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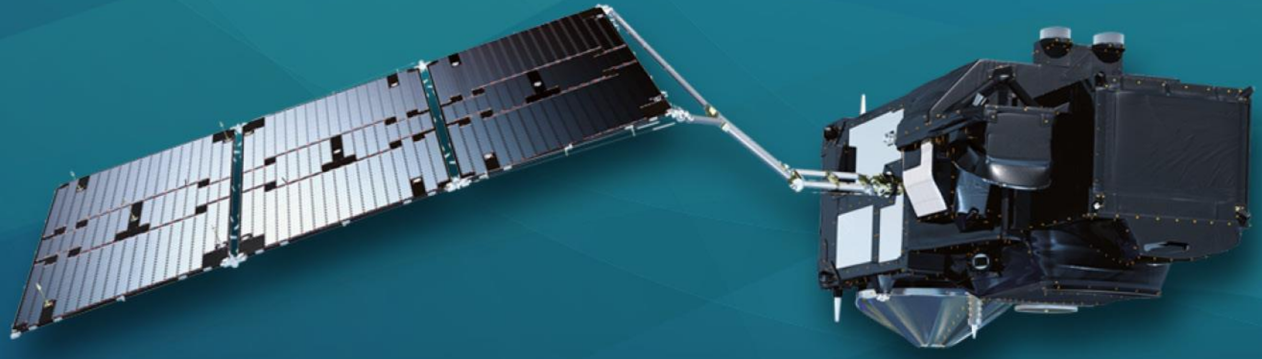


9th Sentinel-3 Validation Team meeting 2026

30 March–01 April 2026 | ESA–ESRIN | Frascati (Rome), Italy

Sci4MaST: Improvements to the SLSTR SST processor

Owen Embury, Niall McCarroll, Lauren James, Claire Bulgin,
Jon Mittaz, Chris Merchant, Caroline Ribere

University of Reading work in the framework of Activity 1:

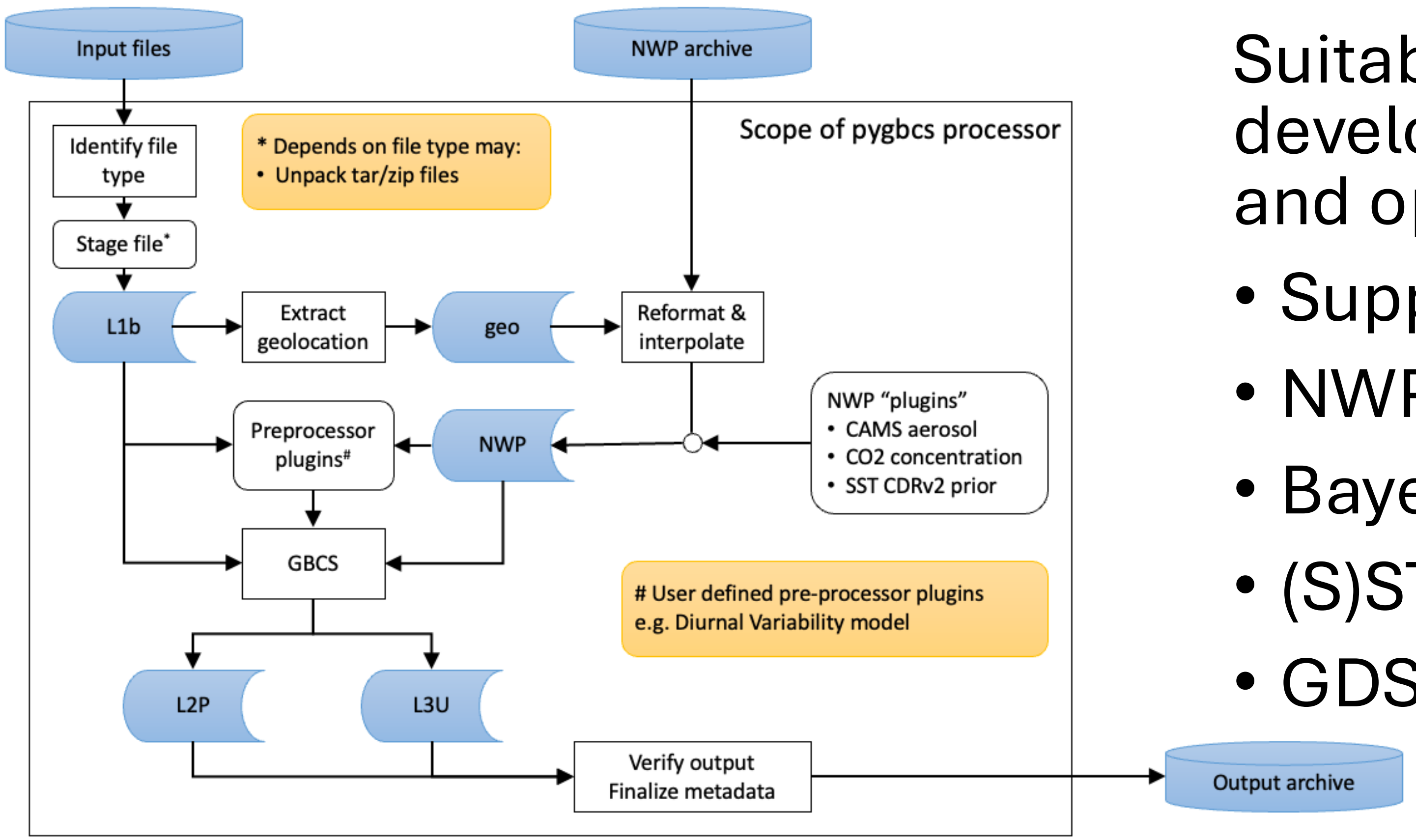
Improvement to Sentinel-3 SLSTR sea and sea-ice surface temperature product quality

- Sci4MaST Prototype Processor
- Coefficient Generation Tool
- Investigate day-time use of 3.7 micron channel (see poster)

Sci4MaST Prototype Processor

- Bayesian Cloud Detection and SST retrieval processor developed by U. Reading
- Same software as used in SST CCI – proven capability to generate CDR and ICDRs
- Software has been developed under several projects. Primarily:
  - 2005-2008 Thermal and Reflectance Imagery Cloud Screening (TRICS)
  - 2006-2011 ATSR Reprocessing for Climate (ARC)
  - 2011-ongoing ESA SST CCI
- Additional development:
  - EUMETSAT projects, C3S, ARC-Lake, Globolakes, GlobTemperature, CCI-Lakes, CCI-Land, Bureau of Meteorology, NCEO

Sci4MaST Prototype Processor



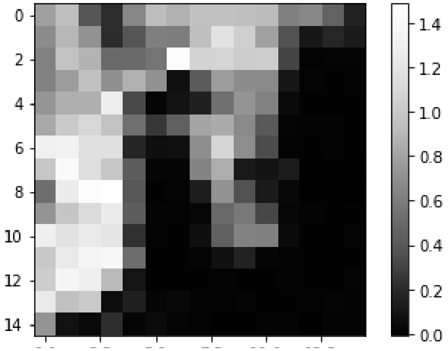
Modern Fortran 2003 and Python 3 code

Suitable for algorithm development, CDR production, and operational SST products

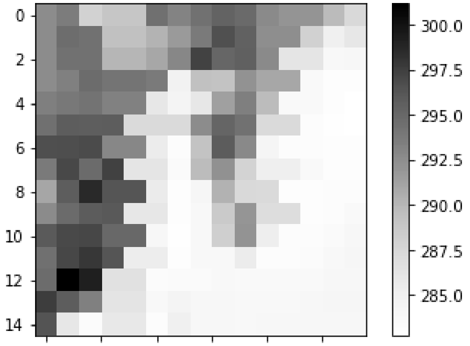
- Supports multiple sensors
- NWP interpolation
- Bayesian Cloud Detection
- (S)ST Retrieval
- GDS format output

SLSTR Regridding

- SLSTR pixels are remapped from conical scan to regular grid aligned with sub-satellite track in Level 1b using nearest neighbour
  - Centre of “observation” can be up to ½ pixel from nominal location on grid
- Simple 2x2 averaging **cannot** be used to reduce Vis/NIR resolution to match TIR
  - Coastal example where alignment of TIR scan and nominal grid results in saw tooth edge as “best” IR pixel alternates +½ and –½ offset



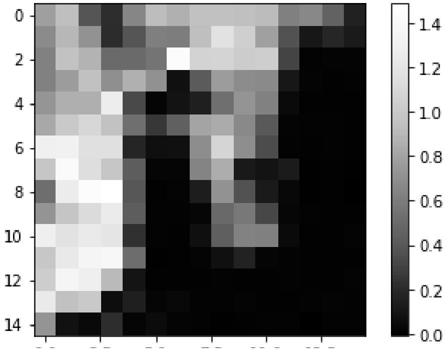
Vis: 2x2



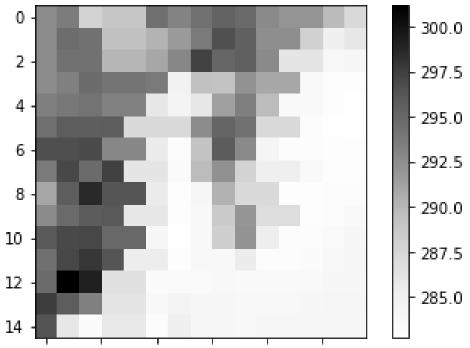
TIR

SLSTR Regridding

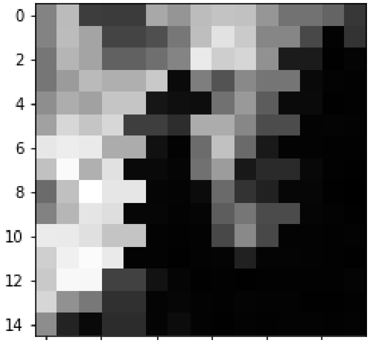
- SLSTR pixels are remapped from conical scan to regular grid aligned with sub-satellite track in Level 1b using nearest neighbour
  - Centre of “observation” can be up to ½ pixel from nominal location on grid
- Simple 2x2 averaging can not be used to reduce Vis/NIR resolution to match TIR
- K-nearest neighbour remapping gives correct alignment between channels
  - Can include orphan pixels and both a and b stripes



Vis: 2x2



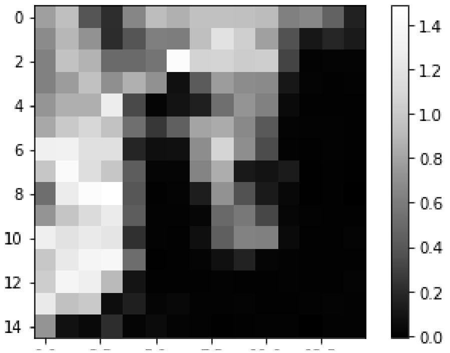
TIR



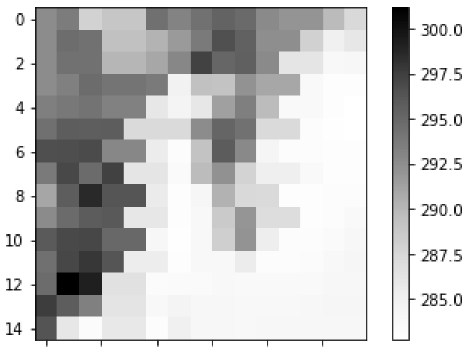
Vis: k-nearest

SLSTR Regridding

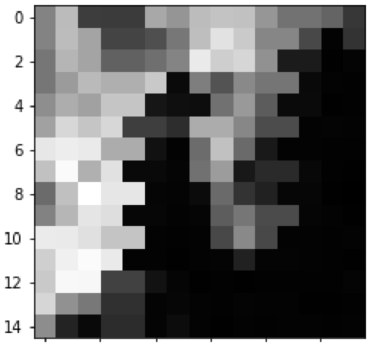
- PP supports k-nearest remapping with user defined k (default=5)
  - Includes options to calculate “sub-pixel texture” as used in previous work
- Can remap during data read or use pre-generated “SLSTR-Lite” files



Vis: 2x2



TIR



Vis: k-nearest

Bayesian Cloud detection

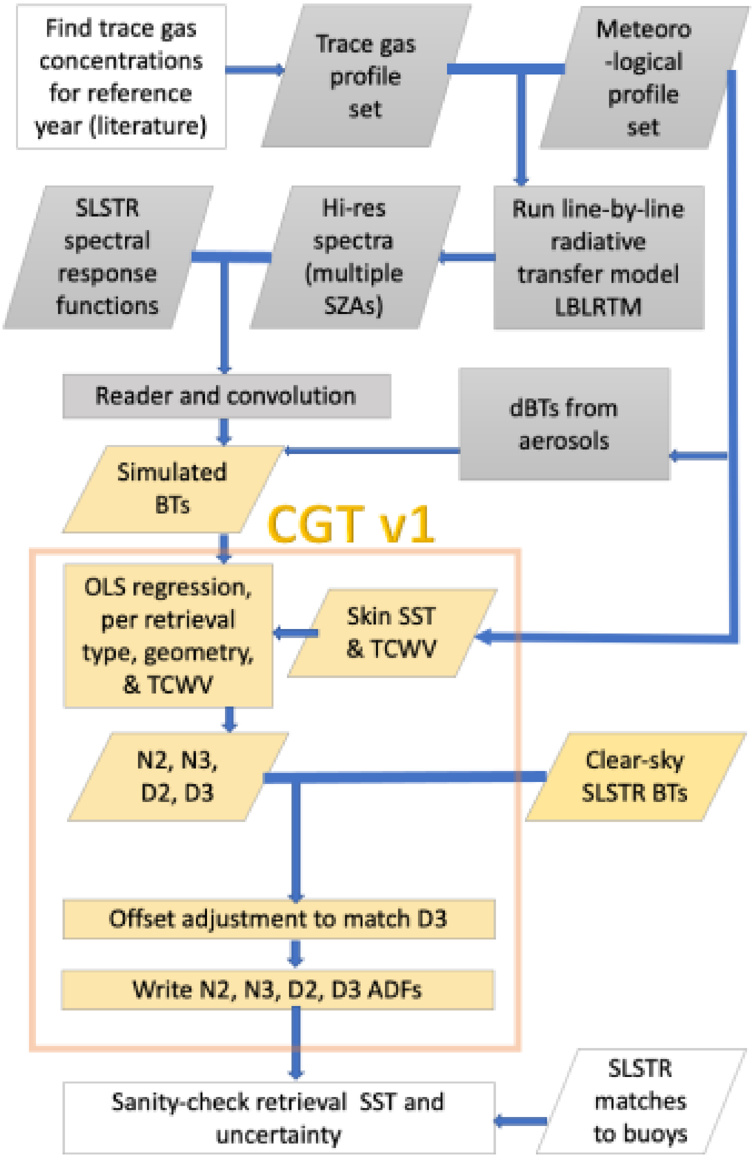
- Estimates the probability that a given pixel is clear from:
  - Observations: $\boldsymbol{y}$
  - Expected observations under clear-sky conditions estimated using RTTOV: $\mathbf{F}(\boldsymbol{x}_a)$
  - Uncertainties associated with observations ($\mathbf{S}_\varepsilon$) and prior ($\mathbf{S}_a$)
- $P(\text{clear}|\boldsymbol{y},\boldsymbol{x}_a) = \dfrac{P(\boldsymbol{y}|\boldsymbol{x}_a,\text{clear})P(\boldsymbol{x}_a|\text{clear})\text{P}(\text{clear})}{P(\boldsymbol{y}|\boldsymbol{x}_a)P(\boldsymbol{x}_a)}$
- Probability of observations assuming clear are calculated:
  - $P(\boldsymbol{y}|\boldsymbol{x}_a,\text{clear}) = \dfrac{\exp\left(-0.5(\boldsymbol{y}-\mathbf{F}(\boldsymbol{x}_a))^{\boldsymbol{T}}(\mathbf{K}\mathbf{S}_a\mathbf{K}^{\mathrm{T}}+\mathbf{S}_\varepsilon)^{-1}(\boldsymbol{y}-\mathbf{F}(\boldsymbol{x}_a))\right)}{2\pi^{n/2}|\mathbf{K}\mathbf{S}_a\mathbf{K}^{\mathrm{T}}+\mathbf{S}_\varepsilon|^{1/2}}$
- Probability of observations assuming cloud are taken from lookup tables
- Can also include local measures (e.g. local standard deviation, sub-pixel texture) in Bayesian formulation

Bayesian Cloud detection

- EUMETSAT Operational processor
  - Nadir and Oblique view are cloud screened independently
  - Cloudy PDF lookup tables based on MetOp AVHRR observations
  - Dual-view is considered clear if both nadir and oblique classed as clear
- SST CCI CDR v3 processor
  - Dual-view Bayesian calculation includes both nadir and oblique view in observation vector
  - Better detection of small / optically thin clouds present in a single view
  - Cloudy PDF lookup tables based on AATSR observations
- Sci4MaST prototype processor
  - Full dual-view Bayesian from SST CCI CDRv3 configuration
  - New dual-view cloudy PDFs based on 9 years of SLSTR-A observations
  - Actual match to SLSTR viewing geometry

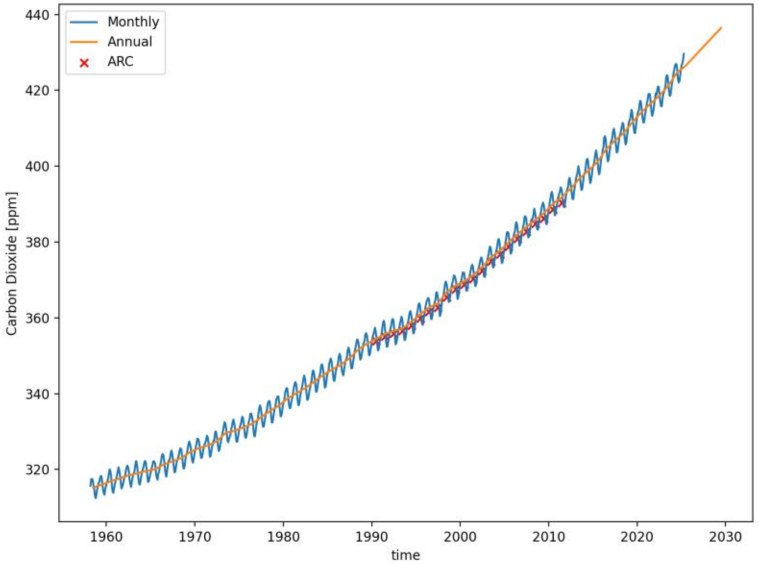
Coefficient Generation Tool v2

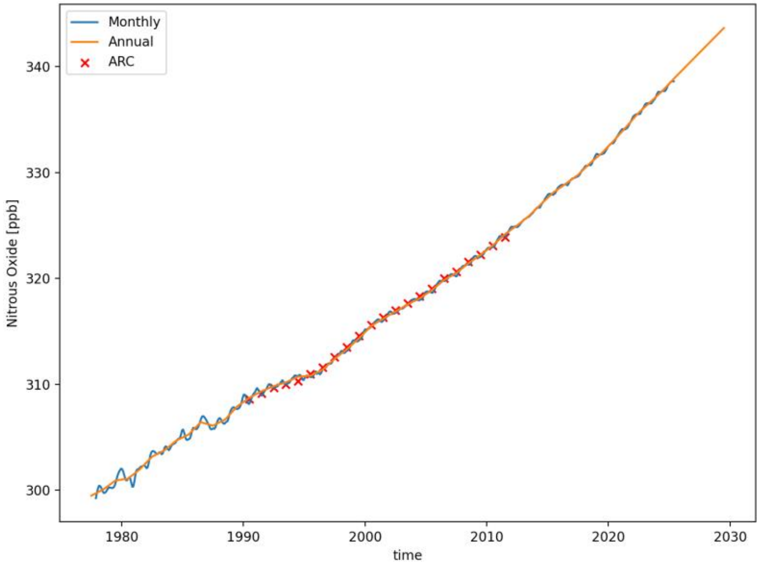
- Generates SLSTR retrieval coefficients
- Based on ARC and SST CCI software
- Rewritten in modern Python 3
- v1 created coeffs from pre-existing line-by-line radiative transfer output
- v2 extends scope to include:
  - Update trace gas profile set
  - Running line-by-line RTM
  - Convolving with instrument spectral response functions (SRFs)

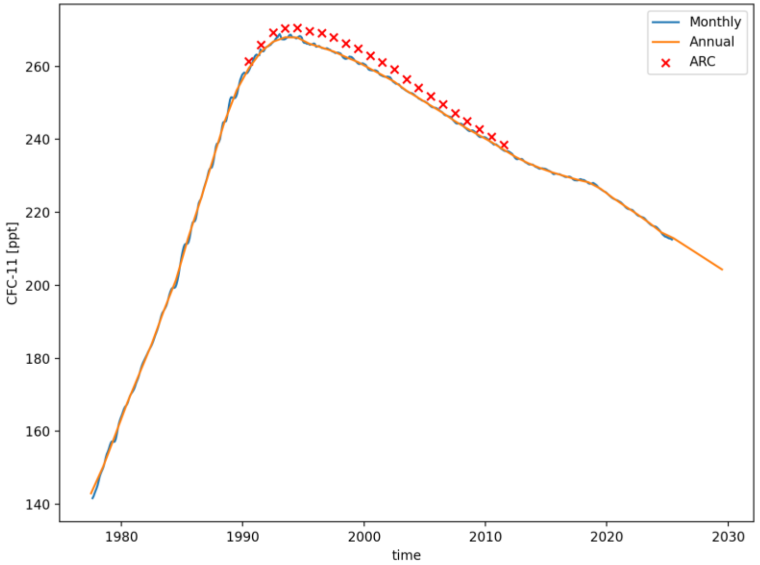


CGT: Trace Gas Concentrations

- ATSR / SLSTR retrievals account for changes in trace gas concentrations by generating new coefficients every 4 years
- Monthly trace gas data obtained from NOAA Global Monitoring Laboratory (GML)
- CO_2 CH_4 N_2O CFC-11 CFC-12





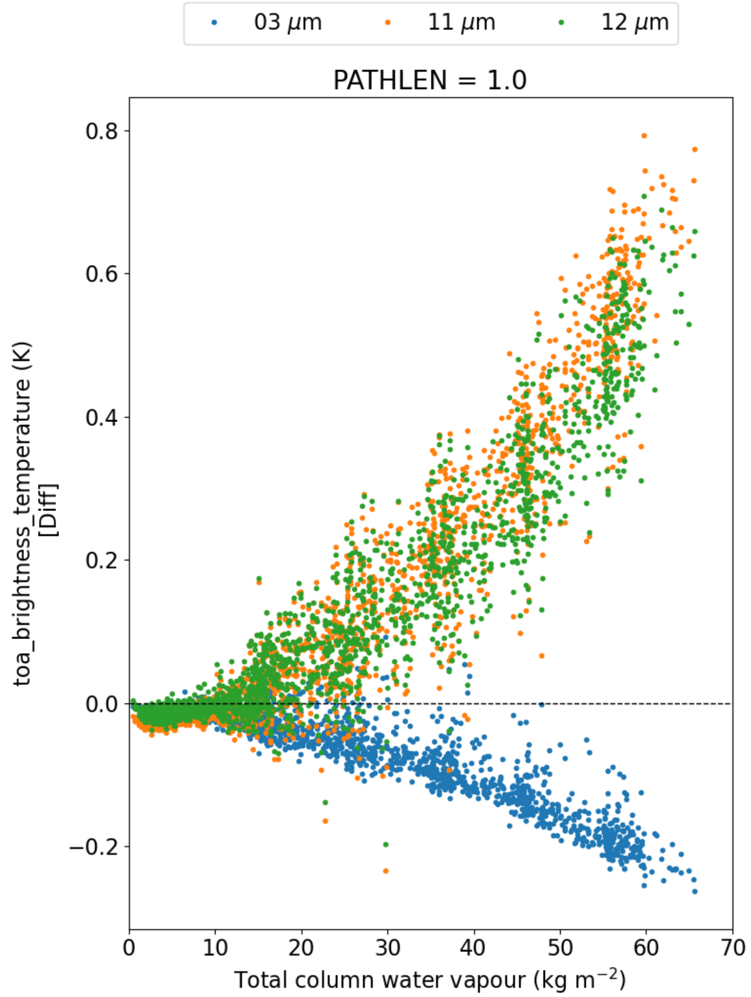


CGT: Line-by-line radiative transfer

- Coefficients are generated from radiative transfer simulations
- Requires accurate RTM – use line-by-line code LBLRTM
- Two versions supported:
  - LBLRTM 12.2_cci – SST CCI used a modified v12.2 to match the WV continuum in earlier ARC work
  - LBLRTM 12.17 – current release

Right: LBLRTM 12.17 – LBLRTM12.2_cci

- 11/12 microns shows differences over 0.5 K at higher water vapour. Due to changes in WV continuum.

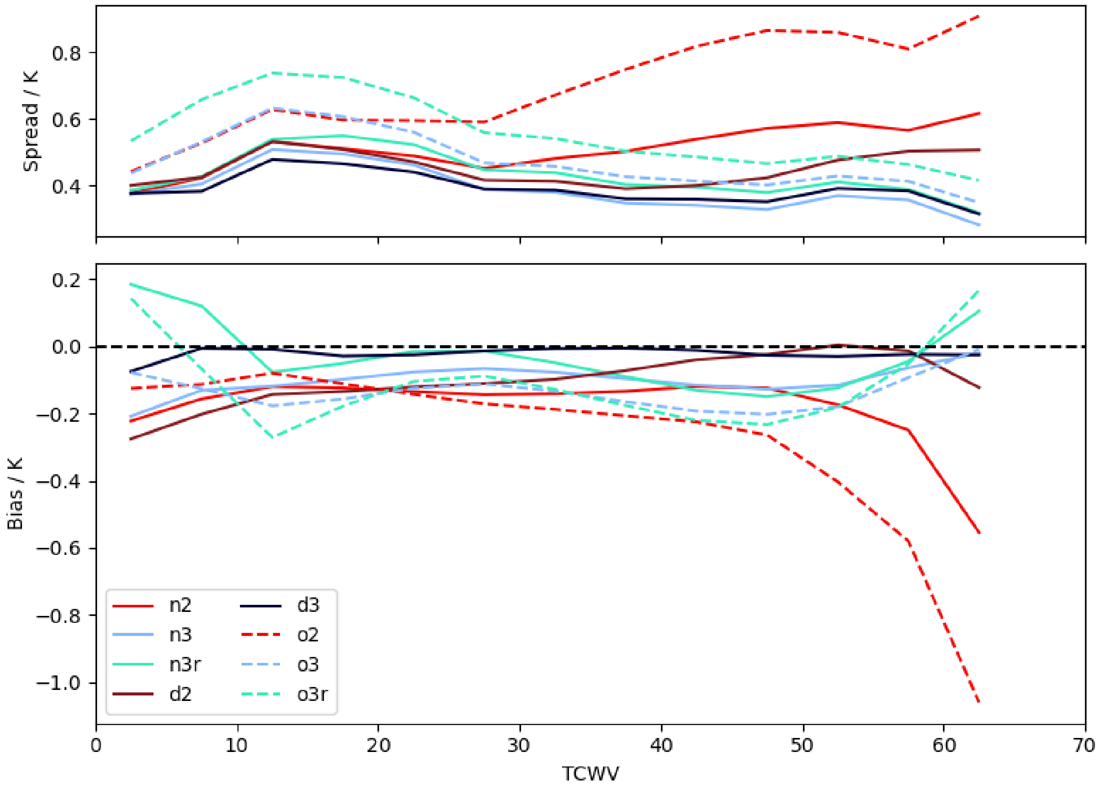


Data:
(1) ARC-coeff/data/bts/lauren/ARCBTs-ESACCI-SLSTRA-2020-LBLRTM-v12.17_linux_intel_dbl.nc
(2) ARCBTs-ESACCI-SLSTRA-2020-LBLRTM-v12.2a_linux_intel_dbl.nc

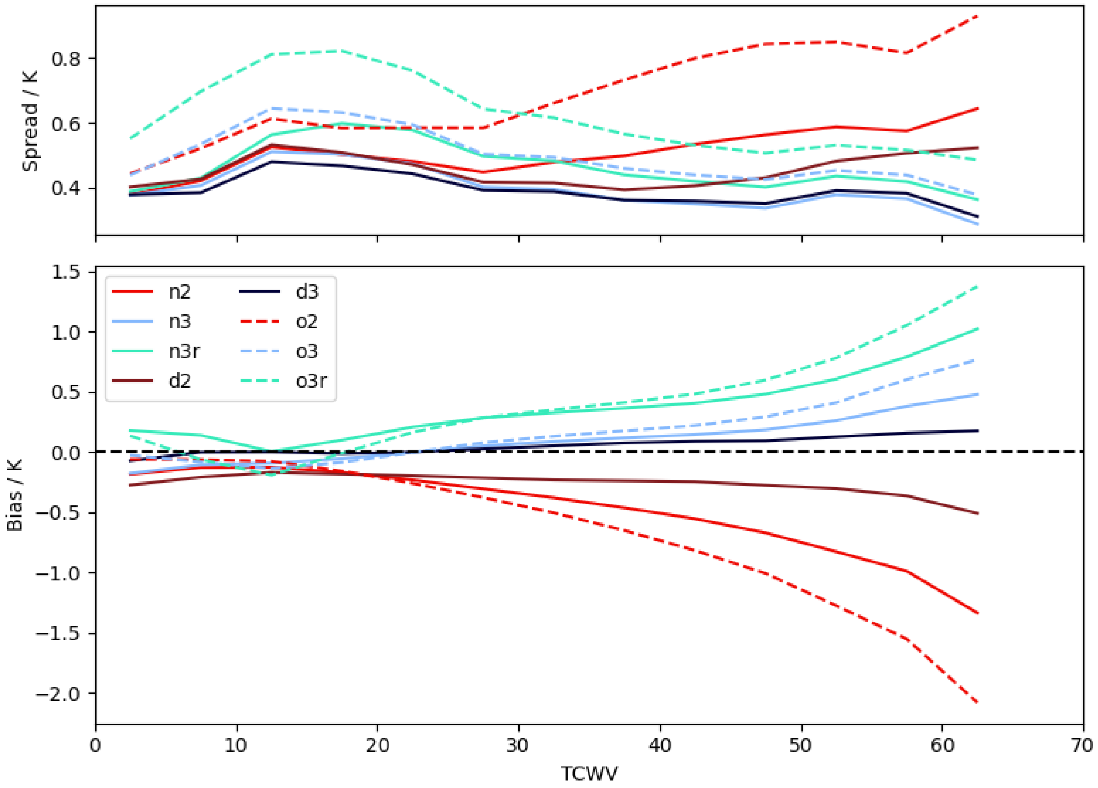
CGT: Line-by-line radiative transfer

- LBLRTM 12.17 increases spread between retrievals, increases bias in D3 retrieval
- LBLRTM 12.2a is producing better (unadjusted) coefficients

v12.2_cci



v12.17

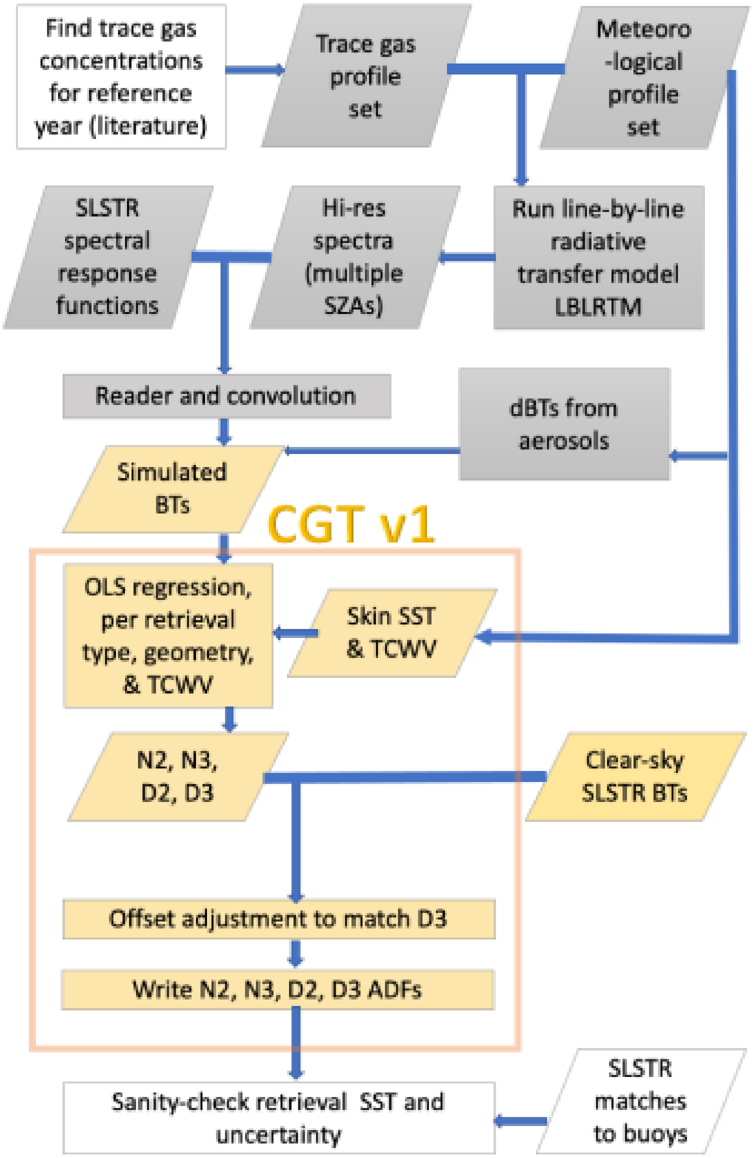


CGT: Aerosol delta-BTs

- Accurate line-by-line calculations are clear-sky only. No scattering
- Need to include aerosol impacts for:
  - Stratospheric aerosol from major volcanic eruptions
  - Tropospheric for marine aerosol etc.
- Aerosol delta-BTs calculated using RTTOV:
  - Wrapper provided to run RTTOV and
  - Aerosol delta-BT = RTTOV(aerosol) – RTTOV(aerosol free)
- Generate coefficients from:
  - BT = LBLRTM(aerosol free) + Aerosol delta-BT

Coefficient Generation Tool v2

- CGT inputs:
  - Reference profile set
  - Trace gas concentrations
  - Instrument spectral response functions (SRFs)
- CGT includes steps for all RTM (LBLRTM, RTTOV), spectral convolution, and coefficient generation
- Output: retrieval coefficients for requested sensor
  - Easy generation of coefficients for new sensors
- Future work:
  - Compare coefficients from different RTM configurations
  - Investigate assumptions in profiles dataset / aerosol simulations



Summary

- Coefficient Generation Tool v2
  - End-to-end generation of new coefficients from profile set and SRFs
- Sci4MaST Prototype Processor
  - Updated to include all developments from SST CCI CDR v3
  - Support for RTTOV 13
  - New PDF lookup tables based on 9 years of SLSTR-A Level 1b