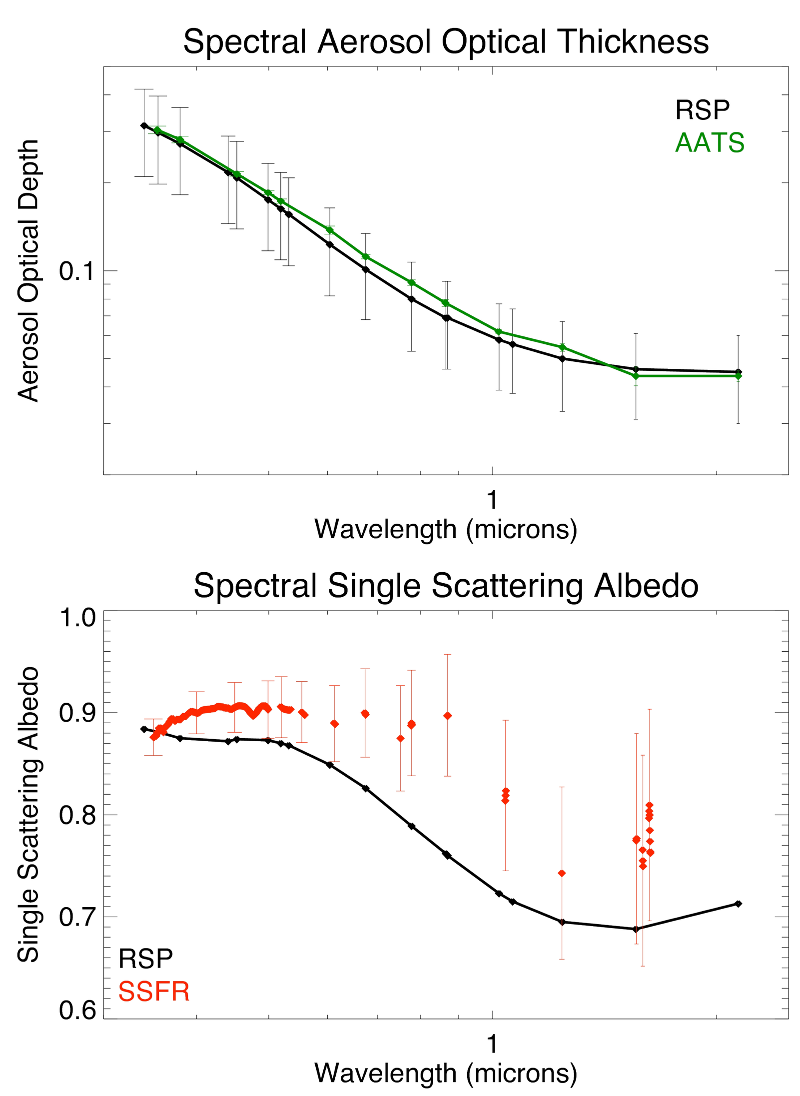
Proposed work: Retrieval and evaluation of Aerosol Above Cloud (AAC) properties with combined polarimeter, Lidar and spectrometer observations

Kirk Knobelspiesse1, **Meloë Kacenelenbogen**2, Matteo Ottaviani3, K. Sebastian Schmidt4

1 NASA Ames Research Center, Moffett Field, CA kirk.knobelspiesse@nasa.gov; 2 Bay Area Environmental Research Institute / NASA Ames Research Center Meloe.s.kacenelenbogen@nasa.gov
3 Stevens Institute of Technology, Hoboken, NJ mottavia@stevens.edu; 4 Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Boulder, CO, Sebastian.schmidt@lasp.colorado.edu

Atmospheric aerosols play a potentially large, but highly uncertain, role in the global climate. Much of this uncertainty is due to the difficulty of observing aerosols and modeling their effects. A particularly challenging scenario is the case where aerosols have been lofted above clouds (Aerosol Above Cloud, AAC). AAC have the potential for large positive (warming) radiative forcing, since the brightness of clouds magnifies the impact of aerosol absorption. Active instruments, such as Lidars, can detect AAC, but often are unable to determine the amount of aerosol absorption. Passive instrument algorithms for AAC have only recently been developed and require assumptions about most aerosol optical properties. However, it may be possible to determine the climate relevant properties of AAC more accurately if active and passive observations are combined – particularly when the passive instrument has sensitivity to linear polarization. Since the measurement of aerosols in cloudy regions has long been recognized as highly uncertain, we will attempt this with newly acquired field observations. The SEAC4RS field campaign included active and passive polarimetric sensors in aircraft that overflew AAC in North America. We intend to build a merged dataset and retrieval algorithm for AAC using data from the Research Scanning Polarimeter (RSP), the Differential Absorption Lidar (DIAL) and the Solar Spectral Flux Radiometer (SSFR). Each instrument has access to different types of information, which we will leverage to produce an AAC retrieval that exceeds the capability of the different instruments independently.

Our goals are to (1) create an accurate algorithm to retrieve AAC optical and microphysical properties, (2) validate these results with comparisons to auxiliary airborne and satellite observations, (3) classify AAC type and compare to aerosol classification from other instruments, (4) improve our understanding of the radiative and climate impact of AAC, and (5) recommend future instrumentation designs. Ultimately, we hope to reduce observational insensitivity to AAC, and make it as regularly scrutinized as other types of aerosols.



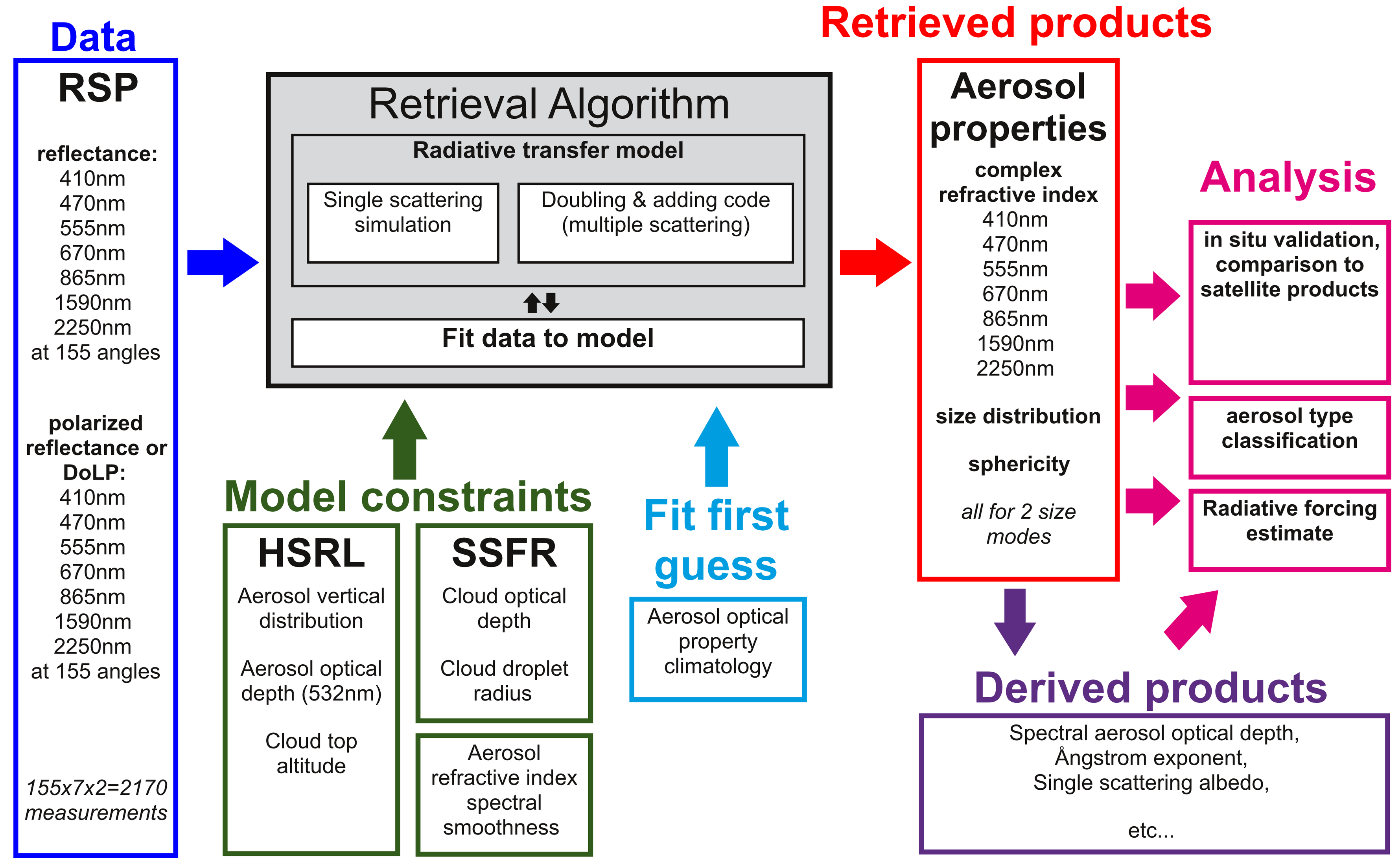
(from Knobelspiesse et al. (2011) Validation of RSP retrieved AAC AOD (top) and Single Scattering Albedo (SSA, bottom) from the MILAGRO field campaign. Comparison AOD was measured by the Ames Airborne Tracking Sunphotometer (AATS), while SSA was determined by multiple altitude observations by the SSFR. Error bars for the RSP SSA were beyond the range of the plot and ommited from the figure.

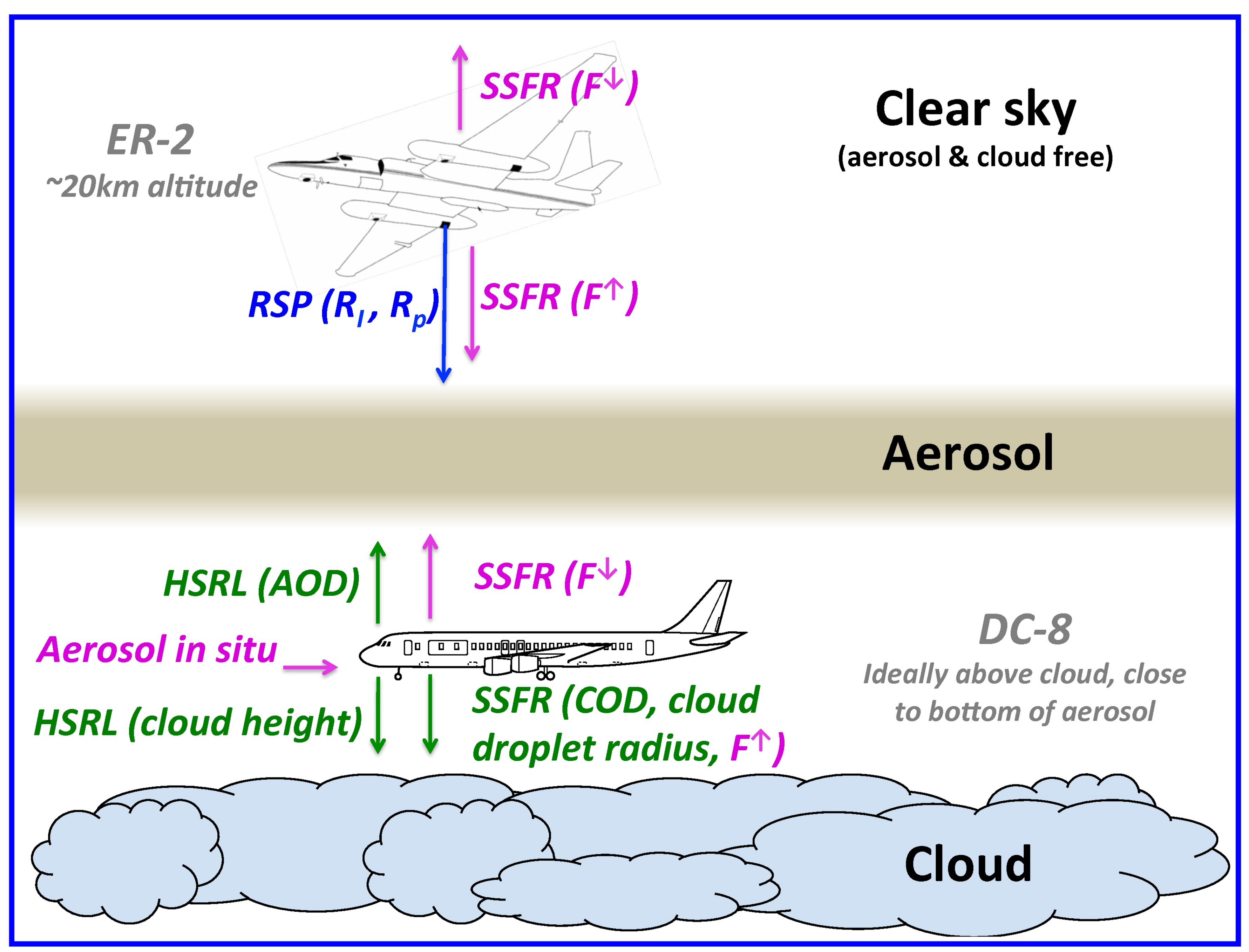
Research Scanning Polarimeter (RSP):
- multi-angle (~150), multi-spectral (VIS-SWIR), polarimetrically sensitive scanner
- has been used previously (Knobelspiesse et al., 2011) to retrieve AAC properties, BUT could be far more successful with accurate constraints of cloud and aerosol optical depth and vertical distribution
- on the ER-2 for SEAC4RS

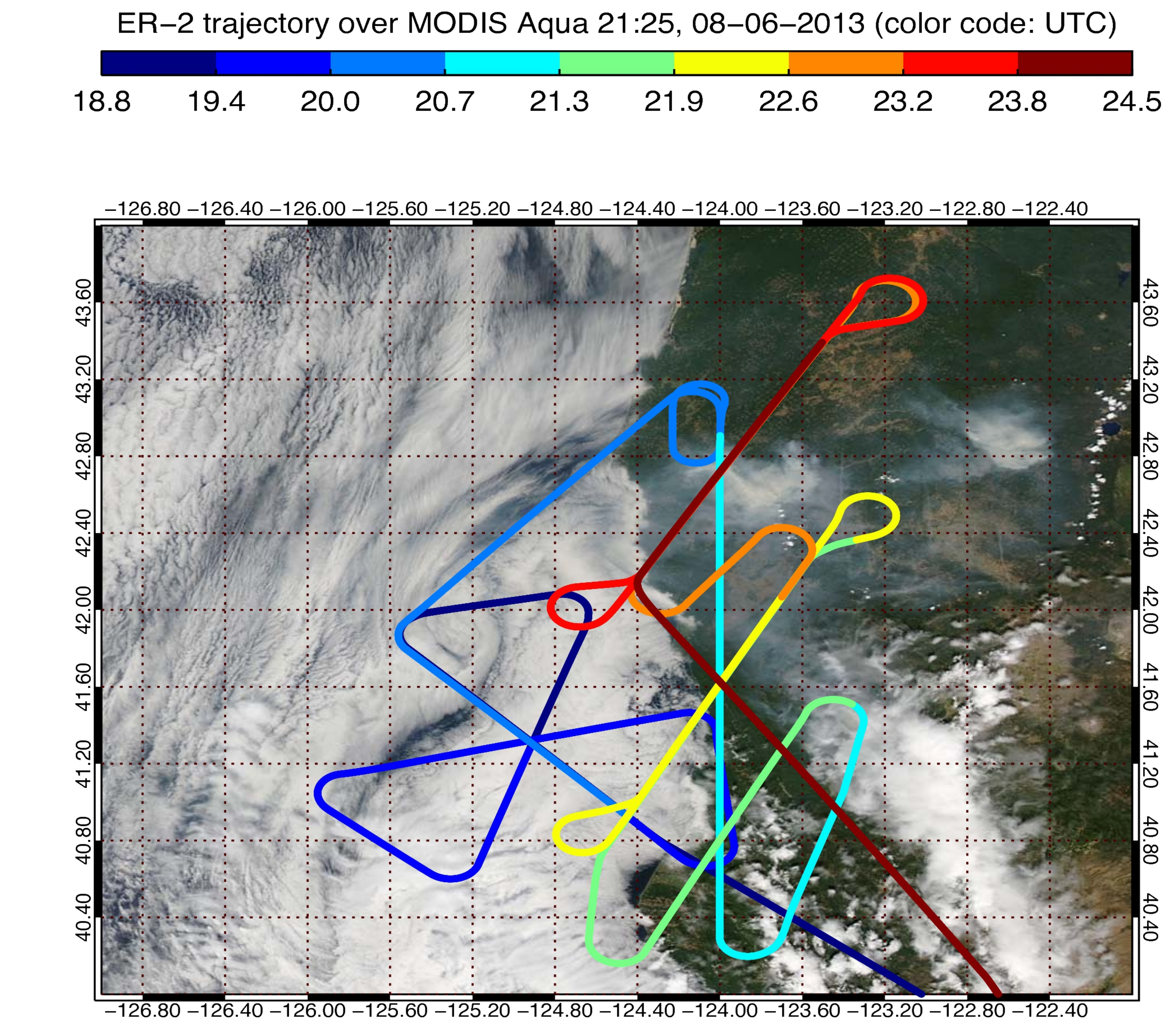
Differential Absorption Lidar (DIAL):
- uses High Spectral Resolution Lidar (HSRL) technique to quantitatively determine vertical profiles of aerosol optical depth and cloud height
- upward and downward looking on the DC-8 for SEAC4RS

Solar Spectral Flux Radiometer (SSFR):
- moderate resolution flux (irradiance) spectrometer, spectral range of 350 to 2200nm.
- mounted in the upwards and downwards directions on both the ER-2 and DC-8
- can determine cloud optical properties, and has also been used to observe aerosols

Aerosol Above Cloud product generation and analysis







Example of a SEAC4RS research flight which successfully sampled significant AAC. The imagery is from a nearly-simultaneous overpass of MODIS on Aqua. The high-altitude ER-2 aircraft (plotted trajectory) was coordinated in this portion of the flight with the DC-8, which carried the DIAL, SSFR and in situ sampling instrumentation.

Date	Location	Satellites nearby	Comments
August 6	Oregon coast	A-Train (21:32) PARASOL (23:58)	Moderately absorbing smoke over ocean, variable cloud albedos
August 12	Alabama/Florida coastline	A-Train (19:13) PARASOL (21:21)	Pollution/haze
August 30	Southeast Missouri	A-Train (19:00)	Pollution

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