Generation of Retrieval Coefficient Sets for ATSR-1/2

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SST Retrieval

$$T_s = a_0 + \sum_i a_i T_i$$

$$T_s = SST$$

$$T_i = Measured\ BT\ in\ channel\ i$$

- The coefficients *a* represent a linear regression of SST on brightness temperature
- In practice, regression is based on model brightness temperatures derived from an ensemble of atmospheric profiles using a Radiative Transfer Model
- Coefficients used for ATSR processing based on RAL model RADGEN

Version History

- Original coefficients based on scheme having 10 across-track bands. Used prior to SADIST-2 version 310
- Aerosol robust coefficients developed by C.J. Merchant
  - Motivation: to generate coefficients insensitive to presence of stratospheric aerosol
  - Work based on rewritten radiative transfer code
  - Introduced new features into atmospheric model
  - Introduced new across-track banding scheme
  - New coefficients introduced into SADIST-2 V310
- Recent work at RAL has introduced the new features into RADGEN
- Derivation of ATSR-2 coefficients used in V310 to V321 affected by known errors
- New coefficients (V322) derived from latest RAL version

Recent program development at RAL

Objectives

- To update the radiative transfer code RADGEN and related code to take account of recent developments in coefficient generation
- To permit generation of revised SST retrieval coefficients for ATSR-2
- To generate new SST retrieval coefficients for ATSR-1 that take account of the detector temperature dependence of the ATSR-1 12 micron channel profile
- To establish and maintain configuration control of the code at RAL: Emphasis on traceability

Coefficient Derivation

Coefficient derivation involves the following steps

- Generate ensemble of atmospheric profiles
  - Profile set should be statistically representative
- Run radiative transfer model (RADGEN) to derive brightness temperatures for each profile
- Derive regression coefficients of surface temperature vs. brightness temperatures
  - Impose constraints at this stage if stratospheric aerosol robust coefficients required

Derivation depends on:

- Ensemble of atmospheric profiles
- Version of RADGEN
- Auxiliary data

Traceability

- A set of coefficients is traceable if sufficient information is on record to permit their derivation to be reproduced exactly. Applies to both
  - Radiative transfer Software
  - Atmospheric profile and auxiliary data
- Radiative Transfer Software: revision control should include
  - Continuum model
  - Tropospheric aerosol model
  - Stratospheric aerosol model
- Primary auxiliary data
  - Atmospheric spectroscopy
  - Channel filter profiles
- Derived auxiliary data
  - Radiance to brightness temperature tables, derived from channel filter profiles

Radiative Transfer Model

Specific changes to the RADGEN program have addressed the following requirements

- Ability to read atmospheric profiles derived from ECMWF data
  - Requires new extraction software
  - Interpolation with respect to relative humidity rather than water vapour density
- Enhanced tropospheric aerosol model
- Revised air mass and emissivity definitions to accommodate revised across-track banding scheme
- Inclusion of parameterised wind speed effects in the forward view (Watts et al, 1996)
- Improved portability, to enable transfer to unix system

Support of ECMWF-derived atmospheric profiles

- Original coefficients (Zavody) based on a set of 158 radiosonde profiles from UK Met. Office
- Merchant et al (1999) introduced a new set of profiles based on ECMWF re-analysis data
- Modified code accepts atmospheric profiles derived from ECMWF data
  - New format includes surface parameters from ECMWF surface parameter files
  - Water vapour specified by means of relative humidity rather than density
- Backwards compatibility retained

ECMWF Profile Data

- Upper air data.
  - Geopotential (Parameter number 129)
  - Temperature (Parameter number 130)
  - Relative humidity (Parameter number 157)
- Surface data.
  - U wind component (Parameter number 165)
  - V wind component (Parameter number 166)
  - Skin temperature (Parameter number 235)
  - Mean sea level pressure (Parameter number 151)
  - 2 metre air temperature (Parameter number 167)
  - 2 metre dew point temperature (Parameter number 168)
- Parameter codes as per ECMWF local code table 2, version 128

Profile Sets

- 16 analysis files selected
  - 4 dates (seasonal variation) × 4 times of day (00:00, 06:00, 12:00, 18:00)
- Ocean points on 2.5 degree grid, filtered to eliminate states with
  - low surface temperature
  - high humidity (potential cloud states)
- Two alternative profile sets generated as follows:
- (a) 1358 profile set (following Merchant)
  - 1991 - 1992 reanalysis data
  - 17 standard pressure levels
- (b)1290 profile set (new)
  - 1995 operational data
  - 15 standard pressure levels

Enhanced tropospheric aerosol treatment

- Tropospheric aerosol subroutine modifications:
  - Optional implementation of ‘hybrid’ model for scattering in place of the older ‘qe = qa’ model
  - Asymmetry coefficients (from Shettle and Fenn, 1979) included
  - Redundant scaling removed
- Modifications to main program:
  - Optional inclusion of ‘constant number density’ scaling as alternative to ‘constant visibility’ scaling
  - Exponential aerosol height distribution introduced (in place of original distribution, uniform below 1 km height)

Interpolation (banding) scheme

- Retrieval coefficients depend on pixel across-track position
  - Interpolation scheme required
  - Early versions used a scheme of 10 bands across the swath (Zavody et al 1995)
- Revised scheme for ATSR processing uses new treatment of stratospheric aerosol (Merchant et al 1999)
  - New scheme with 38 bands incorporated to reduce discontinuities at band edges
  - Now included in the AATSR processor, for both gridded and averaged SSTs

Air mass values redefined

- Modified across-track banding scheme
  - Original scheme used interpolation between 5 standard air mass values computed by RADGEN
  - Revised scheme requires values at swath centre and swath edge for each view
- Watts et al (1996) emissivity treatment
  - Modifies surface reflectivity and emissivity to account for roughness effects in forward view
  - Depends on wind speed
  - Only defined for incidence angles in forward view, so not compatible with original interpolation scheme
  - May be disabled
- Re-interpolation of surface emissivity values to correct incidence angles required

Architectural changes

- COMMON blocks introduced for communication between modules
- VMS-specific I/O calls removed
- Temporary (scratch) binary files removed
- Photon correction removed from 3.7 micron channel

Fixed definitions

The following definitions have been kept fixed in current work on ATSR-2 coefficients

- Atmospheric spectroscopy and filter profiles: no change
- Continuum model: Clough et al CKD 2.2.0
- Stratospheric aerosol: n/a (Merchant constraints used)
- Tropospheric aerosol
  - Hybrid model
  - Constant number density scaling
  - Surface visibility = 27 km at RH = 84%

Variable definitions

The following definitions have been varied in current work on ATSR-2 coefficients

- CO2 density (hard-coded in RADGEN)
  - 357 ppm (as used for all ATSR-1 runs)
  - 364 ppm (as adopted for V310 + ATSR-2 runs)
- Profile set
  - 1358 profile (1991) set
  - 1290 profile (1995) set
- Emissivity scheme
  - Watts et al (1996) wind dependent scheme either enabled or disabled

Selected options

Case	Profile set	CO2 ppm	Wind speed parameterisation
1	1358	364	No
2	1358	364	Yes
3	1290	364	No
4	1358	357	No

Case 2 adopted for SADIST 2 V322 (and also for most recent ATSR-1 detector temperature coefficients)

Potential improvements

- Introduce more recent atmospheric spectroscopy (e.g. HITRAN 2000)
- Introduce Clough et al CKD 2.4.1 continuum model
- Presently adopted tropospheric aerosol parameters (visibility and scaling) are arbitrary
  - How sensitive are coefficients to adopted aerosol model?
  - What is realistic height profile?
  - Optimum scaling? Visibility?