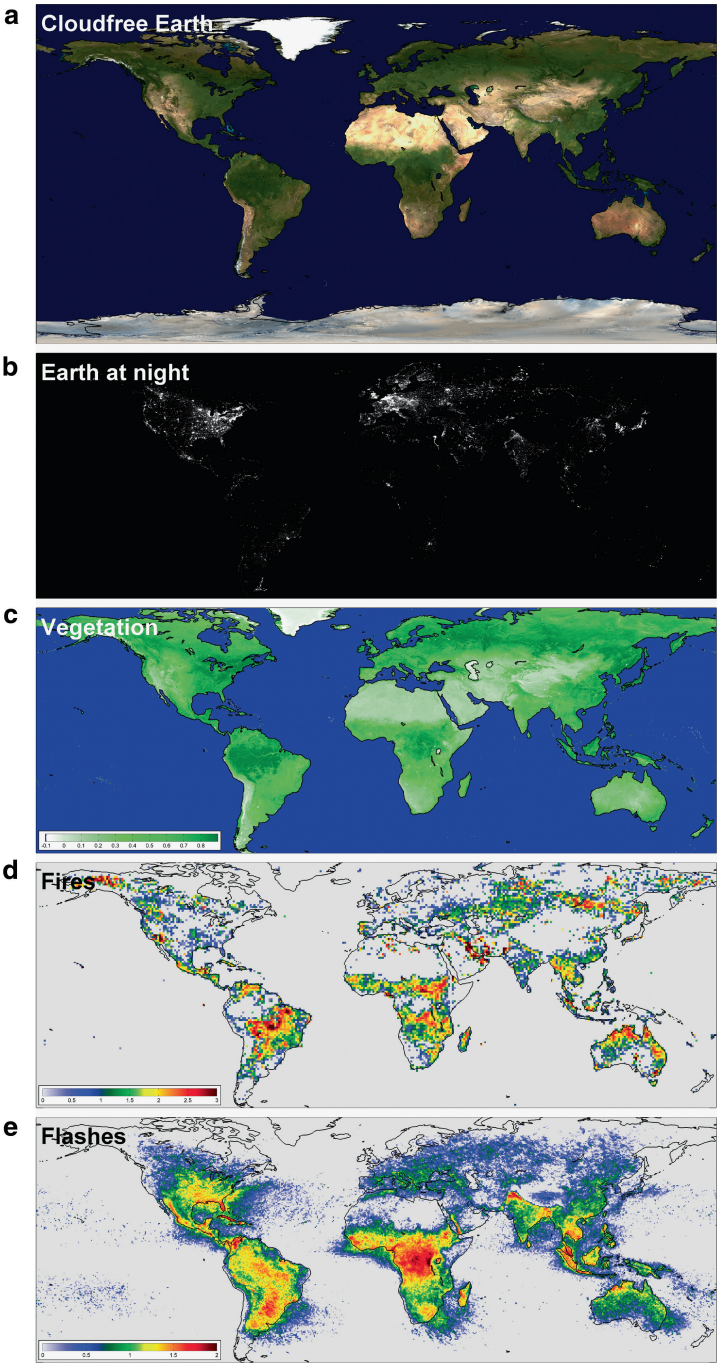
(a) Cloud-free composite of the Earth's view from space (*MODIS/NASA*).
(b) Night-time light pollution derived from DMSP measurements. *Data processing by NOAA's National Geophysical Data Center. DMSP data collected by US Air Force Weather Agency.*
(c) Normalized Differenced Vegetation Index for August 2007 from the NASA instrument MODIS. *Terra/MODIS measurements*; http://neo.sci.gsfc.nasa.gov/.
(d) Fires (absolute fire counts on a 1° grid) 2003–2005, produced from ESA remote sensing data. *ATSR World Fire Atlas, received from the ESA Data User Element.*
(e) Lightning flash climatology (flashes per km^2 per year) derived from LIS/OTD. *The v1.0 gridded satellite lightning data were produced by the NASA LIS/OTD Science Team*; http://ghrc.msfc.nasa.gov.


a
Cloudfree Earth
b
Earth at night
c
Vegetation
d
Fires
e
Flashes

Appendix C: Abbreviations and Acronyms

A list of chemical names and molecular formulae is given just before the first chapter

		Chapters
AAI	Aerosol absorbing index	Appendix D
AATSR	Advanced along-track scanning radiometer	5, 6, Appendix A
ACCENT	Atmospheric Composition Change/The European Network of Excellence	5, 6, 10
ACE	Aerosol characterisation experiment	4
ACE-FTS	Atmospheric chemistry experiment – FTS	3, Appendix A
ADEOS	Advanced earth observation satellite	3
ADV	AATSR dual view algorithm	6
AEROCAN	Canadian aerosol network	6
AERONET	Aerosol robotic network – a ground based network	6, 7
AIRS	Atmospheric infrared sounder	3, 4, Appendix A
AMAERO	OMI multi-wavelength aerosol algorithm	6
AMF	Air mass factor	2, 9
AMS	American Meteorological Society	4
AMSR	Advanced microwave scanning radiometer	4
AMSUA, B	Advanced microwave sounding unit – A, B	4
AMV	Atmospheric motion vectors	4
AOD	Aerosol optical depth	6, 7, 9, Appendix D
AOS	Acousto-optical-spectrometers	4
AOT	Aerosol optical thickness	6, 7, 9, Appendix D
APS	Aerosol polarimetry sensor	6
ARM	Atmospheric radiation measurement site	5
AROME	Application of research to operations in meso-scale	4
ARTS	Atmospheric radiative transfer simulator	4
ASCAT	MetOp's advanced scatterometer	4
AT2	ACCENT-TROPOSAT-2	1
ATLAS	Atmospheric laboratory for application and science	4
ATM	Atmospheric transmission at microwaves	4
ATMOS	Atmospheric trace molecule spectroscopy	3, Appendix A
ATSR-2	Along track scanning radiometer	6, Appendix A
AVHRR	Advanced very high resolution radiometer	4, 5, 6, Appendix A
BAER	Bremen aerosol retrieval algorithm	6
BB	Biomass burning	8
BLUE	Best linear unbiased estimate	9
BRDF	Bi-directional distribution function	2
BRDF	Bi-directional reflection function	6
BT	Brightness temperature	5
BUV	Backscatter ultraviolet ozone experiment	Appendix A
CA	Cloud albedo	Appendix A
CALIOP	Cloud-aerosol lidar with orthogonal polarization	6, Appendix A
CALIPSO	Cloud-aerosol lidar and infrared pathfinder satellite observations	4, 6
CAMA	Toolkit for validation of OMI data	7
CARIBIC	Civil aircraft for the regular investigation of the atmosphere based on an instrument container	7
CCM	Chemistry climate model	9

(*continued*)

		Chapters
CCN	Cloud concentration nuclei	1, 6
CEOS	Committee on Earth observation satellites	7, 10
CERES	Cloud and Earth's radiant energy system	4
CESAR	Cabauw experimental site for atmospheric research	6
CF	Cloud fraction	Appendix A
CFC	Chloroflurocarbon	3
CHAMP	Challenging mini-satellite payload	4
CIMEL	Commercial sun photometer	7
CIW	Cloud ice water	4
CIWSIR	Cloud ice water sub-millimeter imaging radiometer	4
CL	Chemiluminescence	7
CLAES	Cryogenic limb array etalon spectrometer	Appendix A
CLW	Cloud liquid water	4
CNES	Centre National d'Etudes Spatiales	3
COSMIC	Constellation observing system for meteorology ionosphere and climate	4
CoSSIR	Conical scanning submillimeter wave imaging radiometer	4
COT	Cloud optical thickness	5, Appendix A
CPR	Cloud profiling radar	4
CRD	Cloud radiation database	4
CRL	Communications Research Laboratory, Japan	4
CRM	Cloud resolving model	4
CRTM	Community radiative transfer model	4
CSA	Canadian Space Agency	3, 4
CSU	Colorado State University	4
CT	Cloud temperature	Appendix A
CTH	Cloud top height	5, Appendix A
CTM	Chemical transport model	8, 9
CZ	Crystal size	Appendix A
CZCS	Coastal zone colour scanner	5
DA	Data assimilation	9
DDA	Discrete dipole approximation	4
DIAL	Differential absorption lidar	1, 7, 10
DMSP	Defence meteorological satellite program	4
DOAS	Differential optical absorption spectroscopy	1
DOFS	Degrees of freedom for signal	3
DOIT	Discrete ordinate iterative method	4
DPR	Dual-frequency (Ku/Ka-band) precipitation radar	4
DSD	Droplet size distribution	4
DU	Dobson unit	2, 8, 9
DUE	Data users element	6
DUP	Data users program	6
DZ	Droplet size	Appendix A
EARLINET	European research lidar network	6, 7
ECC	Electrochemical concentration cell	7
ECMWF	European Centre for Medium Range Weather Forecasting	3, 4, 10
EGPM	European GPM	4
E-GVAP	EUMETNET GPS water vapour programme	4
ELDO	European Launcher Development Organisation	1

(*continued*)

		Chapters
EMAC	ECHAM/MESSy atmospheric chemistry model	9
ENVISAT	Environmental satellite	3, 5, 6
EOS	Earth observing system	6
EPS	EUMETSAT's polar system	4
ERTS-1	Earth resources technology satellite	6
ESA	European Space Agency	1, 3, 4, 5, 6, 10
ESRO	European Space Research Organisation	1
EUCAARI	European integrated project on aerosol cloud climate air quality interactions	6
EUMETNET	The Network of European meteorological services	4
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites	1, 6, 10
EURAD	European Air Pollution Dispersion model system	9
EUSAAR	European supersites for atmospheric aerosol research	6
FFTS	Fast Fourier transform spectrometer	4
FIRSC	Far infrared sensor for cirrus	4
FMI	Finnish Meteorological Institute	6
FT	Fourier transform	1
FTIR	Fourier transform infra red	7
FTS	Fourier transform spectrometer	3, 4, 5
FWHM	Full width half maximum	1, 3
GADS	Global aerosol data set	6
GAW-PFR	Global Atmospheric Watch – precision filter radiometer	6
GCE	Goddard cumulus ensemble	4
GCM	Global climate model	8
GCM	General circulation model	9
GCOS	Global climate observing system	
GEISA	A spectroscopic database	3
GEMS	Global and regional Earth-system monitoring using satellite and *in situ* data	6
GEO	Geostationary Orbit	1, 4, 10
GEO	Group on Earth Observations	
GEOS	Goddard Earth observing system model	4
GEOS-Chem	Goddard Earth observing system-chemistry model	9
GEOSS	Global observing system of systems	1, 10
GLAS	Geoscience laser altimeter system	6
GMAO	Global modelling and assimilation office	6
GMES	Global Monitoring of Environment and Security	1, 6, 10
GMI	GPM microwave imager	4
GOMAS	Geostationary observatory for microwave atmospheric sounding	4
GOME-2	Global ozone monitoring experiment-2	Appendix A
GOMOS	Global ozone monitoring by occultation of stars	Appendix A
GOSAT	Greenhouse gases observing satellite	5
GPM	Global precipitation measurement	4
GPS	Global positioning system	4
GPSRO	GPS radio occultation	4
GRAS	Global navigation satellite system receiver for atmospheric sounding	4
GSFC	Goddard Space Flight Center	4

(*continued*)

		Chapters
GVS	Ground validation system	4
HALOE	Halogen occultation experiment	Appendix A
HERA	Hybrid extinction algorithm	6
HIRDLS	High resolution dynamics limb sounder	3, Appendix A
HIRS	High-resolution infrared radiation sounder	4
HITRAN	A spectroscopic database	3
HITRAN	High resolution transmission model	4
HSB	Humidity sensor for Brasil	4
HTAP	Hemispheric transport of air pollution	1
IASI	Infrared atmospheric sounding interferometer	3, Appendix A
ICESat	Ice, cloud, and land elevation satellite	6
IDL	Language used in the CAMA toolkit	7
IGACO	Integrated Global Atmospheric Chemistry Observations	10
IGOS	Integrated Global Observing System	1, 10
IGS	International GPS service	4
IGY	International geophysical year	1
IIR	Imaging infrared radiometer	6
ILAS I, II	Improved limb atmospheric spectrometer	Appendix A
ILS	Instrumental line shape	3
IMG	Interferometric monitor for greenhouse gases	3, AA
IPCC	Inter-governmental panel on climate change	1, 10
IR	Infrared	1, 7, 10
ISAMS	Improved stratospheric and mesospheric sounder	Appendix A
ISCCP	International satellite cloud climatology project	4, 5
ISO	International Organisation for Standardization	7
ISS	International space station	4
ITCZ	Inter tropical convergence zone	5
JAXA	Japanese Aerospace Space Agency	1, 4, 5, 10
JCSDA	Joint centre for satellite data assimilation	4
JEM-SMILES	The Japanese experiment module superconducting submillimeter-wave limb-emission sounder	4
JMA	Japan Meteorological Agency	4
JPL	Jet propulsion laboratory	3, 4
KNMI	Royal Netherlands Meteorological Institute	6
LEO	Low earth orbit	1, 4, 10
Lidar	Light detection and ranging	1, 5, 10
LIF	Laser induced fluorescence	7
LIMS	Limb infrared monitor of the stratosphere	4, Appendix A
LIS	Lightning imaging sensor	4, 8
LITE	Lidar in space technology experiment	6
LOS	Line of sight	2
LOWTRAN	Low resolution transition model database	1
LRIR	Limb radiance inversion radiometer	4, Appendix A
LRT	Long range transport	8
LRTAP	Long range transboundary air pollution	1
LT	Lower troposphere	8
LTE	Local thermal equilibrium	3
LUT	Look-up table	5–7
LWP	Liquid water path	5

(*continued*)

		Chapters
MACC	Monitoring atmospheric composition and climate	6, 10
MAN	Maritime aerosol network	6
MAPS	Measurements of atmospheric pollution from satellites	3, Appendix A
MAS	The millimeter-wave atmospheric sounder	4
MAS	Microwave atmospheric sounder	Appendix A
MAXDOAS	Multi-axis differential optical absorption spectroscopy	7
MEGAPOLI	Megacities: emissions, urban, regional and global atmospheric pollution and climate effects, and integrated tools for assessment and mitigation	6
MERIS	Medium resolution imaging spectrometer	5, 6, Appendix A
METEOSAT	Meteorological satellite	6
METOP	MetOp is a series of three satellites, forming a segment of EPS	4, 6
MHS	Microwave humidity sounder	4
MIPAS	Michelson interferometer for passive atmospheric sounding	3, Appendix A
MIR	Millimeter-wave imaging radiometer	4
MISR	Multiangle imaging spectro-radiometer	4, 5, 6
MJO	Madden-Julian oscillation	4
MLS	Microwave limb sounder	4, Appendix A
MODIS	Moderate-resolution imaging spectro-radiometer	4, 5, 6, Appendix A
MOPITT	Measurements of pollution in the troposphere	3, Appendix A
MOZAIC	Measurements of ozone and water vapour by in-service Airbus aircraft	4, 7
MOZART	Model for ozone and related chemical tracers	9
MSC	Meteorological Service of Canada	4
MSG	Meteosat second generation	6
MSS	Multi spectral scanner	6
MSU	Microwave sounding unit	4
MTPE	Mission to planet Earth	4
MWHS	Microwave humidity sounder	4
MWMOD	Microwave model	4
MWRI	Microwave radiation imager	4
MWTS	Microwave-tomographic imaging	4
NADCC	Network for the detection of atmospheric composition change	7
NAO	North Atlantic oscillation	8
NASA	National Aeronautics and Space Administration (USA)	1, 3–6, 10
NASDA	National Space Development Agency in Japan	4
NCEP	National centers for environmental prediction (NOAA)	4
NDVI	Normalised difference vegetation index	6
NEMS	Nimbus-E microwave sensor	4
NESR	Noise-equivalent spectral radiance	3
NEXRAD	Next generation weather radar	4
NH	Northern hemisphere	8, 9
NiCT	National Institute of Information and Communications Technology, Japan	4
NIR	Near infrared	2, 6
NIS	NEXRAD in Space	4

(*continued*)

		Chapters
NMHC	Non-methane hydrocarbons	8
NMVOC	Non-methane volatile organic compounds	8
NOAA	National Oceanic and Atmospheric Administration (USA)	1, 4, 5
NPOESS	National Polar-orbiting Operational Environmental Satellite System	1, 4, 10
NPP	NPOESS preparatory project	
NSF	National Science Foundation	10
NWP	Numerical weather prediction	1,4, 10
NWP-SAF	NWP- Satellite Application Facility	4
OE	Optimal estimation	3
OI	Optimal interpolation	9
OMI	Ozone monitoring instrument	6, Appendix A
OPAC	Optical properties of aerosols and clouds package	6
OPD	Optical path difference	3
OSE	Observing system experiment	4
OSIRIS	Optical spectrograph and infrared imaging system	Appendix A
OSSE	Observing system simulation experiments	4
PAH	Polyaromatic hydrocarbons	1
PARASOL	Polarization and anisotropy of reflectances for atmospheric sciences coupled with observations from a lidar	5, 6, Appendix A
PGR	Polarisation gain ratio	6
PHOTONS	European aerosol network	6, 7
PIA	Path integrated attenuation	4
PM10, PM2.5	Particulate matter (diameter less than 10 μm) (diameter less than 2.5 μm)	6
POAM-II, III	Polar ozone and aerosol measurement II, III	Appendix A
POLDER	Polarization and directionality of the Earth's reflectances	5, 6
POP	Persistent organic pollutants	1
PPS	Precipitation processing system	4
PR	Precipitation radar	4
PREMIER	Process exploration through measurements of infrared and millimeter-wave emitted radiation	4
PW	Precipitable water	4
RADM	Regional acid deposition model	9
RH	Relative humidity	6
RMS	Root mean square	7, 9
RMSD	Root mean square deviation	6
RPV	Raman-Pinty-Verstraete mode	6
RRS	Rotational Raman scattering	1
RTE	Radiative transfer equation	4
RTM	Radiation transfer modelling	2
RTM	Radiation transfer model	6, 7
RTTOV	Radiative transfer for TOVS	4
RVRS	Rotational-vibrational Raman scattering	1
SACURA	Semi-analytical cloud retrieval algorithm	5
SAGE – 1, 2, 3	Stratospheric aerosol and gas experiment 1, 2, 3	Appendix A
SAM, II	Stratospheric aerosol measurement instrument, II	6, Appendix A

(*continued*)

		Chapters
SAMS	Stratospheric and mesospheric sounder	4, Appendix A
SBUV, - 2	Solar backscatter ultraviolet ozone experiment, -2	Appendix A
SCA	Scene classification algorithm	6
SCAMS	Scanning microwave sounder	4
SCD	Slant column density	2
SCIAMACHY	Scanning imaging absorption spectrometer for atmospheric cartography	5, Appendix A
SCR	Selective chopper radiometer	Appendix A
SD	Slant delay	4
SEVIRI	Spinning enhanced visible and infrared imager	6, Appendix A
SH	Southern hemisphere	8, 9
SHADOZ	Southern hemisphere additional ozone sondes	7
SHDOM	Spherical harmonic discrete ordinate method	4
SIBYL	Selective interactive boundary algorithm	6
SIRICE	Submillimeter infrared radiometer ice cloud experiment	4
SIS	Superconductor-insulator-superconductor	4
SLST	Sea and land surface temperature	6
SME	Solar mesospheric experiment	Appendix A
SMLS	Scanning microwave limb sounder	4
SMR	The Odin sub-millimeter radiometer	4
SOA	Secondary organic aerosol	8
SOD	Slant optical density	2
SRT	Surface reference technique	4
SSA	Single scattering albedo	6, Appendix D
SSM/T-1, -2	Special sensor microwave/temperature-1, -2	4
SSMI/S	Special sensor microwave imager/sounder	4
SST	Sea surface temperature	4
SSU	Stratospheric sounding unit	4
STEAM-R	The stratosphere troposphere exchange and climate monitor radiometer	4
SZA	Solar zenith angle	2
TANSO	Thermal and short wave infra-red sensor for observing greenhouse gases	Appendix A
TEMIS	Tropospheric emission monitoring internet service	6
TEOM-FDMS	Tapered element oscillating microbalance with filter dynamics measurement system	6
TES	Tropospheric emission spectrometer	3, 7, Appendix A
THV	Threshold value	5
TIR	Thermal infrared	5, 6, 10
TIROS	Television Infrared Observation Satellite	4, 5
TM4-ECPL	Chemistry transport model version 4 – Environmental chemical processes laboratory	9
TM5	Chemistry transport model version 5	9
TMI	Tropical rainfall measuring mission microwave imager	4
TNO	Netherlands Organisation for Applied Scientific Research	6
TOA	Top of atmosphere	2, 5, 6, 7
TOMS	Total ozone mapping spectrometer	5, 6, Appendix A
TORA	Tropospheric ozone re-analysis method	9

(*continued*)

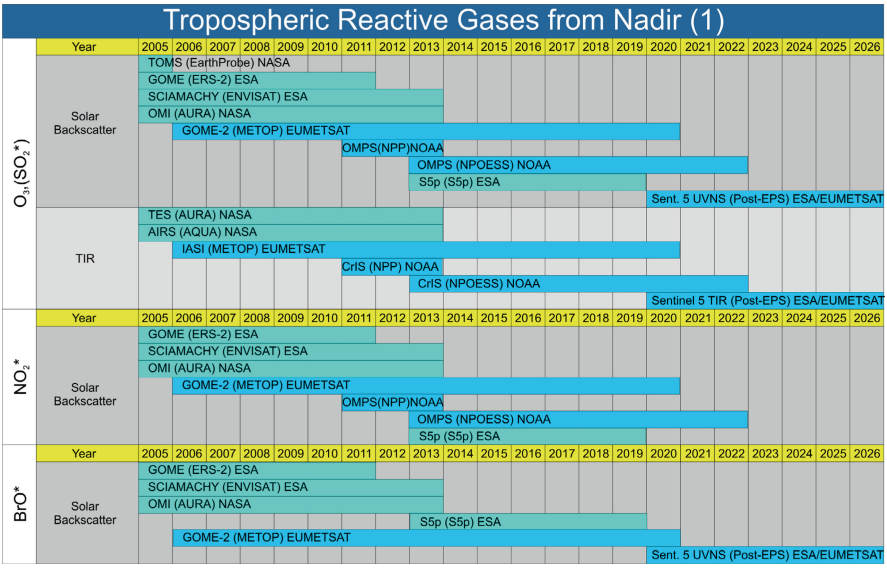
		Chapters
TOVS	TIROS operational vertical sounder	4, 5
TP	Tikhonov – Phillips regularisation	3
TRMM	Tropical rainfall measuring mission	4
TROPOSAT	Use and usability of satellite data for tropospheric research	1, 10
TTL	Tropopause transition layer	4, 8
UAE2	United Arab Emirates Unified Aerosol Experiment	6
UARS	Upper atmosphere research satellite	4
UNECE	United Nations Economic Commission for Europe	1, 10
UNEP	United Nations Environment Programme	1
UNFCCC	United Nations Framework Convention on Climate Change	1
UT	Upper troposphere	8
UTH	Upper tropospheric humidity	4
UTLS	Upper troposphere/lower stratosphere	3, 9
UV	Ultra-violet	6
UV/vis	UV/visible	1, 2, 7
UW-NMS	University of Wisconsin non-hydrostatic modelling system	4
VCD	Vertical column density	2
VFM	Vertical feature mask	6
VIM	International vocabulary for metrology	7
VIRS	Visible and infrared scanner	4
VMR	Volume mixing ratio	8
VOC	Volatile organic compound	1, 8, 9
VRS	Vibration rotation spectra	1
WALES	Water vapour lidar experiment in space	1
WF	Weighting function	2
WFC	Wide field camera	6
WMO	World Meteorological Organisation	1, 10
WOUDC	World ozone and UV radiation data centre	7
ZTD	Zenith total delay	4

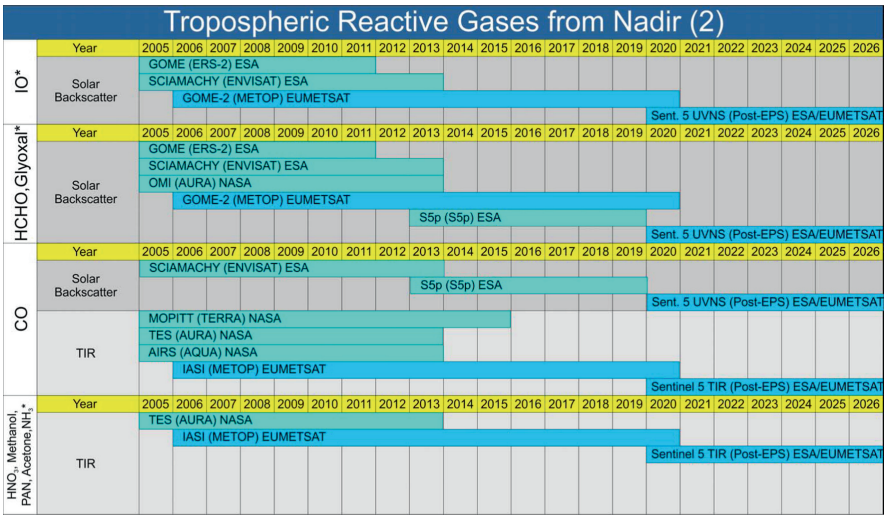
Appendix D: Timelines for Present and Future Missions

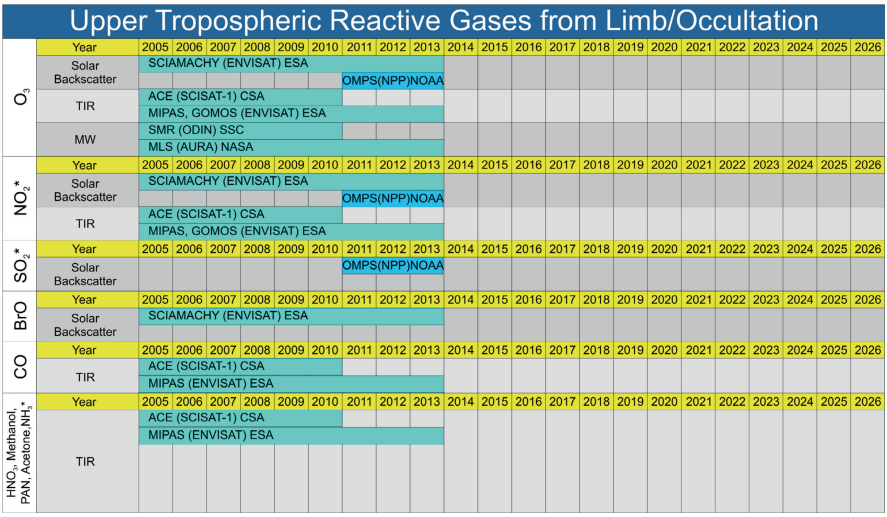
John P. Burrows and Stefan Noel, IUP, Bremen

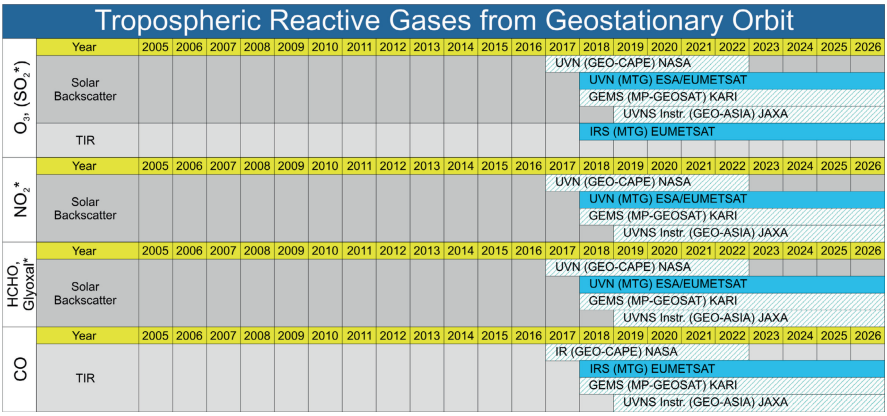
These figures are based on the best available 2010 information.

D.1 Tropospheric Reactive Gases









*Implies short lived gases with highly variable amounts. These are measured when column amounts are above the instrumental detection limit e.g. SO_2 from volcanoes for TIR detection and from tropospheric pollution at the ground retrieved from solar backscattered measurements

Notes

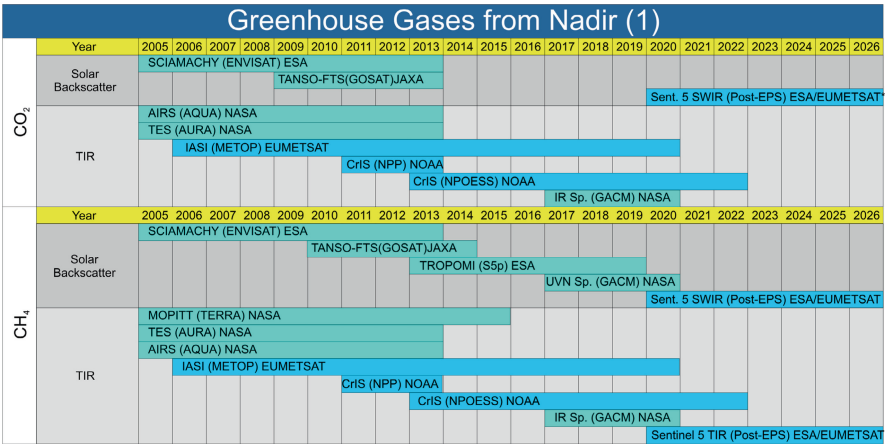
1. Concerning the retrieval of data products for tropospheric trace gases:
   (a) In the TIR, the averaging kernel depends on the temperature difference between the atmosphere and the earth's surface. If this difference is low

there is then little sensitivity to the lower troposphere and the information content in the observation is primarily in the middle and upper troposphere. However measurements can be made both by day and night.

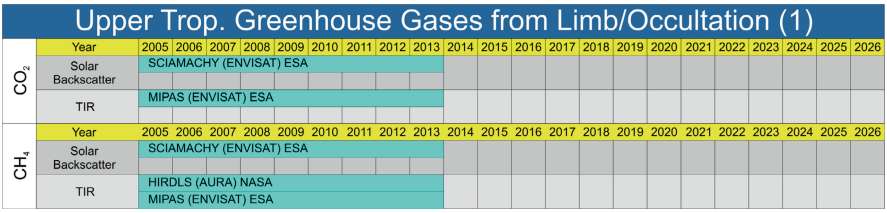
(b) The retrieval of trace gases using solar backscatter is sensitive to the lowermost troposphere as UV, visible and near IR radiation reaches the surface. However the sensitivity is reduced in the ultraviolet as a result of multiple scattering, and no measurements can be made at night.

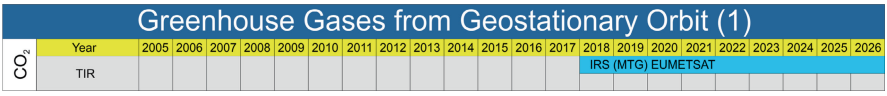
2. Colouring: darker blue implies existing or funded operational meteorological satellites and instrumentation; lighter blue implies funded space agency research missions; the hatched pale blue implies missions under study but not yet funded.

D.2 Greenhouse Gases: CH_4, CO_2



*Used for CH_4 normalisation; not optimised for CO_2 retrieval





Notes

1. Concerning the retrieval of data products for tropospheric trace gases:
   (a) In the TIR, the averaging kernel depends on the temperature difference between the atmosphere and the Earth's surface. If this difference is low there is then little sensitivity to the lower troposphere and the information content in the observation is primarily in the middle and upper troposphere. However measurements can be made both day and night.
   (b) The retrieval of trace gases using solar backscatter is sensitive to the lowermost troposphere as UV, visible and near IR radiation reaches the surface. However the sensitivity is reduced in the ultraviolet as a result of multiple scattering, and no measurements can be made at night.
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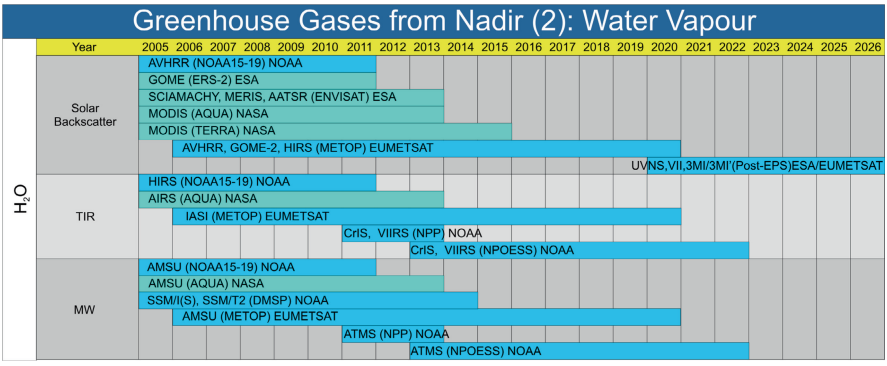
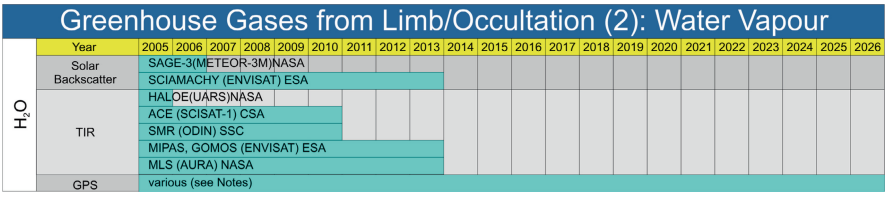
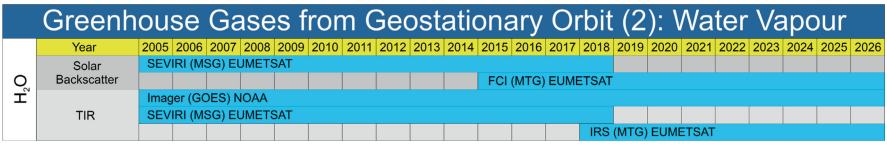
D.3 Greenhouse Gases: Water Vapour



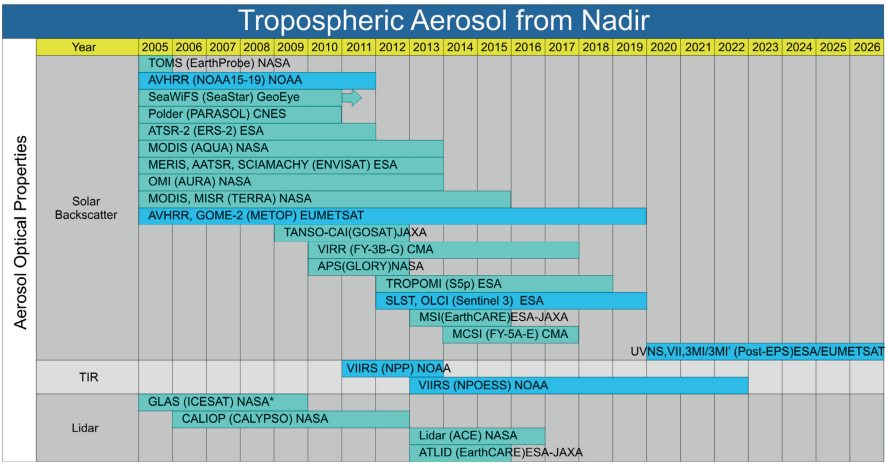




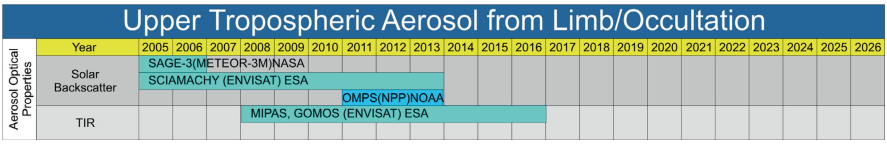
Notes

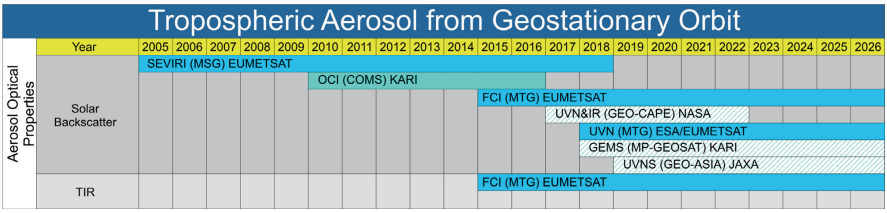
1. GPS refers to all Global Positioning System satellites, which are used for H_2O retrieval. These includes those already delivering water vapour products, e.g. GRAS on METOP and COSMIC, a constellation flown by the South Korean Space Agency in collaboration with NCAR. Further missions which are expected to deliver water vapour products are GALILEO, GLONASS and RO on PostEPS.
2. Concerning the retrieval of data products for tropospheric trace gases:
   (a) In the TIR, the averaging kernel depends on the temperature difference between the atmosphere and the earth's surface. If this difference is low there is then little sensitivity to the lower troposphere and the information content in the observation is primarily in the middle and upper troposphere. However measurements can be made both day and night.
   (b) The retrieval of trace gases using solar backscatter is sensitive to the lowermost troposphere as UV, visible and near IR radiation reaches the surface. However the sensitivity is reduced in the ultraviolet as a result of multiple scattering, and no measurements can be made at night.
3. Colouring: darker blue implies existing or funded operational meteorological satellites and instrumentation; lighter blue implies funded space agency research missions; the hatched pale blue implies missions under study but not yet funded.

D.4 Tropospheric Aerosol



*Intermittent operation



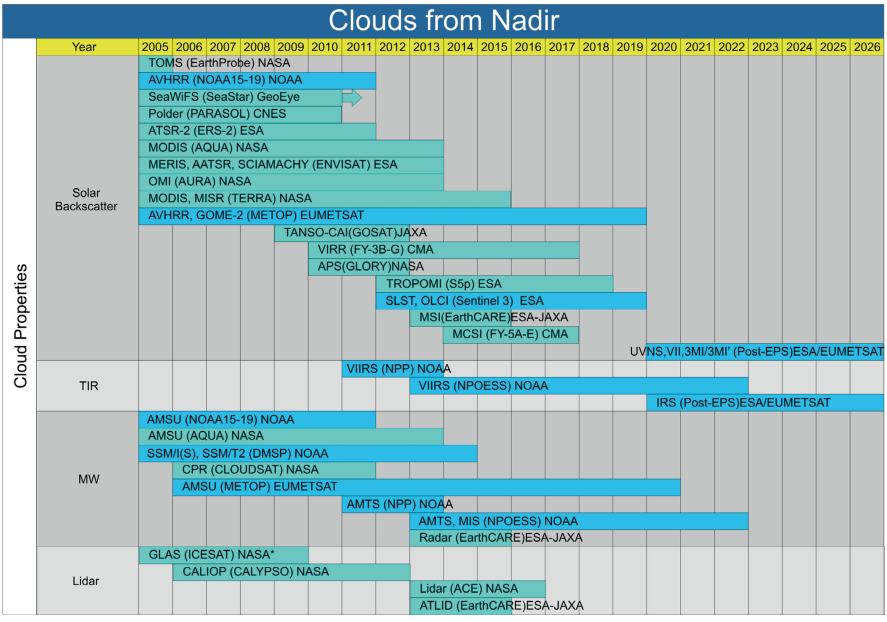


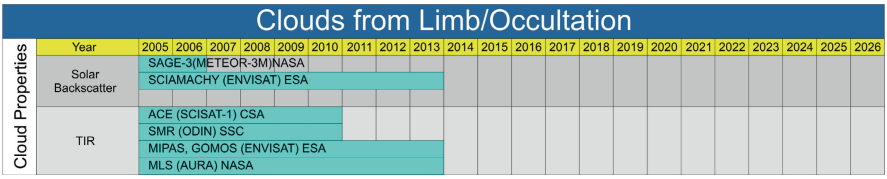
Notes

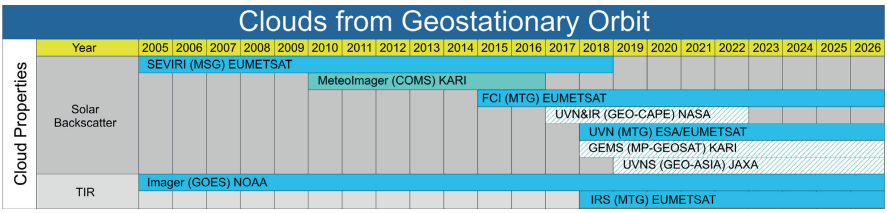
1. The aerosol optical proprieties in the figure description refer to the broad range of aerosol data products generated. These include: aerosol optical thickness, AOT, or aerosol optical depth, AOD, single scattering albedo, SSA, aerosol absorbing index, AAI, size distribution where available, size discrimination, coarse and fine.
2. Colouring: darker blue implies existing or funded operational meteorological satellites and instrumentation; lighter blue implies funded space agency research missions; the hatched pale blue implies missions under study but not yet funded.

*Intermittent operation

D.5 Clouds







Notes

1. Instruments/missions often deliver different cloud products; see the individual missions for details.
2. Colouring: darker blue implies existing or funded operational meteorological satellites and instrumentation; lighter blue implies funded space agency research missions; the hatched pale blue implies missions under study but not yet funded.