ARCTAS-CARB

Collaboration between NASA and California Air Resources Board on Air Quality and Climate

Data Analysis Workshop

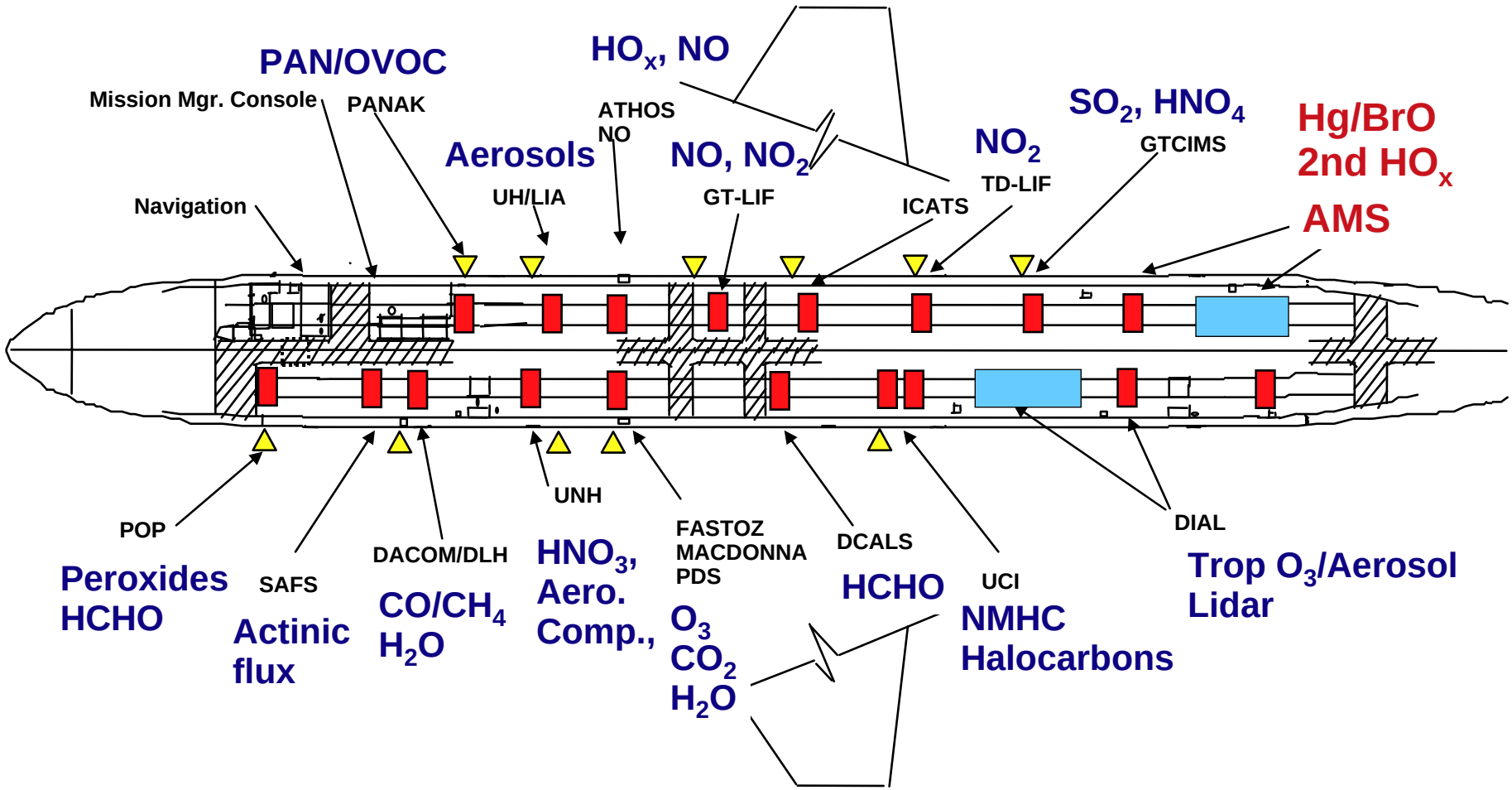
June 30 - July 1, 2009

Davis, California

CARB Priorities and Flights

Jim Pederson

ARCTAS Payload for DC-8 & P-3



P-3: Sun photometer, Solar Flux Radiometer, Cloud Absorption Radiometer, Scanning Polarimeter;

PROBE

ARCTAS-CARB

NASA and CARB Collaboration on Air Quality and Climate

18-26 June 2008
NASA Dryden Aircraft Operations Facility
Palmdale California

CARB's Objectives:

1. Improve accuracy of emissions inventories for greenhouse gases and aerosols
2. Characterize offshore emissions of sulfur and other pollutants from shipping and natural sources
3. Characterize differences in aerosol chemistry offshore and onshore and above and below marine boundary layer
4. Characterize upwind boundary conditions for regional modeling of ozone and aerosols
5. Characterize and contrast concentrations and emissions associated with rural and urban environments

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NASA Collaboration on California Air Quality and Climate Forcing

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CARB's priorities are to better characterize:

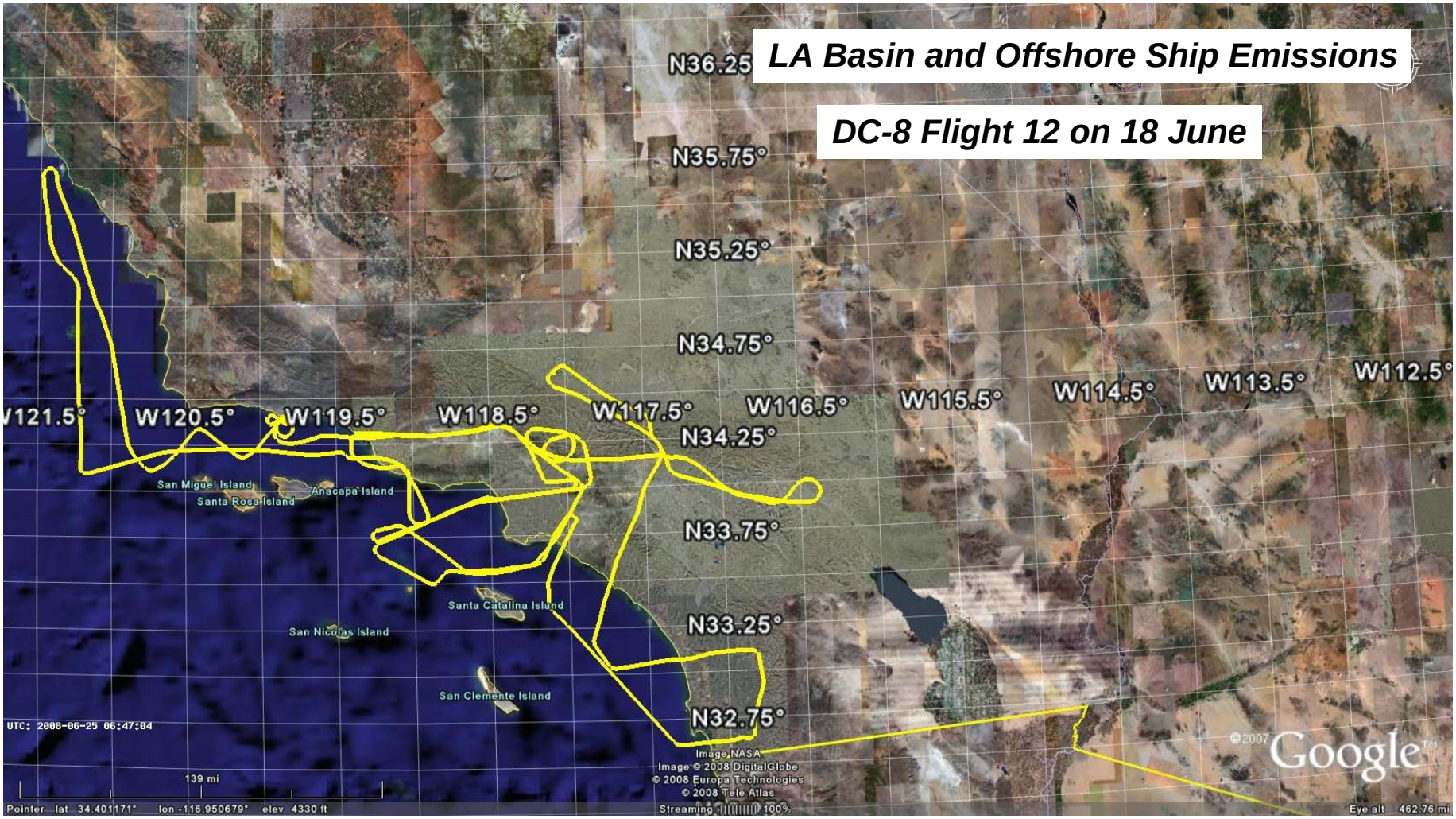
1. Terrestrial emissions of GHG's & other pollutants
2. Marine emission sources of sulfur & other pollutants
3. Gas and aerosol chemistry in & above marine boundary layer
4. Upwind BC's for regional modeling of ozone & aerosols
5. Concentrations & emissions in rural & urban environments

CARB Priority 1:
Improve Characterization of Terrestrial Emissions

- **Characterize terrestrial emission sources of GHG species and precursors of ozone & aerosols**
  - top down emissions estimates of GHG's by covariance/analog with CO or other species
  - spatial distributions of combustion and non-combustion GHG concentrations (e.g., CH4, N2O, ODS,…)
  - How does the urban mix of ODS species differ with region?
  - Specific industrial emissions, refineries, port operations
  - Quantify urban & non-urban sources: CO2, CH4,…

CARB Priorities 2 and 3:
Characterize Emissions & Processes in Marine BL

- Characterize marine emissions of sulfur species and other pollutants
  - Ship plumes
  - Biogenic & geogenic sulfur sources
- Gas and aerosol chemistry in the marine BL
- Vertical structure, gradients of concentration in and above MBL


LA Basin and Offshore Ship Emissions
DC-8 Flight 12 on 18 June
N36.25
N35.75°
N35.25°
N34.75°
N34.25°
N33.75°
N33.25°
N32.75°
W121.5°
W120.5°
W119.5°
W118.5°
W117.5°
W116.5°
W115.5°
W114.5°
W113.5°
W112.5°
San Miguel Island
Santa Rosa Island
Anacapa Island
Santa Catalina Island
San Nicolas Island
San Clemente Island
UTC: 2008-06-25 06:47:04
139 mi
Image NASA
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
© 2008 Tele Atlas
©2007 Google
Pointer lat 34.401171° lon -116.950679° elev 4330 ft
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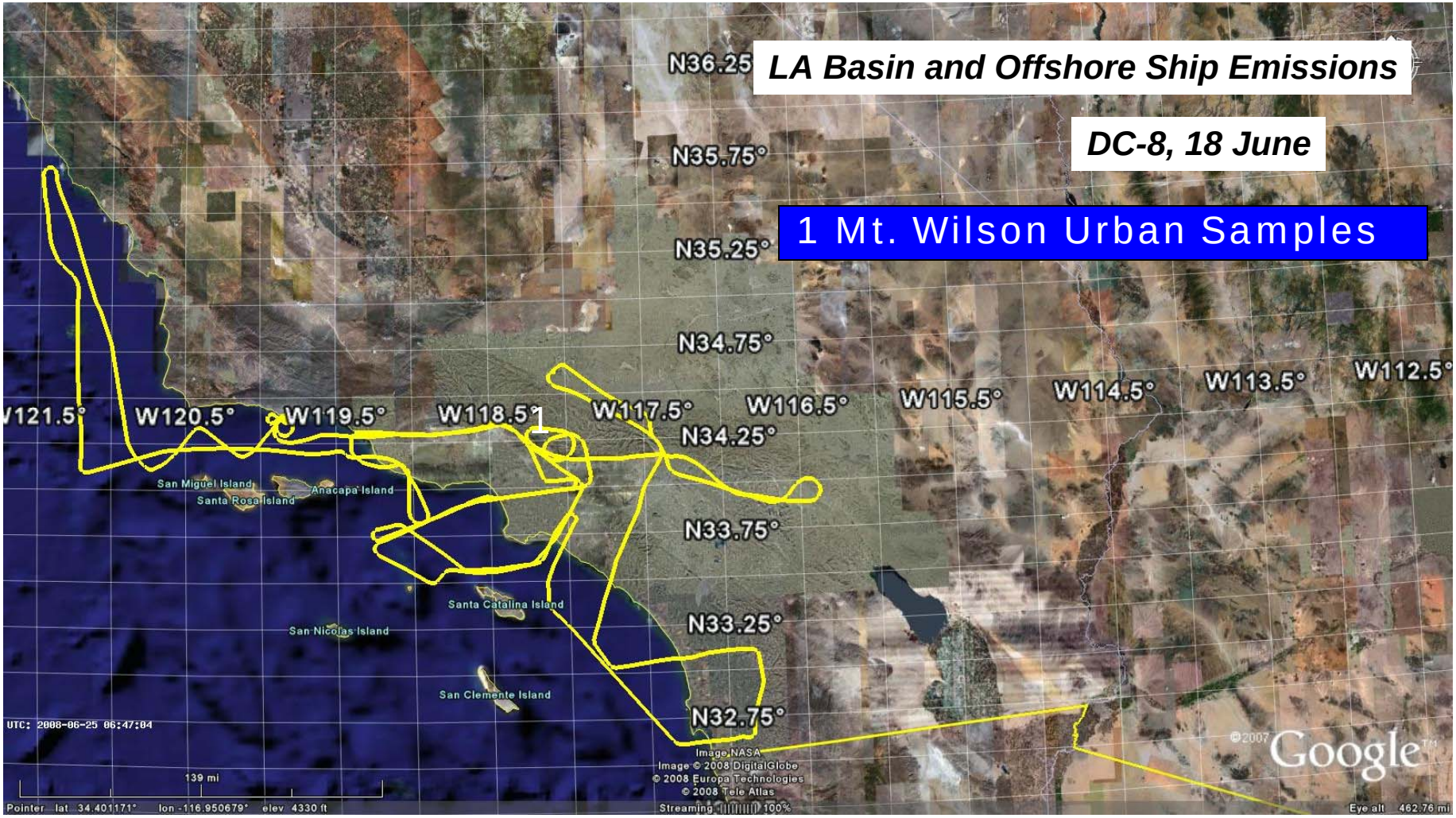
LA Basin and Offshore Ship Emissions
DC-8, 18 June
1 Mt. Wilson Urban Samples
N36.25
N35.75°
N35.25°
N34.75°
N34.25°
N33.75°
N33.25°
N32.75°
W121.5°
W120.5°
W119.5°
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W115.5°
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Santa Rosa Island
Anacapa Island
Santa Catalina Island
San Nicolas Island
San Clemente Island
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Pointer lat 34.401171° lon -116.950679° elev 4330 ft
Image NASA
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
© 2008 Tele Atlas
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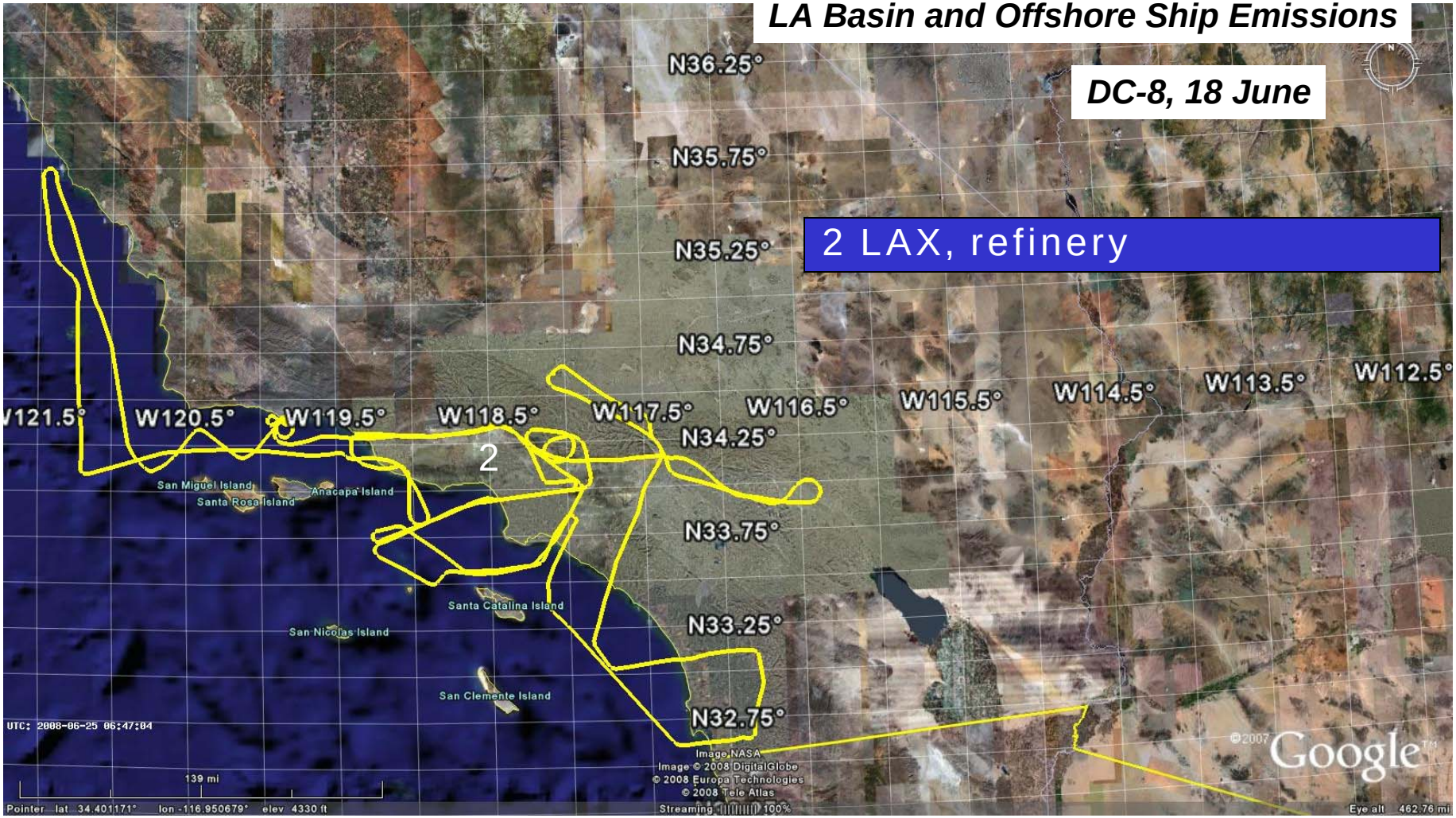
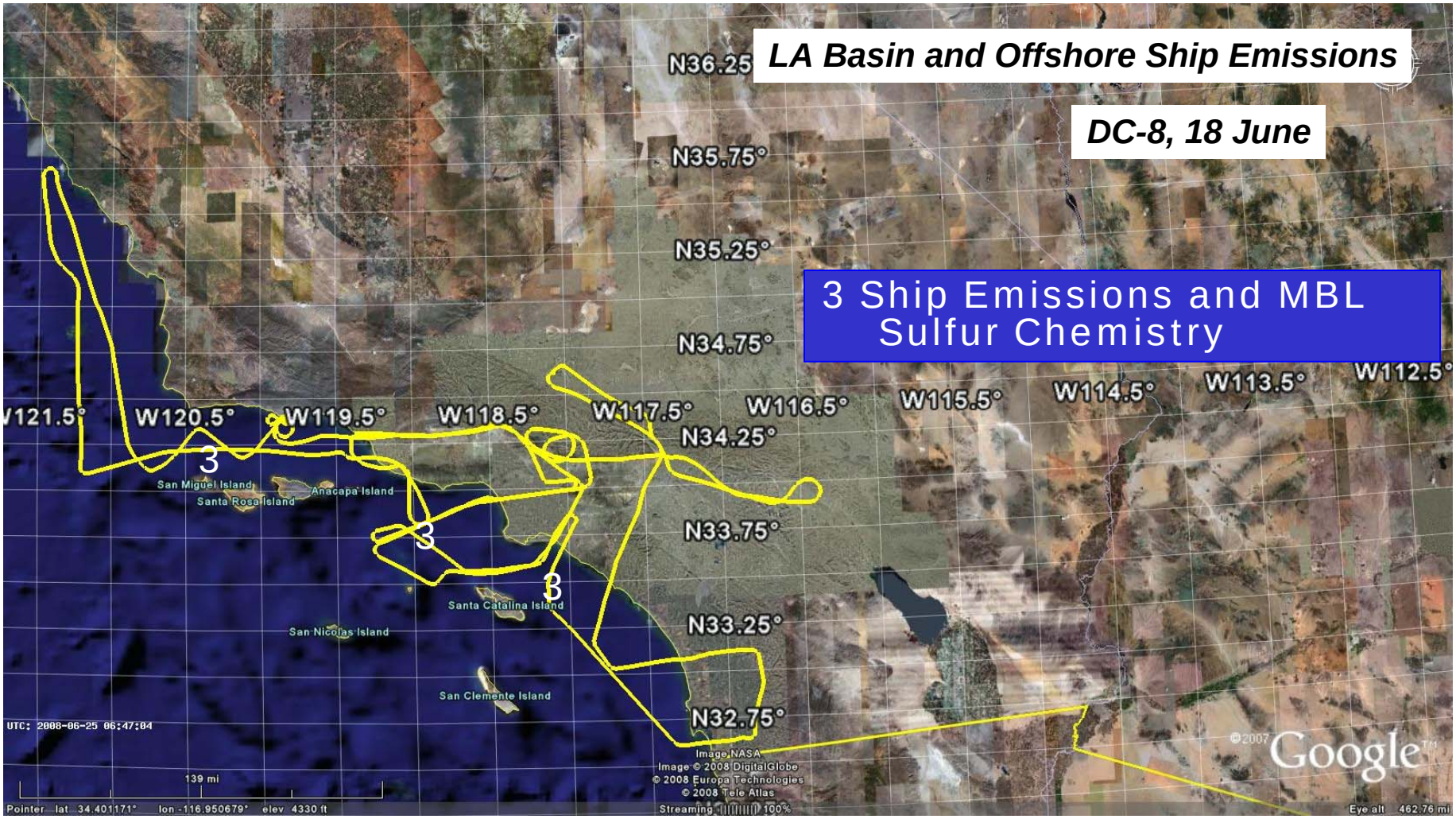
LA Basin and Offshore Ship Emissions




LA Basin and Offshore Ship Emissions
DC-8, 18 June
3 Ship Emissions and MBL Sulfur Chemistry
N36.25
N35.75°
N35.25°
N34.75°
N34.25°
N33.75°
N33.25°
N32.75°
W121.5°
W120.5°
W119.5°
W118.5°
W117.5°
W116.5°
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W114.5°
W113.5°
W112.5°
3
3
3
San Miguel Island
Santa Rosa Island
Anacapa Island
Santa Catalina Island
San Nicolas Island
San Clemente Island
UTC: 2008-06-25 06:47:04
139 mi
Image NASA
Image © 2008 DigitalGlobe
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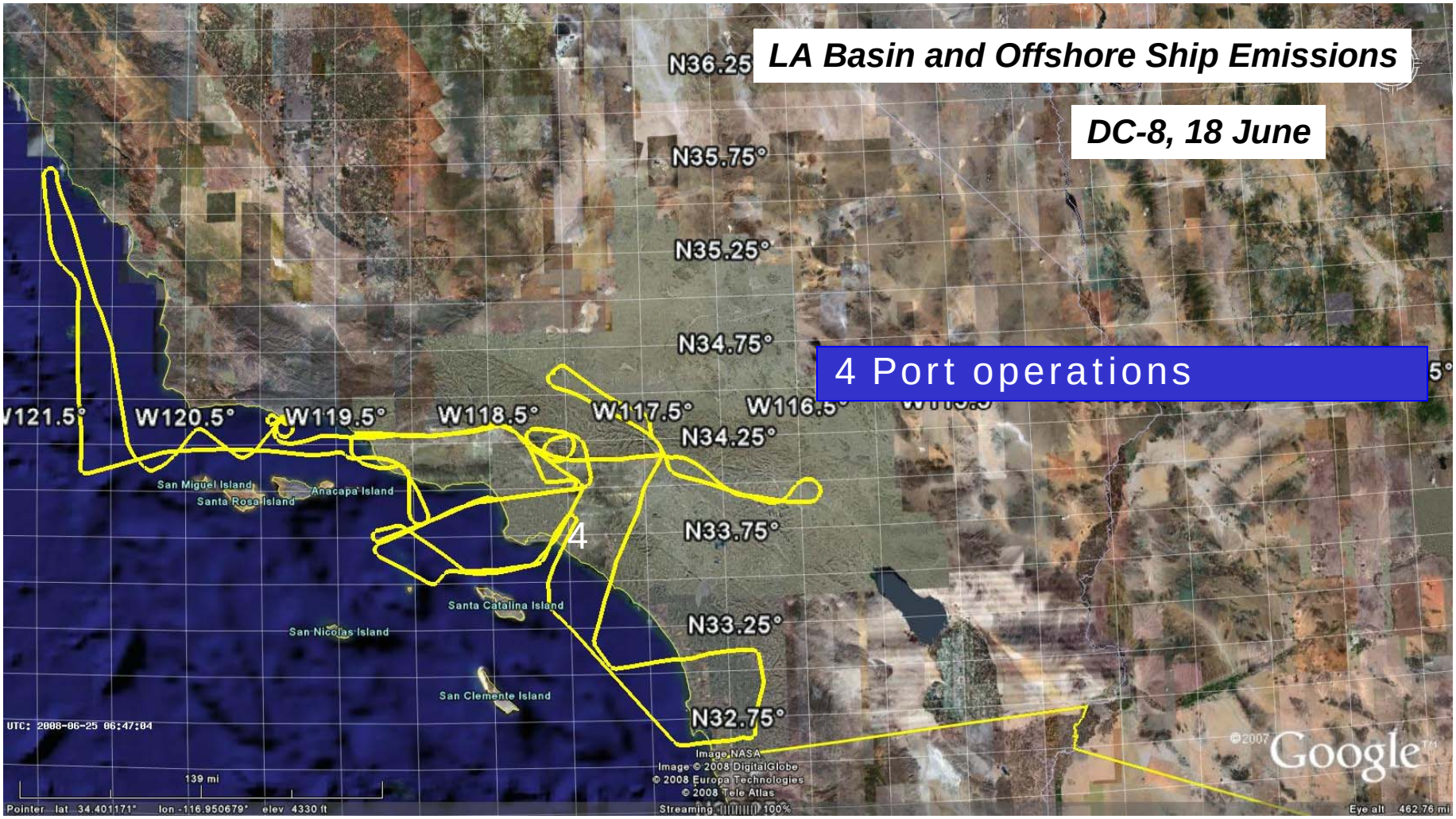
LA Basin and Offshore Ship Emissions
DC-8, 18 June
4 Port operations
N36.25
N35.75°
N35.25°
N34.75°
N34.25°
N33.75°
N33.25°
N32.75°
W120.5°
W119.5°
W118.5°
W117.5°
W116.5°
San Miguel Island
Santa Rosa Island
Anacapa Island
Santa Catalina Island
San Nicolas Island
San Clemente Island
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UTC: 2008-06-25 06:47:04
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Image NASA
Image © 2008 DigitalGlobe
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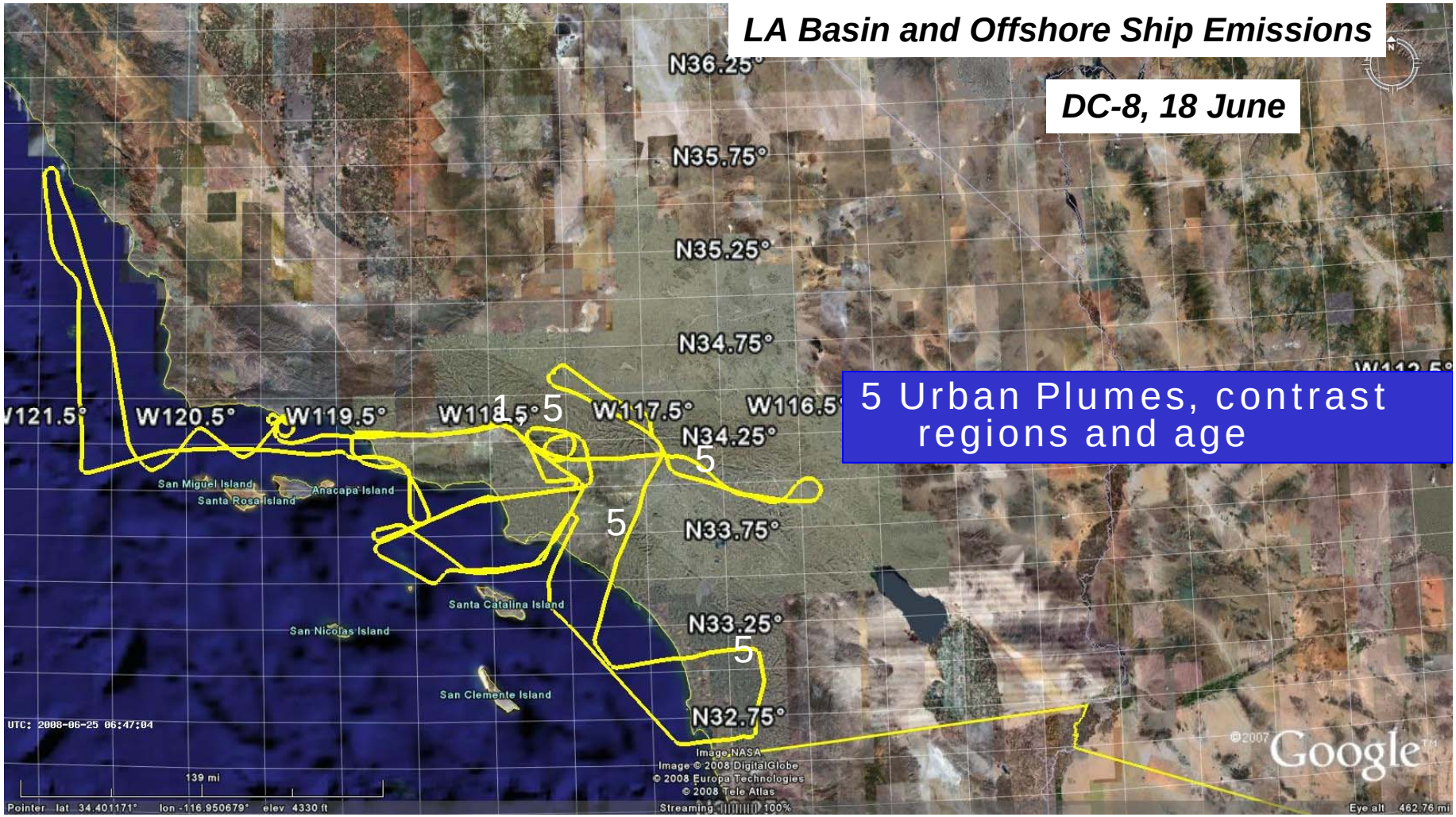
LA Basin and Offshore Ship Emissions
DC-8, 18 June
5 Urban Plumes, contrast regions and age
N36.25°
N35.75°
N35.25°
N34.75°
N34.25°
N33.75°
N33.25°
N32.75°
W121.5°
W120.5°
W119.5°
W118.5°
W117.5°
W116.5°
1
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5
San Miguel Island
Santa Rosa Island
Anacapa Island
Santa Catalina Island
San Nicolas Island
San Clemente Island
UTC: 2008-06-25 06:47:04
139 mi
Image NASA
Image © 2008 DigitalGlobe
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Pointer lat 34.401171° lon -116.950679° elev 4330 ft
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Eye alt 462.76 mi
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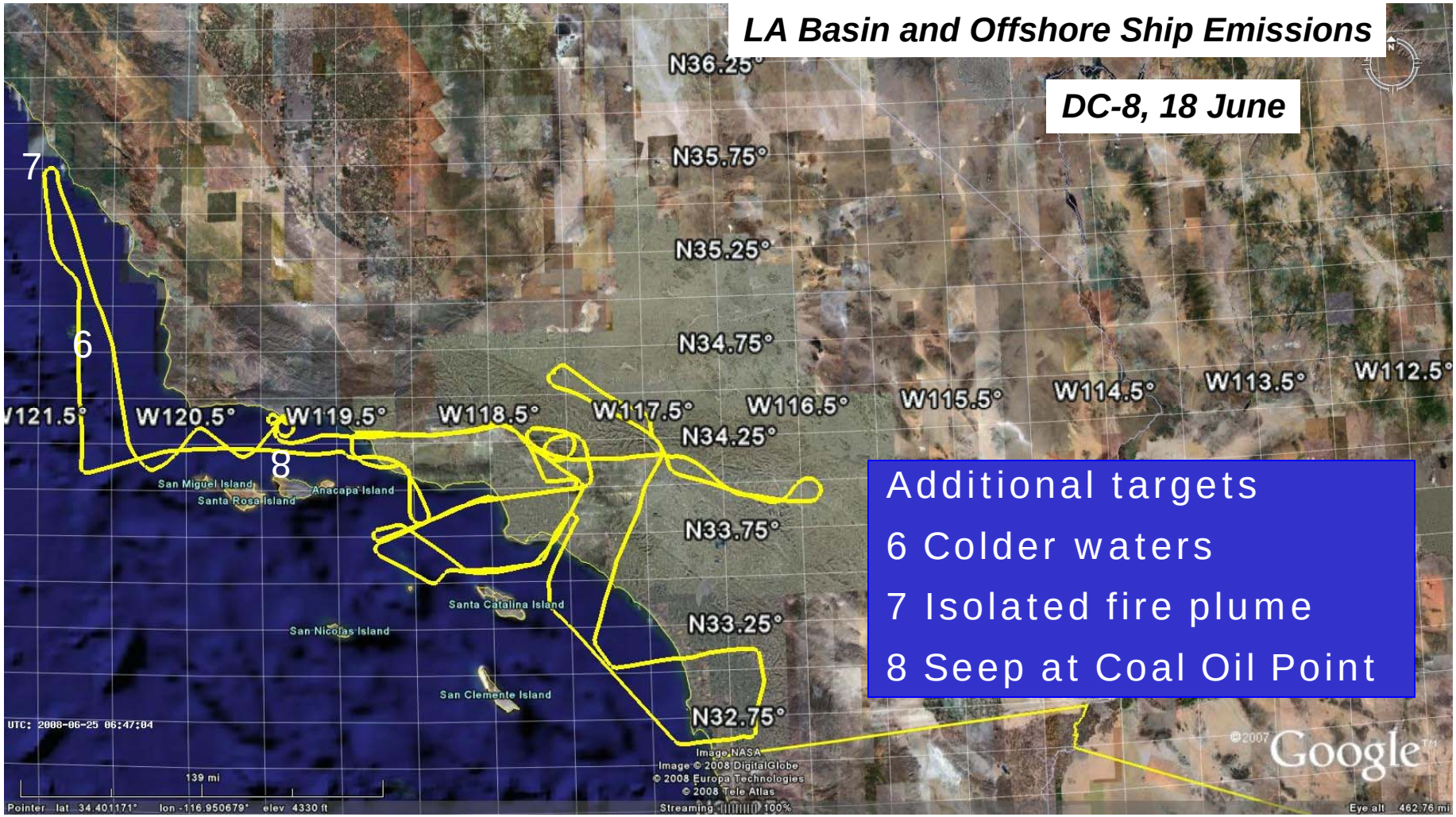
LA Basin and Offshore Ship Emissions
DC-8, 18 June
N36.25°
N35.75°
N35.25°
N34.75°
N34.25°
N33.75°
N33.25°
N32.75°
W121.5°
W120.5°
W119.5°
W118.5°
W117.5°
W116.5°
W115.5°
W114.5°
W113.5°
W112.5°
7
6
8
San Miguel Island
Santa Rosa Island
Anacapa Island
Santa Catalina Island
San Nicolas Island
San Clemente Island
Additional targets
6 Colder waters
7 Isolated fire plume
8 Seep at Coal Oil Point
UTC: 2008-06-25 06:47:04
139 mi
Image NASA
Image © 2008 DigitalGlobe
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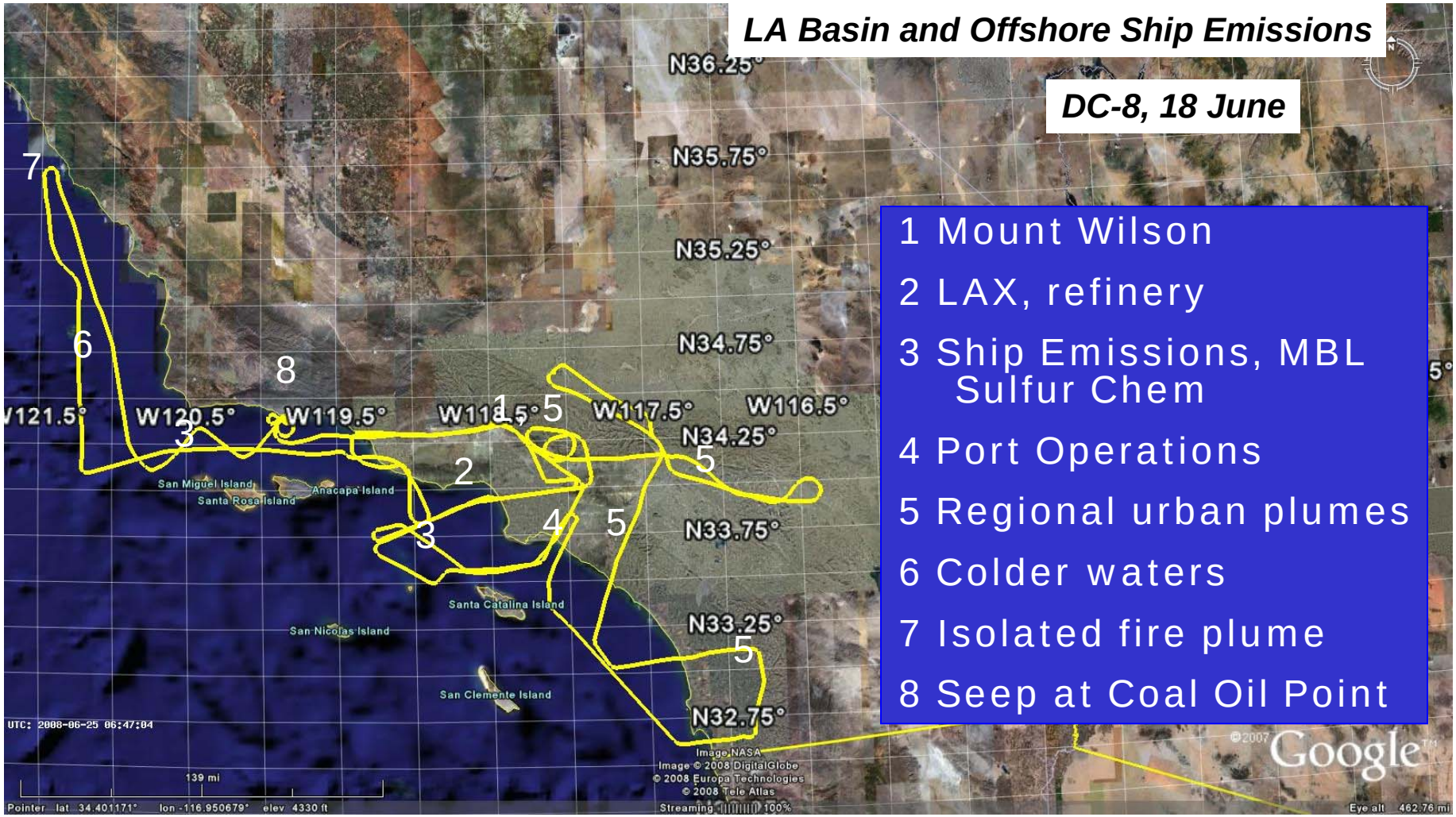
LA Basin and Offshore Ship Emissions
DC-8, 18 June
1 Mount Wilson
2 LAX, refinery
3 Ship Emissions, MBL Sulfur Chem
4 Port Operations
5 Regional urban plumes
6 Colder waters
7 Isolated fire plume
8 Seep at Coal Oil Point
N36.25°
N35.75°
N35.25°
N34.75°
N34.25°
N33.75°
N33.25°
N32.75°
W121.5°
W120.5°
W119.5°
W118.5°
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W116.5°
San Miguel Island
Santa Rosa Island
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Santa Catalina Island
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San Clemente Island
UTC: 2008-06-25 06:47:04
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Image NASA
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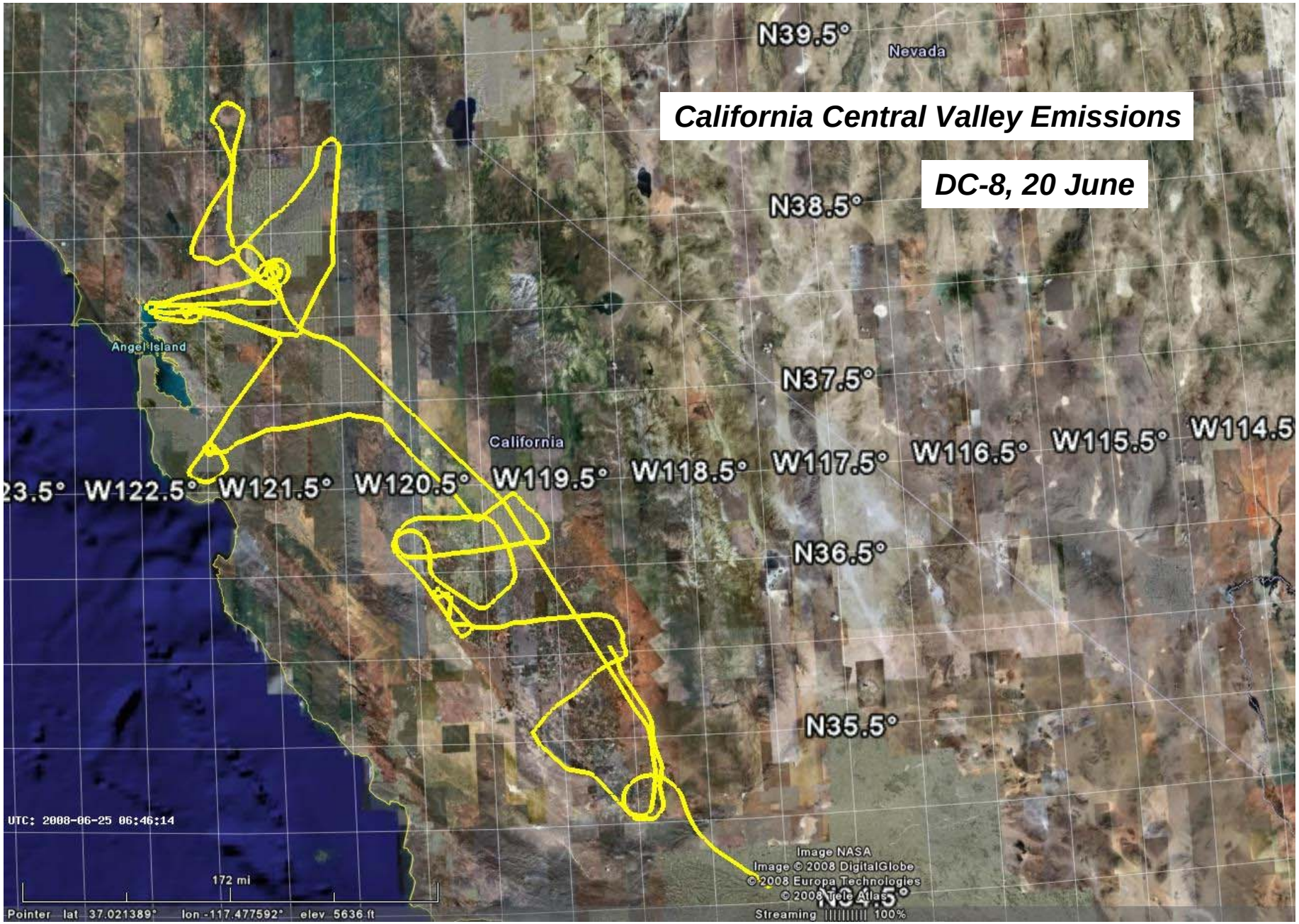
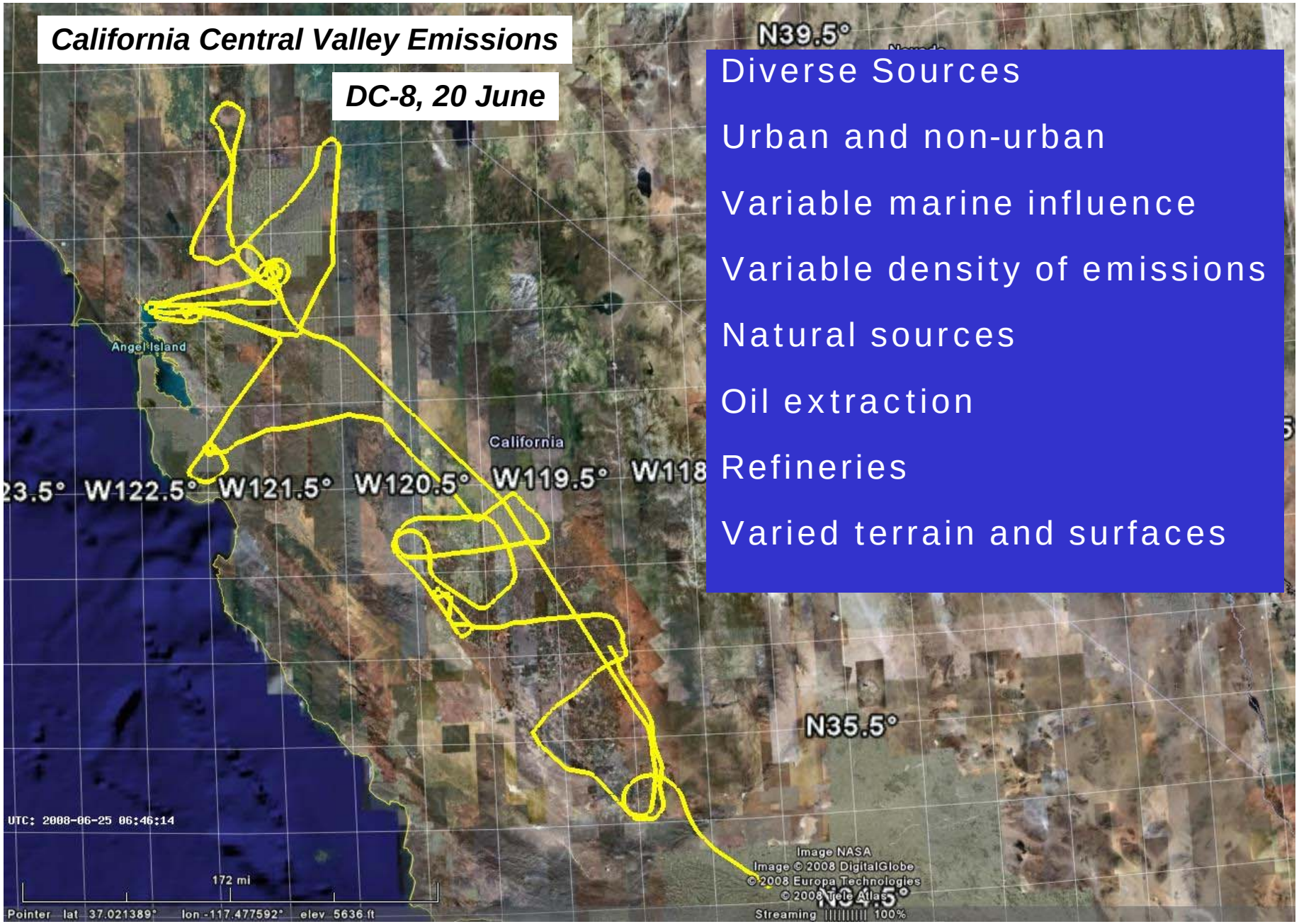
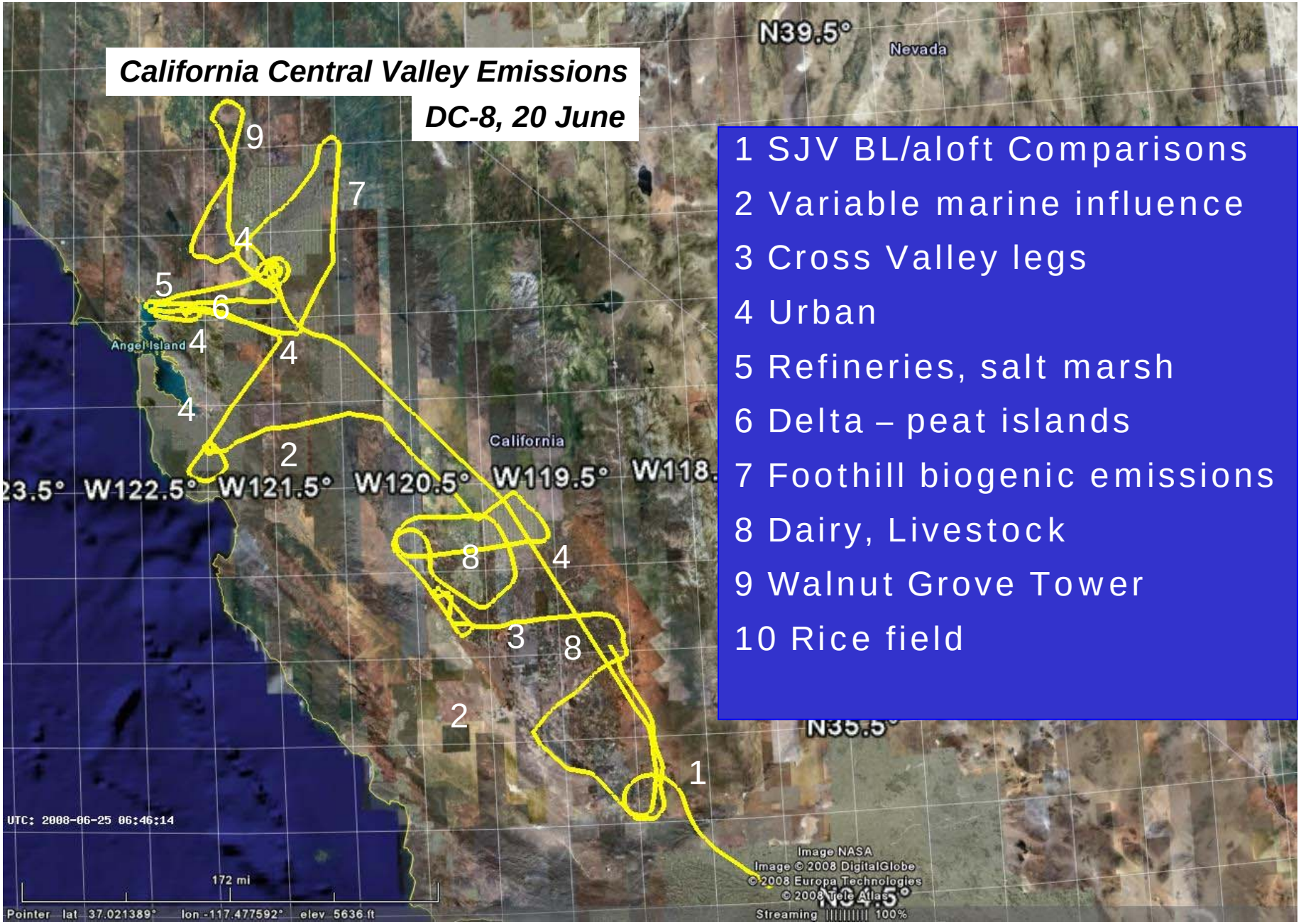

California Central Valley Emissions
DC-8, 20 June
N39.5°
Nevada
N38.5°
N37.5°
N36.5°
N35.5°
Angel Island
California
23.5°
W122.5°
W121.5°
W120.5°
W119.5°
W118.5°
W117.5°
W116.5°
W115.5°
W114.5
UTC: 2008-06-25 06:46:14
172 mi
Image NASA
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
© 2008 Tele Atlas
Streaming 100%
Pointer lat 37.021389° lon -117.477592° elev 5636 ft



- Diverse Sources
- Urban and non-urban
- Variable marine influence
- Variable density of emissions
- Natural sources
- Oil extraction
- Refineries
- Varied terrain and surfaces

Central California Urban Plumes: Valley & Coastal, North & South

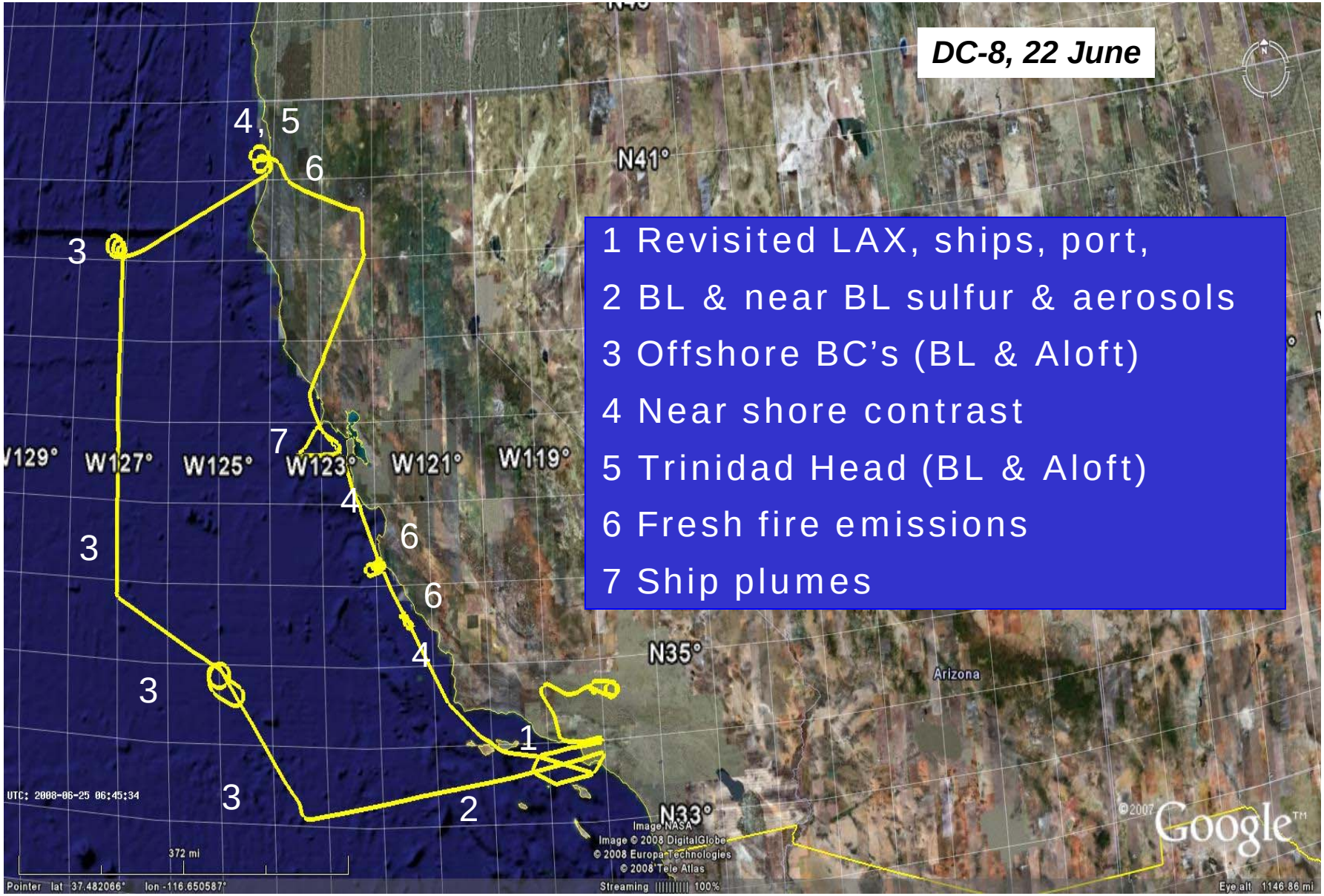


1 SJV BL/aloft Comparisons
2 Variable marine influence
3 Cross Valley legs
4 Urban
5 Refineries, salt marsh
6 Delta – peat islands
7 Foothill biogenic emissions
8 Dairy, Livestock
9 Walnut Grove Tower
10 Rice field

CARB Priority:
Boundary Conditions for Regional Modeling

- **Spatial Variation of Concentration**
  - **Range of observations**
  - **Spatial characteristics**
  - **Contrast offshore and near shore**
  - **Contrast MBL and Aloft**
- **Characterize sulfur species and aerosol contributions**
- **Other combustions species from shipping**
- **Natural sources**
- **Bonus**
  - **Observations vs. continental-scale model outputs**
  - **Fire emissions, different fuel types and ages**

Upwind boundary conditions for regional modeling of ozone and aerosols



June 22

LA Basin Diurnal Evolution and Offshore Ship Emissions, 24 June

DC8

1 SE California, Salton Sea soundings, BL

2 Mexicali, Tijuana

3 SoCal urban outflow

4 Mixed urban & fire emissions

5 Revisited MBL and ship plumes as a complement to the P3

June 26, Palmdale to Canada

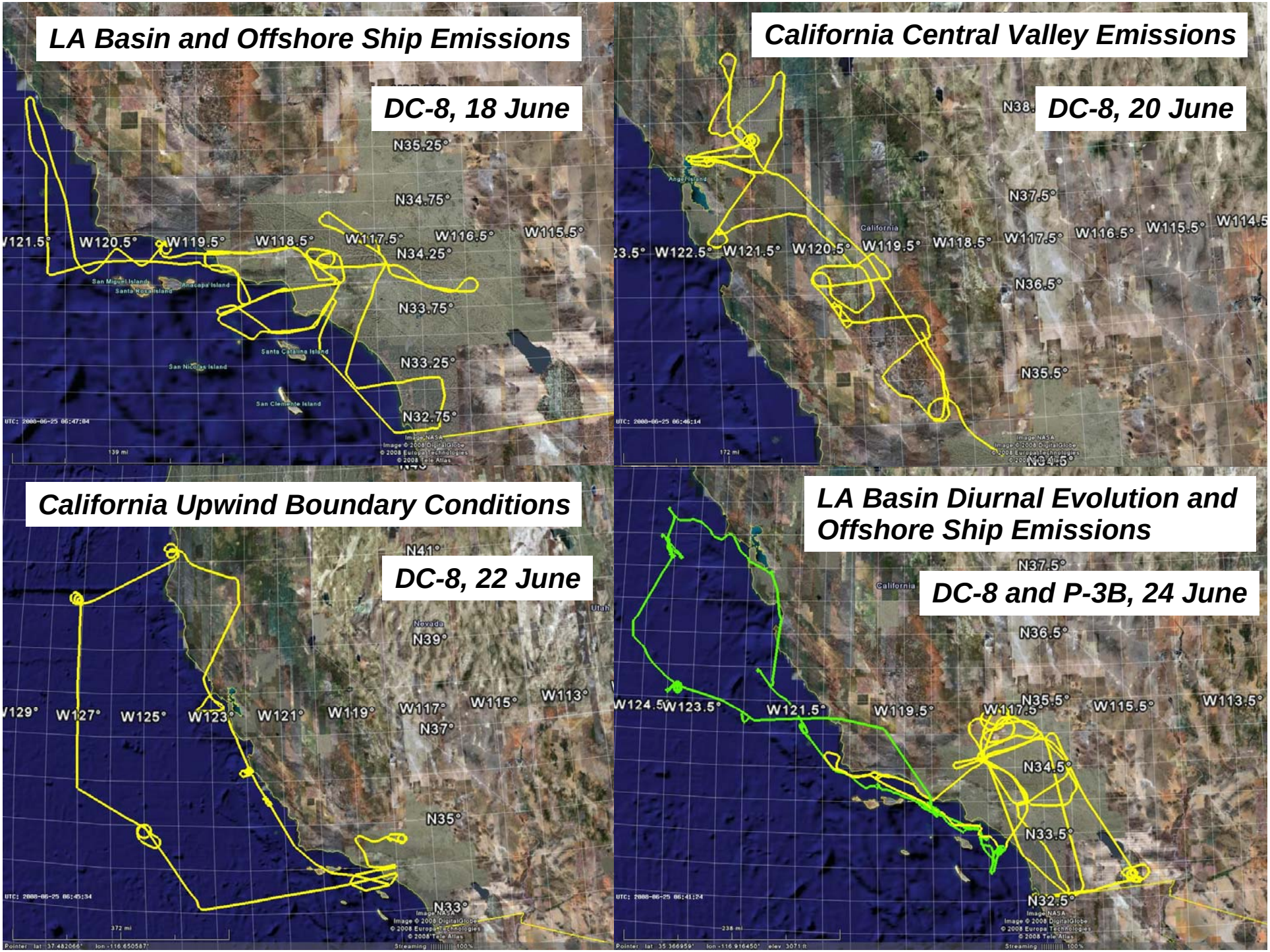
Aerosol & ozone LIDAR curtains

Catalina Island and LA Basin

San Joaquin Valley

Sacramento Valley

Lake Tahoe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DC-8, 18 June
N35.25°
N34.75°
W121.5°
W120.5°
W119.5°
W118.5°
W117.5°
W116.5°
W115.5°
N34.25°
N33.75°
N33.25°
N32.75°
San Miguel Island
Santa Rosa Island
Anacapa Island
Santa Catalina Island
San Nicolas Island
San Clemente Island
California Central Valley Emissions
DC-8, 20 June
Ange Island
California
N37.5°
W122.5°
W121.5°
W120.5°
W119.5°
W118.5°
W117.5°
W116.5°
W115.5°
W114.5
N36.5°
N35.5°
California Upwind Boundary Conditions
DC-8, 22 June
N41°
Nevada
Utah
N39°
W129°
W127°
W125°
W123°
W121°
W119°
W117°
W115°
W113°
N37°
N35°
N33°
LA Basin Diurnal Evolution and Offshore Ship Emissions
DC-8 and P-3B, 24 June
California
N37.5°
N36.5°
N35.5°
W124.5°
W123.5°
W121.5°
W119.5°
W117.5°
W115.5°
W113.5°
N34.5°
N33.5°
N32.5°

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NASA Collaboration on California Air Quality and Climate Forcing

Thank You!

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Great Opportunity for CARB

- DC8 and P3 – speed, endurance, range
- high-sensitivity, fast-response analyzers
  - Spatial range and resolution
  - More complete chemistry and aerosol information
  - Not normally available to ARB through routine monitoring or SIP studies
- LIDAR cross-sections for vertical resolution of ozone & aerosols
- Extensive gaseous species:
  - Sulfur chemistry
  - Combustion species
  - Odd oxygen species
  - Reactive organic compounds
  - ODS and GHG species
  - Mercury
- Aerosol in-situ characterizations
  - number, size, composition, actinic flux,…