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Applications of ISES for Instrument Science

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Introduction

It is often the case that some instruments being used for geophysical measurements cannot measure some parameters that are important for processing the data obtained using the instrument. However, the parameters of interest may be measured by other instruments and these data made available to the operators of the first instrument. One example is that the Total Ozone Mapping Spectrometer (TOMS) measures radiance in several ultraviolet channels to determine ozone column content while scanning large regions of the Earth's surface. It uses the longer wavelengths to detect the presence of clouds, so that the ozone values are determined above cloud height only. However, snow can mimic cloud reflectance, so it is important to have daily maps of global snow cover in order to distinguish snow from clouds (Ref. 1). Another example is provided from the Amazon Boundary Layer Experiment (ABLE). A number of instruments are placed on a DC-8, and it is flown over large regions of the Amazon forest. Most of the instruments are point sensors or in situ instruments, measuring only in the atmosphere that comes in contact with the airplane. Remote sensing lidar has also been included to measure aerosols and ozone from the aircraft height to the ground. In doing so, it provides data that are invaluable to the other instruments in determining the nature and history of the air sampled at flight altitude (Refs. 2 to 5).

For this paper, the following working definition of "instrument science" is defined:

"The on-board processing of data to the advantage of the instrument, the data stream, and near real-time users." In other words, processing the data immediately after it is acquired is useful in directing the operation of the same or different instrument or in providing a quick-look data set to users on the ground. The four applications which are also considered in this paper are:

1. The decision to acquire data due to some important occurrence detected by Eos instruments;
2. The decision not to acquire data at a scheduled time and/or location;
3. The decision to acquire additional data to improve data quality;
4. Combining data from several sources to enhance data quality.

In this paper, general examples will be presented, which may or may not apply directly to Eos instruments on the various platforms.

1. The Decision to Acquire Data Due to Some Important Occurrence Detected by Eos Instruments

This is the case where quick looks at portions of the data streams could be useful in determining the existence of and location of a natural or man-made occurrence of sufficient importance and extent that it could and should be studied further by a suite of Eos instruments. While many of these ideas were presented in other papers, they are presented here for completeness.

A. Volcanic eruption – located by an SO2 plume (TES, AIRS, SAGE III) or an aerosol plume (GLRS, MISR, SAGE III, HIRIS, etc.), then studied using HIRIS, SAR, GLRS. See Appendix A for a list of Eos instruments and their meanings.

B. Large fire – located from the thermal emission of the fire (MODIS, Lightning Imaging Sensor (LIS), or from the aerosol plume, then studied using SAR, TES, AIRS, TRACER/MOPITT.

C. Severe storm or preconditions for adverse weather – located from the clouds, water vapor, winds, etc., similar to what is currently done using meteorological satellites. However, the research instruments on Eos may have improved capabilities for identifying and studying storms.

D. Break up of Arctic polar vortex in spring. A recent NASA expedition to the Arctic found that the preconditions for significant ozone destruction existed in the Arctic polar vortex. Unfortunately, the

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work was curtailed before the sun rose high enough to affect matters, and whether the vortex broke up before or after the sun rose has not been reported. Improved sounding instruments, such as AIRS, which should be able to give good temperature soundings in that region, should help with defining the extent of the vortex.

E. Lightning strikes used to direct tropospheric sounders – the role of lightning in generating NO and other trace molecular species can be better studied if instruments such as TES (if it is sensitive enough) are directed to, or the data tagged for, regions around lightning.

2. The Decision not to Acquire Data at a Scheduled Time and/or Location

Deciding not to acquire data can increase an instrument's lifetime, especially in the case of lasers that may have a finite number of shots possible before failure, as well as reduce the quantity of the data stream. Examples include:

1. Not firing GLRS if optically dense clouds obscure the ground-based retroreflectors of interest. MISR could give a warning, as could MODIS or instruments on other platforms, such as geosynchronous satellites.
2. Not using HIRIS if the region of interest is sufficiently covered by clouds so that little useful data will result.

3. The Decision to Acquire Additional Data to Improve Data Quality

Here is where a quick-look at the data can indicate weaknesses that can be corrected by acquiring additional data, either with the same or with a different instrument. Examples include:

1. Where low signal-to-noise ratios are found, such as with lidar or active microwave instruments, increase the transmitted power levels, the pulse repetition frequency, or integration time;
2. Where low signal-to-noise ratios are found with passive radiometers and related instruments, increase the aperture or reduce the scan rate; and
3. Where clouds or snow may interfere with the measurement, acquire additional data using other instruments on the extent and nature of the cloud cover.

4. Combining Data from Several Sources to Enhance Data Quality

As mentioned in the Introduction, there are many cases where one instrument cannot measure all of the parameters that are required to adequately analyze the data. If the data sets are not required in near real-time, there is no reason to use ISES for combining the data sets. However, if the data are to be shipped down to a user in near real-time, then it would be important to use ISES. Examples are:

1. When using MODIS data to generate phytoplankton maps, ozone data from TOMS could be used to correct for the attenuation in the 550- to 750-nm spectral region due to absorption by the Chappuis band of ozone.
2. When using MODIS data to generate information on vegetative cover or geological features on land surfaces, water vapor column contents derived from several sources can be used to correct for atmospheric water vapor absorption and improve data quality in the water vapor absorption regions, which is where bound water also absorbs. Water vapor content is difficult to measure well, so it would be advantageous to use a number of sources for the data.
3. As mentioned earlier, information on cloud cover and cloud parameters can be useful for a number of instrumental data sets.
4. When generating data sets that rely on in situ data for calibration, it would be useful to have the in situ data relayed to the platform and included in algorithm. The example that comes to mind is the use of instrumented buoys to give sea surface temperature values for infrared sensing instruments of sea surface temperature. The 10- to 12-micron region traditionally used for sea surface temperature measurements is very sensitive to water vapor and aerosols in the intervening atmosphere (ref. 6). In

order to achieve reasonably high accuracy in this spectral region, in situ data are required to pin down the values at various points.

5. GLRS data on cloud-top heights along the Eos ground track combined with CERES data on cloud-top temperatures can be useful in determining the cloud top height of many clouds outside the Eos ground track, assuming a known vertical temperature profile of the atmosphere. AIRS could also contribute useful data.

6. Accurate determination of snow depth requires both microwave radiometer temperature brightness data as well as thermodynamic temperature data (ITIR) to determine the emissivity of snow.

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