Environment Canada Environnement Canada

Canada

Space Activities and Priorities
Environment Canada

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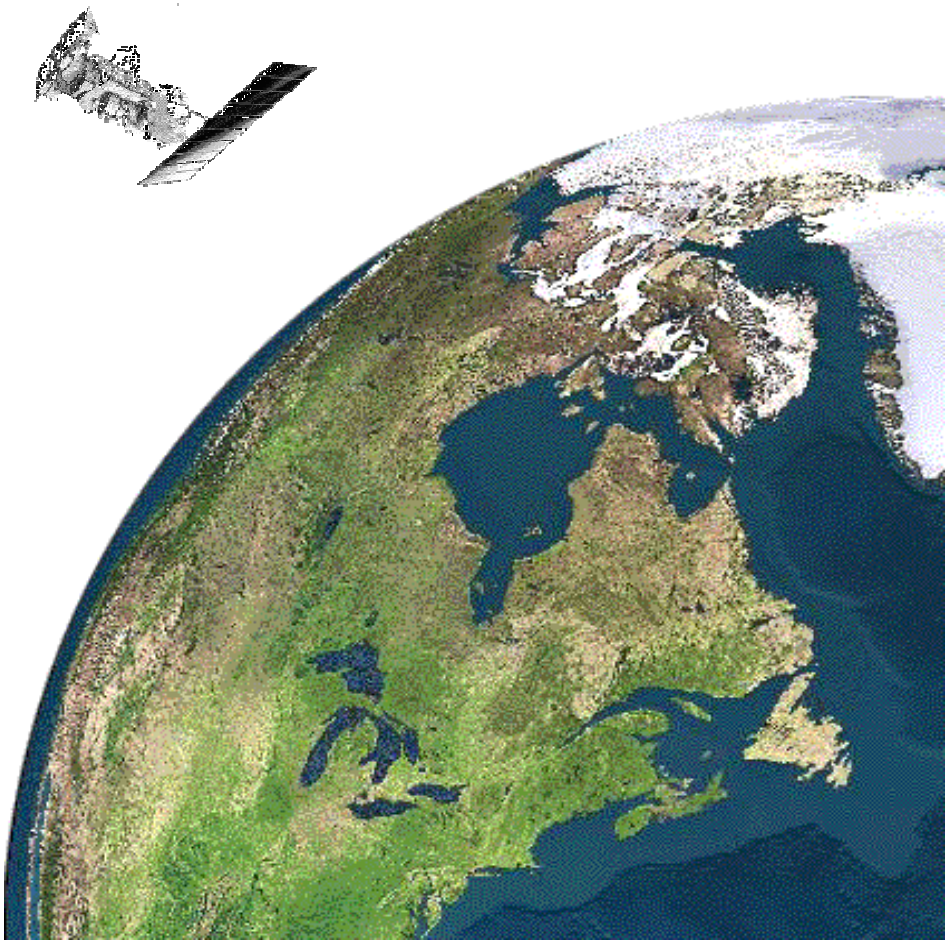
Outline

- EC Context
- Space Activities in EC
- EC Priorities
- Space Policy Framework



Environment Canada's Mandate

- Preserve and enhance the quality of the natural environment, including water, air, soil, flora and fauna
- Conserve Canada's renewable resources
- Conserve and protect Canada's water resources
- Forecast daily weather conditions and warnings, and provide detailed meteorological information to all of Canada
- Enforce rules relating to boundary waters
- Coordinate environmental policies and programs for the federal government

A safe, clean and sustainable environment today, tomorrow and well into the future.

EC Context

- Broad and diverse scope of activities
  - environment- land, water, air, flora, fauna
  - geographic - large monitoring and stewardship responsibilities
  - roles - science, operations, policy and regulations, enforcement

- High use of space capabilities
  - emphasis on access and exploitation of EO data to address data gaps
  - also a user of telecom and navigation services

- EC is the GoC largest user of satellite EO
  - mission-critical dependence on foreign and Canadian missions
  - image and non-image data

EC Context (2)

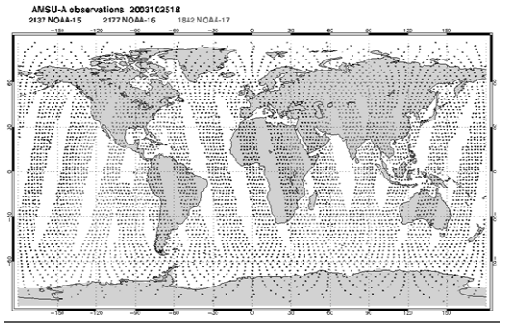
- Continuum of activity in EO
  - activities - science, applied research, technology transfer, operations
  - roles - requirements, mission definition, ground segment operations, exploitation
  - scope - user, investigator, instrument, mission, program

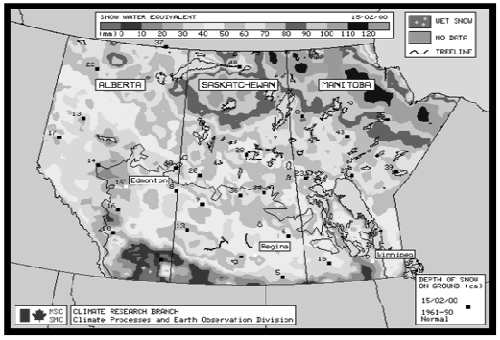
- Space is more than just hardware in orbit
  - mission operations, data policies, ground segment, value-added processing, end-user capabilities

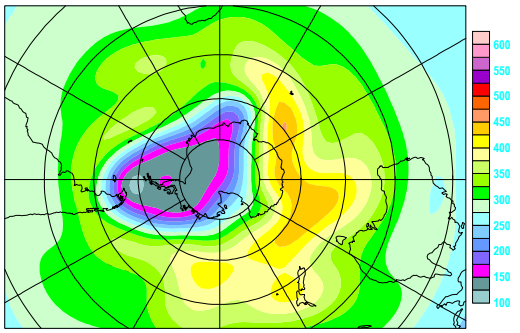
- EC has a proven track record of operationalization of EO

EC Space Activities – S&T

- Satellite Data Assimilation
  - data assimilation into Numeric Weather Prediction models
  - physical, air quality, surface variables
  - wide variety of operational and research satellites
- Climate and Atmospheric Processes
  - requirements, instrument validation, process understanding
  - e.g, clouds, precipitation, snow and ice retrievals
  - wide variety of research satellite data
- Air Quality and Atmospheric Chemistry
  - assimilation into global troposphere-stratospheric chemical-meteorological models
  - UV forecasts, AQ forecasts, reverse modeling
  - ozone, aerosols, GHG from various research satellites





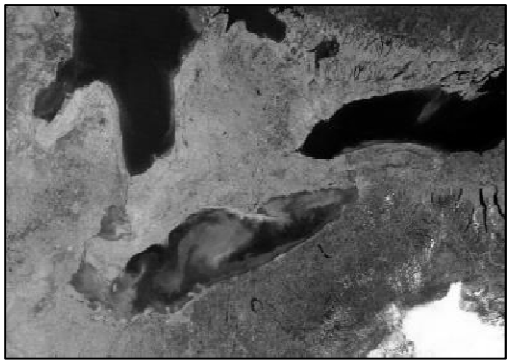


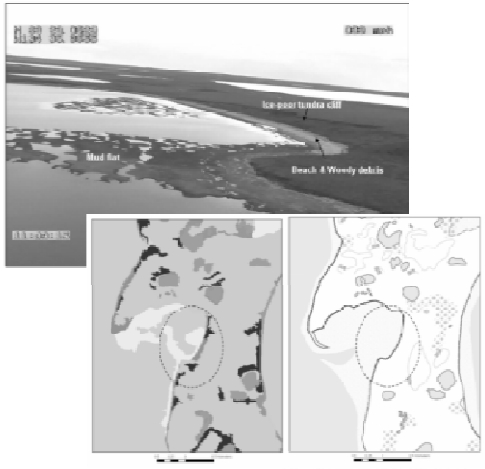
EC Space Activities – S&T

- Ecosystem Assessment and Monitoring
  - vegetation and disturbance land cover mapping
  - species at risk critical habitat
  - assessment of ecological services
  - high and medium resolution optical data, RADARSAT

- Inland Waters
  - surveillance of water colour, biologic activity, water quality, sediment transport
  - medium resolution multi- and hyper-spectral imagery

- Coastal Sensitivity Mapping and Emergency Pollution Incident Preparedness
  - classification of shoreline materials
  - Airborne video, RADARSAT

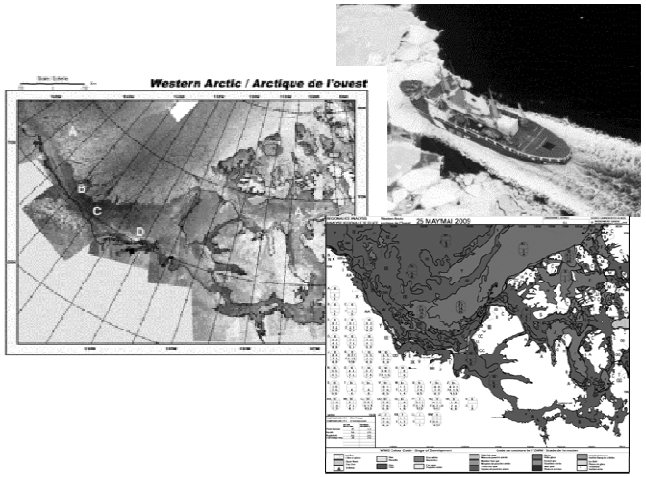




EC Space Activities - Operations

- Weather Forecasts and Warnings
  - 1.5M forecasts, 10k severe weather warnings
  - aviation, marine and ice
- Numerical Weather Prediction (NWP)
  - near-real time global data
  - 15-20 satellites, 4M+ obs/day assimilated
  - 90% of obs are space-based

- Sea Ice Monitoring and Forecasts
  - 2000+ ice charts, 400-500 warnings/yr
  - RADARSAT and other SAR satellites, meteorological missions
  - in partnership with Canadian Coast Guard



EC Meteorological Applications

Satellite Missions Inventory (2014)

16 current
10 future
+ space-based
derived products
from other centres

Satellite Information and MSC Applications

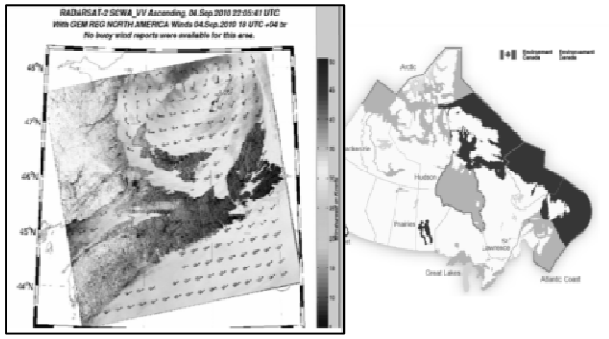
Created by the Satellite Product Working Group (SPWG) Last update: 2014.02.12.

Color code: *Black: Current satellites used in the MSC's regional applications* *Red: Future satellites with high priority in MSC applications* *Magenta: Other future satellites* Acronyms: Added below the table

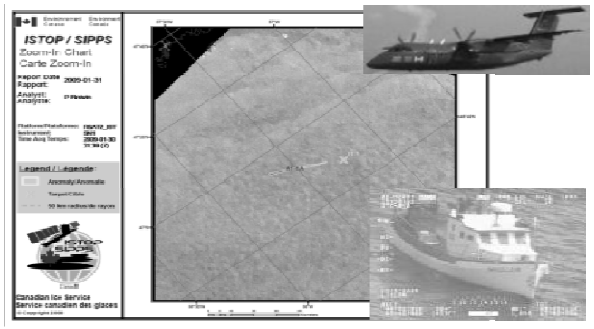
Satellite Series	Satellite	Sensor	Channel /Bands	Provider	Launch/ Operation	EC Direct Broadcast Reception	Applications	Spatial Coverage	Data Usage MSC	Data Usage EC	RAW Data Archive	Orbit	Satellite Photo
GOES Geostationary Satellite System	GOES-13	IMAGER	5 bands	NOAA	2006	Y	Weather forecast, severe storm tracking; (GOES measures Earth-emitted and reflected radiation from which atmospheric temperature, winds, moisture and cloud cover can be derived.)	East	Forecast and research	NWP	CMC and Dorwalview	Geo stationary	
	GOES-14	IMAGER	6 bands	NOAA	2009	Y		Stand by			CMC	Geo stationary	
	GOES-15	IMAGER	5 bands	NOAA	2010	Y		West	Forecast and research	NWP	CMC	Geo stationary	
METEOSAT	Meteosat-10	SEVIRI	12 channels	EUMETSAT	2013	Y	Operational meteorology	Europe and Africa, extend into the Gulf of St. Lawrence	Experimenting		Europe to CMC	Geo stationary	
POES Polar Operational Environmental Satellites	NOAA-15	AVHRR	5 bands	NOAA	1998	Y	Weather analysis and forecasting, climate research and prediction; (detection of cloud,snow,ice,forest fire, water, vegetation, temperature and soil moisture)	Global, 4 times daily	Forecast and analysis	NWP	CMC	Polar orbit	
		AMSU-A	Microwave							NWP			
	NOAA-16	AVHRR	5 bands	NOAA	2000	Y		Global, 4 times daily	Forecast and analysis	NWP	CMC	Polar orbit	
		AMSU-A AMSU-B	Microwave							NWP			
	NOAA-18	AVHRR	5 bands	NOAA	2005	Y		Global, 4 times daily	Forecast and analysis	NWP	CMC	Polar orbit	
		MHS, AMSU-A	Microwave							NWP			
	NOAA-19	AVHRR	5 bands	NOAA	2009	Y		Global	Forecast and analysis	NWP	CMC	Polar orbit	
		MHS, AMSU-A	Microwave							NWP			
	METOP-A	AVHRR	5 bands	EUMETSAT	2006	Y		Global	Forecast and data assimilation	NWP	[illegible]	Polar orbit	
	METOP-B	AVHRR	5 bands	EUMETSAT	2012	Y		Global		NWP	[illegible]		
	Suomi NPP	VIIRS, OMPS, CERES, CrLS, ATMS	22 bands	NOAA	2011	Y	Severe weather, such as deadly tornado outbreaks, blistering heat waves, floods, snowfall and wildfires	Global, US day time	Working to inject data into NinJo		tracking	Polar orbit	
RadarSat	RadarSat-2	SAR	Multiple polarization modes	CSA	1995		Severe weather forcasts	Arctic Daily, Canada every 72 hours, Global every 24 days	Weather forecast		[illegible]		
A-train satellite constellation	AQUA	MODIS	X-band	NASA	2002	Y	Earth's cloud cover, radiation budget and processes occurring in the lower atmosphere. application includes: Wildland fires, aerosol, detection of volcanic ash etc	Global every 1 to 2 days	Forecast/ Validation	NWP	http://modis.gsfc.nasa.gov/data/	Polar orbit	
		AMSU-A	Microwave							NWP			
		AIRS	Microwave							NWP			
	TERRA	MODIS	X-band	NASA	1999	Y		Global every 1 to 2 days	Forecast/ Validation	NWP	http://modis.gsfc.nasa.gov/data/	Polar orbit	
	CloudSat	Radar	W-band	NASA	2006	N	Clouds & Precipitation	Global every 1 to 2 days	Science/ Validation	Science/ Validation	[illegible]		
	CALIPSO	Lidar	3 channels	NASA	2006	N	Clouds & Aerosol	Global every 1 to 2 days	Science/ Validation	Science/ Validation	[illegible]	Polar orbit	
GOES	GOES-R*	ABI, GLM, etc	16 bands	NOAA	2016	Y	Weather forecast, severe storm tracking, lightning detection, rainfall rates, V-signature /Overshooting top detection, etc	Full disk				Geo stationary	
	GOES-S			NOAA	2017	Y	Weather forecast, severe storm tracking					Geo stationary	
POES	METOP-C	AVHRR		EUMETSAT	2017	Y	Weather analysis and forecasting, climate research and prediction					Polar orbit	
JPSS Joint Polar Satellite System	JPSS	VIIRS, OMPS, CERES, CrLS, ATMS		NASA	2016	Y	Monitor weather, atmosphere, oceans, land, and near-space environment	Global					
PCW Polar Communication and Weather Mission	Satellite 1	Spectroradiometer	21 bands	CSA	Aug. 2018		Monitor the Canadian Arctic weather, Improve weather forecast and weather warning for the Arctic	Arctic	Project collaboration	High priority for CSA, EC and DND etc	[illegible]	High elliptical orbit	
	Satellite 2	Spectroradiometer	21 bands	CSA	Nov. 2018								
Canadian Satellite	TICFIRE	Radiometer	6 channels	CSA	2015	N	Polar and cold regions; sever storm; thin ice cloud						
		Limb Image	1 TIR channel										
Global Precipitation Mission	GPM	Ku/Ka-band DPR and GMI		NASA/JAXA	2014	N	Precipitation, rain and snow		Science (Pre launch instrument verification 2013)			Polar orbit	
	SMAP	radar and radiometer		NASA	2014	N	Terrestrial soil moisture						
	SnowSat				2020	N	Snow and ice						

EC Space Activities - Operations

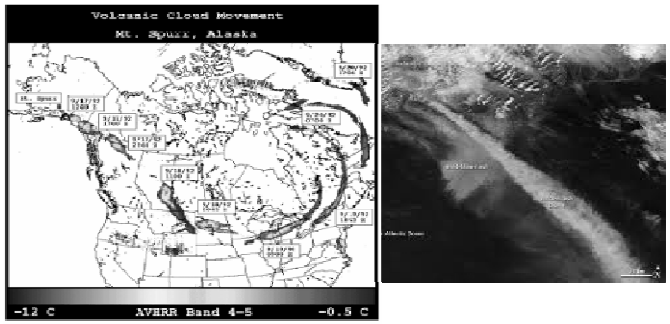
- SAR Winds
  - surface wind speed retrieval over water
  - 2013 - operational for marine forecasts and warnings
  - RADARSAT and other SAR



- Pollution Detection and Deterrence
  - ISTOP - Integrated Detection and Tracking of Polluters
  - aircraft, RADARSAT and other SAR

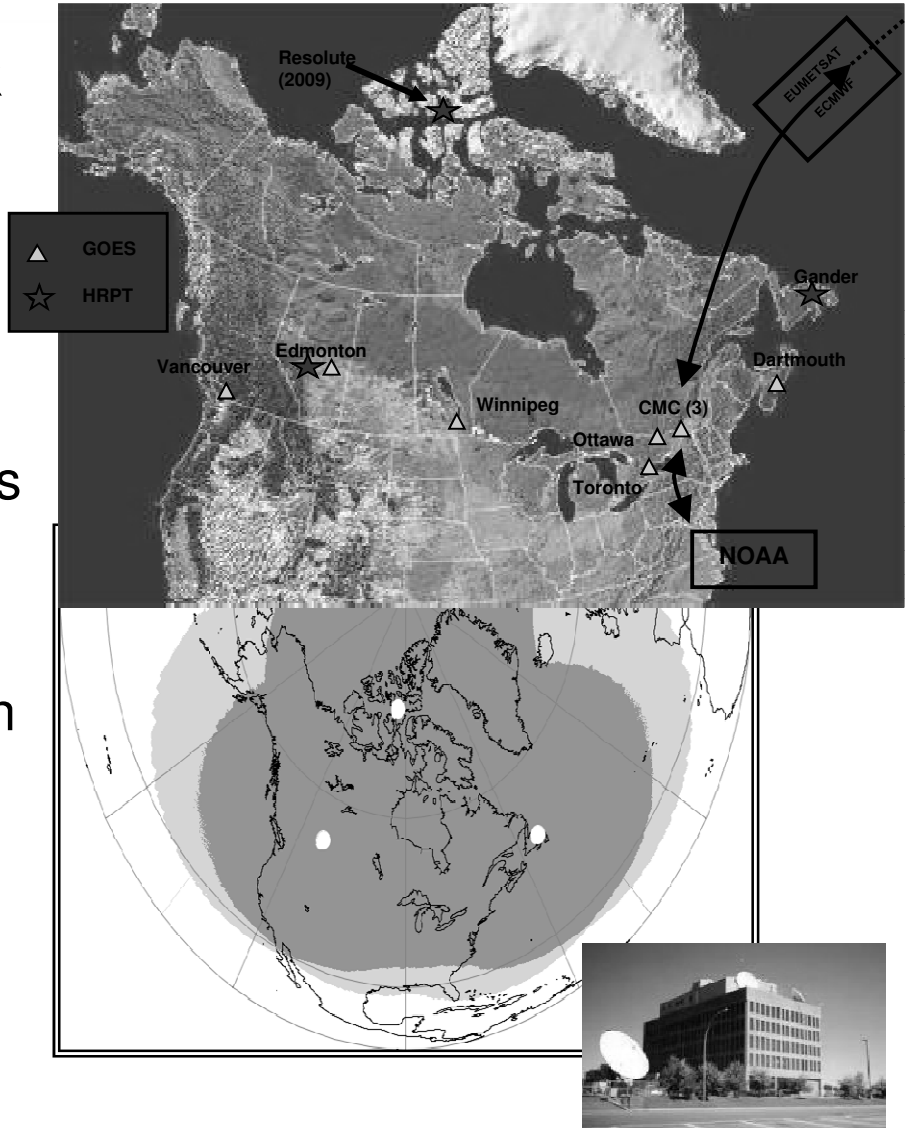


- Environmental Emergency
  - Volcanic Ash Advisory Centre – Dorval
  - plume analysis and reverse modeling (CBRN)
  - oil spill detection and response
  - met, optical, RADARSAT and other SAR

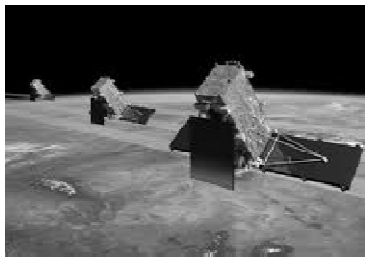


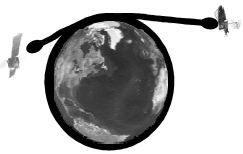
EC Satellite Reception Operations

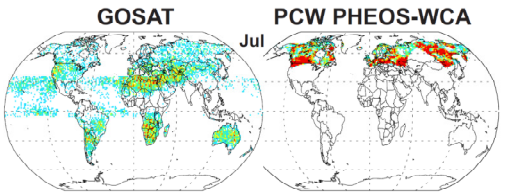
- EC Satellite Reception Network
  - 10 Geostationary (GOES)
  - 4 Polar Orbiting (POES)
  - operational data exchange within WMO global network
- Other data supply arrangements
  - e.g., NOAA, EUMETSAT, WMO
- Preparation for Next-Generation Met Missions – 2017-2020
  - JPSS, GOES-R, Post-EPS



The Future
- EC Space Priorities

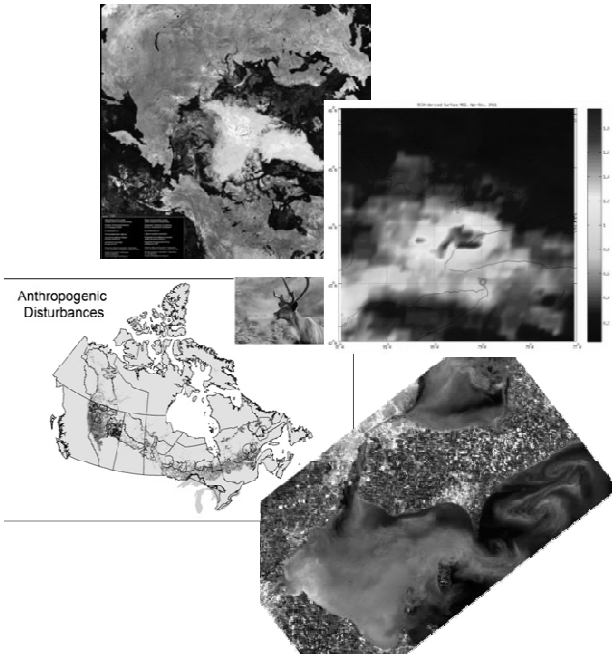






- Activities
  - Maintain space capabilities to support current programs
  - Transition demonstrated applications into operations
  - Enhance integration into policy, regulatory, compliance monitoring

- Capabilities
  - Weather and Climate variables (modeling)
  - Water – quality and quantity
  - Ecosystem Assessment and Monitoring
  - The North



  - Greenhouse Gases
  - Air Quality
  - Climate monitoring

-

Priority on Partnerships

- Partnerships are essential to meet EC requirements
  - federal, academia, industry
  - international
    - research space agencies – NASA, ESA, …
    - operational space agencies – NOAA, EUMETSAT, …
    - WMO Space Programme
    - Group on Earth Observation (GEO)
    - user communities
    - ….
- Benefits to EC
  - access to essential EO data – Canadian and global
  - influence missions to address Canadian requirements
  - leveraging Canadian and international investments in science and technology

Space Policy Framework

- Recognizes the strategic importance of space to Canada
  - strengthens strategic goals and structure of the space program
- Governance
  - higher levels of engagement and decision making welcomed
  - clarifies and increases roles of government departments
    - priority setting, commitments
  - prompting EC to strengthen its internal processes
- Remaining Challenges/Questions – e.g.:
  - ensure the full space value-chain is considered in the program
  - how can departments *'Pay-to-Play'*?
  - how to harness and support academia to advance government priorities
  - availability of CSA expertise to support departments
  - governance - finding the right blend of efficiency and effectiveness
  - others…

Conclusion

- EC is a large, capable, and committed stakeholder in the Canadian space program
  - mission-critical dependencies on Canadian and partner systems
  - end-to-end capability - science, technology transfer, operations
  - strong track record of operationalization

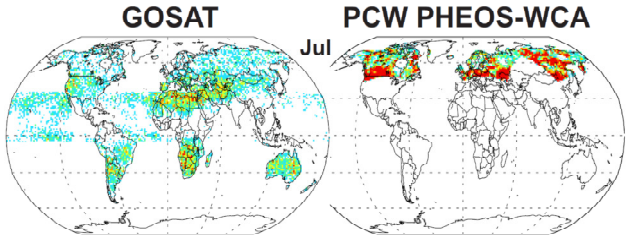
- EC has very broad dependencies, opportunities and expectations from space
  - prioritization and choices are required

- EC will work to support the new Space Policy Framework and governance
  - coordinated and prioritized requirements
  - active participation in governance
  - development of viable approaches to ‘pay-to-play’

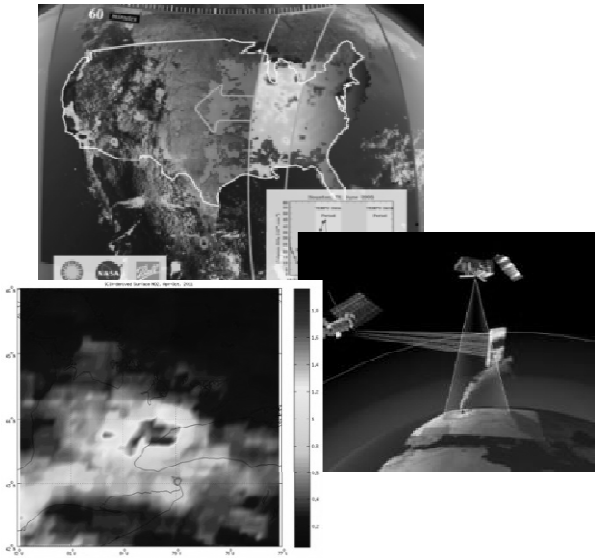
EC Priorities – Extra Slides

EC Space Priorities (1)

- Green House Gases (GHG)
  - continuous, broad geographic observations of CO_2 and CH_4 in the boundary layer

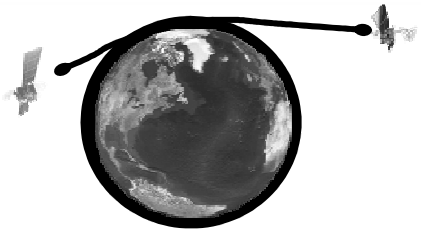


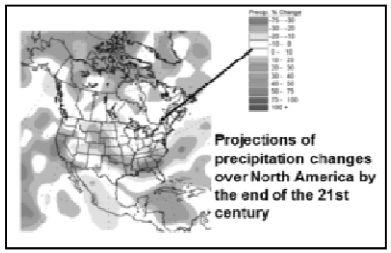
- Air Quality (AQ)
  - measurements of key AQ species near the surface (O_3, NO_2, SO_2, HCHO, CO, aerosol)
  - limb measurements of vertical profiles of key AQ species (O_3, NO_2, aerosol) in the upper troposphere and stratosphere
  - measurements of stratospheric O_3 to better predict surface-UV

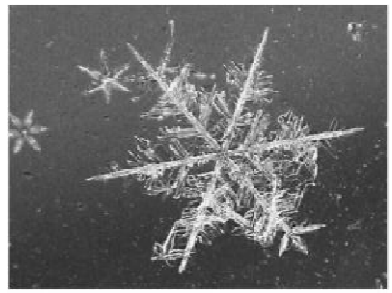


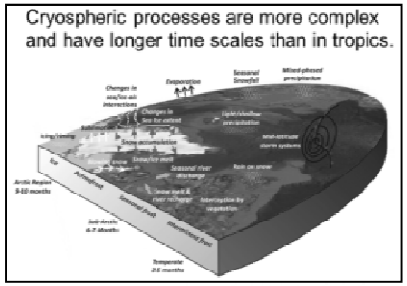
EC Space Priorities (2)

- Weather and Climate Variables
  - for process studies and assimilation into NWP
  - atmospheric - tropics and polar regions
    - temperature and humidity (via radiances, GNSS radio-occultation, other limb-sounding)
    - winds – image motion or active measurement
    - aerosol optical depth
  - snow
    - a major weather/climate variable and a large observation gap
    - falling precipitation and snow-on-ground
  - surface variables
    - land surface temperature and spectral emissivity
    - surface water extent, soil moisture
    - sea surface temperature –diurnal variation
    - sea-ice fraction and thickness



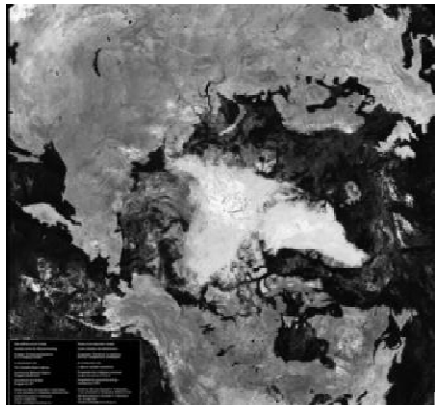


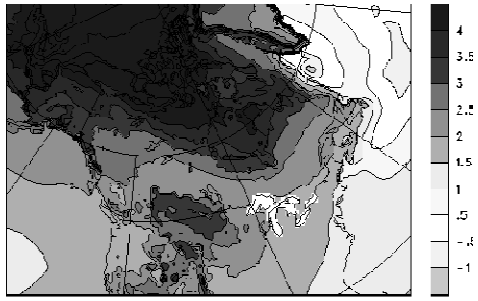


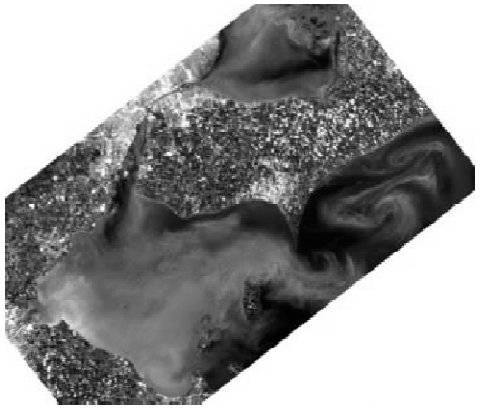


EC Space Priorities (3)

- Climate
  - monitoring
    - Essential Climate Variables (ECVs), Satellite Data Records (SDRs) over Canada
  - model development and validation
    - broad range of atmospheric climate variables, composition, surface characteristics
  - long, homogeneous observational data sets
- Water
  - Productivity assessments of coastal and inland water ecosystems
  - surface water height/extent, soil moisture, ice jams
  - monitoring capabilities for regional water quality; water clarity and harmful algal blooms (NRT detection and long term monitoring)
  - monitor river plumes, erosion, and storm events

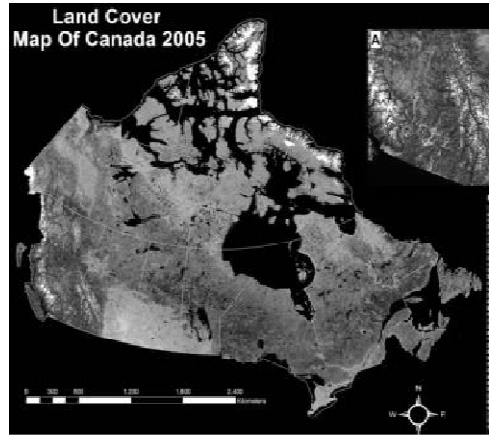


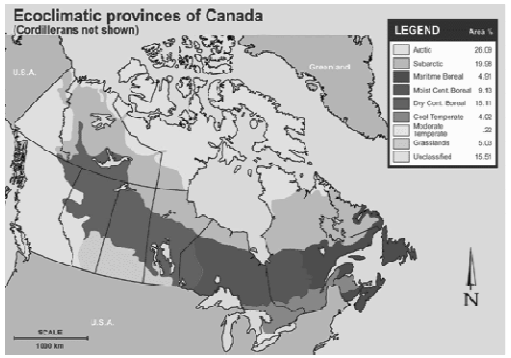




EC Space Priorities (4)

- Ecosystem Assessment and Monitoring
  - Essential Biodiversity Variables (EBVs), Essential Ecosystem Variables (EEVs)
    - monitor and assess habitat/ecosystem change, provision of ecosystem services
    - e.g., disturbance, land cover, wind, snow, precipitation, sea-ice formation, Normalized Difference Vegetation Index, digital elevation, soils, phenology
  - Circumpolar Biodiversity Monitoring Program





EC Space Priorities (5)

- The North
  - region of growing interest
    - environmental change
    - economic development
    - scientific importance
  - seeking space-based solutions to high cost and logistical challenges of the region
  - extension of full range of EC science, operations and services
  - support to Canadian High Arctic Research Station (CHARS)
    - e.g., Circumpolar Biodiversity Monitoring Program – Arctic Council
  - existing and proposed solutions
    - Canadian and foreign missions
    - operations, research, telecommunications