Working with Yoram...from Ideas to Reality.

J. Vanderlei Martins – UMBC
Department of Physics and
J CET/NASA GSFC Climate &
Radiation Laboratory
Acknowledgements

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  – Reed Espinosa
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Three out of the many Projects I had the privilege to work with Yoram:

• Aerosol Absorption

• Cloud Side Measurements

• Design of new satellite missions
The ideas:

• **Aerosol Absorption**
  – Critical Reflectance: *Fraser and Kaufman 1985*
  – Aerosol absorption over sunglint: *Kaufman et al. 2002*
  – Spectral Reflectance measurements: *Martins et al. 2009*

• **Cloud Side Measurements**

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• Cloud Side Measurements
  – Idea presented to Yoram and others in 2002
  – Yoram was the only scientist at the time who answered:
    “Lets do it. I will find the resources to cover it...”

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• **Design of new satellite missions**
  – CO2BRA – measure BC from Space over sunglint:
  – AEROSAT – preview to ACE mission
  – CLAIM-3D – Cloud Side microphysical profiles
Critical Reflectance Maps of Aerosol Absorption

Zhu, Martins and Remer 2011
Wells, K. et al., 2012

Dust Spectral \(\omega_o\) results with MODIS:

Wells, K. et al, 2012

Figure 7: 22 February 2007 0.553 \(\mu\)m \(R_{crit}\) (upper left), SSA (upper right), and spectral SSA at Tamanrasset (lower) from \(R_{crit}\) and AERONET.
Aerosol Spectral Absorption

MODIS Aerosol Bands:

- Dust + Pollution
- Black Carbon in large particles
- Black Carbon in small particles ($\sim 1/\lambda$)
- Dust Particles
- Organics

Absorption Coefficient vs. lambda (um)
Volcanic Ash
Eyjafjallajökull (Iceland)
Ash was collected on the ground, about 35 km from the center of the eruption of the volcano.

Saharan Dust
Sample collected on Bordj Badj Mokthar in Algeria (Supersite 1) during Fennec campaign in June 2011.
Results

STEAR experiment at UMBC Lab

Volcanic ashes:

(Rocha-lima et al. in preparation)
PI-Neph produces unique direct/airborne measurements of polarized phase function of aerosols, and the retrievals of size distribution and refractive indices using both $P_{11}$ and $-P_{12}/P_{11}$ at 3 wavelengths.
Aug 19, 2013 | Case-1, 18:24:17 to 18:36:31 UTC | sphere=76.3%
n*(473,532,671nm)= 1.541+0.00121i, 1.575+0.00099i, 1.664+0.00080i

\[ \sigma_{\text{PIN}}(473,532,671\text{nm}) = 173, 113, 65 \text{ Mm}^{-1} \]
\[ \sigma_{\text{TSL}}(450,550,700\text{nm}) = 184, 117, \text{NaN} \text{ Mm}^{-1} \]

**PI-Neph X LARGE Size Distribution Retrievals**

Espinosa et al. (in preparation)
How the particle properties depend on Ambient conditions?

In Particular RH...
Dried/Humidified Ambient aerosols
PI-Neph X AERONET

2014/08/27

$P_{11}$

Scattering Angle (Deg)
Laboratory measurements of Aerosols

Figure 6 – Example of PI-Neph measured dry versus humidified phase functions for laboratory generated NaCl aerosols. The three figures on the left-hand side show the evolution of P11 at three wavelengths (471, 532, and 671nm) for two different RH values (<20% and ~80%), and the three right-hand side figures shows the variation in P12.
GRASP Inversion X theory for Humidified Refractive indices:

<table>
<thead>
<tr>
<th>Compound</th>
<th>RH(%)</th>
<th>$\kappa$</th>
<th>n GRASP</th>
<th>n Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>$NaCl$</td>
<td>83</td>
<td>0.91-1.12</td>
<td>1.380</td>
<td>1.347-1.352</td>
</tr>
<tr>
<td>$(NH_4)_2SO_4$</td>
<td>84</td>
<td>0.33-0.53</td>
<td>1.380</td>
<td>1.379-1.413</td>
</tr>
<tr>
<td>$(NH_4)NO_3$</td>
<td>82</td>
<td>0.33-0.53</td>
<td>1.375</td>
<td>1.361-1.380</td>
</tr>
</tbody>
</table>

Ambient Aerosols:

Orozco et al. (in preparation)
Figure 12 – Retrieval of the size distribution from the dried aerosols measured by the PI-Neph compared with the size distribution from AERONET. The AERONET results show clearly the stronger coarse mode than the PI-Neph which can derive from a few factors including: humidity and high humidification factor for these aerosols or particle losses in the inlet of the instrument and/or inside the diffusion drier,
In situ measurements of Undisturbed particles:

The Open Imaging Nephelometer
Open Ineph First
Results from DAQ

Measurement of the cloudbow inside the cloud
HARP Polarimeter Specs
- ISS orbit
- 60 angles for cloudbows
- 20 angles for aerosols
- 440, 550, 670, 870nm
- Nadir pixel resolution 600m
- Super pixel 2.5x2.5km
- 94 deg FOV X-track
- 117 deg FOV along track

Repeat for all along track viewing angles

HARP CubeSat Satellite to launch in Dec. 2016
HARP Hyperangular Multi-Wavelength Polarization Images

HARP Prism/Polarization Separation

Stripe Filters: Angular and Wavelength Separation

[\begin{bmatrix} I & Q & U \end{bmatrix}]_{\text{pixel}} = [I_0 \ I_{45} \ I_{90}] \cdot M

HARP
- Up to 60 viewing angles
- 440, 550, 670, 870nm
- 2.5km resolution
- 94 deg FOV X-track
- 110 deg FOV along track

Multi/Hyper Angle with multiple pushbrooms

Multi Wavelength
HARP CubeSat Polarimeter

HARP Pioneering Hyper-Angular Capability will Provide Full Cloudbow Retrievals from Small Area (< 4x4km from space)

Same retrieval capability for all individual pixels with < 4x4km resolution

Water Droplet Distribution

Reff = 20μm
Veff = 0.01

Effective Radius (μm)

0 10 20 30 40

These two cases are undistinguishable from Intensity measurements only (MODIS/VIIRS)
Aerosol above Clouds and Aerosol Absorption (UV and Polarization)

Volcanic Ash, Twilight Aerosols, etc. (Polarim. + Cloud Radiometer)

Ice/water particle’s scattering

**CLAIM-3D**

PI: J. Vanderlei Martins (UMBC – JCET / 613)

- The interaction between aerosol and clouds carry the largest uncertainty in climate forcing
- CLAIM-3D will determine how cloud evolution, droplet sizes, lifetime, vertical structure, thermodynamic phase, and ice particle structure vary as a function of aerosol type and amount

Project Scientist: A. Marshak (GSFC 613)

- CLAIM-3D has unprecedented combination of mature instruments and algorithms to address the interaction between aerosols and clouds
- CLAIM-3D is designed to provide a full court press characterization of the interactions between aerosol and clouds
The ideas:  The reality today...

- **Aerosol Absorption**
  - Multiple critical reflectance papers
  - Sunglint: aerosol absorption over water
  - Spectral reflectance: aerosol microphysics, imaginary refractive indices, composition...

- **Cloud Side Measurements**
  - First cloud scanner instrument was built and demonstrated in the Amazon
  - 3D simulations: Marshak, Zinner, etc.
  - Current measurements and proposals by several European organizations and Brazil

- **Design of new satellite missions**
  - ACE, CLAIM-3D
  - HARP CubeSat satellite early 2017
  - PACS in situ + Remote Sensing Suite
    - PACS Imaging Polarimeter (HARP)
    - High resolution cloud measurements
    - Imaging Nephelometer measurements
Thank you Yoram

...for the ideas, motivation, support, friendship and for the reality...