



VIIRS Marine Isoprene: Linking Ocean Phytoplankton to Air Quality and Climate

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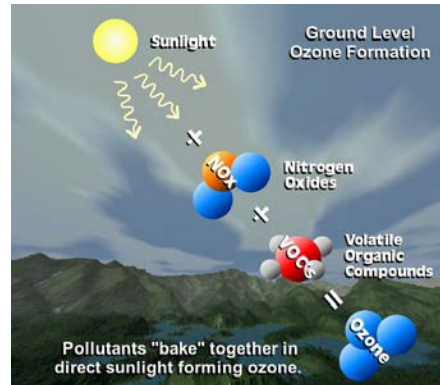
Acknowledge: NOAA JPSS Program for funding support;

What is isoprene

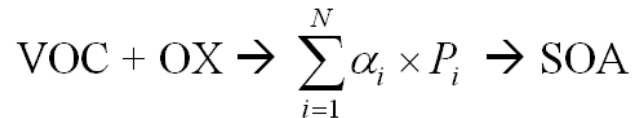
Isoprene ($\text{CH}_2=\text{CH}-\text{C}(\text{CH}_3)=\text{CH}_2$) is a biogenic hydrocarbon emitted by trees, grasses and ocean phytoplankton.

❖ **Purpose of emission:** combat abiotic stresses;

❖ **Ozone formation:**

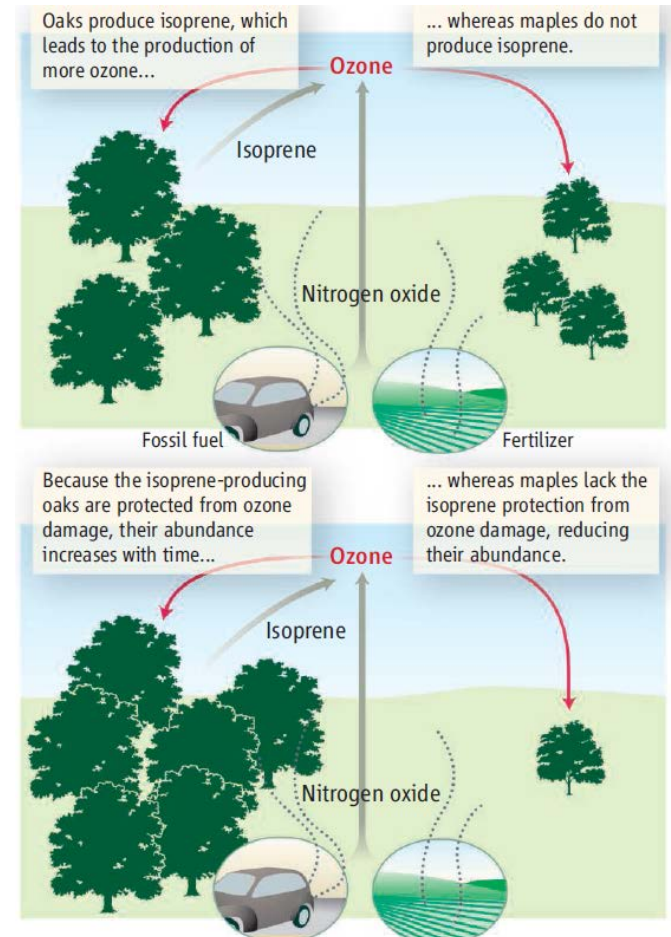


❖ **Aerosol formation:**



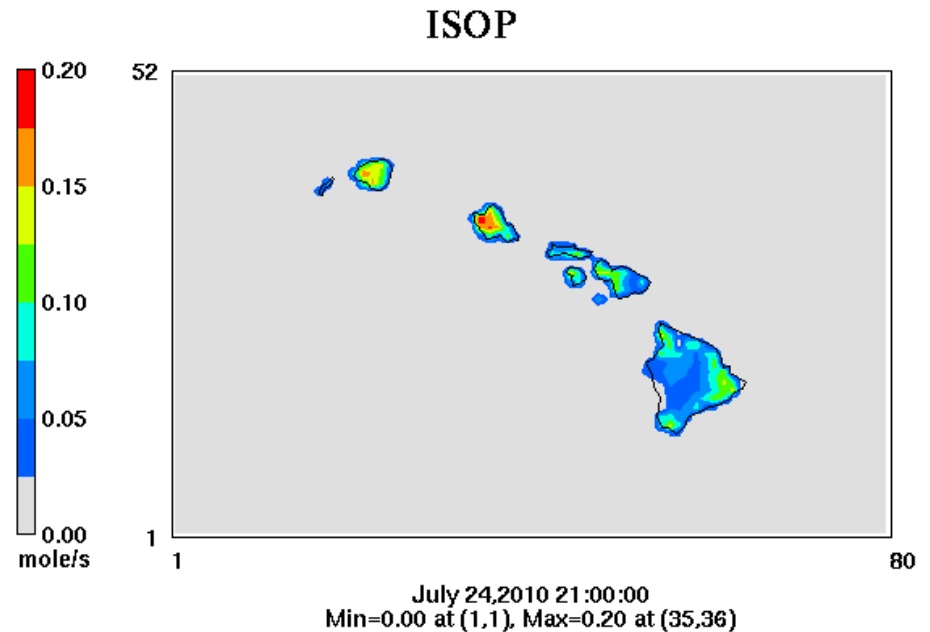
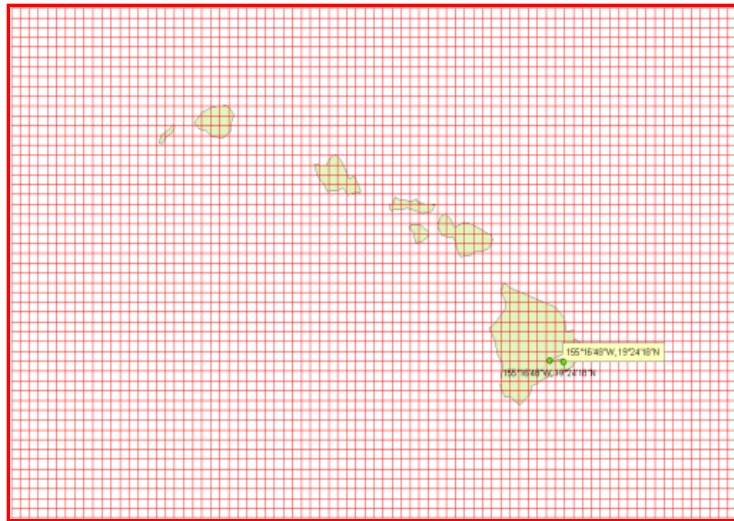
❖ **Cloud formation:** Cloud Condensation Nuclei (CCN);

Ozone, Aerosol, cloudiness all at the central stage of climate change debate



(Lerdau, *Science*, 2007)

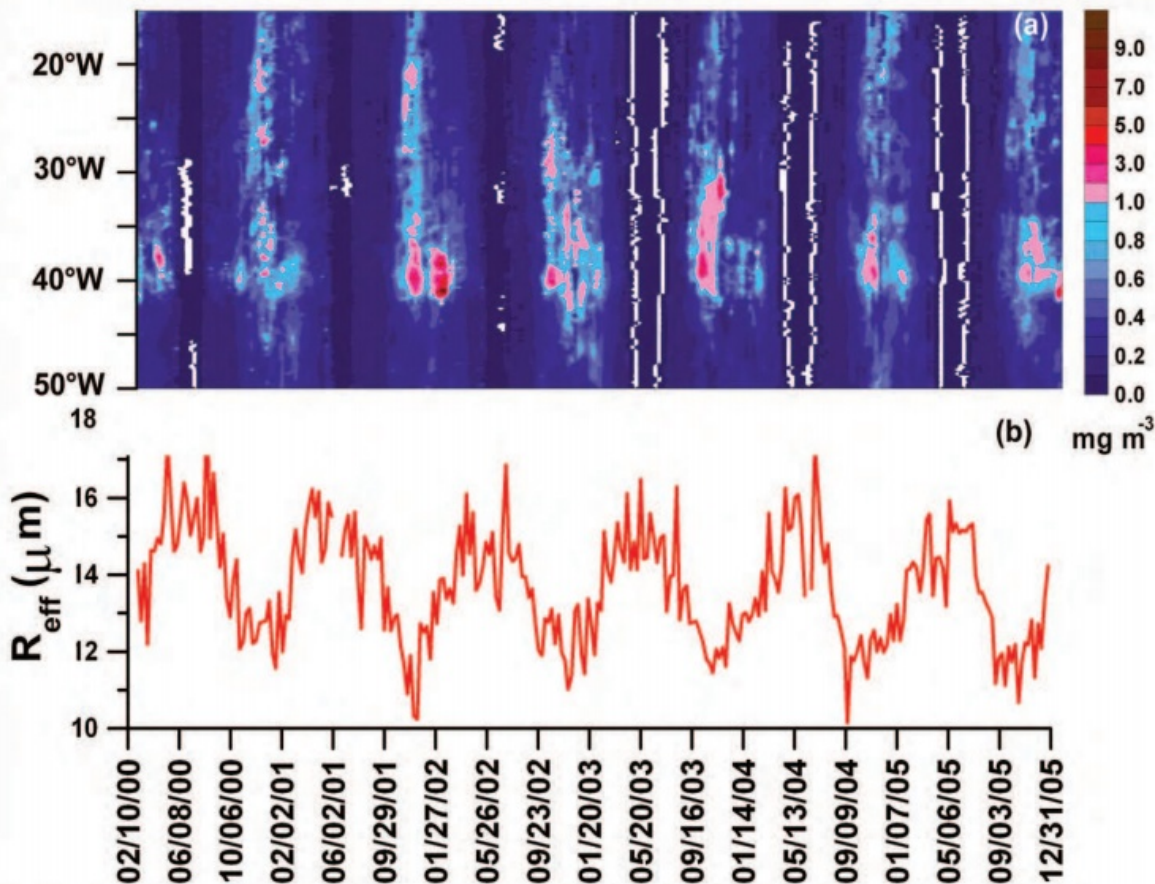
National Air Quality Forecast over Hawaii



A suite of reactive gases and aerosols emitted from the Ocean:

- ❖ Isoprene;
- ❖ Dimethyl Sulfide (DMS);
- ❖ Organic Aerosols;

Algae Bloom and Ocean Cloudiness



(Meskhidze and Nenes, Science, 2006)



A Review of Approaches for Marine Isoprene Emissions

❖ Shaw et al. (2003):

$$E_{iso} = [Chl - a] * V * EF$$

❖ Palmer & Shaw (2005):

$$E_{iso} = K_{AS} * (C_W - H * C_A)$$

$$P - C_W(k_i * C_{Xi} + k_{bio} + k_{AS} / Z_{ML}) - L_{MIX} = 0$$

k_i – chemical reaction rate for oxidant i;

k_{bio} – bacterial loss rate;

L_{MIX} – loss due to downward mixing;

❖ Gantt et al. (2009):

$$E_{iso} = SA * H_{max} * [Chl - a] * F_{iso} * \int_0^{H_{max}} P dh$$

E_{iso} - Isoprene emission;

$[Chl - a]$ - Isoprene emission;

V – euphotic water volume;

EF – Emission factor;

k_{AS} – exchange coeff.;

C_W – isop. conc. in water

C_A – isop. conc. in the air

H – Henry's law constant;

P – isoprene production;

H_{max} – euphotic zone height;

Z_{ML} – mixing layer height;



JPSS marine Isoprene algorithm (V1.0)

❖ Built upon several pioneering works:

$$F = a \times [Chl] \times \sum_{i=1}^N (EF_i \times f_i) \times H_{\max} \times \gamma$$

JPSS Products Used:

- [Chl-a]
- Kd490
- PAR

Euphotic zone height (Gantt et al., 2009)

$$H_{\max} = (-\ln(\frac{2.5}{I_0}) / K_{490})$$

I_0 – ground radiation; K_{490} – diffuse attenuation coefficient in water

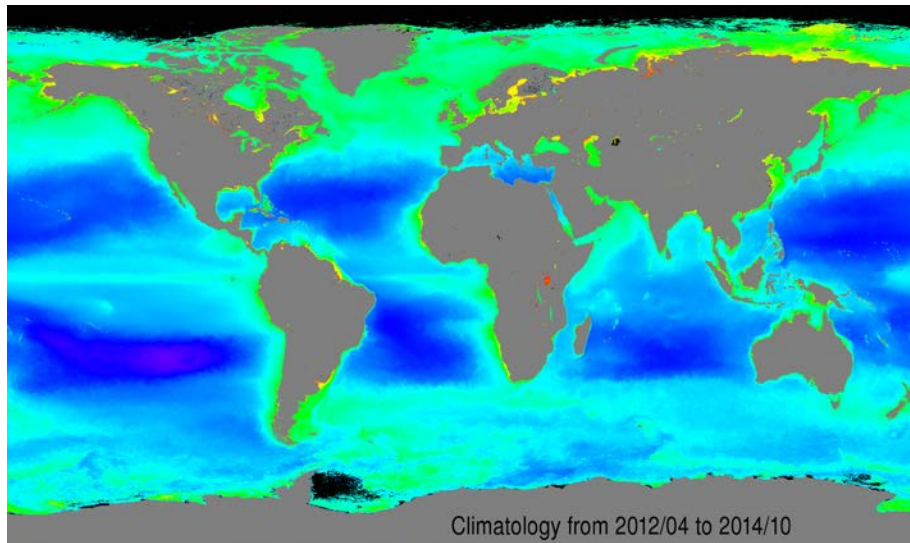
Phytoplankton Functional Types (PFTs) (Arnold et al., 2009)

Determine emission factor (EF) and abundance (f);

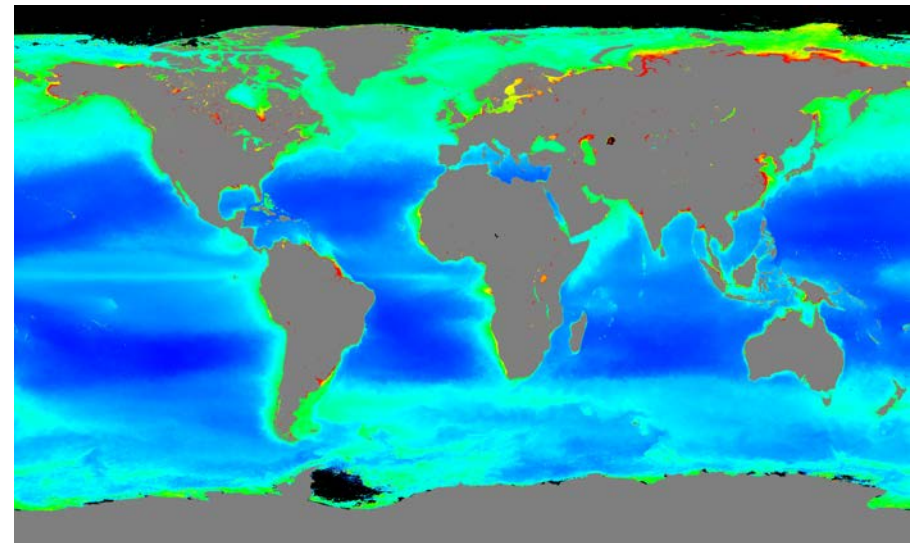
No data available from JPSS, using SeaWiFS climatological data

Chlorophyll-a and $K_d(490)$

- ❖ **Sensor/Satellite:** Visible Infrared Imaging Radiometer Suite (VIIRS) on SNPP
- ❖ **Ocean Color Data Processing:**
 - Multi-Sensor Level-1 to Level-2 (MSL12) is used for VIIRS ocean color data processing
 - Routine ocean color data production from SDR (Level-1B) to ocean color EDR (Level-2), and to global Level-3 data, including nL_w , chlorophyll-a, and $K_d(490)$.
 - Level 3: Products are mapped to the CoastWatch geographic regions
- ❖ **Algorithms (Ocean Color EDR Team):**
 - Chlorophyll-a concentration: VIIRS OC3 algorithm
 - Diffuse attenuation coefficient at 490 nm $K_d(490)$: *Wang et al. (2009)* algorithm



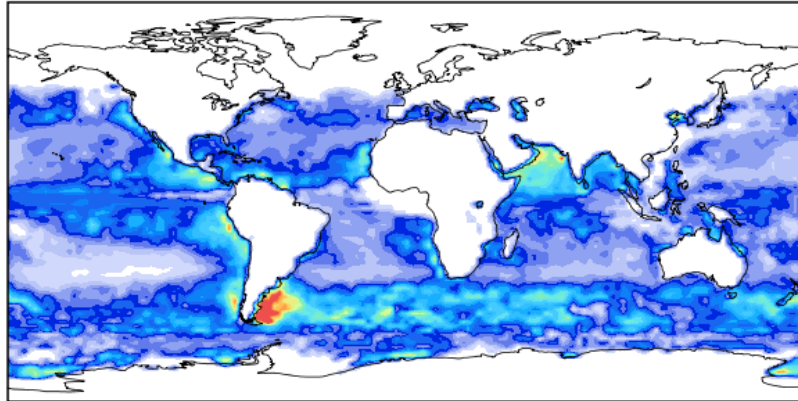
Chlorophyll-a



$K_d(490)$

Global Distribution of Marine Isoprene

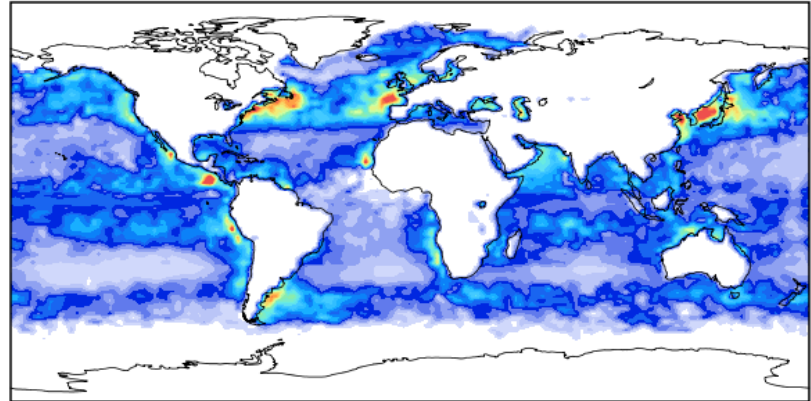
JAN



Marine Isoprene Emissions (molecules/cm²/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

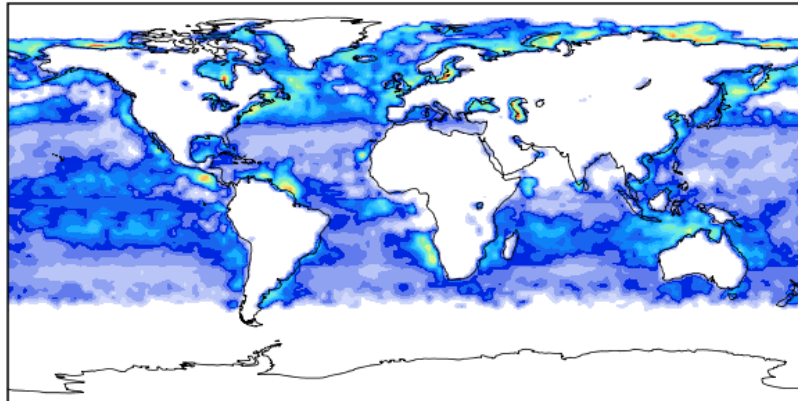
APR



Marine Isoprene Emissions (molecules/cm²/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

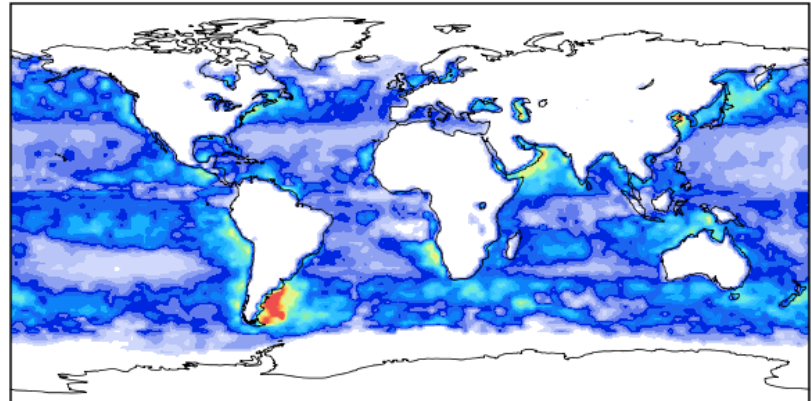
JUL



Marine Isoprene Emissions (molecules/cm²/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

OCT



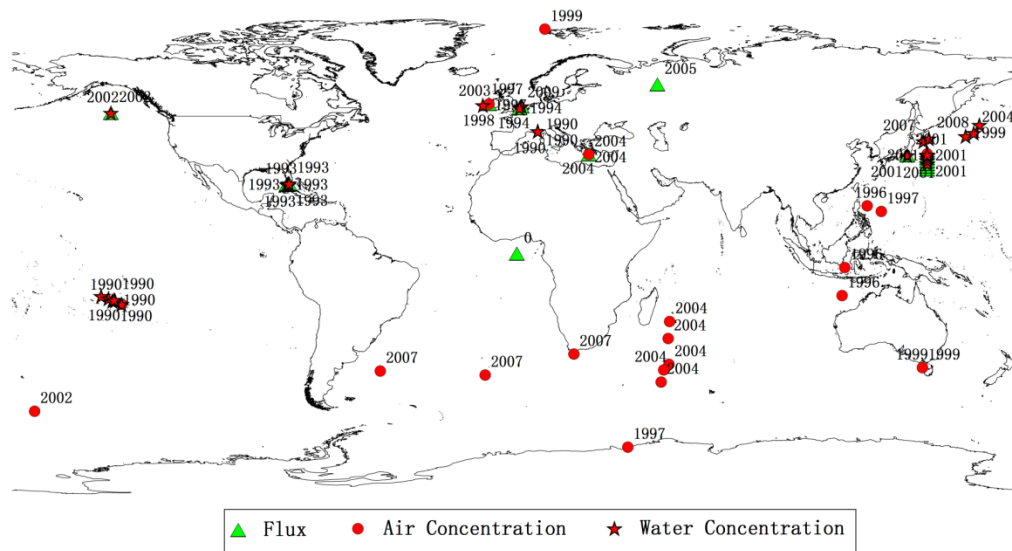
Marine Isoprene Emissions (molecules/cm²/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

Isoprene Observations and Reprocessing

Issue: Some data can not be directly used for product validation.

Reprocessing Approach: Air-sea mass transfer.



Convert seawater conc into flux:

$$E_{iso} = K_{AS} * (C_W - H * C_A)$$

k_{AS} – exchange coeff.;

C_W – isop. conc. in water

C_A – isop. conc. in the air

H – Henry's law constant;

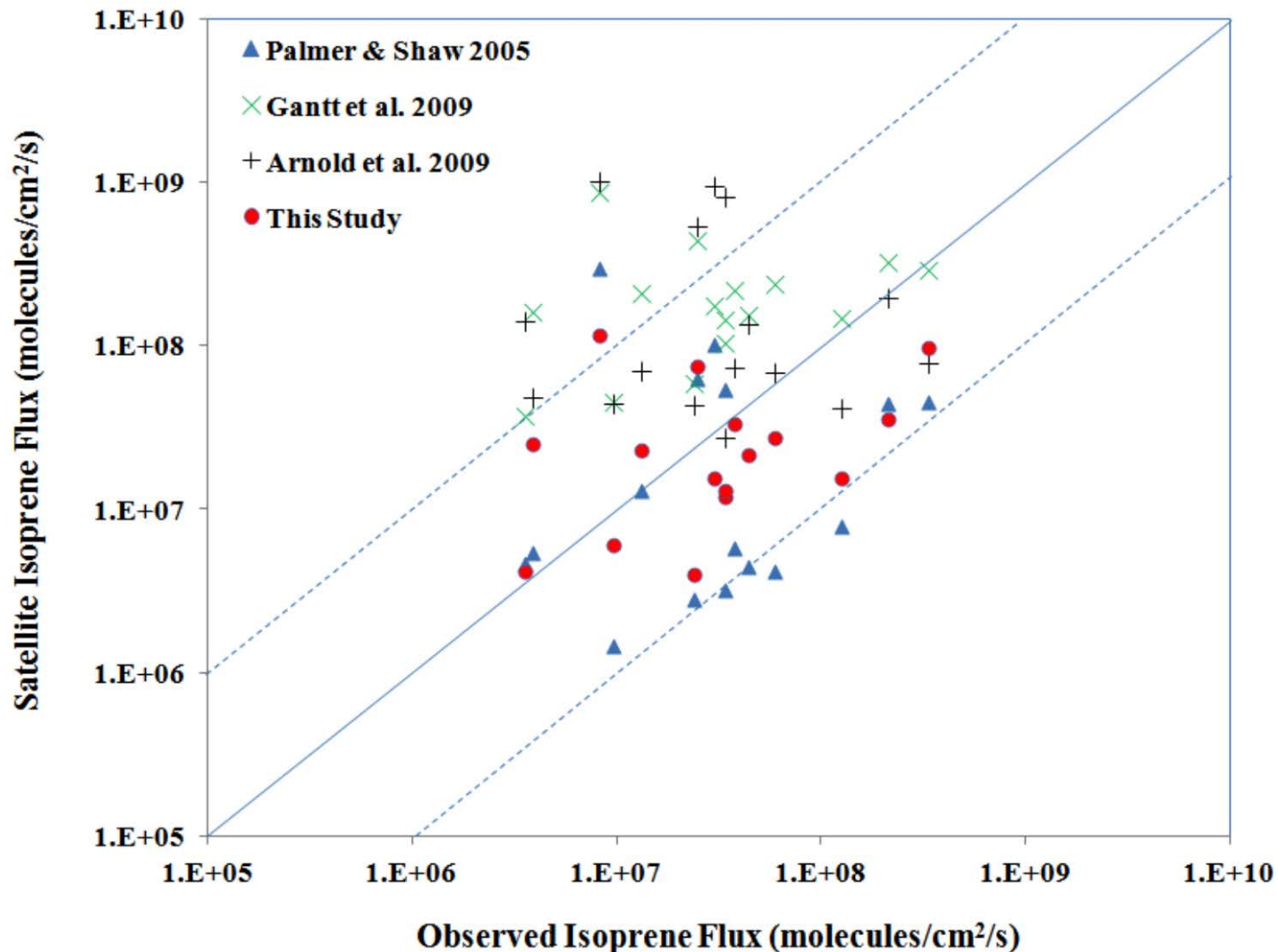
Calculate exchange coeff based on wind speed:

$$K_{AS} = 0.31 * U^2 ((3913.15 - 162.13T + 2.67T^2 - 0.012T^3) / 660)^{-0.5}$$

U – surface wind speed; T – Sea surface Temperature

(Wanninkhof et al., 2004)

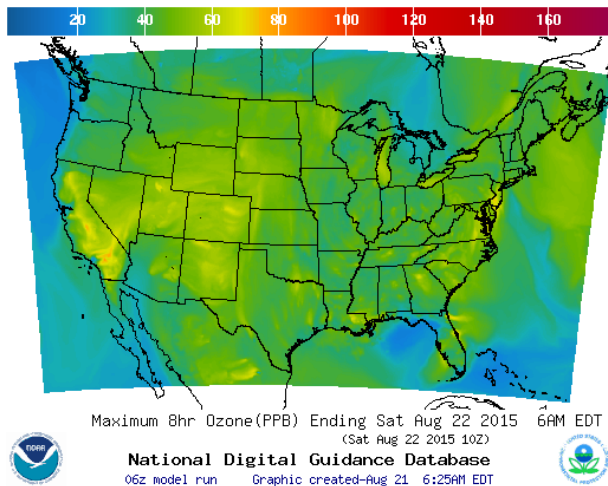
Isoprene Product Validation (Cont.)



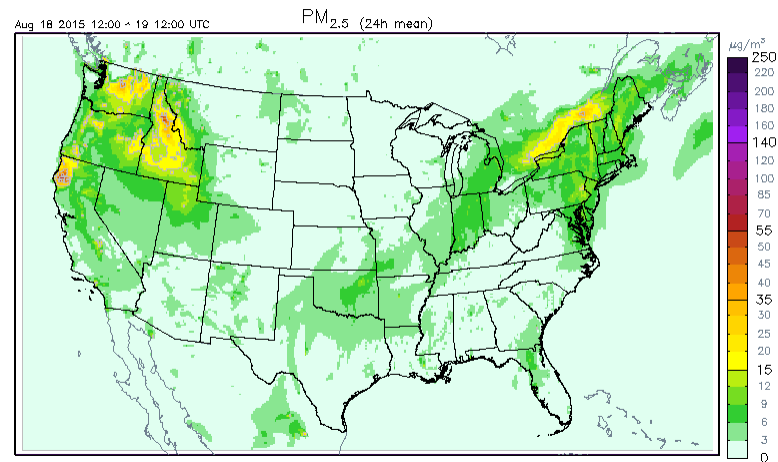
NOAA National Air Quality Forecast Capability (NAQFC)

- ❖ Developed by OAR/Air Resources Laboratory; Operated by National Weather Service (NWS) (PM: I. Stajner).
- ❖ Provides national numeric air quality guidance for ozone (operational product) and PM_{2.5} (particulate matter with diameter < 2.5 µm);

O₃ Forecasting



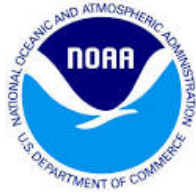
PM_{2.5} Forecasting



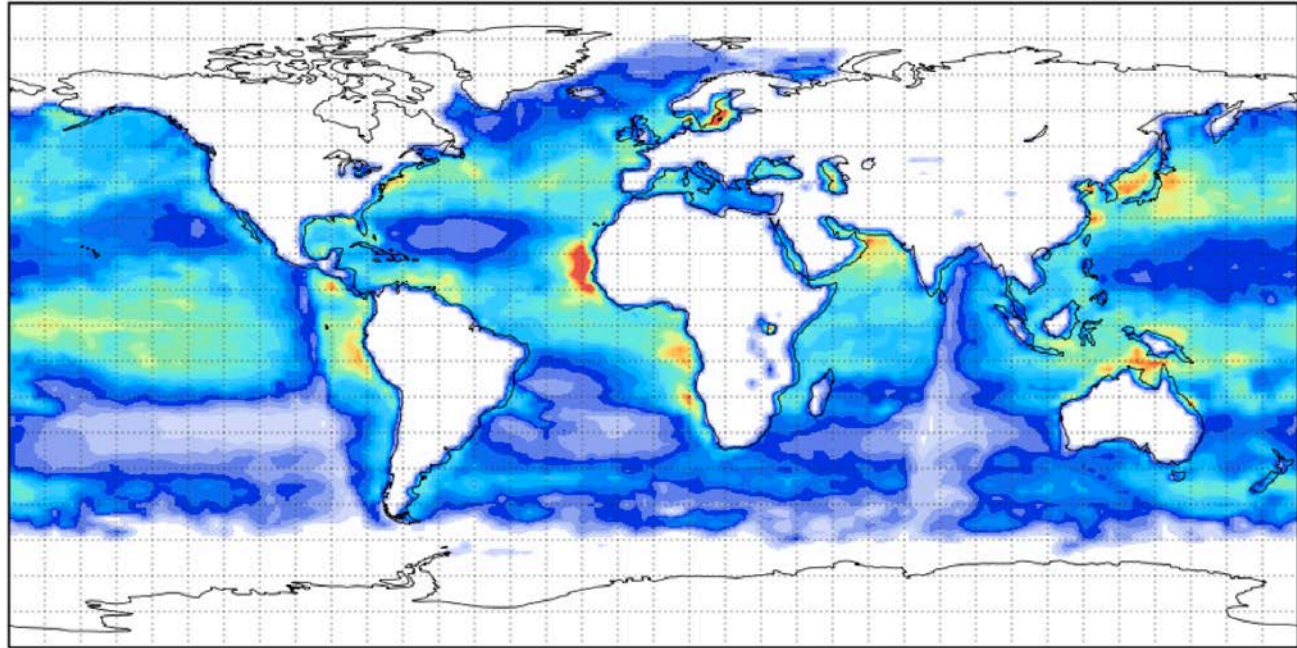
<http://airquality.weather.gov/>

NAQFC is one of the major gateways to disseminate NOAA satellite observations and model prediction of air quality to the public.

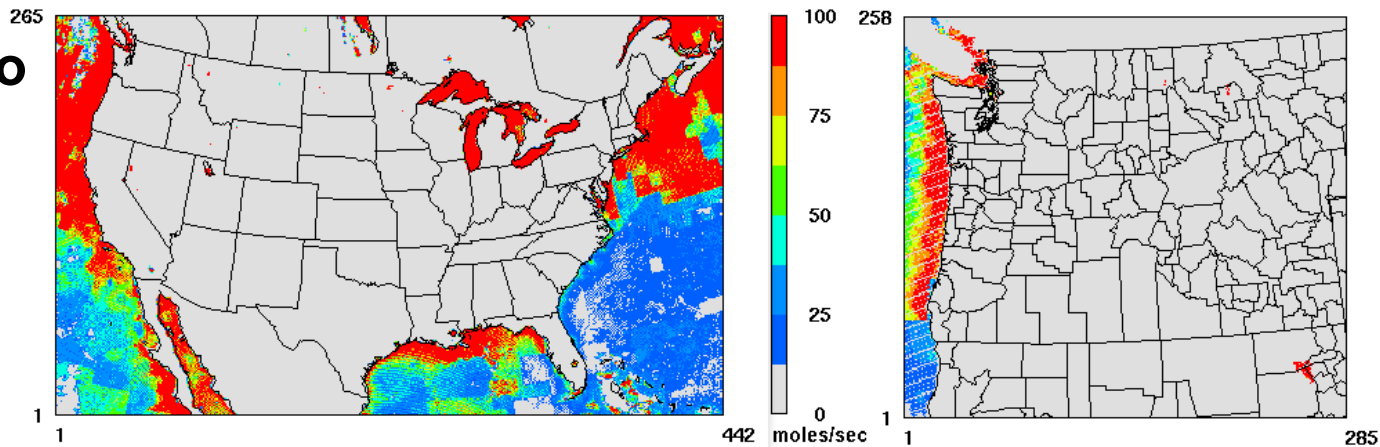
Isoprene applications: National and regional air quality forecasting



**Global
Isoprene
(April 2014)**



**Isoprene into
model
domains**



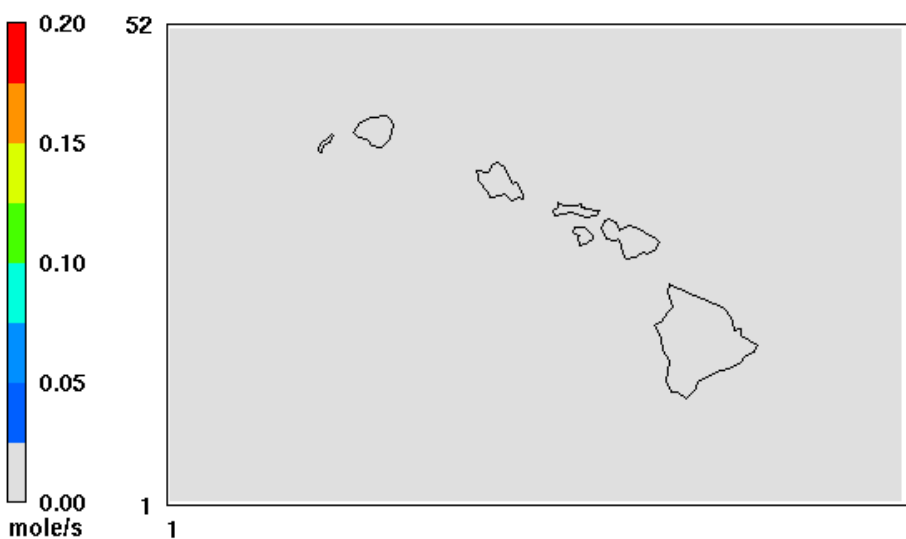


Terrestrial vs. marine isoprene emissions

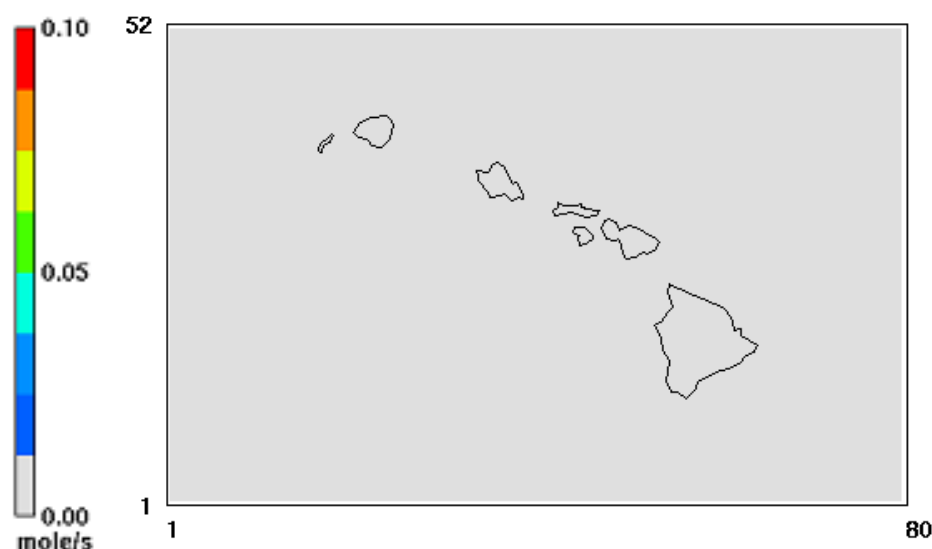
(Preliminary Results)

Land Emission

Marine Emission



July 24, 2010 12:00:00
Min= 0.00 at (1,1), Max= 0.00 at (37,34)



July 21, 2010 12:00:00
Min=0.00 at (1,1), Max=0.00 at (1,1)

JPSS Isoprene product fills the gap of missing ocean emissions in air quality and climate models

JPSS Isoprene User Workshop: September 2, 2015 in College Park, MD

Contact: Daniel.Tong@noaa.gov for details