Improvement of Aerosol Prediction Capability

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LONG-TERM GOALS

This work unit is part of a coupled 6.2-6.4 development effort to implement rapid transition of aerosol prediction and EO tactical decision aid capability to the Fleet and is carried out by NRL-Montery and SPAWAR-SSC. The coupled program will improve the components of the Target Acquisition Weather Software (TAWS) and couple operational EO tactical decision aids (TDA's) to numerical weather prediction and aerosol models. Specific elements of this 6.2/6.4 program (and the responsible person) include: A: Develop and validate operational, diagnostic, and prognostic versions of the Navy Aerosol Analysis and Prediction System (NAAPS) for analysis of airborne dust loads (Westphal/NRL). B: Modify existing radiative transfer codes to ingest NAAPS forecasts and produce practical products that depict the state of the atmosphere in terms of visibility and range (Reid/SSC; Tsay/GSFC; Westphal/NRL). C: Improve the current marine target radiance models by developing new surface wake models and adding improved ship target models that include wake production (Doss-Hammel/SSC). D: Develop and improve operation of TAWS in maritime scenarios by utilizing numerical weather analyses and forecasts and surface and satellite observations (Goroch/NRL).

This work unit addresses parts A and B. The work unit goals are to address EOTDA and operational needs using a predictive, global, operational aerosol model and radiative transfer model to produce global and regional forecasted fields of key radiative and visibility parameters in real time for use in weather forecasting and operational planning.

OBJECTIVES

The objective of this work unit is to rapidly transition NAAPS and related radiative transfer codes to 6.4/operations. This includes validation and documentation of the models and development of a suite of products.

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APPROACH

An existing global aerosol model (NAAPS) will be transitioned according to the conventional procedures. This work includes porting the model to the NRL O2K, converting it to Open-MP, making the input-output compatible with FNMOC standards, writing documentation, conducting global and regional validation, developing a suite of useful products, and documenting the resource requirements. The product line will be developed with input from the users. It will include global and regional fields of radiative fluxes, optical depth, and visibility from aerosol fields as well as real-time and post-time metrics suitable for validation of NAAPS. The validation process will also include comparisons with TAWS transmission calculations.

WORK COMPLETED

We have moved the code to the NRL O2K and are converting it to Open-MP. We have had discussions with FNMOC on the transition process: coding conventions, documentation, validation, reporting, products, timeline, resource requirements, etc. The plan will be formalized by the end of FY03.

J. Reid (SPAWAR-SSC) and S. Tsay (NASA/GSFC) have developed a fast method for calculating the bulk radiative fields for NAAPS fields. We have built interfaces between NOGAPS and MODTRAN (MODerate-resolution radiative TRANsfer model) to compute visibility, and between NAAPS and the Fu-Liou 4-stream radiative transfer model to derive shortwave and longwave fluxes. The interfaces are subroutines that produce the input parameter control files used by MODTRAN and the Fu-Liou radiative transfer codes.

The standard output of NOGAPS and NAAPS in each grid point are profiles of ambient temperature and moisture, aerosol mass and concentration for three aerosol species (dust, smoke and sulfates). Because NAAPS does not compute the aerosol size distribution explicitly (essential for the derivation of optical parameters such as visibility), a methodology has been implemented to derive them. From literature values, three size distributions typical of each aerosol species have been selected and along with the concentrations given by NAAPS. The distributions are fed into a Mie code that computes all the parameters needed for radiative transfer computations (spectral extinction and scattering coefficients and the coefficients of the expansion of the phase function in Legendre polynomials). Then, these parameters are integrated over the spectral bands required by the Fou-Liou radiative transfer code. We continue to work on the selection of size distributions and modification of our Mie code for integration of optical properties.

Two subroutines have been created that will add the capability of computation of aerosol radiative properties by the FL code. One computes the aerosol optical depth, single scattering albedo, and asymmetry factor at each layer and in a band defined by the FL code. The inputs to this subroutine are the aerosol extinction and scattering coefficients and the asymmetry factor in each layer integrated over each spectral band defined by the FL code. Note that for simplicity, we are using a Henyey-Greenstein Phase function, which is not very realistic of actual aerosol phase function but it has the advantage of being very easy to implement. In later versions of the code, the actual Legendre polynomials coefficients will be incorporated. The second subroutine computes the combined single scattering properties due to Rayleigh scattering, water droplets, ice crystals, greenhouse gases and aerosols in each layer. The two subroutines have been incorporated to the FL code and test runs have been performed.

RESULTS

The new post-processor has been developed and tested. It calculates radiative and visibility parameters rapidly for the NAAPS forecasts of aerosol concentration that are produced every 6 hours during each 5-day forecast. An example is shown below in Figure 1. Web pages that present the NAAPS products have been expanded to 10 regions around the world. The web pages will be ported to the NRL SIPRNET site in FY03.

The models and products developed through this program will have considerable impact on estimates of EO propagation, operations, and weather prediction. The current user-specified aerosol type in NAM and TAWS will eventually be replaced by the predicted values from NAAPS. The current forecast products, once they are available over SIPRNET, will aid decision-making for daily Navy activities, such as carrier operations and port entry (the latter have been delayed by dust storms in the past.) The operational aerosol products will be used for initialization or specification of aerosols in COAMPS when new cloud microphysical scheme becomes available.

TRANSITIONS

Simultaneous work is ongoing in the 6.4 component of this RTP to transition NAAPS to operations at FNMOC.

RELATED PROJECTS

The NRL 6.1 base *Atmospheric Physics*, NRL 6.2 base *Improved COAMPS Land Boundary Layers* (includes COAMPS aerosol modeling) and NRL 6.2 *Advanced Moist Physics Modeling* use NAAPS data and products and the satellite retrievals for investigations and validation. The ONR 6.2 *Atmospheric Aerosol Characterization* will also use NAAPS simulations for high energy laser research.

REFERENCES

None.

PUBLICATIONS

None.

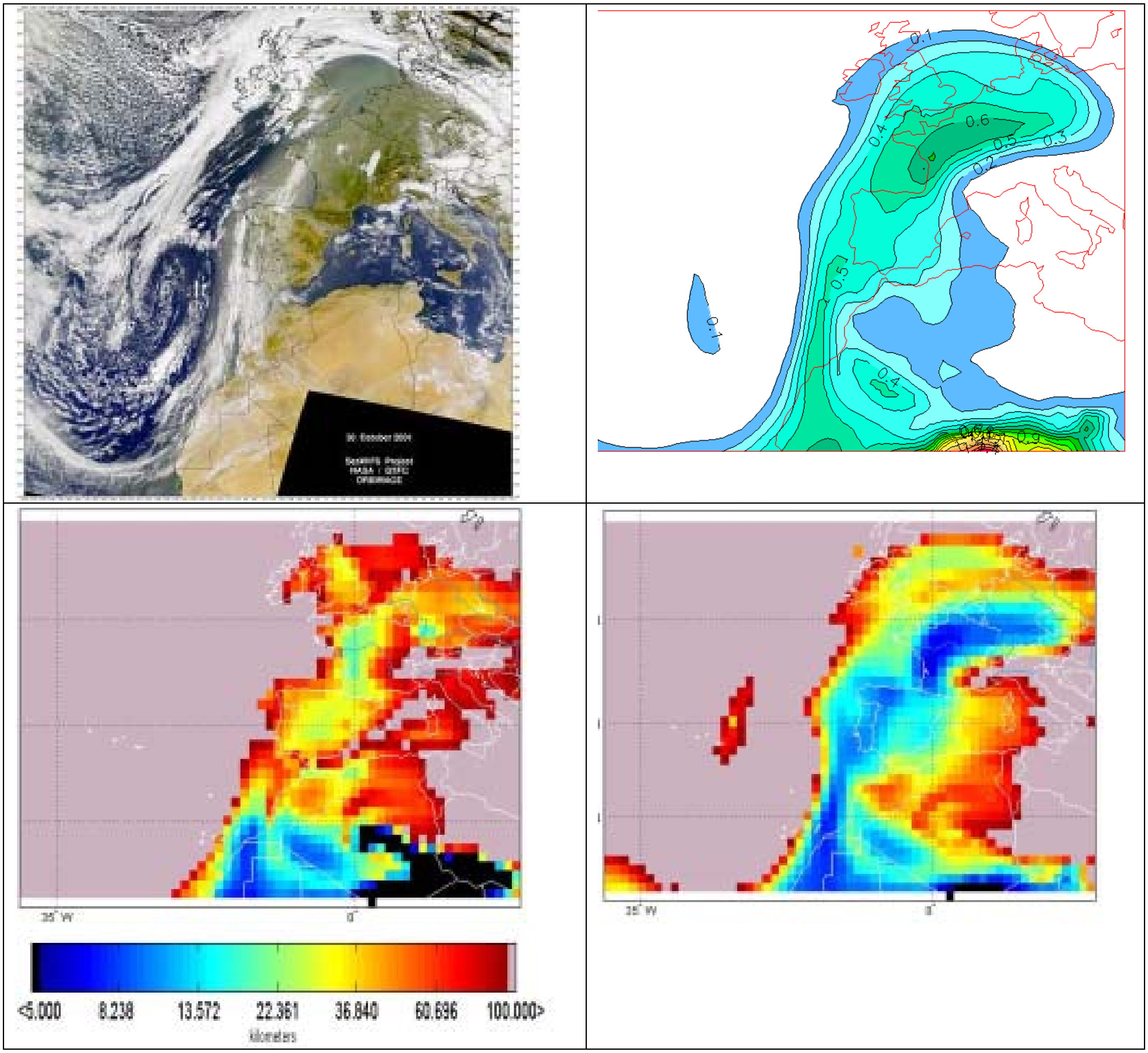

Figure 1. Upper-left panel: SeaWiFS imagery for October 31, 2001 showing a Saharan dust plume traveling north across the Iberian Peninsula and into northern Europe. Upper-right panel: NAAPS simulation of dust optical depth shows the same pattern. The dust seen in the SeaWiFS image and the NAAPS optical depth only show the vertical integral of the dust. However, we can take advantage of the vertical grid structure of NAAPS and calculate the visibility at differing altitudes to reveal the variation with height. Lower-left panel: horizontal visibility (km) at a wavelength of 0.7μm at the surface calculated based on the NAAPS dust distribution. Lower-right panel: horizontal visibility at 2 km (6500 ft). AGL calculated based on the NAAPS dust distribution. Low visibility is found at both altitudes in the well-mixed boundary layer over Africa, but the area of low visibility is confined to upper levels over Europe.