



NAAPS Model Update from NRL

Part 1

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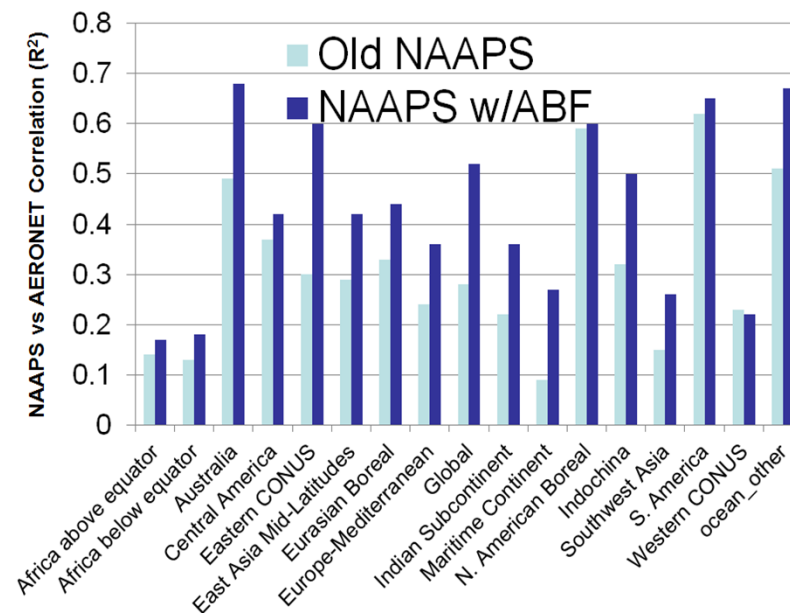
In This Talk

1. NAAPS v1.4: major prediction upgrade
2. Data Assimilation Upgrades:
 1. LEO Aerosol constellation
 2. GEO aerosol assimilation
3. Other work



NAAPS Version 1.4

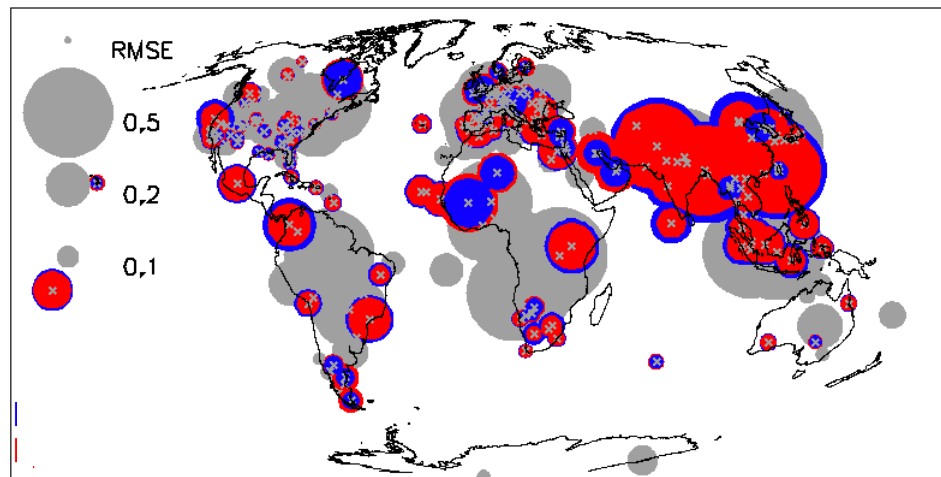
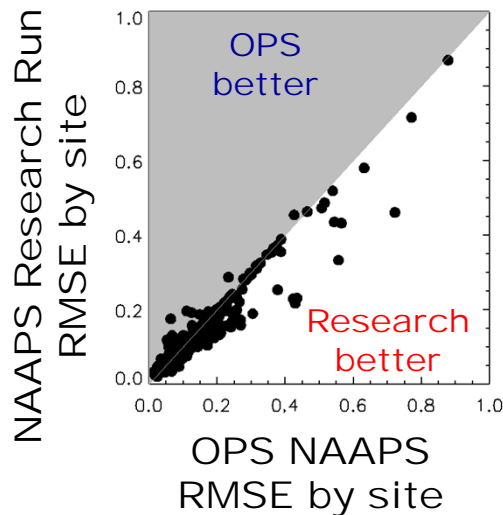
- NAAPS v1.4: **Operational 11/1/2016**
- NAAPS updates in ICAP research run now implemented in operational model
 - **Primary and Secondary organic aerosols now included!**
 - Significant reduction in regional biases, improved forecast skill
 - This represents a huge upgrade for the OPS NAAPS



Updated fine-mode aerosol gives improved model skill in every region of the globe!

NAAPS 1.3 vs AERONET

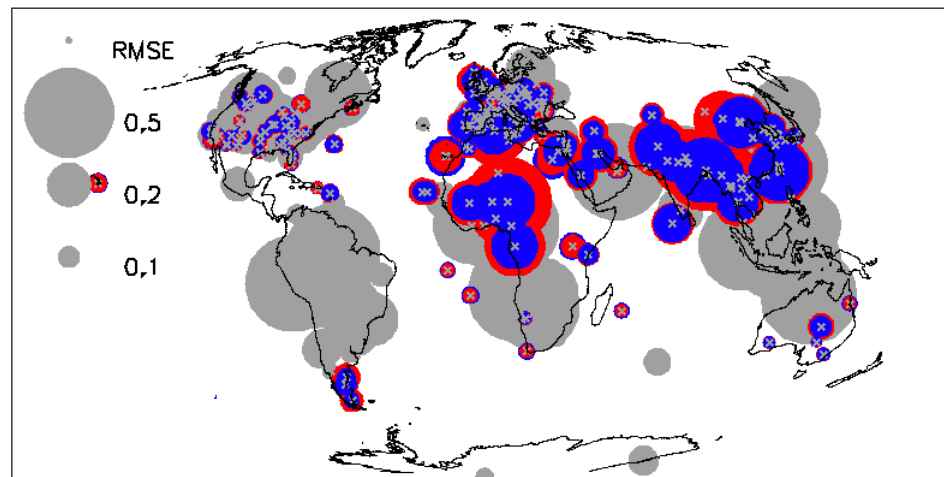
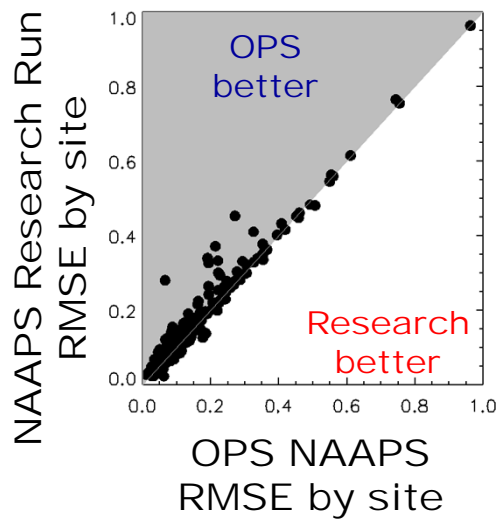
- **Winter 2015: NAAPS v1.3**
- **OPS NAAPS and research NAAPS have widely divergent statistics**
 - OPS NAAPS significantly worse than Research NAAPS in many areas
 - Note: OPS is at 1/3 degree, research is at 1-degree



Winter 2015-2016
Research much better than
OPS NAAPS v1.3

NAAPS 1.4 vs AERONET

- **Winter 2016: NAAPS v1.4 with upgraded sources and data assimilation**
- OPS NAAPS and research NAAPS much more consistent
 - OPS NAAPS outperforms Research NAAPS in almost every area
 - Note: OPS is at 1/3 degree, research is at 1-degree



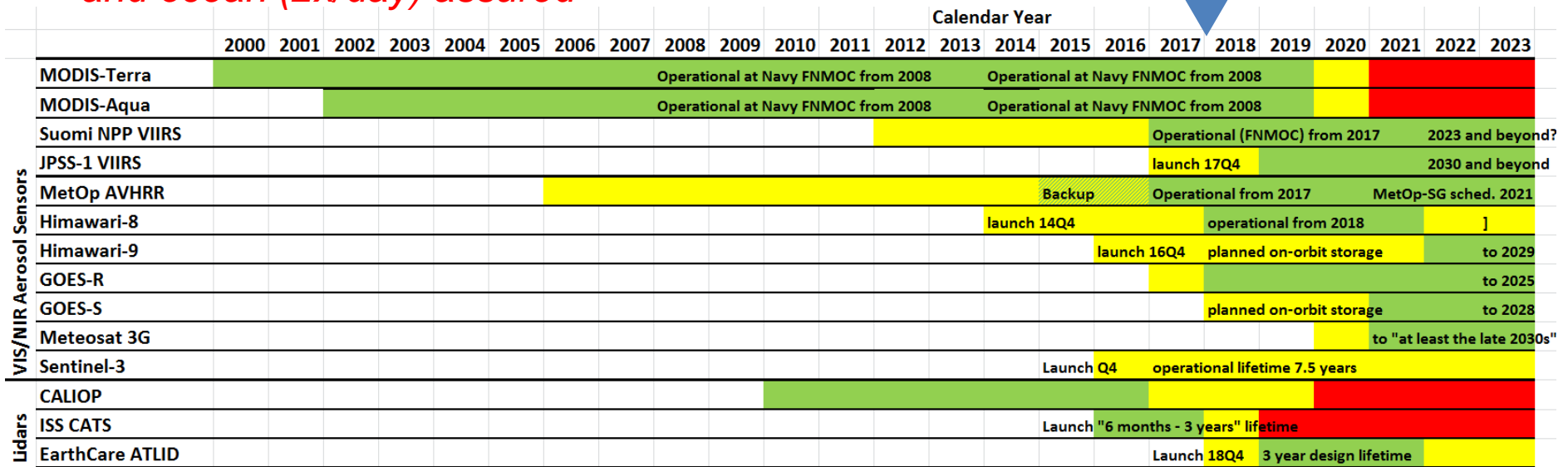
Winter 2015-2016

OPS NAAPS v1.4 (1/3°) beating research NAAPS (1°)



LEO Constellation for Aerosol

- Complete polar constellation: MODIS+VIIRS+AVHRR
 - *After FY17 transitions complete, global land (1x/day) and ocean (2x/day) assured*





Complete polar constellation: MODIS+VIIRS+AVHRR

- **After this year, global land (1x/day) and ocean (2x/day) assured even without MODIS**

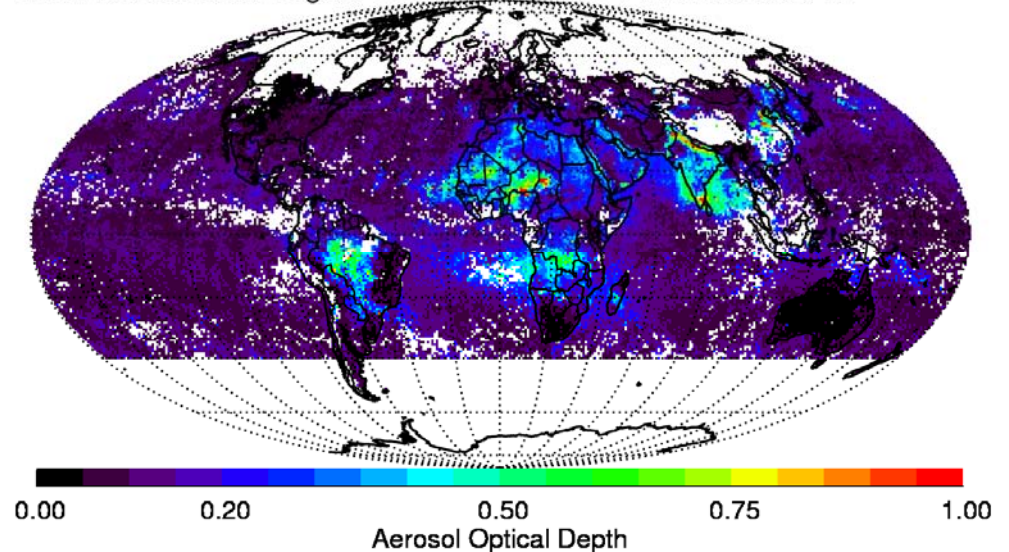
- **Map: Mean global AOD**

- 10/15 – 11/1/2016 (16 days)

NAAPS operational obs

- 2009: MODIS over ocean
- 2012: MODIS ocean+dark land
- 2016: MODIS global (C6)
- 2017: MODIS + AVHRR ACSP0 (ocean only)
- 2017: MODIS+AVHRR+VIIRS

2017: MODIS-Dark Target + MODIS-Deep Blue + AVHRR-ACSP0

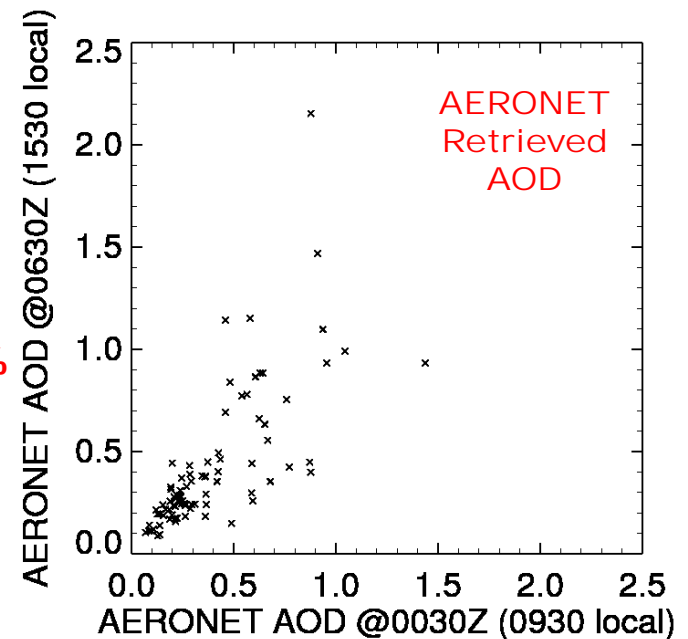




GEO Observations: Motivation for more frequent constraint

- How important is sub-daily variation in EO/visibility prediction?
- How much variation in current NAAPS model compared to obs?
- An example from Korea:
 - April-June 2016
 - Lat/Lon of 7 AERONET stations
 - For each date for each station:
 - NAAPS AOD output at 0Z and 6Z
 - AERONET AOD nearest to 0Z and 6Z
 - GOCI satellite AOD (Yonsei) nearest to 0Z and 6Z

For AERONET retrieved AOD, AM-PM difference exceeds 20% of mean for 61% of cases!



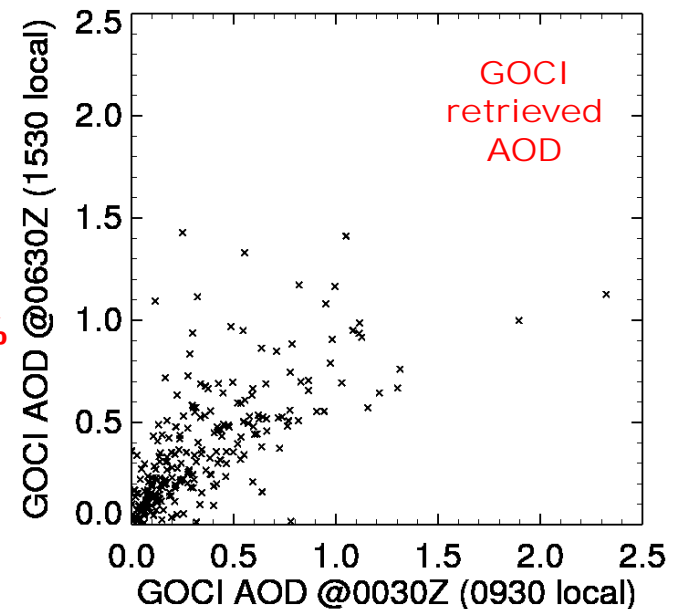


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For AERONET retrieved AOD, AM-PM difference exceeds 20% of mean for 61% of cases!

For GOCI satellite data, AM-PM difference exceeds 20% of mean for 75% of cases!





GEO Observations: Motivation for more frequent constraint

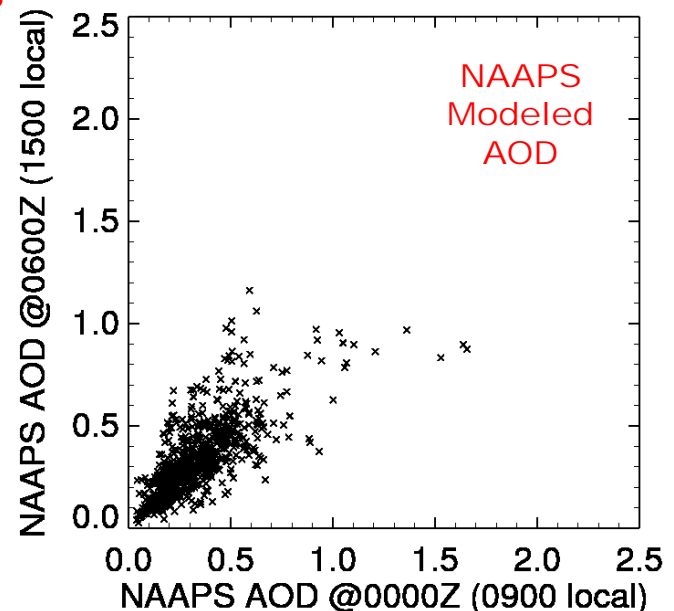
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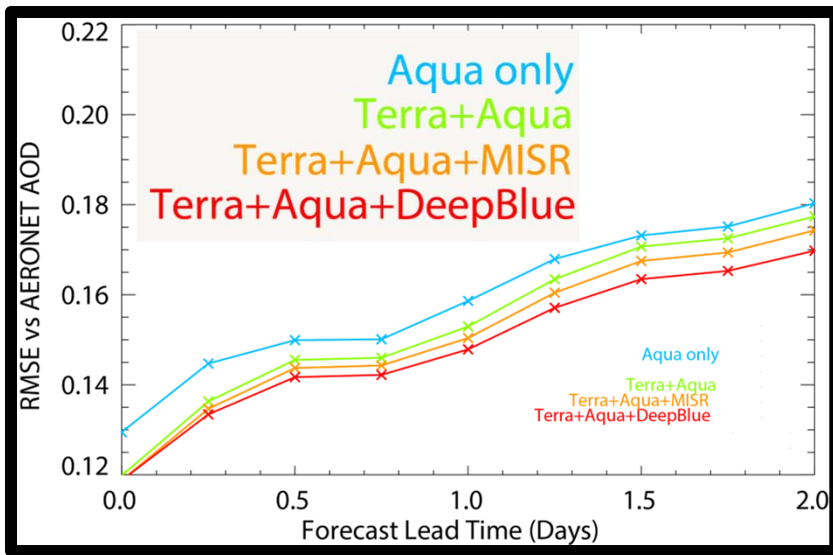
For NAAPS model output, AM-PM difference exceeds 20% of mean for 54% of cases (*figure at right*)

- Predict 1500LST aerosol based on 0900LST: $r^2=0.54$
- Predict 1500LST aerosol based on T-1day: $r^2=0.51$

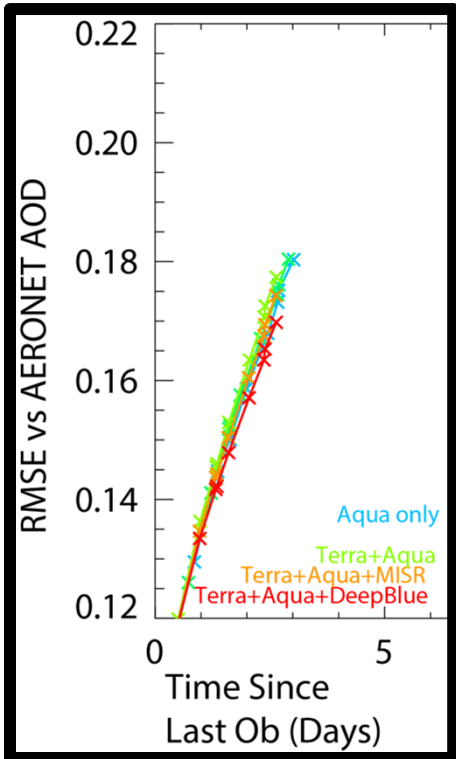


GEO Observations: Motivation for more frequent constraint

- *How do we expect the model to respond to more frequent observations for assimilation?*
- *Forecast error does not grow linearly with forecast lead time*
- *nor shrink linearly with additional obs assimilated.*

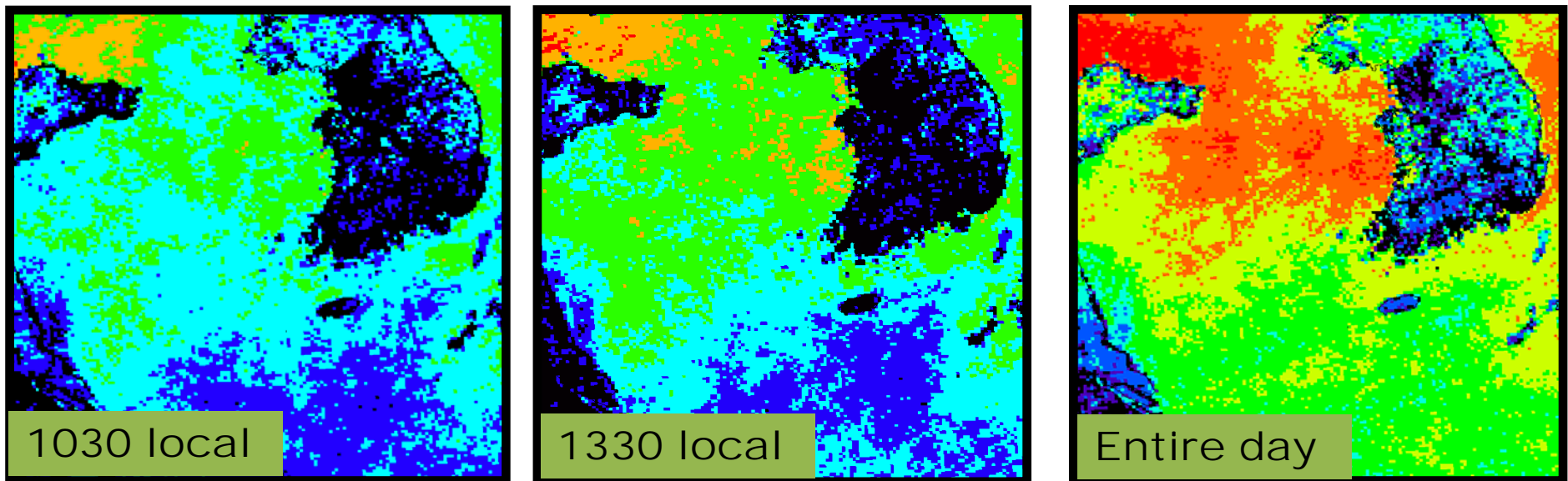


Error can be linearly reduced by shrinking time-since-last-ob



GEO Observations: How Often?

- Geostationary sensors: major advantage for dodging clouds!



May-July 2016

Fraction of days with valid GOCI AOD





Forward Focus for operational NAAPS

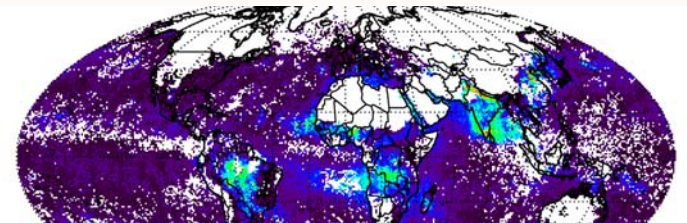
- Pathway to geostationary AOD assimilation
 - Change AOD DA cycle from 6 hours to 3 hours
 - This will pay dividends with MODIS too
 - Settle on a transition candidate AOD product
 - Currently not clear what products will be operationally available to Navy
- FLAMBE
 - GOES-R will replace GOES-13 in November
 - GOES-R, Himawari fire products not yet available, much less characterized
 - Will FLAMBE switch to MODIS-only?
 - Regional tuning for FLAMBE also needed in operational model
- Model I/O streamlining
 - Convert model to use NetCDF natively
 - NetCDF model products for science users
 - Machine-to-machine data delivery– the demand is now there!
- ***Next: Part 2: Juli Rubin (NRL-DC) on NAAPS ensemble, EnKF data assimilation, and more!***



DA Upgrade: MODIS Collection 6

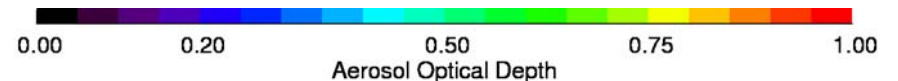
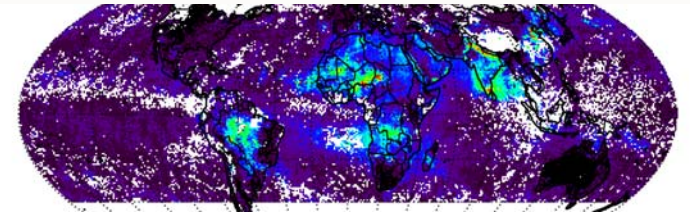
- NAAPS v1.4 transition also included a big upgrade in data assimilation
 - ***Now including MODIS Deep Blue over bright desert!***
 - Upgraded MODIS base data from Collection 5 to Collection 6
 - Better handling of MODIS-Terra degradation
 - Improved cloud masking using cloud proximity (distance-to-cloud)

NAAPS v1.3: MODIS C5 Dark Target



2016: MODIS-Dark Target + MODIS-Deep Blue

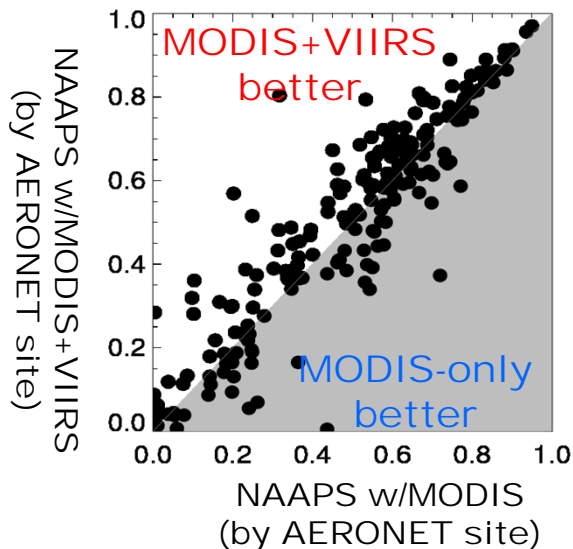
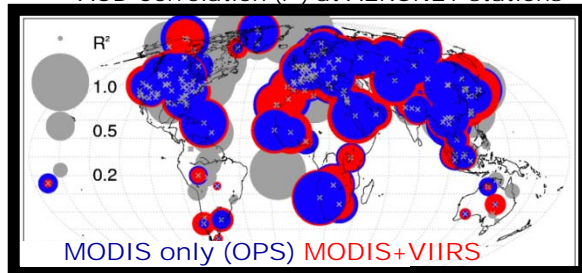
NAAPS v1.4: MODIS C6 Dark Target + C6 Deep Blue



Addition of high-quality observations improves NAAPS analysis!

VIIRS Assimilation Testing

AOD Correlation (r^2) at AERONET stations



- **NAAPS assimilation testing of VIIRS Enterprise Aerosol**
- Global VIIRS data processed 201505-201507 (90 days)
- NAAPS analysis results: **VIIRS+MODIS better than MODIS only**
- Global correlation improved from $r^2=0.68$ (MODIS-only) to $r^2=0.74$ (MODIS+VIIRS)
- Global RMSE decreased from $RMSE=0.12$ (MODIS-only) to $RMSE=0.11$ (MODIS+VIIRS)
- Correlation (r^2) vs AERONET L2.0 increased at 132 of 208 stations
 - Colored symbols on map indicate r^2 difference > 0.05
- Site-by-site RMSE more mixed: 199 sites with $\Delta RMSE > 0.02$:
 - RMSE better at 111/199, worse at 88/199
- **Better results can likely be achieved with additional filtering**
- **VIIRS Enterprise is a vastly upgraded product from initial NOAA IDPS Aerosol Product**
- **Not the only choice for VIIRS: NASA SIPS should now be producing Dark Target and Deep Blue products from VIIRS**