Environmental Objectives

of the

Russian American Observation Satellites (RAMOS)

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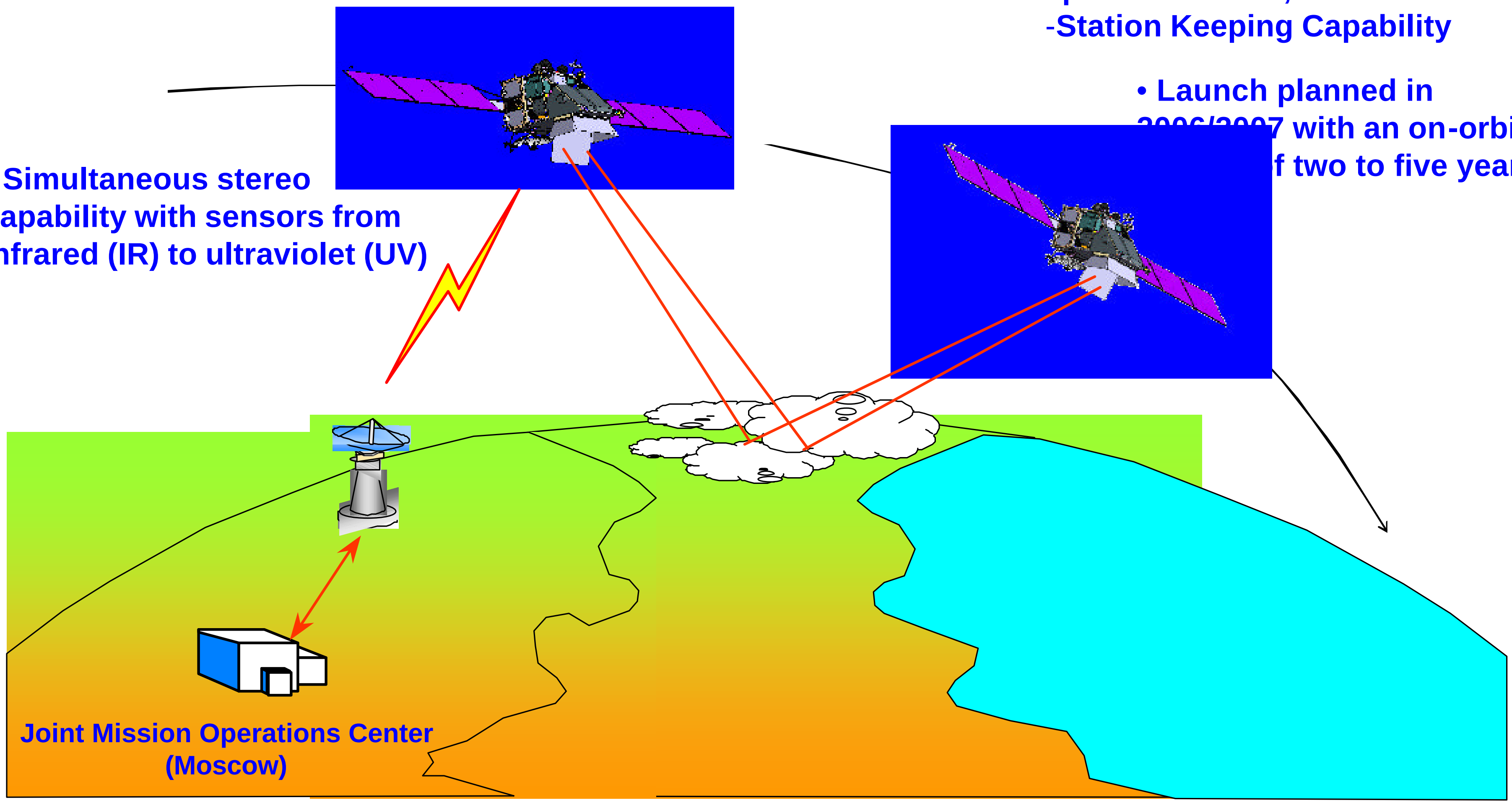
VISIDYNE

RAMOS Program

- Circular 500 km Orbit
- Separation = 50-2,600 km
  - -Station Keeping Capability
- Launch planned in 2006/2007 with an on-orbit ... f two to five years
- Simultaneous stereo capability with sensors from infrared (IR) to ultraviolet (UV)



RAMOS Objectives

- Increase cooperation
  - Engage US and Russia cooperatively in environmental technologies
  - Increase trust between US and Russia
  - Establish groundwork for future cooperative efforts
- Develop mutually beneficial research
  - Study use of multispectral stereo observations for environmental monitoring and forecasting
  - Measure utility of short wave infrared (SWIR) polarization and multispectral techniques to mitigate atmospheric clutter

Approach

- Jointly develop two-satellite configuration
  - Russia builds two spacecraft, provides ground facilities, visible cameras and UV sensors
  - US builds infrared sensors and visible pushbroom scanners
  - Russia launches both satellites
- Jointly perform mission operations

RAMOS Technical History

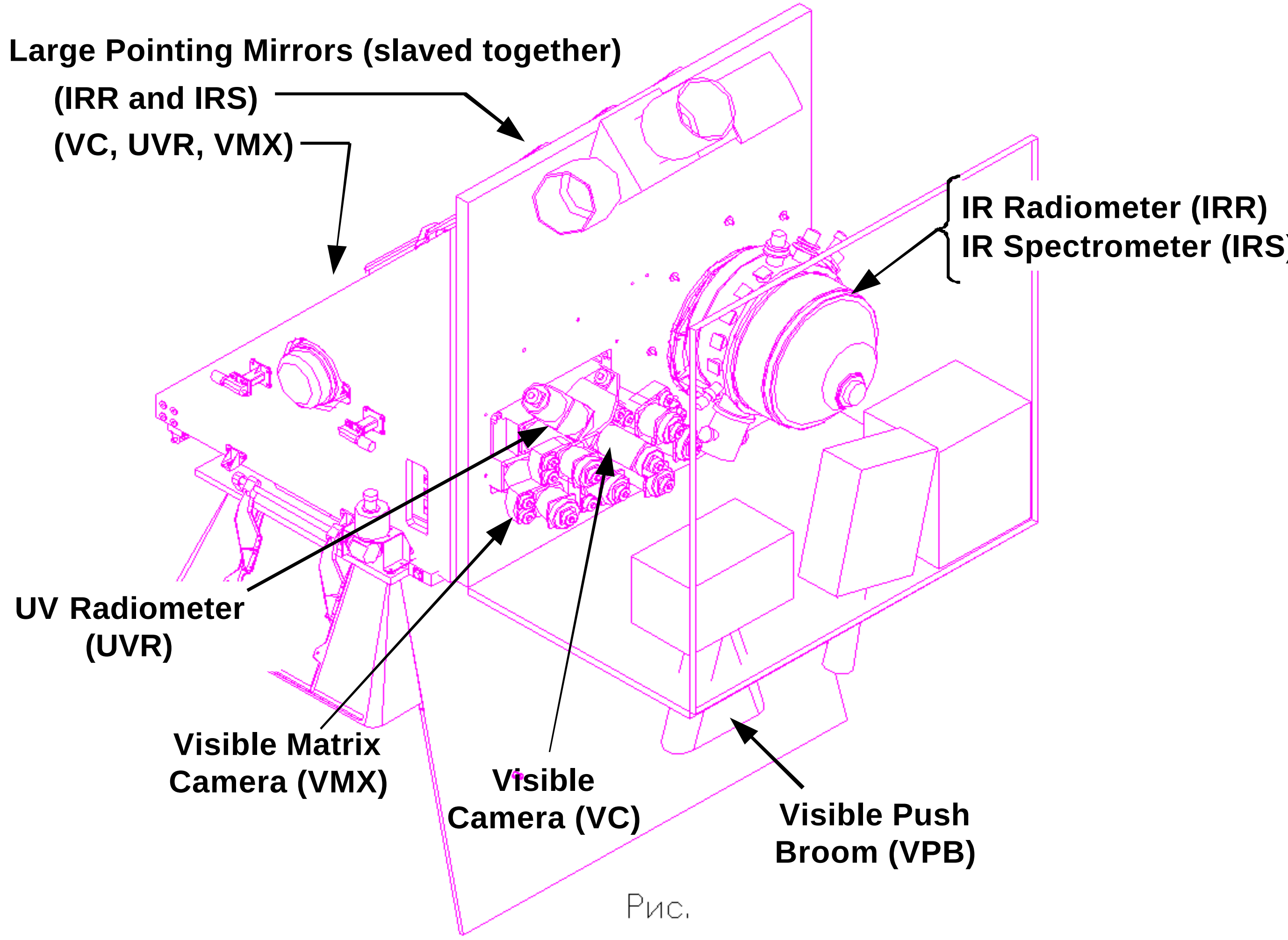
- Russian and American teams demonstrated 10 years of cooperative research
- Stereo, polarization measurements, atmospheric observations, solar scattering and numerous other phenomena
- In 1996, US Midcourse Space Experiment (MSX) satellite and Russian Resurc-O 1 Earth Resources satellite
  - During a near conjunction obtained over 1,200 multispectral images of Mt. Erebus, Antarctica
  - Demonstrated stereoscopic analysis of scene from two separate observation platforms with sensors of totally different design.
- From 1997 until 2000 a series of flights were made using the US FISTA (Flying Infrared Signatures Technology Aircraft)
  - Russian-built water band (MLWIR) radiometer ("Aquameter") to measure atmospheric and cloud scenes
  - Space Dynamics Laboratory's Hyperspectral Imaging Polarimeter (HIP) to study polarization of solar scatter in the SWIR spectral region
- These programs yielded a wealth of information used to design RAMOS sensors

RAMOS Instrument Parameters

Two Satellites (Both Active) – Two ROKOT Launchers		
	Satellite #1	**Satellite #2**
Pointing System #1	Infrared Radiometer/ *Polarimeter*	Infrared Radiometer/ *Spectrometer*
Pointing System #2 (slaved)	High Speed Visible Camera	High Speed Visible Camera
	Wide Field Visible Cameras	Wide Field Visible Cameras
	Ultraviolet Radiometer	Ultraviolet Radiometer
Body Mounted	Visible Push -broom Scanner	Visible Push -broom Scanner

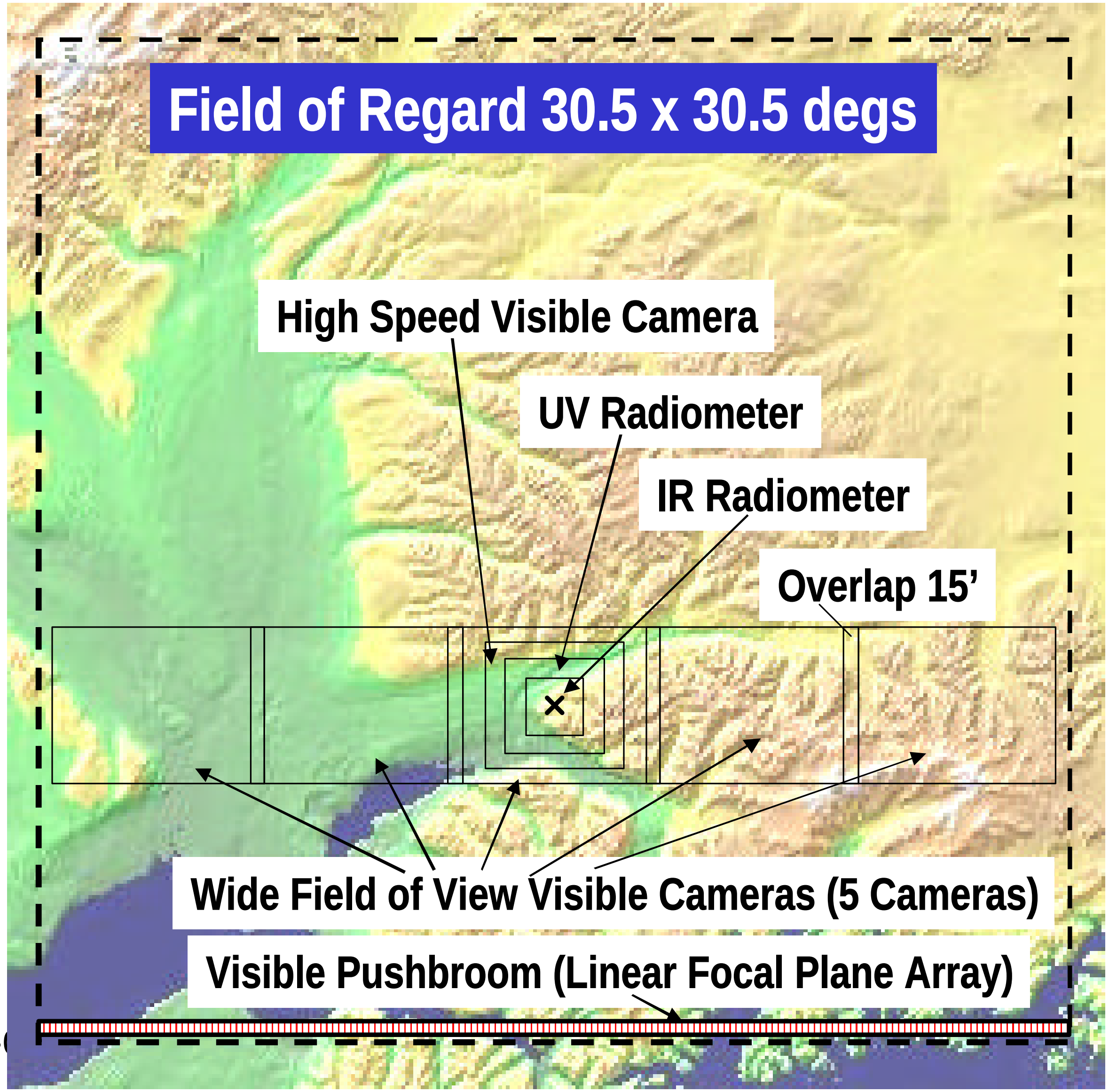
- **IR Radiometer (US)**
  - 1º x 1º FOV, 140µrad IFOV, 1.5 to 7.5 µm, multiple focal planes/dichroic for simultaneous measurements
  - MLWIR (5.4 – 7.2 µm), MWIR (4.23 - 4.45 µm), SWIR (2.7 - 2.95 µm) and multiple “see to the ground” (atmospheric windows) bands
- **High Speed Visible Camera (RF)**
  - 3º x 3º, high speed (=100 Hz) camera (600 - 900 nm)
- **Visible Push Broom Scanner (US)**
  - Body mounted, 30º wide FOV, polarization and cloud top filters
- **Wide Field Visible Camera (RF)**
  - 5 cameras 3º x 30º FOV with RGB and other environmental filters
- **Ultraviolet Radiometer (RF)**
  - Multiple filtered two channel ultraviolet photometer (200-300 nm and 300-400nm)

Payload Configuration



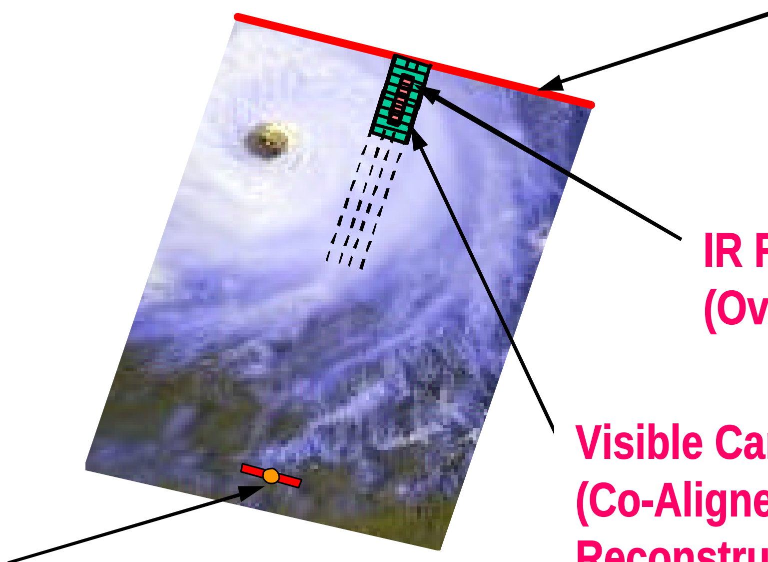
•Two satellites based on the Russian “Yacht” universal space platform

Instrument Coverage

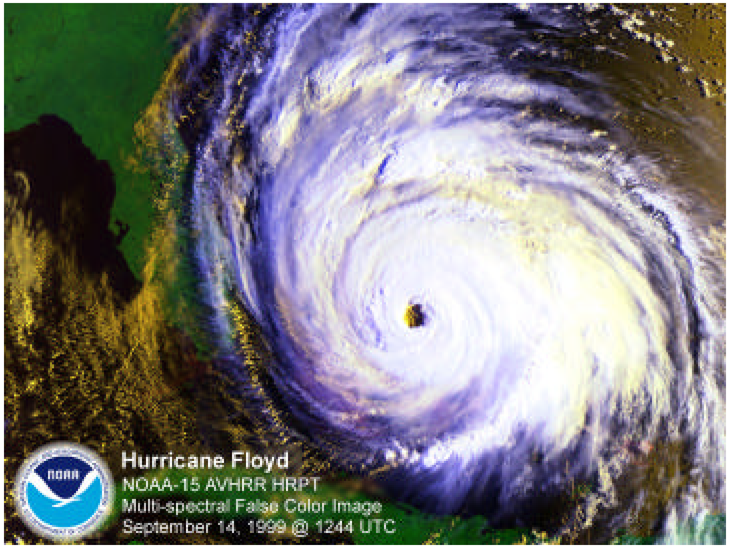


Investigating Global Atmospheric and Dynamic Events

Using stereo observation, multiple wave bands, and small footprint, RAMOS will evaluate the capability to measure and identify fast changing environmental events such as volcano eruptions and forest fires. RAMOS will also demonstrate the capability to measure the wind velocity altitude profile through the use of stereo tracking of cloud fragments and the ability to determine the vertical distribution of water vapor in the atmosphere. These capabilities may assist in weather forecasting such as predicting hurricane strength and movement.



Strength of Cyclones

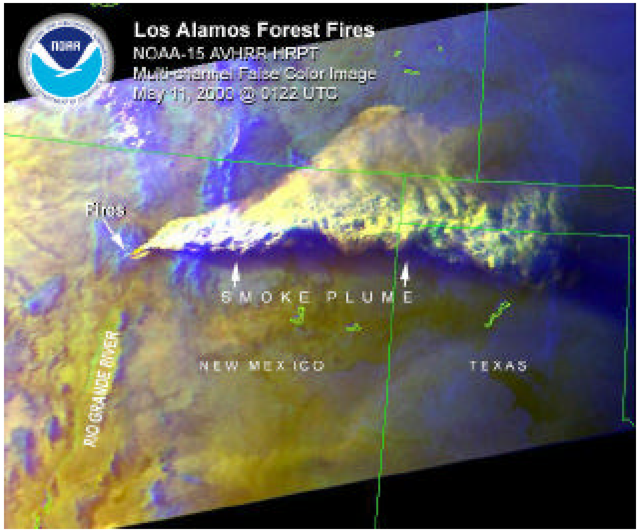


Credit: NOAA

- Cyclones are the most destructive natural calamities both in terms of loss of life and property
  - Strength of cyclones are crudely estimated by aircraft flights into the storms
- Demonstrate ability to measure and predict the strength of the cyclone remotely
  - Determine altitude of the turrets that protrude above the eye-wall to plus or minus100 meters
  - Determine temperature of these turrets to plus or minus a few degrees (K)
- Demonstrate that space-based systems could
  - Provide disaster warnings world wide

Fires

Credit: NOAA



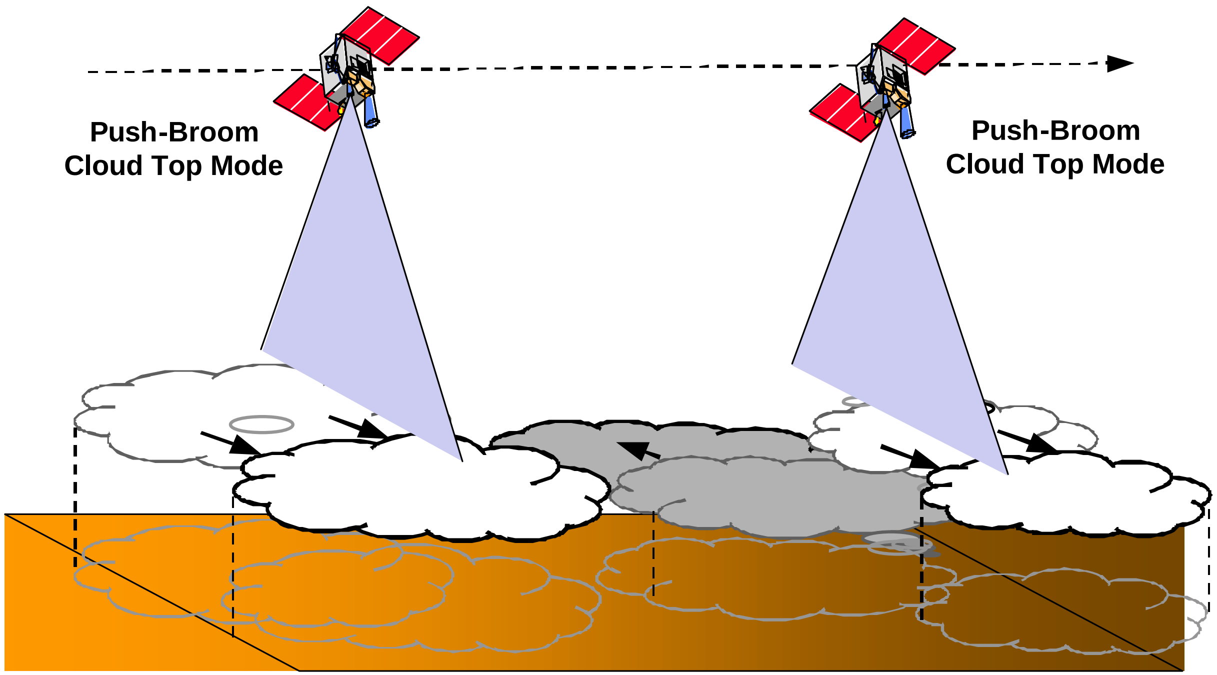
- **Fast Changing Events**
  - **Forest fires**
  - **Industrial, pipeline, or oil field fires**
  - **Fires from accidents**
- **RAMOS sensors' small footprints, stereo location, and the temperature measurement capabilities are unique when compared to other satellite systems**
- **Demonstrate ability for space-based support of disaster control**
  - **Measure and identify these events and report them in a timely fashion to National and Global Disaster Networks**

Volcanic Plume

Credit: NOAA

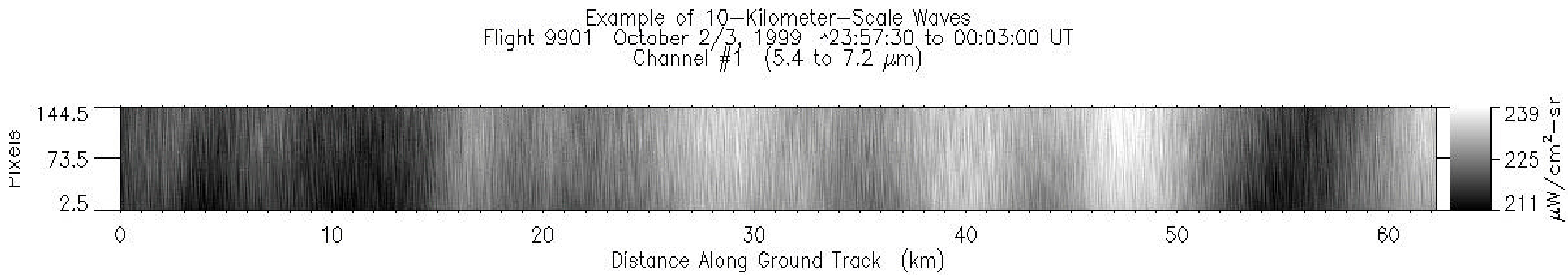
- **Observe plume from an active volcano when it is far removed from the source and has thinned to become a translucent cloud**
  - **Threat to jet aircraft that might penetrate the cloud**
  - **May affect weather patterns.**
- **Define the top and bottom altitudes and the width of the plume**
- **Use tomographic methods with data from each satellite to correlate views to assist in the spatial definition of ash**

Wind Measurements



- Demonstrate wind velocity versus altitude by tracking cloud fragments
- Demonstrate potential improvement of numerical weather forecasting far removed from land based observation sites
- Provide information on the winds that steer cyclones as an assist to the cyclone strength measurements

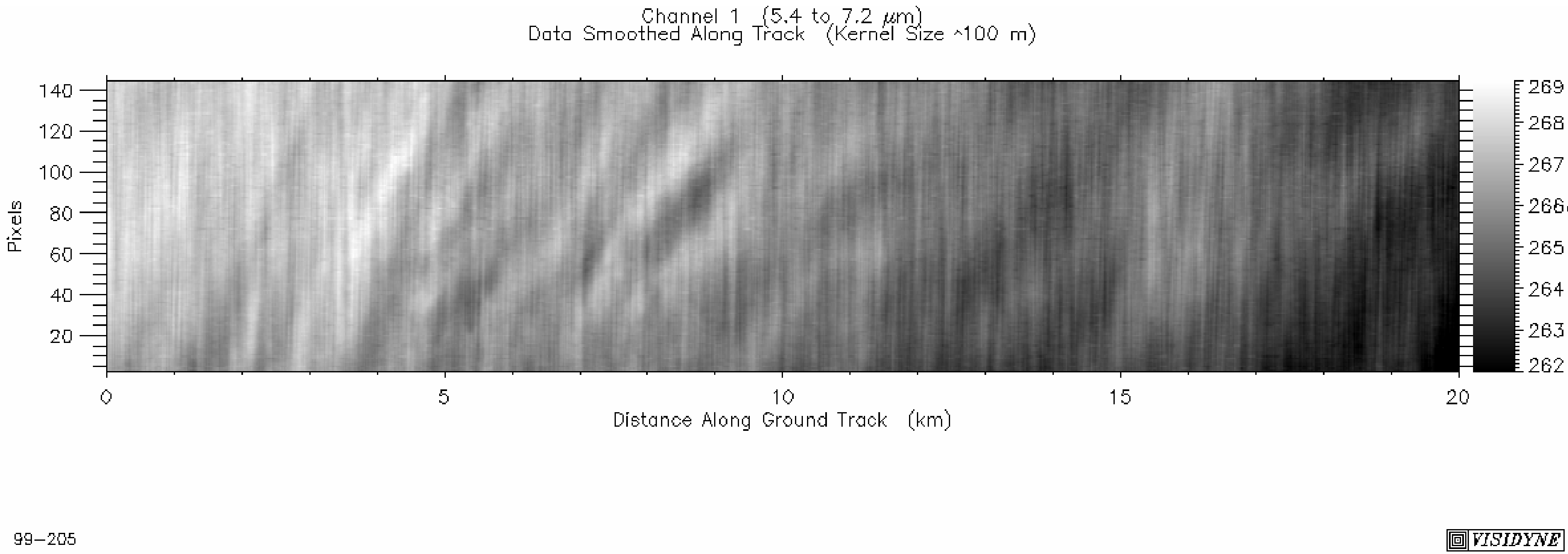
Water Vapor Structure



Calibrated, Aquameter image of 10-kilometer-scale waves observed during FISTA flight in southeastern Utah. Faint, small-scale vertical structures in the image is instrument noise.

- Observe wave-like structures of the troposphere
- Study phenomenology of tropospheric waves
  - Possible gravity waves
  - Temperature, water vapor content
  - Topography influence

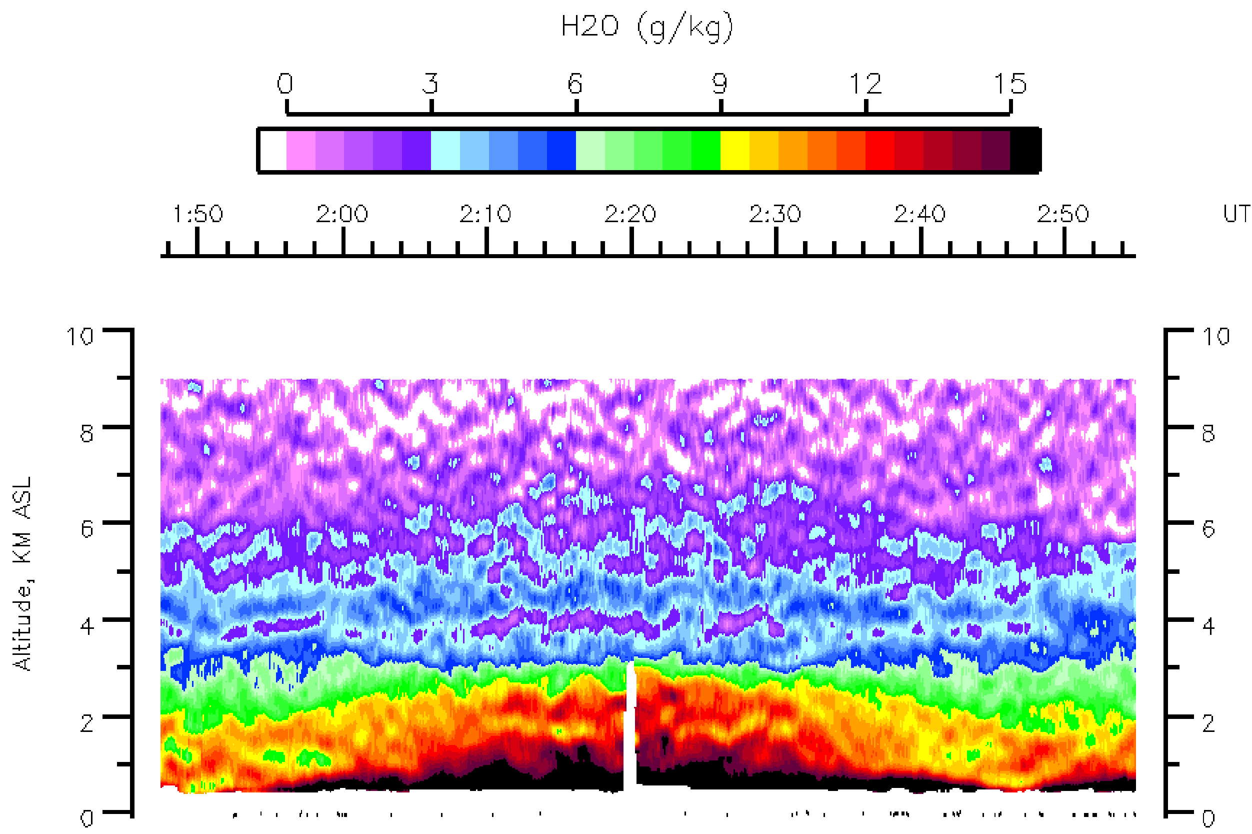
Water Vapor Fine Structure



Calibrated, forward-looking Aquameter image of sub-kilometer-scale waves observed during FISTA flight over the Pacific Ocean off the coast of California. The assumed wave and aircraft altitudes are 7.2 and 12.1 kilometers respectively. Diagonal wave features believed to be gravity waves.

- **Observe fine wave-like structures of the troposphere**

Water Vapor Profiles



- Determine the MLWIR radiometric contribution to spatial scenes (for all local zenith angles including near horizon viewing geometry
- Determine the vertical distribution of water vapor in the atmosphere by spectral measurements
- Demonstrate the capability to measure at the less than 100 meter spatial scale
  - Value in the forecasts of climatological change and weather

Conclusion

- The RAMOS constellation is a demonstration of cooperation between the Russian Federation and the United States
  - Joint experiment planning
  - Exchange of experimental data
- New technologies for the study of the global environment
  - Advance state of knowledge of critical environmental phenomena
- Acquisition of space-based data will create important scientific databases that will benefit international research
- This project has raised the level of cooperation and trust between various US and Russian organizations