CRTM Multiple Transmittance Models

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Abstract

A new transmittance model ODPS (Optical Depth in Pressure Space) have been developed and implemented into CRTM, which will be included in CRTM version 2. The ODPS model can have up to six user input variable absorbers (H_2O, CO_2, O_3, N_2O, CO and CH_4), while the operational Compact-OPTRAN (reference as ODAS, Optical Depth in Absorber Space) in current CRTM only allows two variable absorbers (H_2O and O_3). We also implement the multiple algorithms framework in CRTM to handle the different transmittance algorithms, including the ODAS, ODPS, SSMIS-Zeeman and SARTA, which can be used with the same user interface. Transmittance algorithm is dynamically selected by using the algorithm ID, which is stored in the sensor-dependent transmittance coefficient file.

ODPS Features

Several important features are included in the ODPS model:

(1) the CO_2 now is a user input variable absorber, it can be a profile or single value (same value at all height);

(2) for hyper-spectral sensor, the input variable absorbers can be same as broadband IR, all other gases are treated as dry (fixed) gases;

(3) using Compact-OPTRAN concept to treat water line transmittance if the fitting error for this components meets prescribed conditions compared to ODPS standard water line training error, in this way the water vapor Jacobian smoothness will be remain;

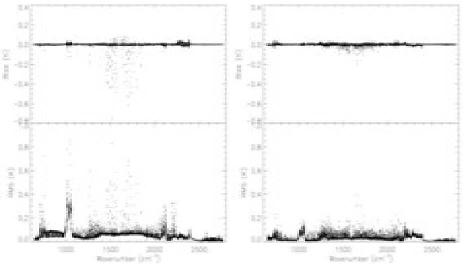
(4) water vapor continua transmittance is treated separately;

(5) The ODPS also considers the Earth curvature effect by adding altitude dependence to the zenith angle profiles.

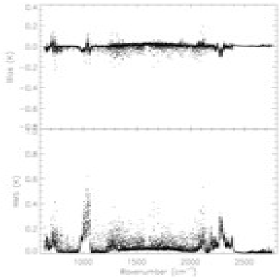
IASI transmittance ODAS, ODPS training results compared to LBL

Compact-OPTRAN:
Variable gases: H_2O, O_3
Fixed gas: CO_2, CO, CH_4, N_2O, O_2

ODPS (with possible ODAS wlo)
Variable gases: CO_2, H_2O, O_3
Fixed gas: CO, CH_4, N_2O, O_2, CFCs and others



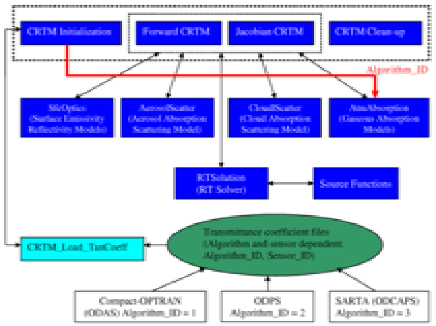
ODPS Independent test for ECMWF 42 diverse profiles



The ODPS transmittance training errors by fitting line-by-line model (LBLRTM_v11.3) is much smaller compared with Compact-OPTRAN, especially for hyper-spectral infrared sensors.

Implementation of Multiple Transmittance Models in CRTM Framework

Multiple algorithms framework



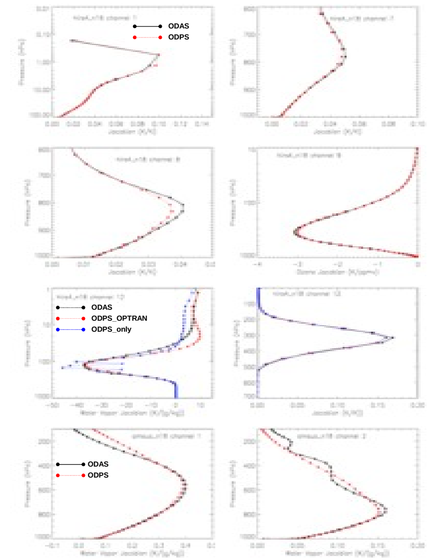
Efficiency comparison between CRTM ODPS and Compact-OPTRAN

Satellite Sensor	Forward Model		K-Matrix Model	
	ODPS	Compact-OPTRAN	ODPS	Compact-OPTRAN
avhrr3_n18*	0m10.12s	0m22.02s	0m49.43s	0m57.58s
hirs4_n18*	0m37.40s	2m13.32s	2m41.37s	4m11.99s
amsua_n18*	0m23.69s	1m29.70s	1m37.38s	2m59.44s
iasiB1_metop-a#	0m38.70s	2m01.69s	2m44.84s	4m30.27s
iasiB2_metop-a#	1m0.41s	3m33.24s	4m4.27s	6m25.05s
iasiB3_metop-a#	0m53.00s	3m12.81s	3m42.78s	5m51.30s

Satellite Sensor	Tangent Linear Model		Adjoint Model	
	ODPS	Compact-OPTRAN	ODPS	Compact-OPTRAN
avhrr3_n18	0m39.67s	0m53.79s	0m42.15s	0m55.14s
hirs4_n18	1m28.29s	3m39.11s	1m34.40s	3m42.18s
amsua_n18	1m3.11s	2m34.89s	1m8.77s	2m35.65s
iasiB1_metop-a	1m7.50s	3m43.84s	1m14.44s	3m45.89s
iasiB2_metop-a	1m45.91s	5m16.16s	1m54.56s	5m18.10s
iasiB3_metop-a	1m28.31s	4m45.37s	1m38.17s	4m48.63s

All sensors were run with UMBC 48 profiles at nadir, and full channels.
* repeat 1000 times; # repeat 10 times.

Jacobian Comparisons



Concluding Remarks and Future Work

The new transmittance model ODPS have been developed and implemented into CRTM. Compared with the current operational Compact-OPTRAN, ODPS is more accurate for forward calculation and more efficient. ODPS is using Compact-OPTRAN concept to treat water line transmittance and keep the water vapor Jacobian smoothness. Our future work will focus on the ODPS bias characteristics in GSI systems and the impacts testing on GSI and GFS systems.