Modeling wildfire emissions from the 2003 and 2007 Santa Ana events

Discussion

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Requirements of the model

Relatively high spatial and temporal resolution

Spatial

500m (cfr. MODIS)

30m (cfr. Landsat) might be overkill

Temporal

at least 6-hourly (cfr. input to regional air pollution model, UCLA)

Bottom-up approach

Emission = BA X FL X CC X EF

BA = Burned Area
FL = Fuel Load
CC = Combustion Completeness
EF = Emission Factor

Burned area and fire progression

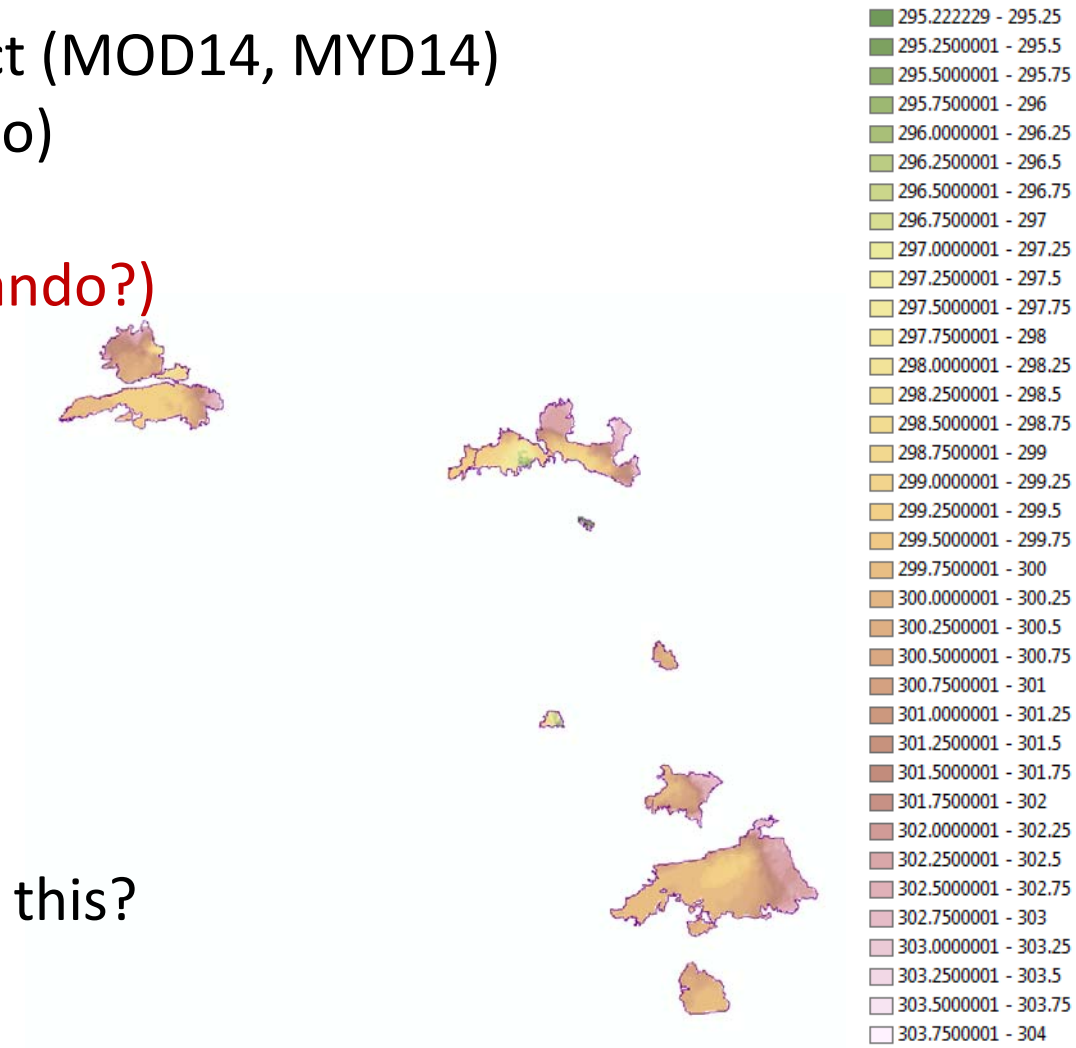
Preferably 6-hourly

Using MODIS active fire product (MOD14, MYD14)
IDW interpolation (cfr. Fernando)

(MCD14L not on Reverb? Fernando?)

In SoCal: 4 acquisitions/day
5-6 AM
9-10 AM
5-6 PM
9-10 PM

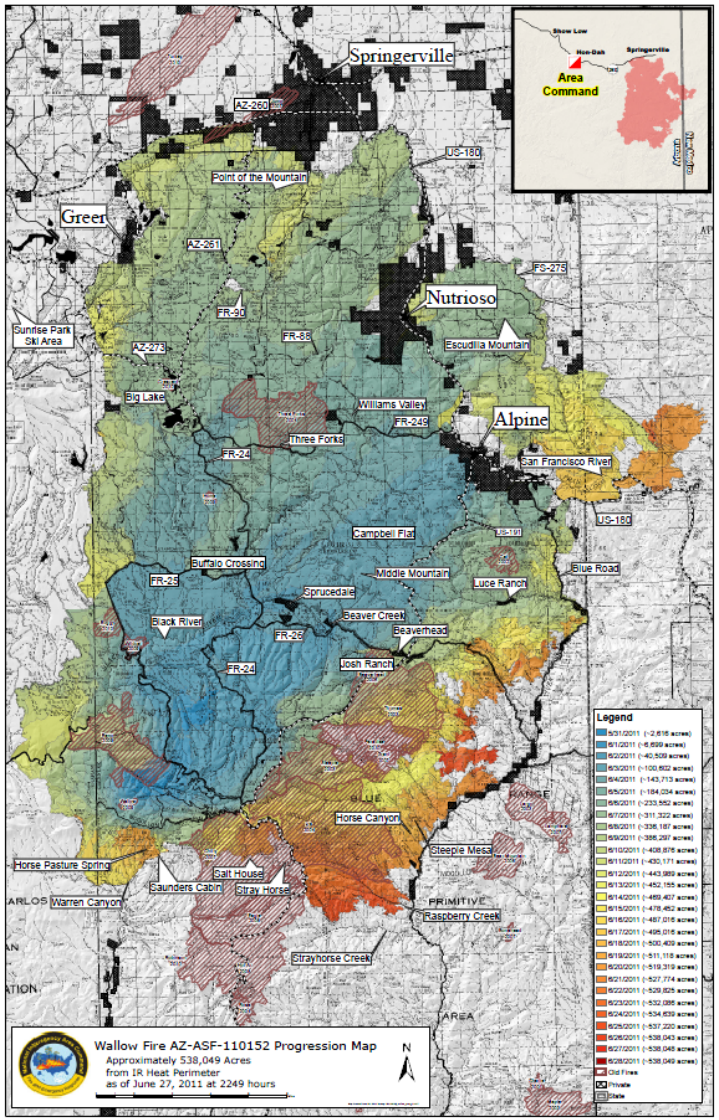
Looks nice, but how to validate this?



Burned area and fire progression: Potential validation

- Availability of ‘ground truth’ over a large fire (2011 Wallow fire, AZ)

- fires in the higher latitudes have more acquisitions
-> use 4 time clusters for modeling
-> use left-over time clusters for validation
-> will give an idea on the quality for regions with only 4 acquisitions such as Socal



Fuel load

CASA

500m MODIS resolution?

Which data input is required and are those readily available?

Combustion completeness

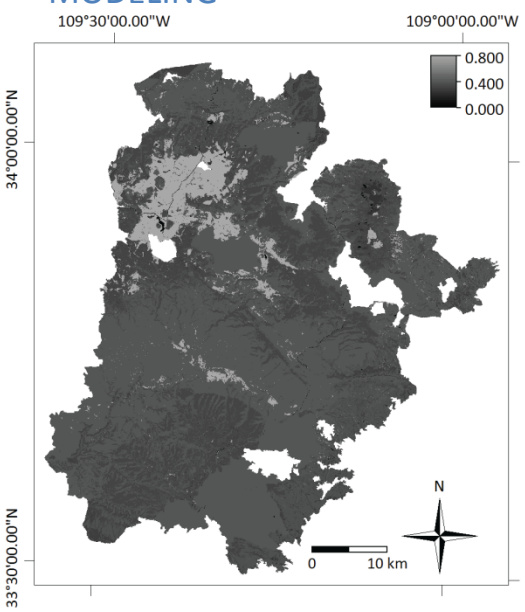
CASA + remote sensing

500m resolution?

First guess CC from CASA
Which data input is required and are those readily available?

Further refined with severity data from remote sensing

MODELING



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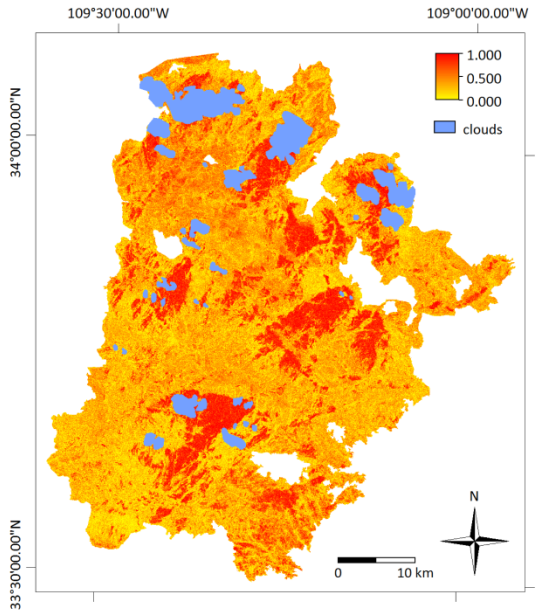
REMOTE SENSING



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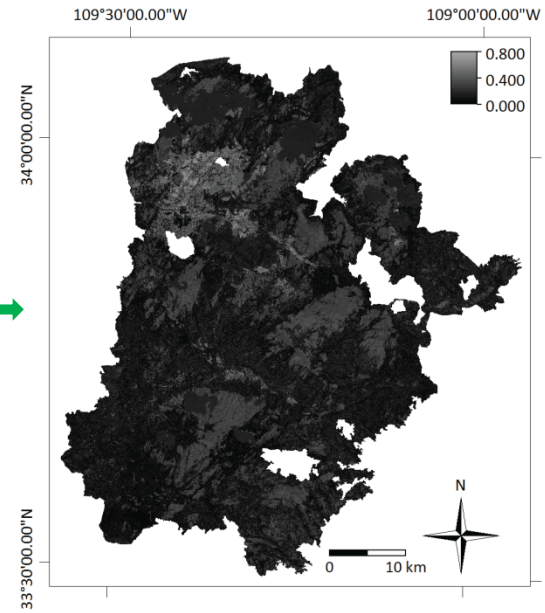
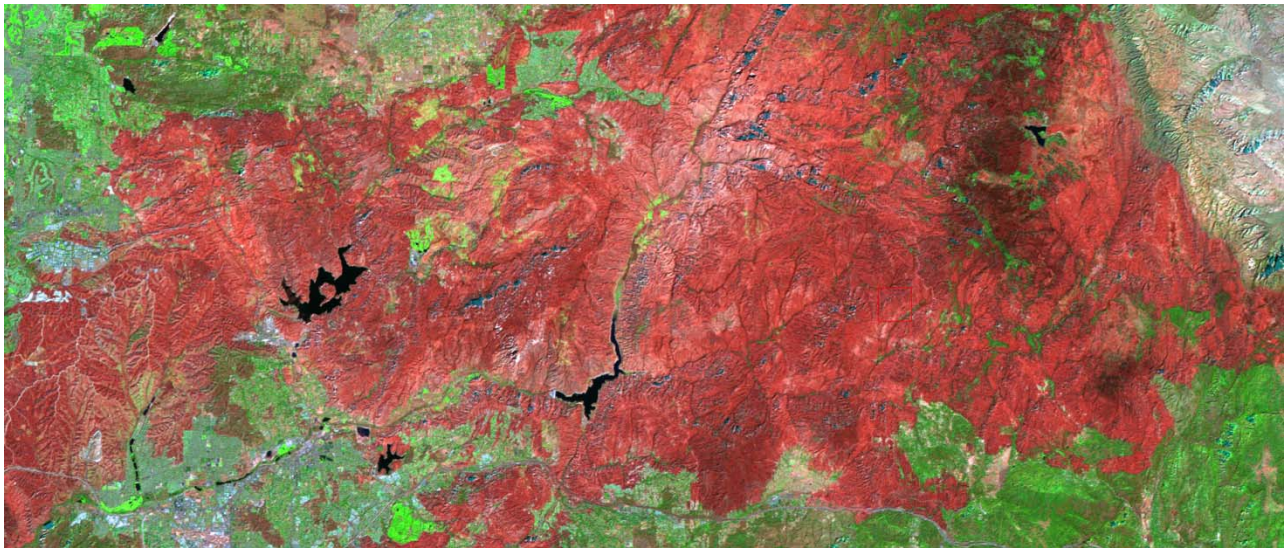
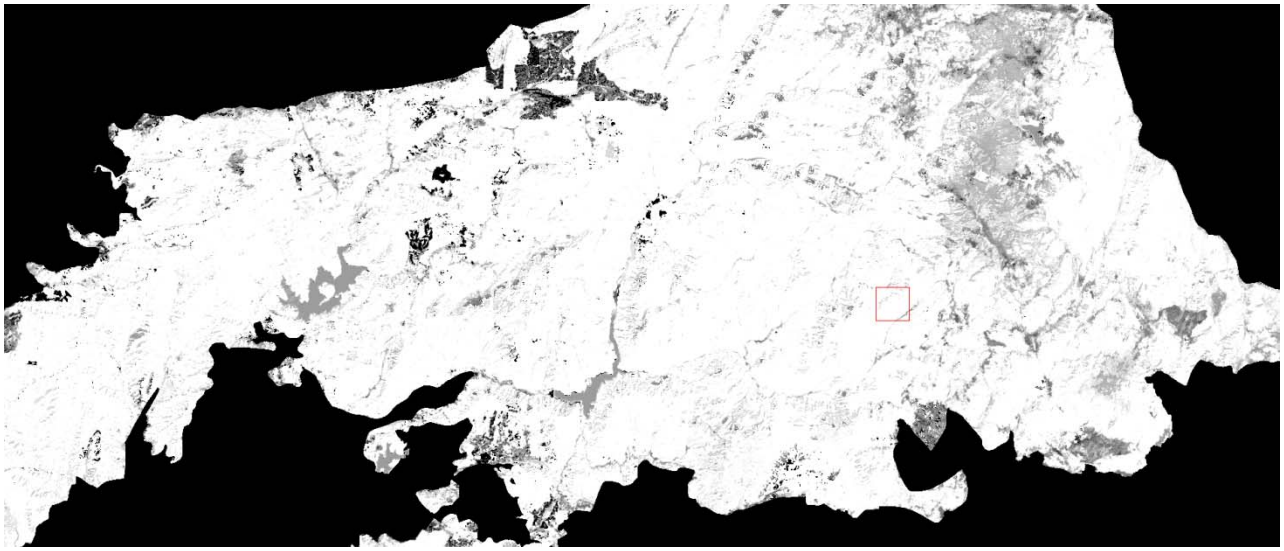
COMBUSTION COMPLETENESS



Combustion completeness

Example of vegetation mortality derived from spectral unmixing





Emission factor

From Andreae and Merlet (2001)

Table 1. Emission Factors for Pyrogenic Species Emitted From Various Types of Biomass Burning[a]

Species	Savanna and Grassland[b]	Tropical Forest[c]	Extratropical Forest[d]	Biofuel Burning[e]	Charcoal Making[f]	Charcoal Burning[f]	Agricultural Residues[i]
CO_2	1613 ± 95	1580 ± 90	1569 ± 131	1550 ± 95	440	2611 ± 241	1515 ± 177
CO	65 ± 20	104 ± 20	107 ± 37	78 ± 31	70	200 ± 38	92 ± 84
CH_4	2.3 ± 0.9	6.8 ± 2.0	4.7 ± 1.9	6.1 ± 2.2	10.7	6.2 ± 3.3	2.7
Total nonmethane hydrocarbons	3.4 ± 1.0	8.1 ± 3.0	5.7 ± 4.6	7.3 ± 4.7	2.0	2.7 ± 1.9	(7.0)[h]
C_2H_2	0.29 ± 0.27	0.21–0.59	0.27 ± 0.09	0.51–0.90	0.04	0.05–0.13	(0.36)[h]
C_2H_4	0.79 ± 0.56	1.0–2.9	1.12 ± 0.55	1.8 ± 0.6	0.10	0.46 ± 0.33	(1.4)[h]
C_2H_6	0.32 ± 0.16	0.5–1.9	0.60 ± 0.15	1.2 ± 0.6	0.10	0.53 ± 0.48	(0.97)[h]
C_3H_4	0.022 ± 0.014	0.013	0.04–0.06	(0.024)[h]	–	(0.06)[h]	(0.032)[h]
C_3H_6	0.26 ± 0.14	0.55	0.59 ± 0.16	0.5–1.9	0.06	0.13–0.56	(1.0)[h]
C_3H_8	0.09 ± 0.03	0.15	0.25 ± 0.11	0.2–0.8	0.04	0.07–0.30	(0.52)[h]
1-butene	0.09 ± 0.06	0.13	0.09–0.16	0.1–0.5	–	0.02–0.20	(0.13)[h]
i-butene	0.030 ± 0.012	0.11	0.05–0.11	0.1–0.5	–	0.01–0.16	(0.08)[h]
trans-2-butene	0.024 ± 0.014	0.05	0.01–0.05	0.05–0.3	–	0.01–0.06	(0.04)[h]
cis-2-butene	0.021 ± 0.011	0.042	0.008–0.13	0.05–0.18	–	0.01–0.03	(0.05)[h]
Butadiene	0.07 ± 0.05		0.06–0.08	0.11–0.36	–	0.01–0.10	(0.09)[h]
n-butane	0.019 ± 0.09	0.041	0.069 ± 0.038	0.03–0.13	–	0.02–0.10	(0.06)[h]
i-butane	0.006 ± 0.003	0.015	0.022 ± 0.009	0.01–0.05	–	0.006–0.01	(0.015)[h]
1-pentene	0.022 ± 0.010	0.056	0.04–0.07	0.5	–	0.028	0.008
n-pentane	0.005 ± 0.004	0.014	0.05–0.06	0.07	–	0.10	(0.025)[h]
2-methyl-butenes	0.008 ± 0.004	0.074	0.033	0.16	–	0.015	0.007
2-methyl-butane	0.011 ± 0.012	0.008	0.026–0.029	0.08	–	0.07	(0.018)[h]
Isoprene	0.020 ± 0.012	0.016	0.10	0.15–0.42	–	0.017	(0.05)[h]
Cyclopentene	0.012 ± 0.008	(0.02)[h]	0.019	0.61	–	0.035	(0.02)[h]
4-methyl-1-pentene	0.048	0.048	(0.05)[h]	0.015	–	(0.09)[h]	0.016
1-hexene	0.037 ± 0.016	0.063	0.07–0.11	(0.05)[h]	–	(0.13)[h]	0.013
n-hexane	0.039 ± 0.045	(0.05)[h]	0.03–0.06	(0.04)[h]	–	0.063	(0.05)[h]
Isohexanes	0.05	(0.08)[h]	(0.08)[h]	(0.06)[h]	–	(0.15)[h]	(0.08)[h]
Heptane	0.05	(0.08)[h]	(0.08)[h]	(0.06)[h]	–	(0.15)[h]	(0.08)[h]
Octenes	0.003–0.008	0.012	0.005	(0.007)[h]	–	(0.017)[h]	0.004
Terpenes	0.015	(0.15)[j]	0.22	(0.15)[j]	–	0.0	(0.015)[h]
Benzene	0.23 ± 0.11	0.39–0.41	0.49 ± 0.08	1.9 ± 1.0	–	0.3–1.7	0.14
Toluene	0.13 ± 0.06	0.21–0.29	0.40 ± 0.10	1.1 ± 0.7	–	0.08–0.61	0.026
Xylenes	0.045 ± 0.025	0.04–0.08	0.20	0.55 ± 0.44	–	0.04–0.22	0.01
Ethylbenzene	0.013 ± 0.003	0.013–0.035	0.048	0.17 ± 0.12	–	0.01–0.07	0.03
Styrene	0.024	(0.03)[h]	0.13	0.04–0.5	–	0.03–0.22	(0.03)[h]
PAH	0.0024	(0.025)[j]	(0.025)[j]	(0.025)[j]	–	(0.025)[j]	(0.025)[j]
Methanol	(1.3)[h]	(2.0)[h]	2.0 ± 1.4	(1.5)[h]	0.16	(3.8)[h]	(2.0)[h]
Ethanol	(0.011)[h]	(0.018)[h]	0.018	(0.013)[h]	–	(0.03)[h]	(0.018)[h]
1-propanol	0.025	(0.04)[h]	(0.04)[h]	(0.03)[h]	–	(0.08)[h]	(0.04)[h]
Butanols	0.008	0.009	(0.011)[h]	(0.008)[h]	–	(0.02)[h]	0.012
Cyclopentanol	0.032	0.031	(0.04)[h]	(0.03)[h]	–	(0.08)[h]	0.017
Phenol	0.003	0.006	(0.005)[h]	(0.004)[h]	–	(0.01)[h]	0.001
Formaldehyde	0.26–0.44	(1.4)[h]	2.2 ± 0.5	0.13 ± 0.05	–	(2.6)[h]	(1.4)[h]
Acetaldehyde	0.50 ± 0.39	(0.65)[h]	0.48–0.52	0.14 ± 0.05	–	(1.2)[h]	(0.65)[h]
Acrolein, propenal	0.08	(0.18)[h]	0.13–0.35	0.01–0.1	–	(0.35)[h]	(0.18)[h]
Propanal	0.009	(0.08)[h]	0.03–0.25	0.02–0.03	–	(0.15)[h]	(0.08)[h]
Butanals	0.053	0.071	0.21	0.04–0.05	–	(0.20)[h]	0.021
Hexanals	0.002–0.024	0.031	0.02	0.004–0.009	–	(0.04)[h]	0.012
Heptanals	0.003	0.003	(0.004)[h]	(0.003)[h]	–	(0.008)[h]	0.001
Acetone	0.25–0.62	(0.62)[h]	0.52–0.59	0.01–0.04	0.02	(1.2)[h]	(0.63)[h]
2-butanone	0.26	(0.43)[h]	0.17–0.74	0.03–0.06	–	(0.83)[h]	(0.44)[h]
2,3-butanedione	(0.57)[h]	(0.92)[h]	0.35–1.5	(0.68)[h]	–	(1.8)[h]	(0.9)[h]
Pentanones	0.01–0.02	0.028	0.09	(0.04)[h]	–	(0.09)[h]	0.007
Heptanones	0.006	0.002	(0.005)[h]	(0.004)[h]	–	(0.01)[h]	0.002
Octanones	0.015	0.019	(0.02)[h]	(0.016)[h]	–	(0.04)[h]	(0.02)[h]
Benzaldehyde	0.029	0.027	(0.036)[h]	0.02–0.03	–	(0.07)[h]	0.009
Furan	0.095	(0.48)[h]	0.40–0.45	0.65	–	(0.9)[h]	(0.5)[h]
2-methyl-furan	0.044–0.048	0.17	0.47	(0.18)[h]	–	(0.46)[h]	0.012
3-methyl-furan	0.006–0.011	0.029	0.05	(0.023)[h]	–	(0.06)[h]	0.003
2-ethylfuran	0.001	0.003	0.006	(0.003)[h]	–	(0.007)[h]	0.001
2,4-dimethyl-furan	0.008	0.024	(0.019)[h]	(0.014)[h]	–	(0.04)[h]	0.002
2,5-dimethyl-furan	0.002	(0.03)[h]	0.05	(0.021)[h]	–	(0.05)[h]	(0.03)[h]
Tetrahydrofuran	0.016	0.016	(0.02)[h]	(0.015)[h]	–	(0.04)[h]	0.006
2,3-dihydrofuran	0.012	0.013	(0.017)[h]	(0.012)[h]	–	(0.031)[h]	0.005
Benzofuran	0.014	0.015	0.026	(0.016)[h]	–	(0.04)[h]	0.004
Furfural	(0.23)[h]	(0.37)[h]	0.29–0.63	0.22	0.12	(0.72)[h]	(0.37)[h]
Methyl formate	(0.015)[h]	(0.025)[h]	0.025	(0.018)[h]	–	(0.05)[h]	(0.025)[h]

In summary

Fire progression

Wildfire emission model for the 2003 and 2007 SA events (6-hourly, 500m)
Combination of CASA and RS