

NATURAL HAZE LEVELS SENSITIVITY ASSESSMENT

4. Making Refined Estimates

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Potential Refinements

(Red = Consider in this Study)

- 1. IMPROVE formula
 - Add sea salt
 - Change OC to POM mass multiplier
 - Different current and natural?
- 2. Method for estimating worst/best 20% haze from average natural conditions (Ames-Malm)
 - Change to 92nd %ile to get worst conditions
 - Different σ for different subregions
 - Effect of non-normality of natural HI (?)

Potential Refinements (cont'd)

- 3. Refine default values of average component concentrations. Options:
 - National -- 2 regions, as now
 - **Regional -- subdivide current regions, e.g., into Interior West, Pacific Northwest, Southeast Coast**
 - Local -- account for local area meteorology and emissions

Contributors to Natural Concentrations and Spatial Variability

- Seasonal
 - Oceans, tidal zones, and surf zones
 - Sea salt
 - POM (primary and secondary)
 - Sulfates
 - Forests and vegetation
 - Sulfates and nitrates
 - POM (primary and secondary)
 - Coarse organic matter (from plant detritus)
 - Ammonia

Contributors to Natural Concentrations and Spatial Variability (cont'd)

- Seasonal (cont'd)
 - Earth's crust
 - Fine and coarse soil particles from wind and natural disturbances (including wildlife)
 - Includes sulfates and nitrates
 - Volcanoes (non-erupting)
 - Sulfates and nitrates (primary and precursors)
 - Emissions from all except volcanoes influenced by meteorology (wind, T, RH)

Contributors to Natural Concentrations and Spatial Variability (cont'd)

- Episodic
 - Windstorms
 - Fine and coarse soil particles
 - Wildfires
 - POM
 - LAC
 - Soil
 - Volcanic eruptions
 - Emissions from all are subject to long range transport
 - Emissions from windstorms and wildfires influenced by meteorology

What Do We Know About Natural Concentrations?

- Oceanic Sea Salt
 - Measured in onshore flow in Florida
 - Inferred from Na, Cl and Sr concentrations at various IMPROVE and SEARCH sites
 - Measured in onshore flow over Amazon basin
 - Measured over Indian Ocean and linked to air mass transport routes
 - Measured over Atlantic Ocean
 - Interacts with organics, sulfates, and nitrates
 - Coarse size, with tail in fine mode; hygroscopic

What Do We Know About Natural Concentrations (2)

- **Oceanic Organics**
 - Measured in Puerto Rico in trade winds from over Atlantic Ocean; absence of black carbon suggests natural origin
 - Measured over Indian Ocean for air masses of various origins
- **Oceanic Sulfates**
 - Measured in several studies throughout world

What Do We Know About Natural Concentrations (3)

- Coastal Biogenic Particles
 - Formed by during daylight from biota in the tidal zone
 - Initially formed by nucleation; grow by condensation to optically important size
 - Involve sulfuric acid, ammonia, water, and perhaps iodine
 - Concentrations of interest to us are poorly quantified

What Do We Know About Natural Concentrations (4)

- **POM from Forests and Other Vegetation**
 - Considered the principal global source of atmospheric POM
 - Nucleation formation and condensation growth process studied extensively in tropical and boreal forests
 - Tropical non-fire and boreal Arctic background concentrations during growing season have been measured
 - Biogenic organic emissions flux (emissions per unit area of land) in some of the US likely to be as large as that in the tropics, according to Seinfeld and Pandis

What Do We Know About Natural Concentrations (5)

- Sulfur from Vegetation
 - Biogenic sulfur concentrations measured in Amazon basin
 - Annual average there about one order of magnitude larger than US default concentrations

What Do We Know About Natural Concentrations (6)

- Nitrates from Lightning
 - Some measurements
- Volcanic Emissions
 - Measurements in Hawaii, at Mt. St. Helens, at Popocatepetl, Mexico, and elsewhere
 - Have measured both concentrations due to dormant emissions and during eruptions

What Do We Know About Natural Concentrations (7)

- **Crustal Fine and Coarse Soil**
 - Lots of IMPROVE measurements, some of which should approximate natural background contributions of local and distant sources
 - Several analyses of seasonal and episodic contributions of transported African dust and Asian emissions on fine soil and CM concentrations at many IMPROVE sites, especially in the West and the Southeast, and also the Virgin Islands
 - Measurements of African soil dust inflow at Miami
 - Measurements of African mineral dust at the Amazon

What Do We Know About Natural Concentrations (8)

- **Wildfire Carbon Emissions**
 - Improved wildfire emission inventories for POM and LAC
 - Concentration estimates with global air pollution models (but have to separate anthropogenic biomass burning from wildfires)
 - (Also emit soil as ash and when picked up by fire-induced wind currents)

Initial Estimates of Component Impacts in the US (Key)

- Table on next slide summarizes the last 8 slides and includes initial (rough) estimates of ranges of impact to fine concentrations (except CM), as non-zero seasonal averages, in $\mu\text{g}/\text{m}^3$
- TBD = may be established after more work
- Impact Area = domain of impact over a season or episode
- S = seasonal (relatively constant over a season, may have diurnal variability or flare up occasionally); Ep = episodic
- Basis for quantification = E, G, F, P

Initial Estimates of Component Impacts in the US

Source	Component	Impact Area	Range $\mu\text{g}/\text{m}^3$	SS, Ep	Basis
Ocean	Sea salt	Coastal	0.4 - 2	SS	E
	POM	Coastal	0.2 - 0.5	SS	G
	Sulfates	Coastal	? (TBD)	SS	F
Coastal	Biogenic POM	Coastal	?	SS	P
Forests & vegetation	POM	Regional	1 - 5+	SS	G
	Sulfates	Regional	0.5 - 2 (?)	SS	F
Lightning	Nitrates	Regional	? (TBD)	SS & Ep	F
Volcanoes	Sulfates & nitrates	Regional	? (TBD)	SS & Ep	F
Crustal	Soil & CM	Regional	0.1 - 1	Ep	G-E
Wildfires	POM & LAC	Regional	0.5 - 2+	Ep	F

Issues with Initial Estimates

- How much of each impact is already included in default values?
- For seasonal values, some seasons greater and some less than default would be consistent with default
- For regional values, some regions greater and some less than default would be consistent with default
- How to incorporate highly episodic background values into refinements?

On Refinements

- It is very hard to estimate natural conditions for a specific Class I area. There are so many imponderables that the process ends up being very subjective.
- Estimates for a region are much more workable and robust, and more supportable scientifically

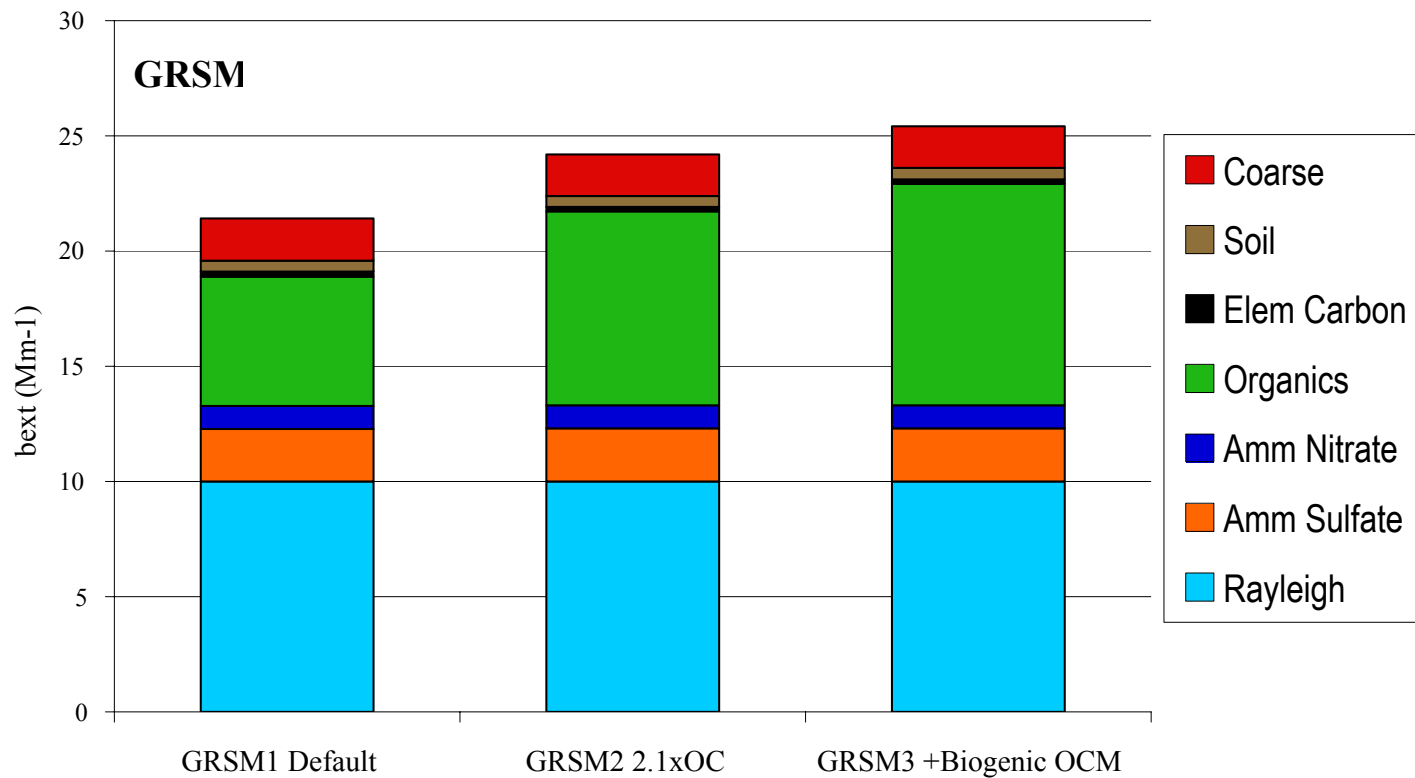
Information Used for Making Regional Natural Conditions Estimates

- Current speciated measurements (IMPROVE, SEARCH, CASTNet, short-term studies, etc.)
- Trijonis' values
- Results of research studies and analyses (e.g., ^{14}C studies, analyses of transport of African and Asian dust)
- Results from modeling with global aerosol models -- of current and natural conditions
- Values measured in remote areas of the globe
- Emission inventories, especially for fires
- Land use
- General climatological conditions -- seasonal T, RH, wind, precipitation, snow cover

Examples in Southeast

- Inland site -- use GRSM as example
 - 1. Default
 - 2. Change POM multiplier to 1.8 for present and to 2.1 for natural conditions
 - 3. Also add $0.3 \mu\text{g}/\text{m}^3$ annual average of biogenic POM
- Coastal site -- use ROMA as example
 - 1. Default
 - 2. Change POM multiplier to 1.8 for present and to 2.1 for natural conditions
 - 3. Also add $1.3 \mu\text{g}/\text{m}^3$ annual average of sea salt
 - 4. Also add $0.2 \mu\text{g}/\text{m}^3$ annual average of oceanic POM
 - 5. Also add annual average of $0.3 \mu\text{g}/\text{m}^3$ of African dust

GRSM Example -- Annual Average Natural Conditions b_{ext} Estimates

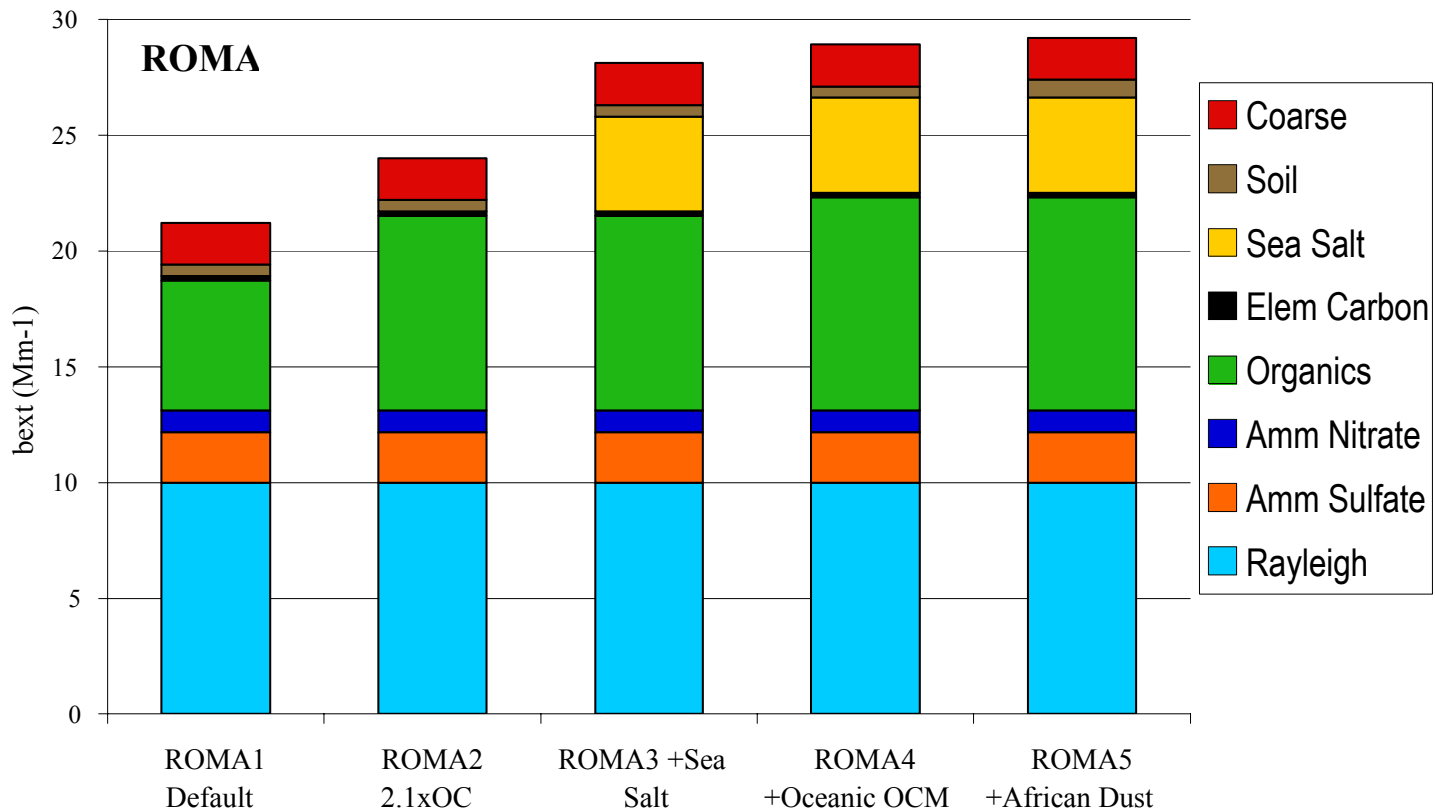


GRSM Implications

-- 20% Haziest Days

	Current HI, dv	Natural Bkgd., dv	dv per decade	% per decade
1 90%ile	29.5	11.4	-3.02	-27.5
1 92%ile	29.5	11.9	-2.95	-26.9
2 2.1 x OC	29.9	13.1	-2.79	-25.7
3 +Biogenic POM	29.9	13.6	-2.71	-25.0

ROMA Example -- Annual Average Natural Conditions b_{ext} Estimates



ROMA Implications

-- 20% Haziest Days

	Current HI, dv	Natural Bkgd., dv	dv per decade	% per decade
1 90%ile	25.9	11.4	-2.42	-23.3
1 92%ile	25.9	11.8	-2.35	-22.7
2 2.1xOC	26.3	13.0	-2.21	-21.4
3 +sea salt	26.6	14.6	-1.99	-19.4
4 +oceanic POM	26.6	14.9	-1.95	-19.0
5 +African dust	26.6	15.0	-1.93	-18.9

Example in Northwest

- Studied area of Northwest that is east of Cascades and west of Rockies (parts of OR, ID, NV)
- Measured average ammonium nitrate, soil, and CM are less than default at some sites in area
- Some other components are just above default
- ==> Average natural conditions for region may be clearer than default. Definitely the case for some sites.

Parting Comments on Things to Do

- Do sensitivity assessment by region
 - Start with IMPROVE regions from 2000 report, refined by data from new sites and consolidated
- Consider seasonal assessments for some regions with high variability or episodic impact
- Don't need a high level of detail for sensitivity assessment, but need to get impacts in the right ranges
- Demonstrate interplay between inherent uncertainties in the prescribed process and possible improvements from refinements