ITSC-19 Radiative Transfer and Surface Properties Working Group

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Table 1: ITSC-19 RTSP working group attendees

Clouds and aerosols

Profile and observation data

Collect existing profile and observation (in-situ and radiance) datasets for use in comparison, validation and training of cloudy/scattering RT models.

Action RTSP-1: Yong Chen to provide the CLOUDSAT profile dataset or information about it to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-2: Marco Matricardi to provide the ECMWF profile dataset or information about it to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-3: Jean-Claude Thelen to check the availability of aircraft data observations and in-situ datasets from the UK Met Office and inform the RTSP working group co-chairs whether the eventual datasets can be provided or information about them to be hosted, or linked to, on the RTSP-WG web page.

Optical properties (IR and MW, spherical and non).

Collect information on existing cloud and aerosol optical properties to be used in RT models simulations.

Action RTSP-4: Mark Liu to provide RTSP working group co-chairs information on the availability of cloud optical properties data from P. Yang (infrared) and Gang Hong

(microwave) and check whether these data can be provided or information about them to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-5: James Hocking to provide recent aerosol optical properties data for volcanic ash and Asian dust or information about it to be hosted, or linked to, on the RTSP-WG web page.

Reference RT model for scattering and their validation

List available models for generating cloud- and/or aerosol- affected radiances for use as a reference.

Action RTSP-6: RTSP working group co-Chairs to continue the compilation of a list of available models and publish it on the RTSP-WG website (with associated links as appropriate).

Action RTSP-7: Jean-Claude Thelen to make available the reference LBL model for scattering developed at the Met Office or information about it to be hosted, or linked to, on the RTSP-WG web page.

Recommendation 1: The RTSP working group recommends that RT developers validate their scattering models against observations using available validation datasets.

Cloudy radiance model intercomprison

The RTSP working group agreed that the intercomparison of cloudy radiative transfer models should be pursued. However, the group also noted that this task is difficult to outline without first defining the input data sets, the particle optical properties, and a reference calculation. No action or recommendation is envisaged at this stage.

Fast model new features

Non-LTE

The group noted that good progress has been made in the implementation of non-LTE in fast forward models. Two items regarding the implementation of non-LTE in fast models were discussed, specifically:

- Where to get the vibration temperature profiles? (e.g. Manuel Lopez-Puertas, Istituto de Astrofisica de Andalucia (IAA))
- What are the accuracies of the current fast model parameterisations?

The following action was introduced:

Action RTSP-8: Marco Matricardi to communicate to the group information on the global dataset of vibrational temperatures generated at IAA and check whether it is possible for this dataset to be distributed to the wider community via a link to the RTSP-WG web page.

Recommendation 2: The RTSP-WG encourages RT developers to thoroughly assess the accuracy of non-LTE parameterisations used in fast RT models.

Unapodised radiance models for FTS sensors.

Radiative transfer models to compute unapodised radiances are not currently used operationally, but their development anticipates a possible future need. It was noted that for Principal Component based fast RT model the simulation of unapodised radiances is already available as a standard feature. This is not the case for the more conventional optical depth based fast RT models. The group also discussed alternative methodologies to simulate unapodised radiances but these were deemed to be too computationally expensive (e.g. deapodisation requires the simulation of the full apodised spectrum). It was also noted that some clarification is needed as with regard to the convolution of the monochromatic spectra (e.g. the treatment of the band edges in the Fourier transform).

Recommendation 3: The RTSP-WG encourages the development of fast unapodised RT models.

Doppler shift

The neglect of Doppler (or Doppler-Fizeau) shift effects due to he Earth's rotation can be a not negligible source of error in RT model simulations.

Recommendation 4: The RTSP-WG encourages the introduction of Doppler shift effects in RT models.

Polarisation

The RTSP-WG recognized that the use of the scalar form of the radiative transfer equation is not adequate for specific microwave simulations. Depending on the application, the full or a reduced number of Stokes vectors is required.

Recommendation 5: The RTSP-WG encourages RT model developers to generalize the form of the RT equation introducing a vector formalism.

Principal Component based fast models

This RT model category includes the PC_RTTOV, PCRTM and HT-FRTM models. The RTSP-WG noted that despite the significant advantages offered in terms of computational efficiency and accuracy, the utilisation of PC based models is seldom explored by fast RT model users.

Recommendation 6: The RTSP-WG encourages members of the TOVS community to exploit the capabilities offered by PC based fast models.

Recommendation 7: The RTSP-WG encourages RT developers to pursue and/or continue the development of PC based fast models.

Instruments

Sensors

Sensors for which instrument characteristics are required are shown in Table 2.

New Sensors		**Old Sensors**	
Meteor-M	*FY-3B*	SSU	SCAMS (Nimbus-6)
EPS-NG	*IASI-NG*	PMR (Nimbus-6)	SSMR (Seasat)
MTG-IRS	*GIFTS/STORM*	HIRS (Nimbus-6)	SSM/T (DMSP)
GEOCOM-2A	*FY-3C*	VTPR (NOAA 2-5)	SSM/T-2 (DMSP)
GOES-R	*Himawari-8*	IRIS-4	
ABI	*AMI*		

Table 2: List of sensors for which instrument characteristics are required.

Action RTSP-9: ITSC group members to contact RTSP-WG co-chairs regarding information on available sensor data.

Action RTSP-10: Paul van Delst to create a sensor acronym glossary on RTSP-WG web site.

Recommendation 8: RTSP working group co-chairs to create a repository of sensor characteristics data for RT modeling community accessible via the RTSP-WP page.

Sensor characteristics

Generation of fast model coefficients for sensors requires timely delivery of sensor characteristics data to RT model developers. Satellite radiance data cannot be effectively used in either NWP or retrieval schemes if the RT model does not accurately reflect the sensor response.

The data typically required are:

- Spectral Response Functions (SRFs)
- Channel polarisations,
- Antenna temperature corrections
- FTS line shape or analytical model. Information on spectral sampling, and how to best handle the band edges should also be supplied.

Action RTSP-11: David Tobin to communicate to RTSP working group co-chairs the most recent specification of the AIRS spectral response function. **COMPLETED** (see **http://asl.umbc.edu/pub/airs/srf/srfhdf.html)**

Action RTSP-12: Mark Liu to check the specification of the ATMS spectral response function and communicate the relevant information to the RTSP working group co-chairs.

Action RTSP-13: Mark Liu to make available to the RTSP working group co-chairs all information regarding the spectral response function of instruments on FY-3C.

Action RTSP-14: Sung-Rae Chung to make available to the RTSP working group co-chairs information on the AMI spectral response function.

Recommendation 9: Sensor vendors should supply digitised channel system responses for both microwave, infrared, and visible instruments.

Recommendation 10: Instrument characteristics should be delivered as early as possible (even if not the final version – or especially so) to allow analysis of data in an RT modeling context.

Surface Properties

The group noted that at visible wavelengths, surface reflected and underwater scattered radiation over oceans can be highly polarized.

Recommendation 11: RT modelers are encouraged to develop surface emissivity models in the visible that include polarization.

Action RTSP-15: RTSP working group co-chairs to compile a list of available surface emissivity models in the visible.

BRDF implementations for fast RT models are required for all land surface types. The working group noted the availability of the MODIS BRDF product.

Recommendation 12: RT modelers should pursue the development of BRDF models for snow and ice.

The RTSP working group was informed of the development of the CEMS emissivity model.

Recommendation 13: Members of the RTSP working group are encouraged to give feedback on the use of the CEMS community model. When applicable, this recommendation should extend to members of the TOVS community at large.

Action RTSP-16: Mark Liu to inform the RTSP working group co-chairs on the status of the CSEM model. Information on the CSEM model and related developments should be communicated in a timely fashion to the RTSP working group co-chairs who should made it available through the RTSP-WG web page.

Surface property physical reference models should be identified for use in validating fast RT surface property modelling. The reference models should have the following characteristics:

- Be themselves validated.
- Include angular dependence.
- Be valid on both micro- and macroscopic scales.
- Be usable with dedicated surface property missions (e.g. SMOS, SMAP)

Recommendation 14: The RTSP working group encourages RT developers to develop physical based emissivity models.

Recommendation 15: Physical models should cover as wide a range of surface types as possible.

Action RTSP-17: Xu Liu to give to RTSP working group co-chairs feedback on physical BDRF models.

Action RTSP-18: Mark Liu to provide to RTSP working group co-chairs information on infrared physical models developments.

Action RTSP-19: Fuzhon Weng to provide to RTSP working group co-chairs information on MW physical models developments.

The RTSP working group noted that the RTTOV model developers are introducing an angular dependence to the land surface emissivities stored in the atlases used for the RTTOV calculations.

Recommendation 16: The RTSP working group encourages RT developers to introduce an angular dependence to the land emissivity data stored in atlases.

The RTSP working group discussed the dependence on temperature of the refractive indices of water. It was noted that for specific situations the neglect of this effect can results in errors up to 0.2/0.3 K.

Recommendation 17: The RTSP working group encourages RT developers to introduce the temperature dependence in the computation of sea surface emissivities.

Action RTSP-20: James Hocking to provide to RTSP working group co-chairs the empirical corrections to the refractive indices of water computed using aircraft derived data.

Spectroscopy and line-by-line (LBL) forward models

Actively used models in this category include LBLRTM, 4A, RFM, kCARTA, ARTS. The RTSP-WG welcomed the launch of the CLBL project (i.e. the update of LBLRTM to current FORTRAN standards and its expansion to a more modular form).

Action RTSP-21: Mark Liu to check whether details of the CLBL project requirements can be made available to the RTSP-WG.

The RTSP-WG discussed a number of issues related to the water vapour continuum absorption. Although in principle the group encourages the adoption of a more physically based approach to the treatment of the water continuum absorption, it is not yet clear whether the science is mature enough. Regarding the MT-CKD-type approach currently used in the LBL models listed above, the group noted that:

- MT-CKD-type of format for continuum coefficients allows for easy insertion into LBLRTM – which is the forward model employed by RTTOV and CRTM to generate the transmittance data used to train the regression models.
- There is a dependence of continua parameterisation on line spectroscopy so the MT-CKD-type of continua updates are not necessarily transferable to other LBL models.

Recommendation 18: LBL model developers to study the possibility of a more physically based approach to the treatment of the water vapour continuum absorption.

Action RTSP-22: Carmine Serio to provide measured continua coefficients for the far-IR and associated documentation (see Serio, C. et al 2012, JQSRT). Although this is an action from the previous conference it was deemed important to be continued and eventually completed.

There was some discussion whether LBL models should be designed to allow their users the utilisation of line data from alternative molecular databases. For instance, for LBLRTM users it is mandatory to utilize the AER line file. The RTSP working group noted that some effort in the direction of the flexible use of line data has already been undertaken within the context of the 4A model.

Recommendation 19: LBL model developers should pursue the adoption of a code design that allows a more flexible approach to the use of molecular data.

The RTSP working group noted that the accuracy of the forward computations carried out by LBL models should be thoroughly assessed using all available datasets. These should include satellite data global datasets which cover a wide range of situations.

Recommendation 20: The RTSP working group encourages the validation and the intercomparison of LBL models/spectroscopy to assess the accuracy of LBL computations, the impact of spectroscopic uncertainties and the differences between line-by-line and fast RT models. The members of the RTSP working group recognise this is a project that will require a large effort.

Recommendation 21: The RTSP working group encourages the use of satellite data global datasets to validate LBL models.

Action RTSP-23: Mark Liu to provide feedback on the coordination of a clear sky LBL/fast RT model validation and intercomparison exercise.

The RTSP working group noted that the launch of the next generation of high resolution infrared sounders offers new and exciting possibilities for the exploitation of satellite data in NWP, Atmospheric composition and Climate. Hence, it is crucial that LBL models and associated spectroscopic data are updated to the highest possible standard.

Recommendation 22: The RTSP working group recommends that adequate funding is assigned to the study of the spectroscopy of atmospheric gas species relevant to NWP, Atmospheric composition and Climate applications. The RTSP working group also recommends that more emphasis should be placed on minor species which could become relevant for future applications.

Recommendation 23: Support for line-by-line (LBL) reference model development is of paramount importance and should be continued to ensure that operational centres have access to the latest updates in LBL forward modelling.

The final LBL item discussed in the RTSP working group was about the treatment of the Zeeman effect in microwave computations. The RTSP working group acknowledged that although good progress has been made in fast RT models, there is, in some cases, still the need for a full treatment of this effect in microwave LBL models.

Recommendation 24: The RTSP working group encourages RT model developers to include of a full treatment of the Zeeman effect in MW LBL models.

Visualisation Packages

The RTSP working group noted that visualisation packages for sounder data are a very valuable tool for research and training.

Recommendation 25: The group encourage the development and maintenance of visualization packages.

Action RTSP-24: James Hocking to communicate information about how to obtain the RTTOV GUI visualisation package and link it to the RTSP-WG website.