Analysis and Mitigation of Atmospheric Crosstalk

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Introduction

• What is crosstalk?
  • When a retrieval algorithm aliases unrelated geophysical signals into the retrieval

• Why is understanding crosstalk important?
  • Can mask important modes of variability (e.g., El Nino)
  • Can produce spurious trends on decadal time scales

• What are primary crosstalk sources for IR SST retrievals?
  • Clouds, water vapor, aerosols

• Why is quantifying IR SST crosstalk difficult?
  • Vapor is correlated with SST, and this correlation is a function of time scale
  • Vapor and cloud are correlated
  • Clouds have significant horizontal, vertical, and microphysical variability
  • Aerosols have a variety of radiative properties and lack unique spectral signature
Objectives

1. Develop a better understanding the effects of water vapor, aerosols, and clouds on VIIRS SST retrievals

2. Develop and implement two VIIRS SST algorithms
   - Physically parameterized statistical algorithm (PPSA)
     - Weighted least-squares algorithm, parameterized in terms of physical quantities
     - Tunable, like a statistical algorithm, by adjusting the a priori values and uncertainties
   - Combined VIIRS and AMSR2 algorithm
     - Uses AMSR2 in specifying a priori values and uncertainties
     - Additional cloud clearing based on AMSR2
     - Identifying and mitigating aerosol effects by comparing AMSR2 and VIIRS

3. Provide a characterization of uncertainties in SST retrievals
Preliminary Results

- Downloaded SDR data from VIIRS SIPS FTP at University of Wisconsin Space Science and Engineering Center
  - SVM12, SVM13, SVM15, SVM16, GMTCO
    - Does cloud clearing require other channels?
  - One granule = 52 MB
  - One day = 52 GB
  - One year = 19 TB

- Our project will be delivering software to VIIRS Ocean SIPS to run the SST algorithms
  - Is this the dataset I should be using for algorithm development?

- Also using RSS AMSR2 retrievals of SST, wind, vapor, cloud, and rain
  - Data available at www.remss.com
  - Resolution: twice daily, 0.25-deg grid
  - Validation of AMSR2 SST: Gentemann and Hilburn, 2015, JGR-O, accepted
  - Intercomparison of RSS and JAXA calibrations: Hilburn and Gentemann, 2015, JGR-O, submitted
  - Note: VIIRS starts October 2011, AMSR2 starts July 2012
Sampling Patterns

• Maps show the number of observations falling in 0.25-deg Earth grid, for one day, separated local AM/PM

• VIIRS resolution = 0.7 km

• Thus, in the swath center the typical number of observations is
  • 25 km (1440 x 720) gives 1225 obs
  • 12.5 km (2880 x 1440) gives 289 obs
  • 9 km (4096 x 2048) gives 144 obs
  • 5 km (7200 x 3600) gives 49 obs

• Sampling patterns are complicated along swath edges because
  • Adjacent passes overlap (increases number of observations)
  • Mitigation of bow-tie effect (decreases number of observations, for two distinct scan angle ranges)

• To handle the TB-scale data volume, our project is to use VIIRS files that are pre-processed onto Earth grids
  • Is there compelling reason to chose particular grid resolution?
  • Since Earth zenith angle increases with scan angle, is there a maximum scan angle beyond which retrieval is not advisable?
  • Avoid high latitude overlap by making each map one orbit?
Viewing Geometry

- The Earth zenith angle varies from 0 deg at swath center to 70 deg at swath edges.
- At swath edge, path through atmosphere is 2.9 x longer than swath center.
- At 4.05 micron there is clear zenith angle dependence:
  - Warmer at zenith angles of 0 deg
  - Cooler at zenith angles of 70 deg
Solar Geometry

• Areas with solar zenith angle less than 25 deg are highlighted with dashed contours

• These correspond to hot areas in the 3.70 micron TB

• Would be preferable to examine sun-glint angle, which is angle between sun reflection vector and boresight vector
Daily Average TB

• Temperatures range from about 260 K over high-latitude ocean to 300 K over tropical ocean

• Areas with TB below 250 K are tall clouds with cold cloud tops, and are most prominent in longer wavelengths

• The 3.70 micron channel most closely resembles SST

Daily average VIIRS TB from 2015/01/01
PM-AM TB Difference

- VIIRS on Suomi NPP satellite has ascending node time of 1:30 PM
- Over land, the increase in temperature from morning to afternoon is strongest at 3.70 micron, indicating the largest surface contribution
- 3.70 micron also has large (20-30 K) positive PM-AM differences over Southern Ocean – this example is from January: sun reflection
- Diurnal differences are on the order 10-20 K at 4.05 micron and are 10 K or less for 10.76 and 12.01 micron

PM-AM (LT) VIIRS TB from 2015/01/01
11-12 Micron TB Difference and Vapor

- Overall, there is a positive correlation between the VIIRS TB difference (top) and AMSR2 total columnar water vapor (bottom)
- This is most evident in the western tropical Pacific
- Other areas with abundant water vapor, like the eastern tropical Pacific and Indian Oceans have a smaller TB differences
- In some areas, like the tropical Atlantic, larger TB differences can be found outside of high vapor areas
- Plumes of vapor that extend into mid-latitudes are sometimes evident in TB difference (north Atlantic), and other times not (northwestern Pacific)
Summary and Conclusions

• Performed initial exploration of VIIRS data and comparison with AMSR2
• There is a clear SST signal in VIIRS TBs
• There is also a clear signal from clouds
• Large TB-SST differences occur where water vapor is abundant
• Large differences also can occur where vapor is low
  • Suggests that effective air temperature also plays important role
• The relationship between 11-12 micron TB diff and vapor varies by region
• First order of business: to produce gridded VIIRS TB with clouds cleared
  • Q/C: sun glint, TB bounds check, scan angle threshold, number of obs threshold
  • Maps should also include time and Earth zenith angle