Atmospheric chemistry products from JPSS and their applications

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JPSS Science Team Meeting
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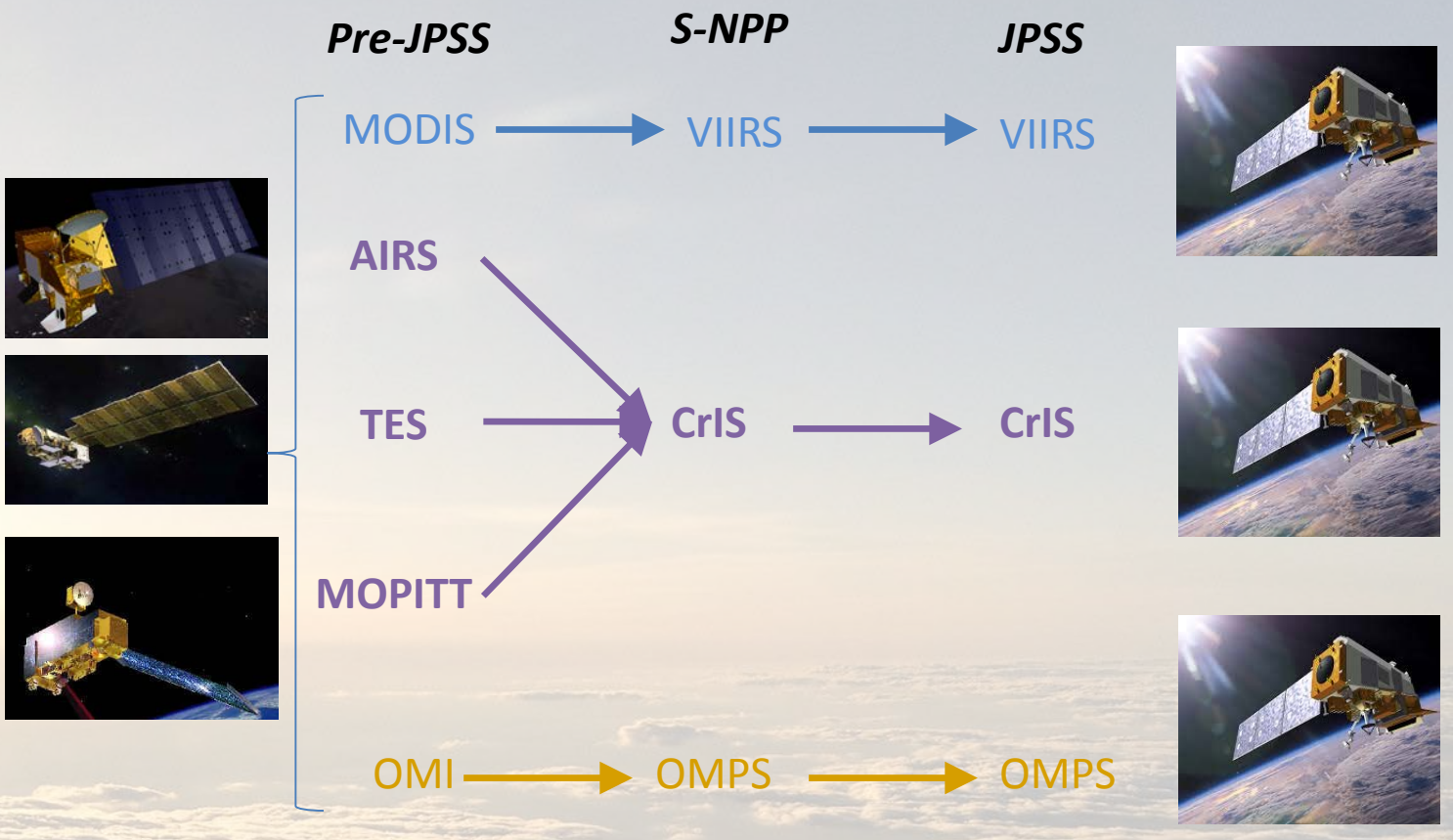
JPSS instrument legacy
(in atmospheric chemistry)



NOTE: **VIIRS**, **OMPS and CrIS** all provide or can provide data relevant to atmospheric chemistry

Atmospheric chemistry products from JPSS: current and future

- CrIS: CO, CO_2, ozone, methane, ammonia, SO_2, *N_2O, PAN, isoprene*…
- OMPS: ozone, NO_2, *formaldehyde*…
- VIIRS: burned area, AOD, other fire products

See Thursday session on Trace Gases for more details

Sources: JPSS standard products, PGRR, NOAA/AC4 funded, NASA

NOAA (OAR/CPO/AC4) effort so far

- **2013**: FY13 FFO funded ammonia product development and validation
- **2014**: FY14 FFO funded further development of ammonia product; CrIS workshop gathers potential (research) users
- **2015**: FY15 FFO funded ammonia product application in GFDL Earth System Model; CrIS workshop report released
- **2016-17**: FY16 FFO funded CrIS/OMPS ozone product development
- **2017**: FY18 FFO solicits for new (BVOC) product development (e.g. isoprene, formaldehyde)

How did we contribute? Mostly through FFO…

More progress: CrIS workshop recommendations (2015)

Scientific community uses TIR satellite observation, so far provided by NASA and EUMETSAT from **MOPITT, TES, AIRS and IASI**. All are past expiration and there are no plans to replace them.

Recommendation 1: Need data

- Provide calibrated radiances Level 1b data at full spectral resolution.

Recommendation 2: Special needs for atmospheric chemistry

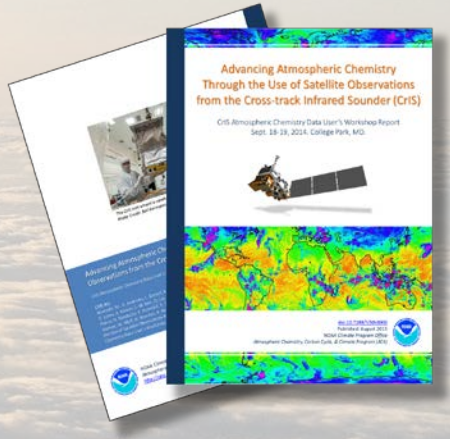
A. Provide reduced file size (like TES "lite) with retrievals for individual trace gases and their observation operators at a reduced vertical resolution.
B. Provide essential information: a priori, averaging kernels, estimated retrieval error.
C. Allow rapid multi-file download from CLASS

Recommendation 3: Validation

A. Coordinate validation with upcoming field campaigns (e.g. FIREX)
B. More frequent ESRL flights to validate trace gases
C. Plan additional field campaigns with retrieval and user communities

Recommendation 4: Future

A. Explore the possibility of new species/products
B. Close spectral gap
C. Reduce noise and increase resolution for future instruments



Most apply to all of JPSS!

What are the applications?

- Improved understanding of atmospheric composition
- NOAA Climate/Earth System Model (GFDL) development and validation
- Air quality forecasting
- NGGPS
- Monitoring of air pollution and greenhouse gases

Note: substantial NASA effort continues

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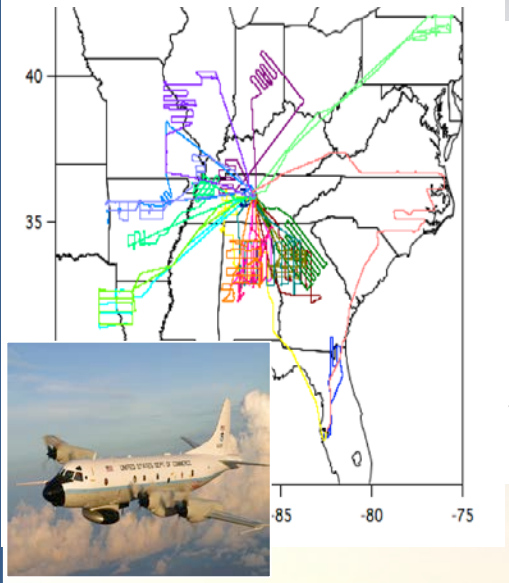
Understanding Emissions and Tropospheric Chemistry using NUCAPS and VIIRS

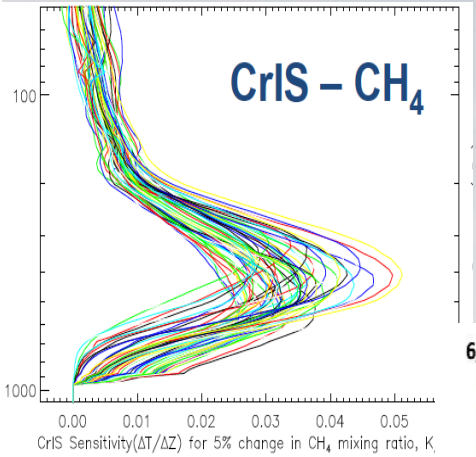
G. Frost, S. McKeen, S.-W. Kim, R. Ahmadov, M. Trainer, Y. Cui, W. Angevine, T. Ryerson, J. Roberts, C. Warneke, C. Granier, K. Rosenlof, J. Brioude; R. B. Pierce; C. Barnet, N. Smith, A. Gambacorta; C. Elvidge

JPSS Proving Ground/ Risk Reduction Program

SENEX 2013 NOAA WP-3 flights

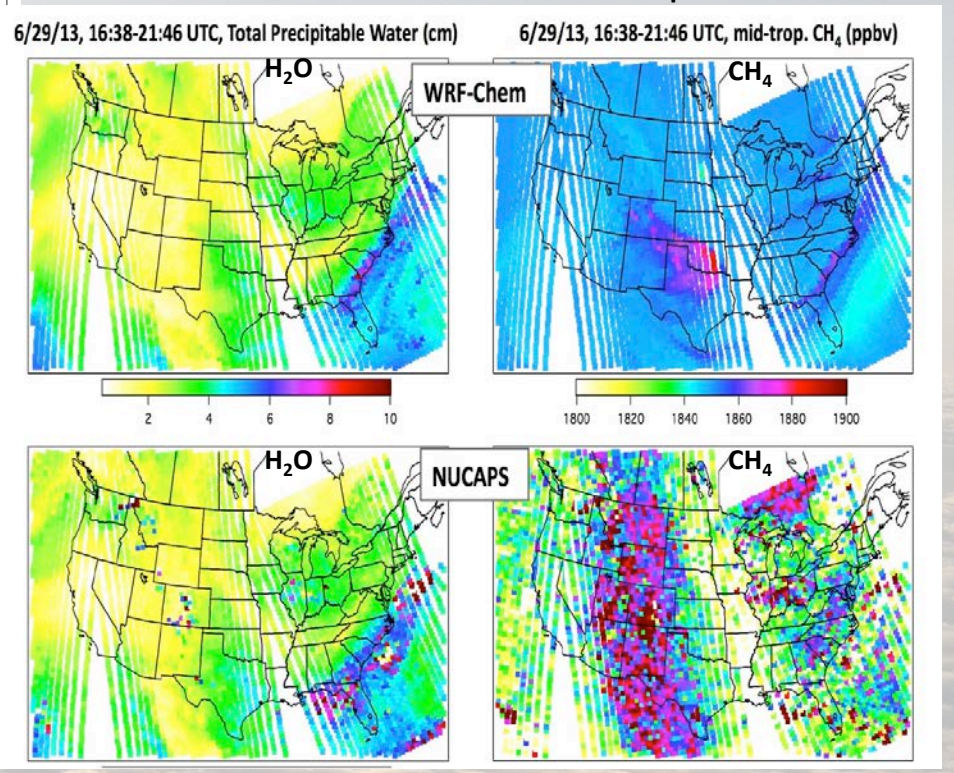


CrIS CH_4 Vertical Sensitivity



- Evaluate NUCAPS (CrIS+ATMS) CH_4 and CO retrievals with aircraft data and aircraft-validated atmospheric model simulations
- Quantify CH_4 and CO spatial-temporal variability with aircraft, models, and NUCAPS

NUCAPS vs. WRF-Chem Model Comparison



Validate NUCAPS retrievals by comparing to aircraft observations and model output

Determining the quality of satellite retrievals when aircraft data for comparison are sparse

Characterize true signals vs. noise with variance scaling using Fourier spectral analysis

Slide courtesy of G. Frost and B. Pierce

http://www.esrl.noaa.gov/csd/projects/senex/

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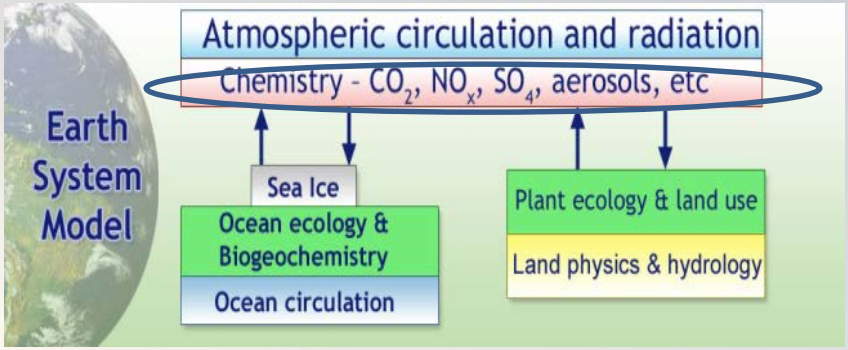
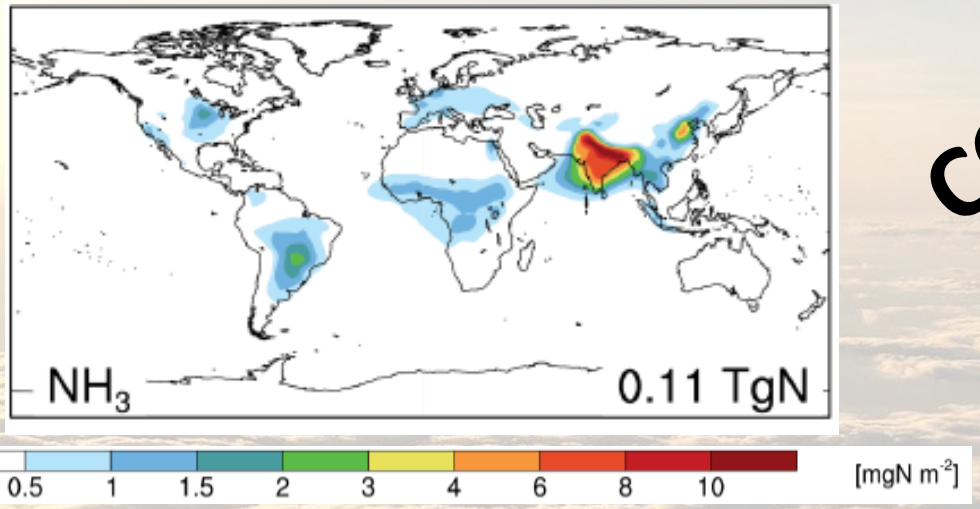
NOAA GFDL model development and validation

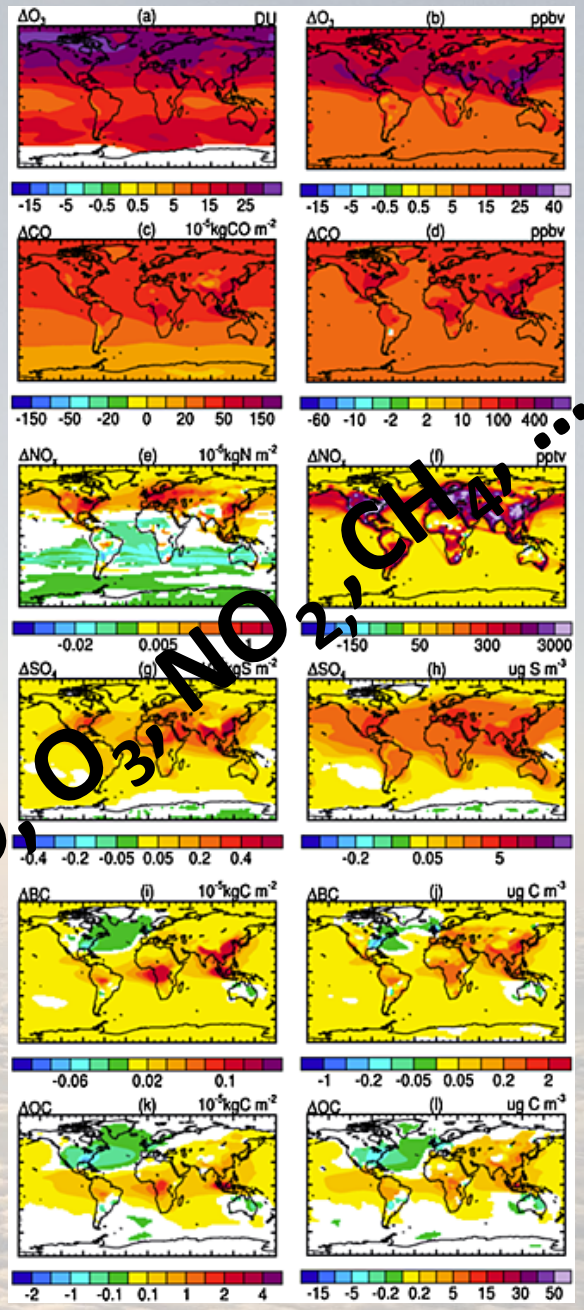


Ammonia in GFDL AM3 model



Paulot et al. 2016

User potential: High latency operational user



Naik et al. 2013

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National Air Quality Forecast Capability

End-to-End Operational Capability

Model: Linked numerical prediction system

Operationally integrated on NCEP's supercomputer

- *NOAA NCEP mesoscale numerical weather prediction*
- *NOAA/EPA community model for air quality: CMAQ*
- *NOAA HYSPLIT model for smoke and dust prediction*

Observational Input:

- *NWS weather observations; NESDIS fire locations; climatology of regions with dust emission potential*
- *EPA emissions inventory!!!!*

Gridded forecast guidance products

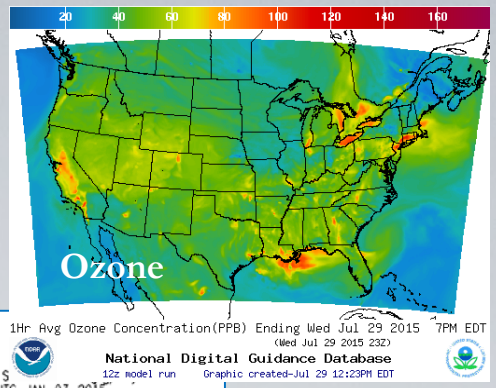
- *On NWS servers: airquality.weather.gov and ftp-servers (12km resolution, hourly for 48 hours)*
- *On EPA servers*
- *Updated 2x daily*

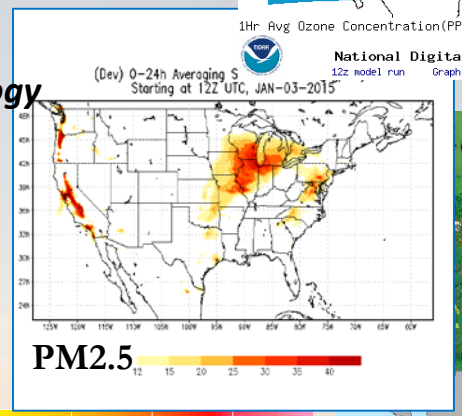
Verification basis, near-real time:

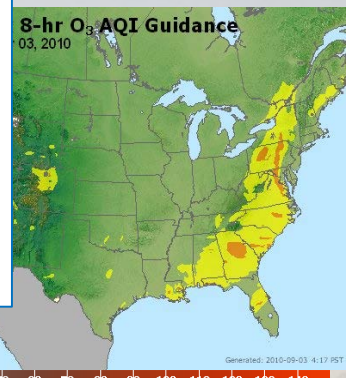
- *Ground-level AIRNow observations surface ozone and PM2.5*
- *Satellite observations of smoke and dust*

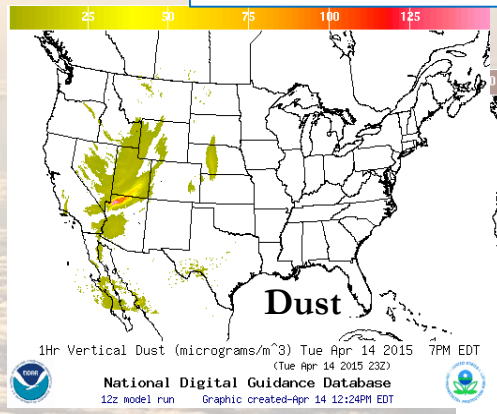
Customer outreach/feedback

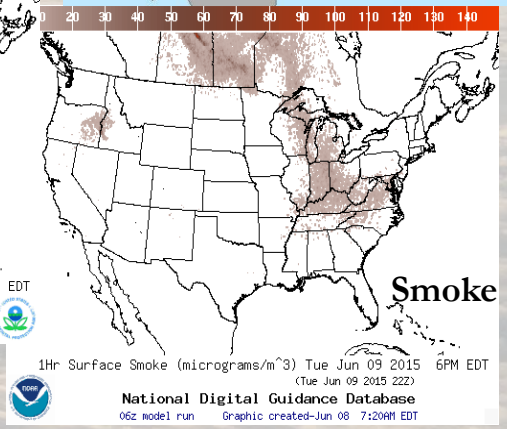
- *State & Local AQ forecasters coordinated with EPA*
- *Public and Private Sector AQ constituents*











Slide from Ivanka Stajner, NOAA/NWS

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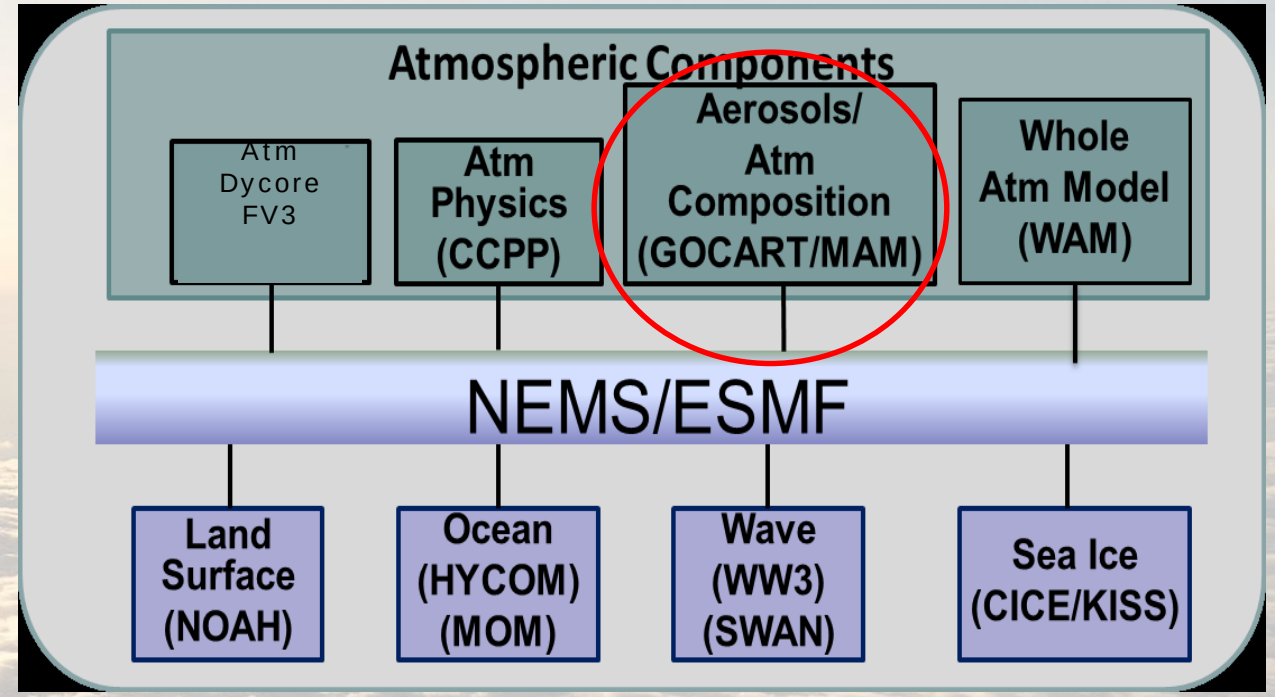
Applications: NOAA NGGPS

Next Generation Global Prediction System (NGGPS) will be a multi-scale unified modeling system that will eventually replace the current GFS, GFS ensemble, and Climate Forecast System (CFS)

Predicting the whole **Earth System**, not just weather!

NGGPS structure



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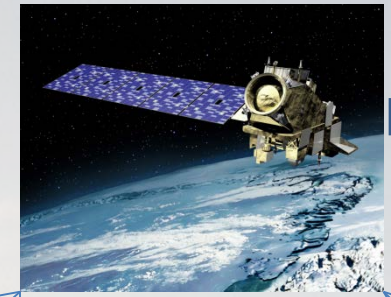
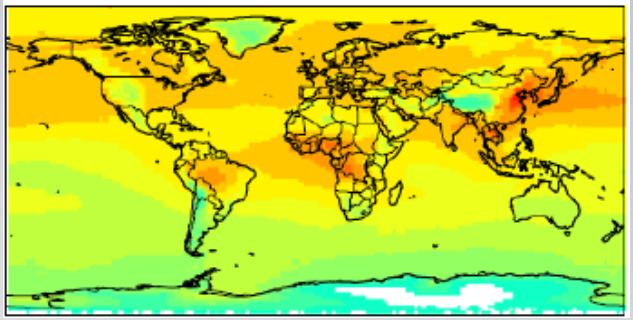
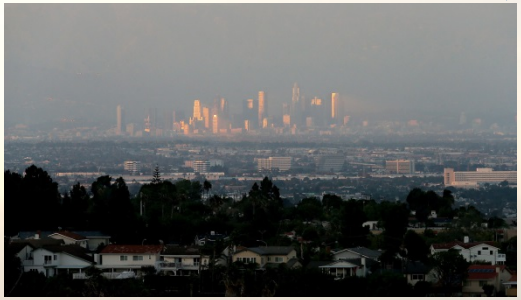
Atmospheric composition monitoring from space: “air pollution”

Daily global maps







Urban smog

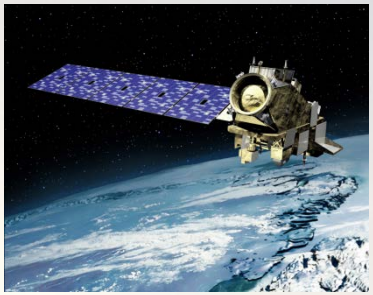
Smoke composition

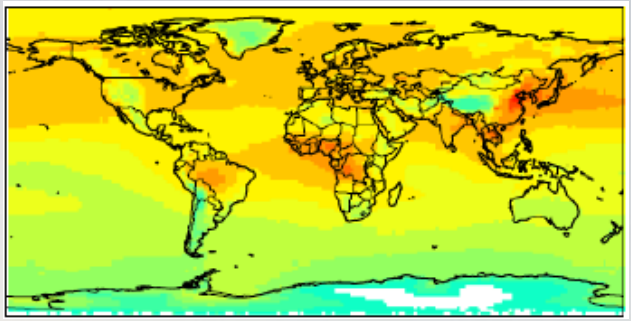
Other, including new sources (e.g. oil & gas extraction)

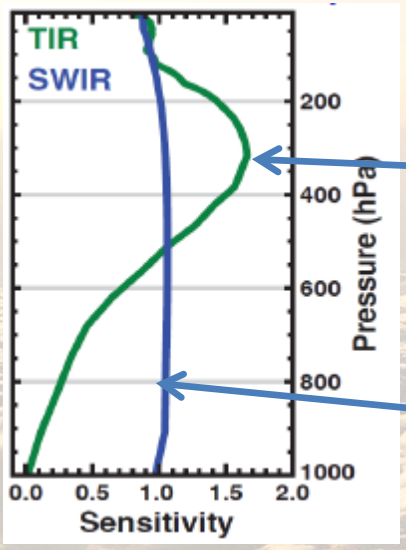
NYTimes, 8/9/17, “We’re choking on smoke in Seattle”

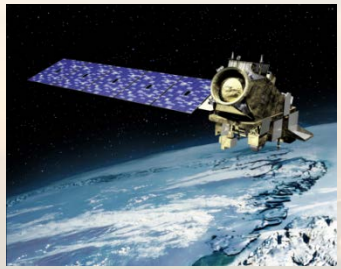
Atmospheric composition monitoring from space: CO_2

Daily global maps.





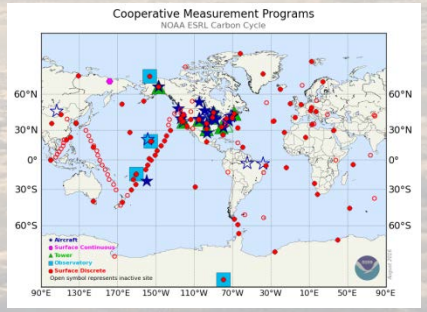




JPSS

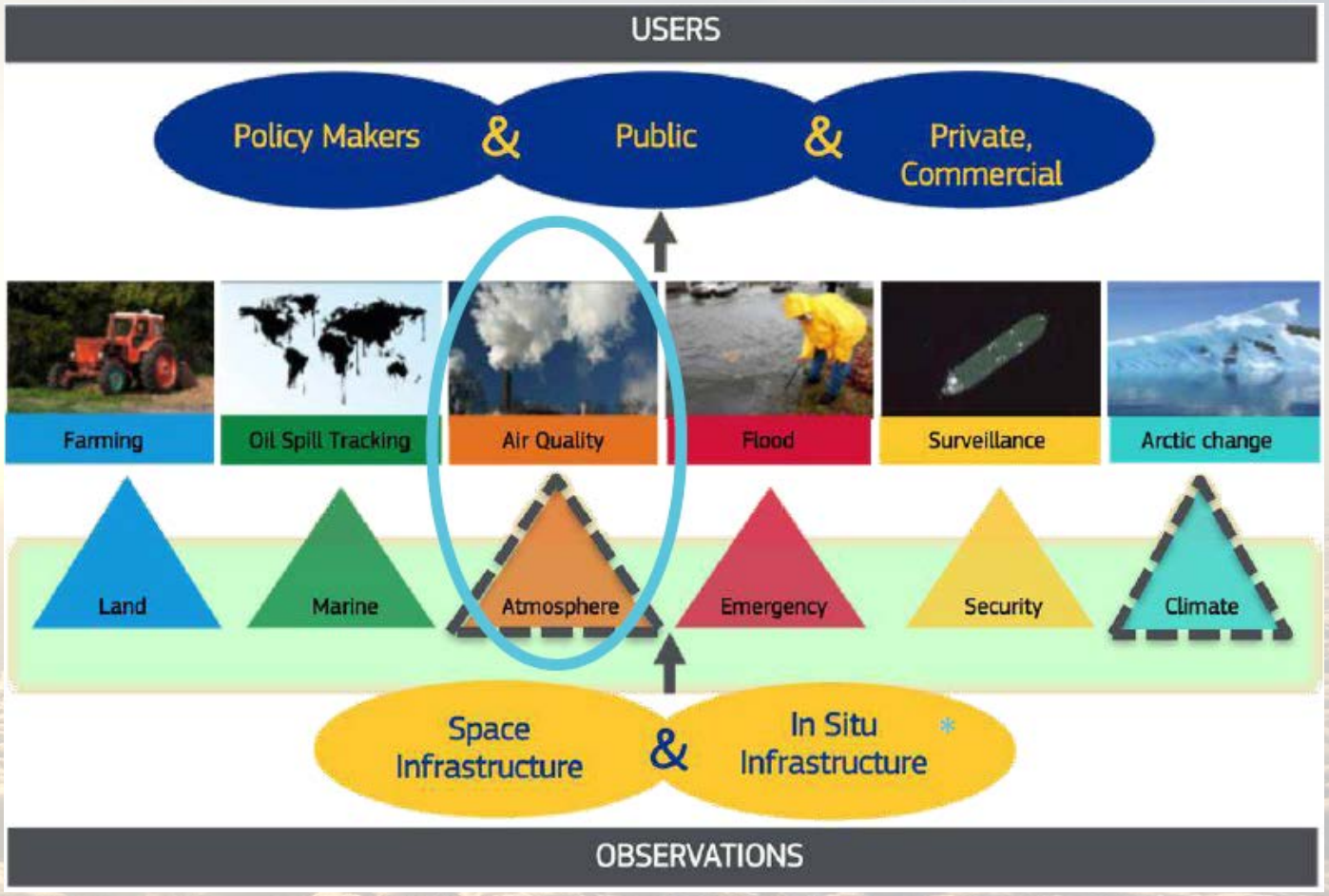
JPSS/CrIS could provide background CO_2 to help estimate very small surface enhancement

OCO-2



Complement to surface station monitoring by ESRL/GMD!

Air quality services: Can we keep up with Copernicus?



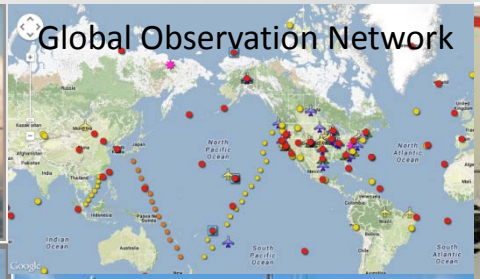
"The service provides near-real-time analysis and 4-day forecasts, as well as reanalysis, of the **European air quality**, thus enabling a permanent assessment of the air we breathe."

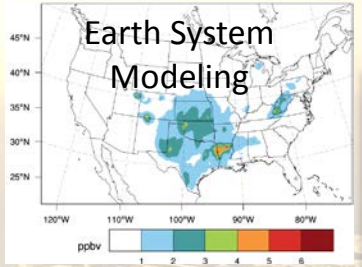
http://atmosphere.copernicus.eu/services/air-quality-atmospheric-composition

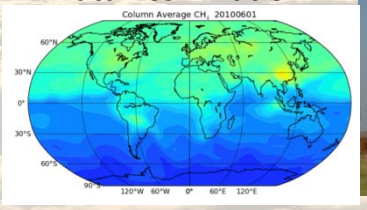
Figure courtesy of Mark Parrington and Vincent-Henri Peuch, ECMWF

OAR in situ and modeling capabilities

Validation with all the aircraft data, including and especially FIREX/FIRE-Chem field campaign







Observing the atmosphere at multiple spatial and temporal scales with a suite of complementary approaches

State-of-the-art earth system modeling and data analysis

http://www.esrl.noaa.gov

Slide from G. Frost and B. Pierce